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Sub report 4-5
Analyses of hydrological models for climate change modelling
WETSPA

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Sub report 4-5 – Analyses of hydrological models for climate change modelling – WETSPA

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Abstract

The water balance model of the Scheldt basin will be used in order to perform low flow forecasts and calculate climate change scenarios. Within the current subtask is investigated which is the most appropriate hydrological model for the sub catchments of the water balance model of the Scheldt basin in order to meet this prerequisite. This sub report describes the evaluation of WETSPA models (Water and energy transfer between Soil plant and atmosphere, Salvadore, E. et al., 2012, 2021).

Hydrological models with WETSPA are developed for the sub catchments included in the water balance model (including the Meuse basin). To assess the water availability and the flow behavior, each catchment was calibrated manually to find an optimal parameter set. The optimization during calibration is performed based on an automatic procedure followed by a visual control. During the optimization routine the parameters set is selected based on 2 criteria: (1) absolute error on cumulated total flow at each time step, and (2) logarithmic Nash-Sutcliff efficiency. The first criterion aims to model the global flow pattern, the latter focuses mainly on the low flows.

In general the simulation of the hydrology of the Scheldt and the Meuse basin gives from reasonable to fairly good results and by consequence the developed hydrological models could be used to predict the future water availability under climate change.

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1 Introduction

1.1 Objectives

The water balance model of the Scheldt basin will be used in order to perform low flow forecasts and calculate climate change scenarios. The goal of this subtask of the project 'Modelling water availability and water allocation strategies in the Scheldt basin', is to define the most appropriate hydrological models for the water balance model of the Scheldt basin in order to meet this prerequisite. Therefore, different hydrological models for each of the sub catchments in the study area are set up and evaluated on their appropriateness for low flow forecasting and climate change scenarios. The regarded models are NAM (©DHI), PDM (©Innovyze), VHM (©Willems, P.) and WETSPA (©VUB). Overall descriptions of these models can be found in Vansteenkiste et al. (2011). After evaluation of each of these hydrological models, the most appropriate model for each catchment can be used for the particular application.

This sub report covers the calibration and evaluation of WETSPA. This spatially distributed model calculates a discharge time series based on the historical rainfall, evapotranspiration time series, topography map, land use map, and soil map. As such, the simulated discharge for the sub catchments in the water balance model can then be used to assess the water balance in the Scheldt and the Meuse basin for a long term period.

The calibration is performed based on an automatic optimization procedure followed by a visual control. During the optimization routine the best parameters set is selected for each catchment based on 2 criteria: (1) absolute error on cumulated total flow at each time step, and (2) logarithmic Nash-Sutcliff efficiency. The first criterion aims to model the global flow pattern, the latter focuses mainly on the low flows.

Ungauged catchments inherit the parameters from similar neighboring catchments.

After validation and robustness checks, the WETSPA models will, if suitable, ready to be used for low flow forecasting and climate change scenario simulations.

1.2 Description of the study area

The study area covers the whole area of Flanders and Wallonia in Belgium and some regions of France (Figure 1). Flanders shares its borders with Wallonia in the south. The rest of the border is shared with the Netherlands in the north and east, and with France and the North Sea in the west. Two main geographical regions cover Flanders: the coastal basin plain in the north-west and a central plain in the remaining areas. Agriculture dominates the land use in Flanders with 61% of total area, mainly livestock and arable farming. Flanders covers part of the international Scheldt and Meuse river basin. The total hydrological system of the Flanders area is distributed over different river basins of different sizes. The main river basins within the area of the Flanders include Zeeschelde, Dender, Demer, Nete, Leie, and Bovenschelde (ISC, 2005).

The Meuse area covers an area of approximately 3600 km², with its 950 km long river (Braunwens, A., et al., 2011). The Meuse originates in Champagne-Ardene in France and flows through France, Belgium and the Netherlands to reach the Haringvliet sea stretch. The basin covers five countries including France, Belgium, Luxembourg, Germany, and the Netherlands. The Meuse is characterized by a rainfall-evaporation regime with high runoff in winter and low in summer.

The climate of the Scheldt and the Meuse basin is maritime temperate, with significant precipitation in all seasons. The average temperature is 3° C in January and 21° C in July. The average precipitation is 65 millimetres in January, and 78 millimetres in July.

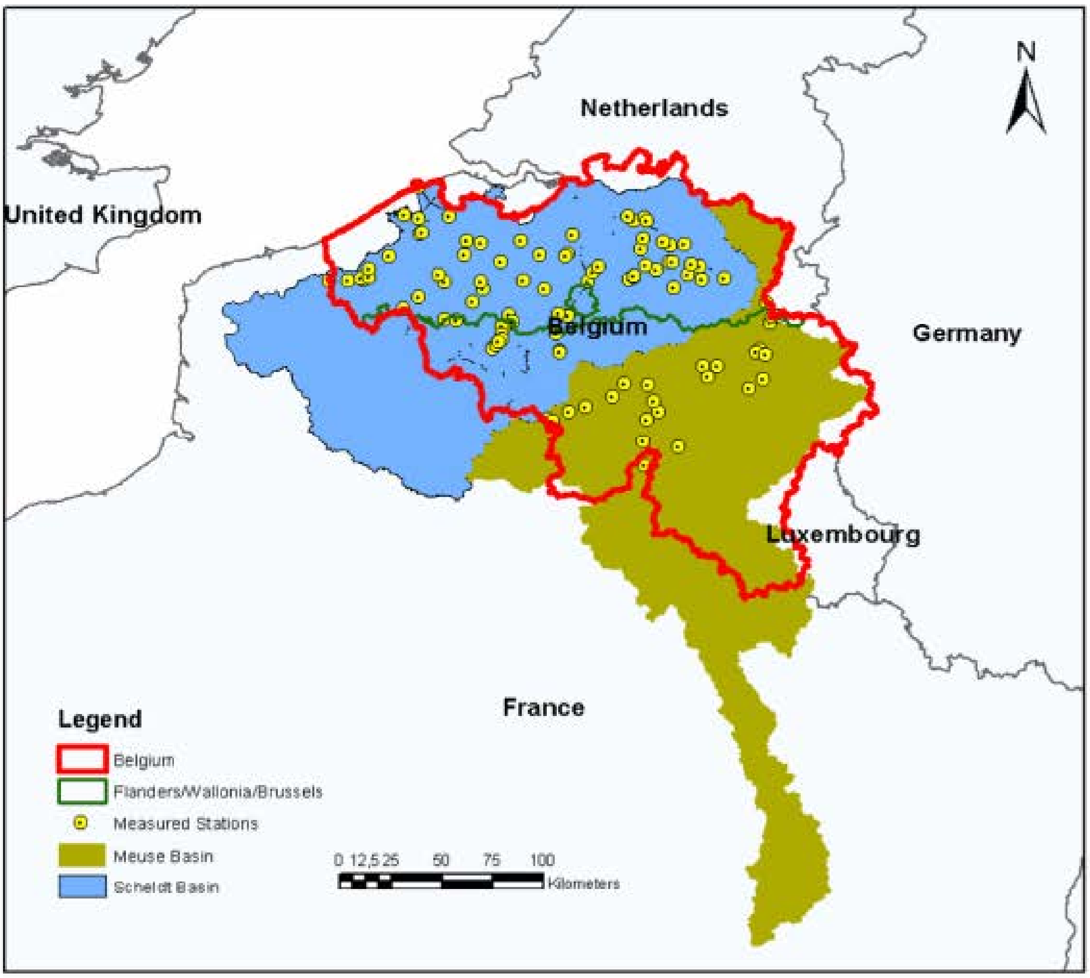

Figure 1 – The location of the Scheldt and the Meuse basin.

1.3 Structure of the report

In a first section, the addressed catchments are defined and reliable gauging stations selected (Section 2). Secondly, rainfall and evapotranspiration are interpolated for the selected catchments, according to the Thiessen polygon method (Section 3). Additionally, in this stage the required spatially distributed maps are prepared as input for the WETSPA model.

The general structure and parameters of the WETSPA model are outlined in Section 4 while the calibration strategy and basic logic behind the automated calibration algorithm are explained in Section 5.

Once all WETSPA models for the gauged catchments are calibrated, flow is simulated for 47 years (1967-2013). Ungauged catchments are simulated using parameters of a nearby catchment with similar characteristics. Results are synthetized in Section 6 and detailed in the appendices.

Section 7 presents conclusions of the calibration and some recommendations to consider when using the calibrated WETSPA models in the next steps of the project.

2 Catchment delineation

2.1 General

The inputs of the water allocation model are discharge time series at the upper boundaries and entries of tributaries in the modelled water network. This rainfall runoff discharge is simulated by means of one of the abovementioned hydrological models (NAM, PDM, VHM, WETSPA). Apart from the Scheldt catchment as such, the IJzer basin and the catchment of the Brugse Polders are also included in the water allocation model and therefore also included to this study. The map on Figure 1 shows the main river basins included in the water allocation model. In this report, results will be structured geographically per basin.

Delineated hydrological subcatchments for the water allocation model were collected in 2010 based on past modelling studies (De Boeck et al. 2011) and updated within the framework of the present study. Figure 2 shows an overview of the delineated catchments in the water allocation model. For the gauged catchments, where a time series of measured discharge is available, the WETSPA models are calibrated.

Some of the gauged catchments in the water allocation model are subdivided in different subcatchments to distribute the inflow over the modelled river stretches. Each of these subcatchments inherits the parameters of the main gauged catchment. An example of this is the Leie catchment upstream of the measuring station the Menen, which is subdivided into 27 subcatchments. The catchment itself is calibrated on the discharge timeseries of the gauging station the Menen. Within the water allocation model the rainfall runoff of each of these 27 subcatchments is calculated based on its particular interpolated rainfall- and evaporation series and linked individually to the appropriate modelled water course. For more detail about the choices and methodology of catchment delineation, please see De Boeck et al. (2011)[1] . Ungauged models inherit WETSPA parameters from similar neighboring catchments.

All catchments of the water allocation model received a unique informative code, as defined in the previous phase of the project (De Boeck et al., 2011). Each code consists of 12 characters, relative to the catchment location, main water course and gauging station:

- **Character 1 :** region where the catchment is located (V: Flanders; W: Wallonia; N: Netherlands; F: France)
- **Characters 2 and 3:** number of the Flemish hydrographic basin to which the catchment belongs.
- **Characters 4,5 and 6:** initials of the main water course
- **Characters 7, 8 and 9:** first three digits of the gauging station code (or 3 letter initials) for gauged catchments, and "000" for ungauged catchments.
- **Characters 10, 11 and 12:** three digit-suffix that ensure catchment code differentiation.

[1] WL2011R724_04c_rev2_1_DO3.doc

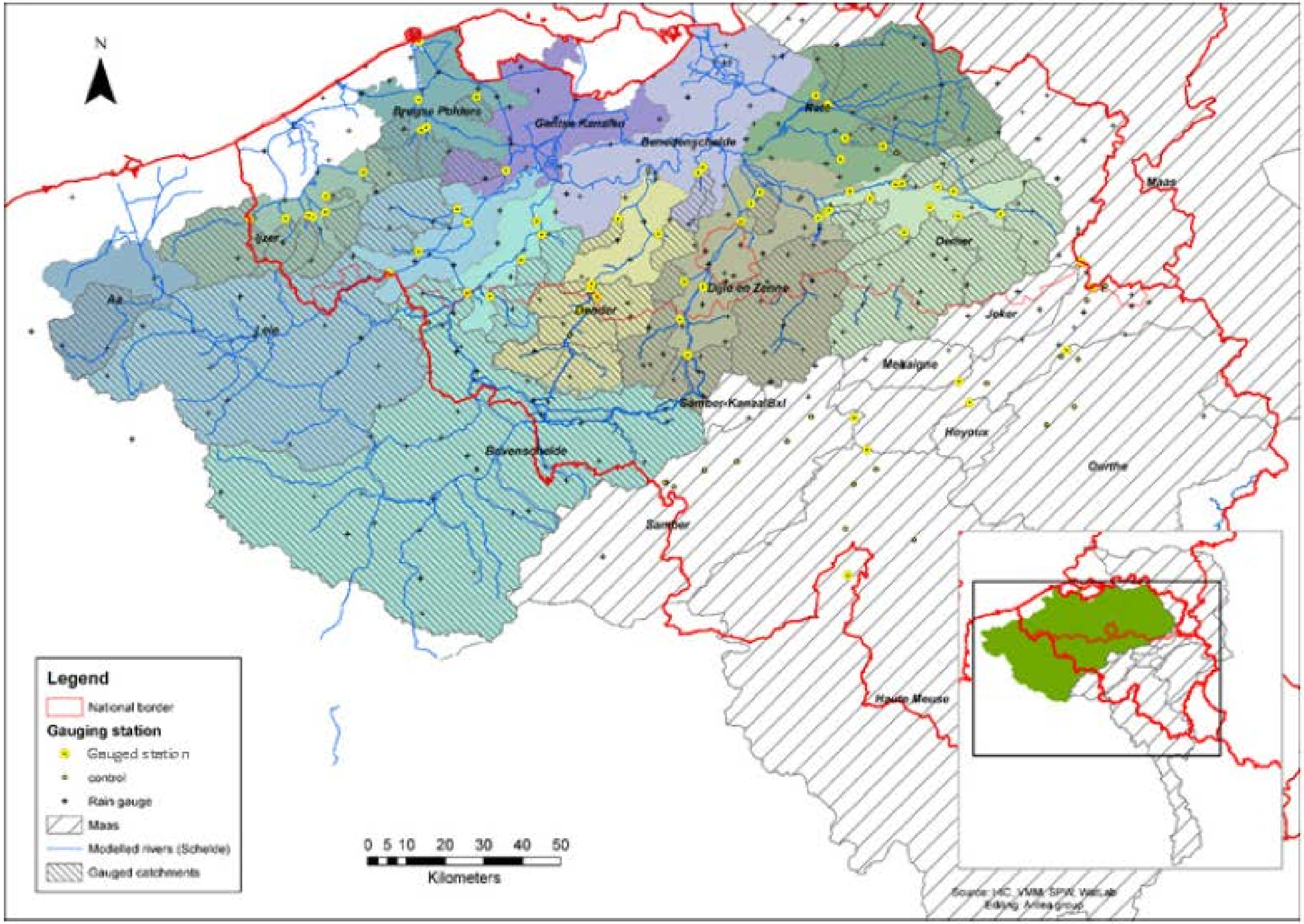

Figure 2 – Map of gauged and ungauged catchments of the Scheldt basin, the Brugse polders and the IJzer.

2.2 Gauged catchments in the Scheldt basin

Table 1 below gives the list of gauged station used for calibration of the rainfall-runoff models. Catchments that were calibrated jointly are listed in Table 2.

Table 1– List of gauging stations on the Scheldt and its tributaries for calibration of hydrological models

Gauging station (code - water course; location)	DSG	Area (km²)	Gauged years
48810102 - Krekelbeek; Kortemark	V01HAN488180	78.6	1994-2016
46810102 - Ijzer; Roesbrugge Haringe	V01HEI468999	393.0	1986-2016
49510102 - Ieperlee; Zuidschote	V01IEP495080	63.4	1983-2014
49270102 - Kemmelbeek; Boezinge	V01KEM492060	73.9	1986-2015
49610102 - St. Jansbeek; Merkem	V01MAR496120	76.1	1986-2016
49110102 - Poperingevaart; Oostvleteren	V01POP491030	84.9	1984-2016
49910102 - Steenbeek; Merkem	V01SSV499140	16.1	1990-2009
44210102 – Ede, Maldegem	V02EDE442120	45.5	1983-2016
42610102 - Hertsbergebeek; Oostkamp	V02HER426010	77.3	1986-2016
4220102 - Kerkebeek, Sint-Michiels	V02KER422030	62.7	1983-2008
42510102 - Rivierbeek; Oostkamp	V02RIV425020	64.0	1983-2016
44656122 - Poekebeek; Nevele	V03POE446000	106.8	1983-2010
3610102 - Kleine Molenbeek, Liezele	V04MOL036110	32.6	1966-2016
3710102 - Grote Molenbeek, Malderen	V04MOM037100	67.3	1966-2016
38680122 - Leie te Menen	F05LEI386999	2981.8	1998-2016
40310102 - Heulebeek; Heule	V05HEU403210	91.9	1972-2016
40110102 - Mandel; Oostrozebeke	V05MAN401230	258.4	1967-2013
32580122 - Bovenschelde; Bossuit	F06BOS325999	5217.6	2001-2014
34710102 - Maarkebeek; Etikhove	V06MAA347160	48.7	1972-2016
34210102 - Zwalm; Nederzwalm	V06ZWA342190	112.1	1972-2016
L5412 - Amougies - Rhosnes	W06RHOL54100	161.9	2012-2016
28510102 - Bellebeek, Essene	V07BEL285070	88.7	
28970102 - Marke, Viane	V07MAR289015	173.9	1976-2016
28210102 - Molenbeek, Erpe Mere	V07MOE282100	46.4	1986-2016
28810102 - Molenbeek, Geraardsbergen	V07MOG288020	23.1	1985-2014
2708-1050 Dendre; Lessines	W07DENLES999	511.8	
11110102-Barebeek, Elewijt	V08BAR111370	69.9	1997-2004
9310102 - Dijle, Wilsele	V08DIJ093400	886.9	1974-2014
23310102 - Zuunbeek, St Pietersleeuw	V08ZUU233100	64.8	1985-2016
2371-10050 Samme, Ronquieres	W08SAMRON000	133.6	1989-2016
L5670 -Senette, Ronquieres	W08SENL56010	70.4	1977-2016
1951-10050 Zenne, Tubize	W08SENTUB030	215.9	1975-2016
13610102 - Demer; Hasselt	V09DEM136000	255.1	1997-2016
15210102 - Gete; Halen	V09GET152080	800.4	1969-2013

Gauging station (code - water course; location)	DSG	Area (km²)	Gauged years
16310102 - Herk, Kermt	V09HER163010	274.6	1977-2016
14710102 - De Hulpe; Molenstede	V09HUL147150	80.1	1986-2016
14310102 - Grote Losting; Wezemaal	V09LOS143300	15.2	1986-2016
16110102 - Mangelbeek; Lummen	V09MAN161040	102.9	1983-2011
14410102 - Motte; Rillaar	V09MOT144270	33.6	1986-2010
14510102 - Velp; Ransberg	V09VEL145100	96.8	1969-2016
14110102 - Rotselaar ; Winge	V09WIN141310	64.7	1986-2016
14810102 - Zwarte Beek; Lummen	V09ZWA148120	96.2	1983-2016
7610102 - Grote Nete/Geel Zammel	V10GNE076999	243.5	1985-2013
5210102 - Kleine Nete; Grobbendonk	V10KNE052000	584.7	1983-2016
6210102 - Molenbeek, Pulle	V10MOP062140	77.3	1986-2014
8210102 – Wimp, Wiekevorst	V10WIM082050	65.4	1989-2007

Table 2– Catchments calibrated jointly based on one gauging station

Gauging station (code - water course; location)	Joint code	Catchments		
46810102 - Ijzer; Roesbrugge Haringe	**F01IJZ468000**	V01HEI468010 F01YSE468000		
38680122 - Leie te Menen	**F05LEI386001**	F05BEC386023	F05DEU386090	V05LEI386180
		F05BEC386025	F05DEU386110	F05LOI386035
		F05BOU386005	F05DEU386120	F05LYS386000
		F05CLA386017	F05DEU386130	F05LYS386010
		F05CLA386020	F05DEU386140	F05LYS386015
		F05DEU386040	F05DEU386150	F05LYS386115
		F05DEU386050	F05DEU386160	F05MAR386070
		F05DEU386060	F05LAW386018	F05MAR386100
		F05DEU386080	F05LAW386030	W05LYS386170
32580122 - Bovenschelde; Bossuit	**F06BOS325001:**	F06BOS325000	F06ERC325030	W06BOS325095
		F06BOS325015	F06HOG325070	W06BOS325105
		F06BOS325016	F06RHO325060	W06BOS325115
		F06BOS325017	F06SCA325020	W06HAI325080
		F06BOS325018	F06SCA325025	W06HAI325085
		F06BOS325019	F06SEL325040	W06HAI325090
		F06ECA325050	F06SEN325010	
14410102 - Motte; Rillaar	**V09WIN141310**	V09LOS143300		
7610102 - GroteNete; Geel-Zammel	**V10GNE076999**	V10GLA086020		

2.3 Gauged catchments in the Meuse basin

In addition to the abovementioned catchments, which are mainly corresponding to the catchments delineated in the first project concerning the water balance model (WL-09-46), the Meuse river is refined in the current water balance model.

In order to produce discharge time series as inputs for the Meuse system between Monsin and Maastricht, the hydrology of the contributing catchments in France and Wallonia needs to be included. The Meuse basin is the second biggest hydrographic district of Belgium (about 20.450 km² in Visé) and the river has its source in France in Pouilly-en Bassigny and enters Belgium in Agimont. The gauging station of Chooz, located in France, is the closest to the Walloon border. The main tributaries of the Walloon Meuse are the Sambre (about 2.700 km²), meeting the Meuse in Namur, and the Ourthe (about 3.600 km²) in Liège.

Figure 3 shows a map of the Meuse basin in Wallonia. The delineation of the catchments and the distinction between ungauged and gauged catchments is done by Maroy et al. (2021).

On Figure 3, flow measuring stations (yellow dots) and their corresponding catchments are displayed. 17 usable gauging stations are selected (Table 3). Chooz station (located in France) is considered to measure the entering flow of the Meuse at the French border, while Solre station is recording the entering flow for the Sambre.

Table 3– List of gauging stations on the Meuse and its tributaries for the calibration of the hydrological models

Catchment	Station/River	Area (km²)	Subcatchment ID	Available data	Owner
Hoyoux	**Marchin/Hoyoux**	**242**	**W11HOY5990**	**1/01/2001-31/12/2013**	**DGO2**
Mehaigne	**Wanze/Mehaigne**	**356**	**W11MEH5820**	**1/01/2001-31/12/2013** (except 2003)	**DGO3**
Haute Meuse	Herock/Lesse	1156	W11LES6610	1/01/2001-31/12/2013	DGO3
Haute Meuse	Yvoir/Bocq	230	W11BOC8134	1/01/1979-31/12/2014	DGO2
Haute Meuse	Warnant/Molignée	125	W11MOL8163	1/01/1969-31/12/2014	DGO2
Haute Meuse	Hastières/Hermeton	166	W11HER8622	1/01/1969-31/12/2014	DGO2
Haute Meuse	**Chooz/Meuse**	**10120**	**F11MAA8702**	**1/01/1990-31/12/2014**	**DGO2**
Ourthe	**Angleur 2 bis/Ourthe**	**3612**	**W11OUR5805**	**1/01/1974-31/12/2014**	**DGO2**
Sambre	Aiseau/Biesme	78	W11BIE5442	1/01/2001-31/12/2013	DGO3
Sambre	Thuin/Biesme l'eau	86	W11BLE6630	1/01/2001-31/12/2013	DGO3
Sambre	Jemeppes-s-O/Orneau	211	W11ORN7241	1/01/2007-31/12/2013	DGO3
Sambre	Jamioulx/Eau d'Heure	322	W11EDH7711	1/01/1995-31/12/2014	DGO2
Sambre	Wiheries/Hantes	142	W11HAN7944	1/01/1985-31/12/2014	DGO2
Sambre	Solre/Sambre	1188	F11SAM7487	1/01/1998-31/12/2015	DGO2
Sambre	**Salzinne Ronet**	**2669**	**W11SAM7319**	**1/07/2006-31/12/2014**	**DGO2**
Berwijn	**Moelingen/Berwijn**	**128**	**W11BER551010**	**1/01/1991-31/12/2014**	**VMM**
Jeker	**Kanne/Jeker**	**465.5**	**W11JEK553010**	**1/01/1993-31/12/2014**	**VMM**

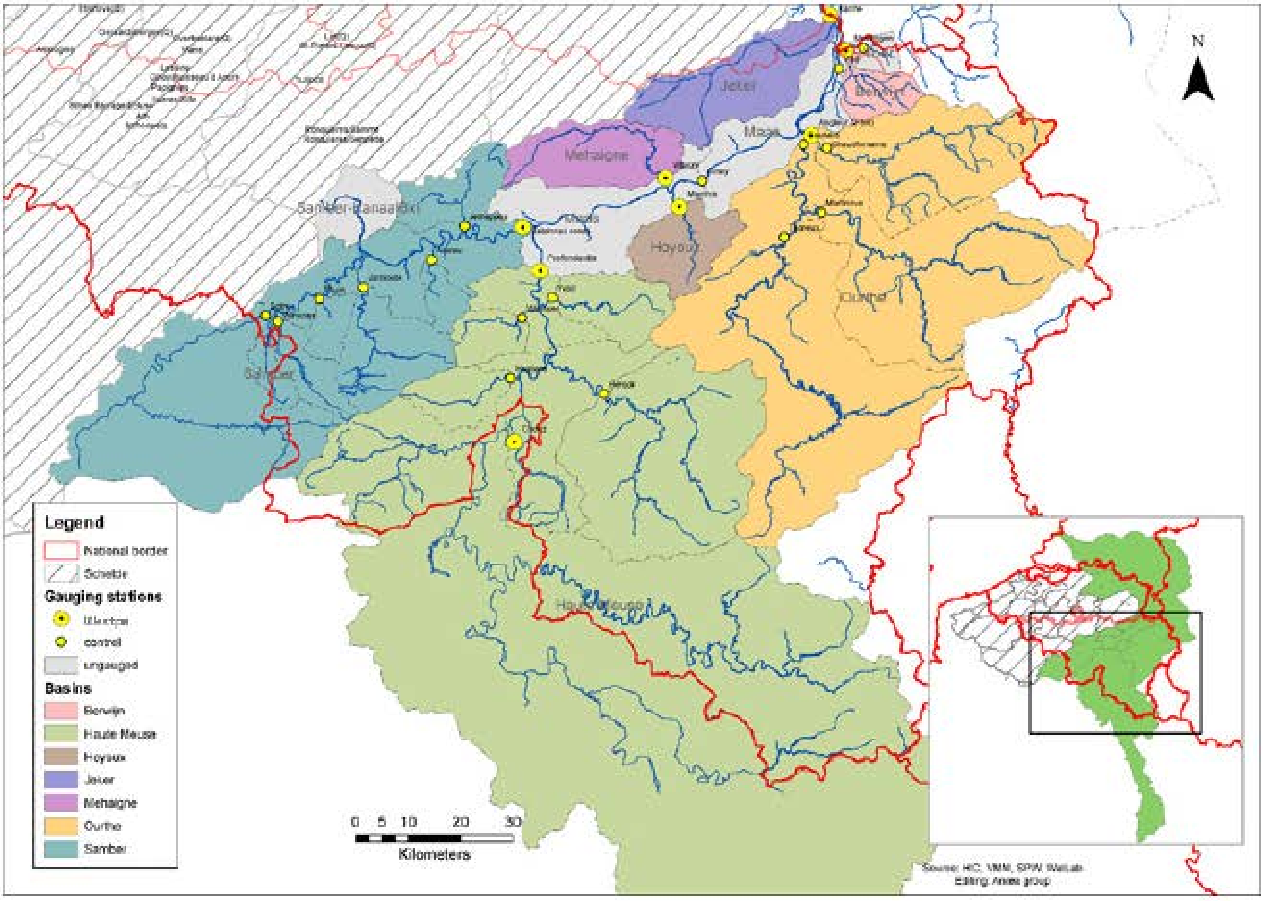

Figure 3 – Map of gauged and ungauged subcatchments of the Meuse basin in Belgium

Because of the large working scale, and because of limited access to data about Walloon water management, quite large subcatchments were finally selected to model the Meuse basin (Table 4). Depending on availability of reliable data, calibration periods of about 5 years were selected in the most recent years. Such long calibration periods were possible thanks to the model fast computation time. Validation was also performed on the period of about 5 years with discharge measurements.

Table 4– Final list of flow measuring stations for the calibration of rain-runoff model parameters in the Meuse basin

Basin	Station/River	Station number	Area (km²) delineation	Subcatchment ID	Calibration period
Hoyoux	Marchin/Hoyoux	5990	242	W11HOY5990	2009-2013
Mehaigne	Wanze/Mehaigne	5820	356	W11MEH5820	2009-2013
"Haute Meuse" (Meuse upstr. from Profondeville)	Profondeville/Meuse	calculated	12586	W11MAAPROF	2009-2013
"French Meuse" (Meuse upstr. Chooz)	Chooz/Meuse	8702	10120	F11MAA8702	2009-2013
Ourthe	Angleur 2 bis/Ourthe (calculated)	5805	3612	W11OUR5805	2008-2012
Sambre	Salzinne Ronet/Sambre	7319	2669[2]	W11SAM7319	2011-2013
Berwijn	Moelingen	551	128	W11BER551010	2000-2004
Jeker	Kanne	553	465.5	W11JEK553010	2009-2013

[2] Surface area draining to the canal Brussels-Charleroi is excluded from the Sambre and Amay catchment.

3 Input data preprocessing

3.1 Thiessen polygon method

Interpolated precipitation was produced for each catchment according to the Thiessen polygon method, using Hydr@ (IMDC, 2010). Rainfall and evapotranspiration are interpolated using weights inversely proportional to the distance to the weather station, using measurements available for each time step. Because of the large scale and the long term nature of timeseries used in this study, a daily time step is used. For consistency reasons, calibration is also based on daily time series. Both meteorological and discharge time series are thus sampled at a daily time step.

3.2 Precipitation

Thiessen precipitation needed to be calculated for all delineated subcatchments (Section 2). Source data consists hereby of rainfall measurements from 1967 to 2013, spread over the entire model area and around. The Scheldt catchment extends over France, Flanders, Wallonia and the Netherlands. Precipitation data was thus gathered from instances in Belgium, Netherlands and France. For Belgium, precipitation data was gathered from KMI (The Royal Meteorological institute) and SPW (Public Services of Wallonia). For France, data was gathered from Météo France.

Since the previous NAM calibration study in Flanders (De Boeck et al. 2011), reliability of the rainfall interpolation was greatly increased for the French Leie and Bovenschelde (discussed in Michielsen et al., 2021). Due to additional data from the French weather stations, the amount of rain gauges for the the Bovenschelde and Leie (including the French part) increases to 46 rain gauges and 30 respectively (Table 5).

Table 5– Number of rain gauges per hydrographic basin

Hydrographic basin	Area (km^2)[3]	Number of subcatchments (gauged and ungauged)	Number of rain gauges
Benedenschelde	1 704	24	21
Bovenschelde	5 380	33	46
Brugse Polders	1 046	24	13
Demer	2 334	36	29
Dender	1 384	17	17
Dijle en Zenne	2 450	49	37
Gentse Kanalen	917	29	11
Ijzer	1 046	18	9
Leie	3 886	39	30
Nete	1 673	20	24

[3] ANON

3.3 Evapotranspiration

Whereas there is a lot of precipitation input data, it doesn't apply for evaporation data. Thiessen evaporation data is very scarce. As an example, for the entire period (from 1967-2013), there was only one active PE station in France, located in Langres, 10 km outside the southernmost part of the Scheldt basin. The evaporation per catchment was calculated based on interpolation of PE data which was already available from the Scheldt and the Meuse basin (a combination of Uccle and Herentals data). All interpolated evapotranspiration timeseries are practically identical because of their geographical proximity.

3.4 Spatial distribution maps

3.4.1 DEM (Digital Elevation map)

The Digital Elevation Model used to model the Meuse and Scheldt basins within Belgium and France was obtained from two different sources. A 5x5m resolution DEM is available for Belgium, while the remaining area is obtained from the GMES RDA project with a resolution of 25x25m. Both DEM's are resampled to a 50x50 resolution to be used as input layer in the WETSPA model (Figure 4).

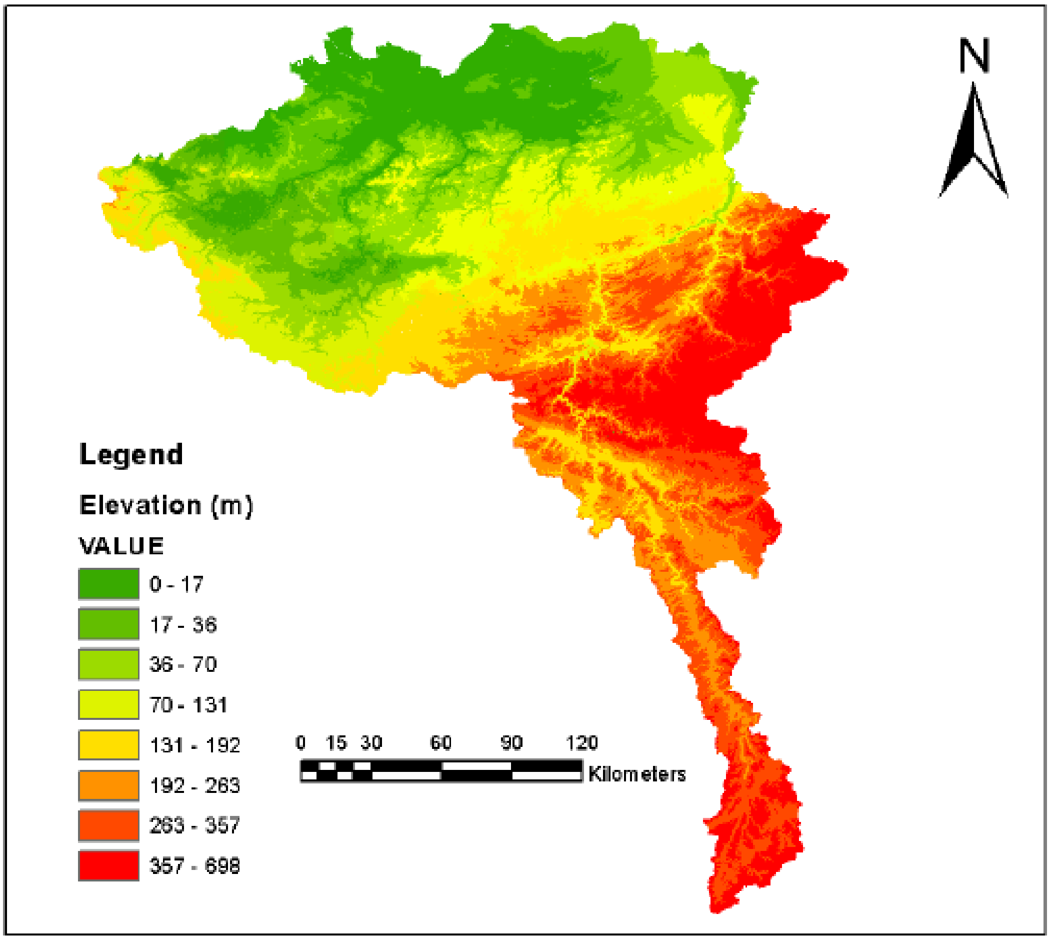

Figure 4 – Digital Elevation Model of the study area.

3.4.2 Land Use

Land Cover Geographic Information System maps are available from the CORINE (Coordination of Information on the Environment). In order to be able to use this raster data in a WETSPA model, attributes are reclassified to match to the WETSPA land use classes as presented in Table 6. Resolution is resampled to 50x50m (Figure 5).

Table 6– Classification of land use according to the WETSPA model.

Corine Code	Description (Dutch)	WETSPA ID	WETSPA Legend
111	Aaneengesloten bebouwing	13	Urban and build-up
112	Discontinue bebouwing	13	Urban and build-up
121	Industrie- of handelszones	13	Urban and build-up
122	Wegen en spoorwegen met bijhorende oppervlakken	13	Urban and build-up
123	Havengebieden	13	Urban and build-up
124	Luchthavens	13	Urban and build-up
131	Ontginningsplaatsen	13	Urban and build-up
132	Stortplaatsen	13	Urban and build-up
133	Constructiezones	13	Urban and build-up
141	Groene stedelijke gebieden	14	Cropland/ Natural vegetation mosaic
142	Sport- en recreatiegebieden	13	Urban and build-up
211	Niet geïrrigeerd akkerland	12	Cropland
222	Boomgaarden	12	Cropland
231	Weiland	12	Cropland
242	Landbouwareaal met complexe percelen	12	Cropland
243	Landbouwareaal met aanwezigheid van natuurlijke vegetatie	12	Cropland
311	Loofbossen	4	Deciduous broadleaf forest
312	Naaldbossen	1	Evergreen needleleaf forest
313	Gemengde bossen	5	Mixed forest
321	Natuurlijk grasland	10	Grassland
322	Heide en struikgewas	7	Open Scrubland
324	Overgangsbos	6	Closed Scrubland
331	Strand, duinen, zandoppervlakken	16	Barren or sparsely vegetated
411	Moeras	11	Permanent wetland
412	Veenmoeras	11	Permanent wetland
421	Zoutmoeras en schorren	11	Permanent wetland
423	Slikken	11	Permanent wetland
511	Waterlopen	17	Water body
512	Wateroppervlakken	17	Water body
522	Estuaria	17	Water body
523	Zee	17	Water body

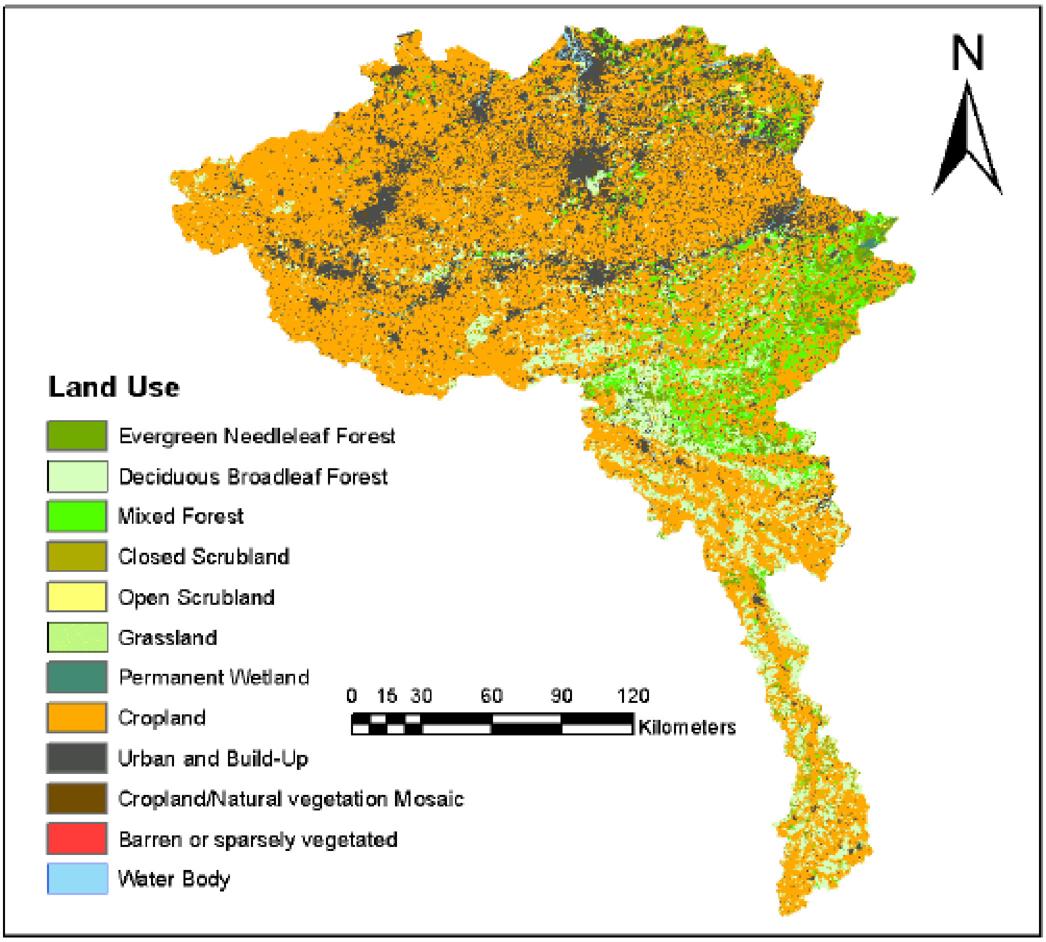

Figure 5 – Land use map used for the WETSPA model

3.4.3 Soil map

The soil map is derived from European Soil Data Centre (ESDAC) of the Joint Research Centre from the European Commission. The soil map is also resampled to a 50m x 50m resolution to match to the land use map and elevation model (Figure 6). WETSPA is currently set up with USDA texture classes (Table 7).

Table 7– Texture classes of the soils used for the WETSPA model

ID	Texture Classes
1	Sand
2	Loamy sand
3	Sandy loam
4	Silt loam
5	Silt
6	Loam
7	Sandy clay loam
8	Silt clay loam
9	Clay loam
10	Sandy clay
11	Silt Clay
12	Clay

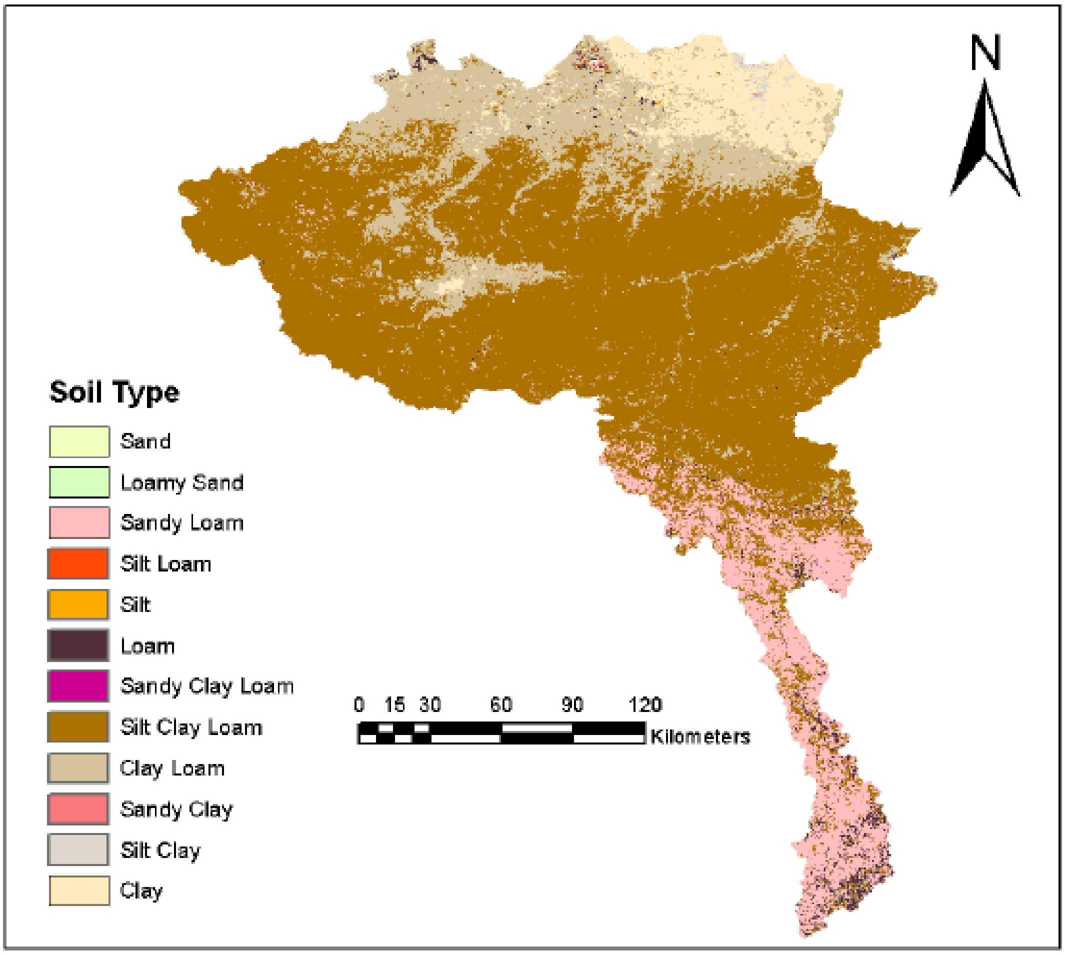

Figure 6 – Soil map used for the WETSPA model

4 Rainfall-runoff modelling methodology

The distributed hydrological WETSPA model is set up to simulate long discharge hydrographs for each catchment within the water balance model. This section introduces the main characteristics and modelling concepts of the WETSPA model. Section 4.1 gives a short introduction of the original WETSPA model, whereas Section 4.2 describes the new Python version of the WETSPA model which is applied in this study. The next Section 5 describes the calibration strategies applied for all catchments.

4.1 The original WETSPA model

The WETSPA model is a GIS-based, spatially-distributed hydrological model for predicting the water and Energy Transfer between Soil, Plants and Atmosphere on regional or basin scale. The model was developed in the Vrije Universiteit of Brussels, Belgium (Wang et al., 1997 and Batelaan et al., 1996) and it has been used and modified ever since for a wide range of applications (Liu et al., 2006;Verbeiren et al., 2013).

The modelled basin is divided into a number of grid cells in order to deal with the heterogeneity. Each cell is further divided into a bare soil and vegetated part, for which the water and energy balance are maintained. The model calculates the water balance at the raster cell level and simulates several physical processes with a cascade approach (Figure 7). Water movement in the soil is simplified as one-dimensional vertical flow, including surface infiltration, percolation and capillary rise in the unsaturated zone and recharge to groundwater. Surface runoff is produced using a modified runoff coefficient method. Based on the geomorphological characteristic of each raster cell, the runoff is then routed as overland and channel flow with the linear diffusive wave approximation and the geomorphological instantaneous unit hydrograph concept (G-IUH). Based on Darcy's law and the kinematic approximation, the model calculates interflow as a function of the effective hydraulic conductivity and the hydraulic gradient, while groundwater flow is estimated with the linear reservoir method on small sub-catchment scale as a function of groundwater storage and a recession coefficient. Time step resolution of inputs and outputs ranges from one hour to days, months and years.

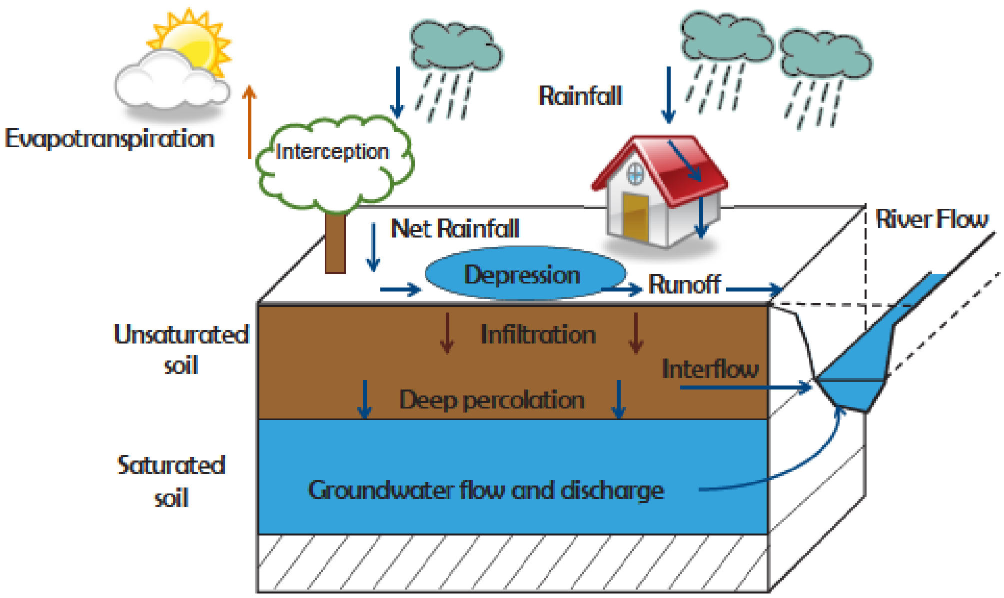

Figure 7 – Different physical processes simulated in the WETSPA model.

The WETSPA model is composed of three components: two pre-processing components and the main simulation code. The two pre-processing components are: (a) the GIS-based parameter maps estimator and (b) the G-IUH routine. The inputs of the model are: (a) precipitation, potential evapotranspiration and temperature time series, which are distributed over the catchment with the Thiessen polygons method; and (b) spatially distributed parameters, which are derived on basis of three maps: topography, soil texture and land use. Typical outputs of the model are: flow hydrographs at catchment and sub-catchment outlets, and maps of major water fluxes for each time step. Calibration can be manually or automatically performed by modifying the 11 global calibration parameters

4.2 The WETSPA-PCRaster-Python Model

4.2.1 General

The WETSPA– PCRaster –Python Model has been developed by Salvadore, E (2013). This model is a reimplementation of the original WETSPA model. The structure and the programming language of the original WETSPA model was modified. The new structure of the model is modular and written in Python language. Every physical based process such as interception, runoff, infiltration, etc. is coded in a separate model and the modules exchange data during running time through a modelling framework prototype.

The input requirements for this model include

- time series of precipitation and potential evapotranspiration,
- spatial distribution maps consisting of the DEM, land use and soil type maps are the base maps for deriving all model parameters. These maps need to be in raster format with the same cell size and the same special extent. The maps need to be converted to PCRaster format before being inputted into the model.

4.2.2 Global parameters

In the WETSPA–PCRaster–Python Model, several global model parameters must be prepared which are applied to each grid cell or each subcatchment. The information on the physical meaning of these parameters is described below:

- *K_ss* is a soil moisture ratio relative to the field capacity for setting up the initial soil moisture content. This gives a uniform distribution of initial relative moisture condition and can be used for model simulation with a long time series.
- *K_ep* is a *correction* factor for potential evapotranspiration.
- *K_run* is an exponent reflecting the effect of rainfall intensity on the actual surface runoff coefficient when the rainfall intensity is very small.
- *Ki* is an interflow scaling factor reflecting the effect of organic material and root systems in the topsoil layer on horizontal hydraulic conductivity.
- *Kg* is a groundwater flow recession coefficient reflecting the groundwater recession regime for the entire catchment.
- *P_max* is a threshold of rainfall intensity in mm/day or mm/hour depending on the modelling time step, over which the value of K_run is set to 1.
- *G0* is the initial groundwater storage in depth (mm).
- *G_max* is the maximum groundwater storage in depth (mm).

4.2.3 Soil based parameters

Soil textural classes are used to provide information concerning soil physical properties, such as porosity, hydraulic conductivity, pore size distribution index, etc. In WETSPA Extension, soil textures are classified into 12 USDA (U.S. Department of Agriculture) classes ranging from 1 to 12 based on the percentage of sand, silt and clay in the soil sample. Fine textured soils have a high percentage of clay and are very sticky when wet and hard when dry, while coarse textured soils have a high percentage of sand and are loose and friable. A lookup table is established as presented in Table 8 to estimate hydraulic properties as a function of soil texture classes using mean values obtained from the literature.

Table 8– Default parameters characterizing soil textural classes in the WETSPA model

Texture Classes	Hydraulic conductivity [mm/h]	Porosity [m³/m³]	Field capacity [m³/m³]	Wilting point [m³/m³]	Residual moisture [m³/m³]	Pore size distribution index [-]
Sand	208.8	0.437	0.062	0.024	0.020	3.39
Loamy sand	61.20	0.437	0.105	0.047	0.035	3.86
Sandy loam	25.92	0.453	0.190	0.085	0.041	4.50
Silt loam	13.32	0.501	0.284	0.135	0.015	4.98
Silt	6.84	0.482	0.258	0.126	0.015	3.71
Loam	5.58	0.463	0.232	0.116	0.027	5.77
Sandy clay loam	4.32	0.398	0.244	0.136	0.068	7.20
Silt clay loam	2.30	0.471	0.342	0.210	0.040	8.32
Clay loam	1.51	0.464	0.310	0.187	0.075	8.32
Sandy clay	1.19	0.430	0.321	0.221	0.109	9.59
Silt Clay	0.90	0.479	0.371	0.251	0.056	10.38
Clay	0.60	0.475	0.378	0.251	0.090	12.13

4.2.4 Land use based parameters:

Land use or land cover is an important boundary condition, which directly or indirectly influences many hydrological processes (Table 9). The most obvious influence of land use on the water balance of a catchment is on the evapotranspiration process. Different land use types have different evapotranspiration rates, due to their different vegetation cover, leaf area indices, root depths and albedo. During storms, interception and depression rates are different for different land use types. Land use also influences the infiltration and soil water redistribution process, because especially the saturated hydraulic conductivity is influenced by plant roots and pores resulting from soil fauna (Ragab & Cooper, 1993). Three factors taken into account in the model and can be summarized as follows:

- Root depth: this function will create a root depth grid based on the lookup table in the model.
- Interception capacity: this function will create a yearly maximum and minimum interception capacity grids respectively based on the lookup table.
- Manning coefficient: this function will create a Manning's coefficient grid for both land surface and river channel based on the geographical information of land use and stream order.

Table 9– Default parameters characterizing land use classes of the WETSPA model

Land use Classes	Interception capacity [mm]		Root depth [m]	Manning coefficient
	Max	Min		
1	2	0.5	1.0	0.40
2	3	0.5	1.0	0.60
3	2	0.5	1.0	0.40
4	3	0.5	1.0	0.80
5	3	0.5	1.0	0.55
6	3	0.5	0.8	0.40
7	2	0.5	0.8	0.40
8	3	0.5	1.0	0.50
9	2	0.5	0.8	0.40
10	2	0.5	0.8	0.30
11	1	0.2	0.5	0.50
12	2	0.5	0.8	0.35
13	0	0.0	0.5	0.05
14	2	0.5	0.8	0.35
15	0	0.0	0.1	0.05
16	1	0.2	0.5	0.10
17	0	0.0	0.1	0.05

5 Calibration strategy

The purpose of calibration is to derive characteristics, equation constants, weighting factors, and other parameters that serve to define the model for a particular watershed. In a distributed and continuous simulation as in the WETSPA model, the calibration process is greatly rigorous and more complex than in model calibration for lumped models.

Regarding the WETSPA model, the initial input data of topography, land use and soils type map are in raster format with resolution of 50 x 50m and the same spatial extent. The water balance is calculated at cell scale for the considered catchment. This results in very high computational time for each simulation, especially for large catchments. To reduce the computation time, the following calibration and validation periods are initially applied:

- Warming up Model: 01 year
- Manual Calibration: 02 years
- Auto-Calibration: 05 years
- Validation: 05 years

These simulation periods could however be reduced if the time series for measured discharge, precipitation and evapotranspiration for a particular catchment do not cover this time span. As listed before the calibration is split up in a manual and an automatic calibration. Choosing the period of 2 years for the manual calibration assures that wet and dry season as well as the transition between wet and dry season are generally covered. Consequently this first manual calibration of the parameters will significantly reduce the risks involved when running the auto-calibration for the model. Below the manual and auto-calibration procedure are described in more detail.

5.1 Manual Calibration

The manual calibration helps to approach the optimum parameters set before running the automatic calibration. For the WETSPA model, the global parameters set described in section 4.2.2 is adjusted during the manual calibration. Based on evaluation of the results and the visual comparison between observed and calculated hydrographs for the addressed simulation period, the global parameters are readjusted. Table 10 is an example of an appropriate parameter set chosen by performing the manual calibration for the catchment V01HAN488180.

Table 10– Chosen global parameters set of the catchment V01HAN488180.

Kep	Ki	Kg	Kss	go	g_max	K_run	P_max
1.0	100	0.0096	1.0	121.39	250.01	2.23	150.72

It is noted that the calibration of the WETSPA model is initially not carried out for all model parameters. Only the most important parameter such as the abovementioned global parameters are addressed at first. Other parameters including hydraulic conductivity, porosity, root depth, interception and depression storage capacity and so on, are set to default values interpolated from the literature. If needed, these parameters could however be adjusted to improve the model results for catchments which have specific conditions.

5.2 Auto-Calibration

Once the manual calibration is succeeded, the suitable global parameter set will be used as starting point for the auto-calibration step. This is done by means of the NSGA II algorithm, implemented in Python.

The Python version of the NSGA II algorithm was adapted for hydrological optimization purposes using a general framework supporting four rainfall-runoff models: NAM, PDM, VHM, and WETSPA. Description of how these models are implemented into the same Python framework can be found in Vansteenkiste et al. (2012) and Tran et al. (2021a and b).

The Python automatic calibration shell currently supports the following operations:

- Optimization of (one, several or all) model parameters for a given calibration period;
- Evaluation of model parameters for a given validation period;
- Plotting results of various alternative parameter sets on the same plot or separately (for example, the final population generated by the algorithm);
- Generating automatic reports of calibration and validation.

Regarding the auto-calibration of the WETSPA model, all eight parameters were optimized and the lower and upper boundaries of each parameter were defined as listed in Table 11. In case that the optimum is not well defined or the algorithm cannot converge in reasonable range, these boundaries are adjusted. If the auto-calibration results are not satisfactory, the manual calibration is considered again to choose a better parameter set to be used as a starting point for the auto-calibration.

Table 11– WETSPA parameters and optimization boundaries of the catchment V01HAN488180.

Parameters	Kep	K_run	P_max	Kss	Ki	go	g_max	Kg
Lower boundary	0.5	1.6	120	0.5	50	90	200	0.002
Higher boundary	3.0	9.0	450	100	300	200	500	0.05

Optimization algorithm

The algorithm used for optimization of WETSPA parameters is the Non-dominated Sorting Genetic Algorithm II or NSGA II[4]. This algorithm is suitable for optimization problems with multiple objective functions.

Variable values are generated in the first iteration. Each solution, that is to say an array of variable values, is called an *individual*. A *population* is a group of N solutions in each iteration. In the following iterations the created individuals are going to be "children" of the previous population, that is to say they are going to inherit "features" from couples of individuals chosen in the previous population according to specified selection and crossover techniques. The user can choose to randomly mutate the children features when an offspring is created.

The algorithm will then perform the *evaluation* of the solutions through the Pareto comparison, that is to say a solution dominates, or is better than, another solution if it is better than or equal to the other solution in all objectives and strictly better in at least one objective. A combined population R of parent and children

[4] Kalyanmoy Deb, Amrit Pratap, Sameer Agarwal, and T. Meyarivan. A Fast Elitist Multi-objective Genetic Algorithm: NSGA-II. IEEE Transactions on Evolutionary Computation, 6(2):182 - 197, April 2002.

population is formed; the individuals in it are sorted according to non-domination. Since all previous and current population members are included in R, the elitism is ensured. The best N solutions will be the population of the next iteration.

Optimization settings

Within the optimization, it is possible to set the following parameters:

- The population size or the number of individuals in the population used by the algorithm
- The number of iteration (maximum generations)
- The number of parameters to optimize
- Eventual seed individuals to include

The population size and the maximum generation are to be set to the same values for all simulation runs. The increase in the number of population size and the maximum generation will help to achieve better auto-calibration results but it also results in long computation time for each simulation.

In summary, the efficient calibration strategy for the WETSPA model is suggested through the following steps:

1. Implement the manual calibration for the period of 2 years and try to obtain the best global parameters set.
2. Reduce the range between lower and higher boundary of the global parameters set
3. Set the population size and max_generations to the lowest possible values.

Sensitivity analysis of different spatial distribution map resolution

In this study, most of the input data set including topography, land use map, and soil map with the resolution of 50x50m were used in the model setup. In order to reduce the simulation time, a courser resolution of the spatial distribution maps could be used to input into the model for some big catchments. The catchment with code F05LEI386999 has been chosen to test the influence of different resolution scenarios (50x50m, 200x200m, 300x300m, 400x400m, and 500x500m) of the spatial distribution maps on flow behaviour at the watershed outlet. The simulated discharge results for the year 2013 at the outlet of the catchment F05LEI386999 is shown in Figure 8.

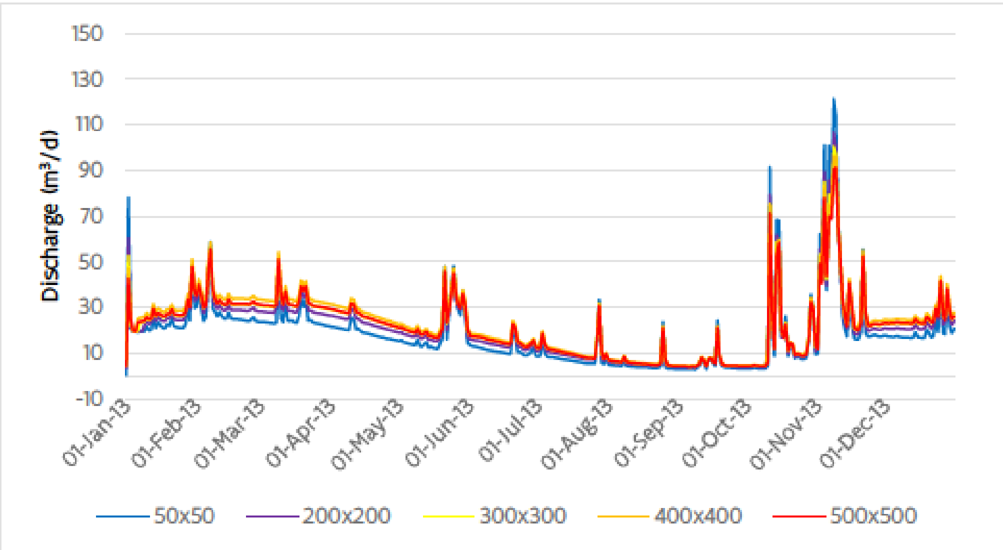

Figure 8– Comparison of different distribution map resolution on daily discharge at the outlet of catchment F05LEI386999.

As can be seen from the Figure 8, the trend and timing of simulated flow corresponding to different resolution scenarios seem to be the same for the whole year 2013. The difference in high flow and low flow among the scenarios of 200x200, 300x300, 400x400, and 500x500m resolution is not significant. A small change in base flow occurs during a short period of time from March – June between the scenario of 50x50m resolution and the others. However, the base flow is not influenced by the resolution during the other months. Based on these results, it is decided to use a courser resolution of 500x500m for the biggest cathments as input data set of the model. The big catchments with 500x500m resolution of the spatial distribution maps are presented in Table 12.

Table 12– List of catchments with a 500x500m resolution of Spatial distribution maps.

Gauging station (code - water course; location)	DSG	Area (km²)	Spatial distribution map resolution (m)
38680122 – Leie; Menen	F05LEI386999	2198.8	500x500
32580122 – Bovenschelde; Bossuit	F06BOS325999	5217.6	500x500
9310102 – Dijle; Wilsele	V08Dij093400	886.9	500x500
15210102 – Gete; Halen	V09GET152080	800.4	500x500
Salzinne Ronet/Sambre	W11SAM7319	2669	500x500
Angleur 2 bis/Ourthe (calculated)	W11OUR5805	5805	500x500
Chooz/Meuse	F11MAA8702	10120	500x500
Profondeville/Meuse	W11MAAPROF	12586	500x500

5.3 Objective function

Automatic calibration consists of optimizing (1) agreement between the average simulated and observed catchment runoff (overall volume error) and (2) overall agreement of the shape of the hydrograph. To assess these two aspects, evaluation is based on the following goodness-of-fit indexes:

1. Absolute error on cumulated total flow at each time step (to minimize), and
2. Logarithmic Nash-Sutcliff efficiency (to maximize).

These two objectives are suited for NSGA-II optimization because they are contradictory for a number of model parameters. A reduced number of objectives (two) facilitates and fastens the algorithm convergence while ensuring good overall performance of the model. It is also important that these objectives be contradictory in order for the optimum to be well defined. There are generally trade-offs between performance for high and low flows. Therefore, final manual and visual checks will complete performance evaluation with possible focus on low or high flow.

The efficiency E proposed by Nash and Sutcliffe (1970) is defined as one minus the sum of the absolute squared differences between the predicted and observed values normalized by the variance of the observed values during the period under investigation. It is calculated as follows:

$$E = 1 - \frac{\sum_{i=1}^{n}(O_i - P_i)^2}{\sum_{i=1}^{n}(O_i - \bar{O})^2} \qquad \text{Eq. 1}$$

with O observed and P predicted values.

To reduce the sensitivity to extreme values, the Nash-Sutcliffe efficiency E is also calculated with logarithmic values of O and P. Through logarithmic transformation of runoff values, the peaks are flattened and the low flows are kept more or less at the same level. As a result, the influence of low flow values is increased in comparison to the flood peaks, resulting in a higher sensitivity of log NSE to systematic model over- or underprediction (Krause et al. 2005).

The second objective of the algorithm is minimizing the absolute error on cumulated values at each time step (day). This ensures that the water balance remains satisfactory throughout the simulation (all years simulated).

The two goodness-of-fit statistics can be represented in 2 dimensions to represent the set of solutions evaluated by the algorithm. The best pairs constitute the Pareto front.

In order to select one single best solution, the two performance indexes were normalized (or rescaled) across the explored range (Eq. 2) with xmin set to zero for the absolute error, and xmax set to 1 for the logarithmic NSE.

$$x' \frac{x-xmin}{xmax-xmin} \qquad \text{Eq. 2}$$

This normalization resulted in values between 0 and 1 for the absolute error and between -1 and 1 for the NSE. The final solution was then selected among the final Pareto front, looking at the minimum Euclidian distance to theoretical optimum: log NSE = 1 and Absolute Error =0 (Eq.3).

$$d = \sqrt{(x_B - x_A)^2 + (y_B - y_A)^2} \qquad \text{Eq. 3}$$

An example of Pareto front and final selection is given in Figure 9 and Figure 10.

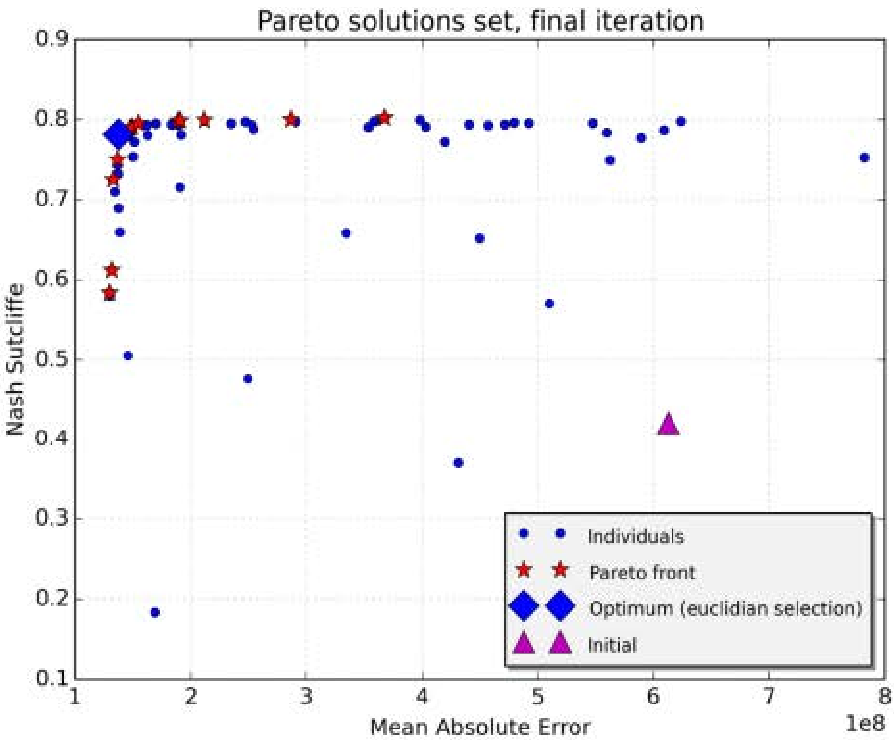

Figure 9 – All evaluated candidates (individuals) and final population of solutions (Pareto front).

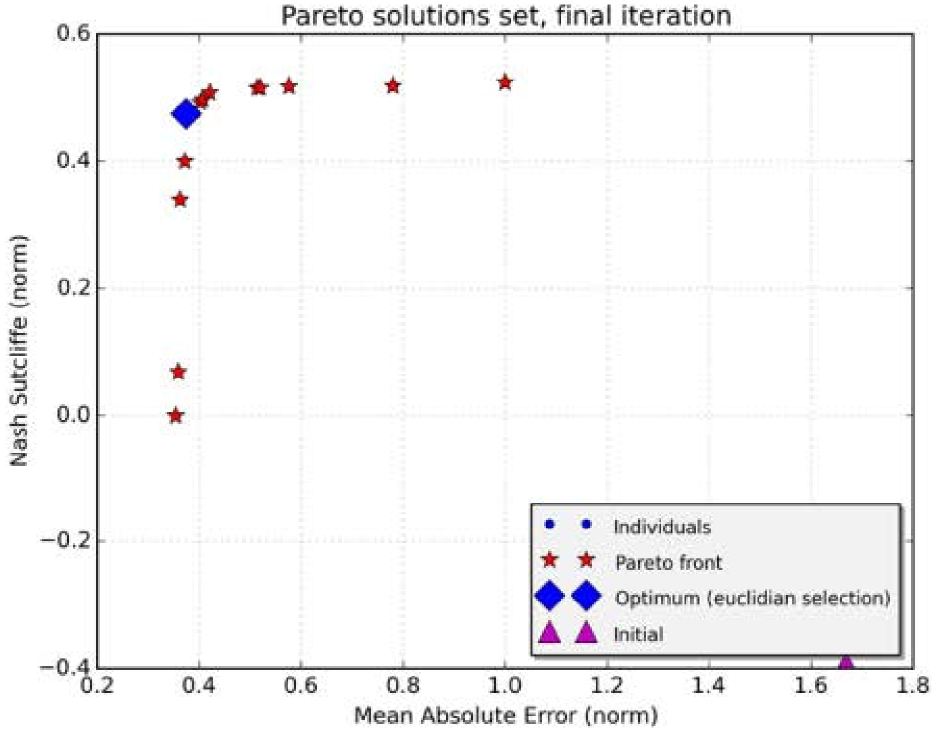

Figure 10 – Rescaled final population of solutions (Pareto front)

6 Calibration of the WETSPA model

The final sets of parameters for each calibrated WETSPA model are summarized Appendix 1. This section presents the main results of simulation for all calibrated catchment structured per hydrographic basin.

Model performance was assessed based on goodness-of-fit indexes as well as by visual evaluation. In this study, log NSE and absolute error already taken into consideration as objective functions within the optimization algorithm. Log NSE values above 0.7 can be considered very well. Values below zero mean that the predictive power of the model is worse than the measured average. In most cases, a calibration time period of 5 years was observed. However, shorter time series were used when available data were insufficient.

The following section synthetizes the main results and conclusions of the WETSPA calibration in each river basin. Detailed graphs and calculated statistics, for calibration and validation periods, are given for each gauged catchments in Appendix 1 to Appendix 23.

6.1 IJzer basin

6.1.1 Context

The IJzer catchment covers an area of 1 101 km² from which about one third is located in France (WL, 2006). This represents 1.6 % of the total study area (Scheldt basin + IJzer, excluding the Meuse). On the French side, the main tributaries are the Peene Becque, the Sale Becque and the Herzeele. In Flanders, the Poperingevaart, the Kemmelbeek, the Ieper-IJzer Canal with the Ieperlee and Martjensvaart, Stenensluisvaart, Houtensluisvaart and Handzamevaart are the main tributaries of the IJzer. Note that these tributaries are all discharging from the right bank of the IJzer River.

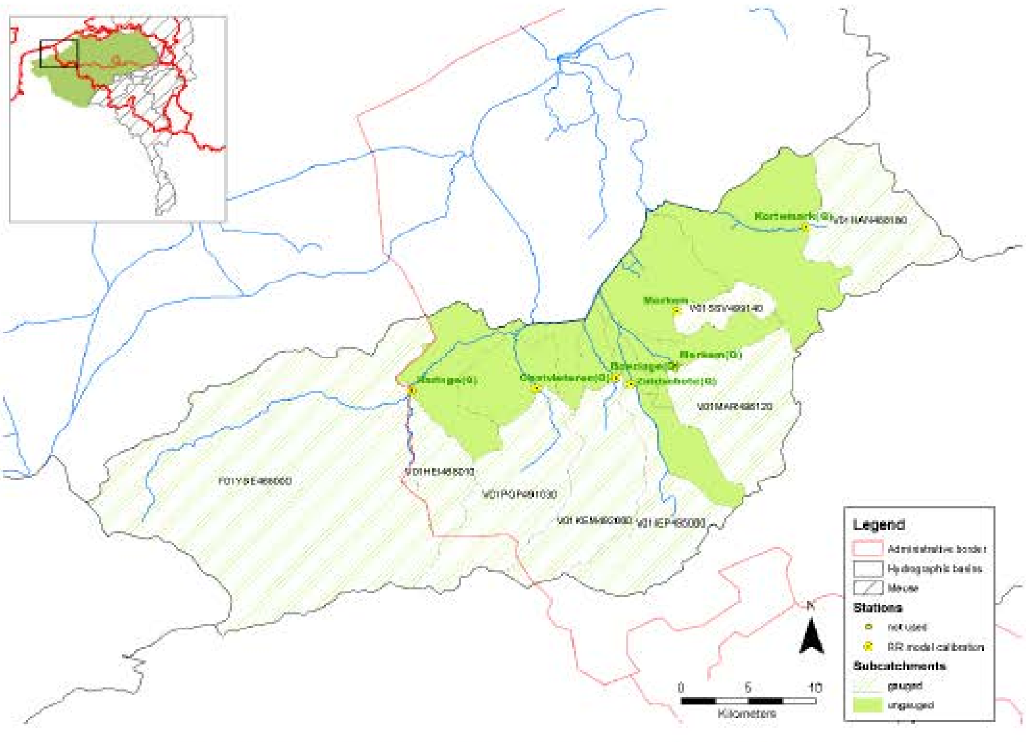

Figure 11 – Catchments and gauging stations on the IJzer basin.

There are 8 gauged catchments in the IJzer catchment, covering 786 km² (70 % of the IJzer catchment area). Subcatchments V01HEI468010 and F01YSE468000 are located upstream of the gauging station in Roesbrugge. The catchments and corresponding measurement points are shown in Figure 11.

6.1.2 Model performance

Table 13 and Table 14 present the performance statistics for the gauged catchments of the IJzer basin for the calibration and validation period. Graphs of simulation for the catchments with code V01HAN488180 (best model performance) and V01POP491030 (worst model performance) are presented below (Figure 12 to Figure 20). For more detailed results of the calibration, validation, and autocalibration on the catchments, is reffered to Appendix 2 and Appendix 3.

Values in Table 13 and Table 14 indicate poor to fair agreement between the simulated and measured discharge for the majority of the catchments, with LogNSE and RelErr values range from 0.29 to 0.67 and from-5.3% to 6.4%, respectively. Regarding catchment with code V01HAN488180, the model performance was satisfactory in simulating the discharge for both the calibration and validation periods with a daily time step (Figure 12 to Figure 16). This is confirmed by the respective values of LogNSE higher than 0.6 and RelErr lower than 2.5%. Another adequate model performance is also found in the catchment V01IEP495080. Nevertheless, the results of the calibration and validation period of the catchments with code V01POP491030, V01SSV499140, and V01HEI468999 are poor (Table 13 and Table 14). As can be seen in Figure 17 and Figure 19, the model underestimated low flow during the simulation period of the year 2008 and then overestimated discharge for the almost the entire validation period at the catchment V01POP491030, resulting in an increase of RelErr values (above 5.3%) (Table 13 and Table 14). With regards to the catchment V01HEI468999, the model overestimated low flow over the validation period, although there is a relative good match between simulated and measured values during the calibration period (Appendix 2). This is presumably due to the input data of the French side including topography, land use and soil map, which were used as input data for the catchment V01HEI468999 and do not reflect properly the reality of the catchment. The catchment with code V01MAR496120 presents an overestimation of low flow in the winter season 2003 and 2006 (Appendix 2), although the general model performance for the entire validation period is adequate (Table 14).

Data remark: The measured discharge from 2005 is not reliable in the catchment V01IEP495080, therefore the calibration and validation period is selected from 1994 -2004.

Table 13– Overview of calibration results for gauged catchments on the IJzer basin

Gauging station	Catchment code	Area (km²)	logNSE	RelErr (%)	Calibration period
48810102 - Krekelbeek; Kortemark	V01HAN488180	78.6	0.67	0.6	2008-2013
46810102 - Ijzer; Roesbrugge Haringe	V01HEI468999 (V01HEI468010 en F01YSE468000)	393.0	0.4	-4.0	1990-1996
49510102 - Ieperlee; Zuidschote	V01IEP495080	63.4	0.54	-2.4	1994-2004
49270102 -Kemmelbeek; Boezinge	V01KEM492060	73.9	0.36	-6.6	2009-2013
49610102 - St. Jansbeek; Merkem	V01MAR496120	76.1	0.40	0.7	2002-2008
49110102-Poperingevaart; Oostvleteren	V01POP491030	84.9	0.33	-5.3	2008-2013
49910102 - Steenbeek; Merkem	V01SSV499140	16.1	0.29	-3.1	1999-2004

Table 14– Overview of validation results for gauged catchments on the IJzer basin

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr (%)	Validation period
48810102 - Krekelbeek; Kortemark	V01HAN488180	78.6	0.64	2.5	2004-2009
46810102 - Ijzer; Roesbrugge Haringe	V01HEI468999 (V01HEI468010 en F01YSE468000)	393.0	0.01	-4.8	2007-2010
49510102 - Ieperlee; Zuidschote	V01IEP495080	63.4	0.59	0.4	1990-1994
49270102 -Kemmelbeek; Boezinge	V01KEM492060	73.9	0.47	-2.6	1986-2008
49610102 - St. Jansbeek; Merkem	V01MAR496120	76.1	0.59	-1.0	1986-1990
49110102-Poperingevaart; Oostvleteren	V01POP491030	84.9	0.31	6.4	2003-2007
49910102 - Steenbeek; Merkem	V01SSV499140	16,1	0.32	2.2	1993-1998

Catchment V01HAN488180

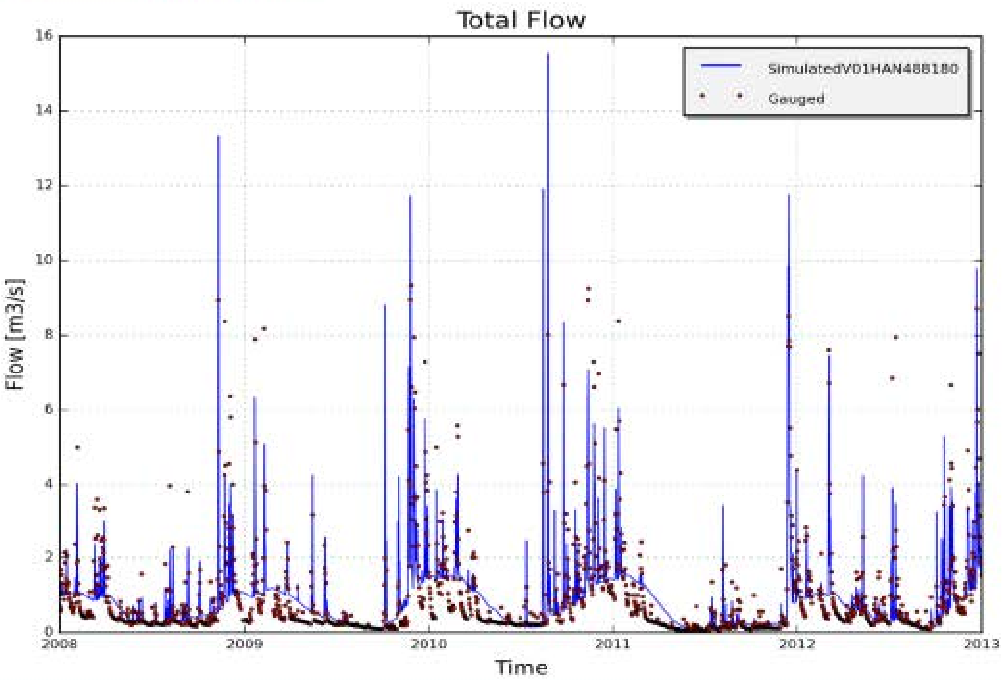

Figure 12 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01HAN488180 (calibration period).

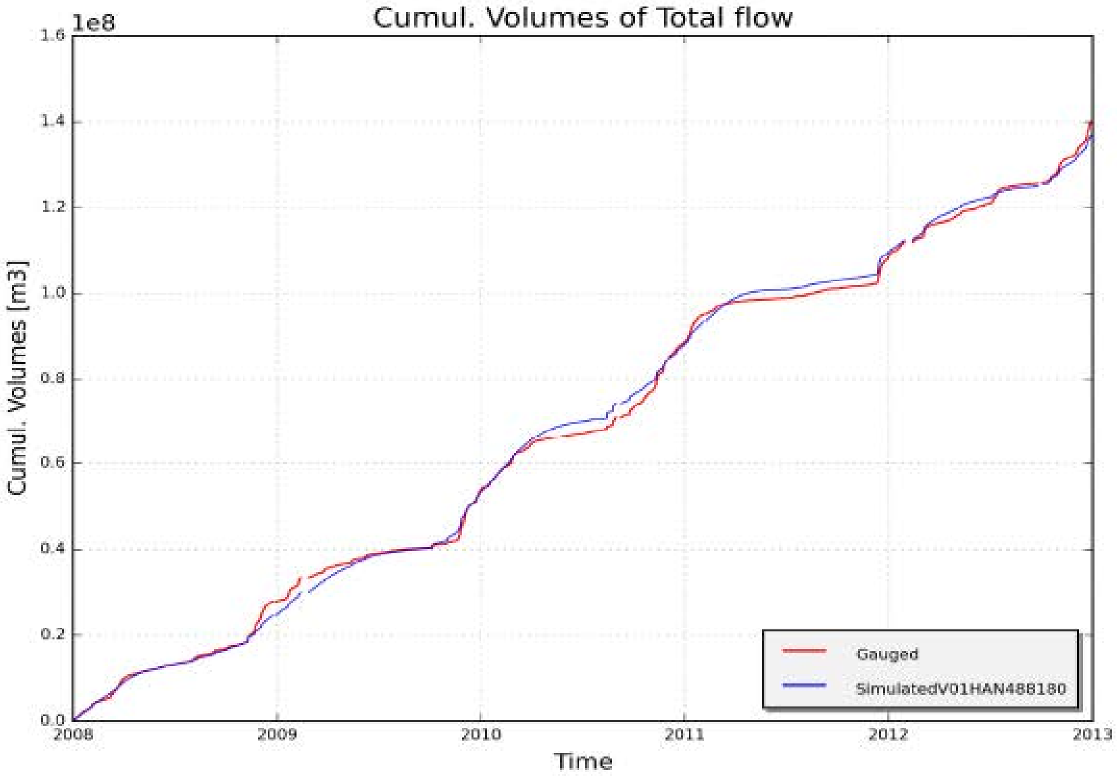

Figure 13 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01HAN488180 (calibration period)

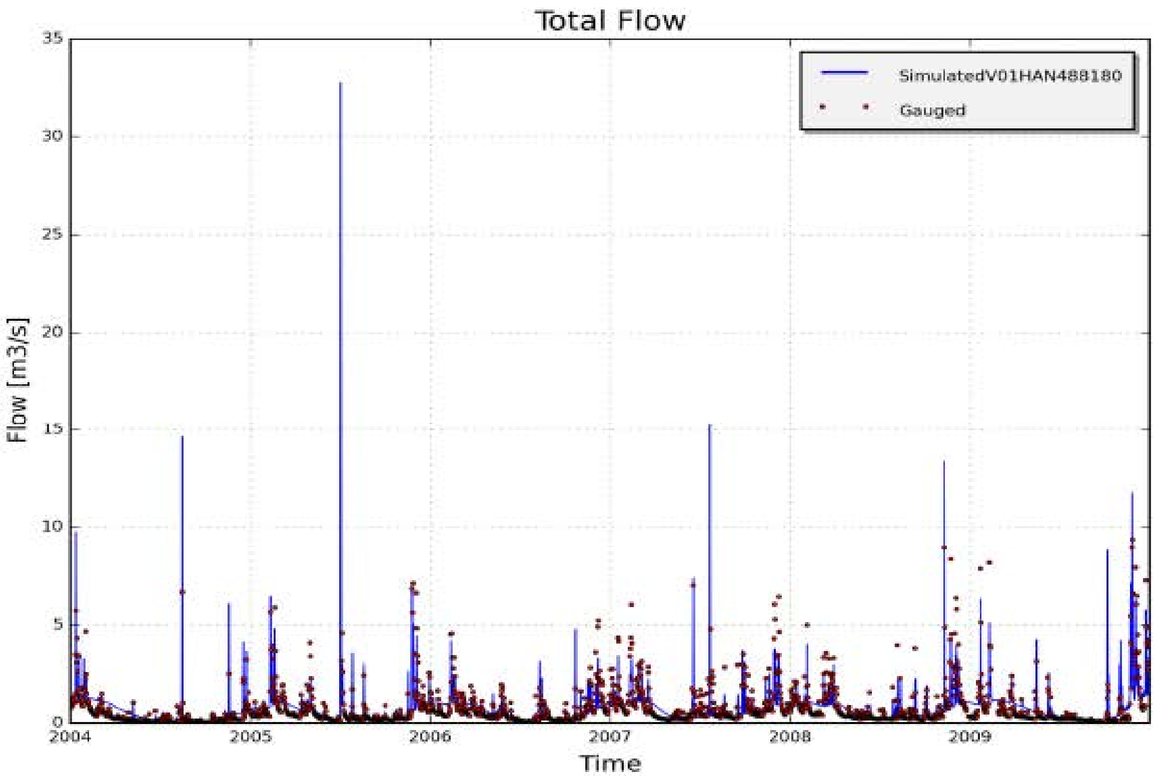

Figure 14 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01HAN488180 (validation period).

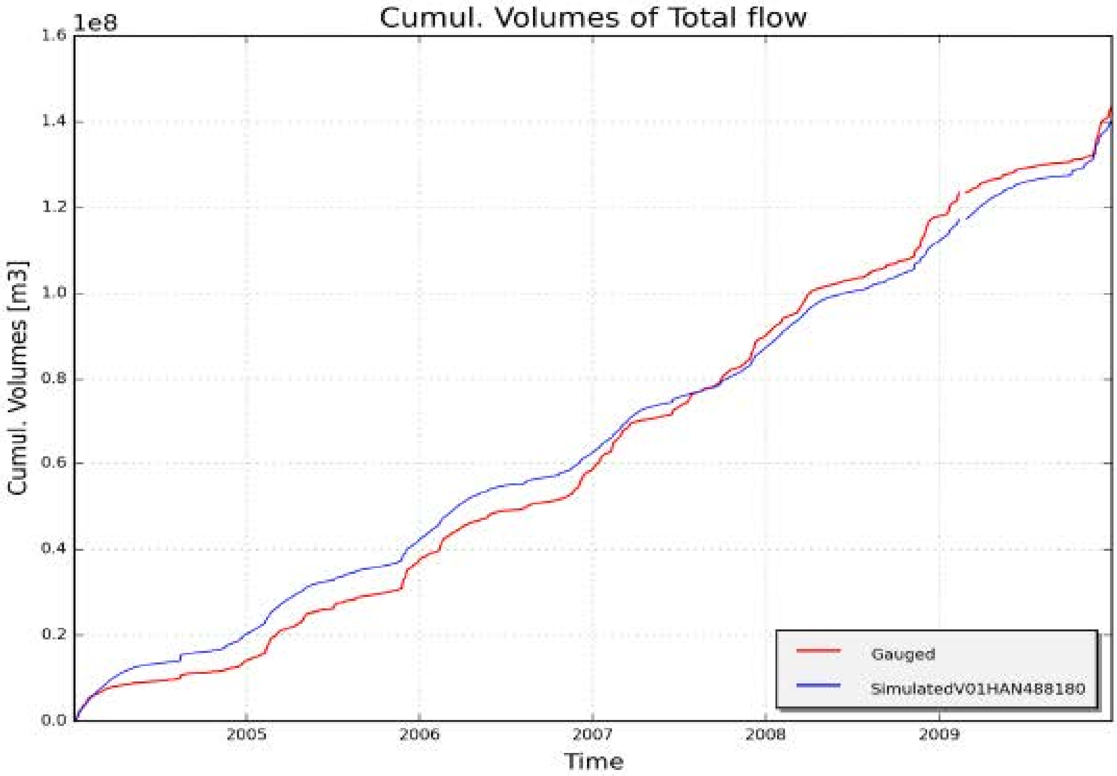

Figure 15 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01HAN488180 (validation period).

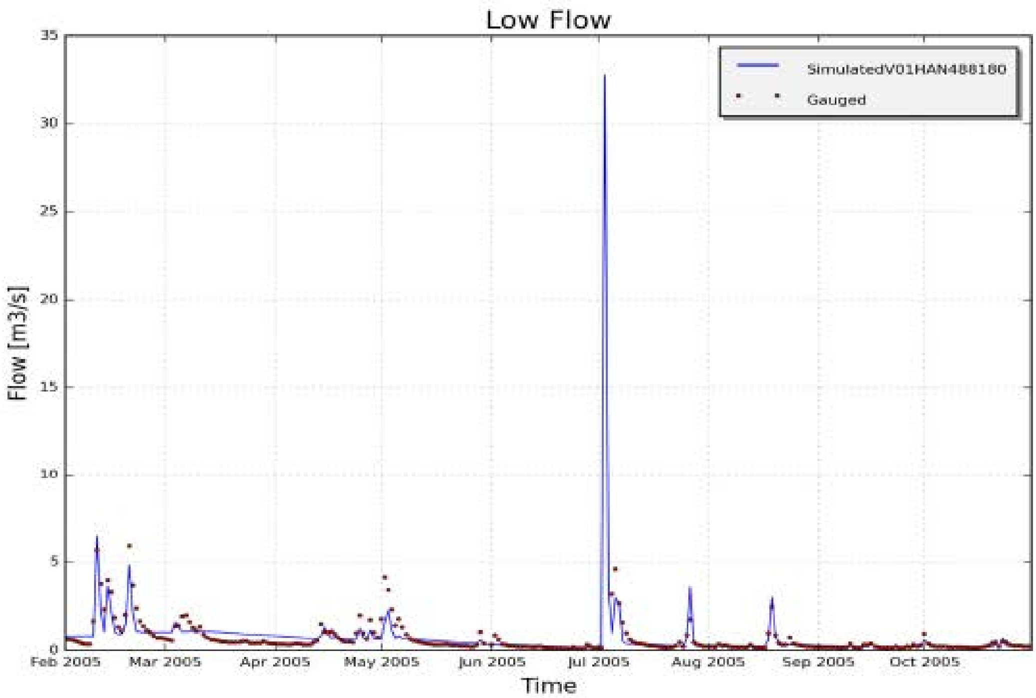

Figure 16 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low flow events on catchment V01HAN488180.

Catchment V01POP491030

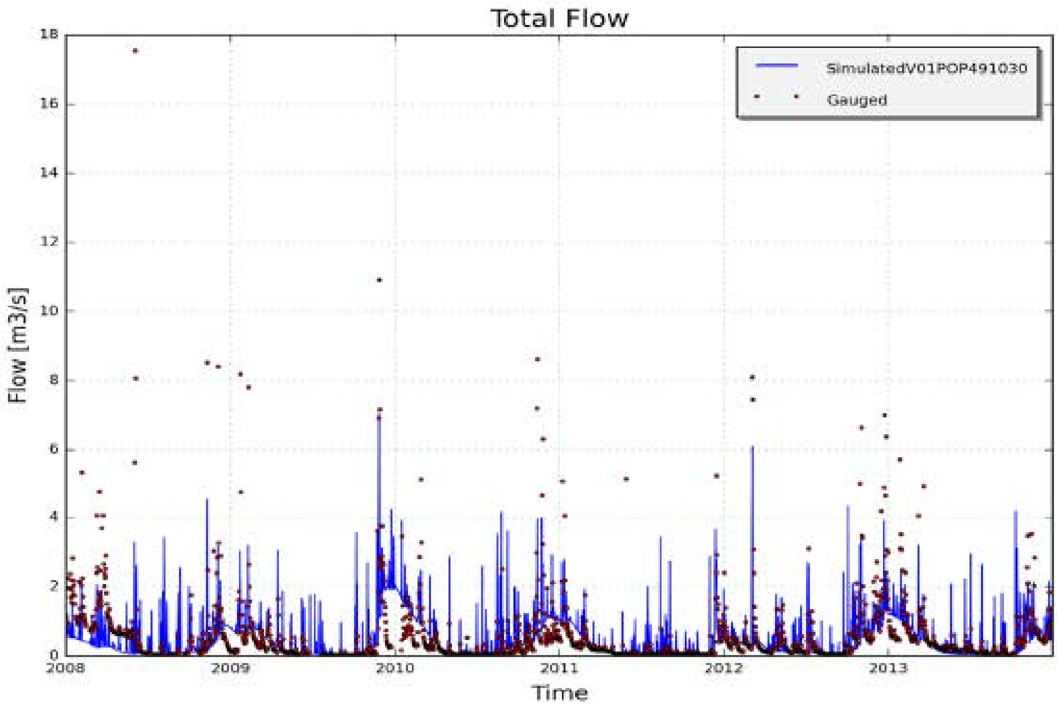

Figure 17 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01POP491030 (calibration period).

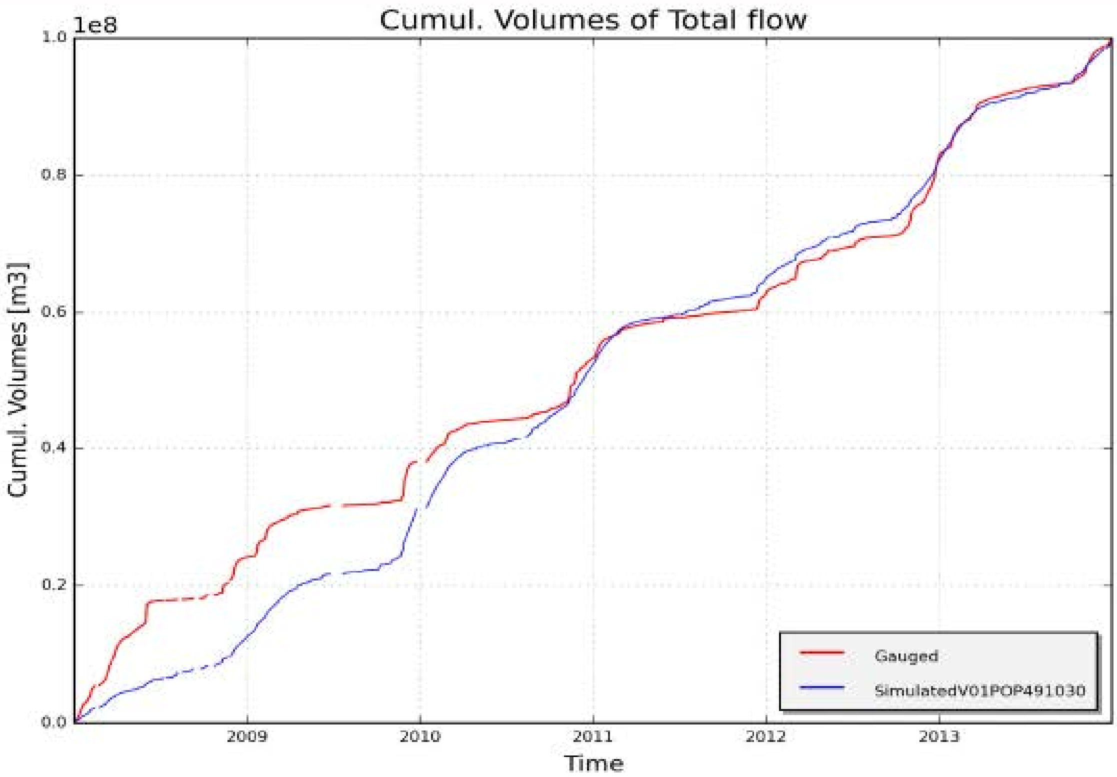

Figure 18 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01POP491030 (Calibration period).

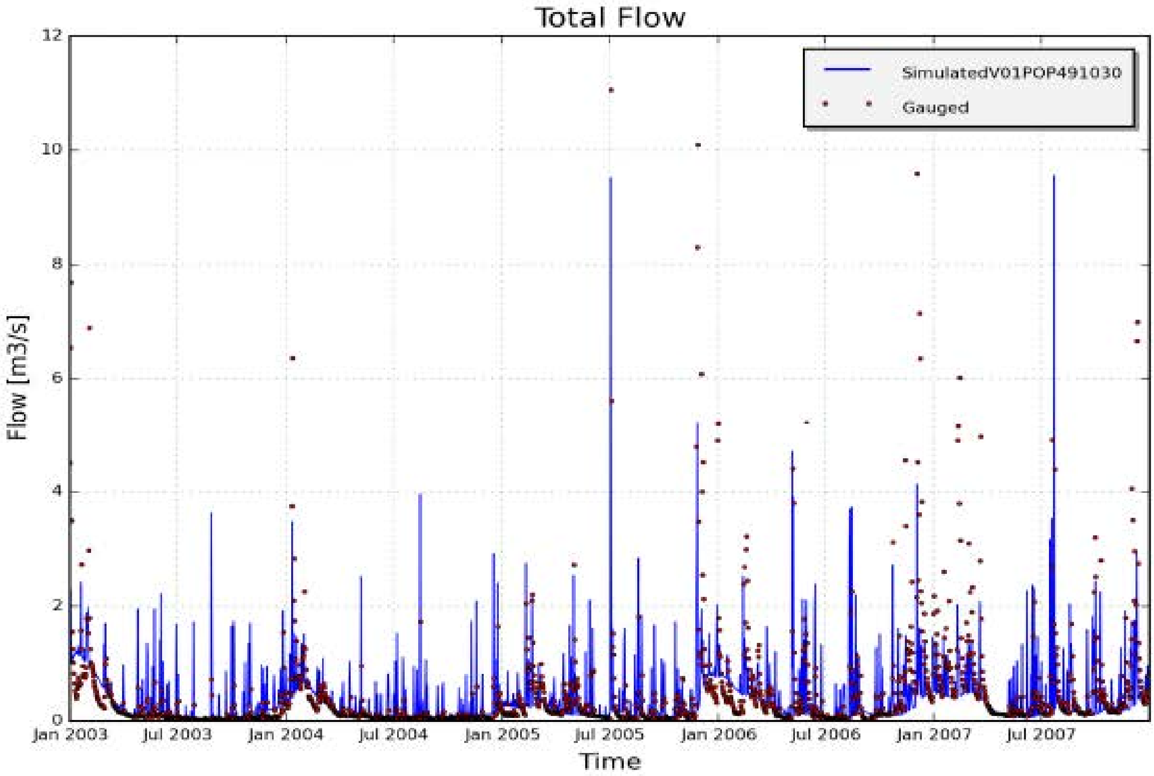

Figure 19 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01POP491030 (validation period).

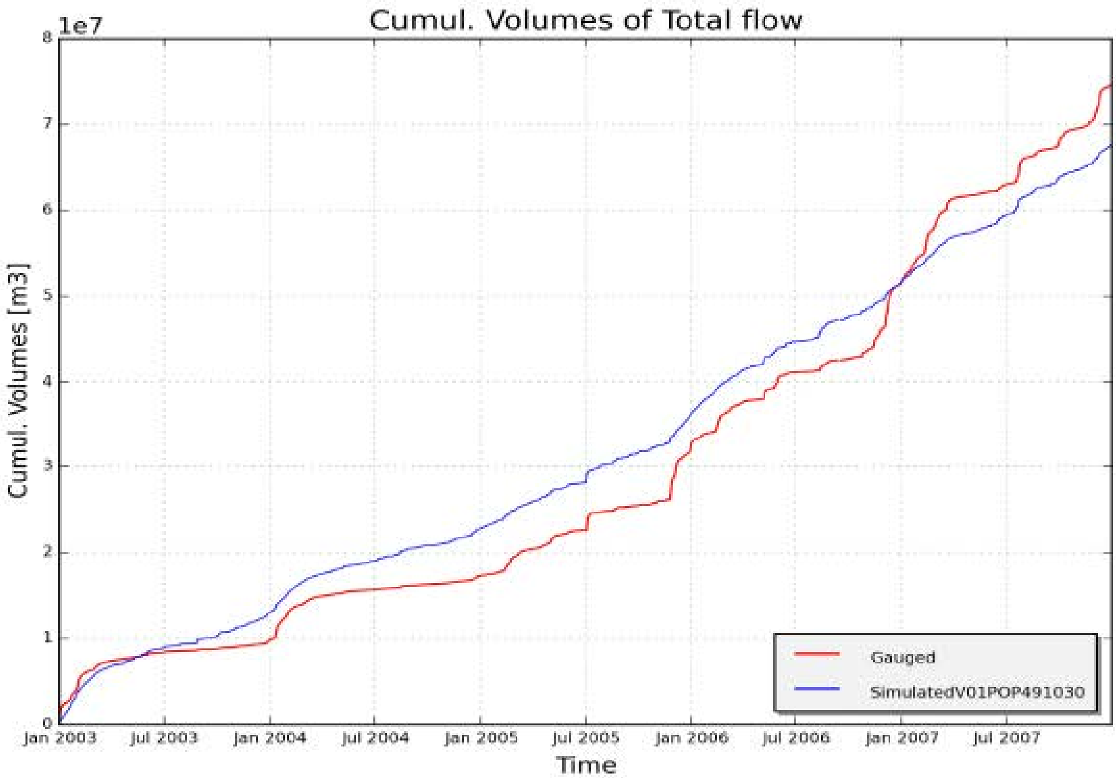

Figure 20 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01POP491030 (validation period).

6.2 Brugse Polders

6.2.1 Context

The catchment of the Brugse Polders has an area of 1046 km², which is 4 % of the total area of subcatchments within the water allocation model. The catchment is limited by the North Sea in the North and by the Dutch border in the Northeast. The main rivers of the basin are the canal connecting Gent and Oostende (Kanaal Gent-Oostende), the deviation canal (Afleidingskanaal) of the Leie and the Leopold canal. These artificial canals transport water from the Leie catchment towards the sea. Additionally, several local polder water courses flow into these canals (De Boeck et al. 2011).

In the Brugse Polders, four gauged catchments account for 29 % of the total surface area. The area of the catchments ranges from 45 to 77 km² (Figure 21).

6.2.2 Model performance

Table 15 and Table 16 present the general performance statistics for the gauged catchments of the Brugse Polders for the calibration and validation period. Graphs of simulations of the catchment V02HER426010 (best performance) and V02EDE442120 (worst performance) are presented from Figure 22 to Figure 29. For more detailed results of the calibration, validation, and autocalibration on catchments, see Appendix 4 and Appendix 5.

Figure 22 and Figure 24 show relatively good agreement between simulated and measured daily discharge with LogNSE at 0.60 and 0.60 for the calibration and validation at the outlet of the catchment V02HER426010, respectively. In addition, the hydrographs indicate that the simulated cumulative discharge fits the measured cumulative discharge well (Figure 23 and Figure 25). This is also confirmed by the RelErr values ranges from -5.1% to 2.4%. Considering the catchment with code V02EDE442120, the model underestimated flow over the winter period of 2012 and 2013 in the calibration period and 2006, 2007, and 2008 in the validation period in general (Figure 26 and Figure 28). This results in high statistical RelErr value, achieved -5.1% for the calibration period and then increased to -10.1% for the validation period (Table 15 and Table 16). For the catchments V02KER422030 and V02RIV425020, the model simulated low flow fairely well for the calibration period, but it overestimated low fllow during the years 1988-1989 (in the case of V02KER422030) and 1986-1990 (in the case of V02RIV425020). However, these catchments show a sufficient model perfomance in predicting total flow (Appendix 4).

Data remark: V02KER422030 does not have data after 2007, by consequence the period 1989-2007 was selected for the calibration and validation.

Figure 21 – Catchments and measurement points on the Brugse Polders.

Table 15 – Overview of calibration results for gauged catchments on the Brugse Polders

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr (%)	Calibration period
44210102 - Maldegem	V02EDE442120	45.5	0.49	-5.1	2009-2013
42610102 - Hertsbergebeek; Oostkamp	V02HER426010	77.3	0.6	-5.1	2000-2013
4220102 - Kerkebeek, Sint-Michiels	V02KER422030	62.7	0.54	-6.1	2003-2007
42510102- Rivierbeek; Oostkamp	V02RIV425020	64.0	0.65	-2.2	2003-2013

Table 16– Overview of validation results for gauged catchments on the Brugse Polders

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr (%)	Validation period
44210102 - Maldegem	V02EDE442120	45.5	0.54	-10.1	2003-2008
42610102 - Hertsbergebeek; Oostkamp	V02HER426010	77.3	0.6	2.4	1986-1994
4220102 - Kerkebeek, Sint-Michiels	V02KER422030	62.7	0.4	3.3	1998-1993
42510102- Rivierbeek; Oostkamp	V02RIV425020	64.0	0.36	0.6	1985-1992

Catchment V02HER426010

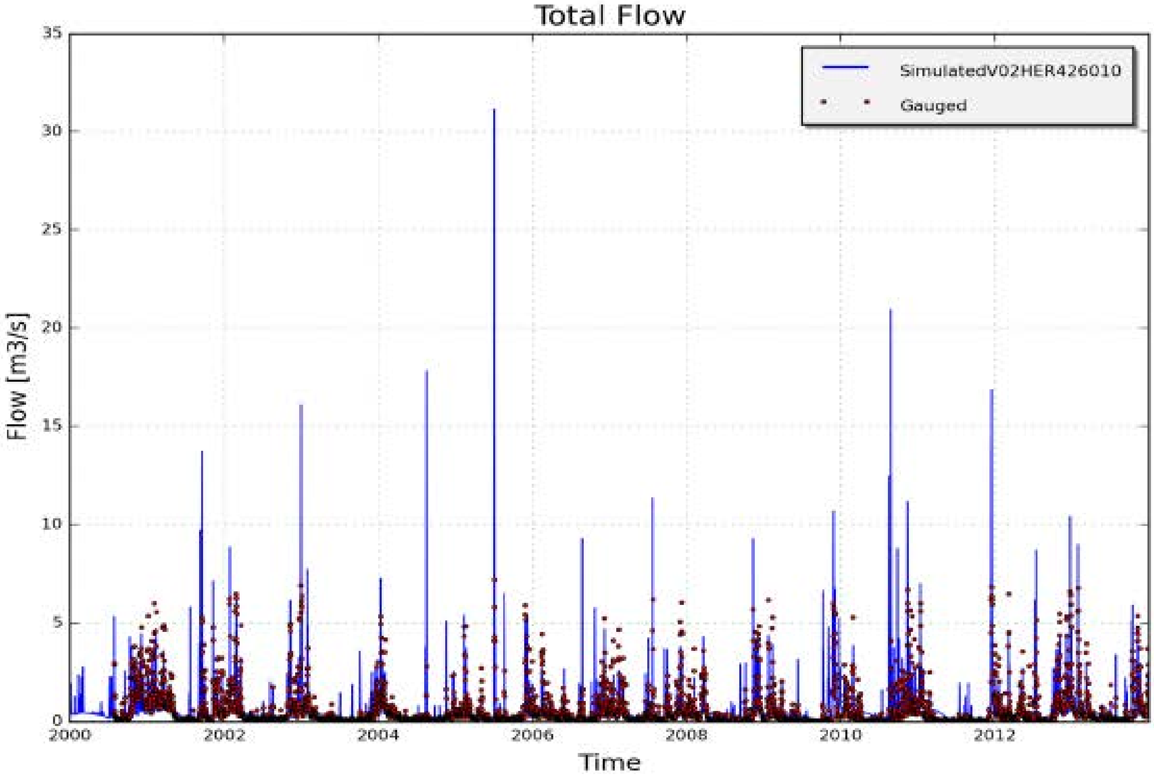

Figure 22 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02HER426010 calibration period)

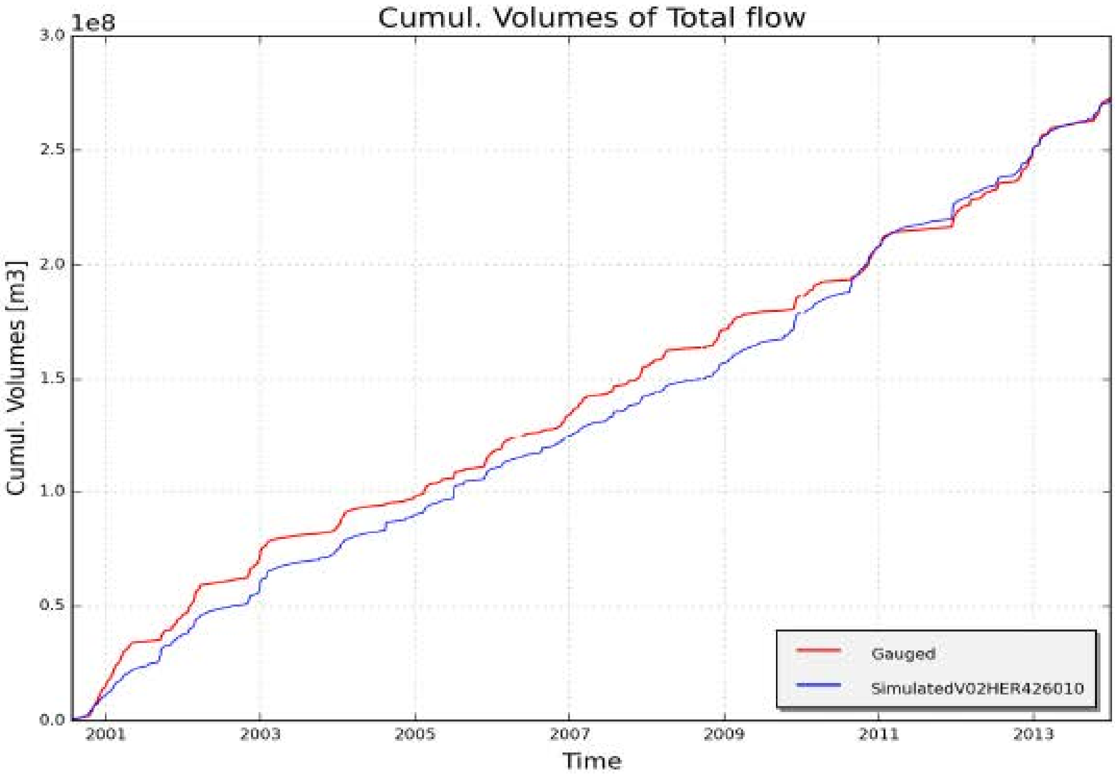

Figure 23 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02HER426010 (calibration period).

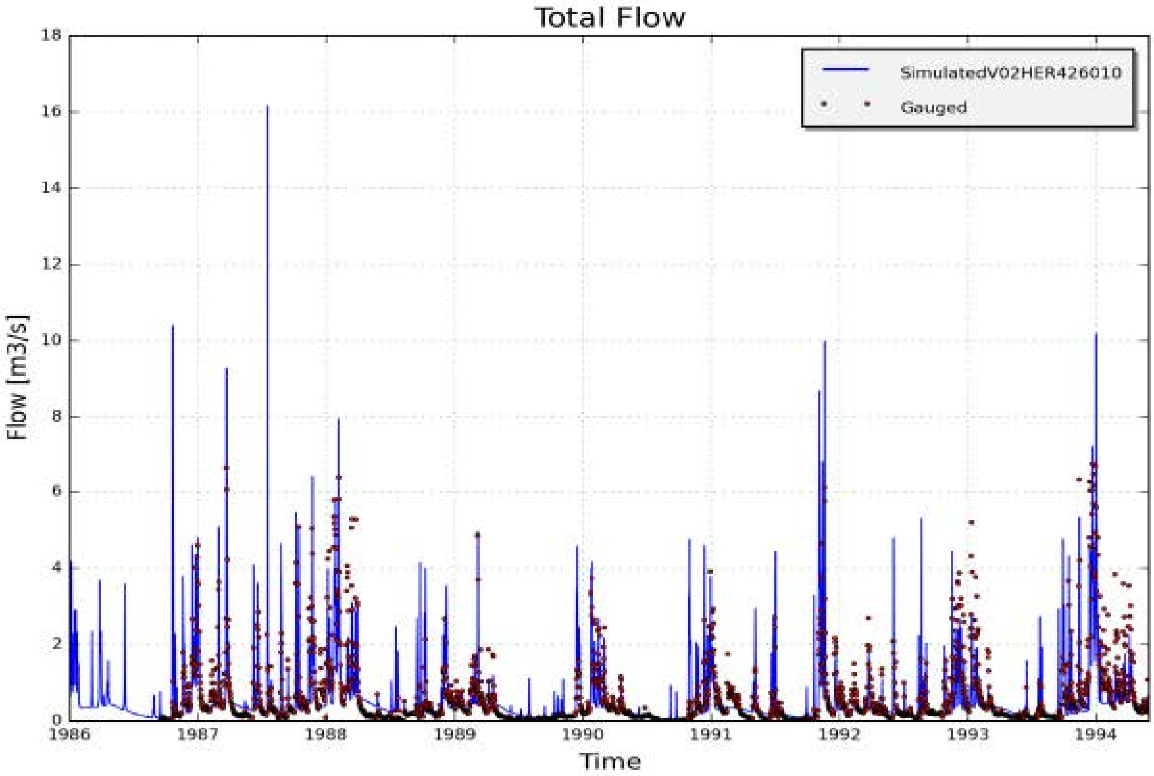

Figure 24 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02HER426010 (validation period)

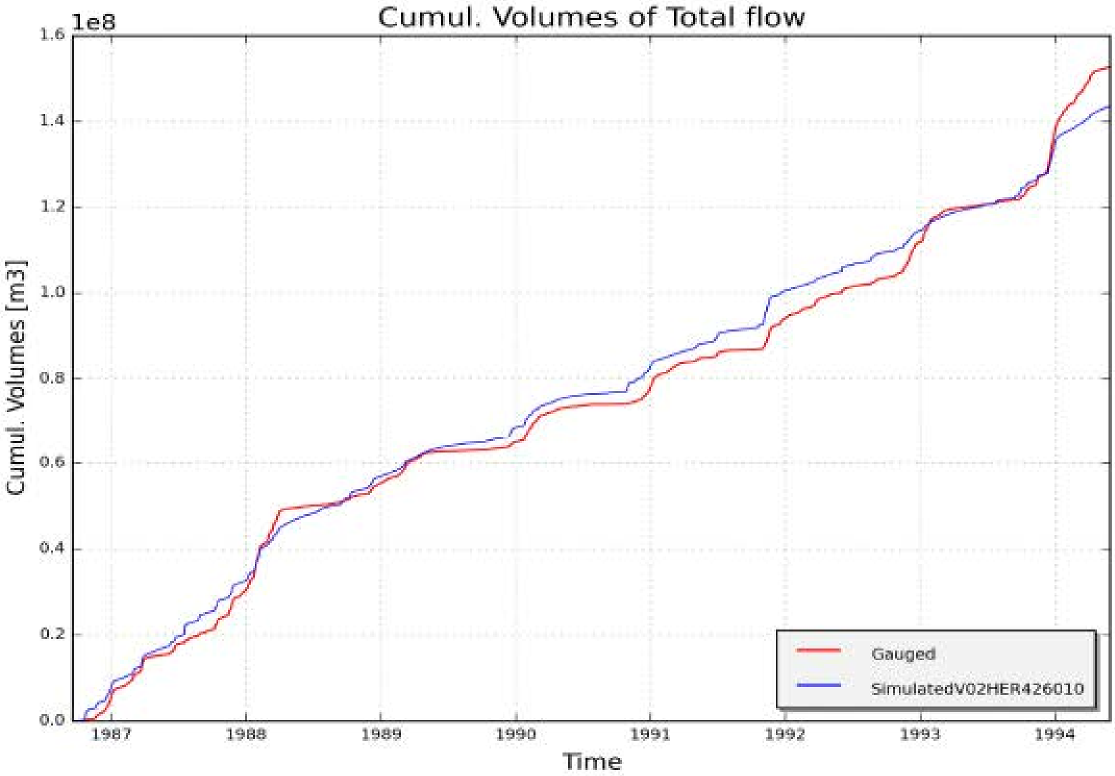

Figure 25 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02HER426010 (validation period).

Catchment V02EDE442120

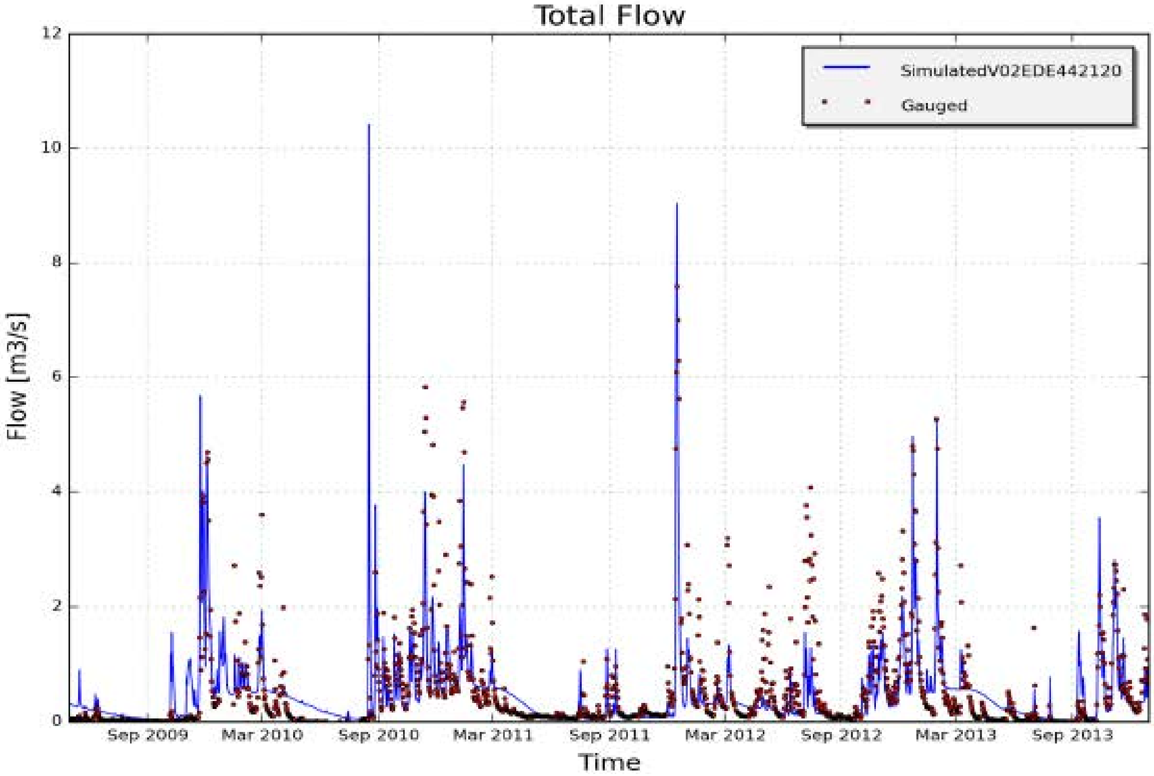

Figure 26 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02EDE442120 (calibration period).

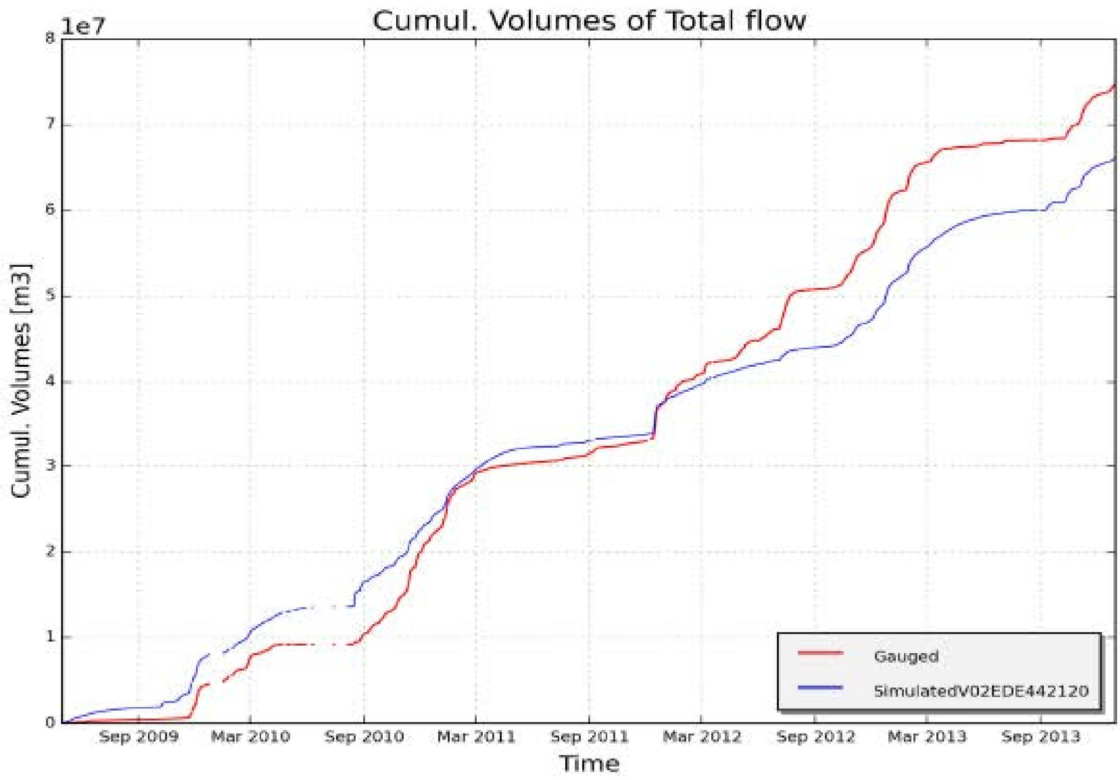

Figure 27 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02EDE442120 (calibration period).

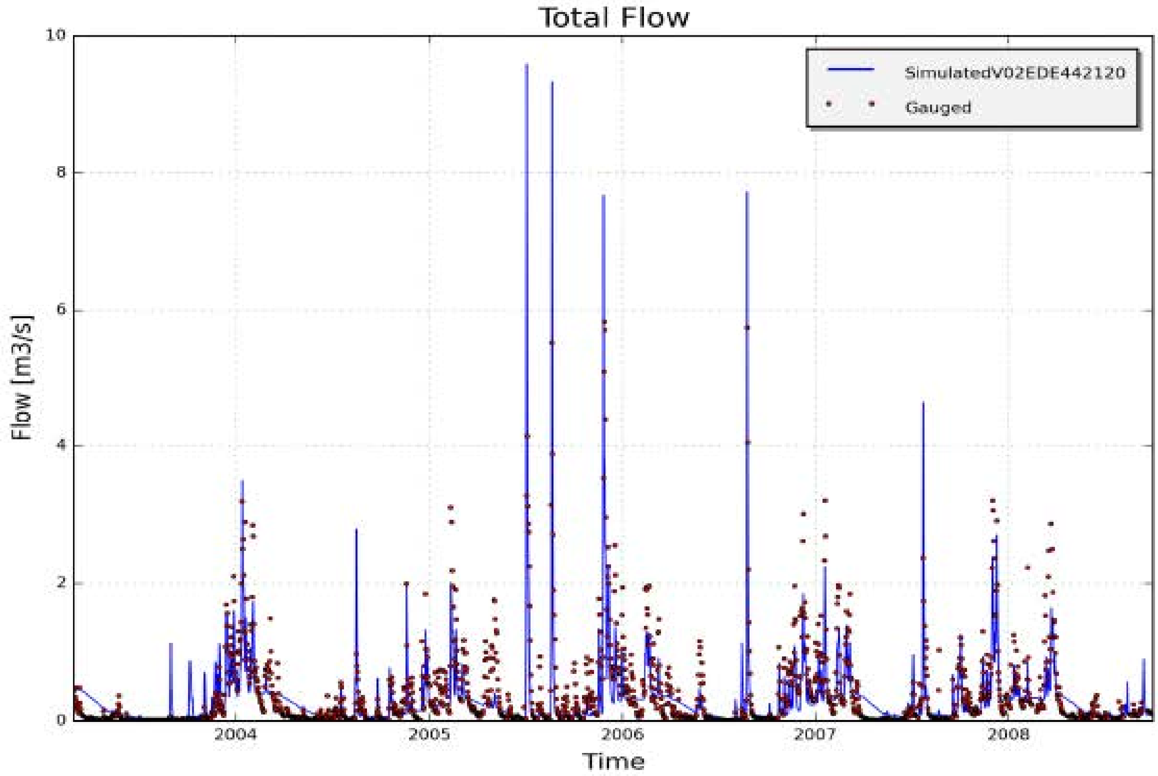

Figure 28 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02EDE442120 (validation period).

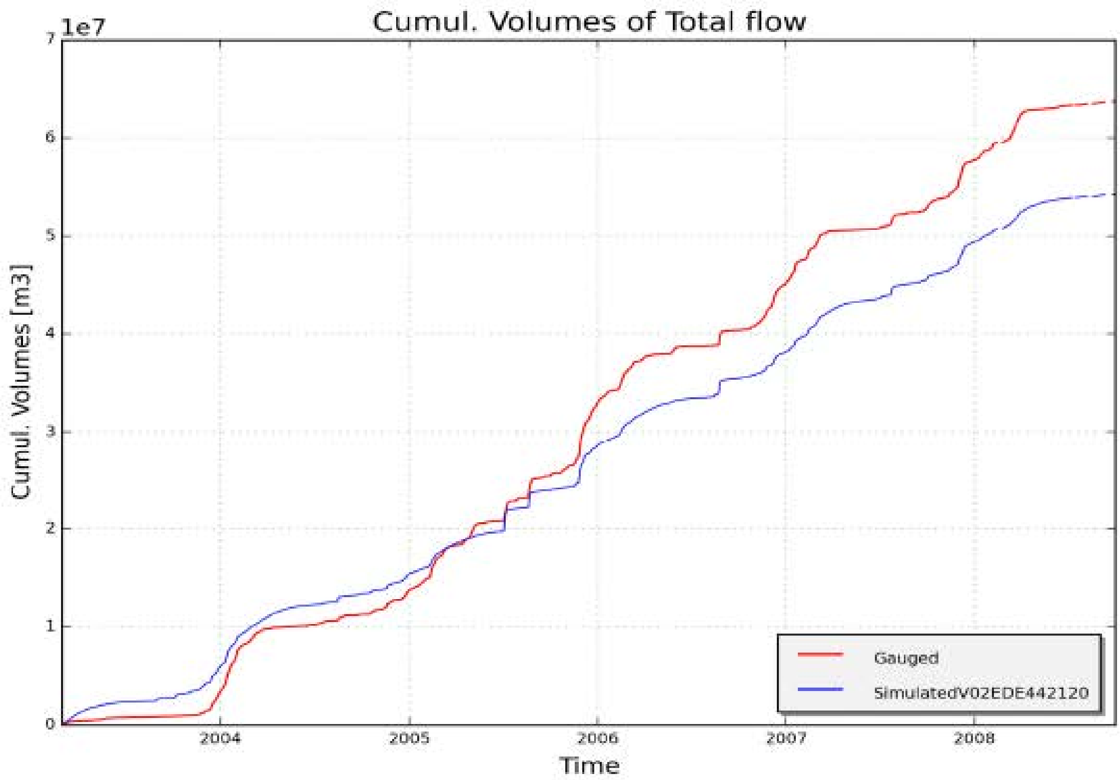

Figure 29 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02EDE442120 (validation period).

6.3 Gentse Kanalen

6.3.1 Context

The Gentse Kanalen catchment, covers a cluster of canals and their respective catchments and has a surface area of 917 km² (De Boeck, 2011). The catchment represents 4 % of the total model area of the water allocation model. The Gentse Kanalen basin is limited West by the Brugse Polders, East by the Benedenschelde and South by the Leie catchment. The Dutch border stands in the North of the basin. Both the Leopold canal and the Gent-Terneuzen canal discharge into the Westerschelde (Western Scheldt) in the Netherlands. In this area, there is only one gauged catchment named V03POE446000. The gauging station of this catchment is 44656122 on the Poekebeek in Nevele (Figure 30).

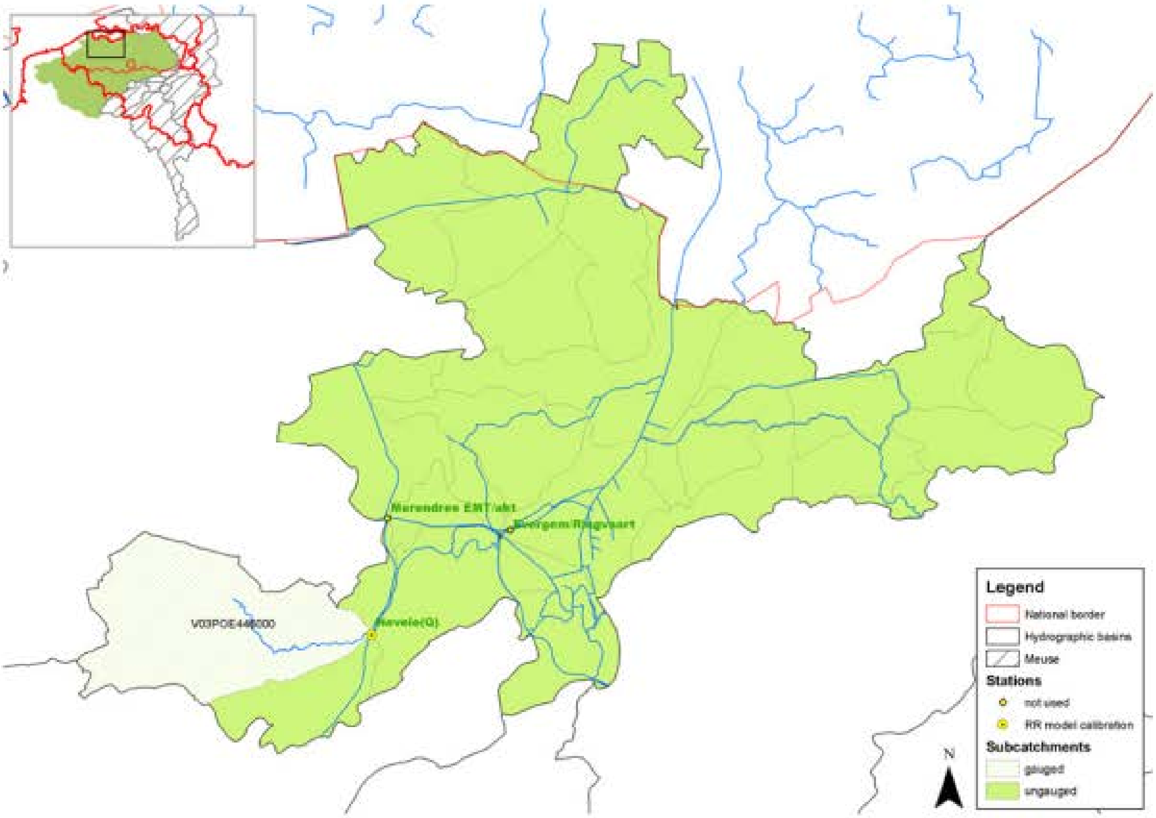

Figure 30 – Subcatchments and measurement points on the Gentse Kanalen catchment

6.3.2 Model performance

Table 17 and Table 18 present general performance statistics for the gauged catchments of the Gentse Kanalen basin for the validation and calibration period. Graphs of the simulation of the catchment V03POE446000 is presented below (Figure 31 to Figure 34). For more detailed results on the other catchments, see Appendix 6 and Appendix 7.

As can be seen from Figure 31 and Figure 33, the trend and magnitude of the discharge are generally in good agrreement with the measured data. This is also confirmed by the LogNSE values in the range of 0.77-0.78 for both the calibration and validation period. The values of RellErr are higher than -1.7% for the calibration and validation period (Table 17 and Table 18).

Data remark: the catchment V03POE446000 does not have data from 18/01/2001 to 29/11/2004 and after 2009. Therefore the calibration and validation period were selected from 2005-2009 and 1995-2000, respectively.

Table 17 – Overview of calibration results for gauged catchments on the Gentse Kanalen

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr (%)	Calibration period
44656122 - Poekebeek; Nevele	**V03POE446000**	106.8	0.77	-1.2	1995-2000

Table 18 – Overview of validation results for gauged catchments on the Gentse Kanalen

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr (%)	Gauged years
44656122 - Poekebeek; Nevele	**V03POE446000**	106.8	0.78	-1.7	1989-1993

Catchment V03POE446000

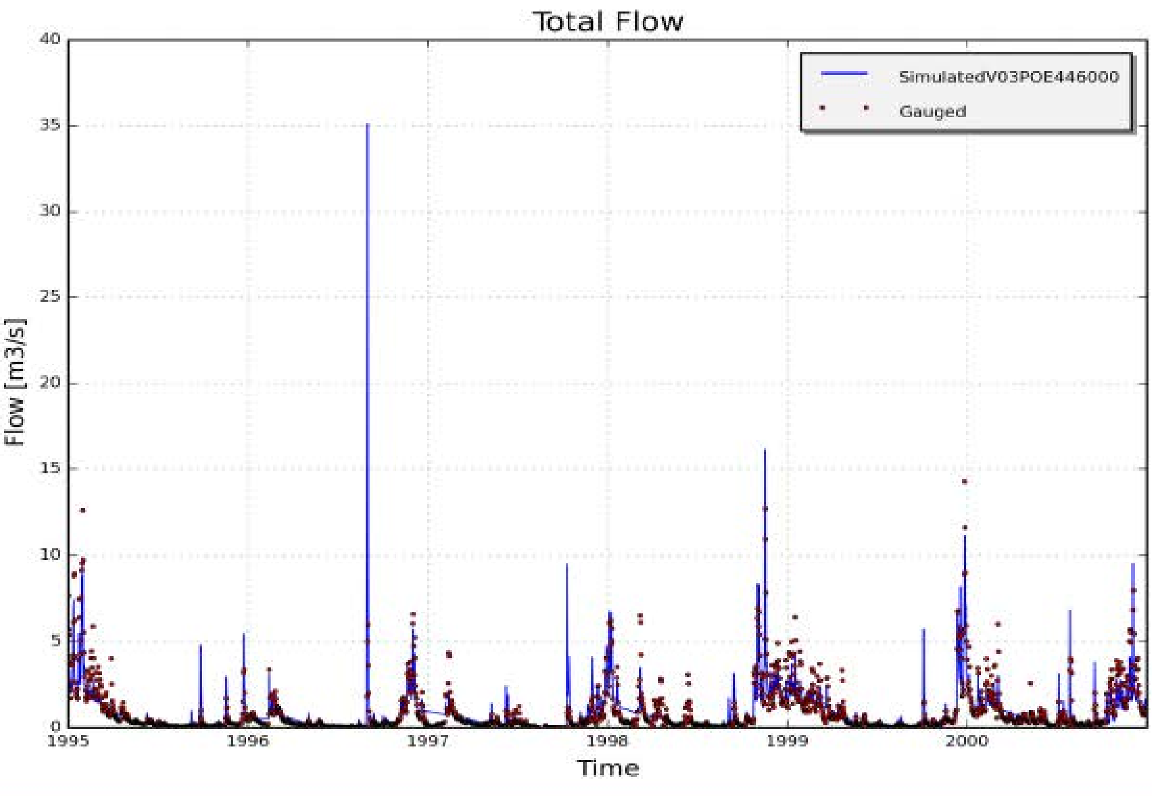

Figure 31 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V03POE446000, (calibration period).

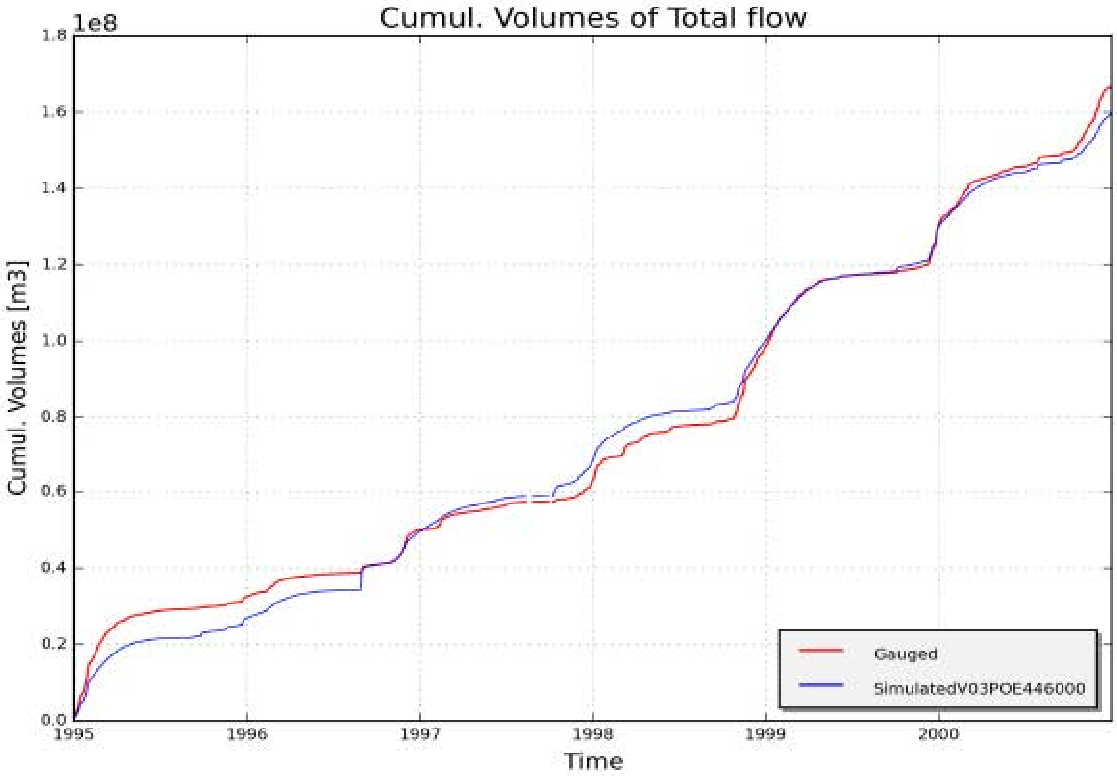

Figure 32 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V03POE446000 (calibration period)

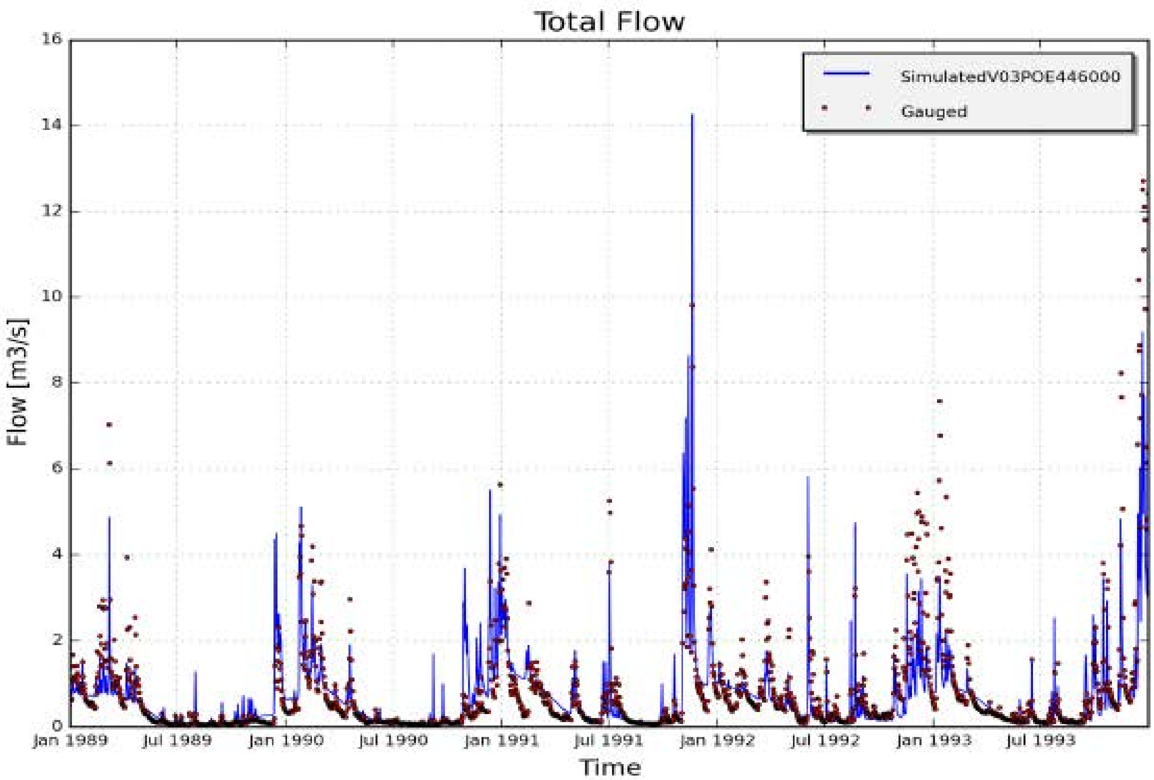

Figure 33 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V03POE446000 (validation period).

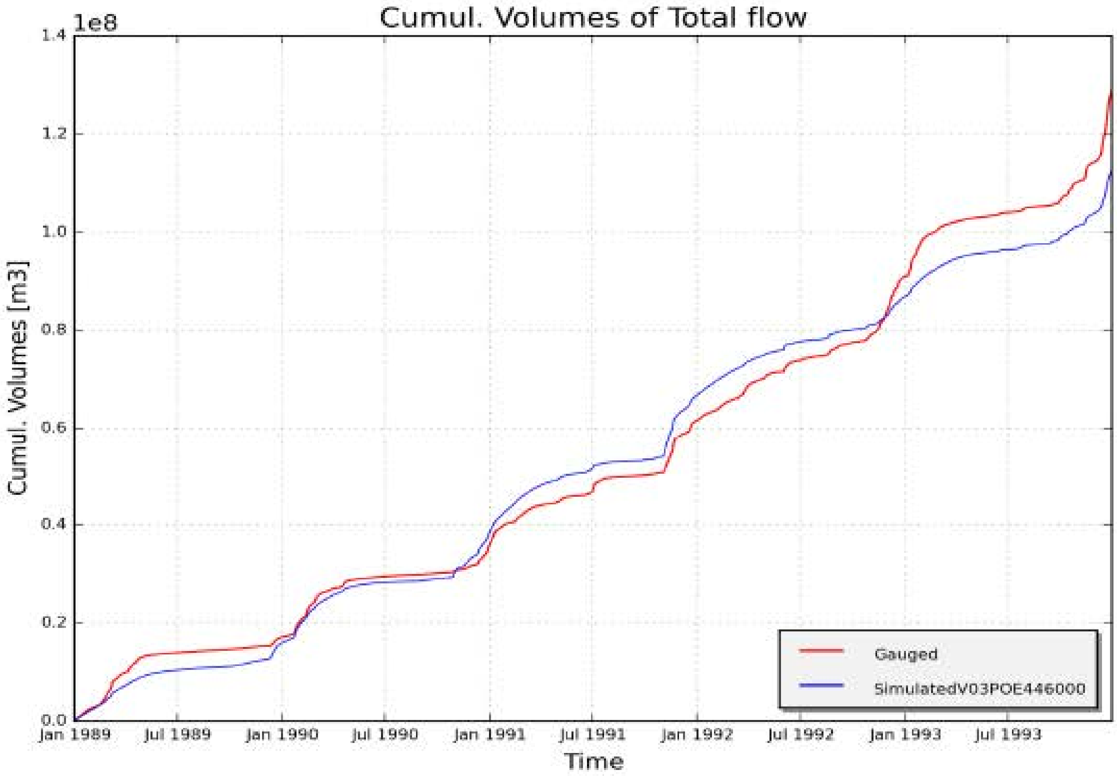

Figure 34 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V03POE446000 (validation period)

6.4 Benedenschelde

6.4.1 Context

The catchment of the Benedenschelde is 1 704 km² and belongs to the main Scheldt catchment. It covers the Flemish part of the tidal rivers in the Scheldt estuary, except the catchments corresponding to the main tributaries in this reach (Nete, Demer, Dijle, Zenne and Dender). The Benedenschelde catchment accounts for 8 % of the total catchment of the study area. There are two gauging stations in this area, named 3610102 - Kleine Molenbeek, Liezele and 3710102 - Grote Molenbeek, Malderen (Figure 35).

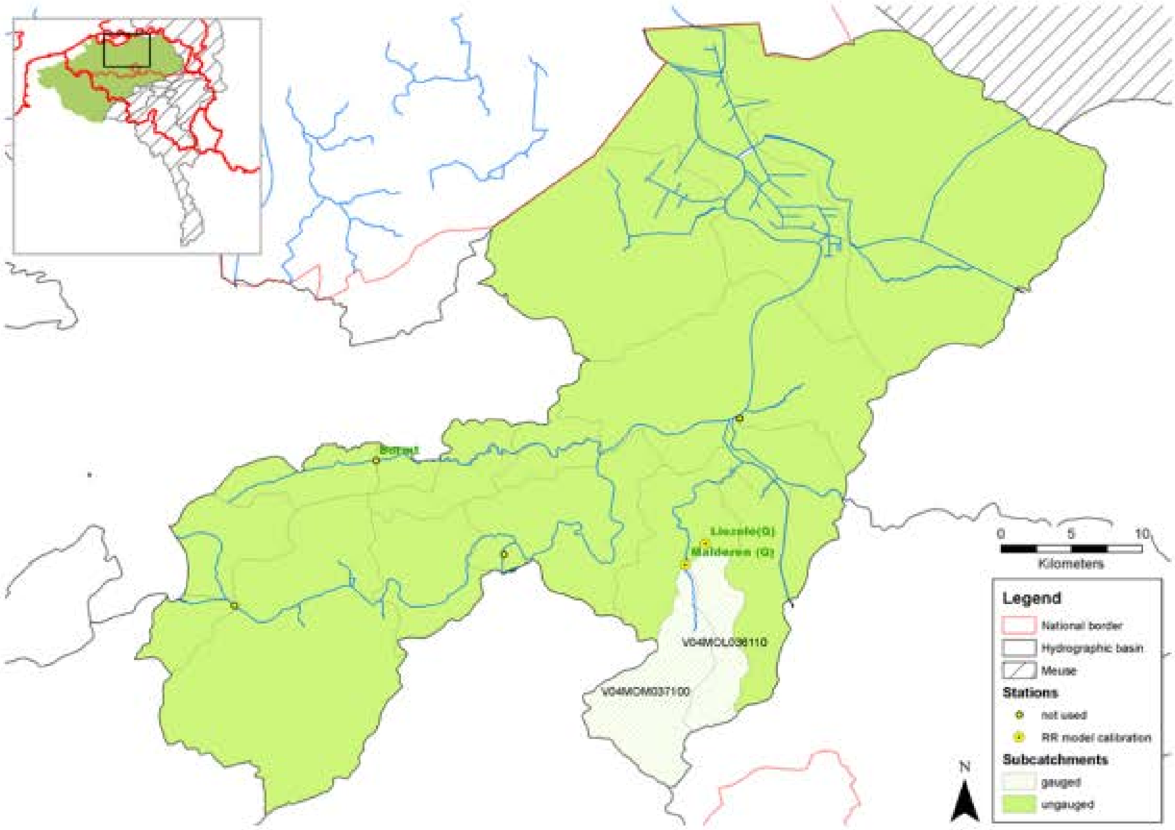

Figure 35 – Subcatchments and measurement points on the Benedenschelde catchment

6.4.2 Model performance

Table 19 and Table 20 present general performance statistics for the gauged catchments of the Benedenschelde basin for the calibration and validation period. Graphs of simulation of the catchments V04MOM037100 (best model performance) and V04MOL036110 (worst model performance) are presented below (Figure 36 to Figure 43). For more detailed results of the calibration, validation, and autocalibration on the catchments, see Appendix 8 and Appendix 9.

The results of the catchment V04MOM037100 showed very good agreement between simulated and measured daily discharge with LogNSE in the range from 0.71-0.82 for both the calibration and validation period, (Table 19 and Table 20). In addition, low values of RelErr, from 0.8% to 3.0 %, indicate that the model adequately predicted peak discharges and runoff volumes for the whole time period. For the catchment V04MOL036110, a slight difference between simulated and measured low flow was occured during the validation period (Figure 42). This resulted in a significant decrease in LogNSE (0.06%) (Table 20). However, the model perfomed satisfactory in simulating total flow for both the calibration and validation period, achieved the RelErr values in the range from 1.3% to 5.5% (Table 19 and Table 20).

Table 19 – Overview of calibration results for gauged catchments on the Benedenschelde basin

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr(%)	Calibration period
3610102 - Kleine Molenbeek, Liezele	**V04MOL036110**	32.6	0.34	1.3	2008-2013
3710102 - Grote Molenbeek, Malderen	**V04MOM037100**	67.3	0.71	0.8	2009-2013

Table 20- Overview of validation results for gauged catchments on the Benedenschelde basin

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr(%)	Validation period
3610102 - Kleine Molenbeek, Liezele	**V04MOL036110**	32.6	0.06	5.5	2003-2007
3710102 - Grote Molenbeek, Malderen	**V04MOM037100**	67.3	0.82	-3.0	2002-2006

Catchment V04MOM037100

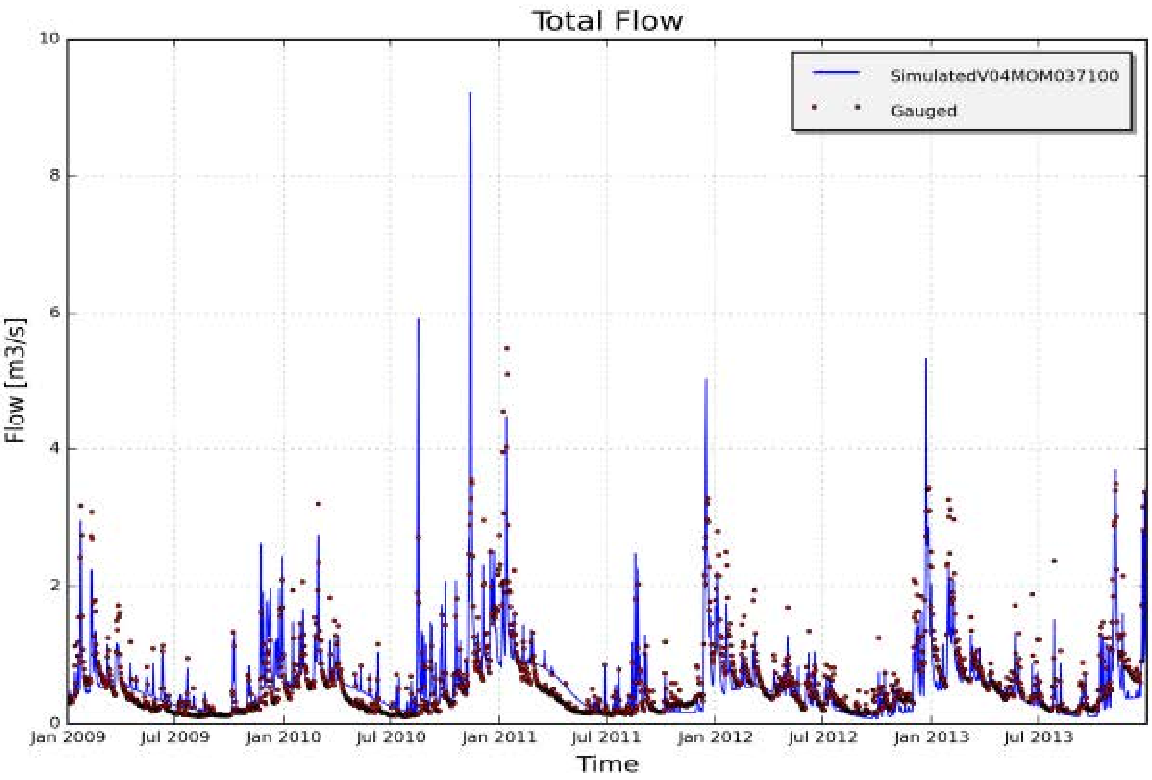

Figure 36 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V04MOM037100 (Calibration period).

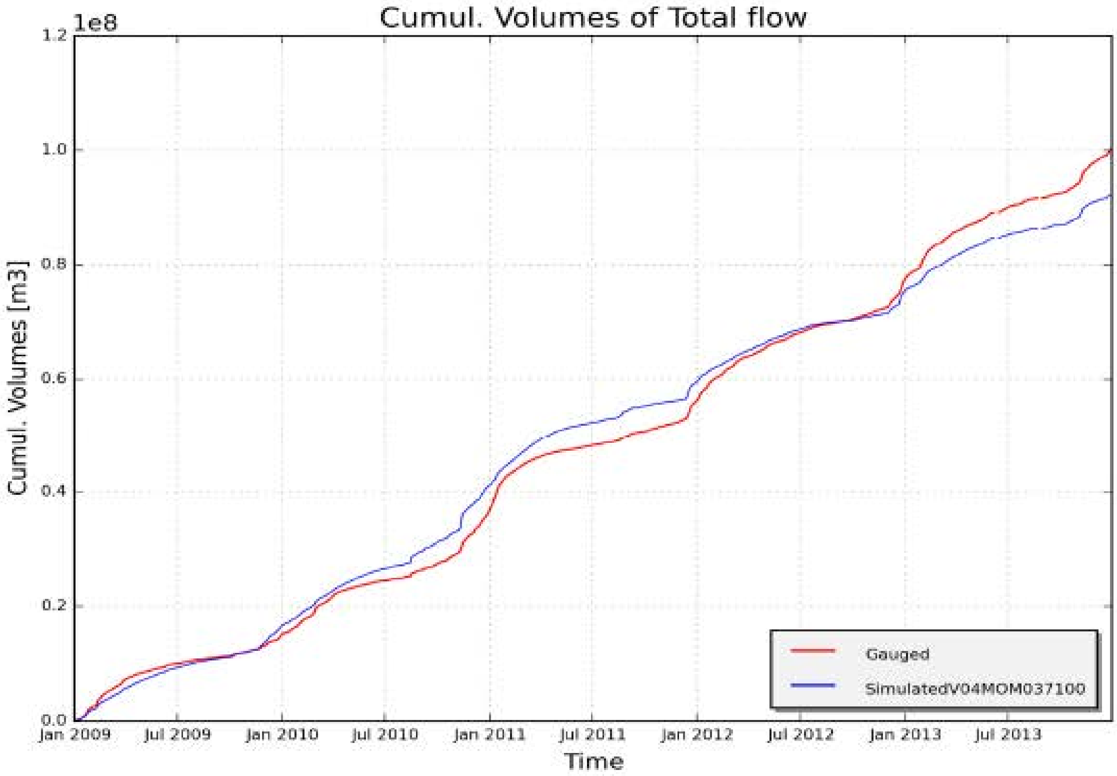

Figure 37 – Measured (red) and simulated (blue) cumulative discharge [m³/s] on catchment V04MOM037100 (Calibration period).

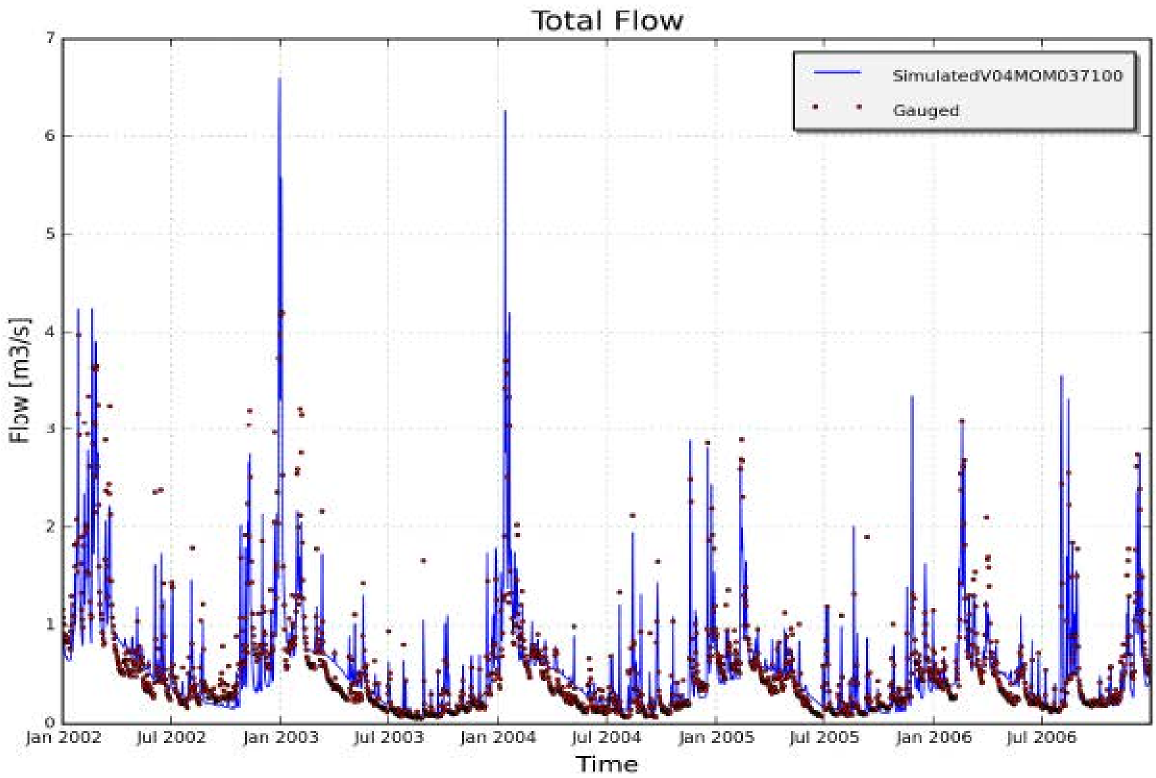

Figure 38 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V04MOM037100 (Validation period).

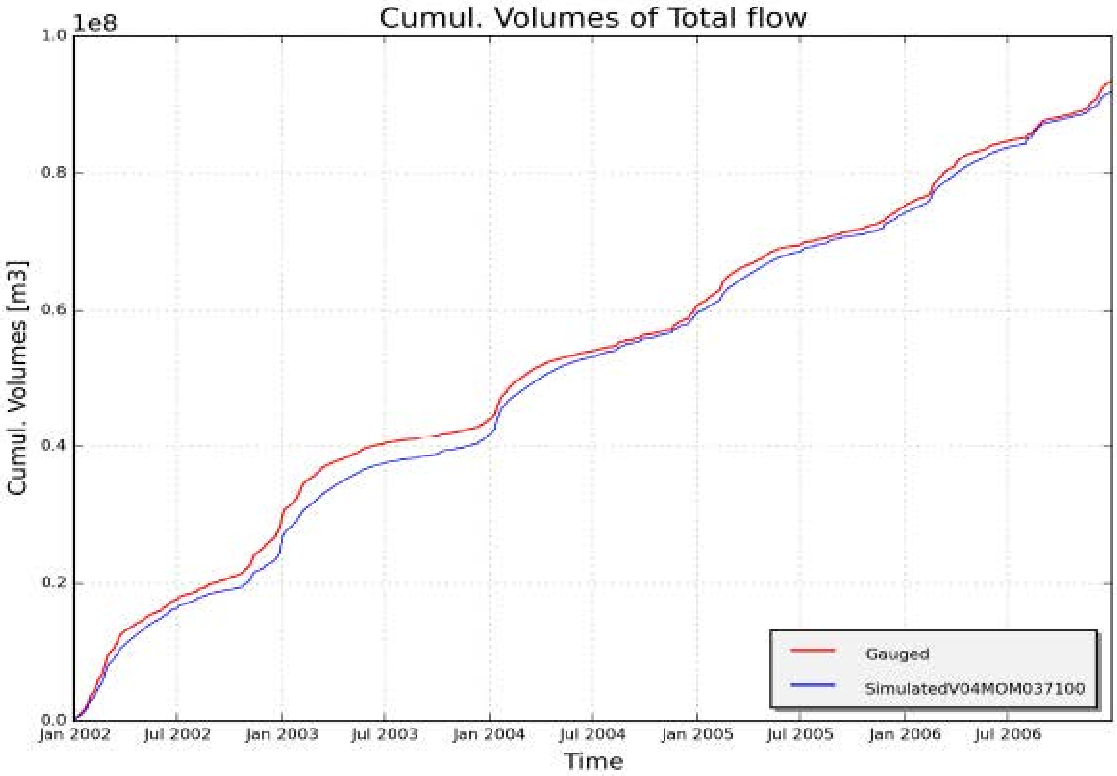

Figure 39 – Measured (red) and simulated (blue) cumulative discharge [m³/s] on catchment V04MOM037100 (Validation period).

Catchment V04MOL036110

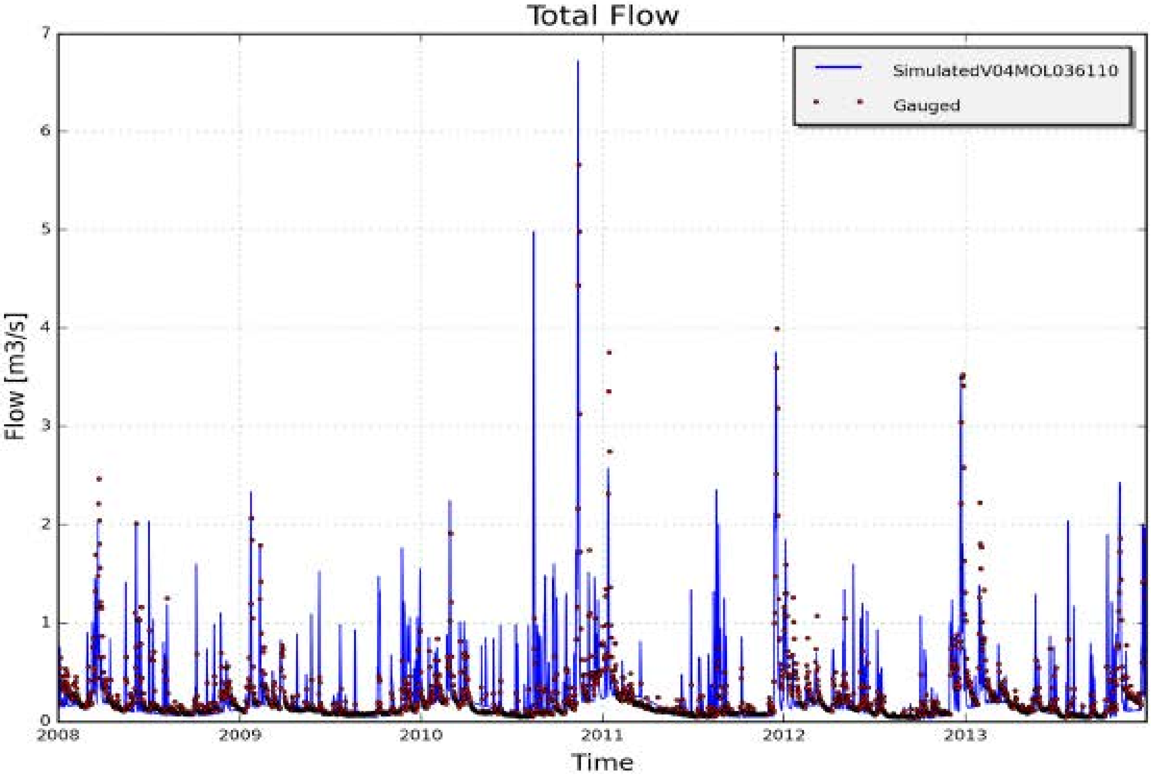

Figure 40 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V04MOL036110 (Calibration period).

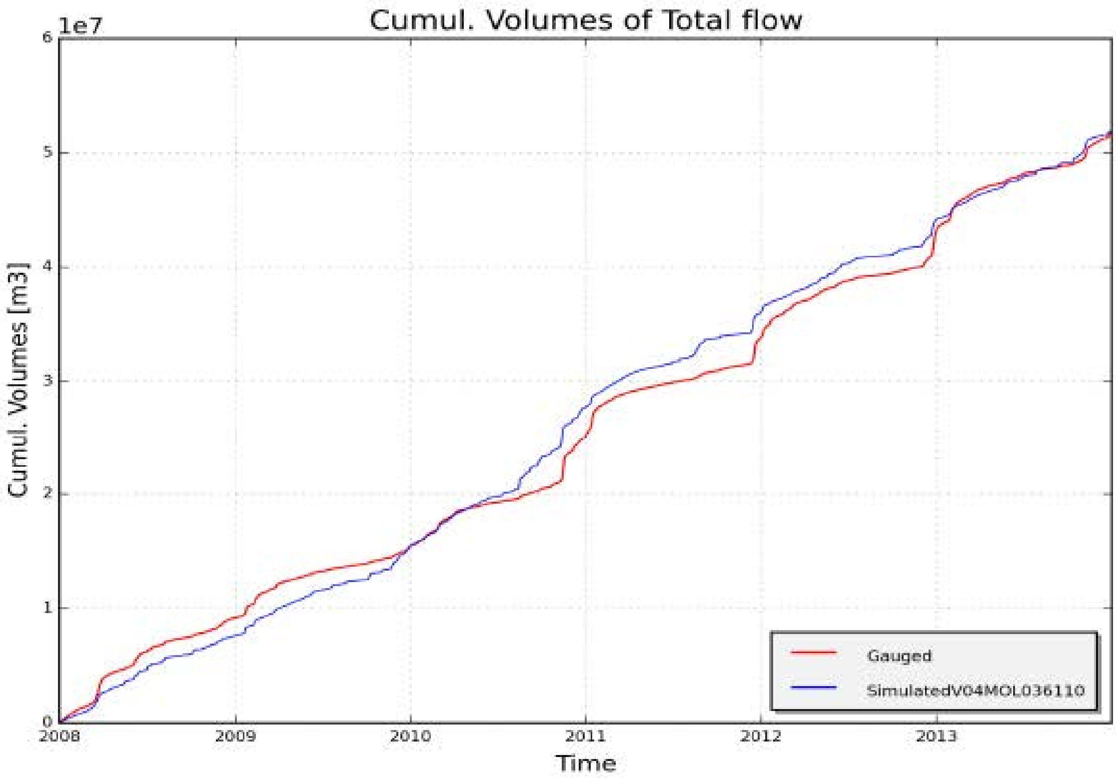

Figure 41 – Measured (red) and simulated (blue) cumulative discharge [m³/s] on catchment V04MOL036110 (Calibration period).

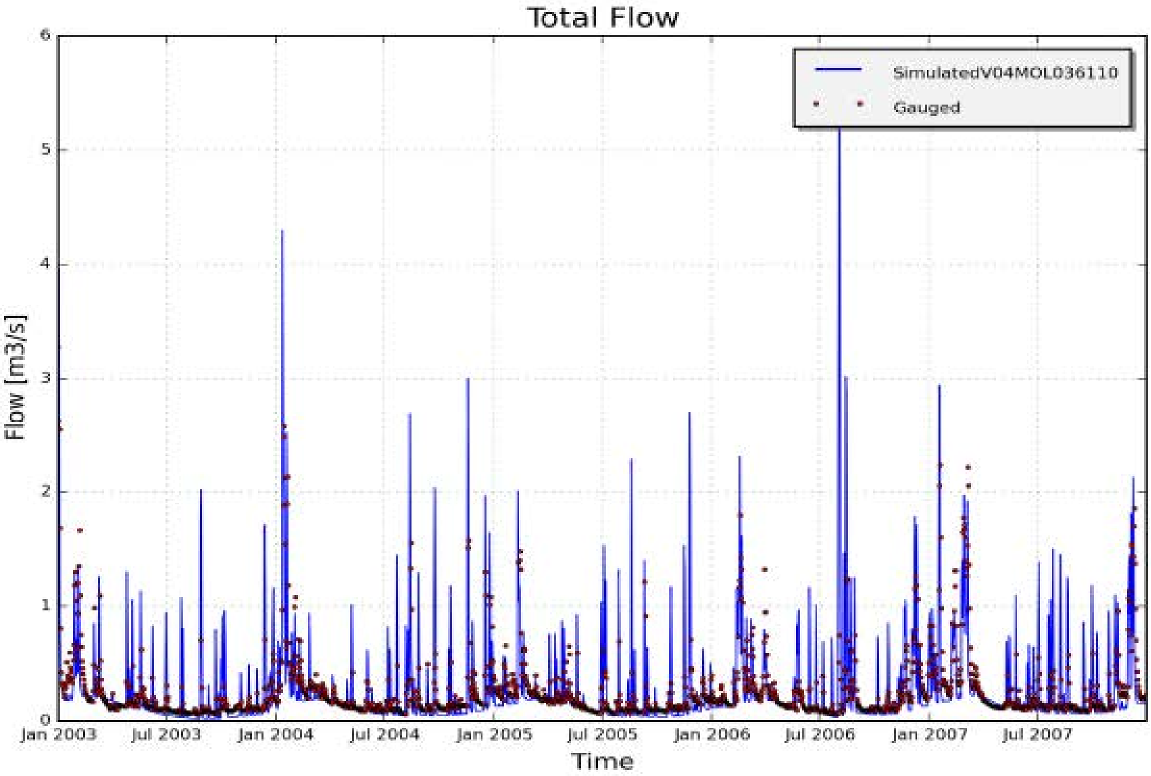

Figure 42 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V04MOL036110 (Validation period).

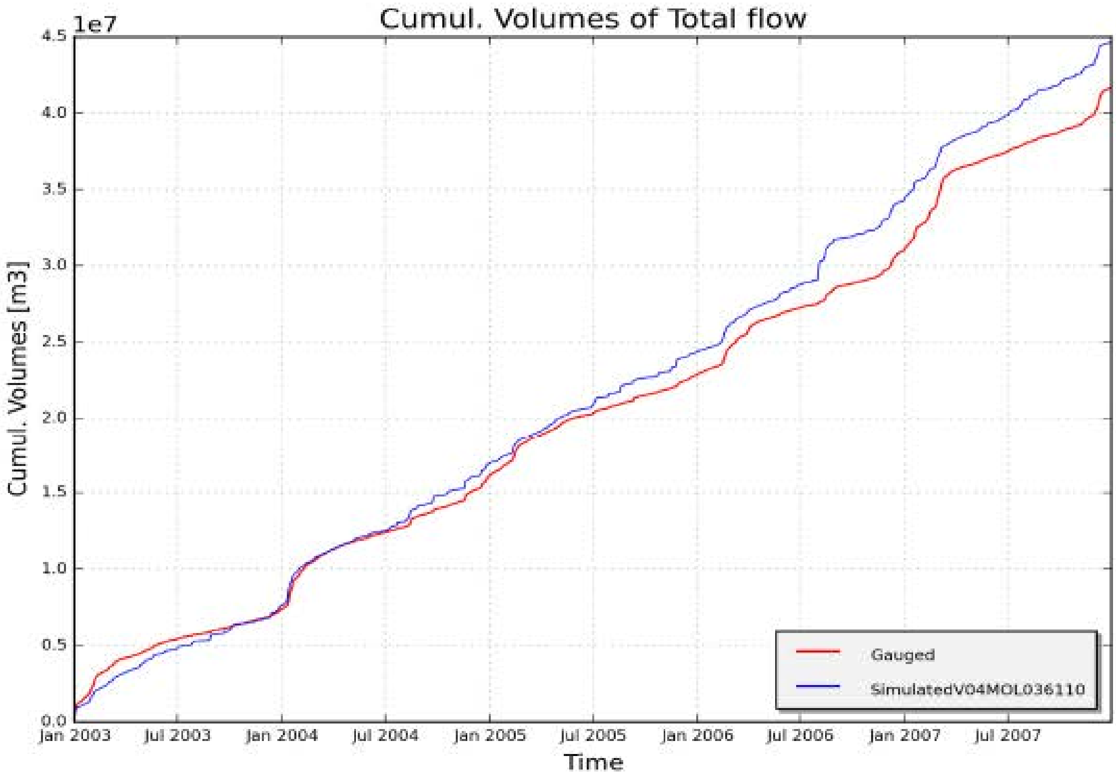

Figure 43 – Measured (red) and simulated (blue) cumulative discharge [m³/s] on catchment V04MOL036110 (Validation period).

6.5 Leie

6.5.1 Context

The Leie catchment, being part of the international "Leie and Deûle" basin, has an area of 3 886 km² of which 982 km² is situated in Flanders. In Ghent, the Leie confluences with the Scheldt. The subcatchments of the Leie count for 18 % of the total study area. In France, the Leie (or Lys in French) is connected to the Canal de Neufossé and the Canal d'Aire à la Bassée, both part of the canal system between Duinkerke and Denain. This canal constitutes the East-West link between the Scheldt, the Deûle, the Leie and the North Sea. The Dunkerque-Denain canal is supplied with water of the Schelde and its tributary, the Scarpe.

The Leie basin consists of 03 gauged catchments, of which catchment F05LEI386999 covers all areas of the France side while the other two gauged catchments, V05HEU403210 and V05MAN401230, are located in Flanders. The location of the gauged stations used for calibration of the WETSPA model on the Leie basin is shown in Figure 44.

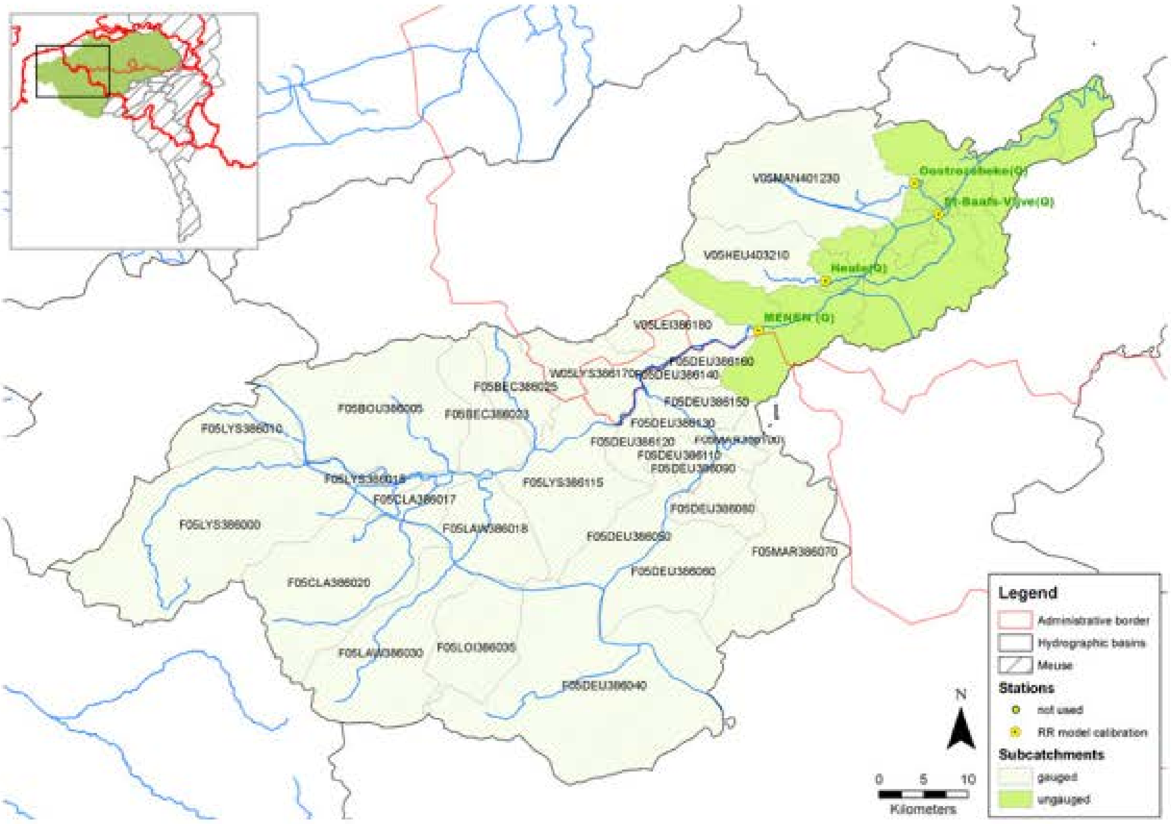

Figure 44 – Subcatchments and measurement points on the Leie catchment

6.5.2 Model performances

Table 21 and Table 22 present general performance statistics for the gauged catchments of the Leie basin for the calibration and validation period. Graphs of simulations for the catchments V05HEU403210 (best model performance) and V05MAN401230 (worst model performance) are presented below (Figure 45 toFigure 53). For more detailed results of the calibration, validation, and autocalibration on the catchments is reffered to Appendix 10 and Appendix 11.

The hydrographs demonstrate a good agreement between simulated and measured values for both the calibration and validation period at the outlet of the catchment V05HEU403210 (Figure 45 and Figure 47). Considering the validation period from 1975-2001, the simulated cumulative discharge fits the measured ones very well. This was confirmed by very low value of RelErr (0.1%). Similar good results could be found for the catchment F05LEI386999. Regarding the catchment V05MAN401230, the model represented the discharge fairly well during the whole period of the calibration and validation (Figure 50 andFigure 52). However, the model underestimated discharge during the winter season of 1988, 1990, and 1991, resulting in a minor difference between the simulated and measured cumulative discharge (Figure 50 andFigure 52). In general, all the catchments show a good model performance for the calibration and validation period. The value of LogNSE ranges from 0.51-0.63 for the calibration period and from 0.55-0.65 for the validation period (Table 21 and Table 22).

Table 21 – Overview of calibration results for gauged catchments on the Leie basin

Gauging station	**Catchment code**	**Surf. Area (km²)**	**logNSE**	**RelErr (%)**	**Calibration period**
38680122, Leie te Menen	**F05LEI386999**	2981.8	0.61	-1.8	2003-2013
40310102 - Heulebeek; Heule	**V05HEU403210**	91.9	0.63	-5.8	2002-2007
40110102 - Mandel; Oostrozebeke	**V05MAN401230**	258.4	0.51	-5.0	1988-1992

Table 22 – Overview of validation results for gauged catchments on the Leie basin

Gauging station	**Catchment code**	**Surf. Area (km²)**	**logNSE**	**RelErr (%)**	**Validation period**
38680122, Leie te Menen	**F05LEI386999**	2981.8	0.73	-1.5	1998-2002
40310102 - Heulebeek; Heule	**V05HEU403210**	91.9	0.65	0.1	1975-2001
40110102 - Mandel; Oostrozebeke	**V05MAN401230**	258.4	0.55	4.3	1970-1975

Catchment V05HEU403210

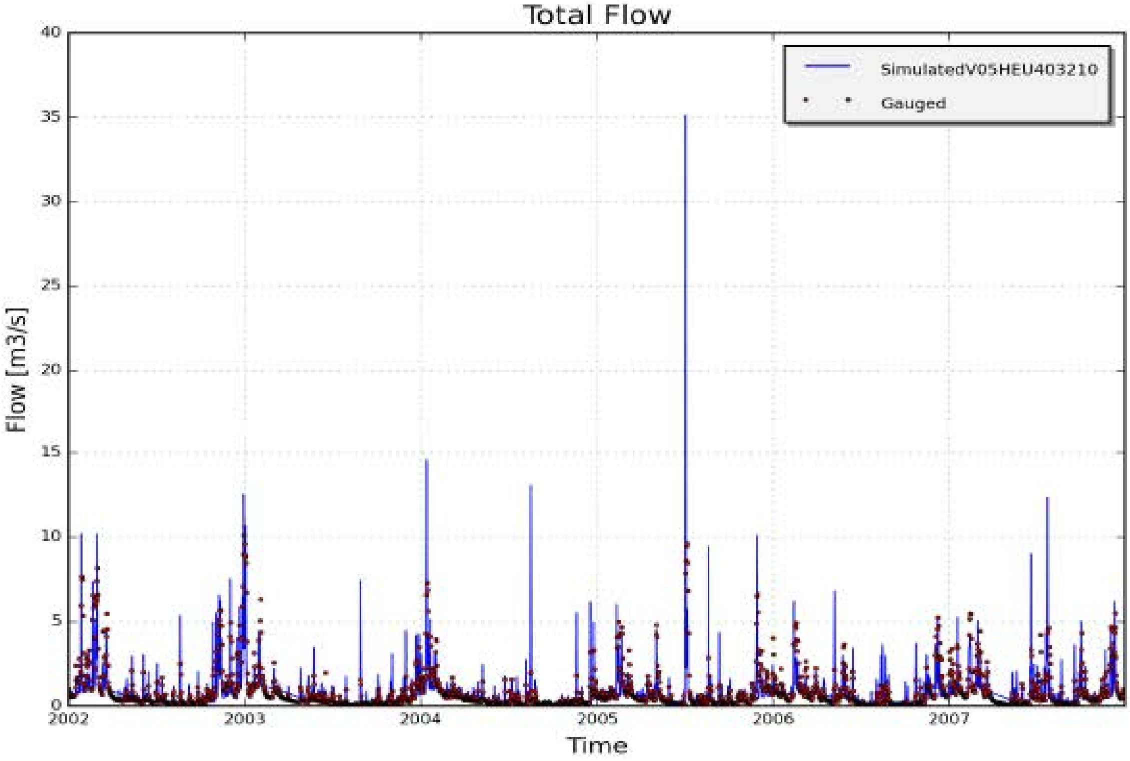

Figure 45 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V05HEU403210 (Calibration period).

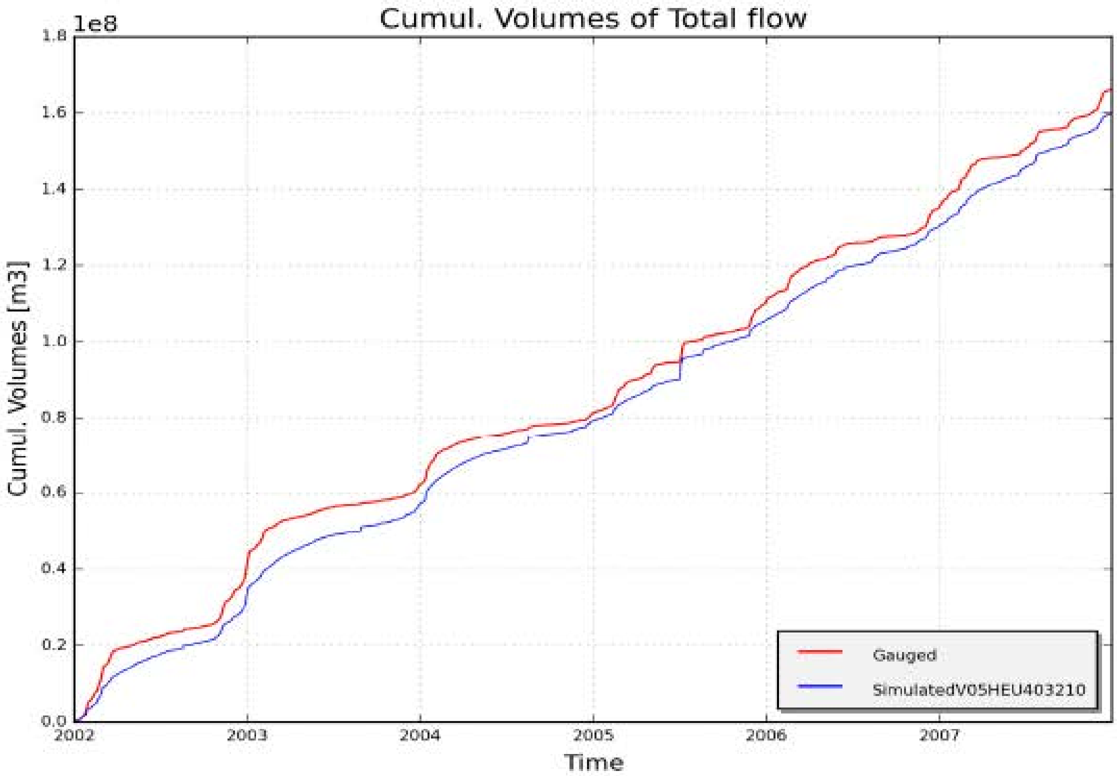

Figure 46 – Measured (red) and simulated (blue) cumulative discharge [m³/s] on catchment V05HEU403210 (Calibration period).

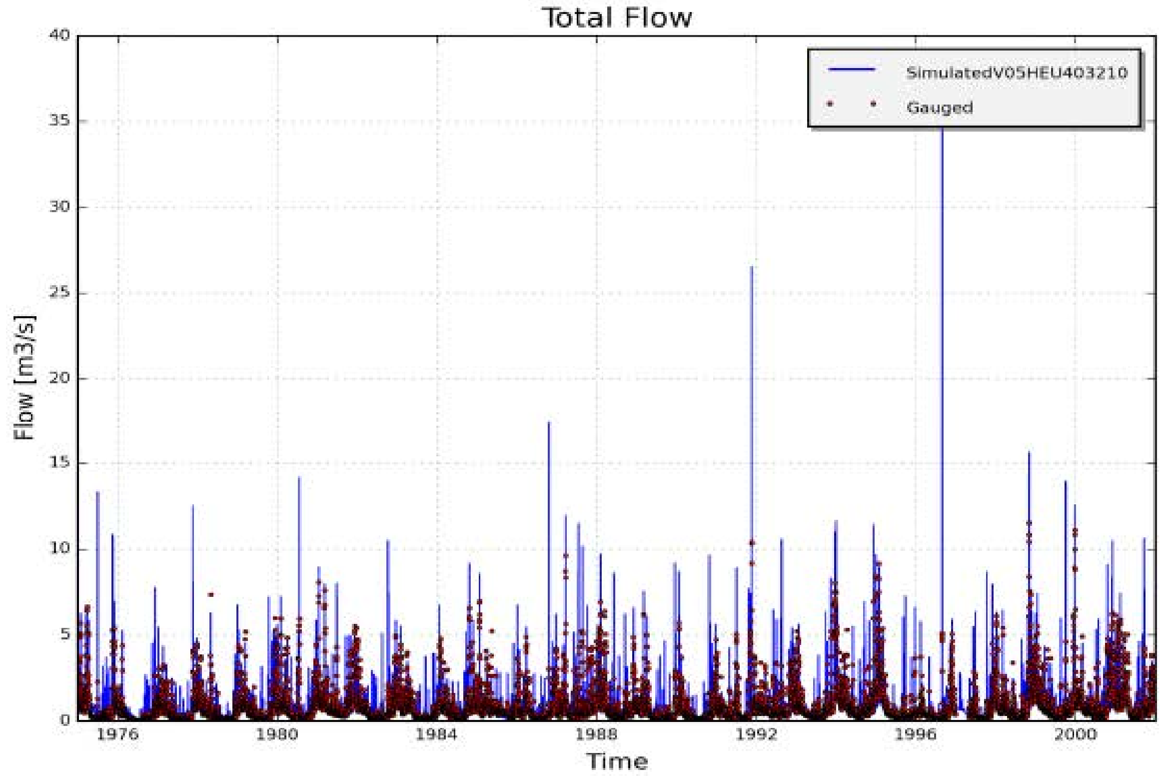

Figure 47 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V05HEU403210 (Validation period).

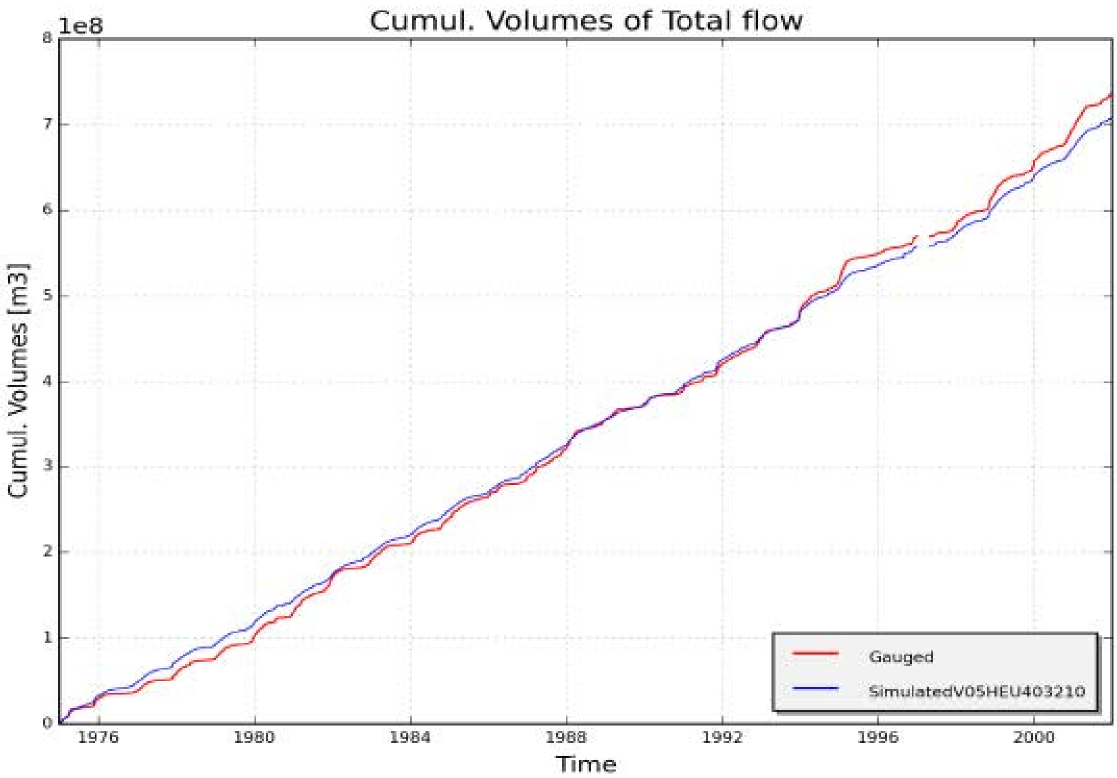

Figure 48 – Measured (red) and simulated (blue) cumulative discharge [m³/s] on catchment V05HEU403210 (Validation period).

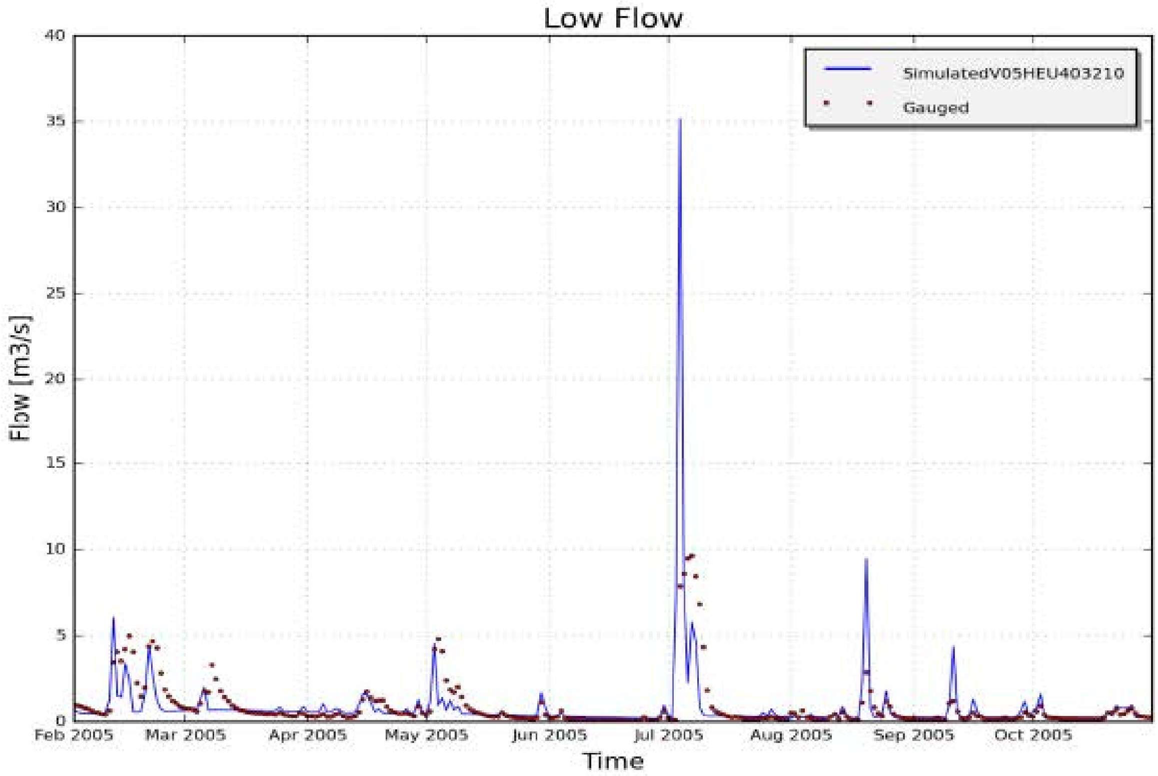

Figure 49 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low flow events on catchment V05HEU403210.

Catchment V05MAN401230

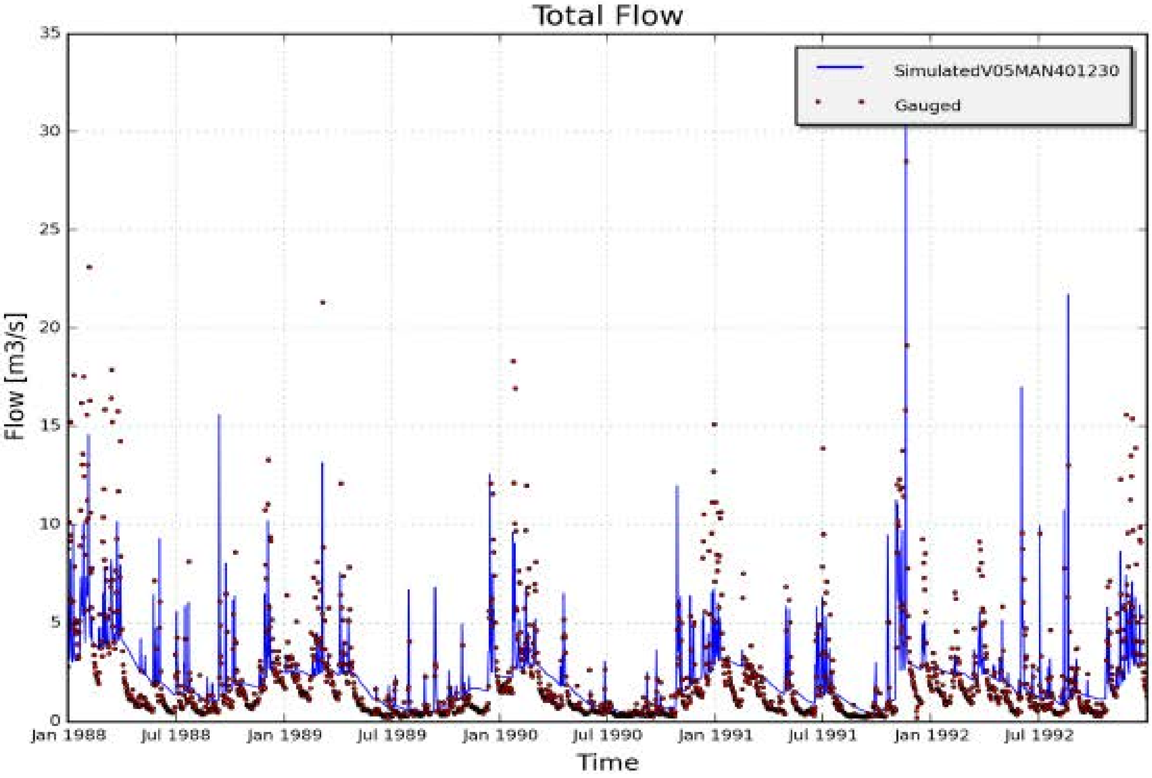

Figure 50 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V05MAN401230 (calibration period).

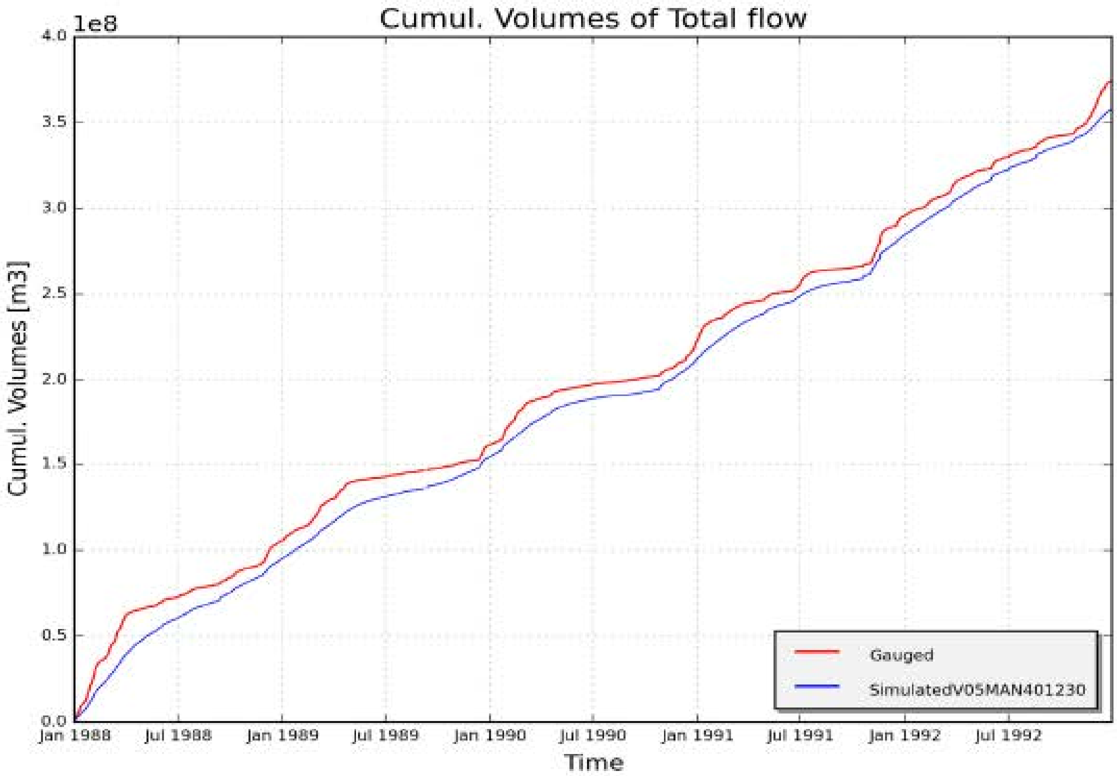

Figure 51 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V05MAN401230 (calibration period).

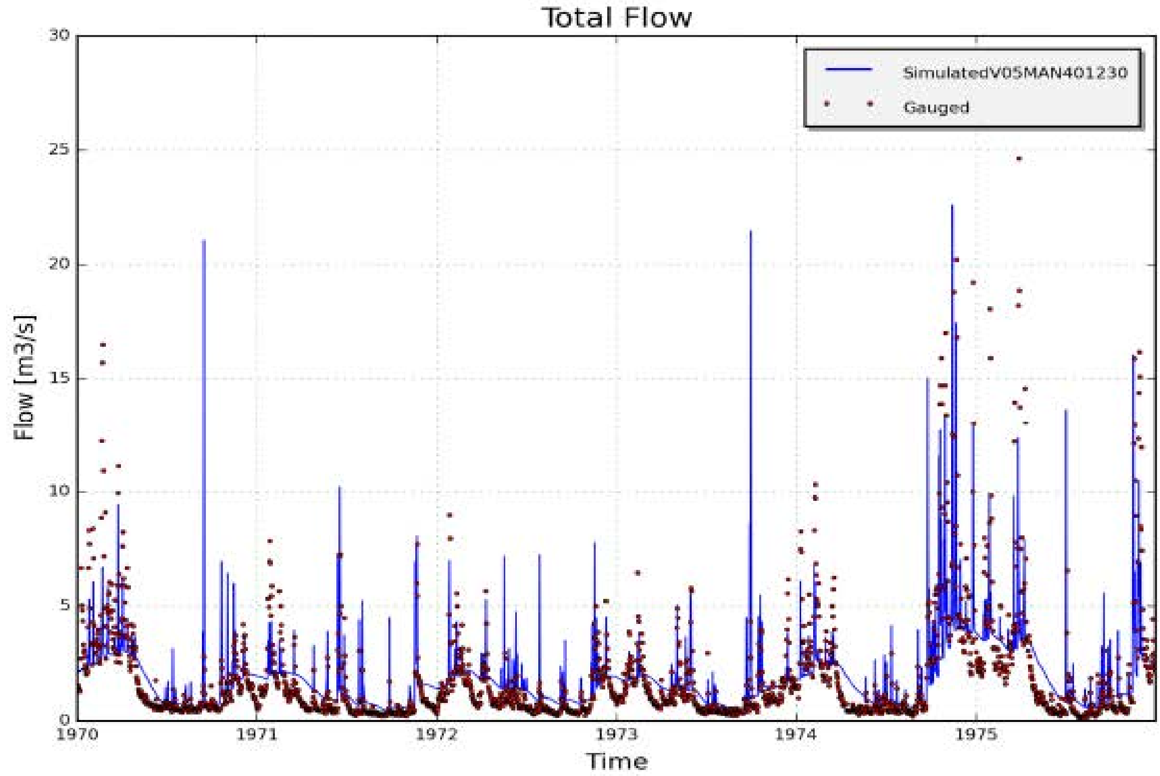

Figure 52 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V05MAN401230 (validation period).

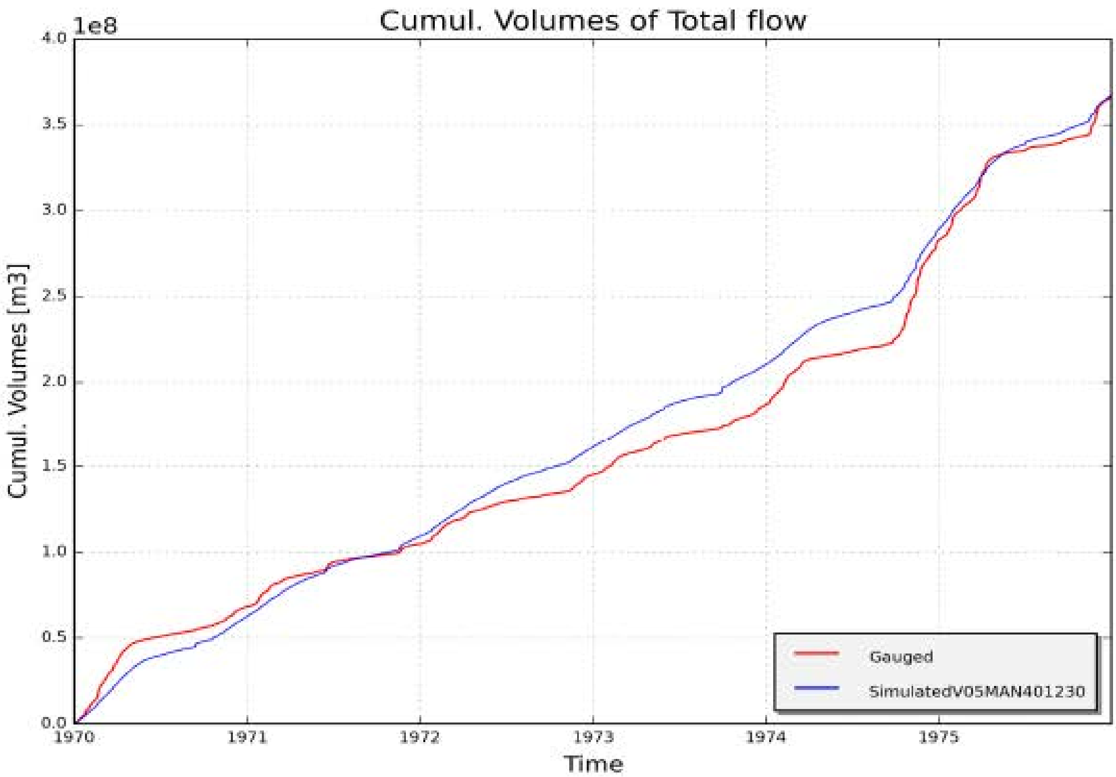

Figure 53 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V05MAN401230 (validation period).

6.6 Bovenschelde

6.6.1 Context

The Bovenschelde basin extends to France, Wallonia and Flanders. This basin covers a surface area of 576 km². Before it enters Flanders in Spiere-Helkijn, the Schelde has covered 124 km, with an upstream catchment of 5 380 km² in France and Wallonia. The Bovenschelde basin accounts for 30 % of the total catchment of the study area. The Bossuit-Kortrijk canal connects the Bovenschelde to the Leie, whereas the Spierekanaal links the Bovenschelde to the Deûle (Figure 54).

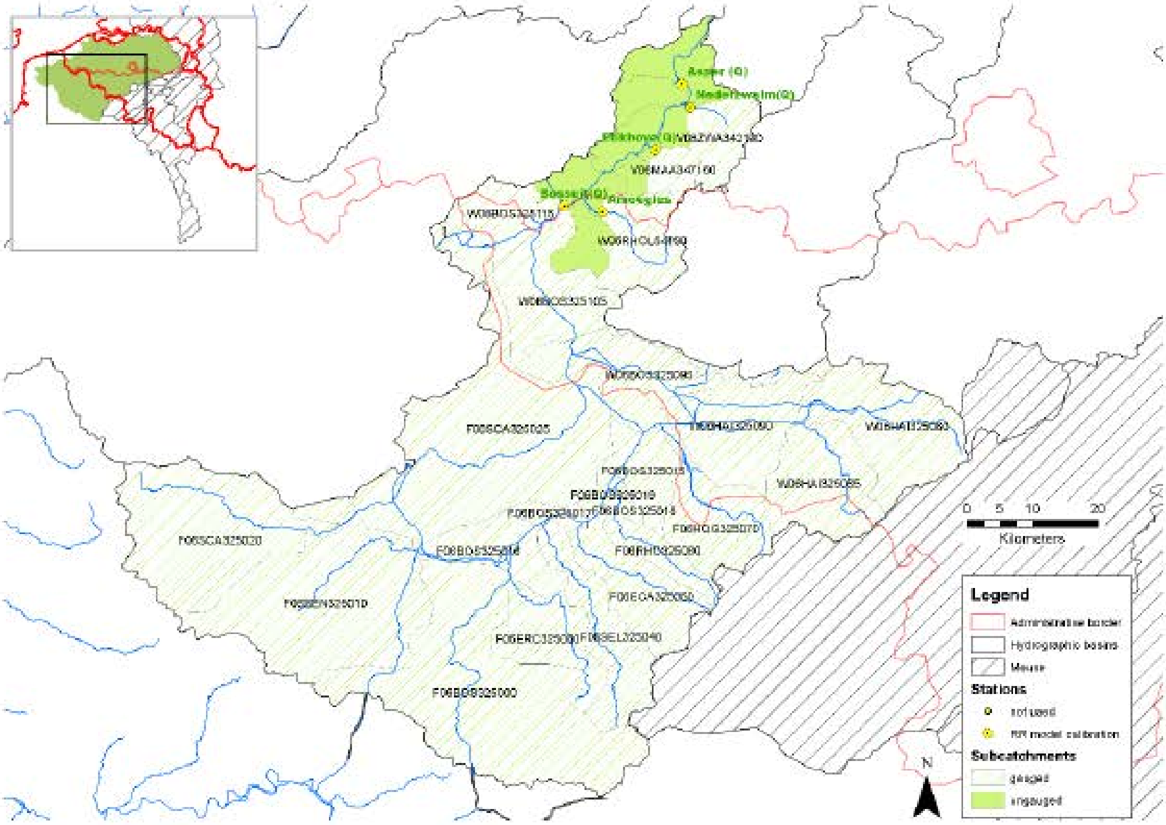

Figure 54 – Catchments and measurement points on the Bovenschelde basin.

6.6.2 Model performance

Table 23 and Table 24 present general performance statistics for the gauged catchments of the Bovenschelde basin for the calibration and validation period. Graphs of simulations of the catchment V06ZWA342190 (the best model perfomance) and F06BOS325999 (the worst model performance) are presented below (Figure 55 and Figure 63). For more detailed results on the catchments is reffered to Appendix 12 and Appendix 13.

Figure 55 and Figure 57 show very good agreement between simulated and measured daily discharge with LogNSE and RelErr at 0.65 and -2.8% for the calibration period and 0.69 and -0.5% for the validation period at the outlet of the catchment V06ZWA342190, respectively. The LogNSE values higher than 0.65 indicate that low flow events were reproduced well for both the calibration and validation period. Another adequate model performance was found for the catchment V06MAA347160 (Appendix 12). Regarding to the catchment F06BOS325999, the respective values of LogNSE and RelErr are 0.6 and -2.6% for the calibration period (Table 23). However, as shown in Figure 62, the difference in low flow is higher within the year 2013. This is probably due to unrealibe measured low flow data in this period. For the catchment W06RHOL54100, the simulation problems in the validation period are due to the short calibration period of 01 year, although the discharge was respresented well for the calibration period (Figure 60). This results are also similar with the NAM model results for this catchment.

Data remark: The station 32580122 – Bovenschelde in Bossuit (F06BOS325999) only has measured discharge from 13/09/2001. The catchment W06RHOL54100 only has observed discharge data from February 2012 so that the calibration and validation periods only cover less than two years.

Table 23 – Overview of calibration results for gauged catchments on the Bovenschelde basin

Gauging station	**Catchment code**	**Surf. Area (km²)**	**logNSE**	**RelErr (%)**	**Calibration period**
32580122 - Bovenschelde; Bossuit	F06BOS325999	5217.6	0.6	-2.6	2005-2013
34710102 - Maarkebeek; Etikhove	V06MAA347160	48.7	0.51	-1.9	1994-2008
34210102 - Zwalm; Nederzwalm	V06ZWA342190	112.1	0.65	-2.8	2008-2012
L5412 Amougies - Rhosnes	W06RHOL54100	161.9	0.73	1.2	01-12.2013

Table 24 – Overview of validation results for gauged catchments on the Bovenschelde basin

Gauging station	**Catchment code**	**Surf. Area (km²)**	**logNSE**	**RelErr (%)**	**Validation period**
32580122 - Bovenschelde; Bossuit	F06BOS325999	5217.6	0.6	-2.6	2003-2013
34710102 - Maarkebeek; Etikhove	V06MAA347160	48.7	0.5	-4.8	2002-2005
34210102 - Zwalm; Nederzwalm	V06ZWA342190	112.1	0.69	-0.5	2003-2008
L5412 Amougies - Rhosnes	W06RHOL54100	161.9	0.4	21.3	01-12.2012

Catchment V06ZWA342190

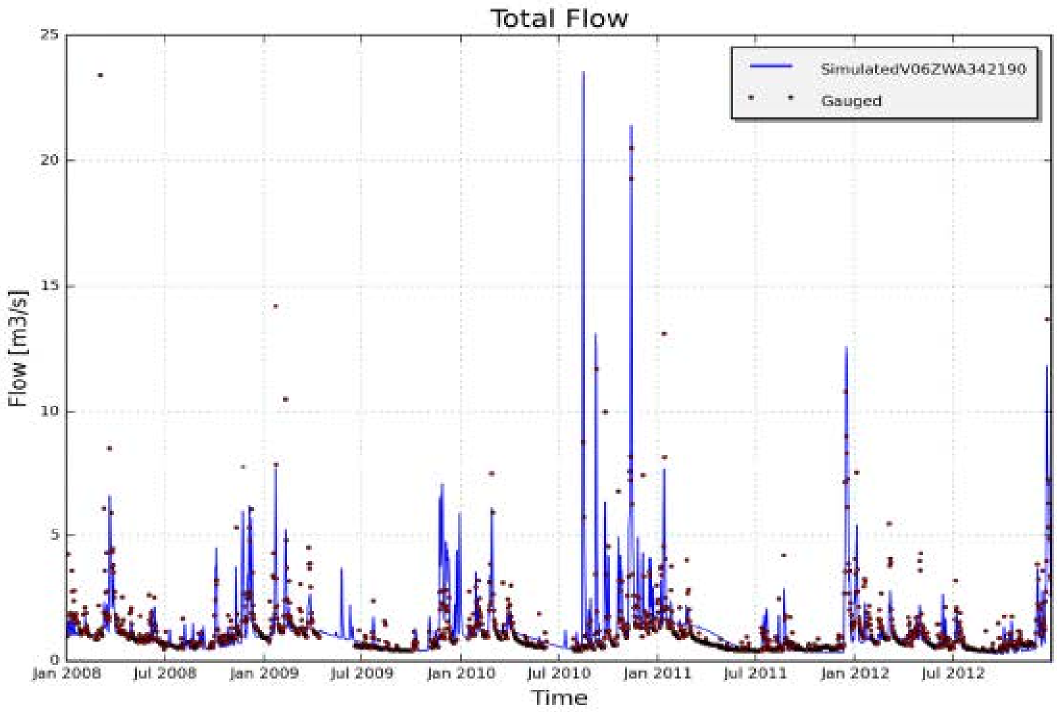

Figure 55 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V06ZWA342190 (Calibration period).

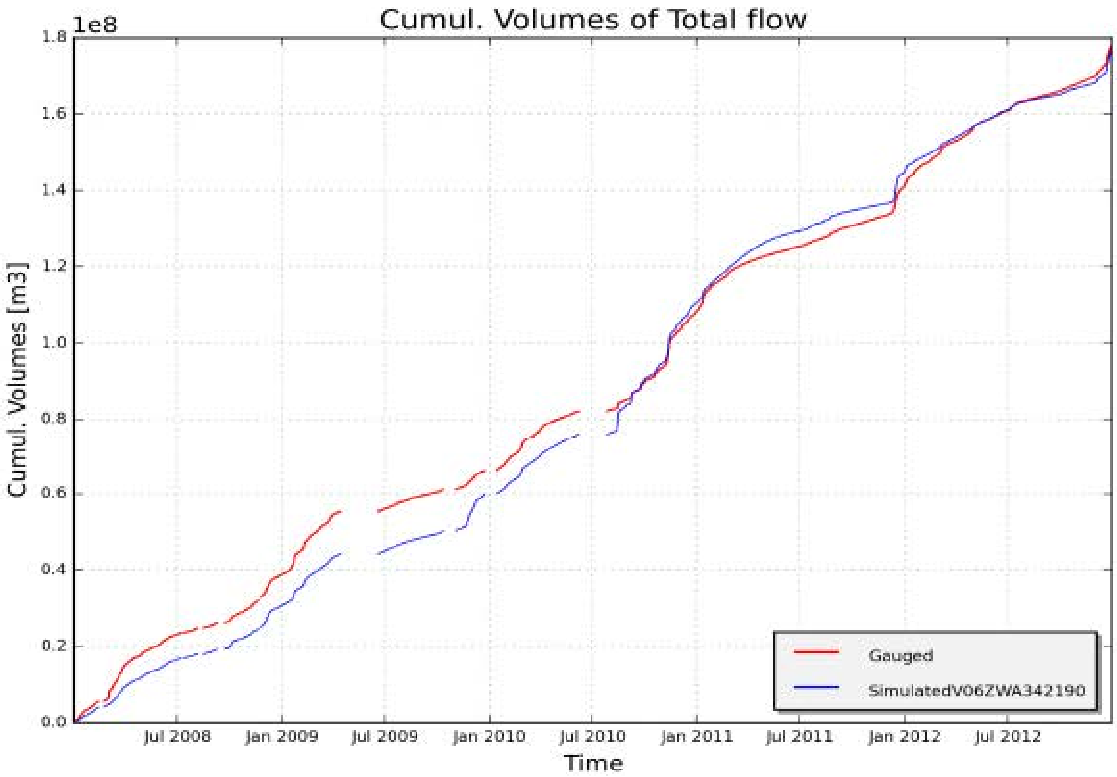

Figure 56 – Measured (red) and simulated (blue) cumulative discharge [m³/s] on catchment V06ZWA342190 (Calibration period).

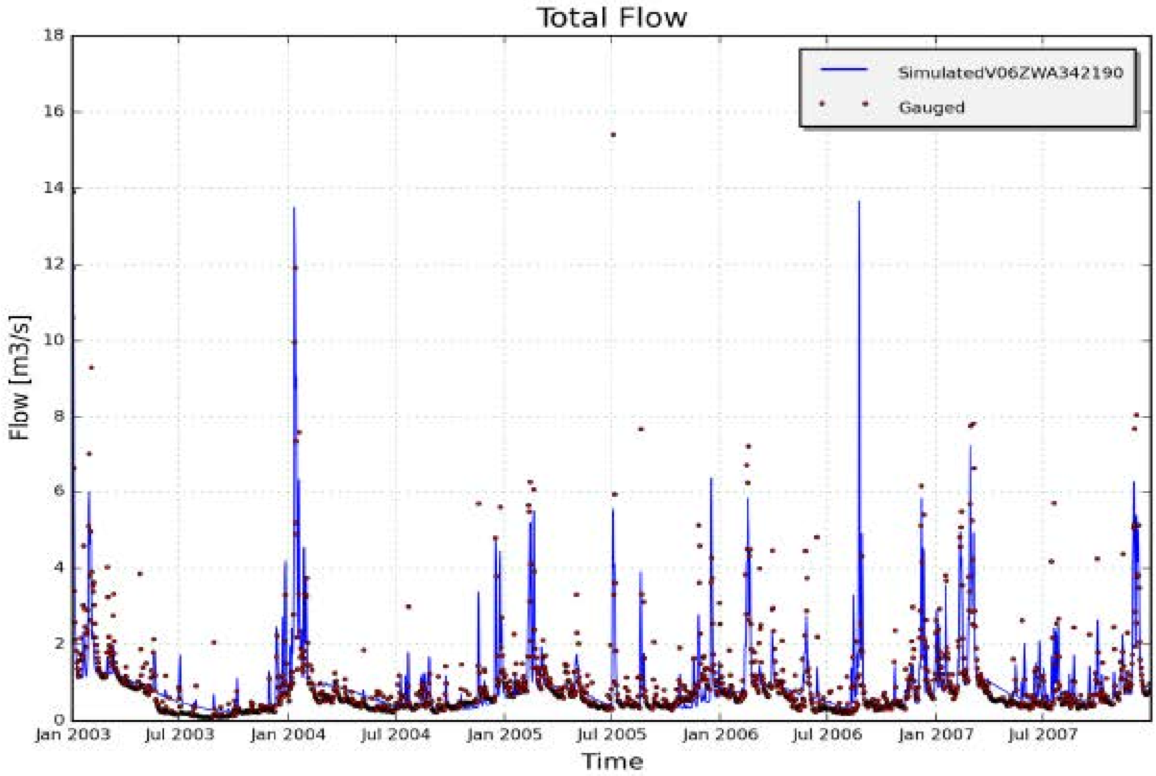

Figure 57 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V06ZWA342190 (Validation period).

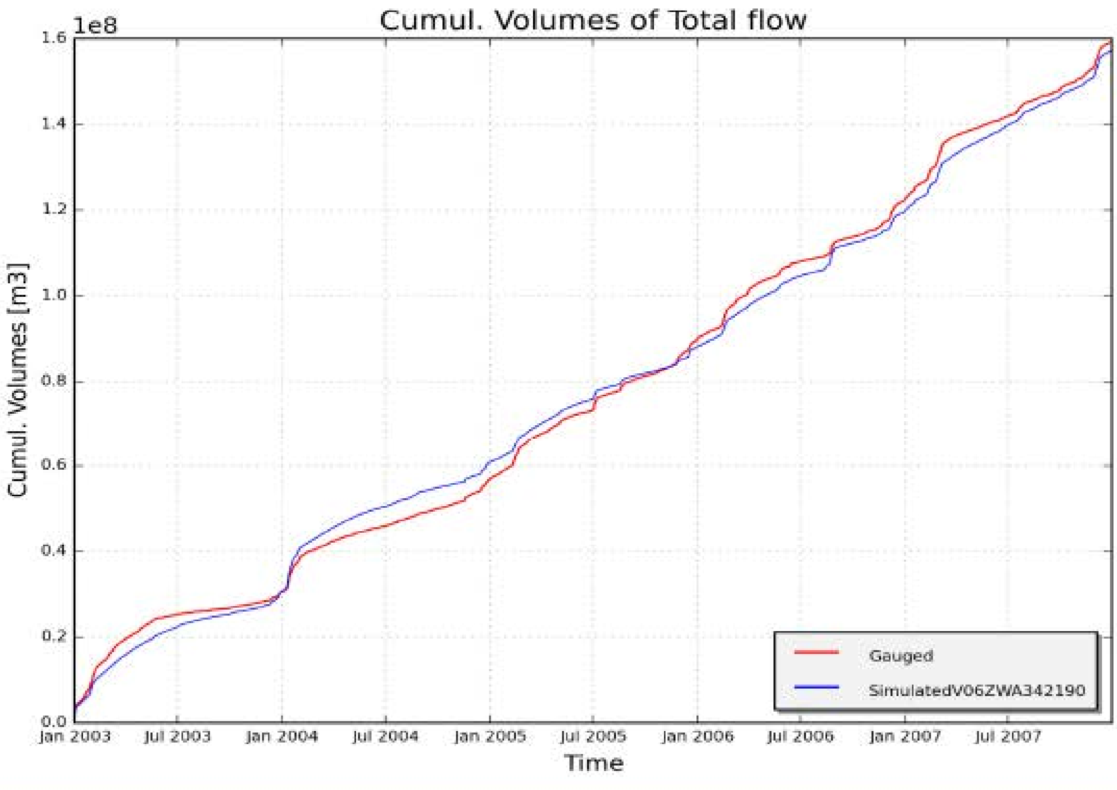

Figure 58 – Measured (red) and simulated (blue) cumulative discharge [m³/s] on catchment V06ZWA342190 (Validation period).

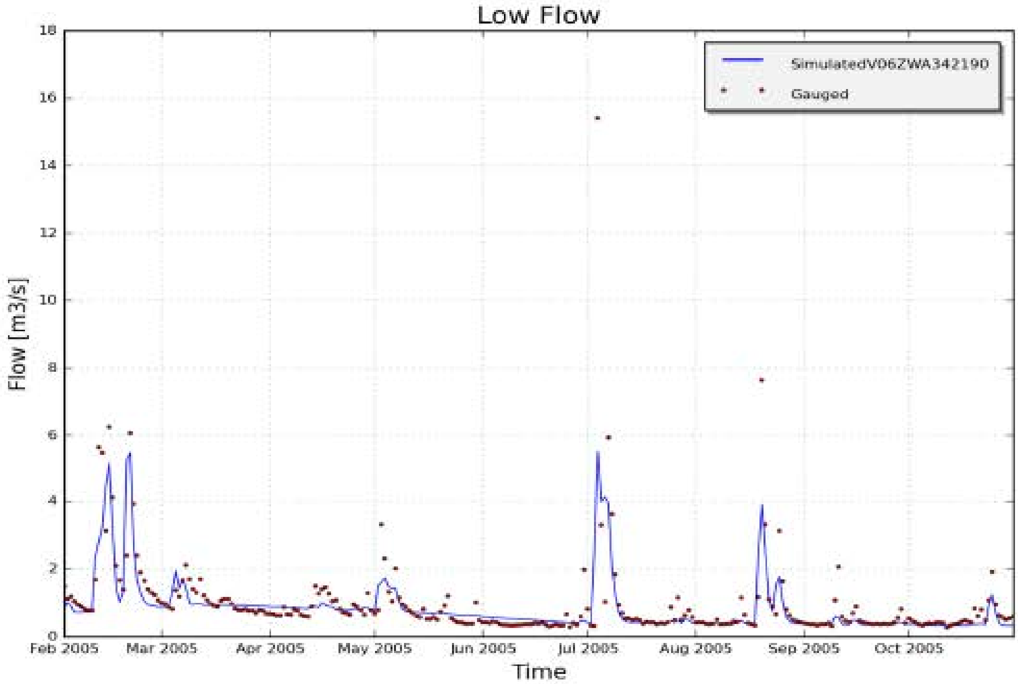

Figure 59 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low flow events on catchment V06ZWA342190.

Catchment F06BOS325999

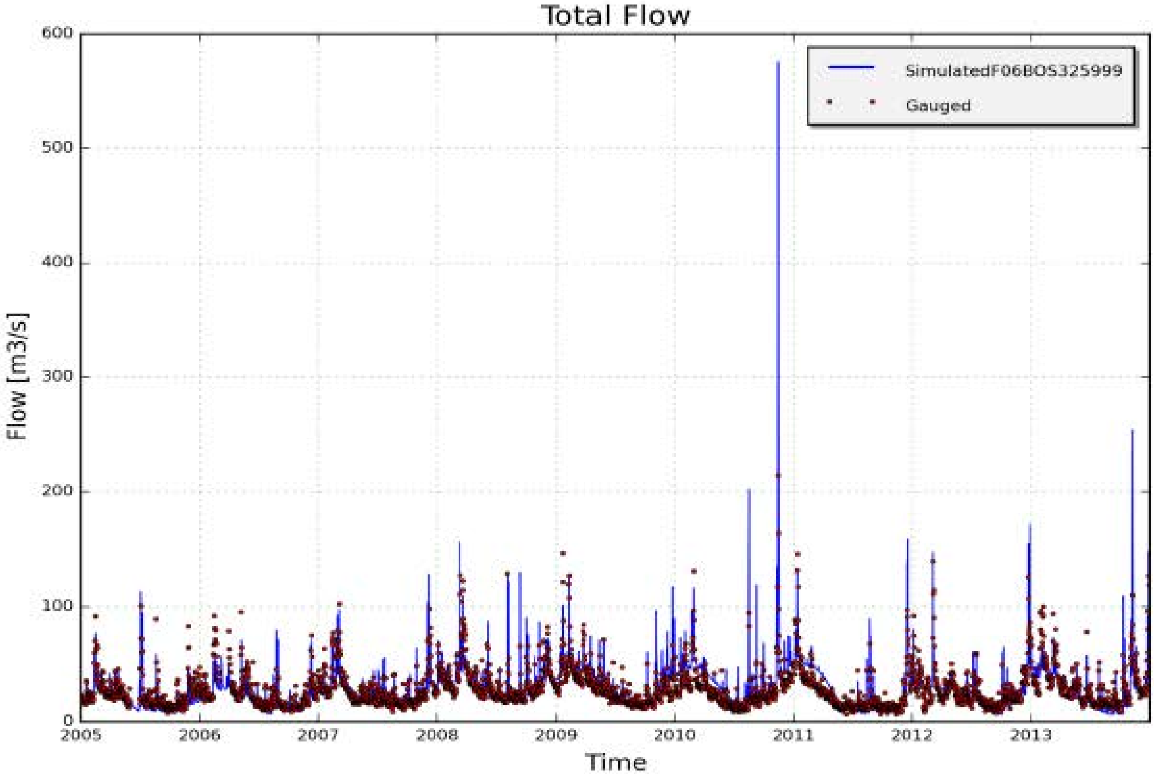

Figure 60 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment F06BOS325999 (Calibration period).

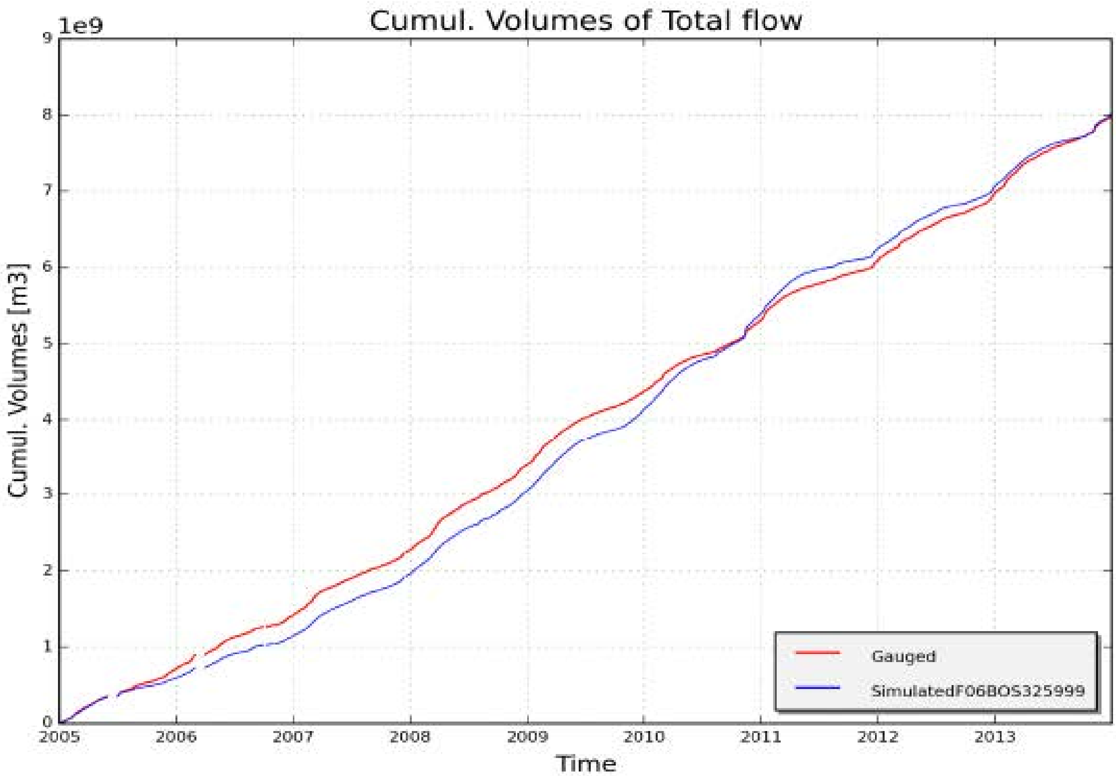

Figure 61 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment F06BOS325999 (calibration period).

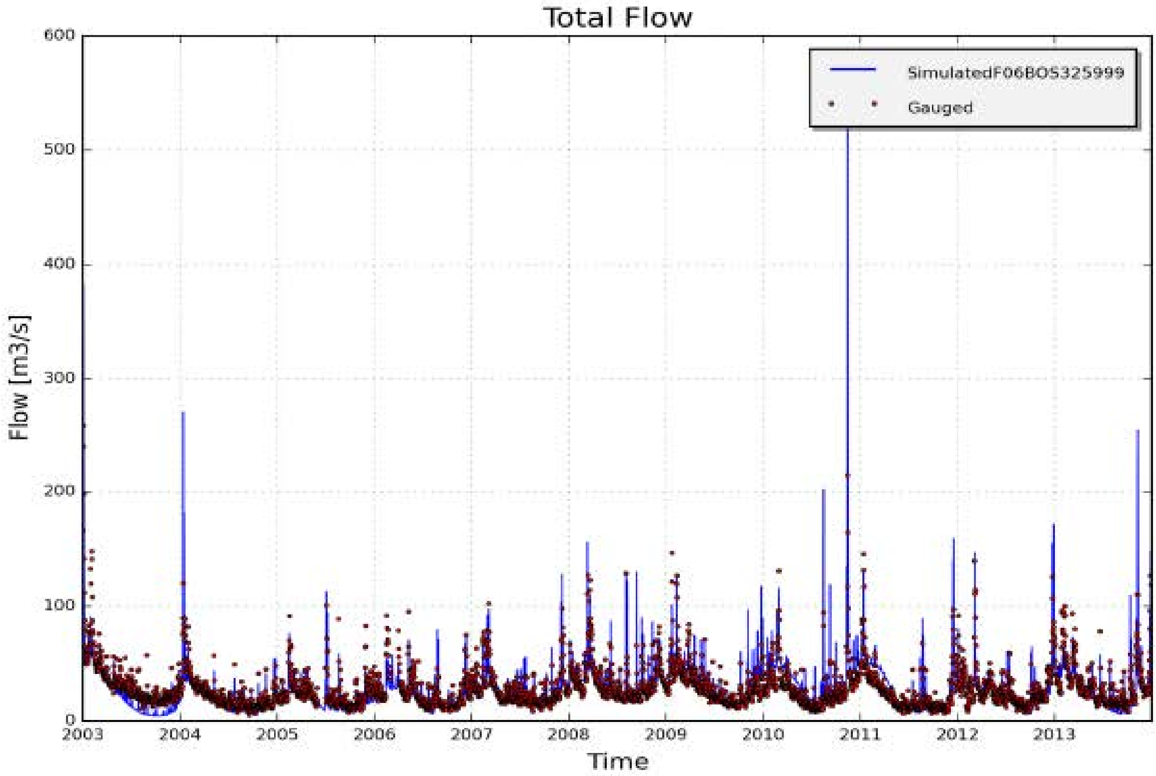

Figure 62 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment F06BOS325999 (Validation period).

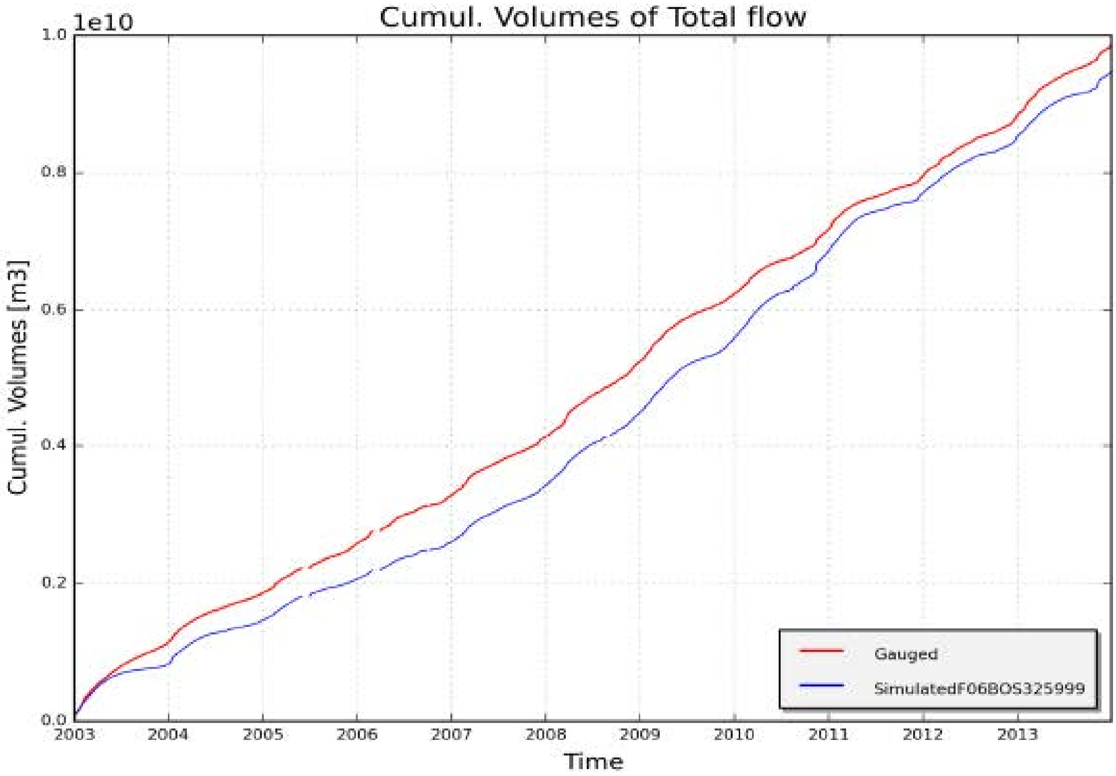

Figure 63 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment F06BOS325999 (validation period).

6.7 Denderbekken

6.7.1 Context

The Dender basin has an area of 1 384 km² and extends over Wallonia and Flanders. The upstream part (675 km²) is located in Wallonia and the lower part (709 km²) in Flanders. The Dender basin accounts for 6 % of the total catchment of the study area.

With 5 gauging stations used for model calibration, the portion of gauged catchments in this basin accounts for 61 % of total catchment area. The gauging station in Lessines is used to calibrate a hydrological model for the catchment upstream of this gauging station. In the water allocation model, this catchment is divided into 3 subcatchments.

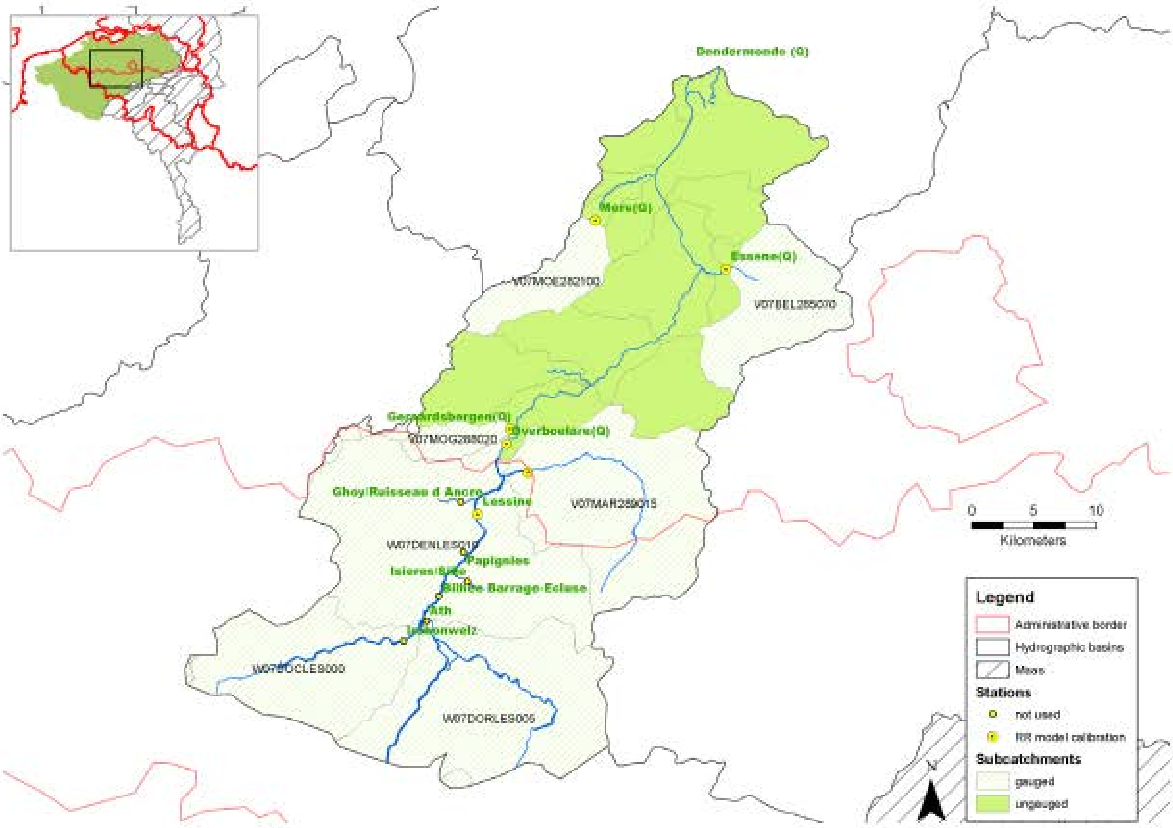

Figure 64 – Catchments and measurement points on the Dender basin.

6.7.2 Model performance

Table 25 and Table 26 present general performance statistics for the gauged catchments of the Dender basin for the calibration and validation period. Graphs of simulations for the catchments V07MOE282100 (the best model performance) and V07DENLES999 (the worst model performance) are presented below (Figure 65 to Figure 72). For more detailed results on the other catchments is reffered to Appendix 14 and Appendix 15.

The simulated flow rates for most of the catchments are in agreement with the observed flow rates, with values of LogNSE higher than 0.52 for both the calibration and validation period, except catchment V07DENLES999. As can be seen in Figure 65 and Figure 67, the model performed well for predicting stream flow in the catchment V07MOE282100. The LogNSE values above 0.69 and the RelErr values below -1.1% showed close agreement between the measured and simulated discharge during the calibration and validation period (Table 25 and Table 26). A similar results could be found for the catchments V07BEL285070, V07MAR289015, and V07MOG288020 (Appendix 14).

Data remark: the gauging station 28210102 - Molenbeek, Erpe Mere (V07MOE282100) does not have discharge data during the years 2010 and 2011, so that the calibration period is limited until 2009. In the catchment V07MOG288020, the years after 2009 have been deleted due to the existence of unreliable measured discharge data and therefore the calibration period is until 2009. The catchment W07DENLES999 does not have discharge data before the year 2008 and therefore the simulation period is selected from 2008 onwards.

Table 25 – Overview of calibration results for gauged catchments on the Dender basin

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr (%)	Calibration period
28510102 - Bellebeek, Essene	**V07BEL285070**	88.7	0.76	0.4	2000-2004
28970102 - Marke, Viane	**V07MAR289015**	173.9	0.57	-1.7	2009-2012
28210102 - Molenbeek, Erpe Mere	**V07MOE282100**	46.4	0.69	-1.1	2005-2009
28810102 - Molenbeek, Geraardsbergen	**V07MOG288020**	23.1	0.37	1.2	2005-2009
Lessines	**W07DENLES999**	511.8	0.52	-5.8	2011-2013

Table 26 – Overview of validation results for gauged catchments on the Dender basin

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr (%)	Validation period
28510102 - Bellebeek, Essene	**V07BEL285070**	88.7	0.71	-0.2	2005-2006
28970102 - Marke, Viane	**V07MAR289015**	173.9	-1.7	0.6	1996-2000
28210102 - Molenbeek, Erpe Mere	**V07MOE282100**	46.4	0.7	-0.5	1986-1998
28810102 - Molenbeek, Geraardsbergen	**V07MOG288020**	23.1	0.7	-7.9	1998-2002
Lessines	**W07DENLES999**	511.8	0.35	5.9	2008-2010

Catchment V07MOE282100

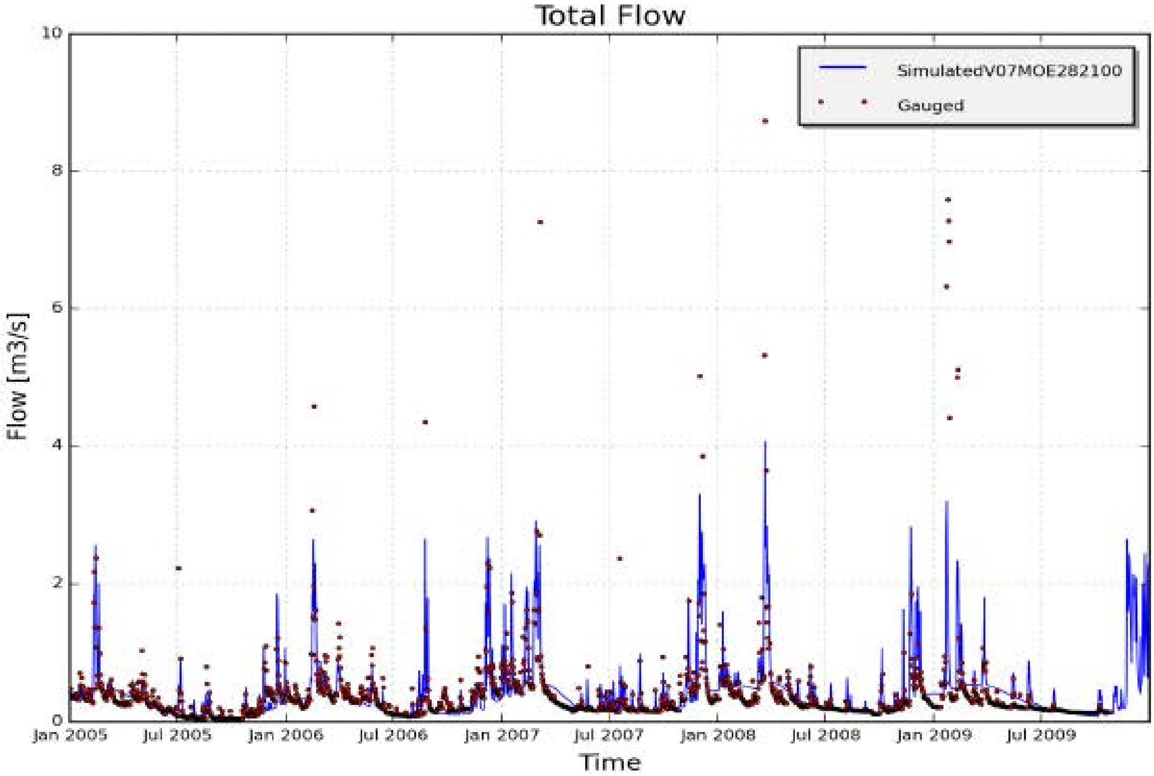

Figure 65 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07MOE282100 (calibration period).

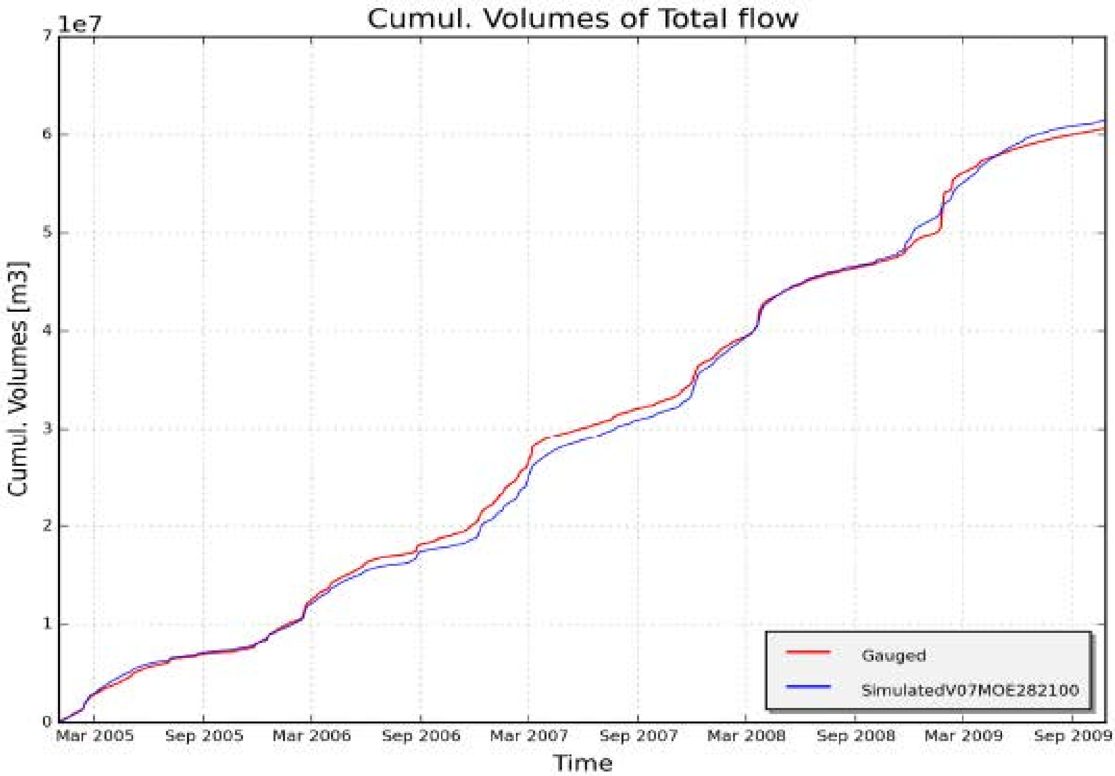

Figure 66 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07MOE282100 (calibration period)

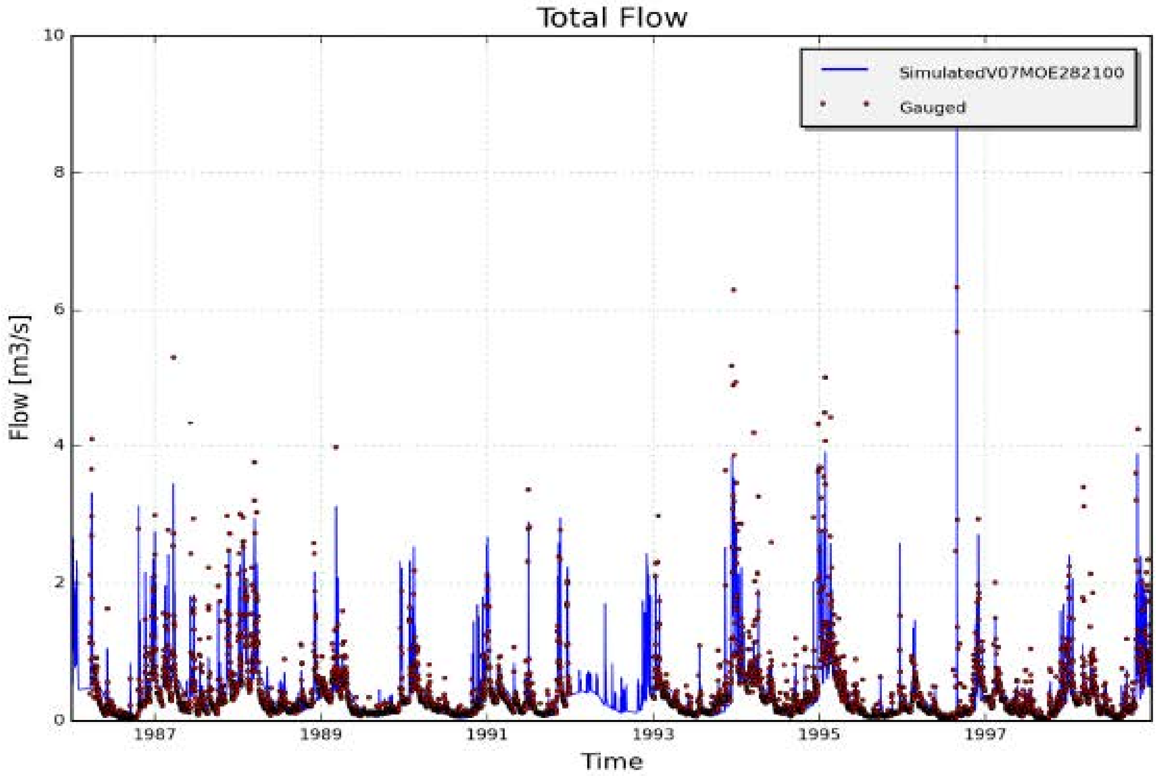

Figure 67 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07MOE282100 (Valibration period).

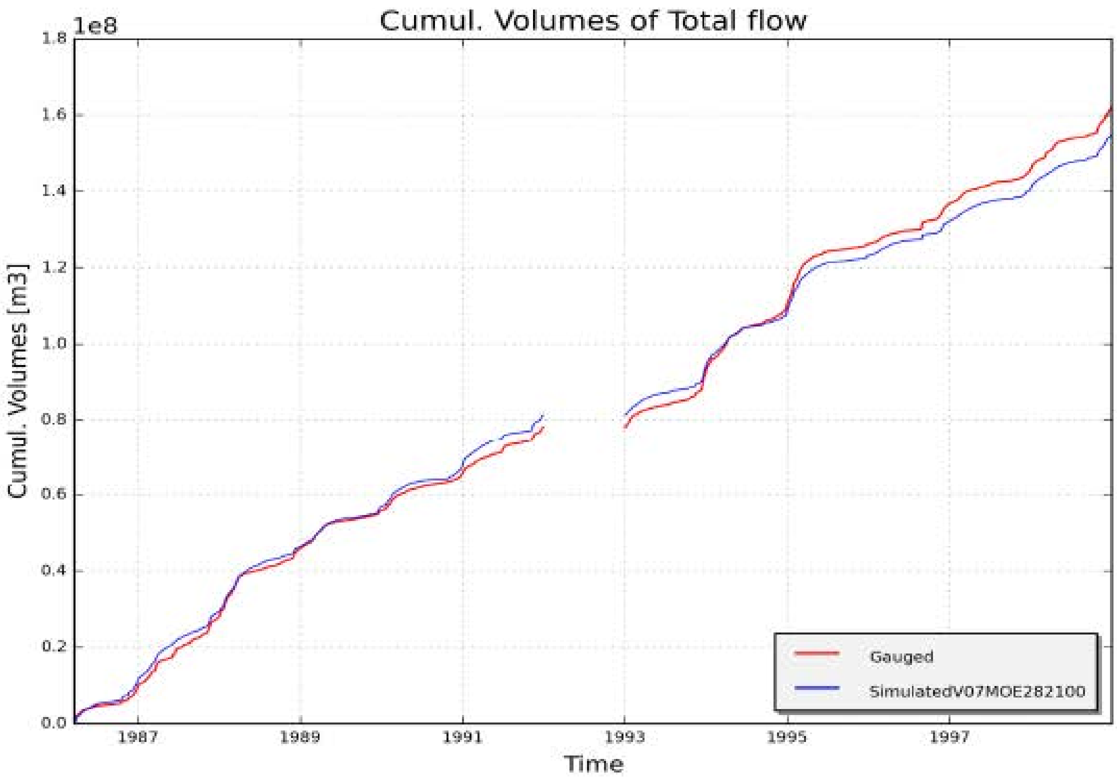

Figure 68 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07MOE282100 (calibration period)

Catchment V07DENLES999

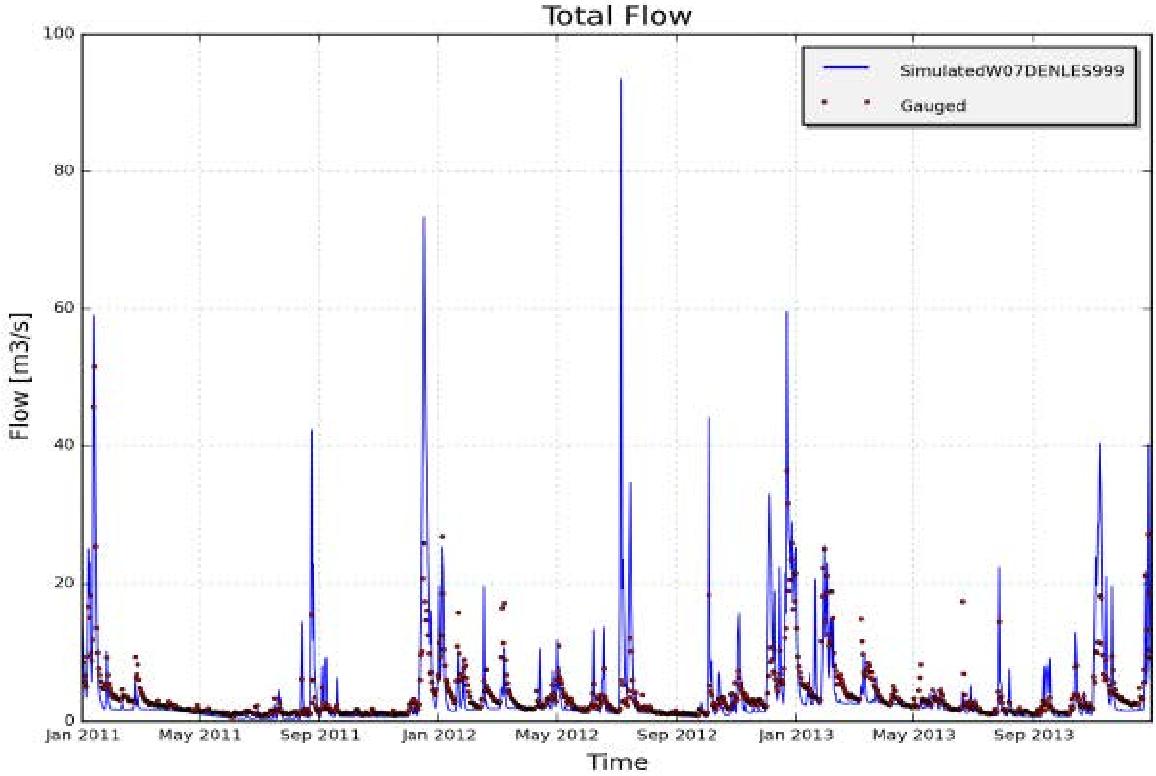

Figure 69 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07DENLES999 (Calibration period).

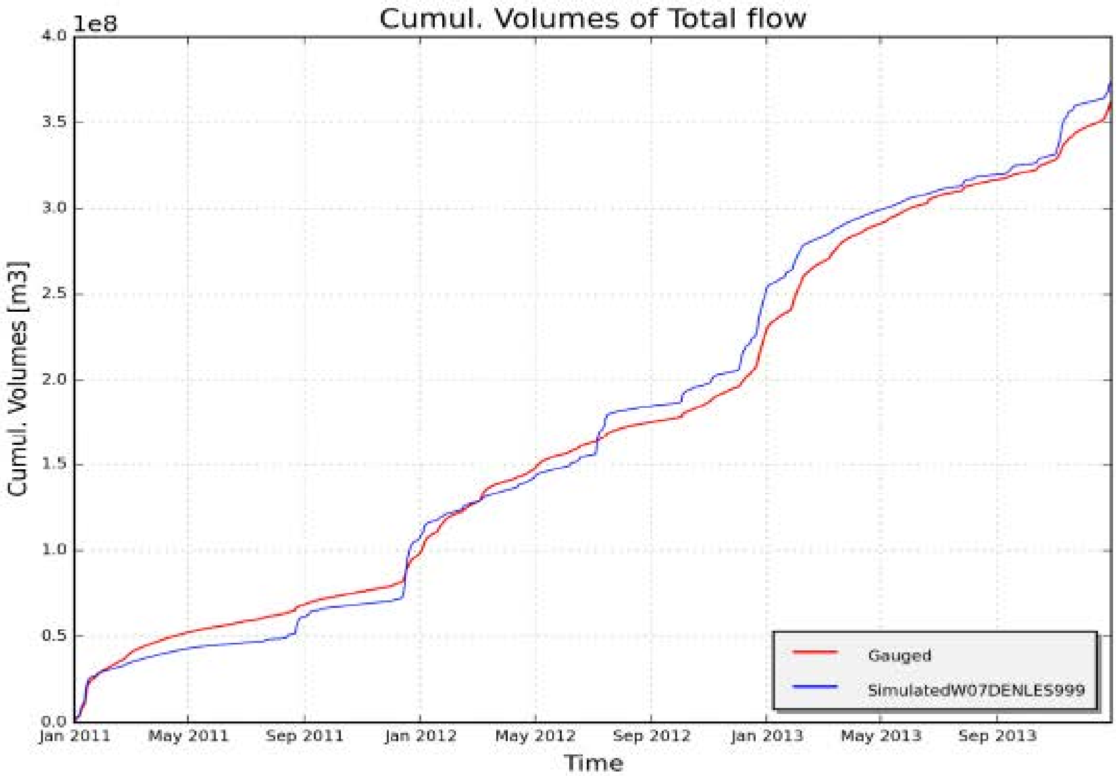

Figure 70 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07DENLES999 (Calibration period).

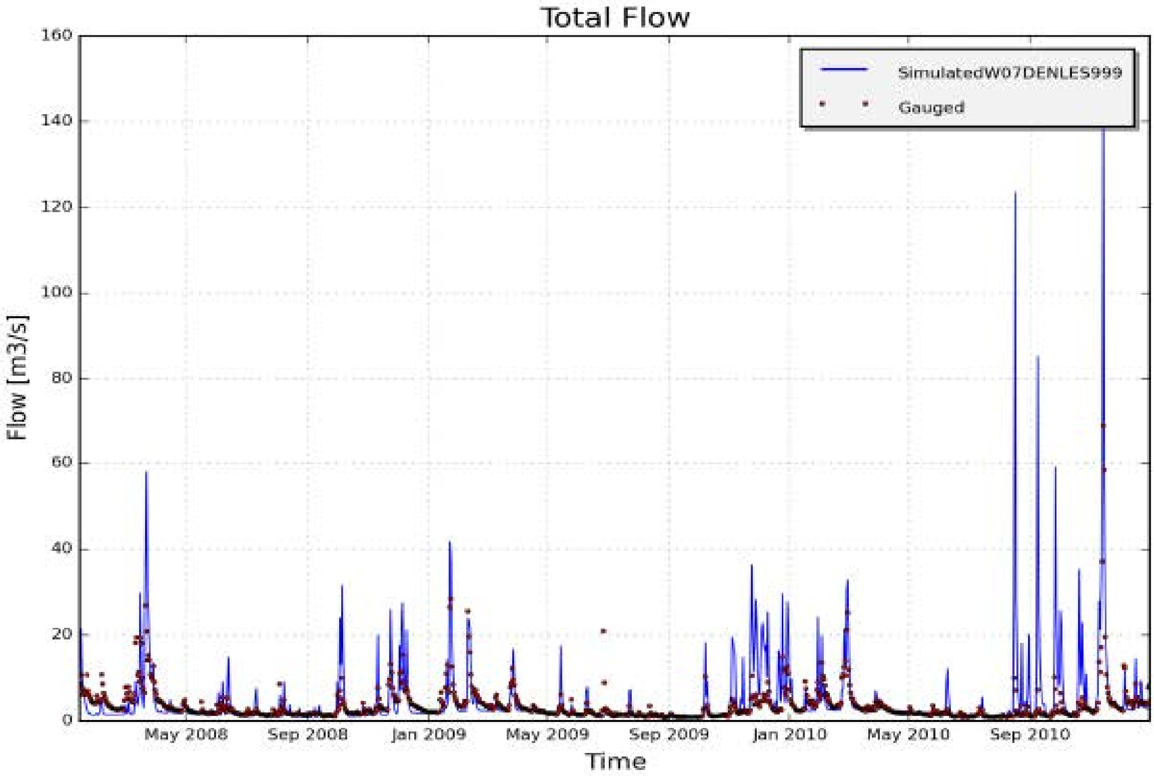

Figure 71 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07DENLES999 (Valibration period).

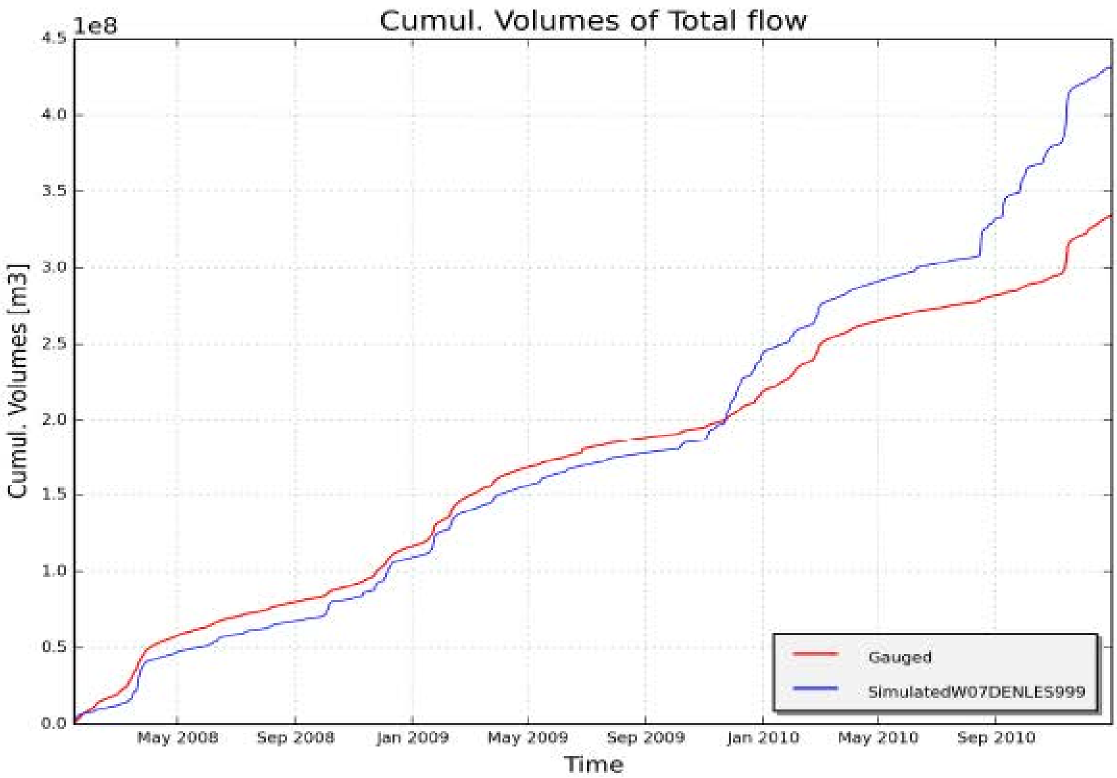

Figure 72 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07DENLES999 (Valibration period).

6.8 Dijle and Zenne

6.8.1 Context

The Dijle basin stretches over Flanders (55 %) and Wallonia (45 %) and has an area of about 1 290 km². The Zenne basin (ca. 1 160 km²) spreads across Wallonia (50 %), Brussels (14 %) and Flanders (36 %). In total, the Dijle and Zenne basin accounts for 11 % of the total area of the Scheldt basin.

Catchments and gauging stations are represented in Figure 73. Figure 73 – Catchments and measurement points on the Dijle and Zenne basins.Five stations are located on the Zenne on its tributaries before the confluence with the Dijle, measuring discharge for 43 % of the Zenne catchment. The discharge of the Dijle is measured by one station in Wilsele (67 % of the catchment surface area is gauged).

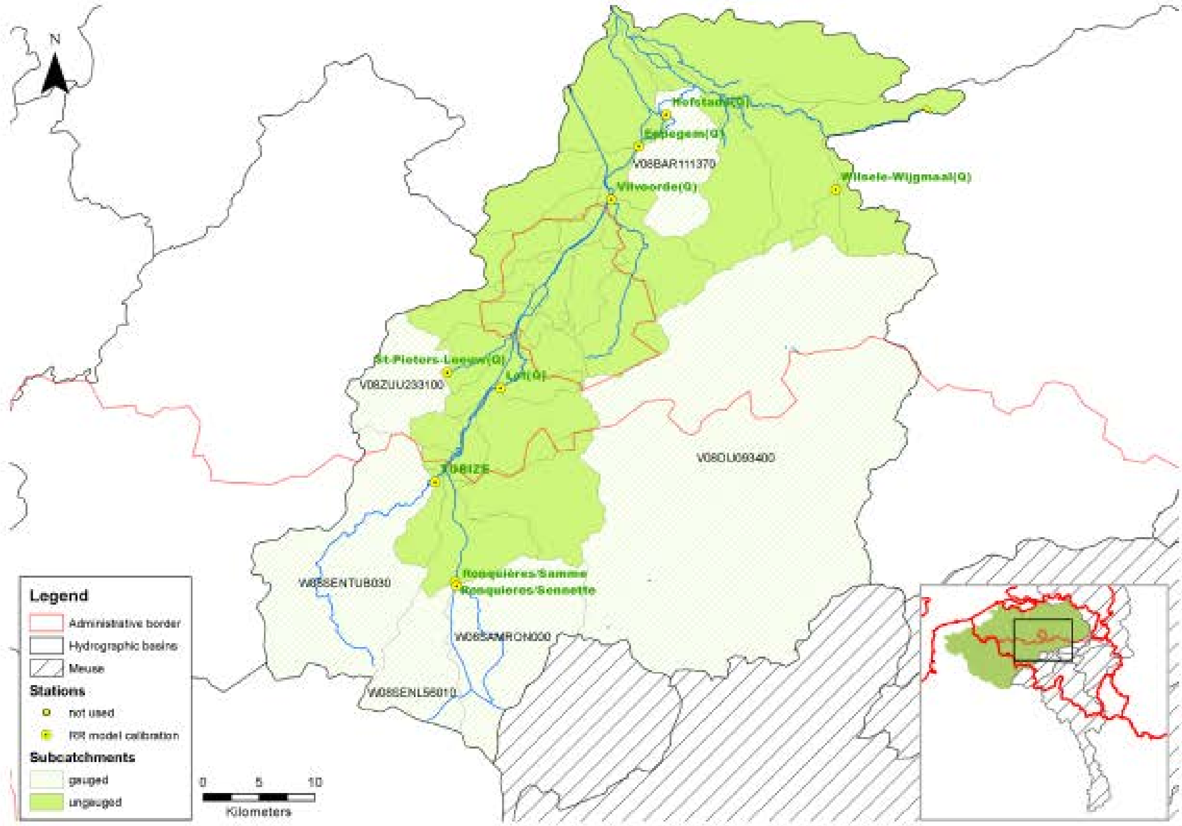

Figure 73 – Catchments and measurement points on the Dijle and Zenne basins.

6.8.2 Model performance

Table 27 and Table 28 present general performance statistics for the gauged catchments of the Dijle and the Zenne basins for the calibration and validation period. Graphs of simulations for the catchments W08SAMRON000 (the best model performance) and V08DIJ093400 (the worst model performance) are presented below (Figure 74 to Figure 81). For more detailed results on the other catchments is referred to Appendix 16 and Appendix 17.

The catchments W08SAMRON000, V08BAR111370, V08ZUU233100, W08SENL56010, and W08SENTUB030 have adequate model performance with LogNSE values above 0.58 (Exept for W08SENL56010 and W08SENTUB030, although these can be considered as adequate as low flows are correctly represented). Overall, the model accurately predicted flow magtitude for these catchments. This is given by the values of RelErr ranging from -0.5% to -5.5% and from -1.0% to 6.1% for the calibration and validation period, respectively (Table 27 and Table 28). The worst model performance was found in the catchment V08DIJ093400. Although the model was performed fairly well in simulating the discharge for the calibration period (1974-1989), overestimedation and underestimation of low flow were occurred in the validation period (Figure 80). Some explanations were considered in a previous report to explain the mismatch between the observed and simulated discharge data (De Boeck et al., 2011). Firstly, the poor results were attributed to the effect of vegetation in the gauging station, which may influence the measurements. Another explanations are the fact of a dam construction in 1994, which would make the relationship no longer valid and the influence of a large sewage plant whose effluent enters the limnigraaf the Dijle to Wilsele.

Data remark: The catchment V08BAR111370 only has measured discharge data from 02/01/1997 to 04/11/2004, so that this entire period from 1997-2003 was selected for the simulation. The catchment W08SAMRON000 does not have data after 2010, therefore the simulation period was chosen until 2010.

Table 27 – Overview of calibration results for gauged catchments on the Dijle and Zenne basins

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr (%)	Calibration period
11110102-Barebeek, Hofstade	V08BAR111370	70.0	0.73	2.5	1998-2003
9310102 - Dijle, Wilsele	V08DIJ093400	861.4	0.39	-1.1	1974-1989
23310102 - Zuunbeek, St Pietersleeuw	V08ZUU233100	64.8	0.59	-5.5	1996-2012
2371-10050 Samme, Ronquieres	W08SAMRON000	134.0	0.62	-0.5	2005-2010
L5670 -Senette, Ronquieres	W08SENL56010	70.4	0.45	1.2	1991-1997
1951-10050 Zenne, Tubize	W08SENTUB030	215.9	0.58	-1.5	2007-2011

Table 28 – Overview of validation results for gauged catchments on the Dijle and Zenne basins

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr (%)	Validation period
11110102-Barebeek, Hofstade	V08BAR111370	70.0	0.74	6.1	1997-2003
9310102 - Dijle, Wilsele	V08DIJ093400	861.4	0.2	-7.0	1998-2002
23310102 - Zuunbeek, St Pietersleeuw	V08ZUU233100	64.8	0.66	1.5	1986-1990
2371-10050 Samme, Ronquieres	W08SAMRON000	134.0	0.74	-1.6	1999-2003
L5670 -Senette, Ronquieres	W08SENL56010	70.4	0.57	-1.0	1979-1983
1951-10050 Zenne, Tubize	W08SENTUB030	215.9	0.46	-2.8	2001-2006

Catchment V08SAMRON000

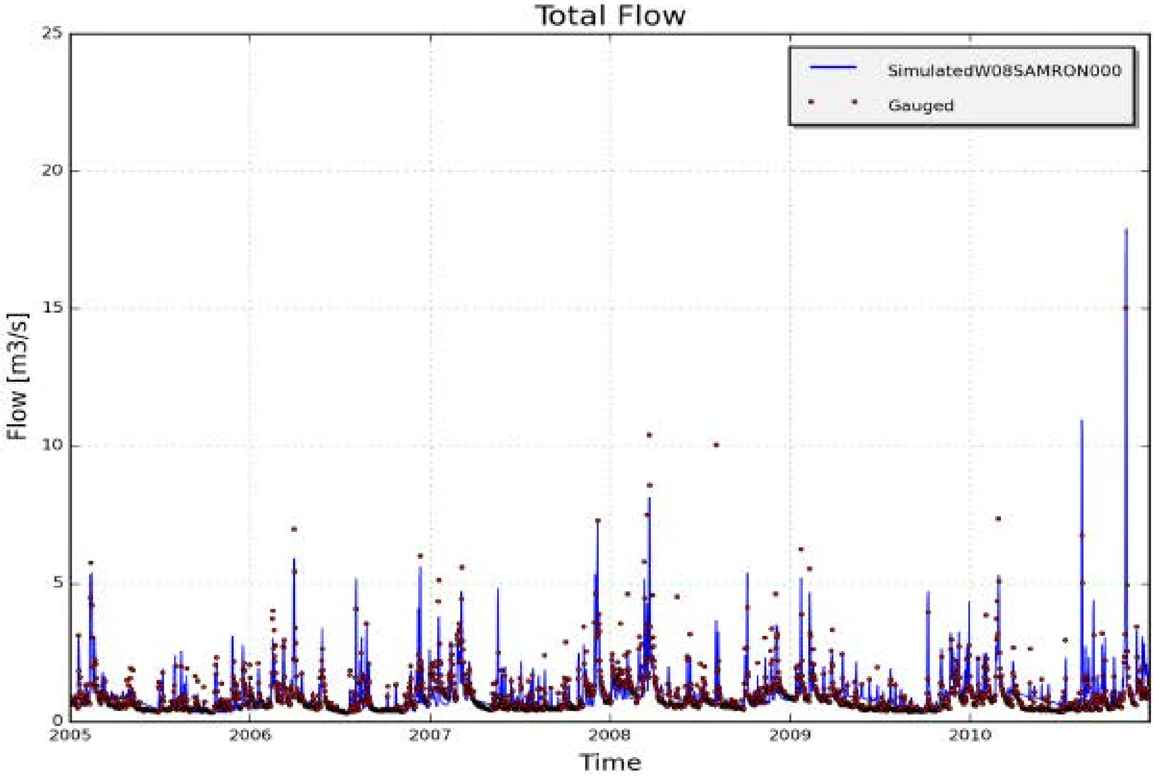

Figure 74 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08SAMRON000 (Calibration).

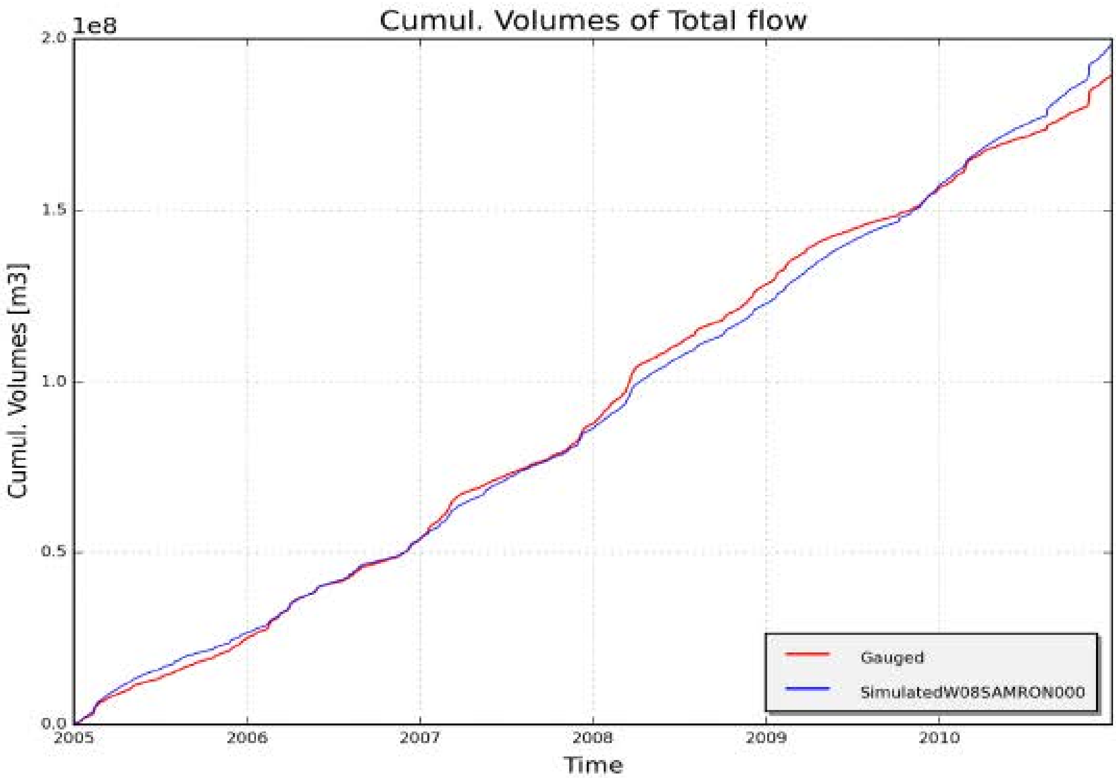

Figure 75 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V08SAMRON000 (Calibration).

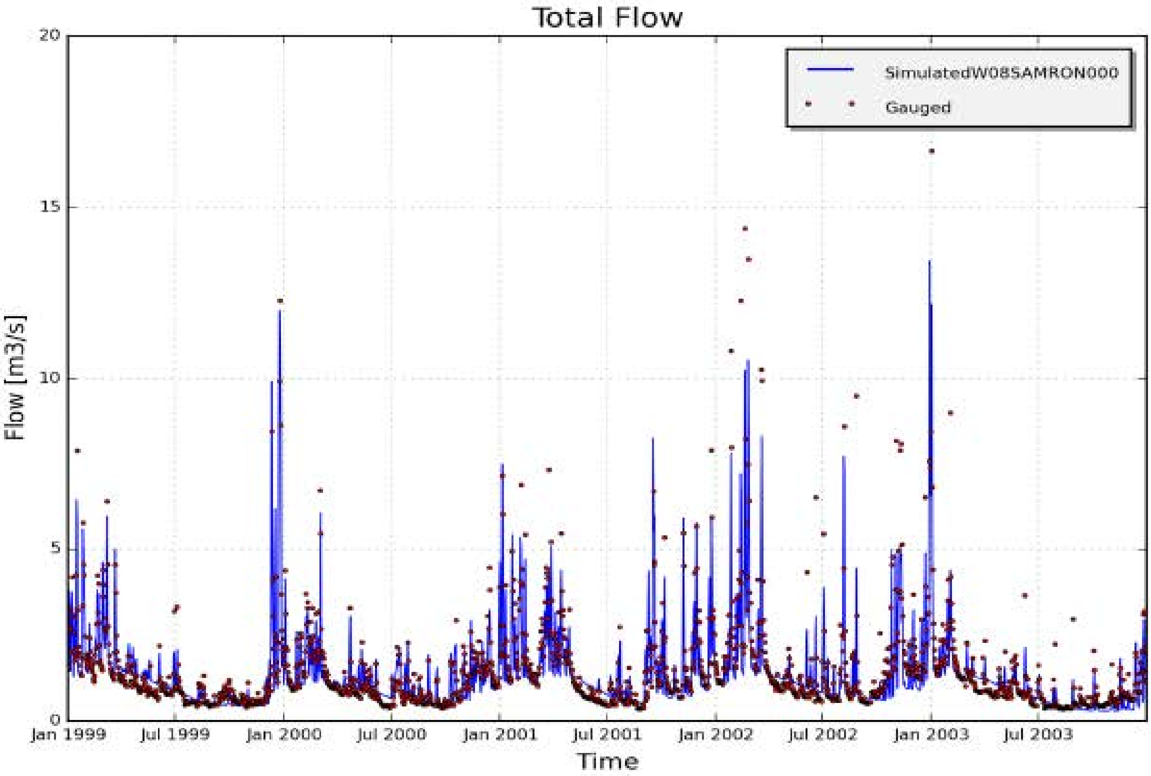

Figure 76 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08SAMRON000 (Validation).

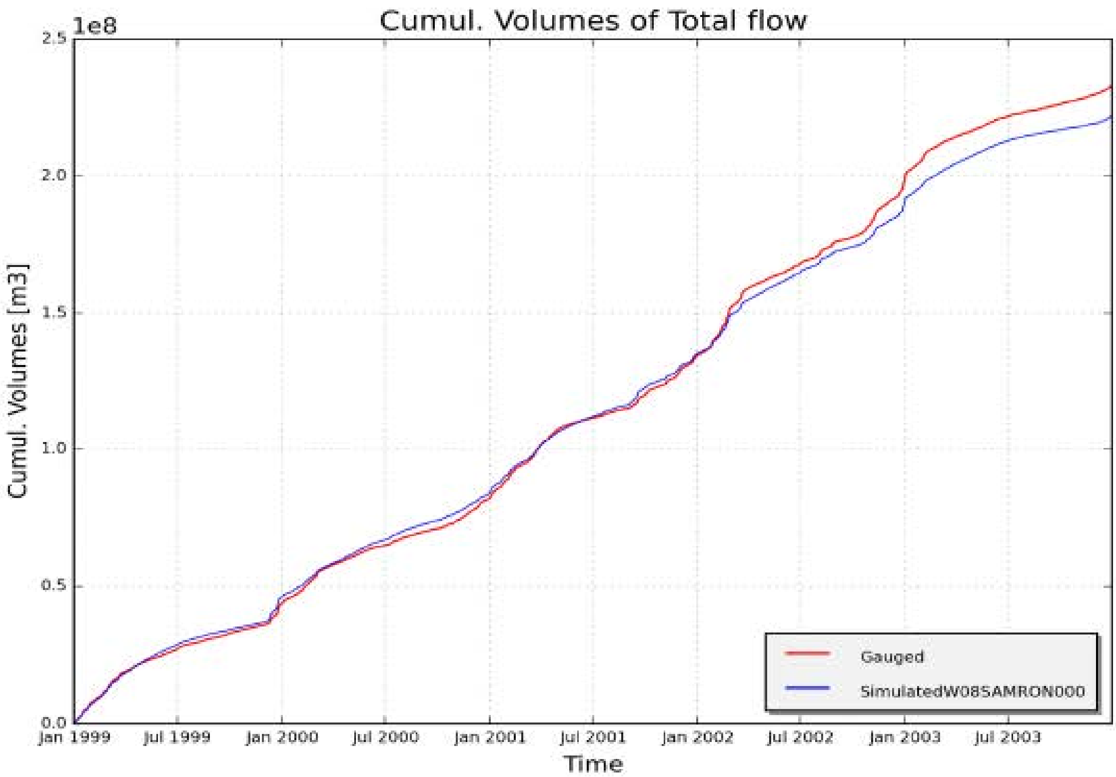

Figure 77 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V08SAMRON000 (Validation).

Catchment V08Dij093400

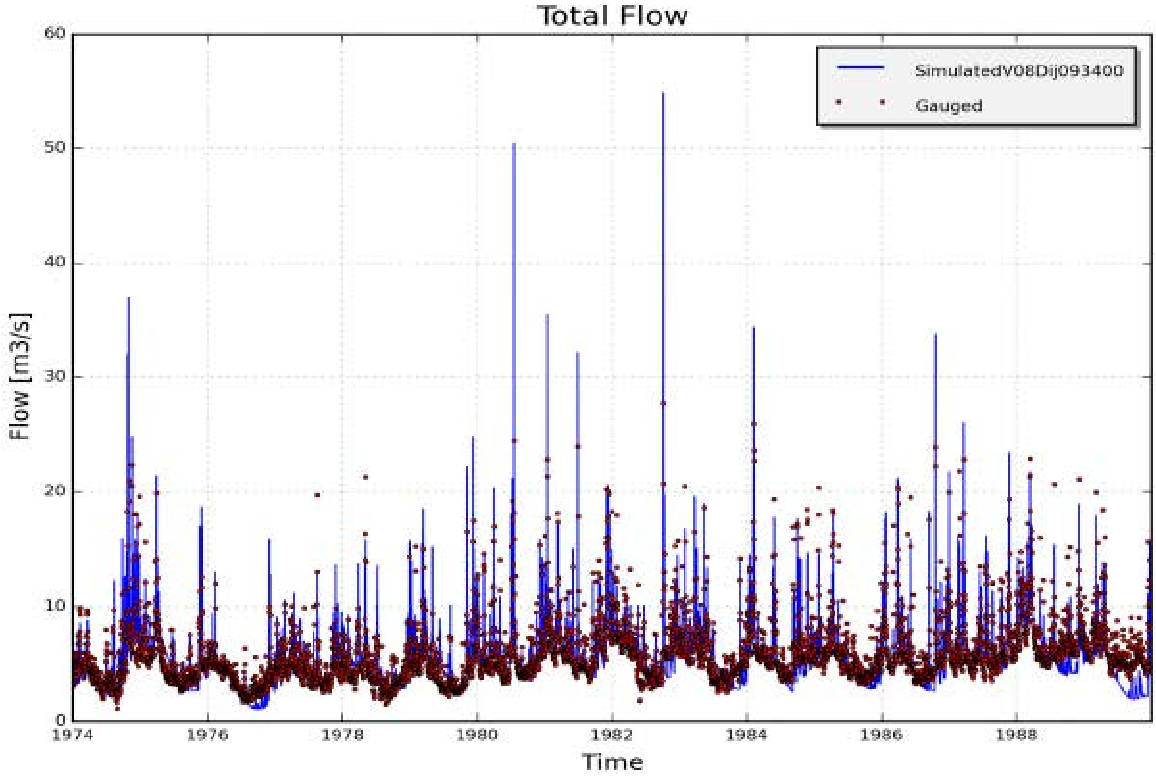

Figure 78 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08Dij093400 (Calibration).

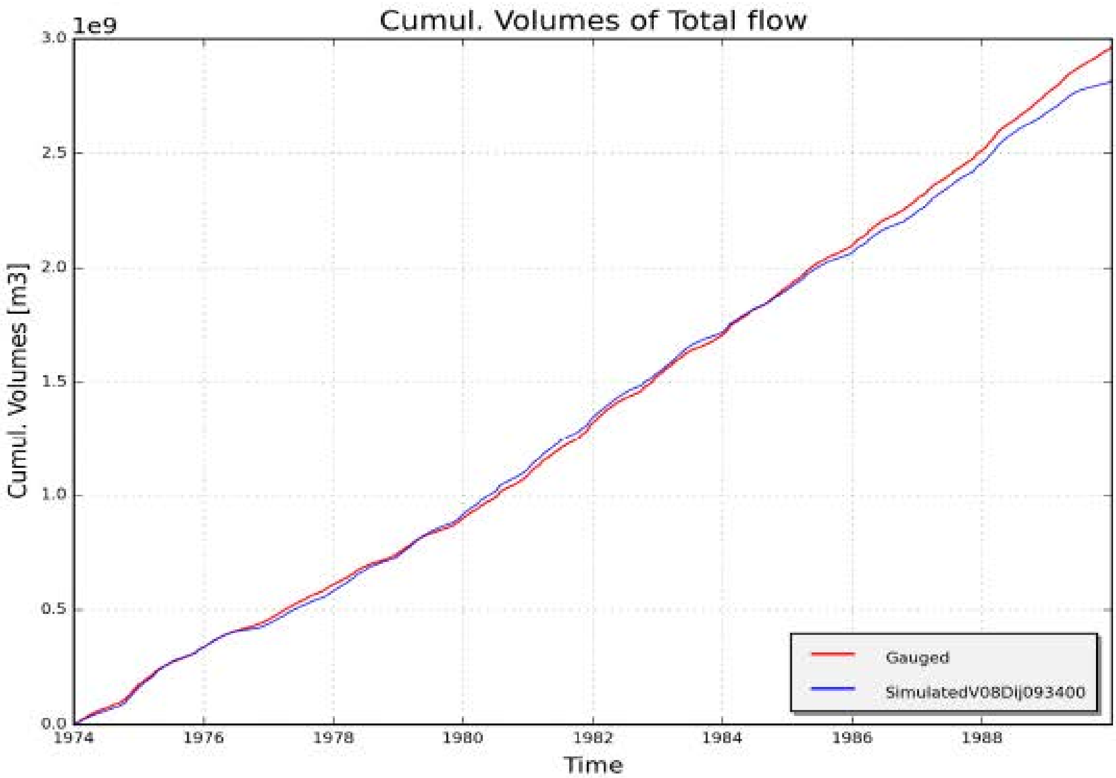

Figure 79 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V08Dij093400 (Calibration).

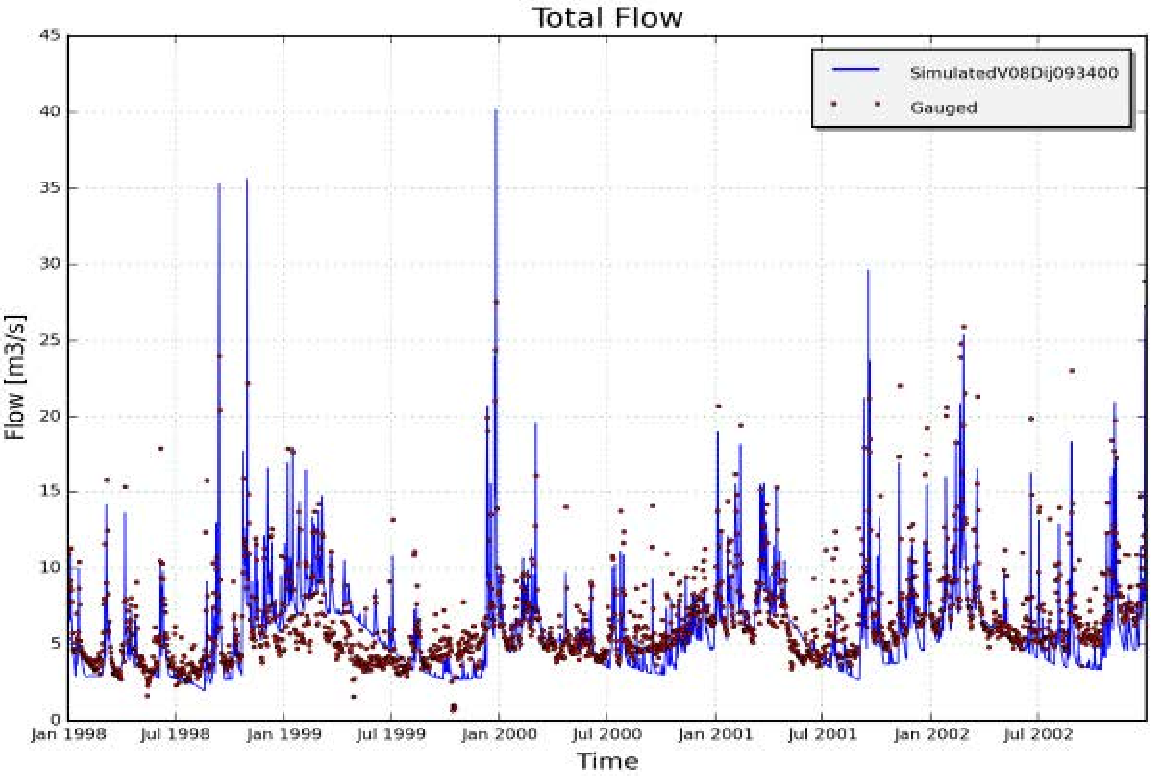

Figure 80 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08Dij093400 (Validation).

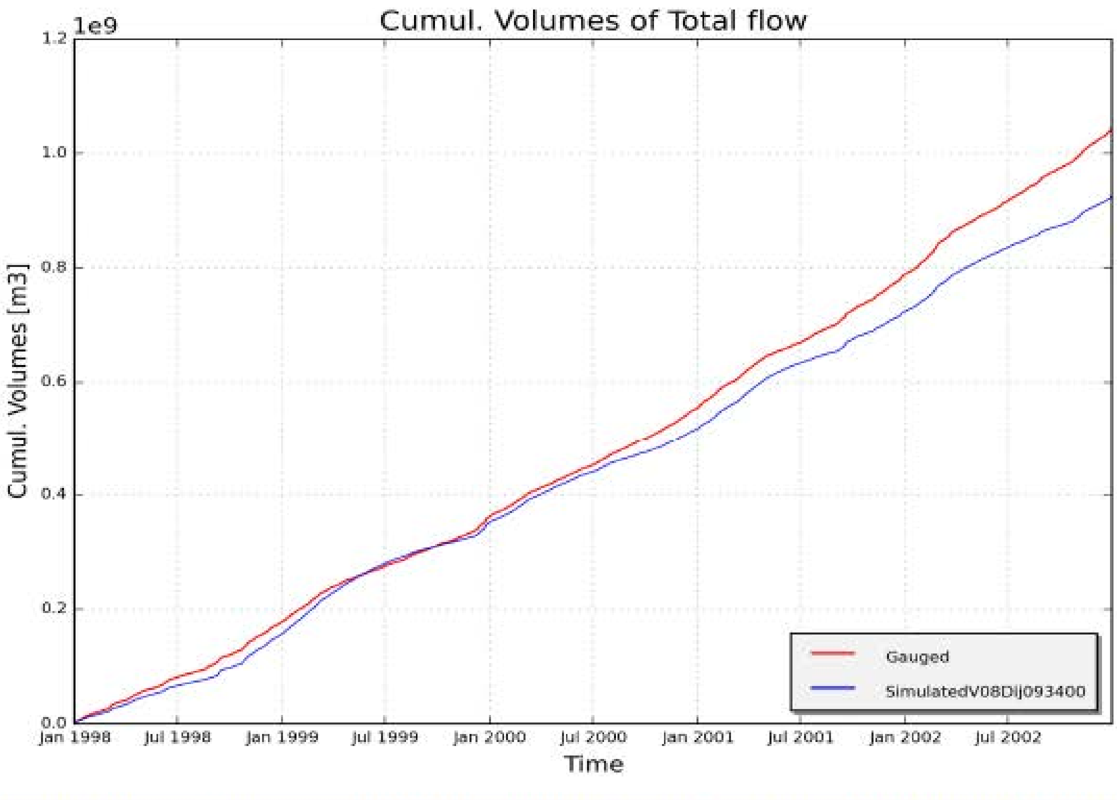

Figure 81 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V08Dij093400 (Validation).

6.9 Demerbekken

6.9.1 Context

The Demer basin has an area of 2 334 km². From that, 1 919 km² is located in Flanders, the rest being in Wallonia. It contributes for 10 % of the total surface area of the Scheldt basin. The navigable rivers in this catchment are the Demer and the Albert canal.

With 10 gauging stations, 80.3 % of the catchments in the Demer are gauged. These stations are depicted on Figure 82.

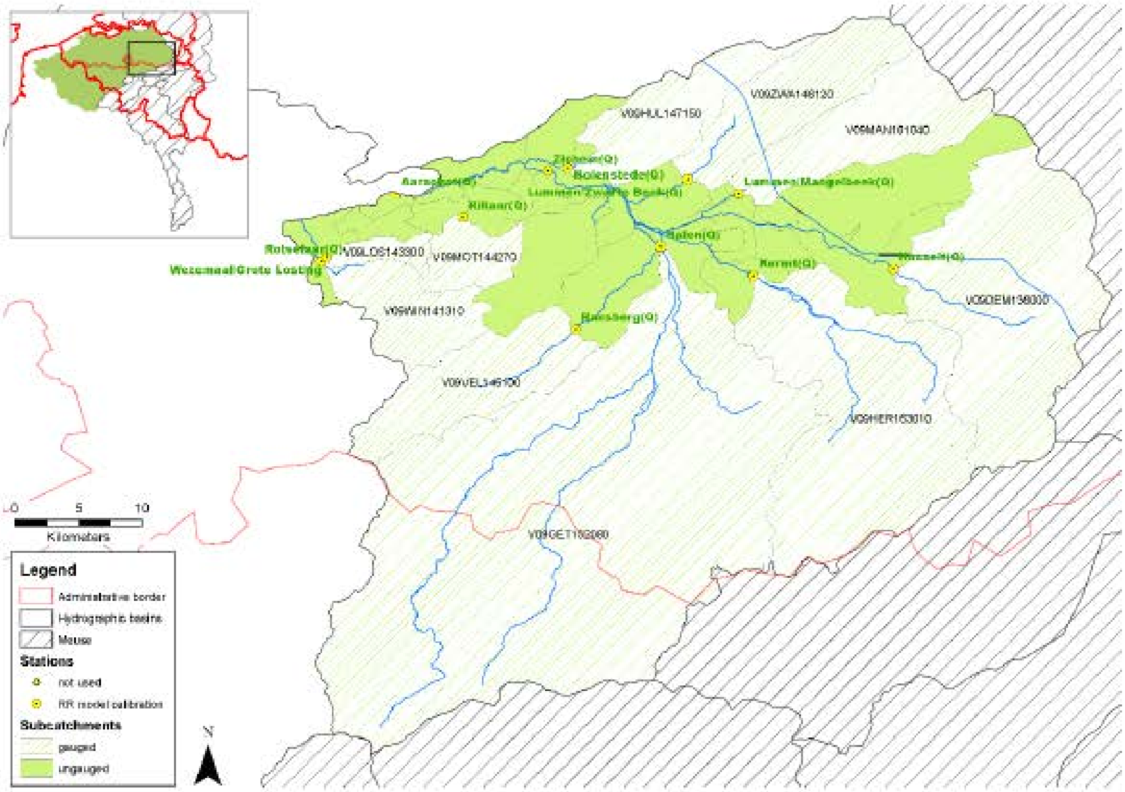

Figure 82 – Catchments and measurement points on the Demer basin.

6.9.2 Model performance

Table 29 and Table 30 present general performance statistics for the gauged catchments of the Demer basin for the calibration and validation period. Graphs of the catchments with code V09WIN141310 (best model performance) and V09MOT144270 (worst model performance) are presented below (Figure 83 to Figure 90). For more detailed results on the other catchments is referred to Appendix 18 and Appendix 19.

The catchments with code V09WIN141310 and V09HER163010 show a good model performance, with values of LogNSE superior to 0.6 for the calibration and validation period (Table 29 and Table 30). A similar behavior of the flow patterns can be found in the case of catchment V09VEL145100.The general behaviour of the model during the calibration period for the catchment V09MOT144270 can be considered as adequate (Figure 87). However, low flows are not correctly represented as in some periods they are overestimated (i.e.2004, 2005, 2010), while in others they are underestimated (i.e. 2006-2009). The simulated low flow results of the validation are poorer than the calibration and it can be suggested a problem with measured data (too low discharge in the winter period of 1994 and 1995). This resulted in an increase of the RelErr value (14.9%), (see Table 30).

Regarding the catchments with code VO9DEM136000, V09GET152080, V09HUL147150, V09MAN161040, V09ZWA148120, low flows were less accurately estimated for the entire simulation periods. This is given by the values of LogNSE ranging from 0.1 to 0.67 for both the calibration and validation period (Table 29 and Table 30). Neverthless, the hydrographs show relative fit between the simulated and easured total flow in general (Appendix 18).

Data remarks: Years 2011-2013 have been deleted from the simulation for the catchment V09DEM136000 due to an unreliability within the measured flow (too high). The catchment V09MAN161040 does not have data available from the beginning of 2011 and between 11/05/2003-31/12/2004, so that the respective periods 2005-2009 and 1997-2002 have been used for the calibartion and validation. In reference to the catchment V09ZWA148120, there is no data between beginning 2008 to 2010 and after 2010 the observed discharge data is not enough reliable. Therefore the period of 2002-2007 was selected for the calibration.

Table 29 – Overview of calibration results for gauged catchments on the Demer basin

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr (%)	Calibrationperiod
13610102 - Demer; Hasselt	V09DEM136000	255.8	0.45	7.8	2005-2010
15210102 - Gete; Halen	V09GET152080	800.4	0.28	-6.6	2000-2013
16310102 - Herk, Kermt	V09HER163010	274.6	0.7	-3.5	2008-2013
14710102 - De Hulpe; Molenstede	V09HUL147150 (inc.V09LOS143300)	95.3	0.47	1.1	2000-2010
16110102 - Mangelbeek; Lummen	V09MAN161040	103.1	0.34	-1.0	2005-2009
14410102 - Motte; Rillaar	V09MOT144270	33.6	0.43	6.0	2003-2013
14510102 - Velp; Ransberg	V09VEL145100	96.8	0.6	-3.5	2005-2009
141 - Rotselaar ; Winge	V09WIN141310	80.01	0.4	3.6	2008-2013
14810102 - Zwarte Beek; Lummen	V09ZWA148120	96.5	0.56	-0.5	2002-2007

Table 30 – Overview of validation results for gauged catchments on the Demer basin

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr (%)	Validation period
13610102 - Demer; Hasselt	V09DEM136000	255.8	0.1	1.1	1999-2003
15210102 - Gete; Halen	V09GET152080	800.4	0.32	-0.8	1969-1999
16310102 - Herk, Kermt	V09HER163010	274.6	0.73	-5.7	1996-2000
14710102 - De Hulpe; Molenstede	V09HUL147150 (inc.V09LOS143300)	95.3	0.3	-2.7	1991-1994
16110102 - Mangelbeek; Lummen	V09MAN161040	103.1	0.67	1.9	1997-2002
14410102 - Motte; Rillaar	V09MOT144270	33.6	0.17	14.9	1993-1997
14510102 - Velp; Ransberg	V09VEL145100	96.8	0.61	-0.01	1983-1987
141 - Rotselaar ; Winge	V09WIN141310	64.7	0.53	-5.3	1992-1996
14810102 - Zwarte Beek; Lummen	V09ZWA148120	96.5	0.49	-1.9	1987-1992

Catchment V09MAN161040

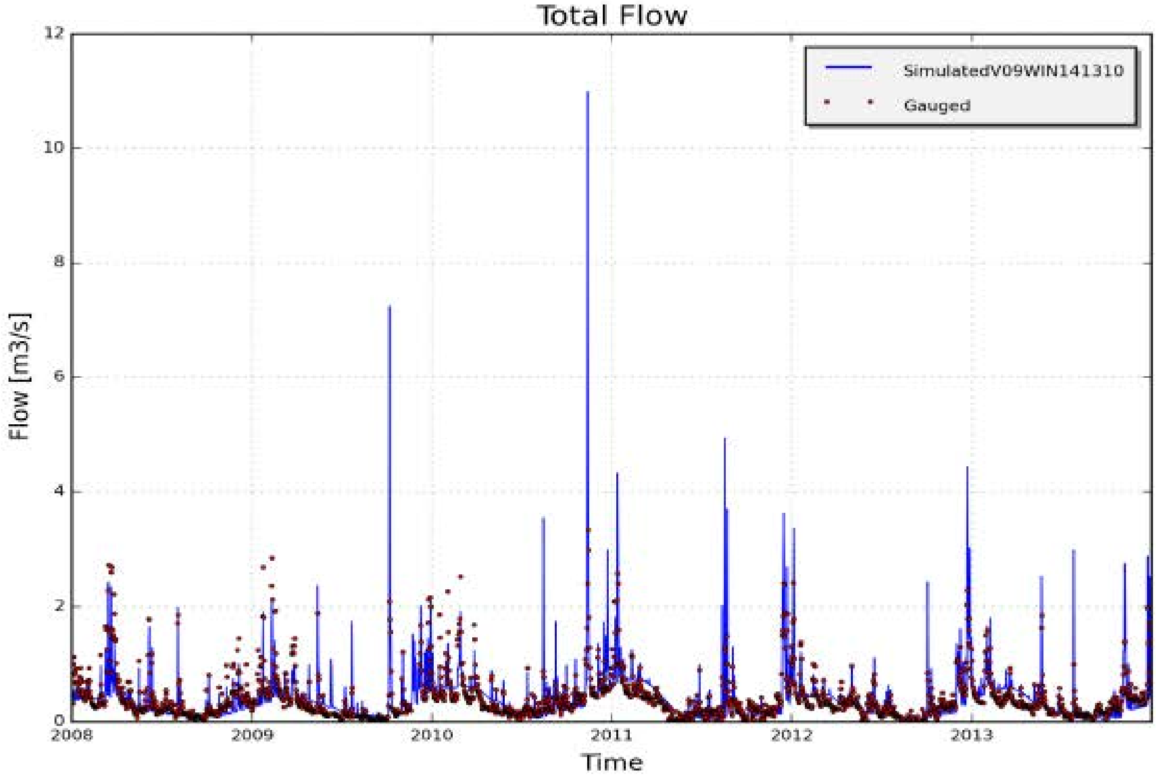

Figure 83 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09WIN141310 (Calibration).

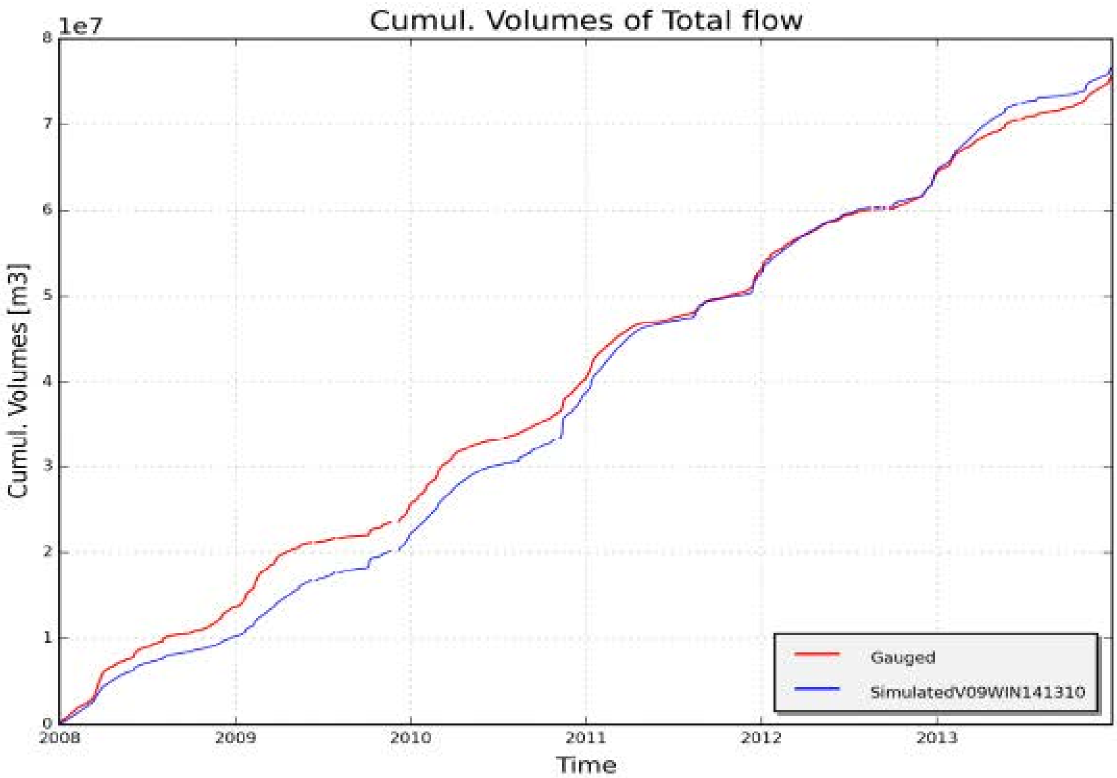

Figure 84 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09WIN141310 (Calibration).

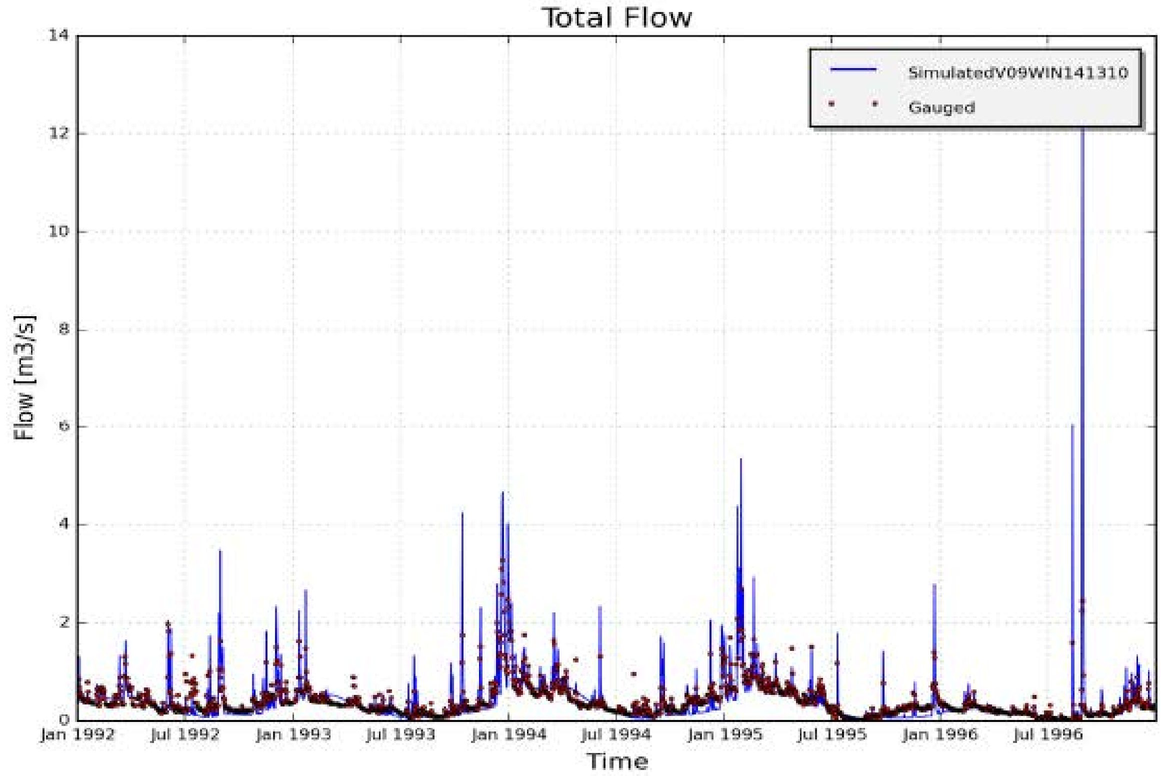

Figure 85 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09WIN141310 (Validation).

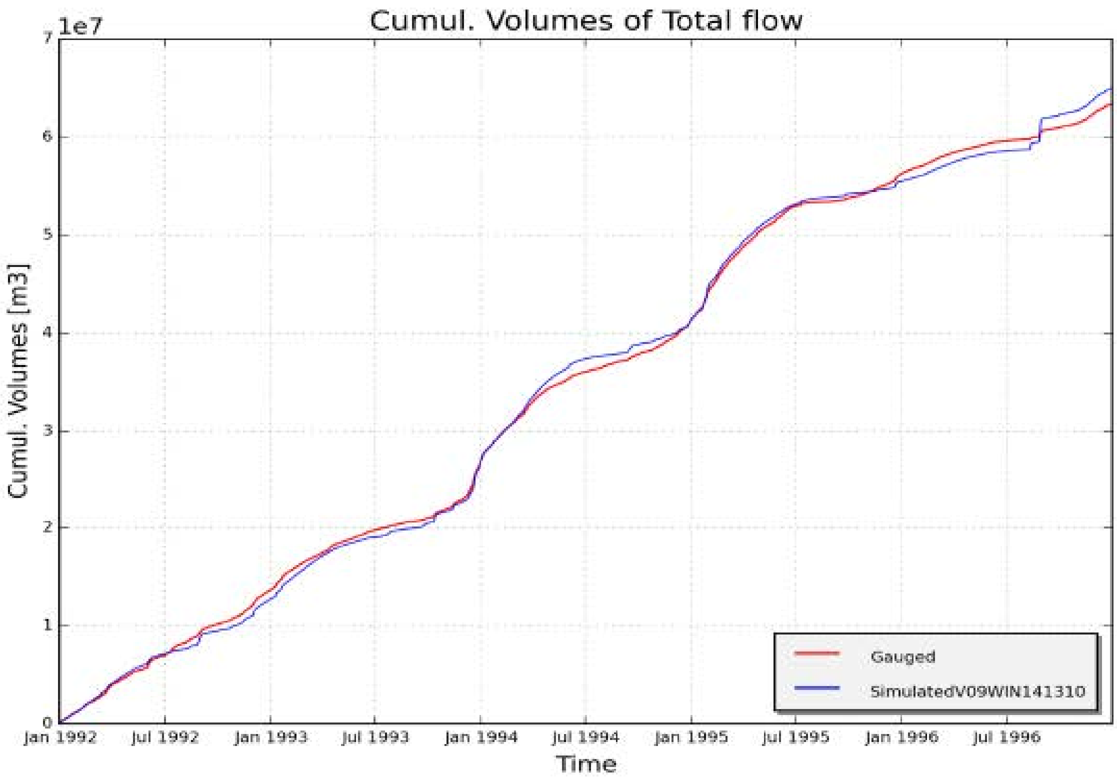

Figure 86 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09WIN141310 (Validation).

Catchment V09MOT144270

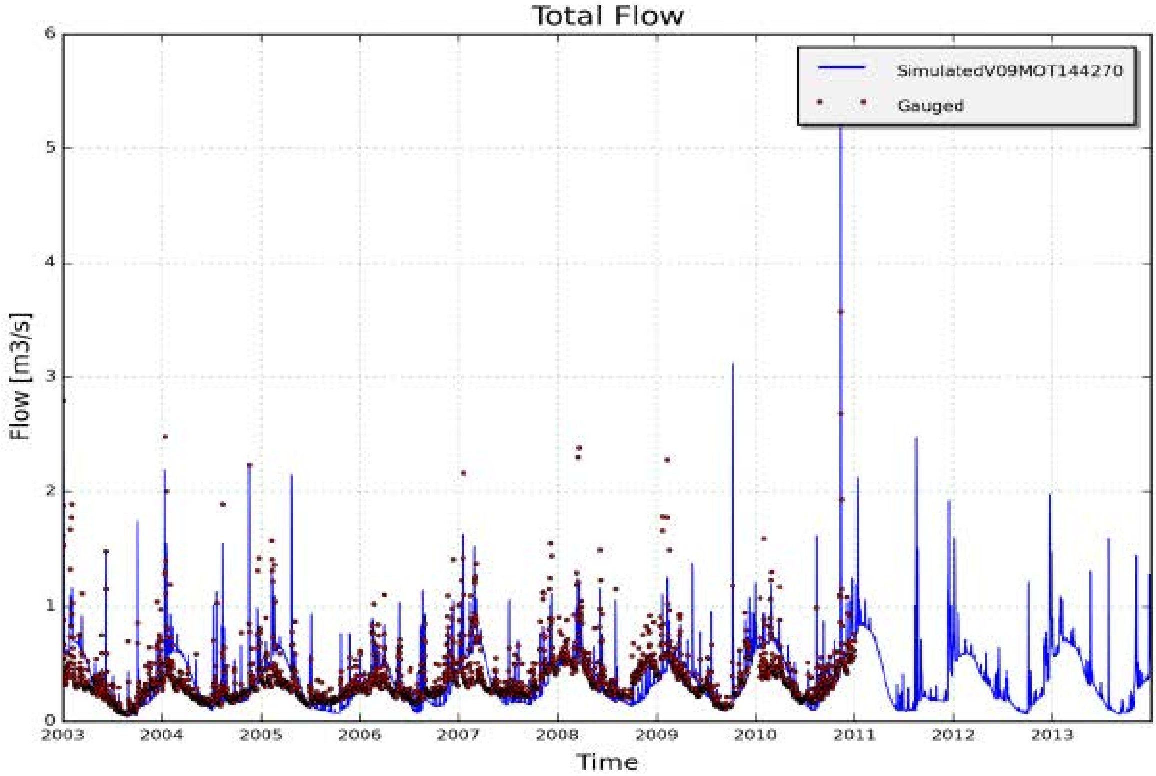

Figure 87 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09MOT144270 (Calibration).

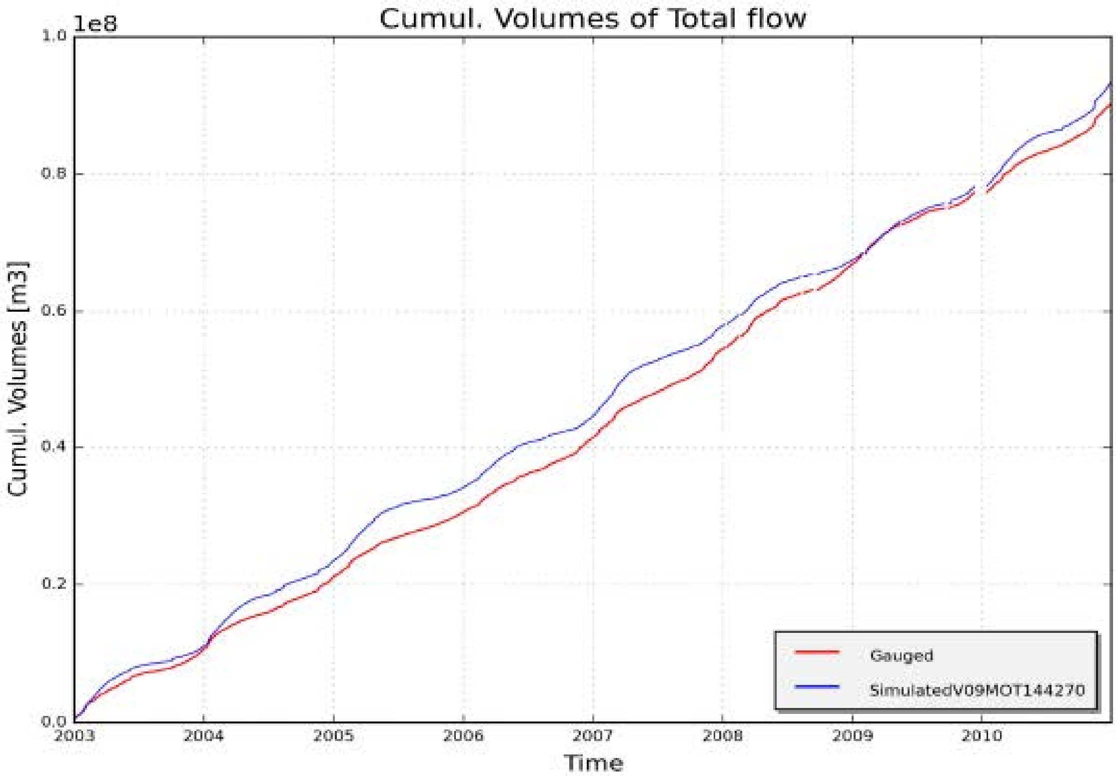

Figure 88 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09MOT144270 (Calibration).

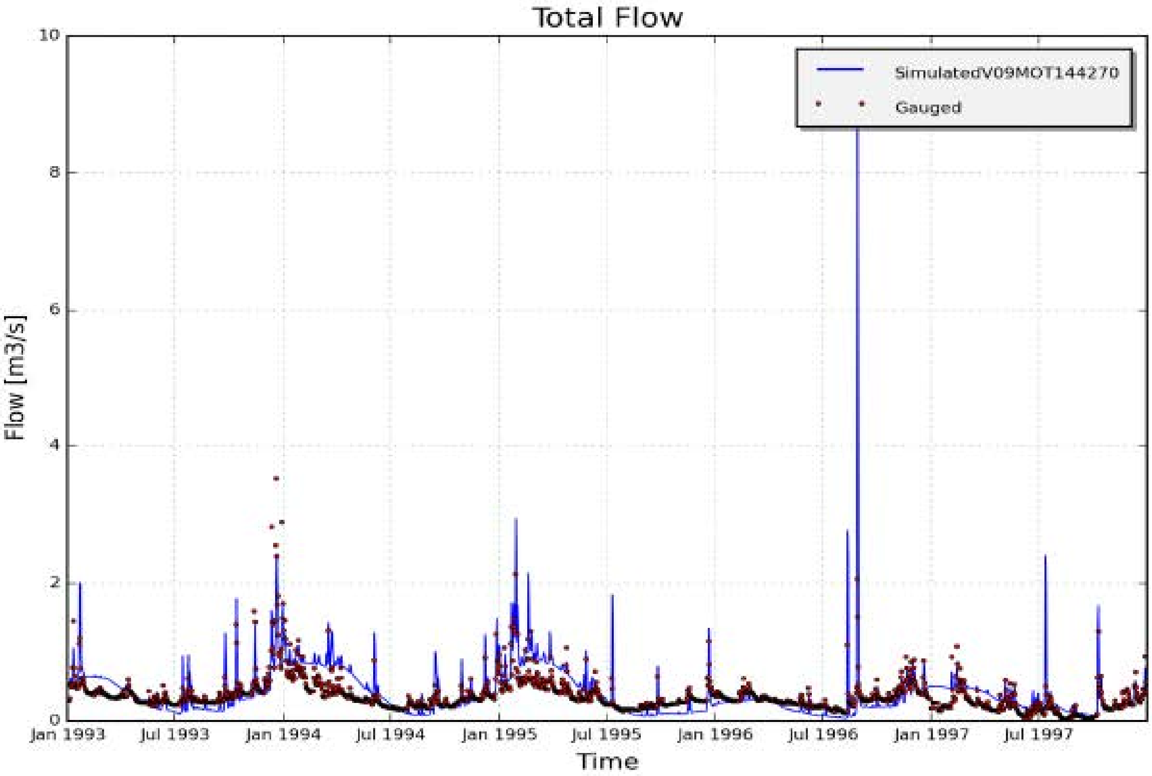

Figure 89 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09MOT144270 (Validation).

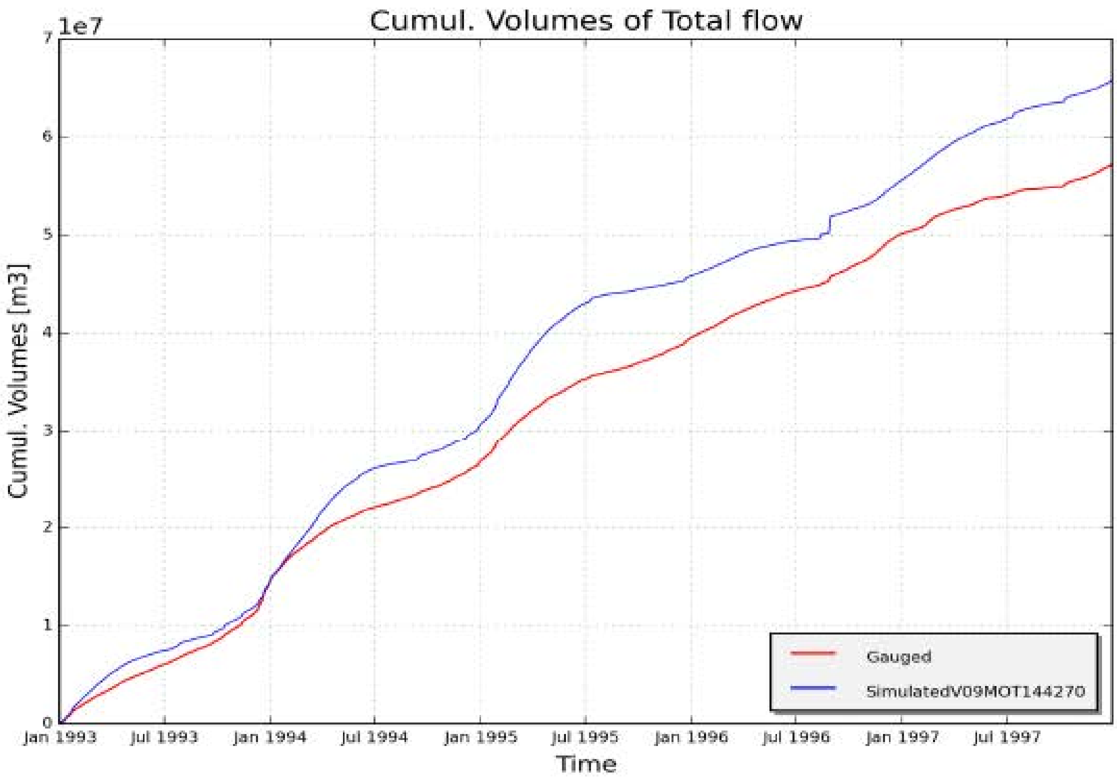

Figure 90 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09MOT144270 (Validation).

6.10 Netebekken

6.10.1 Context

The Nete catchment reaches over 1 673 km² and is located in North-East of Flanders. It can be divided into two catchments corresponding to the main rivers: Kleine Nete and Grote Nete. These two rivers flow together in Lier, where they coincide in the Beneden-Nete. This flows together with the Dijle to become the Rupel. The Nete basin accounts for 8 % of the total surface area of the Scheldt basin.

There are 5 gauging stations used for calibration of the rainfall-runoff models, covering 63 % of the Nete catchment surface area (Figure 91).

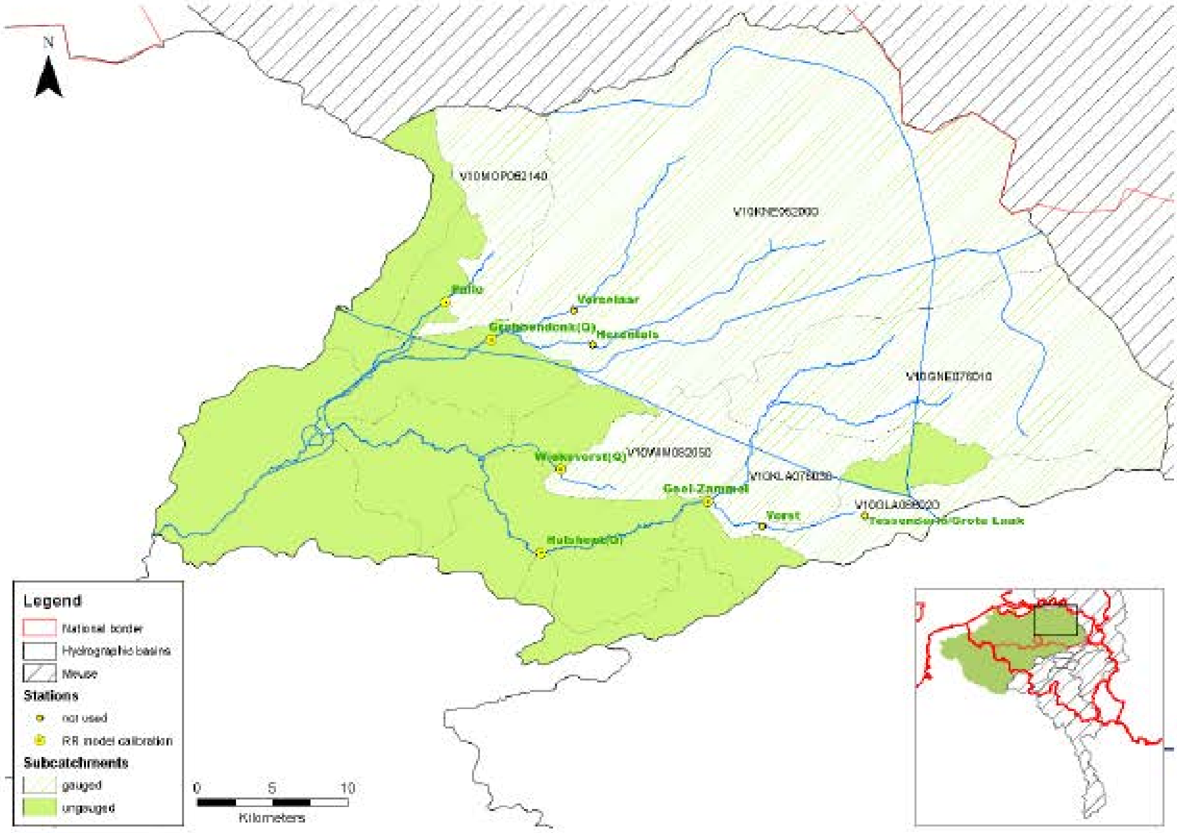

Figure 91 – Catchments and measure points for the Nete basin

6.10.2 Model performance

Table 31 and Table 32 present general performance statistics for the gauged catchments of the Nete basin. Graphs of simulations of the catchments with code V10KNE052000 (best model performance) and V10MOP062140 (worst model performance) are presented below (Figure 92 to Figure 99). For more detailed results on the other catchments is referred to Appendix 20 and Appendix 21.

The model performance is satisfactory for the catchment V10KNE052000, with Log NSE values above 0.70 and RelErr values lower than -5.7% for the whole simuation periods (Table 31 and Table 32). The worst model performance was found in the catchment V10MOP062140. As can be seen from Figure 98, overestimation of low flow was occured during the year 2008, resulting in a significant difference between the simulated and measured total flow in the valibration period. The statistical value of RelErr is -3.3% for the calibration period and then increases to 11.2% for the validation period (Table 31 and Table 32). A similar tendency of flow rates was taken place in the cases of the catchment V10GNE076999 and V10WIM082050 (Appendix 20).

Data remarks: According to the gauging station 8210102 – Wiekevorst (V10WIM082050), the calibration period only lasts until the year 2006 due to unavailability of discharge data.

Table 31 – Overview of calibration results for gauged catchments on the Nete basin

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr	Calibration period
7610102 Grote Nete/Geel Zammel	**V10GNE076999**	243.5	0.45	-0.6	2008-2013
5210102 - Kleine Nete; Grobbendonk	**V10KNE052000**	584.7	0.72	-0.3	2008-2013
6210102 - Molenbeek, Pulle	**V10MOP062140**	77.3	0.45	-3.3	2005-2013
8210102 - Wiekevorst	**V10WIM082050**	65.7	0.46	1.5	1998-2006

Table 32 – Overview of validation results for gauged catchments on the Nete basin

Gauging station	Catchment code	Surf. Area (km²)	logNSE	RelErr	Validation period
7610102 Grote Nete/Geel Zammel	V10GNE076999	243.5	0.54	-8.0	1997-2002
5210102 - Kleine Nete; Grobbendonk	V10KNE052000	584.7	0.72	-5.7	2003-2007
6210102 - Molenbeek, Pulle	V10MOP062140	77.3	0.58	11.2	1998-2002
8210102 - Wiekevorst	V10WIM082050	65.7	0.34	6.3	1995-1999

Catchment V10WIM082050

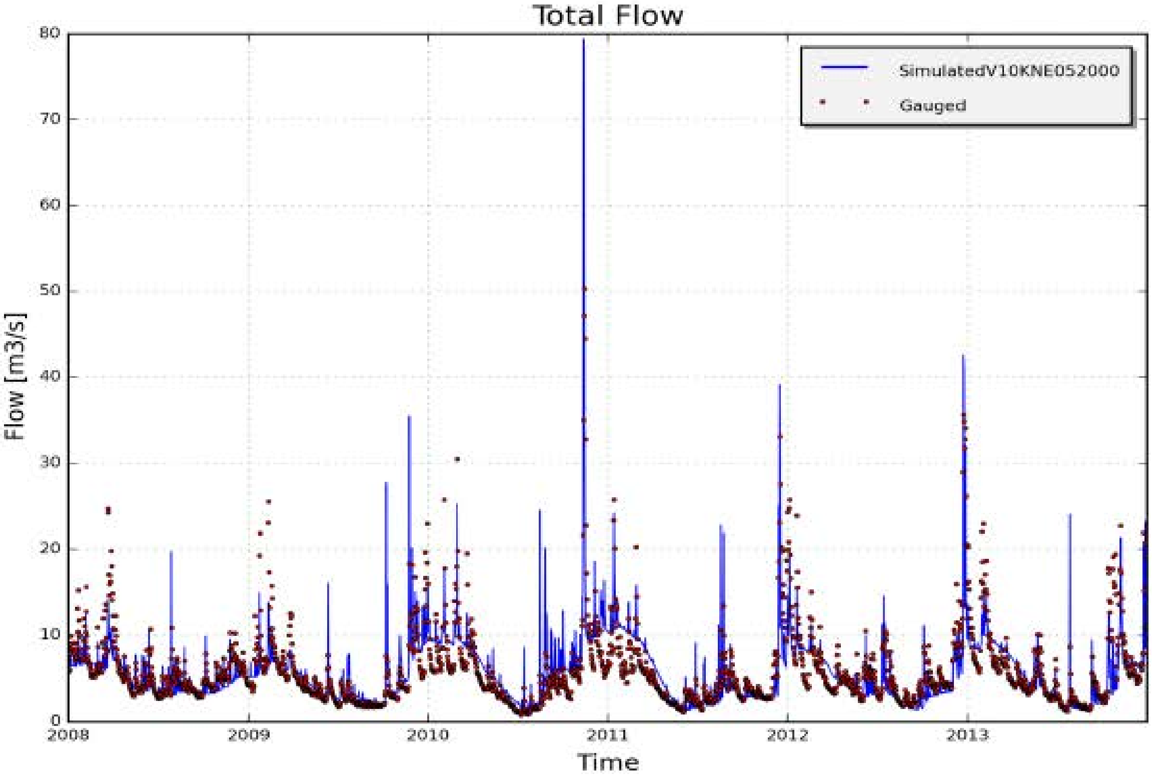

Figure 92 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10KNE052000 (Calibration).

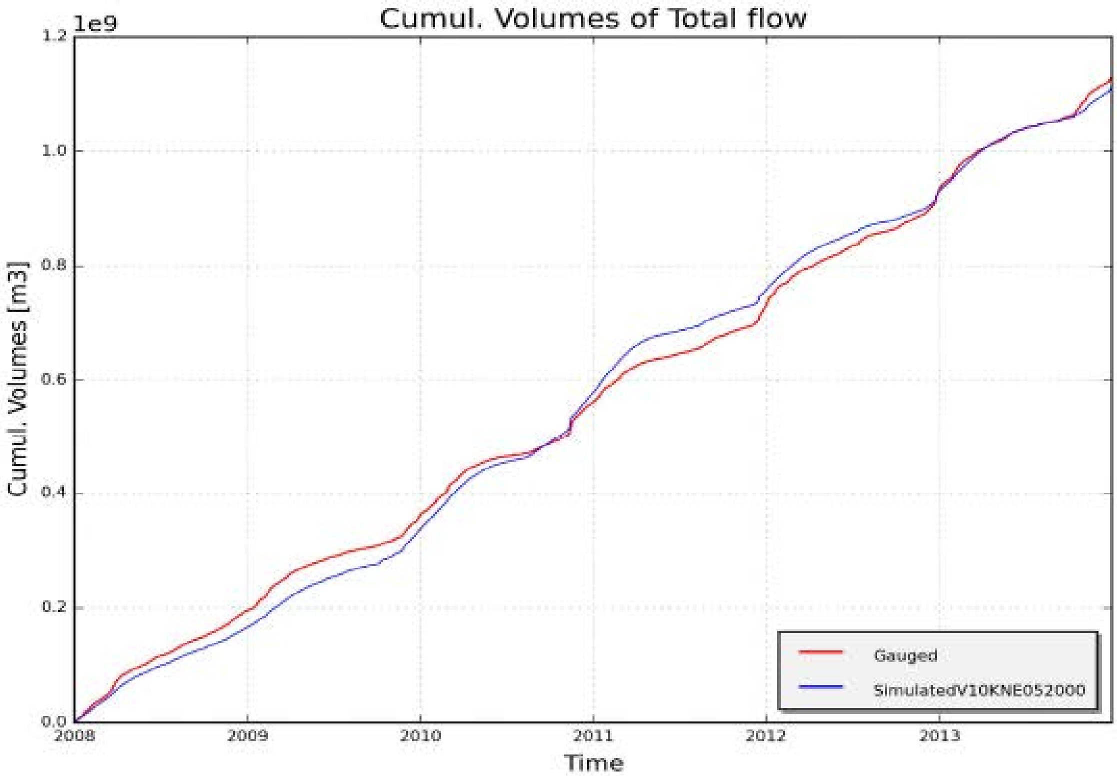

Figure 93 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10KNE052000 (Calibration).

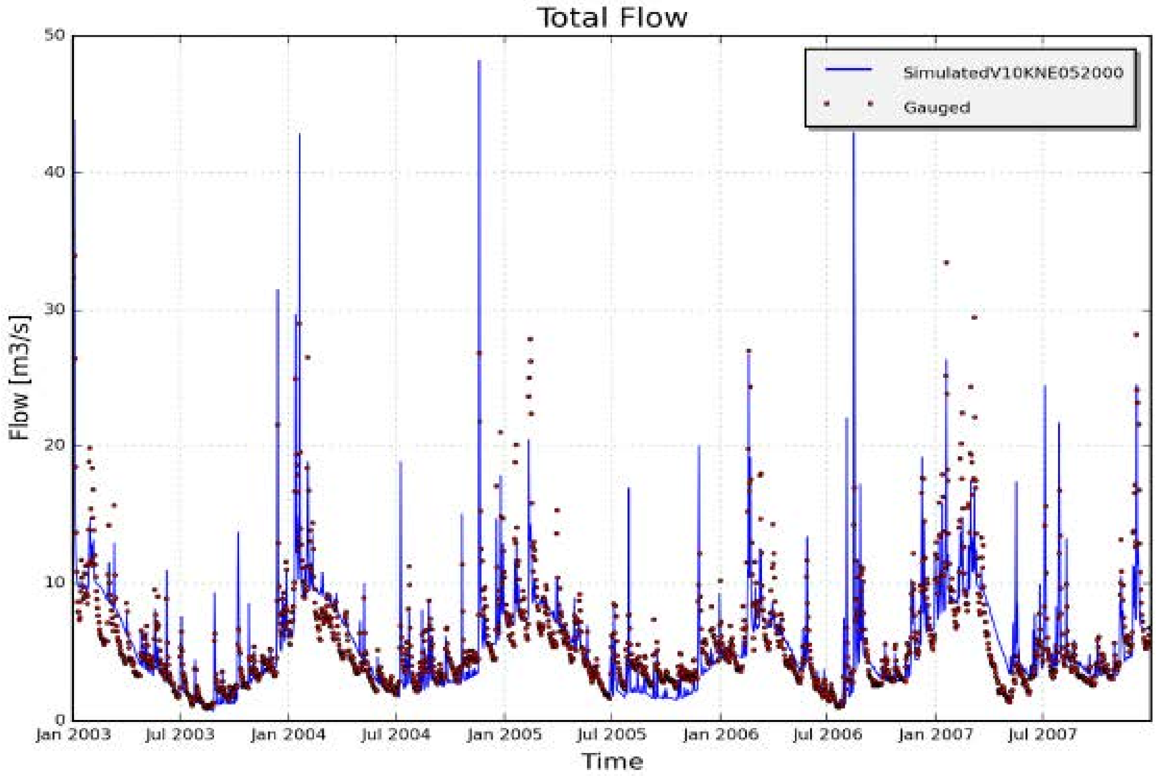

Figure 94 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10KNE052000 (Validation).

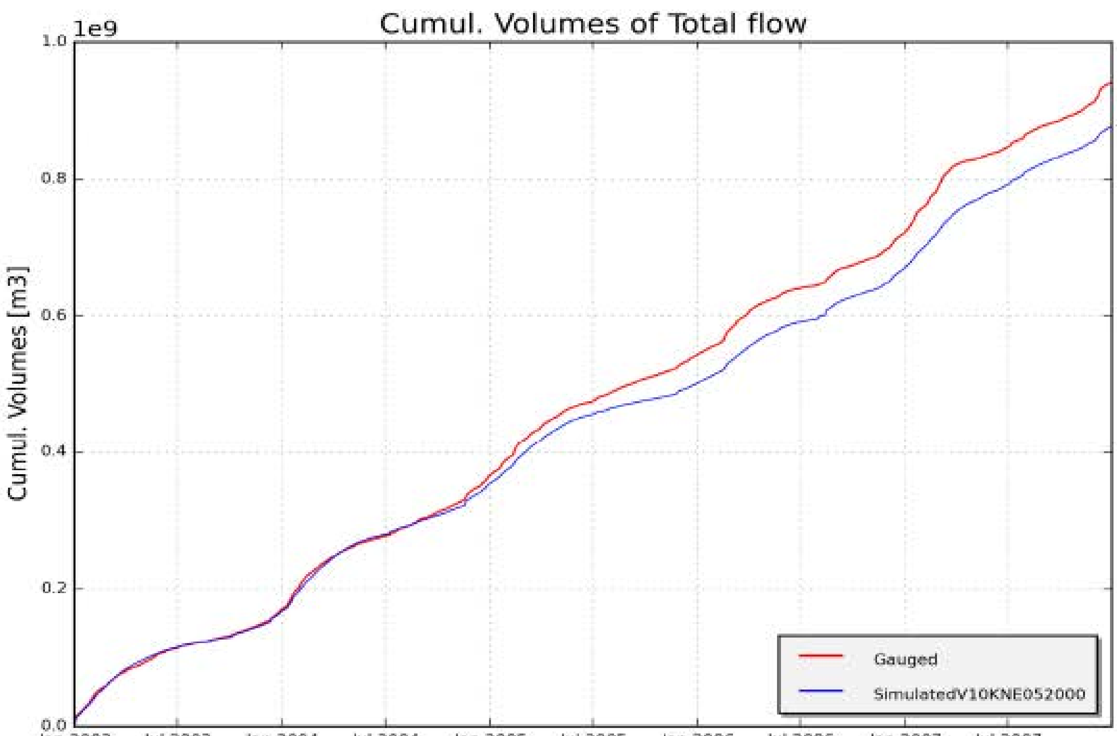

Figure 95 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10KNE052000 (Validation).

Catchment V10MOP062140

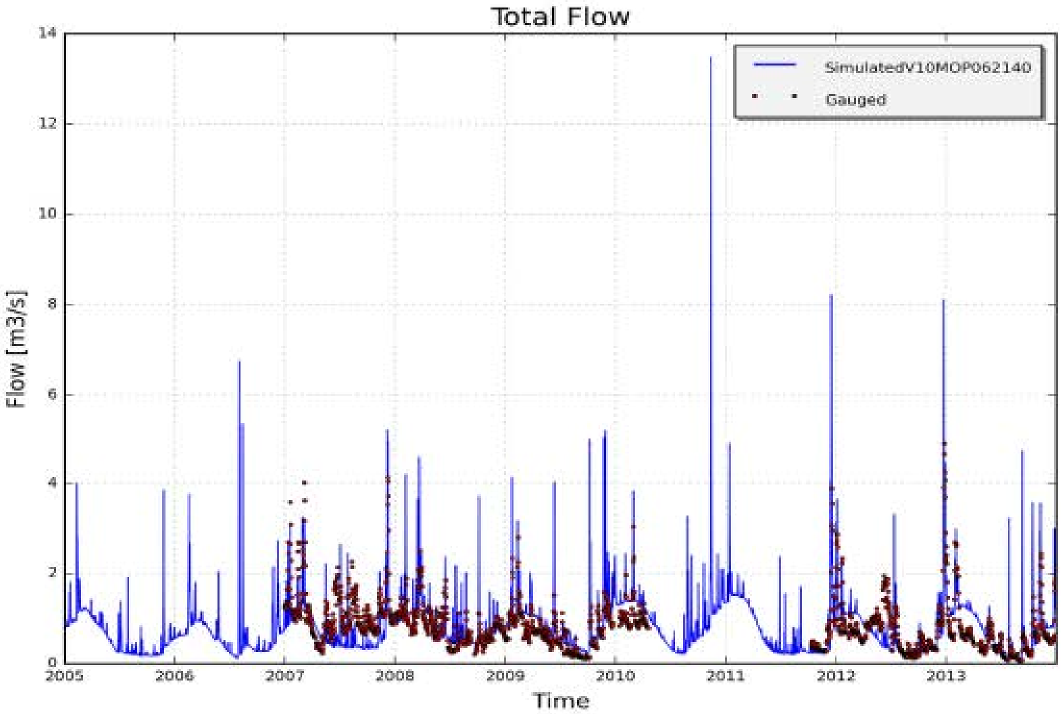

Figure 96 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10MOP062140 (Calibration).

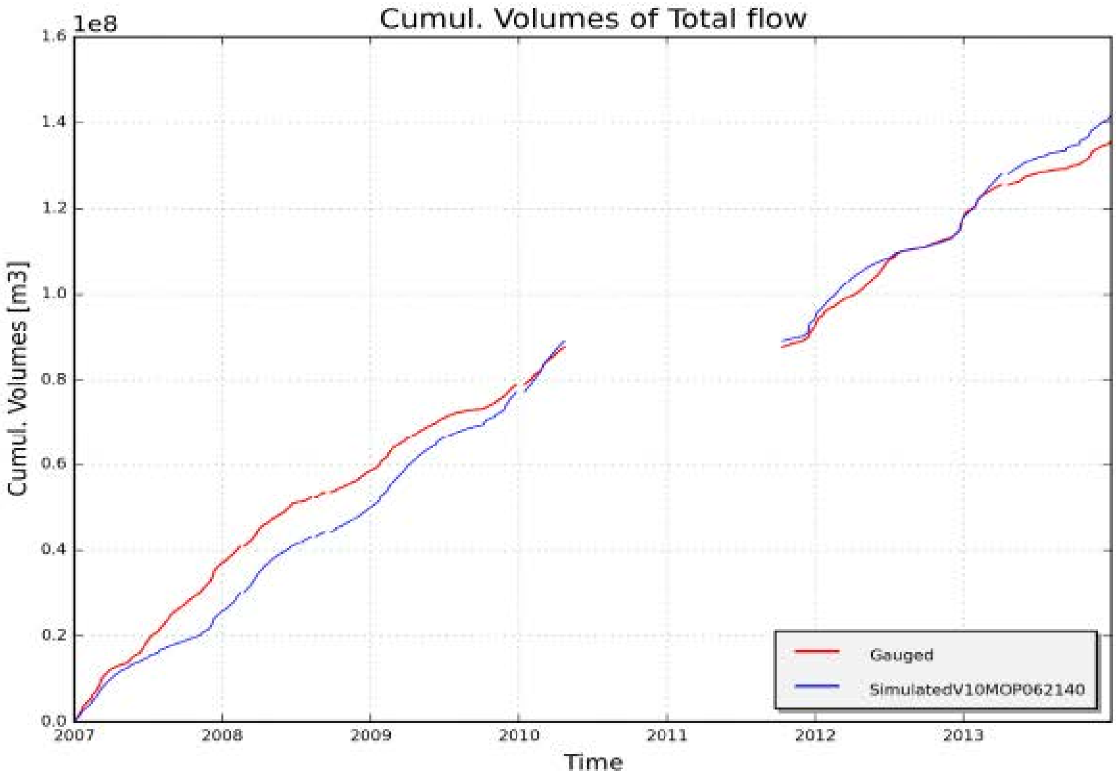

Figure 97 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10MOP062140 (Calibration).

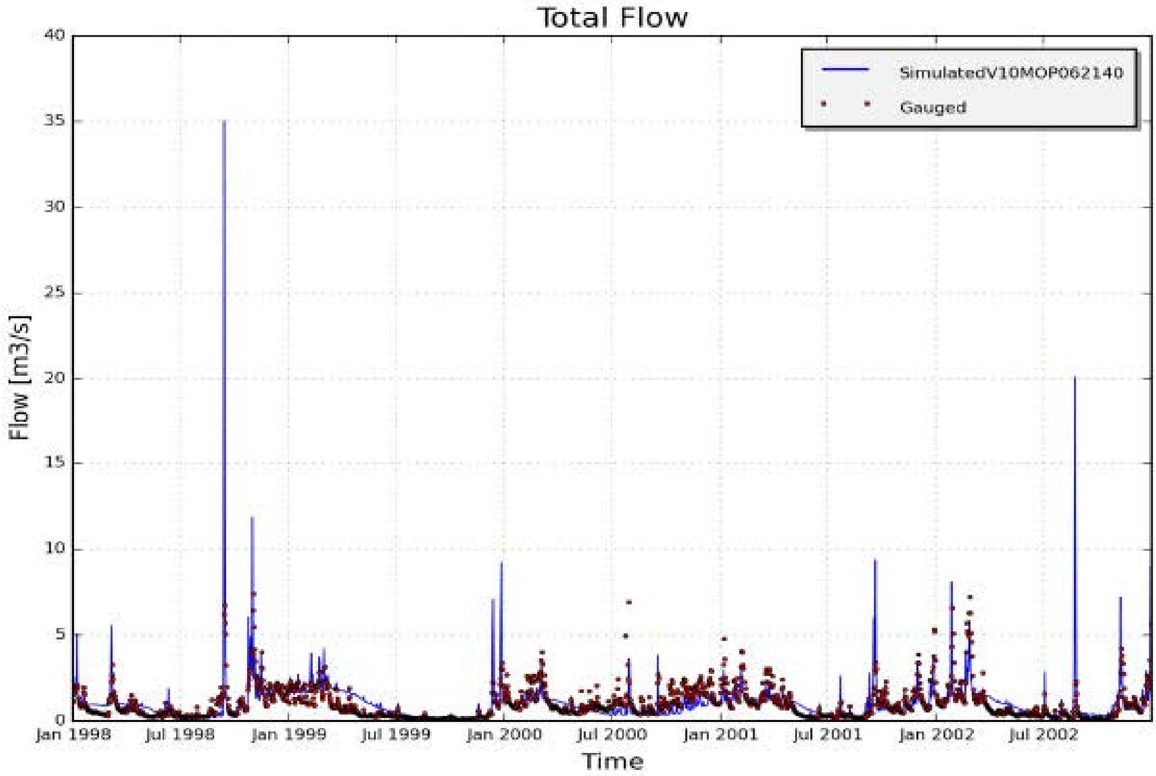

Figure 98 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10MOP062140 (Validation).

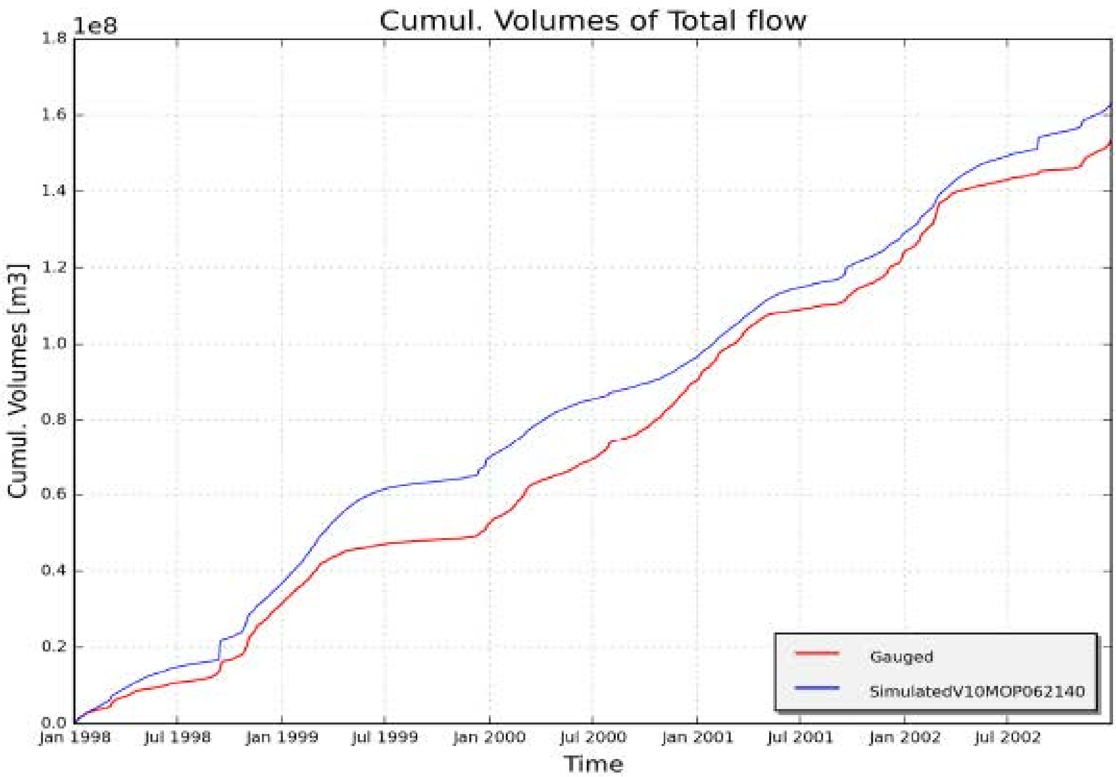

Figure 99 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10MOP062140 (Validation).

6.11 Meuse

6.11.1 Context

There are 8 gauged stations used for the calibration of the rainfall-runoff models. The five calibrated subcatchments upstream Visé were: the Sambre, the Haute Meuse, the Ourthe, the Hoyoux and the Mehaigne. Three additional small catchments downstream Visé including the Mehaigne, The Berwijn (Berwinne), the Jeker (Geer) were needed for the simulation of the situation on the Albert canal and the Campine canal. The locations of the gauged stations and subcatchments are shown in Figure 3.

6.11.2 Model performance

Table 33 and Table 34 present general performance statistics for the gauged catchments of the Meuse basin. Graphs of simulations of the catchments with code F11MAA8702 (best model performance) and W11HOY5990 (worst model performance) are presented below (Figure 104 to Figure 107). For more detailed results on the other catchments is reffered to Appendix 22 and Appendix 23.

Figure 100 and Figure 102 show a very good match between the simulated and measured values of discharge for both the calibration and validation period at the outlet of the catchment F11MAA8702. This is given by the statistical values of LogNSE above 0.75 and RelErr below 0.2% (Table 33 and Table 34). Similar flow behaviour could be found at the catchments with code W11MAAPROF, W11OUR5805, and W11BER551010 (Appendix 22). Although discharge for catchment W11SAM7319 was overestimated during the recession events of the years 2010 and 2011, the model in general represented well both the timing and magnitude of flow for the entire simulation periods (Appendix 22).

Inadequate model performance was found at the catchments W11MEH5820 and W11HOY5990. The hydrographs from Figure 104 to Figure 107 show that the model represented well the total flow of the catchment W11HOY5990. However, low flow was underestimated during the periods from 2001-2006 and 2011-2013. The model performance of the catchment W11BER551010 could be accepted, although total flow was overestimated from 2005-2011 (Appendix 22). The values of RelErr around 0.44 indicate that low flow was predicted well for both the calibration and validation period.

According to the catchment W11JEK553010, the model performed not well in simulating high flow and low flow for both the calibration and validation period (Appendix 22). This is presumably due to erroneous measured data during the simulation periods. Similar results were happened when applying NAM model to predict flow of this catchment.

Data remarks: The catchment W11W11OUR5805 does not have available measured data before the year 2000. Therefore, the simulation period was started from 2001. The catchments F11MAA8702 and W11MAAPROF do not have available measured data before 2007. Therefore, the simulation period was selected from 2007.

Table 33 – Overview of calibration results for gauged catchments on the Meuse basin

Station/River	Catchment code	Surf. Area (km^2)	Log NSE	RelErr	Calibration period
Marchin/Hoyoux	W11HOY5990	242	-0.2	4.9	2009-2013
Wanze/Mehaigne	W11MEH5820	356	0.46	9.8	2001-2008
Profondeville/Meuse	W11MAAPROF	12586	0.62	-1.6	2008-2012
Chooz/Meuse	F11MAA8702	10120	0.75	0.1	2007-2013
Angleur 2 bis/Ourthe (calculated)	W11OUR5805	3612	0.6	-0.4	2003-2012
Salzinne Ronet/Sambre	W11SAM7319	2669	0.61	-0.7	2007-2012
Moelingen	W11BER551010	128	0.58	-0.5	2000-2004
Kanne	W11JEK553010	465.5	-6.9	23.9	2009-2013

Table 34 – Overview of validation results for gauged catchments on the Meuse basin

Station/River	Catchment code	Surf. Area (km^2)	Log NSE	RelErr	Calibration period
Marchin/Hoyoux	W11HOY5990	242	-0.18	1.4	2001-2013
Wanze/Mehaigne	W11MEH5820	356	0.44	12.7	2001-2011
Profondeville/Meuse	W11MAAPROF	12586	0.59	5.2	2003-2007
Chooz/Meuse	F11MAA8702	10120	0.76	0.2	2003-2013
Angleur 2 bis/Ourthe (calculated)	W11OUR5805	3612	0.64	0.9	2001-2006
Salzinne Ronet/Sambre	W11SAM7319	2669	0.55	6.8	2009-2013
Moelingen	W11BER551010	128	0.57	2.9	1997-2004
Kanne	W11JEK553010	465.5	-6.1	19.6	1993-2013

Catchment F11MAA8702

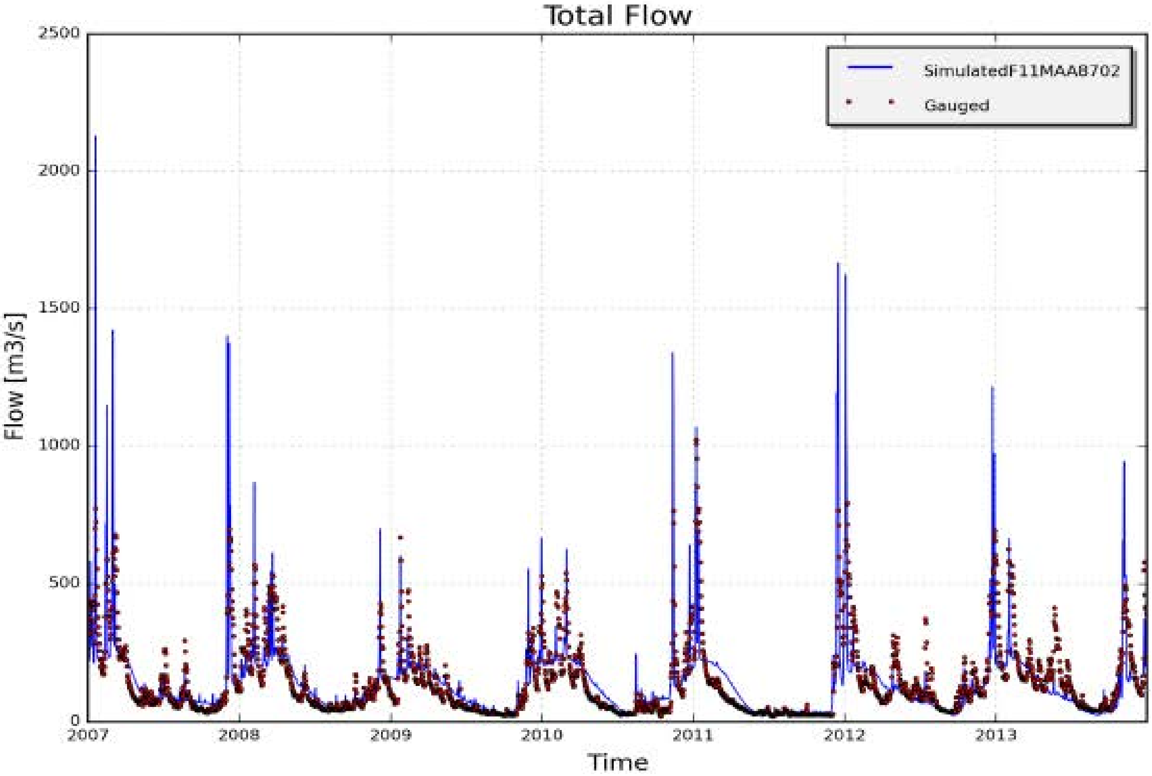

Figure 100 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment F11MAA8702 (Calibration).

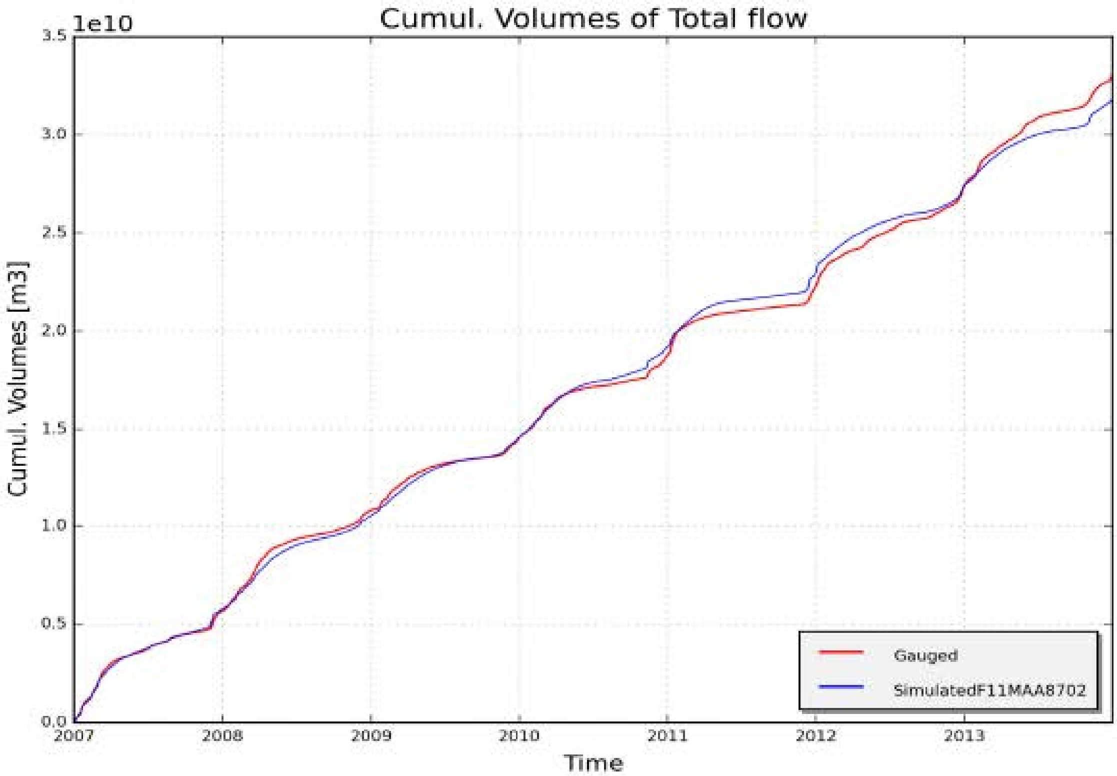

Figure 101 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment F11MAA8702 (calibration period).

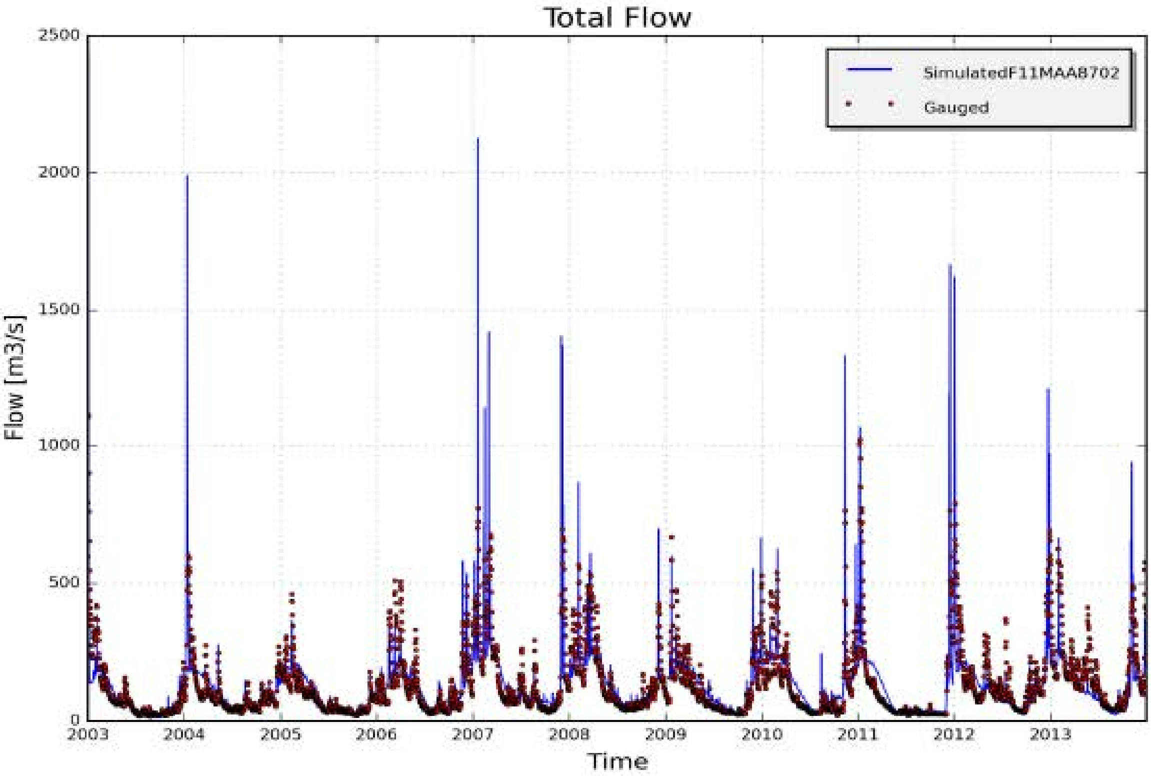

Figure 102 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment F11MAA8702 (Validation).

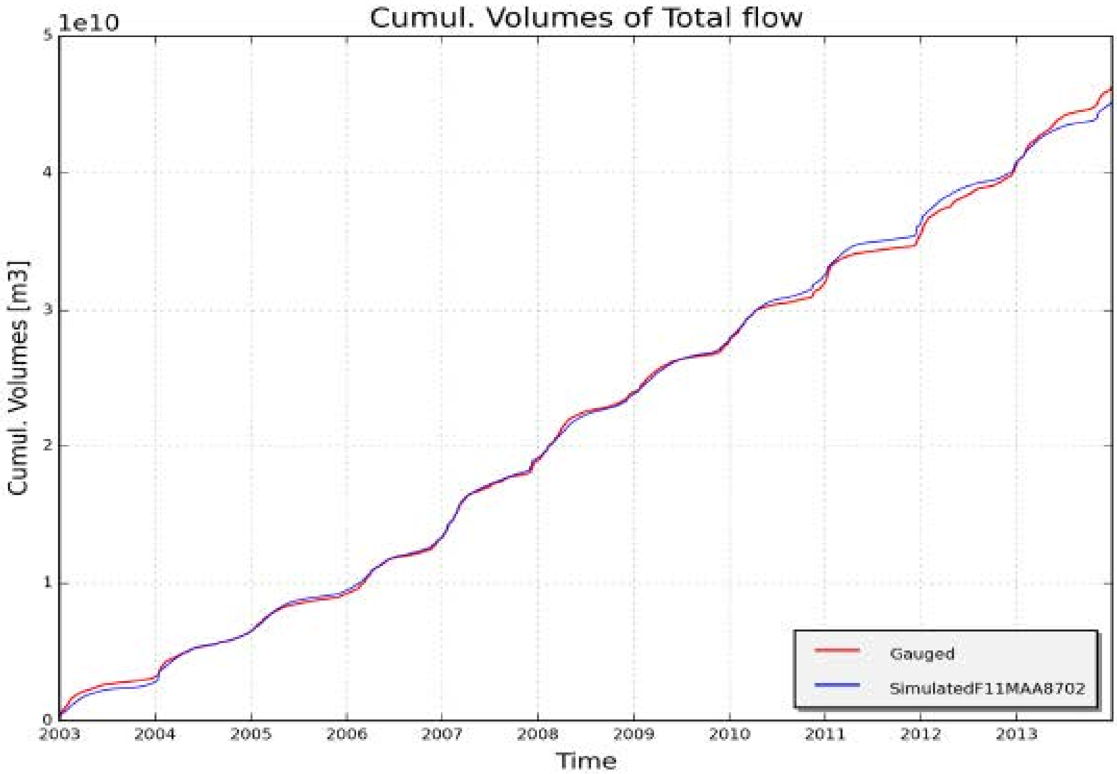

Figure 103 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment F11MAA8702 (Validation period).

Catchment W11HOY5990

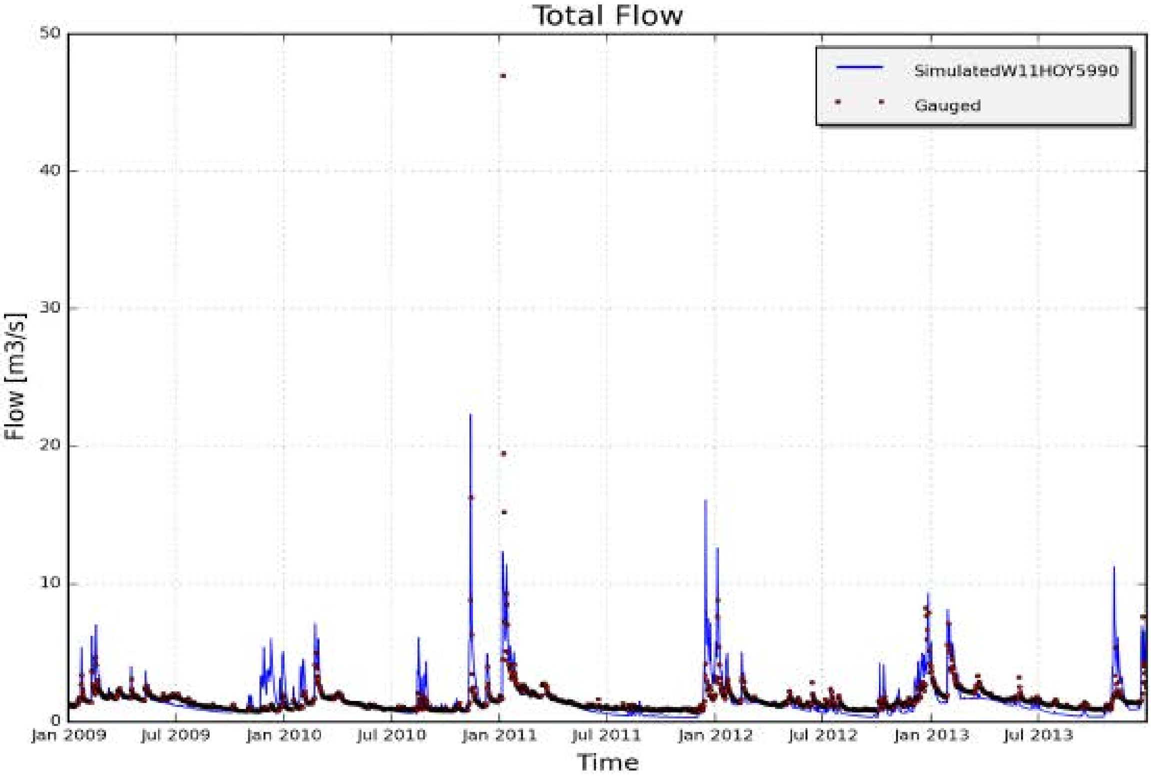

Figure 104 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11HOY5990 (Calibration).

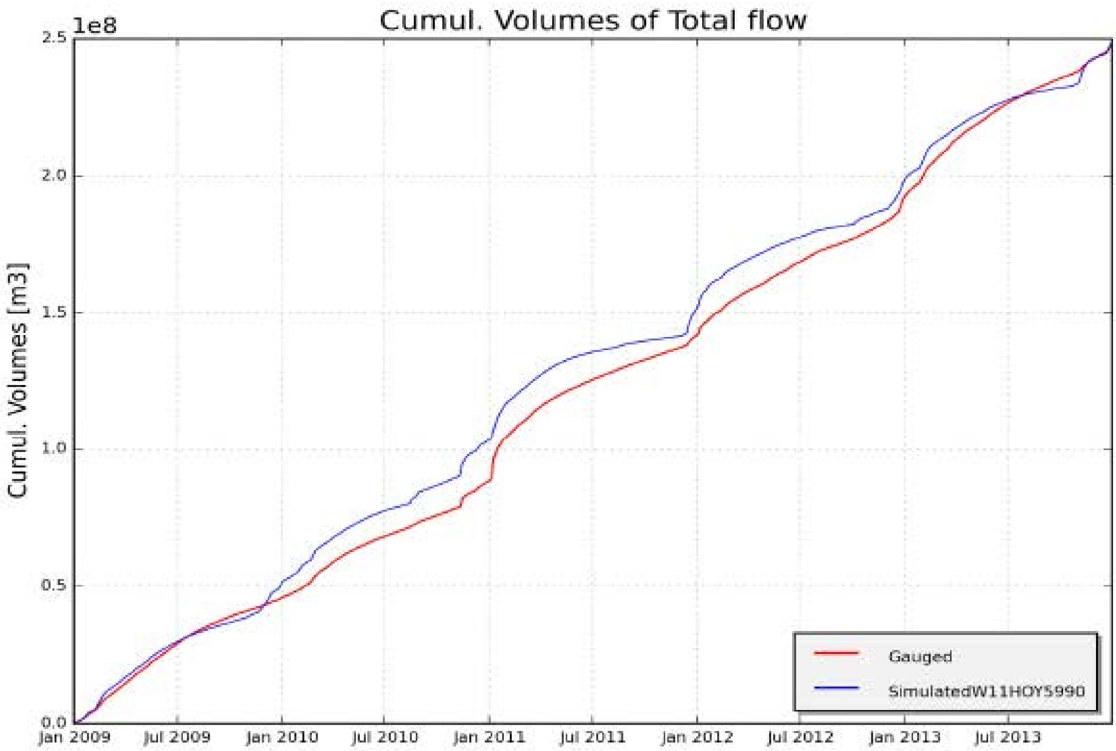

Figure 105 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11HOY5990 (calibration period).

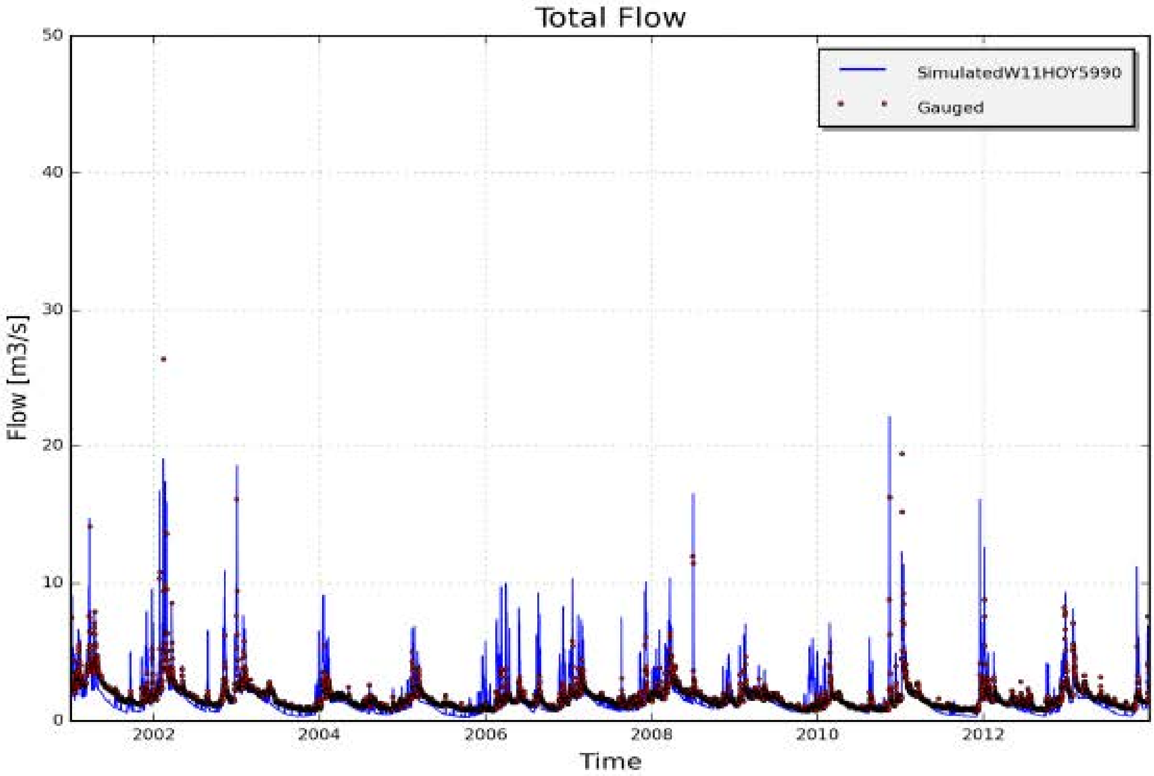

Figure 106 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11HOY5990 (Validation).

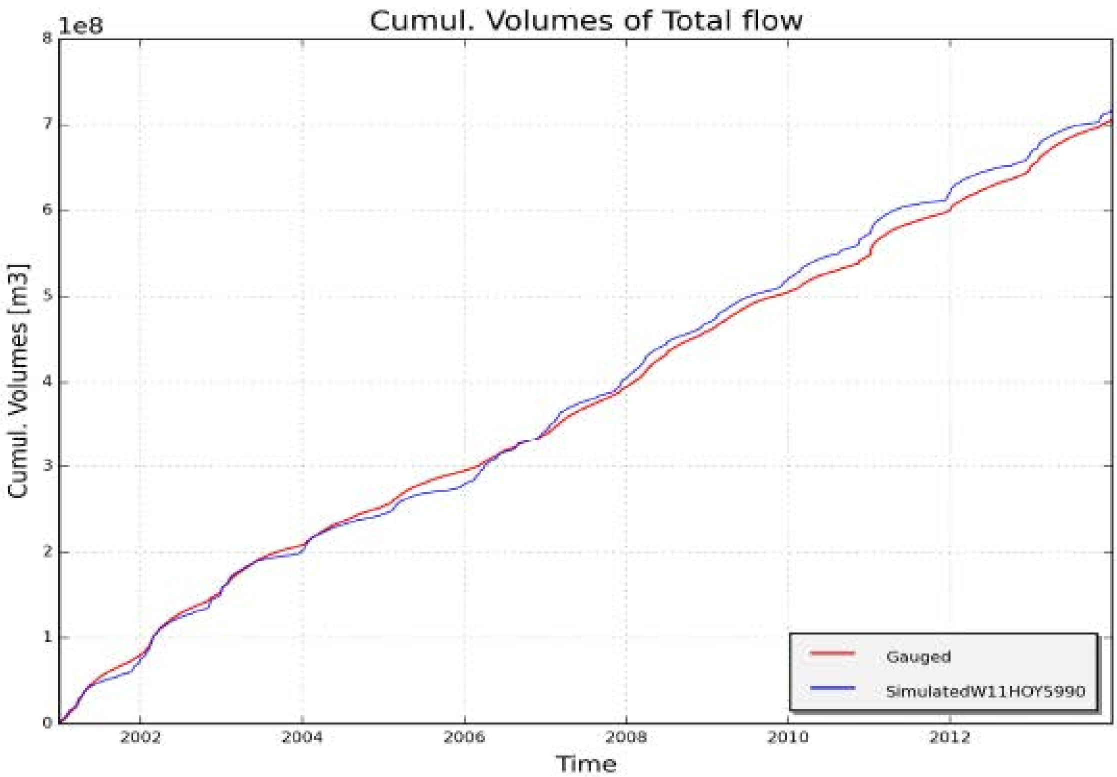

Figure 107 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11HOY5990 (validation period)

7 Conclusions and recommendations

The impacts of human activities on water resources occur partly through climate changes. Those changes affect regional hydrological balance by alter runoff, soil moisture storage, stream flow, aquifer levels (York et al., 2002). These alterations in turn can results in flood, draught, and water supply stresses. By consequence, there is a need to address these issues in order to reduce possible threats posed on water resources at catchment scale.

The water balance model of the Scheldt basin will be used in order to perform low flow forecasts and calculate climate change scenarios. The goal of this subtask of the project 'Modelling water availability and water allocation strategies in the Scheldt basin', is to define the most appropriate hydrological models for the water balance model of the Scheldt basin in order to meet this prerequisite. Therefore, different hydrological models for each of the sub catchments in the study area are set up and evaluated on their appropriateness for low flow forecasting and climate change scenarios. The regarded models are NAM (©DHI), PDM (©Innovyze), VHM (©Willems, P.) and WETSPA (©VUB). After evaluation of each of these hydrological models, the most appropriate model for each catchment can be used for the particular application. This sub report covers the calibration and evaluation of WETSPA. This spatially distributed model calculates a discharge time series based on the historical rainfall, evapotranspiration time series, topography map, land use map, and soil map. As such, the simulated discharge for the sub catchments in the water balance model can then be used to assess the water balance in the Scheldt and the Meuse basin for a long term period.

The WETSPA model was set up for 45 sub catchments of the Schelde basin and 11 sub catchments of the Meuse basin in order to assess the hydrology in these areas. Automatic calibration was performed by optimization, using a genetic algorithm, on 56 gauged sub catchments. During the optimization routine the best parameter set is selected for each catchment based on 2 criteria: (1) absolute error on cumulated total flow at each time step, and (2) logarithmic Nash-Sutcliff efficiency. The first criterion aims to model the global flow pattern, the latter focuses mainly on the low flows.

The current data i.e. climate data, topography, land use and soil map were used as input data for the model setup. The model has been calibrated and validated on a daily time step using measured river flow data at the outlet of the gauged catchments. In general, the WETSPA model performed satisfactorily in simulating daily low flow in catchments of the Scheldt and Meuse basin. These achieved results could serve as reliable basis for predicting water availability in the context of future climate change.

In this study, the default soil parameters applied into the model are interpolated from the literature and used over the entire catchment. Due to the vast variation range, parameters such as hydraulic conductivity, soil porosity, roughness coefficient, etc. may change greatly when applying the model to another place with a different environment. This brings difficulties in model parameterization in calibration of catchments and influence the accuracy of the model results in general. For catchments which have no similar conditions of topography, land use, and soil properties, it is recommended to analyze soil properties in detail before implementing the parameters into the model to get better results of the model simulation.

8 References

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Appendix 1 List of optimized parameters for gauged catchments

Catchment	Area (m²)	Kep	Ki	Kg	Kss	go	G_max	Krum	P_max
V01HAN488180	78558940	1.82	198.68	0.010	0.5	118.73	286.41	3.07	186.25
V01HEI468999	393007000	1.15	156.67	0.0045	3.76	109.28	285.39	3.95	196.49
V01IEP495080	63423128	1.04	25.29	0.001	0.76	3.60	278.38	13.92	170.11
V01KEM492060	73892930	1.44	146.2	0.030	1.51	92.03	81.14	4.30	156.20
V01MAR496120	76136621	3.15	29.96	0.060	1.20	68.51	580.9	8.40	480.60
V01POP491030	84868207	2.84	103.26	0.080	2.15	157.9	4499.00	0.10	244.7
V01SSV499140	16095000	1.76	142.32	0.001	0.74	418.7	594.3	11.54	396.8
V02EDE442120	45489177	1.80	223.49	0.003	2.55	175.12	201.97	3.13	324.20
V02HER426010	77272201	1.38	210.99	0.001	0.96	88.43	246.1	3.71	244.70
V02KER422030	62718738	1.77	47.47	0.001	1.68	182.82	281.49	0.96	590.10
V02RIV425020	63980423	1.50	245.28	0.001	1.12	191.2	812.1	4.86	468.70
V03POE446000	106836849	2.40	293.92	0.010	7.32	154.85	390.9	2.60	79.62
V04MOL036110	32561957	1.56	95.46	0.002	0.10	63.48	281.54	3.92	438.61
V04MOM037100	67301328	1.76	27.6	0.003	0.72	43.26	377.43	3.92	438.61
F05LEI386999	2981779554	1.55	80.25	0.010	2.19	157	442.10	3.40	196.50
V05HEU403210	91912331	2.20	101.96	0.010	4.81	762.64	690.85	1.14	1262.00
V05MAN401230	258441818	1.25	104.81	0.010	2.61	193.62	306.54	3.00	122.86
F06BOS325999	5217586196	1.60	69.87	0.010	0.79	107.9	385.46	3.57	538.30
V06MAA347160	48678191	1.55	61.95	0.003	3.21	83.08	231.80	9.66	156.92
V06ZWA342190	112117540	1.60	56.23	0.010	1.72	87.94	640.41	6.96	201.20
W06RHOL54100	161928446	2.95	97.4	0.010	2.00	163.6	399.53	6.17	87.13
V07BEL285070	88641710	1.39	20.76	0.001	0.79	71.08	306.14	13.01	470.49
V07MAR289015	173908791	1.60	66.99	0.001	1.19	102.78	536.88	4.85	604.50
V07MOE282100	46367171	1.83	67.94	0.010	1.22	134.11	335.95	22.57	263.31
V07MOG288020	23093628	1.77	49.27	0.001	1.23	185.23	300.04	25.94	644.01
W07DENLES999	511840662	1.30	100.00	0.003	1.13	50.00	300.00	7.20	350.00
V08BAR111370	70079800	1.14	50.59	0.003	5.00	70.52	237.62	4.00	71.61

Catchment	Area (m^2)	Kep	Ki	Kg	Kss	go	G_max	Krum	P_max
V08DIJ093400	861413000	1.29	8.91	0.001	0.90	163.47	444.79	6.82	206.15
V08ZUU233100	64771005	1.81	20.33	0.002	0.70	177.18	318.59	20.73	156.27
W08SAMRON000	134097000	1.73	1.20	0.001	1.70	249.66	646.50	5.15	209.37
W08SENL56010	70364773	1.26	183.8	0.002	2.60	124.4	284.29	8.79	268.30
W08SENTUB030	215911078	2.12	52.52	0.010	0.70	116.55	426.14	6.13	163.91
V09DEM136000	255882000	1.86	81.95	0.010	1.79	140.90	300.90	5.23	163.82
V09GET152080	800395376	0.15	42.50	0.010	0.97	184.82	625.19	9.09	521.81
V09HER163010	274602221	1.50	24.99	0.002	0.99	166.33	483.13	5.43	226.86
V09HUL147150	80130245	0.82	80.51	0.002	0.99	166.33	483.13	5.43	226.86
V09MAN161040	103081000	1.92	13.00	0.010	0.96	85.14	560.43	0.48	39.19
V09MOT144270	33590217	1.56	2.28	0.010	2.84	29.87	269.27	2.78	45.31
V09VEL145100	96801128	1.58	18.56	0.003	2.05	133.90	228.74	7.90	304.11
V09WIN141310	64739169	1.95	17.55	0.002	0.80	163.65	252.34	3.44	126.48
V09ZWA148120	96514800	1.85	30.93	0.010	0.63	152.77	489.95	1.09	68.65
V10GNE076999	359885327	1.30	19.28	0.003	2.32	159.75	470.2	1.35	128.70
V10KNE052000	584669408	1.45	113.71	0.010	2.86	87.22	304.77	2.00	40.57
V10MOP062140	77300000	2.32	127.98	0.004	2.87	60.37	434.18	3.96	171.18
V10WIM082050	65400000	2.81	140.66	0.020	9.94	169.18	565.84	0.98	311.23
W11HOY5990	242000000	1.809	11.847	0.002	1.884	204.89	502.03	8.95	413.37
W11MEH5820	356000000	2.40	52.62	0.010	2.045	270.88	833.23	3.00	607.33
W11MAAPOF	12586000000	0.69	46.67	0.070	0.68	283.11	344.69	2.77	53.77
F11MAA8702	10120000000	1.40	113.70	0.010	2.80	150.48	263.27	2.78	74.71
W11OUR5805	3612000000	1.89	83.40	0.010	3.00	73.05	295.60	4.19	226.70
W11SAM7319	26996000000	2.18	64.15	0.010	2.30	122.20	509.40	2.53	116.00
W11JEK553010	465500000	1.36	42.19	0.004	2.00	119.70	274.5	3.00	1027.10
W11BER551010	128000000	1.92	28.38	0.010	2.47	92.66	452.27	7.38	236.41

Appendix 2 IJzer Calibration and Validation

9.2.1 Calibration and validation of WET parameters for catchment "V01HAN488180" (IJzer)

9.2.1.1 Input data

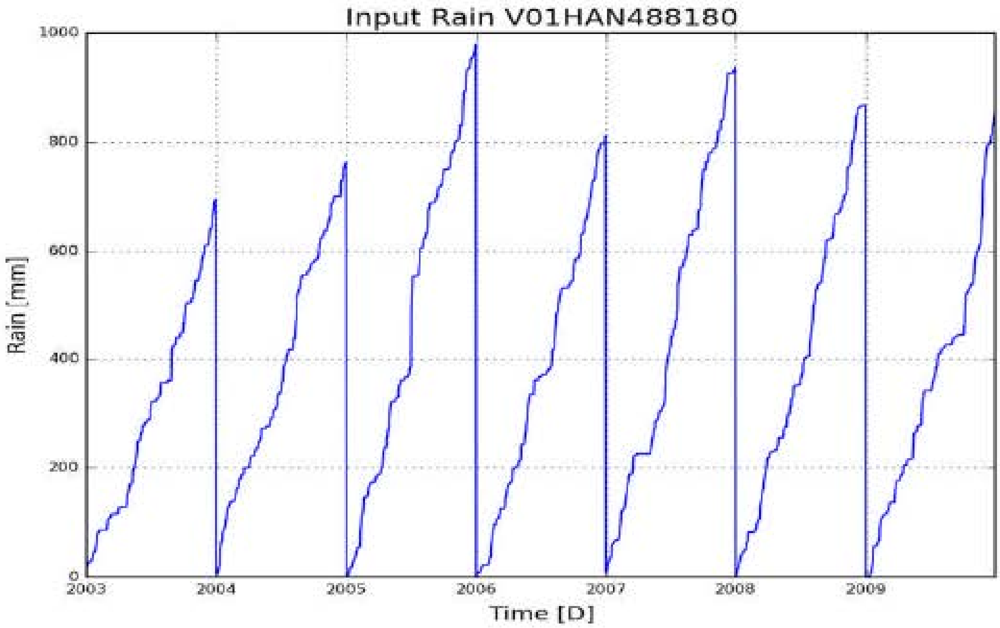


Figure 1: Cumulative precipitation on catchment V01HAN488180 (IJzer)

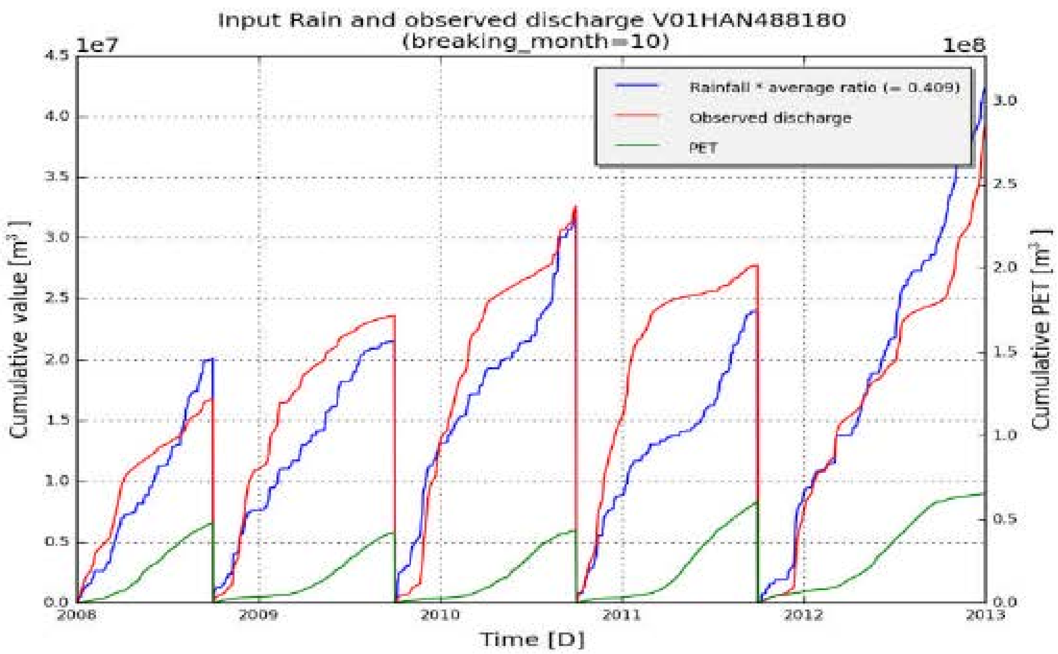


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V01HAN488180 (IJzer)

9.2.1.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V01HAN488180
subcatchment_area [m2]	78600000
Validation start_date	01-01-2004
Validation end_date	31-12-2009
frequency	daily

Optimal parameter set:[('Kep', 1.82), ('Ki', 198.68), ('Kg', 0.01), ('Kss', 0.5), ('g0', 118.73), ('g_max', 286.41), ('K_run', 3.07), ('P_max', 186.25)]

Table 1: Goodness of fit for calibration period (2008 - 2013)

	Full year	Summer	Winter
RelErr	0.6 %	-5.9 %	3.8 %
NS	0.669	0.235	0.661
NS_log	0.67	0.63	0.31
NS_rel	0.569	0.923	-0.138
KGE	0.778	0.614	0.6

Table 2 :Goodness of fit for validation period (2004 - 2009)

	Full year	Summer	Winter
RelErr	2.5 %	-10.0 %	5.1 %
NS	0.631	0.214	0.623
NS_log	0.641	0.605	0.35
NS_rel	0.565	0.847	0.172
KGE	0.744	0.611	0.613

9.2.1.3 Observed and simulated timeseries for optimum parameters

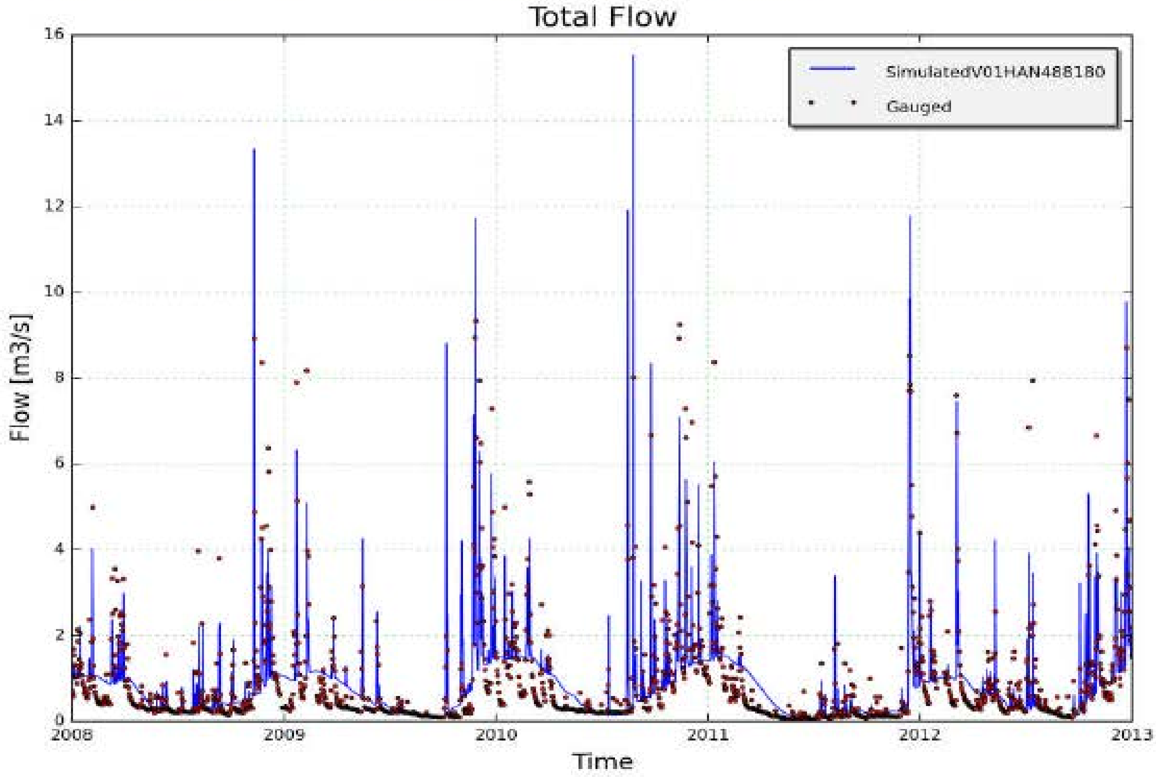


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark(calibration period)

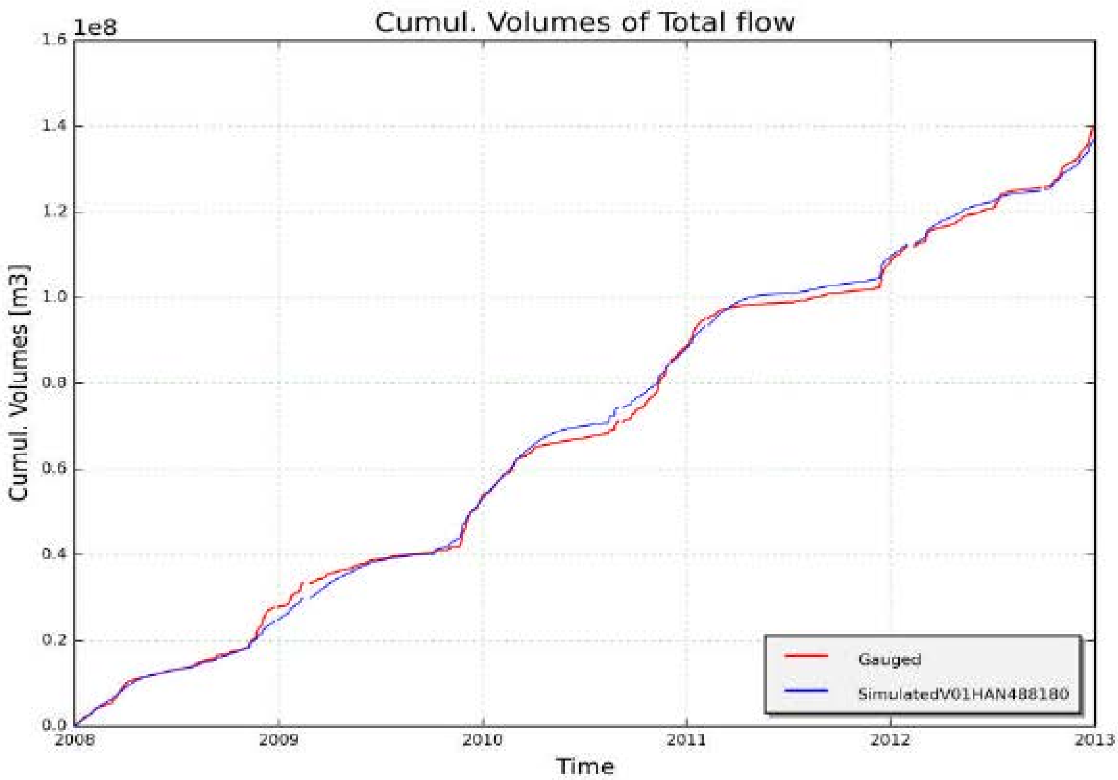


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark (calibration period)

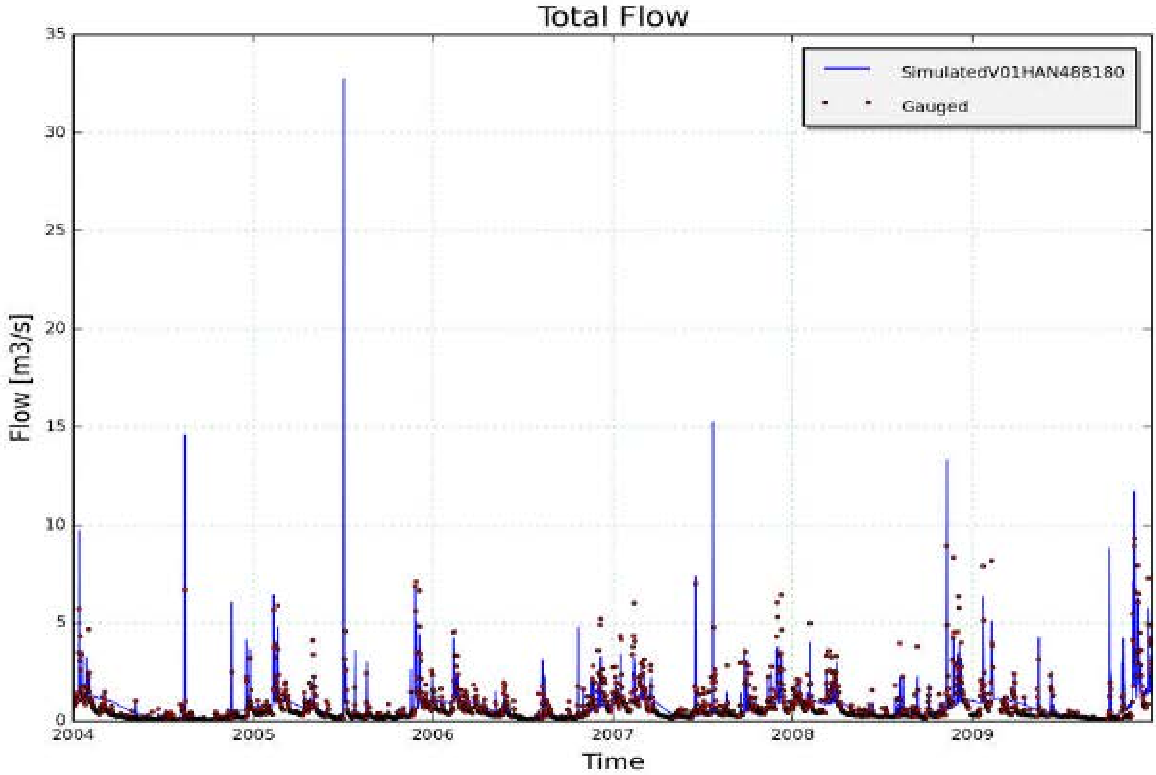


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark (validation period)

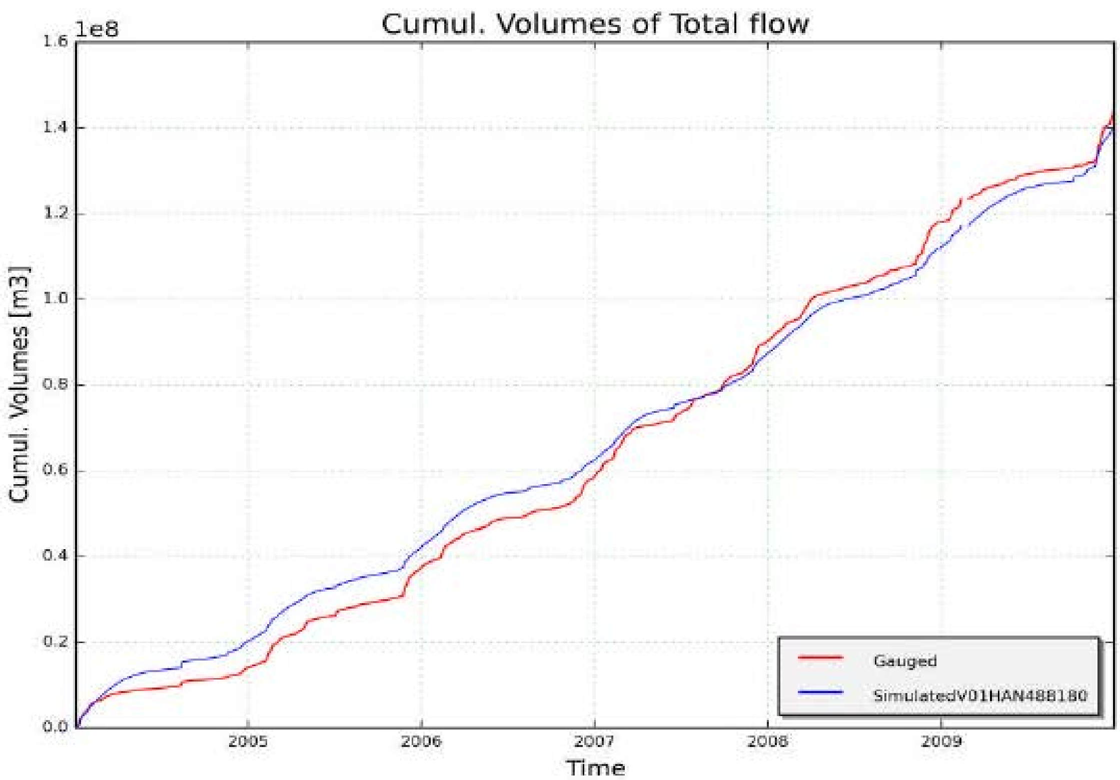


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark (validation period)

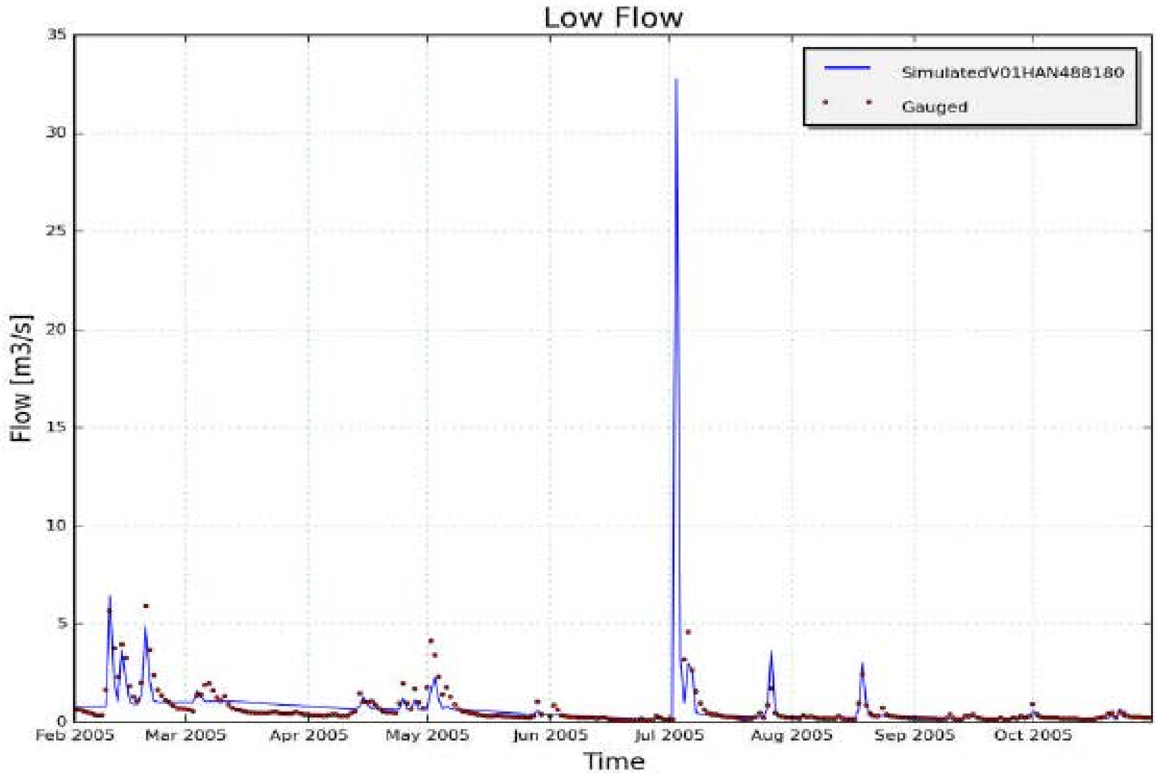


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark

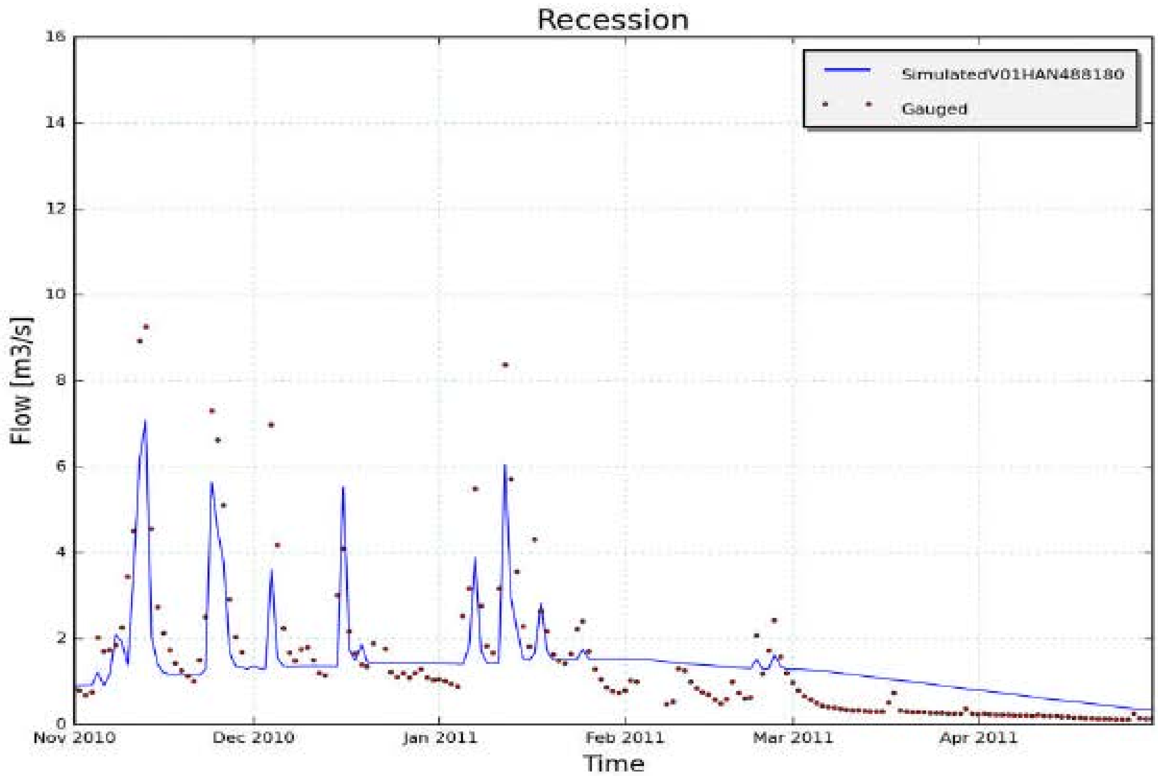


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark

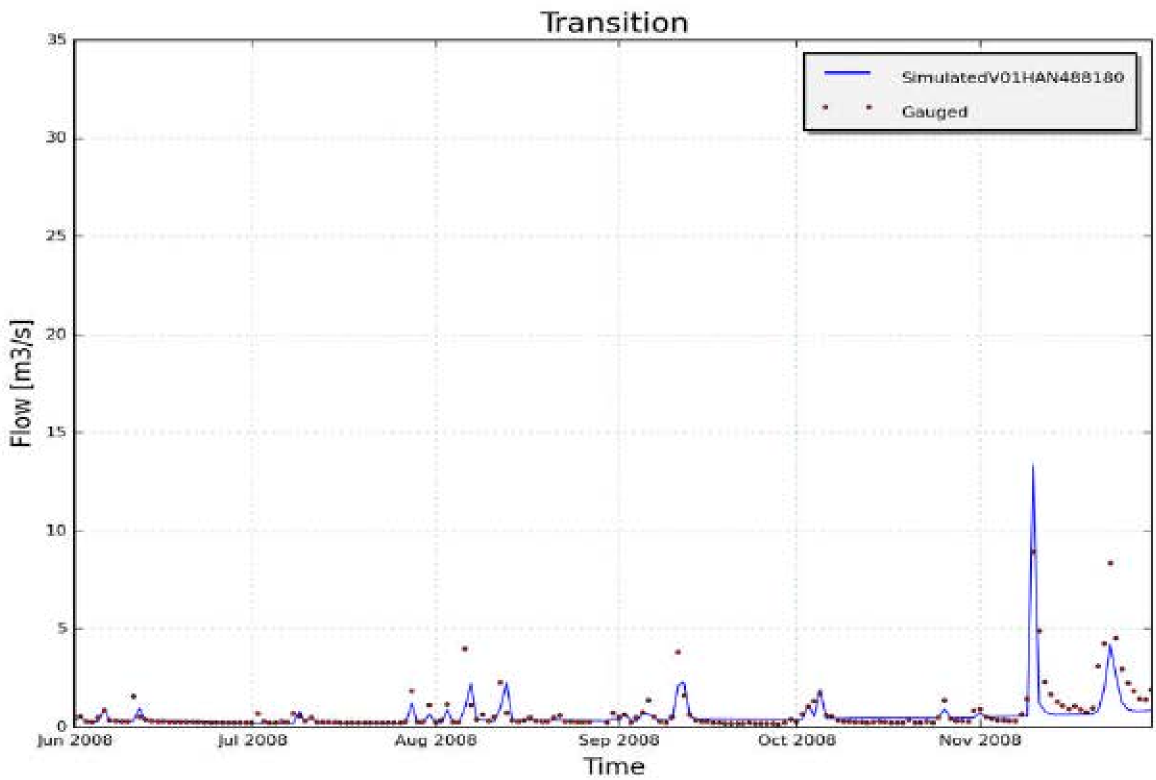


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark

9.2.2 Calibration and validation of WET parameters for catchment "V01HEI468999" (IJzer)

9.2.2.1 Input data

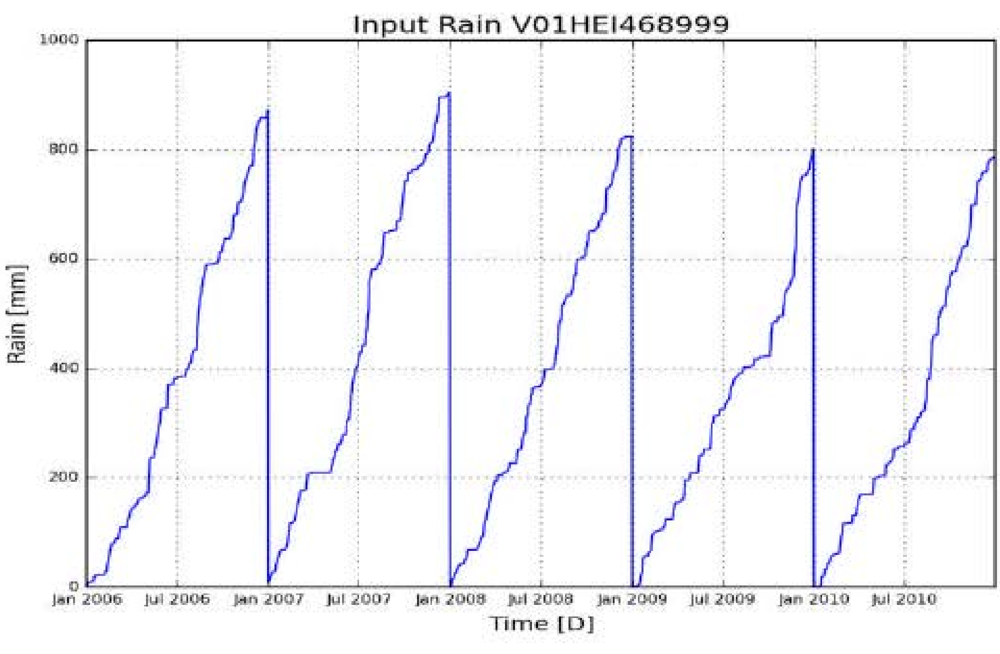


Figure 1: Cumulative precipitation on catchment V01HEI468999 (IJzer)

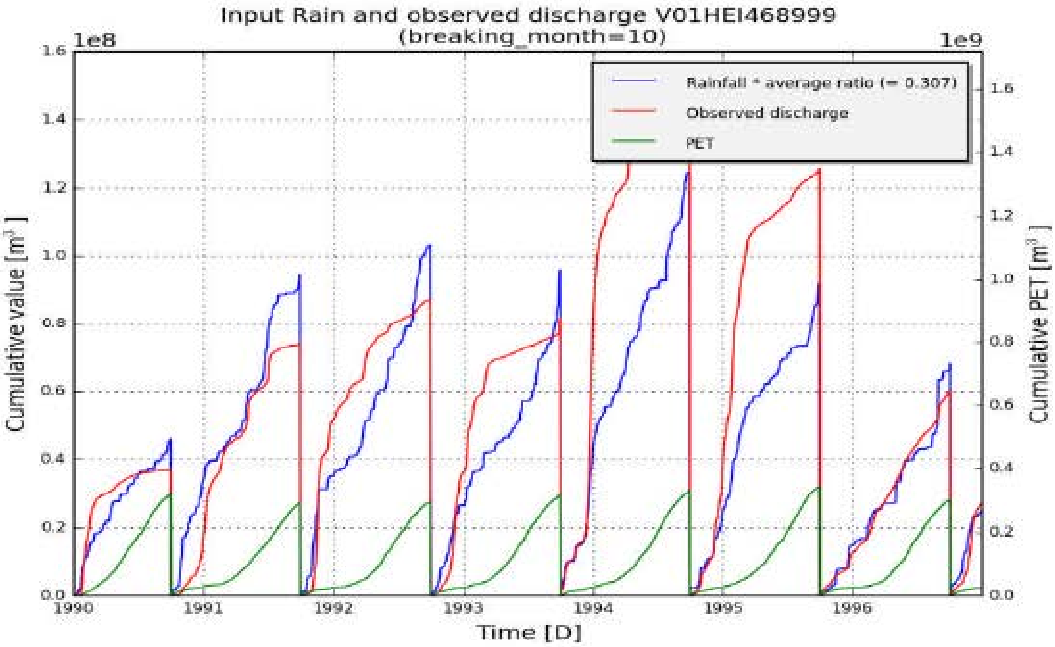


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V01HEI468999 (IJzer)

9.2.2.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V01HEI468999
subcatchment_area [m2]	393000000
Validation start_date	01-01-2007
Validation end_date	31-12-2010
frequency	daily

Optimal parameter set:[('Kep', 1.15), ('Ki', 156.67), ('Kg', 0.0), ('Kss', 3.76), ('g0', 109.28), ('g_max', 285.39), ('K_run', 3.95), ('P_max', 196.49)]

Table 1: Goodness of fit for calibration period (1990 - 1996)

	Full year	Summer	Winter
RelErr	-4.0 %	24.9 %	-26.1 %
NS	0.328	-1.917	0.51
NS_log	0.398	0.138	0.386
NS_rel	-0.23	-0.156	-0.22

	Full year	Summer	Winter
KGE	0.648	-0.133	0.538

Table 2 :Goodness of fit for validation period (2007 - 2010)

	Full year	Summer	Winter
RelErr	-4.8 %	58.3 %	-37.6 %
NS	0.232	-0.992	0.094
NS_log	0.011	-1.566	0.1
NS_rel	-1.225	-0.129	-1.646
KGE	0.559	-0.297	0.026

9.2.2.3 Observed and simulated timeseries for optimum parameters

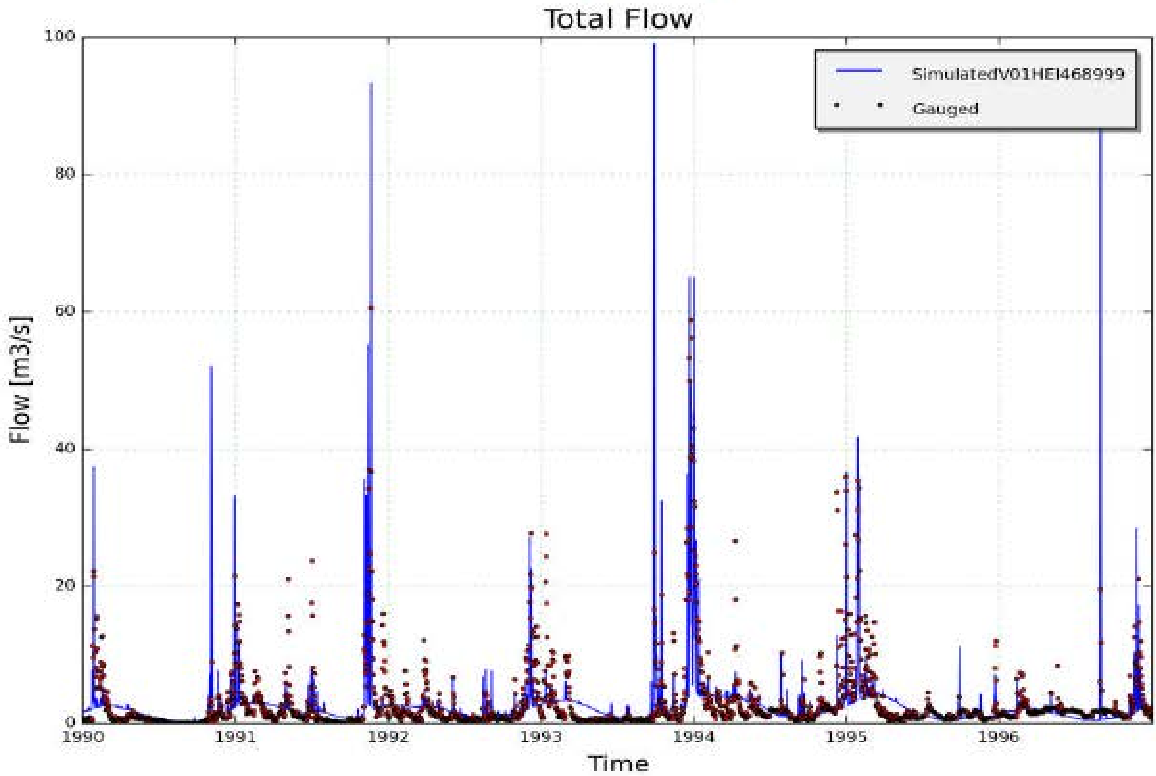


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01HEI468999, station 46810102 - Ijzer; Haringe(calibration period)

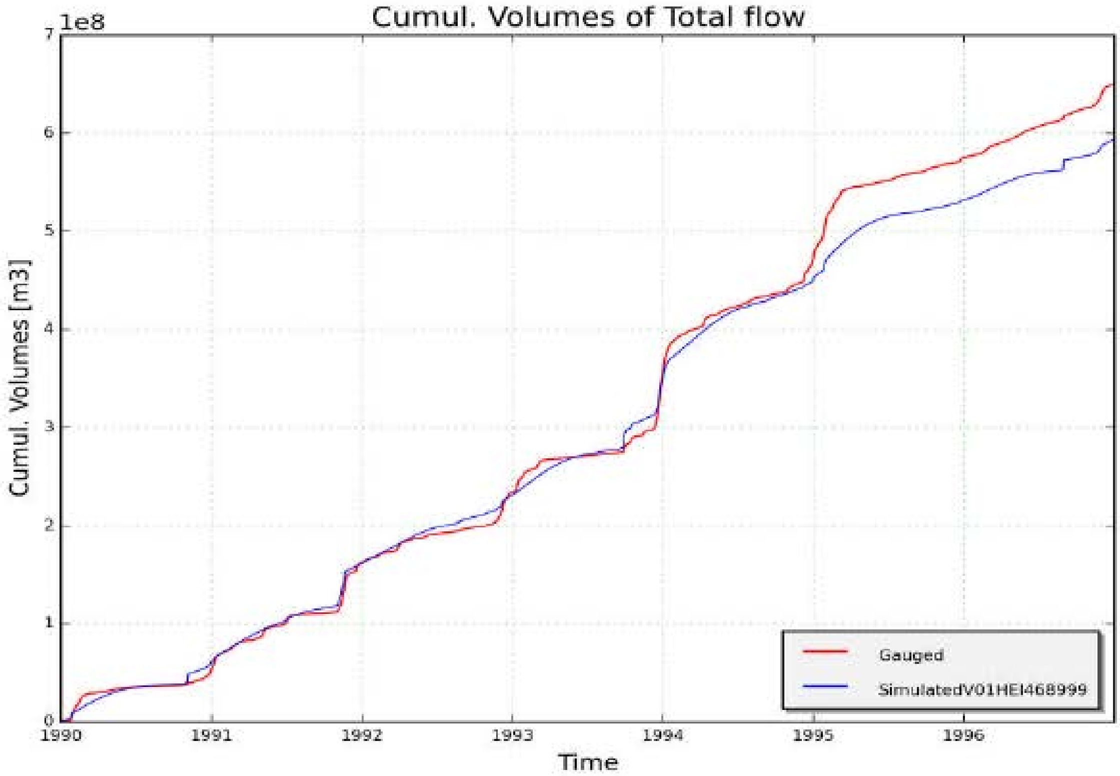


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01HEI468999, station 46810102 - Ijzer; Haringe (calibration period)

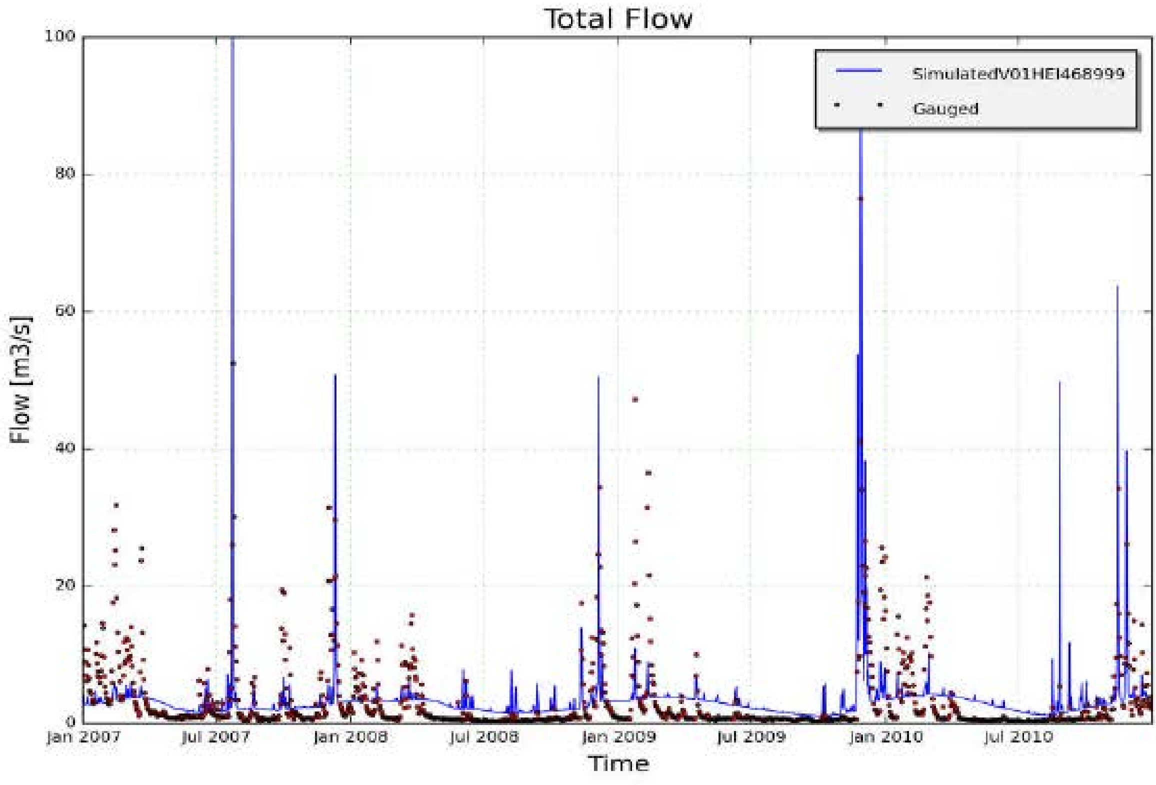


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01HEI468999, station 46810102 - Ijzer; Haringe (validation period)

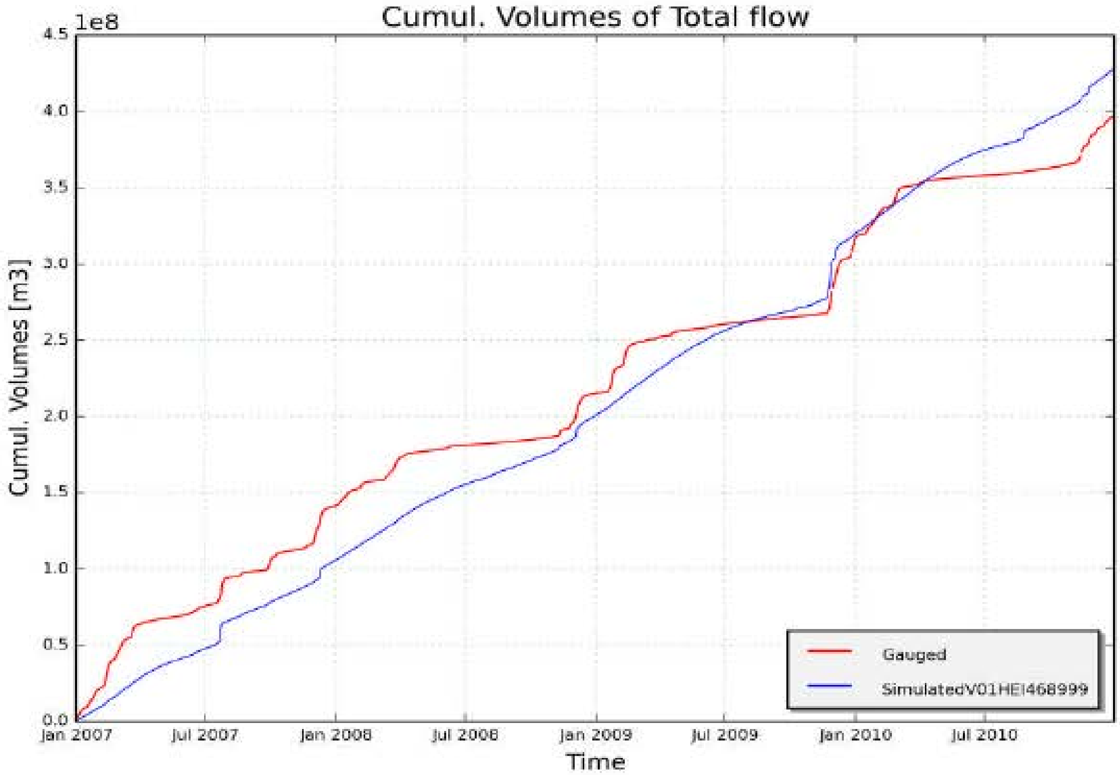


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01HEI468999, station 46810102 - Ijzer; Haringe (validation period)

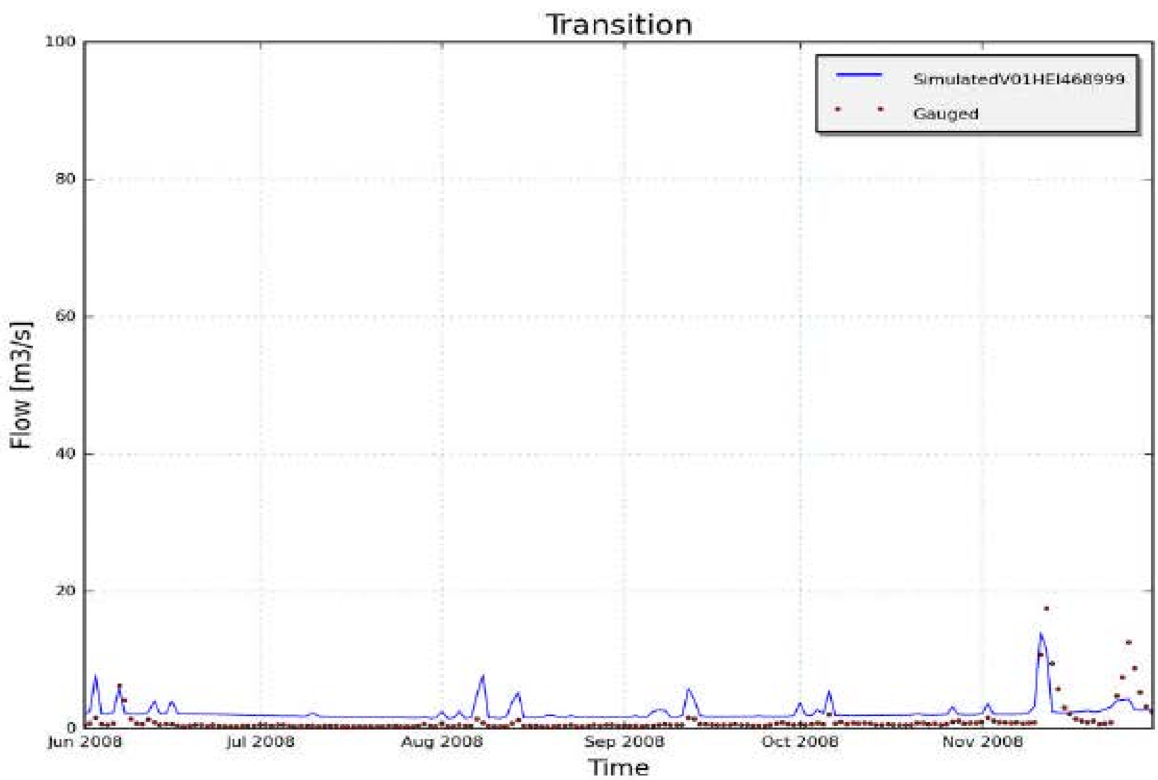


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01HEI468999, station 46810102 - Ijzer; Haringe

9.2.3 Calibration and validation of WET parameters for catchment "V01IEP495080" (IJzer)

9.2.3.1 Input data

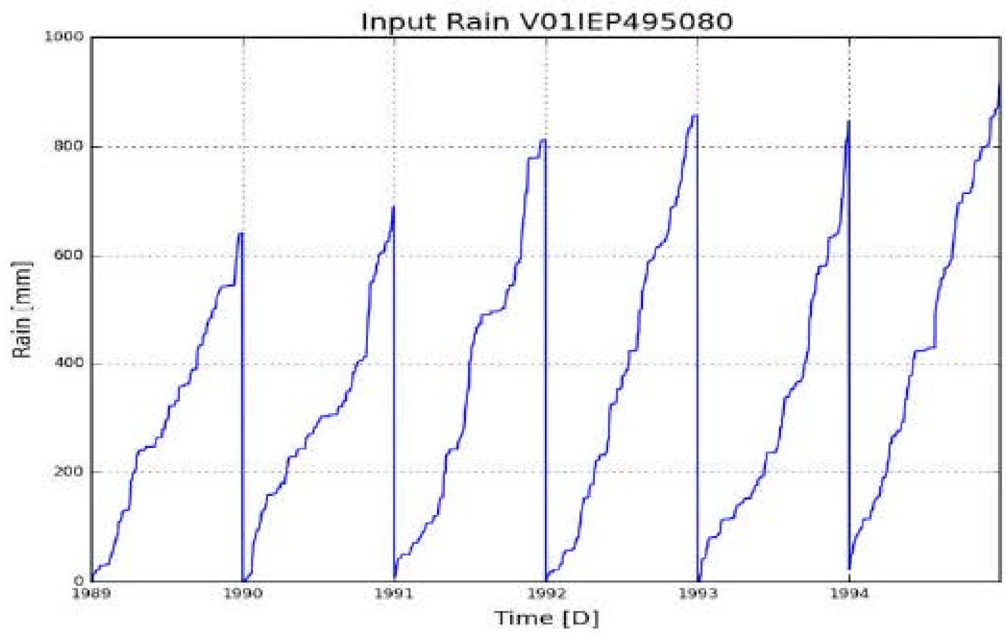


Figure 1: Cumulative precipitation on catchment V01IEP495080 (IJzer)

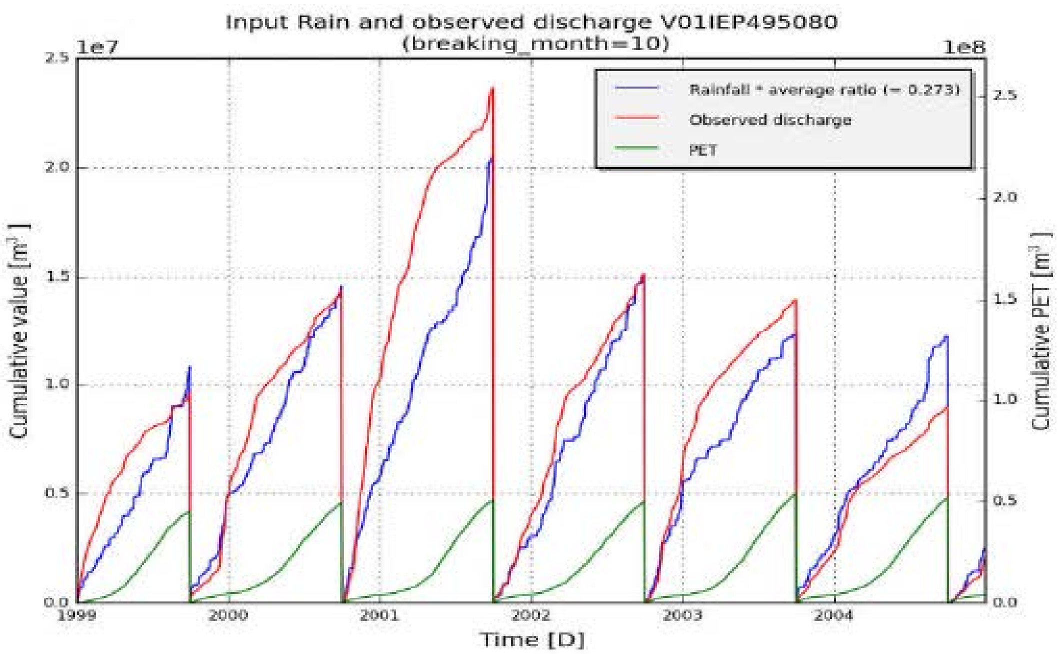


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V01IEP495080 (IJzer)

9.2.3.2 Model summary

model_structure WETSPAclassic.paramset1

subcatchment_name	V01IEP495080
subcatchment_area [m2]	63400000
Validation start_date	01-01-1990
Validation end_date	31-12-1994
frequency	daily

Optimal parameter set:[('Kep', 1.04), ('Ki', 25.29), ('Kg', 0.0), ('Kss', 0.76), ('g0', 3.6), ('g_max', 278.38), ('K_run', 13.92), ('P_max', 170.11)]

Table 1: Goodness of fit for calibration period (1999 - 2004)

	Full year	**Summer**	**Winter**
RelErr	-2.4 %	29.7 %	-17.5 %
NS	0.484	-1.315	0.611
NS_log	0.537	0.129	0.573
NS_rel	-0.837	-4.556	0.601
KGE	0.712	0.021	0.76

Table 2: Goodness of fit for validation period (1990 - 1994)

	Full year	**Summer**	**Winter**
RelErr	0.4 %	-2.7 %	-16.7 %
NS	0.441	0.519	0.398
NS_log	0.592	0.525	0.408
NS_rel	0.022	-1.063	0.163
KGE	0.716	0.741	0.675

9.2.3.3 Observed and simulated timeseries for optimum parameters

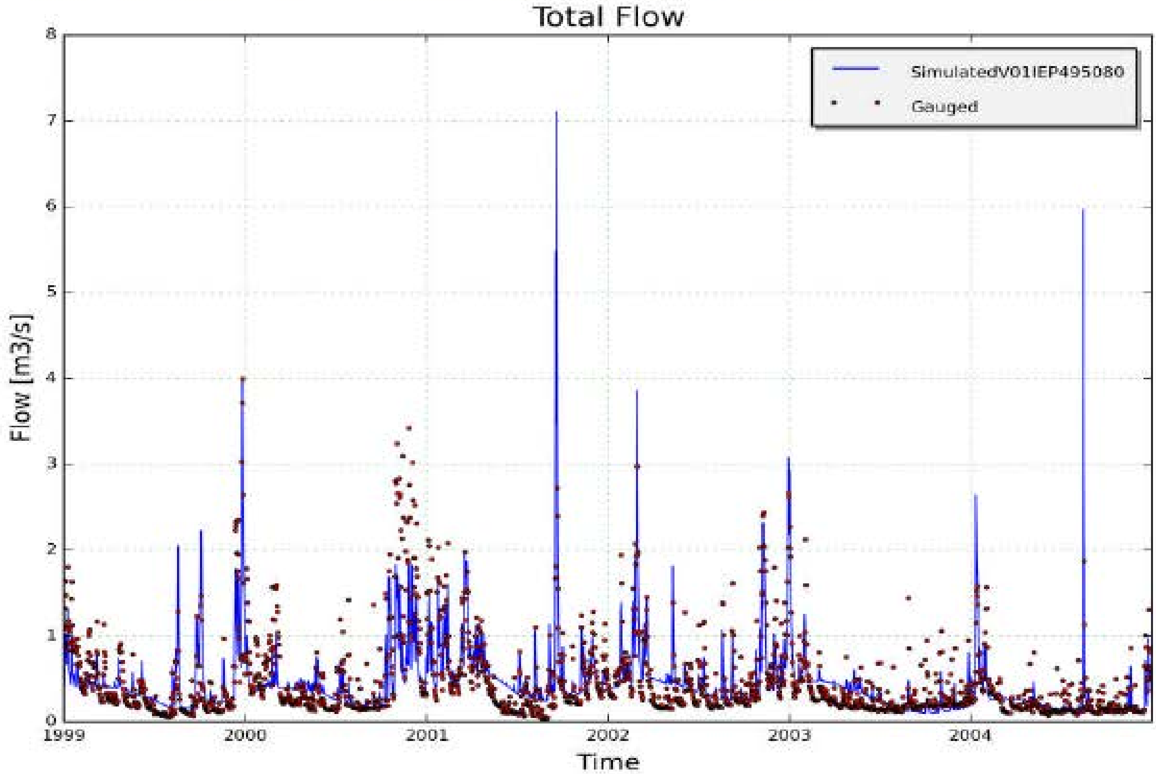


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote (calibration period)

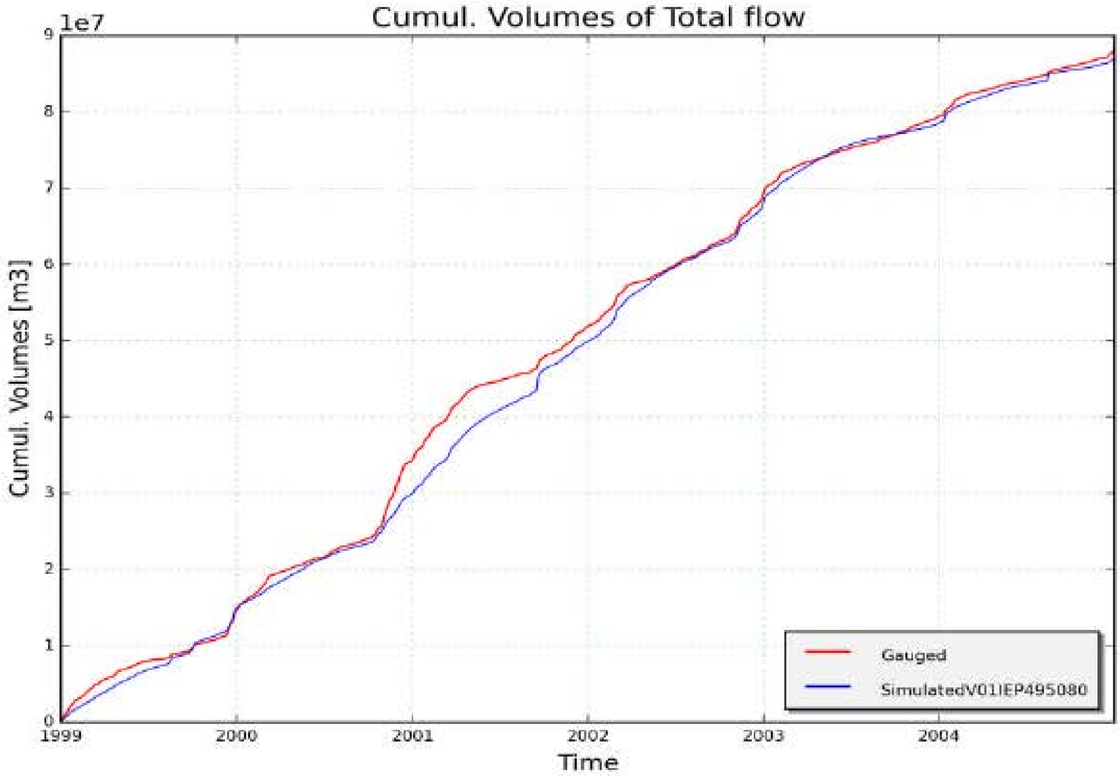


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote (calibration period)

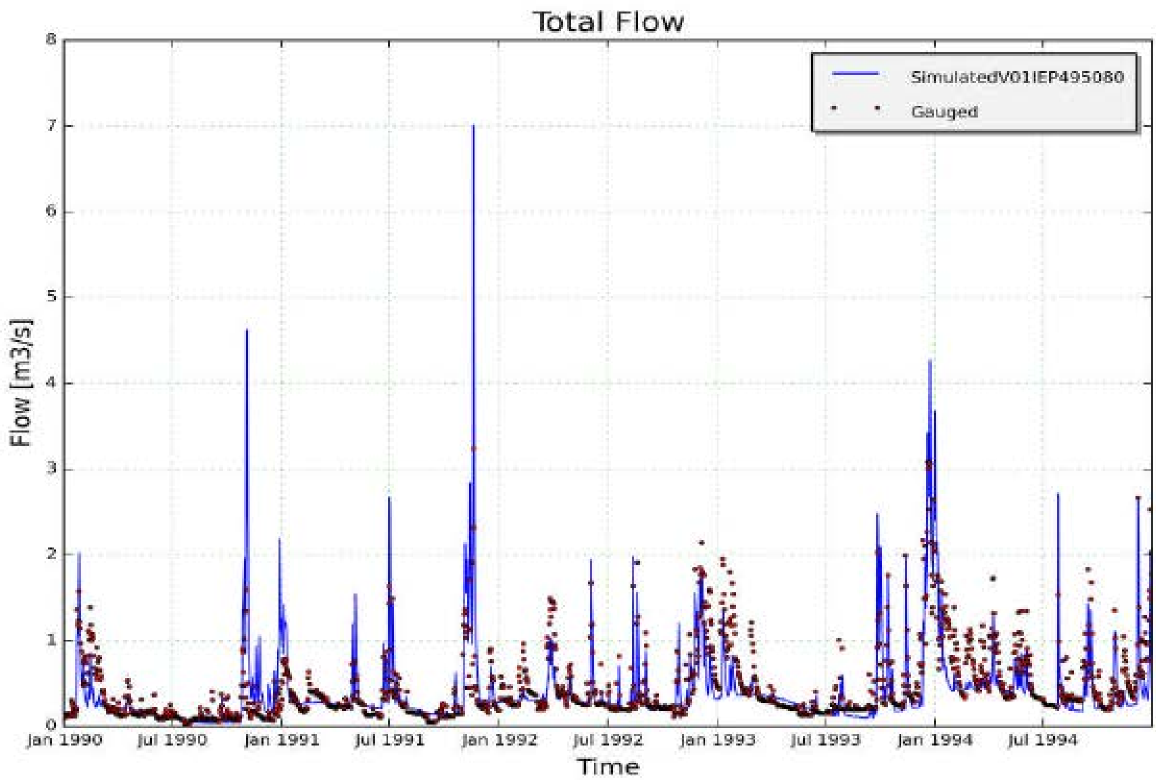


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote (validation period)

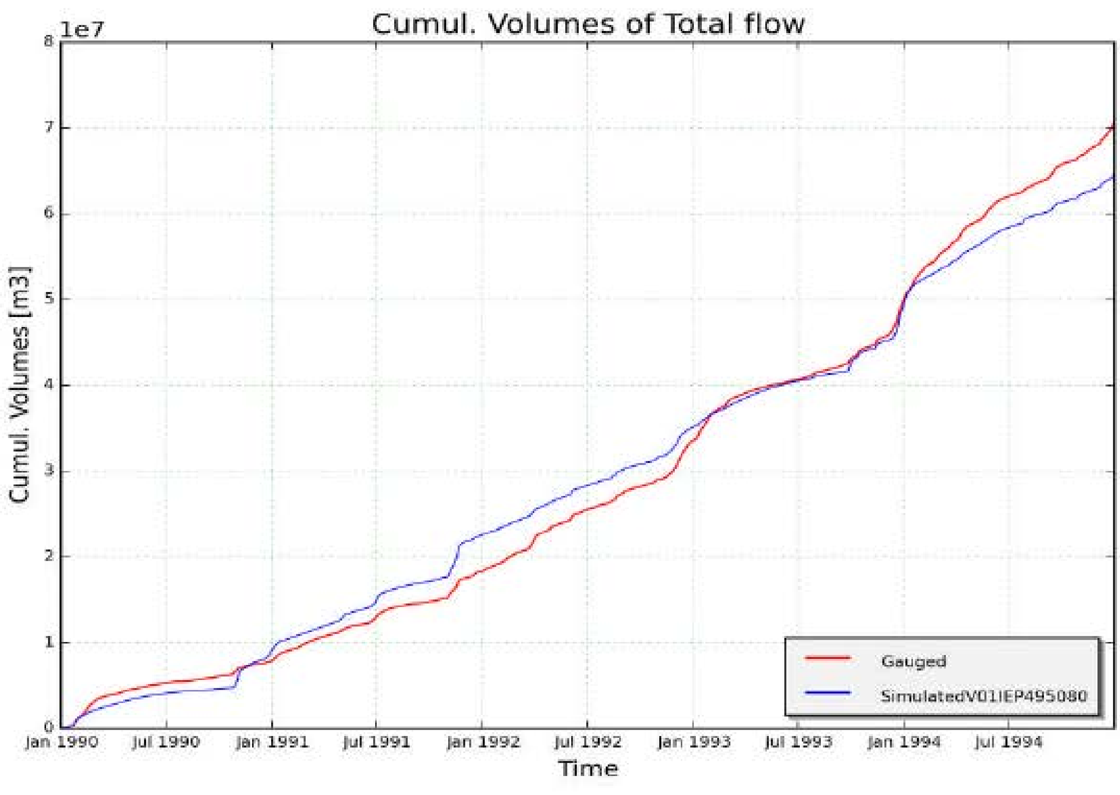


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote (validation period)

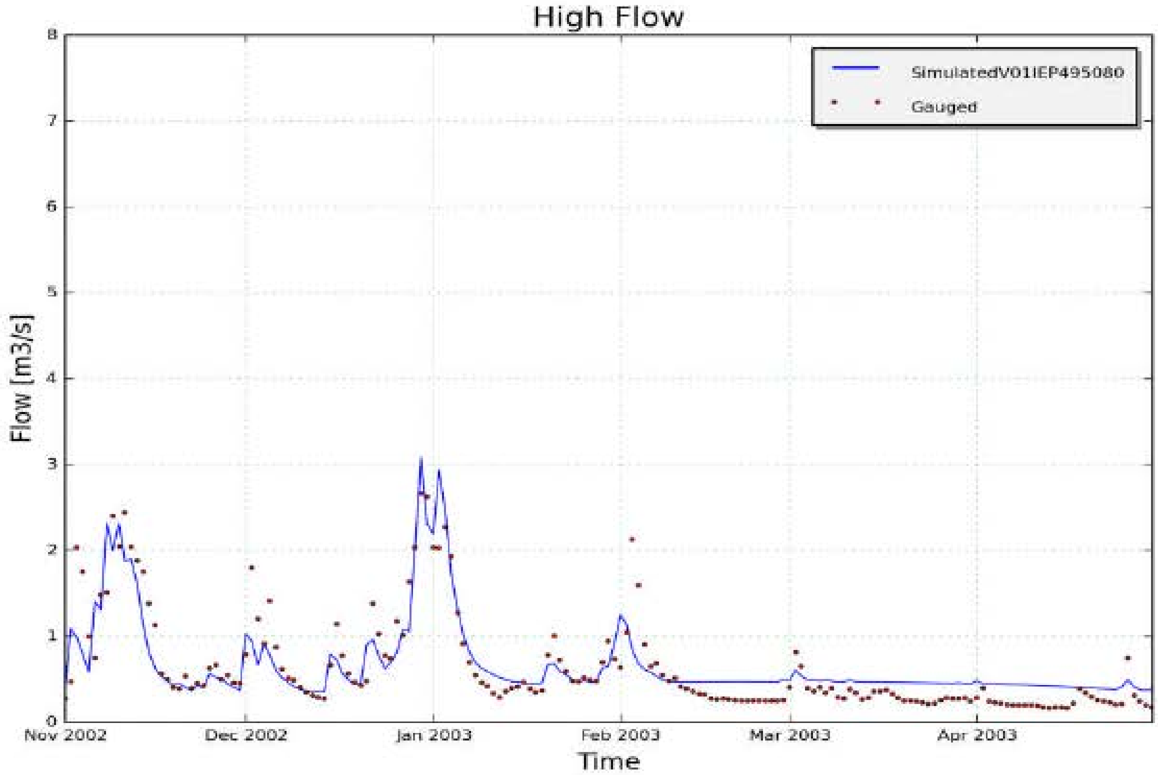


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote

9.2.4 Calibration and validation of WET parameters for catchment "V01KEM492060" (IJzer)

9.2.4.1 Input data

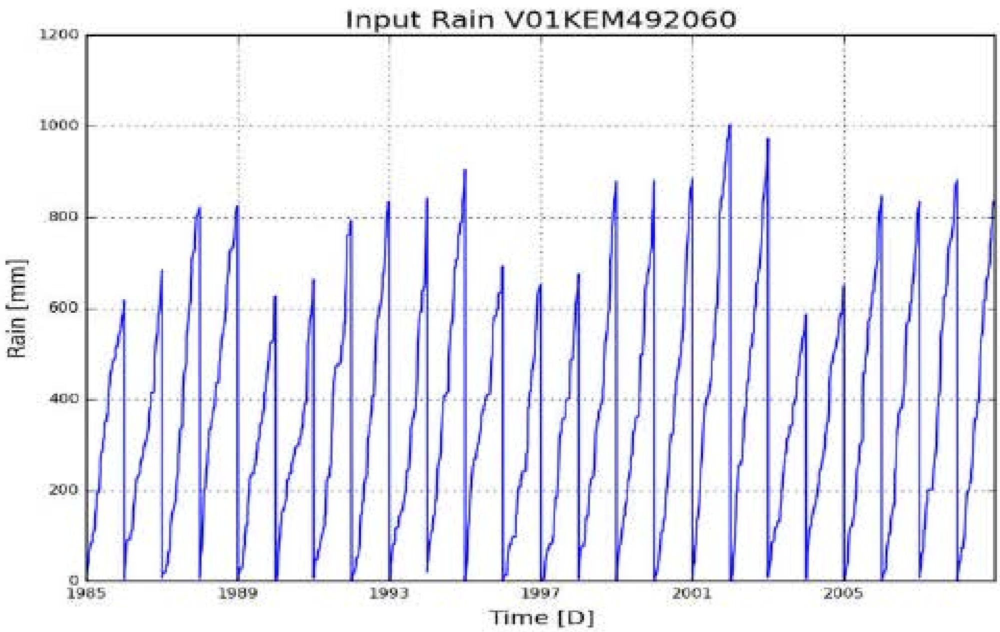


Figure 1: Cumulative precipitation on catchment V01KEM492060 (IJzer)

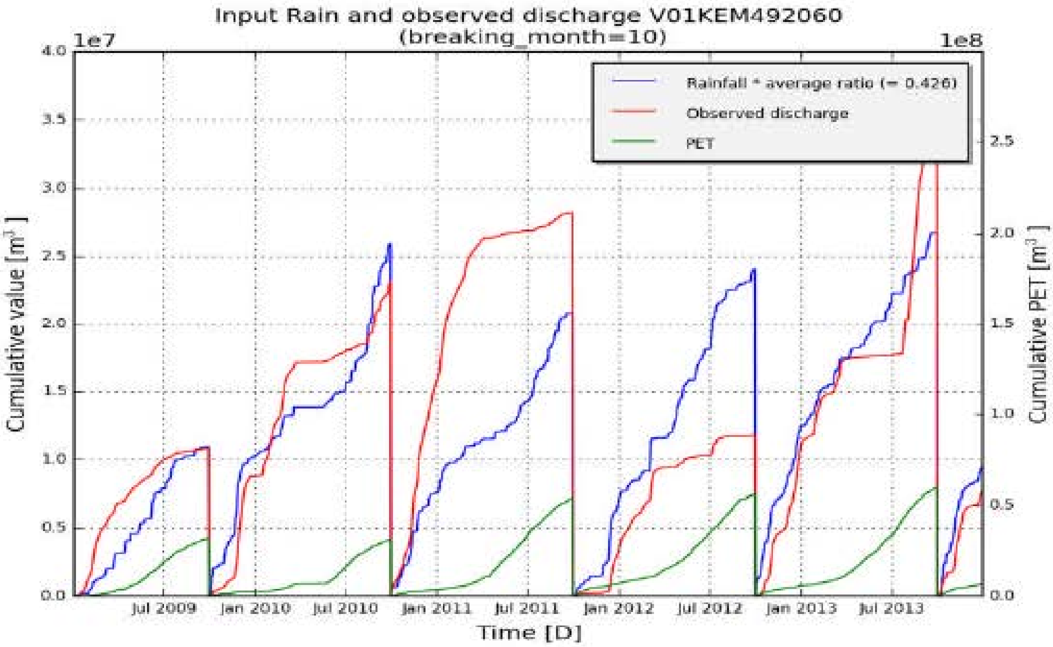


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V01KEM492060 (IJzer)

9.2.4.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V01KEM492060
subcatchment_area [m2]	73900000
Validation start_date	01-01-1986
Validation end_date	31-12-2008
frequency	daily

Optimal parameter set:[('Kep', 1.44), ('Ki', 146.2), ('Kg', 0.03), ('Kss', 1.51), ('g0', 92.03), ('g_max', 81.14), ('K_run', 4.3), ('P_max', 156.2)]

Table 1: Goodness of fit for calibration period (2009 - 2013)

	Full year	Summer	Winter
RelErr	-6.6 %	-42.3 %	3.1 %
NS	0.238	-0.153	0.176
NS_log	0.356	0.039	-0.107
NS_rel	-34.189	-5.859	-8.012

	Full year	Summer	Winter
KGE	0.352	-0.383	0.214

Table 2 :Goodness of fit for validation period (1986 - 2008)

	Full year	Summer	Winter
RelErr	-2.6 %	-36.9 %	8.8 %
NS	0.419	0.131	0.369
NS_log	0.47	0.239	0.109
NS_rel	-0.747	-0.169	-1.331
KGE	0.436	0.294	0.29

9.2.4.3 Observed and simulated timeseries for optimum parameters

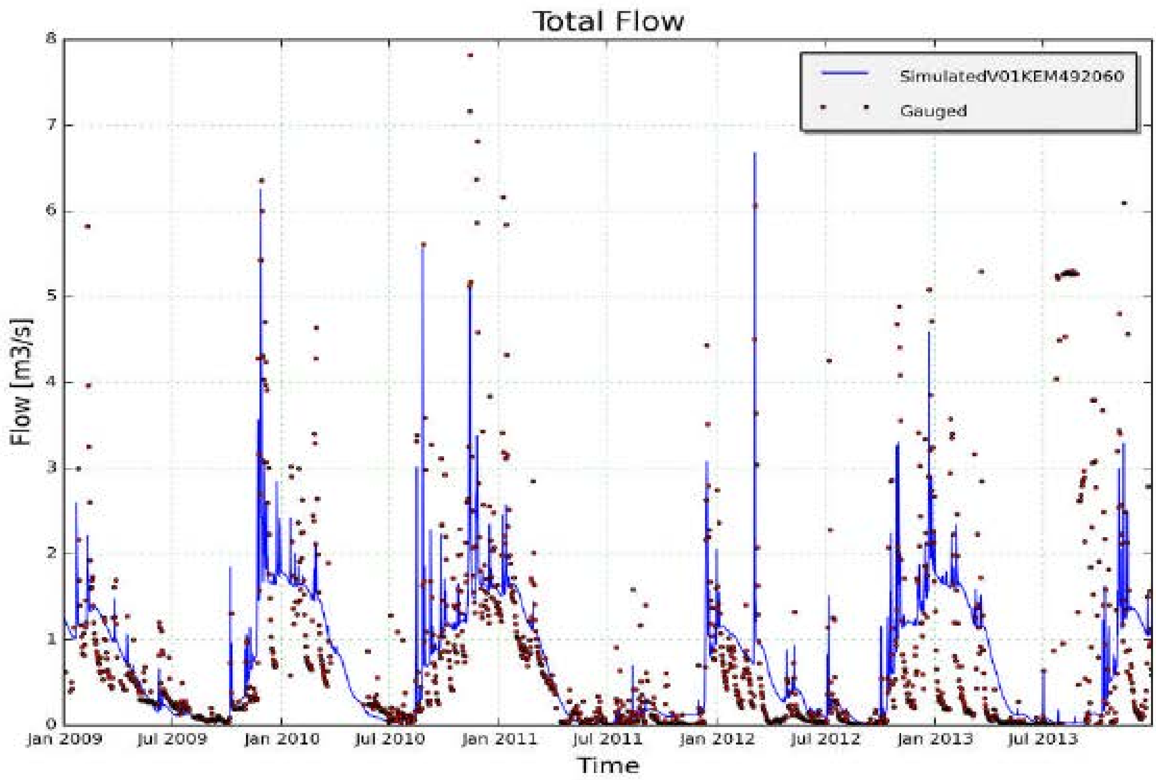


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01KEM492060, station 49270102 - Kemmelbeek; Boezinge(calibration period)

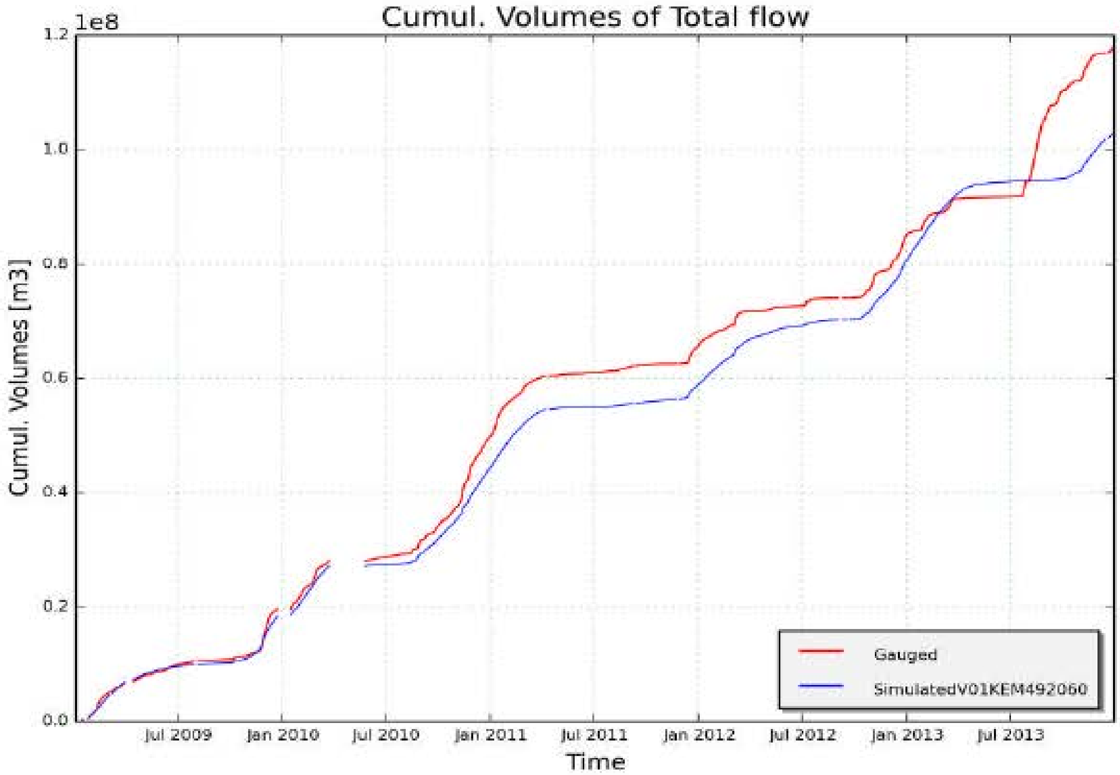


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01KEM492060, station 49270102 - Kemmelbeek; Boezinge (calibration period)

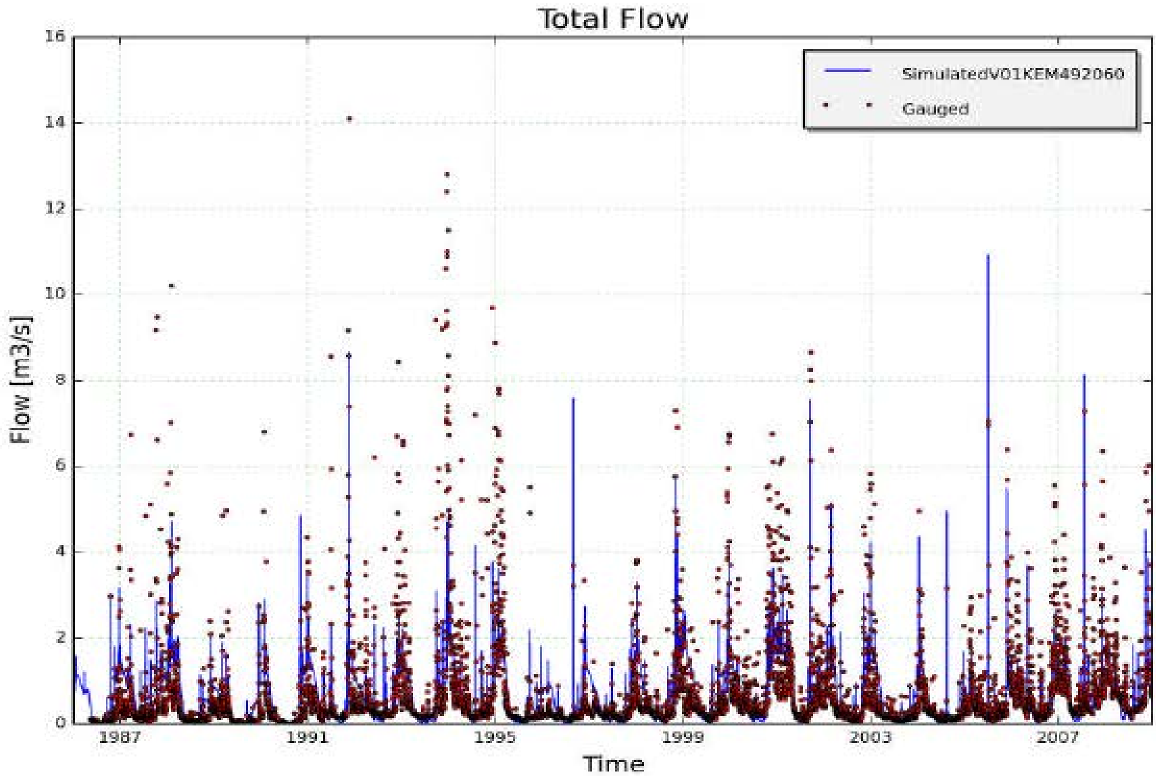


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01KEM492060, station 49270102 - Kemmelbeek; Boezinge (validation period)

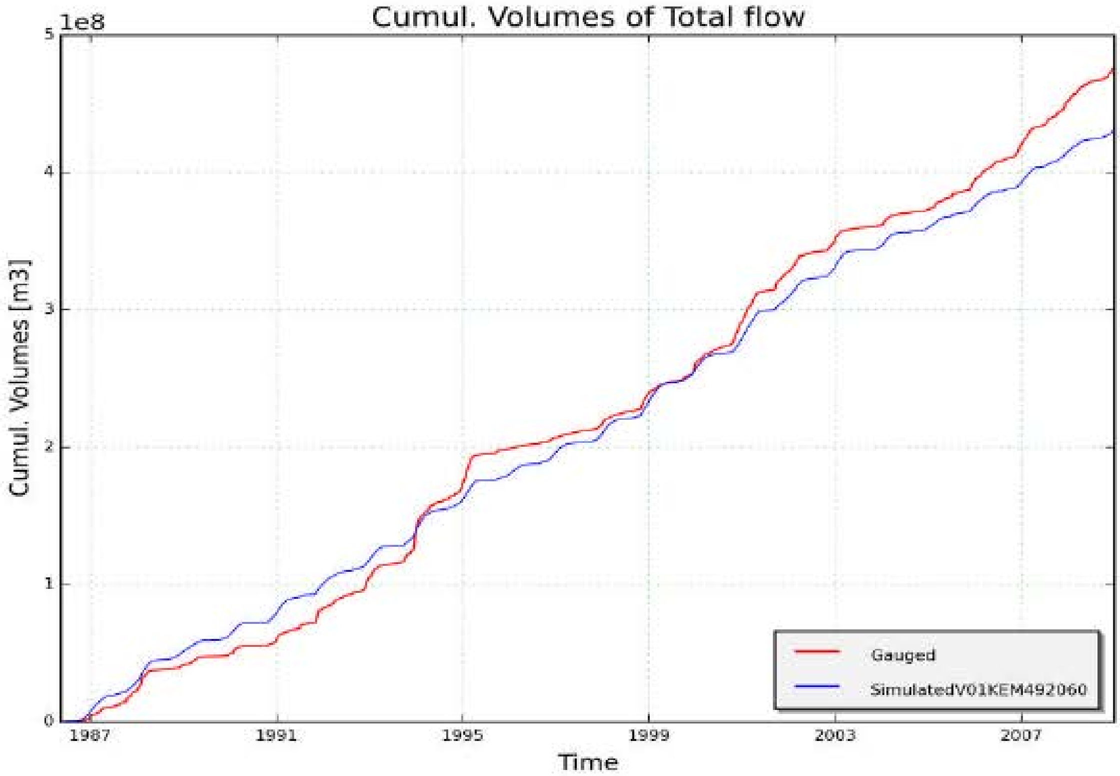


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01KEM492060, station 49270102 - Kemmelbeek; Boezinge (validation period)

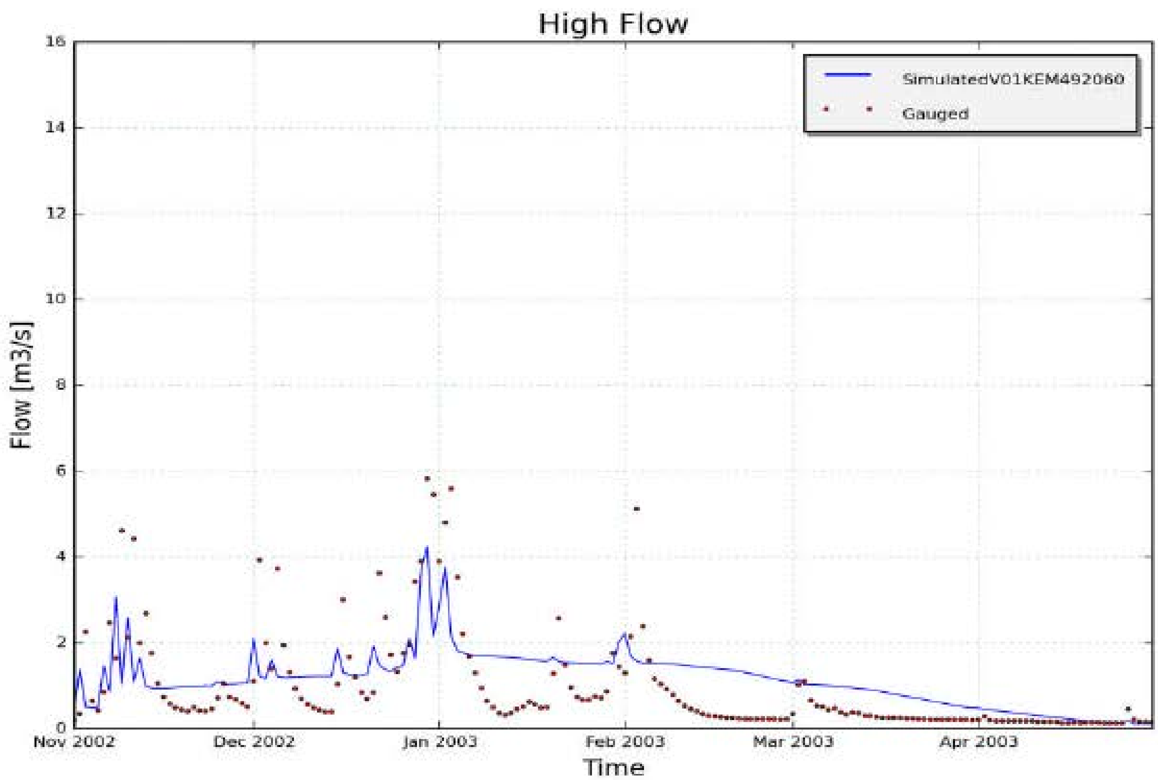


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01KEM492060, station 49270102 -Kemmelbeek; Boezinge

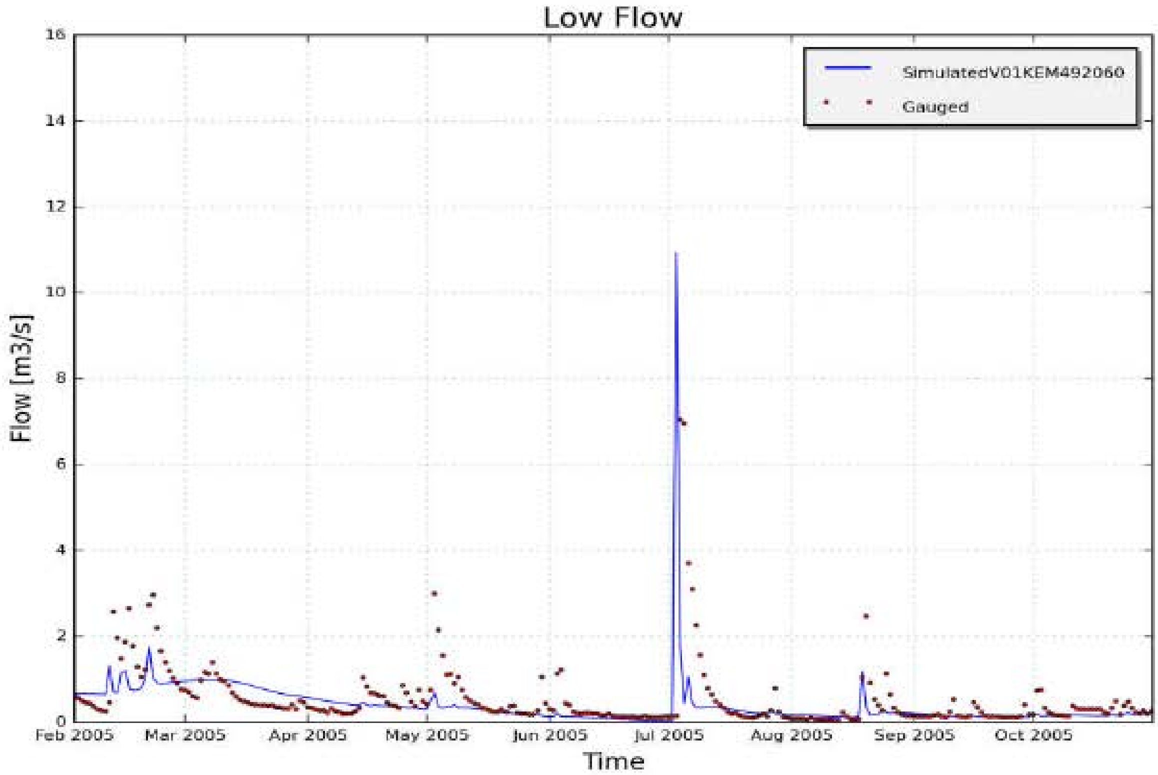


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01KEM492060, station 49270102 -Kemmelbeek; Boezinge

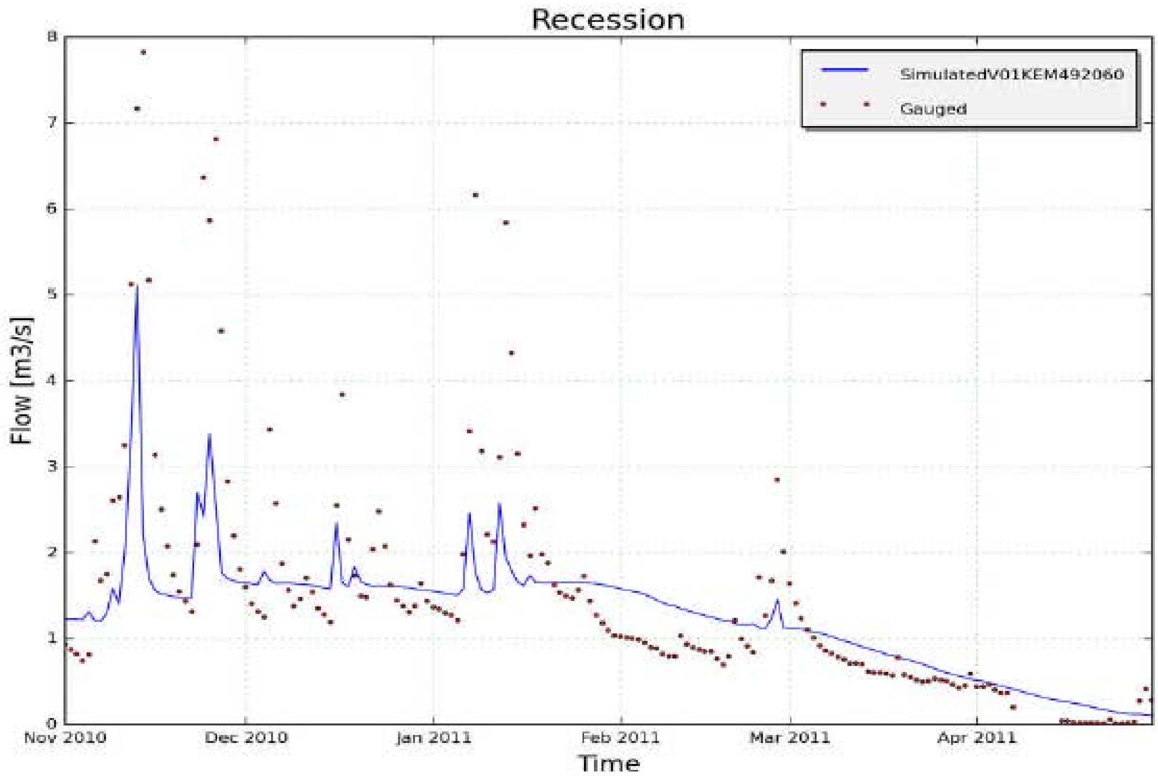


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01KEM492060, station 49270102 -Kemmelbeek; Boezinge

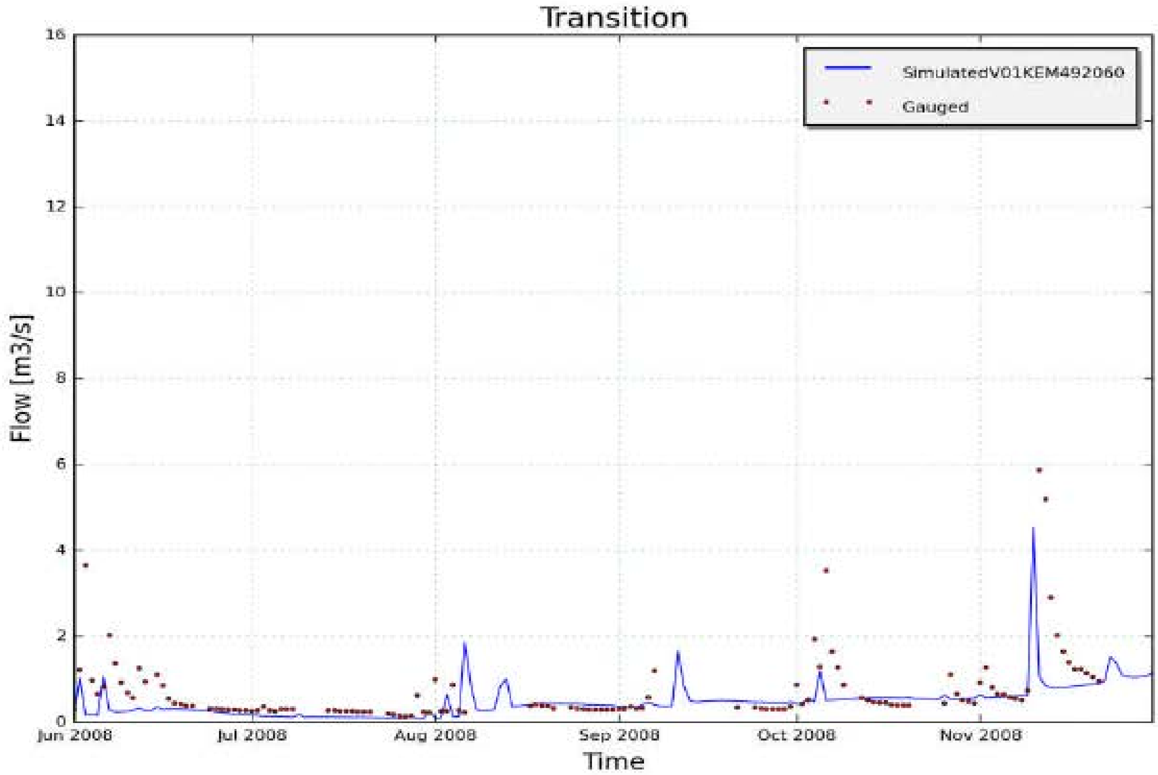


Figure 10: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01KEM492060, station 49270102 -Kemmelbeek; Boezinge

9.2.5 Calibration and validation of WET parameters for catchment "V01MAR496120" (IJzer)

9.2.5.1 Input data

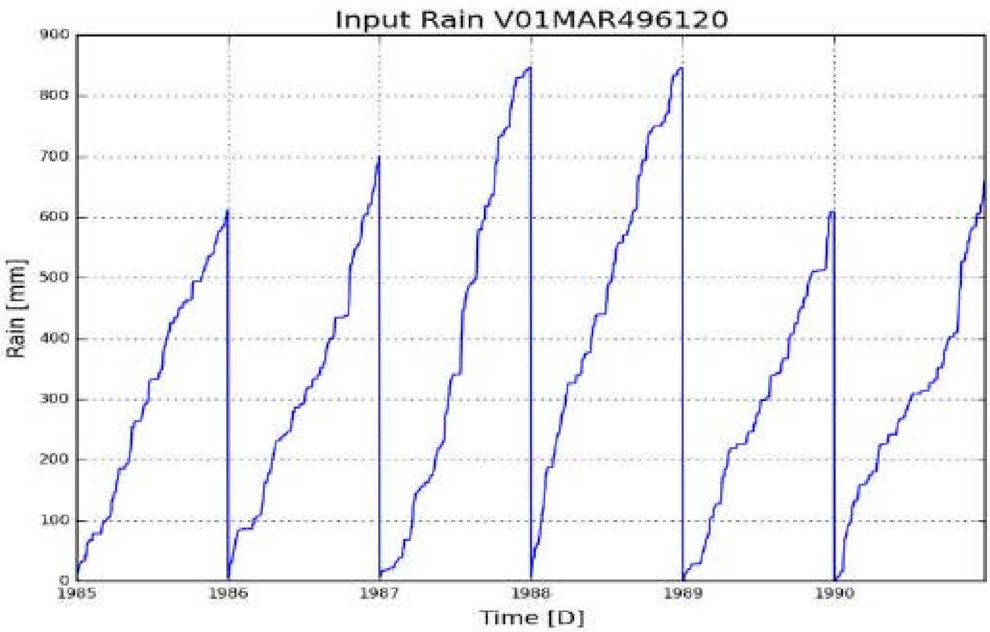


Figure 1: Cumulative precipitation on catchment V01MAR496120 (IJzer)

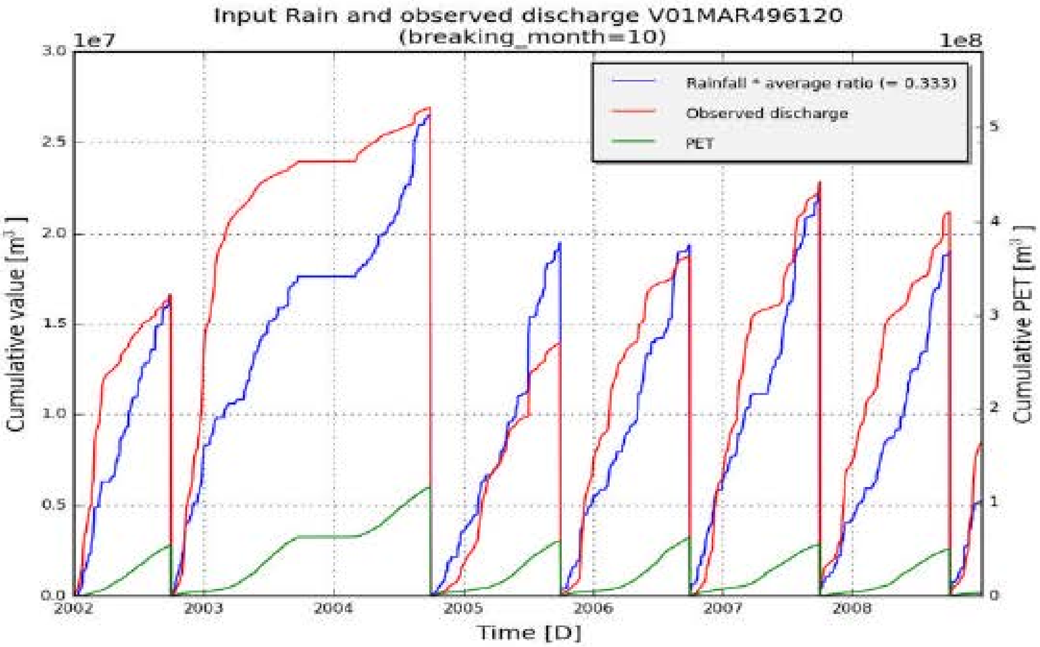


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V01MAR496120 (IJzer)

9.2.5.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V01MAR496120
subcatchment_area [m2]	76100000
Validation start_date	01-01-1986
Validation end_date	31-12-1990
frequency	daily

Optimal parameter set:[('Kep', 3.15), ('Ki', 29.96), ('Kg', 0.06), ('Kss', 1.2), ('g0', 68.51), ('g_max', 580.9), ('K_run', 8.4), ('P_max', 480.6)]

Table 1: Goodness of fit for calibration period (2002 - 2008)

	Full year	Summer	Winter
RelErr	0.7 %	4.8 %	13.3 %
NS	-0.052	-1.984	0.147
NS_log	0.401	-0.065	-0.082
NS_rel	-27.892	-48.94	-1.196

	Full year	Summer	Winter
KGE	0.437	-0.023	0.373

Table 2 :Goodness of fit for validation period (1986 - 1990)

	Full year	Summer	Winter
RelErr	-1.0 %	-33.9 %	1.0 %
NS	0.358	0.586	0.3
NS_log	0.585	0.679	0.054
NS_rel	-2.278	0.781	-4.12
KGE	0.528	0.367	0.392

9.2.5.3 Observed and simulated timeseries for optimum parameters

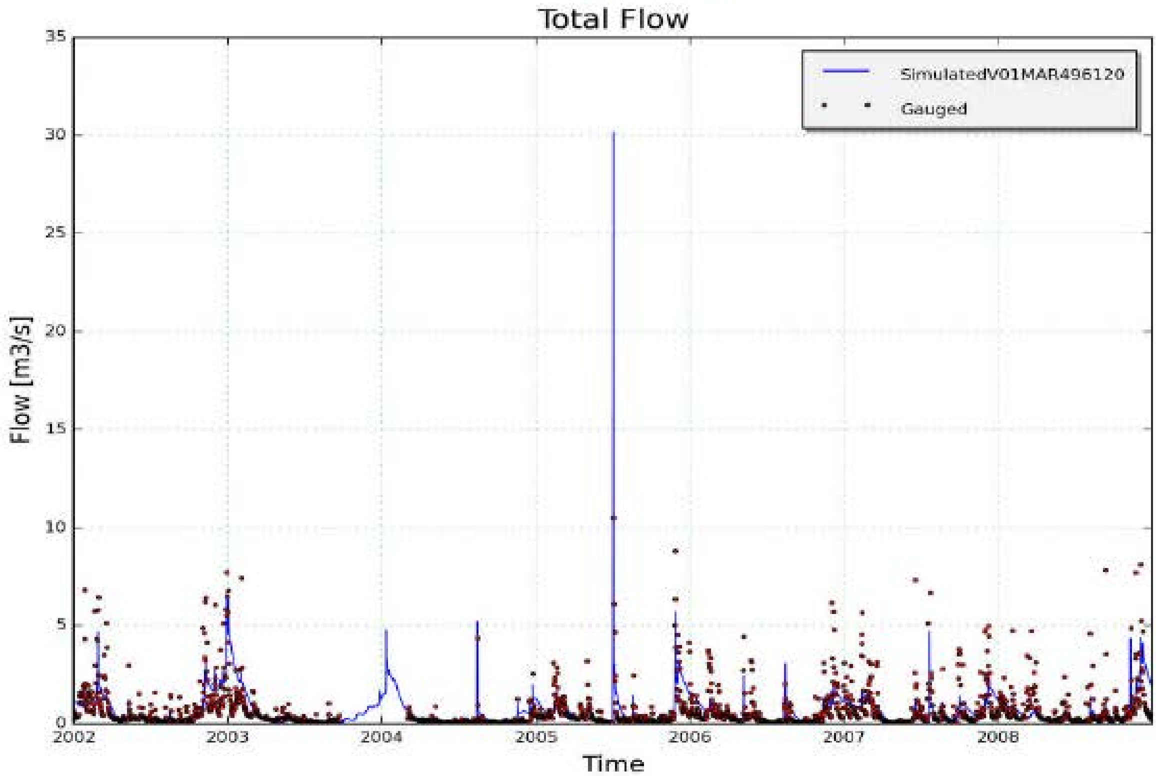


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem(calibration period)

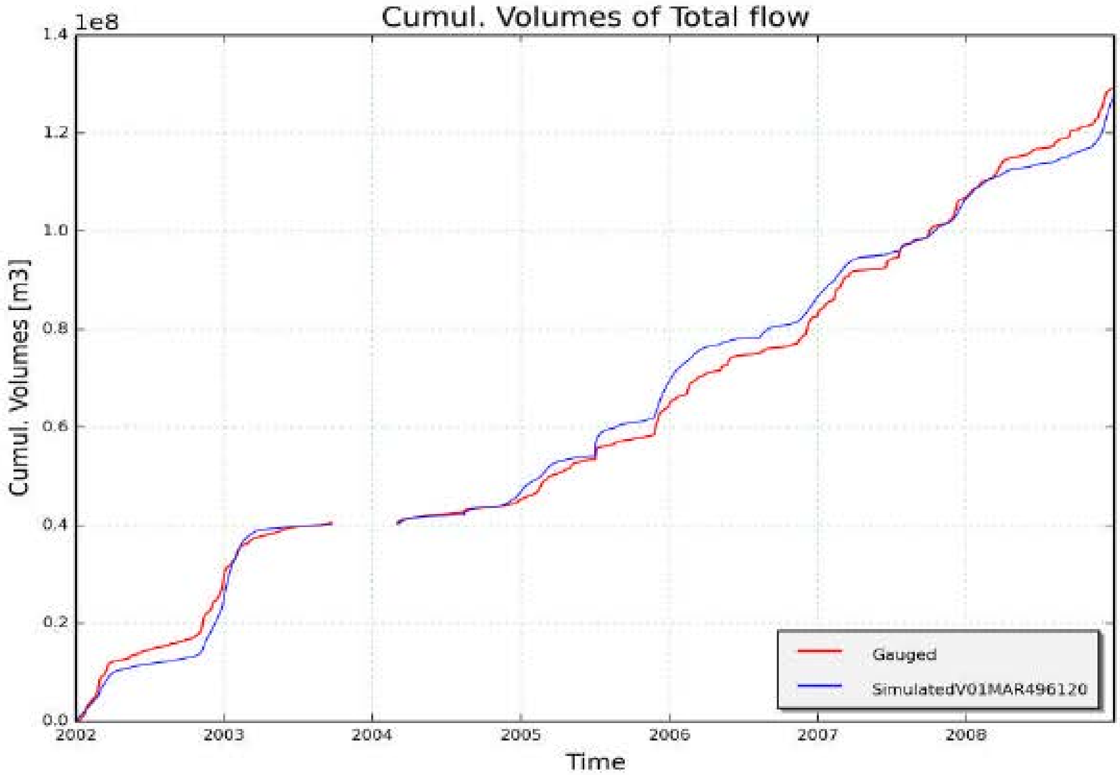


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem (calibration period)

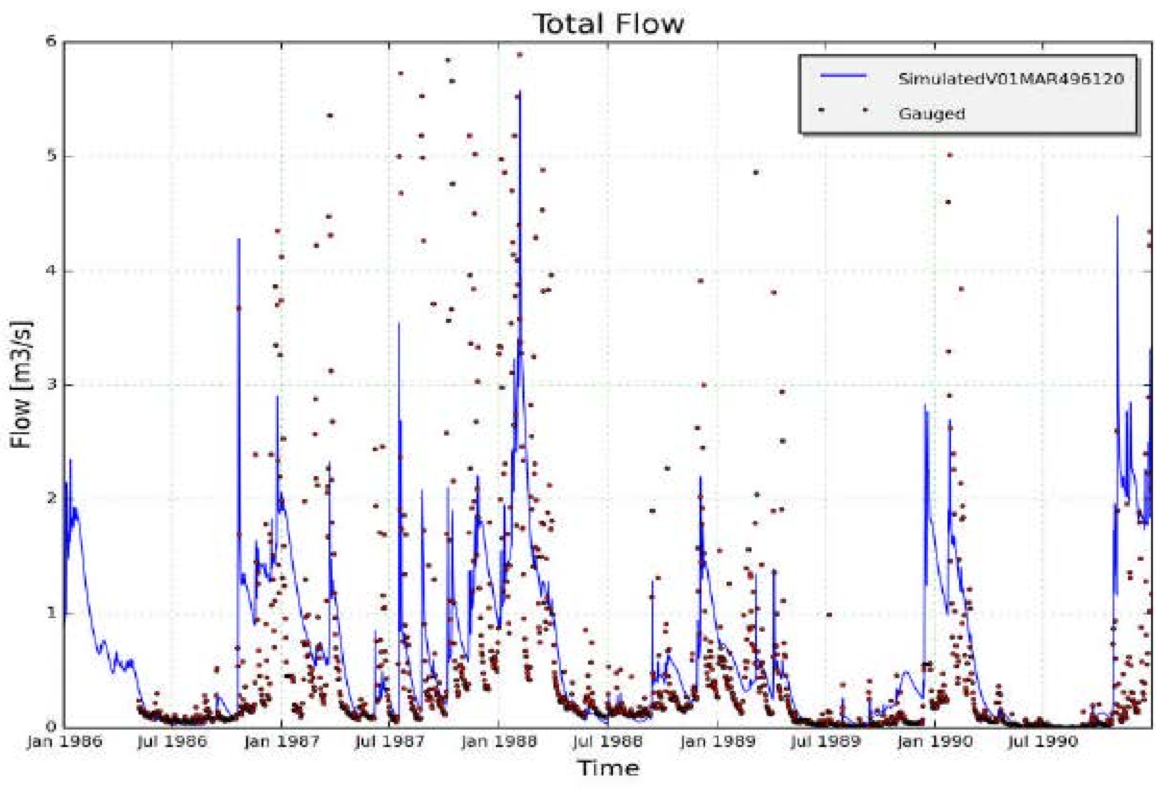


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem (validation period)

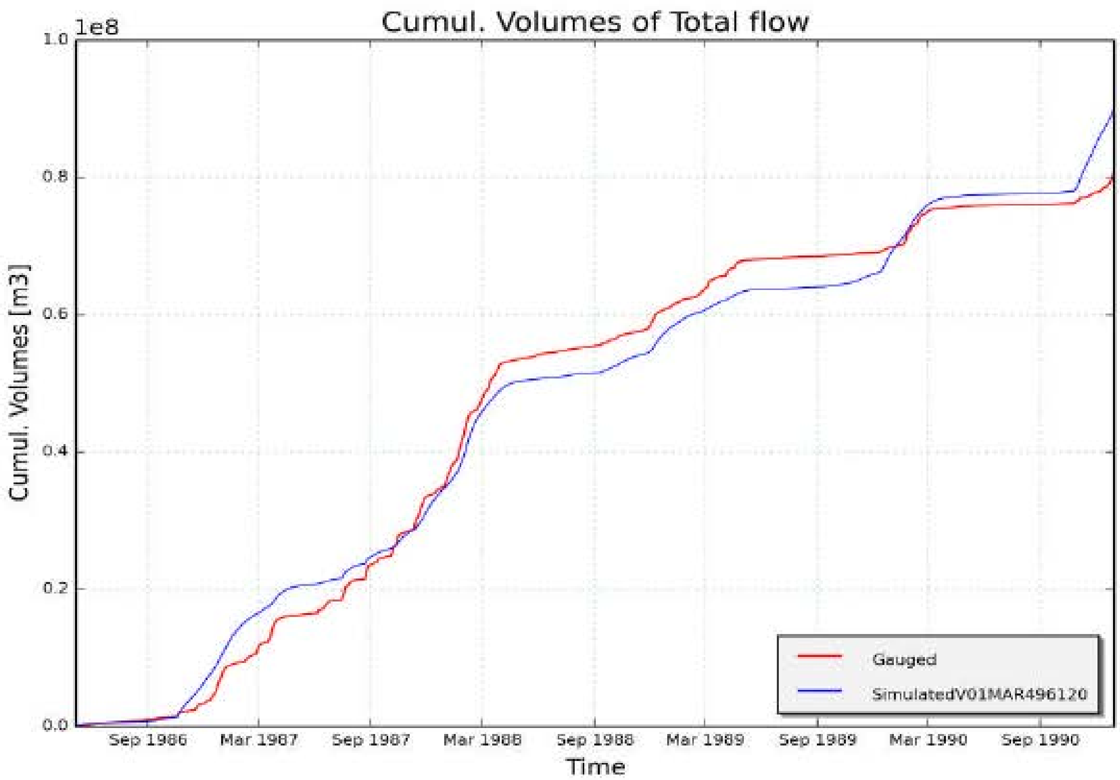


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem (validation period)

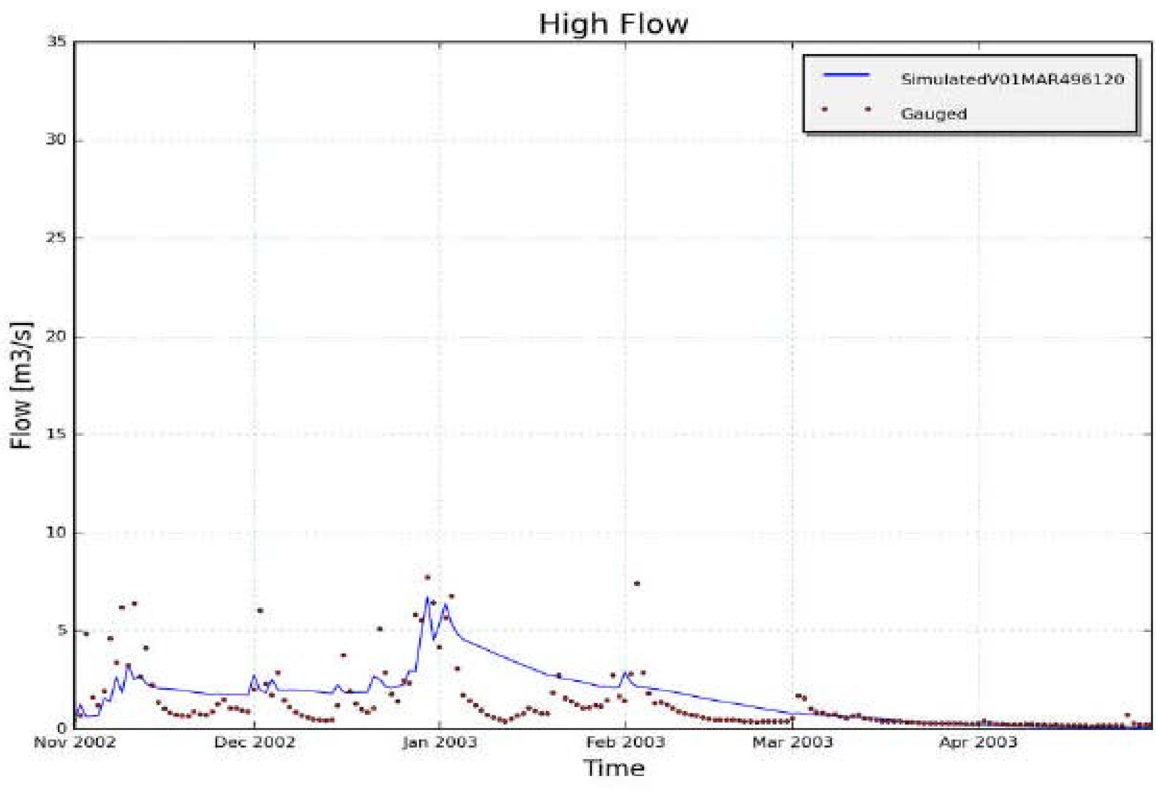


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem

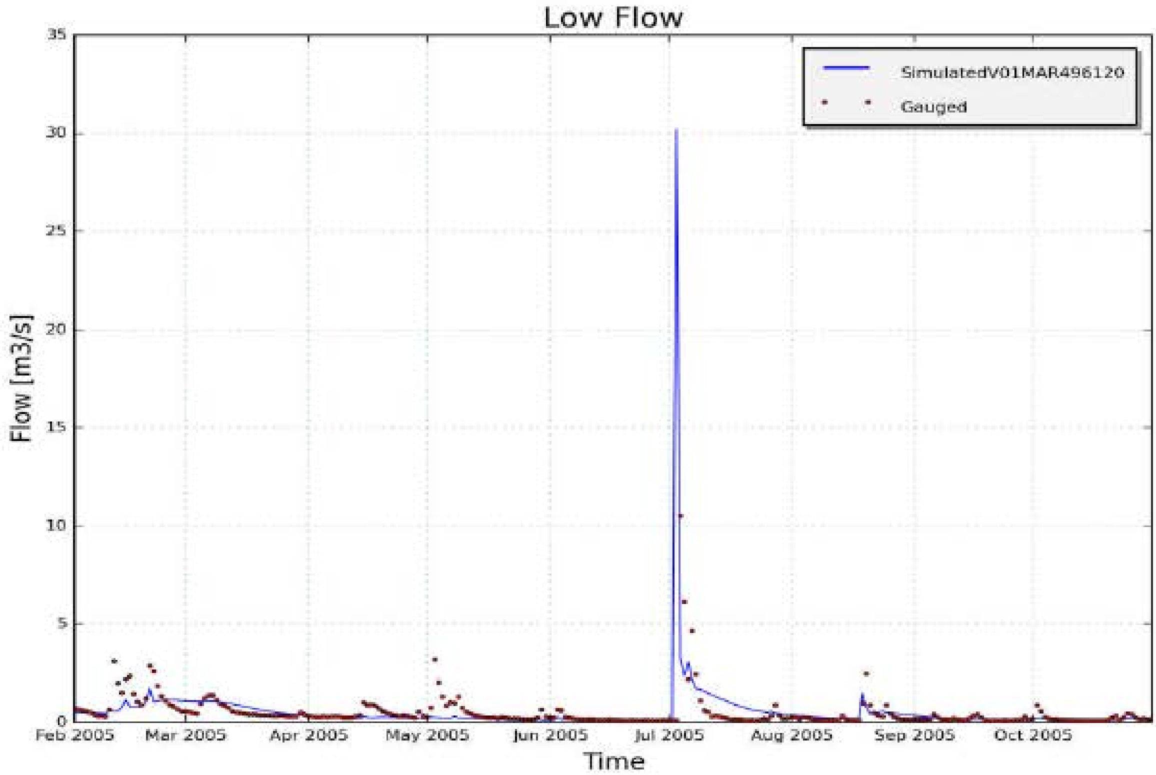


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem

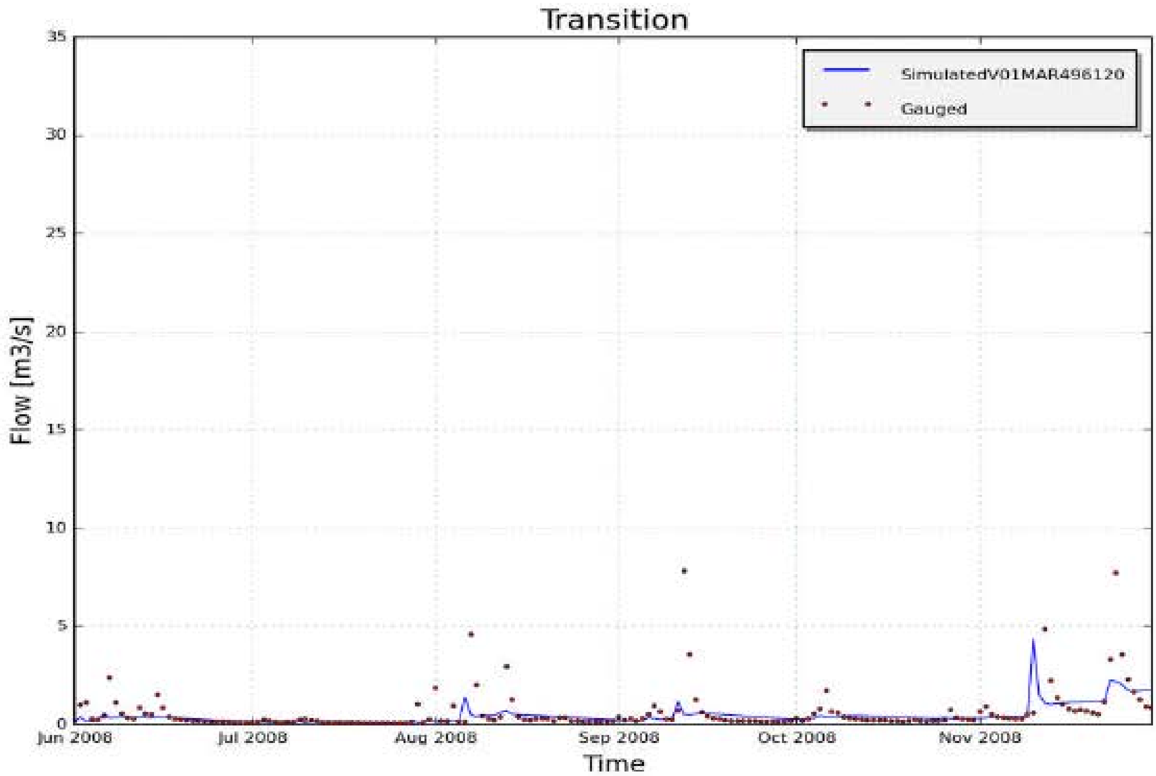


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem

9.2.6 Calibration and validation of WET parameters for catchment "V01POP491030" (IJzer)

9.2.6.1 Input data

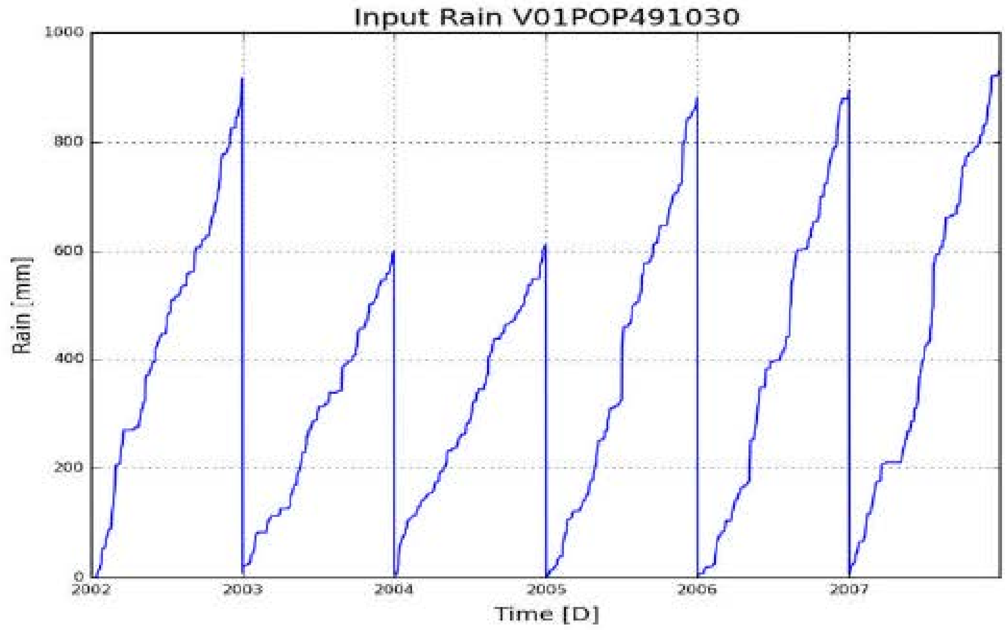


Figure 1: Cumulative precipitation on catchment V01POP491030 (IJzer)

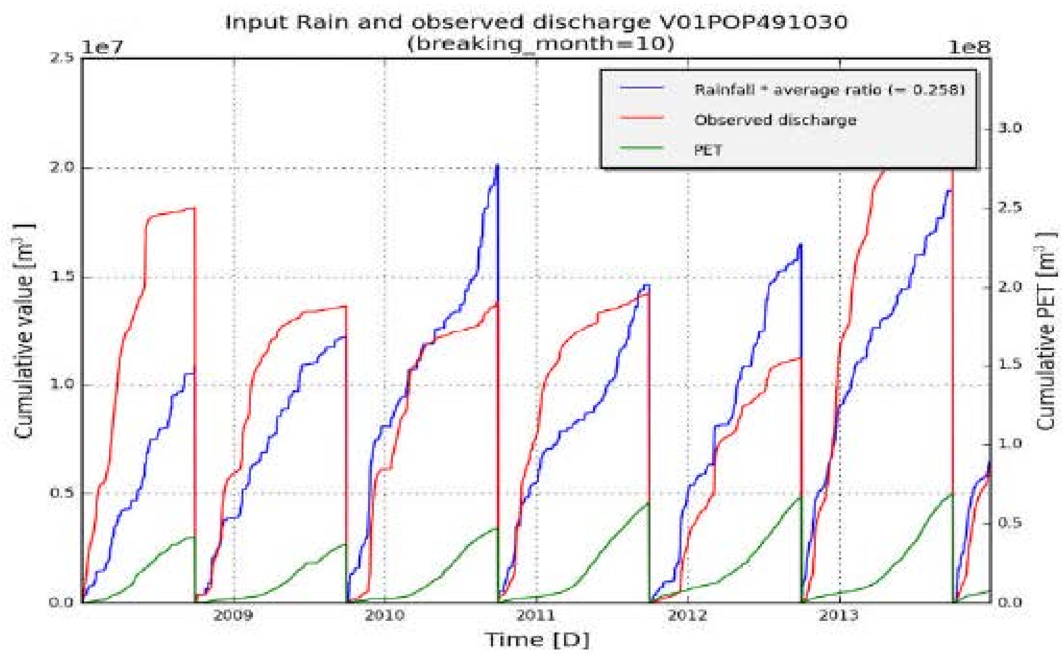


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V01POP491030 (IJzer)

9.2.6.2 Model summary

model_structure WETSPAclassic.paramset1

subcatchment_name	V01POP491030
subcatchment_area [m2]	84868207
Validation start_date	01-01-2003
Validation end_date	31-12-2007
frequency	daily

Optimal parameter set:[('Kep', 2.84), ('Ki', 103.26), ('Kg', 0.08), ('Kss', 2.15), ('g0', 157.9), ('g_max', 4499.93), ('K_run', 0.1), ('P_max', 244.72)]

Table 1: Goodness of fit for calibration period (2008 - 2013)

	Full year	**Summer**	**Winter**
RelErr	-5.3 %	152.8 %	-7.4 %
NS	0.077	-5.116	0.052
NS_log	0.326	-1.202	-0.128
NS_rel	-7.409	-27.87	-1.358
KGE	0.306	-0.974	0.178

Table 2 :Goodness of fit for validation period (2003 - 2007)

	Full year	**Summer**	**Winter**
RelErr	6.4 %	64.4 %	-11.0 %
NS	0.007	-0.574	0.095
NS_log	0.314	-0.05	0.157
NS_rel	-22.756	-29.294	-0.532
KGE	0.238	0.13	0.13

9.2.6.3 Observed and simulated timeseries for optimum parameters

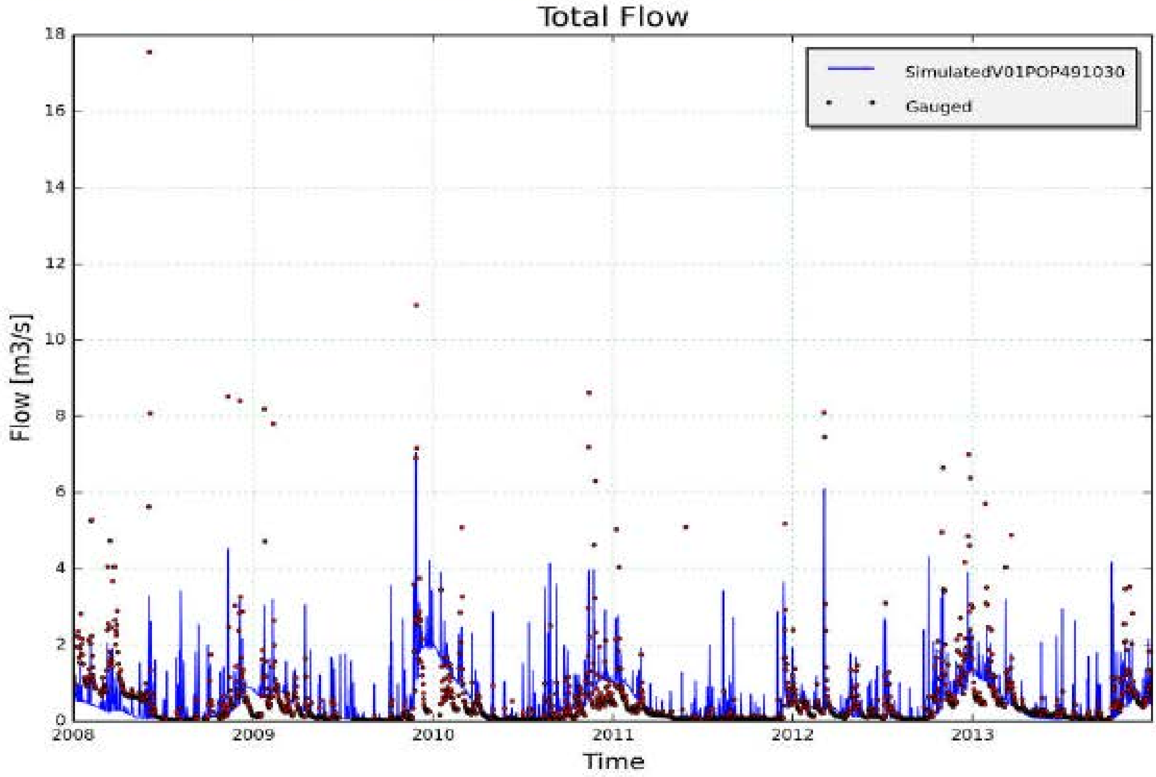


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren(calibration period)

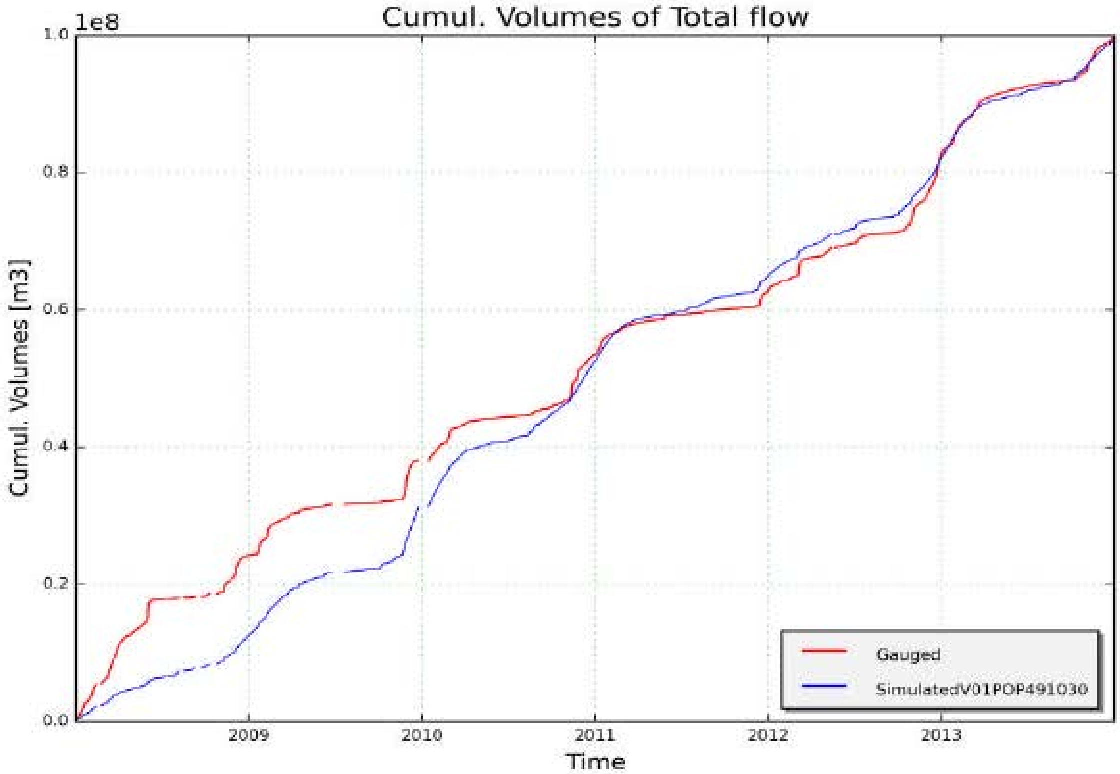


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren (calibration period)

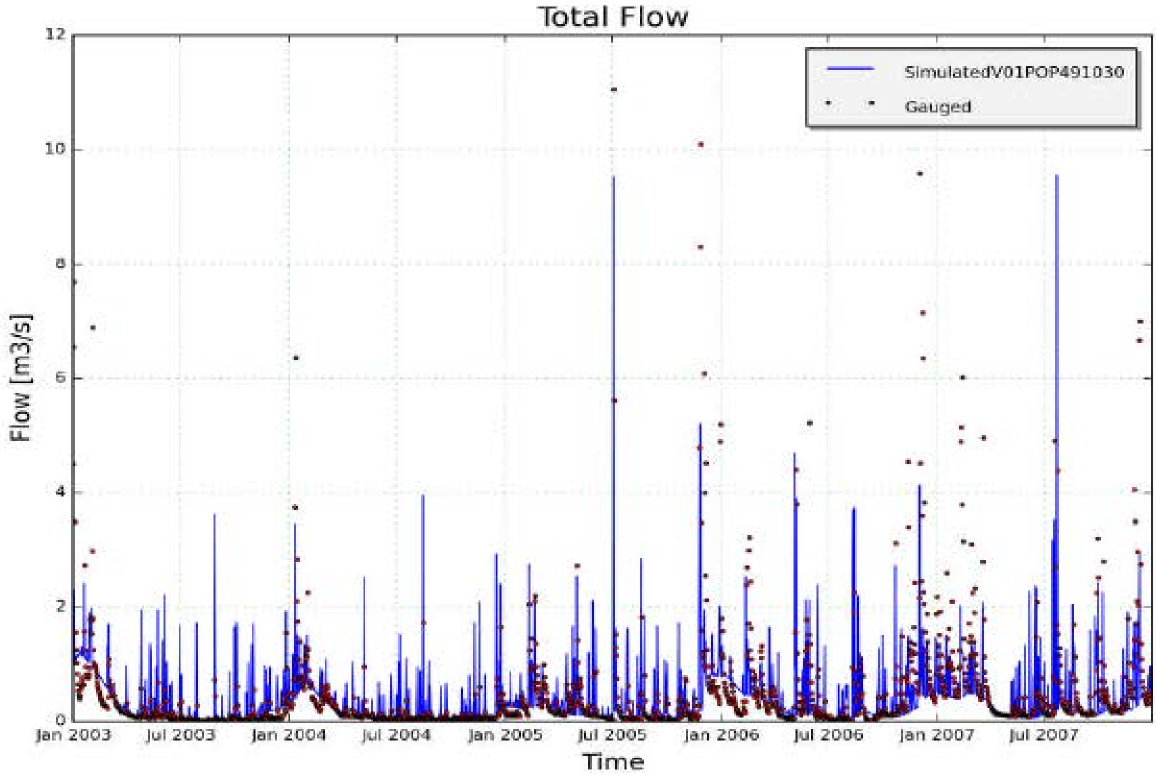


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren (validation period)

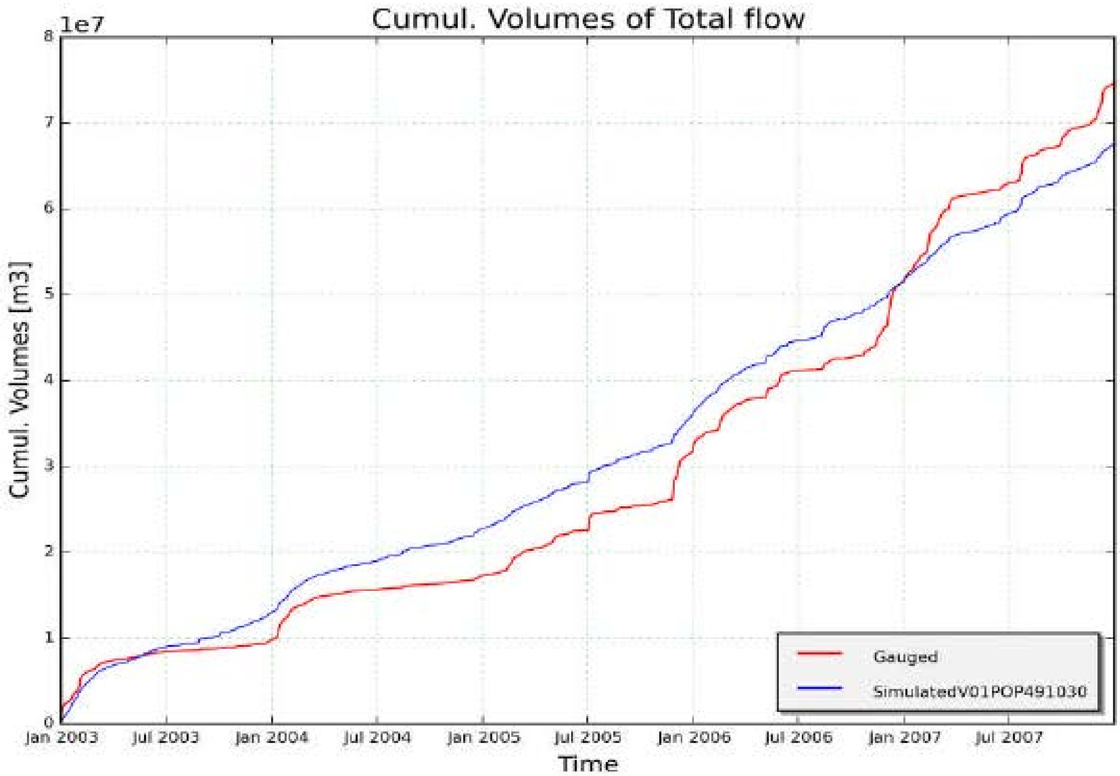


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren (validation period)

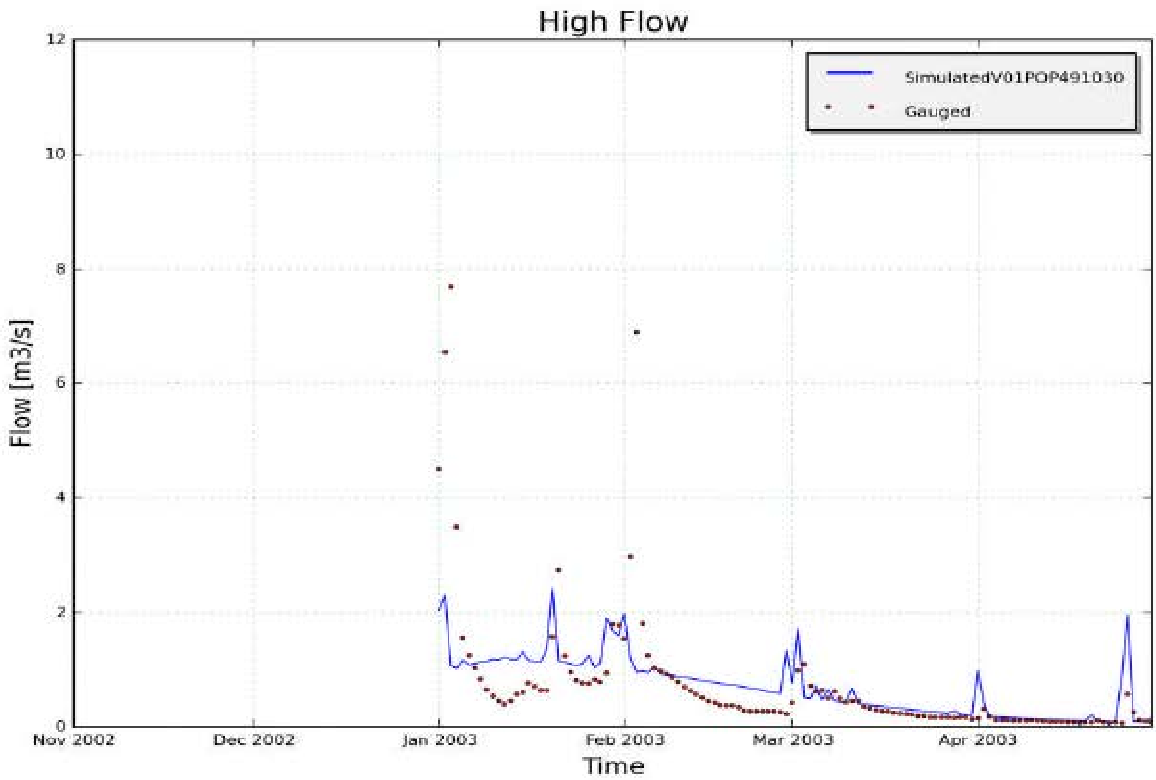


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren

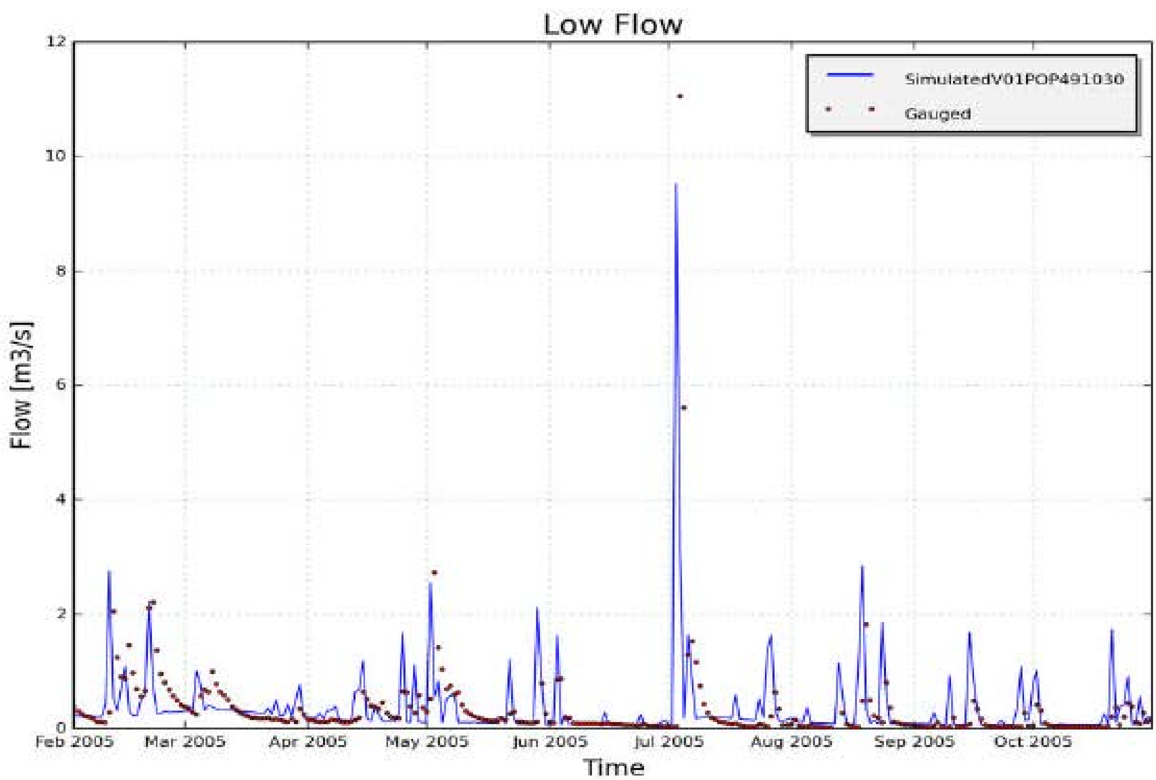


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren

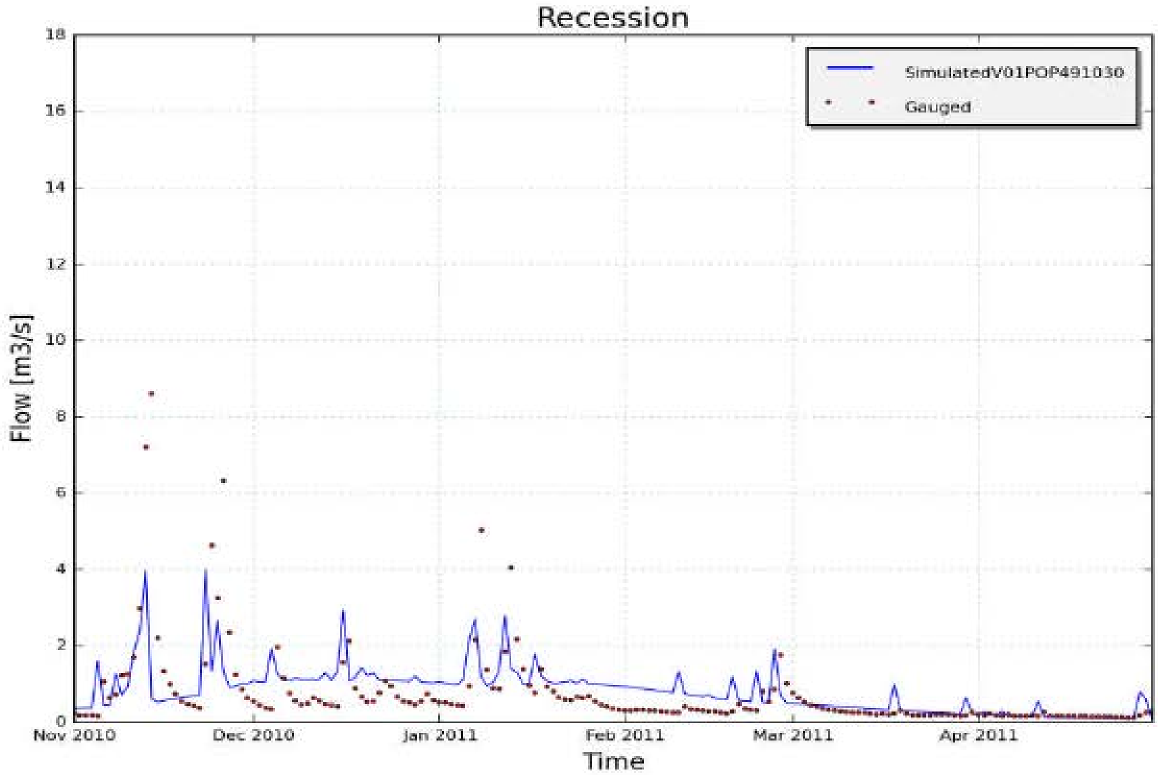


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren

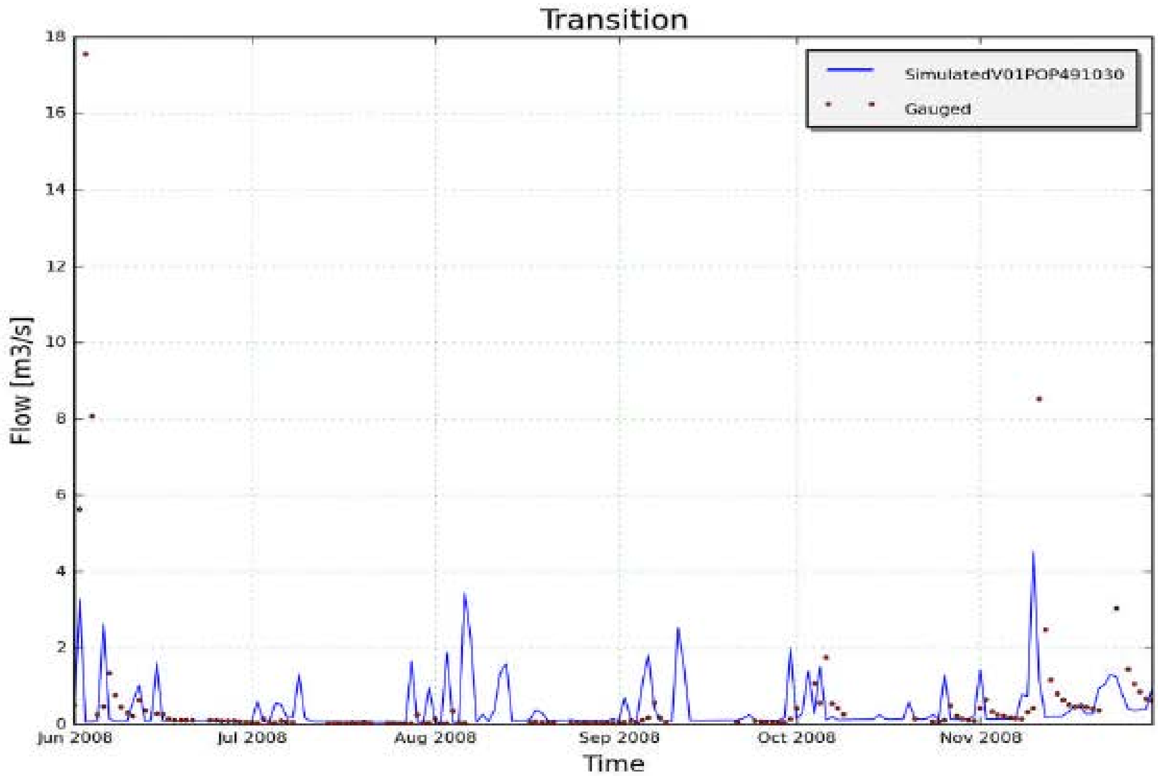


Figure 10: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren

9.2.7 Calibration and validation of WET parameters for catchment "V01SSV499140" (IJzer)

9.2.7.1 Input data

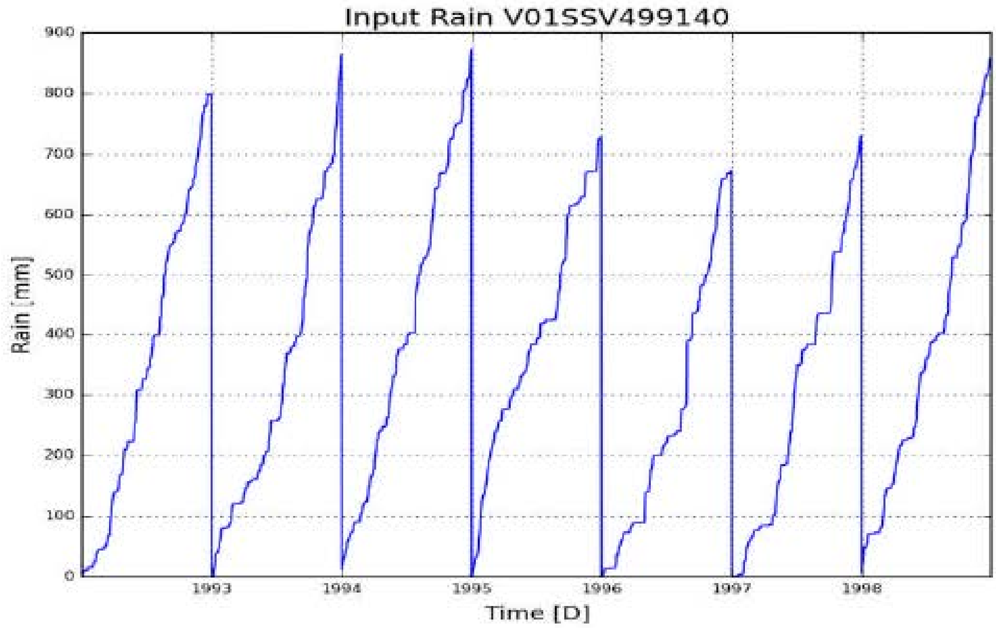


Figure 1: Cumulative precipitation on catchment V01SSV499140 (IJzer)

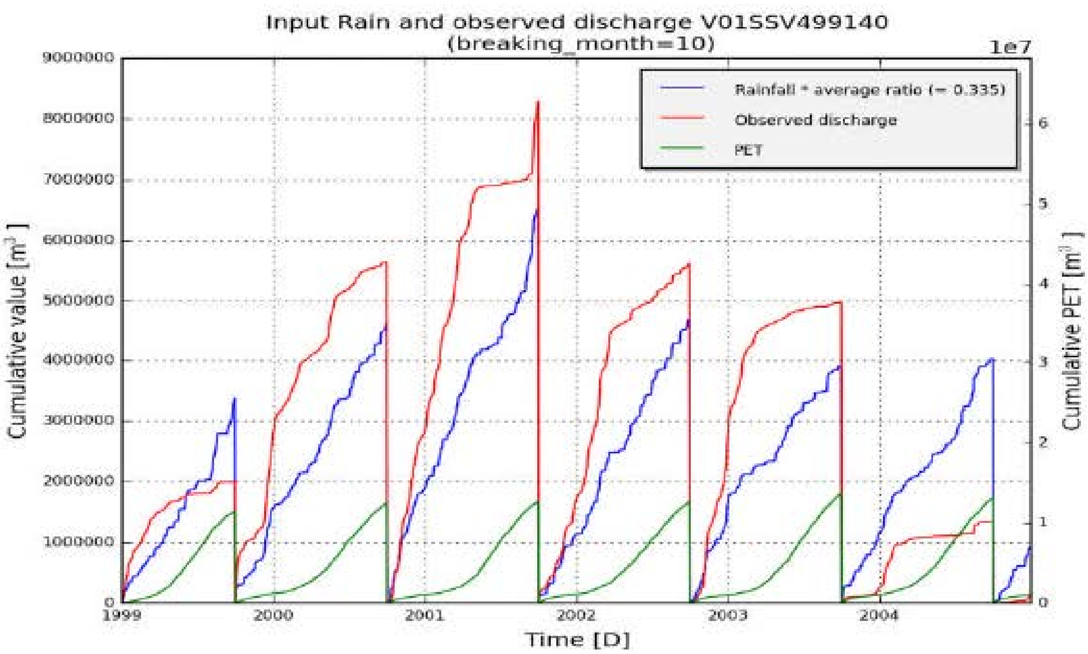


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V01SSV499140 (IJzer)

9.2.7.2 Model summary

model_structure	WETSPAclassic.paramset1

subcatchment_name	V01SSV499140
subcatchment_area [m2]	16100000
Validation start_date	01-01-1993
Validation end_date	31-12-1998
frequency	daily

Optimal parameter set:[('Kep', 1.76), ('Ki', 142.32), ('Kg', 0.0), ('Kss', 0.74), ('g0', 418.7), ('g_max', 594.36), ('K_run', 11.54), ('P_max', 396.8)]

Table 1: Goodness of fit for calibration period (1999 - 2004)

	Full year	**Summer**	**Winter**
RelErr	-3.1 %	117.0 %	-27.5 %
NS	0.453	-0.42	0.492
NS_log	0.288	-0.59	0.426
NS_rel	-265.505	-190.588	-0.311
KGE	0.734	-0.406	0.682

Table 2 :Goodness of fit for validation period (1993 - 1998)

	Full year	**Summer**	**Winter**
RelErr	2.2 %	143.3 %	-34.5 %
NS	-0.334	-7.204	0.562
NS_log	0.324	-0.392	0.573
NS_rel	-25.036	-19.906	0.076
KGE	0.395	-1.897	0.607

9.2.7.3 Observed and simulated timeseries for optimum parameters

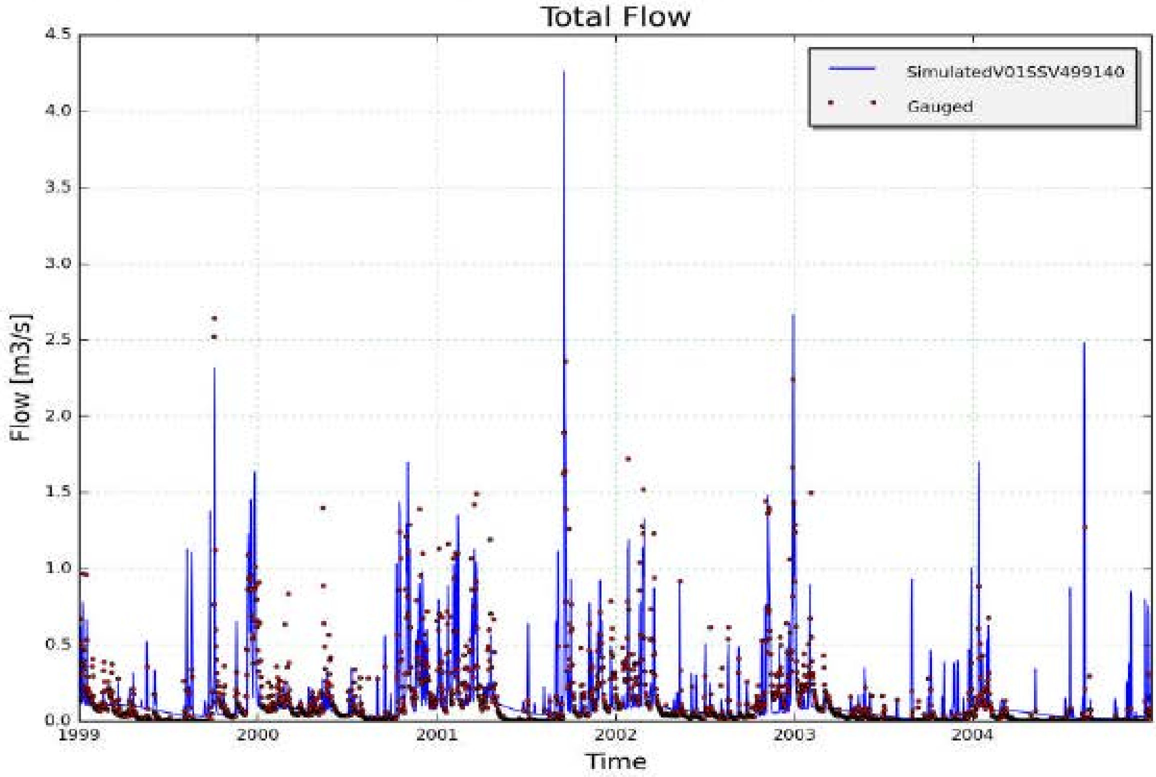


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem(calibration period)

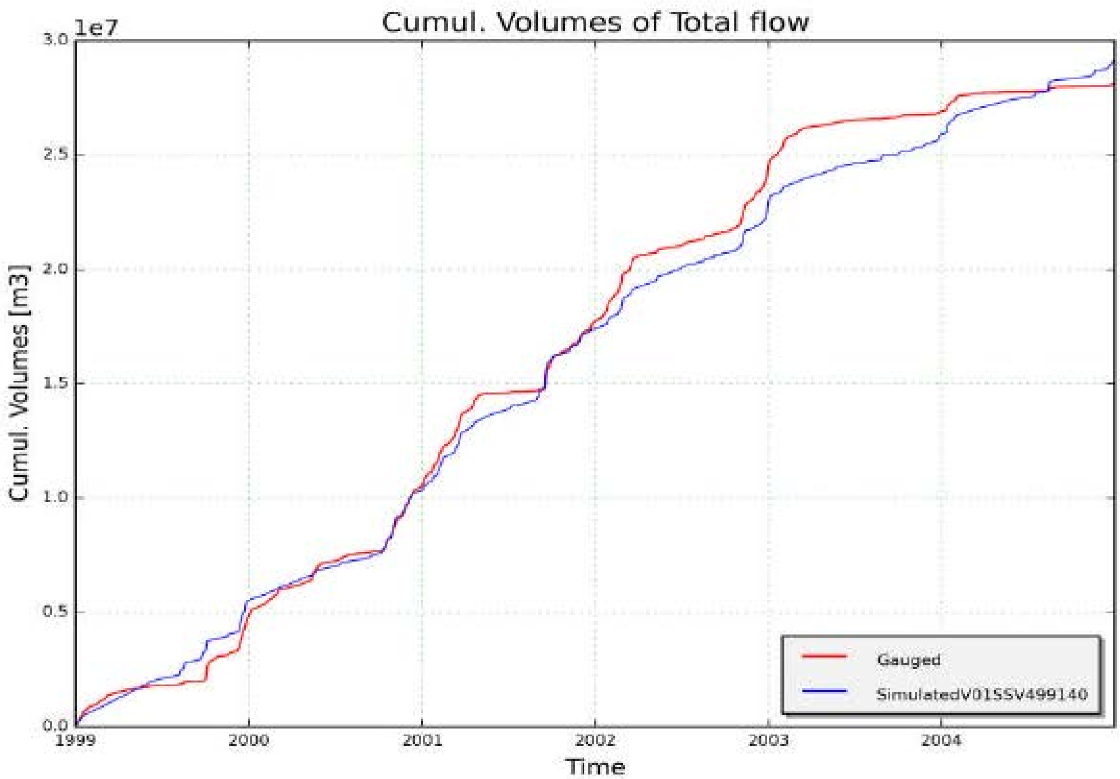


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem (calibration period)

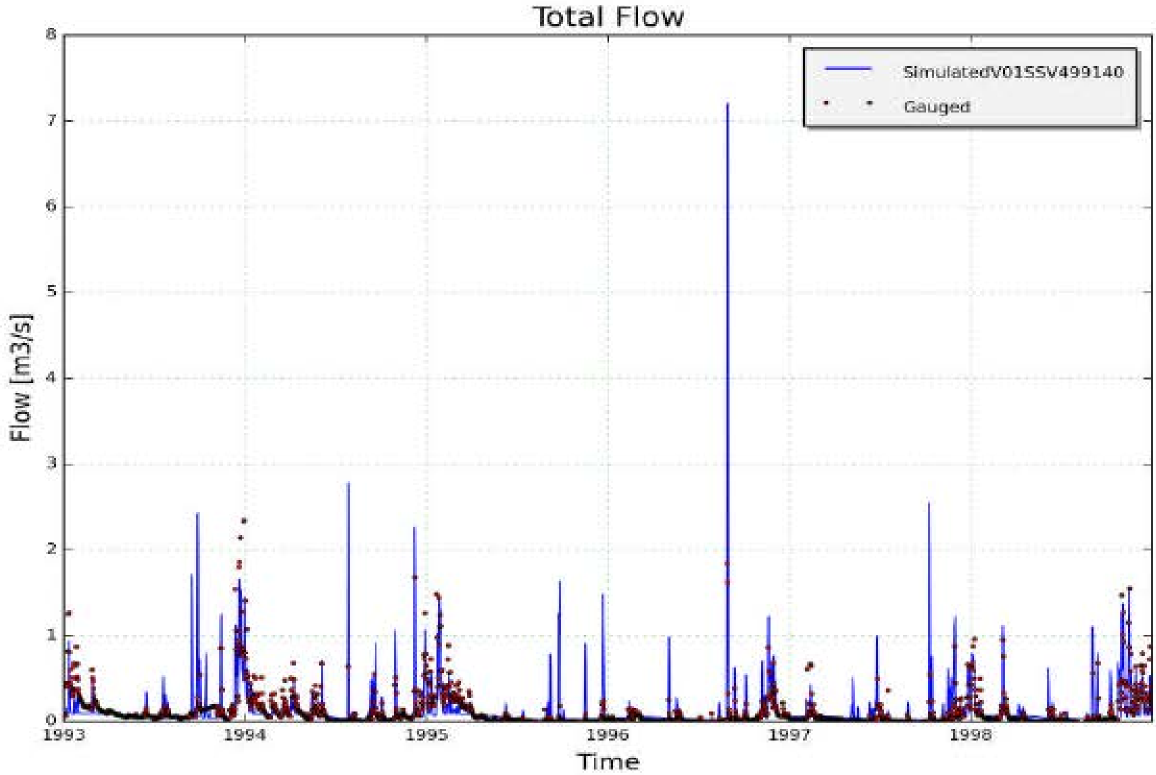


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem (validation period)

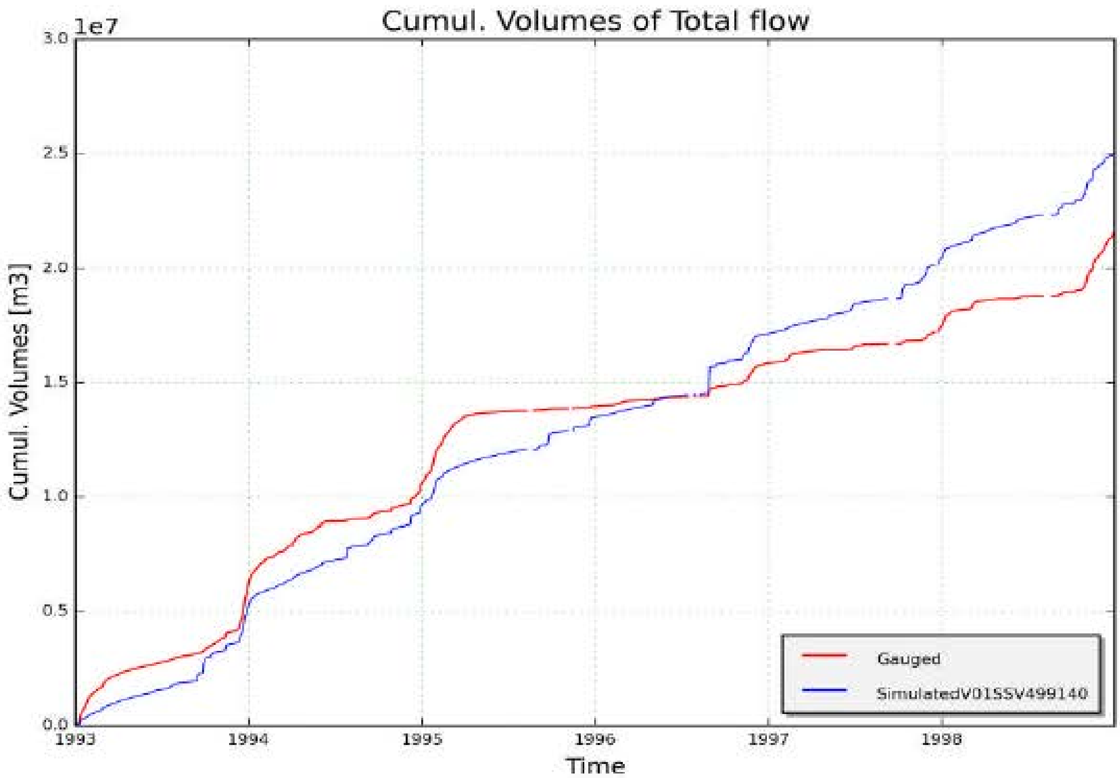


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem (validation period)

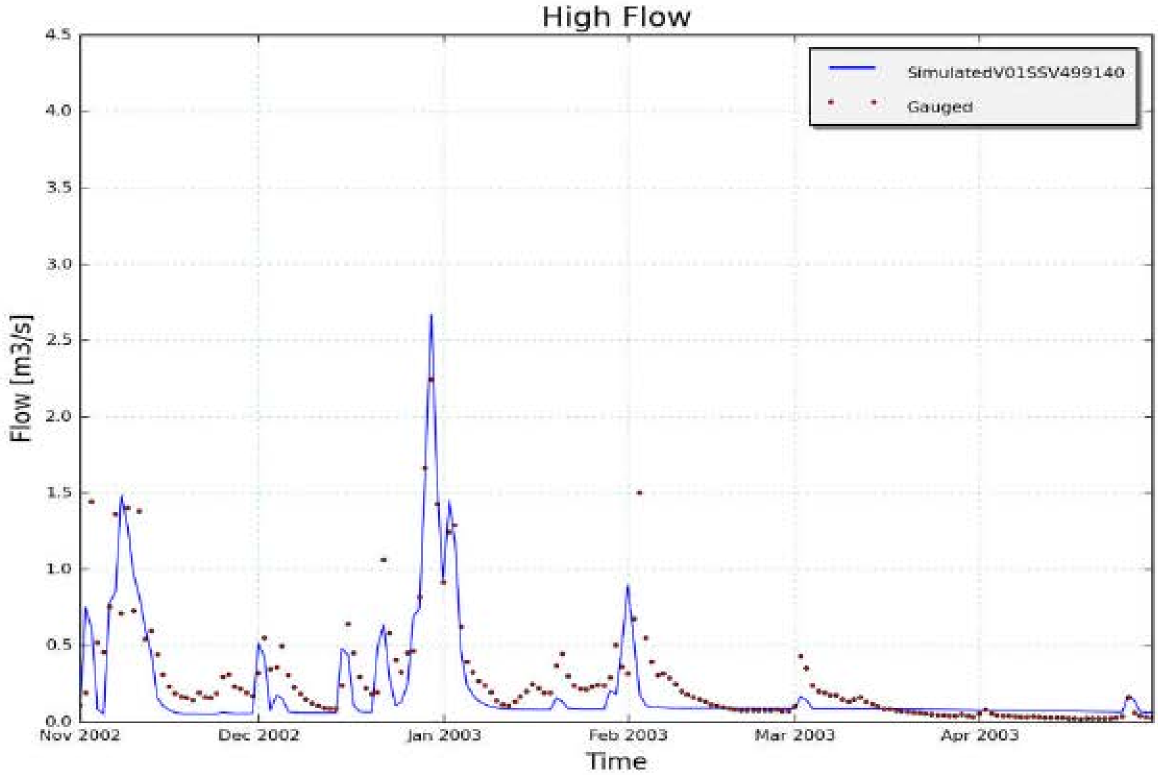


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem

Appendix 3 IJzer Autocalibration

9.3.1 Report on simulation of catchment V01HAN488180 (2017-01-18 19-13)

9.3.1.1 Input data

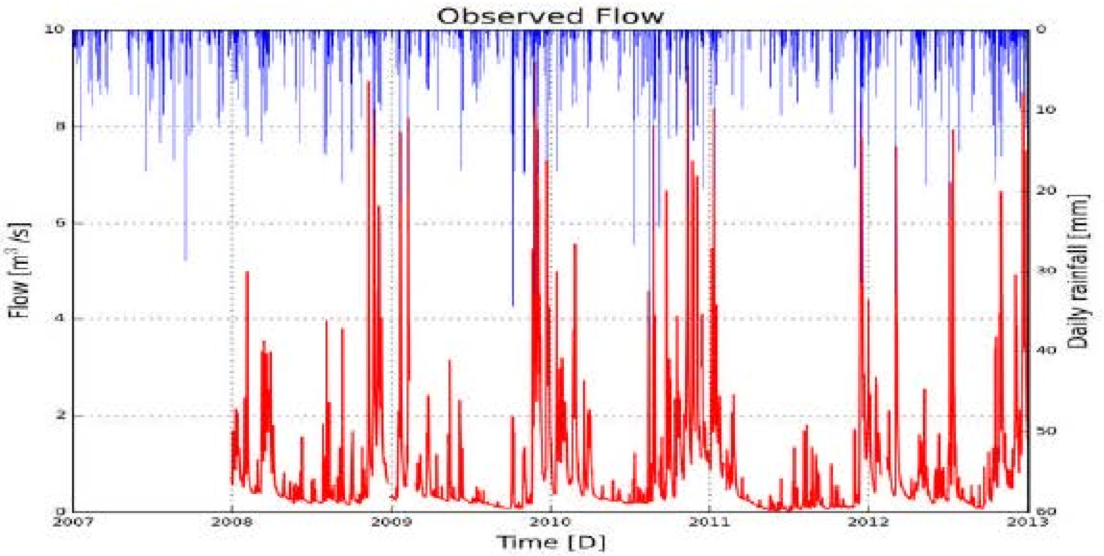


Figure 1: Hyetogram of observed discharge and observed net rain

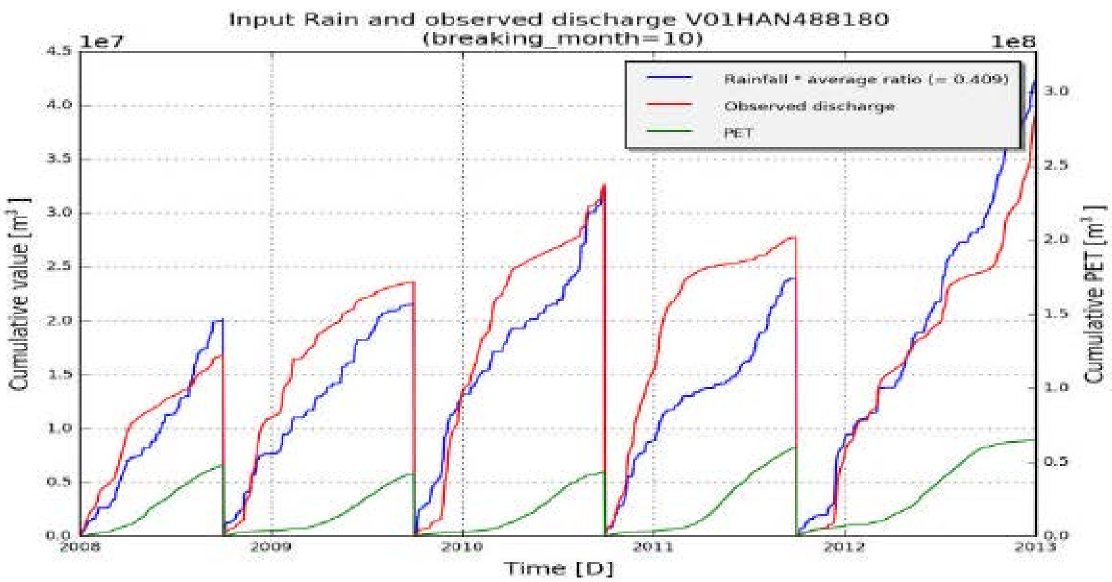


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.3.1.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V01HAN488180
subcatchment_area	78600000
start_date	200801010000
end_date	201301010000
frequency	86400
warmup	365

9.3.1.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.0, 100.0, 0.0096, 1.0, 121.393, 250.017, 2.234, 150.727]
low_bounds	[0.5, 50.0, 0.002, 0.5, 90.0, 200.0, 1.6, 120.0]
high_bounds	[3.0, 300.0, 0.05, 100.0, 200.0, 500.0, 9.0, 450.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.0), ('Ki', 100.0), ('Kg', 0.0096), ('Kss', 1.0), ('g0', 121.393), ('g_max', 250.017), ('K_run', 2.234), ('P_max', 150.727)]
Initial fitness:

- RelErr: 0.518
- AbsErr: 35278771.967
- KGE: 0.446
- NS_rel: -1.941
- NS: 0.596

- RMSE: 40362438.963
- NS_log: 0.075

Computation time:3:35:45.893000

9.3.1.4 Results

Best individual (euclidian): [('Kep', 1.824), ('Ki', 198.677), ('Kg', 0.01), ('Kss', 0.5), ('g0', 118.731), ('g_max', 286.408), ('K_run', 3.071), ('P_max', 186.255)]

Fitness:

- RelErr: 0.006
- AbsErr: 1248795.862
- KGE: 0.778
- NS_rel: 0.569
- NS: 0.669
- RMSE: 1576884.815
- NS_log: 0.67

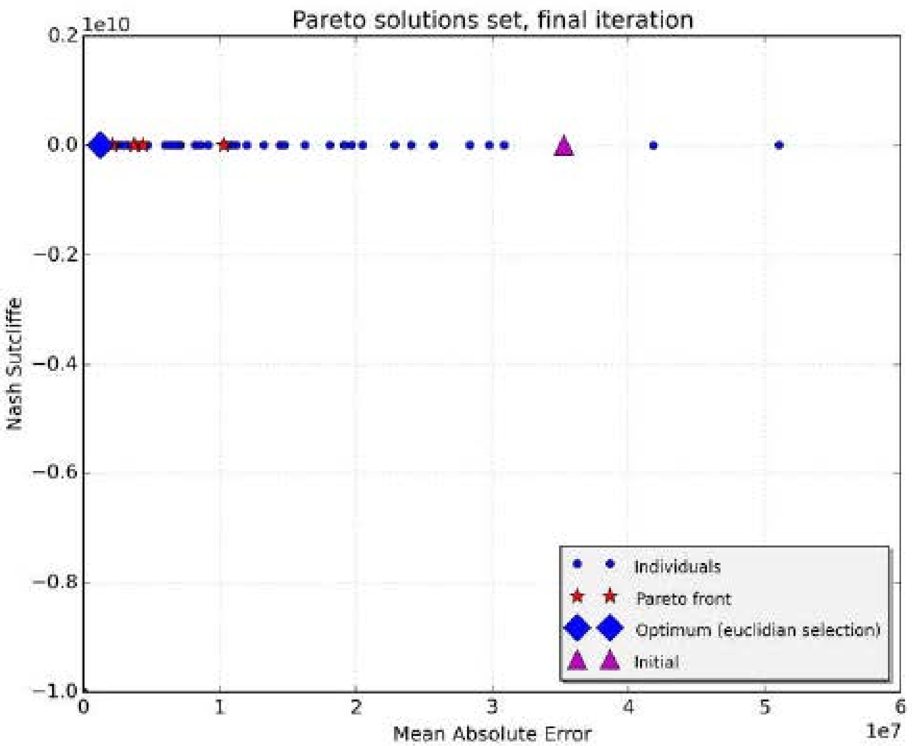


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

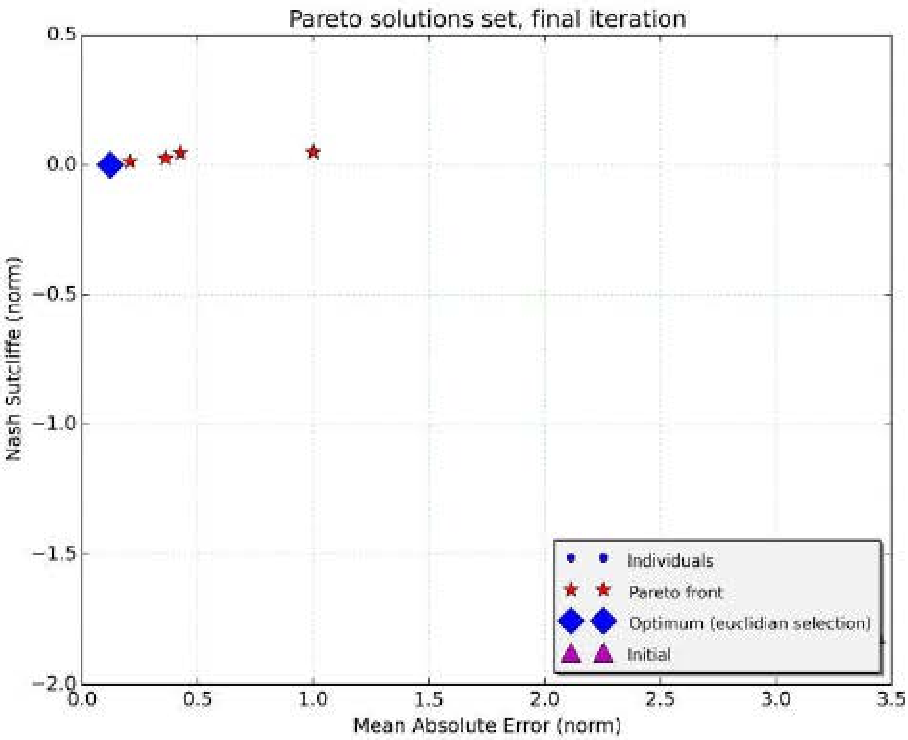


Figure 4: Final population of solutions (Pareto front)

9.3.1.4.1 Initial

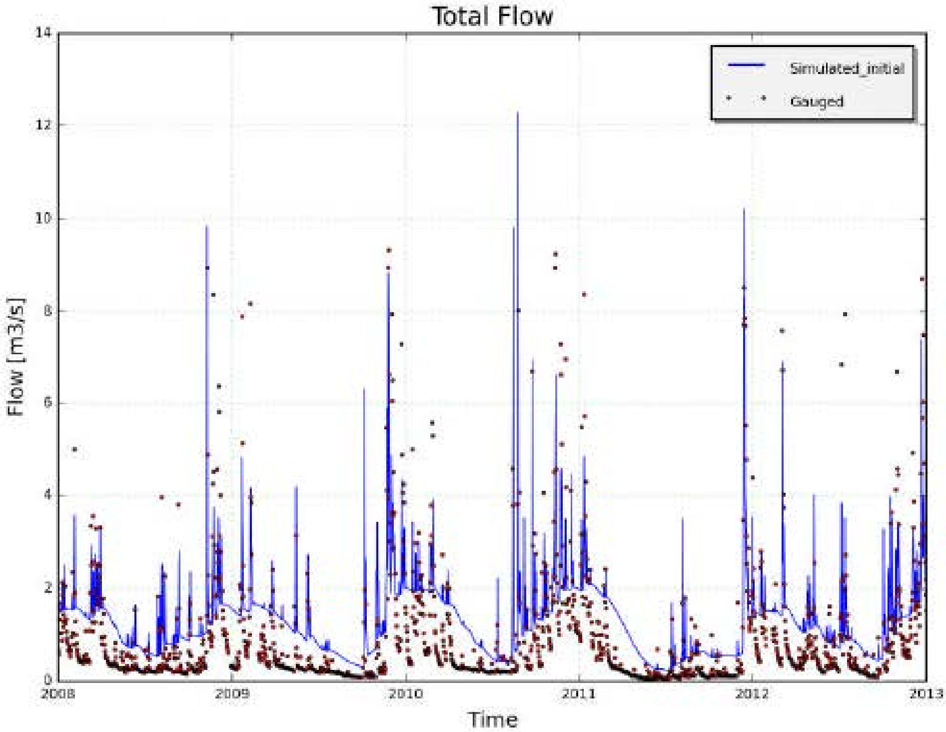


Figure 5: Total flow with initial parameters

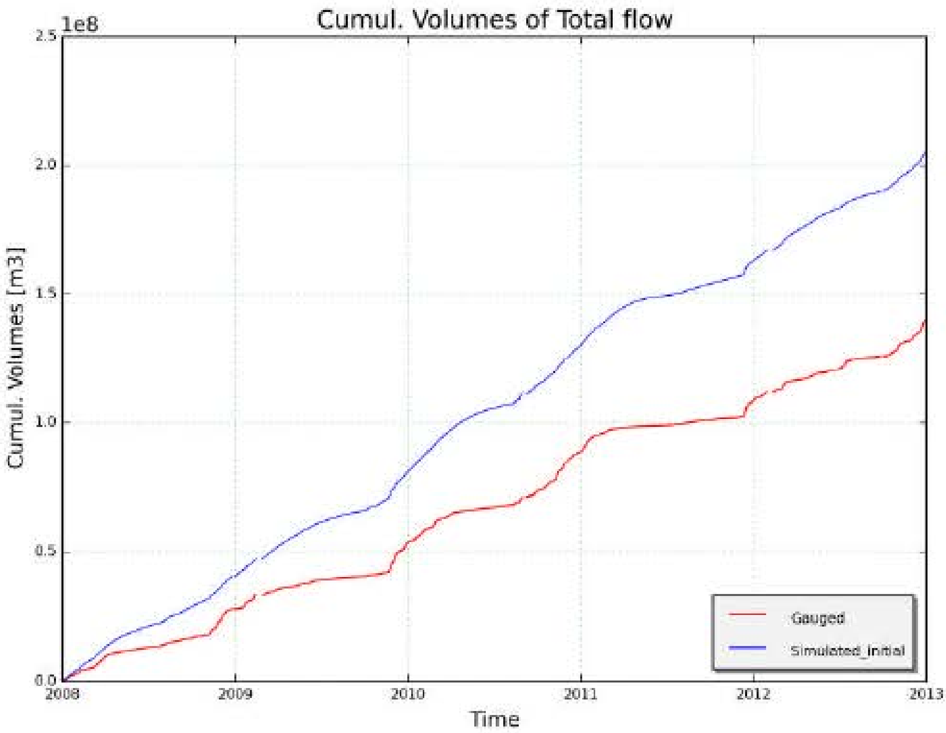


Figure 6: Cumulated flow with initial parameters

9.3.1.4.2 Optimum (euclidian)

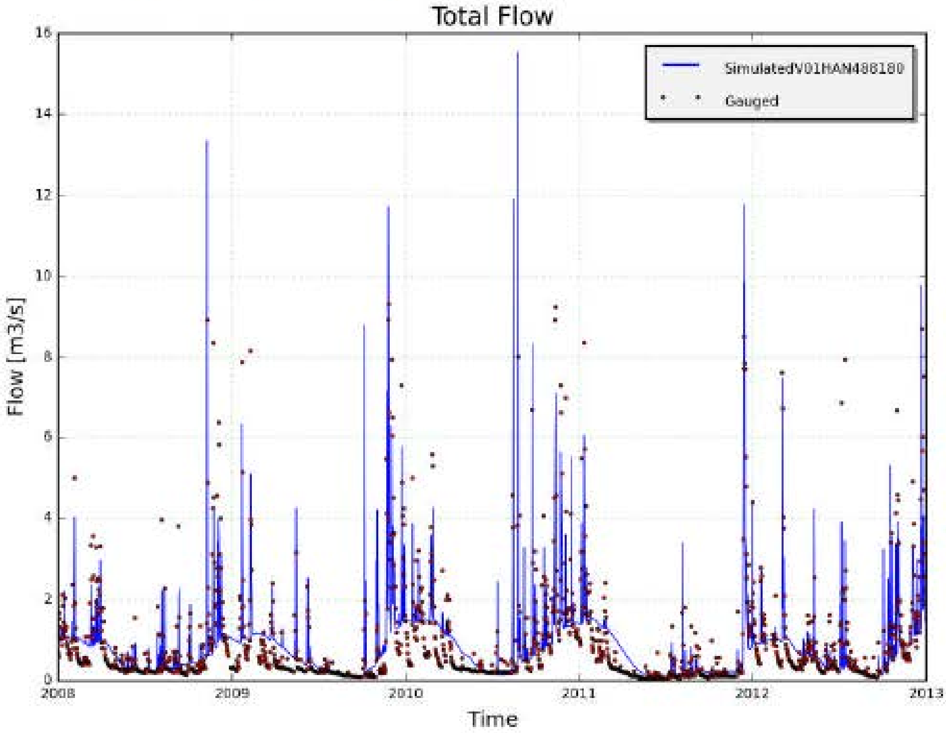


Figure 7: Total flow with optimum parameters

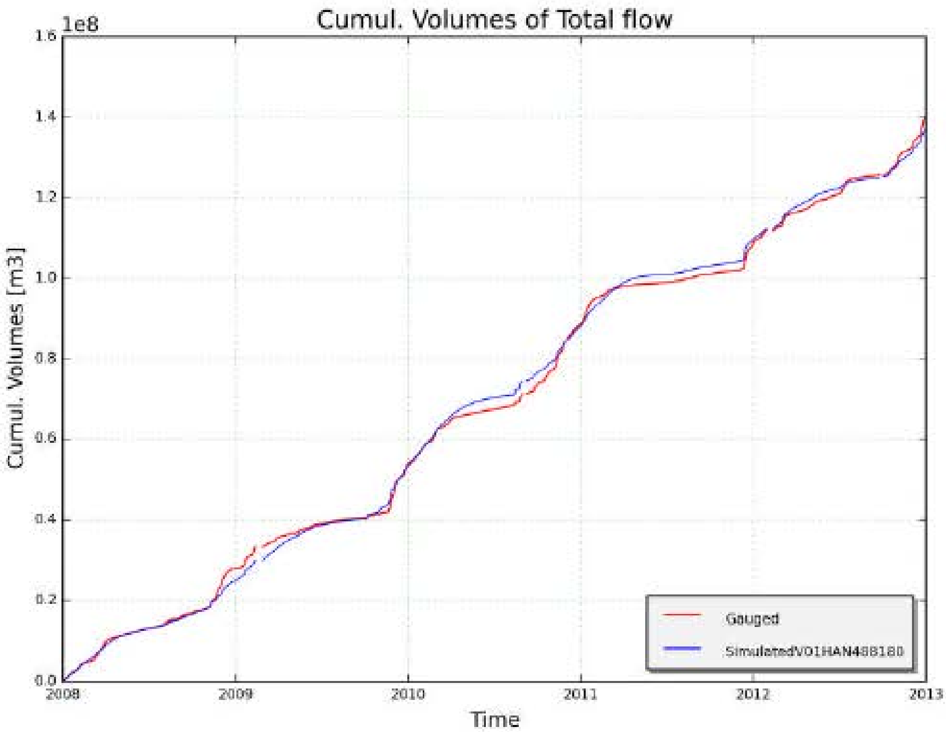


Figure 8: Cumulated flow with optimum parameters

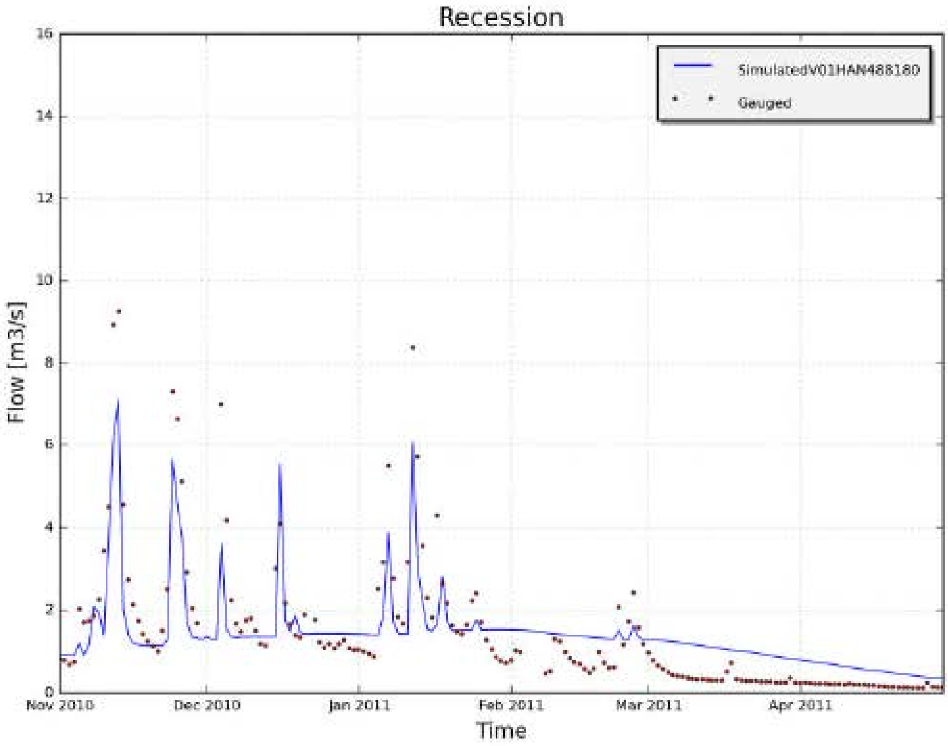


Figure 9: Total flow with optimum parameters (detail)

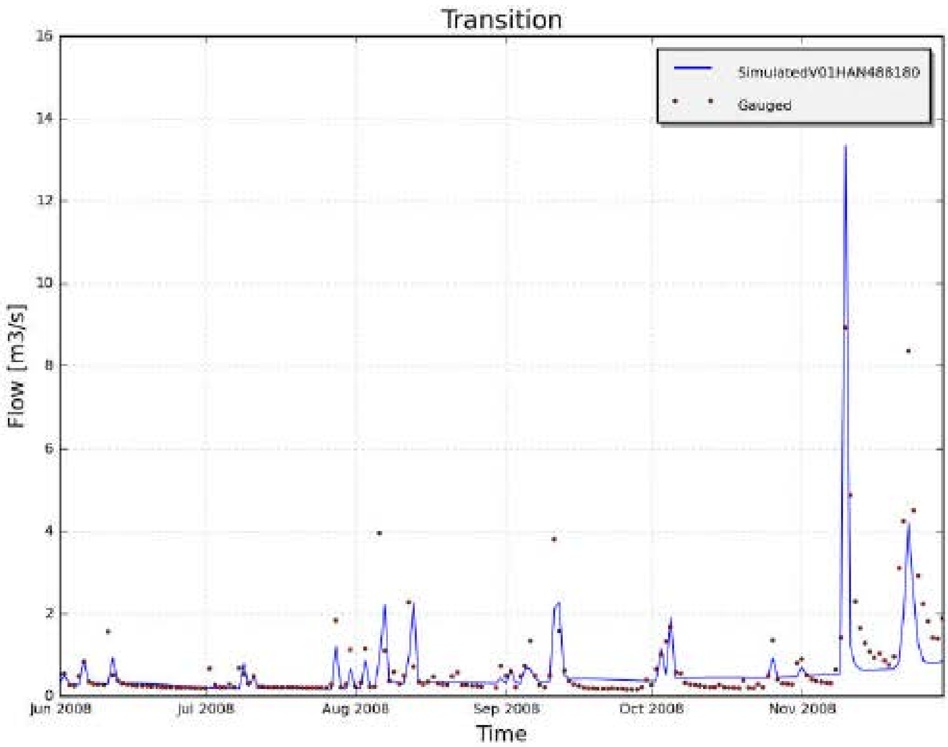
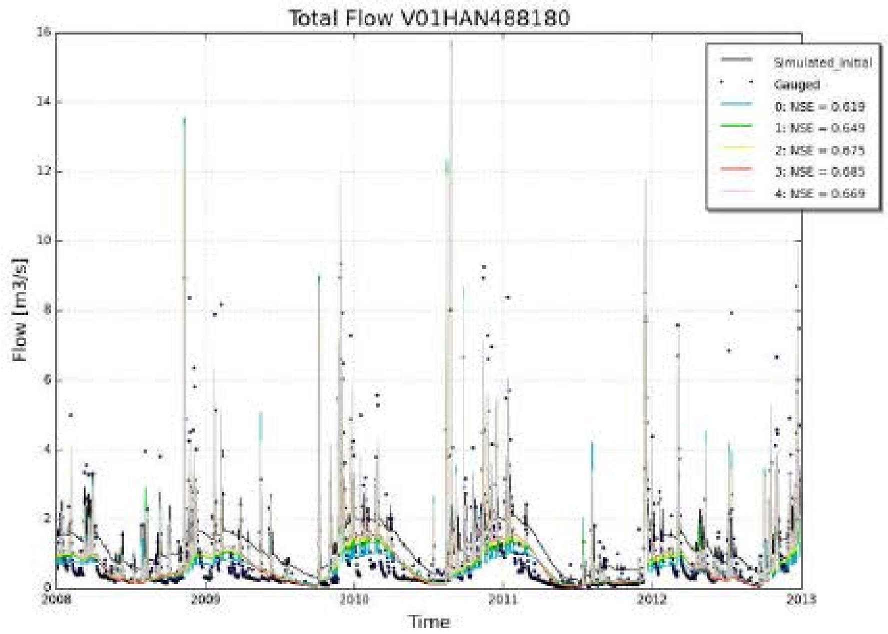
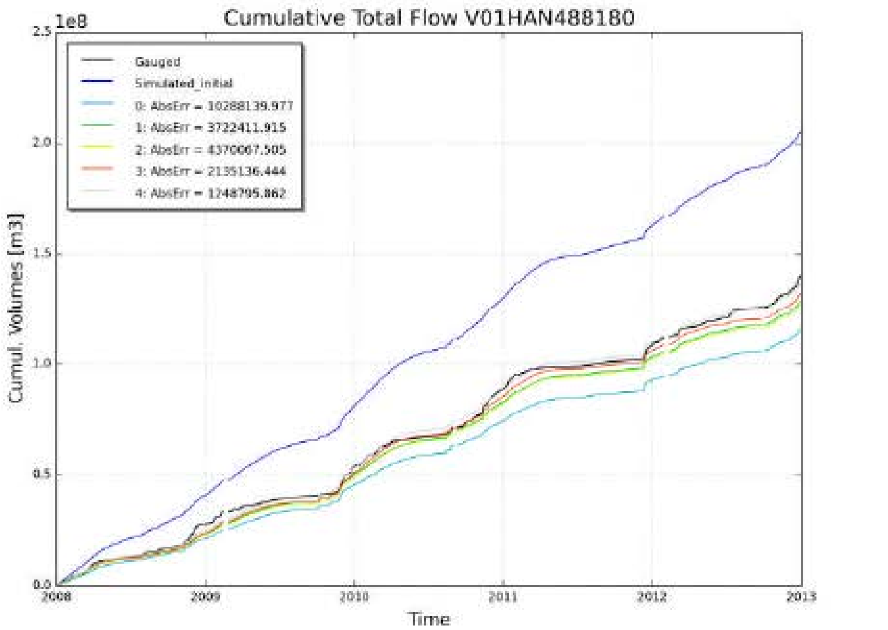


Figure 10: Total flow with optimum parameters (detail)

9.3.1.4.3 Final archive

0 : [1.541, 196.541, 0.005, 3.571, 116.055, 249.588, 2.776, 190.635] : [10288139.977, 0.687]
1 : [1.771, 202.474, 0.008, 0.5, 119.484, 291.493, 2.807, 187.924] : [3722411.915, 0.678]
2 : [1.855, 172.096, 0.008, 1.566, 118.683, 265.449, 1.965, 184.484] : [4370067.505, 0.685]
3 : [1.909, 170.166, 0.01, 4.696, 117.545, 251.508, 3.574, 183.814] : [2135136.444, 0.674]
4 : [1.824, 198.677, 0.01, 0.5, 118.731, 286.408, 3.071, 186.255] : [1248795.862, 0.67]





9.3.2 Report on simulation of catchment V01HEI468999 (2017-02-02 01-08)

9.3.2.1 Input data

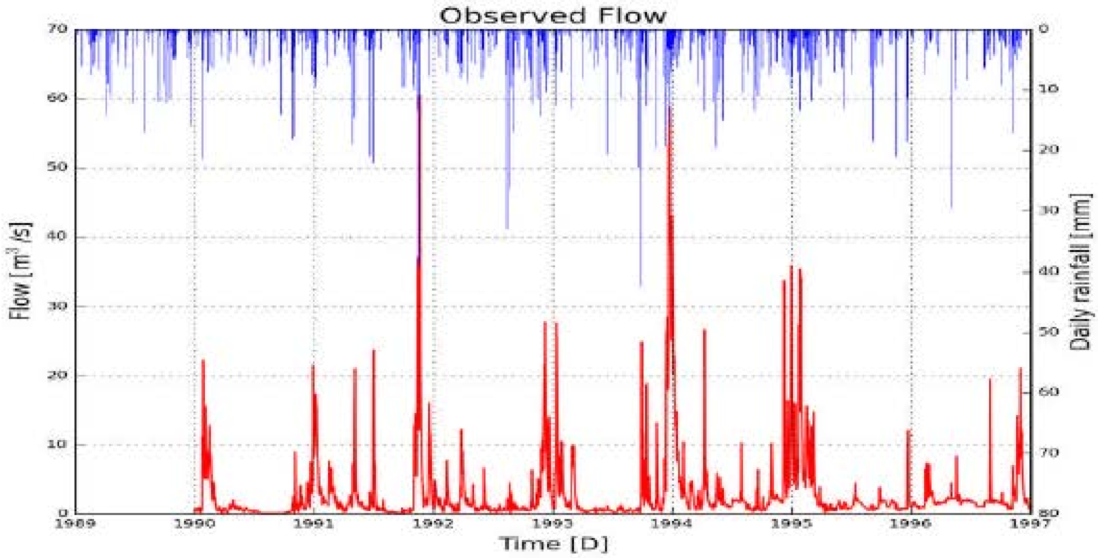


Figure 1: Hyetogram of observed discharge and observed net rain

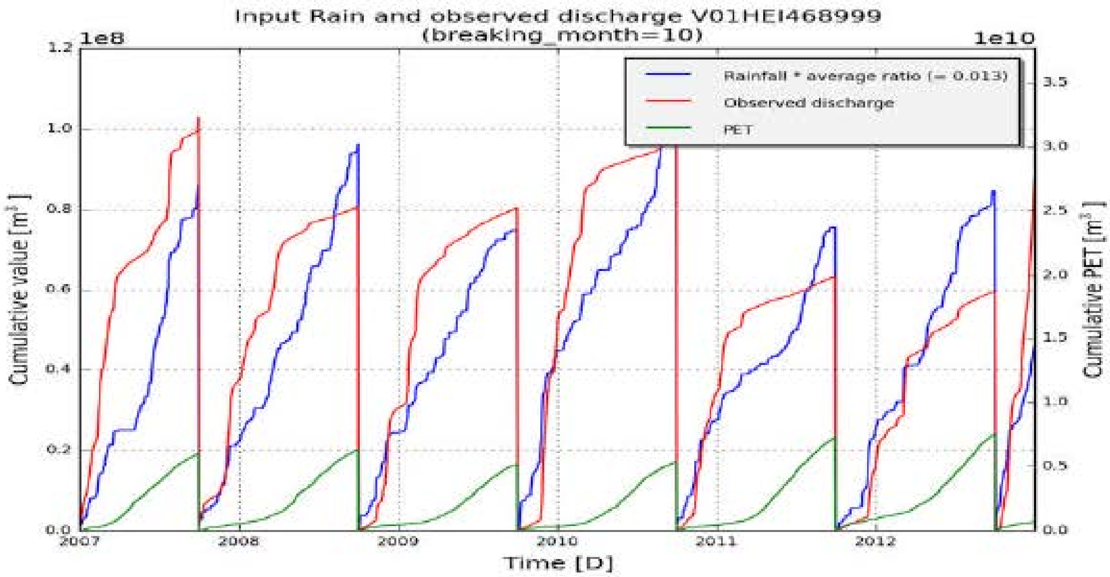


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.3.2.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V01HEI468999
subcatchment_area	393000000
start_date	199001010000
end_date	199612310000
frequency	86400
warmup	365

9.3.2.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.0, 100.0, 0.009, 1.5, 90.0, 150.0, 2.0, 100.0]
low_bounds	[0.2, 30.0, 0.0003, 0.5, 20.0, 40.0, 0.4, 10.0]
high_bounds	[2.0, 250.0, 0.01, 4.0, 250.0, 450.0, 6.0, 300.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.0), ('Ki', 100.0), ('Kg', 0.009), ('Kss', 1.5), ('g0', 90.0), ('g_max', 150.0), ('K_run', 2.0), ('P_max', 100.0)]
Initial fitness:

- RelErr: 0.268
- AbsErr: 83362554.622
- KGE: 0.615
- NS_rel: -1.651
- NS: 0.327
- RMSE: 93391680.759
- NS_log: 0.221

Computation time:2 days, 15:29:55.210000

9.3.2.4 Results

Best individual (euclidian): [('Kep', 1.153), ('Ki', 156.672), ('Kg', 0.005), ('Kss', 3.768), ('g0', 109.282), ('g_max', 285.398), ('K_run', 3.957), ('P_max', 196.498)]

Fitness:

- RelErr: -0.04
- AbsErr: 16516979.119
- KGE: 0.648
- NS_rel: -0.23
- NS: 0.328
- RMSE: 24407009.155
- NS_log: 0.398

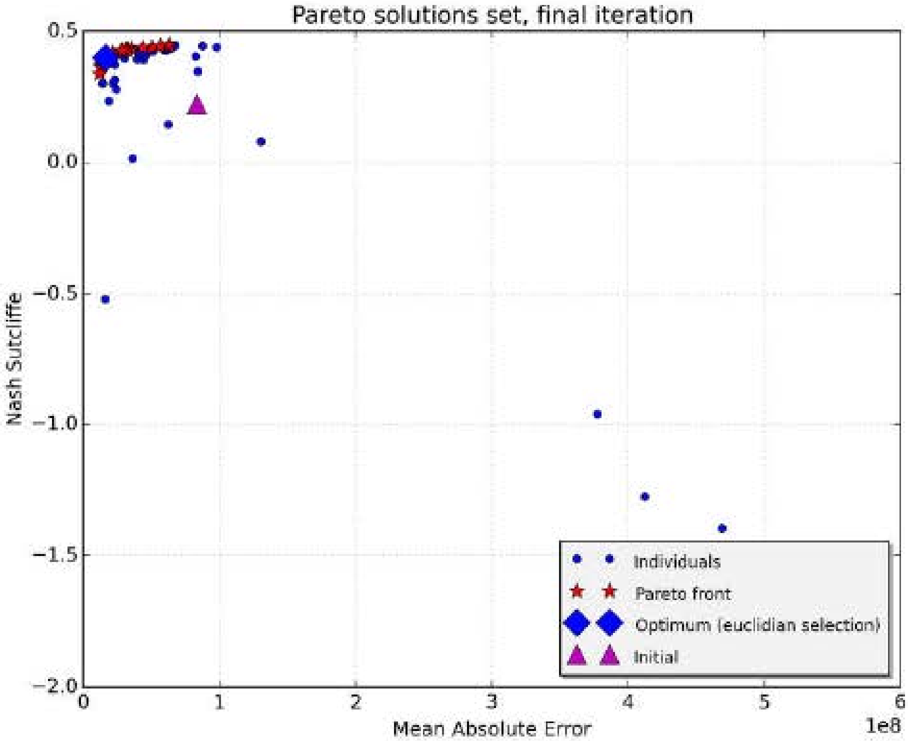


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

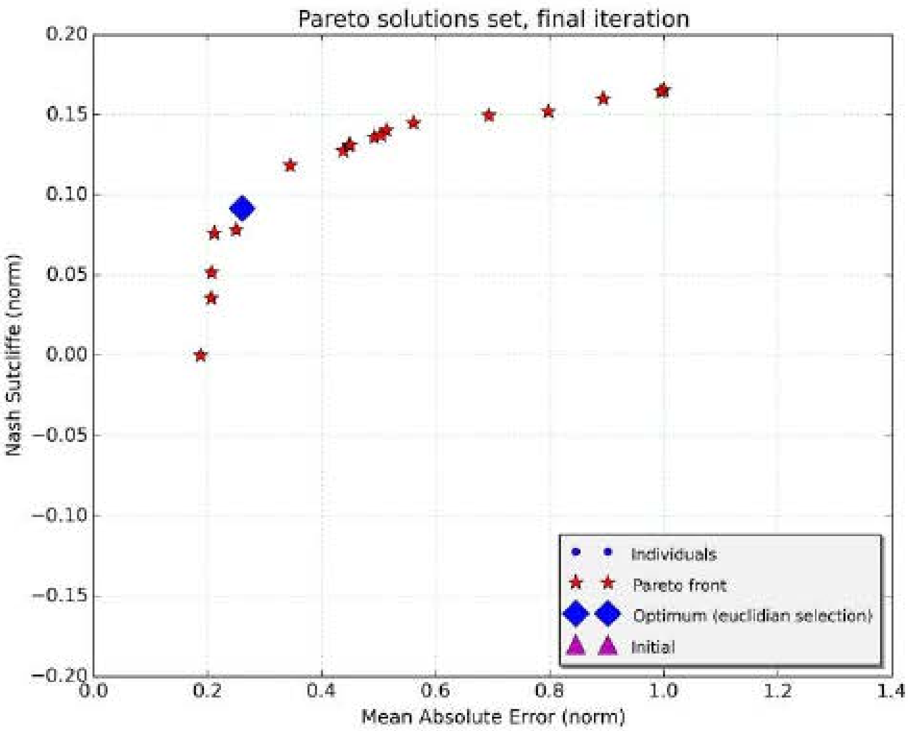


Figure 4: Final population of solutions (Pareto front)

9.3.2.4.1 Initial

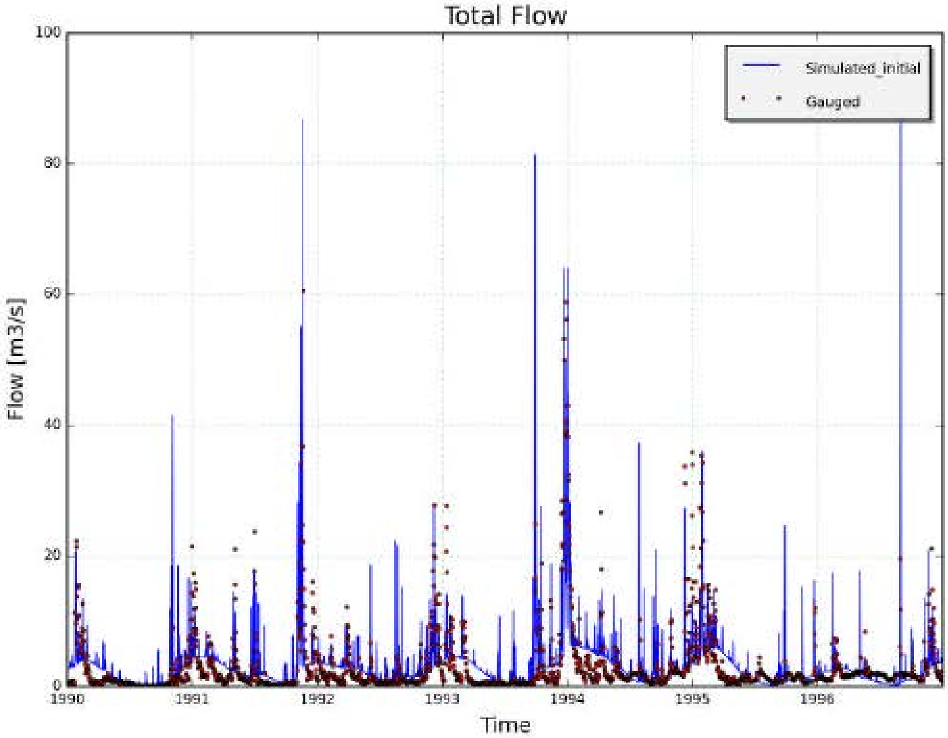


Figure 5: Total flow with initial parameters

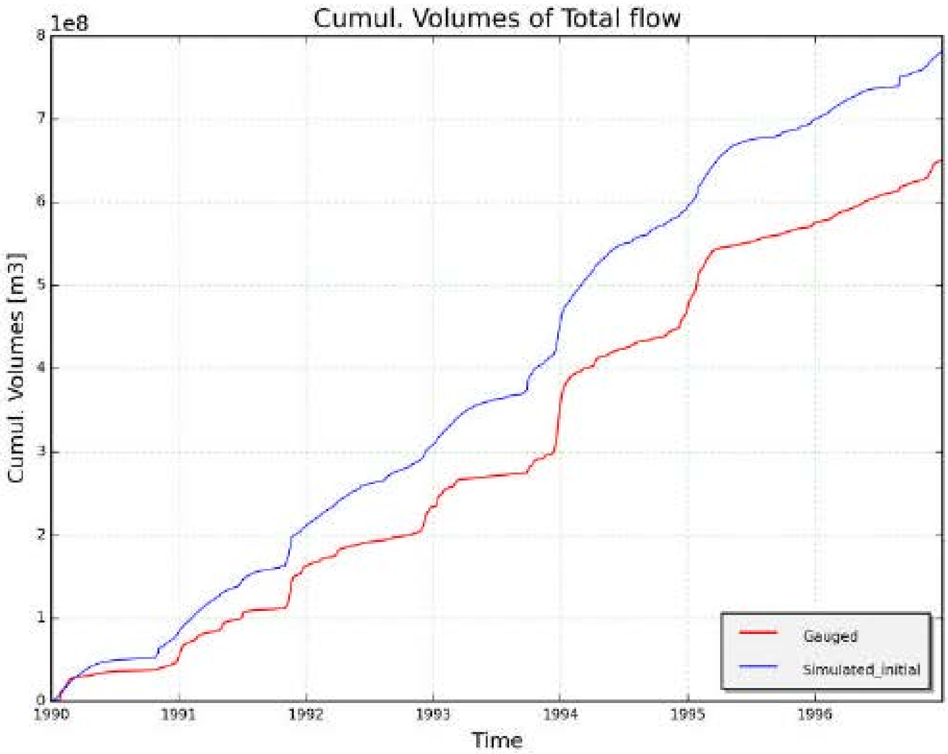


Figure 6: Cumulated flow with initial parameters

9.3.2.4.2 Optimum (euclidian)

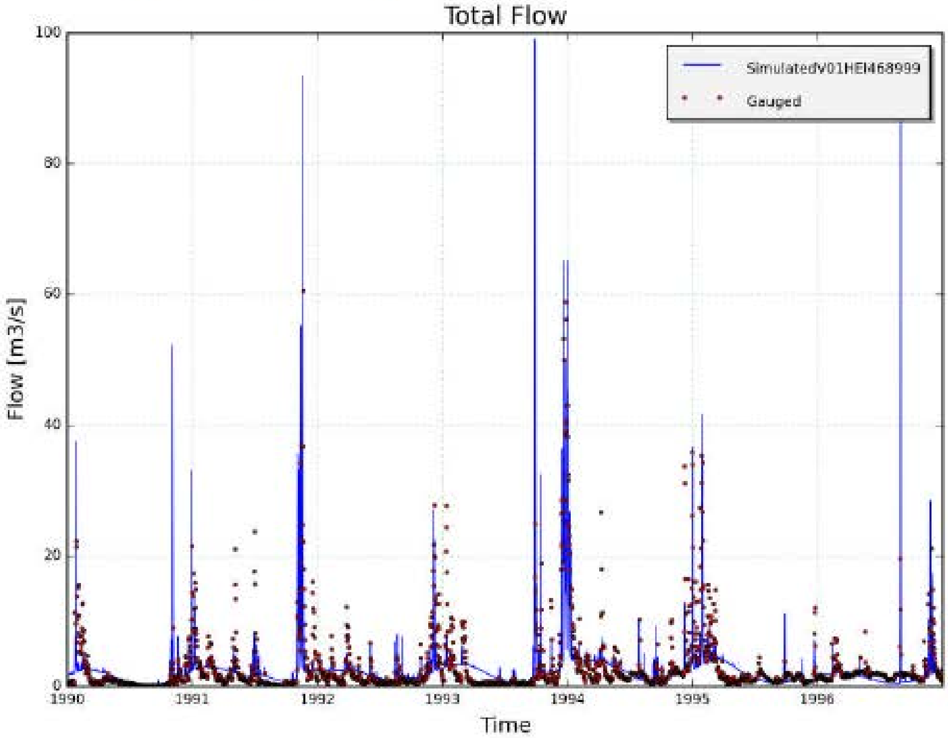


Figure 7: Total flow with optimum parameters

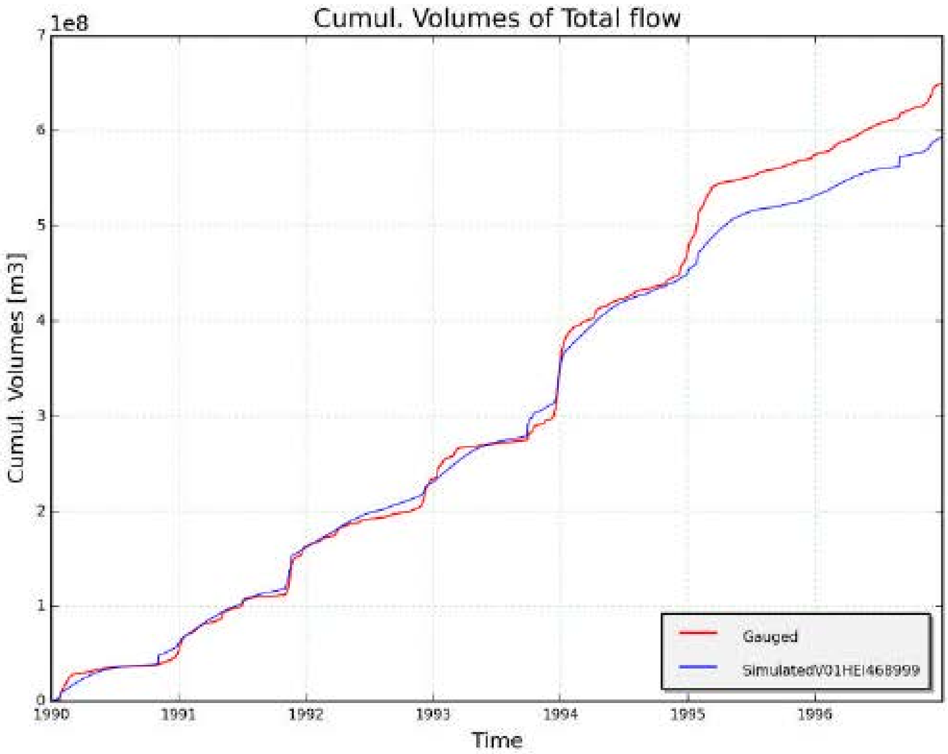
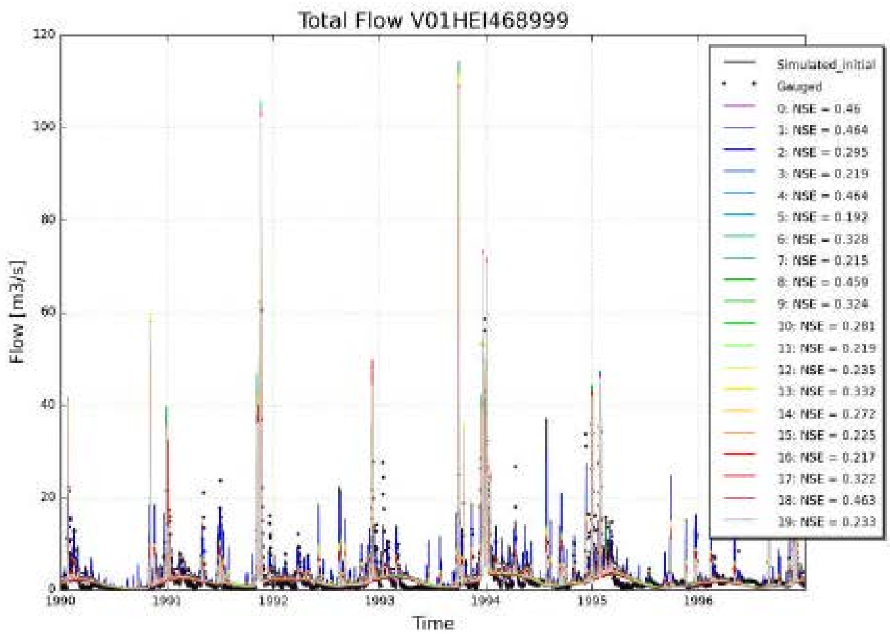
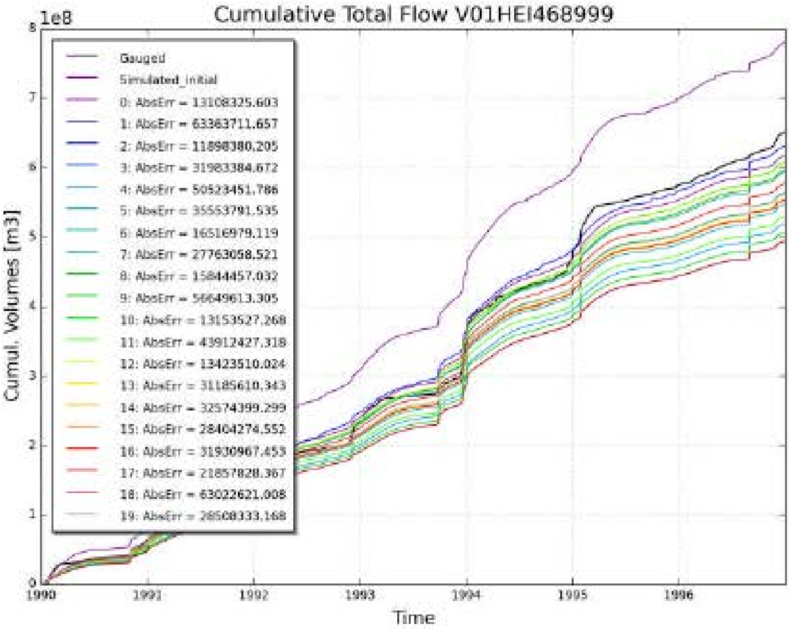


Figure 8: Cumulated flow with optimum parameters

9.3.2.4.3 Final archive

0 : [1.151, 115.411, 0.005, 4.0, 90.985, 303.478, 4.177, 259.29] : [13108325.603, 0.361]
1 : [1.189, 92.631, 0.003, 2.217, 48.987, 298.792, 3.712, 180.686] : [63363711.657, 0.447]
2 : [1.076, 128.726, 0.004, 4.0, 121.196, 272.739, 1.91, 291.335] : [11898380.205, 0.337]
3 : [1.296, 199.528, 0.005, 4.0, 113.324, 306.501, 4.102, 281.31] : [31983384.672, 0.428]
4 : [1.191, 103.142, 0.003, 2.47, 79.627, 299.288, 3.991, 219.081] : [50523451.786, 0.438]
5 : [1.278, 202.383, 0.004, 3.876, 88.388, 300.357, 3.726, 206.595] : [35553791.535, 0.433]
6 : [1.153, 156.672, 0.005, 3.768, 109.282, 285.398, 3.957, 196.498] : [16516979.119, 0.398]
7 : [1.17, 191.113, 0.004, 3.851, 116.136, 257.985, 4.364, 279.393] : [27763058.521, 0.422]
8 : [1.2, 109.885, 0.005, 2.959, 111.546, 308.91, 3.404, 271.378] : [15844457.032, 0.389]
9 : [1.258, 156.321, 0.003, 3.056, 113.103, 338.933, 3.541, 289.017] : [56649613.305, 0.443]
10 : [1.043, 160.353, 0.004, 3.863, 71.195, 299.6, 3.723, 184.93] : [13153527.268, 0.371]
11 : [1.308, 198.994, 0.004, 3.961, 115.808, 297.488, 4.128, 281.082] : [43912427.318, 0.436]
12 : [1.052, 177.78, 0.004, 3.892, 102.232, 274.702, 3.224, 272.739] : [13423510.024, 0.388]
13 : [1.296, 163.564, 0.005, 4.0, 92.548, 302.959, 3.844, 280.5] : [31185610.343, 0.427]
14 : [1.291, 182.532, 0.004, 3.382, 114.466, 316.196, 3.601, 282.418] : [32574399.299, 0.43]
15 : [1.24, 193.161, 0.004, 3.93, 107.627, 307.275, 3.951, 279.788] : [28404274.552, 0.424]
16 : [1.296, 199.879, 0.005, 4.0, 113.324, 306.597, 4.102, 281.31] : [31930967.453, 0.428]
17 : [1.253, 163.663, 0.005, 3.986, 100.857, 304.036, 3.332, 280.308] : [21857828.367, 0.416]
18 : [1.189, 93.434, 0.003, 1.816, 48.987, 298.792, 3.712, 180.686] : [63022621.008, 0.446]
19 : [1.24, 191.417, 0.004, 3.332, 107.957, 307.275, 3.951, 279.788] : [28508333.168, 0.424]





9.3.3 Report on simulation of catchment V01IEP495080 (2017-01-23 14-54)

9.3.3.1 Input data

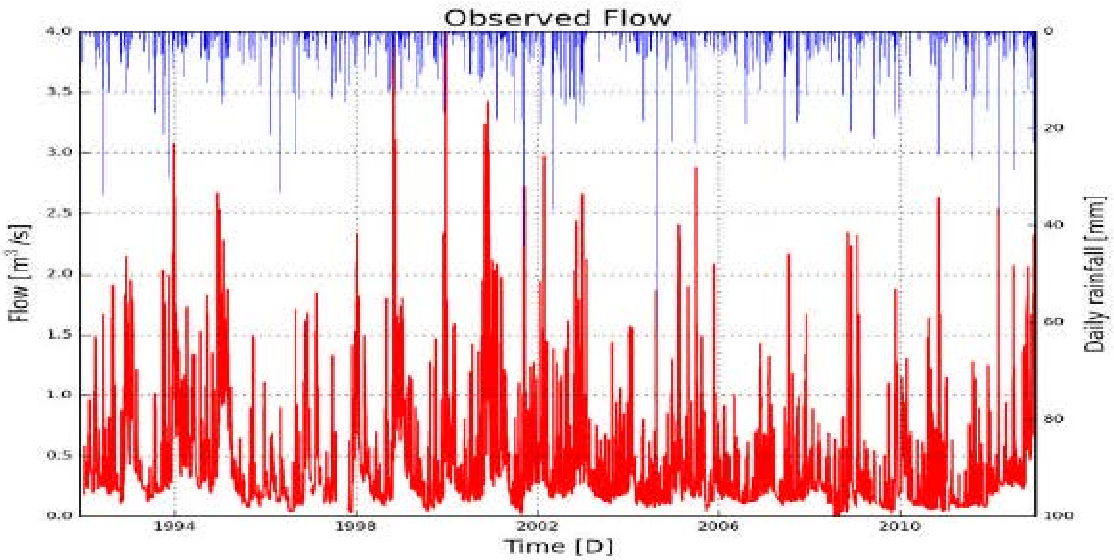


Figure 1: Hyetogram of observed discharge and observed net rain

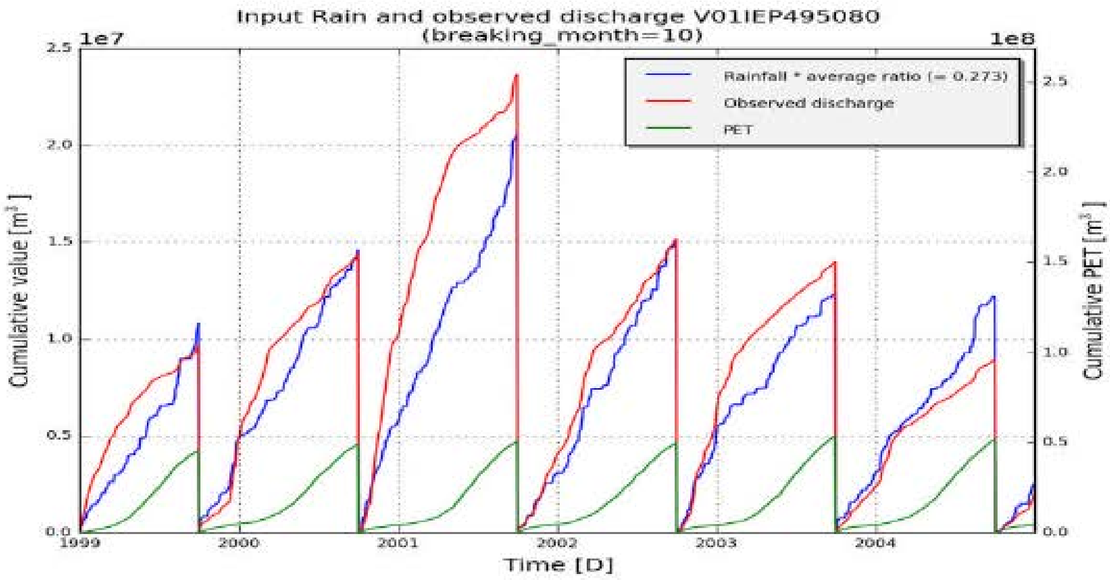


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.3.3.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V01IEP495080
subcatchment_area	63400000
start_date	199901010000
end_date	200412310000
frequency	86400
warmup	365

9.3.3.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[1.04, 25.3, 0.001, 0.713, 4.54, 250.4, 13.34, 200.02]
low_bounds	[0.8, 20.0, 0.0007, 0.5, 3.6, 200.0, 10.0, 160.0]
high_bounds	[1.5, 50.0, 0.009, 0.85, 5.4, 300.0, 16.0, 240.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.04), ('Ki', 25.3), ('Kg', 0.001), ('Kss', 0.713), ('g0', 4.54), ('g_max', 250.4), ('K_run', 13.34), ('P_max', 200.02)]
Initial fitness:

- RelErr: 0.142
- AbsErr: 7005889.187
- KGE: 0.684
- NS_rel: -1.396
- NS: 0.454
- RMSE: 8448439.966
- NS_log: 0.405

Computation time:4:35:25.580000

9.3.3.4 Results

Best individual (euclidian): [('Kep', 1.044), ('Ki', 25.287), ('Kg', 0.001), ('Kss', 0.762), ('g0', 3.6), ('g_max', 278.383), ('K_run', 13.919), ('P_max', 170.107)]

Fitness:

- RelErr: -0.024
- AbsErr: 1277657.124
- KGE: 0.712
- NS_rel: -0.837
- NS: 0.484
- RMSE: 1850260.921
- NS_log: 0.537

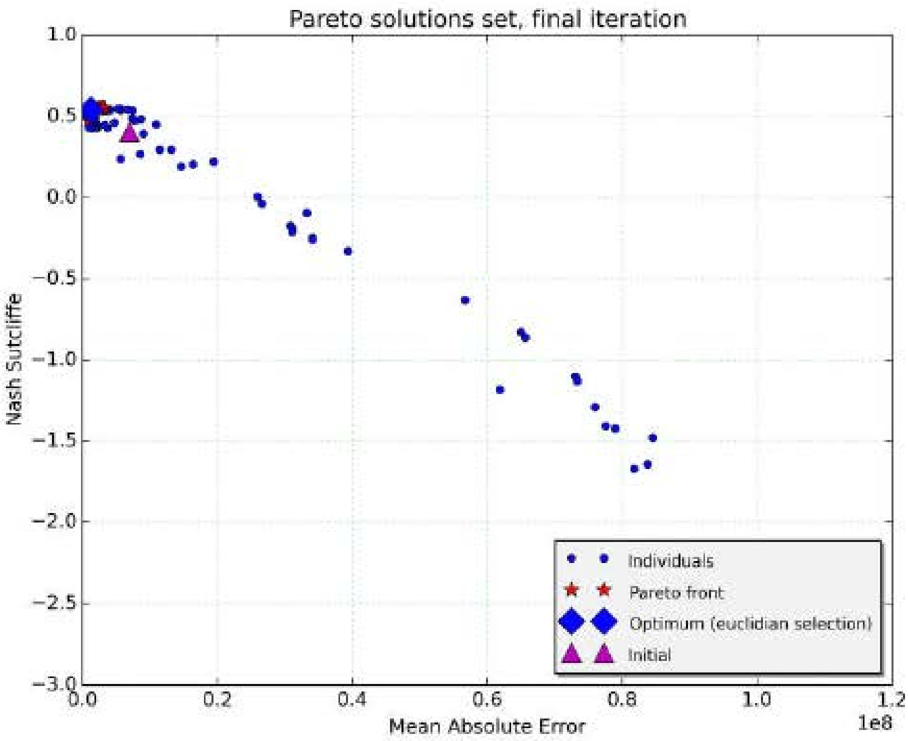


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

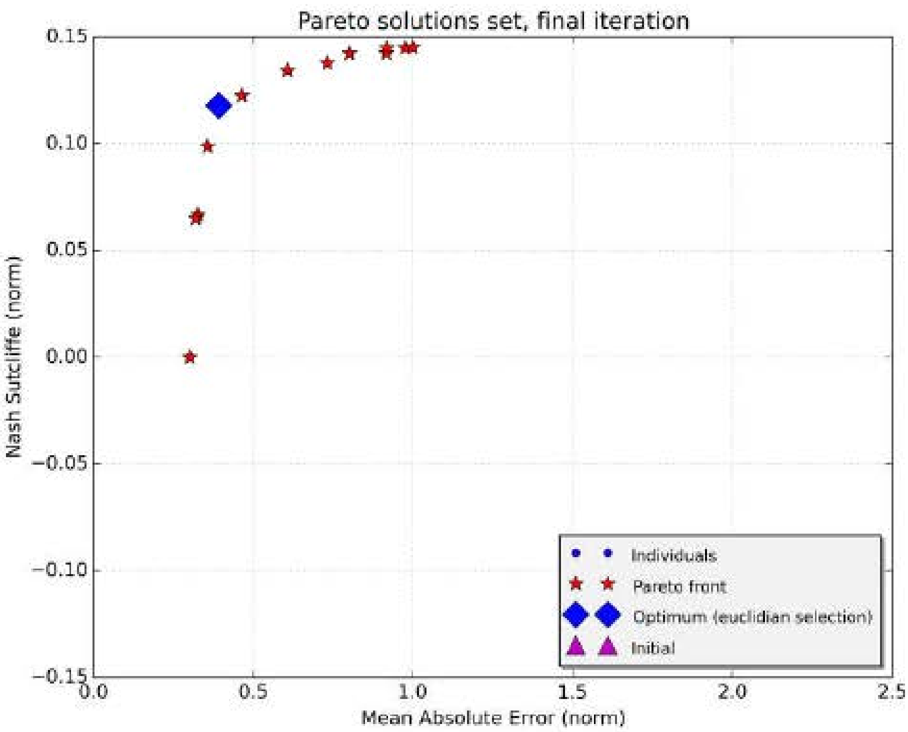


Figure 4: Final population of solutions (Pareto front)

9.3.3.4.1 Initial

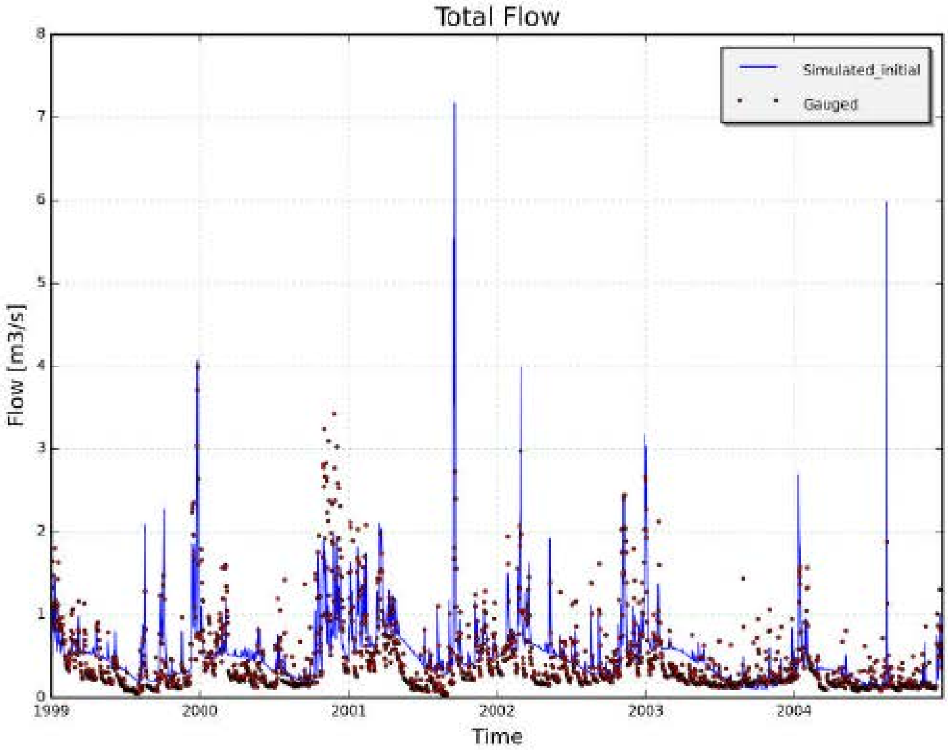


Figure 5: Total flow with initial parameters

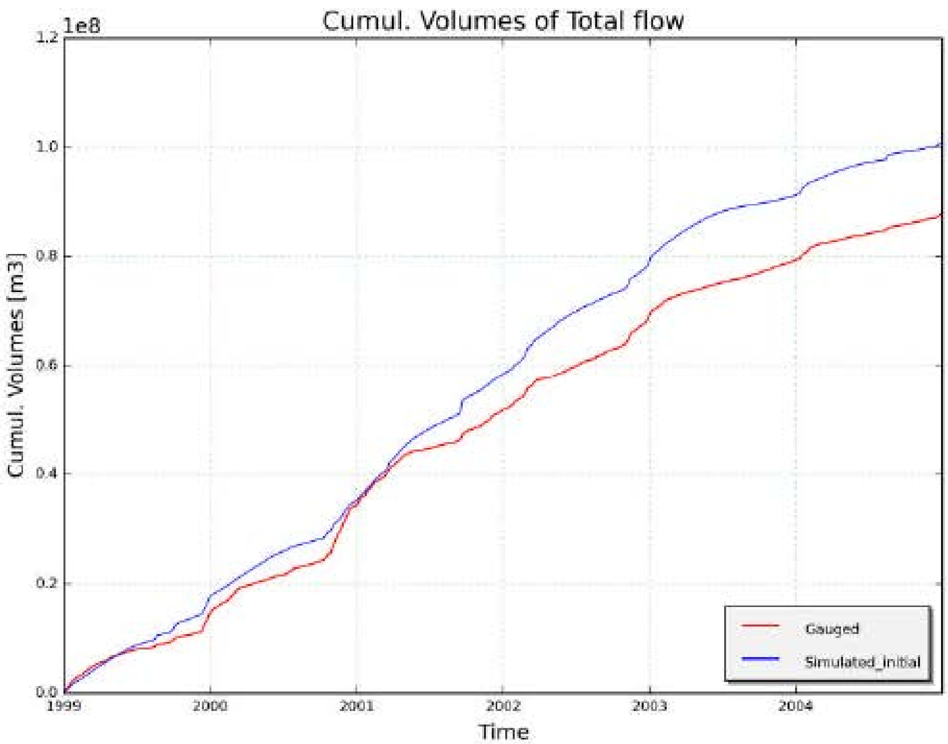


Figure 6: Cumulated flow with initial parameters

9.3.3.4.2 Optimum (euclidian)

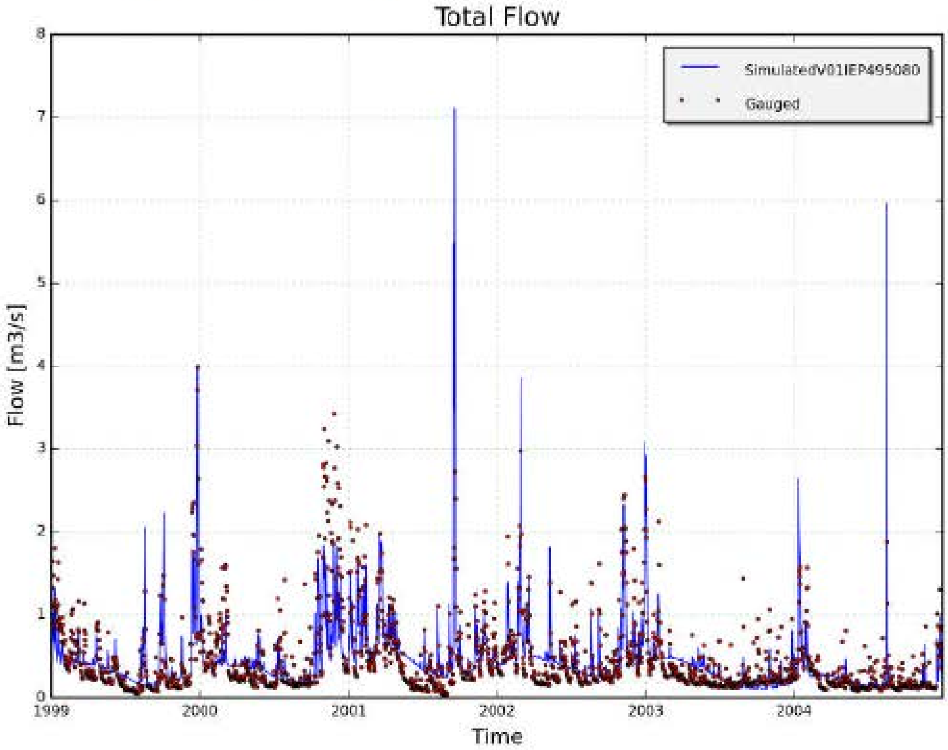


Figure 7: Total flow with optimum parameters

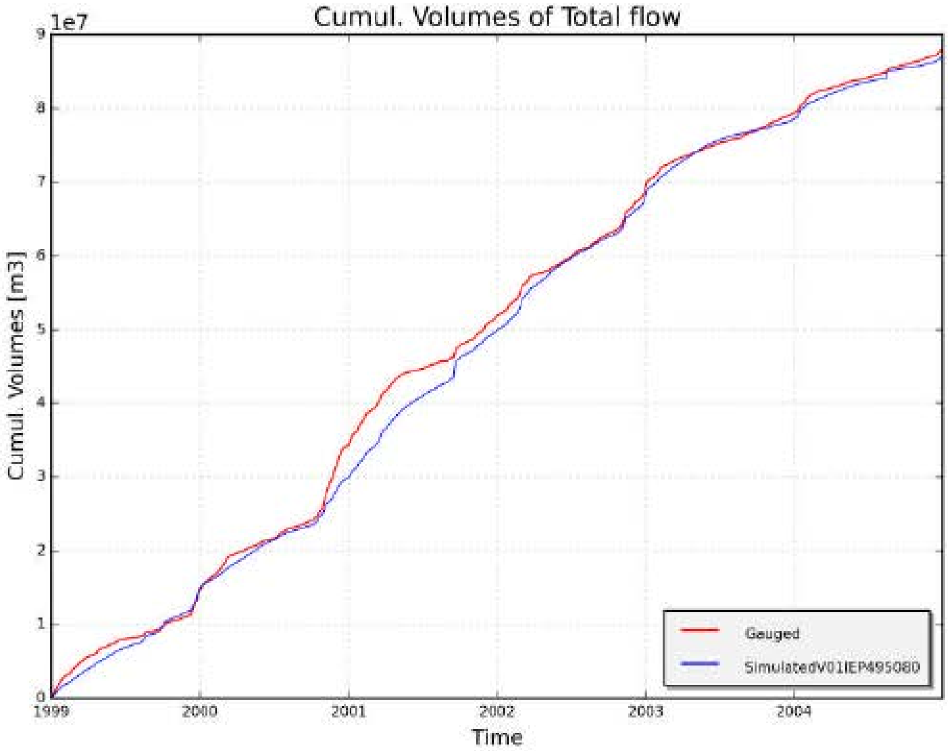


Figure 8: Cumulated flow with optimum parameters

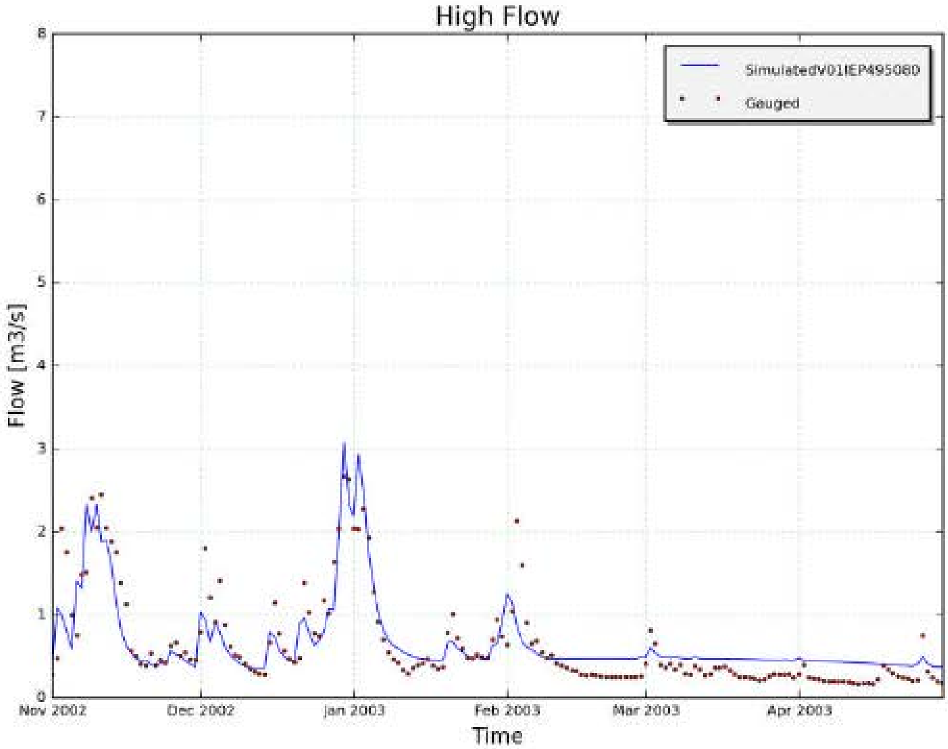
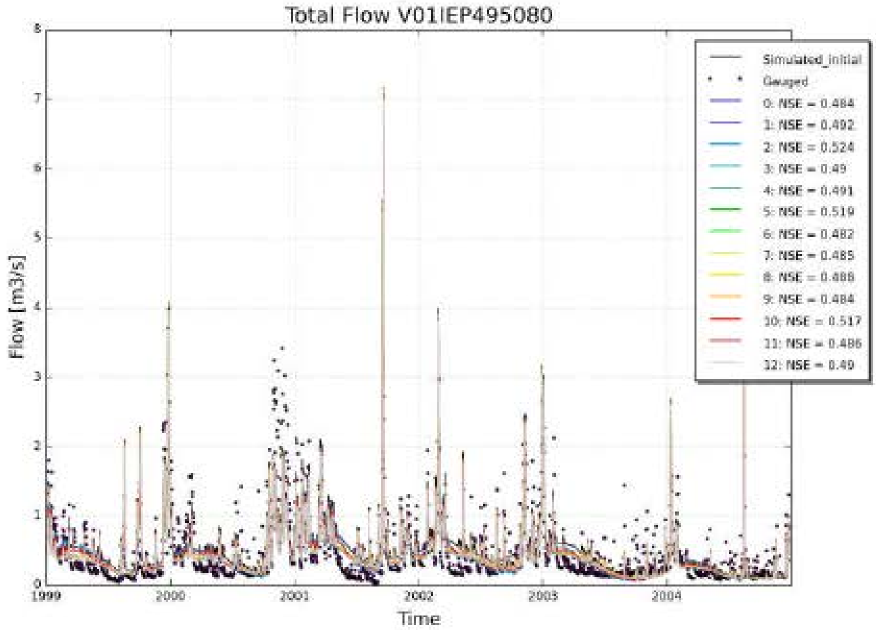
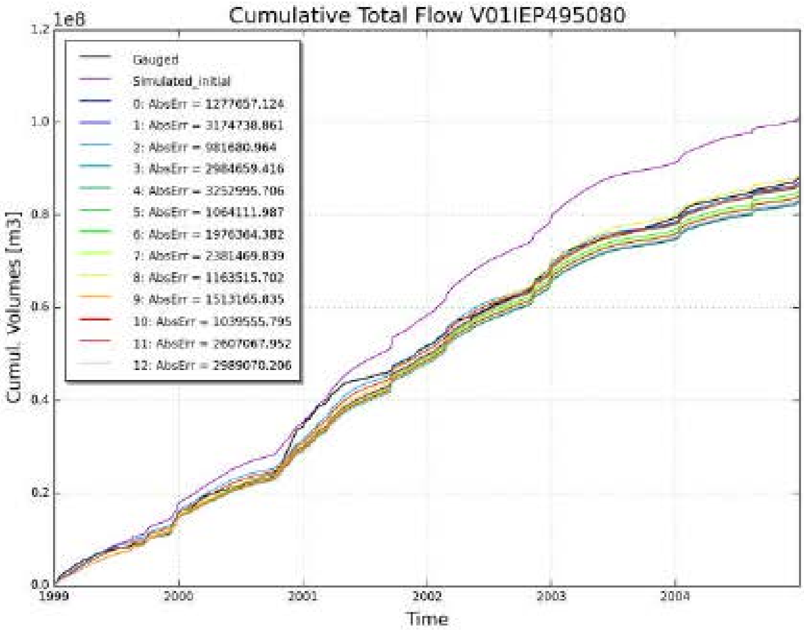


Figure 9: Total flow with optimum parameters (detail)

9.3.3.4.3 Final archive

0	:	[1.044,	25.287,	0.001,	0.762,	3.6,	278.383,	13.919,	170.107]	:	[1277657.124,	0.537]
1	:	[1.084,	25.178,	0.001,	0.85,	4.961,	284.42,	14.139,	179.094]	:	[3174738.861,	0.551]
2	:	[1.255,	23.799,	0.001,	0.5,	5.327,	261.263,	14.127,	192.789]	:	[981680.964,	0.475]
3	:	[1.078,	25.251,	0.001,	0.85,	4.003,	280.97,	13.936,	178.301]	:	[2984659.416,	0.55]
4	:	[1.085,	25.232,	0.001,	0.85,	4.049,	283.007,	14.102,	178.233]	:	[3252995.706,	0.551]
5	:	[1.189,	24.476,	0.001,	0.618,	3.6,	281.476,	14.136,	192.19]	:	[1064111.987,	0.51]
6	:	[1.082,	26.066,	0.001,	0.85,	5.133,	284.449,	13.599,	178.483]	:	[1976364.382,	0.546]
7	:	[1.08,	25.748,	0.001,	0.85,	4.926,	282.843,	13.613,	179.482]	:	[2381469.839,	0.548]
8	:	[1.048,	25.089,	0.001,	0.595,	4.595,	284.991,	14.926,	177.541]	:	[1163515.702,	0.527]
9	:	[1.044,	25.3,	0.001,	0.552,	4.181,	274.978,	14.238,	171.726]	:	[1513165.835,	0.54]
10	:	[1.186,	24.287,	0.001,	0.5,	3.754,	280.689,	12.486,	186.283]	:	[1039555.795,	0.509]
11	:	[1.082,	25.669,	0.001,	0.5,	3.76,	285.29,	13.596,	179.113]	:	[2607067.952,	0.55]
12	:	[1.078,	25.296,	0.001,	0.647,	3.6,	283.285,	14.853,	178.675]	:	[2989070.206,	0.551]


Total Flow V01IEP495080
Flow [m3/s]
Time
Simulated_initial
Gauged
0: NSE = 0.484
1: NSE = 0.492
2: NSE = 0.524
3: NSE = 0.49
4: NSE = 0.491
5: NSE = 0.519
6: NSE = 0.482
7: NSE = 0.485
8: NSE = 0.488
9: NSE = 0.484
10: NSE = 0.517
11: NSE = 0.486
12: NSE = 0.49


Cumulative Total Flow V01IEP495080
1e8
Cumul. Volumes [m3]
Time
Gauged
Simulated_initial
0: AbsErr = 1277657.124
1: AbsErr = 3174738.861
2: AbsErr = 981680.964
3: AbsErr = 2984659.416
4: AbsErr = 3252995.706
5: AbsErr = 1064111.987
6: AbsErr = 1976364.382
7: AbsErr = 2381469.839
8: AbsErr = 1163515.702
9: AbsErr = 1513165.835
10: AbsErr = 1039555.795
11: AbsErr = 2607067.952
12: AbsErr = 2989070.206

9.3.4 Report on simulation of catchment V01KEM492060 (2017-01-20 17-36)

9.3.4.1 Input data

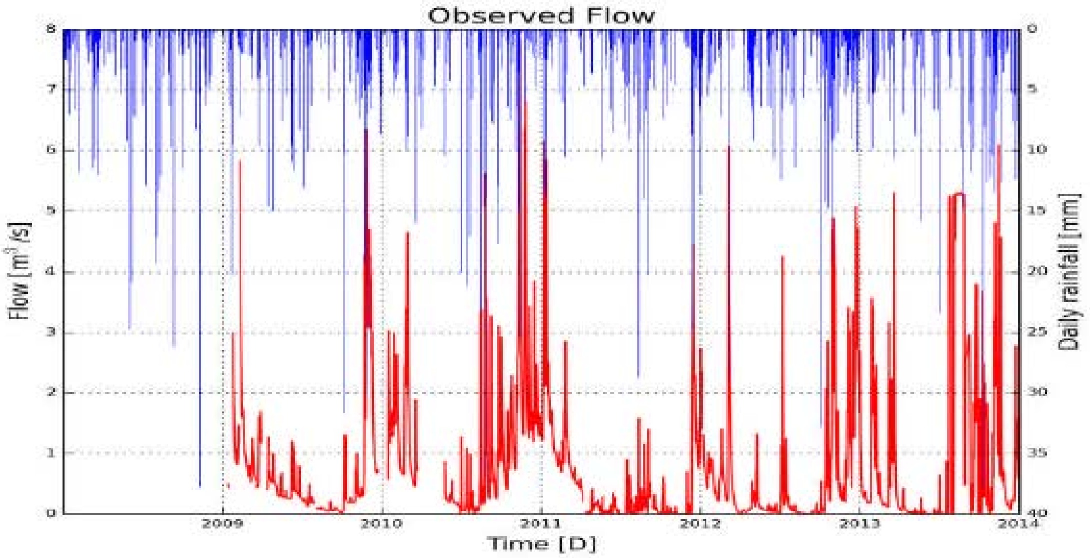


Figure 1: Hyetogram of observed discharge and observed net rain

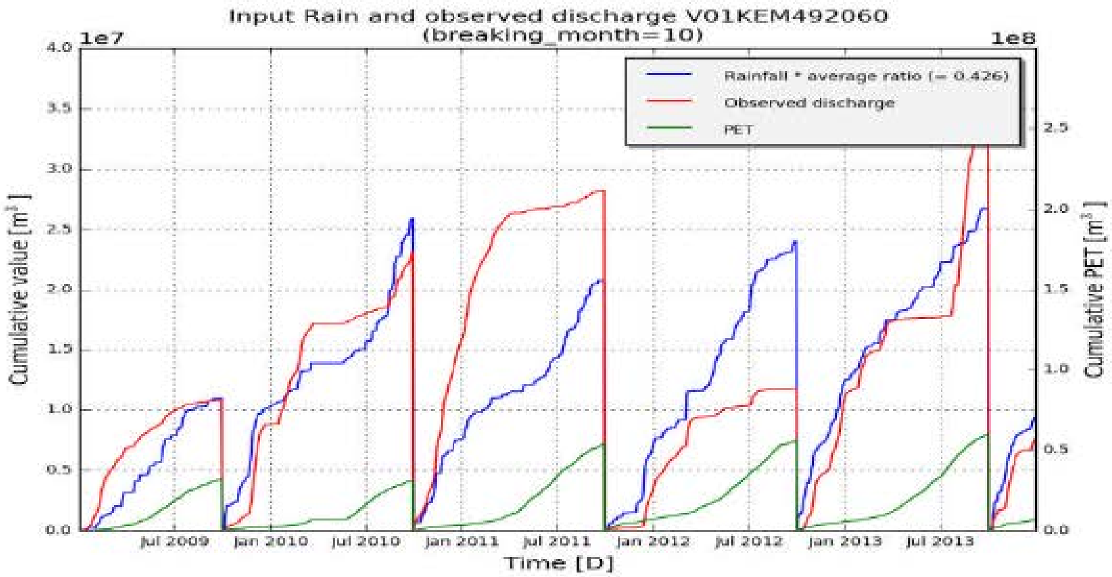


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.3.4.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	V01KEM492060
subcatchment_area	73900000
start_date	200901010000
end_date	201312310000
frequency	86400
warmup	365

9.3.4.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.0, 50.0, 0.009, 1.0, 50.0, 100.0, 2.0, 100.0]
low_bounds	[0.2, 10.0, 0.0018, 0.2, 10.0, 20.0, 0.4, 20.0]
high_bounds	[2.0, 200.0, 0.027, 3.0, 150.0, 400.0, 6.0, 400.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.0), ('Ki', 50.0), ('Kg', 0.009), ('Kss', 1.0), ('g0', 50.0), ('g_max', 100.0), ('K_run', 2.0), ('P_max', 100.0)]
Initial fitness:

- RelErr: -0.099
- AbsErr: 5946019.962
- KGE: 0.19
- NS_rel: -113.405
- NS: 0.182
- RMSE: 7598293.998
- NS_log: 0.189

Computation time:4:46:08.275000

9.3.4.4 Results

Best individual (euclidian): [('Kep', 1.444), ('Ki', 146.208), ('Kg', 0.027), ('Kss', 1.515), ('g0', 92.039), ('g_max', 81.145), ('K_run', 4.305), ('P_max', 156.26)]

Fitness:

- RelErr: -0.066
- AbsErr: 4139431.446
- KGE: 0.352
- NS_rel: -34.189
- NS: 0.238
- RMSE: 5633773.736
- NS_log: 0.356

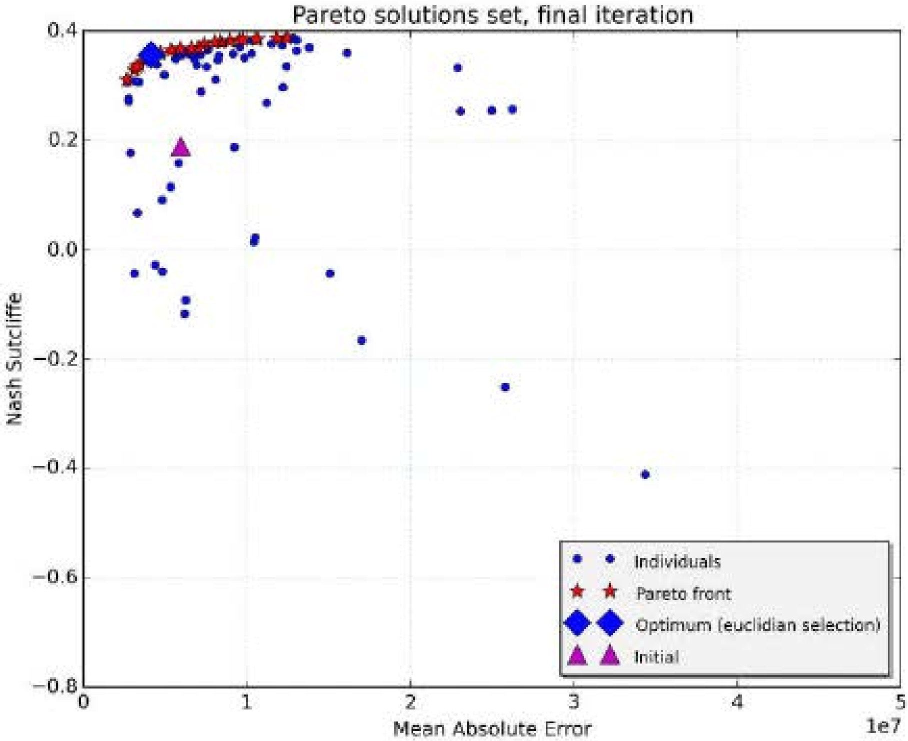


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

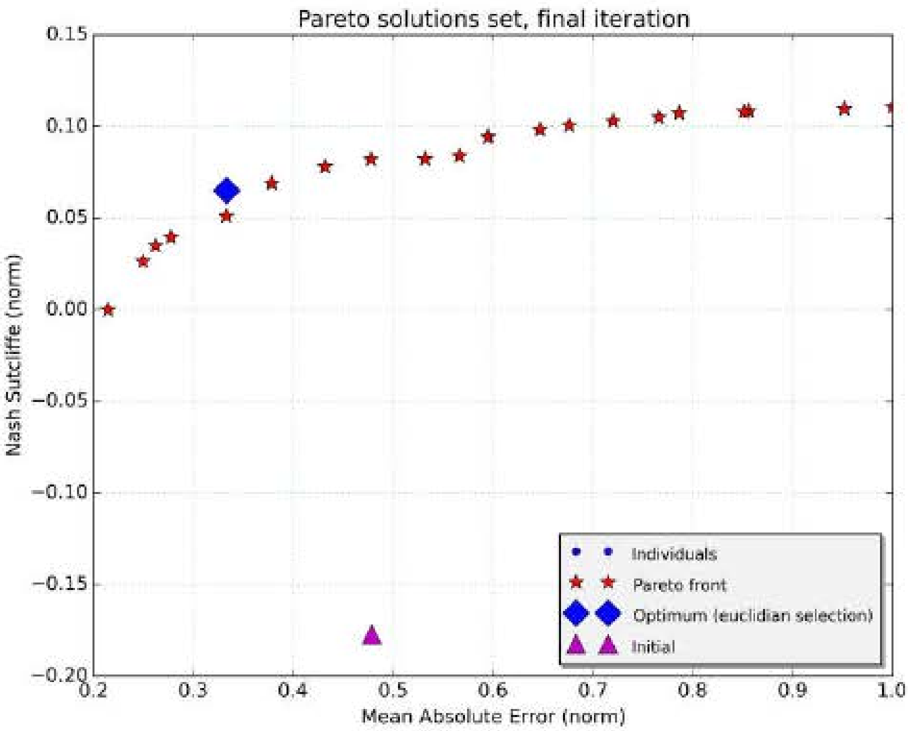


Figure 4: Final population of solutions (Pareto front)

9.3.4.4.1 Initial

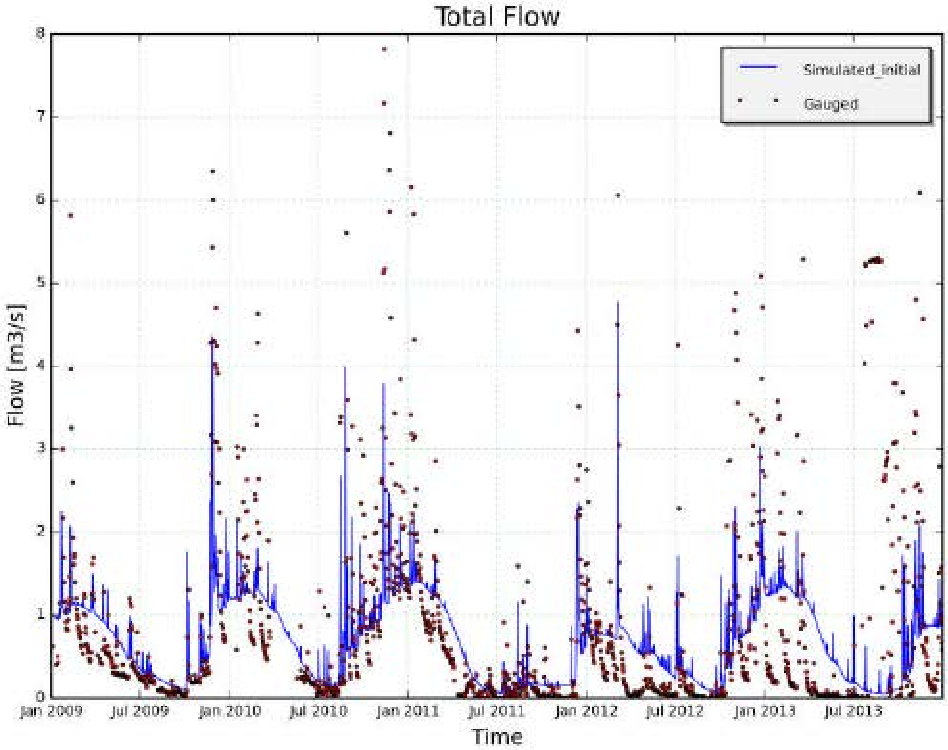


Figure 5: Total flow with initial parameters

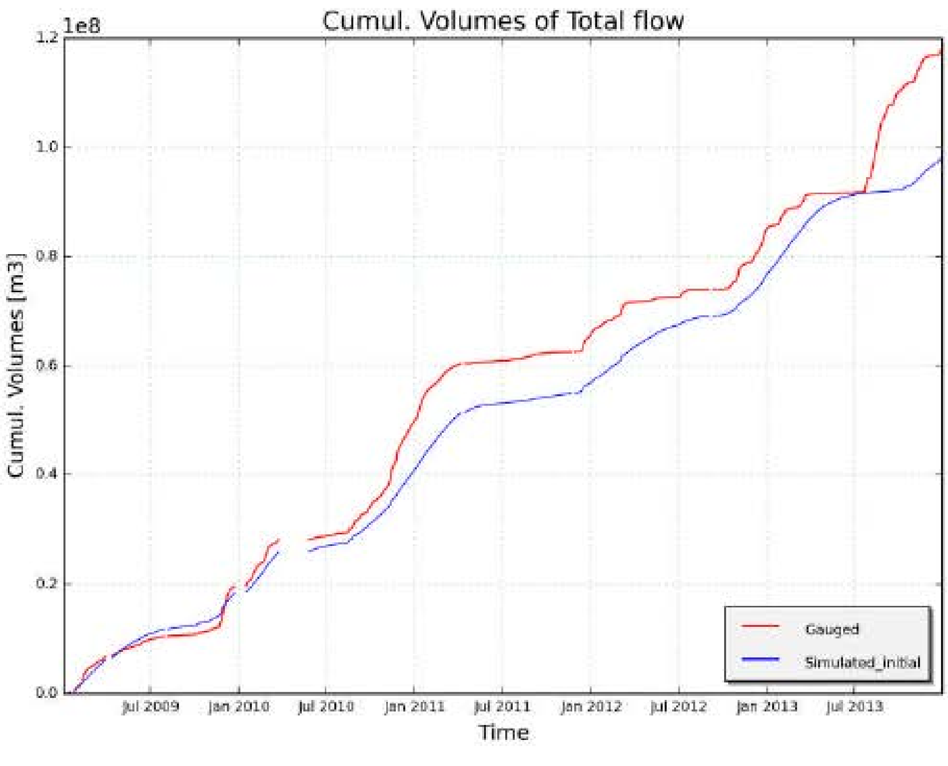


Figure 6: Cumulated flow with initial parameters

9.3.4.4.2 Optimum (euclidian)

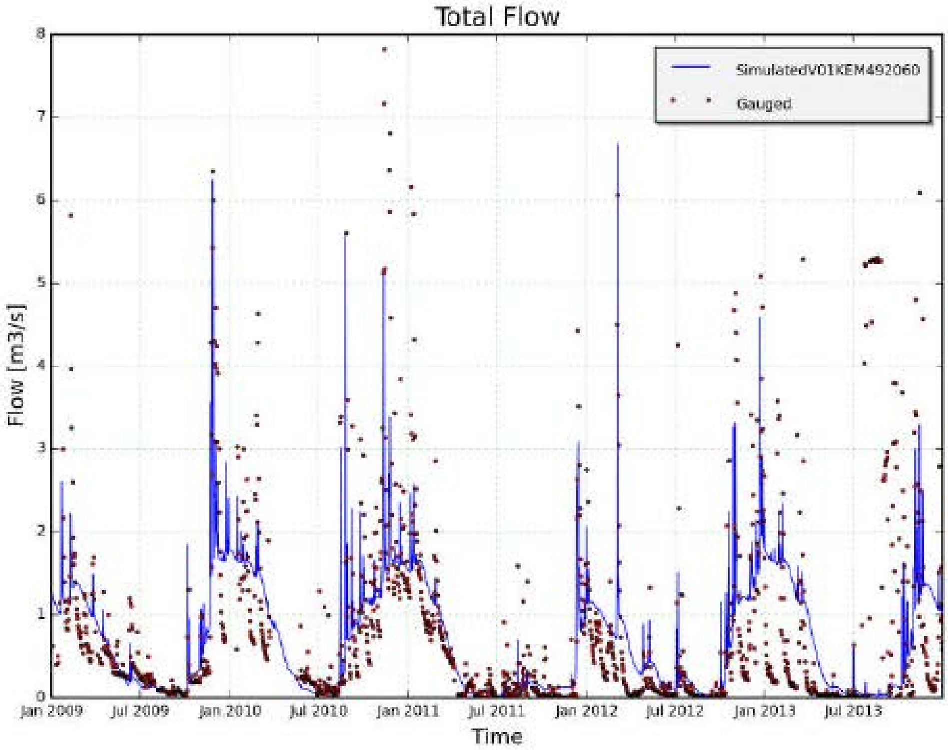


Figure 7: Total flow with optimum parameters

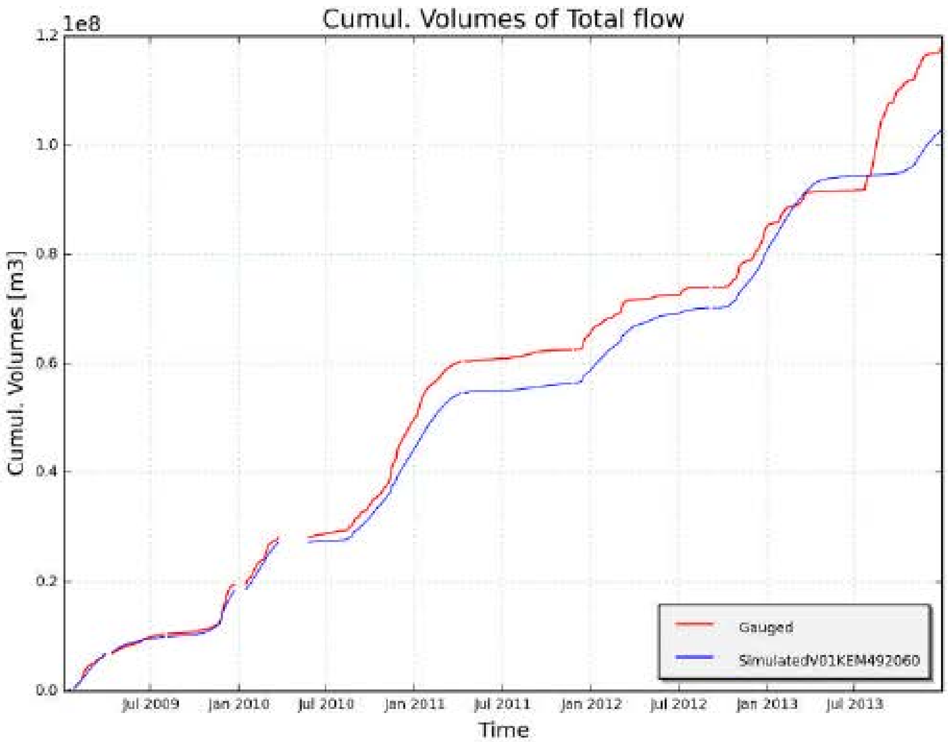


Figure 8: Cumulated flow with optimum parameters

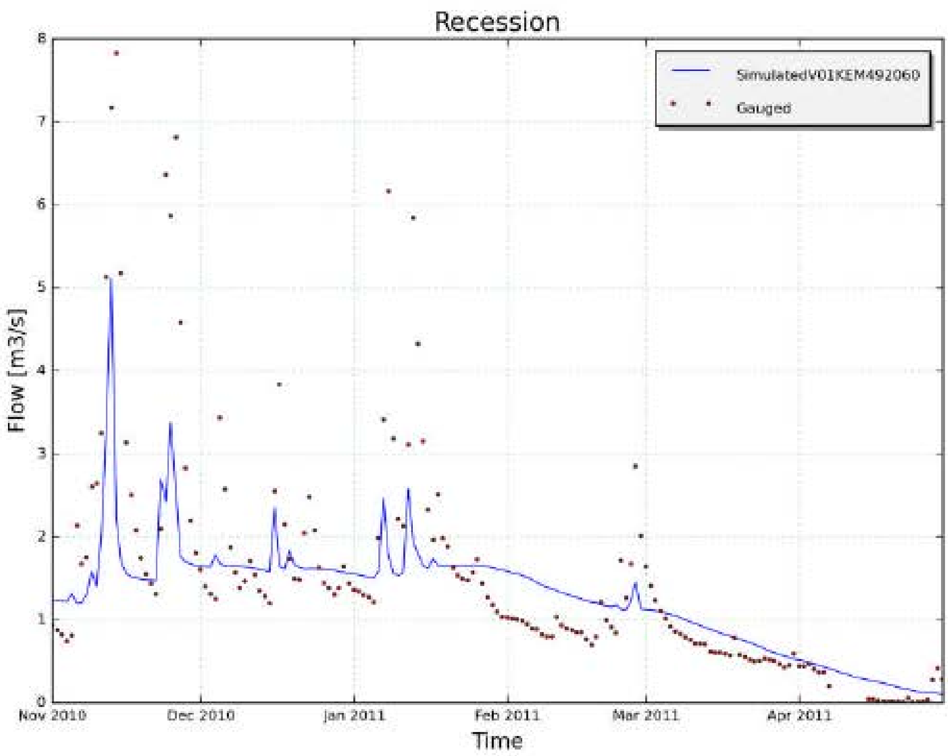


Figure 9: Total flow with optimum parameters (detail)

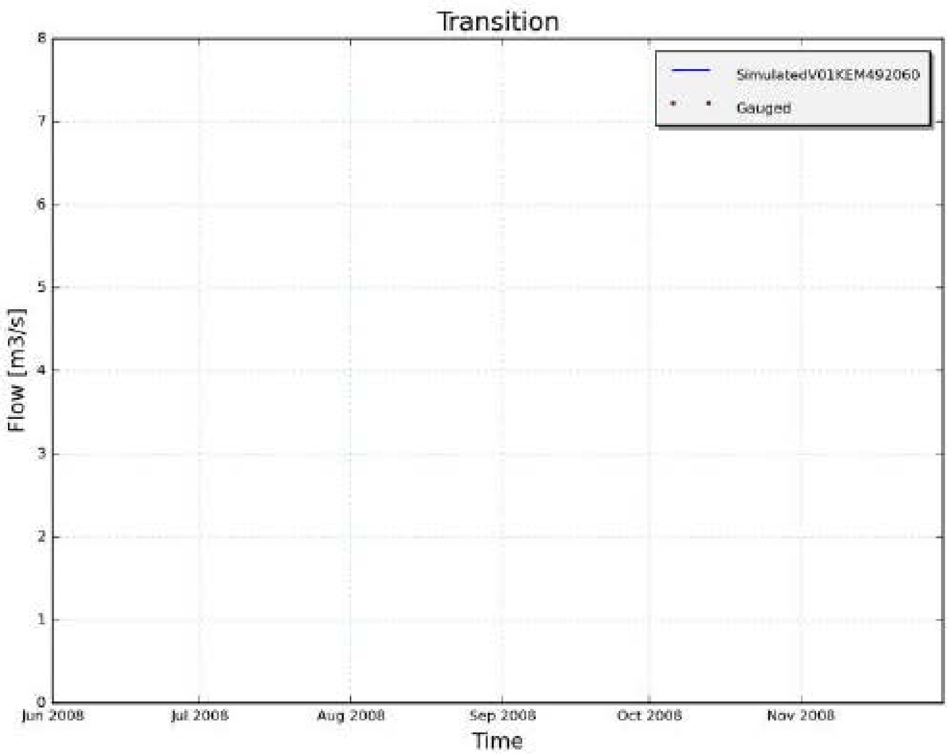
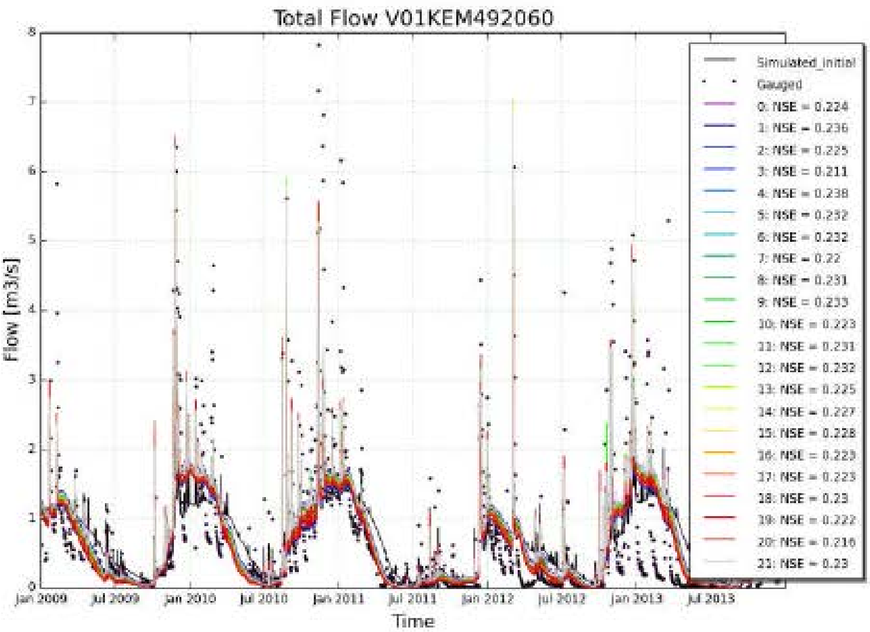
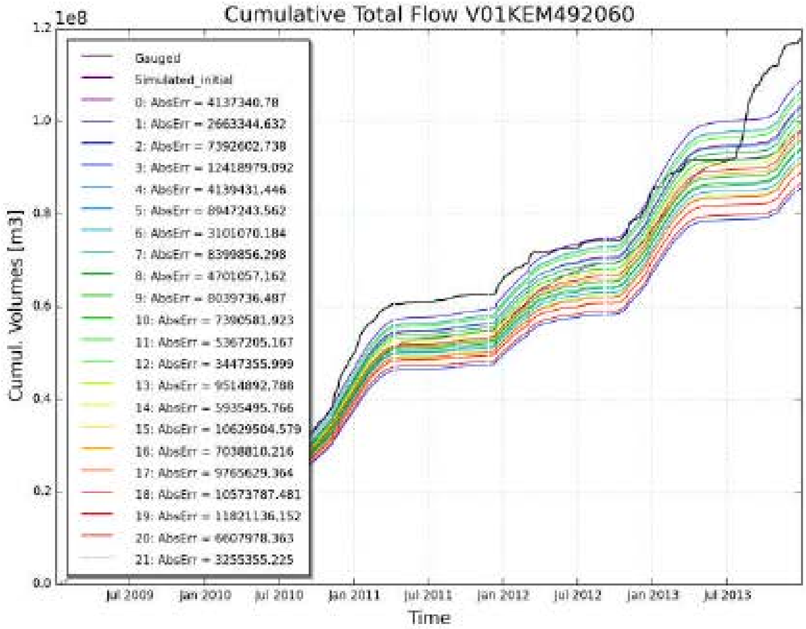


Figure 10: Total flow with optimum parameters (detail)

9.3.4.4.3 Final archive

0 : [1.354, 135.051, 0.027, 1.58, 84.012, 77.804, 2.345, 146.659] : [4137340.78, 0.346]
1 : [1.396, 145.54, 0.027, 1.018, 78.003, 108.588, 4.303, 146.027] : [2663344.632, 0.311]
2 : [1.583, 143.298, 0.027, 0.341, 84.418, 85.952, 2.887, 141.47] : [7392602.738, 0.376]
3 : [2.0, 145.842, 0.027, 1.558, 84.618, 119.824, 2.86, 128.8] : [12418979.092, 0.387]
4 : [1.444, 146.208, 0.027, 1.515, 92.039, 81.145, 4.305, 156.26] : [4139431.446, 0.356]
5 : [1.855, 134.92, 0.027, 1.016, 85.631, 117.491, 4.524, 135.678] : [8947243.562, 0.382]
6 : [1.392, 154.856, 0.027, 0.724, 77.867, 94.35, 4.101, 148.242] : [3101070.184, 0.329]
7 : [1.606, 161.201, 0.027, 0.865, 77.394, 80.893, 3.061, 147.679] : [8399856.298, 0.38]
8 : [1.449, 144.721, 0.027, 1.231, 92.345, 83.061, 3.212, 148.688] : [4701057.162, 0.359]
9 : [1.764, 146.815, 0.027, 1.554, 78.548, 108.546, 4.782, 132.239] : [8039736.487, 0.379]
10 : [1.582, 160.073, 0.027, 0.849, 77.691, 86.317, 3.26, 147.74] : [7390581.923, 0.376]
11 : [1.515, 156.34, 0.027, 0.997, 77.704, 86.163, 4.017, 148.146] : [5367205.167, 0.365]
12 : [1.406, 159.181, 0.027, 1.52, 80.859, 89.631, 4.247, 152.711] : [3447355.999, 0.338]
13 : [1.824, 143.854, 0.027, 1.632, 88.715, 112.028, 3.531, 140.663] : [9514892.788, 0.383]
14 : [1.52, 159.445, 0.027, 0.883, 77.694, 86.164, 3.496, 146.429] : [5935495.766, 0.368]
15 : [1.919, 136.005, 0.027, 0.473, 82.985, 105.514, 4.523, 137.85] : [10629504.579, 0.386]
16 : [1.634, 153.112, 0.027, 1.244, 79.732, 107.467, 3.11, 145.335] : [7038810.216, 0.369]
17 : [1.698, 146.631, 0.027, 0.303, 92.332, 79.83, 3.074, 155.365] : [9765629.364, 0.385]
18 : [1.989, 136.945, 0.027, 0.933, 86.171, 117.667, 5.999, 147.225] : [10573787.481, 0.385]
19 : [1.988, 147.267, 0.027, 0.2, 82.193, 110.68, 4.169, 130.178] : [11821136.152, 0.387]
20 : [1.459, 159.916, 0.027, 0.446, 84.028, 77.059, 2.345, 146.648] : [6607978.363, 0.368]
21 : [1.348, 143.854, 0.027, 1.626, 79.439, 82.445, 3.251, 146.861] : [3255355.225, 0.335]





9.3.5 Report on simulation of catchment V01POP491030 (2017-01-18 23-13)

9.3.5.1 Input data

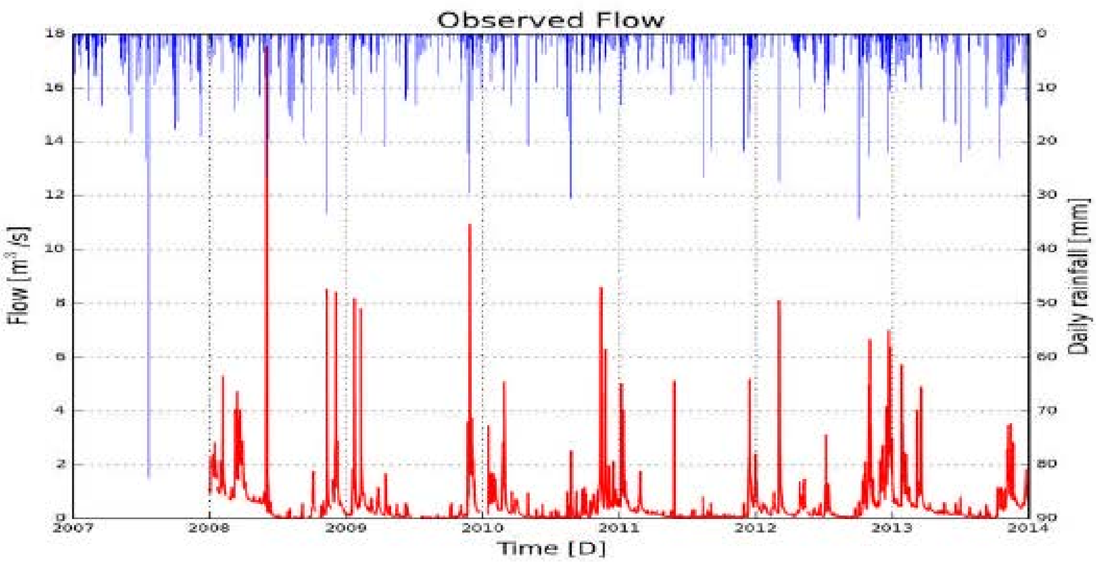


Figure 1: Hyetogram of observed discharge and observed net rain

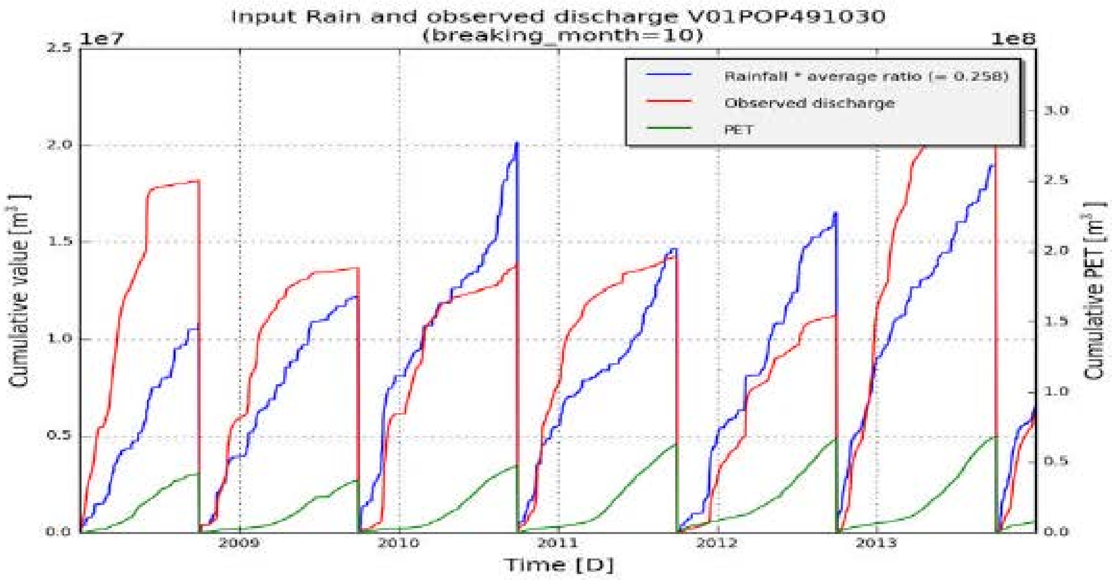


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.3.5.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V01POP491030
subcatchment_area	84868207
start_date	200801010000
end_date	201312310000
frequency	86400
warmup	365

9.3.5.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[2.47, 91.81, 0.123, 1.82, 161.54, 4261.42, 0.08, 267.97]
low_bounds	[2.0, 78.0, 0.08, 1.44, 128.8, 3408.0, 0.064, 200.0]
high_bounds	[3.2, 117.0, 0.12, 2.16, 193.0, 5120.0, 0.1, 300.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 2.47), ('Ki', 91.81), ('Kg', 0.123), ('Kss', 1.82), ('g0', 161.54), ('g_max', 4261.42), ('K_run', 0.08), ('P_max', 267.97)]
Initial fitness:

- RelErr: 0.012
- AbsErr: 5978423.428
- KGE: 0.335
- NS_rel: -7.936
- NS: 0.074
- RMSE: 6571678.239
- NS_log: 0.313

Computation time:10:09:31.398000

9.3.5.4 Results

Best individual (euclidian): [('Kep', 2.844), ('Ki', 103.259), ('Kg', 0.08), ('Kss', 2.146), ('g0', 157.895), ('g_max', 4499.929), ('K_run', 0.1), ('P_max', 244.717)]

Fitness:

- RelErr: -0.053
- AbsErr: 3981364.763
- KGE: 0.306
- NS_rel: -7.409
- NS: 0.077
- RMSE: 5611173.247
- NS_log: 0.326

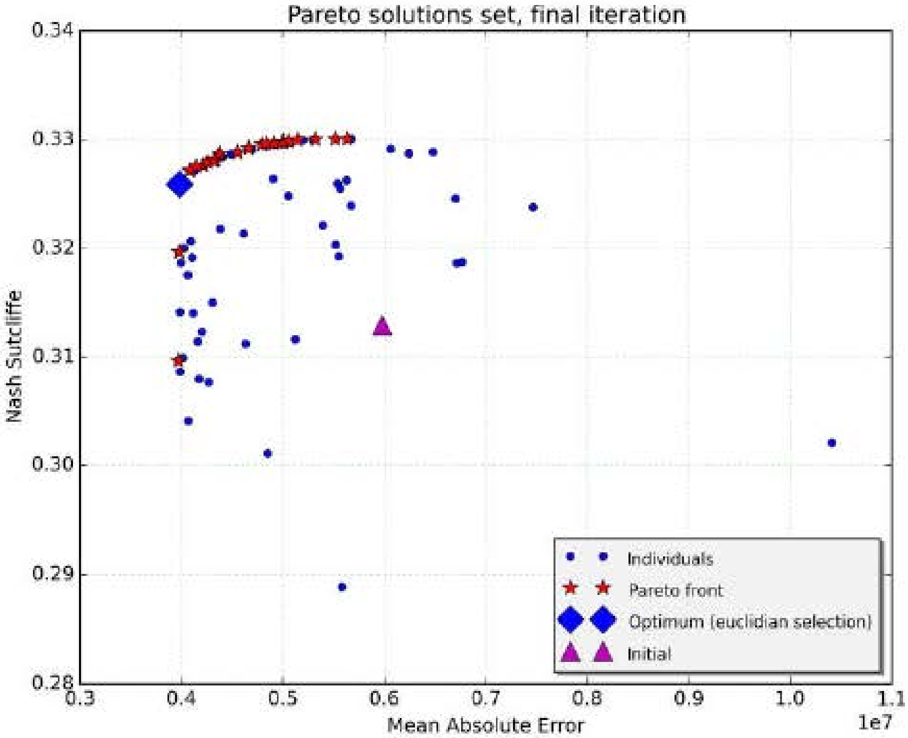


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

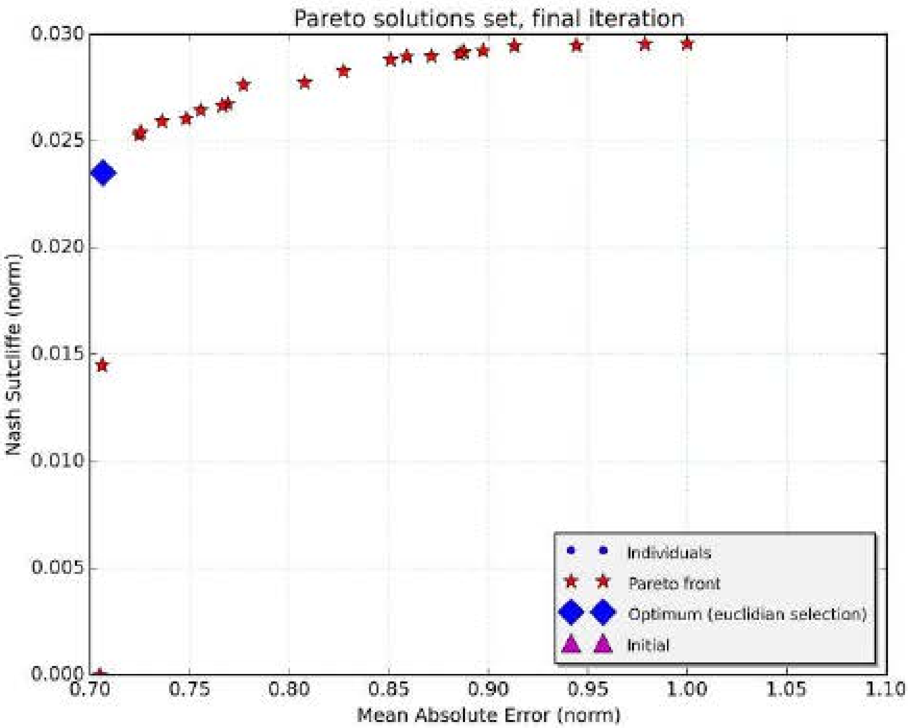


Figure 4: Final population of solutions (Pareto front)

9.3.5.4.1 Initial

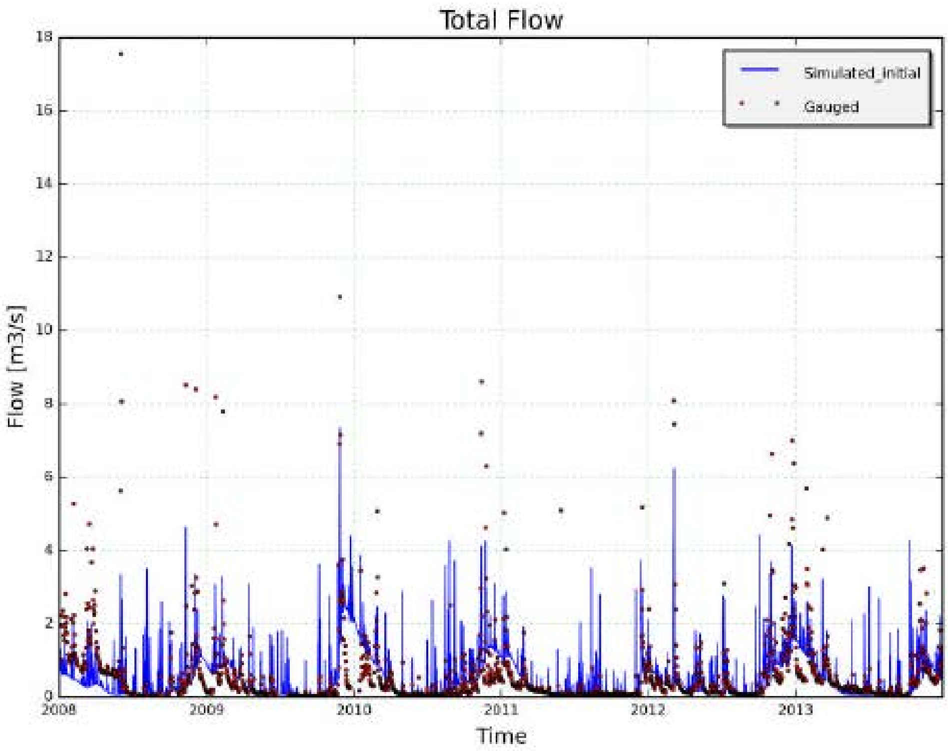


Figure 5: Total flow with initial parameters

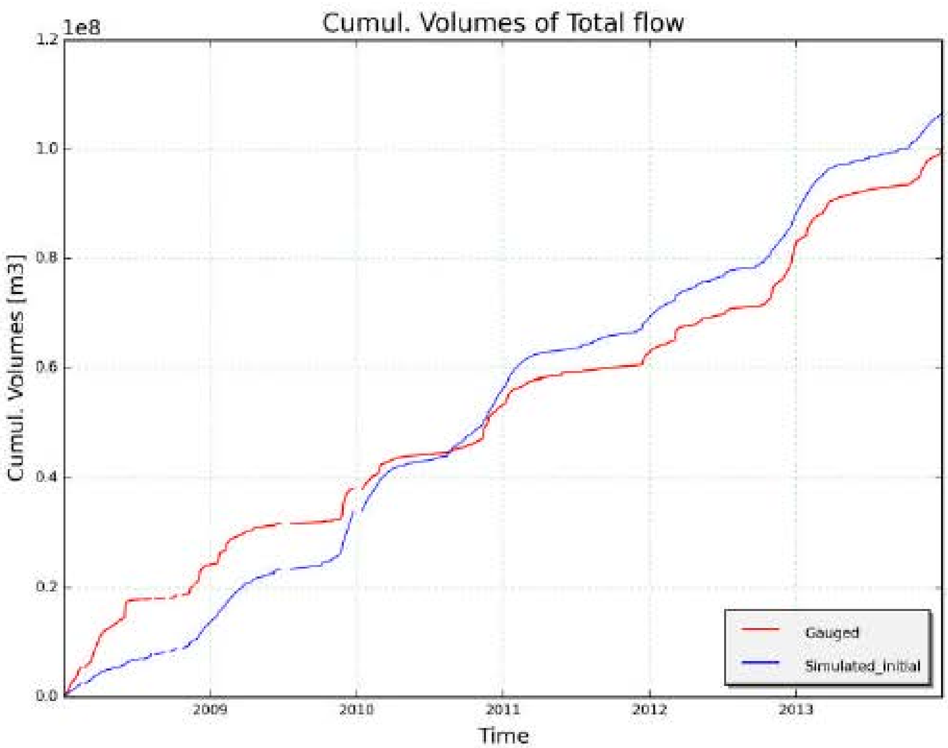


Figure 6: Cumulated flow with initial parameters

9.3.5.4.2 Optimum (euclidian)

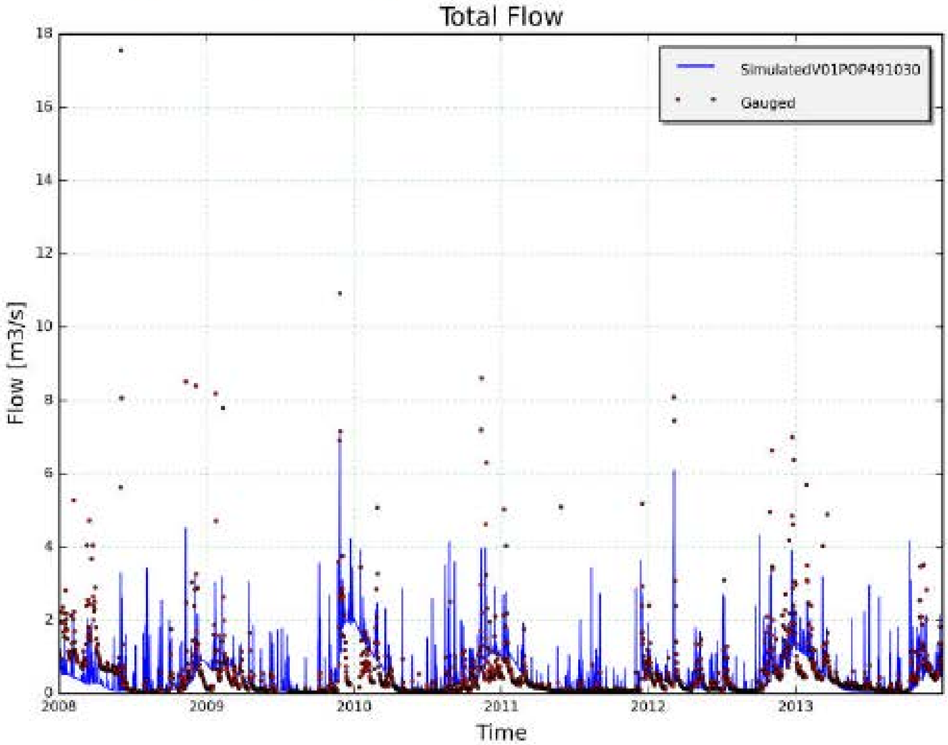


Figure 7: Total flow with optimum parameters

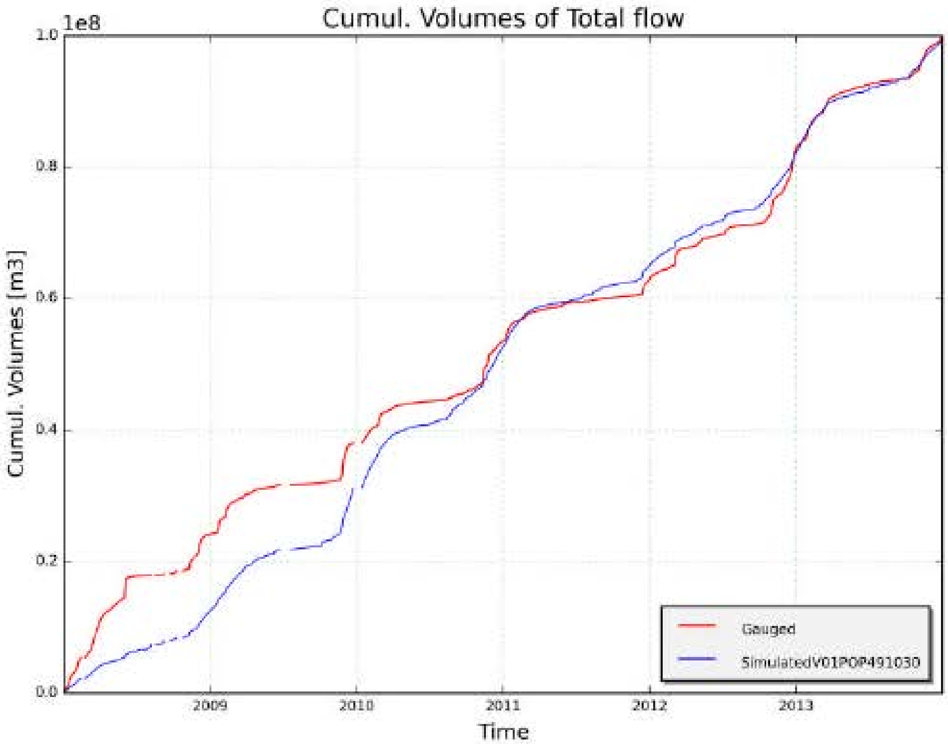


Figure 8: Cumulated flow with optimum parameters

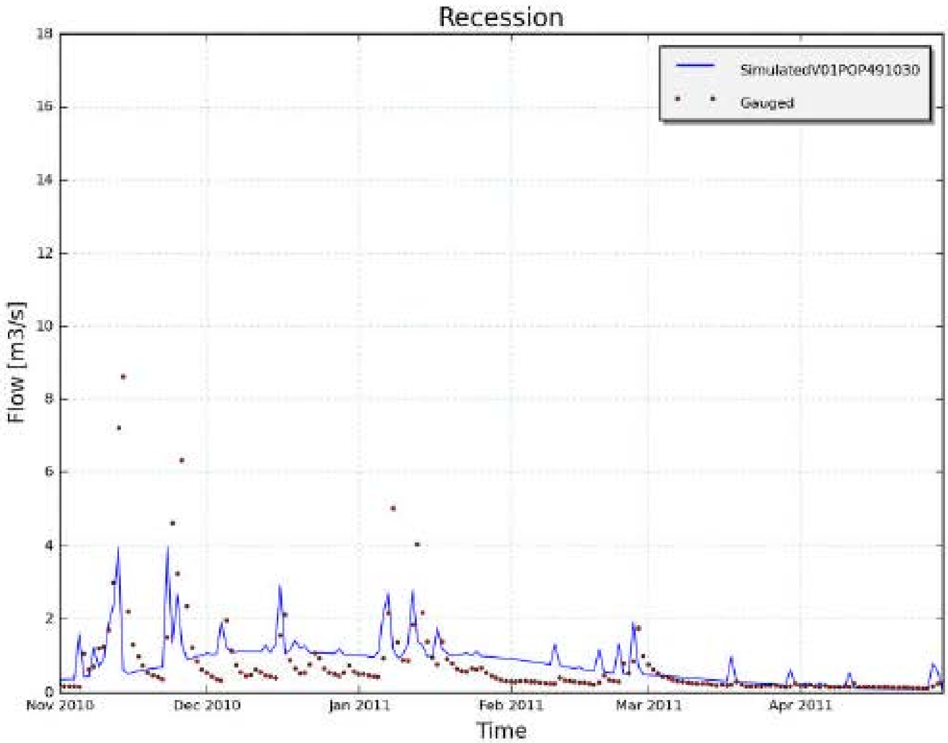


Figure 9: Total flow with optimum parameters (detail)

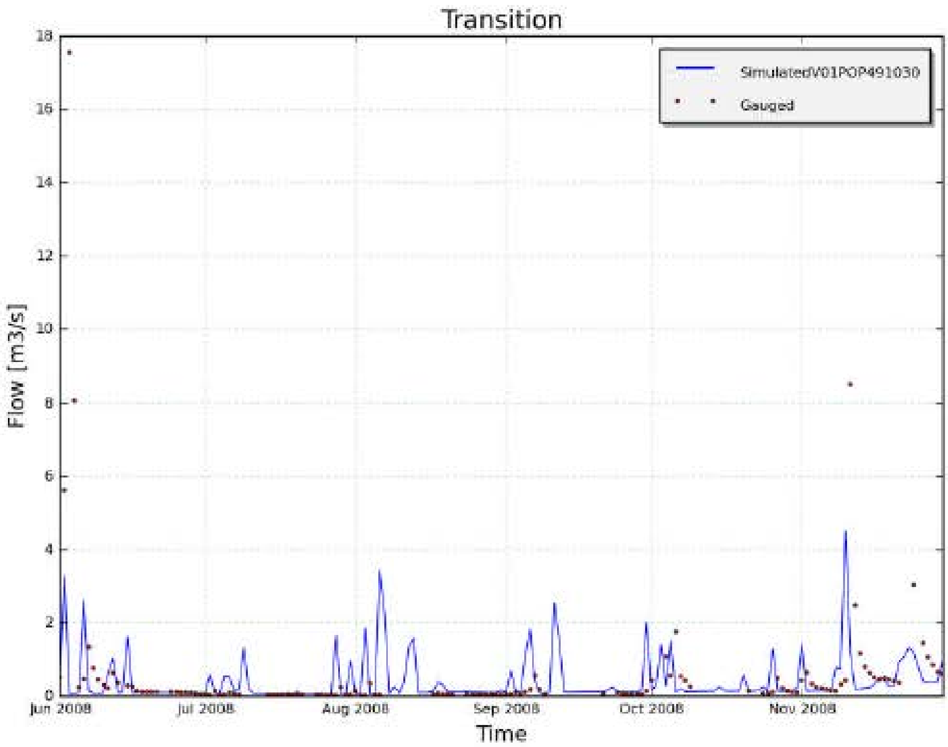


Figure 10: Total flow with optimum parameters (detail)

9.3.5.4.3 Final archive

0 : [2.842, 99.573, 0.104, 1.688, 174.345, 5094.167, 0.072, 217.653] : [3973149.629, 0.31]

1 : [2.825, 107.424, 0.08, 1.893, 162.624, 4452.196, 0.099, 252.984] : [3987608.935, 0.326]

2 : [2.766, 97.093, 0.08, 2.16, 169.068, 4512.259, 0.1, 249.935] : [4217346.675, 0.328]

3 : [2.704, 101.259, 0.08, 1.874, 156.594, 4466.796, 0.1, 250.468] : [4552373.543, 0.329]

4 : [2.744, 99.67, 0.08, 1.44, 162.535, 4485.722, 0.1, 249.902] : [4334632.231, 0.328]

5 : [2.756, 104.359, 0.08, 2.16, 168.434, 4502.867, 0.099, 250.049] : [4258140.237, 0.328]

6 : [2.837, 103.819, 0.096, 1.738, 131.875, 4770.818, 0.1, 215.521] : [3979190.707, 0.32]

7 : [2.79, 108.156, 0.08, 1.911, 162.043, 4474.327, 0.099, 248.295] : [4083162.66, 0.327]

8 : [2.744, 104.254, 0.08, 1.851, 156.99, 4470.082, 0.099, 250.45] : [4319781.73, 0.328]

9 : [2.585, 98.929, 0.08, 1.84, 165.355, 4494.063, 0.1, 241.844] : [5321266.682, 0.33]

10 : [2.54, 99.223, 0.08, 2.16, 162.6, 4513.165, 0.1, 242.599] : [5635346.692, 0.33]

11 : [2.631, 103.416, 0.08, 1.618, 148.116, 4474.316, 0.1, 248.693] : [5001675.653, 0.33]

12 : [2.631, 103.416, 0.08, 1.44, 148.116, 4474.316, 0.1, 248.264] : [5002116.318, 0.33]

13 : [2.79, 105.441, 0.08, 1.914, 161.878, 4511.13, 0.1, 249.41] : [4088207.096, 0.327]

14 : [2.634, 101.59, 0.08, 1.695, 133.869, 4543.01, 0.1, 249.865] : [4991078.955, 0.33]

15 : [2.625, 100.157, 0.08, 2.16, 159.278, 4513.751, 0.1, 244.512] : [5057089.856, 0.33]

16 : [2.739, 101.706, 0.08, 1.895, 169.937, 4666.307, 0.097, 219.213] : [4378220.625, 0.329]

17 : [2.688, 98.636, 0.08, 2.16, 157.814, 4513.34, 0.1, 244.715] : [4662065.976, 0.329]

18 : [2.778, 106.64, 0.08, 2.09, 162.826, 4511.196, 0.1, 250.057] : [4148719.22, 0.328]

19 : [2.558, 99.169, 0.08, 1.44, 163.639, 4513.573, 0.1, 242.944] : [5515028.229, 0.33]

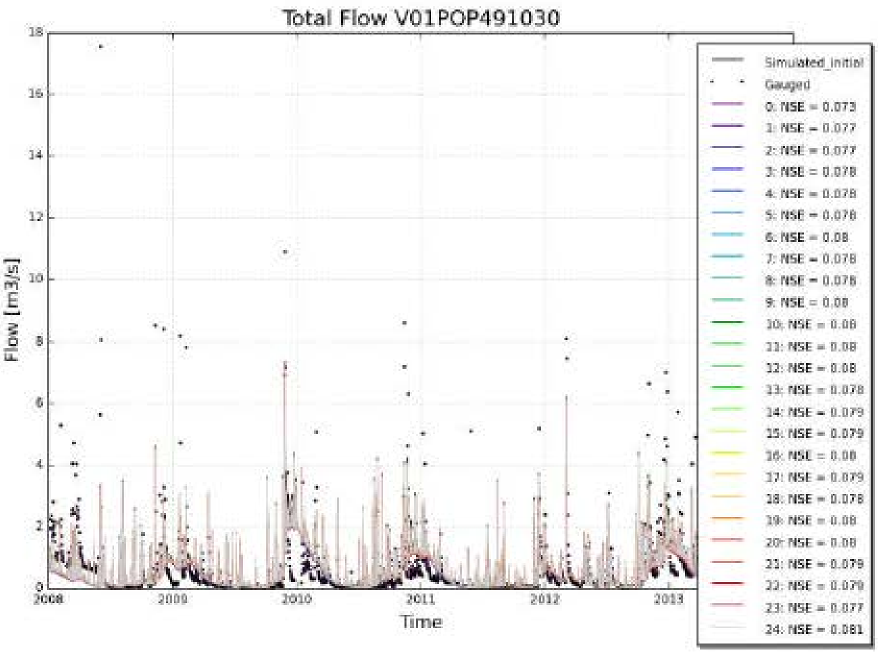
20 : [2.61, 104.964, 0.08, 2.106, 160.859, 4511.646, 0.1, 246.61] : [5146077.891, 0.33]

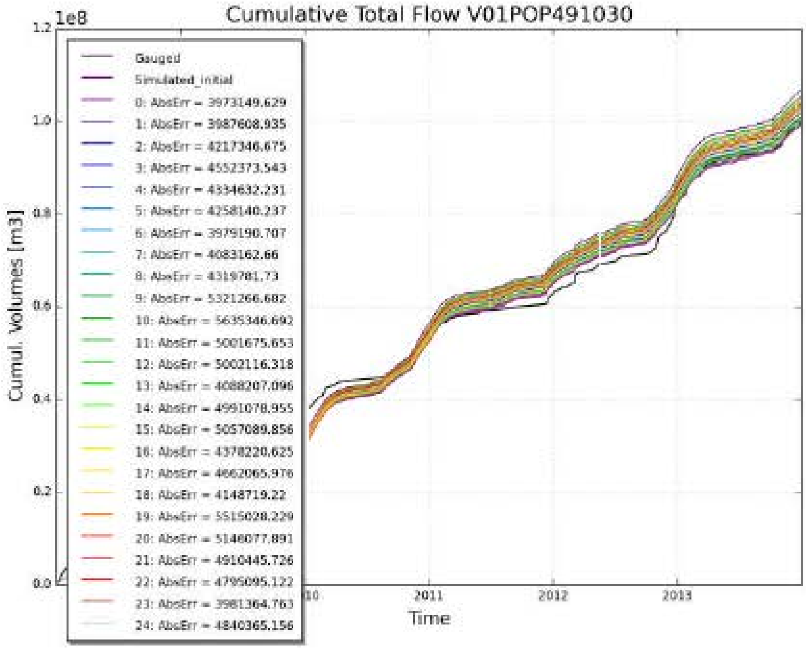
21 : [2.647, 100.127, 0.08, 1.985, 158.541, 4513.075, 0.1, 244.63] : [4910445.726, 0.33]

22 : [2.664, 105.429, 0.08, 2.149, 161.204, 4511.349, 0.1, 247.296] : [4795095.122, 0.33]

23 : [2.844, 103.259, 0.08, 2.146, 157.895, 4499.929, 0.1, 244.717] : [3981364.763, 0.326]

24 : [2.661, 100.286, 0.08, 2.1, 167.965, 4535.805, 0.097, 223.073] : [4840365.156, 0.33]





9.3.6 Report on simulation of catchment V01SSV499140 (2017-01-18 16-40)

9.3.6.1 Input data

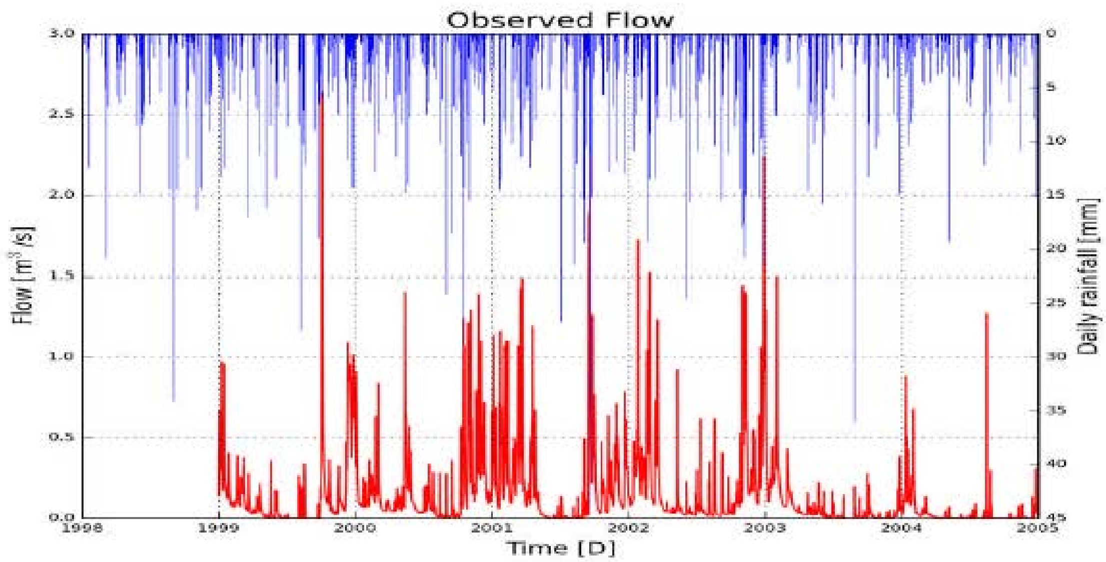


Figure 1: Hyetogram of observed discharge and observed net rain

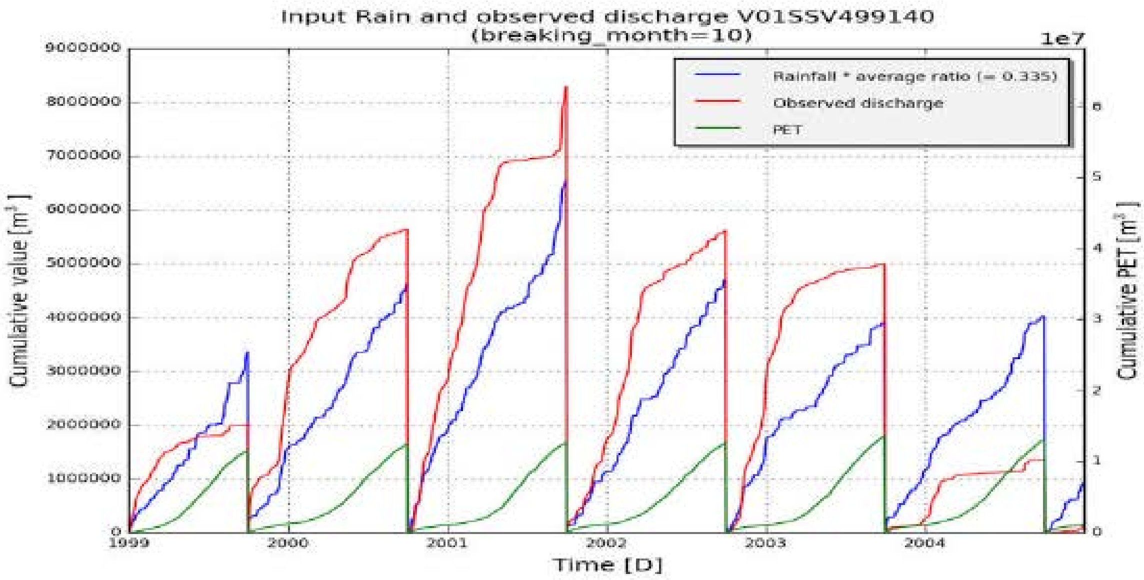


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.3.6.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V01SSV499140
subcatchment_area	16100000
start_date	199901010000
end_date	200412310000
frequency	86400
warmup	365

9.3.6.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[1.507, 123.8, 0.001, 0.9, 399.13, 651.88, 11.7, 383.78]
low_bounds	[1.2, 98.0, 0.00083, 0.7, 310.0, 530.0, 9.7, 306.0]
high_bounds	[1.8, 147.0, 0.0012, 1.08, 478.0, 780.0, 14.3, 460.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.507), ('Ki', 123.8), ('Kg', 0.001), ('Kss', 0.9), ('g0', 399.13), ('g_max', 651.88), ('K_run', 11.7), ('P_max', 383.78)]
Initial fitness:

- RelErr: 0.069
- AbsErr: 1154404.97
- KGE: 0.708
- NS_rel: -282.158
- NS: 0.475
- RMSE: 1450815.537
- NS_log: 0.142

Computation time:3:44:57.758000

9.3.6.4 Results

Best individual (euclidian): [('Kep', 1.759), ('Ki', 142.325), ('Kg', 0.001), ('Kss', 0.743), ('g0', 418.696), ('g_max', 594.361), ('K_run', 11.538), ('P_max', 396.801)]

Fitness:

- RelErr: -0.031
- AbsErr: 750079.0
- KGE: 0.734
- NS_rel: -265.505
- NS: 0.453
- RMSE: 957661.614
- NS_log: 0.288

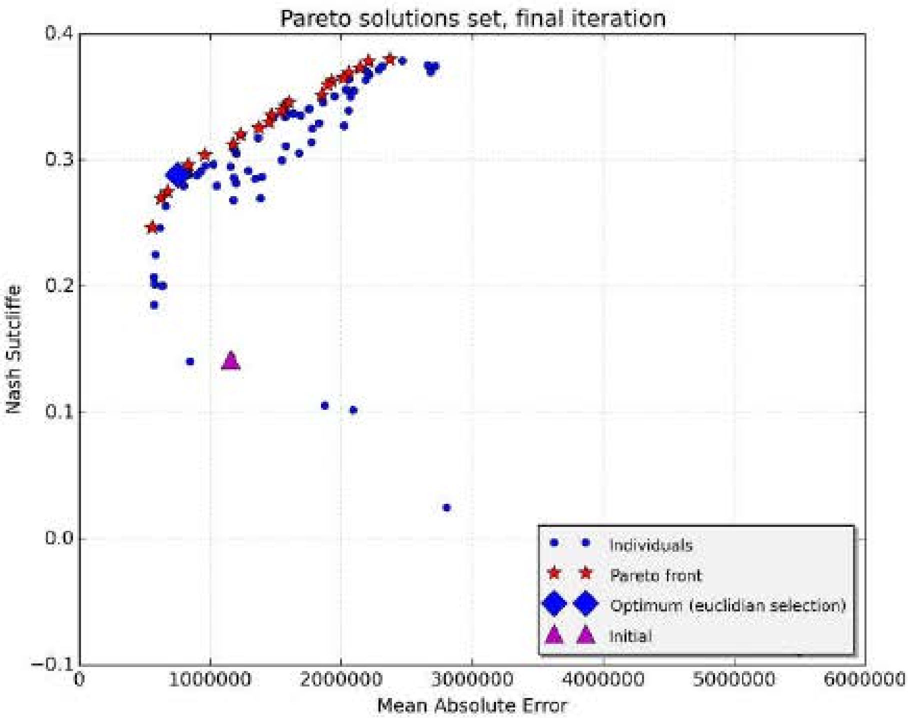


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

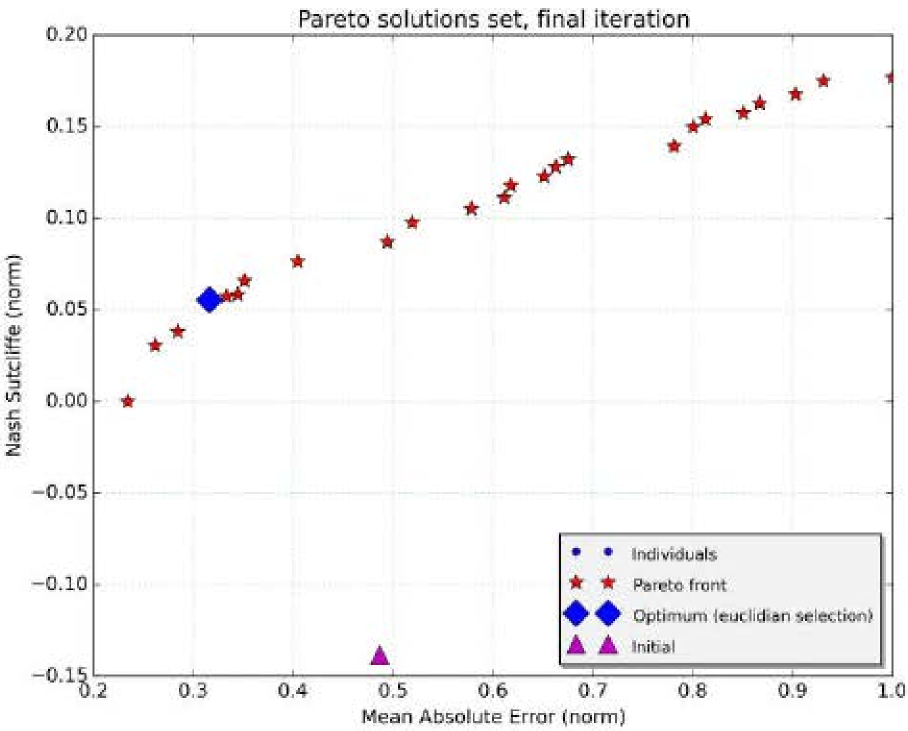


Figure 4: Final population of solutions (Pareto front)

9.3.6.4.1 Initial

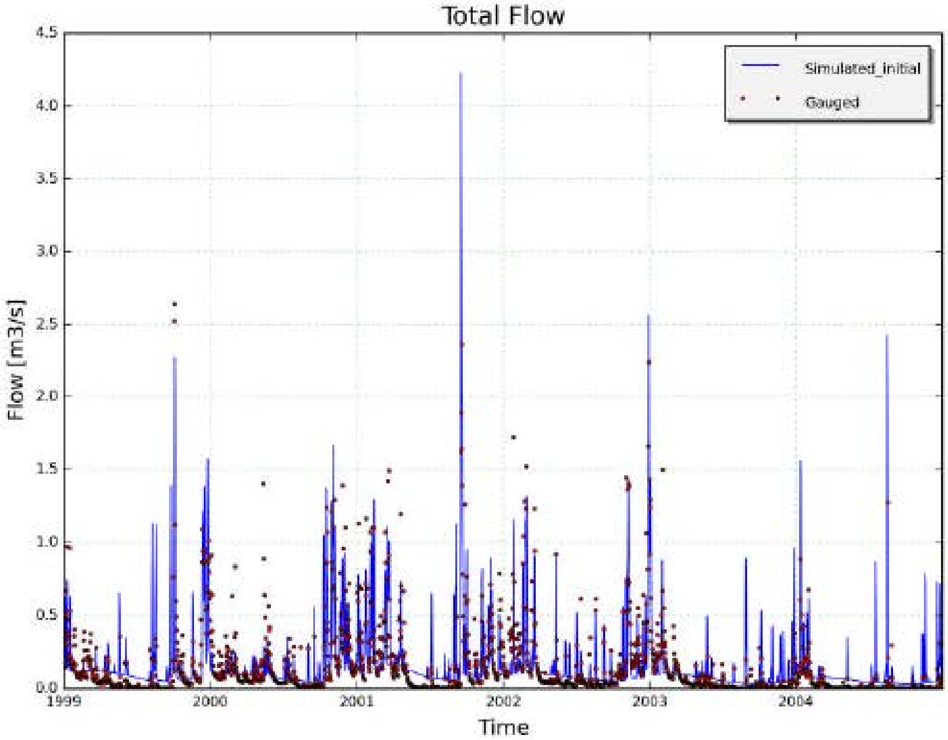


Figure 5: Total flow with initial parameters

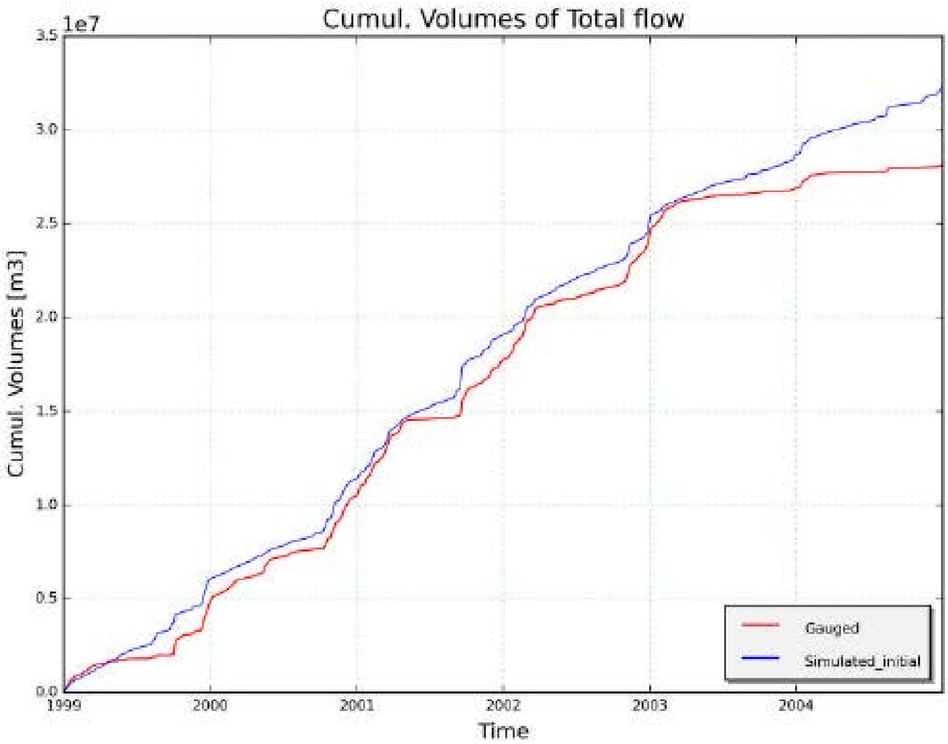


Figure 6: Cumulated flow with initial parameters

9.3.6.4.2 Optimum (euclidian)

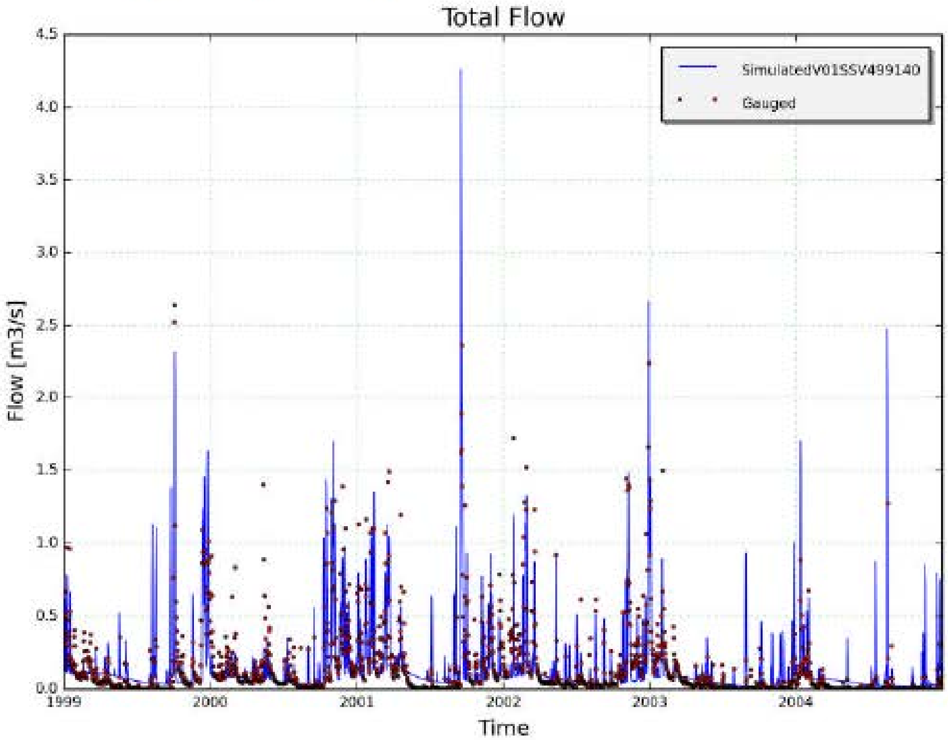


Figure 7: Total flow with optimum parameters

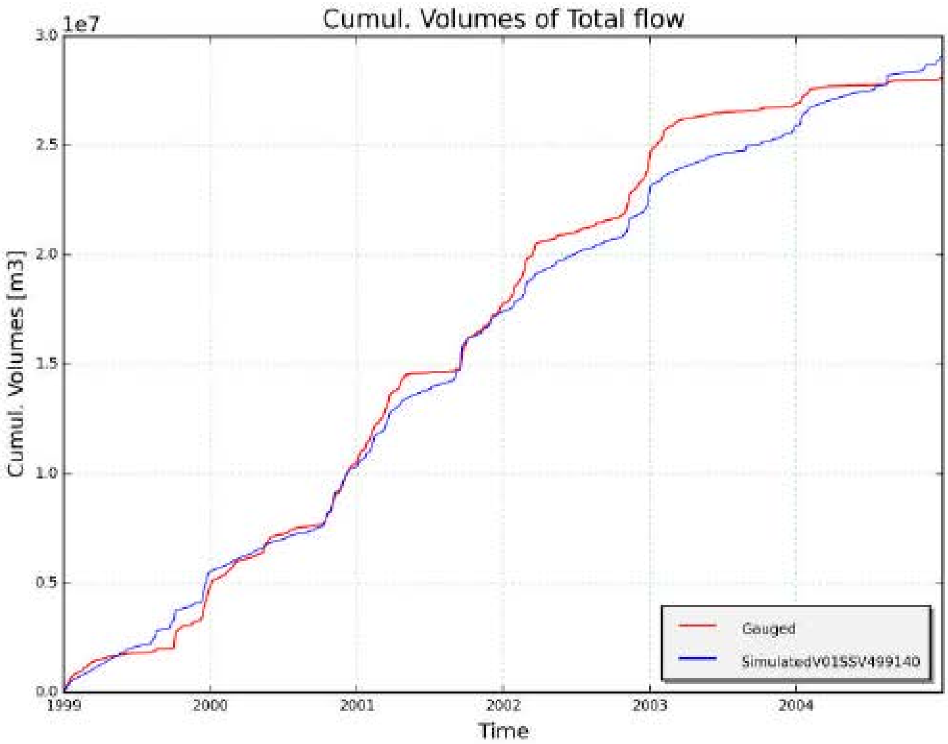


Figure 8: Cumulated flow with optimum parameters

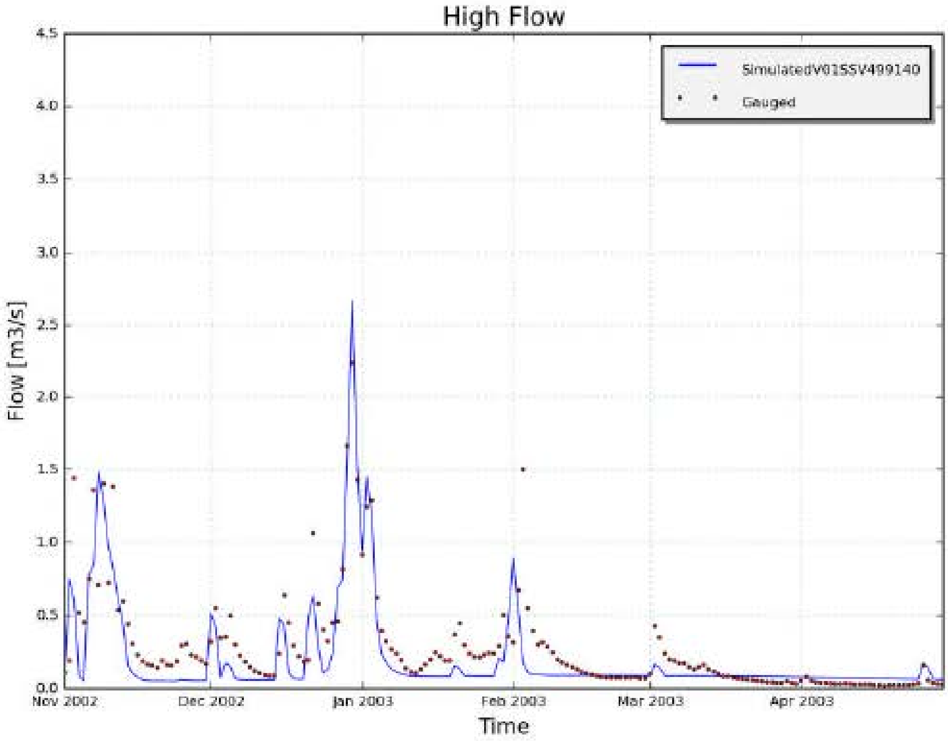
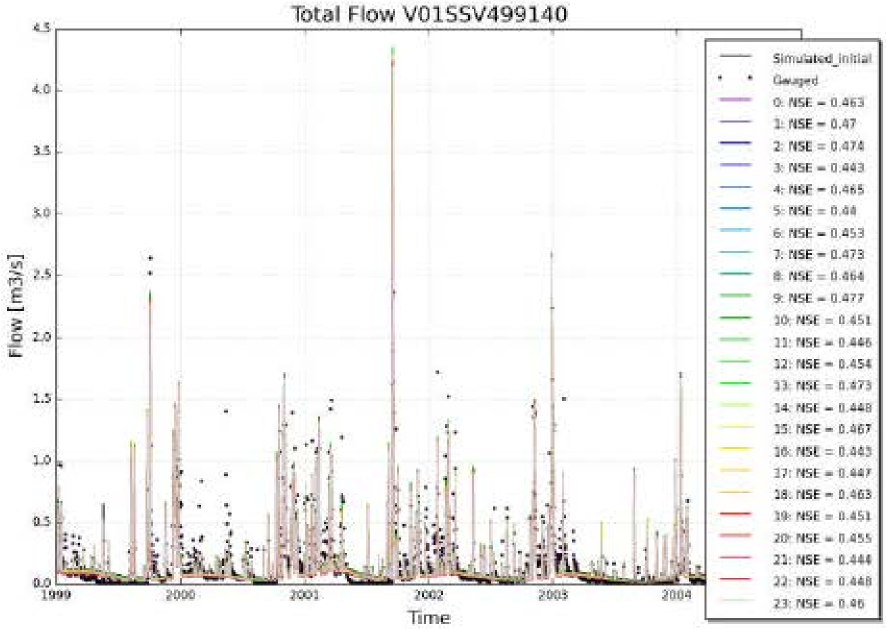
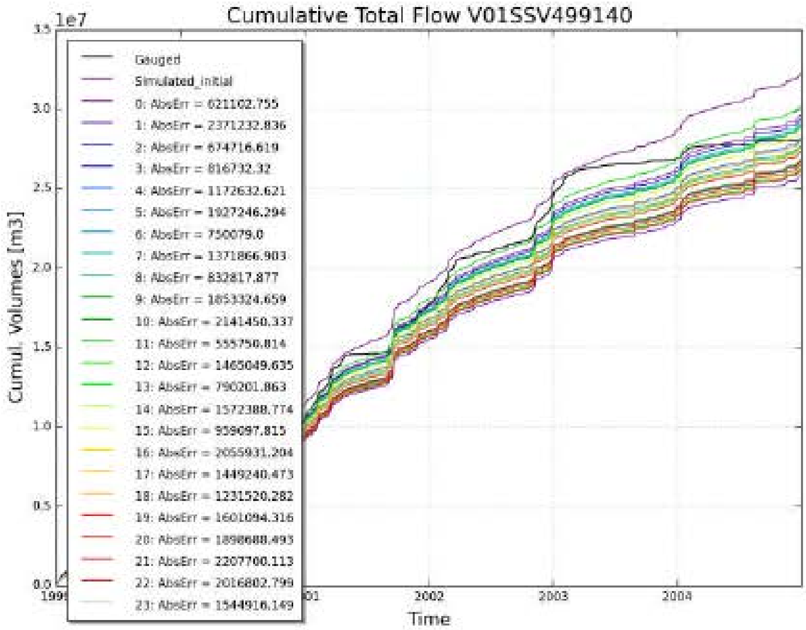


Figure 9: Total flow with optimum parameters (detail)

9.3.6.4.3 Final archive

0 : [1.748, 139.046, 0.001, 1.054, 371.227, 588.936, 10.254, 402.345] : [621102.755, 0.27]
1 : [1.8, 135.359, 0.001, 0.837, 425.627, 581.098, 12.229, 369.29] : [2371232.836, 0.38]
2 : [1.762, 136.451, 0.001, 0.7, 418.223, 587.07, 13.029, 396.27] : [674716.619, 0.275]
3 : [1.747, 144.124, 0.001, 1.08, 423.531, 614.362, 11.073, 402.259] : [816732.32, 0.291]
4 : [1.799, 139.531, 0.001, 0.795, 395.087, 604.101, 10.383, 398.017] : [1172632.621, 0.312]
5 : [1.763, 143.67, 0.001, 0.949, 423.566, 590.481, 12.495, 398.505] : [1927246.294, 0.363]
6 : [1.759, 142.325, 0.001, 0.743, 418.696, 594.361, 11.538, 396.801] : [750079.0, 0.288]
7 : [1.797, 136.807, 0.001, 1.08, 426.686, 586.718, 13.223, 397.685] : [1371866.903, 0.326]
8 : [1.8, 140.817, 0.001, 0.782, 354.572, 586.336, 11.016, 384.072] : [832817.877, 0.296]
9 : [1.8, 134.844, 0.001, 0.7, 416.924, 581.312, 12.473, 374.697] : [1853324.659, 0.352]
10 : [1.782, 140.877, 0.001, 0.862, 423.185, 583.774, 12.451, 371.415] : [2141450.337, 0.373]
11 : [1.593, 137.049, 0.001, 1.08, 410.108, 586.779, 10.84, 397.791] : [555750.814, 0.247]
12 : [1.785, 141.692, 0.001, 0.873, 395.092, 589.246, 11.618, 396.244] : [1465049.635, 0.335]
13 : [1.793, 137.734, 0.001, 0.992, 423.418, 585.62, 12.512, 399.29] : [790201.863, 0.29]
14 : [1.787, 143.344, 0.001, 0.902, 413.511, 591.43, 12.31, 396.984] : [1572388.774, 0.343]
15 : [1.8, 139.327, 0.001, 1.0, 382.613, 585.777, 12.903, 390.86] : [959097.815, 0.304]
16 : [1.779, 143.201, 0.001, 0.915, 409.205, 589.954, 11.62, 397.661] : [2055931.204, 0.369]
17 : [1.671, 138.608, 0.001, 1.08, 412.731, 587.887, 10.597, 396.141] : [1449240.473, 0.33]
18 : [1.787, 139.462, 0.001, 1.079, 426.613, 588.078, 13.058, 397.044] : [1231520.282, 0.32]
19 : [1.8, 142.997, 0.001, 0.963, 390.107, 585.038, 11.985, 395.967] : [1601094.316, 0.346]
20 : [1.797, 140.782, 0.001, 0.759, 424.699, 586.49, 11.388, 389.004] : [1898688.493, 0.36]
21 : [1.8, 143.574, 0.001, 0.96, 384.465, 586.465, 13.25, 392.796] : [2207700.113, 0.378]
22 : [1.771, 141.554, 0.001, 0.897, 423.667, 590.785, 12.032, 383.704] : [2016802.799, 0.365]
23 : [1.796, 140.282, 0.001, 1.054, 417.656, 588.006, 11.675, 396.772] : [1544916.149, 0.339]


Total Flow V01SSV499140
Flow [m3/s]
Time
Simulated_initial
Gauged
0: NSE = 0.463
1: NSE = 0.47
2: NSE = 0.474
3: NSE = 0.443
4: NSE = 0.465
5: NSE = 0.48
6: NSE = 0.453
7: NSE = 0.473
8: NSE = 0.464
9: NSE = 0.477
10: NSE = 0.451
11: NSE = 0.446
12: NSE = 0.454
13: NSE = 0.473
14: NSE = 0.448
15: NSE = 0.467
16: NSE = 0.443
17: NSE = 0.447
18: NSE = 0.463
19: NSE = 0.451
20: NSE = 0.455
21: NSE = 0.444
22: NSE = 0.448
23: NSE = 0.46


Cumulative Total Flow V01SSV499140
1e7
Cumul. Volumes [m3]
Time
Gauged
Simulated_initial
0: AbsErr = 621102.755
1: AbsErr = 2371232.836
2: AbsErr = 674716.619
3: AbsErr = 816732.32
4: AbsErr = 1172632.621
5: AbsErr = 1927246.294
6: AbsErr = 750079.0
7: AbsErr = 1371866.903
8: AbsErr = 832817.877
9: AbsErr = 1853324.659
10: AbsErr = 2141450.337
11: AbsErr = 555750.814
12: AbsErr = 1465049.635
13: AbsErr = 790201.863
14: AbsErr = 1572388.774
15: AbsErr = 939097.815
16: AbsErr = 2055931.204
17: AbsErr = 1449240.473
18: AbsErr = 1231520.282
19: AbsErr = 1601094.316
20: AbsErr = 1898688.493
21: AbsErr = 2207700.113
22: AbsErr = 2016802.799
23: AbsErr = 1544916.149

Appendix 4 Brugse Polders Calibration and Validation

9.4.1 Calibration and validation of WET parameters for catchment "V02EDE442120" (Brugse Polders)

9.4.1.1 Input data

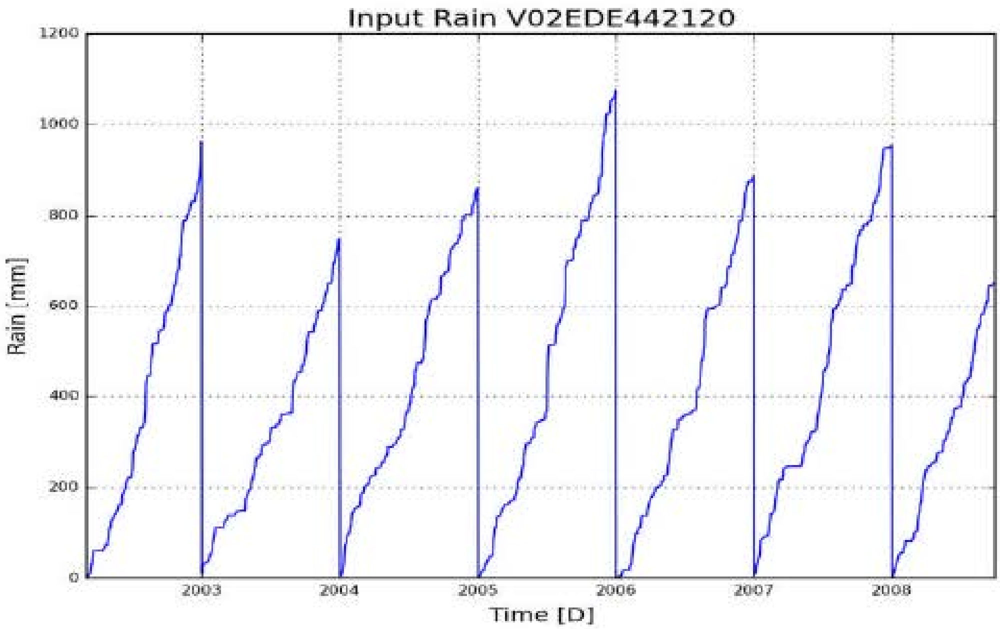


Figure 1: Cumulative precipitation on catchment V02EDE442120 (Brugse Polders)

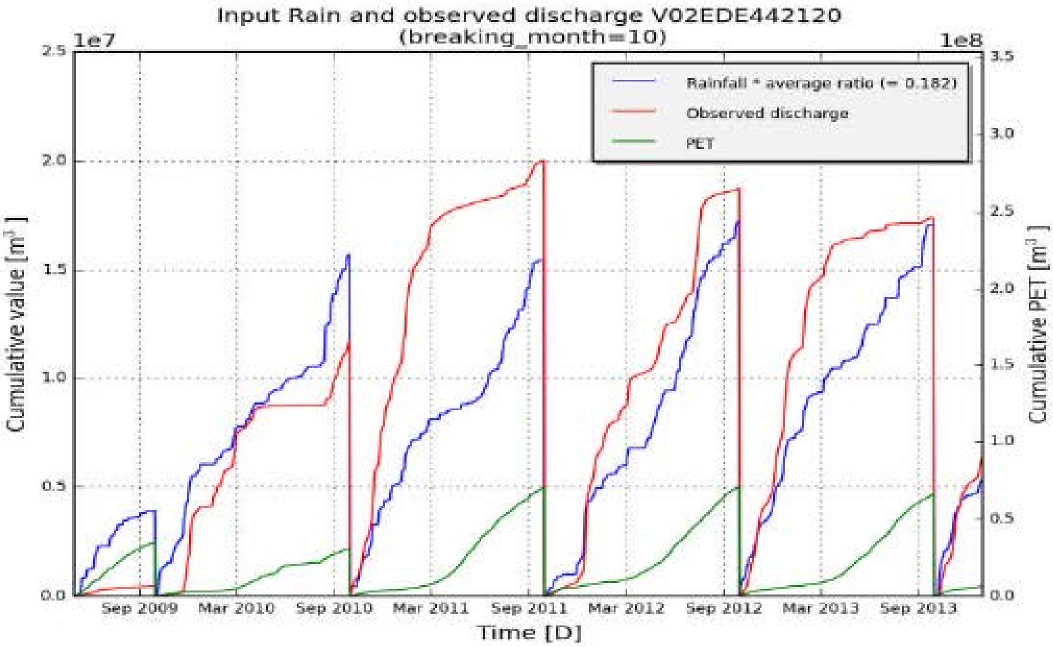


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V02EDE442120 (Brugse Polders)

9.4.1.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V02EDE442120
subcatchment_area [m2]	91900000
Validation start_date	01-03-2003
Validation end_date	30-09-2008
frequency	daily

Optimal parameter set:[('Kep', 1.8), ('Ki', 223.49), ('Kg', 0.0), ('Kss', 2.55), ('g0', 175.12), ('g_max', 201.97), ('K_run', 3.13), ('P_max', 324.2)]

Table 1: Goodness of fit for calibration period (2009 - 2013)

	Full year	Summer	Winter
RelErr	-5.1 %	-2.8 %	-17.2 %
NS	0.622	-0.289	0.688
NS_log	0.49	0.432	0.507

NS_rel	-206.099	-10.585	0.023
KGE	0.703	0.393	0.567

Table 2 :Goodness of fit for validation period (2003 - 2008)

	Full year	**Summer**	**Winter**
RelErr	-10.1 %	6.4 %	-24.9 %
NS	0.626	0.484	0.592
NS_log	0.546	0.531	0.468
NS_rel	-3.279	-0.656	-0.293
KGE	0.737	0.615	0.516

9.4.1.3 Observed and simulated timeseries for optimum parameters

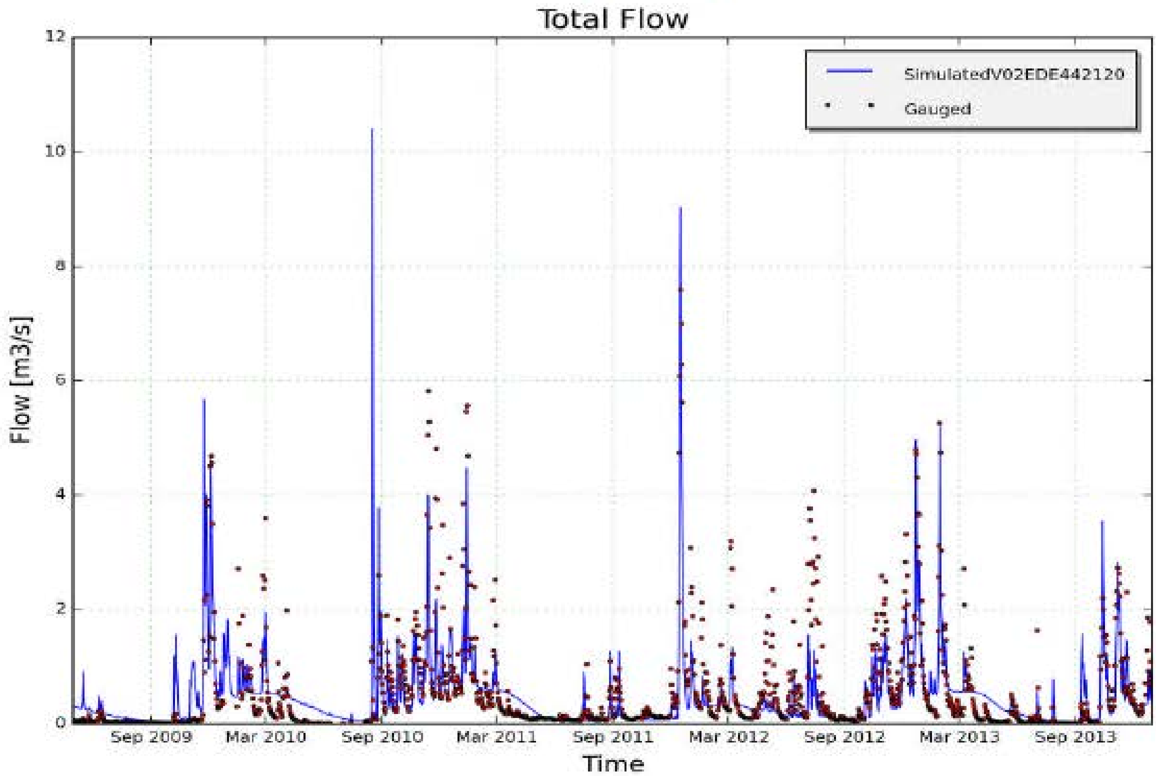


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02EDE442120, station 44210102 - Maldegem(calibration period)

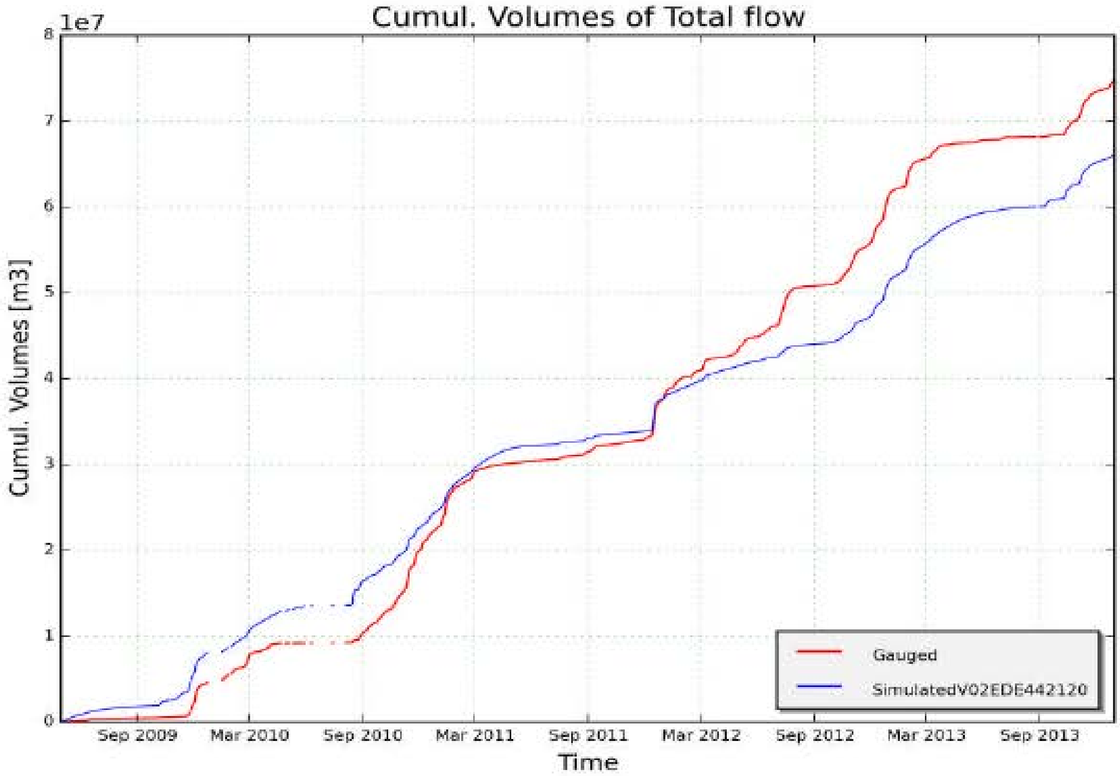


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02EDE442120, station 44210102 - Maldegem (calibration period)

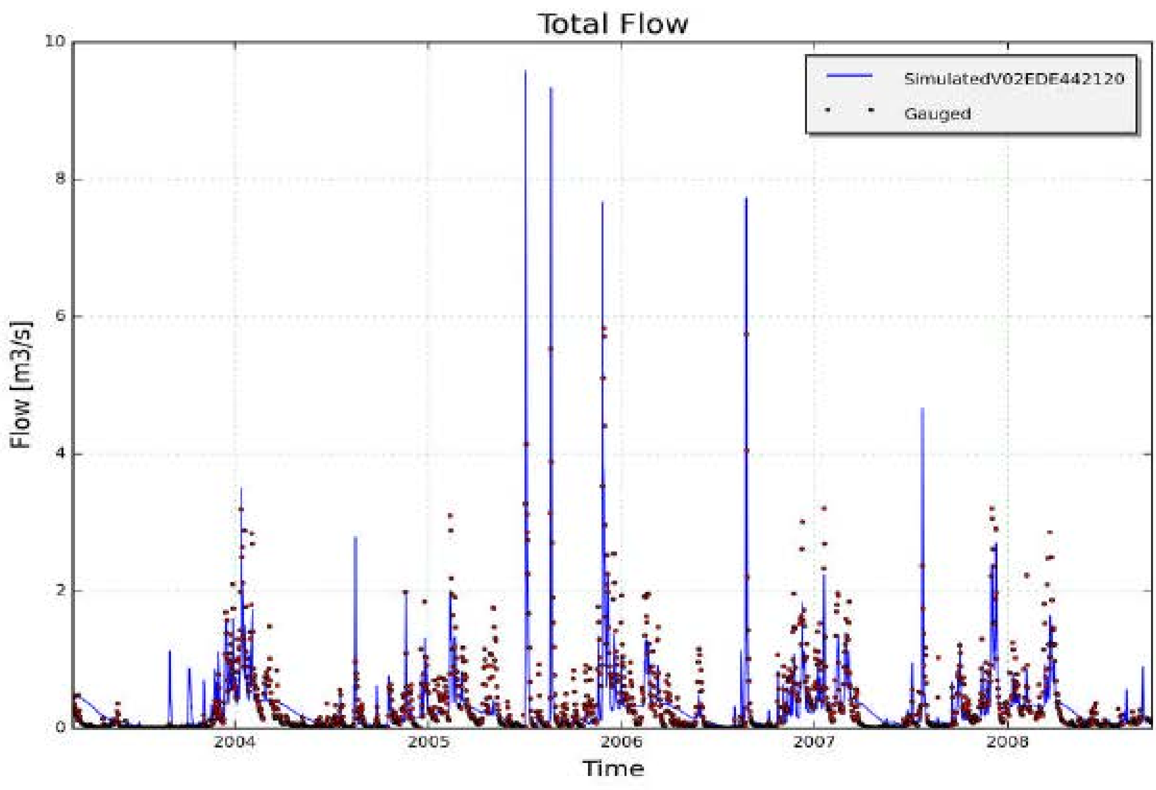


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02EDE442120, station 44210102 - Maldegem (validation period)

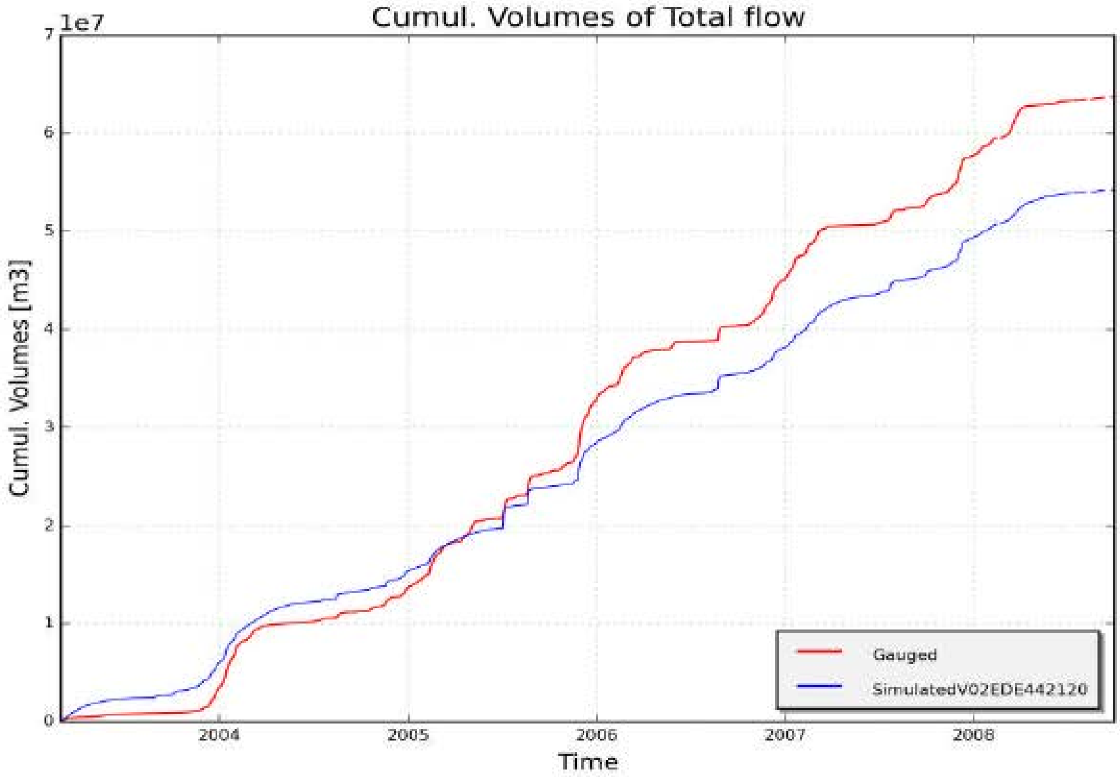


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02EDE442120, station 44210102 - Maldegem (validation period)

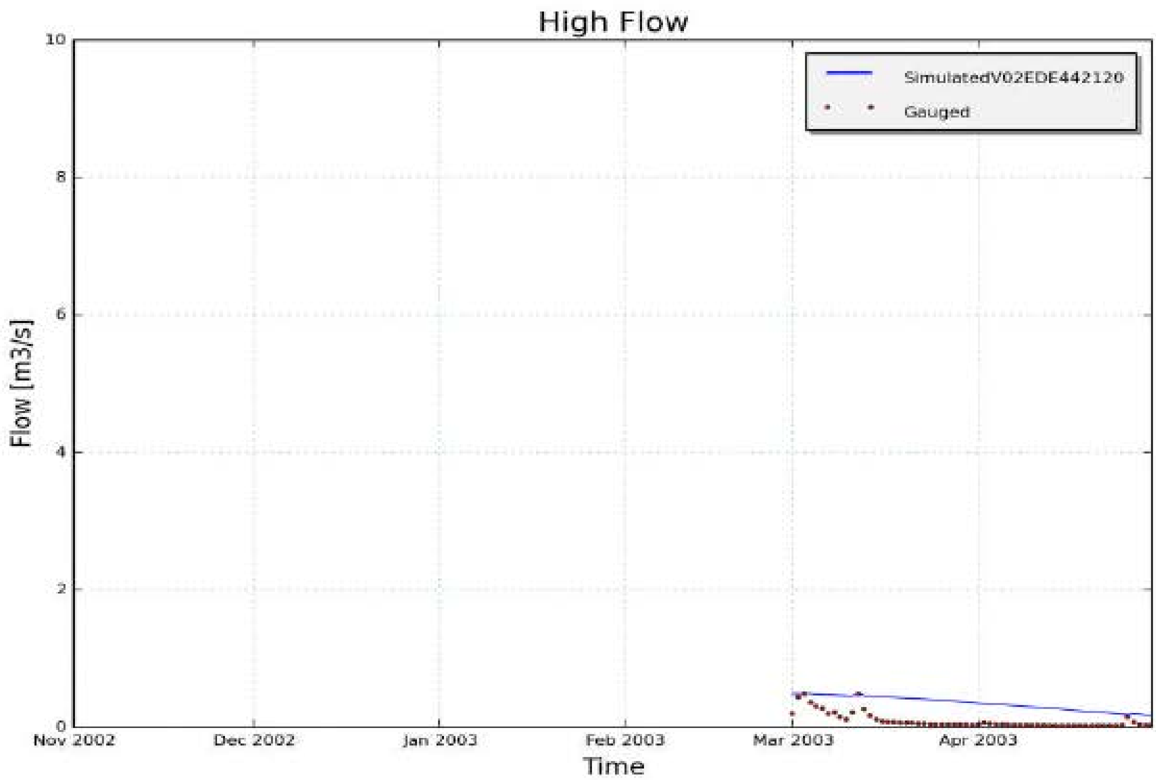


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V02EDE442120, station 44210102 - Maldegem

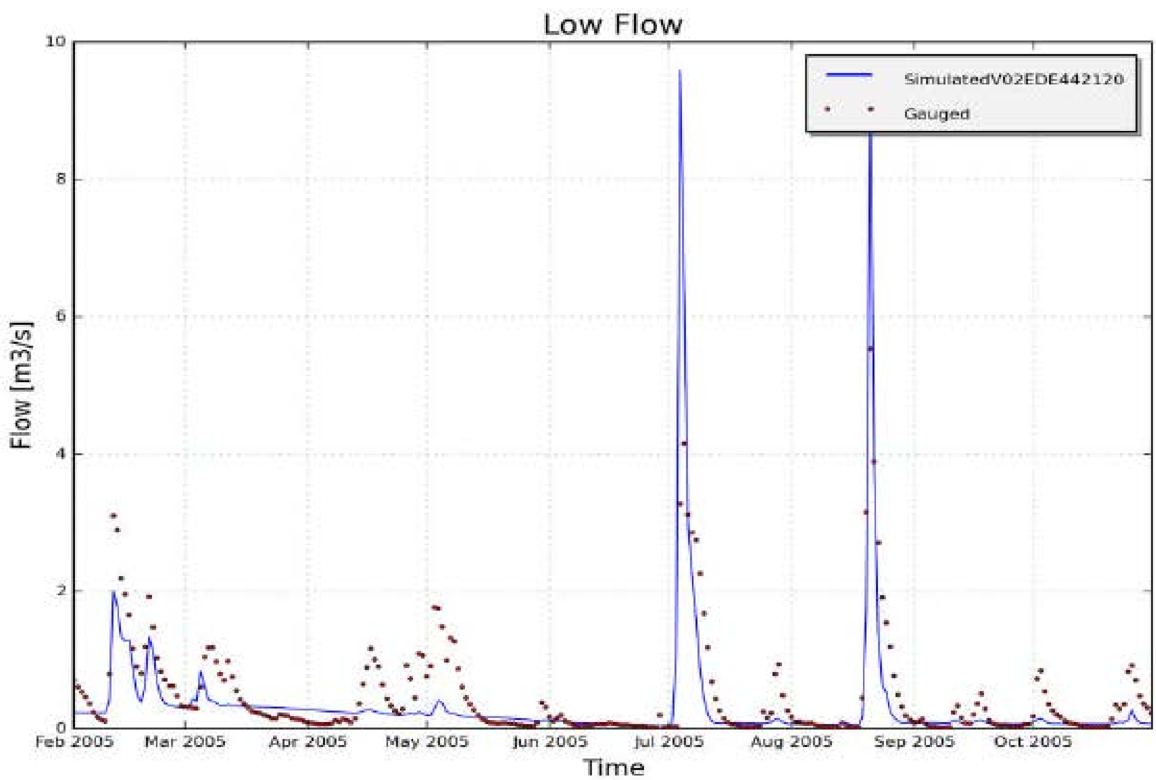


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V02EDE442120, station 44210102 - Maldegem

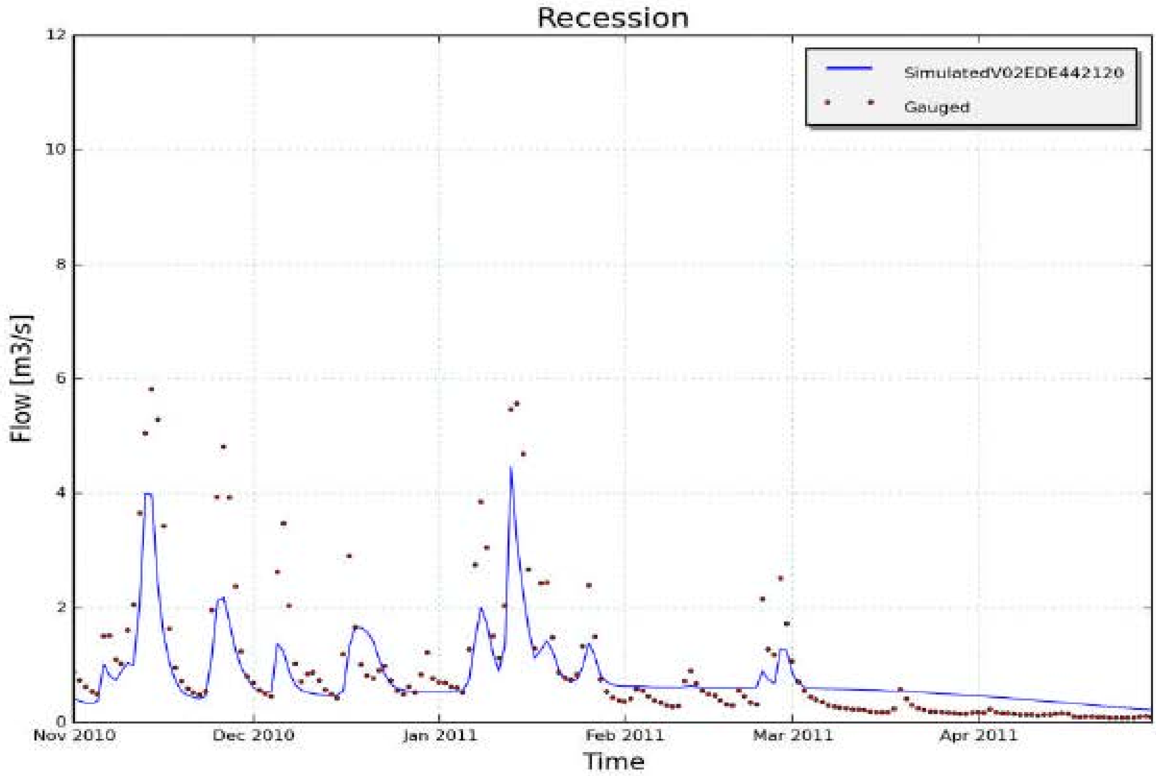


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V02EDE442120, station 44210102 - Maldegem

9.4.2 Calibration and validation of WET parameters for catchment "V02HER426010" (Brugse Polders)

9.4.2.1 Input data

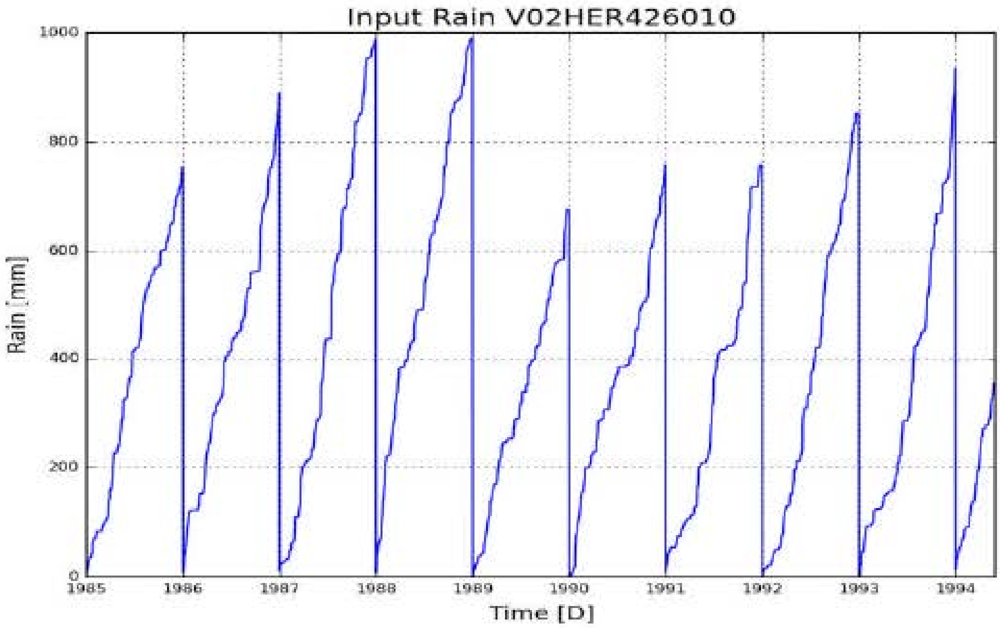


Figure 1: Cumulative precipitation on catchment V02HER426010 (Brugse Polders)

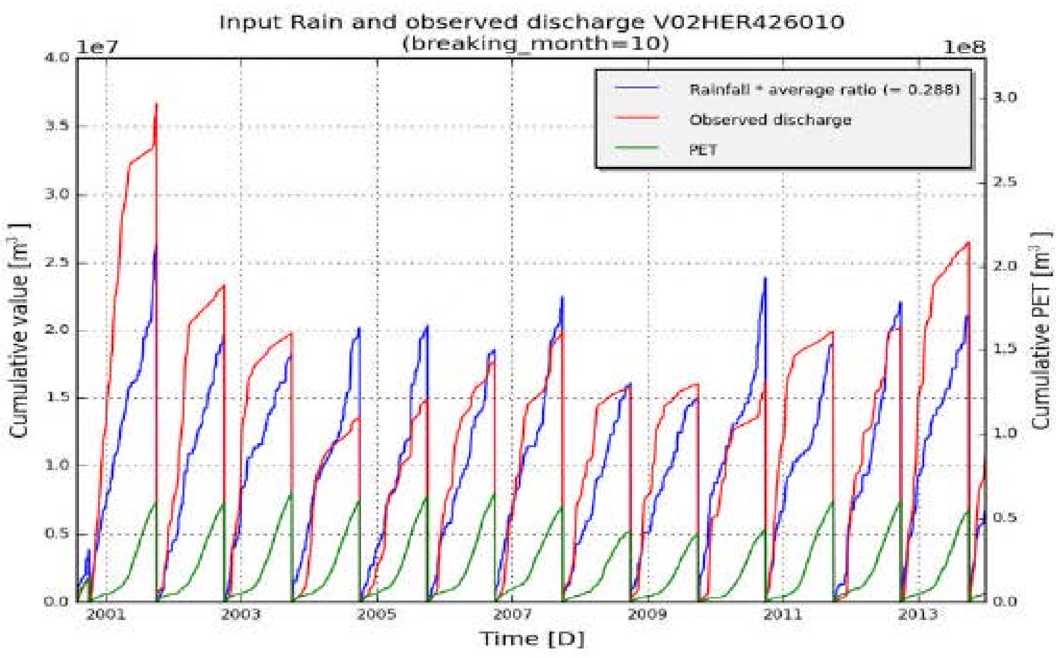


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V02HER426010 (Brugse Polders)

9.4.2.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V02HER426010
subcatchment_area [m2]	77300000
Validation start_date	01-01-1986
Validation end_date	31-05-1994
frequency	daily

Optimal parameter set:[('Kep', 1.38), ('Ki', 210.99), ('Kg', 0.0), ('Kss', 0.96), ('g0', 88.43), ('g_max', 246.07), ('K_run', 3.71), ('P_max', 324.89)]

Table 1: Goodness of fit for calibration period (2000 - 2013)

	Full year	**Summer**	**Winter**
RelErr	-5.1 %	97.8 %	-27.6 %
NS	0.217	-3.974	0.641
NS_log	0.599	0.133	0.563
NS_rel	-0.306	-0.337	0.404
KGE	0.628	-0.974	0.684

Table 2 :Goodness of fit for validation period (1986 - 1994)

	Full year	**Summer**	**Winter**
RelErr	2.4 %	75.7 %	-27.5 %
NS	0.355	-3.64	0.517
NS_log	0.602	0.196	0.474
NS_rel	-7.293	-21.601	0.788
KGE	0.679	-0.717	0.575

9.4.2.3 Observed and simulated timeseries for optimum parameters

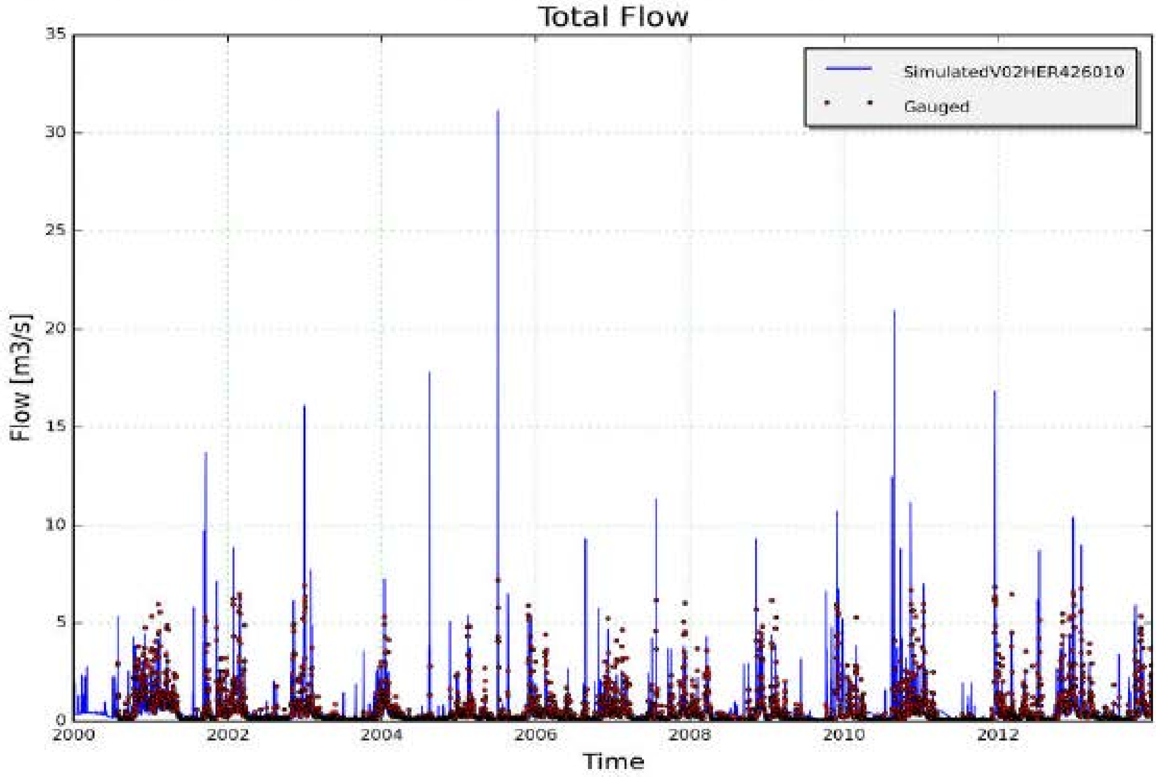


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp(calibration period)

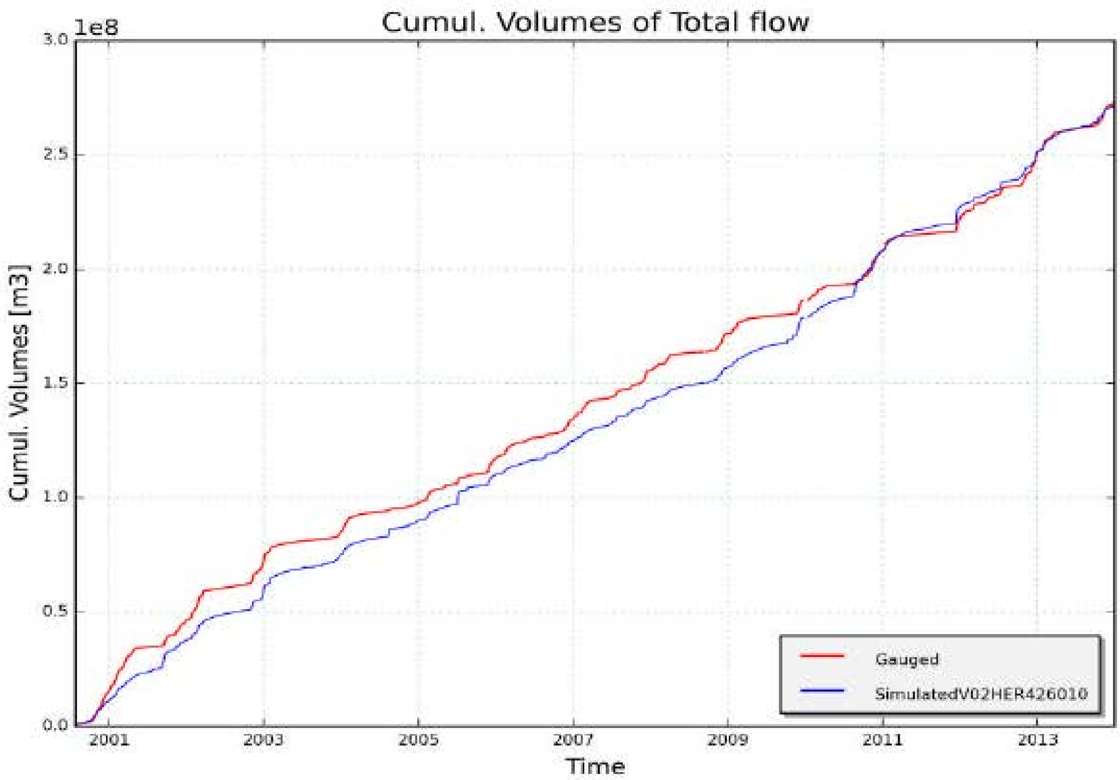


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp (calibration period)

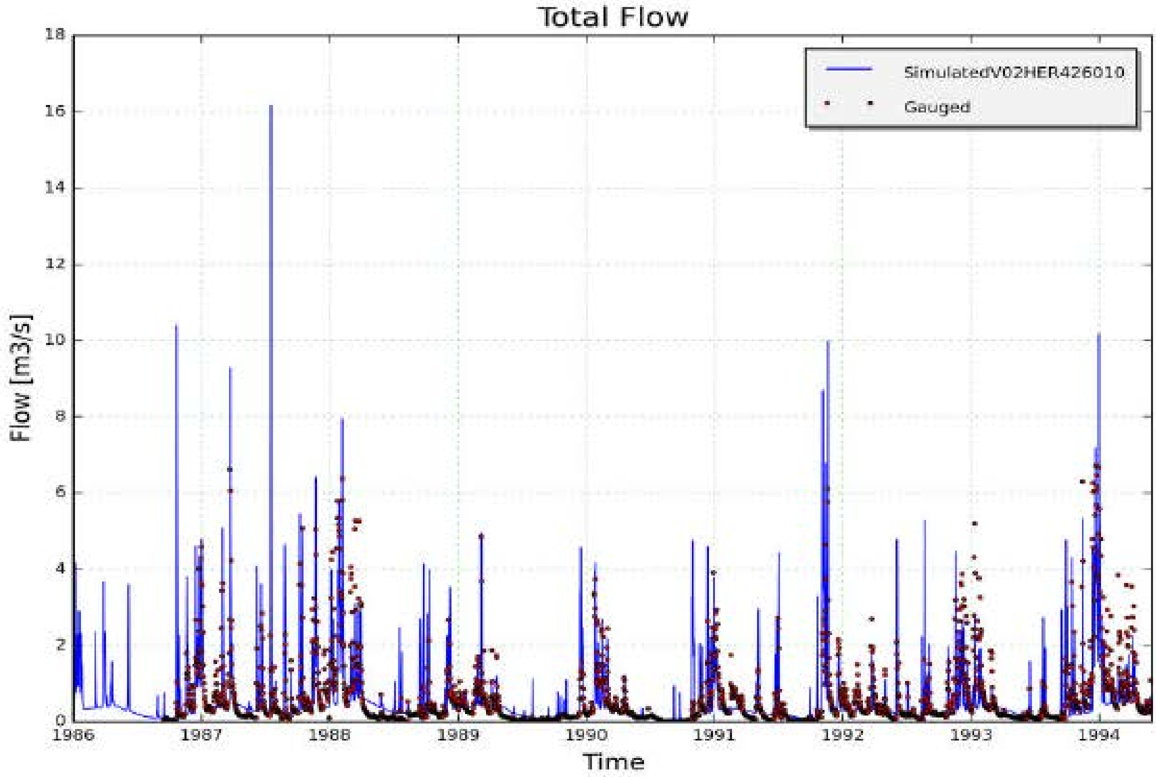


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp (validation period)

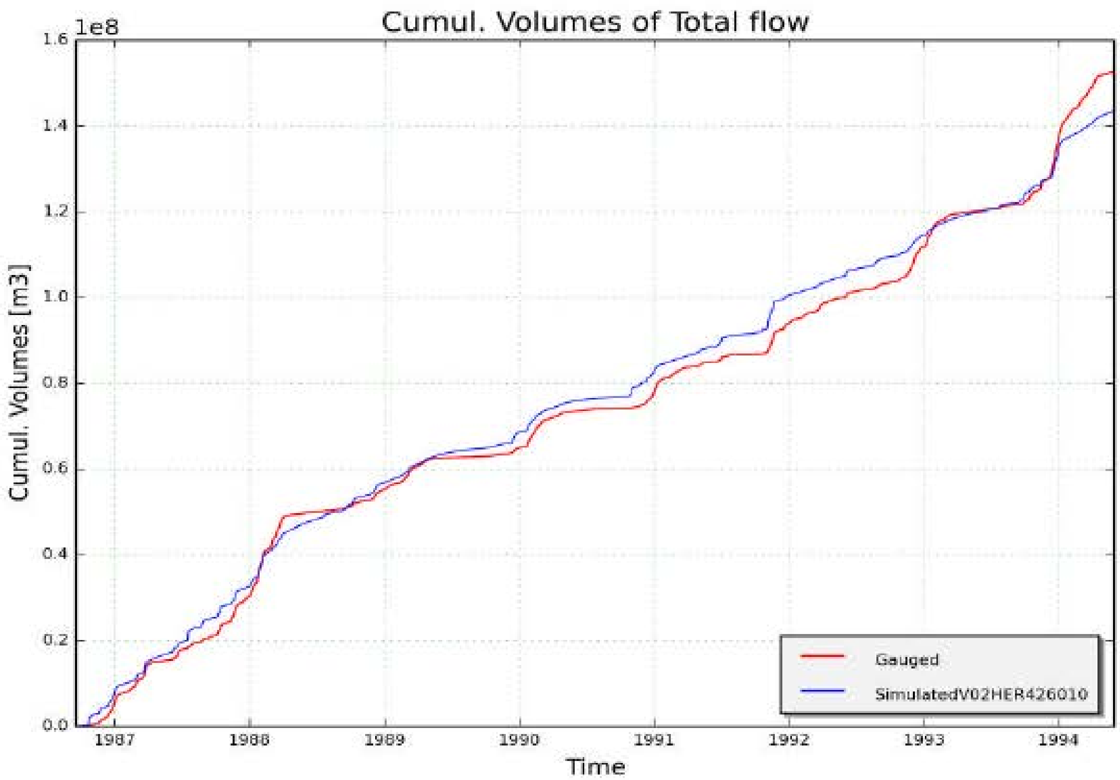


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp (validation period)

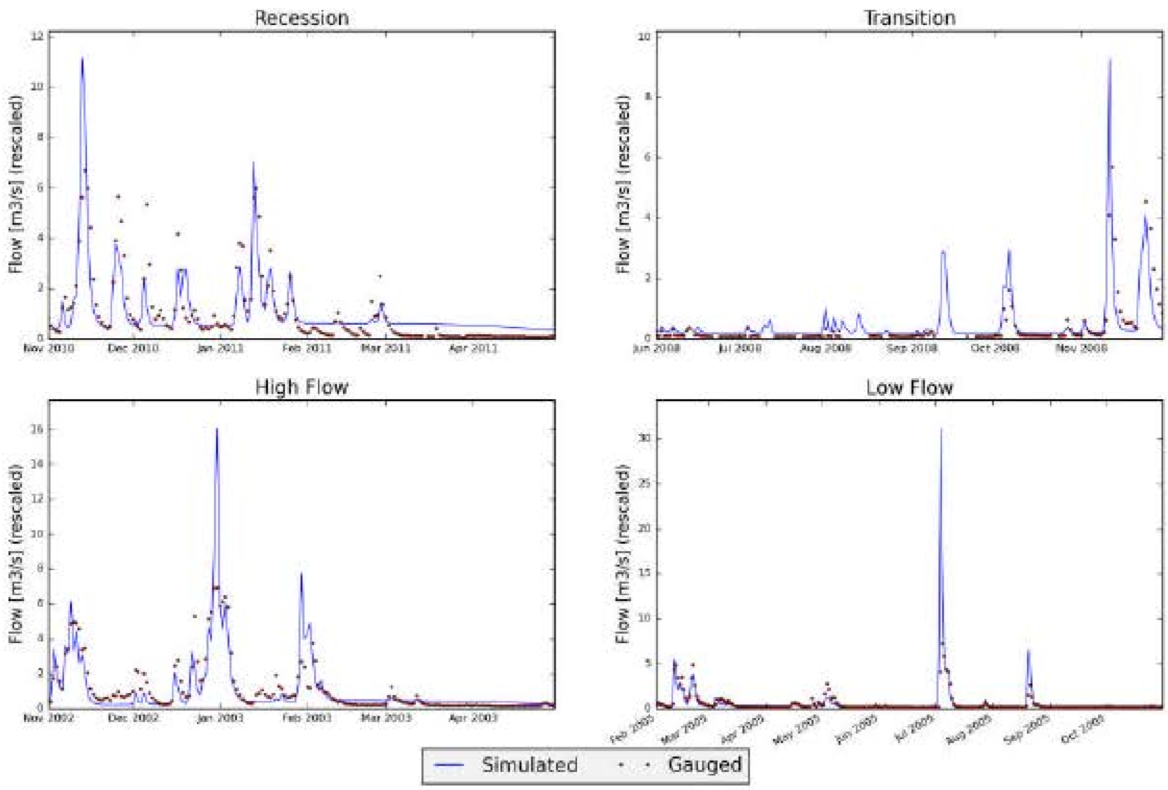


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp

9.4.3 Calibration and validation of WET parameters for catchment "V02KER422030" (Brugse Polders)

9.4.3.1 Input data

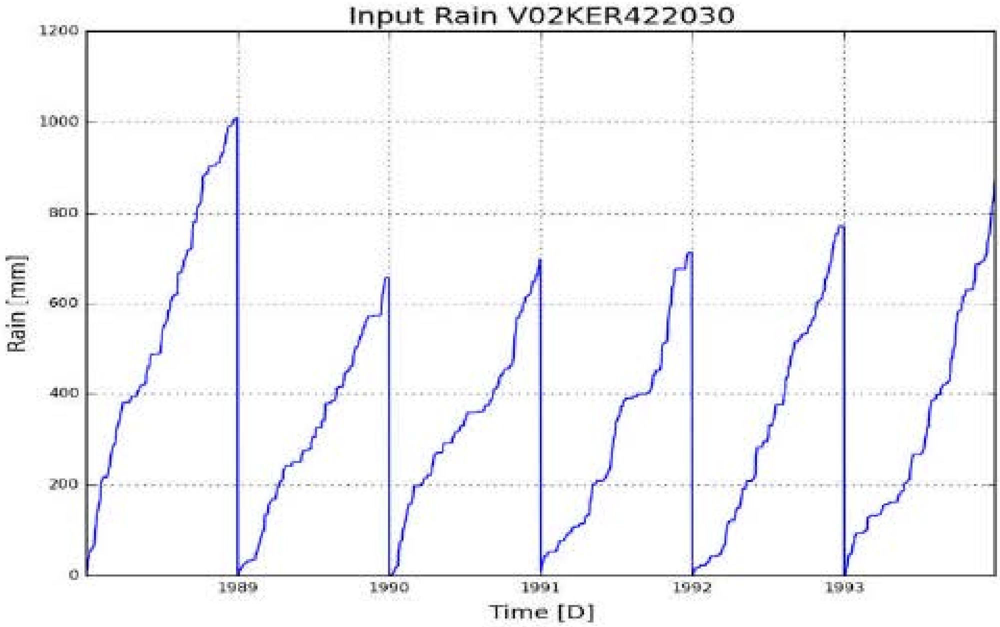


Figure 1: Cumulative precipitation on catchment V02KER422030 (Brugse Polders)

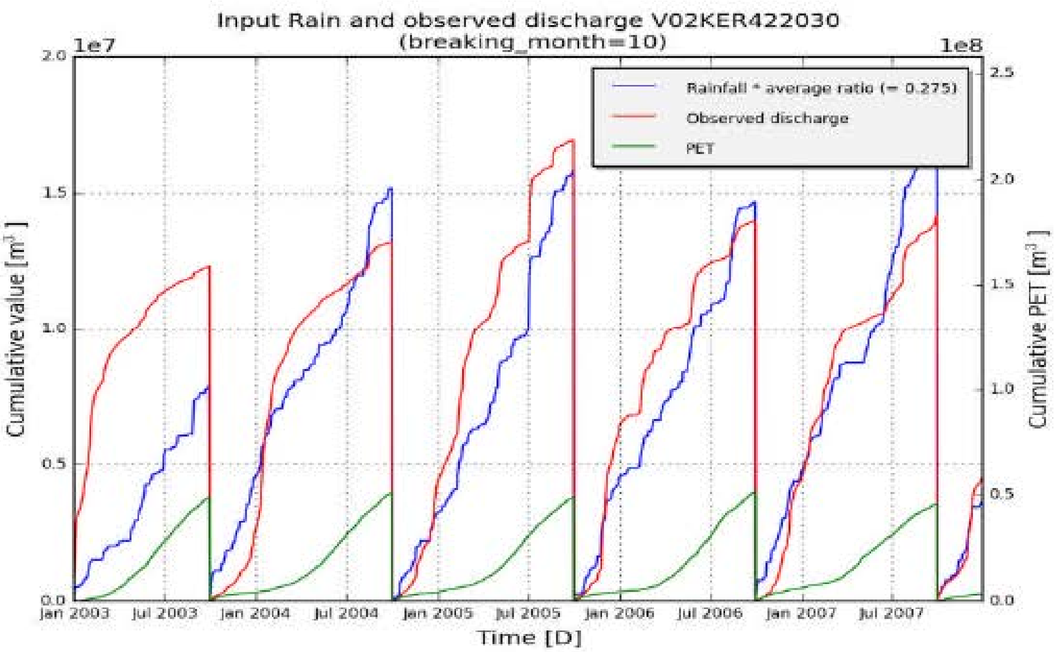


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V02KER422030 (Brugse Polders)

9.4.3.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V02KER422030
subcatchment_area [m2]	62700000
Validation start_date	01-01-1989
Validation end_date	31-12-1993
frequency	daily

Optimal parameter set:[('Kep', 1.77), ('Ki', 47.47), ('Kg', 0.0), ('Kss', 1.68), ('g0', 182.82), ('g_max', 281.49), ('K_run', 0.96), ('P_max', 590.12)]

Table 1: Goodness of fit for calibration period (2003 - 2007)

	Full year	Summer	Winter
RelErr	-6.1 %	65.0 %	-34.1 %
NS	0.594	0.272	0.575
NS_log	0.54	0.429	0.421

NS_rel	-2.665	0.587	-23.892
KGE	0.762	0.08	0.442

Table 2 :Goodness of fit for validation period (1989 - 1993)

	Full year	Summer	Winter
RelErr	3.3 %	41.7 %	-12.6 %
NS	0.311	-0.357	0.271
NS_log	0.399	-0.329	0.264
NS_rel	-2.181	-4.595	-0.376
KGE	0.391	0.169	0.288

9.4.3.3 Observed and simulated timeseries for optimum parameters

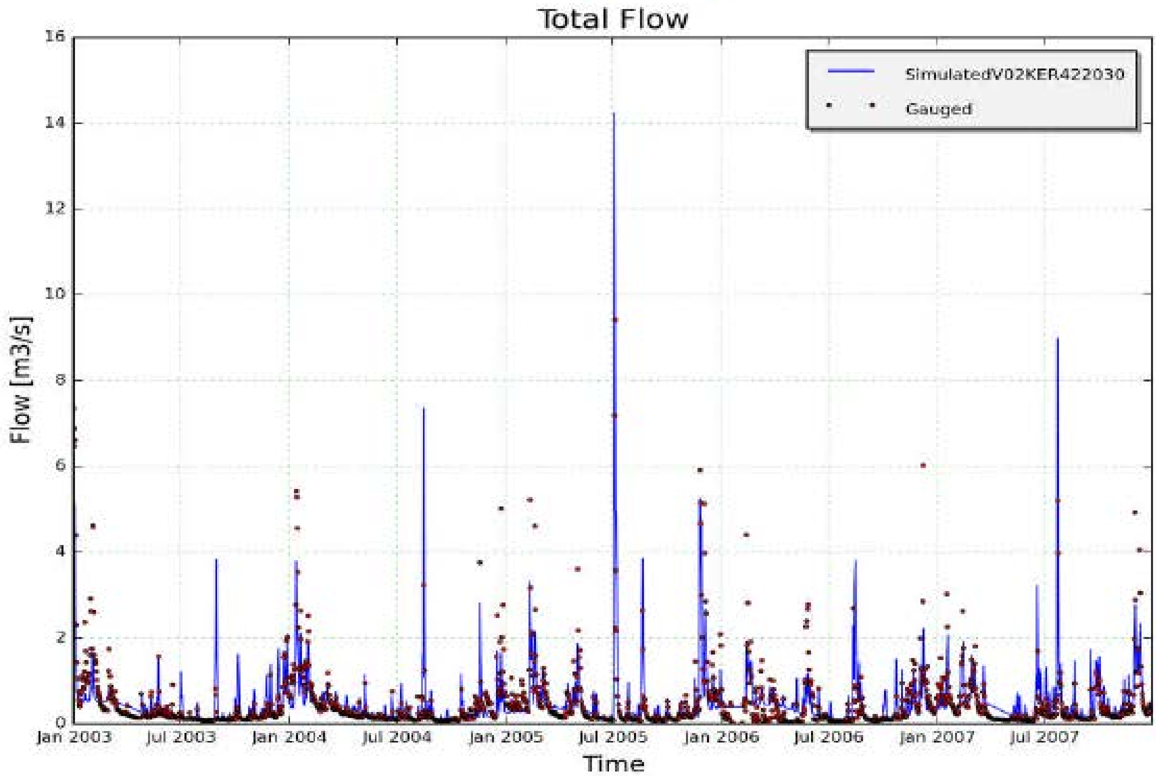


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels(calibration period)

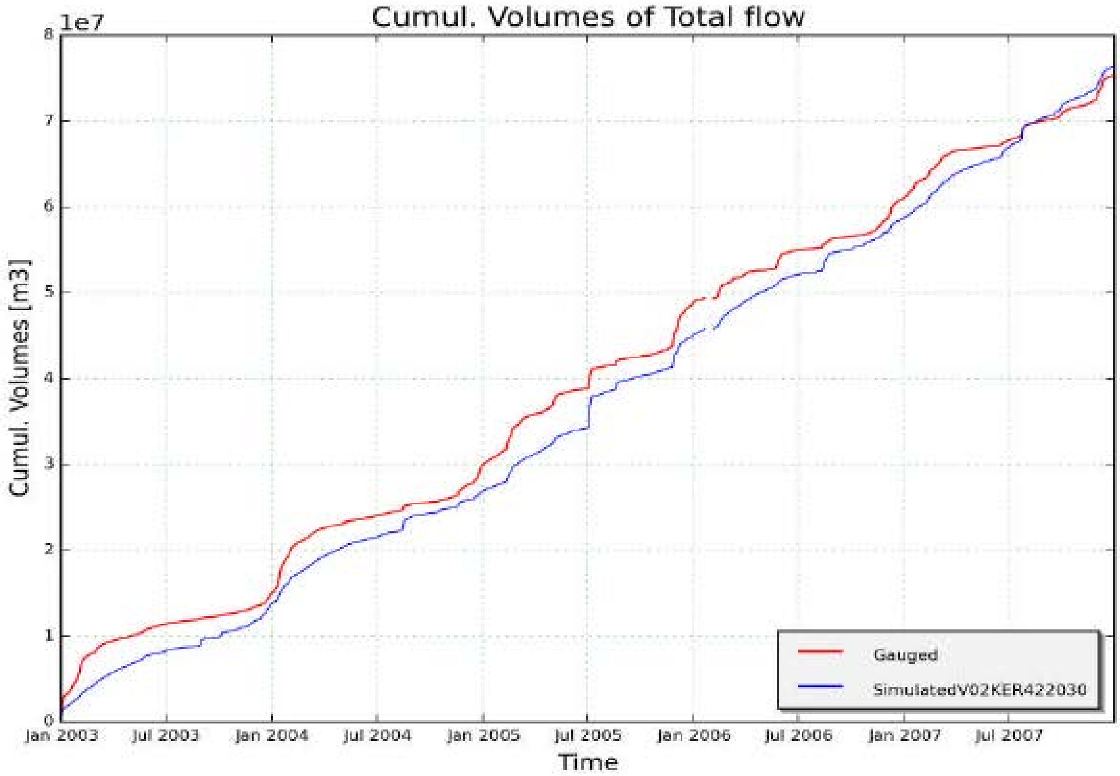


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels (calibration period)

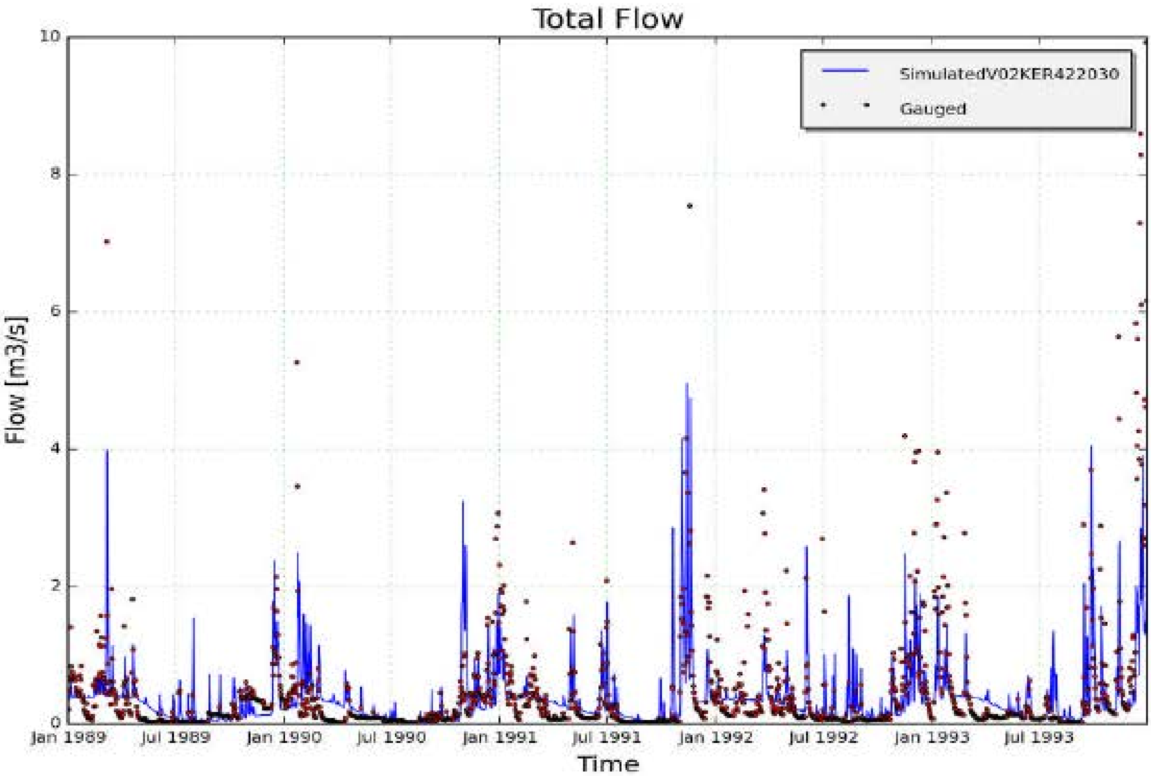


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels (validation period)

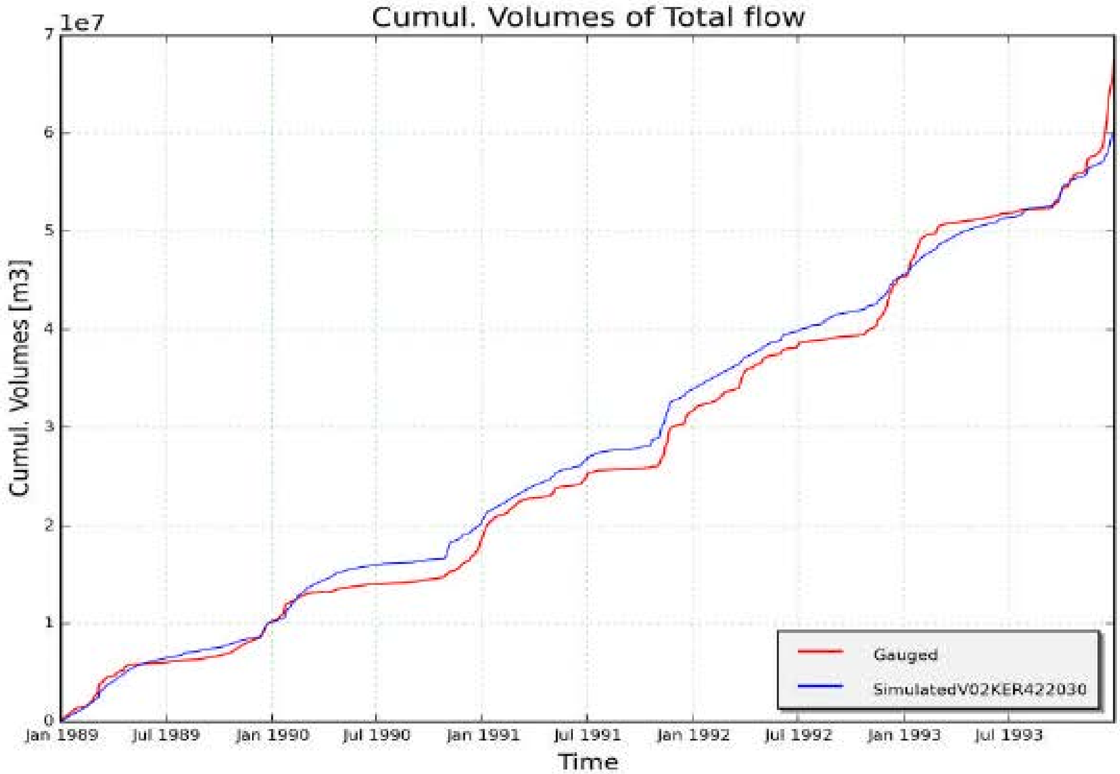


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels (validation period)

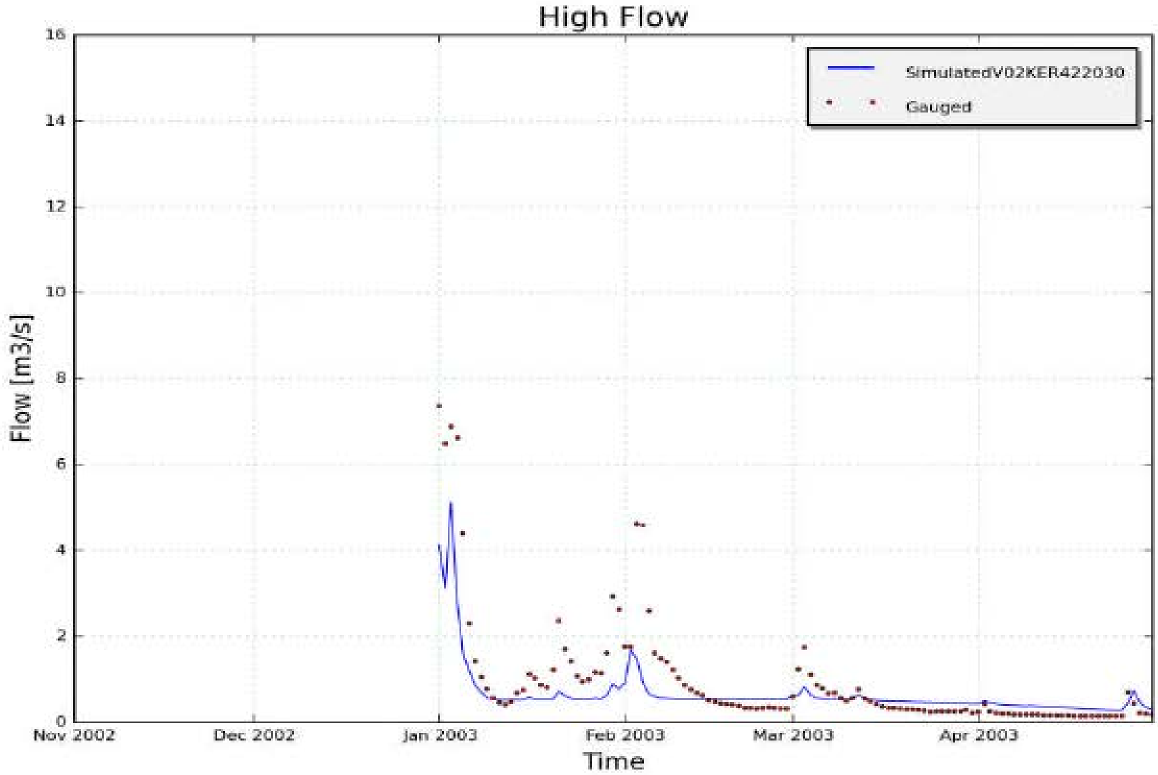


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels

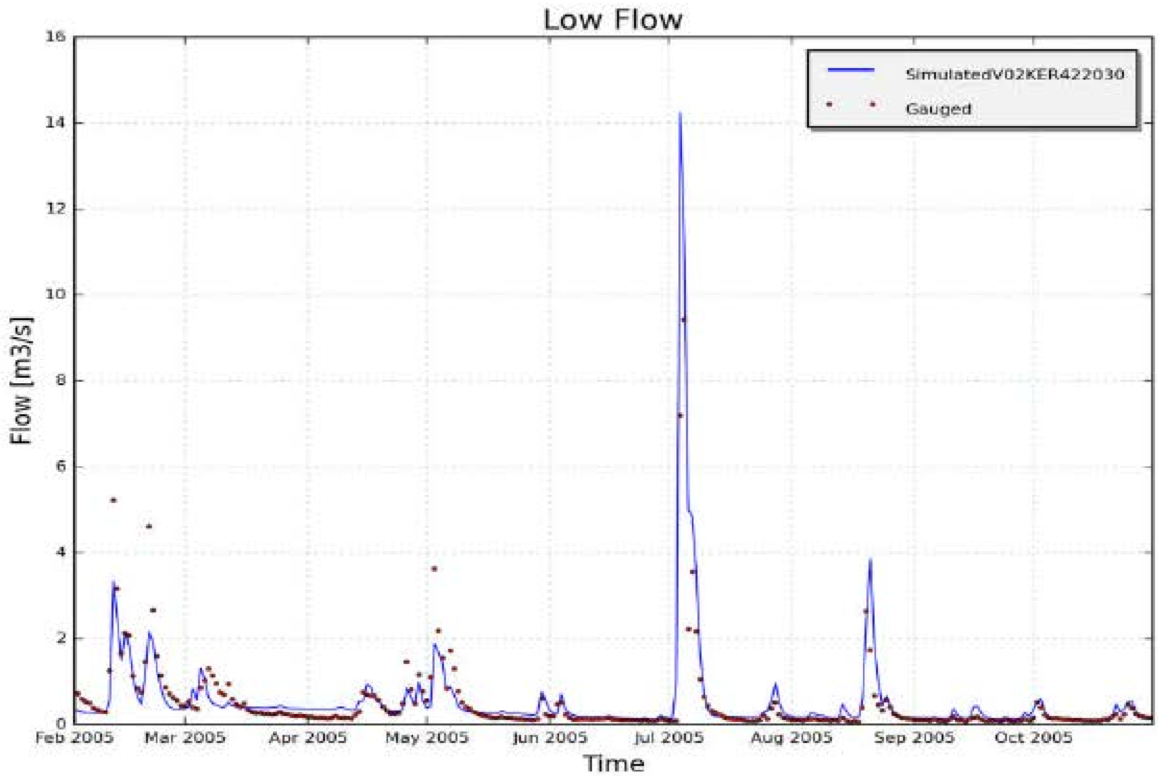


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels

9.4.4 Calibration and validation of WET parameters for catchment "V02RIV425020" (Brugse Polders)

9.4.4.1 Input data

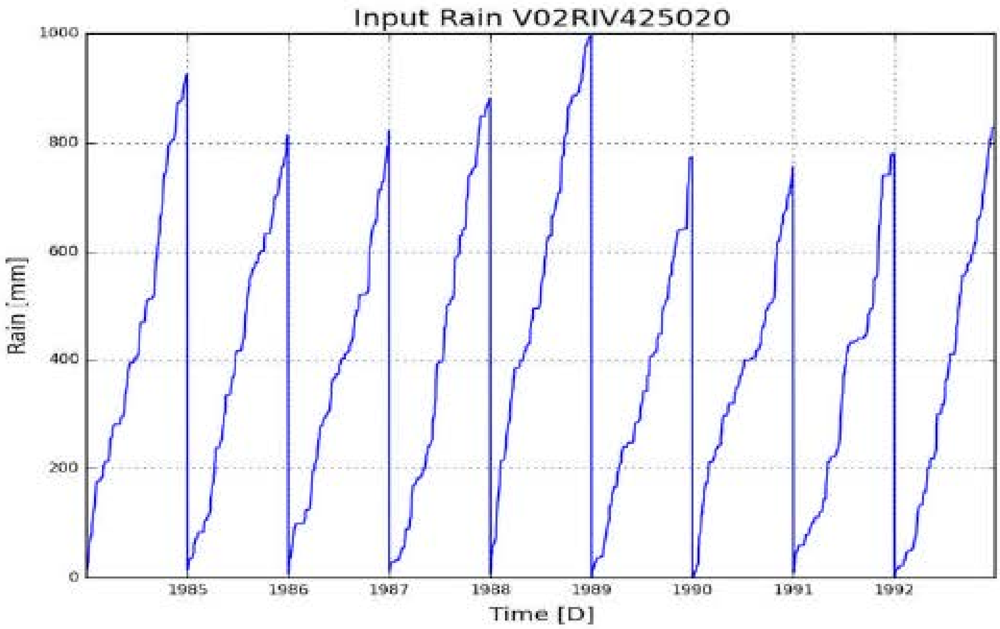


Figure 1: Cumulative precipitation on catchment V02RIV425020 (Brugse Polders)

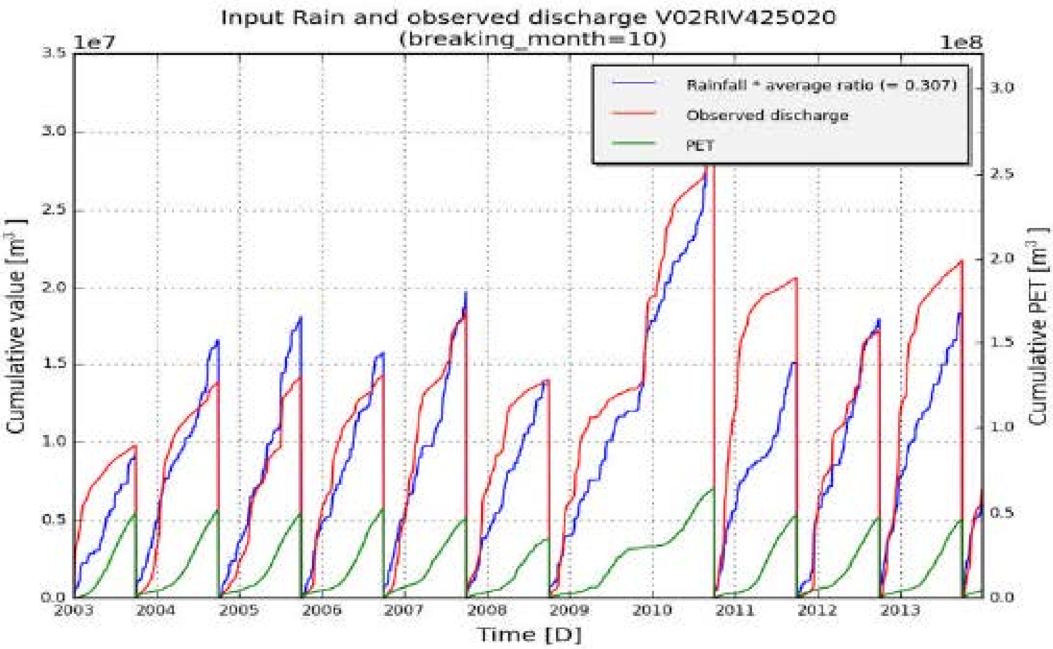


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V02RIV425020 (Brugse Polders)

9.4.4.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V02RIV425020
subcatchment_area [m2]	64000000
Validation start_date	01-01-1985
Validation end_date	31-12-1992
frequency	daily

Optimal parameter set:[('Kep', 1.5), ('Ki', 245.28), ('Kg', 0.0), ('Kss', 1.12), ('g0', 191.27), ('g_max', 812.06), ('K_run', 4.86), ('P_max', 468.7)]

Table 1: Goodness of fit for calibration period (2003 - 2013)

	Full year	Summer	Winter
RelErr	-2.2 %	67.8 %	-31.6 %
NS	-0.058	-3.99	0.639
NS_log	0.648	0.098	0.603

NS_rel	-2.592	0.436	0.873
KGE	0.518	-0.739	0.596

Table 2 :Goodness of fit for validation period (1985 - 1992)

	Full year	Summer	Winter
RelErr	0.6 %	97.0 %	-26.6 %
NS	0.146	-0.502	0.301
NS_log	0.362	-0.298	0.287
NS_rel	-6.159	-18.266	0.602
KGE	0.597	0.172	0.536

9.4.4.3 Observed and simulated timeseries for optimum parameters

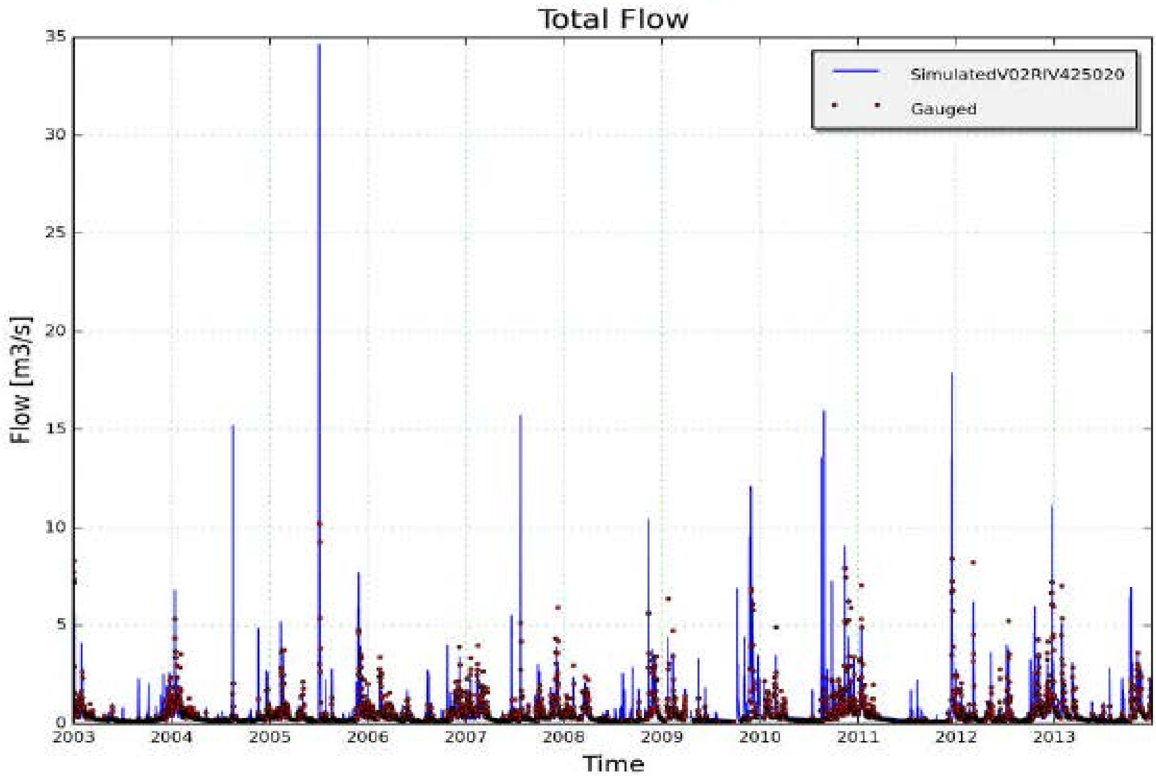


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp(calibration period)

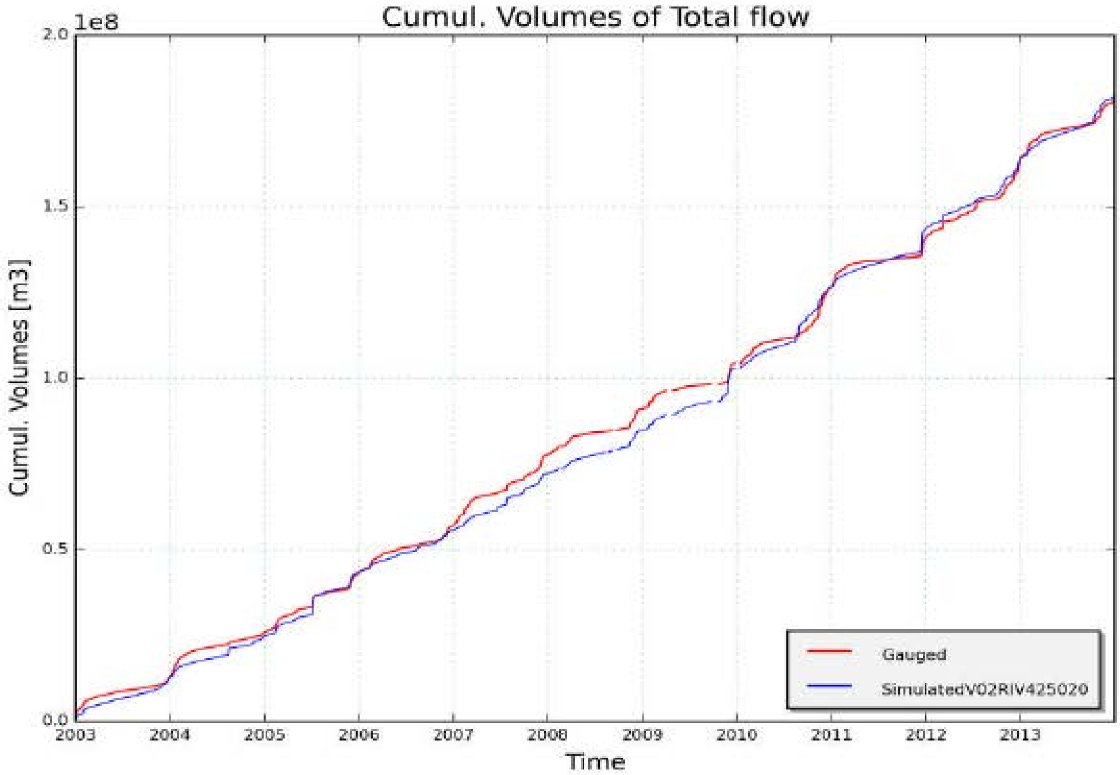


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02RIV425020, station 42510102-Rivierbeek; Oostkamp (calibration period)

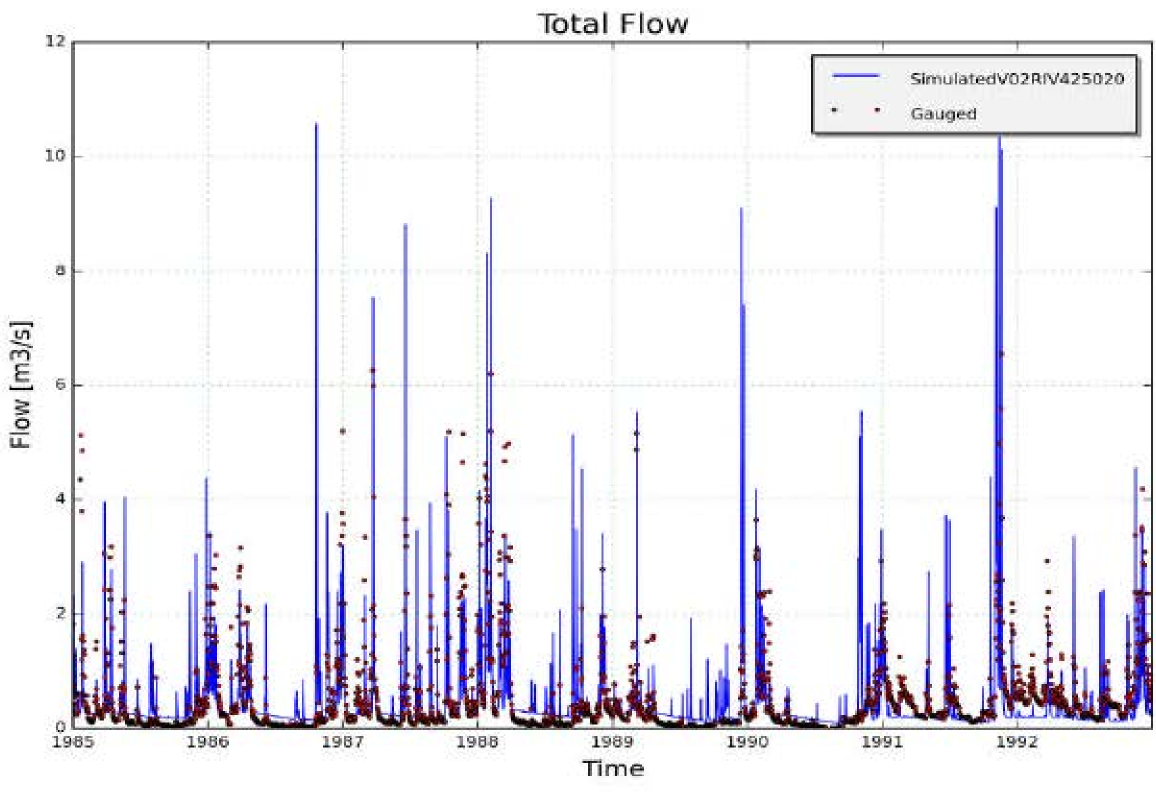


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp (validation period)

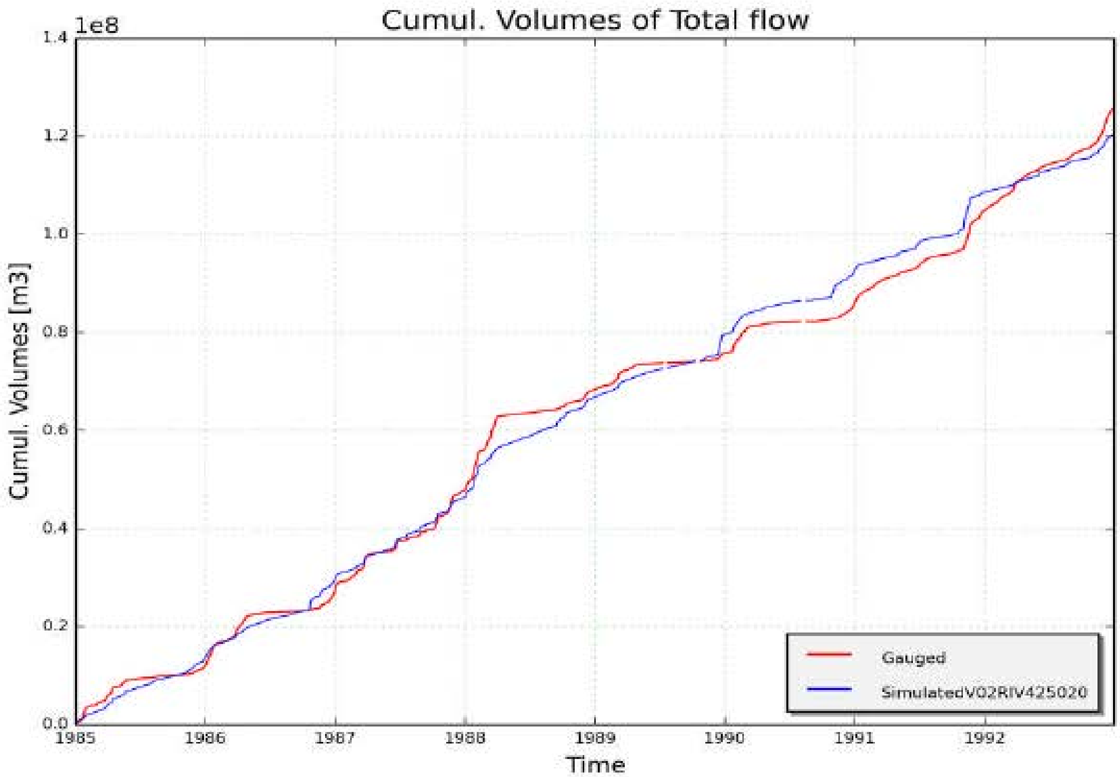


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp (validation period)

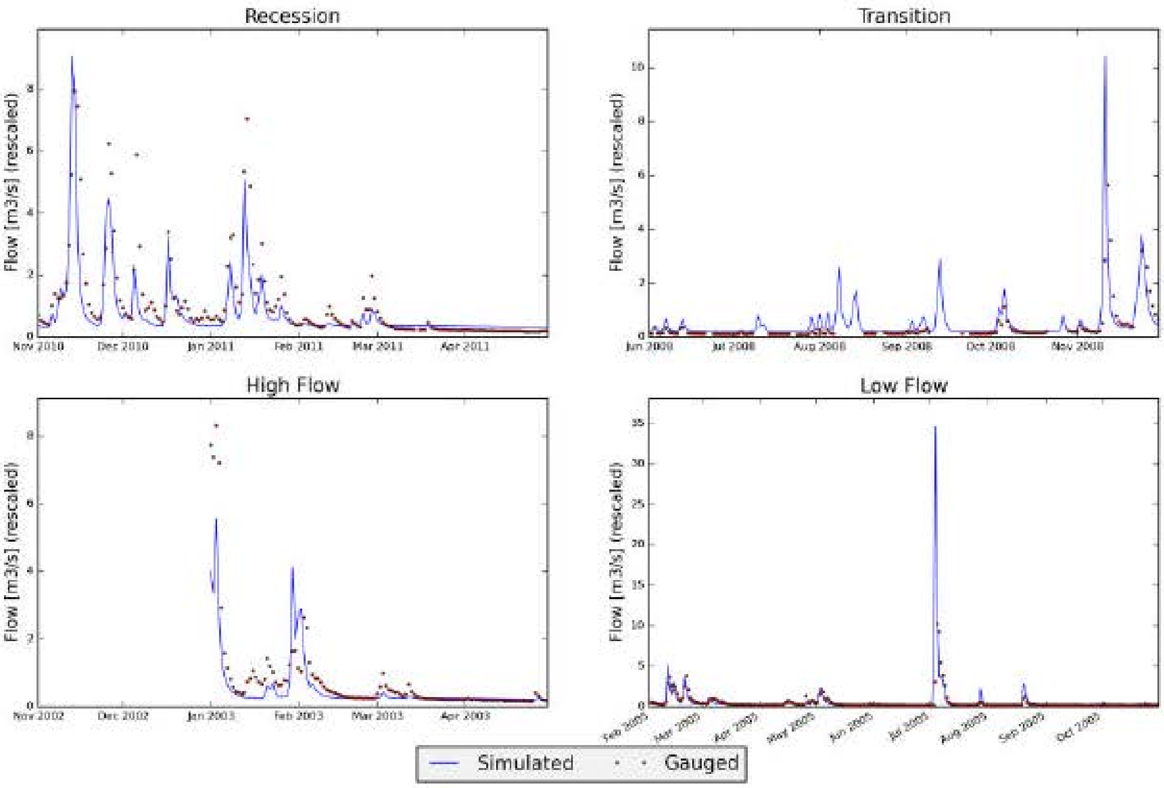


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp

Appendix 5 Brugse Polders - Autocalibration

9.5.1 Report on simulation of catchment V02EDE442120 (2017-01-18 22-57)

9.5.1.1 Input data

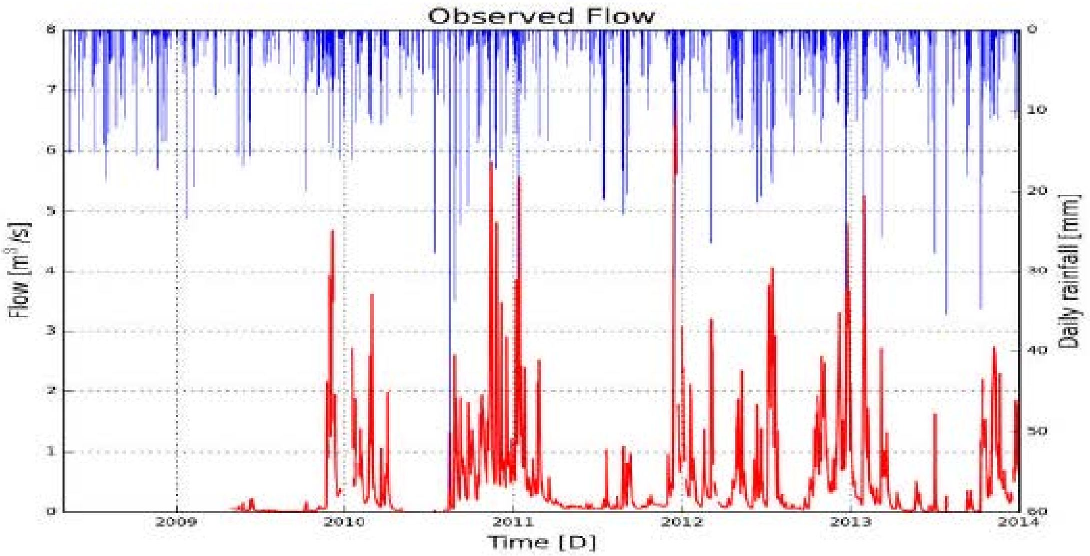


Figure 1: Hyetogram of observed discharge and observed net rain

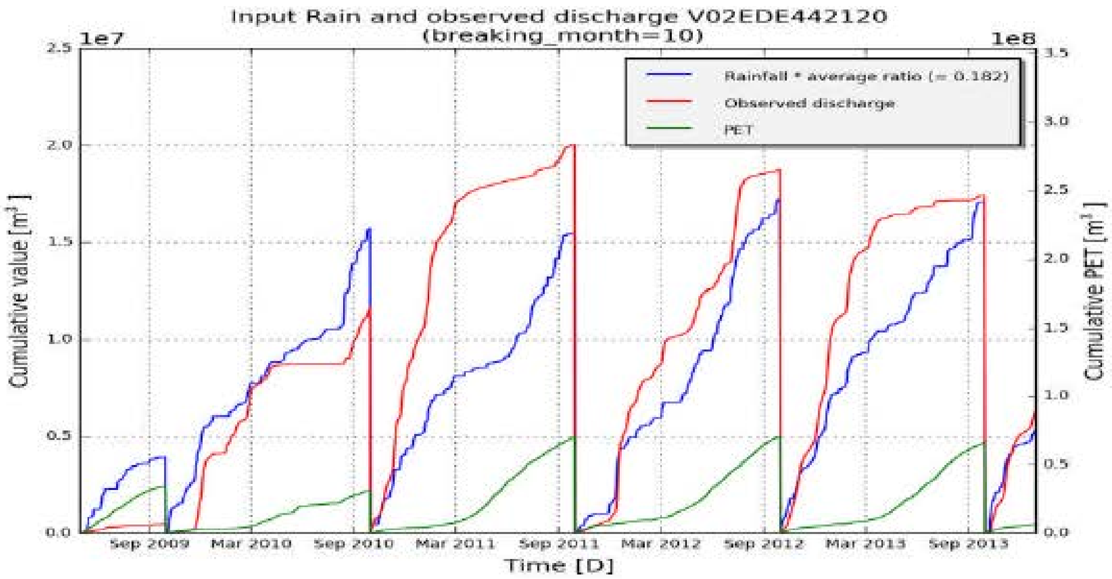


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.1.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V02EDE442120
subcatchment_area	91900000
start_date	200905010000
end_date	201312310000
frequency	86400
warmup	365

9.5.1.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.5, 130.0, 0.001, 1.0, 170.0, 300.0, 2.5, 300.0]
low_bounds	[1.2, 104.0, 0.0008, 0.8, 136.0, 200.0, 2.0, 240.0]
high_bounds	[1.8, 250.0, 0.01, 3.0, 250.0, 360.0, 5.0, 370.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.5), ('Ki', 130.0), ('Kg', 0.001), ('Kss', 1.0), ('g0', 170.0), ('g_max', 300.0), ('K_run', 2.5), ('P_max', 300.0)]
Initial fitness:

- RelErr: -0.231
- AbsErr: 9075619.499
- KGE: 0.495
- NS_rel: -167.306
- NS: 0.586

- RMSE: 11658141.744
- NS_log: 0.453

Computation time:6:36:47.231000

9.5.1.4 Results

Best individual (euclidian): [('Kep', 1.8), ('Ki', 223.489), ('Kg', 0.003), ('Kss', 2.554), ('g0', 175.119), ('g_max', 201.966), ('K_run', 3.125), ('P_max', 324.203)]

Fitness:

- RelErr: -0.051
- AbsErr: 4204338.901
- KGE: 0.703
- NS_rel: -206.099
- NS: 0.622
- RMSE: 5273599.83
- NS_log: 0.49

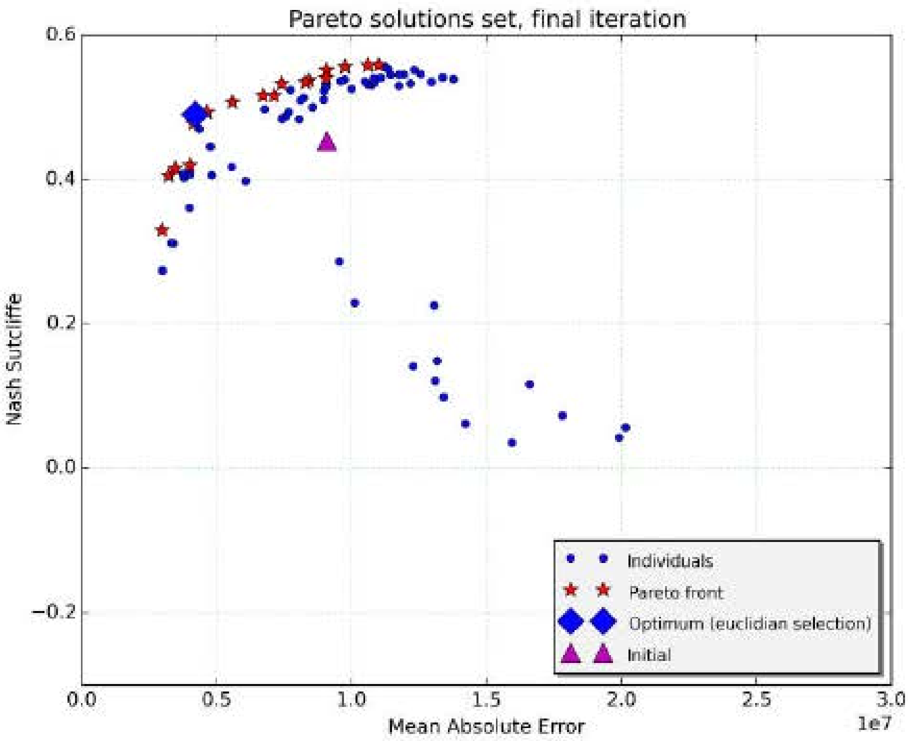


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

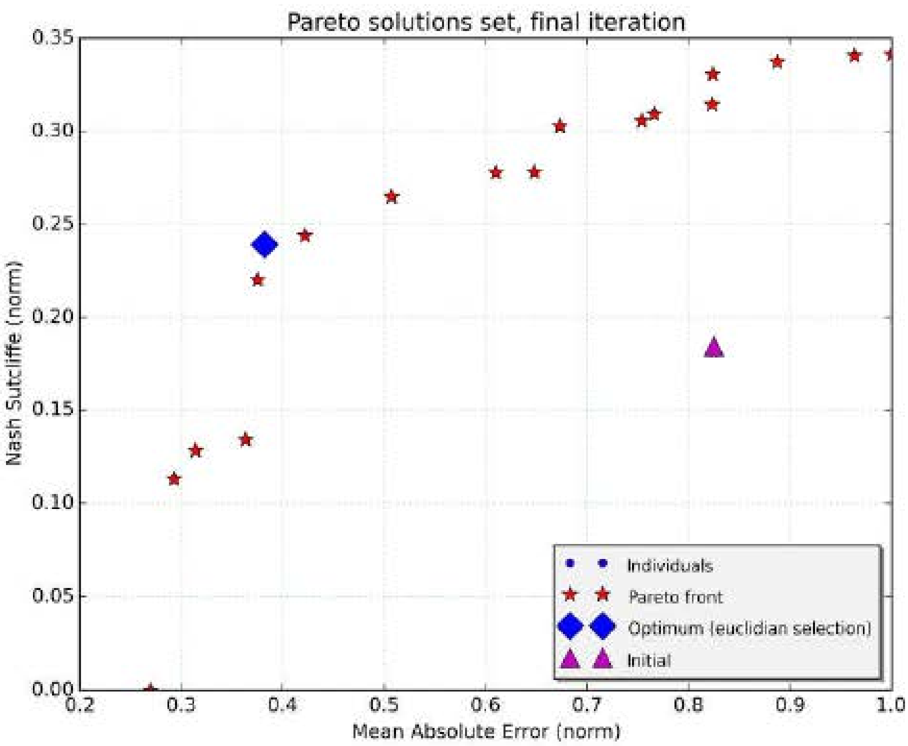


Figure 4: Final population of solutions (Pareto front)

9.5.1.4.1 Initial

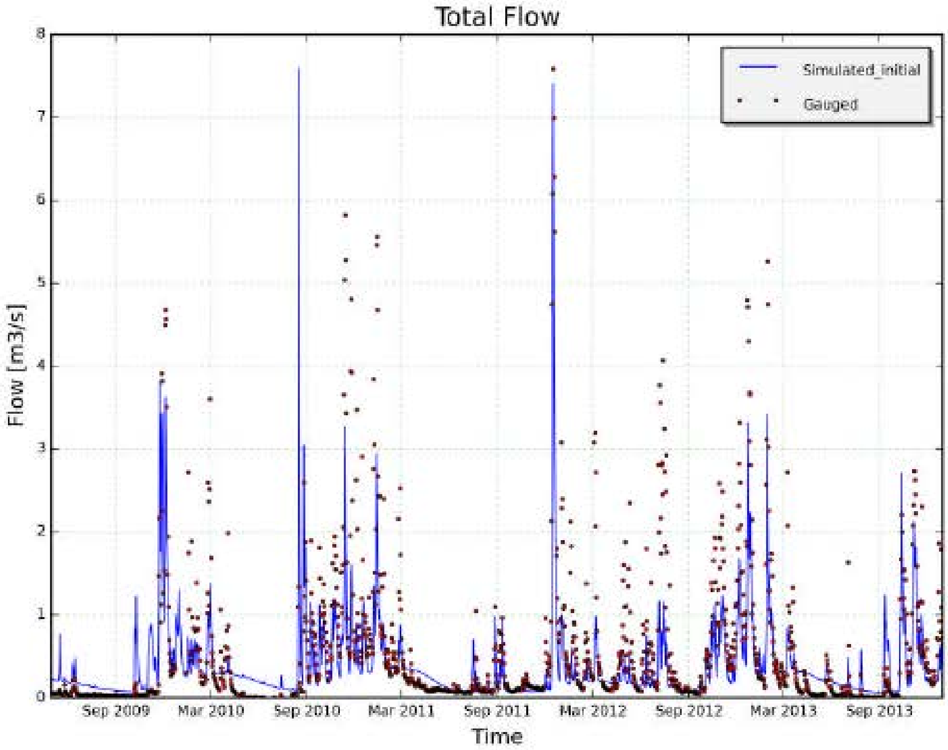


Figure 5: Total flow with initial parameters

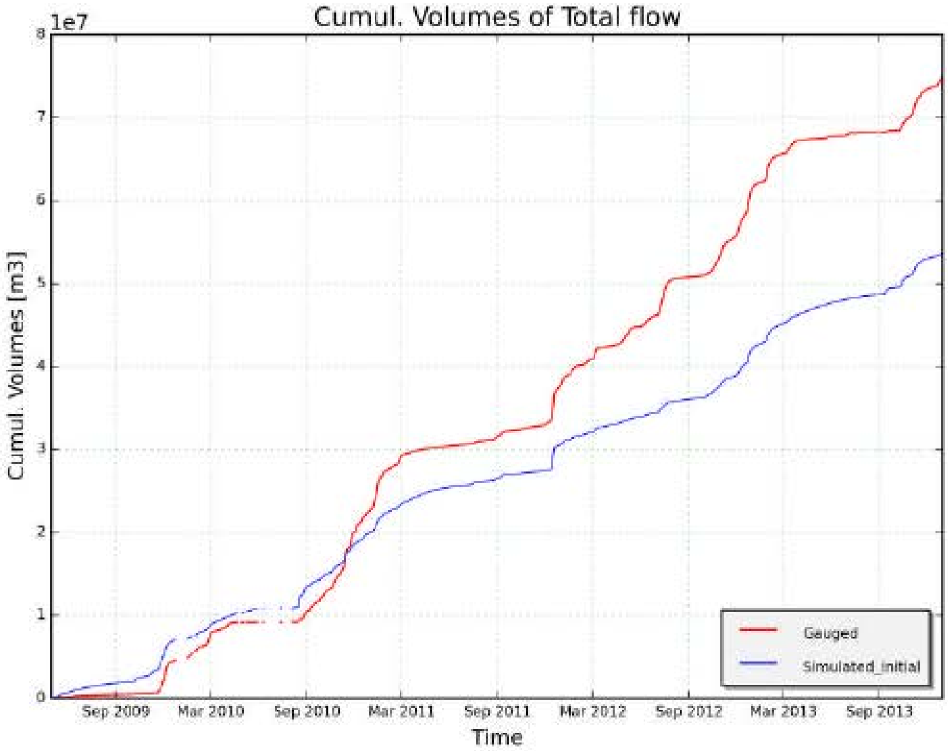


Figure 6: Cumulated flow with initial parameters

9.5.1.4.2 Optimum (euclidian)

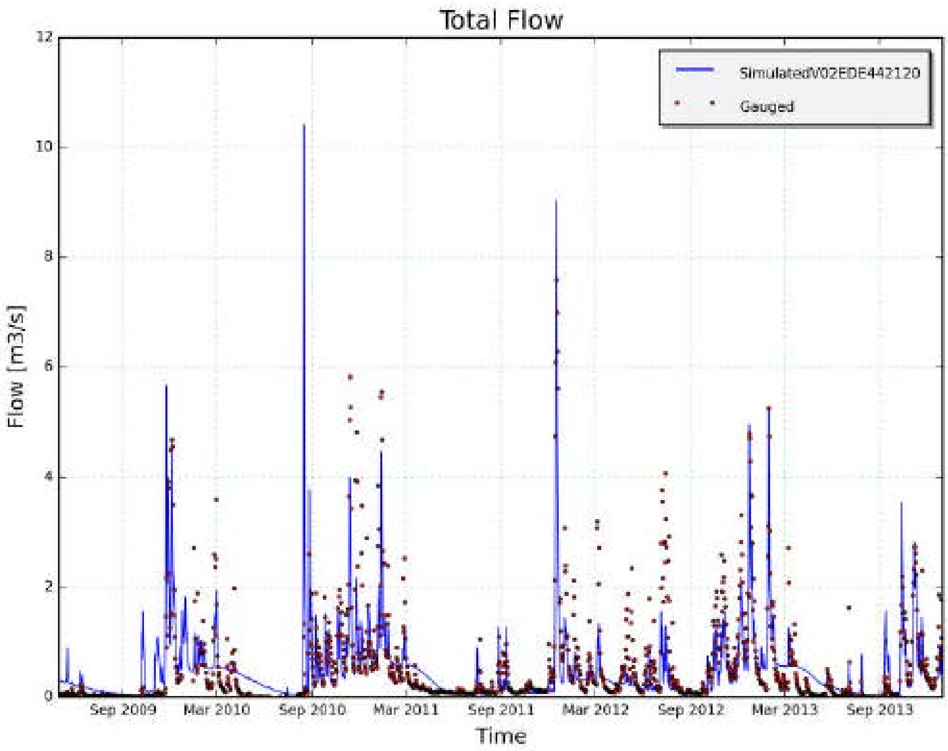


Figure 7: Total flow with optimum parameters

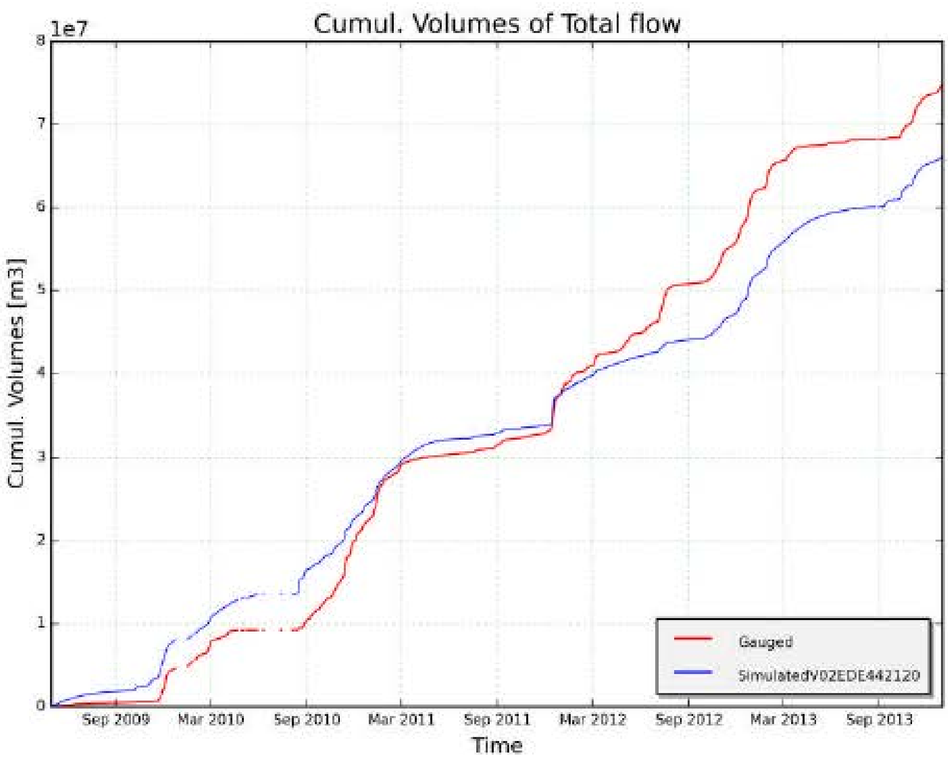


Figure 8: Cumulated flow with optimum parameters

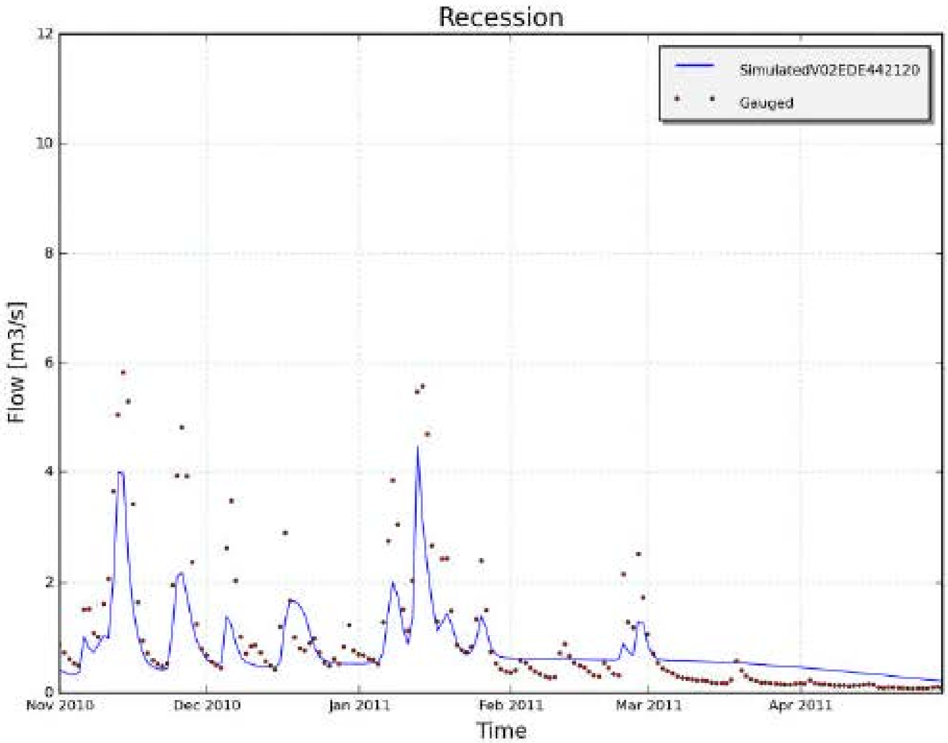


Figure 9: Total flow with optimum parameters (detail)

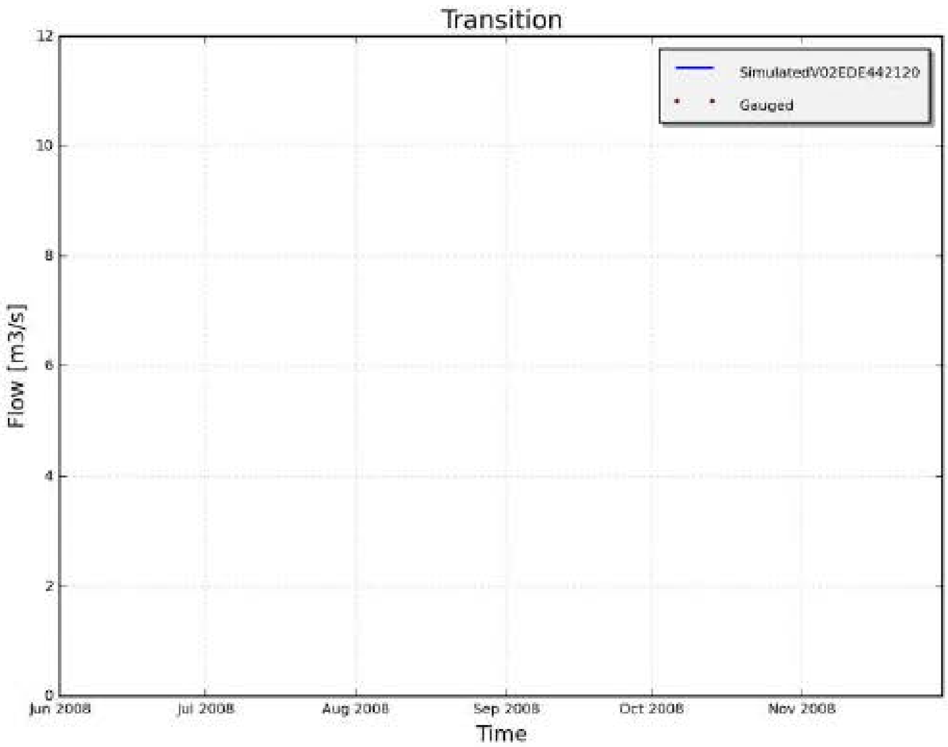
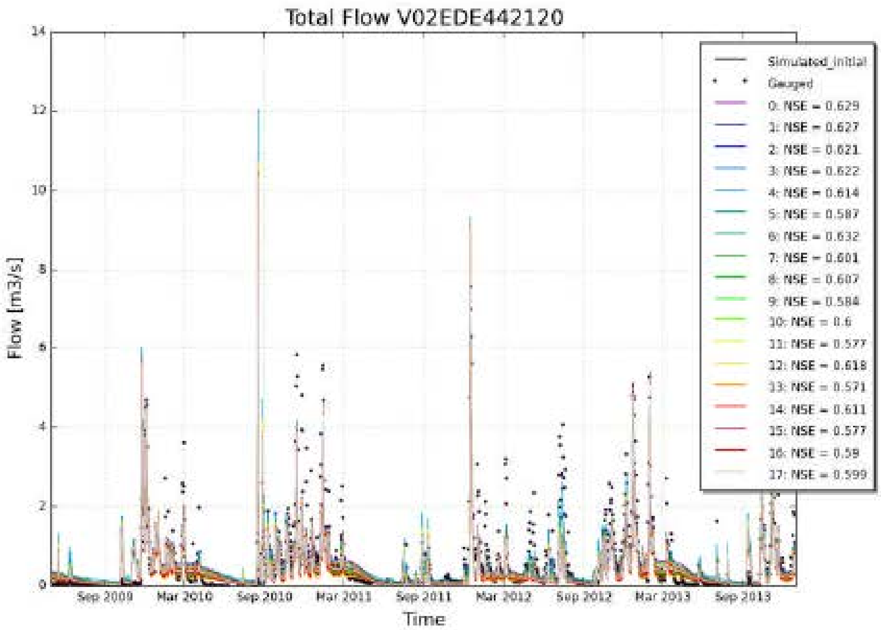
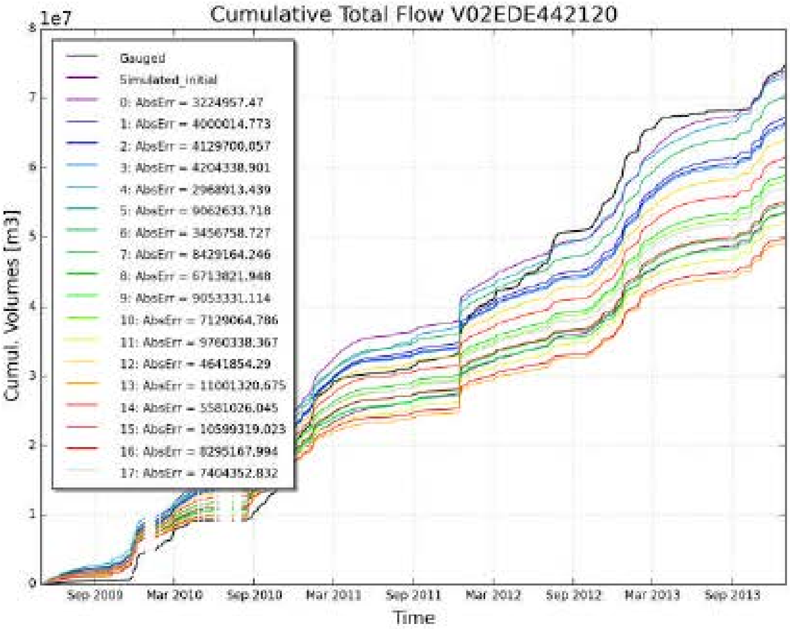


Figure 10: Total flow with optimum parameters (detail)

9.5.1.4.3 Final archive

0 : [1.603, 225.901, 0.003, 2.478, 176.916, 203.263, 4.036, 267.412] : [3224957.47, 0.405]
1 : [1.798, 208.534, 0.003, 2.656, 173.829, 262.889, 2.404, 325.118] : [4000014.773, 0.42]
2 : [1.795, 226.167, 0.003, 2.508, 173.657, 213.1, 3.279, 309.609] : [4129700.057, 0.477]
3 : [1.8, 223.489, 0.003, 2.554, 175.119, 201.966, 3.125, 324.203] : [4204338.901, 0.49]
4 : [1.2, 225.764, 0.001, 2.495, 178.022, 233.868, 4.098, 266.881] : [2968913.439, 0.33]
5 : [1.7, 219.345, 0.001, 1.733, 177.156, 218.888, 2.162, 289.312] : [9062633.718, 0.551]
6 : [1.587, 216.941, 0.003, 3.0, 176.25, 219.379, 2.0, 309.566] : [3456758.727, 0.416]
7 : [1.8, 189.031, 0.002, 3.0, 177.3, 212.83, 2.88, 310.836] : [8429164.246, 0.537]
8 : [1.686, 218.766, 0.002, 3.0, 177.674, 224.145, 2.197, 300.292] : [6713821.948, 0.516]
9 : [1.8, 225.062, 0.001, 3.0, 176.266, 247.464, 2.0, 306.491] : [9053331.114, 0.54]
10 : [1.55, 219.675, 0.001, 2.489, 177.758, 222.934, 2.443, 282.962] : [7129064.786, 0.516]
11 : [1.503, 217.493, 0.001, 3.0, 175.693, 221.492, 2.0, 301.336] : [9760338.367, 0.556]
12 : [1.8, 225.371, 0.003, 0.8, 176.493, 216.764, 2.282, 273.067] : [4641854.29, 0.493]
13 : [1.574, 206.223, 0.001, 1.632, 177.928, 209.52, 2.874, 308.757] : [11001320.675, 0.558]
14 : [1.8, 225.08, 0.002, 2.547, 175.029, 218.139, 3.173, 307.75] : [5581026.045, 0.507]
15 : [1.8, 205.198, 0.001, 1.973, 177.091, 210.704, 2.46, 306.086] : [10599319.023, 0.558]
16 : [1.8, 223.251, 0.002, 3.0, 177.929, 231.082, 3.257, 272.852] : [8295167.994, 0.535]
17 : [1.8, 222.989, 0.002, 3.0, 175.991, 217.85, 2.989, 308.007] : [7404352.832, 0.533]





9.5.2 Report on simulation of catchment V02HER426010 (2017-01-25 17-59)

9.5.2.1 Input data

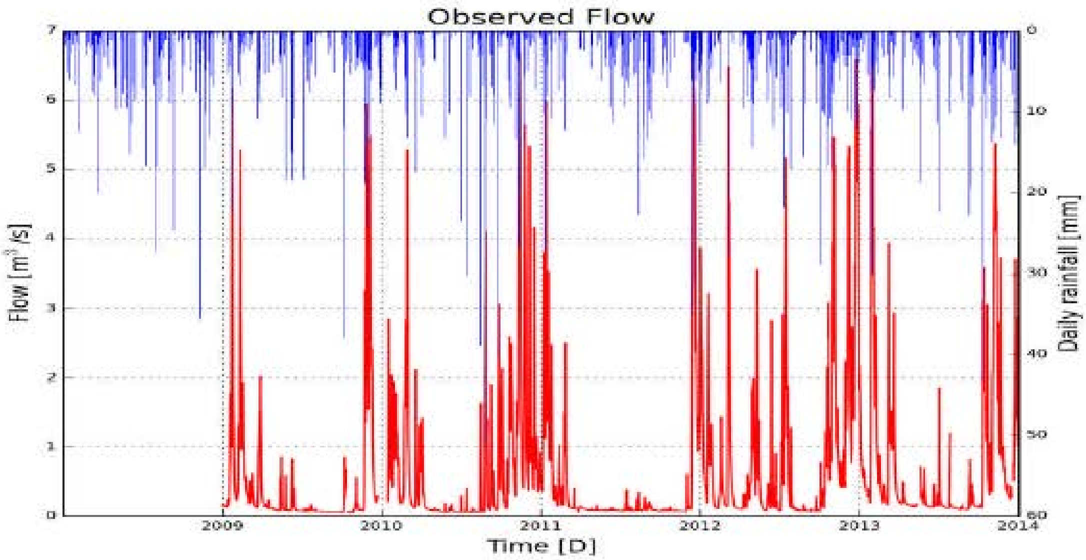


Figure 1: Hyetogram of observed discharge and observed net rain

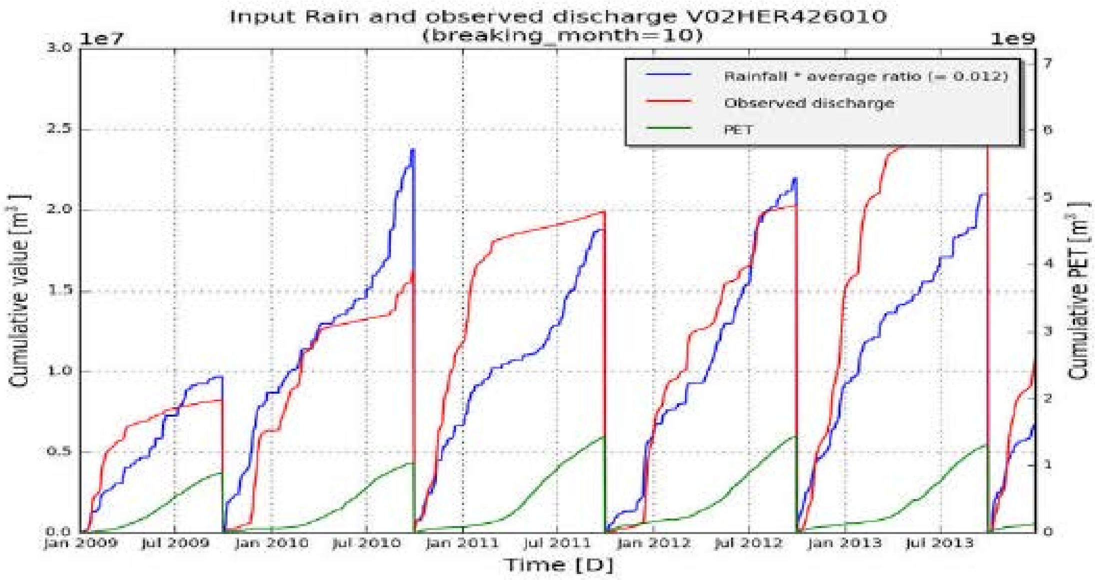


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.2.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V02HER426010
subcatchment_area	77300000
start_date	200001010000
end_date	201312310000
frequency	86400
warmup	365

9.5.2.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[1.5, 200.0, 0.001, 0.8, 88.0, 310.0, 3.6, 383.0]
low_bounds	[0.9, 124.0, 0.0006, 0.48, 52.8, 186.0, 1.5, 230.0]
high_bounds	[1.8, 250.0, 0.01, 0.96, 150.0, 400.0, 5.4, 460.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.5), ('Ki', 200.0), ('Kg', 0.001), ('Kss', 0.8), ('g0', 88.0), ('g_max', 310.0), ('K_run', 3.6), ('P_max', 383.0)]
Initial fitness:

- RelErr: -0.156
- AbsErr: 21832099.29
- KGE: 0.638
- NS_rel: -0.008
- NS: 0.263
- RMSE: 22889256.795
- NS_log: 0.62

Computation time:1 day, 0:46:54.447000

9.5.2.4 Results

Best individual (euclidian): [('Kep', 1.383), ('Ki', 210.994), ('Kg', 0.001), ('Kss', 0.96), ('g0', 86.436), ('g_max', 246.074), ('K_run', 3.715), ('P_max', 324.894)]

Fitness:

- RelErr: -0.051
- AbsErr: 7956291.352
- KGE: 0.628
- NS_rel: -0.306
- NS: 0.217
- RMSE: 9185902.888
- NS_log: 0.599

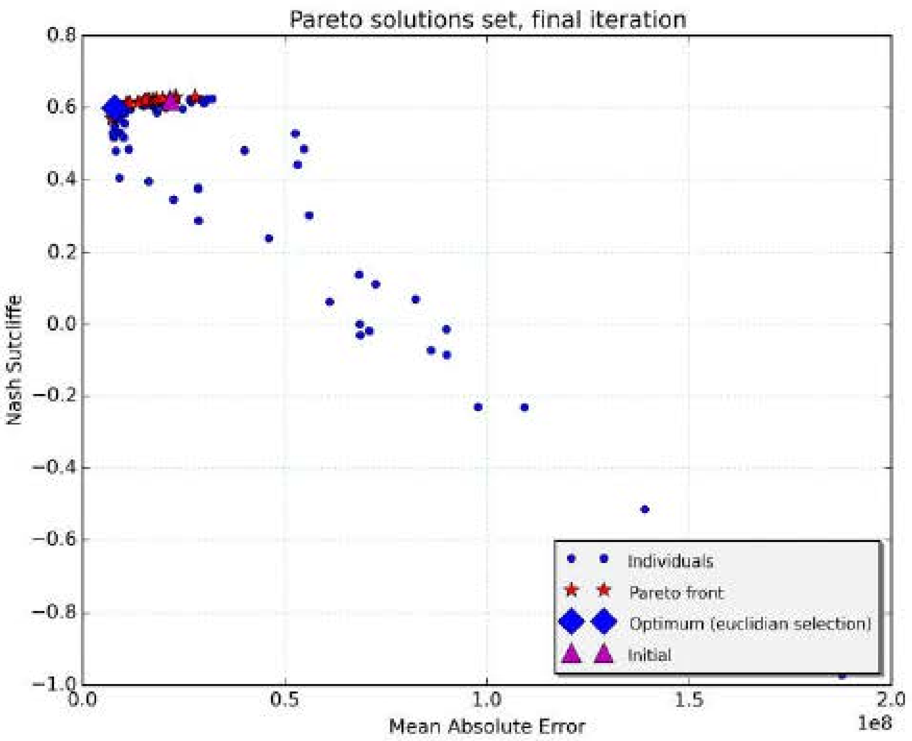


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

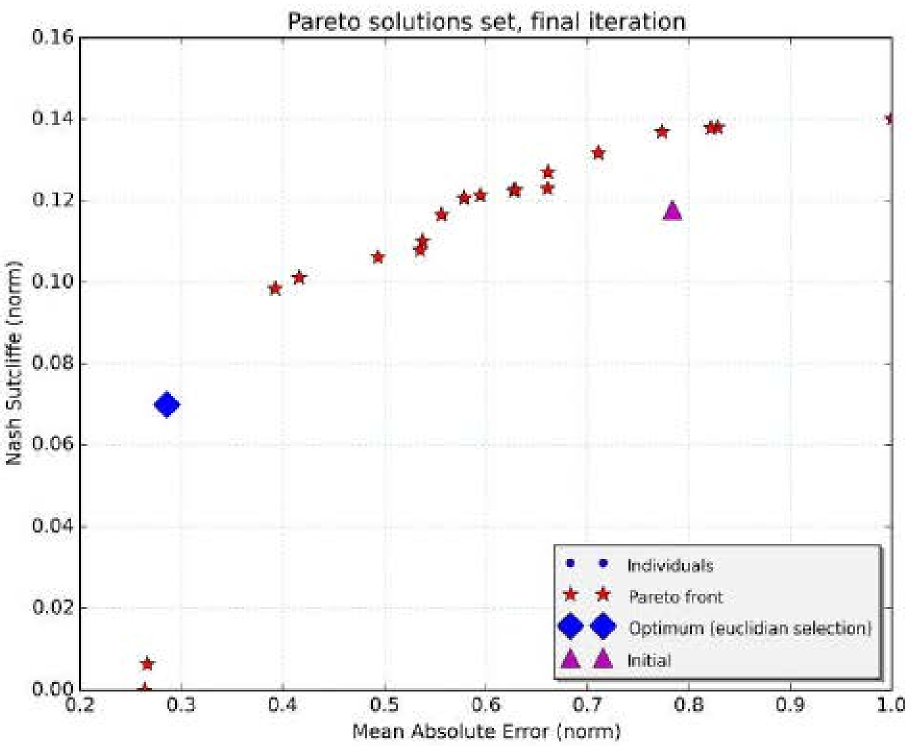


Figure 4: Final population of solutions (Pareto front)

9.5.2.4.1 Initial

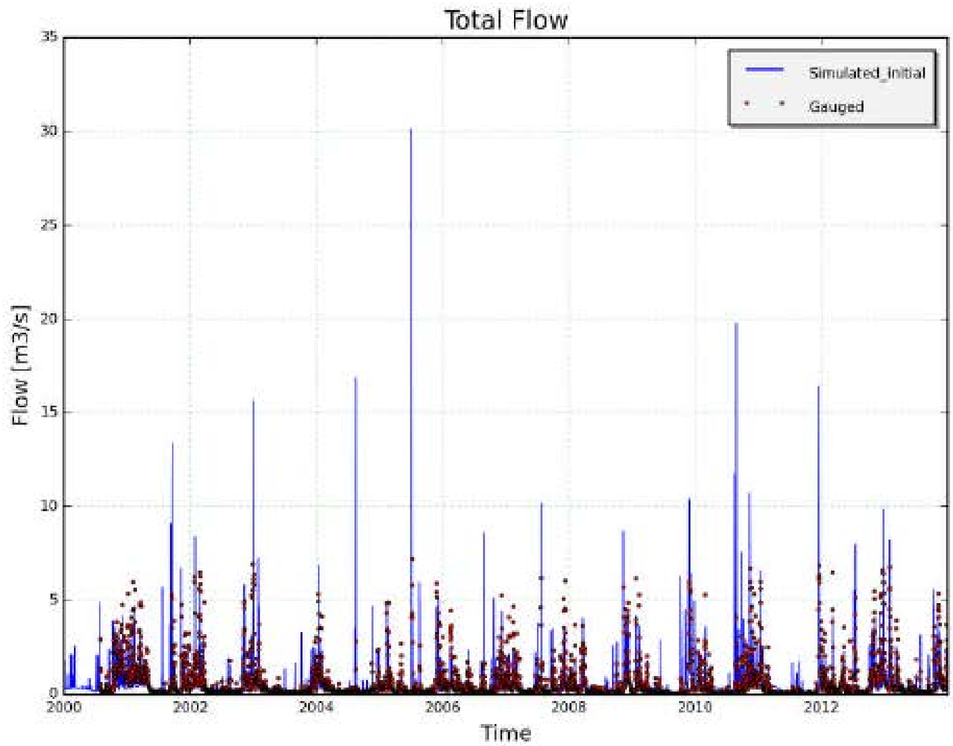


Figure 5: Total flow with initial parameters

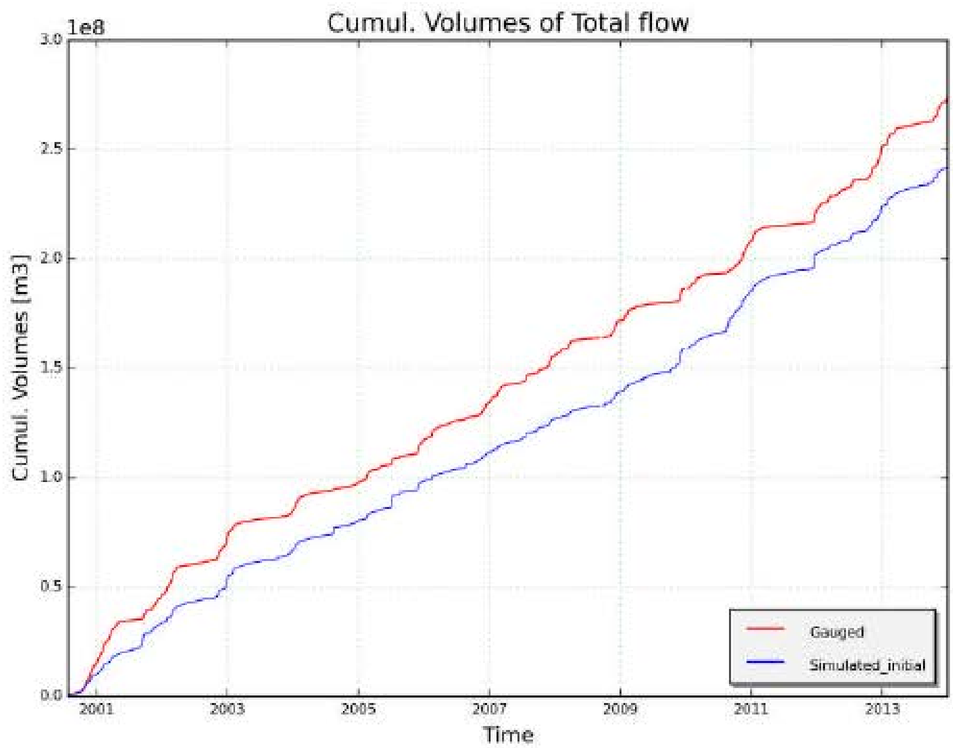


Figure 6: Cumulated flow with initial parameters

9.5.2.4.2 Optimum (euclidian)

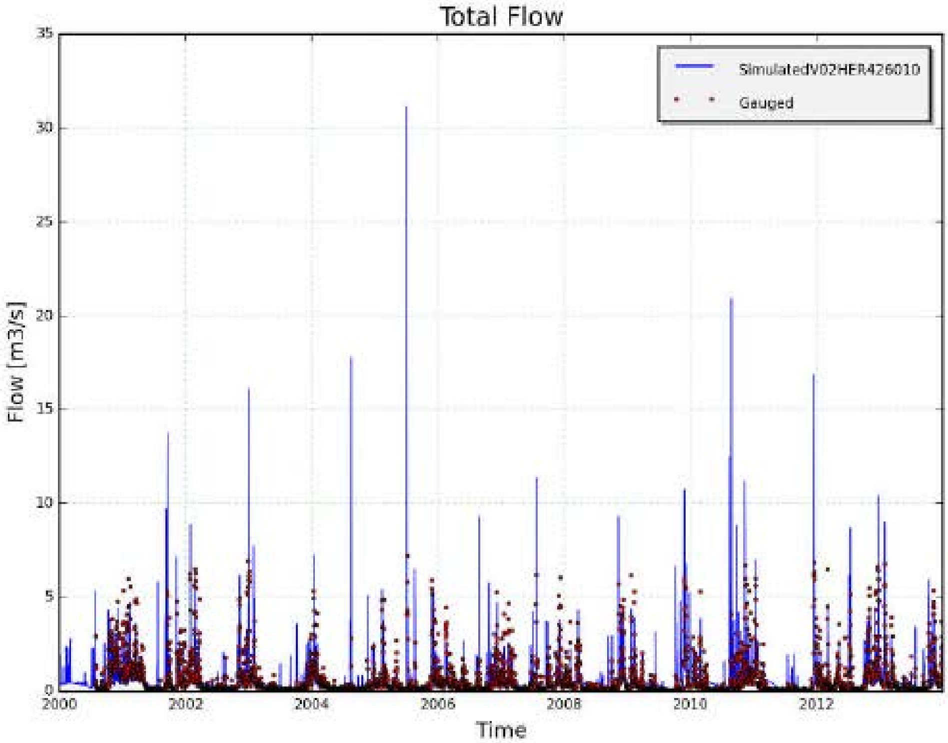


Figure 7: Total flow with optimum parameters

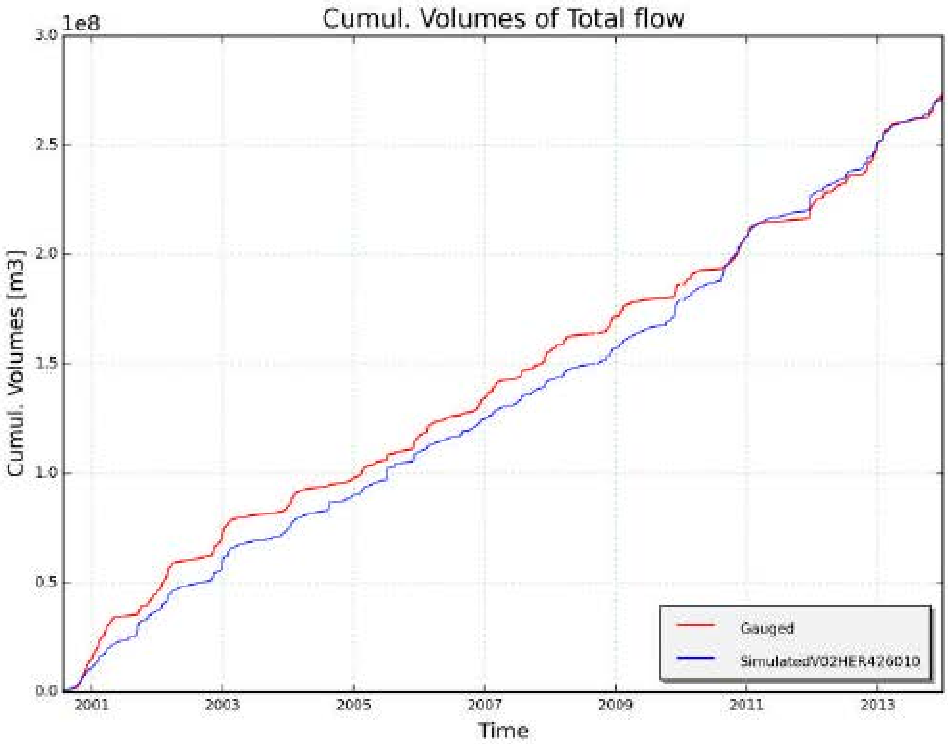


Figure 8: Cumulated flow with optimum parameters

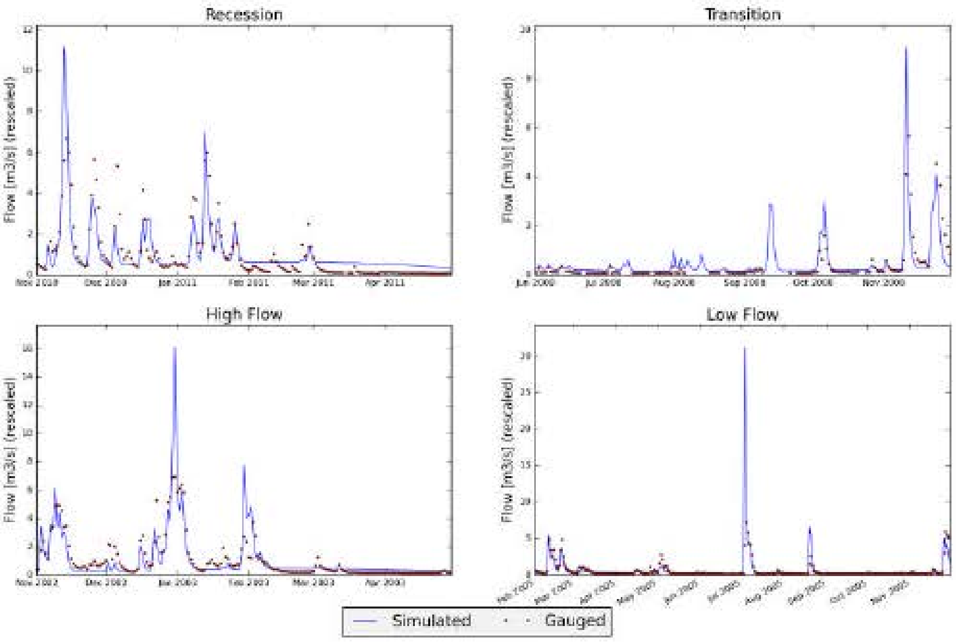


Figure 9: Total flow with optimum parameters (detail)

9.5.2.4.3 Final archive

0 : [1.35, 211.077, 0.001, 0.768, 111.162, 267.678, 2.843, 336.234] : [7353504.366, 0.569]

1 : [1.295, 152.483, 0.001, 0.782, 94.33, 290.74, 3.094, 374.221] : [27849214.25, 0.63]

2 : [1.417, 186.306, 0.001, 0.795, 94.641, 258.309, 2.899, 351.132] : [16560279.955, 0.621]

3 : [1.475, 186.134, 0.001, 0.96, 100.658, 274.413, 1.818, 304.38] : [14909121.091, 0.616]

4 : [1.427, 180.914, 0.001, 0.794, 95.646, 257.023, 3.731, 372.35] : [23067908.665, 0.629]

5 : [1.429, 174.604, 0.001, 0.794, 100.281, 266.144, 3.09, 371.487] : [18404520.736, 0.622]

6 : [1.44, 183.368, 0.001, 0.902, 95.642, 261.496, 2.421, 324.66] : [14969984.521, 0.617]

7 : [1.335, 200.984, 0.001, 0.808, 88.808, 246.146, 2.91, 296.216] : [10925202.721, 0.612]

8 : [1.362, 202.529, 0.001, 0.96, 87.285, 270.736, 2.175, 337.161] : [7426700.724, 0.572]

9 : [1.383, 210.994, 0.001, 0.96, 86.436, 246.074, 3.715, 324.894] : [7956291.352, 0.599]

10 : [1.419, 178.104, 0.001, 0.51, 98.49, 258.18, 3.041, 357.076] : [17479307.422, 0.622]

11 : [1.429, 183.146, 0.001, 0.904, 94.826, 259.343, 3.365, 327.891] : [17522649.487, 0.622]

12 : [1.348, 174.683, 0.001, 0.79, 96.799, 256.962, 3.023, 362.312] : [18406826.577, 0.624]

13 : [1.434, 178.189, 0.001, 0.96, 98.84, 272.602, 1.748, 344.213] : [19791734.146, 0.626]

14 : [1.427, 182.305, 0.001, 0.48, 97.054, 257.023, 3.645, 372.35] : [22879957.799, 0.629]

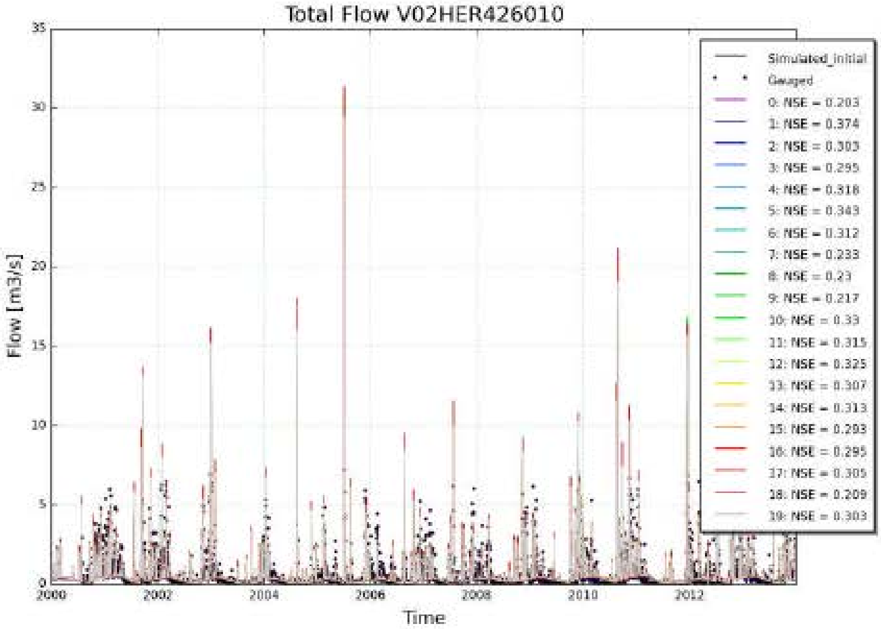
15 : [1.43, 181.867, 0.001, 0.892, 100.26, 257.859, 1.5, 364.917] : [16109860.249, 0.621]

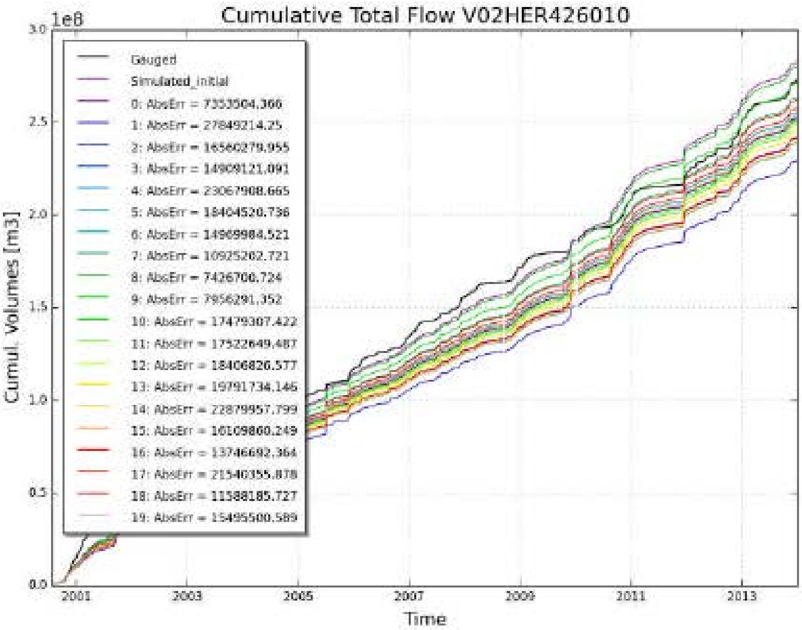
16 : [1.44, 182.508, 0.001, 0.48, 97.85, 260.982, 1.5, 331.576] : [13746692.364, 0.615]

17 : [1.434, 184.464, 0.001, 0.897, 96.925, 267.529, 2.904, 353.736] : [21540355.878, 0.628]

18 : [1.366, 209.662, 0.001, 0.596, 96.56, 258.314, 3.048, 374.708] : [11588185.727, 0.613]

19 : [1.438, 181.962, 0.001, 0.753, 97.164, 261.675, 1.813, 335.873] : [15495500.589, 0.619]


Total Flow V02HER426010
Flow [m3/s]
Time
Simulated_initial
Gauged
0: NSE = 0.203
1: NSE = 0.374
2: NSE = 0.303
3: NSE = 0.295
4: NSE = 0.318
5: NSE = 0.343
6: NSE = 0.312
7: NSE = 0.233
8: NSE = 0.23
9: NSE = 0.217
10: NSE = 0.33
11: NSE = 0.315
12: NSE = 0.325
13: NSE = 0.307
14: NSE = 0.313
15: NSE = 0.293
16: NSE = 0.295
17: NSE = 0.305
18: NSE = 0.209
19: NSE = 0.303


Cumulative Total Flow V02HER426010
1e8
Cumul. Volumes [m3]
Time
Gauged
Simulated_initial
0: AbsErr = 7353504.366
1: AbsErr = 27849214.25
2: AbsErr = 16560279.955
3: AbsErr = 14909121.091
4: AbsErr = 23067908.665
5: AbsErr = 18404520.736
6: AbsErr = 14969984.521
7: AbsErr = 10925202.721
8: AbsErr = 7426700.724
9: AbsErr = 7956291.352
10: AbsErr = 17479307.422
11: AbsErr = 17522649.487
12: AbsErr = 18406826.577
13: AbsErr = 19791734.146
14: AbsErr = 22879957.799
15: AbsErr = 16109860.249
16: AbsErr = 13746692.364
17: AbsErr = 21540355.878
18: AbsErr = 11588185.727
19: AbsErr = 15495500.589

9.5.3 Report on simulation of catchment V02KER422030 (2017-01-18 03-10)

9.5.3.1 Input data

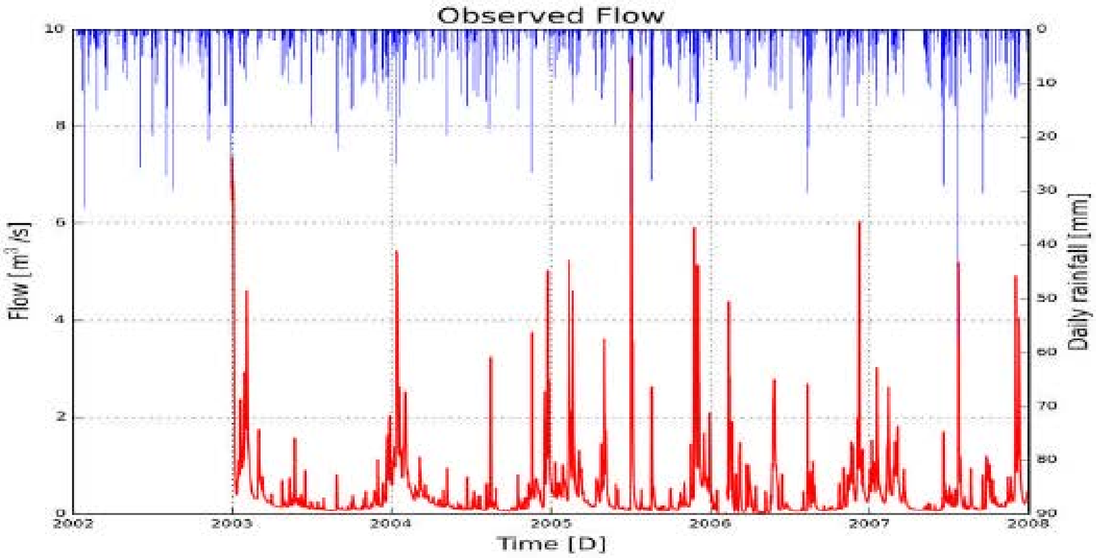


Figure 1: Hyetogram of observed discharge and observed net rain

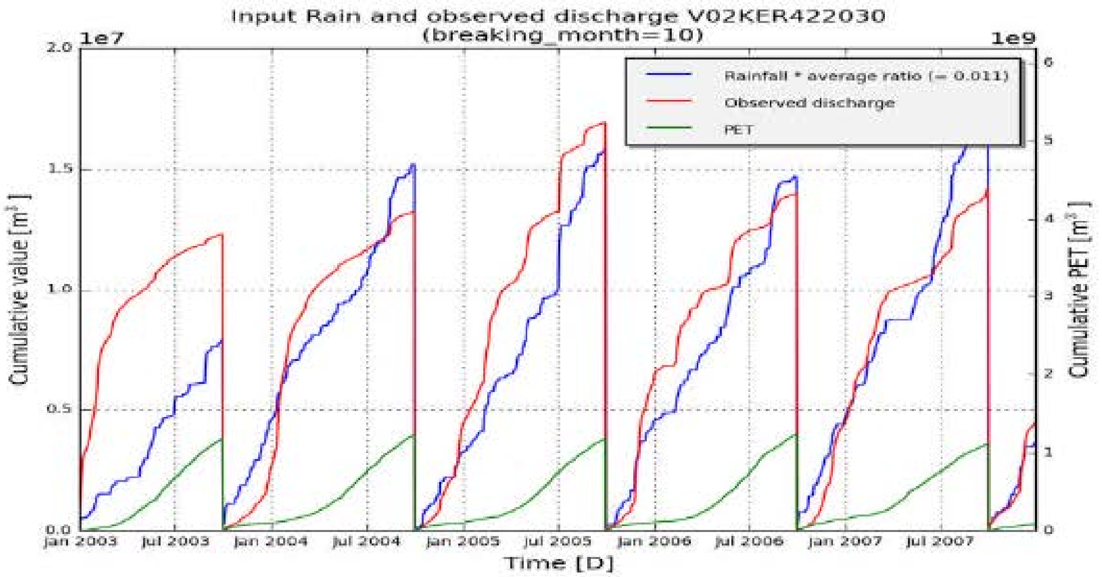


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.3.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	V02KER422030
subcatchment_area	62700000
start_date	200301010000
end_date	200712310000
frequency	86400
warmup	365

9.5.3.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.5, 40.0, 0.0013, 1.4, 190.0, 300.0, 1.2, 600.0]
low_bounds	[1.2, 32.0, 0.0001, 1.12, 152.0, 240.0, 0.96, 480.0]
high_bounds	[1.8, 48.0, 0.0016, 1.68, 228.0, 360.0, 1.44, 720.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.5), ('Ki', 40.0), ('Kg', 0.0013), ('Kss', 1.4), ('g0', 190.0), ('g_max', 300.0), ('K_run', 1.2), ('P_max', 600.0)]
Initial fitness:

- RelErr: -0.002
- AbsErr: 1853689.855
- KGE: 0.697
- NS_rel: -3.964
- NS: 0.601
- RMSE: 2377273.378
- NS_log: 0.416

Computation time:9:52:45.070000

9.5.3.4 Results

Best individual (euclidian): [('Kep', 1.768), ('Ki', 47.473), ('Kg', 0.001), ('Kss', 1.68), ('g0', 182.818), ('g_max', 281.488), ('K_run', 0.96), ('P_max', 590.115)]

Fitness:

- RelErr: -0.061
- AbsErr: 2508018.641
- KGE: 0.762
- NS_rel: -2.665
- NS: 0.594
- RMSE: 2736028.532
- NS_log: 0.54

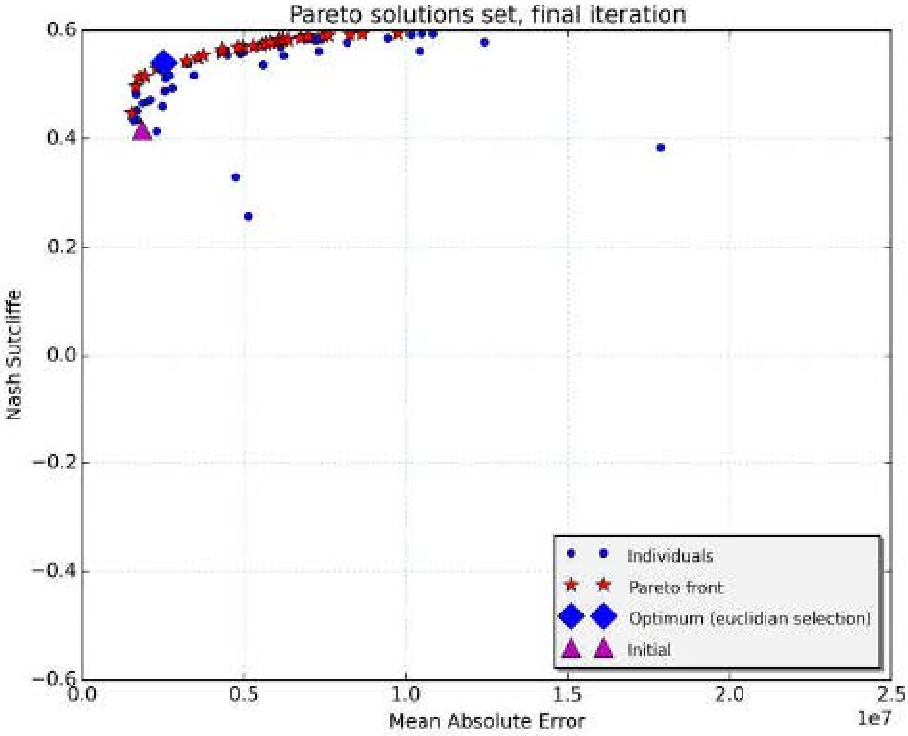


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

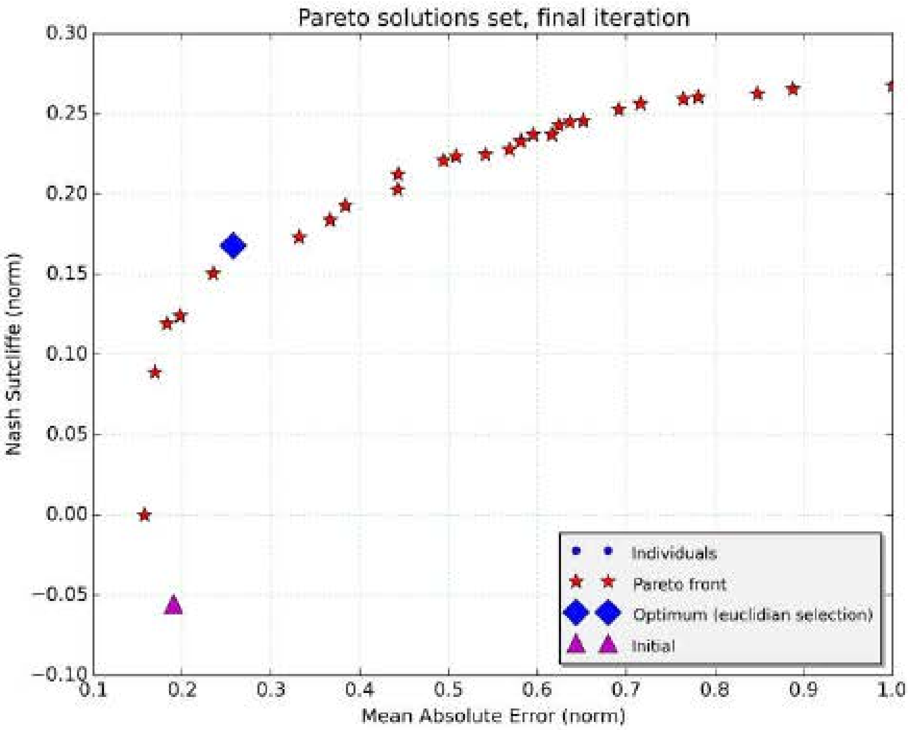


Figure 4: Final population of solutions (Pareto front)

9.5.3.4.1 Initial

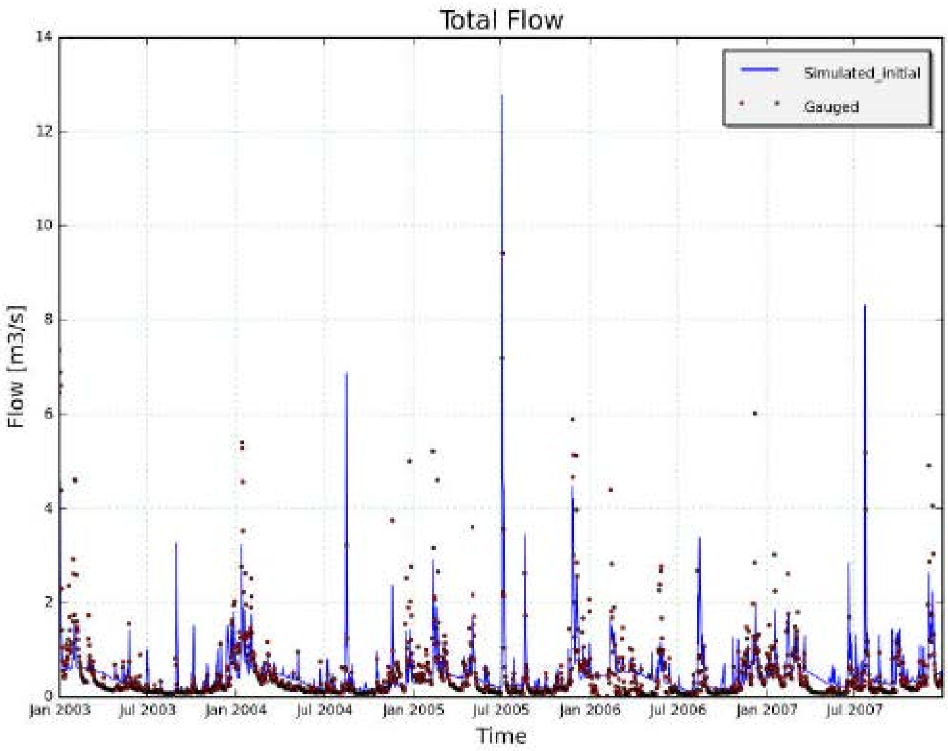


Figure 5: Total flow with initial parameters

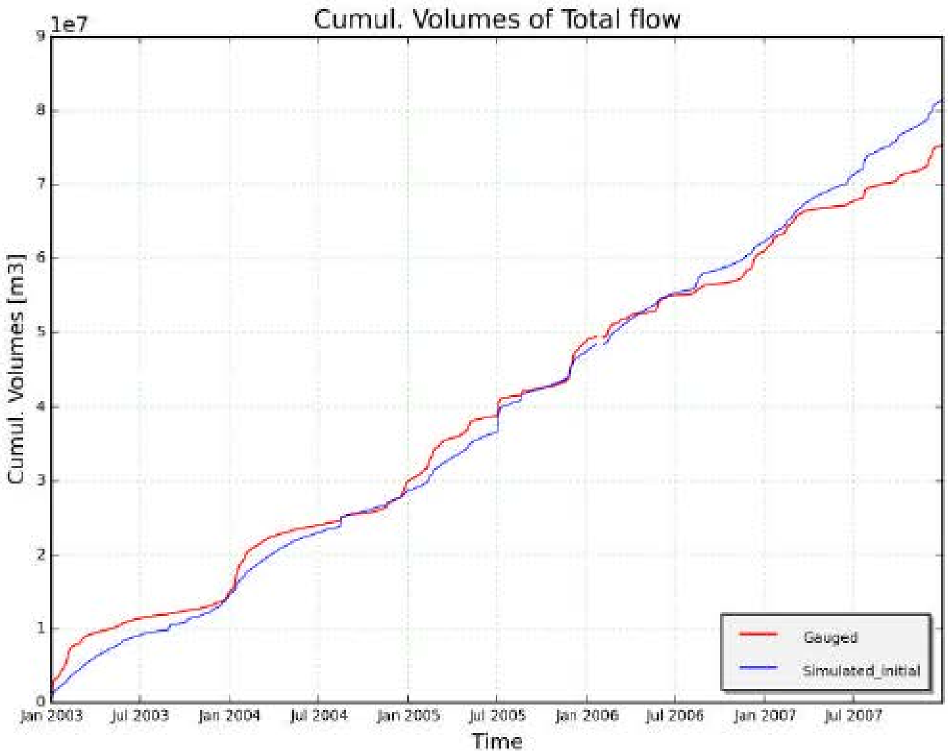


Figure 6: Cumulated flow with initial parameters

9.5.3.4.2 Optimum (euclidian)

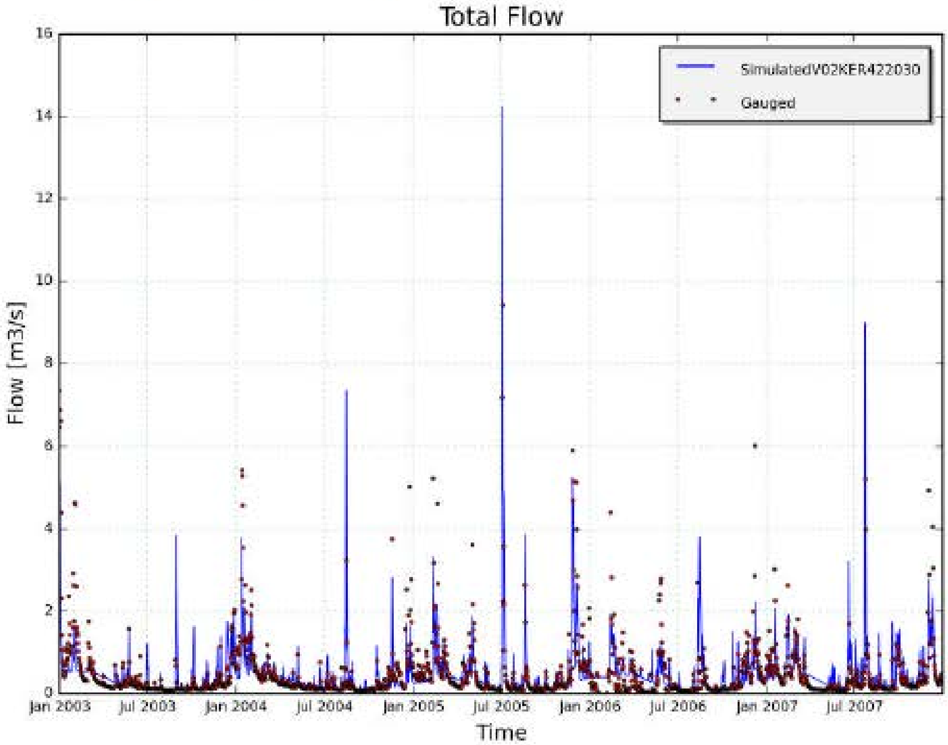


Figure 7: Total flow with optimum parameters

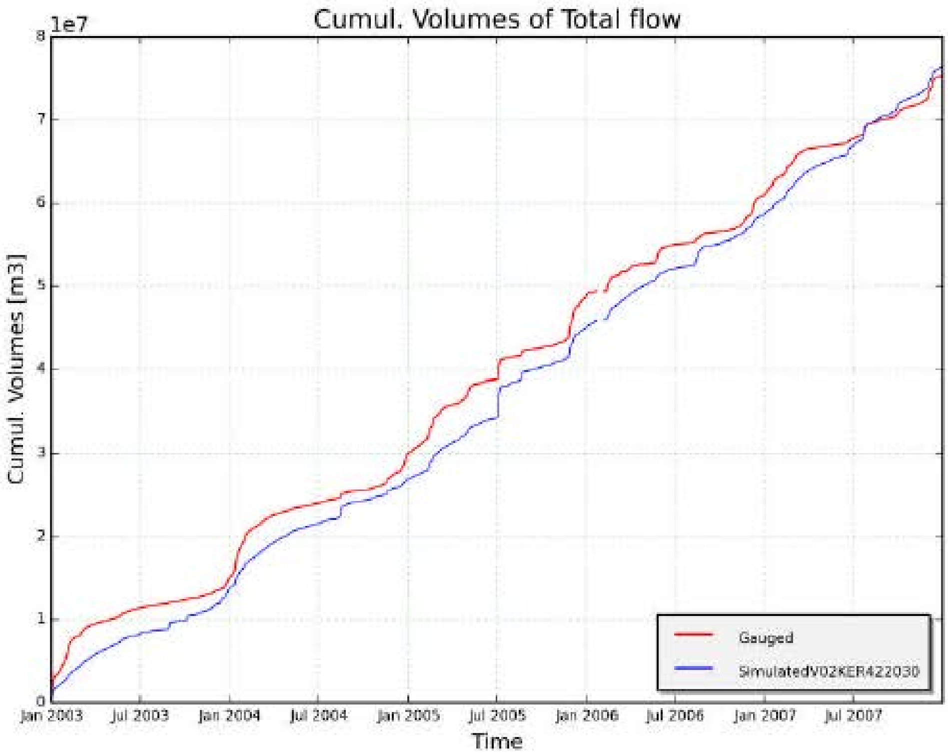


Figure 8: Cumulated flow with optimum parameters

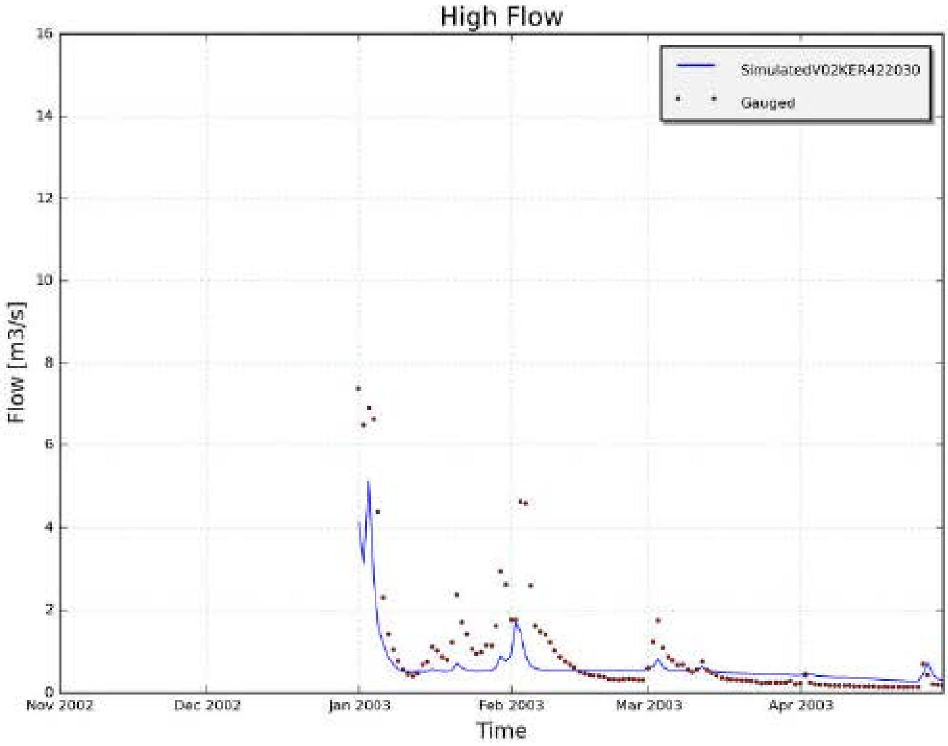


Figure 9: Total flow with optimum parameters (detail)

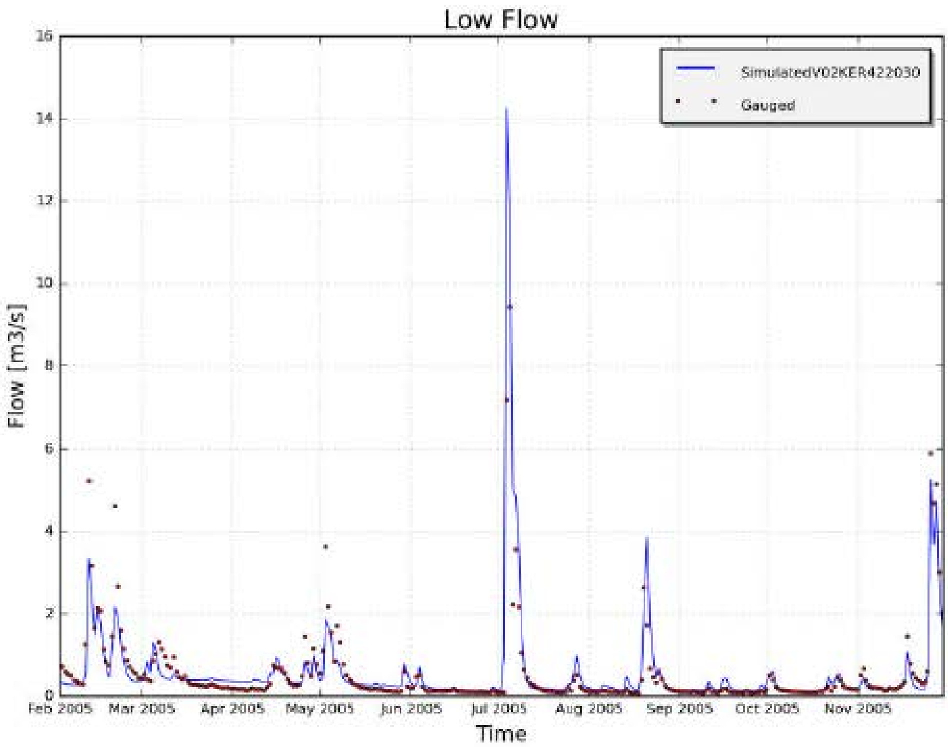
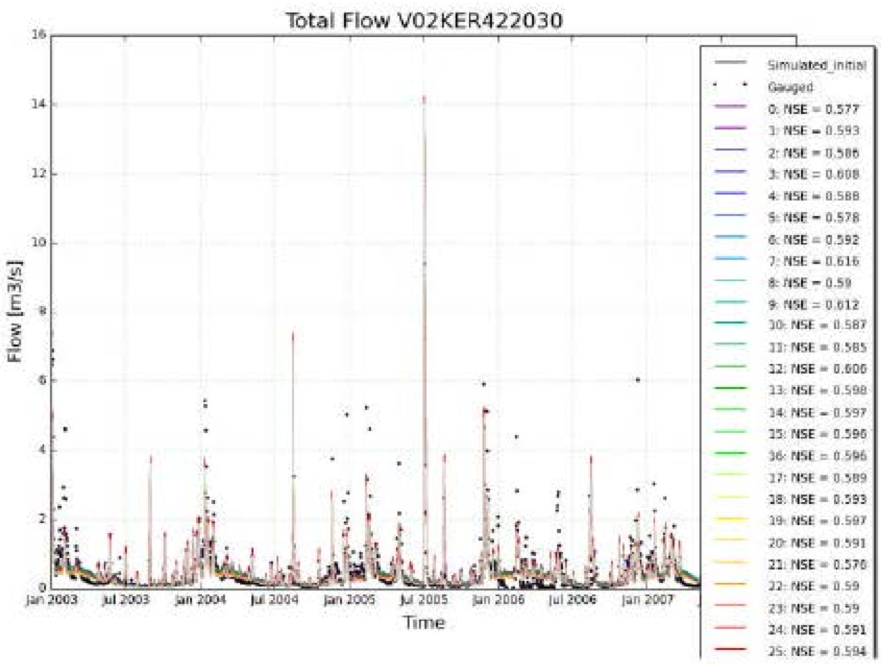
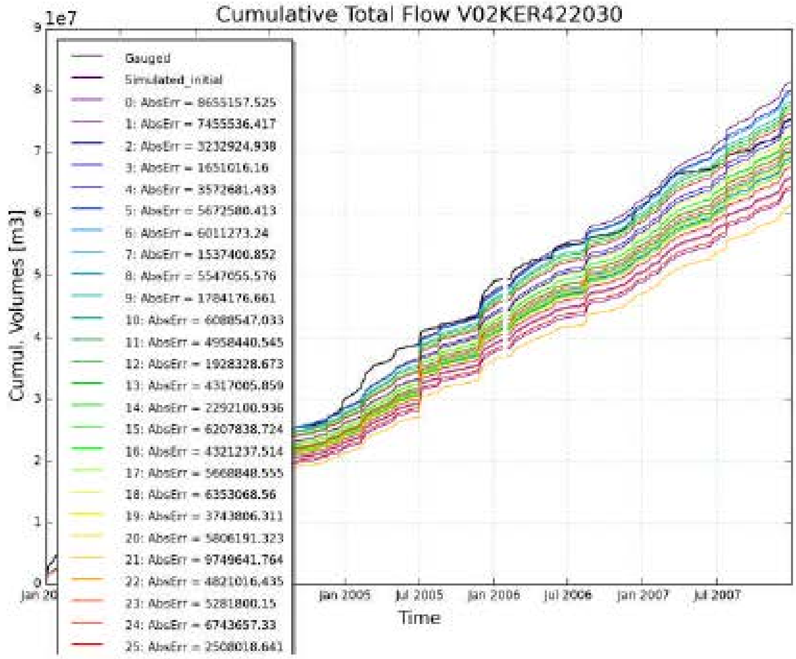


Figure 10: Total flow with optimum parameters (detail)

9.5.3.4.3 Final archive

0 : [1.573, 45.42, 0.001, 1.263, 183.625, 254.495, 1.379, 561.465] : [8655157.525, 0.594]
1 : [1.8, 46.187, 0.001, 1.68, 179.435, 280.812, 1.157, 589.124] : [7455536.417, 0.59]
2 : [1.592, 44.917, 0.001, 1.165, 184.217, 275.26, 0.96, 584.408] : [3232924.938, 0.543]
3 : [1.786, 44.119, 0.002, 1.263, 192.503, 290.449, 0.96, 617.305] : [1651016.16, 0.496]
4 : [1.633, 44.825, 0.001, 1.12, 184.043, 280.986, 0.96, 584.16] : [3572681.433, 0.549]
5 : [1.618, 45.897, 0.001, 1.137, 186.167, 261.307, 0.96, 686.513] : [5672580.413, 0.576]
6 : [1.8, 44.761, 0.001, 1.143, 184.004, 300.626, 0.96, 612.018] : [6011273.24, 0.578]
7 : [1.8, 41.453, 0.002, 1.331, 201.437, 334.897, 1.214, 591.803] : [1537400.852, 0.447]
8 : [1.716, 43.885, 0.001, 1.124, 203.809, 292.015, 0.96, 612.453] : [5547055.576, 0.573]
9 : [1.8, 44.997, 0.002, 1.273, 190.027, 276.937, 1.023, 584.291] : [1784176.661, 0.513]
10 : [1.78, 47.404, 0.001, 1.36, 178.789, 274.615, 0.995, 608.06] : [6088547.033, 0.581]
11 : [1.697, 46.321, 0.001, 1.395, 180.408, 278.487, 0.96, 638.452] : [4958440.545, 0.571]
12 : [1.8, 48.0, 0.002, 1.12, 179.051, 282.036, 1.131, 597.634] : [1928328.673, 0.516]
13 : [1.714, 43.171, 0.001, 1.68, 198.659, 285.279, 0.96, 593.313] : [4317005.859, 0.559]
14 : [1.743, 47.341, 0.001, 1.471, 184.481, 282.248, 1.004, 592.635] : [2292100.936, 0.53]
15 : [1.8, 46.989, 0.001, 1.12, 178.915, 282.02, 1.135, 591.495] : [6207838.724, 0.582]
16 : [1.786, 45.755, 0.001, 1.343, 199.508, 284.548, 0.96, 625.165] : [4321237.514, 0.564]
17 : [1.721, 44.67, 0.001, 1.68, 201.427, 286.491, 0.961, 608.66] : [5668848.555, 0.576]
18 : [1.793, 45.78, 0.001, 1.12, 179.501, 283.14, 1.02, 591.229] : [6353068.56, 0.583]
19 : [1.8, 45.507, 0.001, 1.333, 200.538, 307.074, 0.96, 592.856] : [3743806.311, 0.554]
20 : [1.702, 46.211, 0.001, 1.424, 180.164, 279.13, 1.08, 635.852] : [5806191.323, 0.578]
21 : [1.725, 46.51, 0.001, 1.3, 196.988, 282.607, 1.44, 592.881] : [9749641.764, 0.595]
22 : [1.717, 45.585, 0.001, 1.244, 183.849, 276.505, 0.96, 591.129] : [4821016.435, 0.569]
23 : [1.704, 44.362, 0.001, 1.68, 193.494, 287.946, 0.96, 628.98] : [5281800.15, 0.571]
24 : [1.752, 46.38, 0.001, 1.378, 214.465, 282.479, 1.102, 600.741] : [6743657.33, 0.587]
25 : [1.768, 47.473, 0.001, 1.68, 182.818, 281.488, 0.96, 590.115] : [2508018.641, 0.54]
26 : [1.718, 44.761, 0.001, 1.602, 196.759, 283.813, 1.295, 607.525] : [8267802.61, 0.592]
27 : [1.752, 46.38, 0.001, 1.378, 214.465, 282.479, 1.229, 600.741] : [7615494.561, 0.591]
28 : [1.717, 47.833, 0.001, 1.672, 195.798, 286.202, 1.13, 590.174] : [6985059.319, 0.589]





9.5.4 Report on simulation of catchment V02RIV425020 (2017-01-24 13-40)

9.5.4.1 Input data

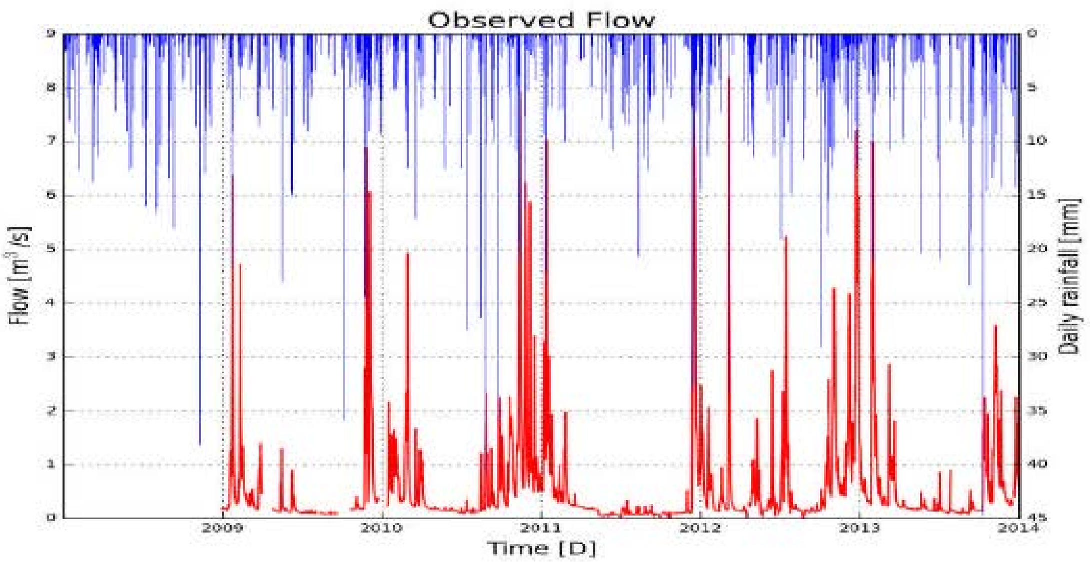


Figure 1: Hyetogram of observed discharge and observed net rain

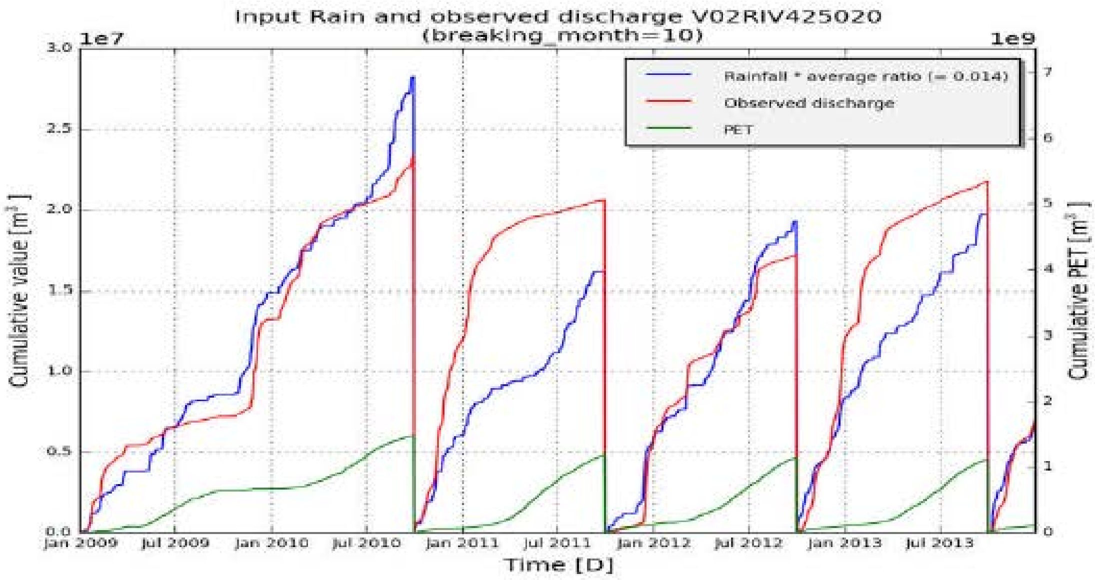


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.4.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V02RIV425020
subcatchment_area	64000000
start_date	200301010000
end_date	201312310000
frequency	86400
warmup	365

9.5.4.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[1.5, 250.0, 0.0005, 1.0, 200.0, 950.0, 4.5, 450.0]
low_bounds	[1.2, 200.0, 0.0004, 0.8, 160.0, 760.0, 3.6, 360.0]
high_bounds	[1.8, 300.0, 0.0006, 1.35, 240.0, 1140.0, 5.4, 540.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.5), ('Ki', 250.0), ('Kg', 0.0005), ('Kss', 1.0), ('g0', 200.0), ('g_max', 950.0), ('K_run', 4.5), ('P_max', 450.0)]

Initial fitness:

- RelErr: -0.033
- AbsErr: 2932618.872
- KGE: 0.508
- NS_rel: -2.871
- NS: -0.083
- RMSE: 3663382.478
- NS_log: 0.642

Computation time:22:03:30.984000

9.5.4.4 Results

Best individual (euclidian): [('Kep', 1.5), ('Ki', 245.281), ('Kg', 0.001), ('Kss', 1.124), ('g0', 191.273), ('g_max', 812.061), ('K_run', 4.865), ('P_max', 468.709)]

Fitness:

- RelErr: -0.022
- AbsErr: 2490803.19
- KGE: 0.518
- NS_rel: -2.592
- NS: -0.058
- RMSE: 3117122.919
- NS_log: 0.648

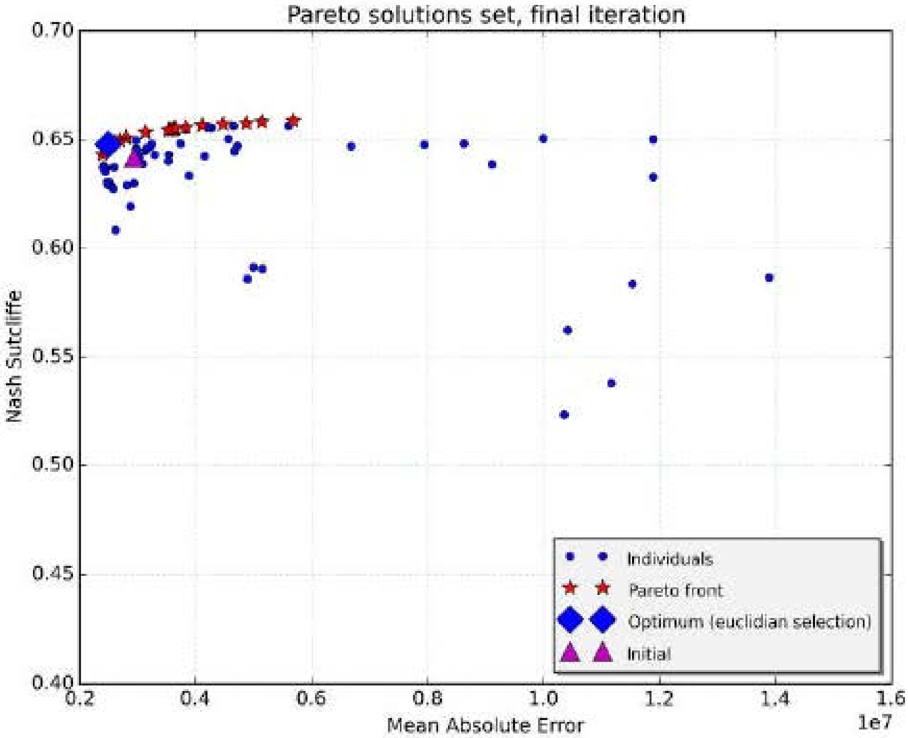


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

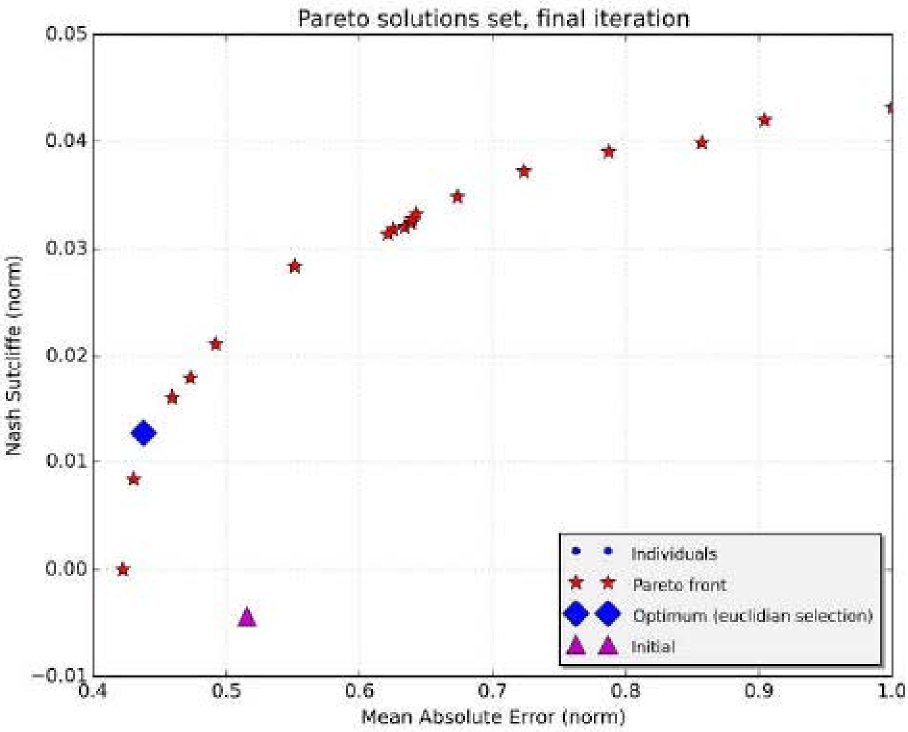


Figure 4: Final population of solutions (Pareto front)

9.5.4.4.1 Initial

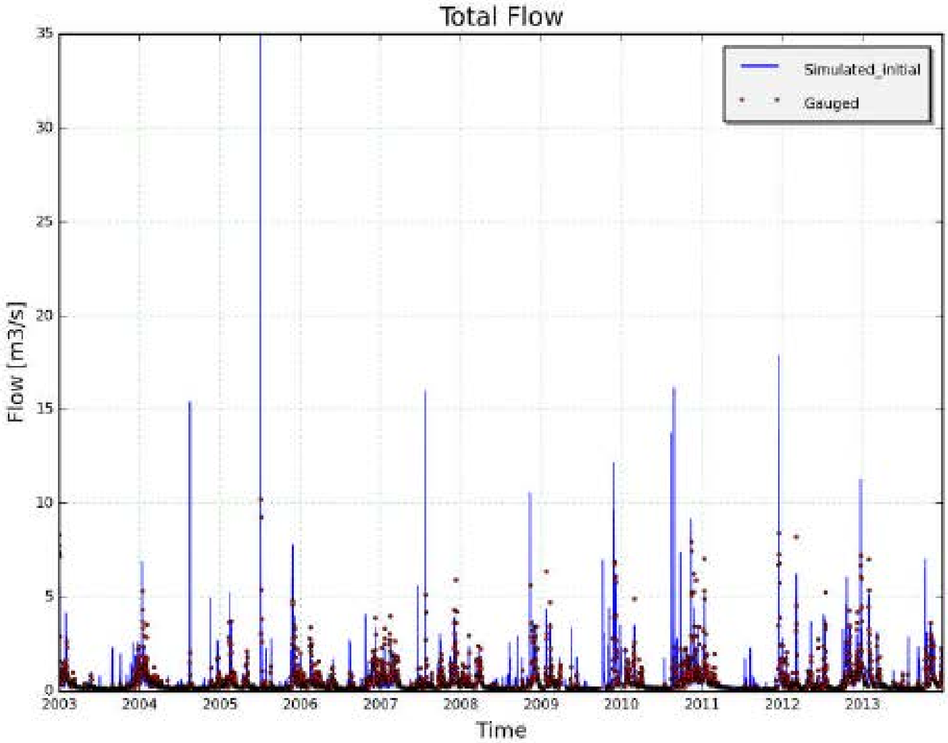


Figure 5: Total flow with initial parameters

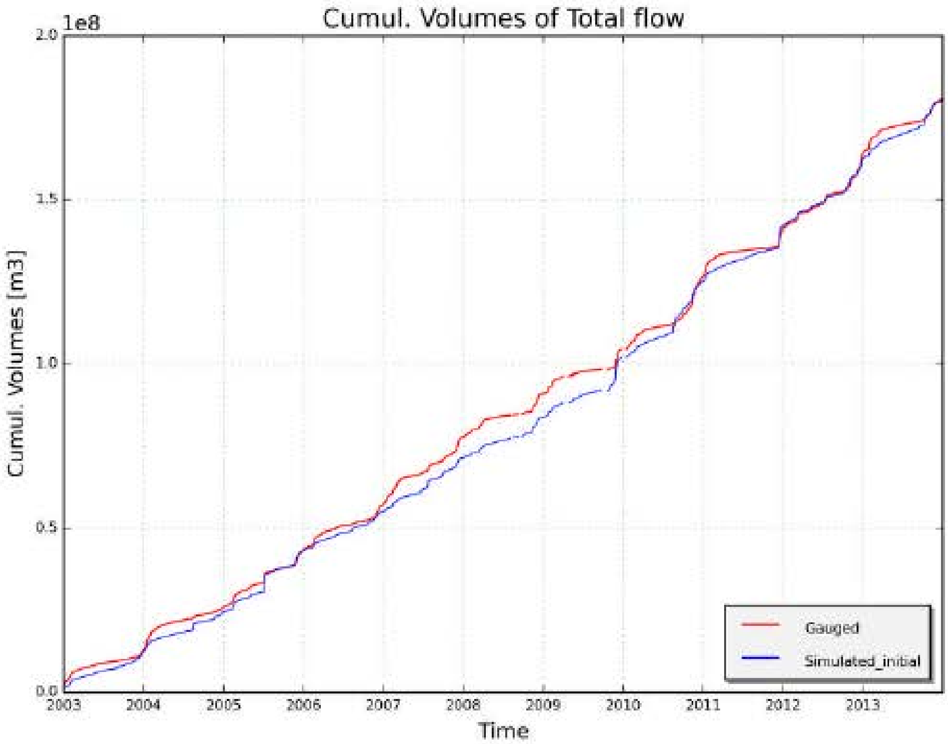


Figure 6: Cumulated flow with initial parameters

9.5.4.4.2 Optimum (euclidian)

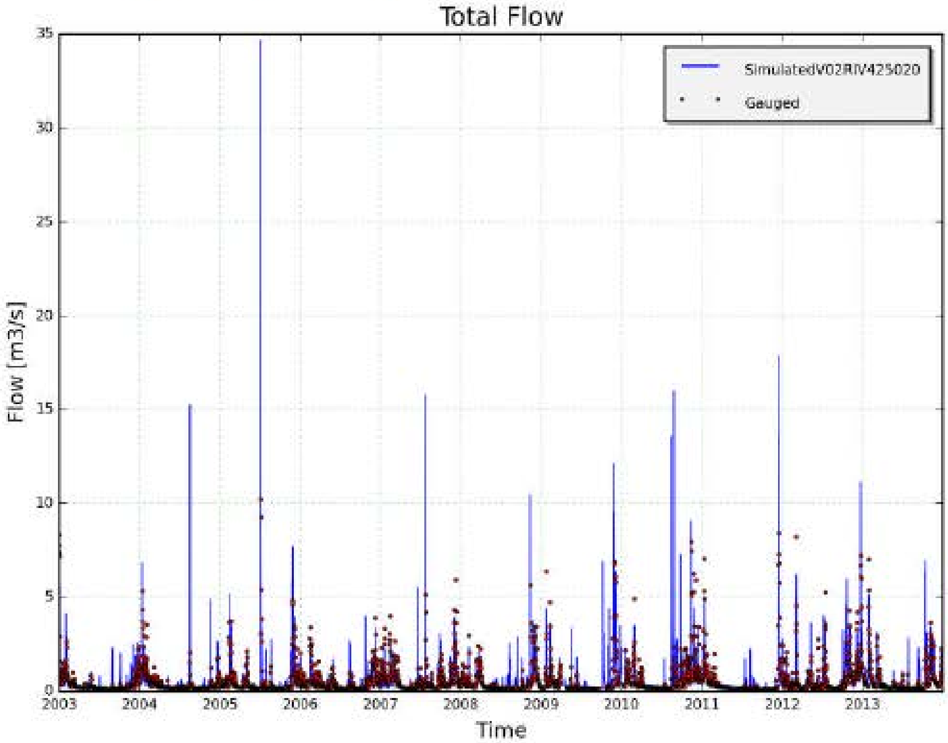


Figure 7: Total flow with optimum parameters

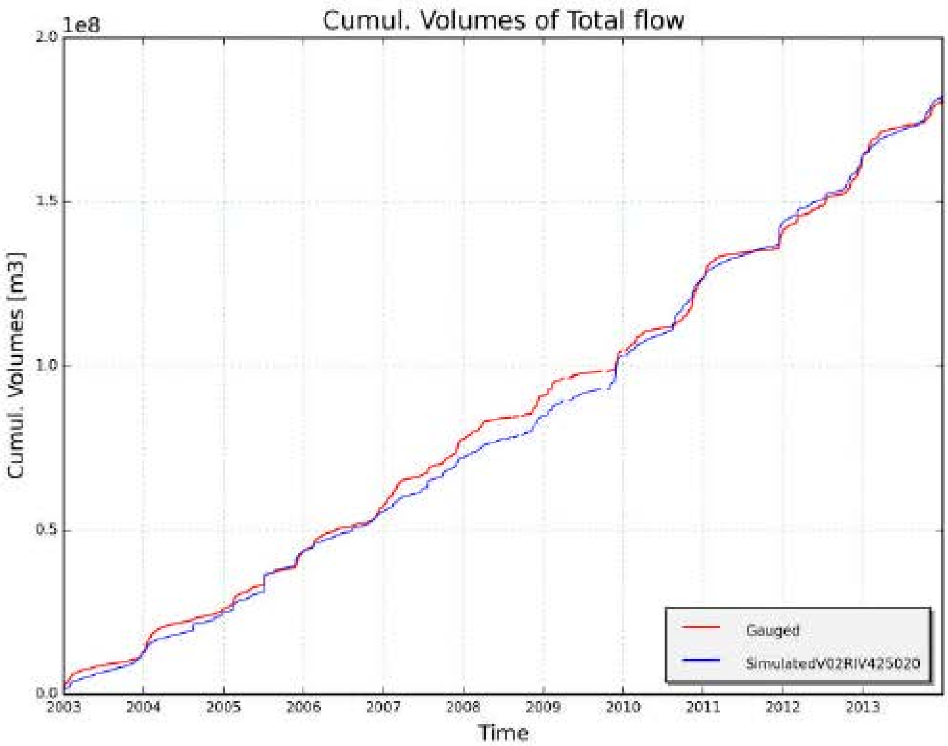


Figure 8: Cumulated flow with optimum parameters

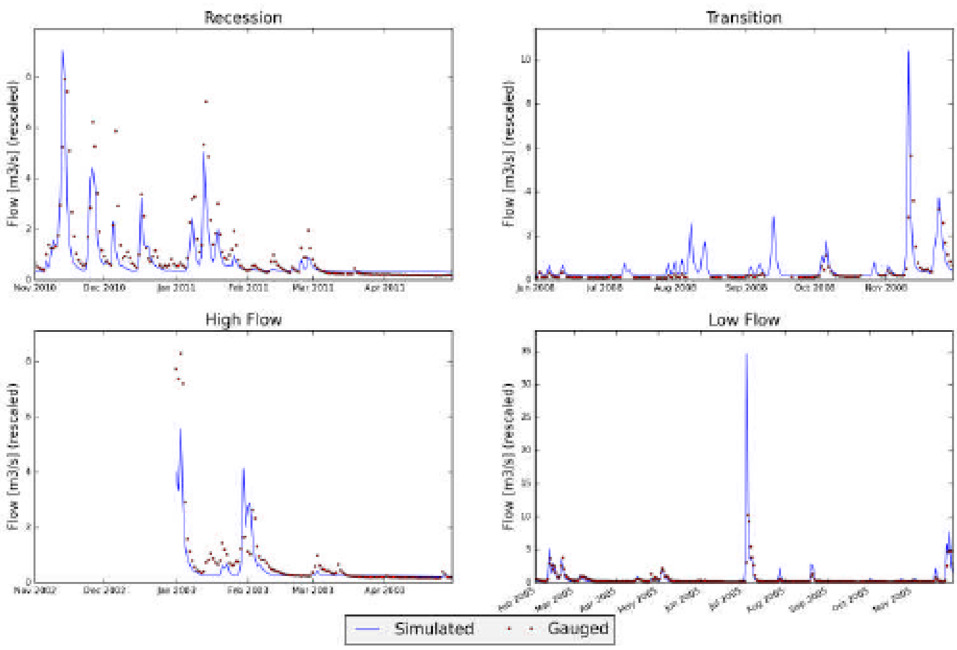
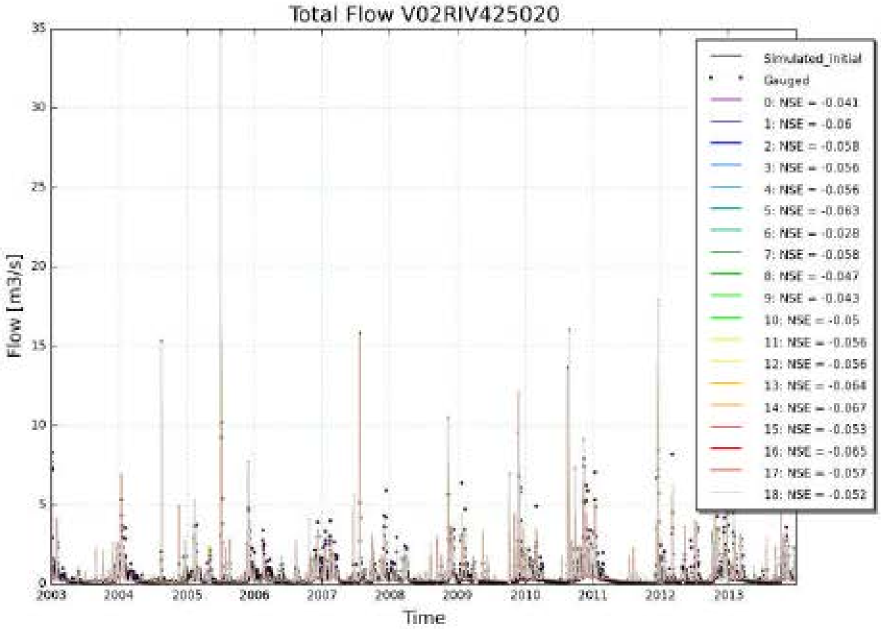
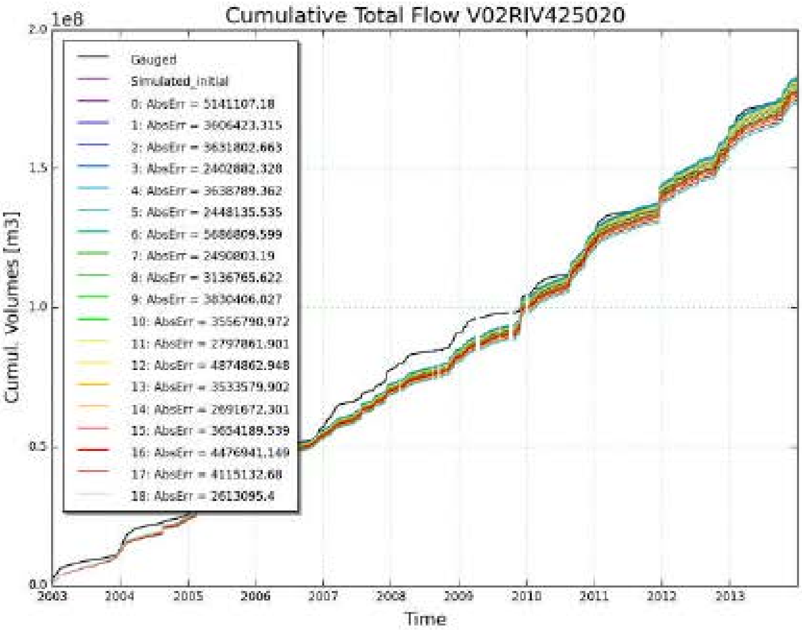


Figure 9: Total flow with optimum parameters (detail)

9.5.4.4.3 Final archive

0 : [1.543, 245.623, 0.001, 0.8, 190.756, 811.589, 3.715, 465.827] : [5141107.18, 0.658]
1 : [1.539, 249.28, 0.001, 0.89, 191.838, 807.678, 3.768, 472.245] : [3606423.315, 0.655]
2 : [1.539, 248.788, 0.001, 0.89, 191.494, 807.678, 3.768, 472.245] : [3631802.663, 0.655]
3 : [1.504, 245.463, 0.001, 1.006, 191.801, 835.055, 4.201, 466.895] : [2402882.328, 0.643]
4 : [1.539, 248.387, 0.001, 0.89, 192.791, 807.678, 3.768, 472.245] : [3638789.362, 0.655]
5 : [1.499, 247.033, 0.001, 0.881, 194.724, 822.077, 3.839, 467.359] : [2448135.535, 0.646]
6 : [1.583, 245.382, 0.001, 0.887, 195.176, 834.214, 3.683, 462.389] : [5686809.599, 0.659]
7 : [1.5, 245.281, 0.001, 1.124, 191.273, 812.061, 4.865, 468.709] : [2490803.19, 0.648]
8 : [1.524, 245.8, 0.001, 0.866, 202.642, 806.947, 3.6, 475.817] : [3136765.622, 0.653]
9 : [1.542, 246.081, 0.001, 1.35, 191.113, 810.55, 3.74, 470.196] : [3830406.027, 0.656]
10 : [1.538, 246.76, 0.001, 0.917, 191.809, 813.121, 4.224, 466.481] : [3556790.972, 0.655]
11 : [1.515, 245.915, 0.001, 1.35, 191.638, 809.427, 4.713, 471.74] : [2797861.901, 0.651]
12 : [1.559, 249.21, 0.001, 0.89, 191.505, 813.556, 3.943, 465.928] : [4874862.948, 0.657]
13 : [1.539, 249.28, 0.001, 0.89, 193.231, 808.527, 4.572, 471.913] : [3533579.902, 0.654]
14 : [1.509, 248.584, 0.001, 0.8, 191.517, 810.436, 3.762, 469.979] : [2691672.301, 0.65]
15 : [1.538, 247.213, 0.001, 0.915, 190.783, 808.858, 4.239, 470.99] : [3654189.539, 0.655]
16 : [1.537, 249.408, 0.001, 1.35, 192.22, 806.769, 4.179, 476.679] : [4476941.149, 0.657]
17 : [1.535, 247.726, 0.001, 0.8, 192.179, 805.254, 4.409, 481.147] : [4115132.68, 0.656]
18 : [1.507, 244.992, 0.001, 0.944, 191.477, 811.98, 4.097, 470.254] : [2613095.4, 0.649]


Total Flow V02RIV425020
Flow [m3/s]
Time
Simulated_initial
Gauged
0: NSE = -0.041
1: NSE = -0.06
2: NSE = -0.058
3: NSE = -0.056
4: NSE = -0.056
5: NSE = -0.063
6: NSE = -0.028
7: NSE = -0.058
8: NSE = -0.047
9: NSE = -0.043
10: NSE = -0.05
11: NSE = -0.056
12: NSE = -0.056
13: NSE = -0.064
14: NSE = -0.067
15: NSE = -0.053
16: NSE = -0.065
17: NSE = -0.057
18: NSE = -0.052


Cumulative Total Flow V02RIV425020
1e8
Cumul. Volumes [m3]
Time
Gauged
Simulated_initial
0: AbsErr = 5141107.18
1: AbsErr = 3606423.315
2: AbsErr = 3631802.663
3: AbsErr = 2402882.328
4: AbsErr = 3638789.362
5: AbsErr = 2448135.535
6: AbsErr = 5686809.599
7: AbsErr = 2490803.19
8: AbsErr = 3136765.622
9: AbsErr = 3830406.027
10: AbsErr = 3556790.972
11: AbsErr = 2797861.901
12: AbsErr = 4874862.948
13: AbsErr = 3533579.902
14: AbsErr = 2691672.301
15: AbsErr = 3654189.539
16: AbsErr = 4476941.149
17: AbsErr = 4115132.68
18: AbsErr = 2613095.4

Appendix 6 Gentse Kanalen Calibration and Validation

9.5.1 Calibration and validation of WET parameters for catchment "V03POE446000" (Gentse Kanalen)

9.5.1.1 Input data

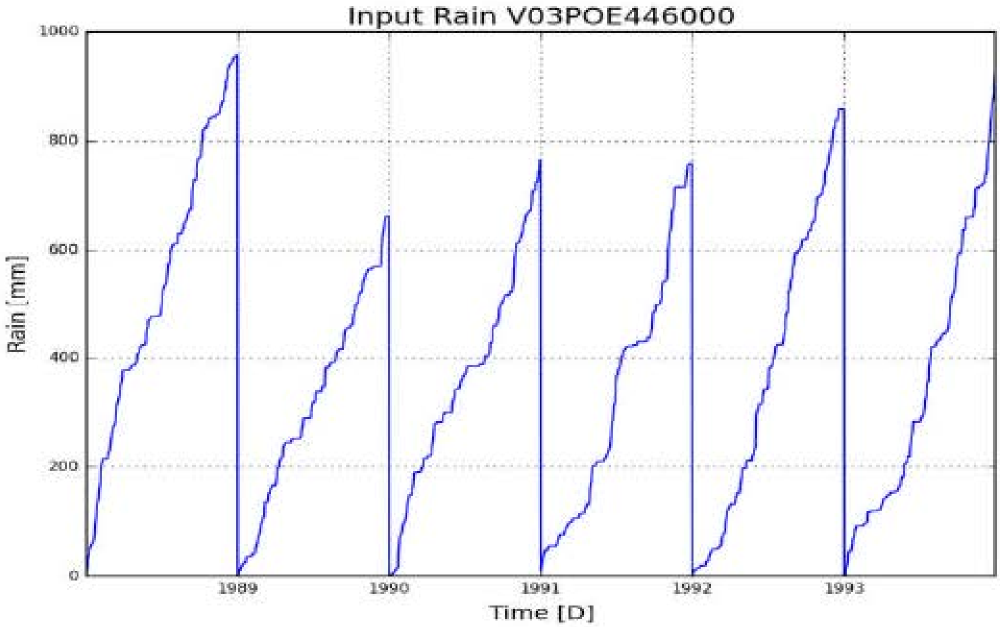


Figure 1: Cumulative precipitation on catchment V03POE446000 (Gentse Kanalen)

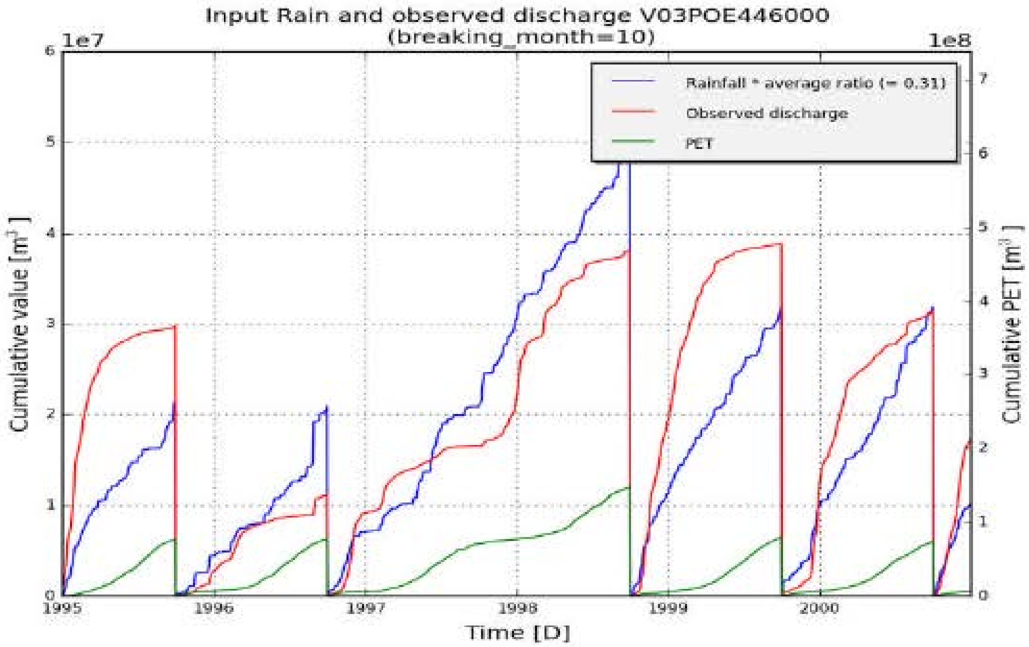


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V03POE446000 (Gentse Kanalen)

9.5.1.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V03POE446000
subcatchment_area [m2]	106800000
Validation start_date	01-01-1989
Validation end_date	31-12-1993
frequency	daily

Optimal parameter set:[('Kep', 2.4), ('Ki', 293.92), ('Kg', 0.01), ('Kss', 7.32), ('g0', 154.85), ('g_max', 390.9), ('K_run', 2.6), ('P_max', 79.62)]

Table 1: Goodness of fit for calibration period (1995 - 2000)

	Full year	Summer	Winter
RelErr	-1.2 %	63.3 %	-13.7 %
NS	0.503	-7.075	0.745
NS_log	0.774	0.598	0.545

	Full year	Summer	Winter
NS_rel	-1.326	0.208	-3.437
KGE	0.743	-1.437	0.625

Table 2 :Goodness of fit for validation period (1989 - 1993)

	Full year	Summer	Winter
RelErr	-1.7 %	-25.6 %	-8.4 %
NS	0.685	0.569	0.668
NS_log	0.781	0.613	0.61
NS_rel	0.764	0.882	0.61
KGE	0.69	0.618	0.58

9.5.1.3 Observed and simulated timeseries for optimum parameters

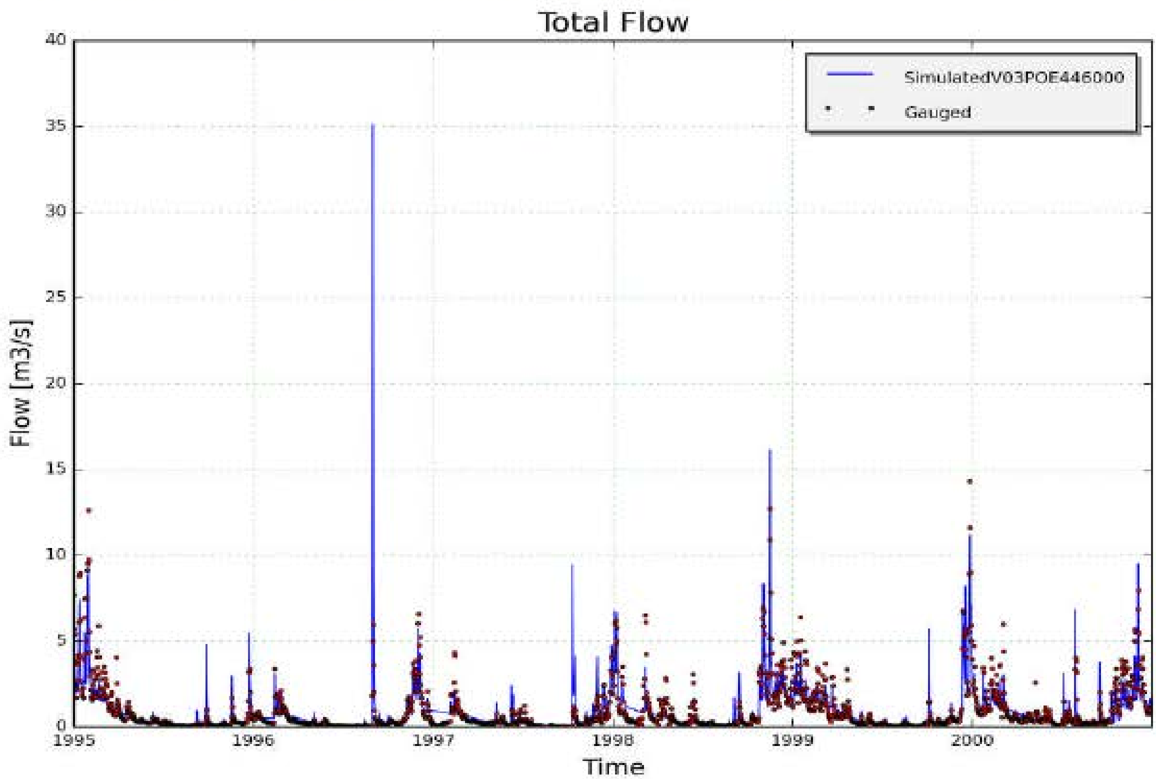


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele(calibration period)

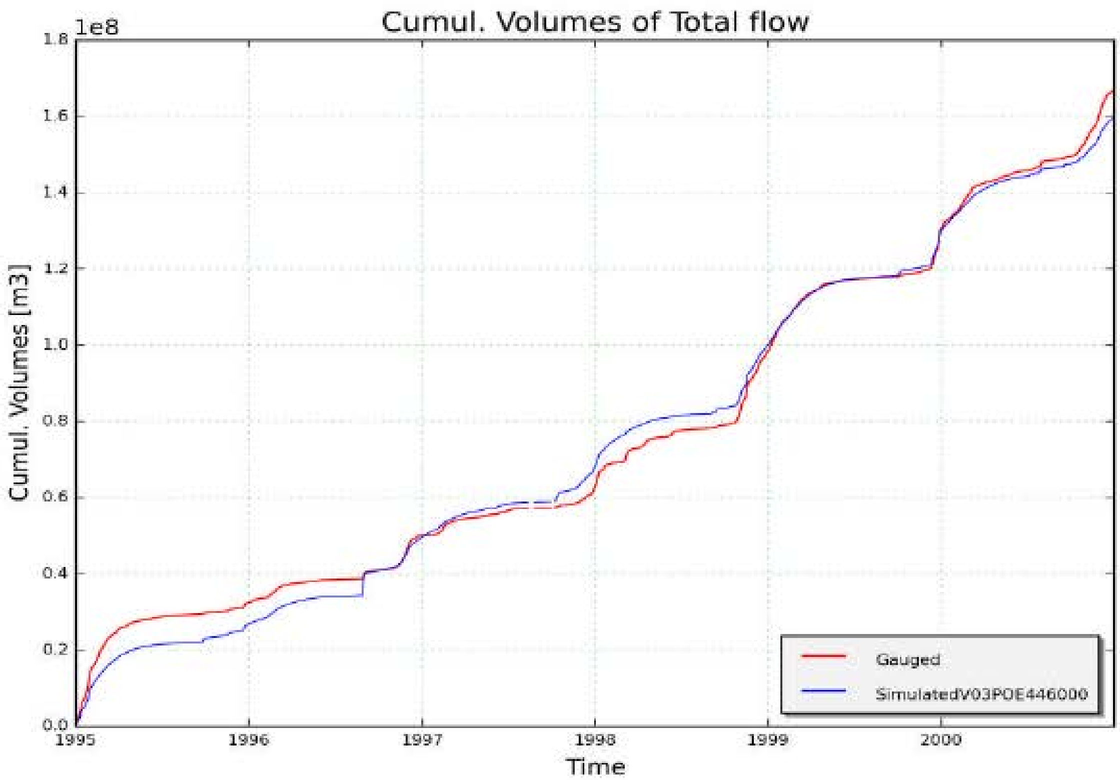


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele (calibration period)

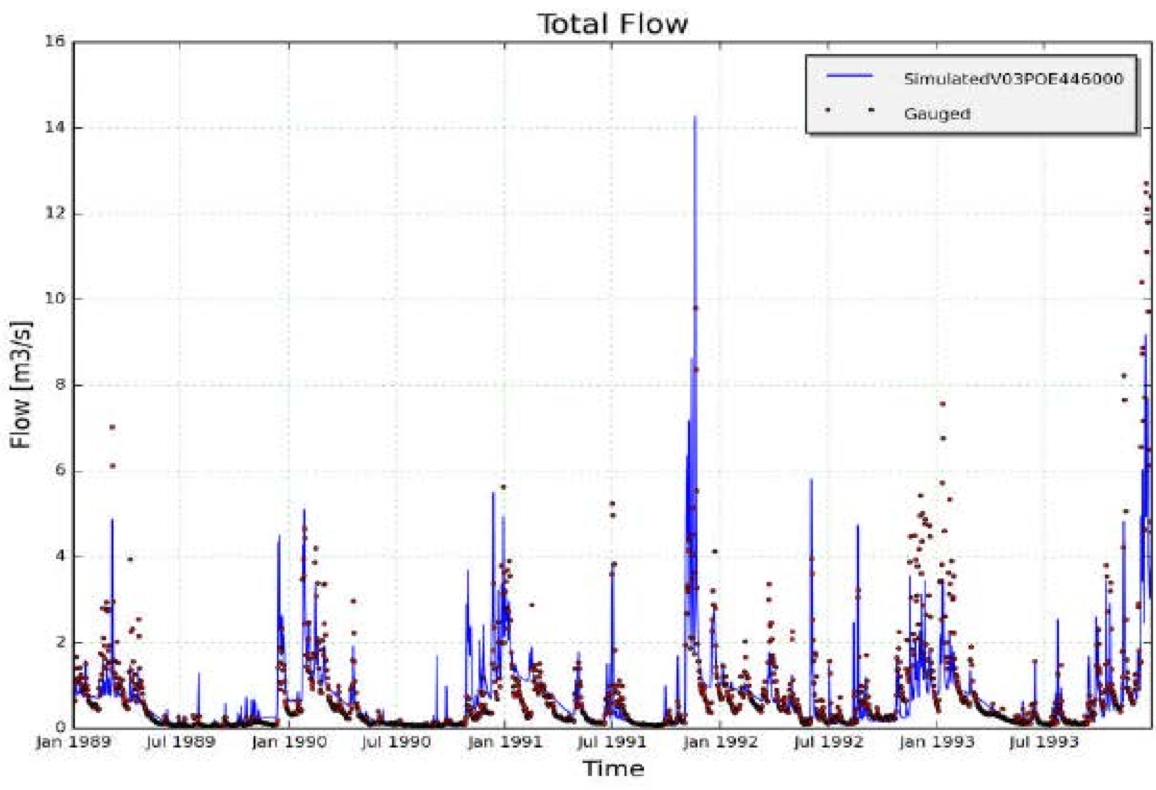


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele (validation period)

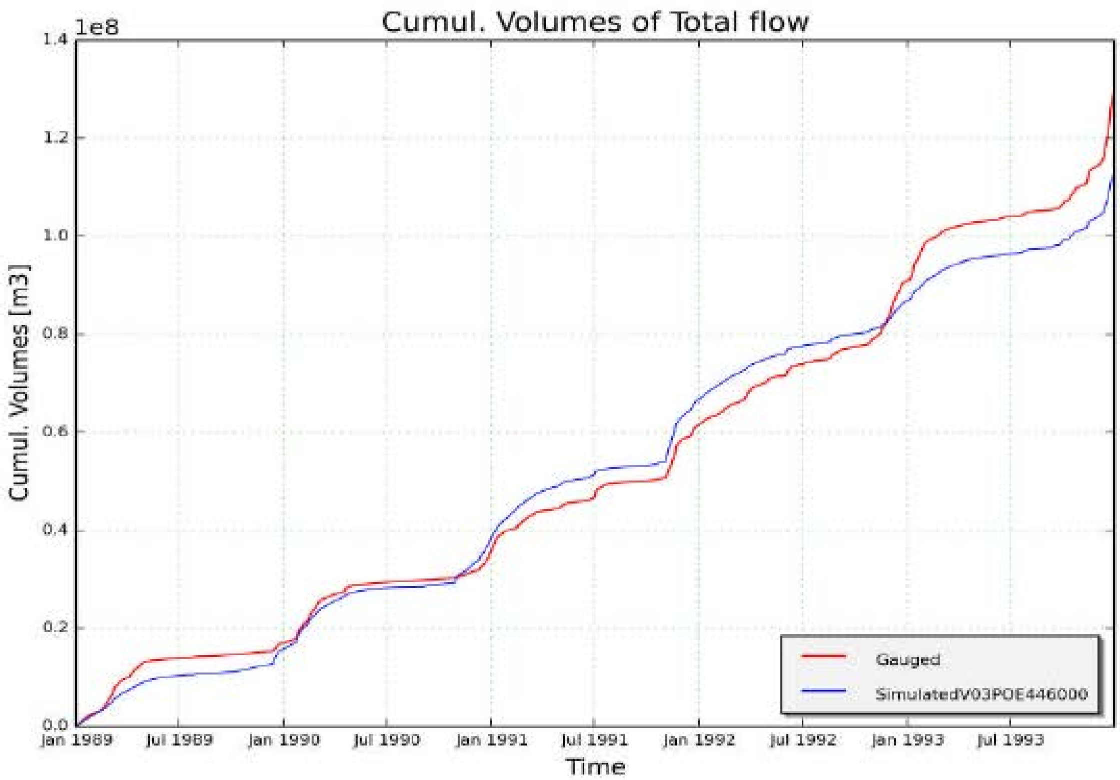


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele (validation period)

Appendix 7 Gentse Kanalen Autocalibration.

9.5.1 Report on simulation of catchment V03POE446000 (2017-01-20 22-08)

9.5.1.1 Input data

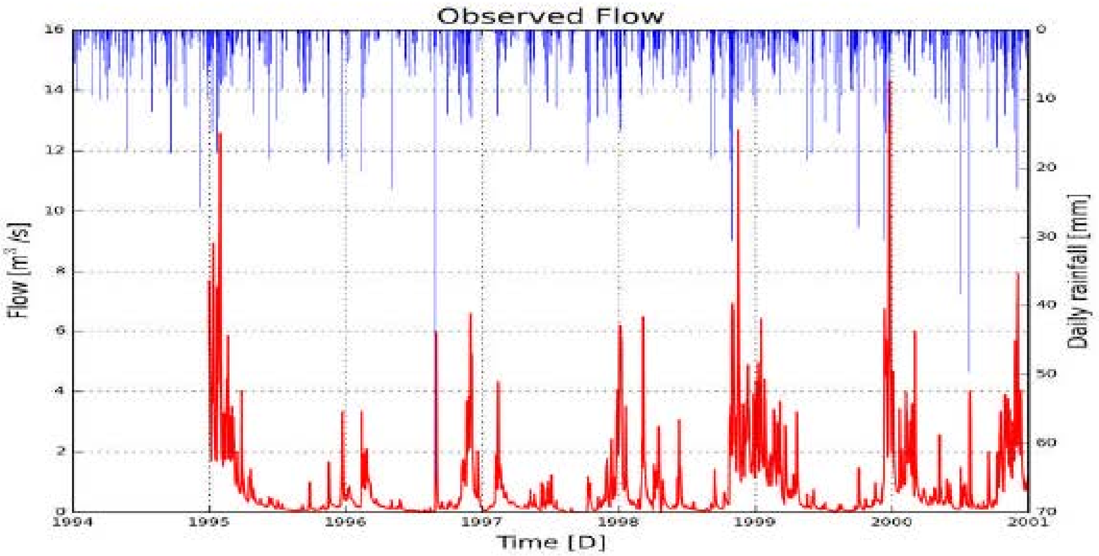


Figure 1: Hyetogram of observed discharge and observed net rain

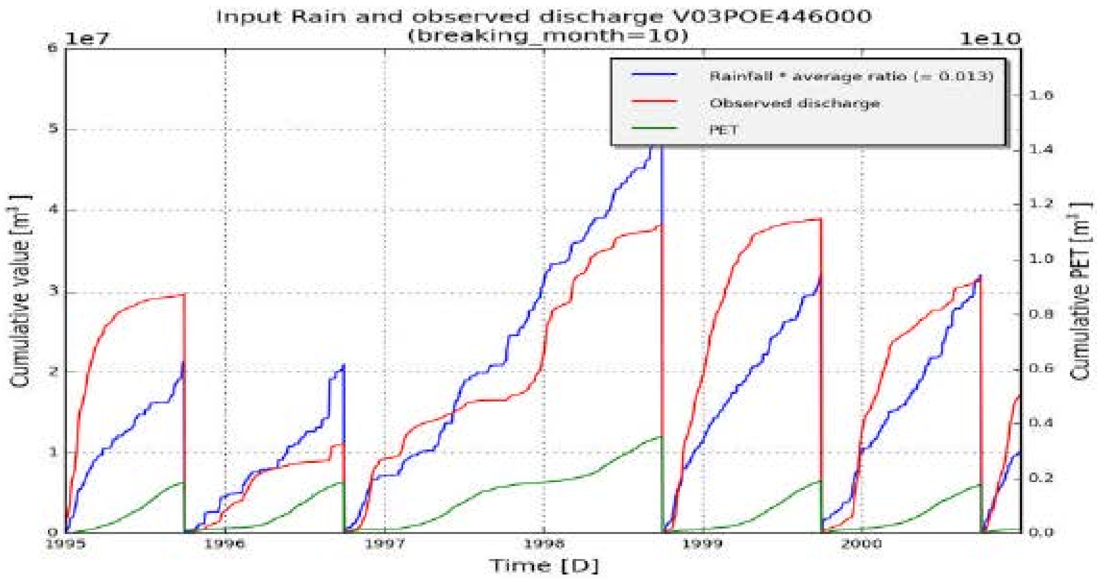


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.1.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V03POE446000
subcatchment_area	106800000
start_date	199501010000
end_date	200012310000
frequency	86400
warmup	365

9.5.1.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[2.109, 340.09, 0.018, 6.229, 144.074, 326.69, 2.211, 86.145]
low_bounds	[1.6, 272.1, 0.0144, 4.98, 115.25, 261.3, 1.76, 68.9]
high_bounds	[2.4, 408.0, 0.02, 7.47, 172.8, 392.0, 2.6, 103.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 2.109), ('Ki', 340.09), ('Kg', 0.018), ('Kss', 6.229), ('g0', 144.074), ('g_max', 326.69), ('K_run', 2.211), ('P_max', 86.145)]
Initial fitness:

- RelErr: 0.113
- AbsErr: 10244378.255
- KGE: 0.727
- NS_rel: -2.126
- NS: 0.457

- RMSE: 11724881.739
- NS_log: 0.745

Computation time:5:55:11.924000

9.5.1.4 Results

Best individual (euclidian): [('Kep', 2.398), ('Ki', 293.921), ('Kg', 0.014), ('Kss', 7.326), ('g0', 154.85), ('g_max', 390.906), ('K_run', 2.6), ('P_max', 79.623)]

Fitness:

- RelErr: -0.012
- AbsErr: 3142891.513
- KGE: 0.743
- NS_rel: -1.326
- NS: 0.503
- RMSE: 3960617.486
- NS_log: 0.774

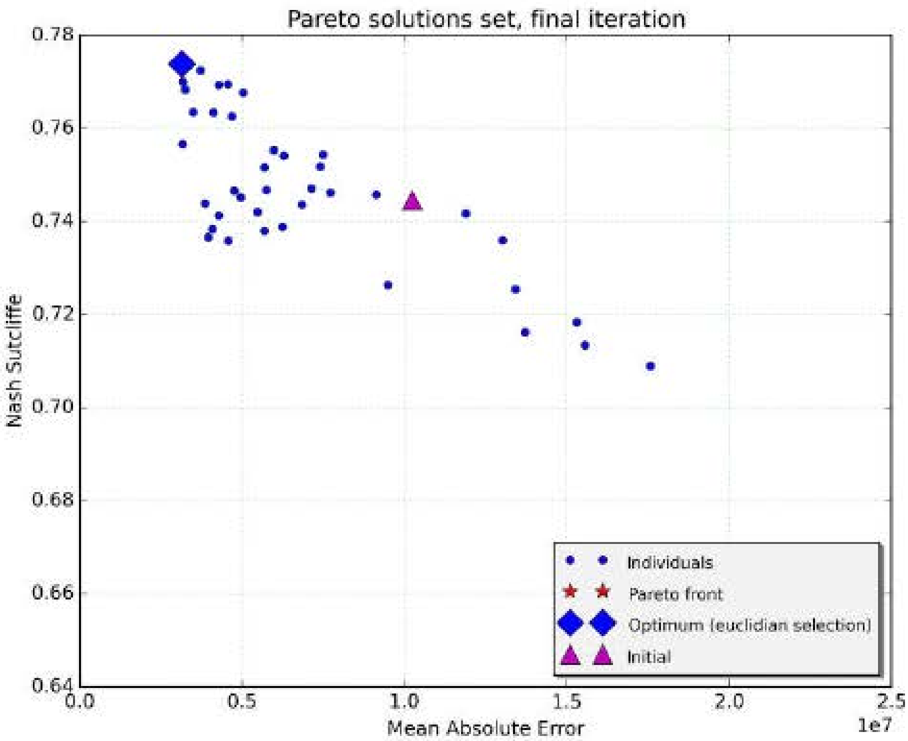


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

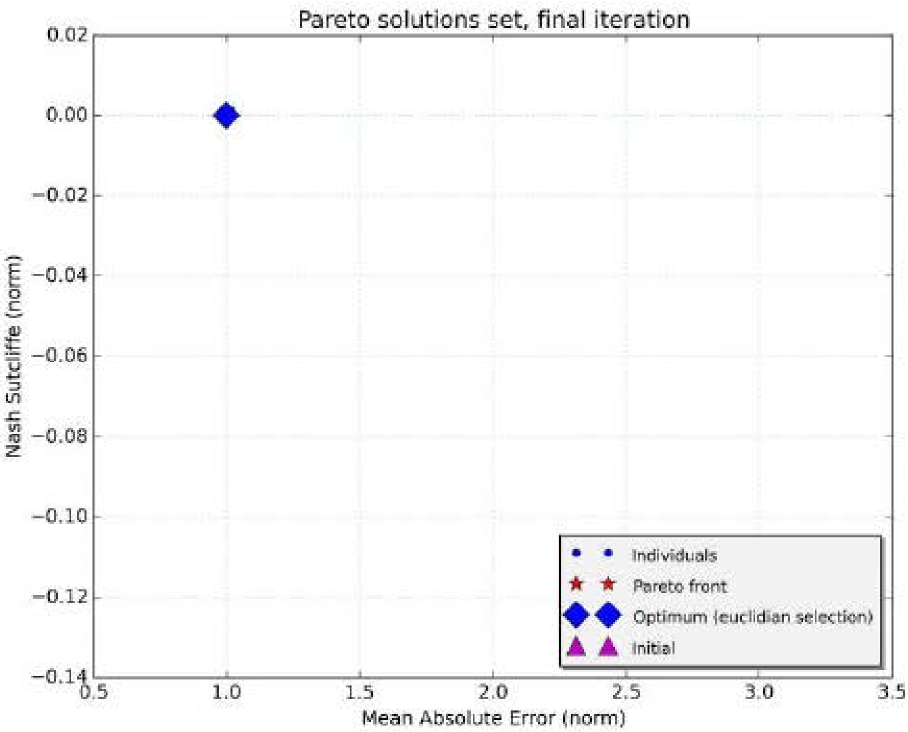


Figure 4: Final population of solutions (Pareto front)

9.5.1.4.1 Initial

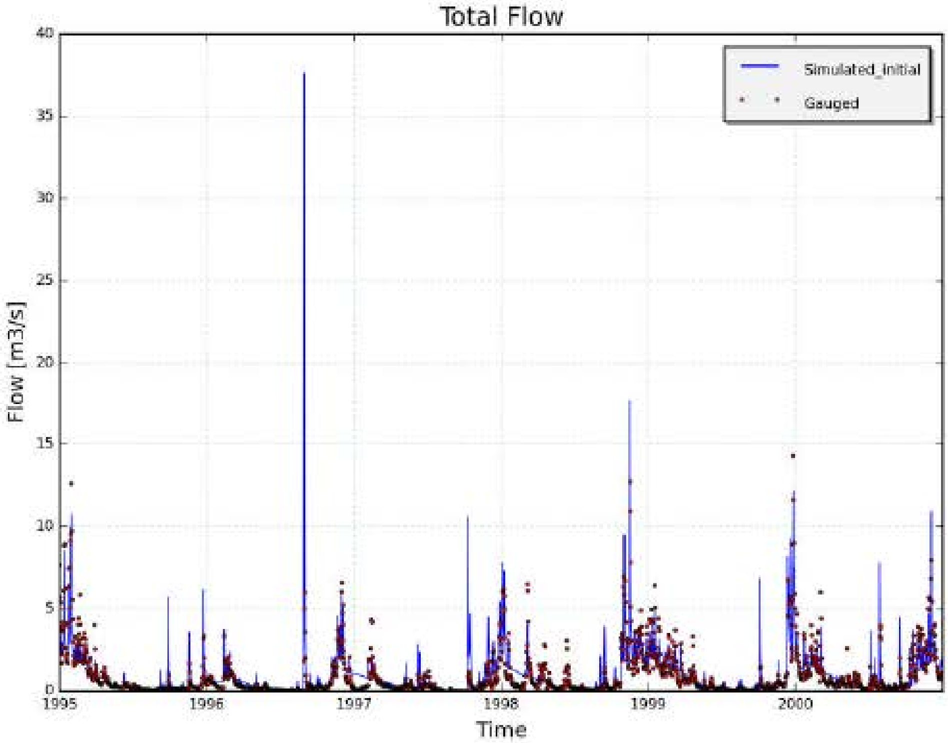


Figure 5: Total flow with initial parameters

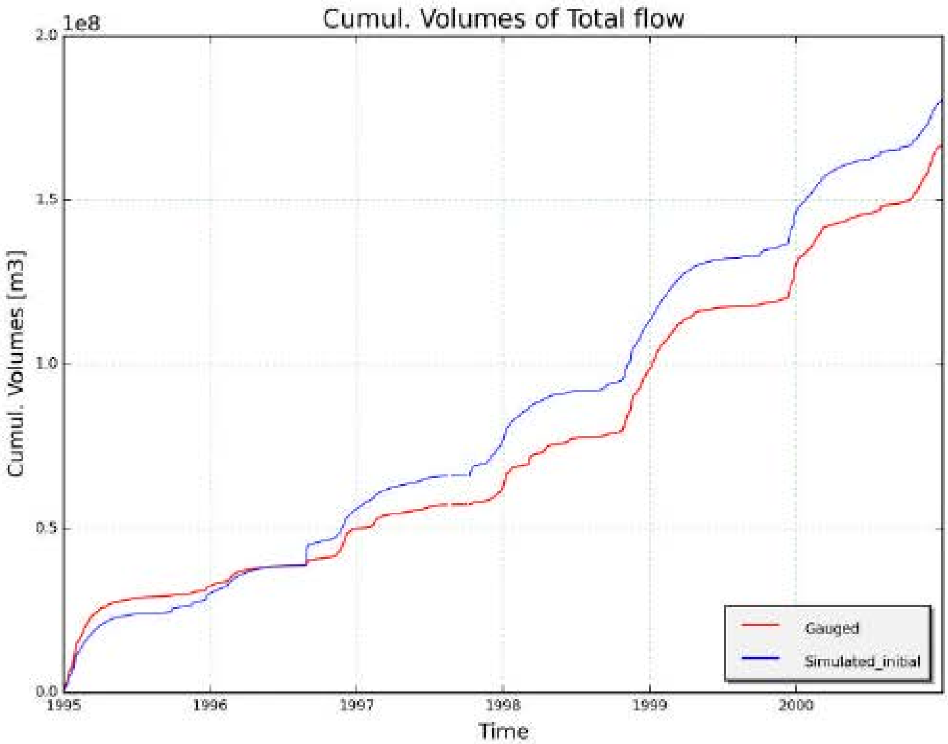


Figure 6: Cumulated flow with initial parameters

9.5.1.4.2 Optimum (euclidian)

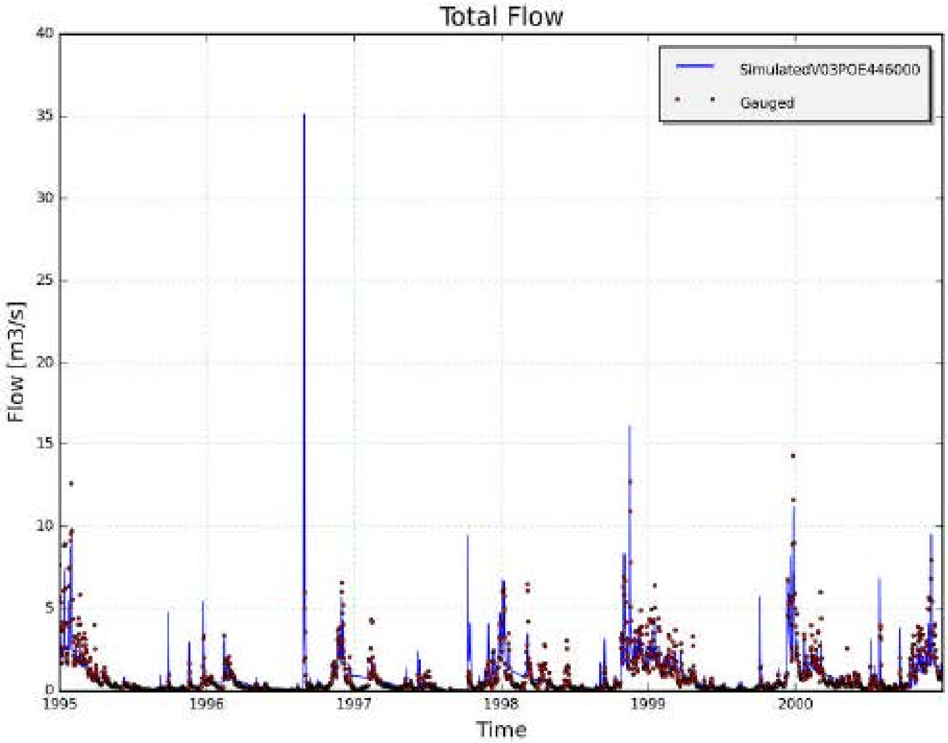


Figure 7: Total flow with optimum parameters

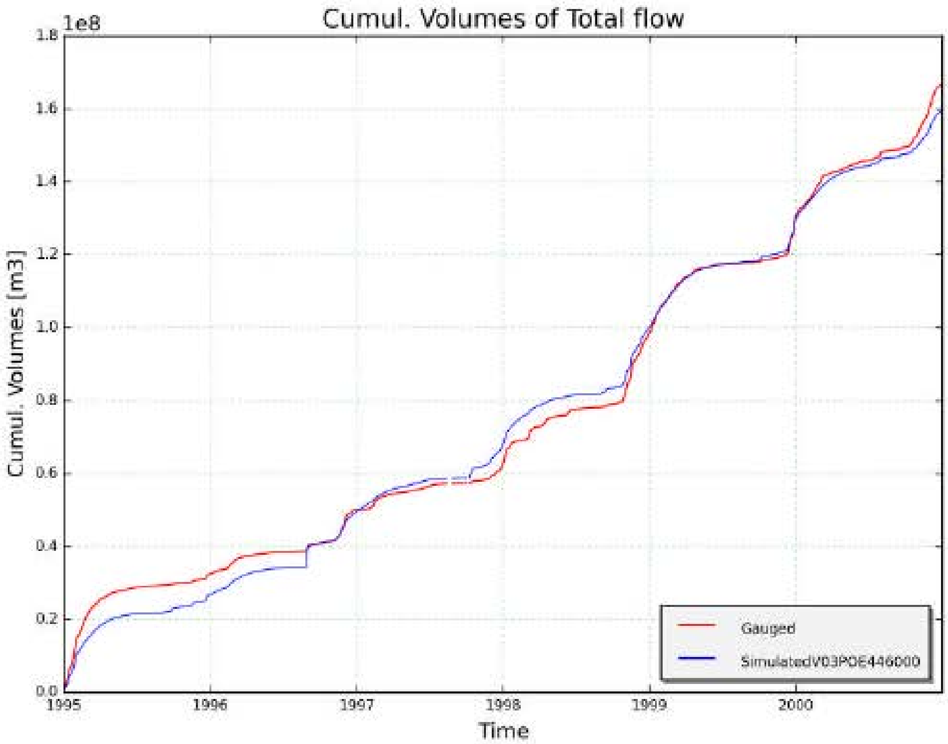
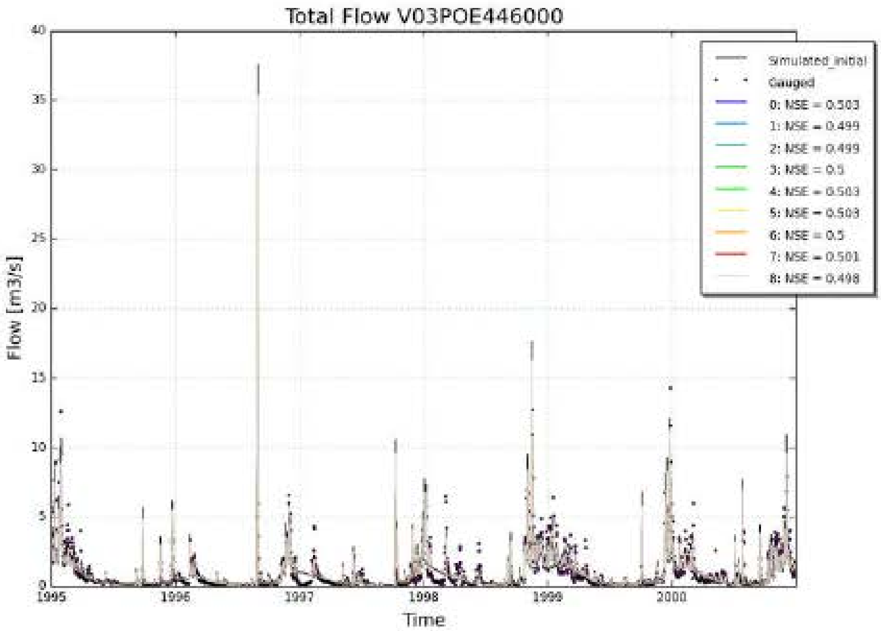
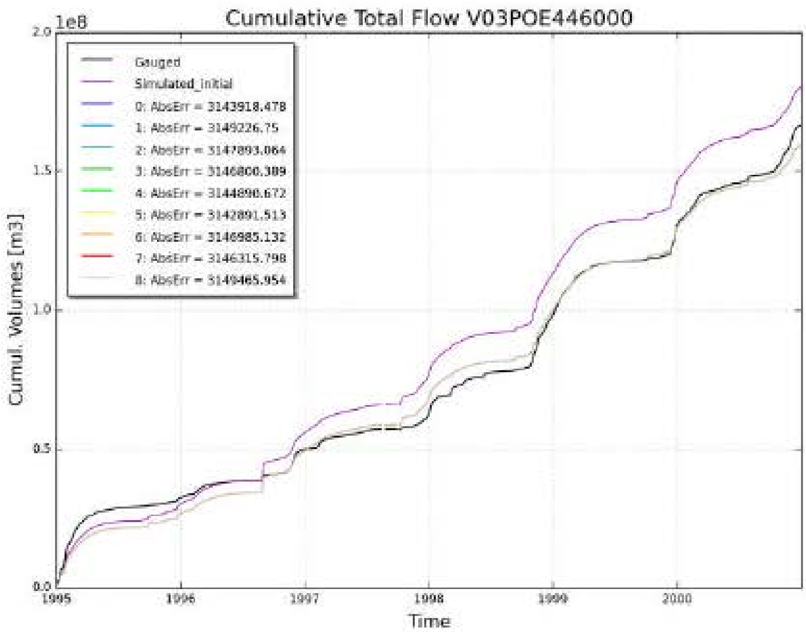


Figure 8: Cumulated flow with optimum parameters

9.5.1.4.3 Final archive

0 : [2.4, 293.648, 0.014, 6.133, 157.0, 390.92, 2.6, 79.454] : [3143918.478, 0.774]
1 : [2.4, 299.118, 0.014, 6.95, 139.984, 391.433, 2.576, 79.375] : [3149226.75, 0.774]
2 : [2.4, 297.442, 0.014, 7.15, 140.314, 391.604, 2.6, 77.954] : [3147893.064, 0.774]
3 : [2.4, 296.848, 0.014, 6.708, 157.777, 391.382, 2.6, 79.08] : [3146800.389, 0.774]
4 : [2.4, 294.543, 0.014, 6.209, 157.1, 392.0, 2.6, 79.176] : [3144890.672, 0.774]
5 : [2.398, 293.921, 0.014, 7.326, 154.85, 390.906, 2.6, 79.623] : [3142891.513, 0.774]
6 : [2.4, 297.029, 0.014, 6.868, 139.732, 391.122, 2.6, 79.178] : [3146985.132, 0.774]
7 : [2.4, 295.618, 0.014, 6.804, 155.947, 392.0, 2.6, 77.601] : [3146315.798, 0.774]
8 : [2.4, 299.462, 0.014, 5.484, 145.043, 391.678, 2.583, 78.823] : [3149465.954, 0.774]





Appendix 8 Benendenschelde Calibration and Validation.

9.5.1 Calibration and validation of WET parameters for catchment "V04MOL036110" (Benedenschelde)

9.5.1.1 Input data

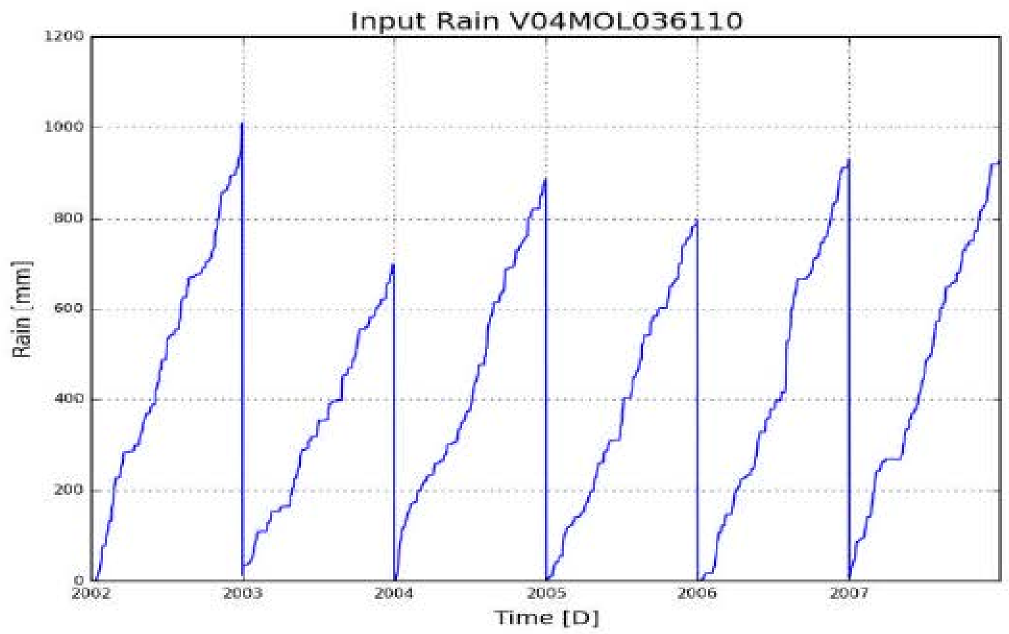


Figure 1: Cumulative precipitation on catchment V04MOL036110 (Benedenschelde)

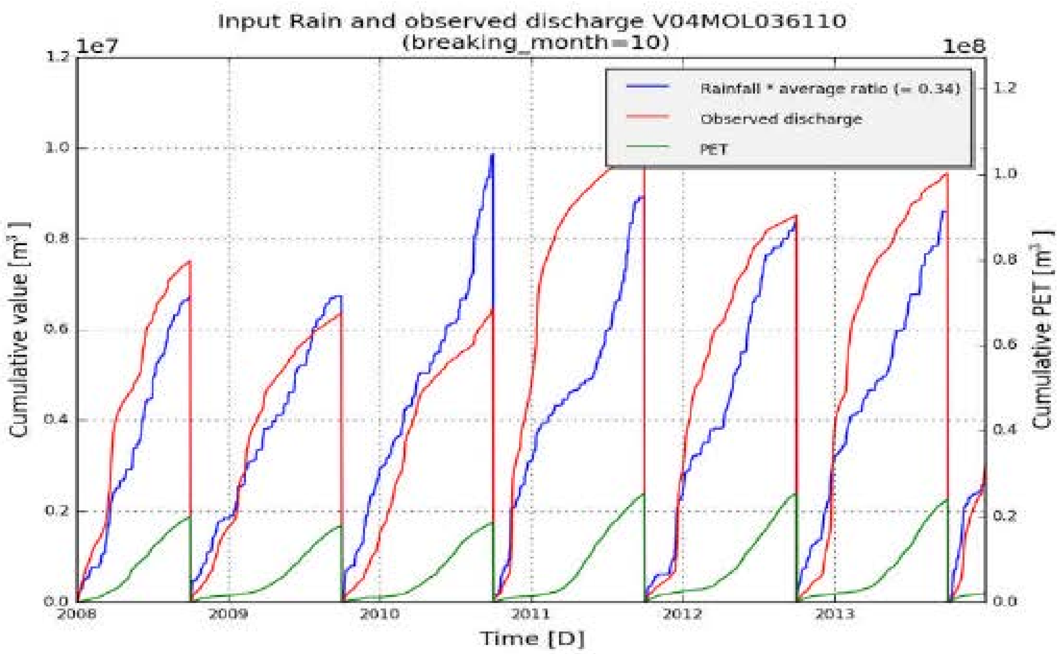


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V04MOL036110 (Benedenschelde)

9.5.1.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V04MOL036110
subcatchment_area [m2]	32600000
Validation start_date	01-01-2003
Validation end_date	31-12-2007
frequency	daily

Optimal parameter set:[('Kep', 1.56), ('Ki', 95.46), ('Kg', 0.0), ('Kss', 0.1), ('g0', 63.48), ('g_max', 281.54), ('K_run', 6.6), ('P_max', 9.9)]

Table 1: Goodness of fit for calibration period (2008 - 2013)

	Full year	**Summer**	**Winter**
RelErr	1.3 %	59.2 %	-23.5 %
NS	-0.03	-6.357	0.172
NS_log	0.344	-0.441	0.101
NS_rel	-0.703	-7.485	0.496
KGE	0.496	-1.232	0.394

Table 2 :Goodness of fit for validation period (2003 - 2007)

	Full year	**Summer**	**Winter**
RelErr	5.5 %	54.8 %	-15.5 %
NS	-0.353	-6.57	0.25
NS_log	0.063	-1.18	0.23
NS_rel	-1.37	-7.234	0.398
KGE	0.416	-1.2	0.619

9.5.1.3 Observed and simulated timeseries for optimum parameters

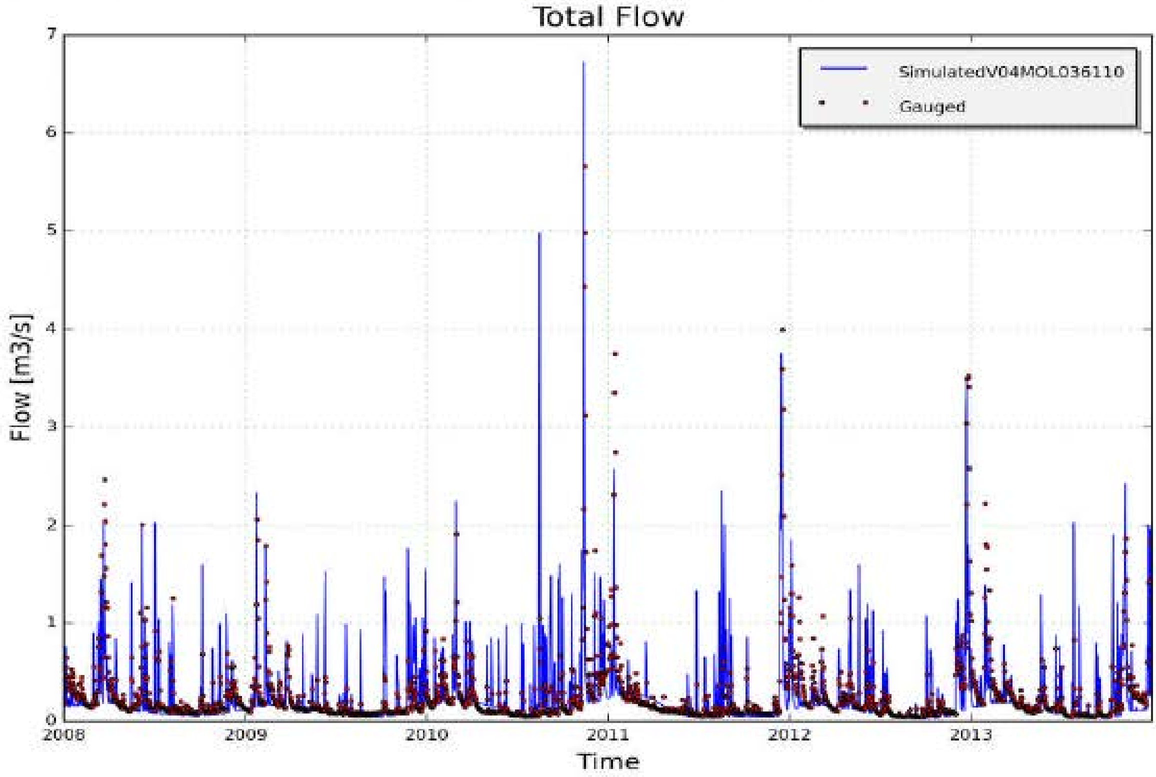


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele(calibration period)

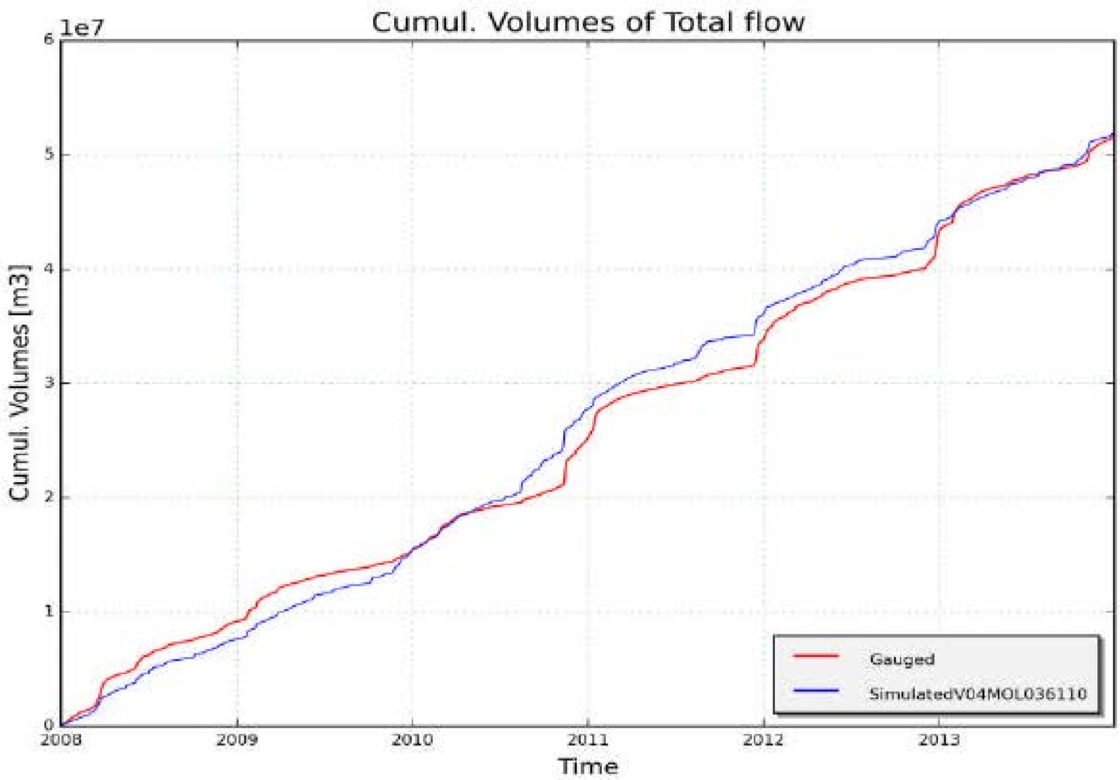


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele (calibration period)

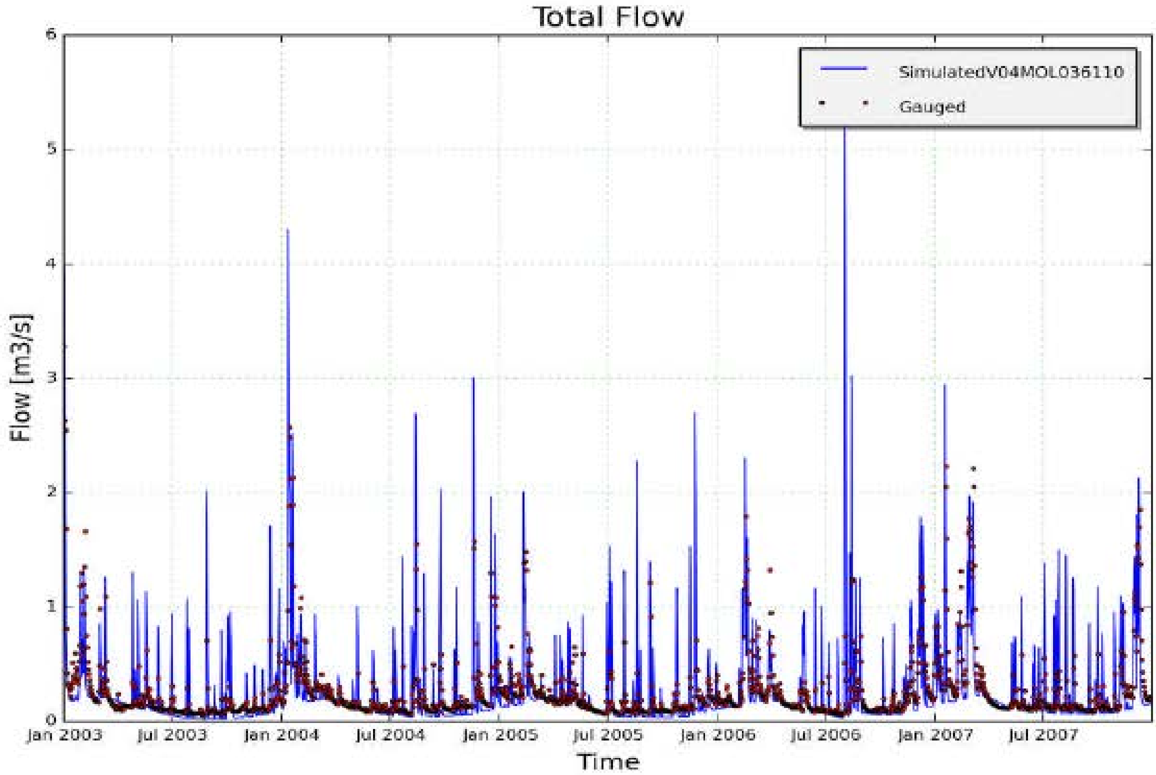


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele (validation period)

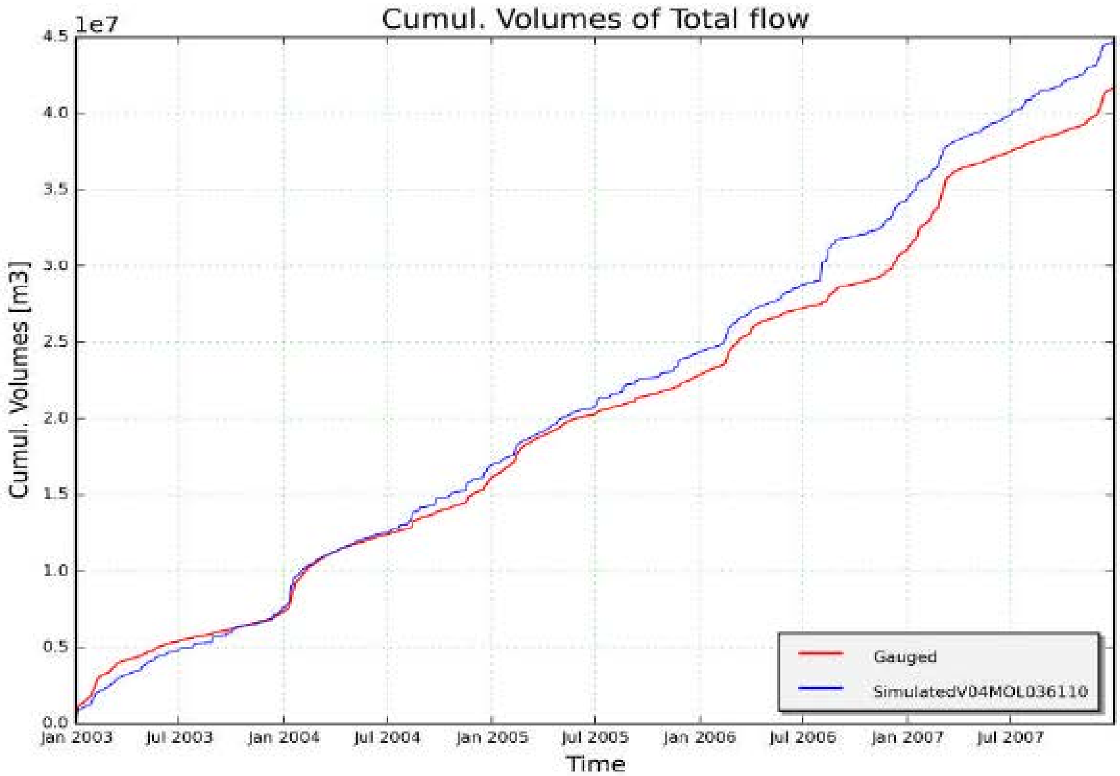


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele (validation period)

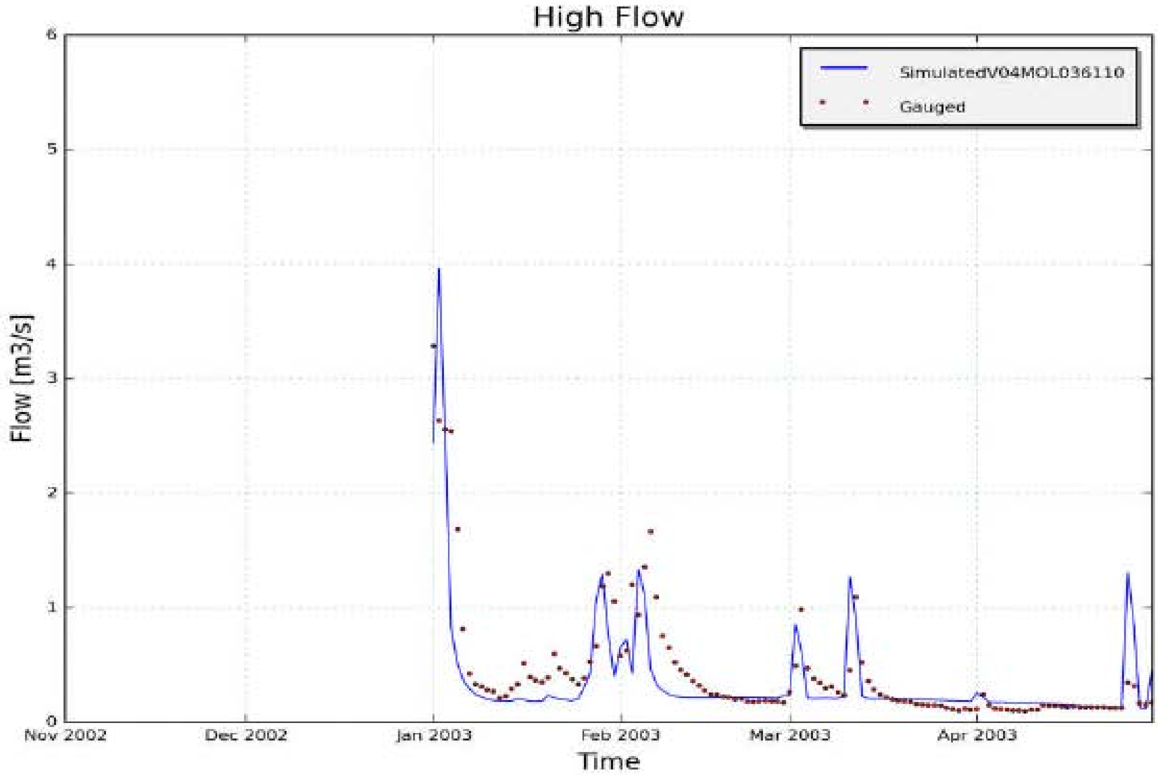


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele

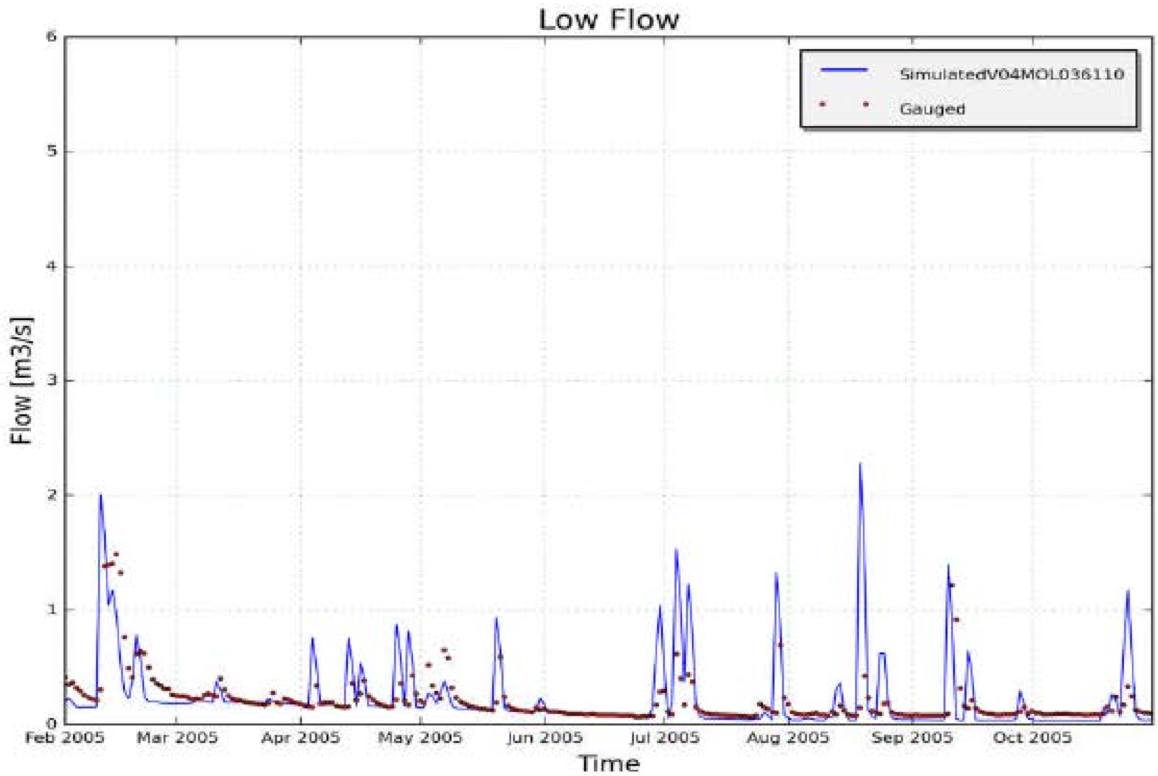


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele

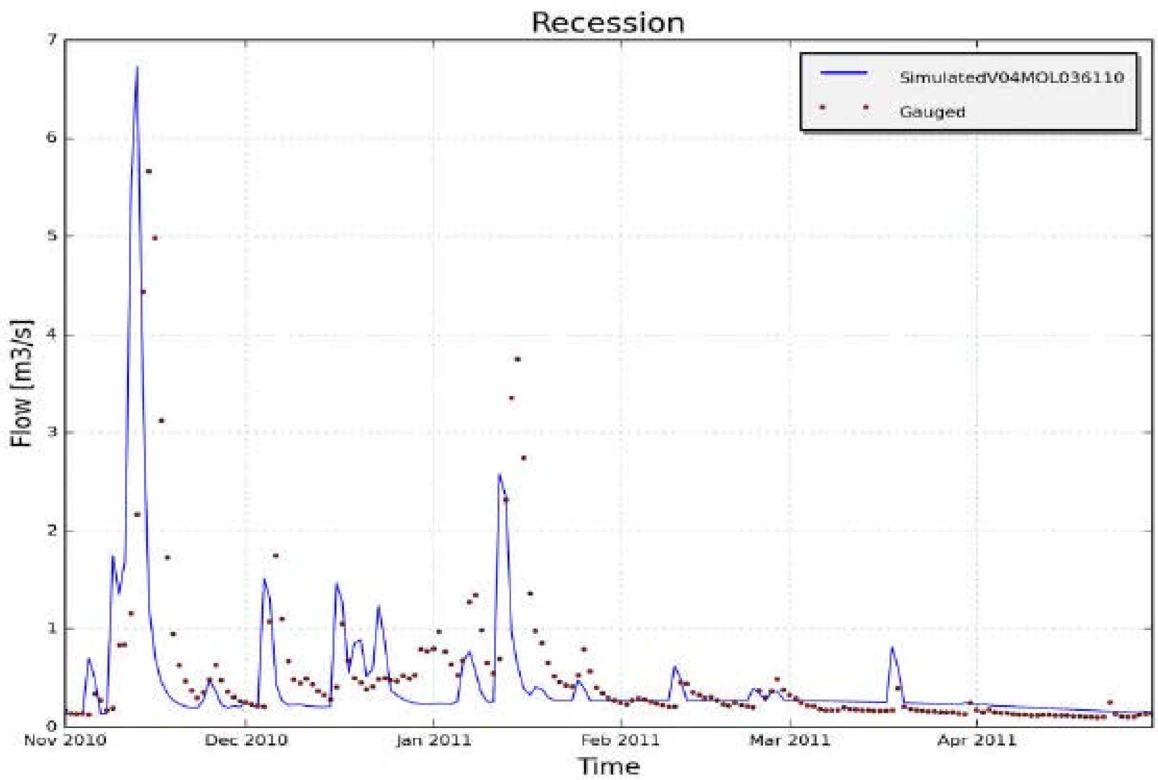


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele

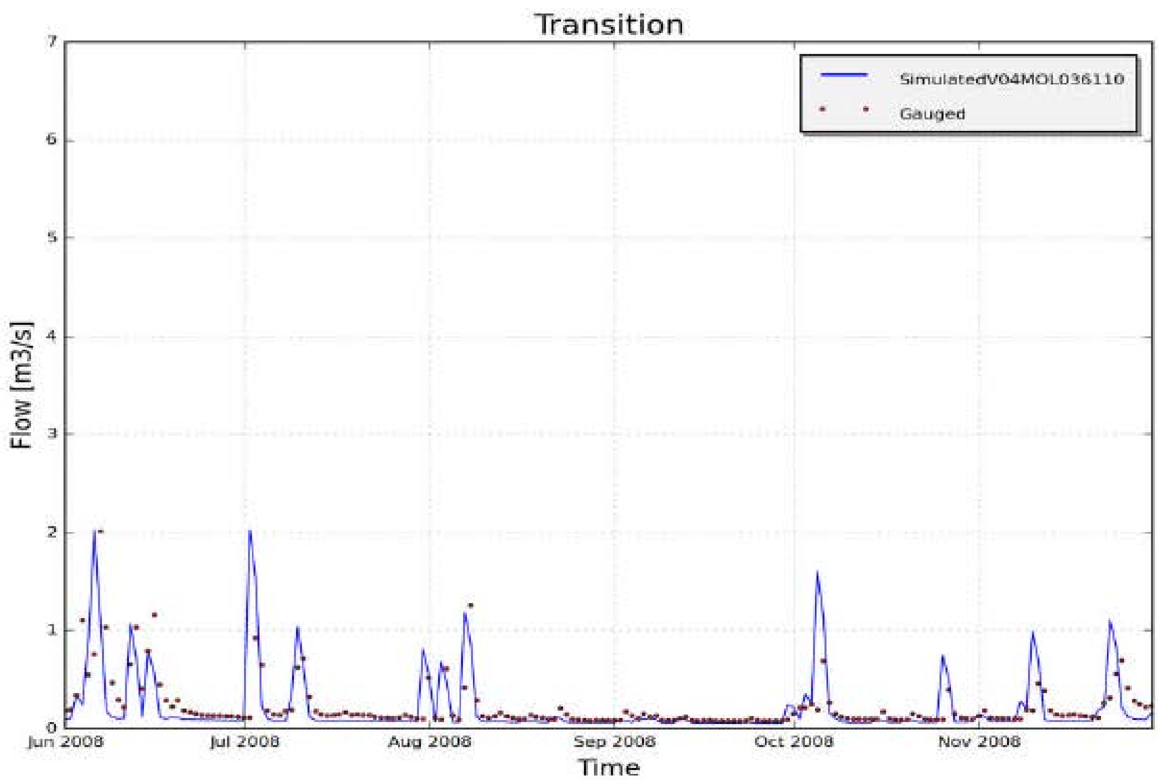


Figure 10: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele

9.5.2 Calibration and validation of WET parameters for catchment "V04MOM037100" (Benedenschelde)

9.5.2.1 Input data

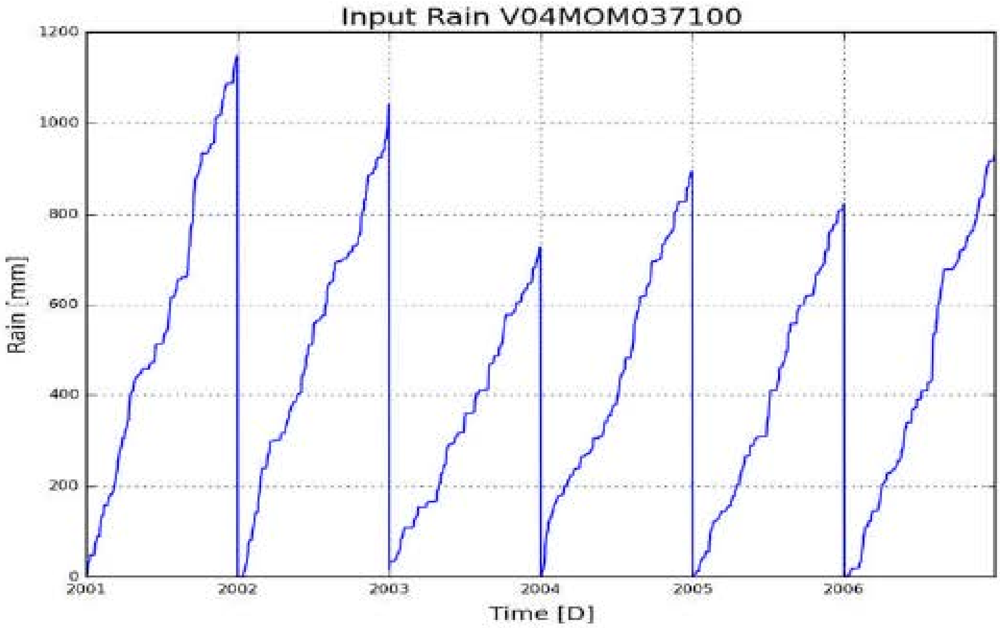


Figure 1: Cumulative precipitation on catchment V04MOM037100 (Benedenschelde)

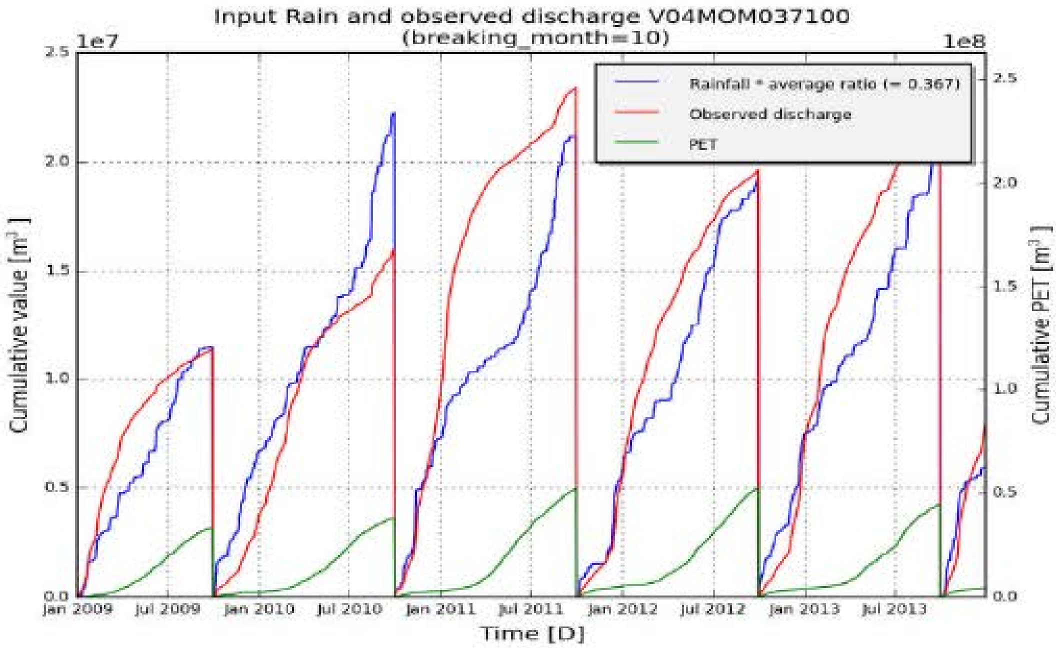


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V04MOM037100 (Benedenschelde)

9.5.2.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V04MOM037100
subcatchment_area [m2]	67300000
Validation start_date	01-01-2002
Validation end_date	31-12-2006
frequency	daily

Optimal parameter set:[('Kep', 1.76), ('Ki', 27.6), ('Kg', 0.0), ('Kss', 0.72), ('g0', 43.26), ('g_max', 377.43), ('K_run', 3.92), ('P_max', 438.61)]

Table 1: Goodness of fit for calibration period (2009 - 2013)

	Full year	**Summer**	**Winter**
RelErr	0.8 %	27.3 %	-18.8 %
NS	0.59	0.308	0.493
NS_log	0.705	0.486	0.532
NS_rel	0.708	0.568	0.732
KGE	0.765	0.567	0.574

Table 2 :Goodness of fit for validation period (2002 - 2006)

	Full year	**Summer**	**Winter**
RelErr	-3.0 %	3.5 %	-7.7 %
NS	0.776	0.707	0.703
NS_log	0.816	0.761	0.801
NS_rel	0.8	0.772	0.863
KGE	0.876	0.82	0.841

9.5.2.3 Observed and simulated timeseries for optimum parameters

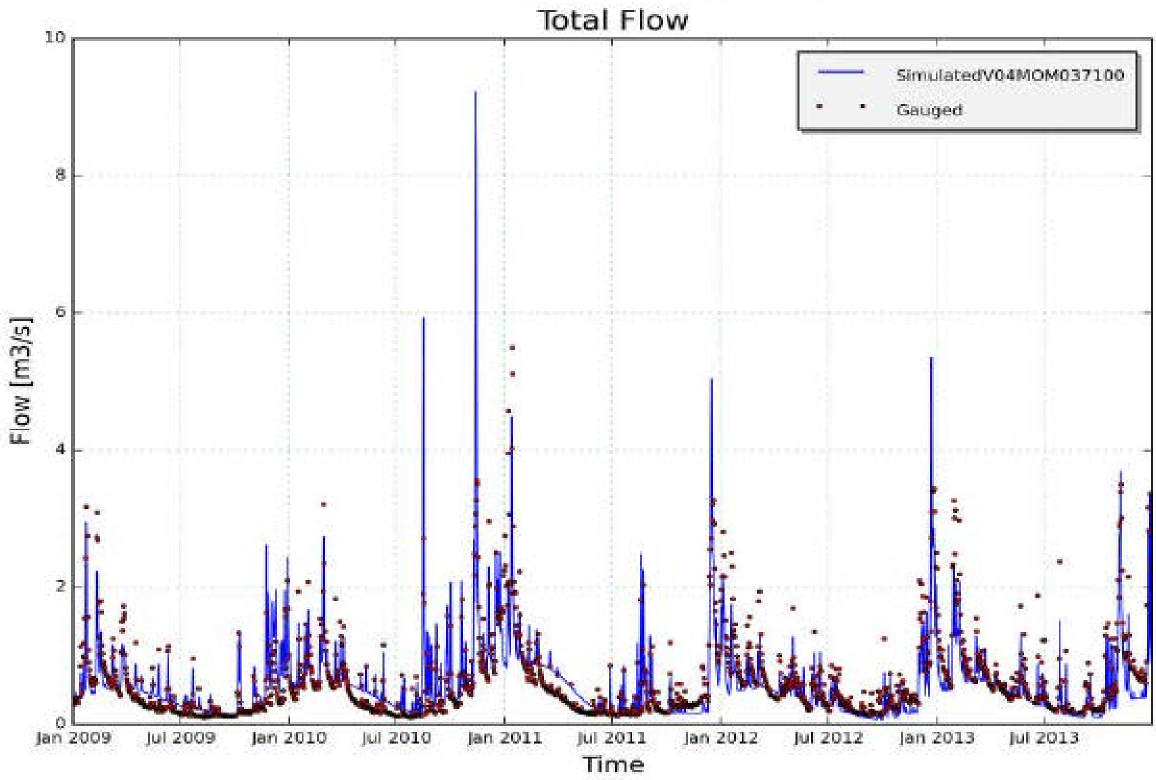


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen(calibration period)

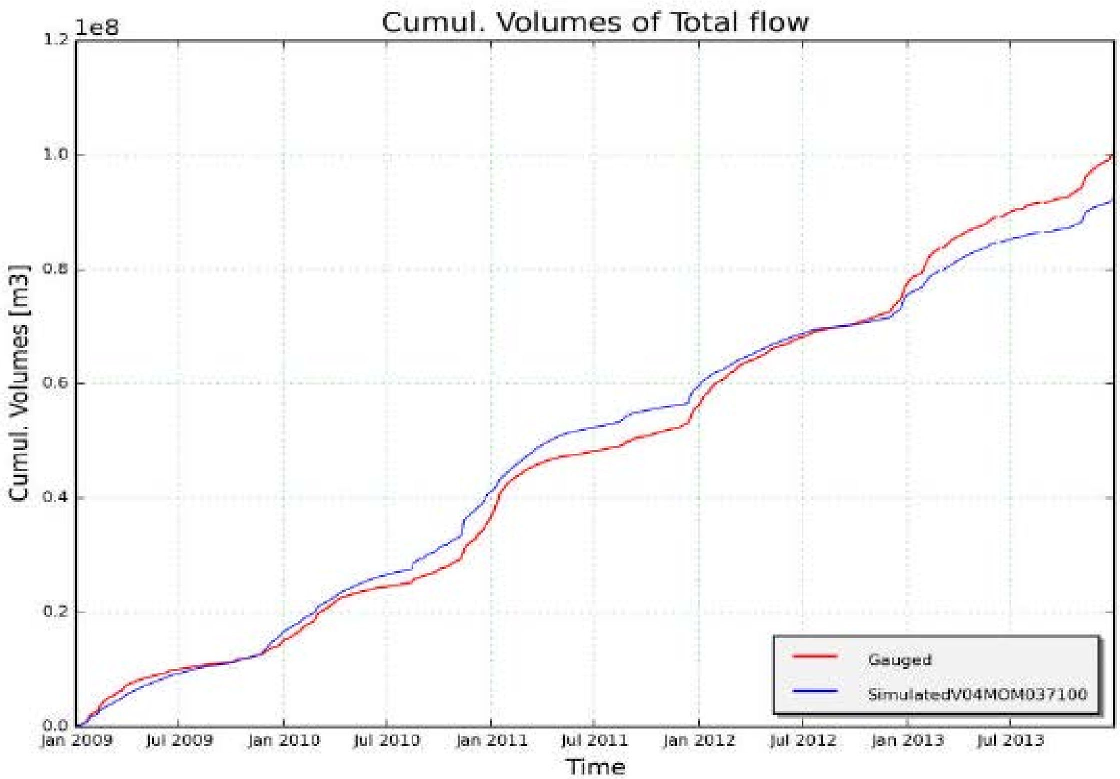


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen (calibration period)

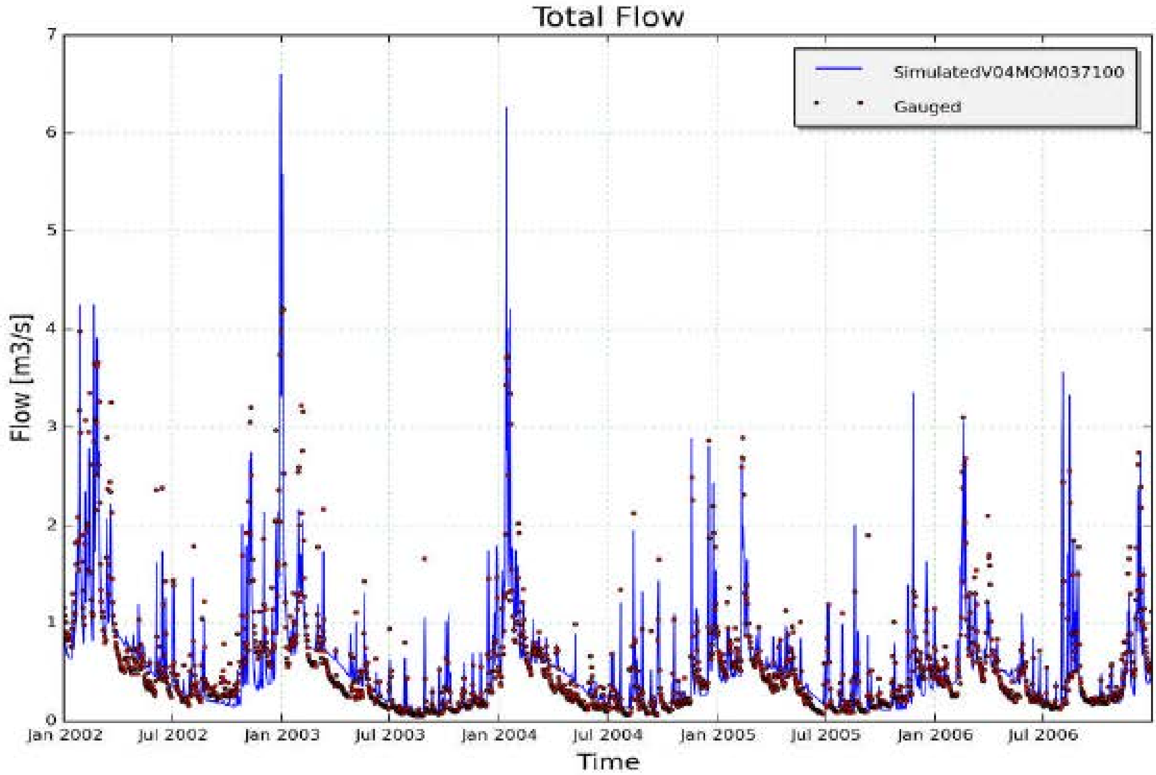


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen (validation period)

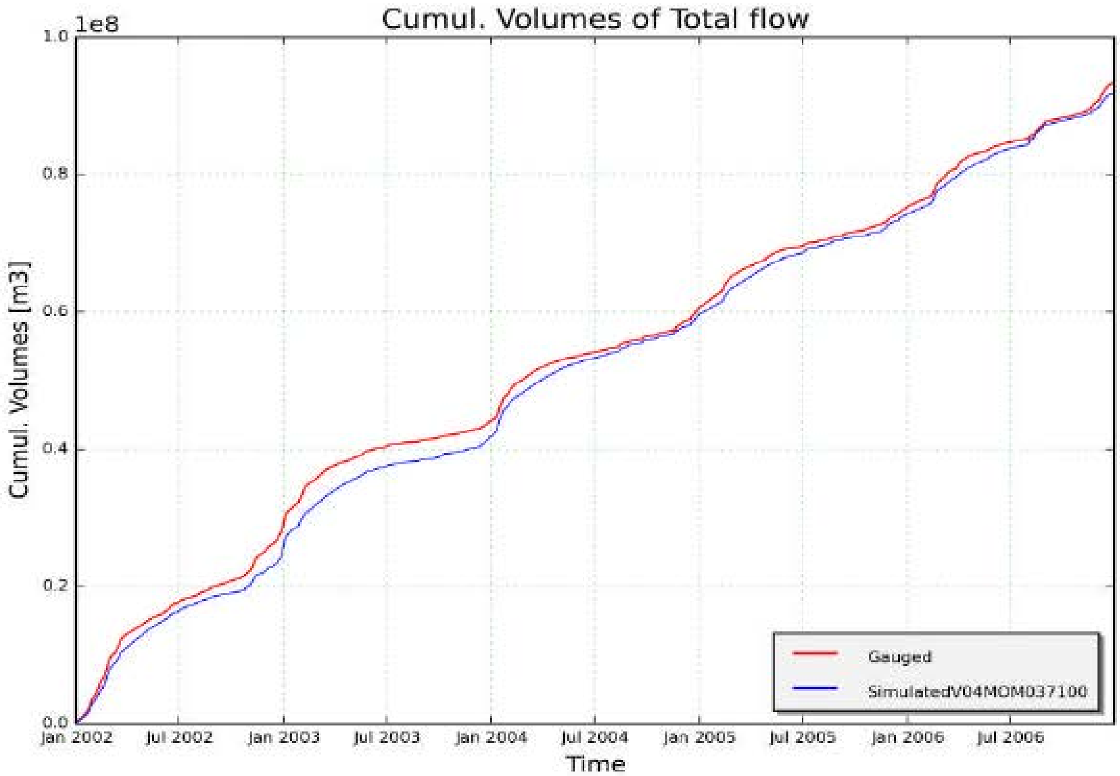


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen (validation period)

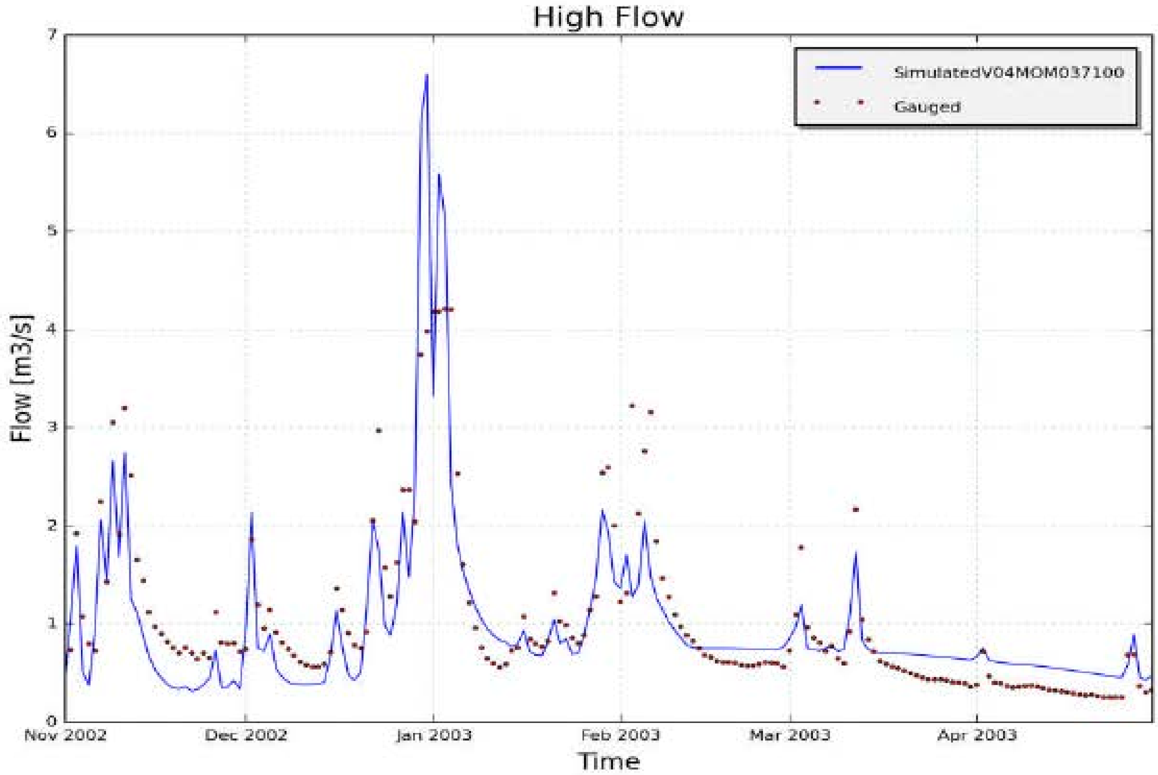


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen

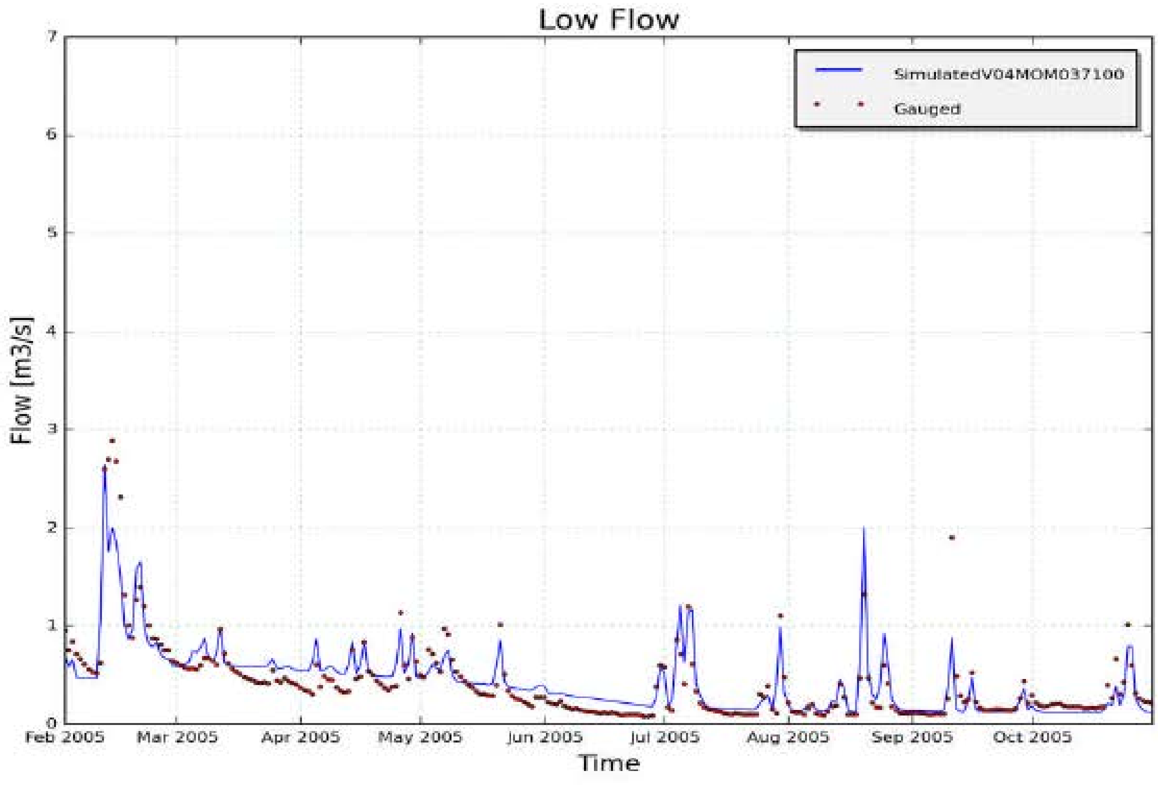


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen

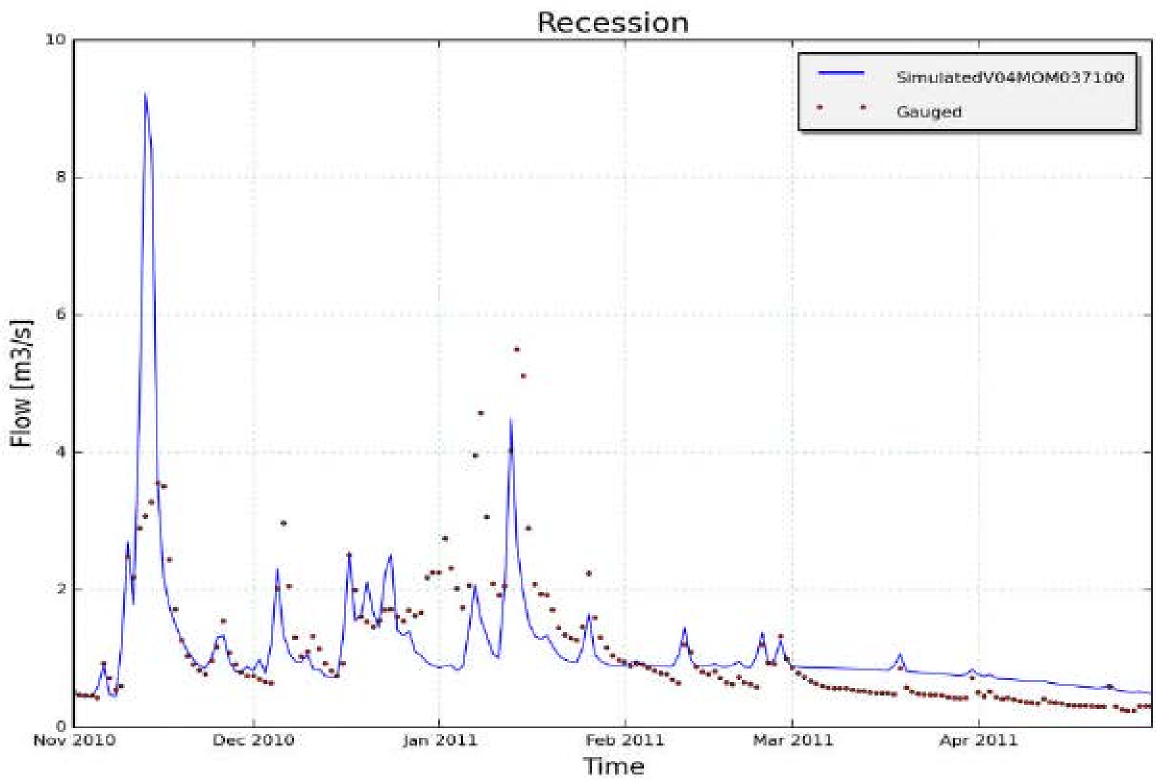


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen

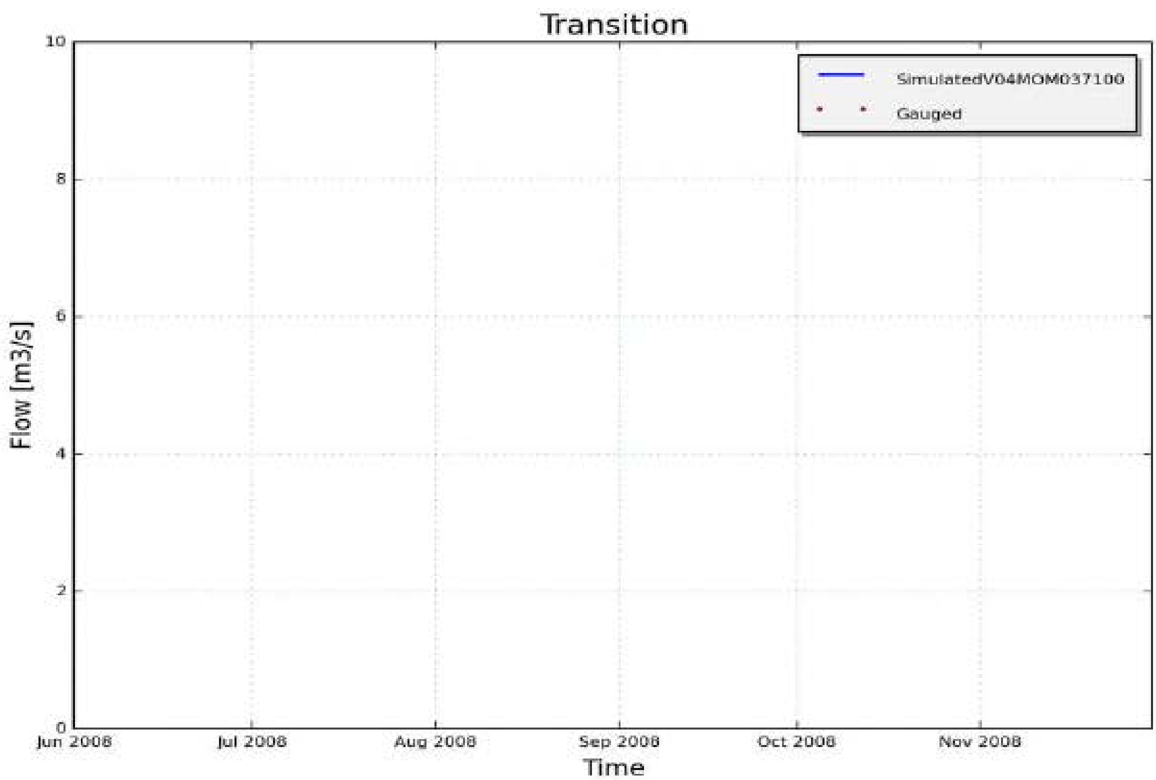


Figure 10: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen

Appendix 9 Benendenschelde Autocalibration.

9.5.1 Report on simulation of catchment V04MOL036110 (2017-01-20 19-55)

9.5.1.1 Input data

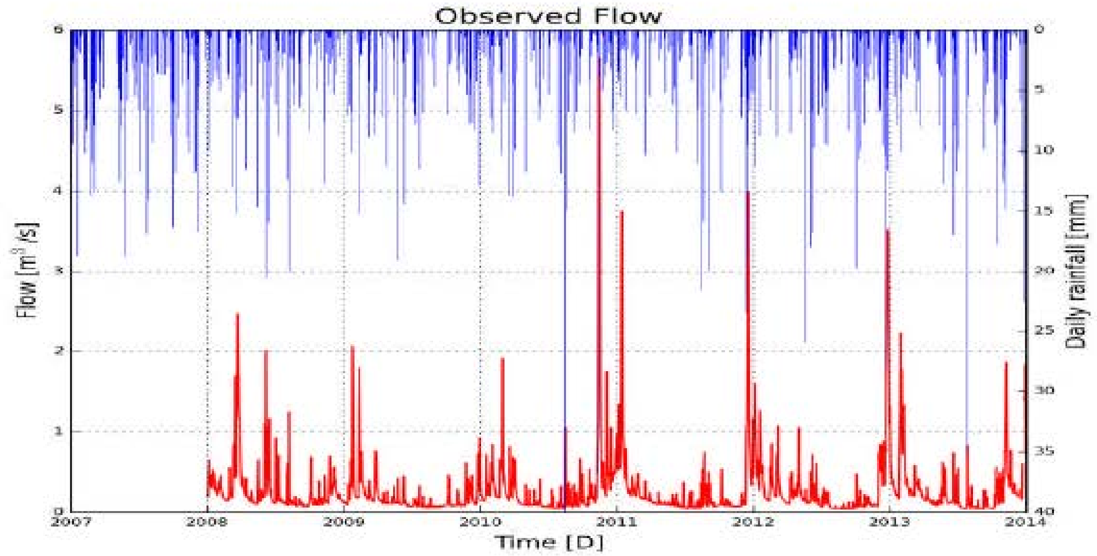


Figure 1: Hyetogram of observed discharge and observed net rain

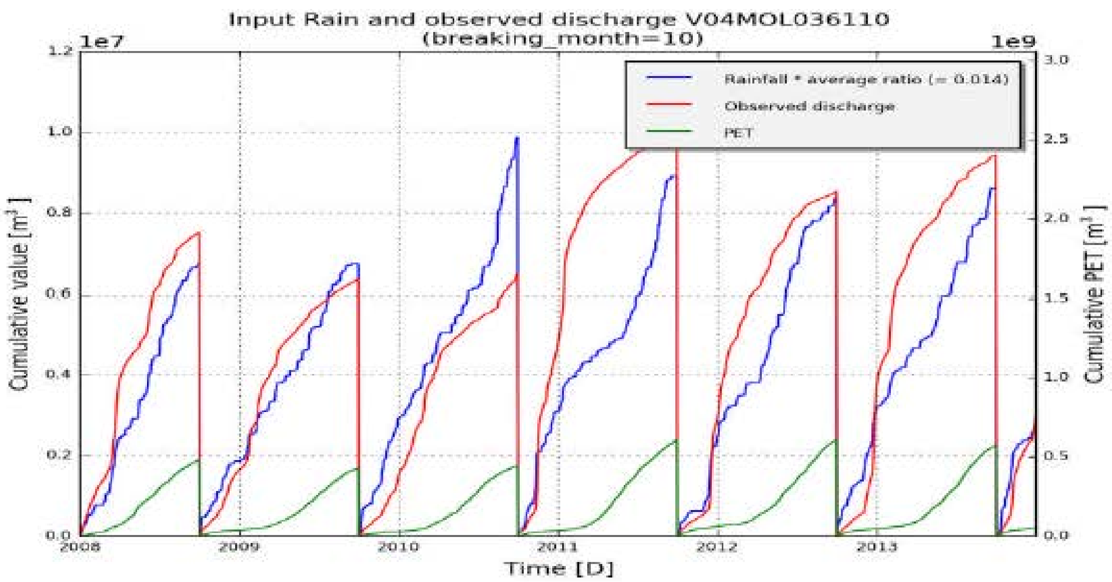


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.1.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V04MOL036110
subcatchment_area	32600000
start_date	200801010000
end_date	201312310000
frequency	86400
warmup	365

9.5.1.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.499, 117.45, 0.0014, 1.253, 70.393, 299.448, 6.8, 204.12]
low_bounds	[0.01, 1.0, 1e-05, 0.1, 1.0, 3.0, 0.1, 1.0]
high_bounds	[1.95, 152.0, 0.0026, 1.6, 91.0, 420.0, 9.0, 10.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.499), ('Ki', 117.45), ('Kg', 0.0014), ('Kss', 1.253), ('g0', 70.393), ('g_max', 299.448), ('K_run', 6.8), ('P_max', 204.12)]
Initial fitness:

- RelErr: -0.128
- AbsErr: 3267564.568
- KGE: 0.569
- NS_rel: 0.681
- NS: 0.364
- RMSE: 3726704.324
- NS_log: 0.622

Computation time:3:41:26.333000

9.5.1.4 Results

Best individual (euclidian): [('Kep', 1.564), ('Ki', 95.467), ('Kg', 0.002), ('Kss', 0.1), ('g0', 63.481), ('g_max', 281.545), ('K_run', 6.653), ('P_max', 9.996)]

Fitness:

- RelErr: 0.013
- AbsErr: 1291419.956
- KGE: 0.496
- NS_rel: -0.703
- NS: -0.03
- RMSE: 1527293.674
- NS_log: 0.344

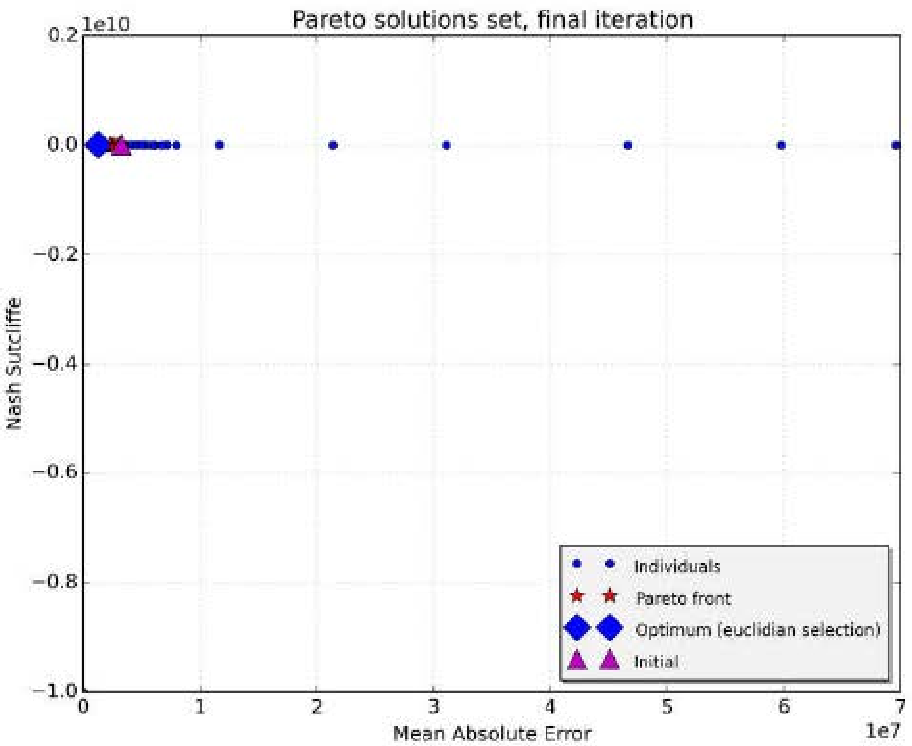


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

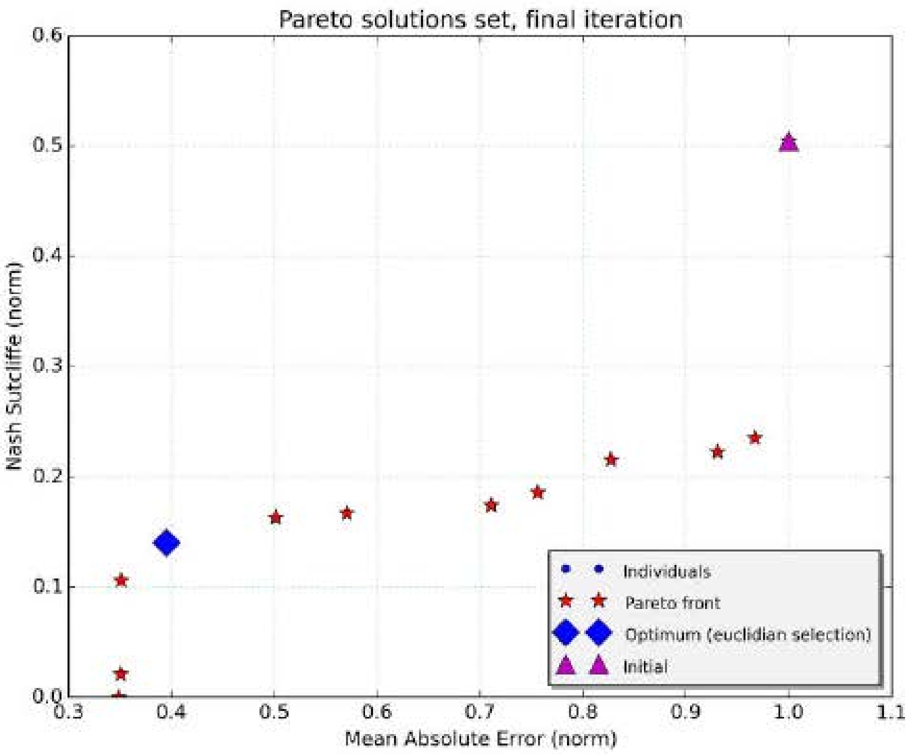


Figure 4: Final population of solutions (Pareto front)

9.5.1.4.1 Initial

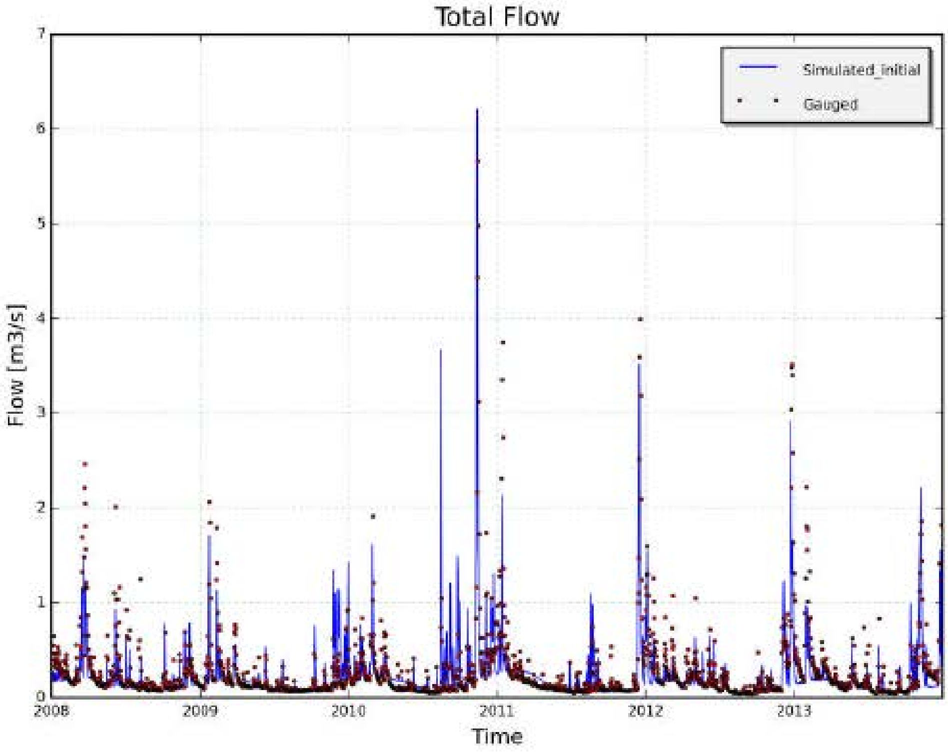


Figure 5: Total flow with initial parameters

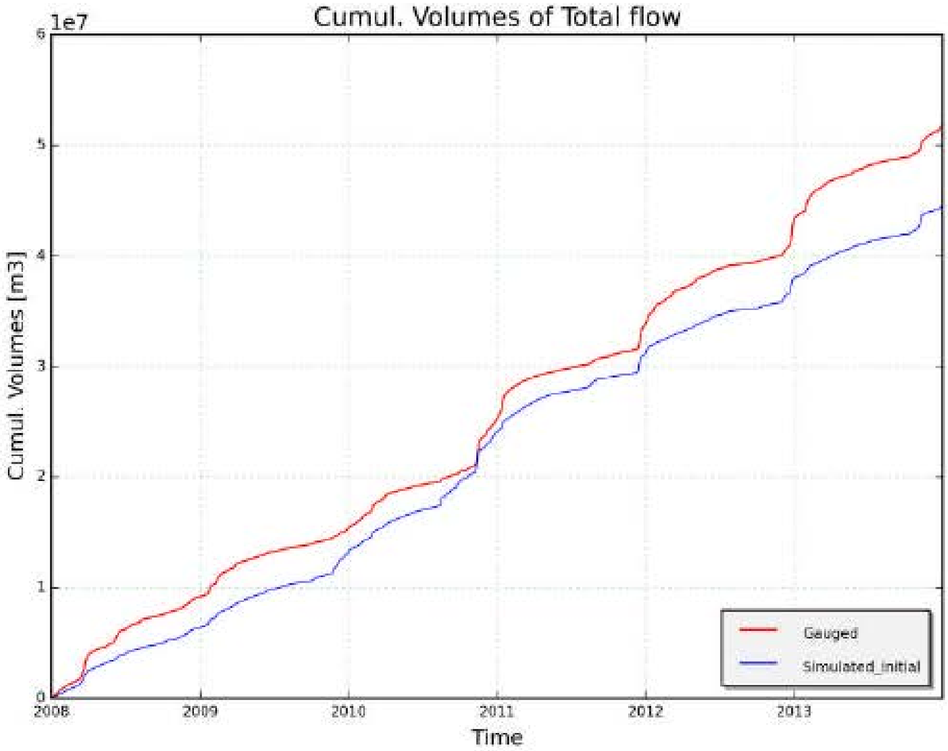


Figure 6: Cumulated flow with initial parameters

9.5.1.4.2 Optimum (euclidian)

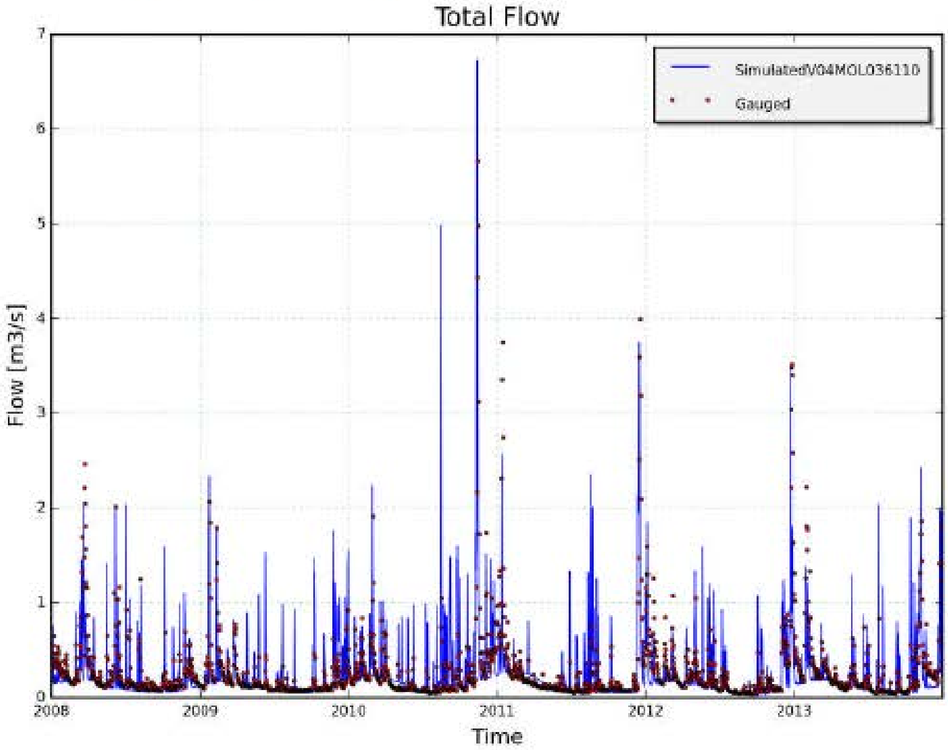


Figure 7: Total flow with optimum parameters

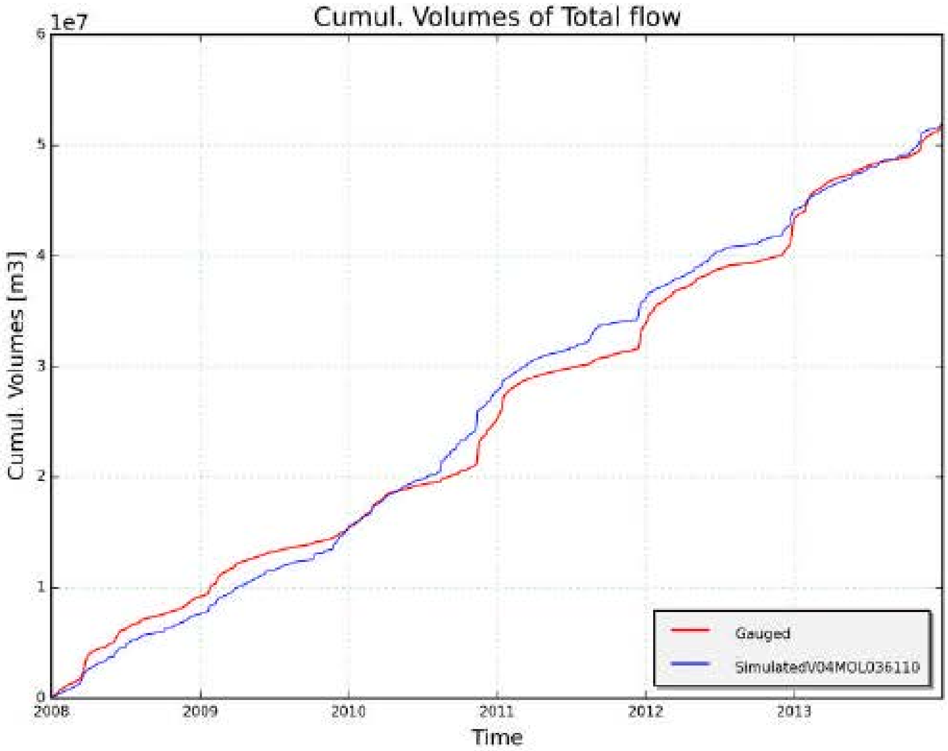


Figure 8: Cumulated flow with optimum parameters

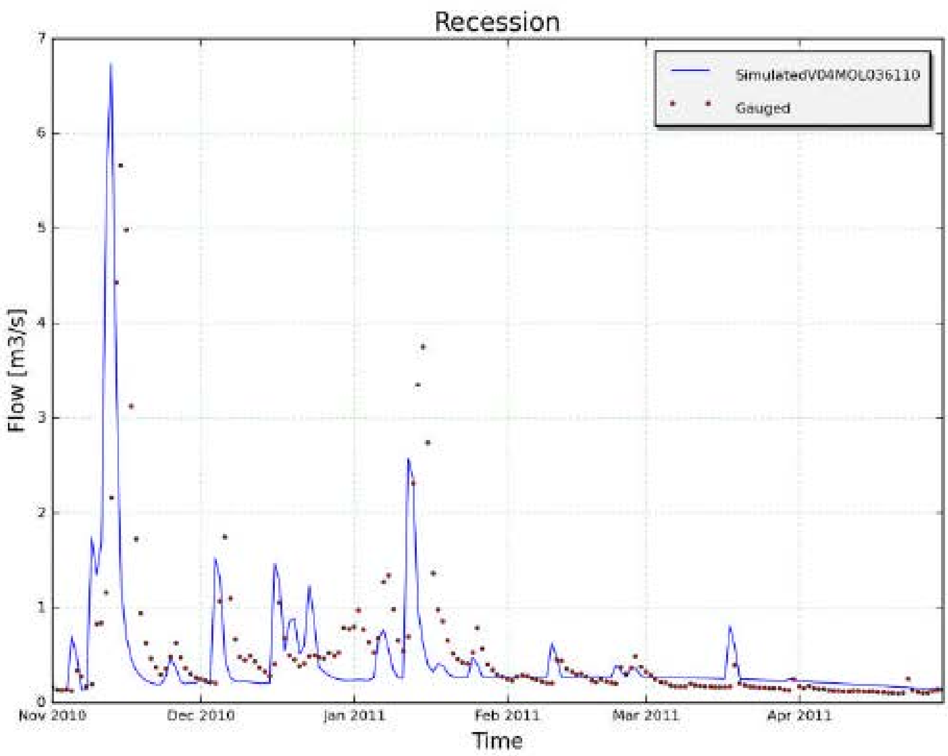


Figure 9: Total flow with optimum parameters (detail)

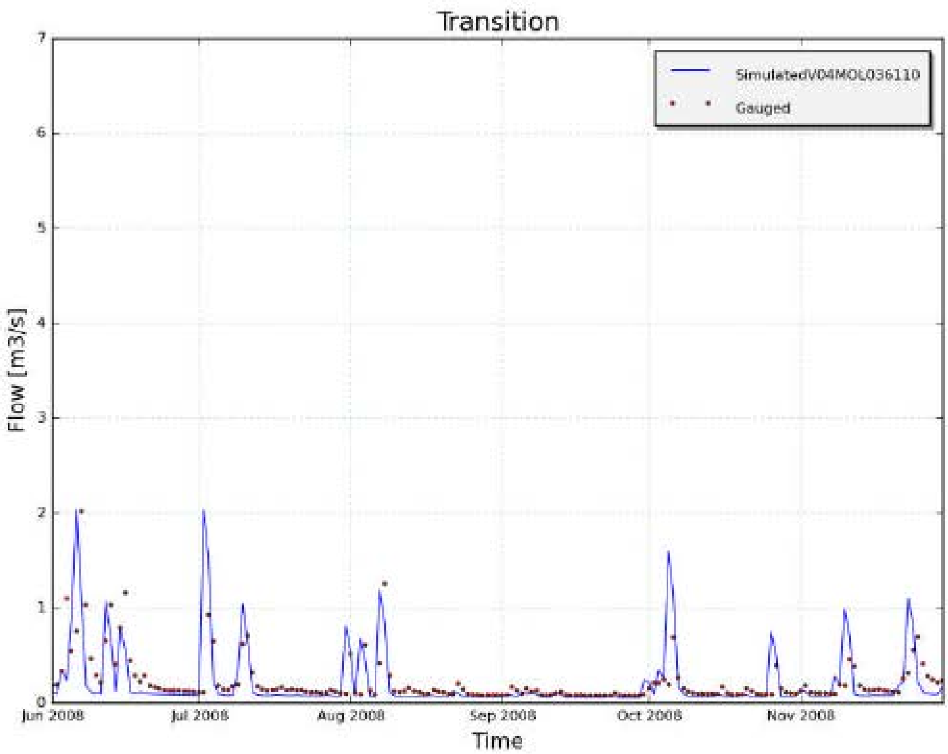
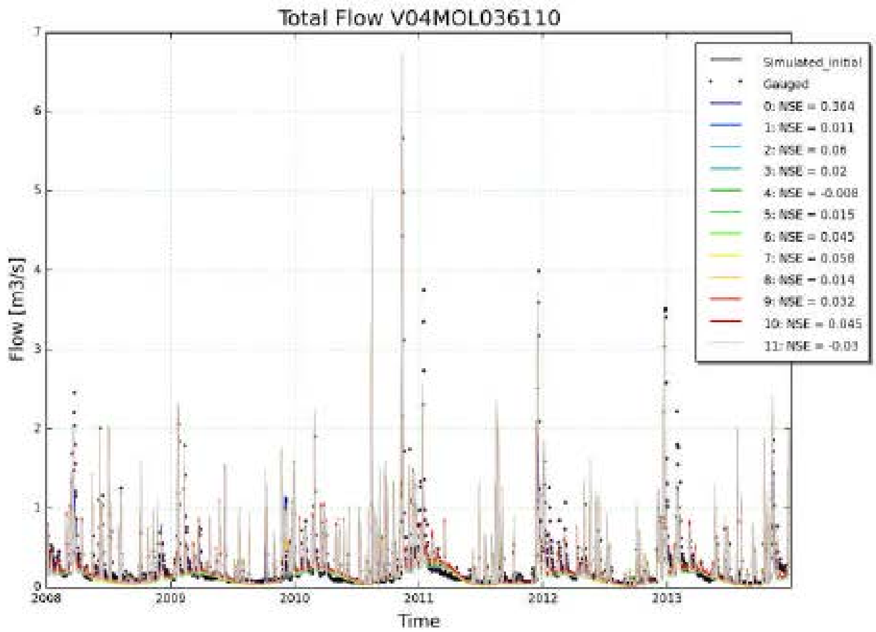


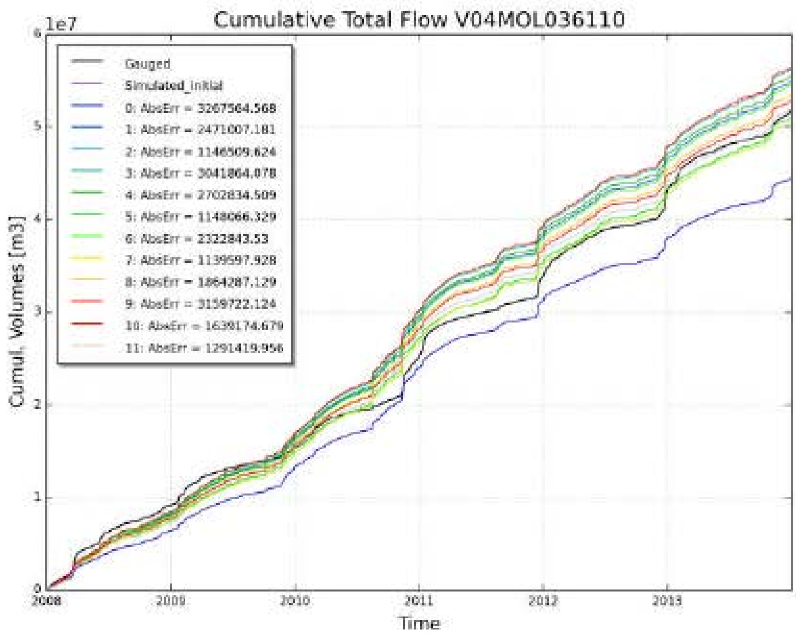
Figure 10: Total flow with optimum parameters (detail)

9.5.1.4.3 Final archive

0 : [1.499, 117.45, 0.001, 1.253, 70.393, 299.448, 6.8, 204.12] : [3267564.568, 0.622]
1 : [1.662, 89.723, 0.002, 1.6, 64.002, 262.605, 5.598, 10.0] : [2471007.181, 0.379]
2 : [1.94, 71.376, 0.002, 1.6, 55.69[illegible], 267.78[illegible], 4.916, 9.994] : [1146509.624, 0.25[illegible]]

3	:	[1.612,	81.8,	0.002,	1.439,	54.637,	273.296,	5.434,	9.99]	:	[3041864.078,	0.407]
4	:	[1.517,	87.194,	0.002,	0.1,	56.348,	262.227,	5.967,	9.996]	:	[2702834.509,	0.401]
5	:	[1.619,	79.707,	0.002,	0.645,	59.827,	287.09,	4.225,	9.996]	:	[1148066.329,	0.317]
6	:	[1.781,	78.529,	0.003,	1.6,	53.25,	272.39,	5.053,	10.0]	:	[2322843.53,	0.37]
7	:	[1.95,	71.376,	0.002,	1.6,	55.697,	267.733,	4.916,	9.611]	:	[1139597.928,	0.237]
8	:	[1.677,	87.268,	0.002,	0.1,	52.504,	273.284,	5.476,	10.0]	:	[1864287.129,	0.364]
9	:	[1.614,	75.396,	0.002,	1.366,	62.545,	278.817,	5.867,	10.0]	:	[3159722.124,	0.416]
10	:	[1.78,	75.838,	0.002,	0.886,	56.209,	279.885,	5.928,	10.0]	:	[1639174.679,	0.361]
11	:	[1.564,	95.467,	0.002,	0.1,	63.481,	281.545,	6.653,	9.996]	:	[1291419.956,	0.344]





9.5.2 Report on simulation of catchment V04MOM037100 (2017-01-20 20-57)

9.5.2.1 Input data

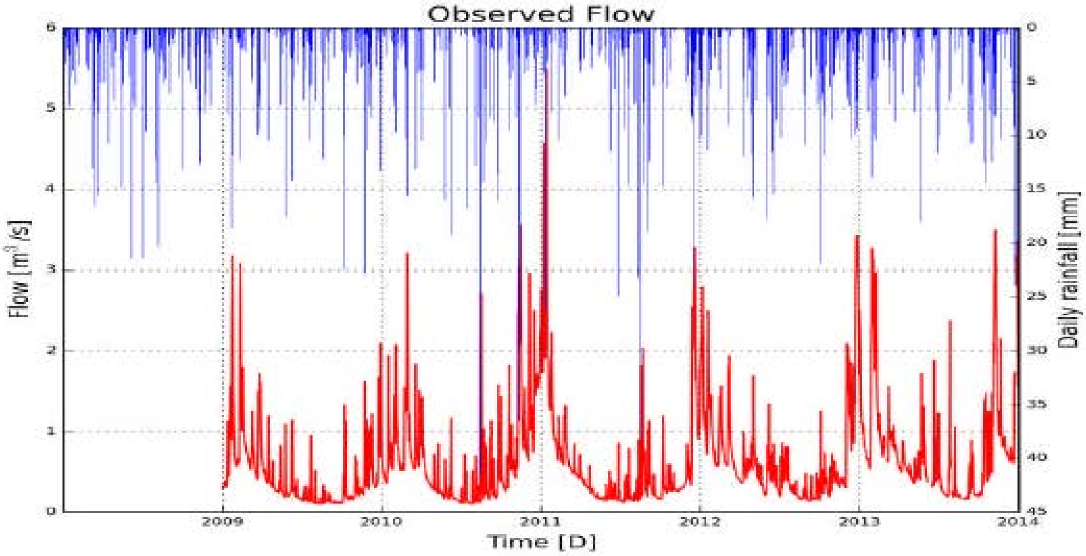


Figure 1: Hyetogram of observed discharge and observed net rain

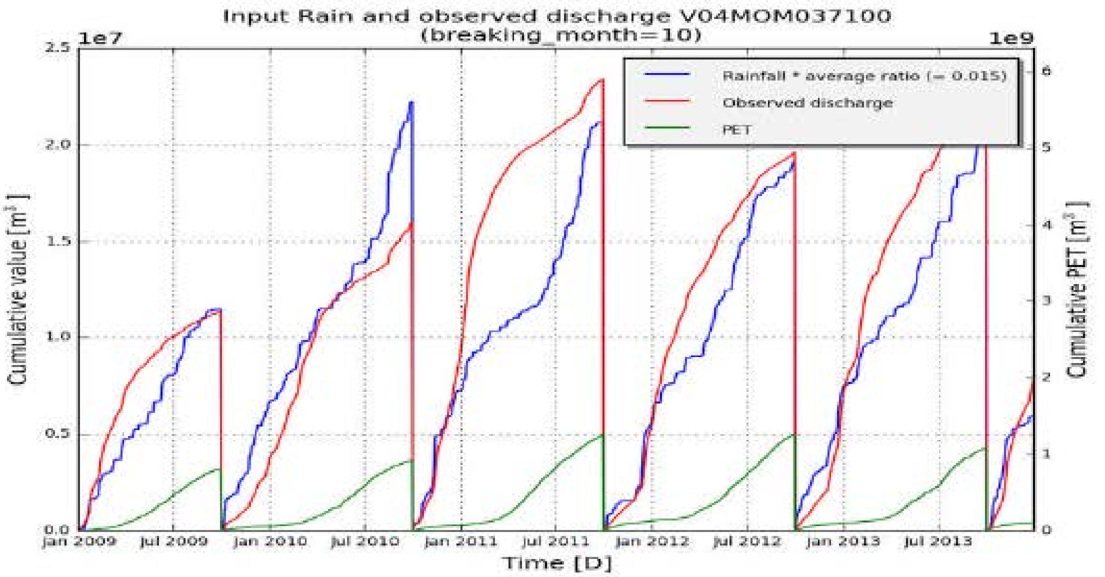


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.2.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V04MOM037100

subcatchment_area	67300000
start_date	200901010000
end_date	201312310000
frequency	86400
warmup	365

9.5.2.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.8, 29.0, 0.0035, 0.9, 40.0, 350.0, 4.5, 450.0]
low_bounds	[1.44, 23.2, 0.0028, 0.72, 32.0, 280.0, 3.6, 360.0]
high_bounds	[2.2, 34.8, 0.0042, 1.08, 48.0, 420.0, 5.4, 540.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.8), ('Ki', 29.0), ('Kg', 0.0035), ('Kss', 0.9), ('g0', 40.0), ('g_max', 350.0), ('K_run', 4.5), ('P_max', 450.0)]
Initial fitness:

- RelErr: 0.055
- AbsErr: 3142875.88
- KGE: 0.787
- NS_rel: 0.692
- NS: 0.623
- RMSE: 3881101.896
- NS_log: 0.697

Computation time:4:42:54.313000

9.5.2.4 Results

Best individual (euclidian): [('Kep', 1.765), ('Ki', 27.611), ('Kg', 0.003), ('Kss', 0.72), ('g0', 43.266), ('g_max', 377.435), ('K_run', 3.924), ('P_max', 438.611)]

Fitness:

- RelErr: 0.008
- AbsErr: 2494801.021
- KGE: 0.765
- NS_rel: 0.708
- NS: 0.59
- RMSE: 3096241.895
- NS_log: 0.705

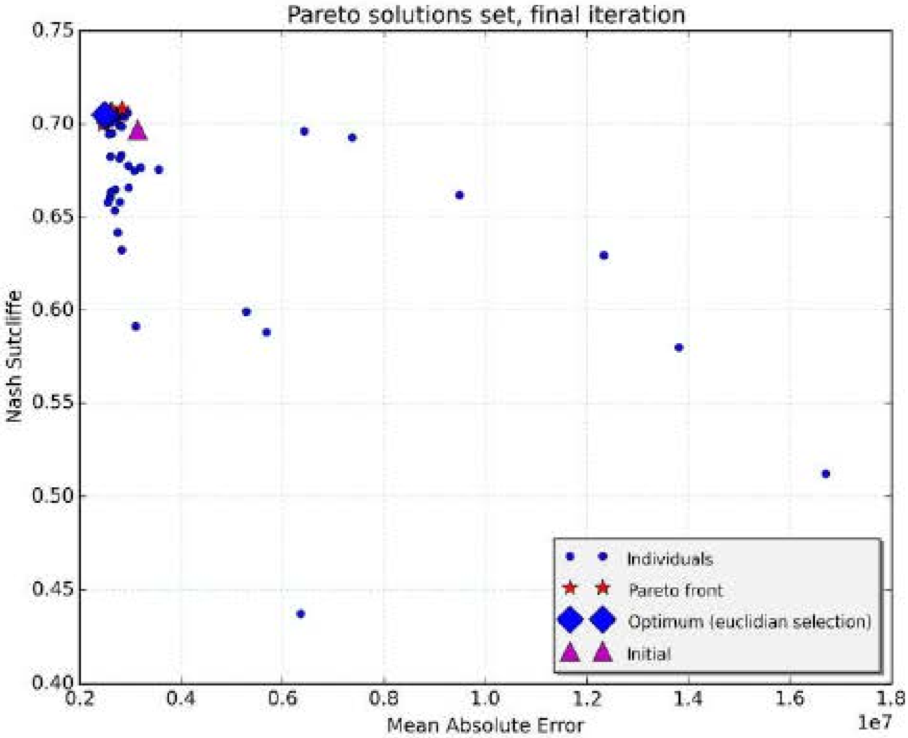


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

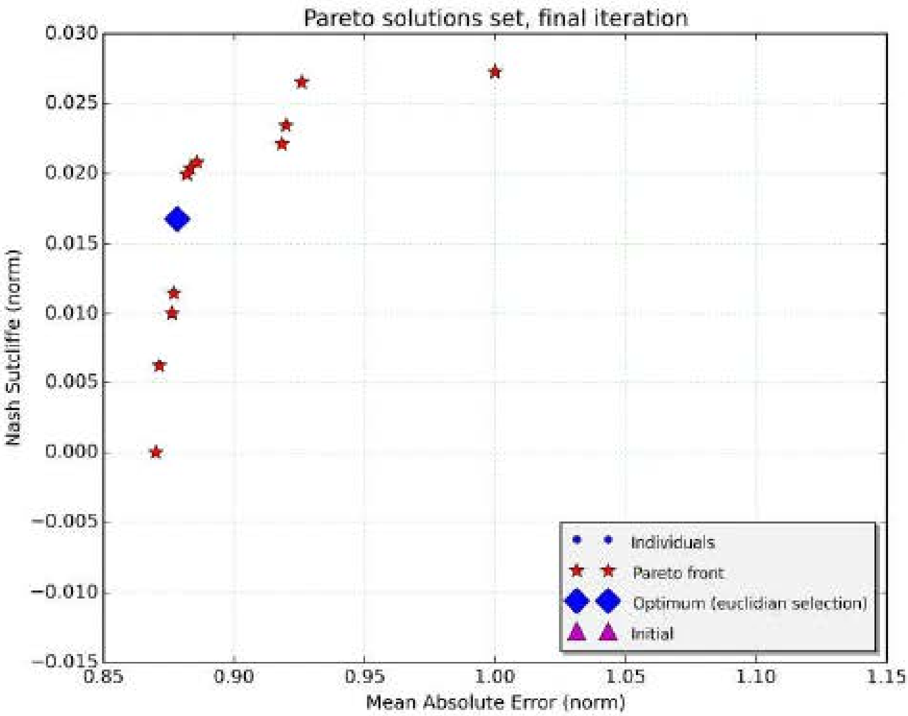


Figure 4: Final population of solutions (Pareto front)

9.5.2.4.1 Initial

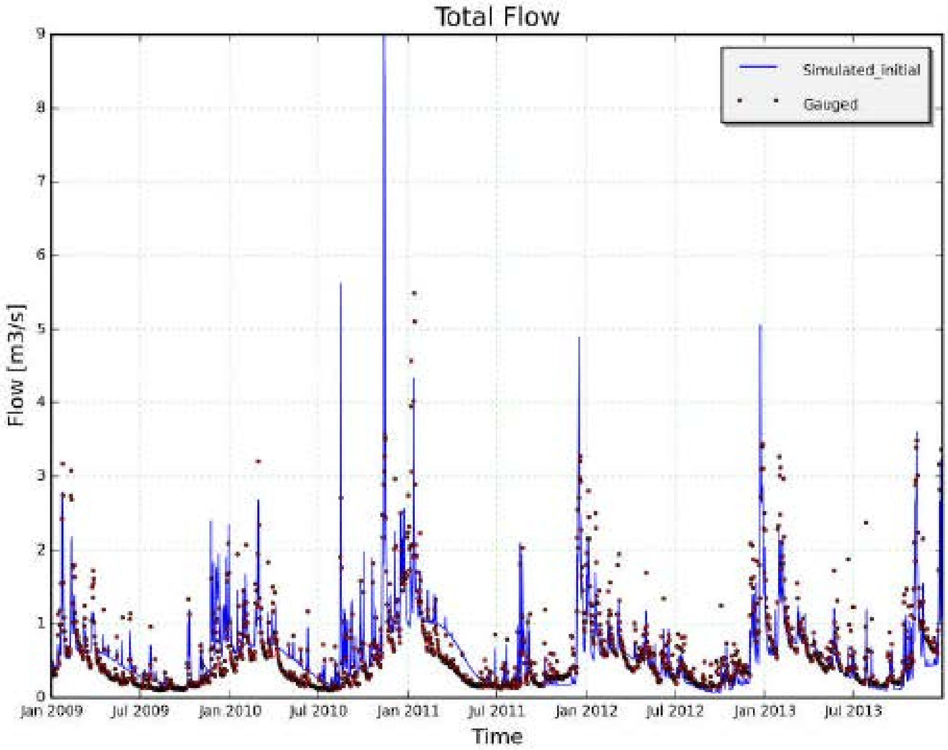


Figure 5: Total flow with initial parameters

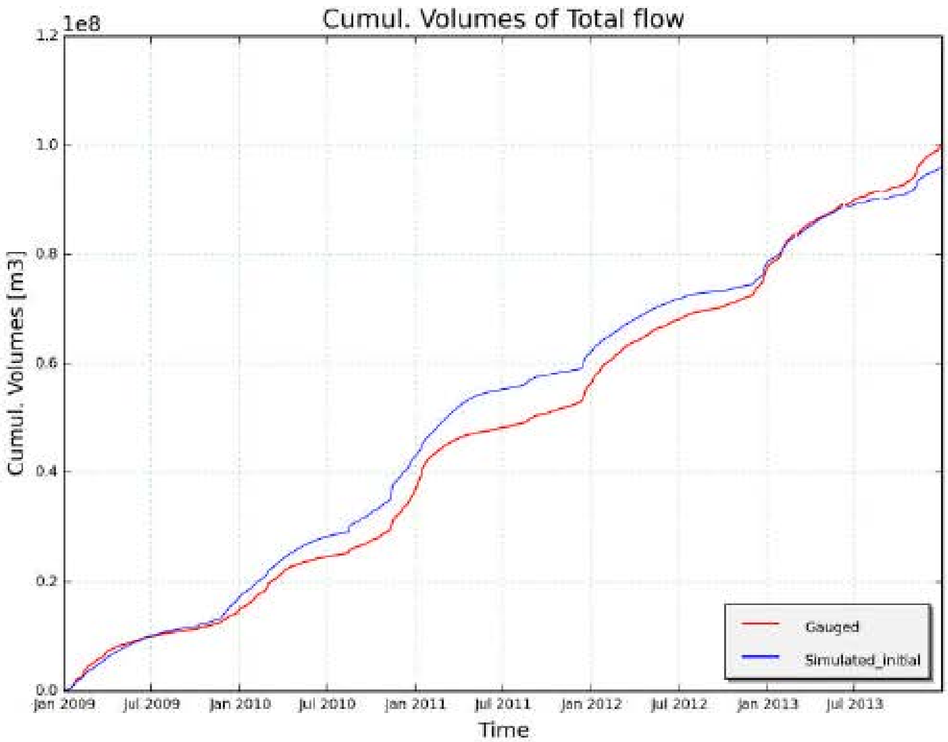


Figure 6: Cumulated flow with initial parameters

9.5.2.4.2 Optimum (euclidian)

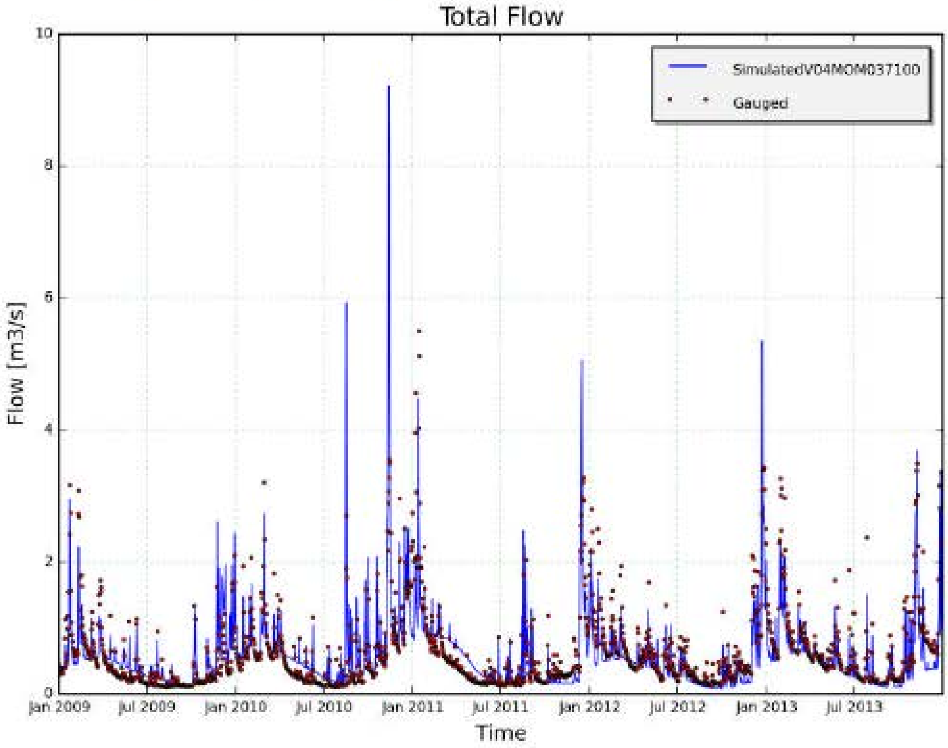


Figure 7: Total flow with optimum parameters

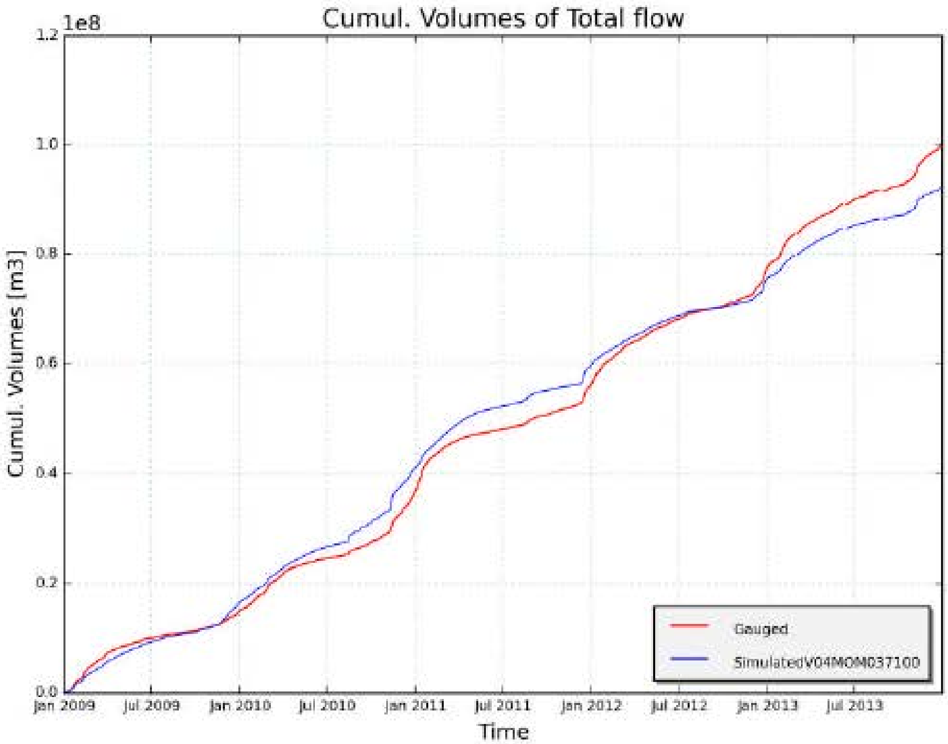


Figure 8: Cumulated flow with optimum parameters

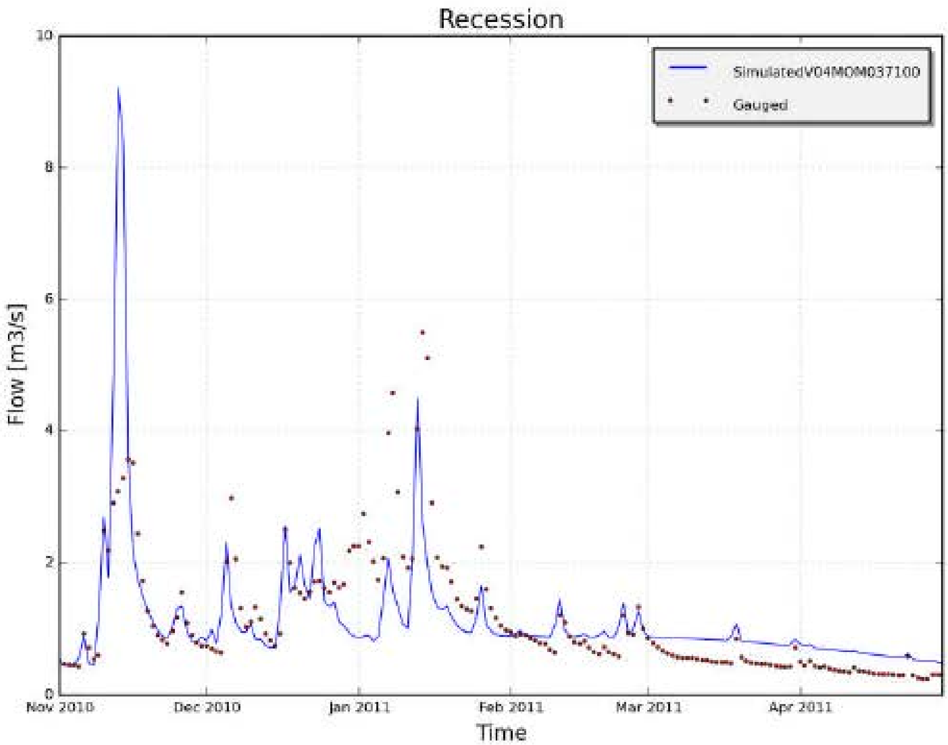


Figure 9: Total flow with optimum parameters (detail)

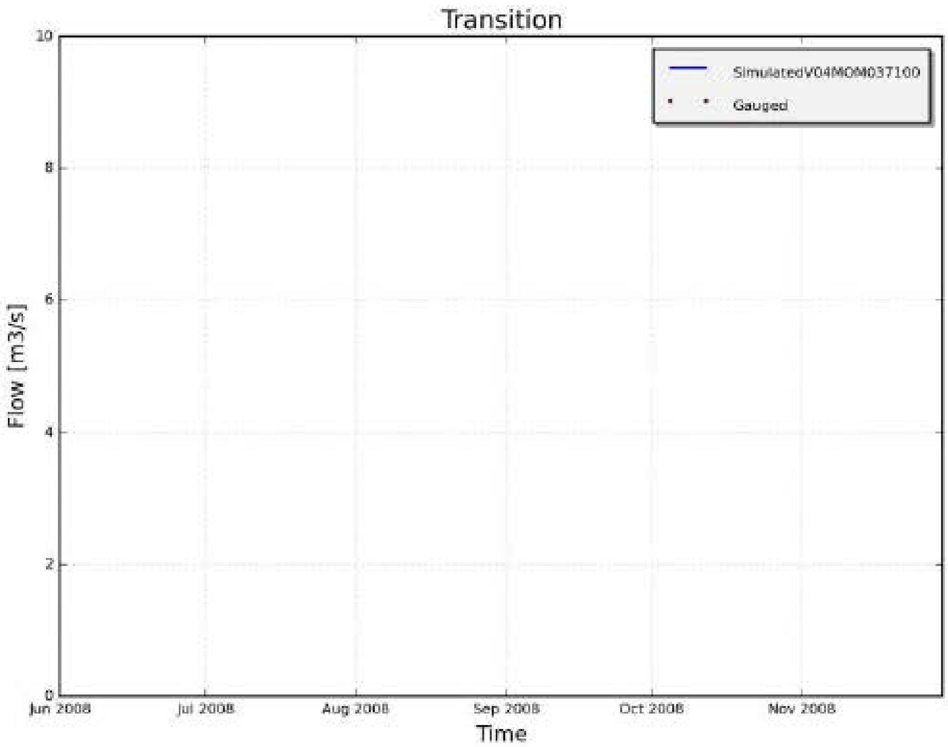
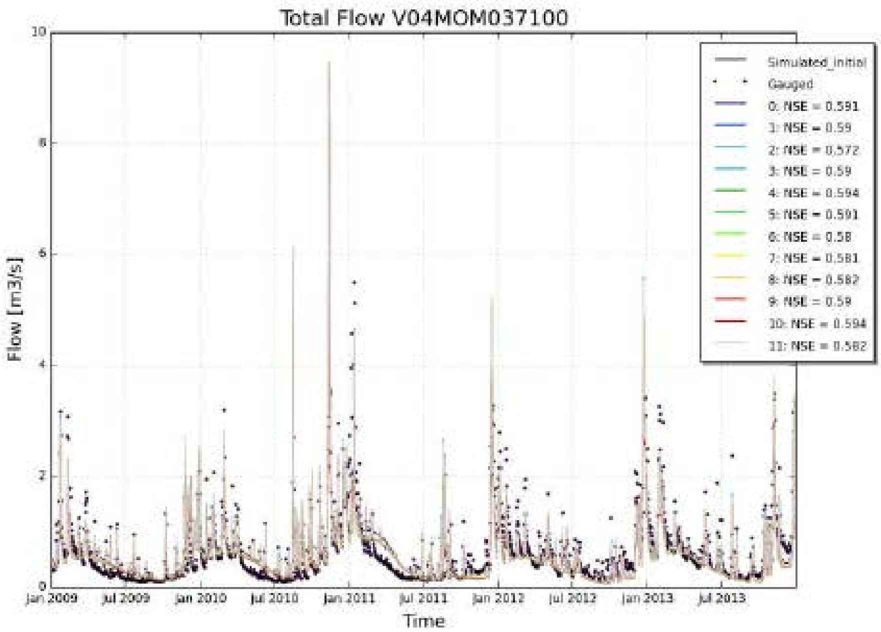


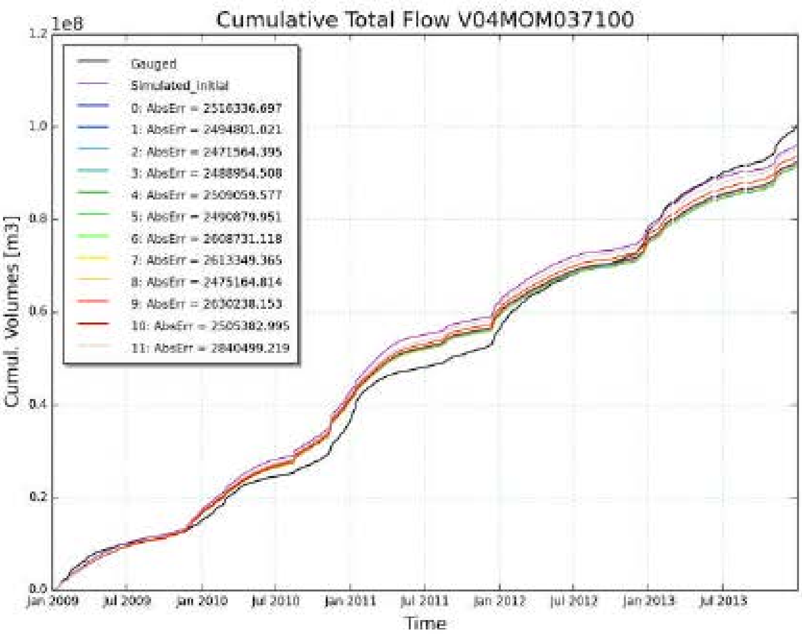
Figure 10: Total flow with optimum parameters (detail)

9.5.2.4.3 Final archive

0 : [1.757, 29.683, 0.003, 0.72, 41.389, 377.215, 4.018, 532.099] : [2516336.697, 0.706]
1 : [1.765, 27.611, 0.003, 0.72, 43.266, 377.435, 3.924, 438.611] : [2494801.021, 0.705]
2 : [1.786, 28.757, 0.003, 0.74, 40.989, 375.949, 3.653, 429.316] : [2471564.395, 0.7]

3	:	[1.78,	27.593,	0.003,	0.727,	41.954,	377.2,	3.929,	445.074]	:	[2488954.508,	0.703]
4	:	[1.758,	27.43,	0.003,	0.72,	40.828,	378.153,	3.978,	463.876]	:	[2509059.577,	0.706]
5	:	[1.777,	27.717,	0.003,	0.741,	41.372,	375.397,	3.95,	428.817]	:	[2490879.951,	0.703]
6	:	[1.745,	29.248,	0.003,	0.737,	41.548,	376.569,	3.802,	452.861]	:	[2608731.118,	0.707]
7	:	[1.744,	30.038,	0.003,	0.736,	41.634,	376.316,	3.831,	494.18]	:	[2613349.365,	0.707]
8	:	[1.785,	27.617,	0.003,	0.723,	42.752,	378.539,	3.773,	450.842]	:	[2475164.814,	0.702]
9	:	[1.736,	28.849,	0.003,	0.728,	41.765,	378.96,	3.964,	451.093]	:	[2630238.153,	0.708]
10	:	[1.758,	27.077,	0.003,	0.726,	39.822,	377.54,	3.966,	454.139]	:	[2505382.995,	0.706]
11	:	[1.712,	28.921,	0.003,	0.772,	42.532,	377.212,	3.806,	472.971]	:	[2840499.219,	0.708]





Appendix 10 Leie Calibration and Validation.

9.5.1 Calibration and validation of WET parameters for catchment "V05HEU403210" (Leiebekken)

9.5.1.1 Input data

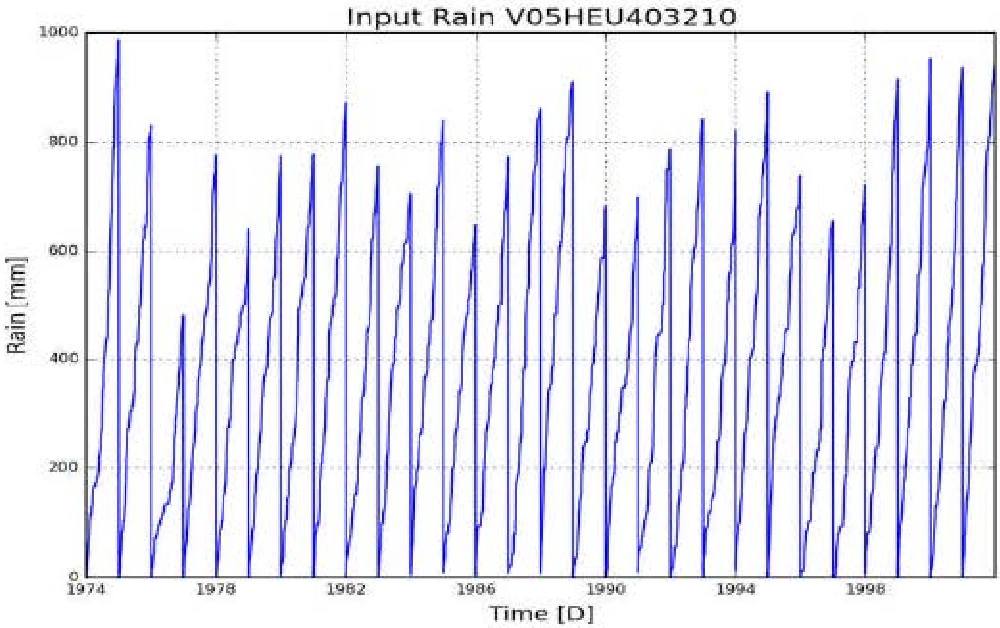


Figure 1: Cumulative precipitation on catchment V05HEU403210 (Leiebekken)

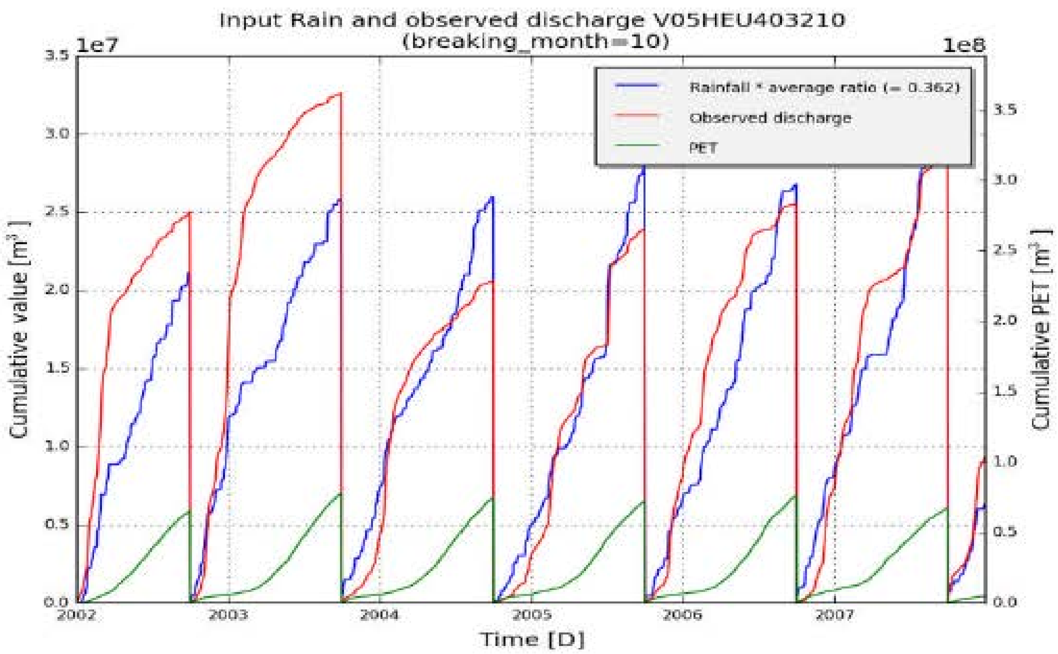


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V05HEU403210 (Leiebekken)

9.5.1.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V05HEU403210
subcatchment_area [m2]	91900000
Validation start_date	01-01-1975
Validation end_date	31-12-2001
frequency	daily

Optimal parameter set:[('Kep', 2.2), ('Ki', 101.96), ('Kg', 0.01), ('Kss', 4.81), ('g0', 762.64), ('g_max', 690.85), ('K_run', 1.14), ('P_max', 1262.8)]

Table 1: Goodness of fit for calibration period (2002 - 2007)

	Full year	**Summer**	**Winter**
RelErr	-5.8 %	38.9 %	-22.7 %
NS	0.193	-1.295	0.389
NS_log	0.629	0.447	0.469
NS_rel	-3.092	-4.851	0.742
KGE	0.621	0.011	0.609

Table 2 :Goodness of fit for validation period (1975 - 2001)

	Full year	**Summer**	**Winter**
RelErr	0.1 %	47.4 %	-16.2 %
NS	0.314	-1.854	0.512
NS_log	0.651	0.358	0.524
NS_rel	-0.177	-0.548	0.416
KGE	0.664	-0.22	0.617

9.5.1.3 Observed and simulated timeseries for optimum parameters

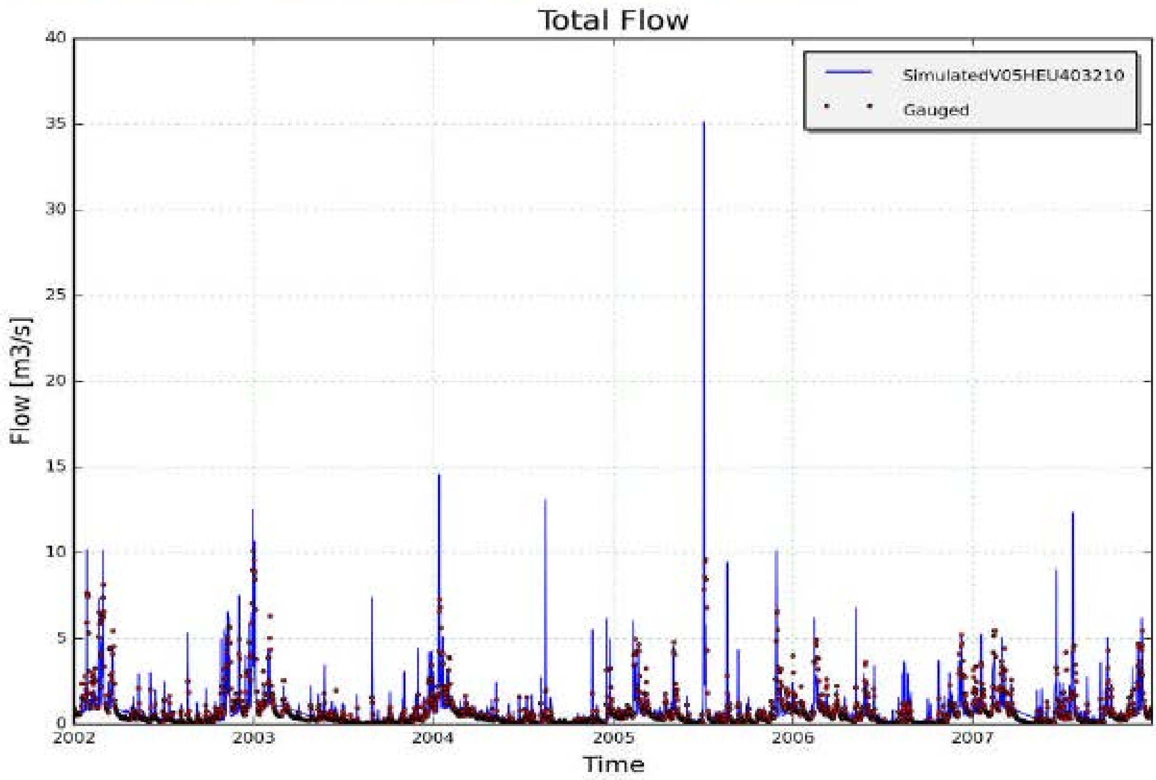


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V05HEU403210, station 40310102 - Heulebeek; Heule(calibration period)

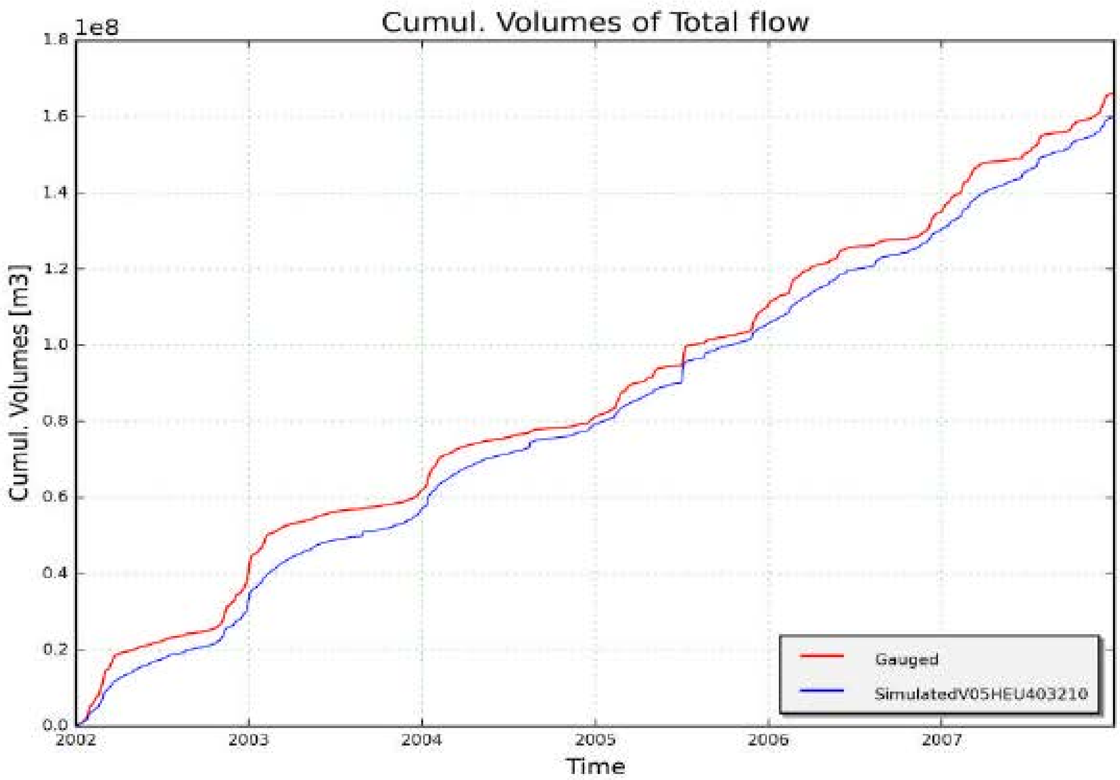


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V05HEU403210, station 40310102 - Heulebeek; Heule (calibration period)

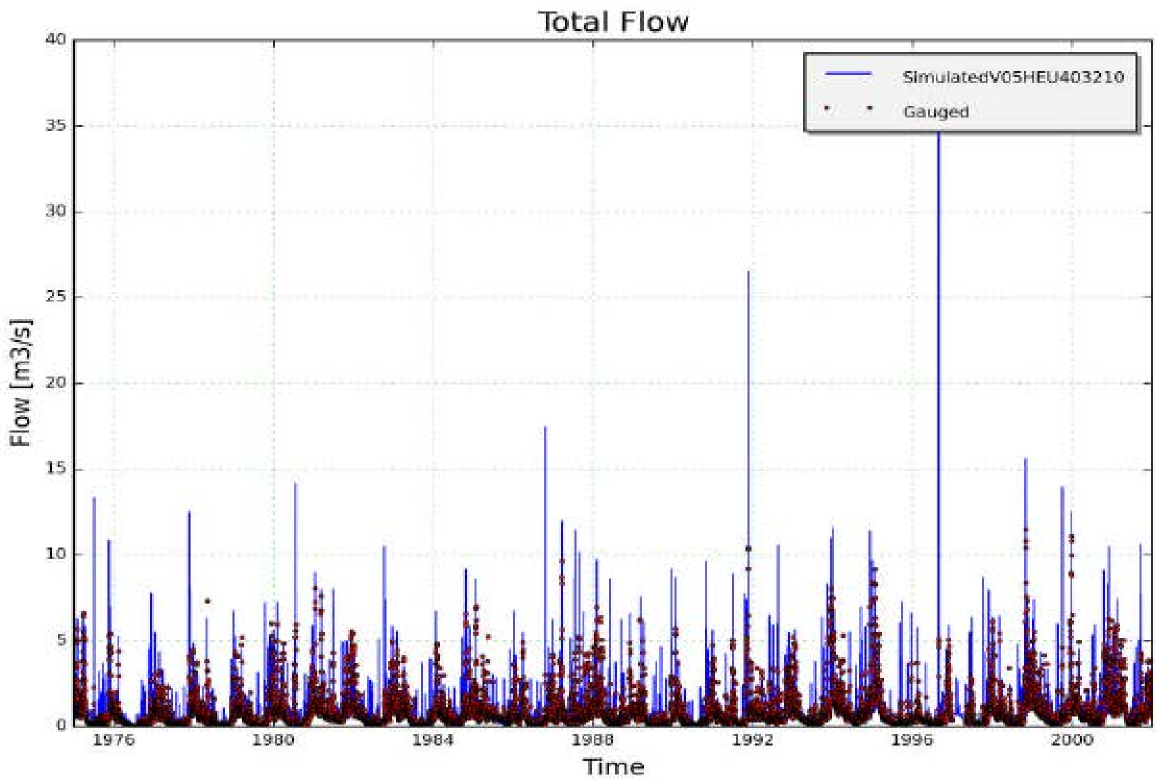


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V05HEU403210, station 40310102 - Heulebeek; Heule (validation period)

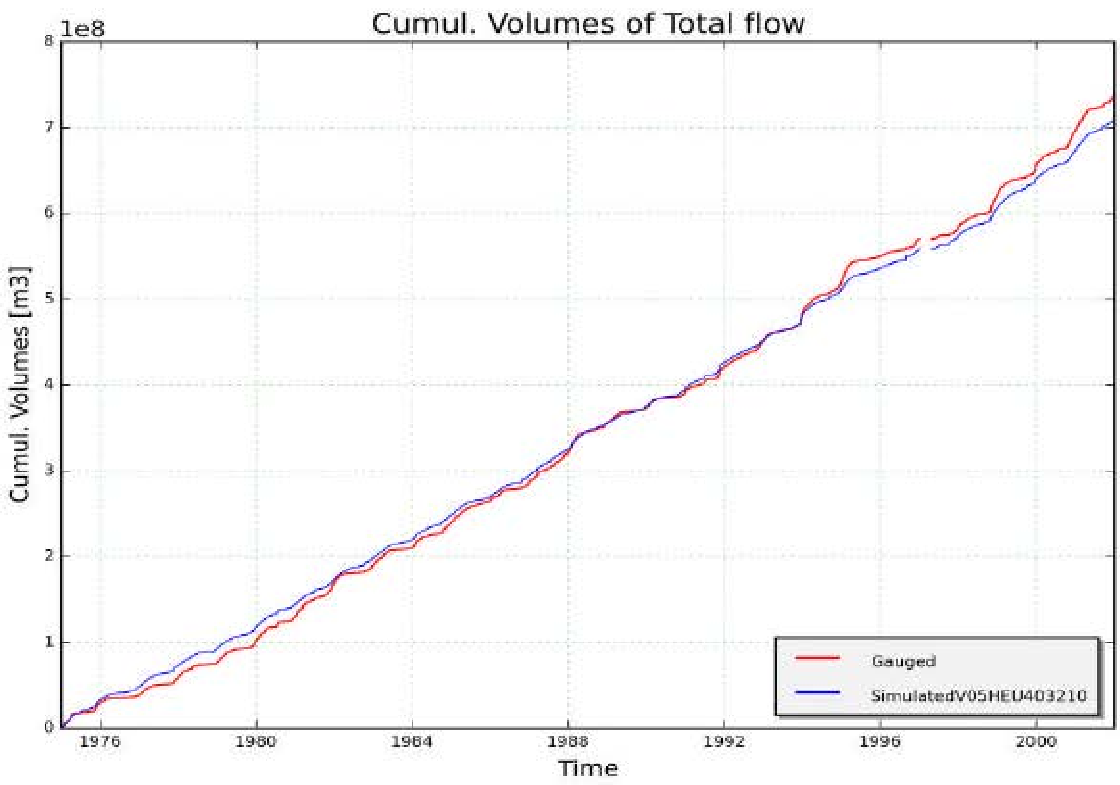


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V05HEU403210, station 40310102 - Heulebeek; Heule (validation period)

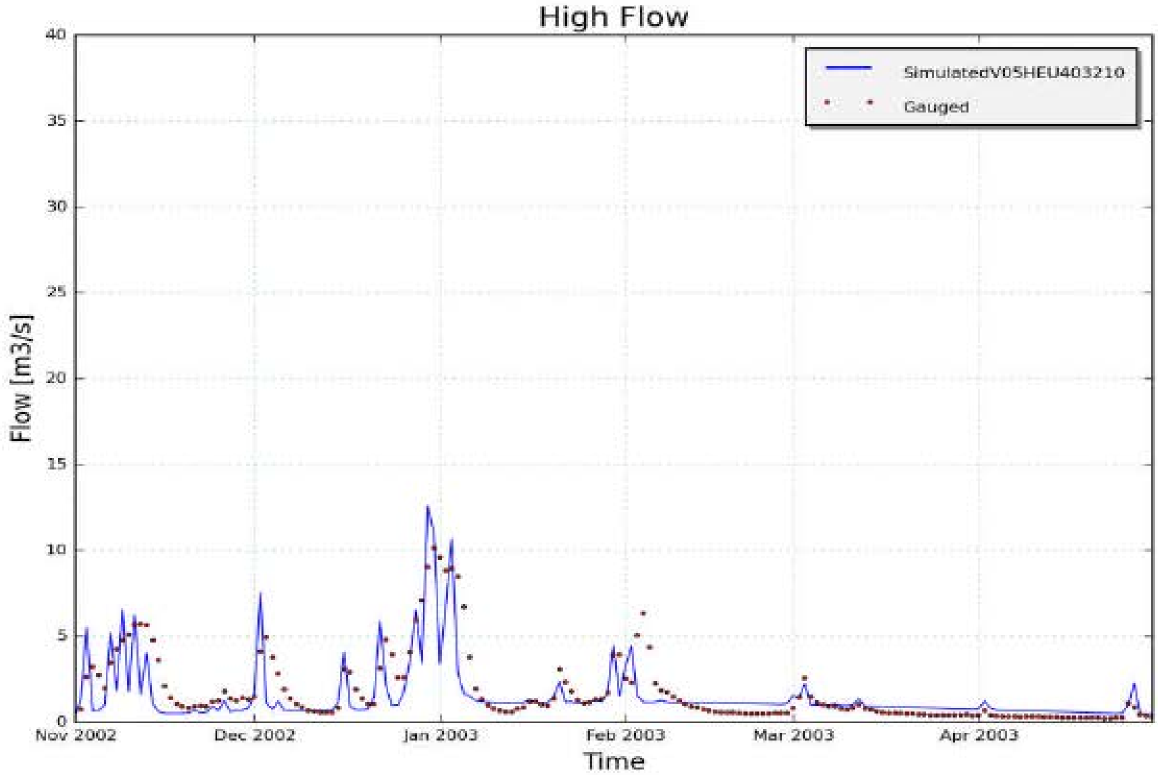


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V05HEU403210, station 40310102 - Heulebeek; Heule

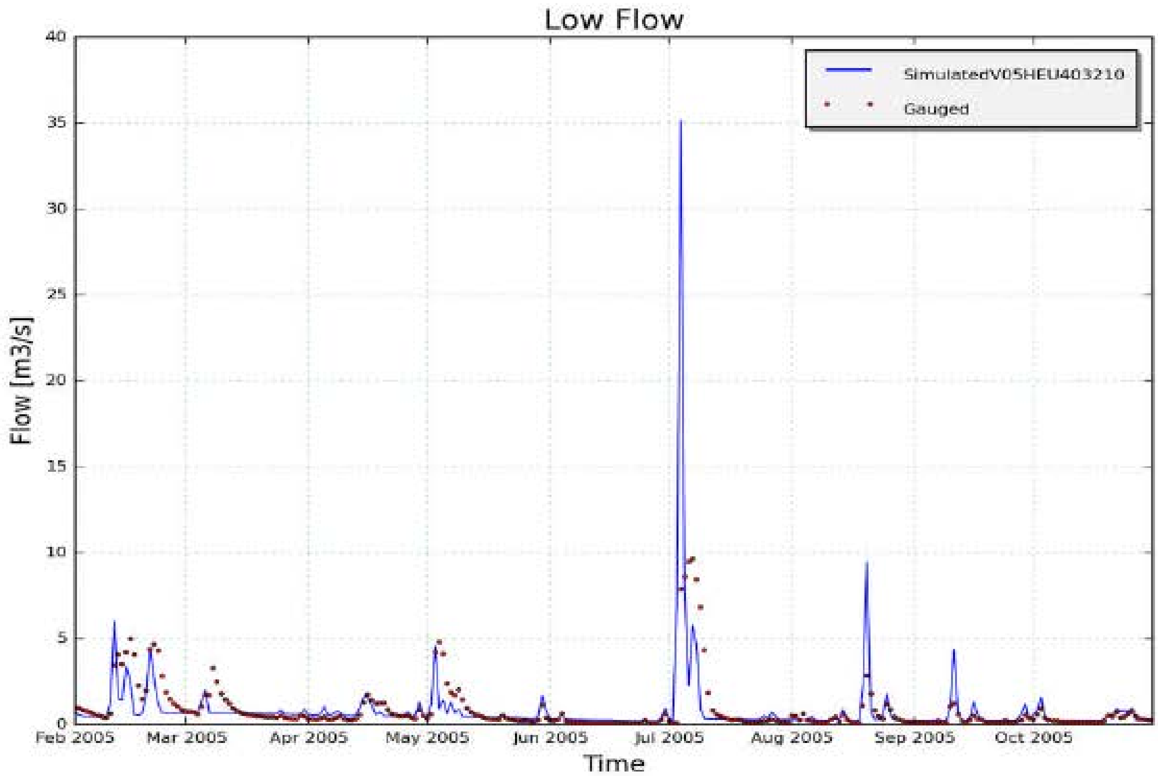


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V05HEU403210, station 40310102 - Heulebeek; Heule

9.5.2 Calibration and validation of WET parameters for catchment "V05MAN401230" (Leiebekken)

9.5.2.1 Input data

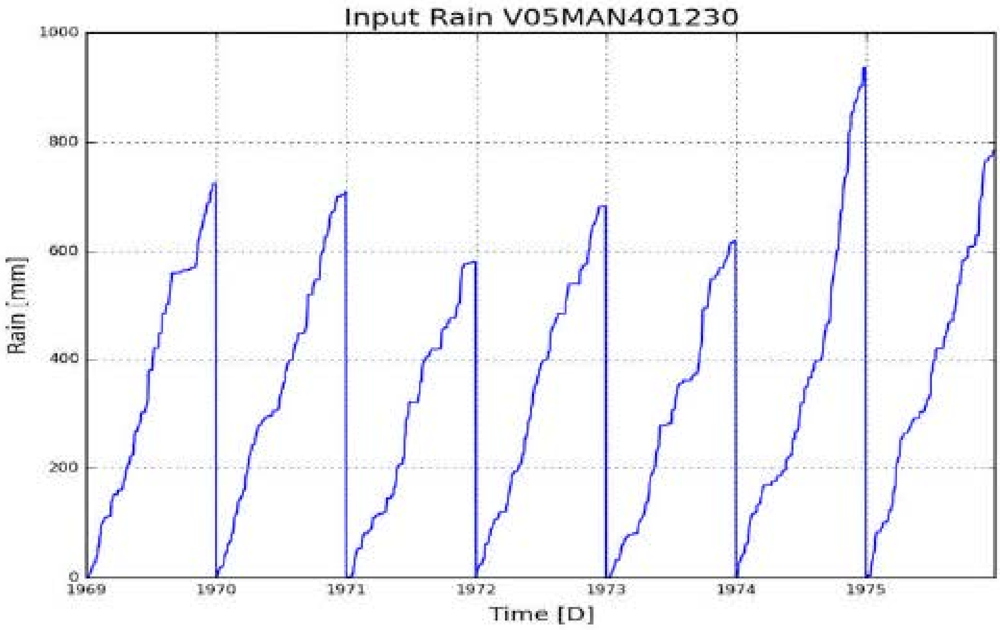


Figure 1: Cumulative precipitation on catchment V05MAN401230 (Leiebekken)

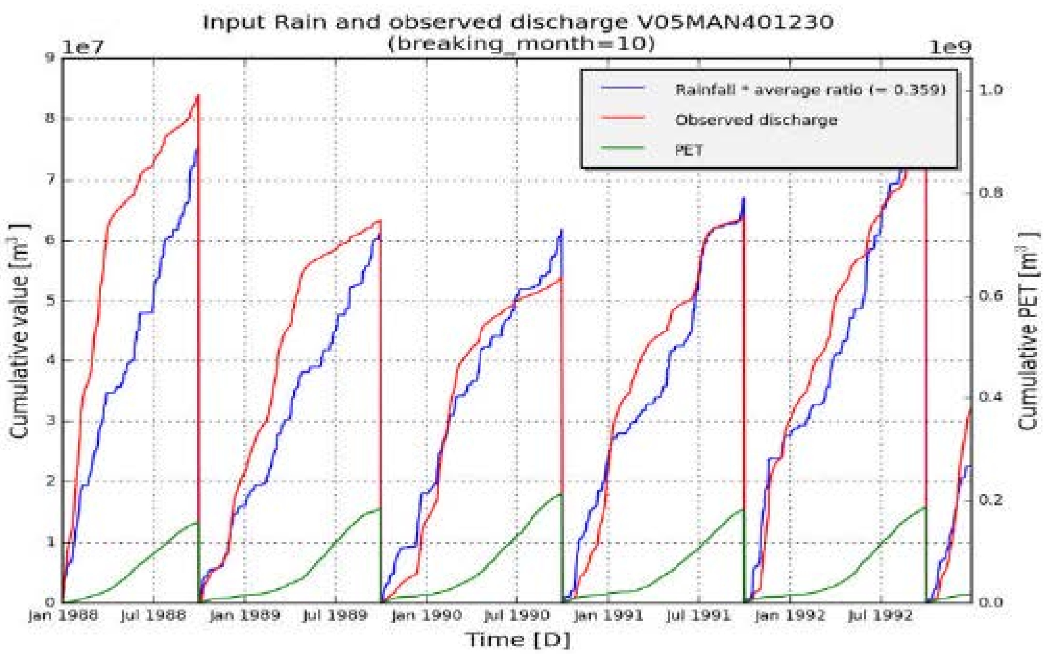


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V05MAN401230 (Leiebekken)

9.5.2.2 Model summary

model_structure	WETSPAclassic.paramset1

subcatchment_name	V05MAN401230
subcatchment_area [m2]	258400000
Validation start_date	01-01-1970
Validation end_date	31-12-1975
frequency	daily

Optimal parameter set:[('Kep', 1.25), ('Ki', 104.81), ('Kg', 0.01), ('Kss', 2.61), ('g0', 193.62), ('g_max', 306.54), ('K_run', 3.0), ('P_max', 122.86)]

Table 1: Goodness of fit for calibration period (1988 - 1992)

	Full year	**Summer**	**Winter**
RelErr	-5.0 %	23.4 %	-27.5 %
NS	0.329	-0.218	0.256
NS_log	0.508	0.3	0.379
NS_rel	0.106	0.32	0.455
KGE	0.43	0.402	0.242

Table 2 :Goodness of fit for validation period (1970 - 1975)

	Full year	**Summer**	**Winter**
RelErr	4.3 %	55.2 %	-17.4 %
NS	0.405	-3.078	0.347
NS_log	0.549	-0.422	0.433
NS_rel	-0.195	-5.637	0.355
KGE	0.496	-0.331	0.336

9.5.2.3 Observed and simulated timeseries for optimum parameters

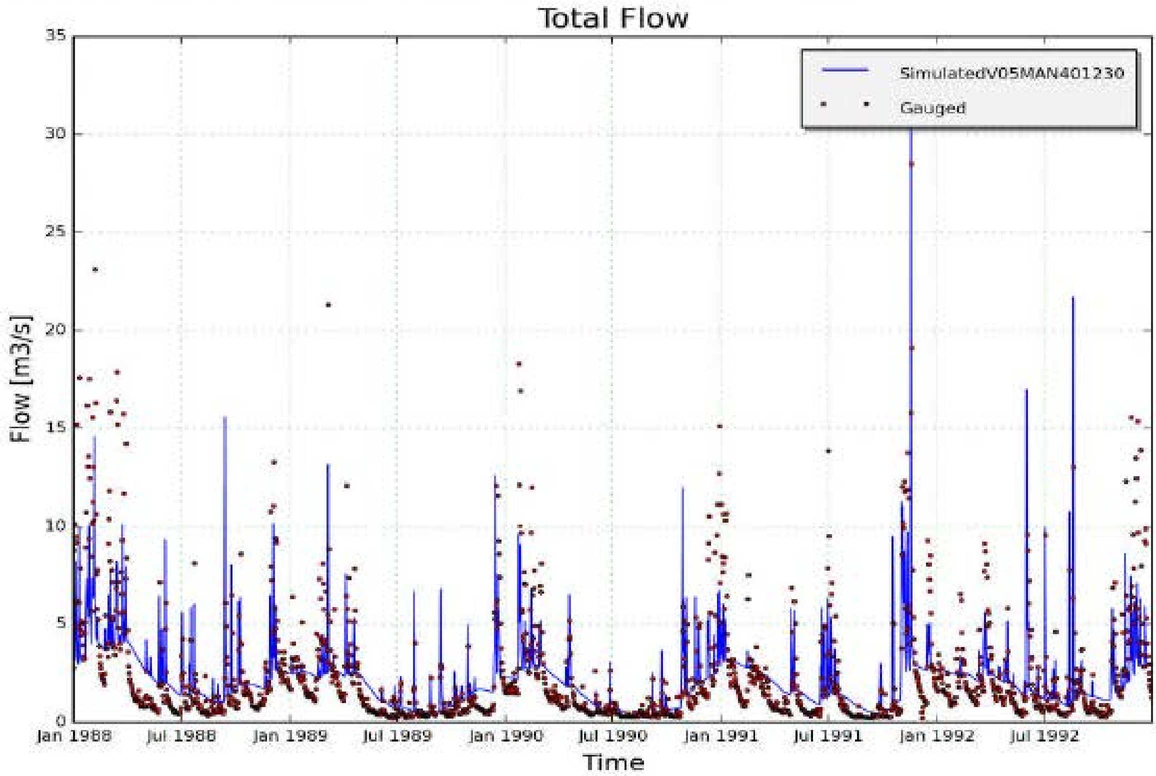


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke(calibration period)

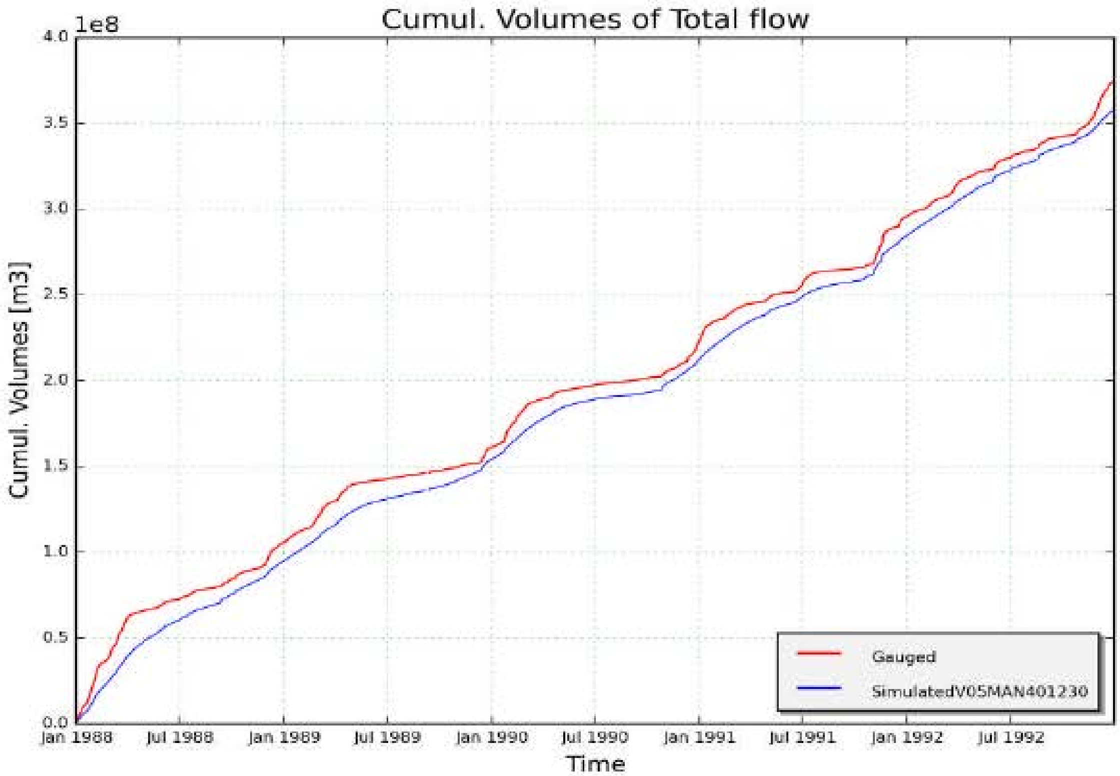


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke (calibration period)

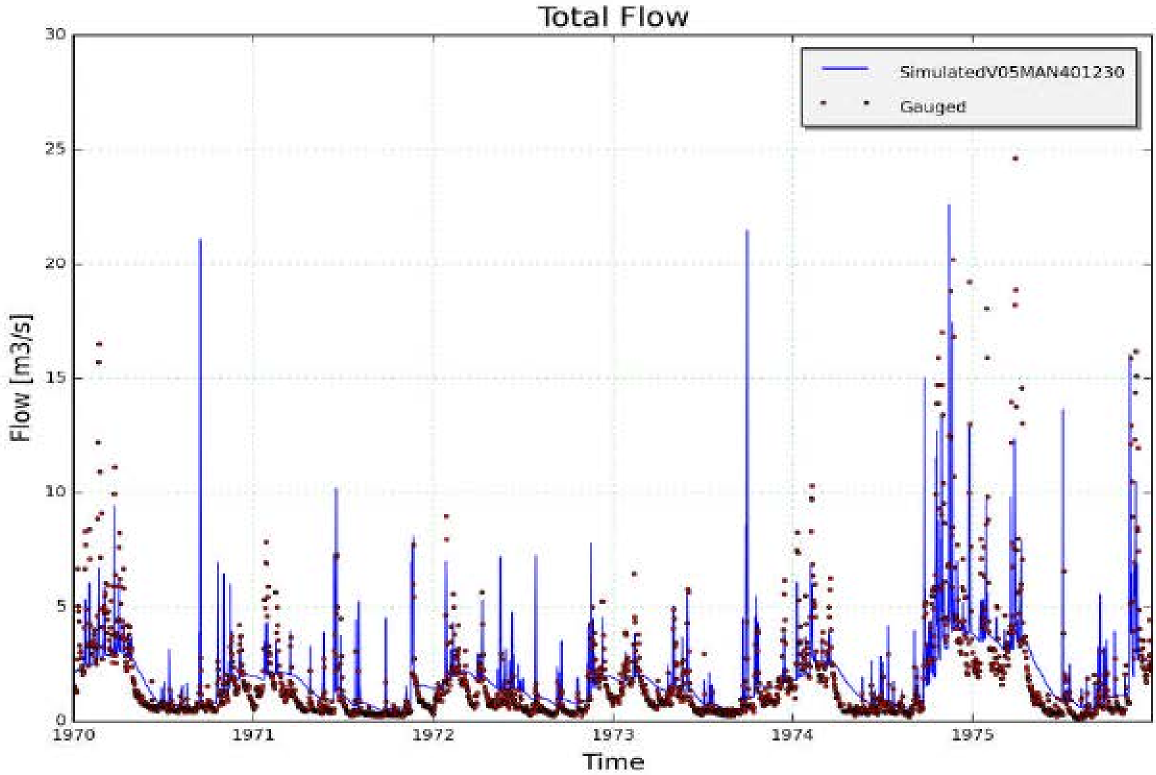


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke (validation period)

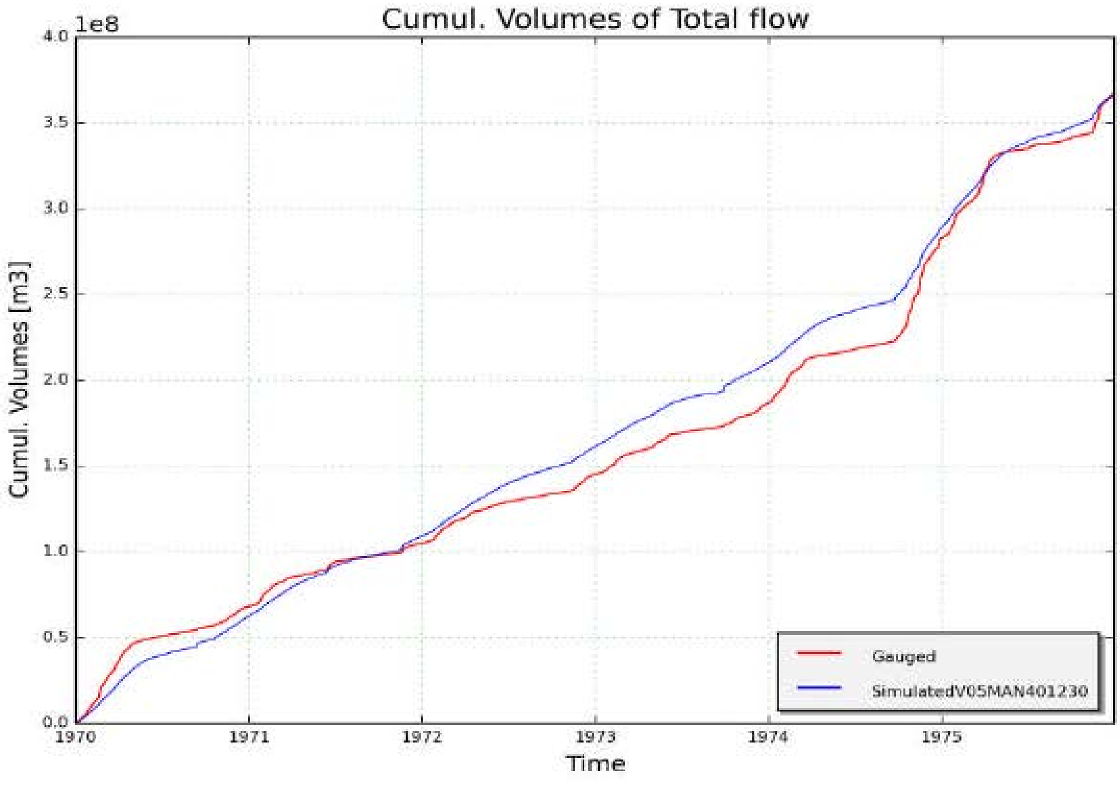


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke (validation period)

9.5.3 Calibration and validation of WET parameters for catchment "F05LEI386999" (Leiebekken)

9.5.3.1 Input data

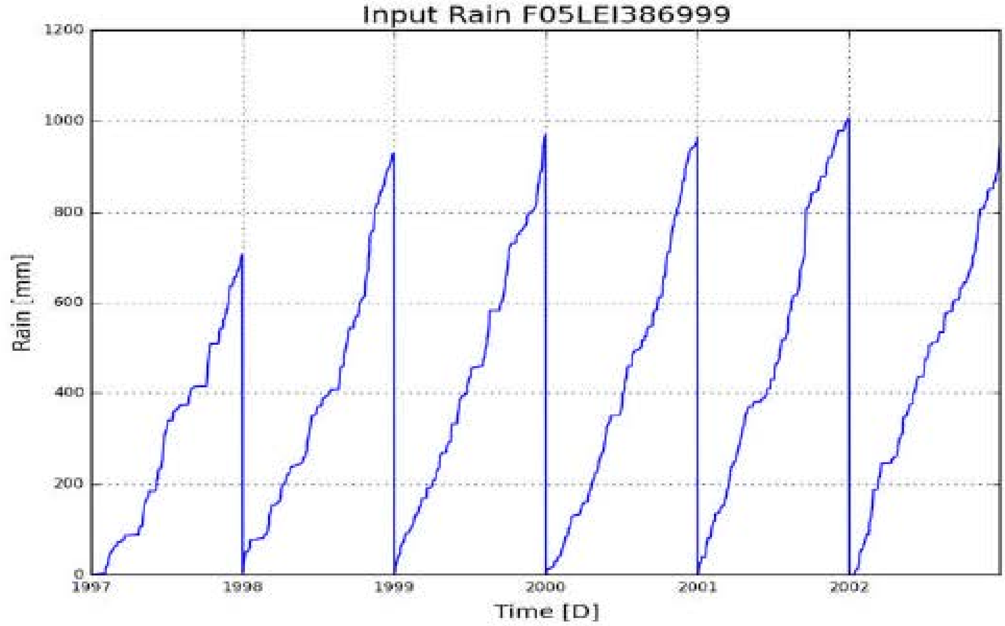


Figure 1: Cumulative precipitation on catchment F05LEI386999 (Leiebekken)

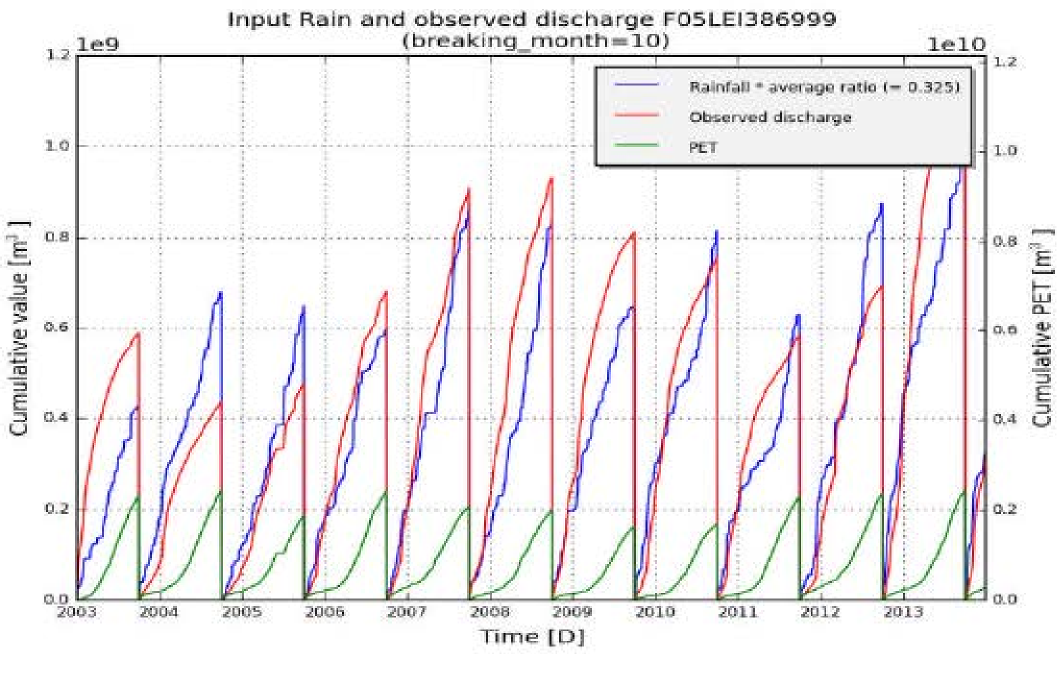


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment F05LEI386999 (Leiebekken)

9.5.3.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	F05LEI386999
subcatchment_area [m2]	2981800000
Validation start_date	01-01-1998
Validation end_date	31-12-2002
frequency	daily

Optimal parameter set:[('Kep', 1.55), ('Ki', 80.25), ('Kg', 0.01), ('Kss', 2.19), ('g0', 157.0), ('g_max', 442.1), ('K_run', 3.4), ('P_max', 196.5)]

Table 1: Goodness of fit for calibration period (2003 - 2013)

	Full year	**Summer**	**Winter**
RelErr	-1.8 %	-3.0 %	-7.8 %
NS	0.457	-0.16	0.573
NS_log	0.607	0.27	0.559
NS_rel	0.663	0.544	0.683
KGE	0.732	0.425	0.767

Table 2 :Goodness of fit for validation period (1998 - 2002)

	Full year	**Summer**	**Winter**
RelErr	-1.5 %	4.4 %	-7.0 %
NS	0.426	-1.53	0.349
NS_log	0.728	0.328	0.464
NS_rel	0.738	0.589	0.637
KGE	0.716	-0.202	0.685

9.5.3.3 Observed and simulated timeseries for optimum parameters

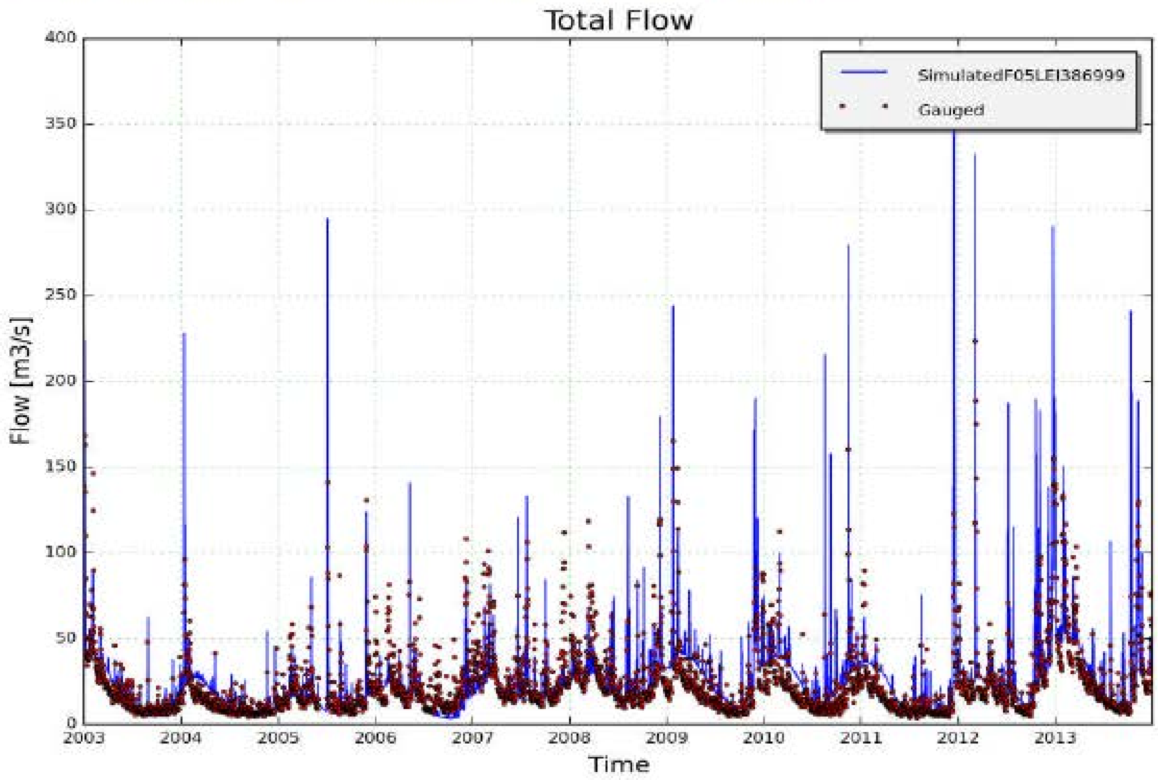


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment F05LEI386999, station unkown(calibration period)

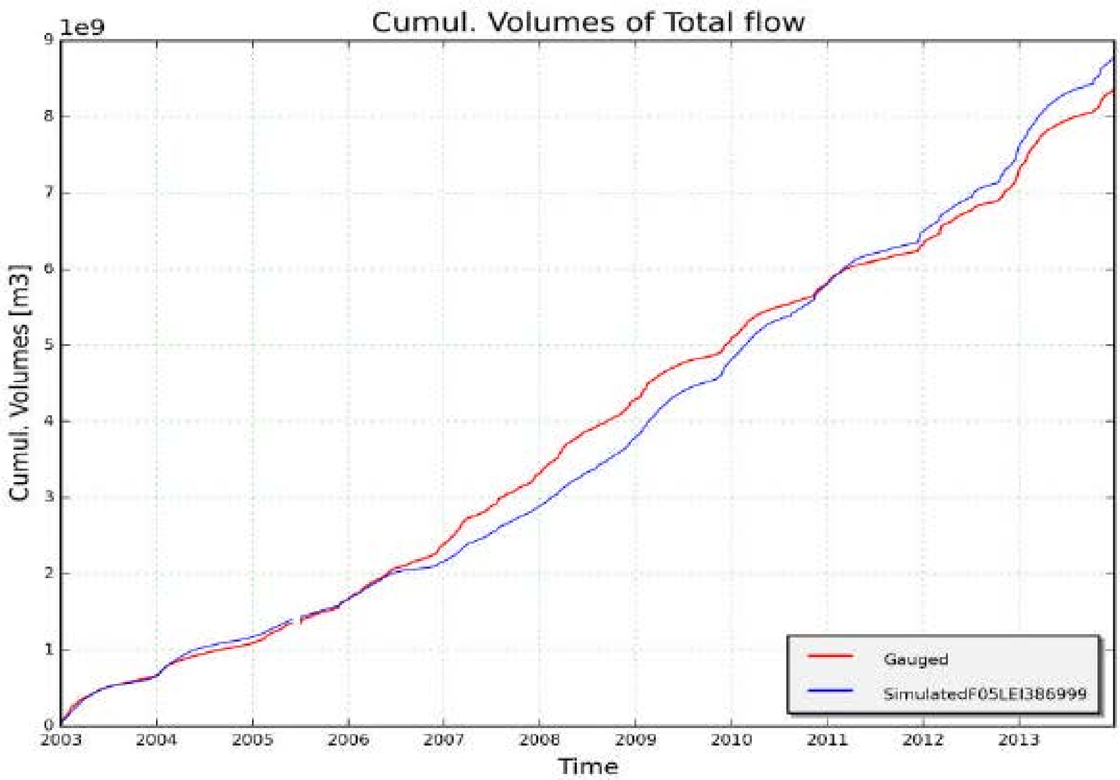


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment F05LEI386999, station unkown (calibration period)

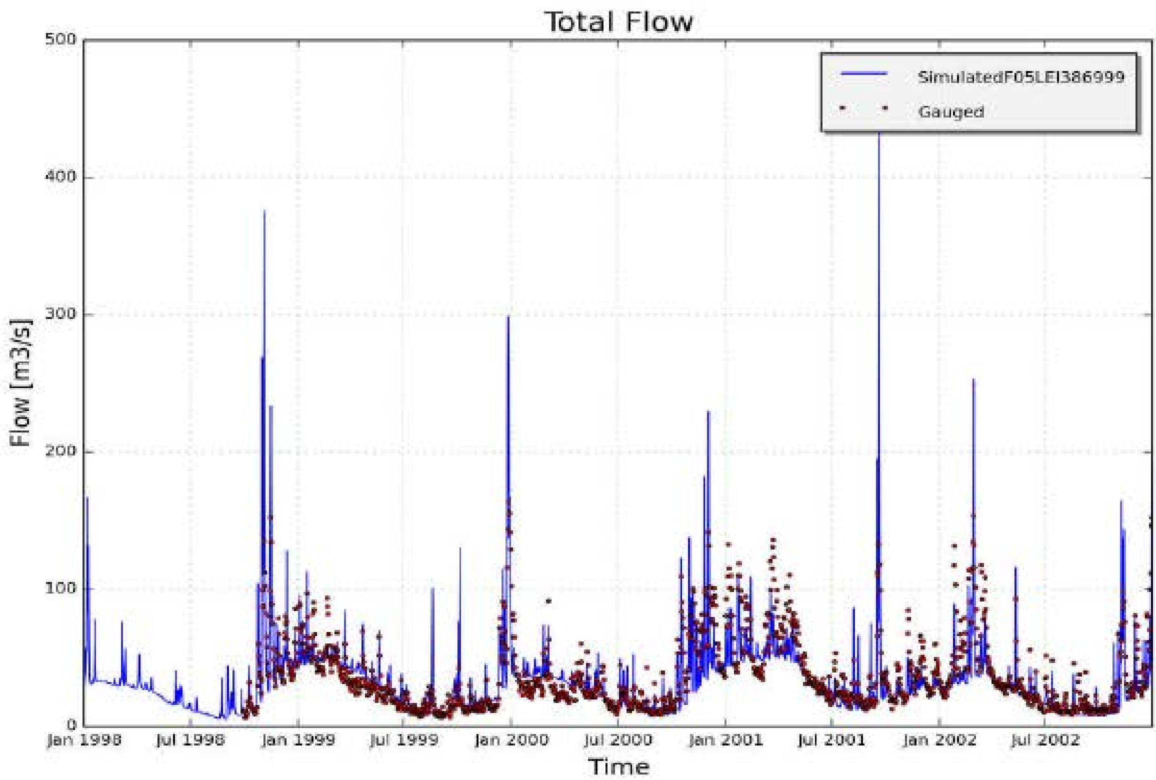


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment F05LEI386999, station unkown (validation period)

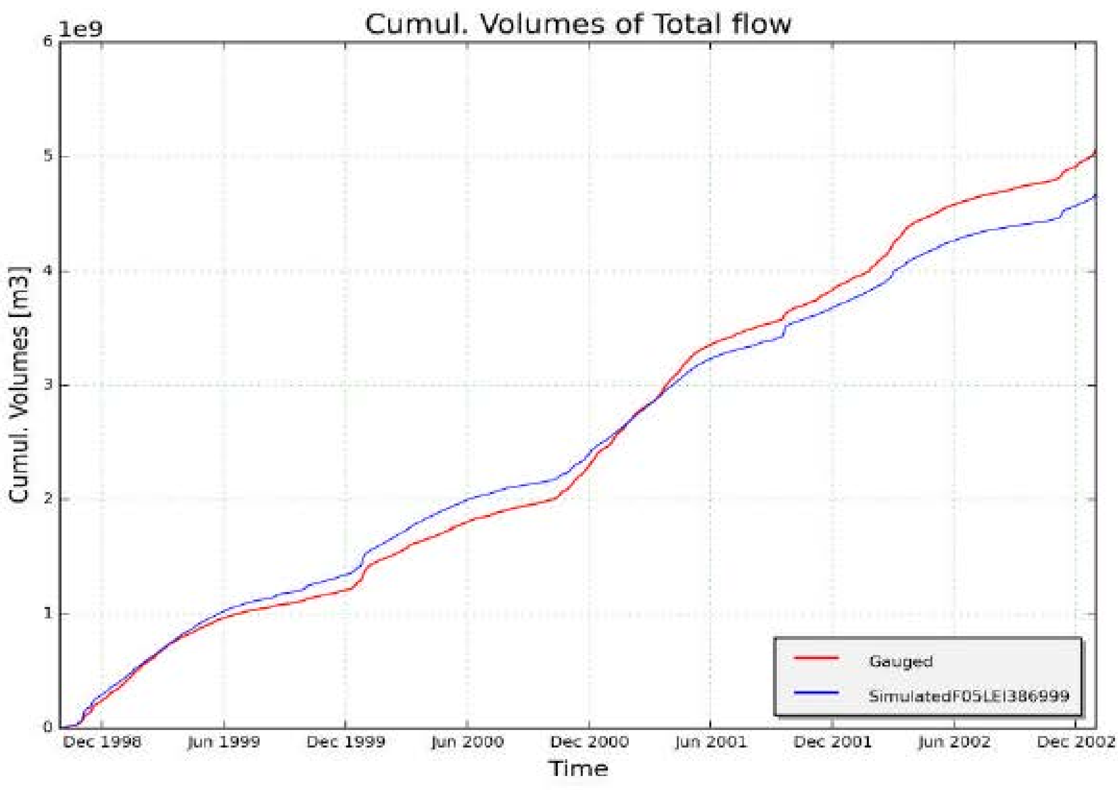


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment F05LEI386999, station unkown (validation period)

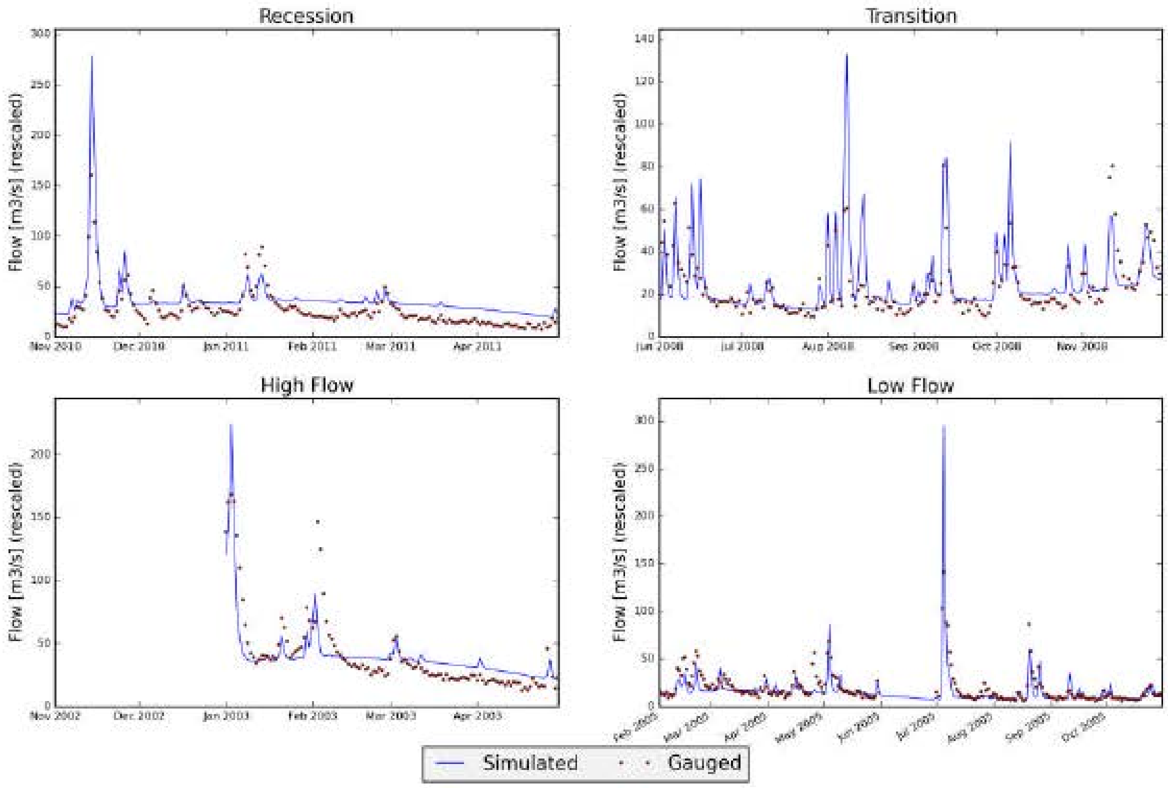


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment F05LEI386999, station unkown

Appendix 11 Leie Autocalibration.

9.5.1 Report on simulation of catchment V05HEU403210 (2017-01-23 20-18)

9.5.1.1 Input data

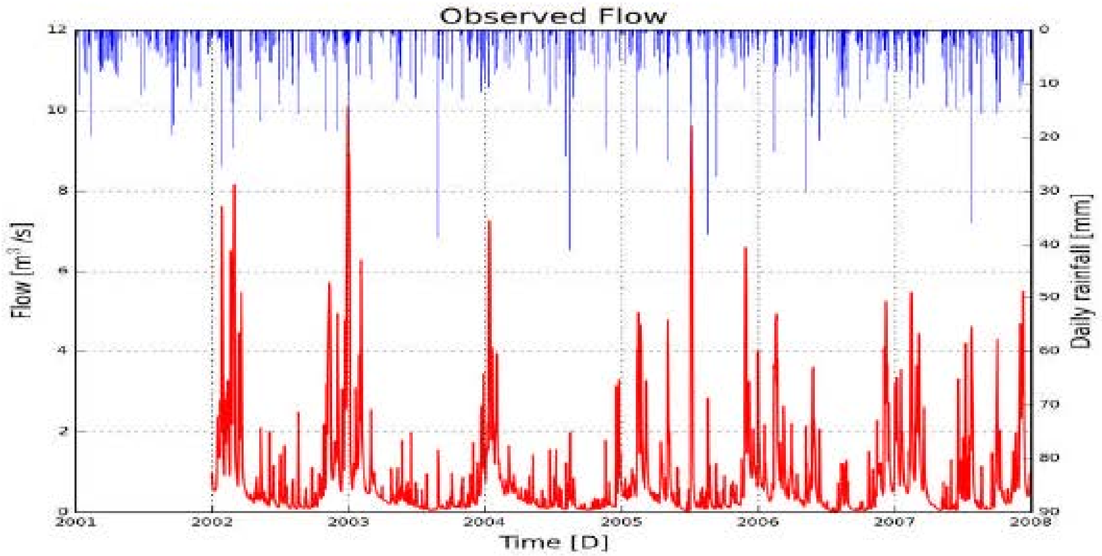


Figure 1: Hyetogram of observed discharge and observed net rain

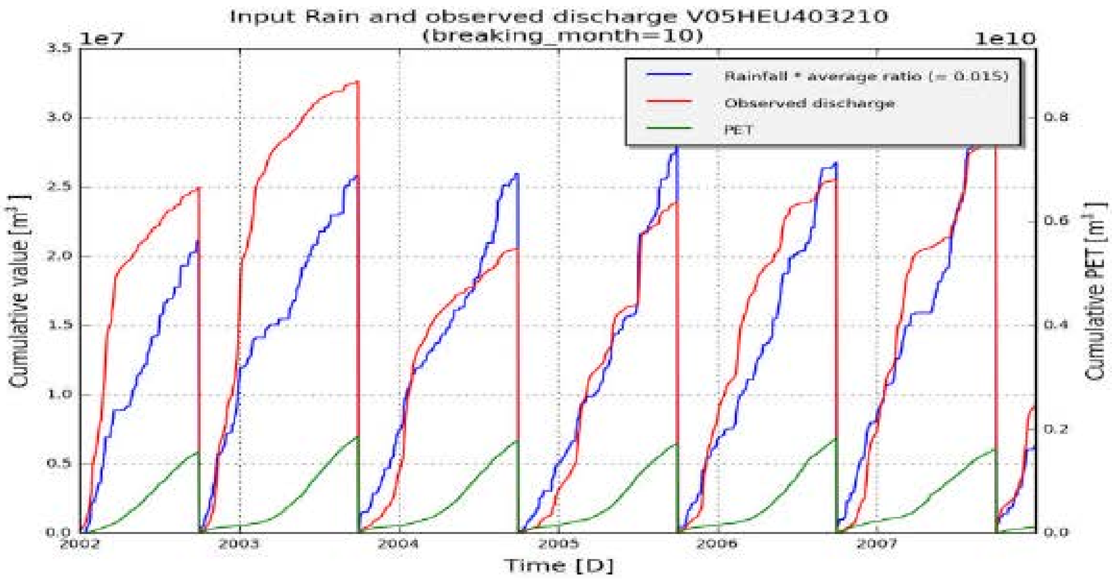


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.1.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V05HEU403210
subcatchment_area	91900000
start_date	200201010000
end_date	200712310000
frequency	86400
warmup	365

9.5.1.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.5, 80.0, 0.0023, 1.0, 170.0, 300.0, 4.7, 600.0]
low_bounds	[0.01, 1.0, 1e-05, 0.1, 1.0, 3.0, 0.1, 1.0]
high_bounds	[5.0, 120.0, 0.01, 6.0, 1000.0, 1000.0, 5.0, 2000.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.5), ('Ki', 80.0), ('Kg', 0.0023), ('Kss', 1.0), ('g0', 170.0), ('g_max', 300.0), ('K_run', 4.7), ('P_max', 600.0)]
Initial fitness:

- RelErr: -0.394
- AbsErr: 34287811.331
- KGE: 0.482
- NS_rel: -1.892
- NS: 0.369
- RMSE: 37757344.724
- NS_log: 0.614

Computation time:9:17:50.732000

9.5.1.4 Results

Best individual (euclidian): [('Kep', 2.2), ('Ki', 101.964), ('Kg', 0.01), ('Kss', 4.814), ('g0', 762.638), ('g_max', 690.85), ('K_run', 1.14), ('P_max', 1262.899)]

Fitness:

- RelErr: -0.058
- AbsErr: 5090530.418
- KGE: 0.621
- NS_rel: -3.092
- NS: 0.193
- RMSE: 5411243.699
- NS_log: 0.629

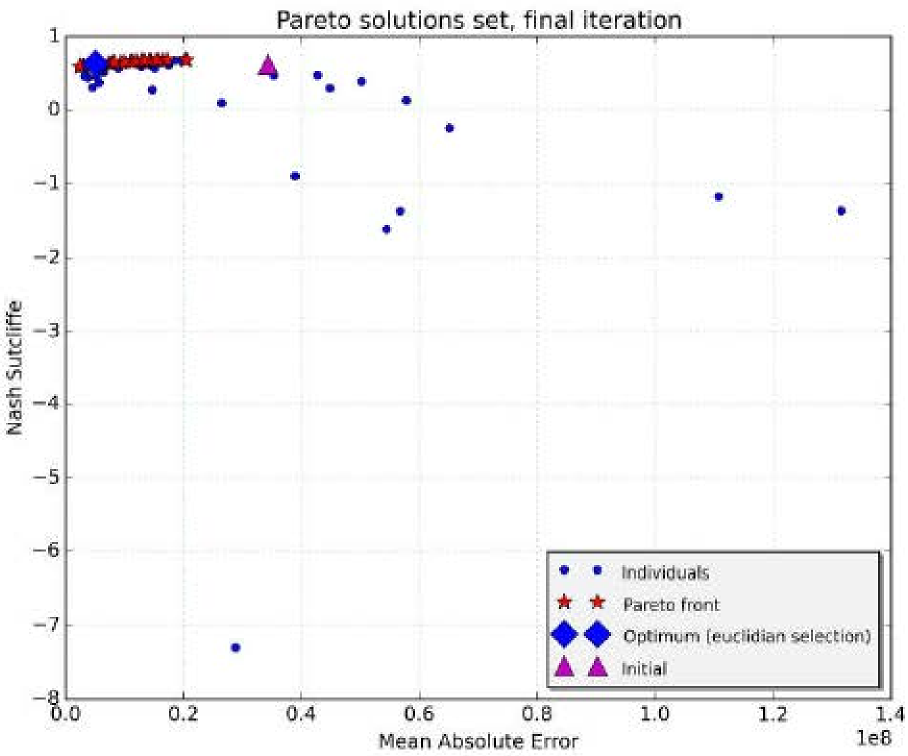


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

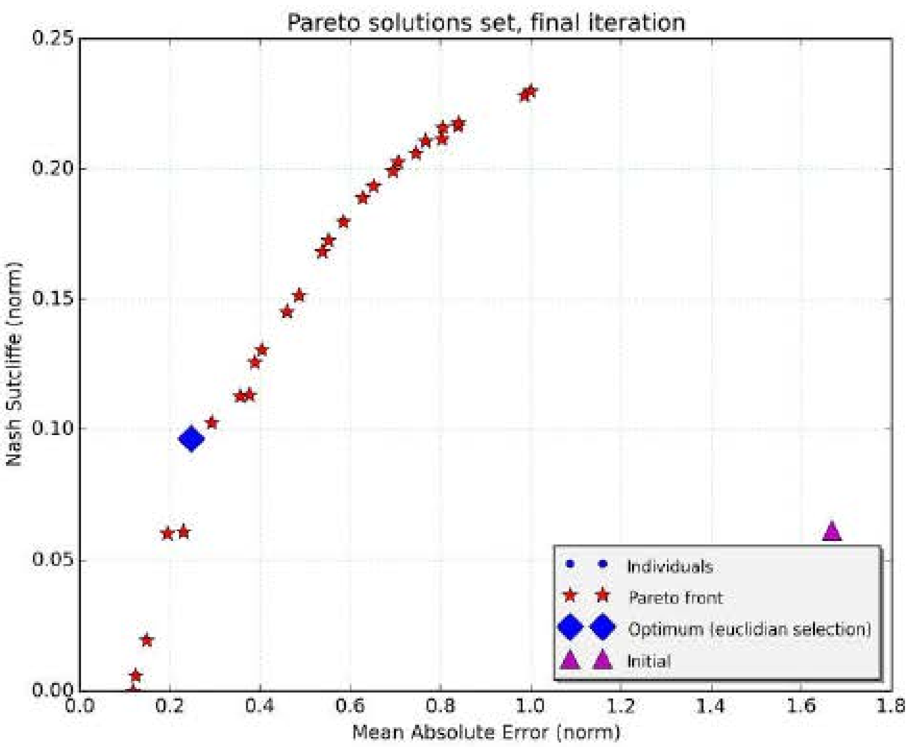


Figure 4: Final population of solutions (Pareto front)

9.5.1.4.1 Initial

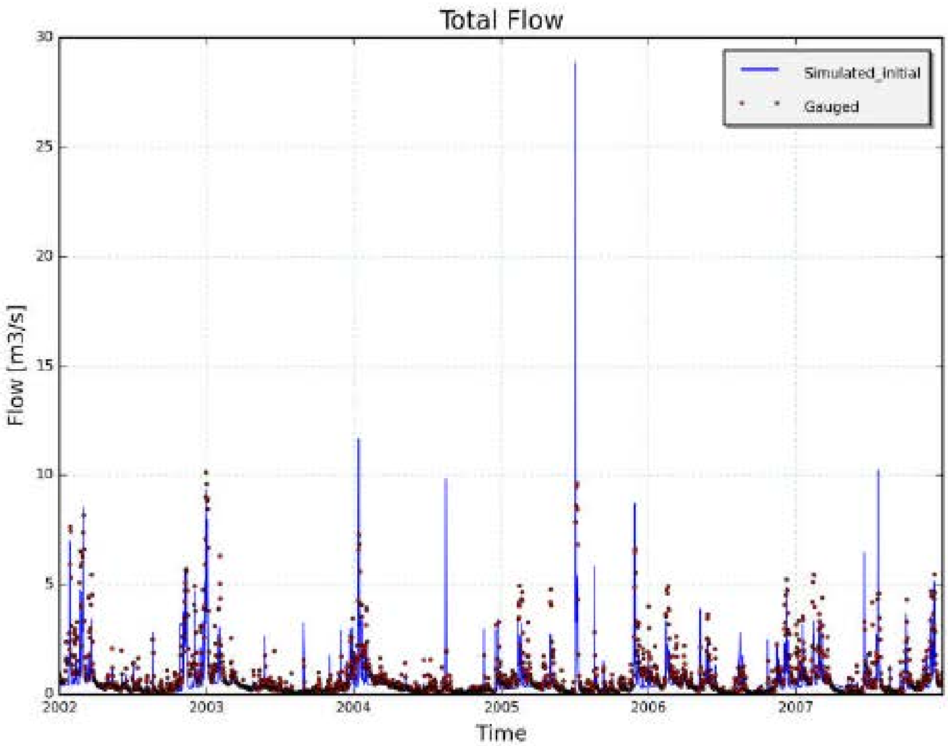


Figure 5: Total flow with initial parameters

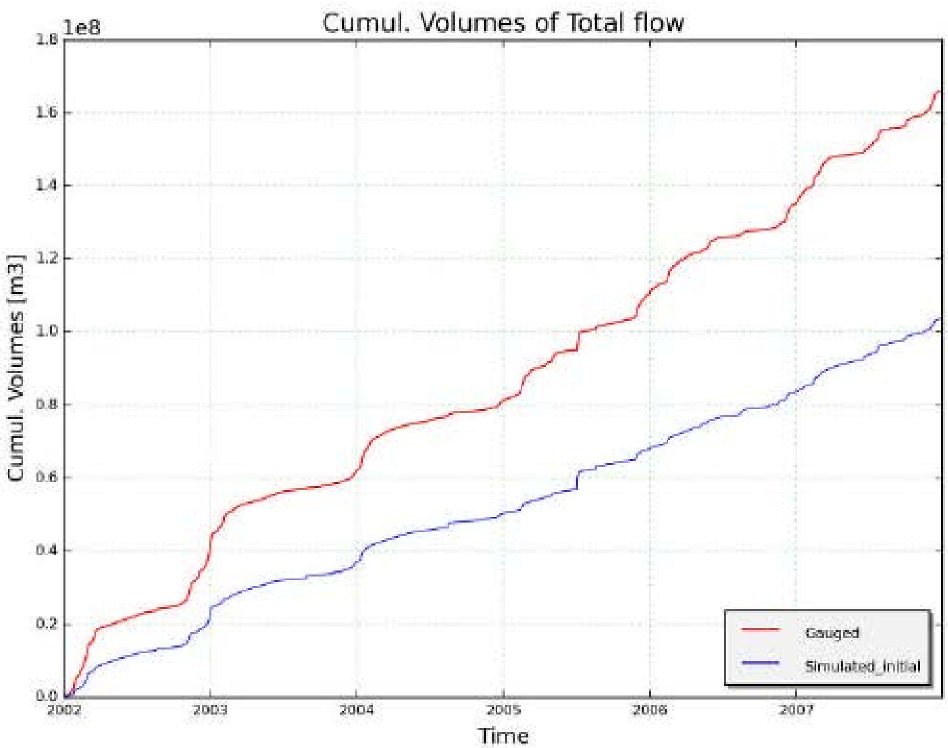


Figure 6: Cumulated flow with initial parameters

9.5.1.4.2 Optimum (euclidian)

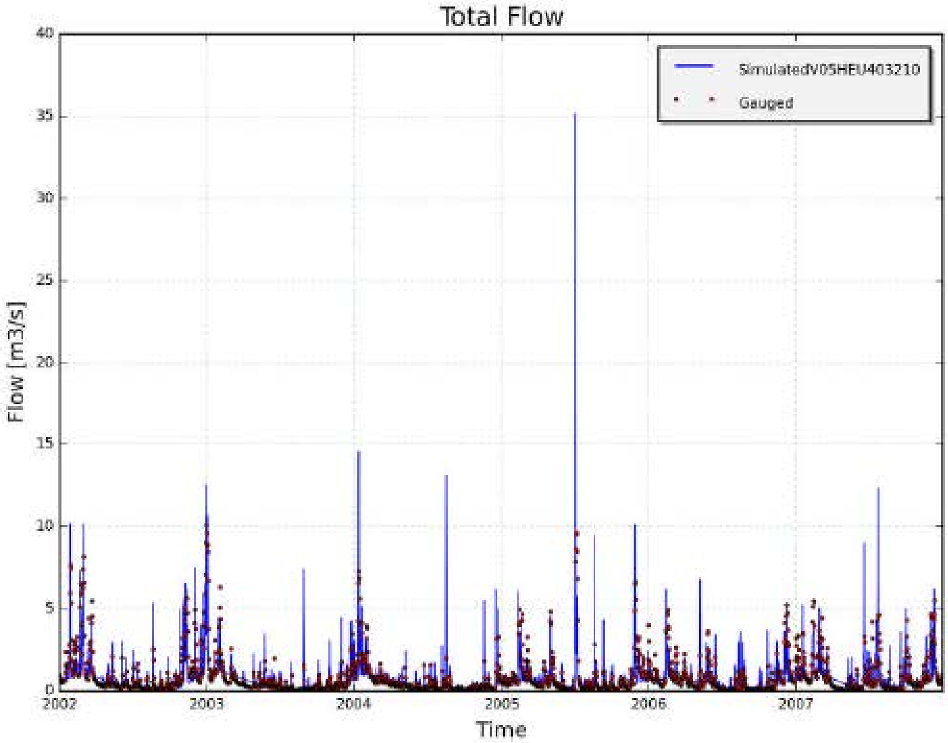


Figure 7: Total flow with optimum parameters

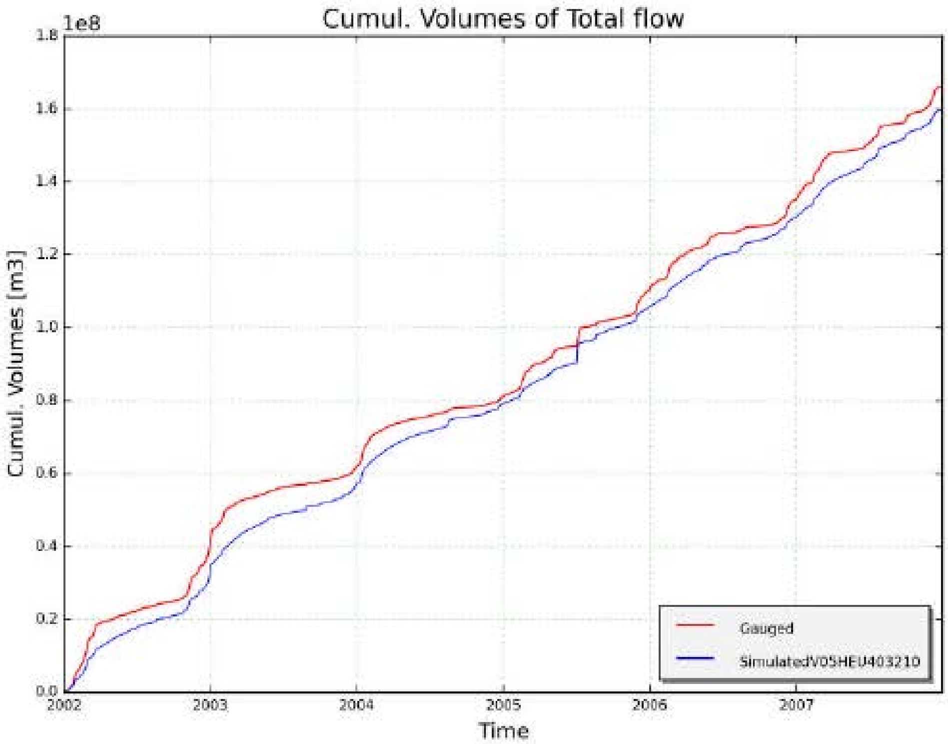


Figure 8: Cumulated flow with optimum parameters

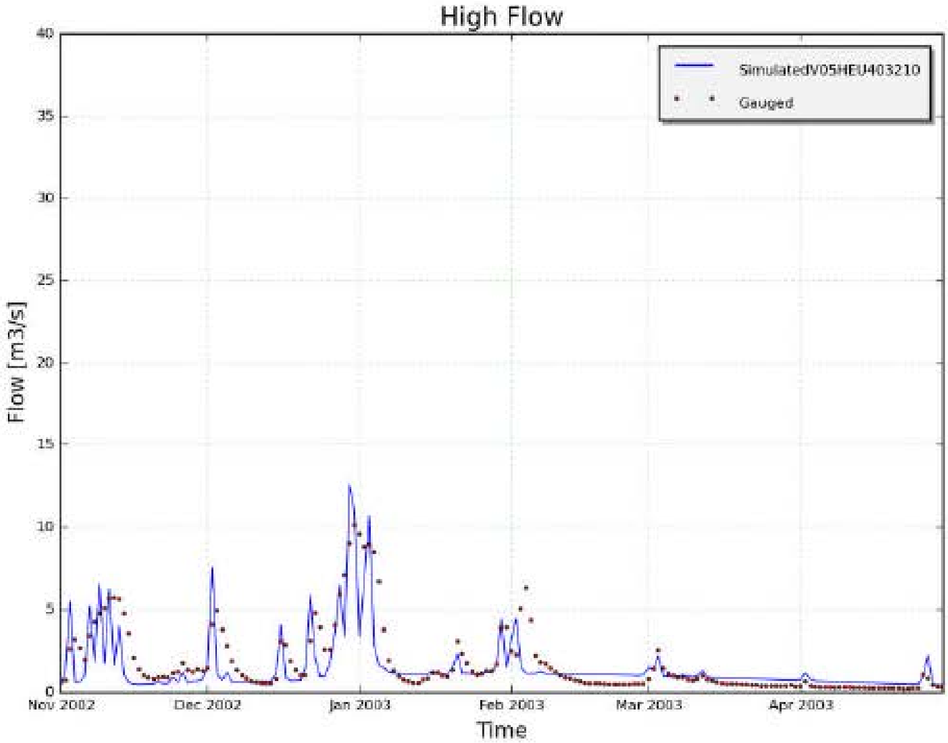


Figure 9: Total flow with optimum parameters (detail)

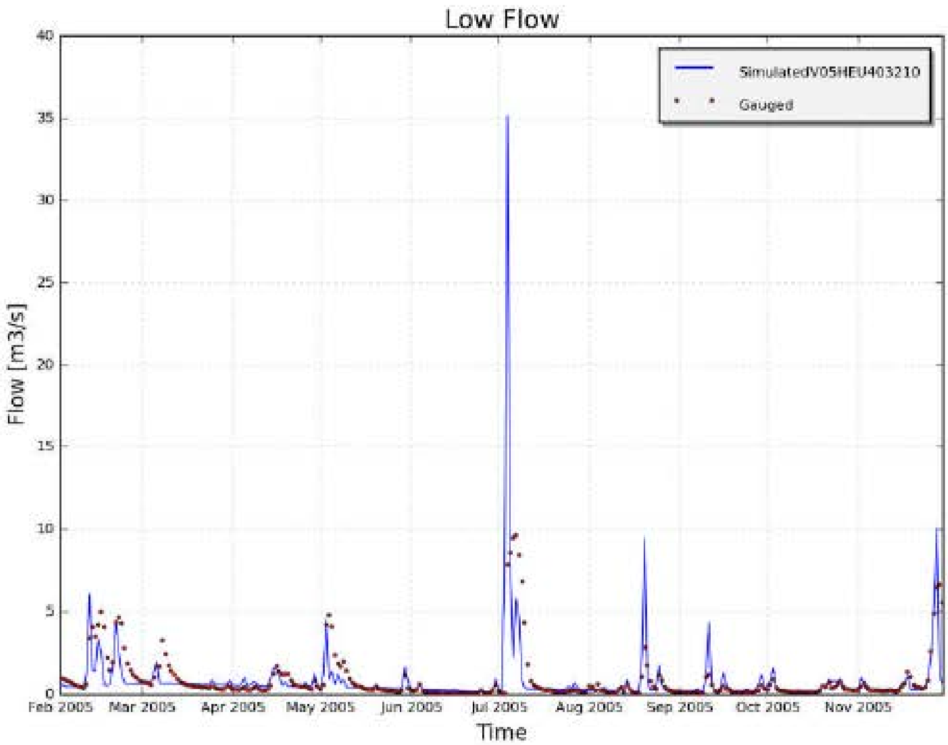
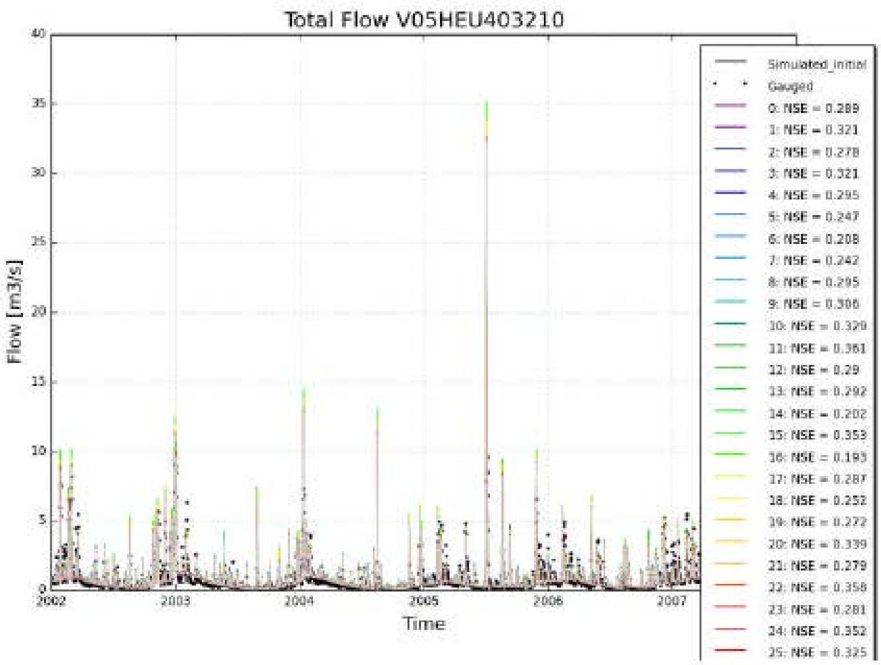


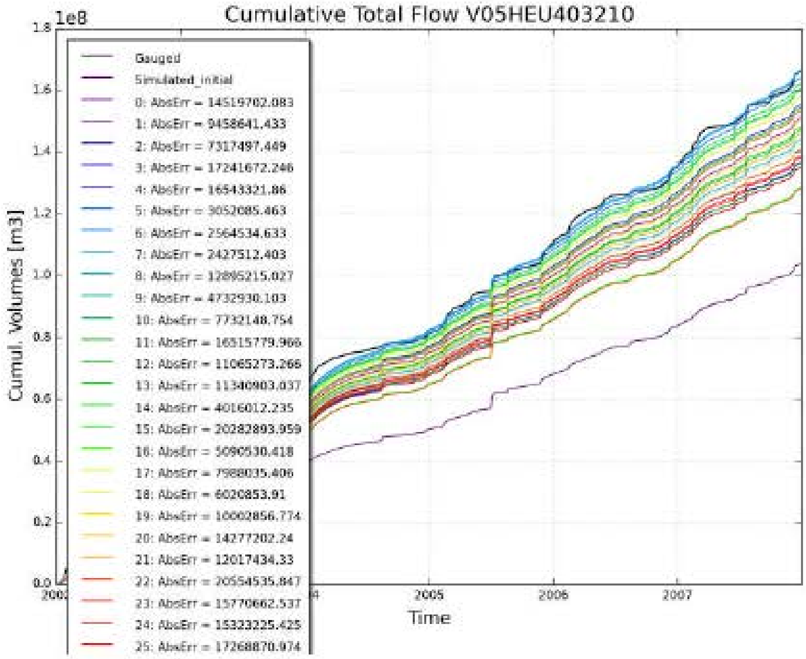
Figure 10: Total flow with optimum parameters (detail)

9.5.1.4.3 Final archive

0 : [2.531, 84.842, 0.01, 4.673, 357.067, 688.011, 1.299, 950.033] : [14519702.083, 0.672]
1 : [2.344, 65.671, 0.01, 5.26, 757.454, 691.934, 1.116, 1094.821] : [9458641.433, 0.649]
2 : [2.346, 65.363, 0.01, 6.0, 755.045, 730.456, 0.948, 1628.989] : [7317497.449, 0.635]

3 : [2.611, 84.058, 0.01, 3.585, 442.46, 712.957, 1.549, 850.996] : [17241672.246, 0.678]
4 : [2.614, 84.178, 0.01, 3.938, 455.31, 681.52, 1.337, 926.303] : [16543321.86, 0.678]
5 : [2.143, 71.943, 0.009, 5.871, 816.113, 737.228, 0.951, 795.717] : [3052085.463, 0.597]
6 : [2.118, 97.252, 0.01, 4.845, 414.462, 777.522, 1.16, 1485.861] : [2564534.633, 0.592]
7 : [2.117, 85.676, 0.01, 3.711, 727.411, 771.618, 1.116, 1119.357] : [2427512.403, 0.589]
8 : [2.466, 81.497, 0.01, 5.199, 424.749, 692.239, 1.262, 1068.279] : [12895215.027, 0.667]
9 : [2.189, 68.418, 0.01, 4.847, 754.165, 718.834, 1.09, 1627.956] : [4732930.103, 0.614]
10 : [2.25, 71.84, 0.01, 4.759, 658.611, 698.283, 1.251, 1376.727] : [7732148.754, 0.636]
11 : [2.514, 77.41, 0.01, 5.196, 505.134, 690.579, 1.704, 938.184] : [16515779.966, 0.676]
12 : [2.402, 76.383, 0.01, 4.709, 331.334, 688.57, 1.158, 1022.314] : [11065273.266, 0.658]
13 : [2.429, 78.532, 0.01, 5.343, 707.734, 704.352, 1.196, 1030.315] : [11340903.037, 0.66]
14 : [2.165, 98.517, 0.01, 3.62, 686.007, 726.898, 1.139, 1437.708] : [4016012.235, 0.614]
15 : [2.695, 80.026, 0.01, 5.173, 744.659, 704.074, 1.811, 1033.881] : [20282893.959, 0.683]
16 : [2.2, 101.964, 0.01, 4.814, 762.638, 690.85, 1.14, 1262.899] : [5090530.418, 0.629]
17 : [2.278, 82.361, 0.01, 4.617, 622.61, 702.302, 1.23, 950.542] : [7988035.406, 0.641]
18 : [2.218, 86.902, 0.01, 4.87, 619.782, 692.234, 1.148, 1335.685] : [6020853.91, 0.631]
19 : [2.433, 74.89, 0.01, 5.512, 718.449, 731.052, 1.054, 1139.278] : [10002856.774, 0.651]
20 : [2.471, 76.701, 0.01, 5.341, 602.054, 692.917, 1.467, 952.147] : [14277202.24, 0.671]
21 : [2.44, 85.527, 0.01, 4.713, 471.536, 697.414, 1.249, 952.536] : [12017434.33, 0.663]
22 : [2.701, 77.255, 0.01, 5.315, 633.716, 699.958, 1.794, 947.013] : [20554535.847, 0.684]
23 : [2.603, 87.127, 0.01, 4.783, 709.902, 687.226, 1.296, 1043.504] : [15770662.537, 0.676]
24 : [2.494, 76.611, 0.01, 5.157, 651.711, 693.256, 1.579, 952.947] : [15323225.425, 0.674]
25 : [2.61, 82.47, 0.01, 4.271, 481.918, 708.797, 1.54, 924.76] : [17268870.974, 0.679]
26 : [2.301, 78.873, 0.01, 5.248, 662.197, 704.496, 1.188, 1342.16] : [8299498.052, 0.643]
27 : [2.522, 79.061, 0.01, 4.844, 673.634, 697.414, 1.184, 1053.447] : [13391858.24, 0.669]





9.5.2 Report on simulation of catchment V05MAN401230 (2017-01-17 23-15)

9.5.2.1 Input data

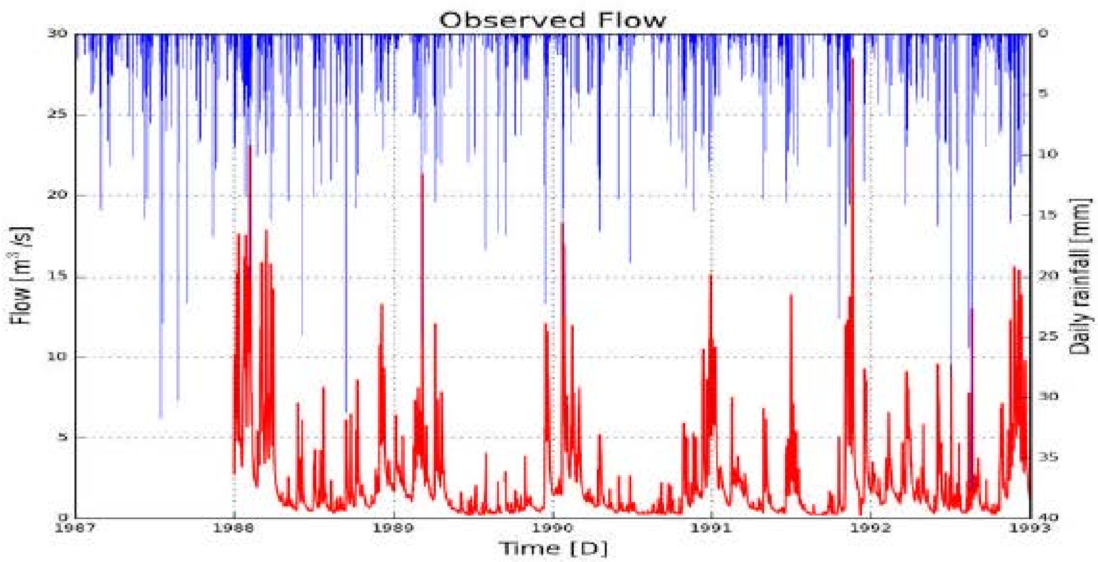


Figure 1: Hyetogram of observed discharge and observed net rain

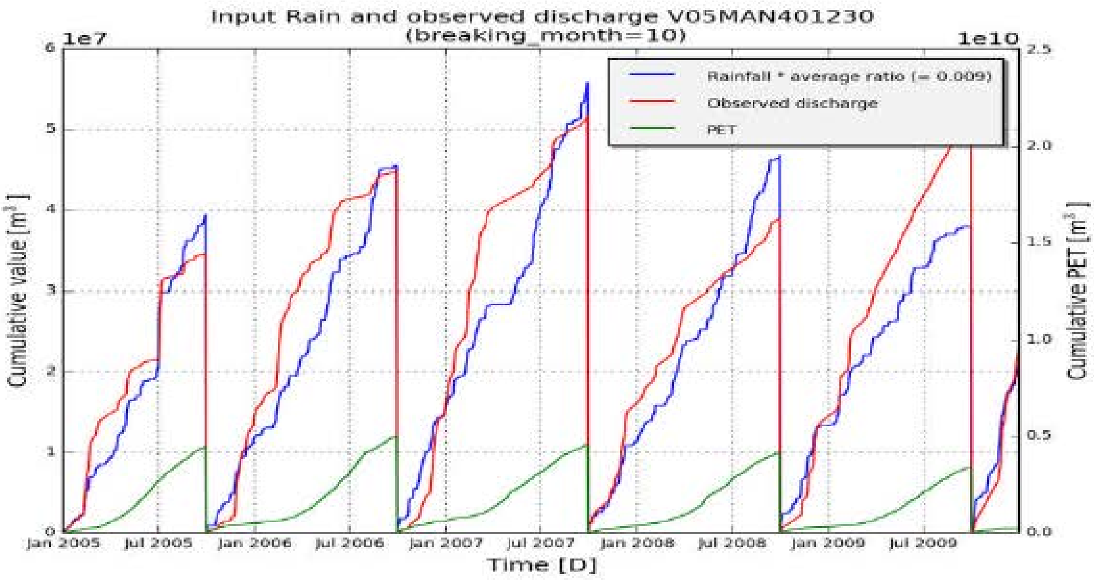


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.2.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V05MAN401230
subcatchment_area	258400000
start_date	198801010000
end_date	199212310000
frequency	86400
warmup	365

9.5.2.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.05, 154.24, 0.009, 3.79, 190.409, 350.488, 1.5, 109.549]
low_bounds	[0.5, 78.7, 0.0001, 1.5, 96.7, 178.6, 0.5, 46.0]

high_bounds	[2.0, 236.0, 0.01, 4.54, 290.0, 700.0, 3.0, 140.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.05), ('Ki', 154.24), ('Kg', 0.009), ('Kss', 3.79), ('g0', 190.409), ('g_max', 350.488), ('K_run', 1.5), ('P_max', 109.549)]
Initial fitness:

- RelErr: 0.01
- AbsErr: 7443319.509
- KGE: 0.419
- NS_rel: -0.378
- NS: 0.165
- RMSE: 8815872.7
- NS_log: 0.396

Computation time:7:49:08.766000

9.5.2.4 Results

Best individual (euclidian): [('Kep', 1.255), ('Ki', 104.807), ('Kg', 0.01), ('Kss', 2.608), ('g0', 193.622), ('g_max', 306.542), ('K_run', 3.0), ('P_max', 122.859)]

Fitness:

- RelErr: -0.05
- AbsErr: 9869501.432
- KGE: 0.43
- NS_rel: 0.106
- NS: 0.329
- RMSE: 10402170.627
- NS_log: 0.508

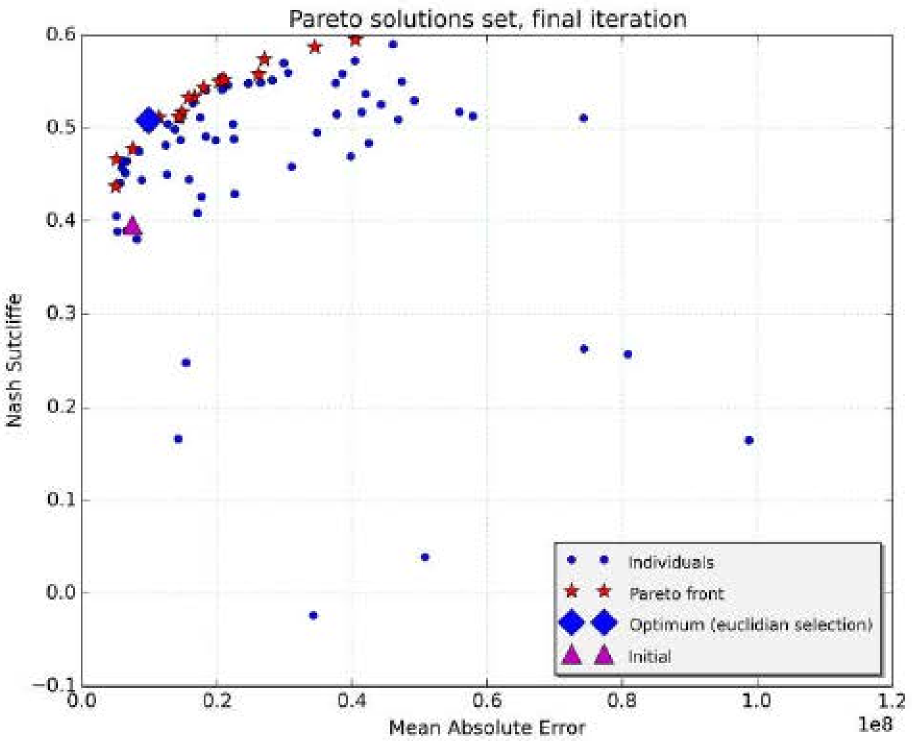


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

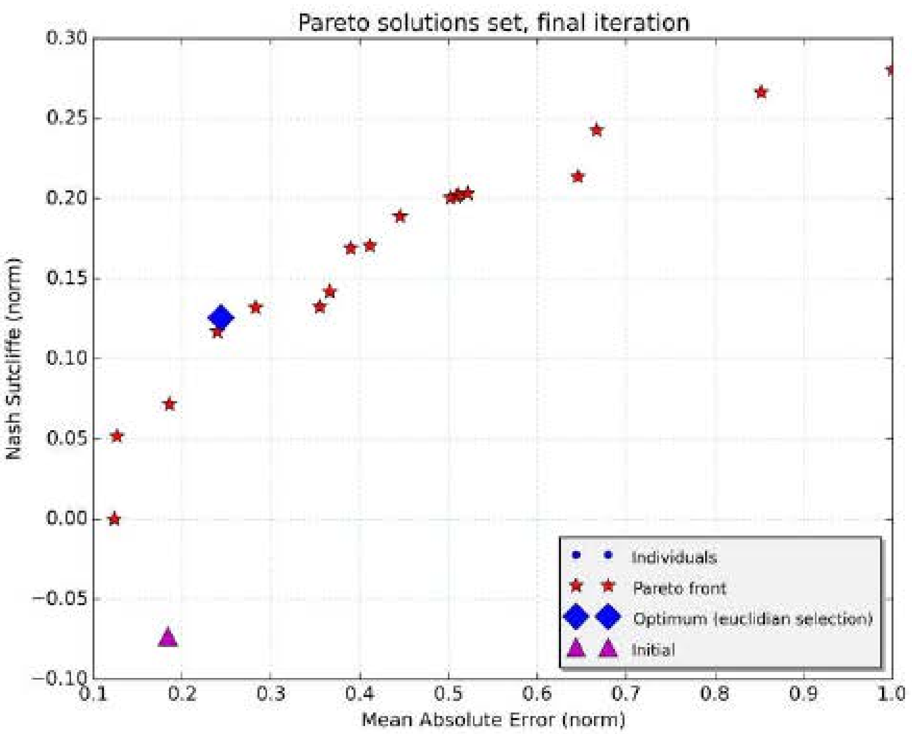


Figure 4: Final population of solutions (Pareto front)

9.5.2.4.1 Initial

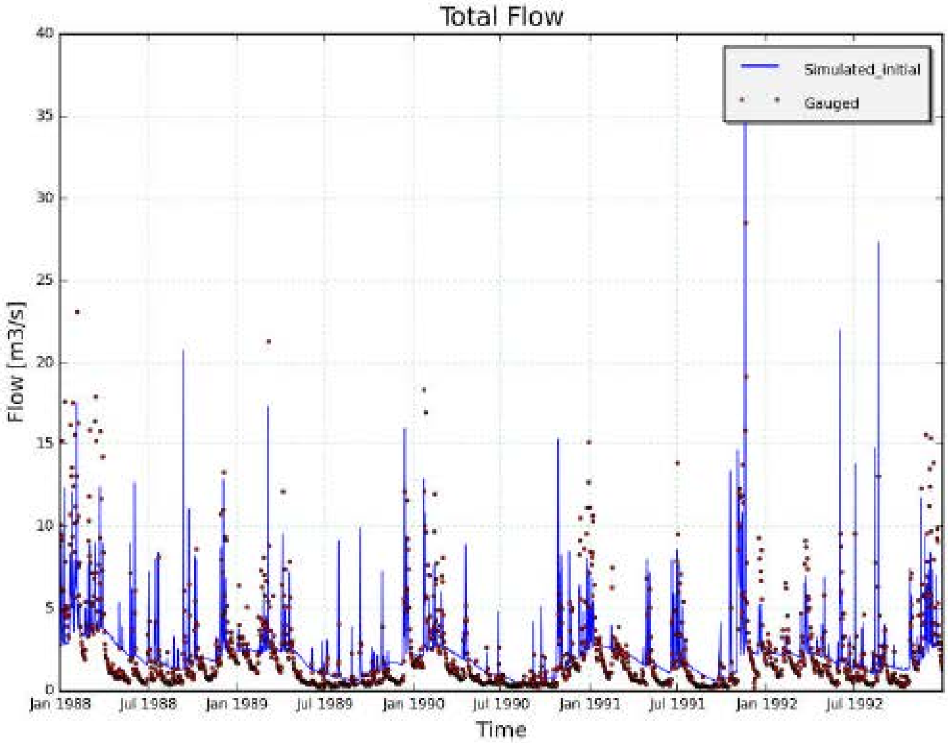


Figure 5: Total flow with initial parameters

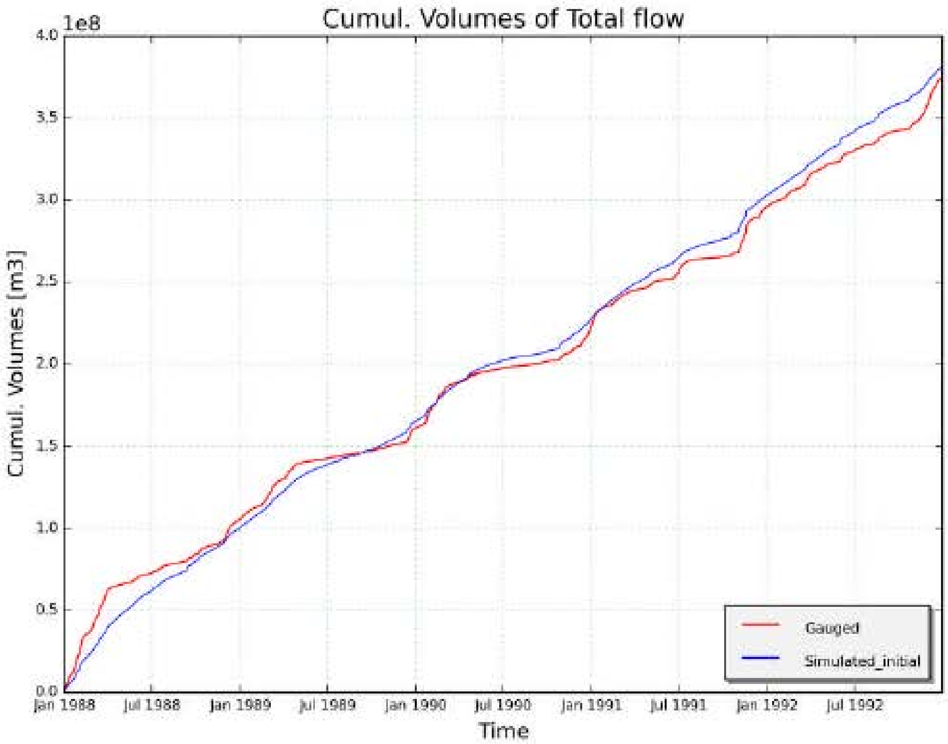


Figure 6: Cumulated flow with initial parameters

9.5.2.4.2 Optimum (euclidian)

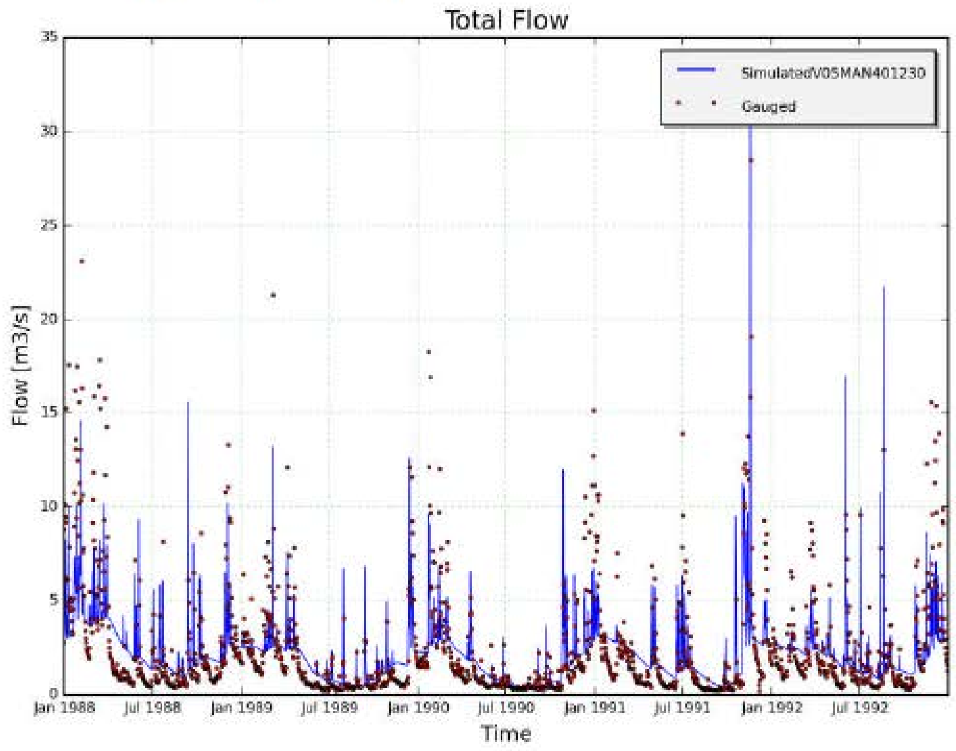


Figure 7: Total flow with optimum parameters

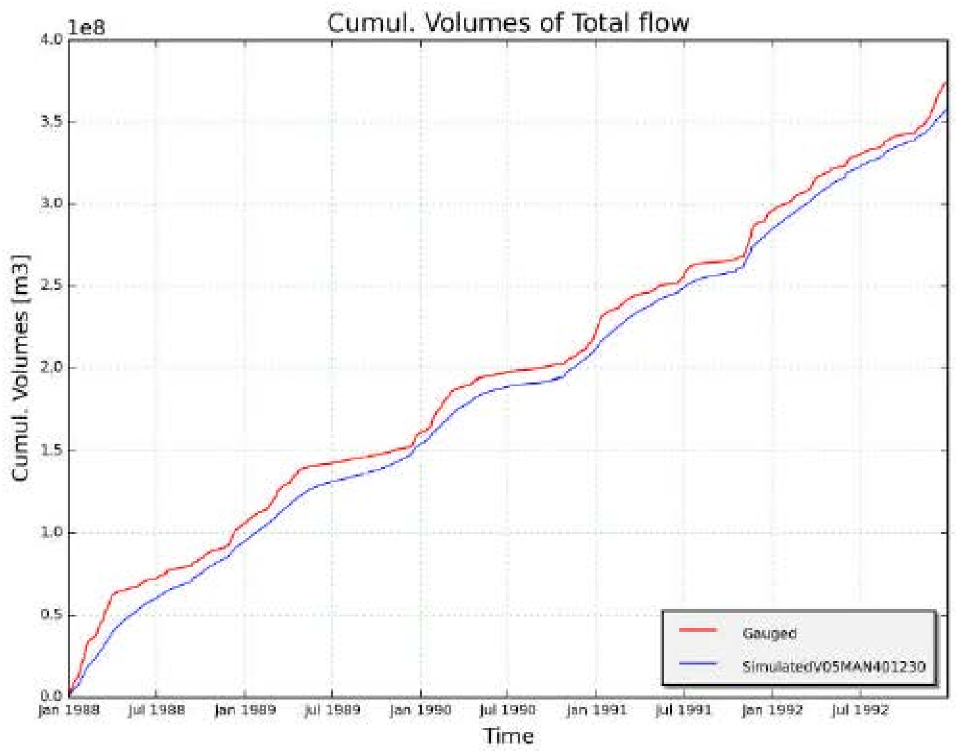
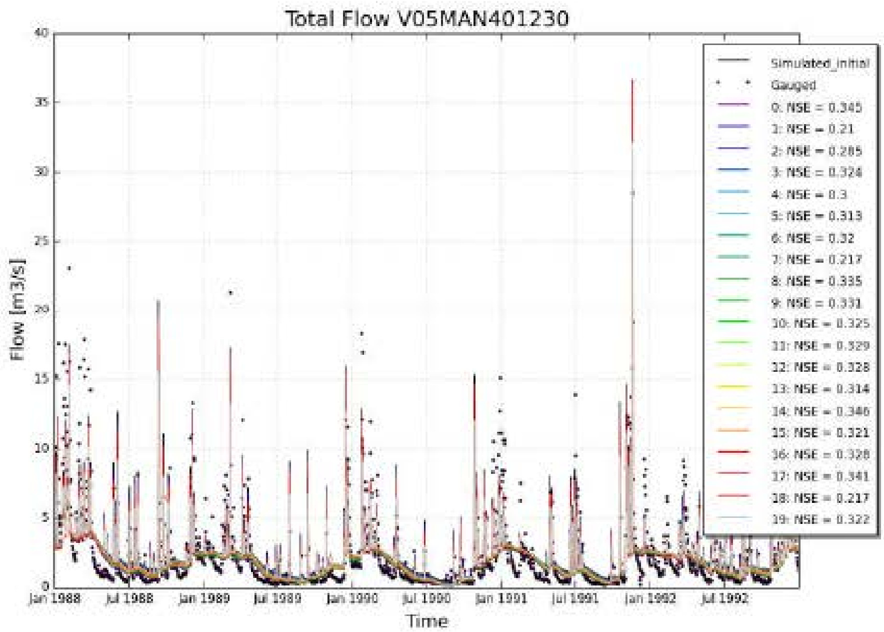


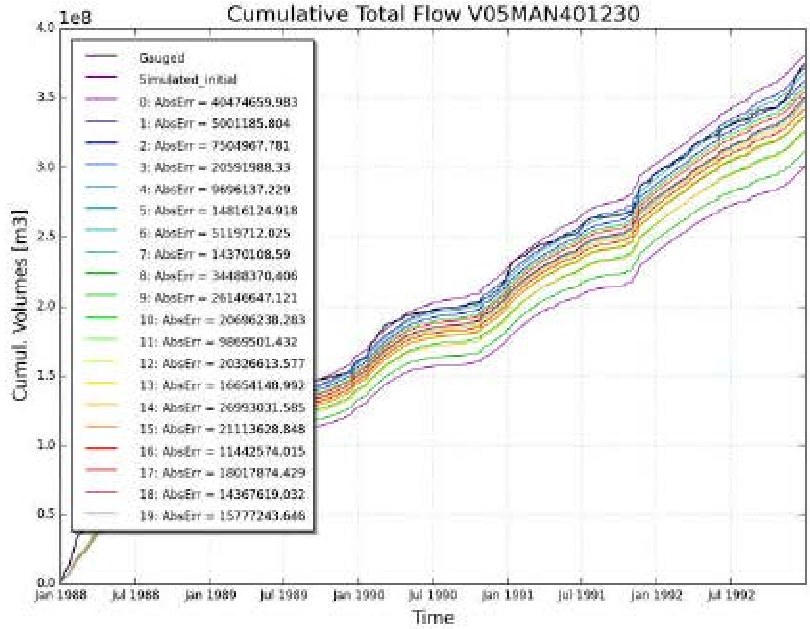
Figure 8: Cumulated flow with optimum parameters

9.5.2.4.3 Final archive

0 : [1.621, 83.726, 0.01, 2.795, 168.37, 290.481, 2.714, 122.699] : [40474659.983, 0.595]
1 : [1.119, 141.478, 0.009, 2.59, 197.[illegible], [illegible], -51.585, 119.846] : [5001185.804, 0.4[illegible]]

2 : [1.165, 116.002, 0.009, 2.111, 197.806, 304.448, 2.24, 121.914] : [7504967.781, 0.478]
3 : [1.366, 105.531, 0.01, 1.5, 194.118, 306.537, 2.945, 115.17] : [20591988.33, 0.55]
4 : [1.232, 117.244, 0.01, 2.748, 191.492, 304.513, 3.0, 123.083] : [9696137.229, 0.503]
5 : [1.257, 107.806, 0.009, 3.173, 192.896, 306.068, 3.0, 122.41] : [14816124.918, 0.517]
6 : [1.167, 104.496, 0.009, 2.58, 196.672, 310.532, 3.0, 122.359] : [5119712.025, 0.466]
7 : [1.232, 150.77, 0.01, 1.985, 185.931, 298.762, 2.991, 124.104] : [14370108.59, 0.512]
8 : [1.546, 93.014, 0.01, 1.839, 189.334, 306.098, 2.551, 122.378] : [34488370.406, 0.587]
9 : [1.36, 94.309, 0.009, 2.044, 188.03, 301.724, 3.0, 122.476] : [26146647.121, 0.558]
10 : [1.366, 105.531, 0.01, 1.5, 193.193, 304.982, 3.0, 114.604] : [20696238.283, 0.551]
11 : [1.255, 104.807, 0.01, 2.608, 193.622, 306.542, 3.0, 122.859] : [9869501.432, 0.508]
12 : [1.366, 103.952, 0.01, 2.86, 194.735, 306.537, 3.0, 114.129] : [20326613.577, 0.55]
13 : [1.308, 107.473, 0.01, 2.591, 194.075, 304.777, 2.229, 122.592] : [16654148.992, 0.533]
14 : [1.458, 92.947, 0.01, 1.5, 188.008, 303.926, 3.0, 122.433] : [26993031.585, 0.574]
15 : [1.366, 105.79, 0.01, 1.702, 193.152, 304.771, 2.637, 117.91] : [21113628.848, 0.552]
16 : [1.26, 103.982, 0.01, 2.465, 195.224, 307.093, 3.0, 120.993] : [11442574.015, 0.512]
17 : [1.351, 97.938, 0.01, 2.361, 182.589, 306.439, 3.0, 122.344] : [18017874.429, 0.544]
18 : [1.232, 150.77, 0.01, 1.985, 187.607, 298.762, 2.991, 124.104] : [14367619.032, 0.512]
19 : [1.31, 107.447, 0.01, 1.53, 192.477, 304.772, 3.0, 116.978] : [15777243.646, 0.533]





9.5.3 Report on simulation of catchment F05LEI386999 (2017-02-07 01-57)

9.5.3.1 Input data

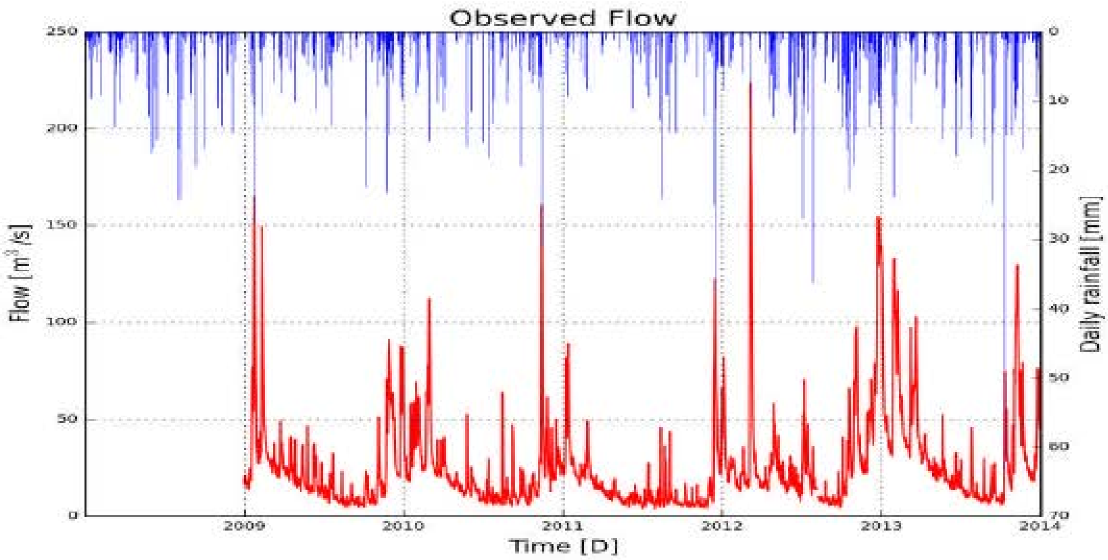


Figure 1: Hyetogram of observed discharge and observed net rain

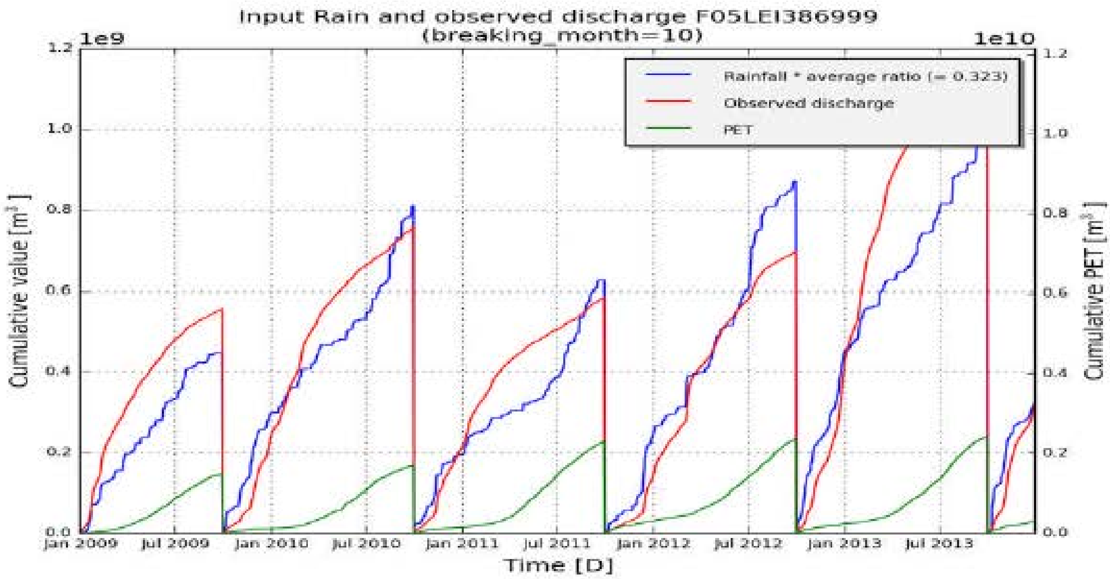


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.3.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	F05LEI386999
subcatchment_area	2981800000
start_date	200301010000
end_date	201312310000
frequency	86400
warmup	365

9.5.3.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.5, 25.0, 0.0047, 1.01, 110.0, 320.0, 4.0, 150.0]
low_bounds	[0.9, 17.0, 0.0009, 0.7, 77.0, 224.0, 2.8, 105.0]

high_bounds	[2.0, 150.0, 0.01, 3.0, 250.0, 500.0, 8.0, 350.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.5), ('Ki', 25.0), ('Kg', 0.0047), ('Kss', 1.01), ('g0', 110.0), ('g_max', 320.0), ('K_run', 4.0), ('P_max', 150.0)]

Initial fitness:

- RelErr: -0.158
- AbsErr: 616606021.806
- KGE: 0.718
- NS_rel: 0.762
- NS: 0.583
- RMSE: 711626288.427
- NS_log: 0.538

Computation time:8:28:46.743000

9.5.3.4 Results

Best individual (euclidian):
[('Kep', 1.553), ('Ki', 80.252), ('Kg', 0.006), ('Kss', 2.194), ('g0', 157.073), ('g_max', 442.08), ('K_run', 3.407), ('P_max', 196.515)]

Fitness:

- RelErr: -0.018
- AbsErr: 204538458.166
- KGE: 0.732
- NS_rel: 0.663
- NS: 0.457
- RMSE: 264710511.116
- NS_log: 0.607

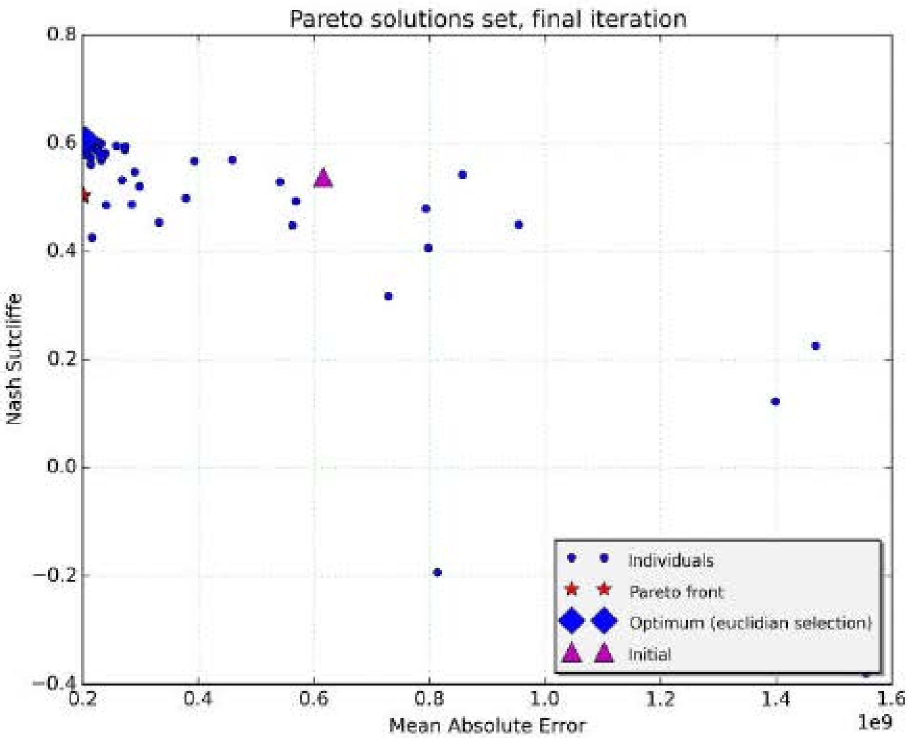


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

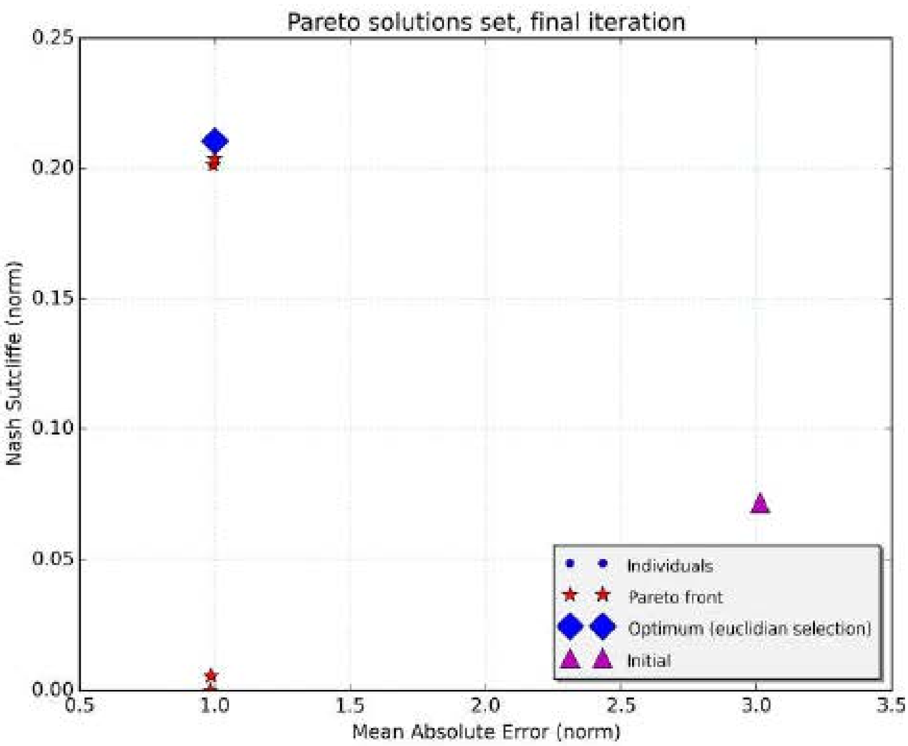


Figure 4: Final population of solutions (Pareto front)

9.5.3.4.1 Initial

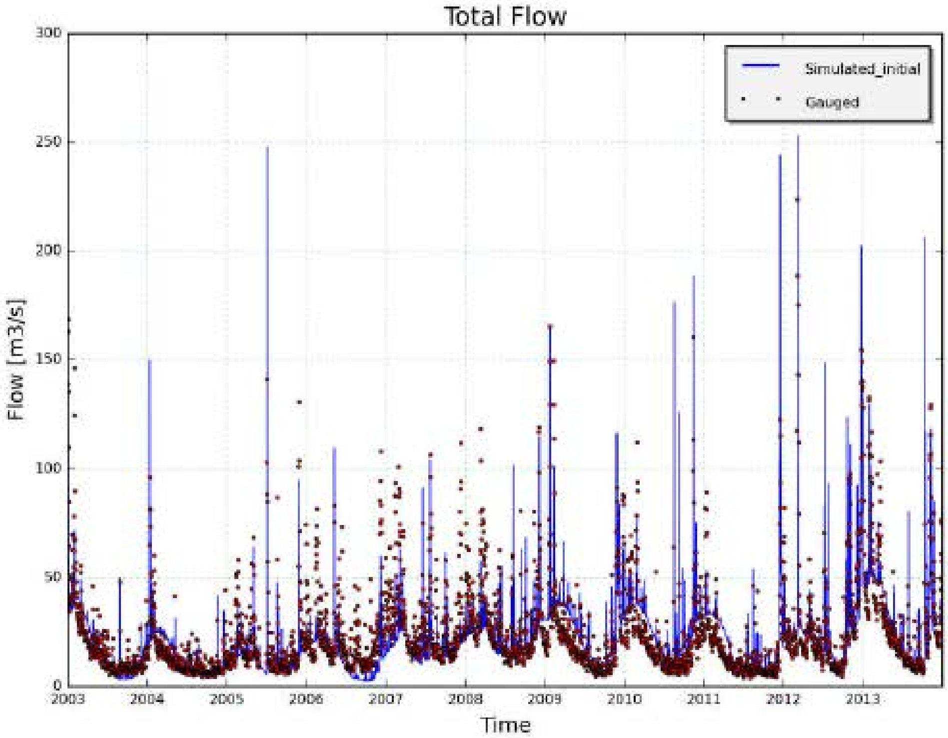


Figure 5: Total flow with initial parameters

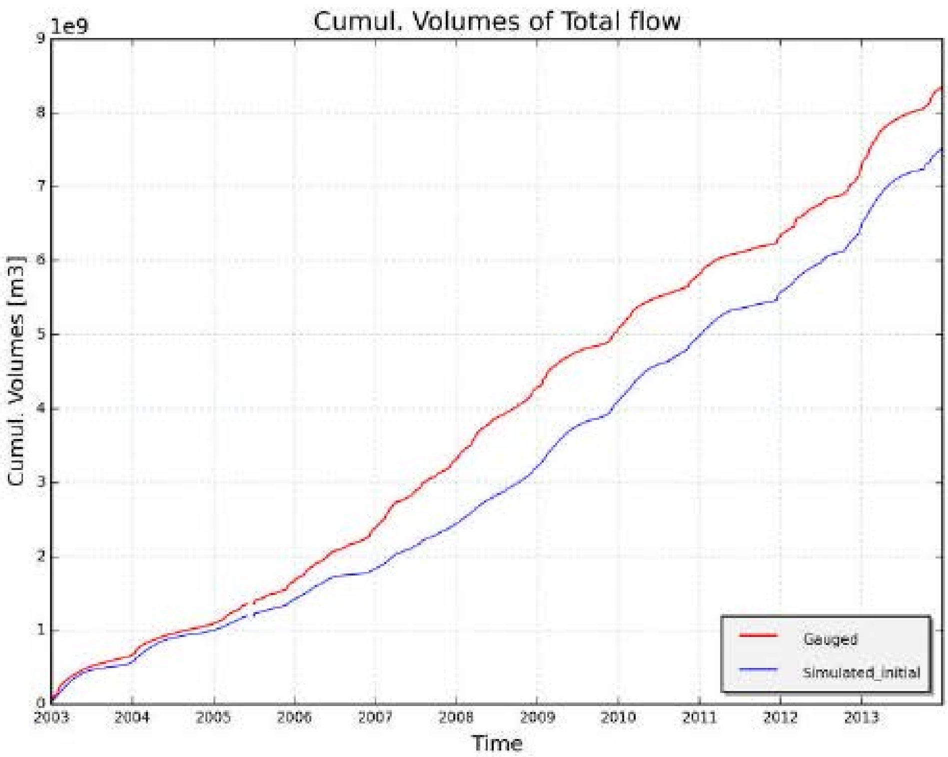


Figure 6: Cumulated flow with initial parameters

9.5.3.4.2 Optimum (euclidian)

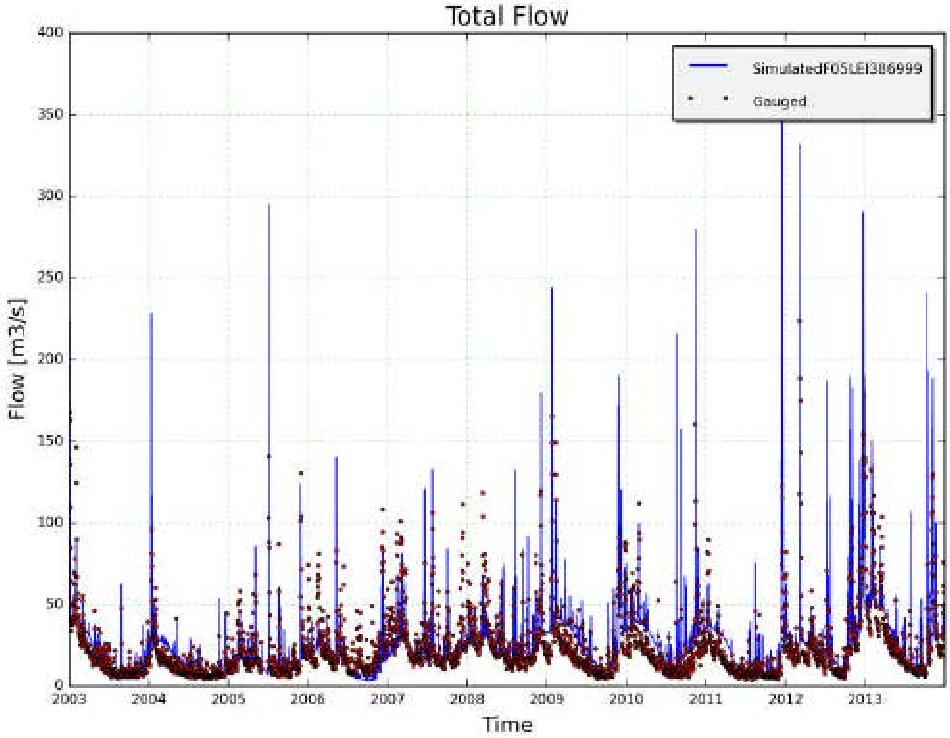


Figure 7: Total flow with optimum parameters

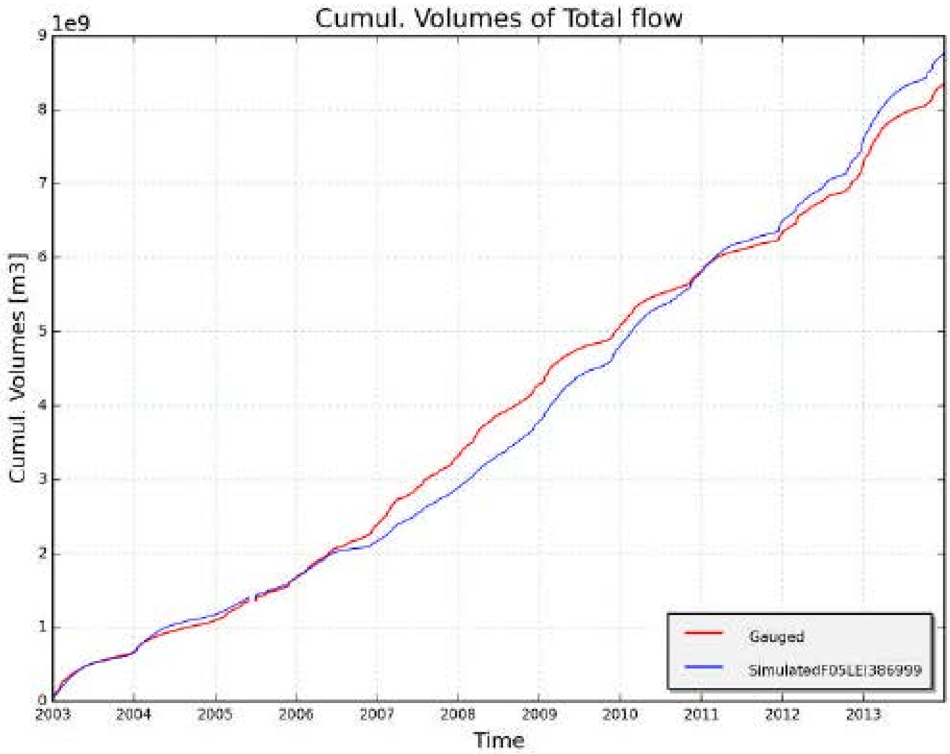


Figure 8: Cumulated flow with optimum parameters

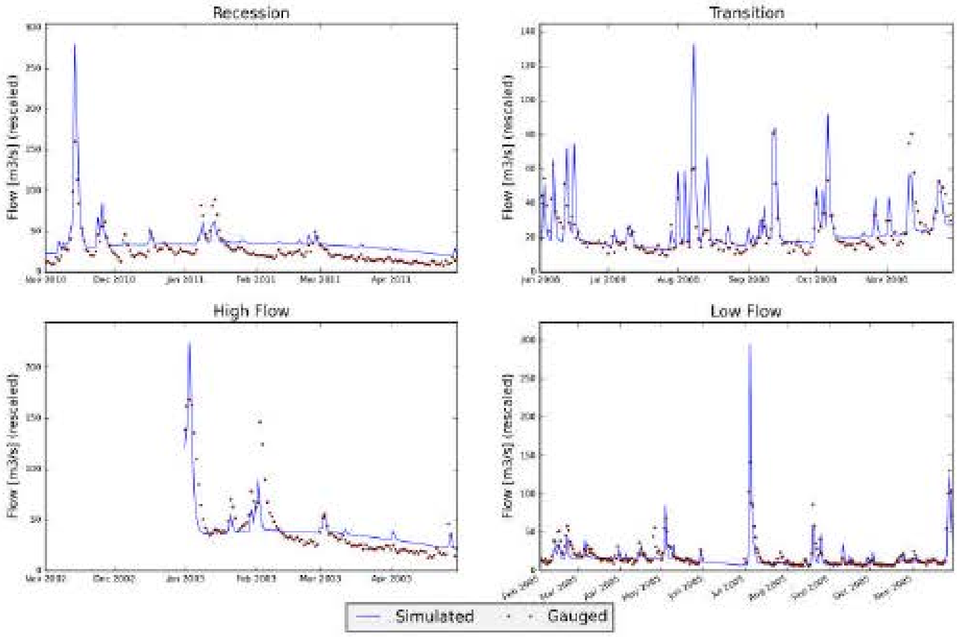
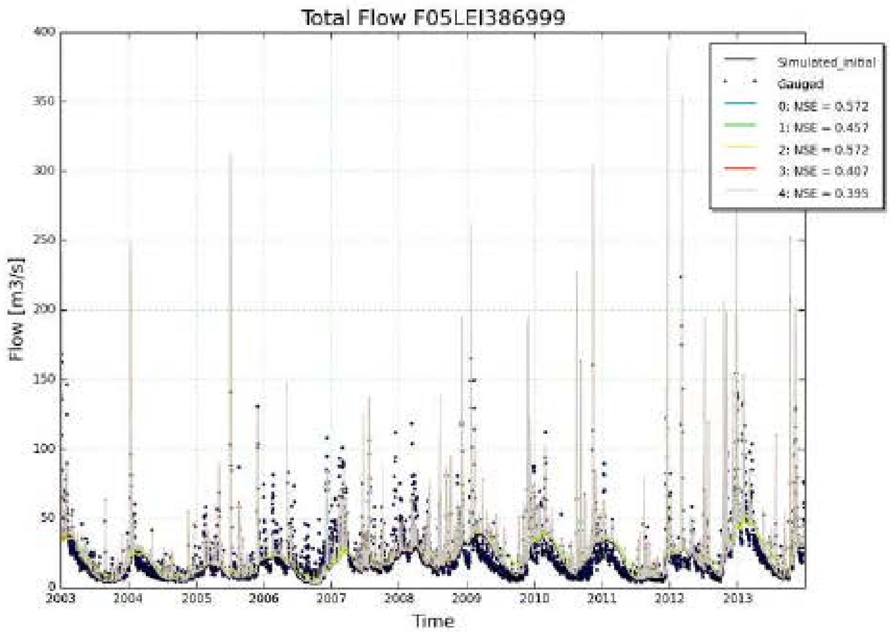
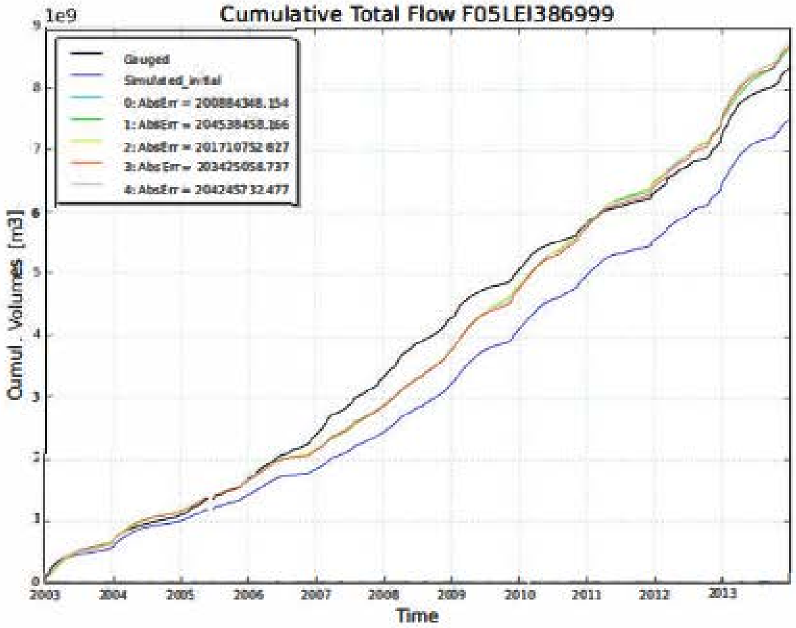


Figure 9: Total flow with optimum parameters (detail)

9.5.3.4.3 Final archive

0 : [1.137, 32.504, 0.003, 1.265, 161.361, 406.973, 5.584, 205.667] : [200884348.154, 0.502]
1 : [1.553, 80.252, 0.006, 2.194, 157.073, 442.08, 3.407, 196.515] : [204538458.166, 0.607]
2 : [1.137, 34.151, 0.003, 1.265, 161.361, 407.482, 5.499, 205.667] : [201710752.827, 0.505]
3 : [1.527, 93.714, 0.006, 2.224, 158.297, 396.556, 3.391, 188.727] : [203425058.737, 0.602]
4 : [1.513, 98.904, 0.006, 1.298, 141.64, 396.227, 3.47, 187.847] : [204245732.477, 0.603]




Cumulative Total Flow F05LEI386999
1e9
Gauged
Simulated_initial
0: AbsErr = 200884348.154
1: AbsErr = 204538458.166
2: AbsErr = 201710752.627
3: AbsErr = 203425058.737
4: AbsErr = 204245732.477
Cumul . Volumes [m3]
Time
0
1
2
3
4
5
6
7
8
9
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

Appendix 12 Bovenschelde Calibration and Validation.

9.5.1 Calibration and validation of WET parameters for catchment "V06MAA347160" (Bovenschelde)

9.5.1.1 Input data

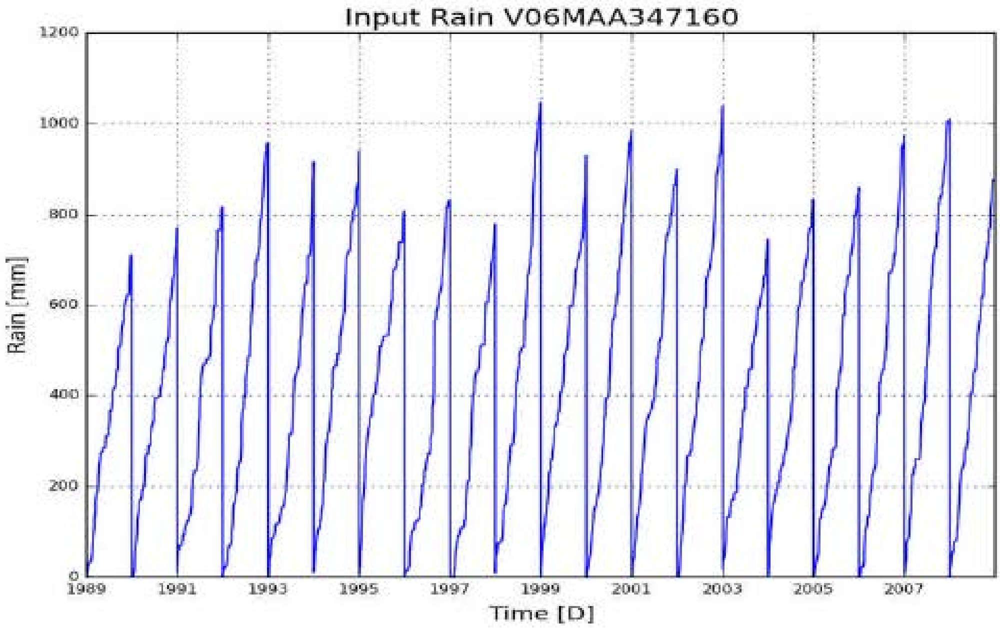


Figure 1: Cumulative precipitation on catchment V06MAA347160 (Bovenschelde)

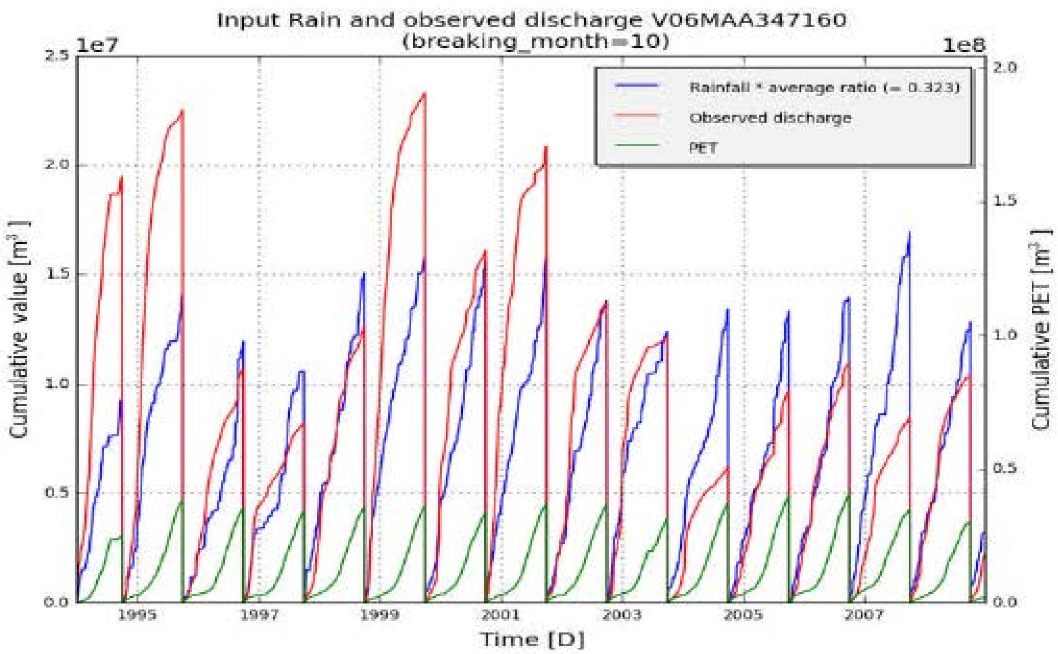


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V06MAA347160 (Bovenschelde)

9.5.1.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V06MAA347160
subcatchment_area [m2]	48678191
Validation start_date	01-01-1990
Validation end_date	31-12-2008
frequency	daily

Optimal parameter set:[('Kep', 1.55), ('Ki', 61.95), ('Kg', 0.0), ('Kss', 3.21), ('g0', 83.08), ('g_max', 231.8), ('K_run', 9.66), ('P_max', 156.92)]

Table 1: Goodness of fit for calibration period (1994 - 2008)

	Full year	**Summer**	**Winter**
RelErr	-1.9 %	21.1 %	-0.1 %
NS	-0.453	-5.137	0.215
NS_log	0.509	0.089	0.464
NS_rel	-0.309	-0.706	-0.112
KGE	0.366	-0.836	0.624

Table 2 :Goodness of fit for validation period (1990 - 2008)

	Full year	**Summer**	**Winter**
RelErr	-4.8 %	-9.0 %	-2.9 %
NS	-0.345	-4.229	0.231
NS_log	0.503	0.176	0.473
NS_rel	-0.291	-0.967	-0.013
KGE	0.401	-0.621	0.628

9.5.1.3 Observed and simulated timeseries for optimum parameters

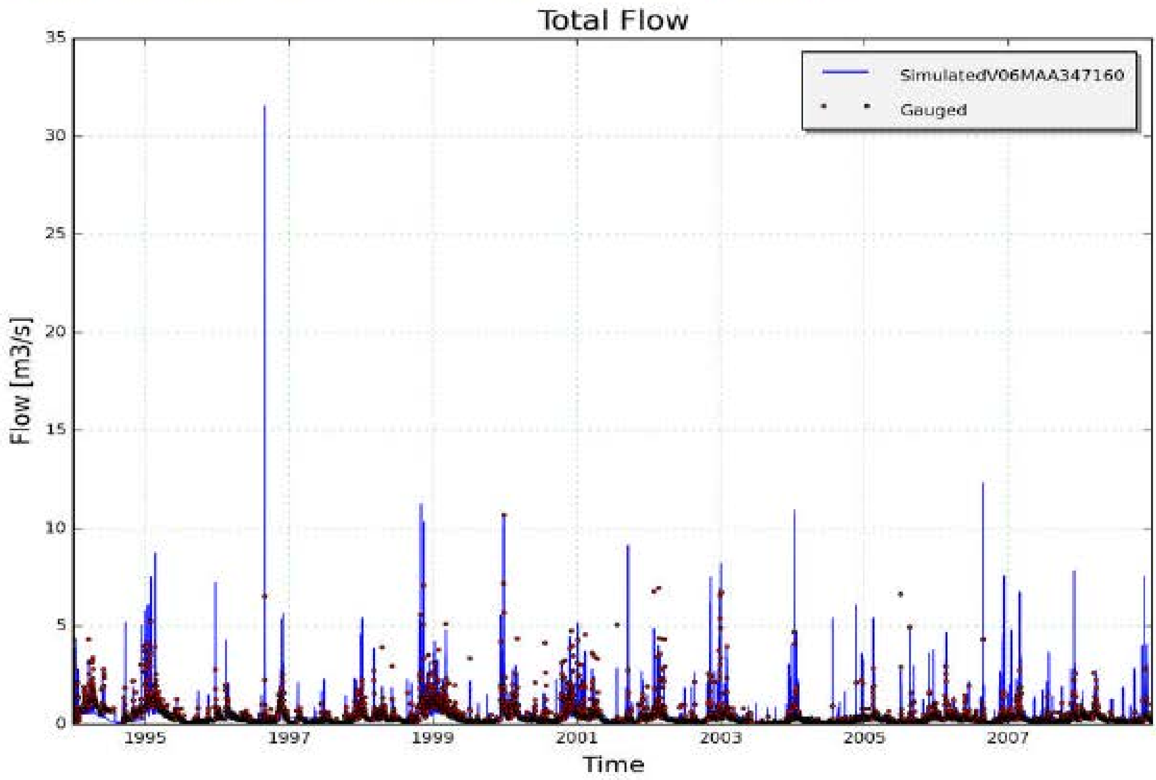


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove(calibration period)

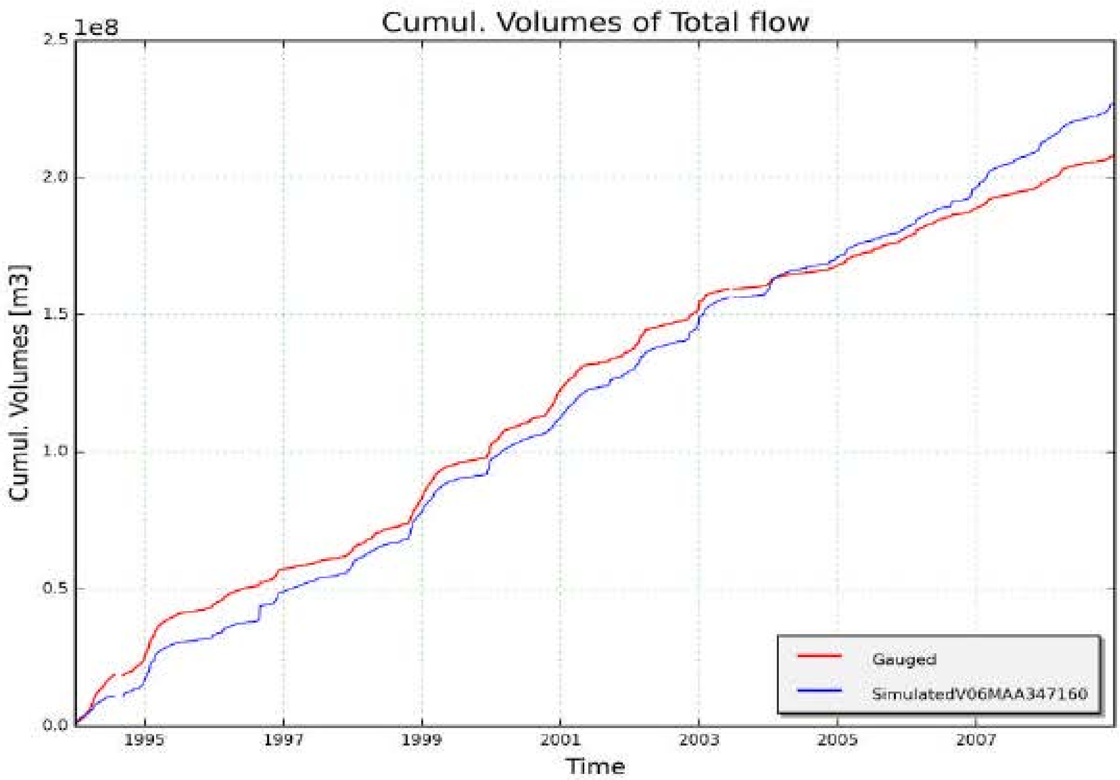


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove (calibration period)

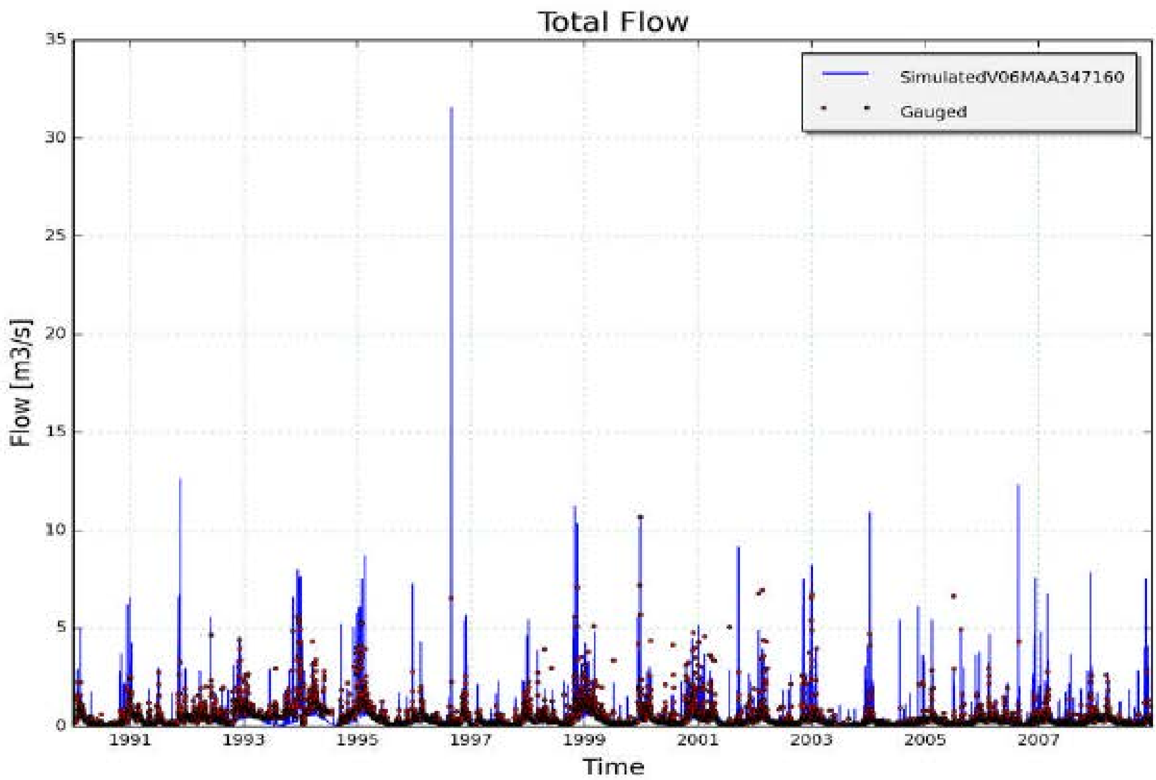


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove (validation period)

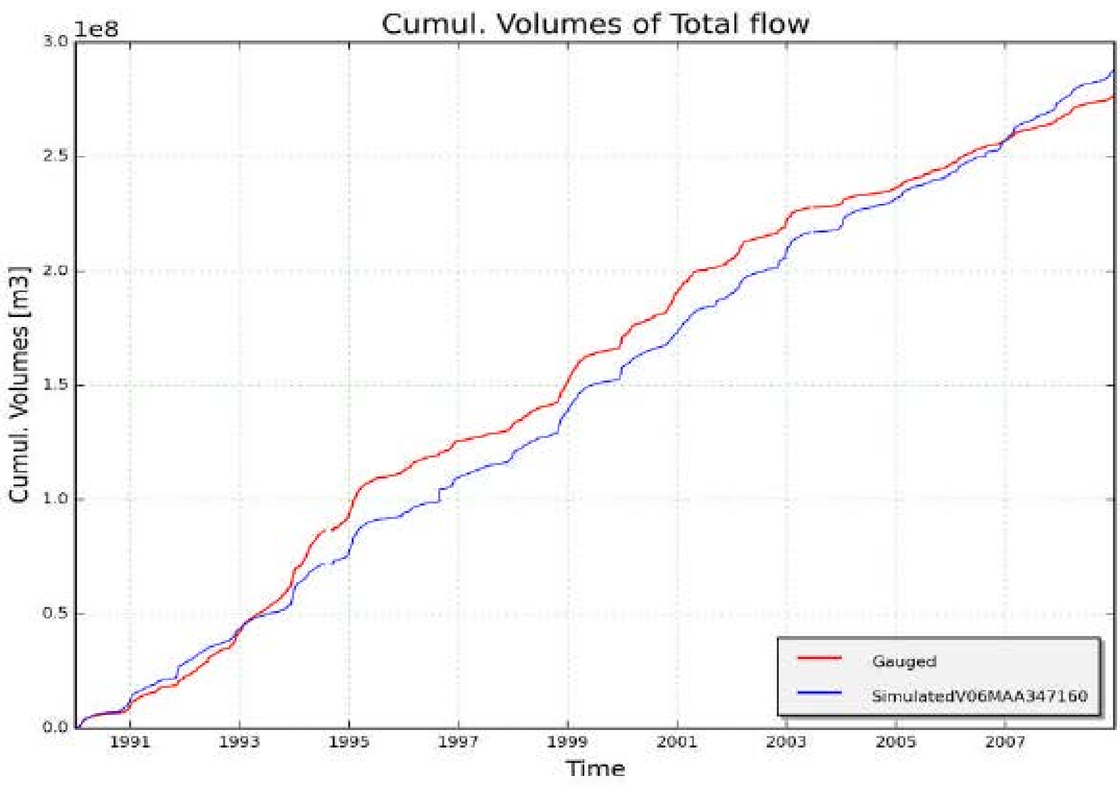


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove (validation period)

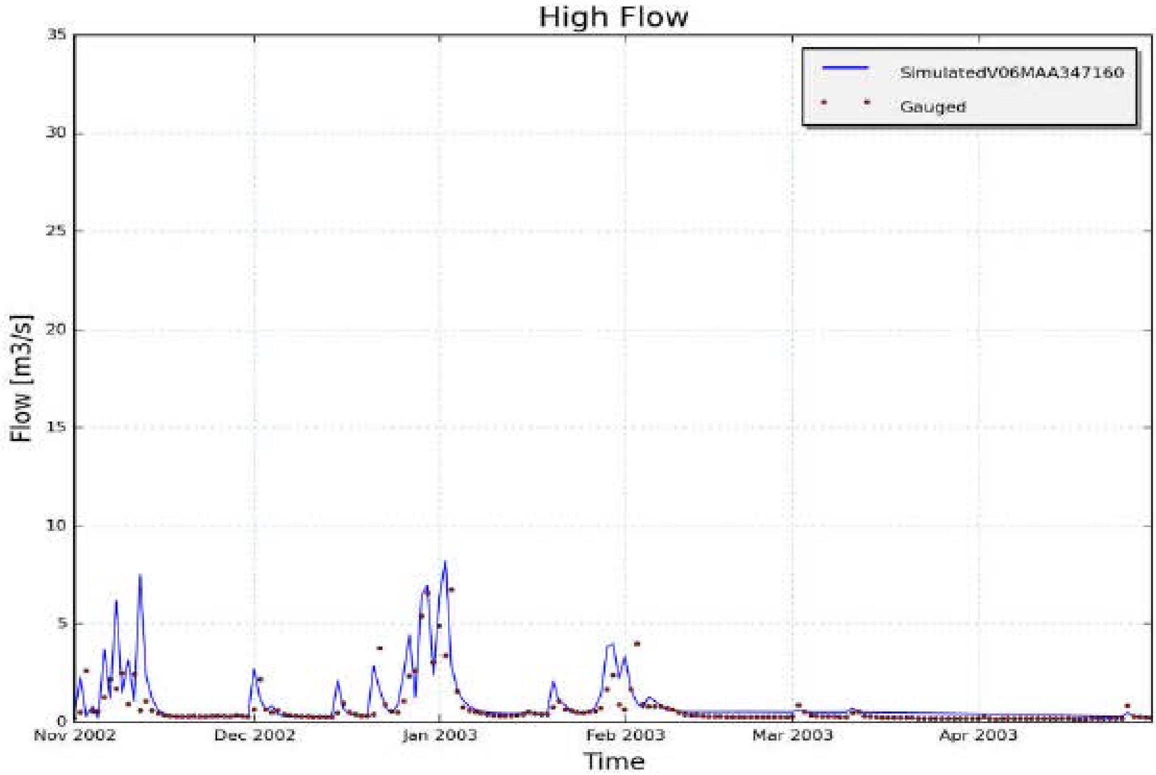


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove

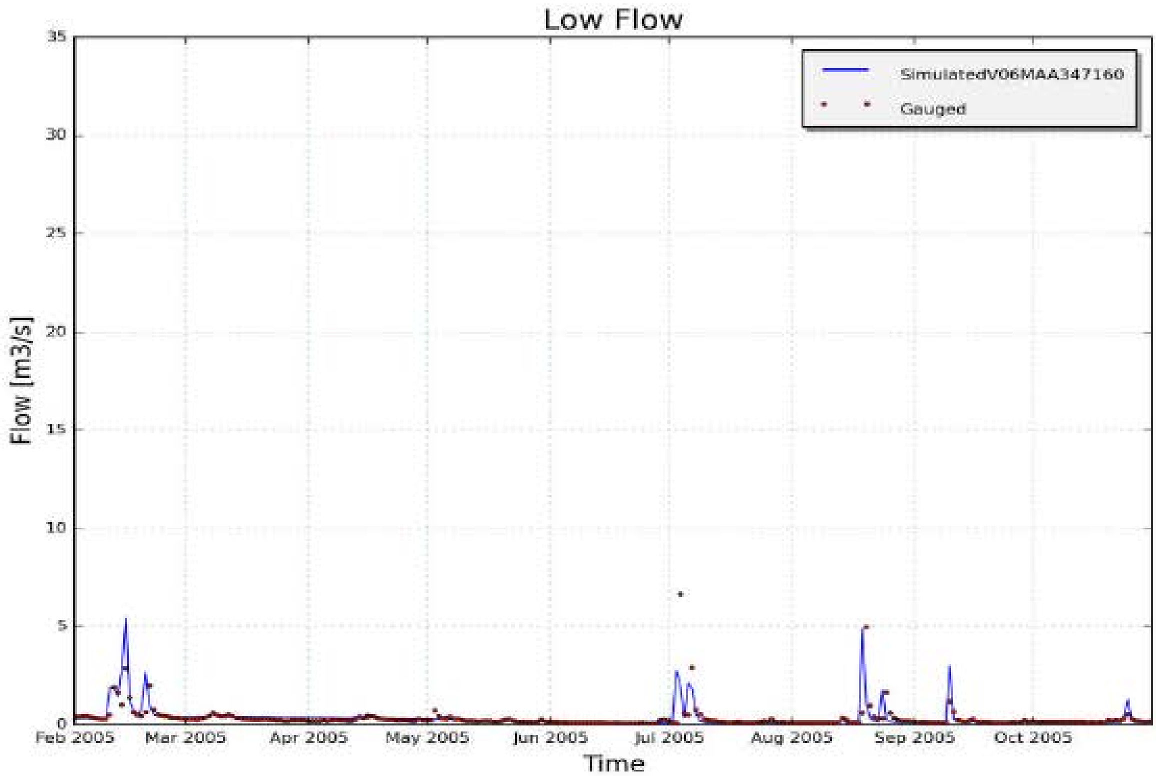


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove

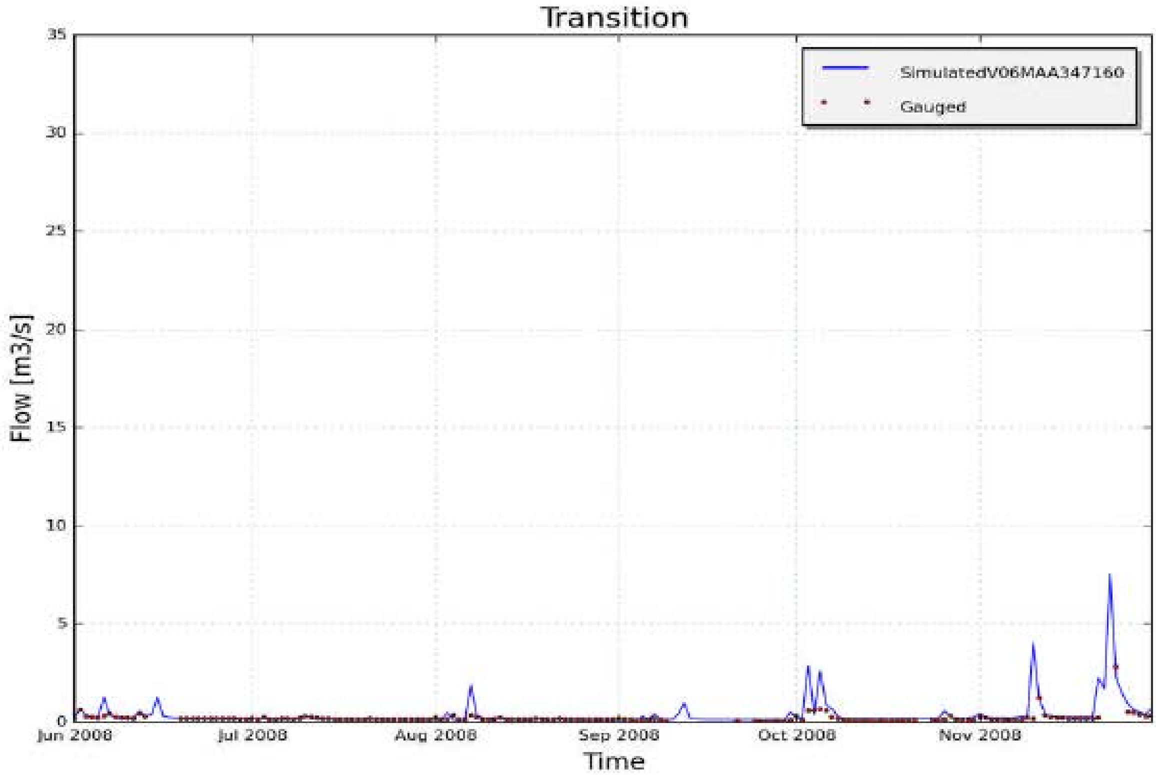


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove

9.5.2 Calibration and validation of WET parameters for catchment "V06ZWA342190" (Bovenschelde)

9.5.2.1 Input data

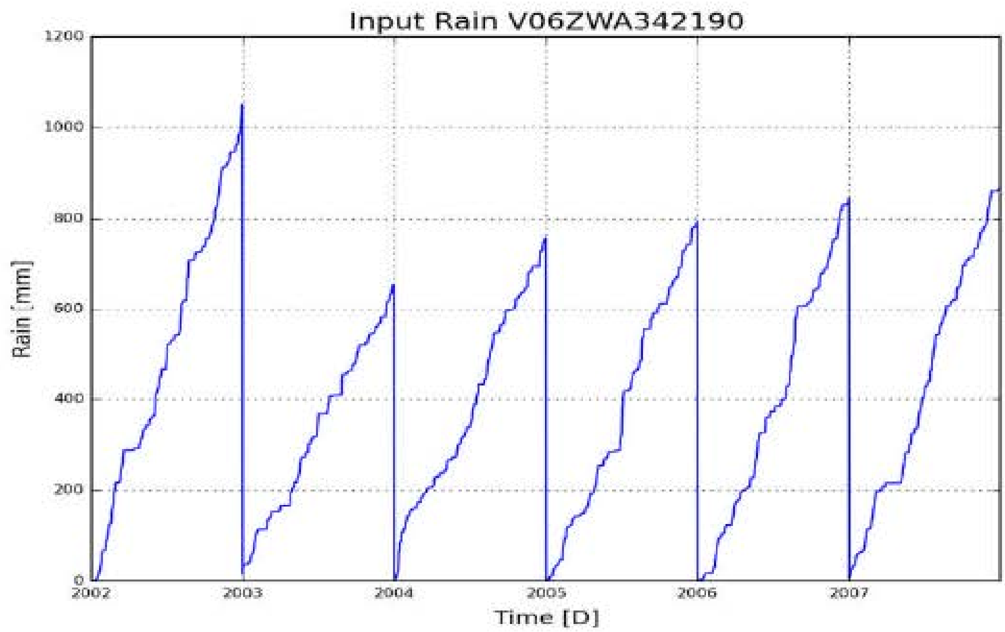


Figure 1: Cumulative precipitation on catchment V06ZWA342190 (Bovenschelde)

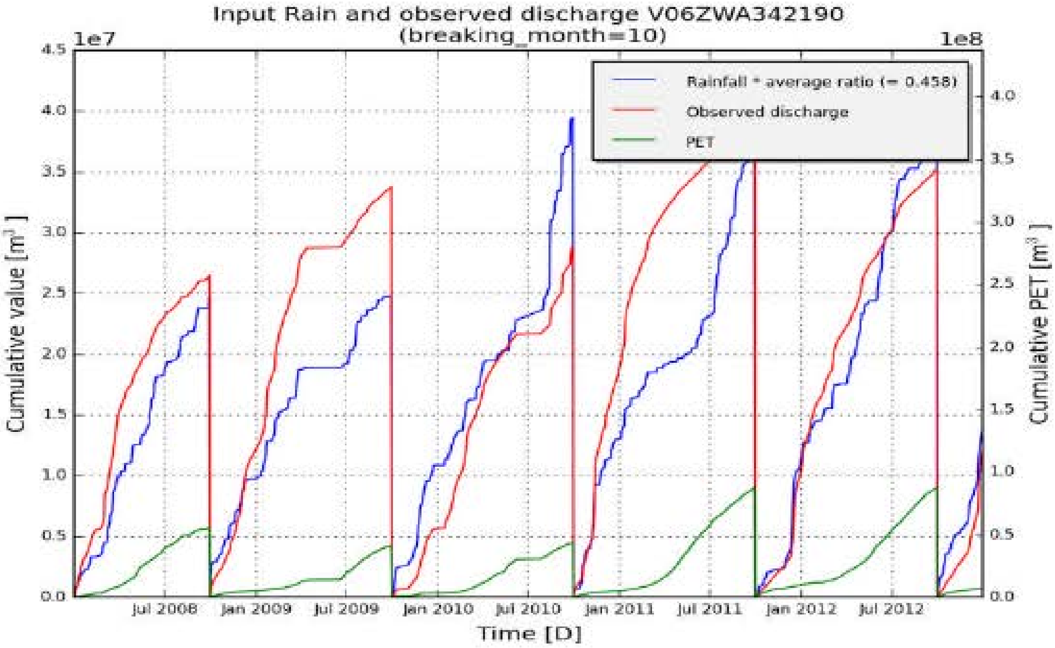


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V06ZWA342190 (Bovenschelde)

9.5.2.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V06ZWA342190
subcatchment_area [m2]	112100000
Validation start_date	01-01-2003
Validation end_date	31-12-2007
frequency	daily

Optimal parameter set:[('Kep', 1.6), ('Ki', 56.23), ('Kg', 0.01), ('Kss', 1.72), ('g0', 87.94), ('g_max', 640.41), ('K_run', 6.96), ('P_max', 201.19)]

Table 1: Goodness of fit for calibration period (2008 - 2012)

	Full year	**Summer**	**Winter**
RelErr	-2.8 %	26.0 %	-21.1 %
NS	0.469	-1.666	0.444
NS_log	0.647	0.23	0.511

	Full year	Summer	Winter
NS_rel	0.335	-1.469	0.859
KGE	0.742	-0.25	0.511

Table 2 :Goodness of fit for validation period (2003 - 2007)

	Full year	Summer	Winter
RelErr	-0.5 %	16.5 %	-6.1 %
NS	0.709	0.464	0.763
NS_log	0.692	0.441	0.714
NS_rel	0.697	0.67	0.817
KGE	0.808	0.628	0.848

9.5.2.3 Observed and simulated timeseries for optimum parameters

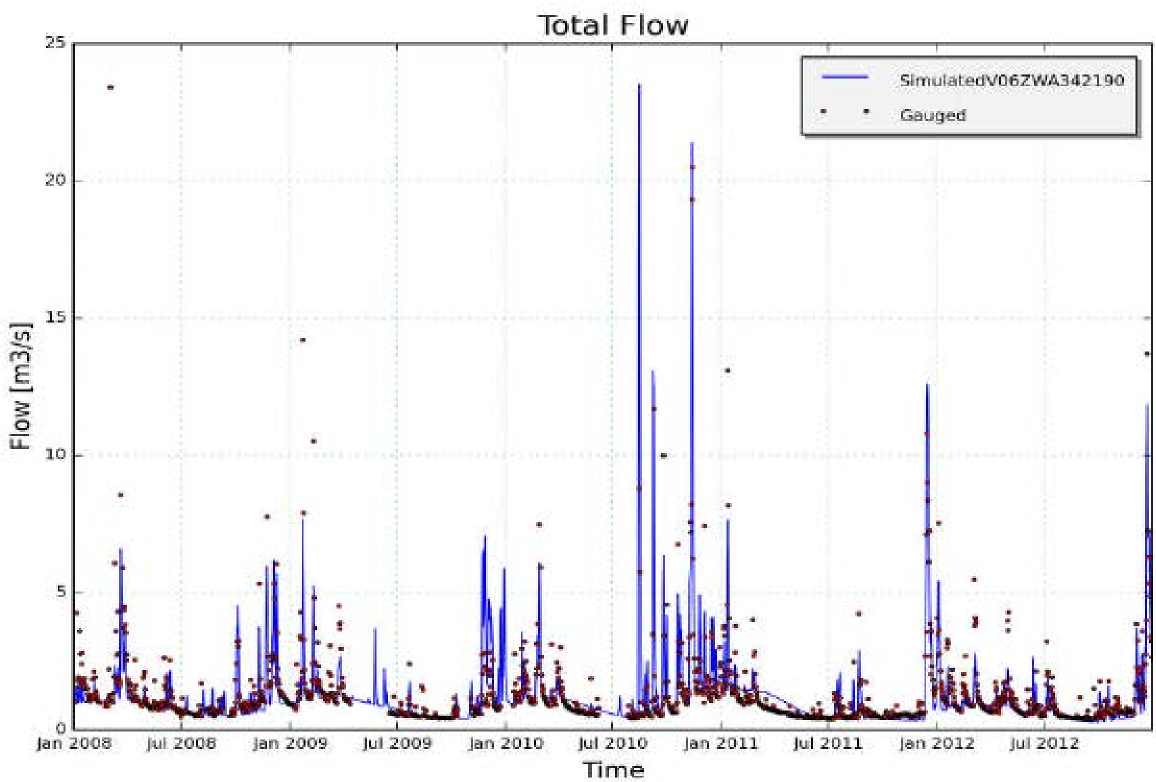


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm(calibration period)

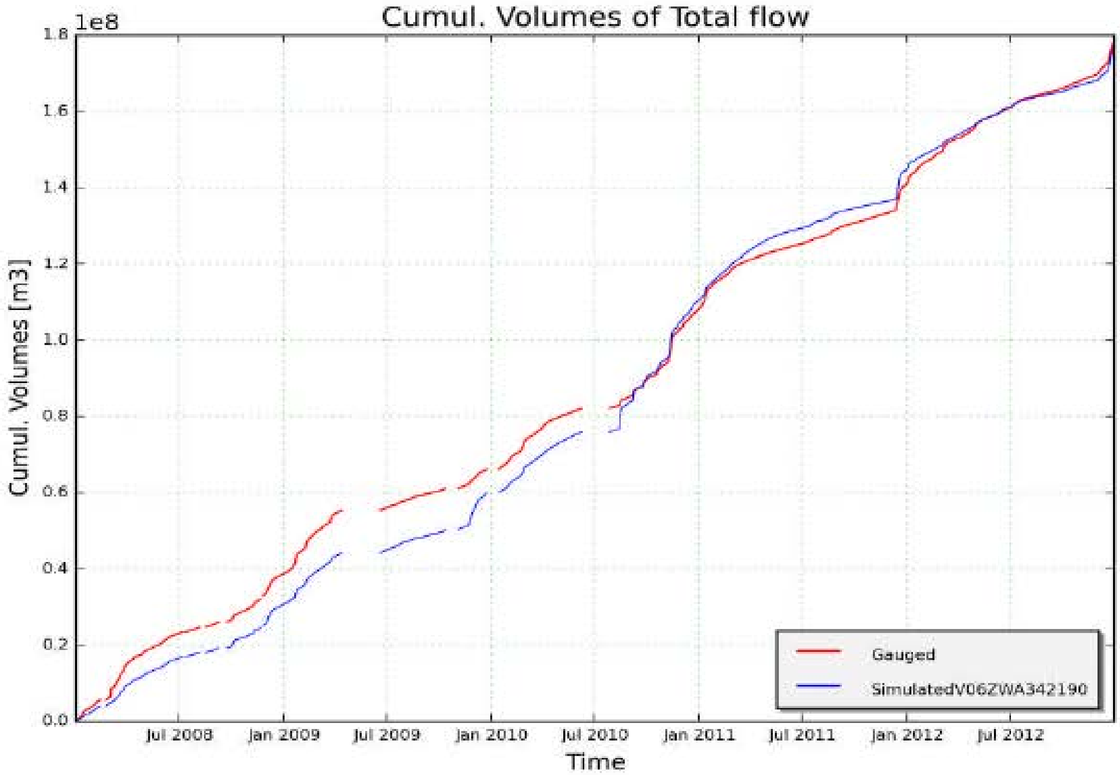


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (calibration period)

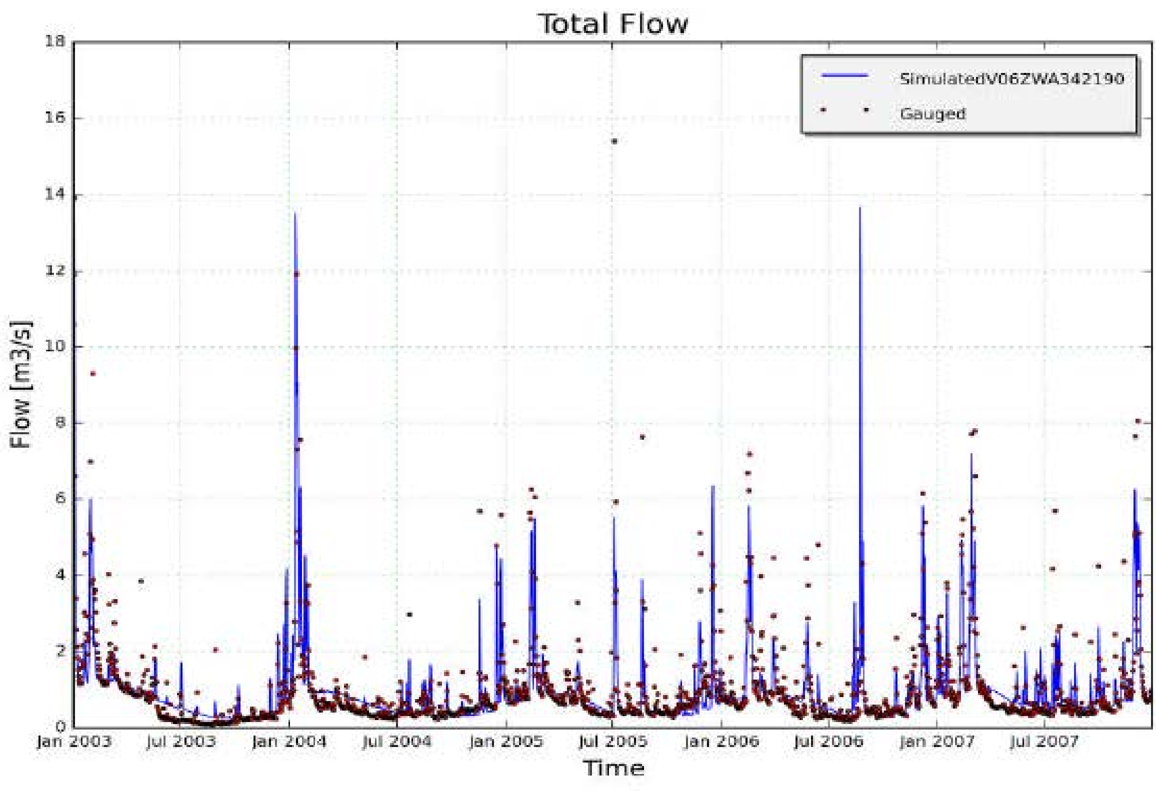


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (validation period)

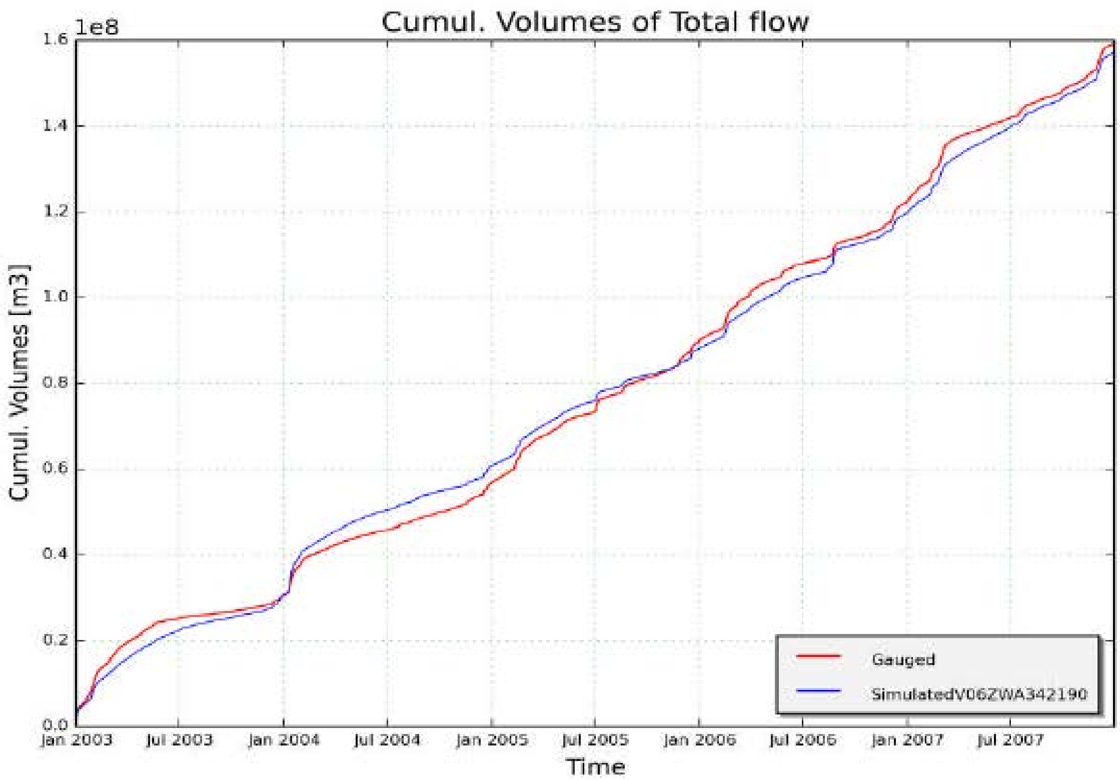


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (validation period)

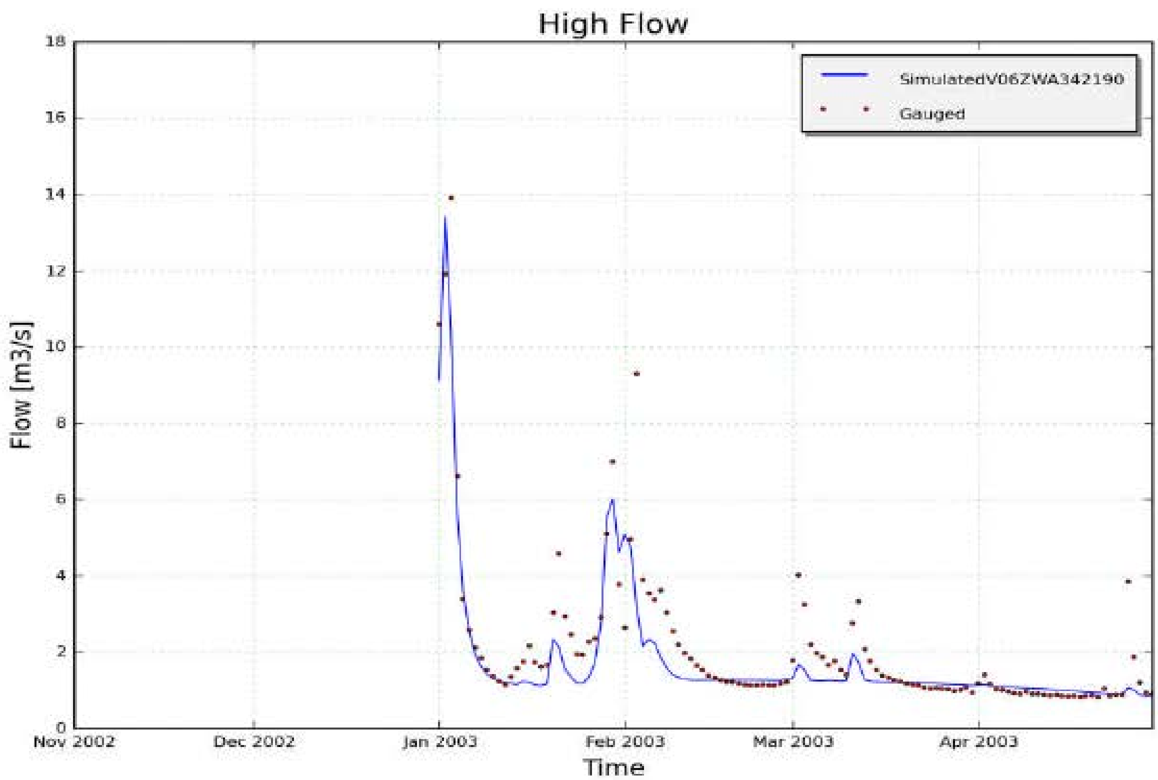


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm

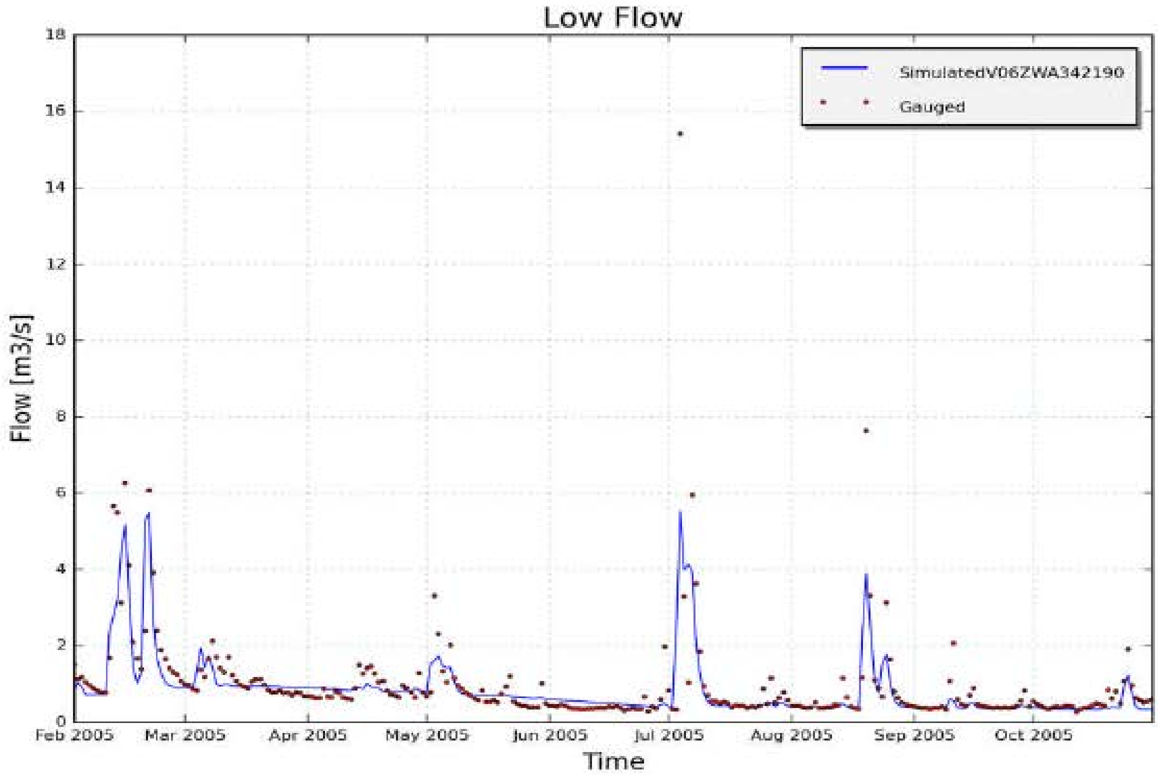


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm

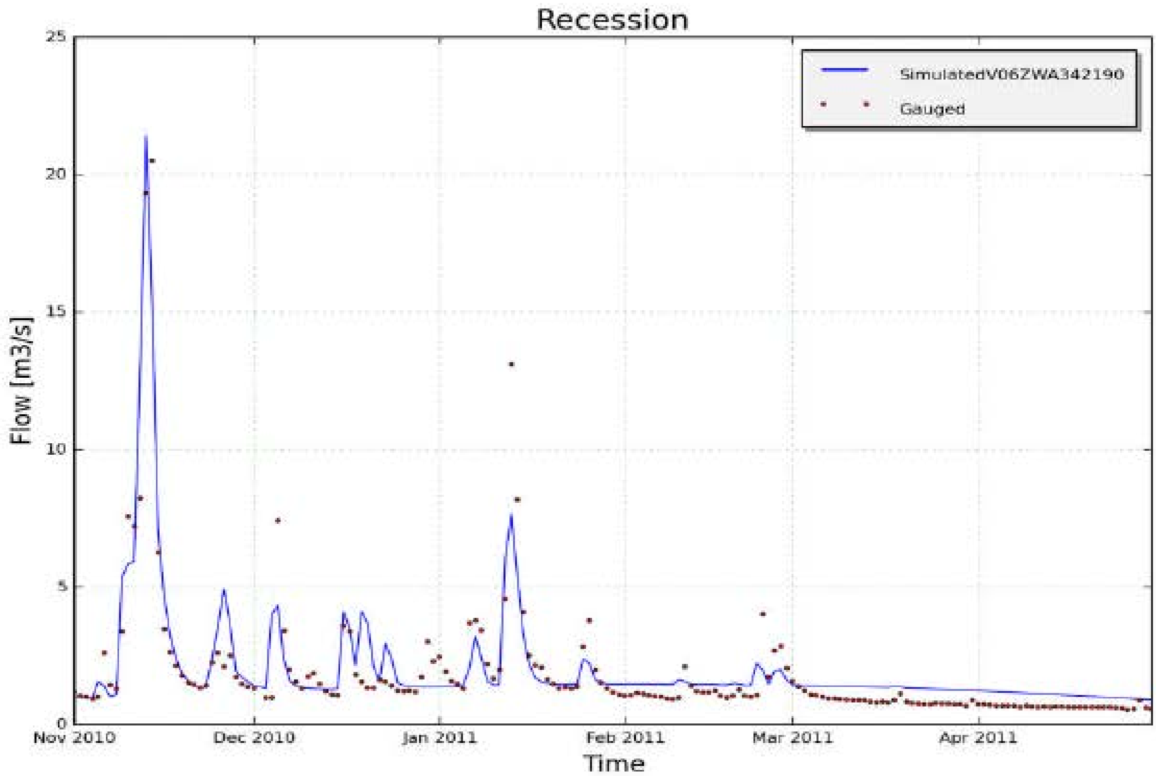


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm

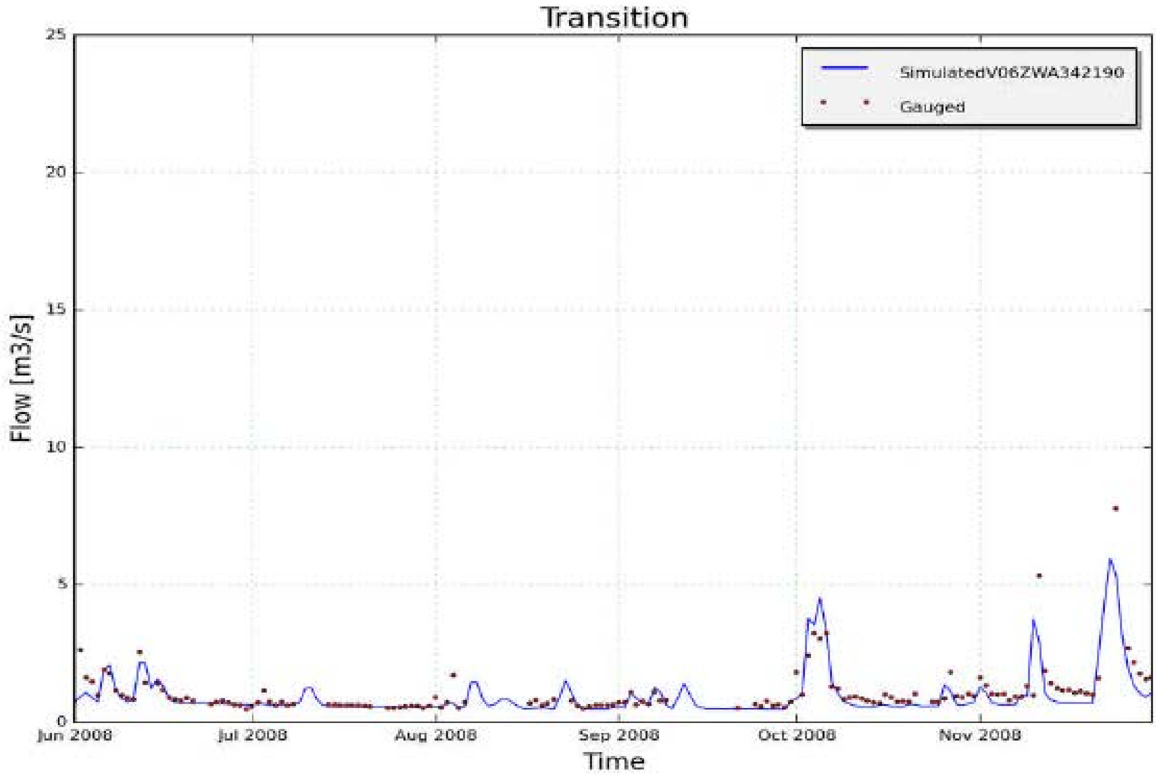


Figure 9 Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm

9.5.3 Calibration and validation of WET parameters for catchment "W06RHOL54100" (Bovenschelde)

9.5.3.1 Input data

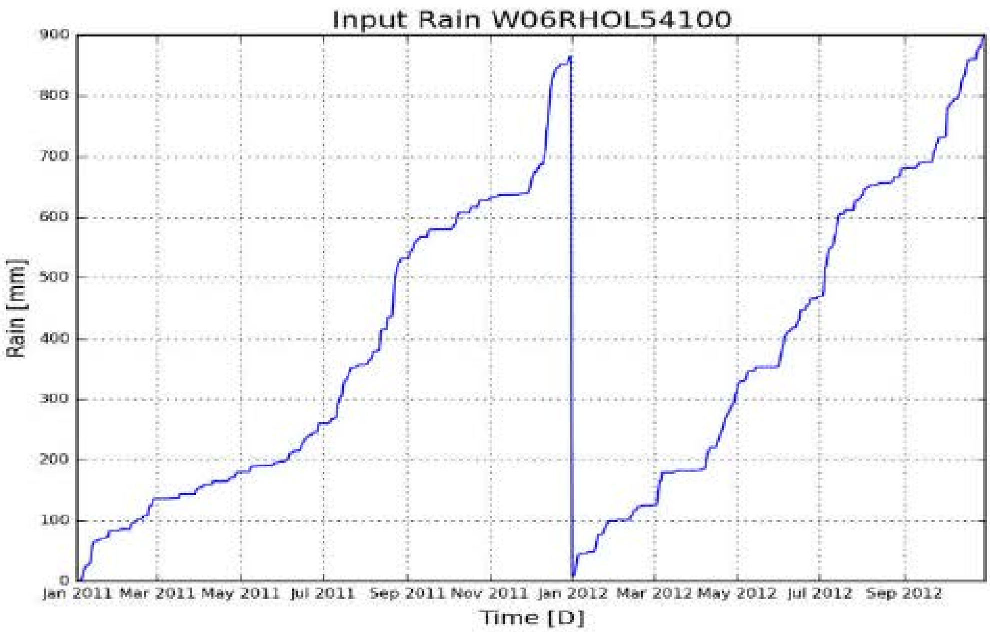


Figure 1: Cumulative precipitation on catchment W06RHOL54100 (Bovenschelde)

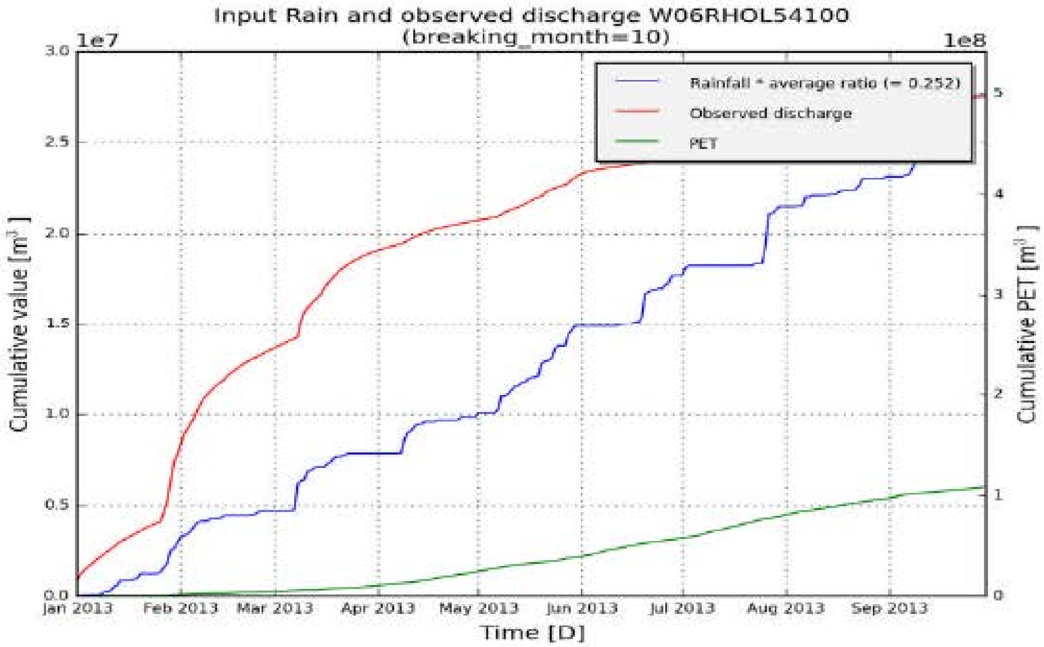


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W06RHOL54100 (Bovenschelde)

9.5.3.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	W06RHOL54100
subcatchment_area [m2]	161900000
Validation start_date	01-01-2012
Validation end_date	31-10-2012
frequency	daily

Optimal parameter set:[('Kep', 2.95), ('Ki', 97.4), ('Kg', 0.01), ('Kss', 2.0), ('g0', 163.6), ('g_max', 399.53), ('K_run', 6.17), ('P_max', 87.13)]

Table 1: Goodness of fit for calibration period (2013 - 2013)

	Full year	Summer	Winter
RelErr	1.2 %	8.5 %	-2.4 %
NS	0.708	-2.311	0.821
NS_log	0.73	0.309	0.629
NS_rel	0.484	-0.084	0.531
KGE	0.839	-0.561	0.885

Table 2 :Goodness of fit for validation period (2012 - 2012)

	Full year	Summer	Winter
RelErr	21.6 %	29.6 %	22.8 %
NS	-0.372	-0.699	0.792
NS_log	0.396	0.426	0.479
NS_rel	-1.283	0.507	0.399
KGE	0.266	-0.016	0.81

9.5.3.3 Observed and simulated timeseries for optimum parameters

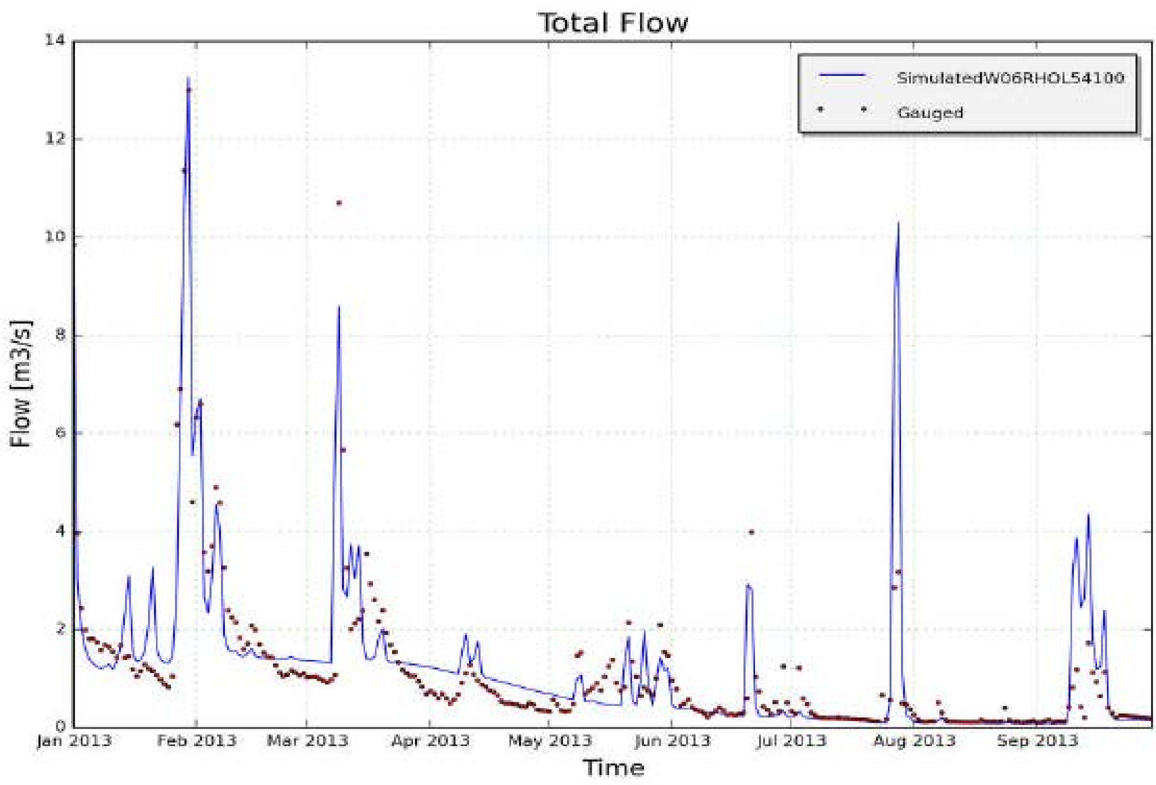


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W06RHOL54100, station L5412 Amougies - Rhosnes(calibration period)

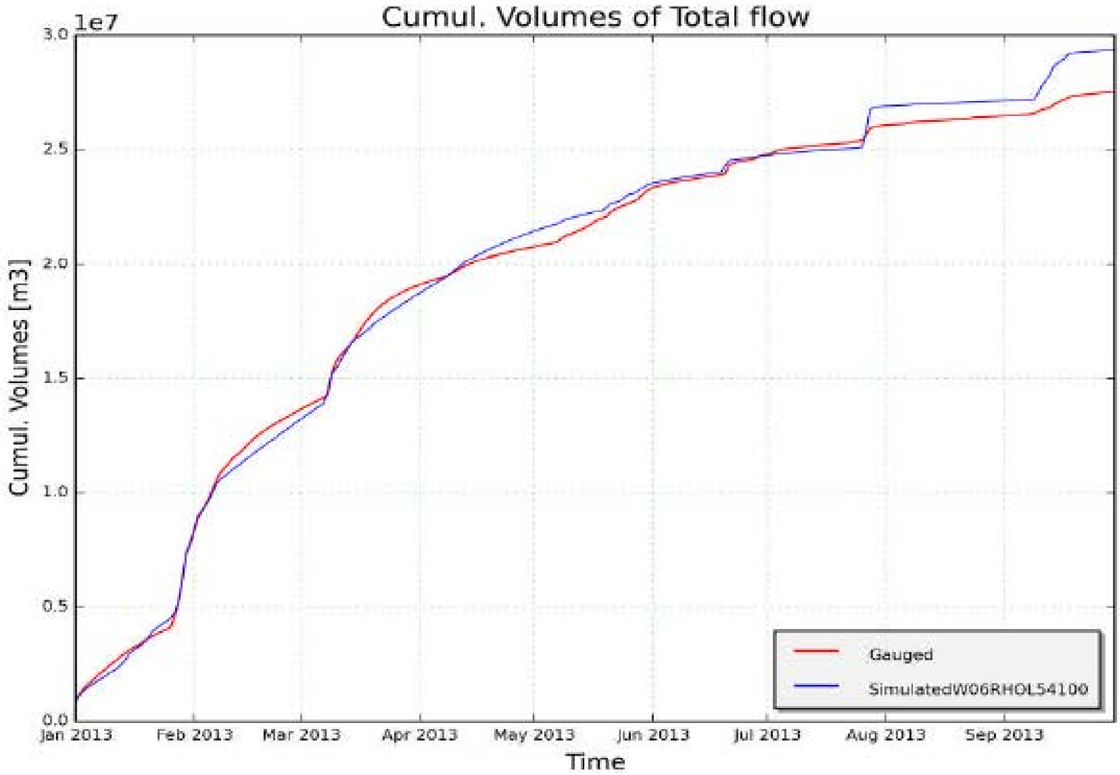


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W06RHOL54100, station L5412 Amougies - Rhosnes (calibration period)

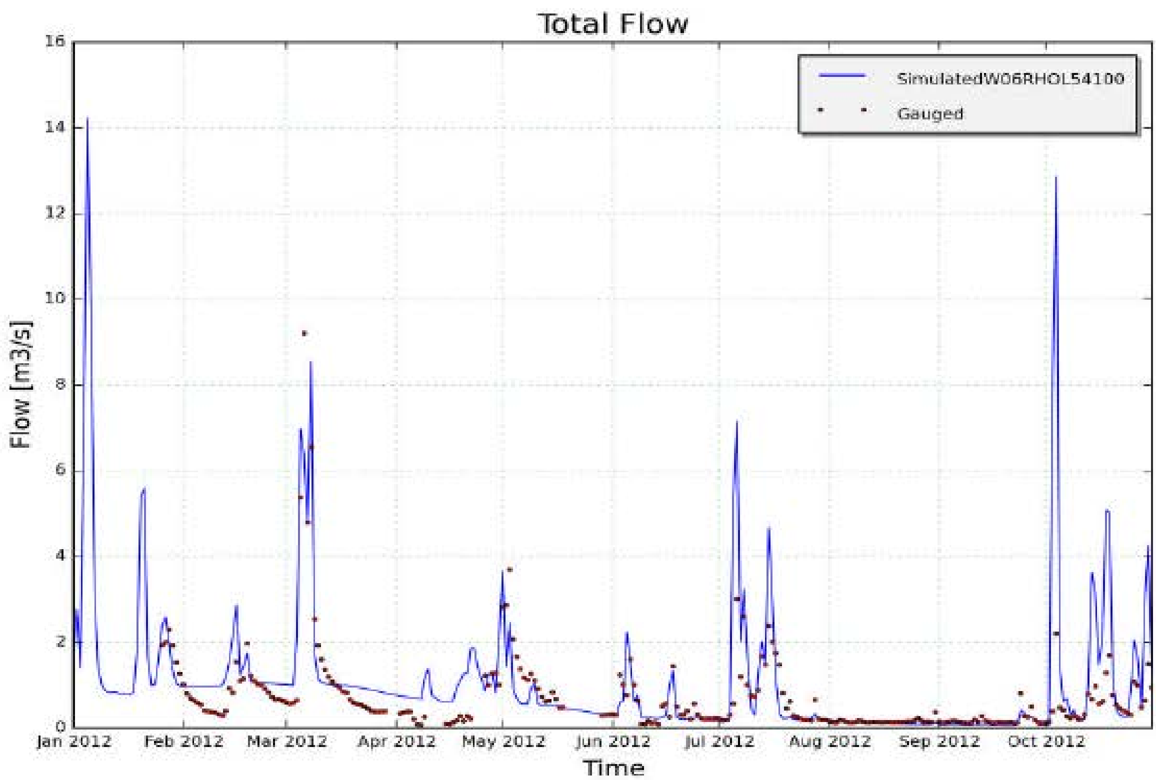


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W06RHOL54100, station L5412 Amougies - Rhosnes (validation period)

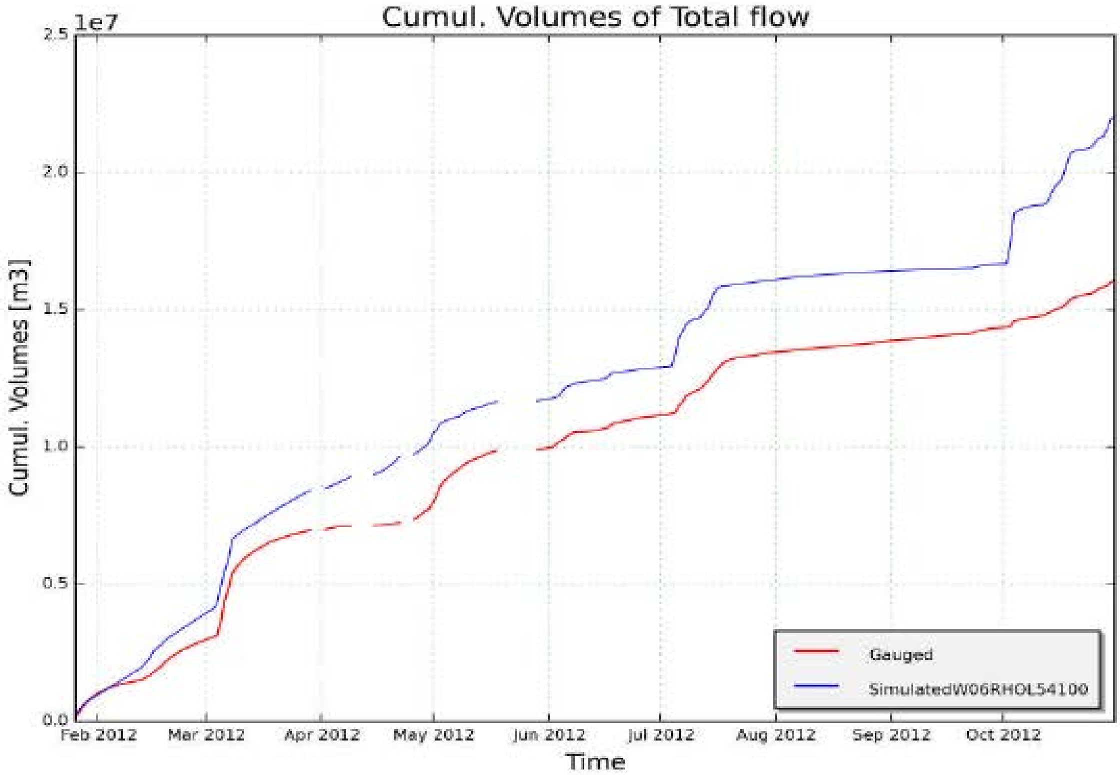


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W06RHOL54100, station L5412 Amougies - Rhosnes (validation period)

9.5.4 Calibration and validation of WET parameters for catchment "F06BOS325999" (Bovenschelde)

9.5.4.1 Input data

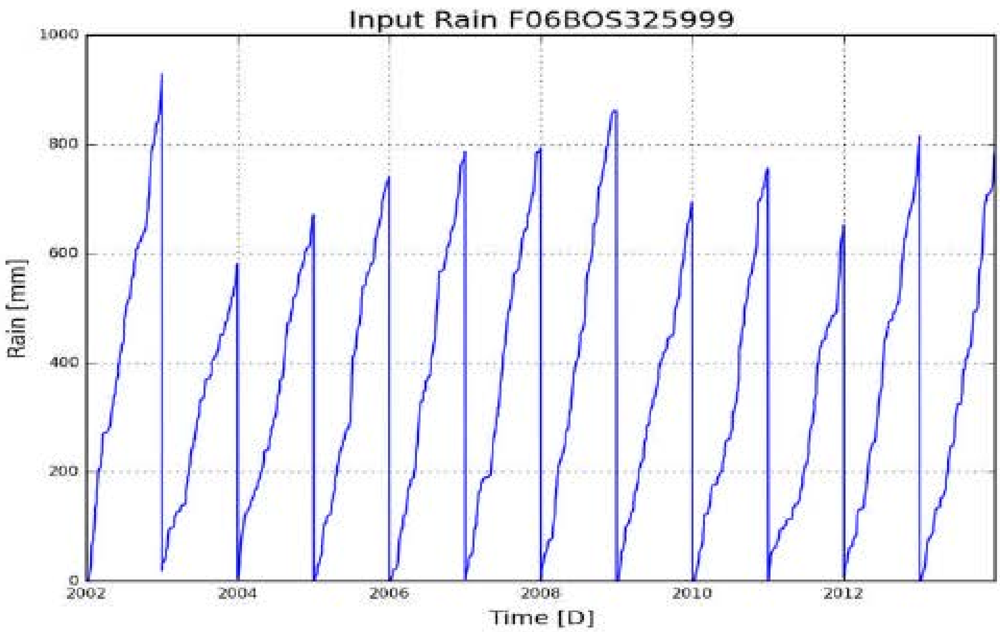


Figure 1: Cumulative precipitation on catchment F06BOS325999 (Bovenschelde)

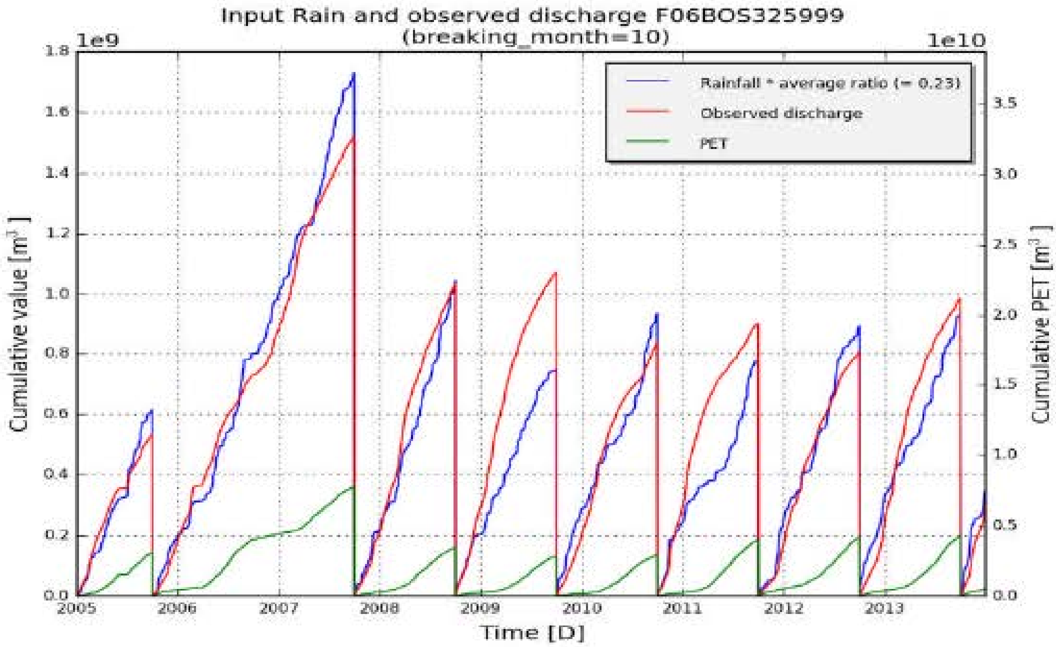


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment F06BOS325999 (Bovenschelde)

9.5.4.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	F06BOS325999
subcatchment_area [m2]	5217600000
Validation start_date	01-01-2003
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:[('Kep', 1.6), ('Ki', 69.87), ('Kg', 0.01), ('Kss', 0.79), ('g0', 107.94), ('g_max', 385.46), ('K_run', 3.57), ('P_max', 538.29)]

Table 1: Goodness of fit for calibration period (2005 - 2013)

	Full year	**Summer**	**Winter**
RelErr	-2.6 %	-8.2 %	-2.8 %
NS	0.467	0.338	0.577
NS_log	0.601	0.204	0.556
NS_rel	0.717	0.674	0.537
KGE	0.701	0.549	0.712

Table 2 :Goodness of fit for validation period (2003 - 2013)

	Full year	Summer	Winter
RelErr	-9.1 %	-22.0 %	-4.7 %
NS	0.509	0.19	0.581
NS_log	0.418	-0.447	0.605
NS_rel	0.722	0.535	0.653
KGE	0.71	0.531	0.793

9.5.4.3 Observed and simulated timeseries for optimum parameters

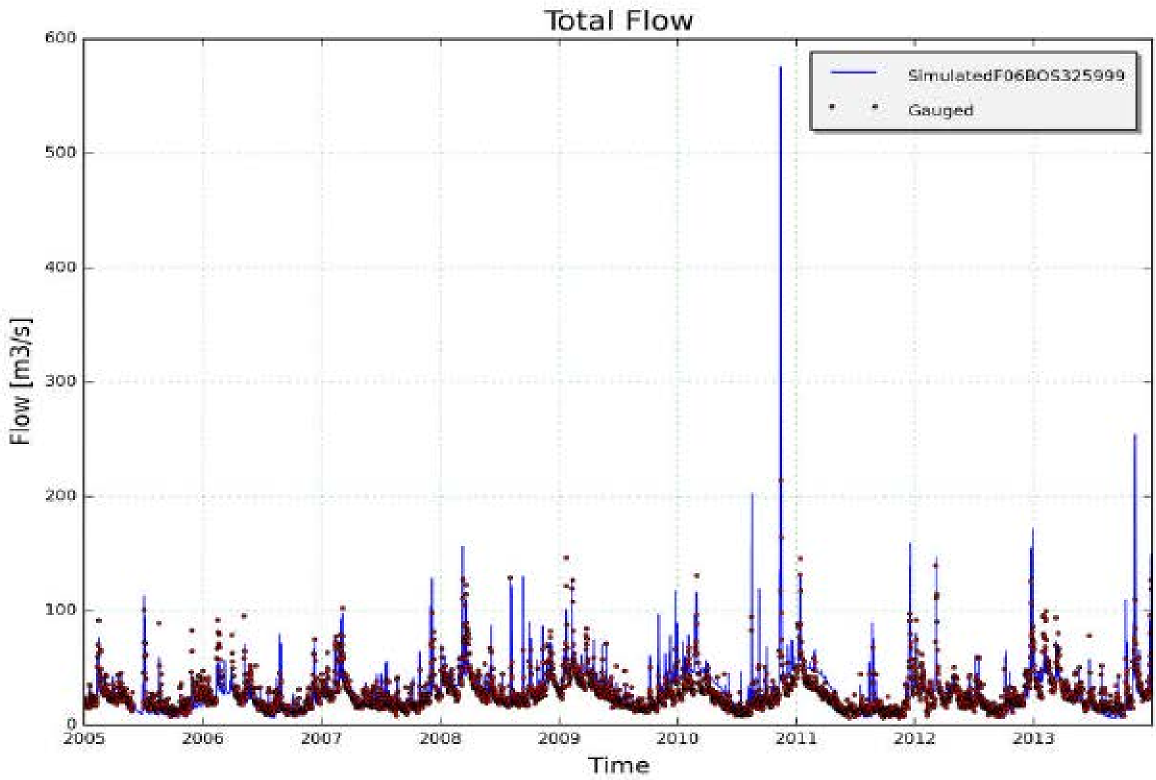


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment F06BOS325999, Bovenschelde Bossuit (calibration period)

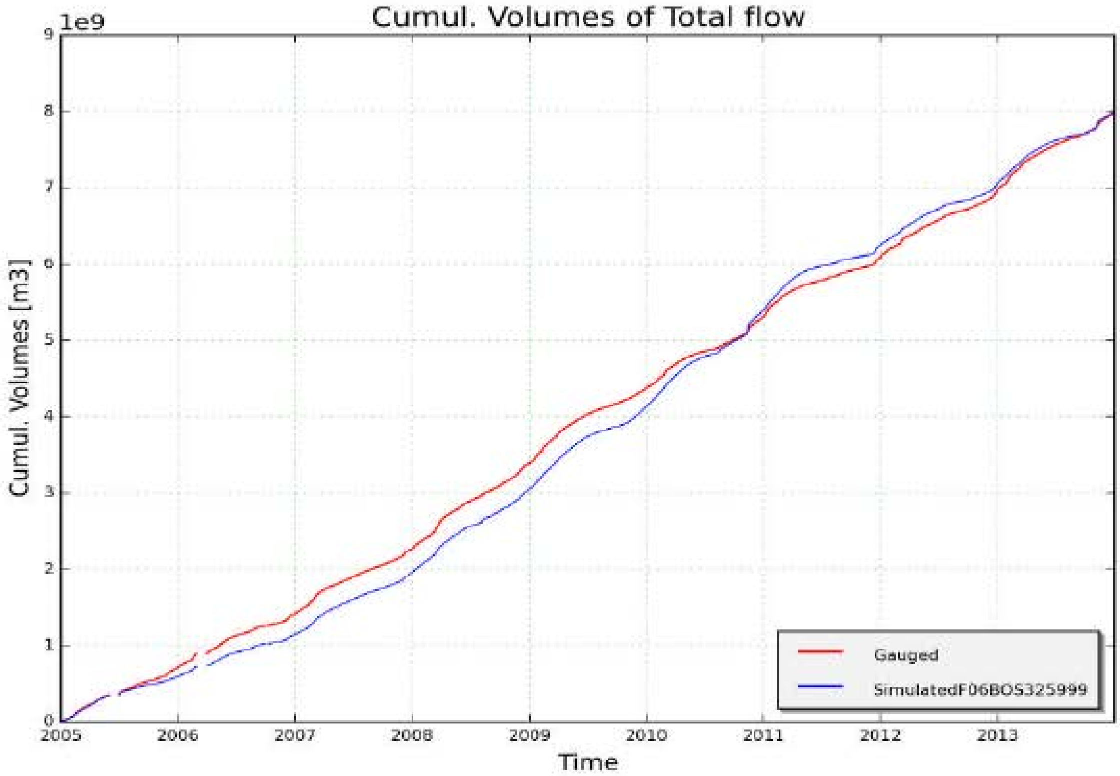


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment F06BOS325999, Bovenschelde Bossuit (calibration period)

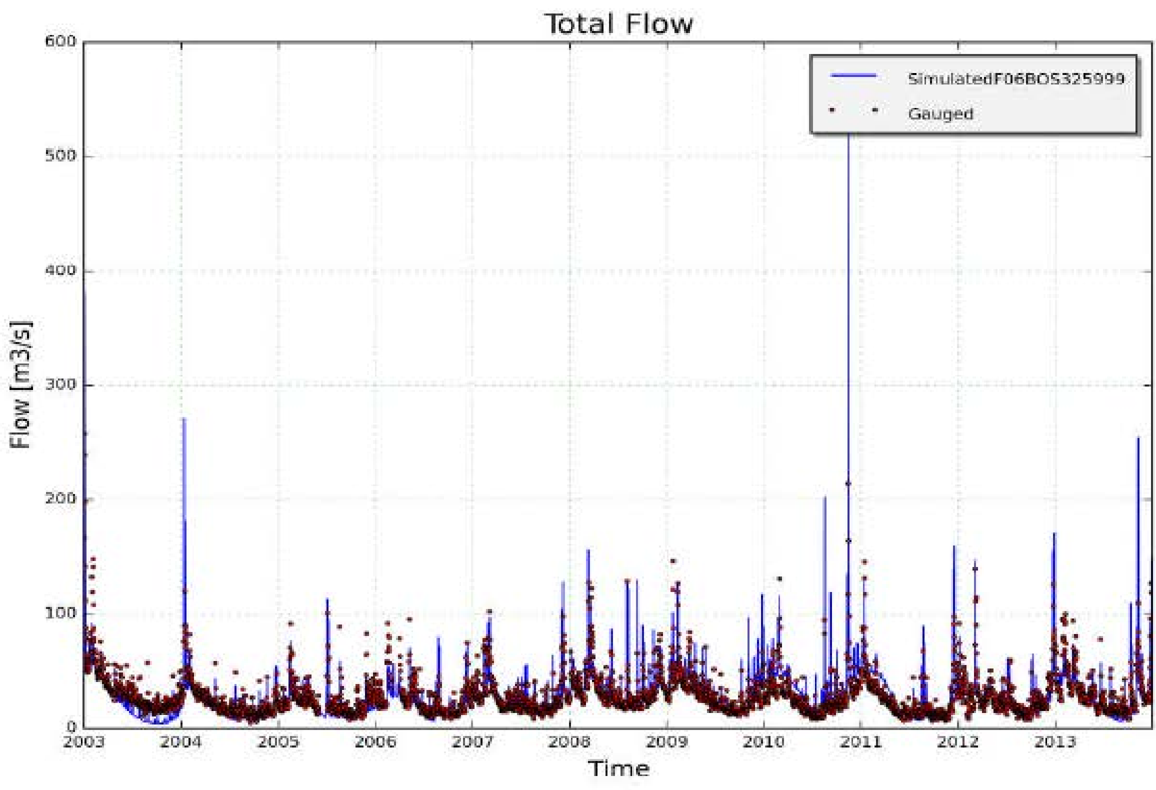


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment F06BOS325999, Bovenschelde Bossuit (validation period)

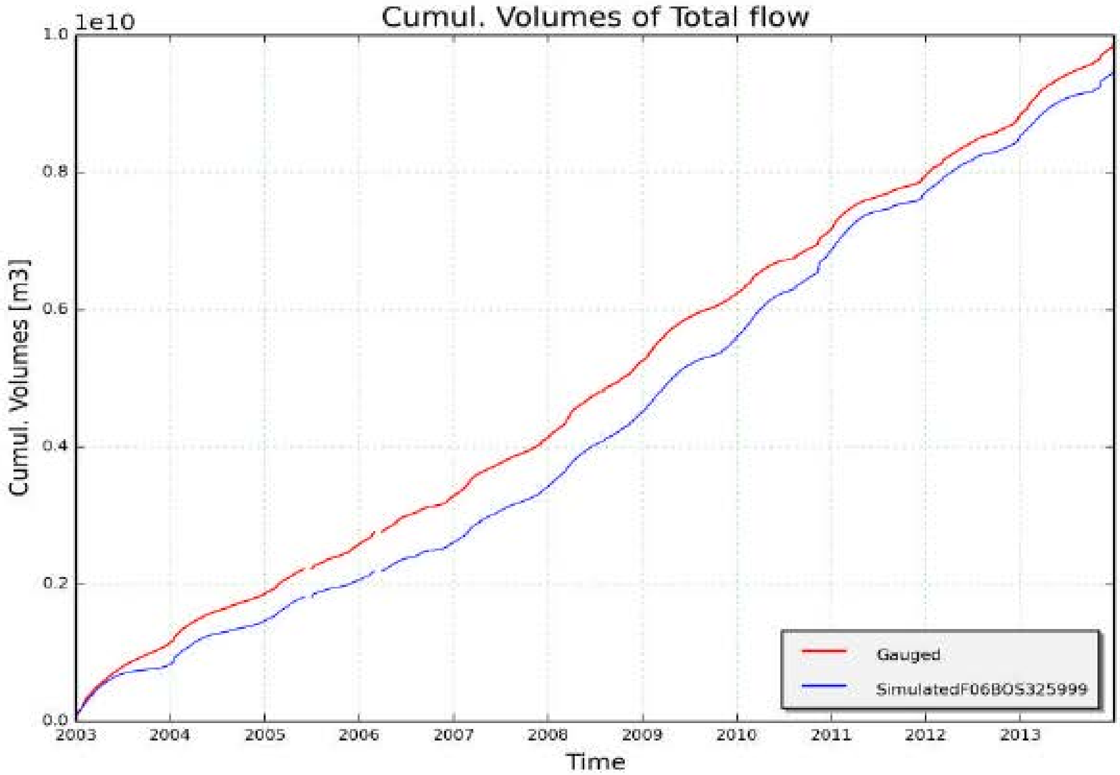


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment F06BOS325999, Bovenschelde Bossuit (validation period)

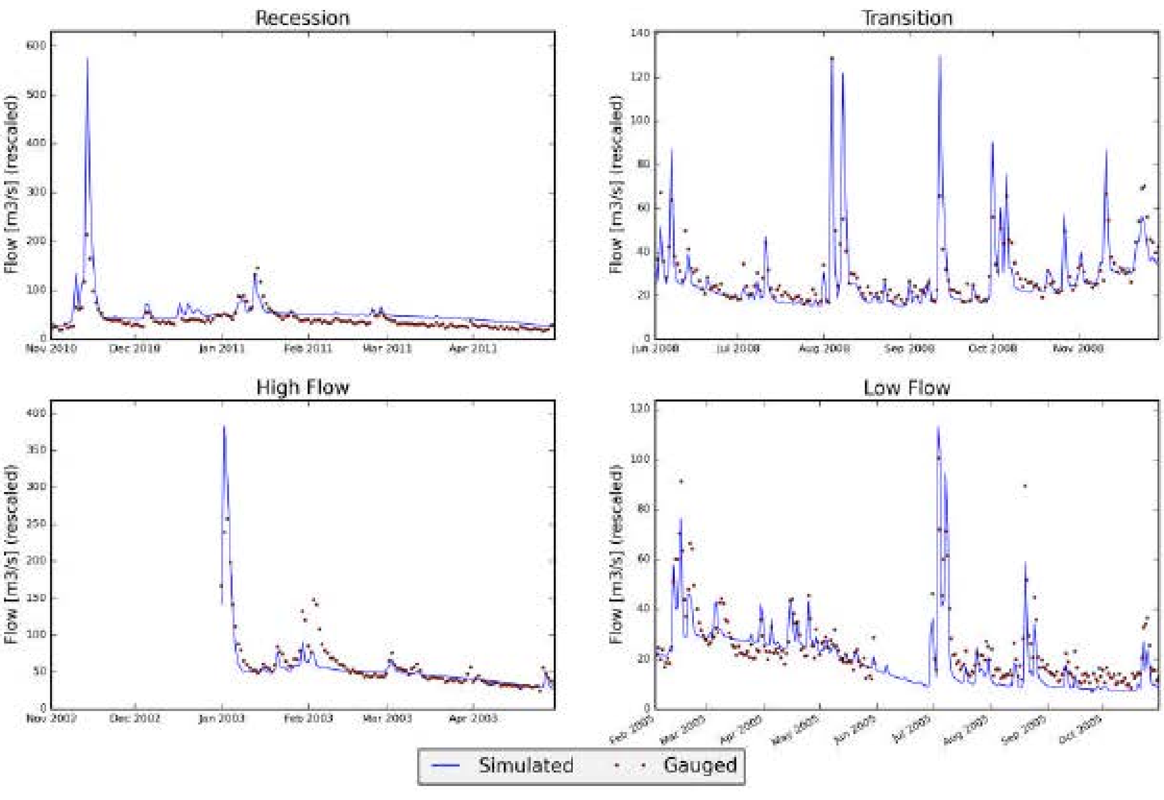


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment F06BOS325999, Bovenschelde Bossuit

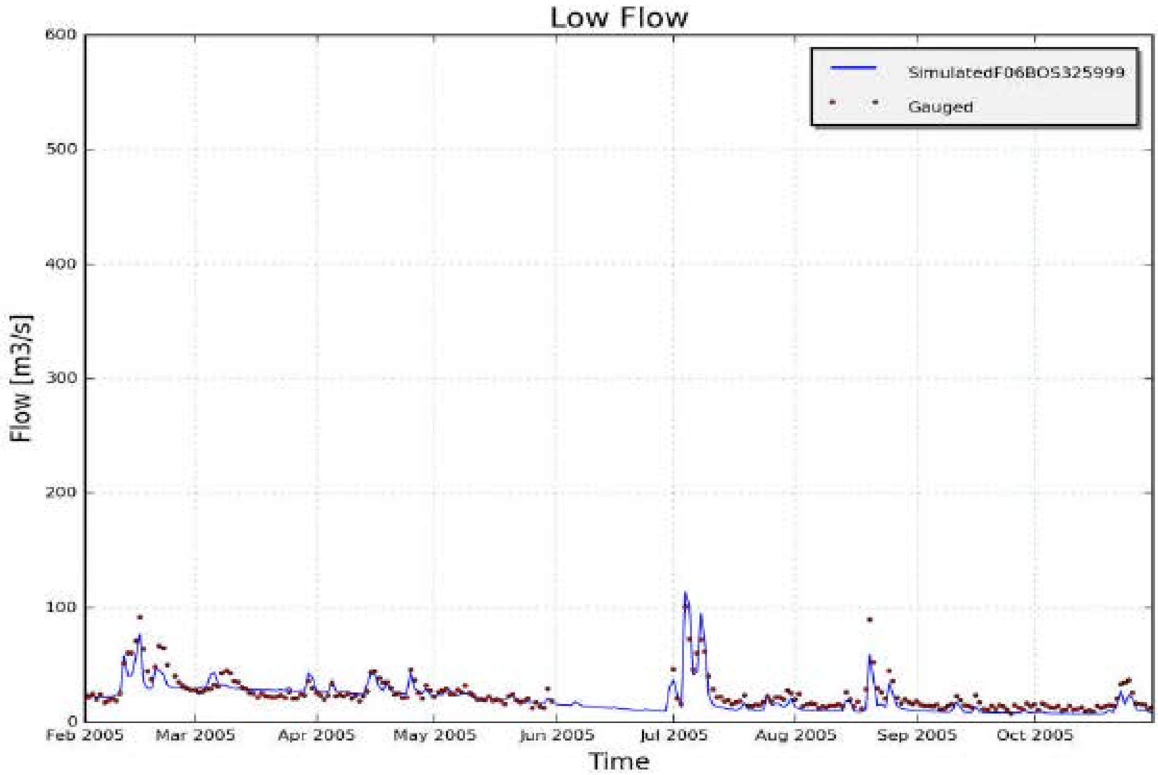


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment F06BOS325999, Bovenschelde Bossuit

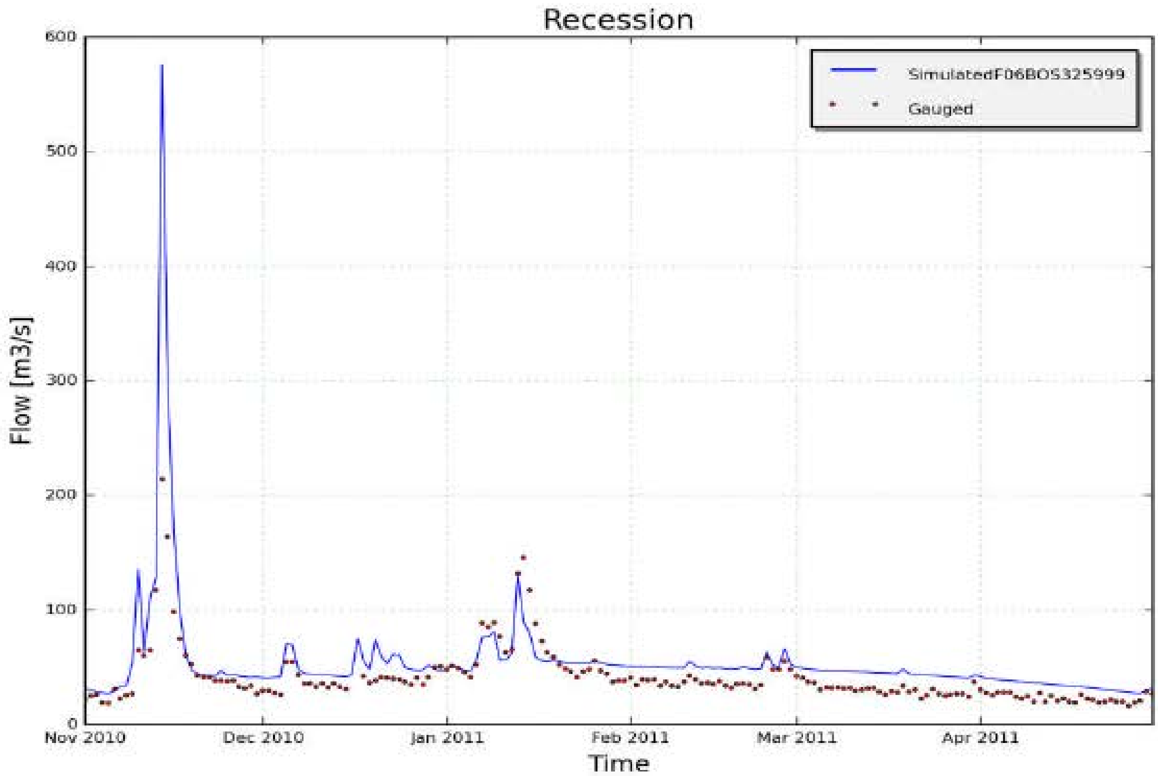


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment F06BOS325999, Bovenschelde Bossuit

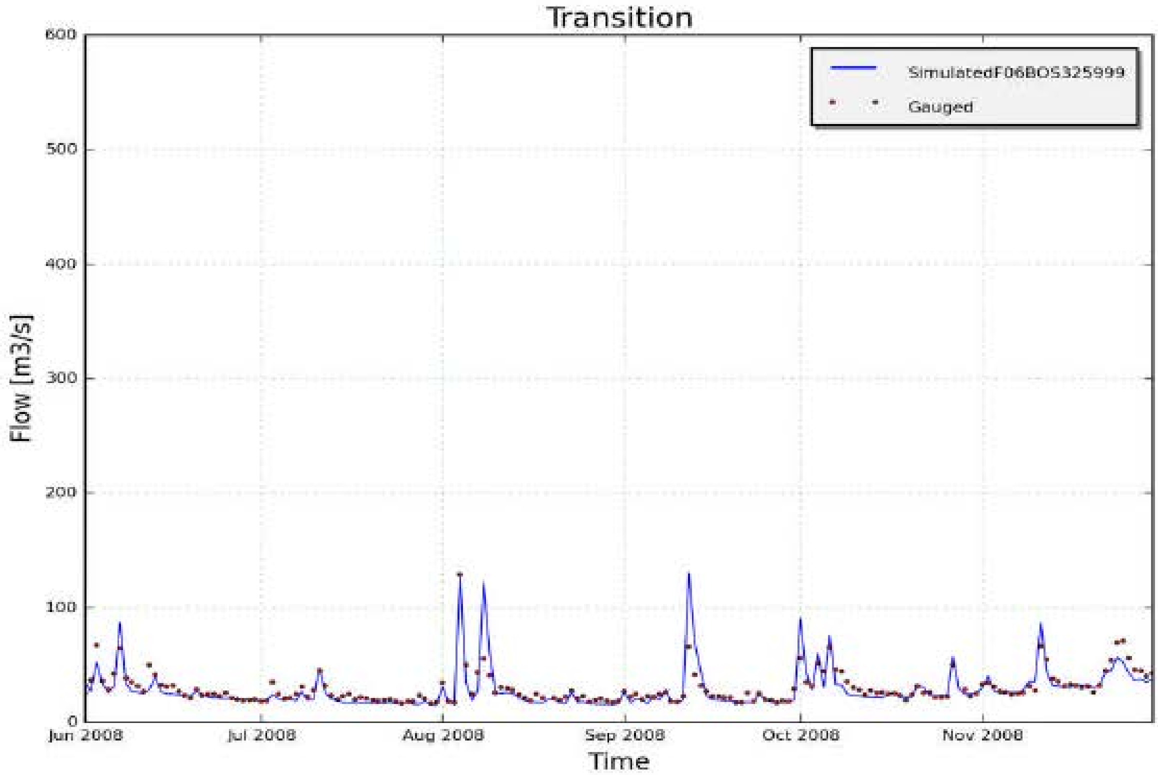


Figure 10: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment F06BOS325999, Bovenschelde Bossuit

Appendix 13 Bovenschelde Autocalibration.

9.5.1 Report on simulation of catchment V06MAA347160 (2017-01-25 06-11)

9.5.1.1 Input data

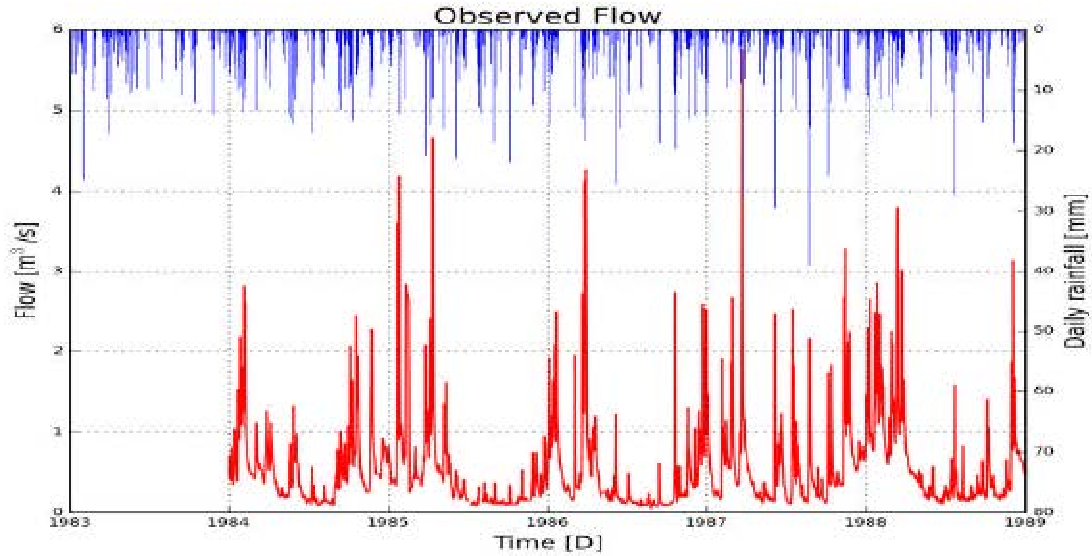


Figure 1: Hyetogram of observed discharge and observed net rain

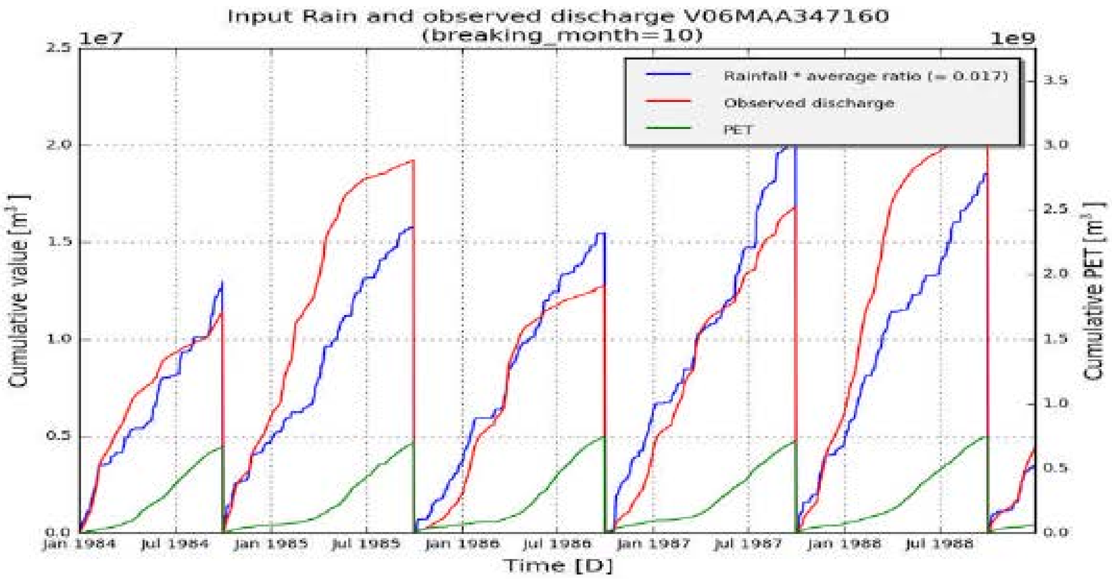


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.1.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V06MAA347160
subcatchment_area	48678191
start_date	199401010000
end_date	200812310000
frequency	86400
warmup	365

9.5.1.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.37, 73.0, 0.002, 1.05, 86.0, 187.0, 5.0, 153.0]
low_bounds	[0.95, 50.0, 0.0004, 0.75, 45.0, 90.0, 2.0, 100.0]
high_bounds	[1.9, 130.0, 0.01, 5.0, 135.0, 300.0, 10.0, 250.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.37), ('Ki', 73.0), ('Kg', 0.002), ('Kss', 1.05), ('g0', 86.0), ('g_max', 187.0), ('K_run', 5.0), ('P_max', 153.0)]
Initial fitness:

- RelErr: -0.079
- AbsErr: 10184433.43
- KGE: 0.187
- NS_rel: -1.395
- NS: -0.994

- RMSE: 11105022.302
- NS_log: 0.281

Computation time:13:55:00.727000

9.5.1.4 Results

Best individual (euclidian): [('Kep', 1.551), ('Ki', 61.946), ('Kg', 0.003), ('Kss', 3.217), ('g0', 83.084), ('g_max', 231.808), ('K_run', 9.667), ('P_max', 156.921)]

Fitness:

- RelErr: -0.019
- AbsErr: 7172991.187
- KGE: 0.366
- NS_rel: -0.309
- NS: -0.453
- RMSE: 8135515.243
- NS_log: 0.509

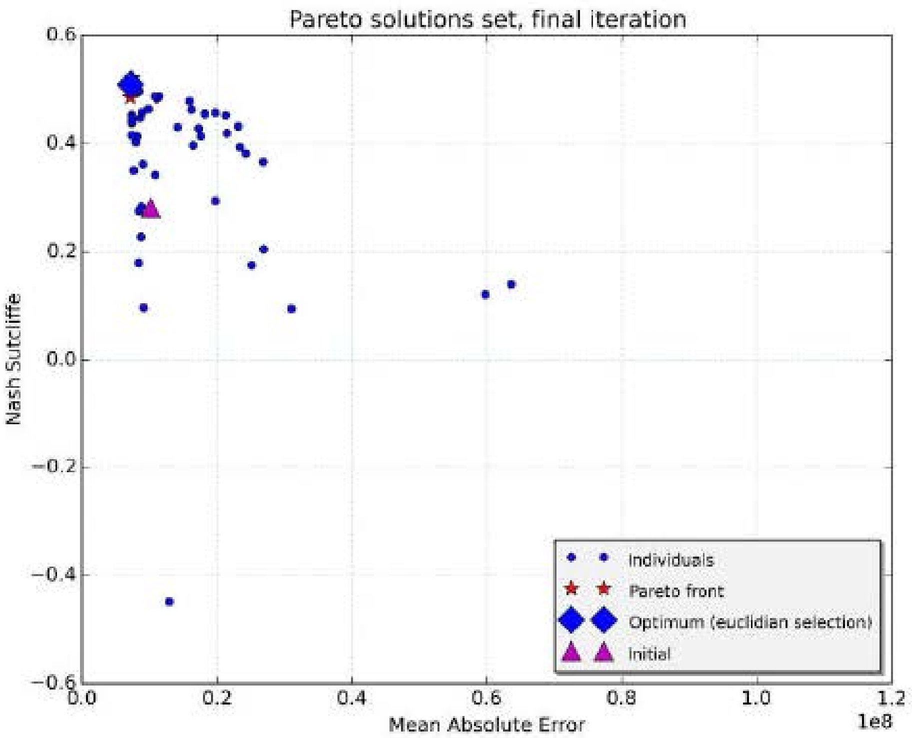


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

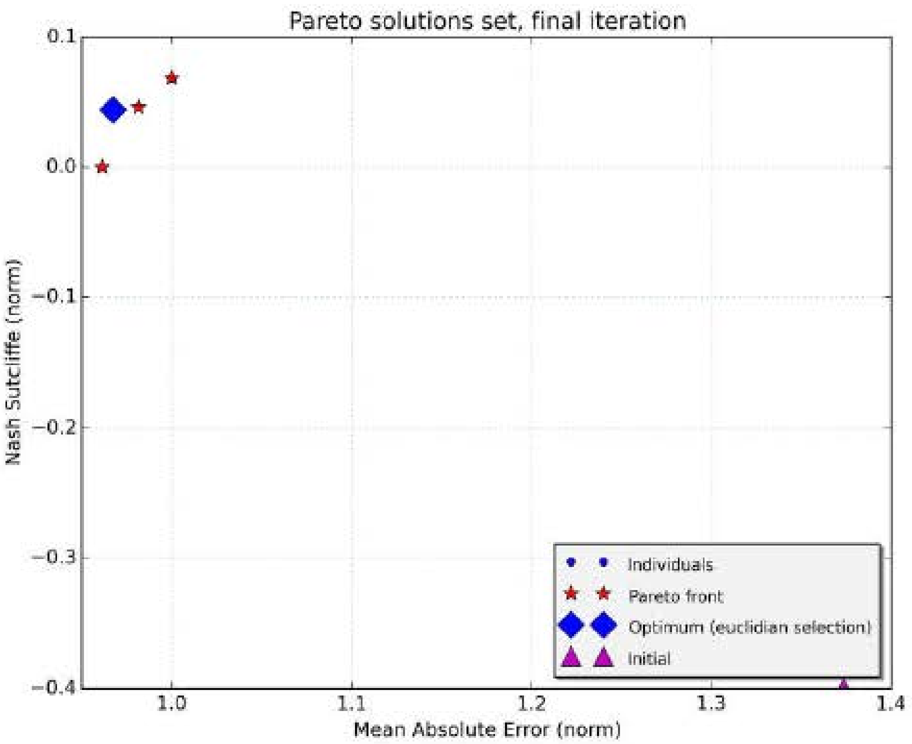


Figure 4: Final population of solutions (Pareto front)

9.5.1.4.1 Initial

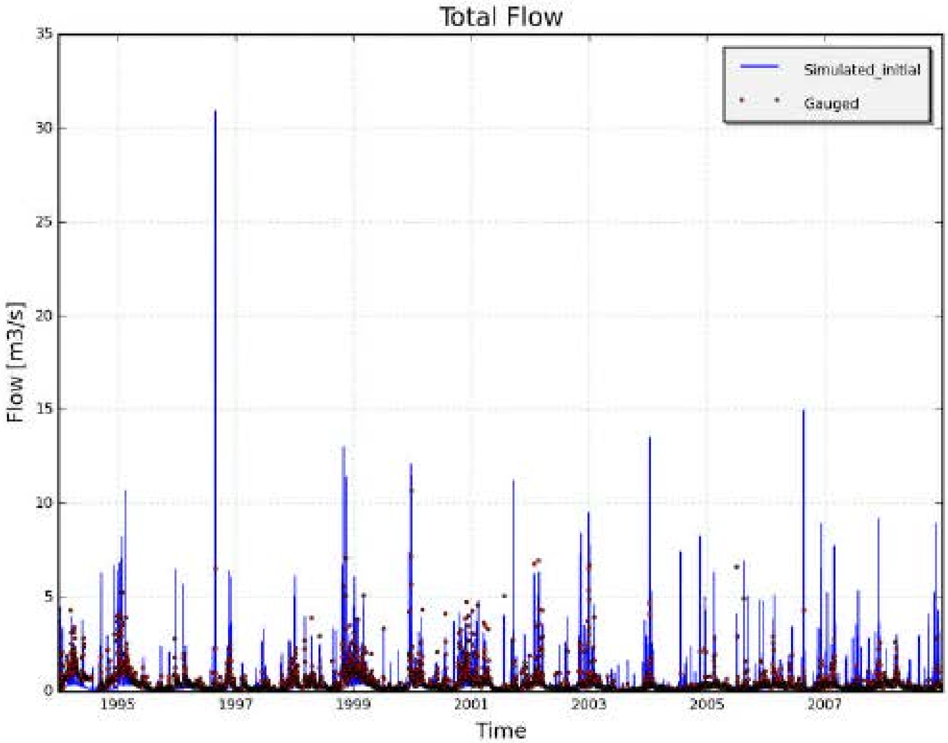


Figure 5: Total flow with initial parameters

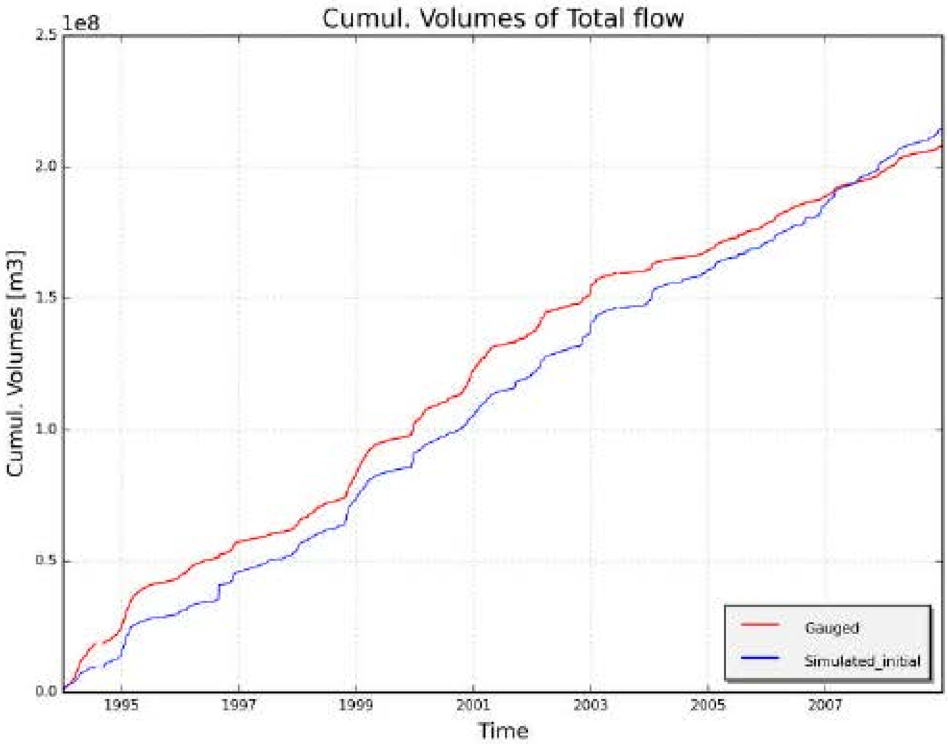


Figure 6: Cumulated flow with initial parameters

9.5.1.4.2 Optimum (euclidian)

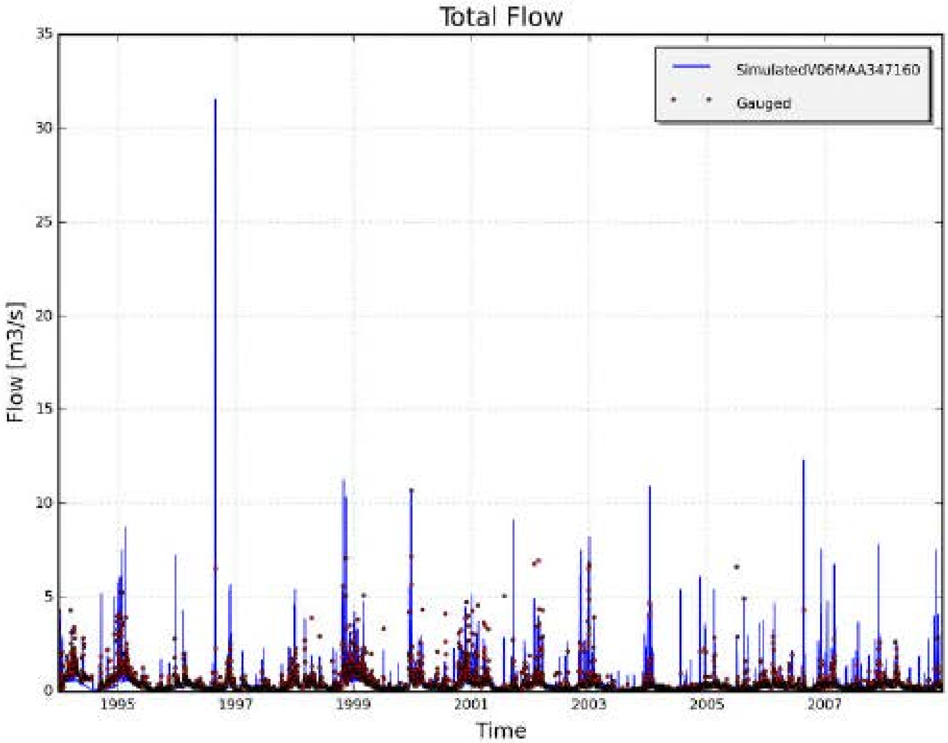


Figure 7: Total flow with optimum parameters

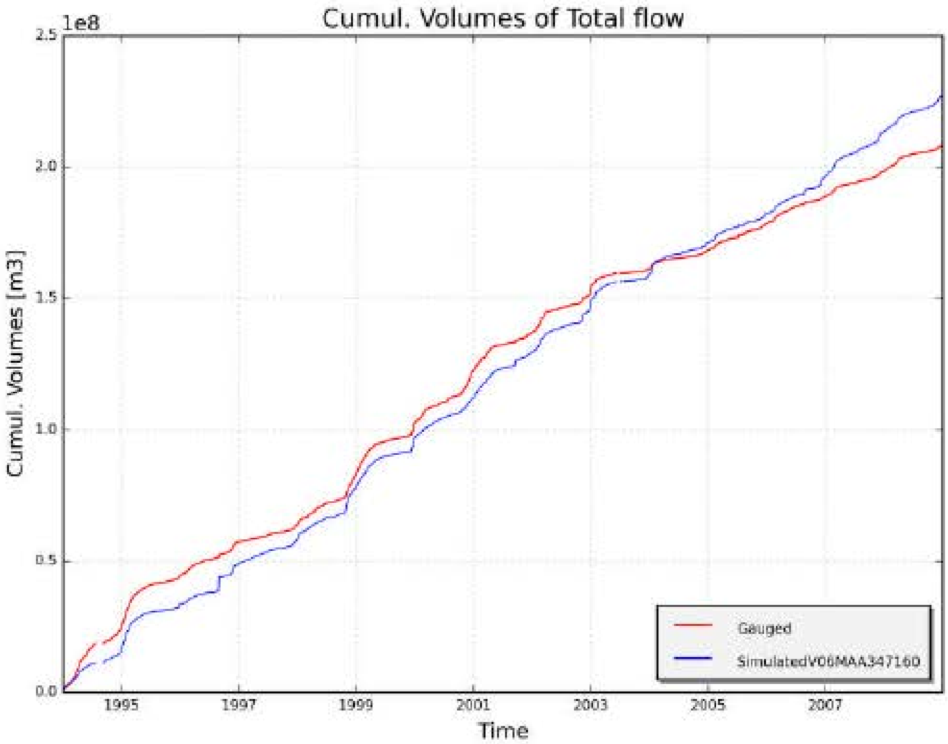


Figure 8: Cumulated flow with optimum parameters

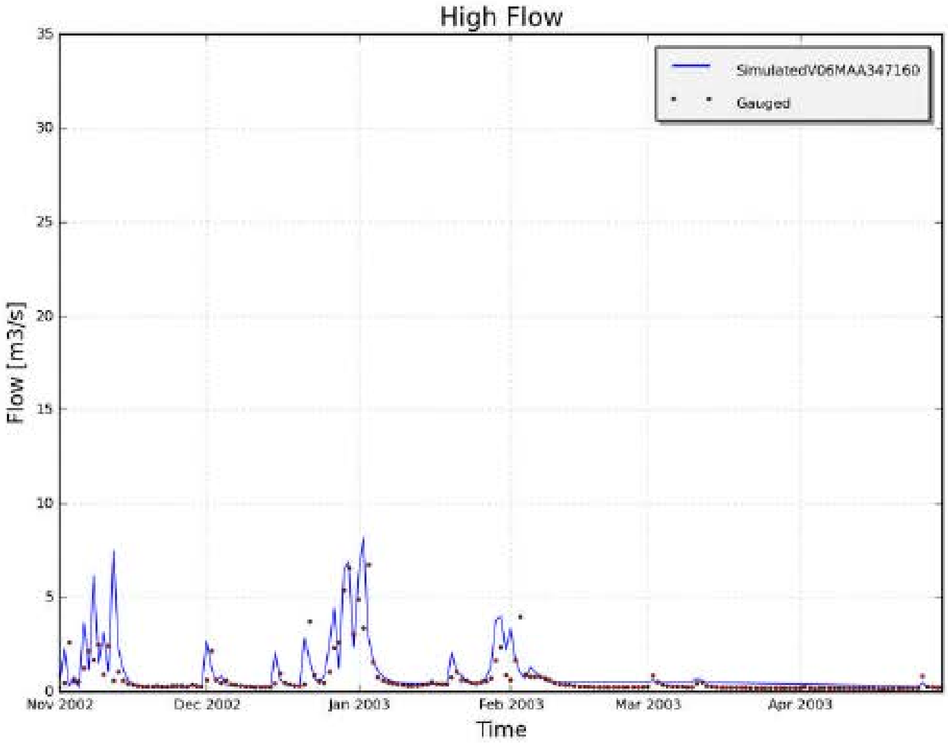


Figure 9: Total flow with optimum parameters (detail)

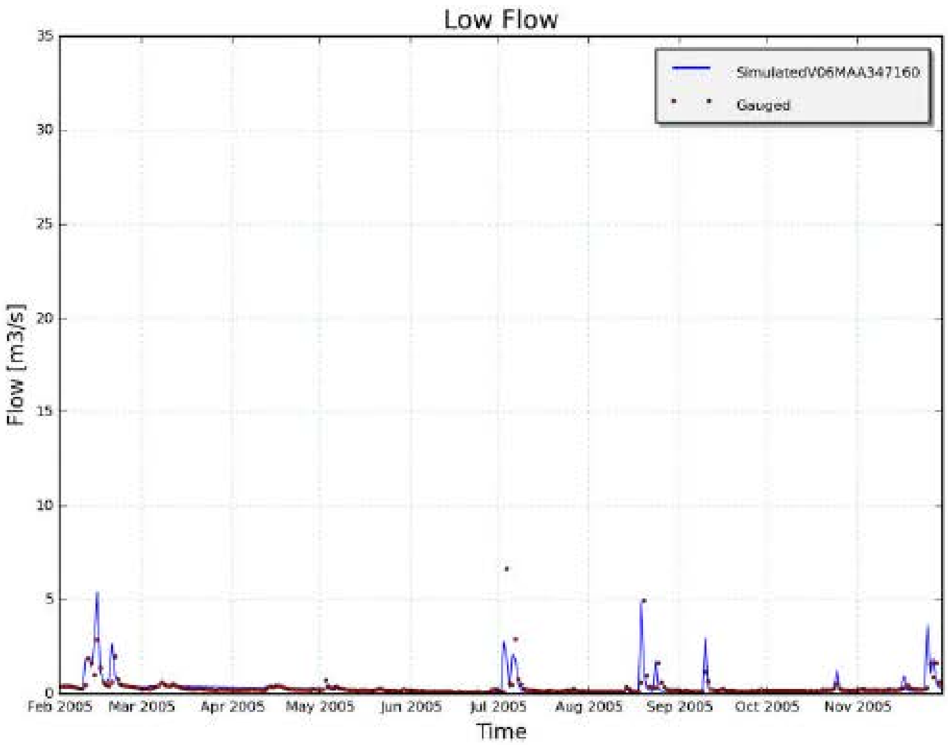


Figure 10: Total flow with optimum parameters (detail)

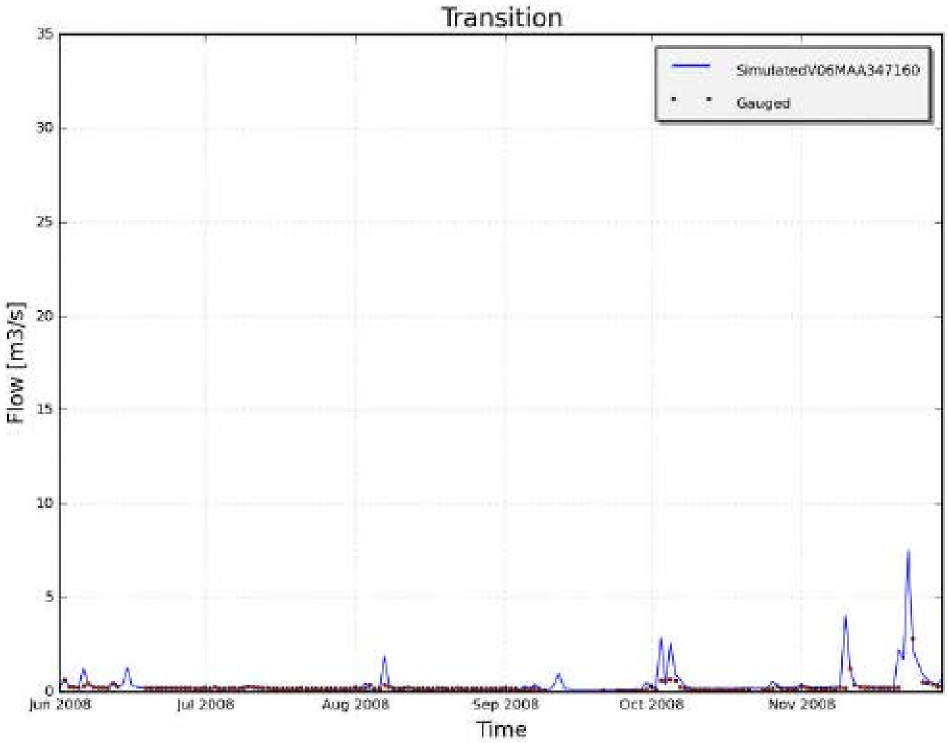
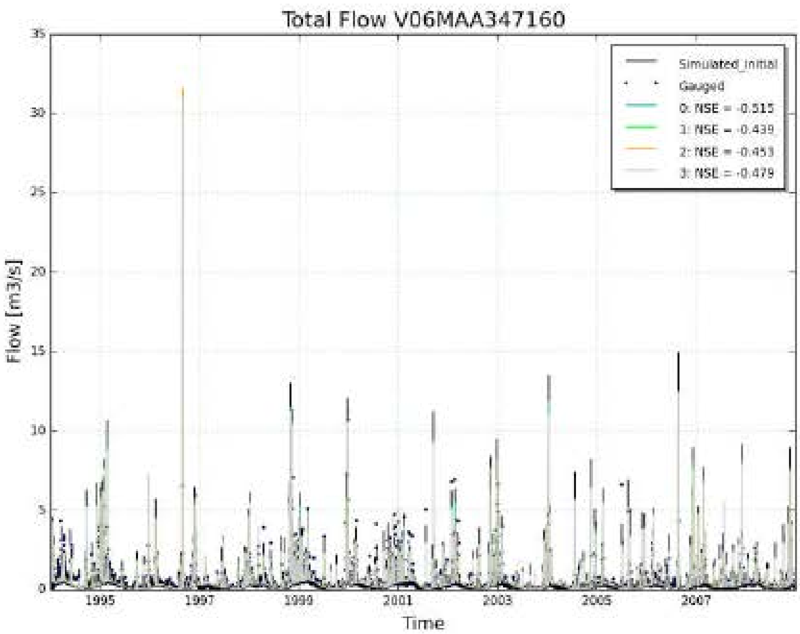
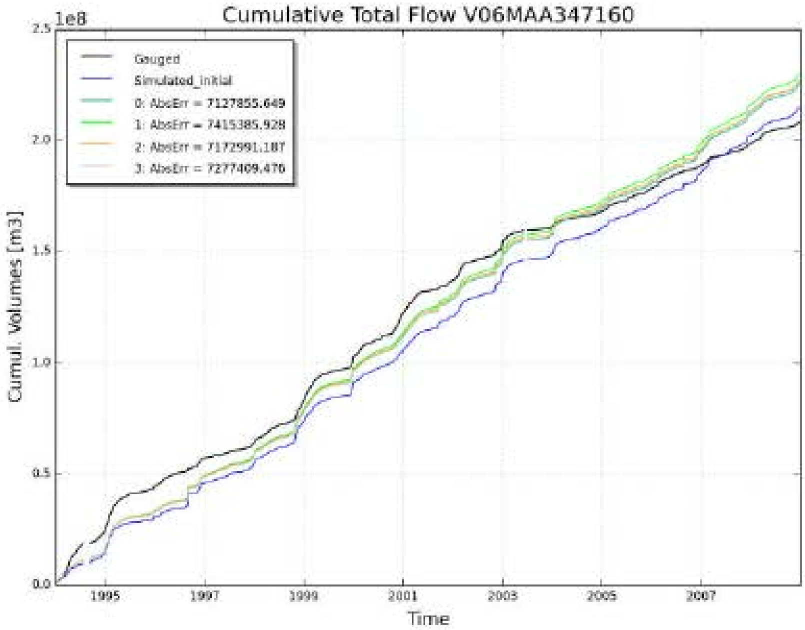


Figure 11: Total flow with optimum parameters (detail)

9.5.1.4.3 Final archive

0 : [1.563, 62.404, 0.003, 1.435, 94.665, 229.318, 7.487, 159.205] : [7127855.649, 0.486]
1 : [1.482, 57.313, 0.003, 1.798, 75.629, 239.662, 7.949, 177.786] : [7415385.928, 0.521]
2 : [1.551, 61.946, 0.003, 3.217, 83.084, 231.808, 9.667, 156.921] : [7172991.187, 0.509]
3 : [1.484, 59.109, 0.003, 2.8, 82.495, 229.993, 7.824, 157.538] : [7277409.476, 0.51]





9.5.2 Report on simulation of catchment V06ZWA342190 (2017-01-18 21-58)

9.5.2.1 Input data

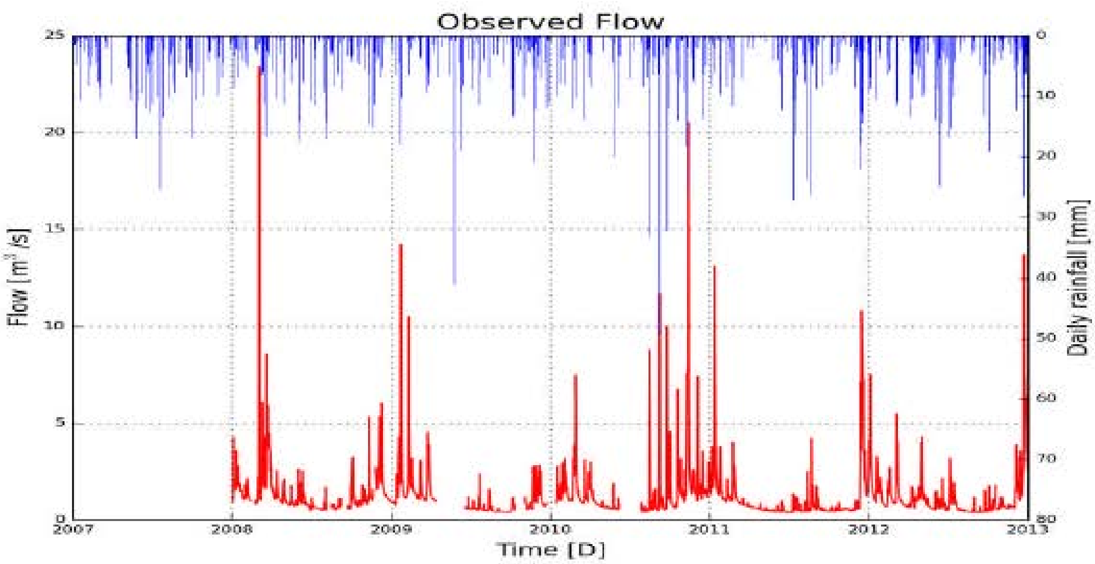


Figure 1: Hyetogram of observed discharge and observed net rain

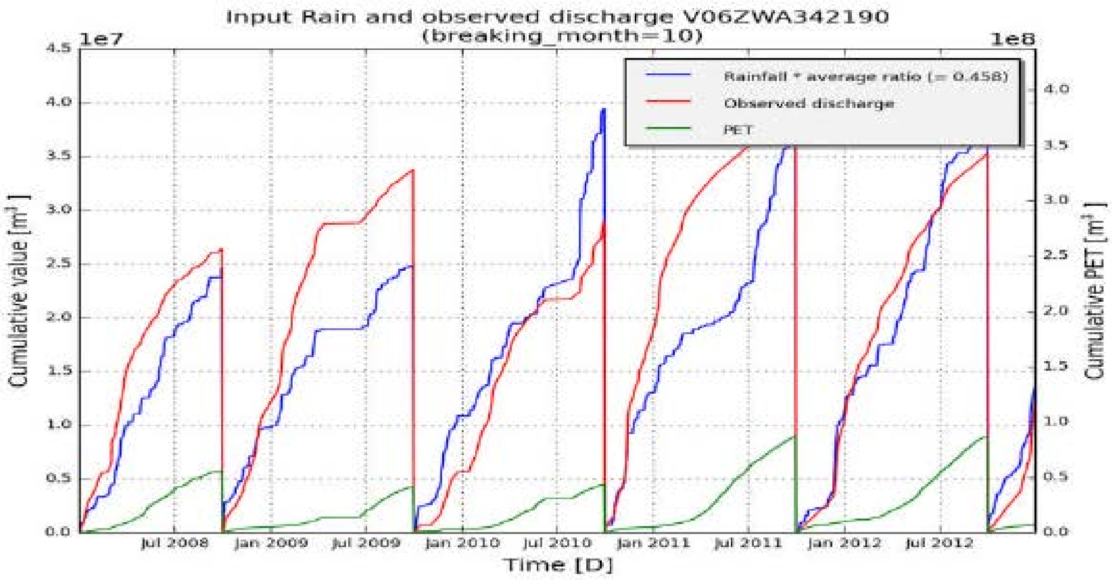


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.2.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V06ZWA342190
subcatchment_area	112100000
start_date	200801010000
end_date	201212310000
frequency	86400
warmup	365

9.5.2.3 Optimization settings

Setting	Value
popul_size	5
max_generations	5
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[1.4, 19.0, 0.003, 1.0, 45.0, 750.0, 6.5, 210.0]
low_bounds	[1.1, 15.2, 0.002, 0.8, 36.0, 550.0, 5.0, 160.0]
high_bounds	[2.0, 70.0, 0.01, 3.0, 150.0, 888.0, 9.0, 300.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.4), ('Ki', 19.0), ('Kg', 0.003), ('Kss', 1.0), ('g0', 45.0), ('g_max', 750.0), ('K_run', 6.5), ('P_max', 210.0)]
Initial fitness:

- RelErr: -0.011
- AbsErr: 5140784.387
- KGE: 0.619
- NS_rel: 0.646
- NS: 0.551
- RMSE: 5782103.06
- NS_log: 0.628

Computation time:4:07:11.409000

9.5.2.4 Results

Best individual (euclidian):
[('Kep', 1.602), ('Ki', 56.233), ('Kg', 0.005), ('Kss', 1.723), ('g0', 87.936), ('g_max', 640.411), ('K_run', 6.957), ('P_max', 201.187)]

Fitness:

- RelErr: -0.028
- AbsErr: 4492488.468
- KGE: 0.742
- NS_rel: 0.335
- NS: 0.469
- RMSE: 5644810.884
- NS_log: 0.647

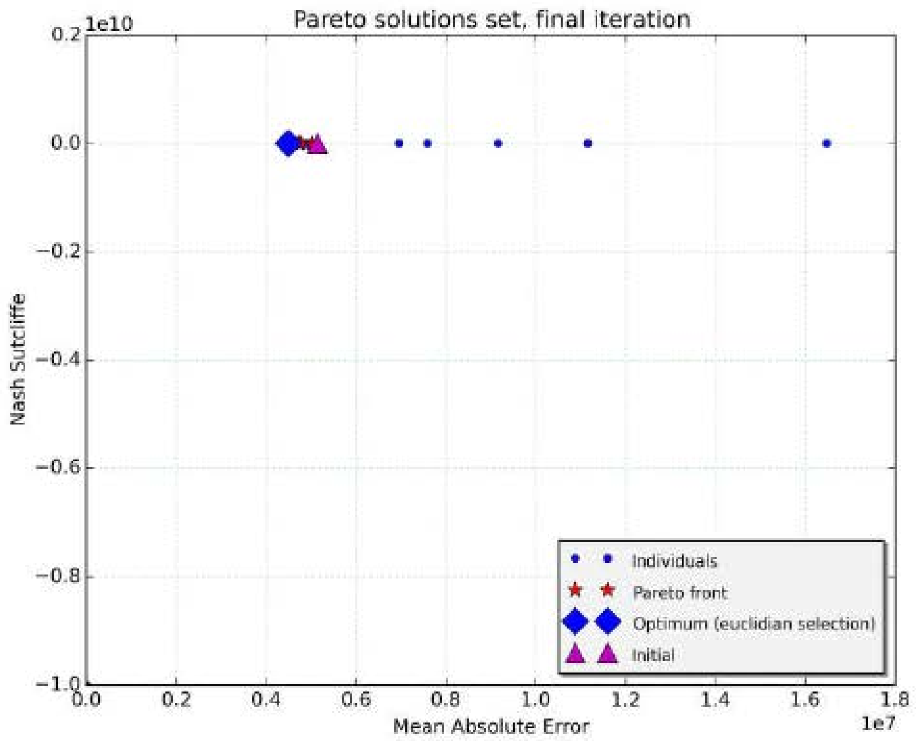


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

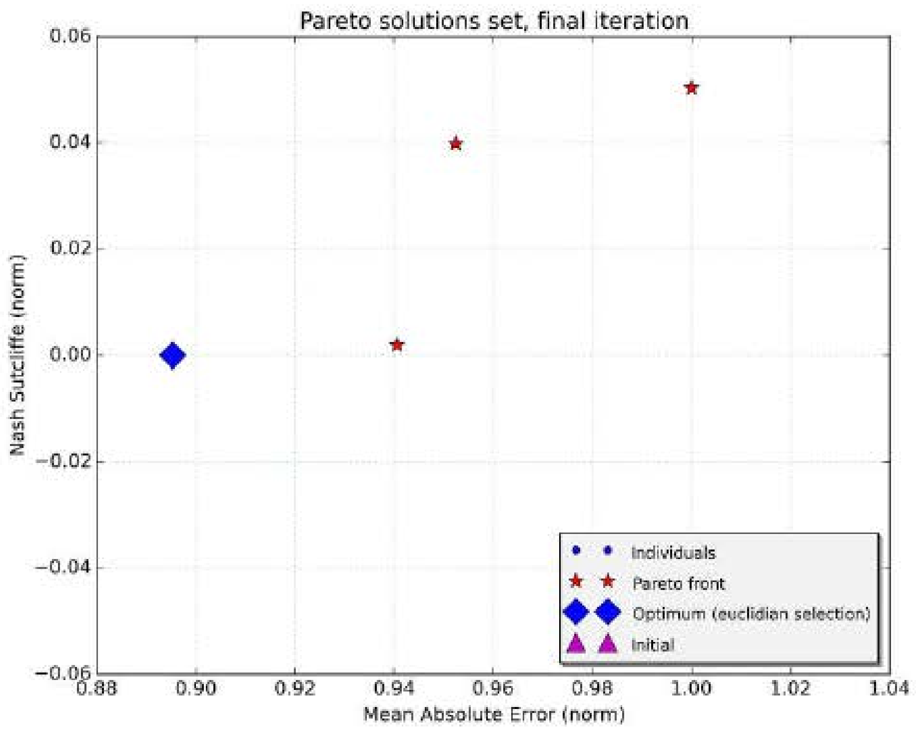


Figure 4: Final population of solutions (Pareto front)

9.5.2.4.1 Initial

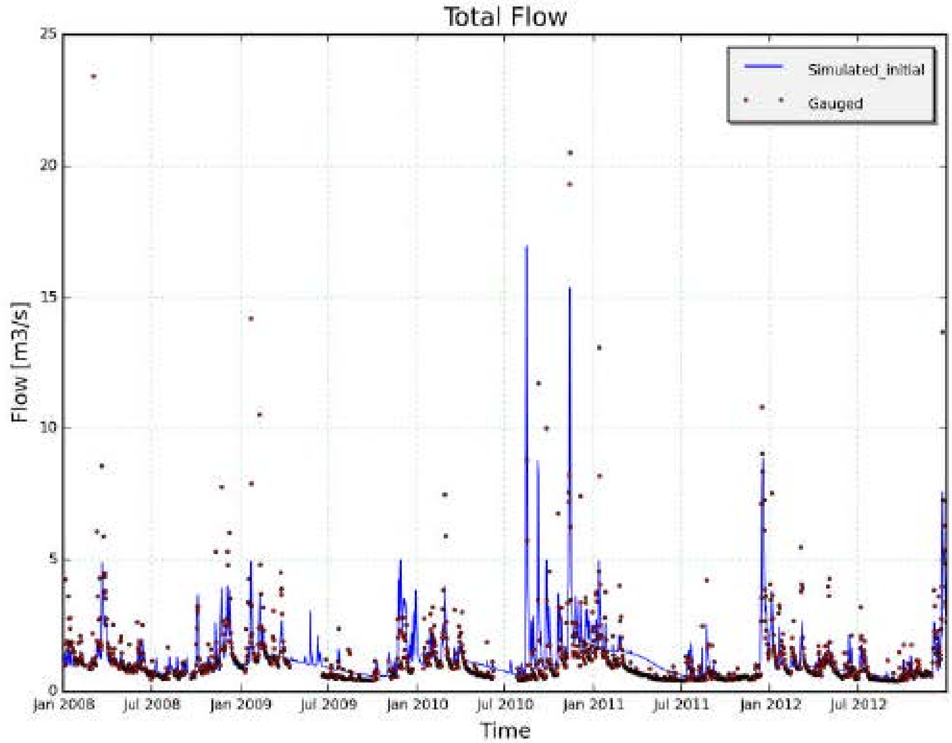


Figure 5: Total flow with initial parameters

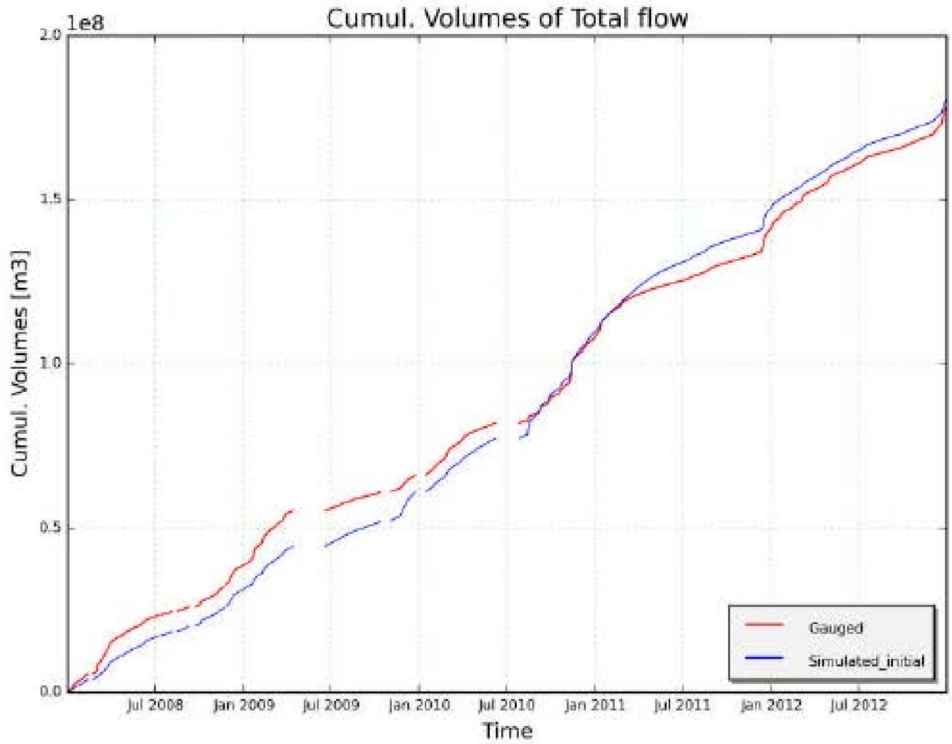


Figure 6: Cumulated flow with initial parameters

9.5.2.4.2 Optimum (euclidian)

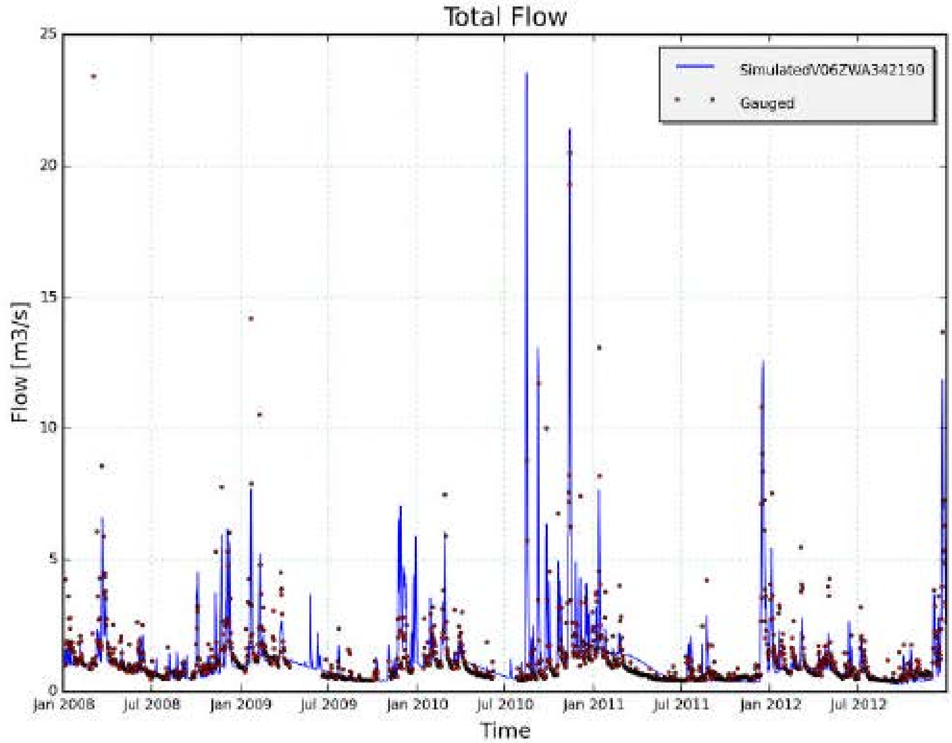


Figure 7: Total flow with optimum parameters

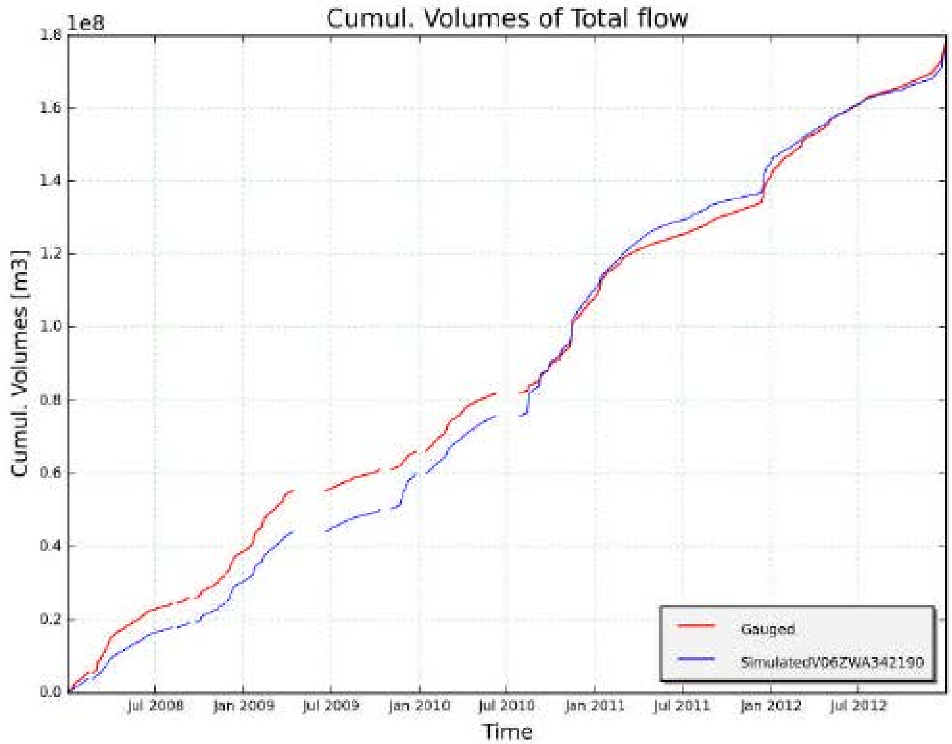


Figure 8: Cumulated flow with optimum parameters

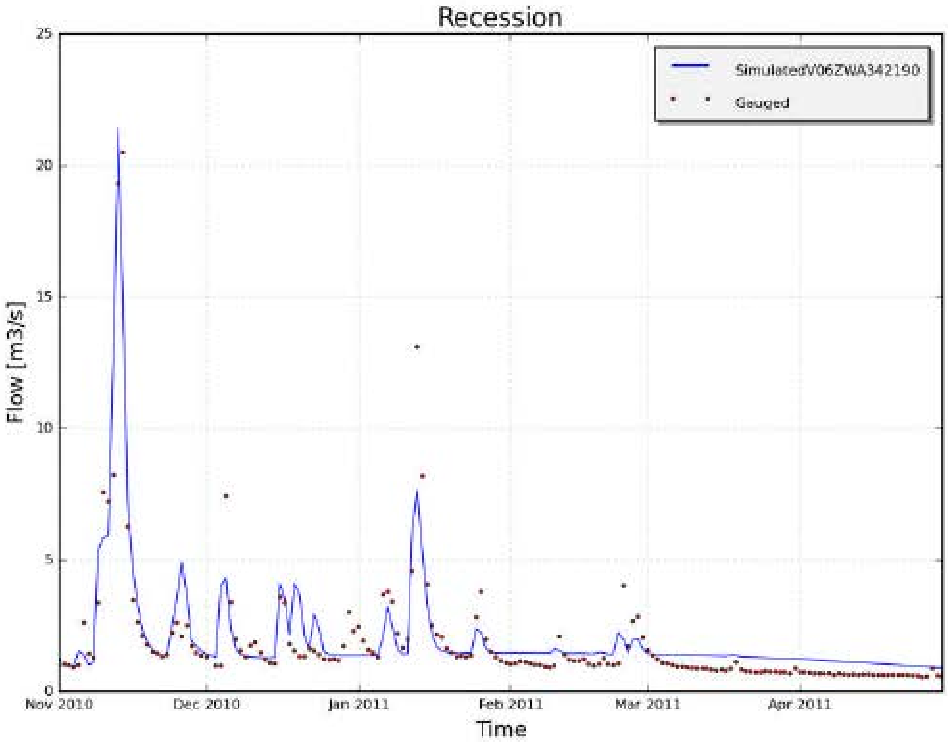


Figure 9: Total flow with optimum parameters (detail)

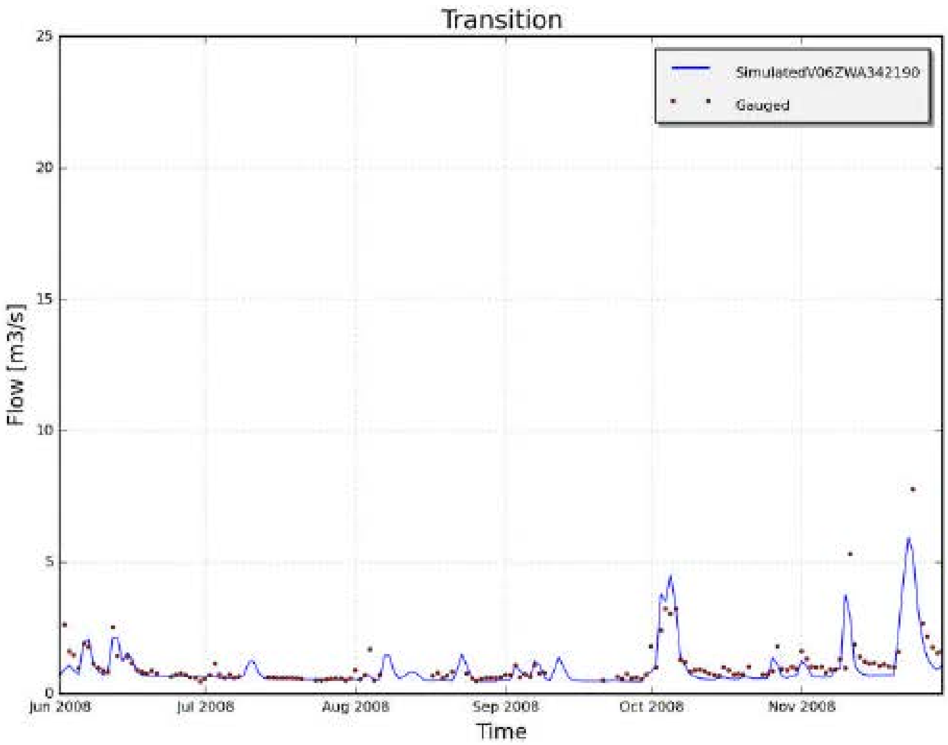
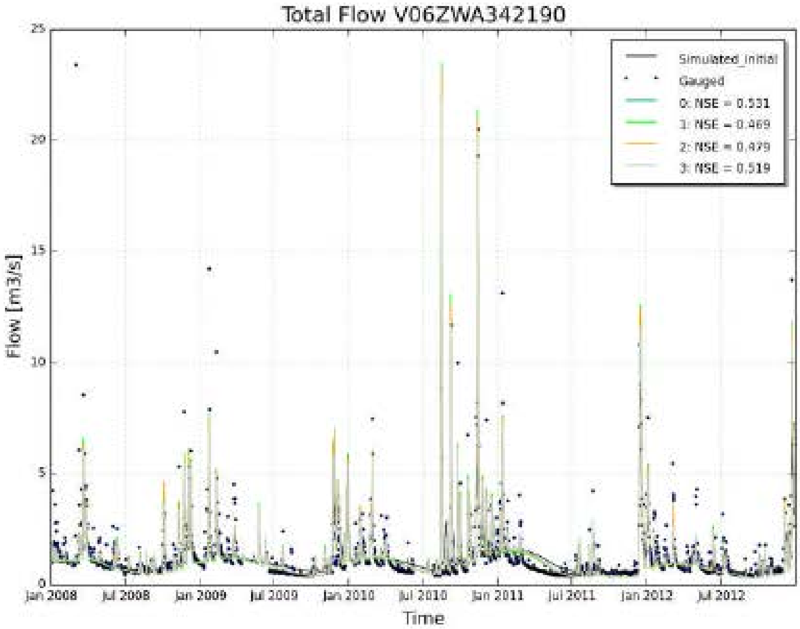
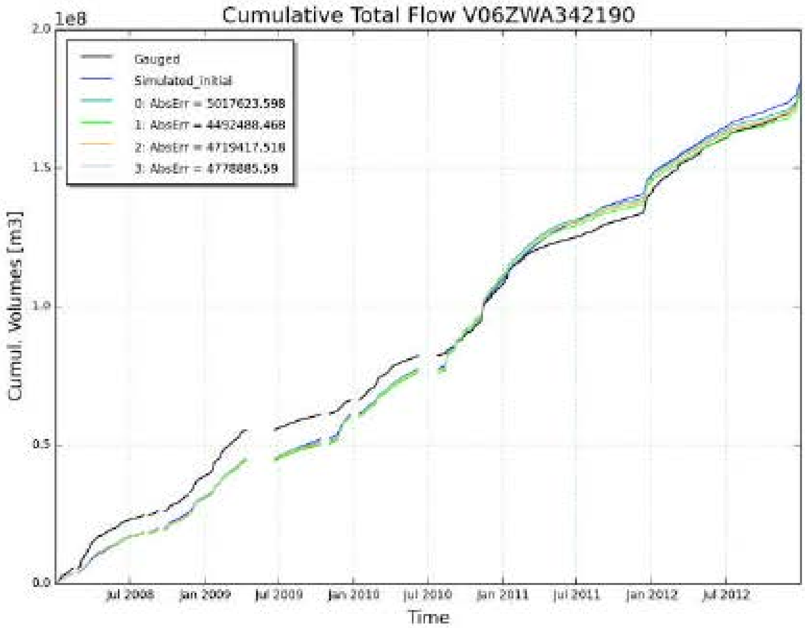


Figure 10: Total flow with optimum parameters (detail)

9.5.2.4.3 Final archive

0 : [1.604, 42.367, 0.005, 1.544, 87.452, 650.43, 6.395, 218.885] : [5017623.598, 0.665]
1 : [1.602, 56.233, 0.005, 1.723, 87.936, 640.411, 6.957, 201.187] : [4492488.468, 0.647]
2 : [1.602, 56.175, 0.005, 1.744, 87.89, 640.609, 8.319, 210.318] : [4719417.518, 0.647]
3 : [1.604, 45.322, 0.005, 1.714, 87.644, 642.365, 6.618, 203.983] : [4778885.59, 0.661]





9.5.3 Report on simulation of catchment W06RHOL54100 (2017-02-01 17-01)

9.5.3.1 Input data

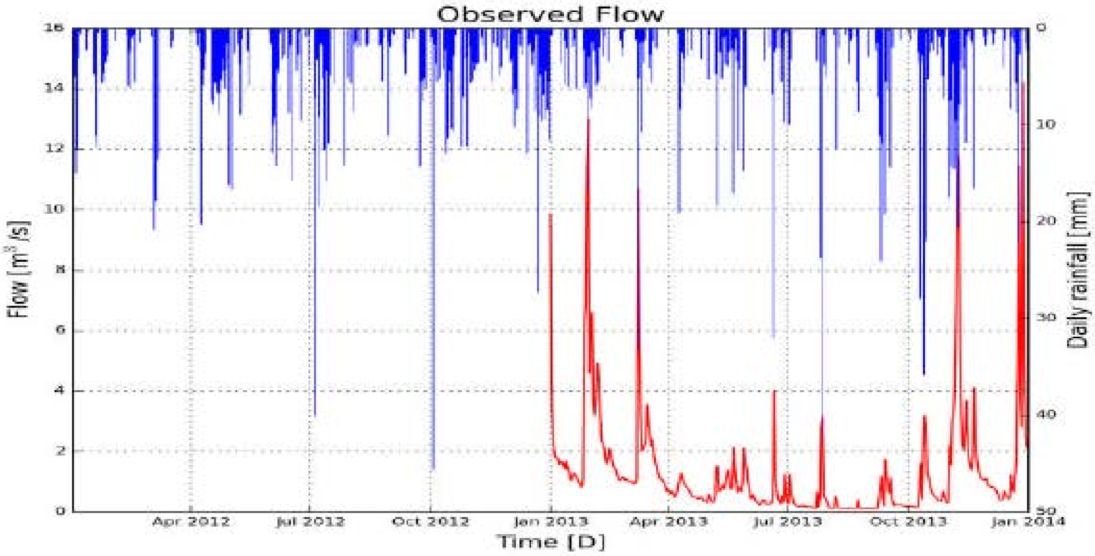


Figure 1: Hyetogram of observed discharge and observed net rain

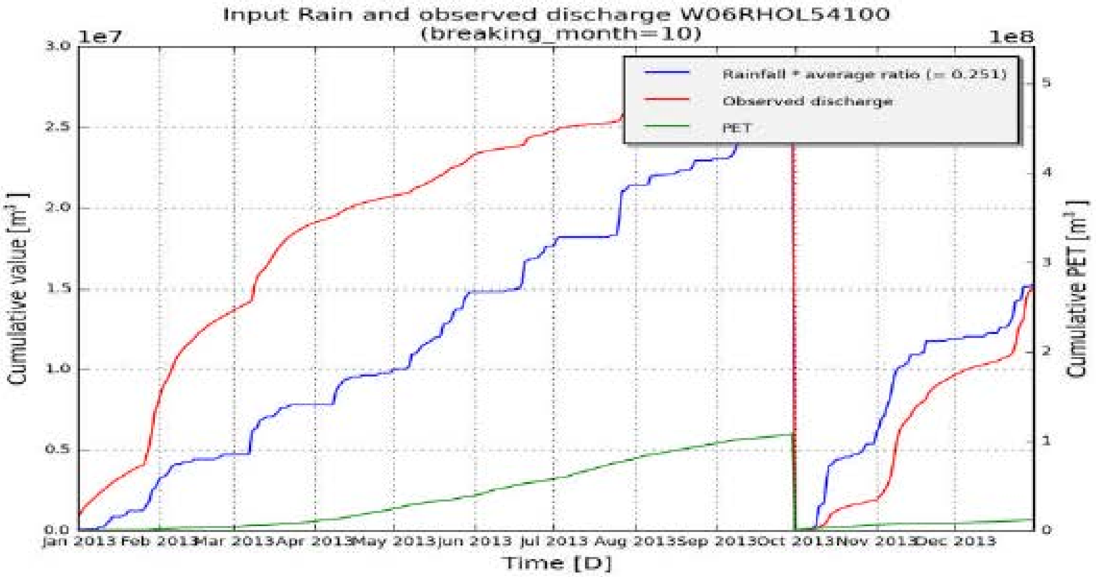


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.3.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	W06RHOL54100
subcatchment_area	161900000
start_date	201301010000
end_date	201309300000
frequency	86400
warmup	365

9.5.3.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[2.97, 95.92, 0.007, 0.72, 161.6, 387.0, 4.5, 102.0]
low_bounds	[1.0, 50.0, 0.002, 0.5, 90.0, 200.0, 2.0, 50.0]
high_bounds	[3.5, 150.0, 0.01, 2.0, 260.0, 600.0, 7.0, 150.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 2.97), ('Ki', 95.92), ('Kg', 0.007), ('Kss', 0.72), ('g0', 161.6), ('g_max', 387.0), ('K_run', 4.5), ('P_max', 102.0)]
Initial fitness:

- RelErr: -0.002
- AbsErr: 553321.394
- KGE: 0.798
- NS_rel: 0.387
- NS: 0.643
- RMSE: 724354.067
- NS_log: 0.715

Computation time:2:19:54.111000

9.5.3.4 Results

Best individual (euclidian): [('Kep', 2.953), ('Ki', 97.461), ('Kg', 0.007), ('Kss', 2.0), ('g0', 163.608), ('g_max', 399.533), ('K_run', 6.173), ('P_max', 87.133)]

Fitness:

- RelErr: 0.012
- AbsErr: 482532.649
- KGE: 0.839
- NS_rel: 0.484
- NS: 0.708
- RMSE: 646495.063
- NS_log: 0.73

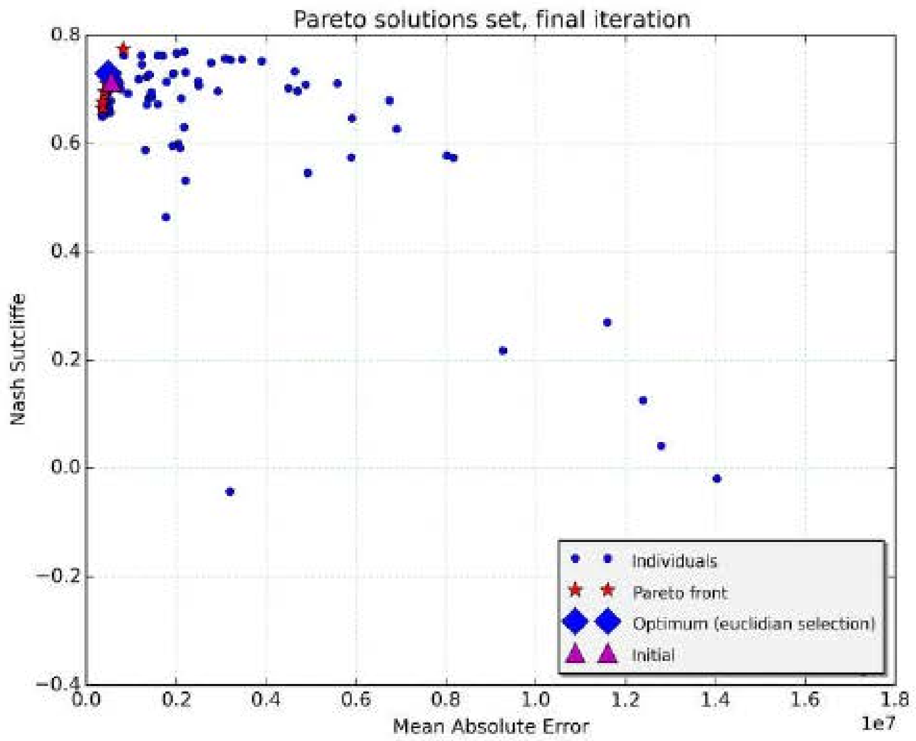


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

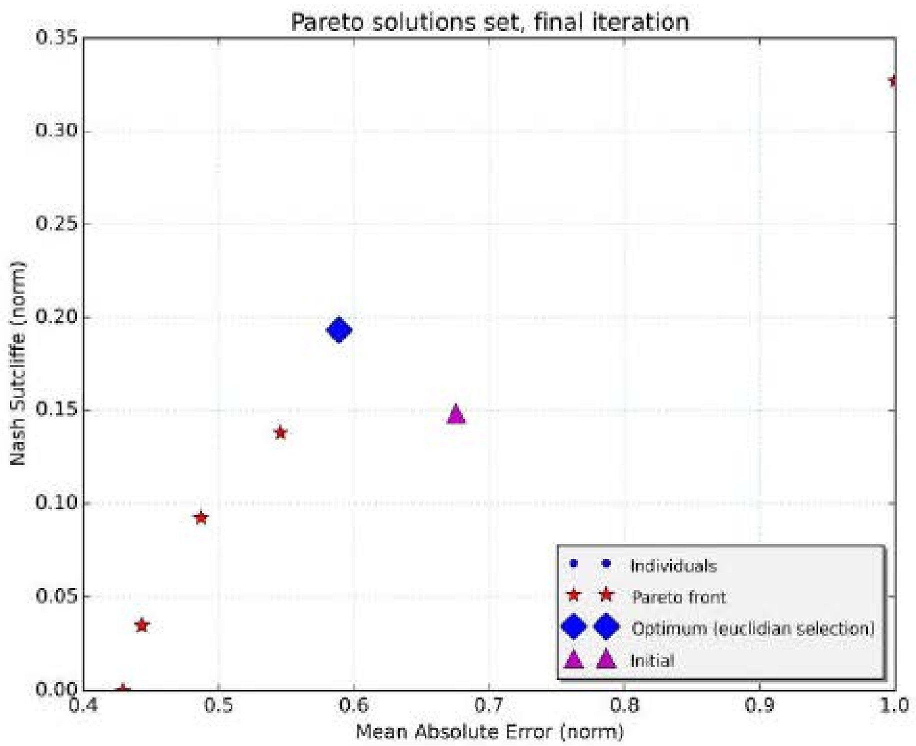


Figure 4: Final population of solutions (Pareto front)

9.5.3.4.1 Initial

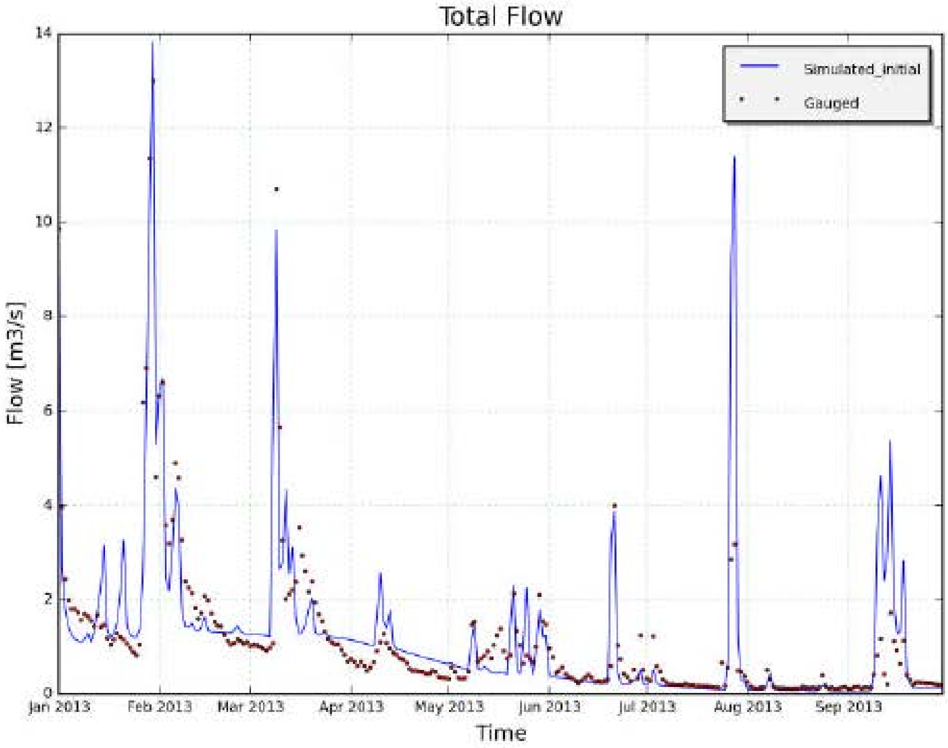


Figure 5: Total flow with initial parameters

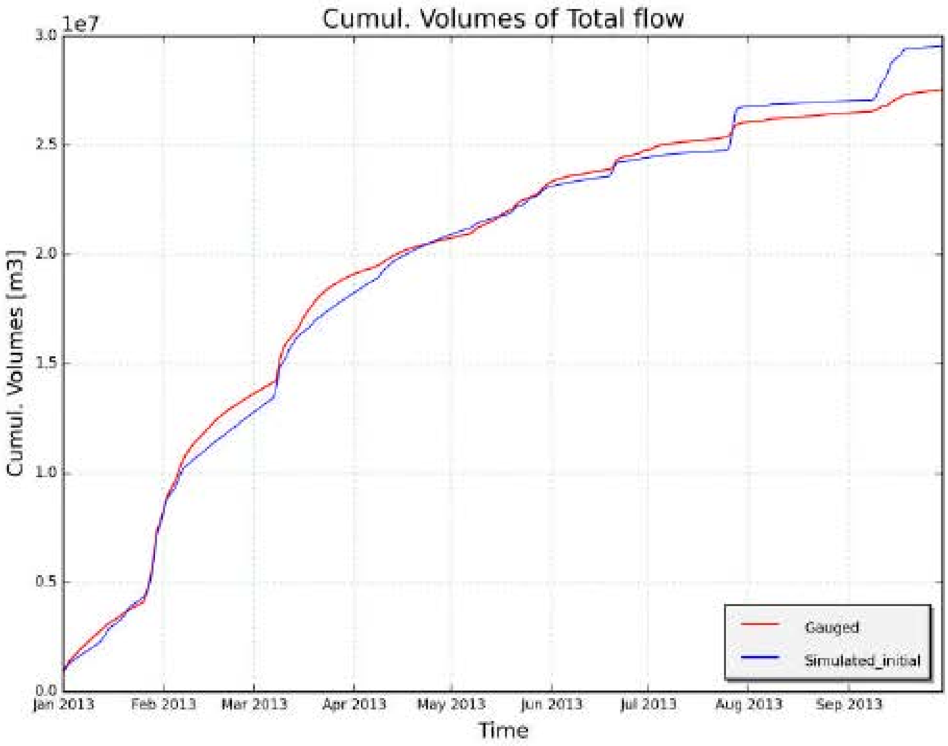


Figure 6: Cumulated flow with initial parameters

9.5.3.4.2 Optimum (euclidian)

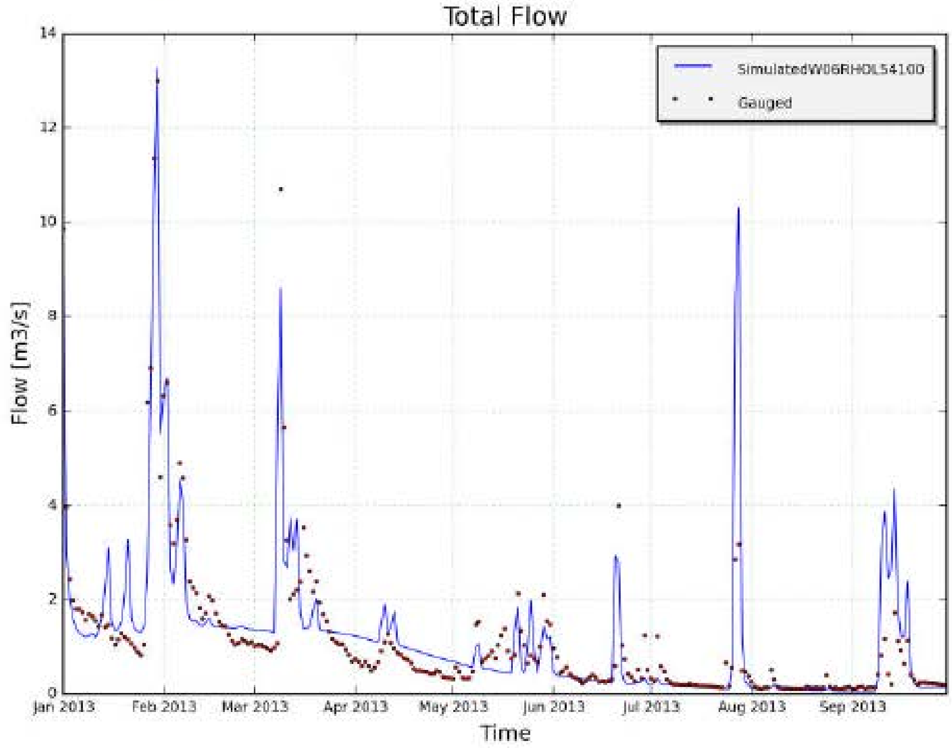


Figure 7: Total flow with optimum parameters

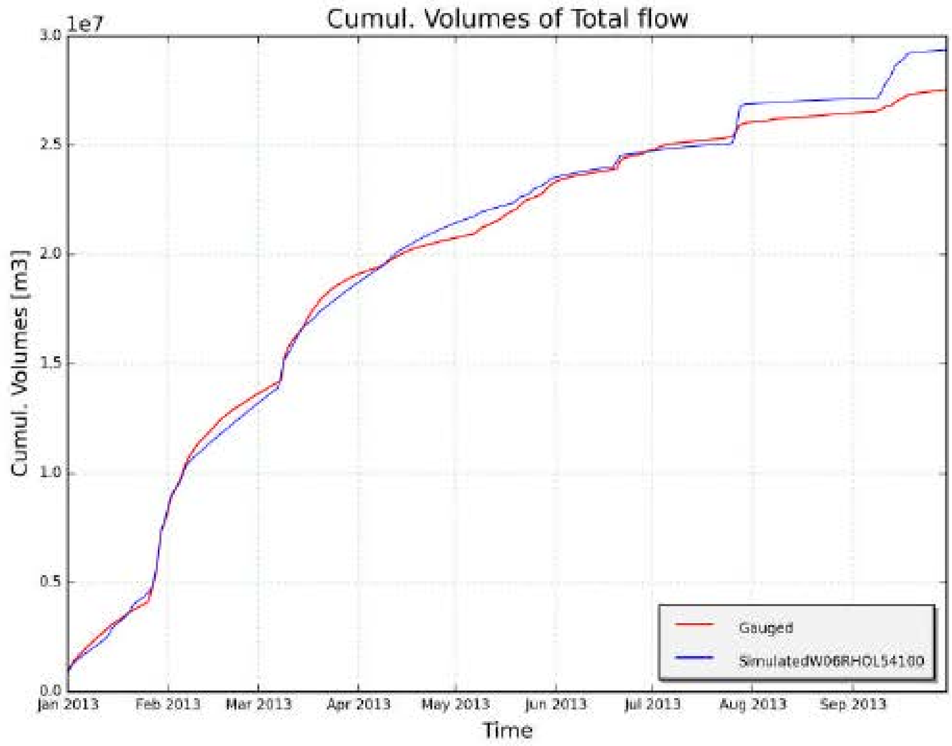
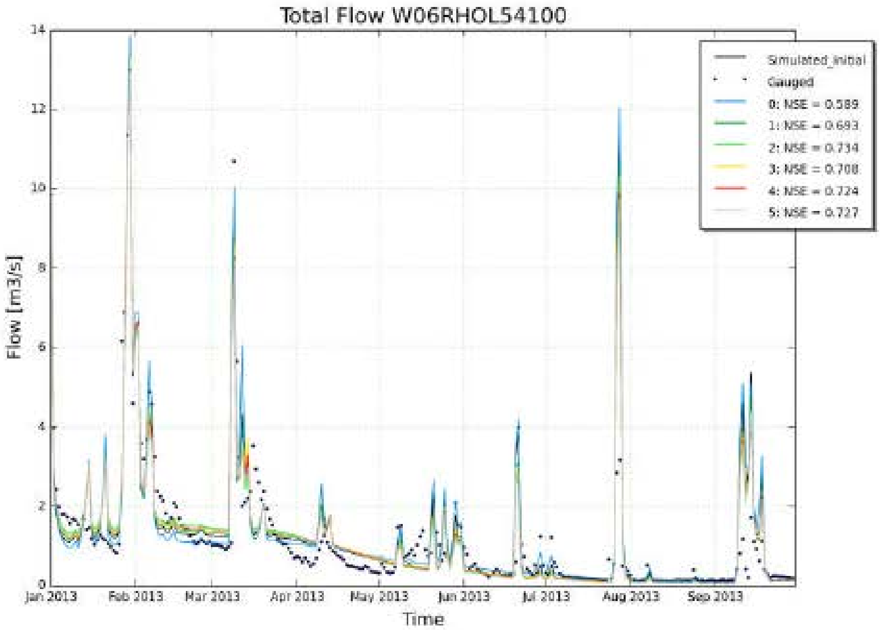
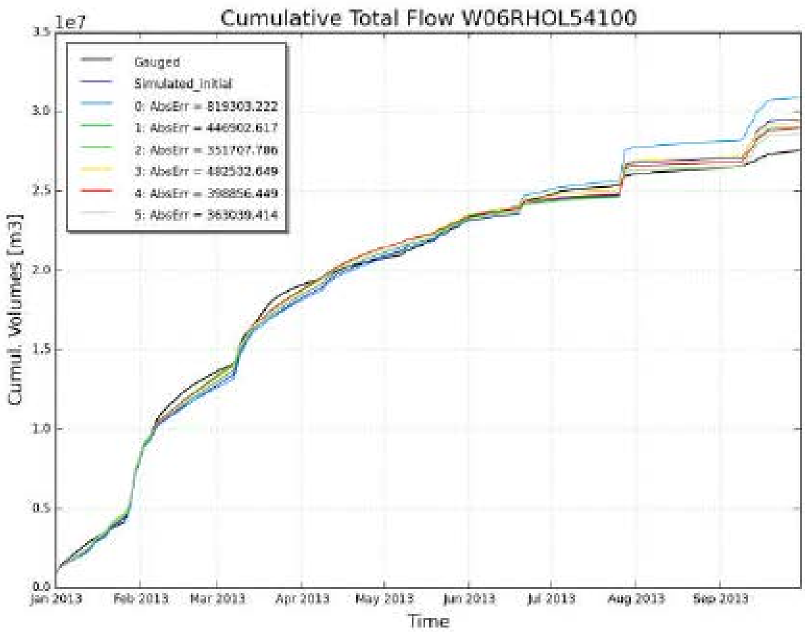


Figure 8: Cumulated flow with optimum parameters

9.5.3.4.3 Final archive

0 : [2.45, 98.429, 0.004, 0.781, 173.217, 409.193, 4.999, 93.642] : [819303.222, 0.775]
1 : [3.015, 94.775, 0.007, 0.62, 165.917, 392.707, 5.608, 86.803] : [446902.617, 0.711]
2 : [3.198, 95.527, 0.009, 2.0, 166.147, 391.897, 6.236, 94.794] : [351707.786, 0.665]
3 : [2.953, 97.461, 0.007, 2.0, 163.608, 399.533, 6.173, 87.133] : [482532.649, 0.73]
4 : [3.077, 95.402, 0.008, 0.5, 166.122, 392.468, 6.281, 88.21] : [398856.449, 0.696]
5 : [3.156, 94.979, 0.009, 1.769, 165.897, 392.398, 6.101, 92.717] : [363039.414, 0.677]





9.5.4 Report on simulation of catchment F06BOS325999 (2017-02-07 02-07)

9.5.4.1 Input data

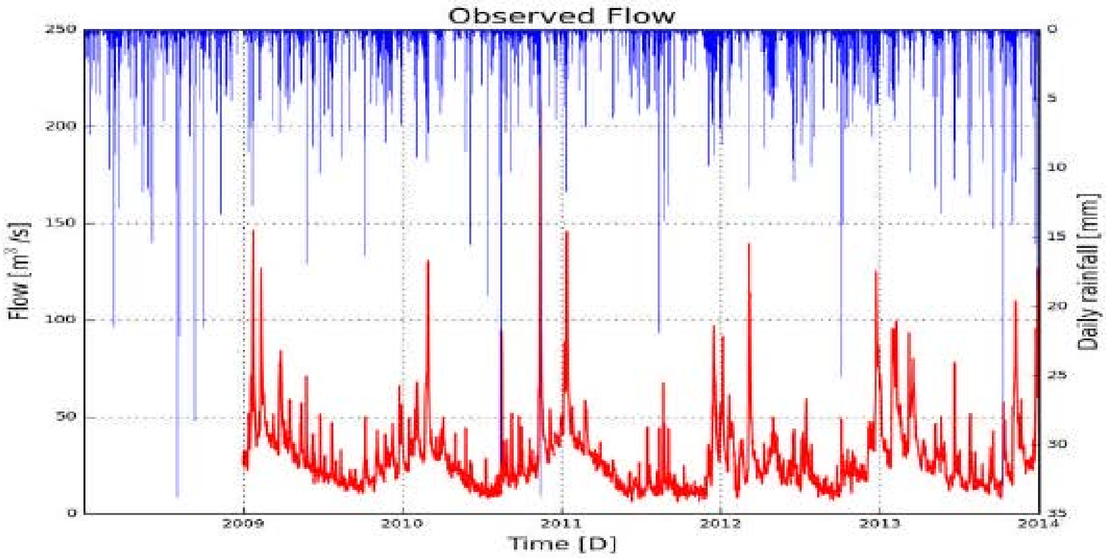


Figure 1: Hyetogram of observed discharge and observed net rain

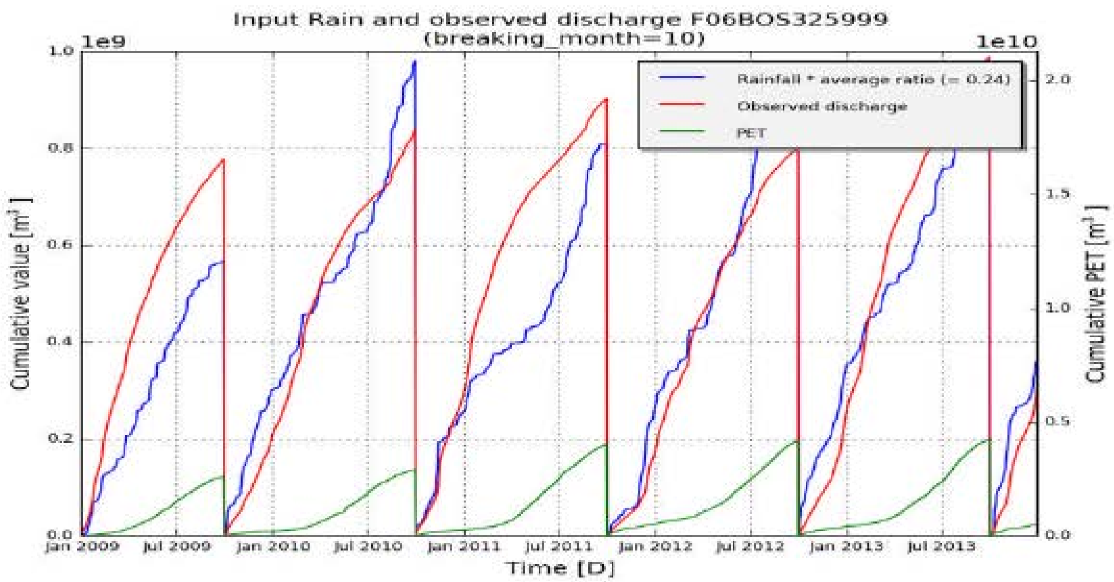


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.4.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	F06BOS325999
subcatchment_area	5217600000
start_date	200501010000
end_date	201312310000
frequency	86400
warmup	365

9.5.4.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.1, 45.0, 0.0098, 1.02, 75.0, 300.0, 3.0, 500.0]
low_bounds	[0.55, 22.0, 0.004, 0.5, 30.0, 150.0, 1.5, 250.0]
high_bounds	[2.2, 90.0, 0.01, 2.04, 120.0, 450.0, 6.0, 700.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.1), ('Ki', 45.0), ('Kg', 0.0098), ('Kss', 1.02), ('g0', 75.0), ('g_max', 300.0), ('K_run', 3.0), ('P_max', 500.0)]
Initial fitness:

- RelErr: 0.691
- AbsErr: 2735876448.56
- KGE: 0.036
- NS_rel: -1.158
- NS: -1.205
- RMSE: 3261778300.01
- NS_log: -0.325

Computation time:8:38:00.724000

9.5.4.4 Results

Best individual (euclidian): [('Kep', 1.602), ('Ki', 69.877), ('Kg', 0.005), ('Kss', 0.792), ('g0', 107.935), ('g_max', 385.46), ('K_run', 3.566), ('P_max', 538.294)]

Fitness:

- RelErr: -0.026
- AbsErr: 179030857.47
- KGE: 0.701
- NS_rel: 0.717
- NS: 0.467
- RMSE: 211846500.206
- NS_log: 0.601

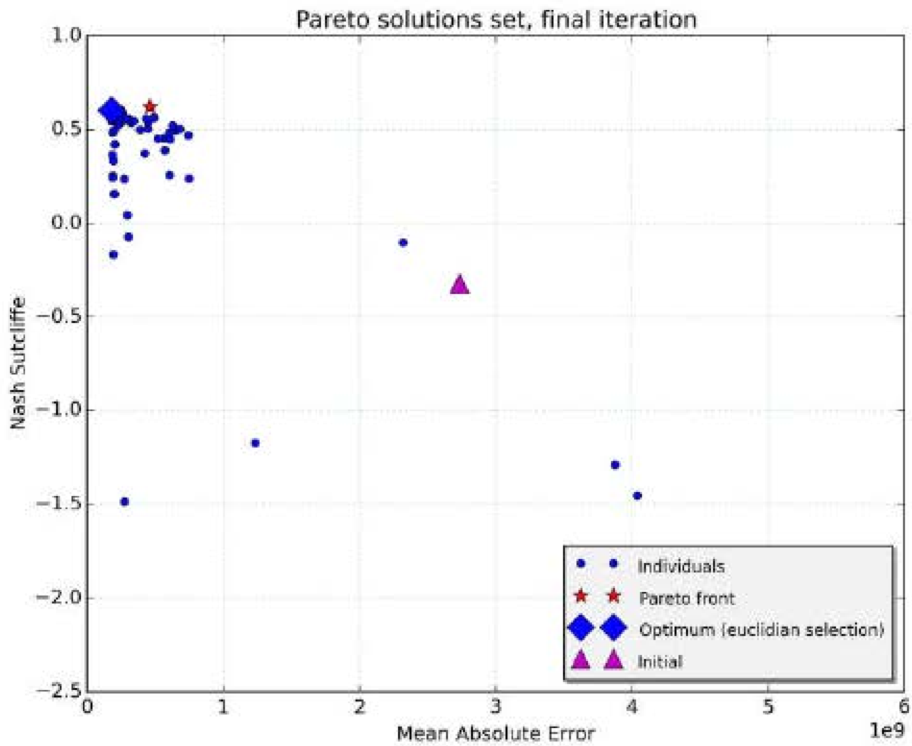


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

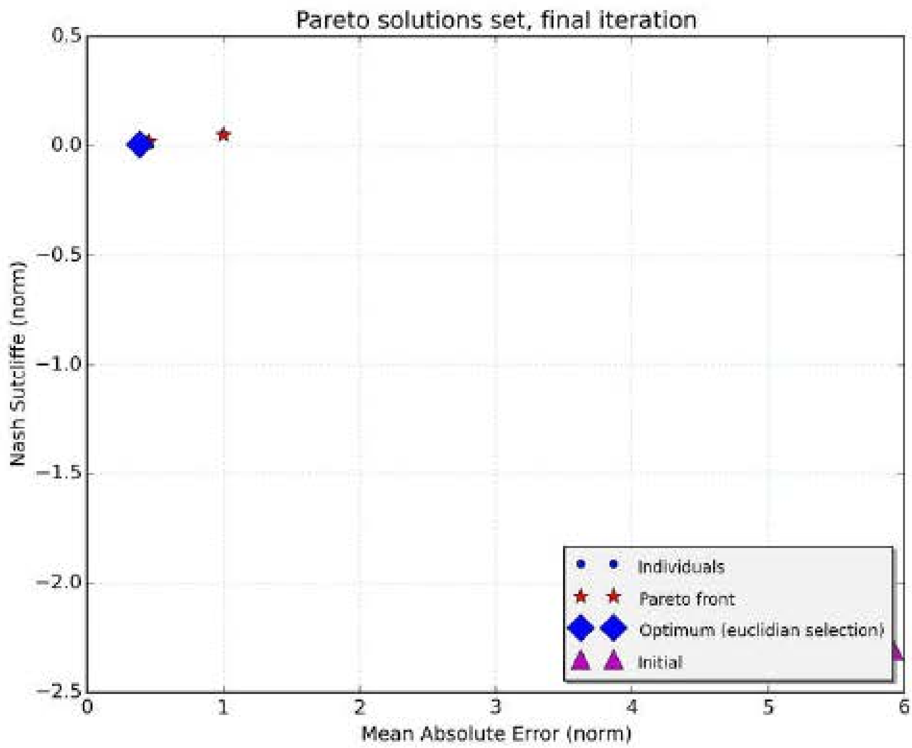


Figure 4: Final population of solutions (Pareto front)

9.5.4.4.1 Initial

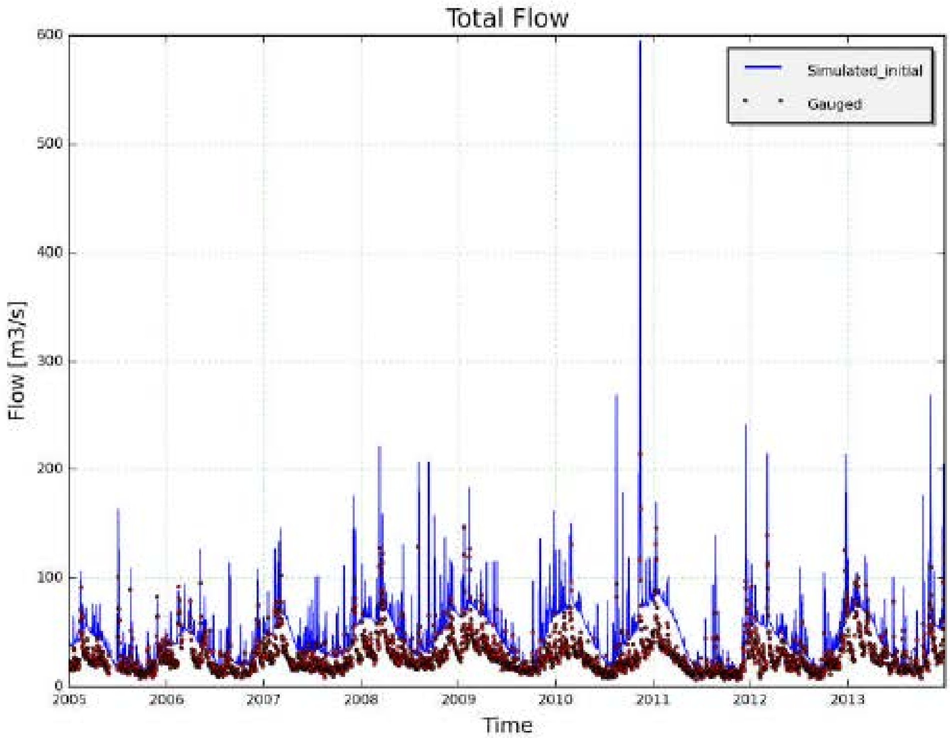


Figure 5: Total flow with initial parameters

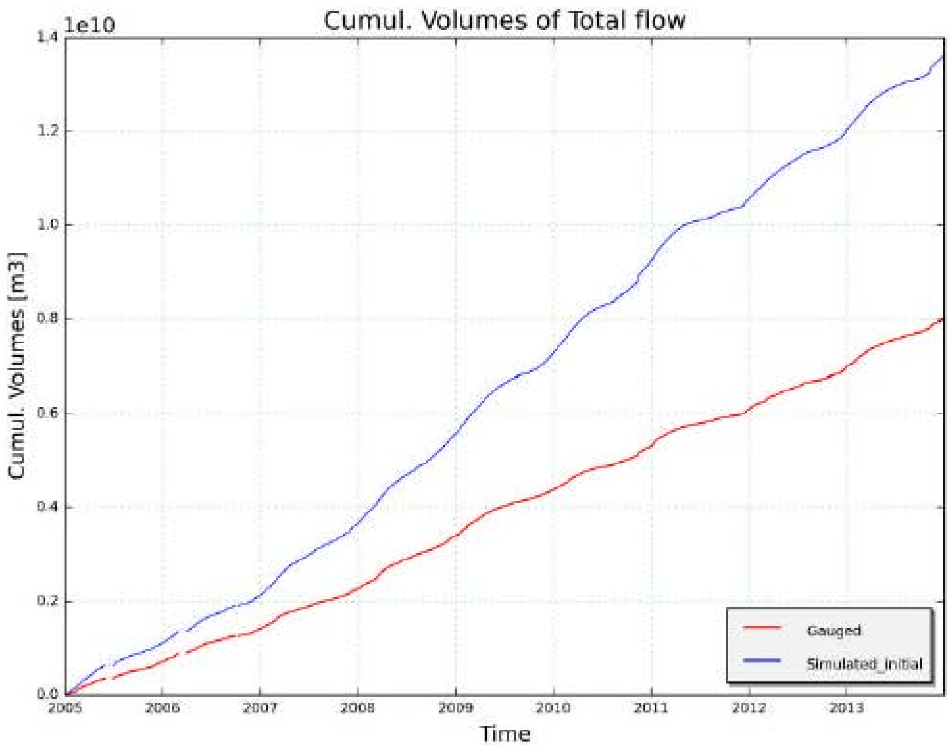


Figure 6: Cumulated flow with initial parameters

9.5.4.4.2 Optimum (euclidian)

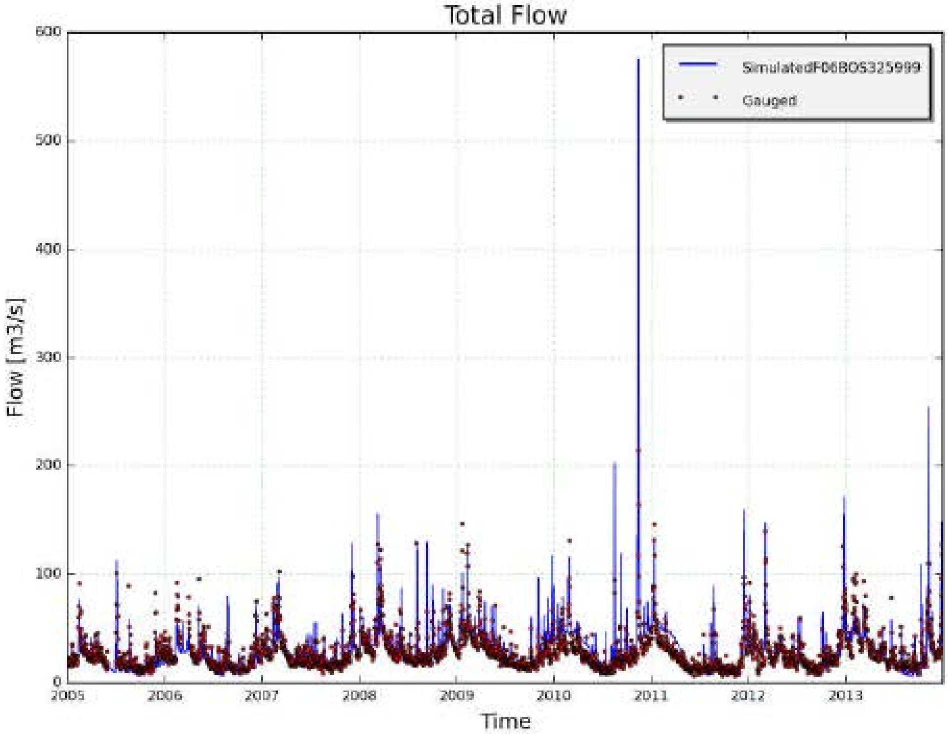


Figure 7: Total flow with optimum parameters

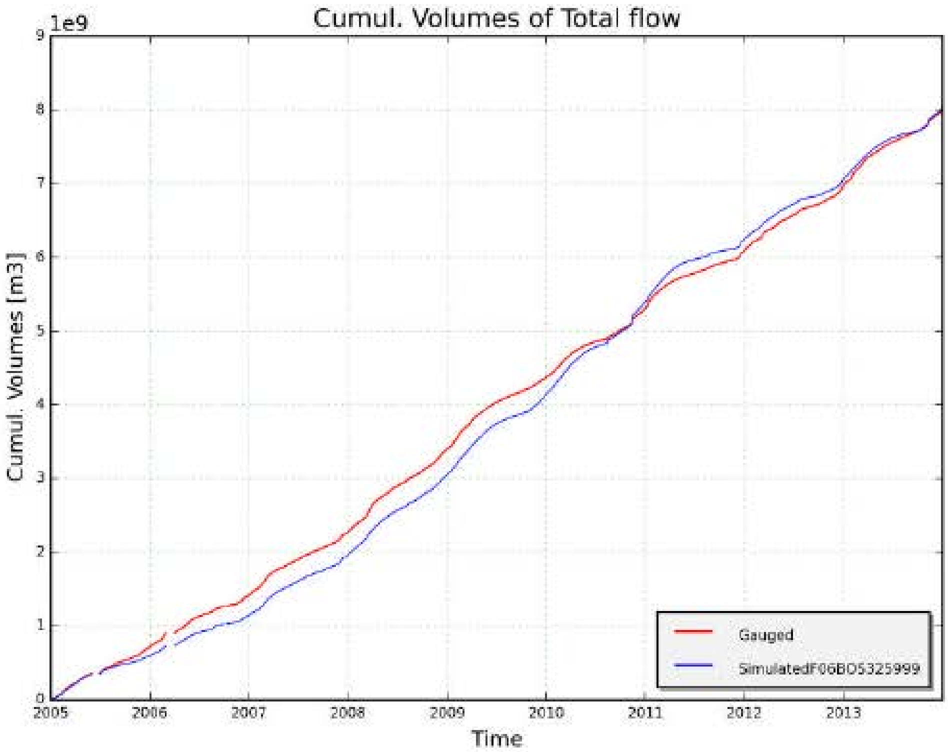


Figure 8: Cumulated flow with optimum parameters

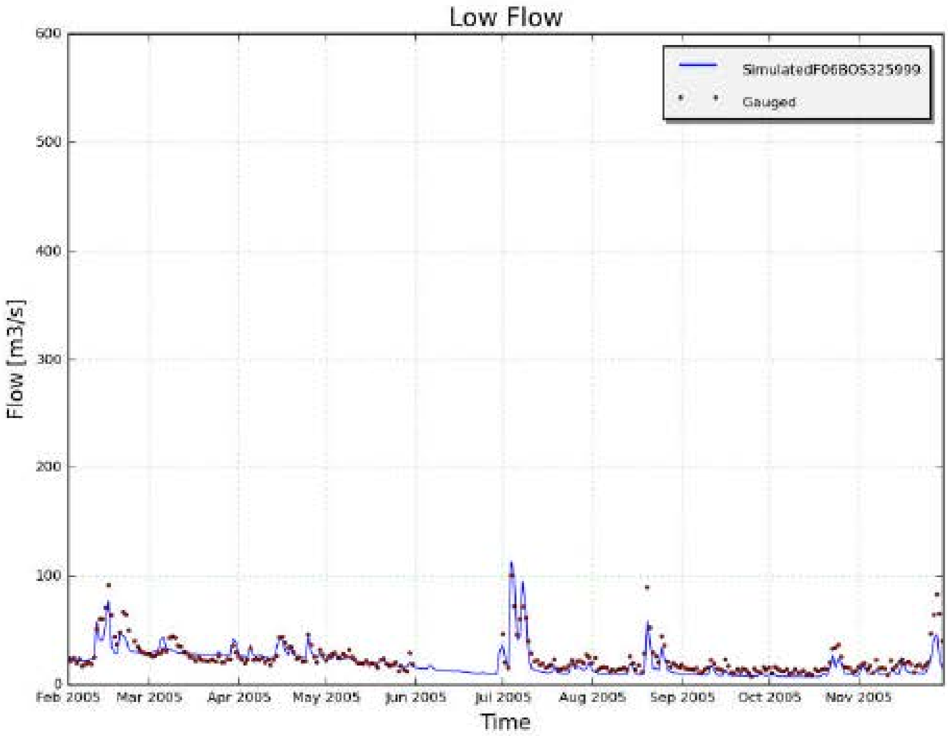


Figure 9: Total flow with optimum parameters (detail)

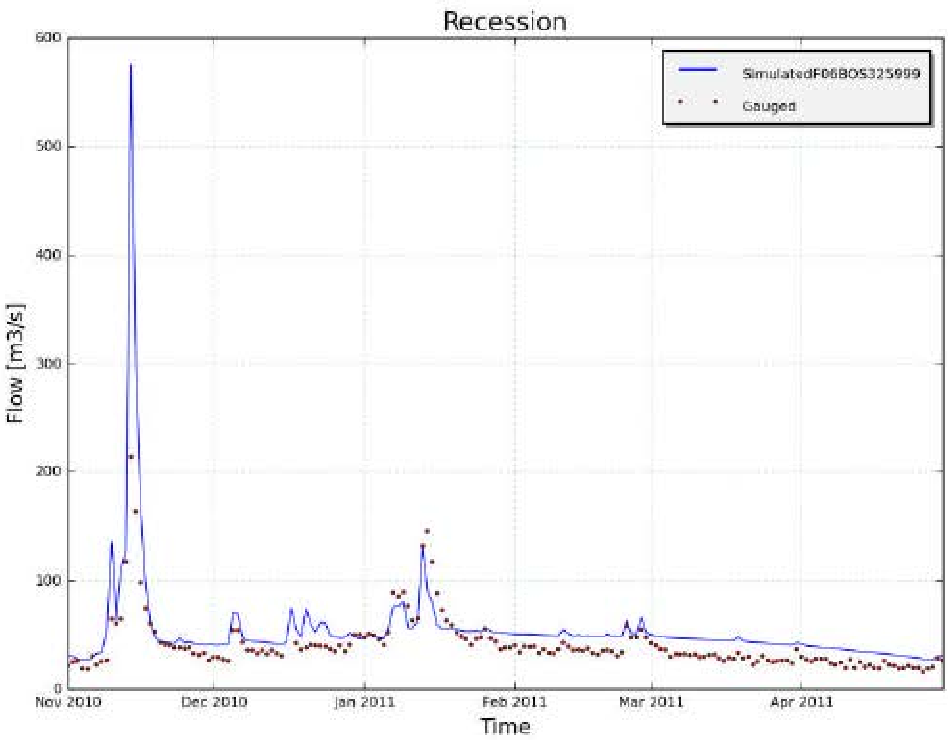


Figure 10: Total flow with optimum parameters (detail)

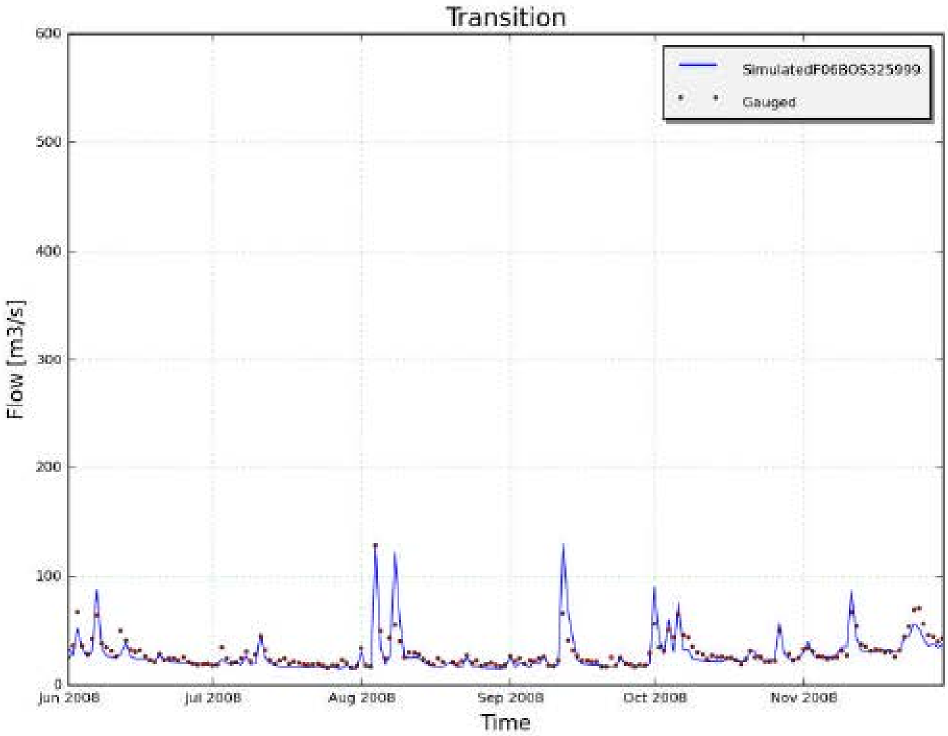
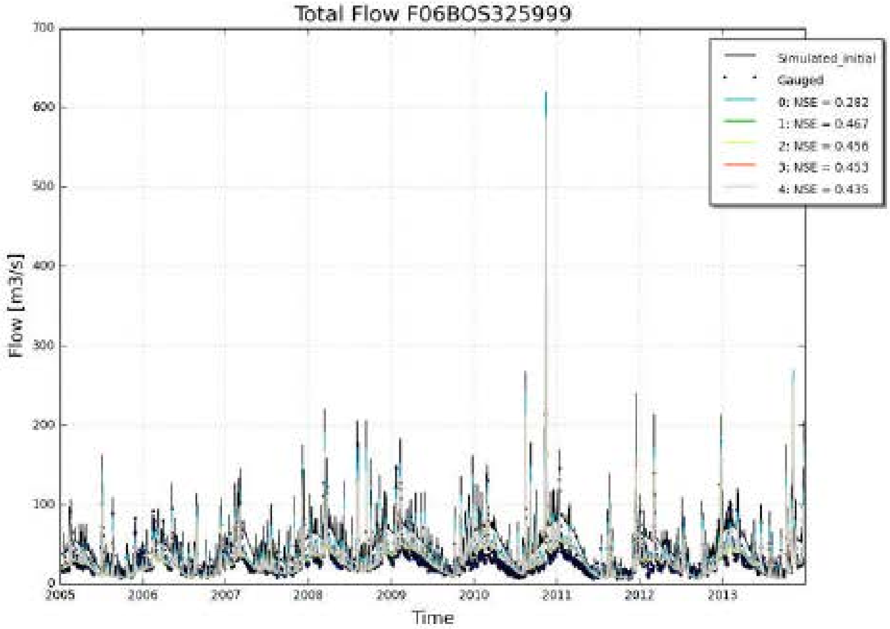
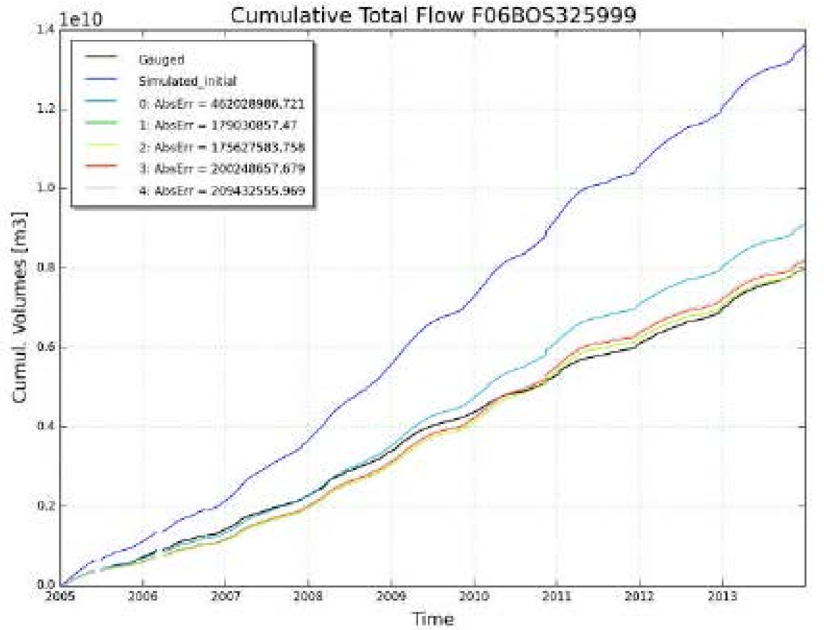


Figure 11: Total flow with optimum parameters (detail)

9.5.4.4.3 Final archive

0 : [1.488, 69.398, 0.005, 0.5, 71.479, 385.548, 3.048, 531.064] : [462028986.721, 0.619]
1 : [1.602, 69.877, 0.005, 0.792, 107.935, 385.46, 3.566, 538.294] : [179030857.47, 0.601]
2 : [1.603, 69.879, 0.005, 1.299, 111.618, 385.069, 3.463, 538.431] : [175627583.758, 0.599]
3 : [1.601, 70.595, 0.005, 2.04, 83.1, 383.025, 3.53, 538.471] : [200248657.679, 0.603]
4 : [1.598, 69.641, 0.005, 1.197, 111.766, 385.424, 3.36, 528.866] : [209432555.969, 0.607]


Total Flow F06BOS325999
Simulated_initial
Gauged
0: NSE = 0.282
1: NSE = 0.467
2: NSE = 0.456
3: NSE = 0.453
4: NSE = 0.435
Flow [m3/s]
Time
0
100
200
300
400
500
600
700
2005
2006
2007
2008
2009
2010
2011
2012
2013


Cumulative Total Flow F06BOS325999
1e10
Gauged
Simulated_initial
0: AbsErr = 462028986.721
1: AbsErr = 179030857.47
2: AbsErr = 175627583.758
3: AbsErr = 200248657.679
4: AbsErr = 209432555.969
Cumul. Volumes [m3]
Time
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
2005
2006
2007
2008
2009
2010
2011
2012
2013

Appendix 14 Denderbekken Calibration and Validation.

9.5.1 Calibration and validation of WET parameters for catchment "V07BEL285070" (Denderbekken)

9.5.1.1 Input data

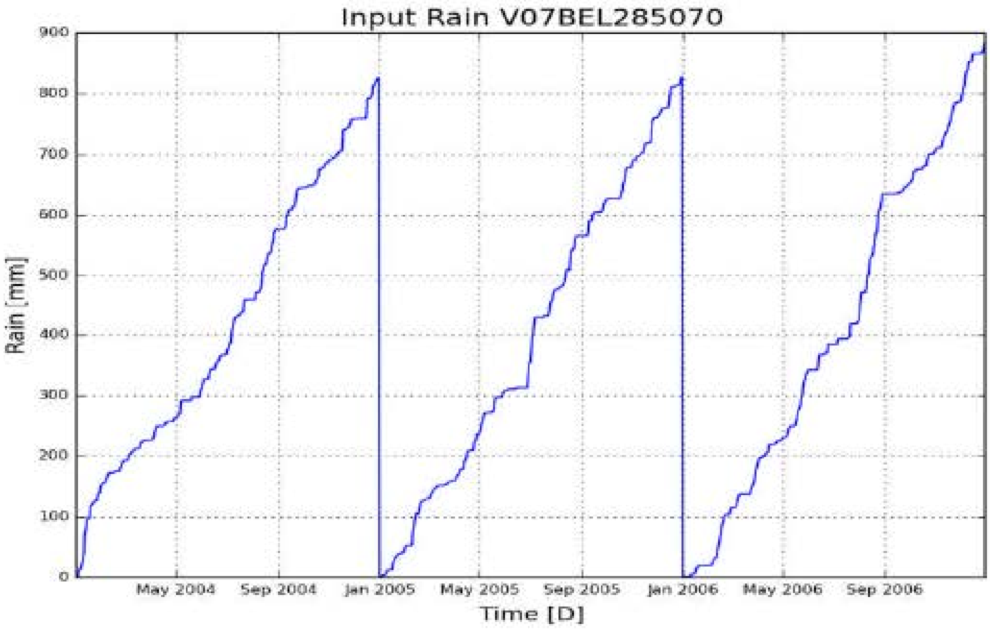


Figure 1: Cumulative precipitation on catchment V07BEL285070 (Denderbekken)

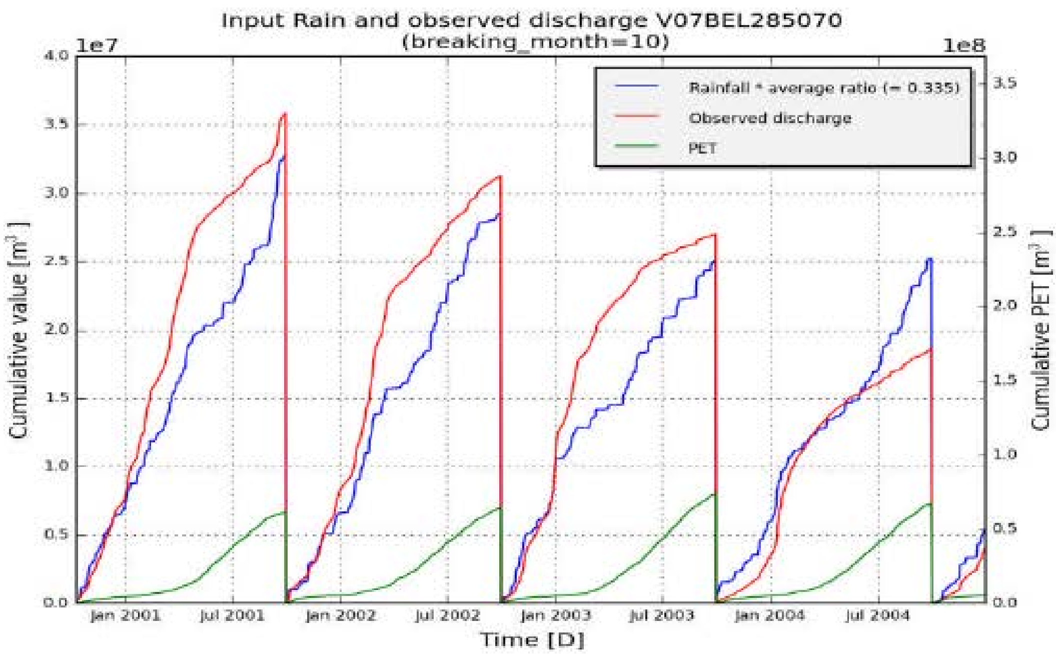


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V07BEL285070 (Denderbekken)

9.5.1.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V07BEL285070
subcatchment_area [m2]	88700000
Validation start_date	01-01-2005
Validation end_date	31-12-2006
frequency	daily

Optimal parameter set:[('Kep', 1.39), ('Ki', 20.76), ('Kg', 0.0), ('Kss', 0.79), ('g0', 71.08), ('g_max', 306.14), ('K_run', 13.01), ('P_max', 470.49)]

Table 1: Goodness of fit for calibration period (2000 - 2004)

	Full year	**Summer**	**Winter**
RelErr	0.4 %	15.4 %	-7.4 %
NS	0.618	-0.016	0.585
NS_log	0.758	0.577	0.668
NS_rel	0.698	0.695	0.631
KGE	0.782	0.481	0.706

Table 2 :Goodness of fit for validation period (2005 - 2006)

	Full year	**Summer**	**Winter**
RelErr	-0.2 %	13.6 %	-5.8 %
NS	0.487	0.123	0.714
NS_log	0.708	0.53	0.54
NS_rel	0.485	0.401	0.695
KGE	0.75	0.561	0.85

9.5.1.3 Observed and simulated timeseries for optimum parameters

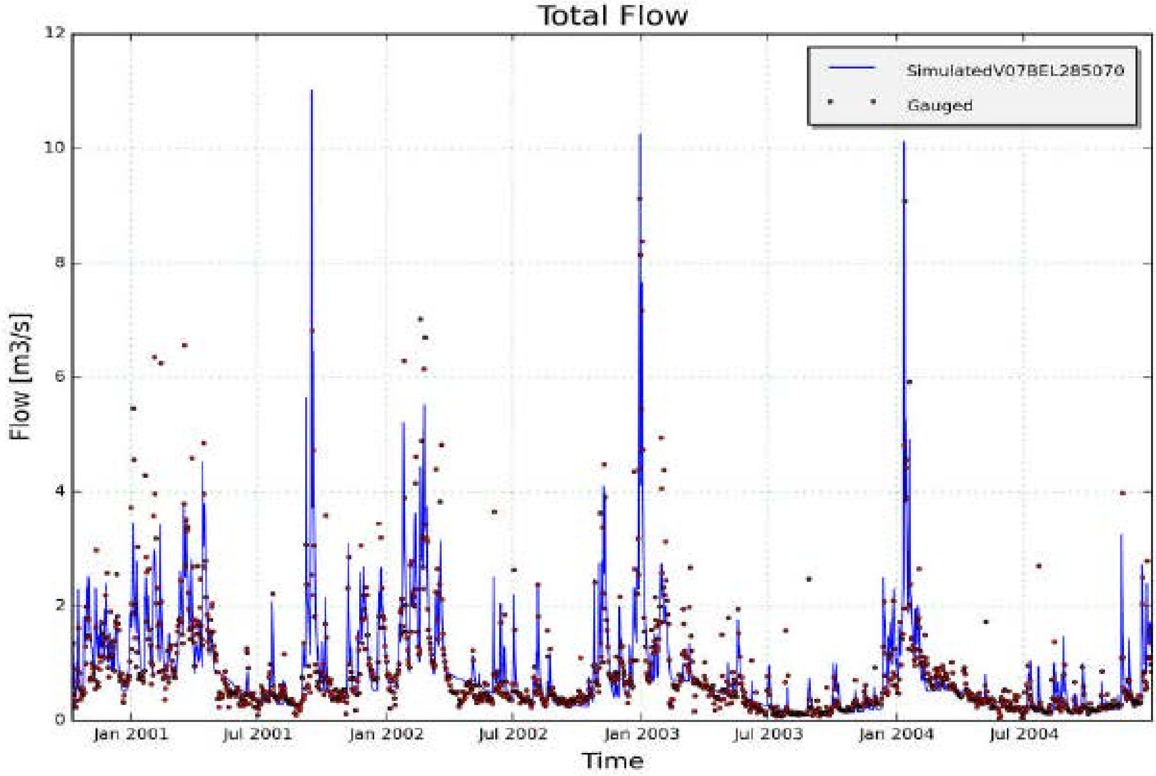


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07BEL285070, station 28510102 - Bellebeek, Essene(calibration period)

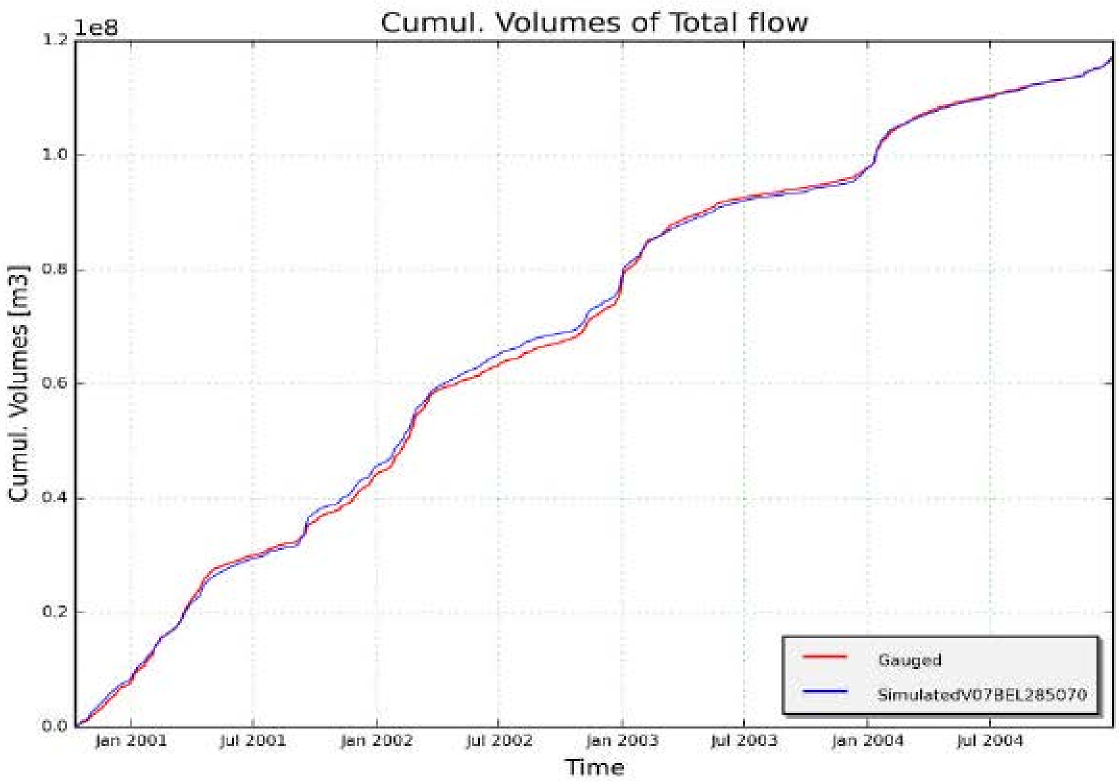


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07BEL285070, station 28510102 - Bellebeek, Essene (calibration period)

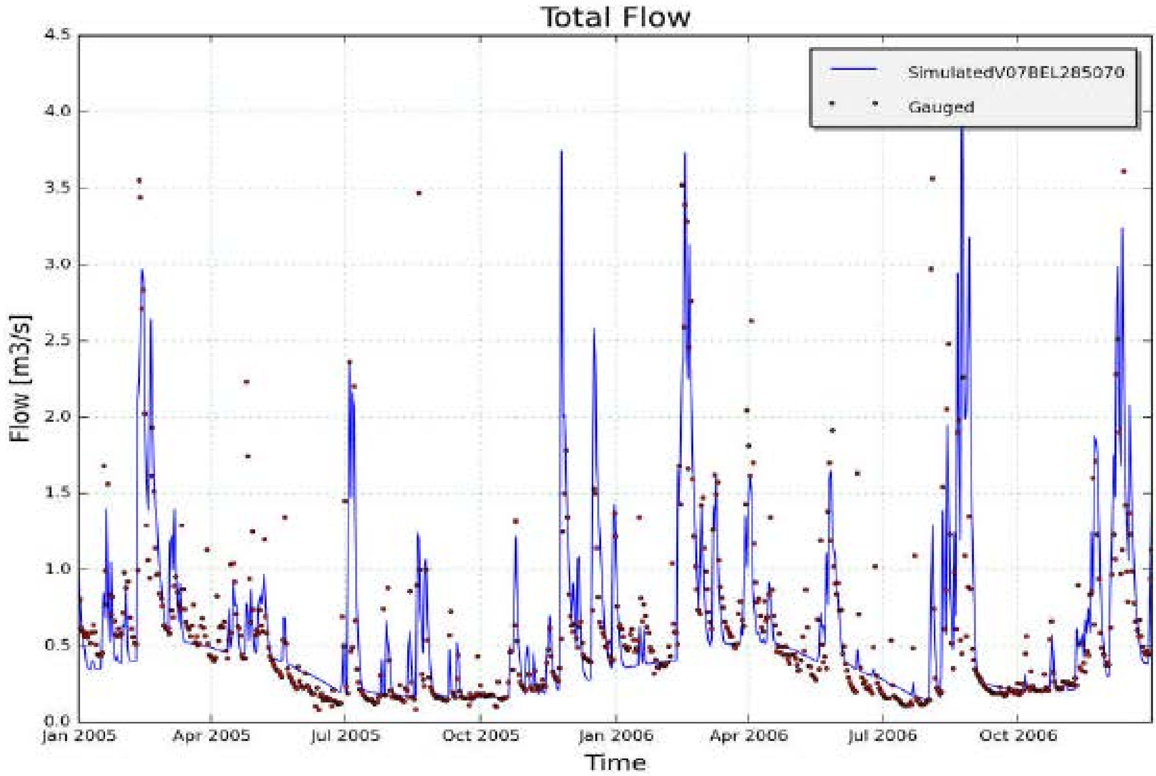


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07BEL285070, station 28510102 - Bellebeek, Essene (validation period)

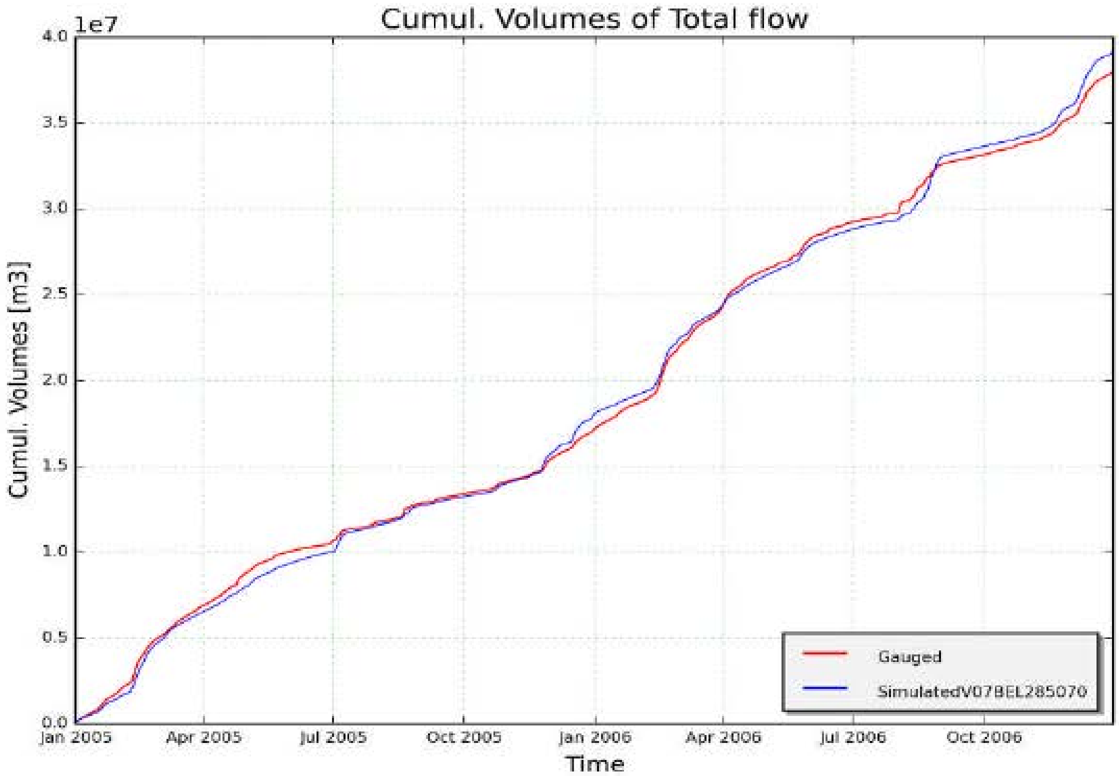


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07BEL285070, station 28510102 - Bellebeek, Essene (validation period)

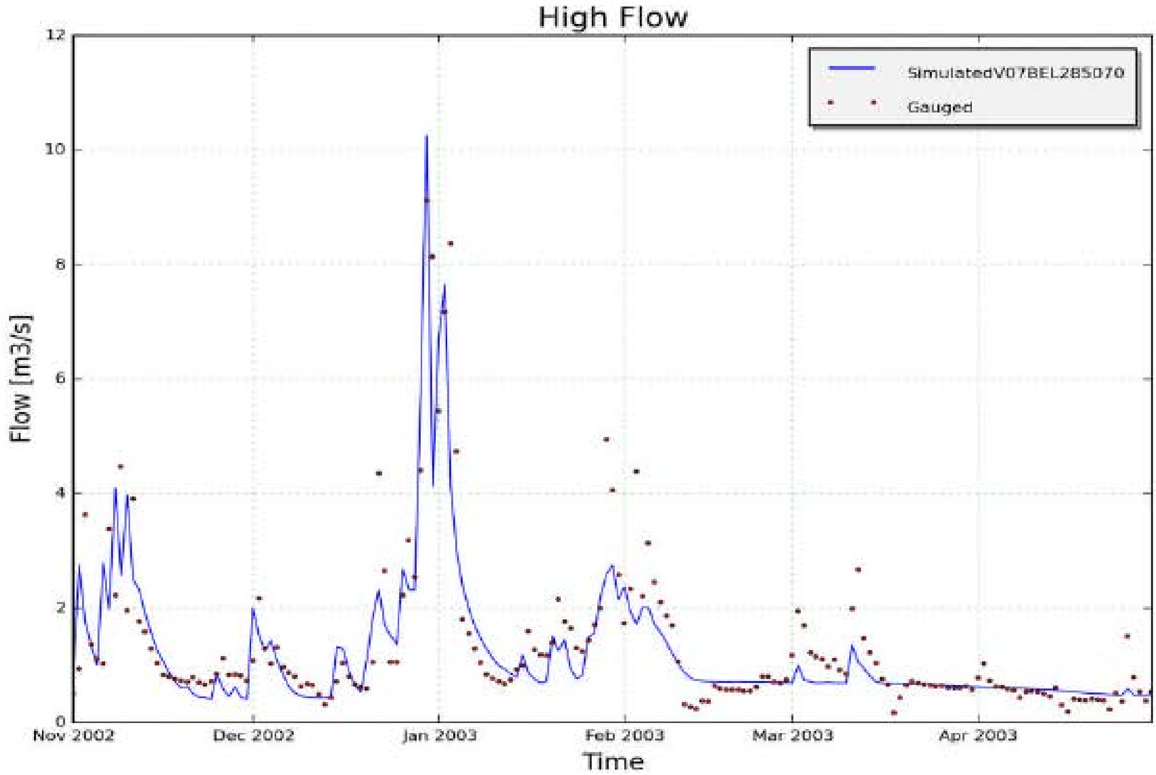


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07BEL285070, station 28510102 - Bellebeek, Essene

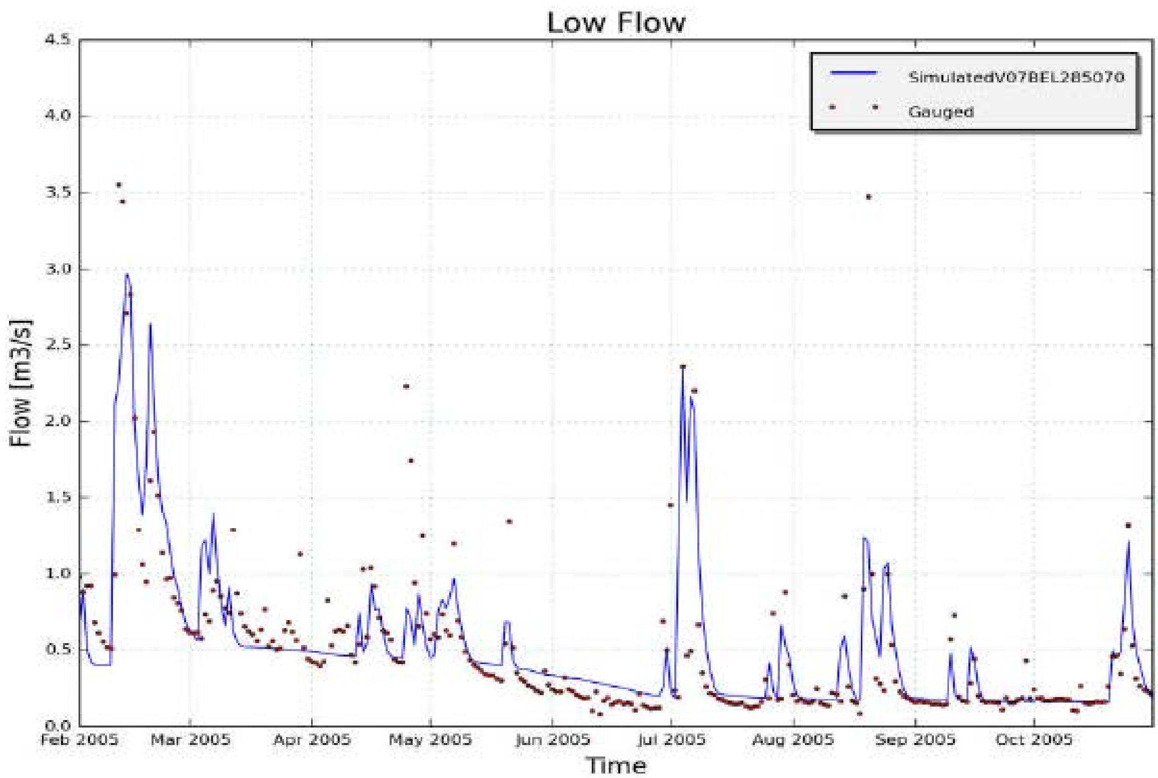


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07BEL285070, station 28510102 - Bellebeek, Essene

9.5.2 Calibration and validation of WET parameters for catchment "V07MAR289015" (Denderbekken)

9.5.2.1 Input data

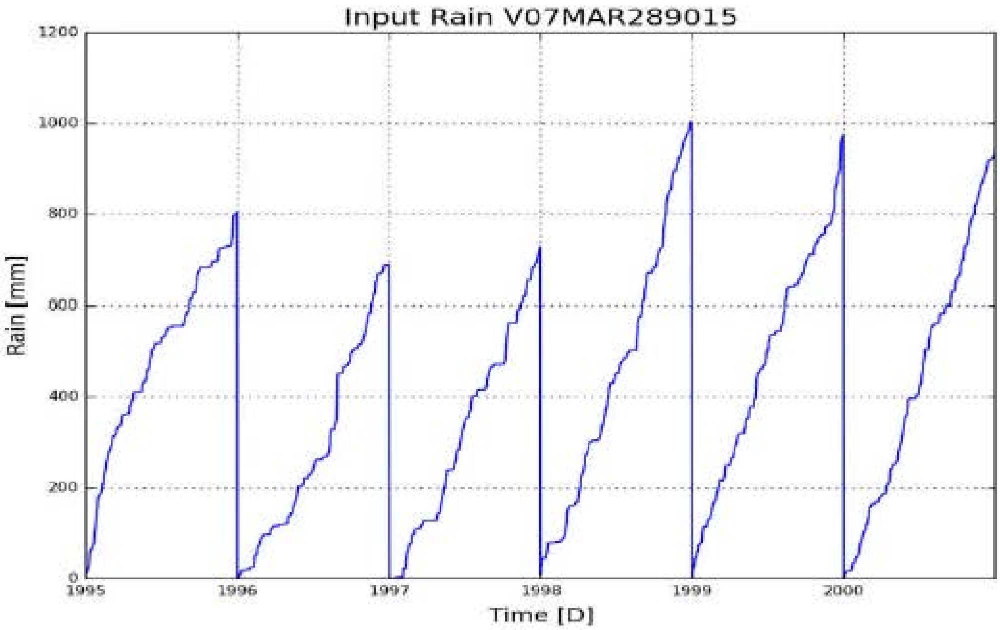


Figure 1: Cumulative precipitation on catchment V07MAR289015 (Denderbekken)

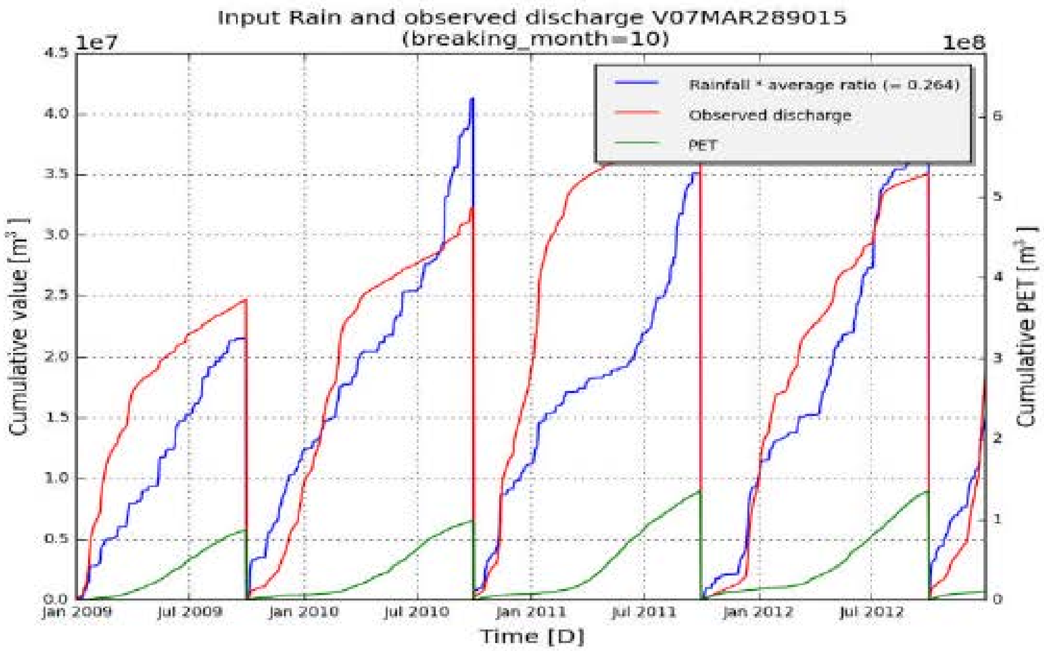


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V07MAR289015 (Denderbekken)

9.5.2.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V07MAR289015
subcatchment_area [m2]	173900000
Validation start_date	01-01-1996
Validation end_date	31-12-2000
frequency	daily

Optimal parameter set:[('Kep', 1.6), ('Ki', 66.99), ('Kg', 0.0), ('Kss', 1.19), ('g0', 102.78), ('g_max', 536.88), ('K_run', 4.85), ('P_max', 604.5)]

Table 1: Goodness of fit for calibration period (2009 - 2012)

	Full year	**Summer**	**Winter**
RelErr	-1.7 %	76.4 %	-37.9 %
NS	0.438	-2.624	0.642
NS_log	0.565	0.009	0.157
NS_rel	0.306	-0.285	0.72
KGE	0.726	-0.481	0.578

Table 2 :Goodness of fit for validation period (1996 - 2000)

	Full year	**Summer**	**Winter**
RelErr	-3.9 %	73.7 %	-28.1 %
NS	0.432	-3.316	0.568
NS_log	0.603	0.232	0.495
NS_rel	0.104	-0.062	0.586
KGE	0.71	-0.649	0.637

9.5.2.3 Observed and simulated timeseries for optimum parameters

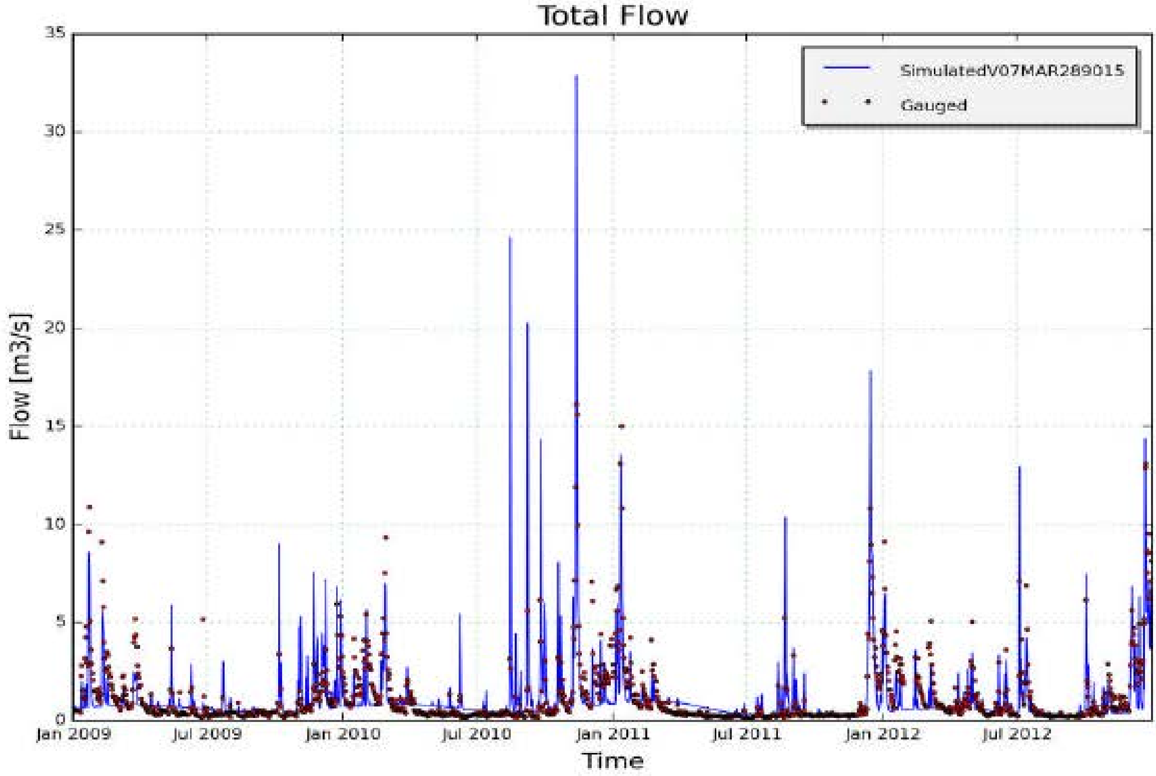


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07MAR289015, station 28970102 - Marke, Viane(calibration period)

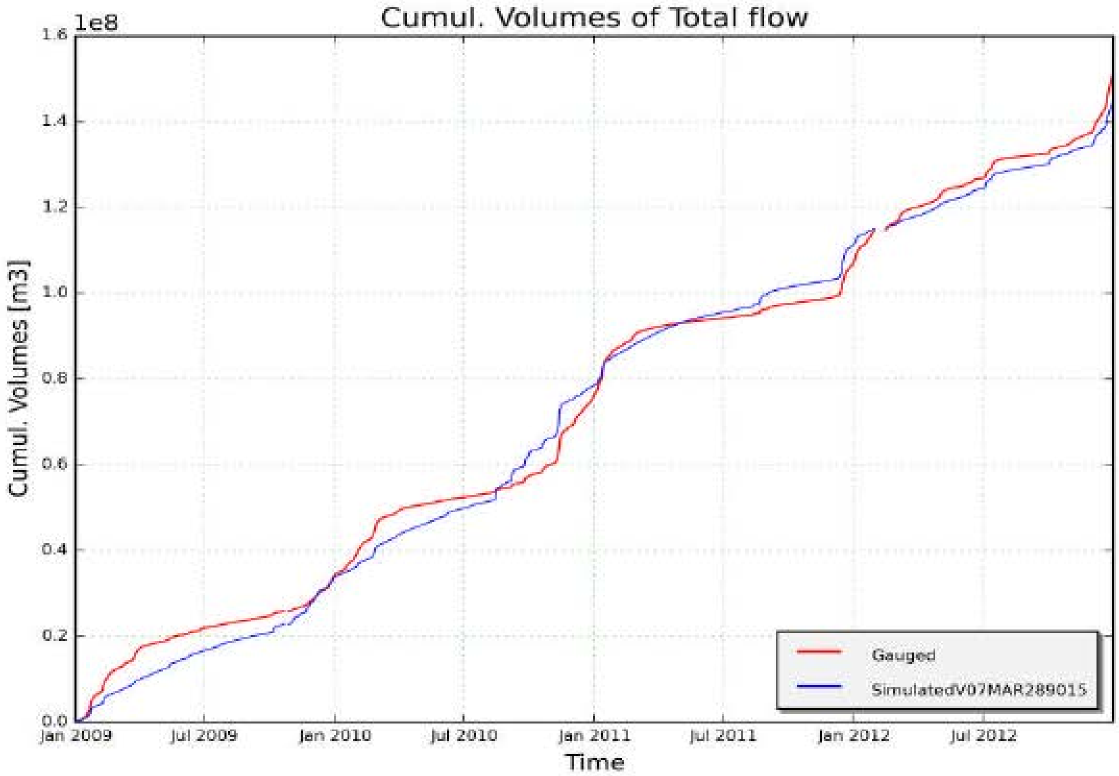


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07MAR289015, station 28970102 - Marke, Viane (calibration period)

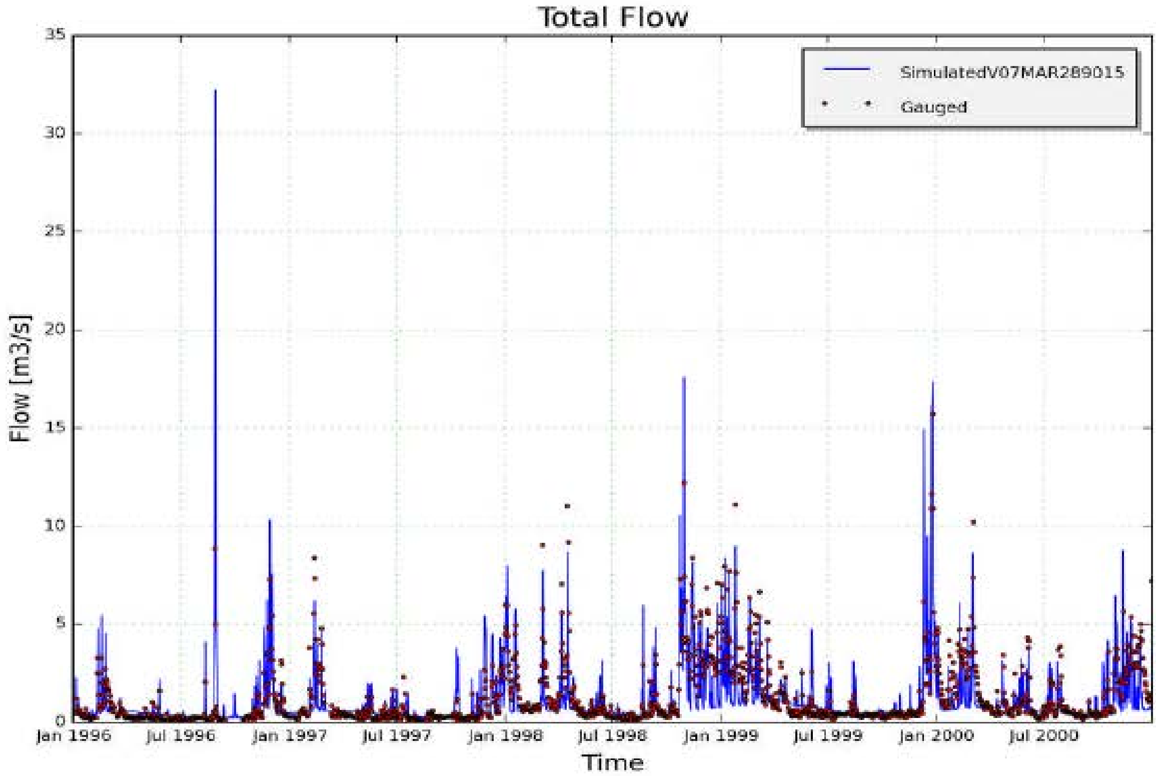


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07MAR289015, station 28970102 - Marke, Viane (validation period)

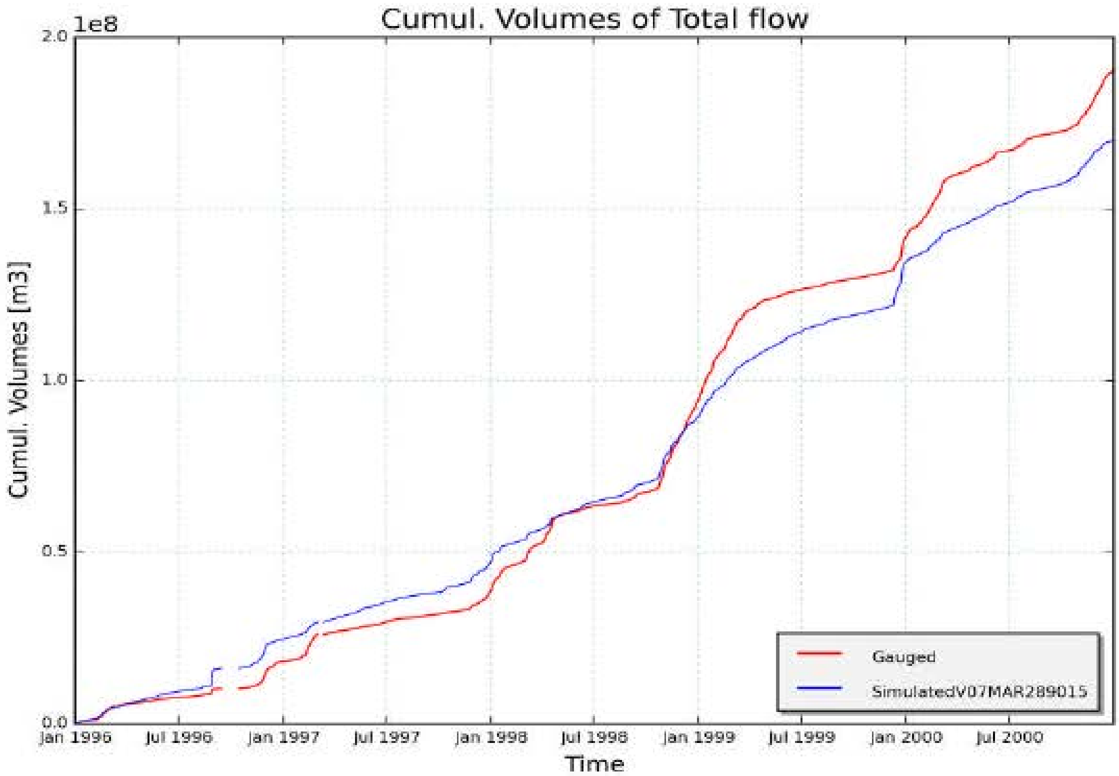


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07MAR289015, station 28970102 - Marke, Viane (validation period)

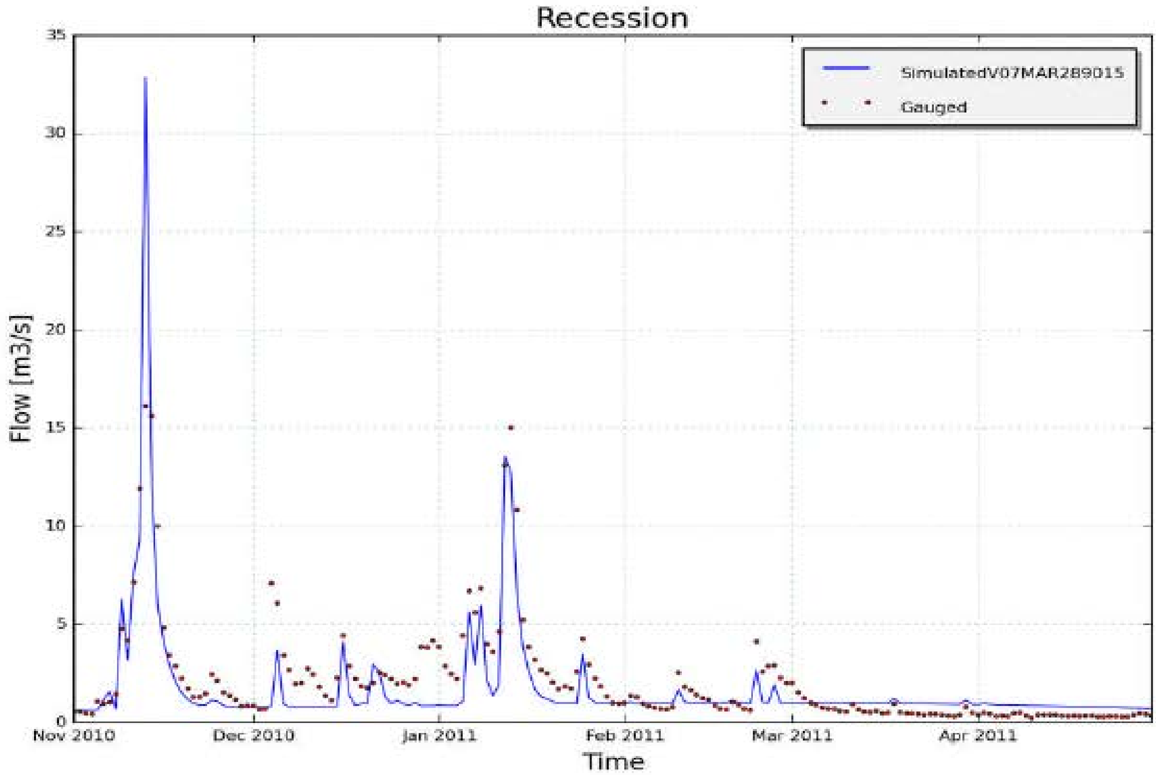


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MAR289015, station 28970102 - Marke, Viane

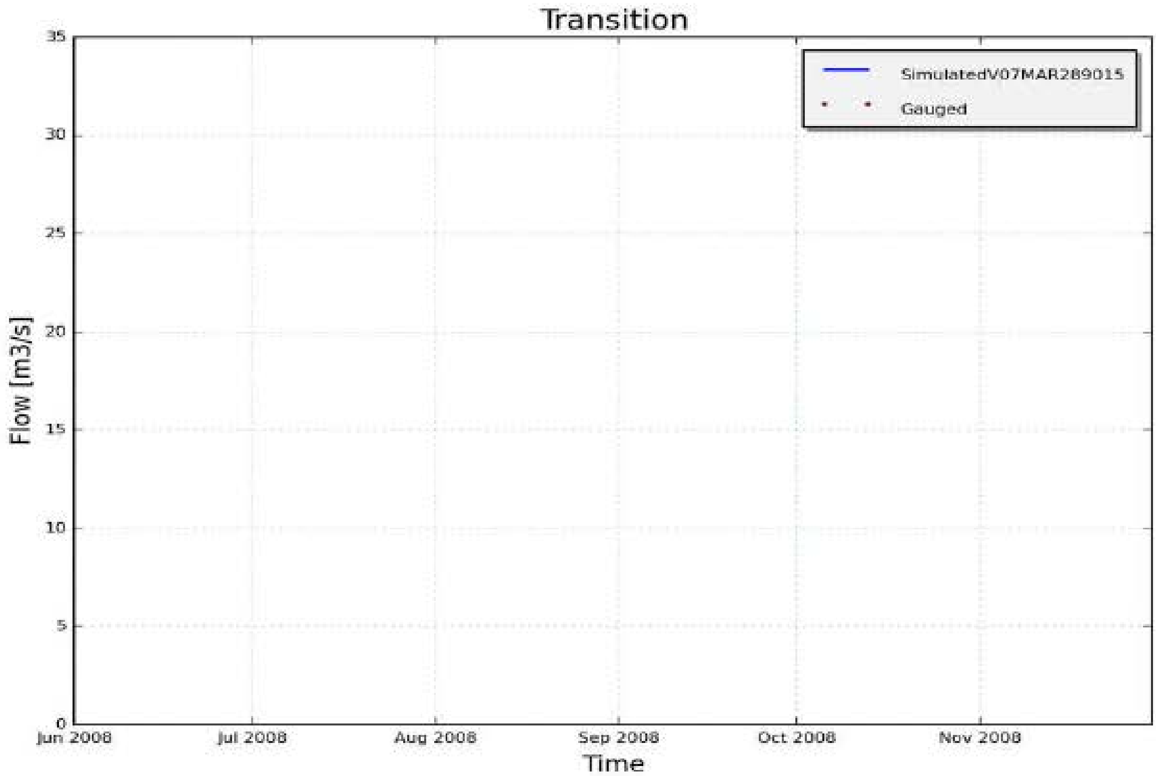


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MAR289015, station 28970102 - Marke, Viane

9.5.3 Calibration and validation of WET parameters for catchment "V07MOE282100" (Denderbekken)

9.5.3.1 Input data

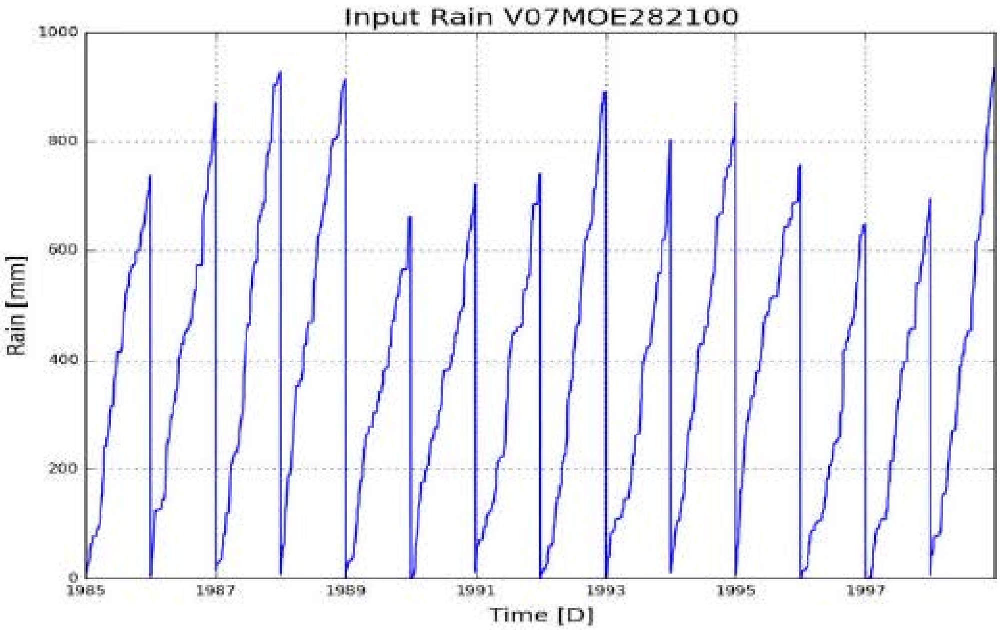


Figure 1: Cumulative precipitation on catchment V07MOE282100 (Denderbekken)

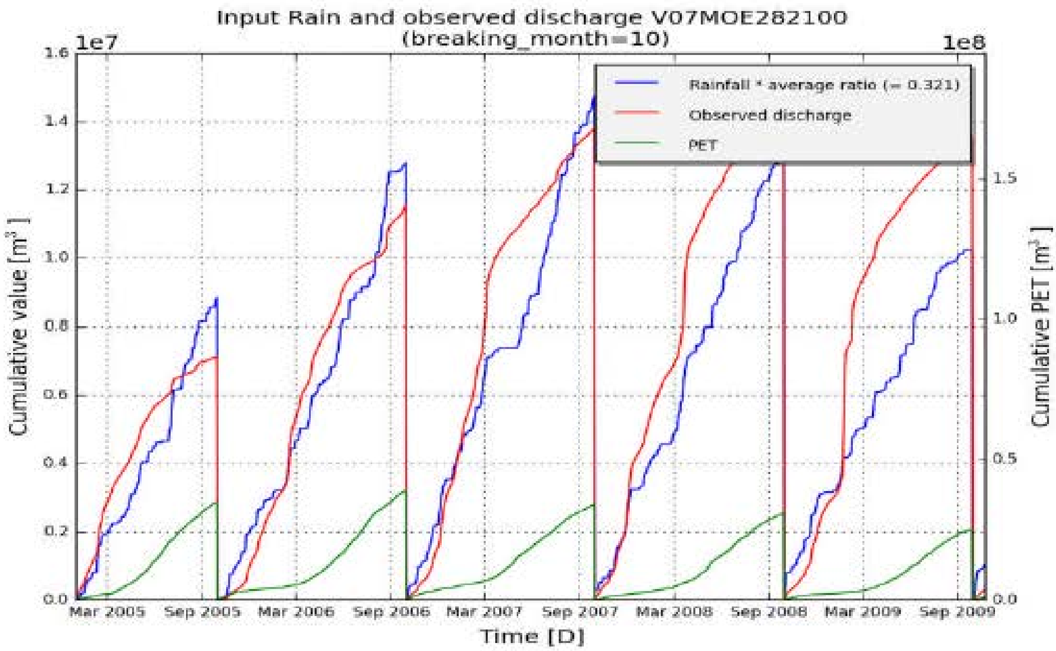


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V07MOE282100 (Denderbekken)

9.5.3.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V07MOE282100
subcatchment_area [m2]	46400000
Validation start_date	01-01-1986
Validation end_date	31-12-1998
frequency	daily

Optimal parameter set:[('Kep', 1.83), ('Ki', 67.94), ('Kg', 0.01), ('Kss', 1.22), ('g0', 134.11), ('g_max', 335.95), ('K_run', 22.57), ('P_max', 263.31)]

Table 1: Goodness of fit for calibration period (2005 - 2009)

	Full year	**Summer**	**Winter**
RelErr	-1.1 %	2.1 %	-3.2 %
NS	0.44	0.581	0.337
NS_log	0.688	0.571	0.509
NS_rel	0.872	0.839	0.856
KGE	0.535	0.656	0.341

Table 2 :Goodness of fit for validation period (1986 - 1998)

	Full year	**Summer**	**Winter**
RelErr	-0.5 %	-13.2 %	-2.3 %
NS	0.696	0.509	0.682
NS_log	0.703	0.362	0.705
NS_rel	0.791	0.904	0.798
KGE	0.797	0.675	0.78

9.5.3.3 Observed and simulated timeseries for optimum parameters

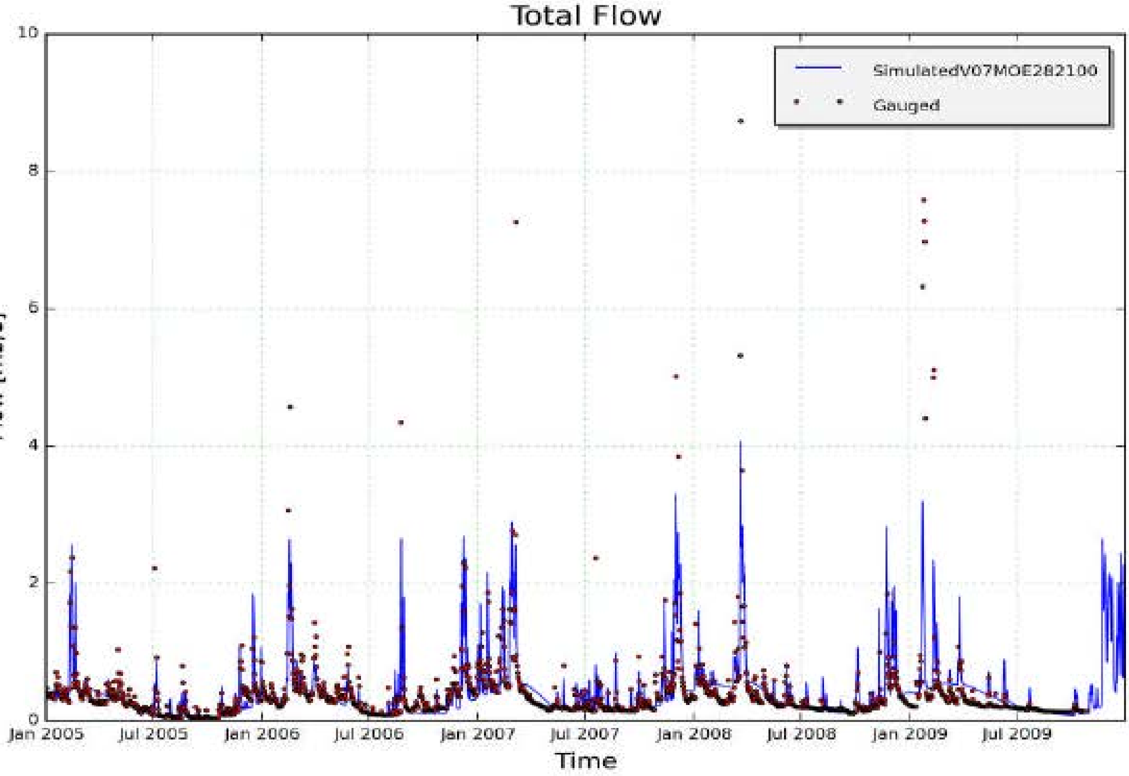


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere(calibration period)

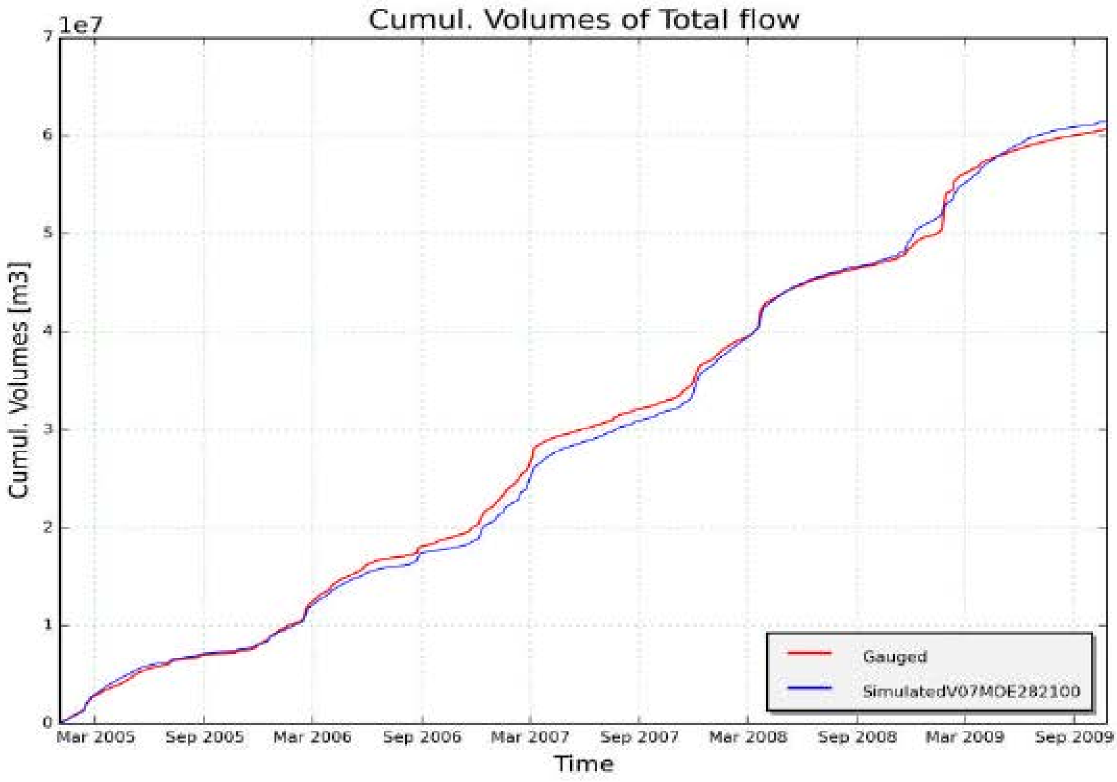


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere (calibration period)

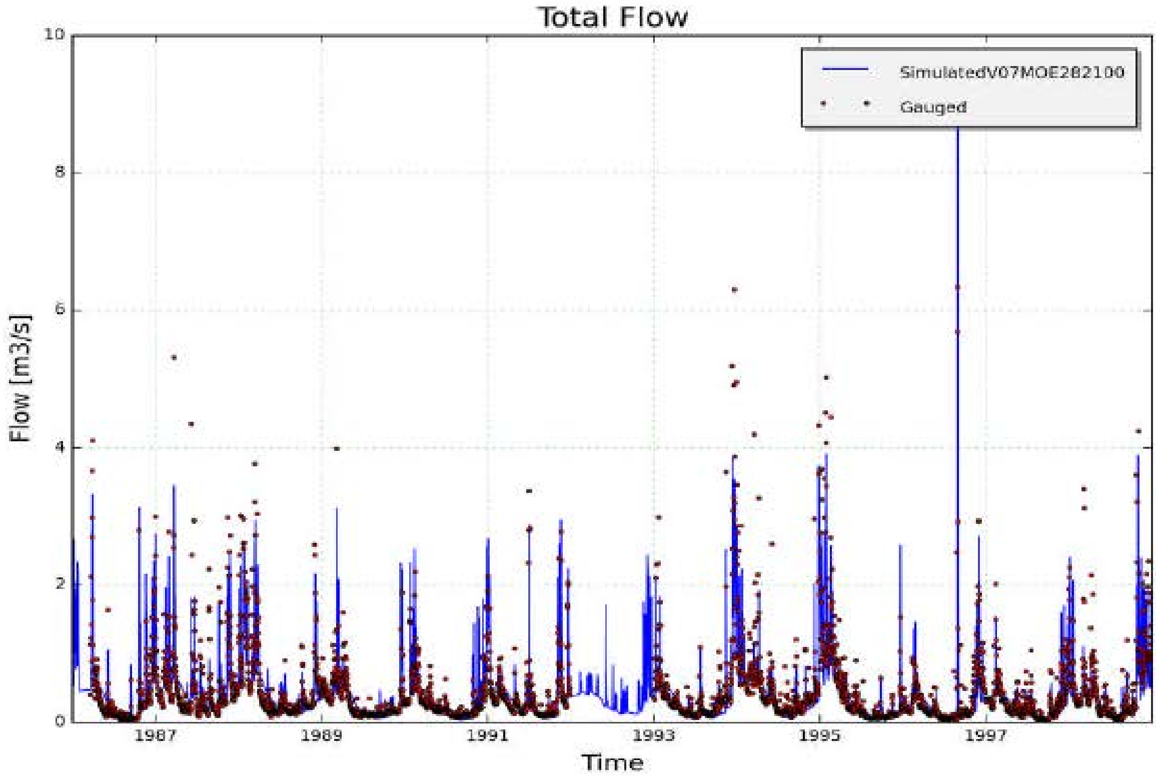


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere (validation period)

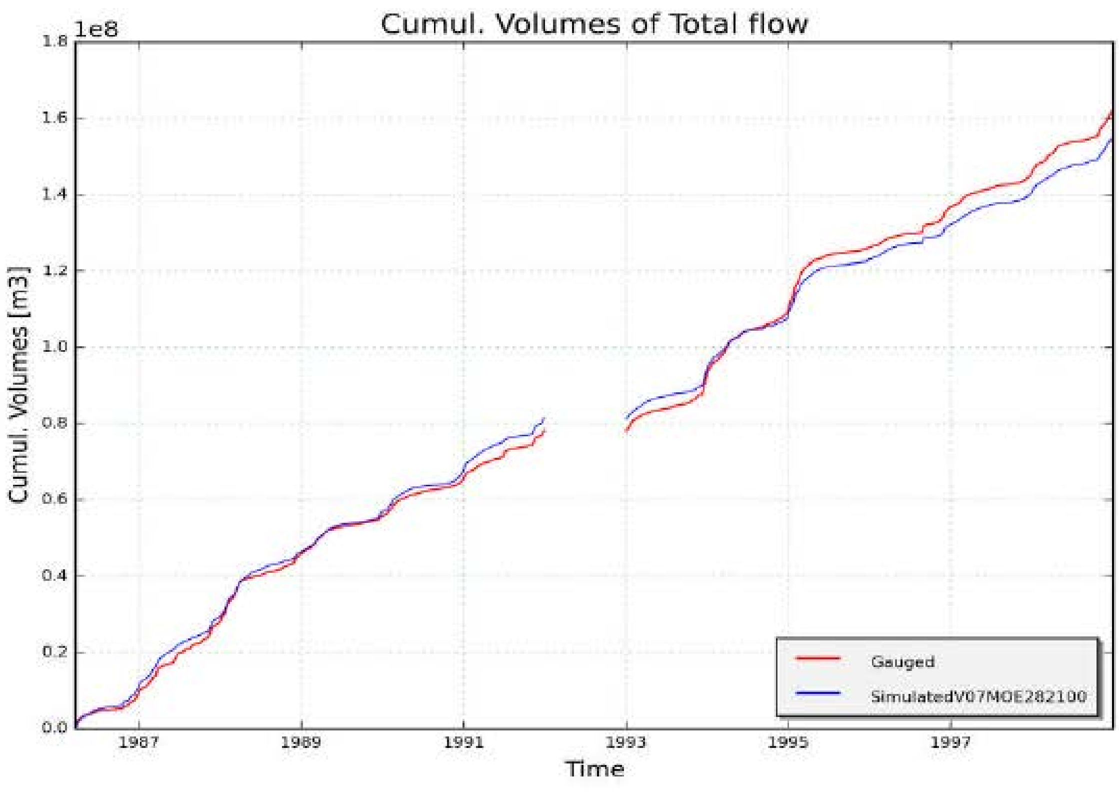


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere (validation period)

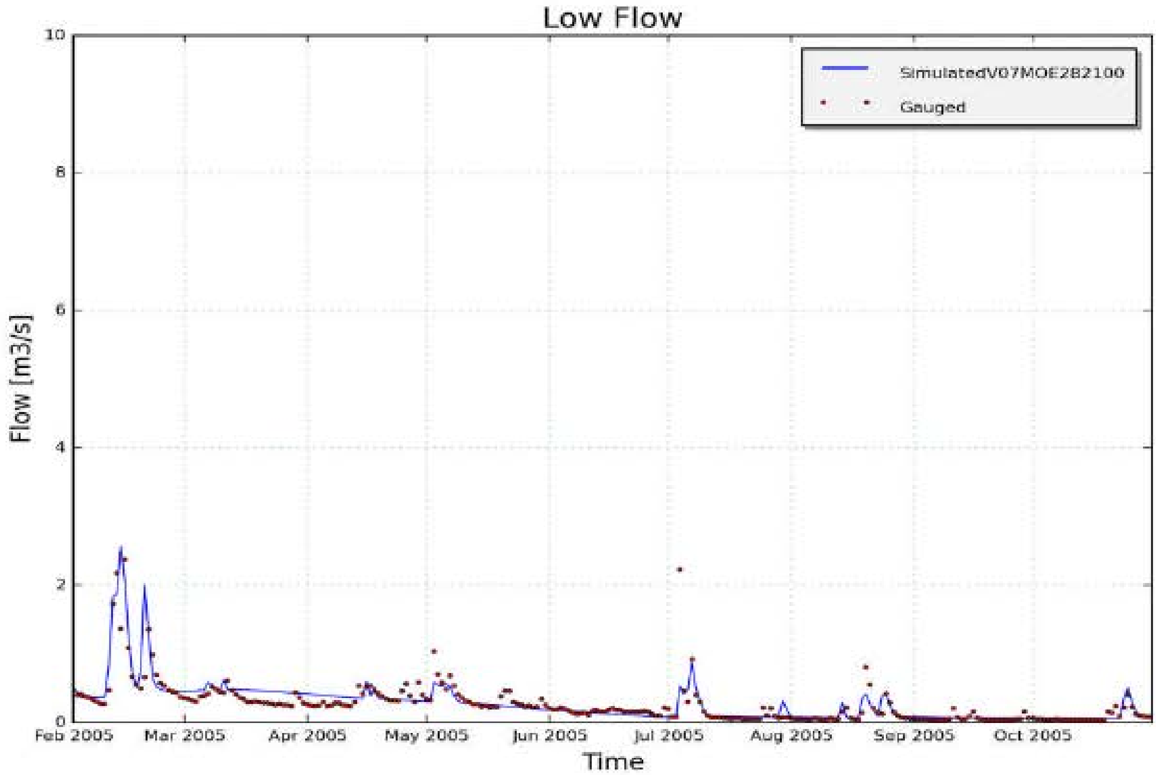


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere

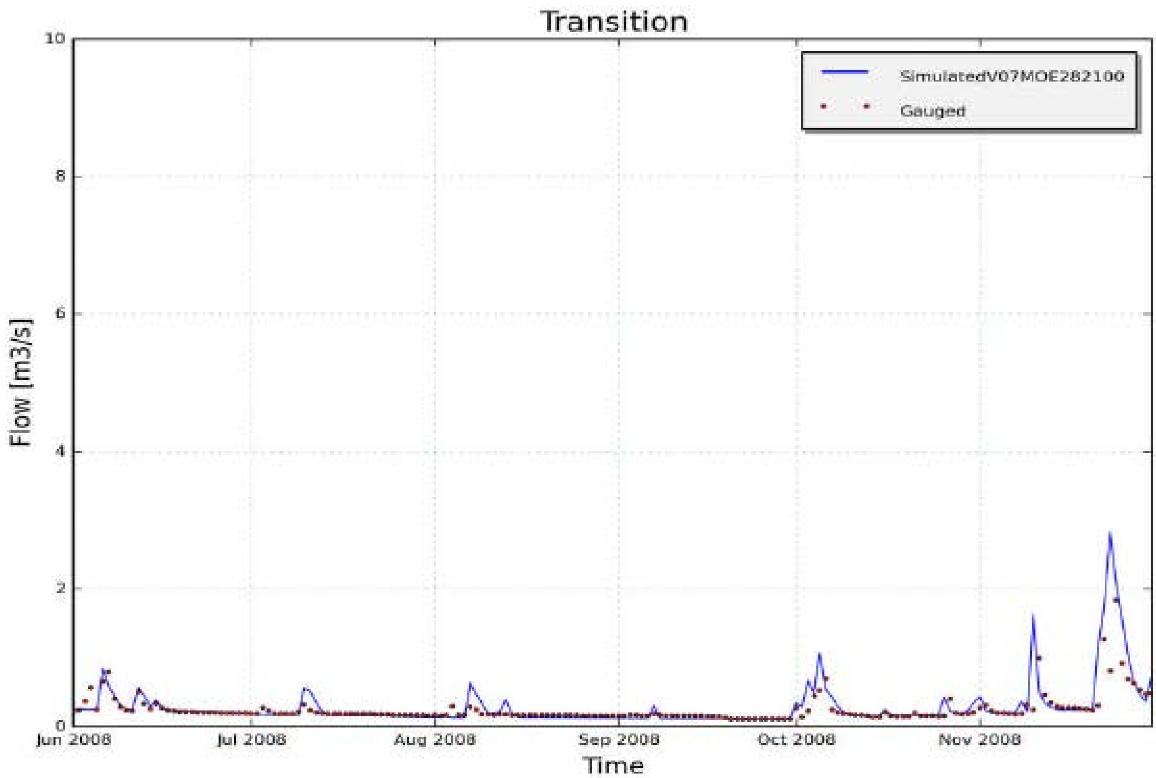


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere

9.5.4 Calibration and validation of WET parameters for catchment "V07MOG288020" (Denderbekken)

9.5.4.1 Input data

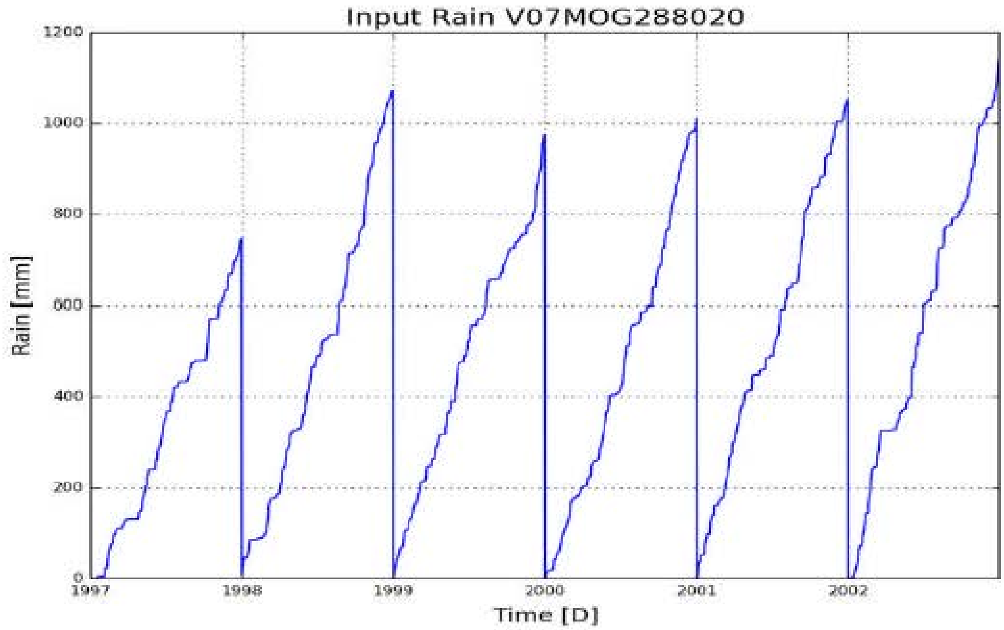


Figure 1: Cumulative precipitation on catchment V07MOG288020 (Denderbekken)

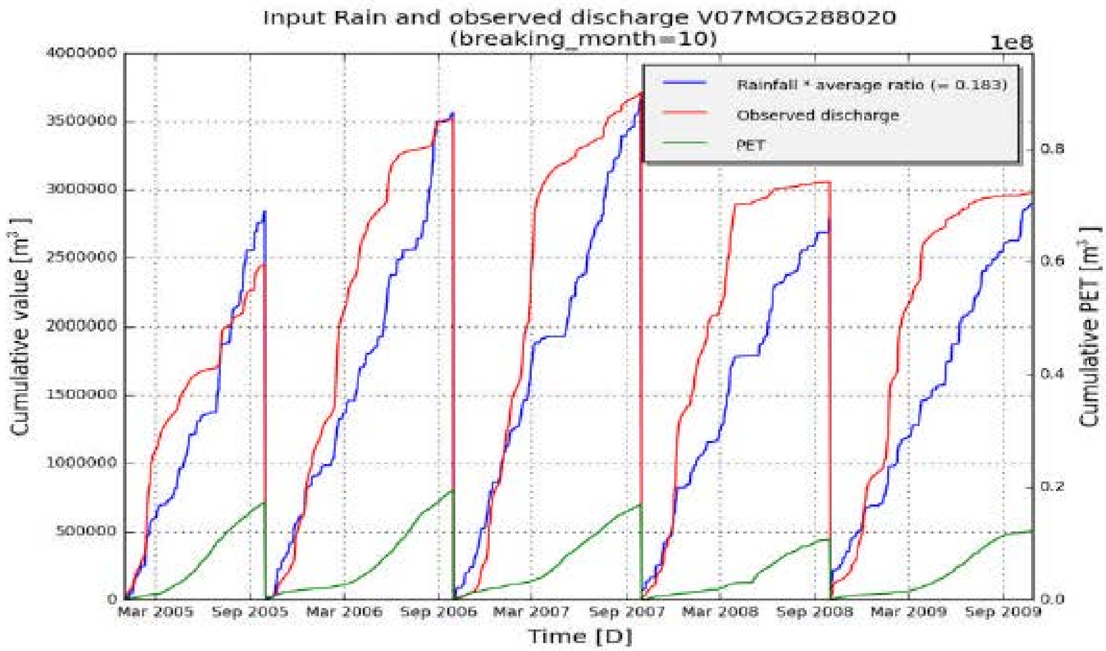


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V07MOG288020 (Denderbekken)

9.5.4.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V07MOG288020
subcatchment_area [m2]	23100000
Validation start_date	01-01-1998
Validation end_date	31-12-2002
frequency	daily

Optimal parameter set:[('Kep', 1.77), ('Ki', 49.27), ('Kg', 0.0), ('Kss', 1.23), ('g0', 185.23), ('g_max', 300.04), ('K_run', 25.94), ('P_max', 644.01)]

Table 1: Goodness of fit for calibration period (2005 - 2009)

	Full year	Summer	Winter
RelErr	-5.8 %	24.4 %	-16.4 %
NS	0.485	-0.458	0.537
NS_log	0.515	-0.1	0.441
NS_rel	-2.958	-4.054	0.583
KGE	0.702	0.245	0.644

Table 2 :Goodness of fit for validation period (1998 - 2002)

	Full year	Summer	Winter
RelErr	-7.9 %	29.5 %	-24.1 %
NS	0.508	-0.036	0.465
NS_log	0.698	0.467	0.153
NS_rel	0.375	-0.01	0.584
KGE	0.698	0.48	0.604

9.5.4.3 Observed and simulated timeseries for optimum parameters

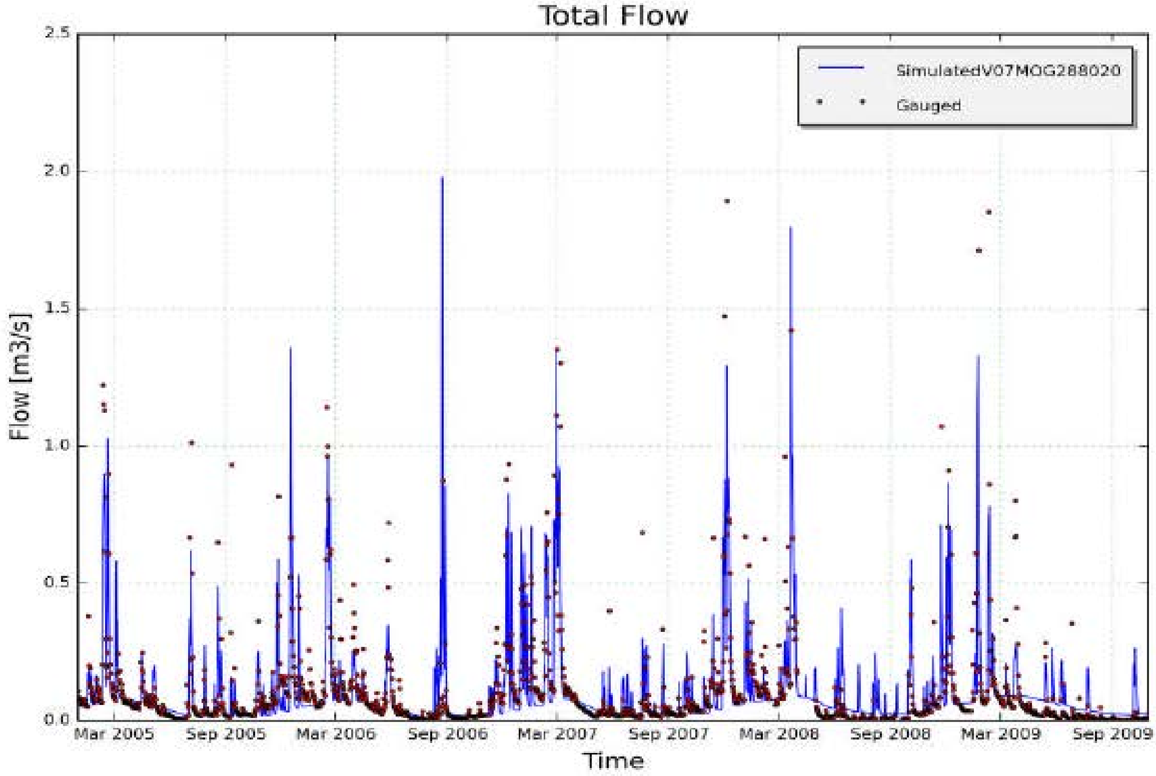


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen(calibration period)

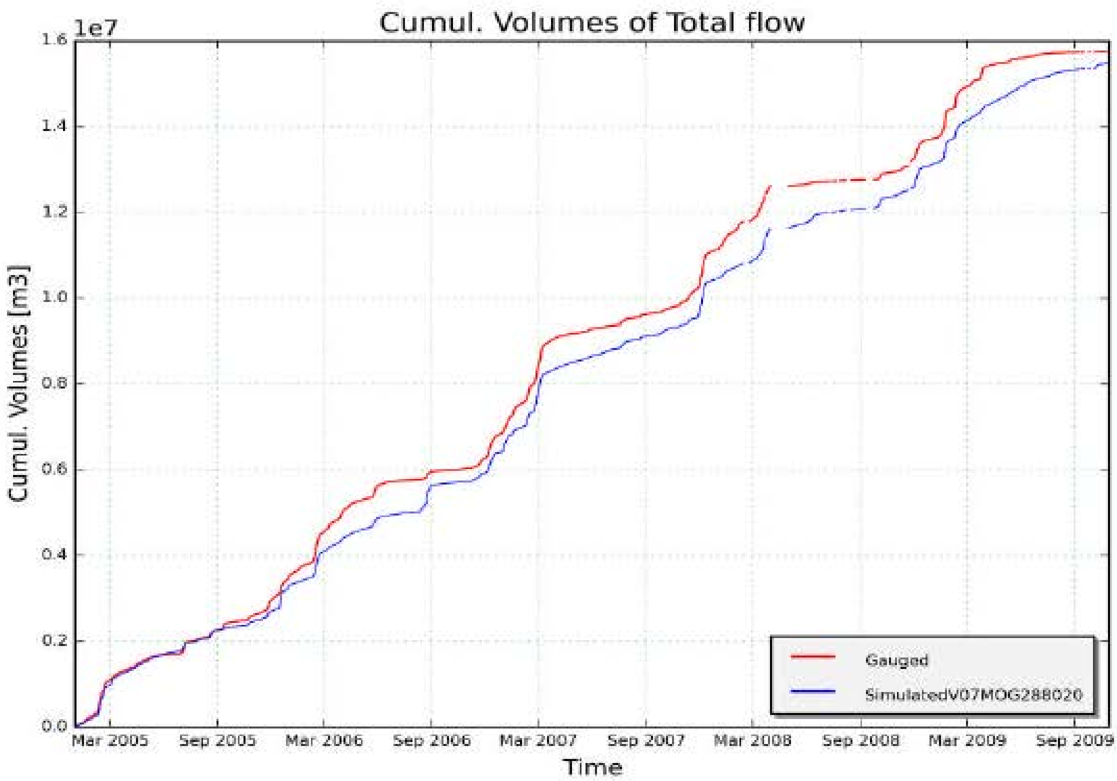


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen (calibration period)

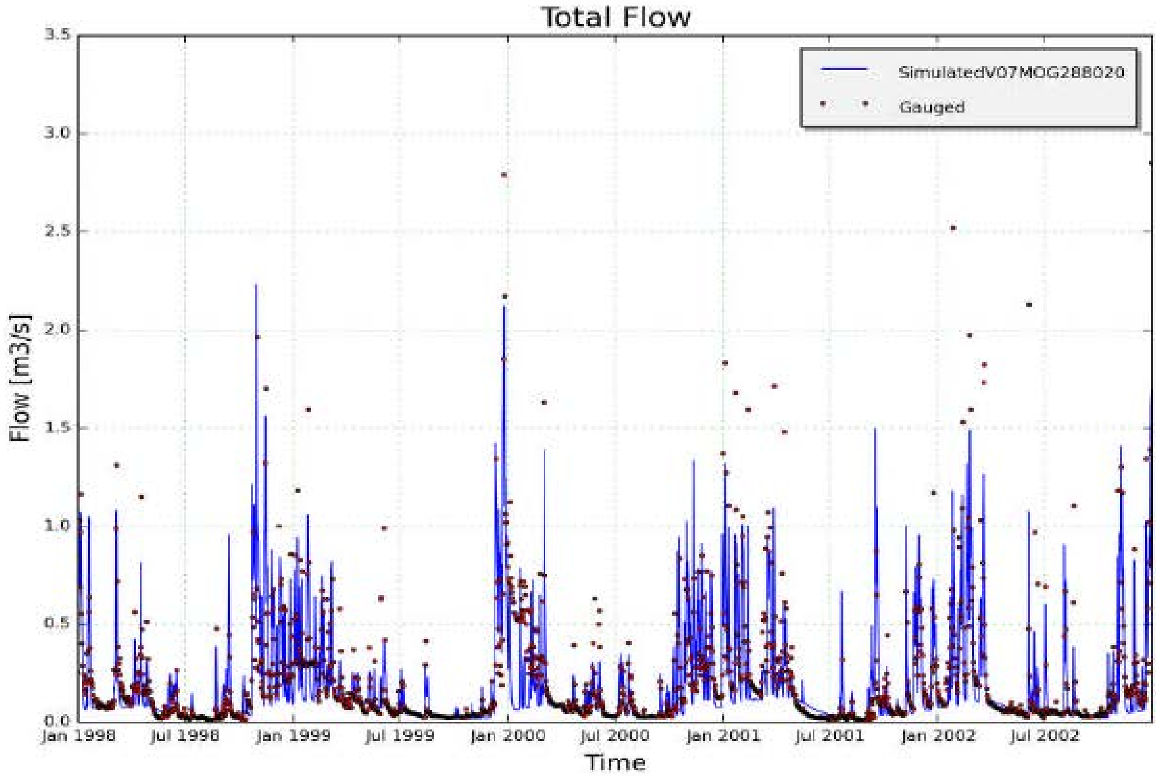


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen (validation period)

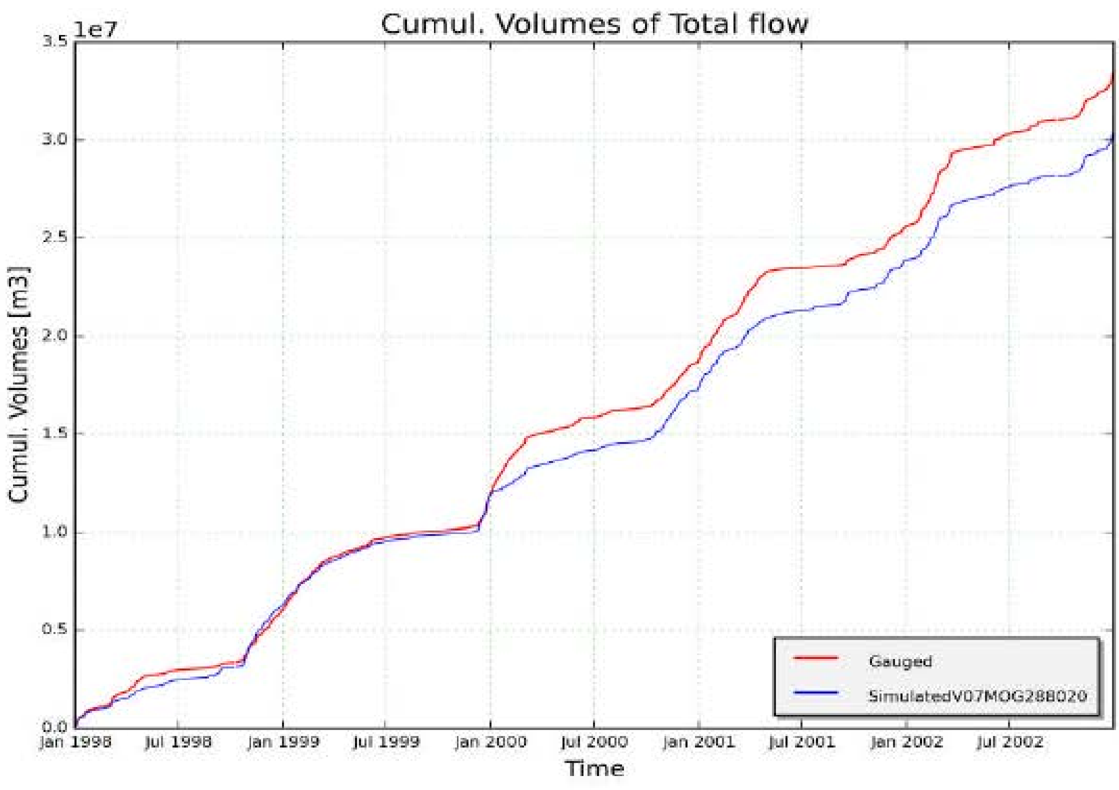


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen (validation period)

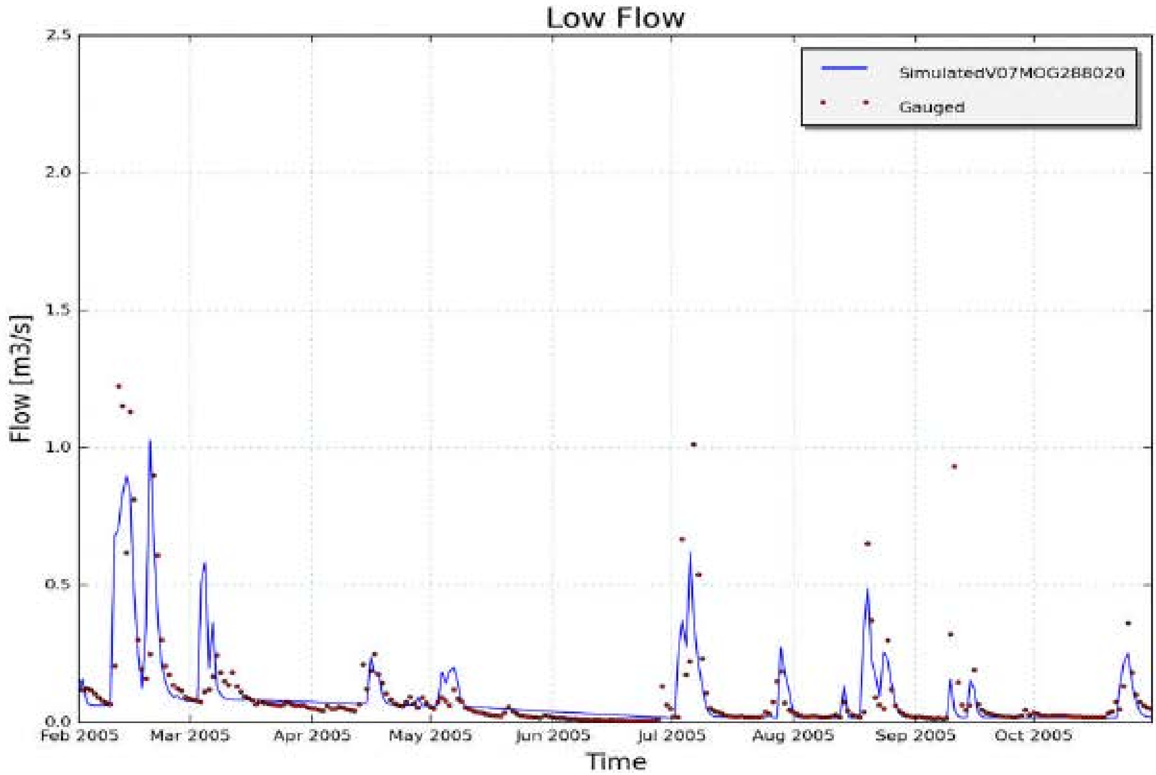


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen

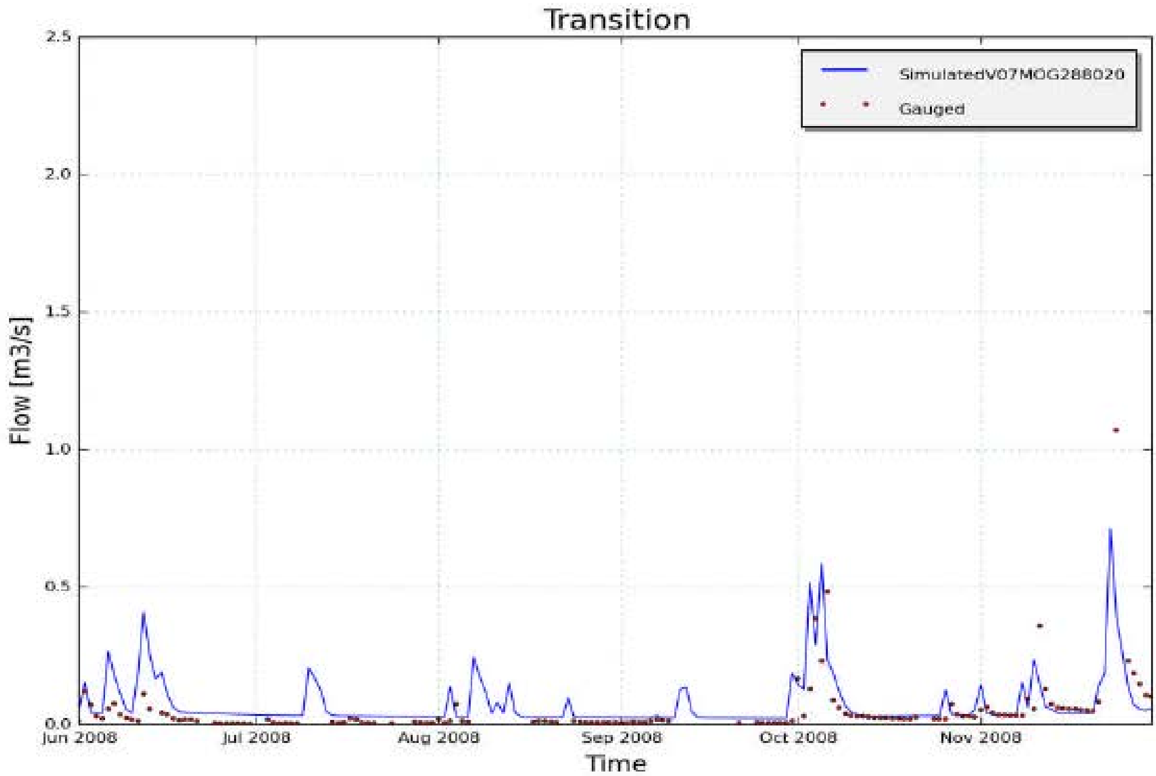


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen

9.5.5 Calibration and validation of WET parameters for catchment "W07DENLES999" (Denderbekken)

9.5.5.1 Input data

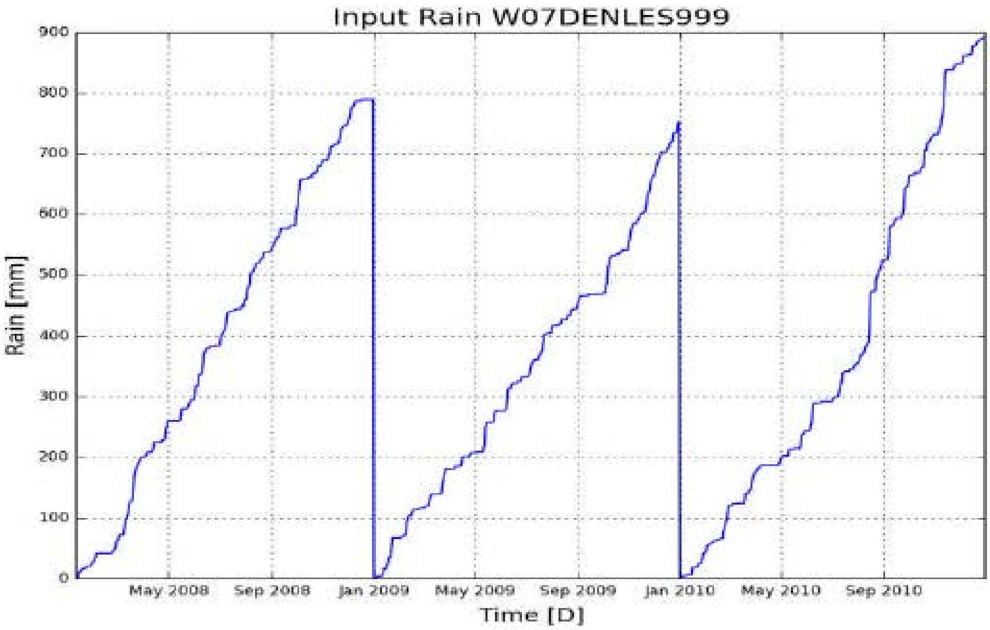


Figure 1: Cumulative precipitation on catchment W07DENLES999 (Denderbekken)

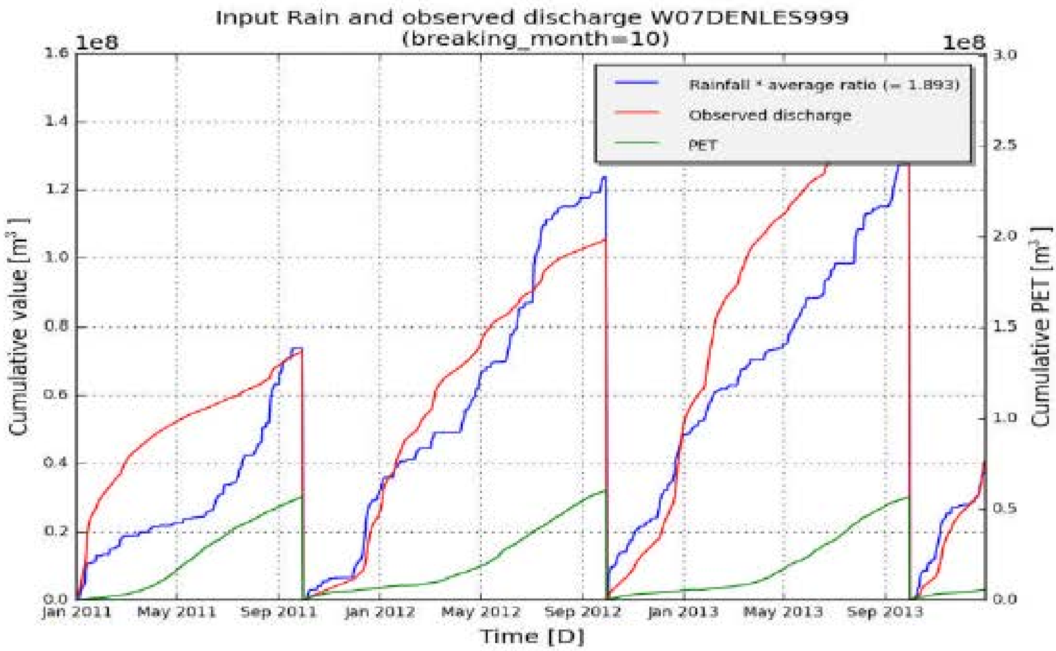


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W07DENLES999 (Denderbekken)

9.5.5.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	W07DENLES999
subcatchment_area [m2]	77319091
Validation start_date	15-01-2008
Validation end_date	31-12-2010
frequency	daily

Optimal parameter set:[('Kep', 1.3), ('Ki', 100.0), ('Kg', 0.0), ('Kss', 1.13), ('g0', 50.0), ('g_max', 300.0), ('K_run', 7.2), ('P_max', 350.0)]

Table 1: Goodness of fit for calibration period (2011 - 2013)

	Full year	**Summer**	**Winter**
RelErr	1.2 %	55.2 %	-14.9 %
NS	-0.227	-10.707	0.66
NS_log	0.366	-1.041	0.15
NS_rel	0.466	-1.102	0.636
KGE	0.294	-1.886	0.685

Table 2 :Goodness of fit for validation period (2008 - 2010)

	Full year	**Summer**	**Winter**
RelErr	5.9 %	3.1 %	-18.7 %
NS	-1.326	-32.836	0.304
NS_log	0.351	-1.207	-0.019
NS_rel	-0.11	-3.176	0.545
KGE	-0.124	-4.158	0.486

9.5.5.3 Observed and simulated timeseries for optimum parameters

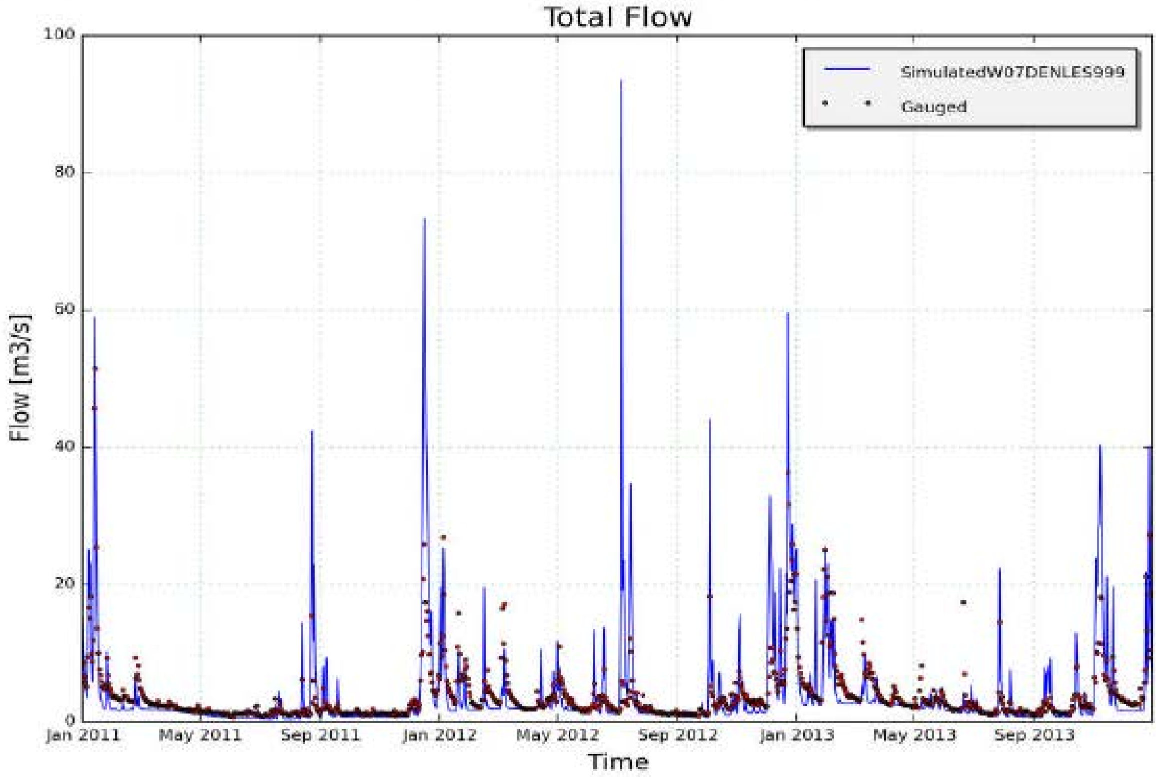


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W07DENLES999, station Lessines(calibration period)

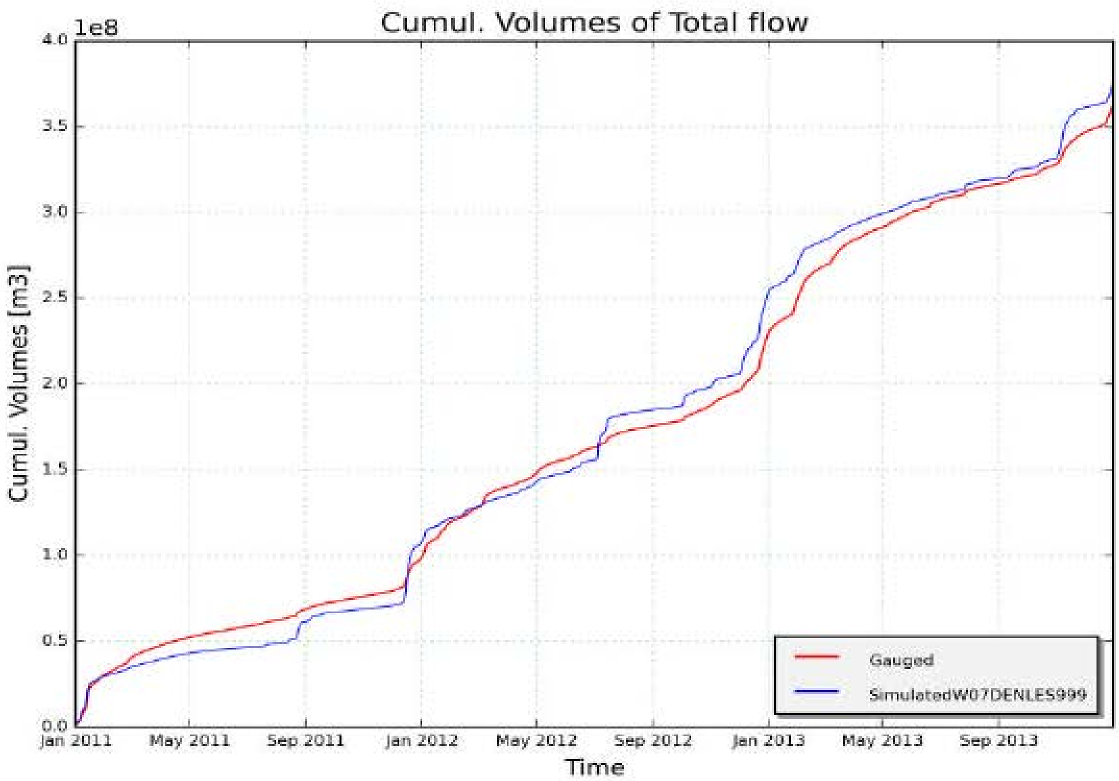


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W07DENLES999, station Lessines (calibration period)

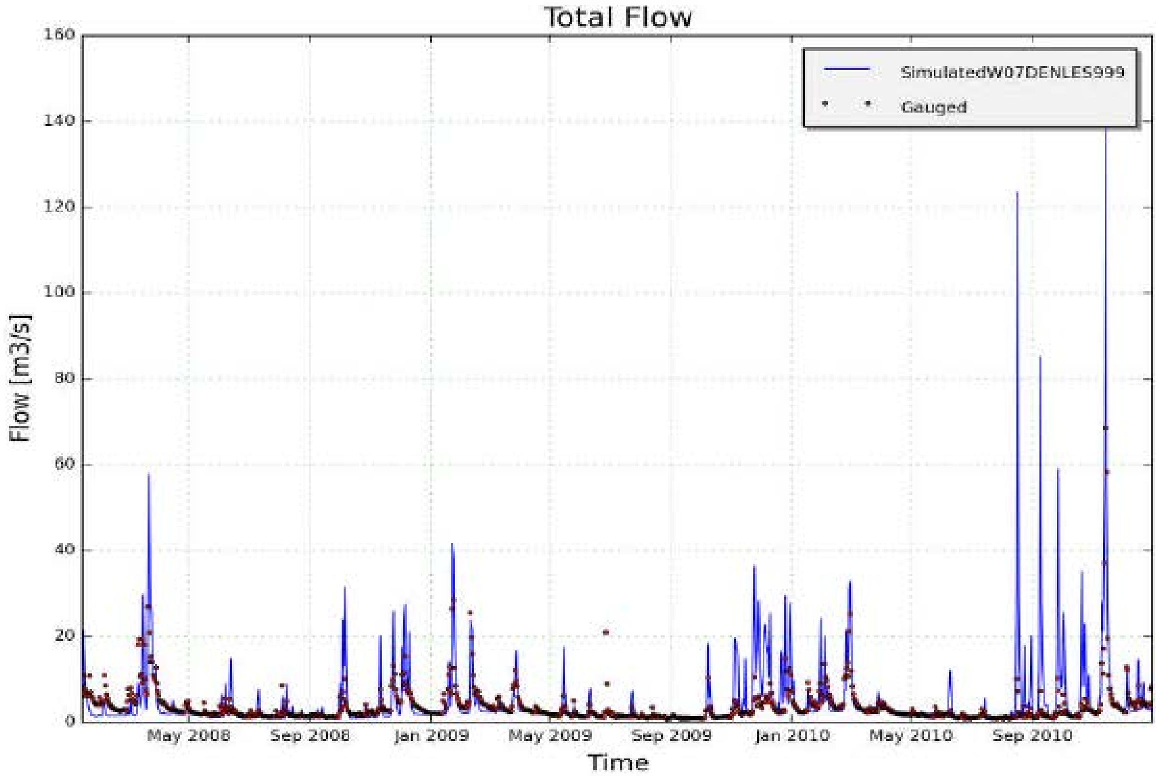


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W07DENLES999, station Lessines (validation period)

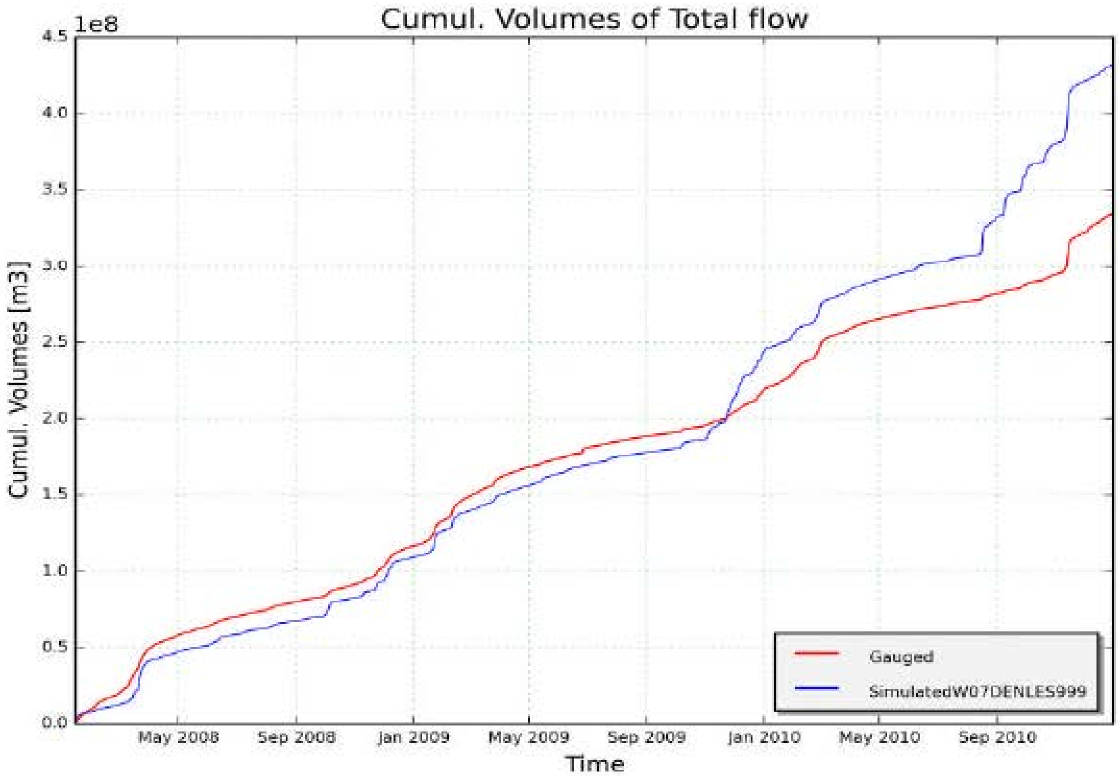


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W07DENLES999, station Lessines (validation period)

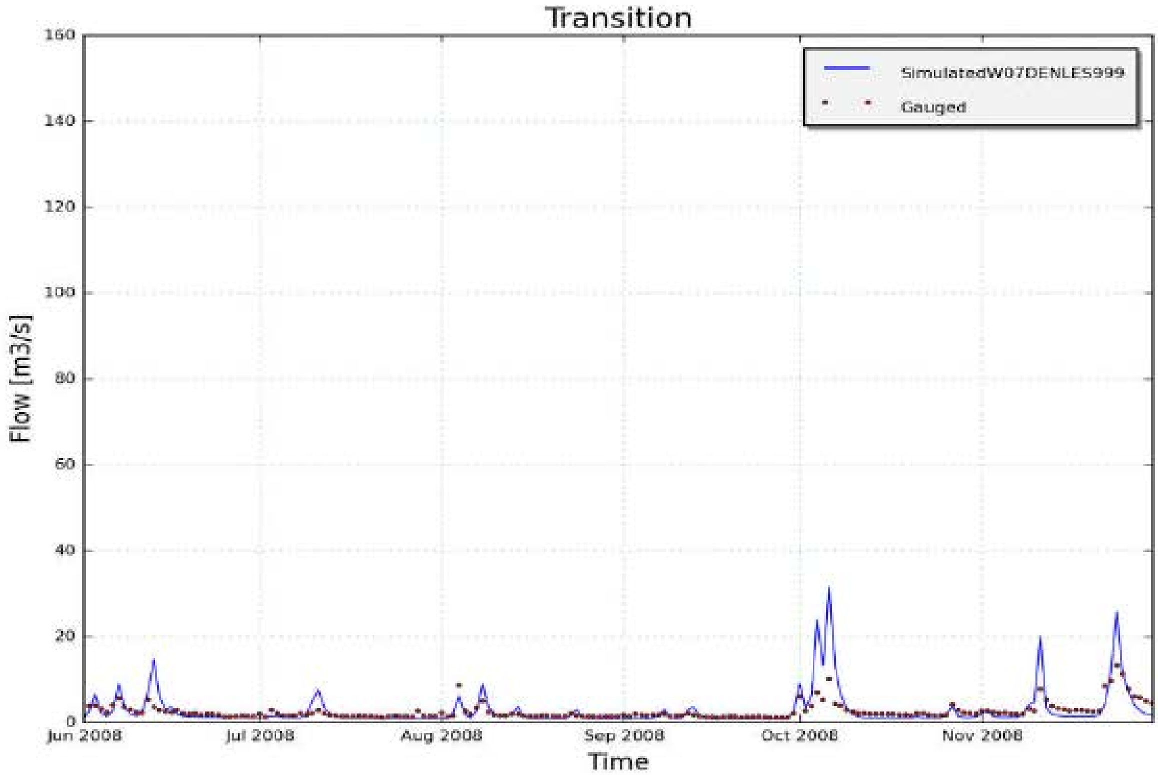


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W07DENLES999, station Lessines

Appendix 15 Denderbekken Autocalibration.

9.5.1 Report on simulation of catchment V07BEL285070 (2017-01-18 23-35)

9.5.1.1 Input data

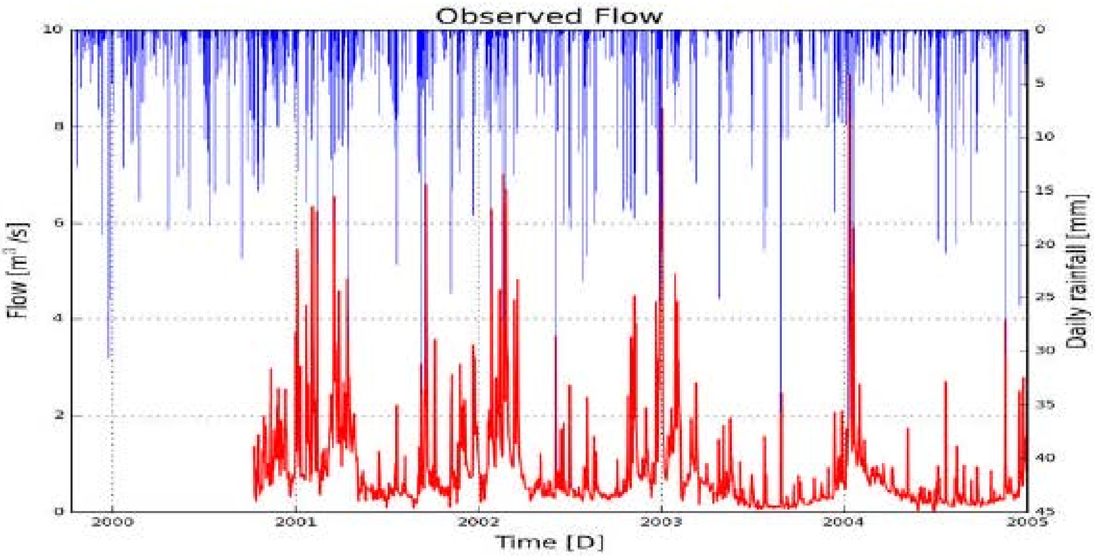


Figure 1: Hyetogram of observed discharge and observed net rain

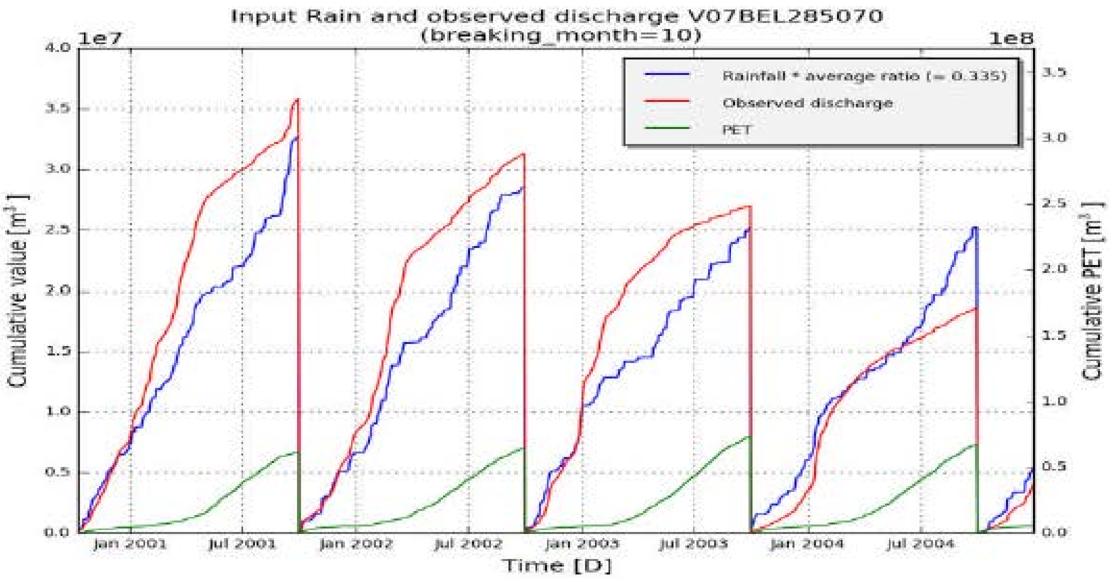


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.1.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V07BEL285070
subcatchment_area	88700000
start_date	20001010000
end_date	200412310000
frequency	86400
warmup	365

9.5.1.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.5026, 20.0347, 0.001583, 0.998, 49.40356, 299.3829, 14.0925, 470.41516]
low_bounds	[1.2, 16.0, 0.0012, 0.79, 39.0, 239.0, 11.0, 376.0]
high_bounds	[1.8, 100.0, 0.01, 3.0, 150.0, 359.0, 16.0, 570.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.5026), ('Ki', 20.0347), ('Kg', 0.001583), ('Kss', 0.998), ('g0', 49.40356), ('g_max', 299.3829), ('K_run', 14.0925), ('P_max', 470.41516)]
Initial fitness:

- RelErr: -0.021
- AbsErr: 1600660.592
- KGE: 0.775
- NS_rel: 0.731
- NS: 0.638

- RMSE: 1996586.879
- NS_log: 0.755

Computation time:5:46:02.874000

9.5.1.4 Results

Best individual (euclidian): [('Kep', 1.386), ('Ki', 20.756), ('Kg', 0.001), ('Kss', 0.79), ('g0', 71.076), ('g_max', 306.136), ('K_run', 13.009), ('P_max', 470.49)]

Fitness:

- RelErr: 0.004
- AbsErr: 743715.945
- KGE: 0.782
- NS_rel: 0.698
- NS: 0.618
- RMSE: 913958.235
- NS_log: 0.758

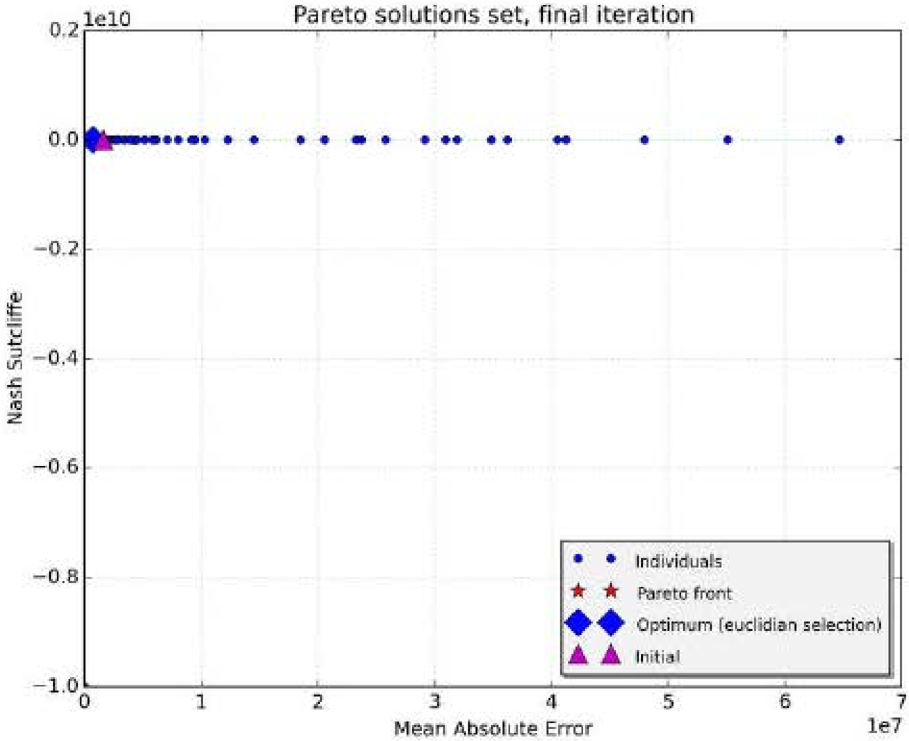


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

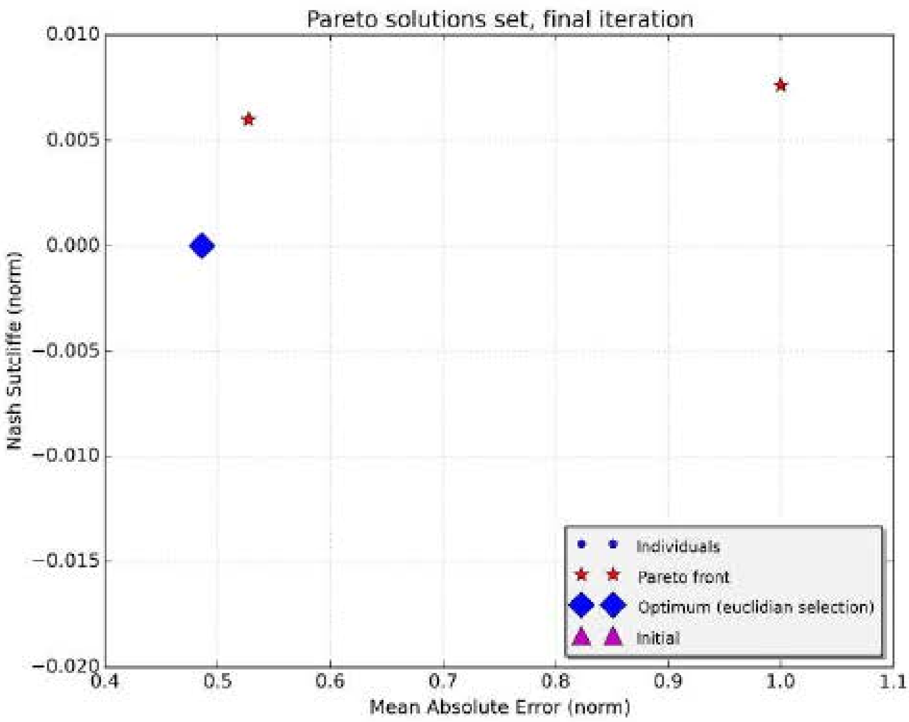


Figure 4: Final population of solutions (Pareto front)

9.5.1.4.1 Initial

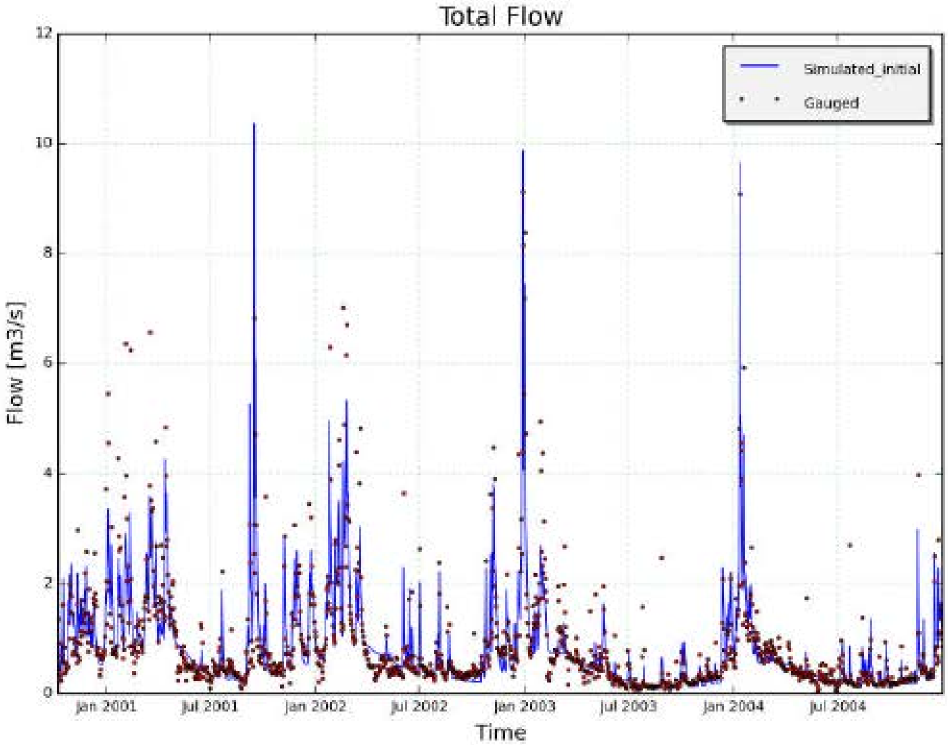


Figure 5: Total flow with initial parameters

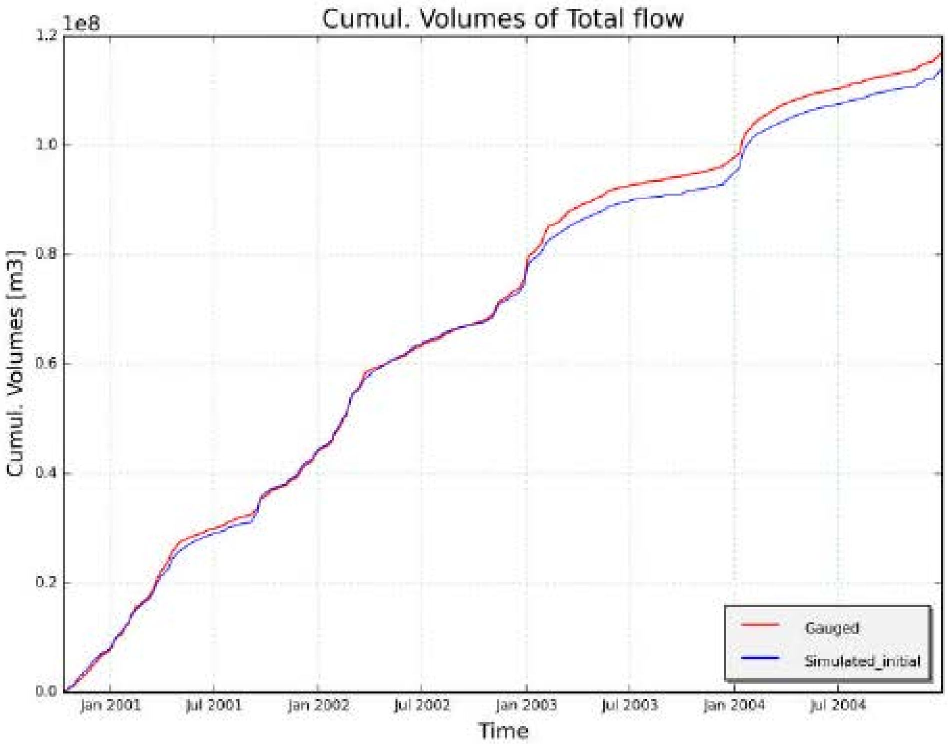


Figure 6: Cumulated flow with initial parameters

9.5.1.4.2 Optimum (euclidian)

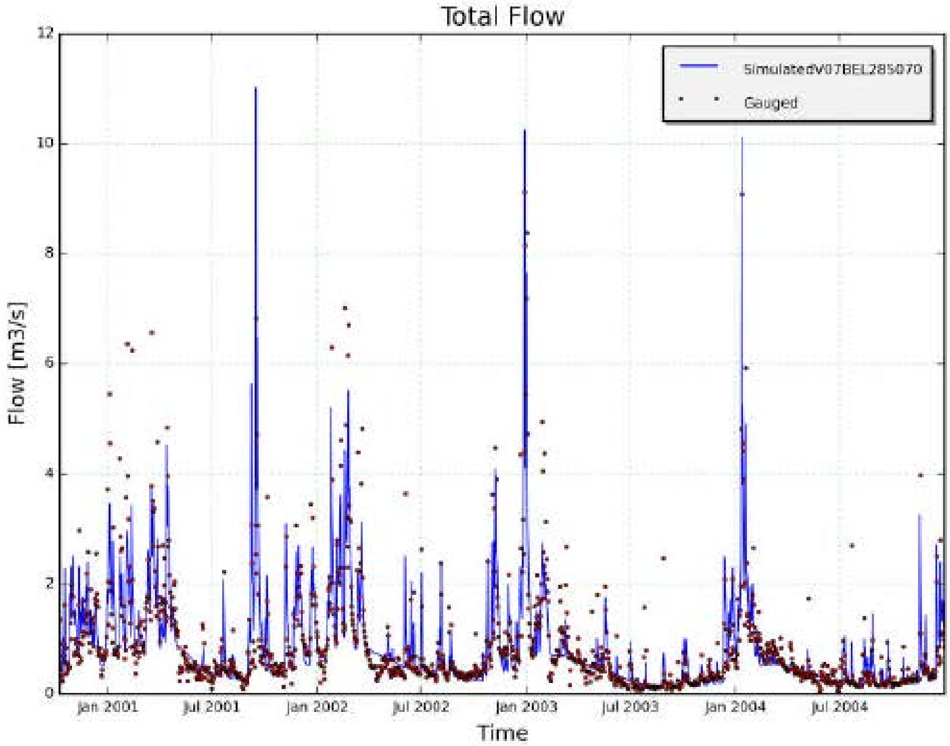


Figure 7: Total flow with optimum parameters

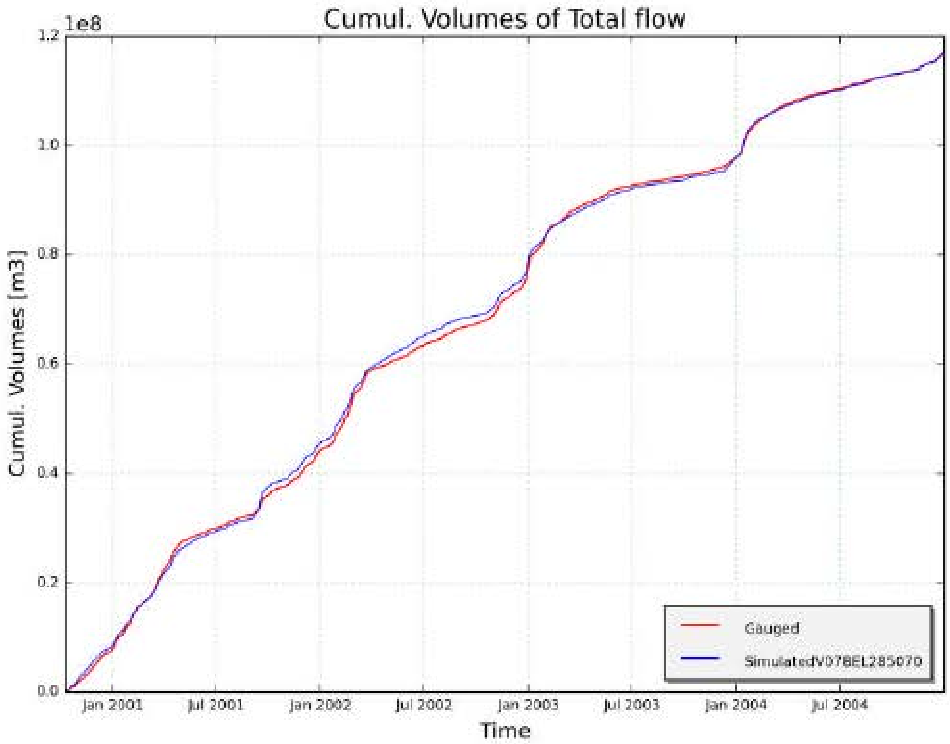


Figure 8: Cumulated flow with optimum parameters

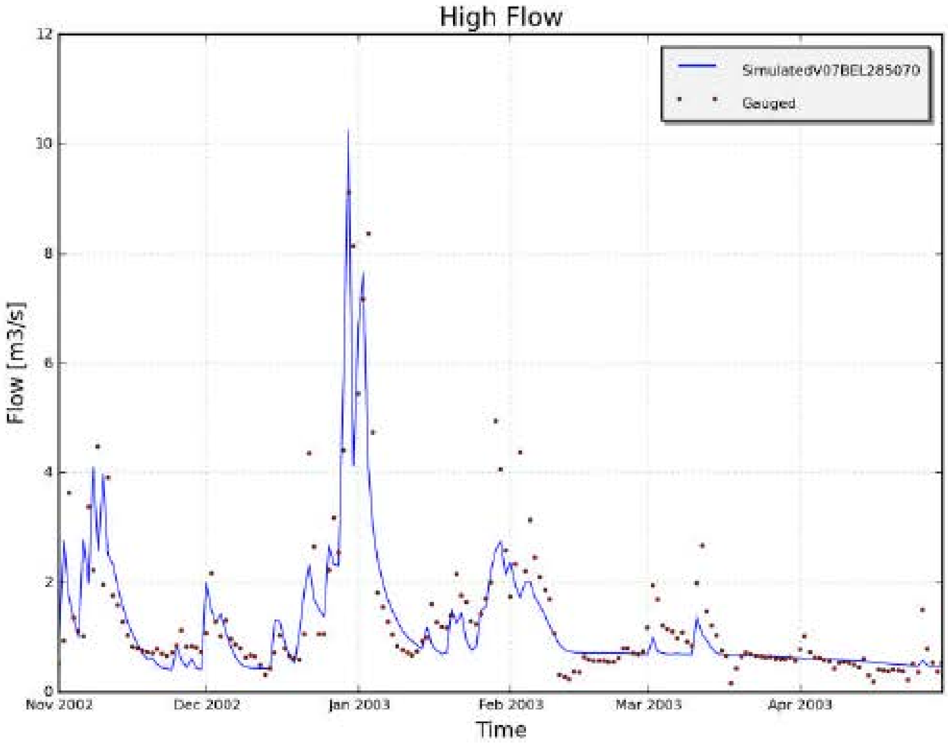
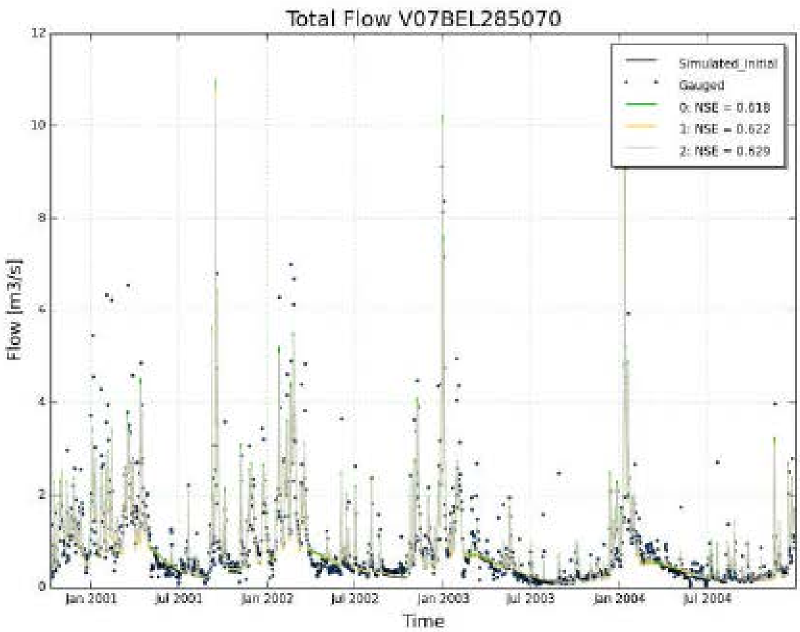
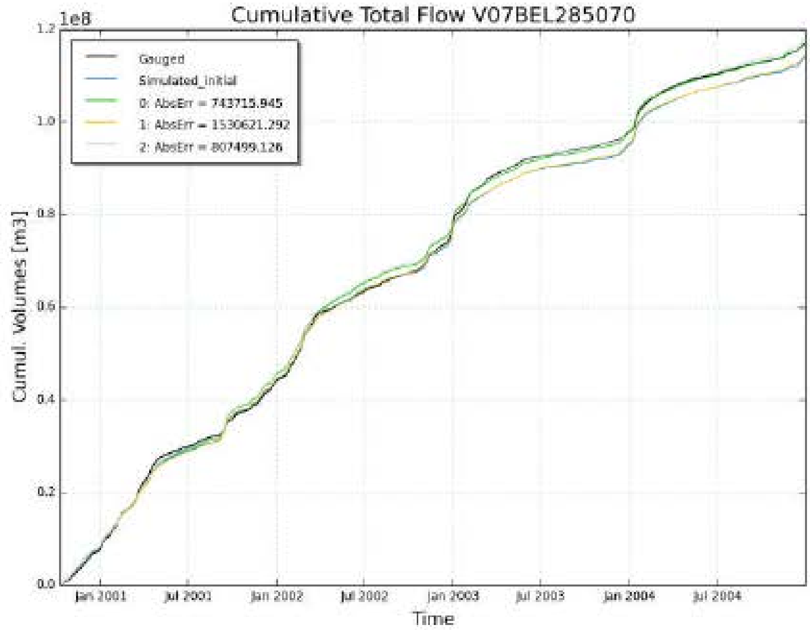


Figure 9: Total flow with optimum parameters (detail)

9.5.1.4.3 Final archive

0 : [1.386, 20.756, 0.001, 0.79, 71.076, 306.136, 13.009, 470.49] : [743715.945, 0.758]
1 : [1.378, 20.031, 0.001, 0.946, 70.953, 308.817, 13.096, 469.542] : [1530621.292, 0.76]
2 : [1.396, 19.583, 0.001, 0.883, 72.783, 305.884, 13.158, 471.014] : [807499.126, 0.76]





9.5.2 Report on simulation of catchment V07MAR289015 (2017-01-20 20-03)

9.5.2.1 Input data

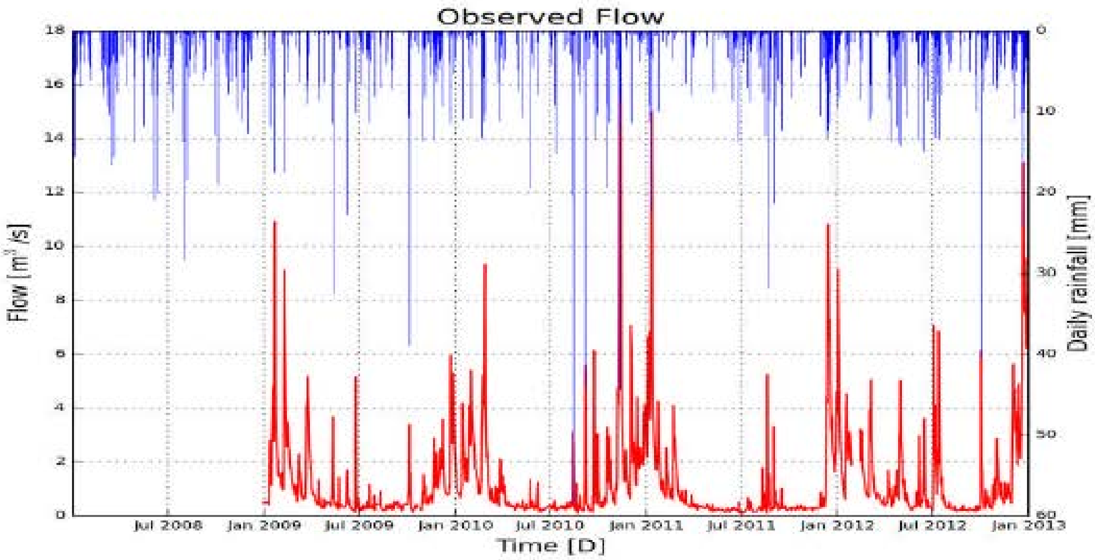


Figure 1: Hyetogram of observed discharge and observed net rain

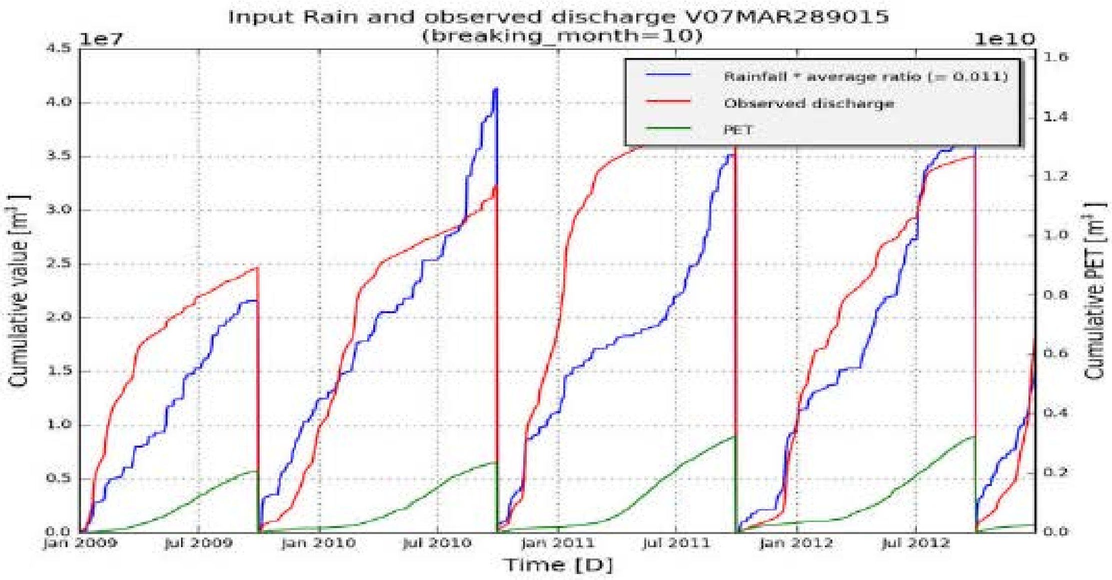


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.2.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V07MAR289015
subcatchment_area	173900000
start_date	200901010000
end_date	201212310000
frequency	86400
warmup	365

9.5.2.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[1.5, 75.0, 0.001, 1.01, 110.0, 550.0, 5.5, 600.0]
low_bounds	[1.2, 60.0, 0.0008, 0.8, 88.0, 440.0, 4.4, 480.0]
high_bounds	[1.8, 90.0, 0.01, 1.212, 132.0, 660.0, 6.6, 720.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.5), ('Ki', 75.0), ('Kg', 0.001), ('Kss', 1.01), ('g0', 110.0), ('g_max', 550.0), ('K_run', 5.5), ('P_max', 600.0)]
Initial fitness:

- RelErr: 0.001
- AbsErr: 3105801.978
- KGE: 0.692
- NS_rel: 0.219
- NS: 0.369
- RMSE: 3933645.778
- NS_log: 0.543

Computation time:6:18:08.596000

9.5.2.4 Results

Best individual (euclidian): [('Kep', 1.601), ('Ki', 66.993), ('Kg', 0.001), ('Kss', 1.187), ('g0', 102.787), ('g_max', 536.881), ('K_run', 4.852), ('P_max', 604.507)]

Fitness:

- RelErr: -0.017
- AbsErr: 3151251.414
- KGE: 0.726
- NS_rel: 0.306
- NS: 0.438
- RMSE: 3633131.124
- NS_log: 0.565

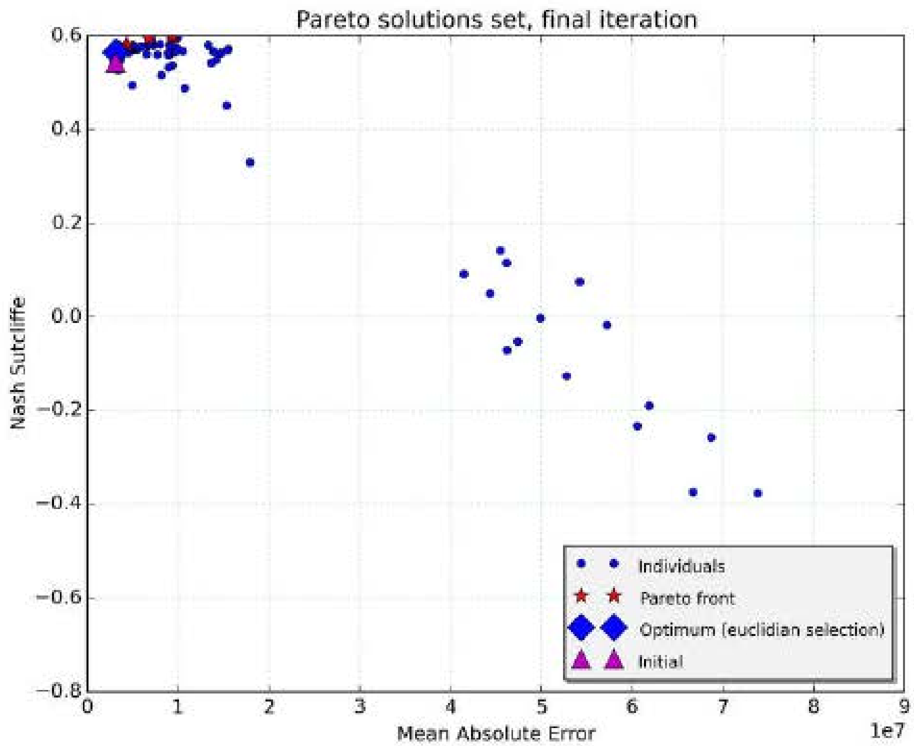


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

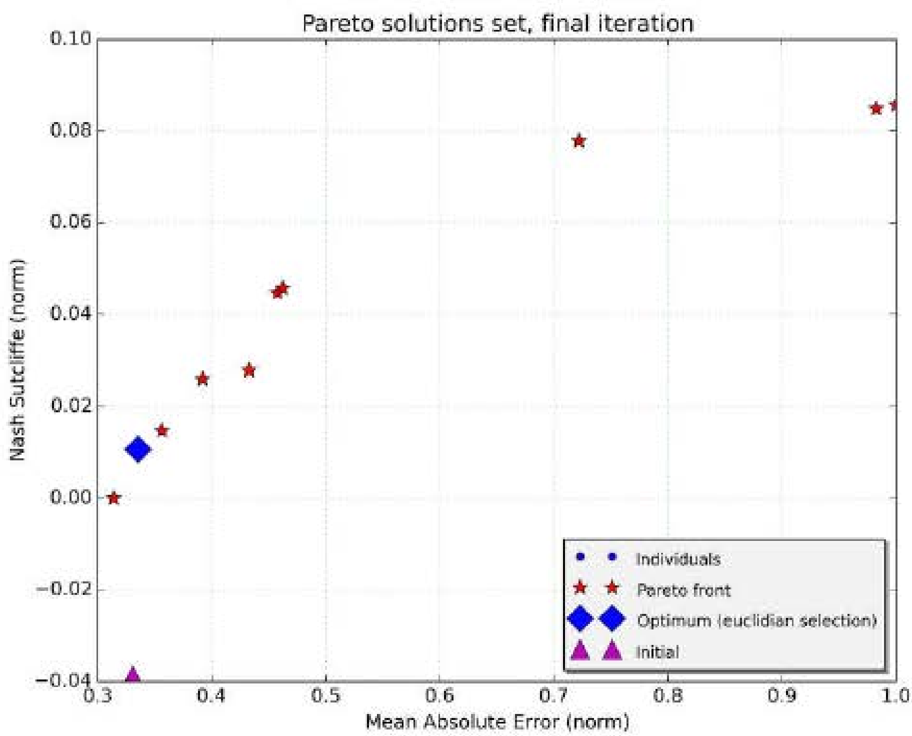


Figure 4: Final population of solutions (Pareto front)

9.5.2.4.1 Initial

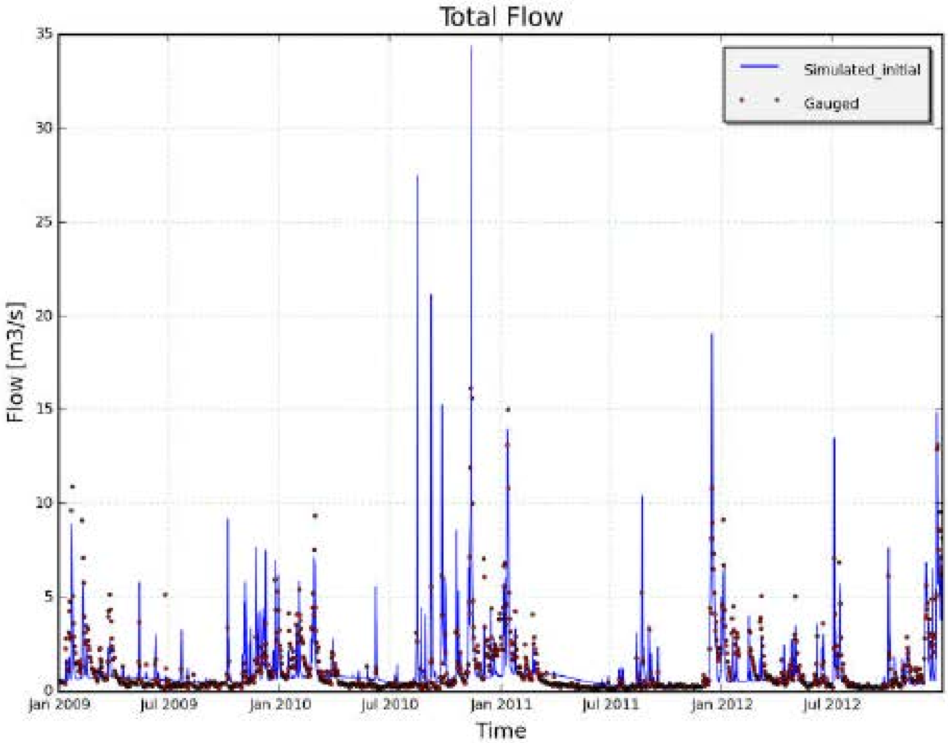


Figure 5: Total flow with initial parameters

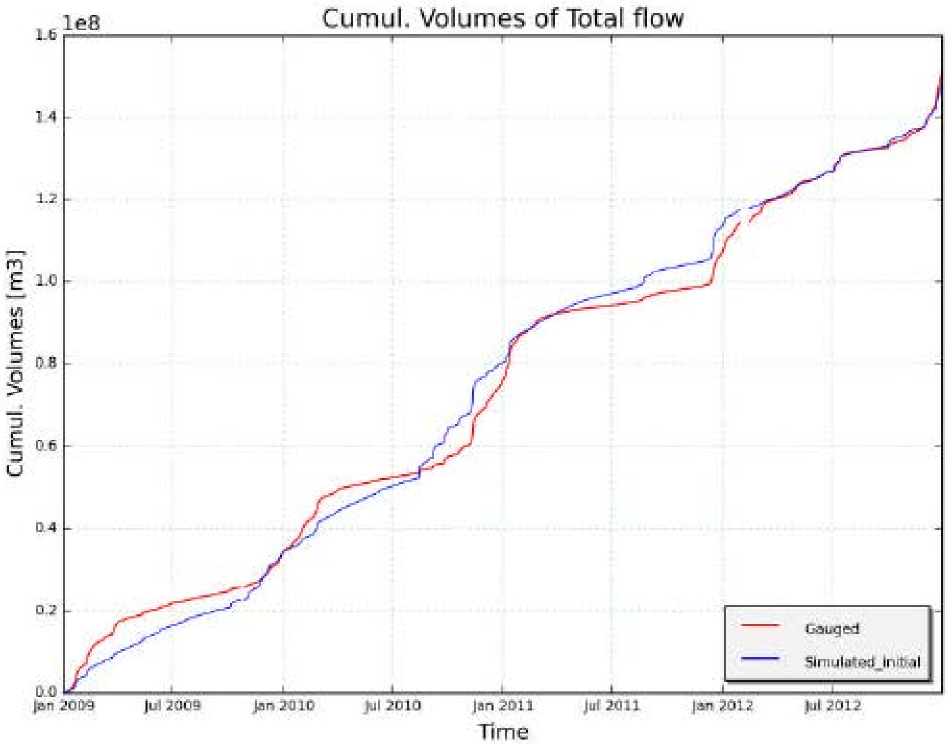


Figure 6: Cumulated flow with initial parameters

9.5.2.4.2 Optimum (euclidian)

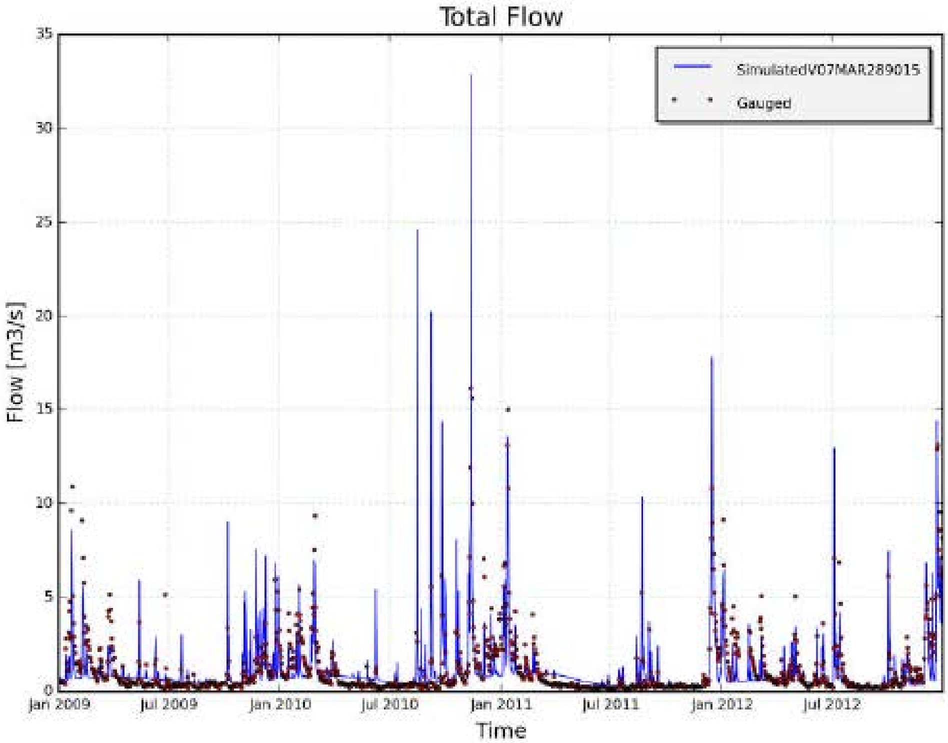


Figure 7: Total flow with optimum parameters

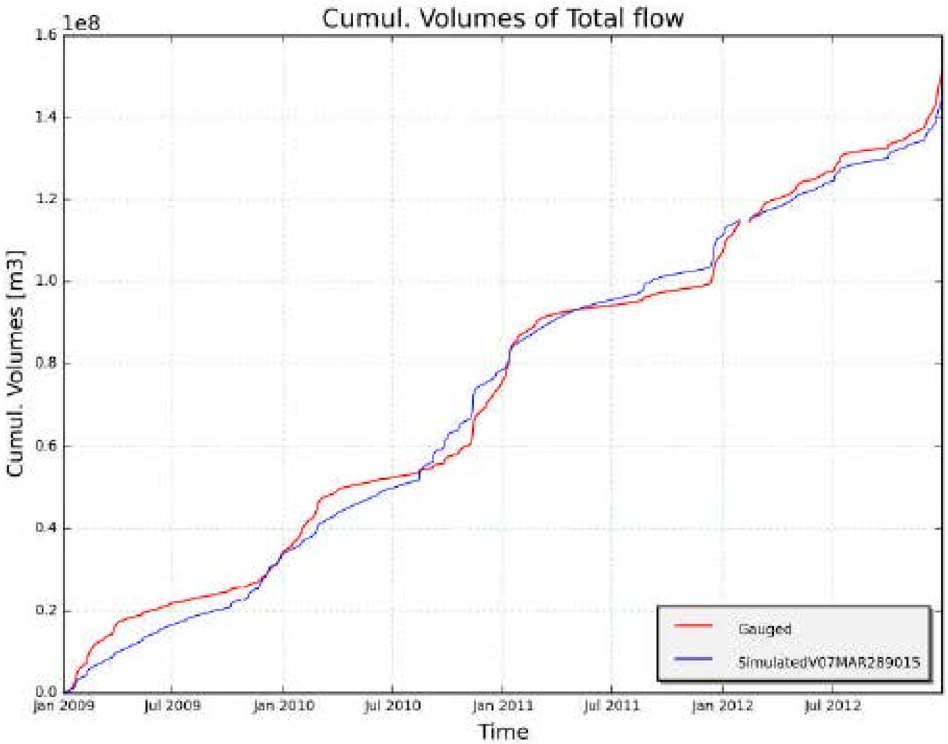


Figure 8: Cumulated flow with optimum parameters

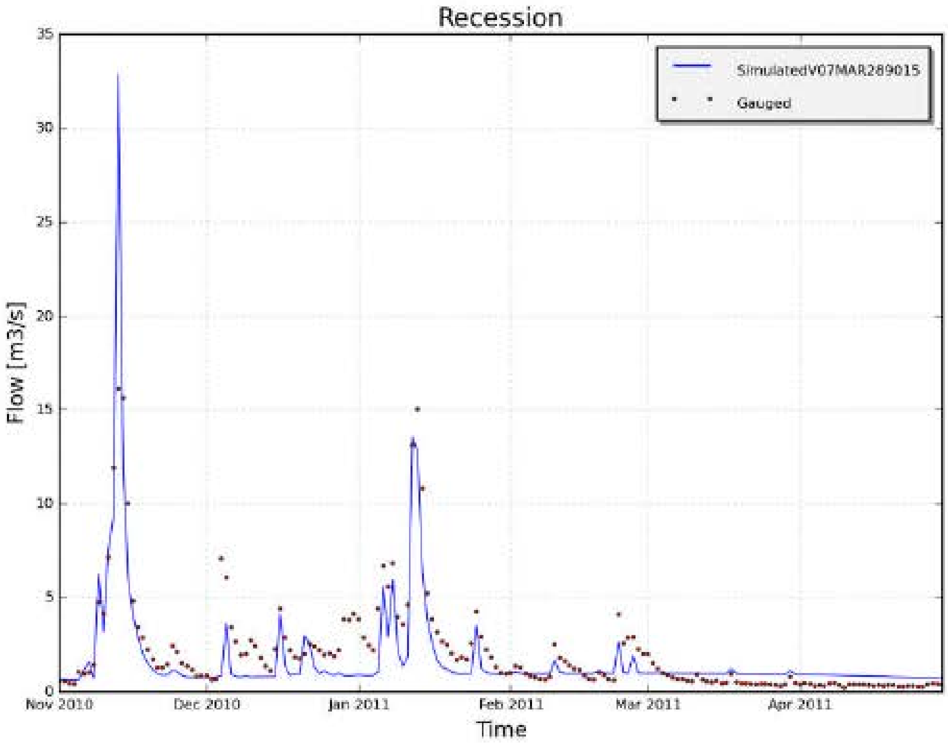


Figure 9: Total flow with optimum parameters (detail)

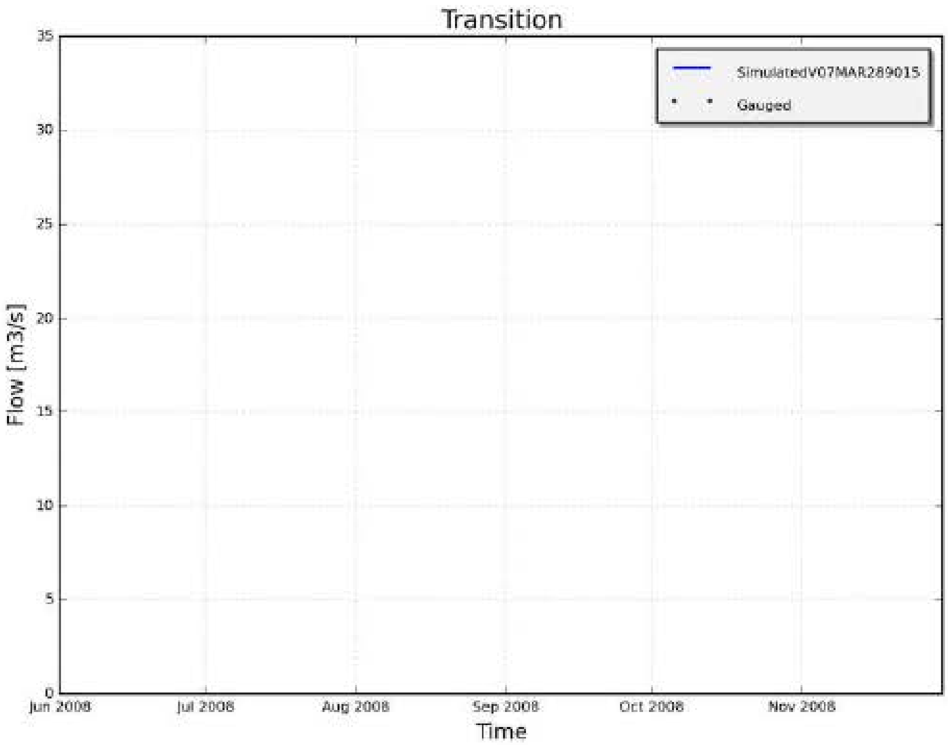
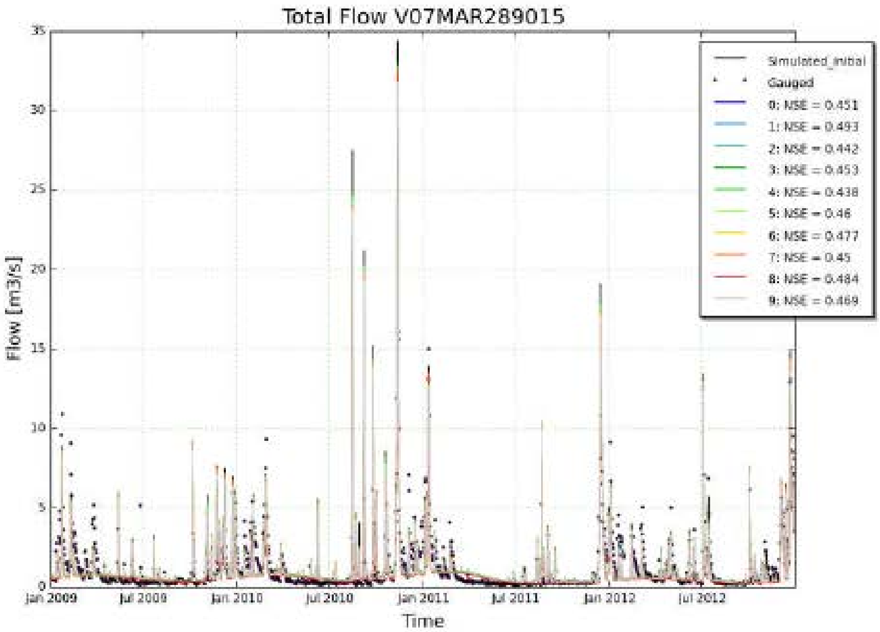
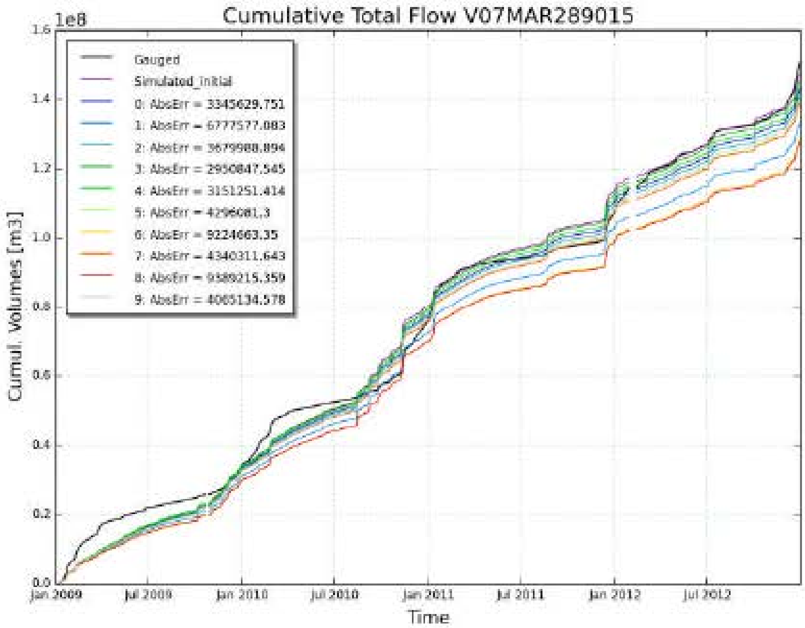


Figure 10: Total flow with optimum parameters (detail)

9.5.2.4.3 Final archive

0 : [1.602, 63.025, 0.001, 1.212, 103.907, 541.667, 4.581, 604.926] : [3345629.751, 0.567]
1 : [1.8, 63.979, 0.001, 1.038, 103.699, 547.897, 4.561, 599.945] : [6777577.083, 0.594]
2 : [1.593, 66.902, 0.001, 1.212, 103.768, 534.295, 5.12, 594.954] : [3679988.894, 0.572]
3 : [1.601, 63.052, 0.001, 1.212, 103.417, 537.808, 4.582, 605.095] : [2950847.545, 0.56]
4 : [1.601, 66.993, 0.001, 1.187, 102.787, 536.881, 4.852, 604.507] : [3151251.414, 0.565]
5 : [1.67, 63.857, 0.001, 1.212, 103.902, 542.653, 4.557, 604.592] : [4296081.3, 0.58]
6 : [1.8, 66.477, 0.001, 0.8, 103.599, 535.431, 5.078, 595.015] : [9224663.35, 0.597]
7 : [1.667, 66.108, 0.001, 1.212, 102.97, 540.193, 4.693, 604.544] : [4340311.643, 0.58]
8 : [1.8, 65.275, 0.001, 1.212, 102.88, 536.993, 5.187, 605.067] : [9389215.359, 0.598]
9 : [1.598, 61.586, 0.001, 1.18, 109.284, 548.104, 4.976, 587.787] : [4065134.578, 0.572]





9.5.3 Report on simulation of catchment V07MOE282100 (2017-01-18 23-17)

9.5.3.1 Input data

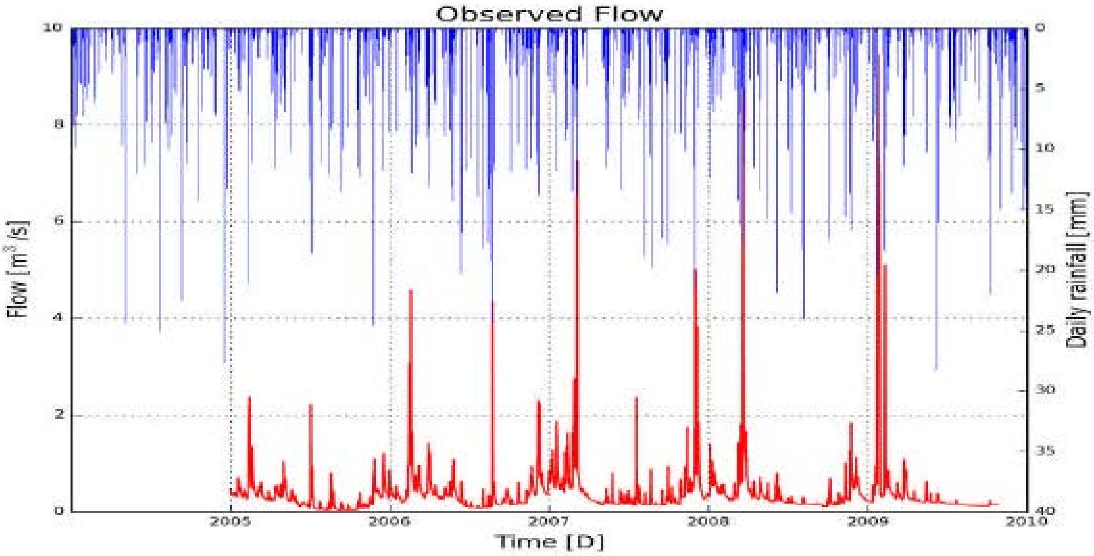


Figure 1: Hyetogram of observed discharge and observed net rain

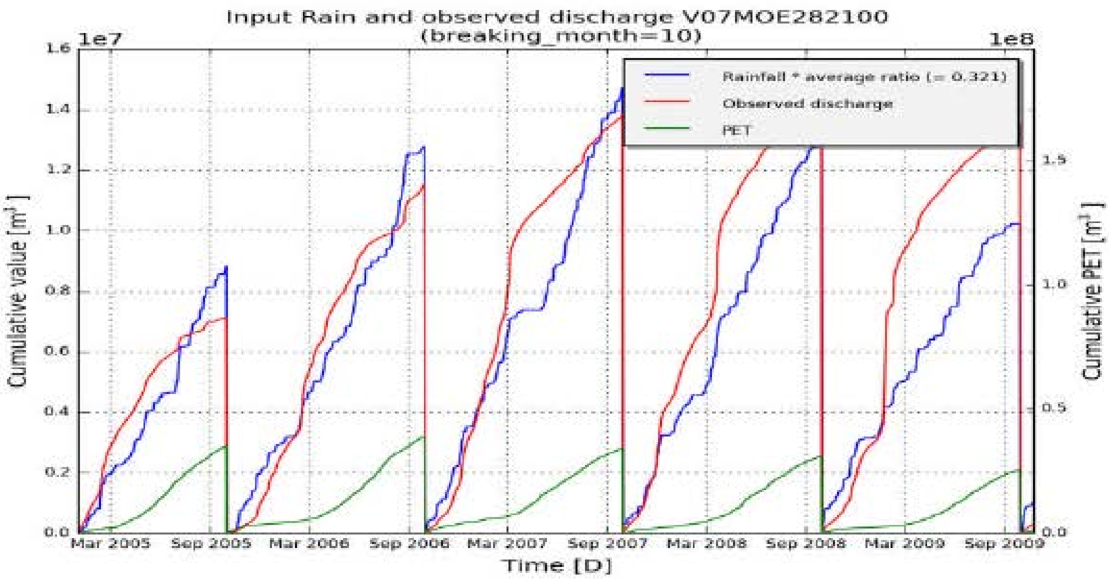


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.3.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V07MOE282100
subcatchment_area	46400000
start_date	200501010000
end_date	200912310000
frequency	86400
warmup	365

9.5.3.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.0, 55.0, 0.001, 1.0, 95.0, 300.0, 22.0, 190.0]
low_bounds	[0.8, 44.0, 0.0008, 0.1, 76.0, 240.0, 15.0, 150.0]
high_bounds	[2.0, 100.0, 0.01, 1.5, 200.0, 500.0, 40.0, 600.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.0), ('Ki', 55.0), ('Kg', 0.001), ('Kss', 1.0), ('g0', 95.0), ('g_max', 300.0), ('K_run', 22.0), ('P_max', 190.0)]
Initial fitness:

- RelErr: -0.01
- AbsErr: 970525.787
- KGE: 0.532
- NS_rel: 0.667
- NS: 0.365

- RMSE: 1190142.355
- NS_log: 0.52

Computation time:5:25:06.025000

9.5.3.4 Results

Best individual (euclidian): [('Kep', 1.831), ('Ki', 67.935), ('Kg', 0.006), ('Kss', 1.215), ('g0', 134.108), ('g_max', 335.952), ('K_run', 22.568), ('P_max', 263.315)]

Fitness:

- RelErr: -0.011
- AbsErr: 681877.302
- KGE: 0.535
- NS_rel: 0.872
- NS: 0.44
- RMSE: 852693.688
- NS_log: 0.688

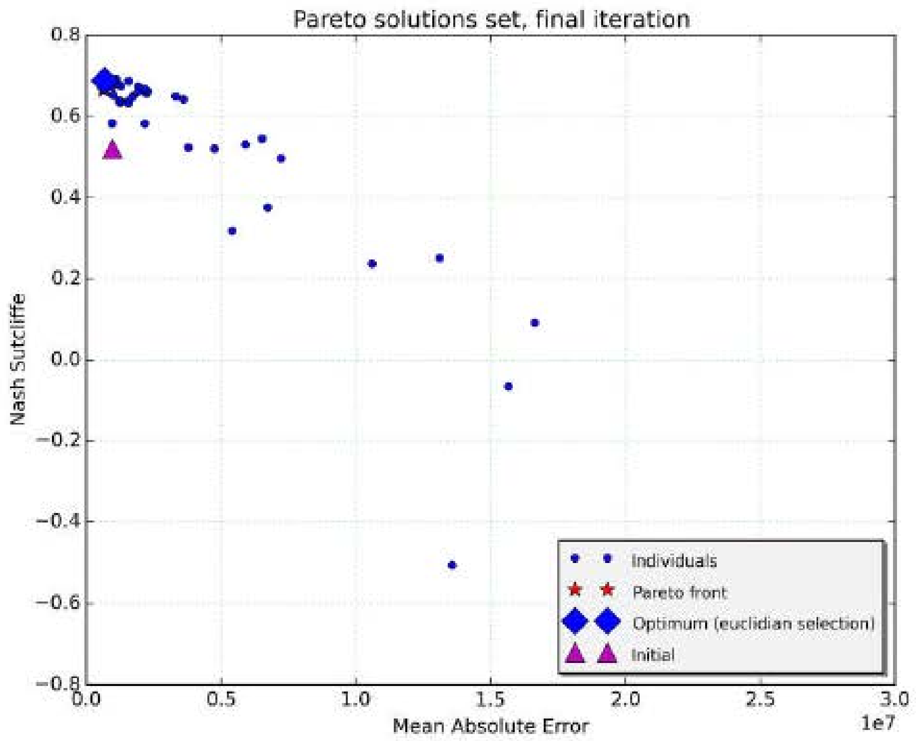


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

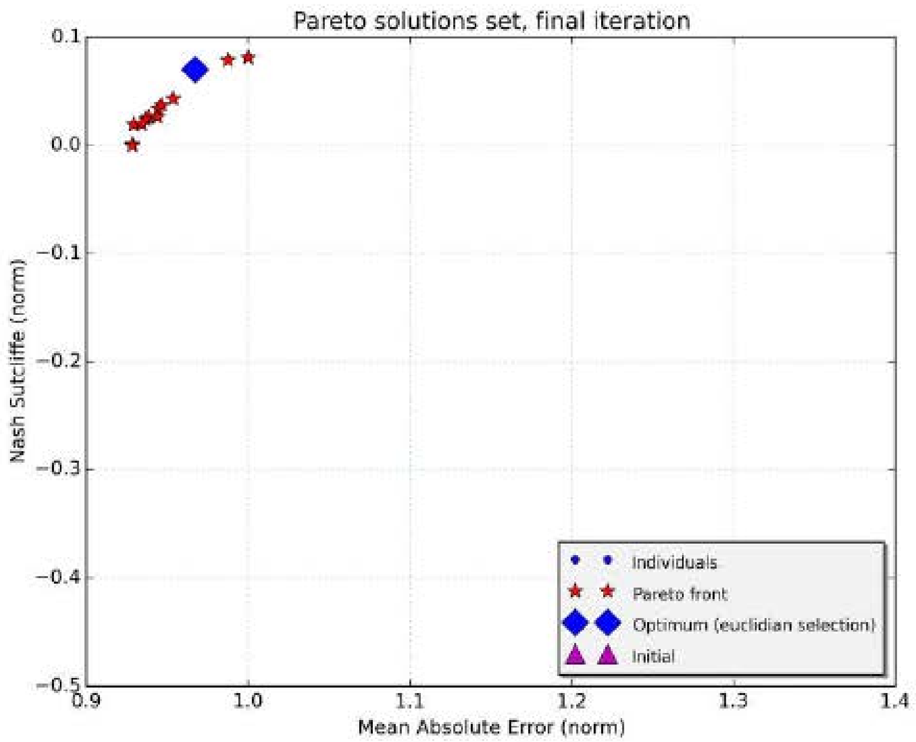


Figure 4: Final population of solutions (Pareto front)

9.5.3.4.1 Initial

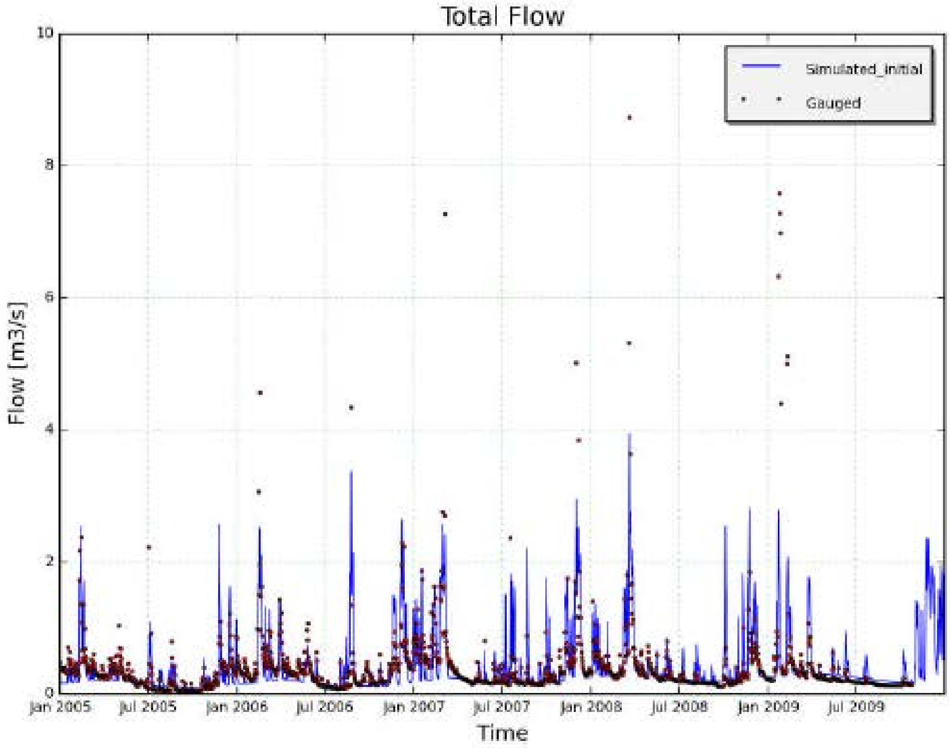


Figure 5: Total flow with initial parameters

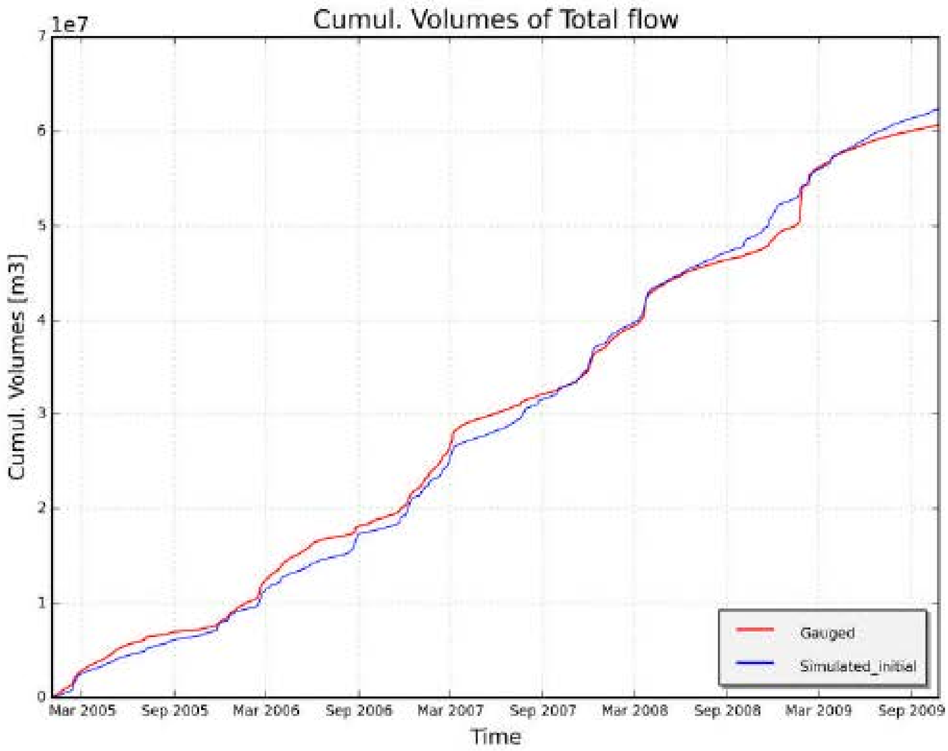


Figure 6: Cumulated flow with initial parameters

9.5.3.4.2 Optimum (euclidian)

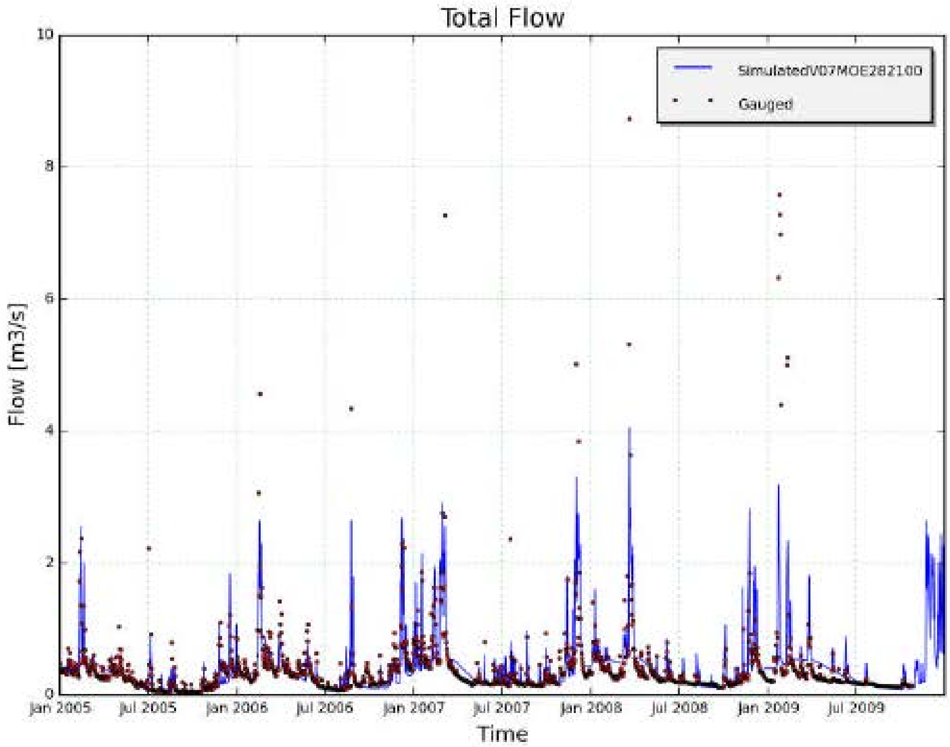


Figure 7: Total flow with optimum parameters

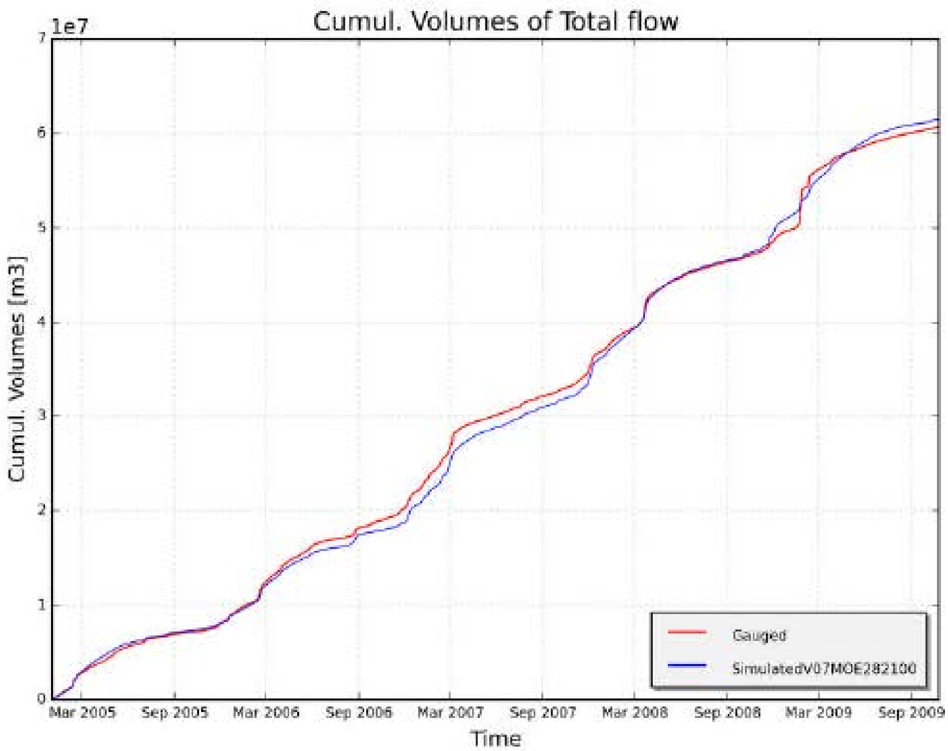


Figure 8: Cumulated flow with optimum parameters

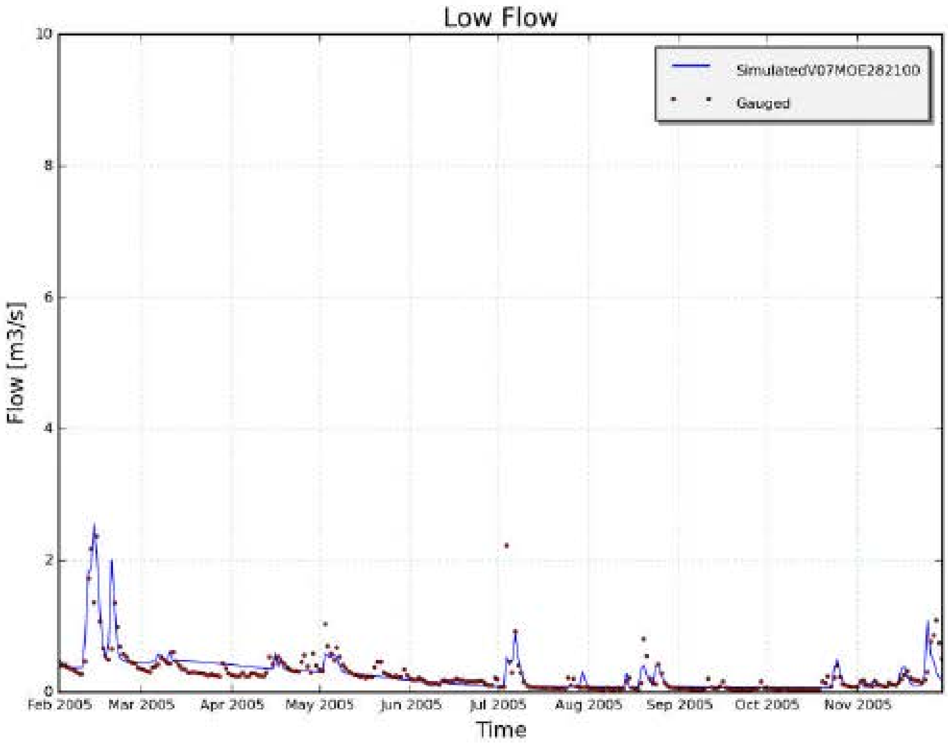


Figure 9: Total flow with optimum parameters (detail)

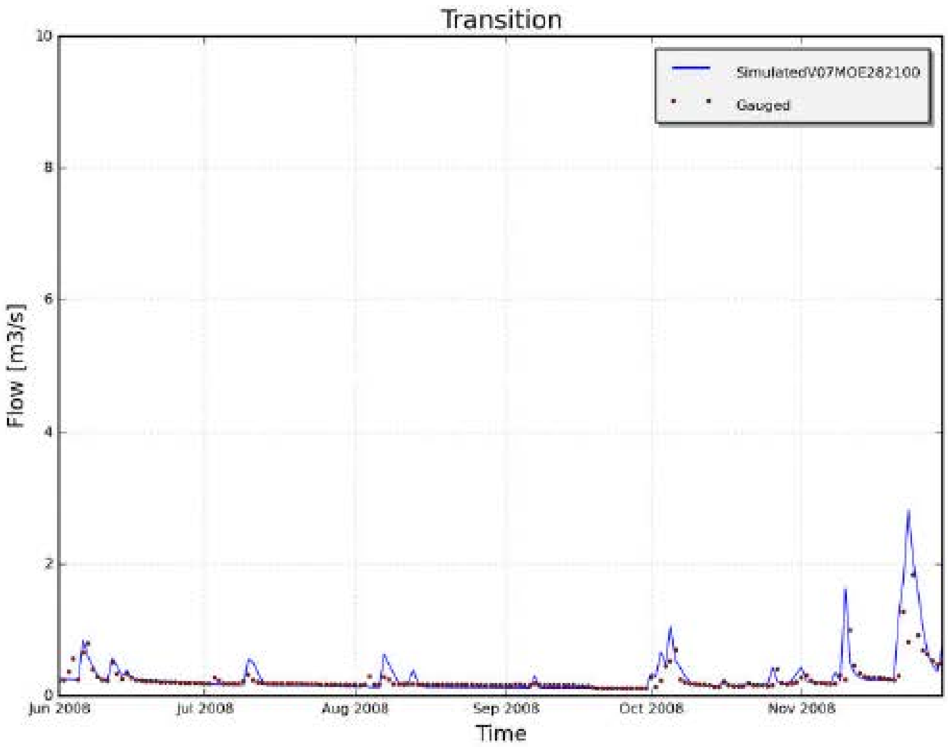
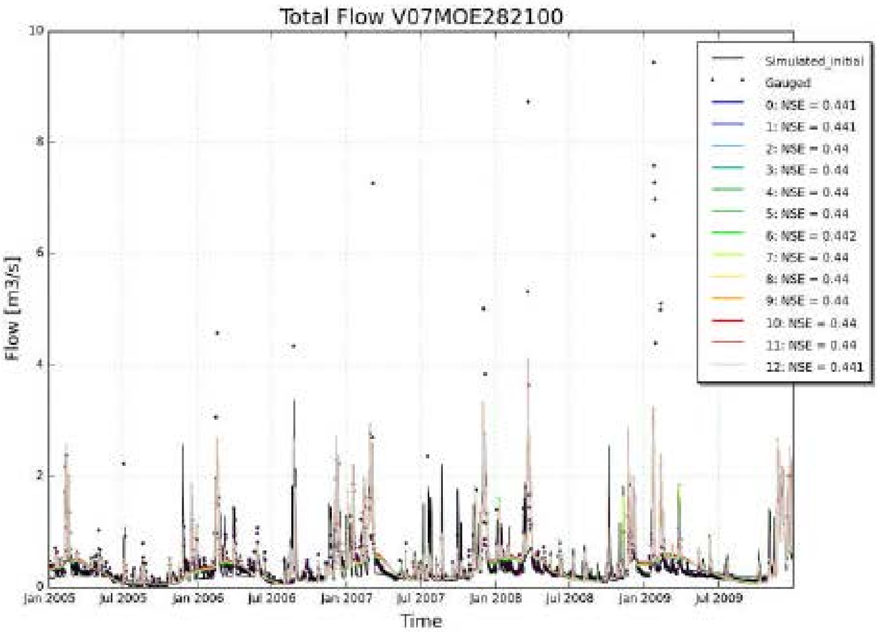
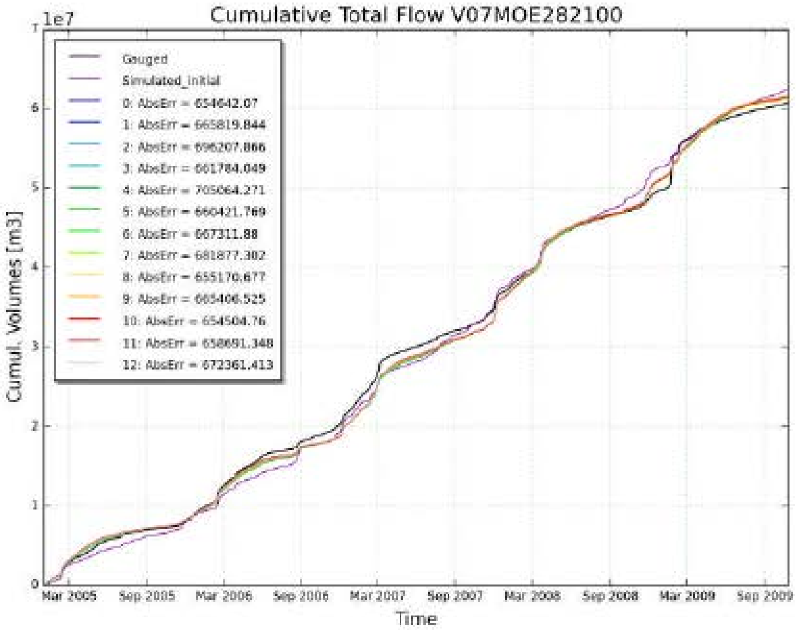


Figure 10: Total flow with optimum parameters (detail)

9.5.3.4.3 Final archive

0 : [1.959, 66.599, 0.008, 1.013, 142.022, 331.667, 19.433, 276.158] : [654642.07, 0.665]
1 : [1.891, 68.142, 0.007, 1.5, 102.769, 324.224, 22.935, 239.042] : [665819.844, 0.676]
2 : [1.804, 68.227, 0.006, 0.654, 129.326, 350.771, 19.666, 276.509] : [696207.866, 0.691]
3 : [1.881, 68.574, 0.007, 1.0, 102.432, 315.244, 22.756, 239.034] : [661784.049, 0.673]
4 : [1.817, 67.835, 0.006, 0.334, 139.74, 355.708, 18.604, 274.027] : [705064.271, 0.692]
5 : [1.881, 69.307, 0.007, 1.0, 102.432, 315.544, 22.756, 239.034] : [660421.769, 0.673]
6 : [1.892, 66.854, 0.007, 0.1, 102.902, 323.543, 21.046, 270.709] : [667311.88, 0.677]
7 : [1.831, 67.935, 0.006, 1.215, 134.108, 335.952, 22.568, 263.315] : [681877.302, 0.688]
8 : [1.888, 69.317, 0.007, 1.085, 102.746, 315.205, 22.788, 239.029] : [655170.677, 0.671]
9 : [1.88, 68.714, 0.007, 0.1, 101.546, 315.728, 23.24, 240.236] : [665406.525, 0.674]
10 : [1.959, 67.59, 0.008, 1.013, 144.224, 332.922, 19.433, 277.347] : [654504.76, 0.665]
11 : [1.888, 69.129, 0.007, 0.1, 122.32, 315.178, 22.749, 249.472] : [658691.348, 0.671]
12 : [1.869, 68.39, 0.007, 0.942, 110.488, 323.43, 19.118, 246.331] : [672361.413, 0.679]





9.5.4 Report on simulation of catchment V07MOG288020 (2017-01-18 22-00)

9.5.4.1 Input data

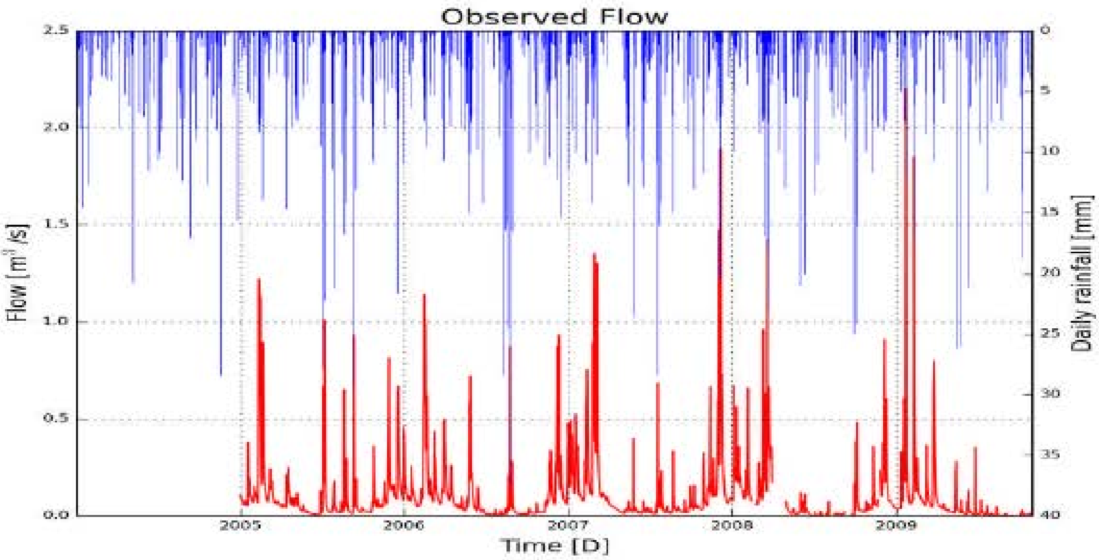


Figure 1: Hyetogram of observed discharge and observed net rain

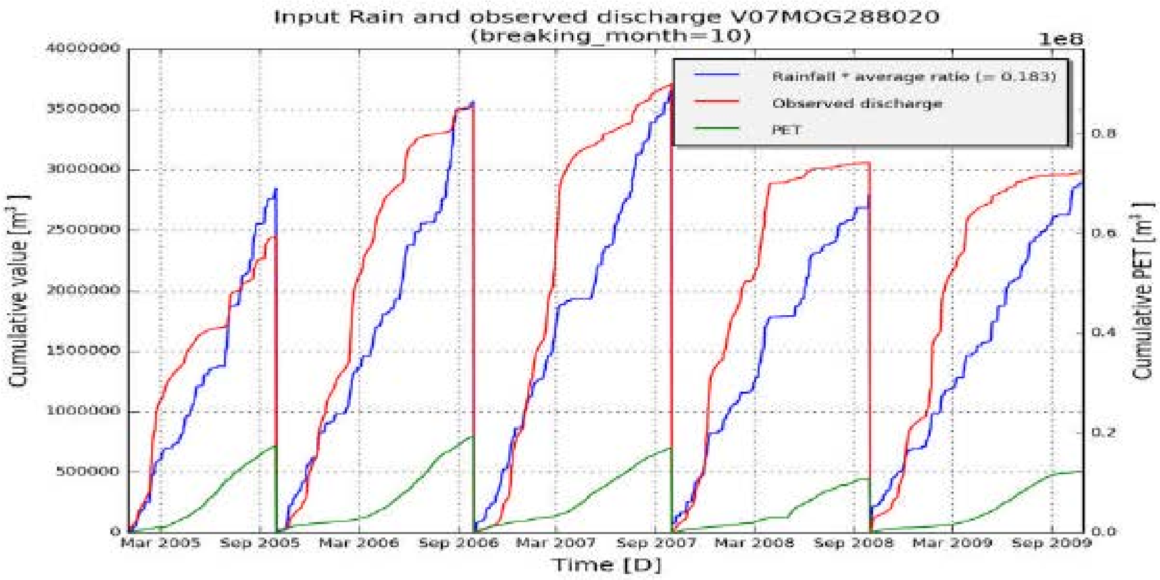


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.4.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V07MOG288020
subcatchment_area	23100000
start_date	200501010000
end_date	200910300000
frequency	86400
warmup	365

9.5.4.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[1.59, 42.0, 0.001, 1.2, 187.0, 340.0, 26.612, 690.0]
low_bounds	[1.2, 32.0, 0.0008, 0.96, 150.0, 270.0, 20.0, 530.0]
high_bounds	[2.0, 100.0, 0.01, 3.0, 250.0, 450.0, 30.0, 750.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.59), ('Ki', 42.0), ('Kg', 0.001), ('Kss', 1.2), ('g0', 187.0), ('g_max', 340.0), ('K_run', 26.612), ('P_max', 690.0)]
Initial fitness:

- RelErr: -0.064
- AbsErr: 537589.578
- KGE: 0.695
- NS_rel: -3.576
- NS: 0.505
- RMSE: 612143.735
- NS_log: 0.485

Computation time:4:07:00.653000

9.5.4.4 Results

Best individual (euclidian): [('Kep', 1.774), ('Ki', 49.272), ('Kg', 0.002), ('Kss', 1.234), ('g0', 185.233), ('g_max', 300.039), ('K_run', 25.939), ('P_max', 644.015)]

Fitness:

- RelErr: -0.058
- AbsErr: 488764.03
- KGE: 0.702
- NS_rel: -2.958
- NS: 0.485
- RMSE: 560440.884
- NS_log: 0.515

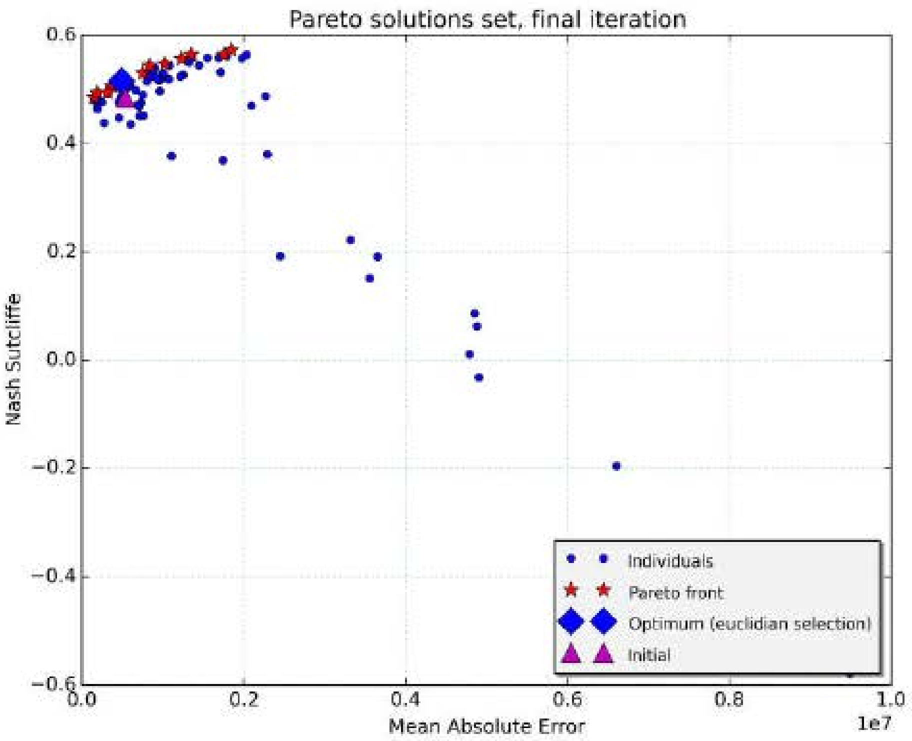


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

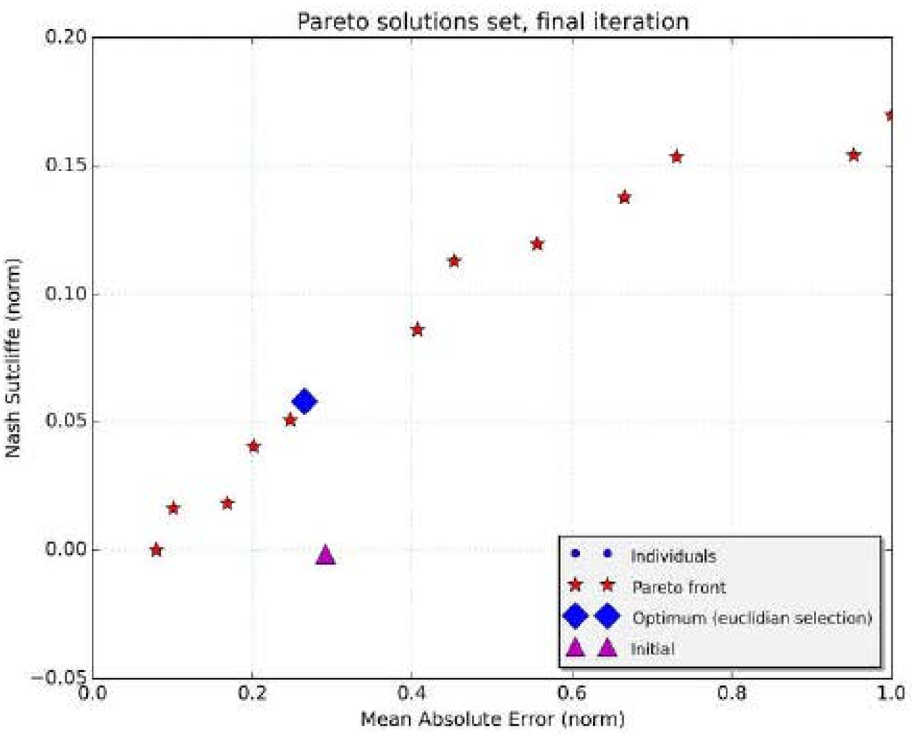


Figure 4: Final population of solutions (Pareto front)

9.5.4.4.1 Initial

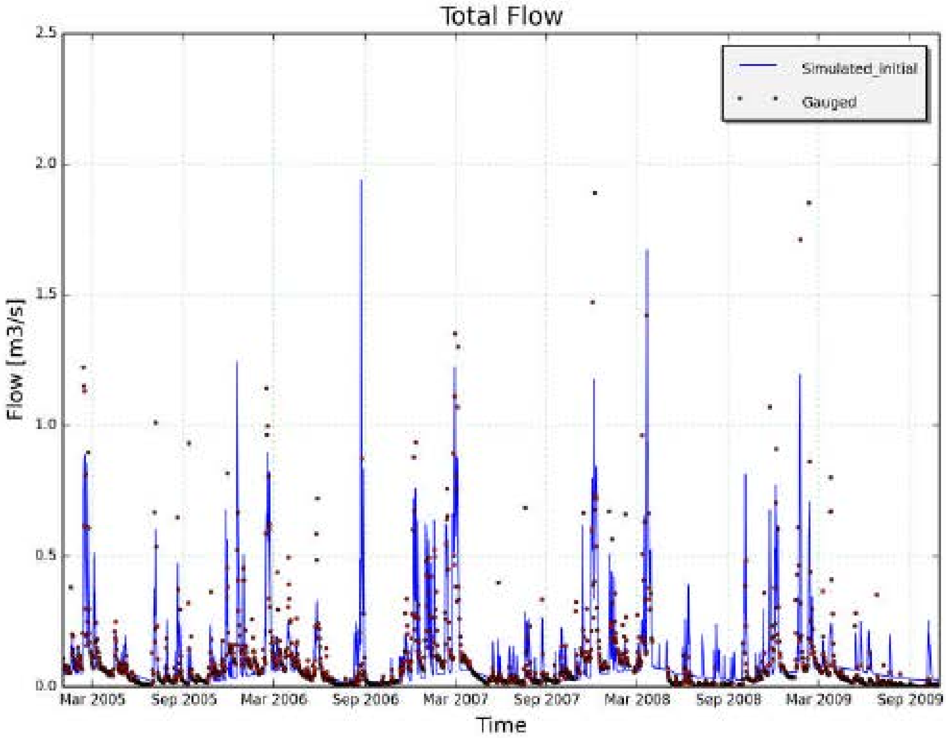


Figure 5: Total flow with initial parameters

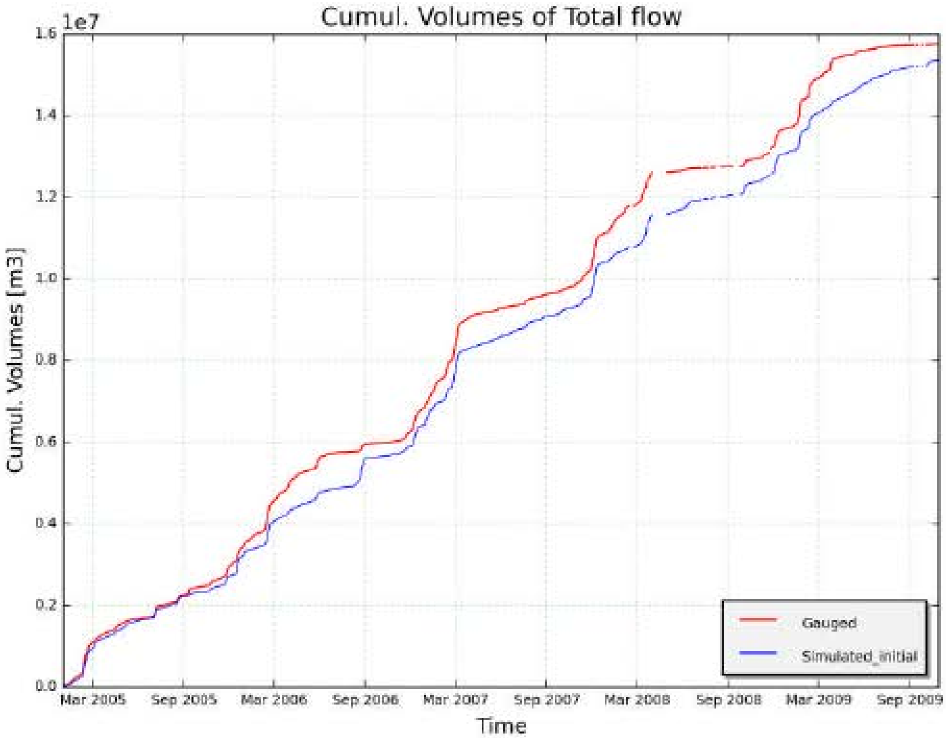


Figure 6: Cumulated flow with initial parameters

9.5.4.4.2 Optimum (euclidian)

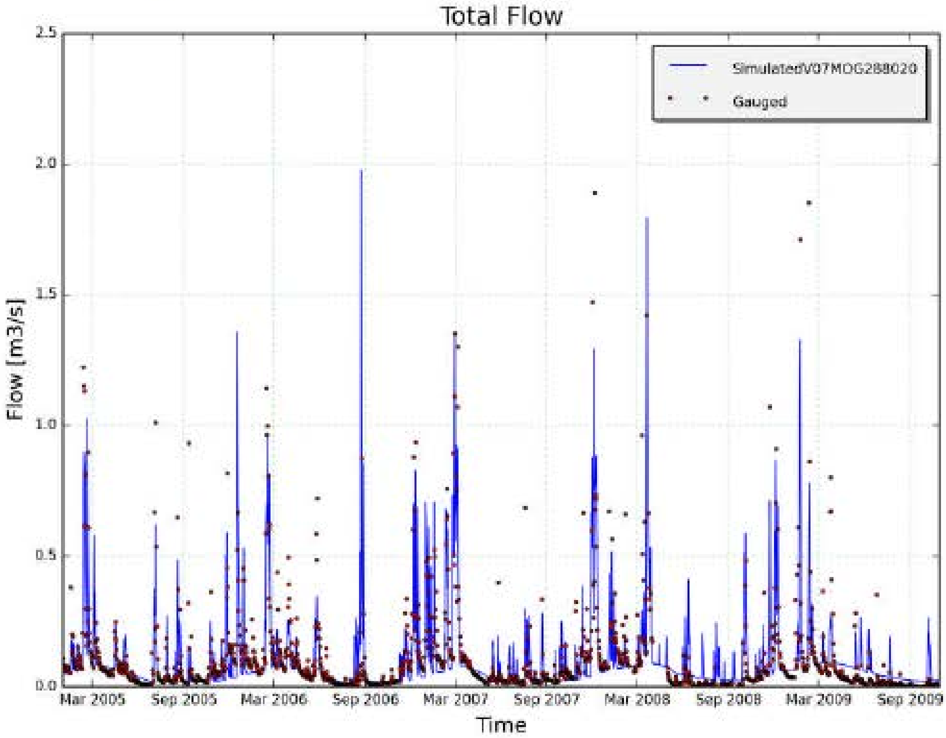


Figure 7: Total flow with optimum parameters

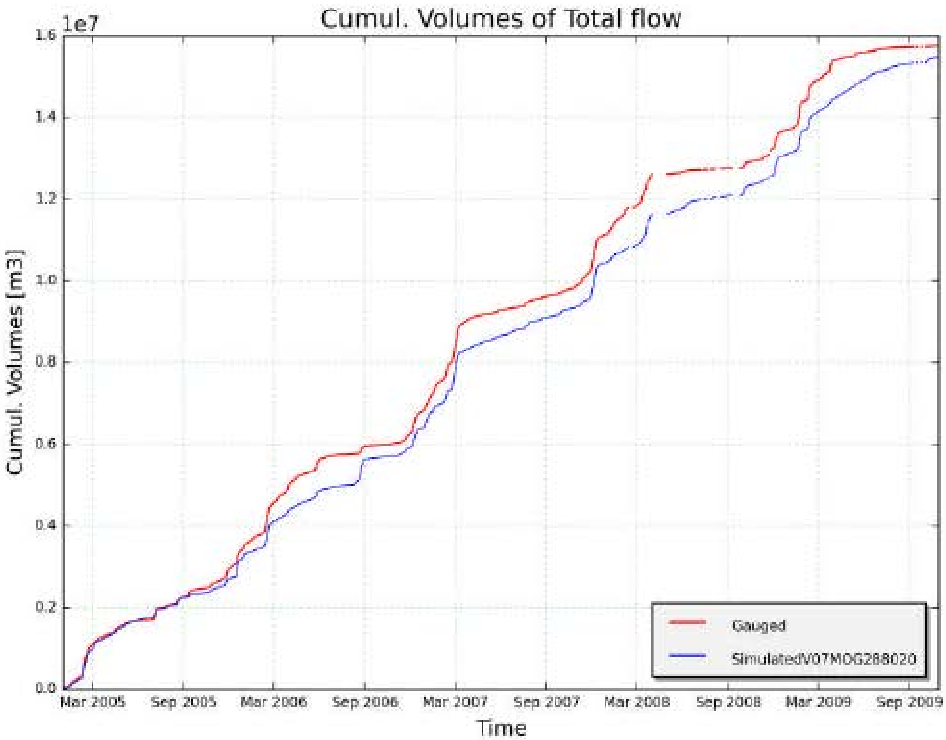


Figure 8: Cumulated flow with optimum parameters

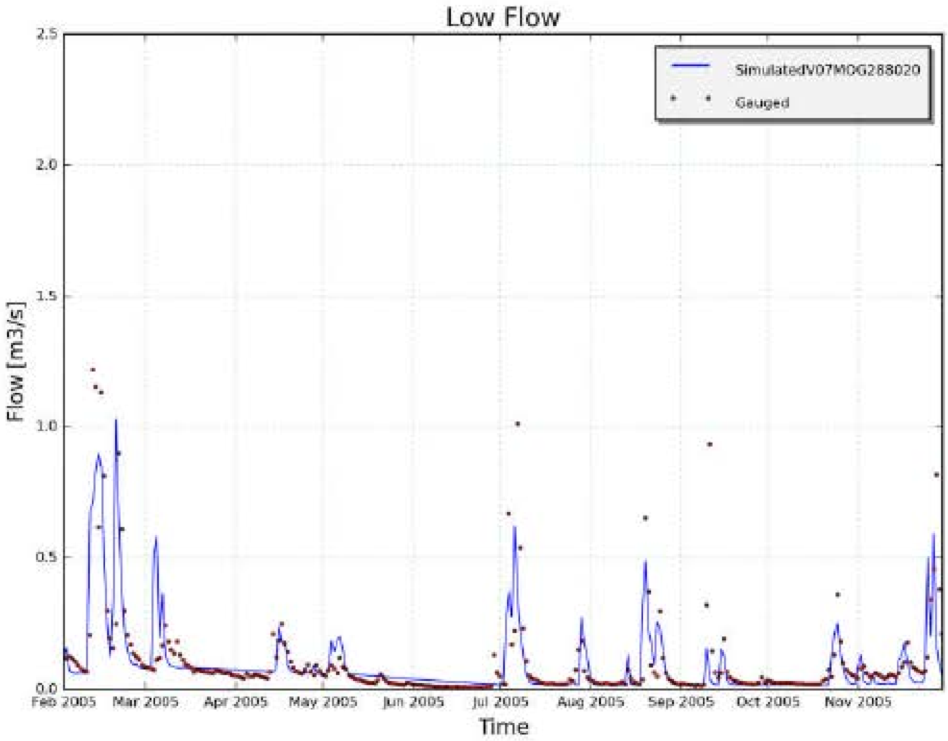


Figure 9: Total flow with optimum parameters (detail)

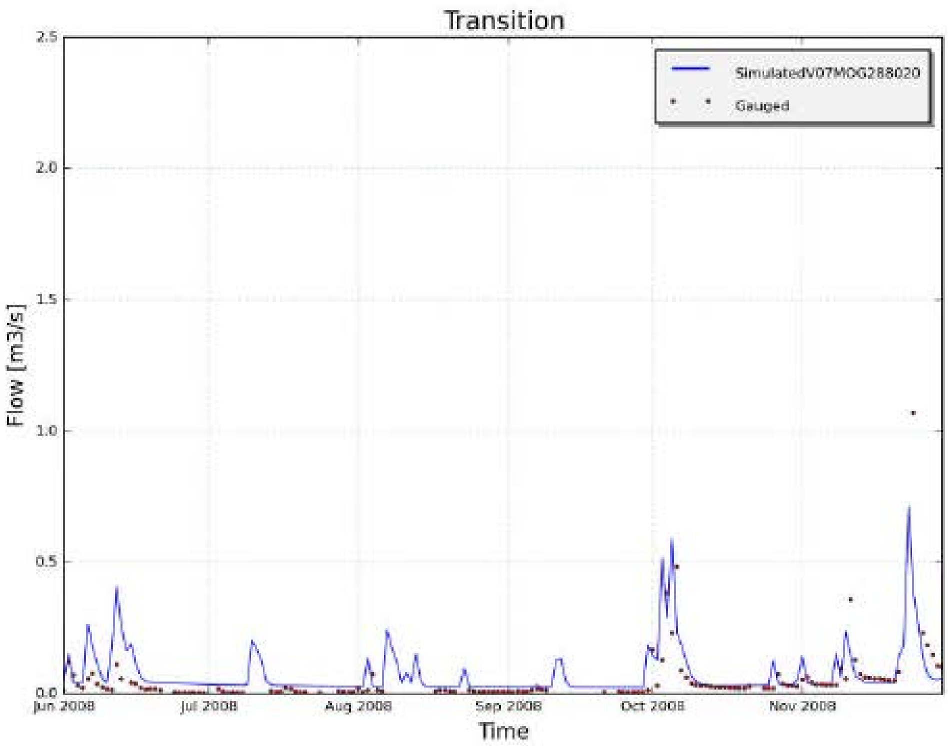
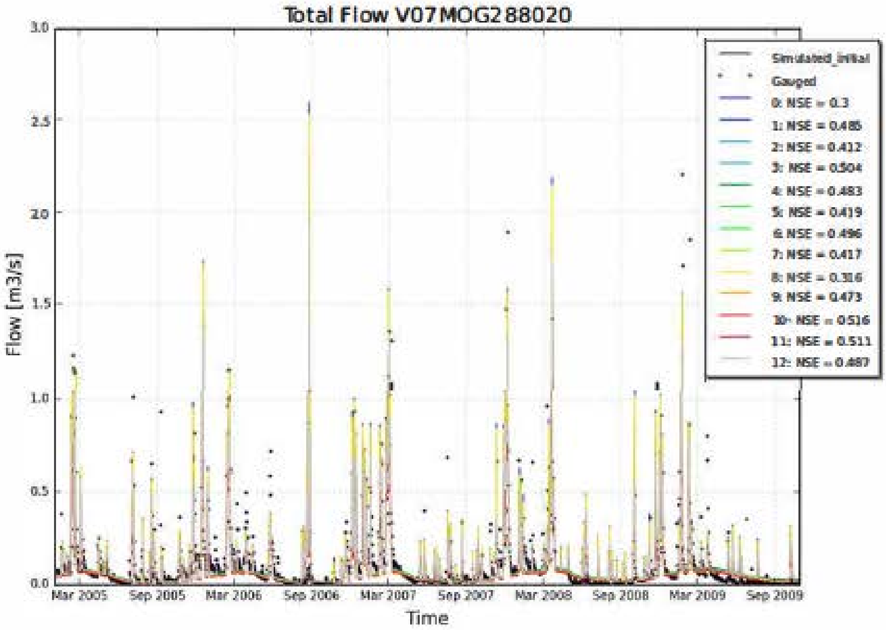
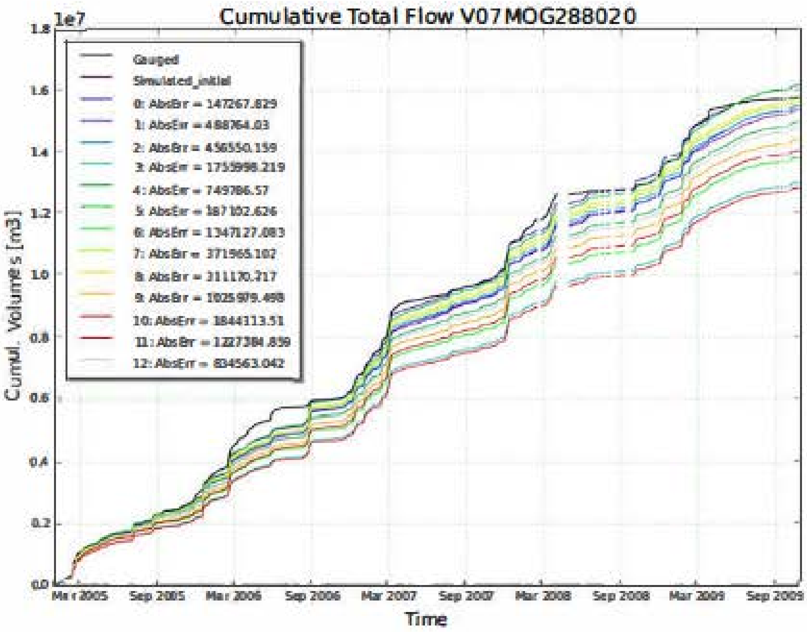


Figure 10: Total flow with optimum parameters (detail)

9.5.4.4.3 Final archive

0 : [1.584, 62.572, 0.001, 1.404, 187.363, 281.474, 24.522, 680.487] : [147267.829, 0.486]
1 : [1.774, 49.272, 0.002, 1.234, 185.233, 300.039, 25.939, 644.015] : [488764.03, 0.515]
2 : [1.635, 53.717, 0.001, 0.96, 204.108, 282.1, 25.82, 682.939] : [456550.159, 0.512]
3 : [1.992, 47.619, 0.001, 1.21, 186.973, 291.188, 25.587, 642.279] : [1755998.219, 0.565]
4 : [1.772, 49.225, 0.001, 1.78, 186.383, 294.612, 25.191, 688.43] : [749786.57, 0.53]
5 : [1.773, 57.173, 0.002, 1.885, 186.098, 301.433, 26.232, 652.62] : [187102.626, 0.494]
6 : [2.0, 50.799, 0.002, 0.96, 186.099, 298.612, 26.193, 648.124] : [1347127.083, 0.565]
7 : [1.604, 52.887, 0.001, 0.991, 189.139, 282.929, 25.786, 683.41] : [371965.102, 0.506]
8 : [1.627, 62.24, 0.001, 1.134, 197.747, 282.764, 24.415, 683.389] : [311170.217, 0.495]
9 : [1.83, 51.335, 0.001, 2.455, 187.824, 283.177, 24.699, 669.796] : [1025979.498, 0.547]
10 : [2.0, 44.821, 0.001, 1.158, 187.282, 288.728, 25.985, 648.735] : [1844113.51, 0.573]
11 : [1.884, 45.955, 0.001, 1.864, 187.21, 296.807, 26.675, 646.656] : [1227384.859, 0.557]
12 : [1.82, 49.469, 0.002, 1.362, 201.783, 286.585, 26.622, 675.582] : [834563.042, 0.544]


Total Flow V07MOG288020
Flow [m3/s]
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Mar 2005
Sep 2005
Mar 2006
Sep 2006
Mar 2007
Sep 2007
Mar 2008
Sep 2008
Mar 2009
Sep 2009
Time
Simulated_initial
Gauged
0: NSE = 0.3
1: NSE = 0.485
2: NSE = 0.412
3: NSE = 0.504
4: NSE = 0.483
5: NSE = 0.419
6: NSE = 0.496
7: NSE = 0.417
8: NSE = 0.316
9: NSE = 0.473
10: NSE = 0.516
11: NSE = 0.511
12: NSE = 0.487


Cumulative Total Flow V07MOG288020
1e7
Cumul. Volumes [m3]
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Mar 2005
Sep 2005
Mar 2006
Sep 2006
Mar 2007
Sep 2007
Mar 2008
Sep 2008
Mar 2009
Sep 2009
Time
Gauged
Simulated_initial
0: AbsErr = 147267.829
1: AbsErr = 488764.03
2: AbsErr = 456550.159
3: AbsErr = 1755998.219
4: AbsErr = 749786.57
5: AbsErr = 187102.626
6: AbsErr = 1347127.083
7: AbsErr = 371965.102
8: AbsErr = 311170.717
9: AbsErr = 1025979.498
10: AbsErr = 1844113.51
11: AbsErr = 1227384.859
12: AbsErr = 834563.042

Appendix 16 Dijle and Zenne Calibration and Validation.

9.5.1 Calibration and validation of WET parameters for catchment "V08BAR111370" (Dijle/Zennebekken)

9.5.1.1 Input data

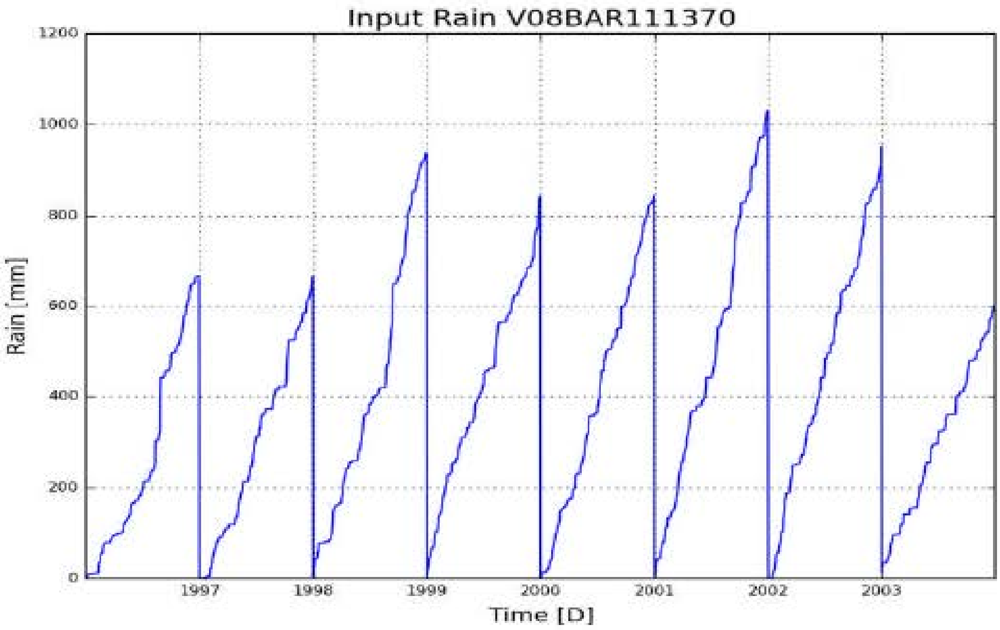


Figure 1: Cumulative precipitation on catchment V08BAR111370 (Dijle/Zennebekken)

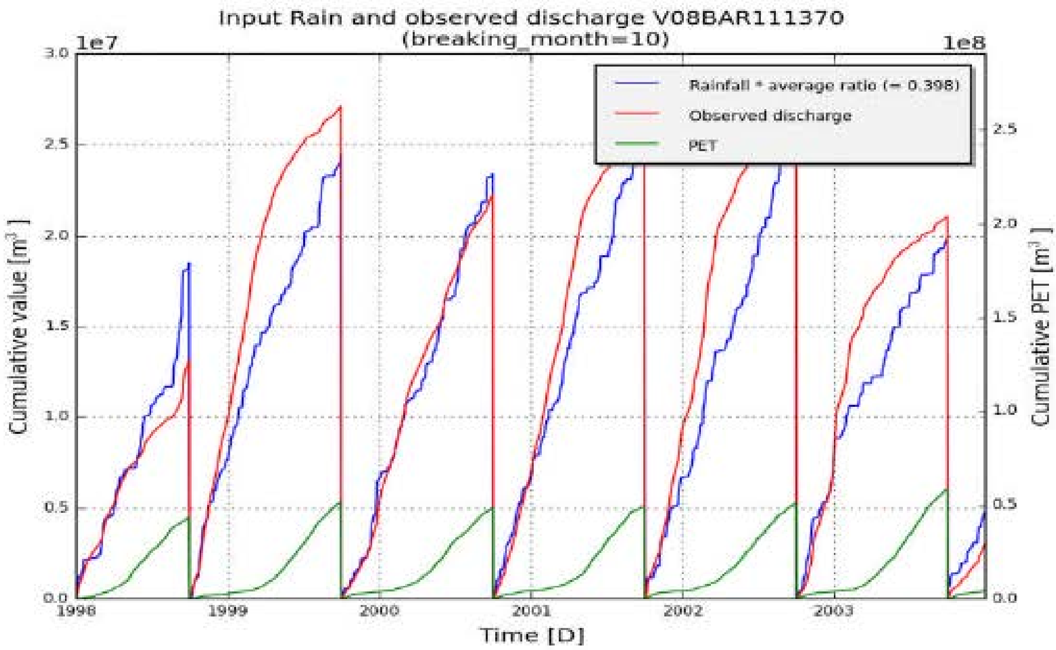


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V08BAR111370 (Dijle/Zennebekken)

9.5.1.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V08BAR111370
subcatchment_area [m2]	69900000
Validation start_date	01-01-1997
Validation end_date	31-12-2003
frequency	daily

Optimal parameter set:[('Kep', 1.14), ('Ki', 50.59), ('Kg', 0.0), ('Kss', 5.0), ('g0', 70.52), ('g_max', 237.62), ('K_run', 4.0), ('P_max', 71.61)]

Table 1: Goodness of fit for calibration period (1998 - 2003)

	Full year	Summer	Winter
RelErr	2.5 %	28.7 %	-4.1 %
NS	0.562	-0.535	0.632
NS_log	0.725	0.57	0.698
NS_rel	0.601	0.513	0.745
KGE	0.782	0.148	0.705

Table 2 :Goodness of fit for validation period (1997 - 2003)

	Full year	Summer	Winter
RelErr	6.1 %	27.4 %	-0.3 %
NS	0.573	-0.483	0.659
NS_log	0.74	0.585	0.72
NS_rel	0.631	0.543	0.747
KGE	0.787	0.168	0.712

9.5.1.3 Observed and simulated timeseries for optimum parameters

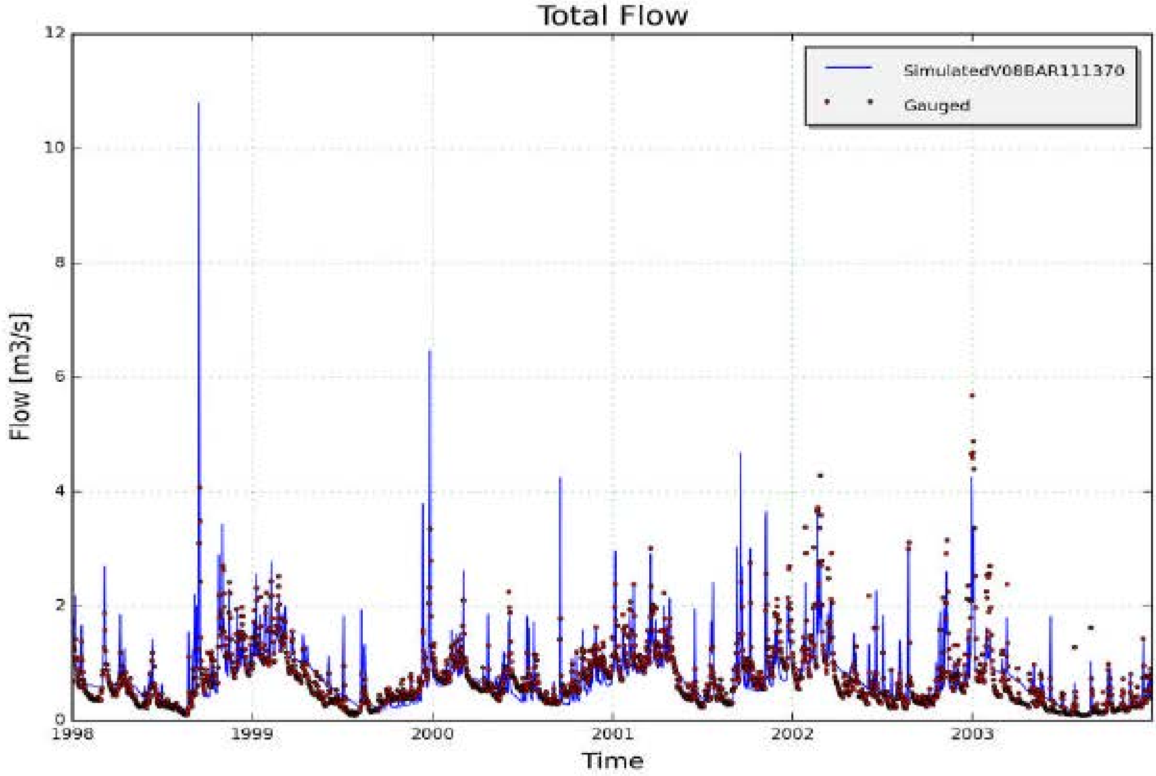


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08BAR111370, station 11110102-Barebeek(calibration period)

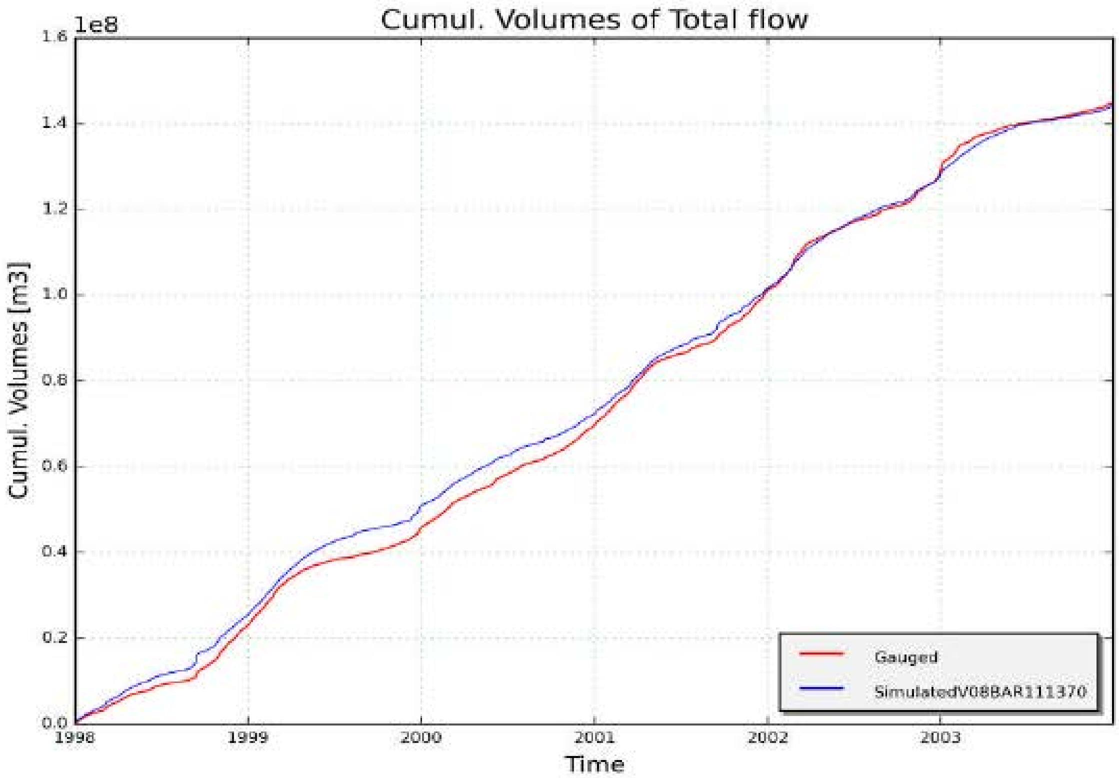


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V08BAR111370, station 11110102-Barebeek (calibration period)

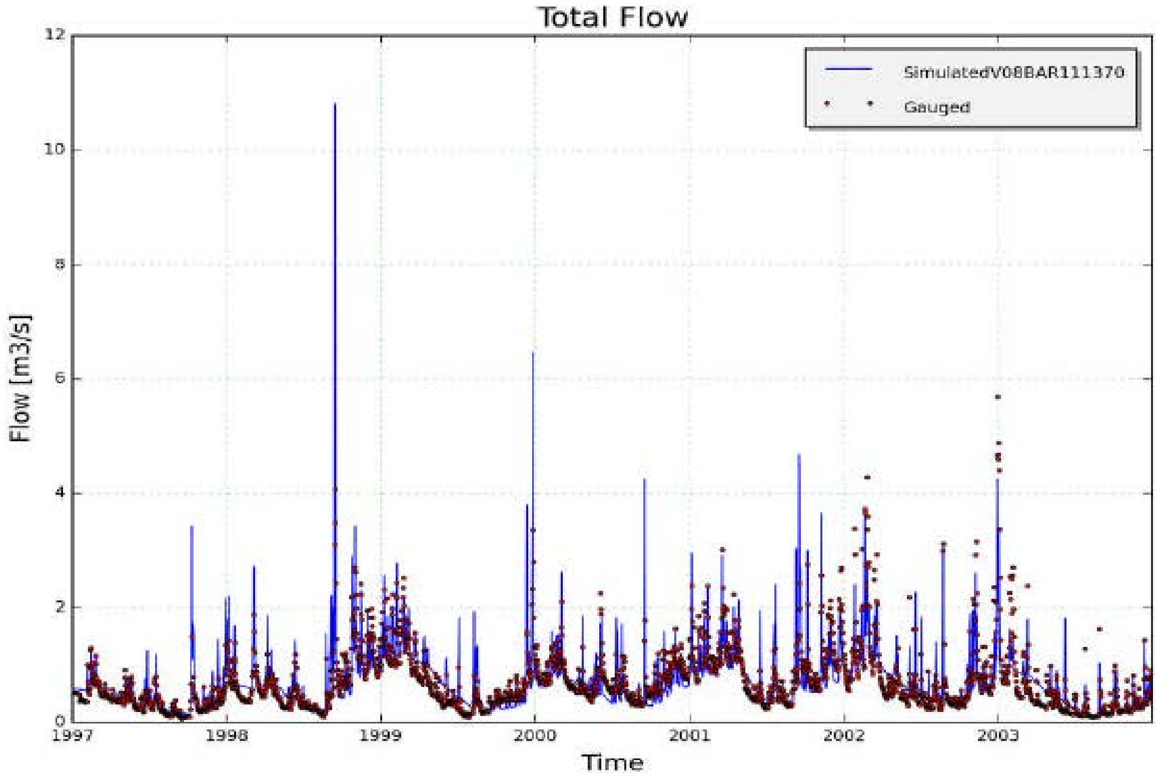


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08BAR111370, station 11110102-Barebeek (validation period)

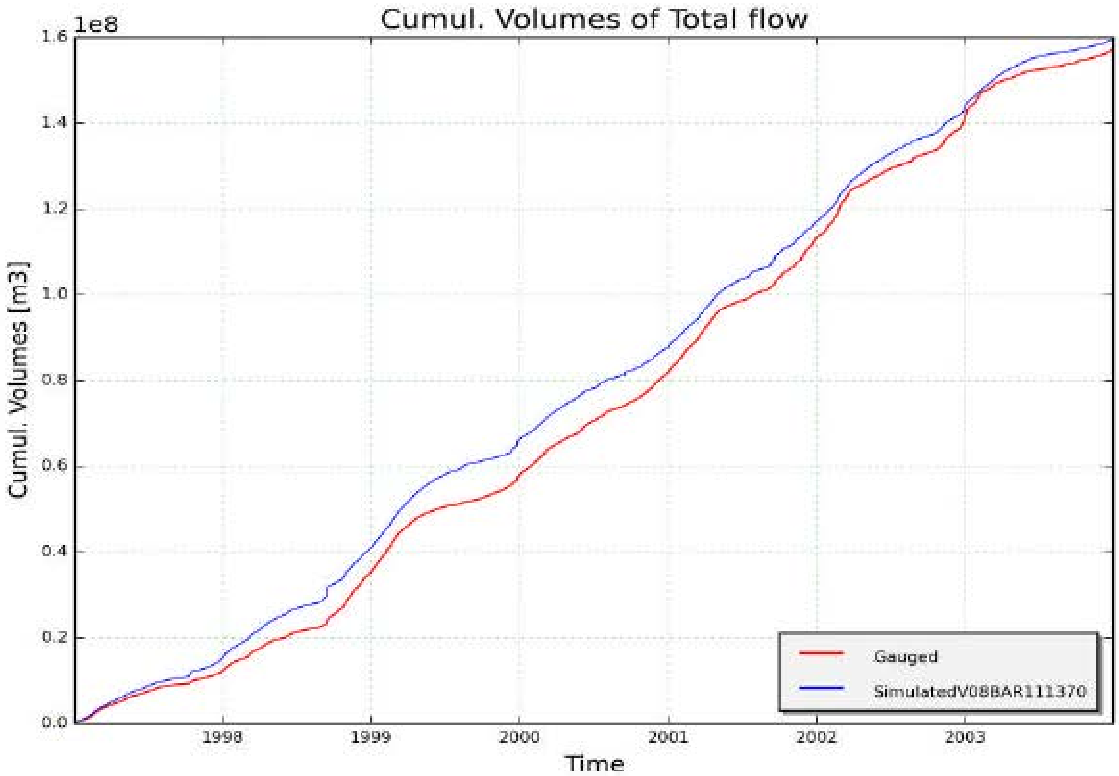


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V08BAR111370, station 11110102-Barebeek (validation period)

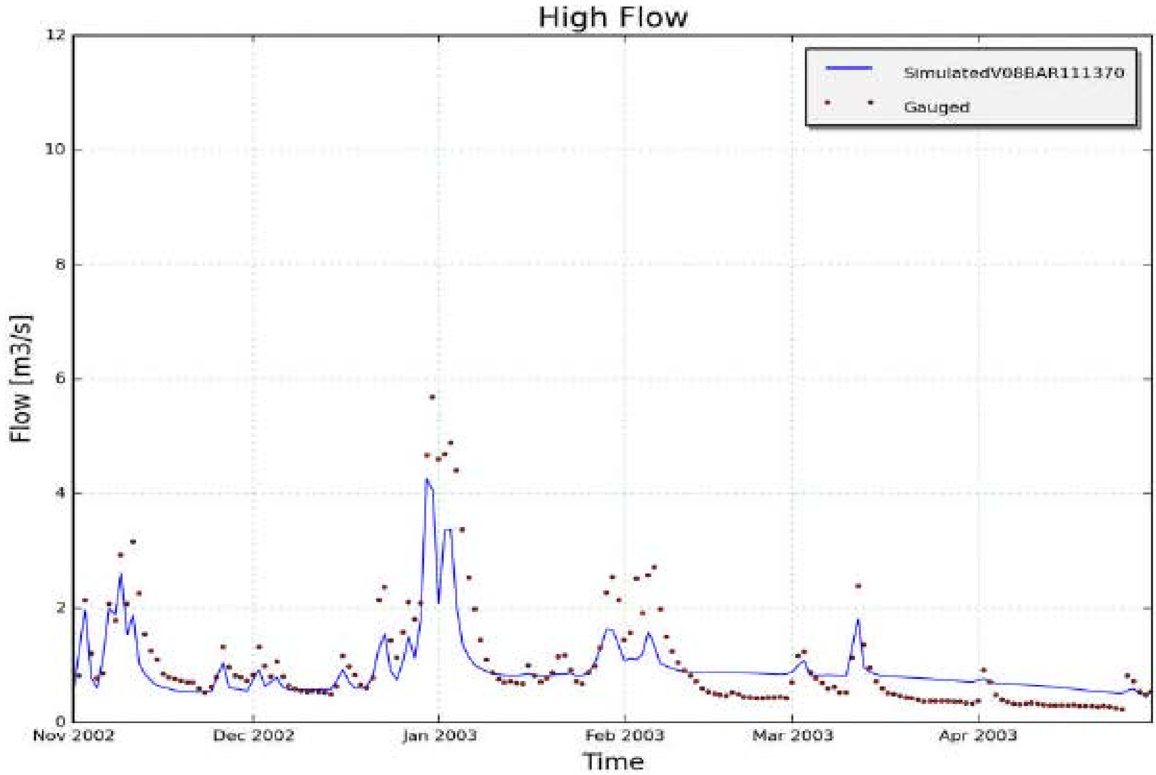


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V08BAR111370, station 11110102-Barebeek

9.5.2 Calibration and validation of WET parameters for catchment "V08Dij093400" (Dijle/Zennebekken)

9.5.2.1 Input data

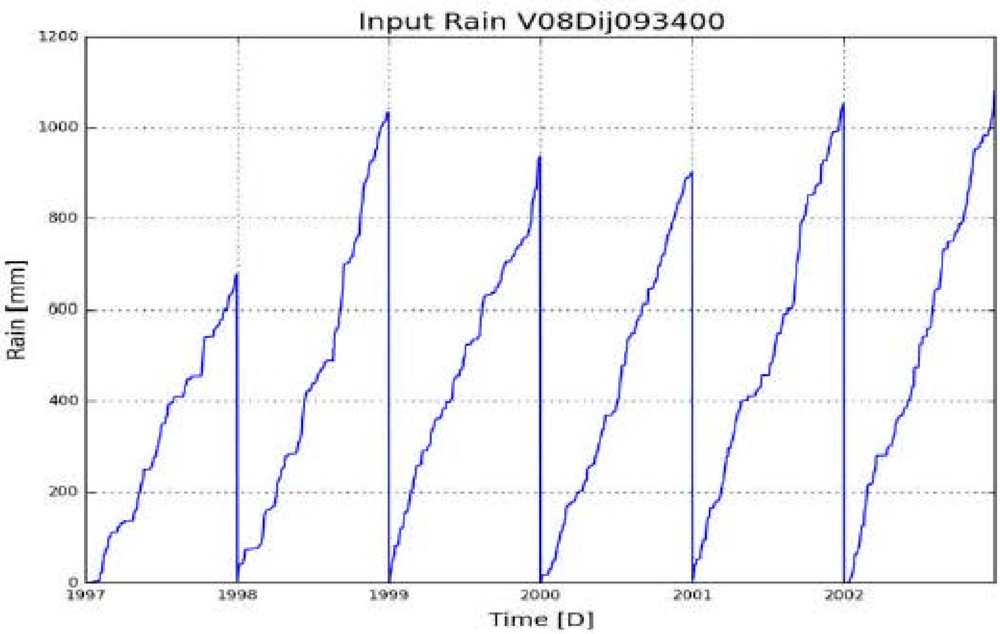


Figure 1: Cumulative precipitation on catchment V08Dij093400 (Dijle/Zennebekken)

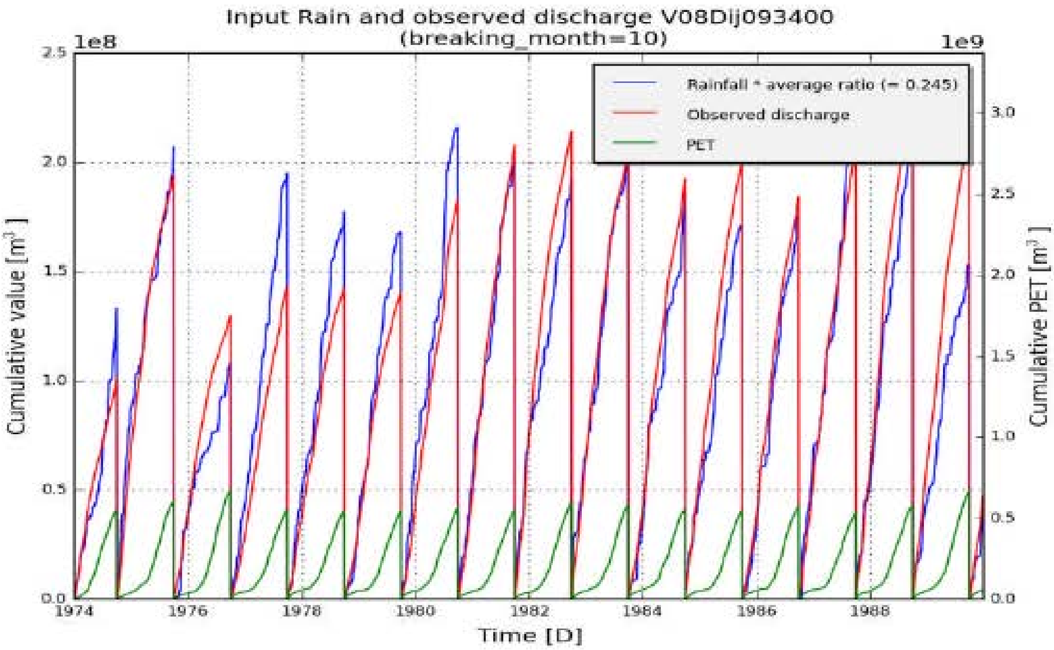


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V08Dij093400 (Dijle/Zennebekken)

9.5.2.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V08Dij093400
subcatchment_area [m2]	886900000
Validation start_date	01-01-1998
Validation end_date	31-12-2002
frequency	daily

Optimal parameter set:[('Kep', 1.29), ('Ki', 8.91), ('Kg', 0.0), ('Kss', 0.9), ('g0', 163.47), ('g_max', 444.79), ('K_run', 6.82), ('P_max', 206.15)]

Table 1: Goodness of fit for calibration period (1974 - 1989)

	Full year	Summer	Winter
RelErr	-1.1 %	-1.6 %	0.2 %
NS	0.329	0.155	0.355
NS_log	0.394	0.226	0.497

	Full year	Summer	Winter
NS_rel	0.569	0.548	0.599
KGE	0.679	0.608	0.646

Table 2 :Goodness of fit for validation period (1998 - 2002)

	Full year	Summer	Winter
RelErr	-7.0 %	-20.1 %	-2.7 %
NS	0.187	-0.029	0.28
NS_log	0.203	-0.133	0.439
NS_rel	0.398	0.515	0.566
KGE	0.6	0.525	0.619

9.5.2.3 Observed and simulated timeseries for optimum parameters

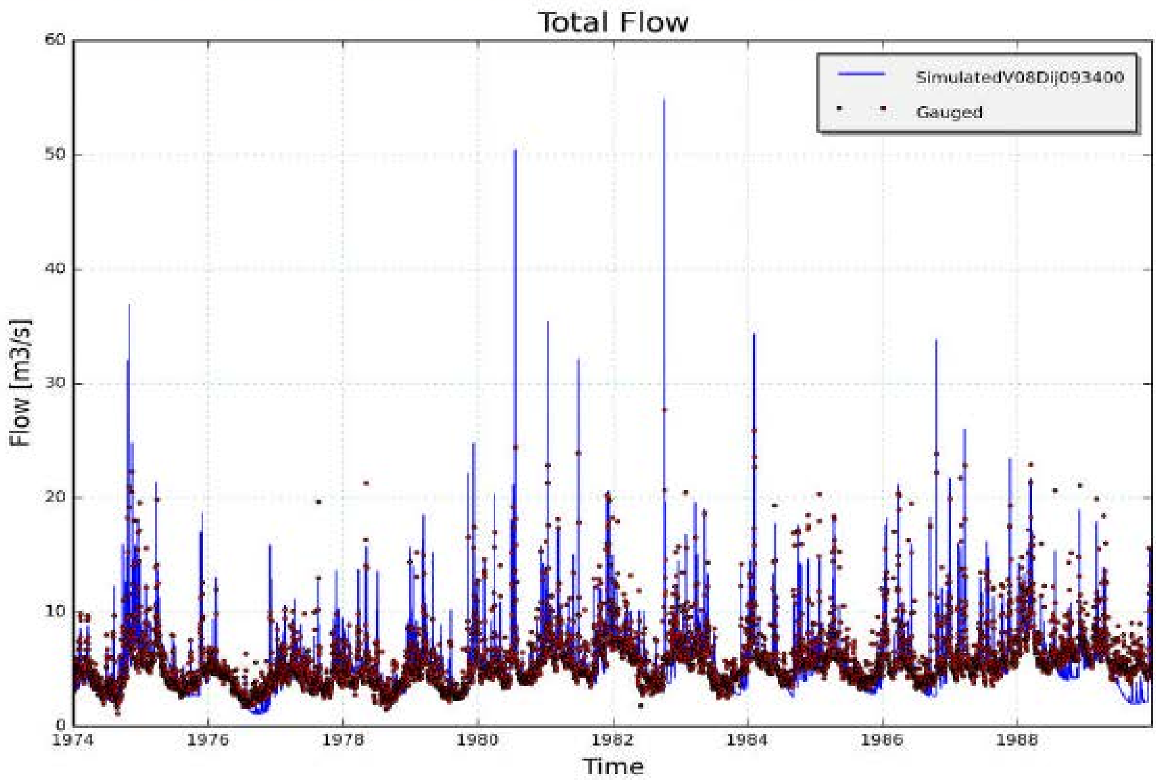


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08Dij093400, station unkown(calibration period)

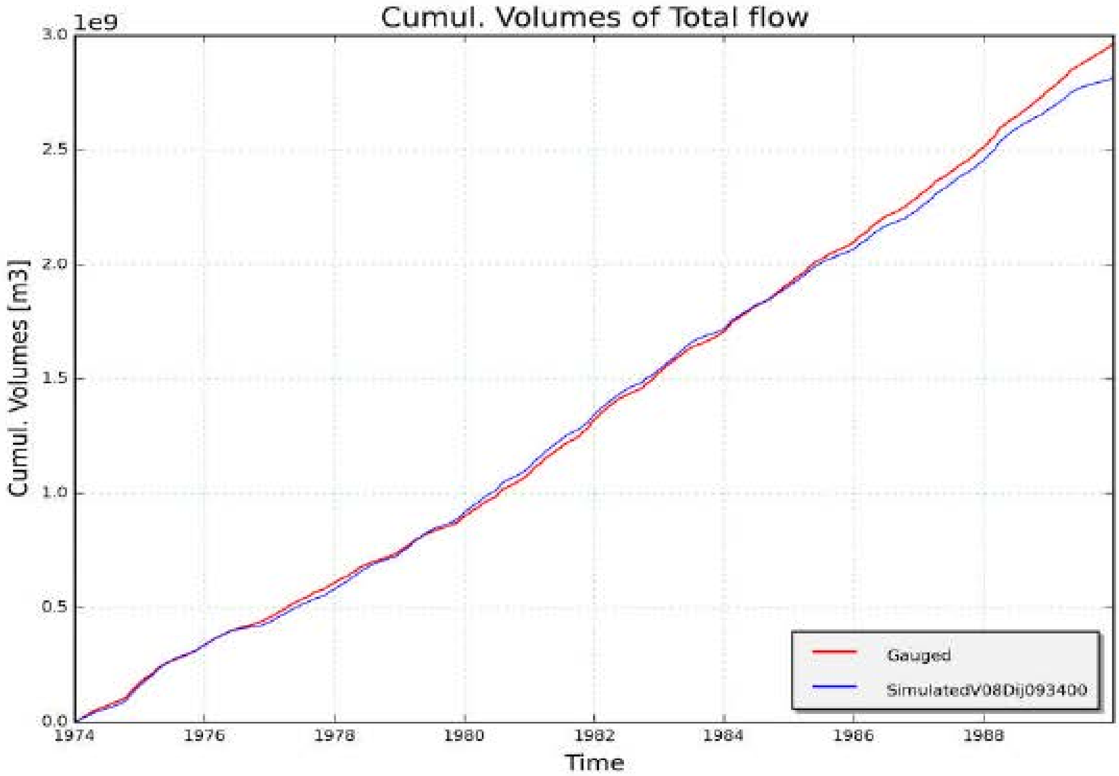


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V08Dij093400, station unkown (calibration period)

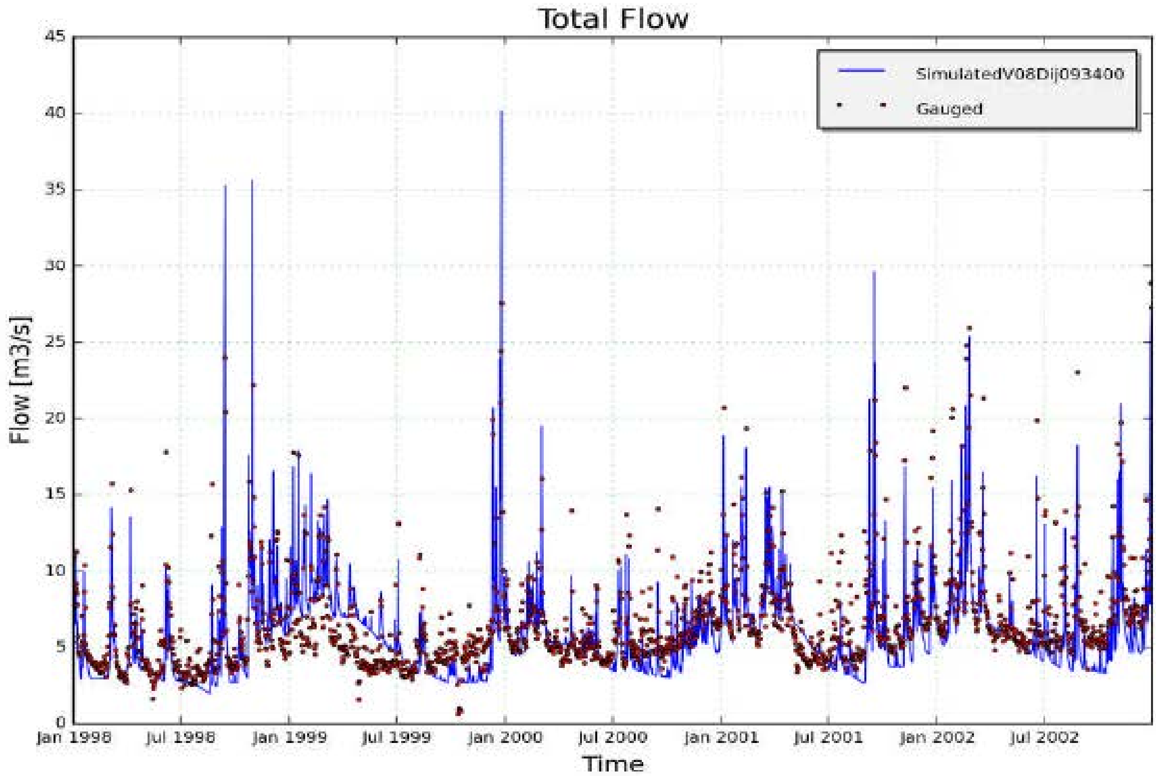


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08Dij093400, station unkown (validation period)

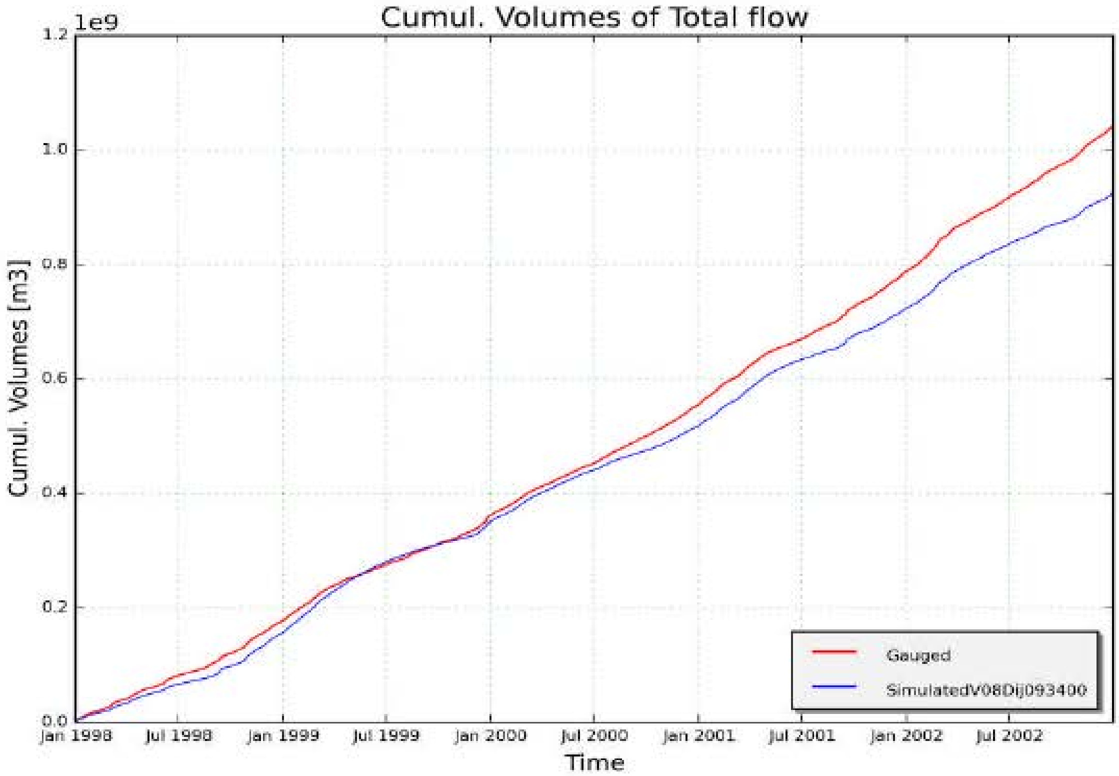


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V08Dij093400, station unkown (validation period)

9.5.3 Calibration and validation of WET parameters for catchment "V08ZUU233100" (Dijle/Zennebekken)

9.5.3.1 Input data

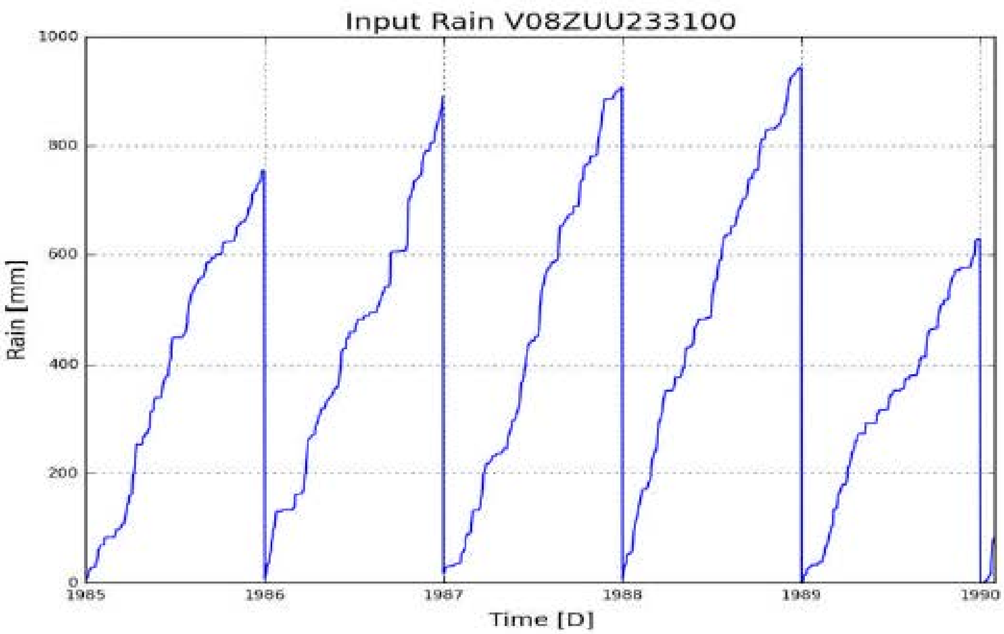


Figure 1: Cumulative precipitation on catchment V08ZUU233100 (Dijle/Zennebekken)

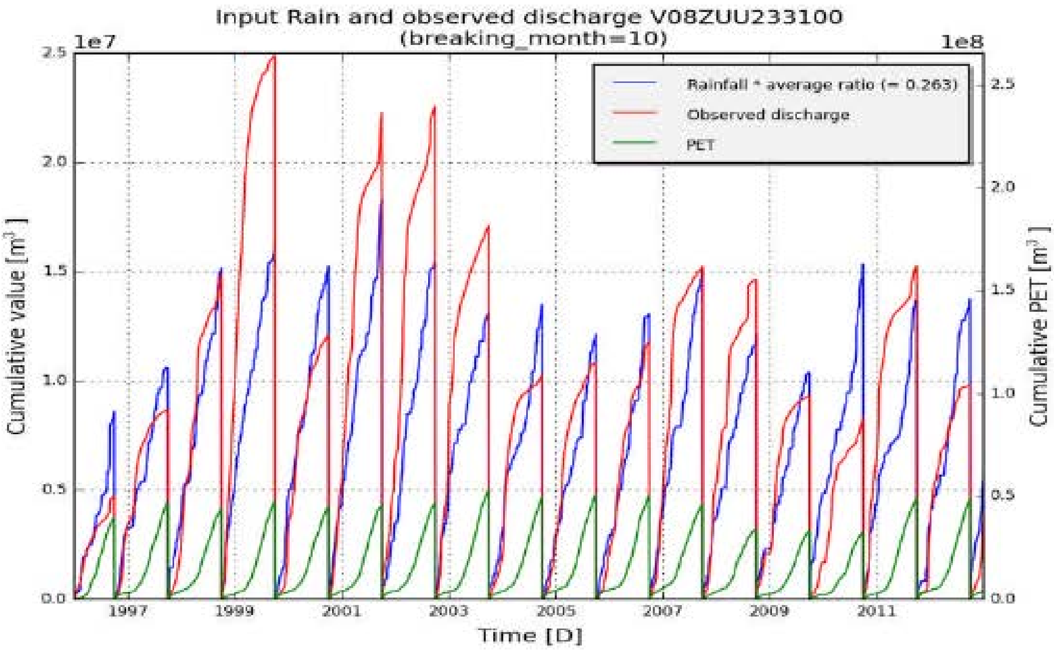


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V08ZUU233100 (Dijle/Zennebekken)

9.5.3.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V08ZUU233100
subcatchment_area [m2]	64800000
Validation start_date	01-01-1986
Validation end_date	31-01-1990
frequency	daily

Optimal parameter set:[('Kep', 1.81), ('Ki', 20.33), ('Kg', 0.0), ('Kss', 0.7), ('g0', 177.18), ('g_max', 318.59), ('K_run', 20.73), ('P_max', 156.27)]

Table 1: Goodness of fit for calibration period (1996 - 2012)

	Full year	**Summer**	**Winter**
RelErr	-5.5 %	-4.6 %	-8.0 %
NS	0.548	-0.037	0.568
NS_log	0.592	0.178	0.614

	Full year	Summer	Winter
NS_rel	0.343	0.613	0.678
KGE	0.628	0.342	0.57

Table 2 :Goodness of fit for validation period (1986 - 1990)

	Full year	Summer	Winter
RelErr	1.5 %	1.4 %	-3.3 %
NS	0.63	0.47	0.613
NS_log	0.664	0.52	0.673
NS_rel	0.504	0.65	0.439
KGE	0.596	0.422	0.55

9.5.3.3 Observed and simulated timeseries for optimum parameters

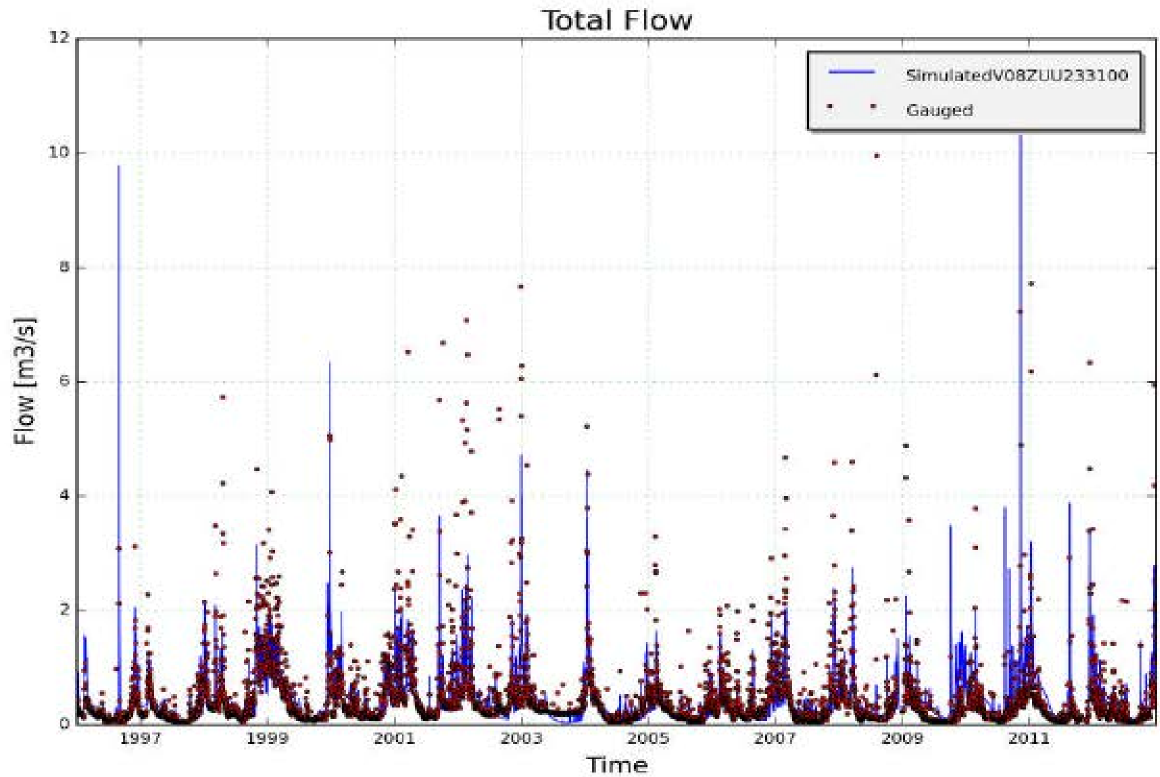


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08ZUU233100, station 23310102 - Zuunbeek, St Pieterssleeuw(calibration period)

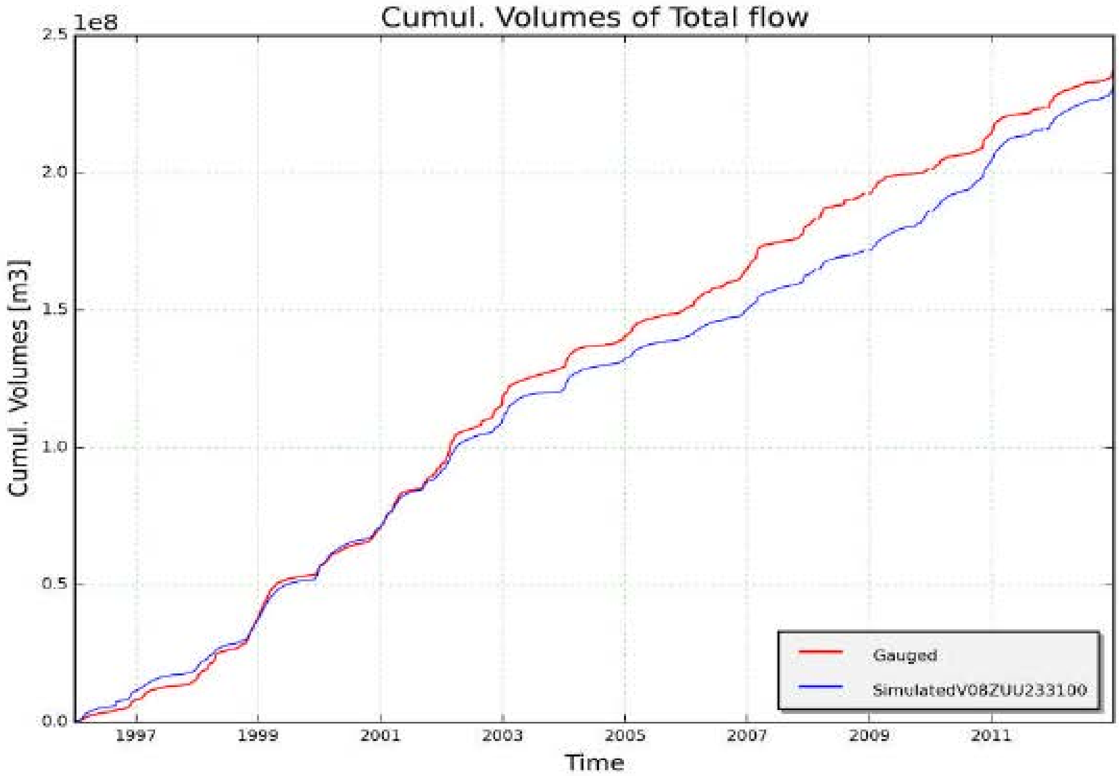


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V08ZUU233100, station 23310102 - Zuunbeek, St Pietersleeuw (calibration period)

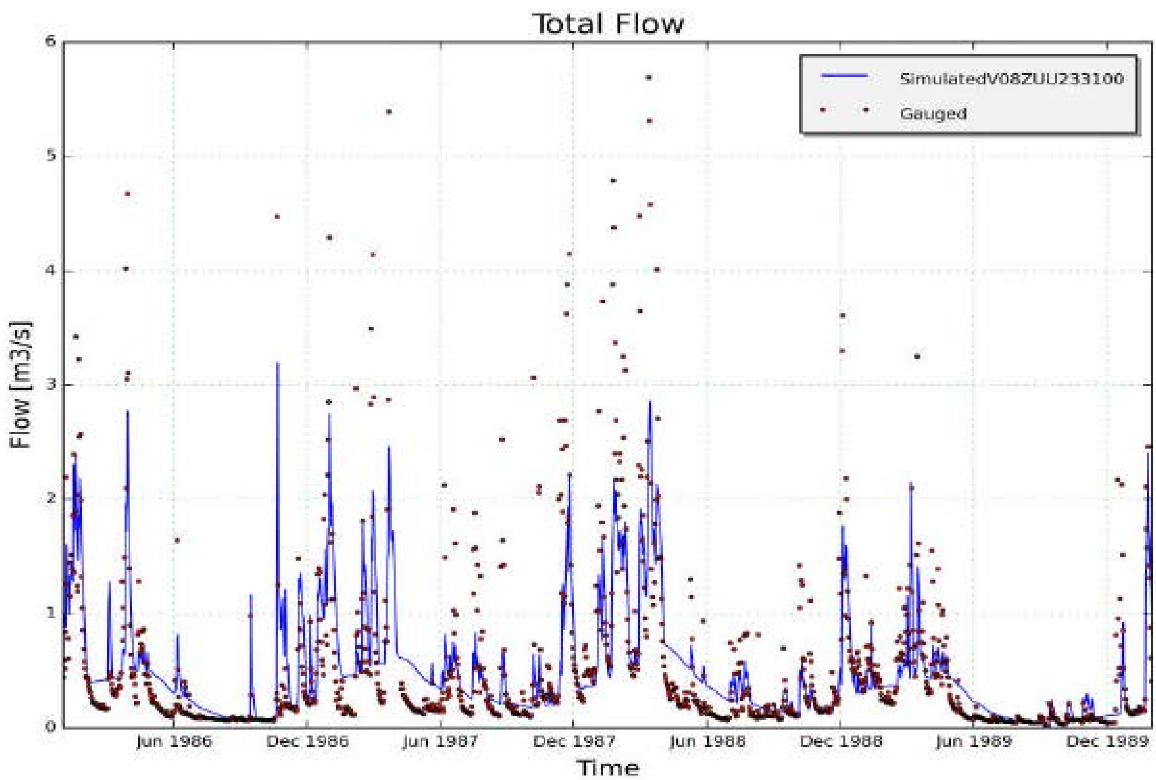


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08ZUU233100, station 23310102 - Zuunbeek, St Pietersleeuw (validation period)

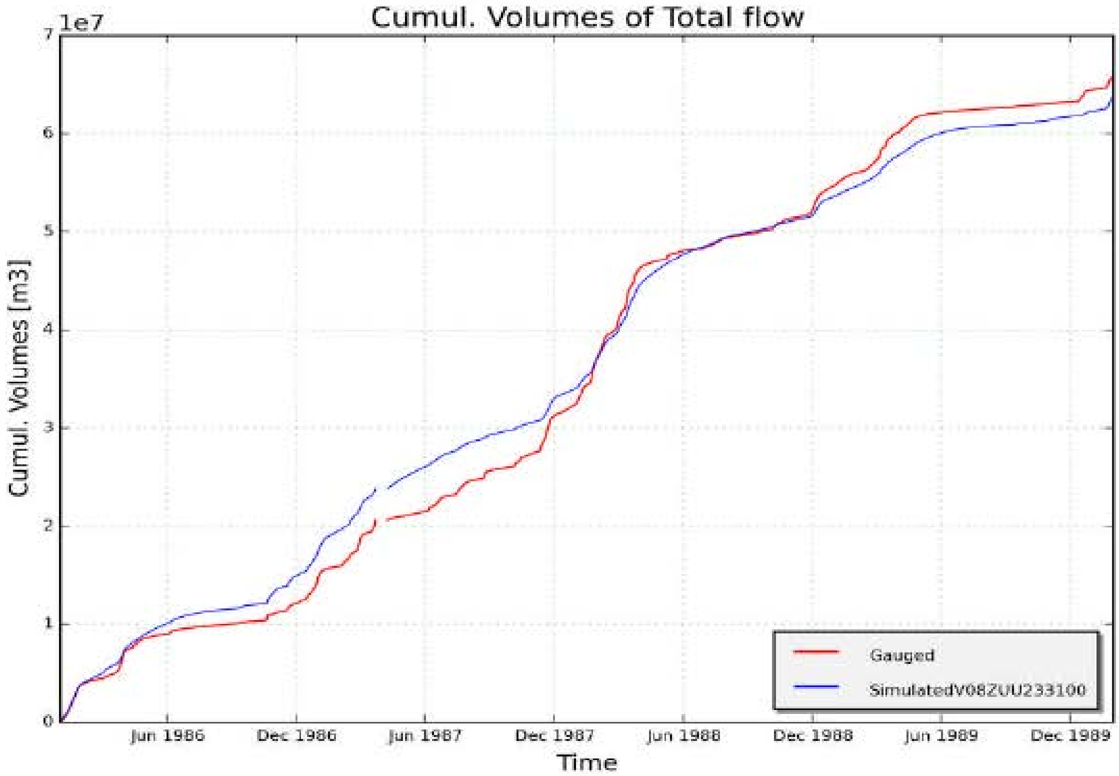


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V08ZUU233100, station 23310102 - Zuunbeek, St Pietersleeuw (validation period)

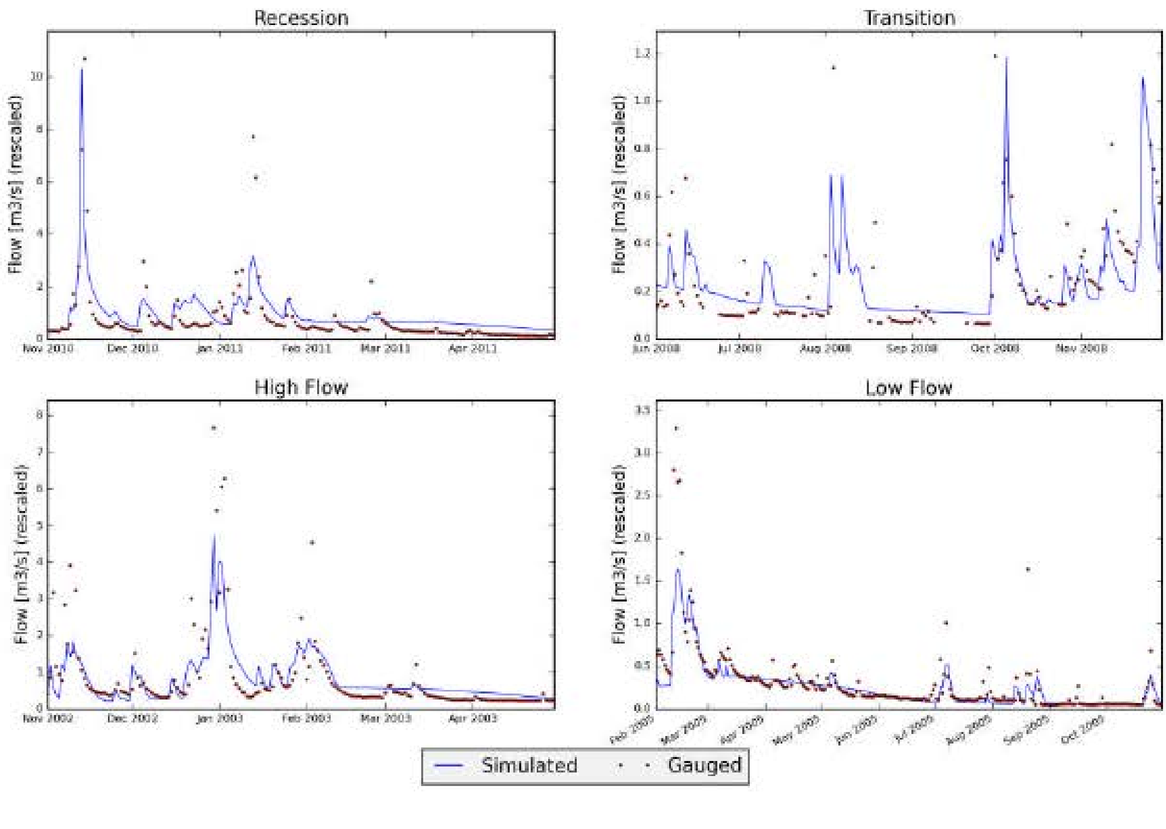


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V08ZUU233100, station 23310102 - Zuunbeek, St Pietersleeuw

9.5.4 Calibration and validation of WET parameters for catchment "W08SAMRON000" (Dijle/Zennebekken)

9.5.4.1 Input data

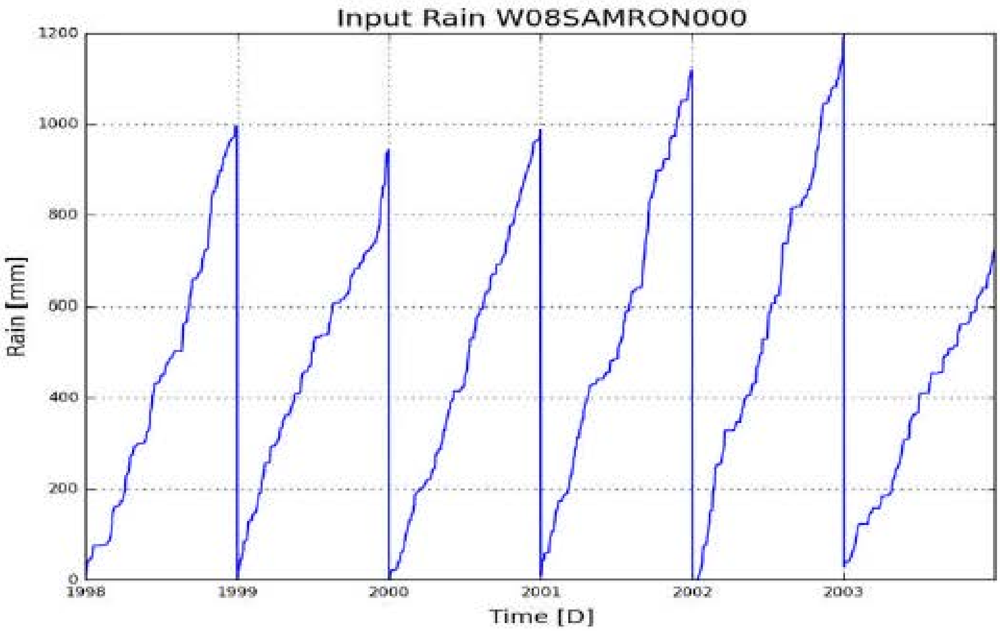


Figure 1: Cumulative precipitation on catchment W08SAMRON000 (Dijle/Zennebekken)

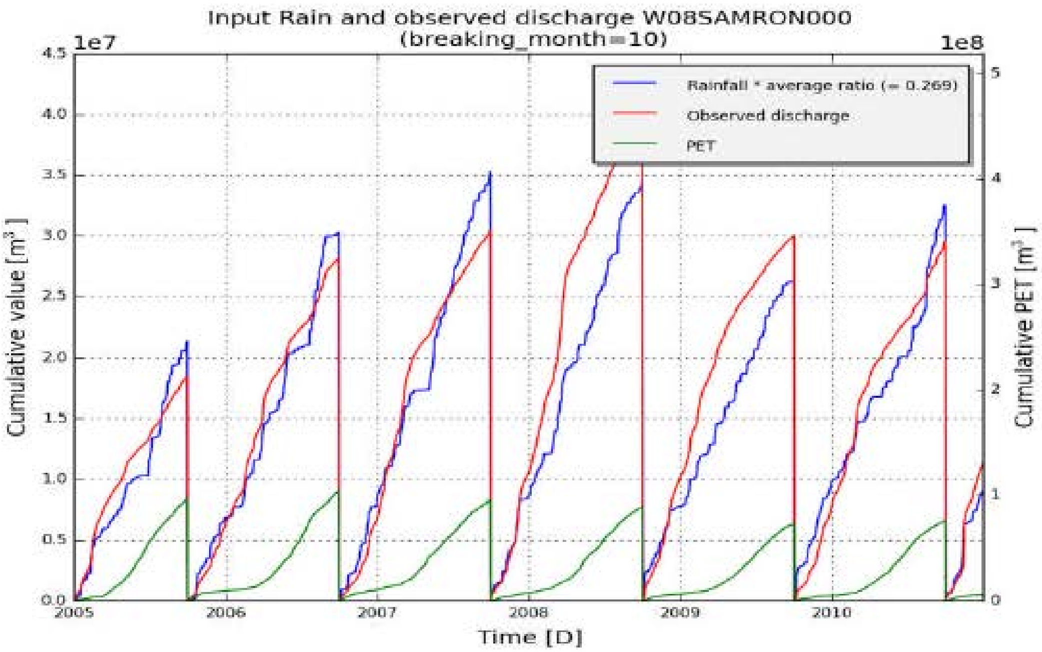


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W08SAMRON000 (Dijle/Zennebekken)

9.5.4.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	W08SAMRON000
subcatchment_area [m2]	133600000
Validation start_date	01-01-1999
Validation end_date	31-12-2003
frequency	daily

Optimal parameter set:[('Kep', 1.73), ('Ki', 1.2), ('Kg', 0.0), ('Kss', 1.7), ('g0', 249.66), ('g_max', 646.5), ('K_run', 5.15), ('P_max', 209.37)]

Table 1: Goodness of fit for calibration period (2005 - 2010)

	Full year	**Summer**	**Winter**
RelErr	-0.5 %	8.8 %	-11.0 %
NS	0.739	0.344	0.685
NS_log	0.616	0.468	0.549
NS_rel	0.765	0.746	0.703
KGE	0.846	0.625	0.758

Table 2 :Goodness of fit for validation period (1999 - 2003)

	Full year	**Summer**	**Winter**
RelErr	-1.6 %	11.6 %	-9.0 %
NS	0.753	0.619	0.722
NS_log	0.744	0.668	0.614
NS_rel	0.847	0.85	0.794
KGE	0.808	0.795	0.776

9.5.4.3 Observed and simulated timeseries for optimum parameters

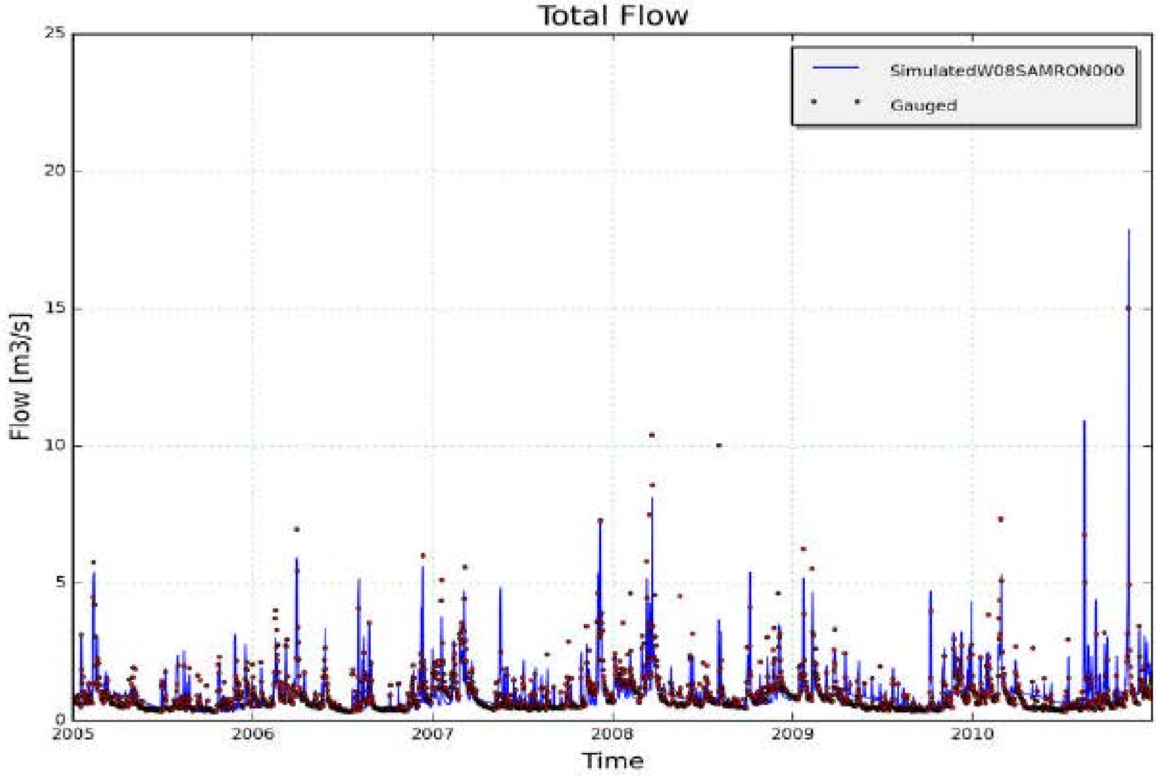


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres(calibration period)

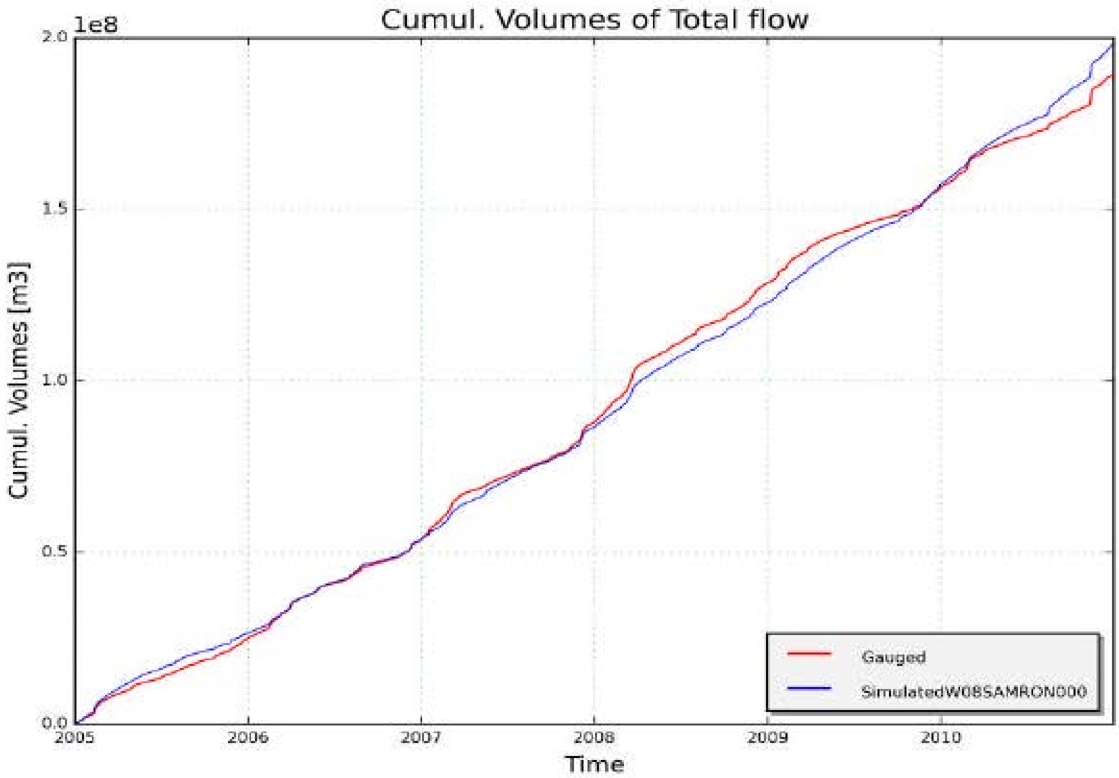


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres (calibration period)

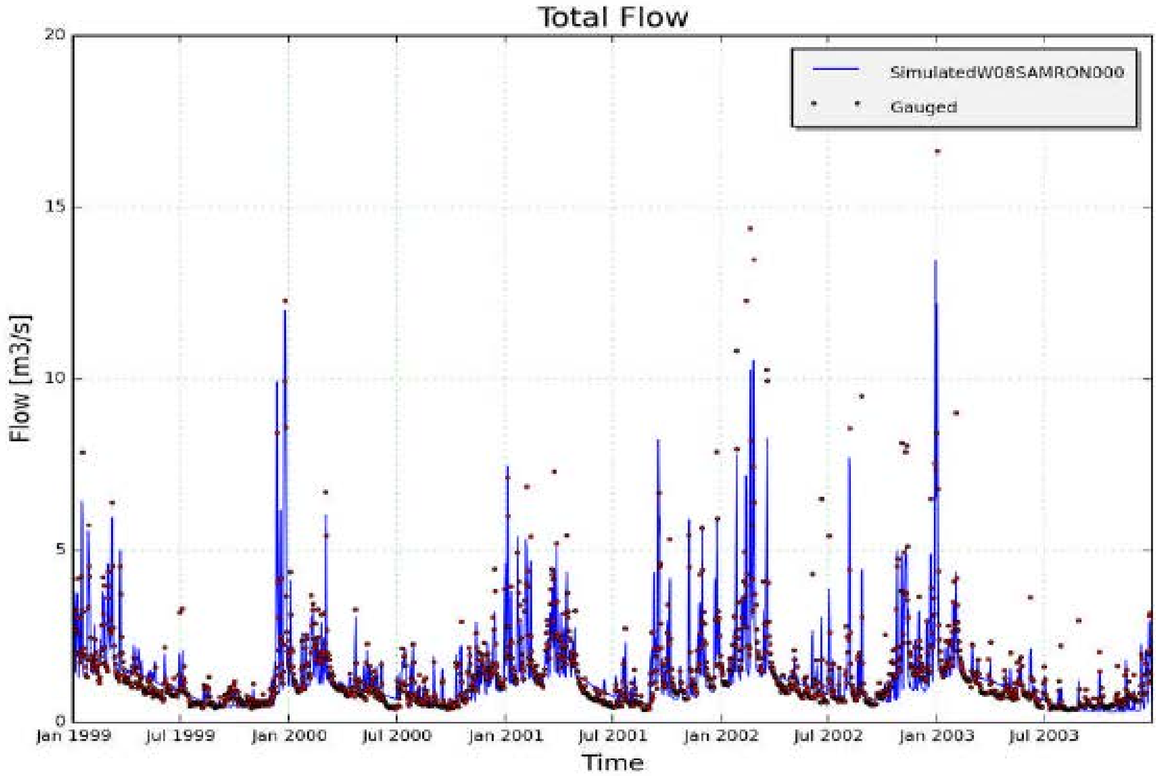


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres (validation period)

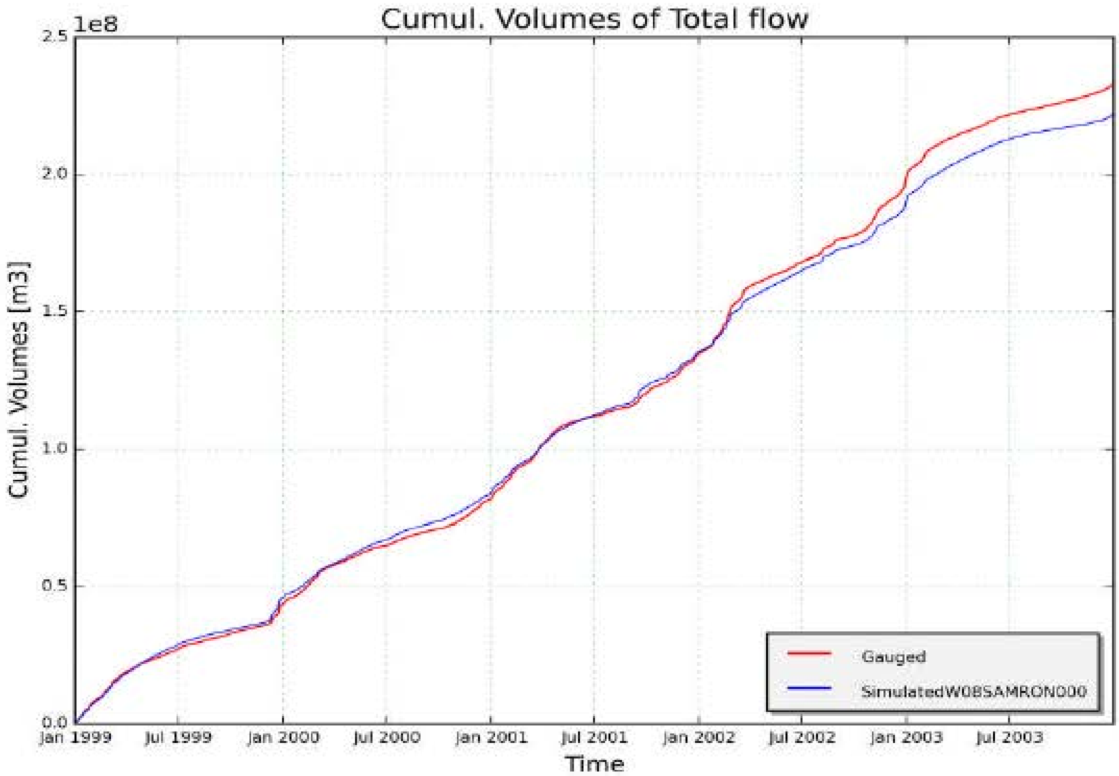


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres (validation period)

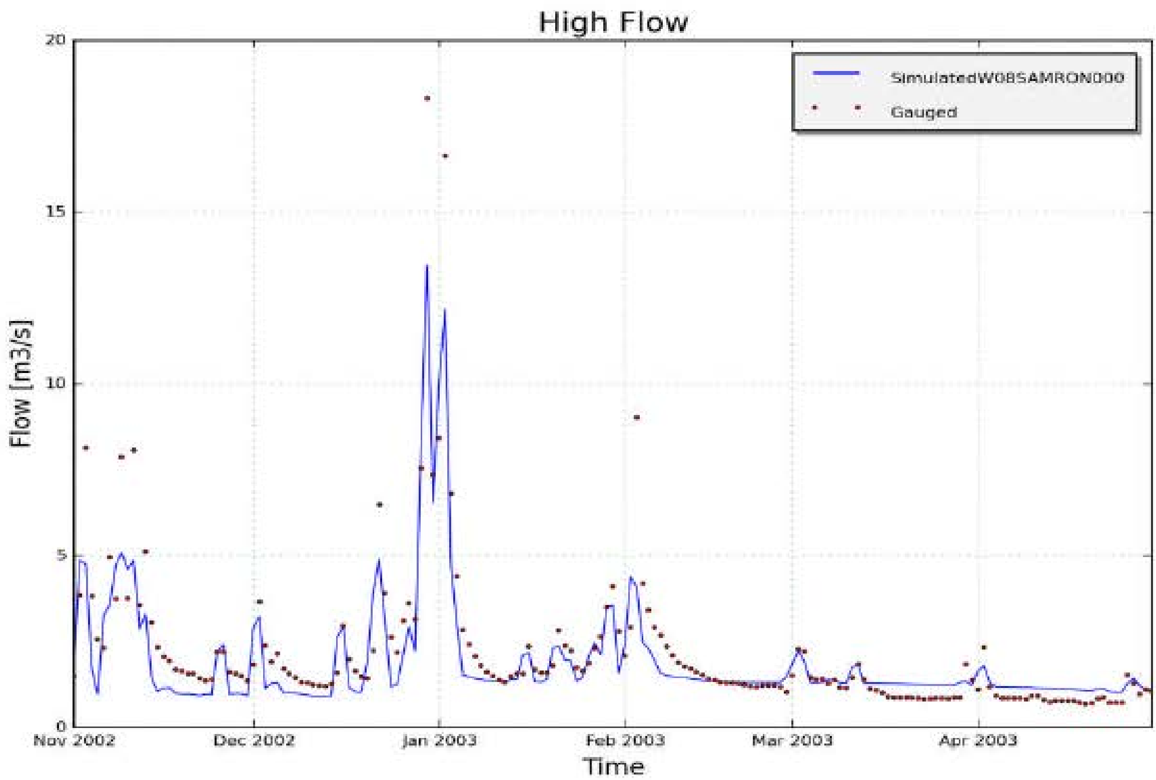


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres

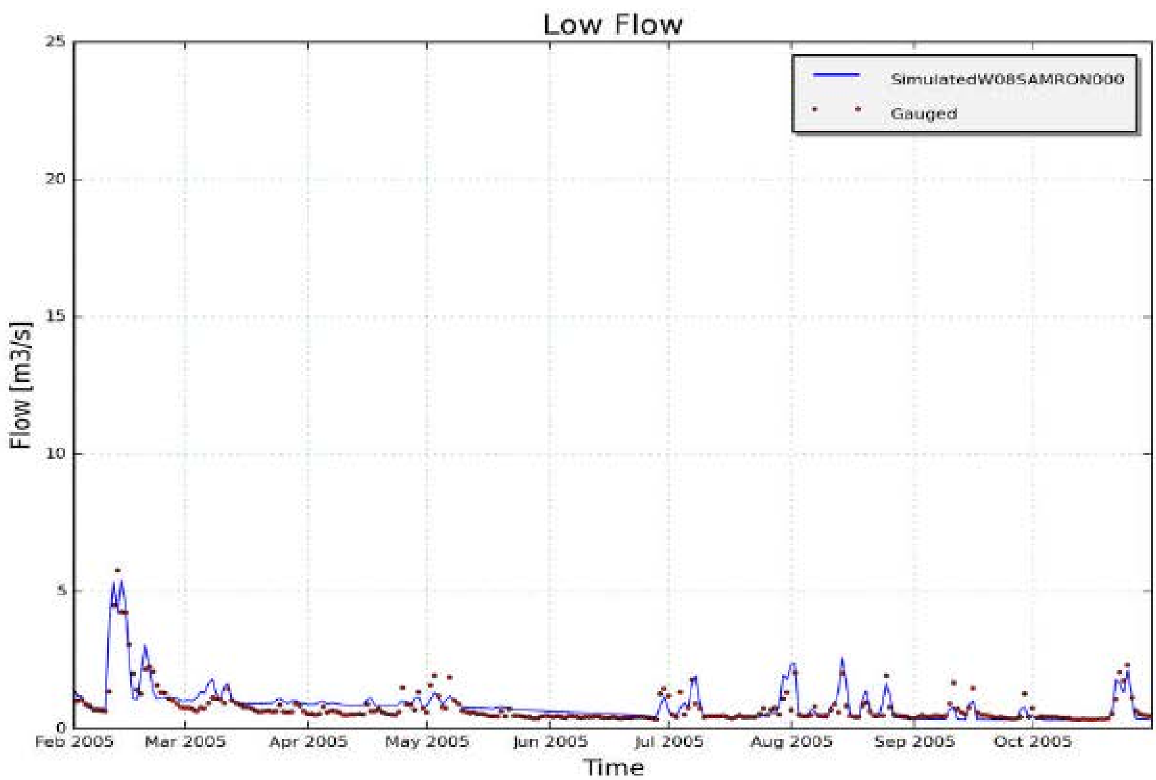


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres

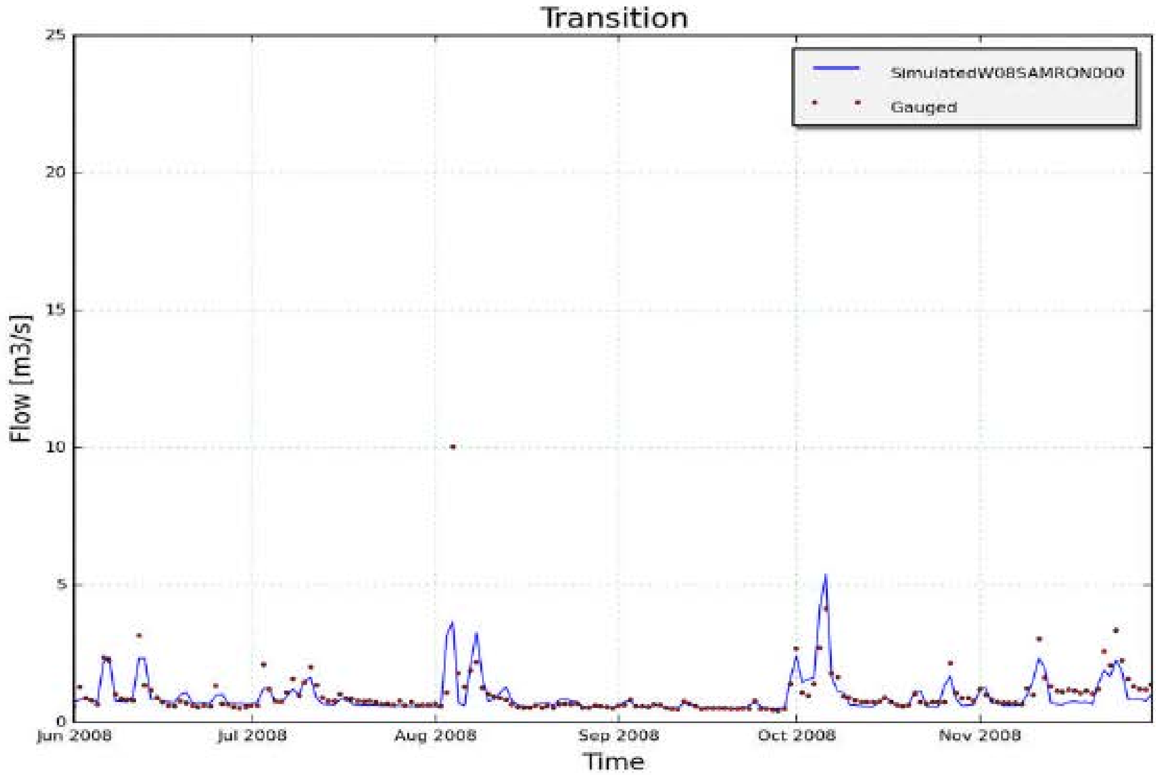


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres

9.5.5 Calibration and validation of WET parameters for catchment "W08SENL56010" (Dijle/Zennebekken)

9.5.5.1 Input data

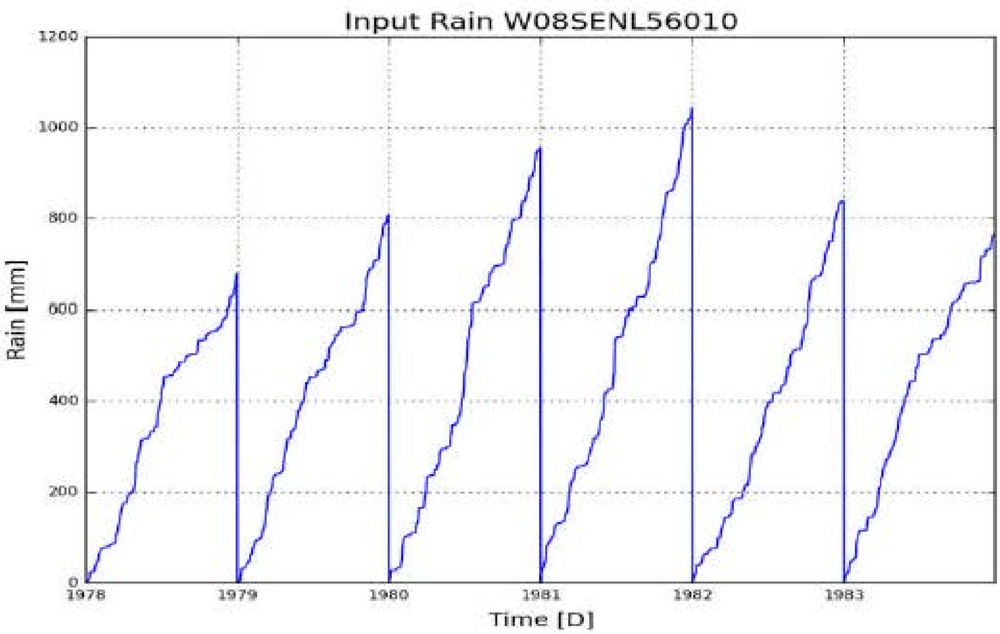


Figure 1: Cumulative precipitation on catchment W08SENL56010 (Dijle/Zennebekken)

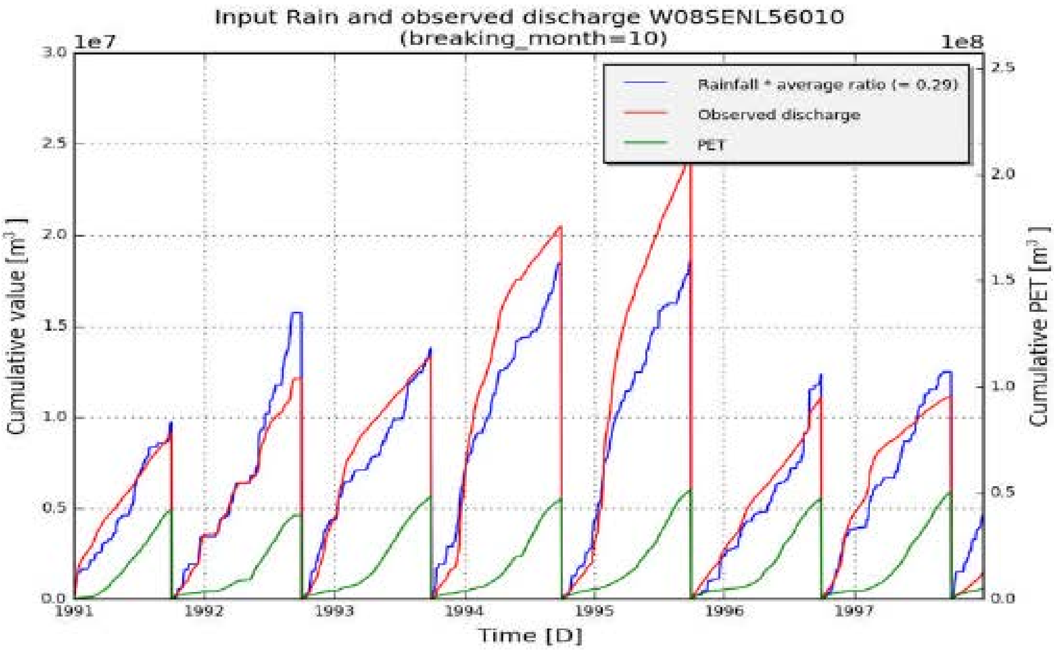


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W08SENL56010 (Dijle/Zennebekken)

9.5.5.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	W08SENL56010
subcatchment_area [m2]	70400000
Validation start_date	01-01-1979
Validation end_date	31-12-1983
frequency	daily

Optimal parameter set:[('Kep', 1.26), ('Ki', 183.8), ('Kg', 0.0), ('Kss', 2.6), ('g0', 124.4), ('g_max', 284.29), ('K_run', 8.79), ('P_max', 268.35)]

Table 1: Goodness of fit for calibration period (1991 - 1997)

	Full year	Summer	Winter
RelErr	1.2 %	-18.3 %	-0.8 %
NS	0.54	0.048	0.604
NS_log	0.454	-0.053	0.694

	Full year	Summer	Winter
NS_rel	0.719	0.848	0.72
KGE	0.655	0.452	0.583

Table 2 :Goodness of fit for validation period (1979 - 1983)

	Full year	Summer	Winter
RelErr	-1.0 %	-16.5 %	-9.8 %
NS	0.504	0.444	0.429
NS_log	0.575	0.249	0.586
NS_rel	0.67	0.781	0.747
KGE	0.577	0.481	0.437

9.5.5.3 Observed and simulated timeseries for optimum parameters

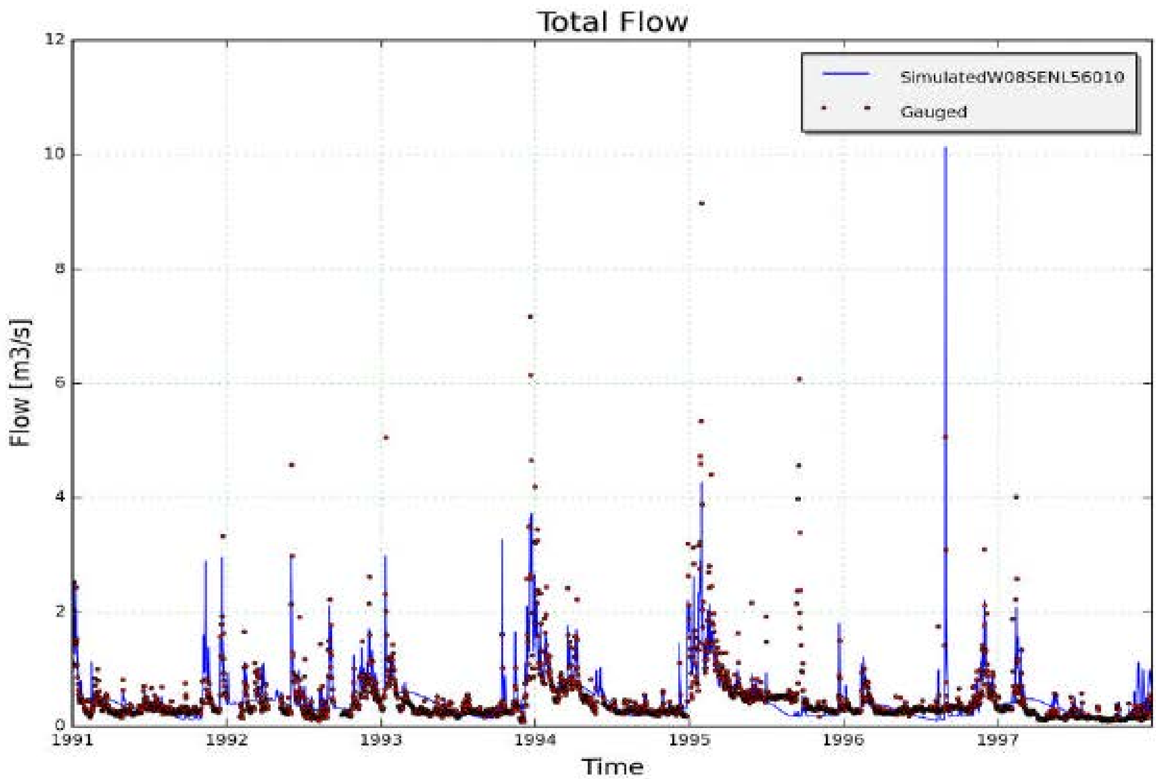


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W08SENL56010, station L5670 -Senette, Ronquieres(calibration period)

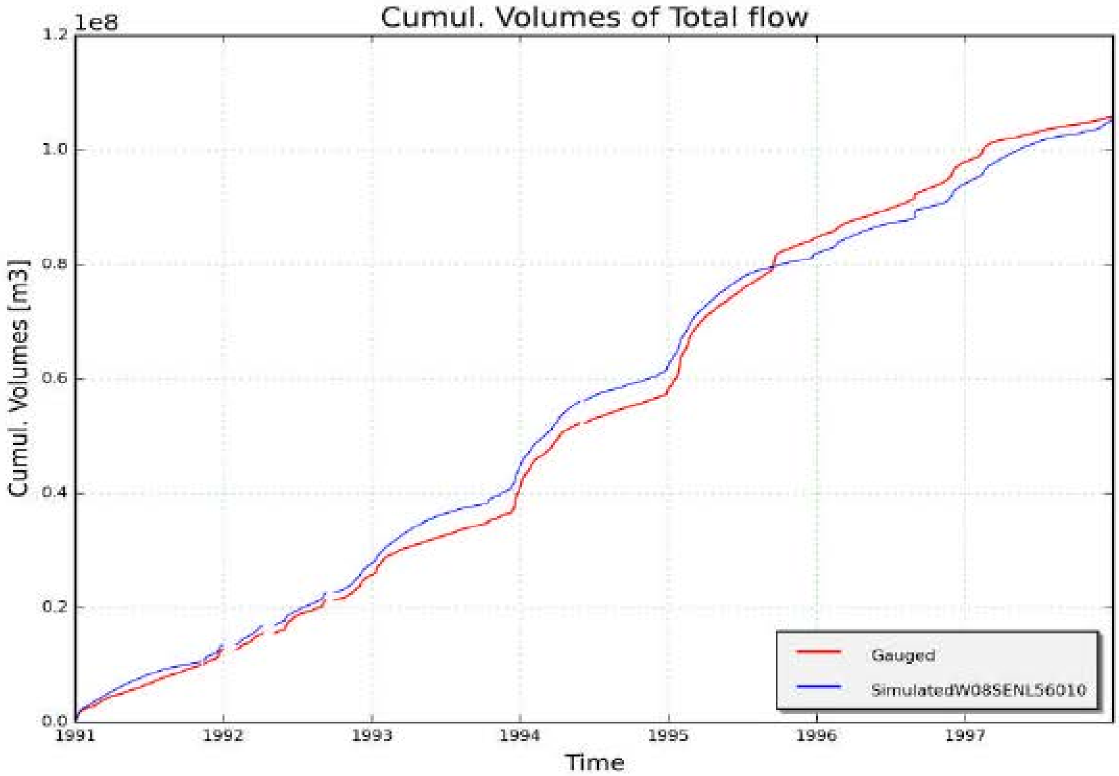


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W08SENL56010, station L5670 - Senette, Ronquieres (calibration period)

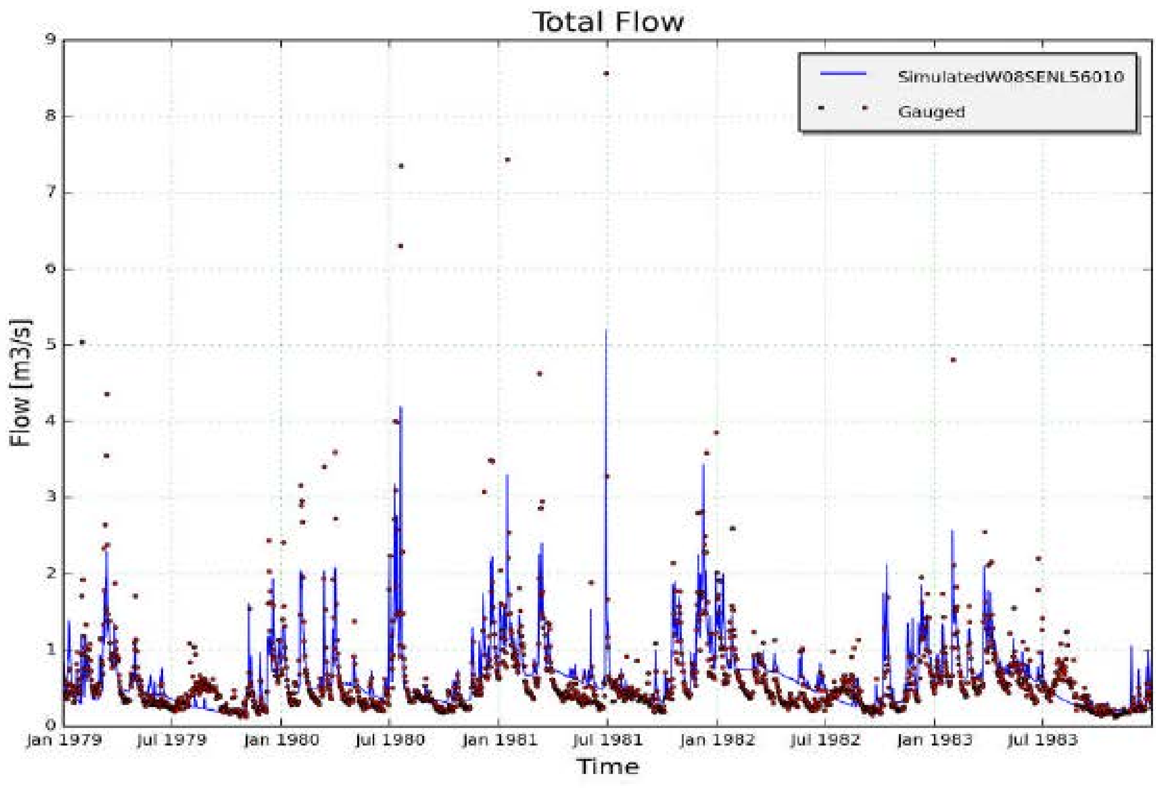


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W08SENL56010, station L5670 -Senette, Ronquieres (validation period)

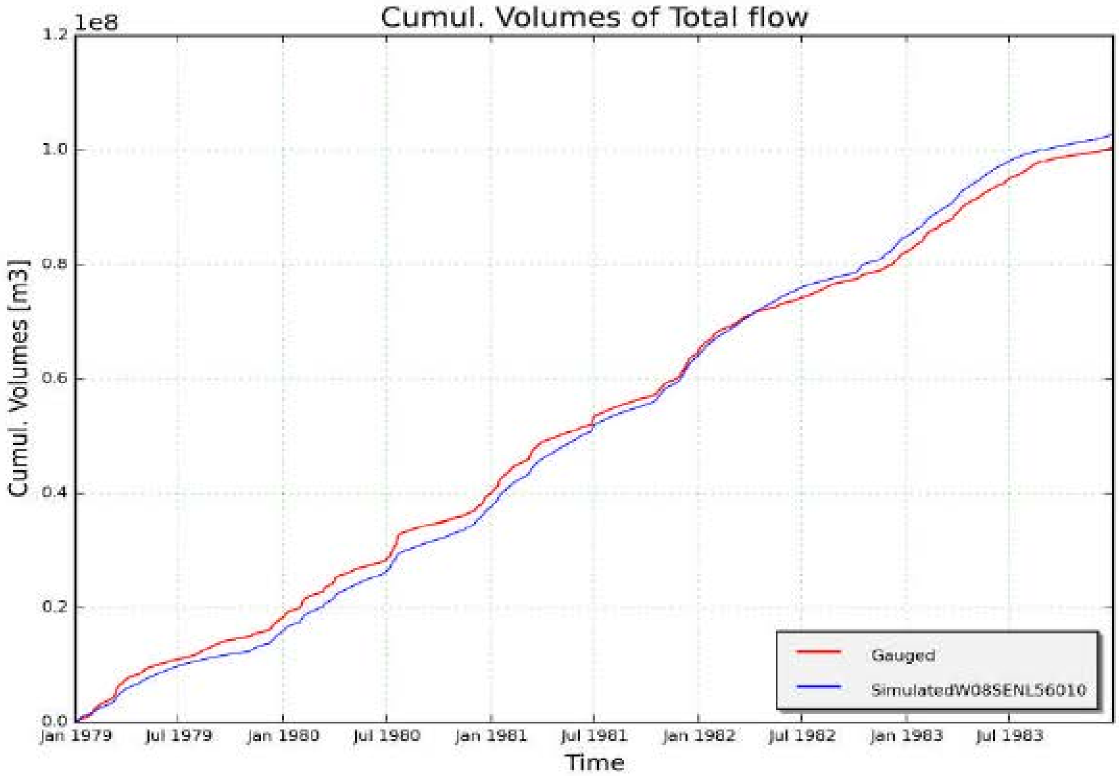


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W08SENL56010, station L5670 - Senette, Ronquieres (validation period)

9.5.6 Calibration and validation of WET parameters for catchment "W08SENTUB030" (Dijle/Zennebekken)

9.5.6.1 Input data

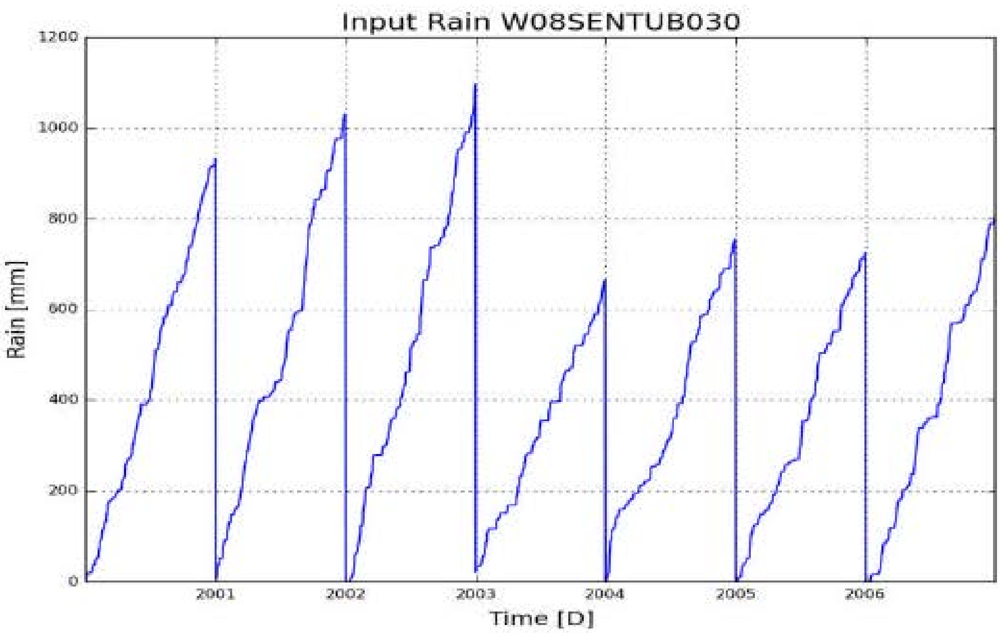


Figure 1: Cumulative precipitation on catchment W08SENTUB030 (Dijle/Zennebekken)

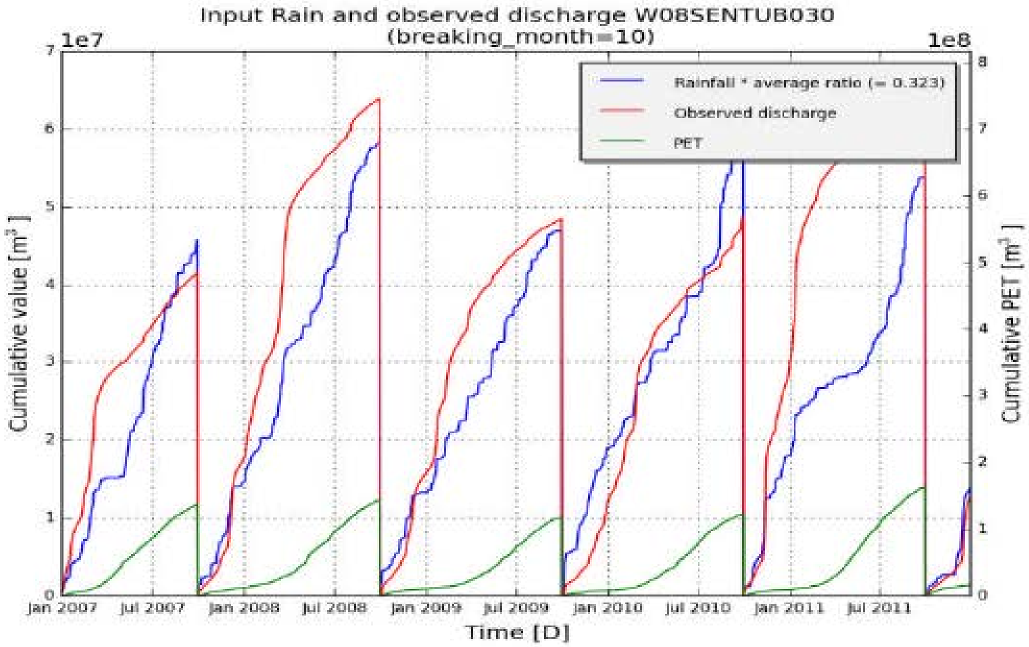


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W08SENTUB030 (Dijle/Zennebekken)

9.5.6.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	W08SENTUB030
subcatchment_area [m2]	215900000
Validation start_date	01-01-2001
Validation end_date	31-12-2006
frequency	daily

Optimal parameter set:[('Kep', 2.12), ('Ki', 52.52), ('Kg', 0.01), ('Kss', 0.7), ('g0', 116.55), ('g_max', 426.14), ('K_run', 6.13), ('P_max', 163.91)]

Table 1: Goodness of fit for calibration period (2007 - 2011)

	Full year	**Summer**	**Winter**
RelErr	-1.5 %	-16.1 %	-10.3 %
NS	0.711	0.005	0.632
NS_log	0.581	-0.102	0.468
NS_rel	0.828	0.67	0.589

	Full year	Summer	Winter
KGE	0.774	0.451	0.603

Table 2 :Goodness of fit for validation period (2001 - 2006)

	Full year	Summer	Winter
RelErr	-2.8 %	-15.7 %	0.5 %
NS	0.753	0.283	0.736
NS_log	0.456	-1.556	0.693
NS_rel	0.851	0.728	0.682
KGE	0.82	0.58	0.734

9.5.6.3 Observed and simulated timeseries for optimum parameters

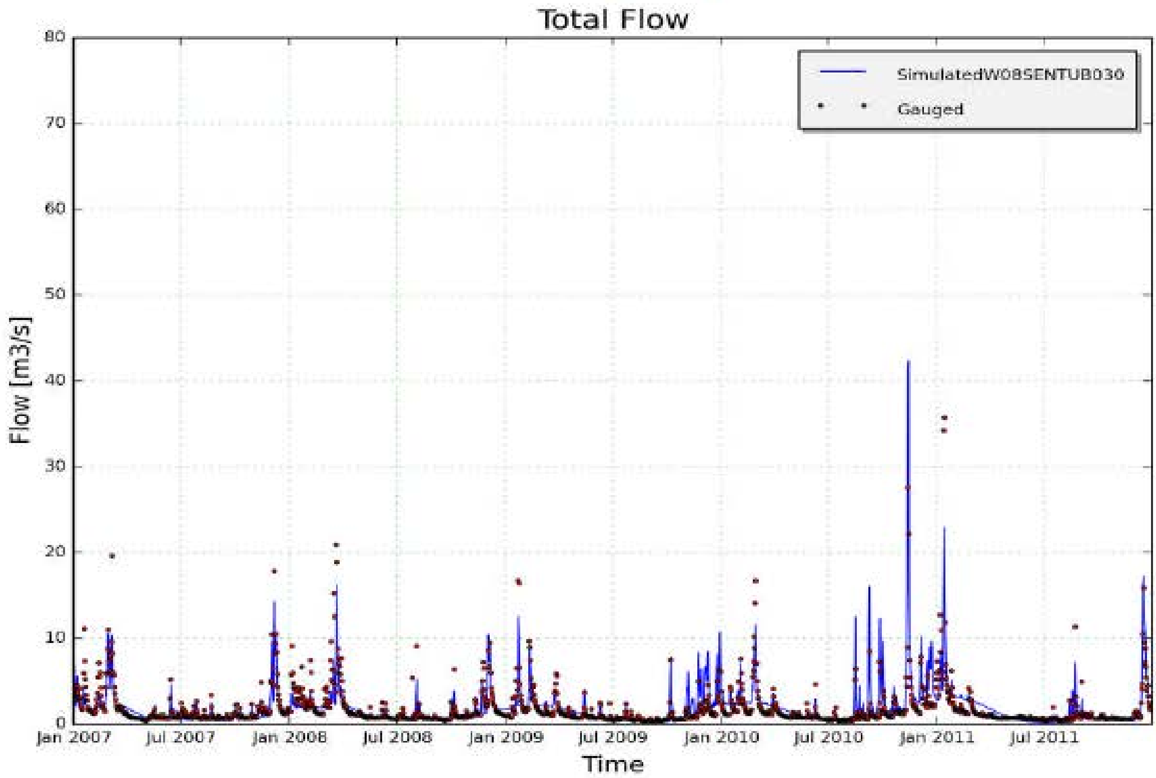


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize(calibration period)

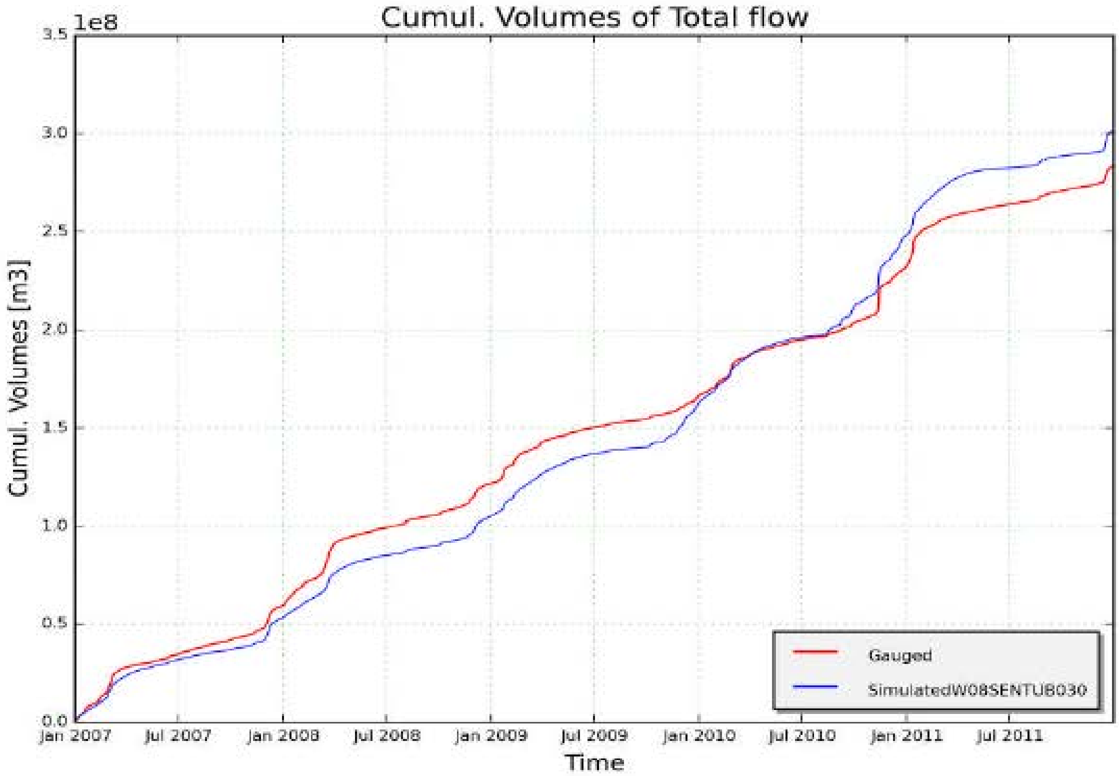


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize (calibration period)

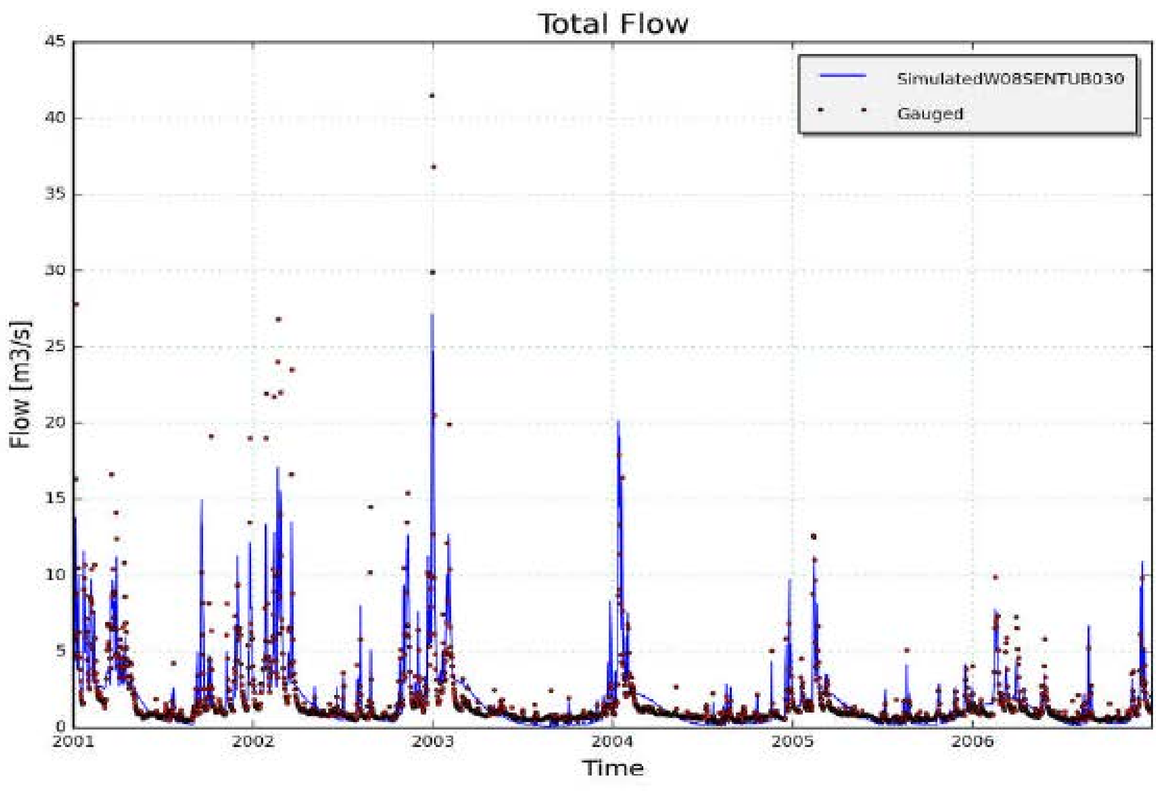


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize (validation period)

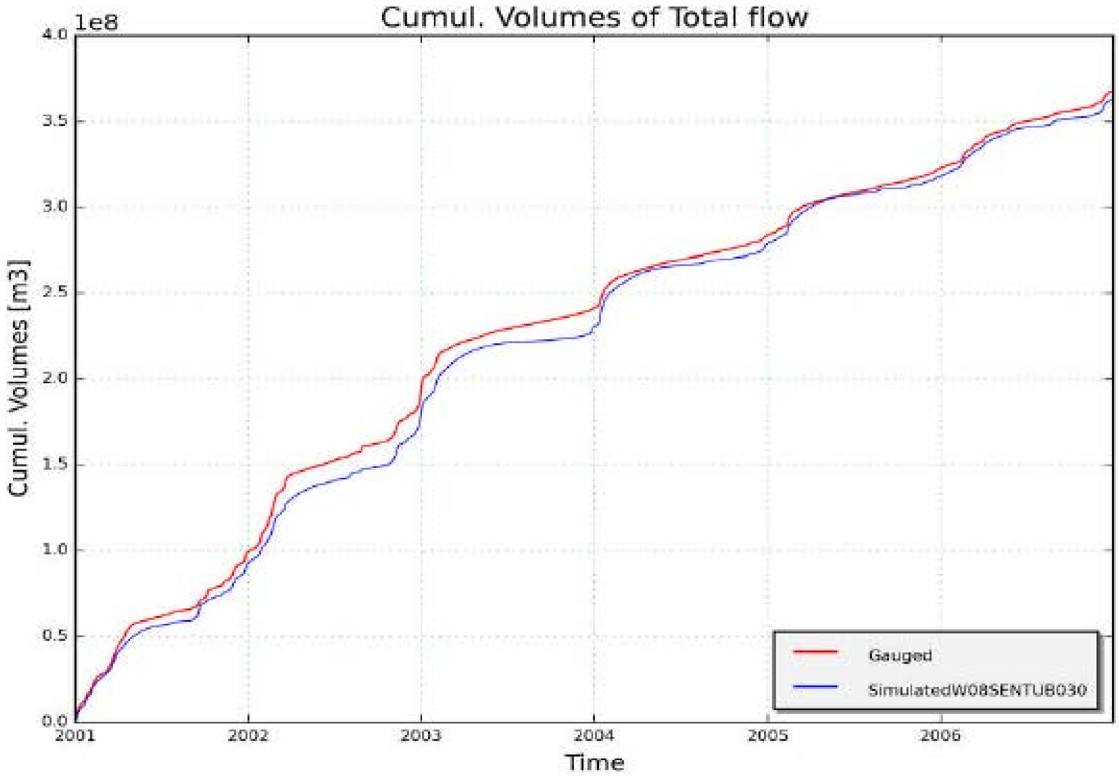


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize (validation period)

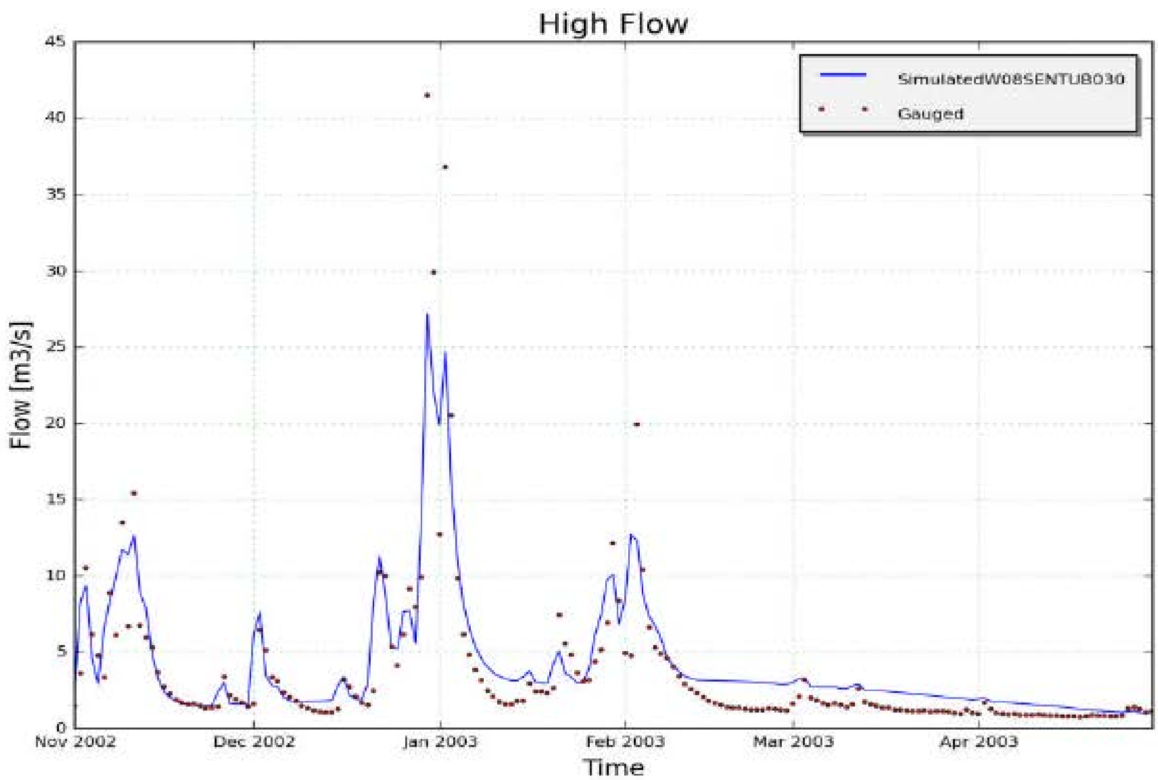


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize

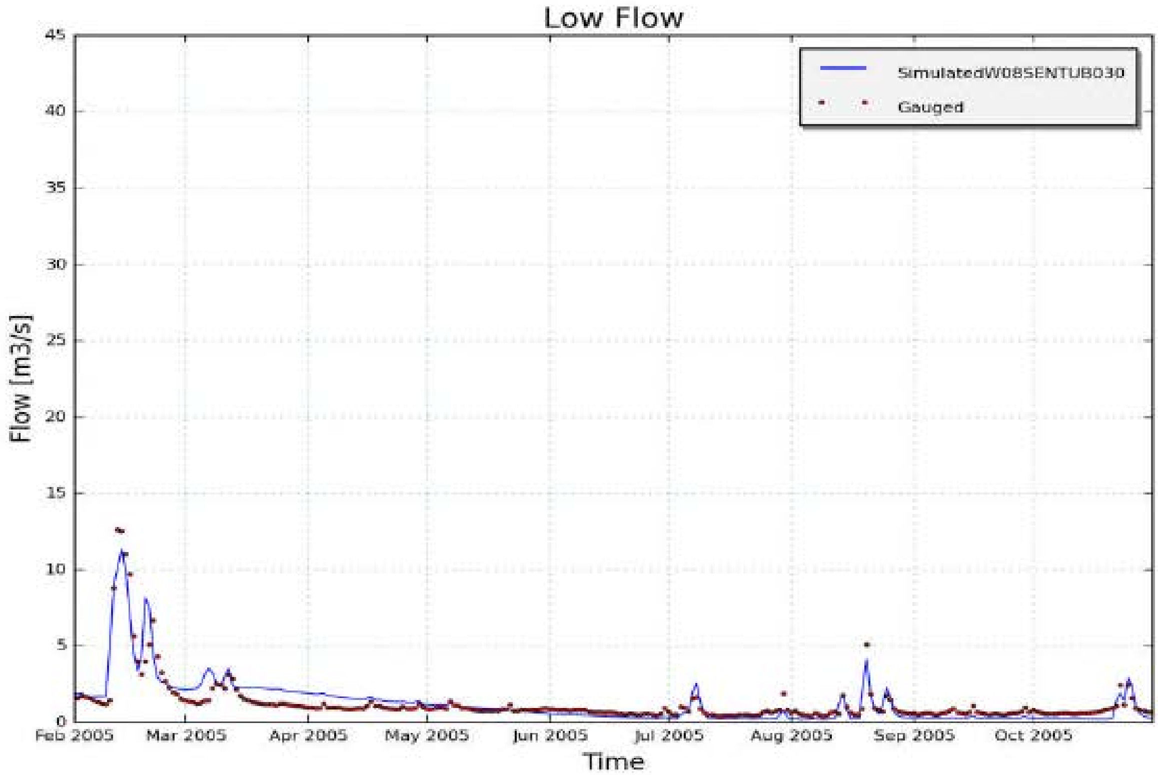


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize

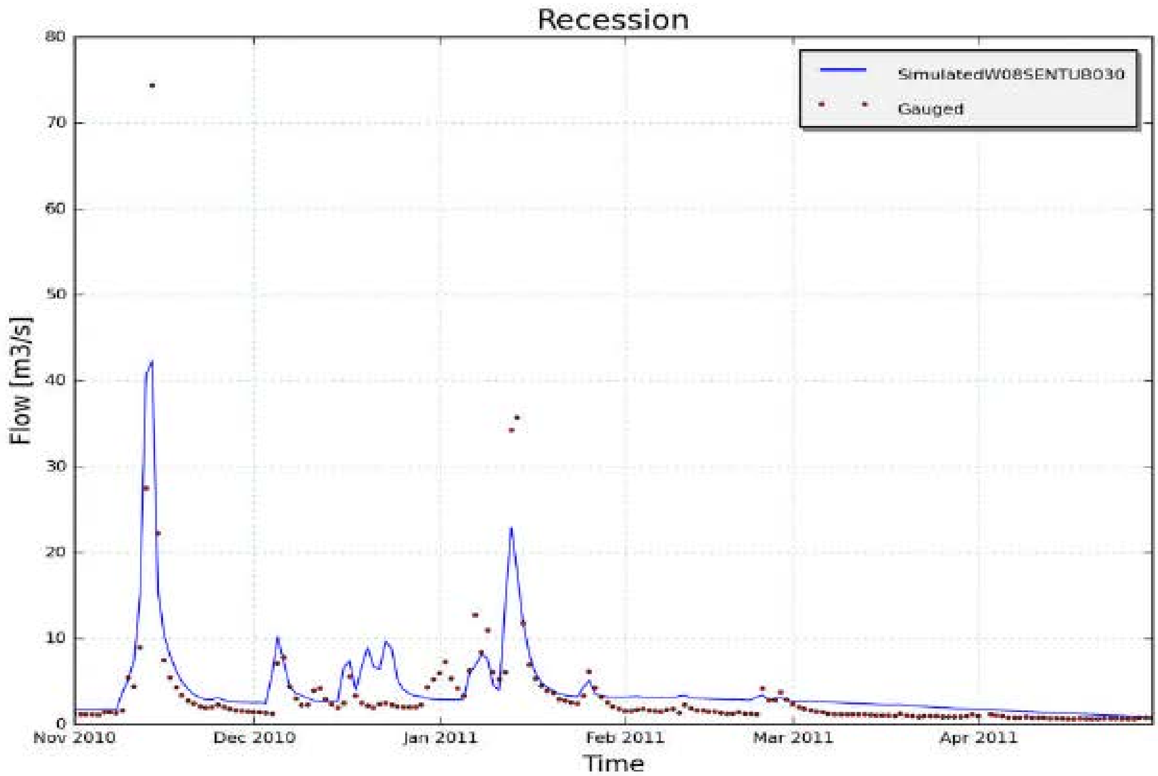


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize

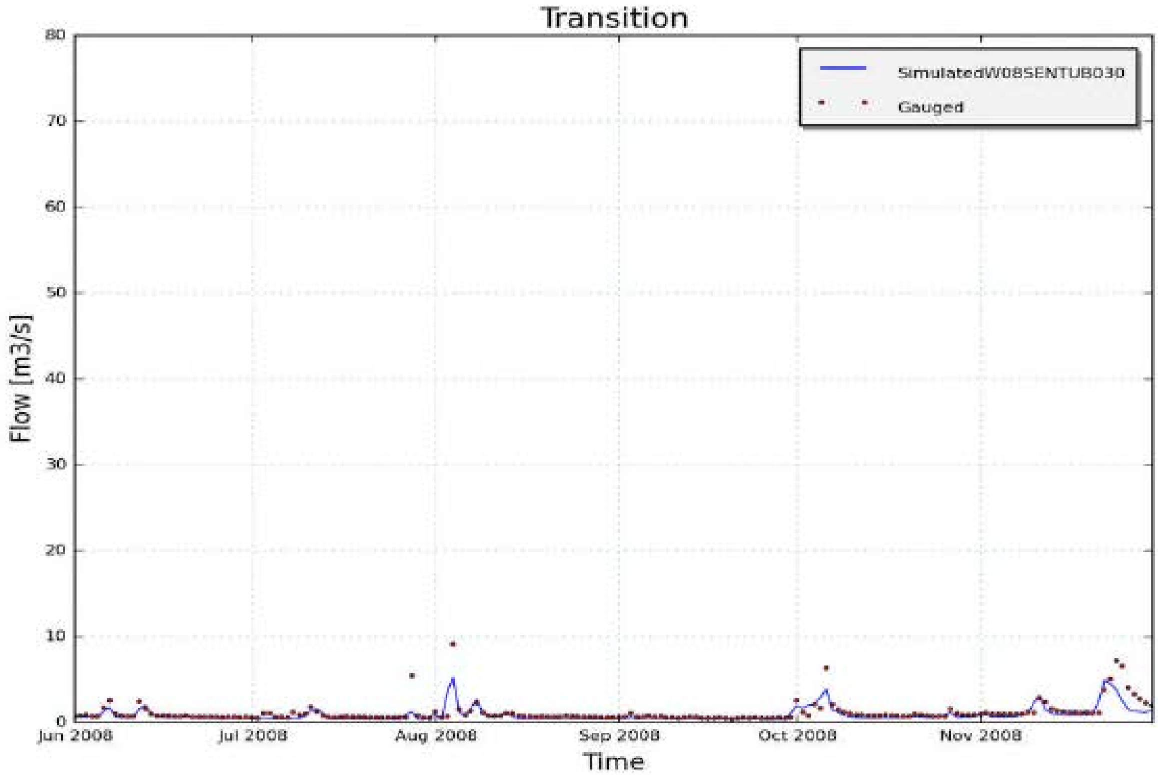


Figure 10: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize

Appendix 17 Dijle and Zenne Autocalibration.

9.5.1 Report on simulation of catchment V08BAR111370 (2017-01-20 16-08)

9.5.1.1 Input data

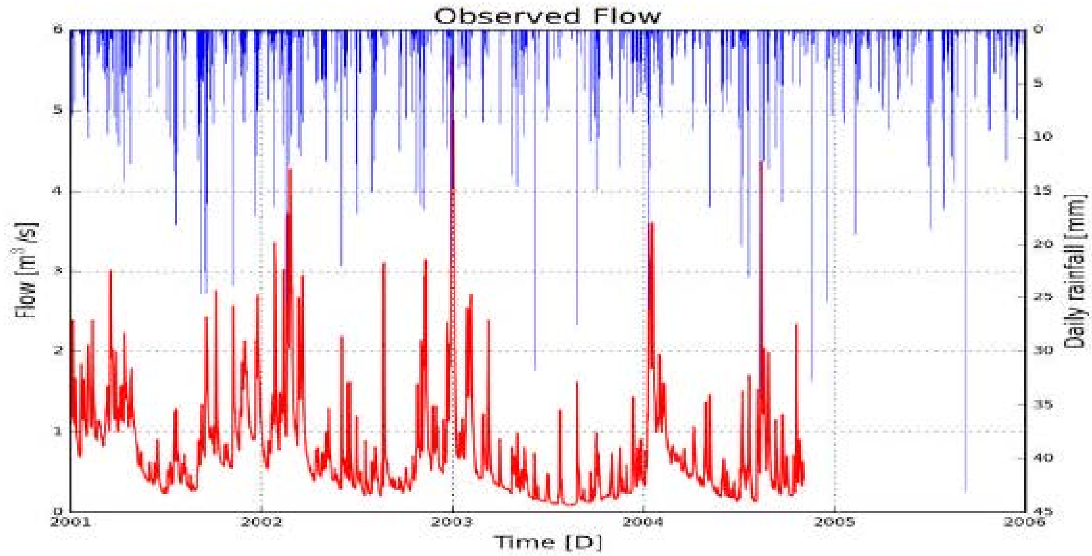


Figure 1: Hyetogram of observed discharge and observed net rain

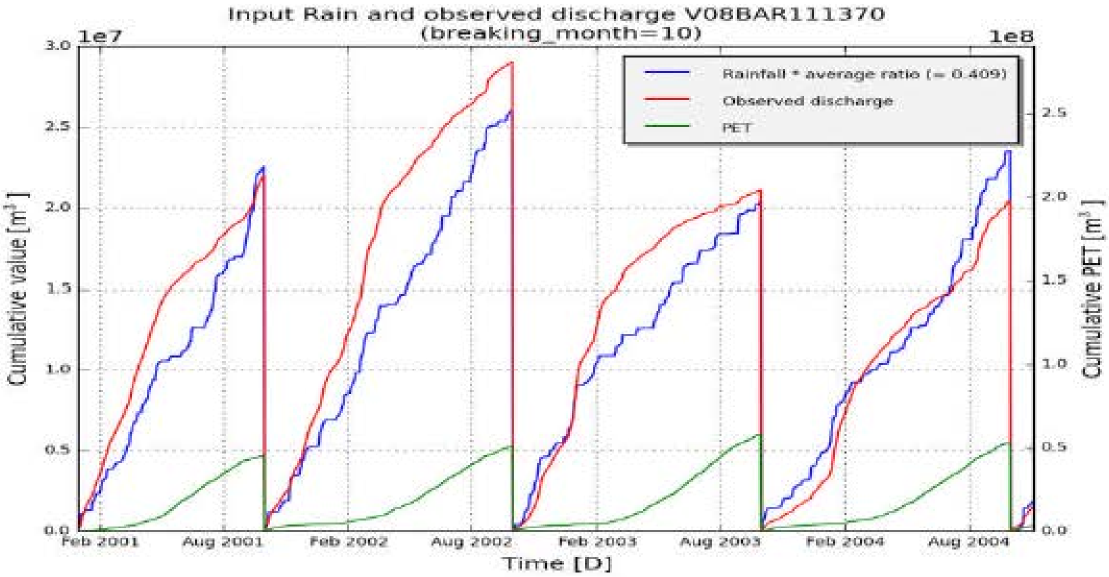


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.1.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V08BAR111370
subcatchment_area	69900000
start_date	199801010000
end_date	200312310000
frequency	86400
warmup	365

9.5.1.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.0, 50.0, 0.003, 3.5, 50.0, 200.0, 2.2, 65.0]
low_bounds	[0.8, 30.0, 0.0024, 2.8, 40.0, 158.0, 1.8, 45.0]
high_bounds	[1.5, 120.0, 0.01, 5.0, 150.0, 300.0, 4.0, 200.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.0), ('Ki', 50.0), ('Kg', 0.003), ('Kss', 3.5), ('g0', 50.0), ('g_max', 200.0), ('K_run', 2.2), ('P_max', 65.0)]
Initial fitness:

- RelErr: 0.033
- AbsErr: 2478398.088
- KGE: 0.719
- NS_rel: 0.518
- NS: 0.419
- RMSE: 2907707.639
- NS_log: 0.688

Computation time:2:10:49.330000

9.5.1.4 Results

Best individual (euclidian): [('Kep', 1.136), ('Ki', 50.596), ('Kg', 0.003), ('Kss', 5.0), ('g0', 70.52), ('g_max', 237.629), ('K_run', 4.0), ('P_max', 71.612)]

Fitness:

- RelErr: 0.025
- AbsErr: 2226176.648
- KGE: 0.782
- NS_rel: 0.601
- NS: 0.562
- RMSE: 2747299.874
- NS_log: 0.725

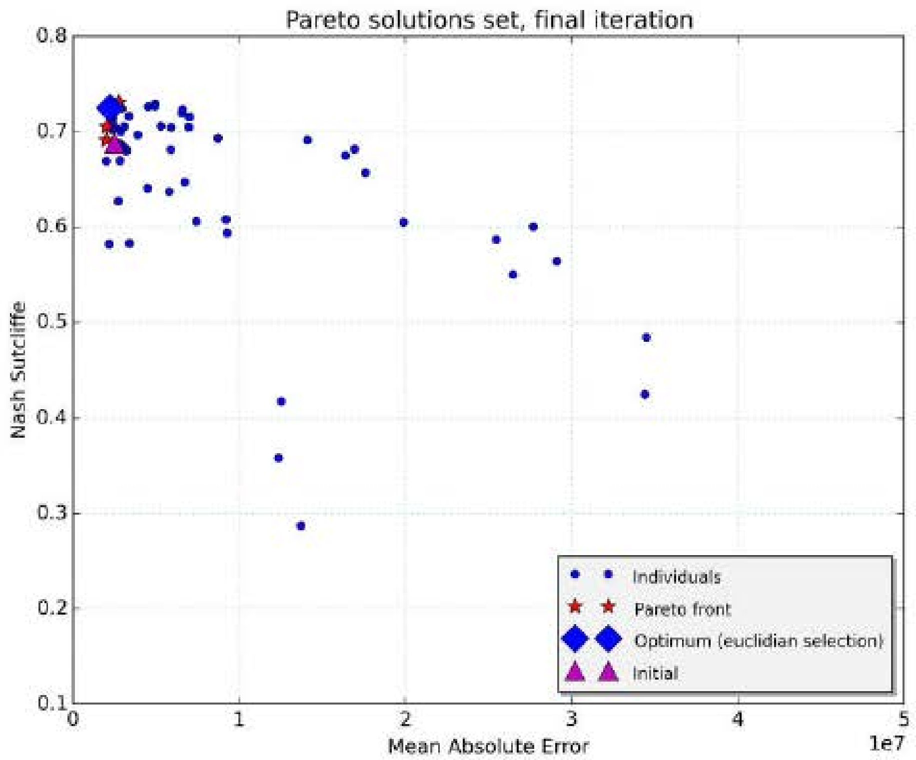


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

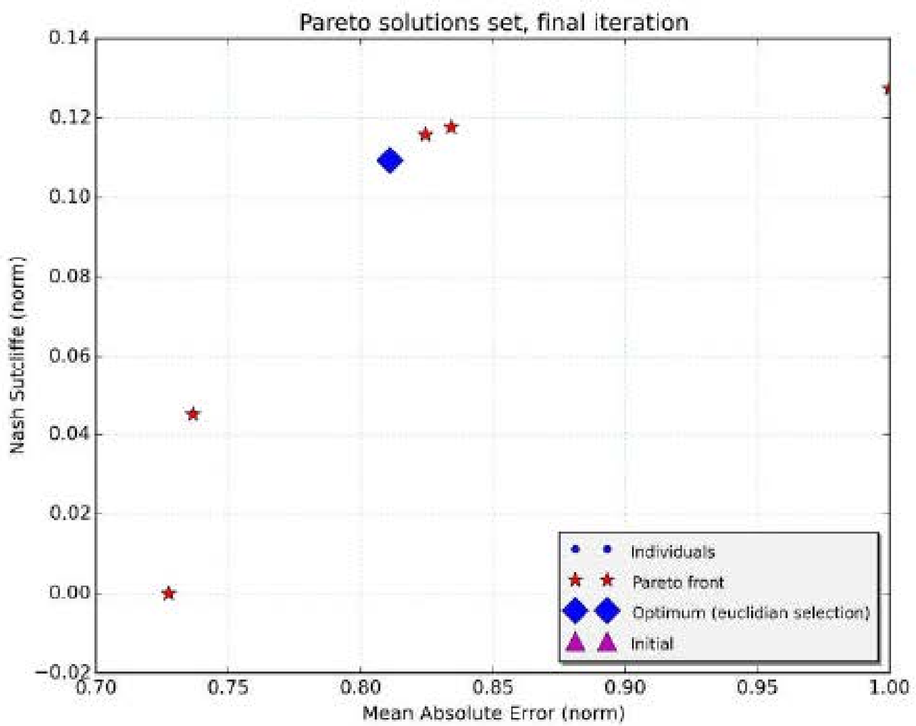


Figure 4: Final population of solutions (Pareto front)

9.5.1.4.1 Initial

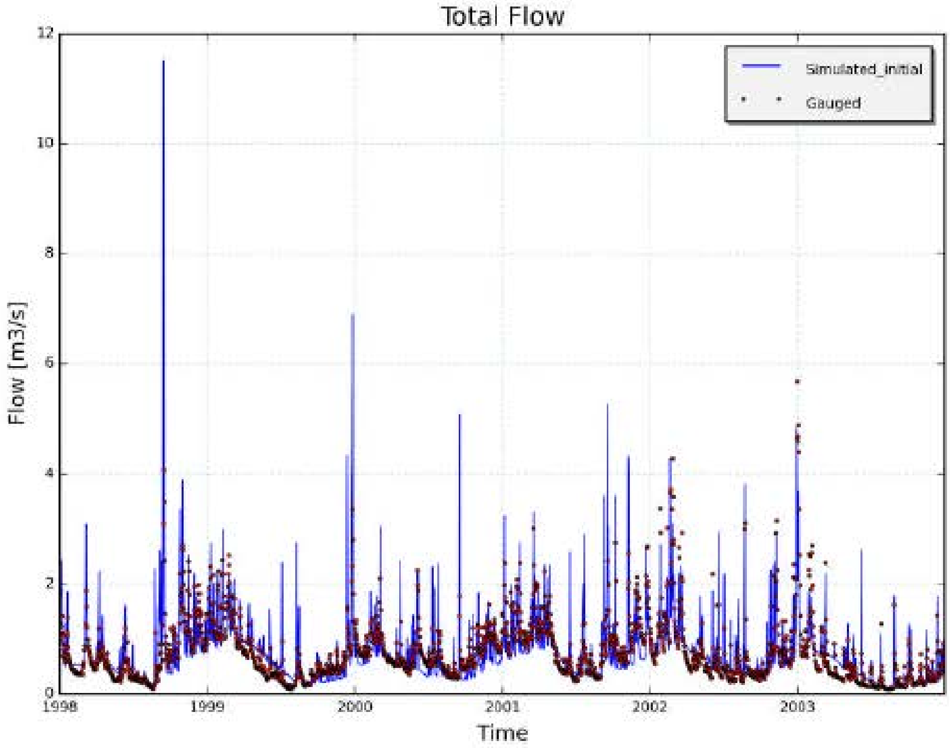


Figure 5: Total flow with initial parameters

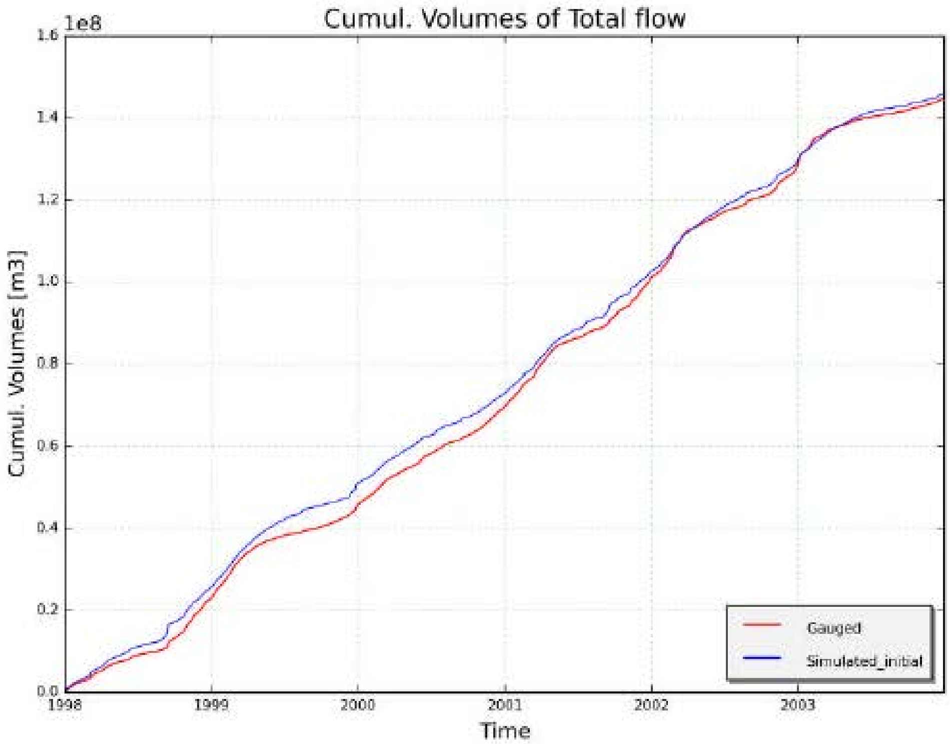


Figure 6: Cumulated flow with initial parameters

9.5.1.4.2 Optimum (euclidian)

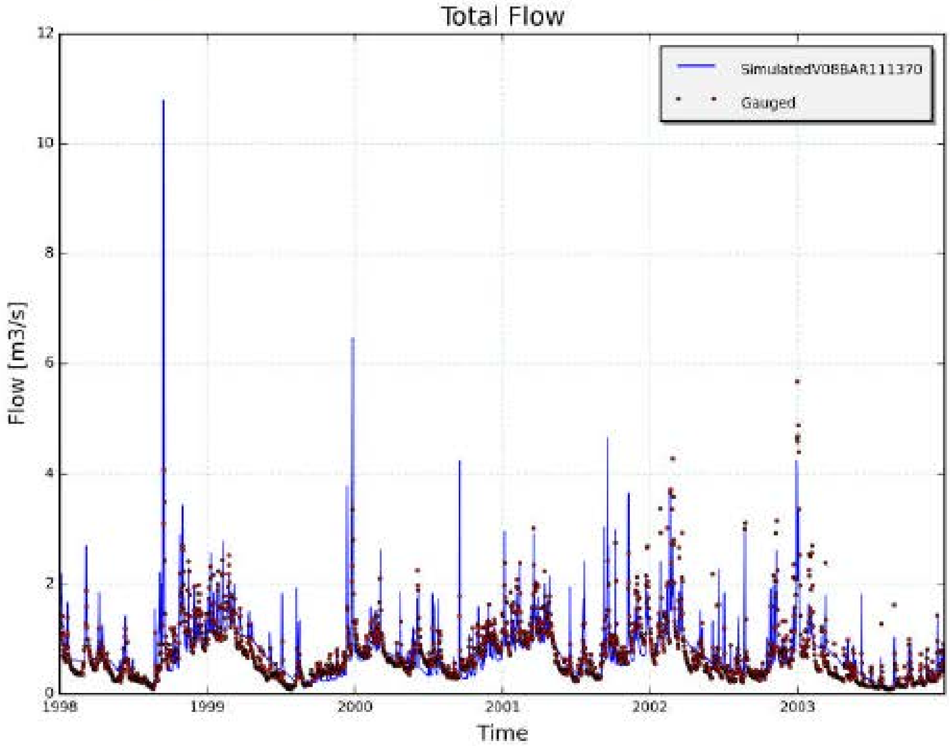


Figure 7: Total flow with optimum parameters

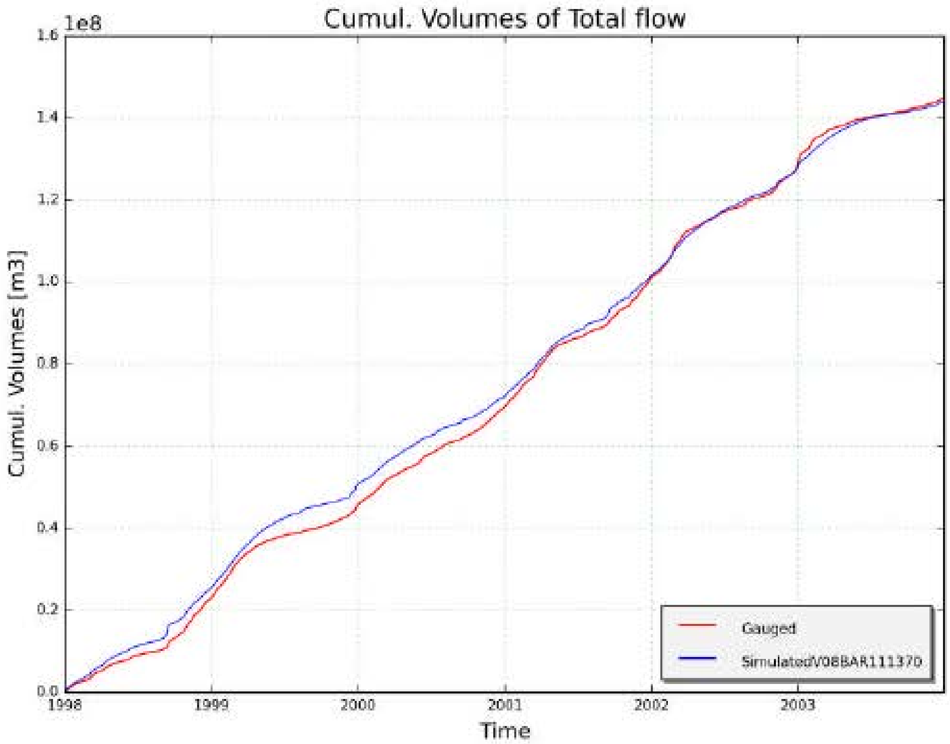


Figure 8: Cumulated flow with optimum parameters

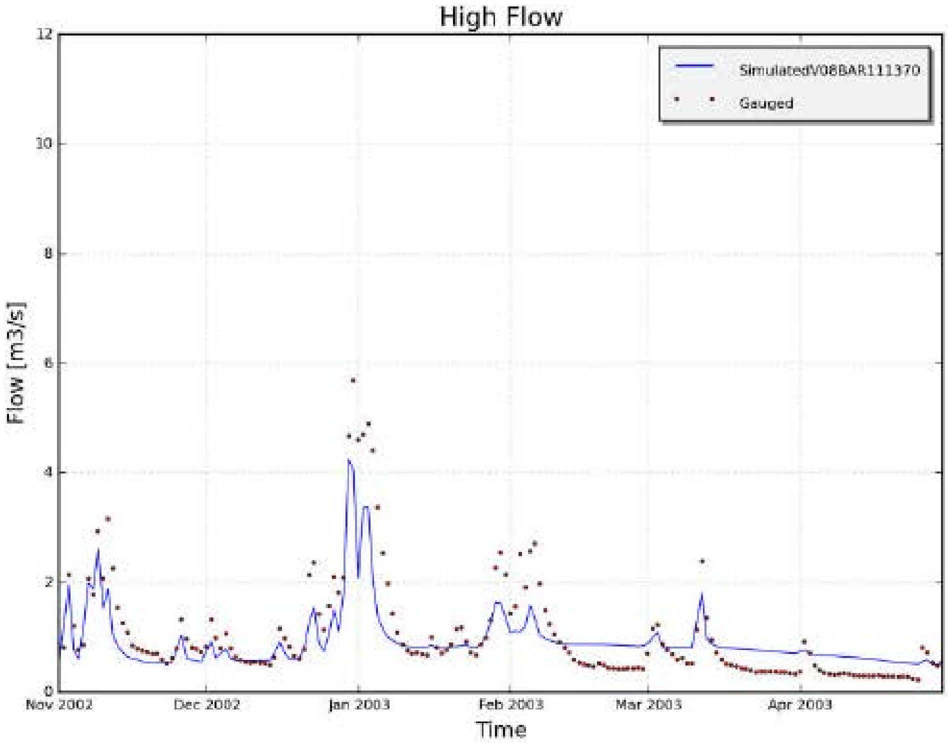
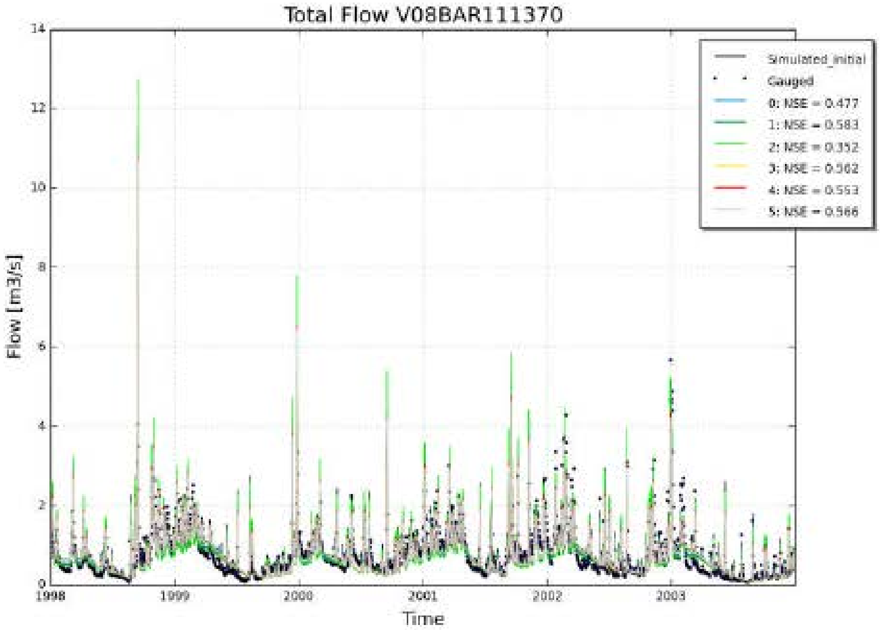
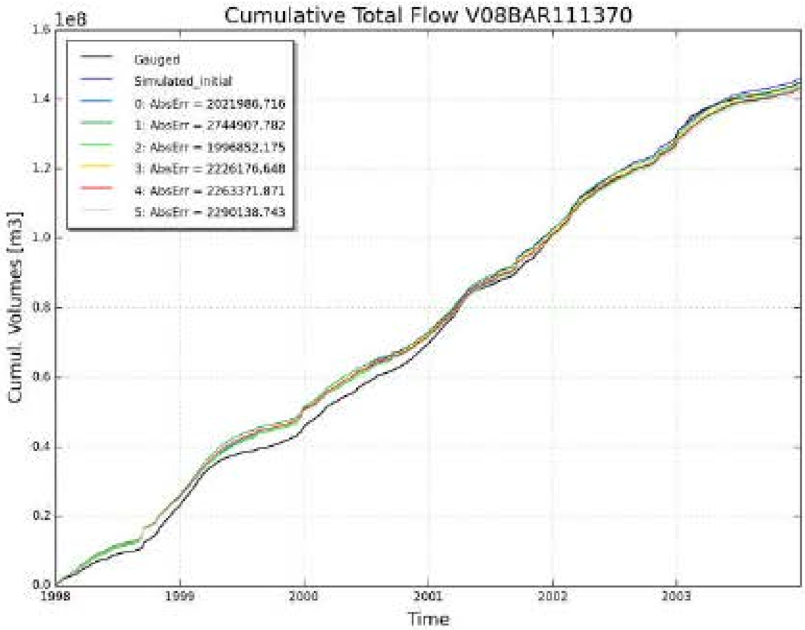


Figure 9: Total flow with optimum parameters (detail)

9.5.1.4.3 Final archive

0 : [1.041, 50.012, 0.003, 4.012, 58.874, 206.943, 2.586, 76.009] : [2021986.716, 0.705]
1 : [1.209, 48.885, 0.004, 3.533, 72.123, 222.75, 3.861, 75.278] : [2744907.782, 0.73]
2 : [1.046, 82.509, 0.003, 3.563, 64.955, 221.122, 3.767, 69.93] : [1996852.175, 0.691]
3 : [1.136, 50.596, 0.003, 5.0, 70.52, 237.629, 4.0, 71.612] : [2226176.648, 0.725]
4 : [1.167, 51.893, 0.004, 4.729, 73.38, 235.131, 3.516, 82.557] : [2263371.871, 0.727]
5 : [1.151, 50.7, 0.003, 4.256, 71.392, 232.706, 3.987, 74.646] : [2290138.743, 0.727]


Total Flow V08BAR111370
Simulated_initial
Gauged
0: NSE = 0.477
1: NSE = 0.583
2: NSE = 0.352
3: NSE = 0.562
4: NSE = 0.553
5: NSE = 0.566
Flow [m3/s]
Time
1998
1999
2000
2001
2002
2003


Cumulative Total Flow V08BAR111370
1e8
Gauged
Simulated_initial
0: AbsErr = 2021986.716
1: AbsErr = 2744907.782
2: AbsErr = 1996852.175
3: AbsErr = 2226176.648
4: AbsErr = 2263371.871
5: AbsErr = 2290138.743
Cumul. Volumes [m3]
Time
1998
1999
2000
2001
2002
2003

9.5.2 Report on simulation of catchment V08Dij093400 (2017-02-07 21-53)

9.5.2.1 Input data

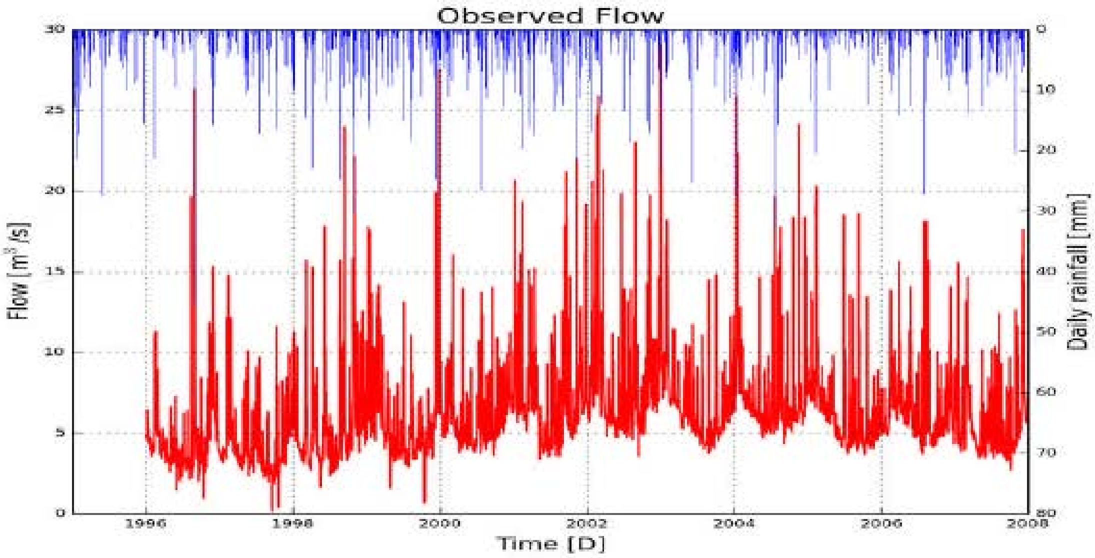


Figure 1: Hyetogram of observed discharge and observed net rain

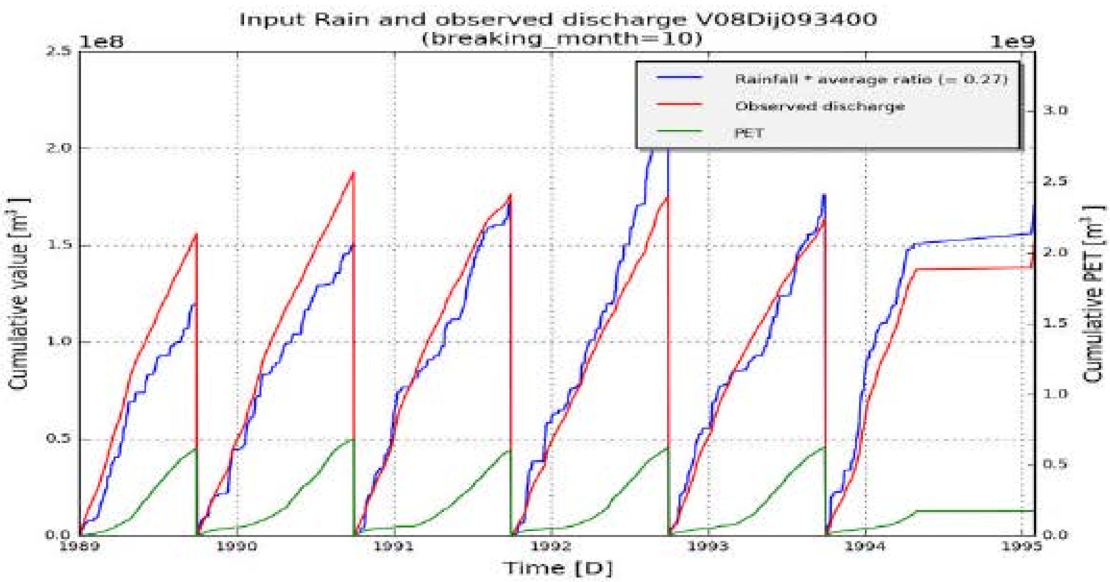


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.2.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	V08Dij093400
subcatchment_area	886900000
start_date	197401010000
end_date	198912310000
frequency	86400
warmup	365

9.5.2.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.25, 8.0, 0.0011, 1.15, 160.0, 420.0, 5.0, 200.0]
low_bounds	[0.5, 4.0, 0.0006, 0.5, 80.0, 150.0, 2.5, 100.0]
high_bounds	[2.5, 100.0, 0.01, 4.0, 270.0, 700.0, 8.0, 400.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.25), ('Ki', 8.0), ('Kg', 0.0011), ('Kss', 1.15), ('g0', 160.0), ('g_max', 420.0), ('K_run', 5.0), ('P_max', 200.0)]
Initial fitness:

- RelErr: 0.229
- AbsErr: 314708596.549
- KGE: 0.497
- NS_rel: 0.02
- NS: -0.162
- RMSE: 361040911.46
- NS_log: 0.209

Computation time:4:44:56.569000

9.5.2.4 Results

Best individual (euclidian): [('Kep', 1.287), ('Ki', 8.919), ('Kg', 0.001), ('Kss', 0.9), ('g0', 163.474), ('g_max', 444.791), ('K_run', 6.82), ('P_max', 206.157)]

Fitness:

- RelErr: -0.011
- AbsErr: 28571655.282
- KGE: 0.679
- NS_rel: 0.569
- NS: 0.329
- RMSE: 39402161.81
- NS_log: 0.394

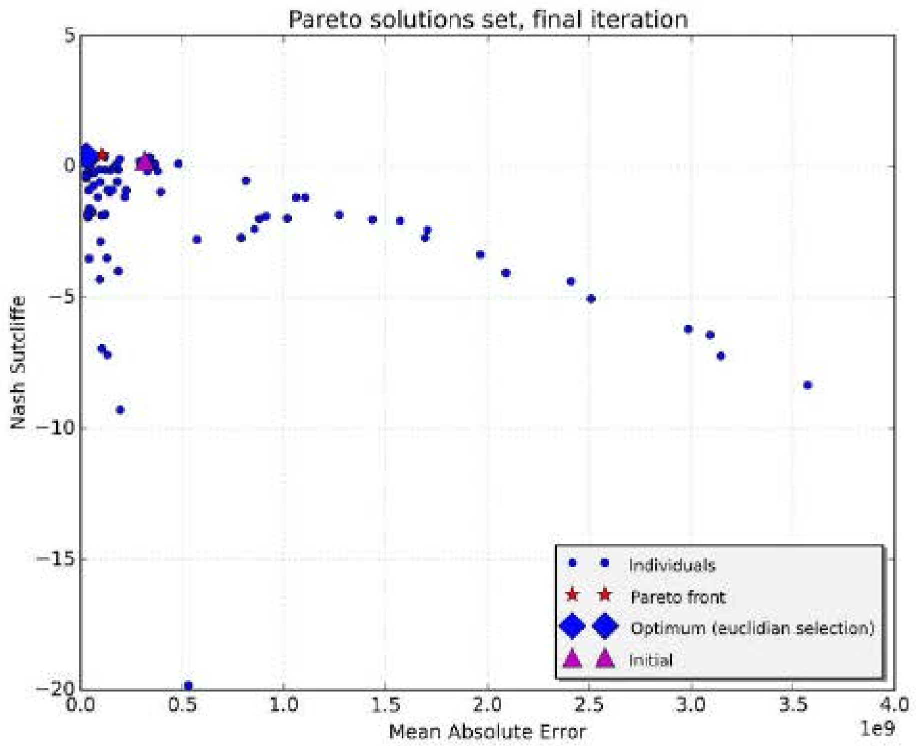


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

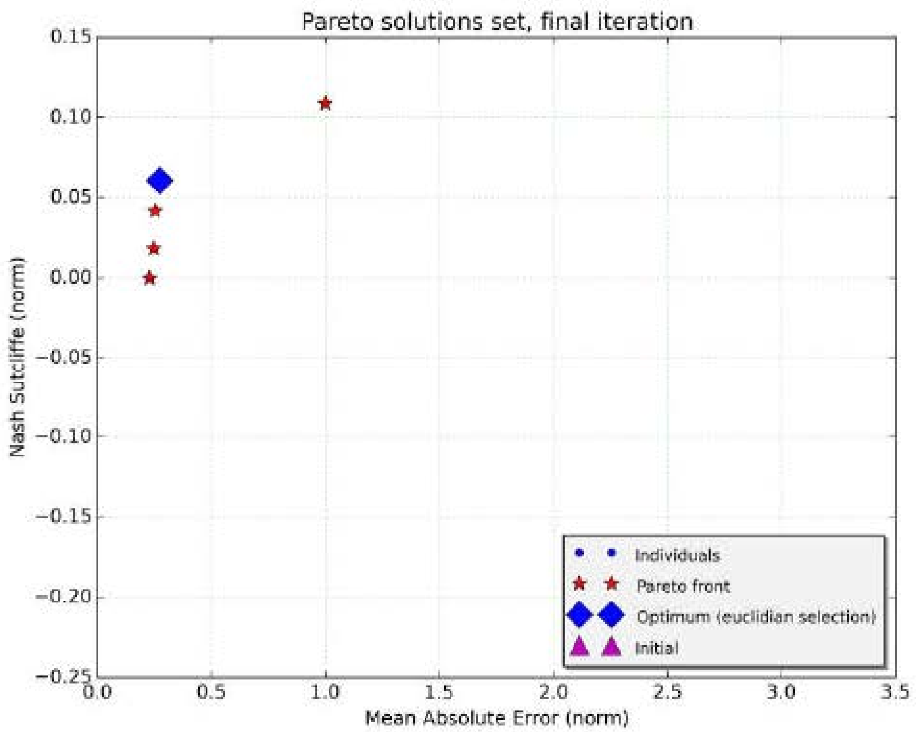


Figure 4: Final population of solutions (Pareto front)

9.5.2.4.1 Initial

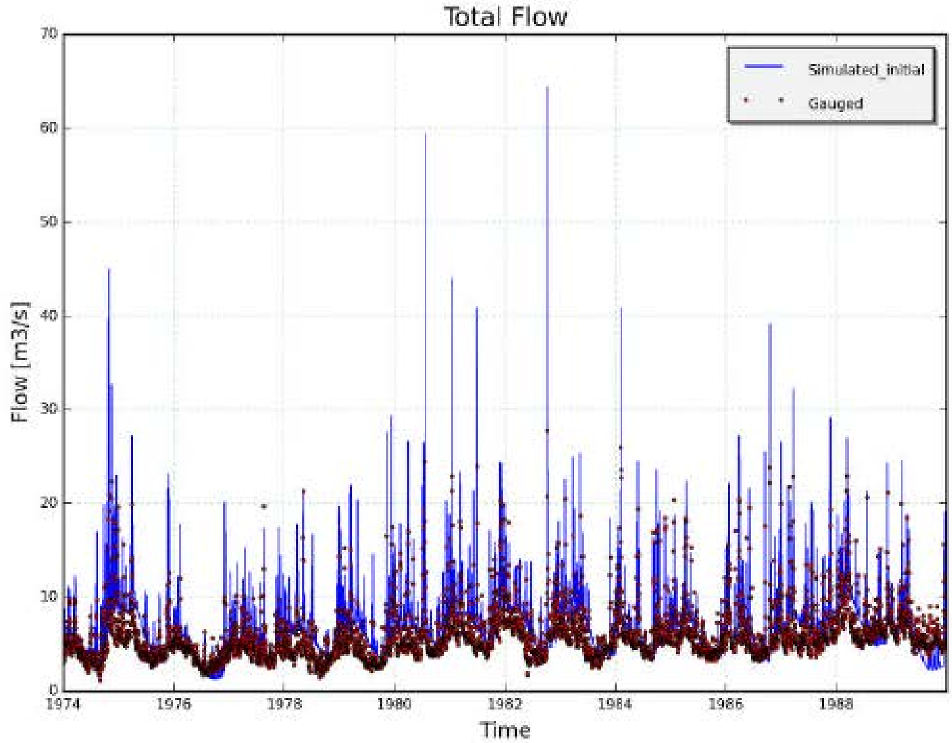


Figure 5: Total flow with initial parameters

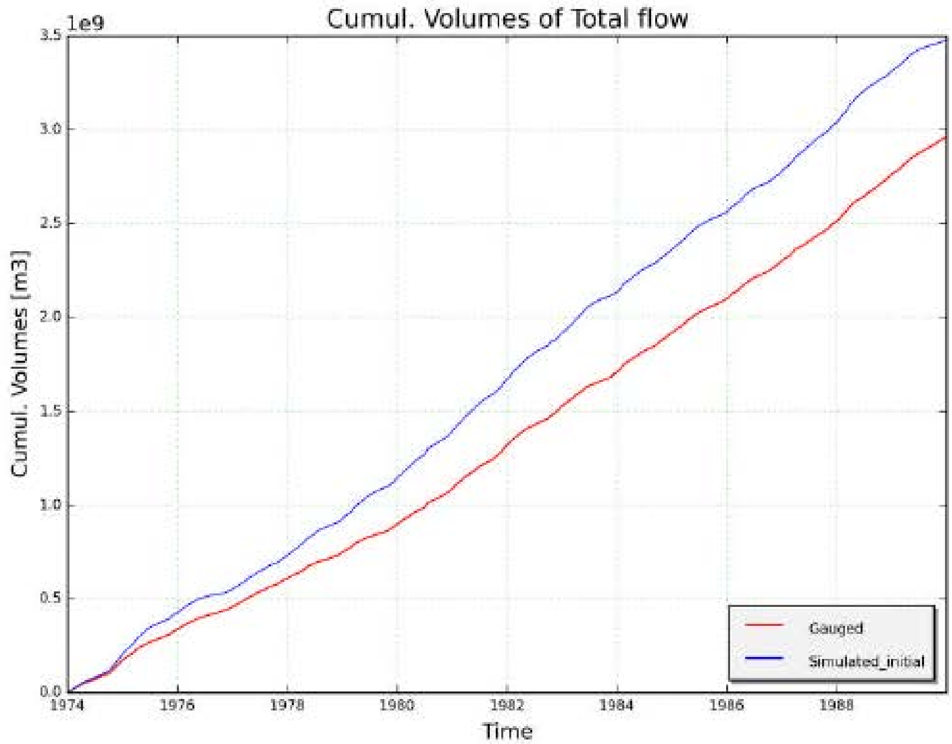


Figure 6: Cumulated flow with initial parameters

9.5.2.4.2 Optimum (euclidian)

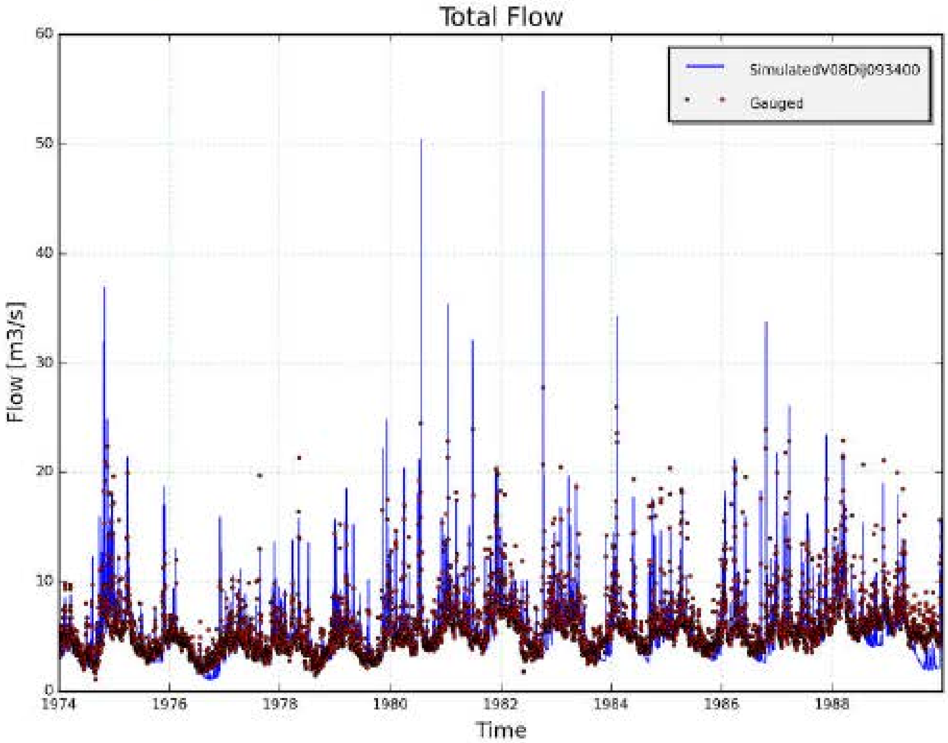


Figure 7: Total flow with optimum parameters

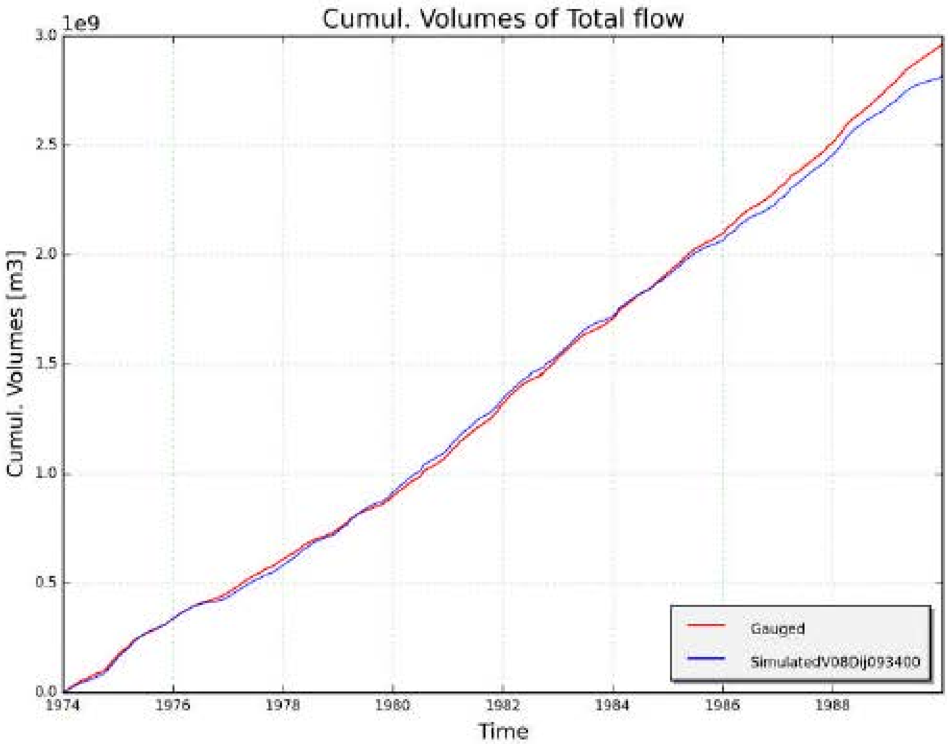
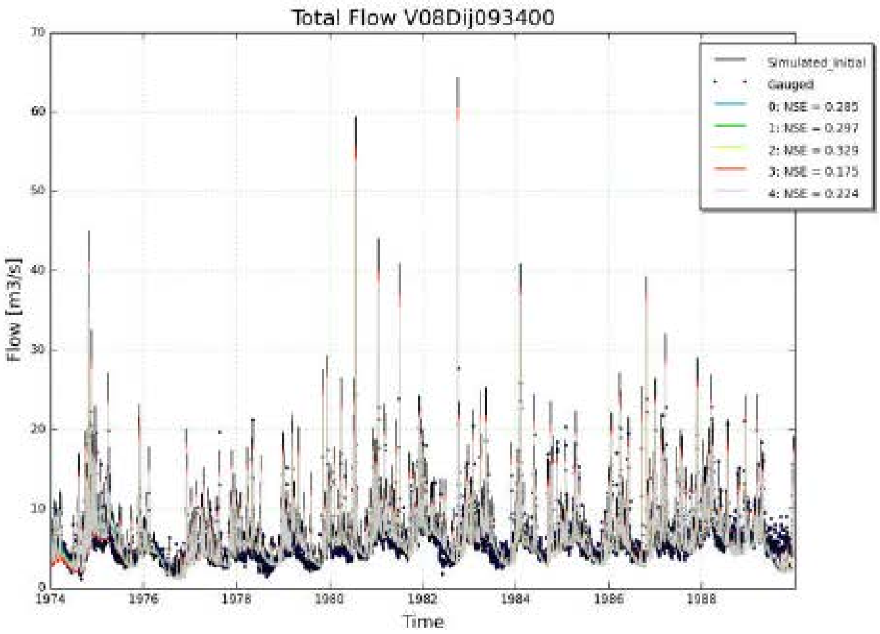
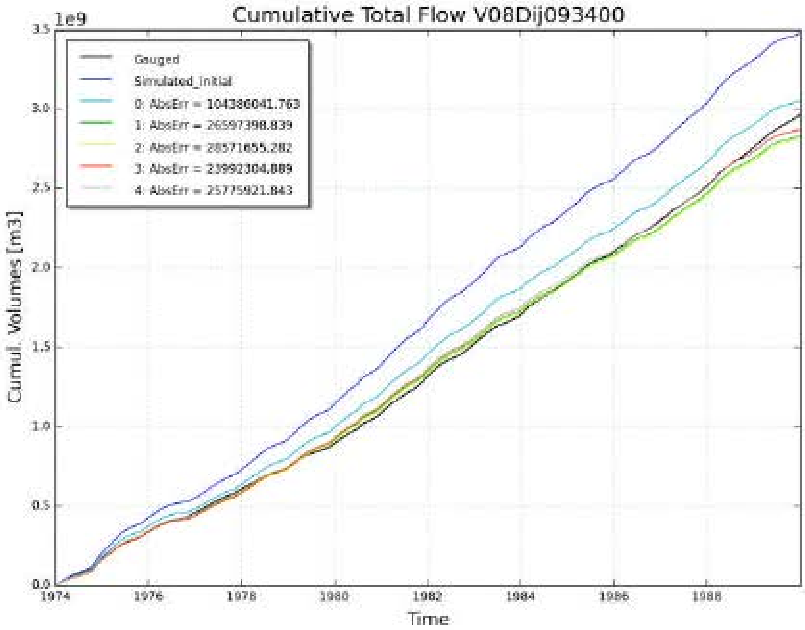


Figure 8: Cumulated flow with optimum parameters

9.5.2.4.3 Final archive

0 : [1.239, 9.506, 0.001, 1.775, 163.599, 422.11, 6.638, 205.998] : [104386041.763, 0.425]
1 : [1.266, 7.145, 0.001, 1.545, 169.824, 434.623, 6.287, 222.871] : [26597398.839, 0.382]
2 : [1.287, 8.919, 0.001, 0.9, 163.474, 444.791, 6.82, 206.157] : [28571655.282, 0.394]
3 : [1.252, 8.66, 0.001, 3.117, 165.019, 438.004, 5.652, 205.616] : [23992304.889, 0.355]
4 : [1.274, 8.796, 0.001, 1.114, 163.612, 439.357, 5.953, 205.002] : [25775921.843, 0.366]





9.5.3 Report on simulation of catchment V08ZUU233100 (2017-01-25 14-06)

9.5.3.1 Input data

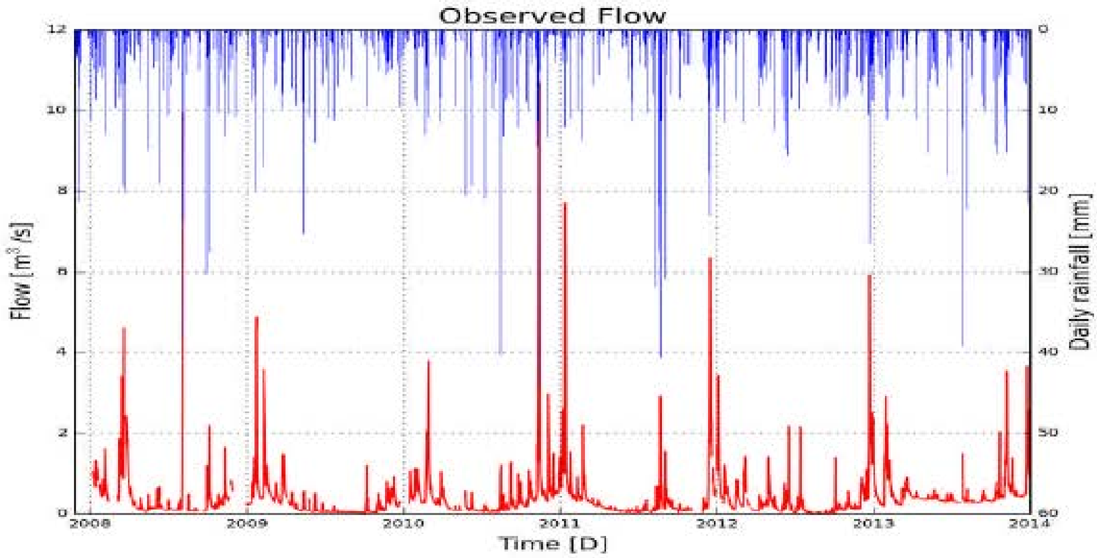


Figure 1: Hyetogram of observed discharge and observed net rain

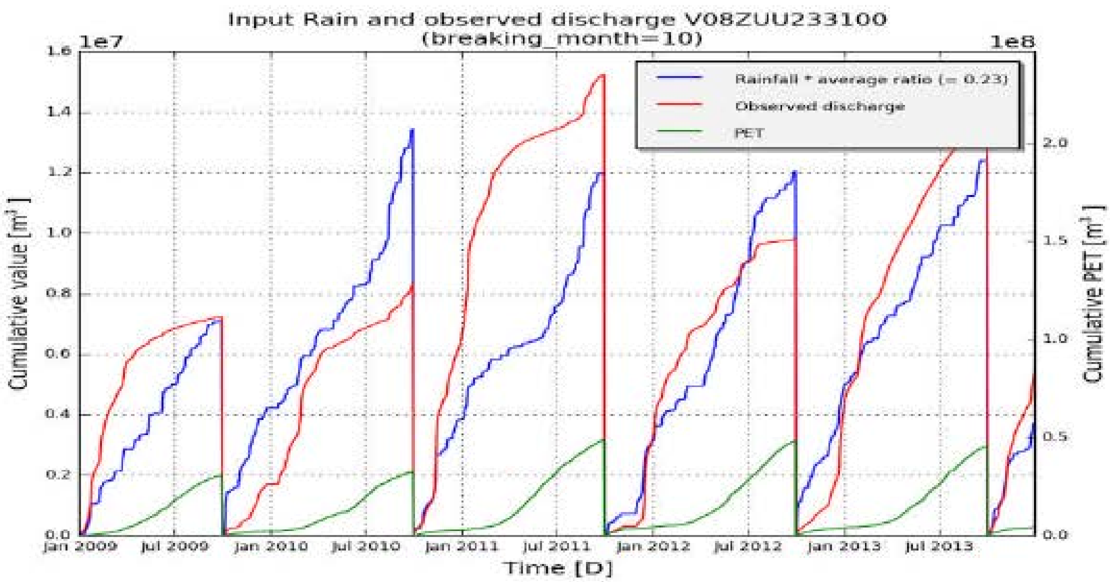


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.3.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	V08ZUU233100
subcatchment_area	64800000
start_date	199601010000
end_date	201212310000
frequency	86400
warmup	365

9.5.3.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.5, 15.0, 0.001, 1.09, 65.0, 300.0, 20.0, 100.0]
low_bounds	[0.75, 7.5, 0.0001, 0.3, 30.0, 150.0, 5.0, 50.0]
high_bounds	[2.2, 150.0, 0.01, 5.0, 250.0, 500.0, 30.0, 350.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.5), ('Ki', 15.0), ('Kg', 0.001), ('Kss', 1.09), ('g0', 65.0), ('g_max', 300.0), ('K_run', 20.0), ('P_max', 100.0)]
Initial fitness:

- RelErr: -0.221
- AbsErr: 27382656.751
- KGE: 0.504
- NS_rel: 0.511
- NS: 0.499
- RMSE: 32433973.136
- NS_log: 0.621

Computation time:20:38:06.097000

9.5.3.4 Results

Best individual (euclidian): [('Kep', 1.815), ('Ki', 20.332), ('Kg', 0.002), ('Kss', 0.7), ('g0', 177.183), ('g_max', 318.598), ('K_run', 20.735), ('P_max', 156.276)]

Fitness:

- RelErr: -0.055
- AbsErr: 7772100.411
- KGE: 0.628
- NS_rel: 0.343
- NS: 0.548
- RMSE: 9843064.996
- NS_log: 0.592

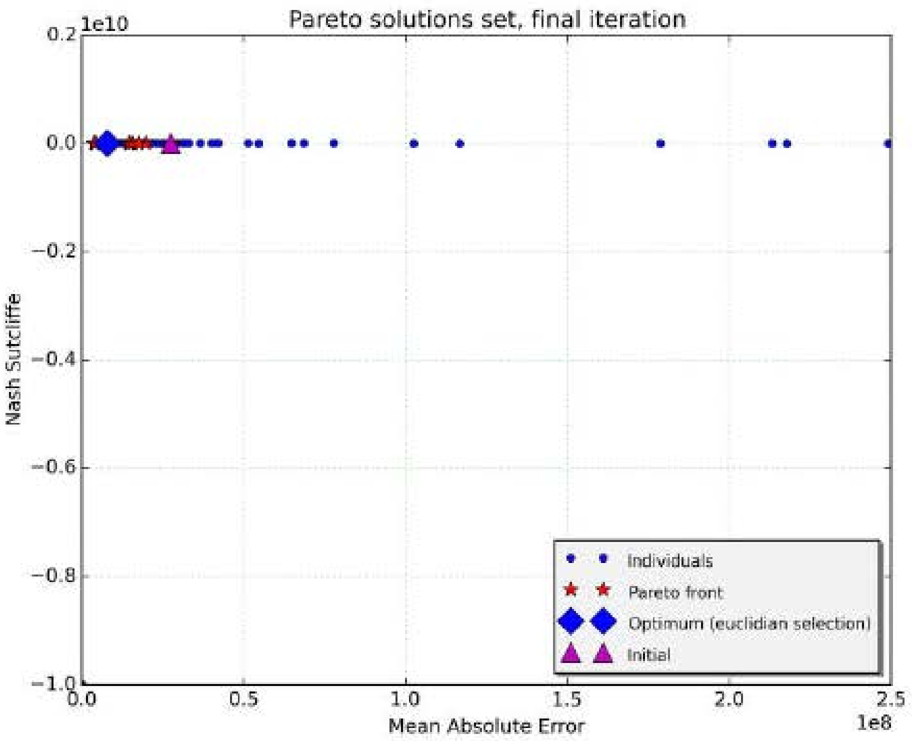


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

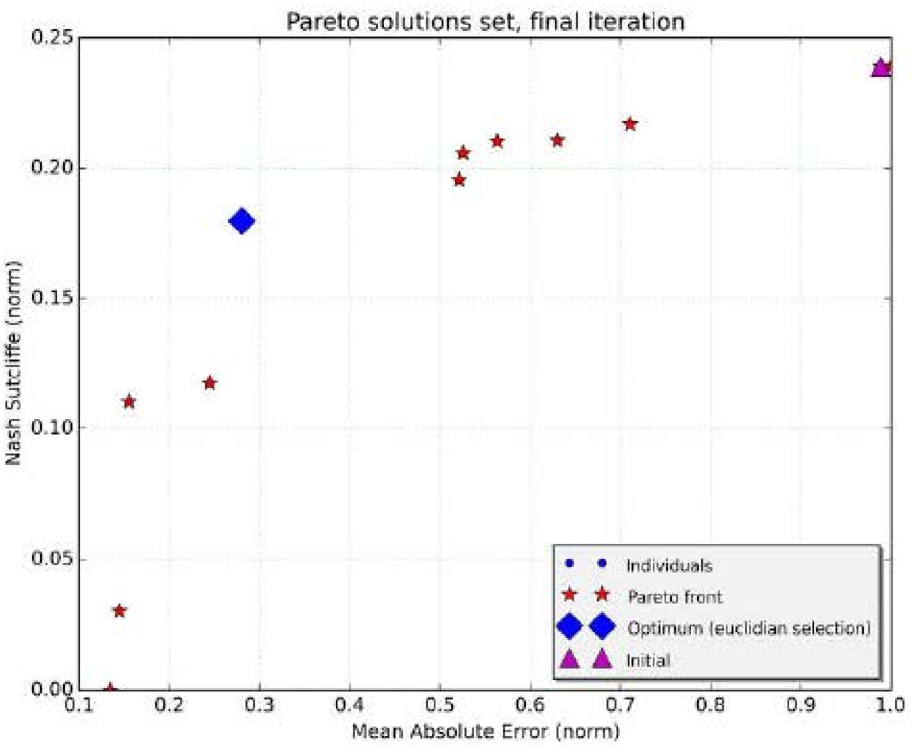


Figure 4: Final population of solutions (Pareto front)

9.5.3.4.1 Initial

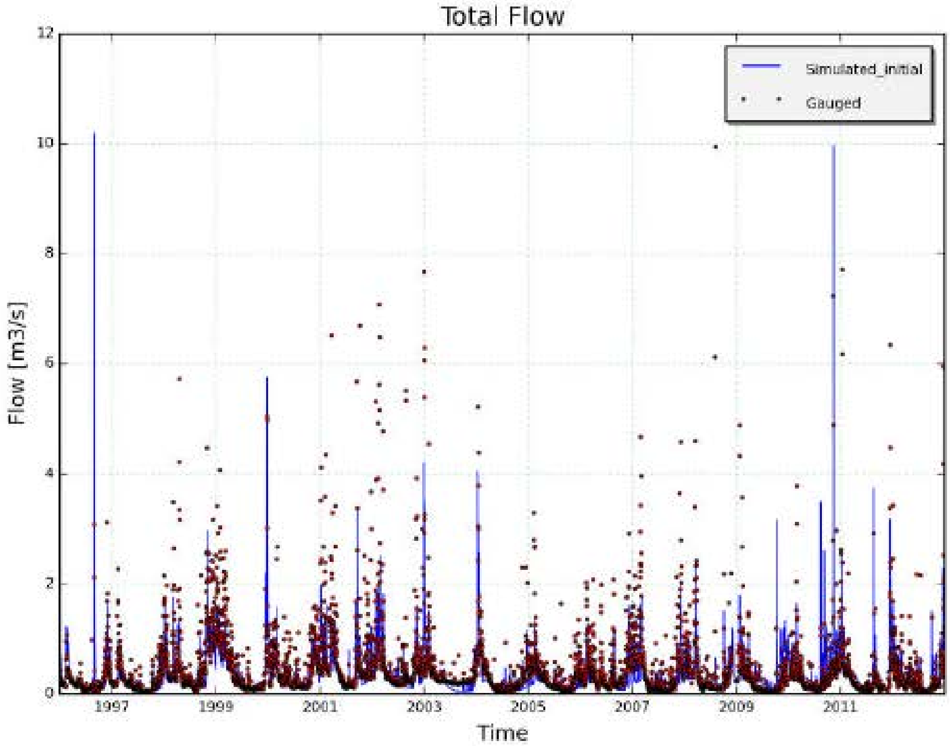


Figure 5: Total flow with initial parameters

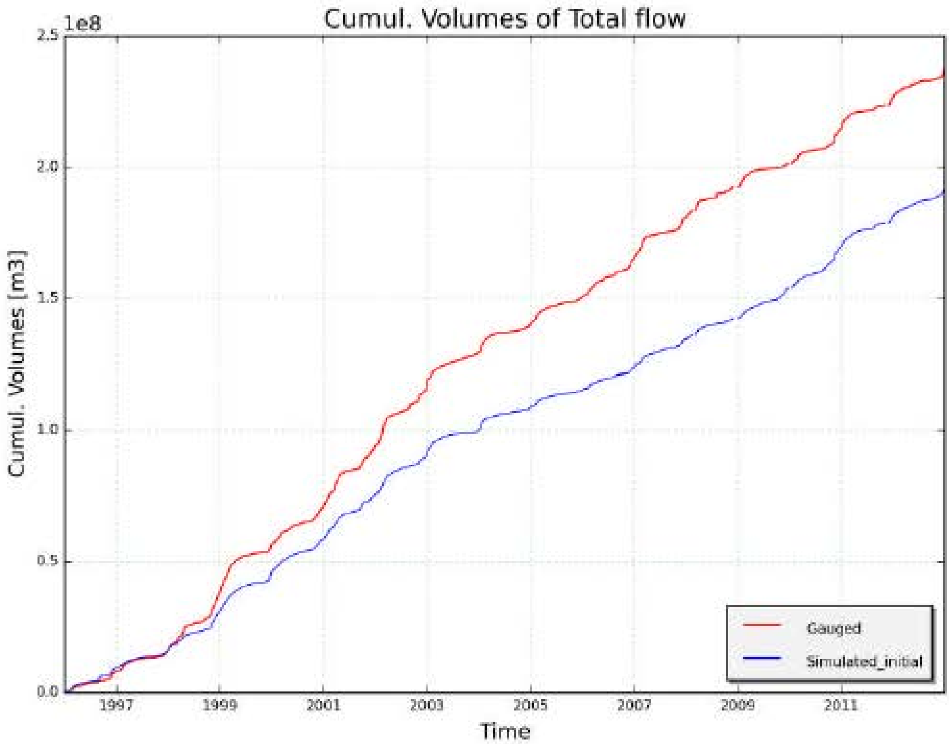


Figure 6: Cumulated flow with initial parameters

9.5.3.4.2 Optimum (euclidian)

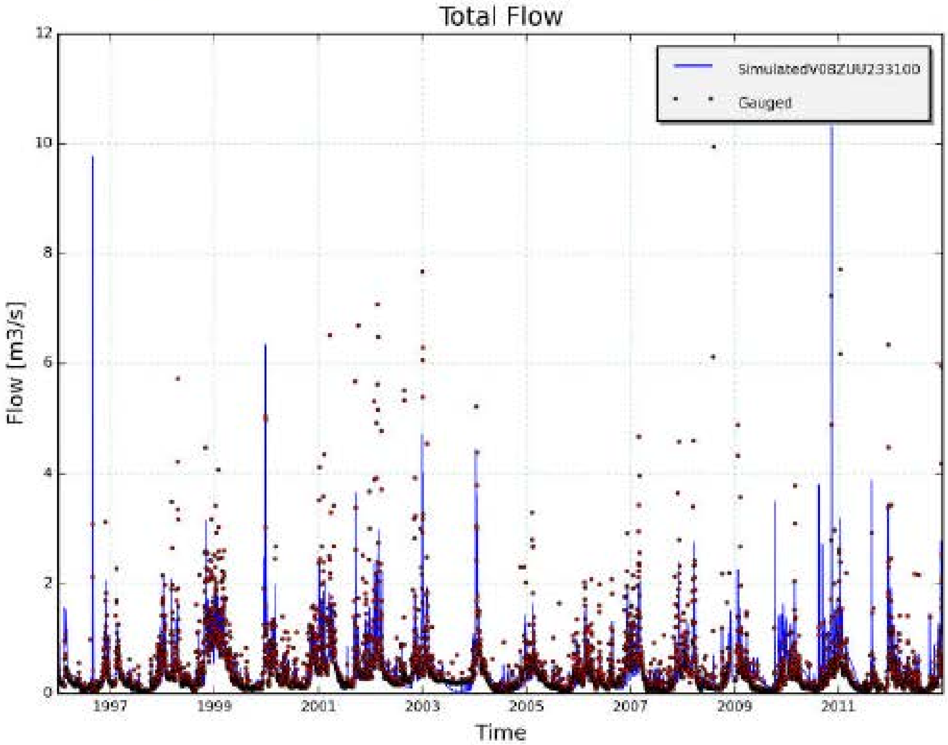


Figure 7: Total flow with optimum parameters

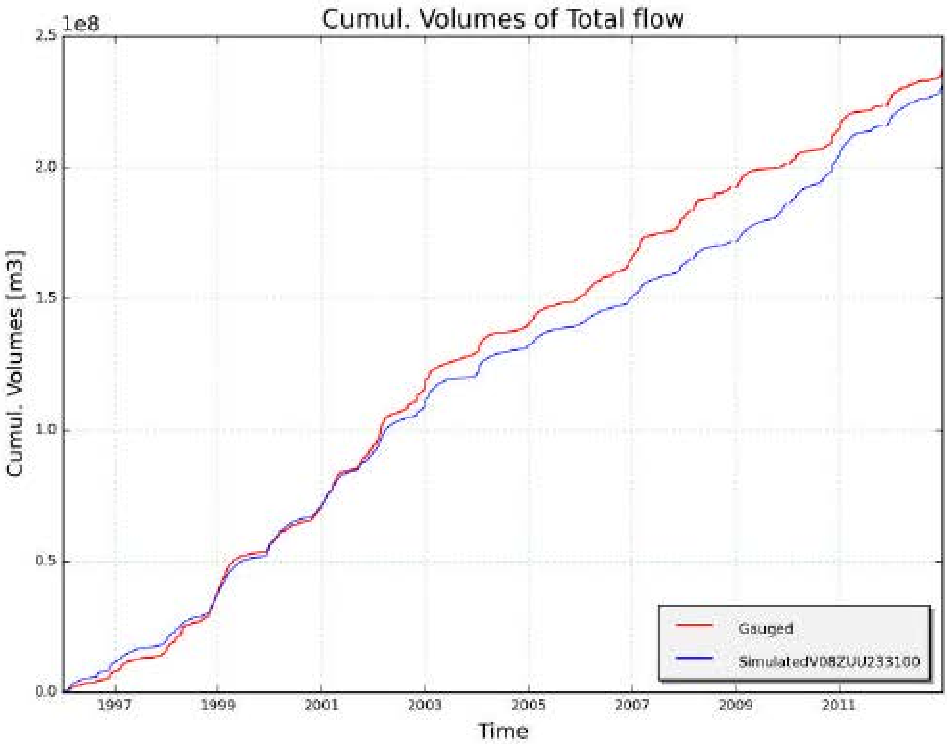


Figure 8: Cumulated flow with optimum parameters

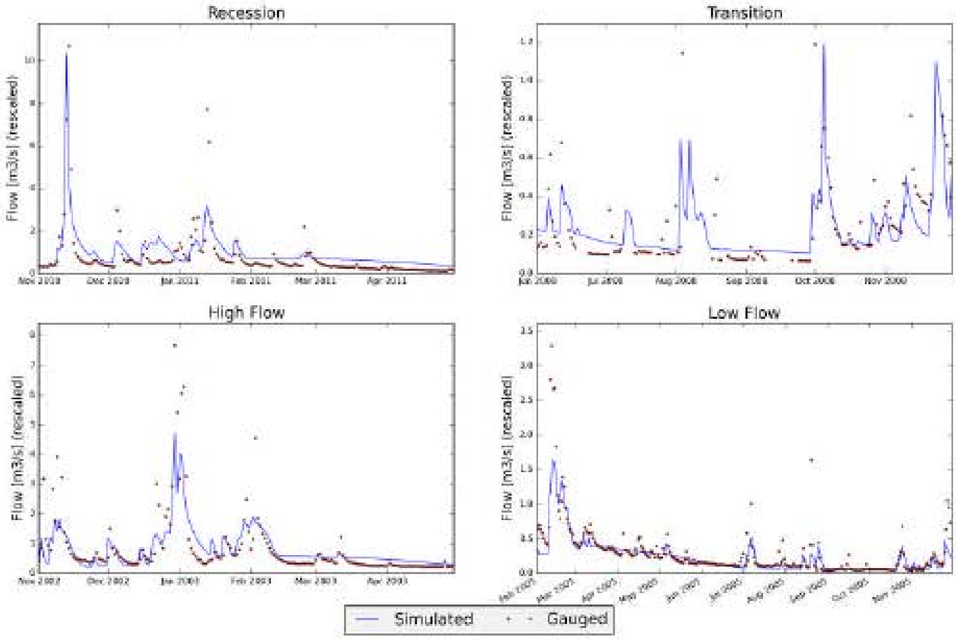


Figure 9: Total flow with optimum parameters (detail)

9.5.3.4.3 Final archive

0 : [1.5, 15.0, 0.001, 1.09, 65.0, 300.0, 20.0, 100.0] : [27382656.751, 0.621]

1 : [1.5, 14.736, 0.001, 1.099, 65.0, 300.028, 20.0, 100.0] : [27704639.265, 0.621]

2 : [1.399, 22.814, 0.001, 1.292, 70.641, 307.365, 19.928, 211.479] : [4305288.212, 0.557]

3 : [1.821, 19.703, 0.002, 1.122, 177.713, 318.286, 20.051, 141.477] : [14564983.901, 0.605]

4 : [1.815, 20.332, 0.002, 0.7, 177.183, 318.598, 20.735, 156.276] : [7772100.411, 0.592]

5 : [1.773, 60.954, 0.002, 0.765, 105.657, 305.603, 21.142, 172.995] : [3733400.906, 0.502]

6 : [1.875, 57.305, 0.002, 1.191, 108.19, 313.706, 20.956, 196.352] : [4011532.163, 0.517]

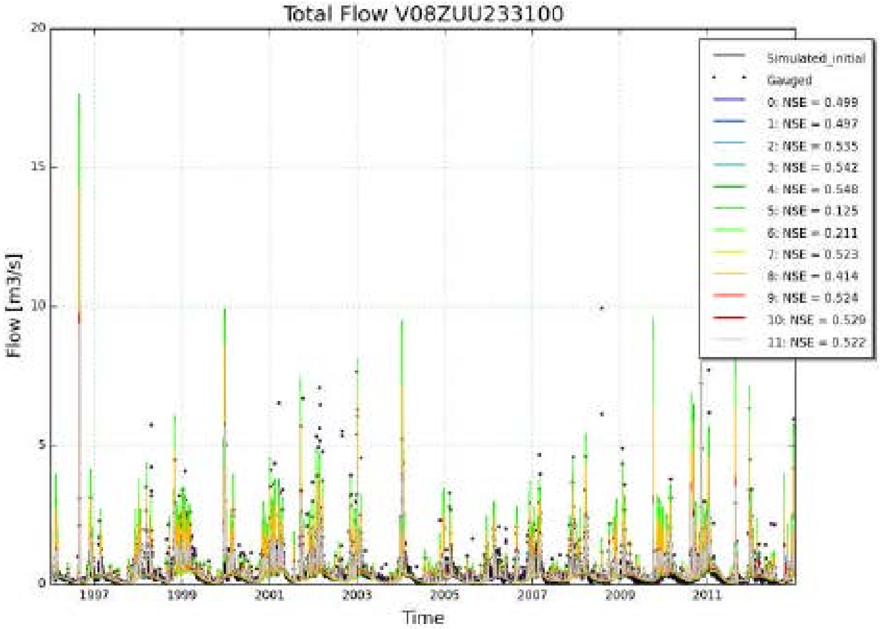
7 : [1.708, 15.603, 0.002, 0.623, 71.354, 302.298, 20.784, 119.669] : [19690472.641, 0.61]

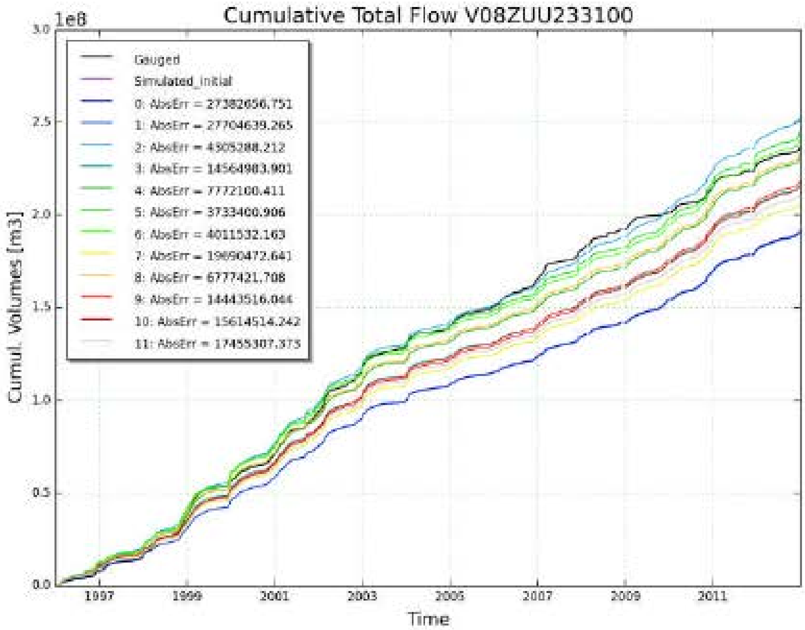
8 : [1.759, 41.434, 0.002, 0.3, 84.12, 305.448, 21.134, 158.148] : [6777421.708, 0.561]

9 : [1.504, 15.209, 0.001, 0.937, 70.722, 299.889, 20.003, 111.053] : [14443516.044, 0.599]

10 : [1.473, 15.962, 0.001, 1.068, 68.044, 301.891, 21.865, 116.609] : [15614514.242, 0.607]

11 : [1.663, 15.205, 0.002, 0.3, 70.852, 300.826, 20.046, 113.961] : [17455307.373, 0.607]


Total Flow V08ZUU233100
Flow [m3/s]
Time
Simulated_initial
Gauged
0: NSE = 0.499
1: NSE = 0.497
2: NSE = 0.535
3: NSE = 0.542
4: NSE = 0.548
5: NSE = 0.125
6: NSE = 0.211
7: NSE = 0.523
8: NSE = 0.414
9: NSE = 0.524
10: NSE = 0.520
11: NSE = 0.522


Cumulative Total Flow V08ZUU233100
1e8
Cumul. Volumes [m3]
Time
Gauged
Simulated_initial
0: AbsErr = 27382656.751
1: AbsErr = 27704639.265
2: AbsErr = 4905288.212
3: AbsErr = 14564983.901
4: AbsErr = 7772100.411
5: AbsErr = 3733400.906
6: AbsErr = 4011532.163
7: AbsErr = 19690472.641
8: AbsErr = 6777421.708
9: AbsErr = 14443516.044
10: AbsErr = 15614514.242
11: AbsErr = 17455307.373

9.5.4 Report on simulation of catchment W08SAMRON000 (2017-01-19 06-32)

9.5.4.1 Input data

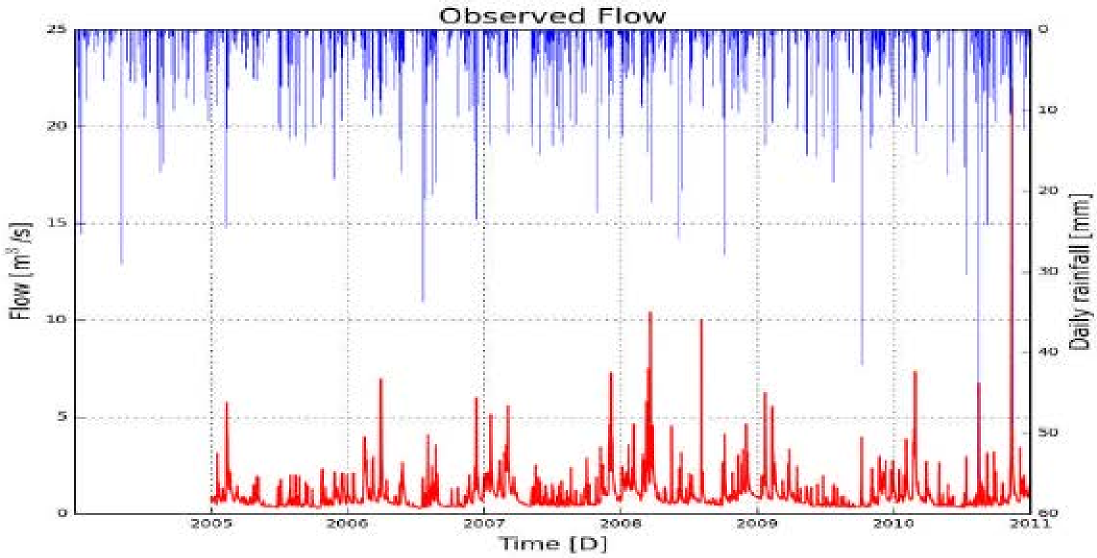


Figure 1: Hyetogram of observed discharge and observed net rain

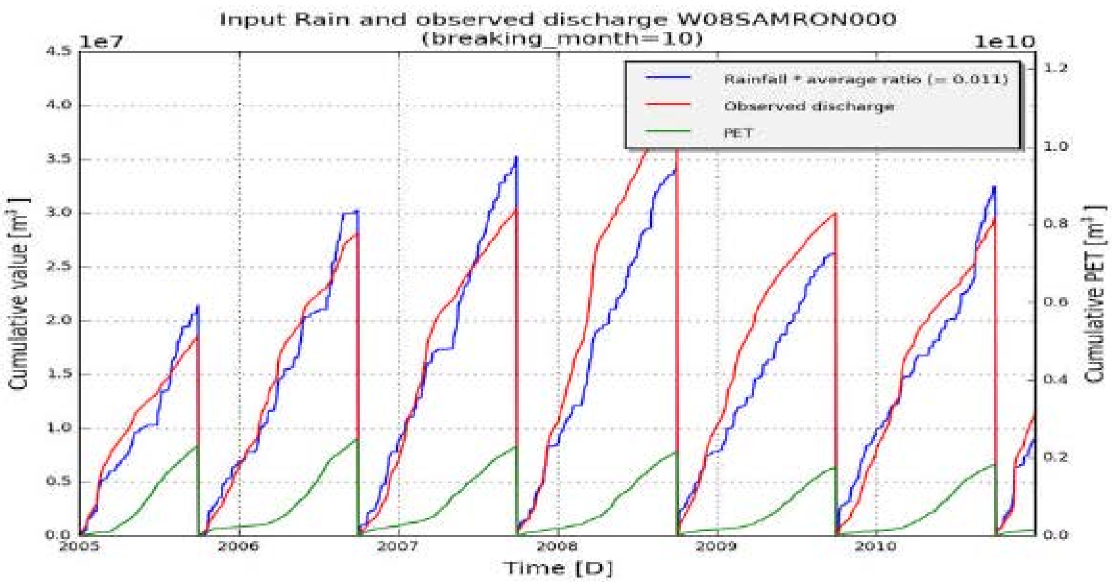


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.4.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	W08SAMRON000
subcatchment_area	133600000
start_date	200501010000
end_date	201012310000
frequency	86400
warmup	365

9.5.4.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.71218, 1.0, 0.0007, 1.6213, 250.0, 601.005, 5.0, 199.765]
low_bounds	[1.36, 0.8, 0.00056, 1.29, 200.0, 480.0, 4.0, 159.0]
high_bounds	[2.0, 1.2, 0.001, 1.9, 300.0, 721.0, 6.0, 240.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.71218), ('Ki', 1.0), ('Kg', 0.0007), ('Kss', 1.6213), ('g0', 250.0), ('g_max', 601.005), ('K_run', 5.0), ('P_max', 199.765)]
Initial fitness:

- RelErr: -0.083
- AbsErr: 7756471.832
- KGE: 0.853
- NS_rel: 0.799
- NS: 0.726
- RMSE: 9221529.454
- NS_log: 0.596

Computation time:12:37:32.669000

9.5.4.4 Results

Best individual (euclidian): [('Kep', 1.732), ('Ki', 1.2), ('Kg', 0.001), ('Kss', 1.701), ('g0', 249.661), ('g_max', 646.495), ('K_run', 5.148), ('P_max', 209.372)]

Fitness:

- RelErr: -0.005
- AbsErr: 2561488.406
- KGE: 0.846
- NS_rel: 0.765
- NS: 0.739
- RMSE: 3291212.191
- NS_log: 0.616

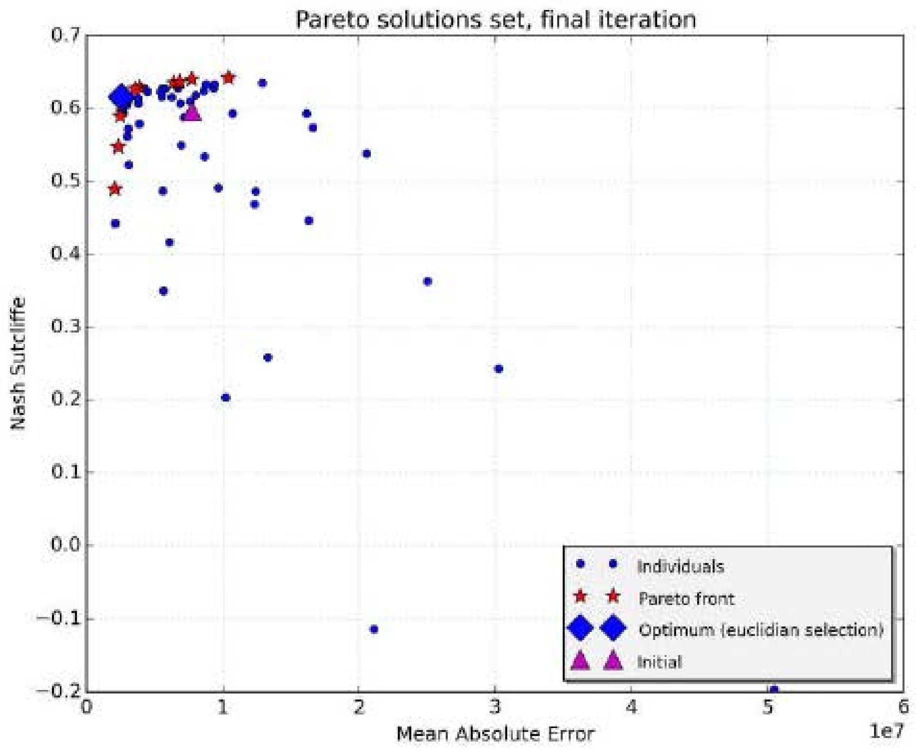


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

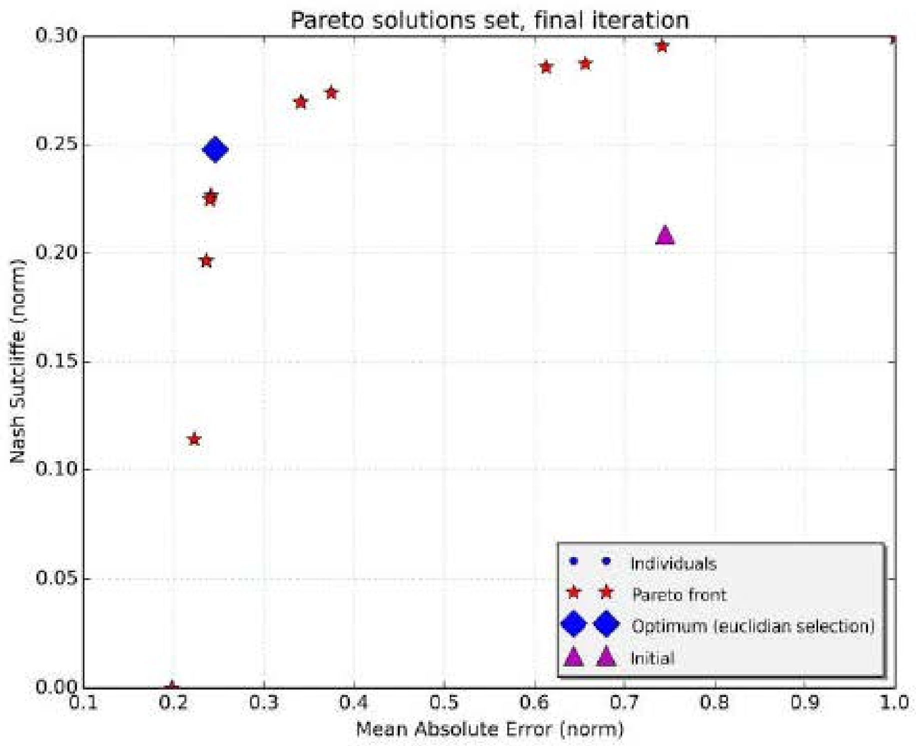


Figure 4: Final population of solutions (Pareto front)

9.5.4.4.1 Initial

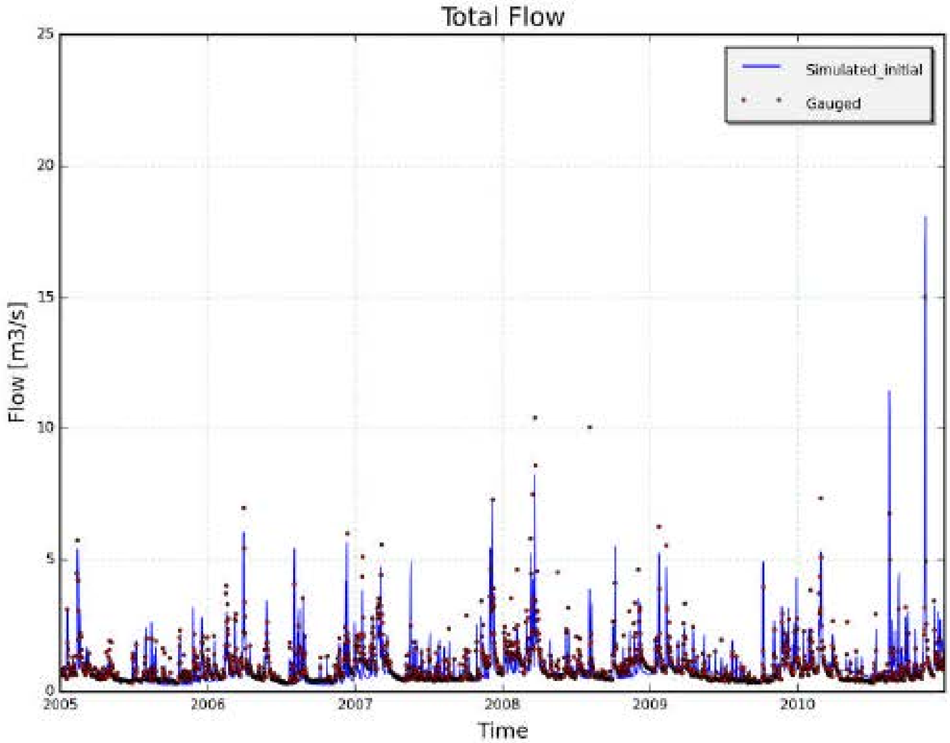


Figure 5: Total flow with initial parameters

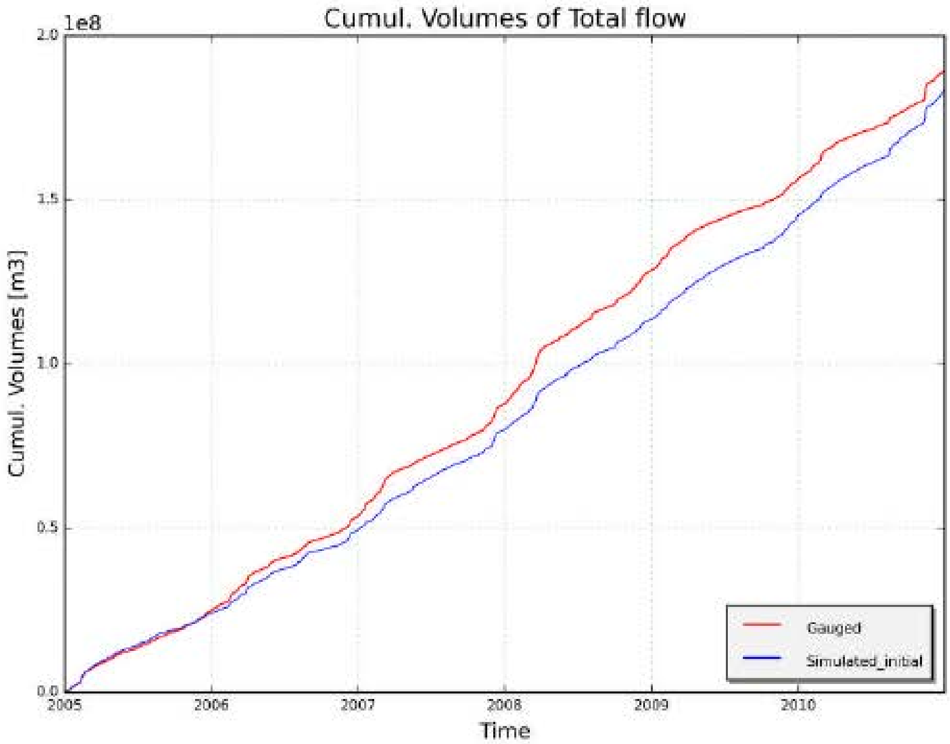


Figure 6: Cumulated flow with initial parameters

9.5.4.4.2 Optimum (euclidian)

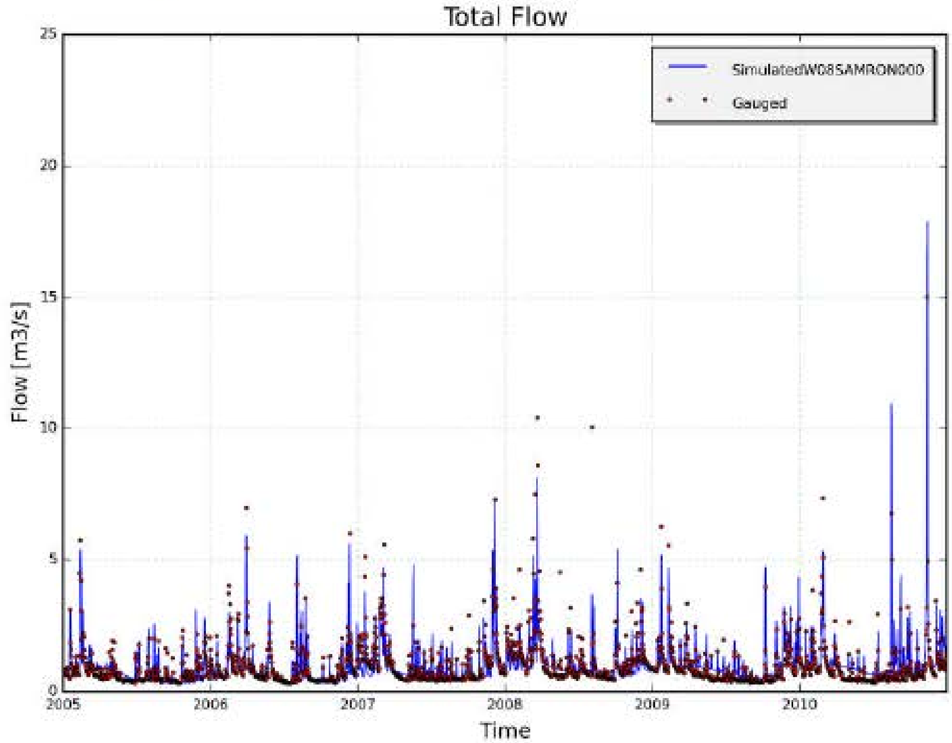


Figure 7: Total flow with optimum parameters

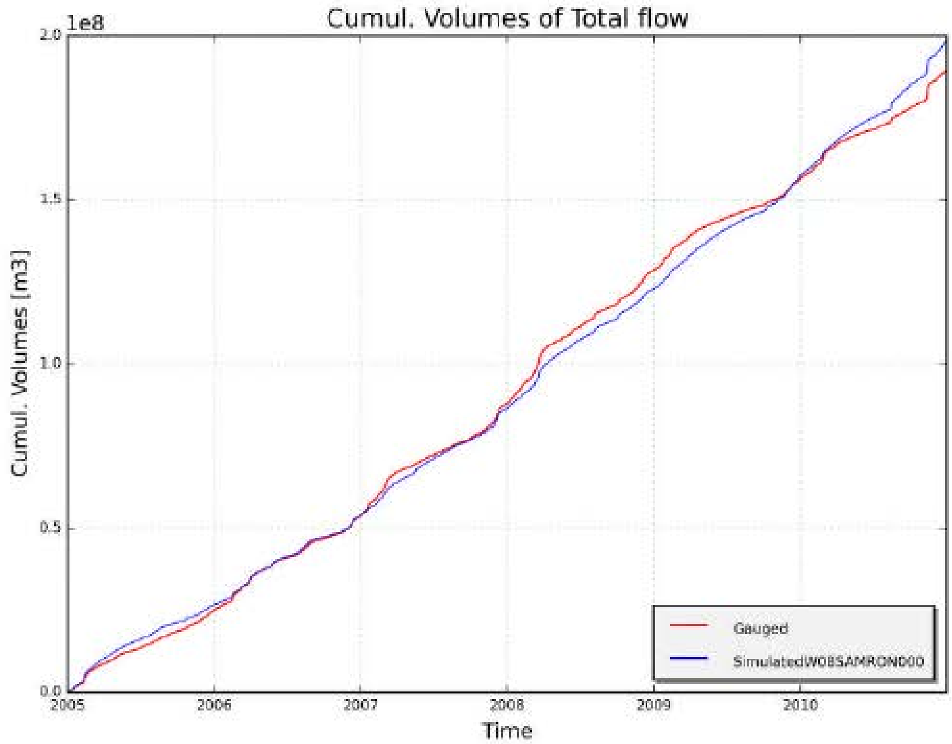


Figure 8: Cumulated flow with optimum parameters

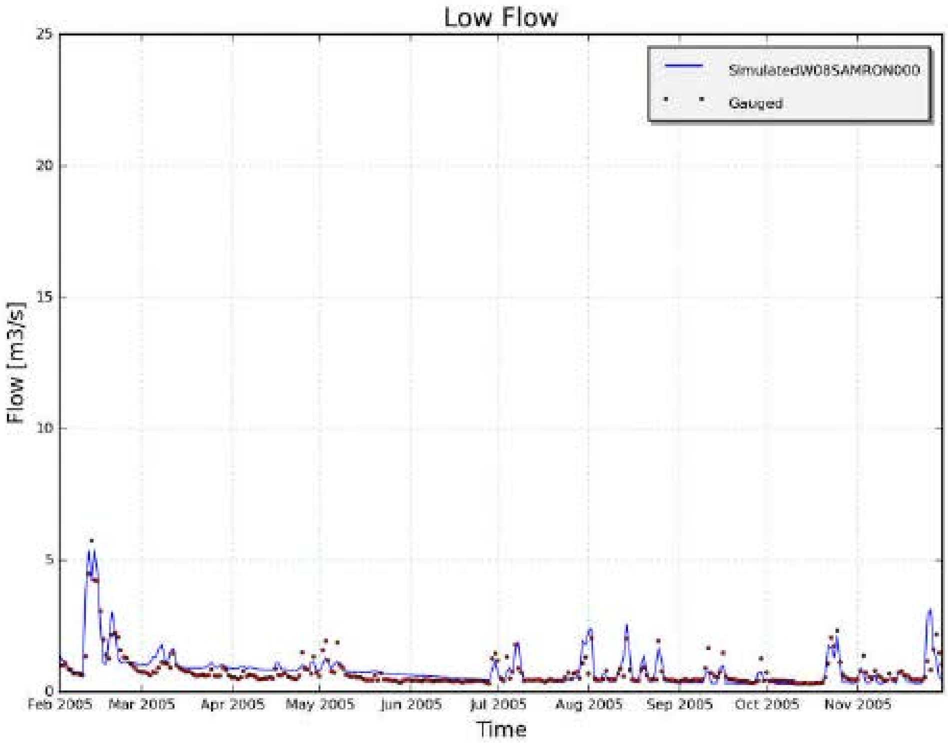


Figure 9: Total flow with optimum parameters (detail)

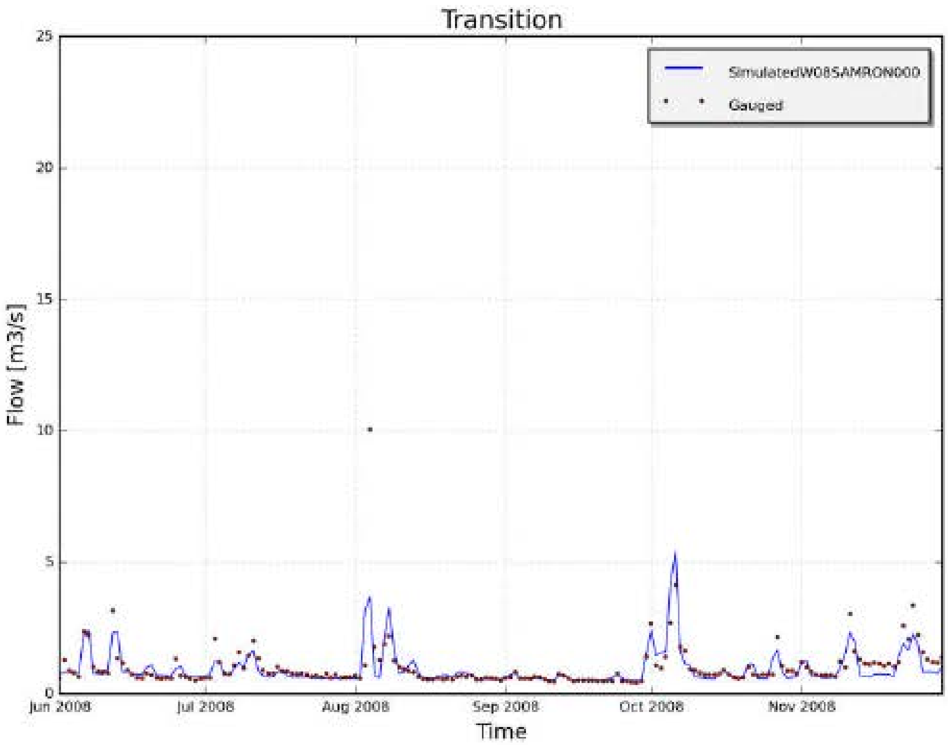
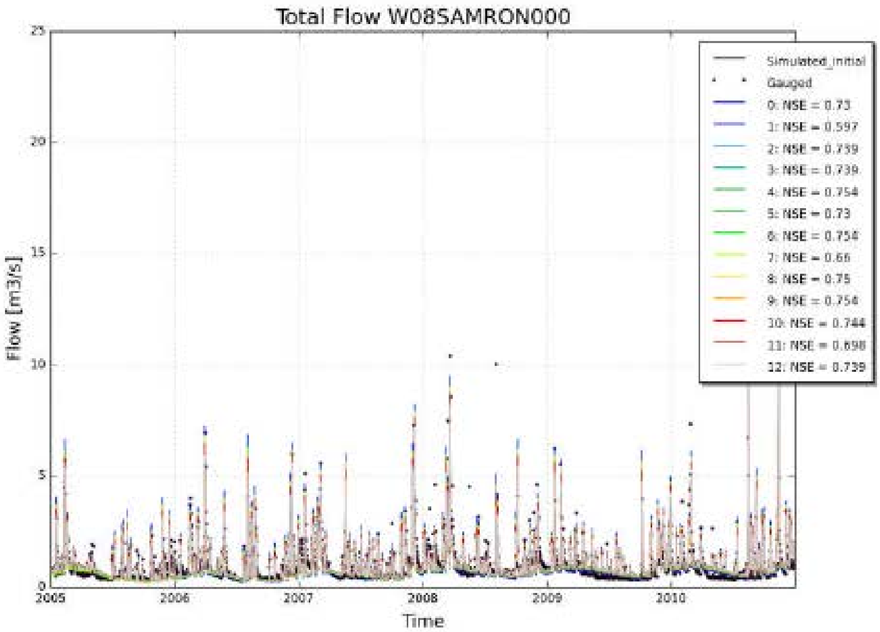
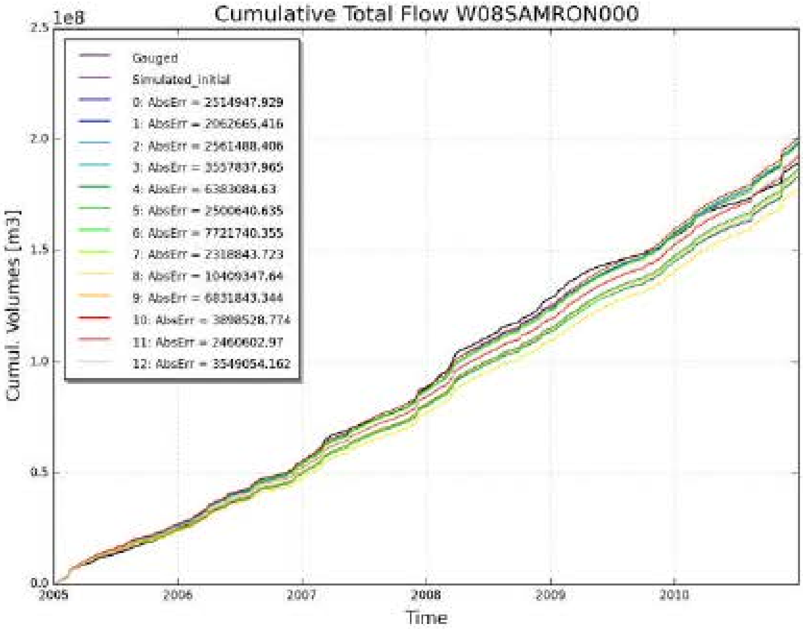


Figure 10: Total flow with optimum parameters (detail)

9.5.4.4.3 Final archive

0 : [1.71, 0.949, 0.001, 1.616, 255.108, 656.103, 5.04, 215.394] : [2514947.929, 0.605]
1 : [1.696, 0.8, 0.001, 1.895, 250.86, 647.369, 4.106, 224.641] : [2062665.416, 0.49]
2 : [1.732, 1.2, 0.001, 1.701, 249.661, 646.495, 5.148, 209.372] : [2561488.406, 0.616]
3 : [1.677, 1.2, 0.001, 1.767, 254.276, 638.772, 5.143, 219.357] : [3557837.965, 0.627]
4 : [1.735, 1.2, 0.001, 1.9, 251.831, 620.032, 5.509, 215.562] : [6383084.63, 0.635]
5 : [1.71, 0.949, 0.001, 1.9, 255.338, 658.048, 5.055, 216.434] : [2500640.635, 0.604]
6 : [1.718, 1.2, 0.001, 1.78, 253.802, 636.696, 5.544, 216.663] : [7721740.355, 0.64]
7 : [1.74, 0.8, 0.001, 1.29, 249.977, 656.943, 4.391, 215.196] : [2318843.723, 0.548]
8 : [1.727, 1.2, 0.001, 1.81, 254.788, 637.594, 6.0, 224.178] : [10409347.64, 0.642]
9 : [1.736, 1.2, 0.001, 1.9, 258.141, 621.3, 5.461, 226.997] : [6831843.344, 0.636]
10 : [1.711, 1.2, 0.001, 1.808, 254.28, 647.33, 5.217, 216.53] : [3898528.774, 0.629]
11 : [1.699, 0.956, 0.001, 1.868, 250.981, 644.628, 4.695, 218.762] : [2460602.97, 0.59]
12 : [1.677, 1.2, 0.001, 1.767, 253.887, 638.772, 5.143, 217.534] : [3549054.162, 0.627]





9.5.5 Report on simulation of catchment W08SENL56010 (2017-01-18 14-41)

9.5.5.1 Input data

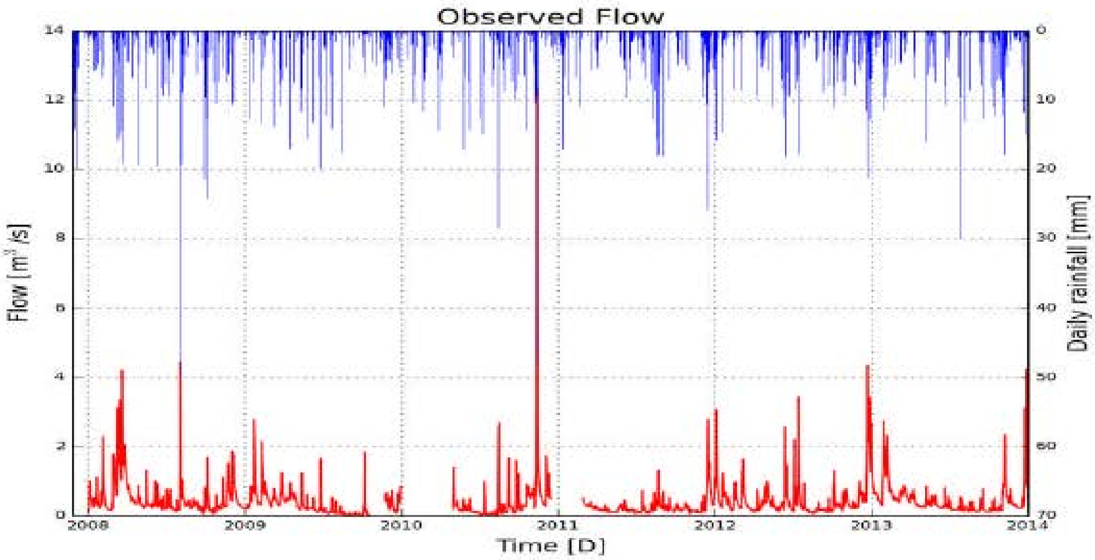


Figure 1: Hyetogram of observed discharge and observed net rain

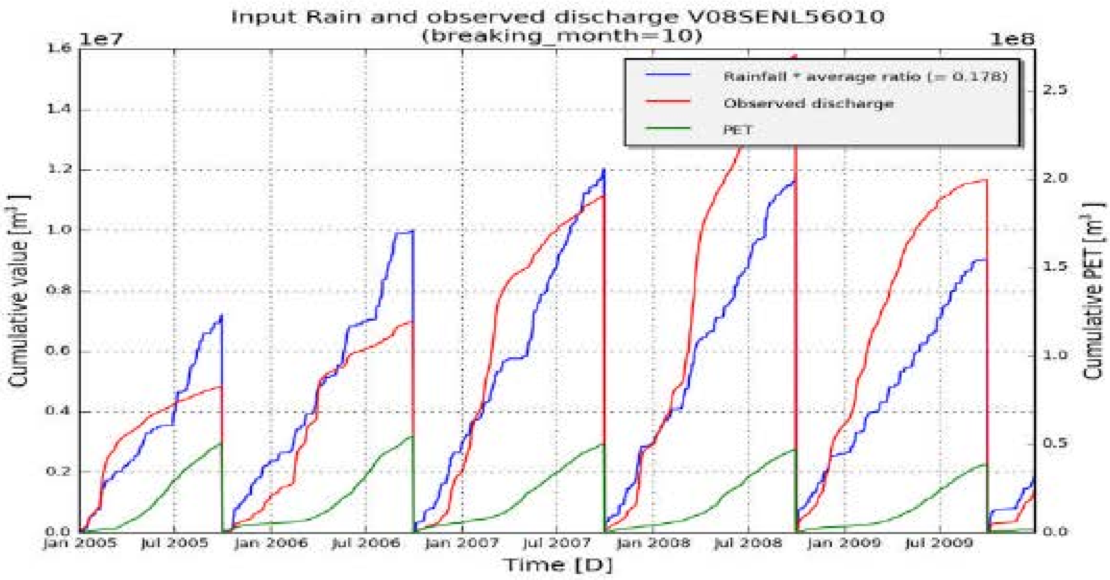


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.5.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	W08SENL56010
subcatchment_area	70400000
start_date	199101010000
end_date	199712310000
frequency	86400
warmup	365

9.5.5.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[1.36, 16.77, 0.0011, 1.407, 81.59, 278.0, 7.5, 167.0]
low_bounds	[1.088, 13.416, 0.0007, 1.12, 65.2, 222.4, 6.01, 133.6]
high_bounds	[1.63, 100.0, 0.01, 5.0, 200.0, 400.0, 9.0, 400.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.36), ('Ki', 16.77), ('Kg', 0.0011), ('Kss', 1.407), ('g0', 81.59), ('g_max', 278.0), ('K_run', 7.5), ('P_max', 167.0)]
Initial fitness:

- RelErr: -0.252
- AbsErr: 13994333.195
- KGE: 0.532
- NS_rel: 0.813
- NS: 0.471
- RMSE: 17400182.141
- NS_log: 0.059

Computation time:4:06:12.414000

9.5.5.4 Results

Best individual (euclidian): [('Kep', 1.258), ('Ki', 18.847), ('Kg', 0.002), ('Kss', 2.608), ('g0', 124.452), ('g_max', 284.293), ('K_run', 8.794), ('P_max', 268.346)]

Fitness:

- RelErr: 0.012
- AbsErr: 2420615.42
- KGE: 0.655
- NS_rel: 0.719
- NS: 0.54
- RMSE: 2659240.415
- NS_log: 0.454

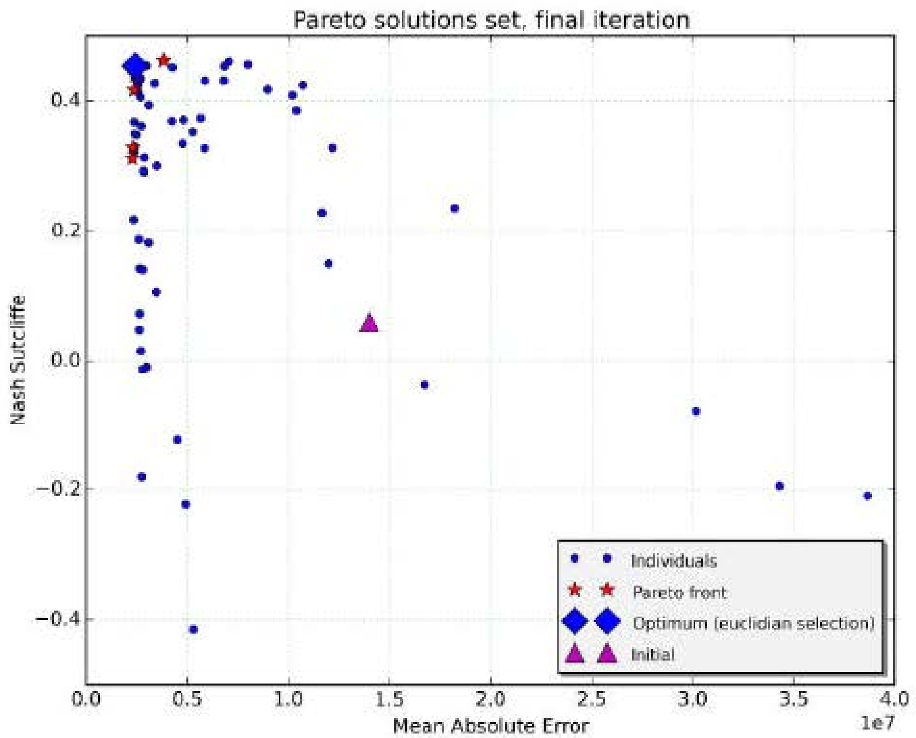


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

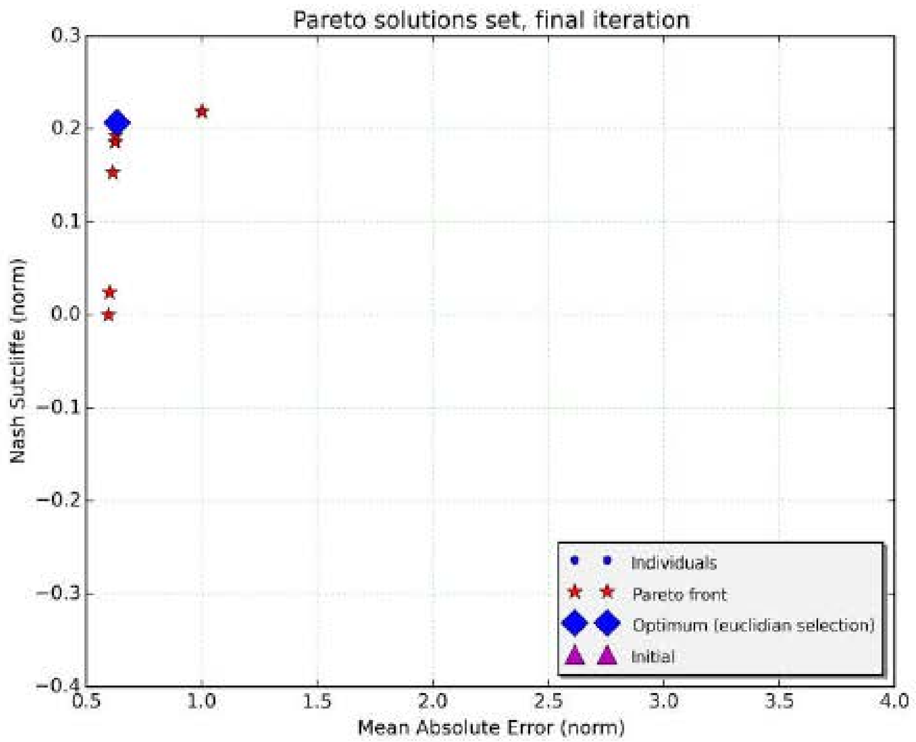


Figure 4: Final population of solutions (Pareto front)

9.5.5.4.1 Initial

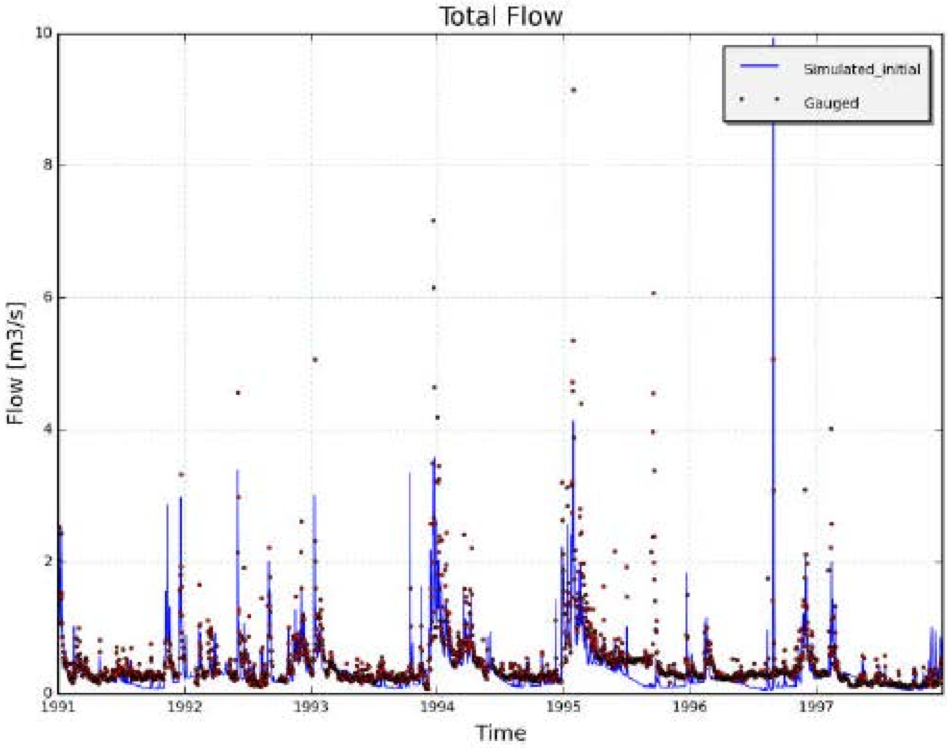


Figure 5: Total flow with initial parameters

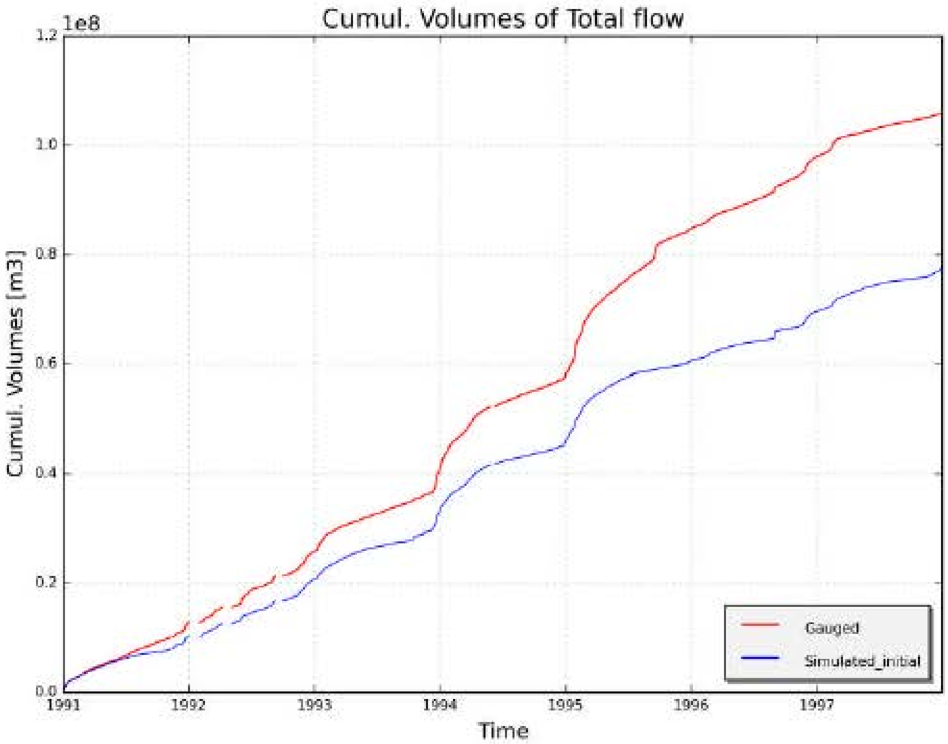


Figure 6: Cumulated flow with initial parameters

9.5.5.4.2 Optimum (euclidian)

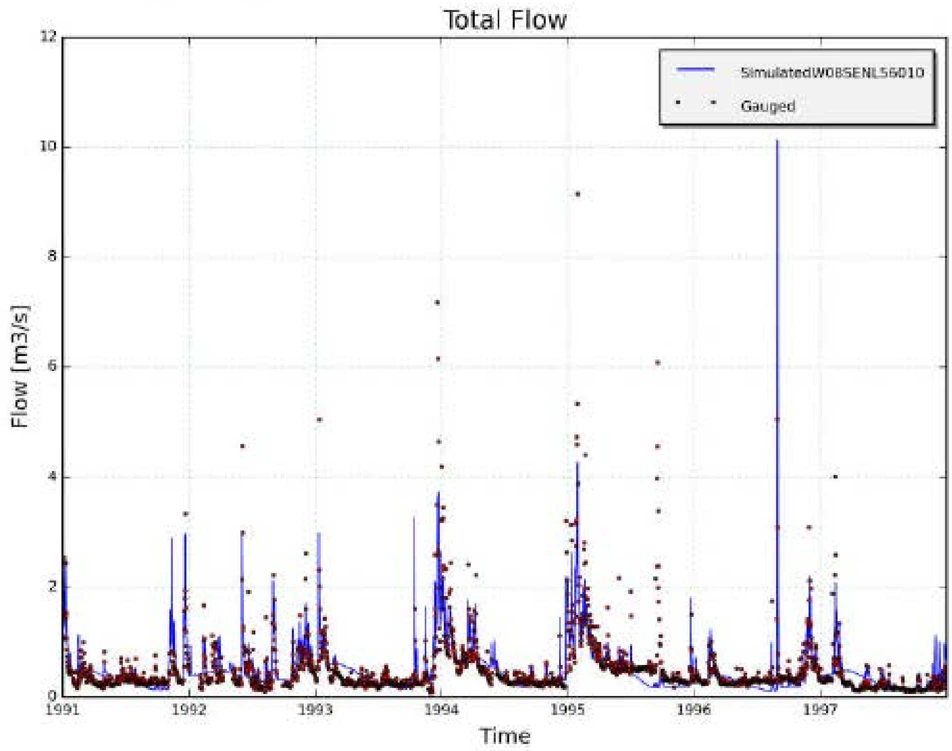


Figure 7: Total flow with optimum parameters

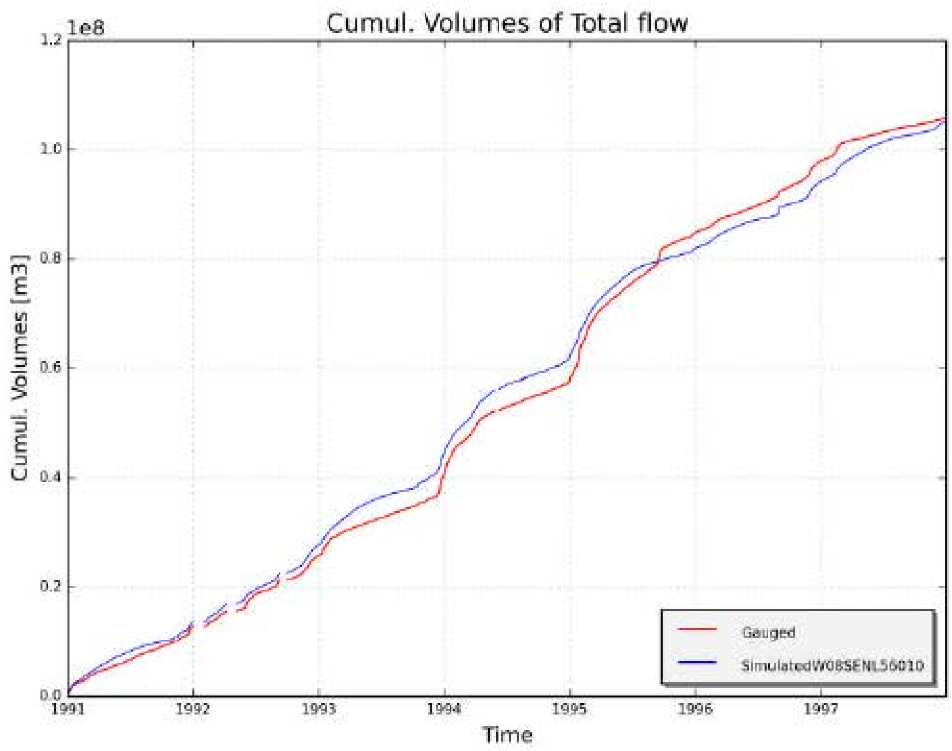
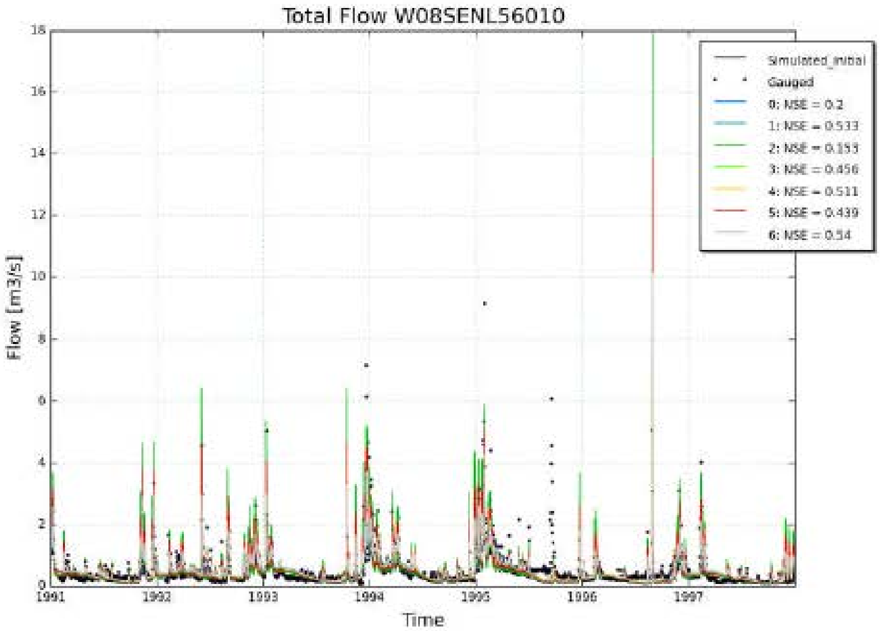
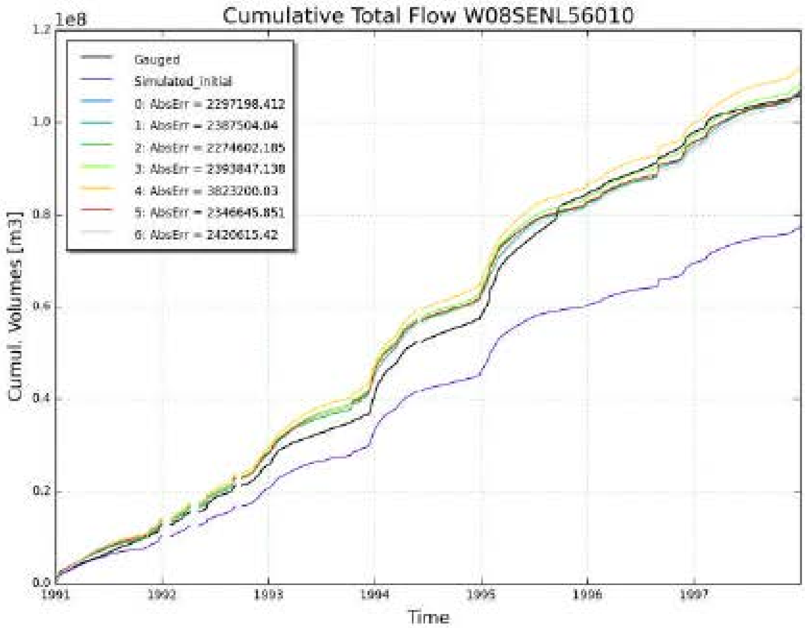


Figure 8: Cumulated flow with optimum parameters

9.5.5.4.3 Final archive

0 : [1.319, 58.491, 0.002, 2.089, 124.477, 323.782, 9.0, 284.158] : [2297198.412, 0.328]
1 : [1.215, 15.341, 0.002, 2.458, 122.507, 260.785, 8.487, 280.975] : [2387504.04, 0.439]
2 : [1.288, 58.564, 0.002, 3.152, 127.243, 313.977, 7.741, 279.615] : [2274602.185, 0.312]
3 : [1.279, 33.504, 0.002, 2.466, 124.615, 318.484, 8.15, 279.282] : [2393847.138, 0.444]
4 : [1.219, 24.986, 0.002, 2.398, 112.123, 297.676, 8.407, 283.978] : [3823200.03, 0.462]
5 : [1.258, 35.01, 0.002, 1.752, 123.965, 295.059, 8.228, 282.753] : [2346645.851, 0.417]
6 : [1.258, 18.847, 0.002, 2.608, 124.452, 284.293, 8.794, 268.346] : [2420615.42, 0.454]





9.5.6 Report on simulation of catchment W08SENTUB030 (2017-01-18 04-35)

9.5.6.1 Input data

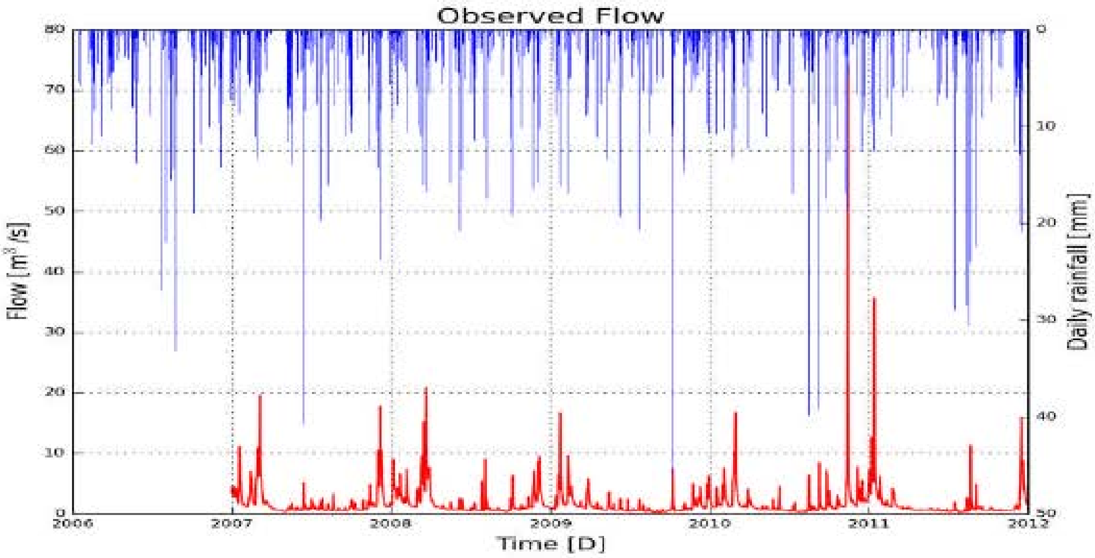


Figure 1: Hyetogram of observed discharge and observed net rain

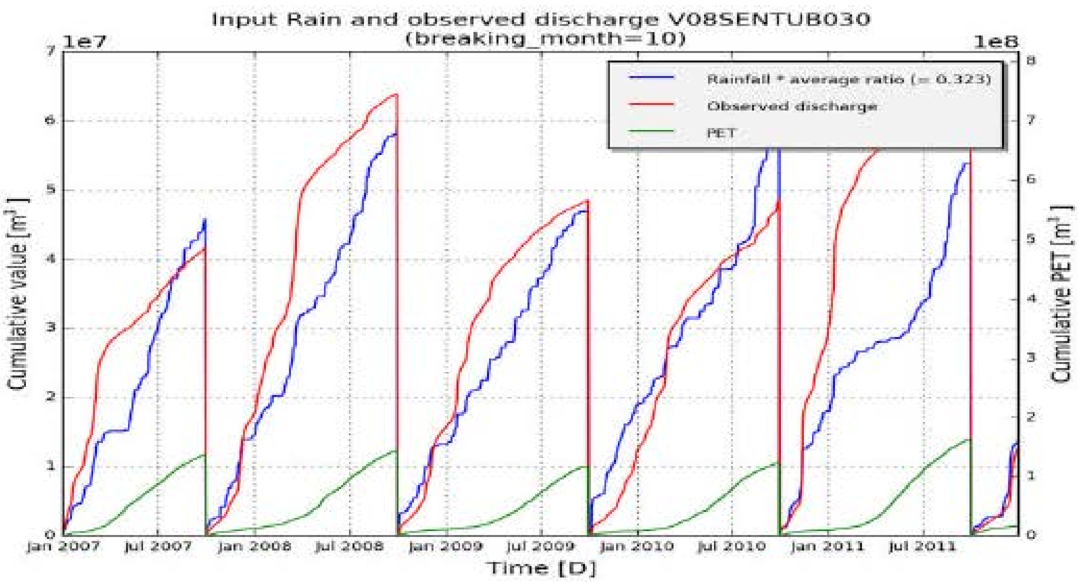


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.6.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	W08SENTUB030
subcatchment_area	215900000
start_date	200701010000
end_date	201112310000
frequency	86400
warmup	365

9.5.6.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.5, 20.0, 0.01, 1.2, 90.0, 300.0, 5.5, 70.0]
low_bounds	[1.2, 16.0, 0.0003, 0.7, 70.0, 240.0, 4.1, 56.0]
high_bounds	[2.5, 300.0, 0.015, 1.8, 135.0, 500.0, 8.25, 200.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.5), ('Ki', 20.0), ('Kg', 0.01), ('Kss', 1.2), ('g0', 90.0), ('g_max', 300.0), ('K_run', 5.5), ('P_max', 70.0)]
Initial fitness:

- RelErr: 0.284
- AbsErr: 41617390.029
- KGE: 0.567
- NS_rel: 0.591
- NS: 0.625
- RMSE: 53207060.066
- NS_log: 0.442

Computation time:11:08:08.774000

9.5.6.4 Results

Best individual (euclidian): [('Kep', 2.121), ('Ki', 52.517), ('Kg', 0.011), ('Kss', 0.7), ('g0', 116.555), ('g_max', 426.144), ('K_run', 6.126), ('P_max', 163.905)]

Fitness:

- RelErr: -0.015
- AbsErr: 10579057.481
- KGE: 0.774
- NS_rel: 0.828
- NS: 0.711
- RMSE: 12297087.372
- NS_log: 0.581

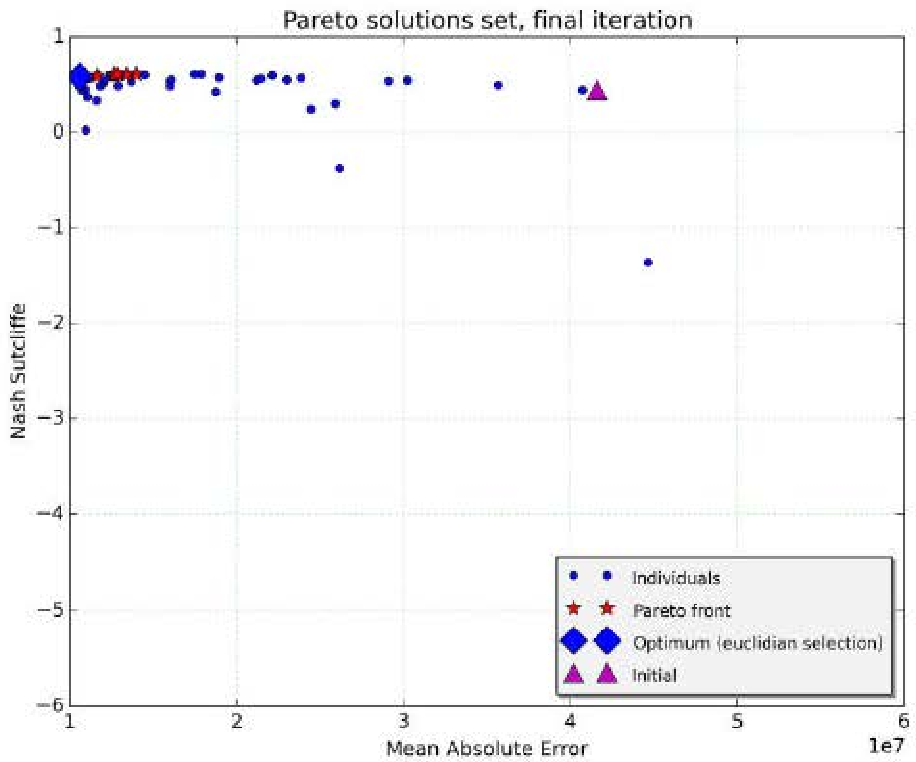


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

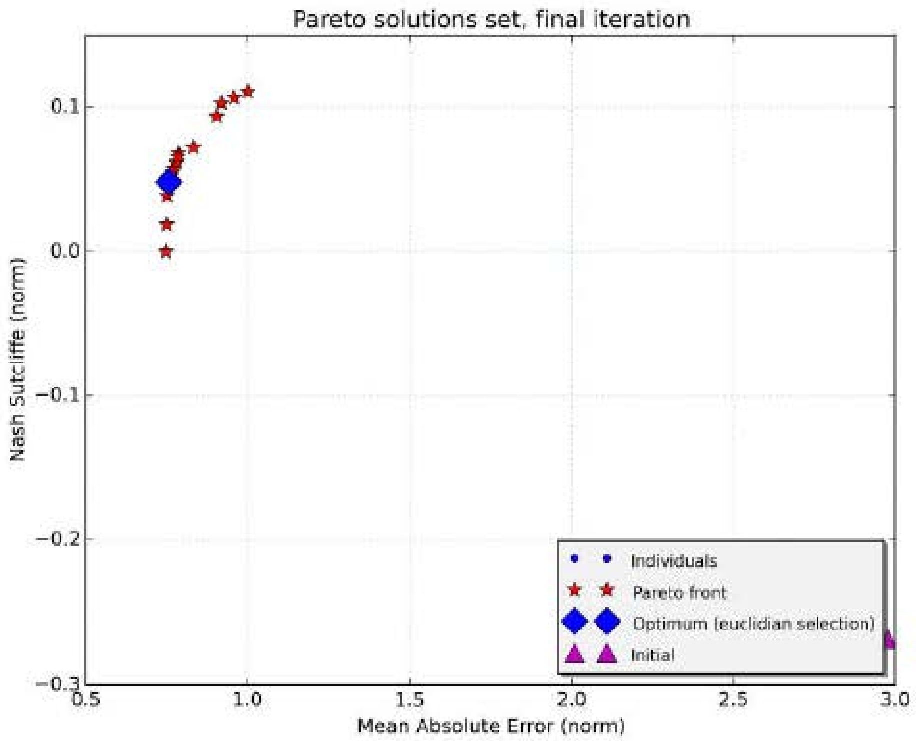


Figure 4: Final population of solutions (Pareto front)

9.5.6.4.1 Initial

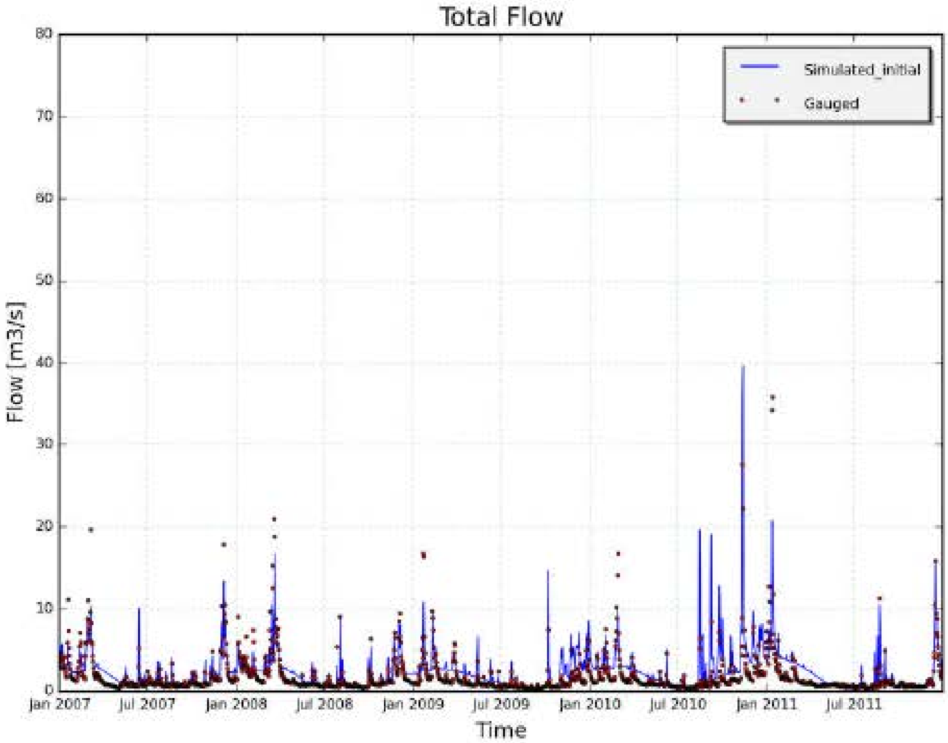


Figure 5: Total flow with initial parameters

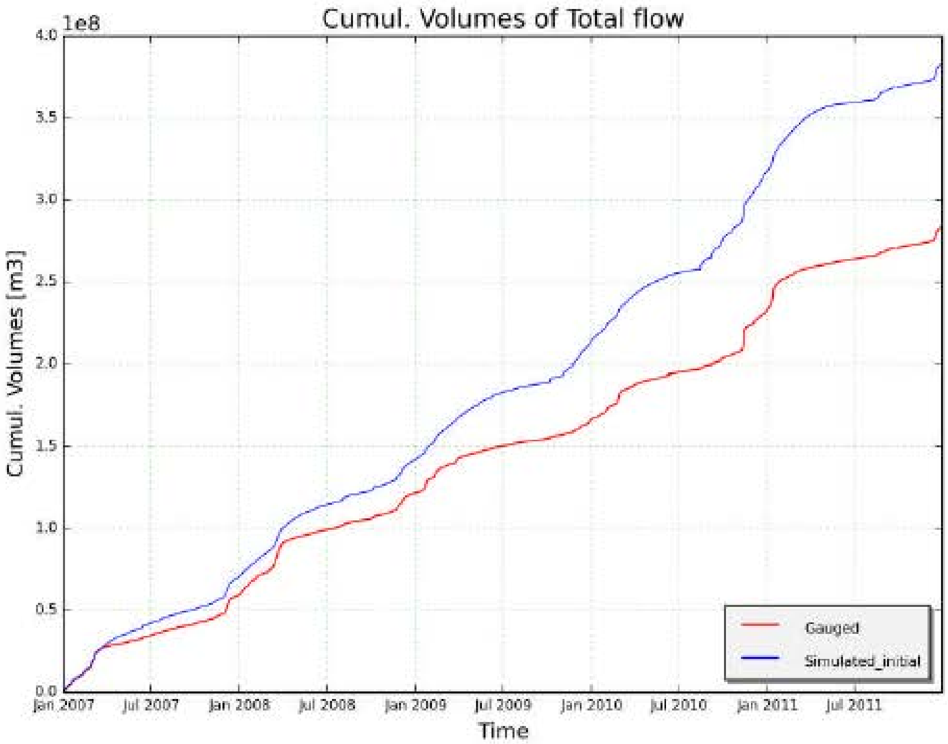


Figure 6: Cumulated flow with initial parameters

9.5.6.4.2 Optimum (euclidian)

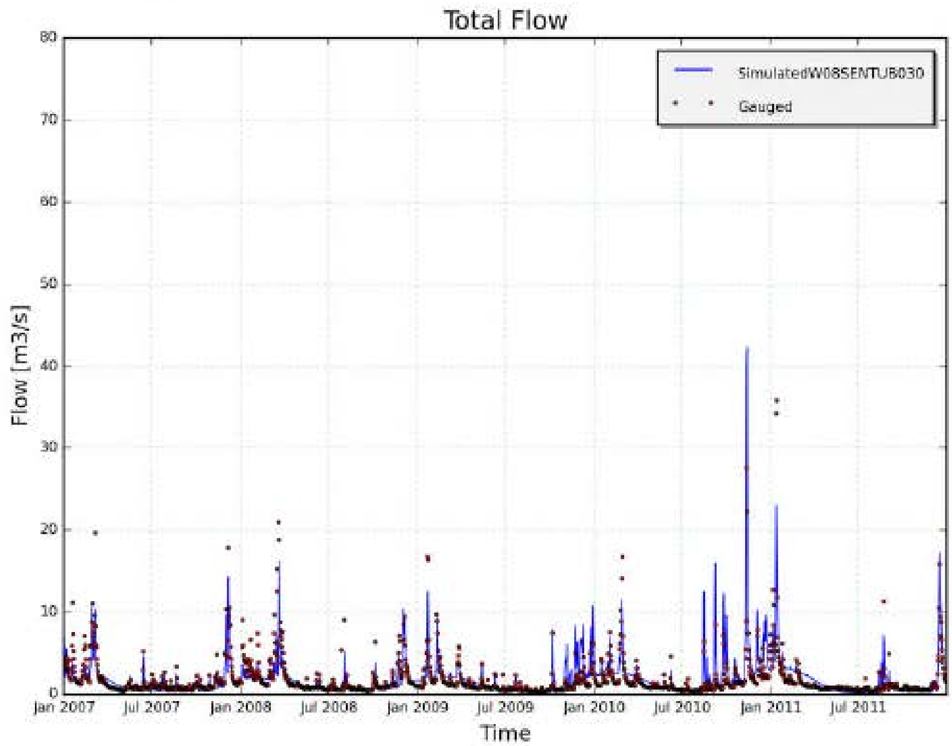


Figure 7: Total flow with optimum parameters

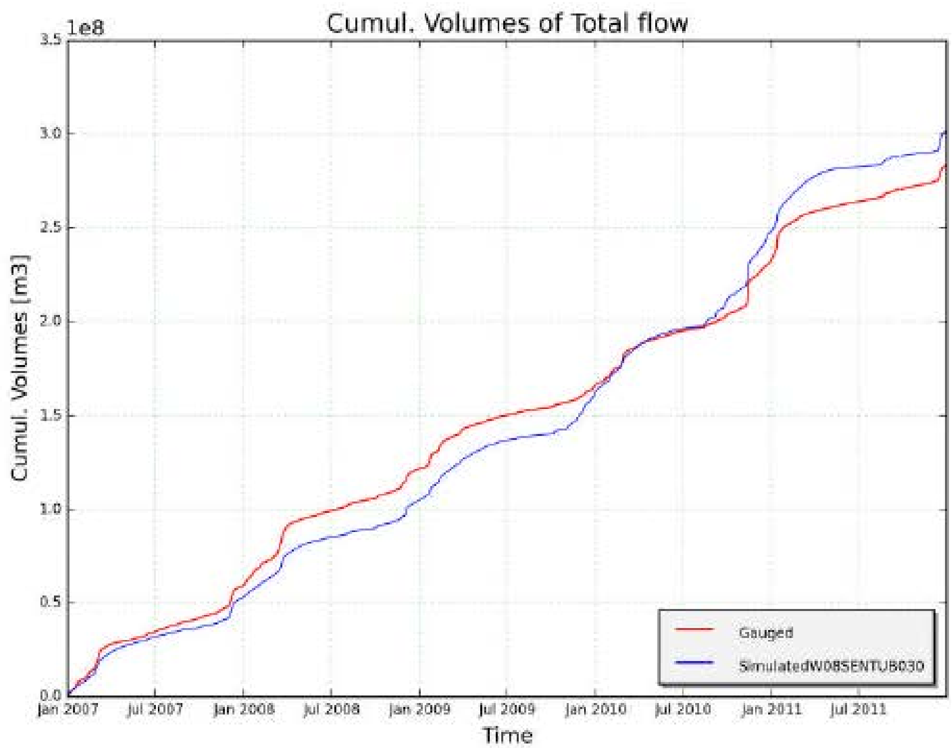


Figure 8: Cumulated flow with optimum parameters

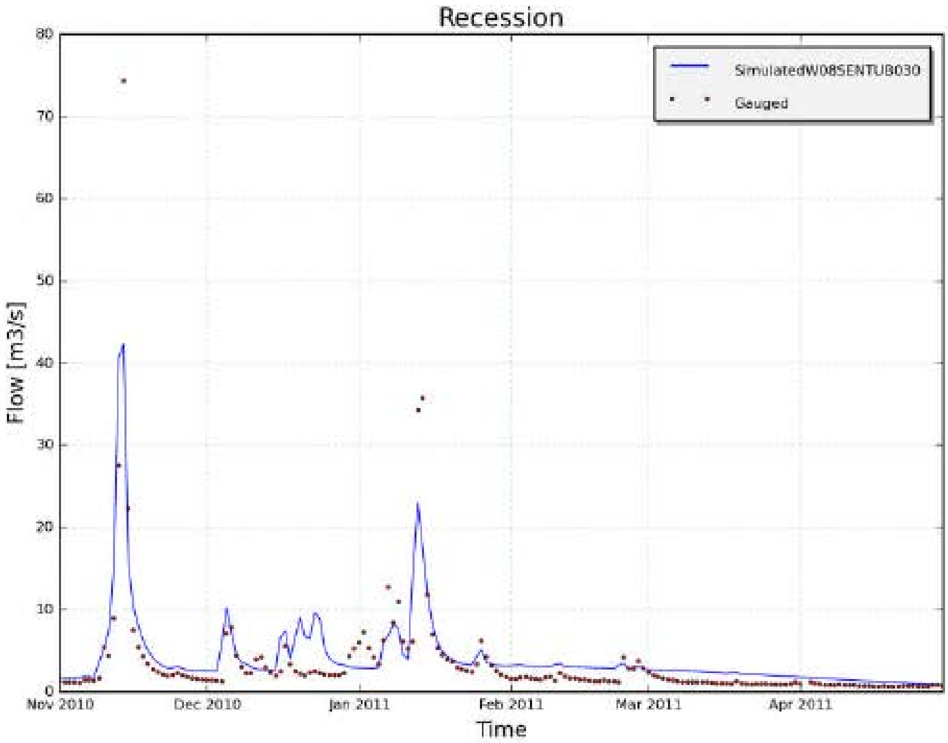


Figure 9: Total flow with optimum parameters (detail)

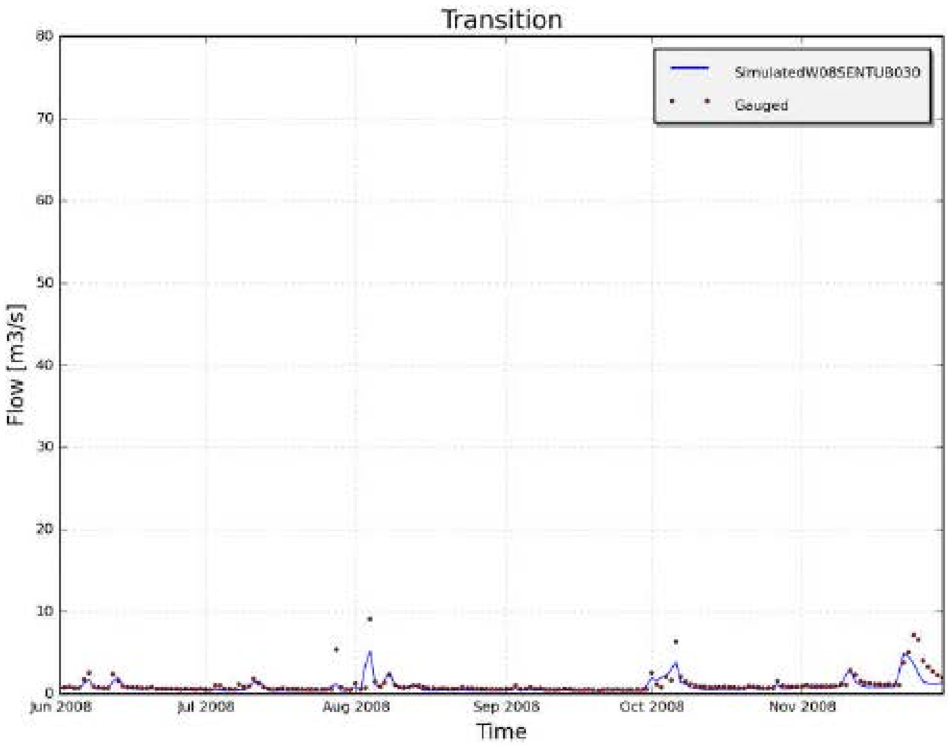
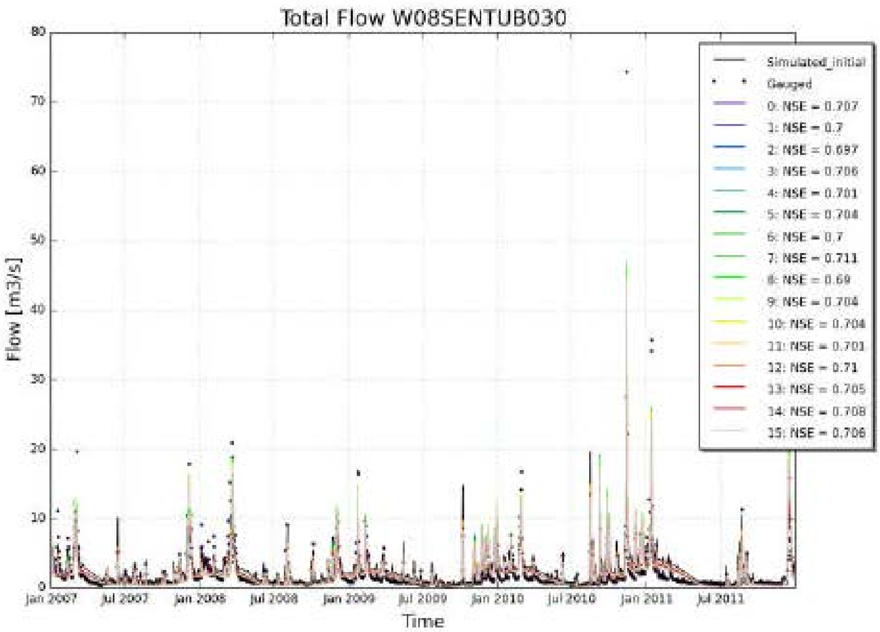
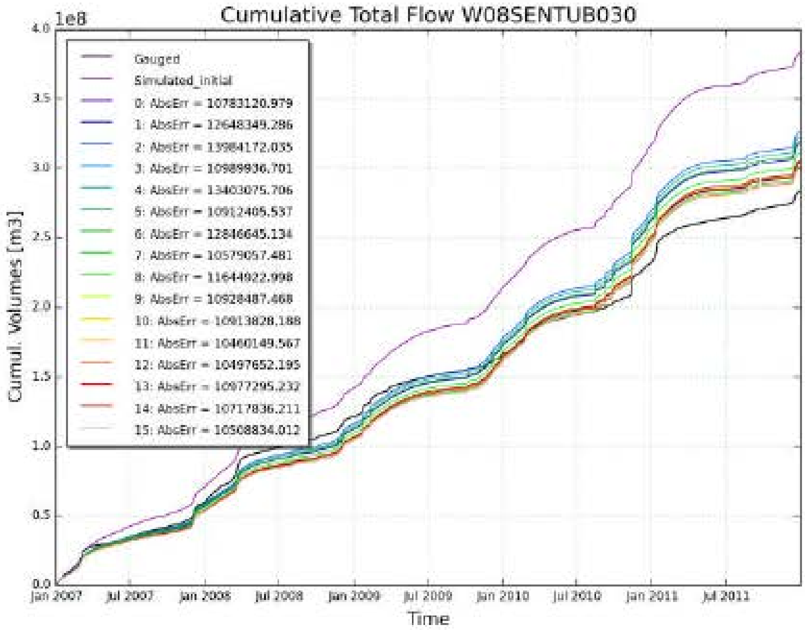


Figure 10: Total flow with optimum parameters (detail)

9.5.6.4.3 Final archive

0 : [2.118, 53.819, 0.011, 1.386, 118.303, 432.634, 5.43, 156.591] : [10783120.979, 0.585]
1 : [1.99, 65.2, 0.011, 1.8, 118.375, 434.945, 8.25, 157.502] : [12648349.286, 0.601]
2 : [1.937, 61.063, 0.011, 1.263, 122.184, 433.123, 6.533, 160.868] : [13984172.035, 0.609]
3 : [2.08, 39.491, 0.011, 1.04, 117.397, 422.742, 6.337, 167.21] : [10989936.701, 0.59]
4 : [1.958, 60.918, 0.011, 1.31, 124.326, 435.517, 7.357, 160.243] : [13403075.706, 0.607]
5 : [2.093, 62.649, 0.011, 1.248, 120.696, 430.758, 6.179, 160.045] : [10912405.537, 0.587]
6 : [1.997, 59.784, 0.011, 1.55, 116.514, 434.051, 5.921, 161.482] : [12846645.134, 0.605]
7 : [2.121, 52.517, 0.011, 0.7, 116.555, 426.144, 6.126, 163.905] : [10579057.481, 0.581]
8 : [2.056, 72.58, 0.011, 1.496, 120.108, 434.465, 6.141, 161.965] : [11644922.998, 0.592]
9 : [2.093, 62.649, 0.011, 1.735, 120.696, 431.604, 6.179, 162.137] : [10928487.468, 0.588]
10 : [2.093, 62.64, 0.011, 1.166, 120.854, 431.04, 6.179, 161.742] : [10913828.188, 0.587]
11 : [2.165, 60.944, 0.011, 1.229, 120.701, 426.608, 5.068, 160.122] : [10460149.567, 0.56]
12 : [2.132, 61.141, 0.011, 1.245, 119.077, 426.225, 7.042, 160.183] : [10497652.195, 0.568]
13 : [2.08, 38.497, 0.011, 1.04, 117.397, 421.451, 6.337, 166.84] : [10977295.232, 0.589]
14 : [2.119, 53.838, 0.011, 1.531, 117.07, 430.332, 5.532, 161.808] : [10717836.211, 0.584]
15 : [2.135, 61.12, 0.011, 1.46, 118.469, 431.717, 6.146, 160.038] : [10508834.012, 0.577]




Cumulative Total Flow W08SENTUB030
1e8
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Cumul. Volumes [m3]
Gauged
Simulated_initial
0: AbsErr = 10783120.979
1: AbsErr = 12648349.286
2: AbsErr = 13984172.035
3: AbsErr = 10989936.701
4: AbsErr = 13403075.706
5: AbsErr = 10912405.537
6: AbsErr = 12846645.134
7: AbsErr = 10579057.481
8: AbsErr = 11644922.998
9: AbsErr = 10928487.468
10: AbsErr = 10913828.188
11: AbsErr = 10460149.567
12: AbsErr = 10497652.195
13: AbsErr = 10977295.232
14: AbsErr = 10717836.211
15: AbsErr = 10508834.012
Jan 2007
Jul 2007
Jan 2008
Jul 2008
Jan 2009
Jul 2009
Jan 2010
Jul 2010
Jan 2011
Jul 2011
Time

Appendix 18 Demerbekken Calibration and Validation.

9.5.1 Calibration and validation of WET parameters for catchment "V09DEM136000" (Demerbekken)

9.5.1.1 Input data

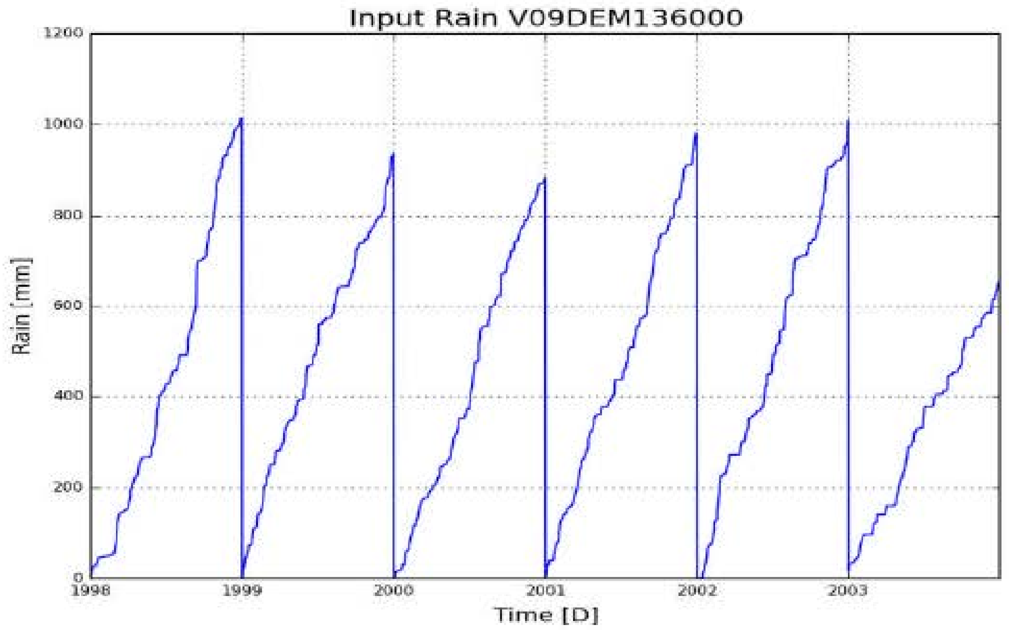


Figure 1: Cumulative precipitation on catchment V09DEM136000 (Demerbekken)

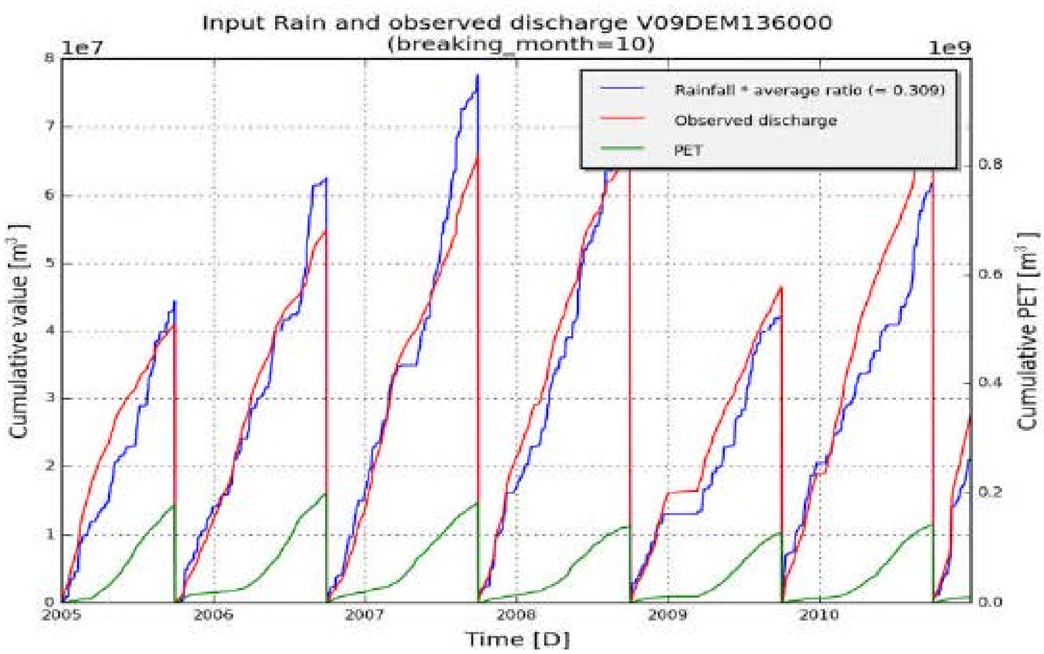


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09DEM136000 (Demerbekken)

9.5.1.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V09DEM136000
subcatchment_area [m2]	255100000
Validation start_date	01-01-1999
Validation end_date	31-12-2003
frequency	daily

Optimal parameter set:[('Kep', 1.86), ('Ki', 81.95), ('Kg', 0.01), ('Kss', 1.79), ('g0', 140.9), ('g_max', 300.9), ('K_run', 5.23), ('P_max', 163.82)]

Table 1: Goodness of fit for calibration period (2005 - 2010)

	Full year	**Summer**	**Winter**
RelErr	7.8 %	7.1 %	15.6 %
NS	-0.477	-0.988	-0.015
NS_log	0.454	-0.018	0.582
NS_rel	0.718	0.528	0.488
KGE	0.021	-0.186	0.372

Table 2 :Goodness of fit for validation period (1999 - 2003)

	Full year	**Summer**	**Winter**
RelErr	1.1 %	-19.8 %	15.6 %
NS	0.388	0.024	0.28
NS_log	0.045	-1.748	0.708
NS_rel	0.609	0.32	0.73
KGE	0.464	0.296	0.399

9.5.1.3 Observed and simulated timeseries for optimum parameters

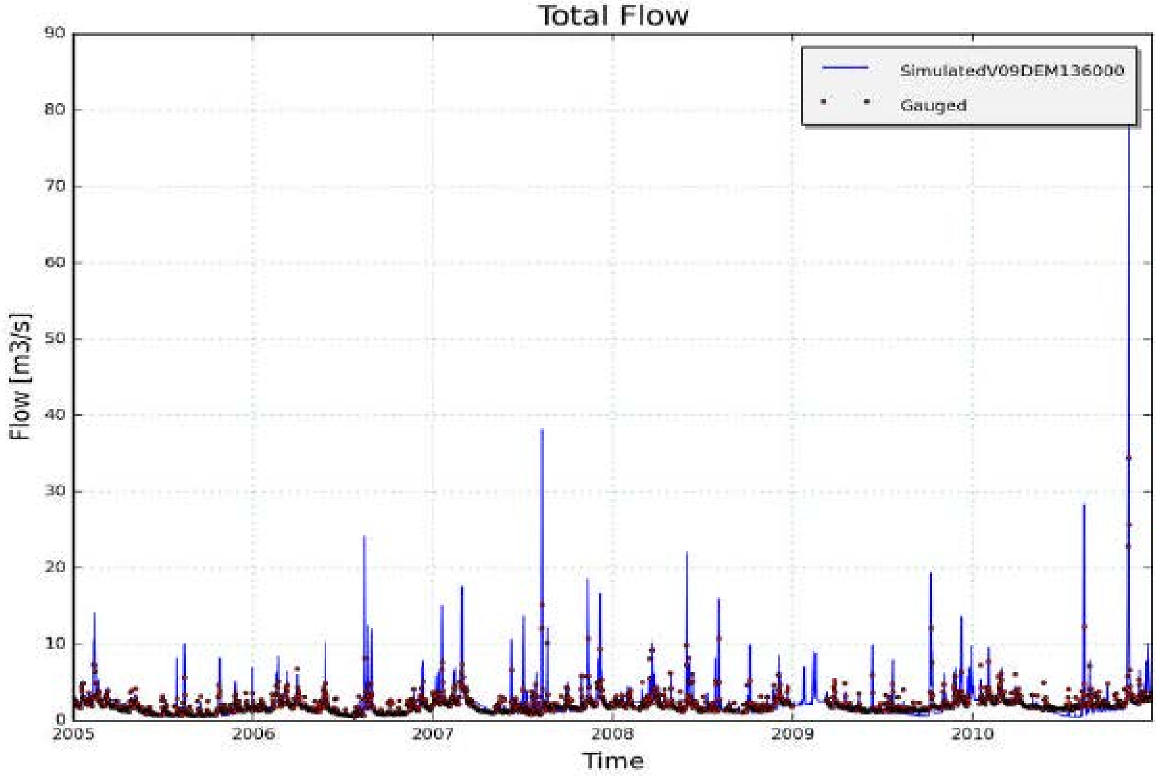


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09DEM136000, station 13610102 - Demer; Hasselt(calibration period)

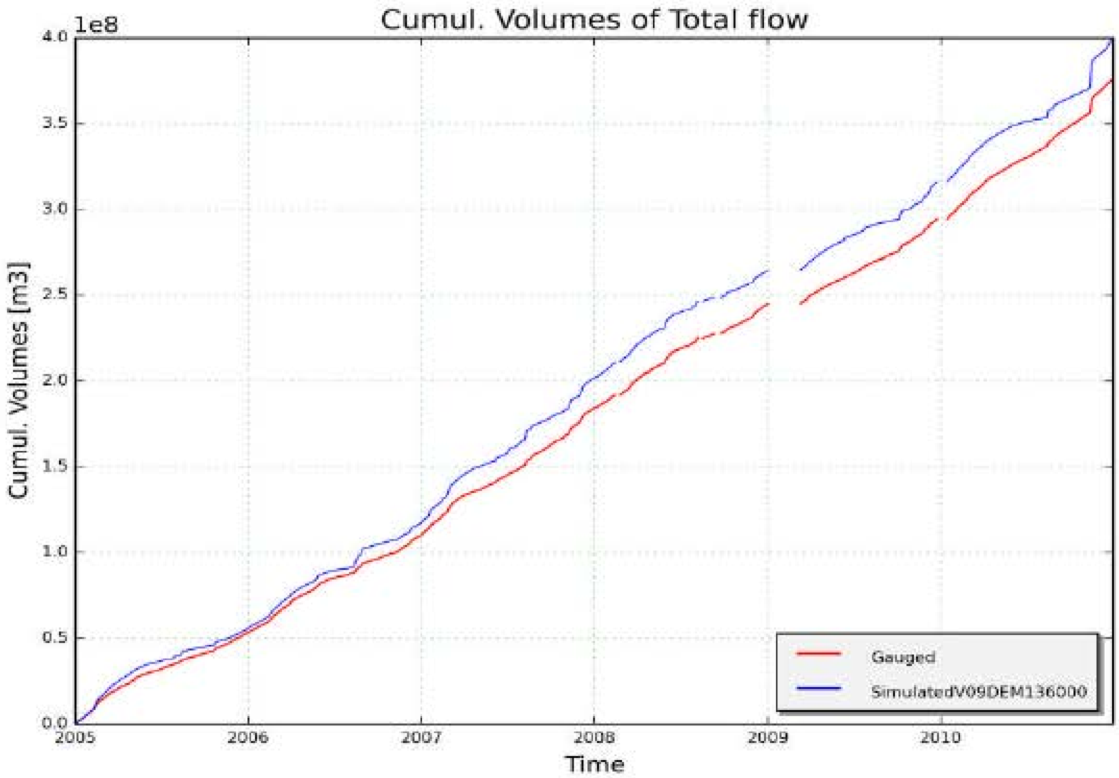


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09DEM136000, station 13610102 - Demer; Hasselt (calibration period)

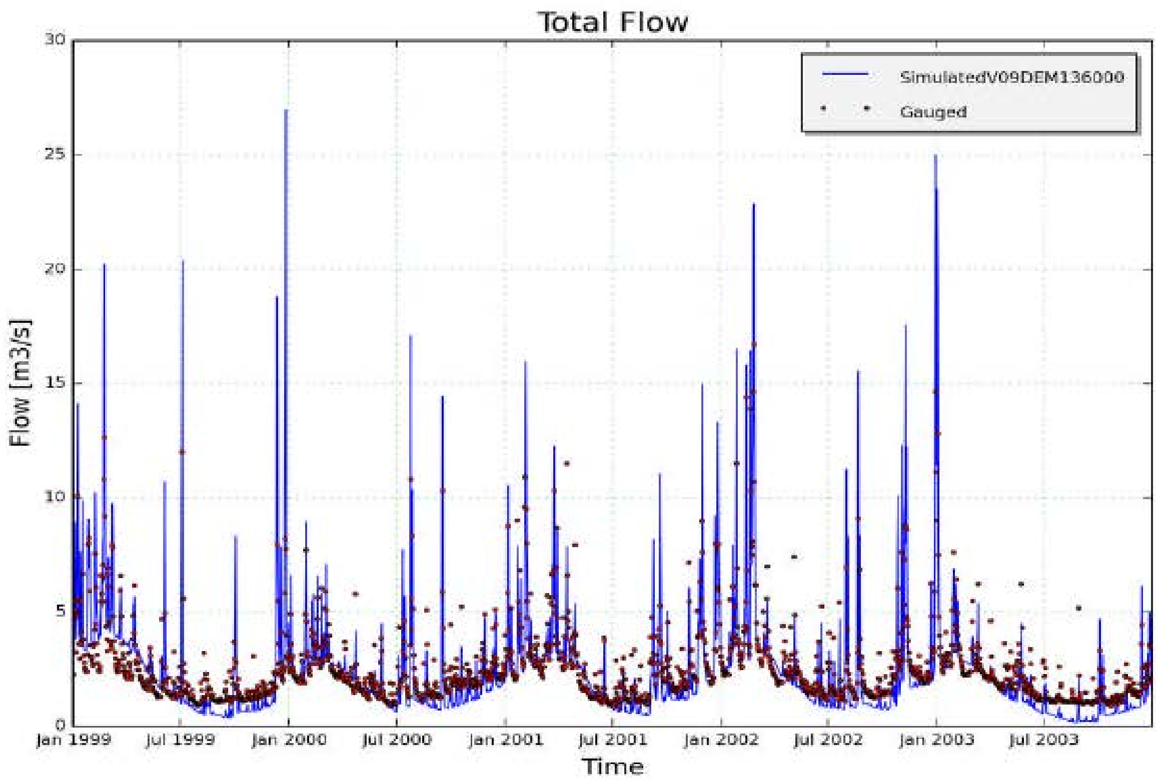


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09DEM136000, station 13610102 - Demer; Hasselt (validation period)

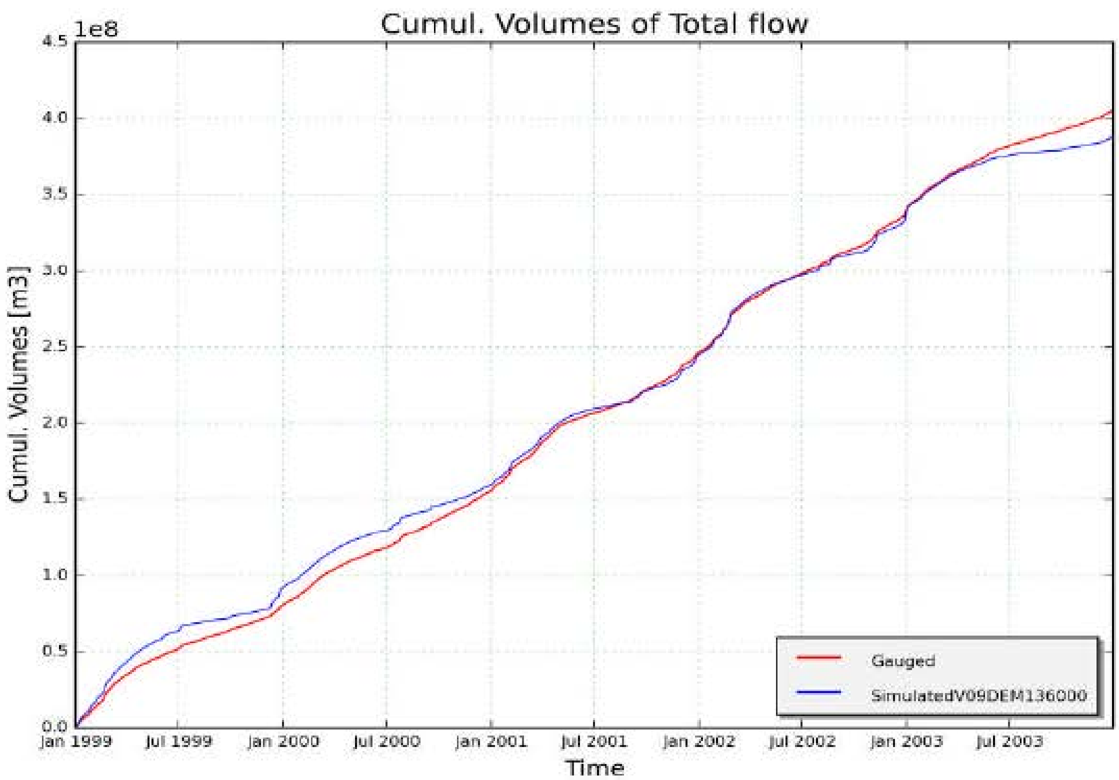


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09DEM136000, station 13610102 - Demer; Hasselt (validation period)

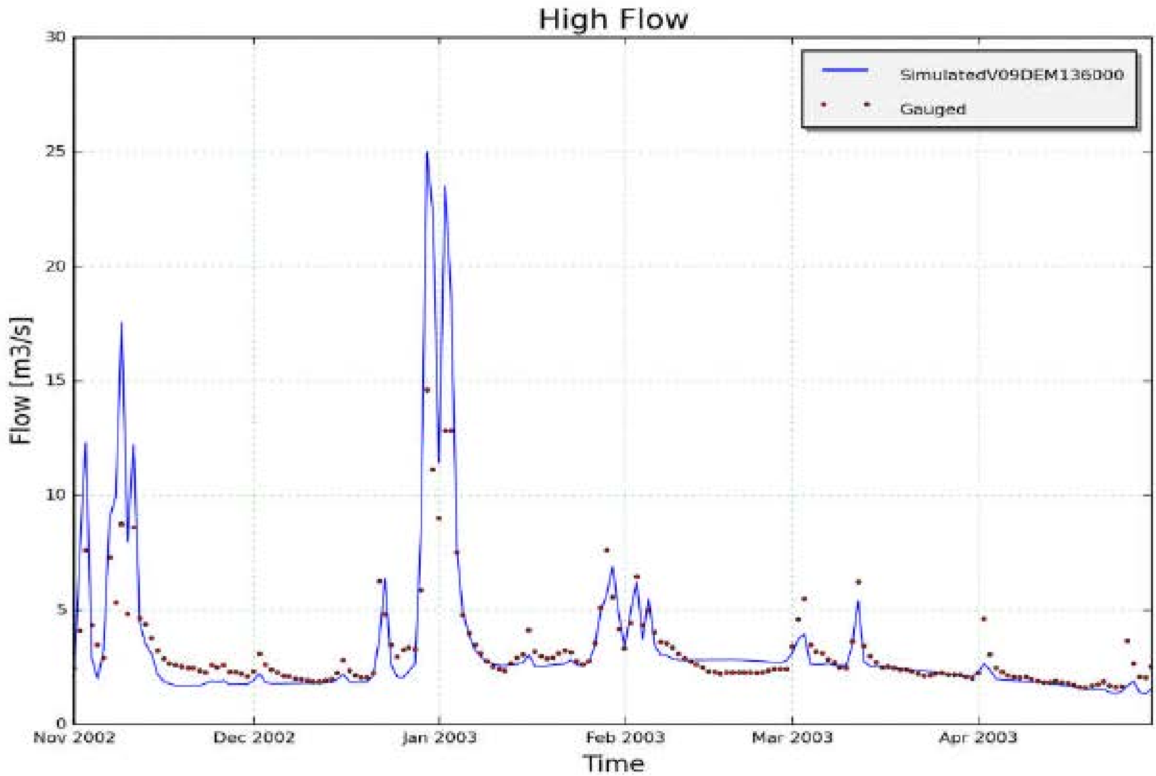


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09DEM136000, station 13610102 - Demer; Hasselt

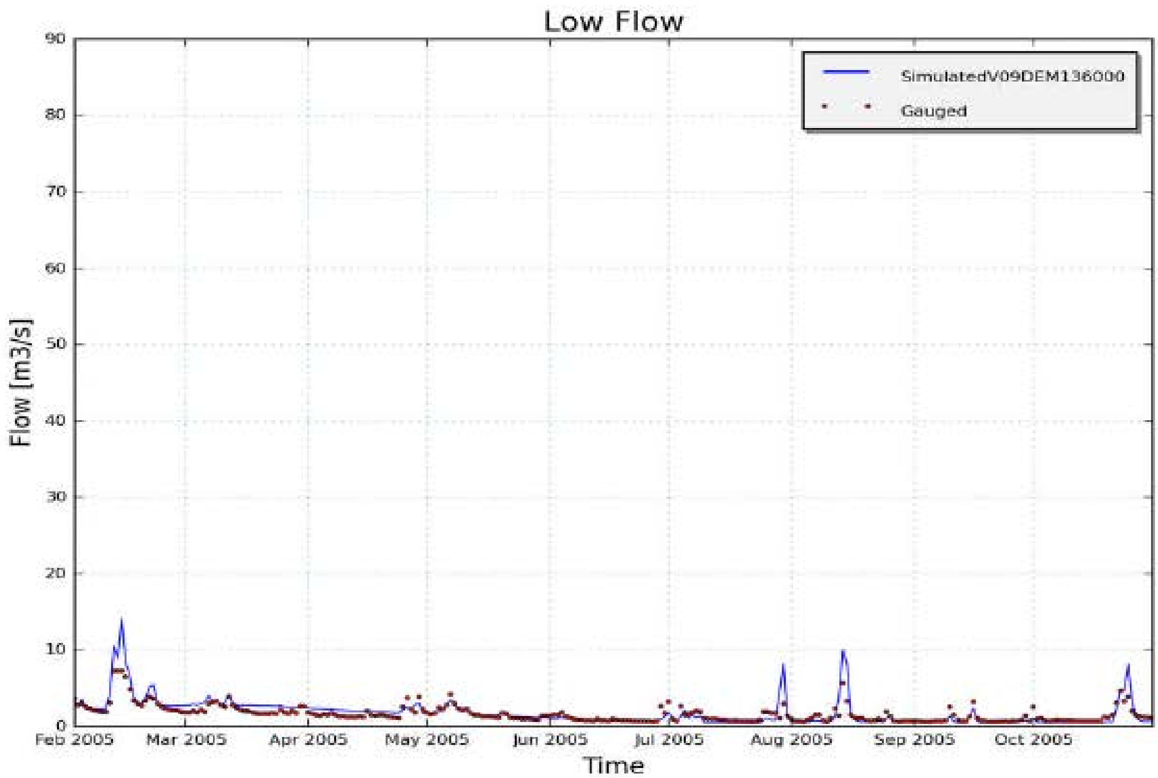


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09DEM136000, station 13610102 - Demer; Hasselt

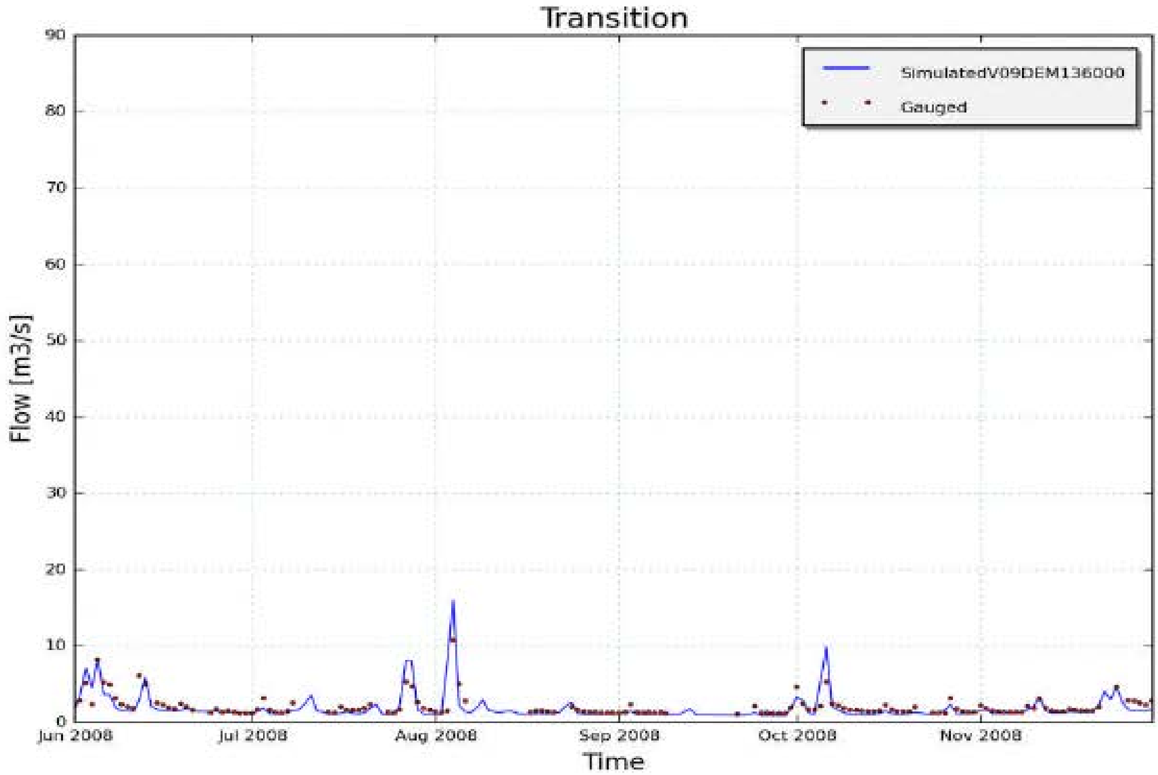


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09DEM136000, station 13610102 - Demer; Hasselt

9.5.2 Calibration and validation of WET parameters for catchment "V09GET152080" (Demerbekken)

9.5.2.1 Input data

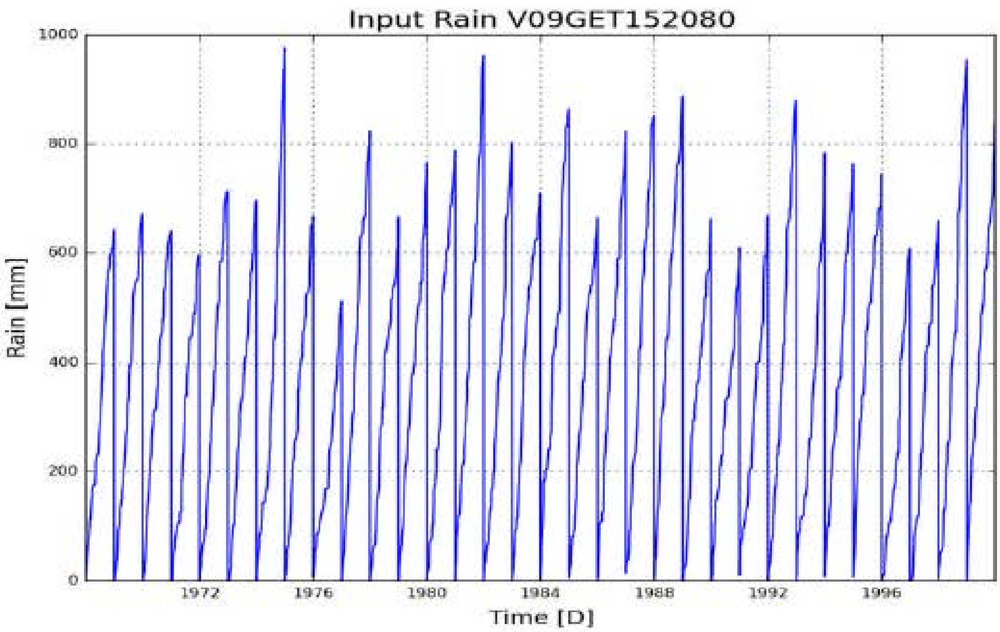


Figure 1: Cumulative precipitation on catchment V09GET152080 (Demerbekken)

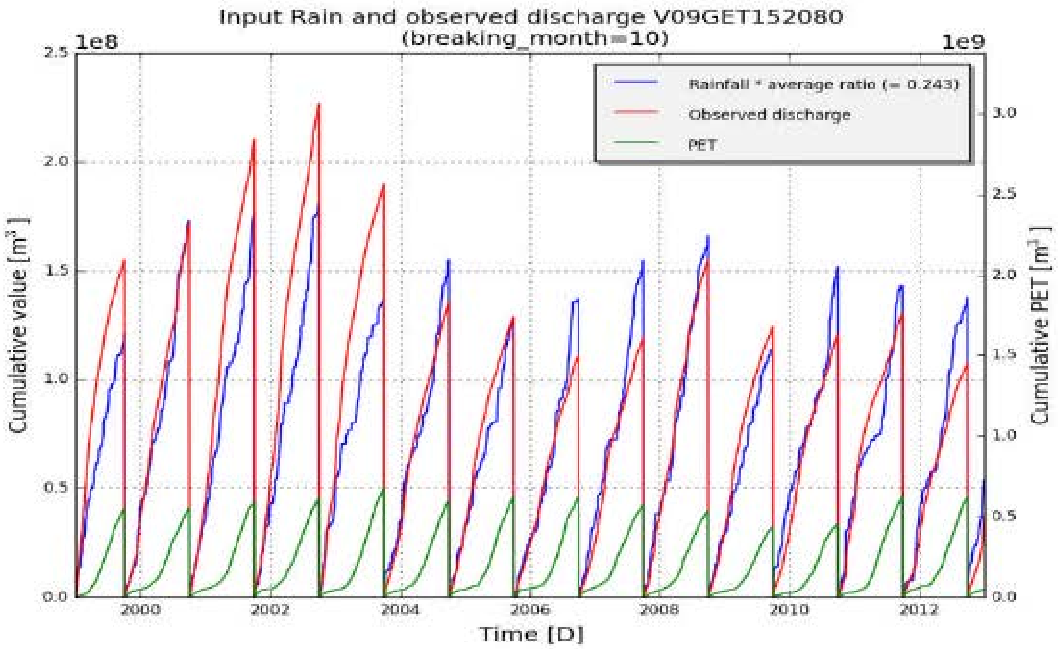


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09GET152080 (Demerbekken)

9.5.2.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V09GET152080
subcatchment_area [m2]	800400000
Validation start_date	01-01-1969
Validation end_date	31-12-1999
frequency	daily

Optimal parameter set:[('Kep', 0.15), ('Ki', 42.5), ('Kg', 0.01), ('Kss', 0.97), ('g0', 184.82), ('g_max', 625.19), ('K_run', 9.09), ('P_max', 521.81)]

Table 1: Goodness of fit for calibration period (2000 - 2013)

	Full year	**Summer**	**Winter**
RelErr	-6.6 %	14.1 %	-26.6 %
NS	0.274	-0.006	0.088
NS_log	0.276	-0.34	0.255
NS_rel	0.411	-0.35	0.72
KGE	0.216	0.262	0.121

Table 2 :Goodness of fit for validation period (1969 - 1999)

	Full year	Summer	Winter
RelErr	-0.8 %	44.2 %	-24.8 %
NS	0.324	-0.179	0.137
NS_log	0.318	-0.886	0.313
NS_rel	0.381	-0.547	0.675
KGE	0.263	0.224	0.185

9.5.2.3 Observed and simulated timeseries for optimum parameters

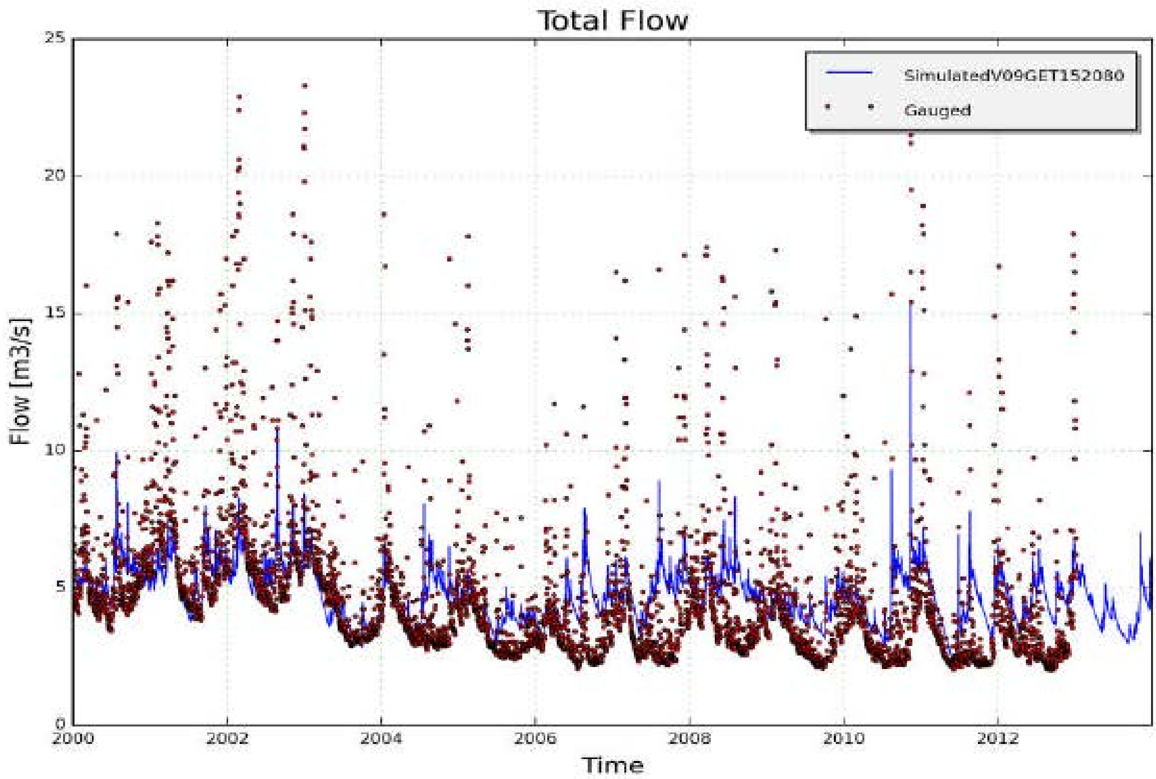


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09GET152080, station 15210102 - Gete; Halen(calibration period)

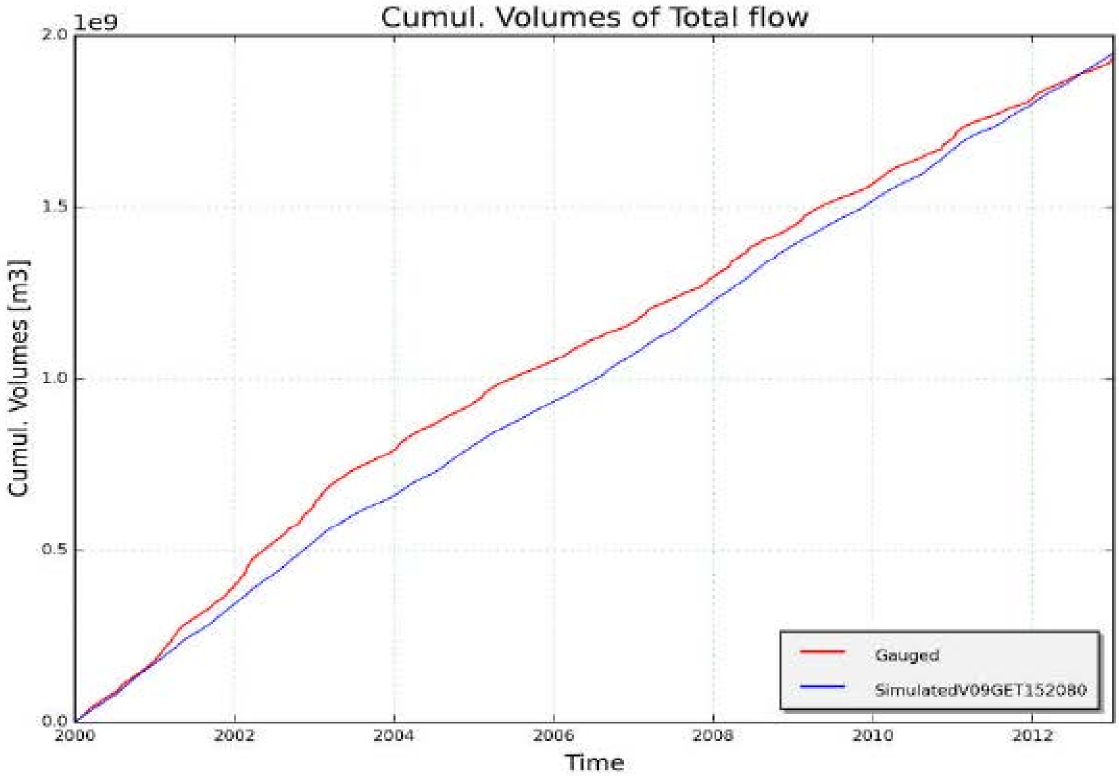


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09GET152080, station 15210102 - Gete; Halen (calibration period)

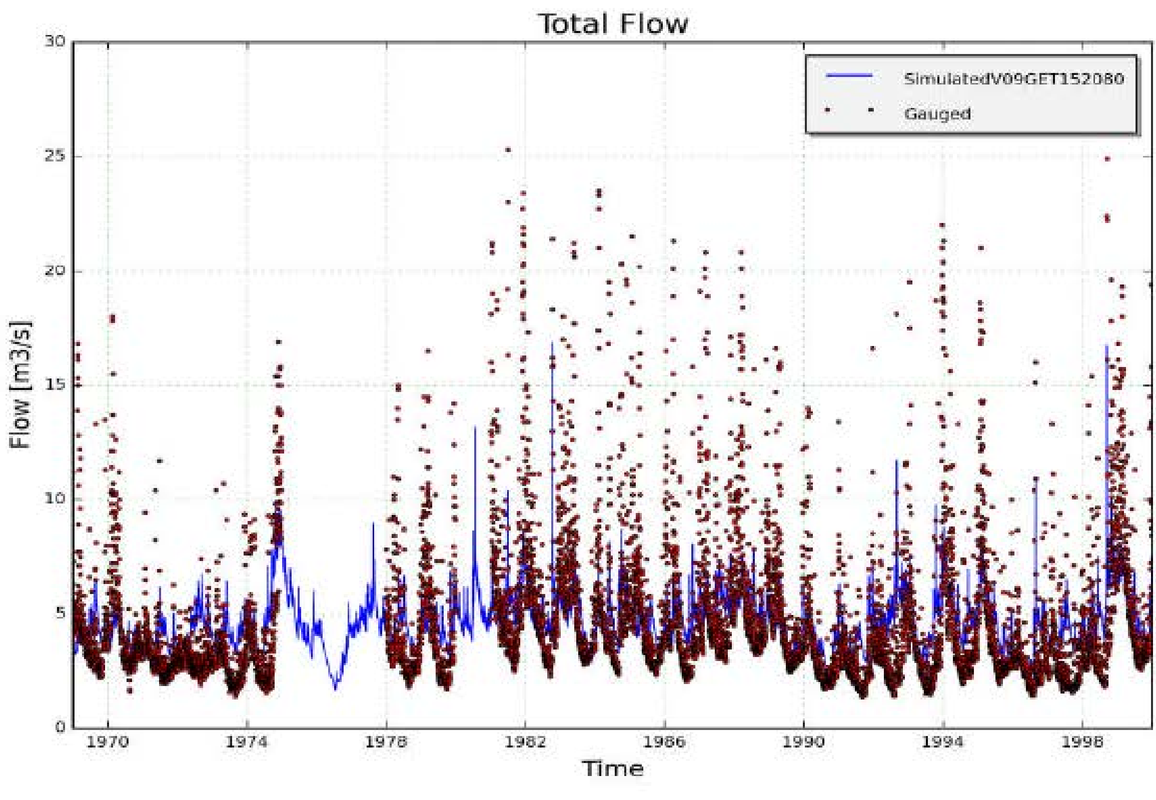


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09GET152080, station 15210102 - Gete; Halen (validation period)

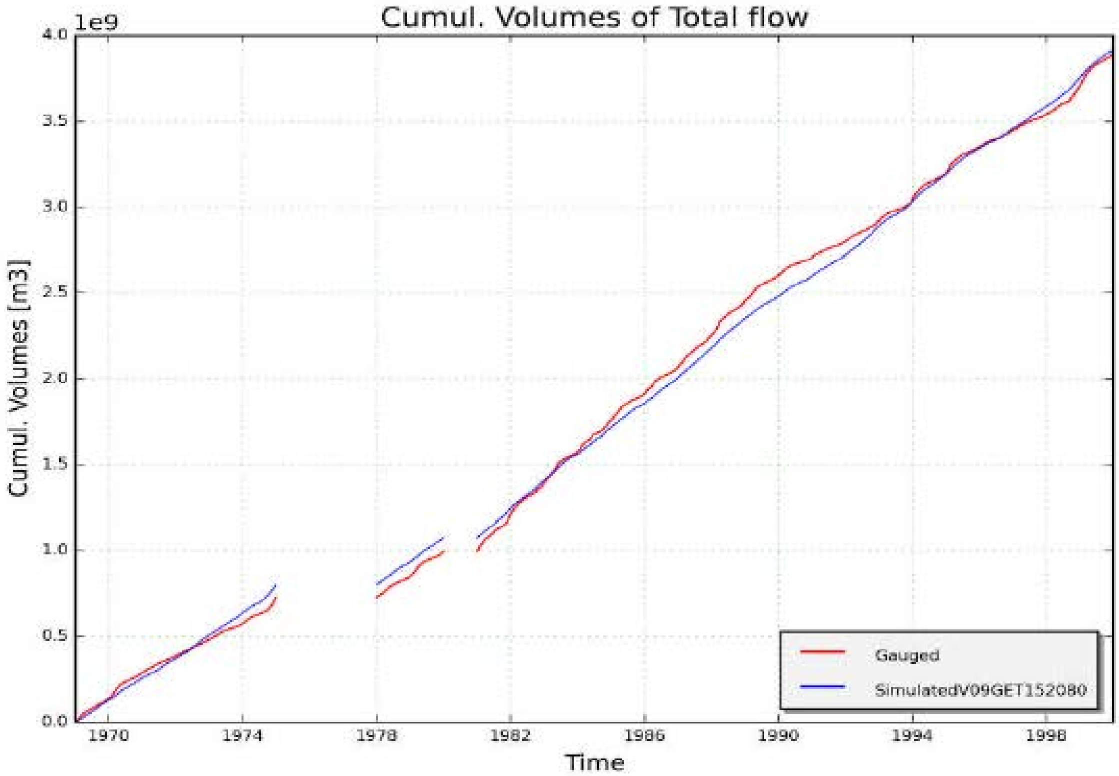


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09GET152080, station 15210102 - Gete; Halen (validation period)

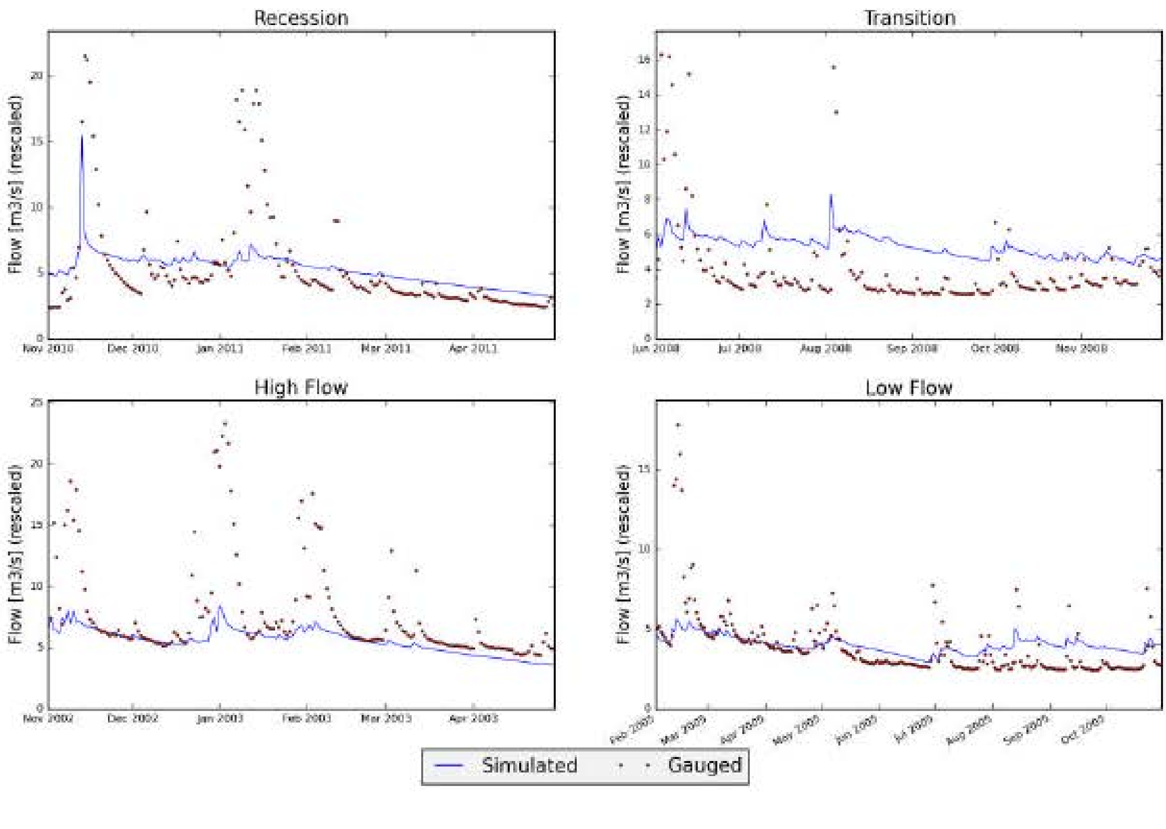


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09GET152080, station 15210102 - Gete; Halen

9.5.3 Calibration and validation of WET parameters for catchment "V09HER163010" (Demerbekken)

9.5.3.1 Input data

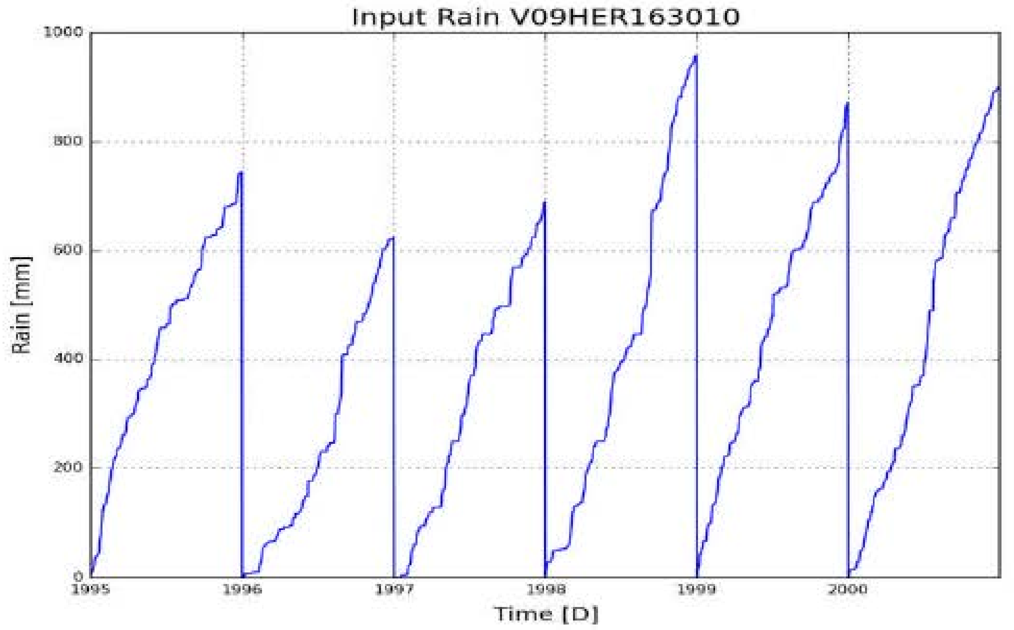


Figure 1: Cumulative precipitation on catchment V09HER163010 (Demerbekken)

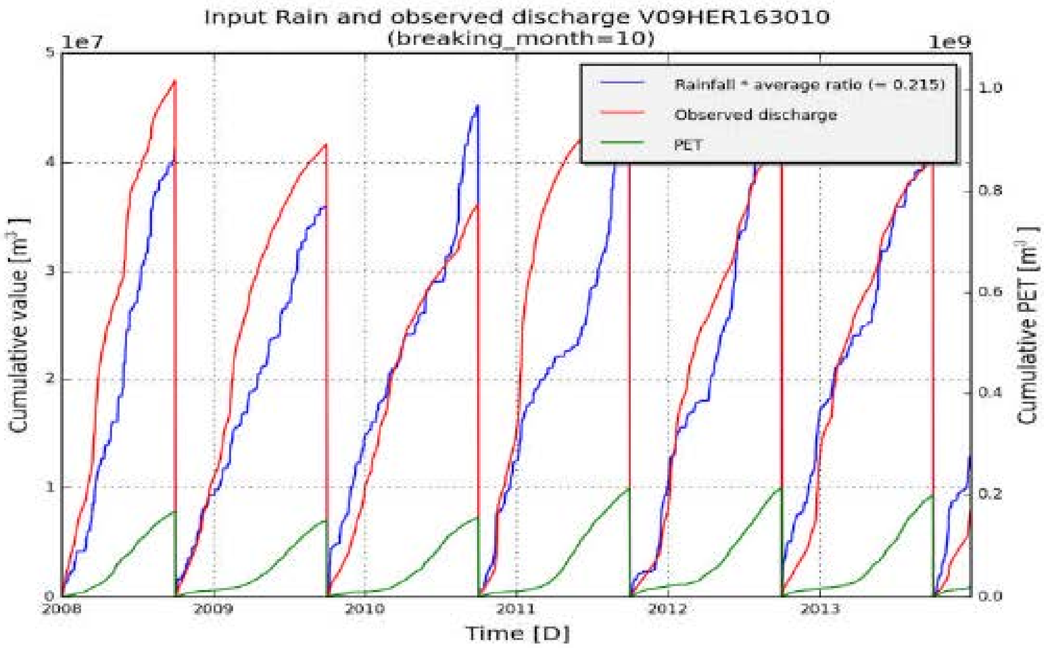


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09HER163010 (Demerbekken)

9.5.3.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V09HER163010
subcatchment_area [m2]	274600000
Validation start_date	01-01-1996
Validation end_date	31-12-2000
frequency	daily

Optimal parameter set:[('Kep', 1.5), ('Ki', 24.99), ('Kg', 0.0), ('Kss', 0.99), ('g0', 166.33), ('g_max', 483.13), ('K_run', 5.43), ('P_max', 226.86)]

Table 1: Goodness of fit for calibration period (2008 - 2013)

	Full year	Summer	Winter
RelErr	-3.5 %	16.6 %	-16.6 %
NS	0.459	0.132	0.633
NS_log	0.695	0.523	0.528
NS_rel	0.825	0.741	0.747
KGE	0.707	0.422	0.789

Table 2 :Goodness of fit for validation period (1996 - 2000)

	Full year	Summer	Winter
RelErr	-5.7 %	15.8 %	-16.1 %
NS	0.143	-0.952	0.701
NS_log	0.729	0.66	0.705
NS_rel	0.814	0.823	0.816
KGE	0.489	-0.073	0.777

9.5.3.3 Observed and simulated timeseries for optimum parameters

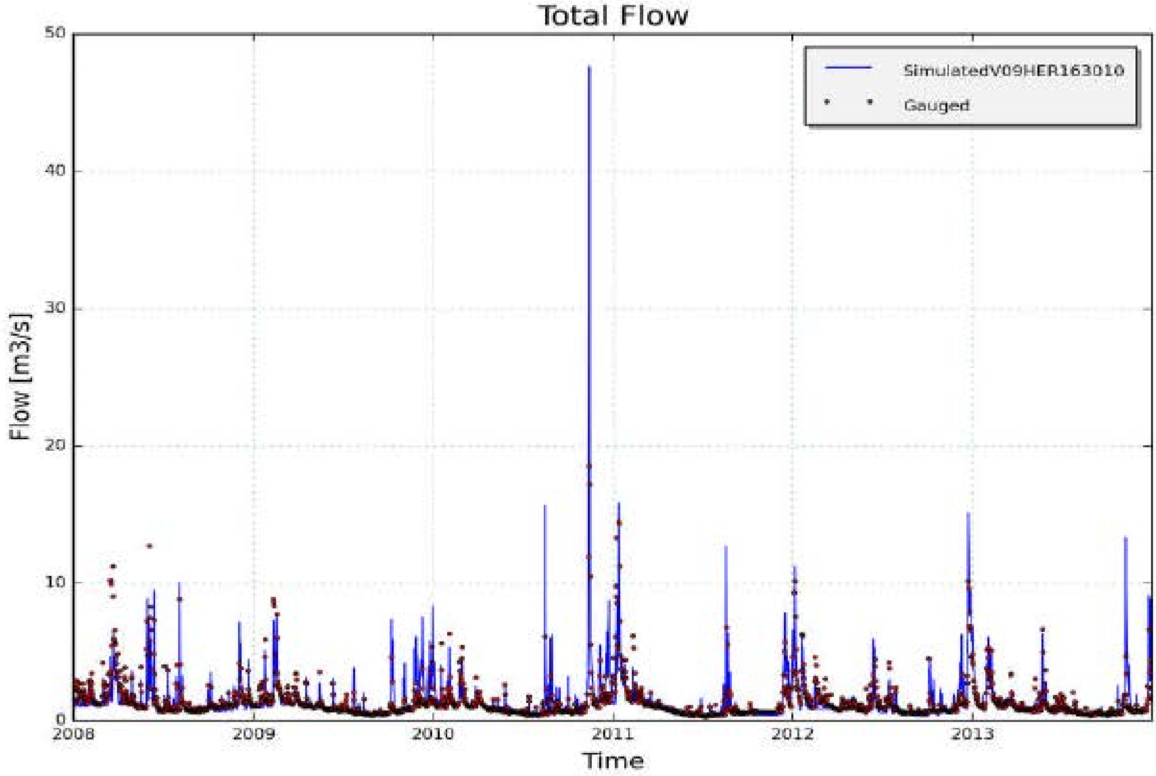


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09HER163010, station 16310102 - Herk, Kermt(calibration period)

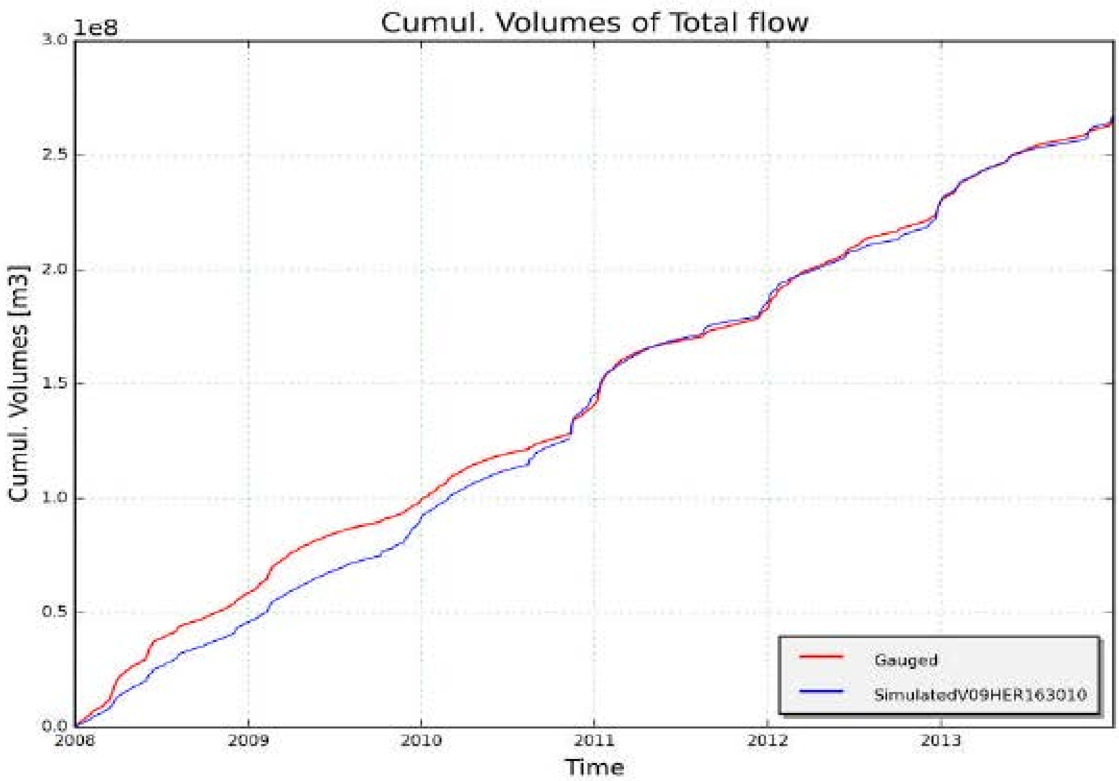


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09HER163010, station 16310102 - Herk, Kermt (calibration period)

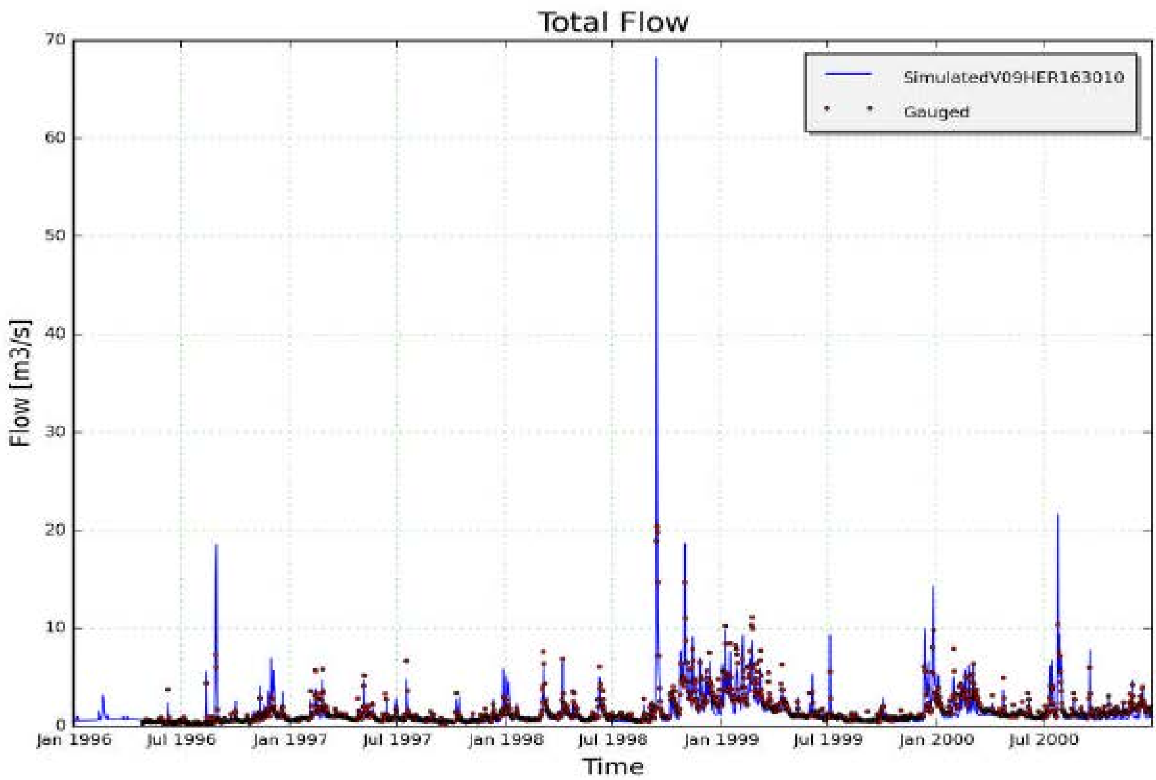


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09HER163010, station 16310102 - Herk, Kermt (validation period)

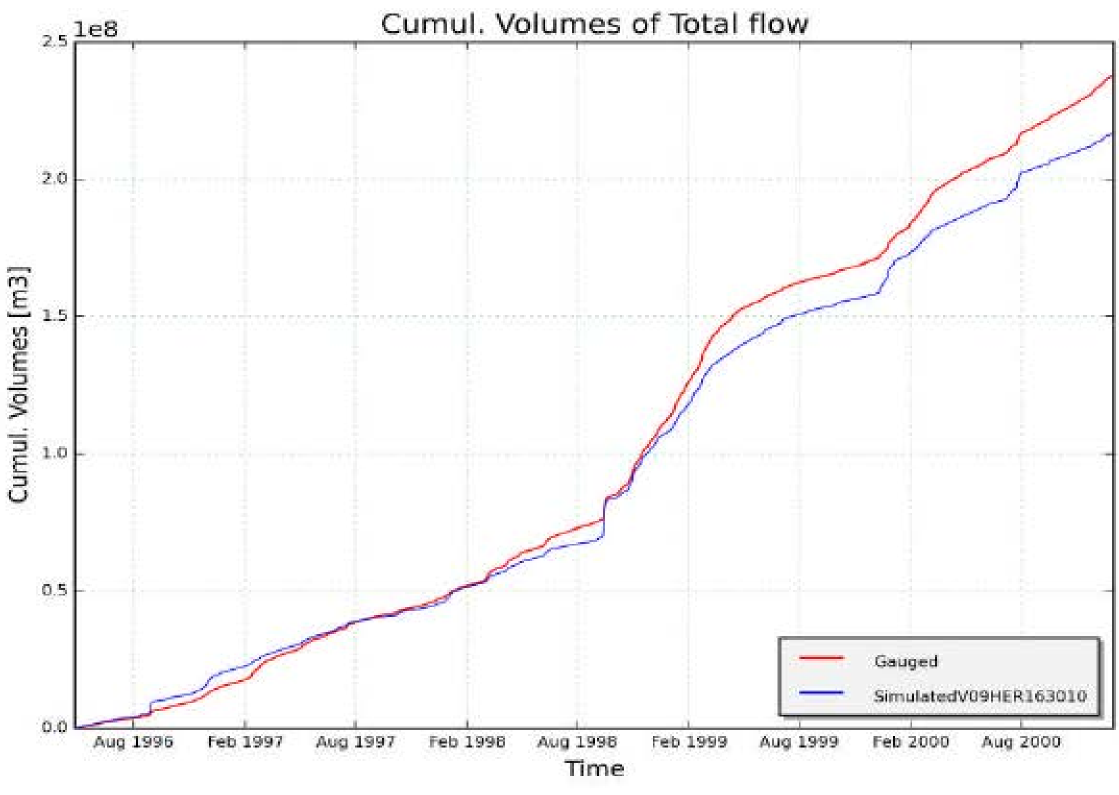


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09HER163010, station 16310102 - Herk, Kermt (validation period)

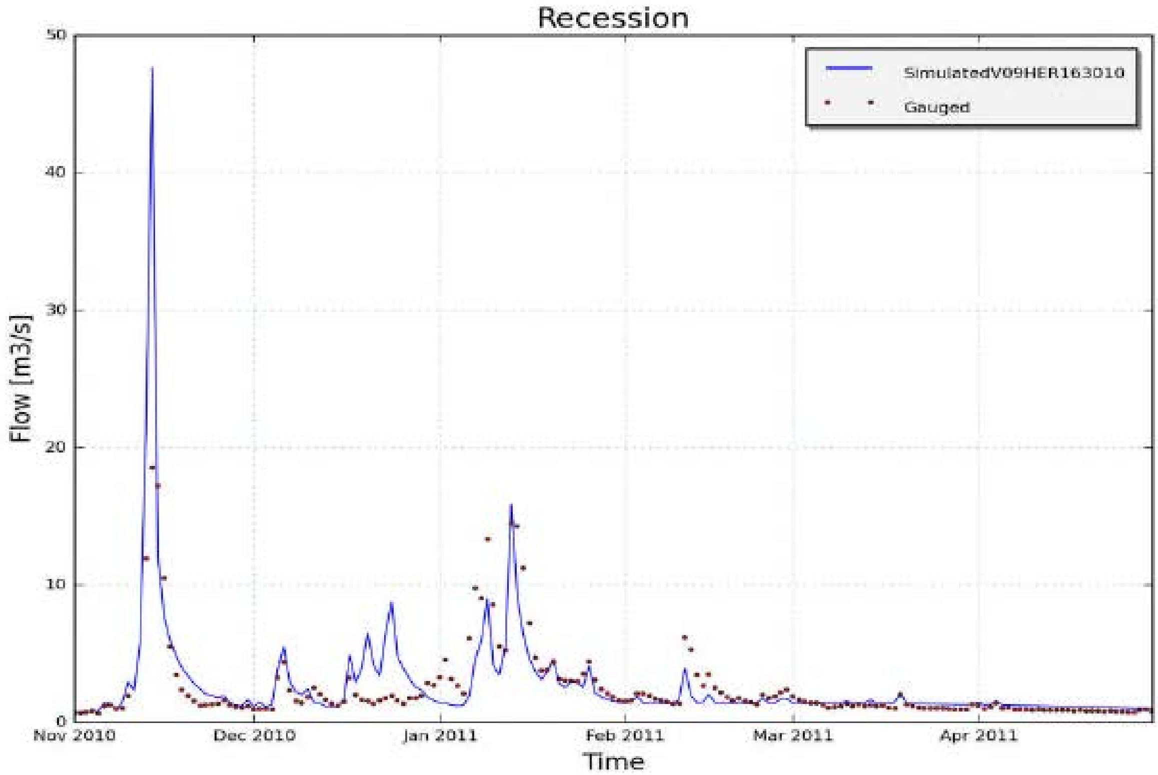


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09HER163010, station 16310102 - Herk, Kermt

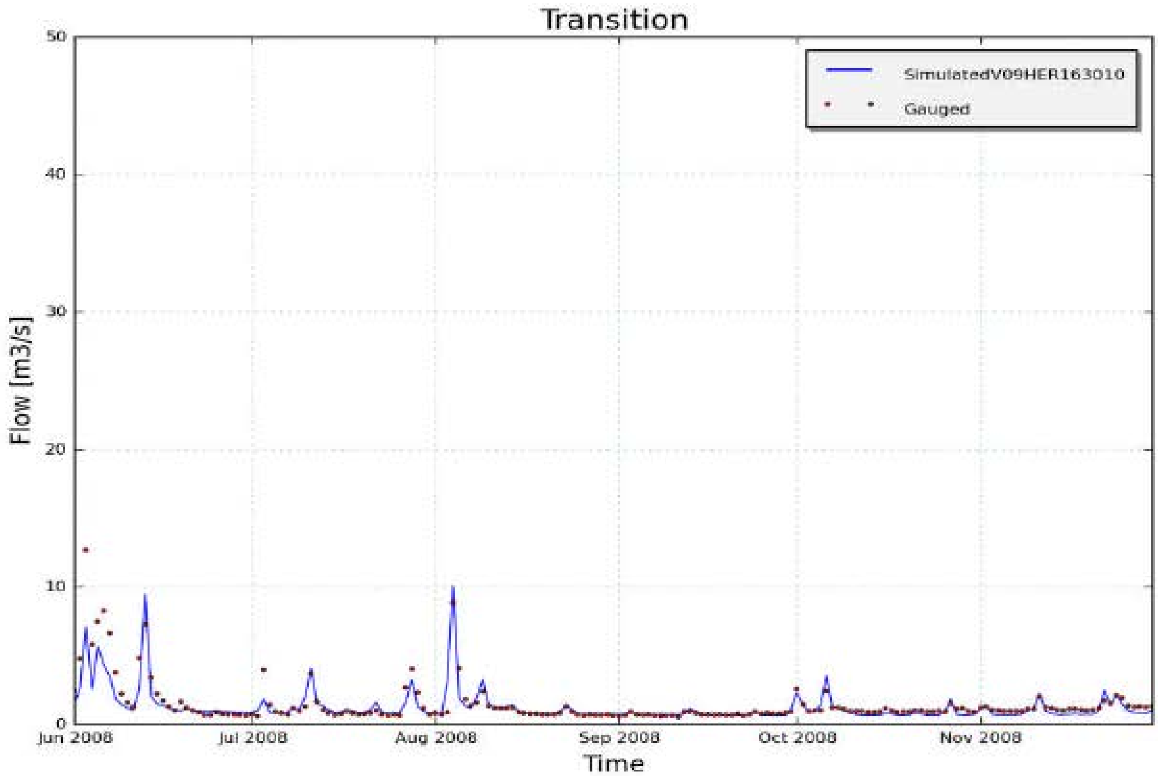


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09HER163010, station 16310102 - Herk, Kermt

9.5.4 Calibration and validation of WET parameters for catchment "V09HUL147150" (Demerbekken)

9.5.4.1 Input data

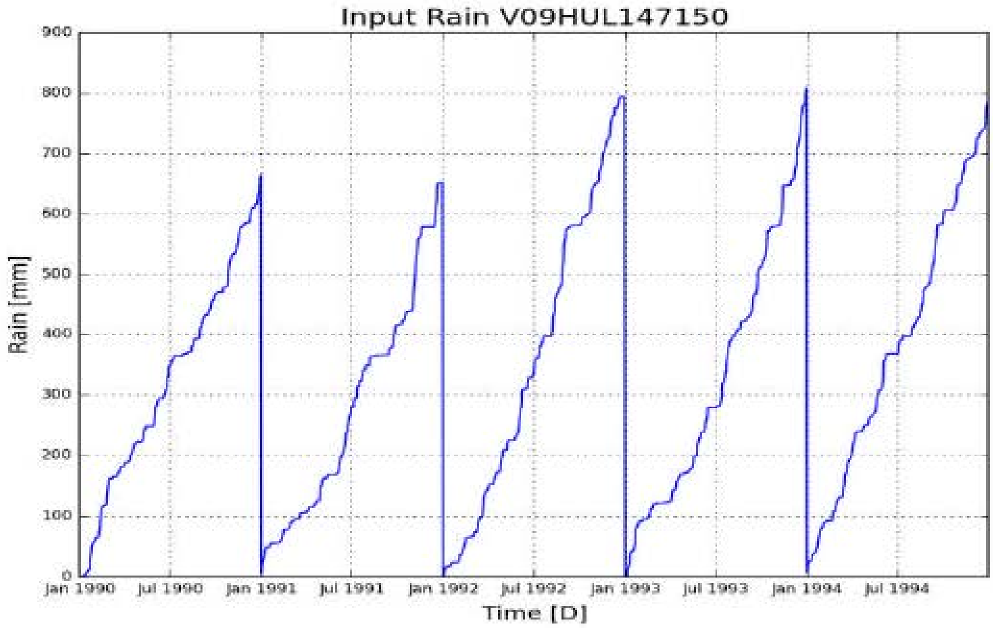


Figure 1: Cumulative precipitation on catchment V09HUL147150 (Demerbekken)

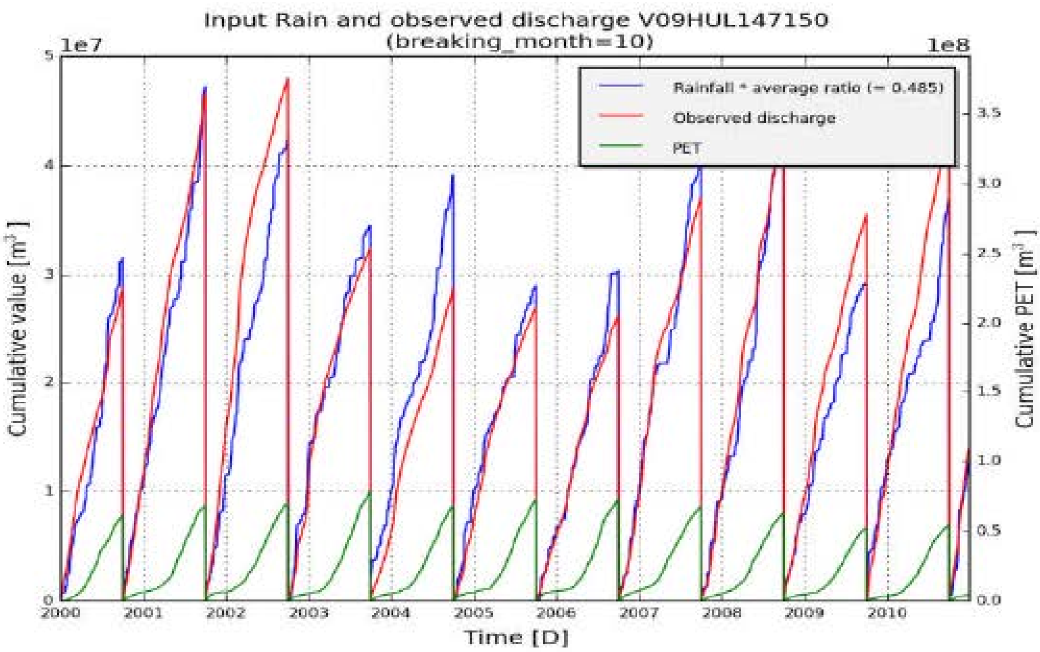


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09HUL147150 (Demerbekken)

9.5.4.2 Model summary

model_structure	WETSPAclassic.paramset1

subcatchment_name	V09HUL147150
subcatchment_area [m2]	95300000
Validation start_date	01-01-1991
Validation end_date	31-12-1994
frequency	daily

Optimal parameter set:[('Kep', 0.82), ('Ki', 80.51), ('Kg', 0.0), ('Kss', 1.86), ('g0', 65.09), ('g_max', 329.85), ('K_run', 1.46), ('P_max', 73.55)]

Table 1: Goodness of fit for calibration period (2000 - 2010)

	Full year	**Summer**	**Winter**
RelErr	1.1 %	9.6 %	-7.8 %
NS	-0.511	-1.87	0.394
NS_log	0.47	0.346	0.588
NS_rel	0.457	0.211	0.717
KGE	0.331	-0.143	0.703

Table 2 :Goodness of fit for validation period (1991 - 1994)

	Full year	**Summer**	**Winter**
RelErr	-2.7 %	8.9 %	-13.6 %
NS	-0.839	-5.739	0.092
NS_log	0.298	-0.313	0.27
NS_rel	0.001	-1.554	0.574
KGE	0.164	-1.057	0.529

9.5.4.3 Observed and simulated timeseries for optimum parameters

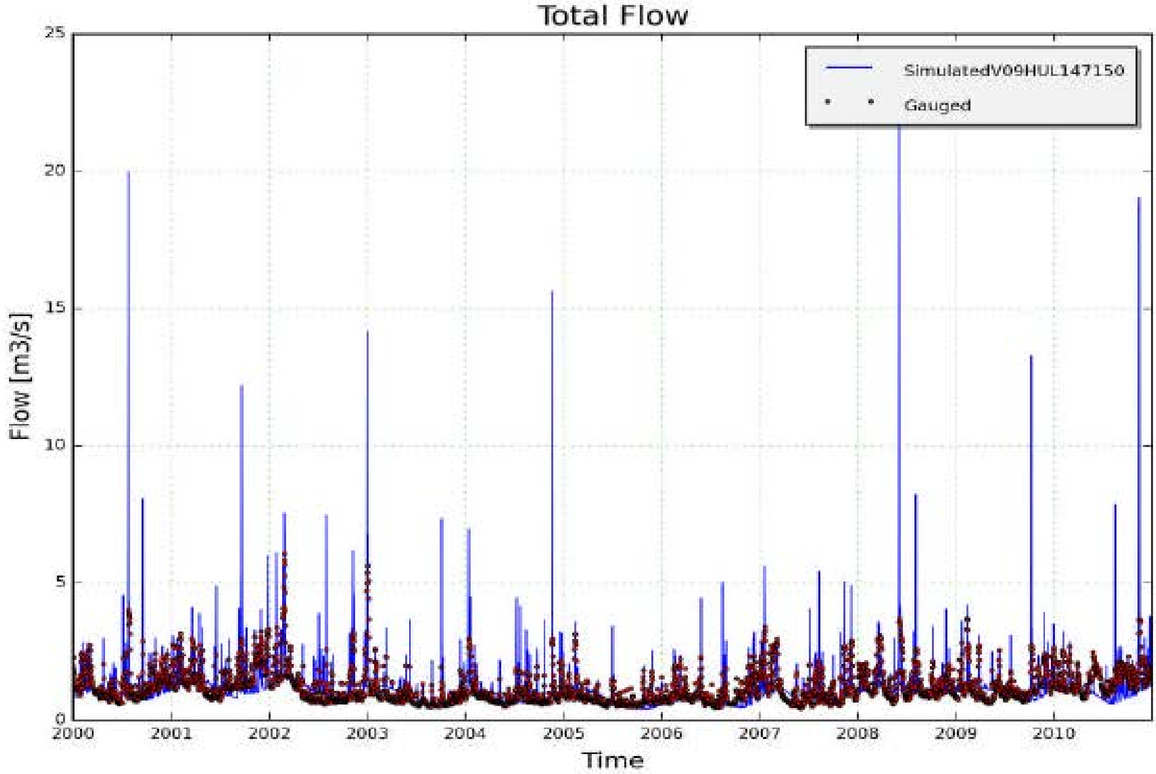


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede(calibration period)

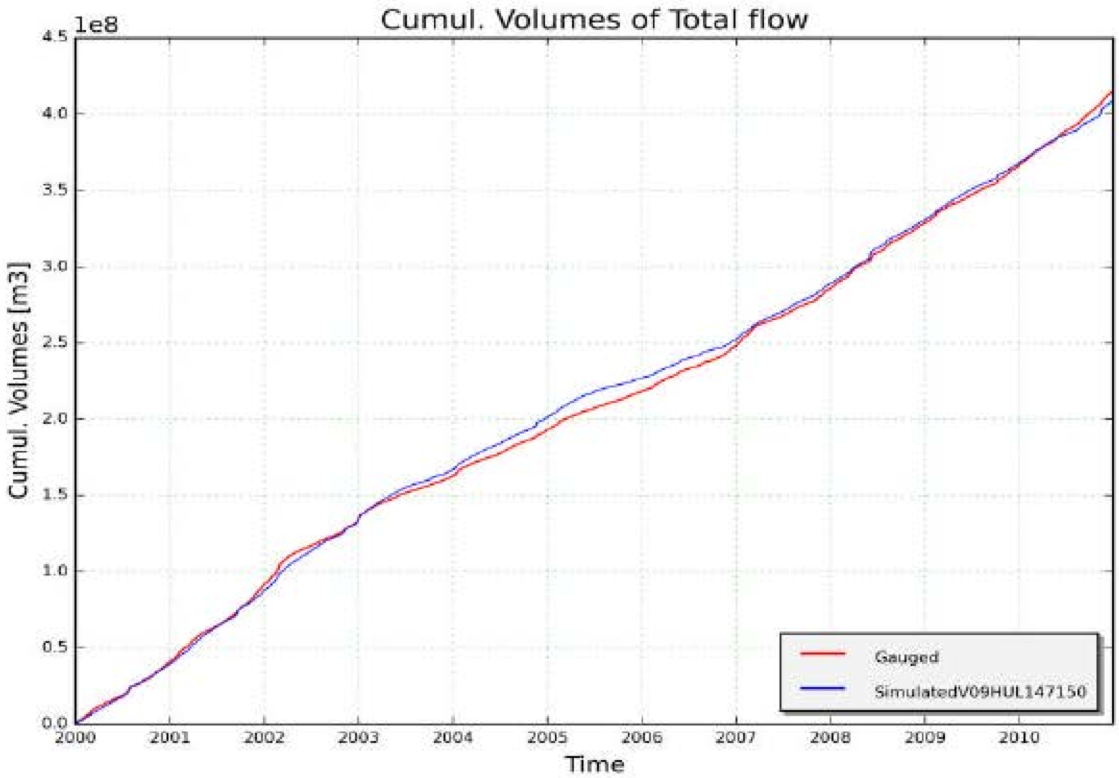


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede (calibration period)

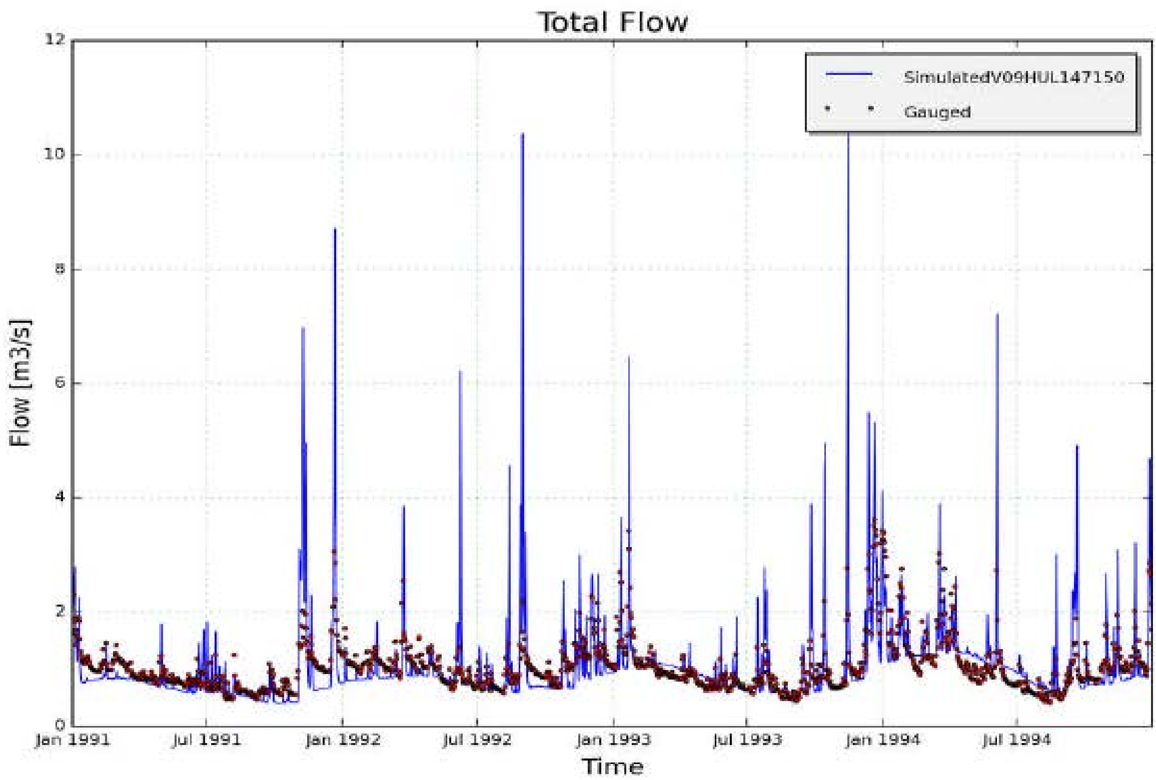


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede (validation period)

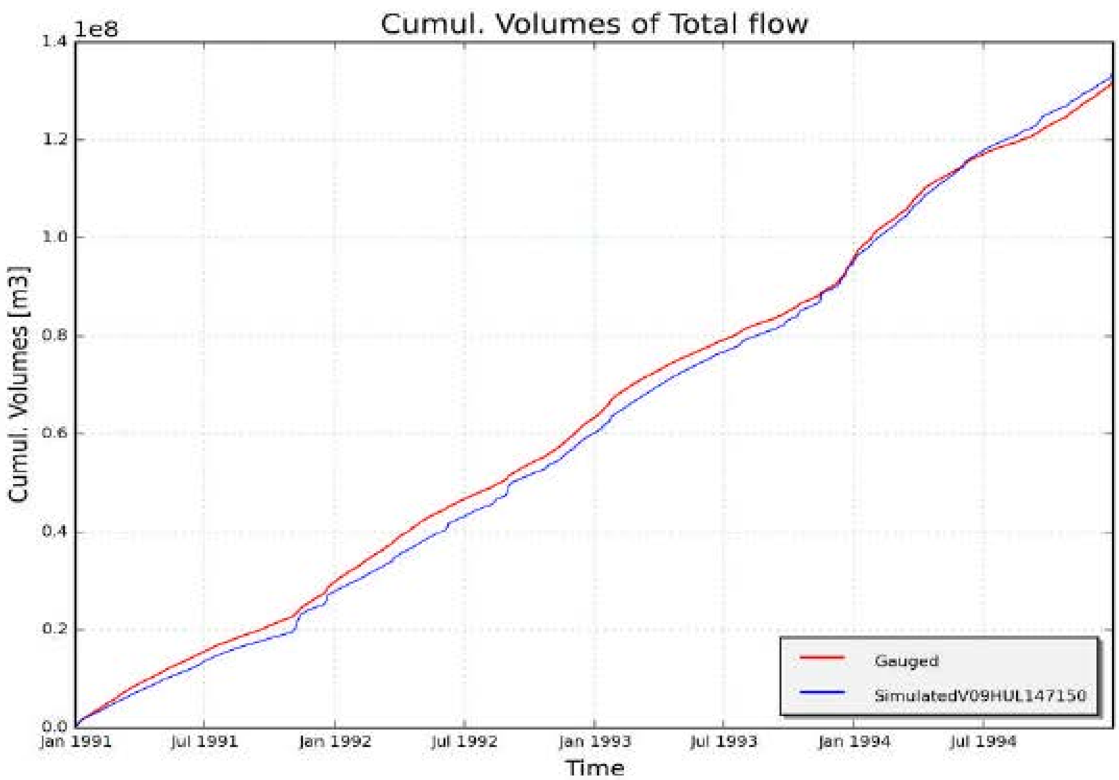


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede (validation period)

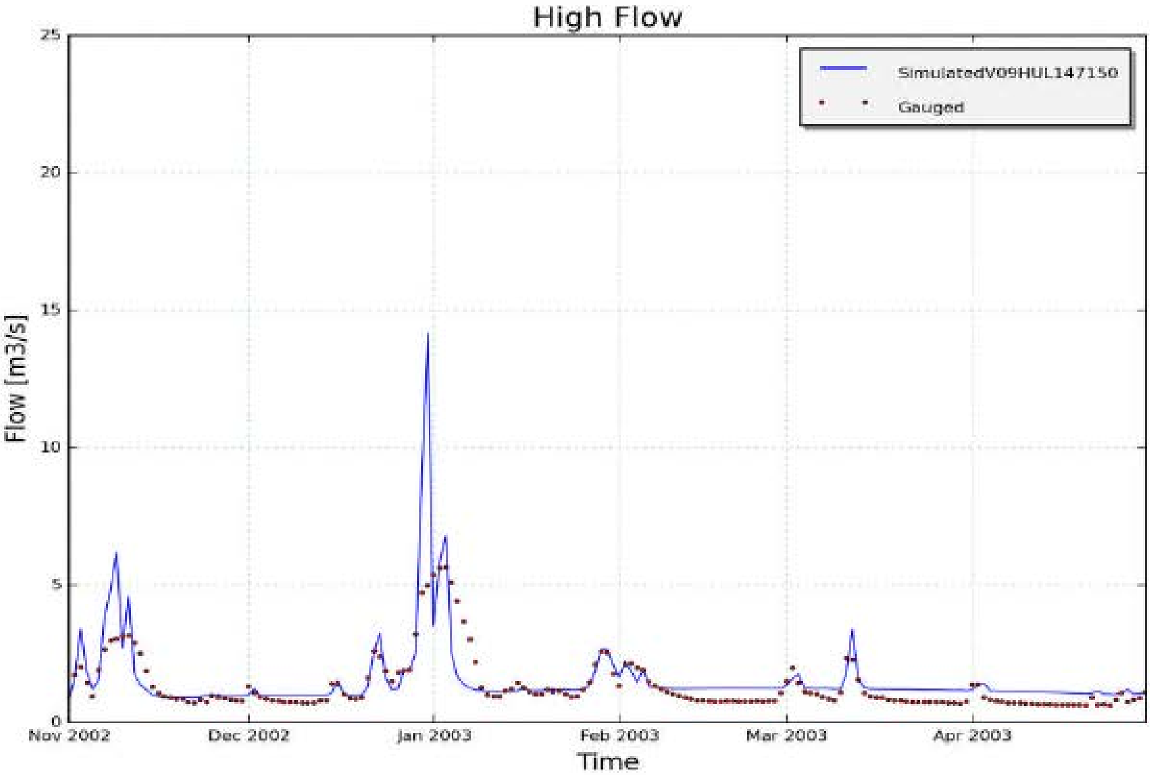


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede

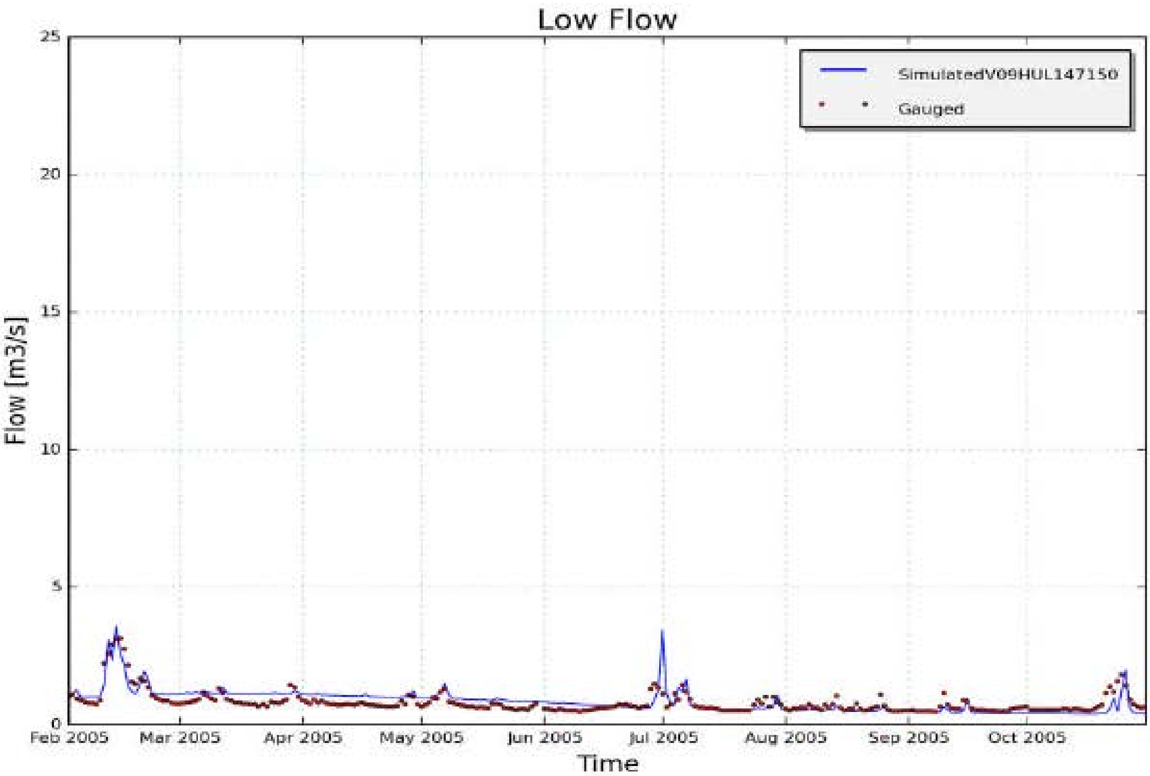


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede

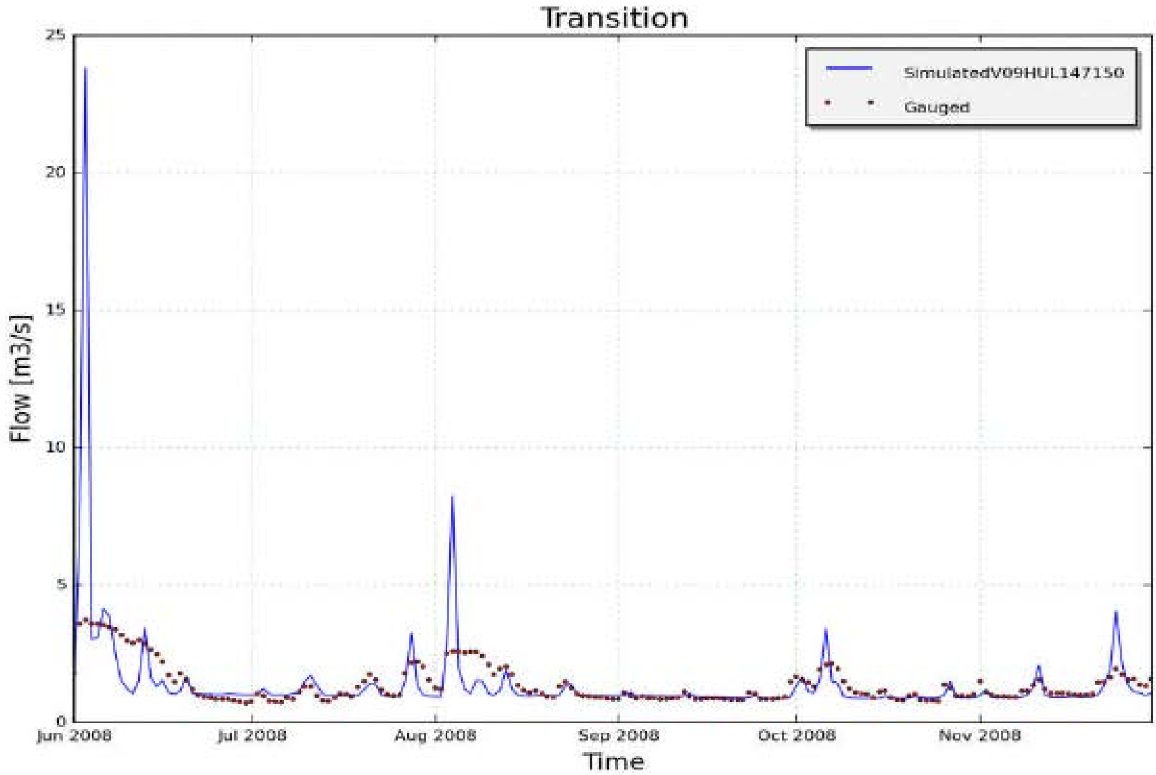


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede

9.5.5 Calibration and validation of WET parameters for catchment "V09MAN161040" (Demerbekken)

9.5.5.1 Input data

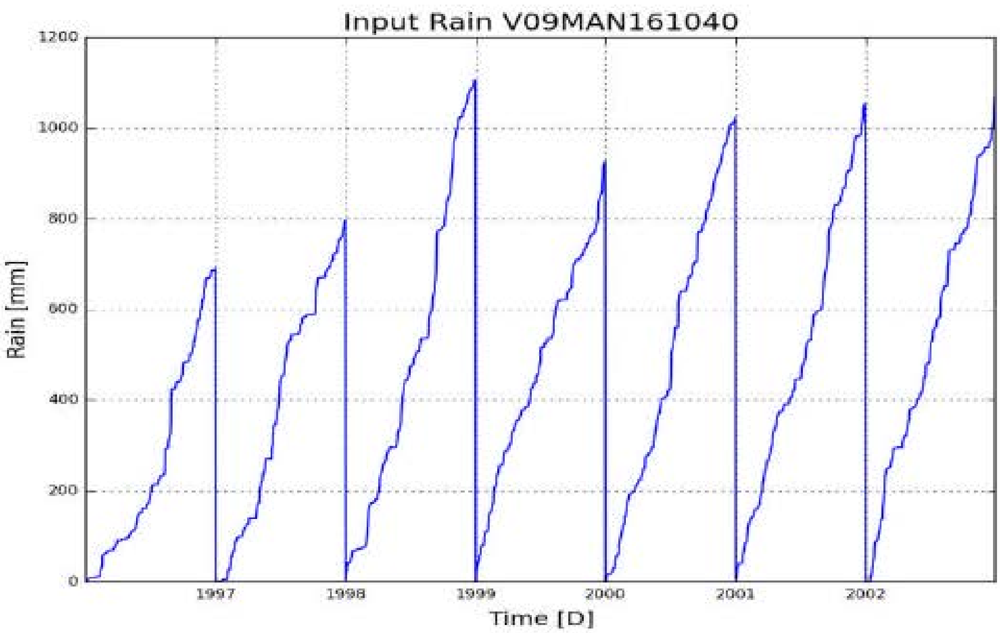


Figure 1: Cumulative precipitation on catchment V09MAN161040 (Demerbekken)

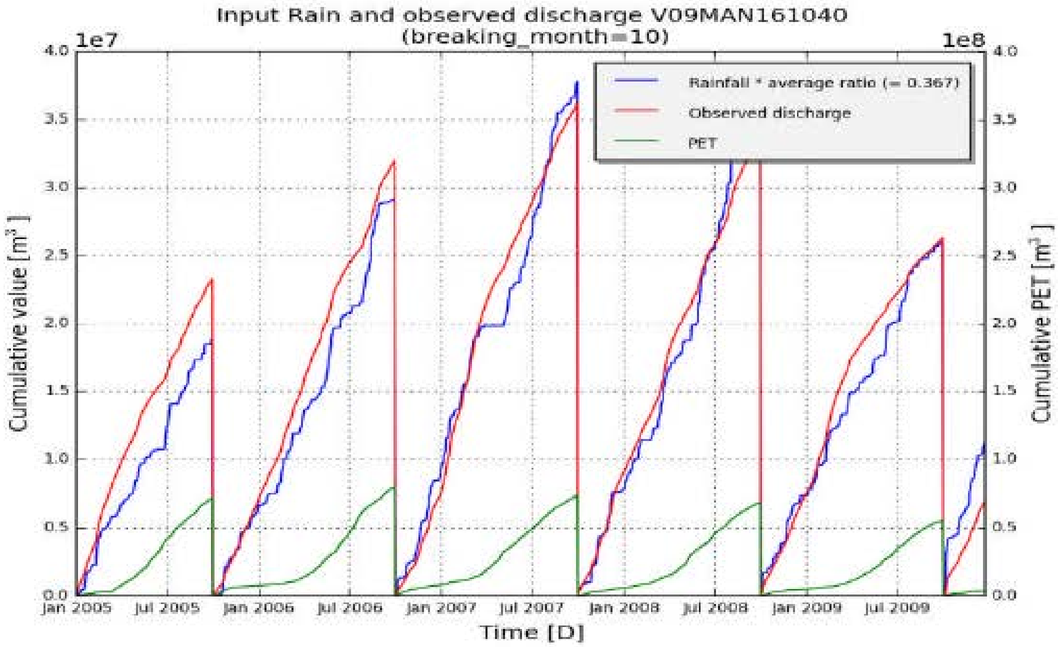


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09MAN161040 (Demerbekken)

9.5.5.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V09MAN161040
subcatchment_area [m2]	102900000
Validation start_date	01-01-1997
Validation end_date	31-12-2002
frequency	daily

Optimal parameter set:[('Kep', 1.92), ('Ki', 13.0), ('Kg', 0.01), ('Kss', 0.96), ('g0', 85.14), ('g_max', 560.43), ('K_run', 0.48), ('P_max', 39.19)]

Table 1: Goodness of fit for calibration period (2005 - 2009)

	Full year	Summer	Winter
RelErr	-1.0 %	-14.3 %	5.9 %
NS	0.577	0.594	0.679
NS_log	0.359	0.287	0.514
NS_rel	0.465	0.63	0.487
KGE	0.788	0.793	0.757

Table 2 :Goodness of fit for validation period (1997 - 2002)

	Full year	Summer	Winter
RelErr	1.9 %	-2.7 %	8.2 %
NS	0.724	0.598	0.788
NS_log	0.672	0.615	0.703
NS_rel	0.642	0.684	0.595
KGE	0.86	0.784	0.862

9.5.5.3 Observed and simulated timeseries for optimum parameters

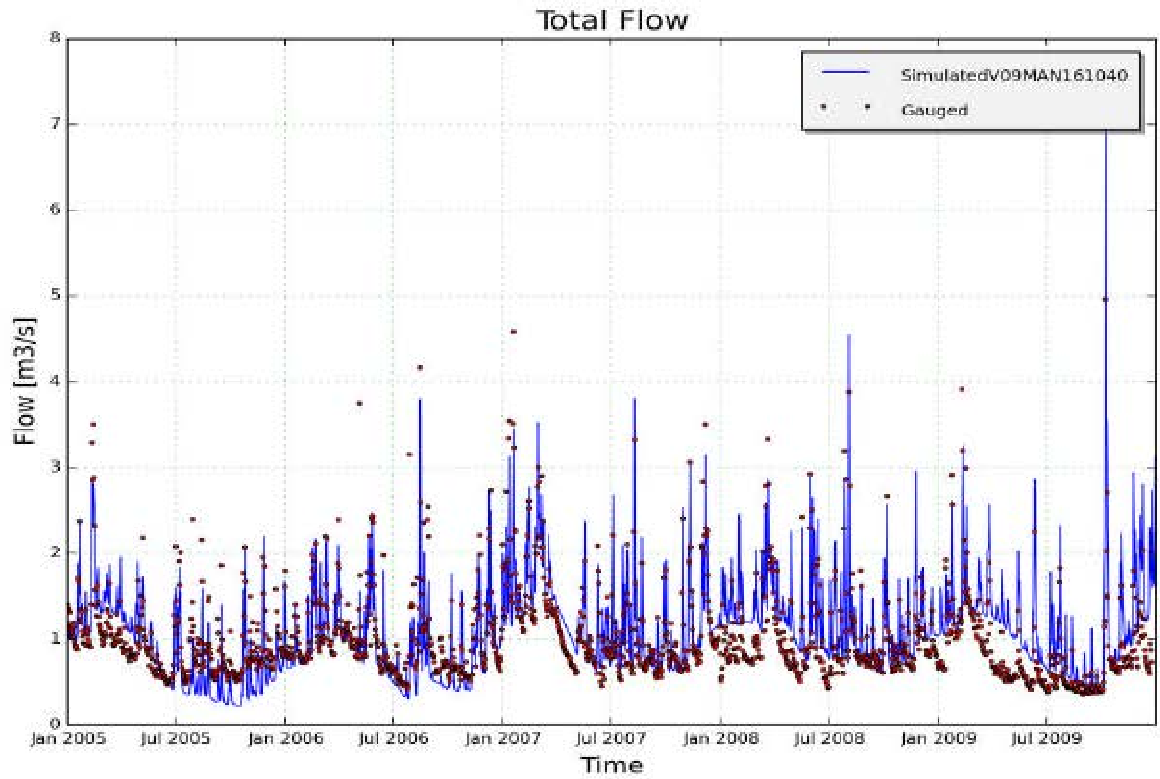


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen(calibration period)

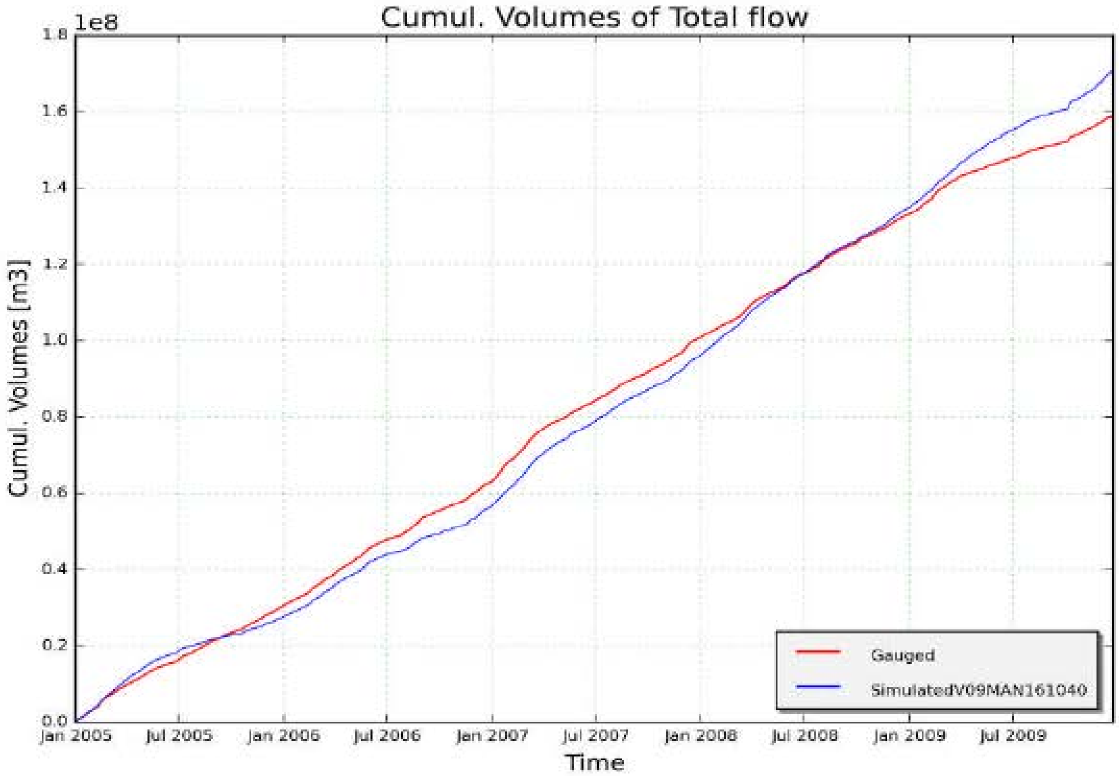


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen (calibration period)

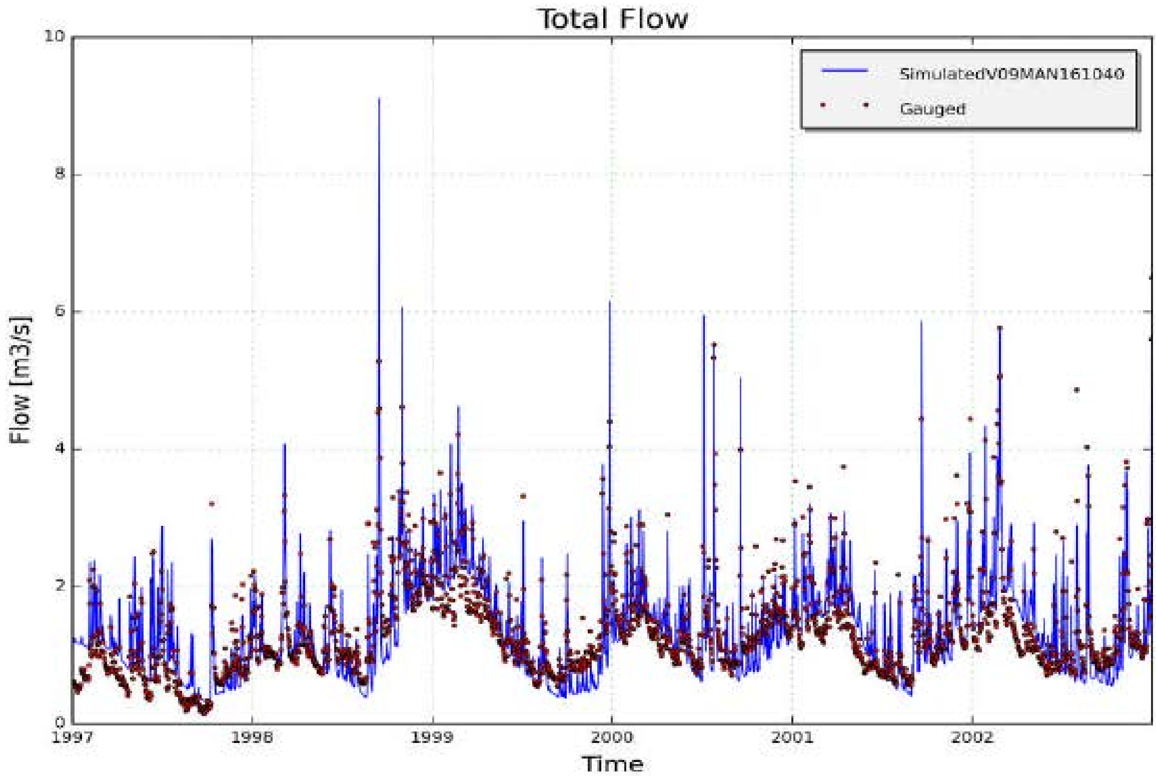


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen (validation period)

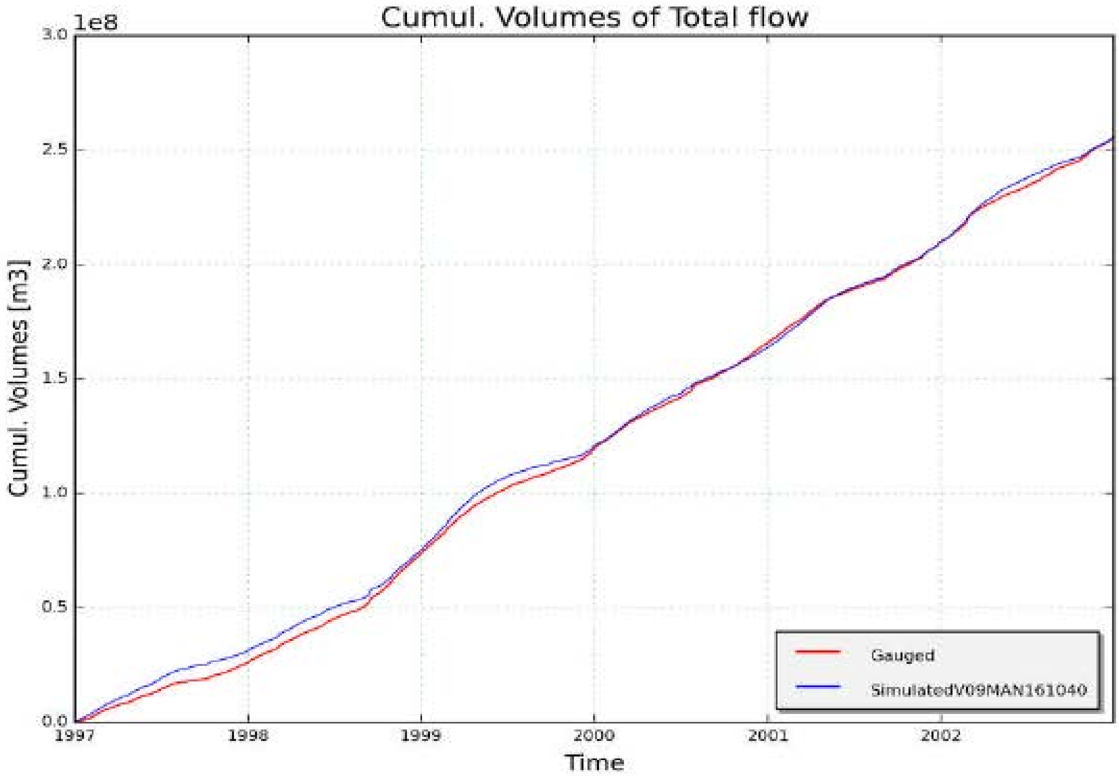


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen (validation period)

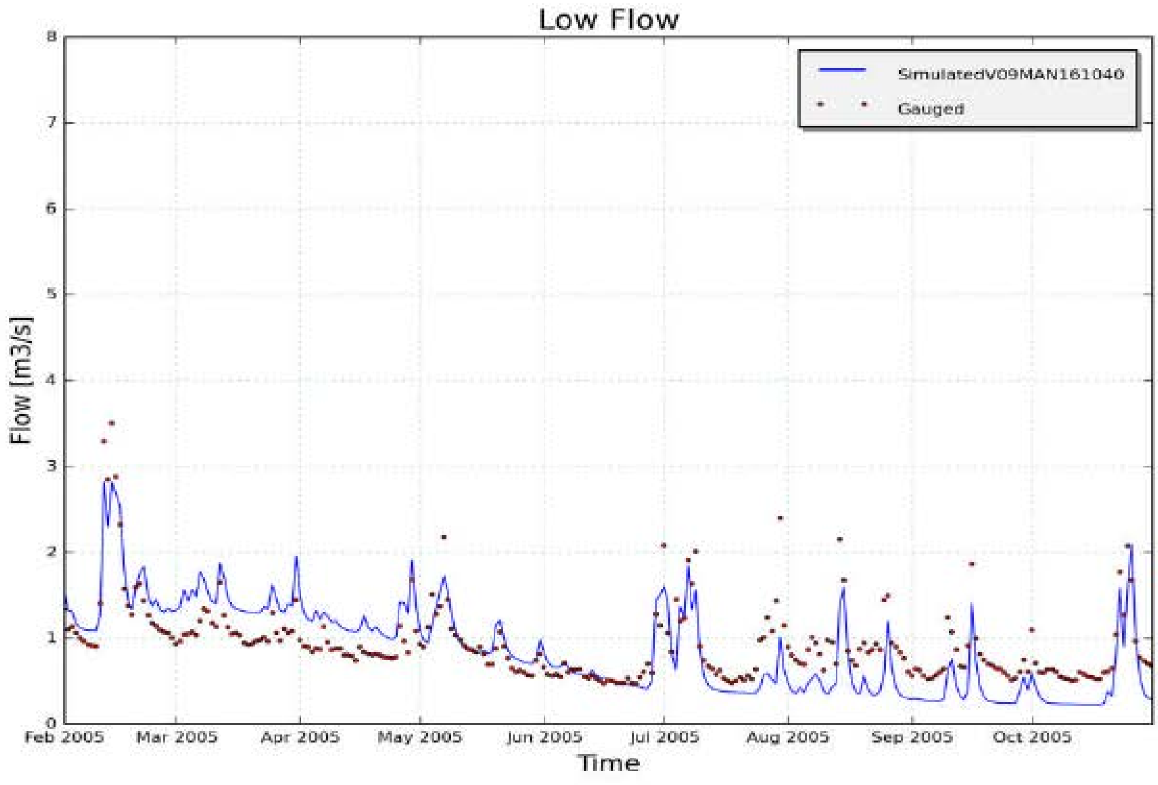


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen

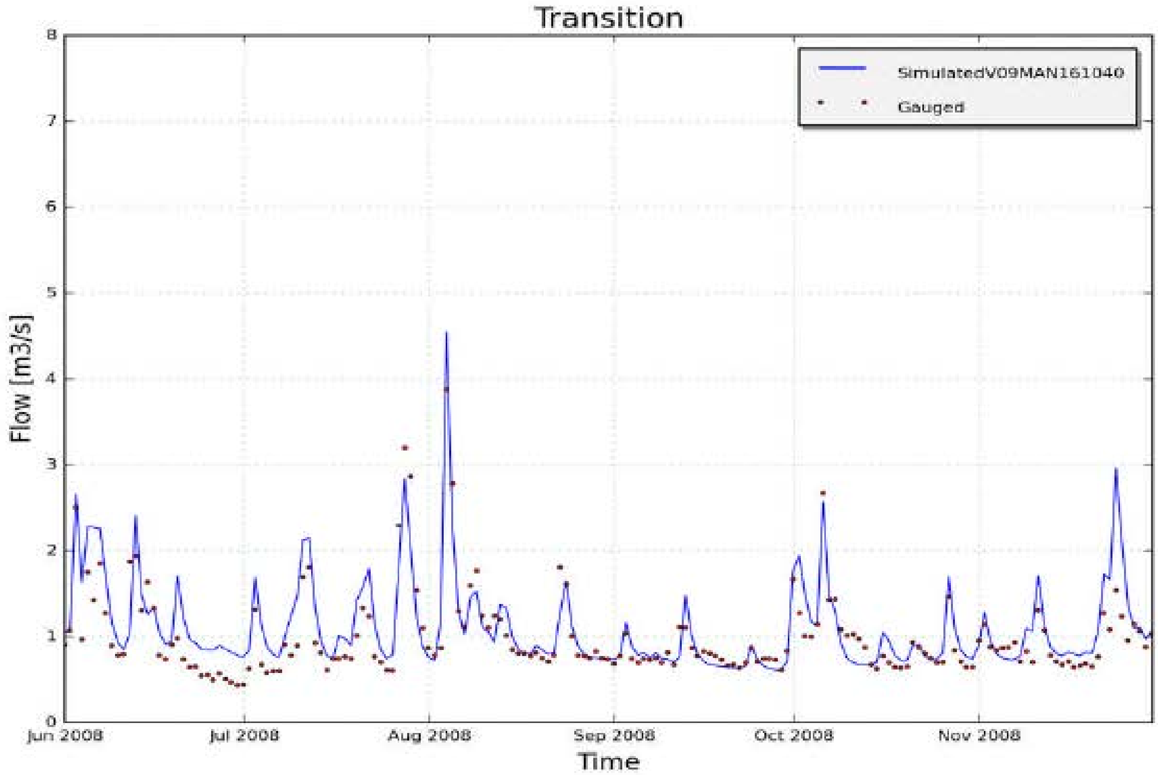


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen

9.5.6 Calibration and validation of WET parameters for catchment "V09MOT144270" (Demerbekken)

9.5.6.1 Input data

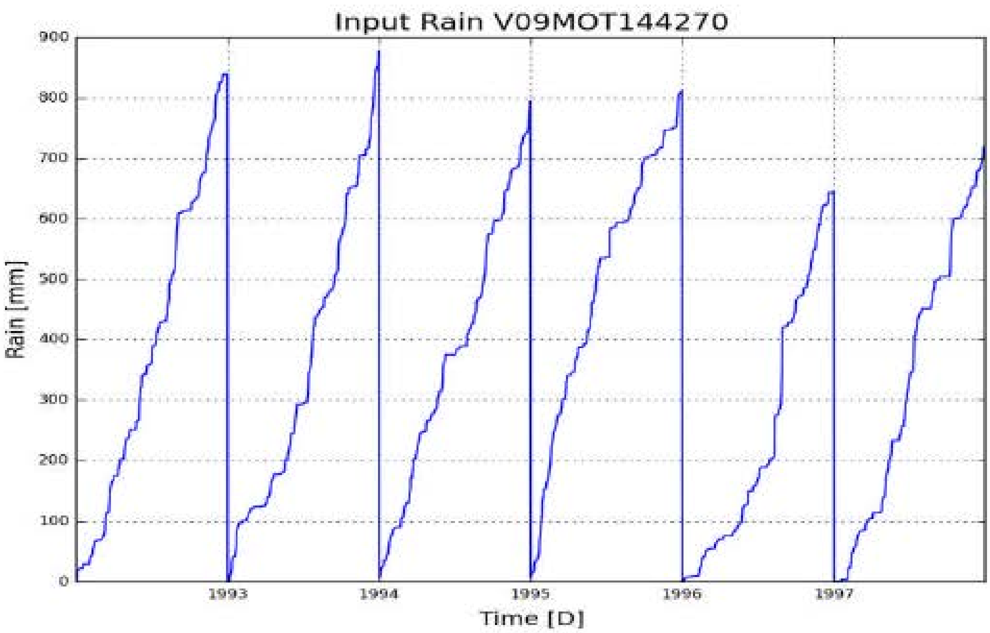


Figure 1: Cumulative precipitation on catchment V09MOT144270 (Demerbekken)

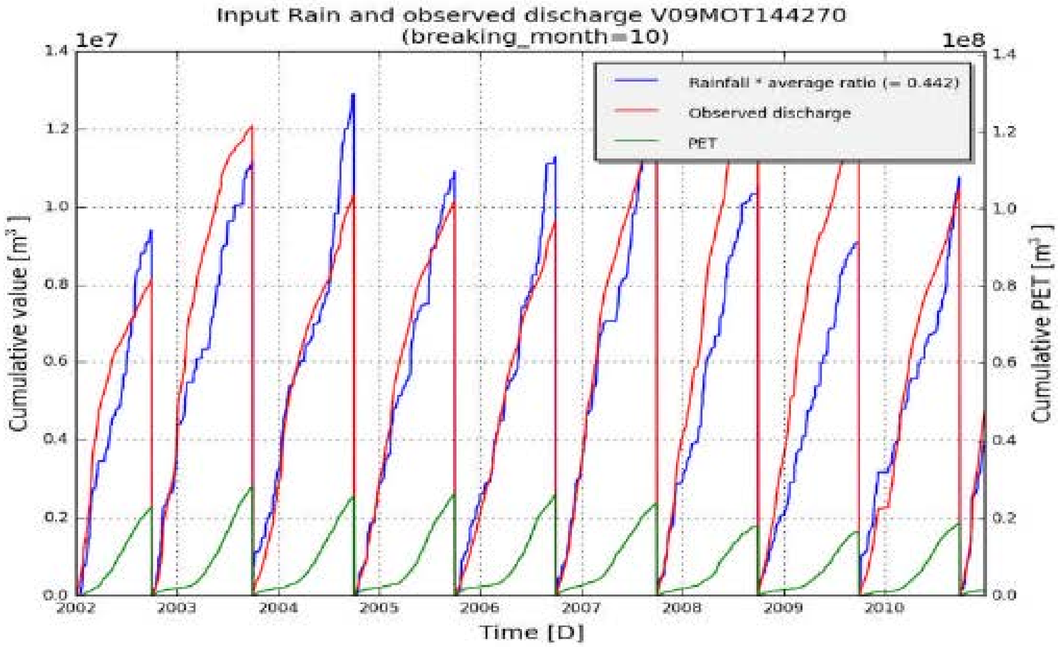


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09MOT144270 (Demerbekken)

9.5.6.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V09MOT144270
subcatchment_area [m2]	33600000
Validation start_date	01-01-1993
Validation end_date	31-12-1997
frequency	daily

Optimal parameter set:[('Kep', 1.56), ('Ki', 20.28), ('Kg', 0.01), ('Kss', 2.84), ('g0', 29.87), ('g_max', 269.27), ('K_run', 2.78), ('P_max', 45.31)]

Table 1: Goodness of fit for calibration period (2003 - 2013)

	Full year	Summer	Winter
RelErr	6.0 %	-10.5 %	16.5 %
NS	0.45	0.051	0.469
NS_log	0.426	0.194	0.254
NS_rel	0.551	0.333	0.303
KGE	0.733	0.503	0.584

Table 2 :Goodness of fit for validation period (1993 - 1997)

	Full year	Summer	Winter
RelErr	14.9 %	-8.8 %	29.8 %
NS	-0.413	-9.659	0.142
NS_log	0.165	-0.593	0.082
NS_rel	-0.319	-2.588	-0.314
KGE	0.309	-1.902	0.581

9.5.6.3 Observed and simulated timeseries for optimum parameters

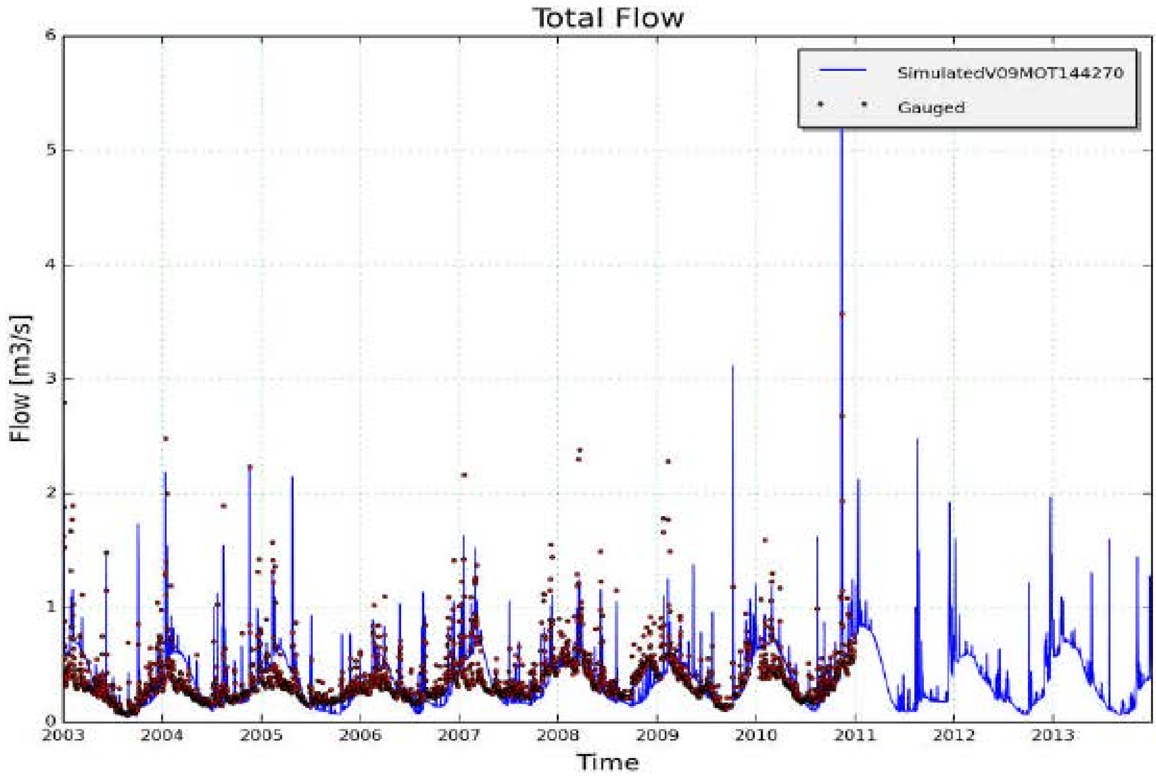


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09MOT144270, station 14410102 - Motte; Rillaar(calibration period)

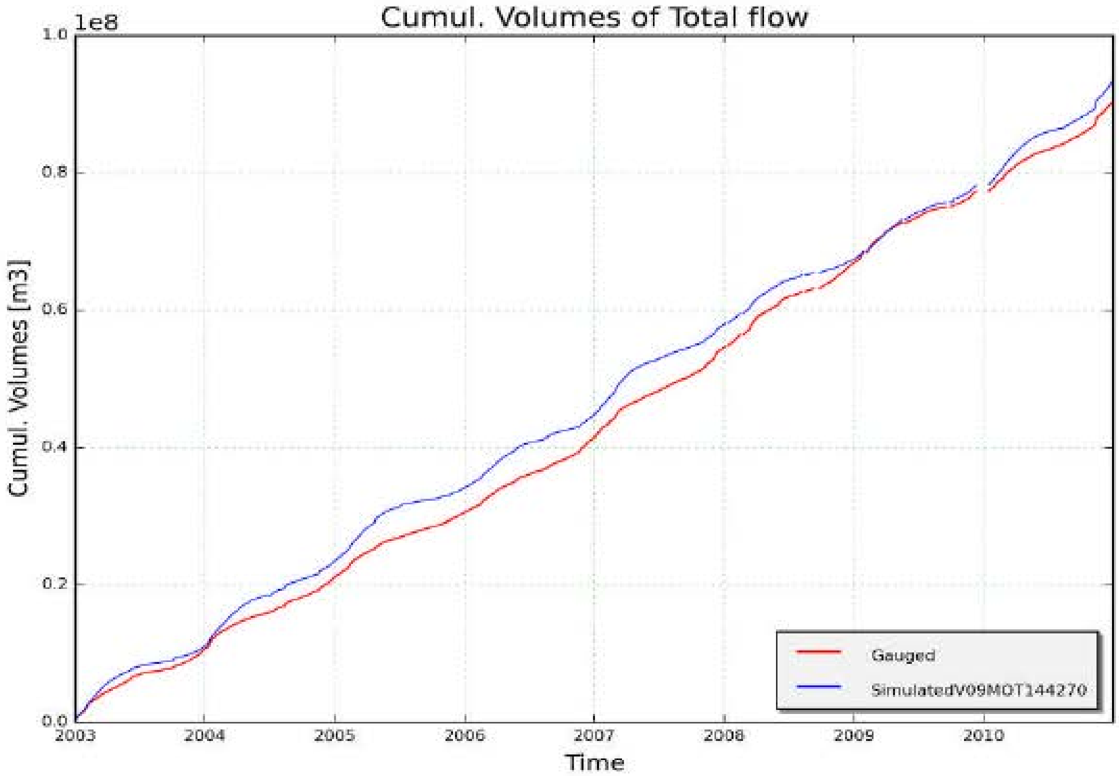


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09MOT144270, station 14410102 - Motte; Rillaar (calibration period)

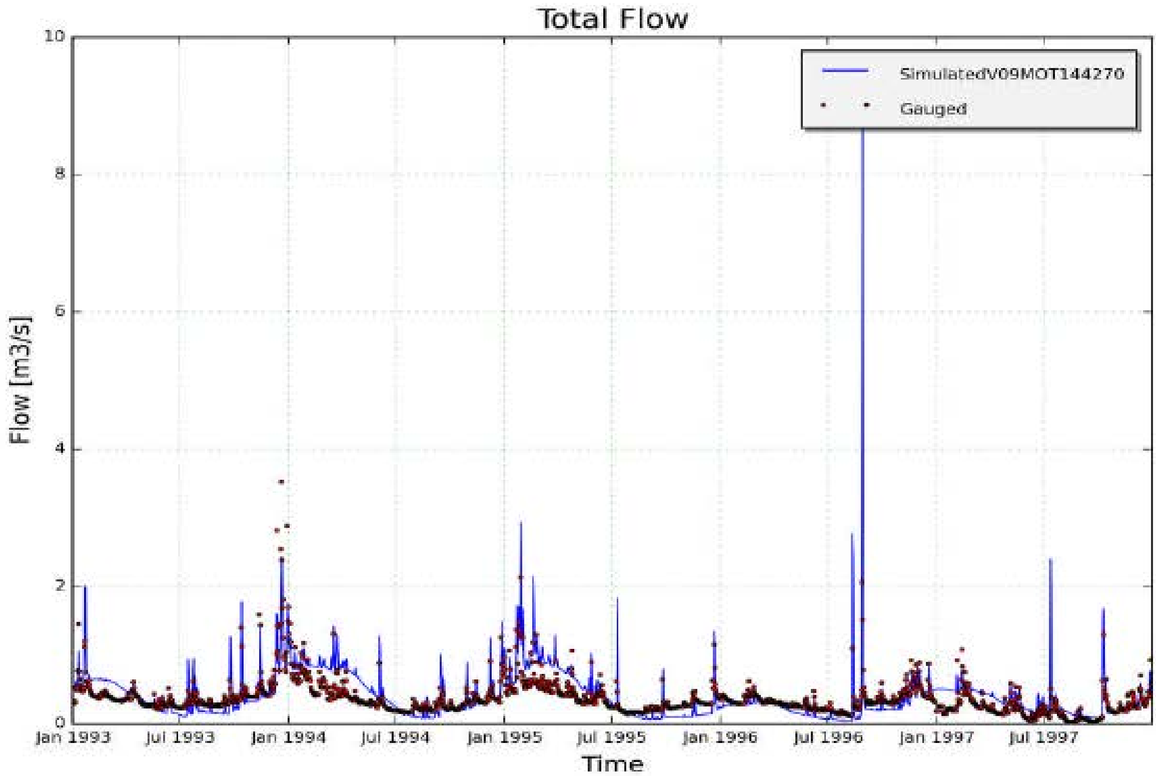


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09MOT144270, station 14410102 - Motte; Rillaar (validation period)

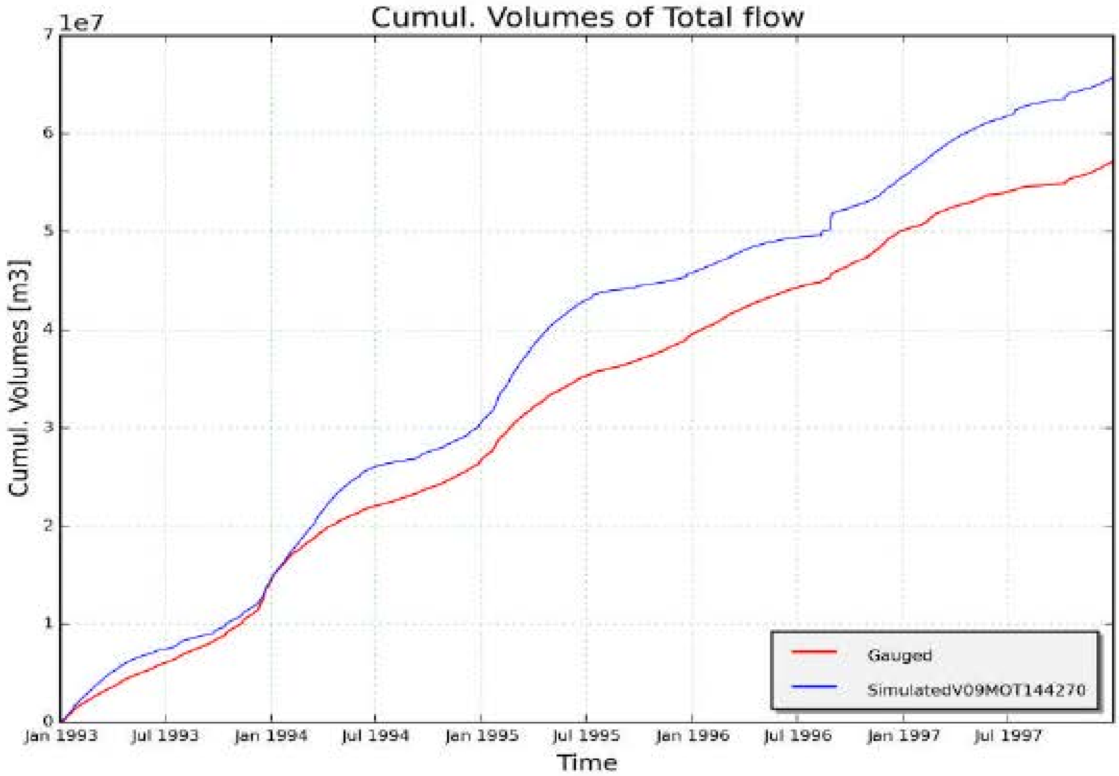


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09MOT144270, station 14410102 - Motte; Rillaar (validation period)

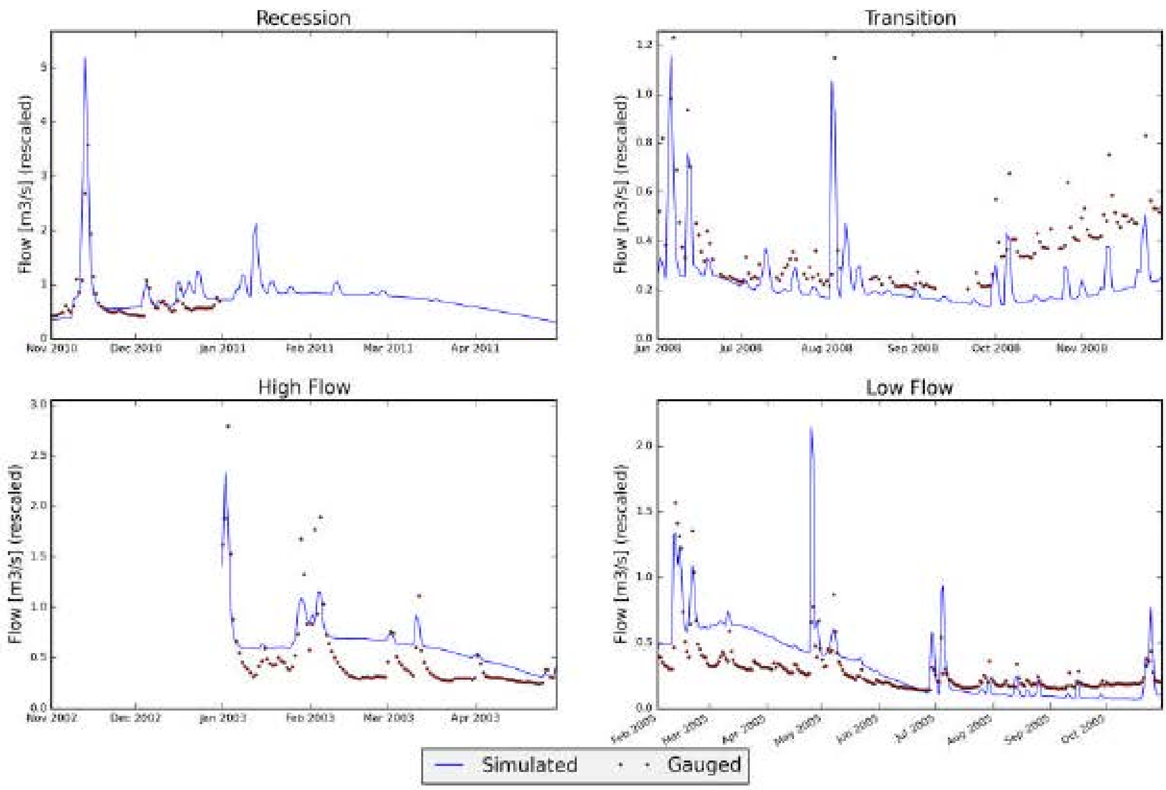


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09MOT144270, station 14410102 - Motte; Rillaar

9.5.7 Calibration and validation of WET parameters for catchment "V09VEL145100" (Demerbekken)

9.5.7.1 Input data

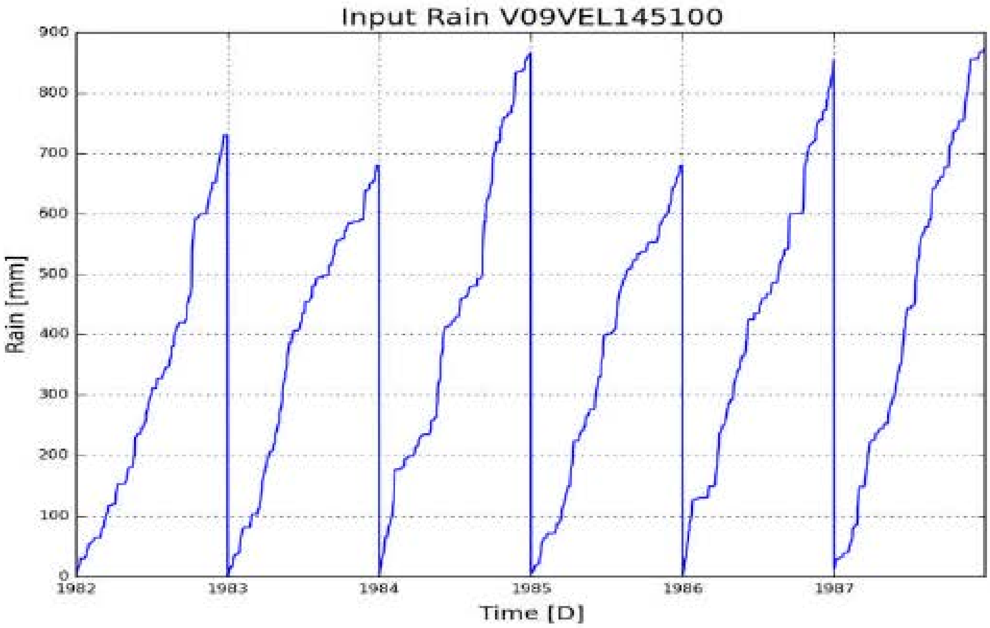


Figure 1: Cumulative precipitation on catchment V09VEL145100 (Demerbekken)

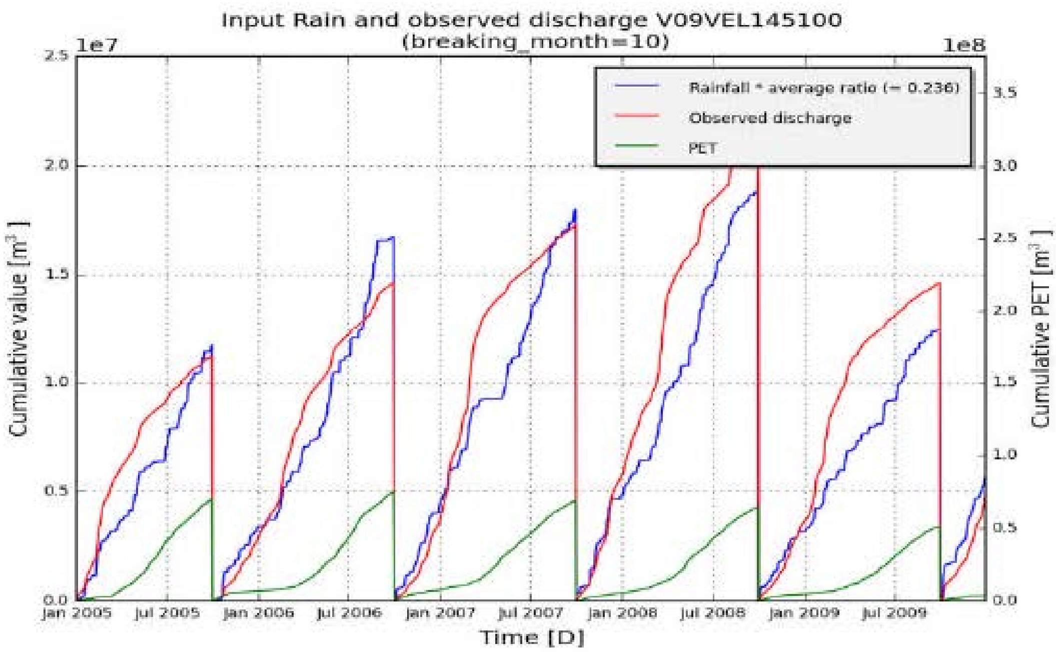


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09VEL145100 (Demerbekken)

9.5.7.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V09VEL145100
subcatchment_area [m2]	96800000
Validation start_date	01-01-1983
Validation end_date	31-12-1987
frequency	daily

Optimal parameter set:[('Kep', 1.58), ('Ki', 18.56), ('Kg', 0.0), ('Kss', 2.05), ('g0', 133.9), ('g_max', 228.74), ('K_run', 7.9), ('P_max', 304.11)]

Table 1: Goodness of fit for calibration period (2005 - 2009)

	Full year	Summer	Winter
RelErr	-0.5 %	-4.1 %	-6.9 %
NS	0.493	-0.238	0.445
NS_log	0.562	-0.114	0.477
NS_rel	0.626	0.423	0.641
KGE	0.601	0.362	0.439

Table 2 :Goodness of fit for validation period (1983 - 1987)

	Full year	Summer	Winter
RelErr	-1.9 %	29.2 %	-4.1 %
NS	0.54	-0.238	0.545
NS_log	0.491	0.092	0.395
NS_rel	0.447	-0.073	0.638
KGE	0.668	0.392	0.653

9.5.7.3 Observed and simulated timeseries for optimum parameters

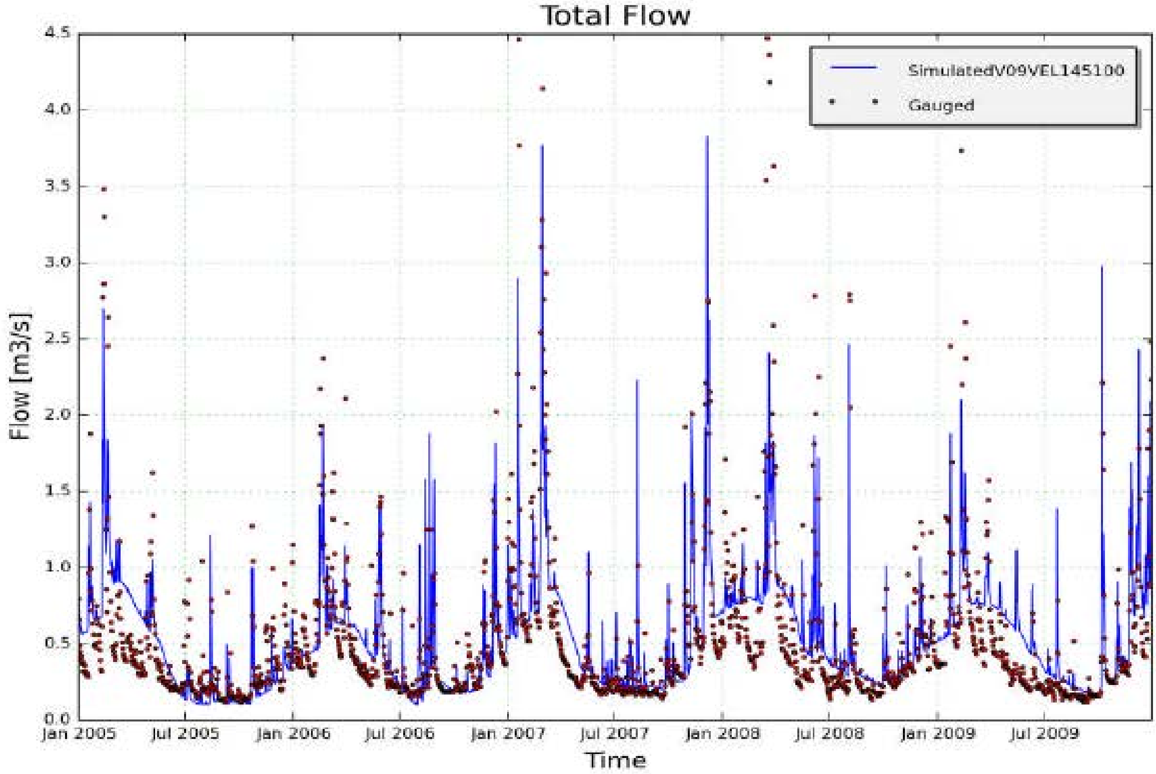


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09VEL145100, station 14510102 - Velp; Ransberg(calibration period)

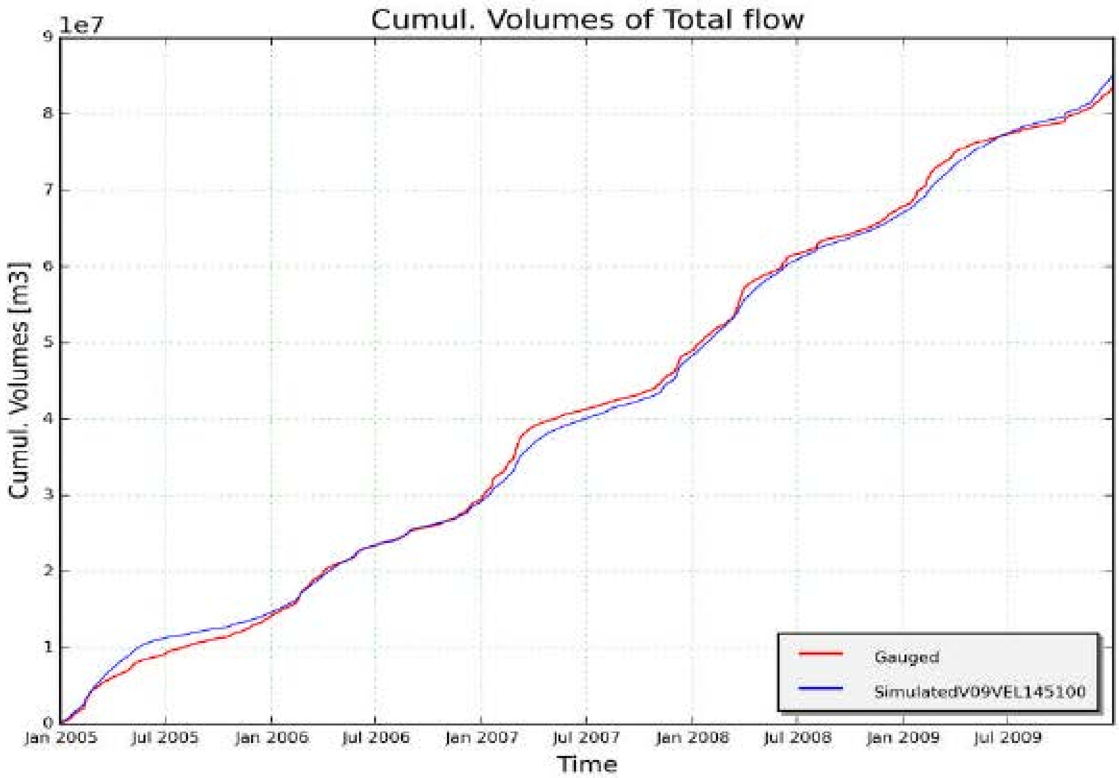


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09VEL145100, station 14510102 - Velp; Ransberg (calibration period)

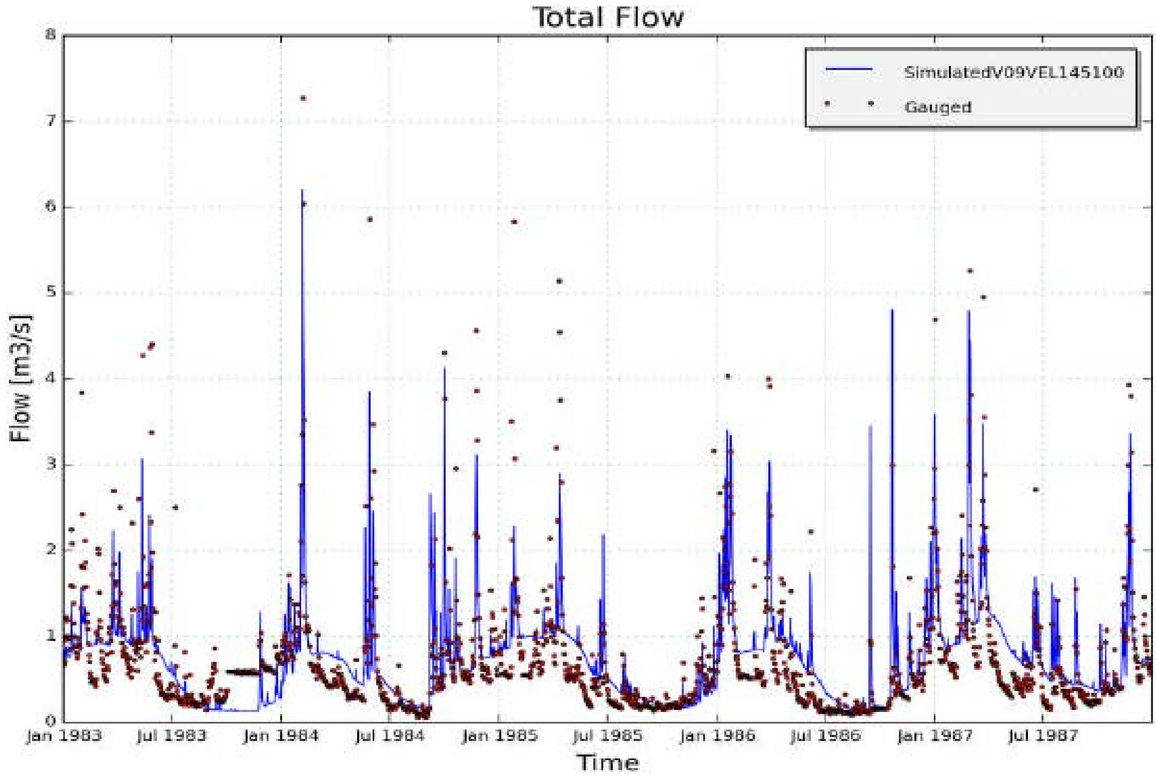


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09VEL145100, station 14510102 - Velp; Ransberg (validation period)

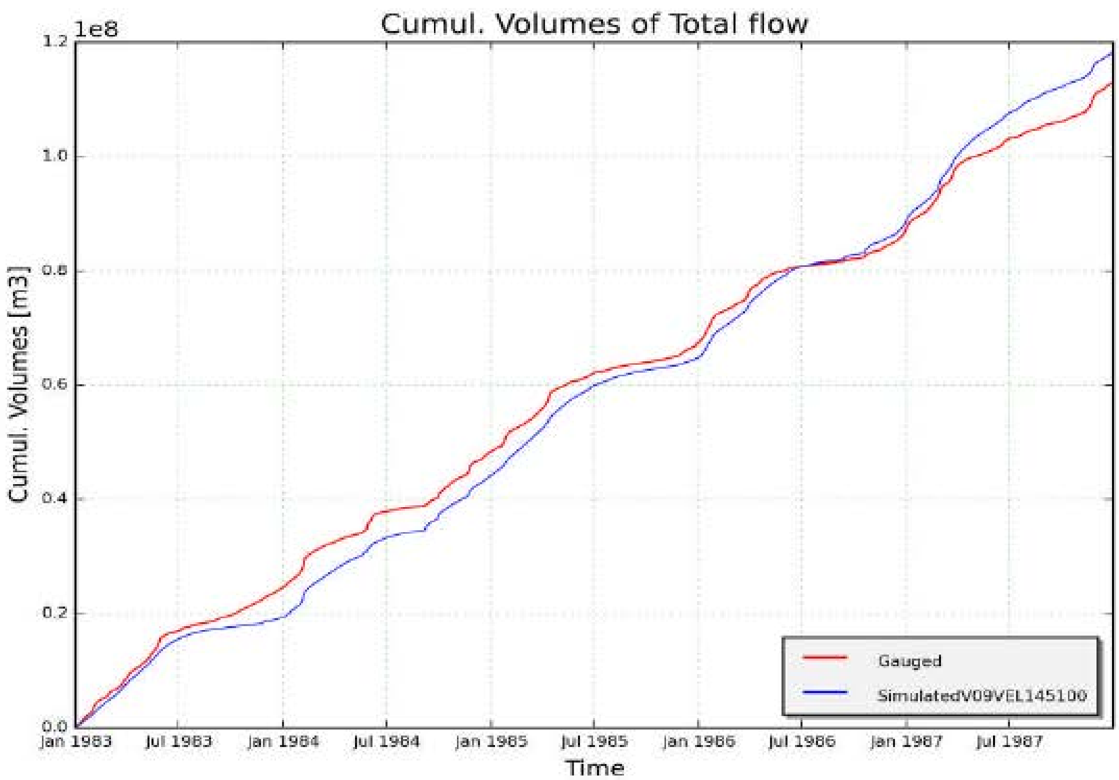


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09VEL145100, station 14510102 - Velp; Ransberg (validation period)

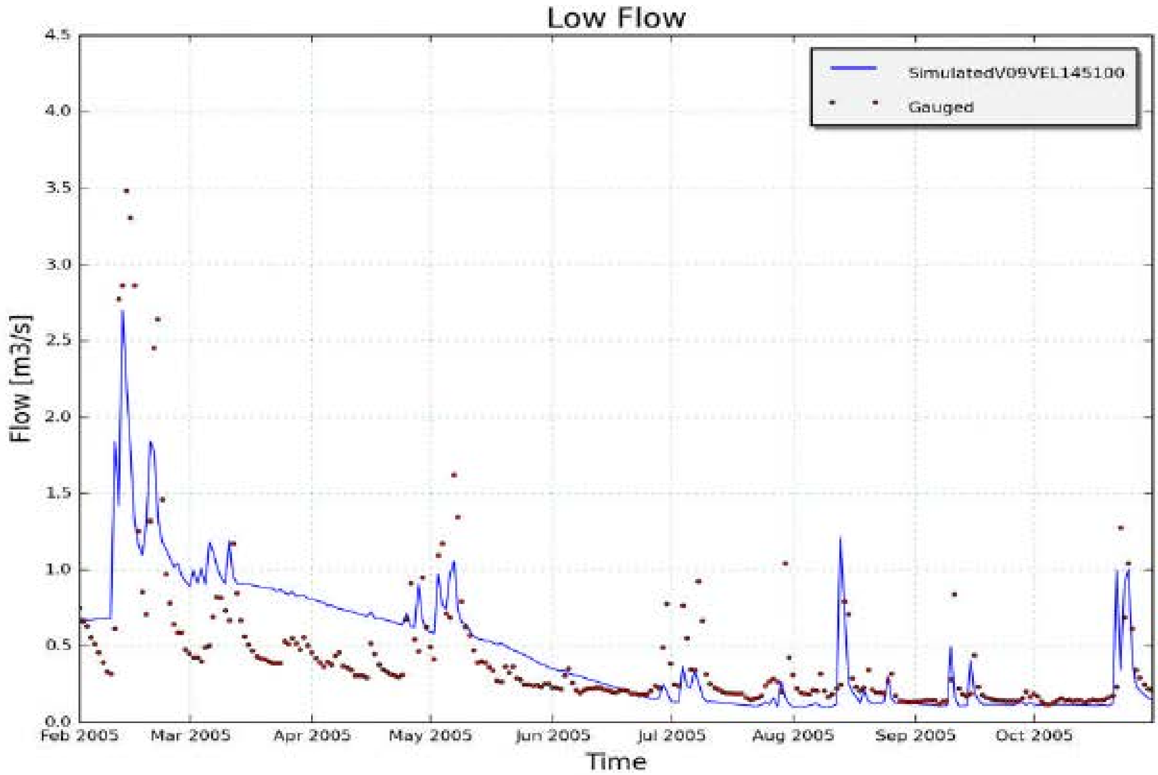


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09VEL145100, station 14510102 - Velp; Ransberg

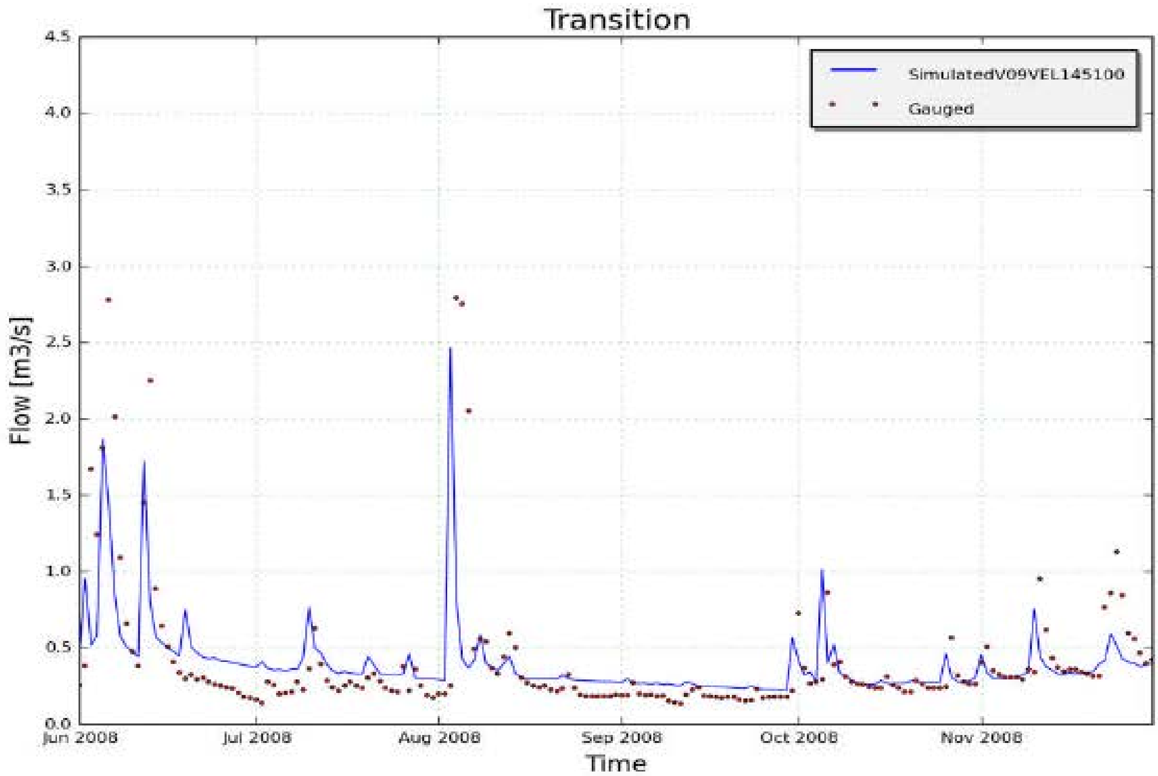


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09VEL145100, station 14510102 - Velp; Ransberg

9.5.8 Calibration and validation of WET parameters for catchment "V09WIN141310" (Demerbekken)

9.5.8.1 Input data

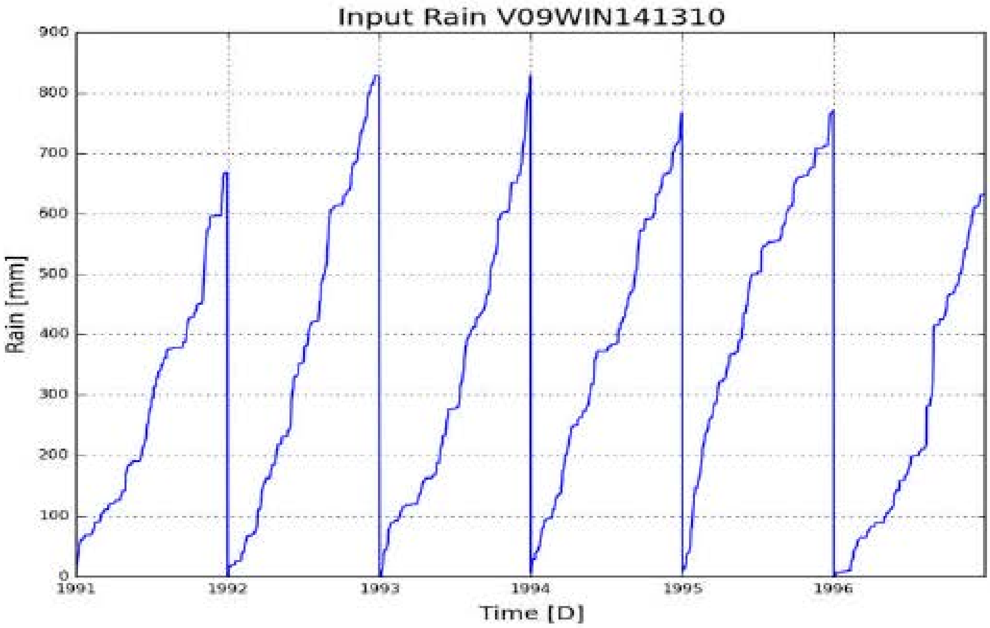


Figure 1: Cumulative precipitation on catchment V09WIN141310 (Demerbekken)

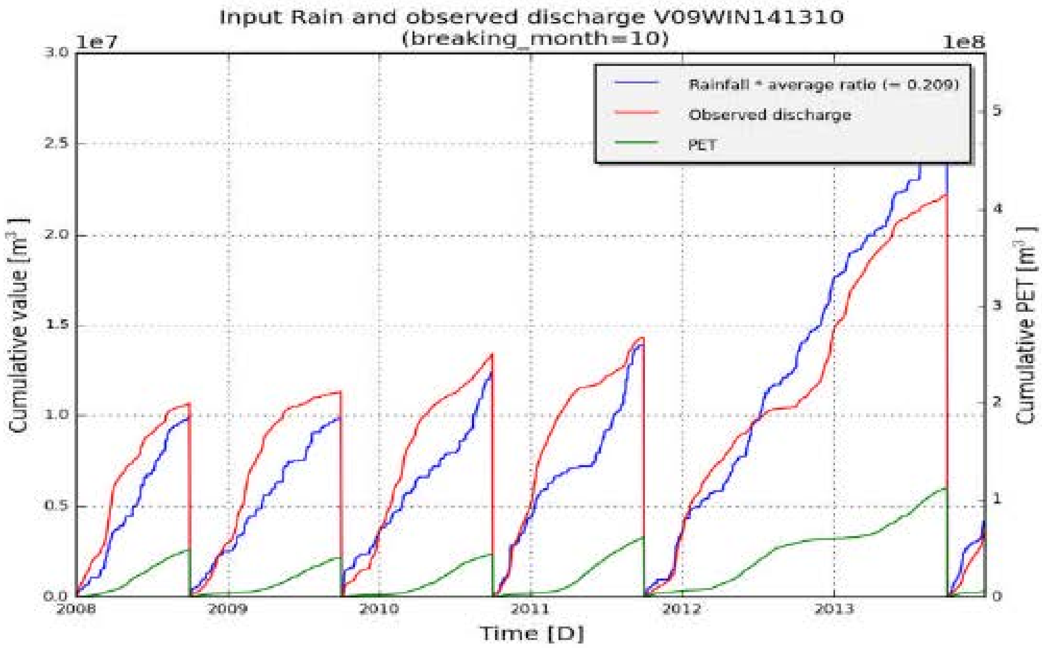


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09WIN141310 (Demerbekken)

9.5.8.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V09WIN141310
subcatchment_area [m2]	80015463
Validation start_date	01-01-1992
Validation end_date	31-12-1996
frequency	daily

Optimal parameter set:[('Kep', 1.95), ('Ki', 17.55), ('Kg', 0.0), ('Kss', 0.8), ('g0', 163.65), ('g_max', 252.34), ('K_run', 3.44), ('P_max', 126.48)]

Table 1: Goodness of fit for calibration period (2008 - 2013)

	Full year	**Summer**	**Winter**
RelErr	-3.5 %	5.9 %	-12.3 %
NS	0.25	-0.855	0.465
NS_log	0.603	0.416	0.475
NS_rel	-24.215	-7.864	0.565
KGE	0.612	0.045	0.732

Table 2 :Goodness of fit for validation period (1992 - 1996)

	Full year	**Summer**	**Winter**
RelErr	-0.01 %	-15.8 %	8.5 %
NS	-0.132	-5.383	0.553
NS_log	0.611	0.44	0.734
NS_rel	0.539	0.324	0.817
KGE	0.281	-1.241	0.556

9.5.8.3 Observed and simulated timeseries for optimum parameters

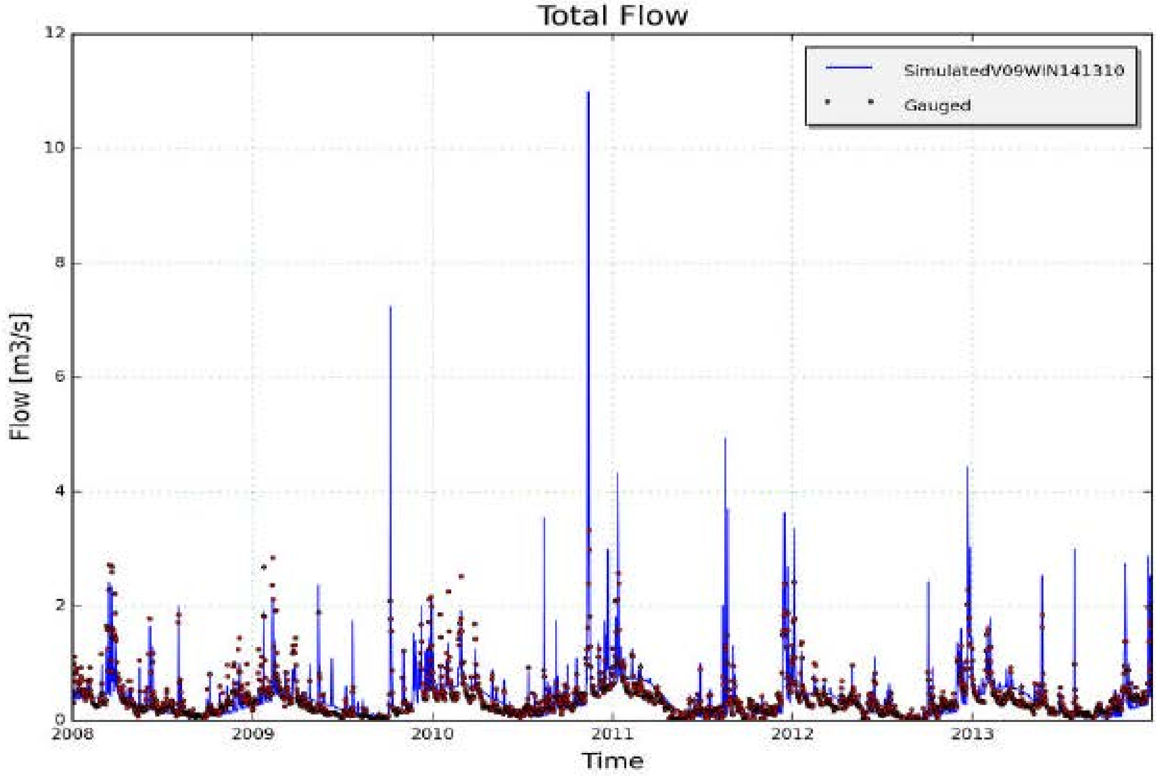


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09WIN141310, station 141 - Rotselaar ; Winge(calibration period)

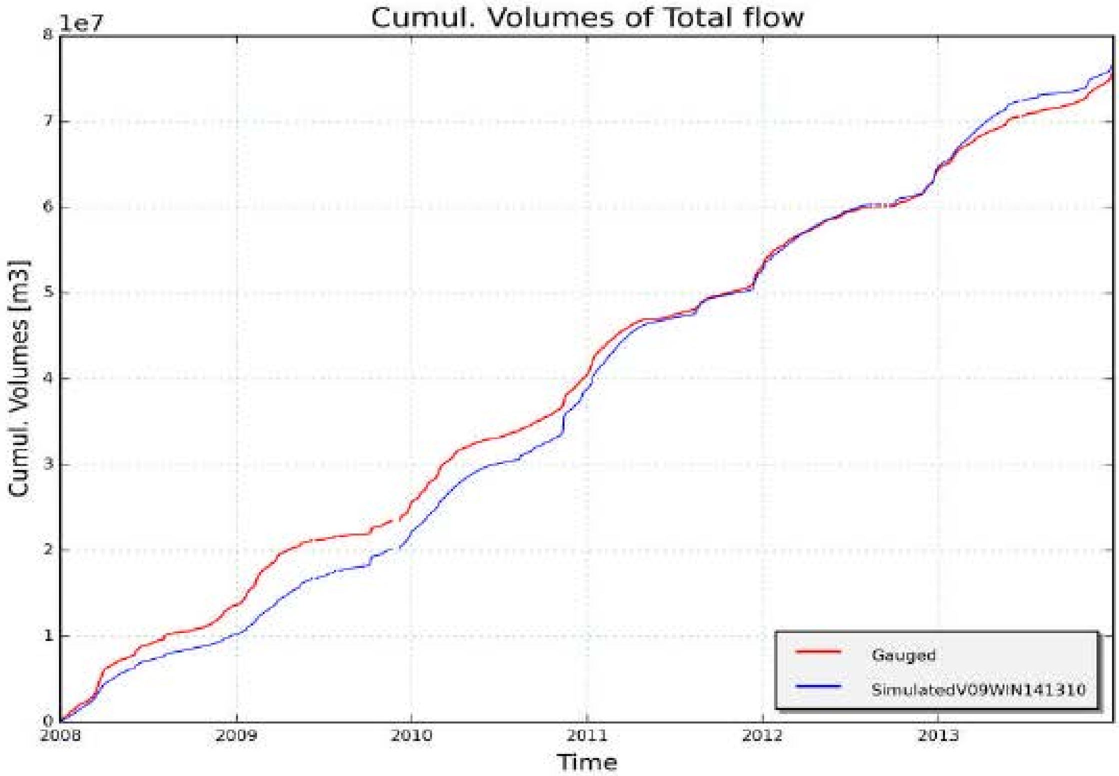


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09WIN141310, station 141 - Rotselaar ; Winge (calibration period)

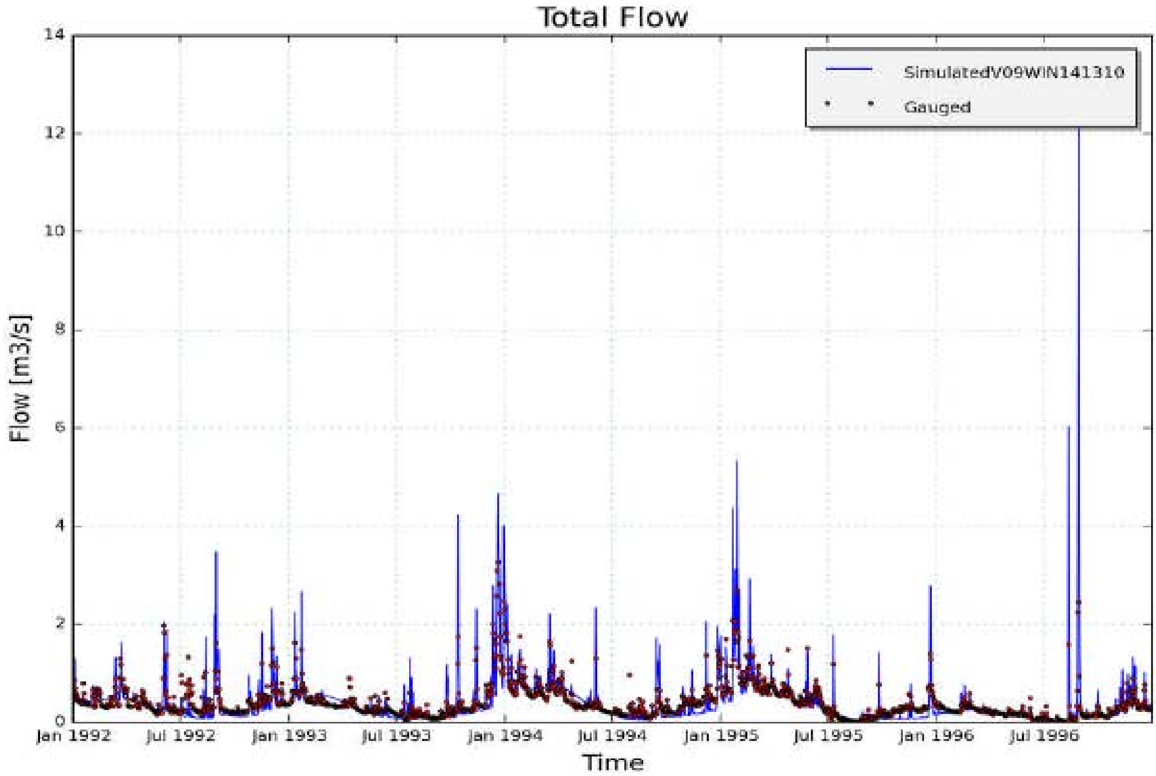


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09WIN141310, station 141 - Rotselaar ; Winge (validation period)

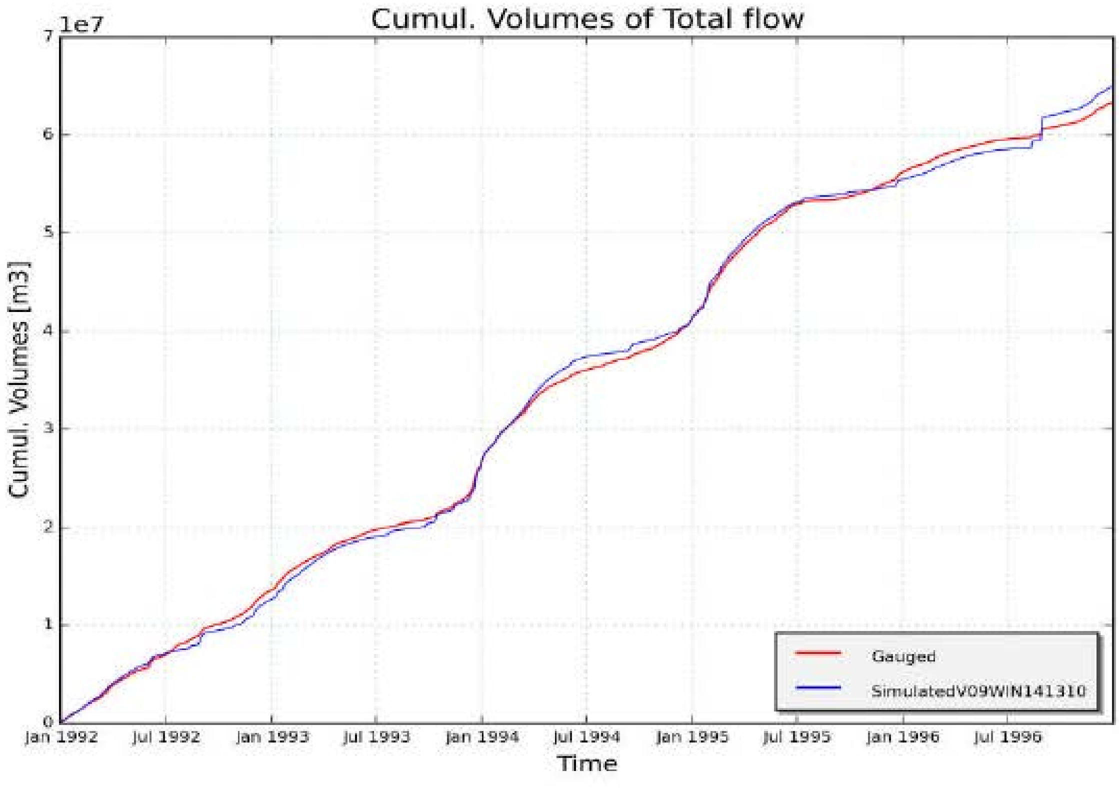


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09WIN141310, station 141 - Rotselaar ; Winge (validation period)

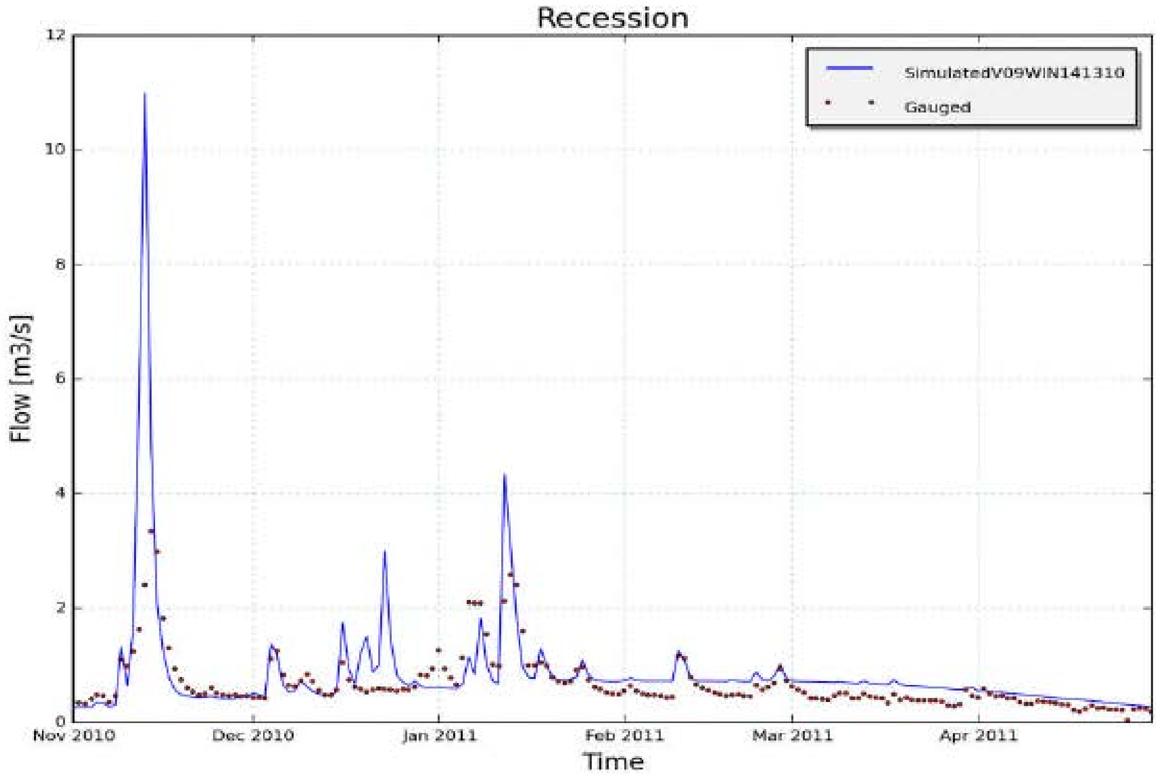


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09WIN141310, station 141 - Rotselaar ; Winge

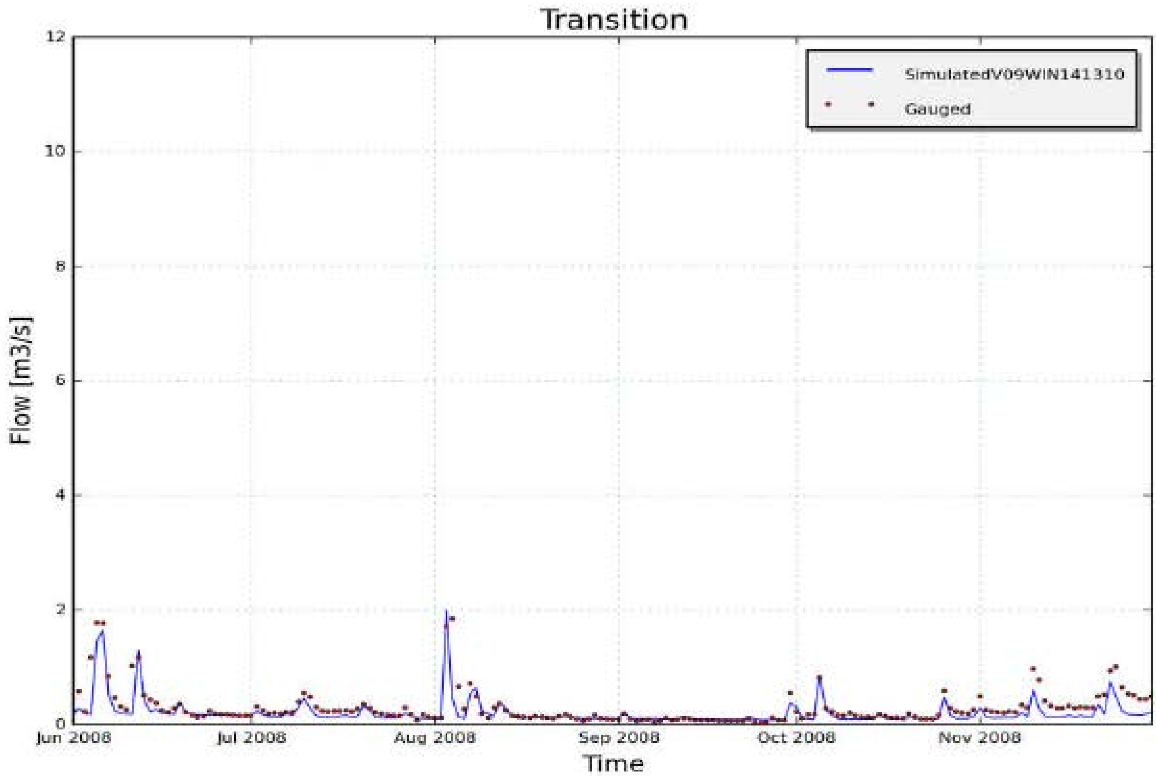


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09WIN141310, station 141 - Rotselaar ; Winge

9.5.9 Calibration and validation of WET parameters for catchment "V09ZWA148120" (Demerbekken)

9.5.9.1 Input data

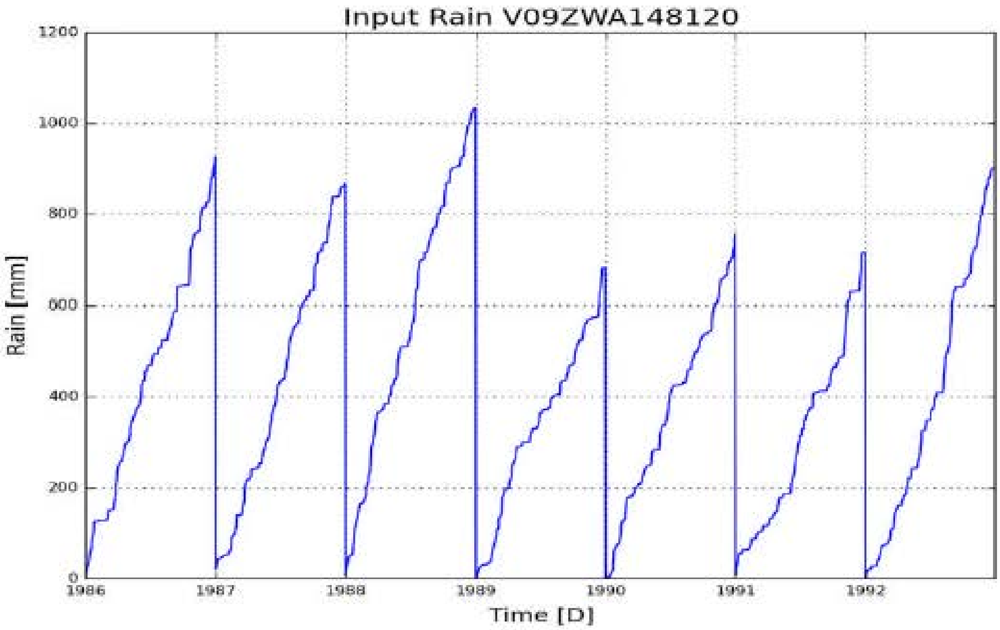


Figure 1: Cumulative precipitation on catchment V09ZWA148120 (Demerbekken)

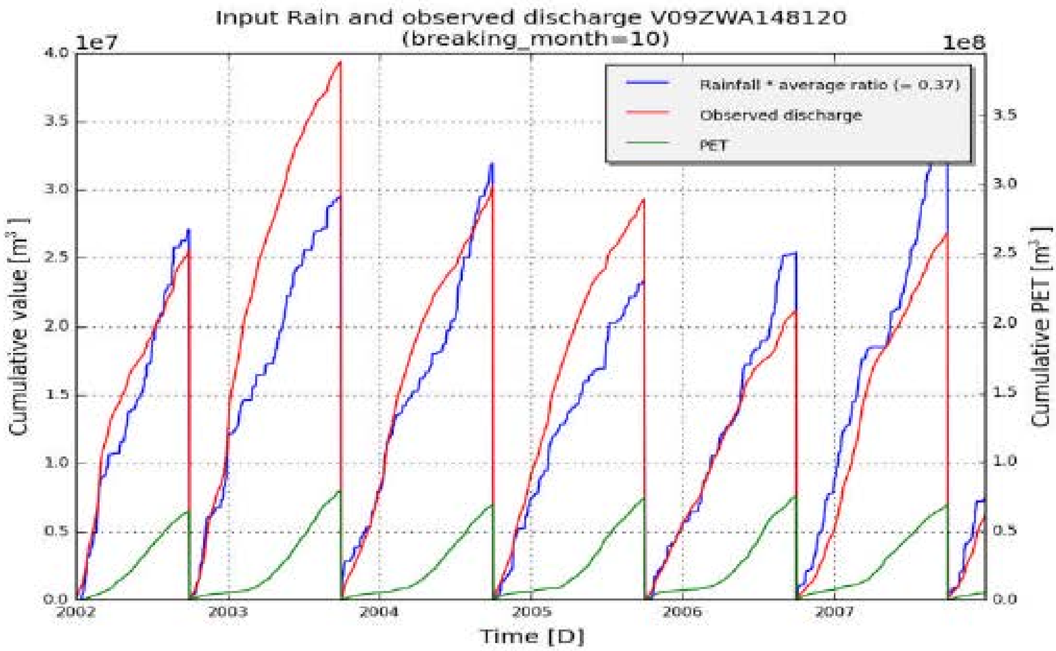


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09ZWA148120 (Demerbekken)

9.5.9.2 Model summary

subcatchment_name	V09ZWA148120
subcatchment_area [m2]	96200000
Validation start_date	01-01-1987
Validation end_date	31-12-1992
frequency	daily

Optimal parameter set:[('Kep', 1.85), ('Ki', 30.93), ('Kg', 0.01), ('Kss', 0.63), ('g0', 152.77), ('g_max', 489.95), ('K_run', 1.09), ('P_max', 68.65)]

Table 1: Goodness of fit for calibration period (2002 - 2007)

	Full year	**Summer**	**Winter**
RelErr	3.6 %	-18.4 %	12.7 %
NS	0.556	0.17	0.613
NS_log	0.396	0.023	0.55
NS_rel	0.554	0.437	0.514
KGE	0.768	0.607	0.753

Table 2 :Goodness of fit for validation period (1987 - 1992)

	Full year	**Summer**	**Winter**
RelErr	-5.3 %	-21.8 %	3.5 %
NS	0.397	0.035	0.197
NS_log	0.532	0.433	0.397
NS_rel	-1.258	-5.064	0.482
KGE	0.712	0.553	0.61

9.5.9.3 Observed and simulated timeseries for optimum parameters

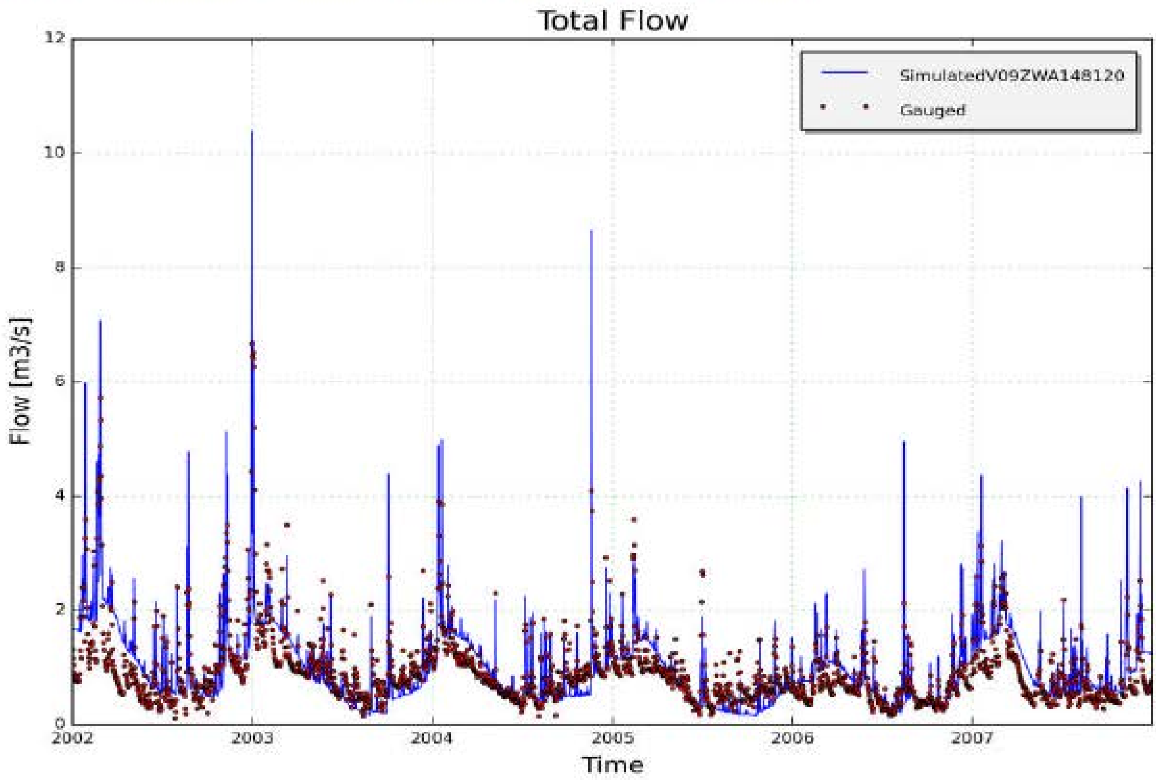


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen(calibration period)

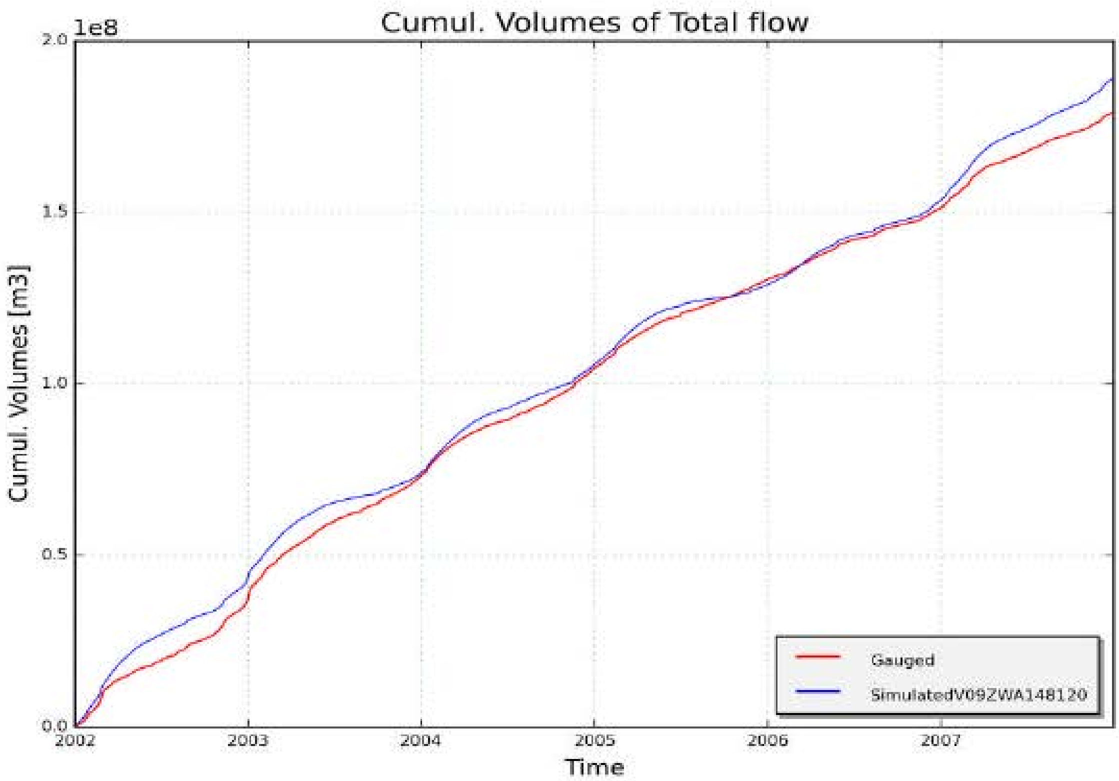


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen (calibration period)

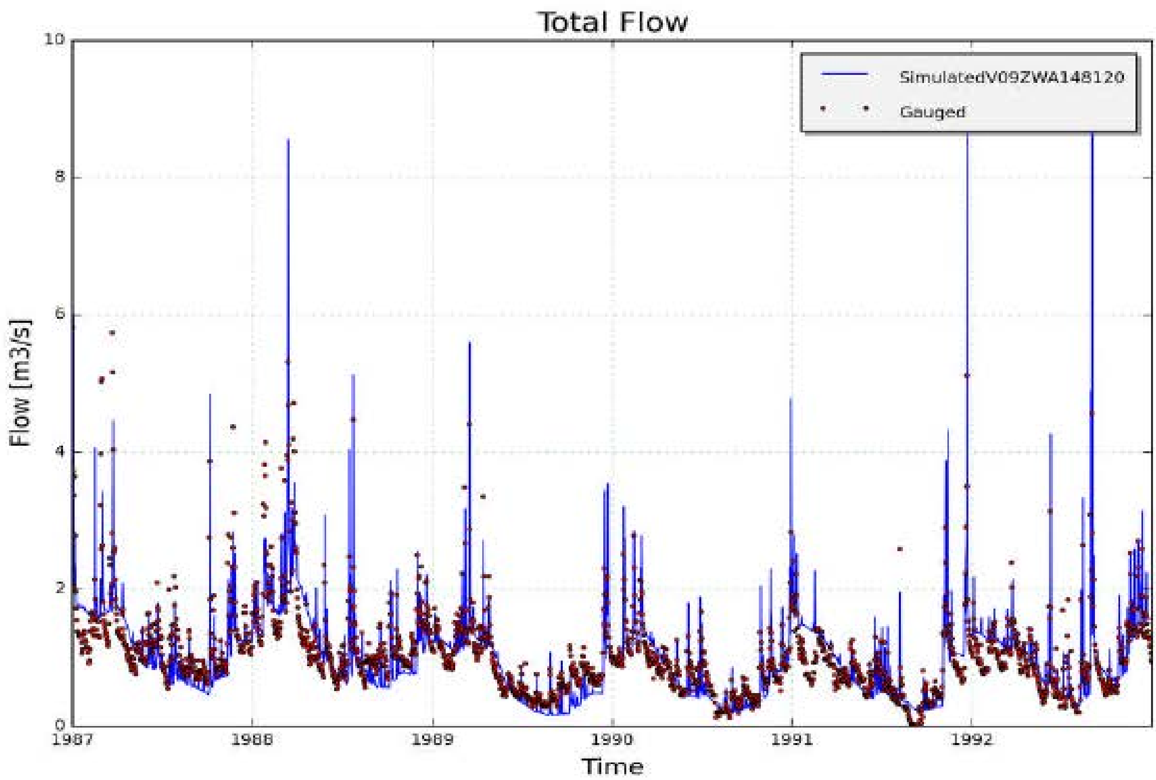


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen (validation period)

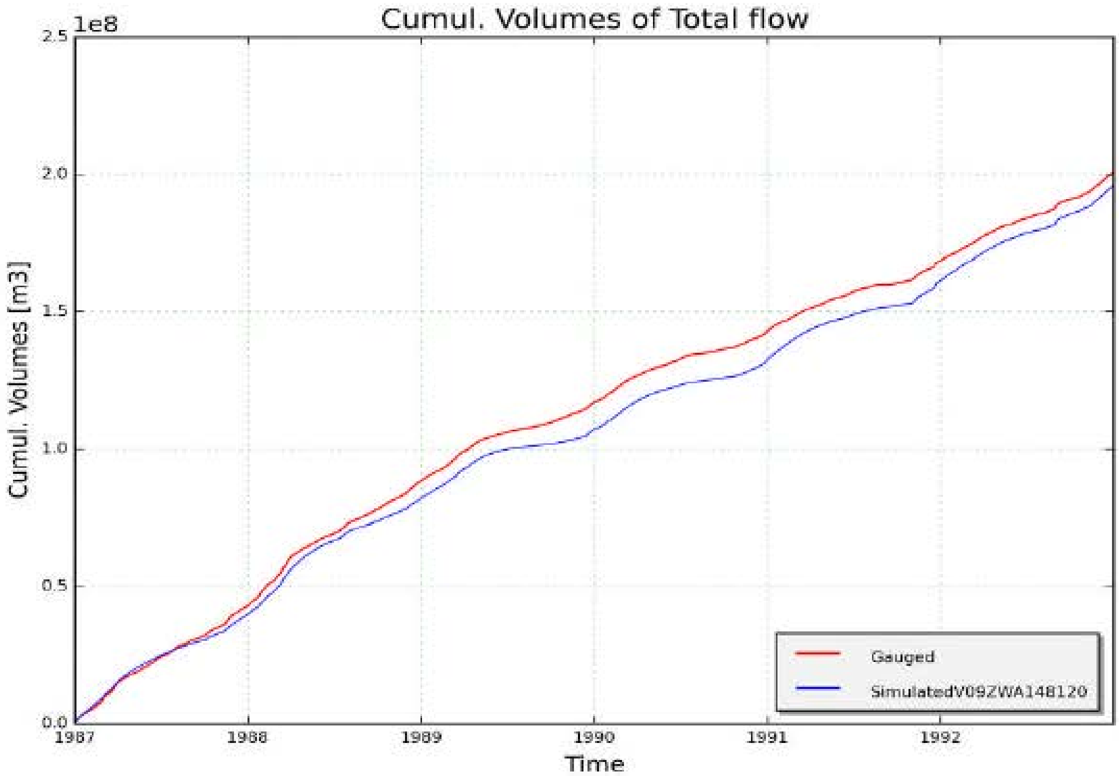


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen (validation period)

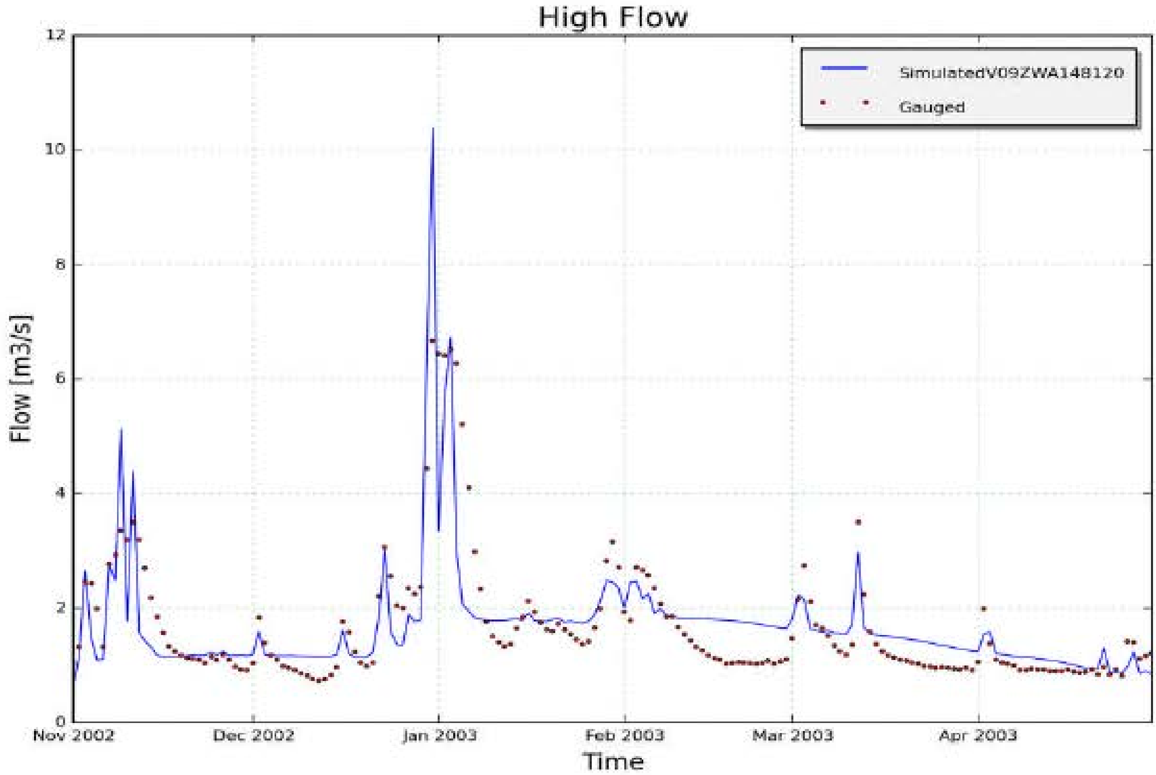


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen

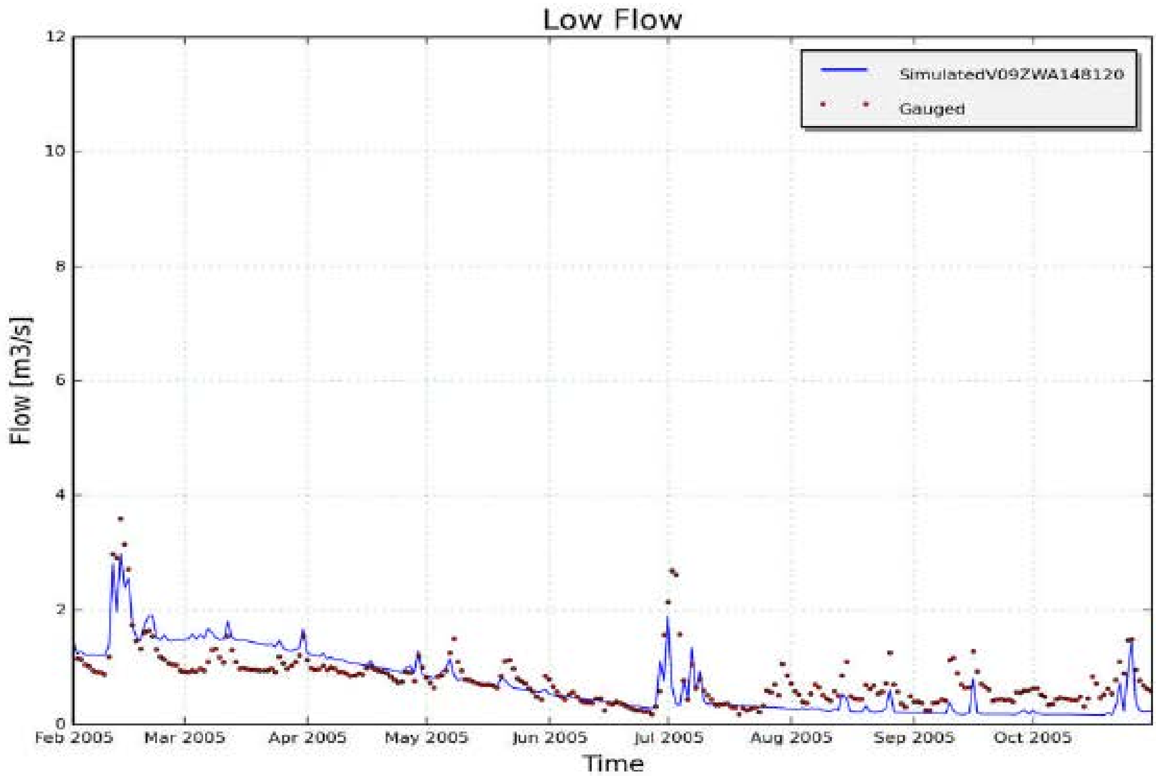


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen

Appendix 19 Demerbekken Autocalibration.

9.5.1 Report on simulation of catchment V09DEM136000 (2017-01-25 07-06)

9.5.1.1 Input data

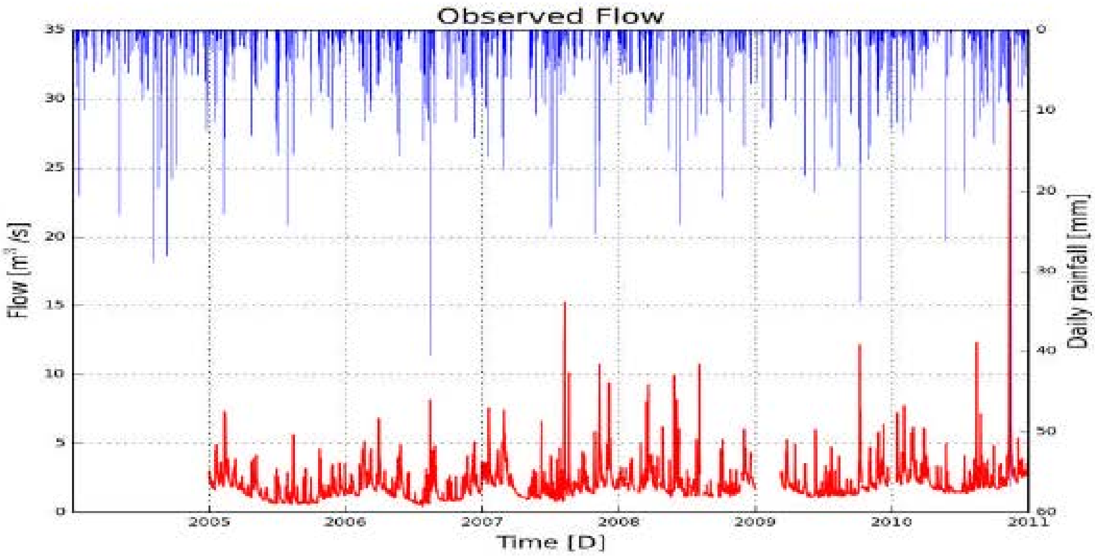


Figure 1: Hyetogram of observed discharge and observed net rain

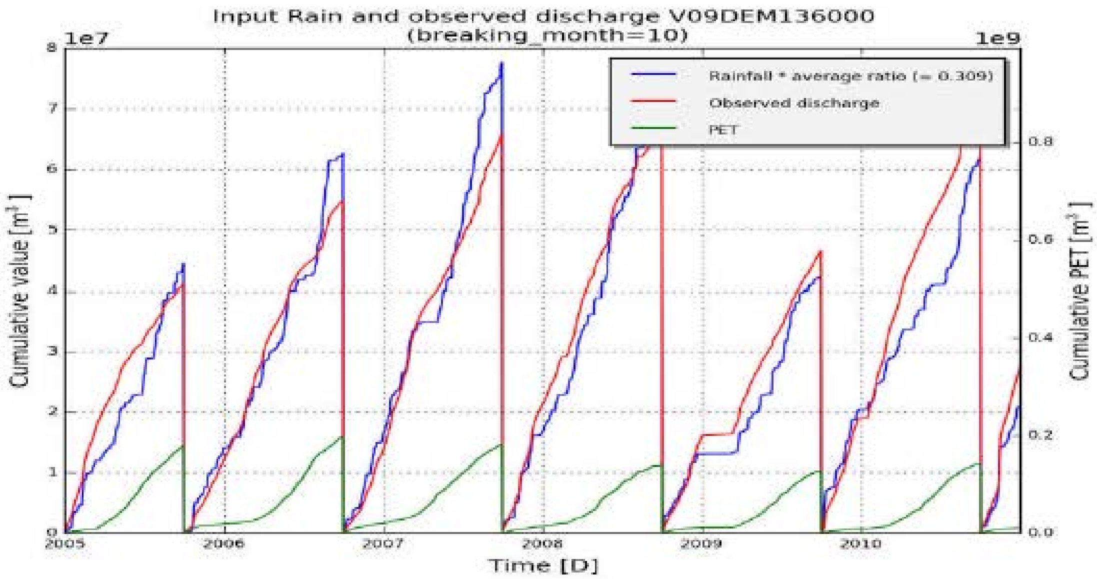


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.1.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V09DEM136000
subcatchment_area	255100000
start_date	200501010000
end_date	201012310000
frequency	86400
warmup	365

9.5.1.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.0, 50.0, 0.0009, 1.05, 90.0, 150.0, 3.0, 70.0]
low_bounds	[0.1, 25.0, 0.0005, 0.5, 45.0, 75.0, 1.5, 35.0]
high_bounds	[3.0, 150.0, 0.01, 3.0, 270.0, 450.0, 6.0, 300.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.0), ('Ki', 50.0), ('Kg', 0.0009), ('Kss', 1.05), ('g0', 90.0), ('g_max', 150.0), ('K_run', 3.0), ('P_max', 70.0)]
Initial fitness:

- RelErr: -0.196
- AbsErr: 34023246.221
- KGE: 0.022
- NS_rel: 0.476
- NS: -0.515
- RMSE: 37568428.822
- NS_log: -0.783

Computation time:1 day, 13:50:29.331000

9.5.1.4 Results

Best individual (euclidian): [('Kep', 1.866), ('Ki', 81.955), ('Kg', 0.005), ('Kss', 1.794), ('g0', 140.923), ('g_max', 300.905), ('K_run', 5.23), ('P_max', 163.869)]

Fitness:

- RelErr: 0.078
- AbsErr: 13479407.965
- KGE: 0.021
- NS_rel: 0.718
- NS: -0.477
- RMSE: 15440287.49
- NS_log: 0.454

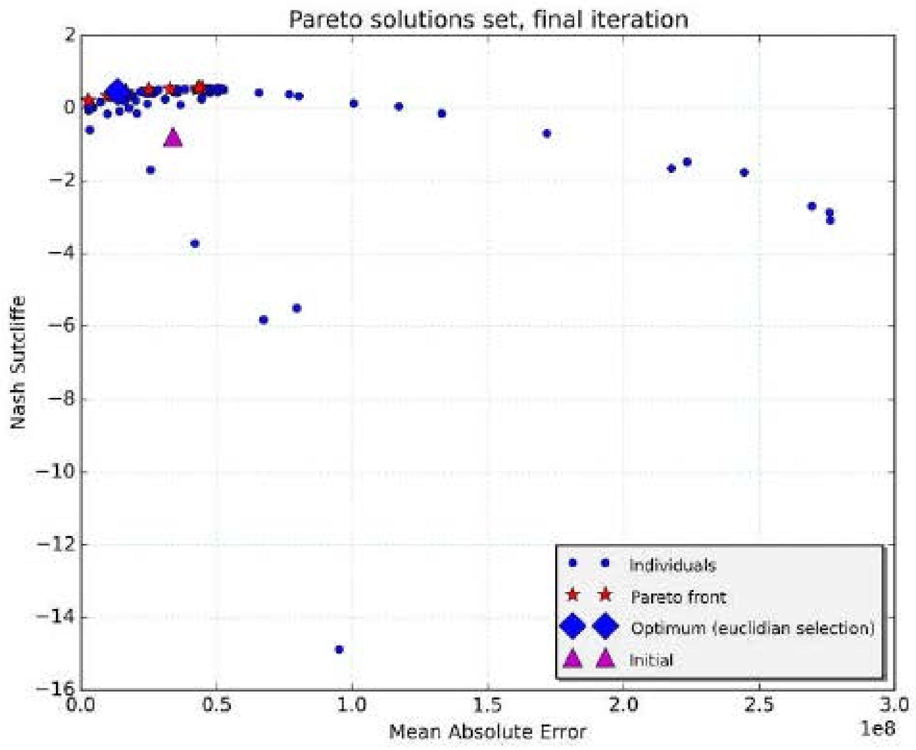


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

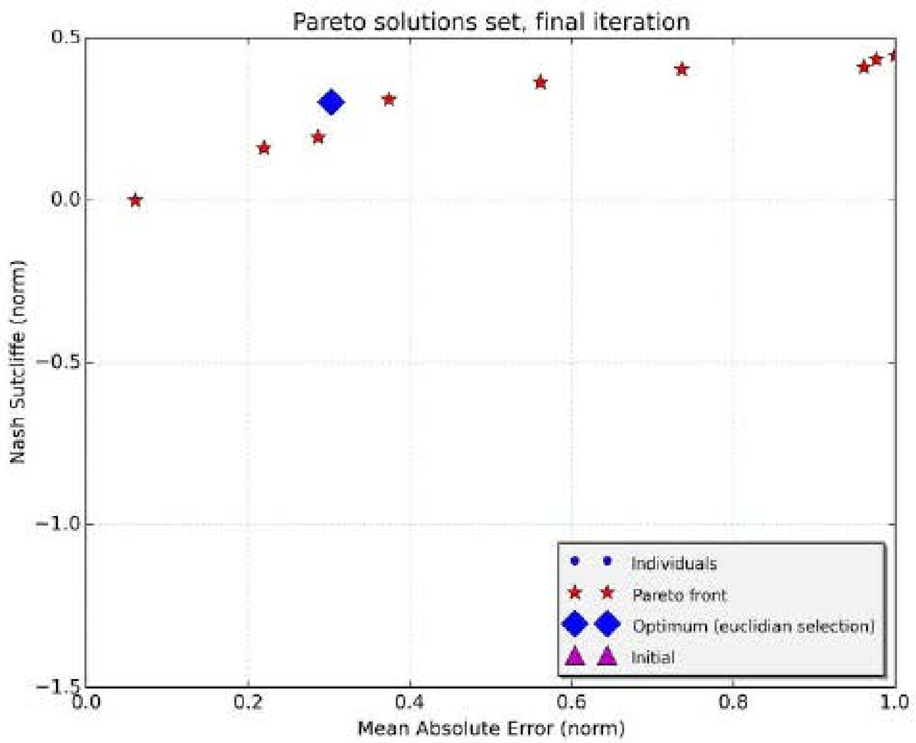


Figure 4: Final population of solutions (Pareto front)

9.5.1.4.1 Initial

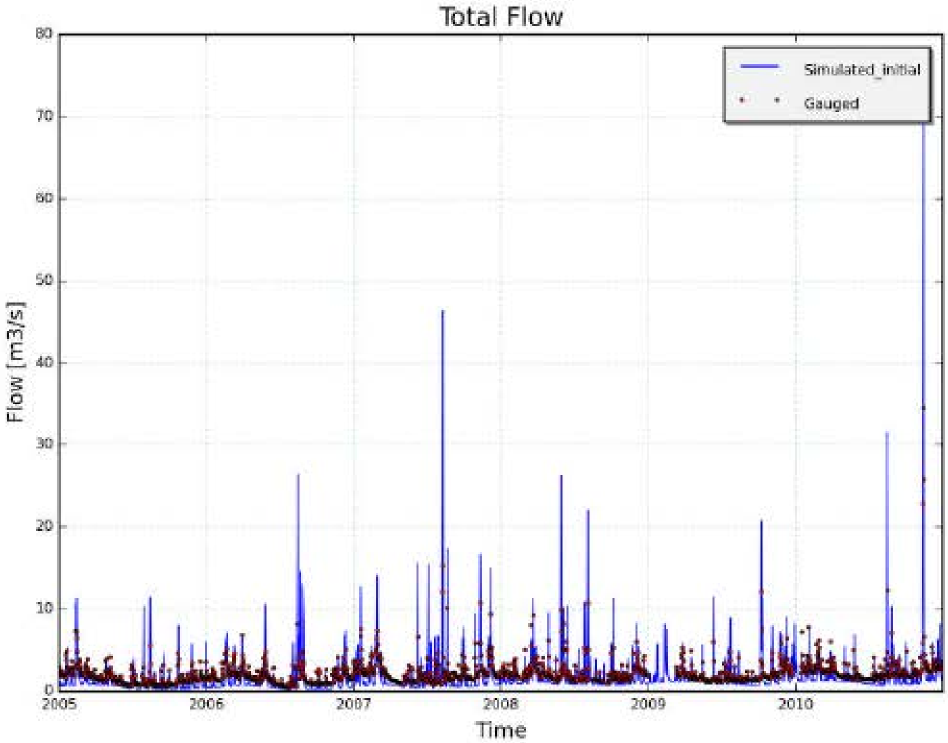


Figure 5: Total flow with initial parameters

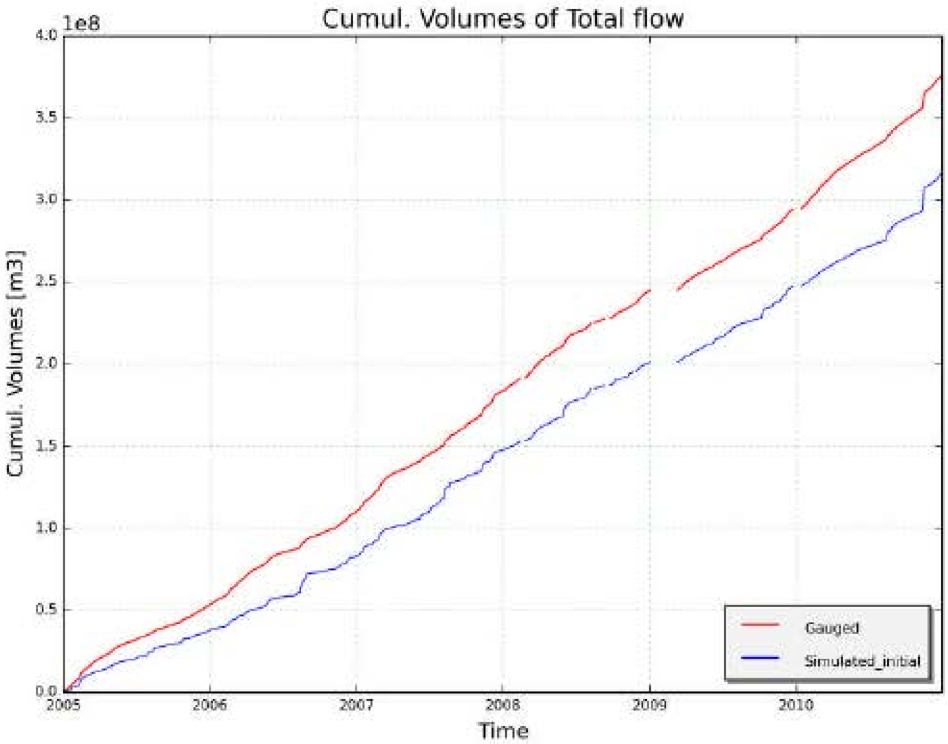


Figure 6: Cumulated flow with initial parameters

9.5.1.4.2 Optimum (euclidian)

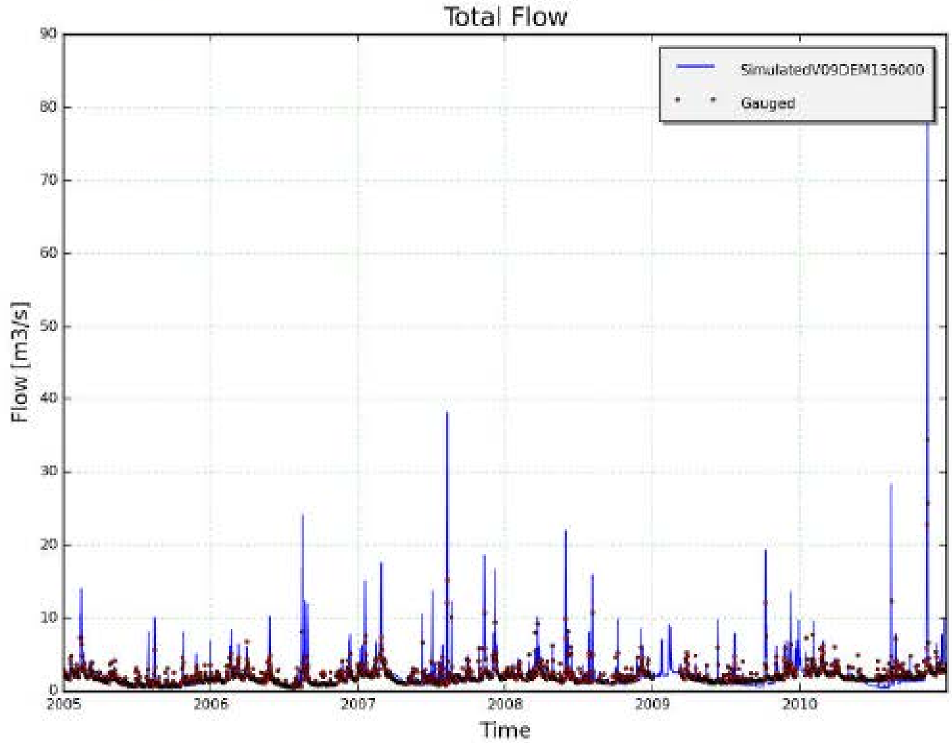


Figure 7: Total flow with optimum parameters

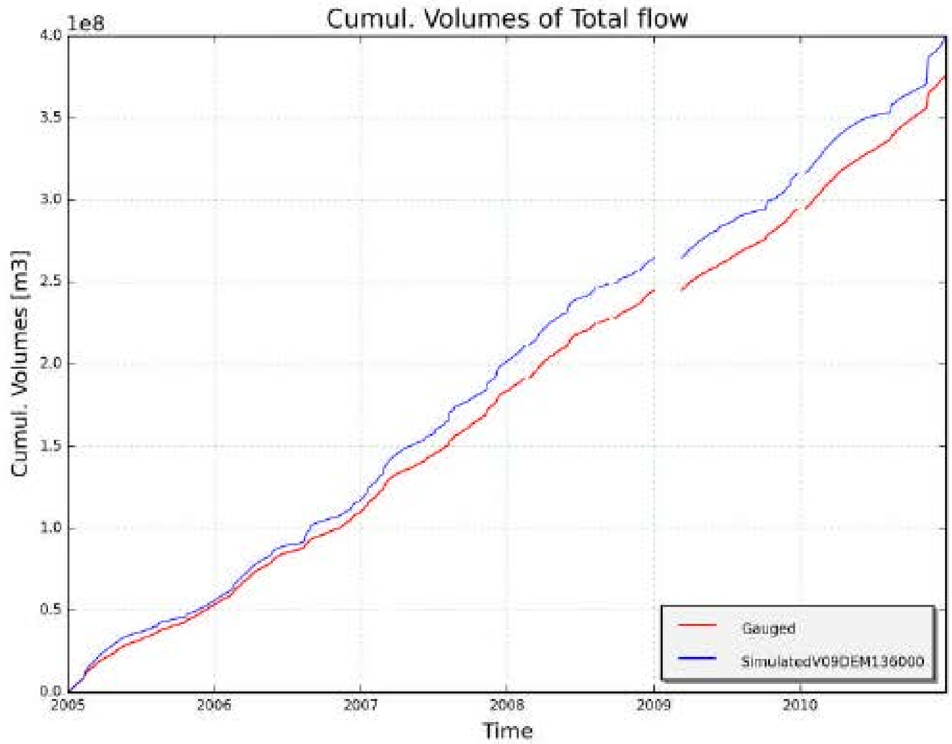


Figure 8: Cumulated flow with optimum parameters

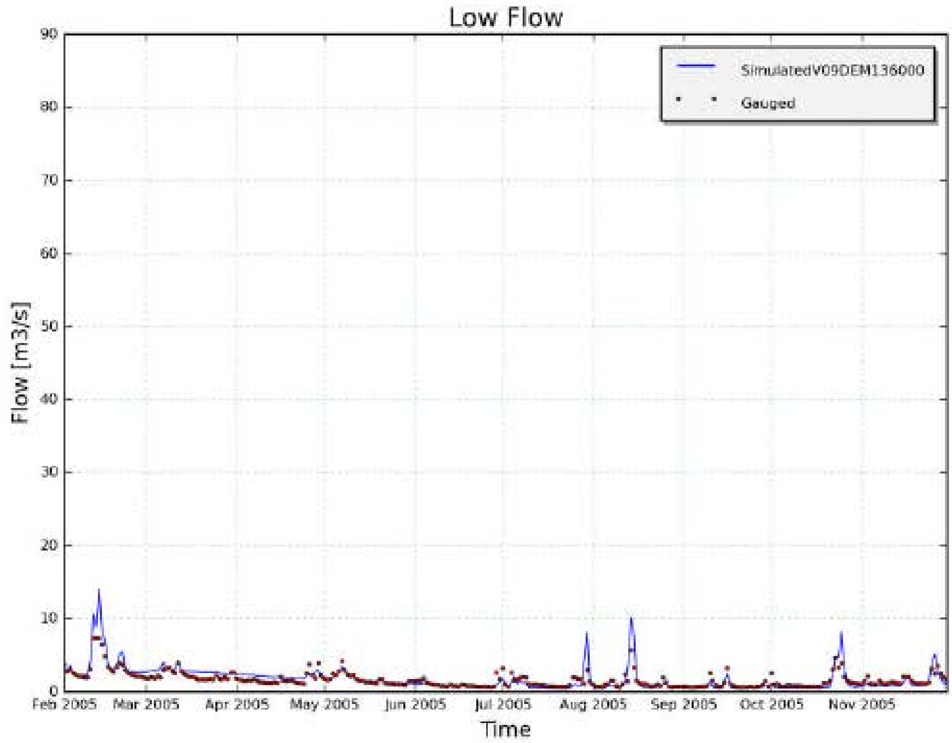


Figure 9: Total flow with optimum parameters (detail)

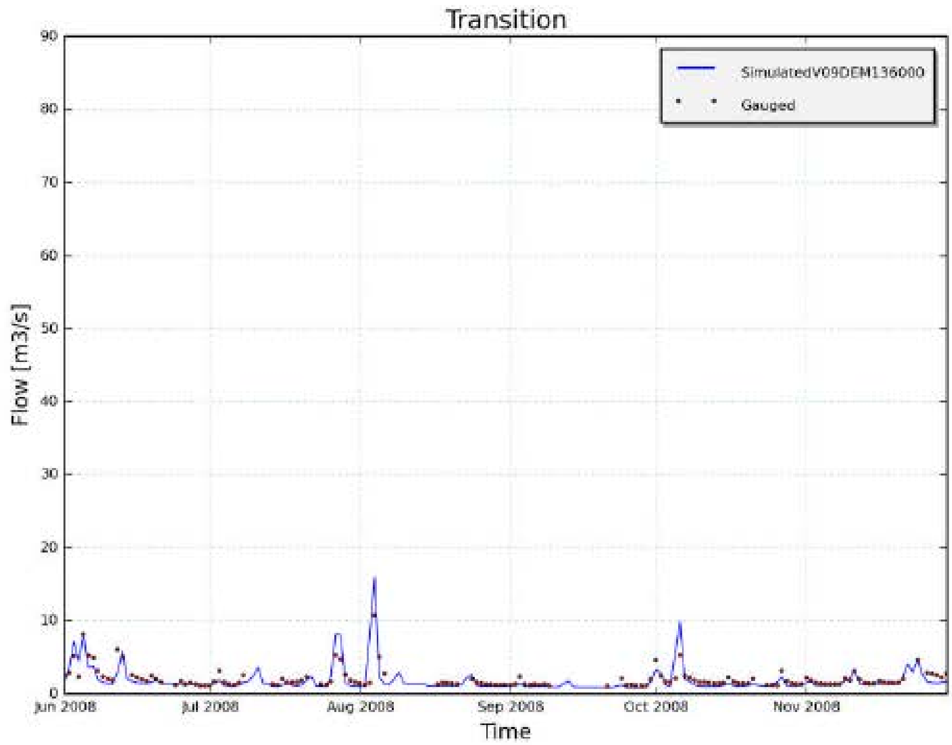
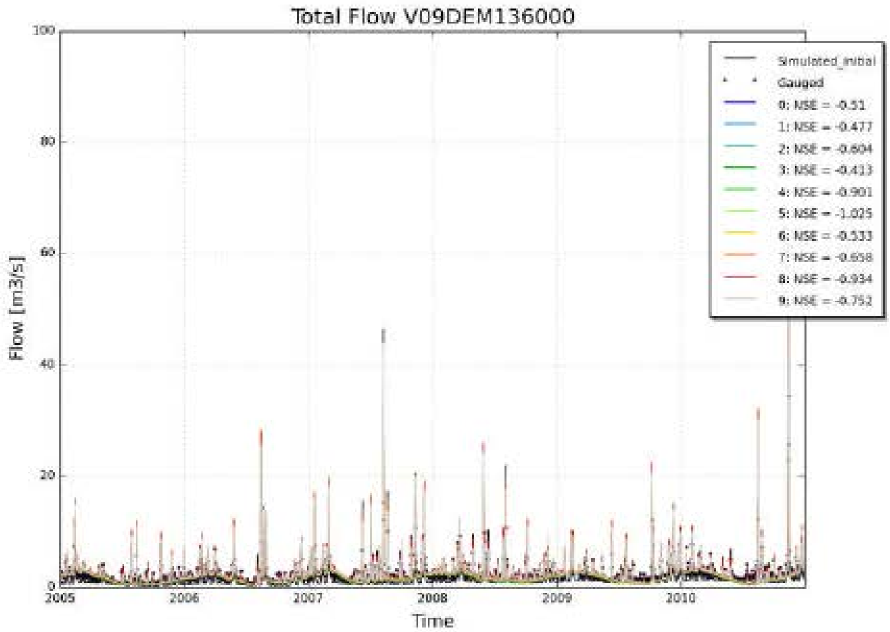
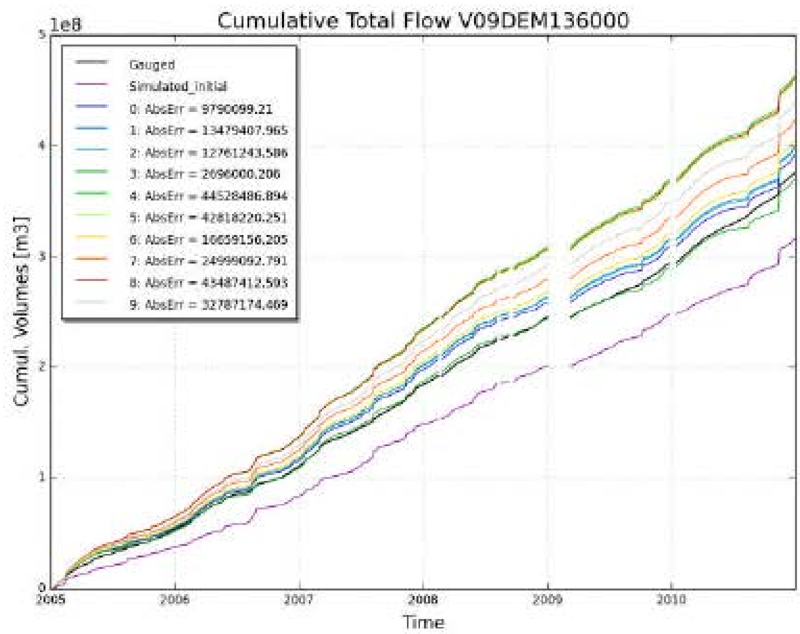


Figure 10: Total flow with optimum parameters (detail)

9.5.1.4.3 Final archive

0 : [1.994, 83.296, 0.006, 0.67, 101.709, 299.341, 3.069, 116.758] : [9790099.21, 0.343]
1 : [1.866, 81.955, 0.005, 1.794, 140.923, 300.905, 5.23, 163.869] : [13479407.965, 0.454]
2 : [1.979, 88.315, 0.006, 1.802, 131.84, 302.217, 3.174, 248.247] : [12761243.586, 0.369]
3 : [2.185, 86.972, 0.006, 1.347, 131.226, 315.211, 5.365, 247.014] : [2696000.206, 0.218]
4 : [1.622, 86.147, 0.005, 0.5, 140.365, 316.287, 3.153, 187.134] : [44528486.894, 0.566]
5 : [1.729, 94.332, 0.006, 2.494, 149.412, 318.876, 3.173, 241.287] : [42818220.251, 0.539]
6 : [1.863, 82.092, 0.005, 1.729, 130.22, 299.814, 3.697, 160.175] : [16659156.205, 0.461]
7 : [1.885, 88.179, 0.006, 0.888, 133.266, 317.263, 4.29, 247.089] : [24999092.791, 0.501]
8 : [1.668, 88.752, 0.006, 2.478, 140.651, 318.24, 3.131, 198.352] : [43487412.593, 0.558]
9 : [1.549, 82.928, 0.005, 0.646, 145.609, 248.675, 4.901, 166.168] : [32787174.469, 0.533]





9.5.2 Report on simulation of catchment V09GET152080 (2017-02-07 20-30)

9.5.2.1 Input data

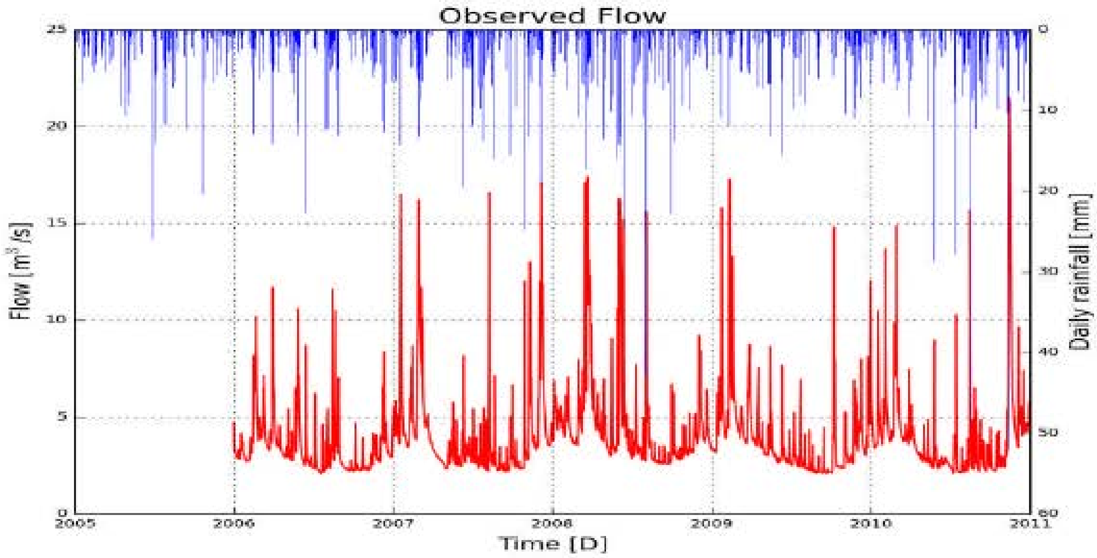


Figure 1: Hyetogram of observed discharge and observed net rain

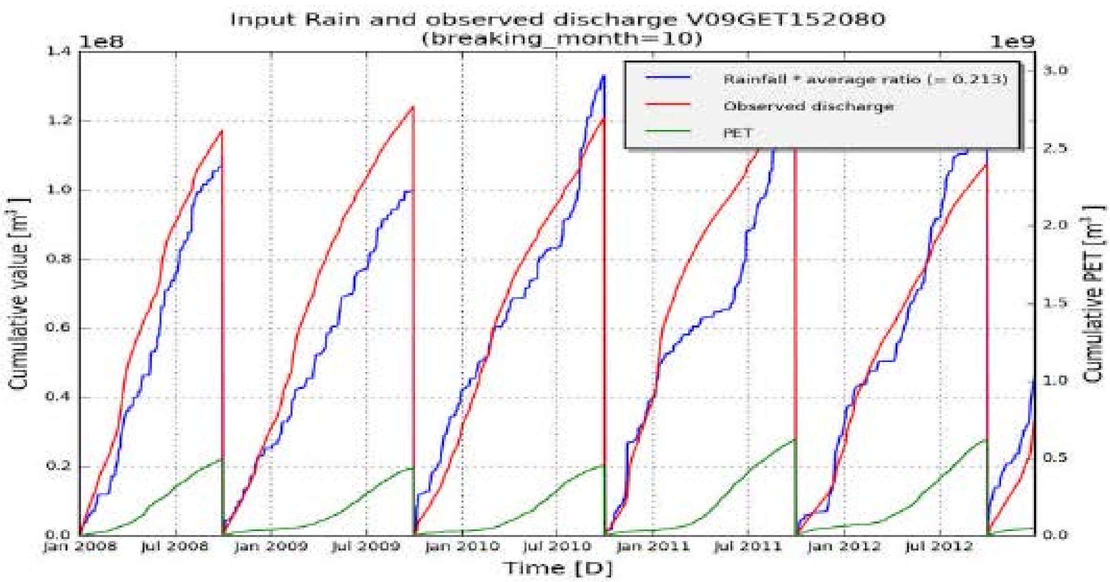


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.2.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	V09GET152080
subcatchment_area	800400000
start_date	200001010000
end_date	201312310000
frequency	86400
warmup	365

9.5.2.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[0.5, 55.86, 0.012, 1.951, 86.57, 297.29, 8.8, 294.0]
low_bounds	[0.1, 27.0, 0.0009, 0.97, 40.0, 150.0, 3.0, 147.0]
high_bounds	[3.0, 200.0, 0.05, 6.0, 250.0, 750.0, 15.0, 600.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 0.5), ('Ki', 55.86), ('Kg', 0.012), ('Kss', 1.951), ('g0', 86.57), ('g_max', 297.29), ('K_run', 8.8), ('P_max', 294.0)]
Initial fitness:

- RelErr: -0.345
- AbsErr: 372271571.709
- KGE: 0.216
- NS_rel: 0.712
- NS: 0.105
- RMSE: 406262605.822
- NS_log: 0.089

Computation time:8:37:15.253000

9.5.2.4 Results

Best individual (euclidian): [('Kep', 0.151), ('Ki', 42.497), ('Kg', 0.013), ('Kss', 0.97), ('g0', 184.824), ('g_max', 625.189), ('K_run', 9.087), ('P_max', 521.81)]

Fitness:

- RelErr: -0.066
- AbsErr: 72392358.436
- KGE: 0.216
- NS_rel: 0.411
- NS: 0.274
- RMSE: 84557382.245
- NS_log: 0.277

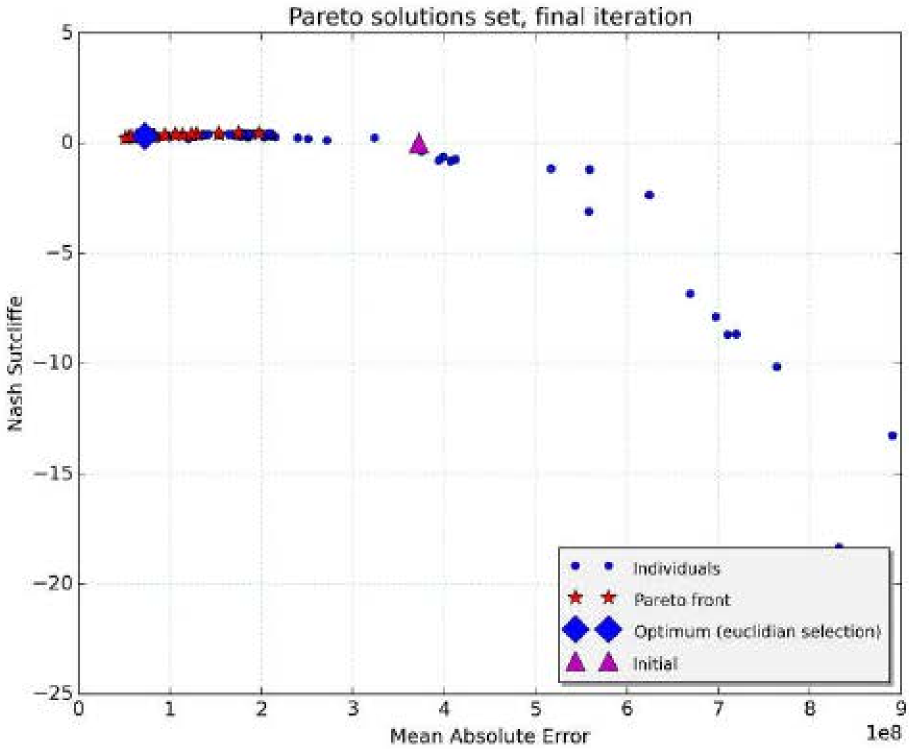


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

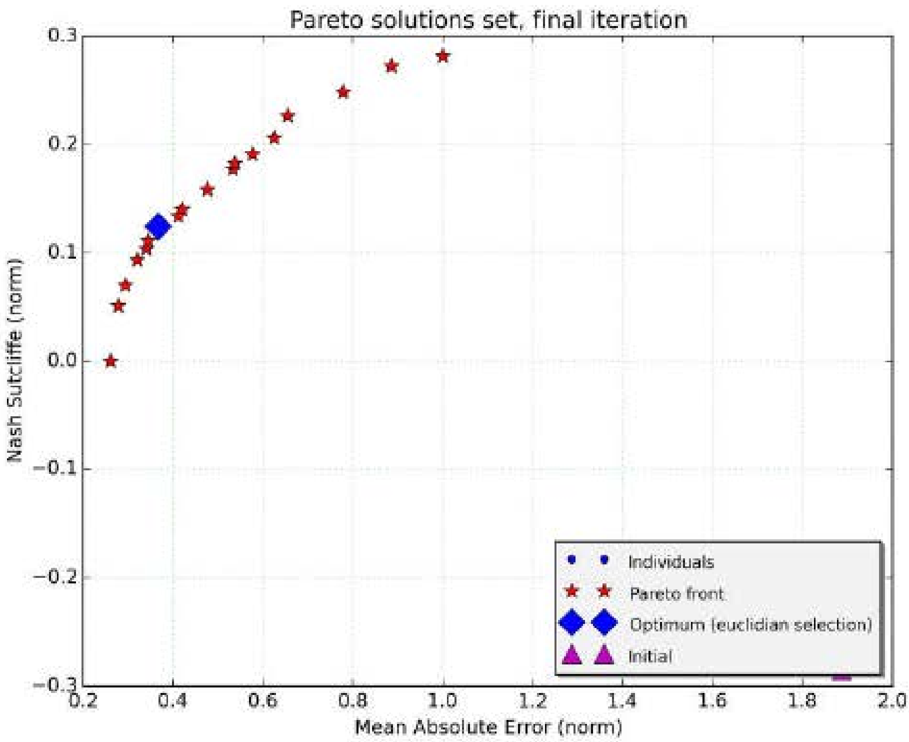


Figure 4: Final population of solutions (Pareto front)

9.5.2.4.1 Initial

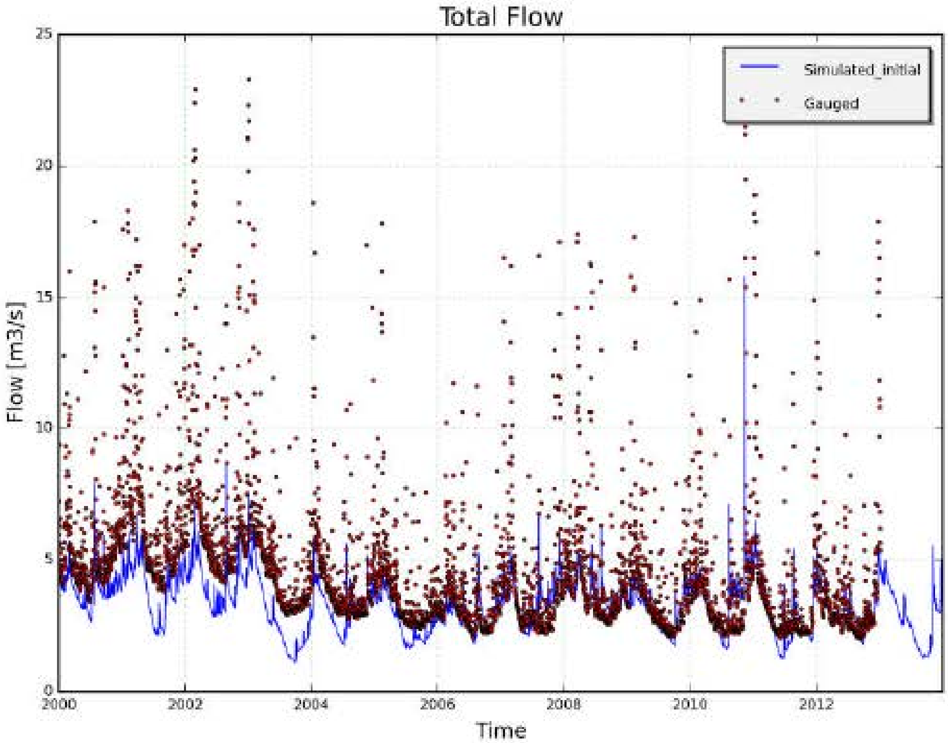


Figure 5: Total flow with initial parameters

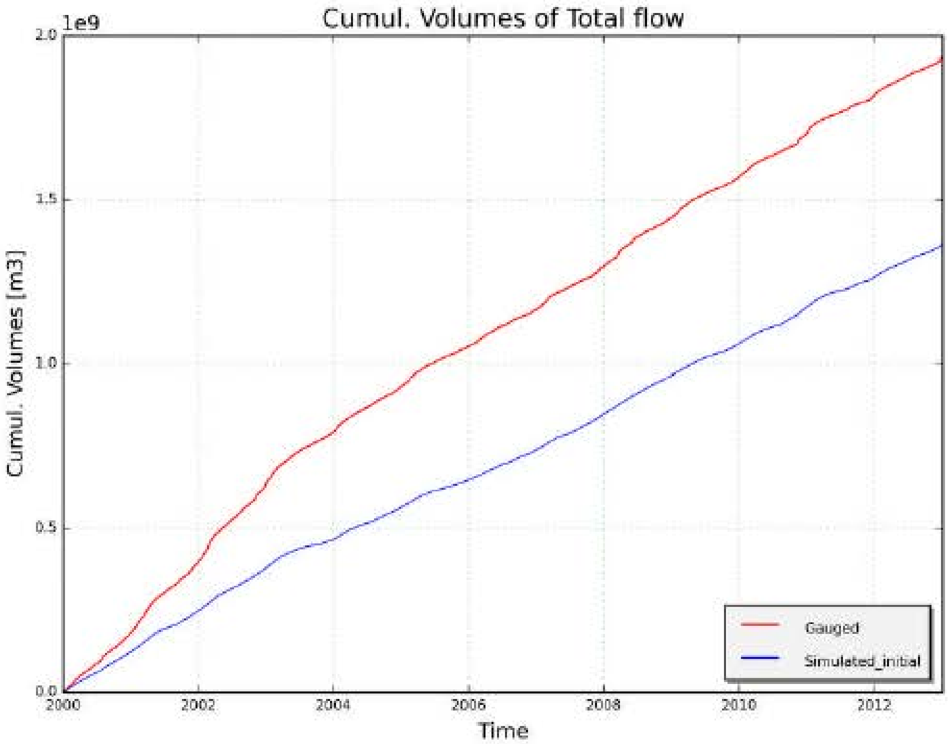


Figure 6: Cumulated flow with initial parameters

9.5.2.4.2 Optimum (euclidian)

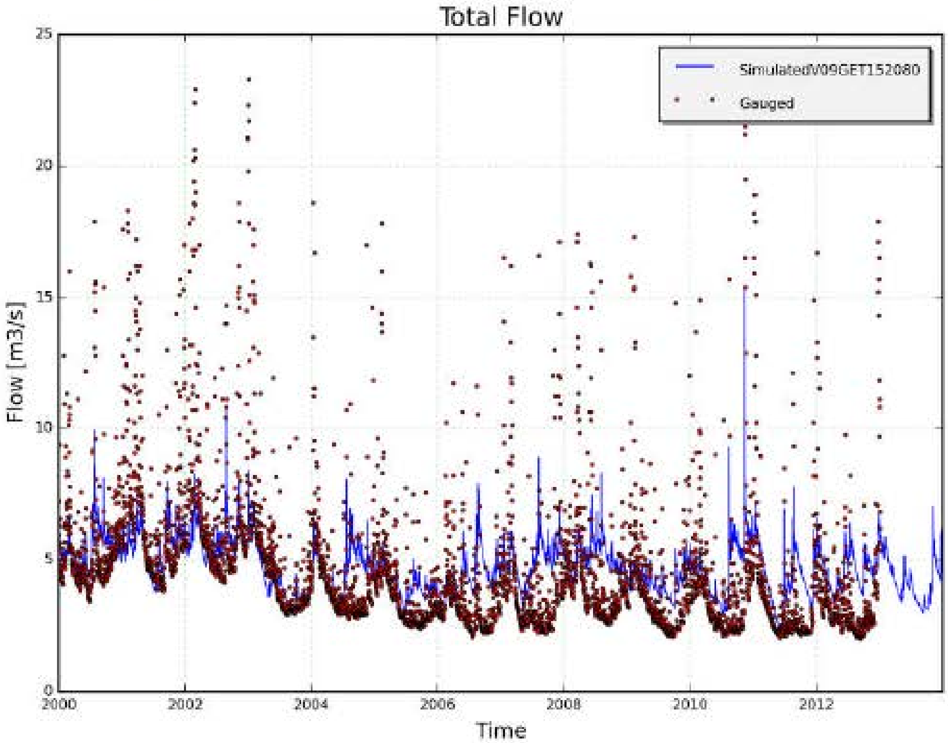


Figure 7: Total flow with optimum parameters

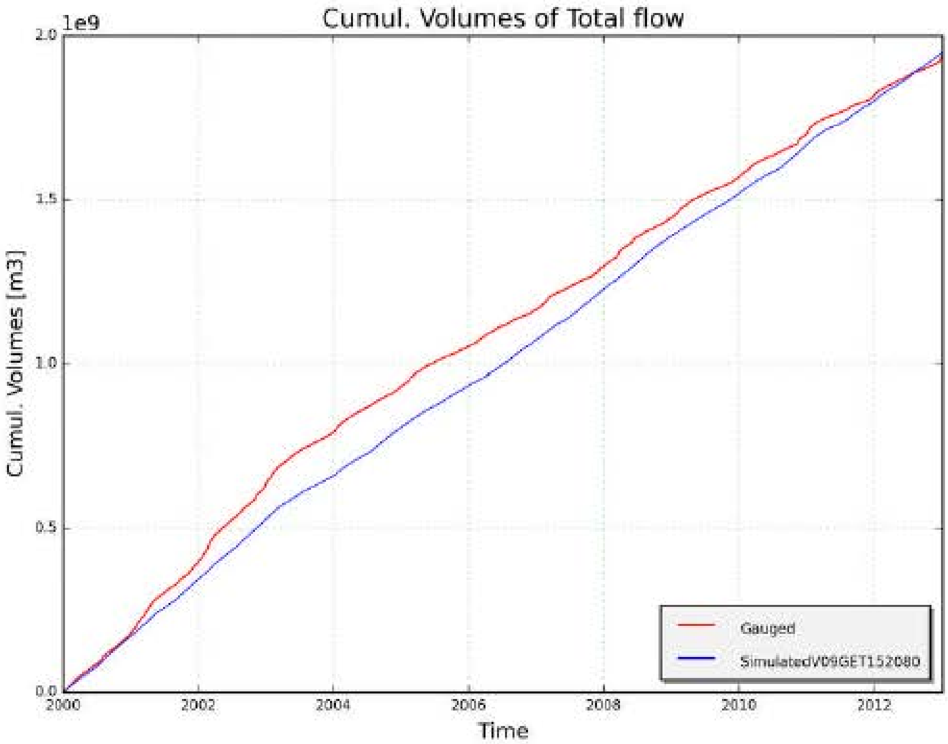


Figure 8: Cumulated flow with optimum parameters

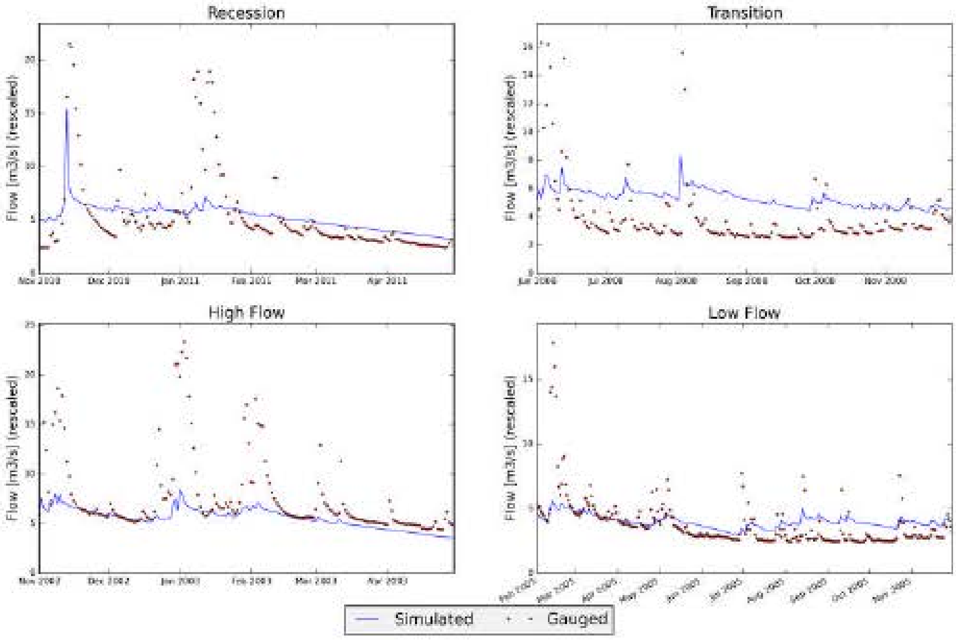
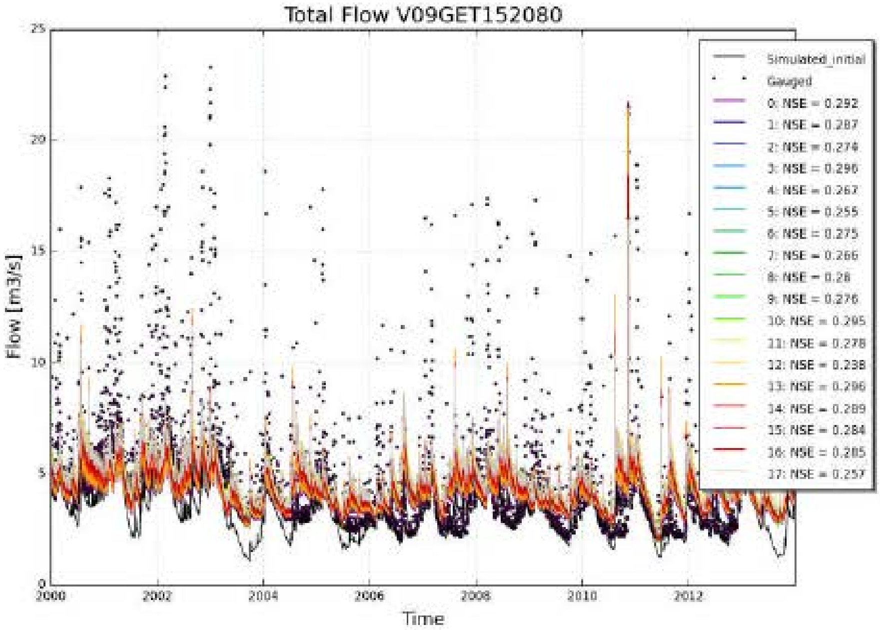
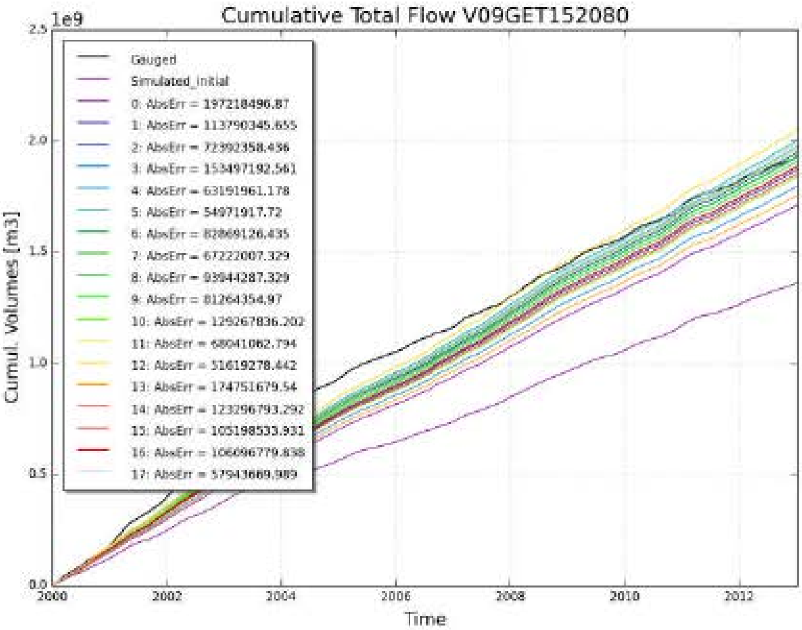


Figure 9: Total flow with optimum parameters (detail)

9.5.2.4.3 Final archive

0 : [0.153, 110.082, 0.013, 0.981, 166.834, 508.01, 11.413, 547.438] : [197218496.87, 0.441]
1 : [0.118, 69.795, 0.016, 1.117, 185.559, 495.704, 9.288, 521.841] : [113790345.655, 0.37]
2 : [0.151, 42.497, 0.013, 0.97, 184.824, 625.189, 9.087, 521.81] : [72392358.436, 0.318]
3 : [0.129, 89.784, 0.015, 0.97, 187.821, 622.315, 10.407, 530.316] : [153497192.561, 0.415]
4 : [0.1, 52.752, 0.014, 1.335, 177.0, 466.459, 9.744, 522.795] : [63191961.178, 0.294]
5 : [0.1, 47.128, 0.015, 1.562, 200.889, 426.552, 9.551, 474.378] : [54971917.72, 0.261]
6 : [0.138, 49.563, 0.015, 1.0, 185.816, 641.458, 8.655, 507.387] : [82869126.435, 0.33]
7 : [0.122, 46.617, 0.014, 1.036, 186.859, 588.472, 8.192, 517.997] : [67222007.329, 0.302]
8 : [0.115, 61.141, 0.015, 1.206, 200.748, 485.956, 9.064, 477.911] : [93944287.329, 0.345]
9 : [0.104, 58.941, 0.015, 1.0, 188.078, 476.709, 9.067, 512.127] : [81264354.97, 0.326]
10 : [0.166, 64.015, 0.015, 1.192, 188.767, 600.404, 11.753, 520.428] : [129267836.202, 0.398]
11 : [0.101, 54.219, 0.01, 1.464, 177.552, 452.334, 9.763, 522.214] : [68041062.794, 0.308]
12 : [0.1, 41.82, 0.016, 0.976, 185.094, 566.746, 11.371, 537.775] : [51619278.442, 0.222]
13 : [0.128, 105.642, 0.013, 0.981, 201.848, 589.372, 11.154, 500.01] : [174751679.54, 0.434]
14 : [0.128, 70.897, 0.015, 0.97, 185.401, 578.94, 9.199, 520.617] : [123296793.292, 0.382]
15 : [0.109, 68.233, 0.015, 1.077, 186.438, 490.896, 9.064, 512.974] : [105198533.931, 0.36]
16 : [0.138, 59.537, 0.015, 0.989, 184.968, 532.387, 9.185, 521.825] : [106096779.838, 0.364]
17 : [0.1, 47.103, 0.015, 1.101, 197.65, 486.362, 8.191, 504.298] : [57943669.989, 0.276]


Total Flow V09GET152080
Flow [m3/s]
Time
Simulated_initial
Gauged
0: NSE = 0.292
1: NSE = 0.287
2: NSE = 0.274
3: NSE = 0.296
4: NSE = 0.267
5: NSE = 0.255
6: NSE = 0.275
7: NSE = 0.266
8: NSE = 0.28
9: NSE = 0.276
10: NSE = 0.295
11: NSE = 0.278
12: NSE = 0.238
13: NSE = 0.296
14: NSE = 0.289
15: NSE = 0.284
16: NSE = 0.285
17: NSE = 0.257


Cumulative Total Flow V09GET152080
Cumul. Volumes [m3]
Time
Gauged
Simulated_initial
0: AbsErr = 197218496.87
1: AbsErr = 113790345.655
2: AbsErr = 72392358.436
3: AbsErr = 153497192.561
4: AbsErr = 63191961.178
5: AbsErr = 54971917.72
6: AbsErr = 82869126.435
7: AbsErr = 67222007.329
8: AbsErr = 93944287.329
9: AbsErr = 81264354.97
10: AbsErr = 129267836.202
11: AbsErr = 68041062.794
12: AbsErr = 51619278.442
13: AbsErr = 174751679.54
14: AbsErr = 123296793.292
15: AbsErr = 105198533.931
16: AbsErr = 106096779.838
17: AbsErr = 57943669.989

9.5.3 Report on simulation of catchment V09HER163010 (2017-01-19 07-42)

9.5.3.1 Input data

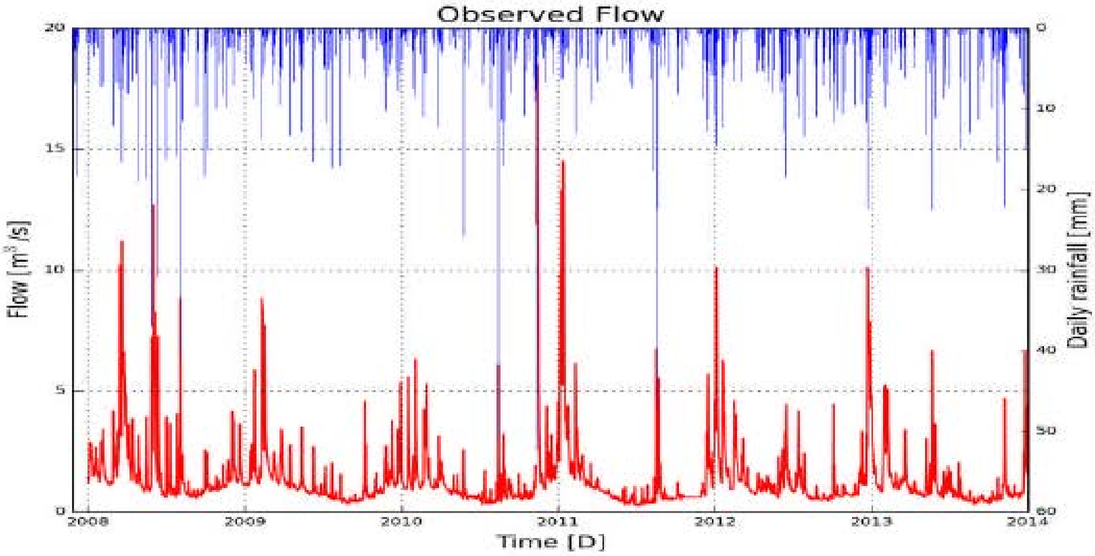


Figure 1: Hyetogram of observed discharge and observed net rain

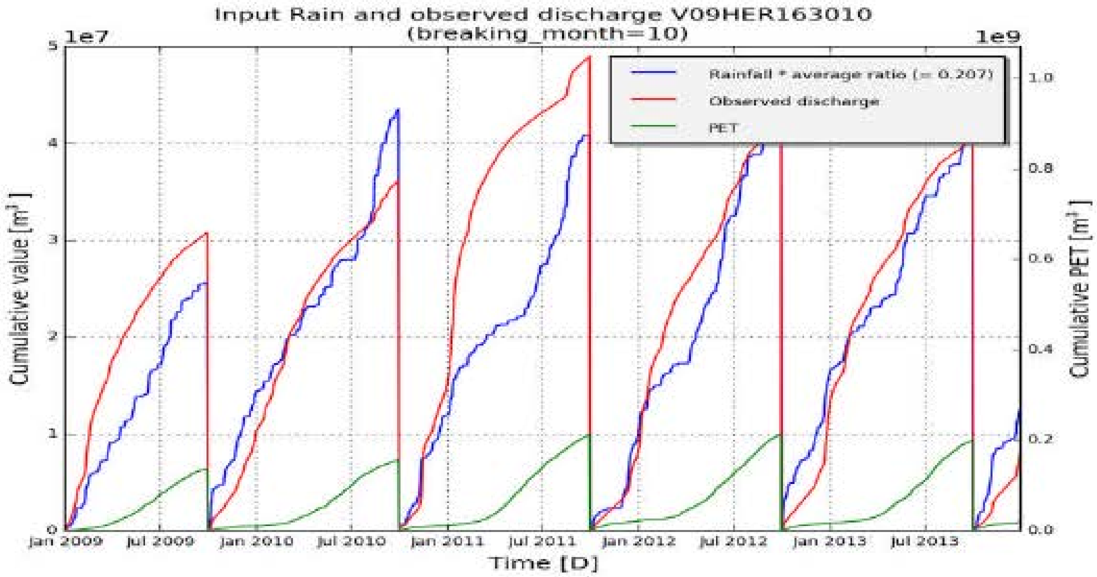


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.3.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	V09HER163010
subcatchment_area	274600000
start_date	200801010000
end_date	201312310000
frequency	86400
warmup	365

9.5.3.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.31, 19.0, 0.001, 0.18, 180.0, 450.0, 5.0, 150.0]
low_bounds	[1.0, 15.0, 0.0008, 0.1, 120.0, 350.0, 3.0, 110.0]
high_bounds	[1.5, 50.0, 0.01, 1.0, 250.0, 550.0, 7.0, 250.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.31), ('Ki', 19.0), ('Kg', 0.001), ('Kss', 0.18), ('g0', 180.0), ('g_max', 450.0), ('K_run', 5.0), ('P_max', 150.0)]
Initial fitness:

- RelErr: -0.091
- AbsErr: 13014510.686
- KGE: 0.676
- NS_rel: 0.813
- NS: 0.395
- RMSE: 13652384.657
- NS_log: 0.618

Computation time:13:39:51.978000

9.5.3.4 Results

Best individual (euclidian): [('Kep', 1.496), ('Ki', 24.988), ('Kg', 0.002), ('Kss', 0.992), ('g0', 166.333), ('g_max', 483.132), ('K_run', 5.427), ('P_max', 226.862)]

Fitness:

- RelErr: -0.035
- AbsErr: 5676961.589
- KGE: 0.707
- NS_rel: 0.825
- NS: 0.459
- RMSE: 7887278.801
- NS_log: 0.695

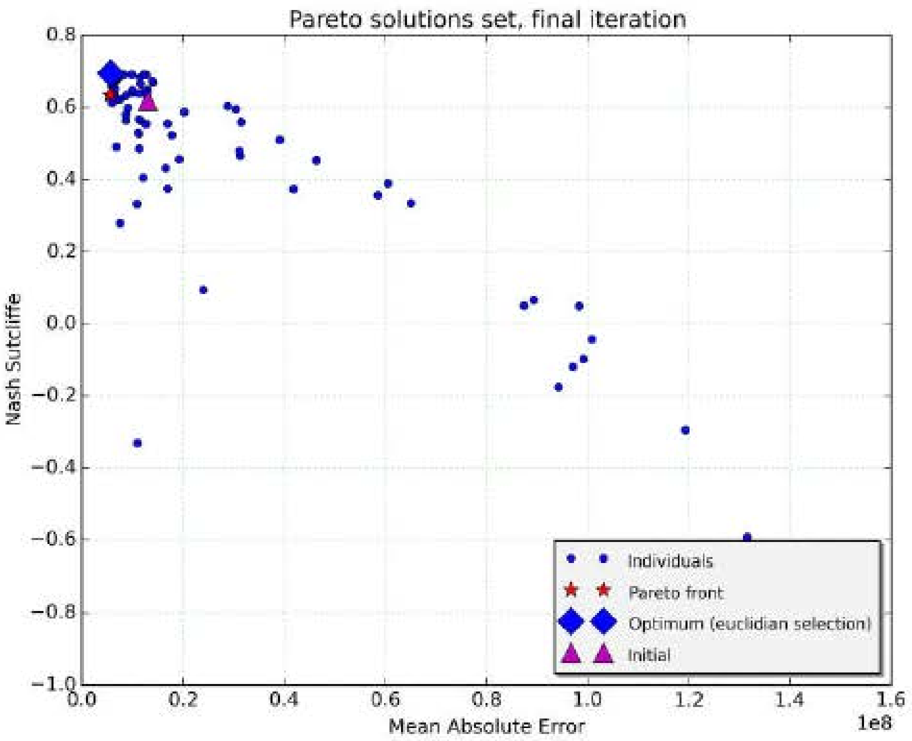


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

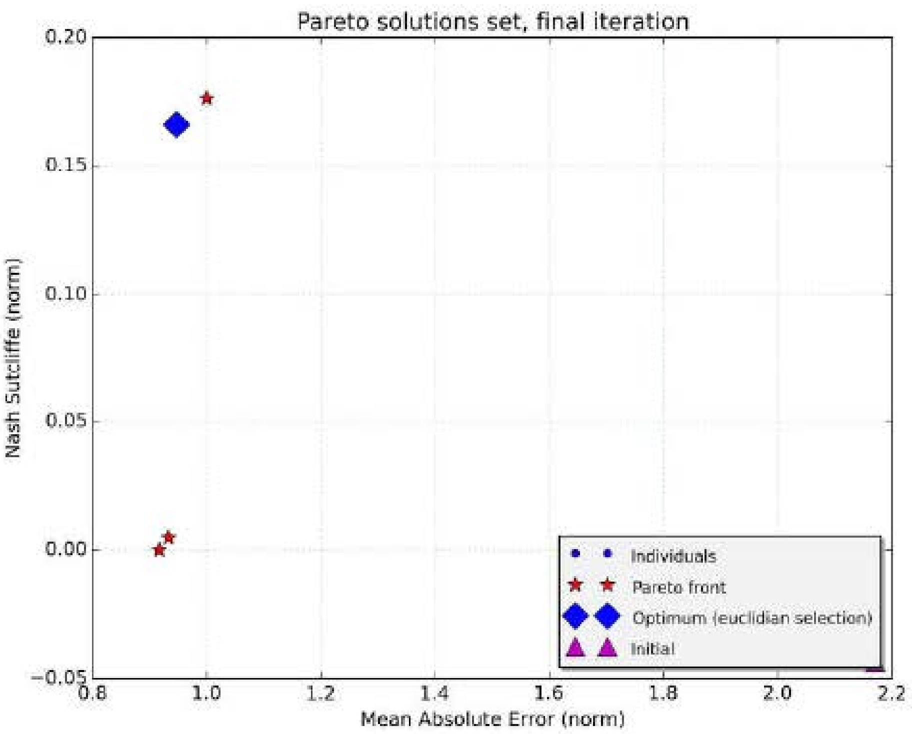


Figure 4: Final population of solutions (Pareto front)

9.5.3.4.1 Initial

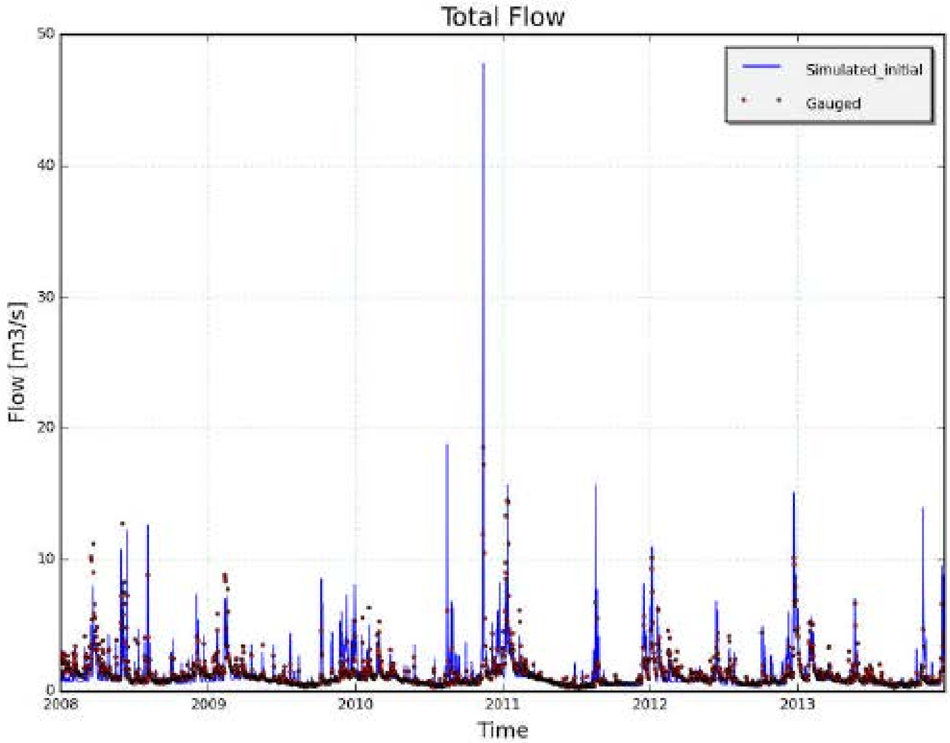


Figure 5: Total flow with initial parameters

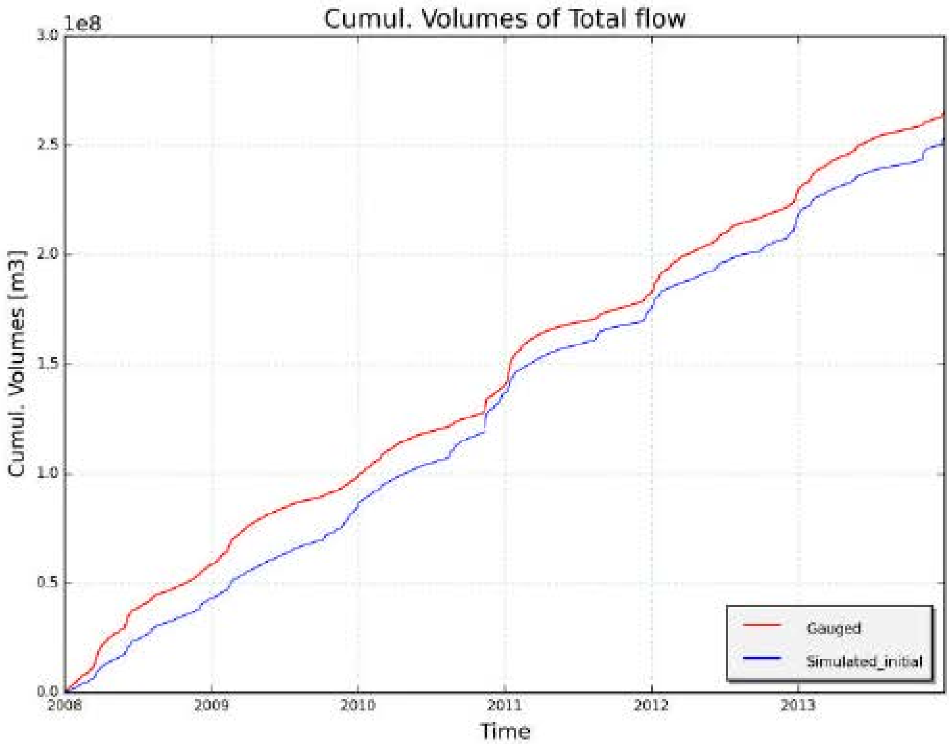


Figure 6: Cumulated flow with initial parameters

9.5.3.4.2 Optimum (euclidian)

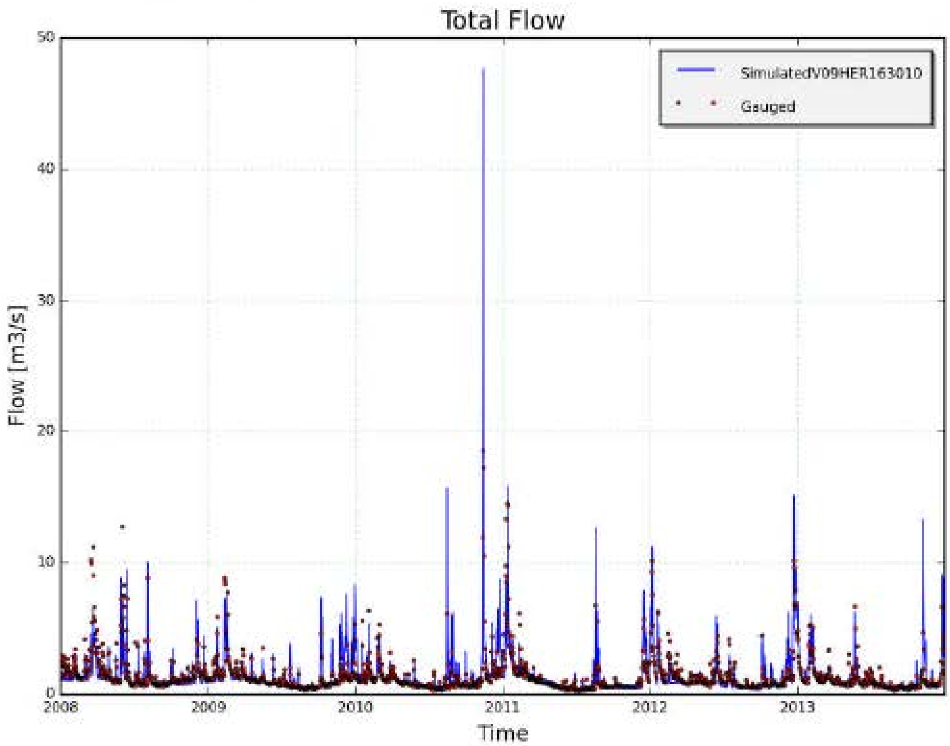


Figure 7: Total flow with optimum parameters

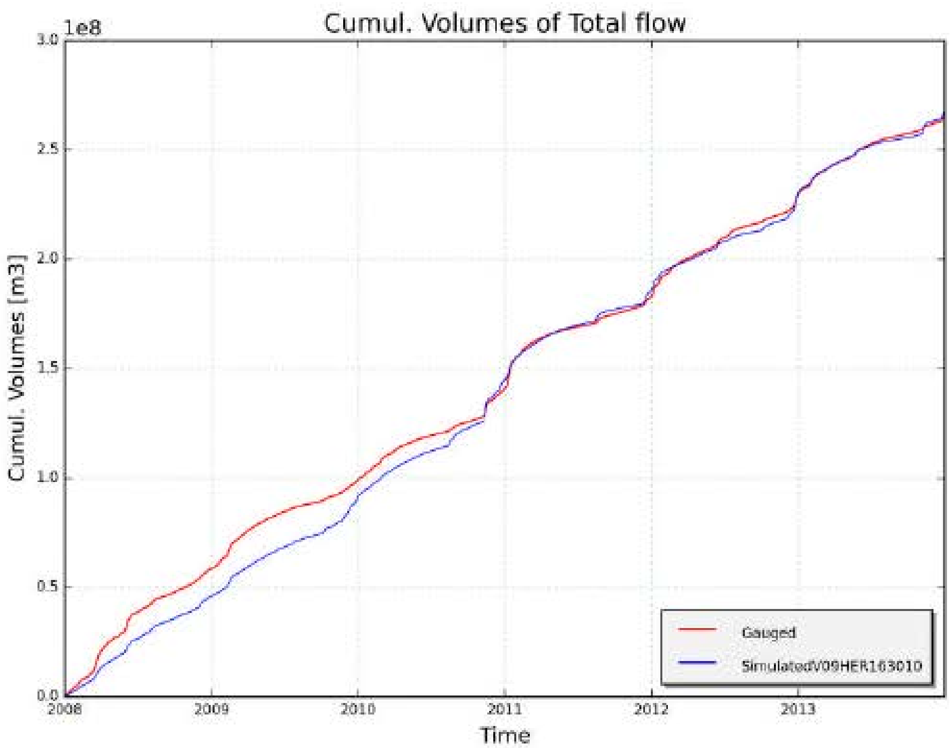


Figure 8: Cumulated flow with optimum parameters

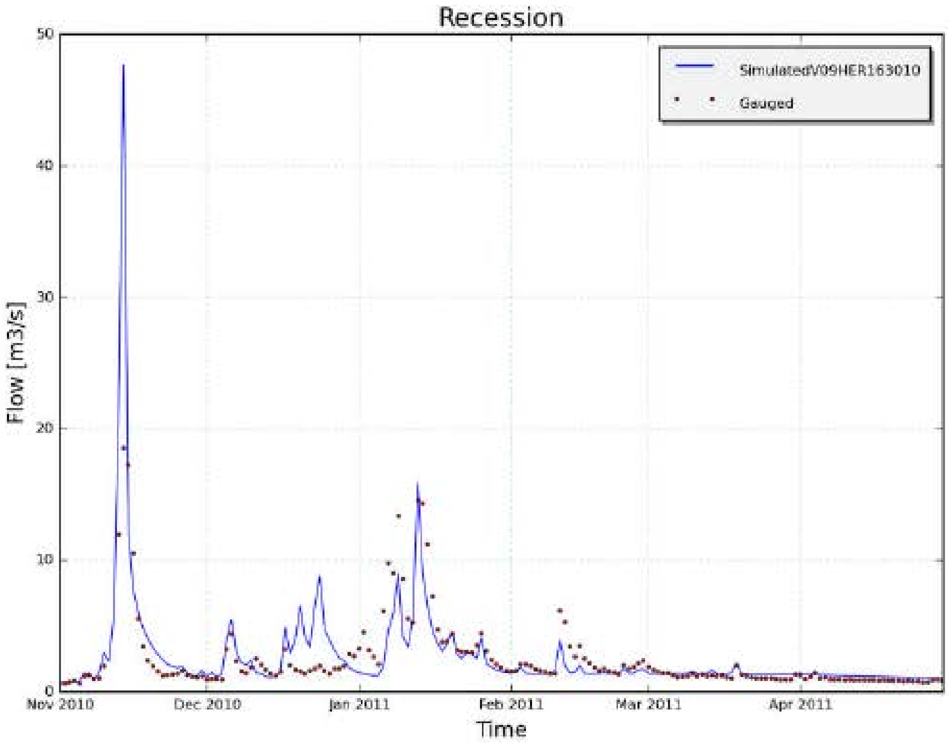


Figure 9: Total flow with optimum parameters (detail)

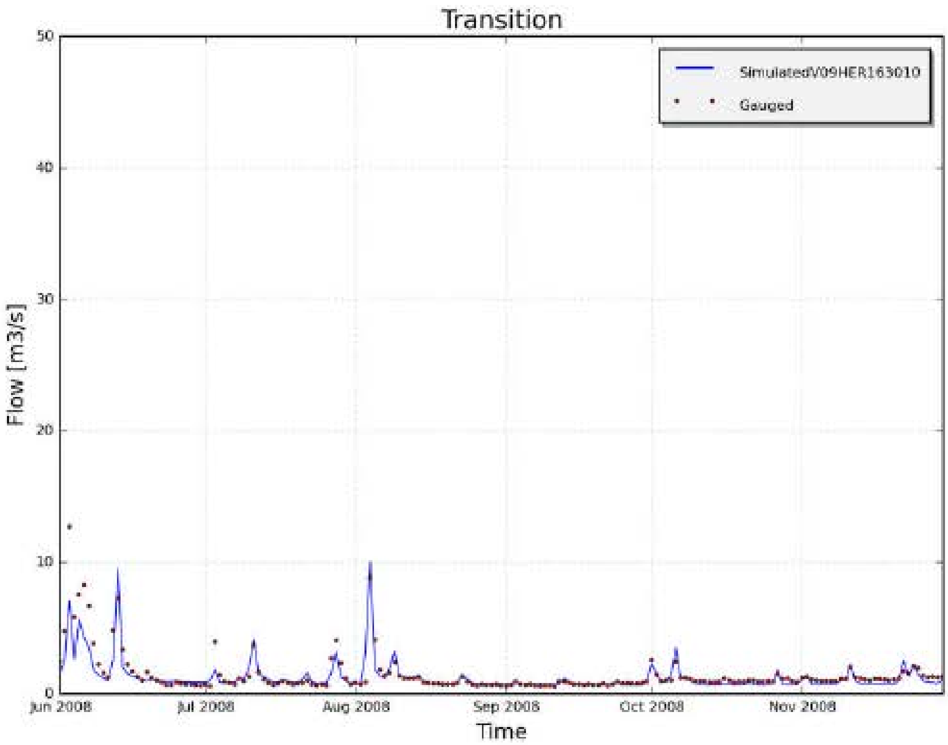
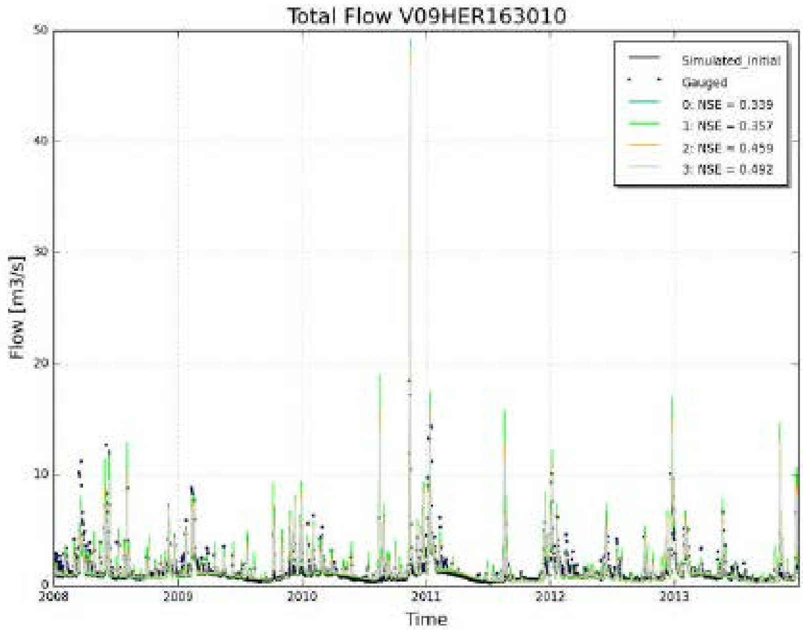
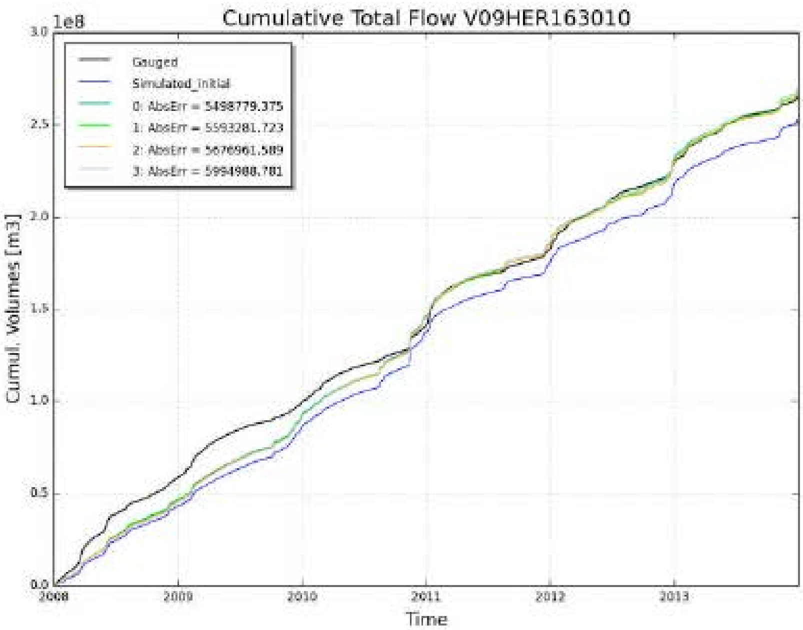


Figure 10: Total flow with optimum parameters (detail)

9.5.3.4.3 Final archive

0 : [1.5, 23.541, 0.001, 1.0, 163.973, 486.342, 4.287, 226.665] : [5498779.375, 0.634]
1 : [1.5, 22.527, 0.001, 0.853, 164.493, 486.342, 4.287, 226.665] : [5593281.723, 0.636]
2 : [1.496, 24.988, 0.002, 0.992, 166.333, 483.132, 5.427, 226.862] : [5676961.589, 0.695]
3 : [1.448, 24.988, 0.002, 0.403, 166.835, 483.173, 6.152, 226.64] : [5994988.781, 0.699]





9.5.4 Report on simulation of catchment V09HUL147150 (2017-01-25 19-15)

9.5.4.1 Input data

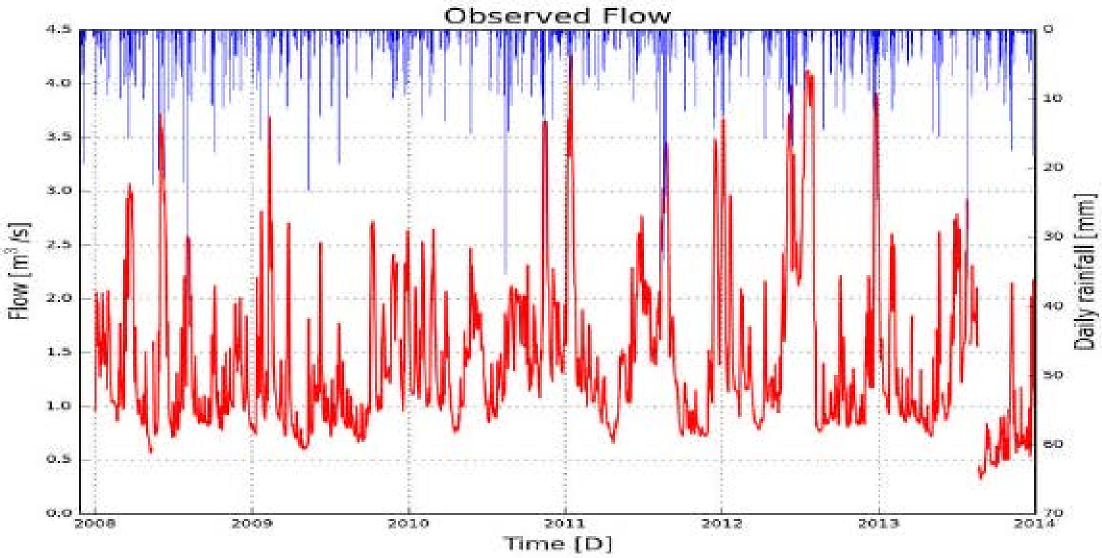


Figure 1: Hyetogram of observed discharge and observed net rain

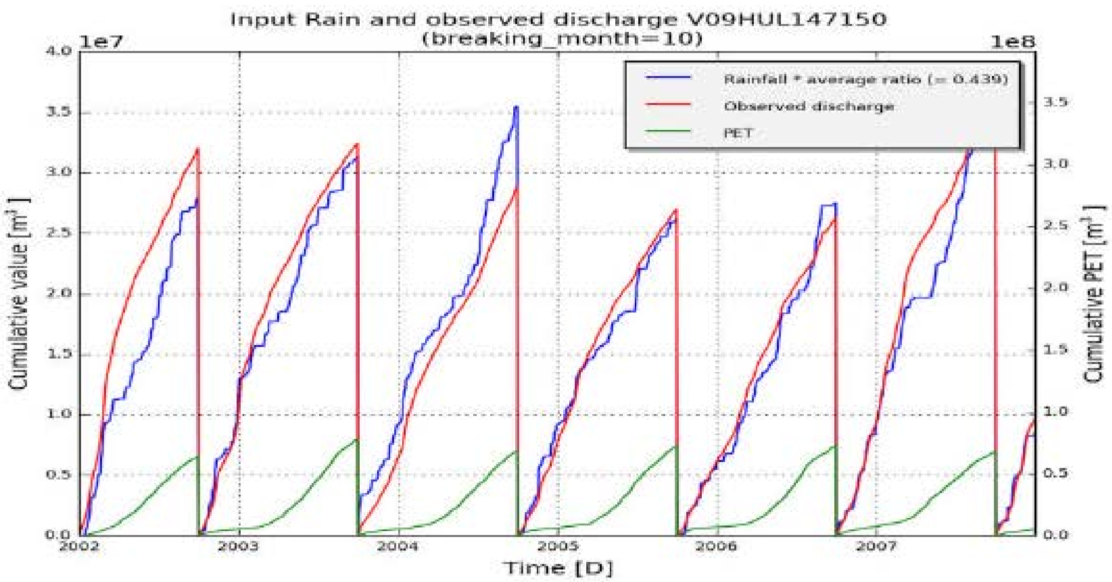


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.4.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	V09HUL147150
subcatchment_area	95300000
start_date	200001010000
end_date	201012310000
frequency	86400
warmup	365

9.5.4.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.0, 50.0, 0.001, 1.3, 90.0, 250.0, 1.0, 100.0]
low_bounds	[0.3, 10.0, 0.0007, 0.2, 20.0, 75.0, 0.5, 20.0]
high_bounds	[5.0, 250.0, 0.01, 5.0, 300.0, 550.0, 5.0, 500.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.0), ('Ki', 50.0), ('Kg', 0.001), ('Kss', 1.3), ('g0', 90.0), ('g_max', 250.0), ('K_run', 1.0), ('P_max', 100.0)]

Initial fitness:

- RelErr: -0.458
- AbsErr: 94860972.401
- KGE: 0.364
- NS_rel: -0.12
- NS: -0.691
- RMSE: 108256670.871
- NS_log: -2.744

Computation time:1 day, 7:59:24.346000

9.5.4.4 Results

Best individual (euclidian): [('Kep', 0.823), ('Ki', 80.511), ('Kg', 0.003), ('Kss', 1.86), ('g0', 65.095), ('g_max', 329.857), ('K_run', 1.46), ('P_max', 73.553)]

Fitness:

- RelErr: 0.011
- AbsErr: 3794622.81
- KGE: 0.331
- NS_rel: 0.457
- NS: -0.511
- RMSE: 4708766.885
- NS_log: 0.47

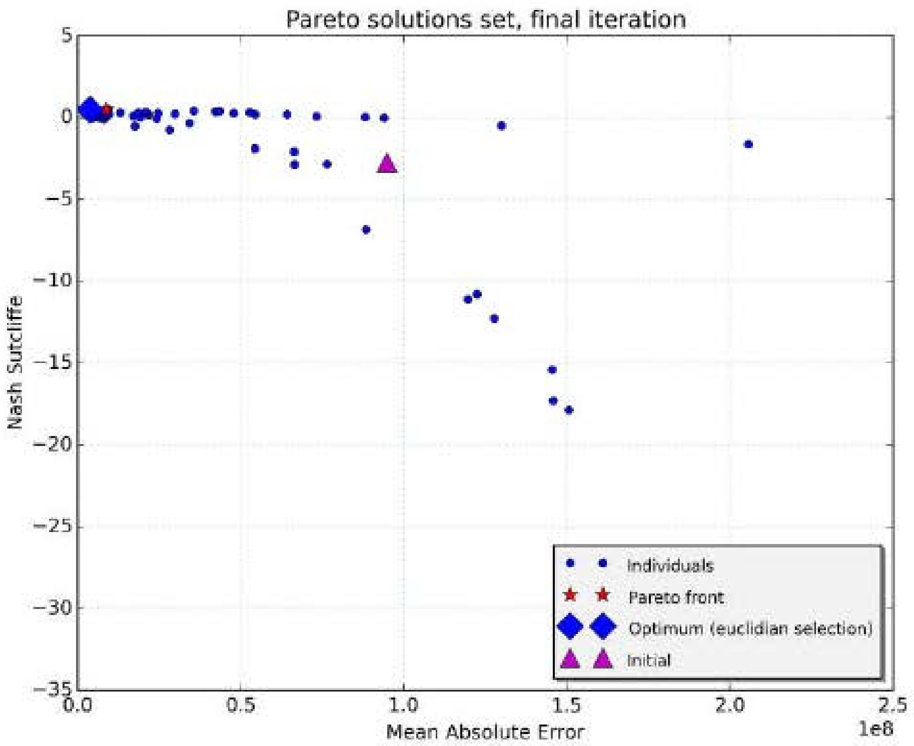


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

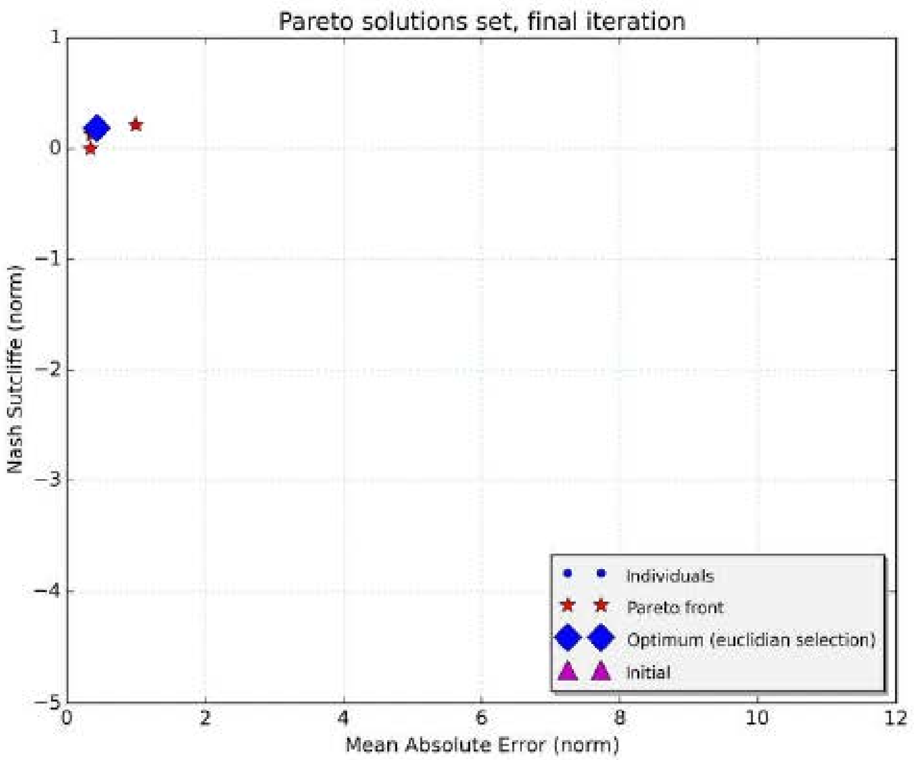


Figure 4: Final population of solutions (Pareto front)

9.5.4.4.1 Initial

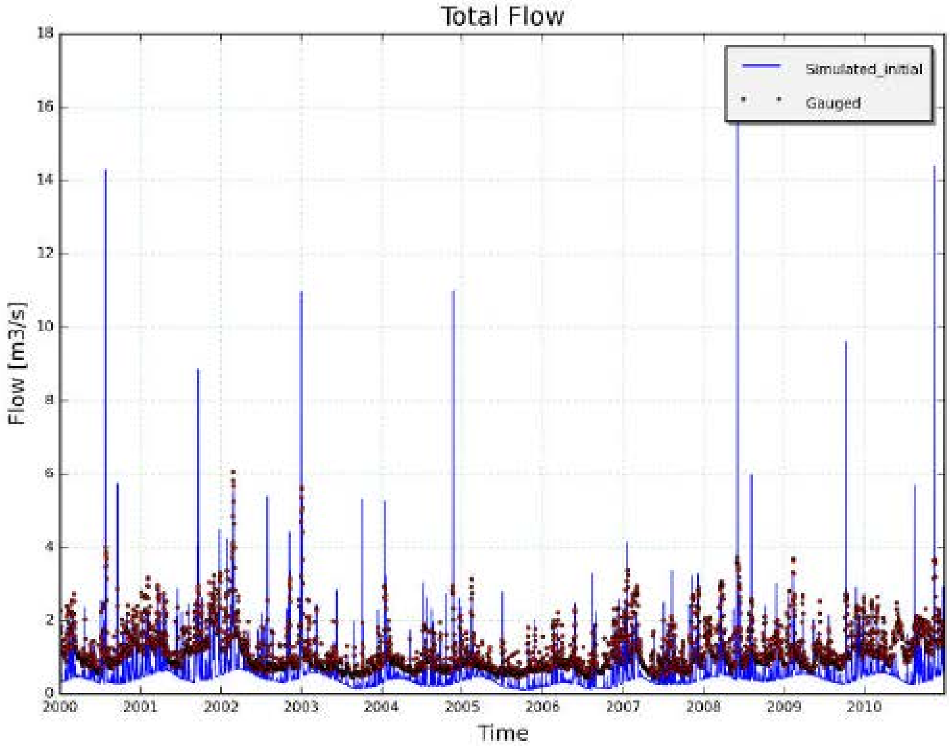


Figure 5: Total flow with initial parameters

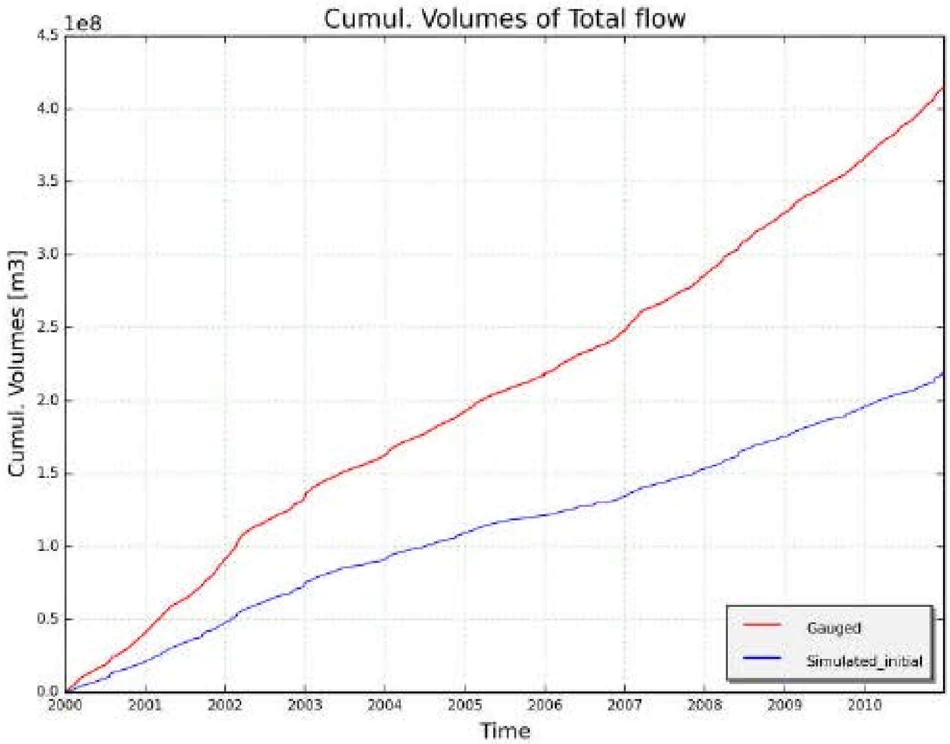


Figure 6: Cumulated flow with initial parameters

9.5.4.4.2 Optimum (euclidian)

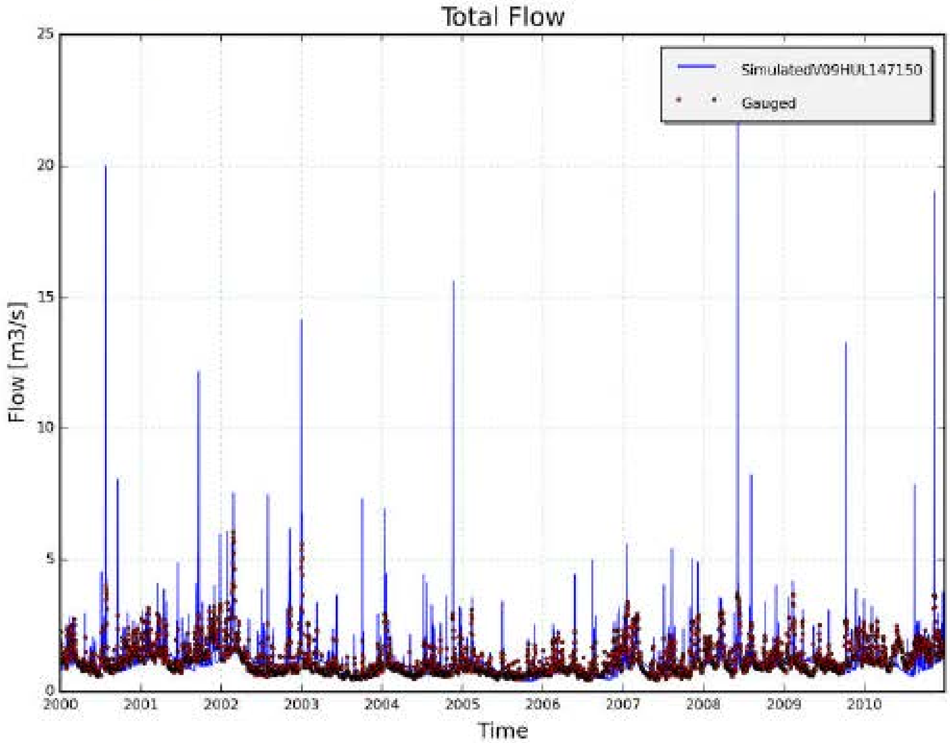


Figure 7: Total flow with optimum parameters

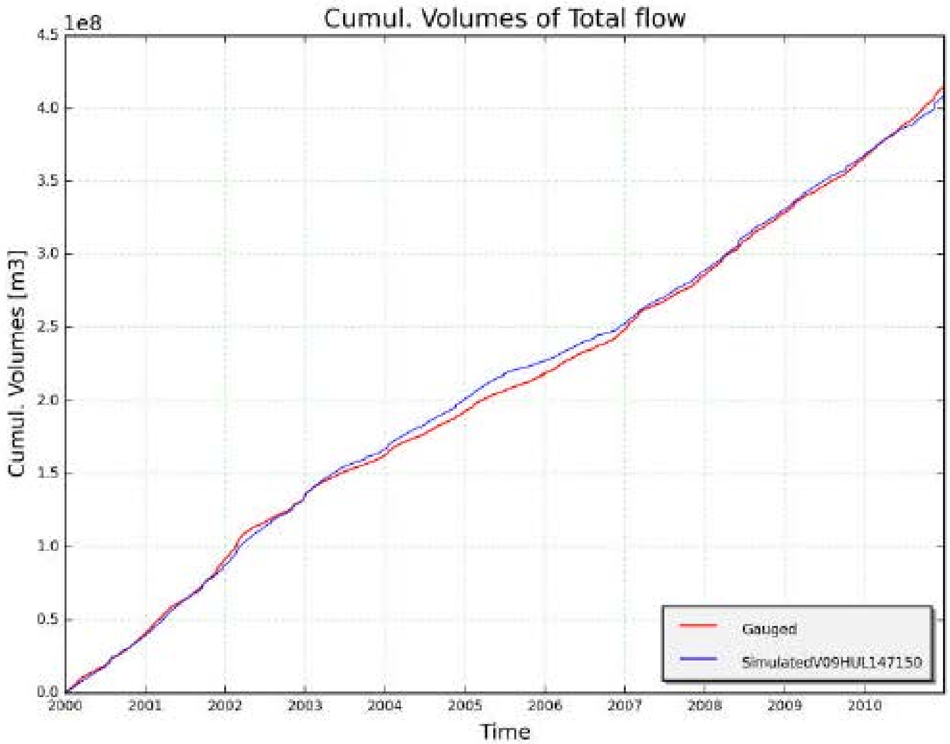


Figure 8: Cumulated flow with optimum parameters

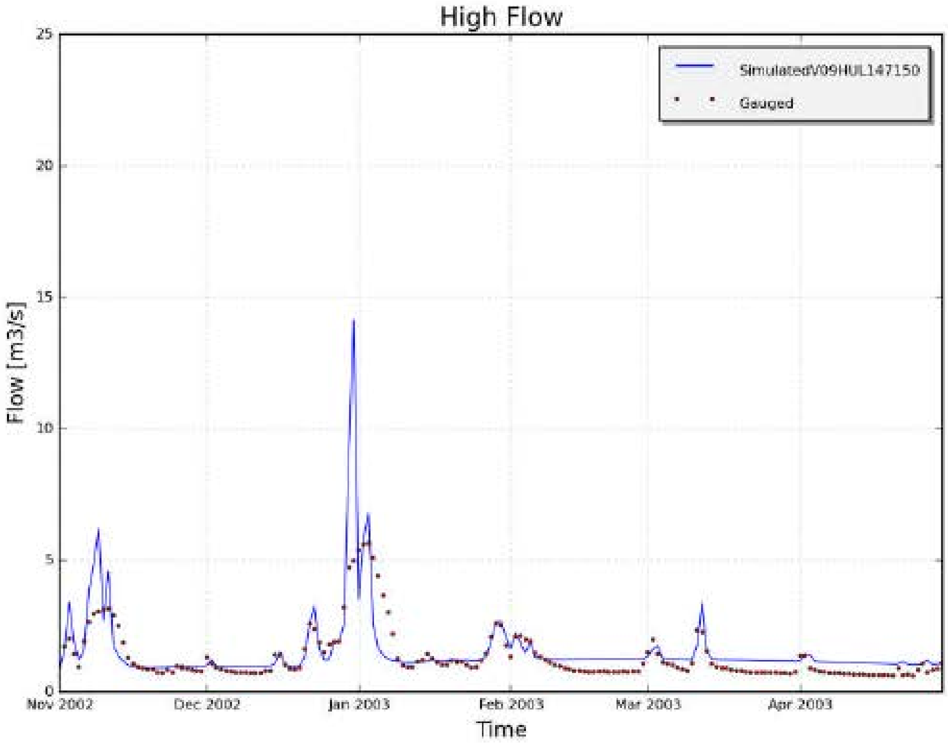


Figure 9: Total flow with optimum parameters (detail)

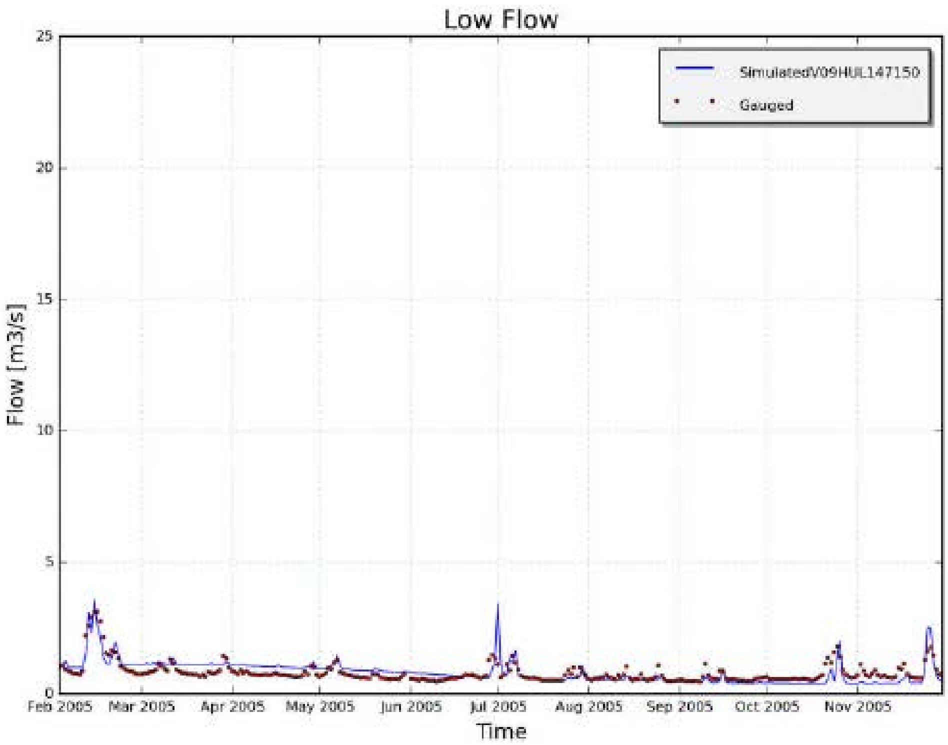


Figure 10: Total flow with optimum parameters (detail)

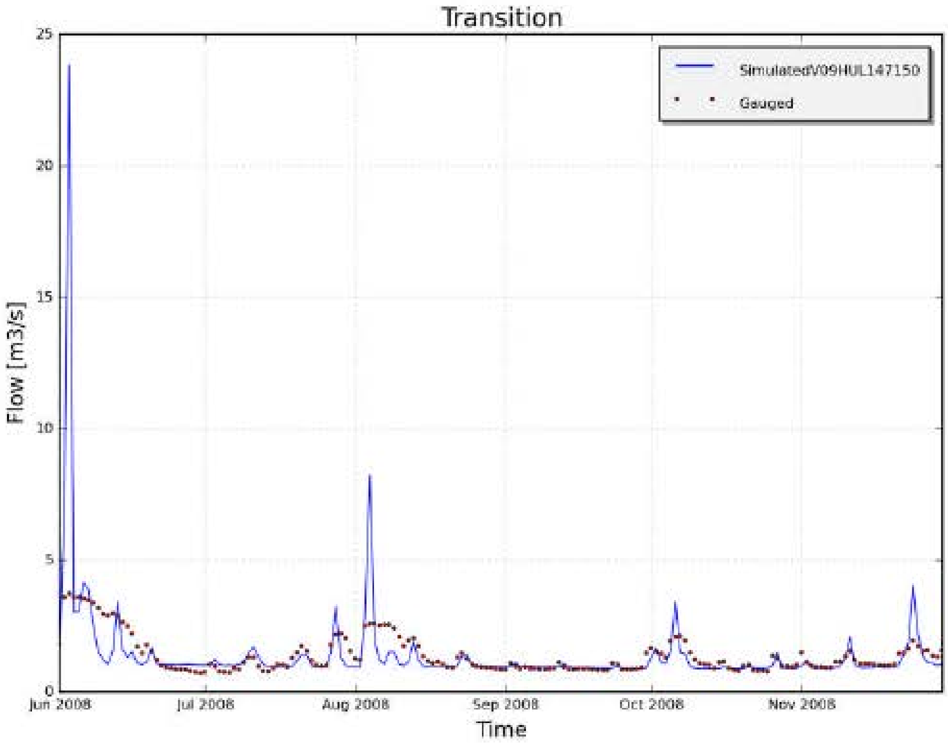
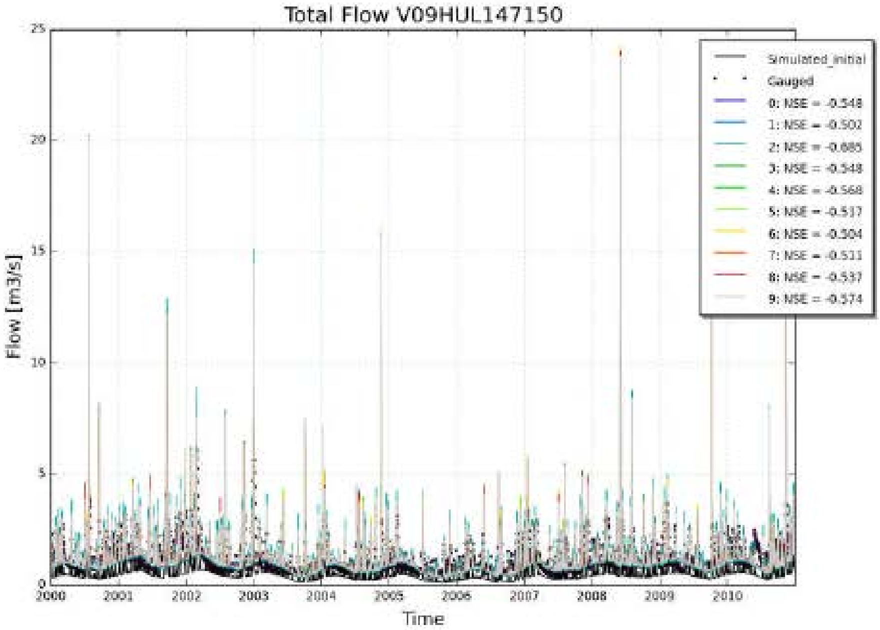
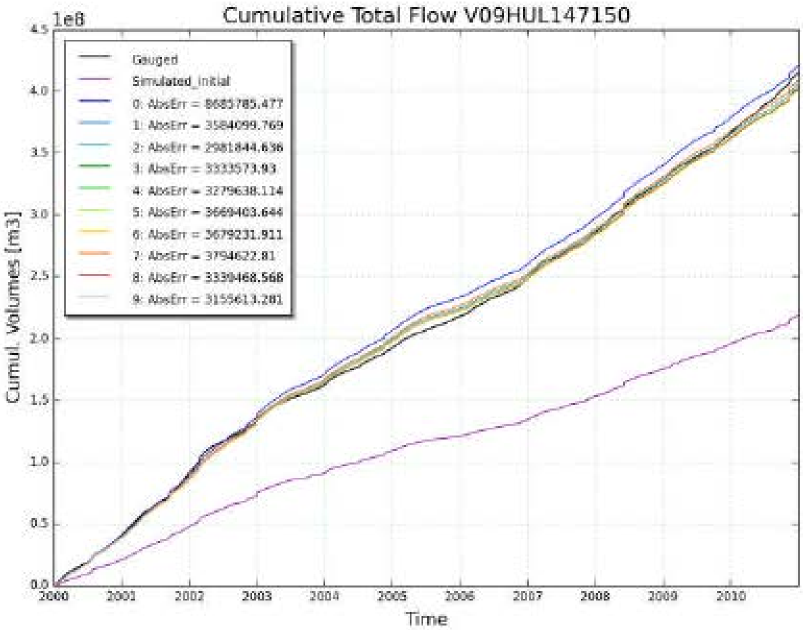


Figure 11: Total flow with optimum parameters (detail)

9.5.4.4.3 Final archive

0 : [0.823, 82.243, 0.003, 1.534, 65.321, 366.771, 1.433, 73.752] : [8685785.477, 0.488]
1 : [0.823, 80.503, 0.003, 2.452, 60.568, 307.365, 1.673, 73.095] : [3584099.769, 0.453]
2 : [0.822, 82.162, 0.003, 1.533, 61.218, 294.053, 0.519, 71.104] : [2981844.636, 0.351]
3 : [0.823, 81.698, 0.003, 2.255, 60.568, 307.031, 1.271, 73.009] : [3333573.93, 0.442]
4 : [0.823, 82.56, 0.003, 0.822, 60.568, 307.977, 1.251, 72.81] : [3279638.114, 0.441]
5 : [0.823, 81.898, 0.003, 0.853, 61.265, 307.601, 2.098, 73.633] : [3669403.644, 0.453]
6 : [0.823, 81.261, 0.003, 2.025, 61.15, 307.012, 3.038, 74.195] : [3679231.911, 0.455]
7 : [0.823, 80.511, 0.003, 1.86, 65.095, 329.857, 1.46, 73.553] : [3794622.81, 0.47]
8 : [0.823, 81.727, 0.003, 1.404, 59.493, 308.717, 1.456, 74.184] : [3339468.568, 0.449]
9 : [0.822, 82.166, 0.003, 0.951, 60.7, 304.973, 1.049, 72.329] : [3155613.281, 0.432]


Total Flow V09HUL147150
Flow [m3/s]
Time
Simulated_initial
Gauged
0: NSE = -0.548
1: NSE = -0.502
2: NSE = -0.685
3: NSE = -0.548
4: NSE = -0.568
5: NSE = -0.517
6: NSE = -0.504
7: NSE = -0.511
8: NSE = -0.537
9: NSE = -0.574


Cumulative Total Flow V09HUL147150
1e8
Cumul. Volumes [m3]
Time
Gauged
Simulated_initial
0: AbsErr = 8685785.477
1: AbsErr = 3584099.769
2: AbsErr = 2981844.636
3: AbsErr = 3333573.93
4: AbsErr = 3279638.114
5: AbsErr = 3669403.644
6: AbsErr = 3679231.911
7: AbsErr = 3794622.81
8: AbsErr = 3330468.568
9: AbsErr = 3155613.281

9.5.5 Report on simulation of catchment V09MAN161040 (2017-01-18 03-37)

9.5.5.1 Input data

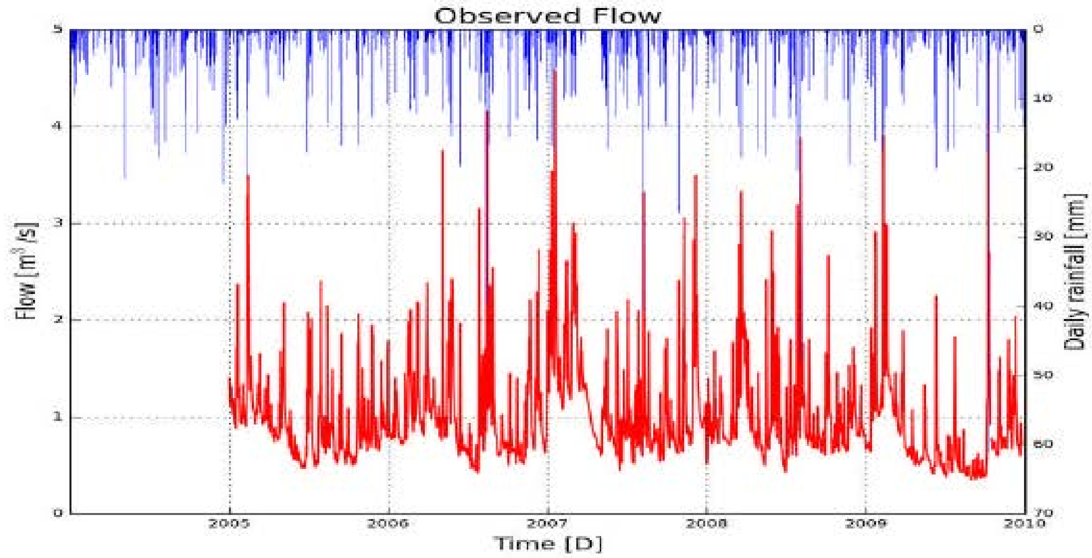


Figure 1: Hyetogram of observed discharge and observed net rain

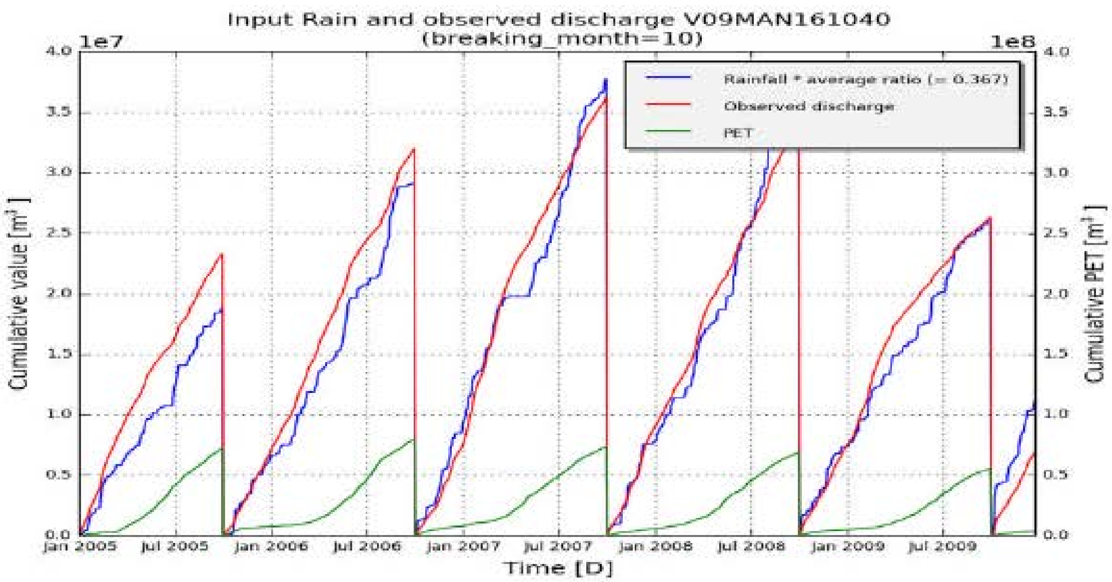


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.5.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	V09MAN161040
subcatchment_area	102900000
start_date	200501010000
end_date	200912310000
frequency	86400
warmup	365

9.5.5.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.5, 10.0, 0.004, 1.05, 90.0, 450.0, 0.5, 30.0]
low_bounds	[1.2, 8.0, 0.0032, 0.84, 72.0, 360.0, 0.4, 24.3]
high_bounds	[1.95, 13.0, 0.01, 1.35, 120.0, 600.0, 0.7, 50.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.5), ('Ki', 10.0), ('Kg', 0.004), ('Kss', 1.05), ('g0', 90.0), ('g_max', 450.0), ('K_run', 0.5), ('P_max', 30.0)]
Initial fitness:

- RelErr: 0.028
- AbsErr: 4978720.183
- KGE: 0.764
- NS_rel: 0.346
- NS: 0.538
- RMSE: 6858020.444
- NS_log: 0.349

Computation time:10:00:25.972000

9.5.5.4 Results

Best individual (euclidian): [('Kep', 1.923), ('Ki', 13.0), ('Kg', 0.005), ('Kss', 0.965), ('g0', 85.139), ('g_max', 560.431), ('K_run', 0.478), ('P_max', 39.19)]

Fitness:

- RelErr: -0.01
- AbsErr: 3800535.824
- KGE: 0.788
- NS_rel: 0.465
- NS: 0.577
- RMSE: 4649862.594
- NS_log: 0.359

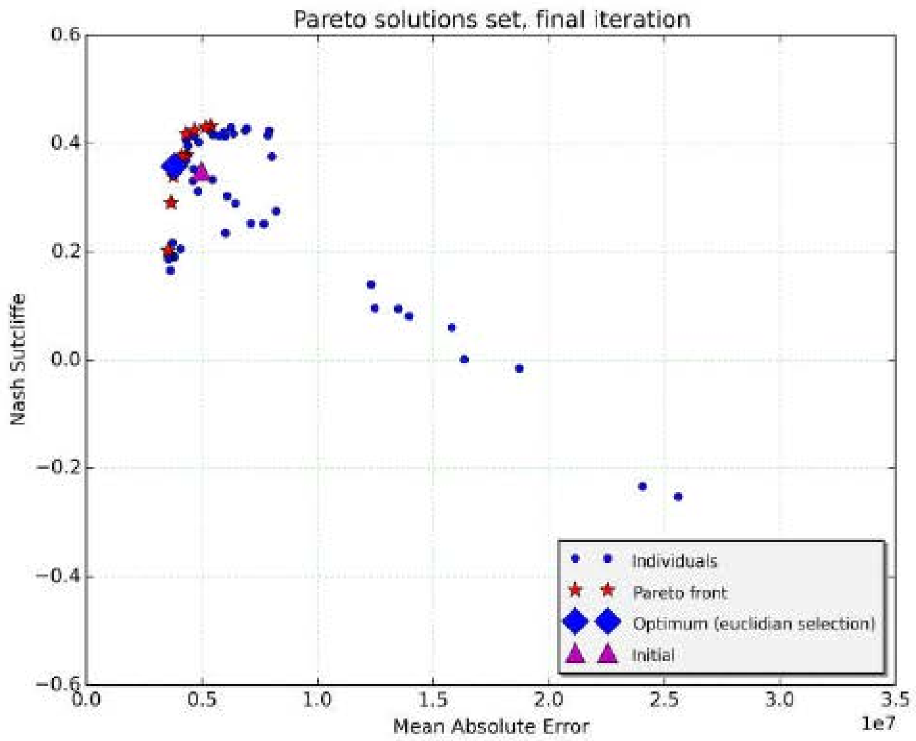


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

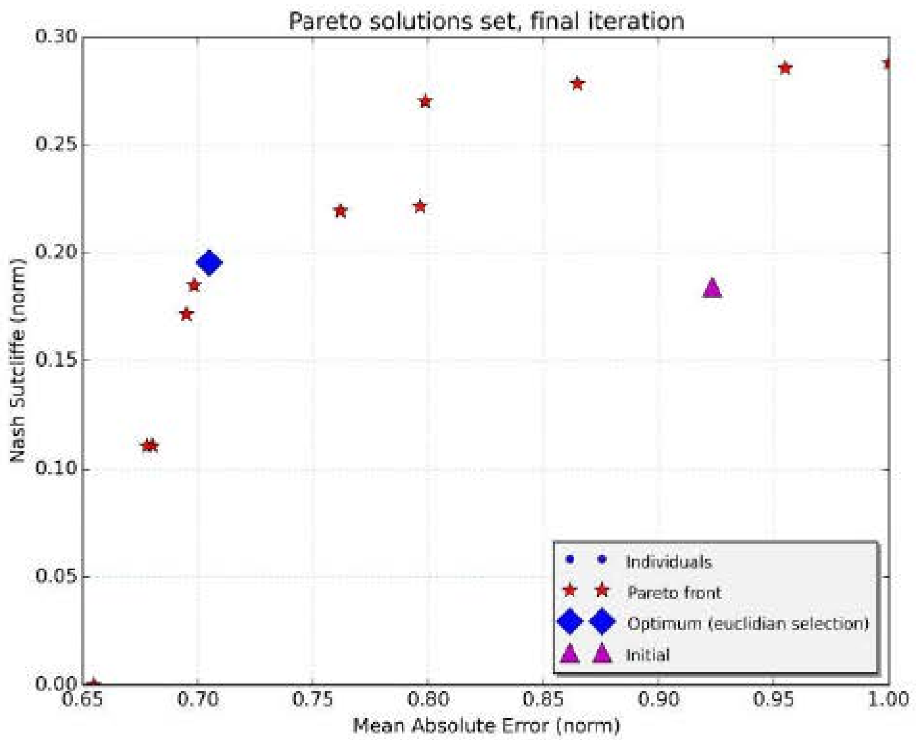


Figure 4: Final population of solutions (Pareto front)

9.5.5.4.1 Initial

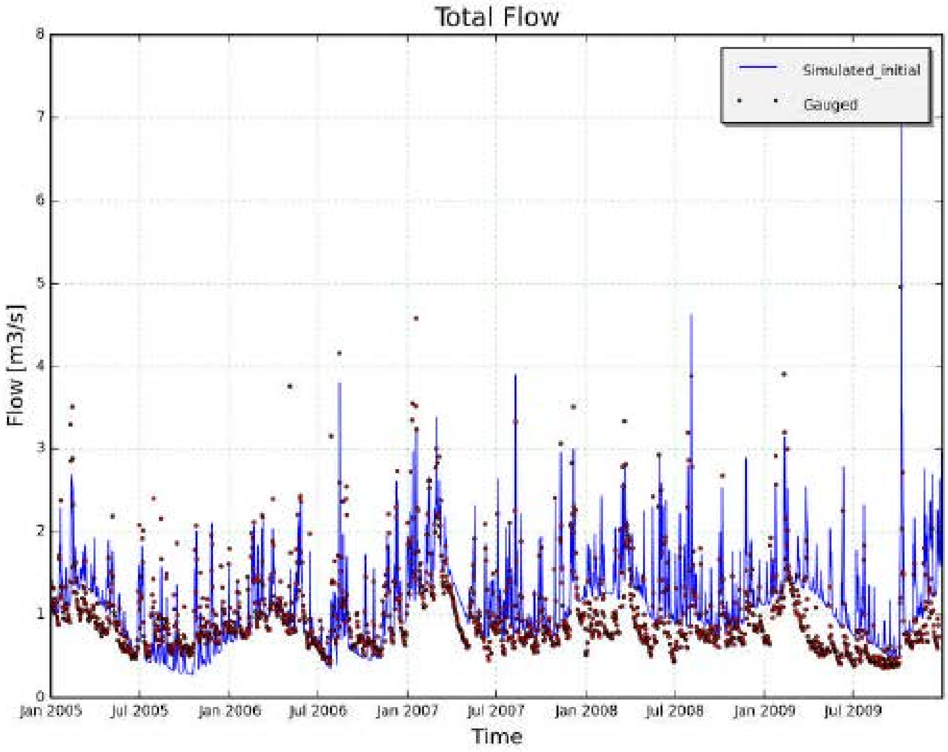


Figure 5: Total flow with initial parameters

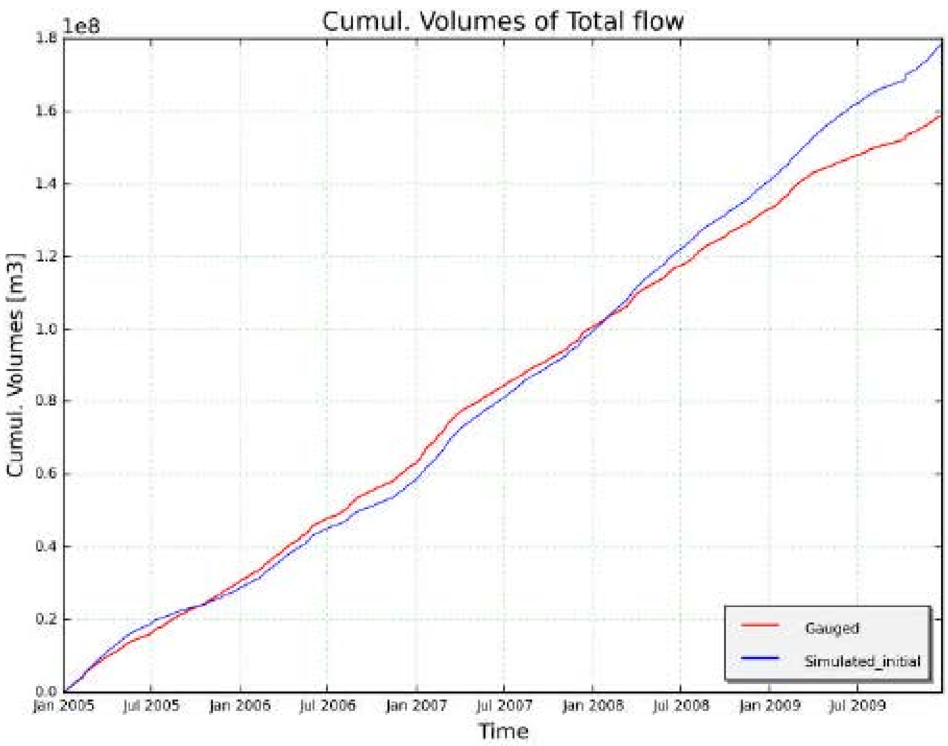


Figure 6: Cumulated flow with initial parameters

9.5.5.4.2 Optimum (euclidian)

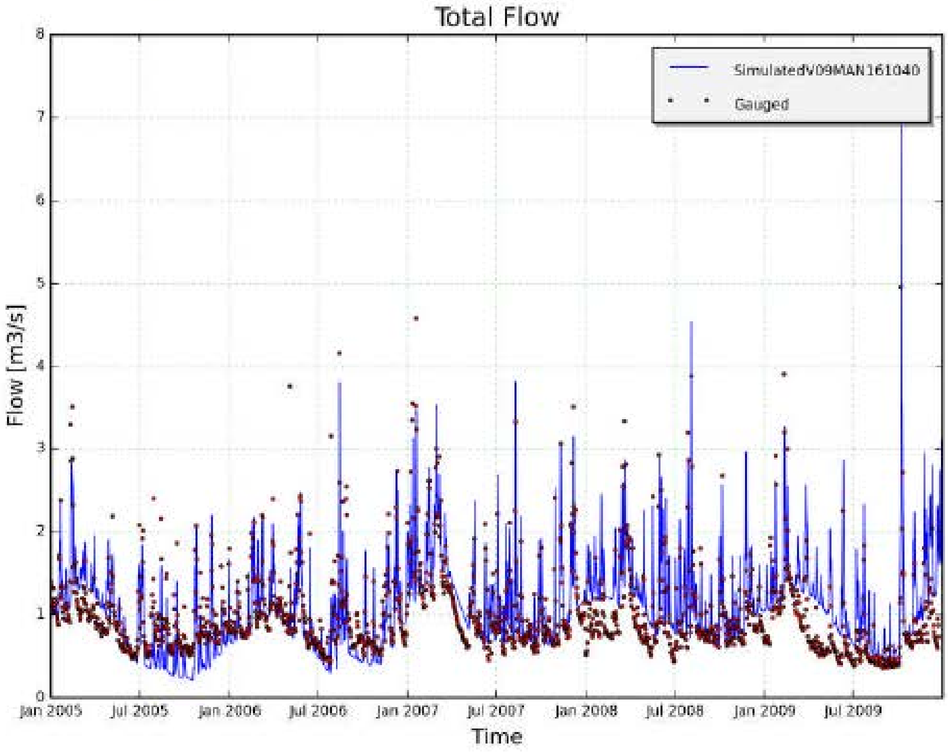


Figure 7: Total flow with optimum parameters

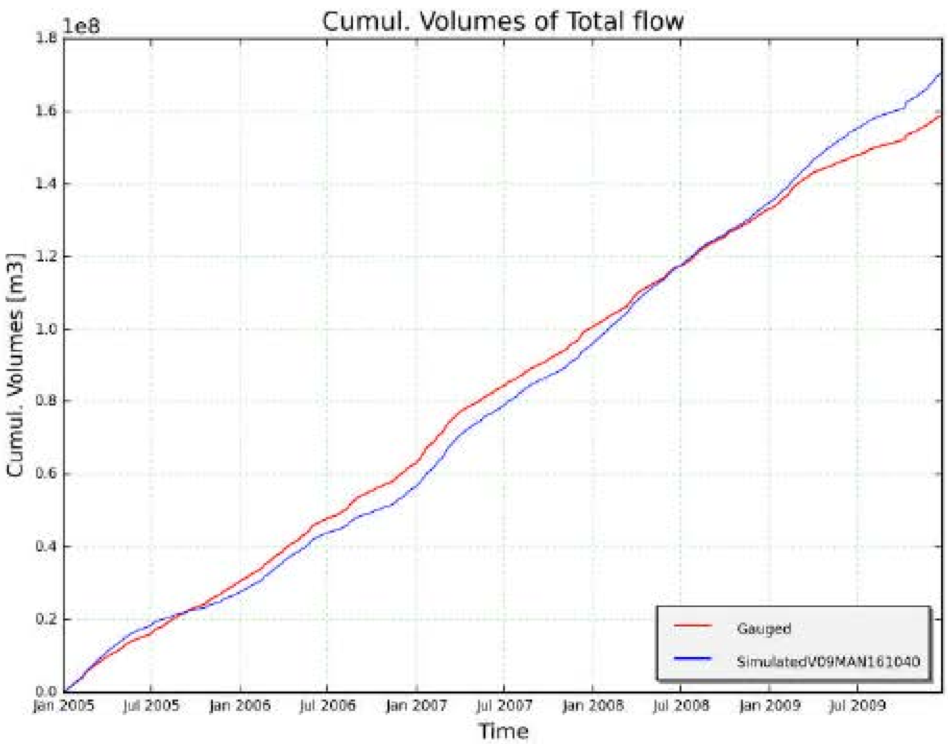


Figure 8: Cumulated flow with optimum parameters

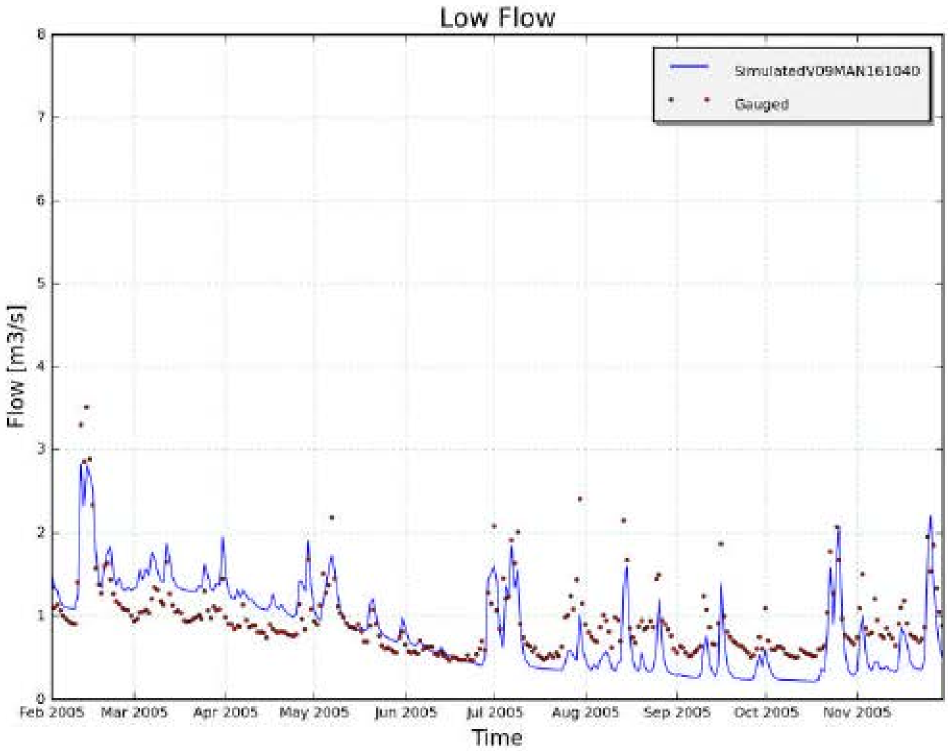


Figure 9: Total flow with optimum parameters (detail)

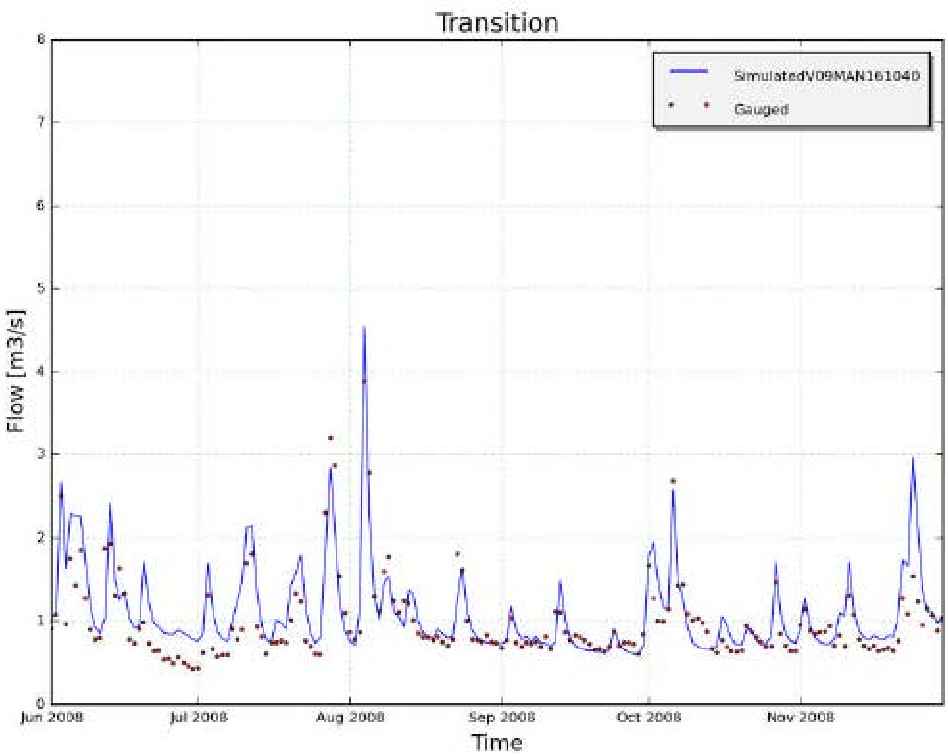
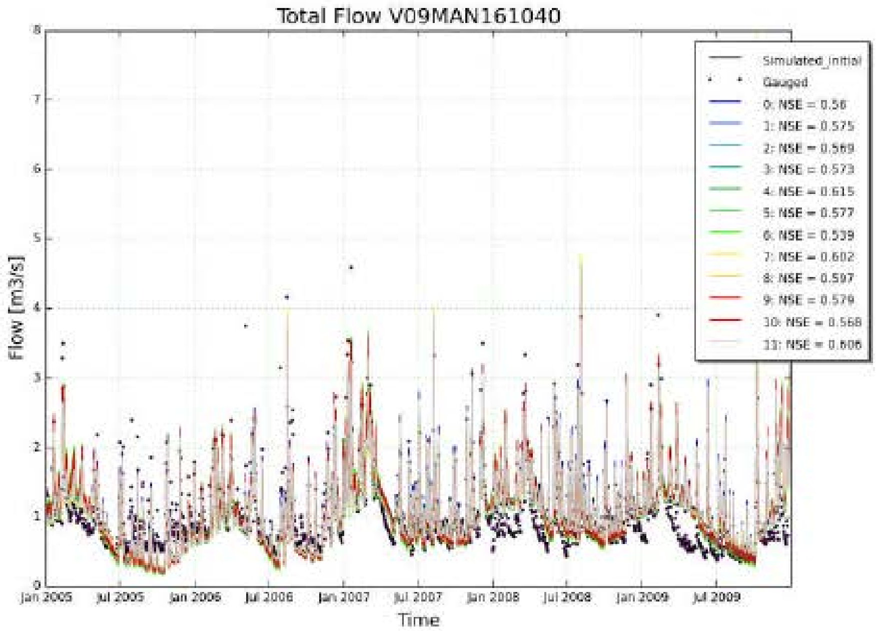
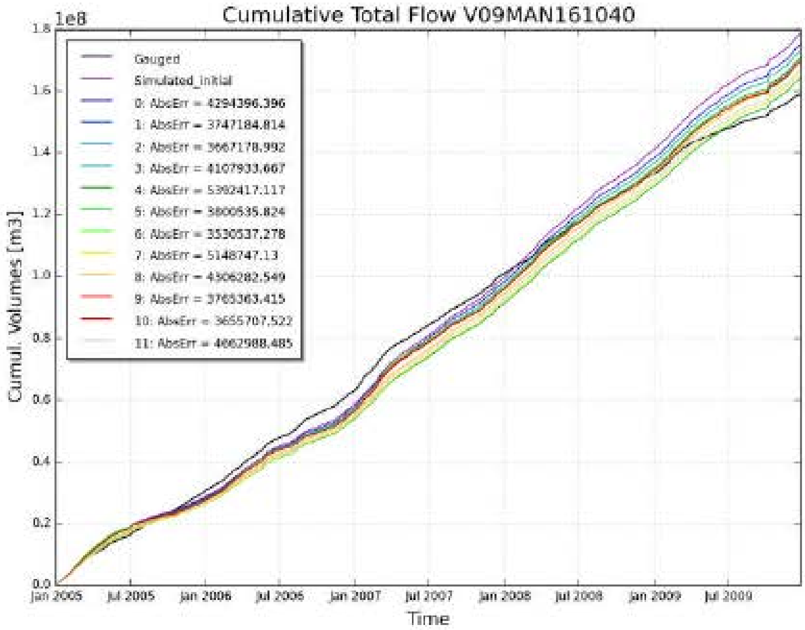


Figure 10: Total flow with optimum parameters (detail)

9.5.5.4.3 Final archive

0 : [1.708, 12.531, 0.004, 1.052, 89.301, 530.646, 0.416, 38.067] : [4294396.396, 0.379]
1 : [1.95, 10.869, 0.005, 0.84, 91.091, 544.764, 0.46, 34.306] : [3747184.814, 0.339]
2 : [1.892, 11.644, 0.005, 1.069, 84.212, 460.713, 0.4, 38.004] : [3667178.992, 0.291]
3 : [1.745, 11.952, 0.004, 0.966, 84.715, 530.242, 0.478, 35.46] : [4107933.667, 0.378]
4 : [1.621, 11.639, 0.003, 1.35, 81.707, 544.165, 0.541, 37.69] : [5392417.117, 0.432]
5 : [1.923, 13.0, 0.005, 0.965, 85.139, 560.431, 0.478, 39.19] : [3800535.824, 0.359]
6 : [1.95, 13.0, 0.006, 1.35, 79.646, 410.505, 0.403, 35.797] : [3530537.278, 0.203]
7 : [1.598, 12.965, 0.003, 0.92, 81.198, 553.278, 0.601, 37.549] : [5148747.13, 0.43]
8 : [1.625, 10.954, 0.003, 1.35, 80.556, 551.053, 0.564, 37.804] : [4306282.549, 0.418]
9 : [1.94, 11.667, 0.005, 1.35, 82.603, 554.037, 0.518, 34.998] : [3765363.415, 0.35]
10 : [1.892, 11.644, 0.005, 1.35, 84.212, 460.564, 0.4, 38.004] : [3655707.522, 0.291]
11 : [1.646, 11.844, 0.003, 0.976, 98.978, 550.102, 0.52, 38.484] : [4662988.485, 0.425]





9.5.6 Report on simulation of catchment V09MOT144270 (2017-01-23 23-27)

9.5.6.1 Input data

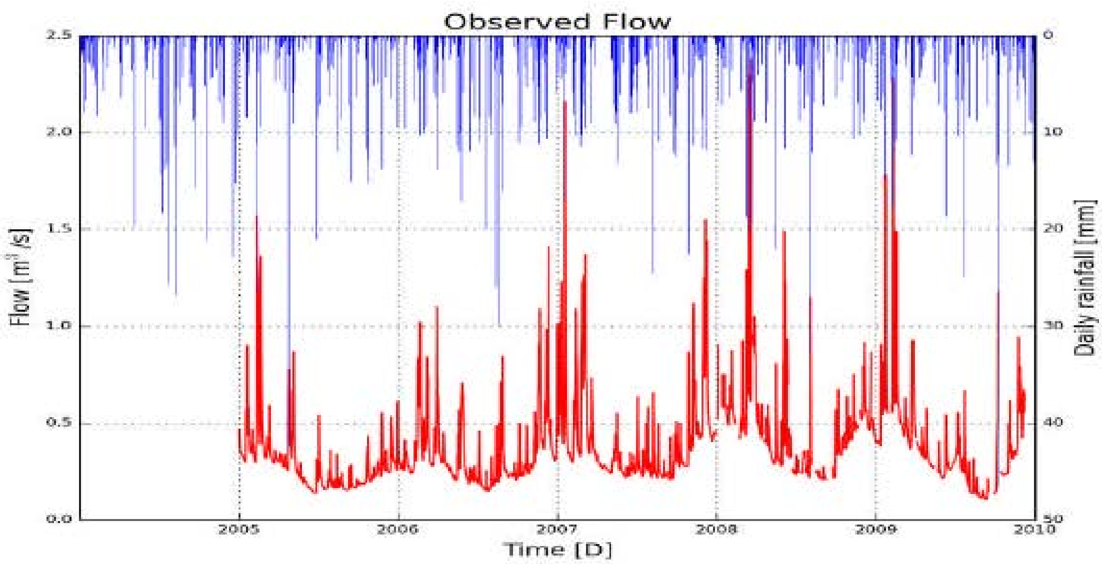


Figure 1: Hyetogram of observed discharge and observed net rain

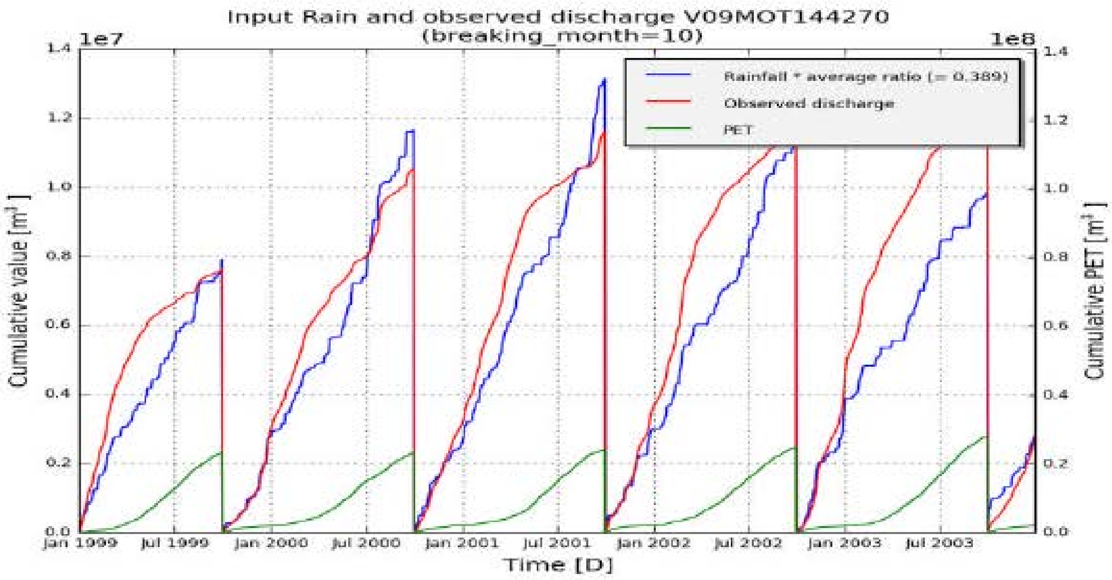


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.6.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V09MOT144270
subcatchment_area	33600000
start_date	200301010000
end_date	201312310000
frequency	86400
warmup	365

9.5.6.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[2.2, 24.829, 0.005, 2.801, 9.0, 296.0, 1.5, 58.0]
low_bounds	[1.54, 17.0, 0.003, 1.7, 5.0, 200.0, 1.0, 35.0]
high_bounds	[2.9, 30.0, 0.01, 4.0, 50.0, 350.0, 3.0, 70.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 2.2), ('Ki', 24.829), ('Kg', 0.005), ('Kss', 2.801), ('g0', 9.0), ('g_max', 296.0), ('K_run', 1.5), ('P_max', 58.0)]
Initial fitness:

- RelErr: -0.238
- AbsErr: 10127959.141
- KGE: 0.64
- NS_rel: 0.408
- NS: 0.346
- RMSE: 12715386.051
- NS_log: -1.022

Computation time:8:43:06.680000

9.5.6.4 Results

Best individual (euclidian): [('Kep', 1.558), ('Ki', 20.282), ('Kg', 0.006), ('Kss', 2.844), ('g0', 29.876), ('g_max', 269.276), ('K_run', 2.78), ('P_max', 45.317)]

Fitness:

- RelErr: 0.06
- AbsErr: 2565256.092
- KGE: 0.733
- NS_rel: 0.551
- NS: 0.45
- RMSE: 2928200.243
- NS_log: 0.426

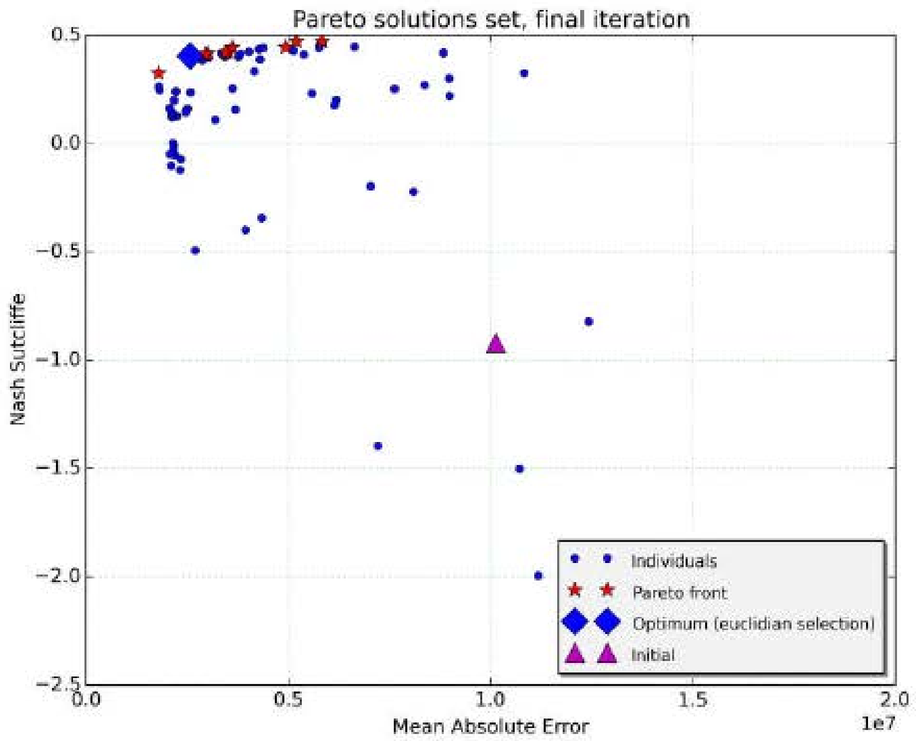


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

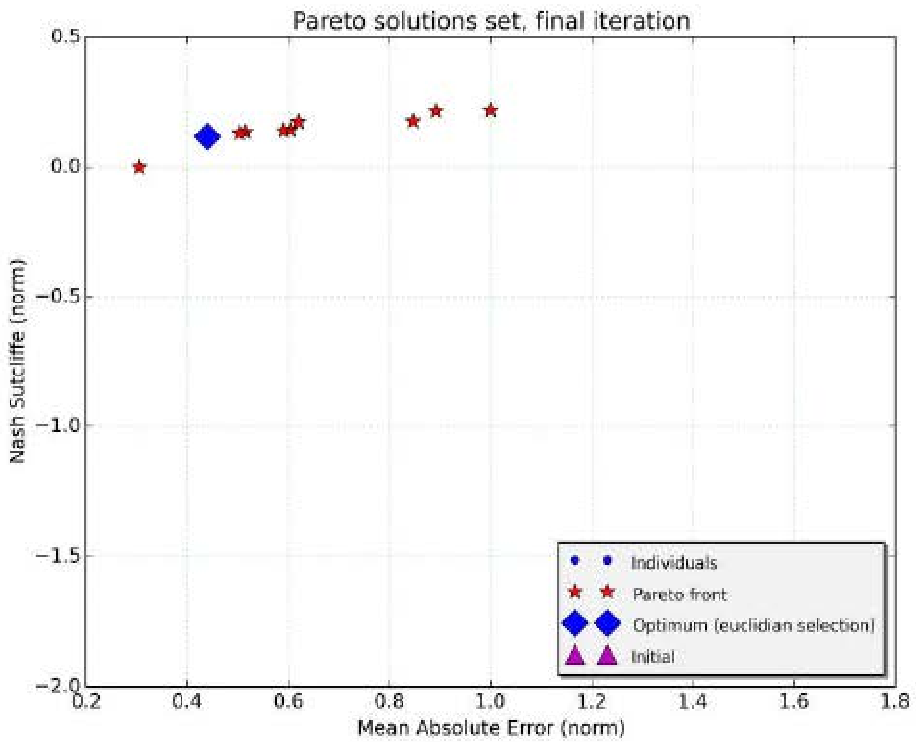


Figure 4: Final population of solutions (Pareto front)

9.5.6.4.1 Initial

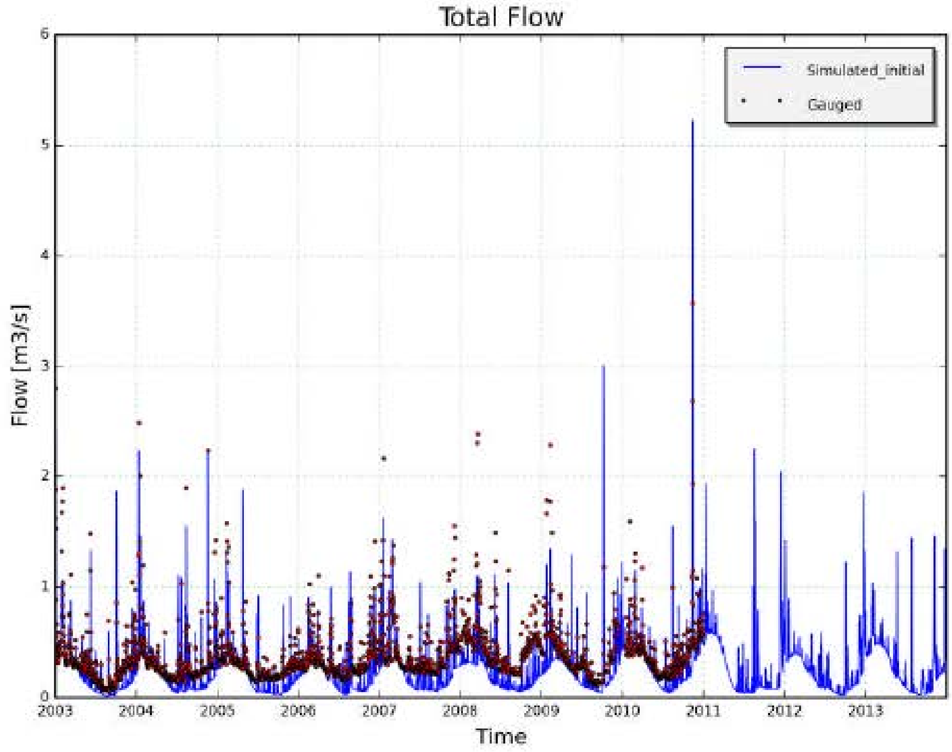


Figure 5: Total flow with initial parameters

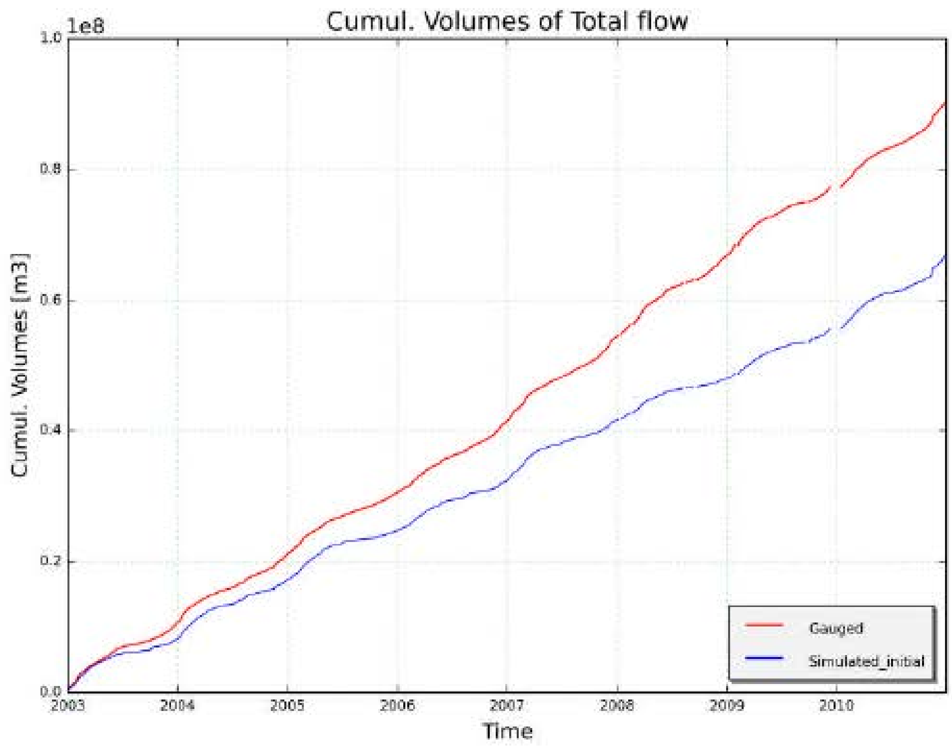


Figure 6: Cumulated flow with initial parameters

9.5.6.4.2 Optimum (euclidian)

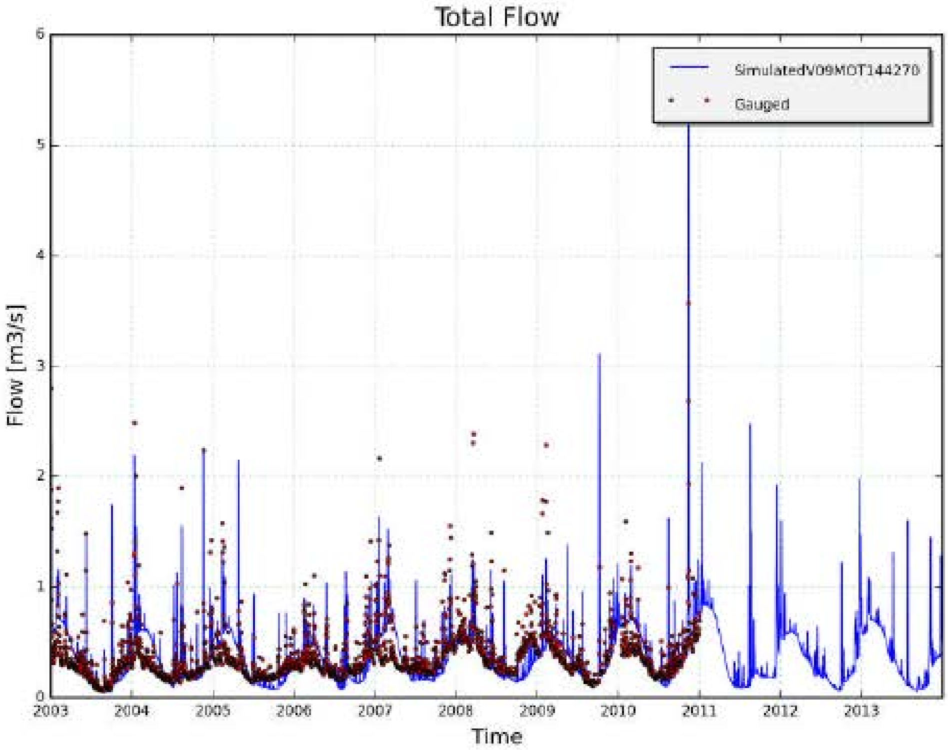


Figure 7: Total flow with optimum parameters

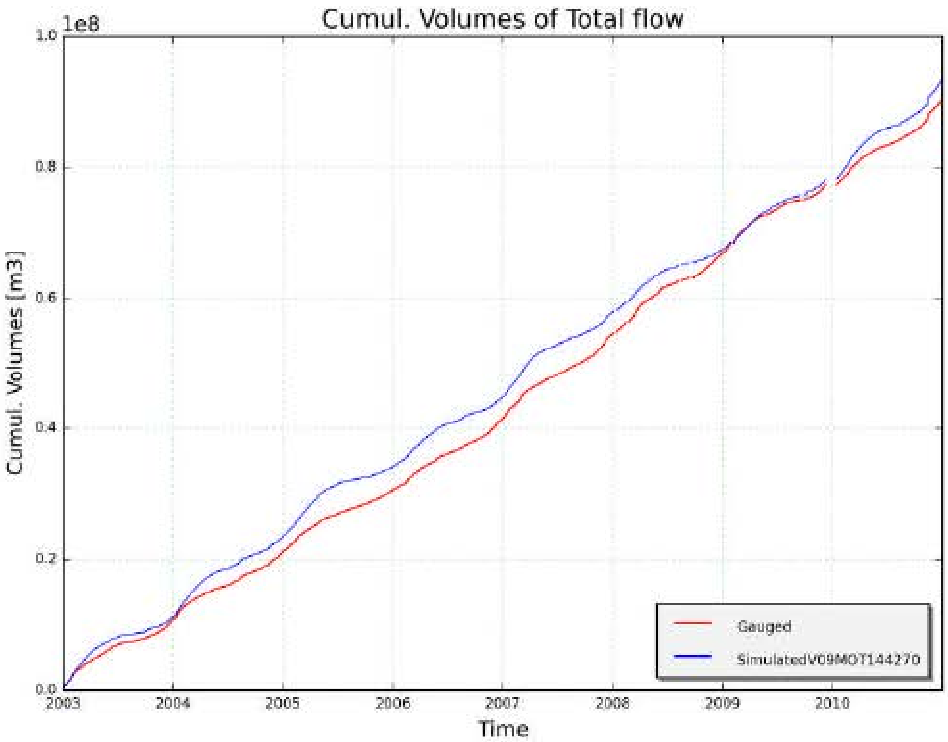


Figure 8: Cumulated flow with optimum parameters

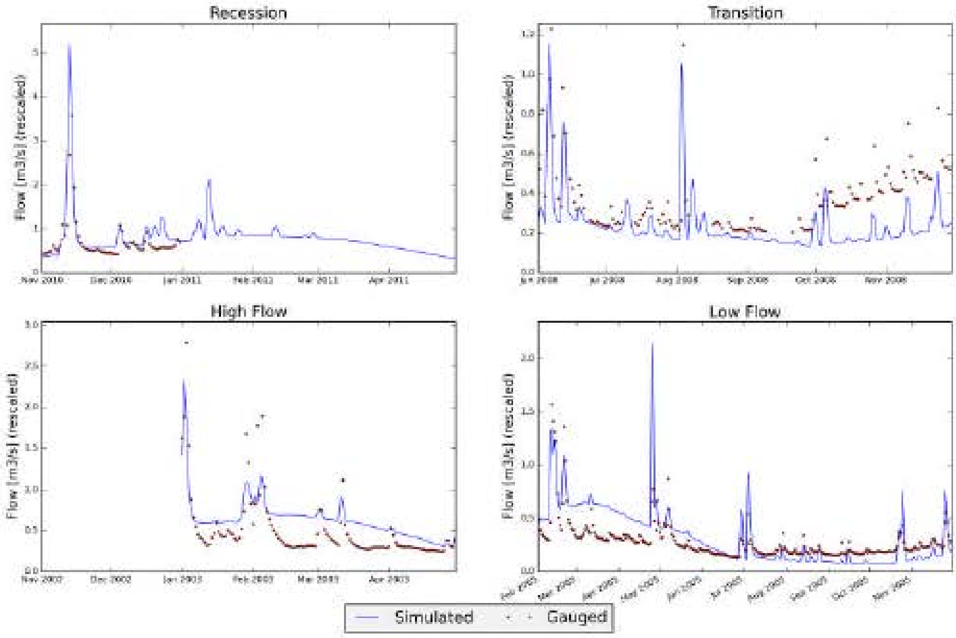
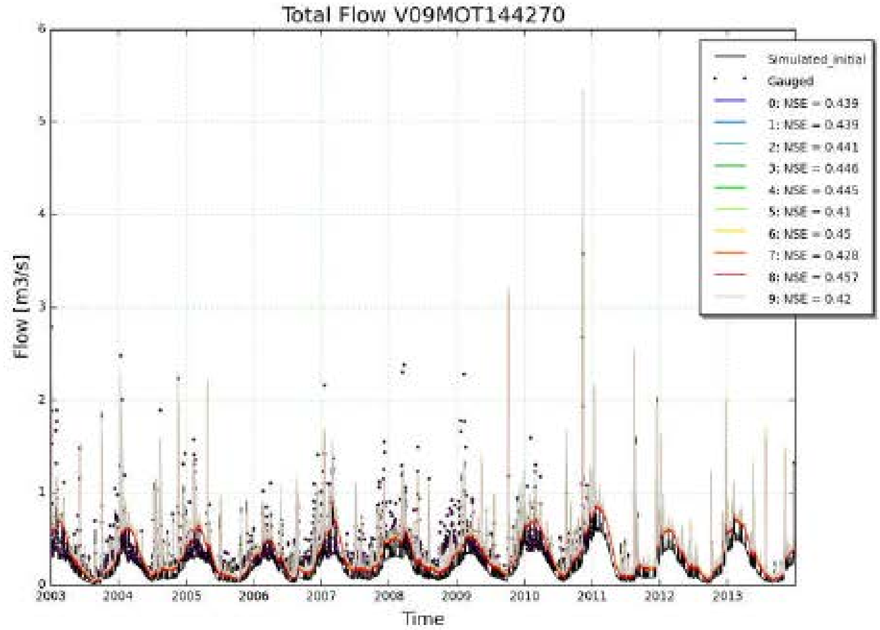
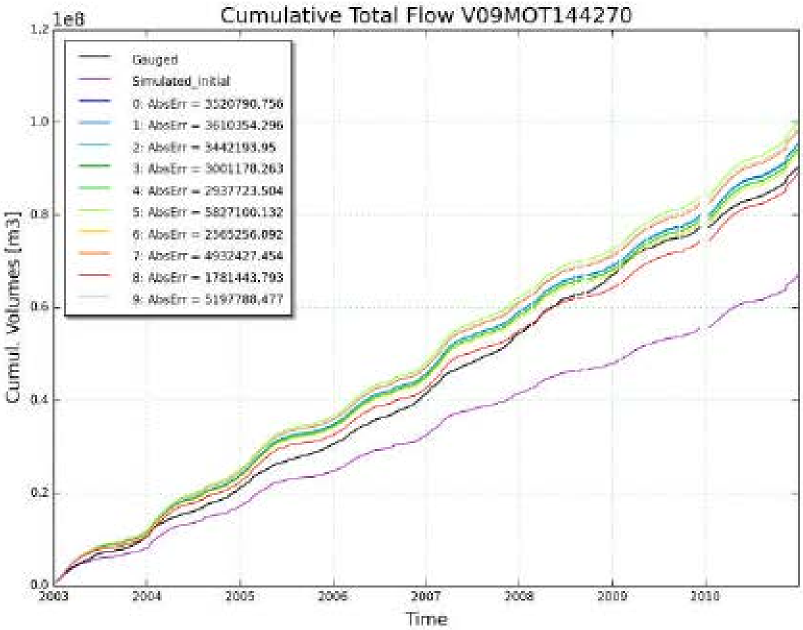


Figure 9: Total flow with optimum parameters (detail)

9.5.6.4.3 Final archive

0 : [1.54, 20.28, 0.006, 2.758, 30.173, 270.717, 3.0, 45.414] : [3520790.756, 0.422]
1 : [1.54, 20.28, 0.006, 1.7, 29.331, 272.312, 3.0, 45.414] : [3610354.296, 0.444]
2 : [1.54, 20.306, 0.006, 2.758, 30.173, 269.097, 3.0, 45.77] : [3442193.95, 0.42]
3 : [1.54, 20.282, 0.006, 2.844, 29.876, 269.276, 2.78, 45.317] : [3001178.263, 0.417]
4 : [1.54, 20.696, 0.006, 2.929, 29.768, 268.536, 3.0, 45.281] : [2937723.504, 0.414]
5 : [1.54, 21.458, 0.006, 1.7, 29.328, 317.193, 3.0, 44.541] : [5827100.132, 0.473]
6 : [1.558, 20.282, 0.006, 2.844, 29.876, 269.276, 2.78, 45.317] : [2565256.092, 0.405]
7 : [1.54, 19.872, 0.007, 2.758, 30.173, 293.726, 2.802, 45.118] : [4932427.454, 0.445]
8 : [1.644, 20.435, 0.006, 2.845, 30.142, 268.169, 3.0, 44.92] : [1781443.793, 0.326]
9 : [1.54, 21.366, 0.006, 1.7, 29.628, 307.08, 3.0, 44.993] : [5197788.477, 0.472]


Total Flow V09MOT144270
Simulated_initial
Gauged
0: NSE = 0.439
1: NSE = 0.439
2: NSE = 0.441
3: NSE = 0.446
4: NSE = 0.445
5: NSE = 0.41
6: NSE = 0.45
7: NSE = 0.428
8: NSE = 0.457
9: NSE = 0.42
Flow [m3/s]
0
1
2
3
4
5
6
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Time


Cumulative Total Flow V09MOT144270
1e8
Gauged
Simulated_initial
0: AbsErr = 3520790.756
1: AbsErr = 3610354.296
2: AbsErr = 3442193.95
3: AbsErr = 3001178.263
4: AbsErr = 2937723.504
5: AbsErr = 5827100.132
6: AbsErr = 2365256.092
7: AbsErr = 4932427.454
8: AbsErr = 1781443.793
9: AbsErr = 5197788.477
Cumul. Volumes [m3]
0.0
0.2
0.4
0.6
0.8
1.0
1.2
2003
2004
2005
2006
2007
2008
2009
2010
Time

9.5.7 Report on simulation of catchment V09VEL145100 (2017-01-19 00-03)

9.5.7.1 Input data

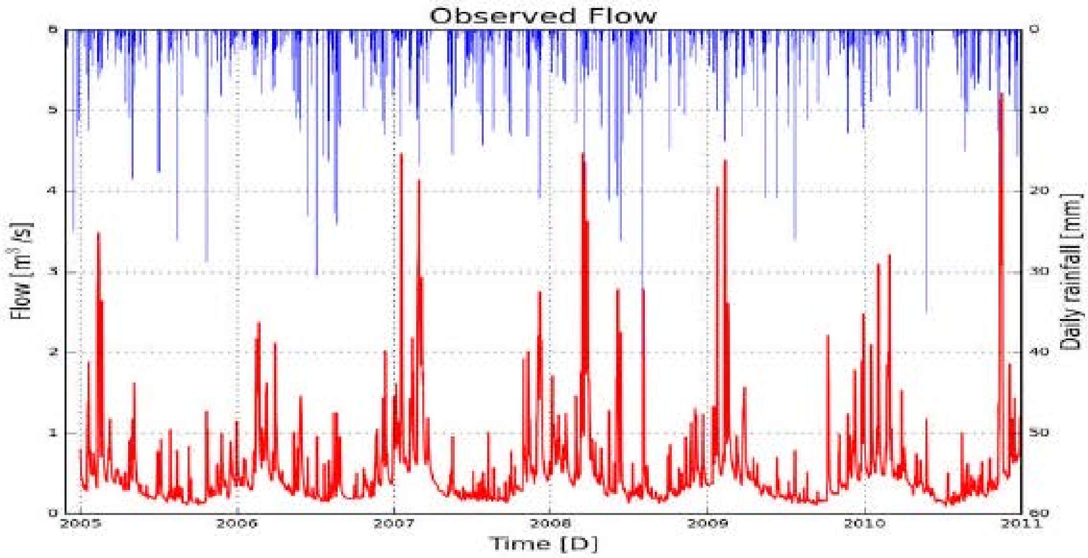


Figure 1: Hyetogram of observed discharge and observed net rain

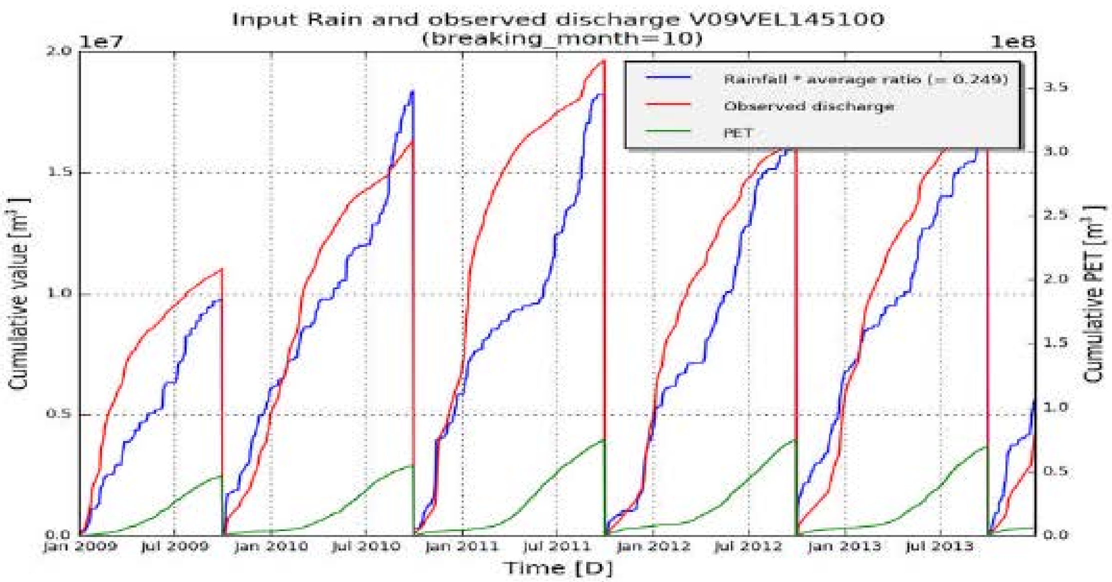


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.7.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	V09VEL145100
subcatchment_area	96800000
start_date	200501010000
end_date	200912310000
frequency	86400
warmup	365

9.5.7.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.32, 15.0, 0.002, 1.045, 89.959, 200.0, 6.746, 299.459]
low_bounds	[1.05, 10.0, 0.0016, 0.832, 71.0, 120.0, 5.4, 239.0]
high_bounds	[1.58, 120.0, 0.01, 3.0, 200.0, 350.0, 8.0, 400.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.32), ('Ki', 15.0), ('Kg', 0.002), ('Kss', 1.045), ('g0', 89.959), ('g_max', 200.0), ('K_run', 6.746), ('P_max', 299.459)]
Initial fitness:

- RelErr: 0.01
- AbsErr: 847828.714
- KGE: 0.573
- NS_rel: 0.562
- NS: 0.472
- RMSE: 1162712.628
- NS_log: 0.544

Computation time:7:21:21.755000

9.5.7.4 Results

Best individual (euclidian):
[('Kep', 1.58), ('Ki', 18.568), ('Kg', 0.003), ('Kss', 2.053), ('g0', 133.905), ('g_max', 228.748), ('K_run', 7.9), ('P_max', 304.105)]

Fitness:

- RelErr: -0.005
- AbsErr: 846225.762
- KGE: 0.601
- NS_rel: 0.626
- NS: 0.493
- RMSE: 1034610.228
- NS_log: 0.562

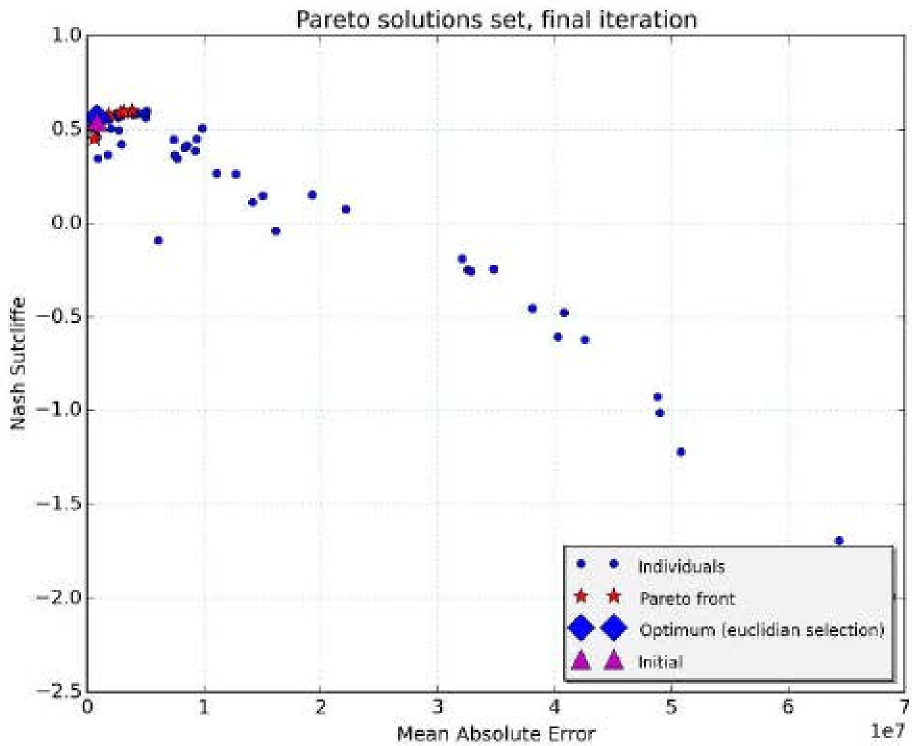


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

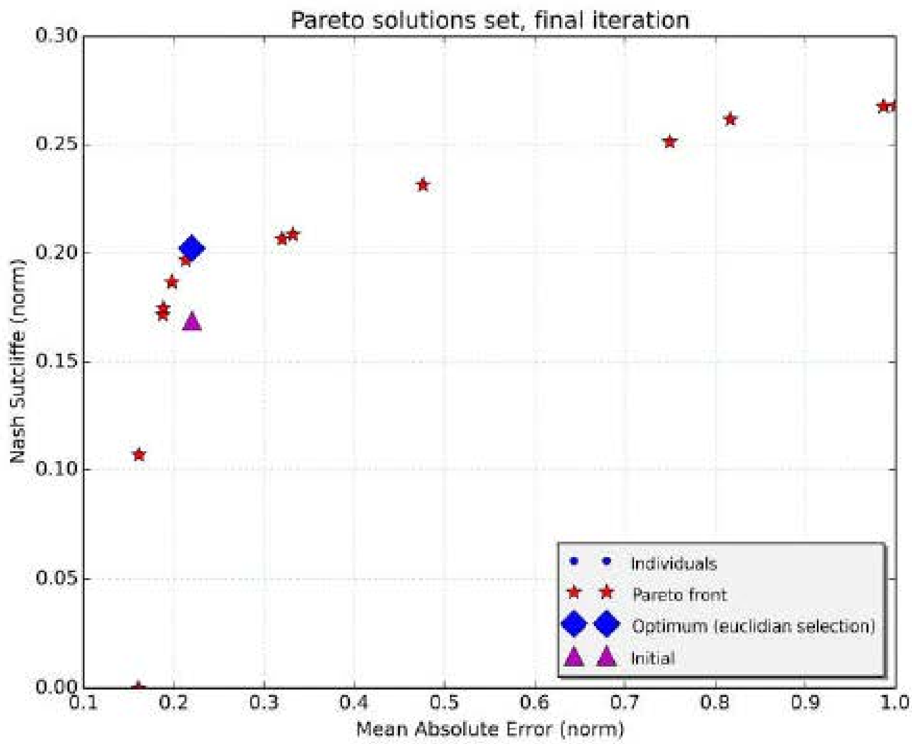


Figure 4: Final population of solutions (Pareto front)

9.5.7.4.1 Initial

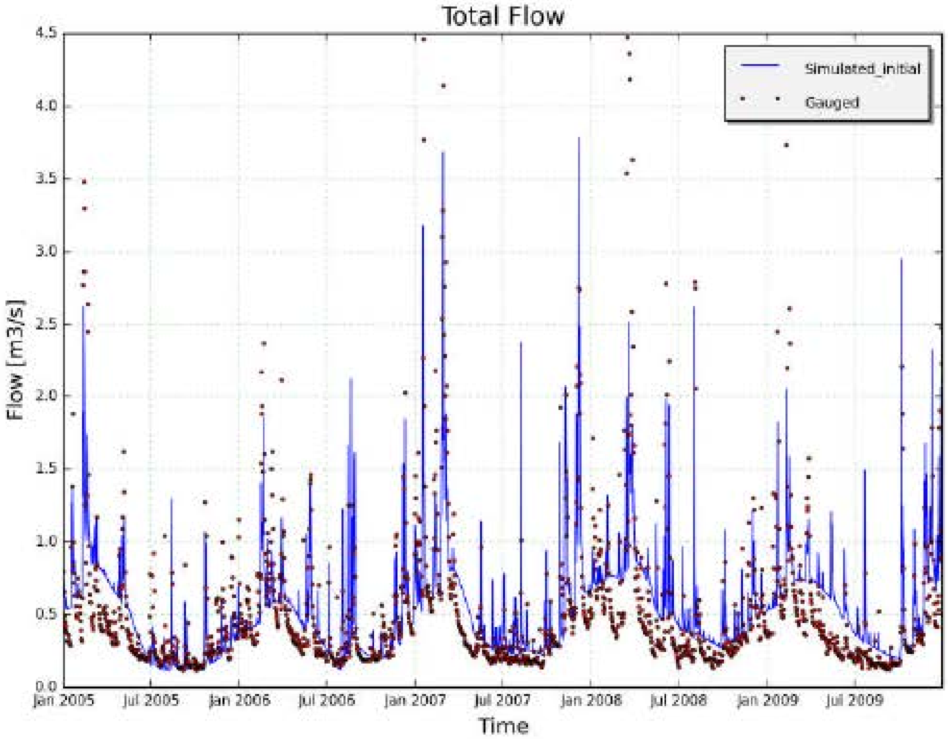


Figure 5: Total flow with initial parameters

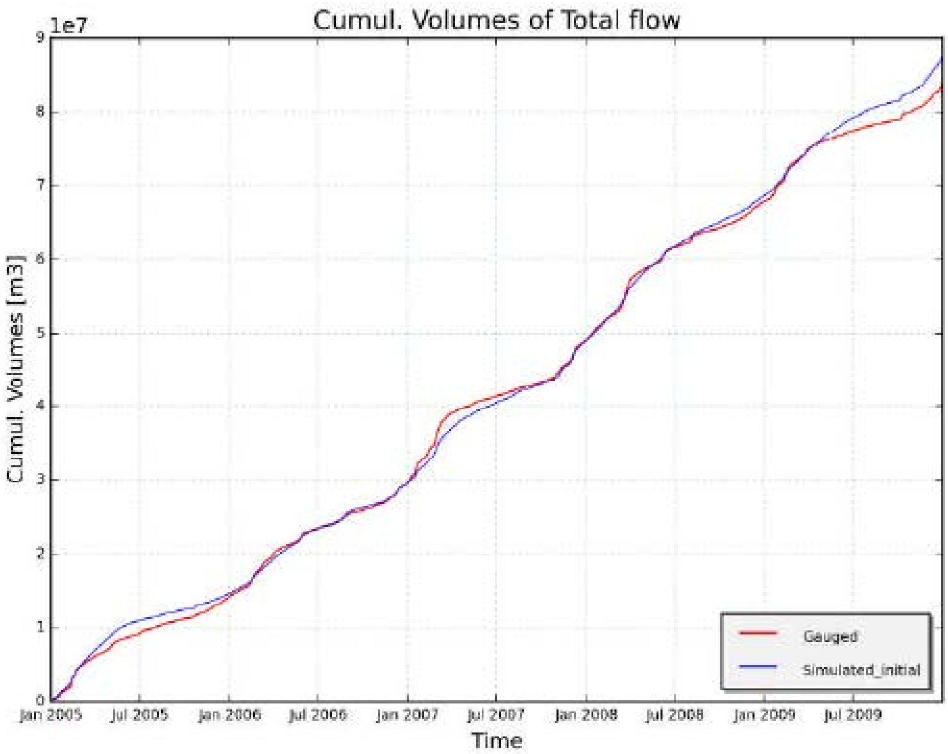


Figure 6: Cumulated flow with initial parameters

9.5.7.4.2 Optimum (euclidian)

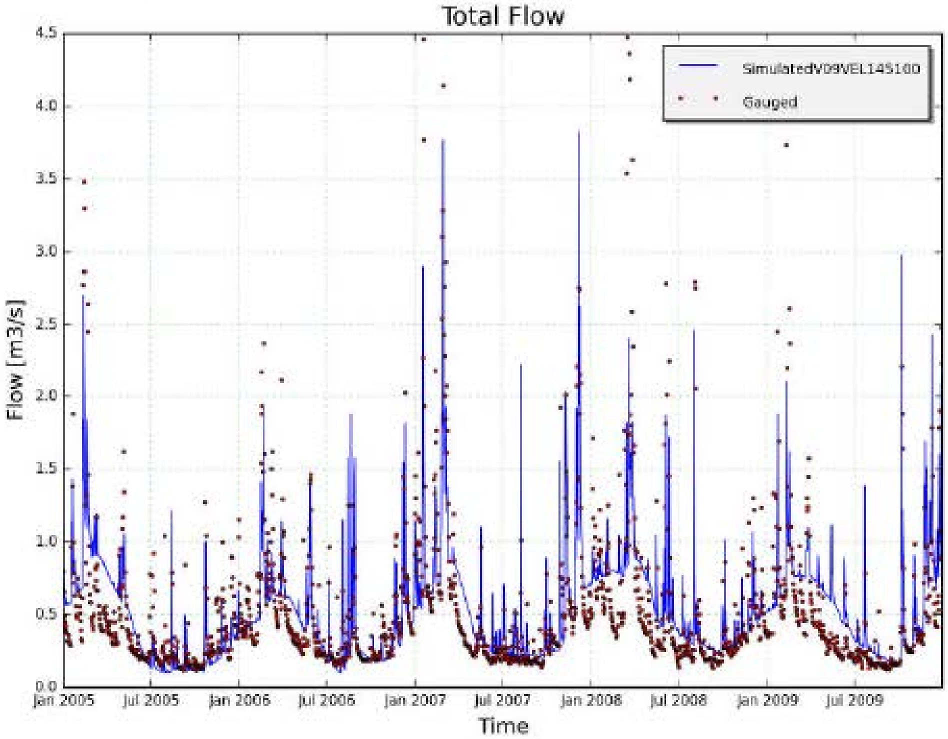


Figure 7: Total flow with optimum parameters

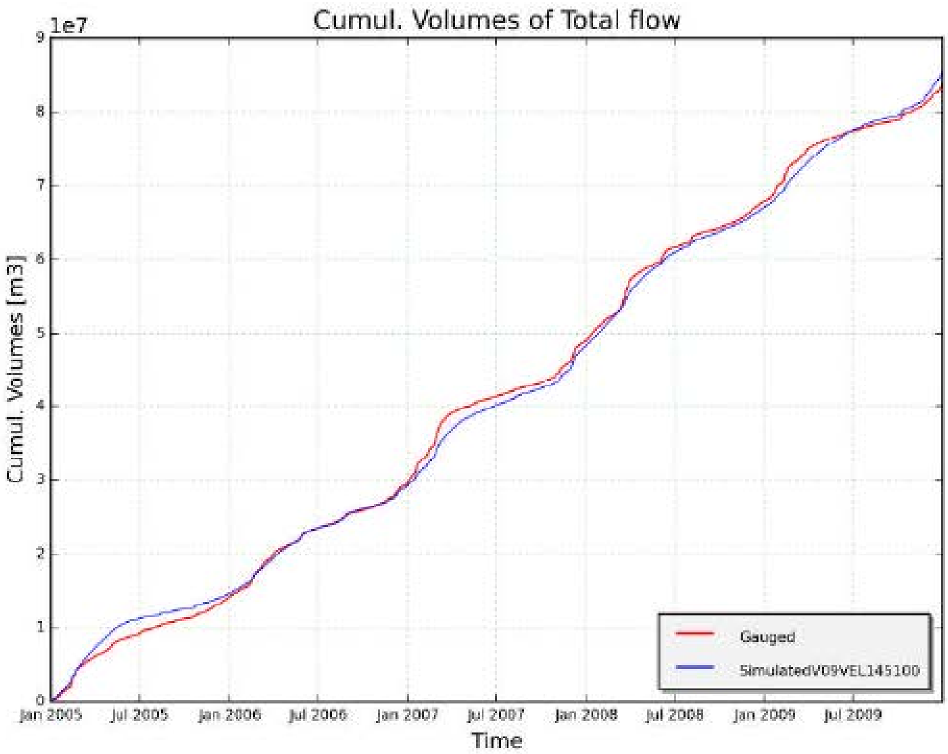


Figure 8: Cumulated flow with optimum parameters

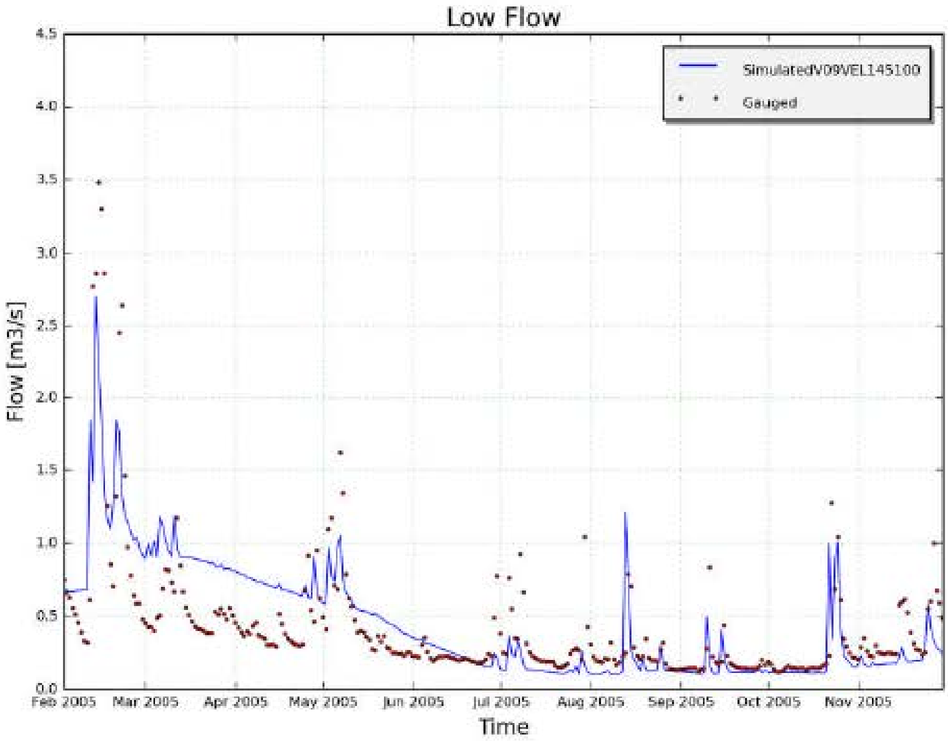


Figure 9: Total flow with optimum parameters (detail)

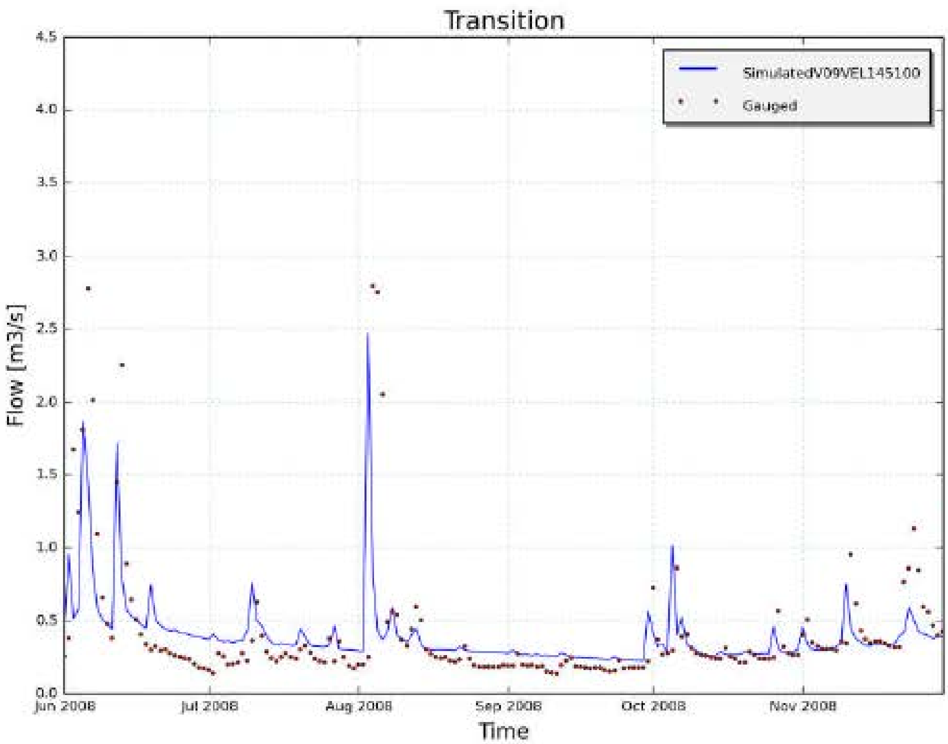
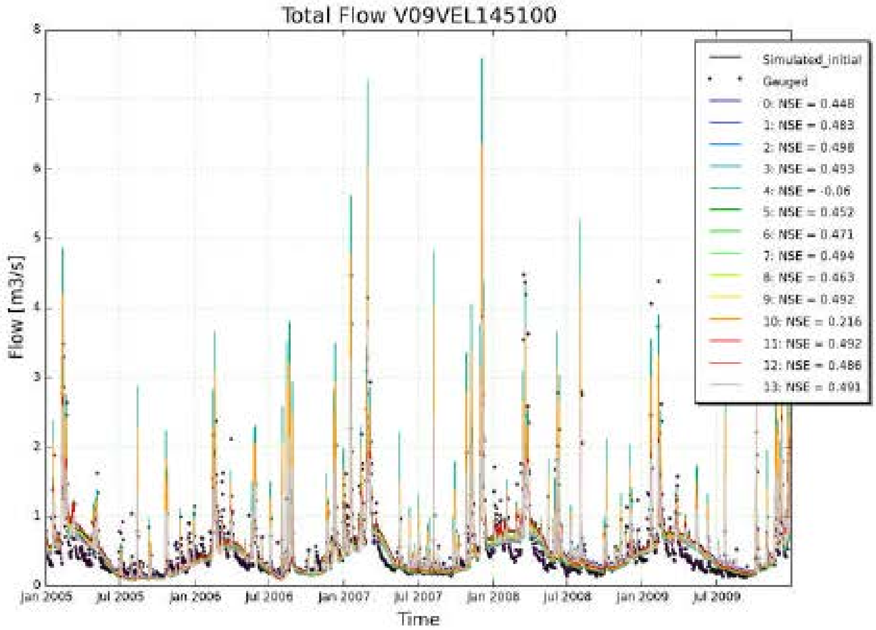
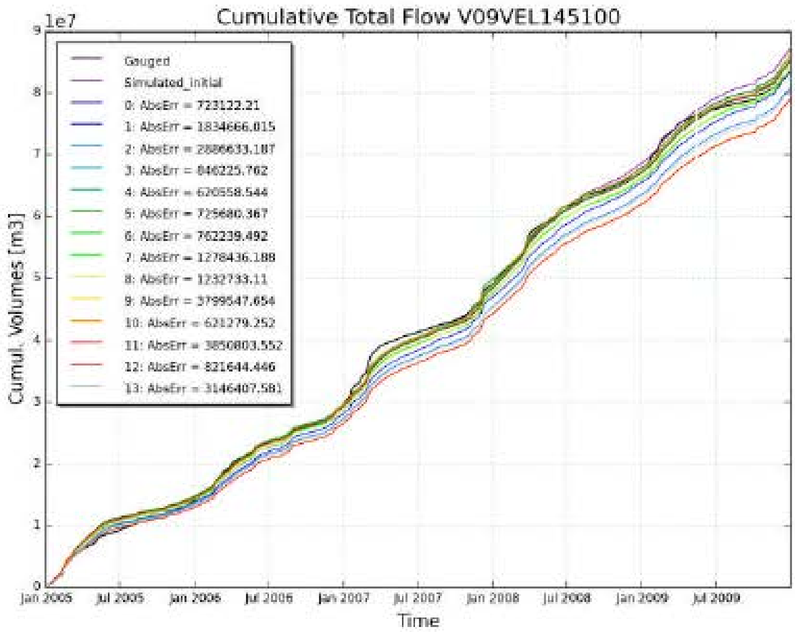


Figure 10: Total flow with optimum parameters (detail)

9.5.7.4.3 Final archive

0 : [1.58, 20.087, 0.003, 0.87, 133.832, 228.968, 6.303, 302.704] : [723122.21, 0.545]
1 : [1.329, 19.182, 0.002, 1.036, 98.128, 230.943, 7.731, 311.642] : [1834666.015, 0.578]
2 : [1.322, 14.936, 0.002, 0.832, 90.023, 202.761, 8.0, 299.813] : [2886633.187, 0.589]
3 : [1.58, 18.568, 0.003, 2.053, 133.905, 228.748, 7.9, 304.105] : [846225.762, 0.562]
4 : [1.5, 55.041, 0.002, 0.832, 96.13, 202.253, 7.741, 303.39] : [620558.544, 0.451]
5 : [1.58, 20.031, 0.003, 1.549, 133.269, 228.913, 6.42, 303.064] : [725680.367, 0.547]
6 : [1.58, 18.975, 0.003, 2.013, 134.055, 228.876, 6.855, 304.191] : [762239.492, 0.554]
7 : [1.558, 17.153, 0.002, 1.177, 96.723, 222.105, 7.828, 298.113] : [1278436.188, 0.565]
8 : [1.45, 18.877, 0.002, 1.536, 134.051, 229.914, 6.698, 305.268] : [1232733.11, 0.565]
9 : [1.324, 17.345, 0.002, 1.978, 93.173, 215.89, 8.0, 308.154] : [3799547.654, 0.598]
10 : [1.57, 41.262, 0.002, 1.217, 115.317, 220.308, 7.073, 303.375] : [621279.252, 0.51]
11 : [1.324, 17.327, 0.002, 2.07, 93.173, 215.484, 8.0, 308.154] : [3850803.552, 0.598]
12 : [1.567, 18.344, 0.003, 2.832, 118.82, 224.791, 7.475, 299.897] : [821644.446, 0.559]
13 : [1.321, 18.445, 0.002, 0.832, 92.145, 217.145, 8.0, 298.476] : [3146407.581, 0.595]





9.5.8 Report on simulation of catchment V09WIN141310 (2017-01-19 00-27)

9.5.8.1 Input data

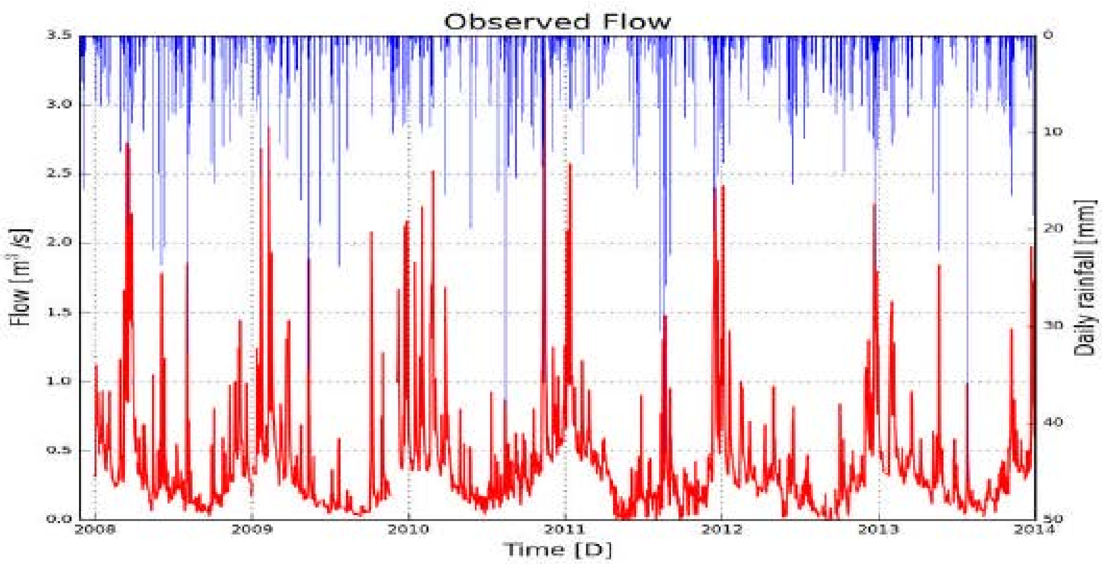


Figure 1: Hyetogram of observed discharge and observed net rain

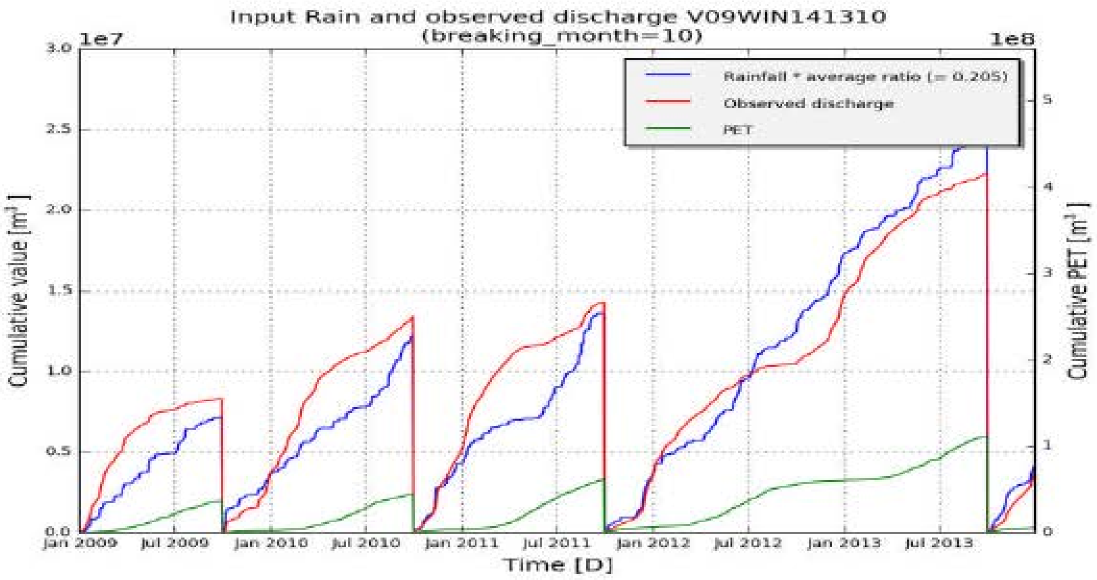


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.8.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V09WIN141310
subcatchment_area	80015463
start_date	200801010000
end_date	201312310000
frequency	86400
warmup	365

9.5.8.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[2.0, 20.0, 0.002, 1.0, 150.0, 250.0, 3.5, 120.0]
low_bounds	[1.6, 16.0, 0.0016, 0.8, 120.0, 180.0, 2.5, 90.0]
high_bounds	[2.5, 50.0, 0.01, 3.0, 250.0, 400.0, 5.0, 300.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 2.0), ('Ki', 20.0), ('Kg', 0.002), ('Kss', 1.0), ('g0', 150.0), ('g_max', 250.0), ('K_run', 3.5), ('P_max', 120.0)]
Initial fitness:

- RelErr: -0.028
- AbsErr: 1940610.402
- KGE: 0.565
- NS_rel: -21.615
- NS: 0.171
- RMSE: 2403123.452
- NS_log: 0.601

Computation time:6:30:27.107000

9.5.8.4 Results

Best individual (euclidian): [('Kep', 1.953), ('Ki', 17.546), ('Kg', 0.002), ('Kss', 0.8), ('g0', 163.65), ('g_max', 252.342), ('K_run', 3.443), ('P_max', 126.484)]

Fitness:

- RelErr: -0.035
- AbsErr: 1867329.508
- KGE: 0.612
- NS_rel: -24.215
- NS: 0.25
- RMSE: 2382280.219
- NS_log: 0.603

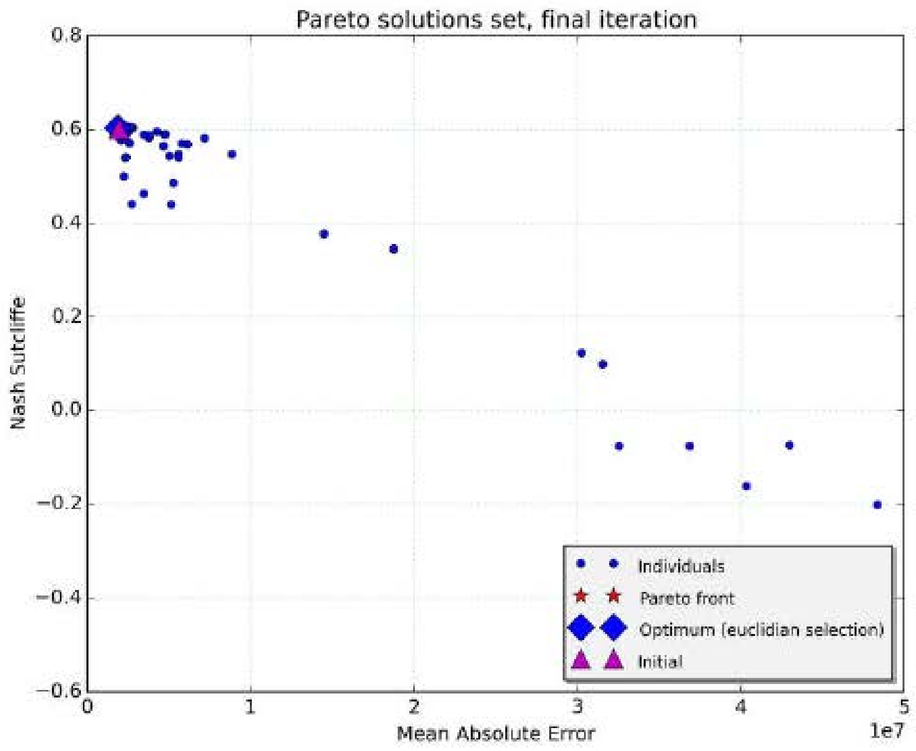


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

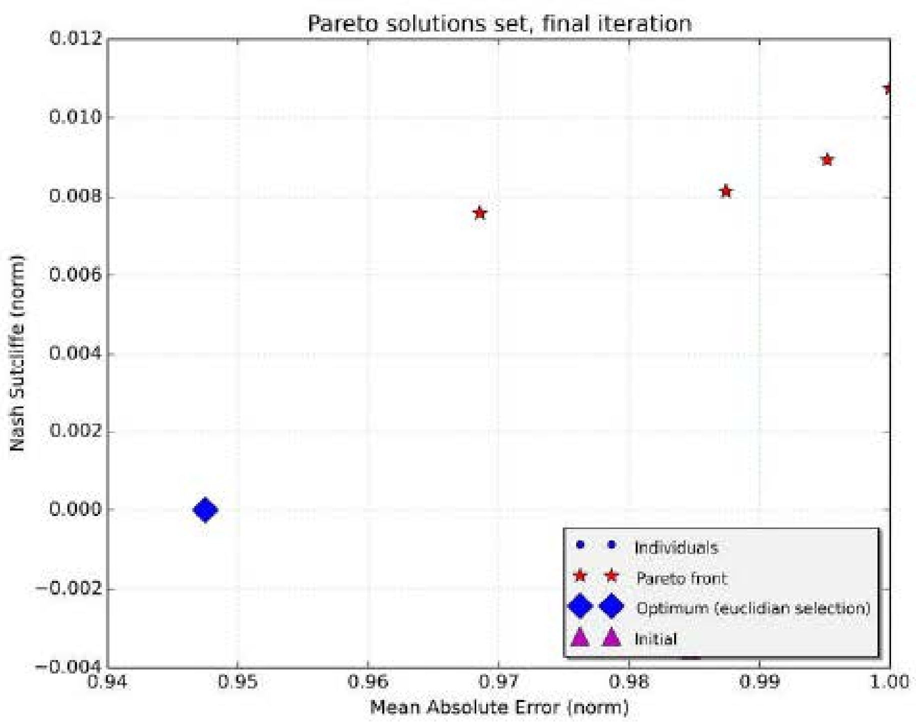


Figure 4: Final population of solutions (Pareto front)

9.5.8.4.1 Initial

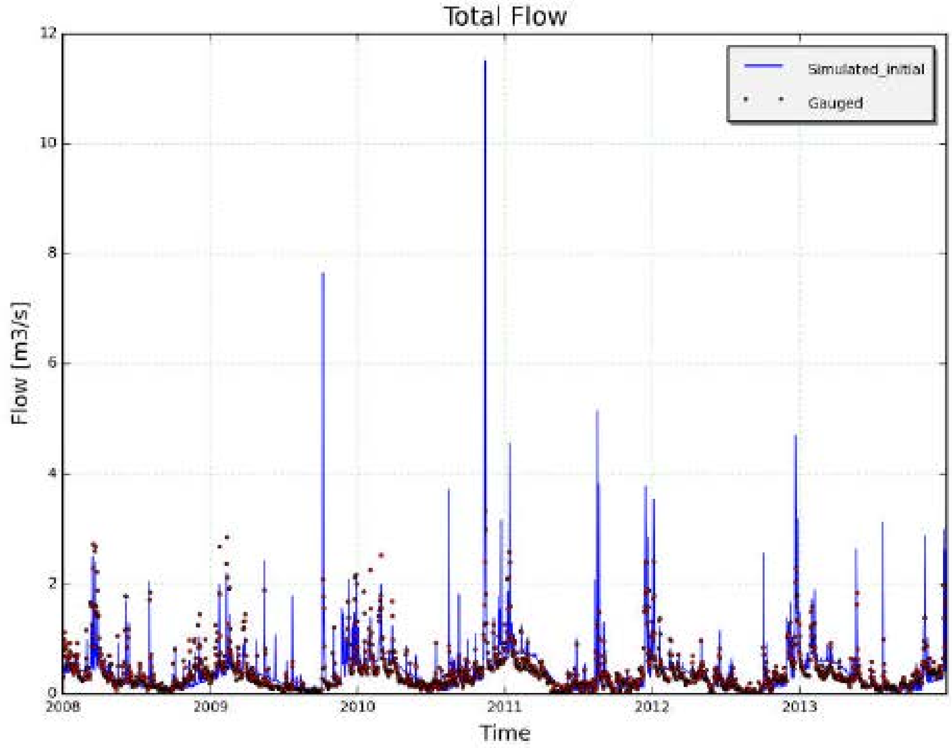


Figure 5: Total flow with initial parameters

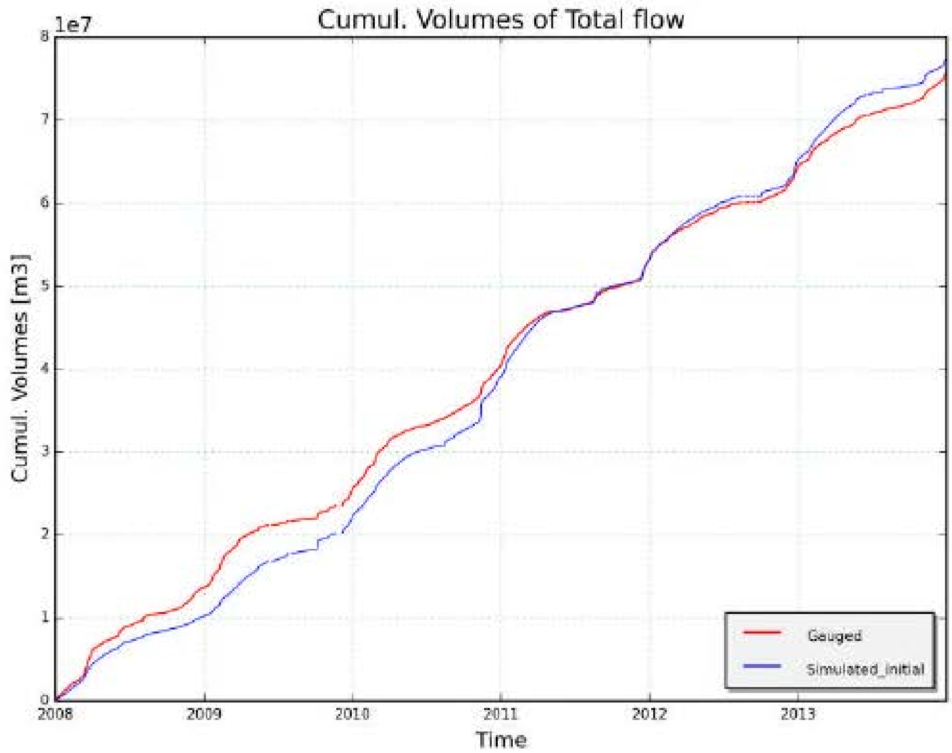


Figure 6: Cumulated flow with initial parameters

9.5.8.4.2 Optimum (euclidian)

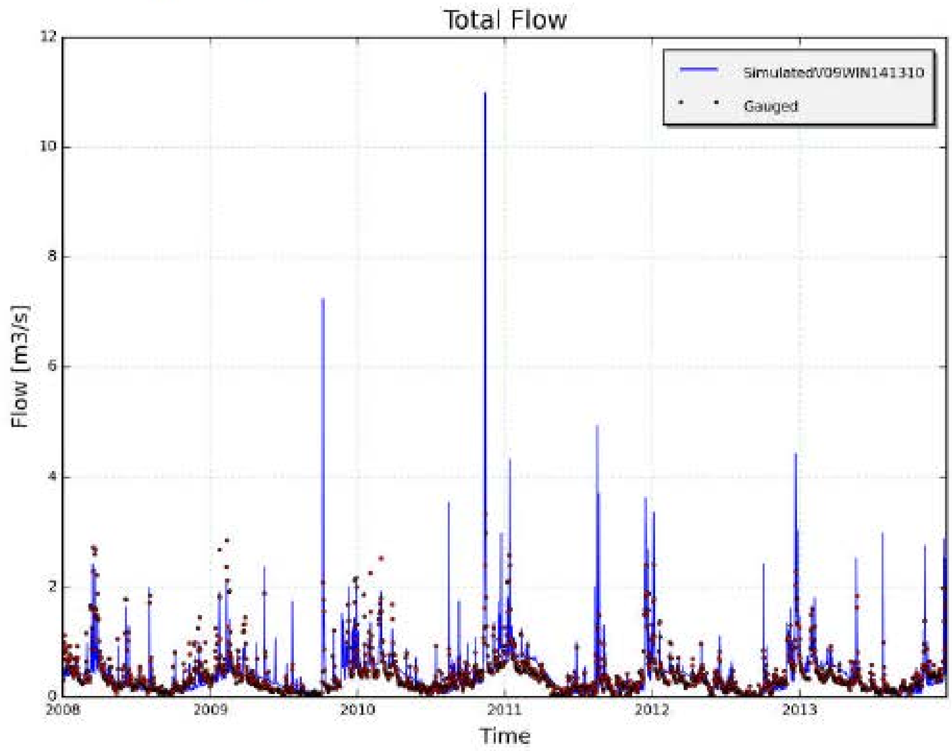


Figure 7: Total flow with optimum parameters

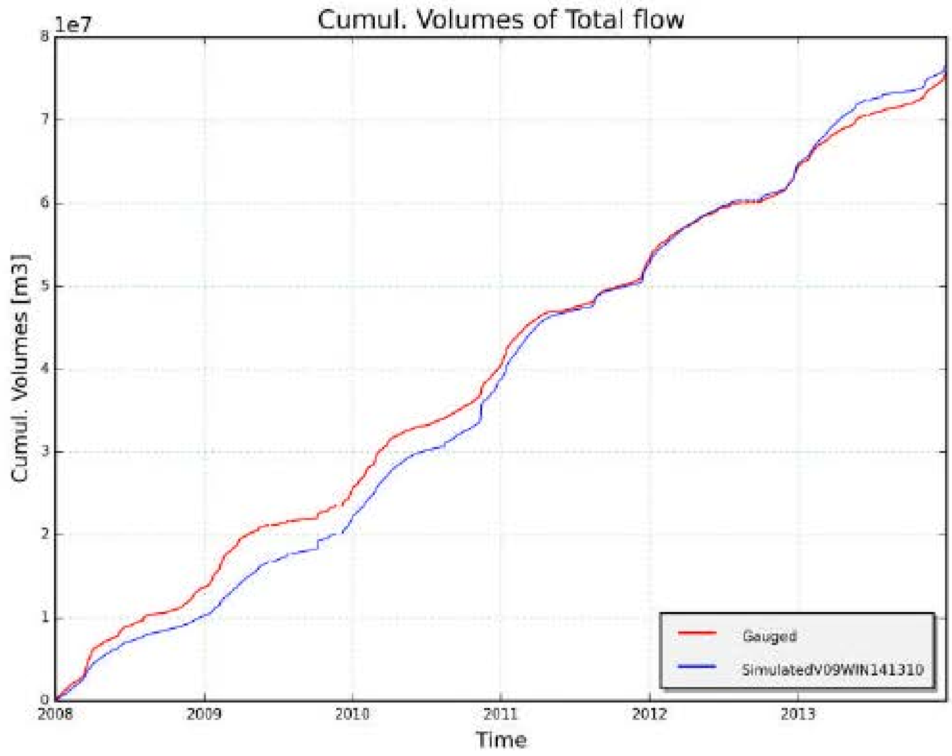


Figure 8: Cumulated flow with optimum parameters

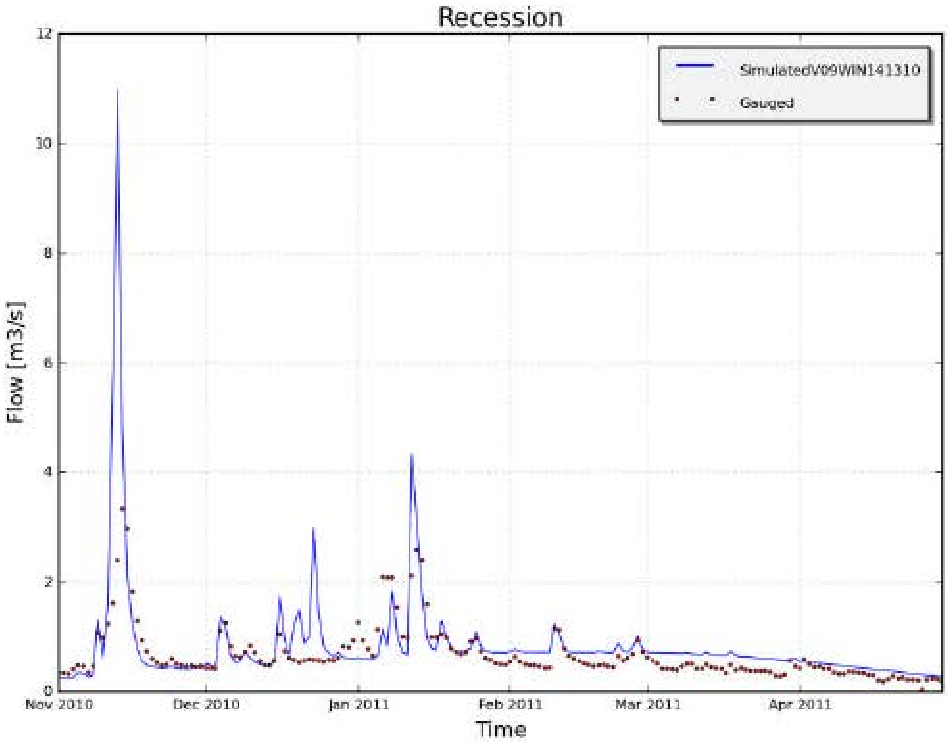


Figure 9: Total flow with optimum parameters (detail)

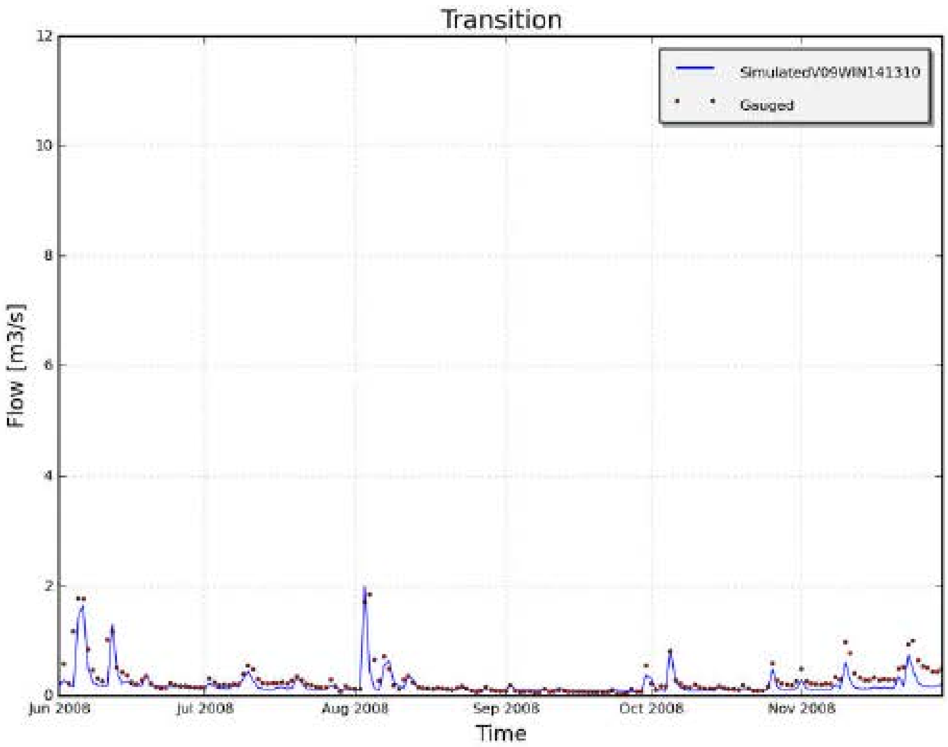
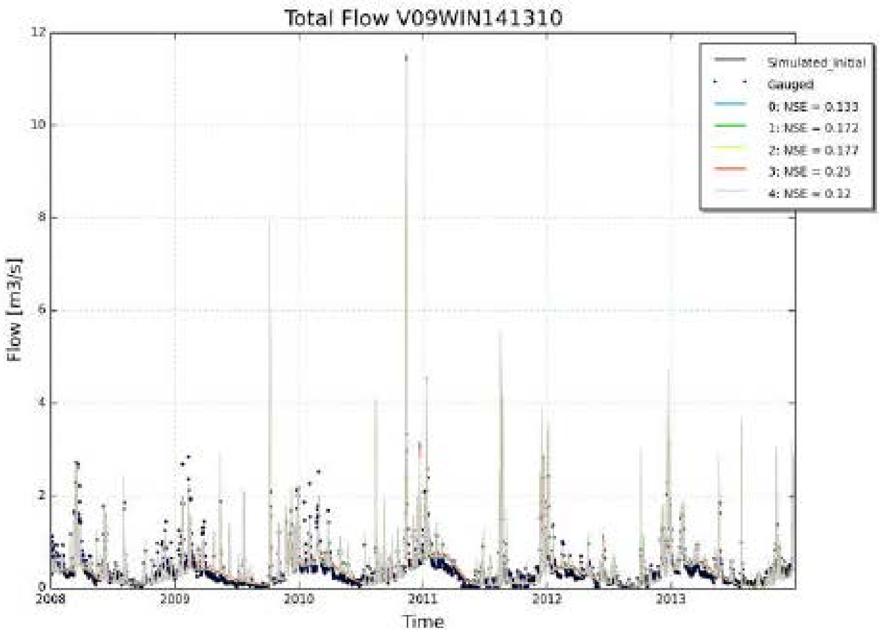
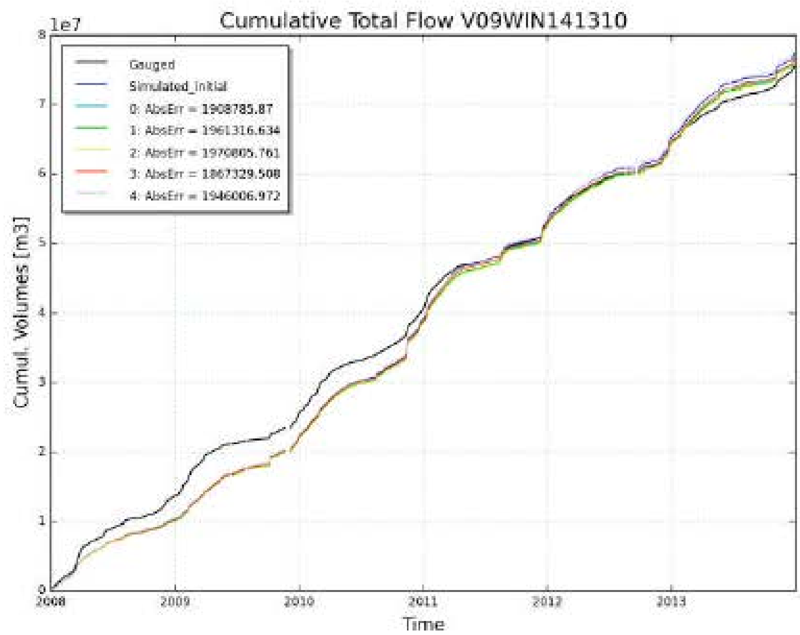


Figure 10: Total flow with optimum parameters (detail)

9.5.8.4.3 Final archive

0 : [1.98, 17.392, 0.002, 1.369, 167.073, 255.489, 2.782, 126.412] : [1908785.87, 0.606]
1 : [1.996, 18.217, 0.002, 1.058, 148.46, 249.767, 3.108, 122.202] : [1961316.634, 0.606]
2 : [1.985, 16.9, 0.002, 1.179, 158.926, 249.601, 2.876, 127.684] : [1970805.761, 0.607]
3 : [1.953, 17.546, 0.002, 0.8, 163.65, 252.342, 3.443, 126.484] : [1867329.508, 0.603]
4 : [1.979, 17.344, 0.002, 2.574, 163.288, 252.674, 2.741, 124.292] : [1946006.972, 0.606]





9.5.9 Report on simulation of catchment V09ZWA148120 (2017-01-25 00-23)

9.5.9.1 Input data

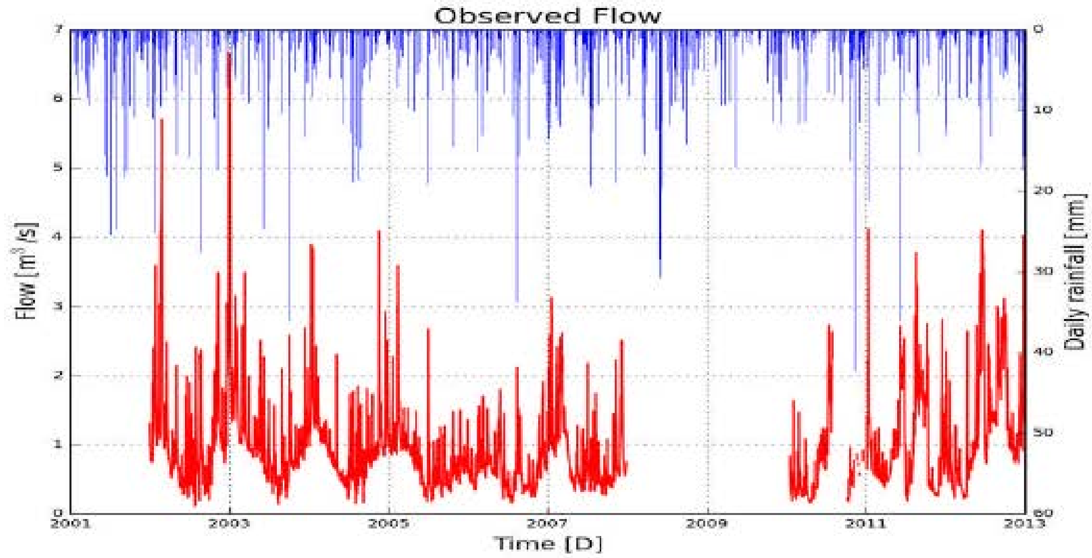


Figure 1: Hyetogram of observed discharge and observed net rain

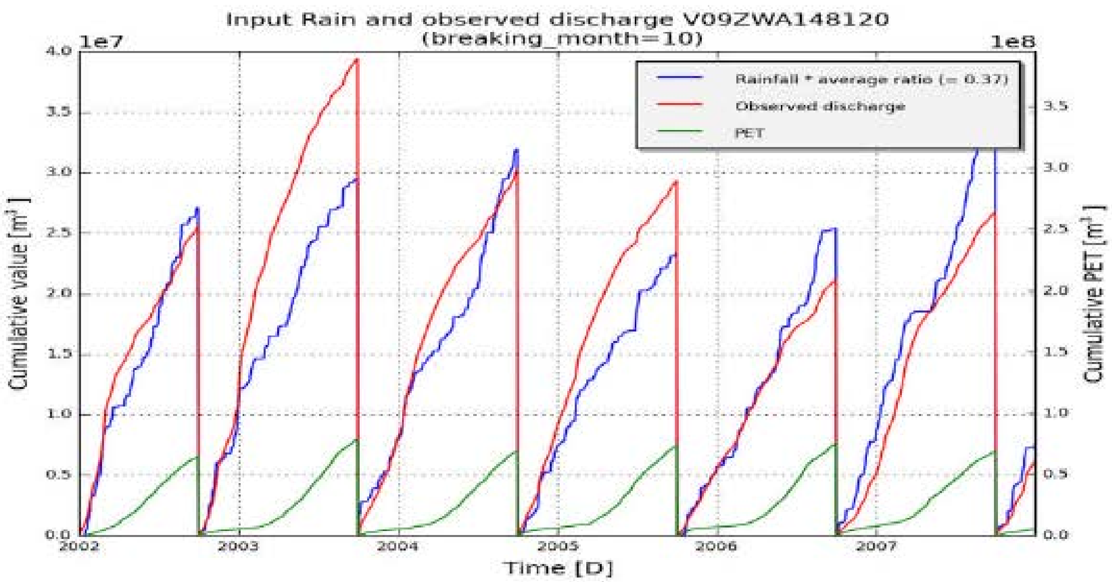


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.9.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	V09ZWA148120
subcatchment_area	96200000
start_date	200201010000
end_date	200712310000
frequency	86400
warmup	365

9.5.9.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.7, 25.0, 0.01, 1.05, 150.0, 500.0, 0.5, 20.0]
low_bounds	[1.0, 10.0, 0.0009, 0.63, 50.0, 100.0, 0.3, 12.0]
high_bounds	[2.5, 100.0, 0.1, 3.0, 230.0, 600.0, 2.0, 300.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.7), ('Ki', 25.0), ('Kg', 0.01), ('Kss', 1.05), ('g0', 150.0), ('g_max', 500.0), ('K_run', 0.5), ('P_max', 20.0)]
Initial fitness:

- RelErr: 0.14
- AbsErr: 13869448.797
- KGE: 0.71
- NS_rel: 0.406
- NS: 0.507
- RMSE: 15040665.165
- NS_log: 0.394

Computation time:10:08:37.678000

9.5.9.4 Results

Best individual (euclidian):
[('Kep', 1.85), ('Ki', 30.931), ('Kg', 0.009), ('Kss', 0.63), ('g0', 152.772), ('g_max', 489.955), ('K_run', 1.09), ('P_max', 68.656)]

Fitness:

- RelErr: 0.036
- AbsErr: 3659931.354
- KGE: 0.768
- NS_rel: 0.554
- NS: 0.556
- RMSE: 4438367.733
- NS_log: 0.396

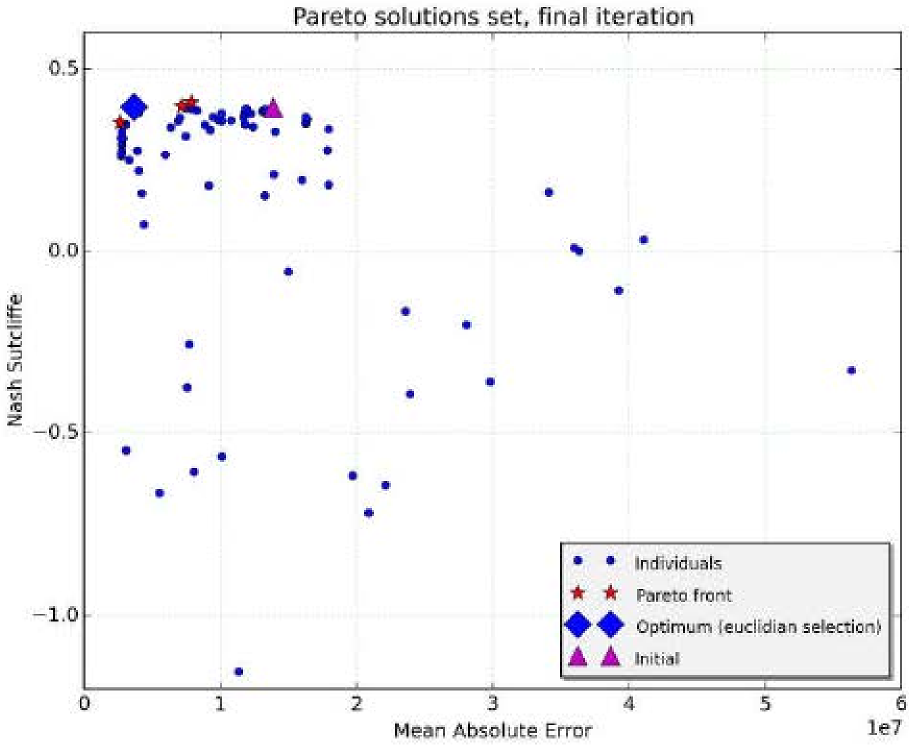


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

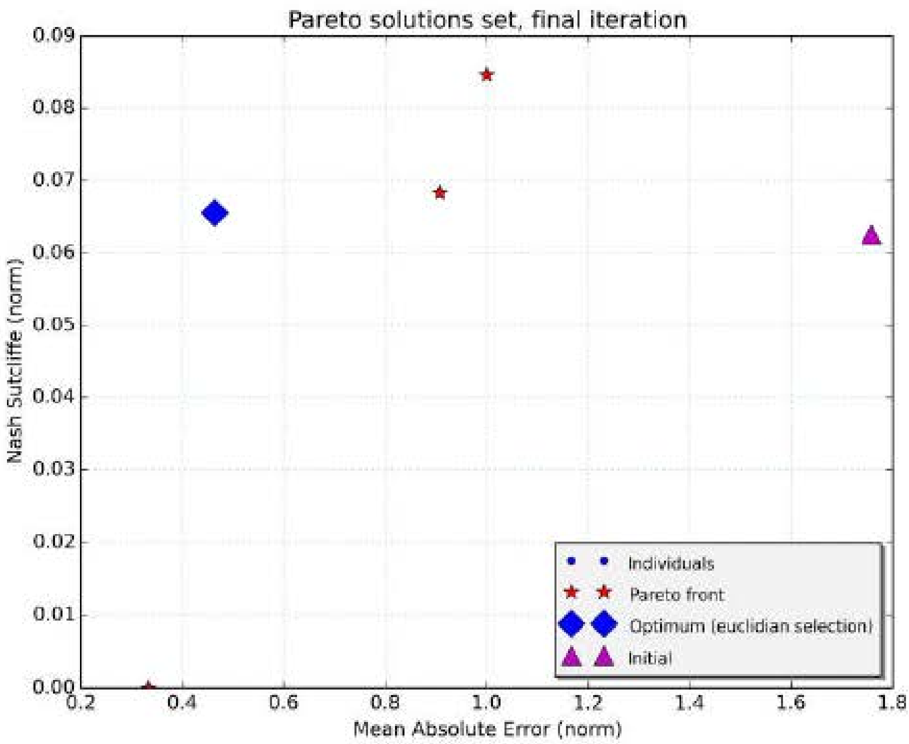


Figure 4: Final population of solutions (Pareto front)

9.5.9.4.1 Initial

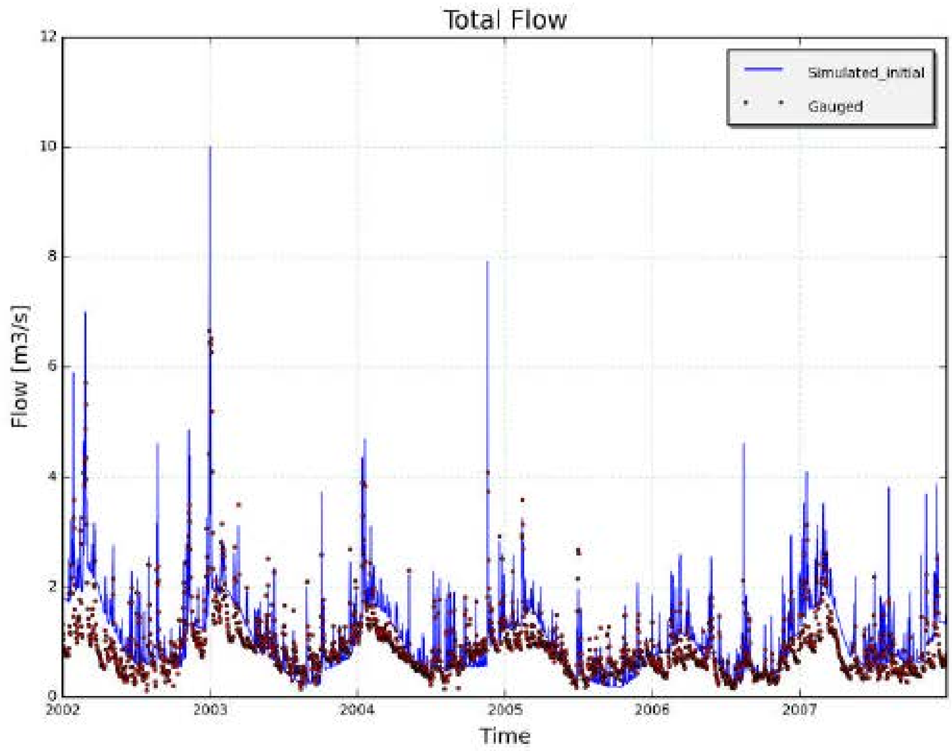


Figure 5: Total flow with initial parameters

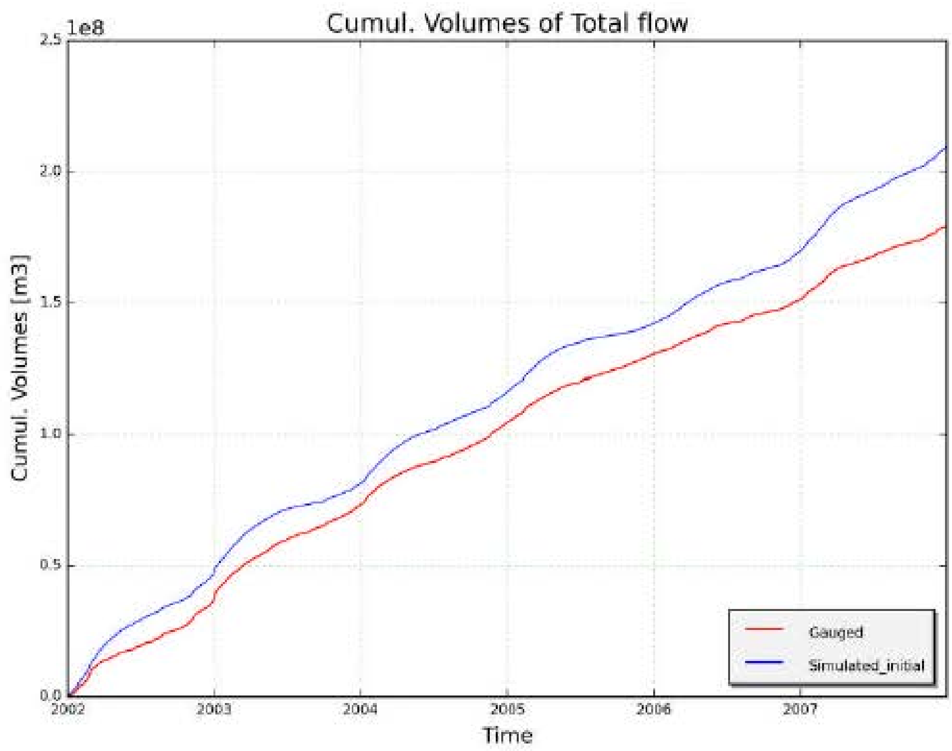


Figure 6: Cumulated flow with initial parameters

9.5.9.4.2 Optimum (euclidian)

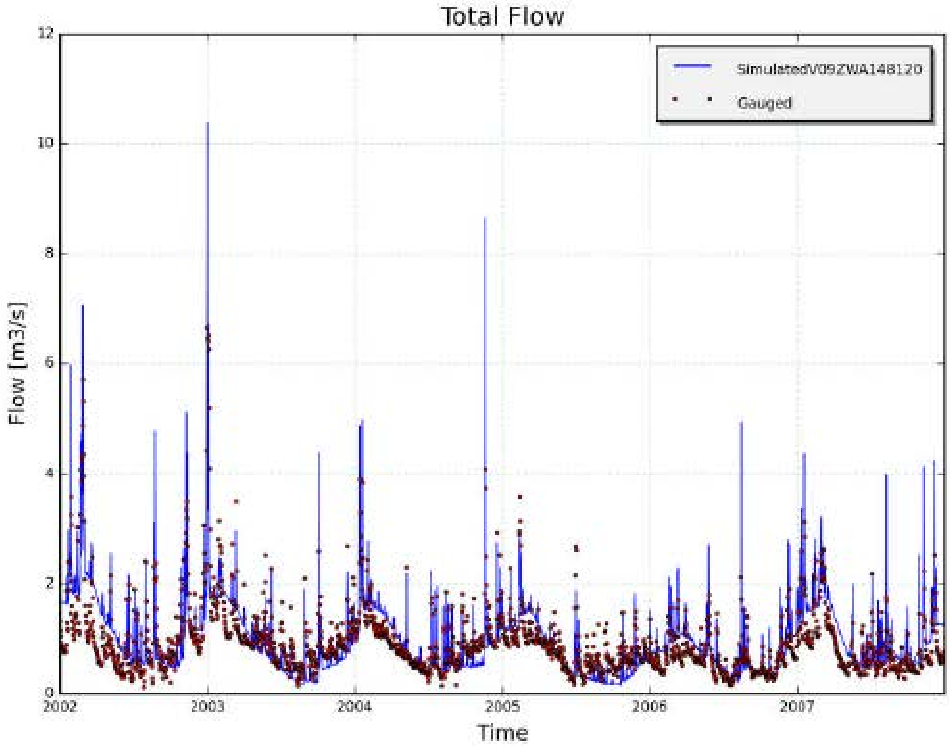


Figure 7: Total flow with optimum parameters

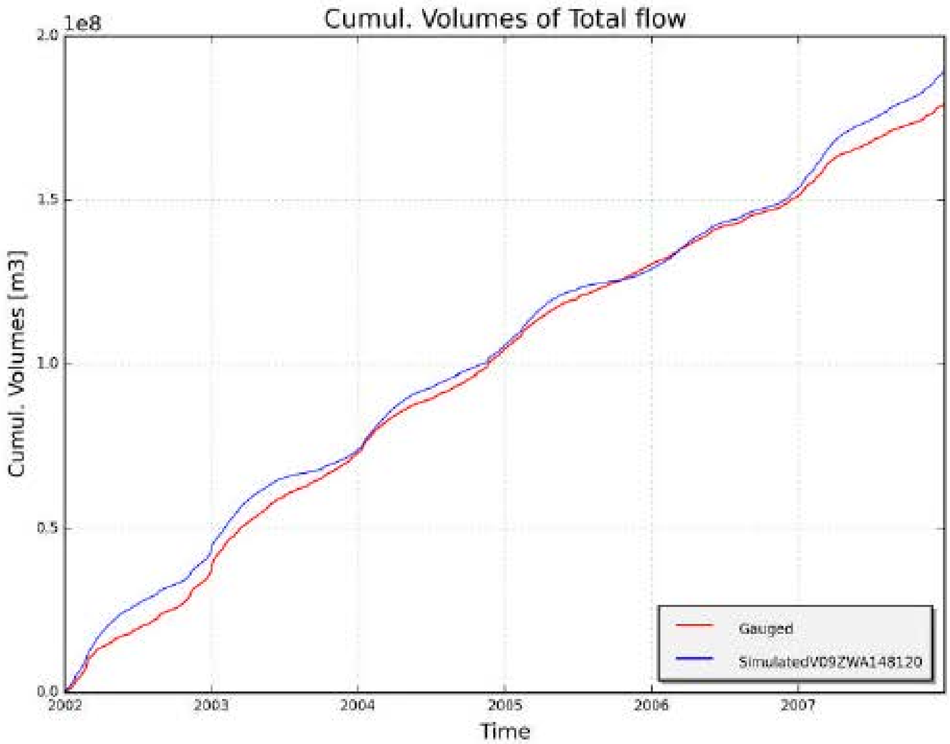


Figure 8: Cumulated flow with optimum parameters

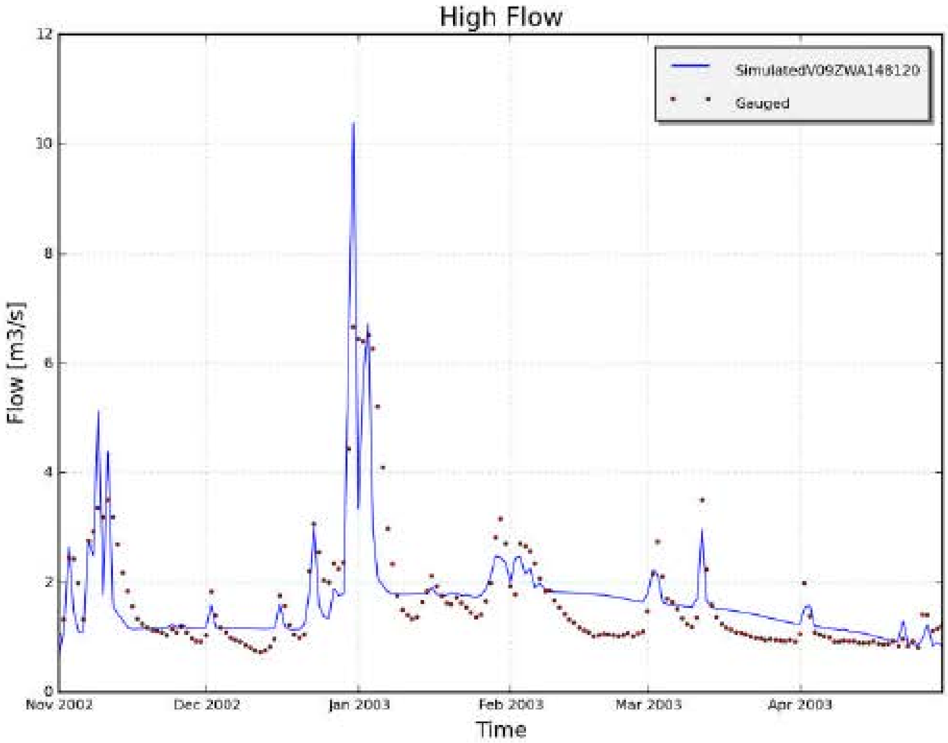


Figure 9: Total flow with optimum parameters (detail)

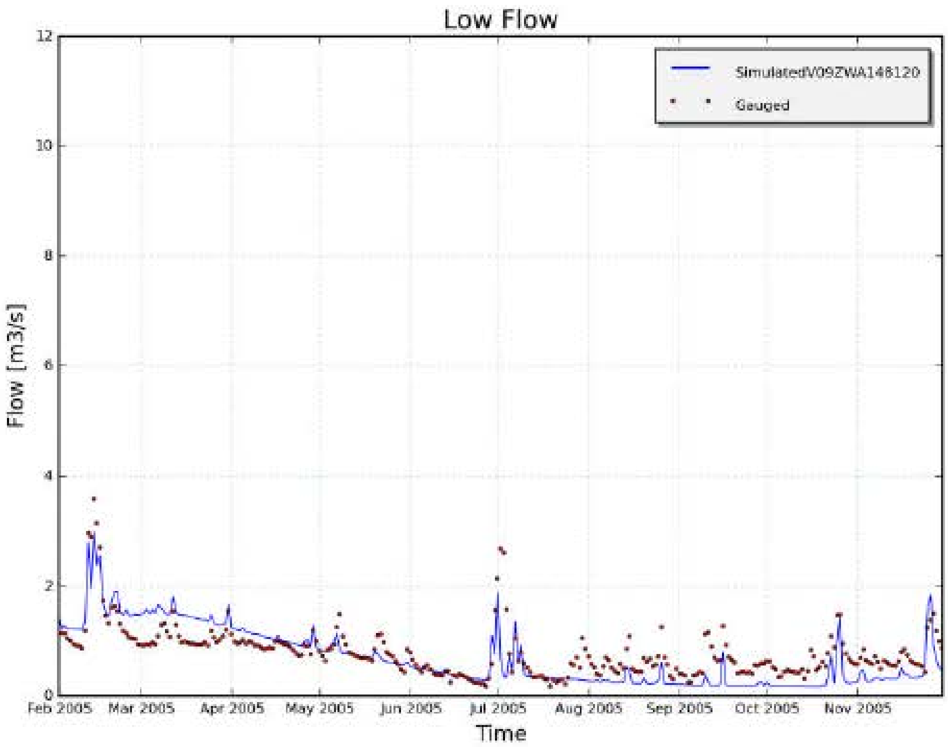
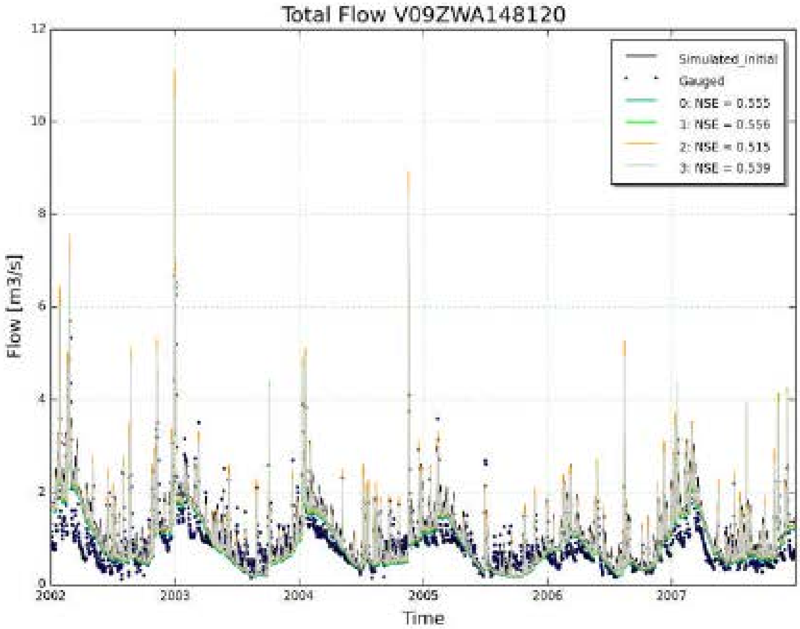
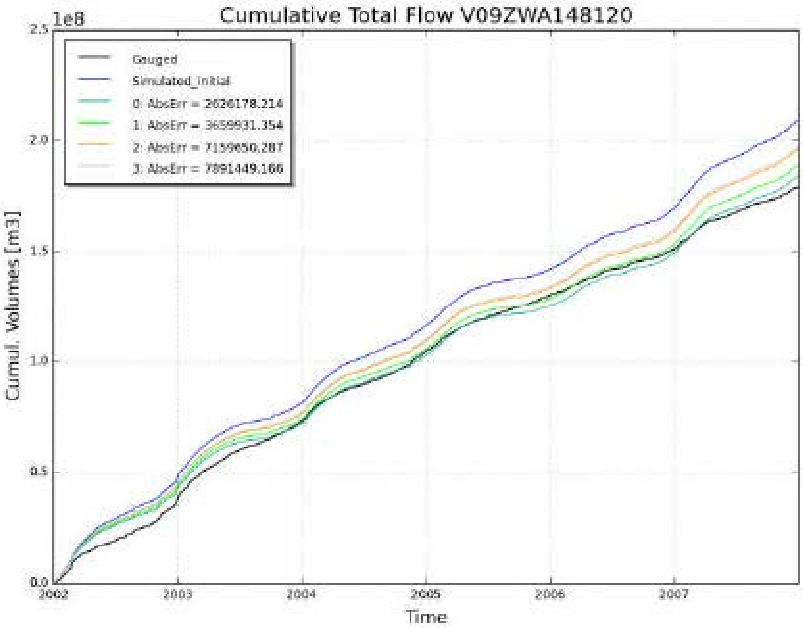


Figure 10: Total flow with optimum parameters (detail)

9.5.9.4.3 Final archive

0 : [1.924, 31.558, 0.009, 0.655, 146.874, 469.186, 0.855, 69.454] : [2626178.214, 0.354]
1 : [1.85, 30.931, 0.009, 0.63, 152.772, 489.955, 1.09, 68.656] : [3659931.354, 0.396]
2 : [1.821, 31.431, 0.009, 1.212, 146.686, 493.09, 0.823, 74.403] : [7159650.287, 0.398]
3 : [1.796, 29.13, 0.009, 1.172, 153.455, 500.287, 0.813, 13.631] : [7891449.166, 0.408]





Appendix 20 Nete Calibration and Validation.

9.5.1 Calibration and validation of WET parameters for catchment "V10GNE076999" (Nete)

9.5.1.1 Input data

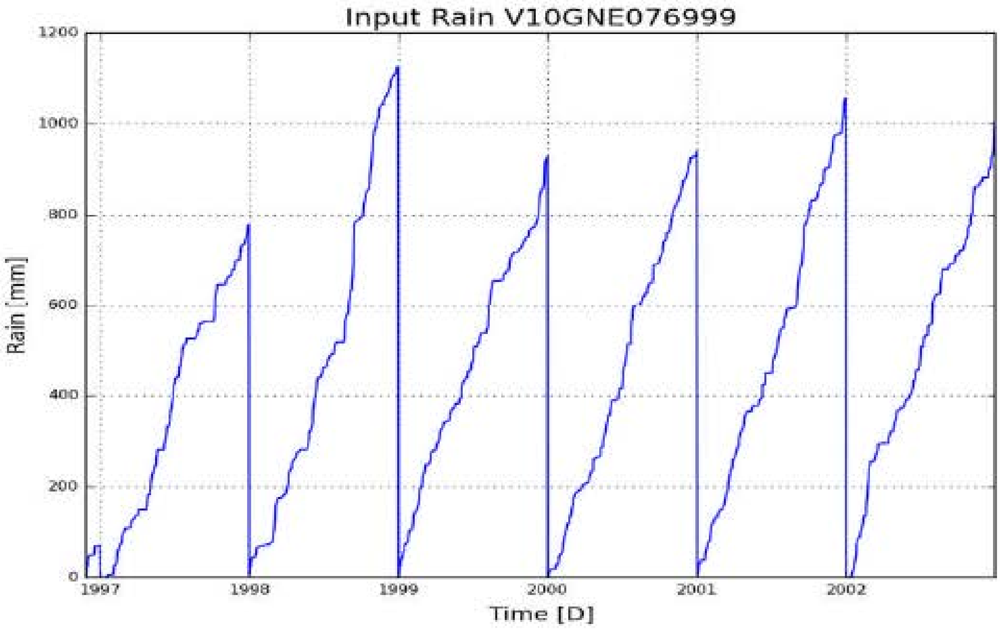


Figure 1: Cumulative precipitation on catchment V10GNE076999 (Nete)

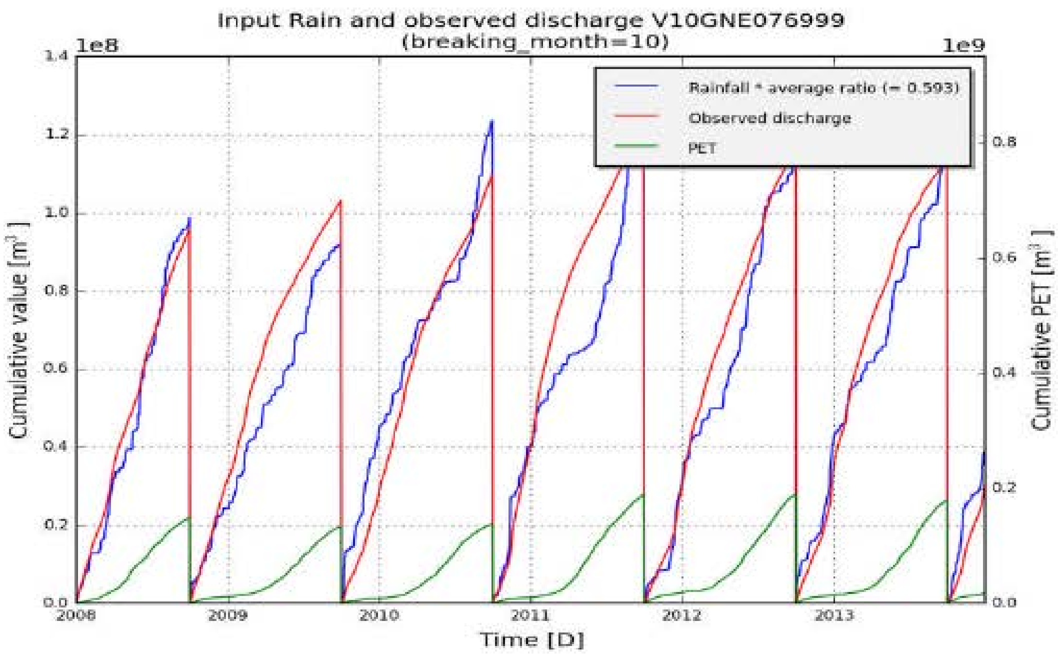


Figure 2 Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V10GNE076999 (Nete)

9.5.1.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V10GNE076999
subcatchment_area [m2]	243500000
Validation start_date	01-01-1997
Validation end_date	31-12-2002
frequency	daily

Optimal parameter set:[('Kep', 1.3), ('Ki', 19.28), ('Kg', 0.0), ('Kss', 2.32), ('g0', 159.75), ('g_max', 470.2), ('K_run', 1.35), ('P_max', 128.7)]

Table 1: Goodness of fit for calibration period (2008 - 2013)

	Full year	Summer	Winter
RelErr	-0.6 %	-0.8 %	-3.1 %
NS	0.255	-0.59	0.36
NS_log	0.449	0.149	0.329
NS_rel	0.598	0.21	0.62
KGE	0.654	0.286	0.571

Table 2 :Goodness of fit for validation period (1997 - 2002)

	Full year	Summer	Winter
RelErr	-8.0 %	6.3 %	-13.6 %
NS	0.32	-0.367	0.354
NS_log	0.541	0.45	0.422
NS_rel	0.544	0.587	0.503
KGE	0.626	0.403	0.644

9.5.1.3 Observed and simulated timeseries for optimum parameters

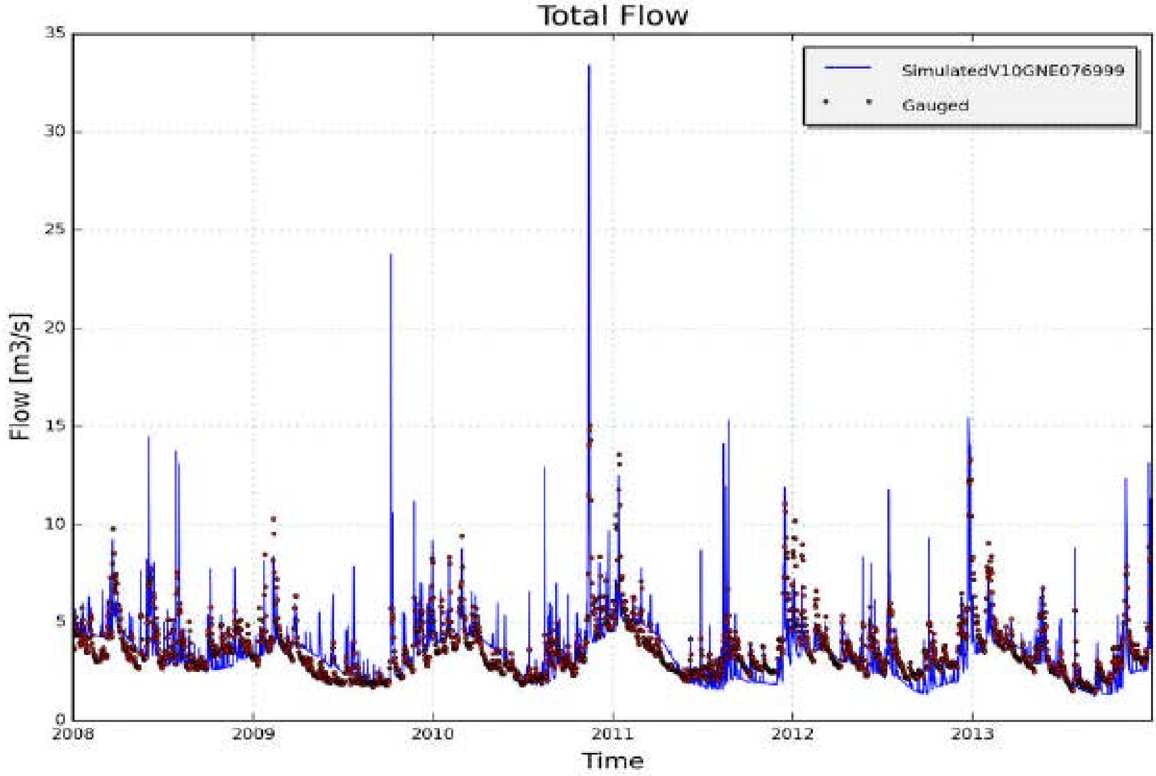


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel(calibration period)

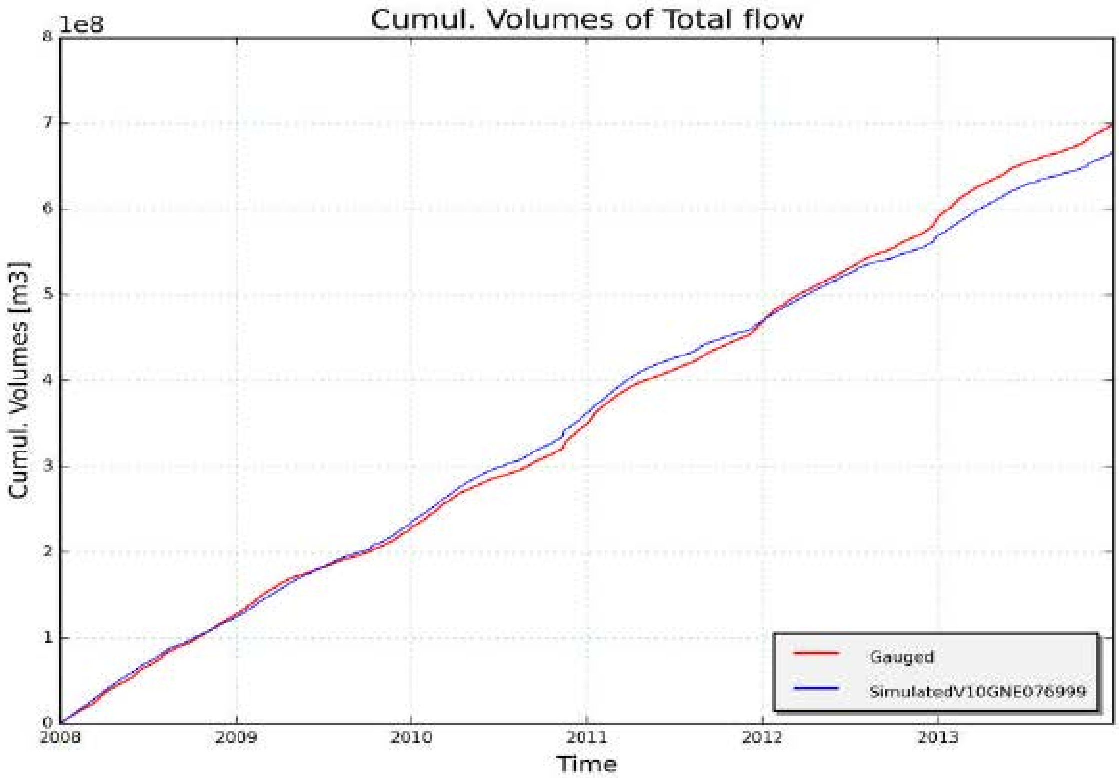


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel (calibration period)

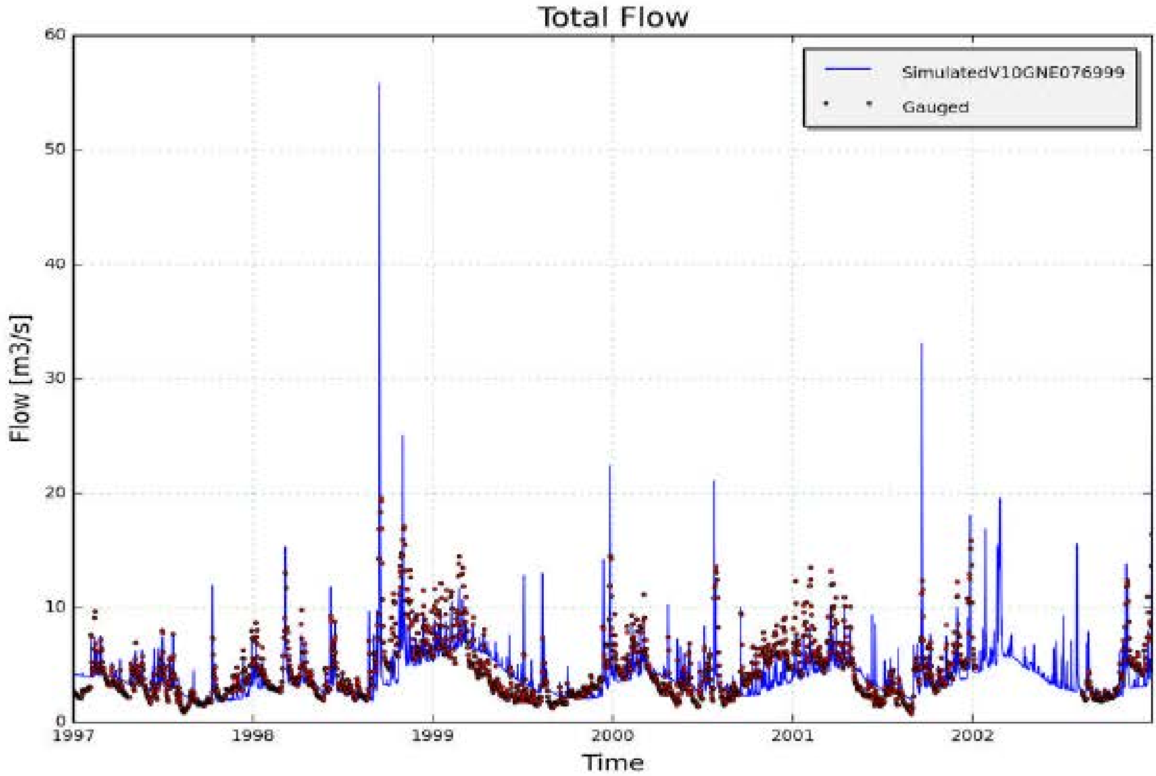


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel (validation period)

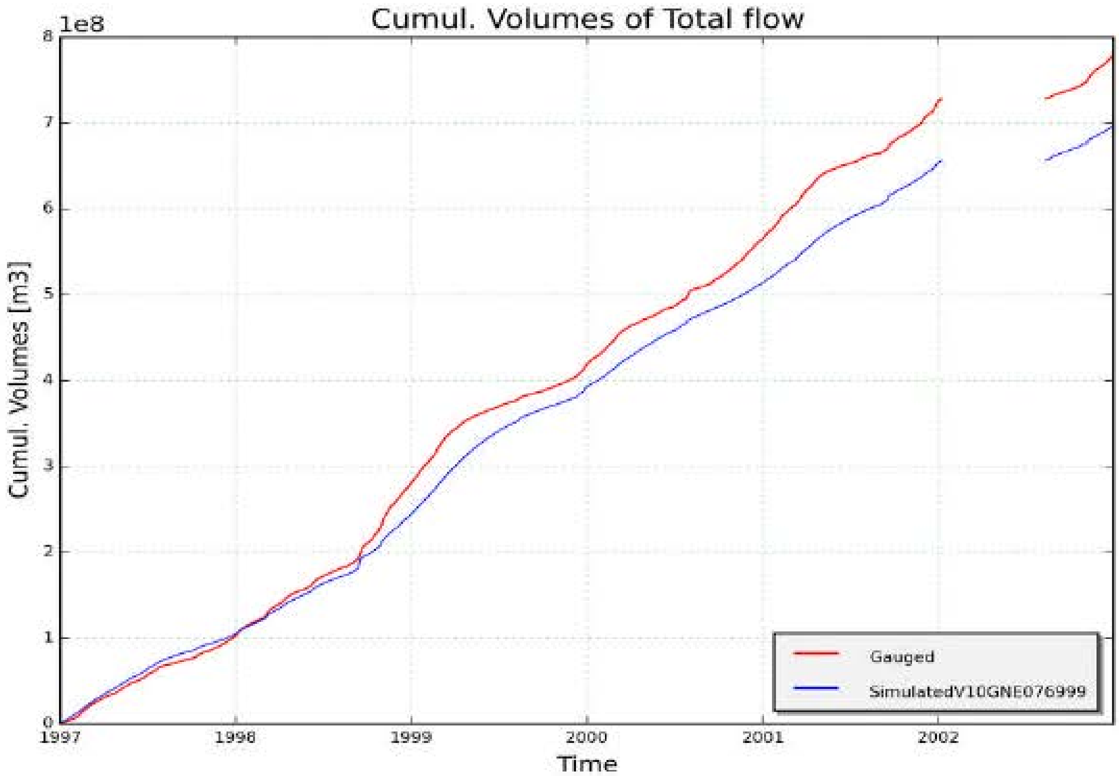


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel (validation period)

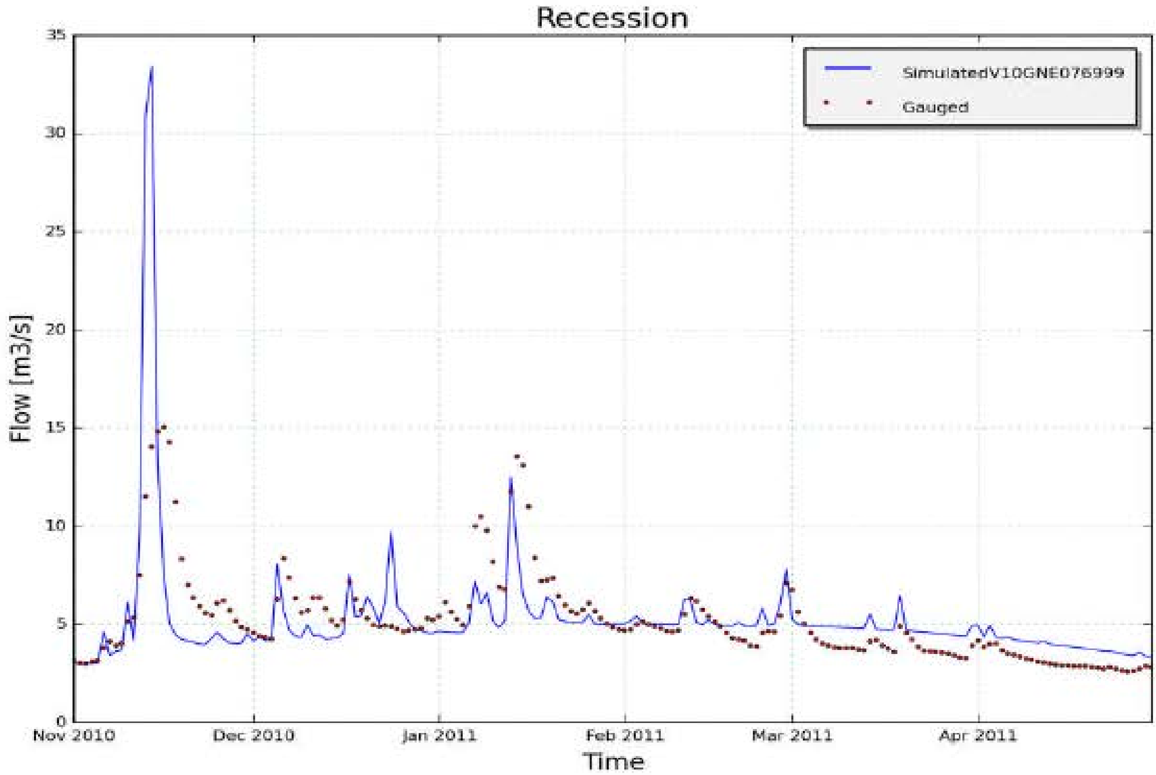


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel

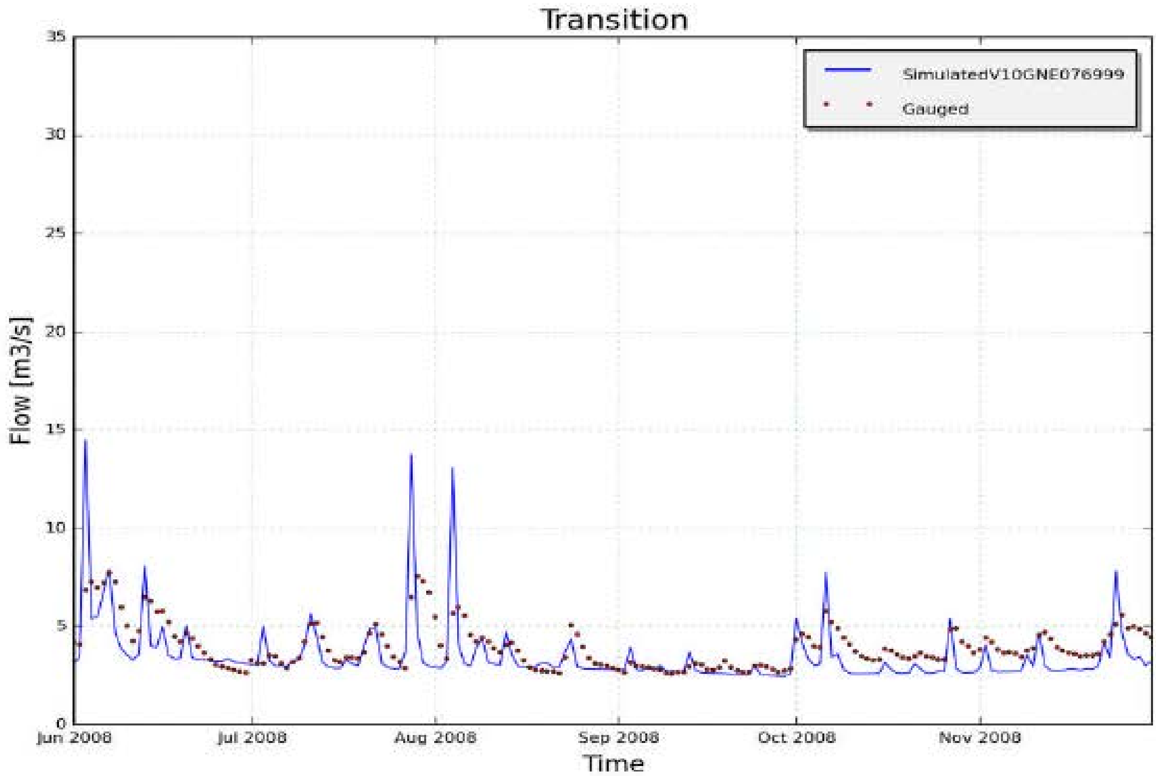


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel

9.5.1.4 Input data

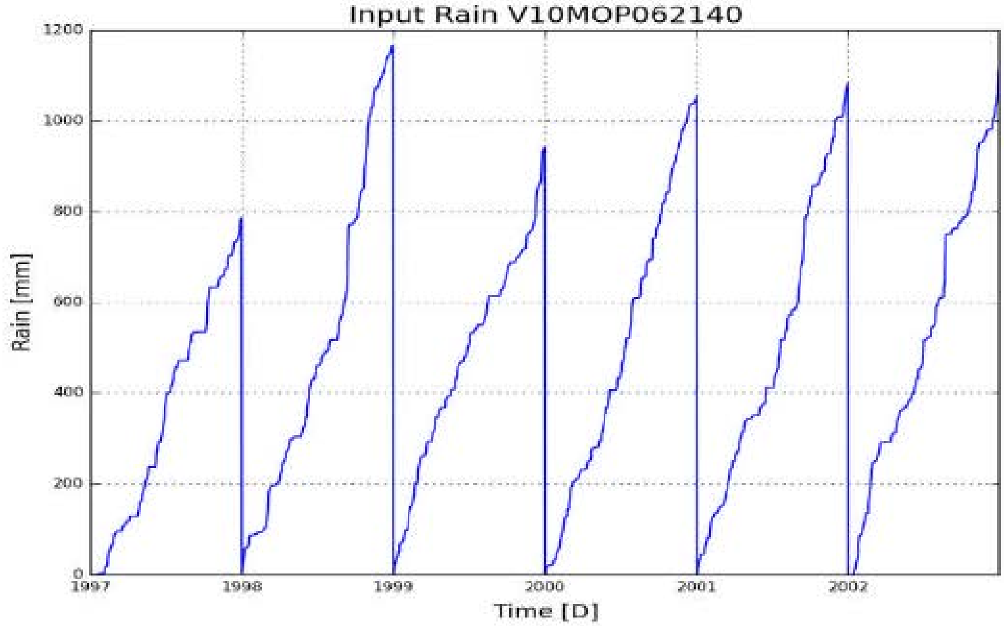


Figure 1: Cumulative precipitation on catchment V10MOP062140 (Nete)

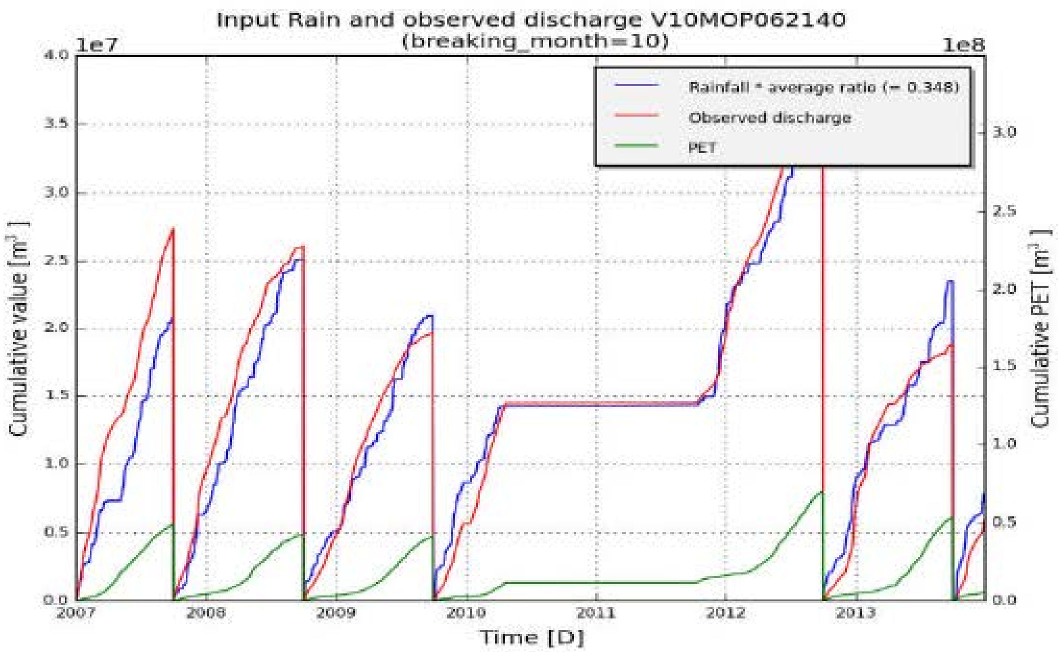


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V10MOP062140 (Nete)

9.5.1.5 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V10MOP062140

subcatchment_area [m2]	77319091
Validation start_date	01-01-1998
Validation end_date	31-12-2002
frequency	daily

Optimal parameter set:[('Kep', 2.32), ('Ki', 127.98), ('Kg', 0.0), ('Kss', 2.87), ('g0', 60.37), ('g_max', 434.18), ('K_run', 3.96), ('P_max', 171.18)]

Table 1: Goodness of fit for calibration period (2005 - 2013)

	Full year	**Summer**	**Winter**
RelErr	-3.3 %	-33.0 %	4.1 %
NS	0.037	-0.296	0.064
NS_log	0.45	0.358	0.147
NS_rel	0.047	-0.144	0.079
KGE	0.565	0.242	0.5

Table 2 :Goodness of fit for validation period (1998 - 2002)

	Full year	**Summer**	**Winter**
RelErr	11.2 %	9.2 %	7.4 %
NS	-0.418	-4.135	0.12
NS_log	0.583	0.405	0.454
NS_rel	-0.358	0.047	0.293
KGE	0.398	-0.72	0.536

9.5.1.6 Observed and simulated timeseries for optimum parameters

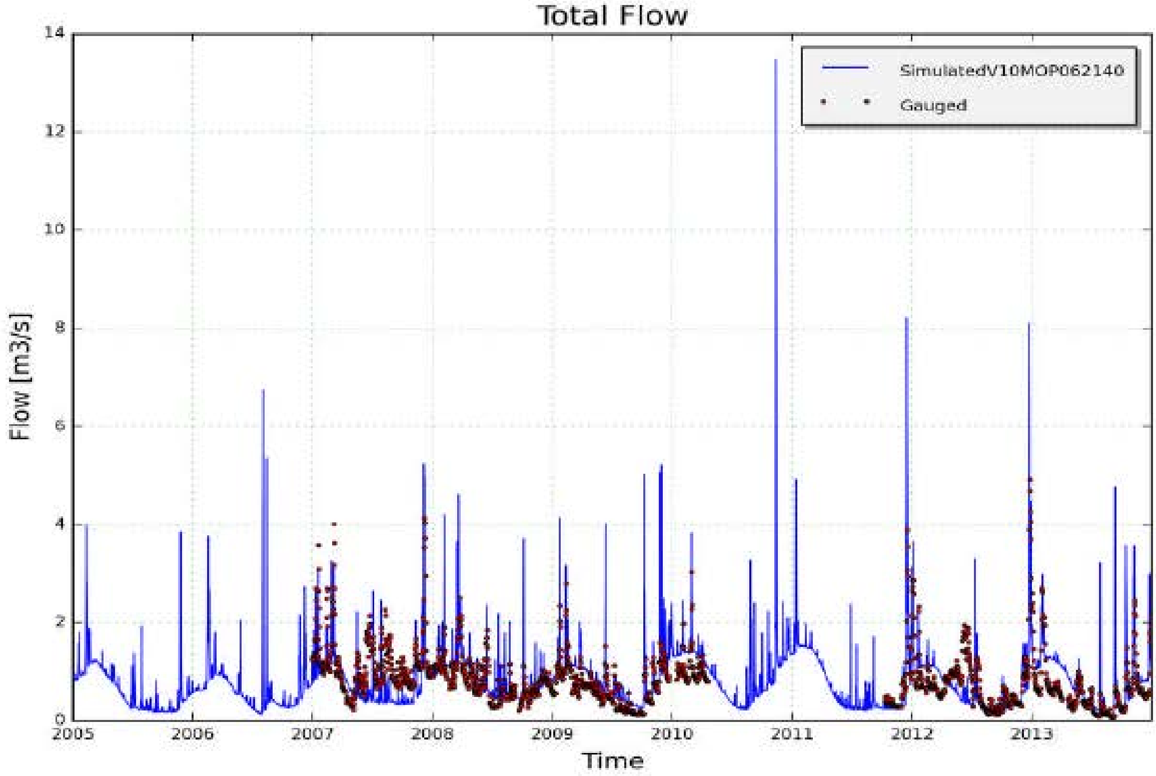


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle(calibration period)

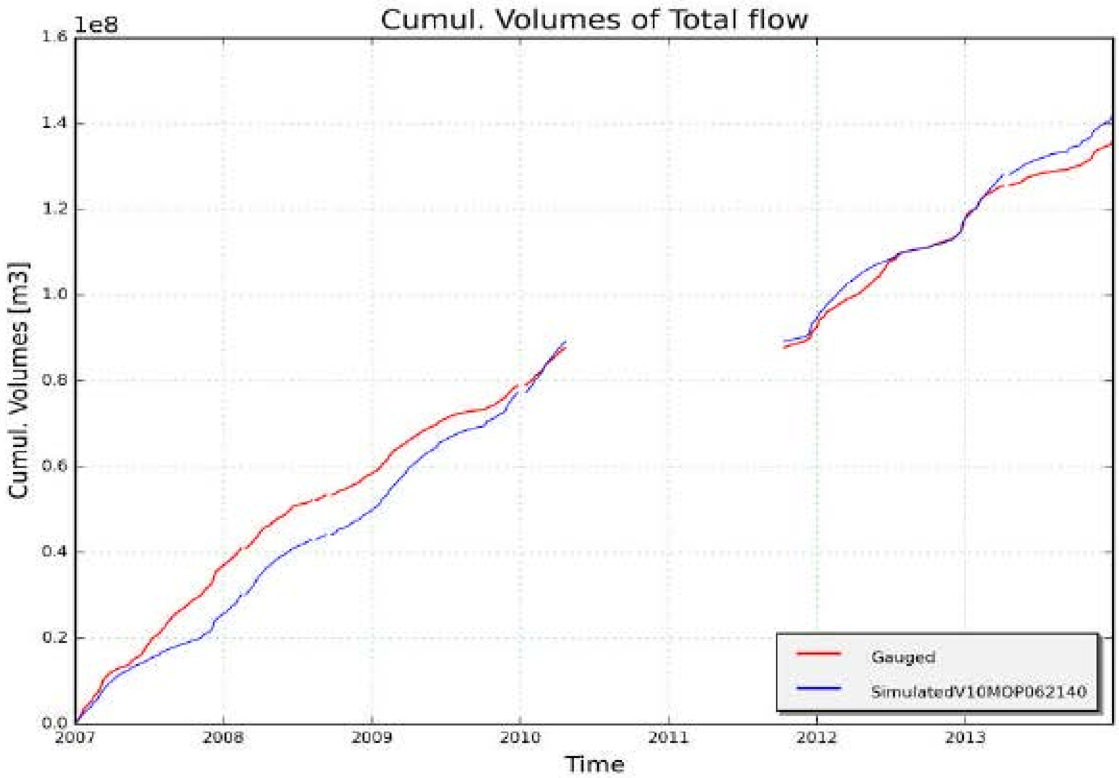


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle (calibration period)

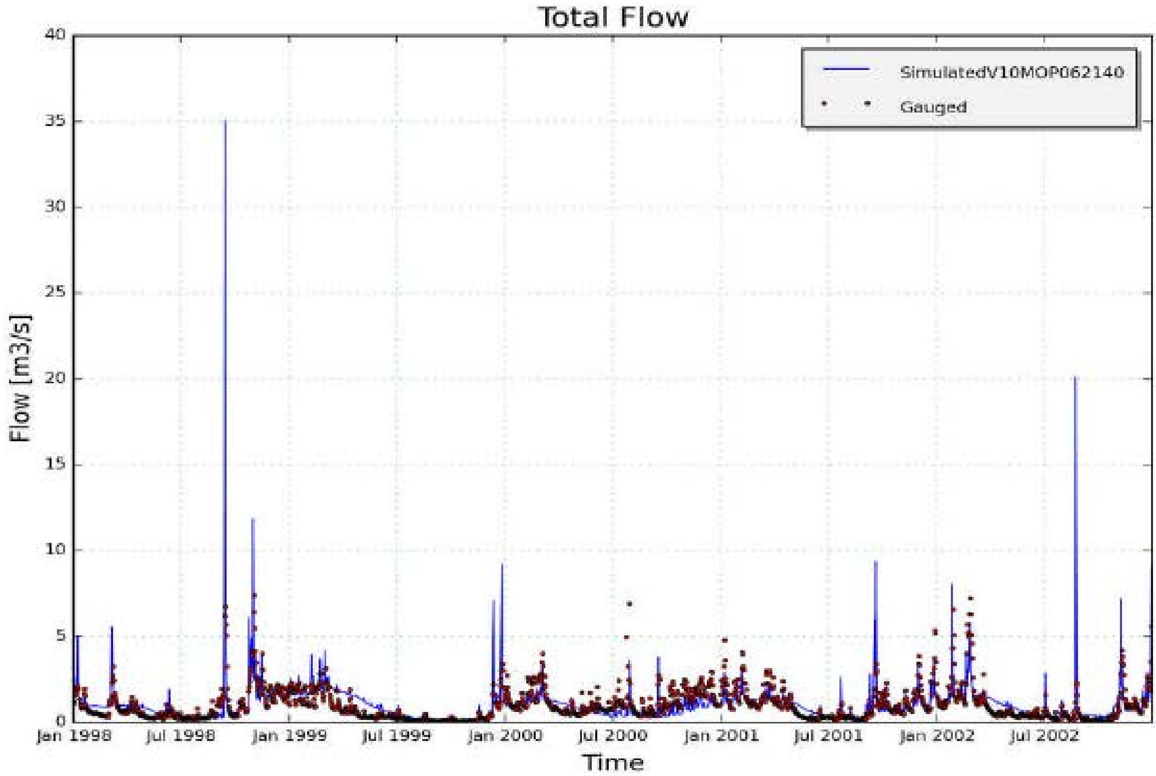


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle (validation period)

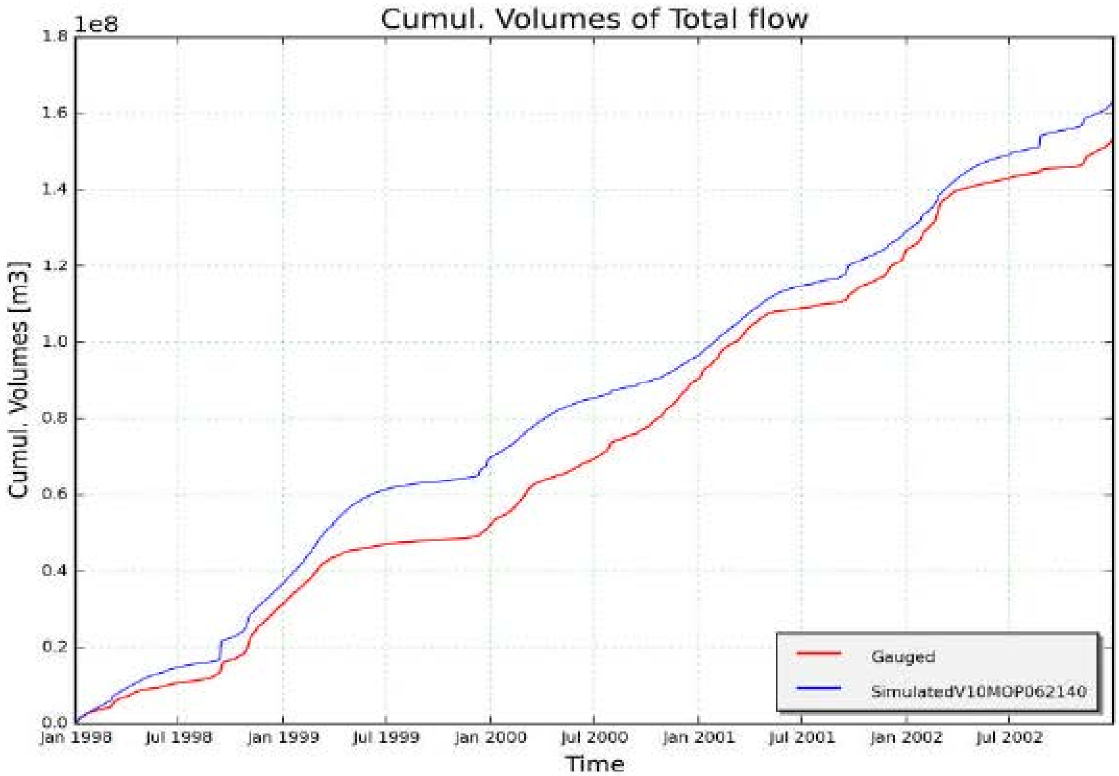


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle (validation period)

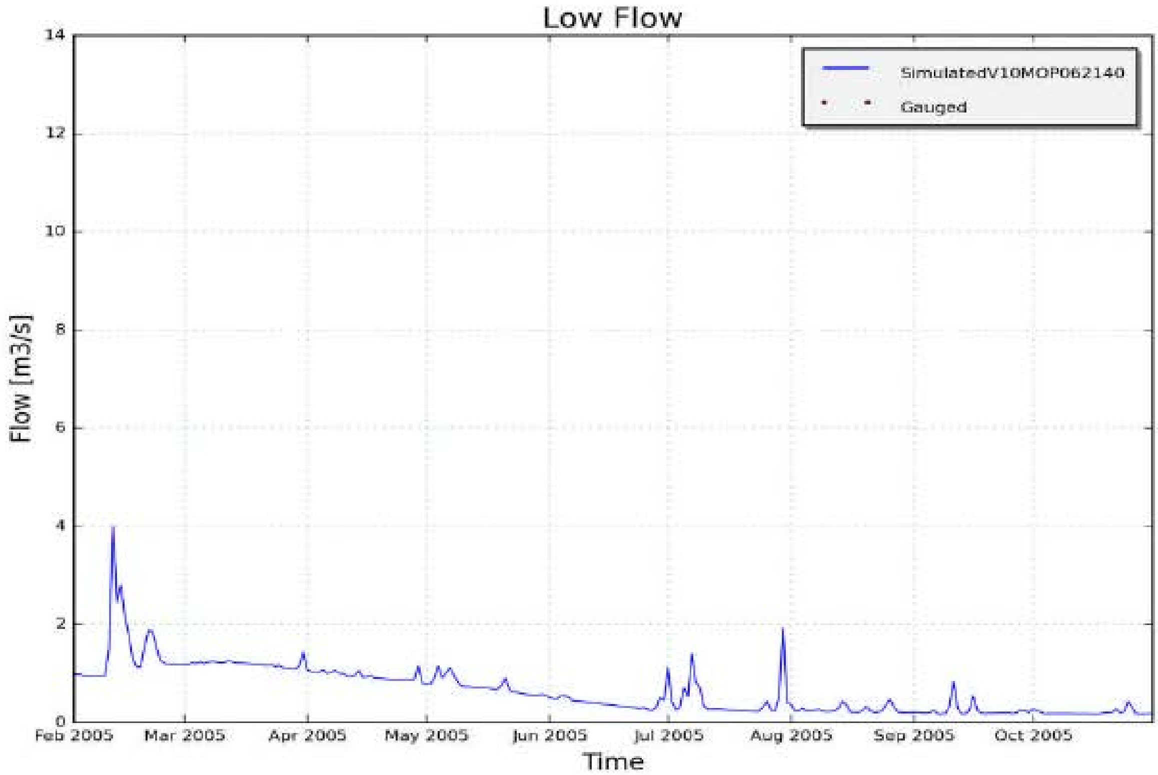


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle

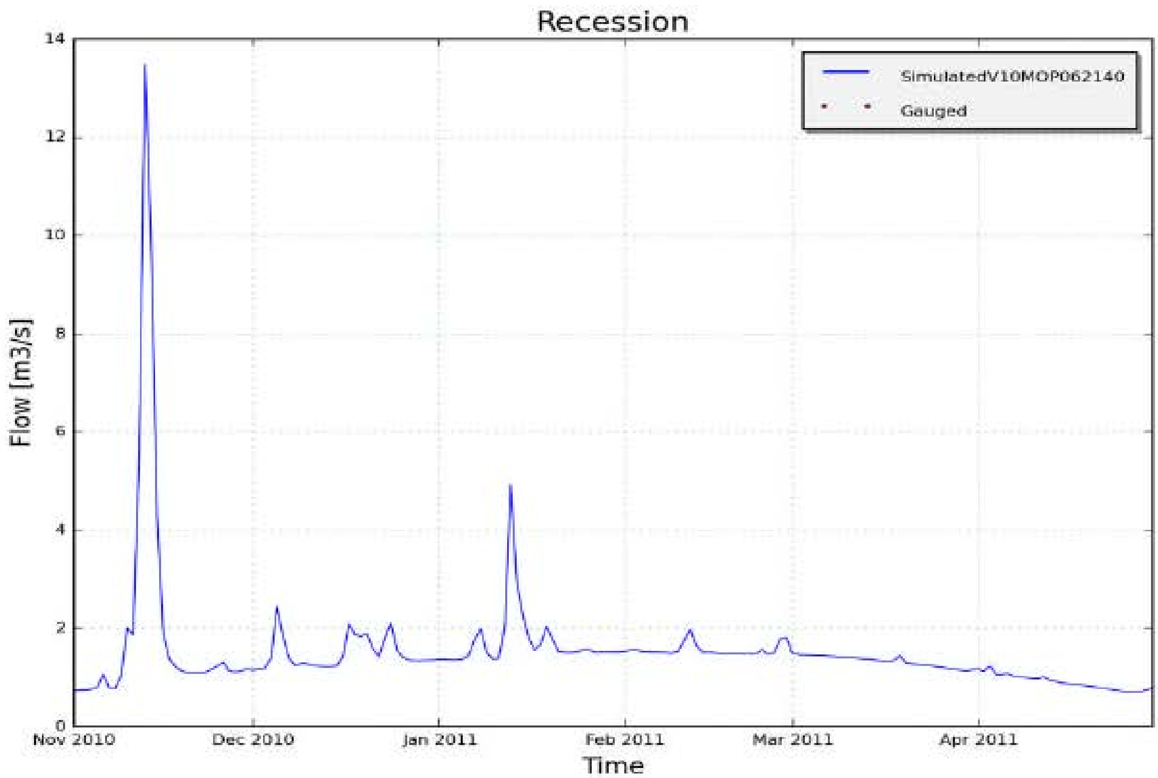


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle

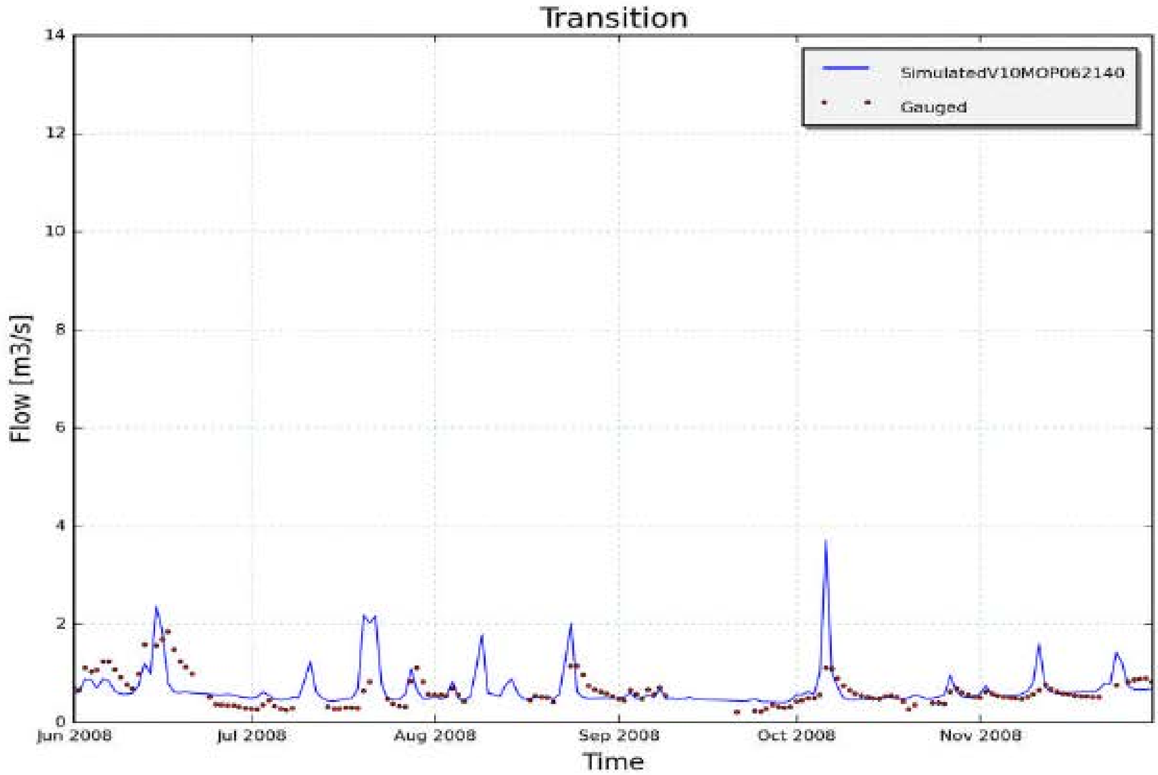


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle

9.5.2 Calibration and validation of WET parameters for catchment "V10KNE052000" (Nete)

9.5.2.1 Input data

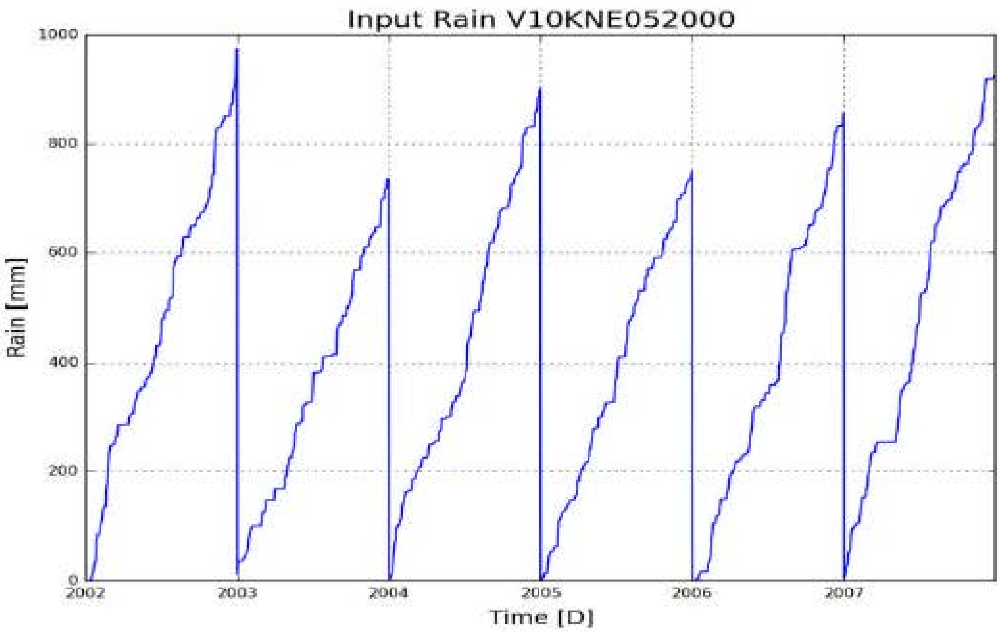


Figure 1: Cumulative precipitation on catchment V10KNE052000 (Nete)

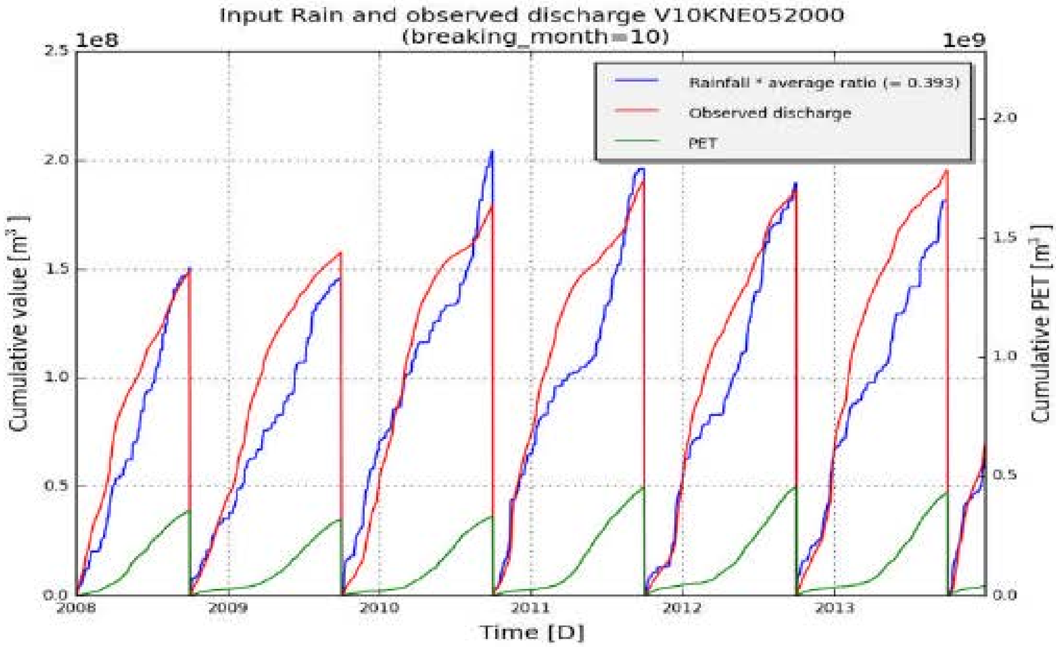


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V10KNE052000 (Nete)

9.5.2.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V10KNE052000
subcatchment_area [m2]	584669408
Validation start_date	01-01-2003
Validation end_date	31-12-2007
frequency	daily

Optimal parameter set:[('Kep', 1.45), ('Ki', 113.71), ('Kg', 0.01), ('Kss', 2.86), ('g0', 87.22), ('g_max', 304.77), ('K_run', 2.0), ('P_max', 40.57)]

Table 1: Goodness of fit for calibration period (2008 - 2013)

	Full year	Summer	Winter
RelErr	-0.3 %	4.5 %	-3.7 %
NS	0.568	-0.066	0.496
NS_log	0.715	0.58	0.394
NS_rel	0.77	0.502	0.499
KGE	0.771	0.494	0.559

Table 2 :Goodness of fit for validation period (2003 - 2007)

	Full year	Summer	Winter
RelErr	-5.7 %	-15.4 %	-5.9 %
NS	0.697	0.036	0.668
NS_log	0.715	0.535	0.704
NS_rel	0.78	0.677	0.805
KGE	0.812	0.472	0.692

9.5.2.3 Observed and simulated timeseries for optimum parameters

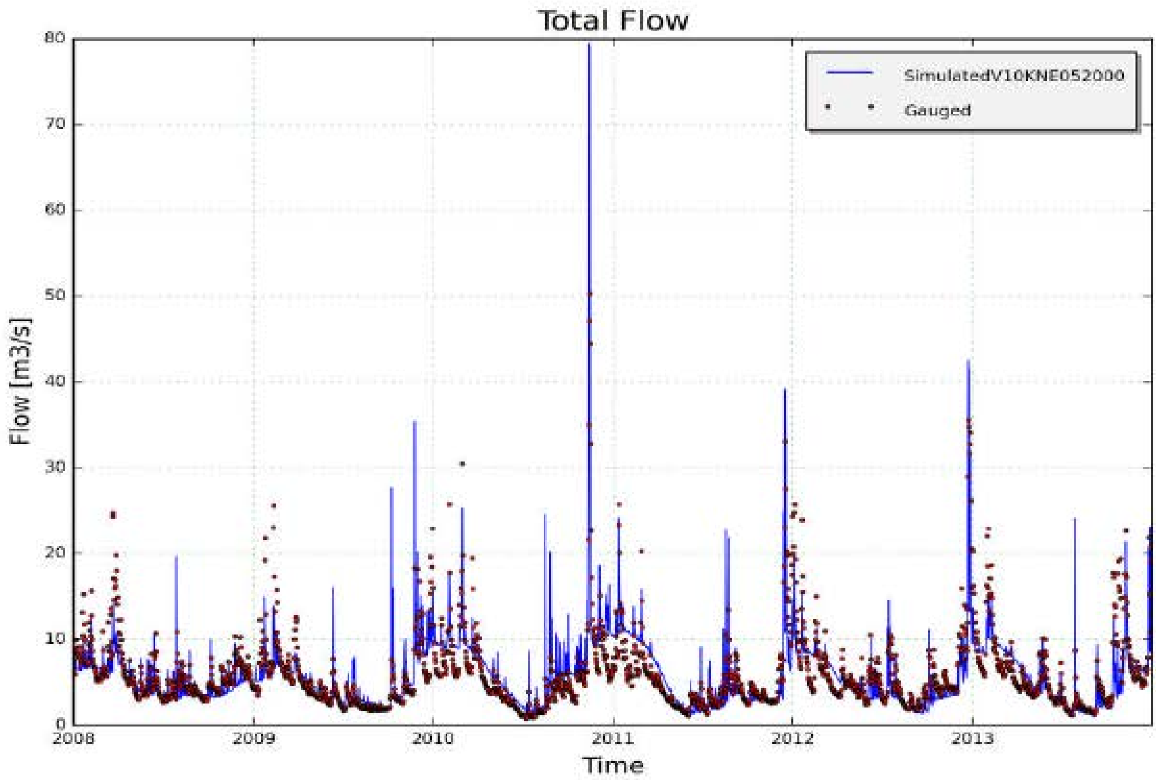


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk(calibration period)

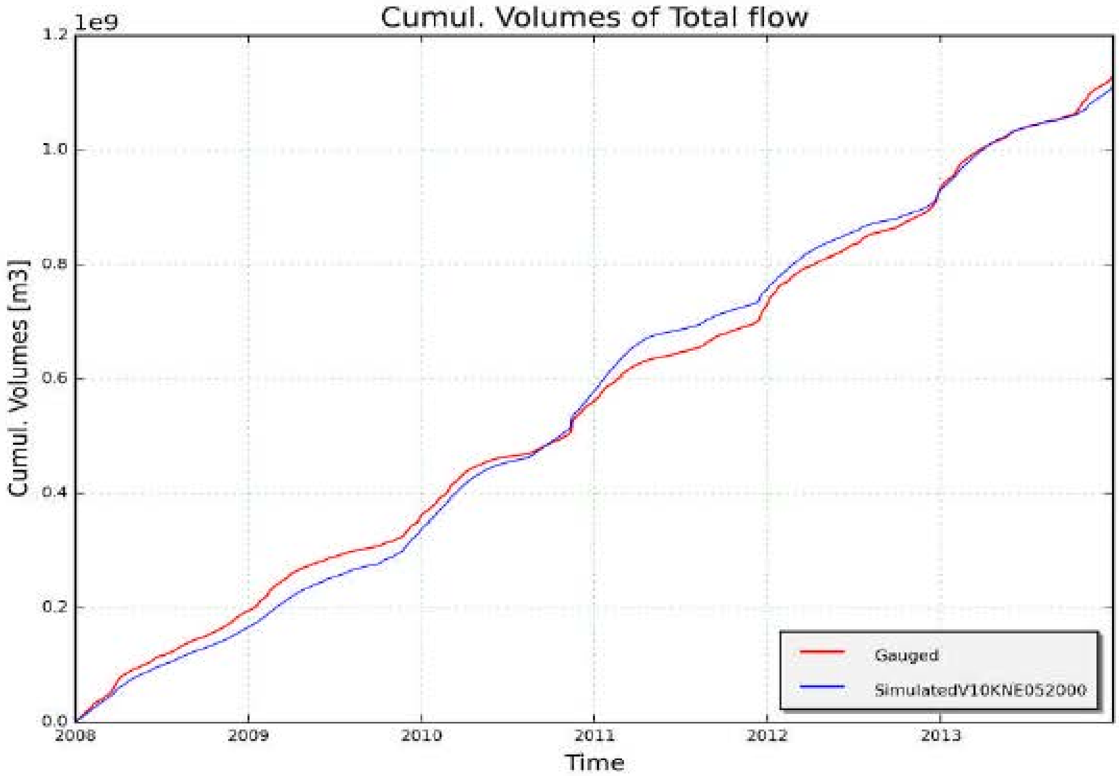


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk (calibration period)

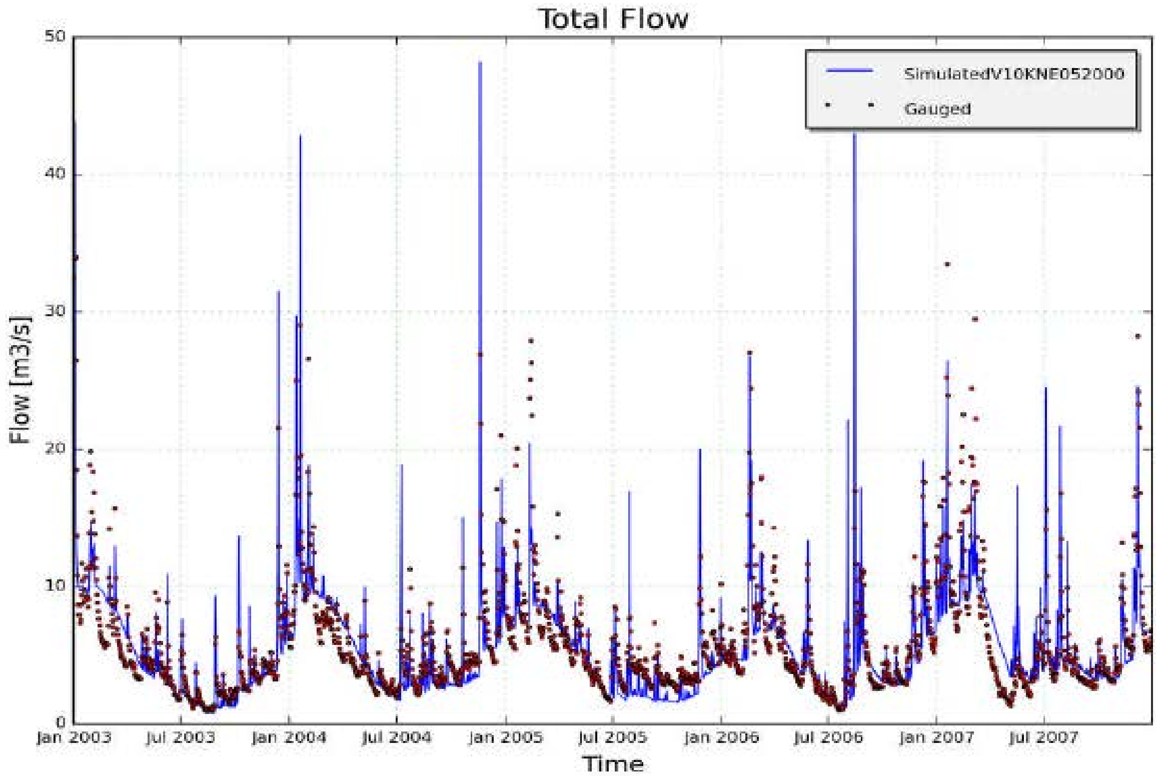


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk (validation period)

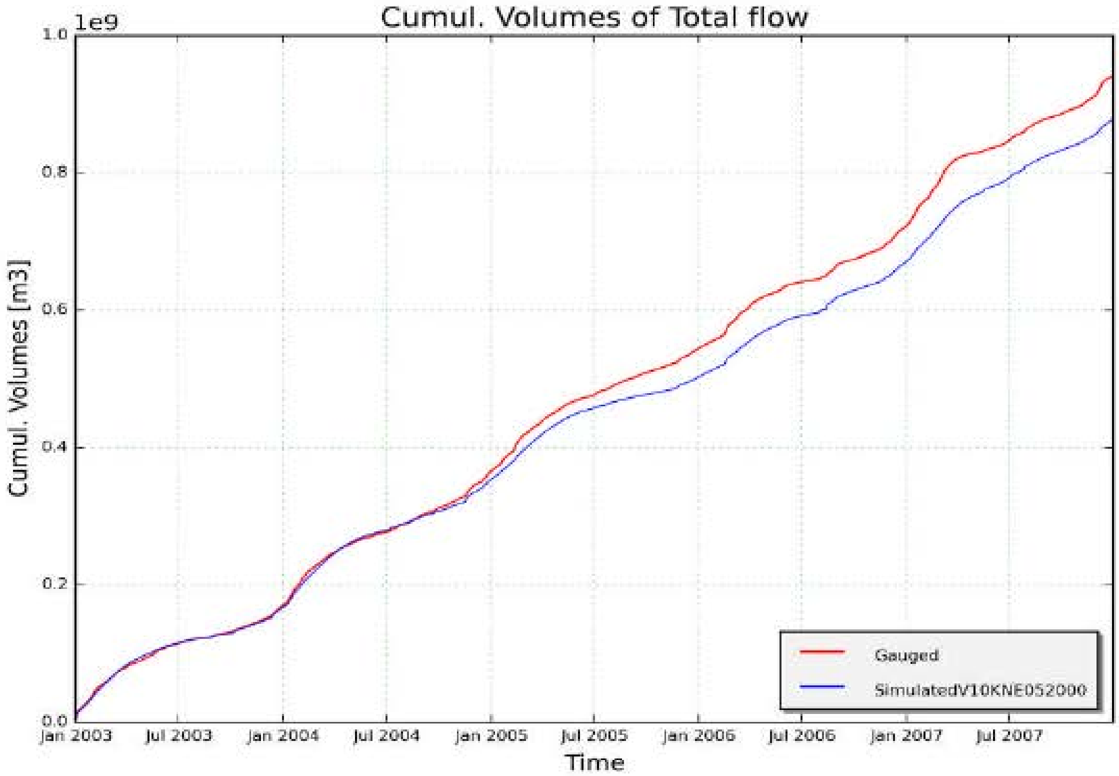


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk (validation period)

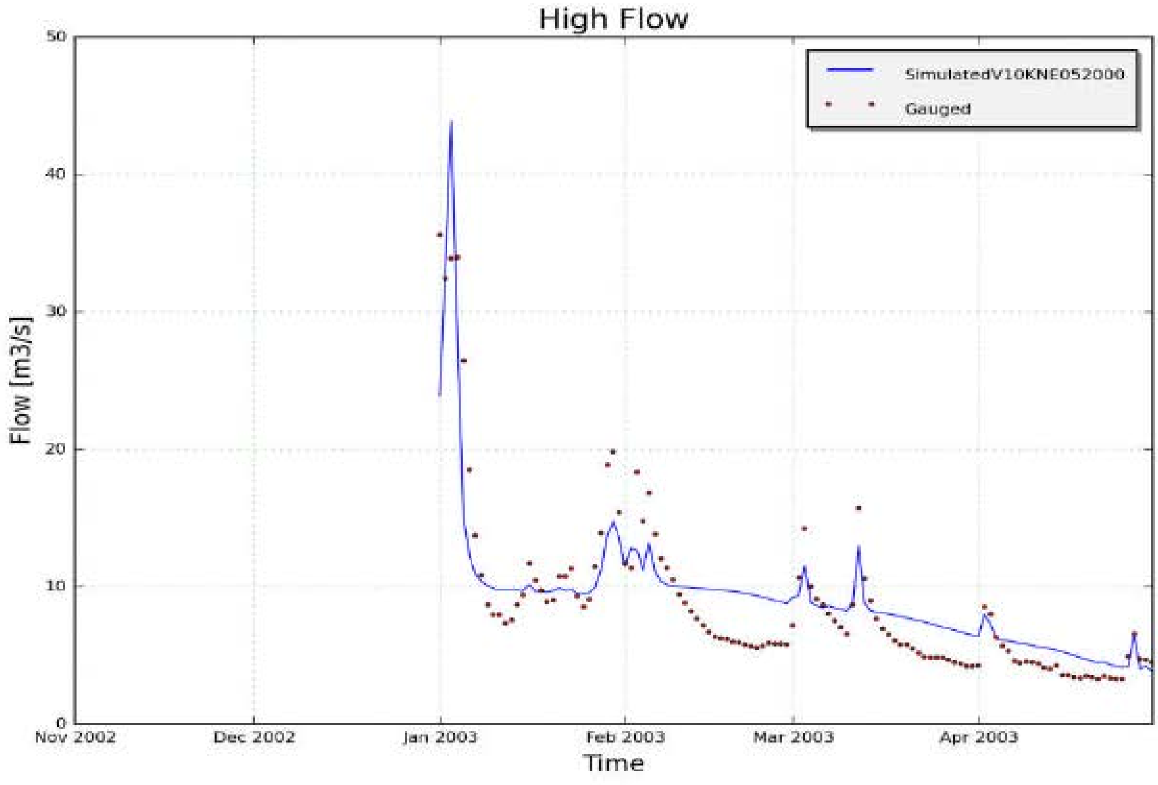


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk

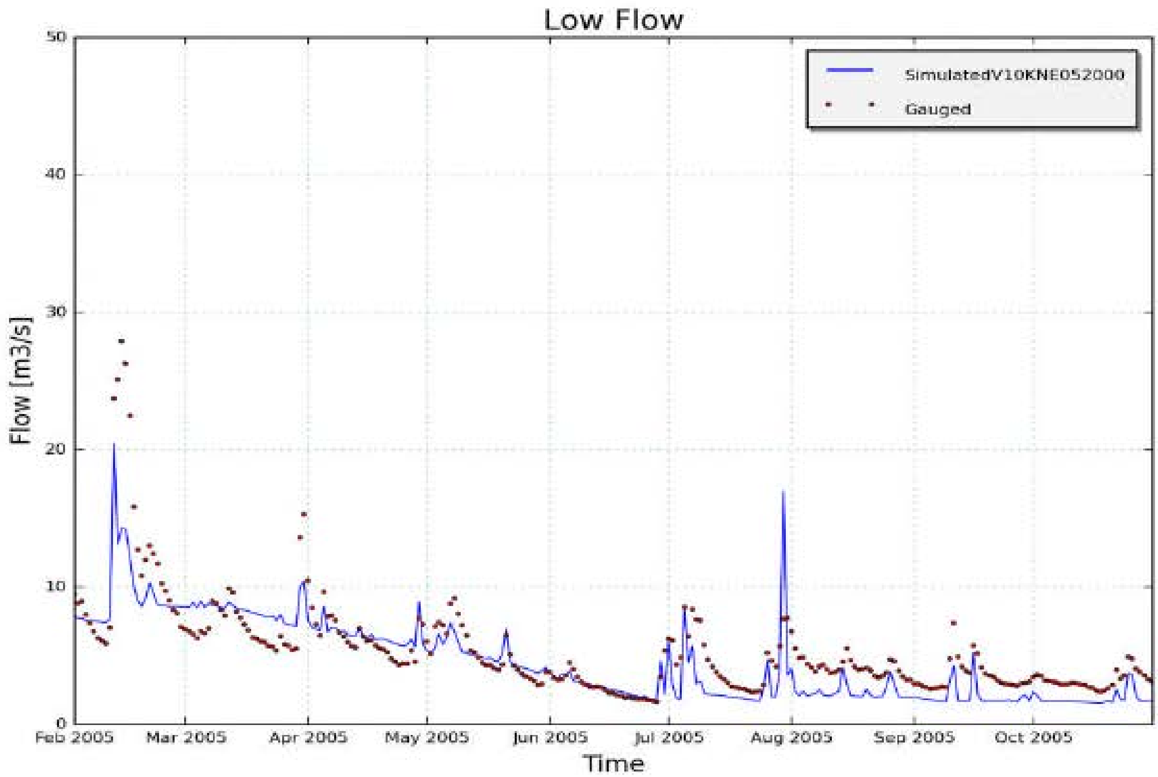


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk

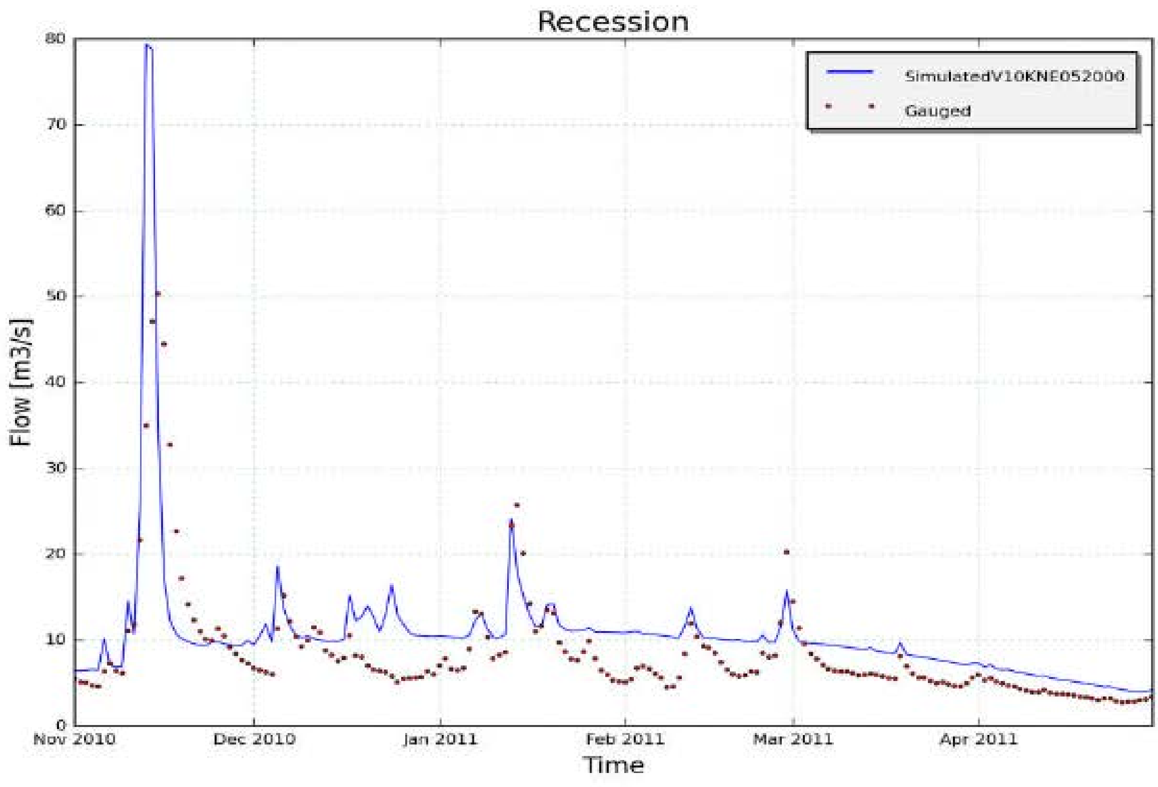


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk

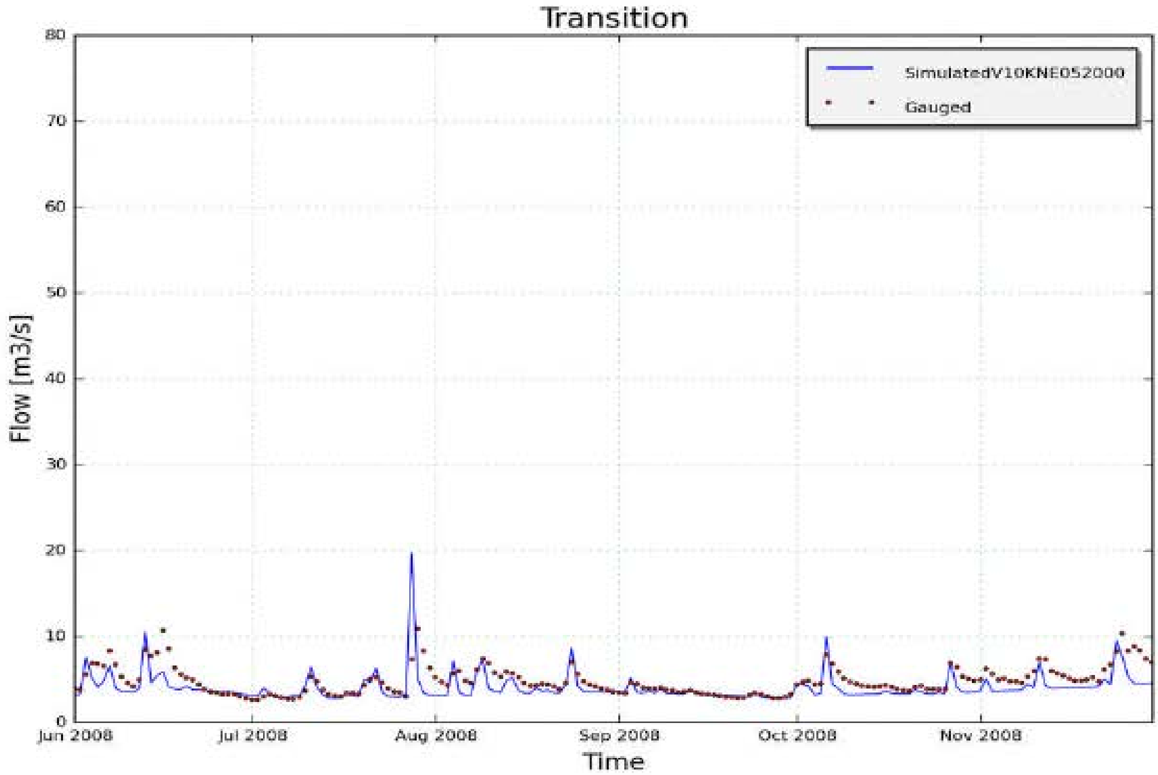


Figure 10: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk

9.5.3 Calibration and validation of WET parameters for catchment "V10MOP062140" (Nete)

9.5.3.1 Input data

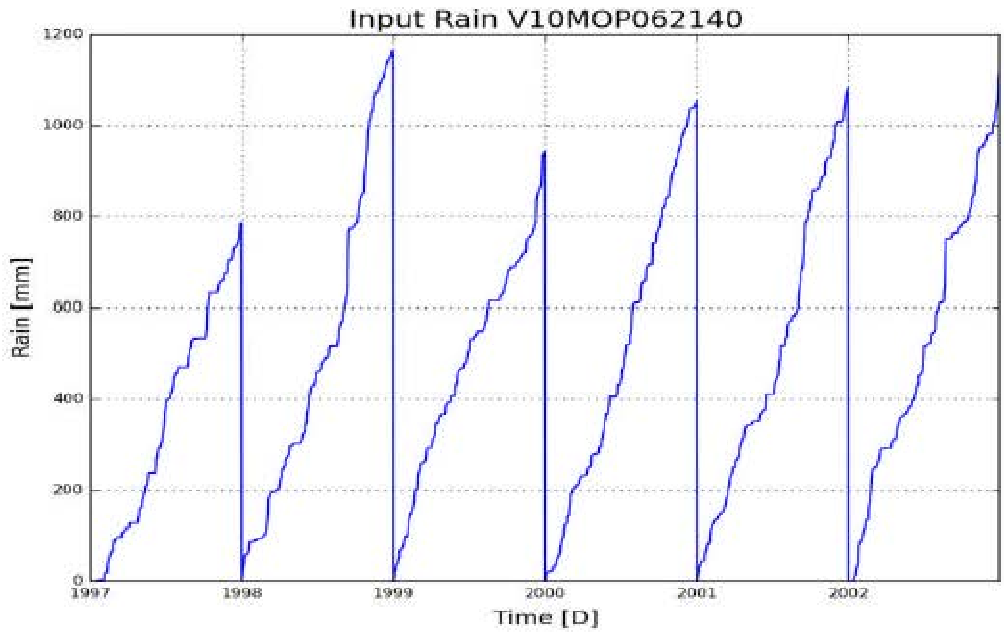


Figure 1: Cumulative precipitation on catchment V10MOP062140 (Nete)

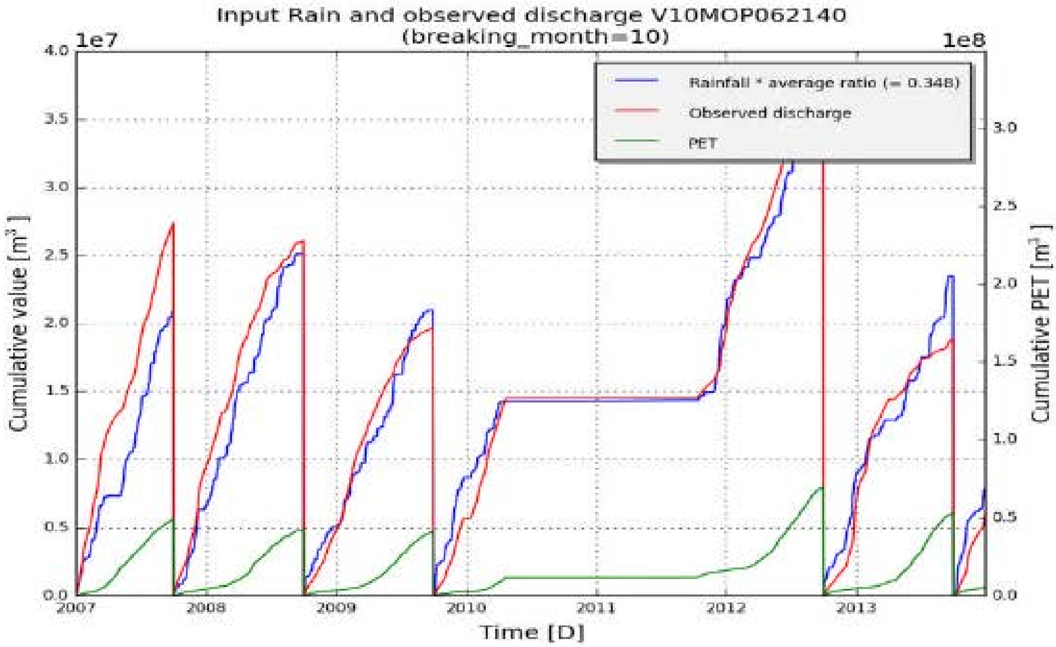


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V10MOP062140 (Nete)

9.5.3.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	V10MOP062140
subcatchment_area [m2]	77319091
Validation start_date	01-01-1998
Validation end_date	31-12-2002
frequency	daily

Optimal parameter set:[('Kep', 2.32), ('Ki', 127.98), ('Kg', 0.0), ('Kss', 2.87), ('g0', 60.37), ('g_max', 434.18), ('K_run', 3.96), ('P_max', 171.18)]

Table 1: Goodness of fit for calibration period (2005 - 2013)

	Full year	**Summer**	**Winter**
RelErr	-3.3 %	-33.0 %	4.1 %
NS	0.037	-0.296	0.064
NS_log	0.45	0.358	0.147
NS_rel	0.047	-0.144	0.079
KGE	0.565	0.242	0.5

Table 2 :Goodness of fit for validation period (1998 - 2002)

	Full year	Summer	Winter
RelErr	11.2 %	9.2 %	7.4 %
NS	-0.418	-4.135	0.12
NS_log	0.583	0.405	0.454
NS_rel	-0.358	0.047	0.293
KGE	0.398	-0.72	0.536

9.5.3.3 Observed and simulated timeseries for optimum parameters

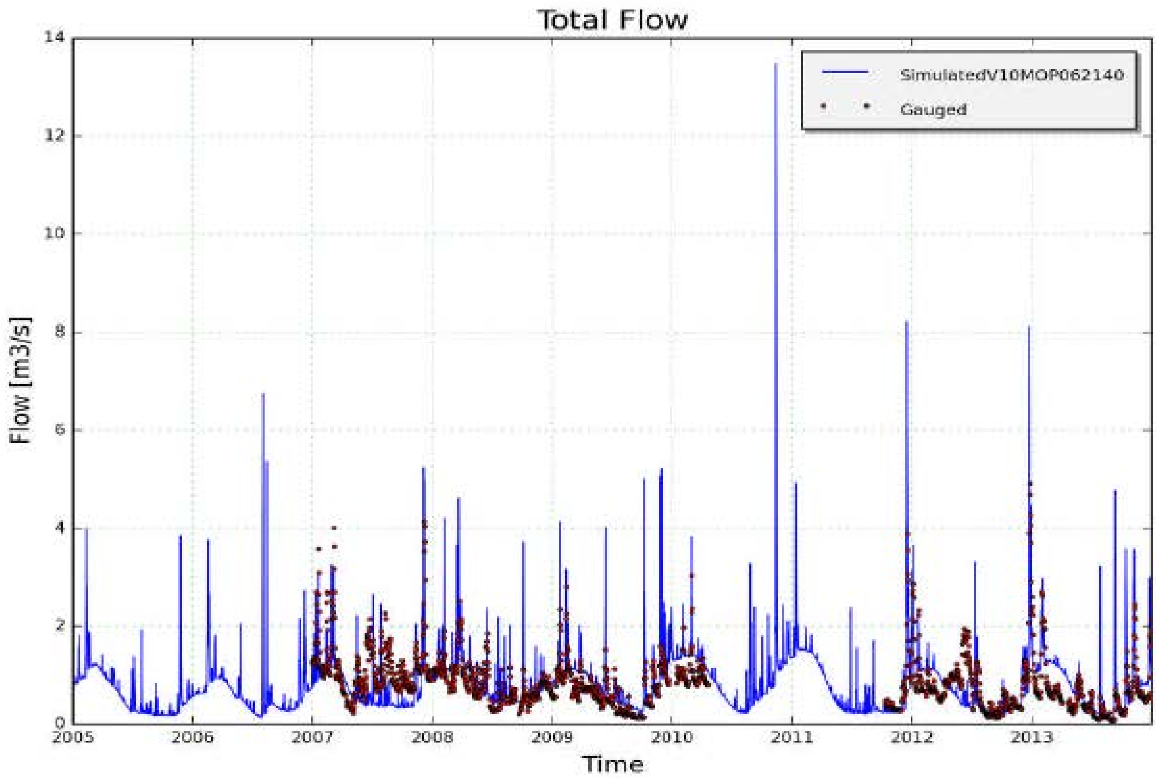


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle(calibration period)

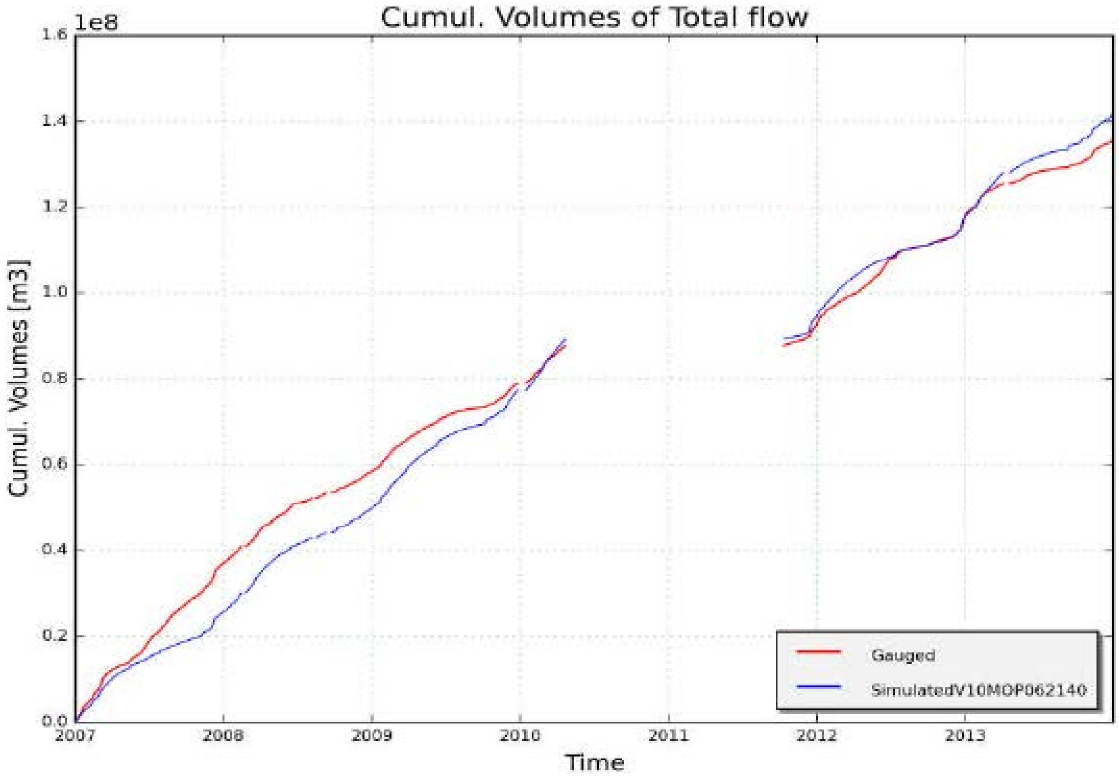


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle (calibration period)

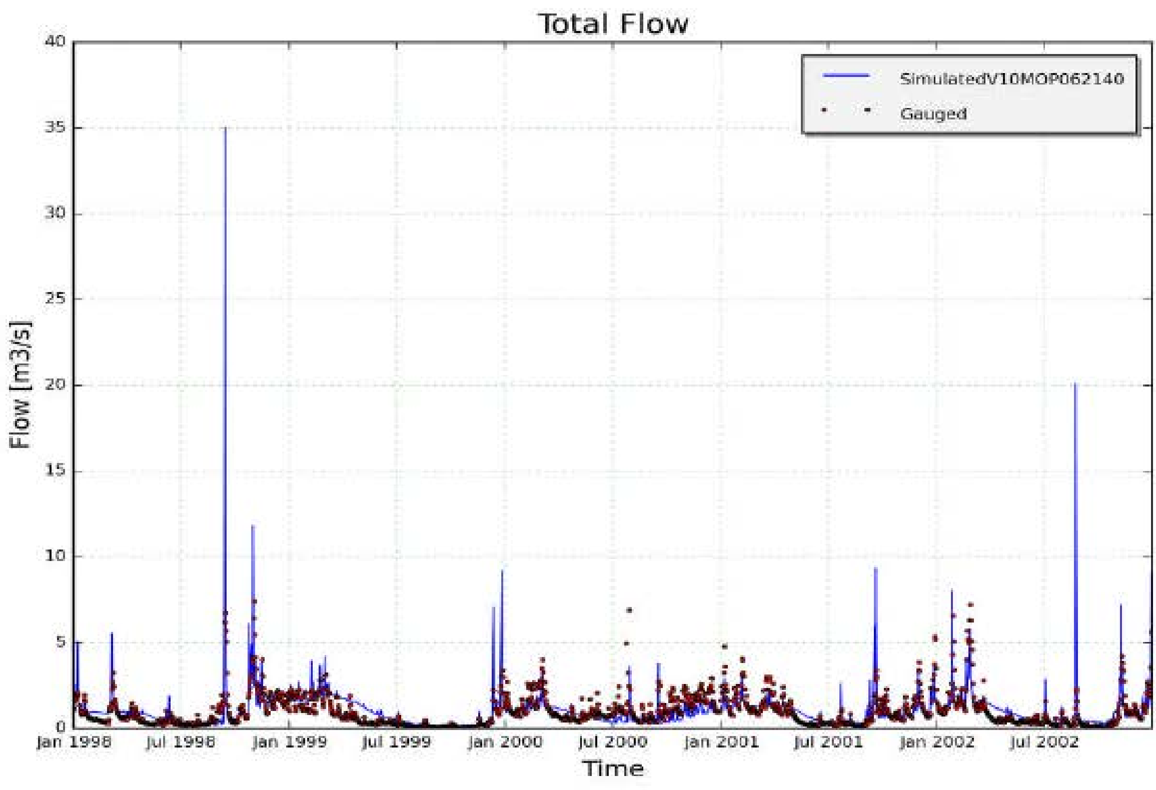


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle (validation period)

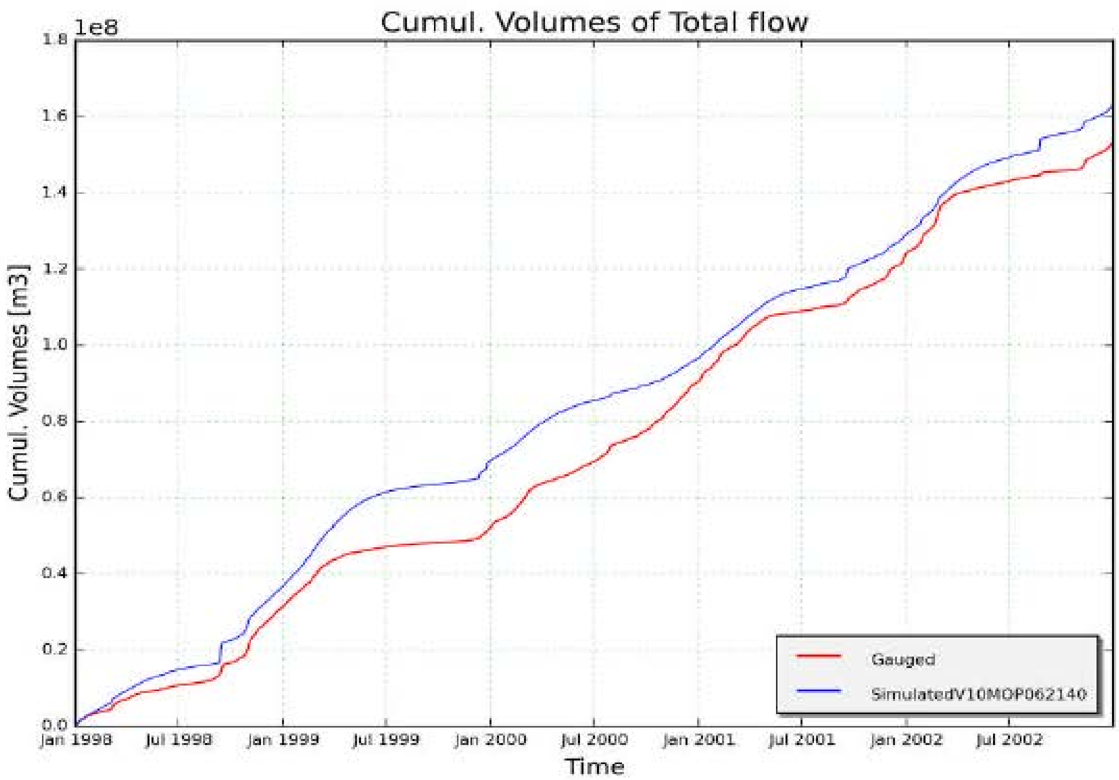


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle (validation period)

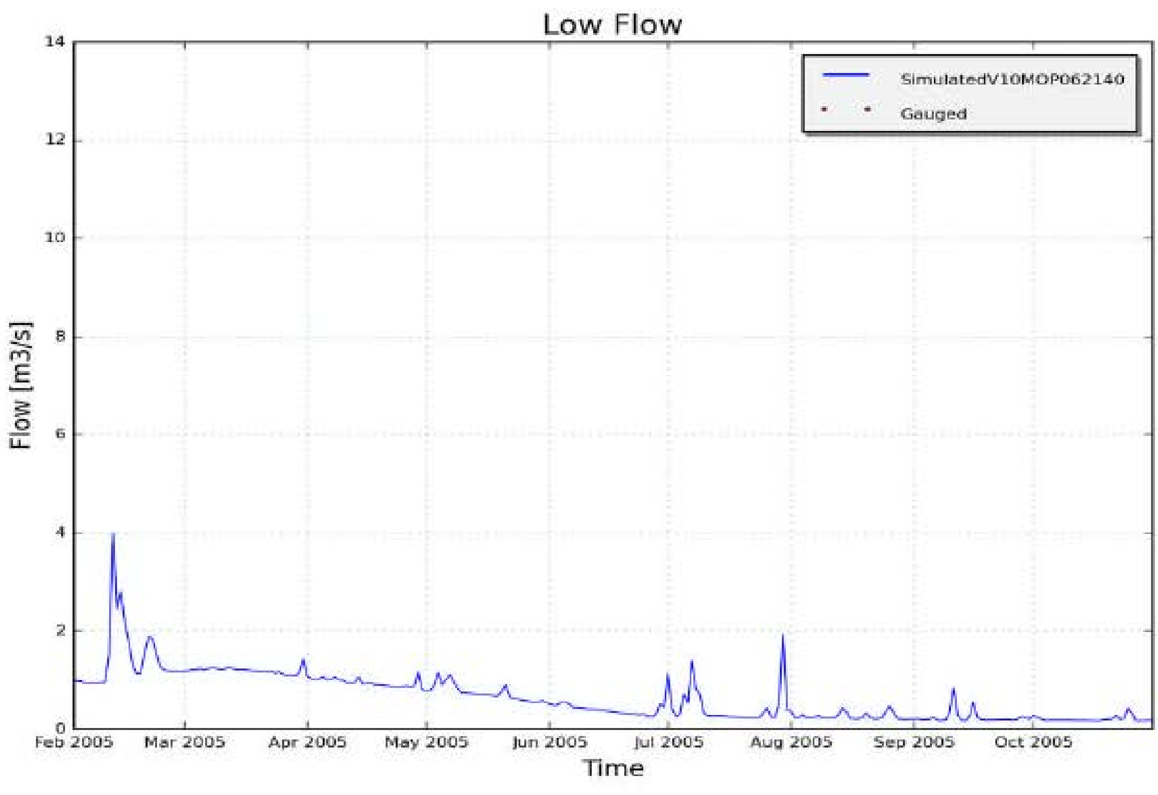


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle

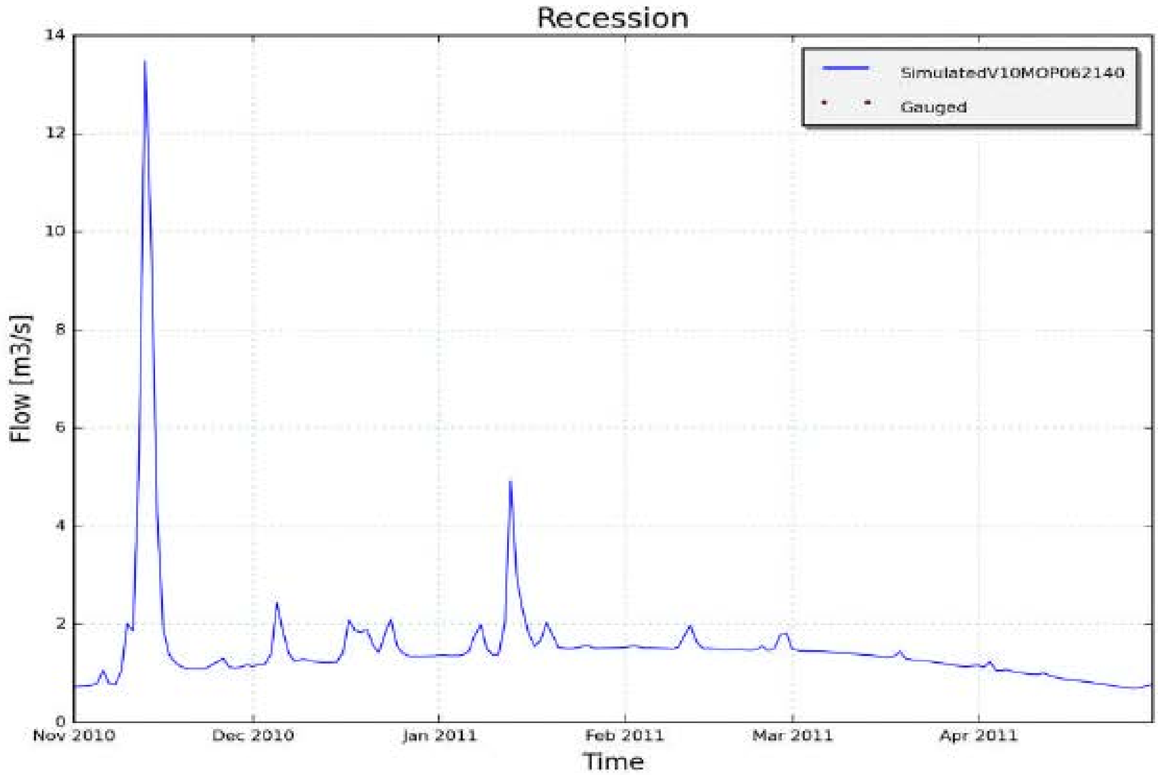


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle

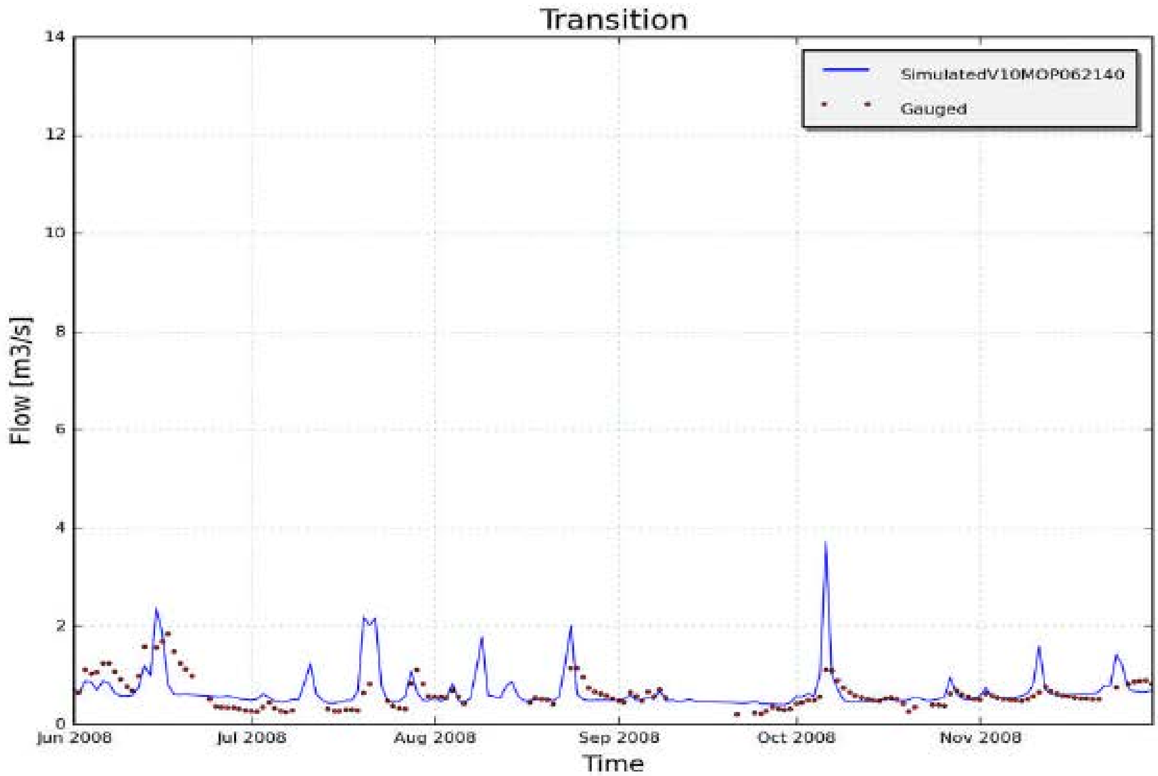


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle

9.5.4 Calibration and validation of WET parameters for catchment "V10WIM082050" (Nete)

9.5.4.1 Input data

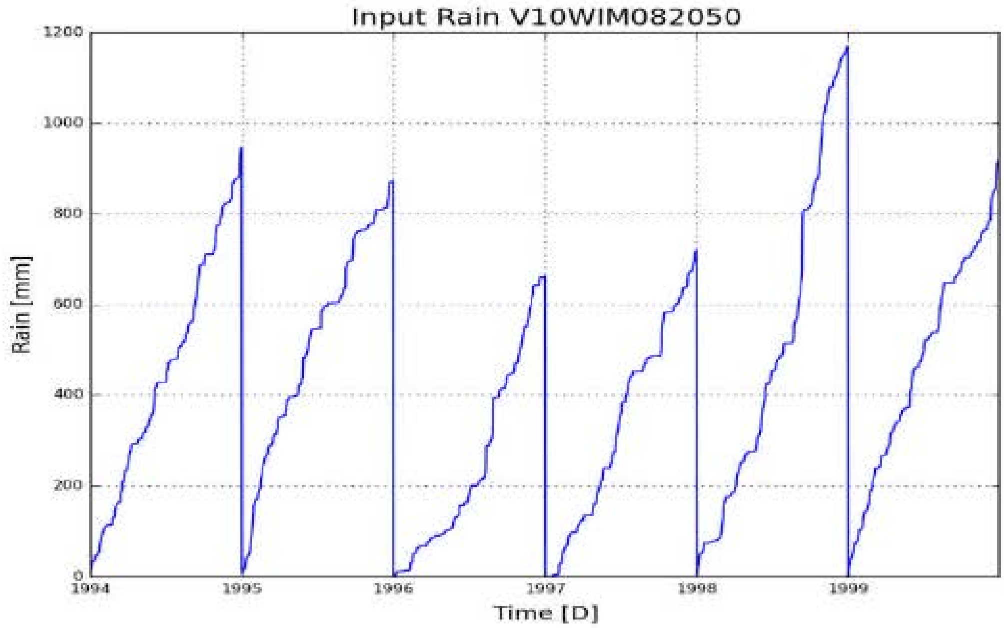


Figure 1: Cumulative precipitation on catchment V10WIM082050 (Nete)

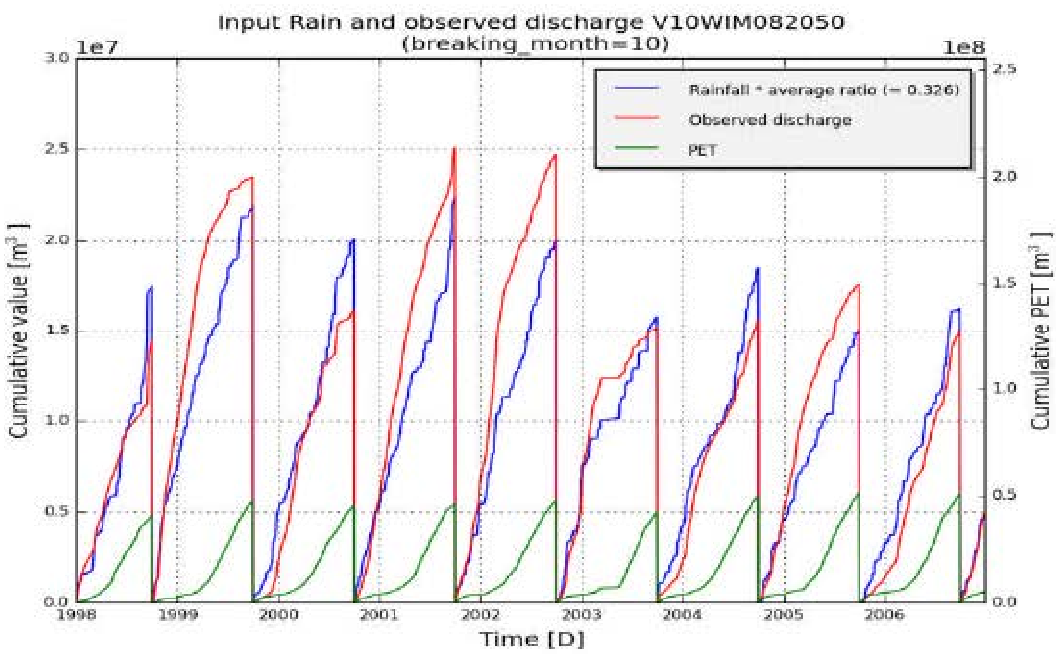


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V10WIM082050 (Nete)

9.5.4.2 Model summary

model_structure WETSPAclassic.paramset1

subcatchment_name	V10WIM082050
subcatchment_area [m2]	65400000
Validation start_date	01-01-1995
Validation end_date	31-12-1999
frequency	daily

Optimal parameter set:[('Kep', 2.81), ('Ki', 140.66), ('Kg', 0.02), ('Kss', 9.94), ('g0', 169.18), ('g_max', 565.84), ('K_run', 0.98), ('P_max', 311.23)]

Table 1: Goodness of fit for calibration period (1998 - 2006)

	Full year	**Summer**	**Winter**
RelErr	1.5 %	-25.1 %	19.2 %
NS	0.458	0.041	0.619
NS_log	0.445	0.025	0.507
NS_rel	-3.689	-6.13	0.015
KGE	0.718	0.414	0.763

Table 2 :Goodness of fit for validation period (1995 - 1999)

	Full year	**Summer**	**Winter**
RelErr	6.3 %	-42.5 %	41.3 %
NS	0.343	0.134	0.392
NS_log	0.377	-0.188	0.315
NS_rel	-4.713	-6.255	-0.615
KGE	0.613	0.465	0.559

9.5.4.3 Observed and simulated timeseries for optimum parameters

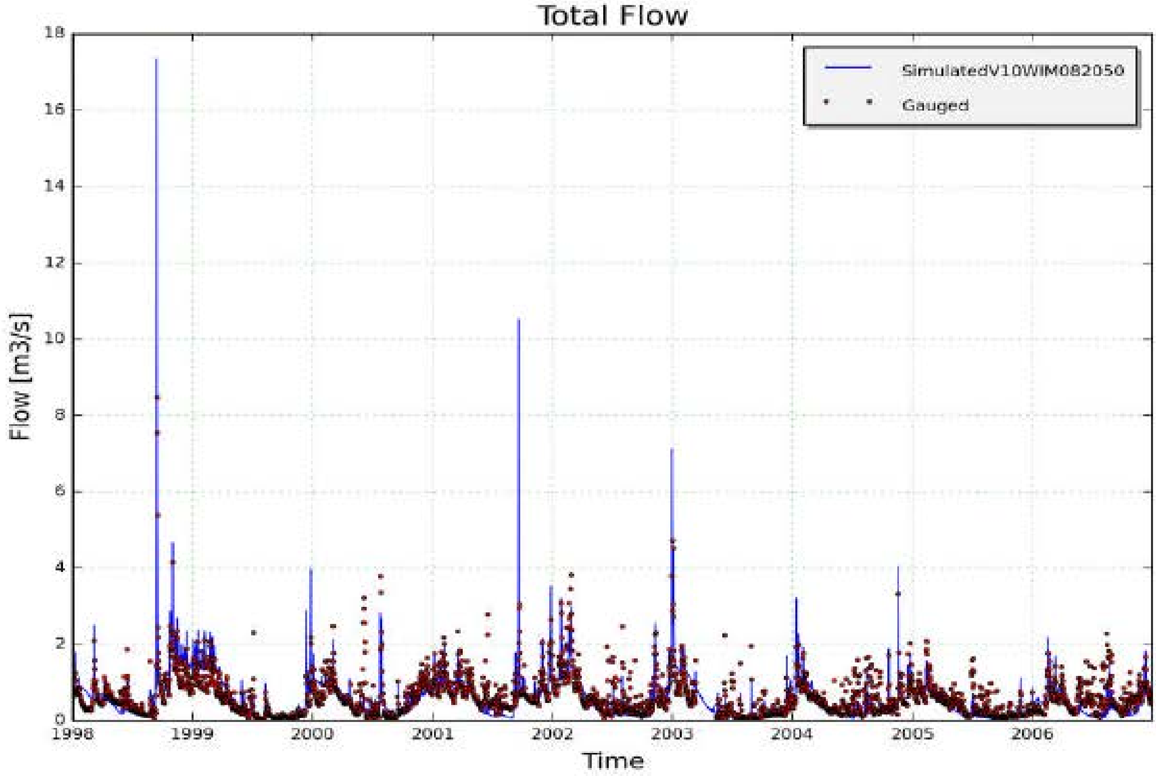


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10WIM082050, station 8210102 - Wiekevorst(calibration period)

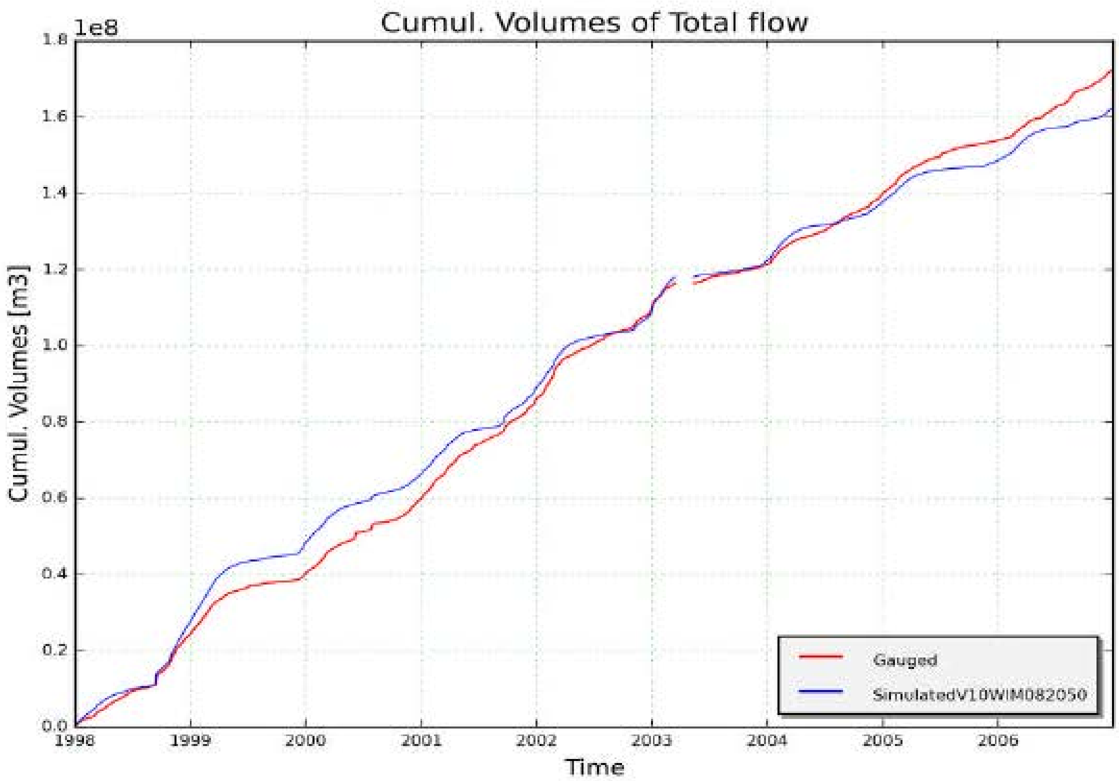


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10WIM082050, station 8210102 - Wiekevorst (calibration period)

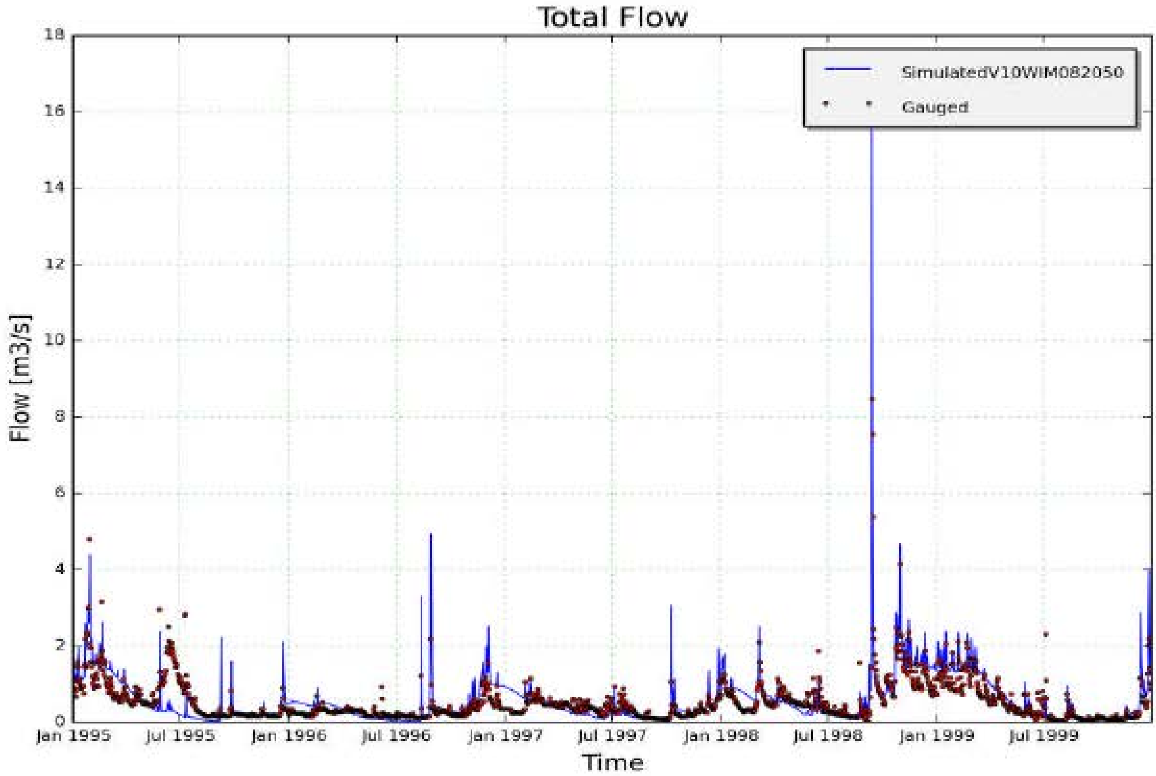


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10WIM082050, station 8210102 - Wiekevorst (validation period)

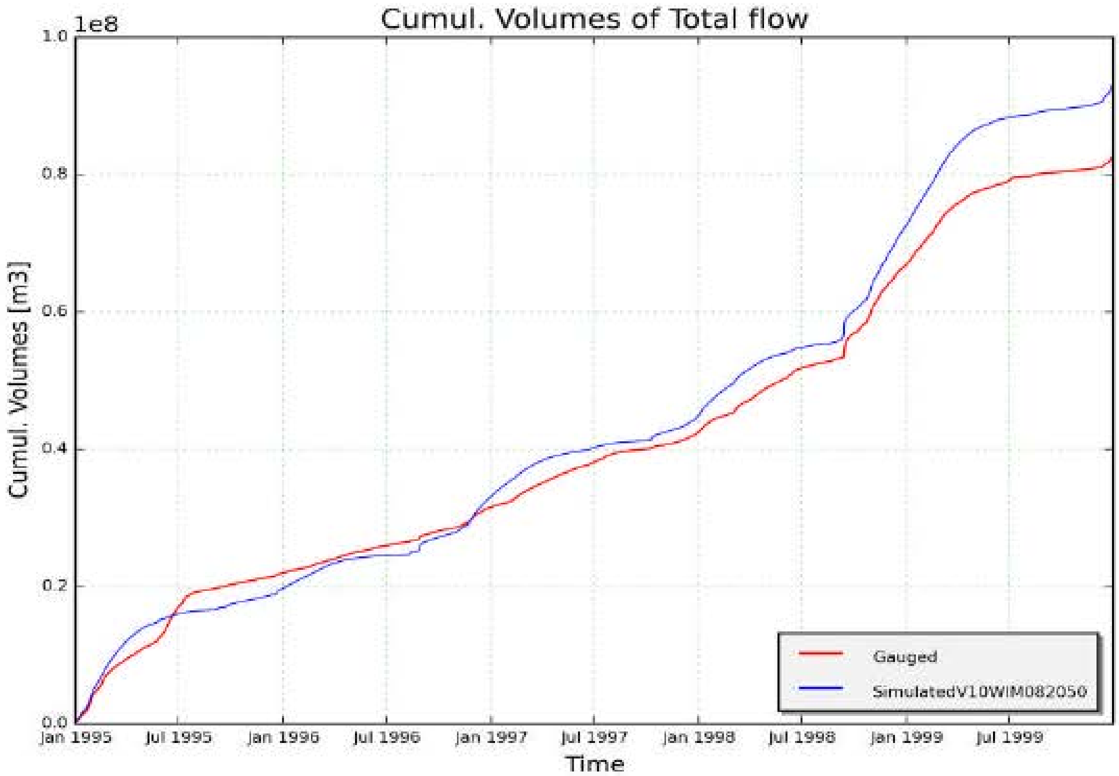


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10WIM082050, station 8210102 - Wiekevorst (validation period)

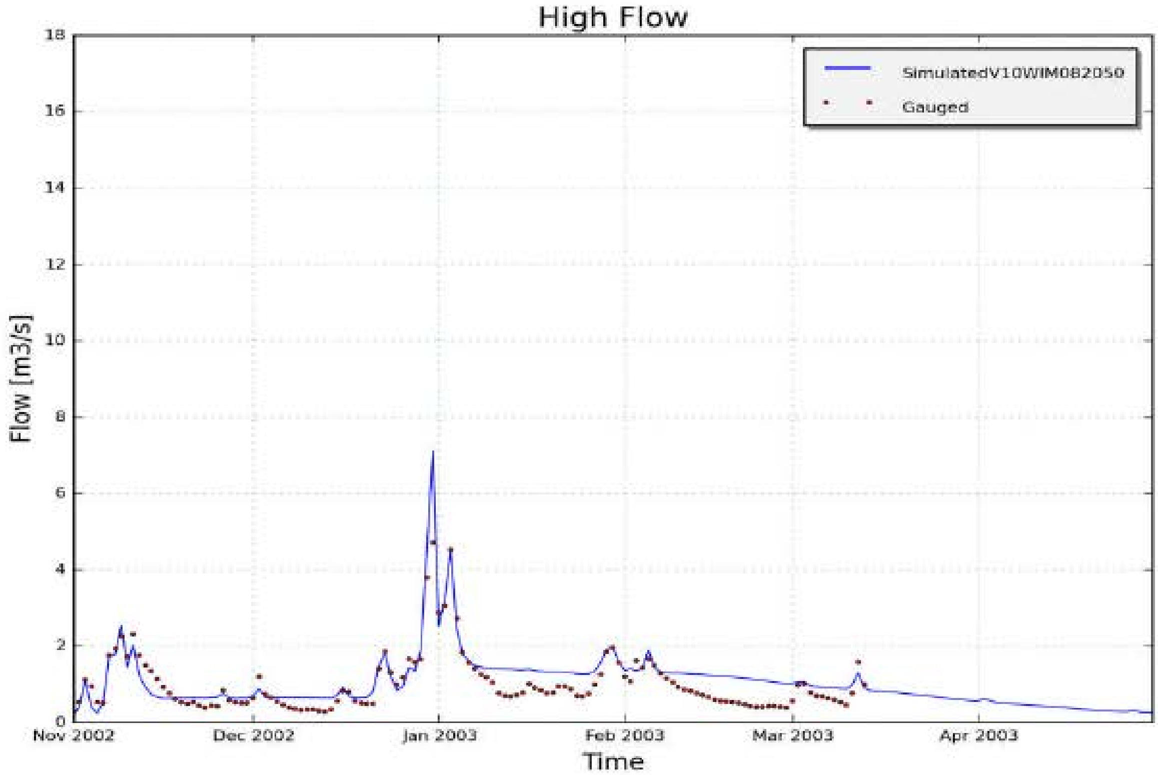


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10WIM082050, station 8210102 - Wiekevorst

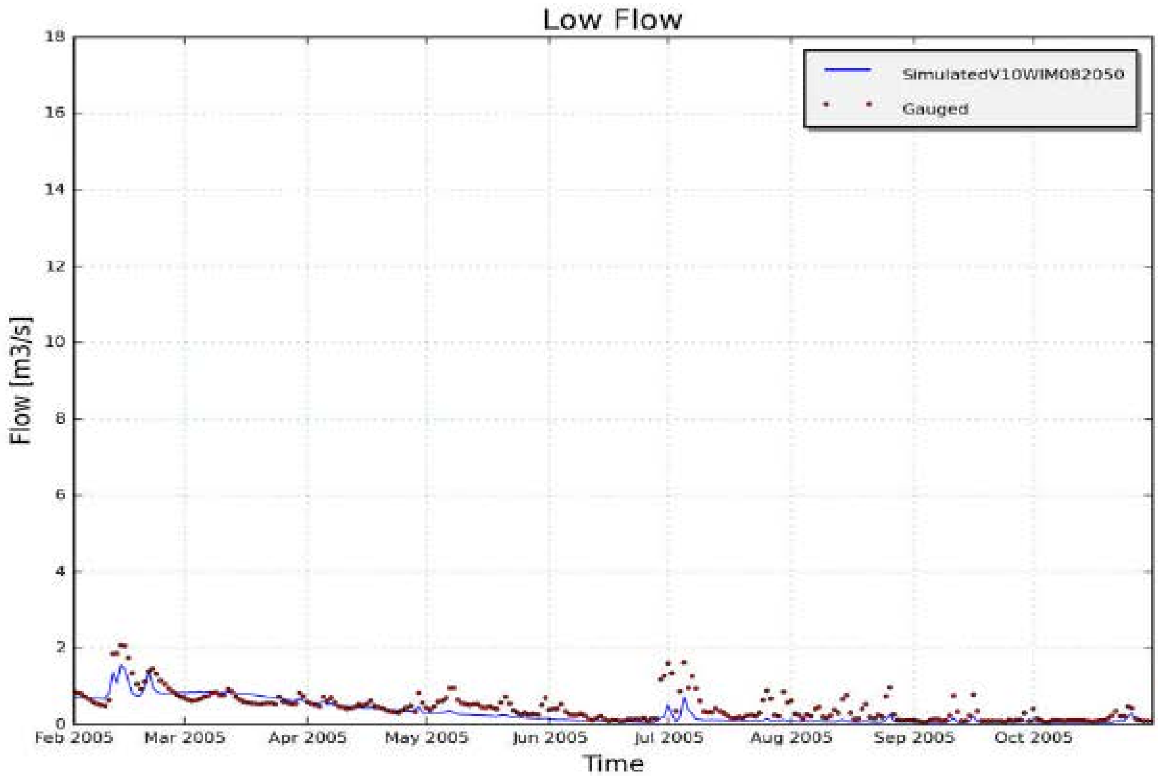


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10WIM082050, station 8210102 - Wiekevorst

Appendix 21 Nete Autocalibration.

9.5.1 Report on simulation of catchment V10GNE076999 (2017-02-02 10-31)

9.5.1.1 Input data

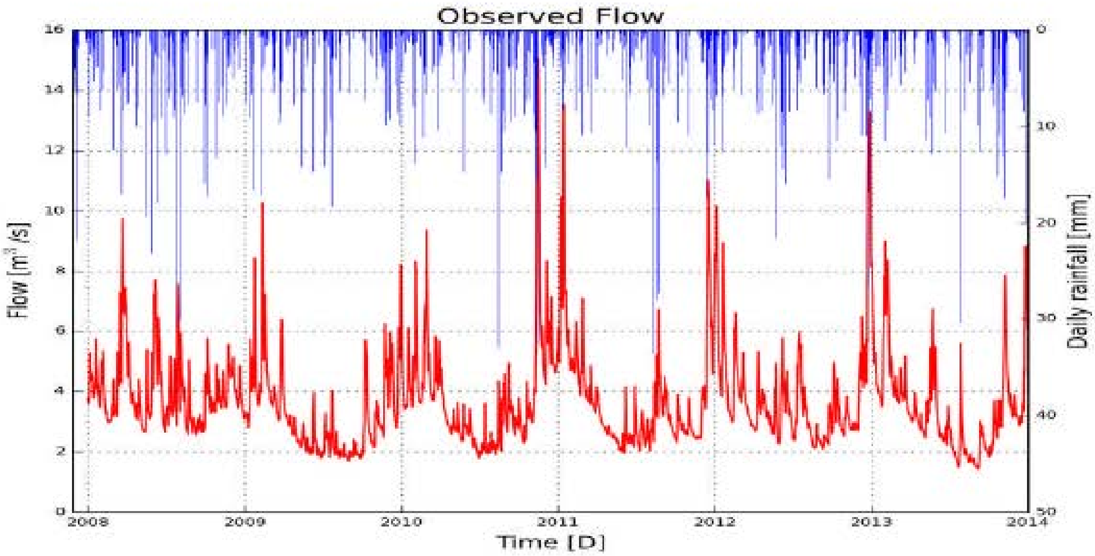


Figure 1: Hyetogram of observed discharge and observed net rain

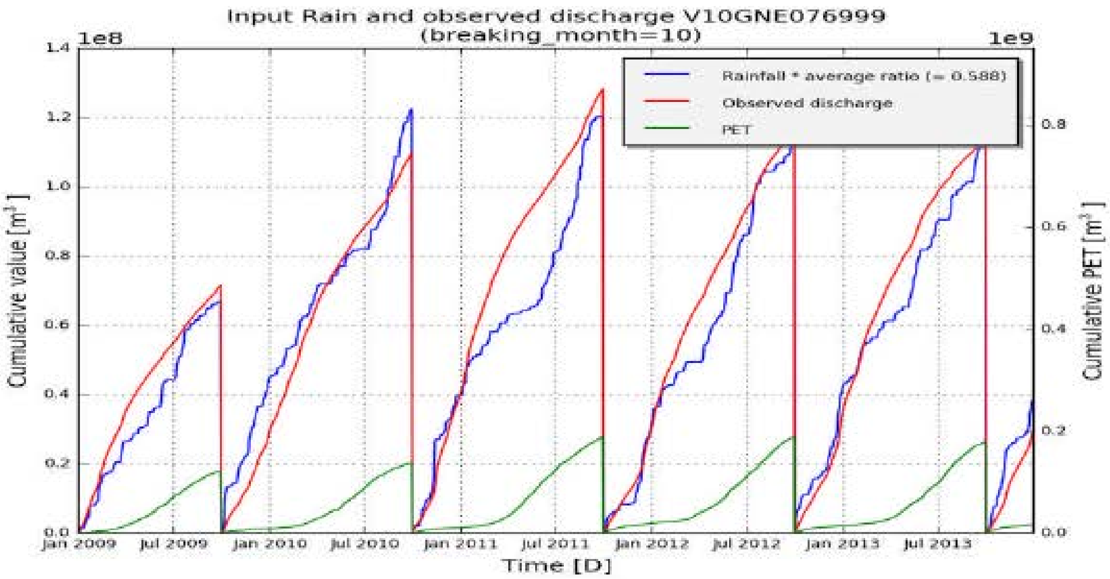


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.1.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V10GNE076999
subcatchment_area	243500000
start_date	200801010000
end_date	201312310000
frequency	86400
warmup	365

9.5.1.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.3, 20.0, 0.0025, 1.05, 160.0, 470.0, 3.9, 130.0]
low_bounds	[0.01, 1.0, 1e-05, 0.1, 1.0, 3.0, 0.1, 1.0]
high_bounds	[15.0, 500.0, 10.0, 100.0, 1000.0, 1000.0, 150.0, 1000.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.3), ('Ki', 20.0), ('Kg', 0.0025), ('Kss', 1.05), ('g0', 160.0), ('g_max', 470.0), ('K_run', 3.9), ('P_max', 130.0)]
Initial fitness:

- RelErr: -0.082
- AbsErr: 29153536.069
- KGE: 0.668
- NS_rel: 0.7
- NS: 0.462

- RMSE: 34706575.944
- NS_log: 0.485

Computation time:1 day, 5:23:33.468000

9.5.1.4 Results

Best individual (euclidian): [('Kep', 1.3), ('Ki', 19.282), ('Kg', 0.003), ('Kss', 2.325), ('g0', 159.75), ('g_max', 470.265), ('K_run', 1.357), ('P_max', 128.782)]

Fitness:

- RelErr: -0.006
- AbsErr: 10409357.964
- KGE: 0.654
- NS_rel: 0.598
- NS: 0.255
- RMSE: 13390501.511
- NS_log: 0.449

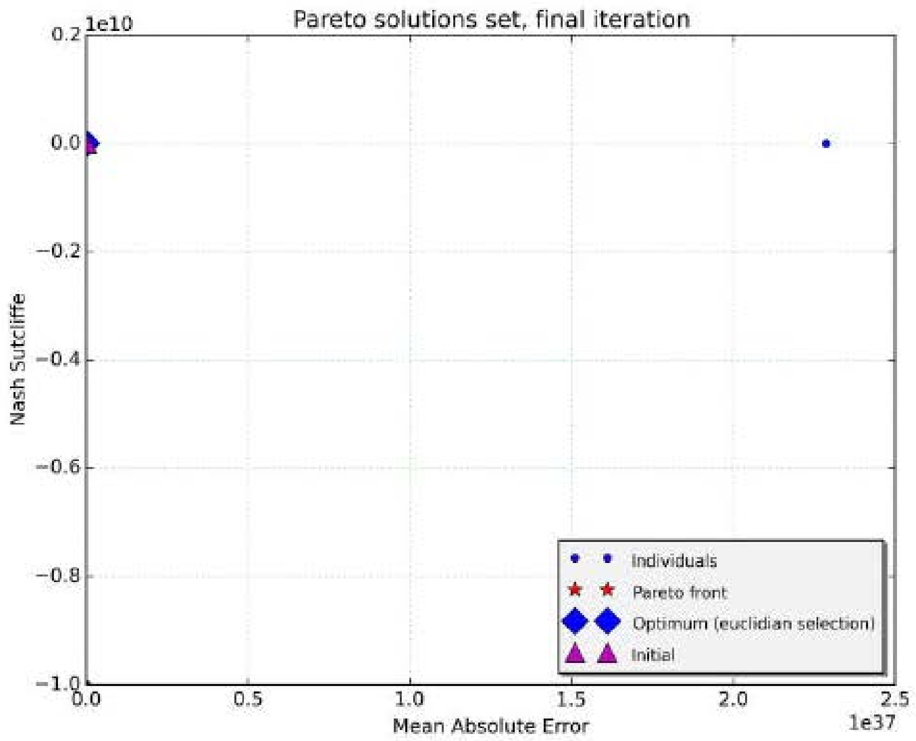


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

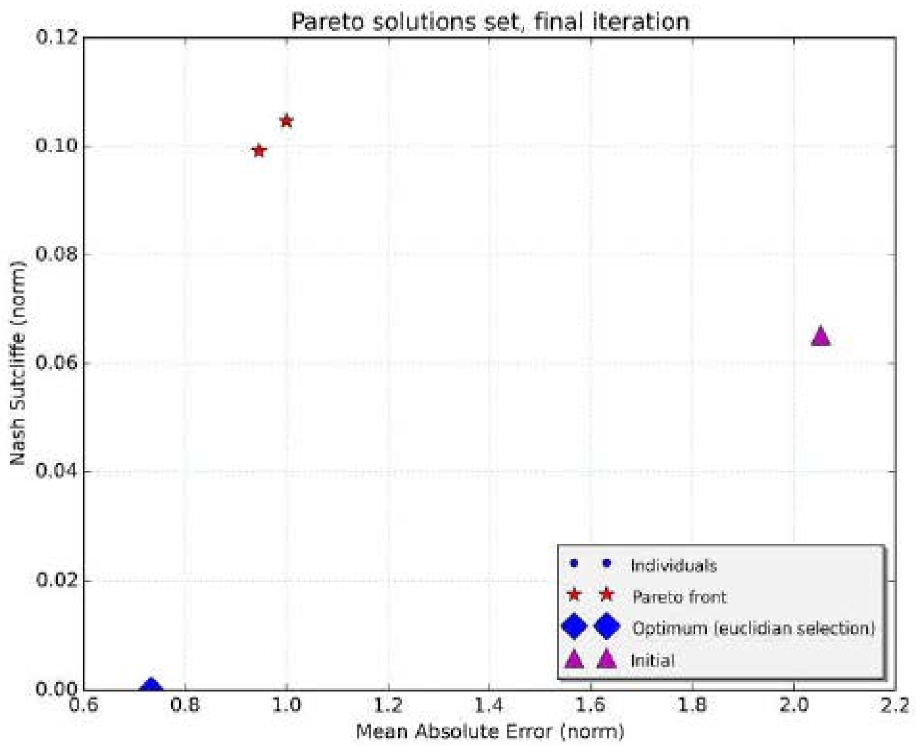


Figure 4: Final population of solutions (Pareto front)

9.5.1.4.1 Initial

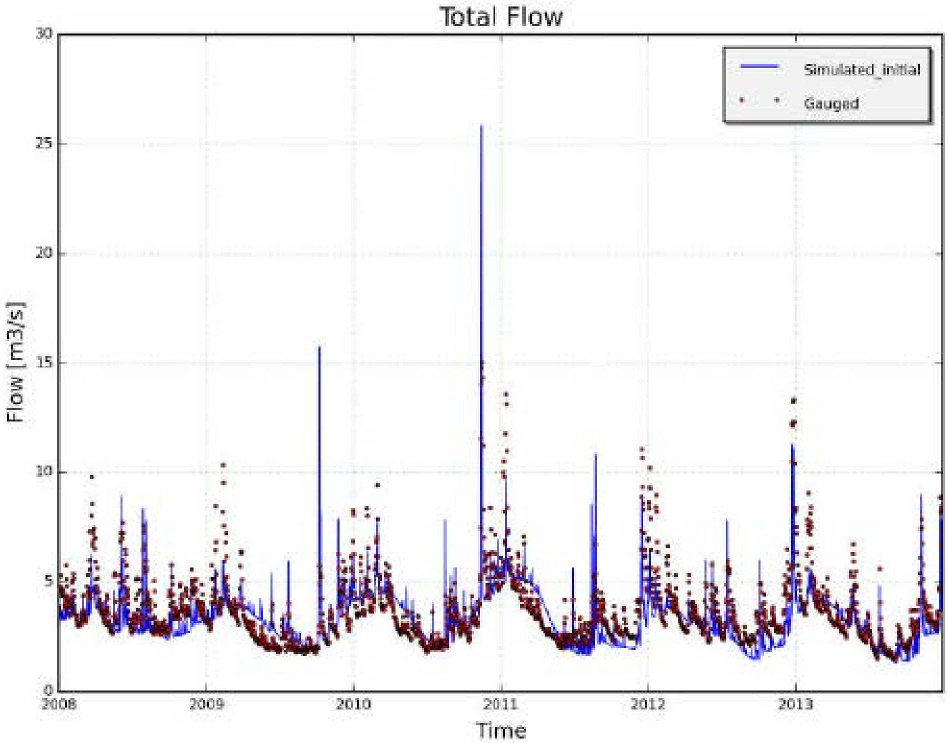


Figure 5: Total flow with initial parameters

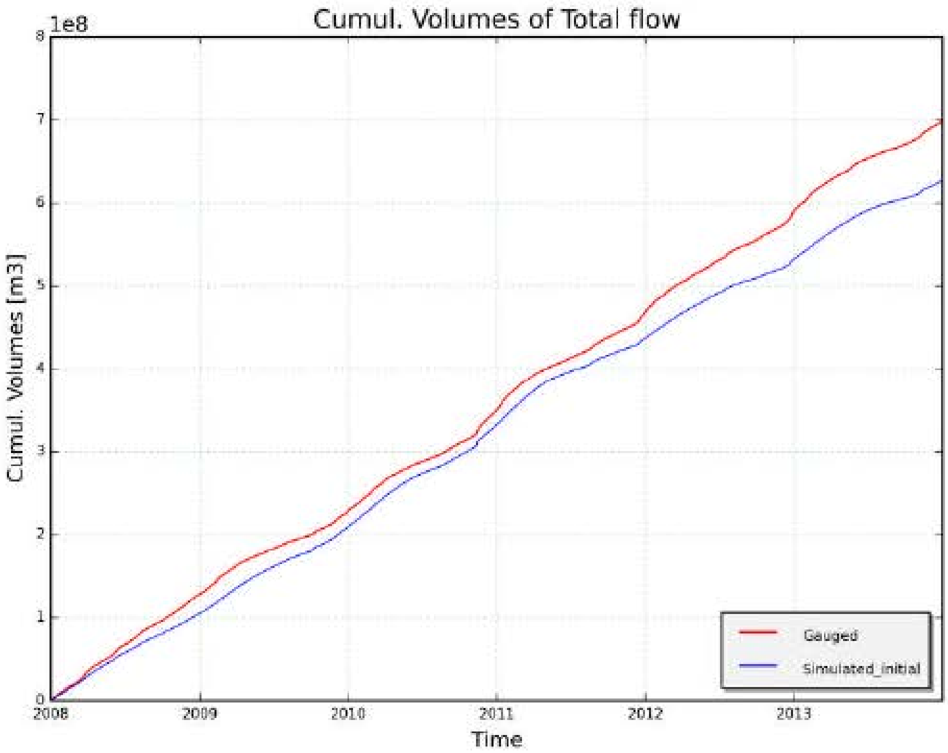


Figure 6: Cumulated flow with initial parameters

9.5.1.4.2 Optimum (euclidian)

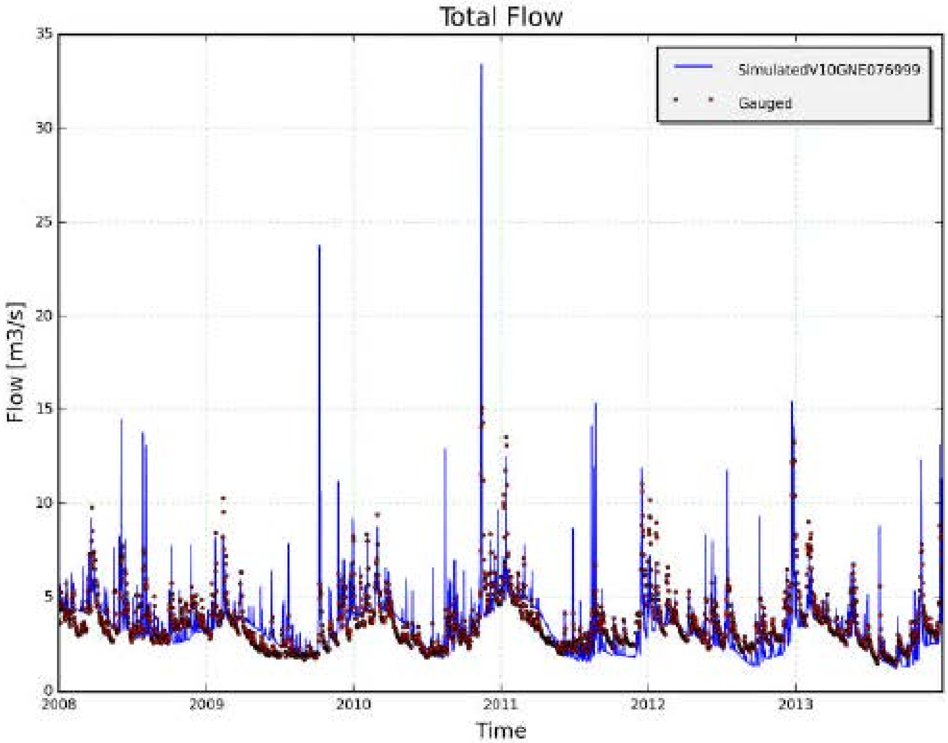


Figure 7: Total flow with optimum parameters

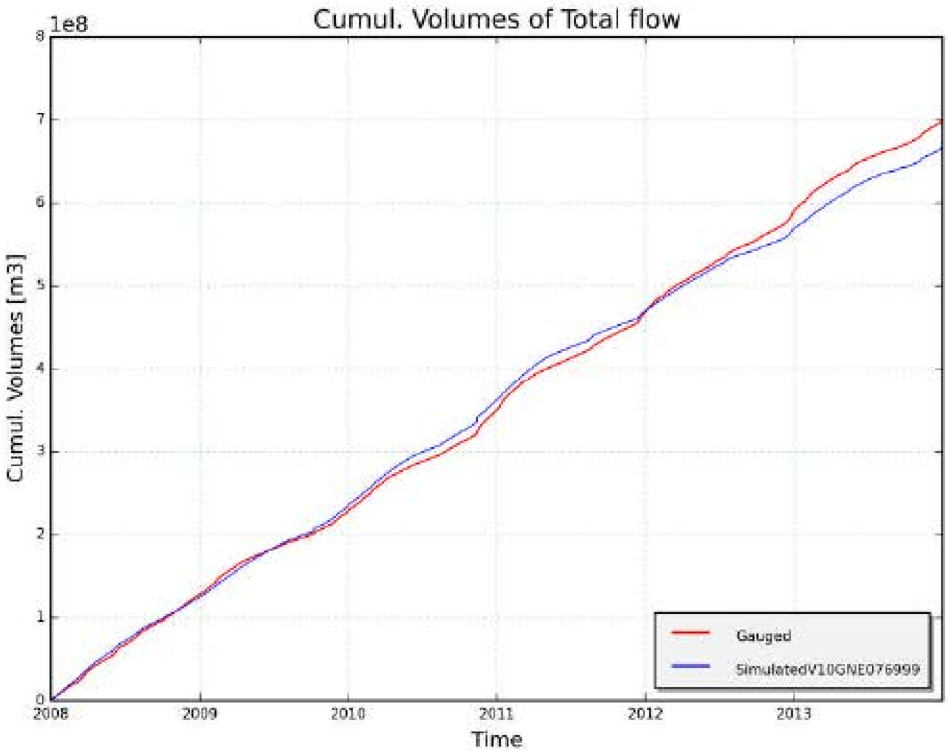


Figure 8: Cumulated flow with optimum parameters

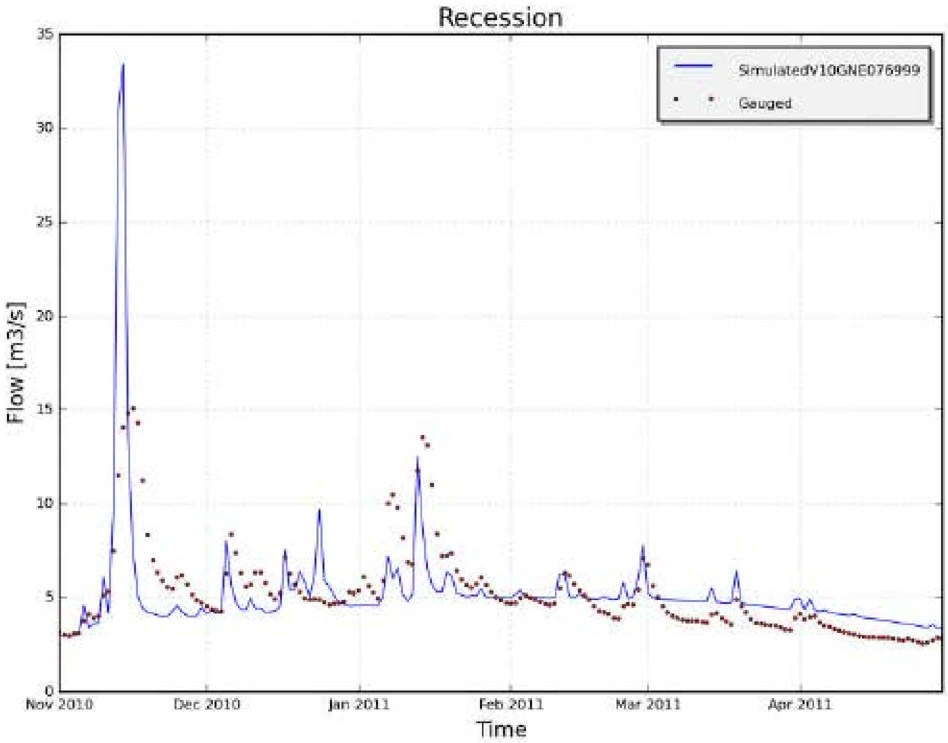


Figure 9: Total flow with optimum parameters (detail)

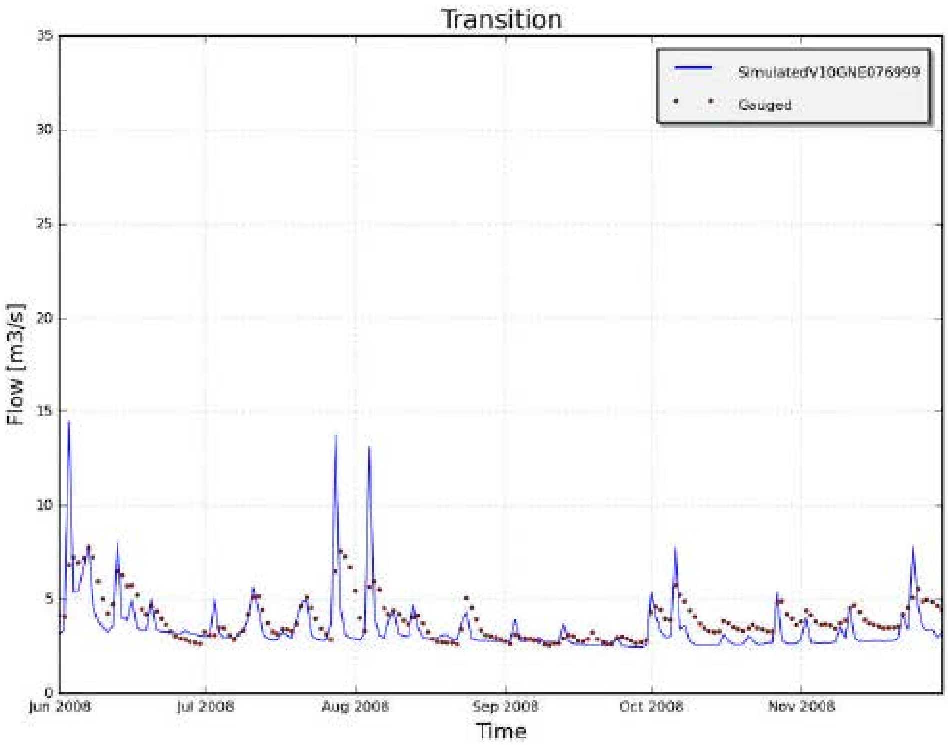
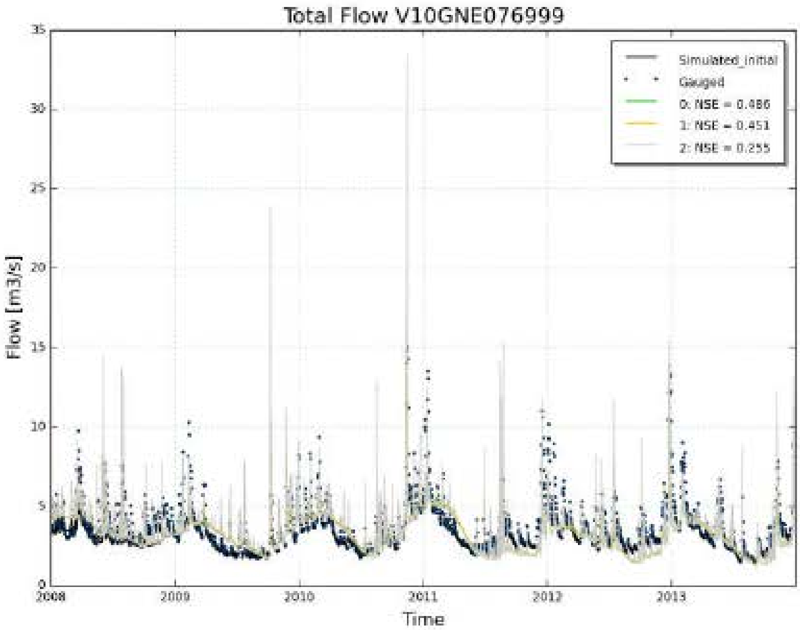
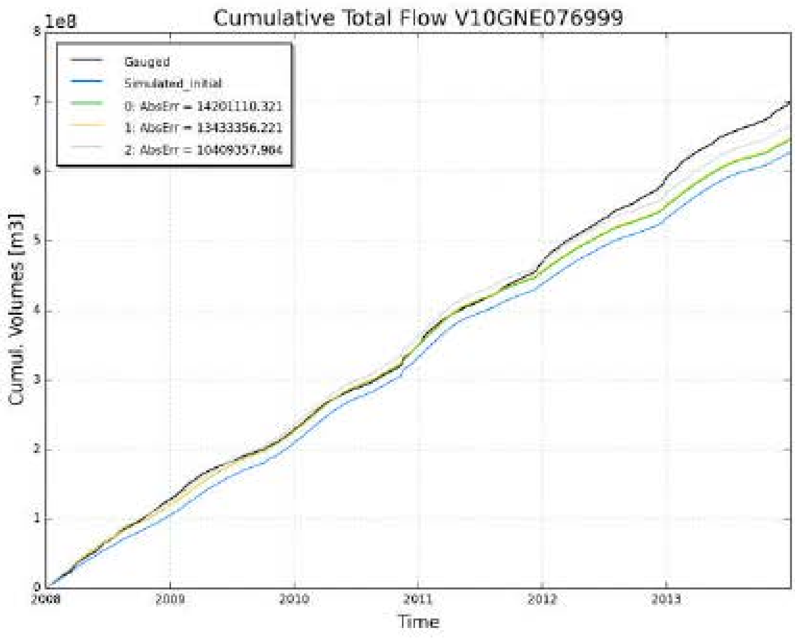


Figure 10: Total flow with optimum parameters (detail)

9.5.1.4.3 Final archive

0 : [1.299, 20.163, 0.003, 2.365, 159.925, 470.088, 4.555, 128.687] : [14201110.321, 0.507]
1 : [1.296, 20.146, 0.003, 2.586, 159.046, 470.719, 2.684, 129.507] : [13433356.221, 0.504]
2 : [1.3, 19.282, 0.003, 2.325, 159.75, 470.265, 1.357, 128.782] : [10409357.964, 0.449]





9.5.2 Report on simulation of catchment V10KNE052000 (2017-02-03 00-39)

9.5.2.1 Input data

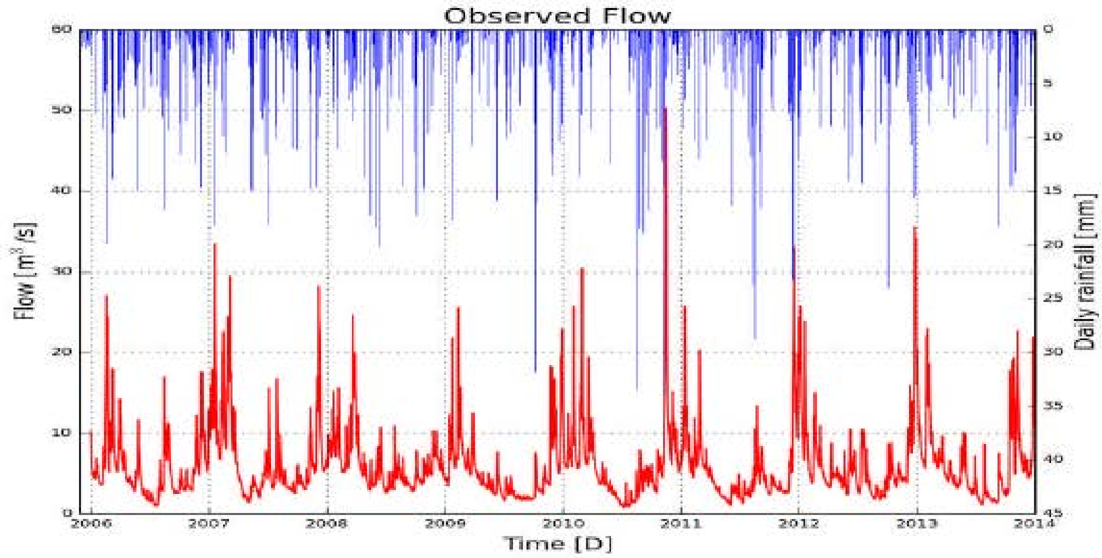


Figure 1: Hyetogram of observed discharge and observed net rain

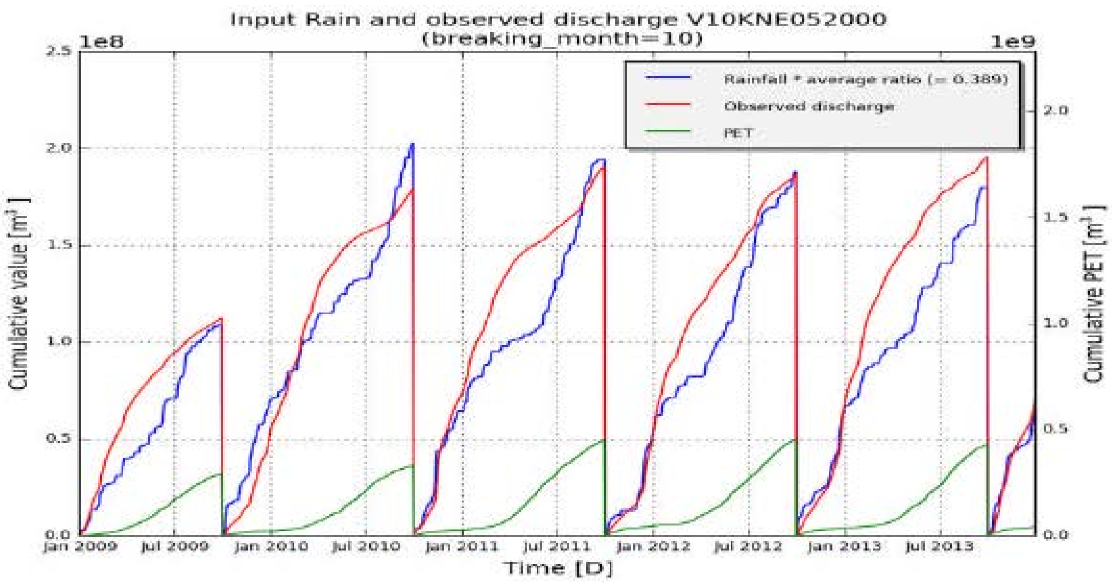


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.2.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	V10KNE052000
subcatchment_area	584669408
start_date	200801010000
end_date	201312310000
frequency	86400
warmup	365

9.5.2.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.48, 95.1, 0.009, 2.02, 81.27, 334.288, 0.78, 20.1]
low_bounds	[1.18, 76.08, 0.0072, 1.62, 64.9, 267.3, 0.6, 16.0]
high_bounds	[1.7, 150.0, 0.01, 3.0, 120.0, 400.0, 2.0, 50.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.48), ('Ki', 95.1), ('Kg', 0.009), ('Kss', 2.02), ('g0', 81.27), ('g_max', 334.288), ('K_run', 0.78), ('P_max', 20.1)]
Initial fitness:

- RelErr: 0.008
- AbsErr: 22209899.348
- KGE: 0.775
- NS_rel: 0.734
- NS: 0.578
- RMSE: 25780991.911
- NS_log: 0.687

Computation time:9 days, 7:24:50.357000

9.5.2.4 Results

Best individual (euclidian): [('Kep', 1.445), ('Ki', 113.712), ('Kg', 0.009), ('Kss', 2.856), ('g0', 87.22), ('g_max', 304.771), ('K_run', 2.0), ('P_max', 40.577)]

Fitness:

- RelErr: -0.003
- AbsErr: 20013987.335
- KGE: 0.771
- NS_rel: 0.77
- NS: 0.568
- RMSE: 23525543.185
- NS_log: 0.715

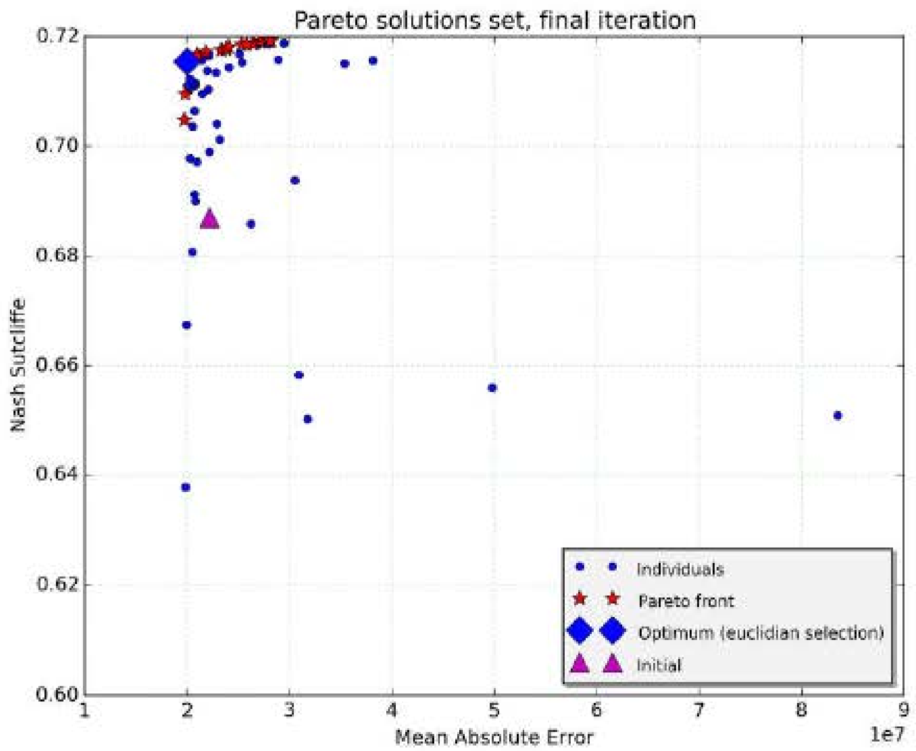


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

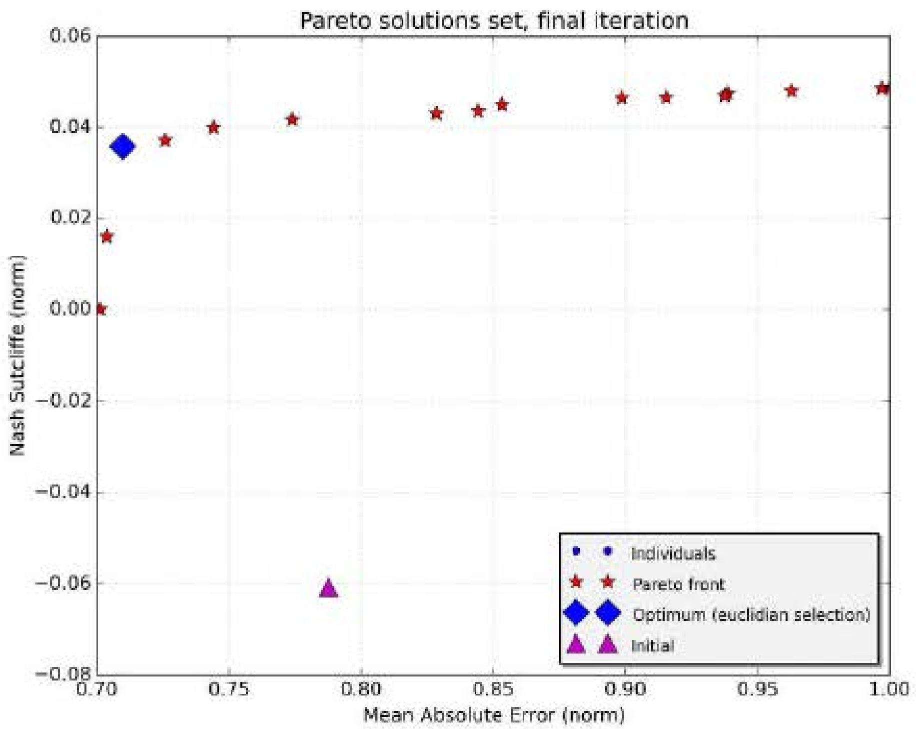


Figure 4: Final population of solutions (Pareto front)

9.5.2.4.1 Initial

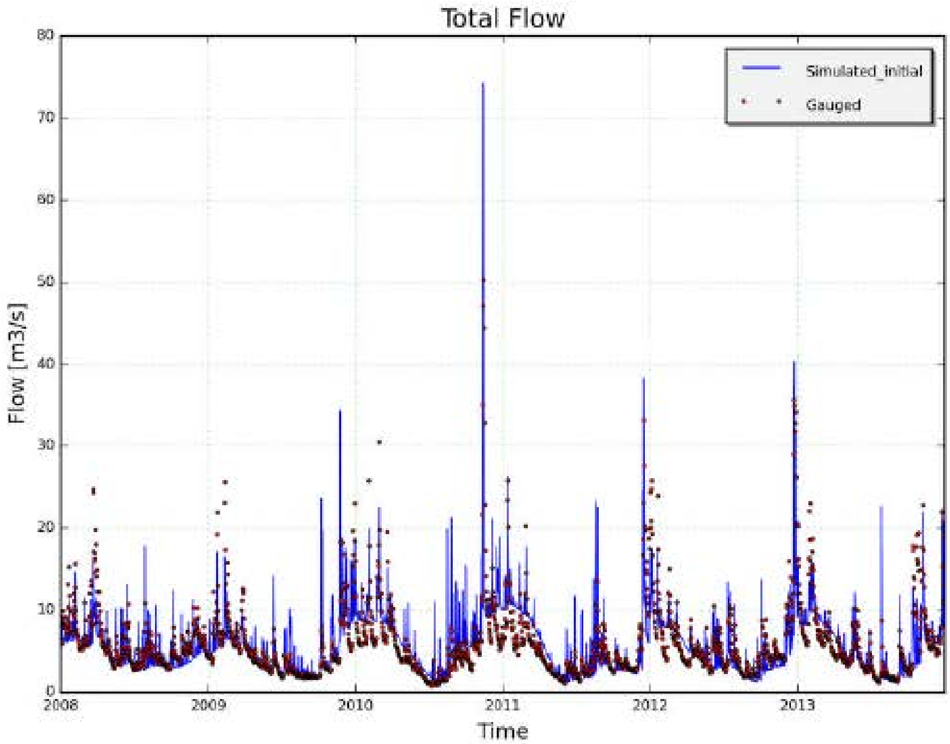


Figure 5: Total flow with initial parameters

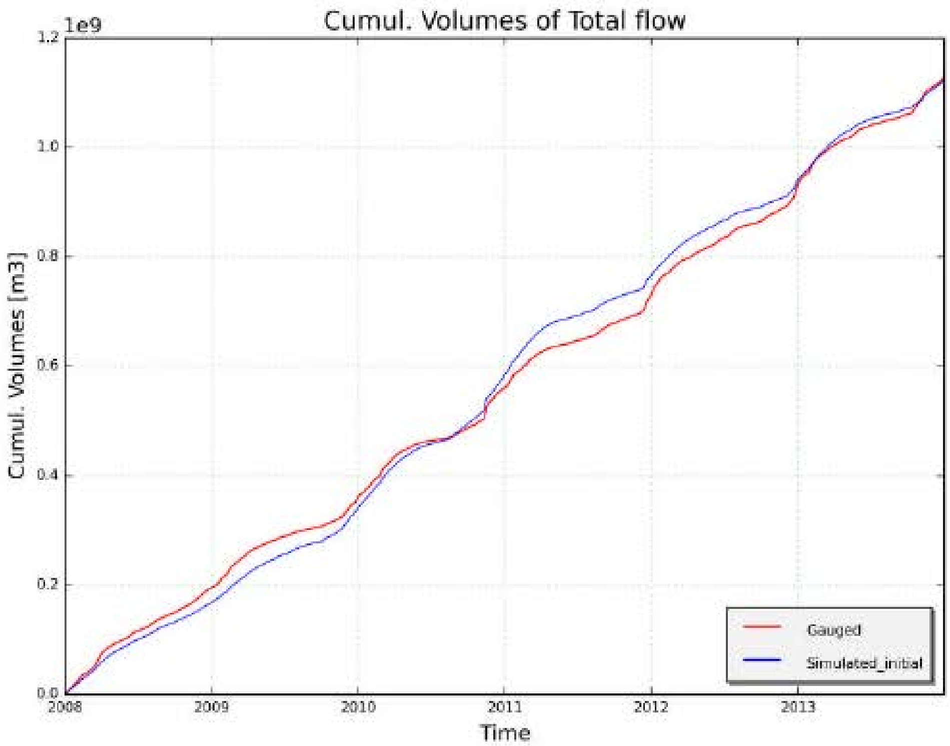


Figure 6: Cumulated flow with initial parameters

9.5.2.4.2 Optimum (euclidian)

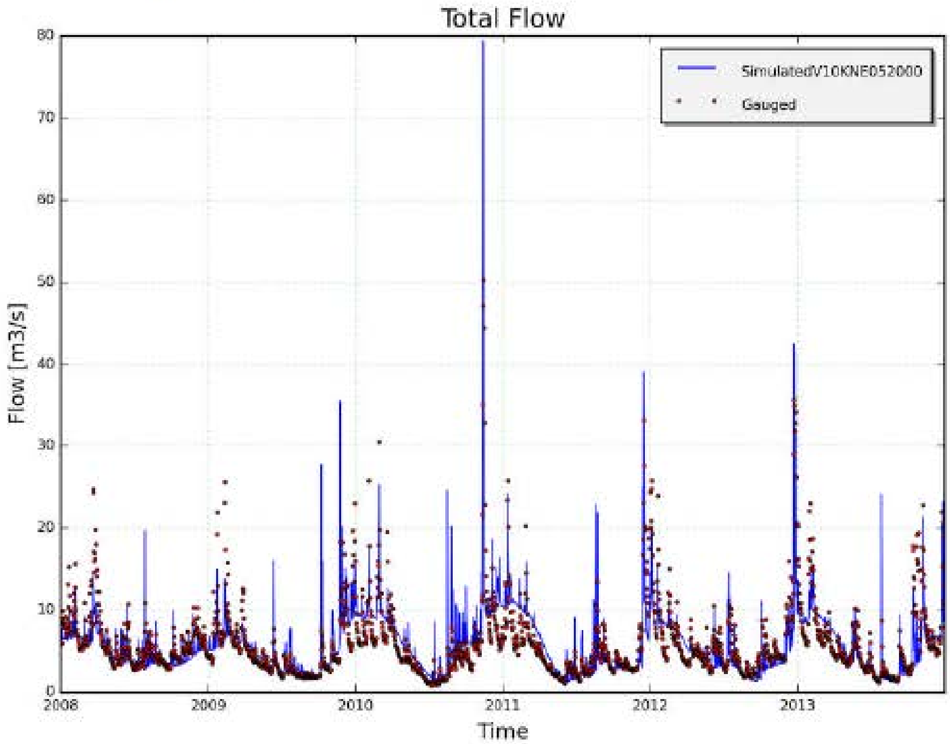


Figure 7: Total flow with optimum parameters

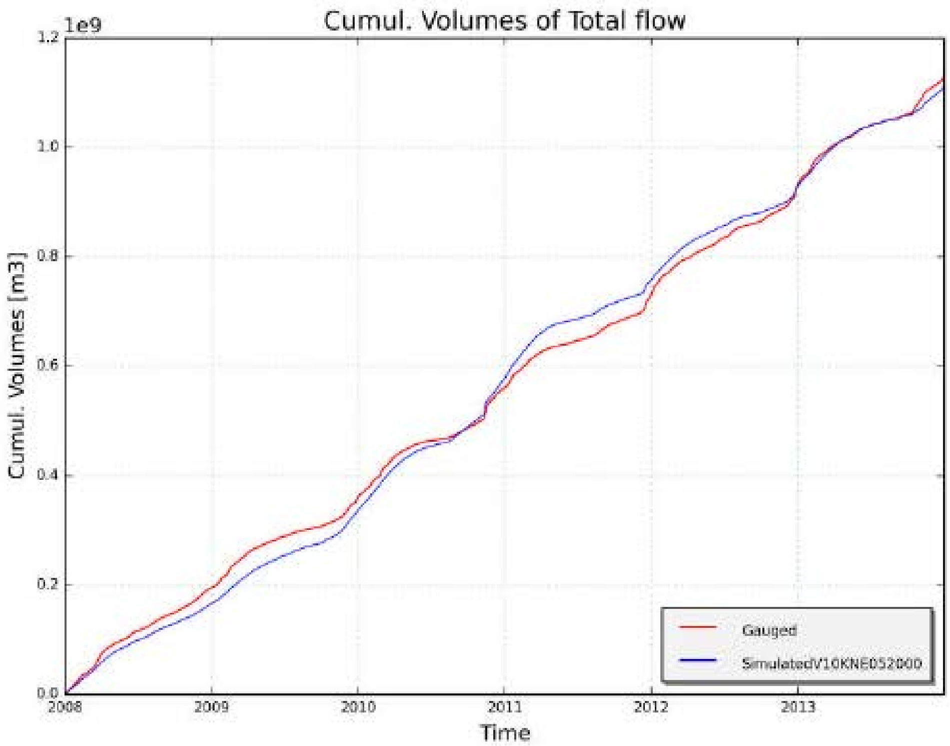


Figure 8: Cumulated flow with optimum parameters

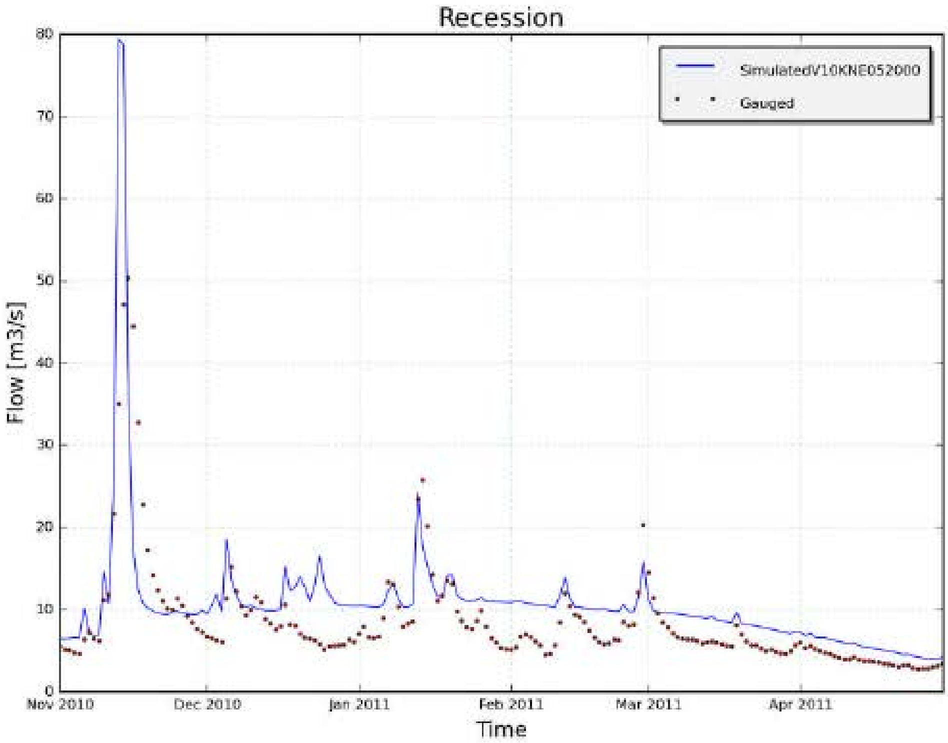


Figure 9: Total flow with optimum parameters (detail)

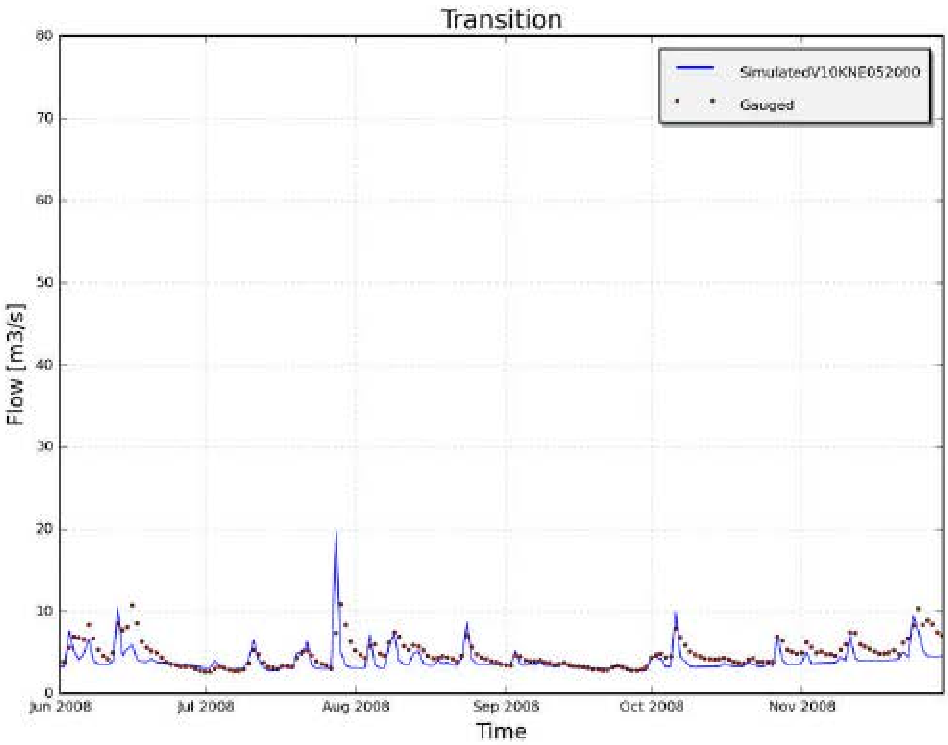
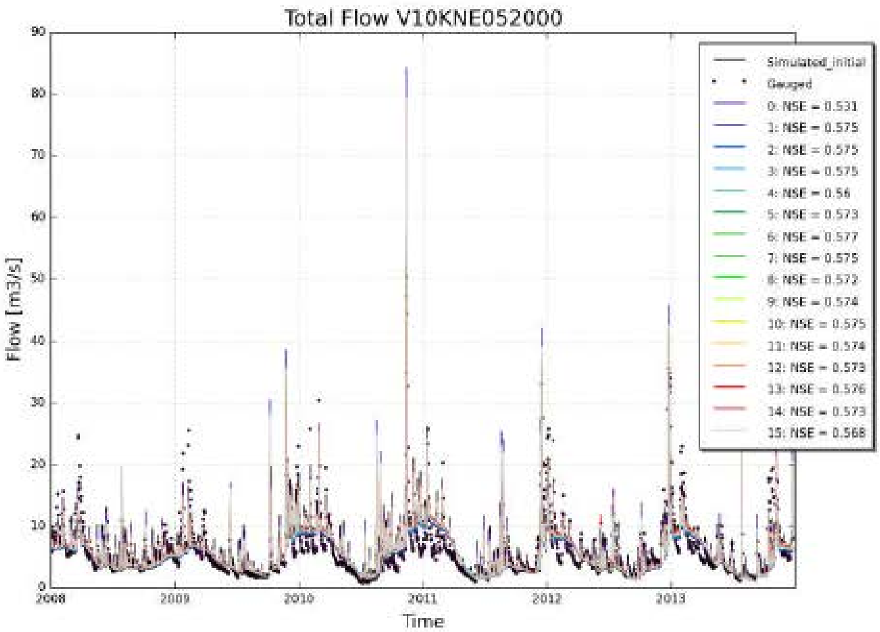
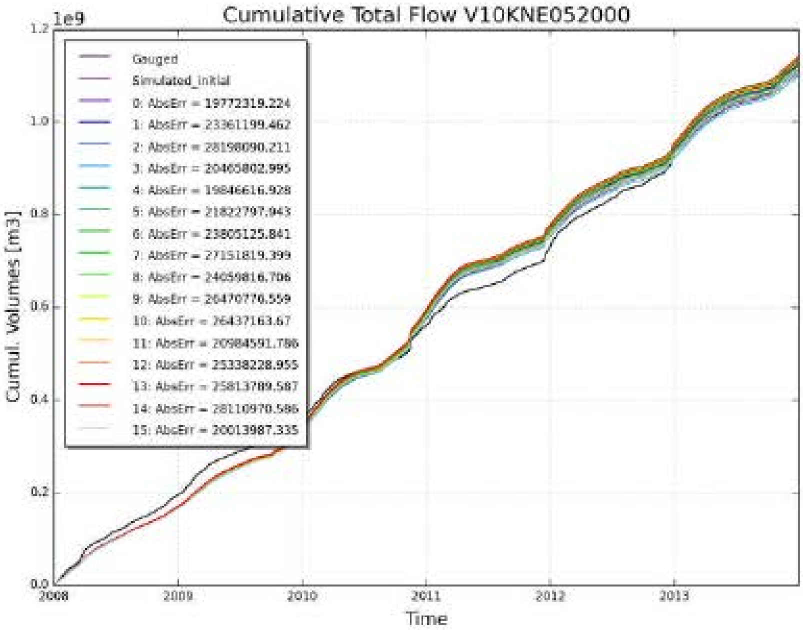


Figure 10: Total flow with optimum parameters (detail)

9.5.2.4.3 Final archive

0 : [1.42, 124.994, 0.008, 3.0, 76.199, 332.613, 1.529, 36.255] : [19772319.224, 0.705]
1 : [1.447, 110.818, 0.01, 2.784, 86.724, 304.699, 1.917, 43.121] : [23361199.462, 0.718]
2 : [1.432, 111.631, 0.01, 1.995, 86.658, 302.624, 2.0, 42.816] : [28198090.211, 0.719]
3 : [1.43, 107.958, 0.009, 2.006, 85.392, 302.577, 1.964, 40.242] : [20465802.995, 0.716]
4 : [1.437, 112.384, 0.008, 2.863, 83.904, 331.371, 2.0, 36.979] : [19846616.928, 0.71]
5 : [1.439, 112.306, 0.009, 2.865, 85.666, 305.048, 2.0, 42.335] : [21822797.943, 0.717]
6 : [1.46, 110.863, 0.01, 2.803, 87.18, 304.967, 2.0, 43.568] : [23805125.841, 0.718]
7 : [1.441, 112.085, 0.01, 2.077, 86.805, 304.765, 2.0, 43.593] : [27151819.399, 0.719]
8 : [1.446, 112.298, 0.01, 2.907, 86.269, 301.33, 1.973, 41.543] : [24059816.706, 0.718]
9 : [1.445, 112.142, 0.01, 2.554, 88.212, 303.506, 1.997, 42.935] : [26470776.559, 0.719]
10 : [1.445, 110.909, 0.01, 1.62, 86.725, 303.725, 1.95, 42.934] : [26437163.67, 0.719]
11 : [1.44, 110.783, 0.009, 2.419, 86.672, 303.968, 1.963, 42.576] : [20984591.786, 0.717]
12 : [1.446, 112.43, 0.01, 2.928, 86.209, 304.368, 1.981, 42.698] : [25338228.955, 0.719]
13 : [1.448, 111.138, 0.01, 2.008, 86.808, 304.911, 2.0, 43.594] : [25813789.587, 0.719]
14 : [1.431, 112.273, 0.01, 2.841, 86.332, 303.04, 2.0, 42.231] : [28110970.586, 0.719]
15 : [1.445, 113.712, 0.009, 2.856, 87.22, 304.771, 2.0, 40.577] : [20013987.335, 0.715]





9.5.3 Report on simulation of catchment V10MOP062140 (2017-01-24 08-08)

9.5.3.1 Input data

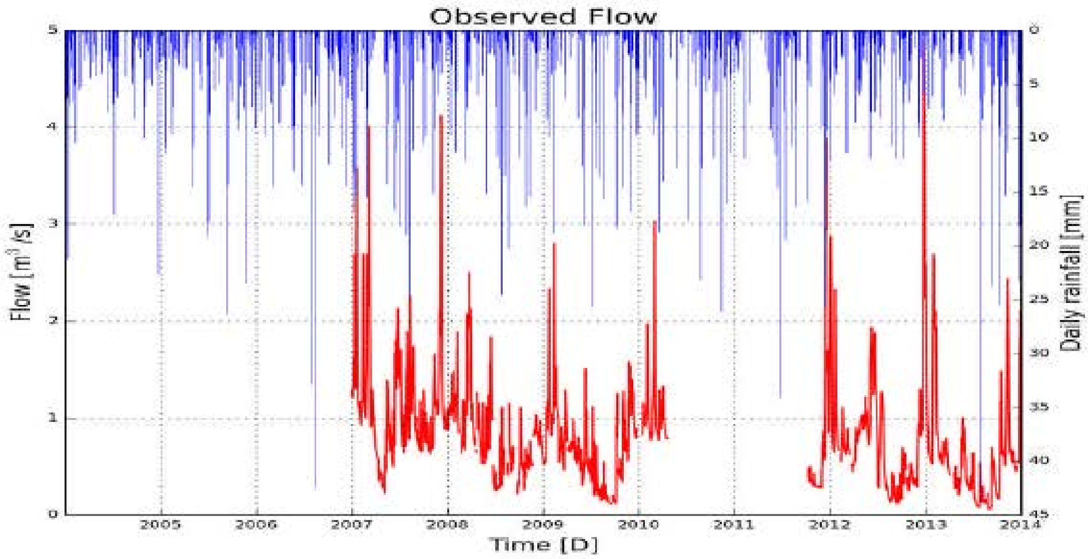


Figure 1: Hyetogram of observed discharge and observed net rain

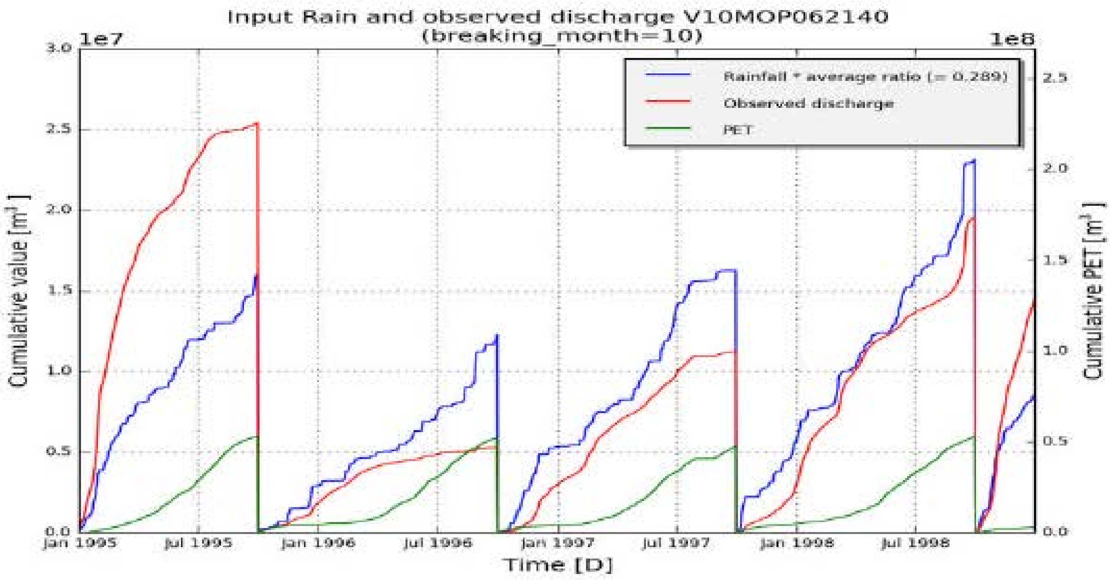


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.3.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V10MOP062140
subcatchment_area	77319091
start_date	200501010000
end_date	201312310000
frequency	86400
warmup	365

9.5.3.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[1.1, 40.0, 0.008, 1.0, 50.0, 150.0, 1.7, 50.0]
low_bounds	[0.5, 20.0, 0.004, 0.5, 25.0, 50.0, 0.85, 25.0]
high_bounds	[3.0, 160.0, 0.01, 3.0, 150.0, 450.0, 5.0, 300.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.1), ('Ki', 40.0), ('Kg', 0.008), ('Kss', 1.0), ('g0', 50.0), ('g_max', 150.0), ('K_run', 1.7), ('P_max', 50.0)]
Initial fitness:

- RelErr: 0.799
- AbsErr: 60418984.032
- KGE: -0.033
- NS_rel: -4.855
- NS: -1.776
- RMSE: 71279059.143
- NS_log: -0.508

Computation time:14:46:51.102000

9.5.3.4 Results

Best individual (euclidian): [('Kep', 2.322), ('Ki', 127.977), ('Kg', 0.004), ('Kss', 2.866), ('g0', 60.368), ('g_max', 434.182), ('K_run', 3.955), ('P_max', 171.177)]

Fitness:

- RelErr: -0.033
- AbsErr: 4426042.119
- KGE: 0.565
- NS_rel: 0.047
- NS: 0.037
- RMSE: 5599467.709
- NS_log: 0.45

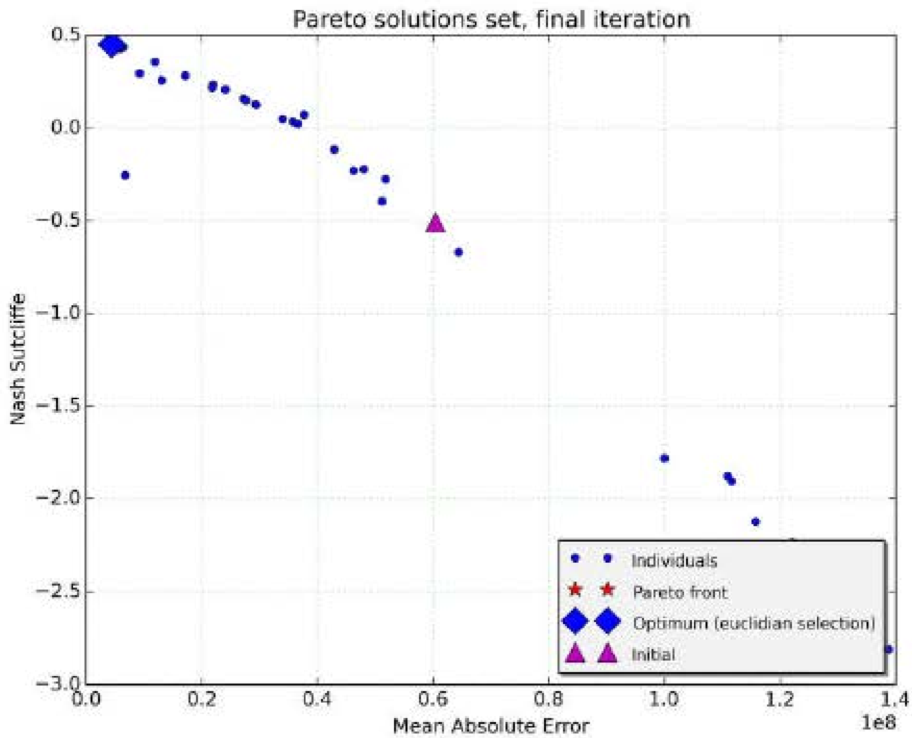


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

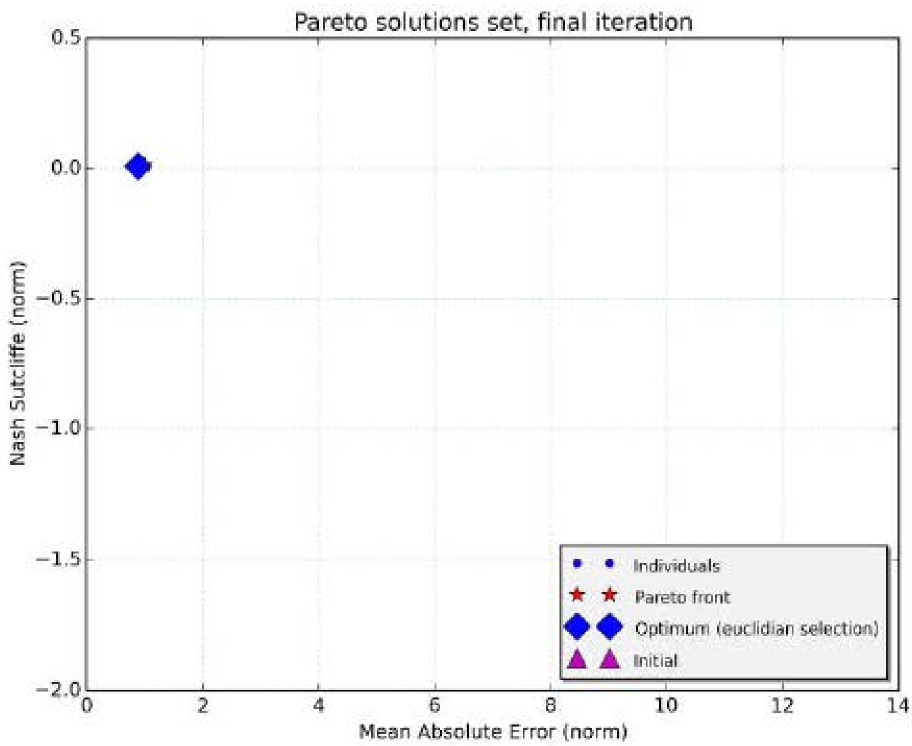


Figure 4: Final population of solutions (Pareto front)

9.5.3.4.1 Initial

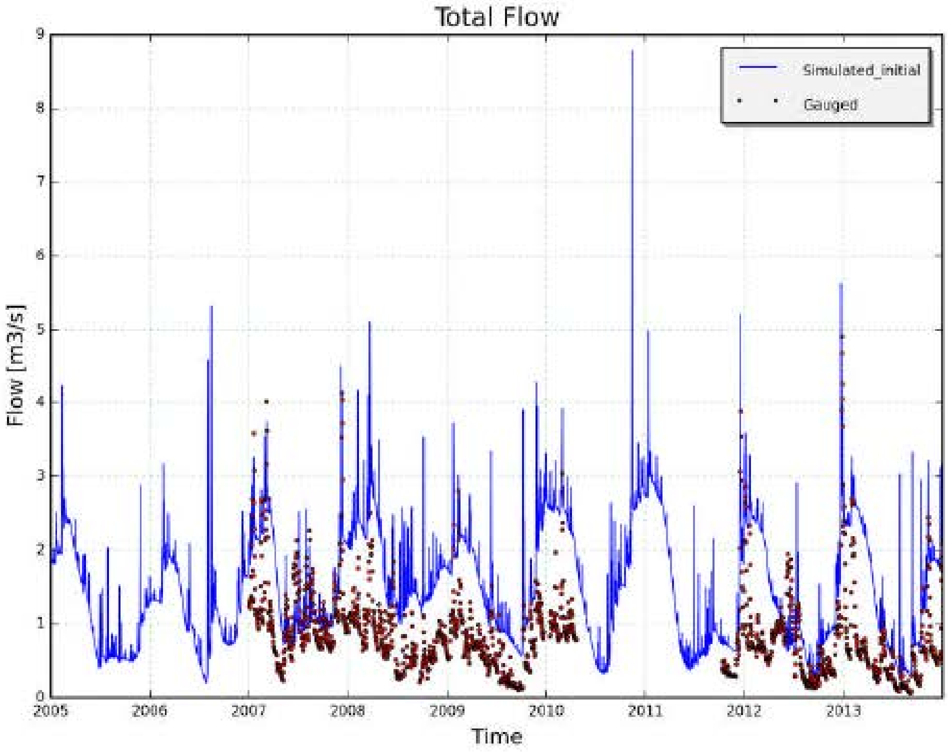


Figure 5: Total flow with initial parameters

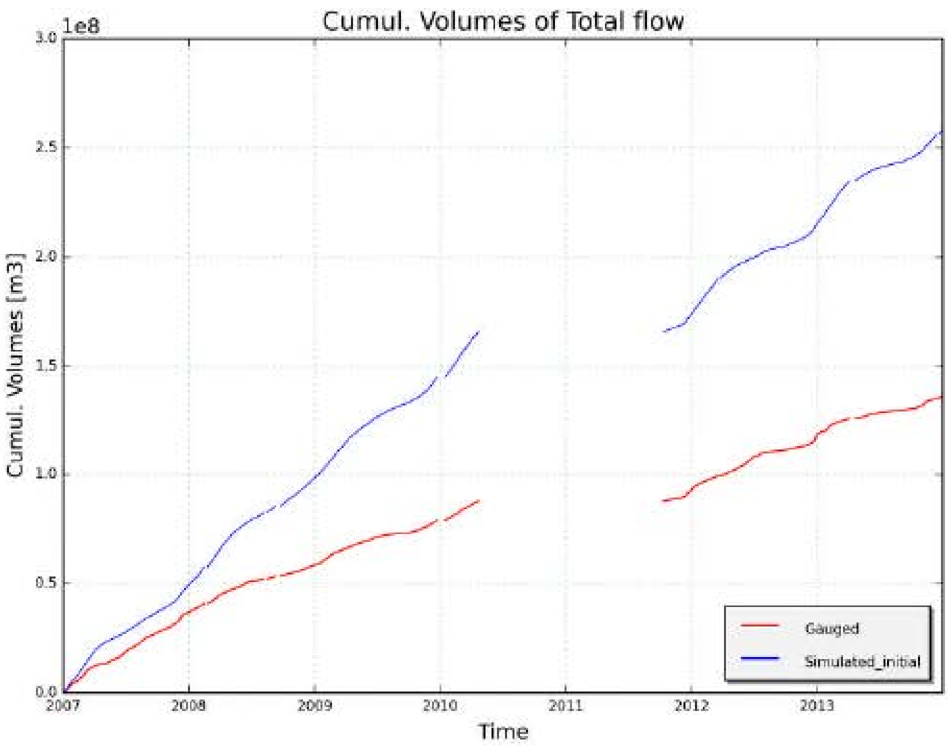


Figure 6: Cumulated flow with initial parameters

9.5.3.4.2 Optimum (euclidian)

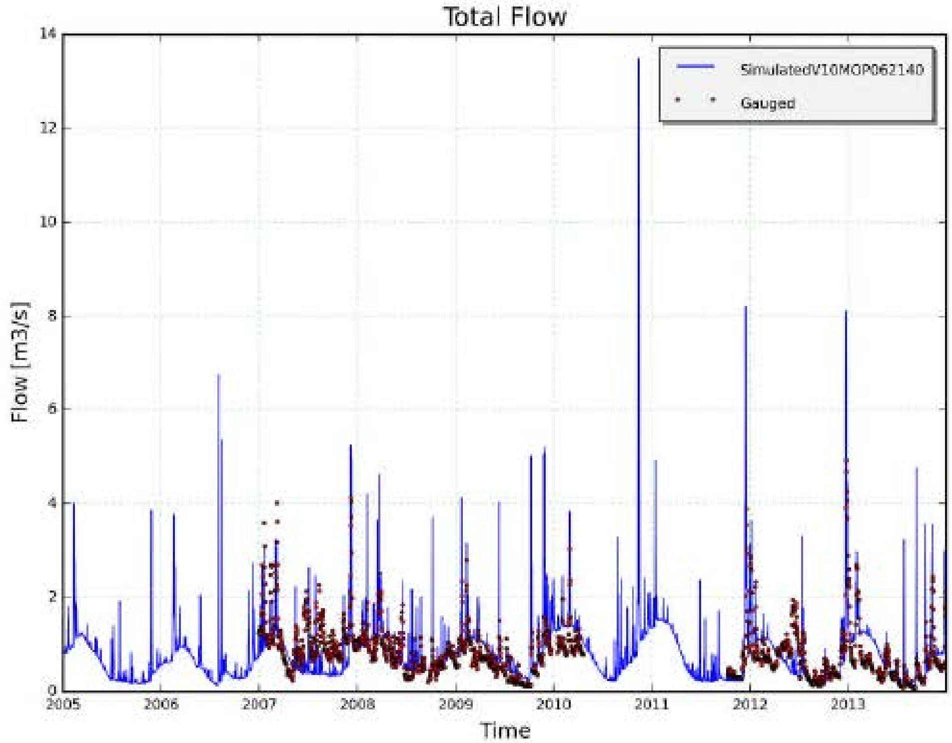


Figure 7: Total flow with optimum parameters

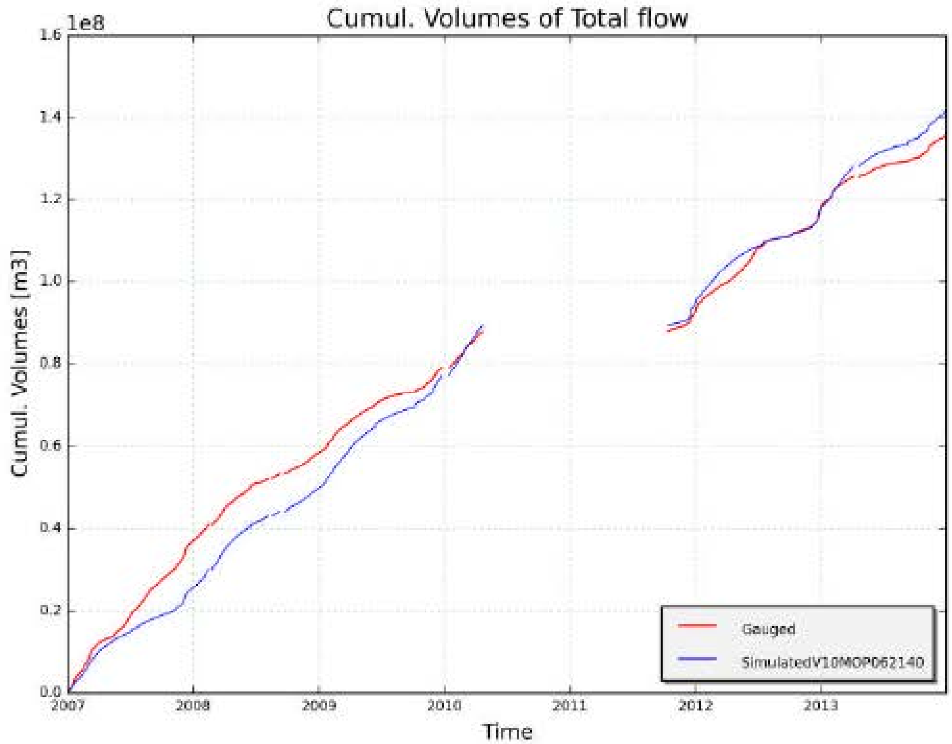


Figure 8: Cumulated flow with optimum parameters

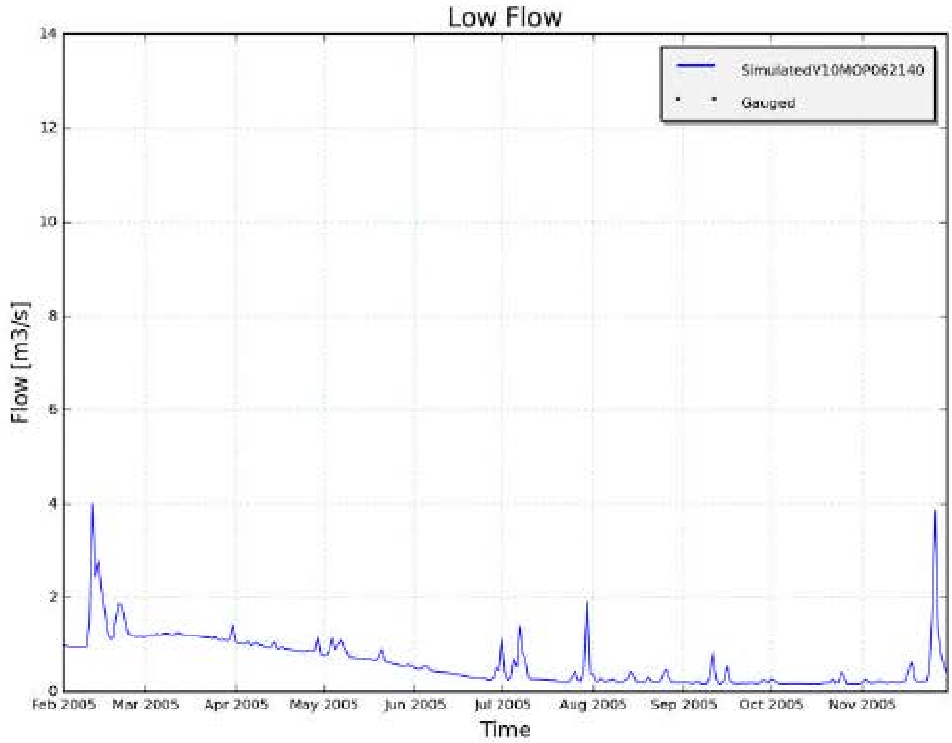


Figure 9: Total flow with optimum parameters (detail)

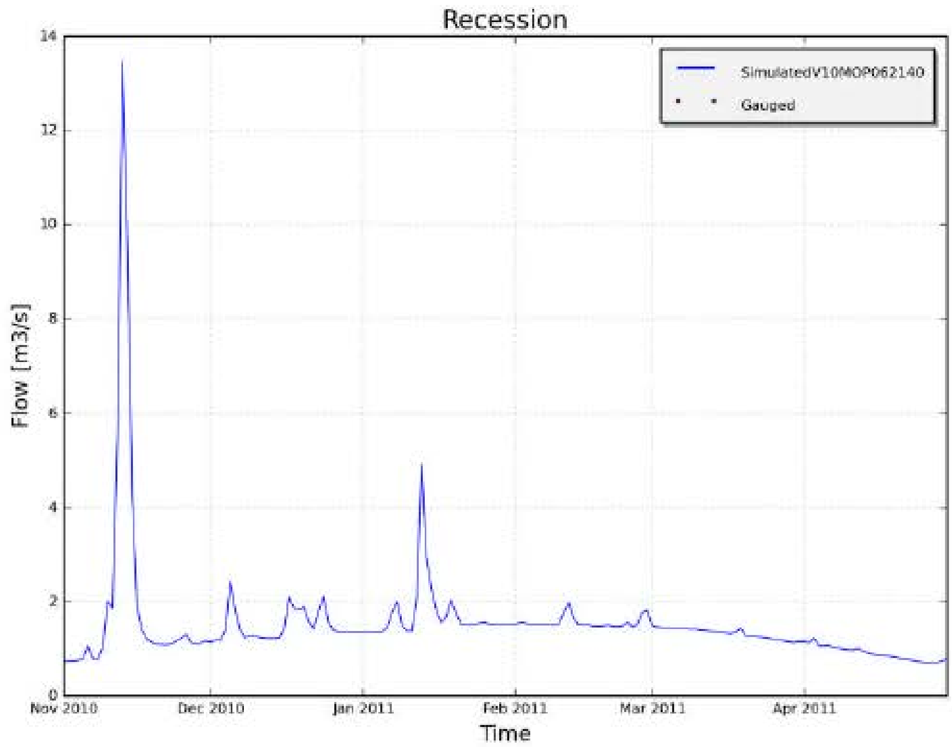


Figure 10: Total flow with optimum parameters (detail)

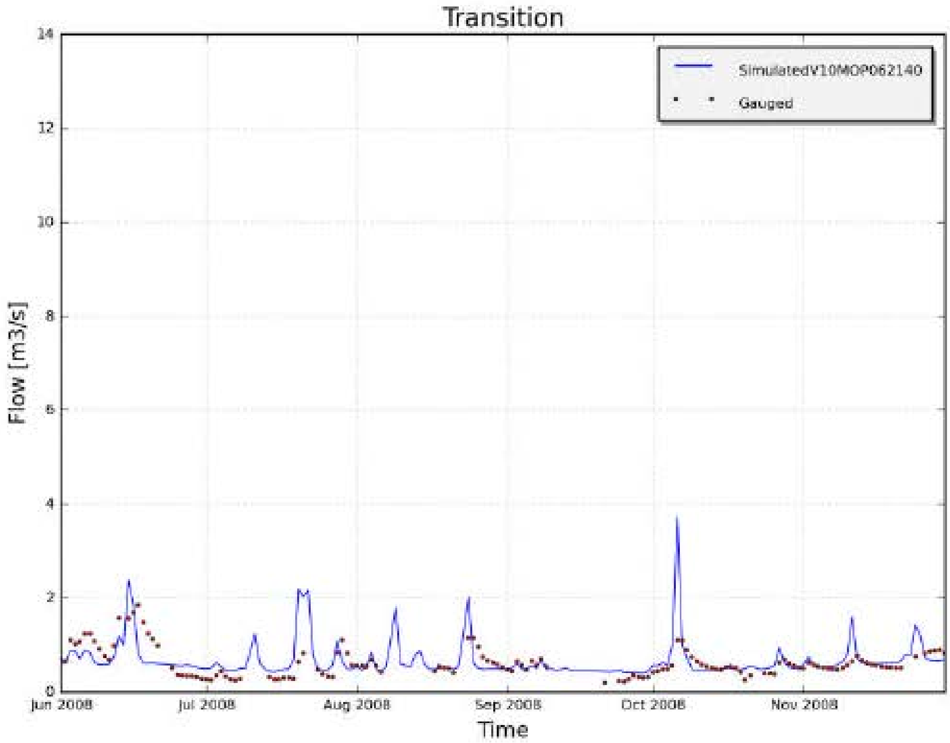
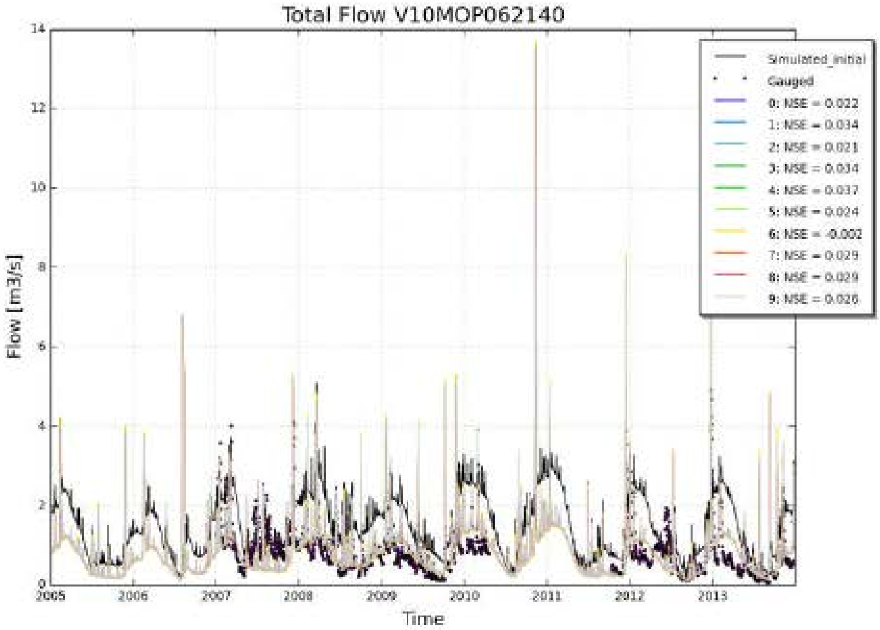
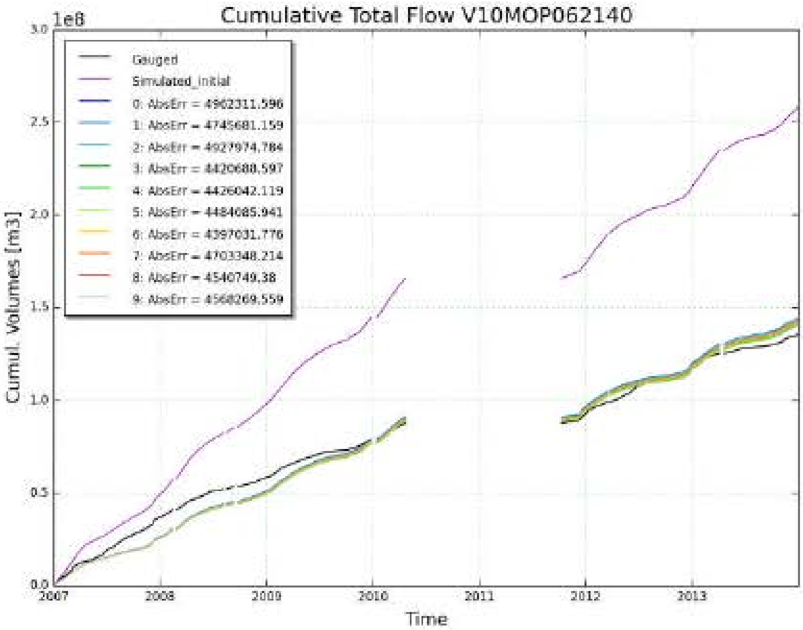


Figure 11: Total flow with optimum parameters (detail)

9.5.3.4.3 Final archive

0 : [2.22, 127.78, 0.004, 1.938, 63.654, 405.413, 4.931, 165.341] : [4962311.596, 0.453]
1 : [2.292, 127.798, 0.004, 2.668, 59.667, 438.23, 3.033, 172.267] : [4745681.159, 0.452]
2 : [2.227, 127.983, 0.004, 0.752, 64.358, 408.084, 5.0, 165.986] : [4927974.784, 0.453]
3 : [2.293, 127.799, 0.004, 2.225, 60.145, 410.457, 4.209, 166.581] : [4420688.597, 0.448]
4 : [2.322, 127.977, 0.004, 2.866, 60.368, 434.182, 3.955, 171.177] : [4426042.119, 0.45]
5 : [2.28, 129.321, 0.004, 2.637, 60.636, 418.156, 3.125, 171.878] : [4484085.941, 0.451]
6 : [2.293, 129.448, 0.004, 0.5, 63.519, 419.761, 1.972, 170.038] : [4397031.776, 0.446]
7 : [2.292, 128.178, 0.004, 3.0, 59.897, 432.482, 4.431, 171.149] : [4703348.214, 0.452]
8 : [2.275, 127.977, 0.004, 1.622, 63.631, 415.661, 4.916, 166.242] : [4540749.38, 0.451]
9 : [2.257, 128.139, 0.004, 0.907, 64.187, 408.297, 4.405, 169.303] : [4568269.559, 0.451]


Total Flow V10MOP062140
Flow [m3/s]
Time
Simulated_initial
Gauged
0: NSE = 0.022
1: NSE = 0.034
2: NSE = 0.021
3: NSE = 0.034
4: NSE = 0.037
5: NSE = 0.024
6: NSE = -0.002
7: NSE = 0.029
8: NSE = 0.029
9: NSE = 0.026
0
2
4
6
8
10
12
14
2005
2006
2007
2008
2009
2010
2011
2012
2013


Cumulative Total Flow V10MOP062140
1e8
Cumul. Volumes [m3]
Time
Gauged
Simulated_initial
0: AbsErr = 4962311.596
1: AbsErr = 4745681.159
2: AbsErr = 4927974.784
3: AbsErr = 4420688.597
4: AbsErr = 4426042.119
5: AbsErr = 4484085.941
6: AbsErr = 4397031.776
7: AbsErr = 4703348.214
8: AbsErr = 4540749.38
9: AbsErr = 4568269.559
0.0
0.5
1.0
1.5
2.0
2.5
3.0
2007
2008
2009
2010
2011
2012
2013

9.5.4 Report on simulation of catchment V10WIM082050 (2017-01-25 01-21)

9.5.4.1 Input data

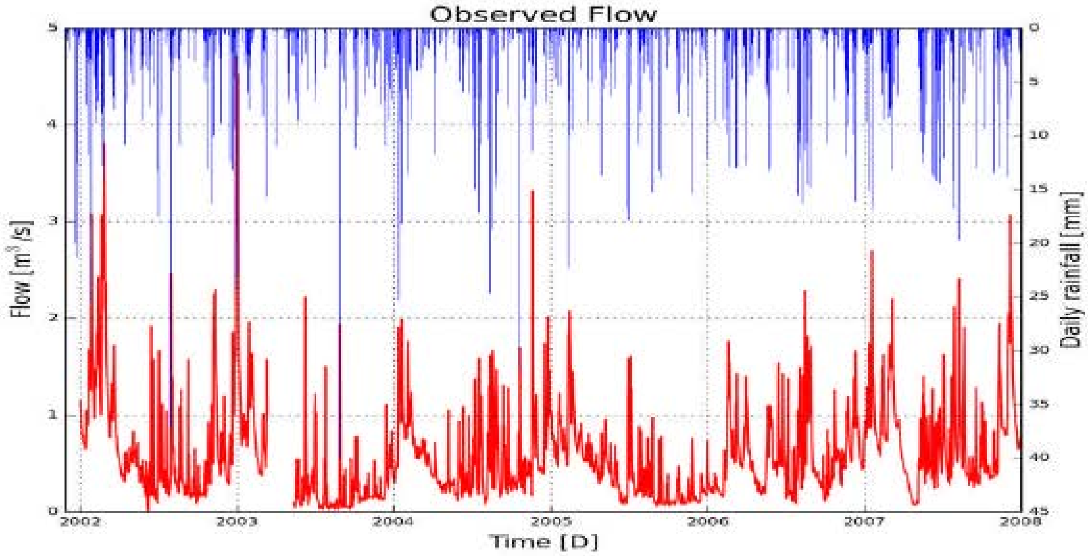


Figure 1: Hyetogram of observed discharge and observed net rain

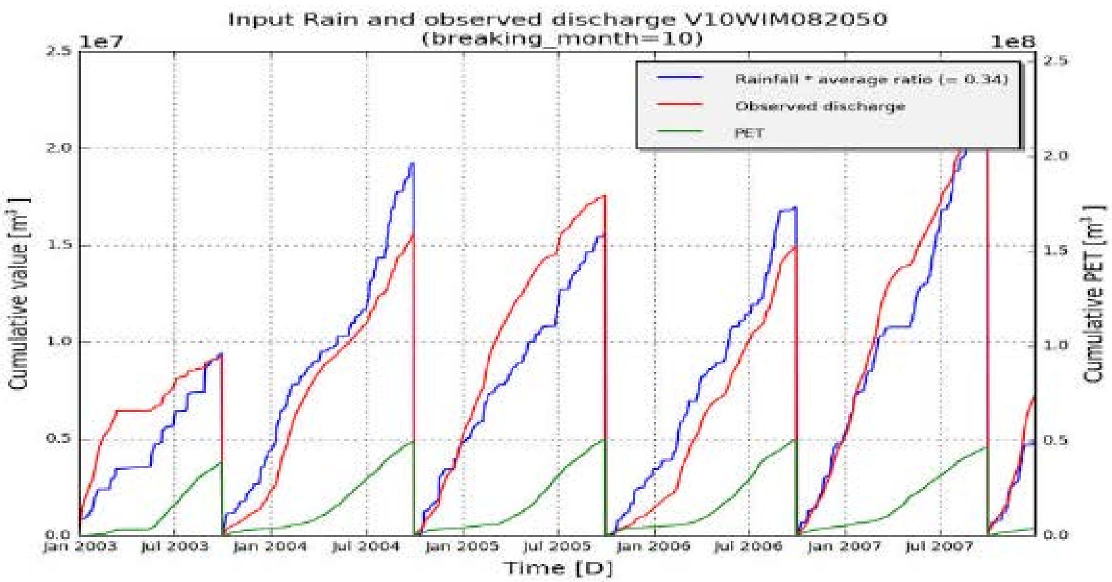


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.4.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	V10WIM082050
subcatchment_area	65400000
start_date	199801010000
end_date	200612310000
frequency	86400
warmup	365

9.5.4.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[2.9, 107.0, 0.25, 12.6, 205.0, 573.0, 0.1, 426.0]
low_bounds	[0.5, 53.6, 0.0009, 1.0, 50.0, 150.0, 0.05, 100.0]
high_bounds	[3.5, 250.0, 0.3, 14.0, 250.0, 650.0, 2.0, 550.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 2.9), ('Ki', 107.0), ('Kg', 0.25), ('Kss', 12.6), ('g0', 205.0), ('g_max', 573.0), ('K_run', 0.1), ('P_max', 426.0)]
Initial fitness:

- RelErr: 0.14
- AbsErr: 12818443.704
- KGE: 0.301
- NS_rel: -26.95
- NS: -0.089

- RMSE: 13605048.322
- NS_log: -0.574

Computation time:8:05:41.681000

9.5.4.4 Results

Best individual (euclidian): [('Kep', 2.811), ('Ki', 140.655), ('Kg', 0.016), ('Kss', 9.945), ('g0', 169.187), ('g_max', 565.844), ('K_run', 0.983), ('P_max', 311.232)]

Fitness:

- RelErr: 0.015
- AbsErr: 3832313.809
- KGE: 0.718
- NS_rel: -3.689
- NS: 0.458
- RMSE: 4731285.043
- NS_log: 0.445

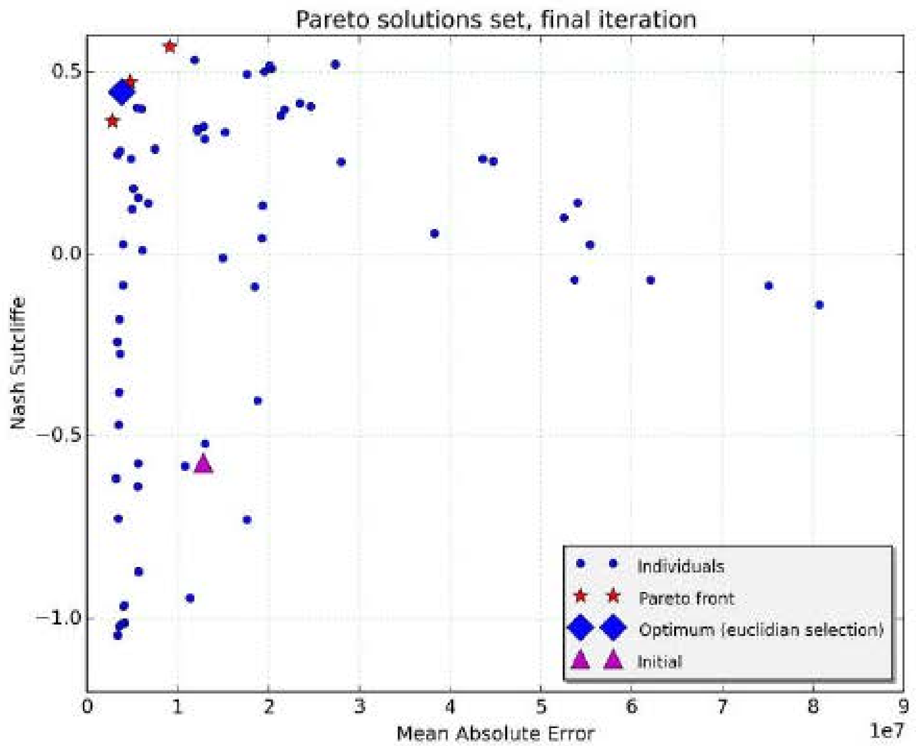


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

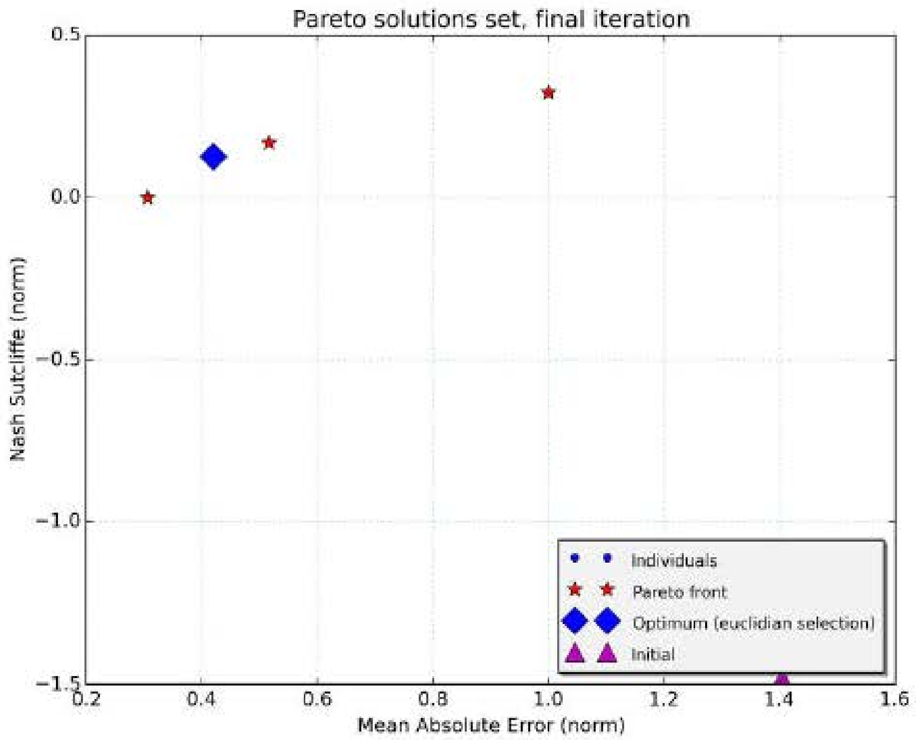


Figure 4: Final population of solutions (Pareto front)

9.5.4.4.1 Initial

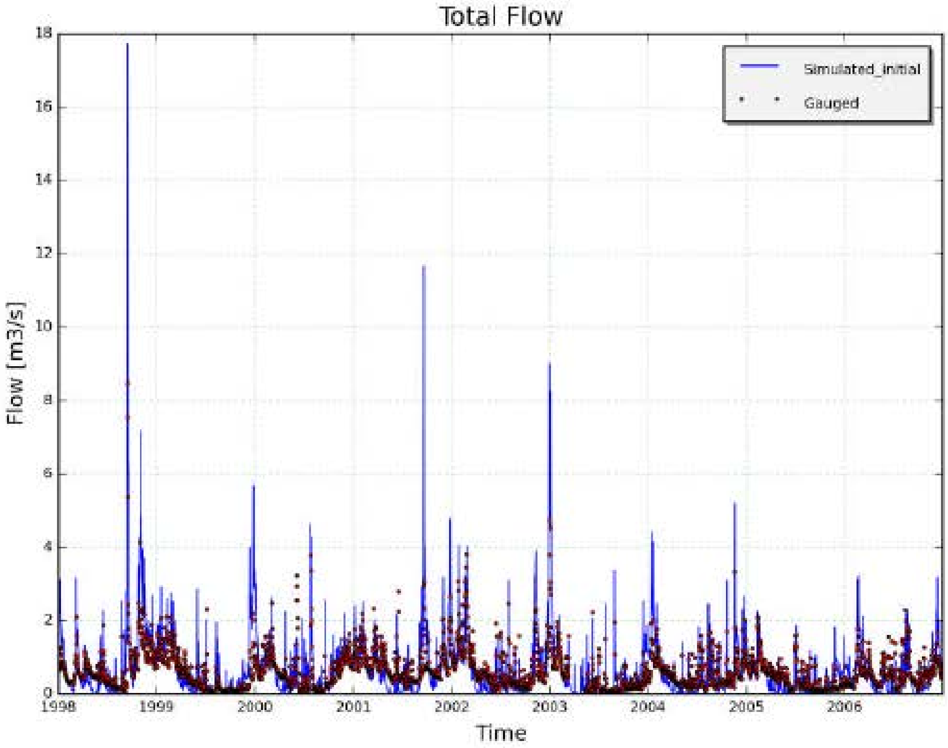


Figure 5: Total flow with initial parameters

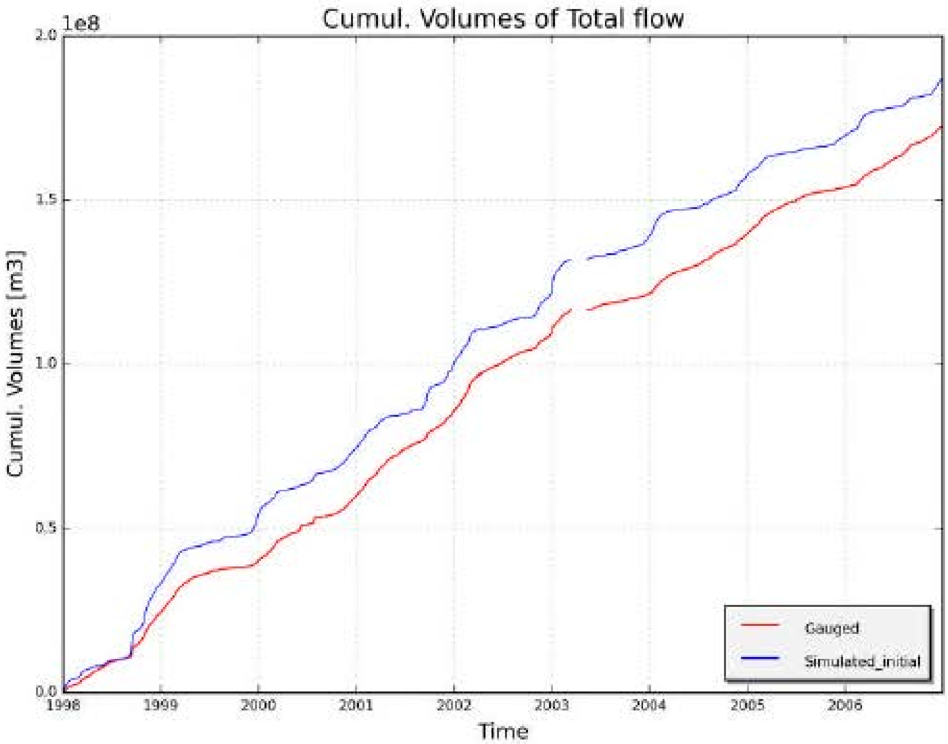


Figure 6: Cumulated flow with initial parameters

9.5.4.4.2 Optimum (euclidian)

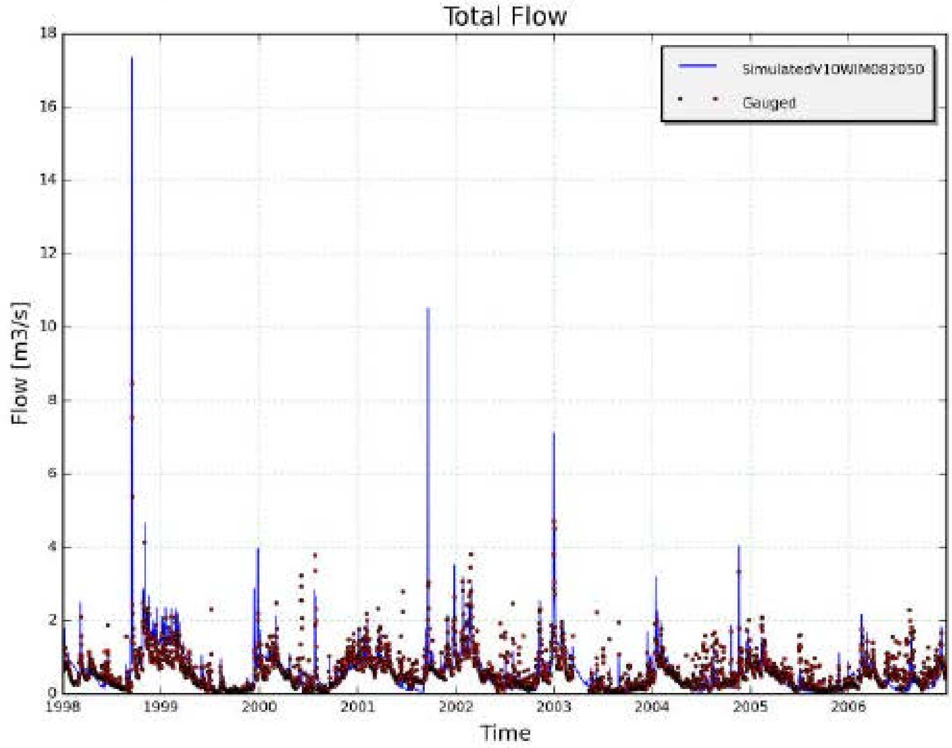


Figure 7: Total flow with optimum parameters

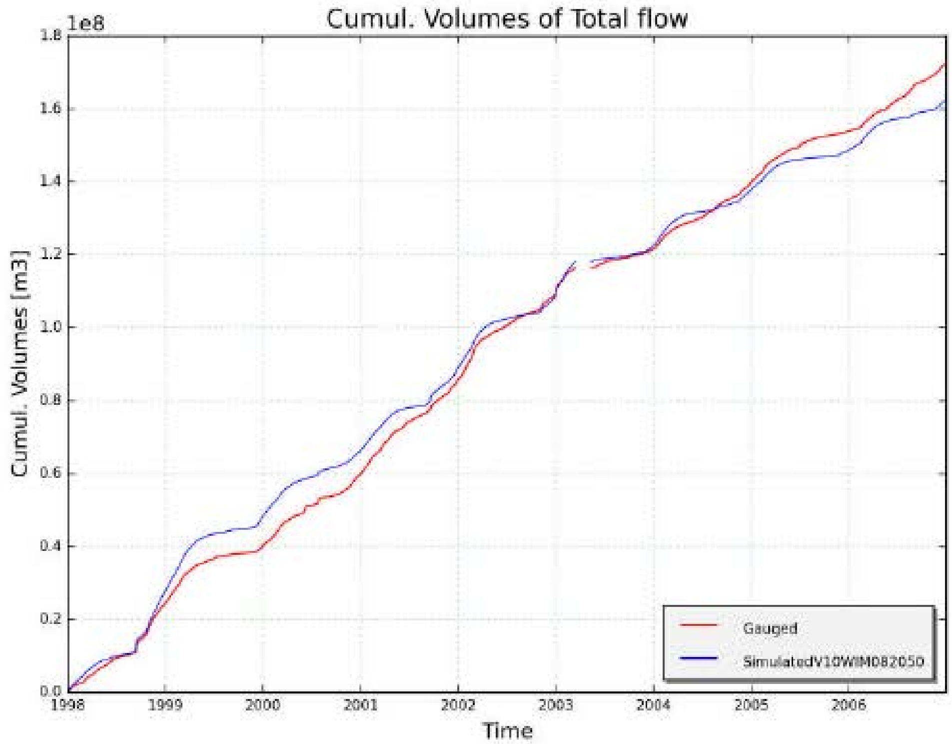


Figure 8: Cumulated flow with optimum parameters

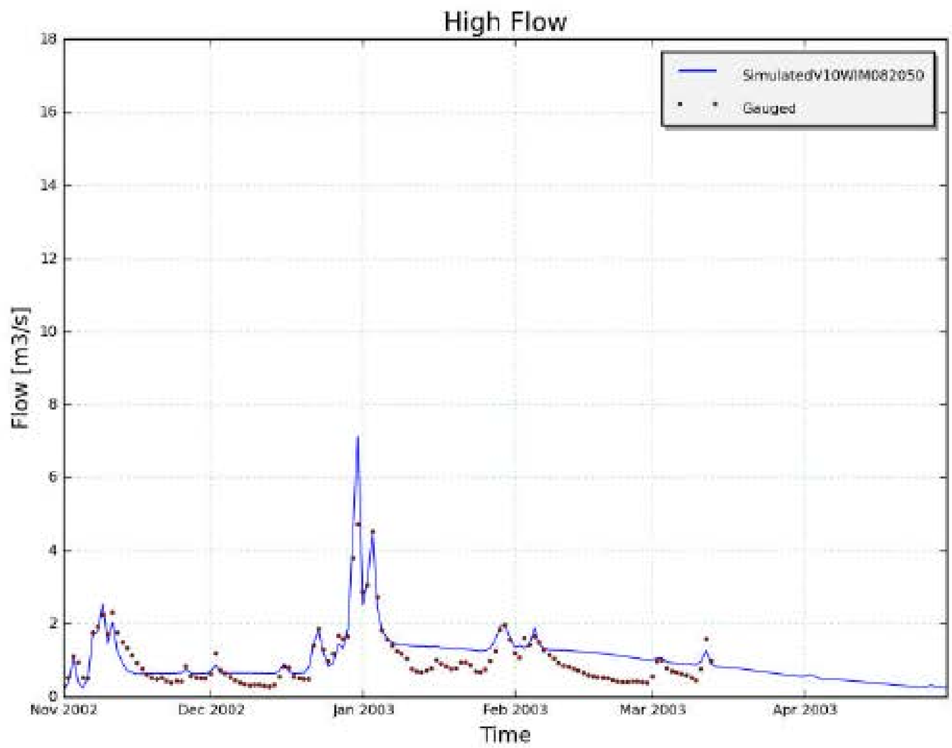


Figure 9: Total flow with optimum parameters (detail)

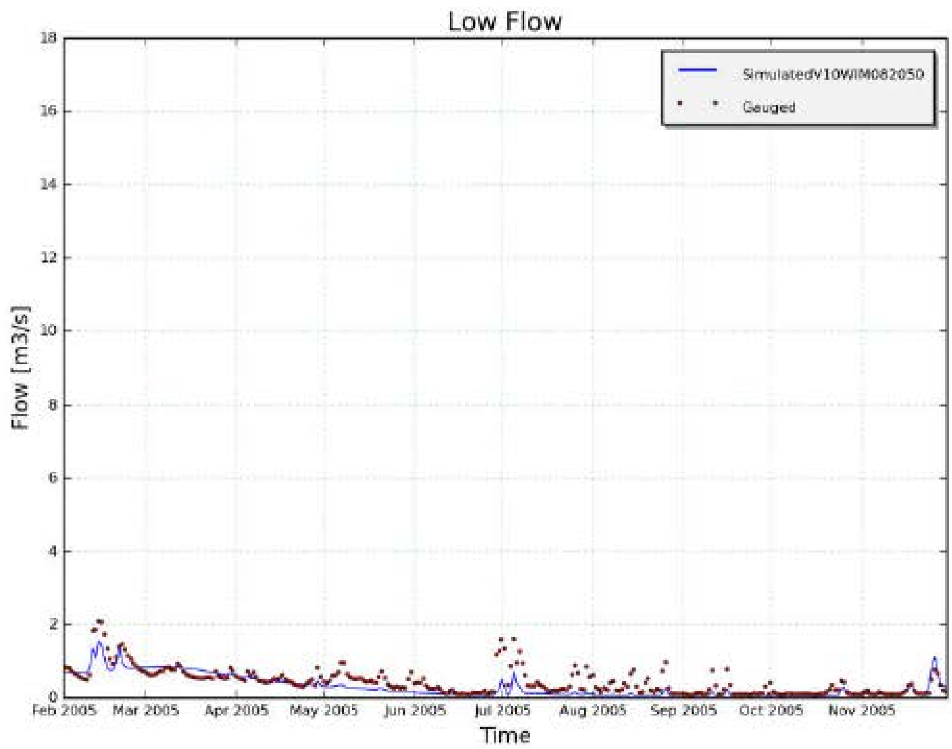
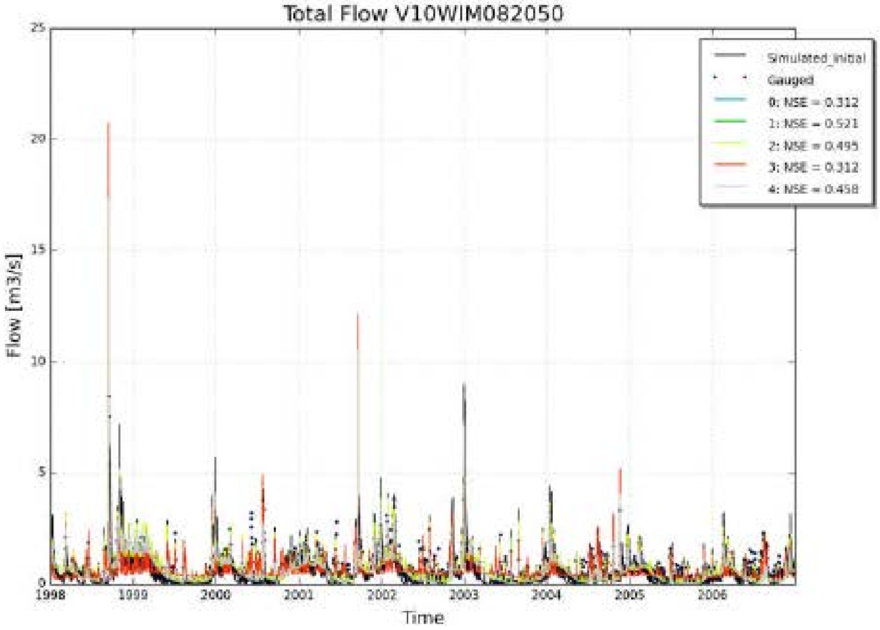
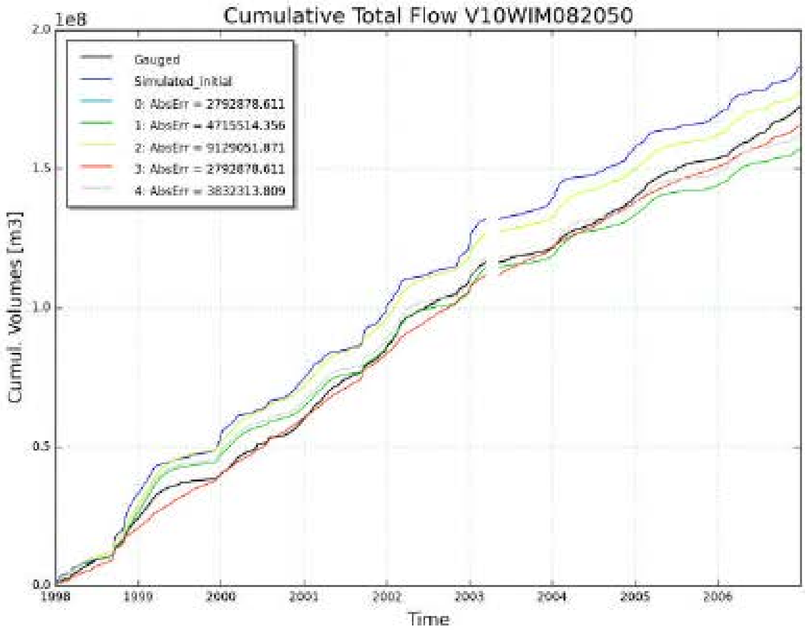


Figure 10: Total flow with optimum parameters (detail)

9.5.4.4.3 Final archive

0 : [0.794, 151.637, 0.001, 8.943, 169.737, 528.112, 0.852, 367.906] : [2792878.611, 0.366]
1 : [2.651, 115.587, 0.013, 11.385, 161.341, 478.314, 0.831, 361.724] : [4715514.356, 0.472]
2 : [2.231, 122.656, 0.014, 9.889, 190.639, 472.46, 0.172, 359.826] : [9129051.871, 0.571]
3 : [0.794, 151.637, 0.001, 9.803, 169.737, 528.112, 0.852, 367.906] : [2792878.611, 0.366]
4 : [2.811, 140.655, 0.016, 9.945, 169.187, 565.844, 0.983, 311.232] : [3832313.809, 0.445]





Appendix 22 Meuse Calibration and Validation.

9.5.1 Calibration and validation of WET parameters for catchment "W11SAM7319" (Meuse)

9.5.1.1 Input data

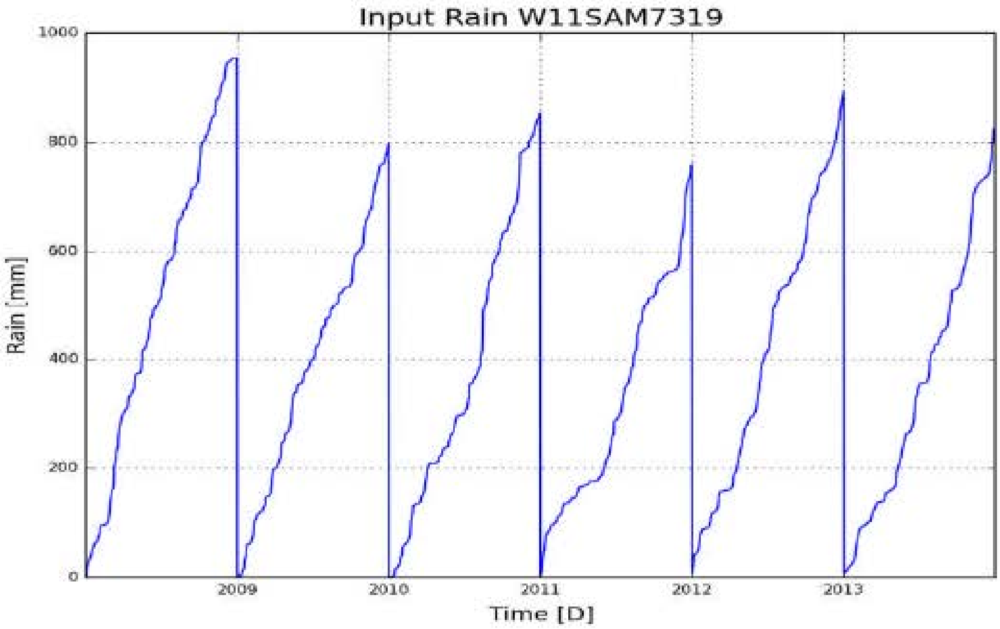


Figure 1: Cumulative precipitation on catchment W11SAM7319 (Meuse)

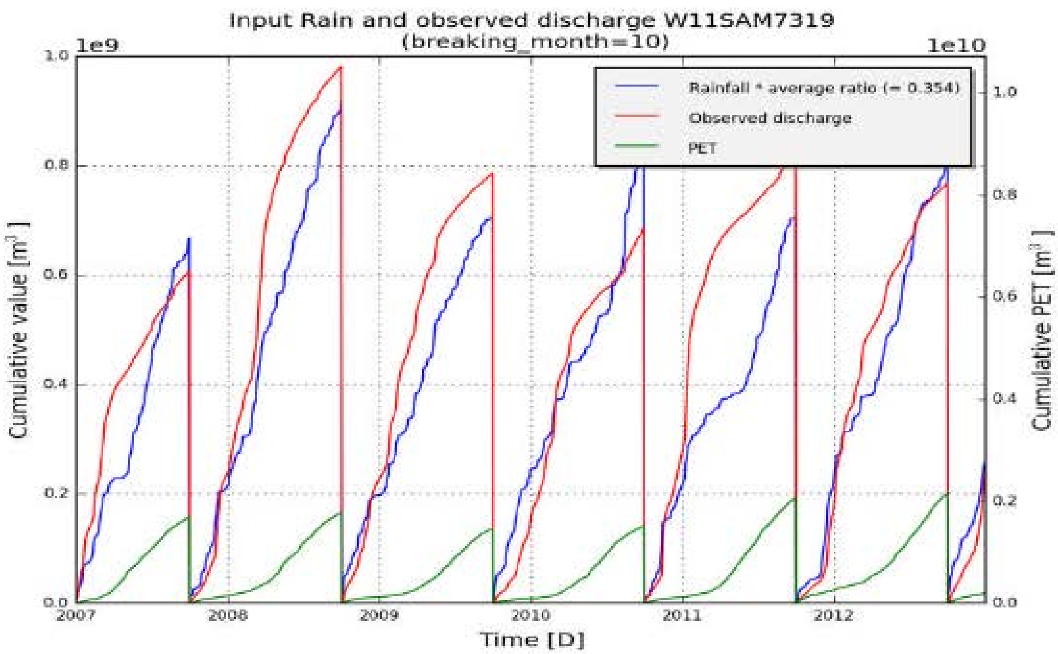


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W11SAM7319 (Meuse)

9.5.1.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	W11SAM7319
subcatchment_area [m2]	2669000000
Validation start_date	01-01-2009
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:[('Kep', 2.18), ('Ki', 64.15), ('Kg', 0.01), ('Kss', 2.3), ('g0', 122.2), ('g_max', 509.4), ('K_run', 2.53), ('P_max', 116.0)]

Table 1: Goodness of fit for calibration period (2007 - 2012)

	Full year	**Summer**	**Winter**
RelErr	-0.7 %	7.9 %	-10.1 %
NS	0.594	-0.146	0.418
NS_log	0.614	0.286	0.322
NS_rel	0.72	0.606	0.421
KGE	0.656	0.34	0.39

Table 2 :Goodness of fit for validation period (2009 - 2013)

	Full year	**Summer**	**Winter**
RelErr	6.8 %	10.3 %	-4.2 %
NS	0.571	-0.258	0.396
NS_log	0.554	0.005	0.285
NS_rel	0.713	0.595	0.425
KGE	0.656	0.286	0.369

9.5.1.3 Observed and simulated timeseries for optimum parameters

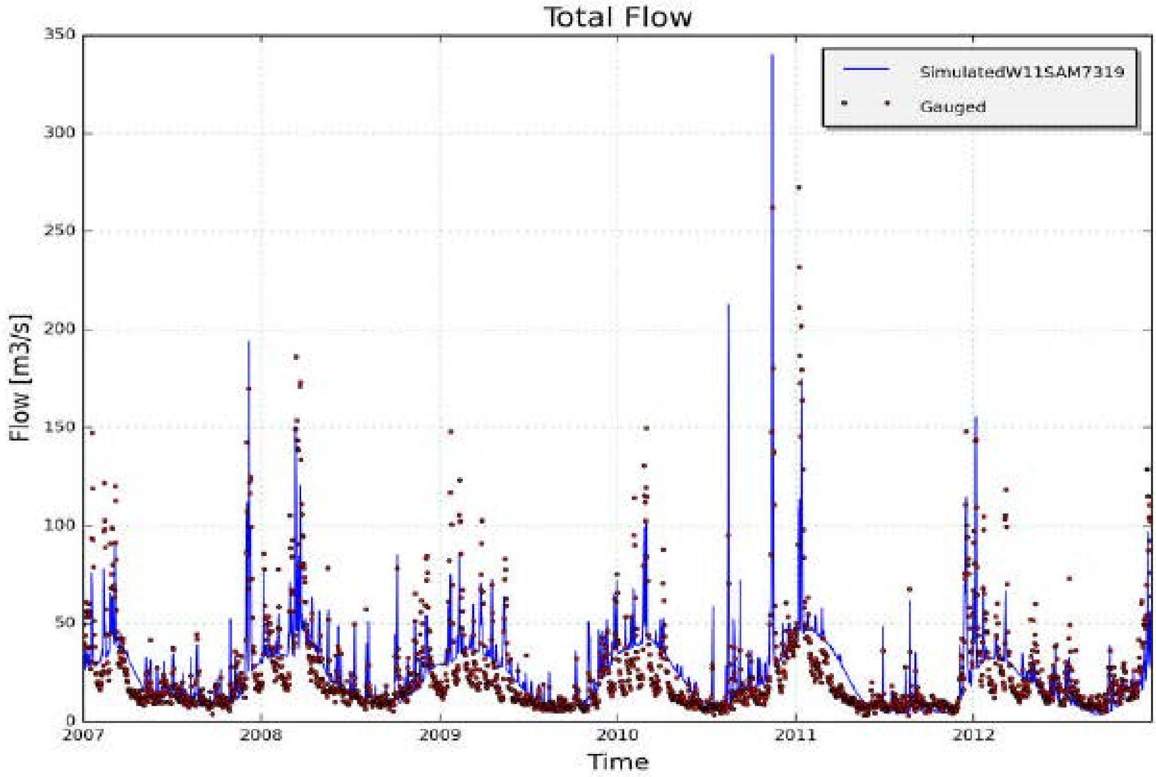


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11SAM7319, station Samber, Salzinne(calibration period)

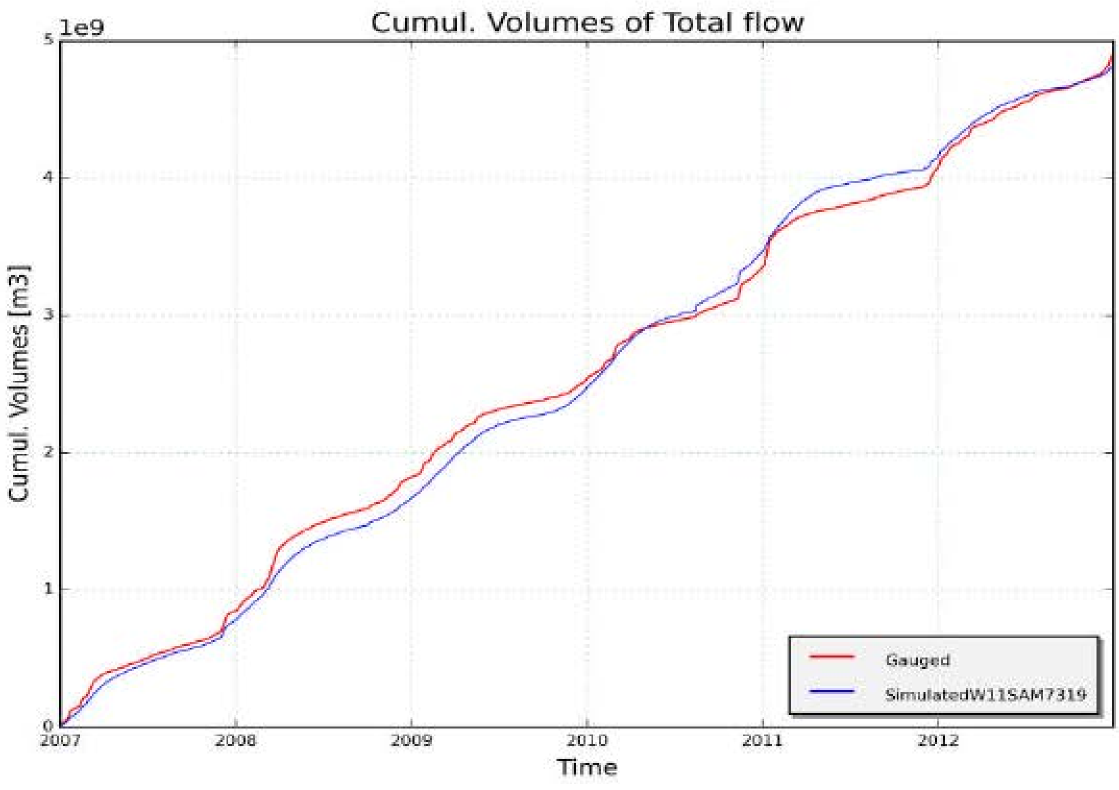


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11SAM7319, station Samber, Salzinne (calibration period)

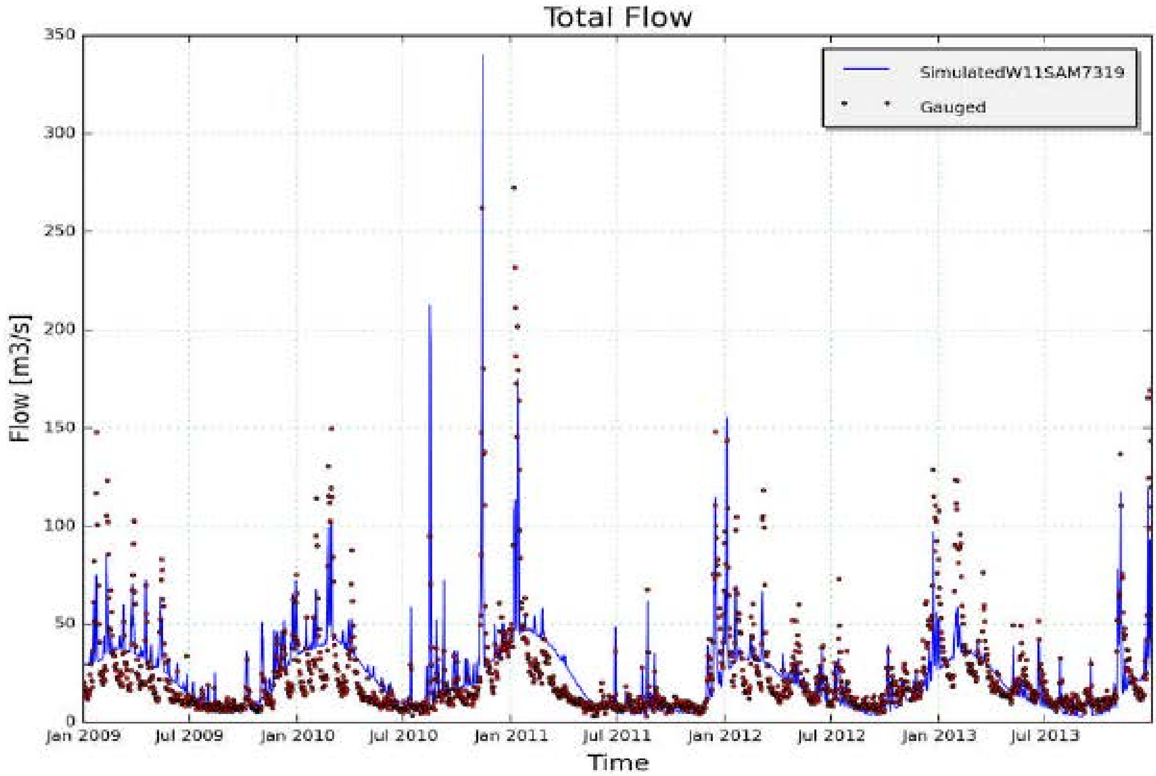


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11SAM7319, station Samber, Salzinne (validation period)

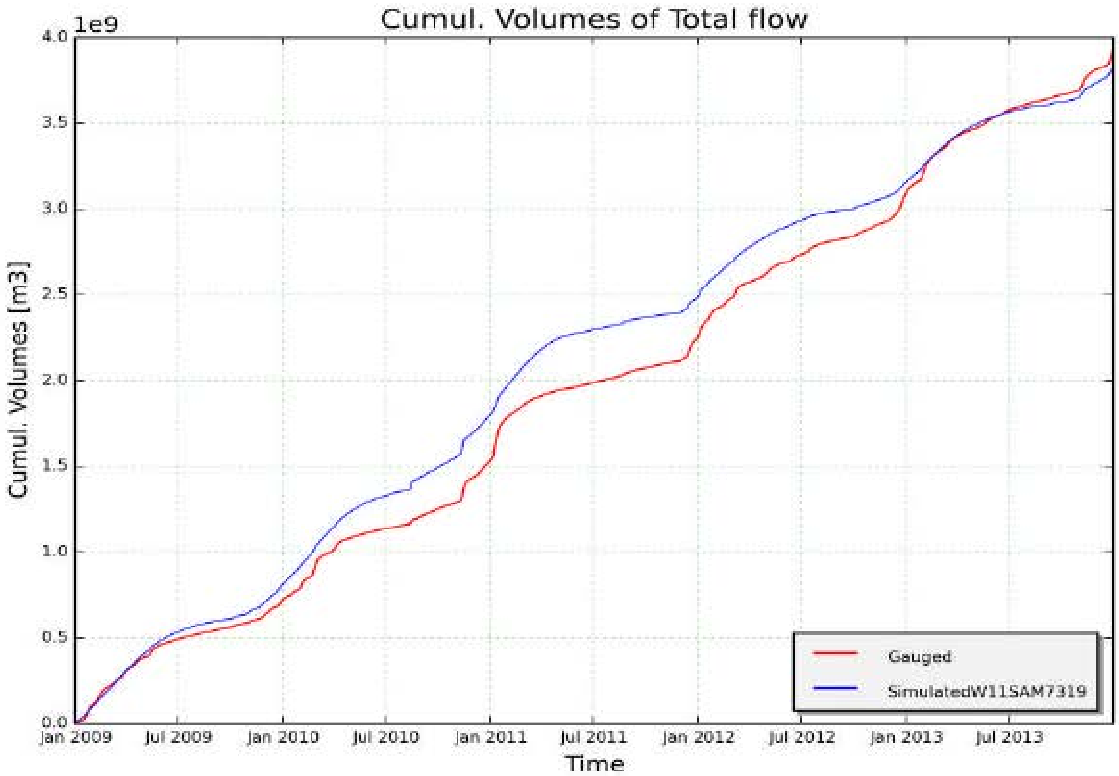


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11SAM7319, station Samber, Salzinne (validation period)

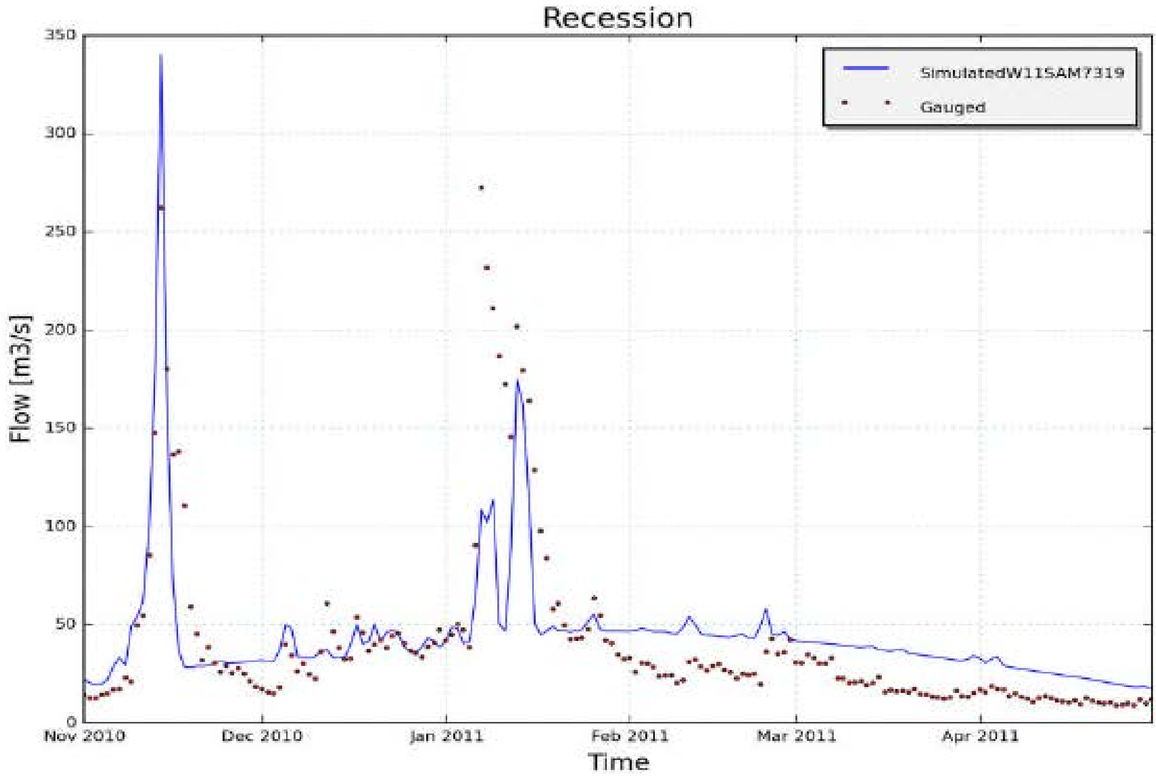


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11SAM7319, station Samber, Salzinne

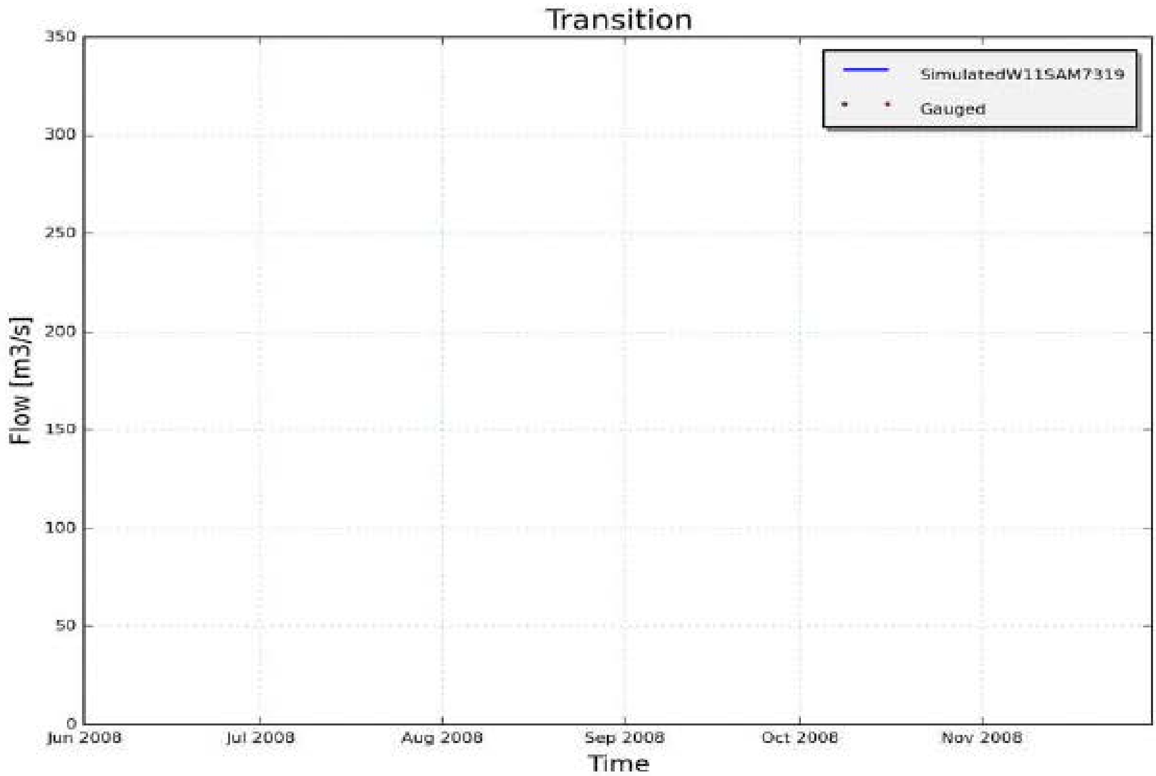


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11SAM7319, station Samber, Salzinne

9.5.2 Calibration and validation of WET parameters for catchment "W11BER551010" (Meuse)

9.5.2.1 Input data

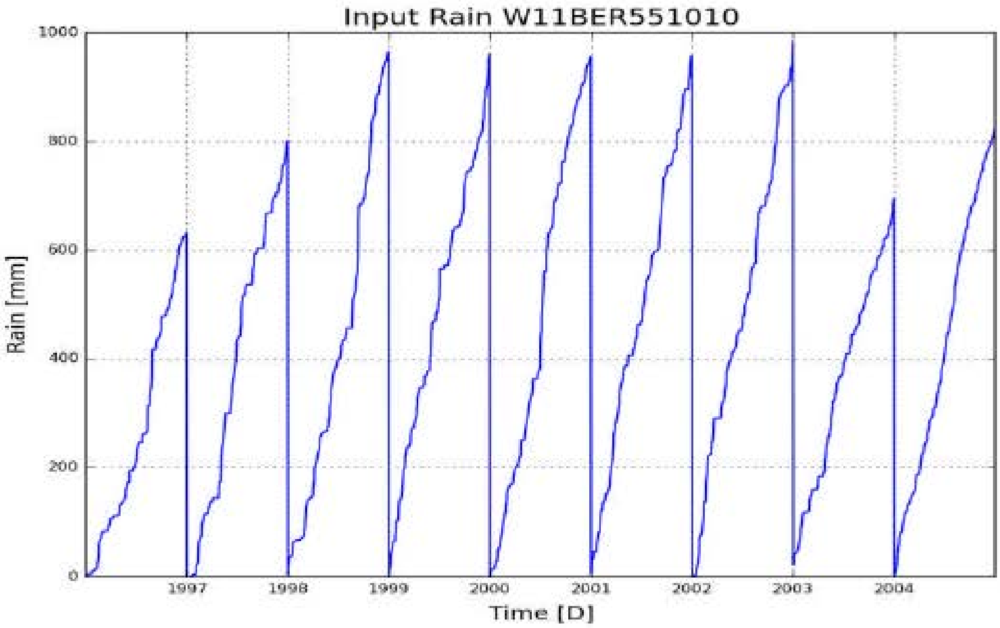


Figure 1: Cumulative precipitation on catchment W11BER551010 (Meuse)

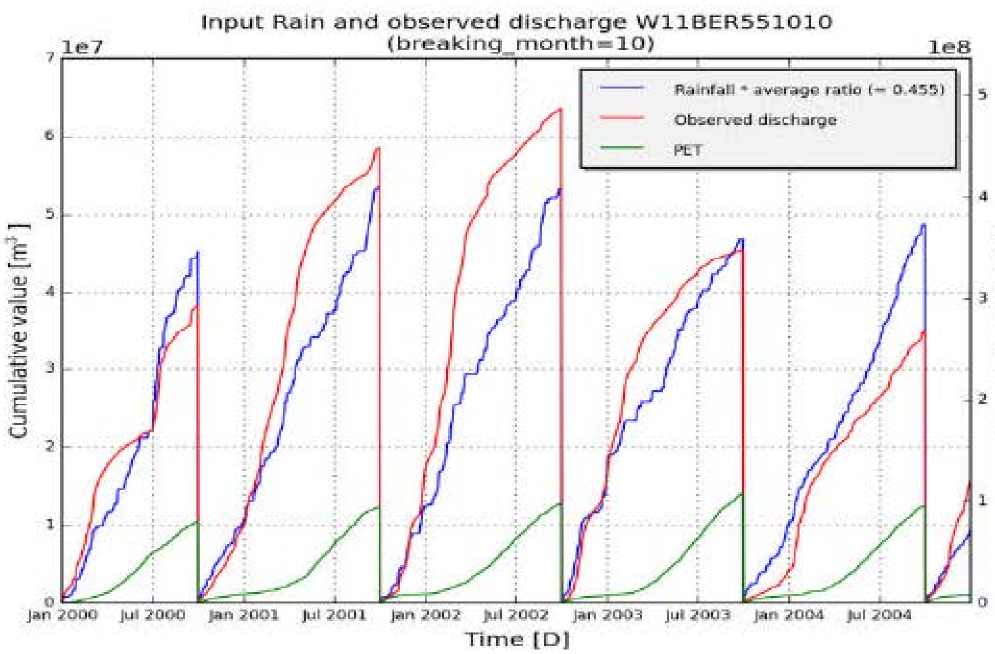


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W11BER551010 (Meuse)

9.5.2.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	W11BER551010
subcatchment_area [m2]	128000000
Validation start_date	01-01-1997
Validation end_date	31-12-2004
frequency	daily

Optimal parameter set:[('Kep', 1.92), ('Ki', 28.38), ('Kg', 0.01), ('Kss', 2.47), ('g0', 92.66), ('g_max', 452.27), ('K_run', 7.38), ('P_max', 236.41)]

Table 1: Goodness of fit for calibration period (2000 - 2004)

	Full year	**Summer**	**Winter**
RelErr	-0.5 %	-3.7 %	-8.7 %
NS	0.555	0.426	0.53
NS_log	0.581	0.495	0.48
NS_rel	0.482	0.711	0.354
KGE	0.648	0.547	0.655

Table 2 :Goodness of fit for validation period (1997 - 2004)

	Full year	**Summer**	**Winter**
RelErr	2.9 %	-0.7 %	2.3 %
NS	0.345	-0.484	0.534
NS_log	0.556	0.469	0.498
NS_rel	0.269	0.299	0.029
KGE	0.64	0.385	0.659

9.5.2.3 Observed and simulated timeseries for optimum parameters

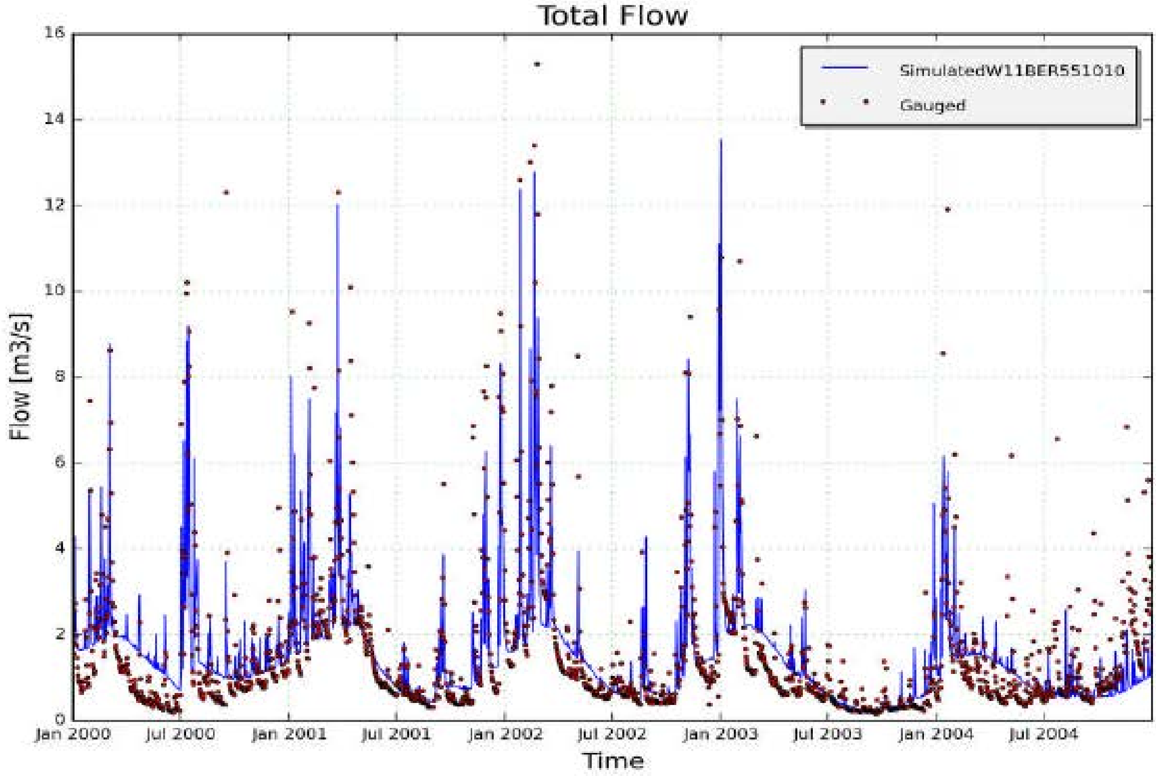


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11BER551010, station unkown(calibration period)

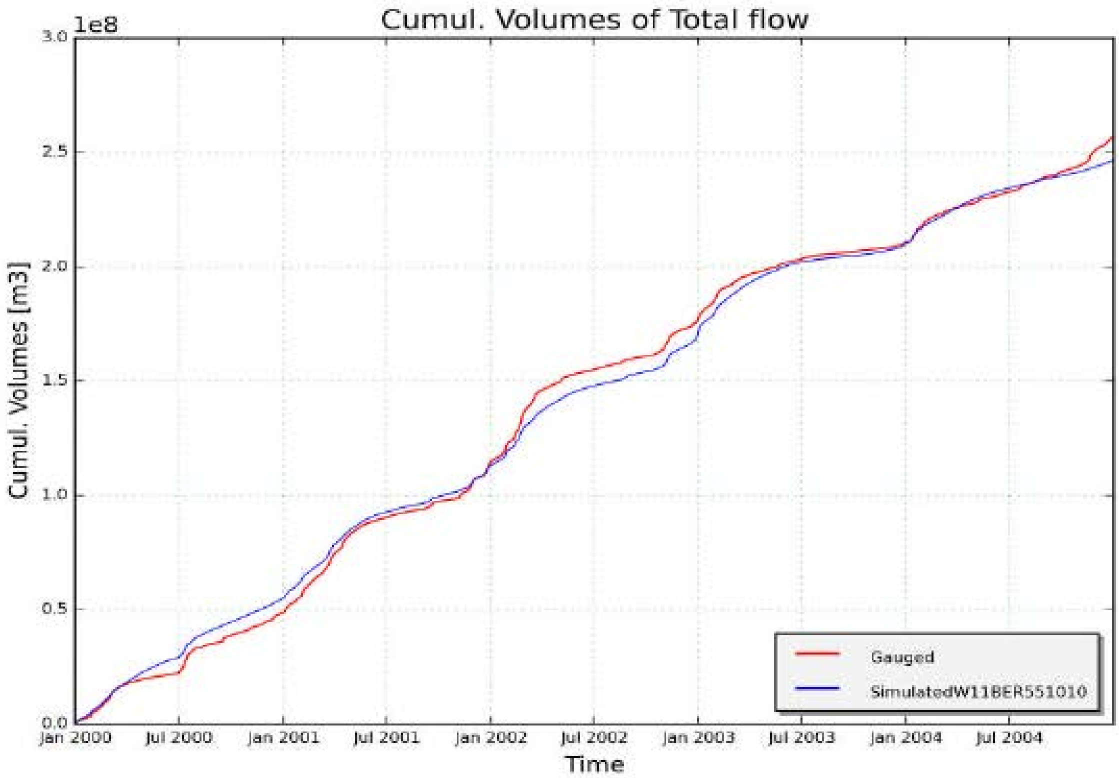


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11BER551010, station unkown (calibration period)

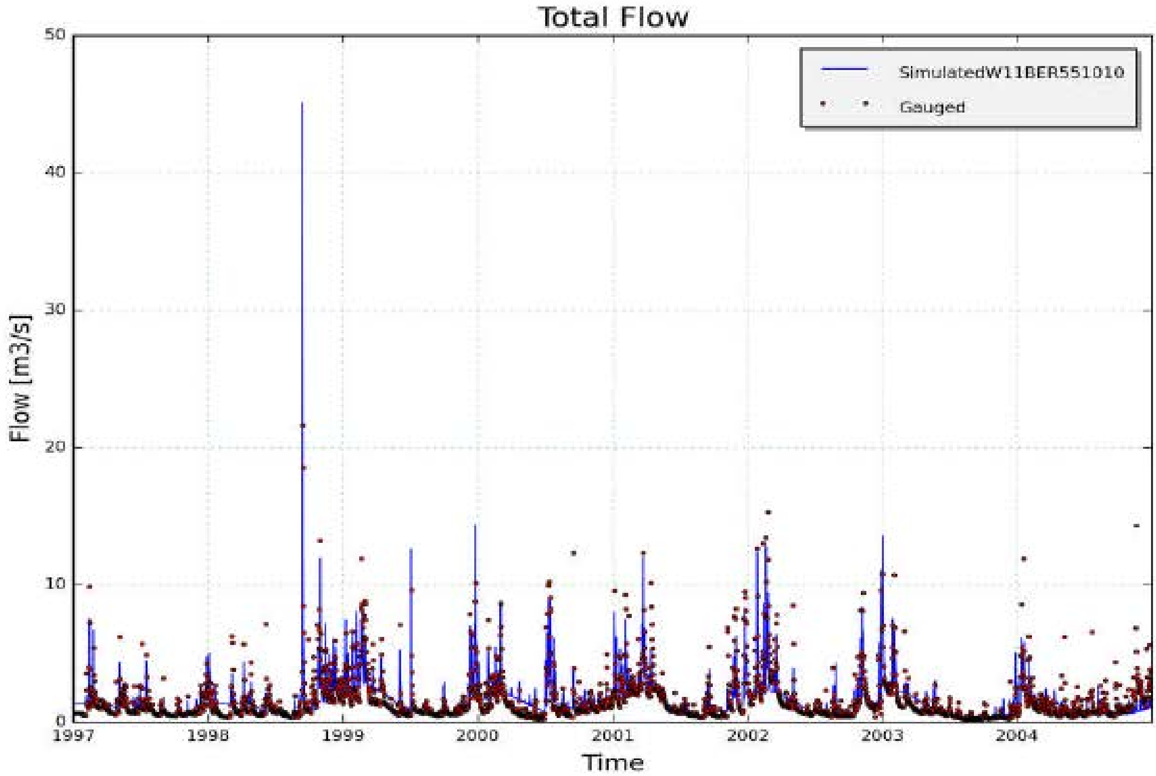


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11BER551010, station unkown (validation period)

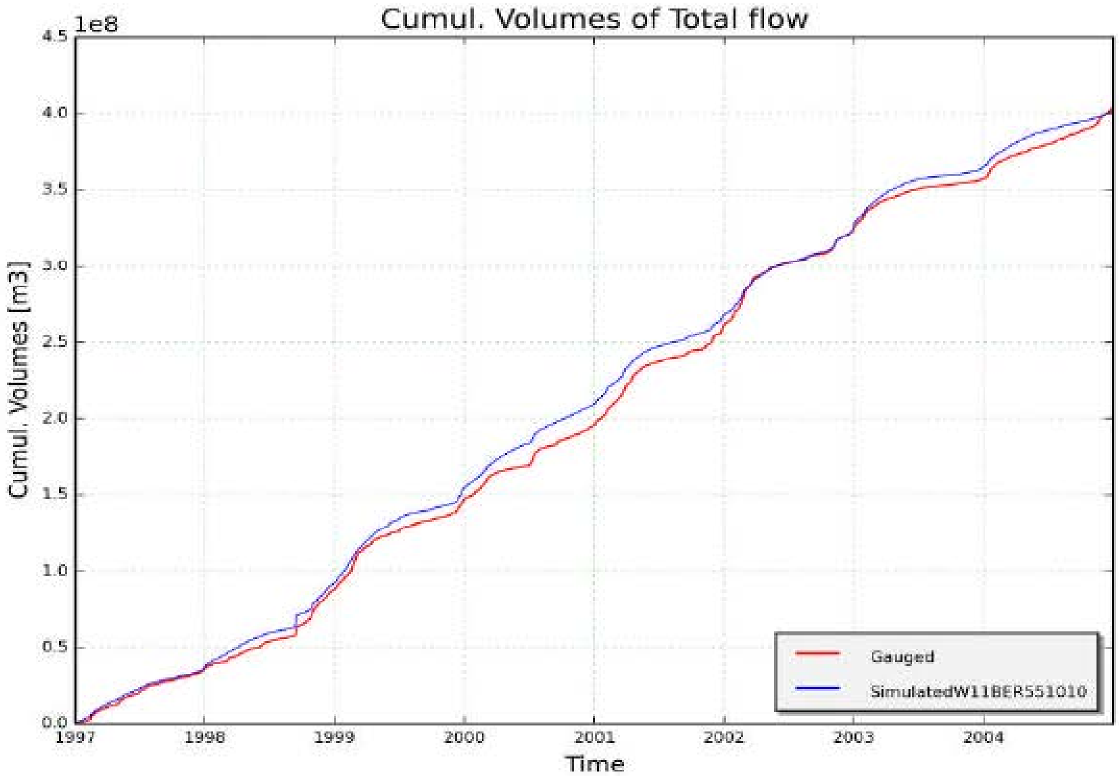


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11BER551010, station unkown (validation period)

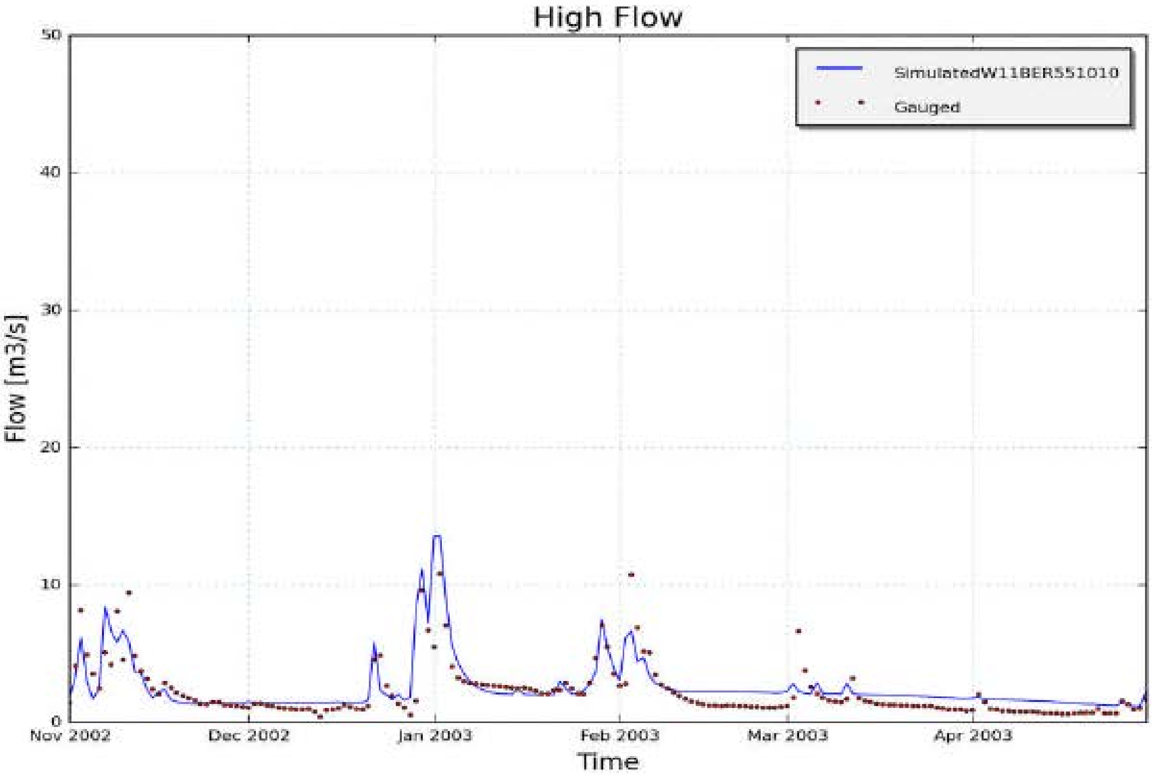


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11BER551010, station unkown

9.5.3 Calibration and validation of WET parameters for catchment "W11HOY5990" (Meuse)

9.5.3.1 Input data

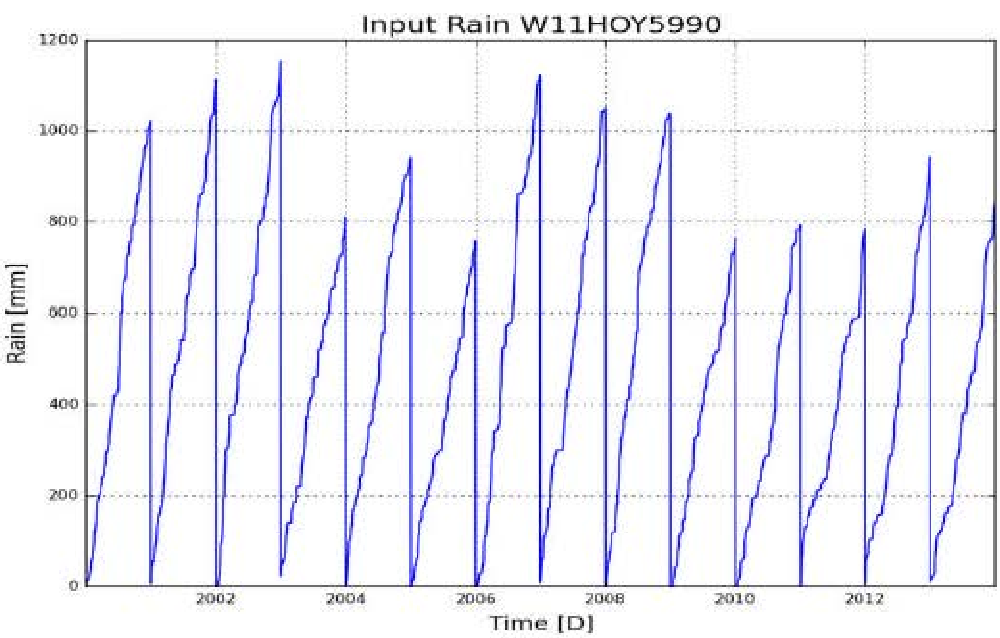


Figure 1: Cumulative precipitation on catchment W11HOY5990 (Meuse)

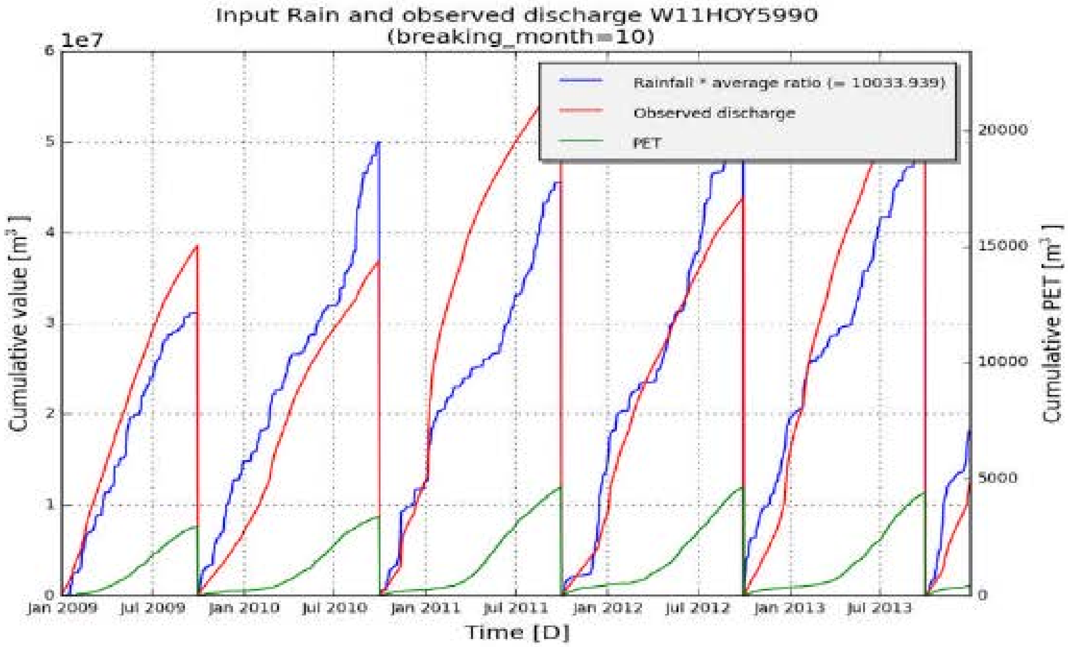


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W11HOY5990 (Meuse)

9.5.3.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	W11HOY5990
subcatchment_area [m2]	5990
Validation start_date	01-01-2001
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:[('Kep', 1.81), ('Ki', 11.84), ('Kg', 0.0), ('Kss', 1.88), ('g0', 204.9), ('g_max', 502.03), ('K_run', 8.96), ('P_max', 413.37)]

Table 1: Goodness of fit for calibration period (2009 - 2013)

	Full year	**Summer**	**Winter**
RelErr	4.9 %	-22.4 %	13.0 %
NS	0.229	-2.9	0.376
NS_log	-0.2	-4.985	0.468
NS_rel	0.626	-2.367	0.771

	Full year	Summer	Winter
KGE	0.621	-0.076	0.501

Table 2 :Goodness of fit for validation period (2001 - 2013)

	Full year	Summer	Winter
RelErr	1.4 %	-30.2 %	26.5 %
NS	0.141	-0.7	0.262
NS_log	-0.183	-3.494	0.258
NS_rel	0.423	-0.335	0.414
KGE	0.582	0.305	0.599

9.5.3.3 Observed and simulated timeseries for optimum parameters

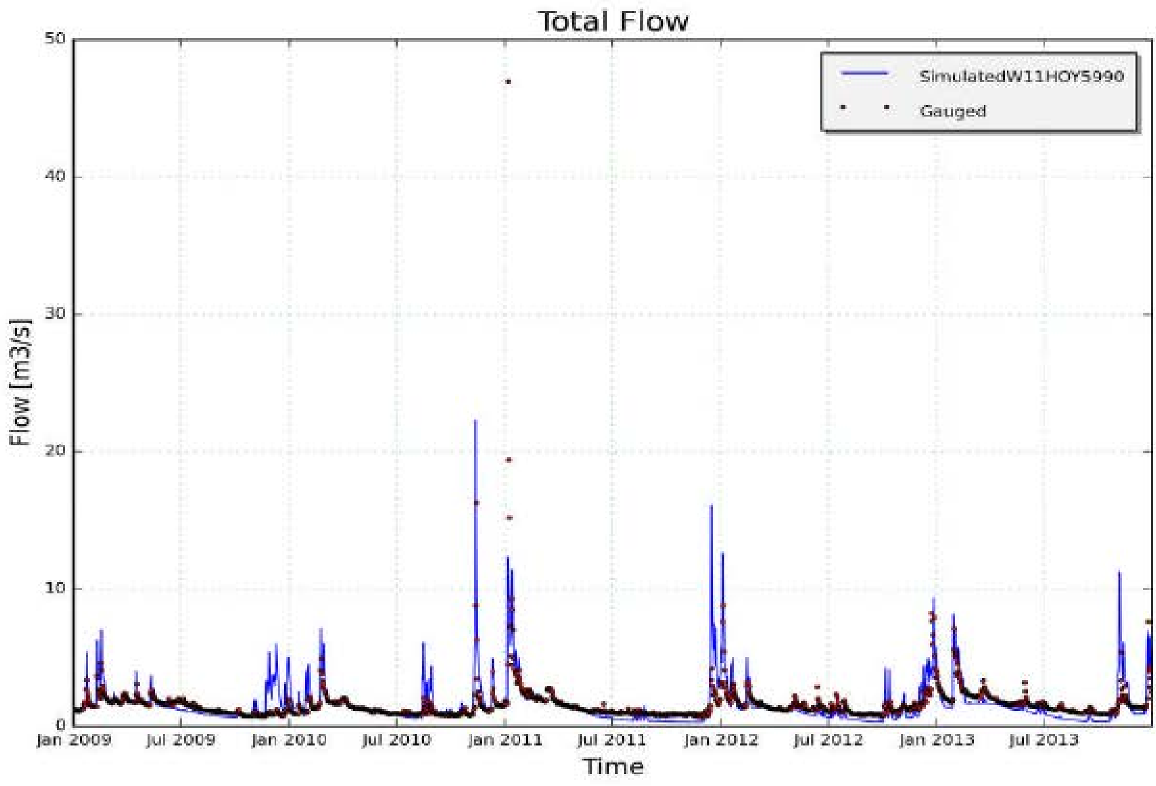


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11HOY5990, station Hoyoux, Marchin(calibration period)

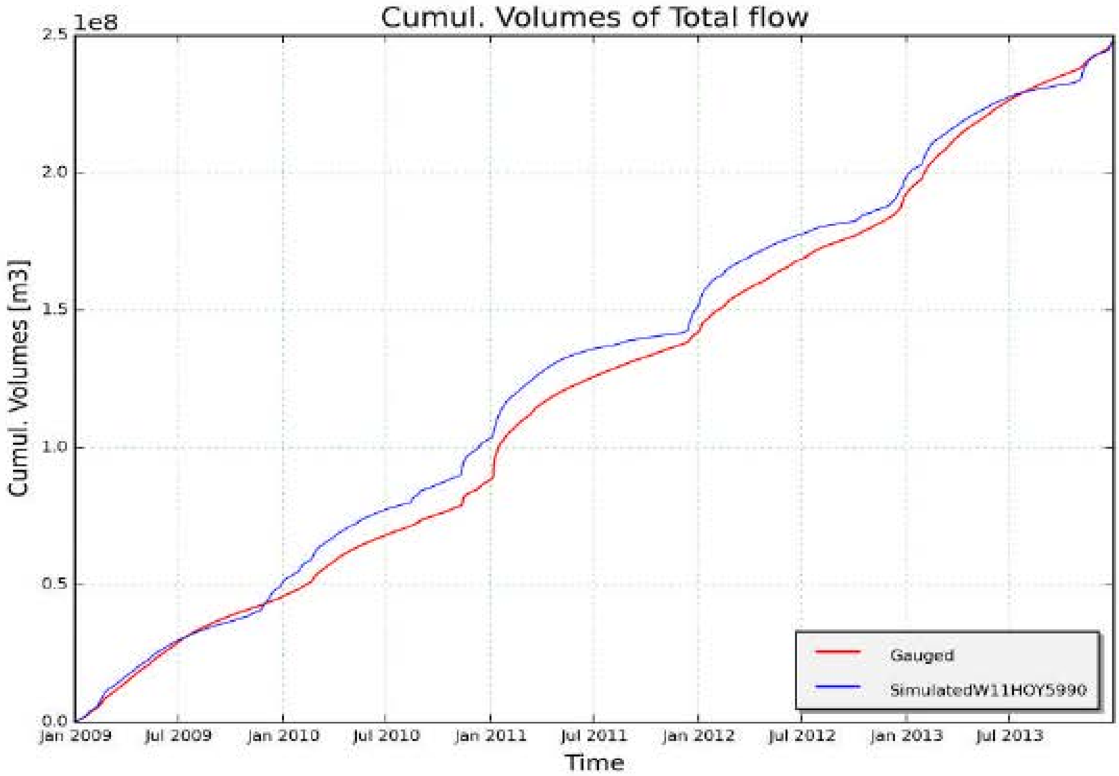


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11HOY5990, station Hoyoux, Marchin (calibration period)

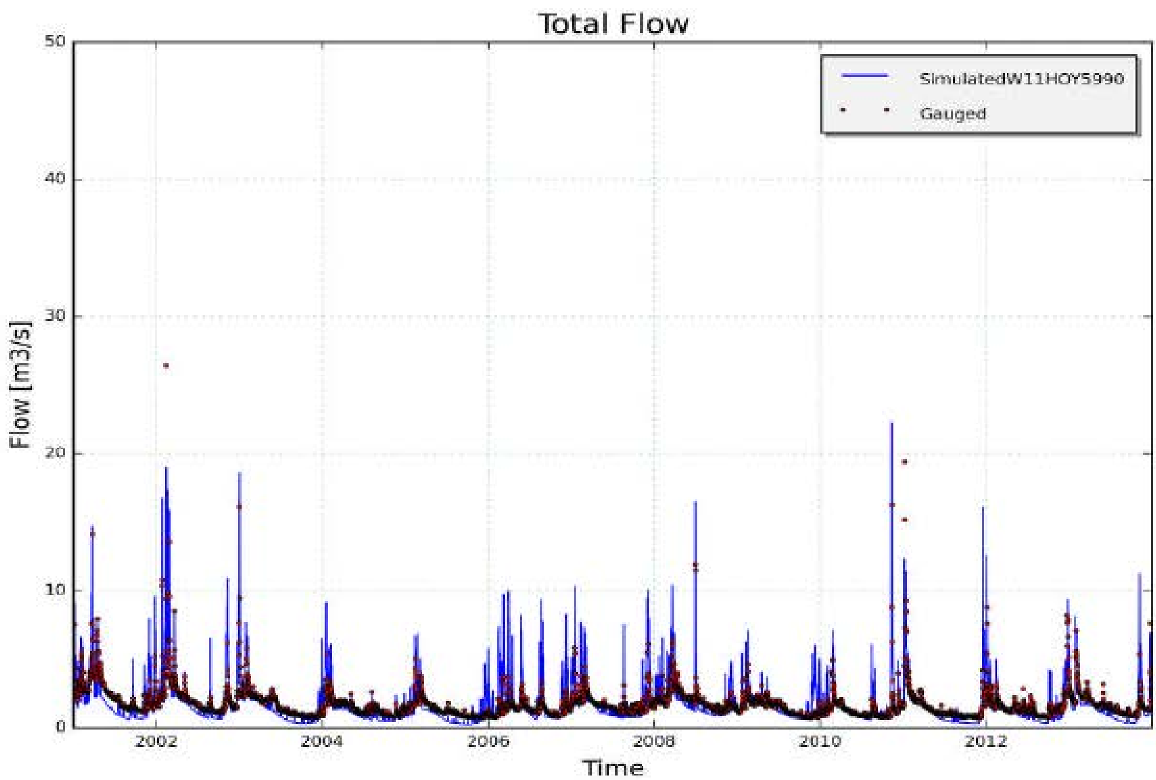


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11HOY5990, station Hoyoux, Marchin (validation period)

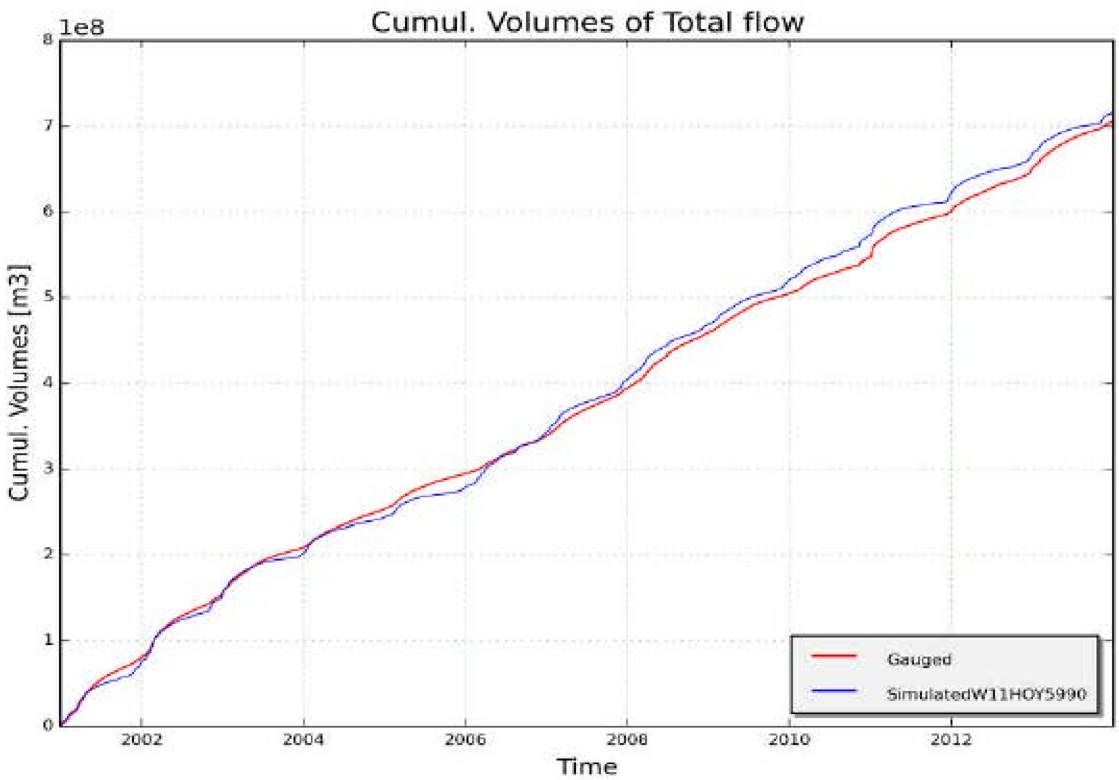


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11HOY5990, station Hoyoux, Marchin (validation period)

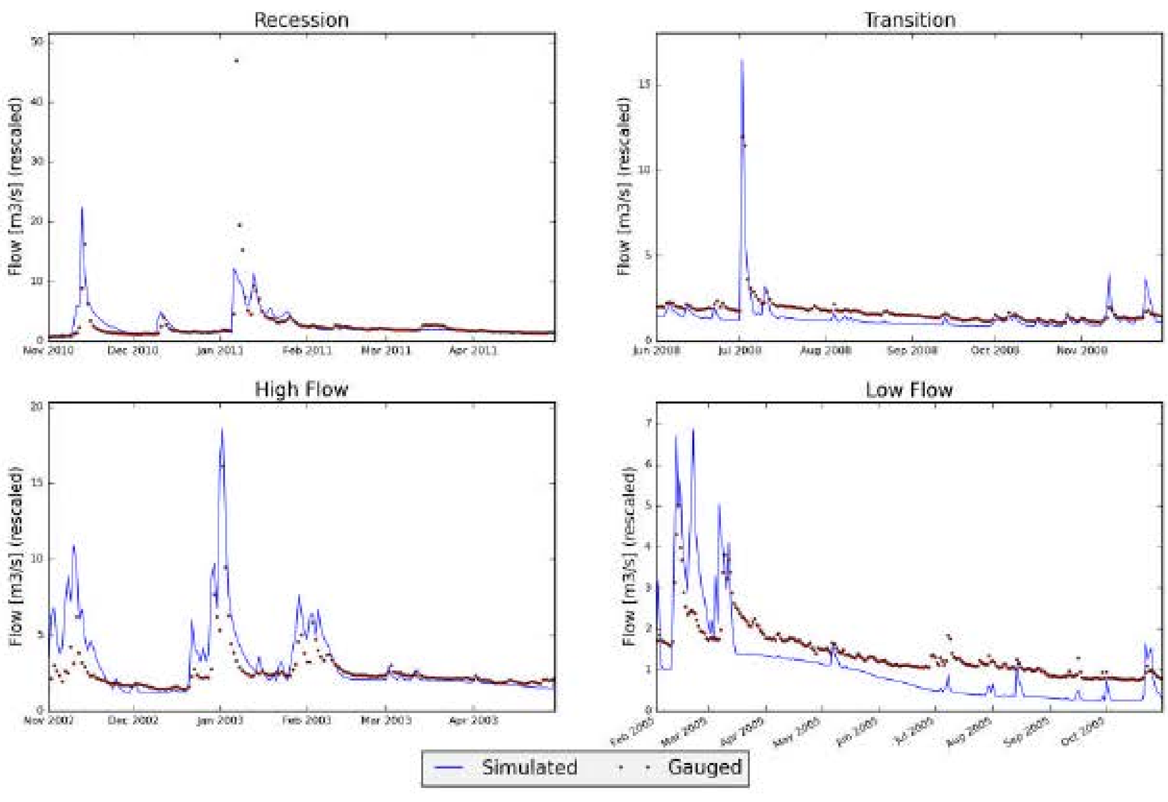


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11HOY5990, station Hoyoux, Marchin

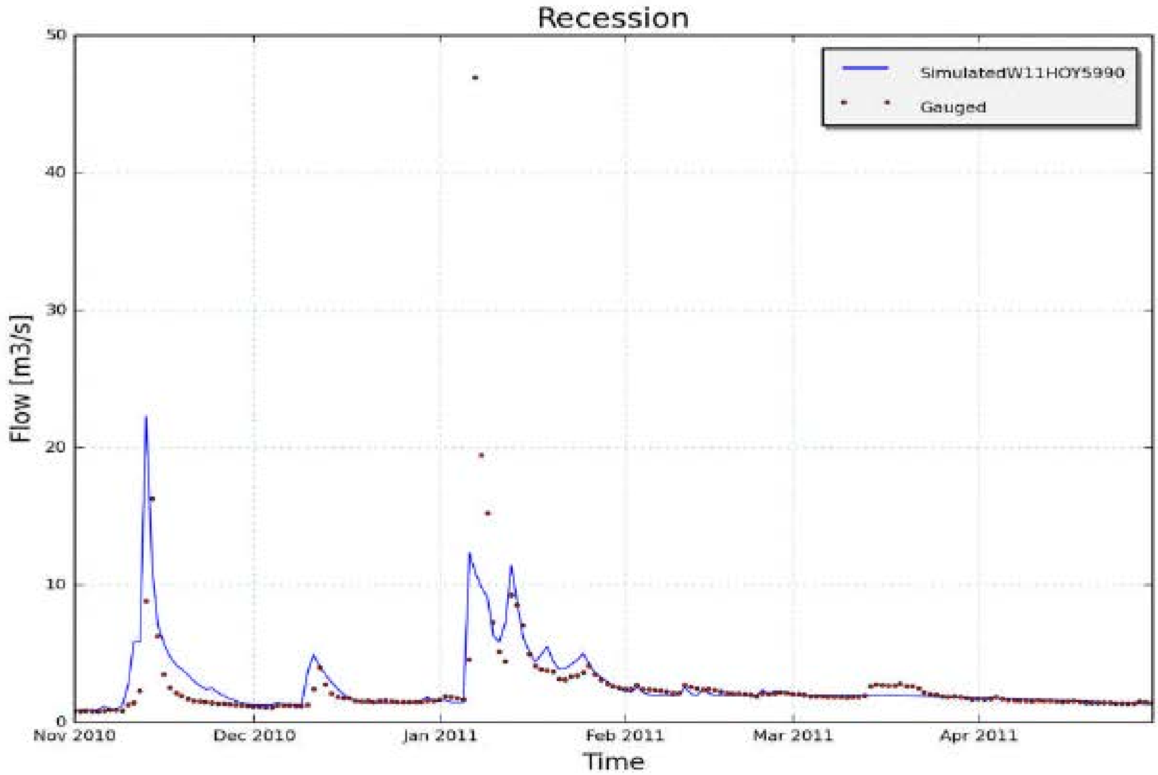


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11HOY5990, station Hoyoux, Marchin

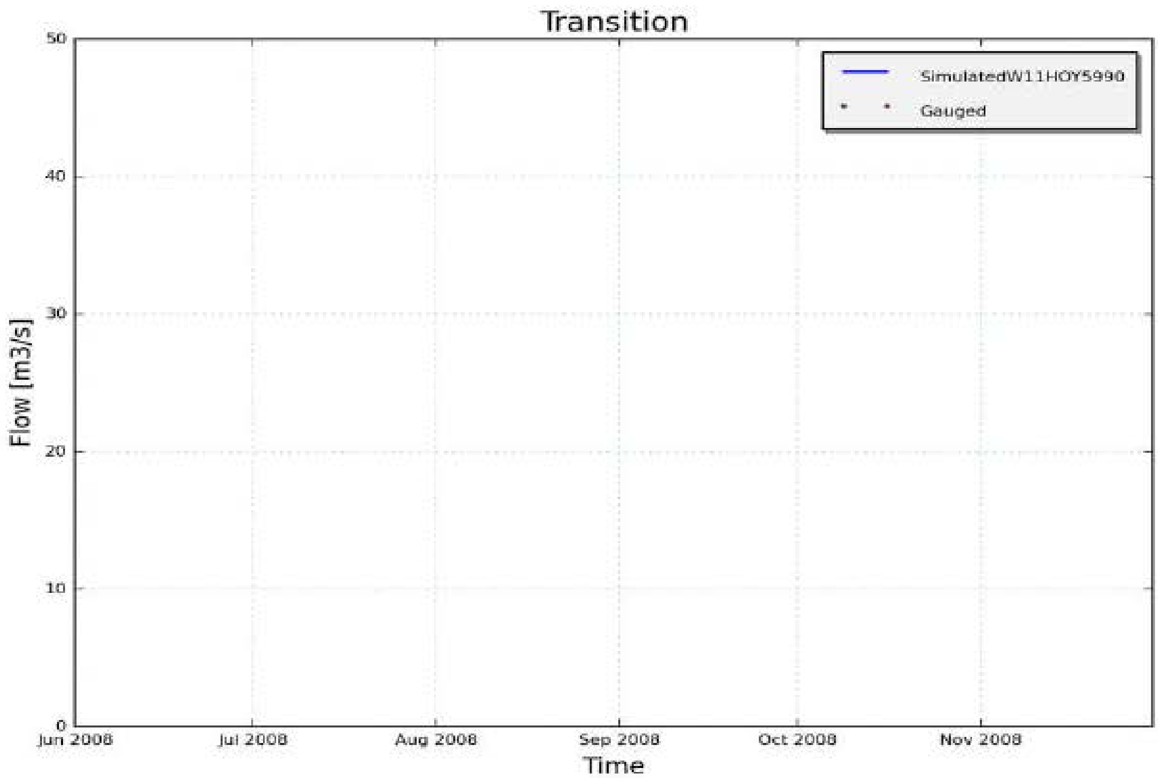


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11HOY5990, station Hoyoux, Marchin

9.5.4 Calibration and validation of WET parameters for catchment "W11MEH5820" (Meuse)

9.5.4.1 Input data

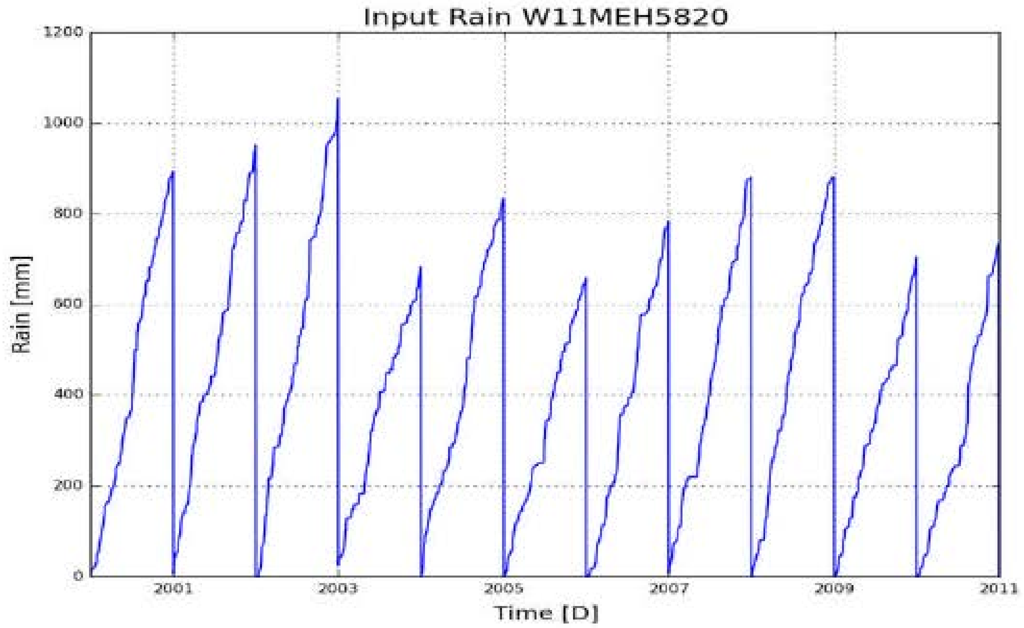


Figure 1: Cumulative precipitation on catchment W11MEH5820 (Meuse)

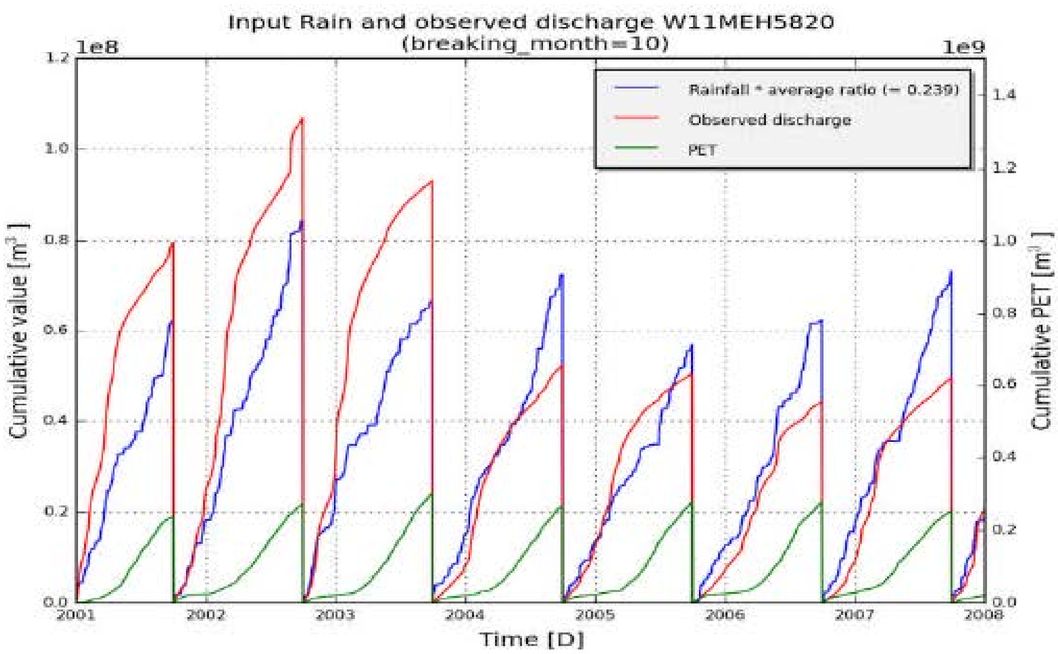


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W11MEH5820 (Meuse)

9.5.4.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	W11MEH5820
subcatchment_area [m2]	356000000
Validation start_date	01-01-2001
Validation end_date	03-01-2011
frequency	daily

Optimal parameter set:[('Kep', 2.4), ('Ki', 52.61), ('Kg', 0.01), ('Kss', 2.04), ('g0', 270.88), ('g_max', 833.23), ('K_run', 3.0), ('P_max', 607.33)]

Table 1: Goodness of fit for calibration period (2001 - 2008)

	Full year	Summer	Winter
RelErr	9.8 %	4.7 %	20.1 %
NS	0.308	-0.22	0.146
NS_log	0.463	-0.85	0.552
NS_rel	0.581	0.595	0.395
KGE	0.581	0.453	0.489

Table 2 :Goodness of fit for validation period (2001 - 2011)

	Full year	Summer	Winter
RelErr	12.7 %	10.6 %	20.5 %
NS	0.12	-0.627	0.041
NS_log	0.443	-0.698	0.407
NS_rel	0.38	0.407	0.074
KGE	0.488	0.291	0.463

9.5.4.3 Observed and simulated timeseries for optimum parameters

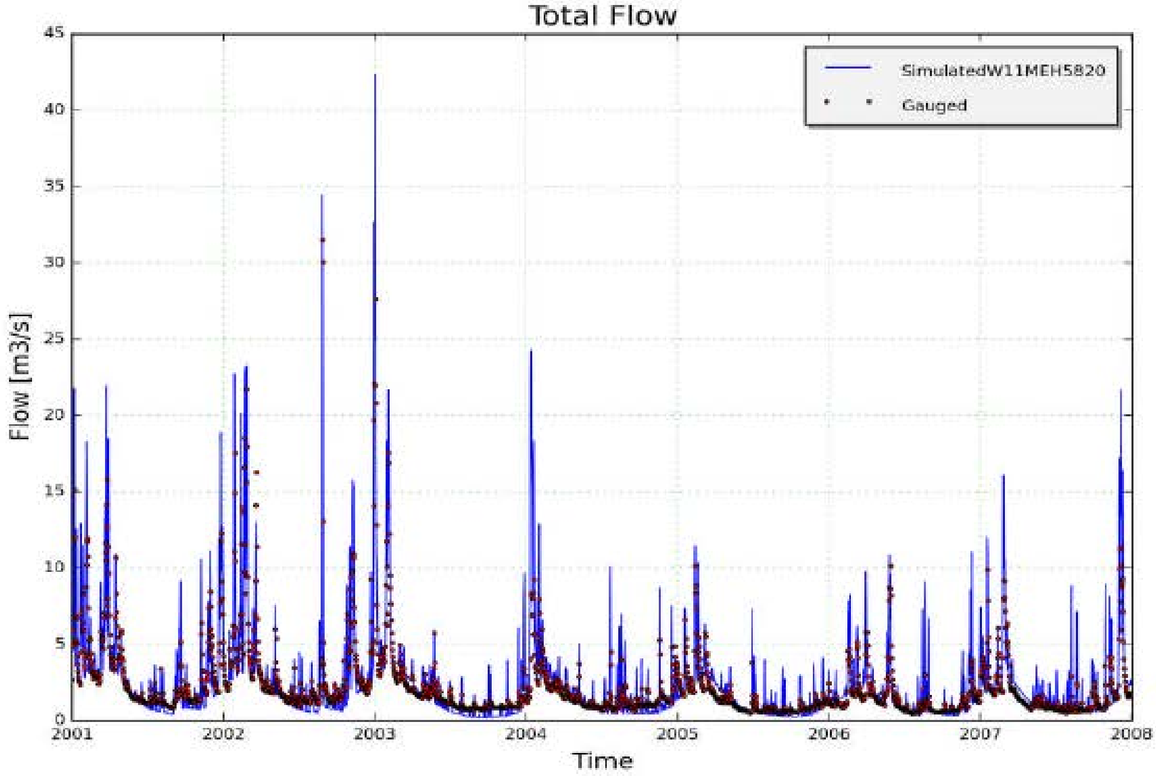


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11MEH5820, station Mehaigne, Wanze(calibration period)

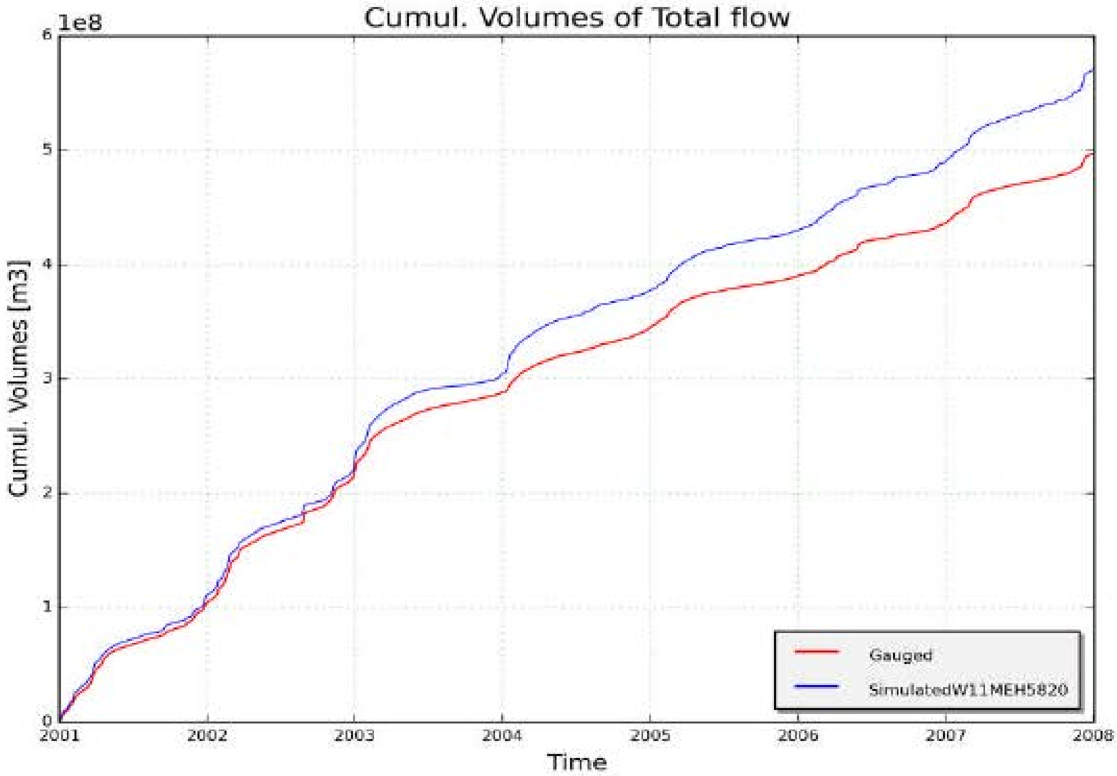


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11MEH5820, station Mehaigne, Wanze (calibration period)

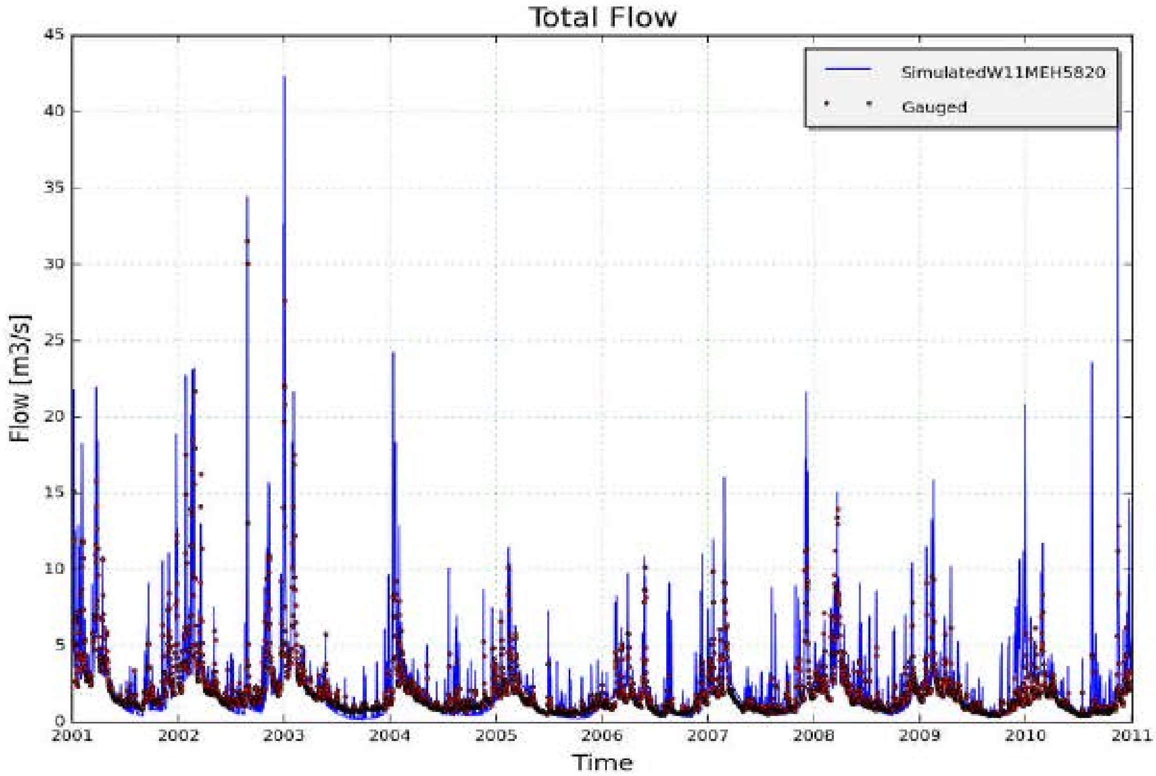


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11MEH5820, station Mehaigne, Wanze (validation period)

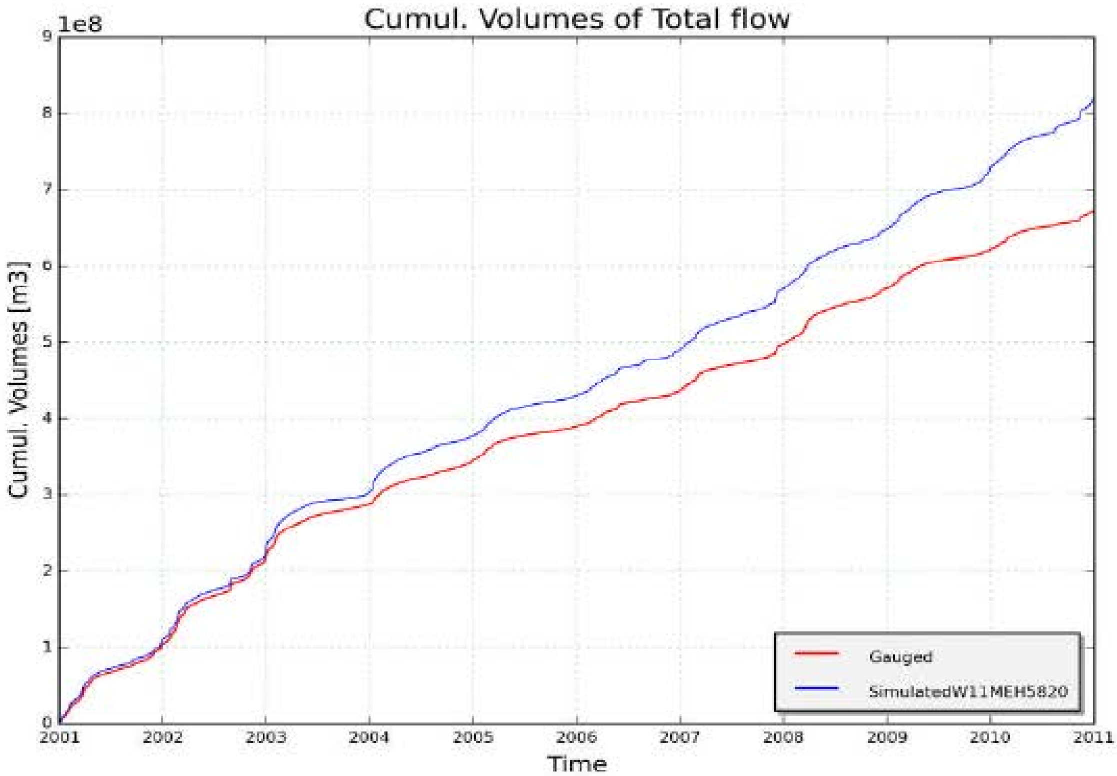


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11MEH5820, station Mehaigne, Wanze (validation period)

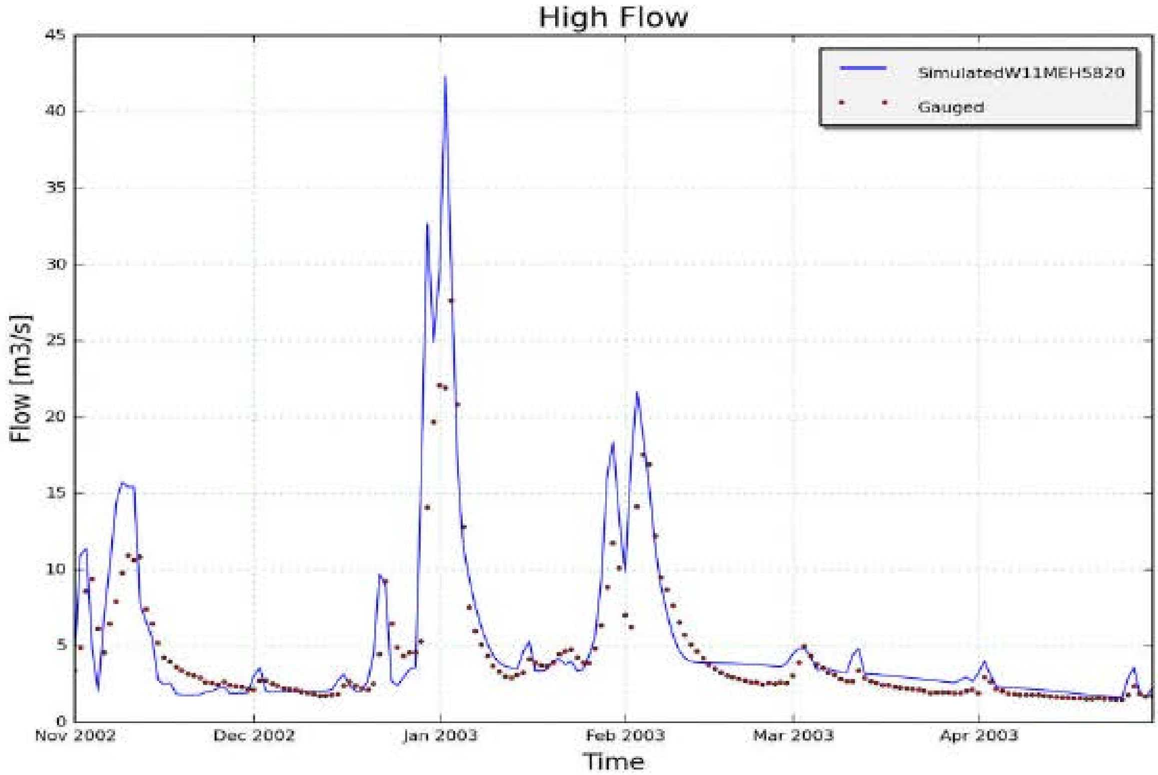


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11MEH5820, station Mehaigne, Wanze

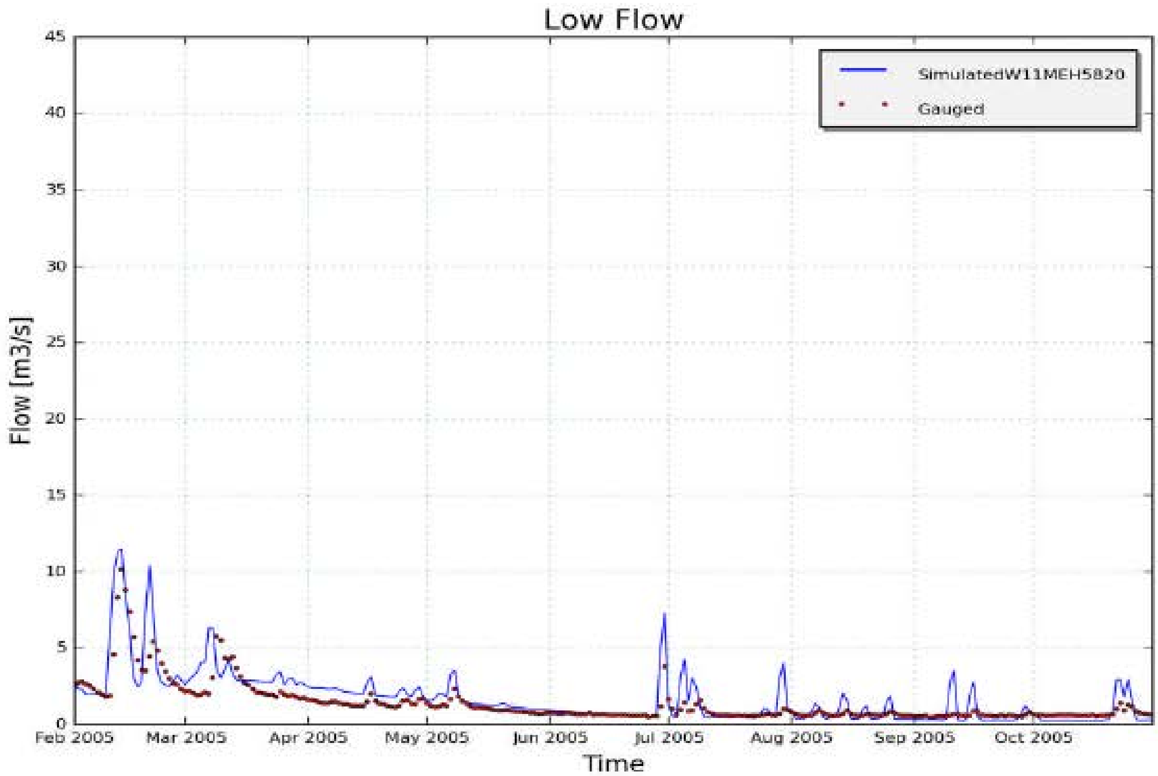


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11MEH5820, station Mehaigne, Wanze

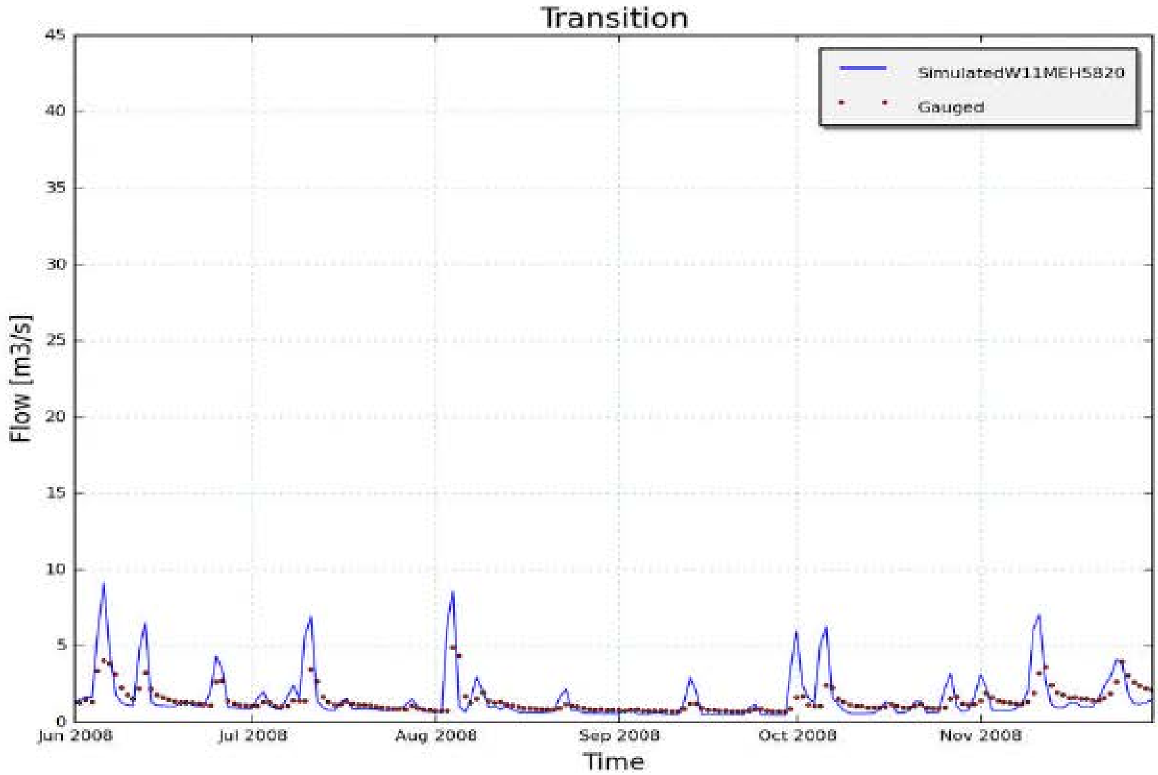


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11MEH5820, station Mehaigne, Wanze

9.5.5 Calibration and validation of WET parameters for catchment "W11OUR5805" (Meuse)

9.5.5.1 Input data

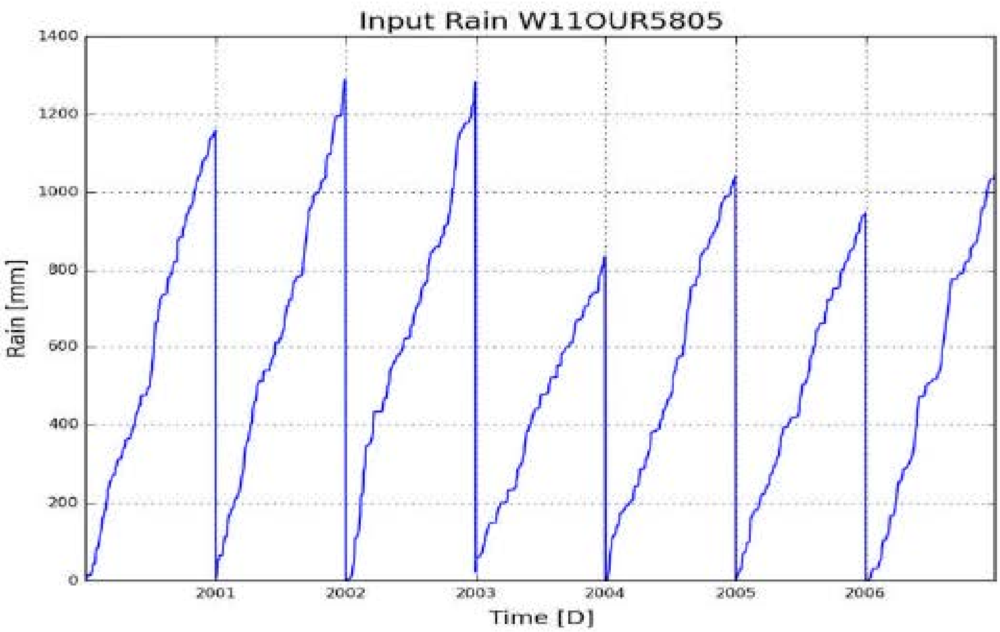


Figure 1: Cumulative precipitation on catchment W11OUR5805 (Meuse)

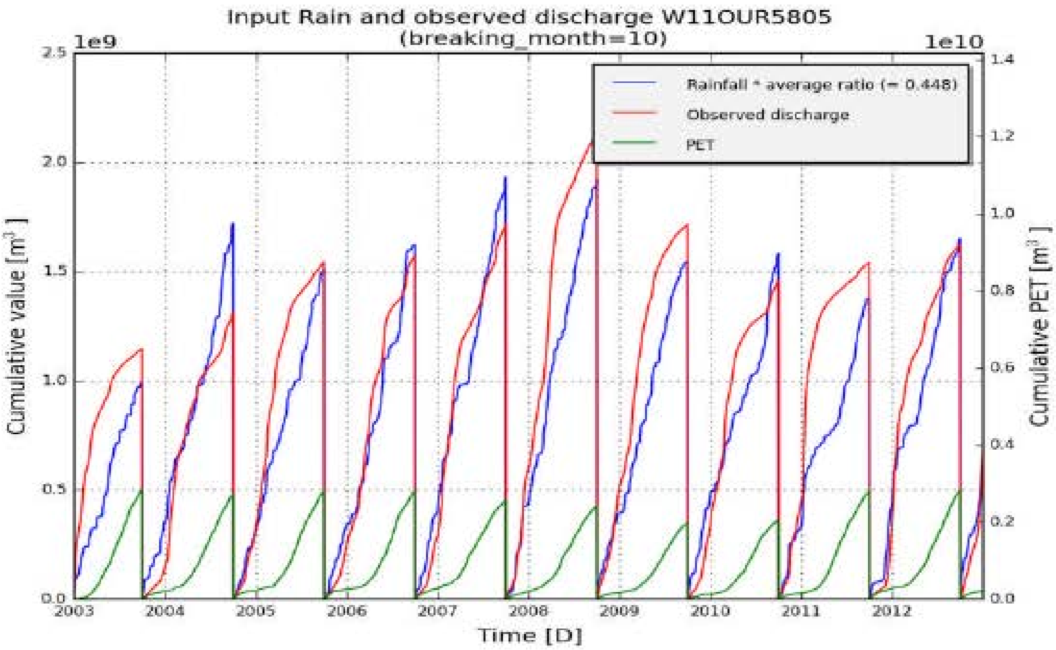


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W11OUR5805 (Meuse)

9.5.5.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	W11OUR5805
subcatchment_area [m2]	3612000000
Validation start_date	01-01-2001
Validation end_date	31-12-2006
frequency	daily

Optimal parameter set:[('Kep', 1.89), ('Ki', 83.4), ('Kg', 0.01), ('Kss', 3.0), ('g0', 73.05), ('g_max', 295.6), ('K_run', 4.19), ('P_max', 226.7)]

Table 1: Goodness of fit for calibration period (2003 - 2012)

	Full year	Summer	Winter
RelErr	-0.4 %	-20.5 %	-2.2 %
NS	0.391	0.077	0.145
NS_log	0.6	0.061	0.251

	Full year	Summer	Winter
NS_rel	0.658	0.554	0.333
KGE	0.637	0.354	0.433

Table 2 :Goodness of fit for validation period (2001 - 2006)

	Full year	Summer	Winter
RelErr	0.9 %	-15.1 %	-0.6 %
NS	0.338	-0.111	0.001
NS_log	0.643	-0.079	0.303
NS_rel	0.732	0.688	0.195
KGE	0.661	0.361	0.499

9.5.5.3 Observed and simulated timeseries for optimum parameters

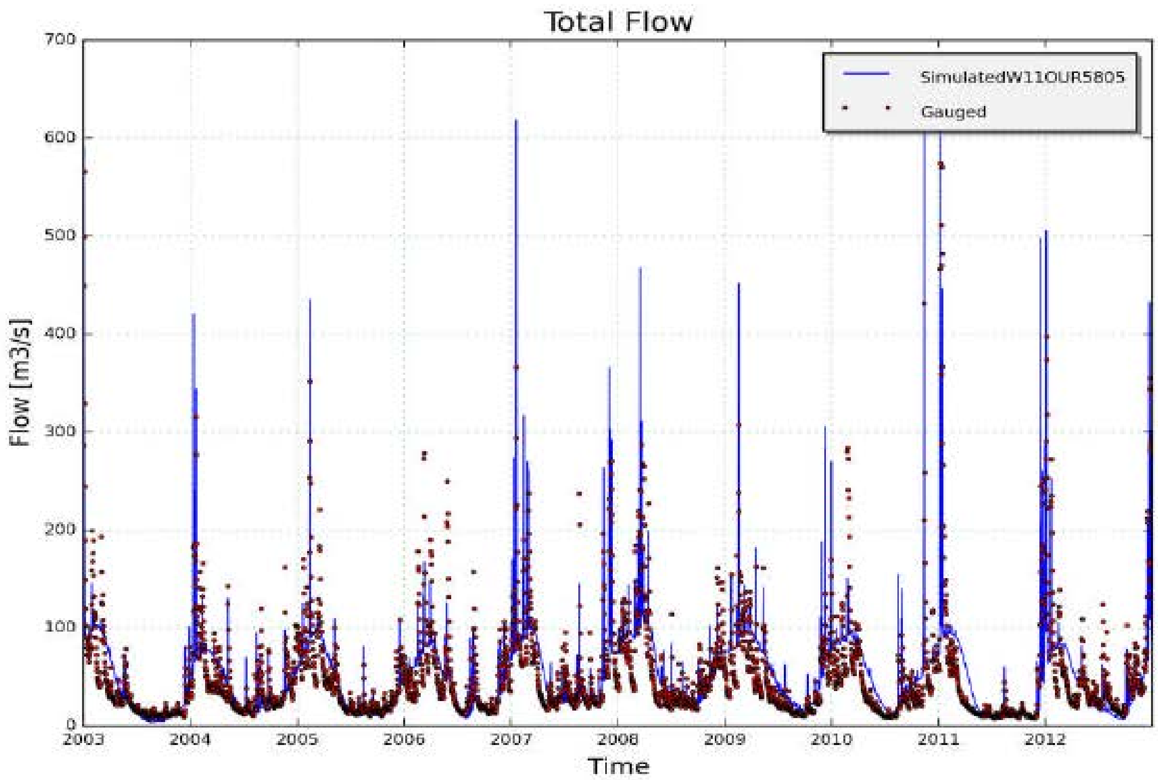


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11OUR5805, station Ourthe, Angleur 2 bis(calibration period)

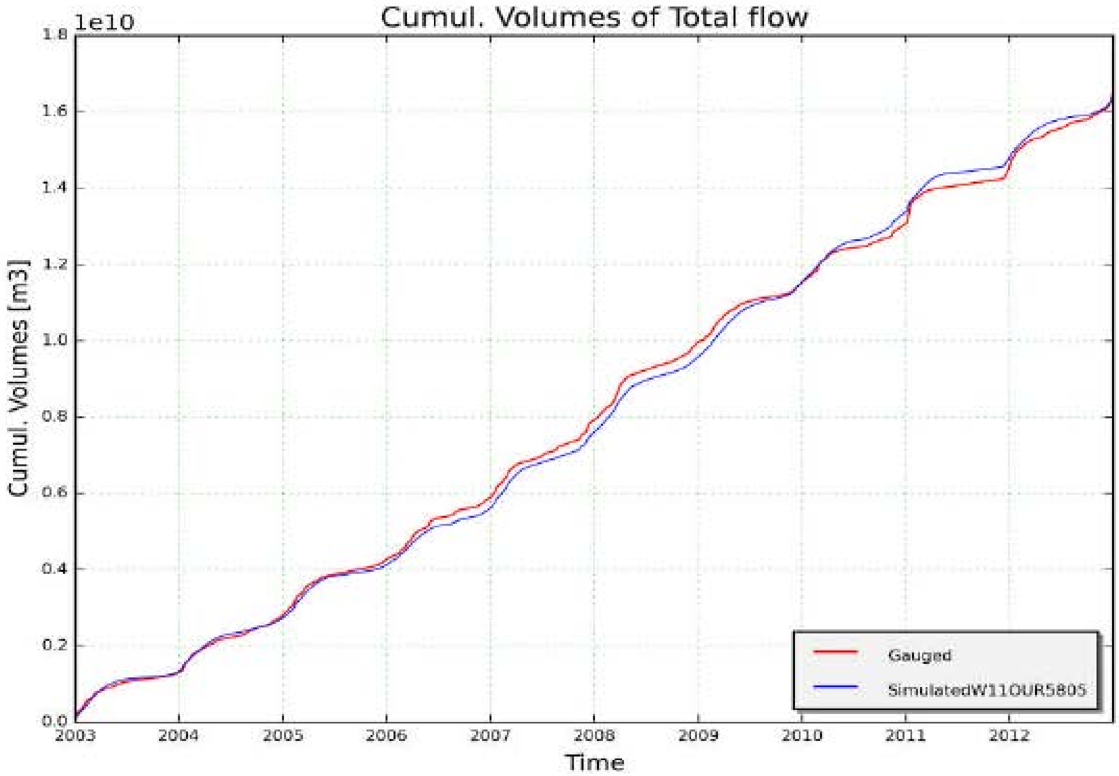


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11OUR5805, station Ourthe, Angleur 2 bis (calibration period)

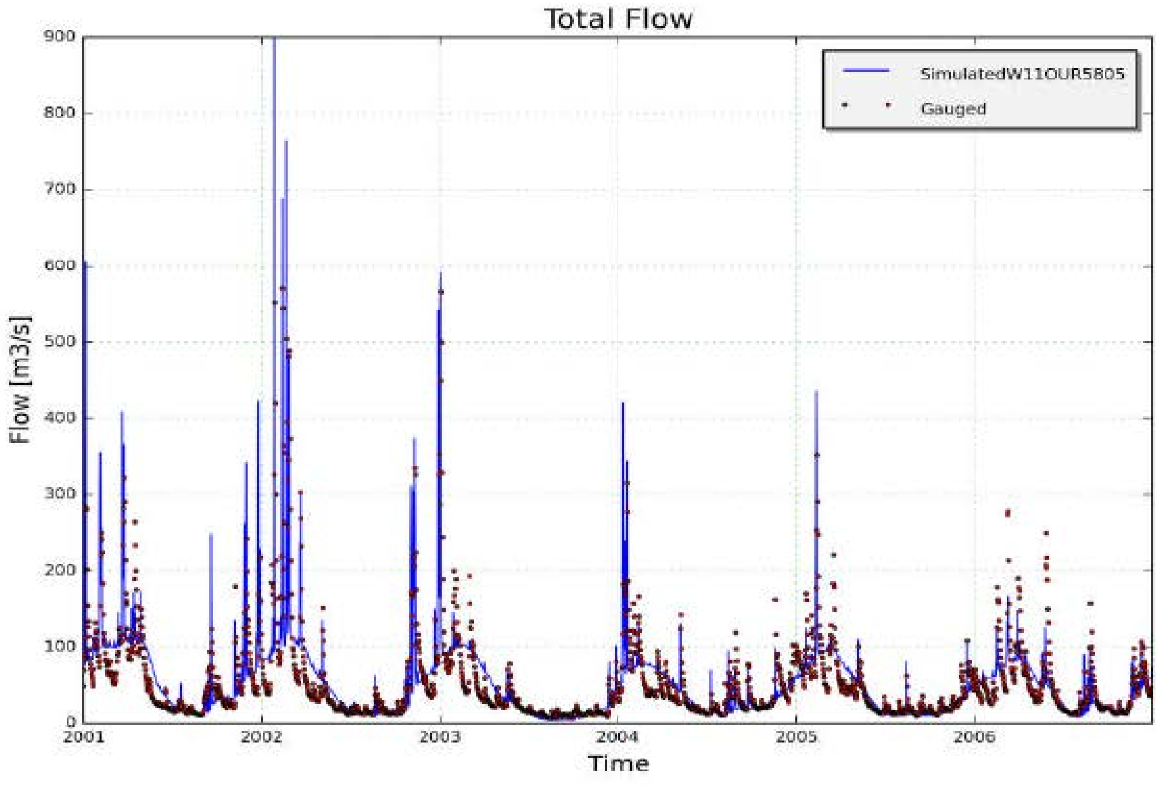


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11OUR5805, station Ourthe, Angleur 2 bis (validation period)

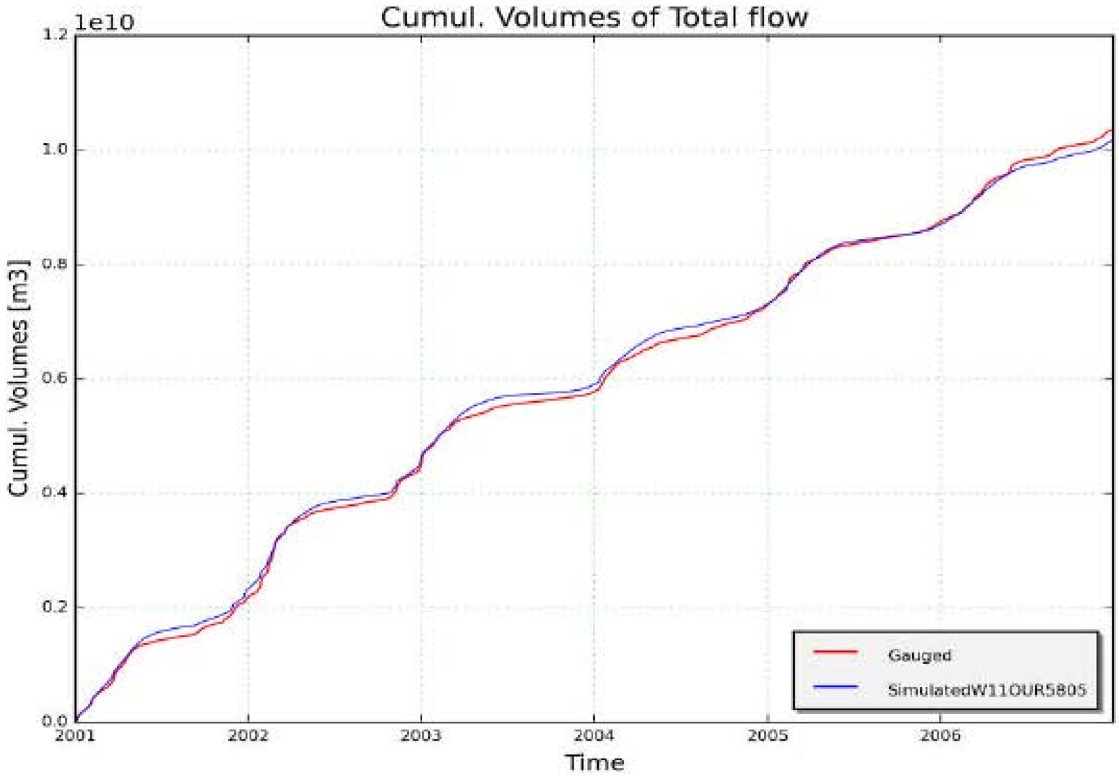


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11OUR5805, station Ourthe, Angleur 2 bis (validation period)

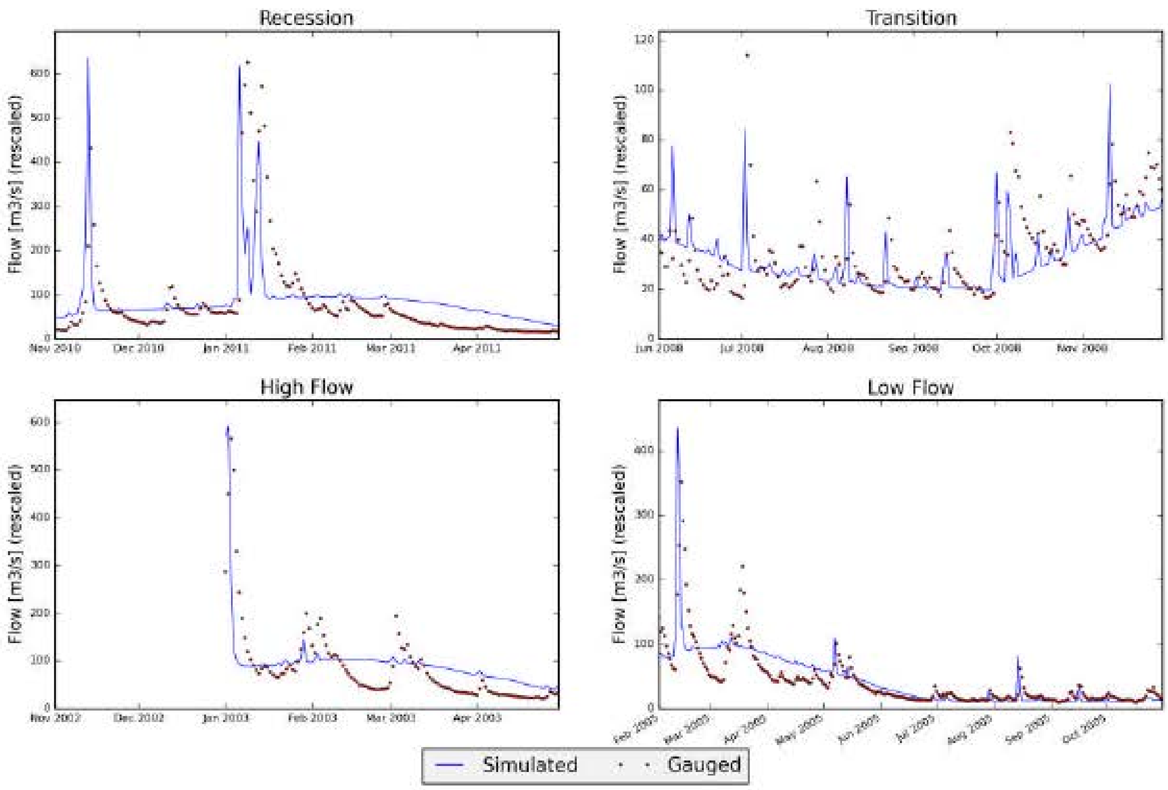


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11OUR5805, station Ourthe, Angleur 2 bis

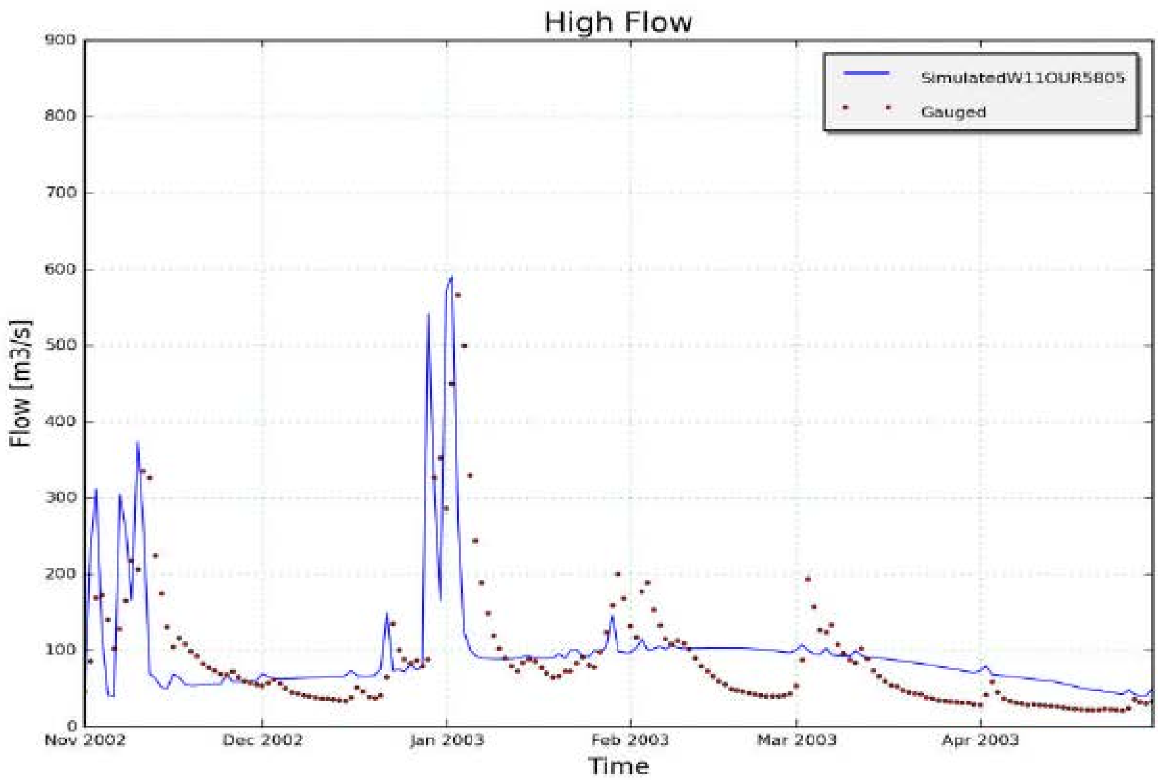


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11OUR5805, station Ourthe, Angleur 2 bis

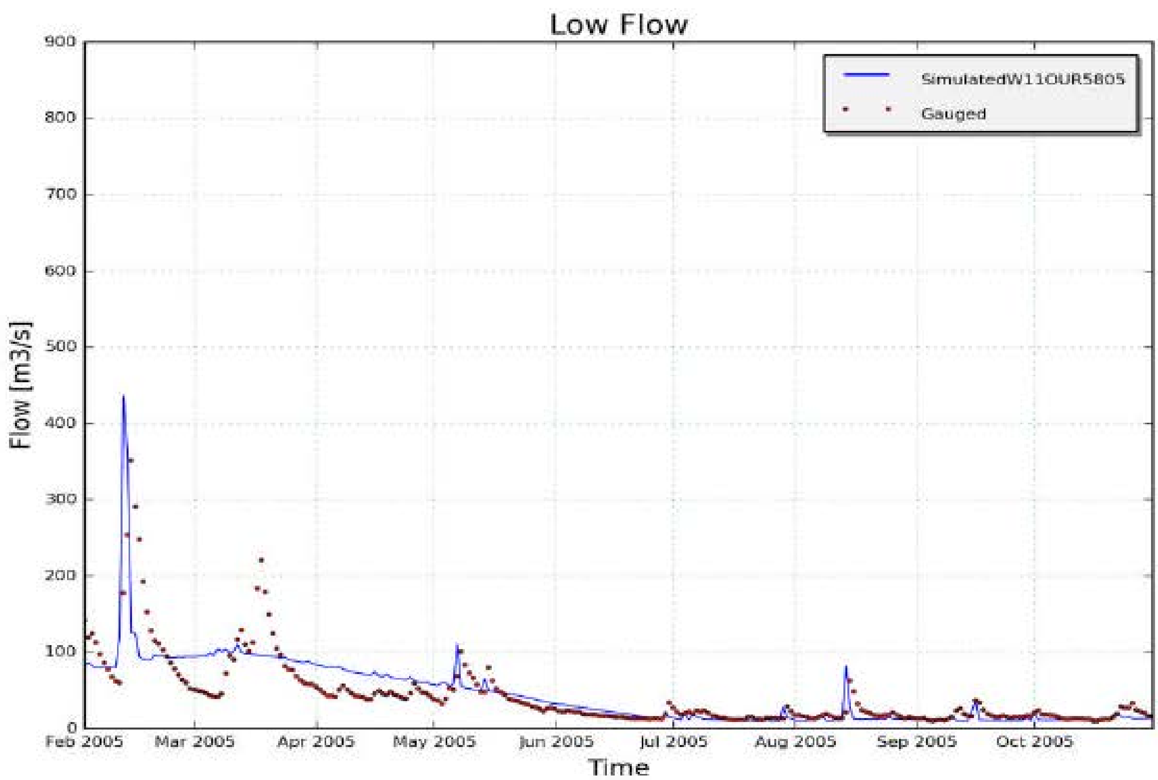


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11OUR5805, station Ourthe, Angleur 2 bis

9.5.6 Calibration and validation of WET parameters for catchment "W11JEK553010" (Meuse)

9.5.6.1 Input data

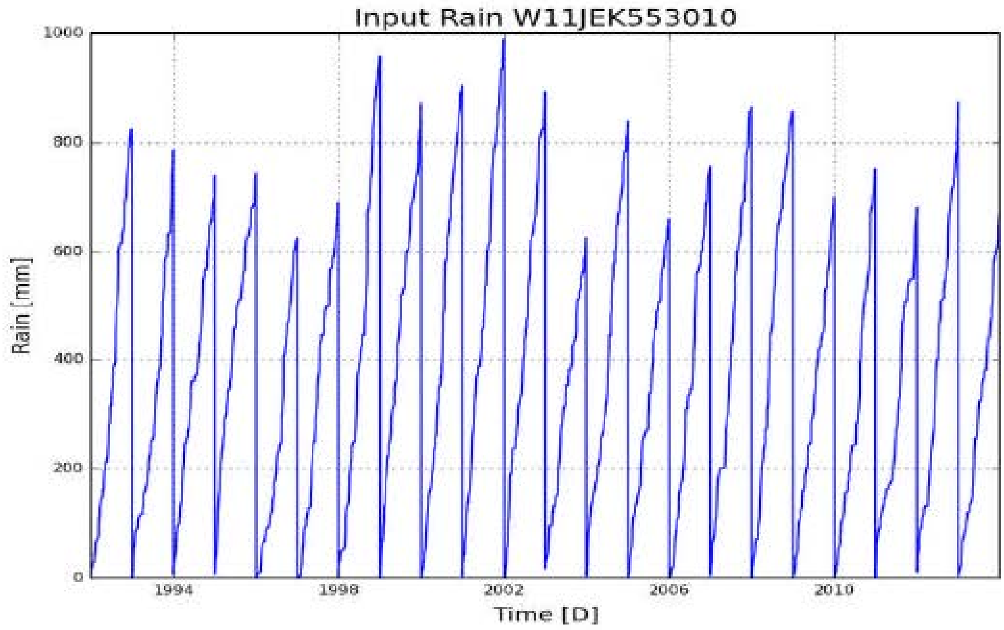


Figure 1: Cumulative precipitation on catchment W11JEK553010 (Meuse)

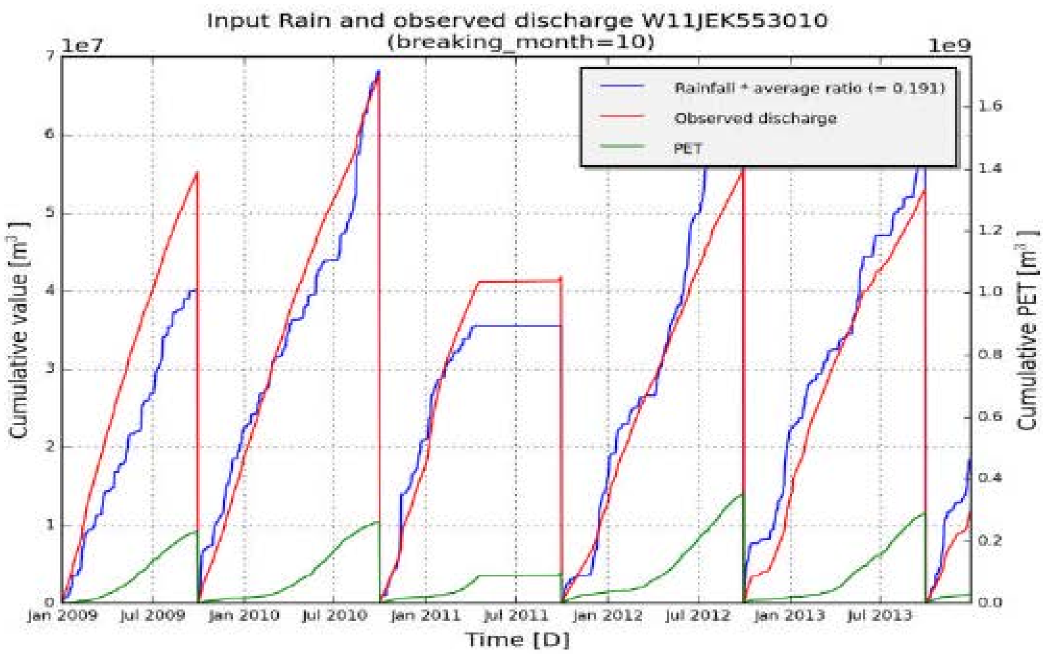


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W11JEK553010 (Meuse)

9.5.6.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	W11JEK553010
subcatchment_area [m2]	465500000
Validation start_date	01-01-1993
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:[('Kep', 1.36), ('Ki', 42.19), ('Kg', 0.0), ('Kss', 2.0), ('g0', 119.7), ('g_max', 274.5), ('K_run', 3.0), ('P_max', 1027.15)]

Table 1: Goodness of fit for calibration period (2009 - 2013)

	Full year	**Summer**	**Winter**
RelErr	23.9 %	-17.8 %	48.4 %
NS	-21.659	-10.176	-16.788
NS_log	-6.905	-15.389	-4.113
NS_rel	-5.436	-2.829	-8.262
KGE	-3.451	-2.138	-2.694

Table 2 :Goodness of fit for validation period (1993 - 2013)

	Full year	**Summer**	**Winter**
RelErr	19.6 %	-4.4 %	61.3 %
NS	-12.441	-15.751	-11.895
NS_log	-6.037	-9.521	-3.015
NS_rel	-3.578	-2.658	-5.08
KGE	-2.345	-2.761	-2.193

9.5.6.3 Observed and simulated timeseries for optimum parameters

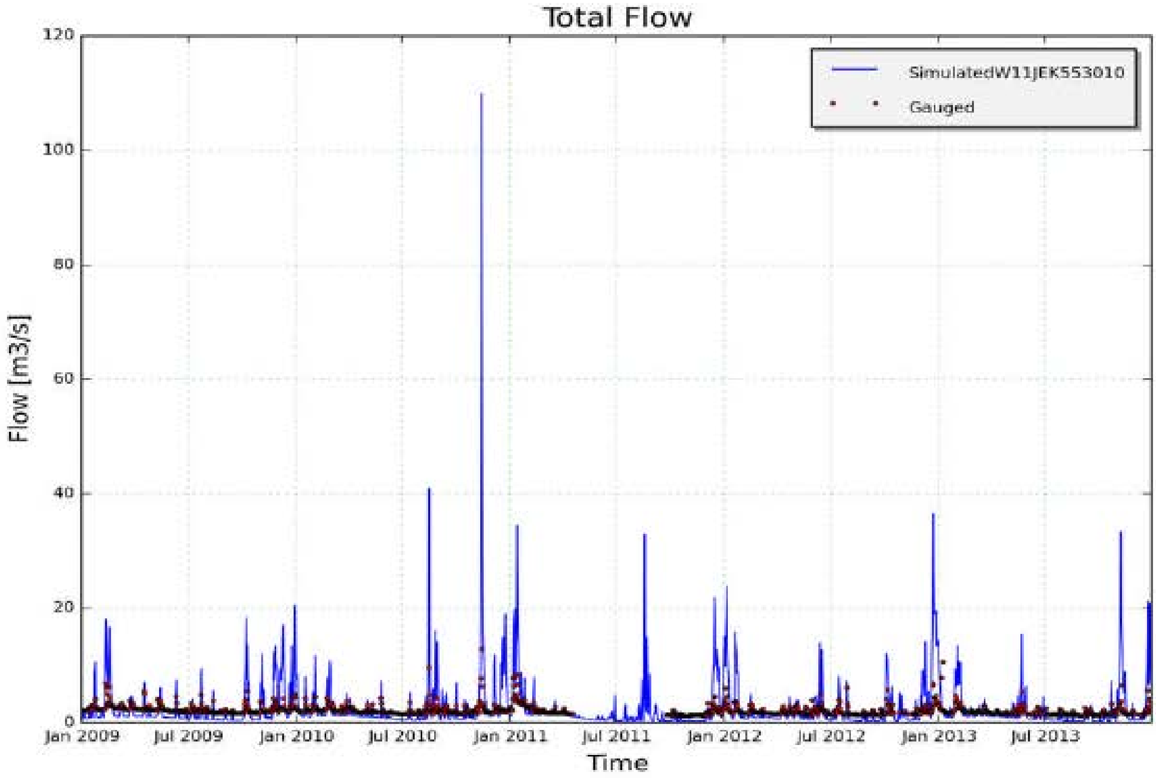


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11JEK553010, station unkown(calibration period)

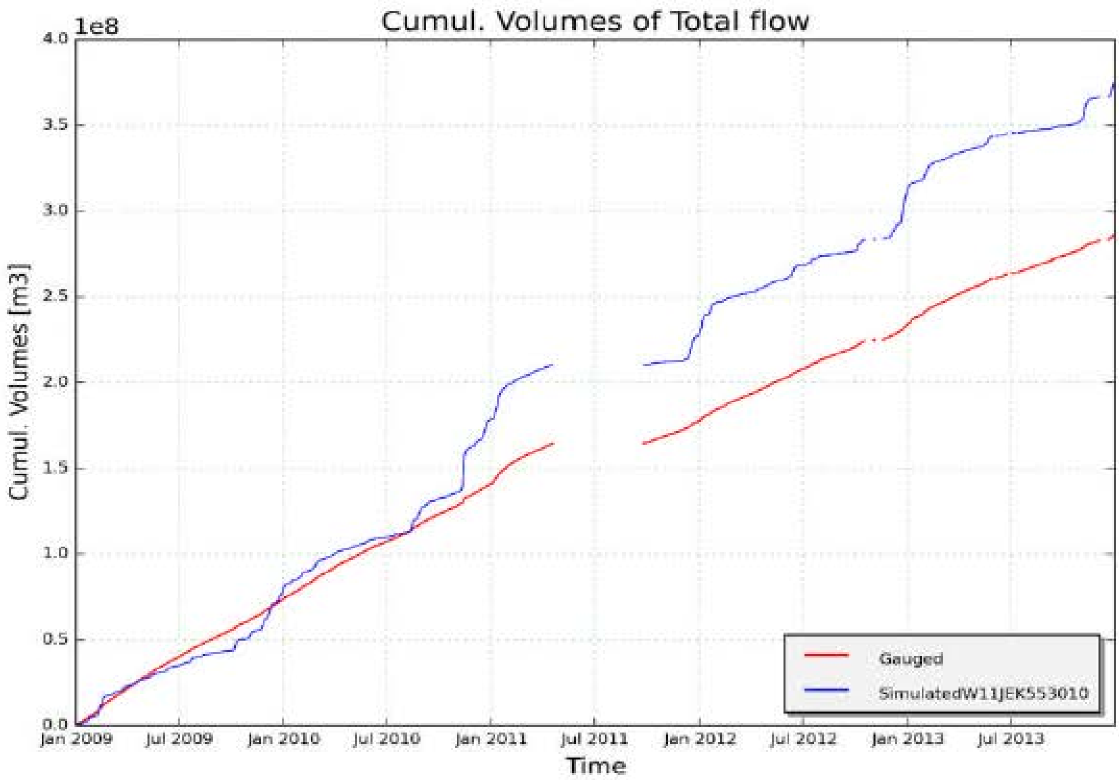


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11JEK553010, station unkown (calibration period)

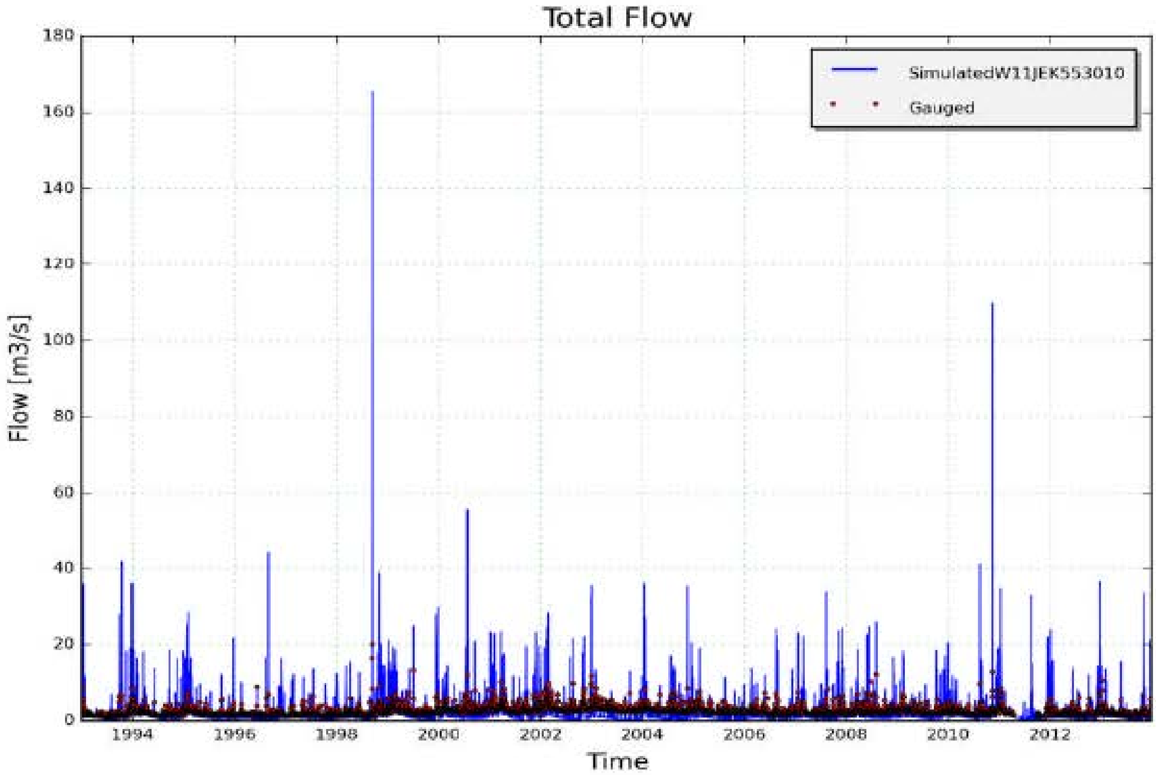


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11JEK553010, station unkown (validation period)

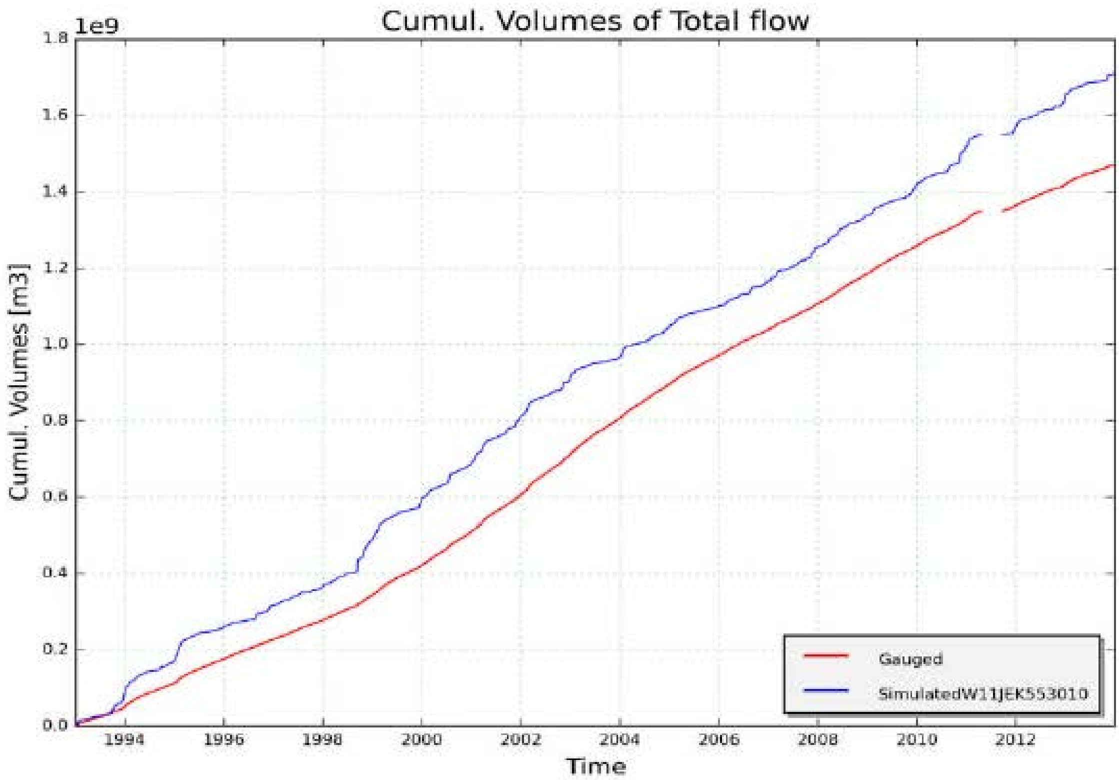


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11JEK553010, station unkown (validation period)

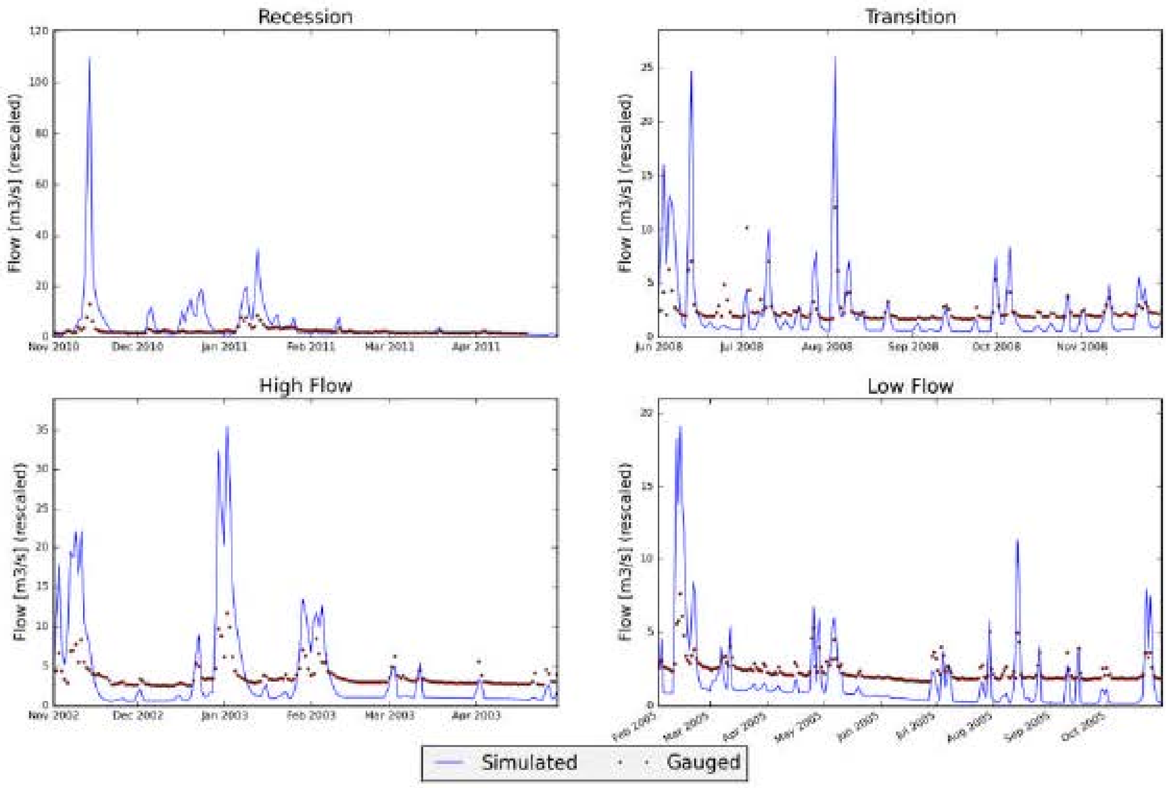


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11JEK553010, station unkown

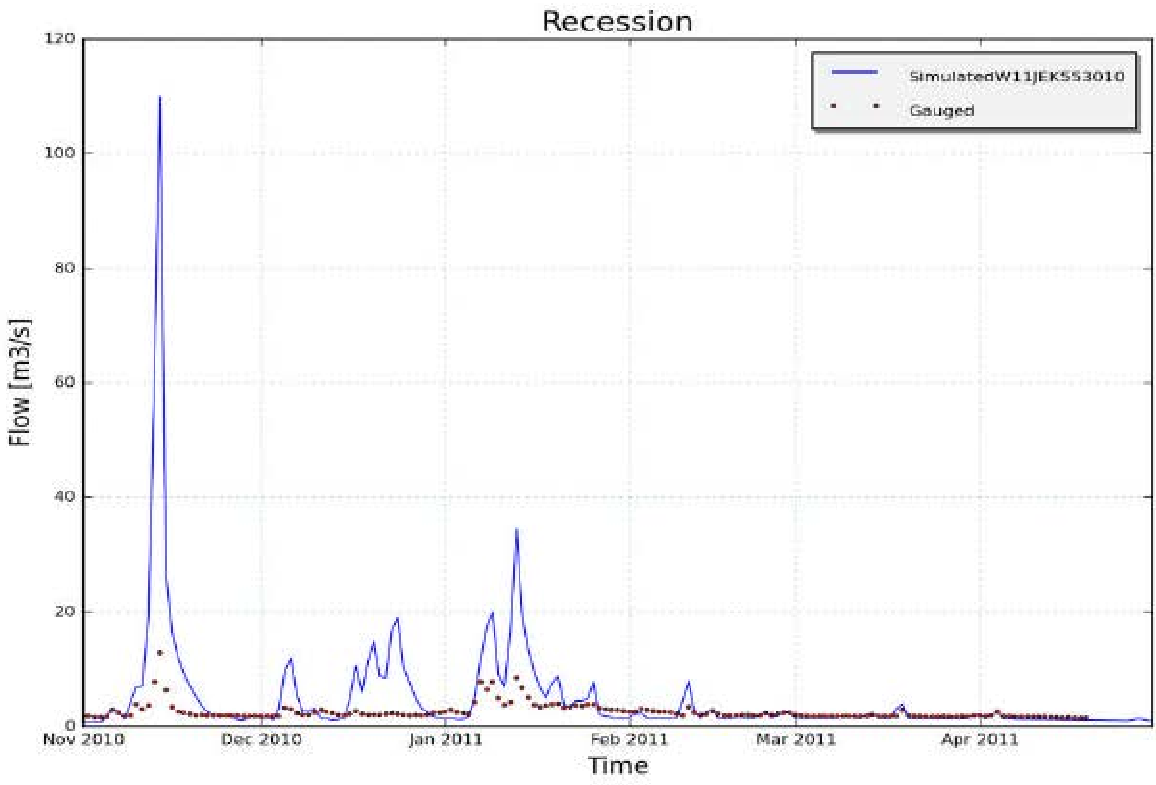


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11JEK553010, station unkown

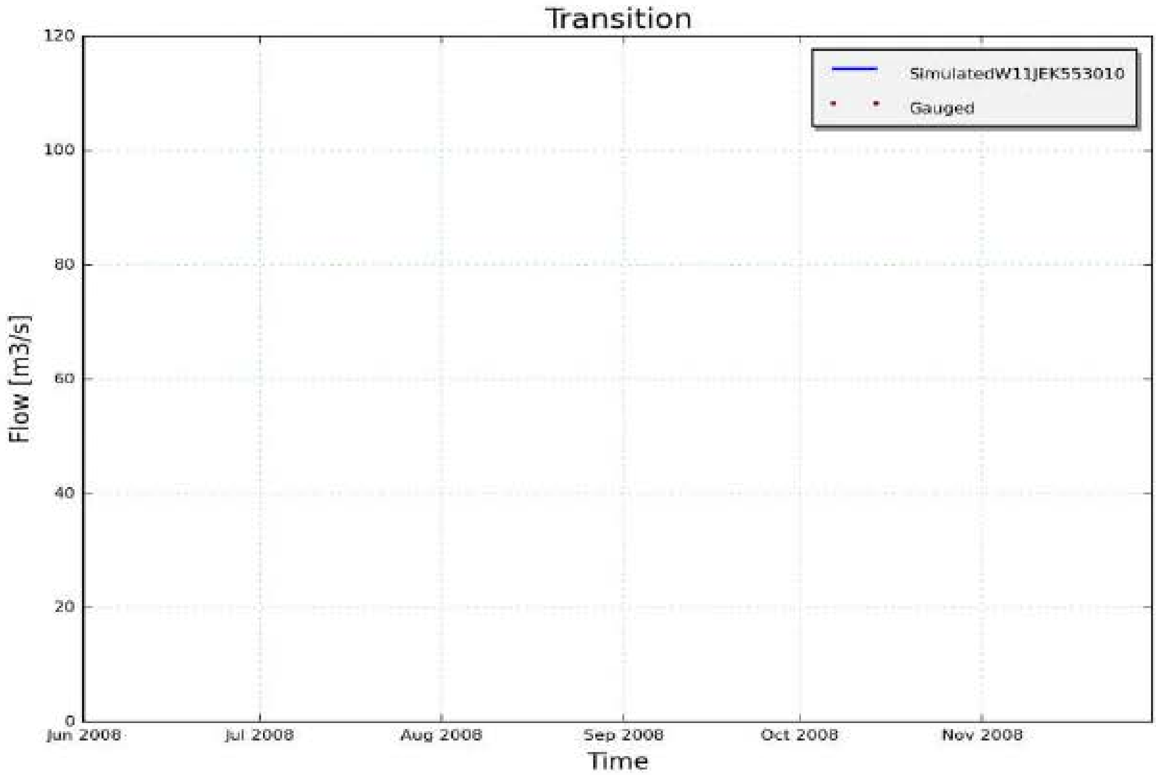


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11JEK553010, station unkown

9.5.7 Calibration and validation of WET parameters for catchment "F11MAA8702" (Meuse)

9.5.7.1 Input data

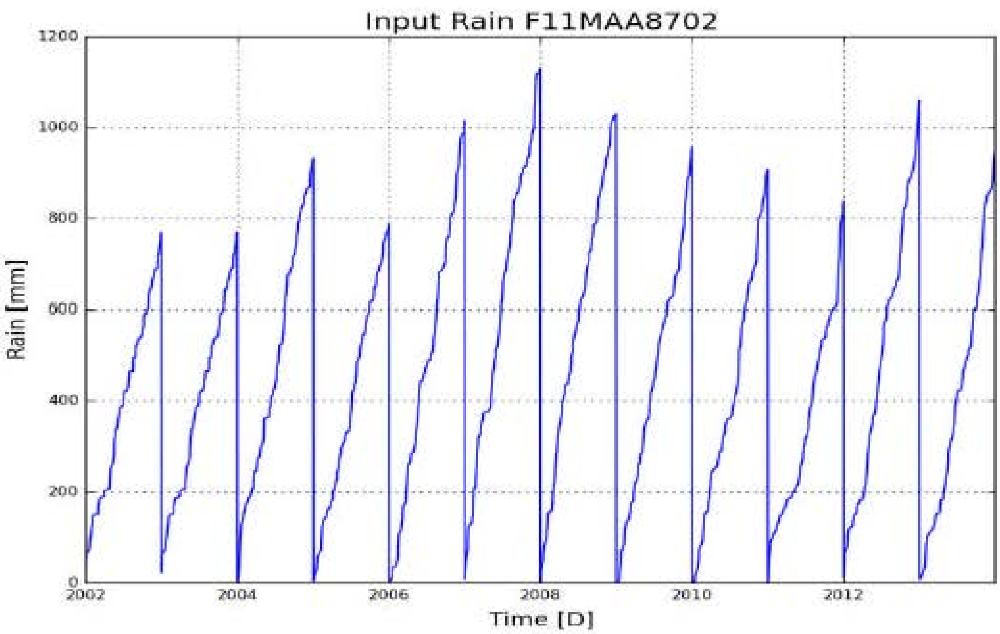


Figure 1: Cumulative precipitation on catchment F11MAA8702 (Meuse)

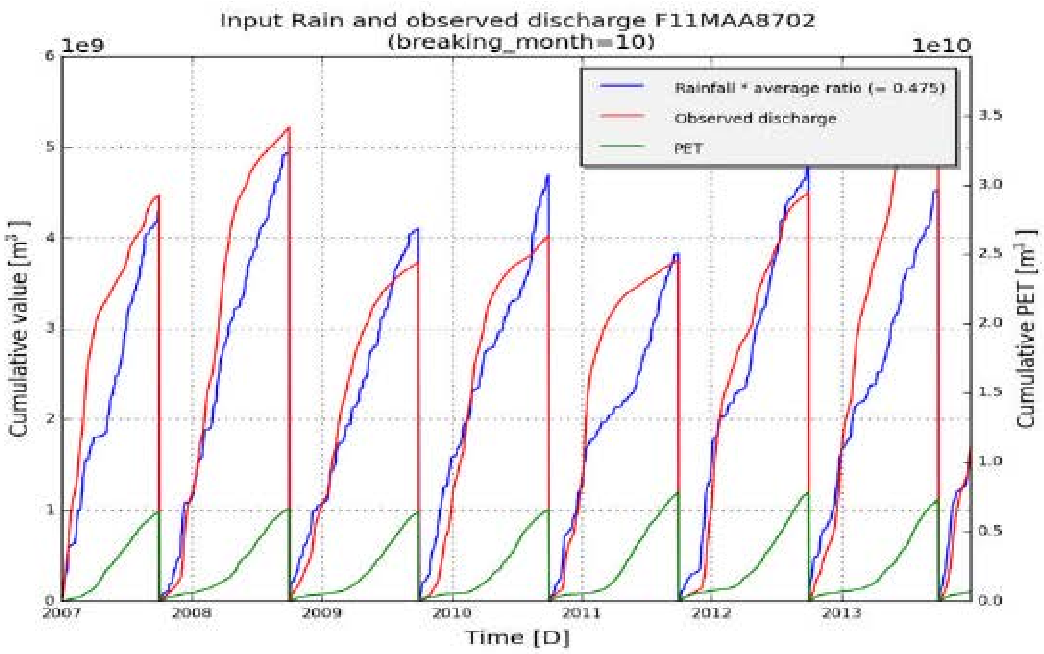


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment F11MAA8702 (Meuse)

9.5.7.2 Model summary

model_structure	WETSPAclassic.paramset1
subcatchment_name	F11MAA8702
subcatchment_area [m2]	10120000000
Validation start_date	01-01-2003
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:[('Kep', 1.4), ('Ki', 113.7), ('Kg', 0.01), ('Kss', 2.8), ('g0', 150.48), ('g_max', 263.27), ('K_run', 2.78), ('P_max', 74.71)]

Table 1: Goodness of fit for calibration period (2007 - 2013)

	Full year	**Summer**	**Winter**
RelErr	0.1 %	4.2 %	-9.6 %
NS	0.427	0.369	0.032
NS_log	0.747	0.488	0.344
NS_rel	0.722	0.702	0.404

KGE	0.717	0.454	0.539

Table 2 :Goodness of fit for validation period (2003 - 2013)

	Full year	**Summer**	**Winter**
RelErr	0.2 %	0.9 %	-7.7 %
NS	0.428	0.389	0.017
NS_log	0.755	0.421	0.408
NS_rel	0.766	0.706	0.44
KGE	0.722	0.515	0.552

9.5.7.3 Observed and simulated timeseries for optimum parameters

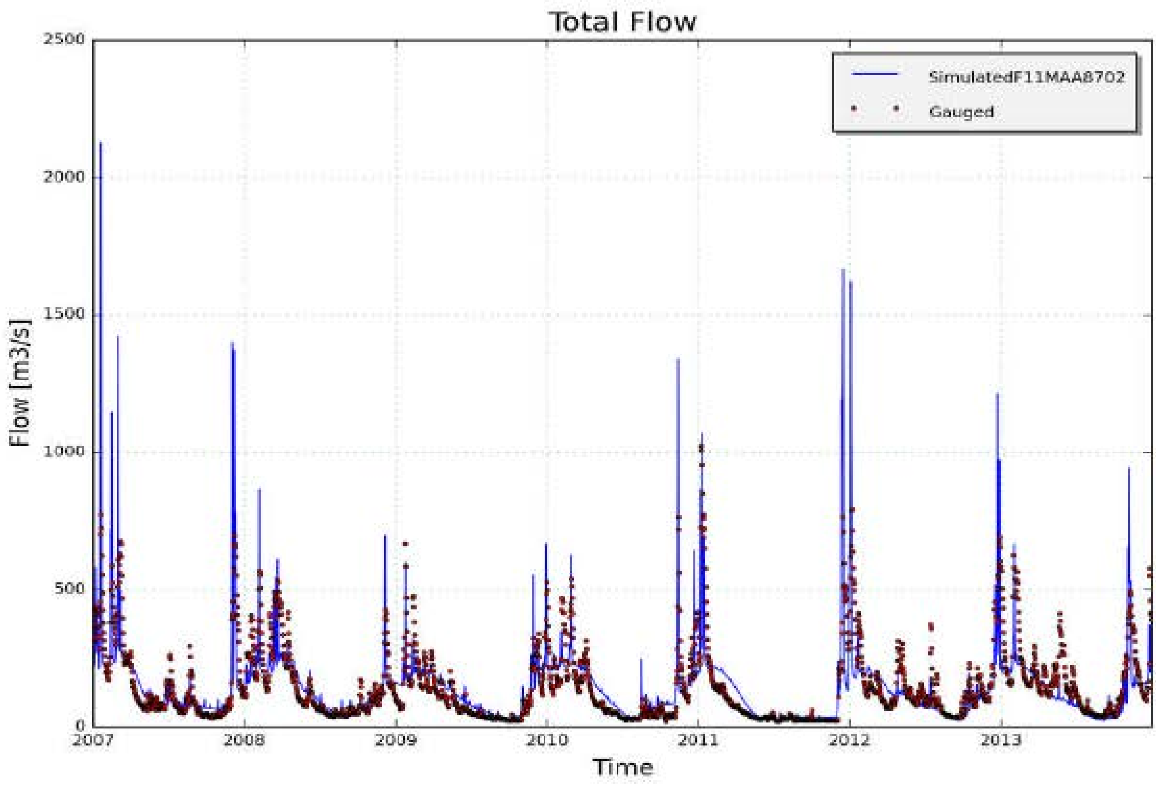


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment F11MAA8702, station Meuse, Chooz(calibration period)

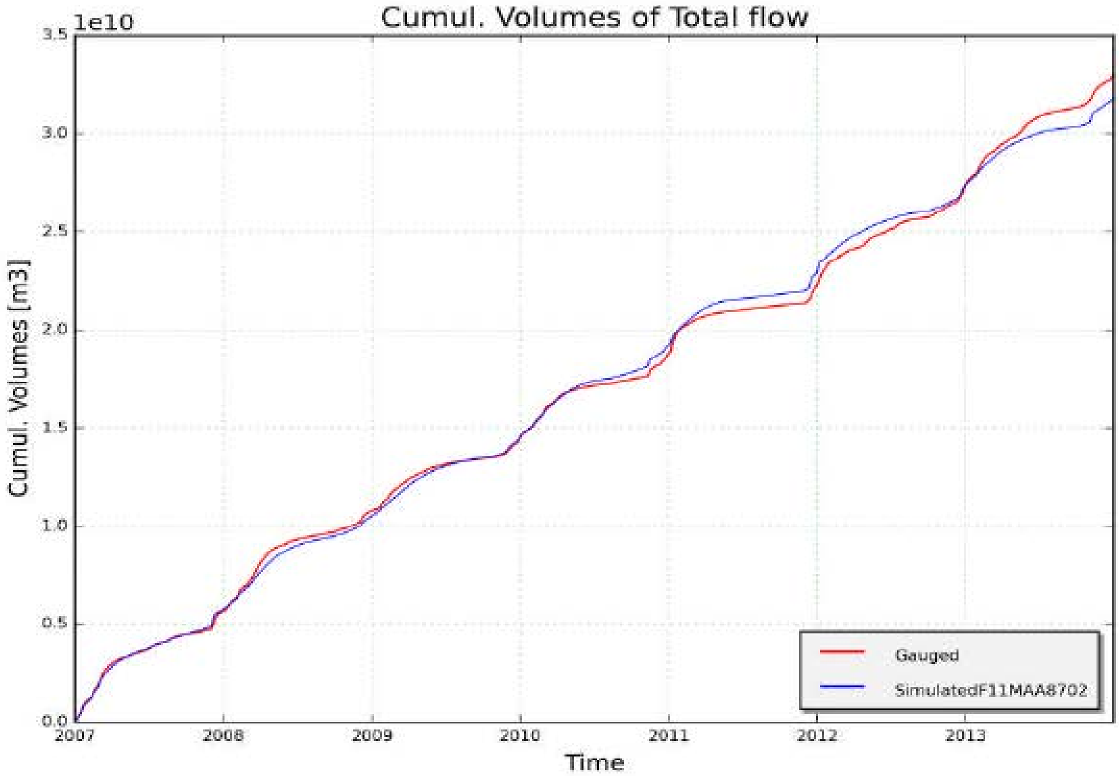


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment F11MAA8702, station Meuse, Chooz (calibration period)

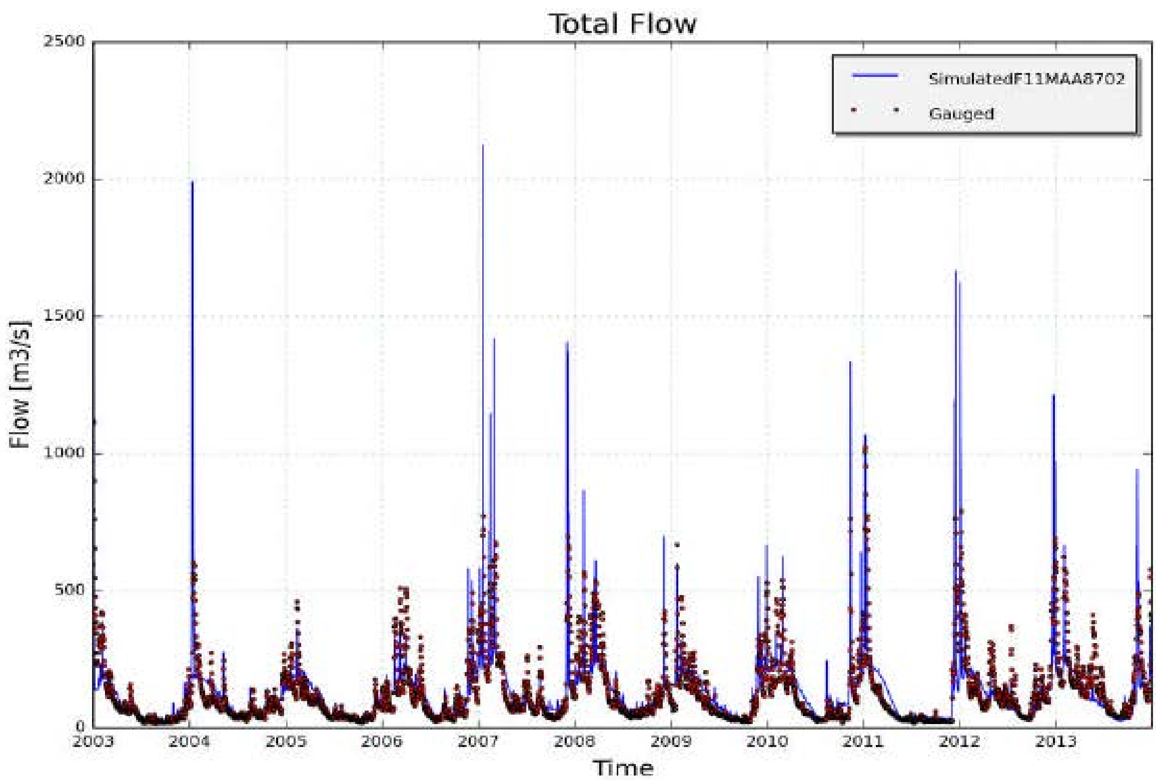


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment F11MAA8702, station Meuse, Chooz (validation period)

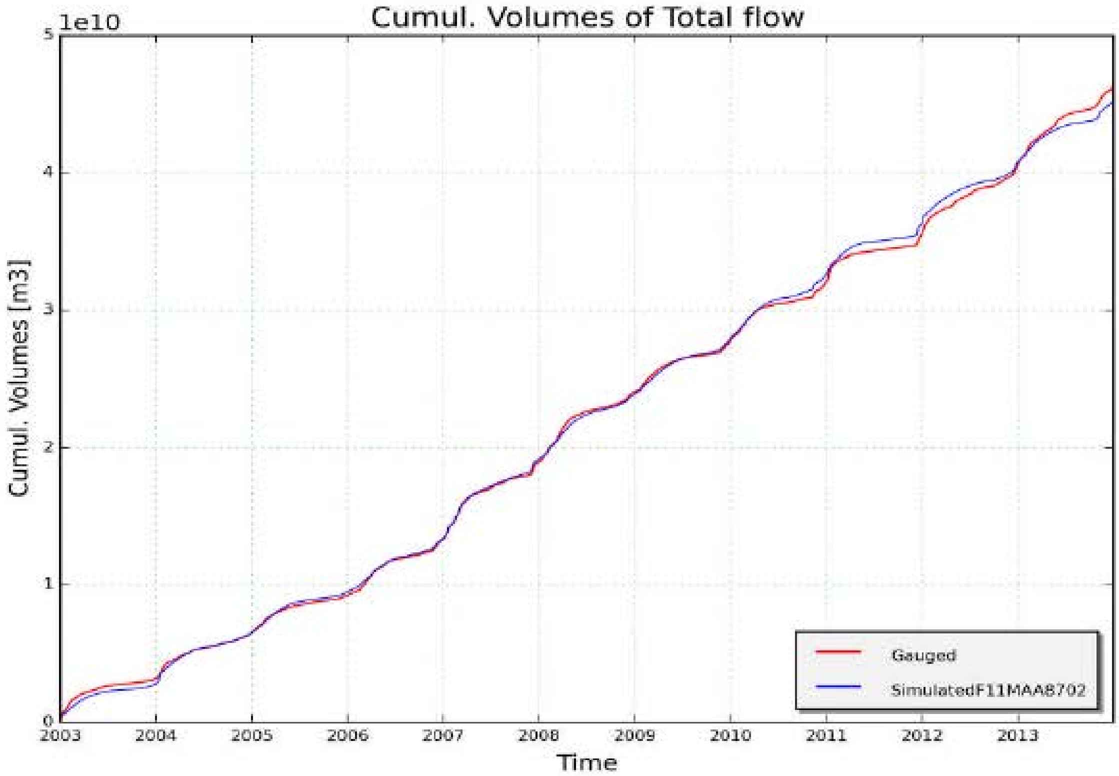


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment F11MAA8702, station Meuse, Chooz (validation period)

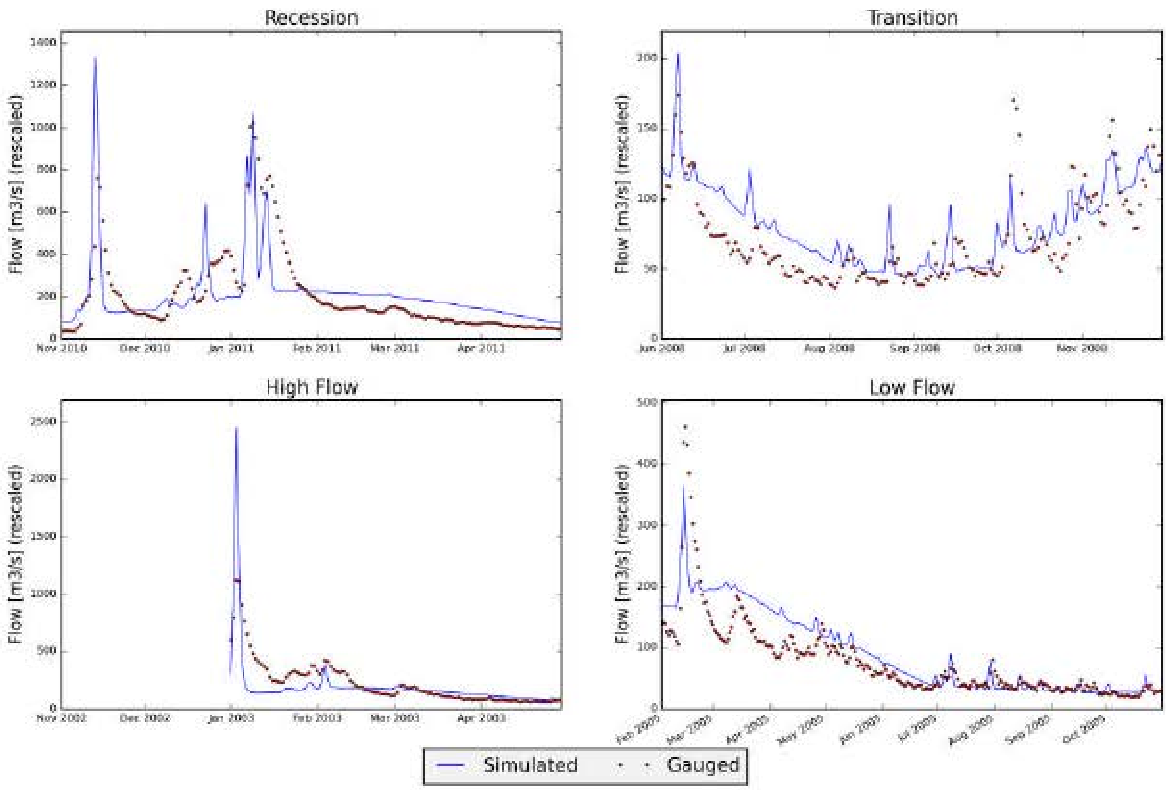


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment F11MAA8702, station Meuse, Chooz

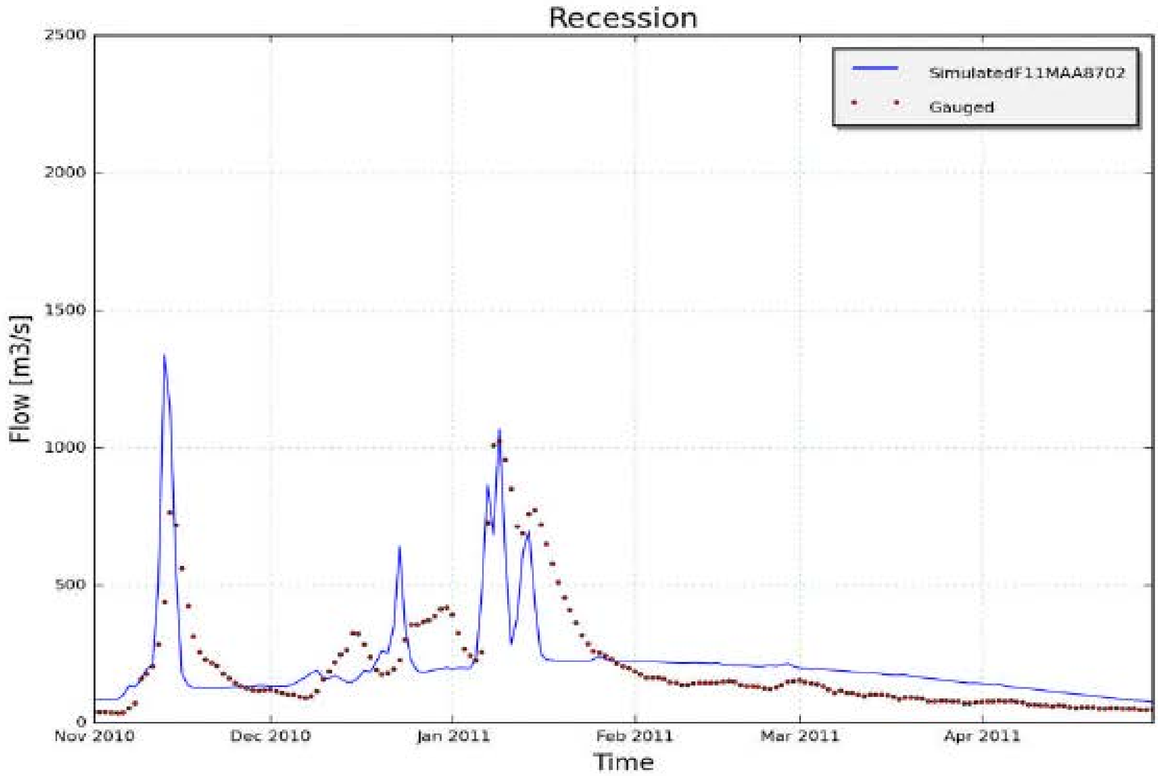


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment F11MAA8702, station Meuse, Chooz

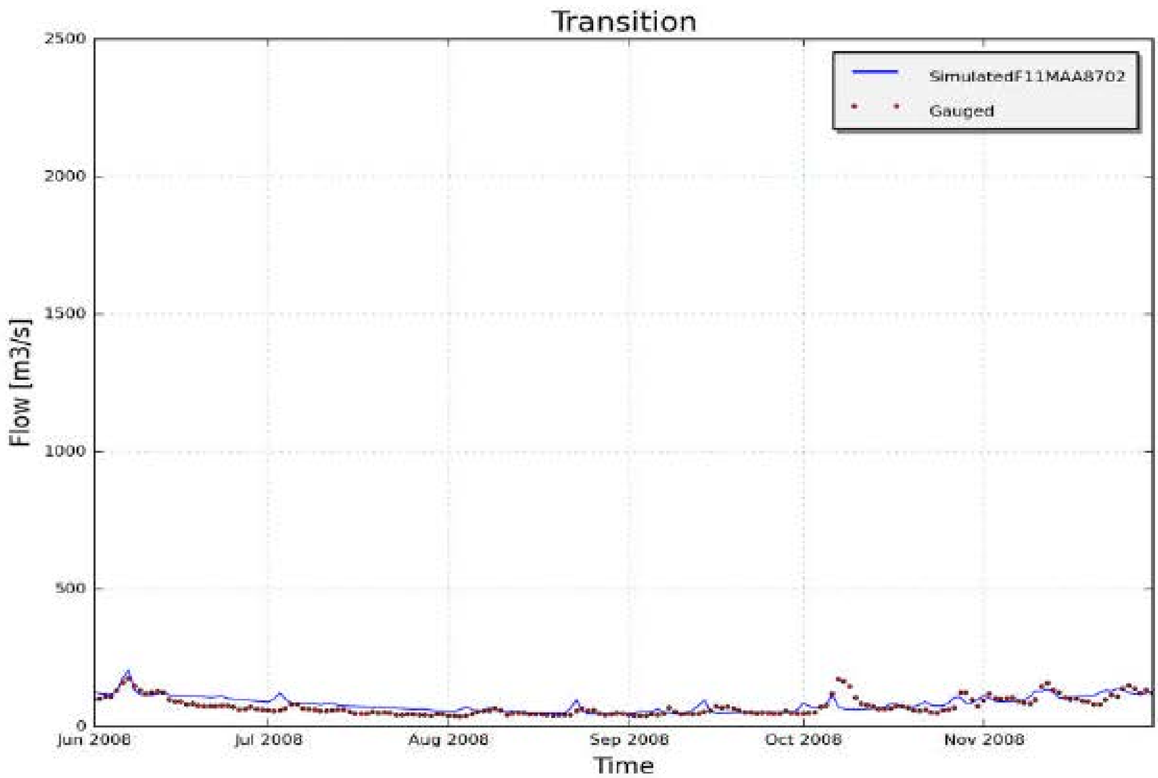


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment F11MAA8702, station Meuse, Chooz

9.5.8 Calibration and validation of WET parameters for catchment "W11MAAPROF12586" (Meuse)

9.5.8.1 Input data

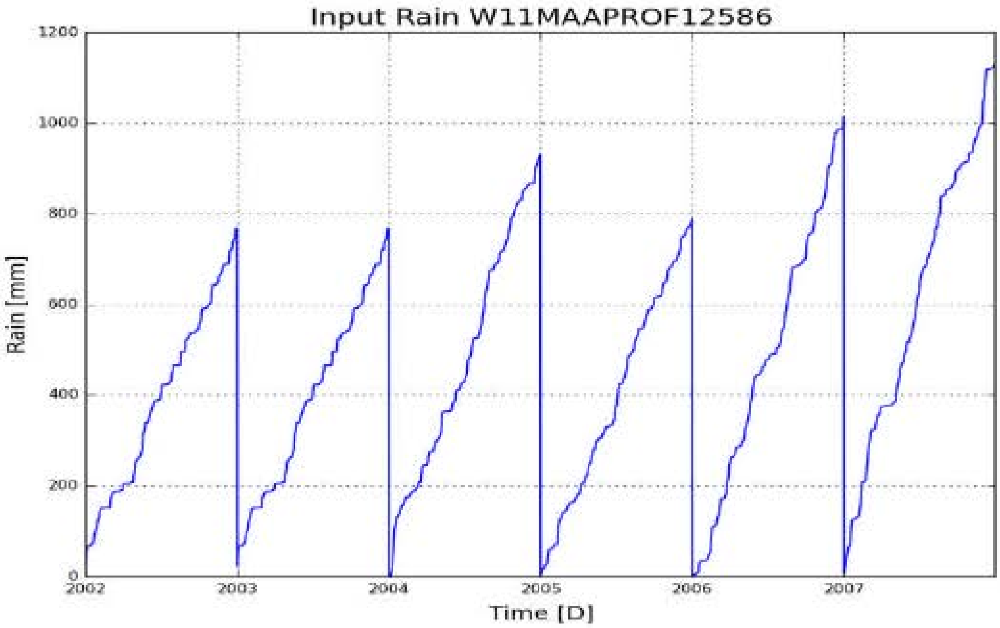


Figure 1: Cumulative precipitation on catchment W11MAAPROF12586 (Meuse)

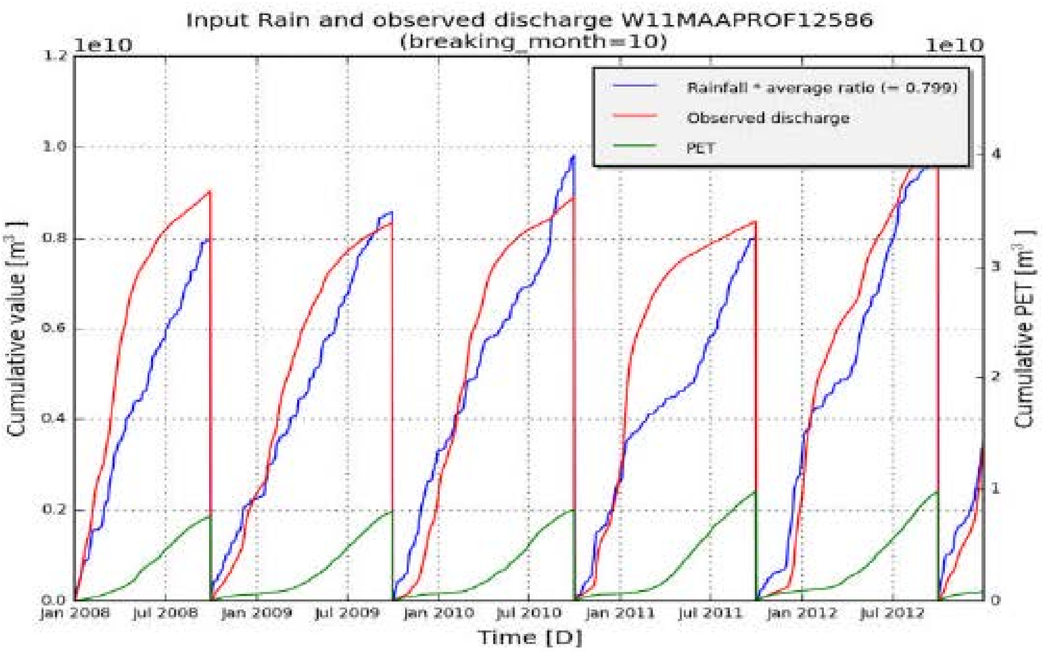


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W11MAAPROF12586 (Meuse)

9.5.8.2 Model summary

model_structure	WETSPAclassic.paramset1

subcatchment_name	W11MAAPROF12586
subcatchment_area [m2]	12586000000
Validation start_date	01-01-2003
Validation end_date	31-12-2007
frequency	daily

Optimal parameter set:[('Kep', 0.69), ('Ki', 46.67), ('Kg', 0.07), ('Kss', 0.68), ('g0', 283.11), ('g_max', 344.69), ('K_run', 2.77), ('P_max', 53.77)]

Table 1: Goodness of fit for calibration period (2008 - 2012)

	Full year	**Summer**	**Winter**
RelErr	-1.6 %	71.2 %	-22.0 %
NS	0.667	-0.595	0.455
NS_log	0.622	-0.844	0.573
NS_rel	0.243	-1.261	0.756
KGE	0.638	0.253	0.478

Table 2 :Goodness of fit for validation period (2003 - 2007)

	Full year	**Summer**	**Winter**
RelErr	5.2 %	54.6 %	-12.3 %
NS	0.718	-0.423	0.609
NS_log	0.591	-0.194	0.641
NS_rel	0.395	-0.587	0.656
KGE	0.684	0.249	0.594

9.5.8.3 Observed and simulated timeseries for optimum parameters

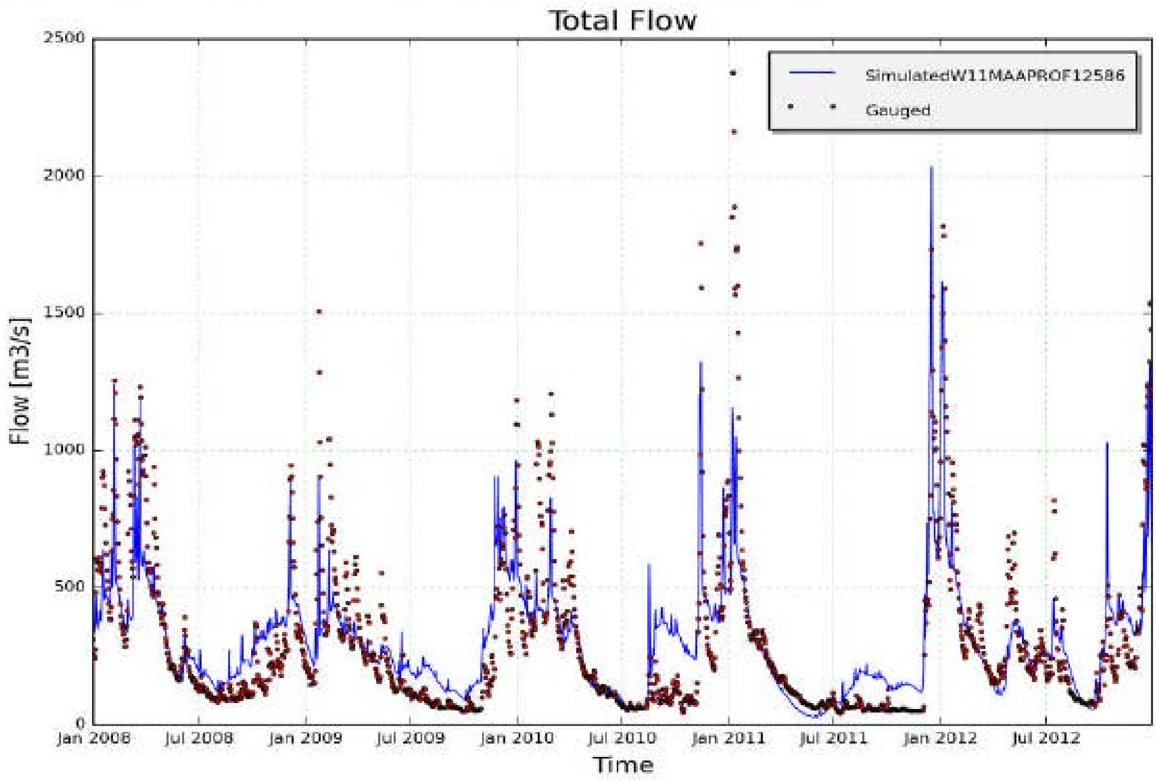


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11MAAPROF12586, station unkown(calibration period)

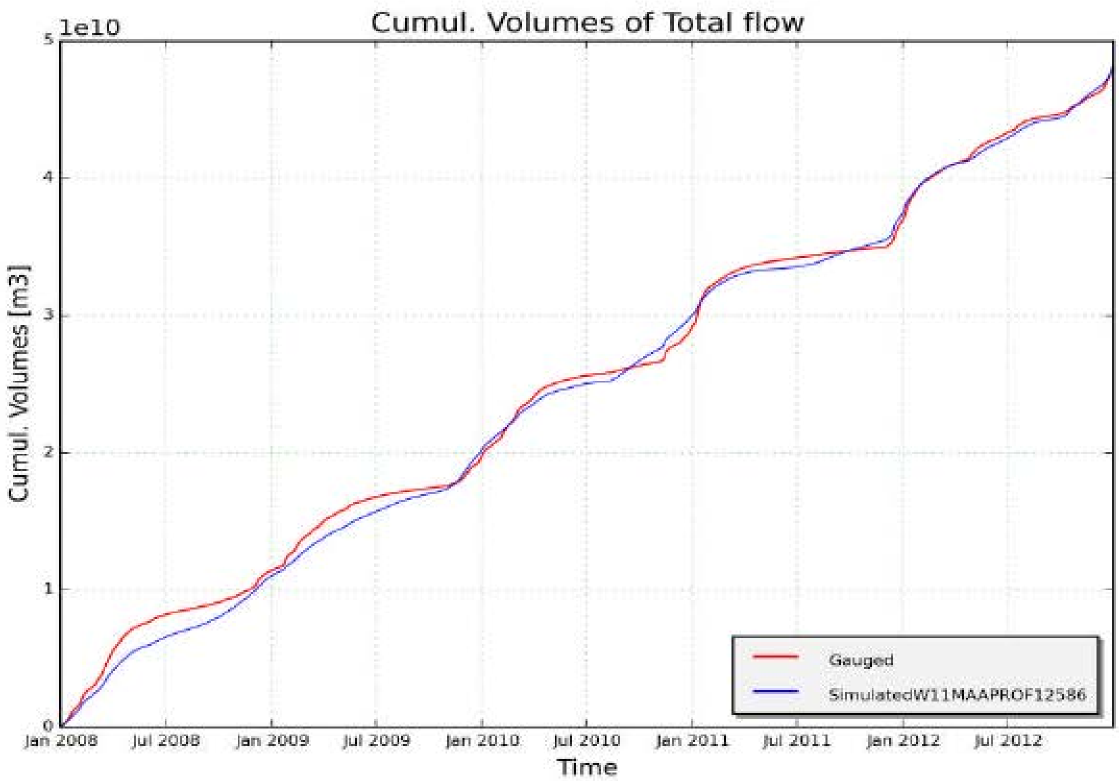


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11MAAPROF12586, station unkown (calibration period)

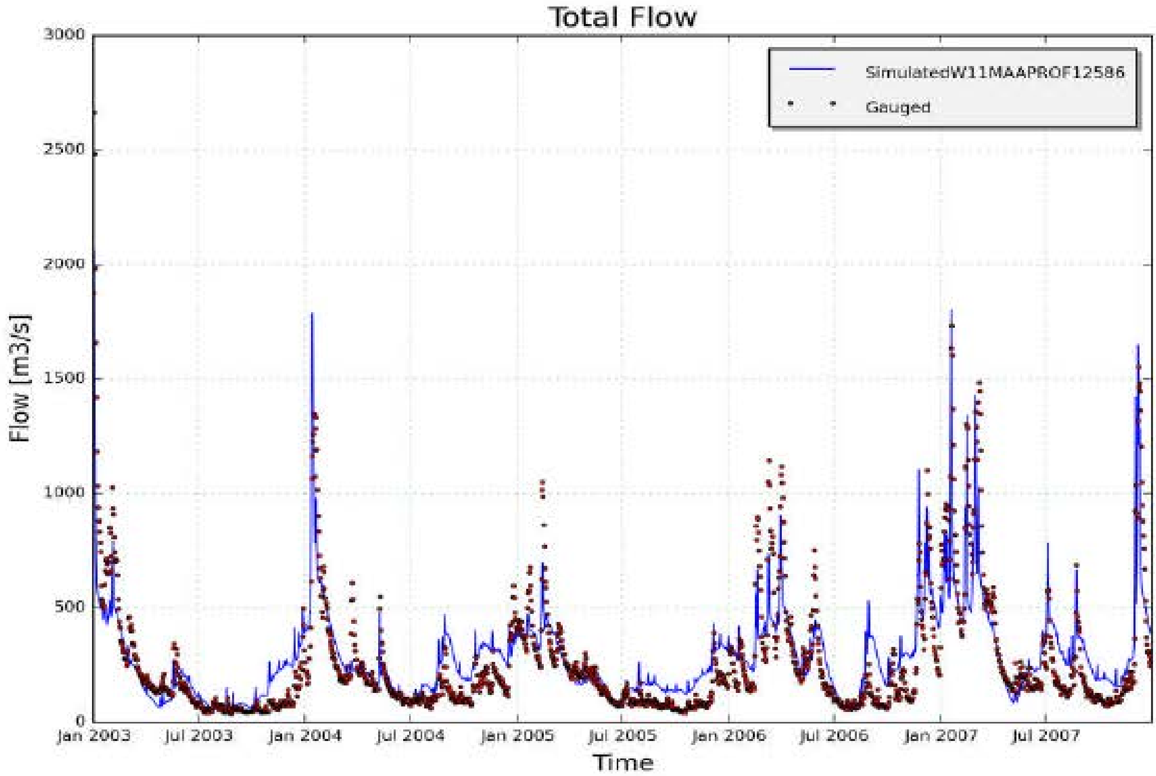


Figure 5: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W11MAAPROF12586, station unkown (validation period)

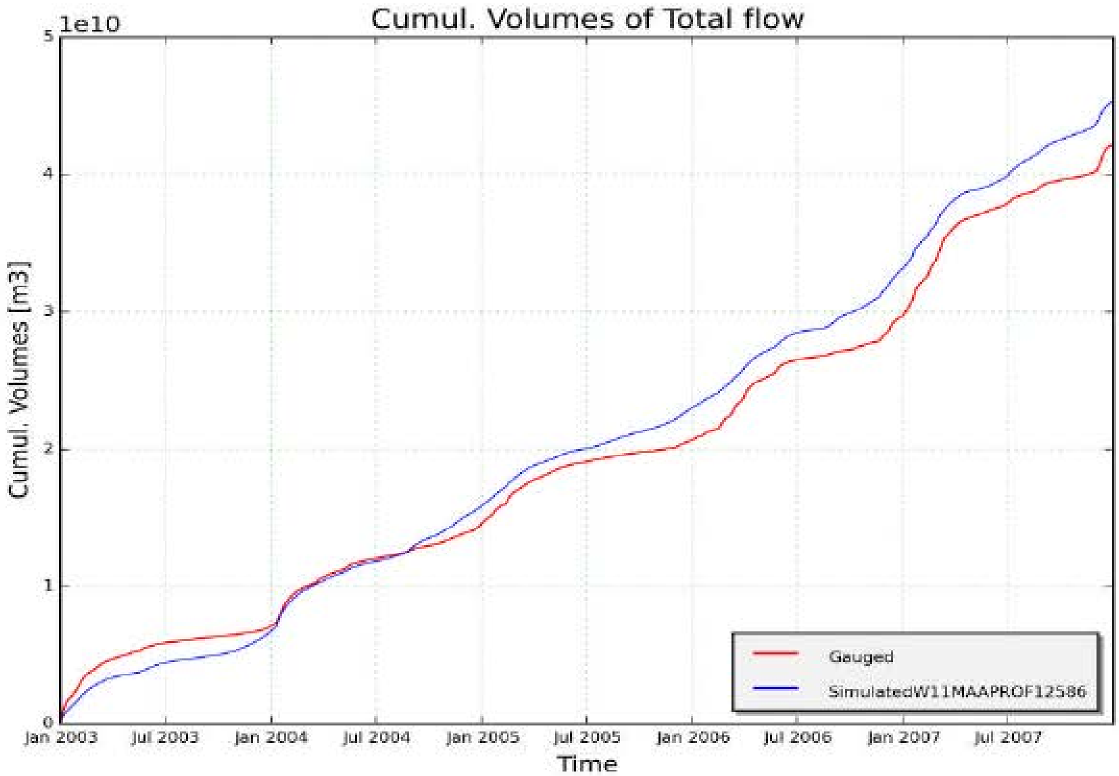


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W11MAAPROF12586, station unkown (validation period)

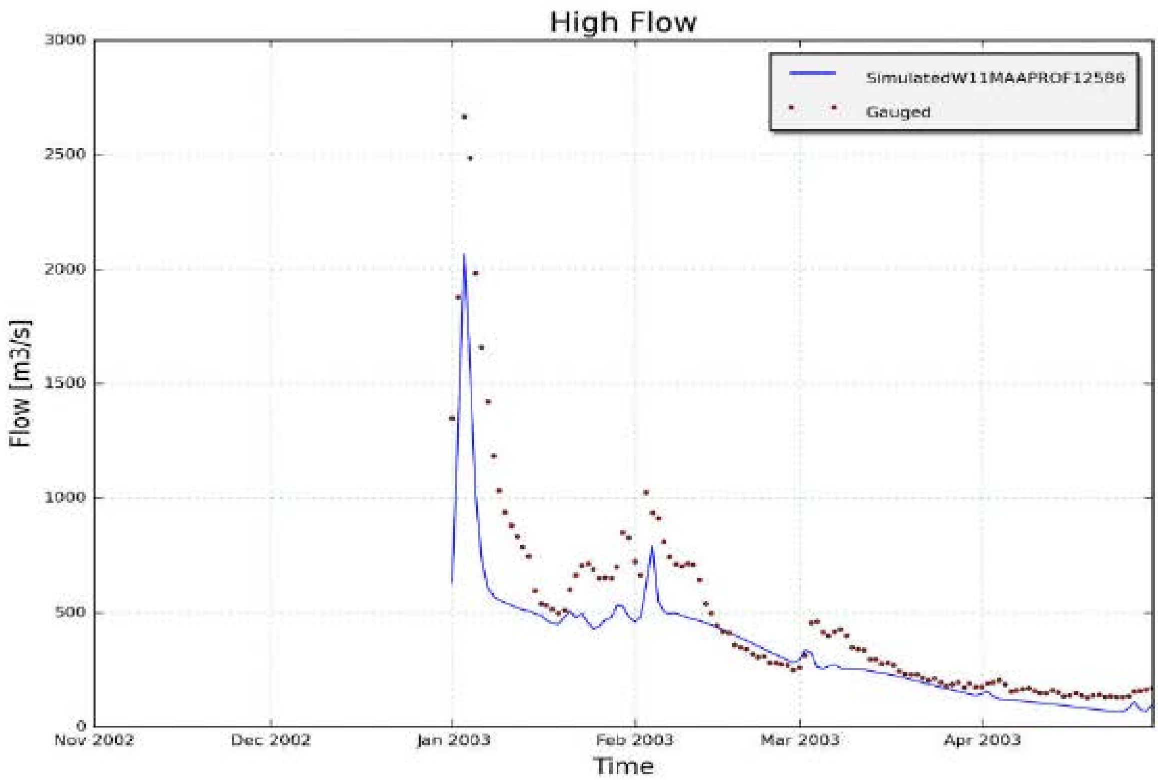


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11MAAPROF12586, station unkown

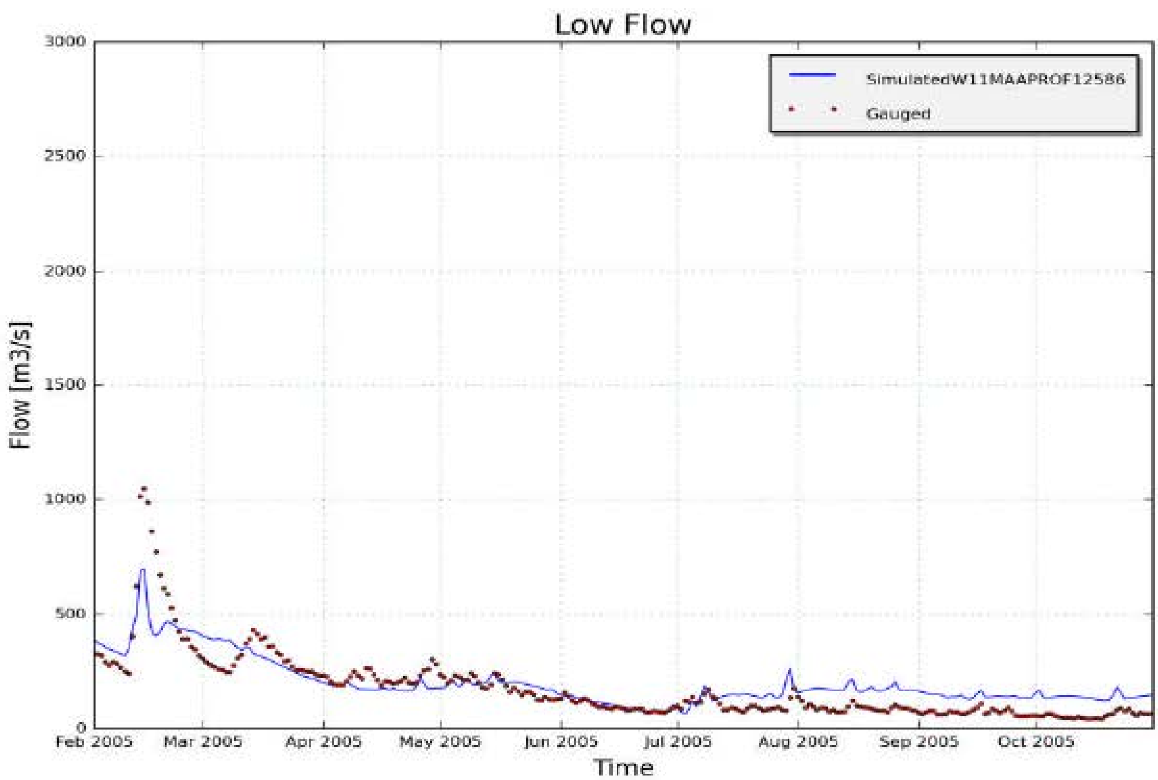


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11MAAPROF12586, station unkown

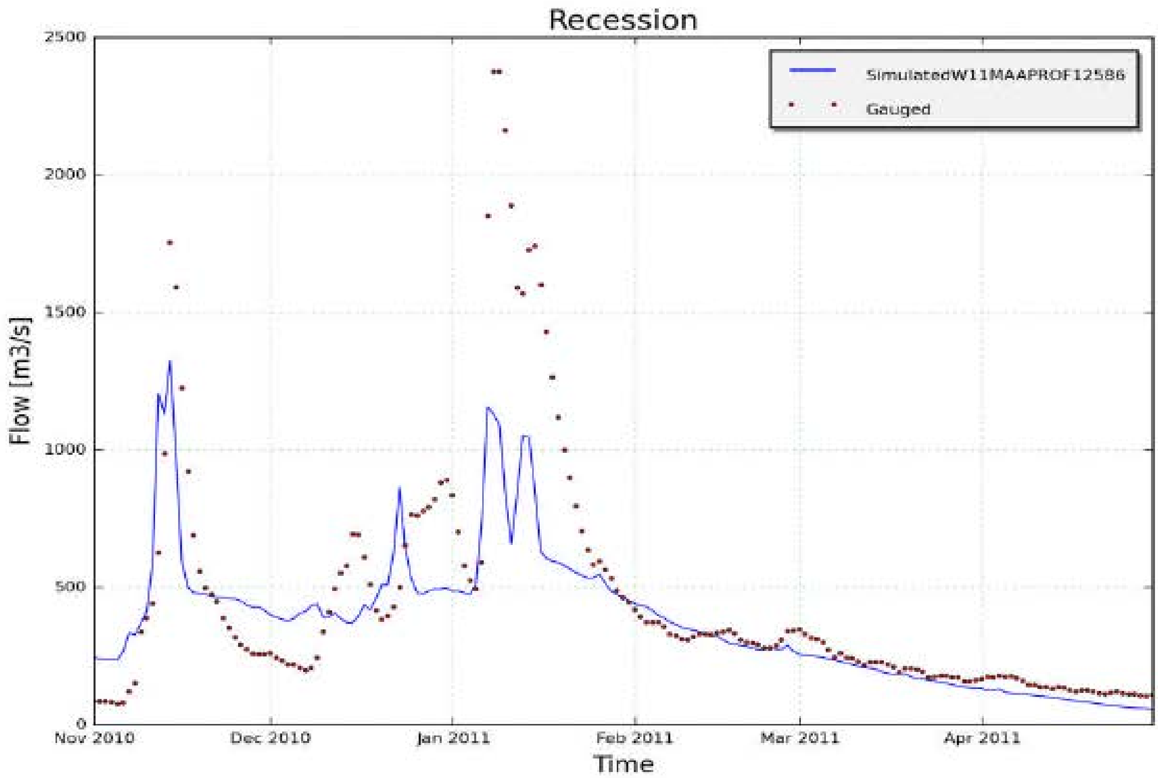


Figure 9: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11MAAPROF12586, station unkown

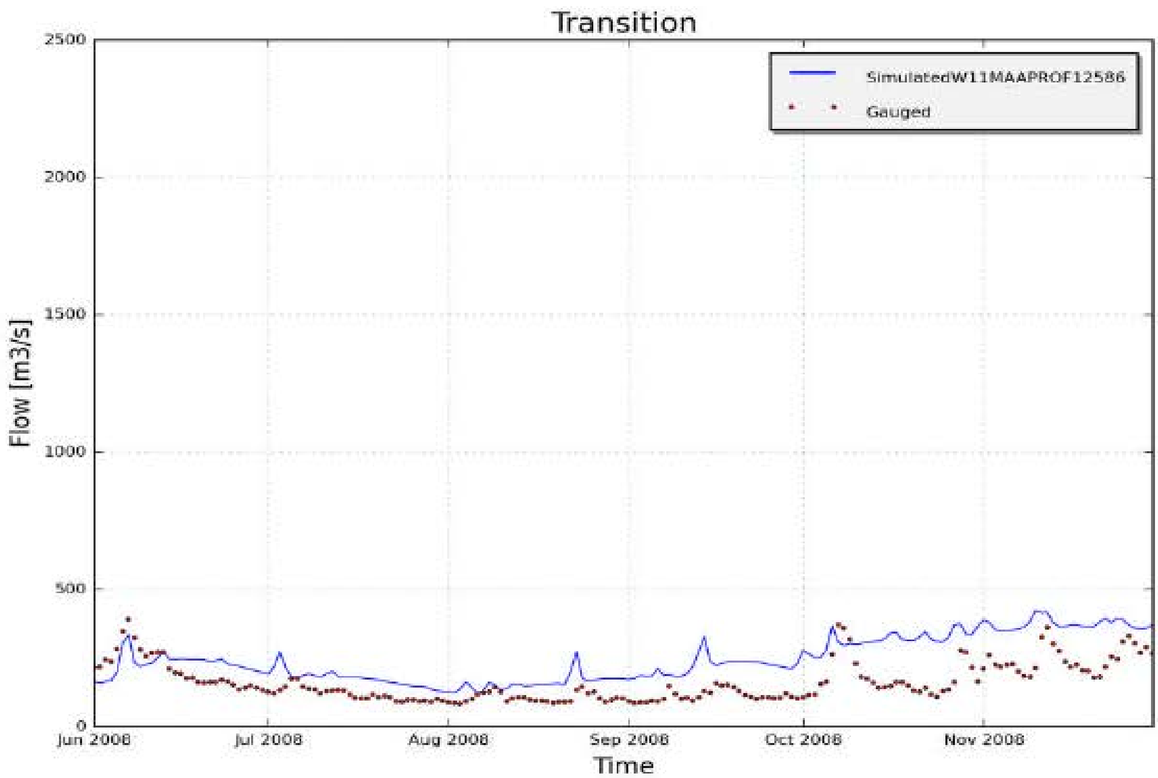


Figure 10: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W11MAAPROF12586, station unkown

Appendix 23 Meuse Autocalibration.

9.5.1 Report on simulation of catchment W11SAM7319 (2017-02-07 15-36)

9.5.1.1 Input data

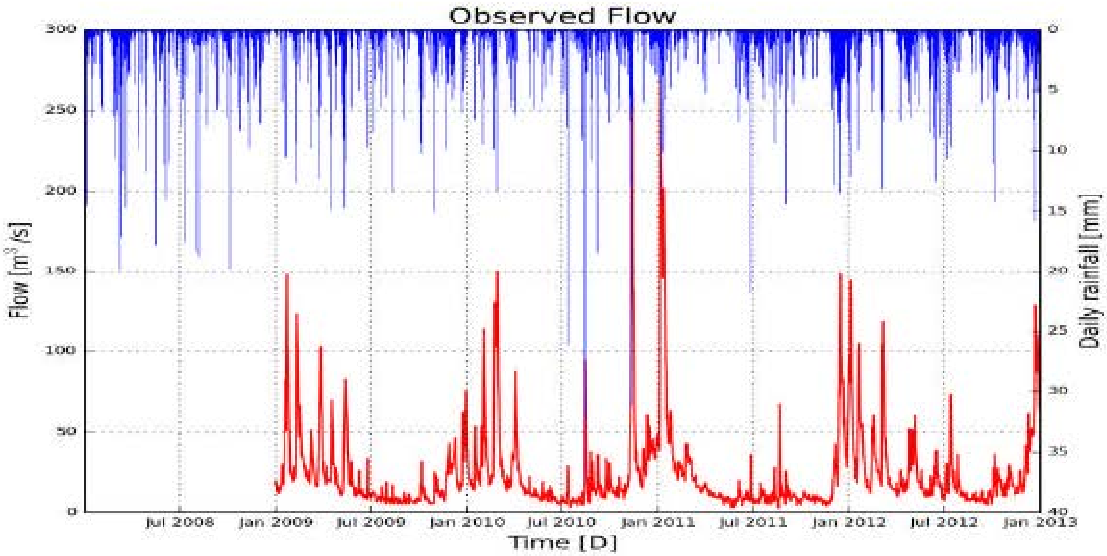


Figure 1: Hyetogram of observed discharge and observed net rain

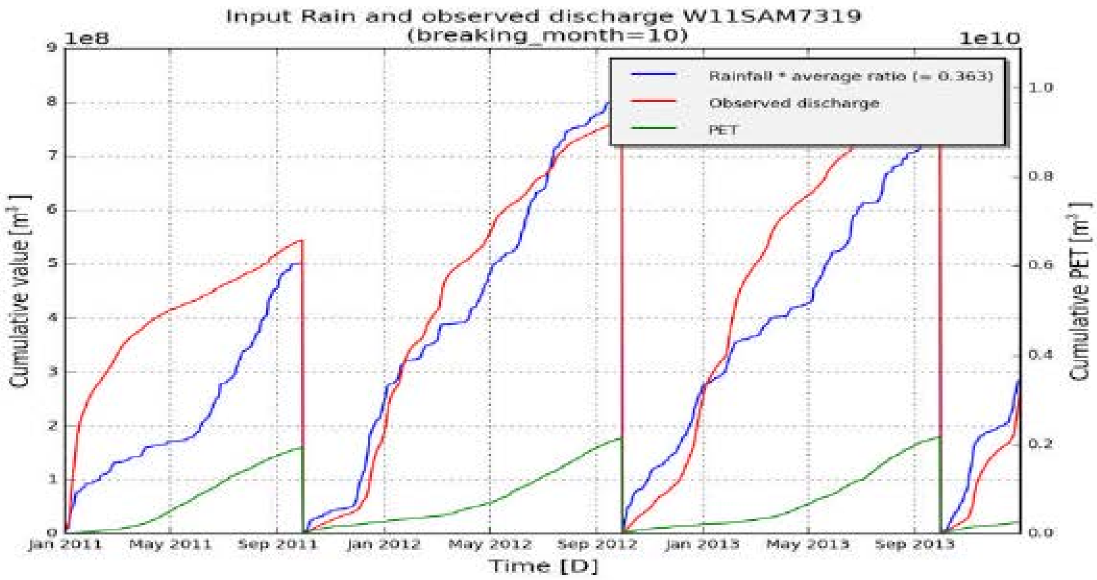


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.1.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	W11SAM7319
subcatchment_area	2669000000
start_date	200701010000
end_date	201212310000
frequency	86400
warmup	365

9.5.1.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.0, 50.0, 0.003, 1.15, 50.0, 90.0, 1.0, 30.0]
low_bounds	[0.75, 5.0, 0.0009, 0.5, 50.0, 50.0, 0.5, 10.0]
high_bounds	[5.0, 150.0, 0.01, 4.0, 450.0, 900.0, 10.0, 450.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.0), ('Ki', 50.0), ('Kg', 0.003), ('Kss', 1.15), ('g0', 50.0), ('g_max', 90.0), ('K_run', 1.0), ('P_max', 30.0)]
Initial fitness:

- RelErr: 0.076
- AbsErr: 213258856.406
- KGE: 0.66
- NS_rel: 0.301
- NS: 0.298
- RMSE: 261619133.924

- NS_log: 0.353

Computation time:3:36:25.473000

9.5.1.4 Results

Best individual (euclidian): [('Kep', 2.189), ('Ki', 64.155), ('Kg', 0.01), ('Kss', 2.301), ('g0', 122.221), ('g_max', 509.403), ('K_run', 2.536), ('P_max', 116.059)]

Fitness:

- RelErr: -0.007
- AbsErr: 83207352.307
- KGE: 0.656
- NS_rel: 0.72
- NS: 0.594
- RMSE: 95853580.242
- NS_log: 0.614

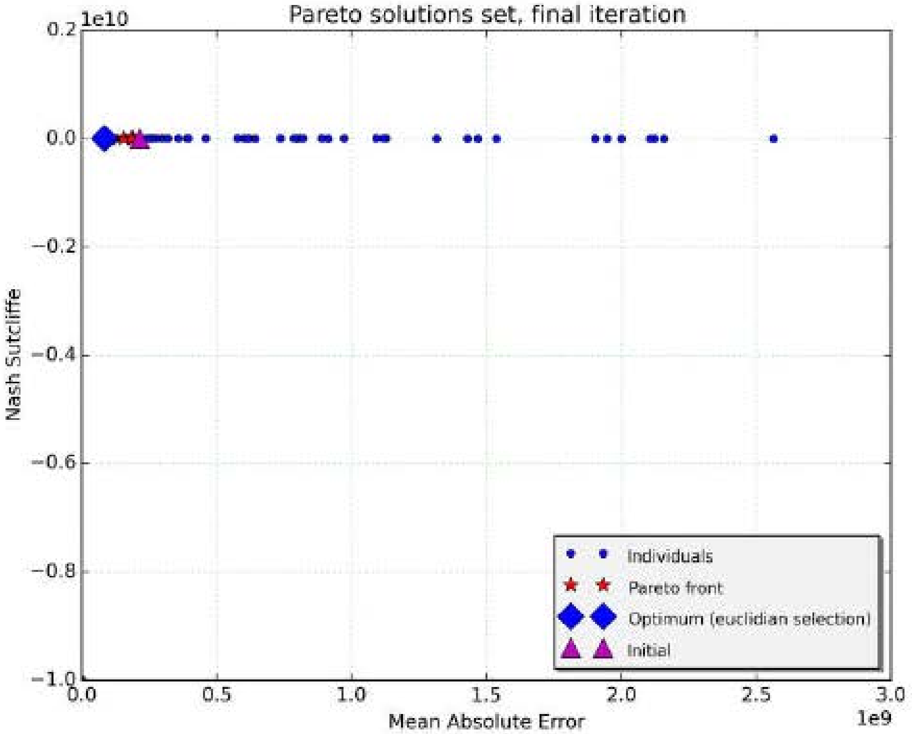


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

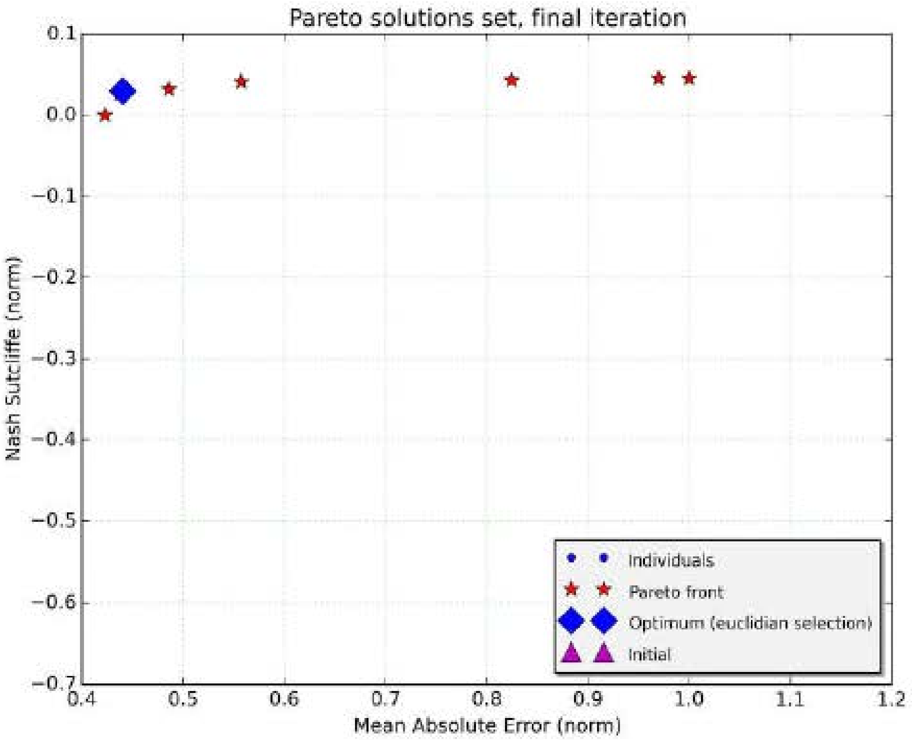


Figure 4: Final population of solutions (Pareto front)

9.5.1.4.1 Initial

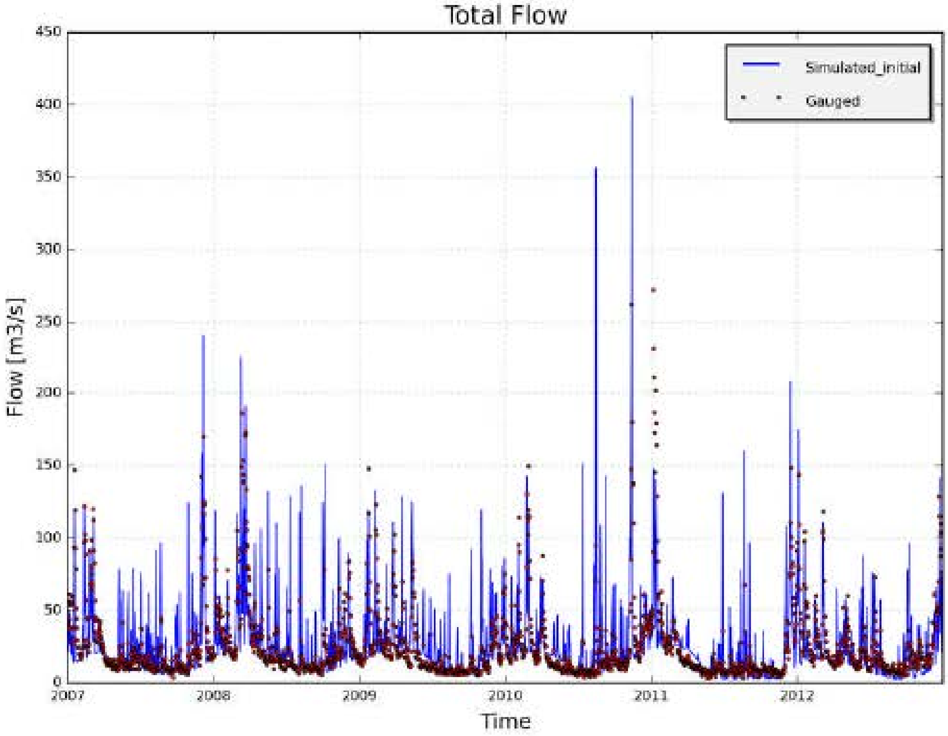


Figure 5: Total flow with initial parameters

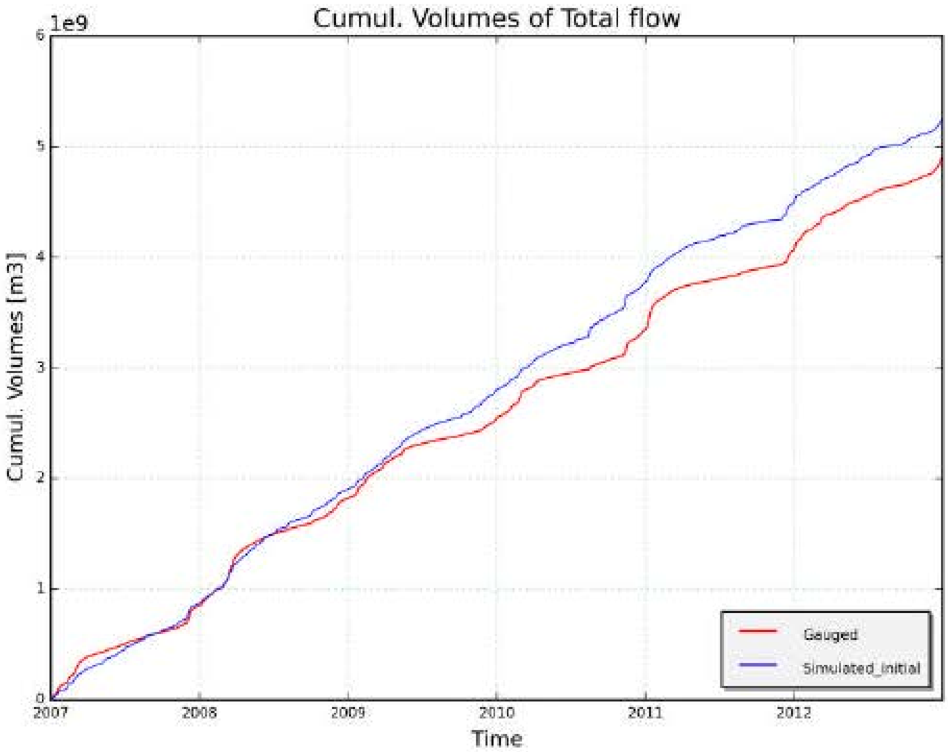


Figure 6: Cumulated flow with initial parameters

9.5.1.4.2 Optimum (euclidian)

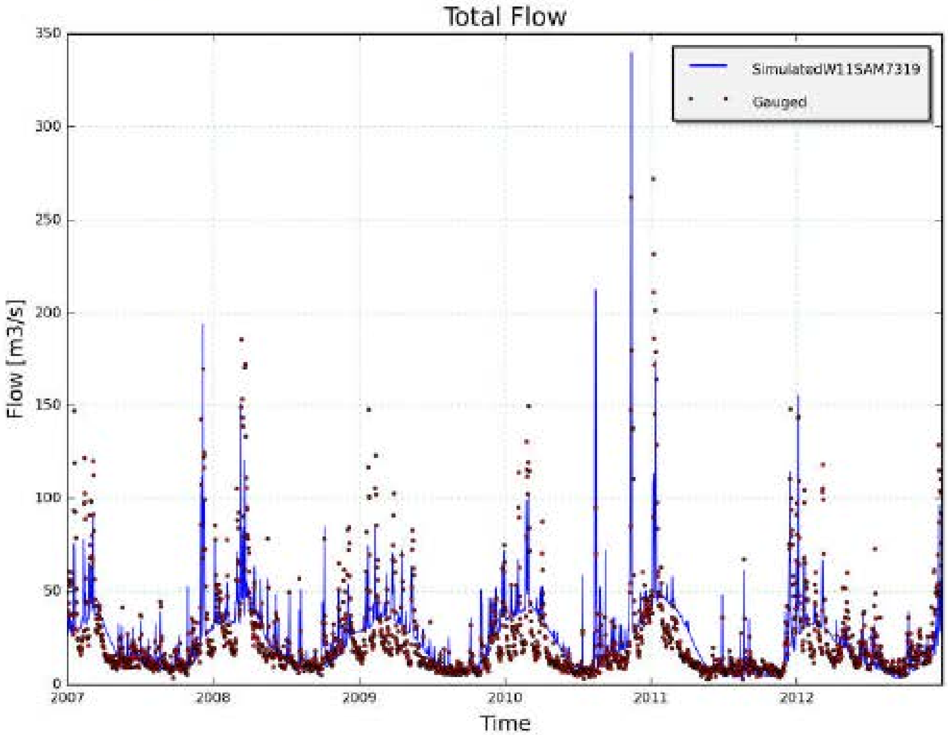


Figure 7: Total flow with optimum parameters

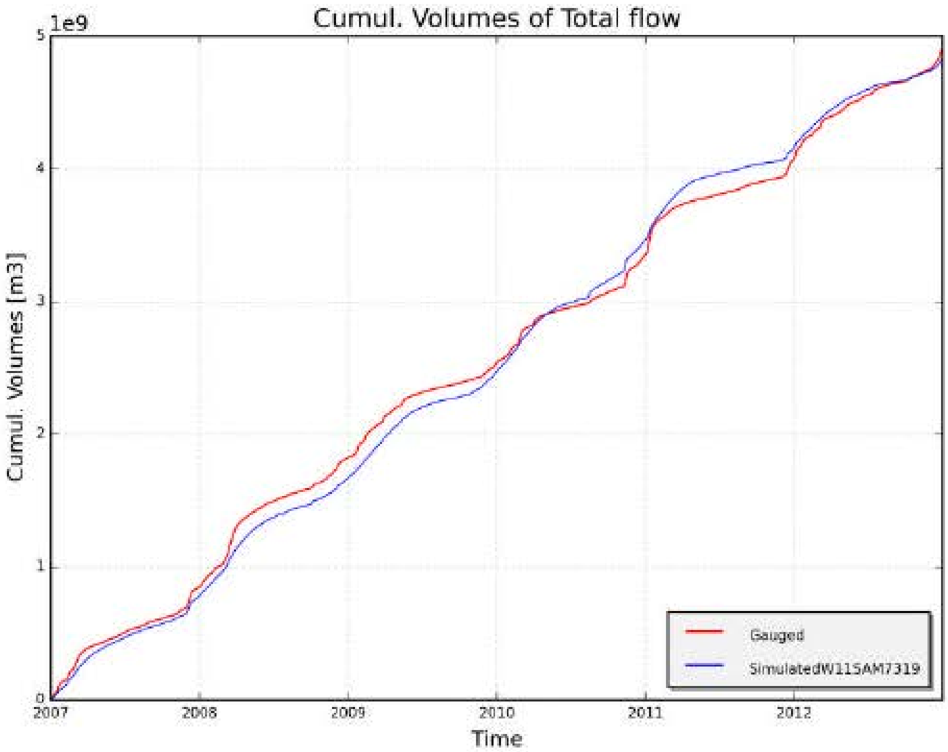


Figure 8: Cumulated flow with optimum parameters

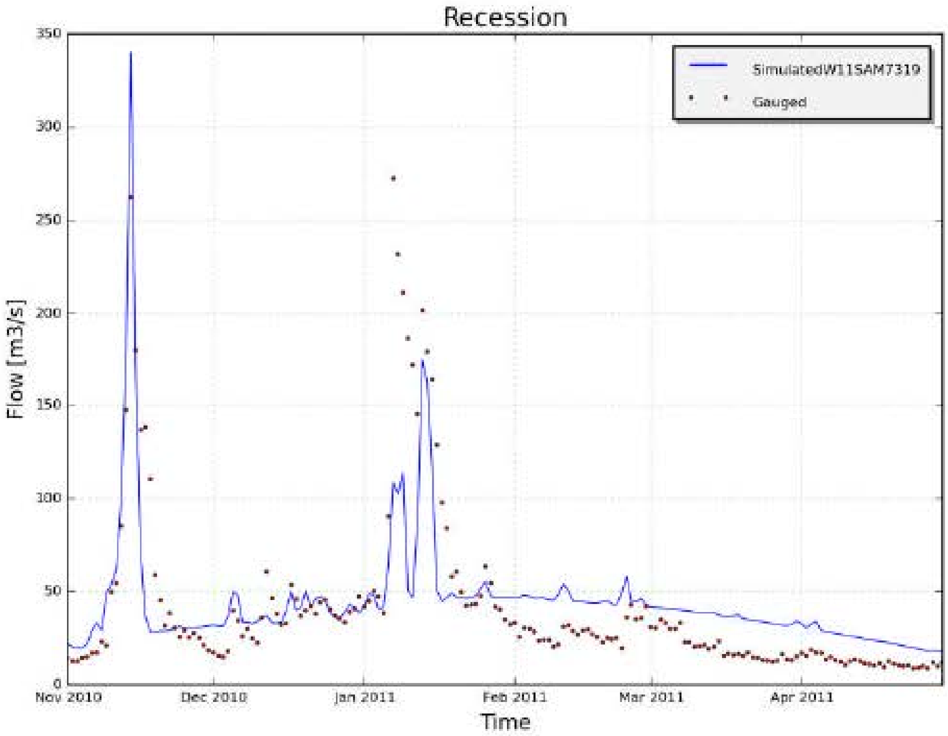


Figure 9: Total flow with optimum parameters (detail)

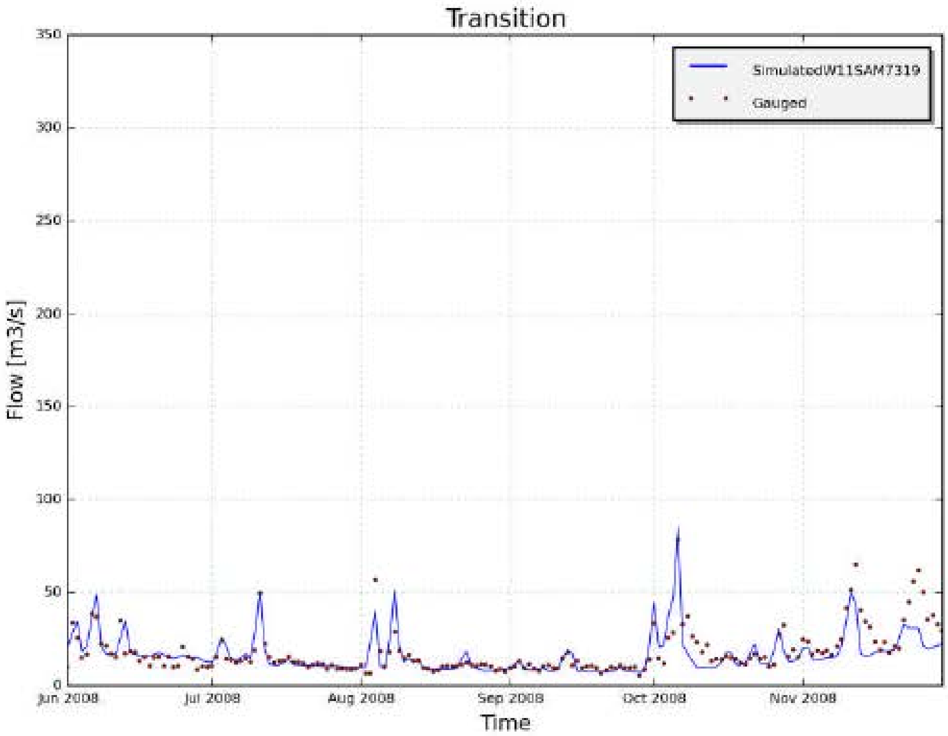
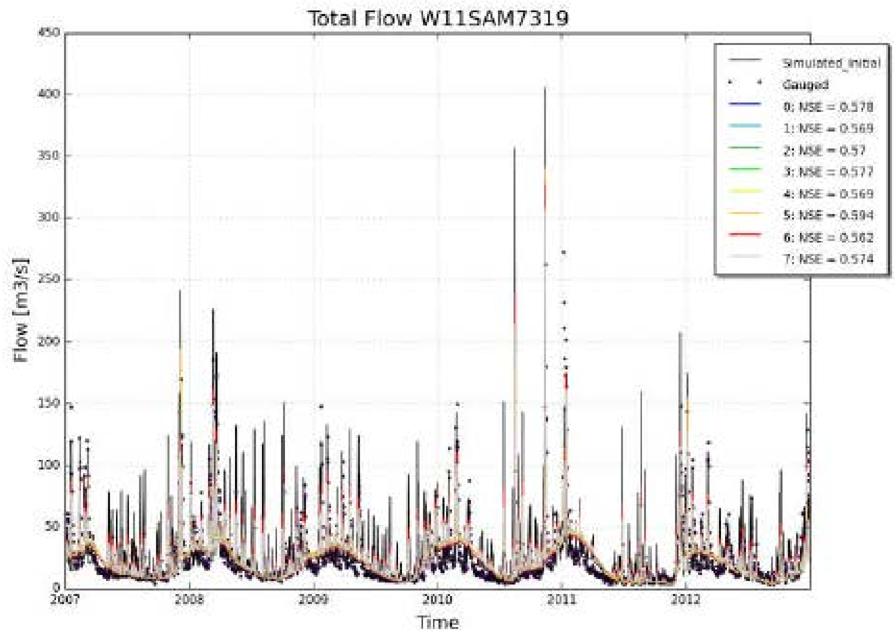
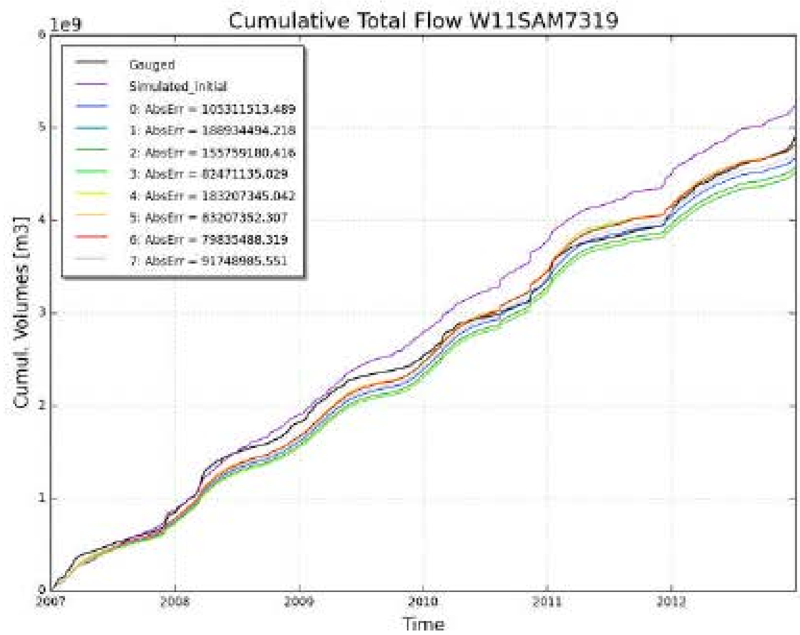


Figure 10: Total flow with optimum parameters (detail)

9.5.1.4.3 Final archive

0 : [2.501, 58.672, 0.01, 1.414, 189.658, 835.976, 2.255, 211.214] : [105311513.489, 0.619]
1 : [2.626, 64.602, 0.01, 2.618, 108.219, 900.0, 2.367, 204.441] : [188934494.218, 0.621]
2 : [2.59, 67.84, 0.01, 2.325, 145.058, 880.681, 2.245, 218.514] : [155759180.416, 0.62]
3 : [2.443, 65.136, 0.01, 2.964, 93.728, 900.0, 2.326, 132.315] : [82471135.029, 0.613]
4 : [2.616, 66.294, 0.01, 1.996, 117.732, 888.164, 2.339, 208.293] : [183207345.042, 0.621]
5 : [2.189, 64.155, 0.01, 2.301, 122.221, 509.403, 2.536, 116.059] : [83207352.307, 0.614]
6 : [2.497, 65.407, 0.01, 2.936, 130.366, 894.586, 1.879, 169.543] : [79835488.319, 0.603]
7 : [2.491, 53.207, 0.01, 2.293, 117.891, 888.133, 2.296, 122.958] : [91748985.551, 0.616]





9.5.2 Report on simulation of catchment W11BER551010 (2017-01-25 03-12)

9.5.2.1 Input data

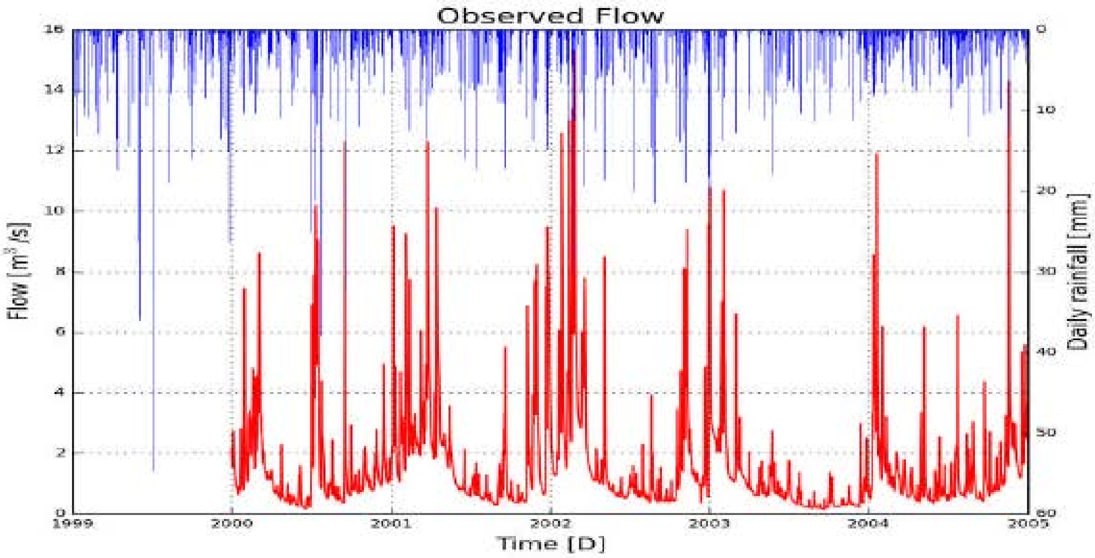


Figure 1: Hyetogram of observed discharge and observed net rain

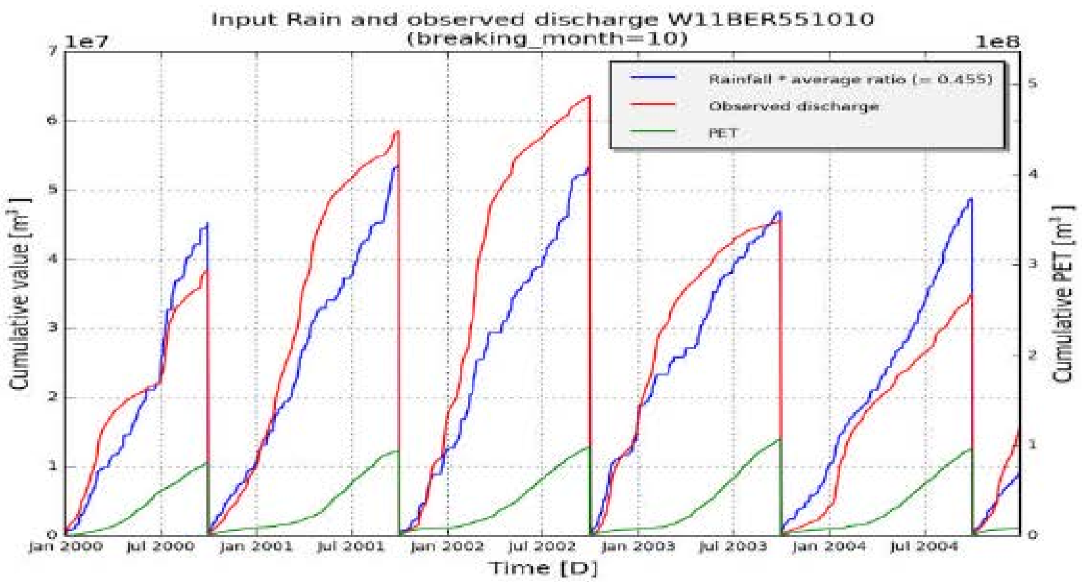


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.2.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	W11BER551010
subcatchment_area	128000000
start_date	200001010000
end_date	200412310000
frequency	86400
warmup	365

9.5.2.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[2.0, 25.0, 0.004, 0.9, 80.0, 500.0, 7.0, 130.0]
low_bounds	[1.0, 12.5, 0.0007, 0.45, 40.0, 250.0, 3.5, 65.0]
high_bounds	[3.0, 150.0, 0.01, 5.0, 200.0, 600.0, 9.0, 300.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 2.0), ('Ki', 25.0), ('Kg', 0.004), ('Kss', 0.9), ('g0', 80.0), ('g_max', 500.0), ('K_run', 7.0), ('P_max', 130.0)]

Initial fitness:

- RelErr: -0.143
- AbsErr: 20088437.214
- KGE: 0.561
- NS_rel: 0.636
- NS: 0.513
- RMSE: 23868552.855
- NS_log: 0.587

Computation time:9:51:33.408000

9.5.2.4 Results

Best individual (euclidian): [('Kep', 1.923), ('Ki', 28.381), ('Kg', 0.006), ('Kss', 2.473), ('g0', 92.661), ('g_max', 452.272), ('K_run', 7.384), ('P_max', 236.416)]

Fitness:

- RelErr: -0.005
- AbsErr: 3710837.342
- KGE: 0.648
- NS_rel: 0.482
- NS: 0.555
- RMSE: 4565738.29
- NS_log: 0.581

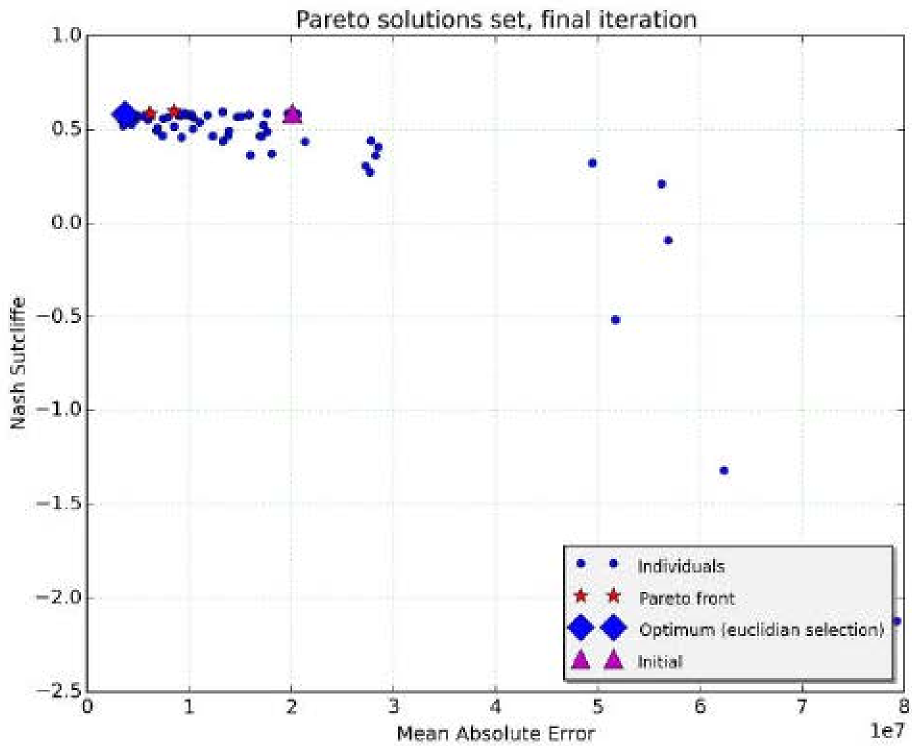


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

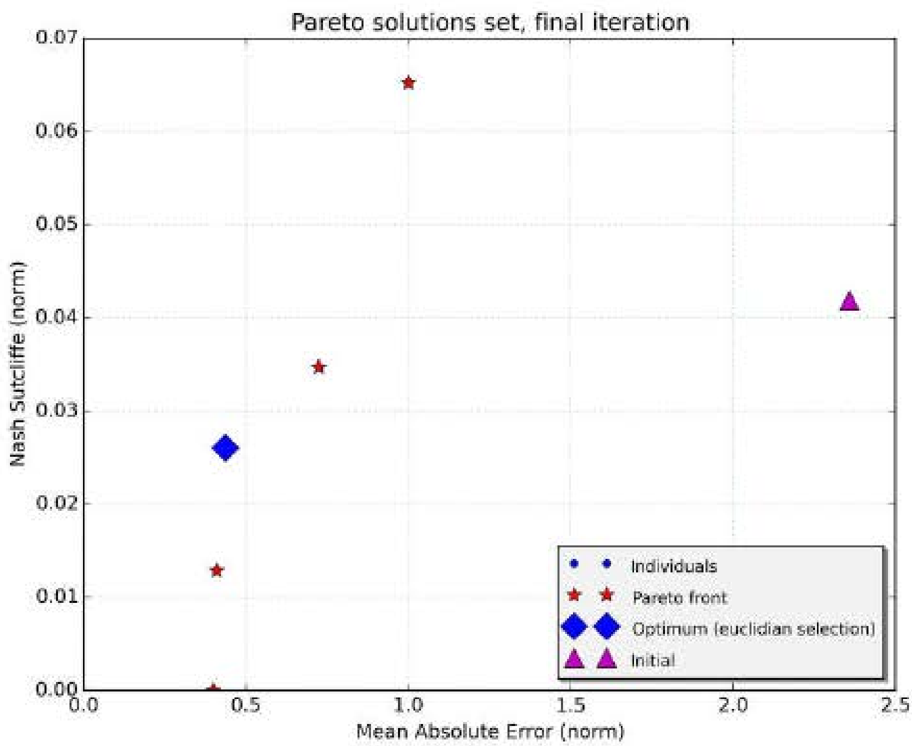


Figure 4: Final population of solutions (Pareto front)

9.5.2.4.1 Initial

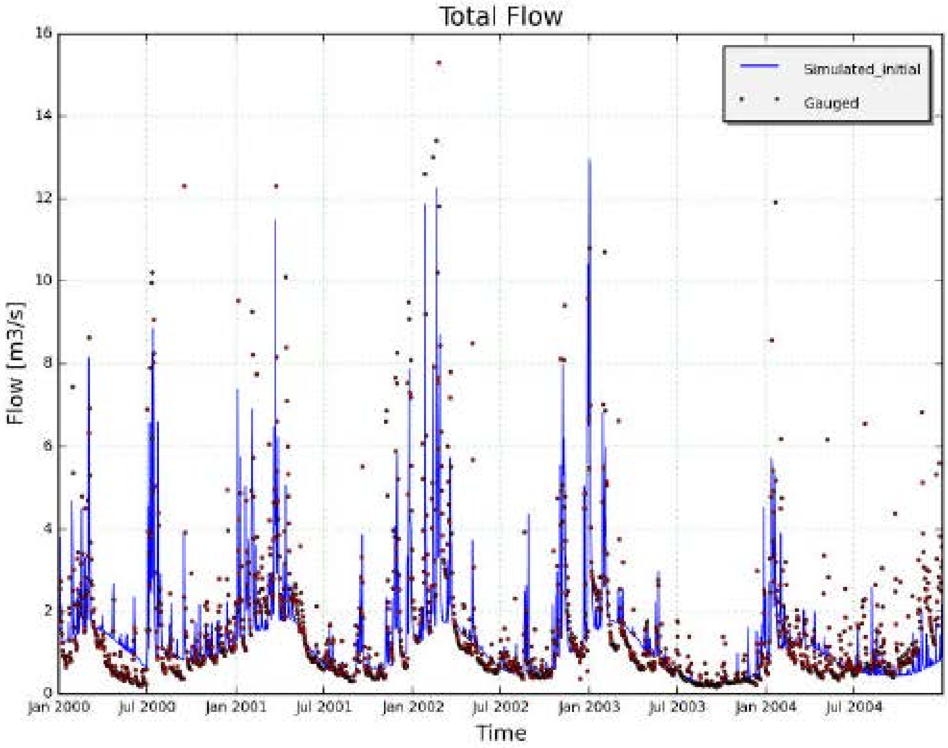


Figure 5: Total flow with initial parameters

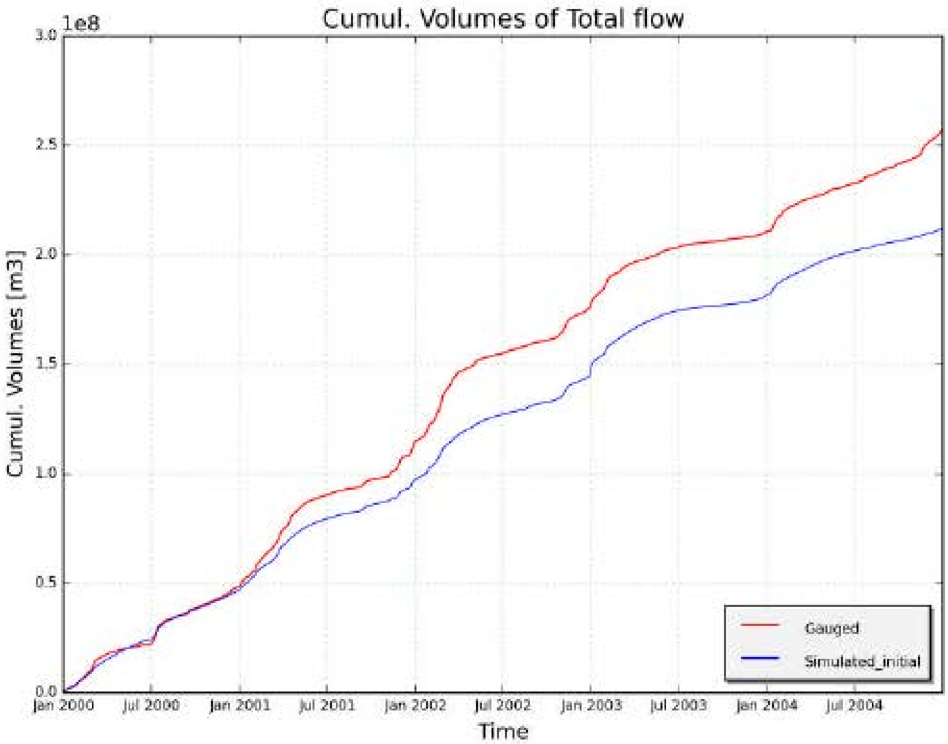


Figure 6: Cumulated flow with initial parameters

9.5.2.4.2 Optimum (euclidian)

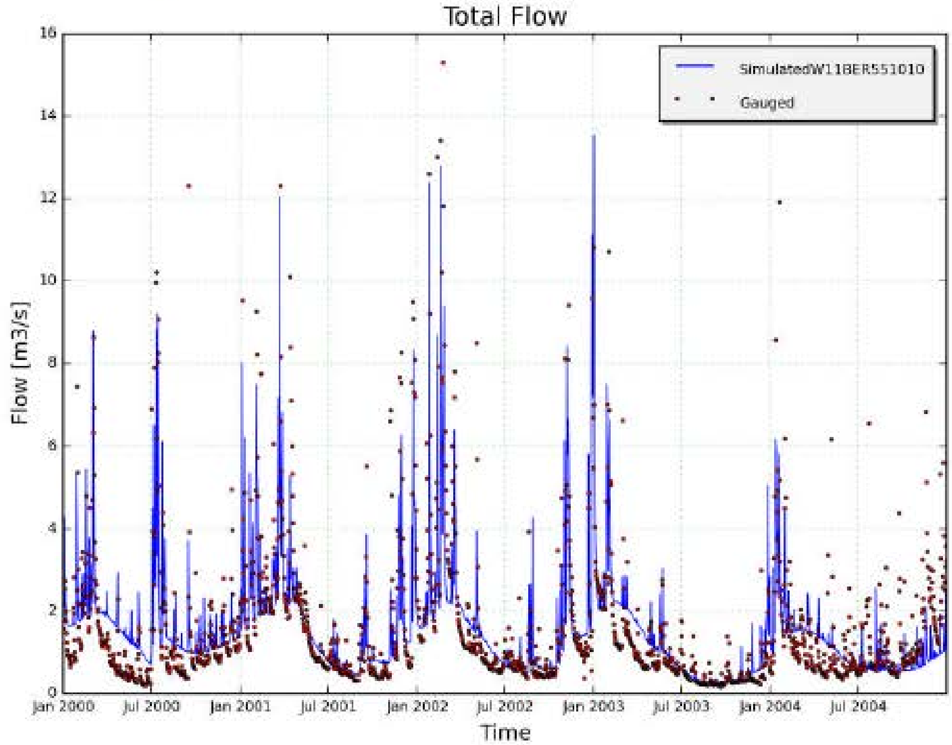


Figure 7: Total flow with optimum parameters

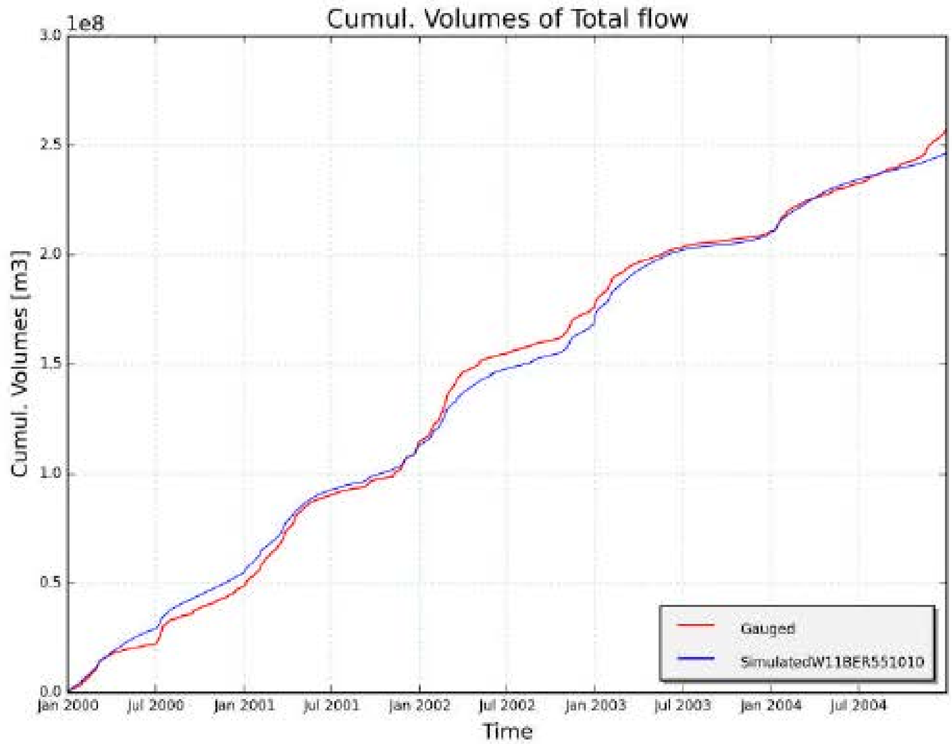


Figure 8: Cumulated flow with optimum parameters

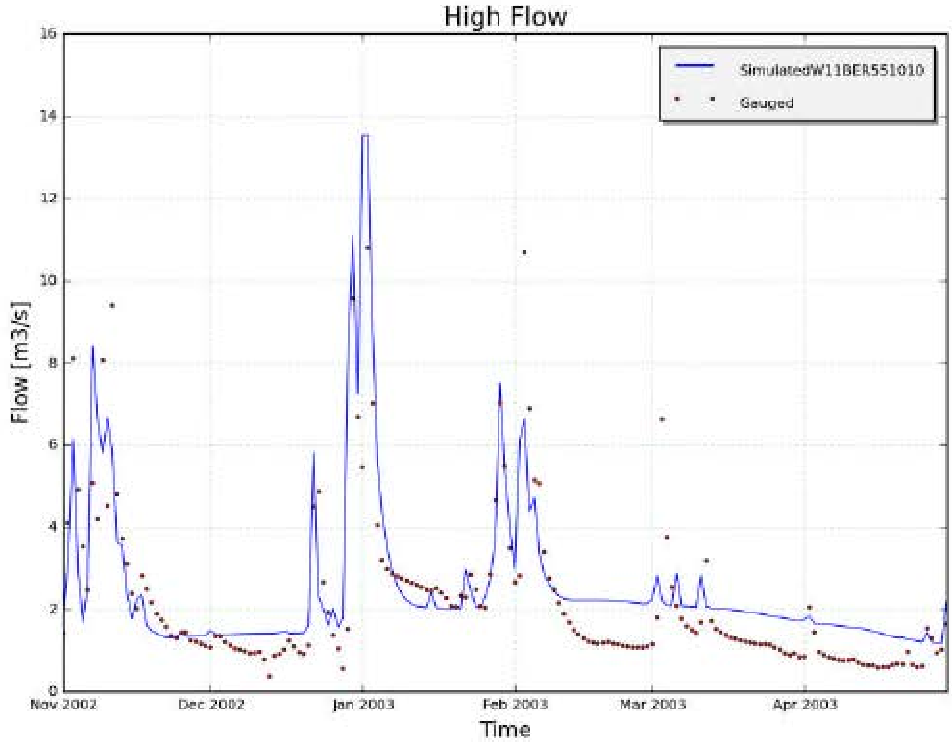
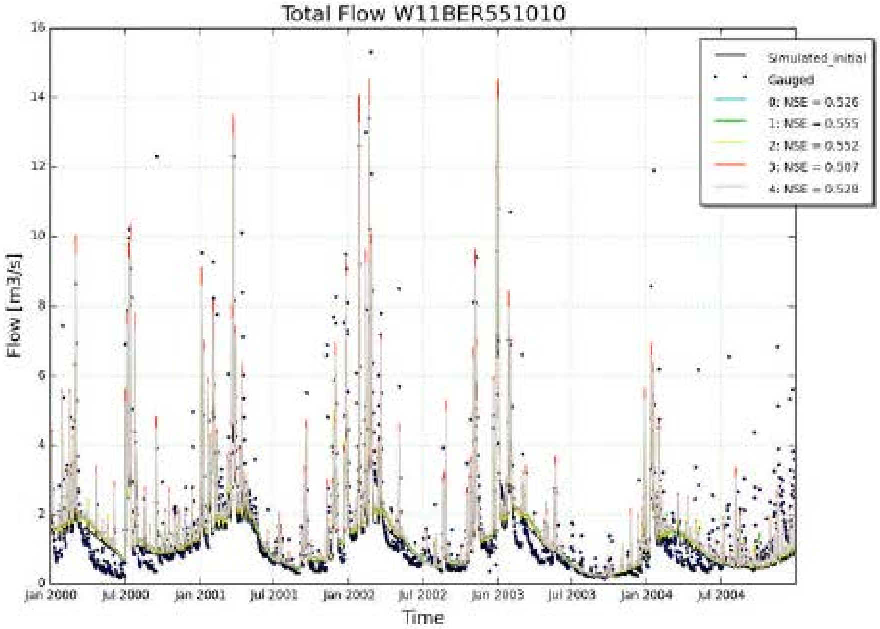
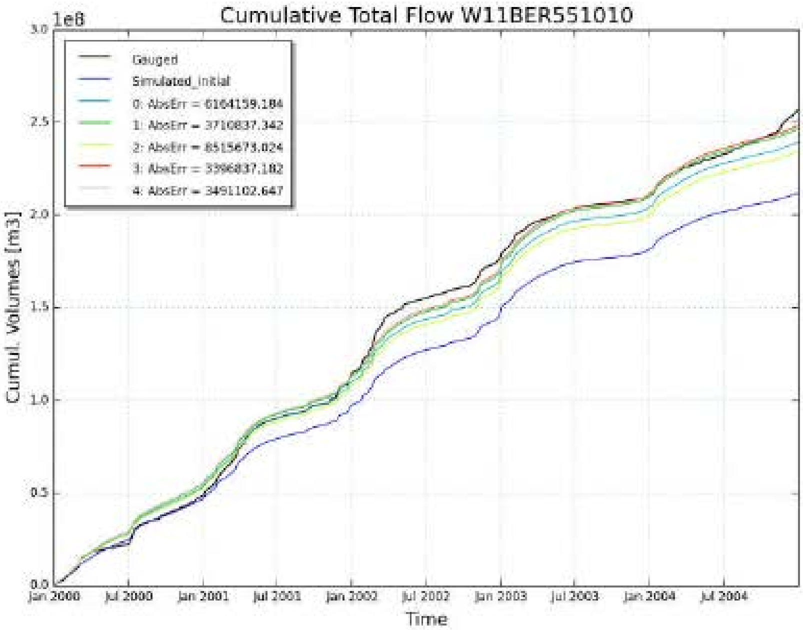


Figure 9: Total flow with optimum parameters (detail)

9.5.2.4.3 Final archive

0 : [1.855, 30.179, 0.005, 1.972, 91.741, 401.498, 6.288, 239.121] : [6164159.184, 0.584]
1 : [1.923, 28.381, 0.006, 2.473, 92.661, 452.272, 7.384, 236.416] : [3710837.342, 0.581]
2 : [1.872, 30.079, 0.005, 1.59, 91.656, 409.425, 7.824, 233.011] : [8515673.024, 0.597]
3 : [1.856, 31.158, 0.006, 2.533, 95.743, 398.926, 5.655, 232.726] : [3396837.182, 0.569]
4 : [1.852, 28.44, 0.006, 2.508, 94.285, 395.577, 5.964, 236.685] : [3491102.647, 0.575]


Total Flow W11BER551010
Simulated_initial
Gauged
0: NSE = 0.526
1: NSE = 0.555
2: NSE = 0.552
3: NSE = 0.507
4: NSE = 0.528
Flow [m3/s]
0
2
4
6
8
10
12
14
16
Jan 2000
Jul 2000
Jan 2001
Jul 2001
Jan 2002
Jul 2002
Jan 2003
Jul 2003
Jan 2004
Jul 2004
Time


Cumulative Total Flow W11BER551010
1e8
Gauged
Simulated_initial
0: AbsErr = 6164159.184
1: AbsErr = 3710837.342
2: AbsErr = 8515673.024
3: AbsErr = 3396837.182
4: AbsErr = 3491102.647
Cumul. Volumes [m3]
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Jan 2000
Jul 2000
Jan 2001
Jul 2001
Jan 2002
Jul 2002
Jan 2003
Jul 2003
Jan 2004
Jul 2004
Time

9.5.3 Report on simulation of catchment W11HOY5990 (2017-02-09 20-59)

9.5.3.1 Input data

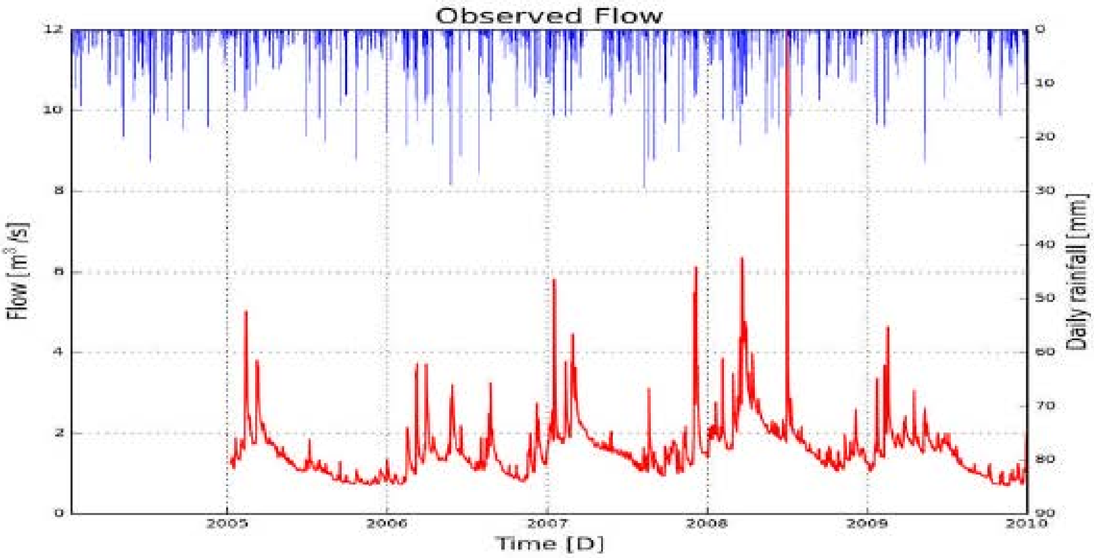


Figure 1: Hyetogram of observed discharge and observed net rain

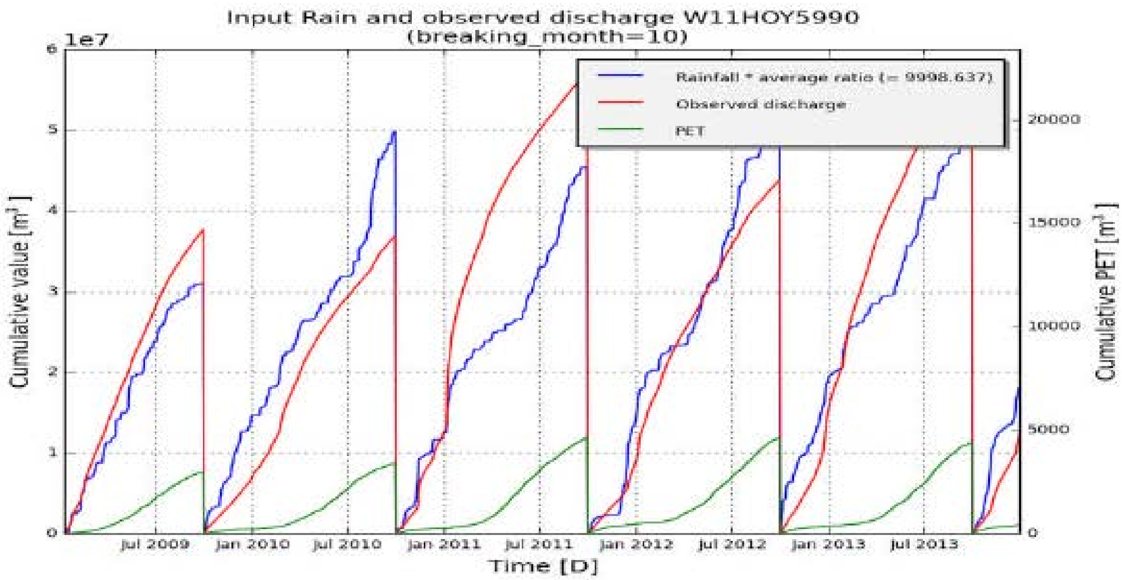


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.3.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	W11HOY5990
subcatchment_area	5990
start_date	200901010000
end_date	201312310000
frequency	86400
warmup	365

9.5.3.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.0, 20.0, 0.001, 1.68, 180.93, 422.34, 6.48, 308.12]
low_bounds	[0.7, 10.0, 0.0007, 1.3, 144.7, 337.0, 4.0, 240.0]
high_bounds	[1.9, 30.0, 0.012, 2.5, 317.1, 550.0, 12.0, 470.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.0), ('Ki', 20.0), ('Kg', 0.001), ('Kss', 1.68), ('g0', 180.93), ('g_max', 422.34), ('K_run', 6.48), ('P_max', 308.12)]
Initial fitness:

- RelErr: 0.628
- AbsErr: 76505791.407
- KGE: 0.017
- NS_rel: -0.876
- NS: -1.335
- RMSE: 86678086.255
- NS_log: -0.655

Computation time:4:59:47.305000

9.5.3.4 Results

Best individual (euclidian):
[('Kep', 1.809), ('Ki', 11.847), ('Kg', 0.002), ('Kss', 1.884), ('g0', 204.896), ('g_max', 502.034), ('K_run', 8.959), ('P_max', 413.371)]

Fitness:

- RelErr: 0.049
- AbsErr: 6507377.408
- KGE: 0.621
- NS_rel: 0.626
- NS: 0.229
- RMSE: 7712882.196
- NS_log: -0.2

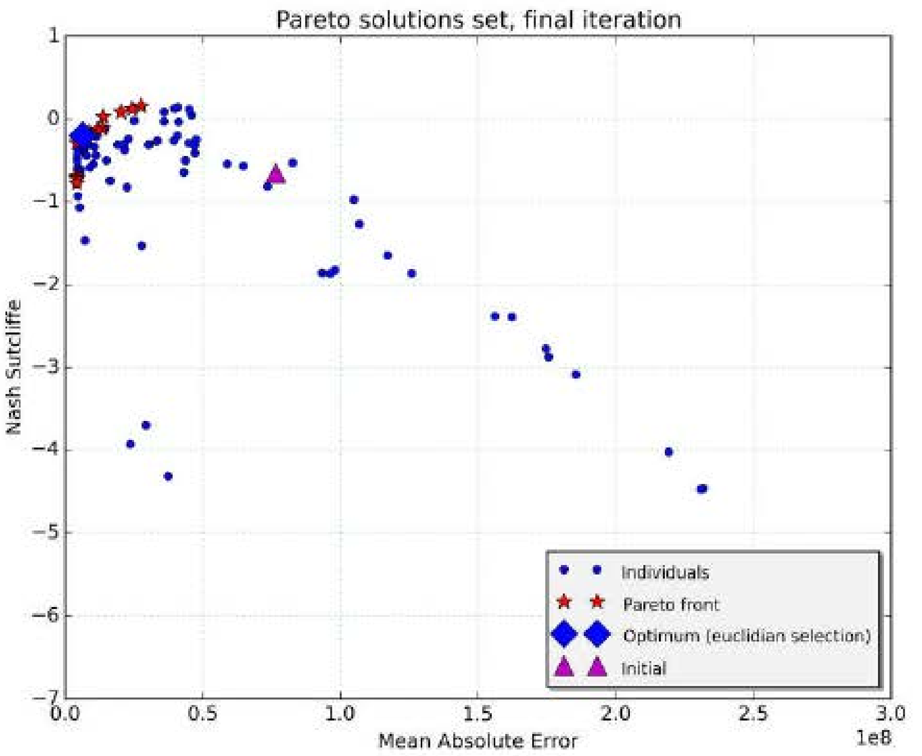


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

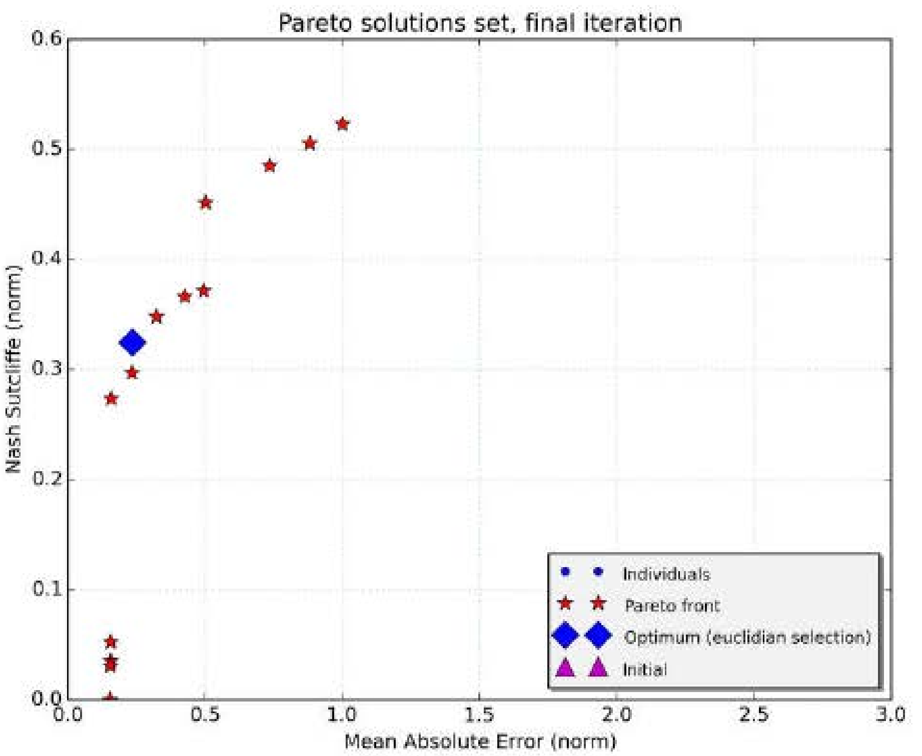


Figure 4: Final population of solutions (Pareto front)

9.5.3.4.1 Initial

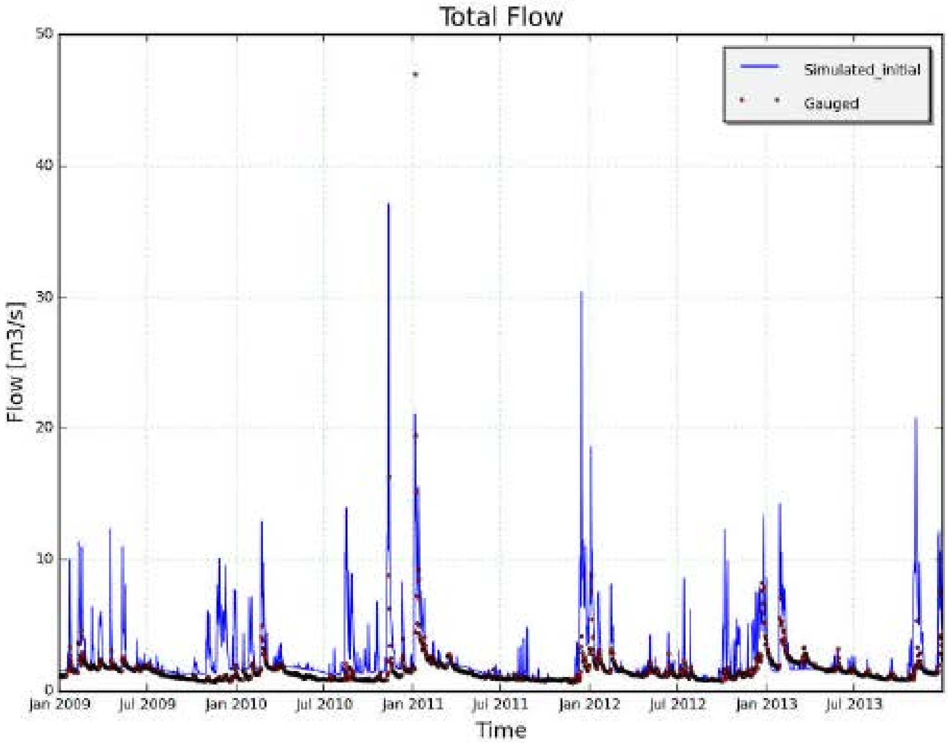


Figure 5: Total flow with initial parameters

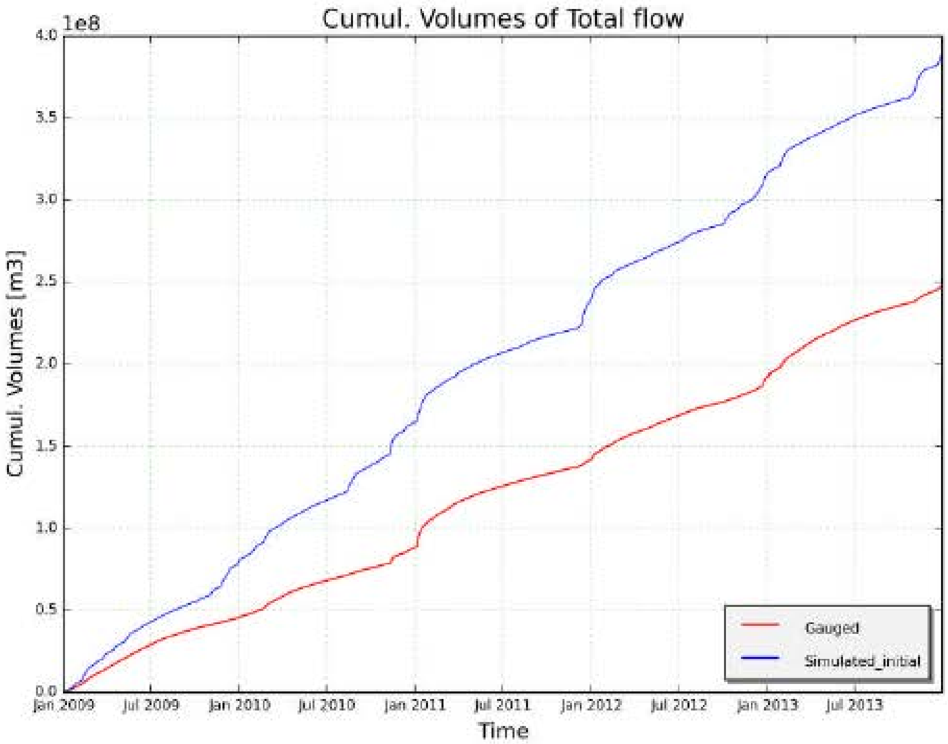


Figure 6: Cumulated flow with initial parameters

9.5.3.4.2 Optimum (euclidian)

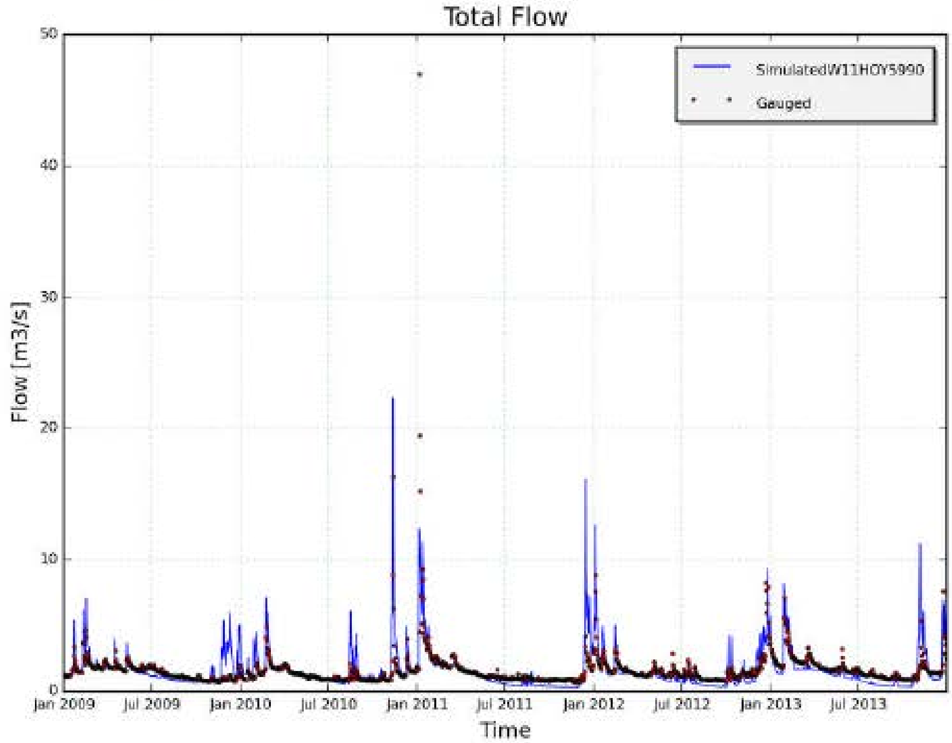


Figure 7: Total flow with optimum parameters

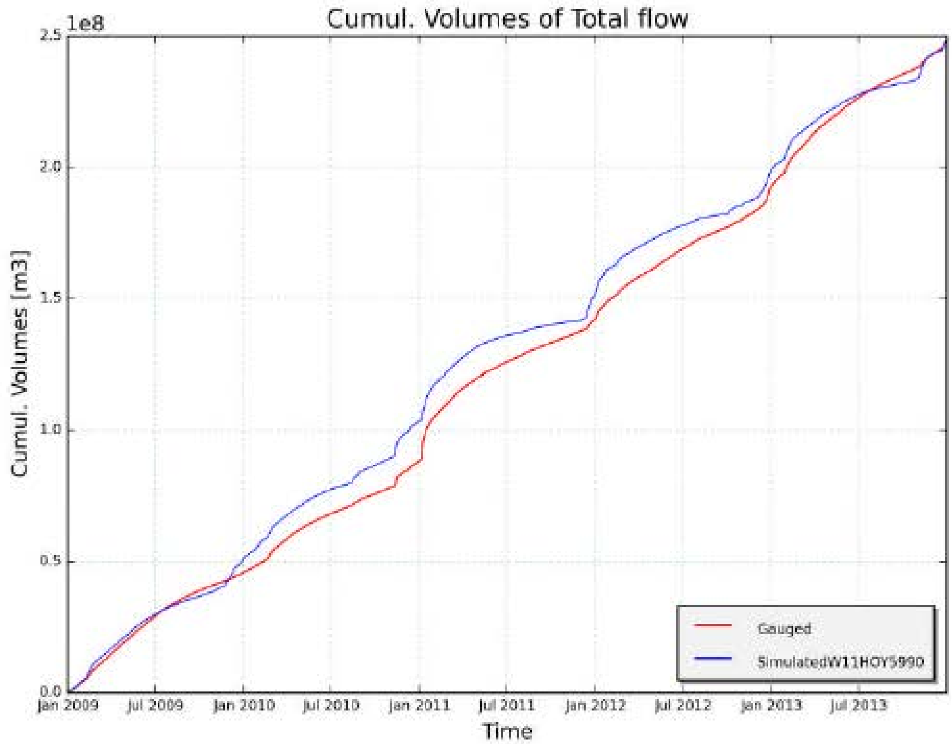


Figure 8: Cumulated flow with optimum parameters

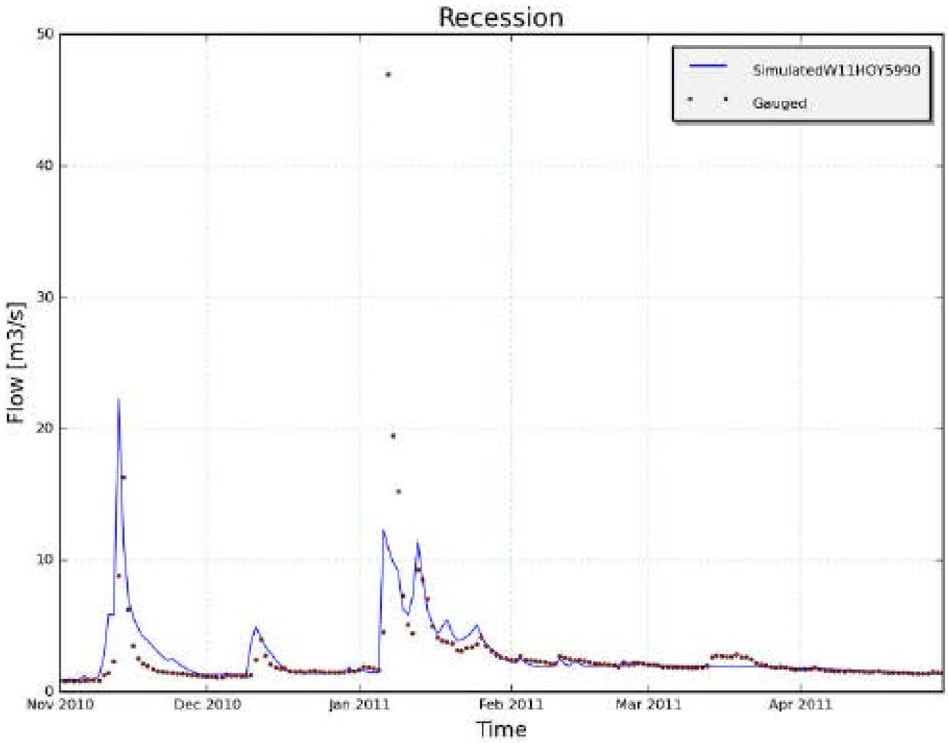


Figure 9: Total flow with optimum parameters (detail)

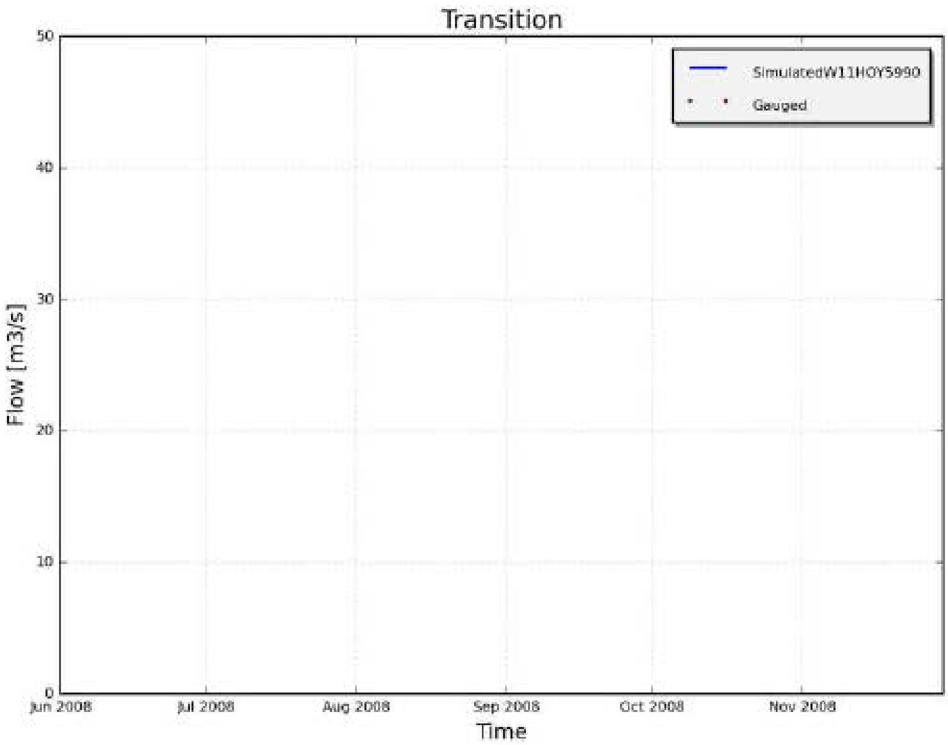
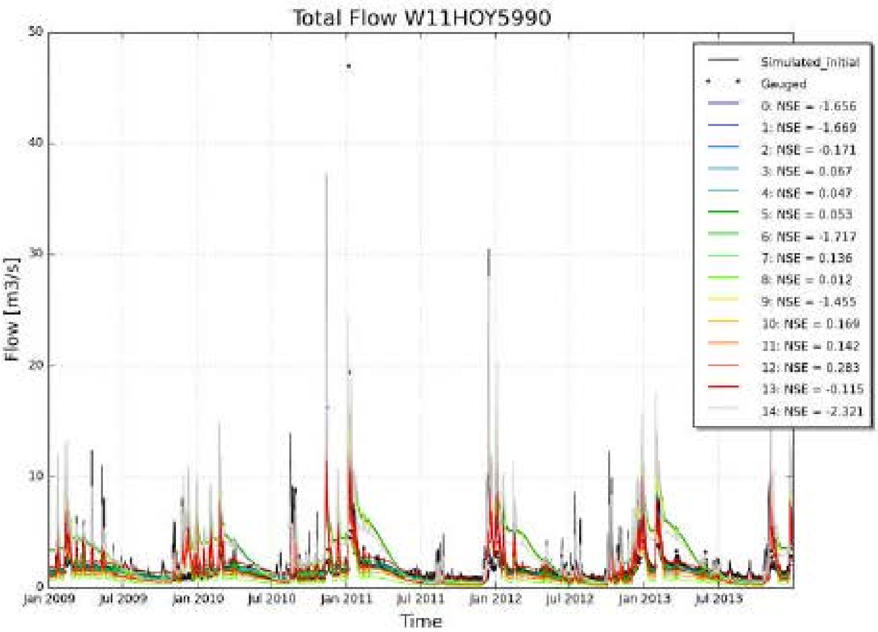
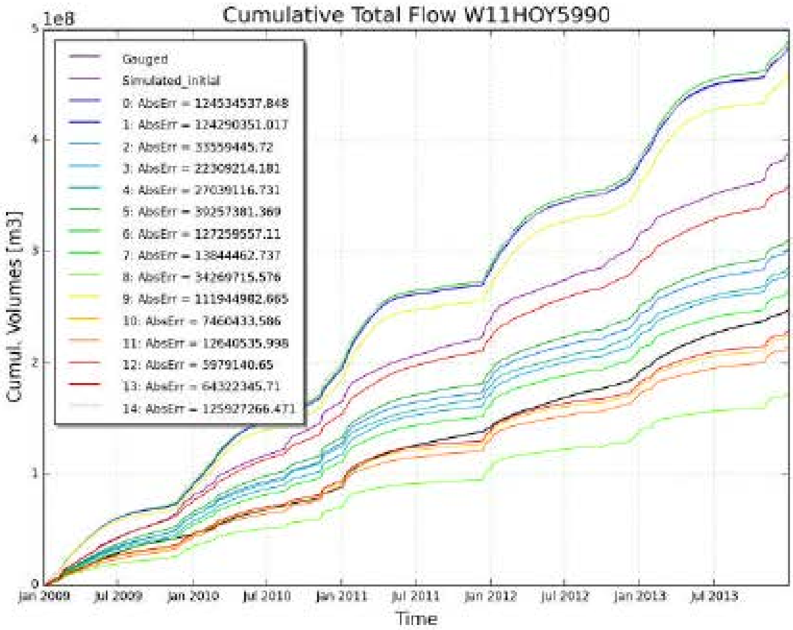


Figure 10: Total flow with optimum parameters (detail)

9.5.3.4.3 Final archive

0 : [1.9, 15.854, 0.002, 2.22, 189.866, 498.252, 8.871, 435.411] : [4297770.427, -0.714]
1 : [1.184, 11.55, 0.001, 1.957, 209.601, 483.315, 9.767, 387.862] : [20325774.288, 0.085]
2 : [1.803, 12.243, 0.002, 1.507, 205.713, 490.366, 11.377, 401.33] : [13673342.29, -0.117]
3 : [1.809, 11.847, 0.002, 1.884, 204.896, 502.034, 8.959, 413.371] : [6507377.408, -0.2]
4 : [1.788, 13.087, 0.002, 1.77, 214.033, 501.274, 10.205, 424.543] : [11763387.157, -0.126]
5 : [1.78, 12.276, 0.002, 2.162, 212.672, 491.951, 9.039, 435.414] : [8912748.589, -0.159]
6 : [1.9, 15.365, 0.002, 2.5, 201.696, 497.569, 8.917, 434.549] : [4336604.669, -0.683]
7 : [1.537, 12.146, 0.002, 1.874, 209.693, 486.551, 9.844, 411.817] : [27624740.804, 0.152]
8 : [1.587, 13.2, 0.002, 2.5, 211.787, 489.48, 10.716, 419.424] : [24342898.448, 0.121]
9 : [1.9, 17.067, 0.002, 2.359, 197.101, 497.935, 10.66, 401.594] : [4274276.0, -0.721]
10 : [1.9, 17.191, 0.002, 2.5, 196.421, 497.685, 9.108, 385.215] : [4252675.167, -0.776]
11 : [1.356, 12.244, 0.001, 2.157, 209.852, 495.115, 9.235, 417.616] : [4344386.204, -0.29]
12 : [1.81, 12.522, 0.002, 2.5, 210.982, 491.084, 9.22, 424.714] : [6469129.052, -0.249]
13 : [1.548, 12.782, 0.001, 2.306, 210.542, 489.963, 9.595, 421.421] : [13844462.737, 0.025]





9.5.4 Report on simulation of catchment W11MEH5820 (2017-02-14 05-36)

9.5.4.1 Input data

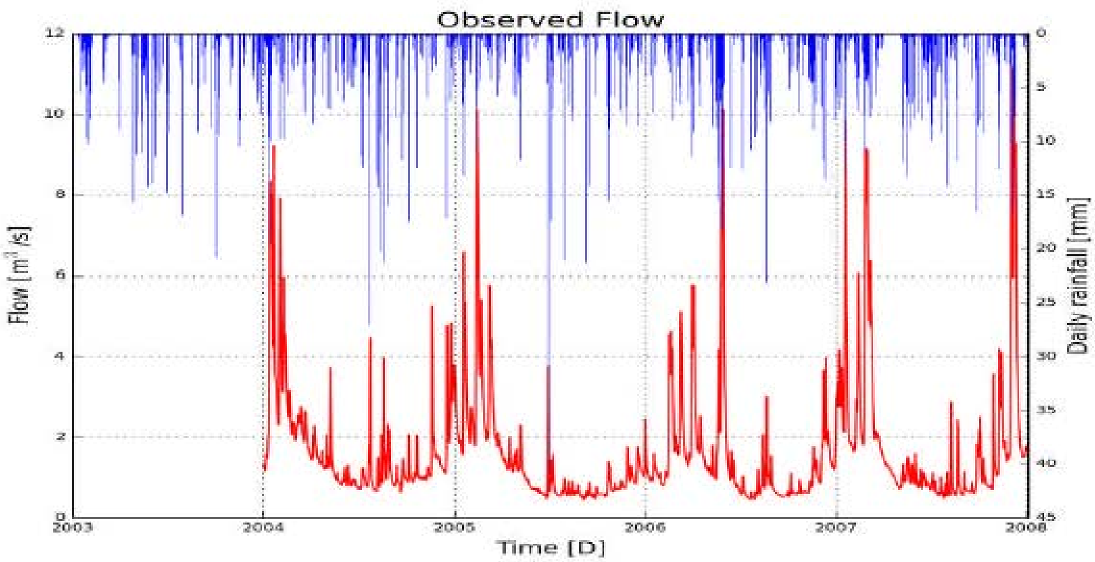


Figure 1: Hyetogram of observed discharge and observed net rain

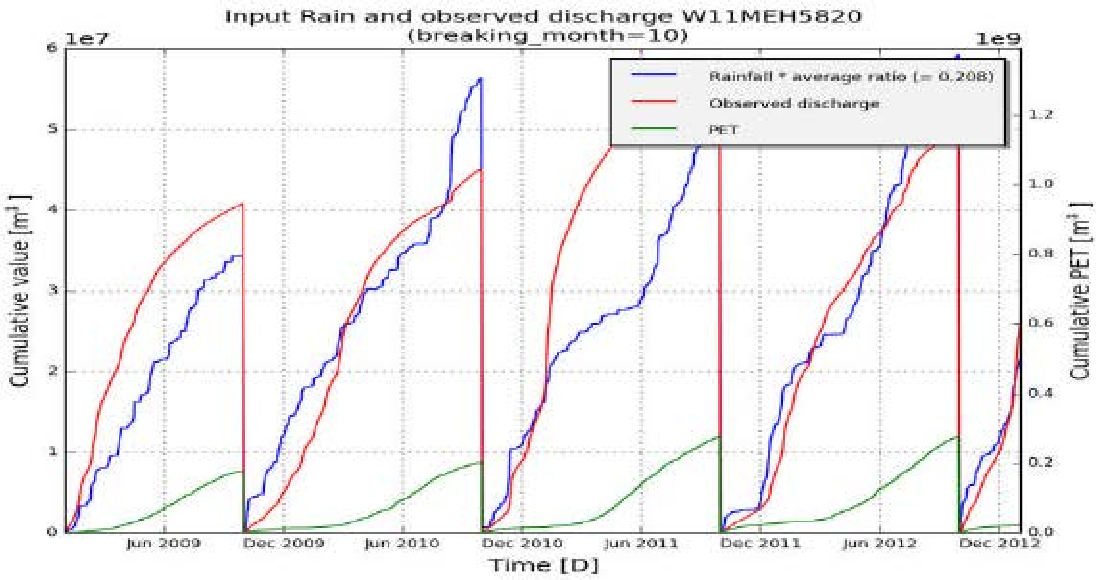


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.4.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	W11MEH5820
subcatchment_area	356000000
start_date	200101010000
end_date	200801030000
frequency	86400
warmup	365

9.5.4.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[2.0, 62.087, 0.004, 1.62, 172.23, 705.1, 2.4, 557.66]
low_bounds	[1.6, 50.0, 0.01, 1.2, 137.7, 560.0, 1.6, 450.0]
high_bounds	[2.4, 80.0, 0.01, 2.5, 300.0, 950.0, 3.0, 1000.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 2.0), ('Ki', 62.087), ('Kg', 0.004), ('Kss', 1.62), ('g0', 172.23), ('g_max', 705.1), ('K_run', 2.4), ('P_max', 557.66)]
Initial fitness:

- RelErr: 0.131
- AbsErr: 38949230.334
- KGE: 0.396
- NS_rel: 0.172
- NS: -0.096
- RMSE: 46127086.381
- NS_log: 0.307

Computation time:20:36:22.953000

9.5.4.4 Results

Best individual (euclidian): [('Kep', 2.4), ('Ki', 52.618), ('Kg', 0.01), ('Kss', 2.045), ('g0', 270.882), ('g_max', 833.236), ('K_run', 3.0), ('P_max', 607.335)]

Fitness:

- RelErr: 0.098
- AbsErr: 29201899.947
- KGE: 0.581
- NS_rel: 0.581
- NS: 0.308
- RMSE: 35445645.314
- NS_log: 0.463

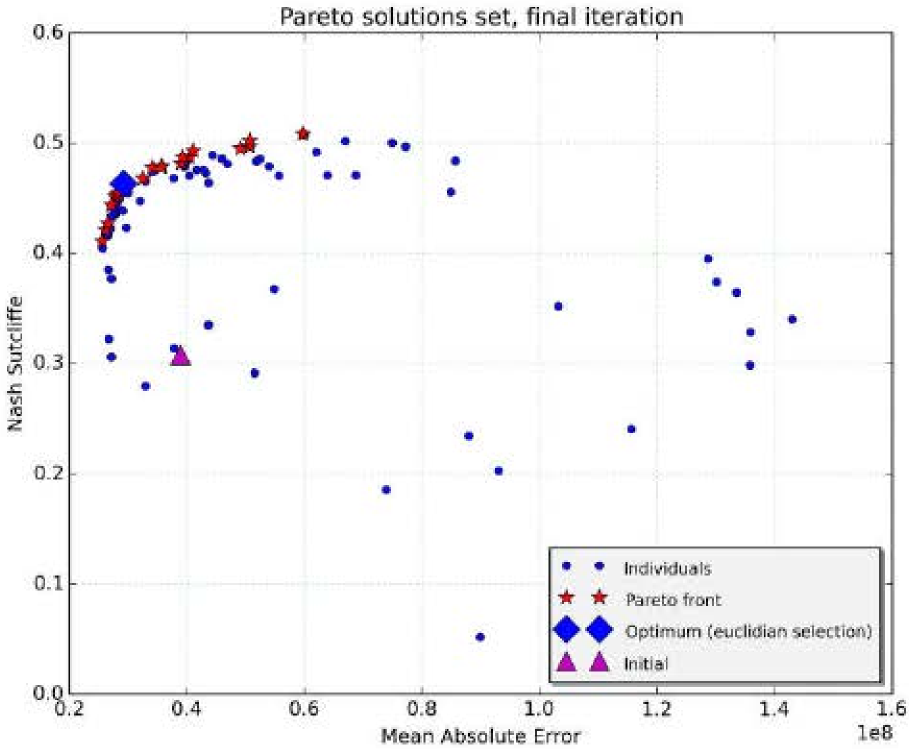


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

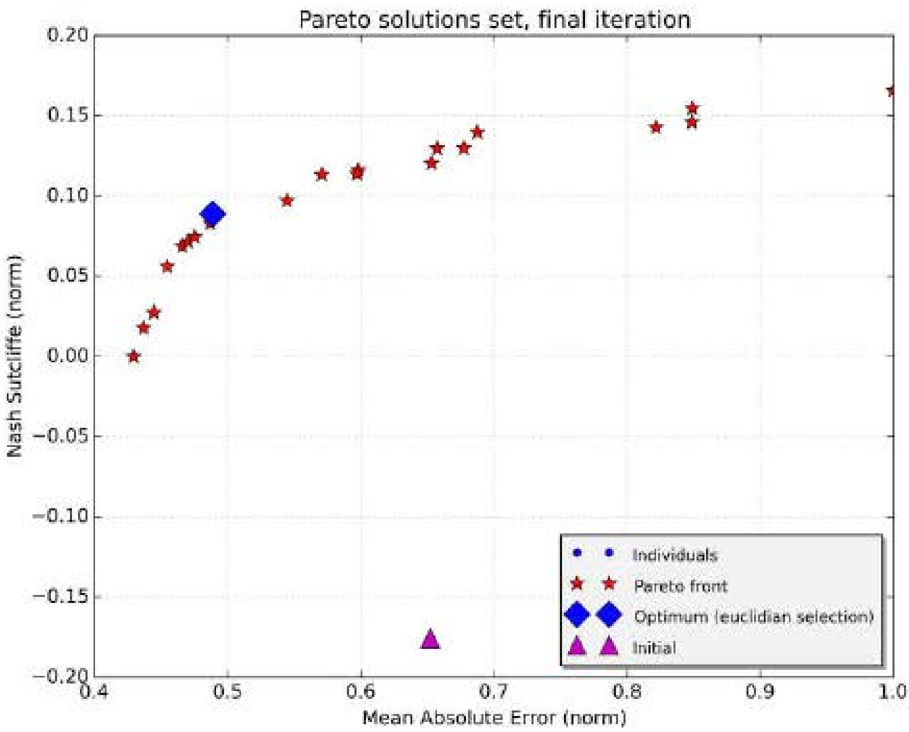


Figure 4: Final population of solutions (Pareto front)

9.5.4.4.1 Initial

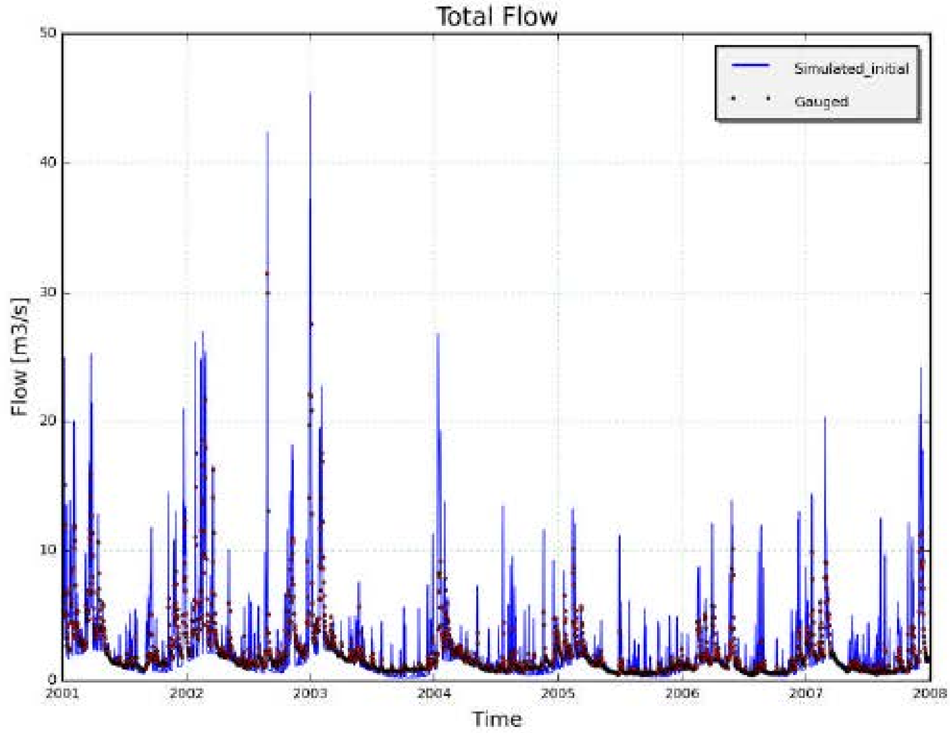


Figure 5: Total flow with initial parameters

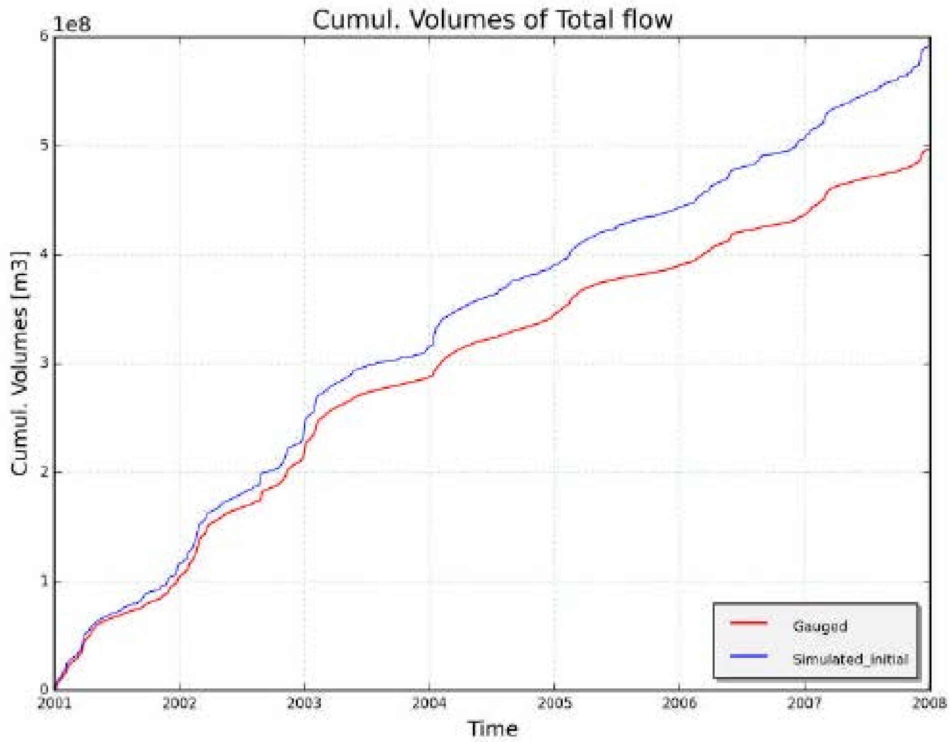


Figure 6: Cumulated flow with initial parameters

9.5.4.4.2 Optimum (euclidian)

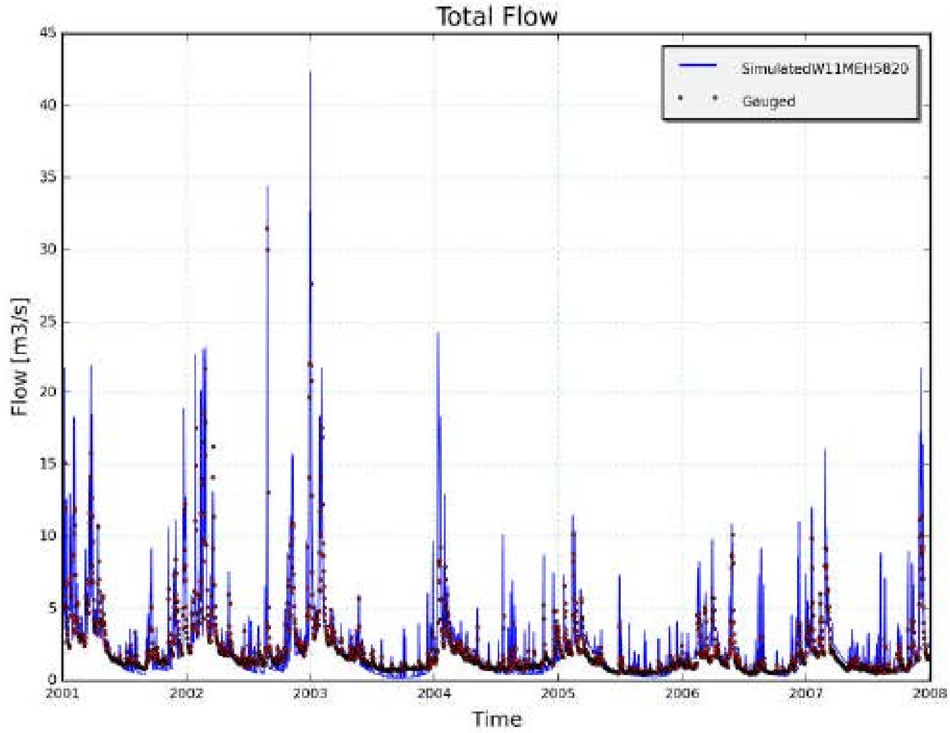


Figure 7: Total flow with optimum parameters

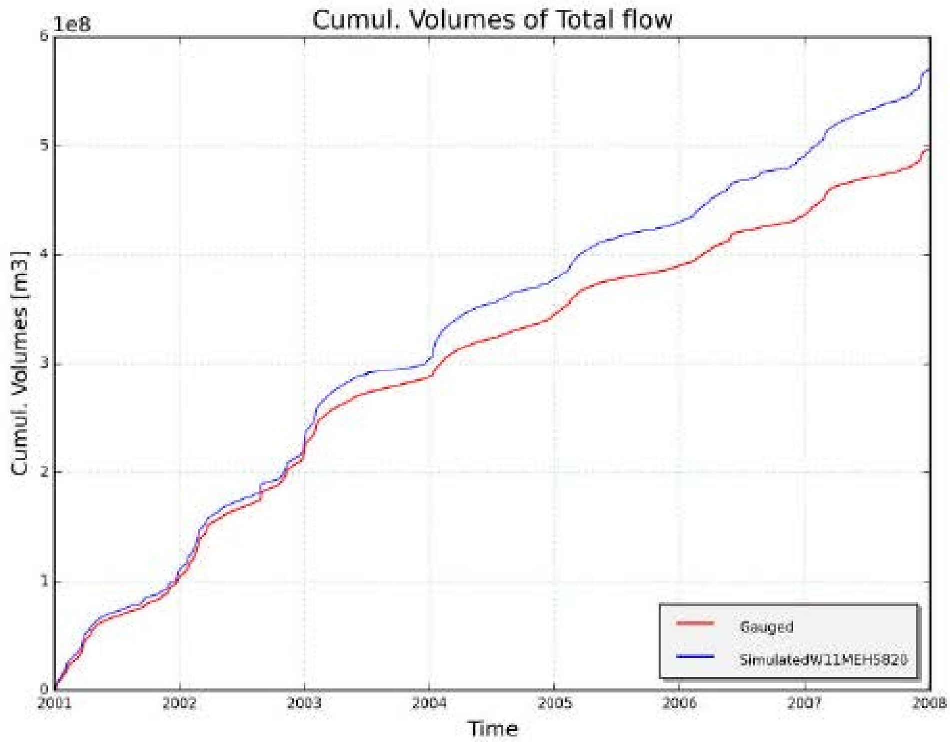


Figure 8: Cumulated flow with optimum parameters

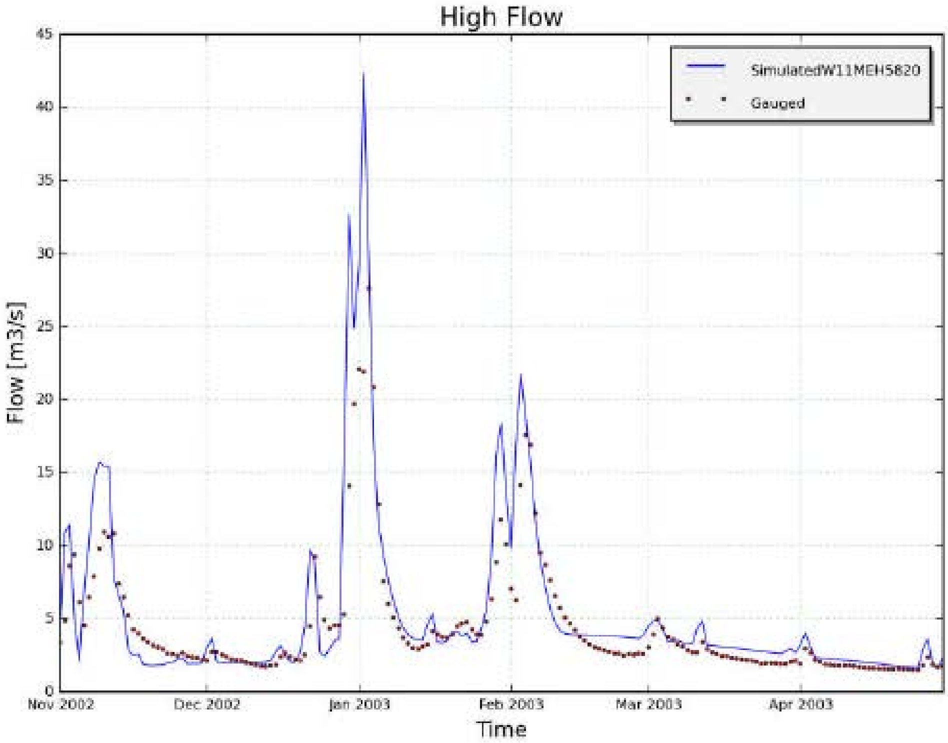


Figure 9: Total flow with optimum parameters (detail)

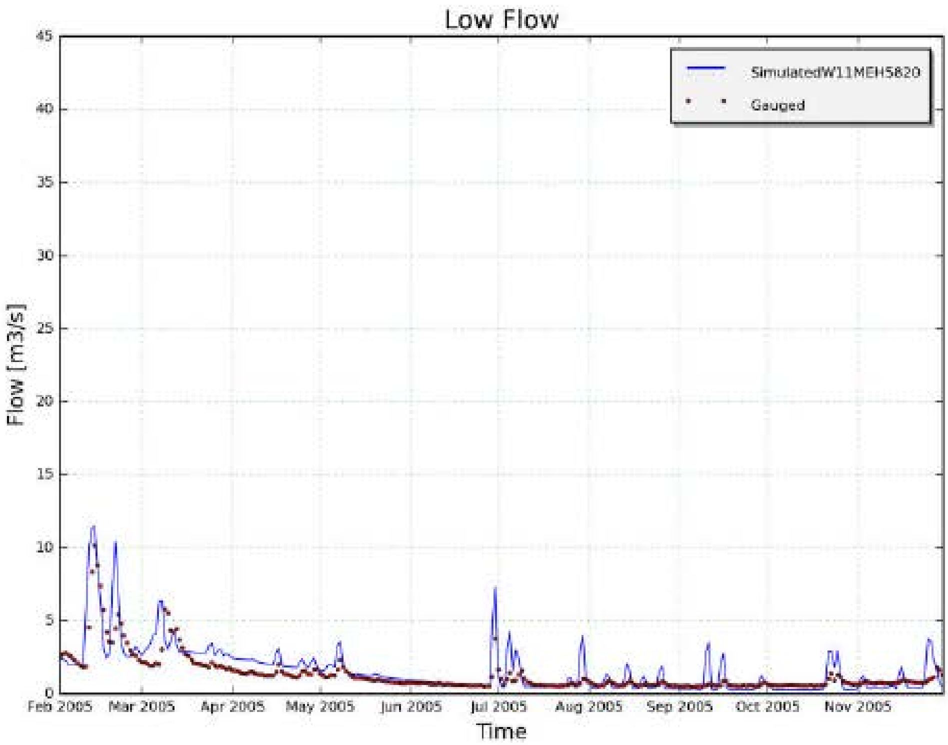
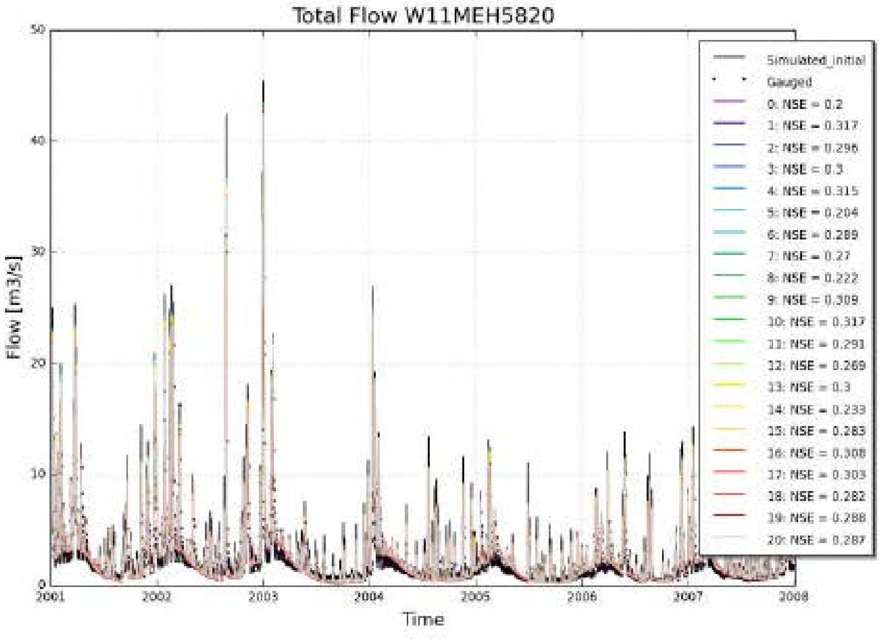
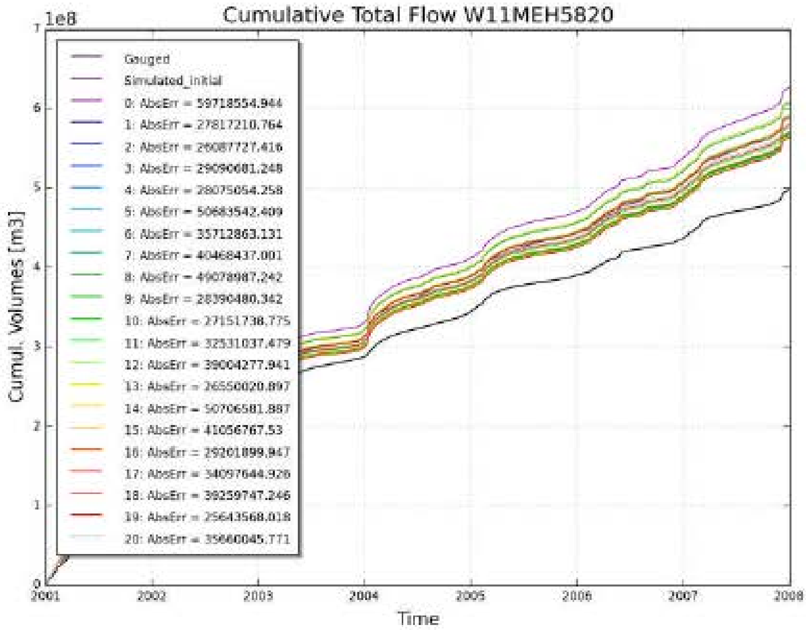


Figure 10: Total flow with optimum parameters (detail)

9.5.4.4.3 Final archive

0 : [2.16, 52.643, 0.01, 1.978, 270.914, 833.779, 3.0, 612.605] : [59718554.944, 0.508]
1 : [2.4, 51.466, 0.01, 2.049, 247.332, 799.554, 3.0, 578.844] : [27817210.764, 0.451]
2 : [2.4, 54.287, 0.01, 2.35, 239.11, 749.545, 3.0, 592.987] : [26087727.416, 0.421]
3 : [2.4, 53.579, 0.01, 2.5, 265.246, 829.2, 3.0, 614.521] : [29090681.248, 0.46]
4 : [2.4, 51.764, 0.01, 2.453, 266.819, 804.569, 3.0, 588.474] : [28075054.258, 0.453]
5 : [2.229, 55.96, 0.01, 2.142, 254.951, 835.833, 3.0, 600.785] : [50683542.409, 0.497]
6 : [2.346, 52.588, 0.01, 2.143, 265.58, 833.144, 3.0, 607.538] : [35712863.131, 0.479]
7 : [2.307, 52.834, 0.01, 2.353, 271.99, 831.738, 3.0, 607.948] : [40468437.001, 0.487]
8 : [2.237, 54.429, 0.01, 2.448, 259.33, 821.416, 3.0, 610.374] : [49078987.242, 0.495]
9 : [2.4, 52.416, 0.01, 2.484, 266.535, 811.734, 3.0, 594.937] : [28390480.342, 0.455]
10 : [2.4, 51.54, 0.01, 2.232, 245.644, 782.642, 3.0, 590.887] : [27151738.775, 0.444]
11 : [2.37, 53.365, 0.01, 2.5, 260.857, 825.455, 3.0, 609.619] : [32531037.479, 0.468]
12 : [2.318, 53.548, 0.01, 1.751, 261.63, 825.964, 3.0, 598.864] : [39004277.941, 0.482]
13 : [2.398, 53.641, 0.01, 1.782, 235.281, 755.828, 3.0, 597.393] : [26550020.897, 0.427]
14 : [2.227, 52.615, 0.01, 2.128, 268.87, 832.323, 3.0, 608.563] : [50706581.887, 0.502]
15 : [2.302, 51.053, 0.01, 2.193, 269.364, 836.371, 3.0, 613.431] : [41056767.53, 0.493]
16 : [2.4, 52.618, 0.01, 2.045, 270.882, 833.236, 3.0, 607.335] : [29201899.947, 0.463]
17 : [2.357, 51.299, 0.01, 2.387, 270.13, 830.235, 3.0, 597.304] : [34097644.926, 0.478]
18 : [2.316, 51.835, 0.01, 2.342, 272.295, 831.647, 3.0, 613.99] : [39259747.246, 0.487]
19 : [2.4, 55.262, 0.01, 1.913, 254.941, 734.099, 3.0, 599.49] : [25643568.018, 0.411]
20 : [2.345, 52.761, 0.01, 2.376, 271.361, 829.708, 3.0, 608.784] : [35660045.771, 0.478]





9.5.5 Report on simulation of catchment W11OUR5805 (2017-02-07 01-49)

9.5.5.1 Input data

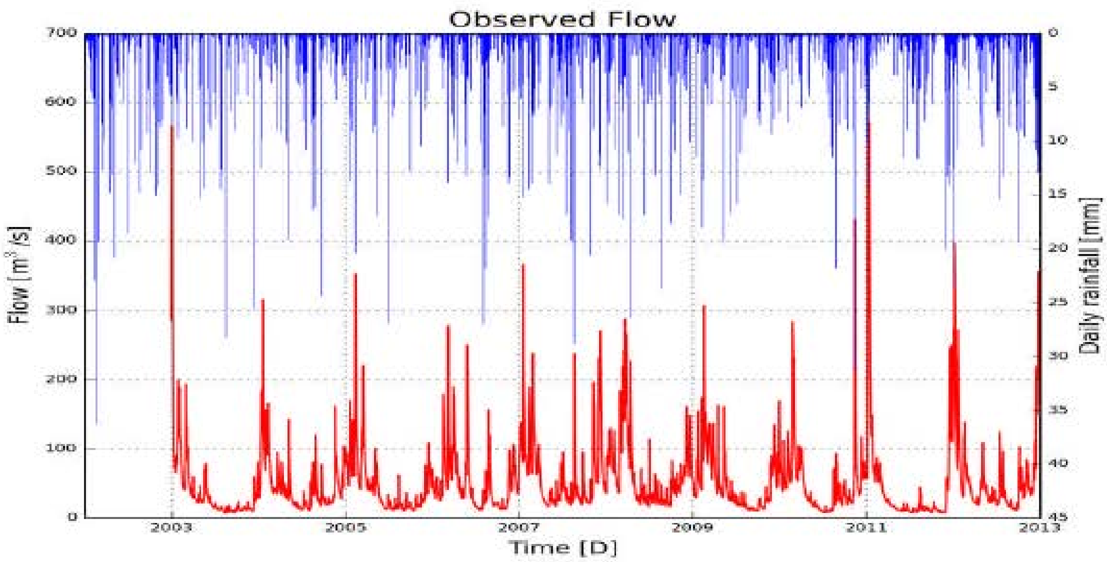


Figure 1: Hyetogram of observed discharge and observed net rain

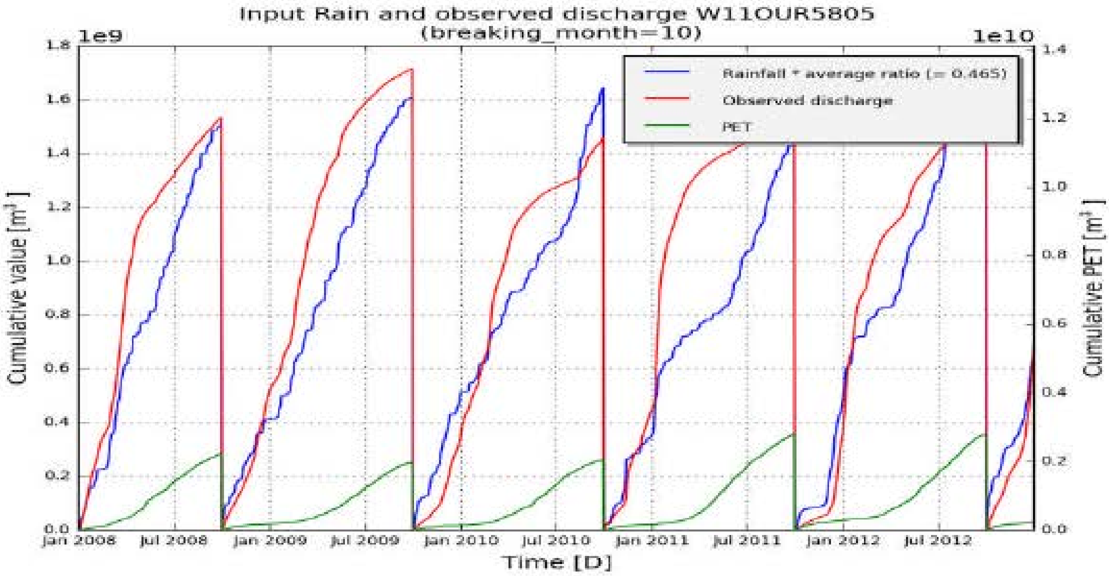


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.5.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	W11OUR5805
subcatchment_area	3612000000
start_date	200301010000
end_date	201212310000
frequency	86400
warmup	365

9.5.5.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[1.5, 20.0, 0.025, 1.05, 40.0, 200.0, 3.0, 100.0]
low_bounds	[1.0, 14.0, 0.0009, 0.73, 28.0, 140.0, 2.1, 70.0]
high_bounds	[3.0, 150.0, 0.01, 3.0, 200.0, 400.0, 6.0, 400.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.5), ('Ki', 20.0), ('Kg', 0.025), ('Kss', 1.05), ('g0', 40.0), ('g_max', 200.0), ('K_run', 3.0), ('P_max', 100.0)]
Initial fitness:

- RelErr: 0.453
- AbsErr: 3665187226.09
- KGE: 0.488
- NS_rel: 0.034
- NS: 0.307
- RMSE: 4308469316.39
- NS_log: 0.401

Computation time:8:22:58.200000

9.5.5.4 Results

Best individual (euclidian): [('Kep', 1.891), ('Ki', 83.472), ('Kg', 0.01), ('Kss', 3.0), ('g0', 73.059), ('g_max', 295.613), ('K_run', 4.191), ('P_max', 226.702)]

Fitness:

- RelErr: -0.004
- AbsErr: 168427657.046
- KGE: 0.637
- NS_rel: 0.658
- NS: 0.391
- RMSE: 200923155.962
- NS_log: 0.6

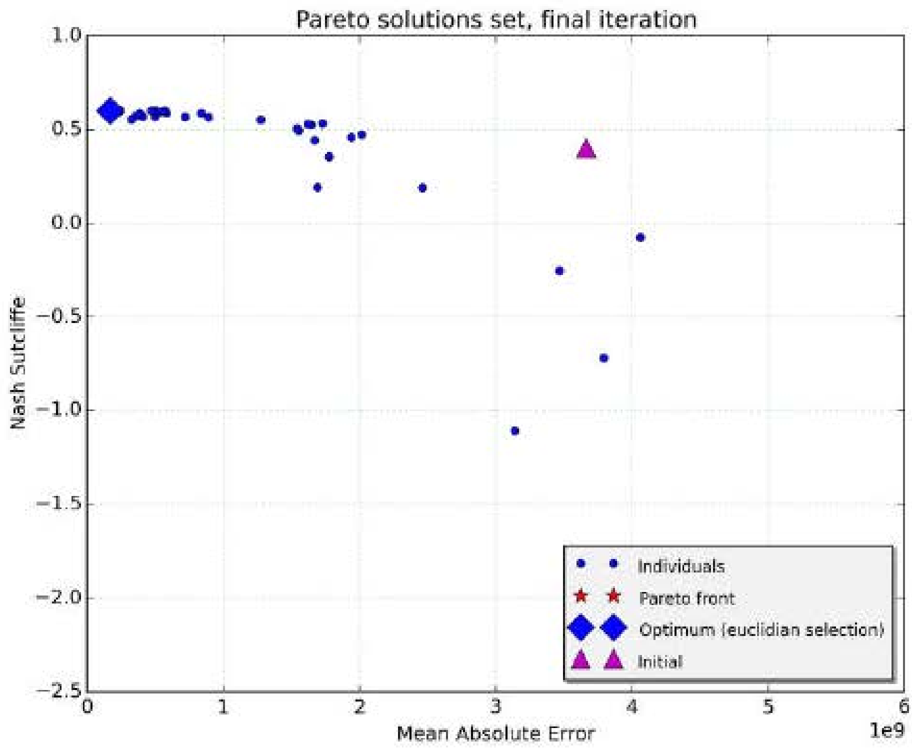


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

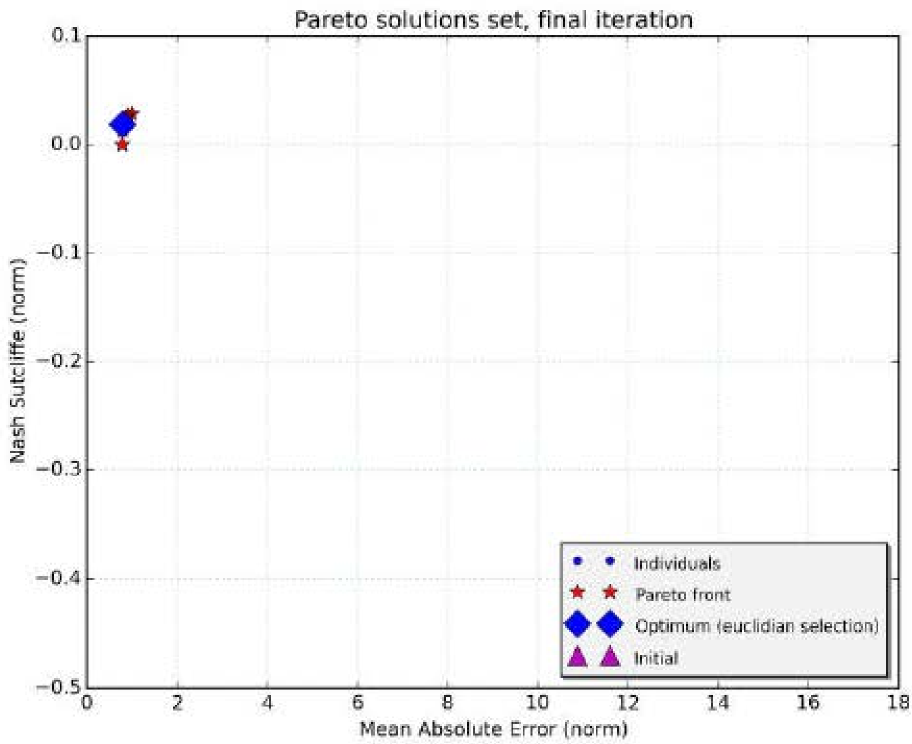


Figure 4: Final population of solutions (Pareto front)

9.5.5.4.1 Initial

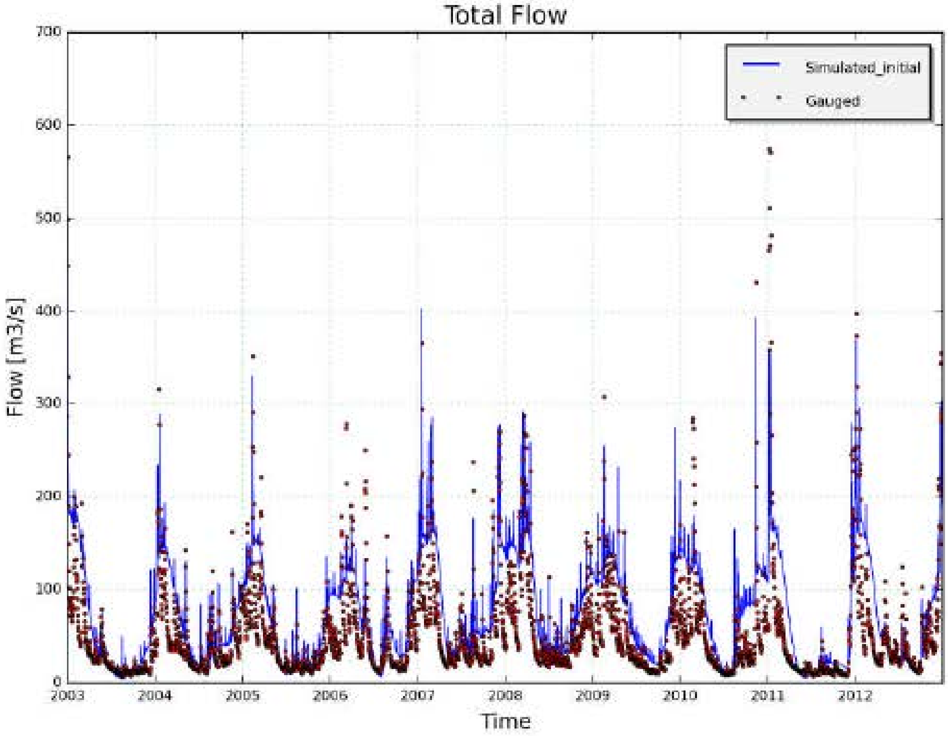


Figure 5: Total flow with initial parameters

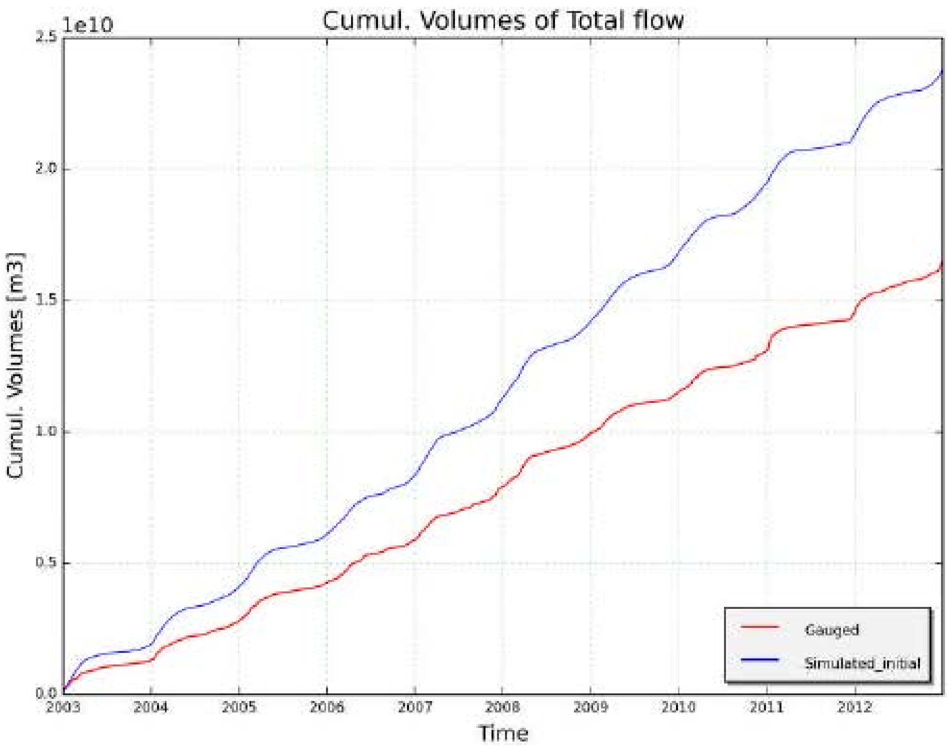


Figure 6: Cumulated flow with initial parameters

9.5.5.4.2 Optimum (euclidian)

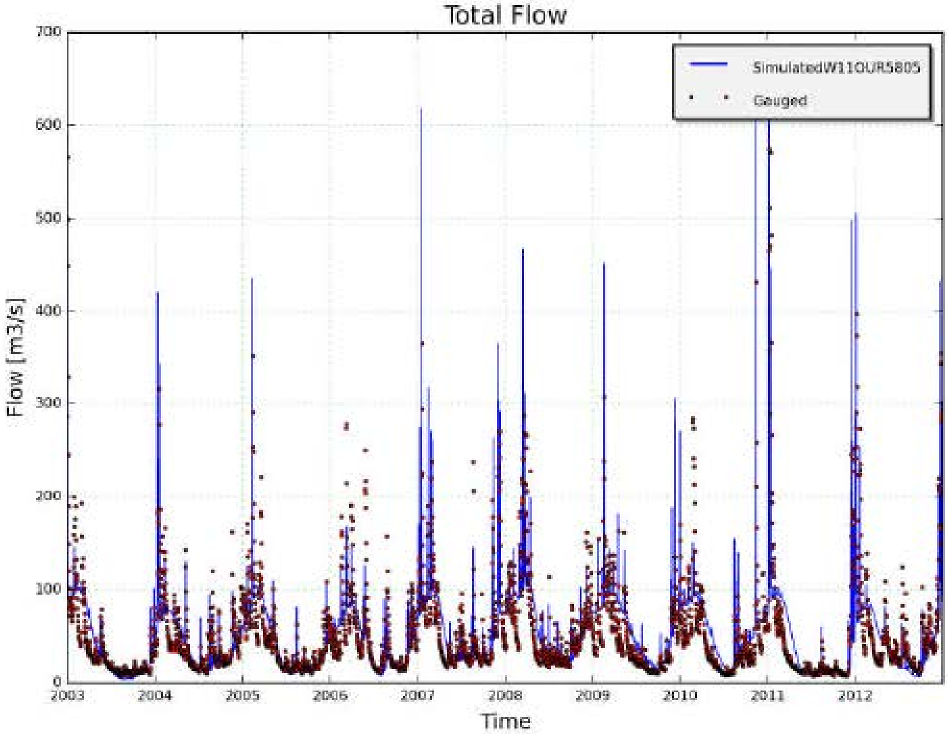


Figure 7: Total flow with optimum parameters

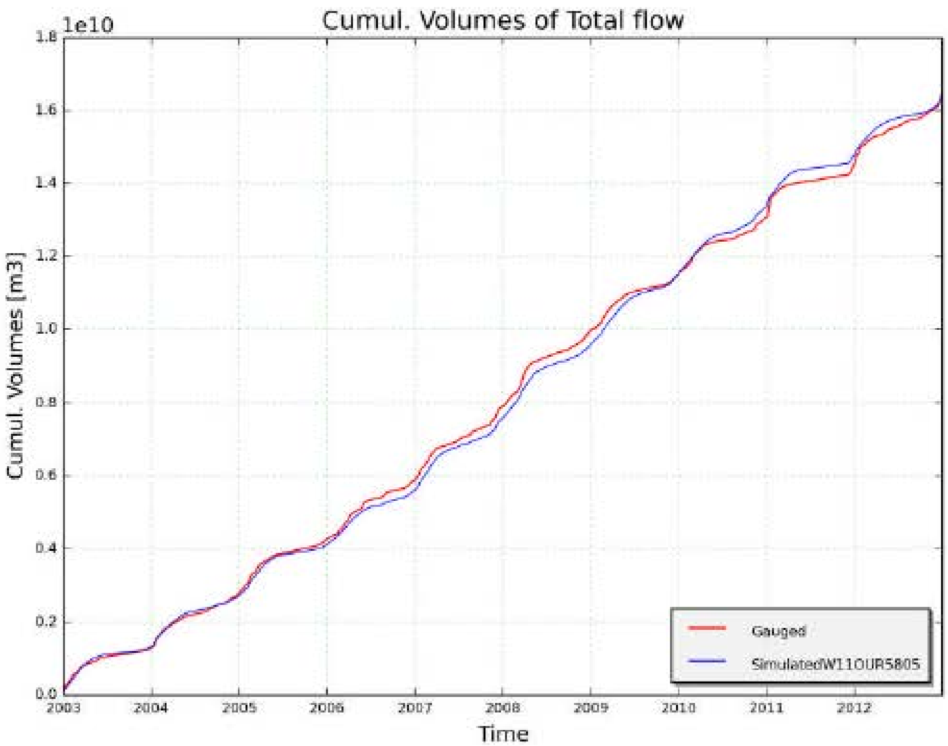


Figure 8: Cumulated flow with optimum parameters

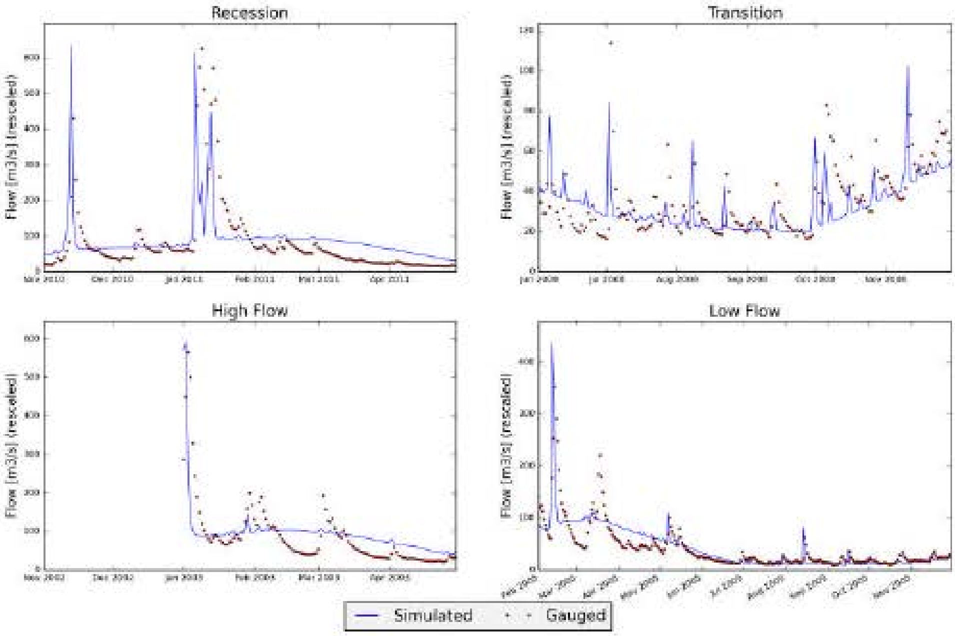
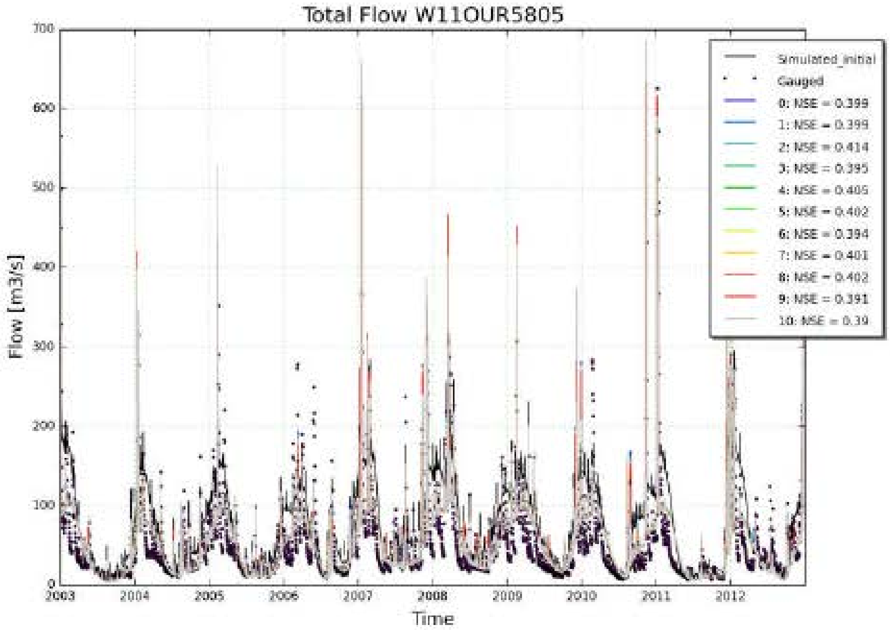
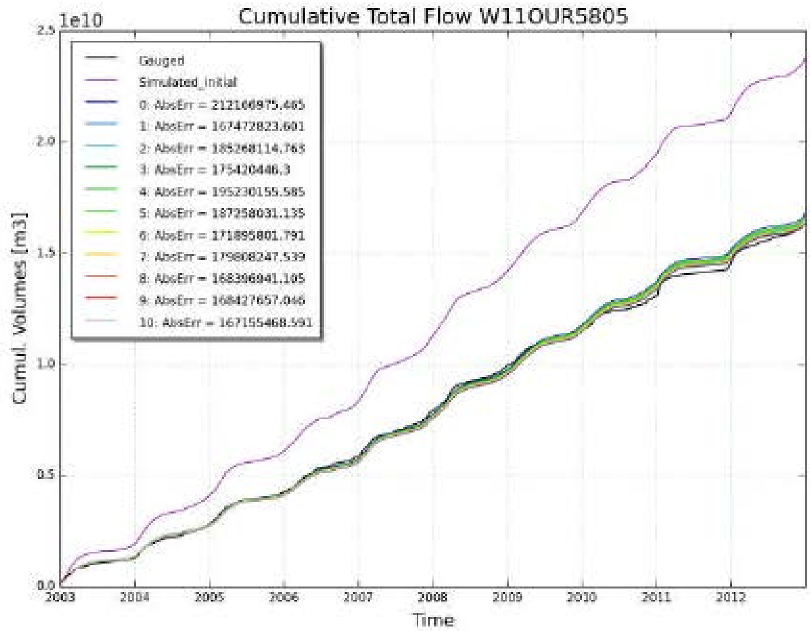


Figure 9: Total flow with optimum parameters (detail)

9.5.5.4.3 Final archive

0 : [1.892, 81.195, 0.01, 2.047, 69.042, 309.855, 4.565, 226.216] : [212166975.465, 0.604]
1 : [1.884, 81.15, 0.01, 3.0, 86.341, 285.503, 4.173, 228.581] : [167472823.601, 0.598]
2 : [1.894, 77.299, 0.01, 3.0, 70.931, 299.063, 4.532, 227.815] : [185268114.763, 0.602]
3 : [1.887, 82.104, 0.01, 3.0, 75.885, 299.279, 4.182, 225.968] : [175420446.3, 0.602]
4 : [1.886, 79.458, 0.01, 3.0, 77.331, 302.164, 4.259, 226.781] : [195230155.585, 0.603]
5 : [1.883, 80.11, 0.01, 3.0, 83.756, 299.198, 4.259, 228.071] : [187258031.135, 0.603]
6 : [1.893, 82.683, 0.01, 2.439, 71.757, 297.341, 4.362, 226.046] : [171895801.791, 0.601]
7 : [1.884, 80.503, 0.01, 2.465, 80.754, 298.619, 4.304, 227.556] : [179808247.539, 0.602]
8 : [1.892, 80.412, 0.01, 3.0, 69.717, 290.322, 4.354, 226.316] : [168396941.105, 0.599]
9 : [1.891, 83.472, 0.01, 3.0, 73.059, 295.613, 4.191, 226.702] : [168427657.046, 0.6]
10 : [1.884, 79.989, 0.01, 2.3, 75.062, 294.719, 3.19, 225.984] : [167155468.591, 0.592]


Total Flow W11OUR5805
Flow [m3/s]
Time
0
100
200
300
400
500
600
700
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Simulated_initial
Gauged
0: NSE = 0.399
1: NSE = 0.399
2: NSE = 0.414
3: NSE = 0.395
4: NSE = 0.405
5: NSE = 0.402
6: NSE = 0.394
7: NSE = 0.401
8: NSE = 0.402
9: NSE = 0.391
10: NSE = 0.39


Cumulative Total Flow W11OUR5805
1e10
Cumul. Volumes [m3]
Time
0.0
0.5
1.0
1.5
2.0
2.5
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Gauged
Simulated_initial
0: AbsErr = 212166975.465
1: AbsErr = 167472823.601
2: AbsErr = 185268114.763
3: AbsErr = 175420446.3
4: AbsErr = 195230155.585
5: AbsErr = 187258031.135
6: AbsErr = 171895801.791
7: AbsErr = 179808247.539
8: AbsErr = 168396941.105
9: AbsErr = 168427657.046
10: AbsErr = 167155468.591

9.5.6 Report on simulation of catchment W11JEK553010 (2017-02-07 20-18)

9.5.6.1 Input data

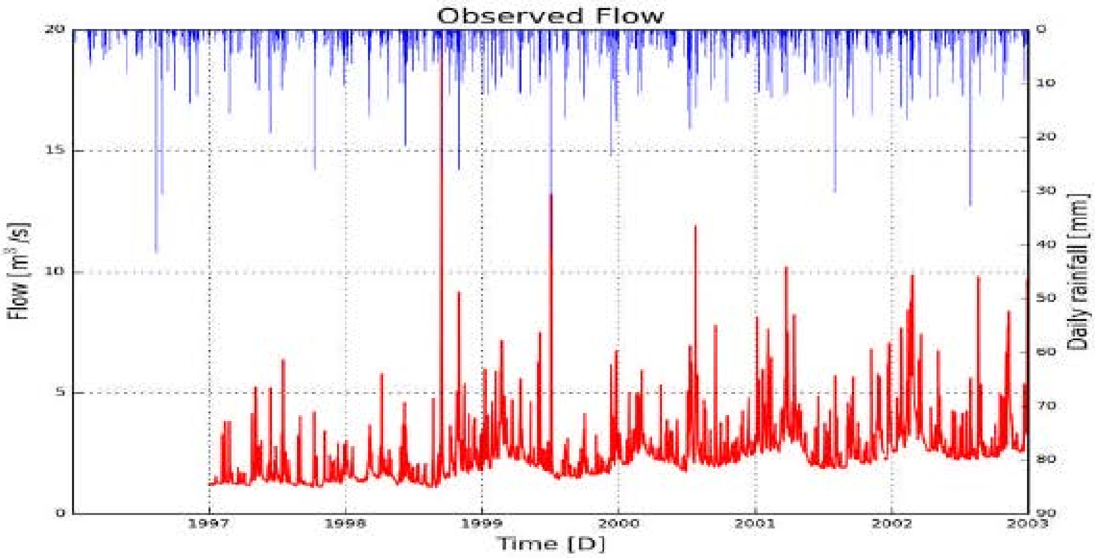


Figure 1: Hyetogram of observed discharge and observed net rain

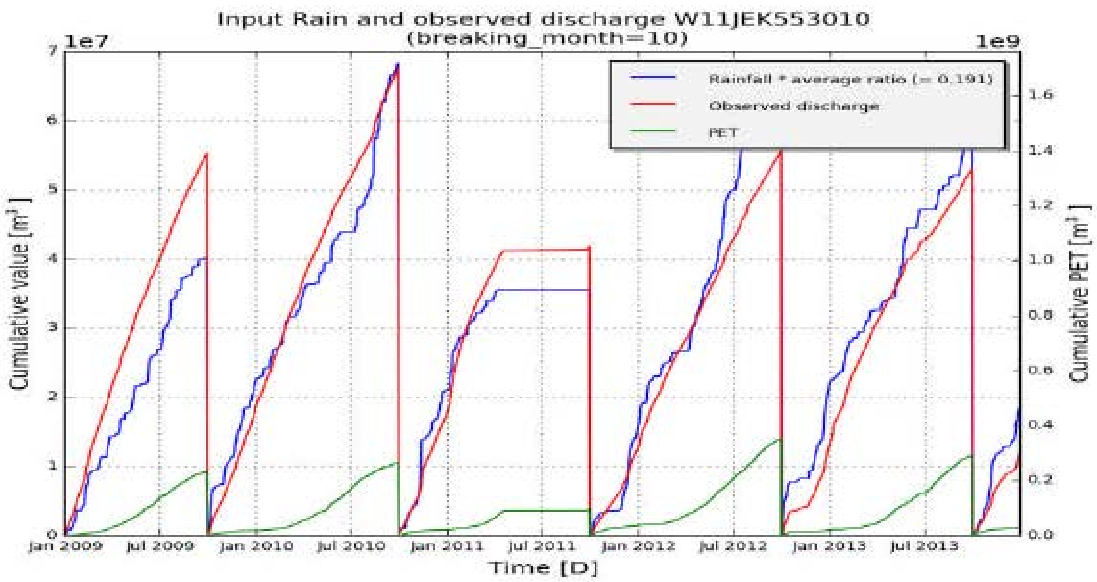


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.6.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	W11JEK553010
subcatchment_area	465500000
start_date	200901010000
end_date	201312310000
frequency	86400
warmup	365

9.5.6.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[1.0, 50.0, 0.004, 1.15, 70.0, 150.0, 1.5, 100.0]
low_bounds	[0.7, 35.0, 0.001, 0.5, 35.0, 75.0, 0.75, 50.0]
high_bounds	[2.0, 100.0, 0.01, 2.0, 140.0, 300.0, 3.0, 250.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.0), ('Ki', 50.0), ('Kg', 0.004), ('Kss', 1.15), ('g0', 70.0), ('g_max', 150.0), ('K_run', 1.5), ('P_max', 100.0)]
Initial fitness:

- RelErr: 1.176
- AbsErr: 176878774.086
- KGE: -5.244
- NS_rel: -14.625
- NS: -47.137
- RMSE: 209706201.977
- NS_log: -5.487

Computation time:1 day, 10:28:12.049000

9.5.6.4 Results

Best individual (euclidian): [('Kep', 1.367), ('Ki', 42.119), ('Kg', 0.001), ('Kss', 2.0), ('g0', 119.792), ('g_max', 274.512), ('K_run', 3.0), ('P_max', 127.155)]

Fitness:

- RelErr: 0.239
- AbsErr: 37833654.991
- KGE: -3.451
- NS_rel: -5.436
- NS: -21.659
- RMSE: 48685134.743
- NS_log: -6.905

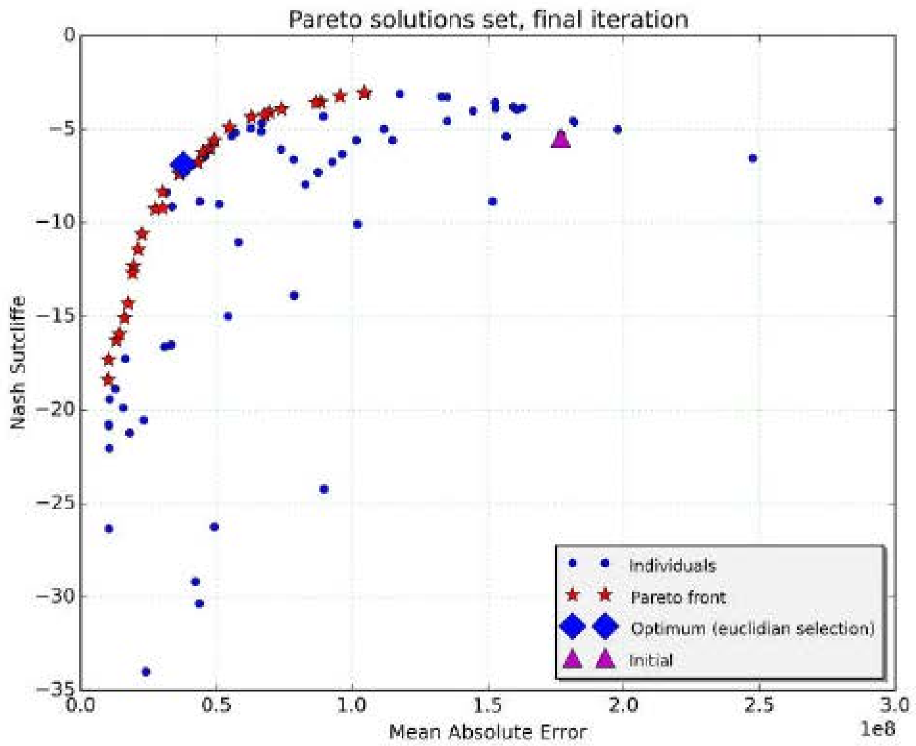


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

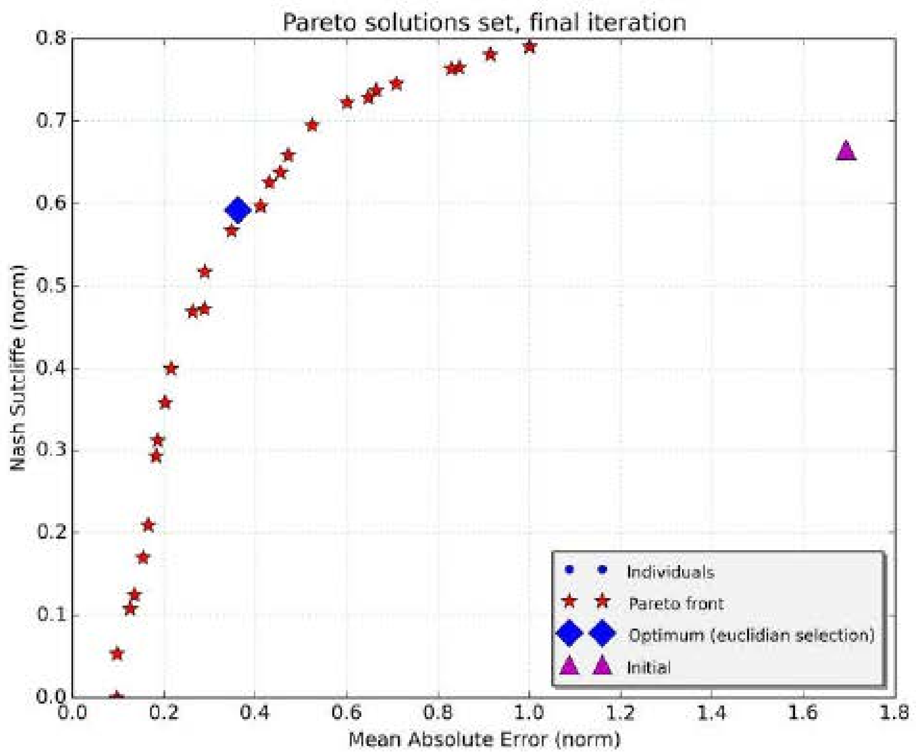


Figure 4: Final population of solutions (Pareto front)

9.5.6.4.1 Initial

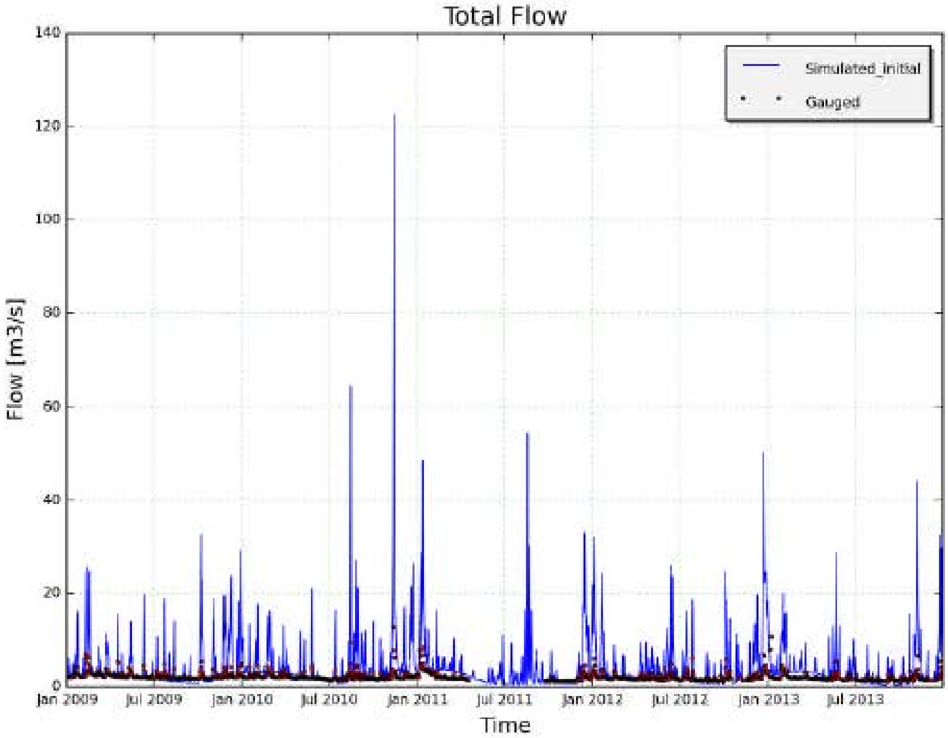


Figure 5: Total flow with initial parameters

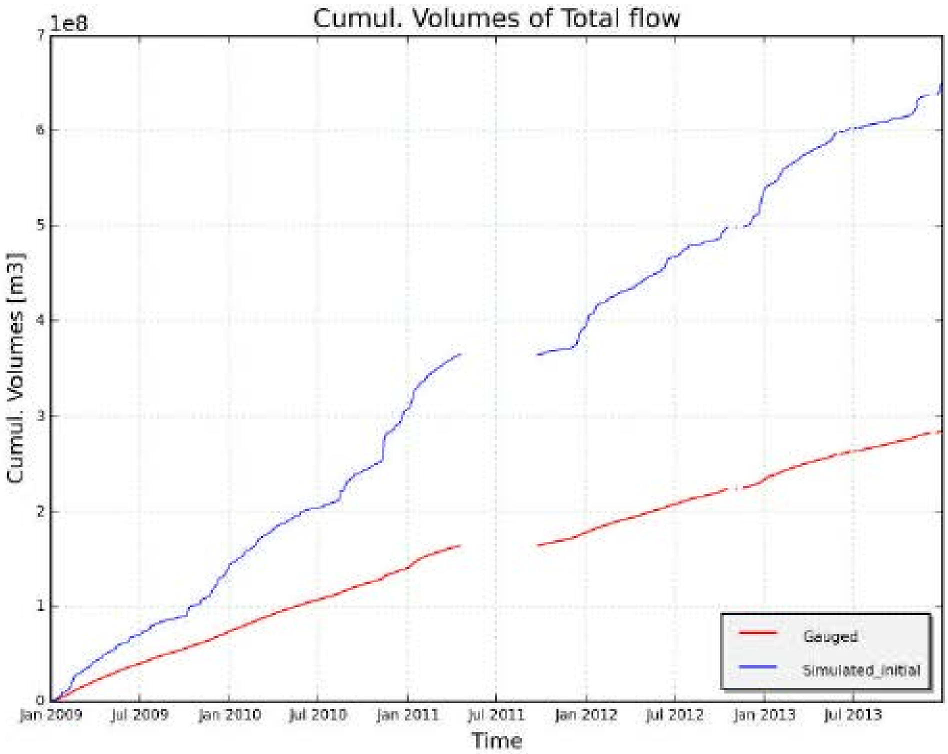


Figure 6: Cumulated flow with initial parameters

9.5.6.4.2 Optimum (euclidian)

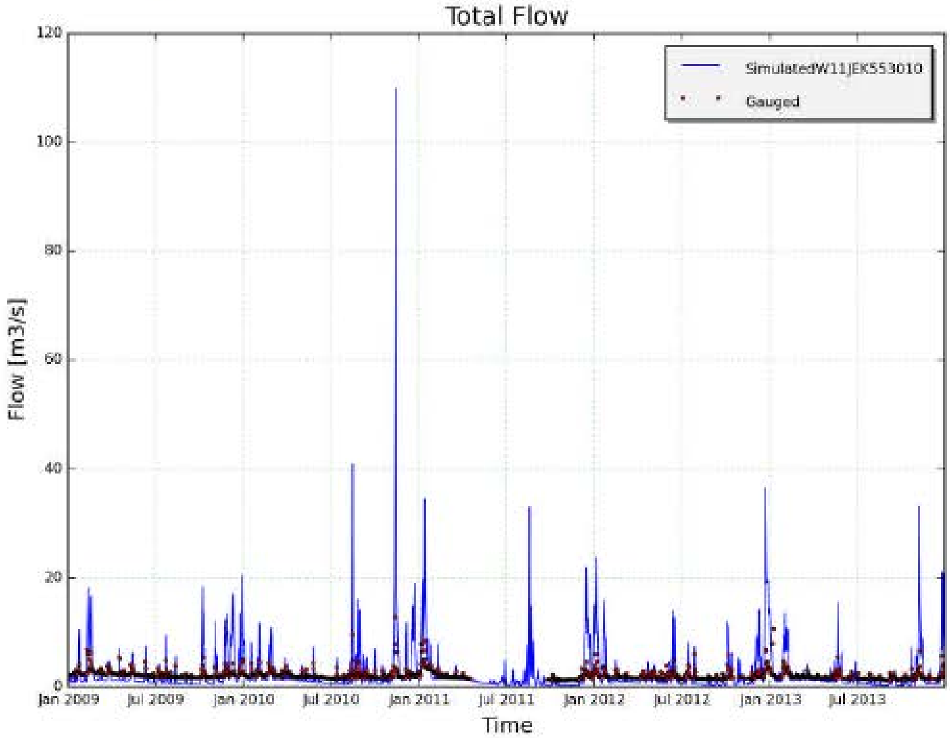


Figure 7: Total flow with optimum parameters

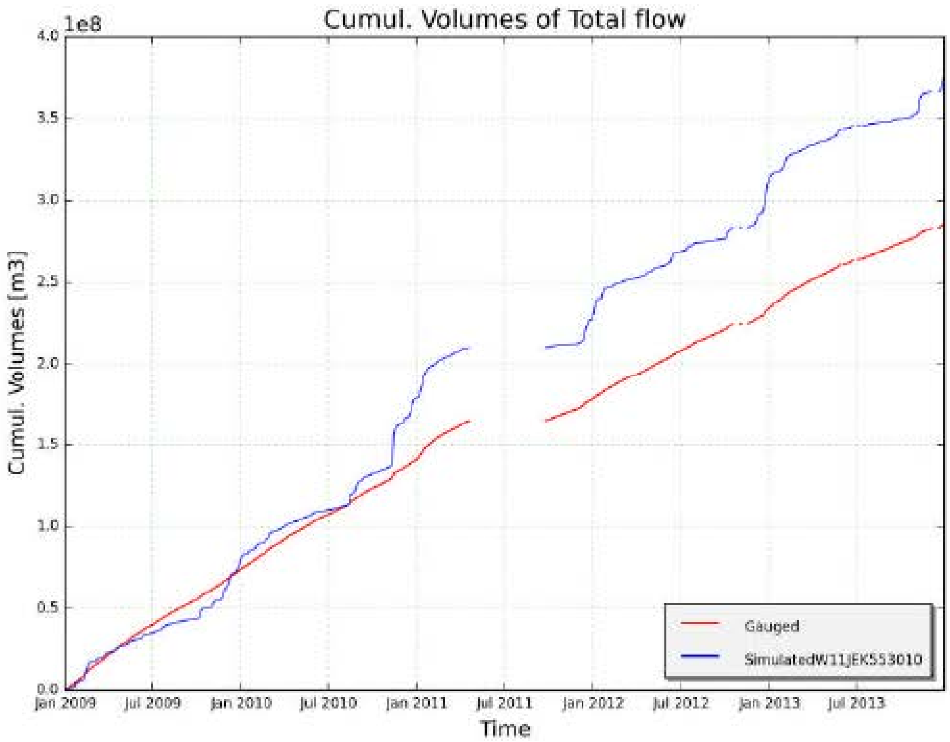


Figure 8: Cumulated flow with optimum parameters

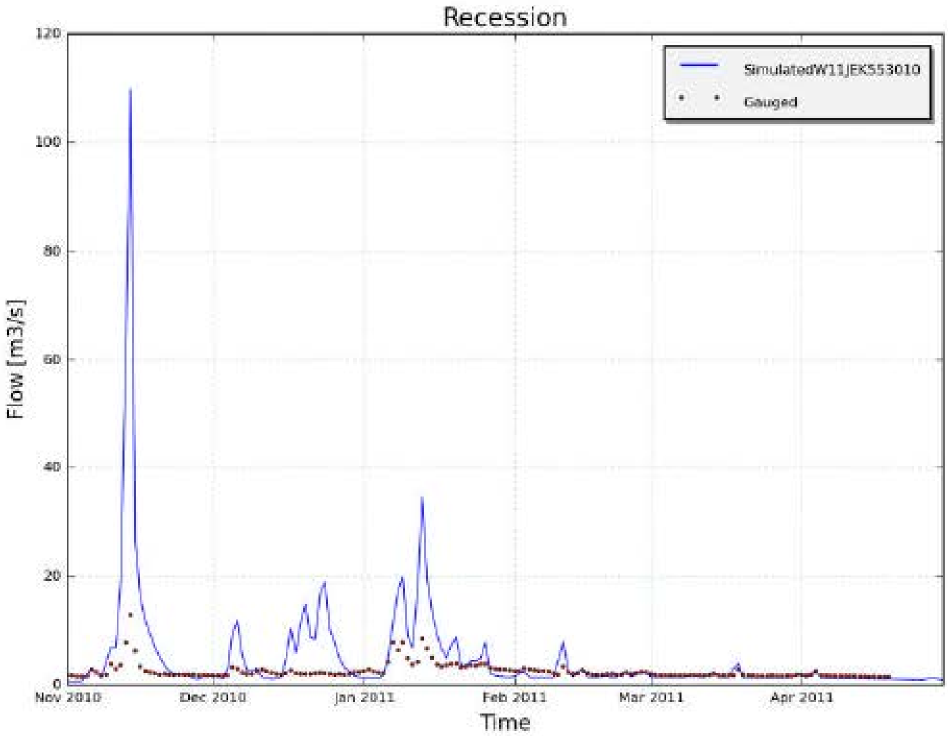


Figure 9: Total flow with optimum parameters (detail)

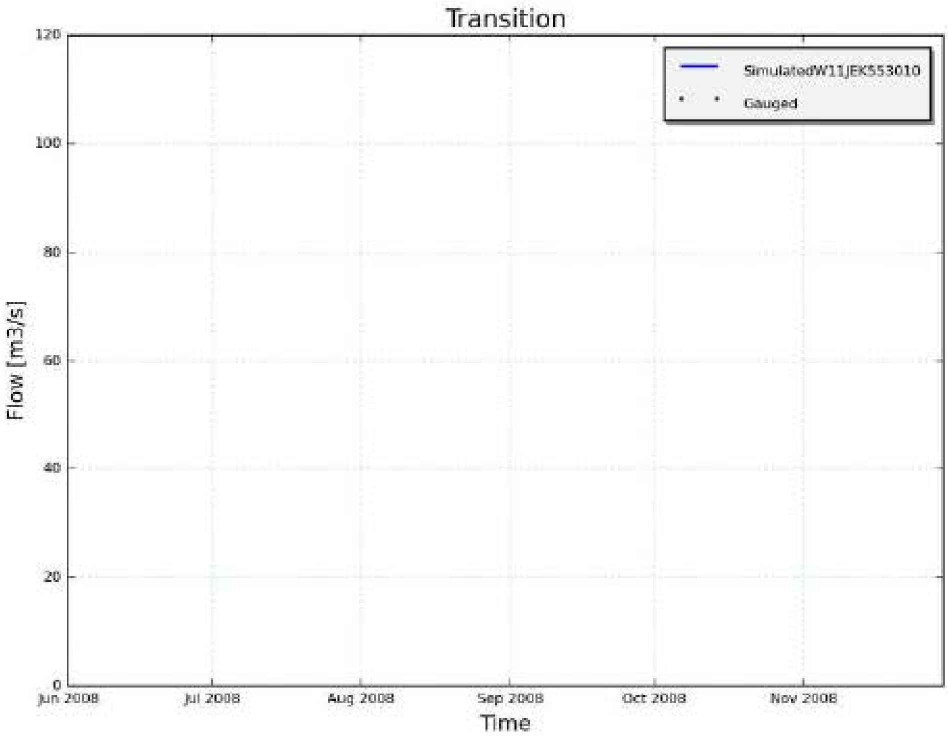
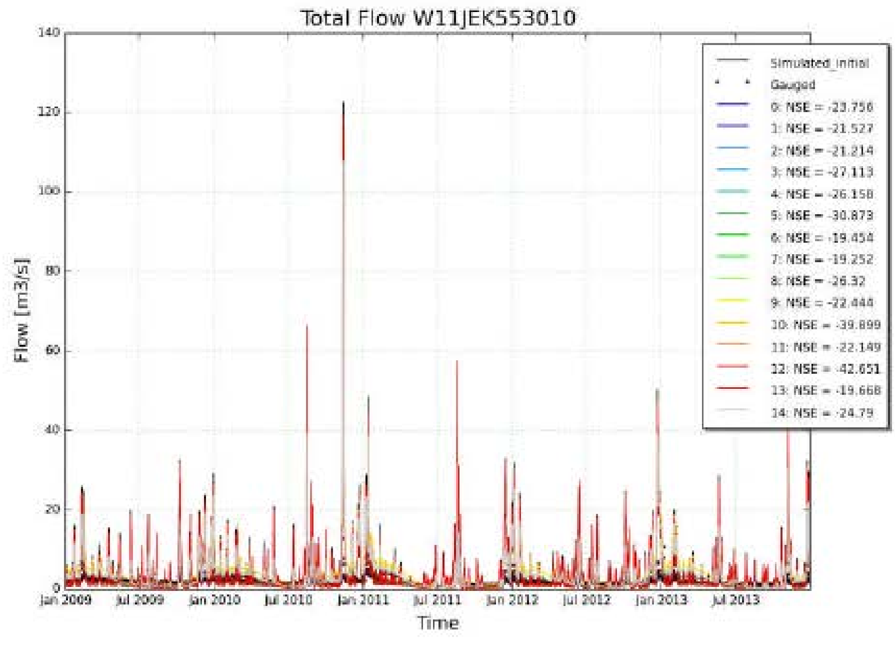
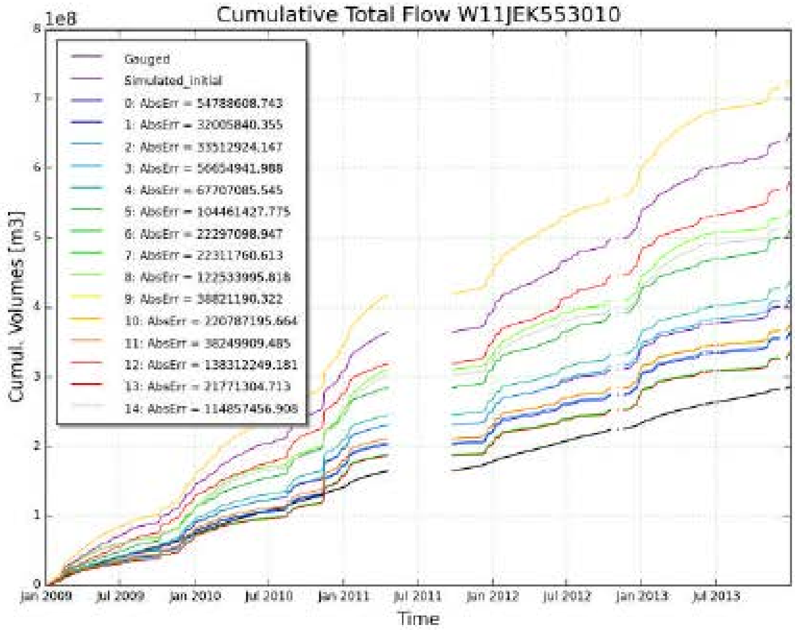


Figure 10: Total flow with optimum parameters (detail)

9.5.6.4.3 Final archive

0 : [1.124, 44.981, 0.001, 1.702, 117.012, 275.983, 3.0, 125.055] : [69485044.981, -4.085]
1 : [1.601, 43.571, 0.001, 0.966, 118.894, 274.555, 3.0, 135.822] : [22560995.775, -10.623]
2 : [1.806, 44.5, 0.001, 1.328, 94.317, 249.742, 2.969, 136.878] : [13172681.366, -16.297]
3 : [1.706, 44.018, 0.001, 0.64, 104.272, 248.728, 2.905, 135.587] : [17386198.126, -14.332]
4 : [1.835, 50.475, 0.001, 1.165, 105.298, 268.234, 3.0, 139.815] : [14225962.237, -15.971]
5 : [1.674, 45.12, 0.001, 1.524, 103.608, 270.358, 3.0, 127.435] : [19506604.349, -12.337]
6 : [1.63, 43.707, 0.001, 0.934, 114.828, 269.802, 2.97, 136.111] : [21182995.917, -11.457]
7 : [2.0, 42.471, 0.001, 0.5, 118.198, 269.466, 2.9, 129.152] : [10248594.267, -17.354]
8 : [1.005, 46.648, 0.001, 1.508, 116.247, 252.779, 3.0, 125.931] : [88401033.234, -3.554]
9 : [1.106, 44.259, 0.001, 1.598, 119.153, 276.045, 2.898, 127.109] : [74041119.03, -3.93]
10 : [1.317, 41.952, 0.001, 1.75, 118.275, 274.414, 2.852, 128.042] : [45023609.773, -6.251]
11 : [1.296, 43.77, 0.001, 0.753, 118.127, 273.226, 2.917, 126.158] : [47542594.091, -6.017]
12 : [1.523, 44.785, 0.001, 1.534, 118.087, 275.838, 2.997, 126.704] : [27461248.135, -9.288]
13 : [2.0, 43.832, 0.001, 0.613, 118.769, 254.416, 3.0, 131.366] : [10130127.313, -18.38]
14 : [1.367, 42.119, 0.001, 2.0, 119.792, 274.512, 3.0, 127.155] : [37833654.991, -6.905]
15 : [1.687, 43.971, 0.001, 1.176, 116.369, 266.894, 2.917, 132.421] : [19143019.275, -12.705]
16 : [1.327, 45.082, 0.001, 1.075, 118.359, 276.489, 3.0, 128.531] : [49338767.495, -5.616]
17 : [1.312, 44.947, 0.001, 0.5, 116.959, 256.977, 3.0, 126.866] : [43082001.446, -6.809]
18 : [1.015, 46.119, 0.001, 1.035, 117.135, 253.864, 3.0, 125.652] : [86644557.727, -3.581]
19 : [1.459, 43.099, 0.001, 1.014, 112.187, 250.467, 2.909, 132.331] : [30200982.914, -9.22]
20 : [1.472, 43.243, 0.001, 1.171, 119.722, 274.536, 3.0, 135.115] : [30261407.38, -8.355]
21 : [0.977, 43.24, 0.001, 1.193, 115.475, 262.084, 2.879, 131.77] : [95551035.935, -3.246]
22 : [1.172, 42.954, 0.001, 1.498, 115.729, 275.321, 3.0, 132.199] : [62834277.238, -4.371]
23 : [1.738, 43.71, 0.001, 1.32, 118.532, 245.58, 2.887, 133.834] : [16131299.381, -15.086]
24 : [1.382, 43.182, 0.001, 0.5, 119.665, 267.87, 3.0, 127.213] : [36377263.932, -7.381]
25 : [0.915, 43.685, 0.001, 0.571, 107.886, 268.138, 2.956, 126.853] : [104461427.775, -3.063]
26 : [1.28, 44.181, 0.001, 0.521, 119.636, 277.752, 3.0, 130.413] : [54788608.743, -4.91]
27 : [1.116, 43.703, 0.001, 0.5, 114.237, 264.082, 2.967, 127.247] : [67707085.545, -4.252]





9.5.7 Report on simulation of catchment F11MAA8702 (2017-02-07 03-18)

9.5.7.1 Input data

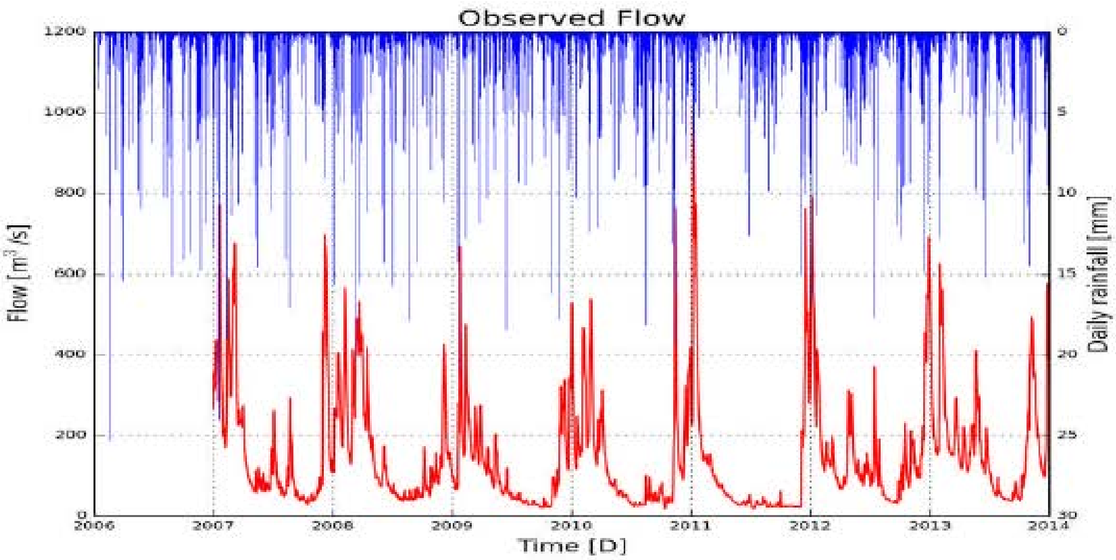


Figure 1: Hyetogram of observed discharge and observed net rain

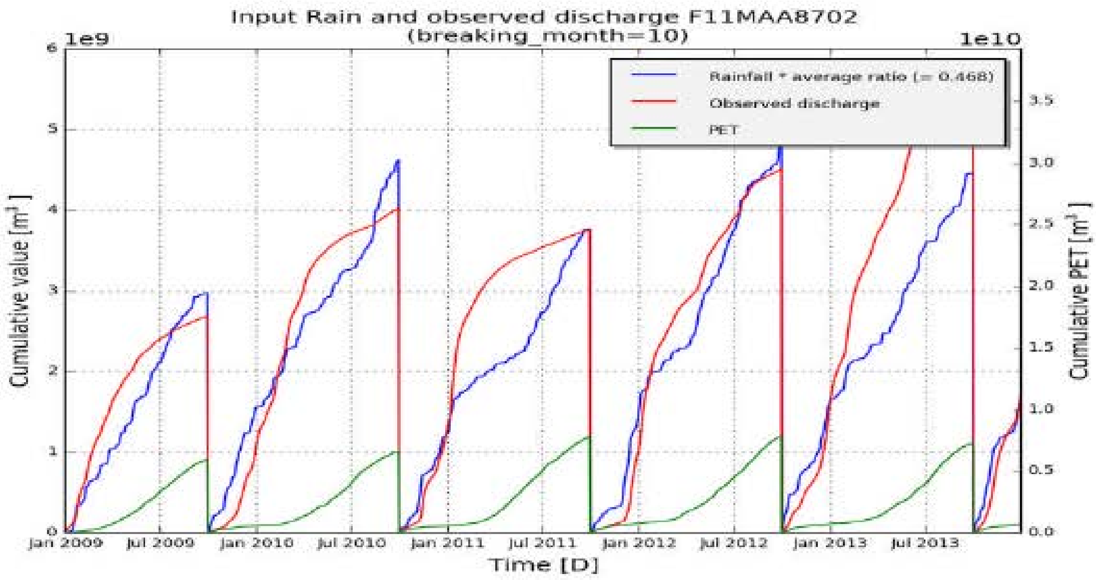


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.7.2 Simulation settings

Setting	Value
model_structure	WETSPAclassic.paramset1
subcatchment_name	F11MAA8702
subcatchment_area	10120000000
start_date	200701010000
end_date	201312310000
frequency	86400
warmup	365

9.5.7.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']

list_seeds	[1.3, 70.0, 0.01, 0.95, 100.0, 300.0, 2.5, 50.0]
low_bounds	[0.65, 35.0, 0.005, 0.4, 50.0, 150.0, 1.2, 25.0]
high_bounds	[2.5, 250.0, 0.03, 2.8, 250.0, 500.0, 5.0, 150.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 1.3), ('Ki', 70.0), ('Kg', 0.01), ('Kss', 0.95), ('g0', 100.0), ('g_max', 300.0), ('K_run', 2.5), ('P_max', 50.0)]
Initial fitness:

- RelErr: 0.07
- AbsErr: 1192604123.45
- KGE: 0.735
- NS_rel: 0.564
- NS: 0.558
- RMSE: 1401926970.73
- NS_log: 0.702

Computation time:13:41:05.884000

9.5.7.4 Results

Best individual (euclidian): [('Kep', 1.402), ('Ki', 113.689), ('Kg', 0.01), ('Kss', 2.8), ('g0', 150.048), ('g_max', 263.272), ('K_run', 2.787), ('P_max', 74.713)]

Fitness:

- RelErr: 0.001
- AbsErr: 332586446.144
- KGE: 0.717
- NS_rel: 0.722
- NS: 0.427
- RMSE: 432121615.448
- NS_log: 0.747

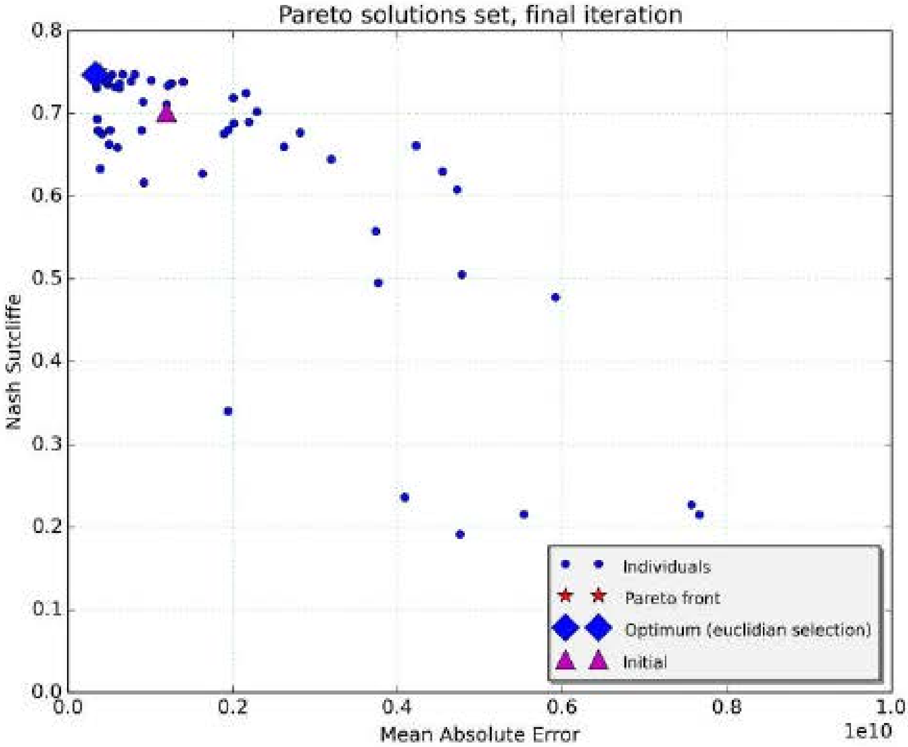


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

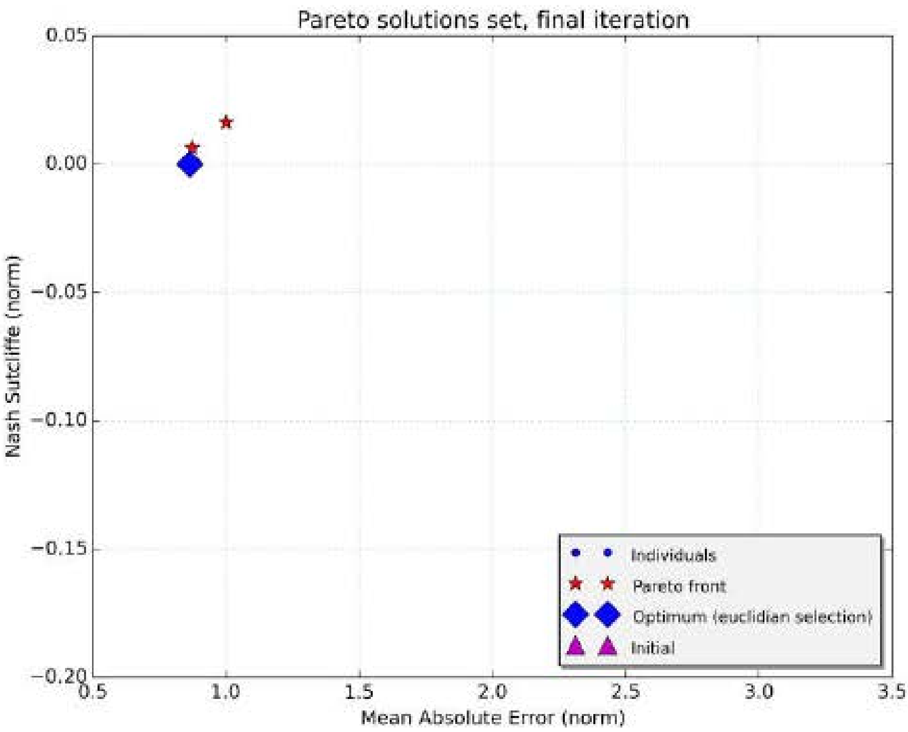


Figure 4: Final population of solutions (Pareto front)

9.5.7.4.1 Initial

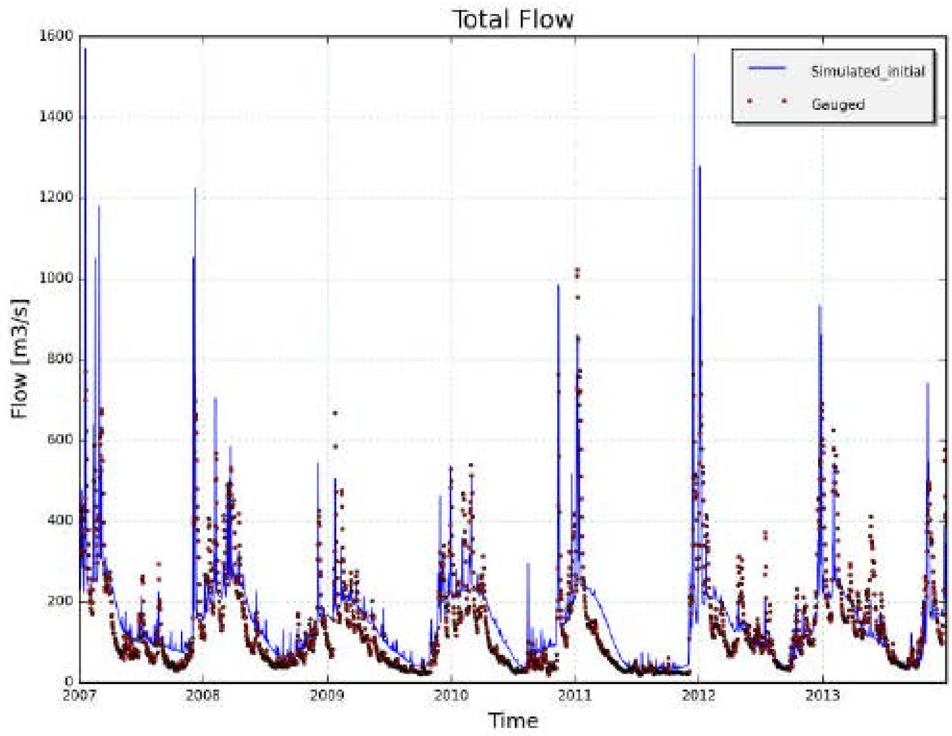


Figure 5: Total flow with initial parameters

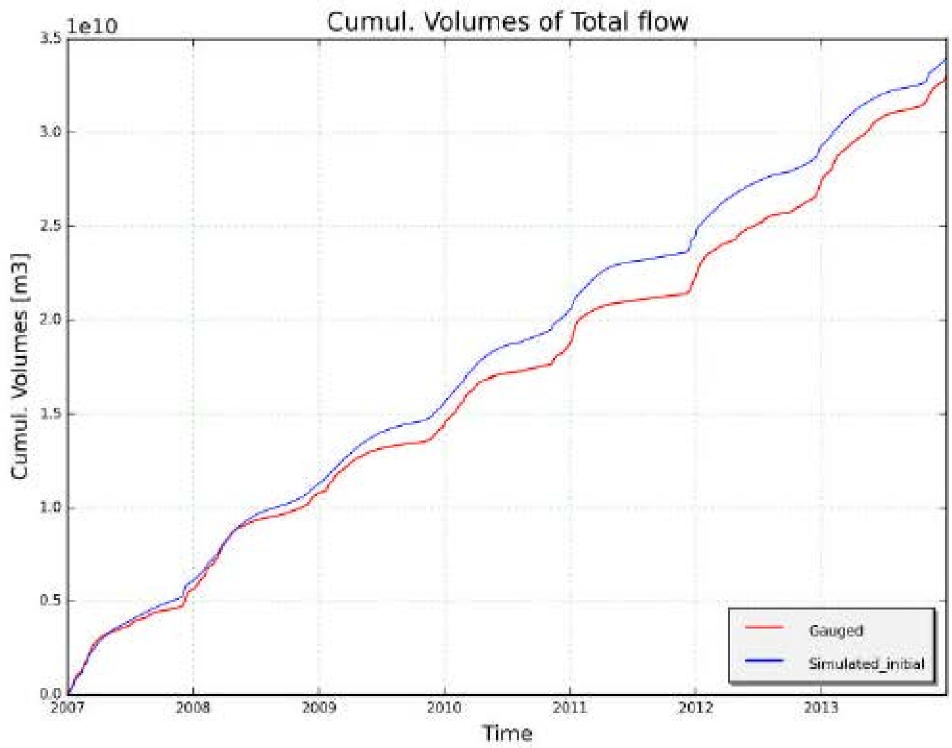


Figure 6: Cumulated flow with initial parameters

9.5.7.4.2 Optimum (euclidian)

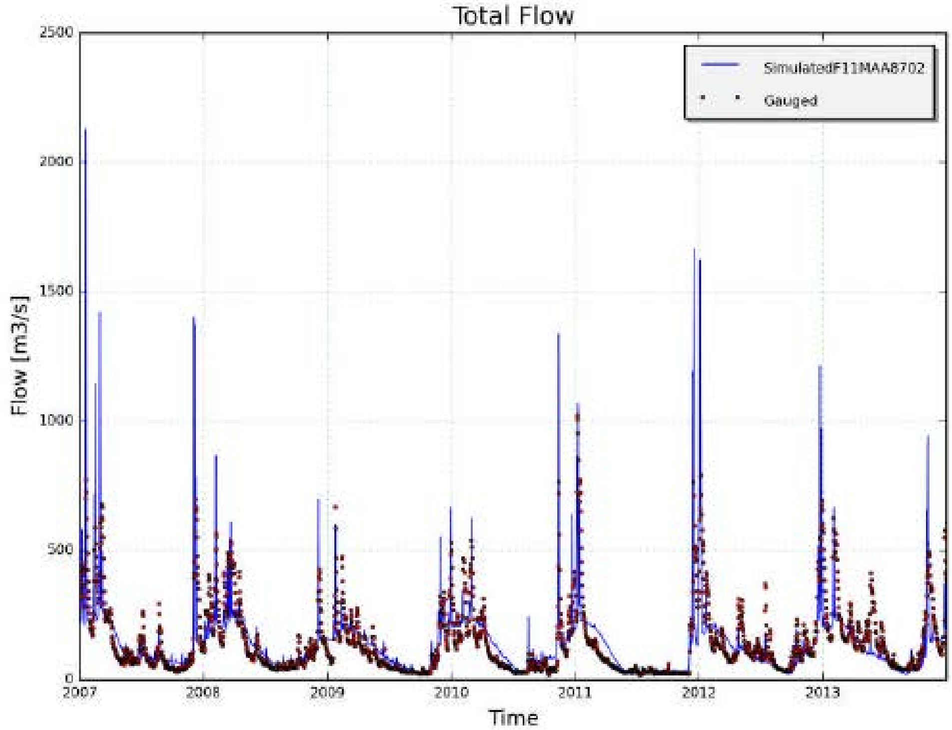


Figure 7: Total flow with optimum parameters

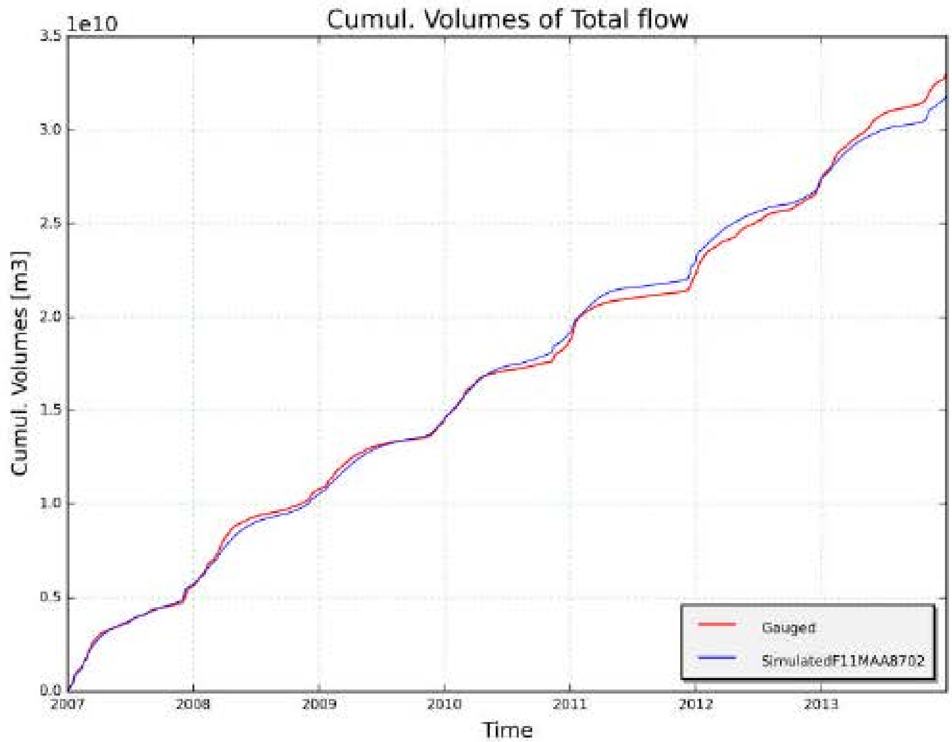


Figure 8: Cumulated flow with optimum parameters

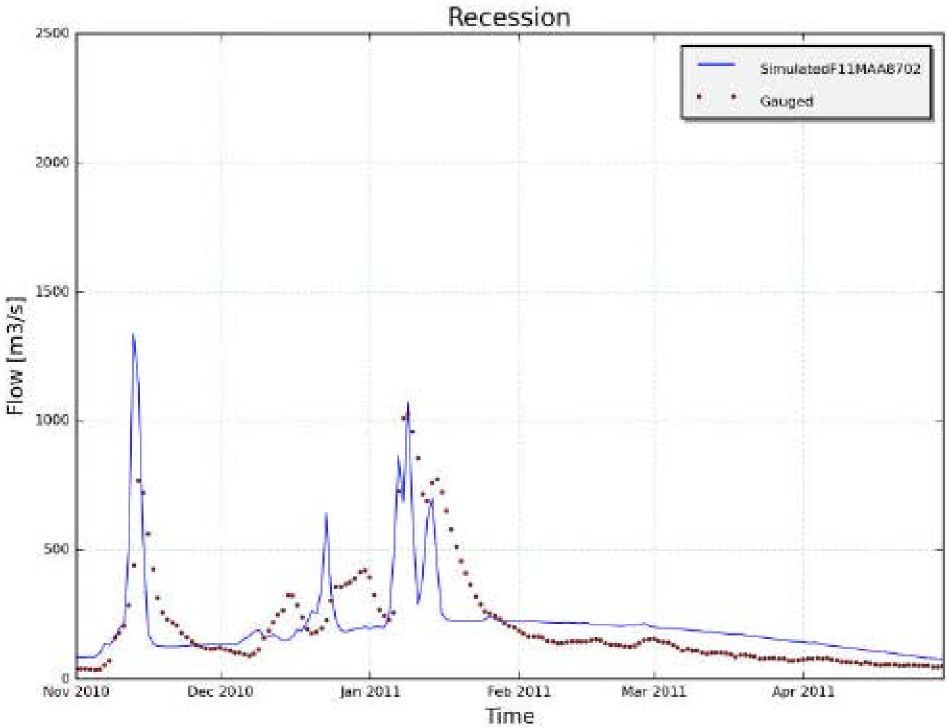


Figure 9: Total flow with optimum parameters (detail)

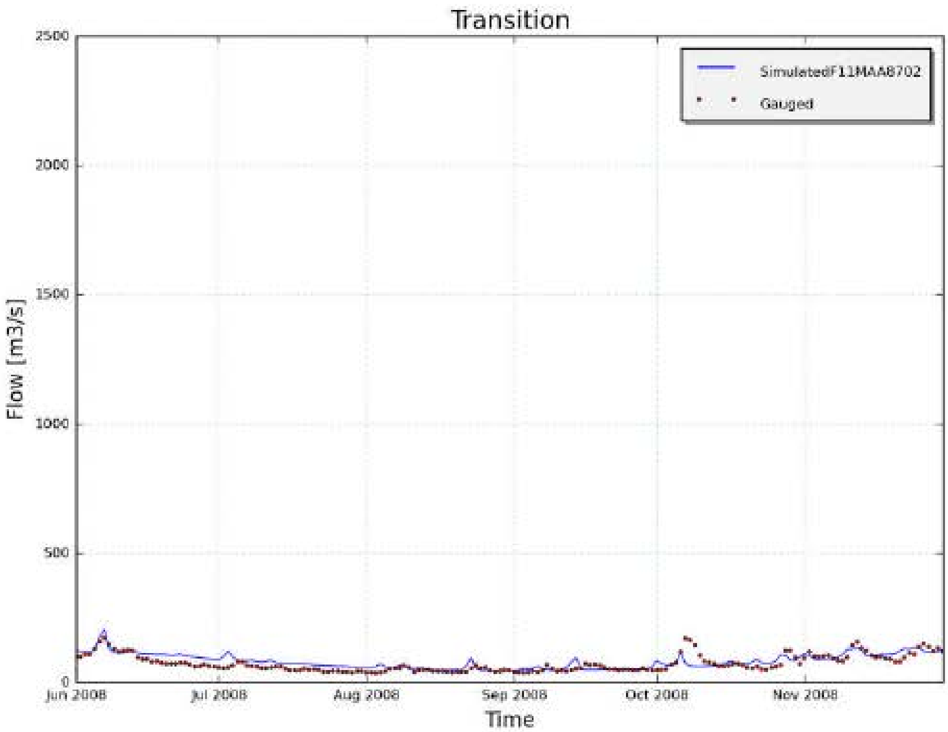
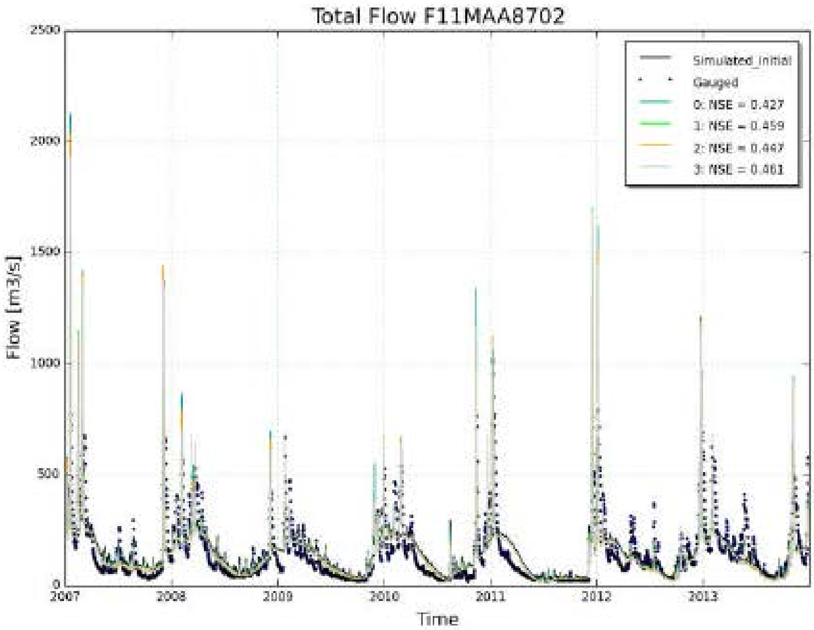
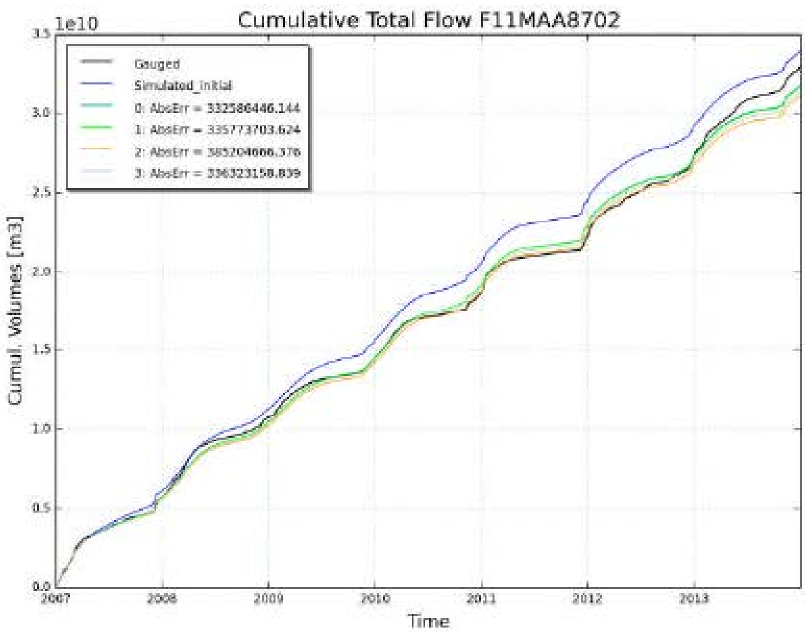


Figure 10: Total flow with optimum parameters (detail)

9.5.7.4.3 Final archive

0 : [1.402, 113.689, 0.01, 2.8, 150.048, 263.272, 2.787, 74.713] : [332586446.144, 0.747]
1 : [1.293, 101.298, 0.009, 1.074, 124.407, 207.611, 3.438, 74.193] : [335773703.624, 0.747]
2 : [1.379, 106.902, 0.01, 1.104, 131.479, 226.621, 3.504, 74.07] : [385204666.376, 0.751]
3 : [1.308, 101.0, 0.009, 0.854, 126.202, 211.319, 4.079, 75.604] : [336323158.839, 0.749]





9.5.8 Report on simulation of catchment W11MAAPROF12586 (2017-02-07 06-38)

9.5.8.1 Input data

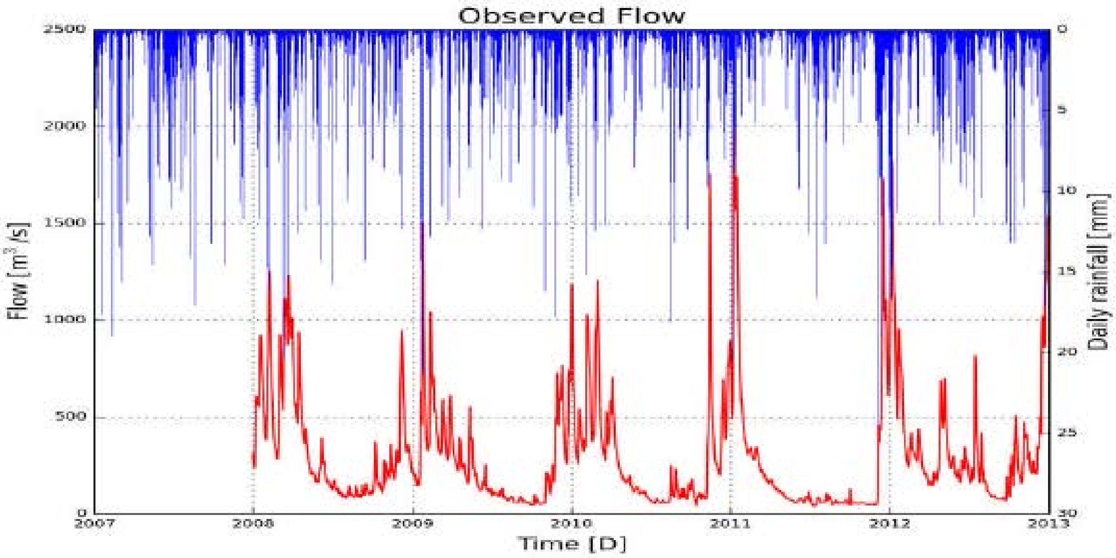


Figure 1: Hyetogram of observed discharge and observed net rain

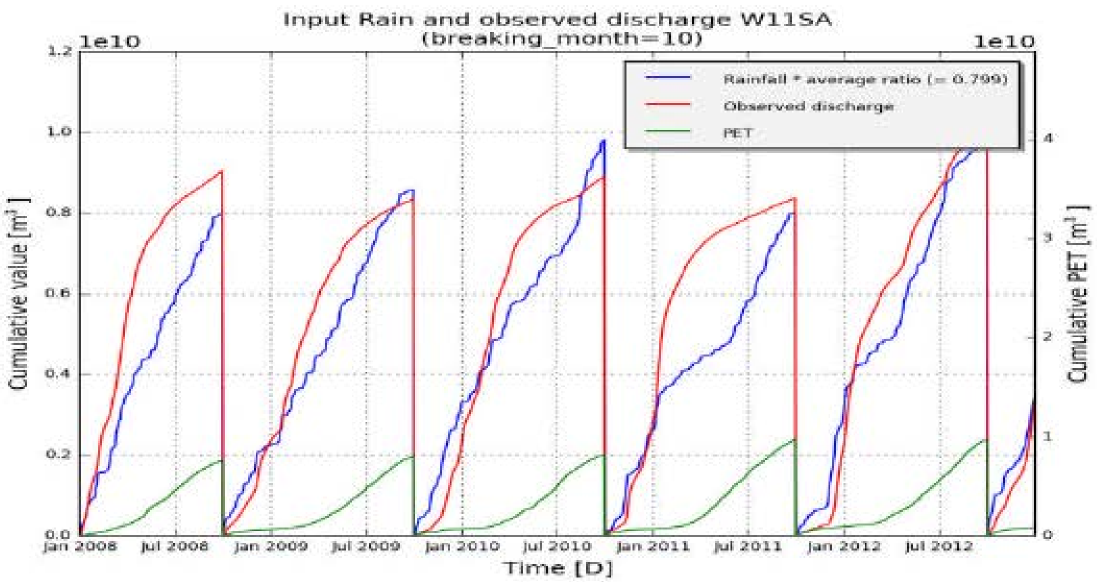


Figure 2: Annual cumulated discharge and scaled precipation using average runoff coefficient RC is calculated based on the whole available timeseries

9.5.8.2 Simulation settings

Setting	Value

model_structure	WETSPAclassic.paramset1
subcatchment_name	W11MAAPROF12586
subcatchment_area	12586000000
start_date	200801010000
end_date	201212310000
frequency	86400
warmup	365

9.5.8.3 Optimization settings

Setting	Value
popul_size	15
max_generations	15
list_var	['Kep', 'Ki', 'Kg', 'Kss', 'g0', 'g_max', 'K_run', 'P_max']
list_seeds	[0.7, 50.0, 0.08, 0.75, 290.0, 350.0, 2.7, 50.0]
low_bounds	[0.63, 45.0, 0.072, 0.675, 261.0, 315.0, 2.43, 45.0]
high_bounds	[0.77, 55.0, 0.088, 0.825, 319.0, 385.0, 2.97, 55.0]
OF1	AbsErr
OF2	NS_log

Non-optimized variables: []

Initial individual:[('Kep', 0.7), ('Ki', 50.0), ('Kg', 0.08), ('Kss', 0.75), ('g0', 290.0), ('g_max', 350.0), ('K_run', 2.7), ('P_max', 50.0)]
Initial fitness:

- RelErr: -0.023
- AbsErr: 698123545.05
- KGE: 0.648
- NS_rel: 0.261
- NS: 0.666
- RMSE: 823485201.03
- NS_log: 0.624

Computation time:20:36:14.540000

9.5.8.4 Results

Best individual (euclidian): [('Kep', 0.69), ('Ki', 46.647), ('Kg', 0.072), ('Kss', 0.675), ('g0', 283.11), ('g_max', 344.699), ('K_run', 2.77), ('P_max', 53.771)]

Fitness:

- RelErr: -0.016
- AbsErr: 602786699.028
- KGE: 0.638
- NS_rel: 0.243
- NS: 0.667
- RMSE: 744668909.506
- NS_log: 0.622

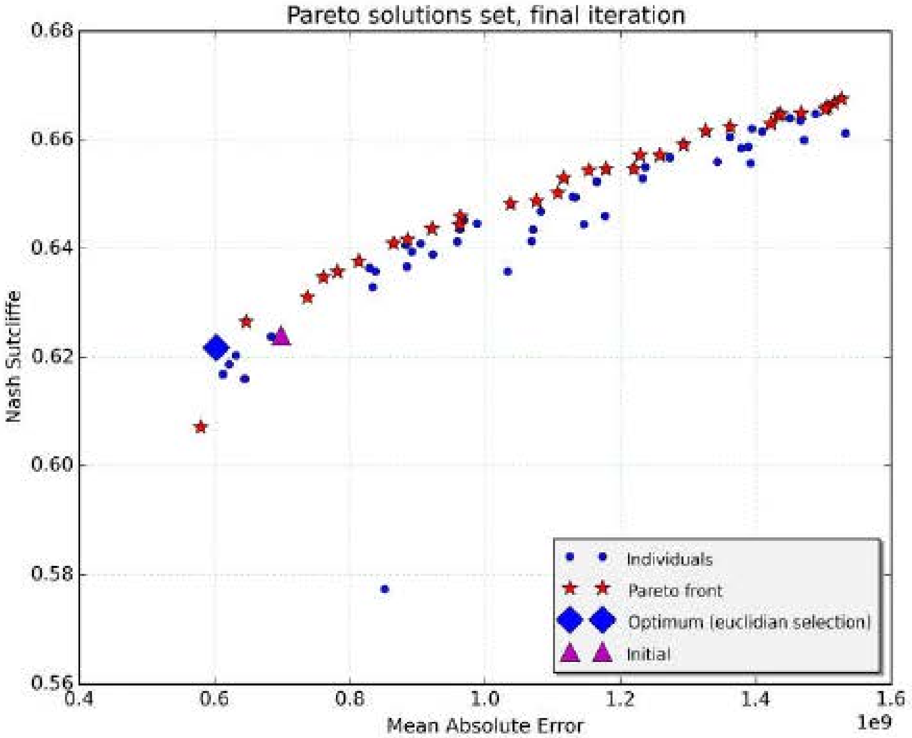


Figure 3: All evaluated candidates (individuals) and final population of solutions (Pareto front)

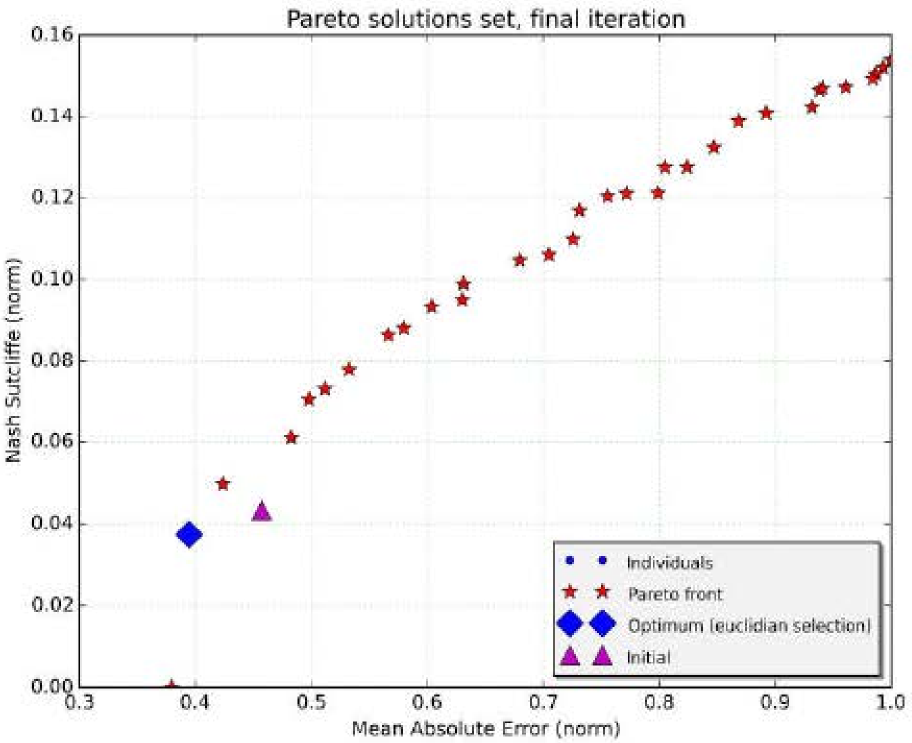


Figure 4: Final population of solutions (Pareto front)

9.5.8.4.1 Initial

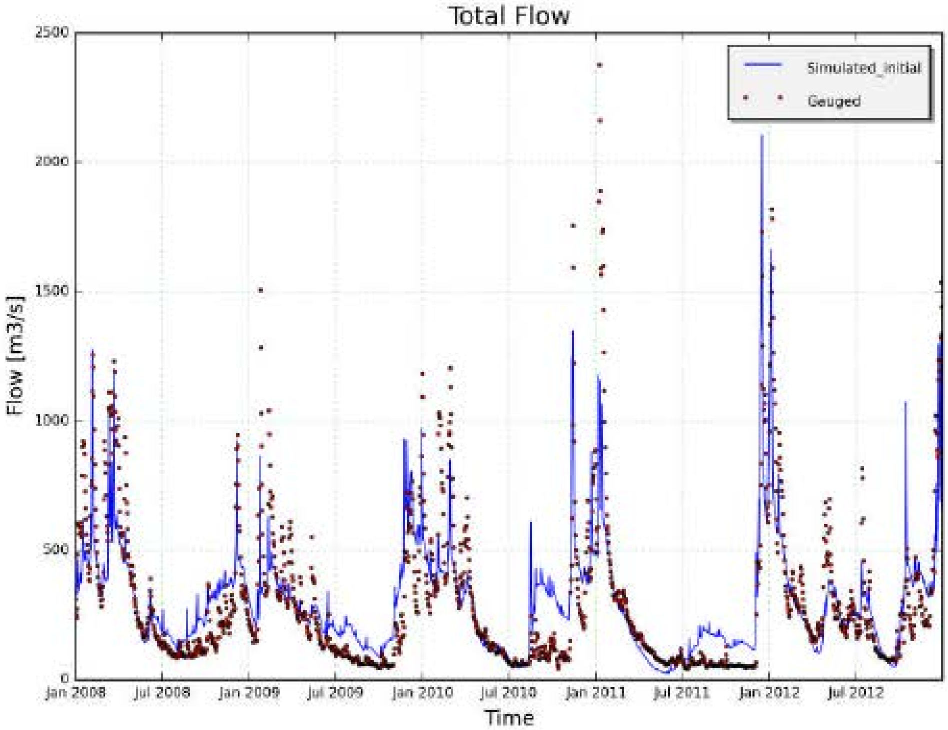


Figure 5: Total flow with initial parameters

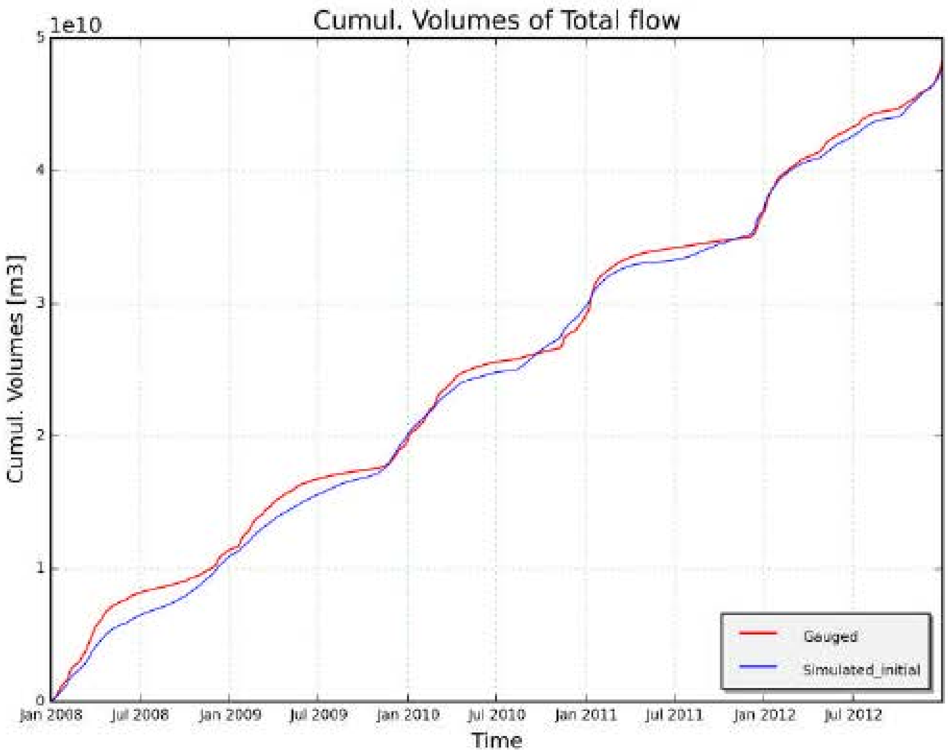


Figure 6: Cumulated flow with initial parameters

9.5.8.4.2 Optimum (euclidian)

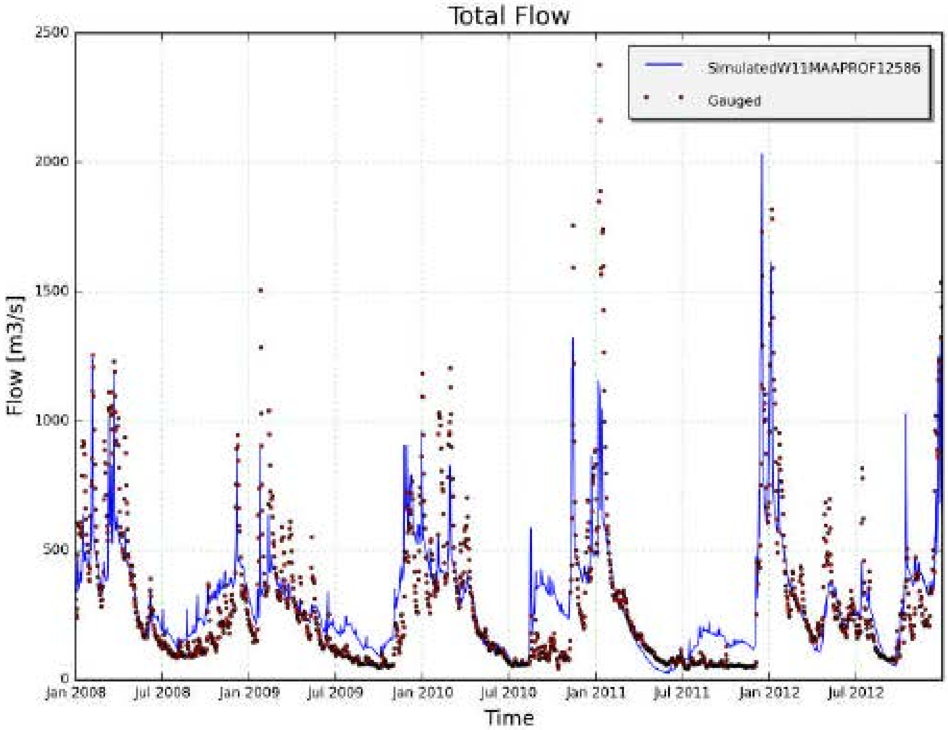


Figure 7: Total flow with optimum parameters

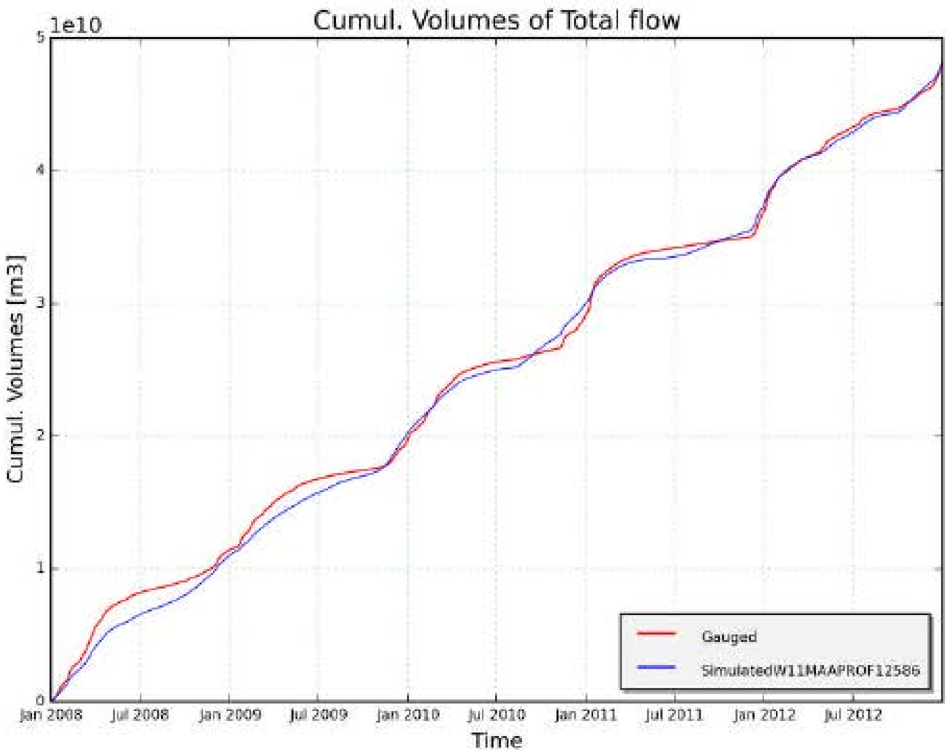


Figure 8: Cumulated flow with optimum parameters

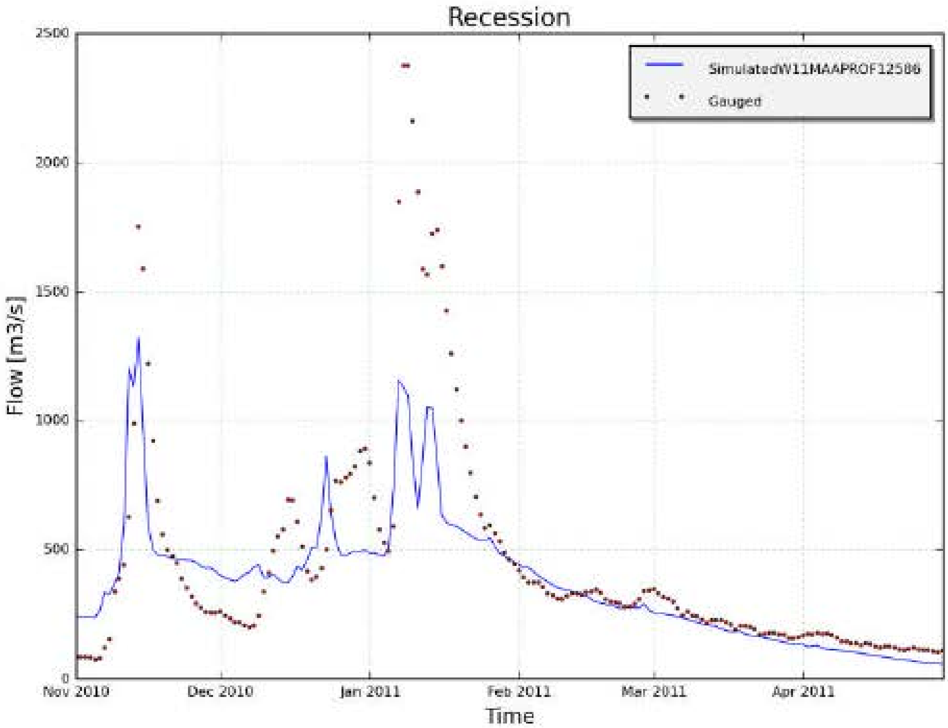


Figure 9: Total flow with optimum parameters (detail)

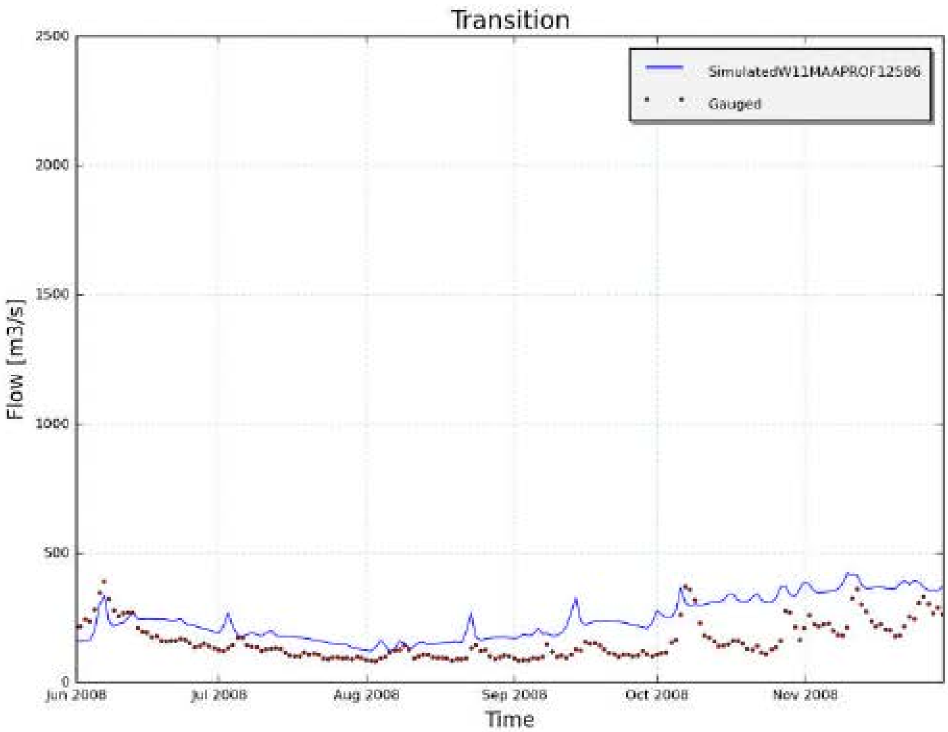
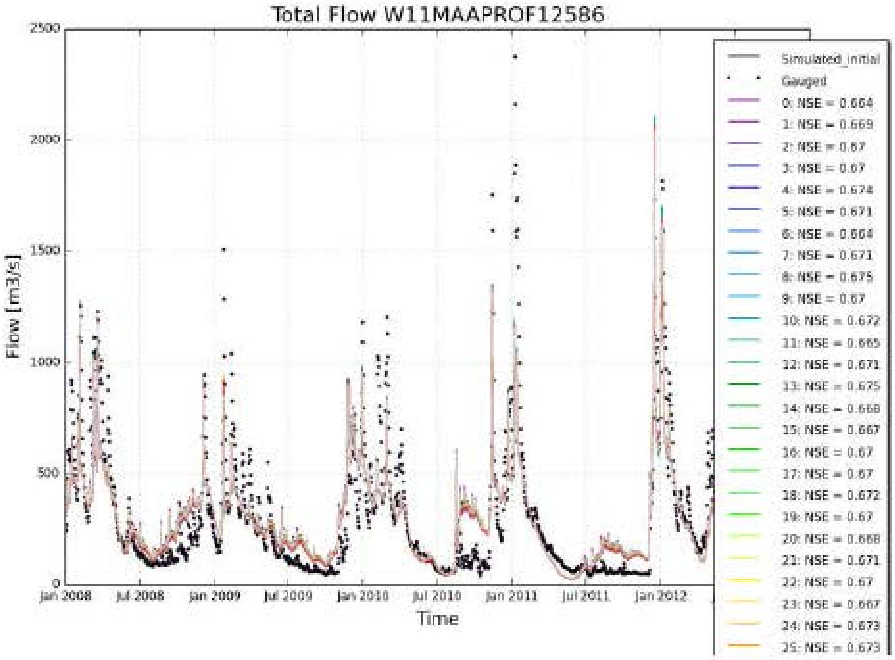
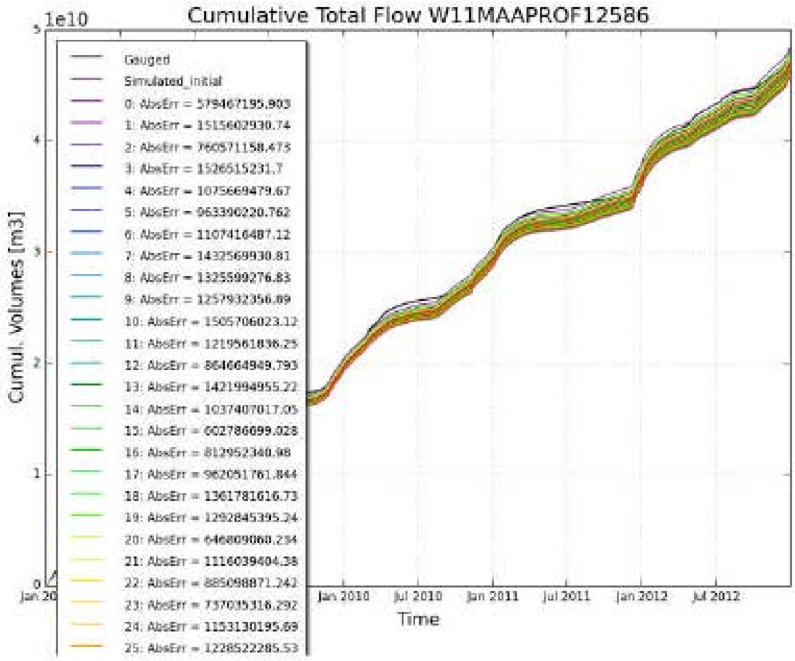


Figure 10: Total flow with optimum parameters (detail)

9.5.8.4.3 Final archive

0 : [0.671, 45.556, 0.078, 0.709, 269.902, 332.339, 2.61, 50.856] : [579467195.903, 0.607]
1 : [0.77, 49.86, 0.072, 0.765, 296.745, 371.995, 2.526, 49.342] : [1515602930.738, 0.667]
2 : [0.712, 47.43, 0.072, 0.813, 298.803, 347.295, 2.97, 47.832] : [760571158.473, 0.635]
3 : [0.77, 47.726, 0.072, 0.675, 296.745, 371.995, 2.43, 49.342] : [1526515231.699, 0.668]
4 : [0.741, 46.977, 0.075, 0.812, 294.428, 350.361, 2.97, 45.0] : [1075669479.672, 0.649]
5 : [0.731, 47.577, 0.072, 0.675, 297.201, 365.642, 2.873, 49.102] : [963390220.762, 0.646]
6 : [0.735, 51.107, 0.072, 0.813, 300.35, 364.09, 2.453, 47.321] : [1107416487.119, 0.65]
7 : [0.762, 45.0, 0.072, 0.775, 302.189, 348.288, 2.436, 45.67] : [1432569930.807, 0.665]
8 : [0.761, 45.168, 0.072, 0.768, 303.448, 348.175, 2.847, 46.669] : [1325599276.833, 0.662]
9 : [0.755, 52.379, 0.072, 0.812, 301.831, 367.555, 2.97, 49.993] : [1257932356.895, 0.657]
10 : [0.77, 47.965, 0.073, 0.691, 283.024, 348.67, 2.549, 54.633] : [1505706023.125, 0.666]
11 : [0.744, 52.976, 0.072, 0.825, 300.812, 366.381, 2.502, 49.818] : [1219561836.253, 0.655]
12 : [0.723, 47.554, 0.072, 0.813, 300.434, 363.596, 2.97, 47.507] : [864664949.793, 0.641]
13 : [0.769, 47.276, 0.074, 0.701, 285.528, 349.454, 2.885, 52.786] : [1421994955.224, 0.663]
14 : [0.734, 49.882, 0.072, 0.825, 298.447, 364.432, 2.73, 49.206] : [1037407017.047, 0.648]
15 : [0.69, 46.647, 0.072, 0.675, 283.11, 344.699, 2.77, 53.771] : [602786699.028, 0.622]
16 : [0.716, 48.092, 0.072, 0.825, 286.215, 354.033, 2.866, 53.39] : [812952340.98, 0.638]
17 : [0.729, 48.642, 0.073, 0.675, 292.258, 351.09, 2.843, 47.175] : [962051761.844, 0.644]
18 : [0.762, 47.689, 0.072, 0.675, 297.956, 373.794, 2.716, 49.282] : [1361781616.727, 0.662]
19 : [0.755, 49.336, 0.072, 0.813, 298.423, 365.483, 2.674, 49.252] : [1292845395.239, 0.659]
20 : [0.698, 47.26, 0.072, 0.798, 289.625, 350.012, 2.889, 51.857] : [646809060.234, 0.627]
21 : [0.741, 45.183, 0.072, 0.703, 290.433, 363.868, 2.63, 48.437] : [1116039404.378, 0.653]
22 : [0.724, 48.587, 0.072, 0.825, 288.352, 369.95, 2.871, 52.128] : [885098871.242, 0.642]
23 : [0.704, 46.95, 0.074, 0.825, 277.311, 342.29, 2.611, 51.392] : [737035316.292, 0.631]
24 : [0.748, 48.539, 0.072, 0.805, 297.924, 374.487, 2.97, 48.972] : [1153130195.69, 0.654]
25 : [0.754, 48.279, 0.072, 0.825, 298.721, 351.636, 2.968, 49.294] : [1228522285.525, 0.657]
26 : [0.77, 48.948, 0.072, 0.813, 298.788, 364.128, 2.923, 48.789] : [1436095369.386, 0.665]
27 : [0.77, 49.588, 0.073, 0.735, 293.169, 362.469, 2.784, 48.461] : [1466793015.294, 0.665]
28 : [0.747, 49.173, 0.072, 0.821, 290.787, 353.206, 2.804, 50.013] : [1178148627.982, 0.655]
29 : [0.724, 46.094, 0.072, 0.678, 292.794, 366.506, 2.614, 48.585] : [921644357.58, 0.644]
30 : [0.716, 48.092, 0.072, 0.825, 286.215, 353.531, 2.866, 53.39] : [813142360.982, 0.638]
31 : [0.77, 48.784, 0.073, 0.675, 297.111, 342.897, 2.623, 49.959] : [1502428828.62, 0.666]
32 : [0.711, 47.194, 0.072, 0.825, 291.064, 354.699, 2.721, 51.758] : [781302186.273, 0.636]


Total Flow W11MAAPROF12586
Flow [m3/s]
Time
Jan 2008
Jul 2008
Jan 2009
Jul 2009
Jan 2010
Jul 2010
Jan 2011
Jul 2011
Jan 2012
Simulated_initial
Gauged
0: NSE = 0.664
1: NSE = 0.669
2: NSE = 0.67
3: NSE = 0.67
4: NSE = 0.674
5: NSE = 0.671
6: NSE = 0.664
7: NSE = 0.671
8: NSE = 0.675
9: NSE = 0.67
10: NSE = 0.672
11: NSE = 0.665
12: NSE = 0.671
13: NSE = 0.675
14: NSE = 0.668
15: NSE = 0.667
16: NSE = 0.67
17: NSE = 0.67
18: NSE = 0.672
19: NSE = 0.67
20: NSE = 0.668
21: NSE = 0.671
22: NSE = 0.67
23: NSE = 0.667
24: NSE = 0.673
25: NSE = 0.673


Cumulative Total Flow W11MAAPROF12586
1e10
Cumul. Volumes [m3]
Time
Jan 2010
Jul 2010
Jan 2011
Jul 2011
Jan 2012
Jul 2012
Gauged
Simulated_initial
0: AbsErr = 579467195.903
1: AbsErr = 1515602930.74
2: AbsErr = 760571158.475
3: AbsErr = 1526515231.7
4: AbsErr = 1075669479.67
5: AbsErr = 963390220.762
6: AbsErr = 1107416487.12
7: AbsErr = 1432569930.81
8: AbsErr = 1325599276.83
9: AbsErr = 1257932356.89
10: AbsErr = 1505706023.12
11: AbsErr = 1219561836.25
12: AbsErr = 864664949.793
13: AbsErr = 1421994955.22
14: AbsErr = 1037407017.05
15: AbsErr = 602786699.028
16: AbsErr = 812952340.98
17: AbsErr = 962051761.844
18: AbsErr = 1361781616.73
19: AbsErr = 1292845395.24
20: AbsErr = 646809060.234
21: AbsErr = 1116039404.38
22: AbsErr = 885098871.242
23: AbsErr = 737035316.292
24: AbsErr = 1153130195.69
25: AbsErr = 1228522285.53

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