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Sub report 4-3
Analyses of hydrological models for climate change modelling – PDM modelling

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Sub report 4-3 – Analyses of hydrological models for climate change modelling – PDM modelling

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Abstract

The water balance model of the Scheldt and Meuse basins 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 calibration and evaluation of the PDM model, a lumped conceptual model for continuous rainfall-runoff simulation (Moore, 2007) developed by the UK Centre for Ecology and Hydrology.

The optimization during calibration is performed based on an automatic procedure, followed by a visual control. During the optimization routine the parameter sets are 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.

Overall, the performance of the calibrated PDM models, is as good if not better compared to the other lumped rainfall-runoff models already calibrated: NAM. The summarized results for each of the gauged sub catchments within the study area, allow the user to get insight in the performance of the PDM model for each of the involved sub catchments. Based on this information and the evaluation of the NAM, VHM and WETSPA models, the user can make a well-grounded decision on which model to use for the considered objective.

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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, 2009), PDM (Moore, 2007), VHM (Willems, P.) and Wetspa. 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 recalibration and evaluation of the NAM models, which are part of the MIKE 11 software package (DHI, 2009). In the previous project “Modelling of water availability and water allocation strategies for the Scheldt basin (project WL-09-46) the hydrological input of the water balance model was already generated by means of NAM models (De Boeck, K. et al, 2011). These NAM models were hitherto developed at Flanders Hydraulics within the scope of different projects, whereby the focus was mainly on flood forecasting and consequently on a good representation of high flows.

In the current project, hydrological PDM models for the gauged catchments (i.e. catchments upstream of a gauging station) are calibrated whereby the focus is mainly on low flows. For each of the hydrological catchments, the PDM parameters will be determined.

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 will inherit model parameters from similar neighbouring catchments.

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

1.2 Structure of the report

In a first section, the addressed catchments are defined and reliable gauging stations selected (Section 2). Second, rainfall and evapotranspiration are then interpolated for the selected catchments, according to the Thiessen polygon method (Section 3).

The general structure and parameters of the PDM 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 PDM 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 PDM 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 sub catchments 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. The sub catchments of the Meuse basin were delineated in the framework of the NAM model update (Maroy et al., 2021). Figure 1 shows an overview of the delineated catchments in the water allocation model.

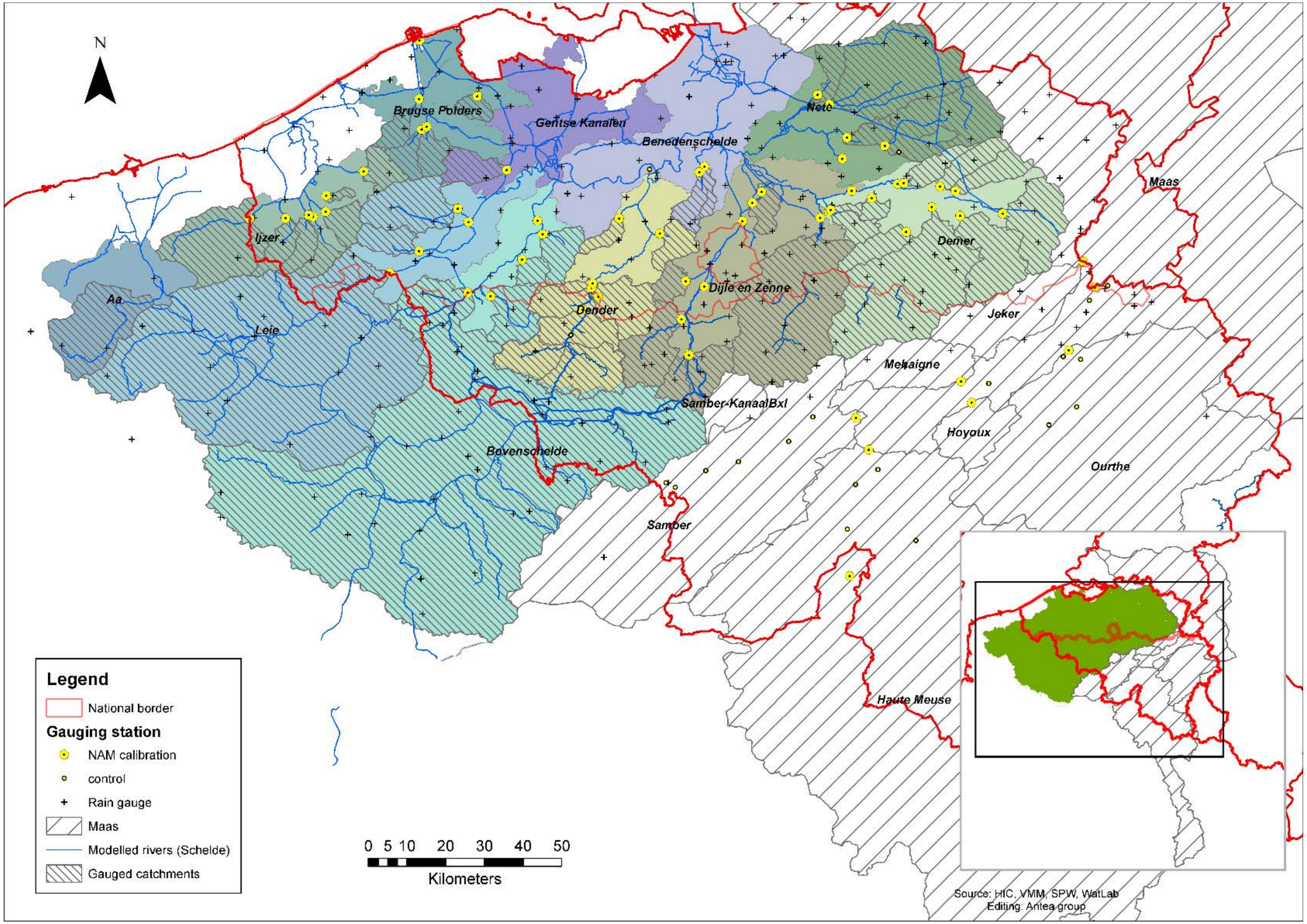
PDM models are calibrated for a selection of gauged catchments, where a time series of measured discharge is available. Some of the gauged catchments in the water allocation model are subdivided in different sub catchments to distribute the inflow over the modelled river stretches. Each of these sub catchments 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 sub catchments. 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 sub catchments 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] .

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 1 – Map of gauged and ungauged catchments of the Scheldt basin, Meuse, the Brugse polders and the IJzer



2.2 Gauged catchments

Table 1 lists the gauged stations 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)	**Catchment ID**	**Area (km²)**	**Gauged years**
48810102 - Handzamevaart; Kortemark	V01HAN488180	78,6	1994-2016
46810102 - Ijzer; Roesbrugge Haringe	F01IJZ468000	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; Menen	F05LEI386001	2981,8	1998-2016
40310102 - Heulebeek; Heule	V05HEU403210	91,9	1972-2016
40110102 - Mandel; Oostrozebeke	V05MAN401230	258,4	1967-2013
32580122 - Bovenschelde; Bossuit	F06BOS325001	5217,6	2001-2014
34710102 - Maarkebeek; Etikhove	V06MAA347160	48,7	1972-2016
34210102 - Zwalm; Nederzwalm	V06ZWA342190	112,1	1972-2016
L5412 – Rhosnes; Amougies	W06RHOL54100	161,9	2012-2016
28510102 – Bellebeek; Essene	V07BEL285070	88,7	
28970102 – Mark; 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	W07DENLES004	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	W08SENRON010	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
16310102 – Herk; Kermt	V09HER163010	274,6	1977-2016

Gauging station (code - water course; location)	Catchment ID	Area (km²)	Gauged years
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
8610102 - Grote Laak; Vorst	V10GLA086020	62,6	1986-2014
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

Station (code - water course; location)	Joint code	Catchments
46810102 - IJzer; Roesbrugge Haringe	**F01IJZ468000**	V01HEI468010 F01YSE468000
38680122 – Leie, 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

2.3 Ungauged catchments

The PDM parameters for the ungauged catchments in the modelled area, are inherited from neighbouring gauged catchments. The link between the ungauged and the corresponding gauged catchment will be made based on the catchment characteristics (soil, slope, concentration time, land use). This will be studied in the next step of the study.

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 time series 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. Crosses on Figure 1 show used rainfall metering stations on and around the Scheldt basin (Météo France and KMI).

Since the rainfall-runoff modelling study of 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 3).

Table 3 – Number of rain gauges per hydrographic basin

Hydrographic basin	**Surface area (km²)[2]**	**Number of subcatchments (gauged and ungauged)**	**Number of rain gauges**
Benedenschelde	1 704	24	21
Bovenschelde	5 947	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

[2] Bekkenbeheerplannen Vlaanderen(ANON., 2009)

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 basin (a combination of Uccle and Herentals data). All interpolated evapotranspiration time series are practically identical because of their geographical proximity.

4 Rainfall-runoff modelling methodology

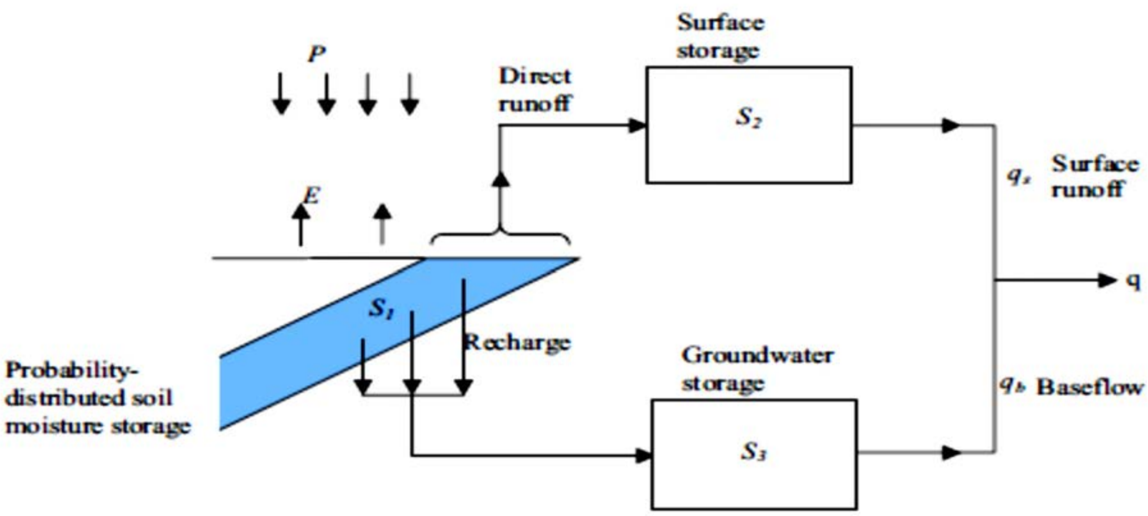
The hydrological model used which is investigated in this subreport is the conceptual rainfall-runoff Probability Distributed Model, or PDM model. PDM is a rainfall-runoff lumped model structure proposed by Moore 2007 and is part of the InfoWorks software package (Innovyze). For each catchment, discharge is simulated based on a unique set of parameters using interpolated rainfall and potential evapotranspiration timeseries as input. A description of PDM is outlined below.

4.1 Structure of the PDM hydrological model

The PDM model is a lumped, conceptual rainfall-runoff model, simulating the overland- and base-flow components as a function of the moisture contents in three storages. Figure 2 below shows the general structure of the PDM model. The main components (reservoirs), state and flow variables, and parameters are represented. PDM includes a probability distributed soil moisture storage, a surface storage for quick flow and groundwater storage for slow flow. Runoff production to the quick flow is represented as a saturation excess controlled by the absorption capacity at the surface. The variability of this absorption capacity within the catchment is characterised by a probability density function, typically a Pareto distribution. The groundwater recharge depends on the soil storage by a power relation on the excess to a threshold storage below which there is no drainage, water being held under soil tension.

Being a lumped model, PDM treats each catchment as a single unit. The parameters and variables represent, therefore, average values for the entire catchment. For that reason, some of the parameters are related to physical processes but final values must be calibrated against hydrological time series. For more detail on the PDM model, please refer to Moore 2007 and the user manual (Halcrow/HR Wallingford , 2000).

Figure 2 – The structure of the PDM rainfall-runoff model (Moore et al. 2007)



4.2 PDM parameters description

Rainfall and evaporation

1. Rainfall factor f_c ("rainfraction") [-]

2. Exponent in actual evaporation function b_e ("bevaporation") [-]

This parameter affects variation between seasons and years. Either a linear (bevaporation = 1) or a quadratic form (= 2) are usually assumed (Moore 2007) but ISIS PDM User manual suggests the value of 2.5.

Moisture storage distribution

These parameters affect time of onset of runoff and rate of wetting up, but also feeds back to evaporation and recharge rates.

3. Minimum and maximum store capacity c_{min} ("cmin") [mm]

4. Maximum store capacity cmax ("cmax") [mm]

5. Exponent of Pareto distribution b ("bpareto") [-]

This b parameter controls the spatial variability of the store capacity

Recharge and runoff

6. Groundwater recharge time constant k_g ("kdrainage") [h mm^{bg-1}]

This parameter controls the rate of aquifer recharge

7. Soil tension storage capacity S_t ("PDM.TG") [mm]

This parameter is the threshold below which no groundwater can occur. Increasing it prevents complete drainage of the soil moisture store.

8. Exponent of recharge capacity b_g ("bdrainage) [-]

Increasing this parameter magnifies the sensitivity of the recharge rate to soil dryness.

Surface flow

9. Time constants of cascade of two linear reservoirs k_1, k_2 ("CK1", "CK2") [h]

These parameters control the sharpness of the peaks in the hydrograph. Typically, values range from 4 to 20, or even up to 50 depending on the size of the catchment.

Base flow

10. Baseflow time constant k_b ("CKBF") [h mm^{m-1}]

This parameter controls the length of the recession. The original PDM structure allows for quadratic or cubic storage but in this version, only the cubic relationship is considered. Values vary from 0 to 500.

5 Calibration strategy

5.1 Optimization algorithm

The algorithm used for optimization of PDM parameters is the Non-dominated Sorting Genetic Algorithm II or NSGA II (Kalyanmoy et al. 2002). 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 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.

5.2 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:

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

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.

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

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).

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

An example of Pareto front and final selection is shown in Figure 3 and Figure 4.

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

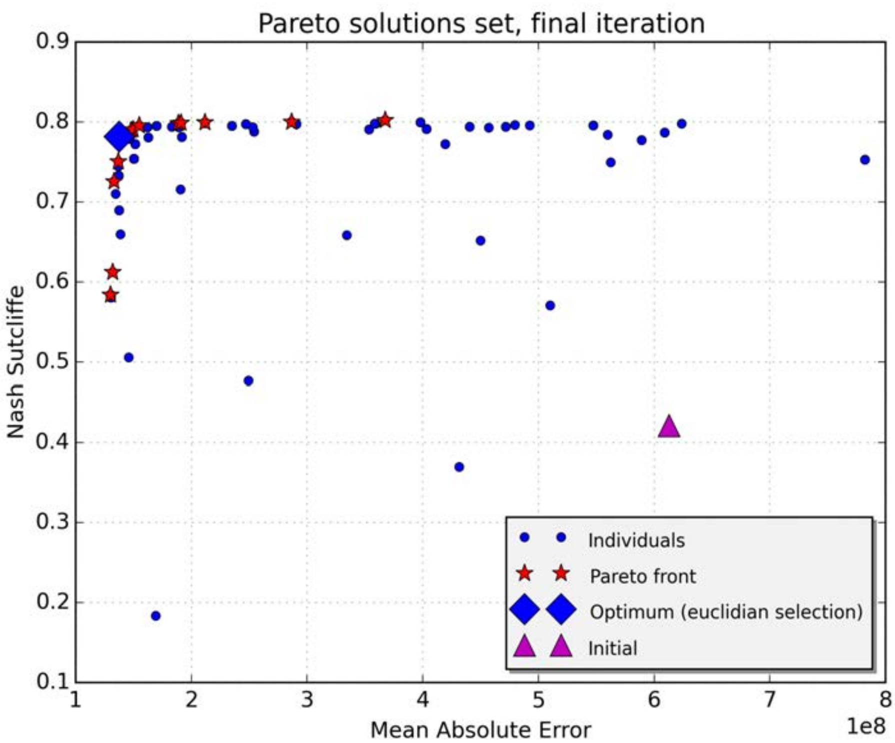
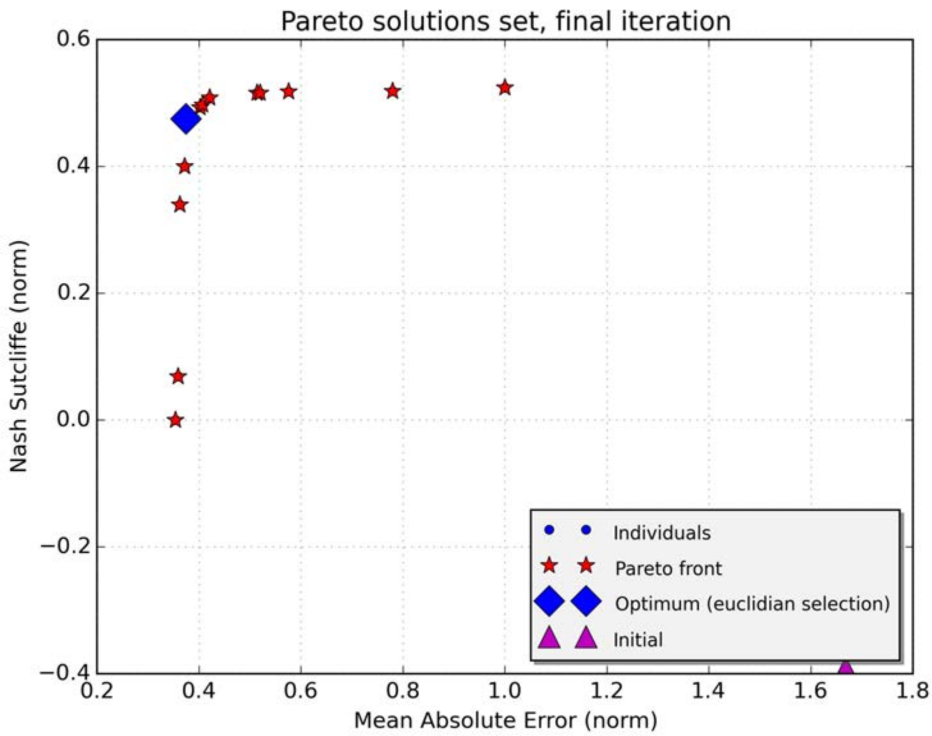


Figure 4 – Rescaled final population of solutions (Pareto front)



5.3 Implementation in Python

The Python version of the NSGA II algorithm was adapted for hydrological optimization purposes using a general framework supporting three rainfall-runoff models: NAM, PDM, VHM and Wetspa. Description of how the PDM model and the other lumped models are being implemented in Python can be found in Vansteenkiste et al. (2011) and Tran et al. (2014 a, b).

The calibration Python shell currently supports the following:

- Optimization of (one 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 as Word document,
- Manual calibration for a given calibration period.

The rainfall-runoff conceptual model used in this subtask is PDM. As a general rule, ten parameters were optimized:

['bpareto', 'bevaporation', 'cmin','cmax', 'CKBF', 'CK1', 'CK2', 'bdrainage', 'kdrainage', 'PDM.TG']

The meteorological inputs and the surface area of the catchments were controlled and assumed correct. Therefore, the parameter “rainfraction” available in the PDM model was not optimised and given a value of 1. Given the scale of the catchments and the length of the simulated series, the level of detail did not require adjustments of the time delay “tdly”. Flow returns and abstractions were not investigated for the gauged subcatchments . Rainfall-runoff models are expected to reproduce hydrological behaviour without constant flow addition or abstraction “qconst”. More generally, those three artificial parameters “rainfraction”, “tdly” and “qconst” are very context-dependant and little transferable to other catchments. Therefore, it is preferable to avoid them in order to transfer parameters in a meaningful manner to the models of ungauged catchments. Moreover, these parameters do not have any equivalent in the other lumped models (NAM and VHM) and calibrating them would make PDM little comparable with the rest. Catchment surface area was considered reliable and was not optimized.

Initial states were the same in all cases (Table 4), with a warmup period of one year.

Table 4 – Initial states and flow

Parameters	**relSM**	**OF**	**IF**	**BF**
value	0.4	0.001	0.001	0.001

The explored parameter space was defined by boundaries in Table 5. These boundaries were assumed according to literature recommendations and past experience with PDM (Moore 2000). In some particular cases, the optimum was not well defined or the algorithm could not converge in reasonable range and these boundaries were adjusted. Whenever optimization was not delivering good results, boundaries were narrowed down using manual calibration.

Table 5 – PDM parameters and optimization boundaries

Parameters	**bpareto**	**bevaporation**	**cmin**	**cmax**	**CKBF**	**CK1**	**CK2**	**bdrainage**	**kdrainage**	**TG**
Lower boundary	0,1	1	0,1	100	0,5	4	4	1	1000	0
Upper boundary	5	2	10	1000	500	50	50	15	45000	7

The model seems almost insensitive to the base flow time constant (CKBF parameter) especially given the large number of years of simulation in this study. It is given the value of 300 for all catchments.

6 PDM model calibration

6.1 Model configuration

In most cases and when data were available, a calibration period of 13 years was used, preferably from January 2001 to December 2013. Nevertheless, different time series were selected when available data were insufficient or unreliable, choosing 13 years of calibration if possible.

Four windows of typical events were selected for visual evaluation:

- 11/2002-04/2003 (high flow) – 6 months
- 06/2008-11/2008 (transition) – 6 months
- 02/2005-11/2005 (low flow) – 10 months
- 11/2010-04/2011 (recession) – 6 months

The calibrated parameters were validated for the entire time series of available data (also outside of the calibration period). Normally this period ranges from 1967 to 2013. Adjustments for a certain catchment are reported in the catchment-specific paragraphs below.

6.2 Model evaluation

While the optimization is limited to two objectives, logarithmic NSE and absolute error, it can be interesting to look at the other indexes listed when evaluating the final results. For example:

- Nash-Sutcliff efficiency
- Relative error (negative or positive) or bias
- Kling-Gupta efficiency (Gupta et al. 2009 and Kling et al. 2012)
- Relative Nash-Sutcliff efficiency

$$E_{rel} = 1 - \frac{\sum_{i=1}^{n}\left(\frac{O_i - P_i}{O_i}\right)^2}{\sum_{i=1}^{n}\left(\frac{O_i - \hat{O}}{O_i}\right)^2} \qquad \text{Eq. 4}$$

Since this work focuses on low flows, more importance is given to logarithmic NSE. However, high NSE values should also be sought in order to ensure good enough performance for higher flows as well, as much as possible.

An exact agreement between simulation and observations must not be expected because of different error sources (errors in meteorological input data, errors in measured discharge, errors inherent to the model structure). Calibration can only minimize those errors due to non-optimal parameter values.

NSE and logNSE values above 0.7 can be considered good. Values below zero mean that the predictive power of the model is worse than the measured average. Considering deviation of the measured discharge time series and errors in the meteorological inputs, NSE values are not expected to be above 0.8 (Willems, 2007).

Visual evaluation of the fit between simulated and observed total discharge is also taken into consideration to select the final solution, with a focus on good agreement of simulations for low flows. When useful, Nash-Sutcliffe efficiency (non-logarithmic) was also taken into account for evaluating the final set of candidates (when other fitness indexes were equivalent for example).

Apart from the calibration period, these goodness-of-fit statistics were calculated on the entire time series of available data (also outside of the calibration period) in order to validate calibrated parameters whenever more than 13 years of data was available.

The following section synthetizes the main results and conclusions of the PDM calibration in each river basin. Detailed graphs and calculated statistics, for calibration and validation periods, are given for each gauged catchments in Annex 3 to Annex 12.

The final sets of parameters for each calibrated PDM model and for each transposed PDM model are summarized in Annex 12.

6.3 IJzer basin

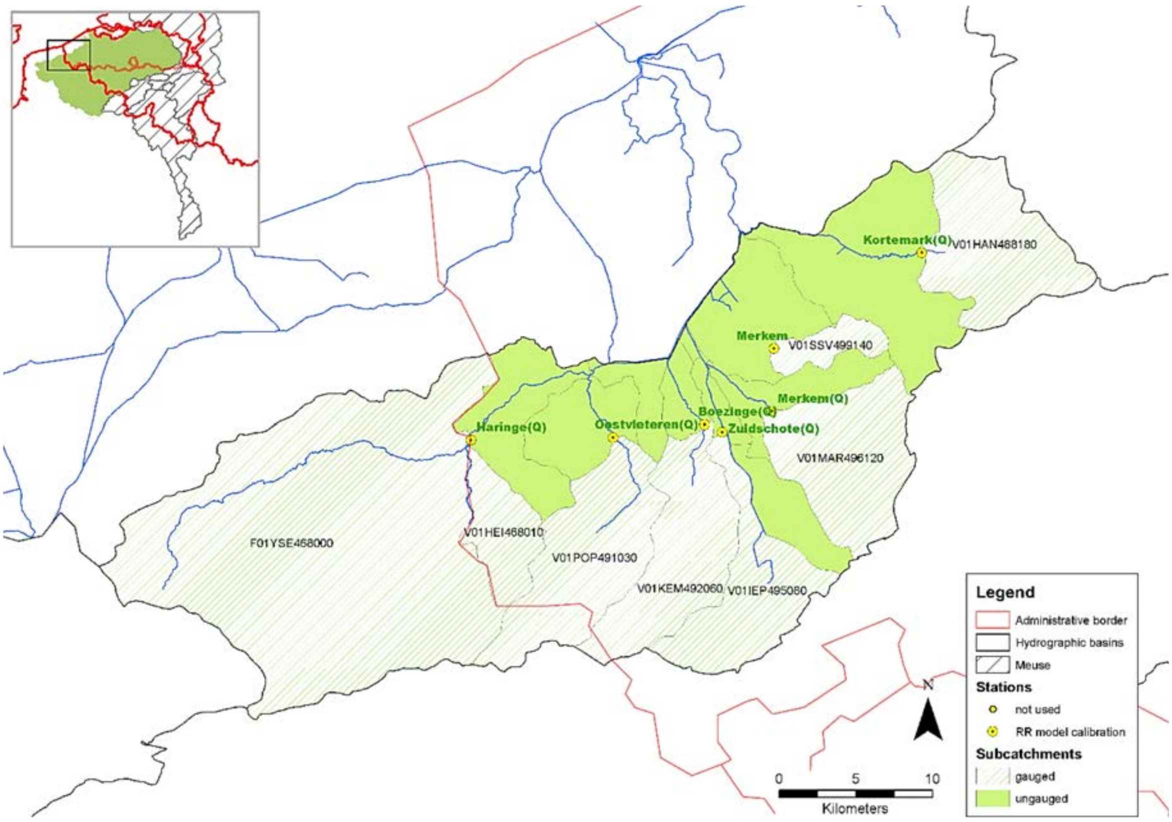
6.3.1 Context

Although there is no interaction between the Scheldt catchment and the IJzer catchment, the latter is included in the regional water allocation model for the sake of completeness.

The total surface area of the IJzer catchment is of 1 101 km² from which about one third is located in France (WL, 2006). 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.

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. Figure 5 shows the catchments and corresponding measurement points.

Figure 5 – Catchments and flow metering station on the IJzer basin



6.3.2 Model performance

Table 6 and Table 7 present general performance statistics for the gauged subcatchments of the IJzer basin for the calibration and validation period. Graphs of simulations for the subcatchments V01HAN488180 (best model performance in this catchment) and V01IEP495080 (worst model performance in this catchment) are presented below (Figure 6 to Figure 13). All detailed results and graphs of the remaining subcatchments can be found in Annex 3.

Values in Table 6 indicate a good agreement between the simulated and measured flow rates for the majority of the catchments, with overall NSE and LogNSE values higher than 0.6 and RelErr lower than 5 %. Nevertheless, the results of the calibration and validation of subcatchment **V01IEP495080** are not acceptable (Table 6 and Table 7). The low values of NSE and LogNSE are attributed to the complex hydrological situation of the catchment, which is influenced by the presence of structures and diversions. However visual inspection (Figure 9 to Figure 13) shows that the results are acceptable for most years, except for the last years. Note that **V01IEP495080** is one of the few catchments to have a groundwater recharge exponent parameter different from 1 (bdrainage = 1.1).

The catchment with code **V01POP491030** presents an overestimation of discharge from 2009, similar to what was concluded from NAM calibration as well. This suggests that the data after 2009 is somewhat unreliable or disturbed. The water balance and the general model performance is nevertheless satisfactory over the entire validation period except for those 4 last years (Table 7).

Remarks on the discharge measurements:

For the catchment **F01IJZ468000,** the period from 1996 to 2005 was discarded (for both calibration and validation) due to unreliable high observed discharge values. The measured base flow is indeed unnaturally high during this period and most likely due to a loss of measurement quality or change of gauging parameters of the station, that were not corrected. This exclusion results in a reduction of the calibration period to 9 years.

The calibration period selected for the catchment with code **V01IEP495080** is 1996-2008 since the discharge data after 2008 is not trustworthy. Very low discharge (< 0.1 m^3/s) often leads to less reliable values in this series. In the catchment **V01SSV499140** there is not observed discharge from the beginning of the year 2009. Moreover, the gauging device for this catchment in Merkem was replaced in 2005 resulting in a shift in the discharge time series. Therefore, data before mid-2005 was discarded from calibration as well as it is not consistent with the time series before. Because years of data are relatively scarce for this catchment , years 2005-2008 are used for validation however, despite their lower quality.

Table 6 – Overview of calibration results for gauged subcatchments in the IJzer basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Calibration period**	**Approx. distance to rain gauge over calibration period (km)**
46810102 - Ijzer; Roesbrugge Haringe	**F01IJZ468000 (V01HEI468010 and F01YSE468000)**	393.0	0.681	0.673	-2.2%	-5.1%	2005-2013	6
48810102 - Handzamevaart; Kortemark	**V01HAN488180**	78.6	0.619	0.784	0.6%	0.3%	2001-2013	< 2004 : 11 >= 2004: 2.5
49510102 - Ieperlee; Zuidschote	**V01IEP495080**	63.4	0.213	0.562	9.8%	12.1%	1996-2008	4
49270102 - Kemmelbeek; Boezinge	**V01KEM492060**	73.9	0.58	0.521	-0.3%	-2.6%	2001-2013	6
49610102 - St. Jansbeek; Merkem	**V01MAR496120**	76.1	0.684	0.683	-4.0%	6.4%	2001-2013	8
49110102- Poperingevaart; Oostvleteren	**V01POP491030**	84.9	0.38	0.62	-7.5%	18.9%	2001-2008 (-2013)	3.6
49910102 - Steenbeek; Merkem	**V01SSV499140**	16.1	0.645	0.675	-3.6%	-4.6%	1996-2005	< mid-2008: 10 >= mid-2008 : 2

Table 7 – Overview of validation results for gauged subcatchments in the IJzer basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Validation period**
46810102 - Ijzer; Roesbrugge Haringe	**F01IJZ468000 (V01HEI468010 and F01YSE468000)**	393.0	0.695	0.62	9.4%	4.2%	1987-2013
48810102 - Handzamevaart; Kortemark	**V01HAN488180**	78.6	0.626	0.782	2.4%	1.7%	1994-2013
49510102 - Ieperlee; Zuidschote	**V01IEP495080**	63.4	0.172	0.589	-11.2%	-2.2%	1983-2013
49270102 -Kemmelbeek; Boezinge	**V01KEM492060**	73.9	0.624	0.565	9.9%	4.0%	1986-2013
49610102 - St. Jansbeek; Merkem	**V01MAR496120**	76.1	0.651	0.644	7.3%	8.6%	1986-2013
49110102- Poperingevaart; Oostvleteren	**V01POP491030**	84.9	0.361	0.677	-4.3%	4.8%	1984-2013
49910102 - Steenbeek; Merkem	**V01SSV499140**	16.1	0.638	0.672	-4.2%	-4.8%	1991-2008

48810102 - Handzamevaart; Kortemark (V01HAN488180)

Figure 6 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01HAN488180, station 48810102 - Handzamevaart; Kortemark (2001-2013)

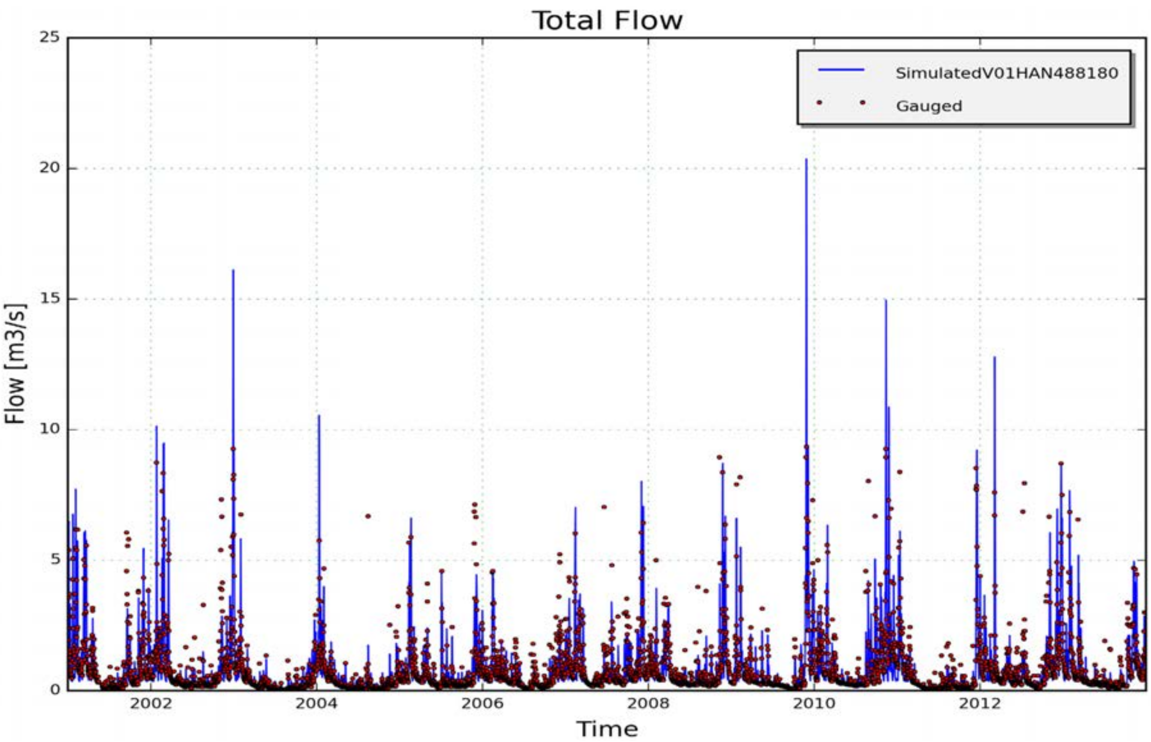


Figure 7 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01HAN488180, station 48810102 - Handzamevaart; Kortemark (2001-2013)

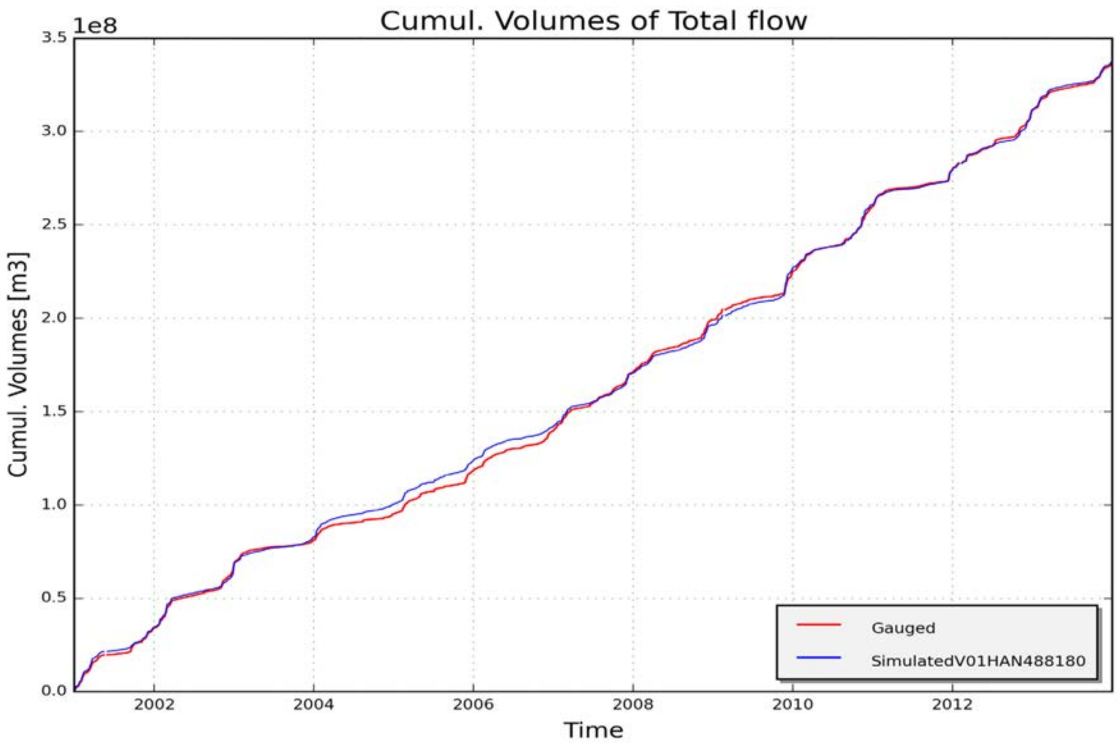
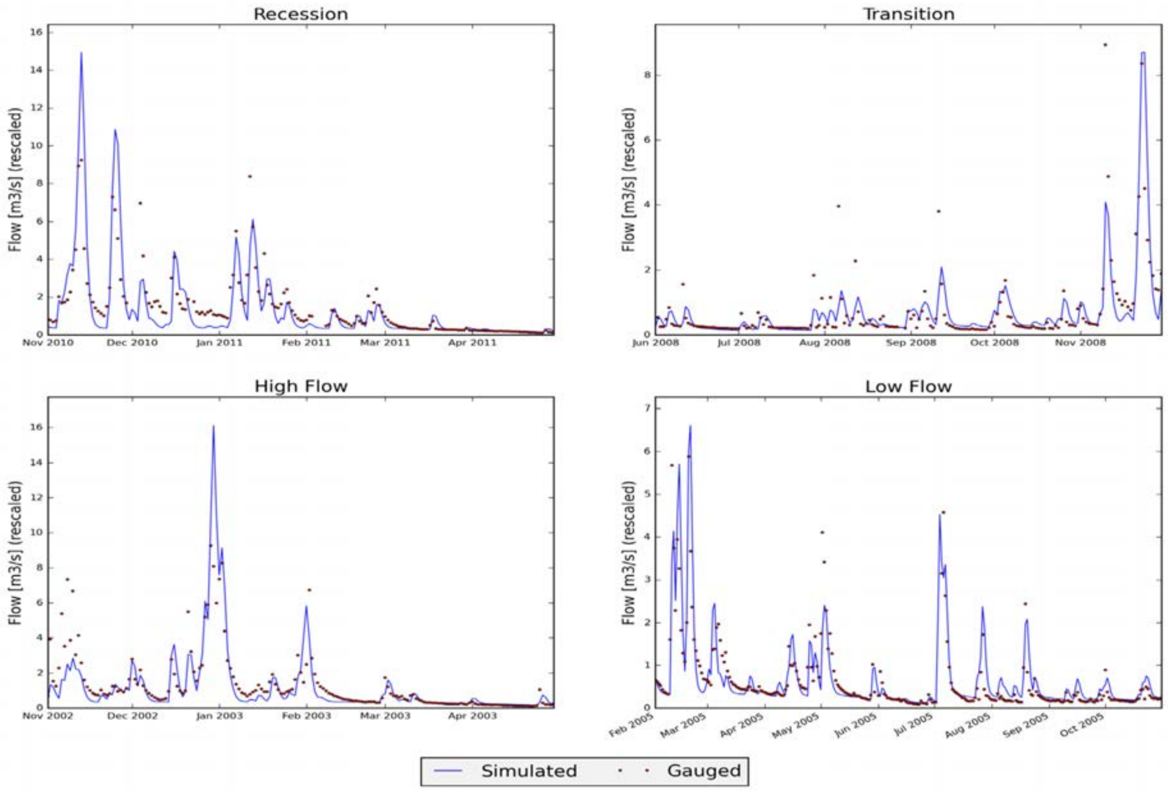


Figure 8 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01HAN488180, station 48810102 - Handzamevaart; Kortemark



49510102 - Ieperlee; Zuidschote (V01IEP495080)

Figure 9 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote(1996-2008)

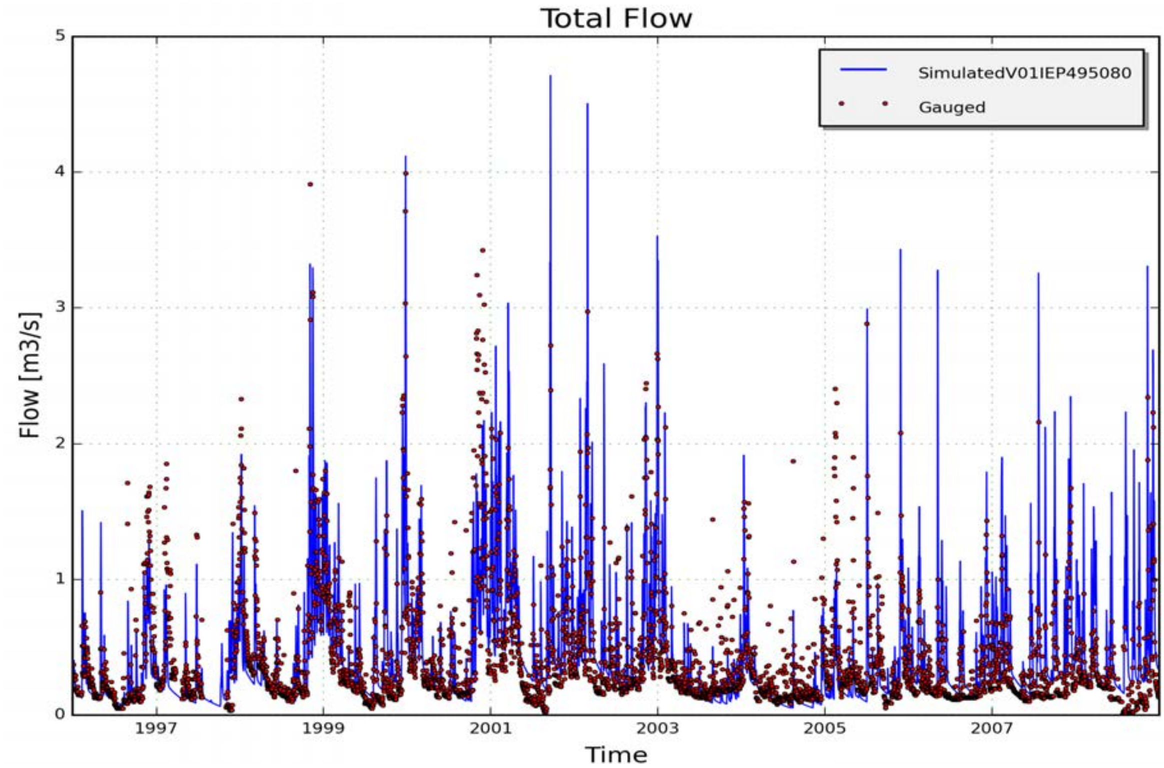


Figure 10 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote (calibration period)

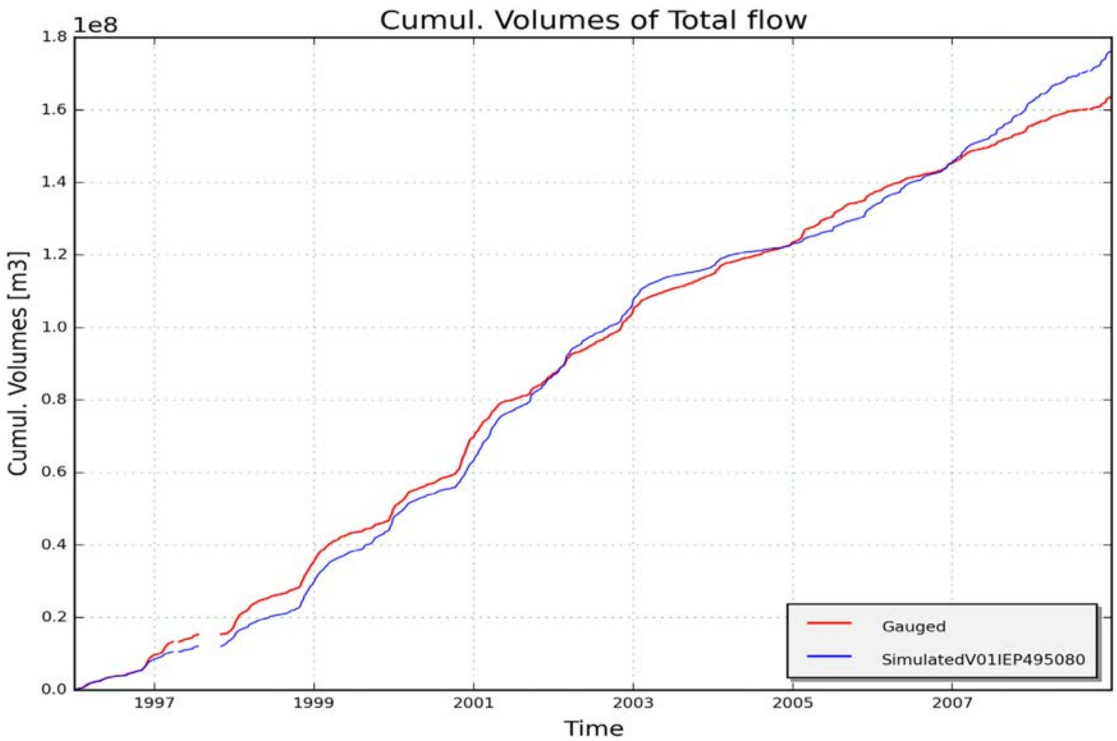


Figure 11 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote

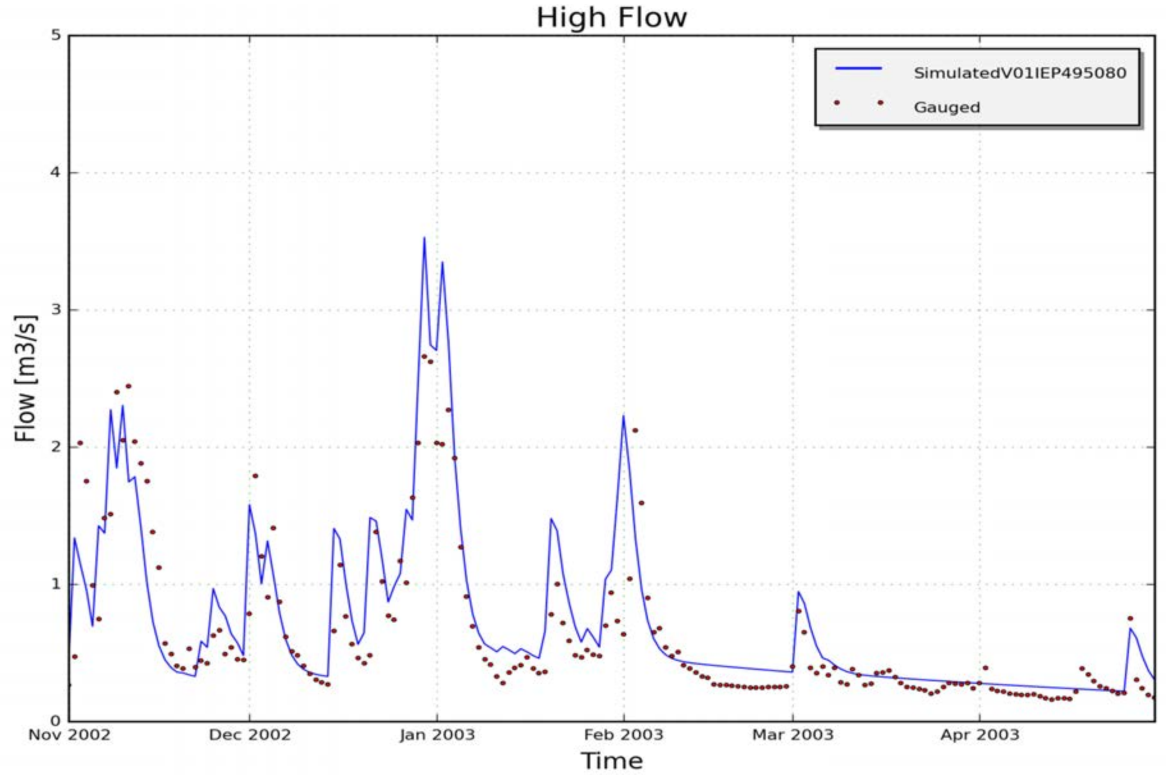


Figure 12 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote

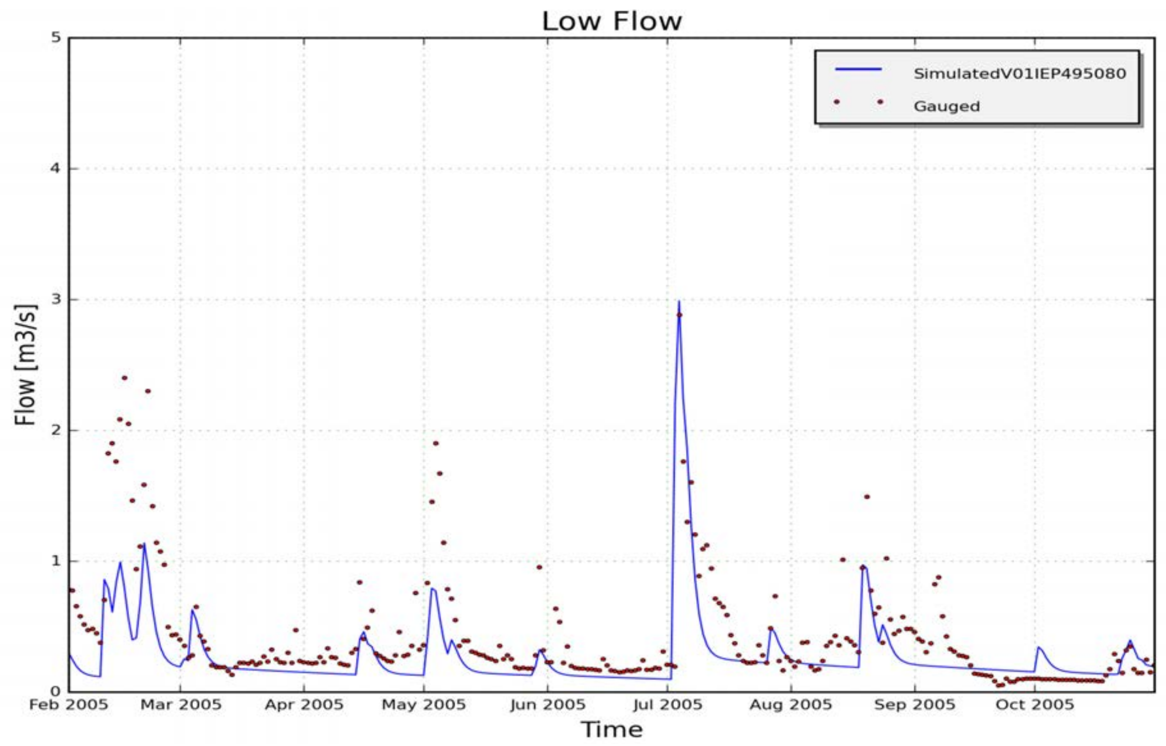
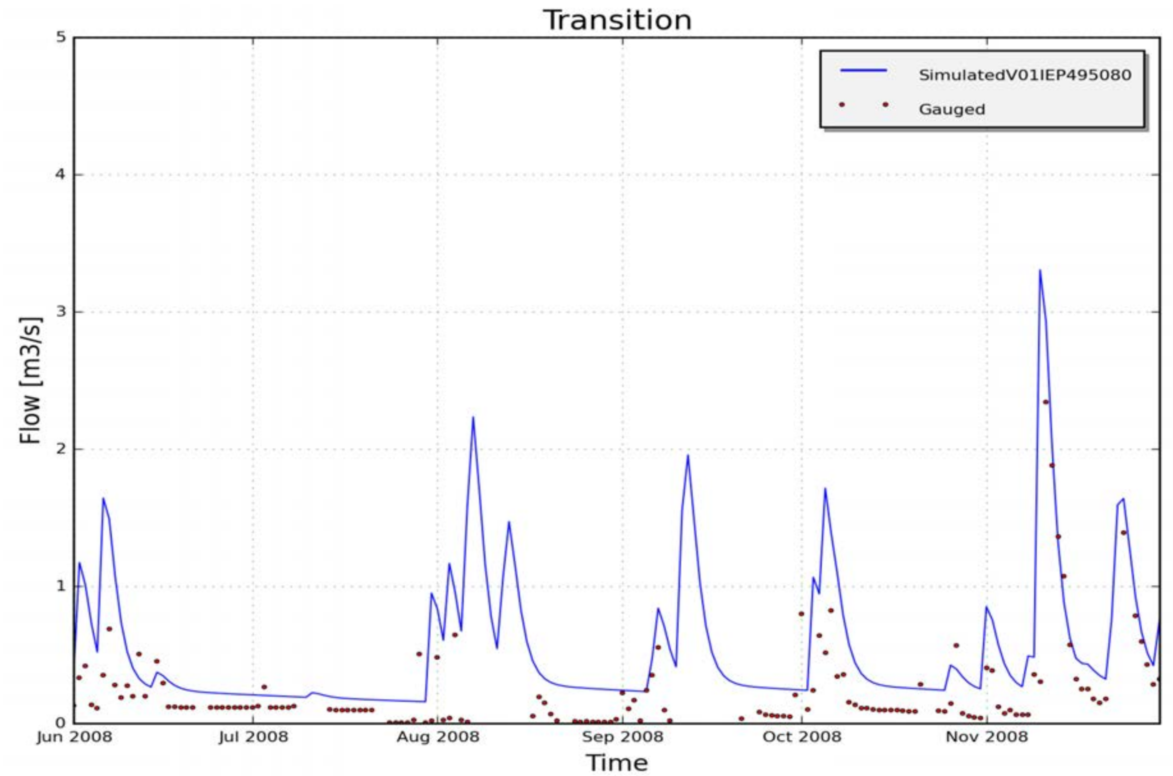


Figure 13 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote



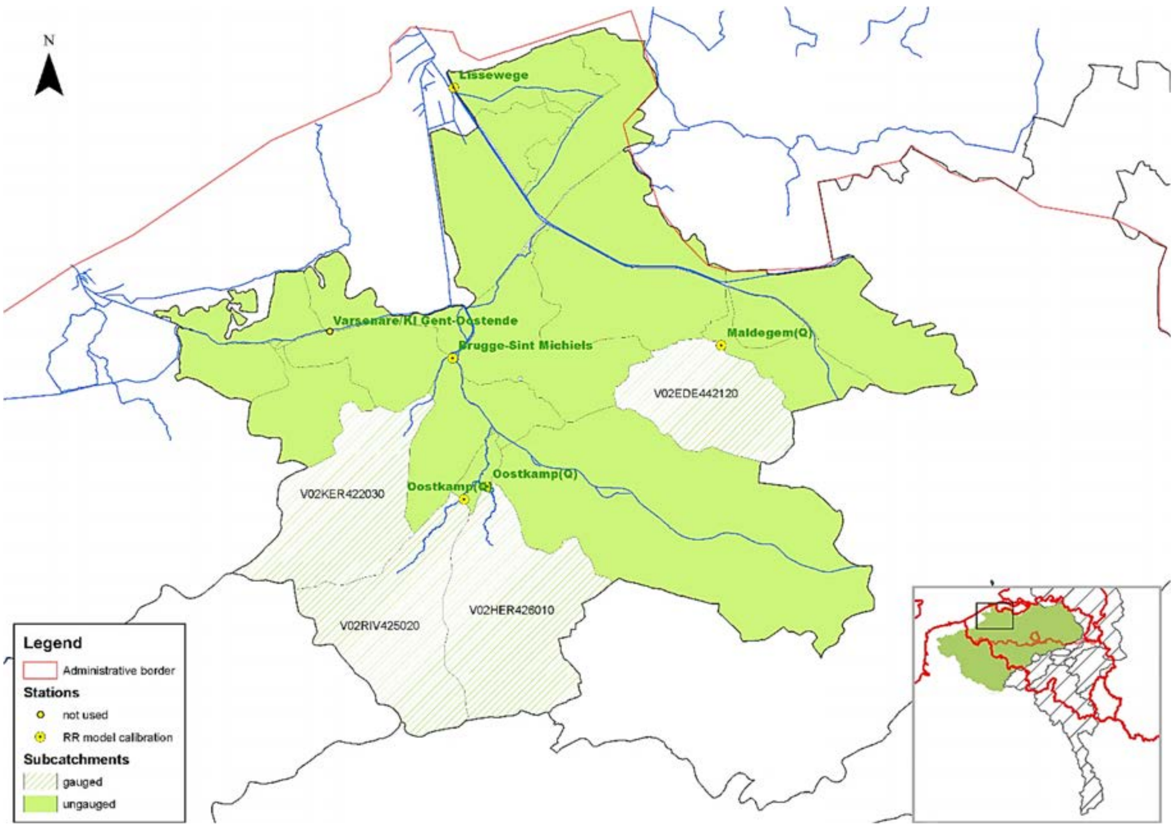
6.4 Brugse Polders

6.4.1 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 Brugse Polders 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 conduct 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 (Figure 14).

Figure 14 – Subcatchments and measurement points in the catchment of the Brugse Polders



6.4.2 Model performance

Table 8 and Table 9 present general performance statistics for the gauged catchments of the Brugse Polders for the calibration and validation period. Graphs of simulations of the subcatchment V02EDE442120 (best performance) and V02HER426010 (worst performance) are presented below (Figure 15 to Figure 20). For more detailed results on the other catchments, see Annex 4.

All the catchments show good performance. Regarding water balance, the total flow is slightly underestimated for V02KER422030 and V02RIV425020, while it is overestimated in the catchment **V02HER426010,** more specially during the high flow events at the end of 2009 and 2010.

Remarks on the data: V02KER422030 does not have data after 2007, consequently the period 1995-2007 was selected for the calibration.

Table 8 – Overview of calibration results for gauged catchments on the Brugse Polders

Gauging station	**Catchment code**	**Area (km^2)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Calibration period**	**Approx. distance to rain gauge over calibration period (km)**
44210102 - Maldegem	V02EDE442120	45.5	0.727	0.719	0.0%	0.7%	2001-2013	<2013 : 7 2013 : 10
42610102 - Hertsbergebeek; Oostkamp	V02HER426010	77.3	0.579	0.761	5.5%	9.9%	2001-2013	2011 & 2013: 13 Other years: 5
4220102 - Kerkebeek, Sint-Michiels	V02KER422030	62.7	0.606	0.705	-1.5%	4.8%	1995-2007	< 2000 : 3 >=2000 : 11
42510102- Rivierbeek; Oostkamp	V02RIV425020	64.0	0.704	0.812	-2.3%	2.4%	2001-2013	2001-2003 : 13 Other years: 7.5

Table 9 – Overview of validation results for gauged catchments on the Brugse Polders

Gauging station	**Catchment code**	**Area (km^2)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Validation period**
44210102 - Maldegem	V02EDE442120	45.5	0.67	0.679	-0.8%	0.4%	1984-2013
42610102 - Hertsbergebeek; Oostkamp	V02HER426010	77.3	0.609	0.754	3.7%	5.6%	1987-2013
4220102 - Kerkebeek, Sint-Michiels	V02KER422030	62.7	0.587	0.672	-5.9%	-0.6%	1984-2007
42510102- Rivierbeek; Oostkamp	V02RIV425020	64.0	0.696	0.745	-5.7%	-4.3%	1984-2013

44210102 - Maldegem (V02EDE442120)

Figure 15 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02EDE442120, station 44210102 - Maldegem(2001-2013)

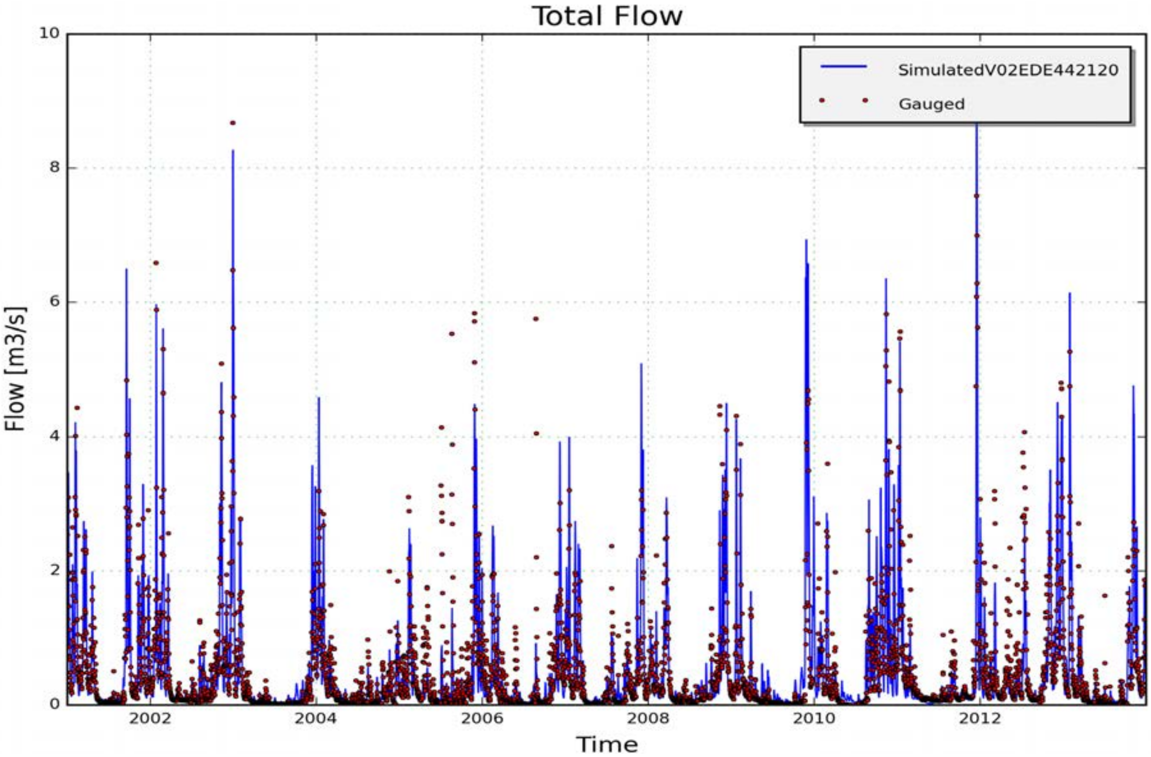


Figure 16 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02EDE442120, station 44210102 - Maldegem (2001-2013)

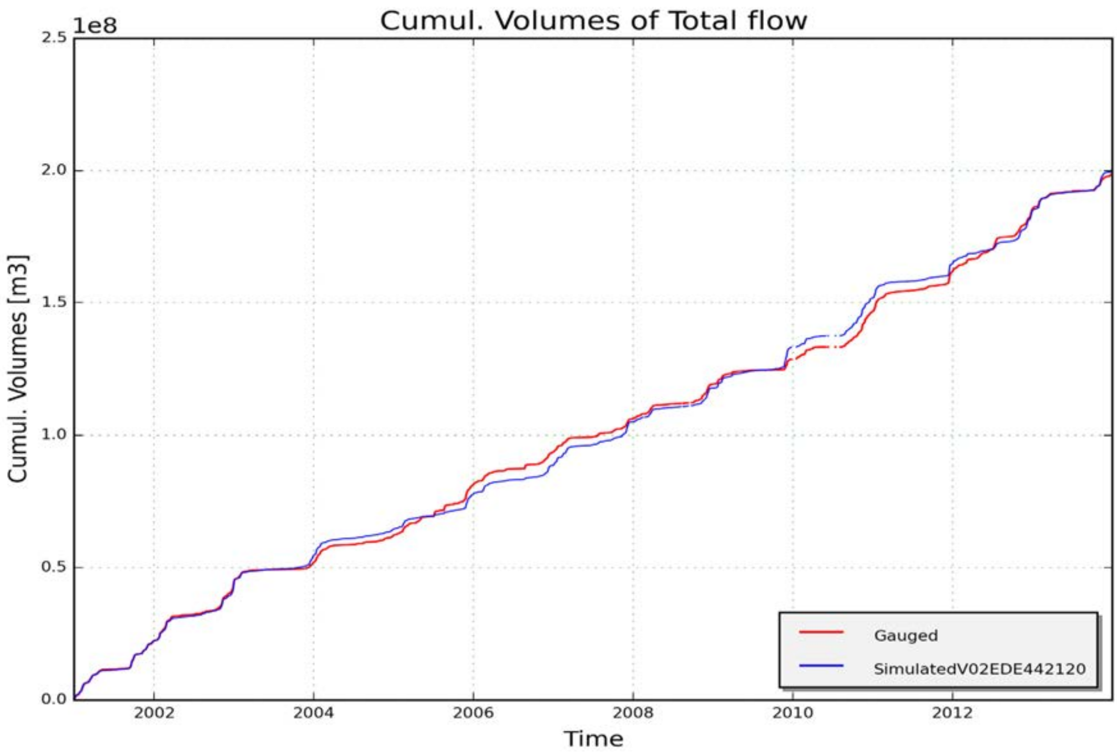
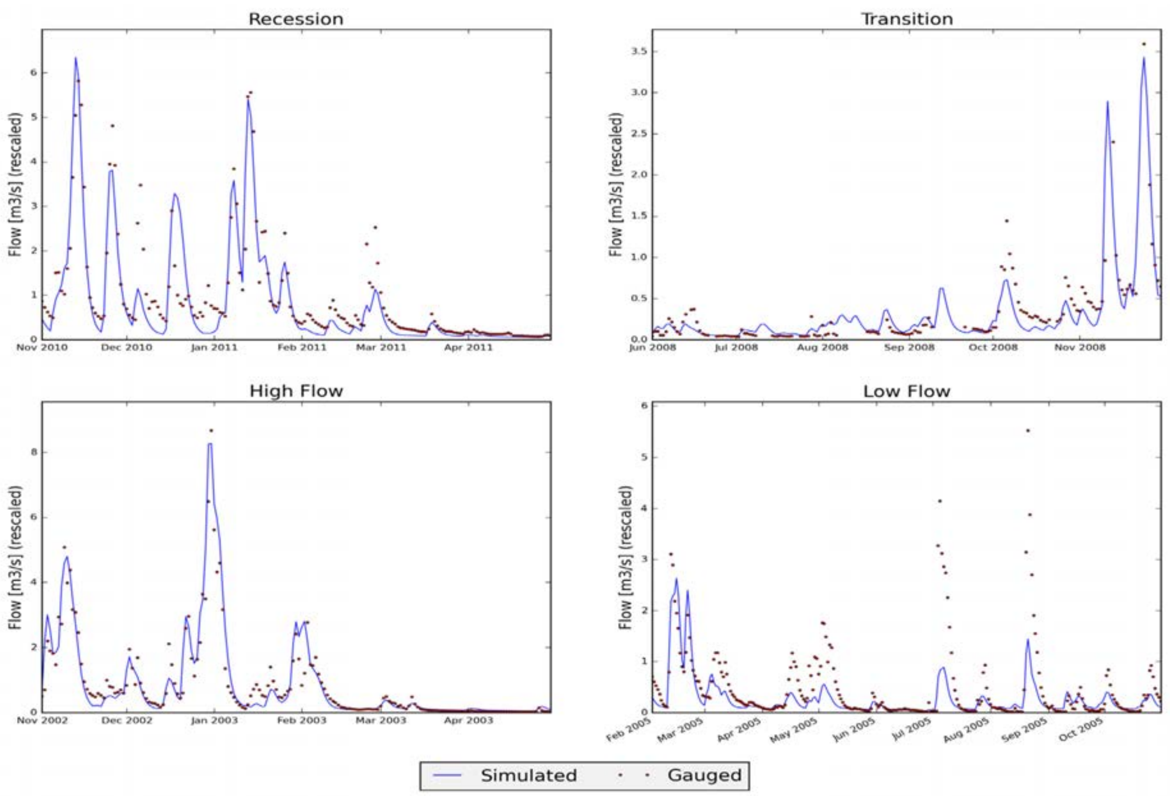


Figure 17 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V02EDE442120, station 44210102 – Maldegem



42510102- Rivierbeek; Oostkamp (V02RIV425020)

Figure 18 – Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp(calibration period)

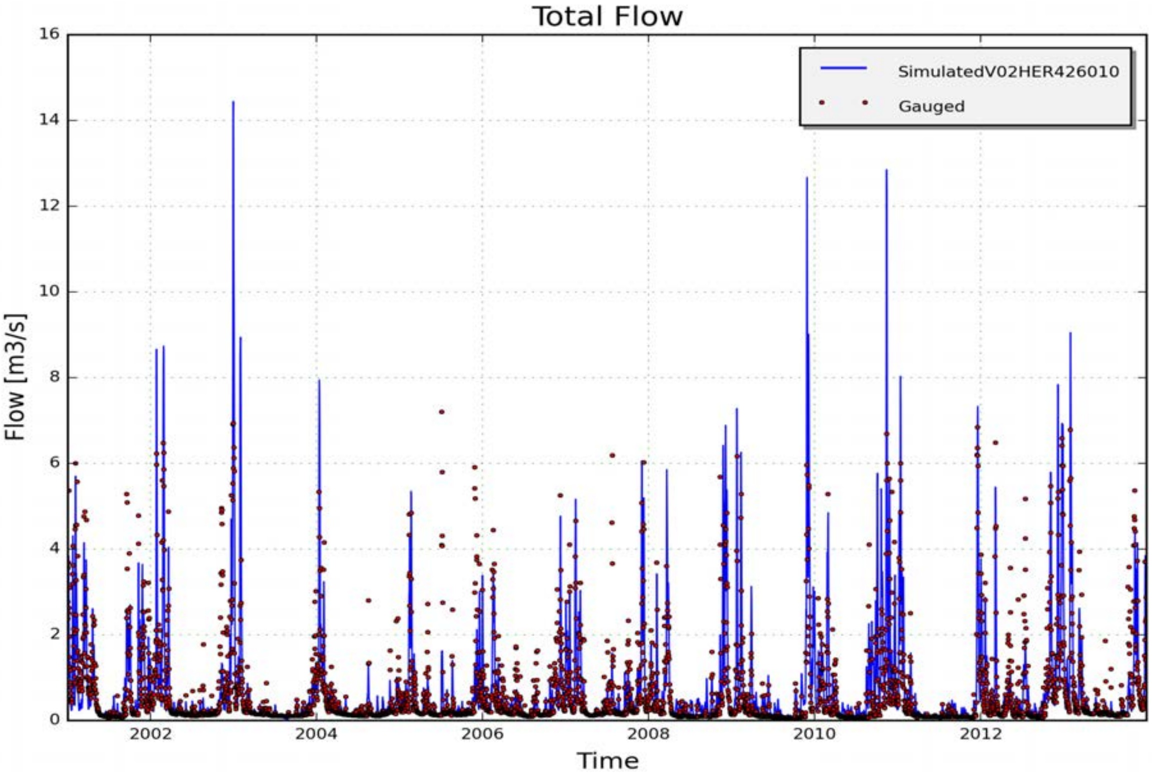


Figure 19 – Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp (calibration period)

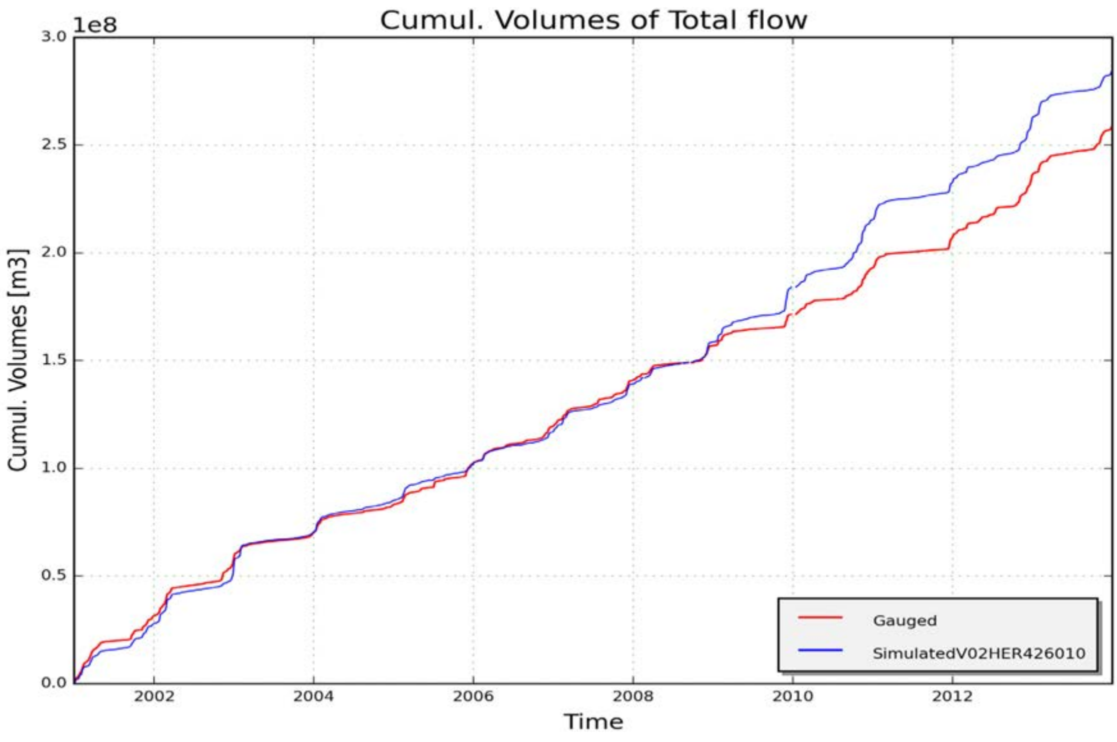
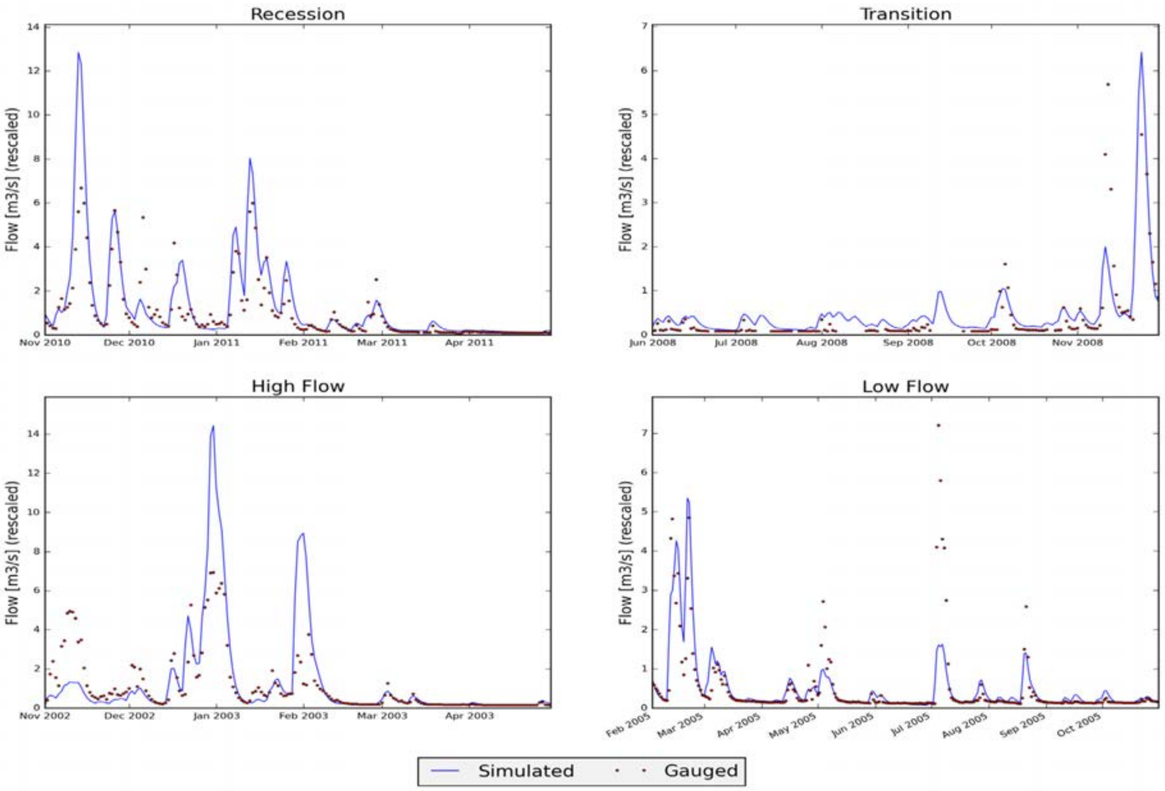


Figure 20 – Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp



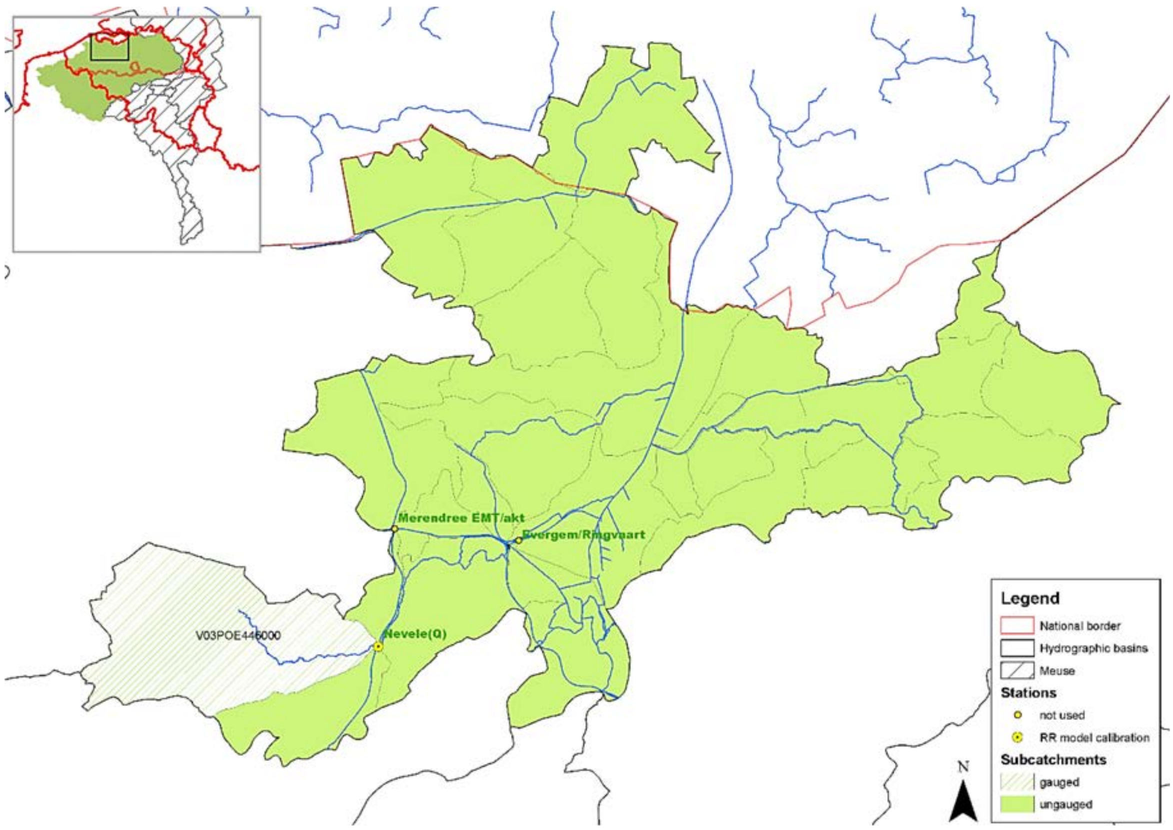
6.5 Gentse Kanalen

6.5.1 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.

There is only one gauged catchment within the basin of the Gentse Kanalen: 44656122 on the Poekebeek in Nevele. During the previous study the discharge at the Molenbeek in Puivelde was checked, based on project specific discharge data of the Sigmaplan update project (De Boeck et al., 2011). This station is not a permanent discharge station and consequently no new calibration is possible for this subcatchment. Catchments and measurement points are shown on the map in Figure 21. The gauged and recalibrated area of the basin amounts for 12 % of the total surface area of the basin.

Figure 21 – Subcatchments and measurement points on the Gentse Kanalen catchment



6.5.2 Model performance

Table 10 and Table 11 present general performance statistics for the only gauged subcatchment of the Gentse Kanalen basin for the validation and calibration periods. The V03POE446000 subcatchment shows a correct performance for both periods with values of NSE and LogNSE around 0.7. Graphs of discharge series are presented at Figure 22 and Figure 23. There are slight underestimations of the discharge in 1994 and 1995 as well as in 2009. The same periods (recession) are also underestimated by the NAM model which suggests uncharacteristic behaviour of the catchment after those high flow events. For more detailed results on the validation, see Annex 5.

Remarks on the data: the Poekebeek (**V03POE44600)** discharge was not measured from 18/01/2001 to 29/11/2004 and after 2009. Hence, the calibration period starts as soon as 1993 in order to include 13 years of data.

Table 10 – Overview of calibration results for gauged catchments on the Gentse Kanalen

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Calibration period**	**Approx. distance to rain gauge over calibration period (km)**
44656122 - Poekebeek; Nevele	**V03POE446000**	106.8	0.71	0.706	-0.3%	6.0%	1993-2010	< 1995 :9 >= 1995 : 6

Table 11 – Overview of validation results for gauged catchments on the Gentse Kanalen

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Gauged years**
44656122 - Poekebeek; Nevele	**V03POE446000**	106.8	0.671	0.737	9.5%	9.3%	1983-2010

44656122 - Poekebeek; Nevele (V03POE446000)

Figure 22 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele(calibration period)

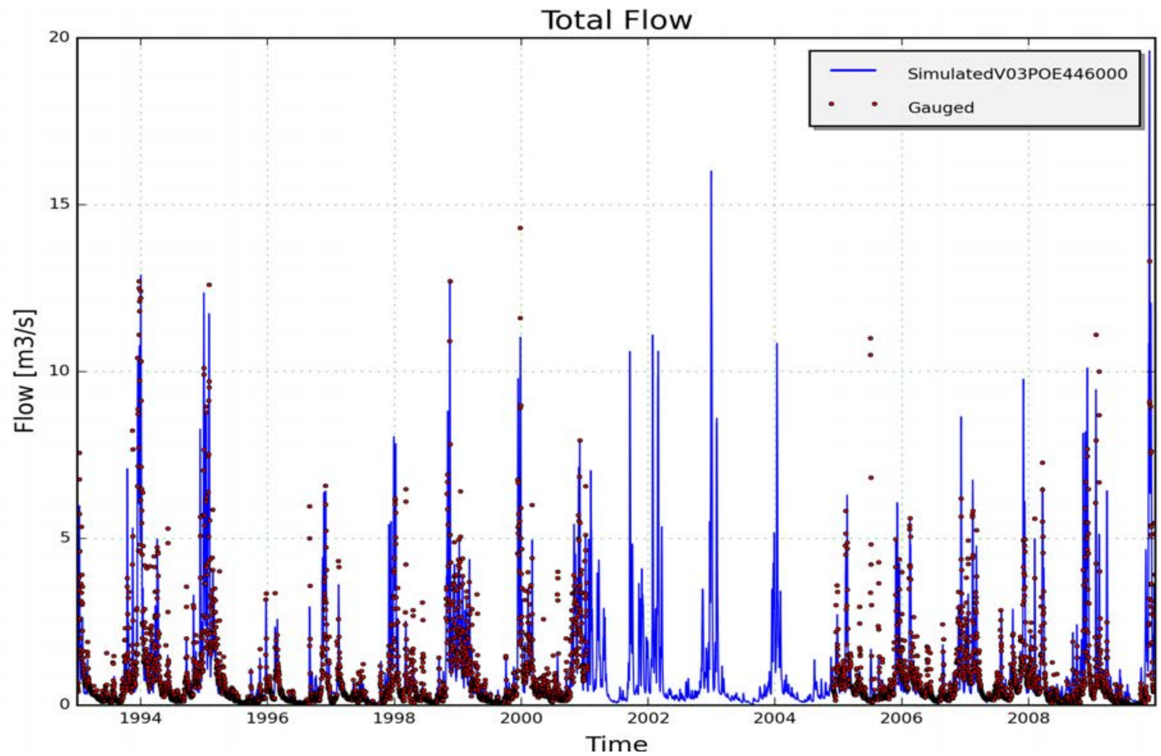
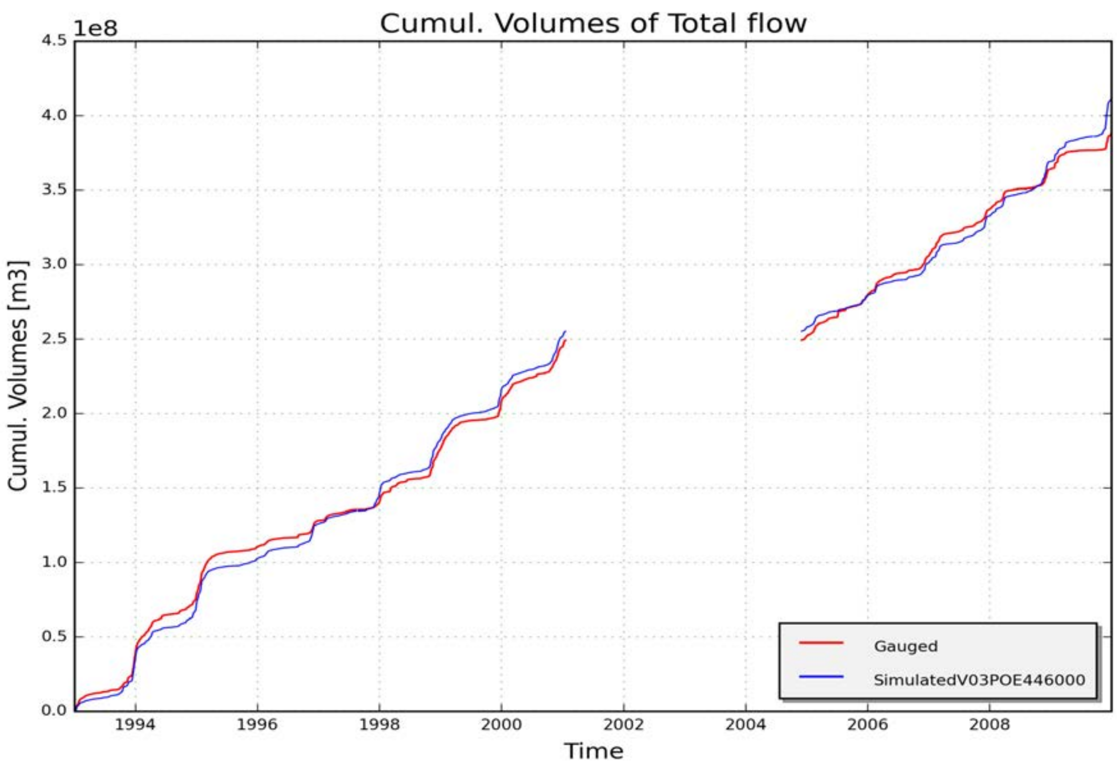


Figure 23 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele (calibration period)



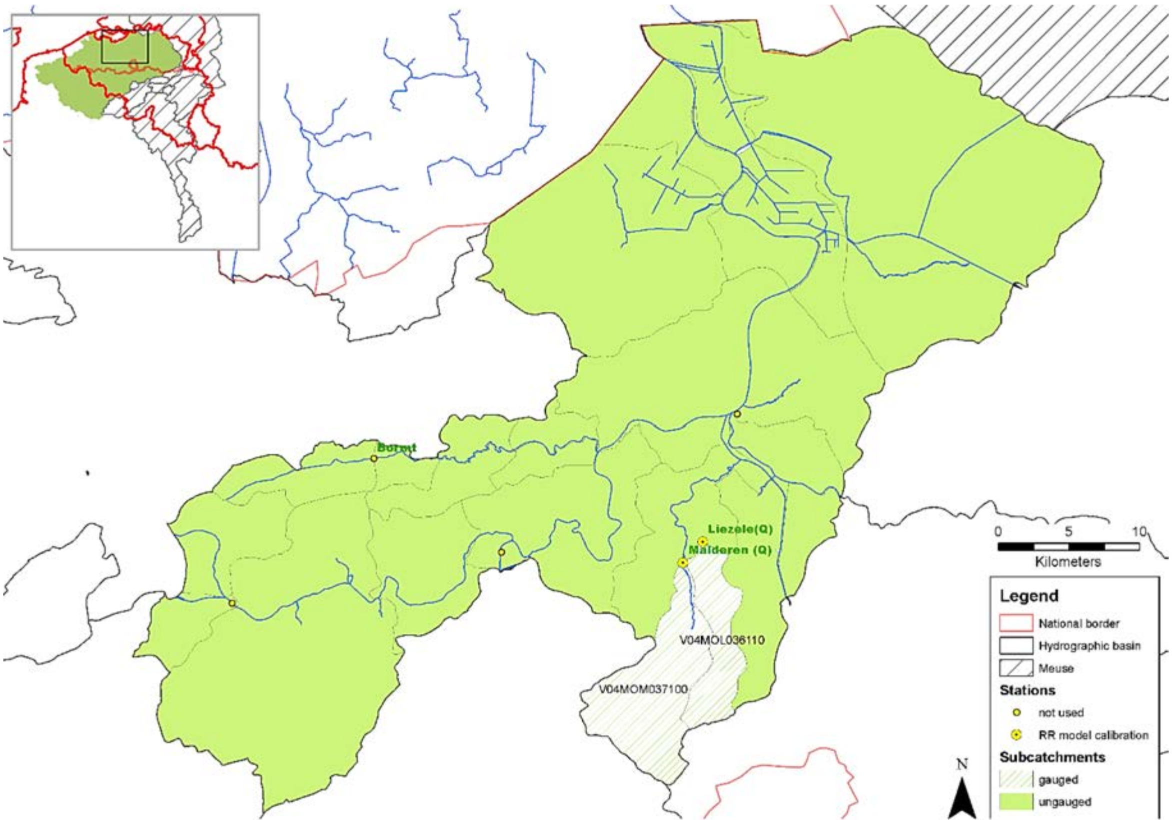
6.6 Benedenschelde

6.6.1 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.

About 6 % of the surface area of the basin is gauged. During the previous study the discharge at the Ledebeek in Bormt was checked, based on project specific discharge data of the Sigmaplan update project (De Boeck et al., 2011). This station is not a permanent discharge station and consequently no new calibration is possible for this subcatchment.

Figure 24 – Subcatchments and measurement points on the Benedenschelde catchment



6.6.2 Model performance

Table 12 and Table 13 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 25 to Figure 30). For more detailed results on the validation, see Annex 6.

The two models show good simulation of low flows with a satisfactory error on volume in the calibration years (below 4 %). Log NSE remains high (around 0.7) for the validation period but there is a model quality loss more important of water balance he relative error on volume increase to 11.5 and 8.4% respectively for the validation in Liezele and Malderen, showing a loss of goodness-of-fit for the validation periods. Low NSE values indicate a poor simulation of flow peaks that are overestimated in both calibration and validation years. In particular, a very high peak is simulated at the end of 2010 that was not measured for V04MOM037100 (Figure 25).

Table 12 – Overview of calibration results for gauged catchments on the Benedenschelde basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Calibration period**	**Approx. distance to rain gauge over calibration period (km)**
3610102 - Kleine Molenbeek, Liezele	**V04MOL036110**	32.6	0.629	0.781	0.4%	-3.1%	2001-2013	< 2007 : 10 >=2007 : 6
3710102 - Grote Molenbeek, Malderen	**V04MOM037100**	67.3	0.406	0.76	0.3%	-3.9%	2001-2013	6

Table 13 – Overview of validation results for gauged catchments on the Benedenschelde basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Validation period**
3610102 - Kleine Molenbeek, Liezele	**V04MOL036110**	32.6	0.579	0.69	15.6%	11.5%	1967-2013
3710102 - Grote Molenbeek, Malderen	**V04MOM037100**	67.3	0.51	0.711	13.8%	8.4%	1967-2013

3710102 - Grote Molenbeek, Malderen (V04MOM037100)

Figure 25 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen(2001-2013)

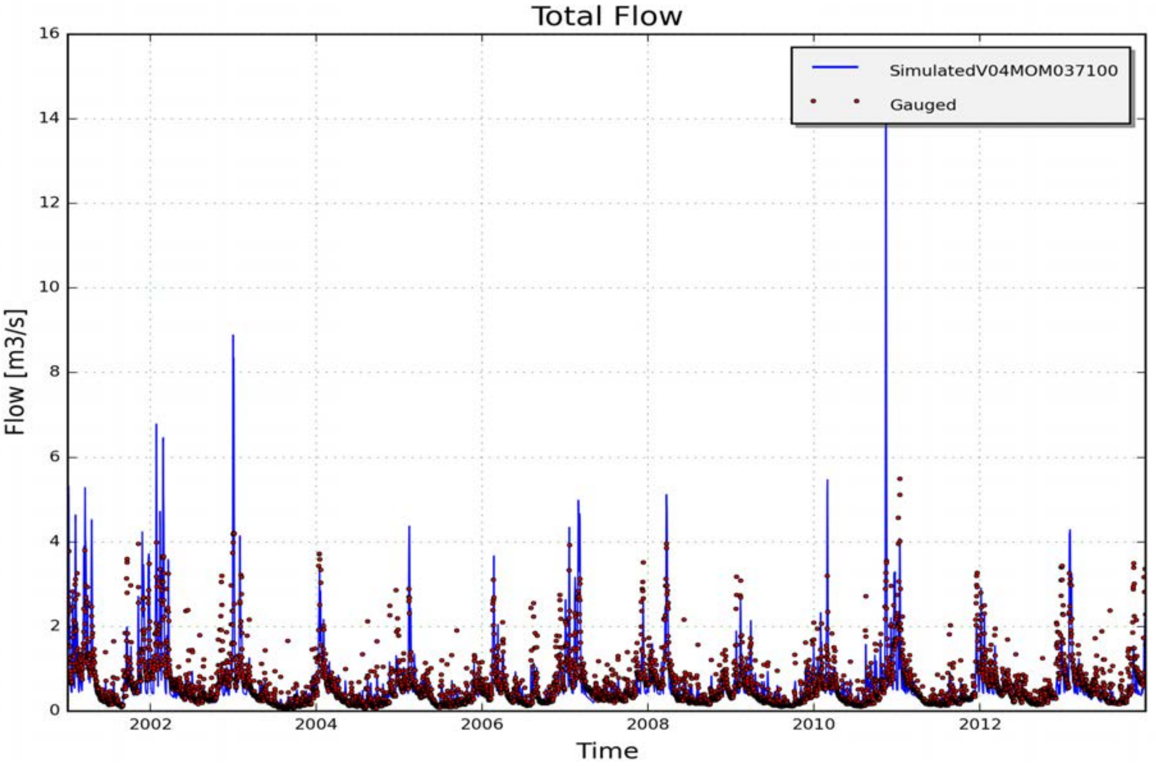


Figure 26 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen (2001-2013)

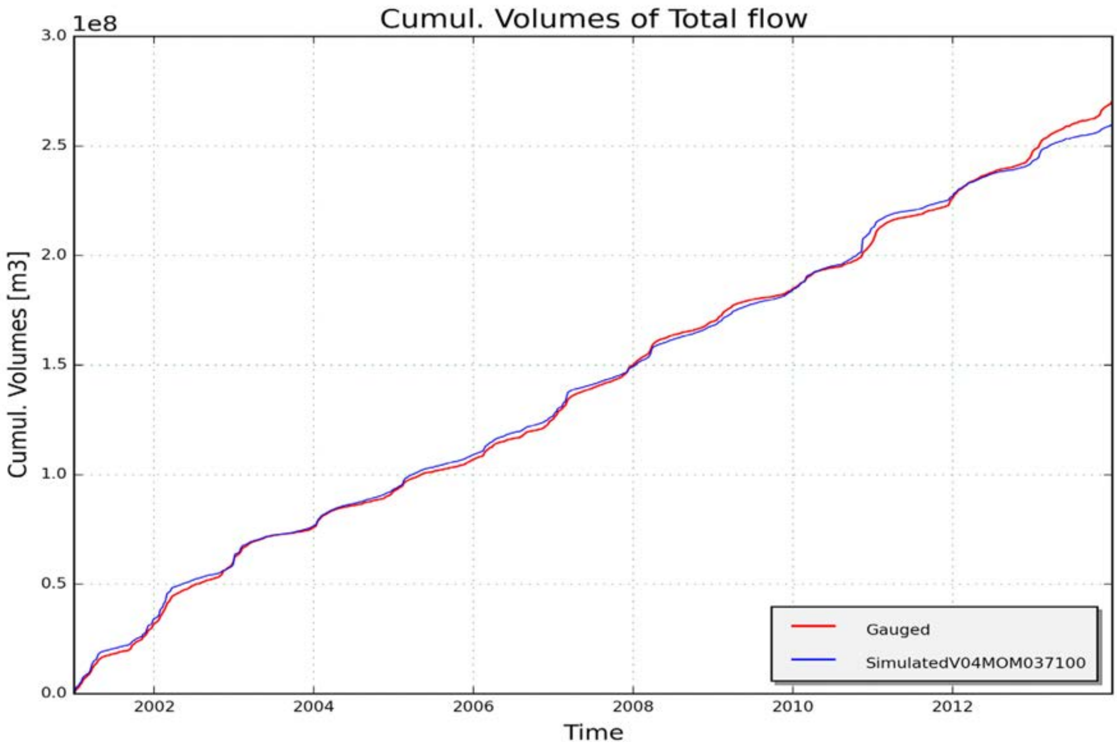
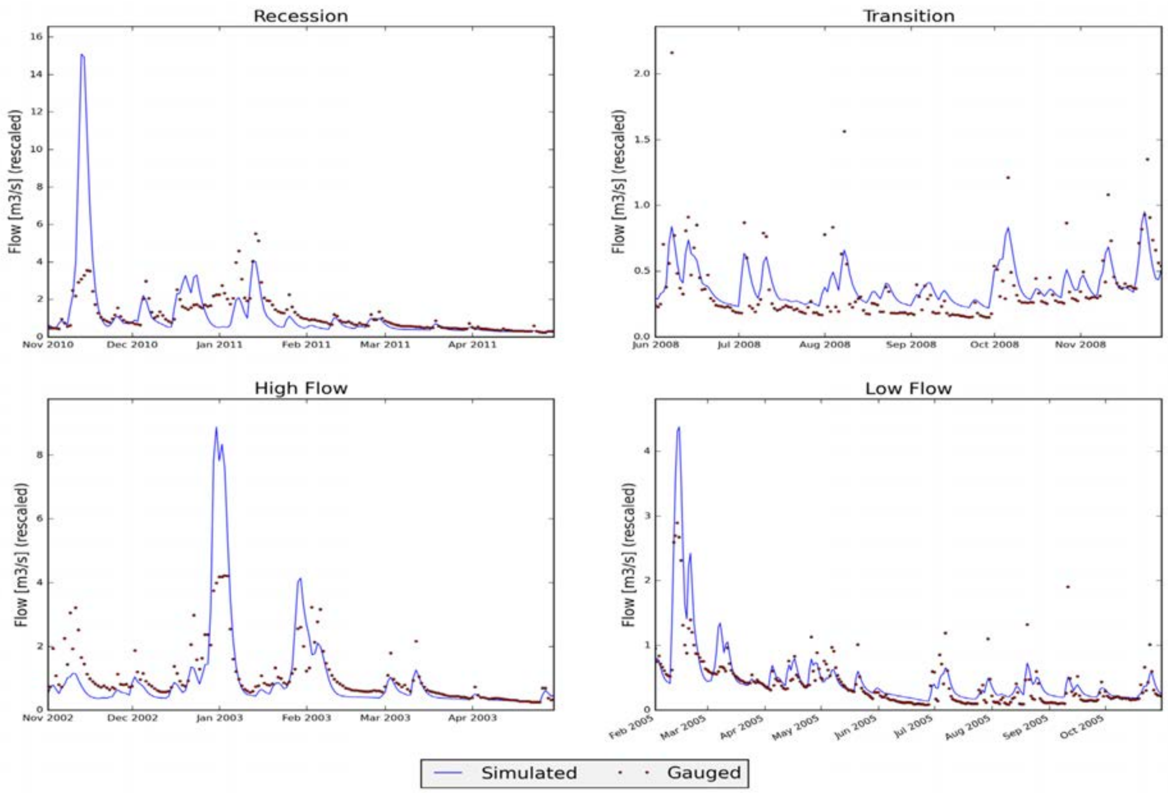


Figure 27 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen



3610102 - Kleine Molenbeek, Liezele (V04MOL036110)

Figure 28 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele(calibration period)

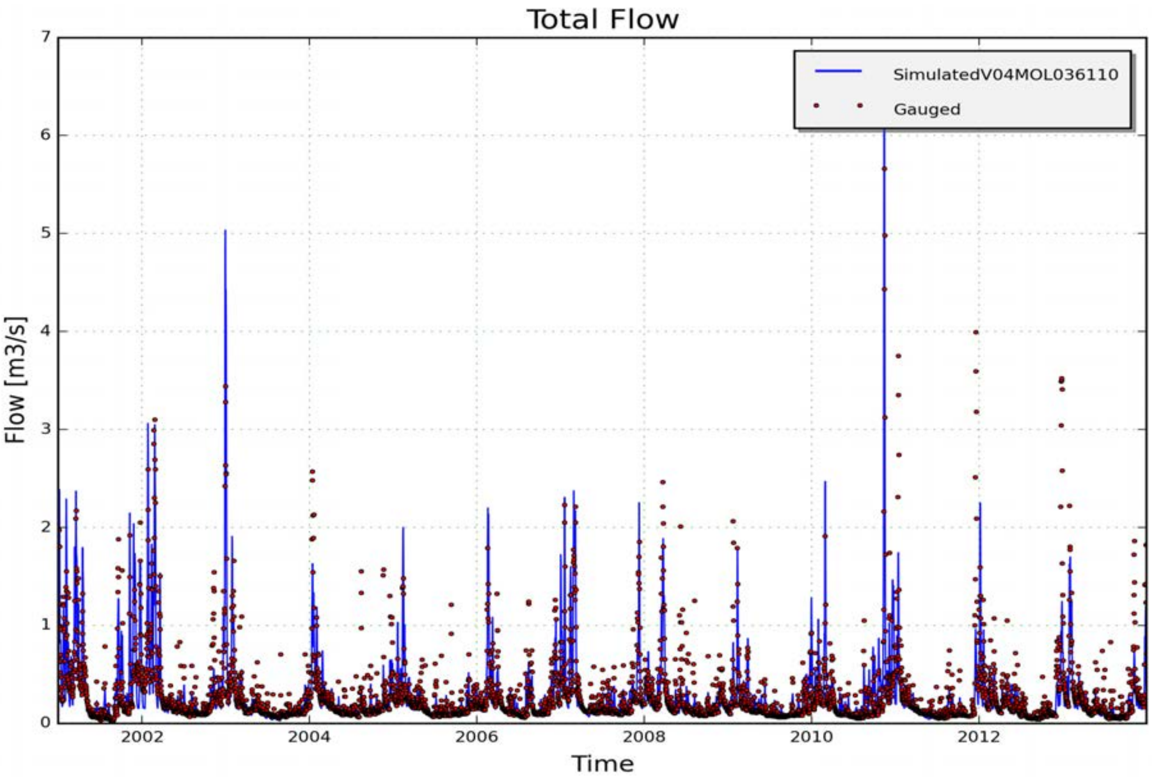


Figure 29 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele (calibration period)

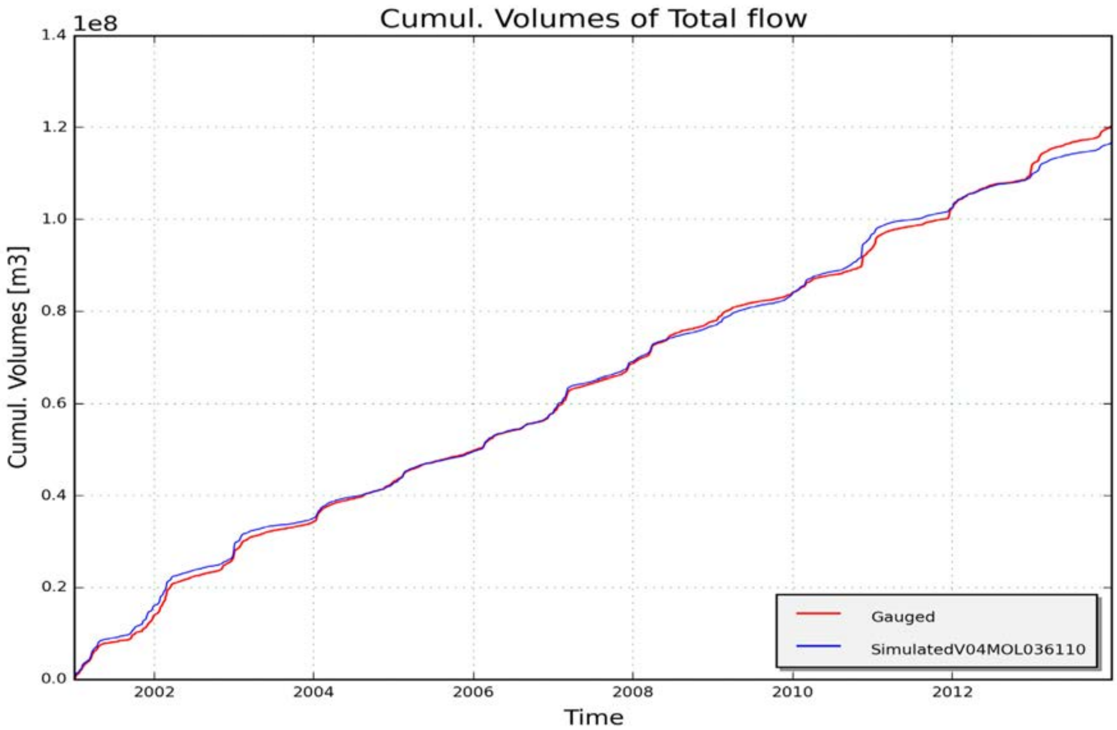
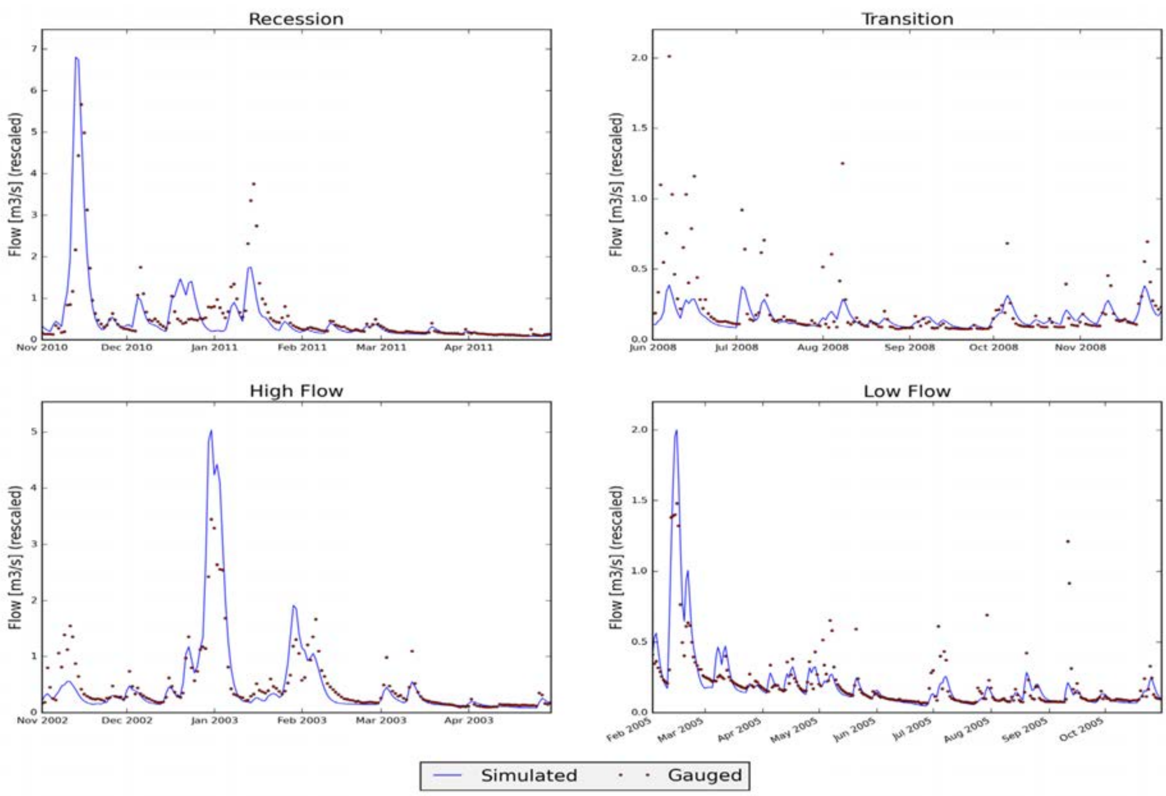


Figure 30 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele



6.7 Leie

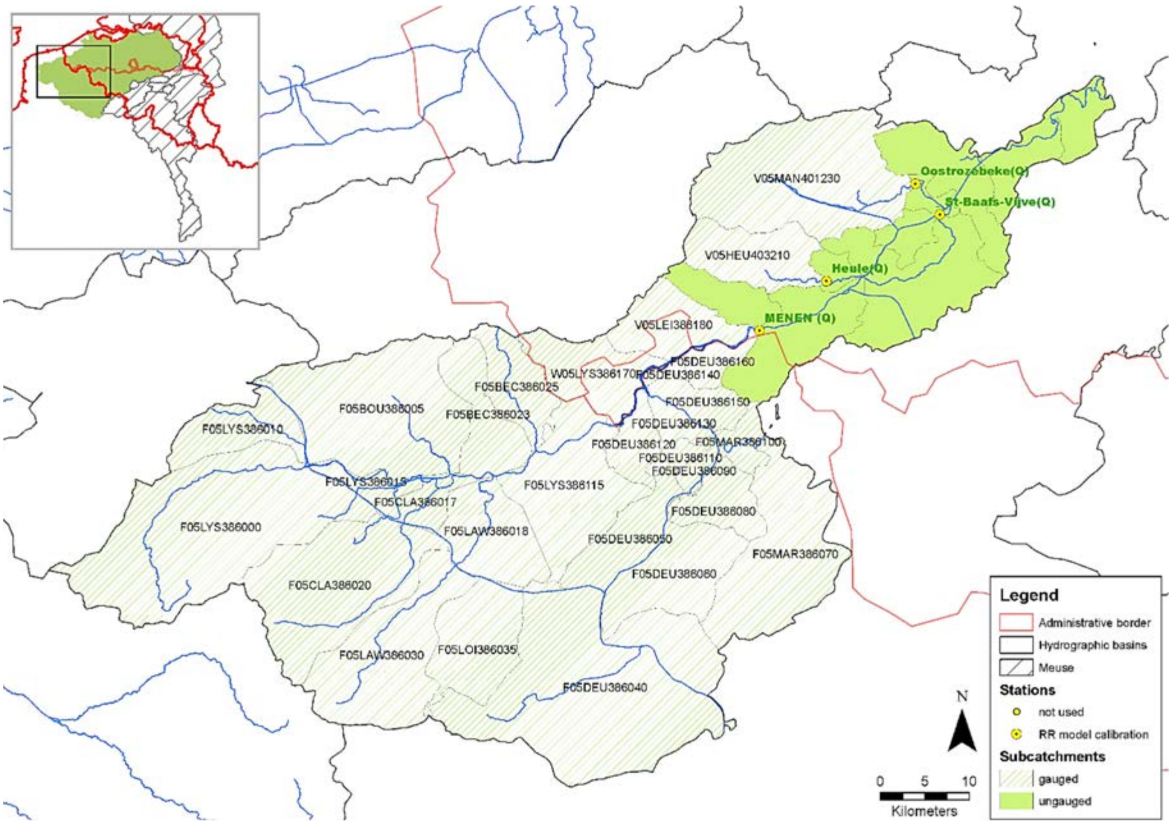
6.7.1 Context

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. Some of the water flowing from the Scheldt in the canal system, flows back to the Leie through the canalised Deûle. This interaction of rivers and canals leads to an enlarged complexity regarding the calibration of a hydrological model for this catchment.

Figure 31 shows the location of the flow gauges used for calibration of the NAM models on the Leie basin.

Figure 31 – Subcatchments and measurement points on the Leie catchment



The recalibration of the catchment upstream of the gauging station in Menen on the Leie (station 38680122), is done for this 1 big gauged subcatchment. However, the final runoff for the water allocation model is simulated separately for the 22 subcatchments separately, to be able to distribute the flow over the complex canal system described above.

With three gauging stations in Menen, Heule and Oostrozebeke, 85,6 % of the Leie basin is covered by discharge measurements.

6.7.2 Model performances

Table 14 and Table 15 present general performance statistics for the gauged catchments of the Leie basin for the calibration and validation period . Graphs of simulations for the catchments F05LEI386001 (best model performance) and V05MAN401230 (worst model performance) are presented below (Figure 32 to Figure 37). For more detailed results on the other catchments, see Annex 7. In paragraph 3.2 it was already mentioned that refinement of the precipitation data in the Leie catchment significantly improves the performance of the hydrological model for the catchment upstream Menen, compared to the first version of the water allocation model (see Michielsen et. al, 2021).

Very good model performance was achieved for the catchments **F05LEI386001** and **V05MAN401230** for the calibration and validation periods. The simulation of the catchment **V05HEU403210** has a good fit for both calibration and validation years but with a slightly higher error on cumulative volumes. Goodness-of-fit statistics appear as especially high but this can be related to the fact that **F05LEI386001** is a very large catchment with high discharge. **V05MAN401230** also, to a smaller extent.

Remarks on the data: The catchment **V05MAN401230** has unreliable observed data for some periods. There is a gap in the data from 1978 to August 1982, and then from 1996 to 2004. In 2005 and the second part of 2006, discharge values were estimated based on the activity of the weir 1km upstream. From the end of 2007 (09/11/2007) on, data also get the “U” data quality flag. Data is therefore less reliable during this period and was excluded from both calibration and validation. Calibration was performed on the continuous period of 1983-1995, preferred to a more recent but discontinued period.

Table 14 – Overview of calibration results for gauged catchments on the Leie basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**		**Calibration period**	**Approx. distance to rain gauge over calibration period (km)**
38680122, Leie te Menen	**F05LEI386001**	2981.8	0.801	0.781	-2.0%	0.0%	2001-2013	*Irrelevant given the size of the basin*
40310102 - Heulebeek; Heule	**V05HEU403210**	91.9	0.758	0.713	-4.6%	0.9%	2001-2013	<2004 : 6 >=2004 : 10
40110102 - Mandel; Oostrozebeke (L05_409)	**V05MAN401230**	258.4	0.812	0.828	0.1%	-1.1%	1983-1995	8

Table 15 – Overview of validation results for gauged catchments on the Leie basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**		**Validation period**
38680122, Leie te Menen	**F05LEI386001**	2981.8	0.808	0.795	-1.6%	-0.1%	1999-2013
40310102 - Heulebeek; Heule	**V05HEU403210**	91.9	0.777	0.736	-5.0%	-3.8%	1975-2013
40110102 - Mandel; Oostrozebeke	**V05MAN401230**	258.4	0.759	0.734	-4.2%	0.9%	1967-2013

38680122, Leie te Menen (F05LEI386001)

Figure 32 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment F05LEI386001, station 38680122 – Leie, Menen(2001-2013)

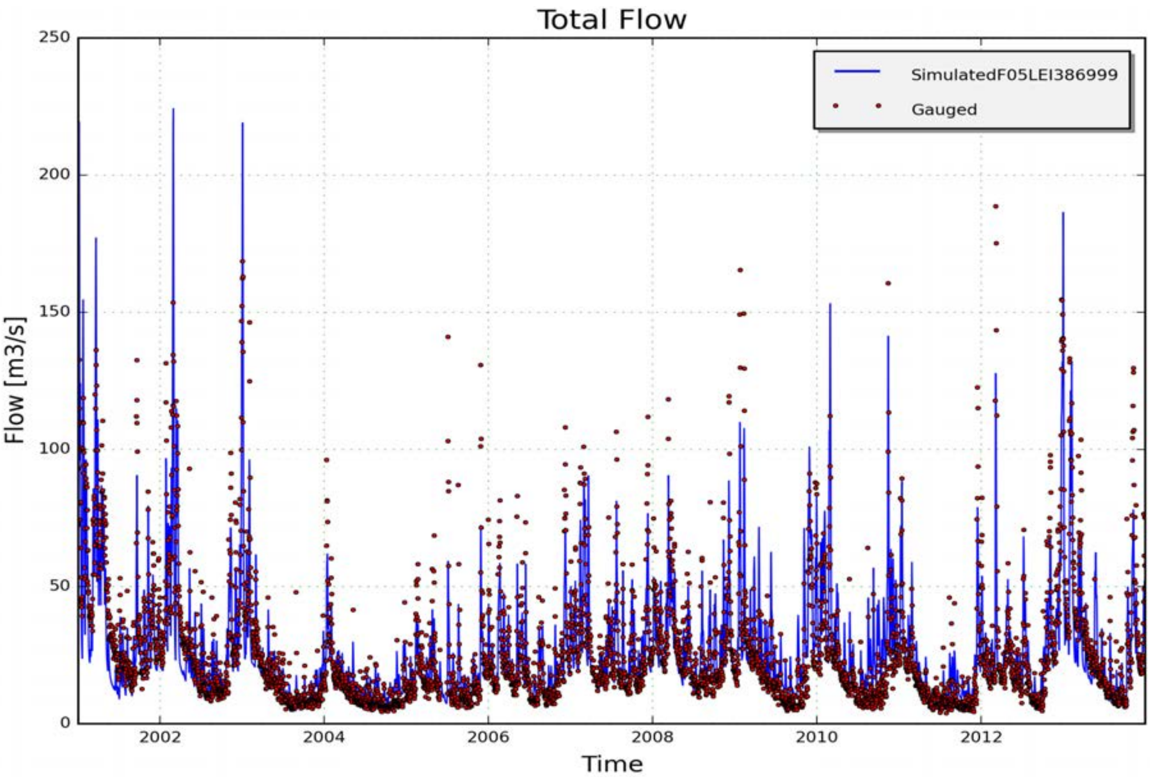


Figure 33 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment F05LEI386001, station 38680122 – Leie, Menen(2001-2013)

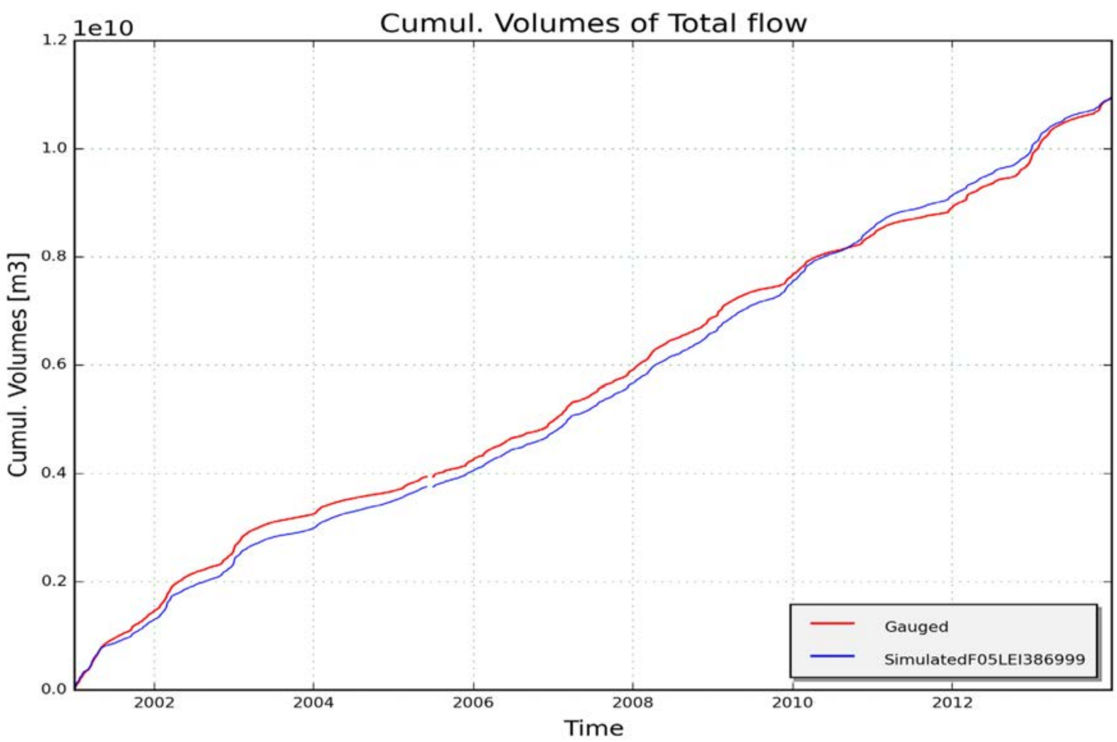
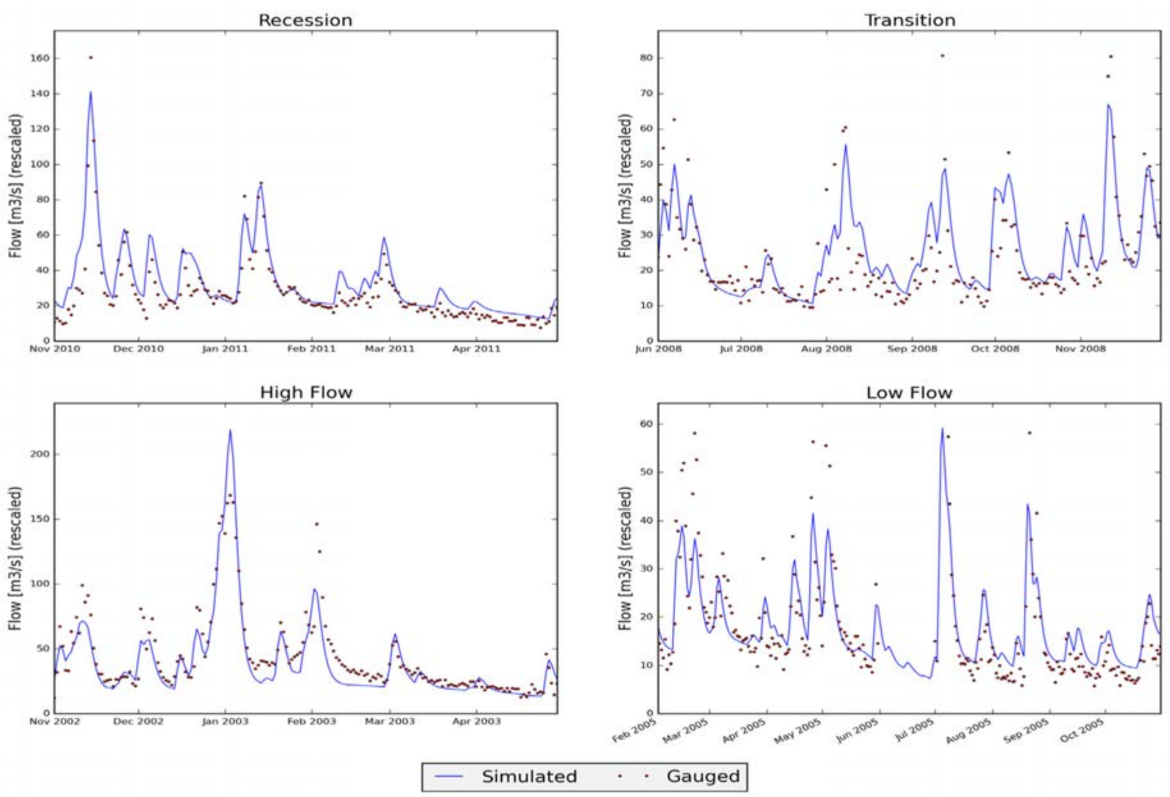


Figure 34 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment F05LEI386001, station 38680122 – Leie, Menen(2001-2013)



40310102 - Heulebeek; Heule (V05HEU403210)

Figure 35 – Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V05HEU403210, station 40310102 - Heulebeek; Heule(calibration period)

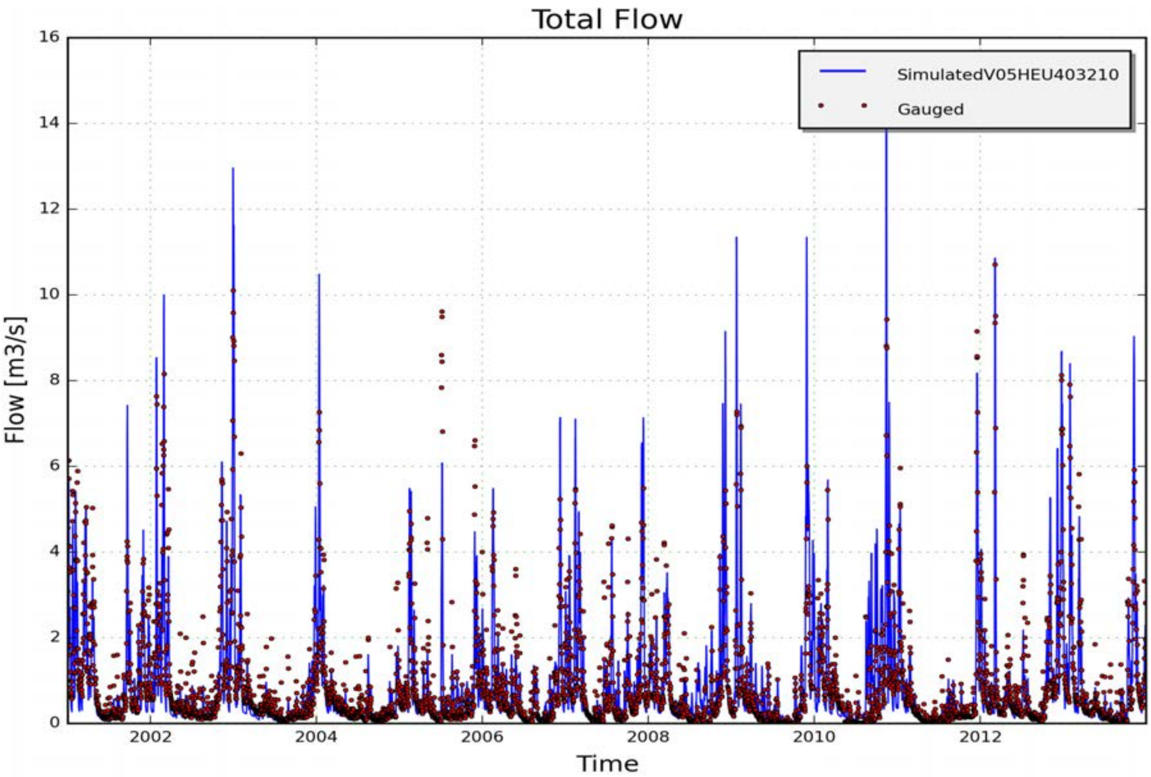


Figure 36 – Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V05HEU403210, station 40310102 - Heulebeek; Heule (calibration period)

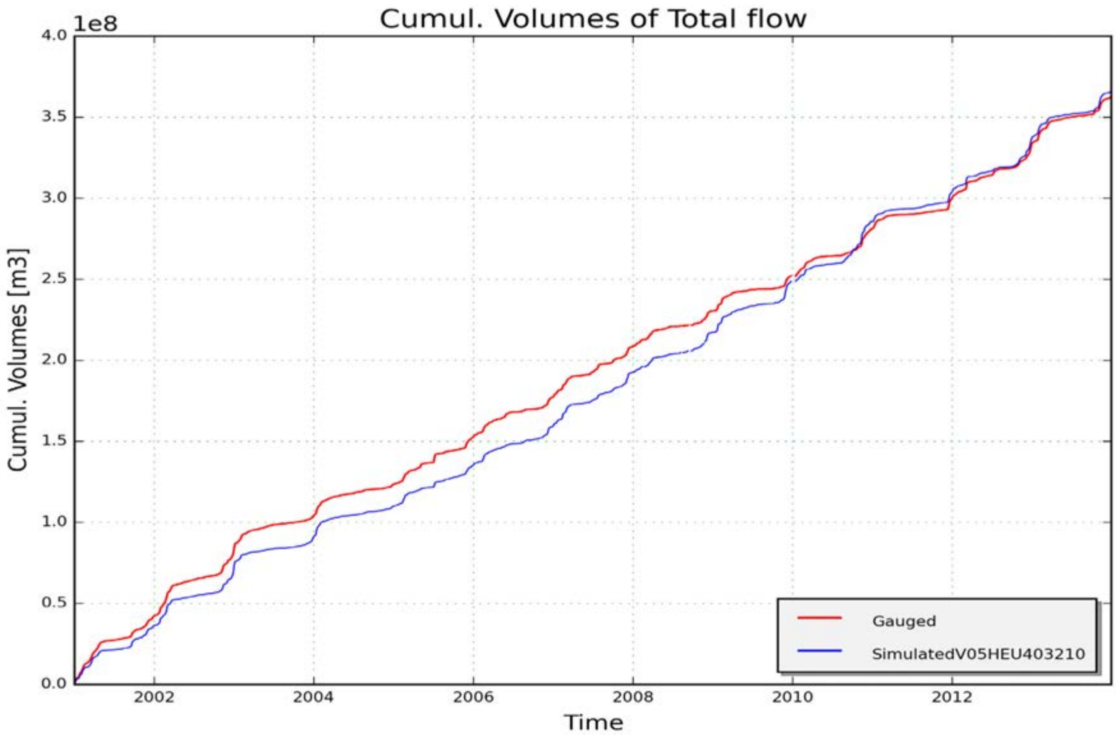
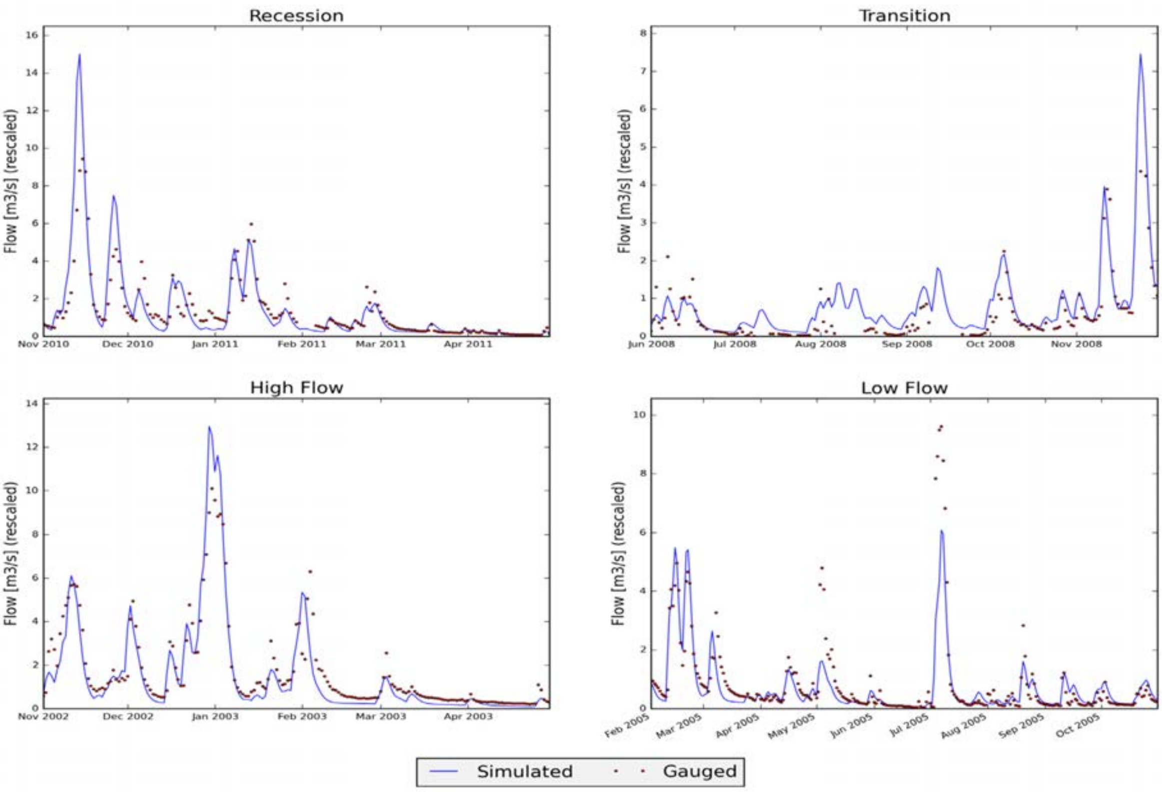


Figure 37 – Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V05HEU403210, station 40310102 - Heulebeek; Heule



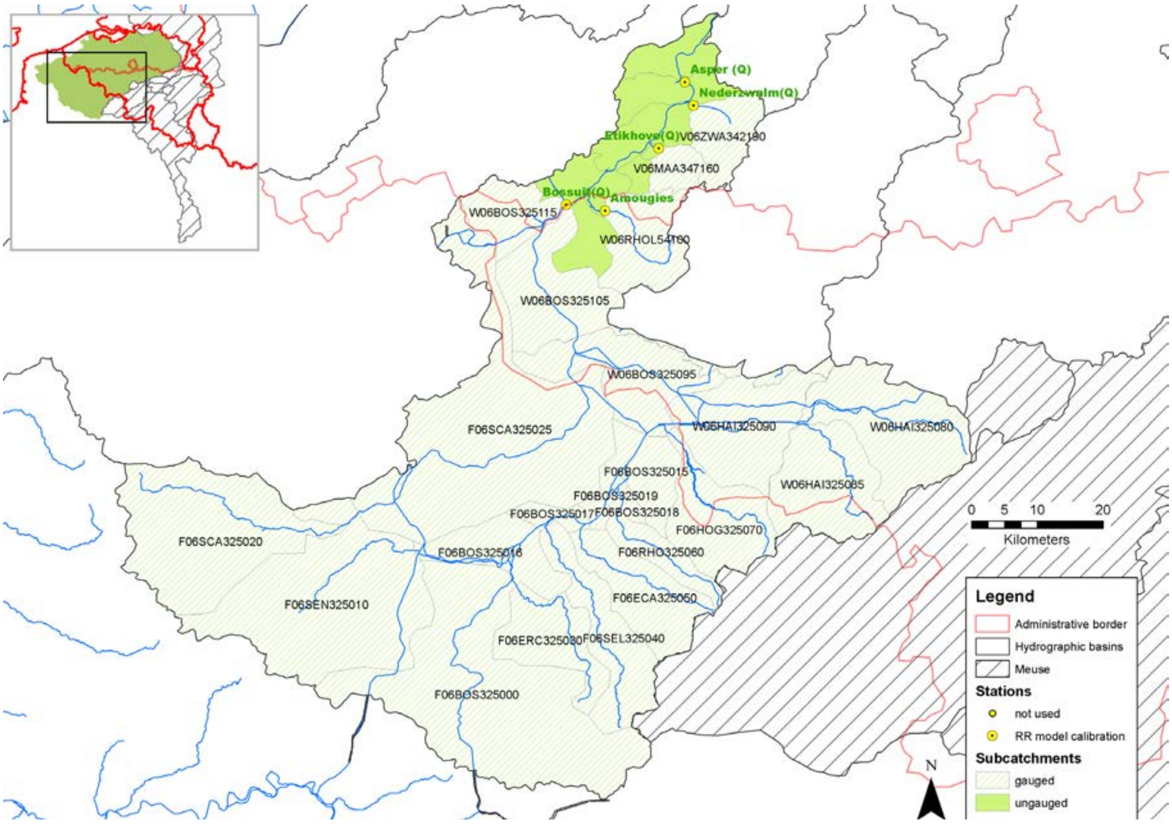
6.8 Bovenschelde

6.8.1 Context

The Bovenschelde basin extends over France, Wallonia and Flanders. This basin has an area of approximately 576 km². Before it enters Flanders in Spiere-Helkijn, the Scheldt has a length of 124 km and a corresponding 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 38 shows the location of the catchments and measuring points on the Bovenschelde basin. Actually, the subcatchments upstream from the station in Bossuit (32580122) can be seen as one gauged subcatchment. However, as stated before, the discharge is simulated separately for each subcatchment to generate input for the water allocation model. The total surface area considered gauged is thus 97 % (Figure 38).

Figure 38 – Subcatchments and measurement points on the Bovenschelde catchment



6.8.2 Model performance

Table 16 and Table 17 present general performance statistics for the gauged catchments of the Bovenschelde basin for the calibration and validation period. Graphs of simulations of the catchments **V06ZWA342190** (best performance) and **V06MAA347160** (worst performance) are presented below (Figure 39 to Figure 44). For more detailed results on the other catchments, see Annex 8.

Adequate modelling was achieved for the catchments **F06BOS325001** and **V06ZWA342190**, although no validation was done in F06BOS325001 due to the absence of additional data besides the calibration period. Worse results were found for V06MAA347160 and W06RHOL54100. There is a an important error on the water volume during validation of the catchment **V06MAA347160**. A large portion of this difference of balance happens in 1993 and 1994 and might be accentuated due to wrong observations at that time. As shown in Figure 42 and Figure 44, discharge during recession is correctly modelled for most of the other years of data. Note that no better could be achieved with a NAM structure, which suggest that the catchment has somewhat unexpected behaviour. The contribution of this subcatchment to discharge of the Scheldt during low flows is low however.

In **W06RHOL54100**, with a gauge located in Amougies (Wallonia), there is a general underestimation of the total flow due to poor flow peak modelling in the years of 2004 to 2008.

Remarks on the data: The station 32580122 on the Bovenschelde in Bossuit **(F06BOS325001)** only has records from 13/09/2001 onwards. The catchment **W06RHOL54100** only has observed discharge data from January 2000 onwards. Using the usual 2001-2013 period for calibration, there is therefore only one year of extra data for validation.

Discharge of the Maarkebeek in Etikhove (**V06MAA347160**) was estimated in 2005 and discharges above 12 m^3/s are mostly estimated.

In Nederzwalm (**V06ZWA342190**), suspicious data was removed in 1982; moreover, data records start to be more unstable and regularly interpolated from August 2012 onwards. Therefore, the year 2013, where the most records were missing or interpolated, is excluded from both calibration and validation periods.

Table 16 – Overview of calibration results for gauged catchments on the Bovenschelde basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Calibration period**	**Approx. distance to rain gauge over calibration period (km)**
32580122 - Bovenschelde; Bossuit	**F06BOS325001**	5217.6	0.59	0.67	-4.8%	0.3%	2002-2013	*Irrelevant given the size of the basin*
34710102 - Maarkebeek; Etikhove	**V06MAA347160**	48.7	0.41	0.61	0.7%	1.1%	2001-2013	6
34210102 - Zwalm; Nederzwalm	**V06ZWA342190**	112.1	0.69	0.71	-3.3%	-2.9%	2000-2012	7
L5412 Amougies - Rhosnes	**W06RHOL54100**	161.9	0.45	0.60	-0.9%	12.8%	2000-2013	< 1999 : 3 1999 - 2000 : 6 2000 - 2009 :13 >=2009 : 5.5

Table 17 – Overview of validation results for gauged catchments on the Bovenschelde basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Validation period**
32580122 - Bovenschelde; Bossuit	**F06BOS325001**	5217.6	No validation in Bossuit				
34710102 - Maarkebeek; Etikhove	**V06MAA347160**	48.7	0.43	0.58	-19.6%	-17.5%	1972-2013
34210102 - Zwalm; Nederzwalm	**V06ZWA342190**	112.1	0.65	0.56	12.2%	6.0%	1973-2013
L5412 Amougies - Rhosnes	**W06RHOL54100**	161.9	0.44	0.61	-2.7%	12.9%	2000-2013

34210102 - Zwalm; Nederzwalm (V06ZWA342190)

Figure 39 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (2000-2012)

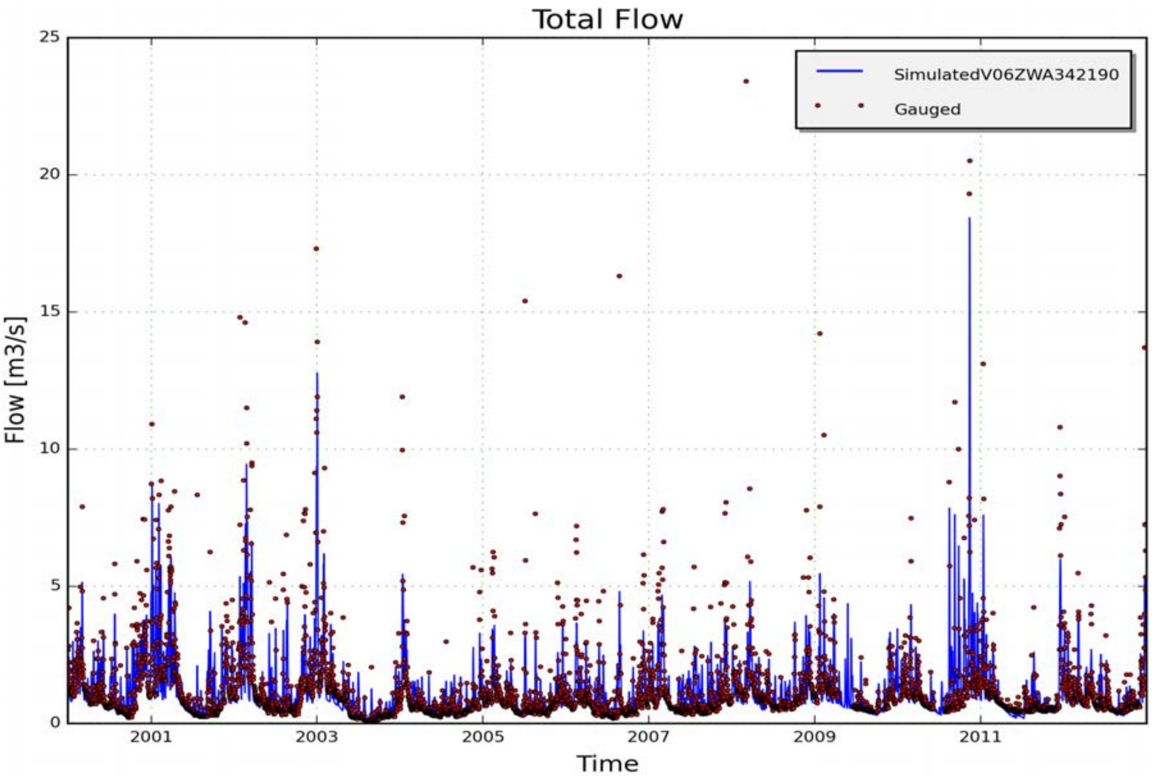


Figure 40 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (2000-2012)

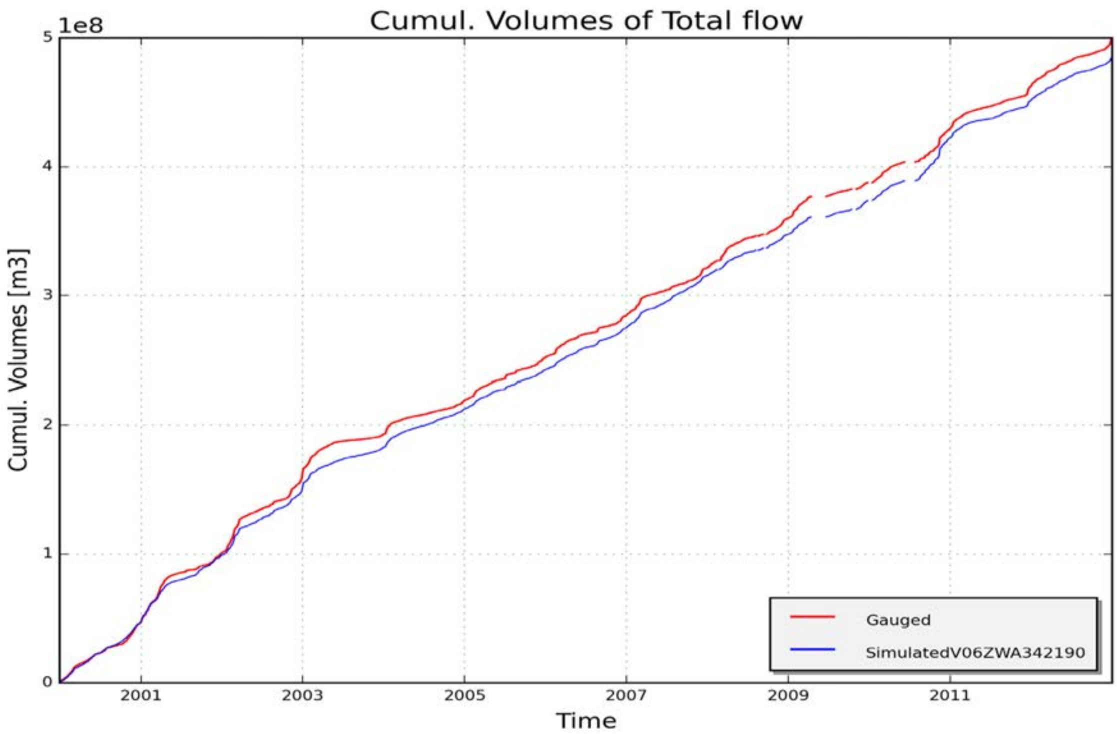
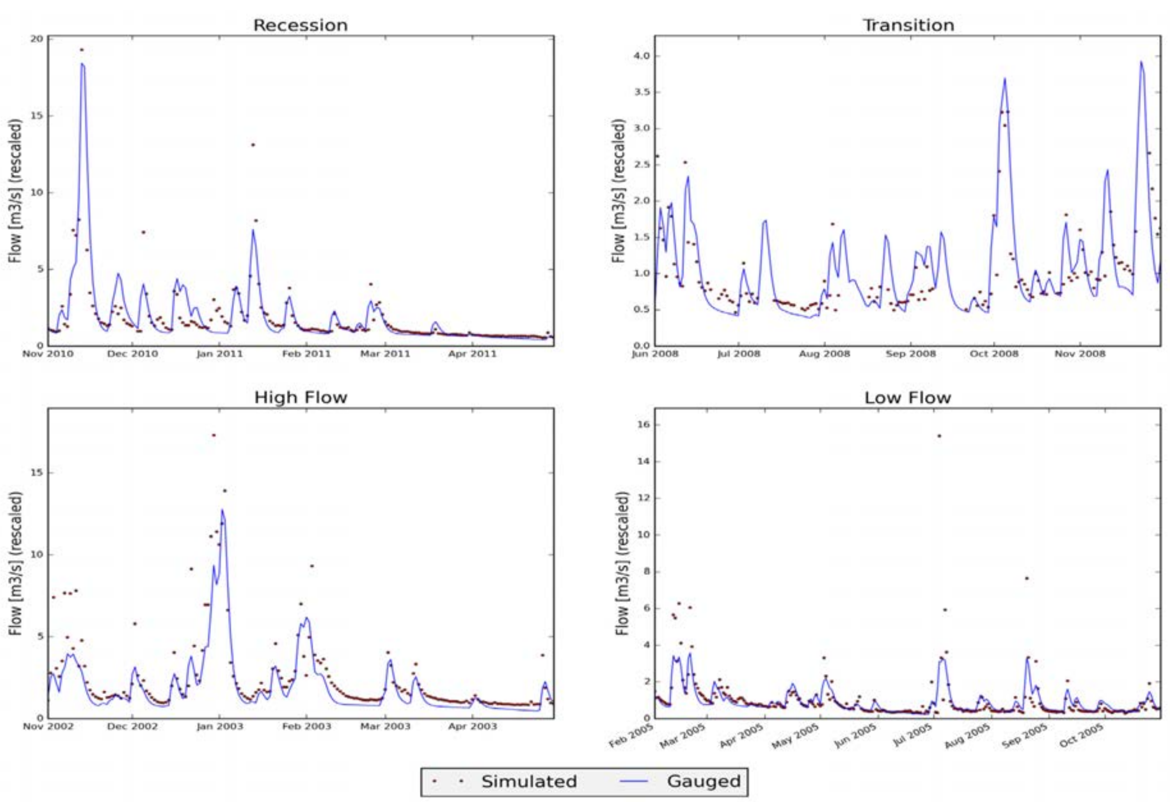


Figure 41 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (calibration period)



34710102 - Maarkebeek; Etikhove (V06MAA347160)

Figure 42 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove (2001-2013)

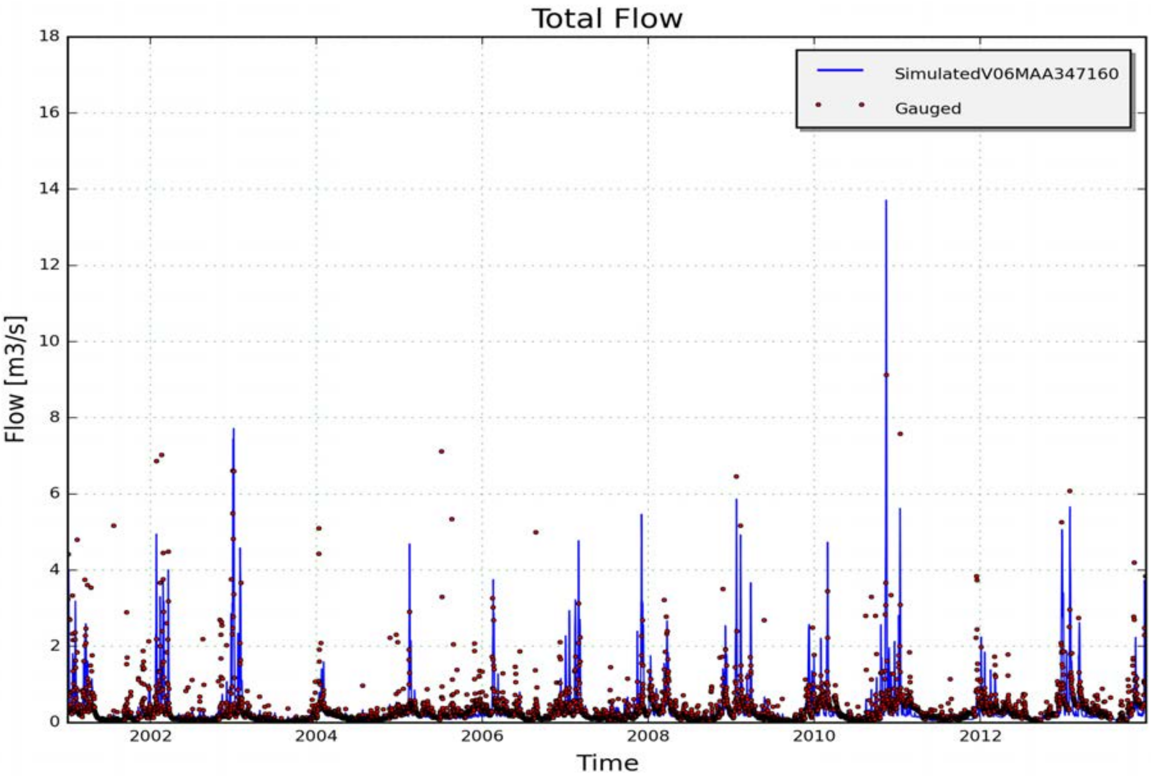


Figure 43 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V06MAA347160, station station 34710102 - Maarkebeek; Etikhove (2001-2013)

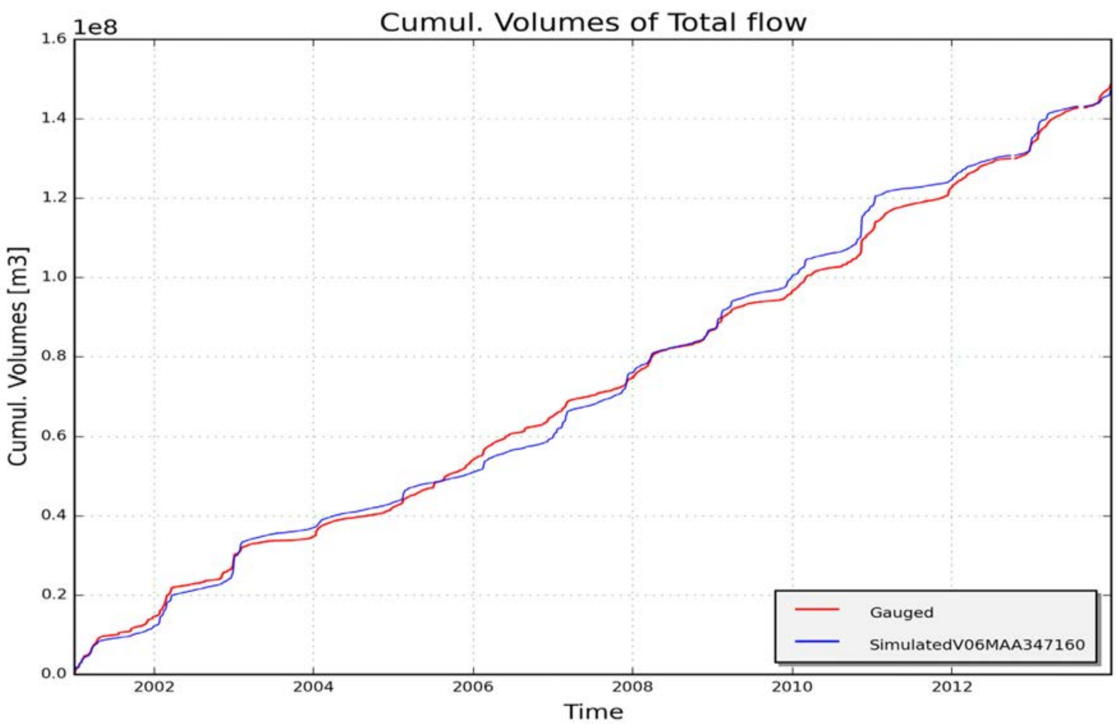
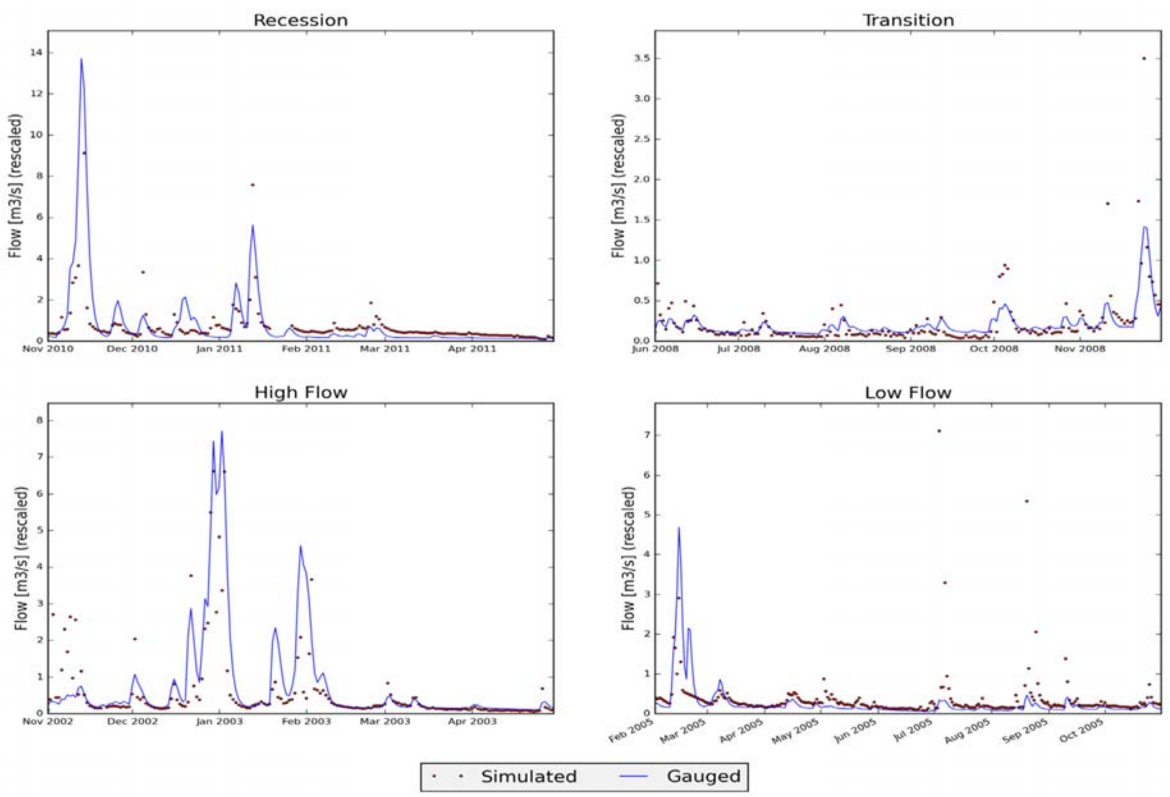


Figure 44 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove



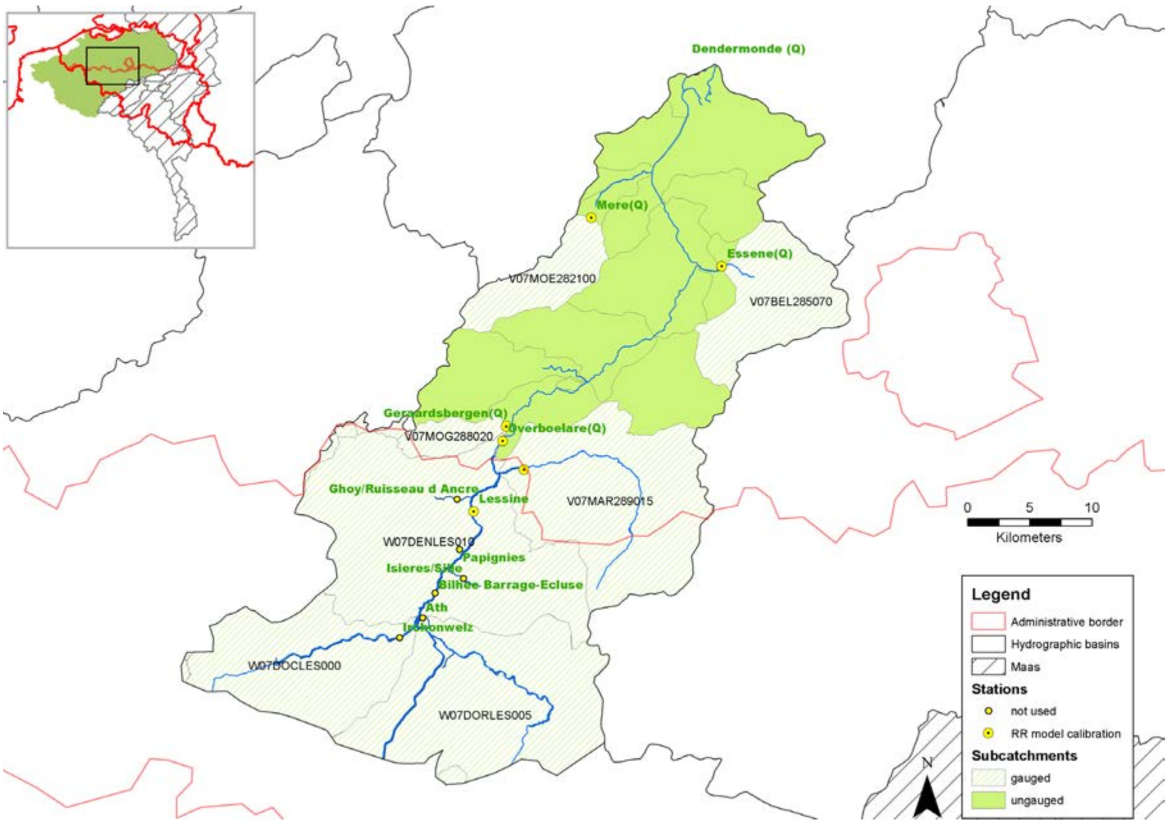
6.9 Denderbekken

6.9.1 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 45 – Subcatchments and measurement points in the Dender catchment



6.9.2 Model performance

Table 18 and Table 19 present the general performance statistics for the gauged catchments of the Dender basin for the calibration and validation periods. Graphs of simulations for the catchments **V07MAR289015** (best model performance) and **V07MOG288020** (worst model performance) are presented below (Figure 46 to Figure 50). More detailed results on the other catchments is in Annex 9.

PDM model calibration was not easy for the subcatchments of the Dender basin. Model performance is overall satisfactory for low flows (high log NSE) but high and intermediate flows are sometimes poorly simulated. Loss of goodness-of-fit from calibration to validation remains limited showing that the models, however limited for reproducing peaks, are robust across the full period with discharge data.

Remarks on the data: For the gauging station 28210102 on the Molenbeek in Erpe Mere (**V07MOE282100**), high discharge values are unreliable above 5m3/s from 1999 to 2003 and in 2005. Discharge data was discarded from 27/10/2009 until 15/06/2011 in the WISKI series. Consequently, the calibration period was limited to 2009. Years 2012 and 2013 have a lot of missing data and interpolated values and show an unusual high-base flow behaviour. They were therefore excluded from both validation and calibration.

For discharge measurements in Geraardsbergen (**V07MOG288020)**, the years after 2009 have been deleted due to the existence of unreliable measured discharge data and therefore the calibration series starts in 2007. In 1999, high discharge values were estimated (above 2.7 m3/s). In 2000 and 2001, high values were estimated with lower accuracy. From 2000 to 2002, low flows measurements had to be corrected because the gauge did not measure low levels adequately.

The discharge data in Lessines start in 15/01/2008 for catchment **W07DENLES004**. Calibration therefore limited to 2008-2013. Validation will happen in Overboelare for both **W07DENLES004 and V07MAR289015.**

Table 18 – Overview of calibration results for gauged catchments on the Dender basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Calibration period**	**Approx. distance to rain gauge over calibration period (km)**
28510102 - Bellebeek, Essene	**V07BEL285070**	88,7	0.523	0.728	0.4%	-0.7%	2001-2013	8
28970102 - Mark, Viane	**V07MAR289015**	173,9	0.585	0.702	-2.6%	1.2%	2001-2013	< 2003 : 12 2003 - 2011: 10 >=2011 :2
28210102 - Molenbeek, Erpe Mere	**V07MOE282100**	46.4	0.606	0.663	-6.4%	-0.6%	1997-2009	< 2004 :10 >= 2004 : 5
28810102 - Molenbeek, Geraardsbergen	**V07MOG288020**	23.1	0.331	0.703	3.0%	6.6%	1997-2009	< 2009 :3 >= 2009 : 15
27081002 – Dender, Lessines	**W07DENLES004**	511.8	0.47	0.66	4.9%	-1.4%	2008-2013	*Irrelevant given the size of the basin (max 16 km)*

Table 19 – Overview of validation results for gauged catchments on the Dender basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Validation period**
28510102 - Bellebeek, Essene	**V07BEL285070**	88.7	0.454	0.644	-7.7%	-3.9%	1973-2013
28970102 - Mark, Viane	**V07MAR289015**	173.9	0.635	0.636	2.4%	3.0%	1977-2013
28210102 - Molenbeek, Erpe Mere	**V07MOE282100**	46.4	0.596	0.689	1.4%	1.3%	1986-2009
28810102 - Molenbeek, Geraardsbergen	**V07MOG288020**	23.1	0.093	0.597	-3.2%	3.1%	1986-2013
26880122 – Dender, Overboelare	**W07DENLES004**	799.2	0.467	0.667	5.2%	-1.3%	2001-2013

28970102 - Mark, Viane (V07MAR289015)

Figure 46 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07MAR289015, station 28970102 - Mark, Viane (2001-2013)

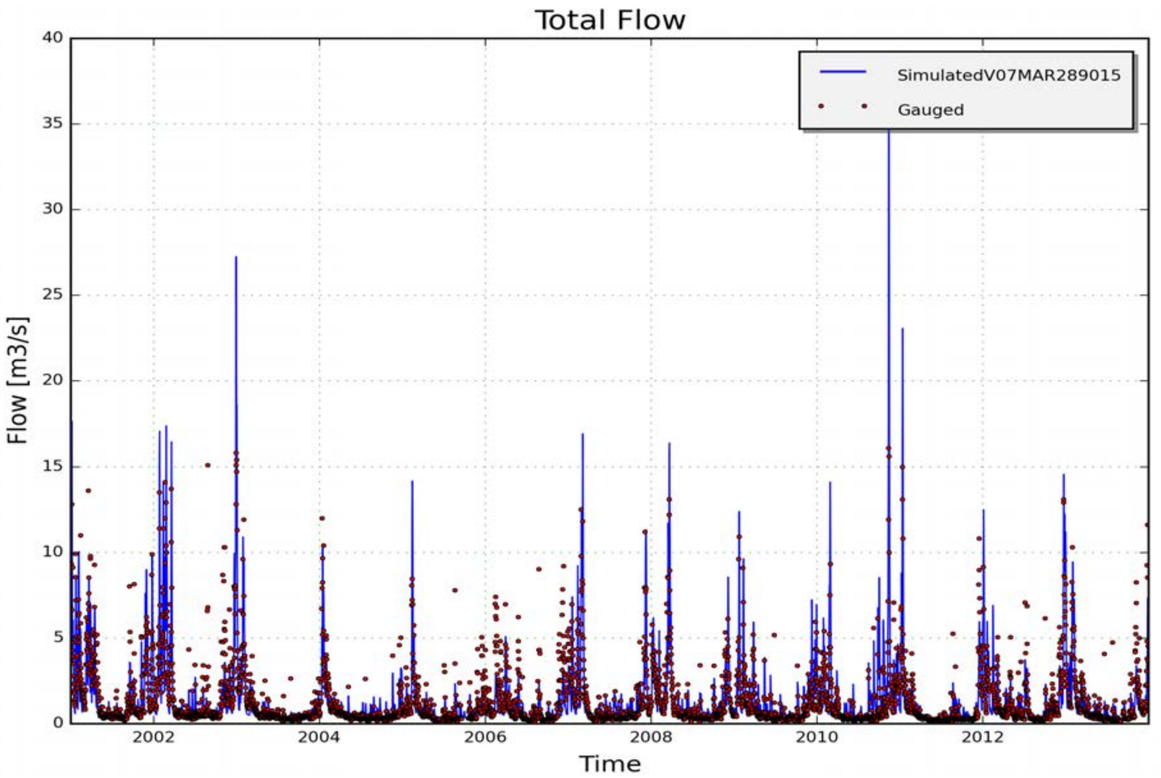


Figure 47 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07MAR289015, station 28970102 - Mark, Viane (2001-2013)

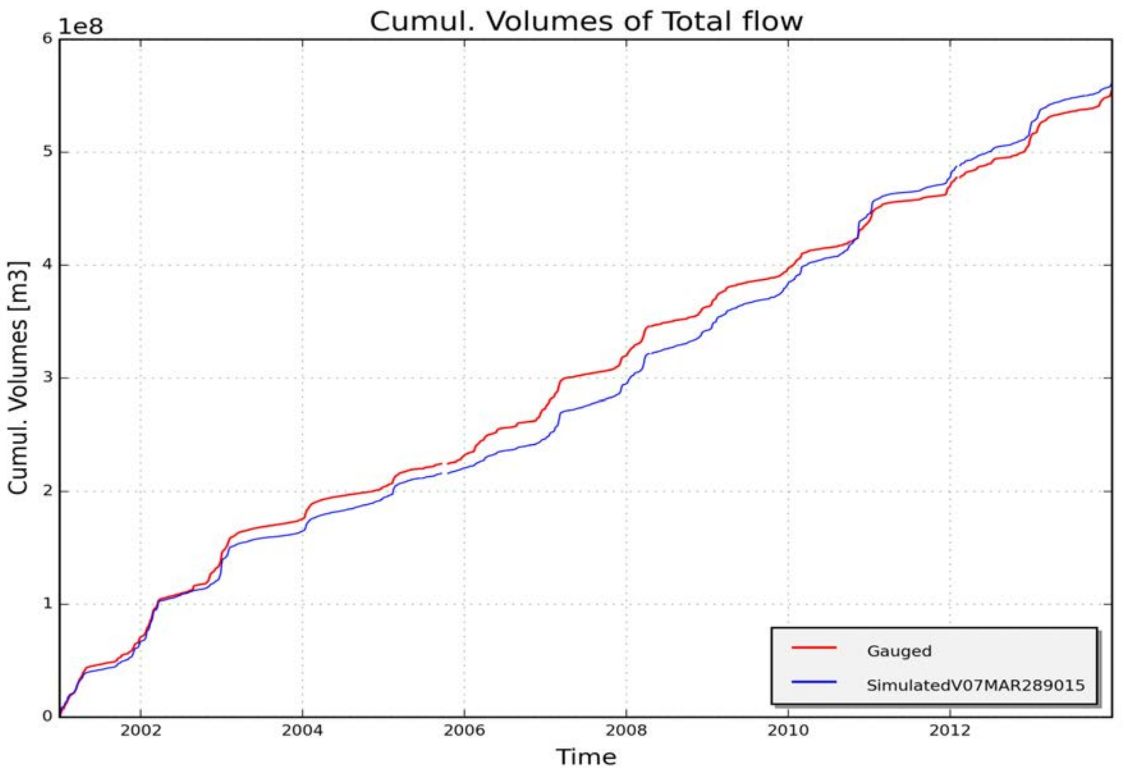
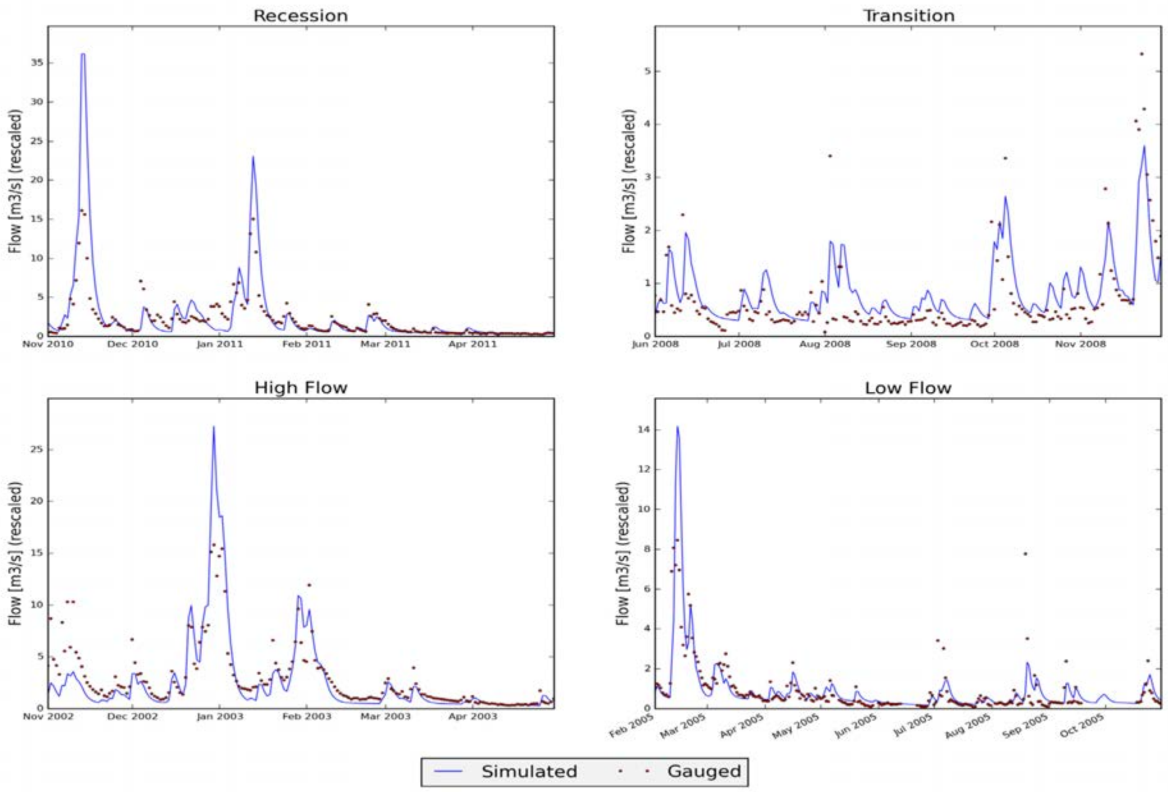


Figure 48 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MAR289015, station 28970102 - Mark, Viane



28810102 - Molenbeek, Geraardsbergen (V07MOG288020)

Figure 49 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen(1997-2009)

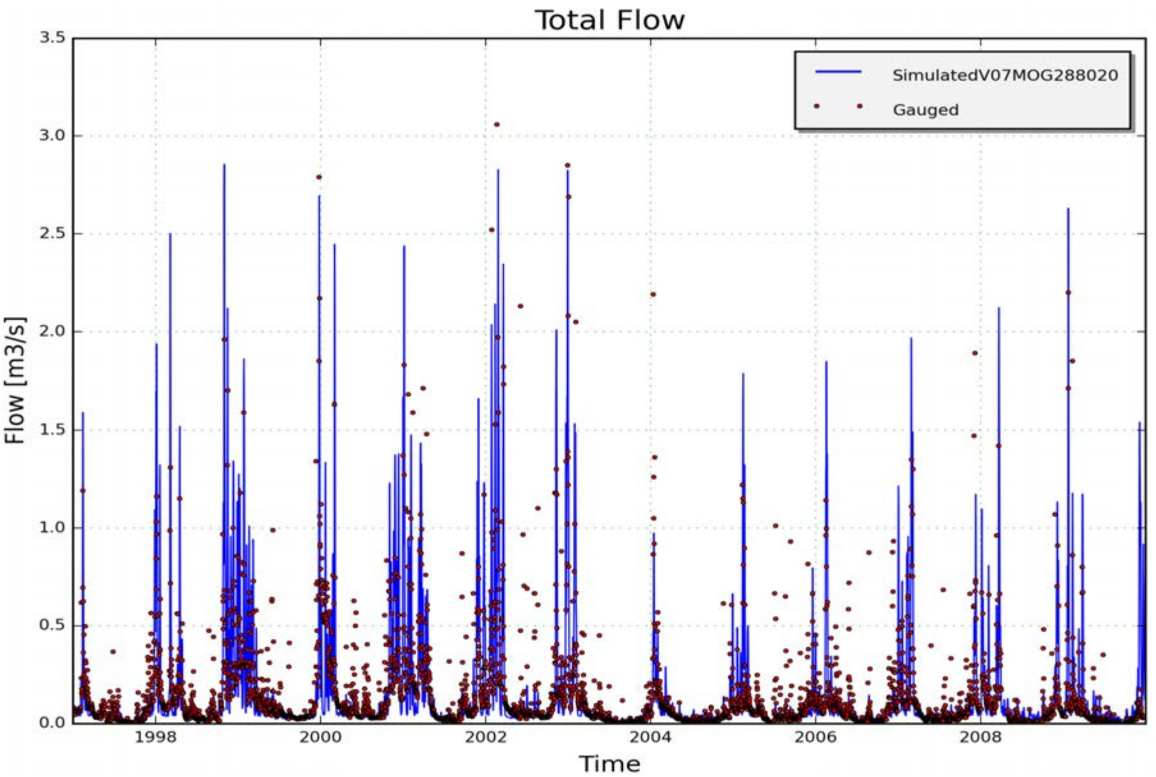


Figure 50 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen (1997-2009)

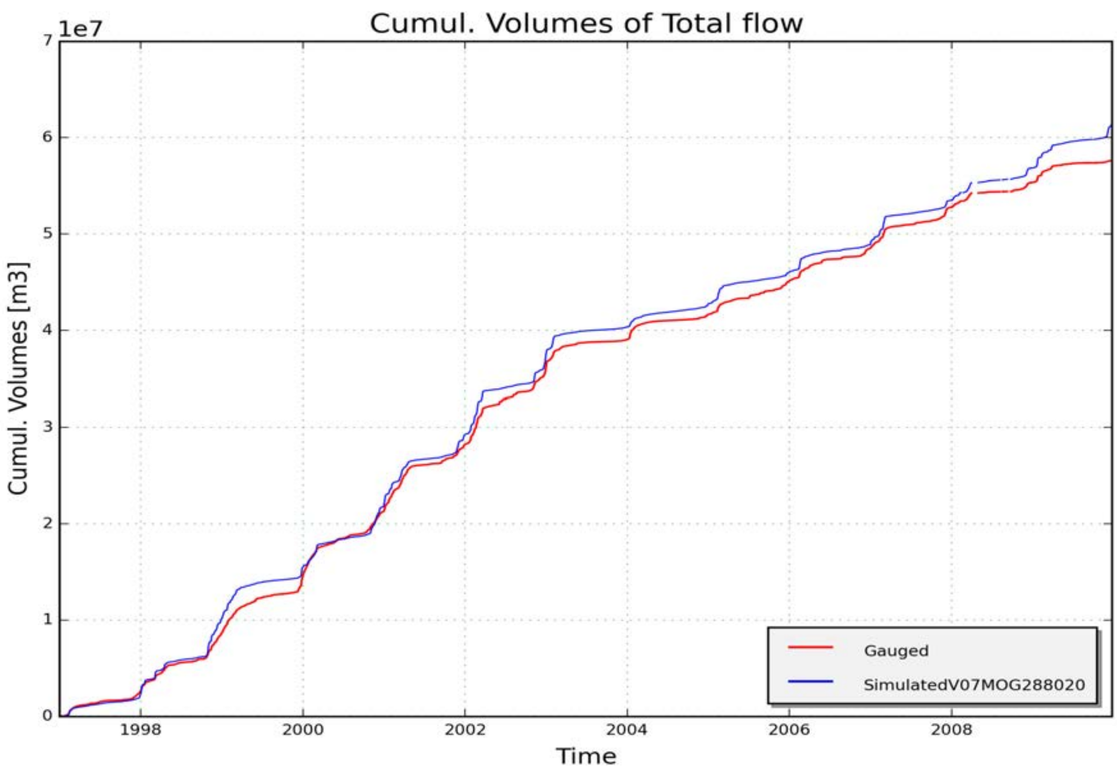
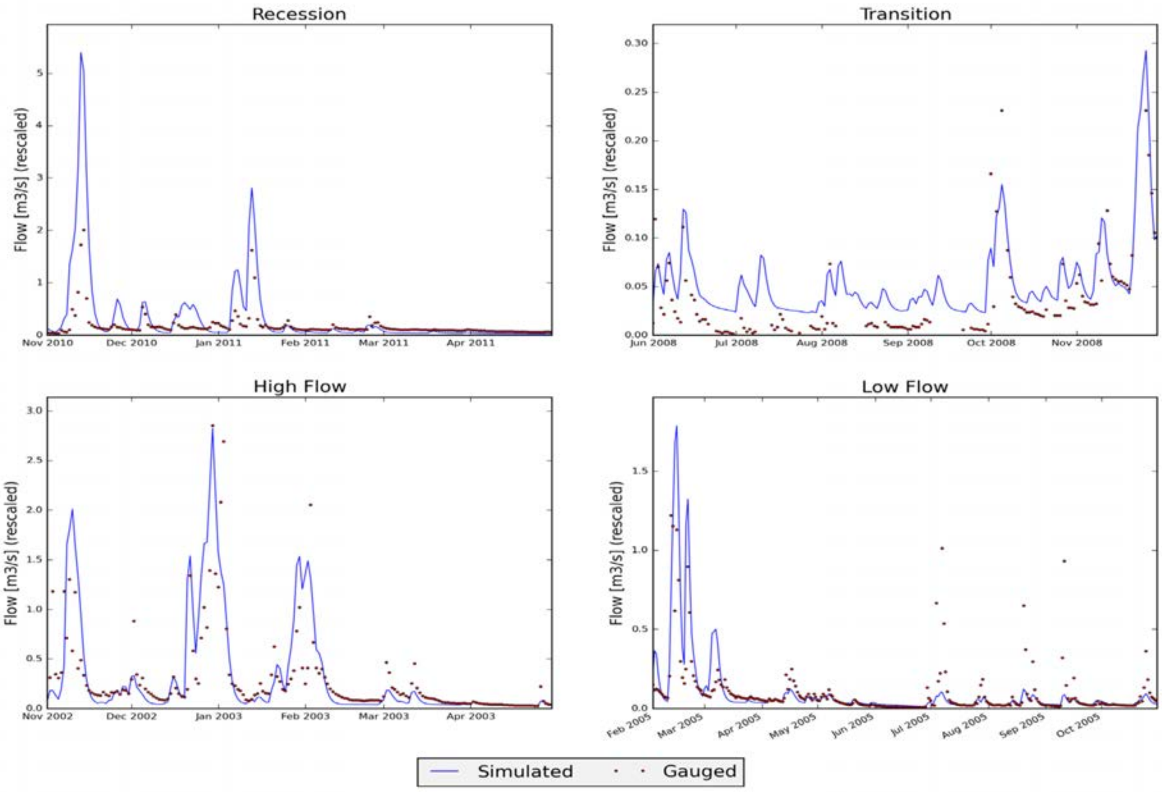


Figure 51 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen



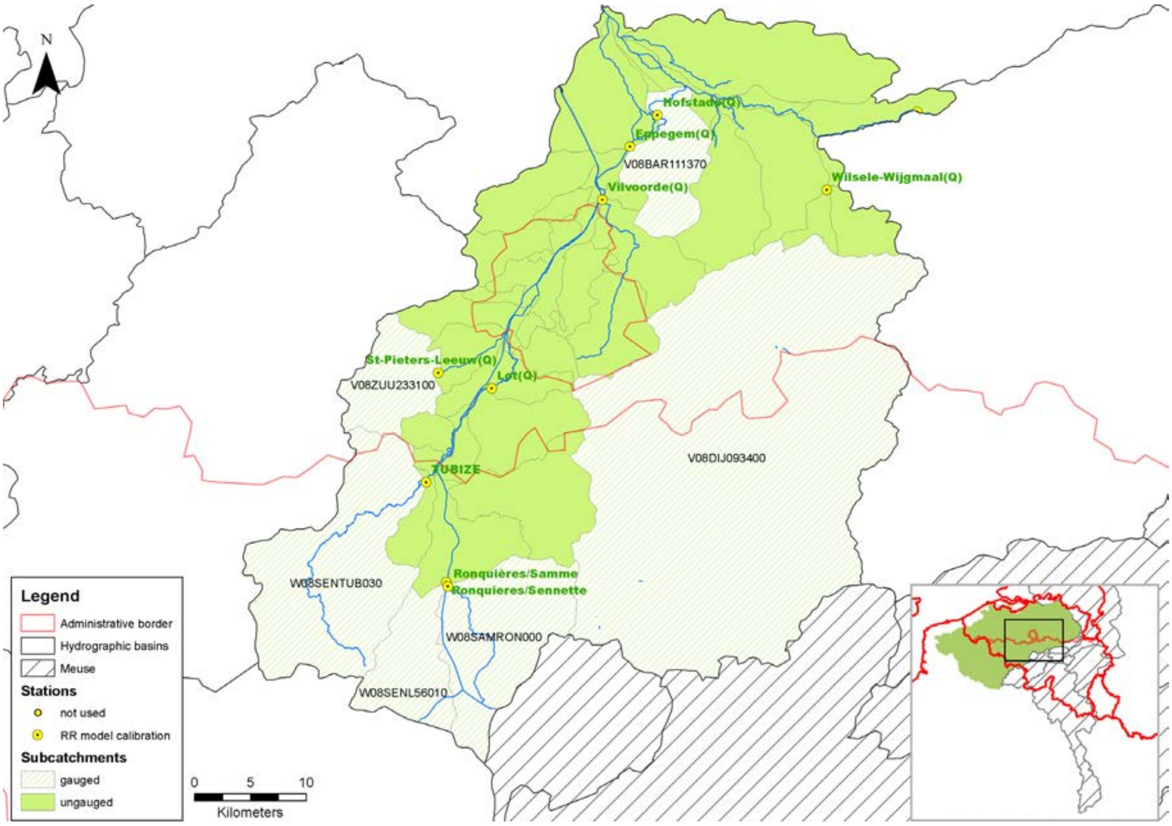
6.10 Dijle and Zenne

6.10.1 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 at Figure 52. 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 52 – Subcatchments and measurement points on the Dijle and Zenne catchment



6.10.2 Model performance

Table 20 and Table 21 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 **W08SENTUB030** (best model performance) and **W08SENRON010** (worst model performance) are presented below (Figure 53 to Figure 57). For more detailed results on the other catchments, see Annex 10.

The catchments **V08BAR111370**, **V08ZUU233100** and **W08SENTUB030** have adequate model performance with NSE and LogNSE values above 0.6. This with the exception of V08ZUU233100, but for the project purpose this hydrological model can even though be considered as adequate as low flows are correctly represented. Overall, all the catchments follow the same pattern as there is a general flow underestimation during the period comprised between 2004 and 2010 and flow overestimation afterwards (i.e. V08ZUU233100 and W08SENTUB030).

W08SAMRON000 shows low NSE and unsatisfactory water balance for calibration. The balance improves for the validation period however, proving the robustness of the model despite frequent overestimation of winter flow peaks**.**

Automatic calibration lead to poor fit of the model for the catchment with code **W08SENRON010,** especially for low flows (Figure 56 and Figure 57). For instance, discharge is underestimated from 2003 and overestimated from 2010. The same trend was observed for NAM calibration as well, which suggests that the cause of the errors might be related to data quality.

The catchment of the Dijle in Wilsele is also known to be difficult to model (**V08DIJ093400).** Calibration based on the period between 2002 and 2014 lead to poor results (Figure 58 and Figure 59). Some explanations were already considered in a previous report to explain the mismatch between the observed and simulated discharge data (de Boeck et al., 2010). Firstly, the poor results were attributed to the effect of vegetation in the gauging station, which may influence the measurements and result in a bad q(h)-relationship. Another possible explanation is the fact of a dam construction in Rotselaar in 1994, which would make the relationship no longer valid and the influence of a large sewage plant whose effluent enters upstream the measurement station in the Dijle in Wilsele. Therefore, we prefer to calibrate this catchment based on the most recent years of 2013 until mid-2015 considered more reliable (Figure 60).

Remarks on the data: The Barebeek catchment (**V08BAR111370)** has measured discharge data from 02/01/1997 to 04/11/2004 only. This entire period was used for calibration. The catchment **W08SAMRON000** does not have data after 2010. A 13-year calibration period was therefore selected from 1998 to 2010.

For **V08ZUU233100,** most of discharge records were estimated or suspect from August 2005 to May 2006. It is suspect in the summer of 1994 and 2008 as well as 2009 (June to November). Measured flow is also suspiciously constant in the spring of 2003 with a lot of repeated records from April to December 2003. This period seems therefore less trustworthy.

Discharge of the Dijle (**V08DIJ093400**) is measured by a VMM station in Wilsele, where measurements are known to be disturbed by plant growth. Corrections were made by the VMM to account for this effect but with limited accuracy. Data quality is poor or suspect on most years until 2013. Therefore, the rainfall and potential evapotranspiration time series were exceptionally extended in order to have two years and a half of reliable data (2013-mid 2015).

Table 20 – Overview of calibration results for gauged catchments on the Dijle and Zenne basins

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Calibration period**	**Approx. distance to rain gauge over calibration period (km)**
11110102-Barebeek, Hofstade (Elewijt)	**V08BAR111370**	70.0	0.72	0.81	1.4%	-4.3%	1997-2004	7
9310102 - Dijle, Wilsele	**V08DIJ093400**	861,4	0.62	0.63	2.5%	-1.6%	2013-2015	*Irrelevant given the size of the basin (max 12)*
23310102 - Zuunbeek, St Pietersleeuw	**V08ZUU233100**	64,8	0.49	0.64	0.9%	7.5%	2001-2013	< 2007 : 12 2007 - 2009 : 10 > 2009 : 10
2371-10050 Samme, Ronquieres	**W08SAMRON000**	134,0	0.44	0.70	5.6%	9.4%	1998-2010	< 2008 : 4 2008 - 2010 : 8 > 2010 : 5
L5670 -Senette, Ronquieres	**W08SENRON010**	70,4	0.57	0.40	-1.7%	4.9%	2001-2013	< 2002 : 2 2002-2006 : 8 > 2006 : 11
1951-10050 Zenne, Tubize	**W08SENTUB030**	215,9	0.75	0.76	-2.1%	-1.2%	2001-2013	6

Table 21 – Overview of validation results for gauged catchments on the Dijle and Zenne basins

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr (%)**	**VolBias (%)**	**Validation period**
11110102-Barebeek, Hofstade	**V08BAR111370**	70.0	0.72	0.81	1.5%	-4.3%	1997-2004
9310102 - Dijle, Wilsele	**V08DIJ093400**	861,4	0.62	0.56	-1.3%	-0.9%	1974-2013
23310102 - Zuunbeek, St Pietersleeuw	**V08ZUU233100**	64,8	0.24	0.64	27.2%	20.7%	1985-2013
2371-10050 Samme, Ronquieres	**W08SAMRON000**	134,0	0.45	0.72	-3.2%	3.1%	1999-2010
L5670 -Senette, Ronquieres	**W08SENRON010**	70,4	0.45	0.45	-10.4%	-6.5%	1977-2013
1951-10050 Zenne, Tubize	**W08SENTUB030**	215,9	0.71	0.74	-9.0%	-6.9%	1975-2013

6.10.2.1 1951-10050 Zenne, Tubize (W08SENTUB030)

Figure 53 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize(2001-2013)

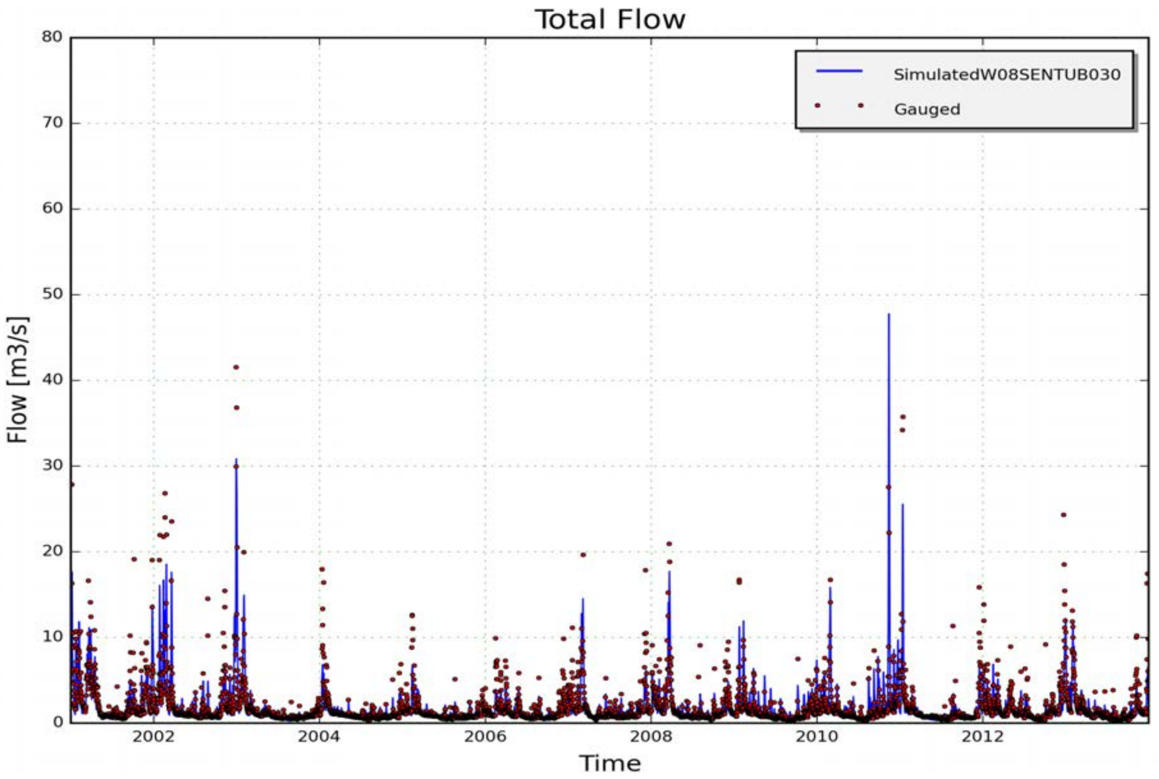


Figure 54 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize (2001-2013)

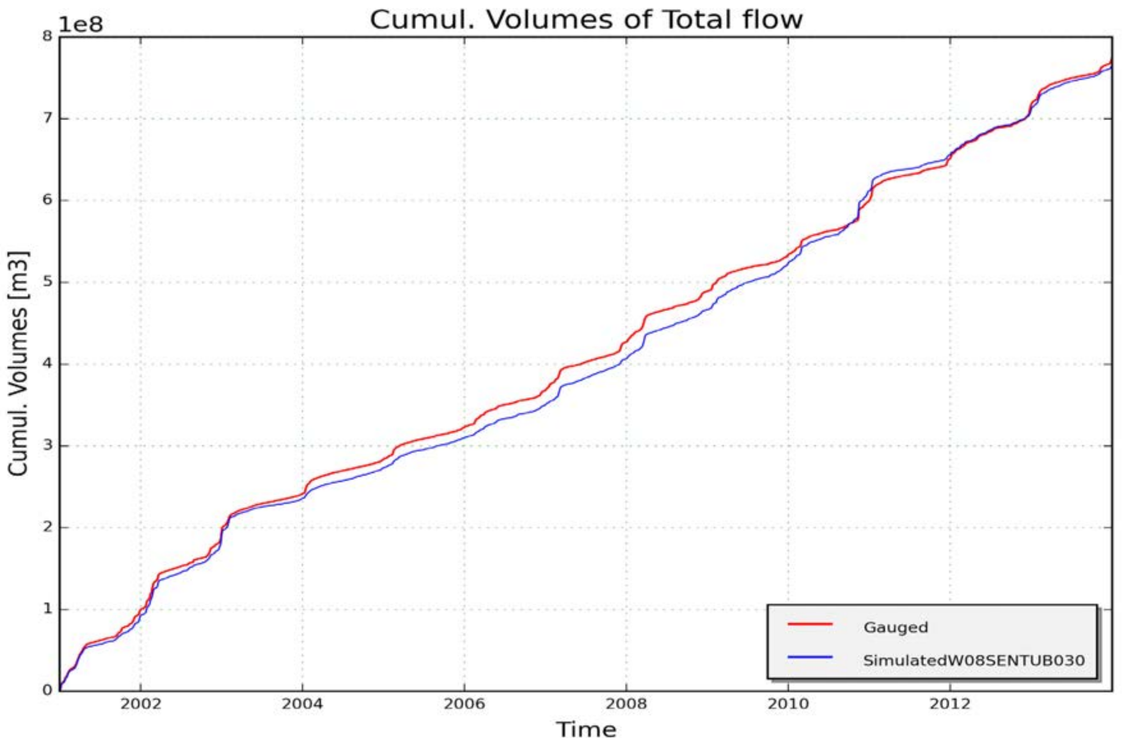
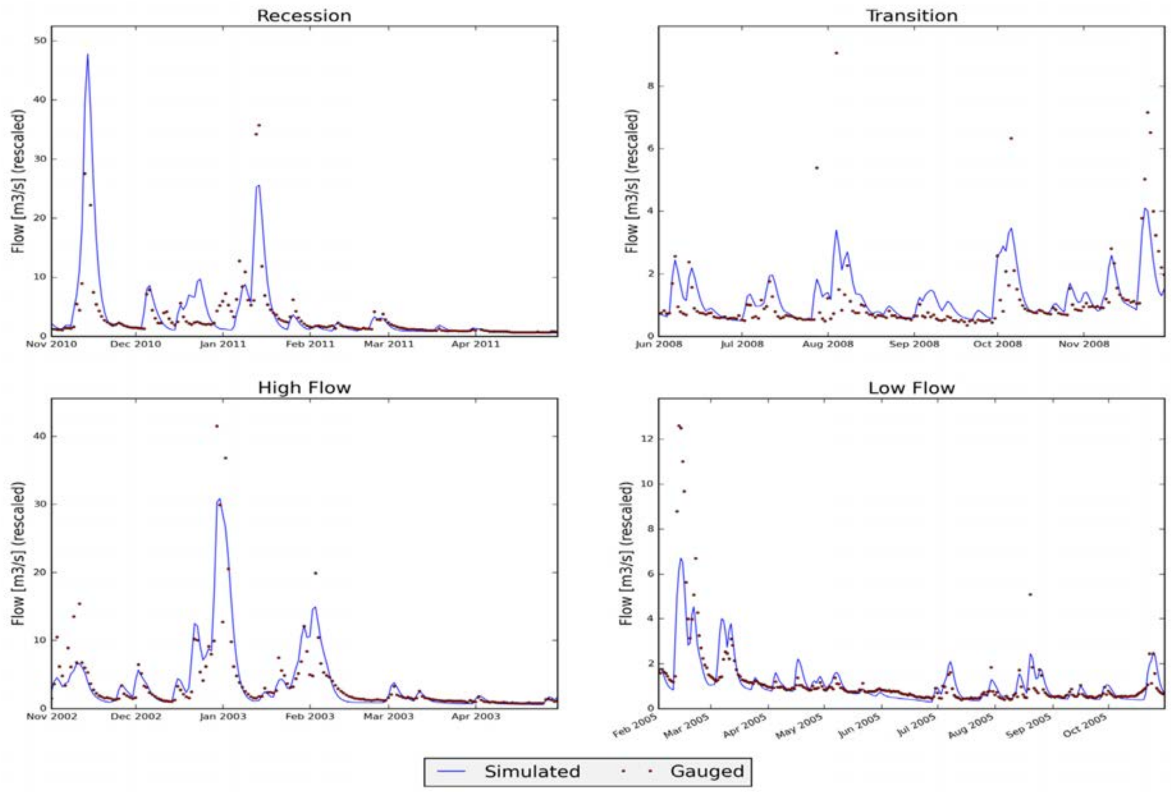


Figure 55 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize



6.10.2.2 L5670 -Senette, Ronquieres

Figure 56 – Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W08SENRON010, station L5670 -Senette, Ronquieres(calibration period)

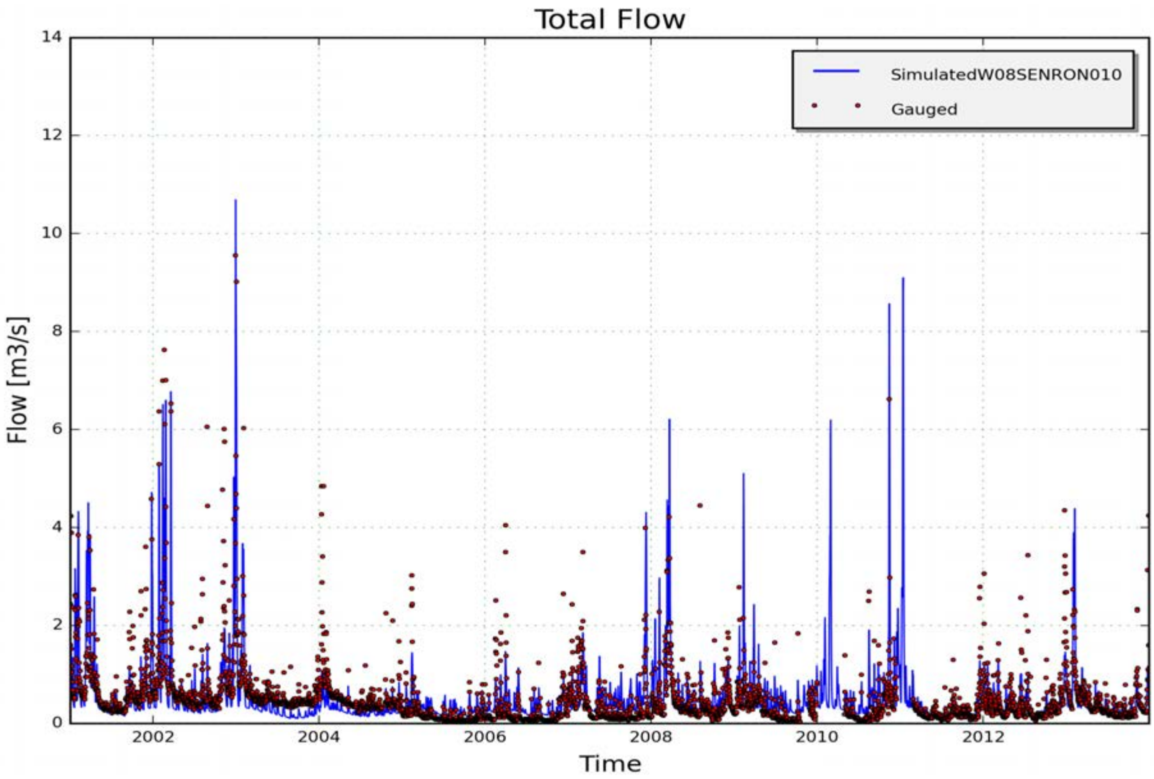
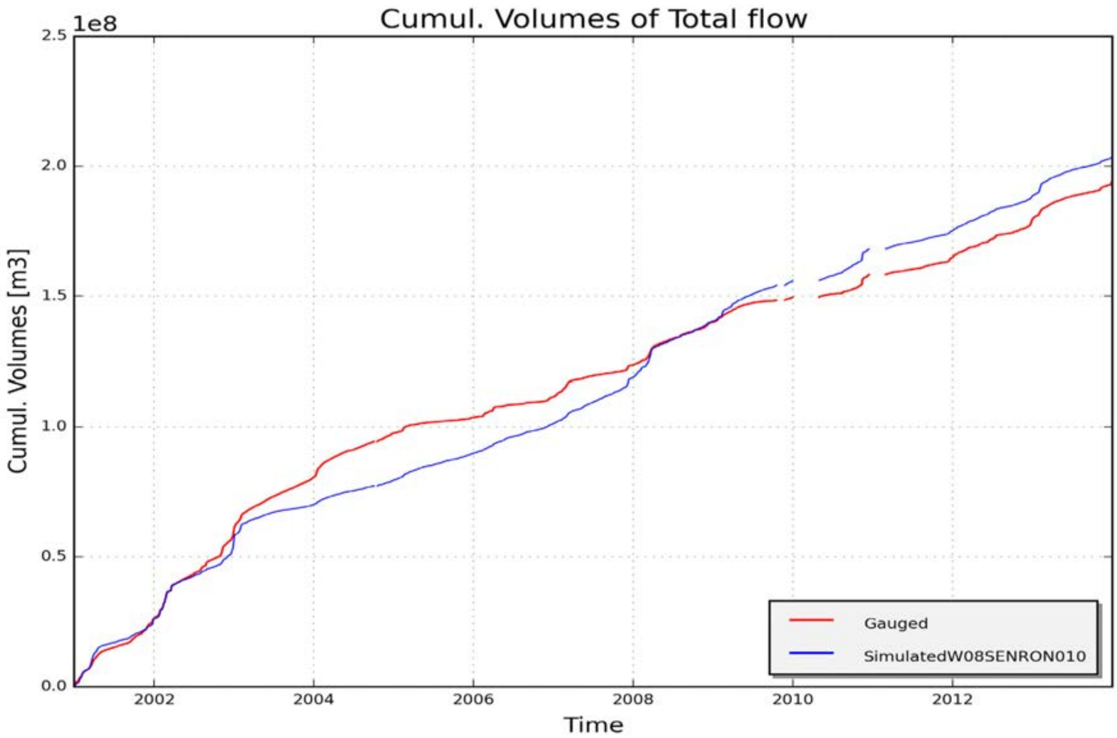


Figure 57 – Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W08SENRON010, station L5670 -Senette, Ronquieres (calibration period)



9310102 - Dijle, Wilsele

Figure 58 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08DIJ093400, station 9310102 - Dijle, Wilsele (2002-2013)

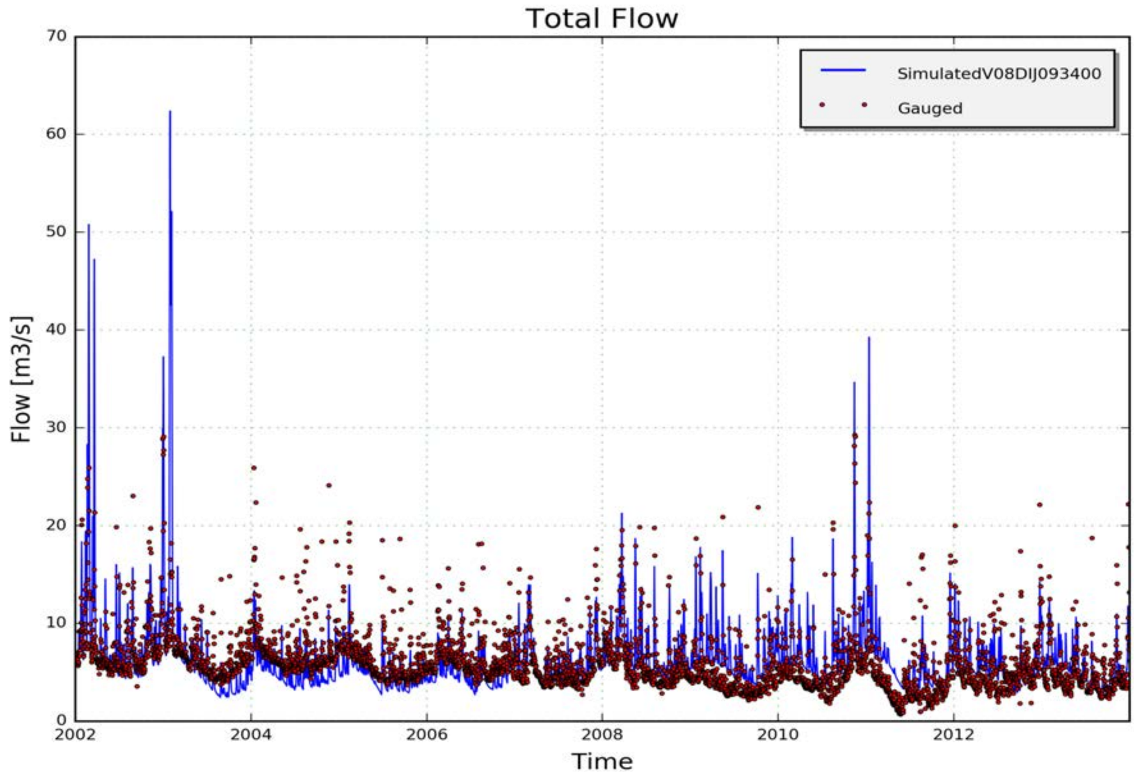


Figure 59 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V08DIJ093400, station 9310102 - Dijle, Wilsele (2002-2013)

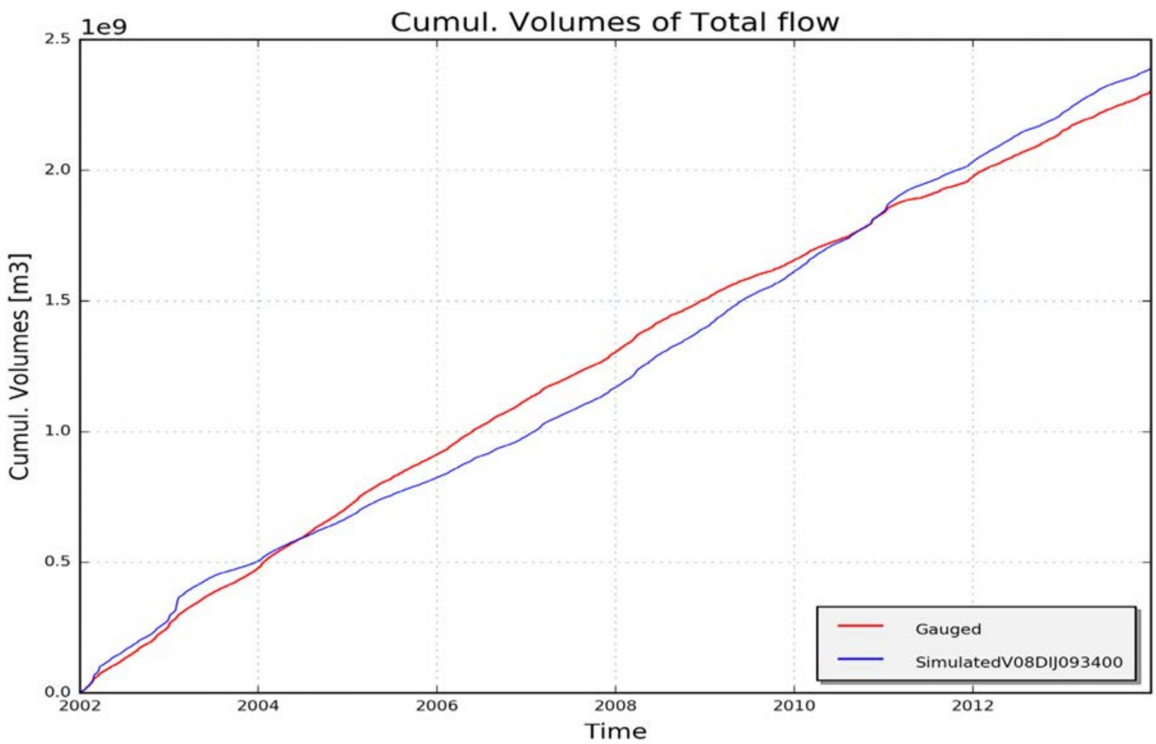
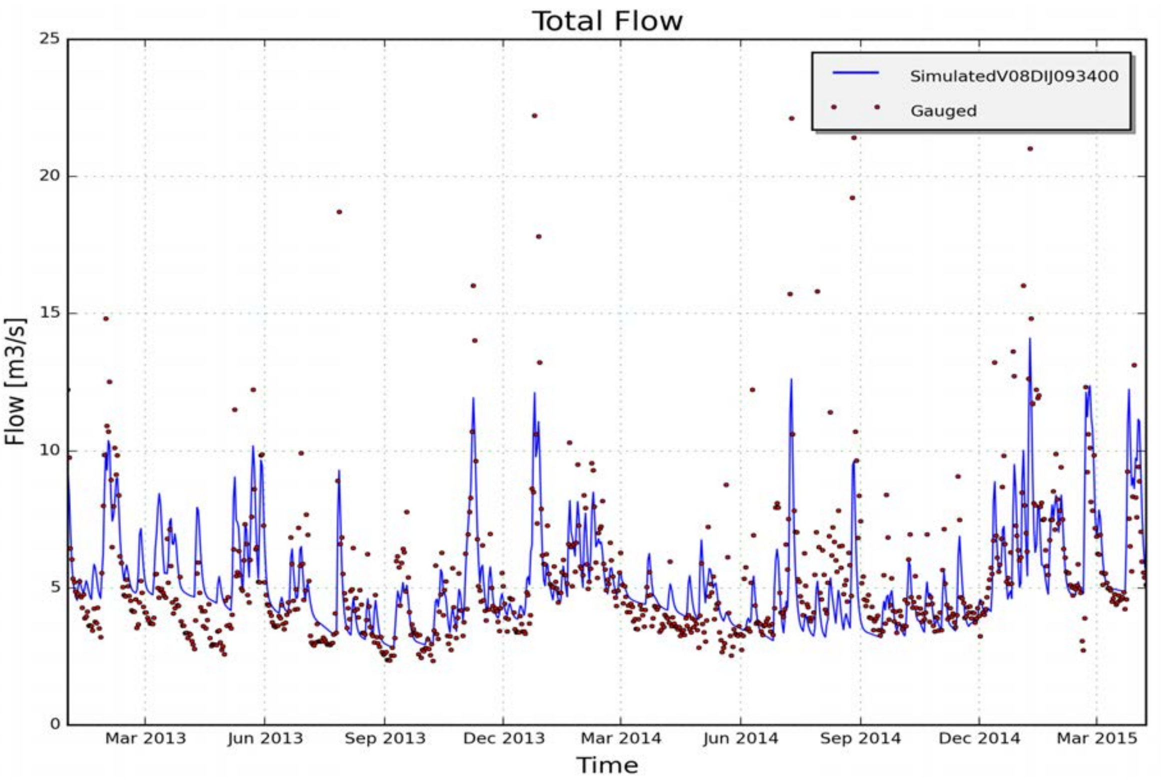


Figure 60 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08DIJ093400, station 9310102 - Dijle, Wilsele, calibration based on 2013 and 2014 only.



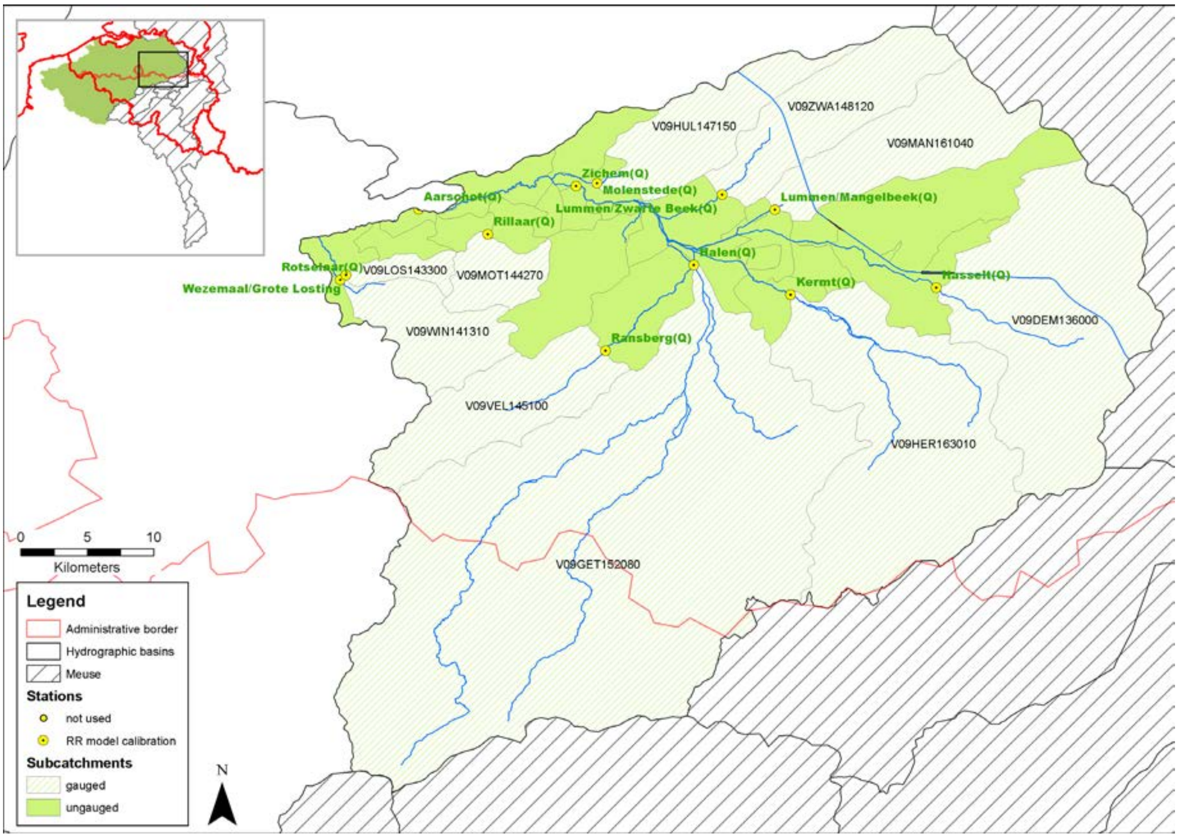
6.11 Demerbekken

6.11.1 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 is gauged. These stations are listed in Table 22 and depicted on Figure 61.

Figure 61 – Subcatchments and measurement points in the Demer catchment



6.11.2 Model performance

Table 22 and Table 23 present general performance statistics for the gauged catchments of the Demer basin for the calibration and validation period. Graphs of the catchments with code **V09HER163010** (best model performance) and **V09ZWA148120** (worst model performance) are presented below (Figure 62 to Figure 67). For more detailed results on the other catchments, see Annex 11.

The catchments with code **V09DEM136000, V09HER163010, V09VEL145100 and V09MOT144270** show a good model performance, with values of NSE and LogNSE close or superior to 0.6 for the calibration period (Table 22). However, all of them present a tendency to overestimate the flow during the period 2001-2003 and 2009-2011.

Although the statistical results are promising for the calibration and validation of the catchment **V09GET152080,** the graphical results show a underestimation of flow during the period 2003-2006 and an overestimation between 2010 and 2012. The catchment with code **V09HUL147150** presents a general underestimation of discharge, especially after the year 2010. The results of the statistical parameters do not reach satisfactory values for the calibration period (2001-2013). Nevertheless, the water balance obtained for the validation period improves considerably, suggesting a deviation in more recent discharge measurements.

The calibration of the total flow for the catchment **V09LOS143300** proved very problematic, possibly due to data quality issues (see remarks below). The behaviour of this catchment was more easily matched by a NAM structure than PDM, which was particularly difficult to calibrate. All indicators are bad for both calibration and validation. This is however a very small catchment.

In the case of the catchment with code **V09MAN161040**, the general behaviour is adequate (NSE=0.60). However, the low flows are not accurately estimated, the LogNSE value is only 0.51 and there is an underestimation of low flows during the years 2005 and 2006, and a overestimation of flows in the most recent years, especially 2009 and 2010.

The general behaviour of the model during the calibration period for the catchment **V09MOT144270** can be considered as adequate. However, low flows are underestimated in some periods of the validation (from 1990 to 1996), resulting in overall underestimation of cumulated volume over the simulation period (RelErr = - 12.4 %).

The model of catchment **V09WIN141310** shows overestimation of the flow during high and moderate flow events, resulting in unsatisfactory NSE coefficient values. Low flows are correctly modelled however in both calibration and validation periods. The increased error in the validation period is caused by a large overestimation of extreme peak flow in 1998.

The NSE and relative error show poor model performance for **V09ZWA148120** for both the calibration and validation periods. Despite high log NSE, this model does not reach the acceptable threshold and the low flows are not very well represented. This catchment caused similar problem for NAM calibration. Because of this, and the presence of several holes in the observed discharge time series make believe that unsatisfactory statistics are due to the data poor quality.

Remarks on the data: Some catchments are calibrated for a different period than usual (2001-2013).

Years 2011-2013 have been deleted from the simulation of the catchment **V09DEM136000** due unreliable (suspiciously high) measured base flow.

The catchment **V09LOS143300** has portions of discharge measurements with moderate to poor quality, or missing values from August 2010, resulting in the years 1997-2010 being used for calibration. Note that data in 2001 and before is unchecked and therefore more uncertain.

The catchment **V09MAN161040** does not have data available from the beginning of 2011 and between 11/05/2003-31/12/2004, so the calibration period 1998-2010 has been used.

In the case of the Herk in Kermt/Spalbeek (**V09HER163010**), data is checked from 2002 until 2016, with the exception of 2010. The calibration period is therefore chosen from 2003 to 2013 in order to ensure maximum reliability during the calibration. The years before are used for validation nevertheless.

There is no observed discharge data for **V09MOT144270** after 2010. High discharge values are estimations above 3 m^3/s from 2000 to 2001 included. Measurements start to be unstable in 2008 and it is unchecked before 1997, so the period chosen for calibration is 1997-2007. Validation can be performed using the station located in Tielt, slightly upstream (station L09_14A with a surface area of approximatively 26.6 km^2).

In reference to the catchment **V09ZWA148120**, there is no discharge data in Lummen (Zwartebeek) between 1997 and 2001. Moreover values are missing or suspect from 2008 on. Therefore, calibration period is selected between 2001 and 2008 to ensure continuous reliable observations. Note that there is uncertainty associated with a correction for the effect of plant growth on observed discharge (discharge was corrected to be lower than actual measurements in the summer of 2002 and 2003).

V09HUL147150 refers to the basin of the Zwart Water river, gauged in Molenstede (L09_147). Data is checked with good quality since 2002. Note that the second half of 2007 is estimated.

For the Zwartebeek discharge in Lummen (**V09ZWA148120**), values are suspect for most of 2011 and less than good quality starting April 2012. Therefore the calibration period is limited to 2001-2008.

Table 22 – Overview of calibration results for gauged catchments on the Demer basin

Gauging station	Catchment code	Area (km²)	NSE	logNSE	RelErr (%)	VolBias (%)	Calibration period	Approx. distance to rain gauge over calibration period (km)
13610102 - Demer; Hasselt	**V09DEM136000**	255,8	0.64	0.74	-0.1%	1.3%	1998-2010	6
15210102 - Gete; Halen	**V09GET152080**	800,4	0.68	0.61	0.7%	7.2	2001-2013	*Irrelevant given the size of the catchment (max 10)*
16310102 - Herk, Kermt (Spalbeek)	**V09HER163010**	274,6	0.67	0.64	-2.1%	3.5%	2003-2012	12
14710102 - Zwart Water (affluent of De Hulpe); Molenstede	**V09HUL147150**	80,1	0.48	0.51	-10.3%	-16.4%	2001-2013	7
14310102 - Grote Losting; Wezemaal	**V09LOS143300**	15,2	-1.32	0.22	73.9%	51.8%	1997-2010	< 2000 : 8 >= 2000 : 4
16110102 - Mangelbeek; Lummen	**V09MAN161040**	103,1	0.60	0.60	0.3%	7.0%	1998-2010	10
14410102 - Motte; Rillaar	**V09MOT144270**	33,6	0.63	0.60	1.3%	-7.4%	1995-2007	5
14510102 - Velp; Ransberg	**V09VEL145100**	96,8	0.56	0.74	1.0%	-1.2%	2001-2013	7
141 - Rotselaar ; Winge	**V09WIN141310**	64,7	0.49	0.60	3.6%	3.5%	2001-2013	< 2001 : 10 >= 2001 : 2
14810102 - Zwarte Beek; Lummen	**V09ZWA148120**	96,5	0.72	0.58	2.7%	0.1%	2001-2008	3

Table 23 – Overview of validation results for gauged catchments on the Demer basin

Gauging station	Catchment code	Area (km²)	NSE	logNSE	RelErr (%)	VolBias (%)	Validation period
13610102 - Demer; Hasselt	**V09DEM136000**	255,8	0.52	0.65	8.6%	9.3%	1997-2013
15210102 - Gete; Halen	**V09GET152080**	800,4	0.429	0.699	6.0%	6.6%	1969-2012
16310102 - Herk, Kermt	**V09HER163010**	274,6	0.64	0.589	8.6%	8.7%	1977-2013
14710102 - De Hulpe; Molenstede	**V09HUL147150**	80,1	0..57	0.59	0.7%	-6.7%	1987-2013
14310102 - Grote Losting; Wezemaal	**V09LOS143300**	15,2	-1.506	0.243	63.5%	51.5%	1987-2012
16110102 - Mangelbeek; Lummen	**V09MAN161040**	103,1	0.656	0.637	2.8%	5.2%	1984-2009
14A - Motte; Tielt	**V09MOT14A100**	33,6	0.482	0.474	-12.4%	-14.4%	2009-2013
14510102 - Velp; Ransberg	**V09VEL145100**	96,8	0.47	0.72	1.2%	6.0%	1969-2013
141 - Rotselaar ; Winge	**V09WIN141310**	64,7	0.19	0.61	5.8%	6.8%	1987-2013
14810102 - Zwarte Beek; Lummen	**V09ZWA148120**	96,5	0.559	0.467	-9.8%	-8.9%	1983-2013

16310102 - Herk, Kermt (V09HER163010)

Figure 62 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09HER163010, station 16310102 - Herk, Kermt (2001-2013)

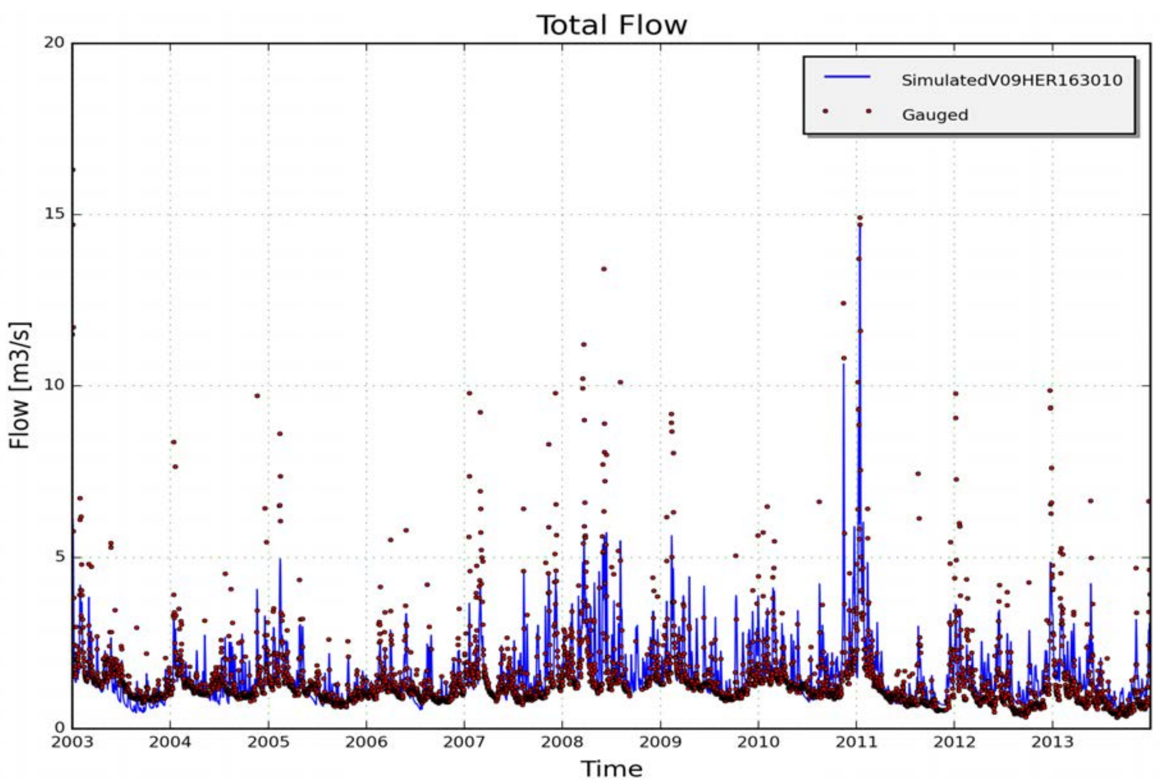


Figure 63 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09HER163010, station 16310102 - Herk, Kermt (2001-2013)

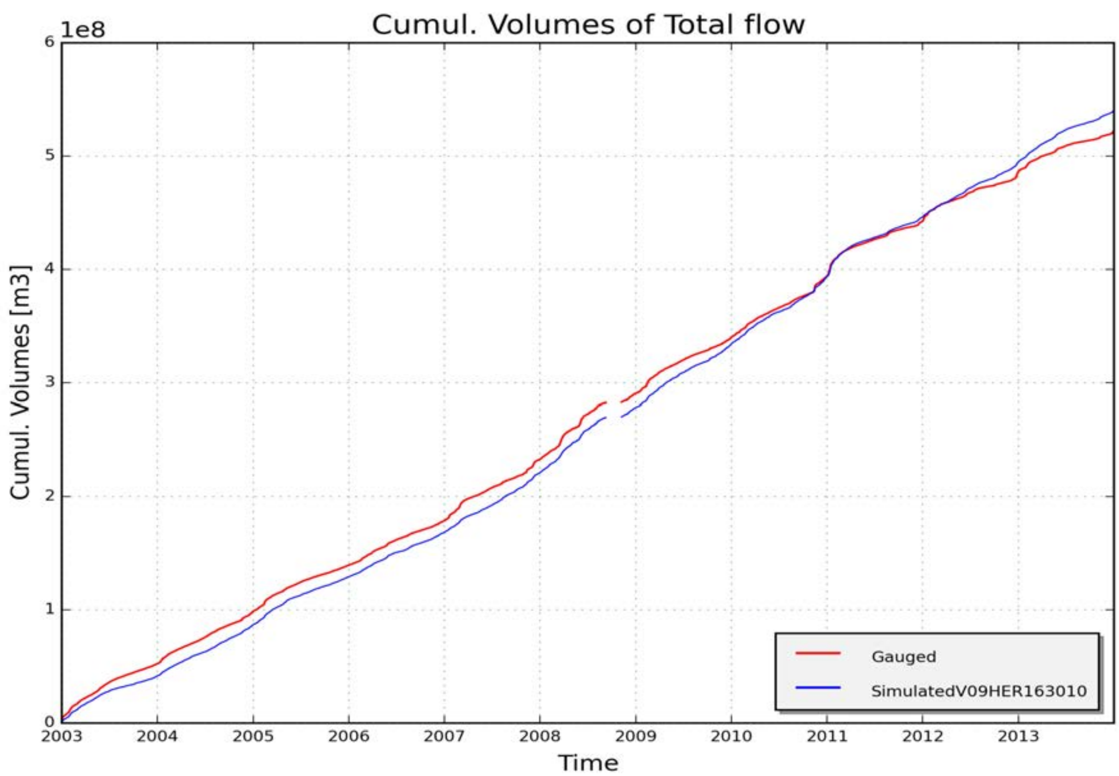
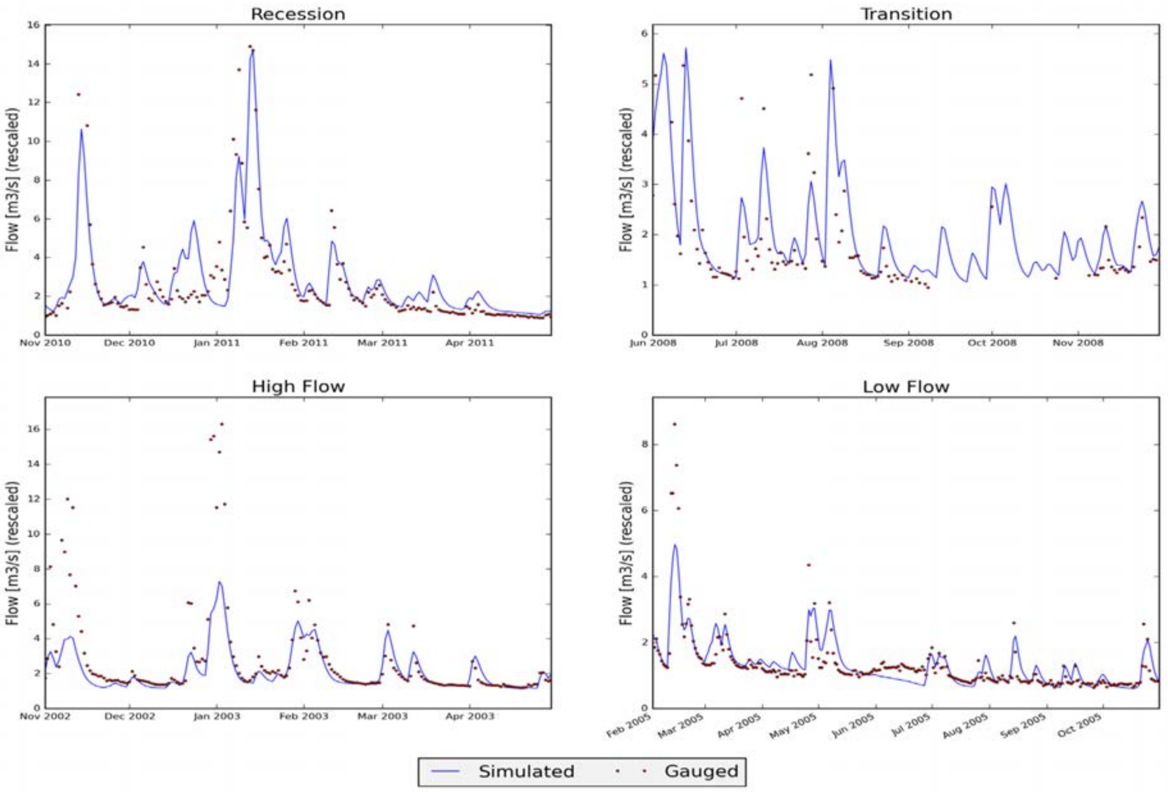


Figure 64 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09HER163010, station 16310102 - Herk, Kermt



14810102 - Zwarte Beek; Lummen (V09ZWA148120)

Figure 65 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen (2001-2007)

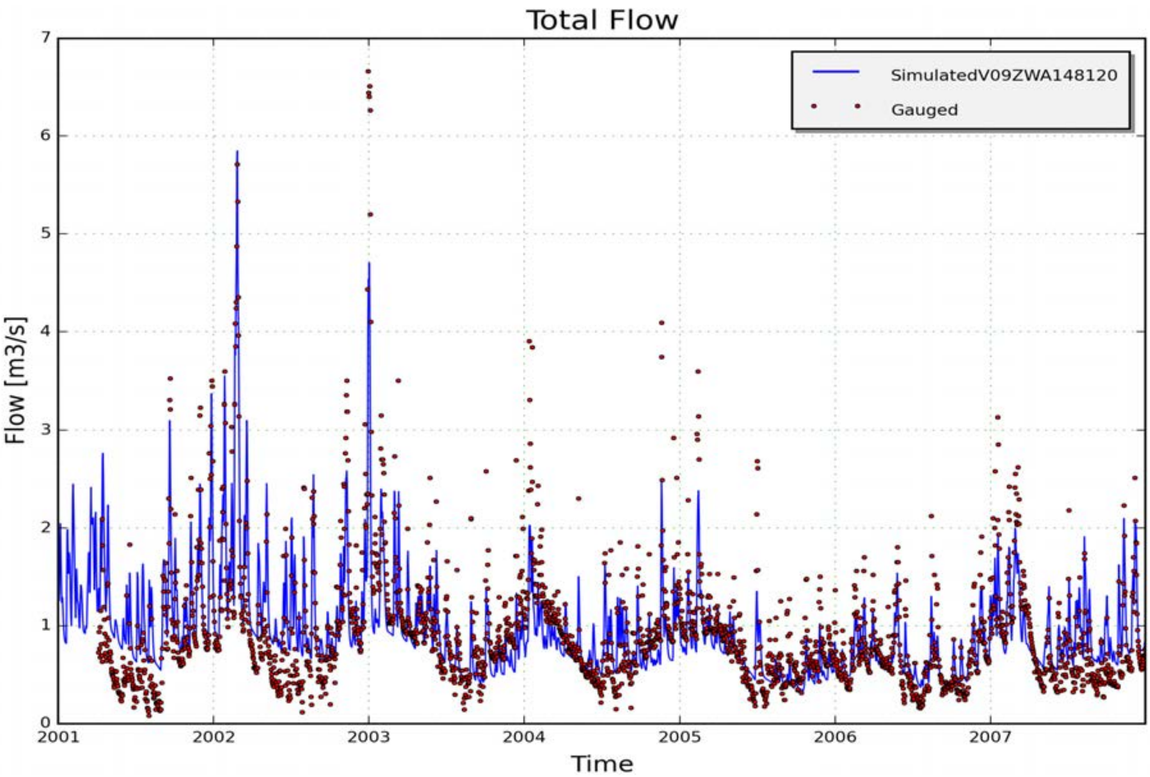


Figure 66 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen (2001-2007)

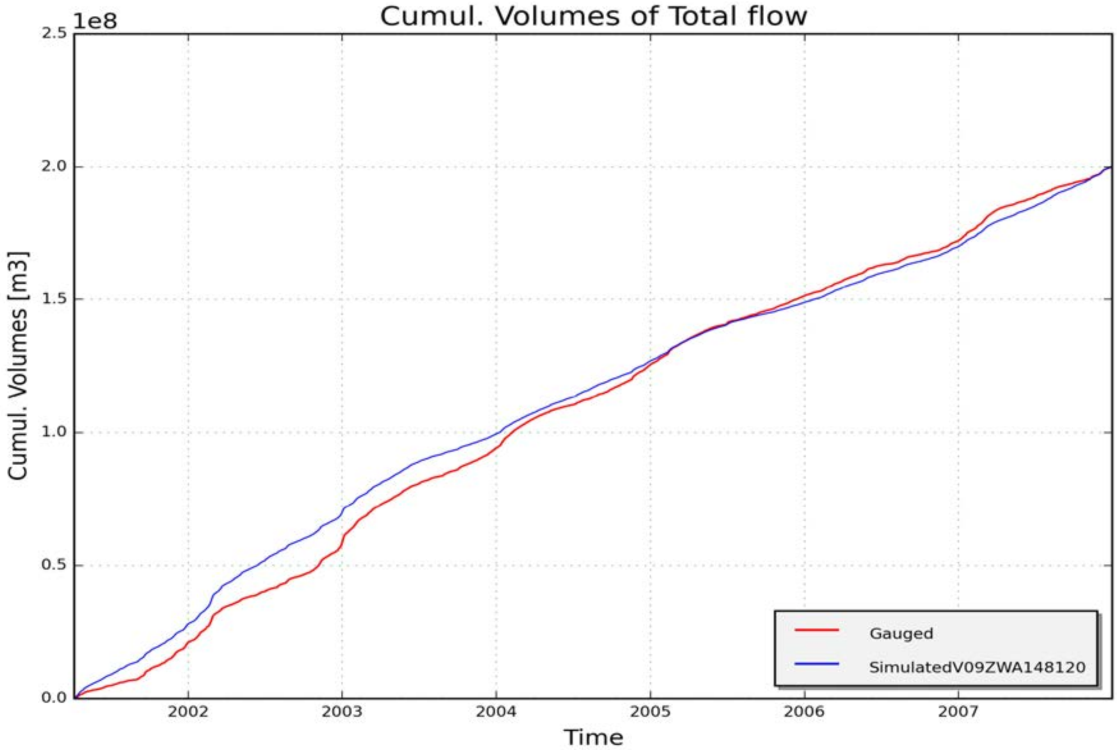
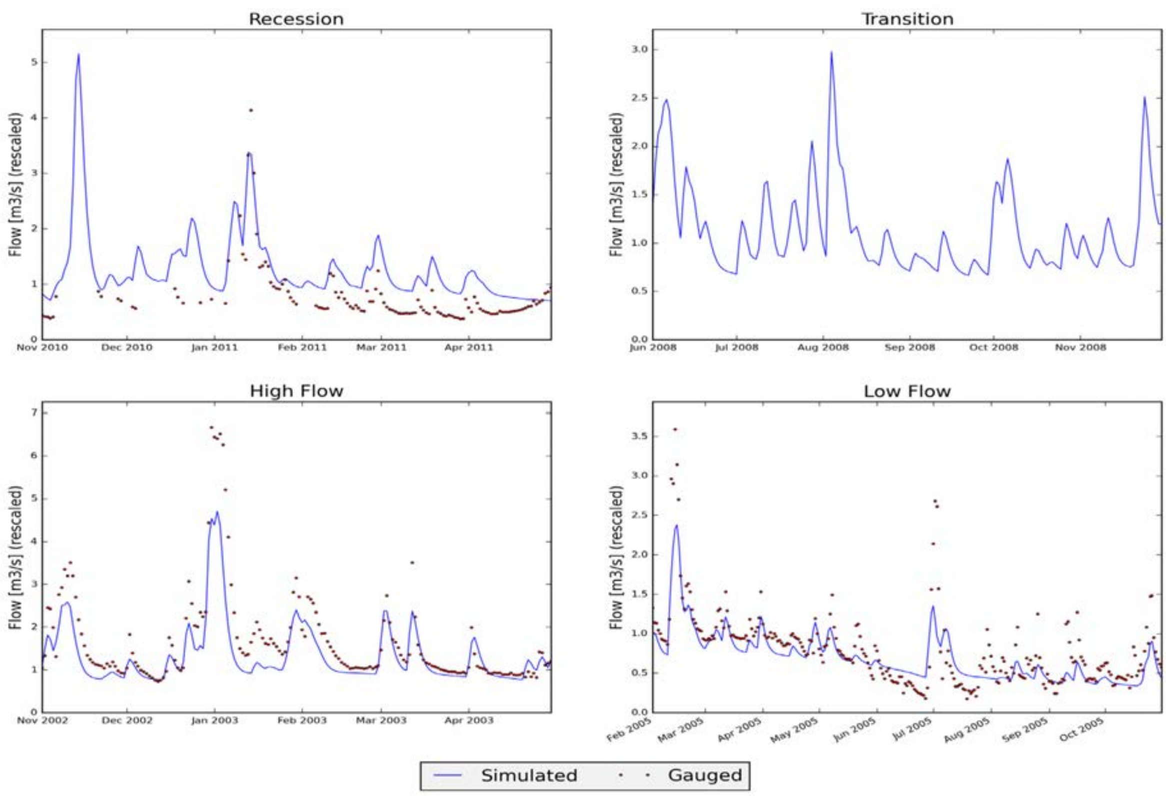


Figure 67 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen



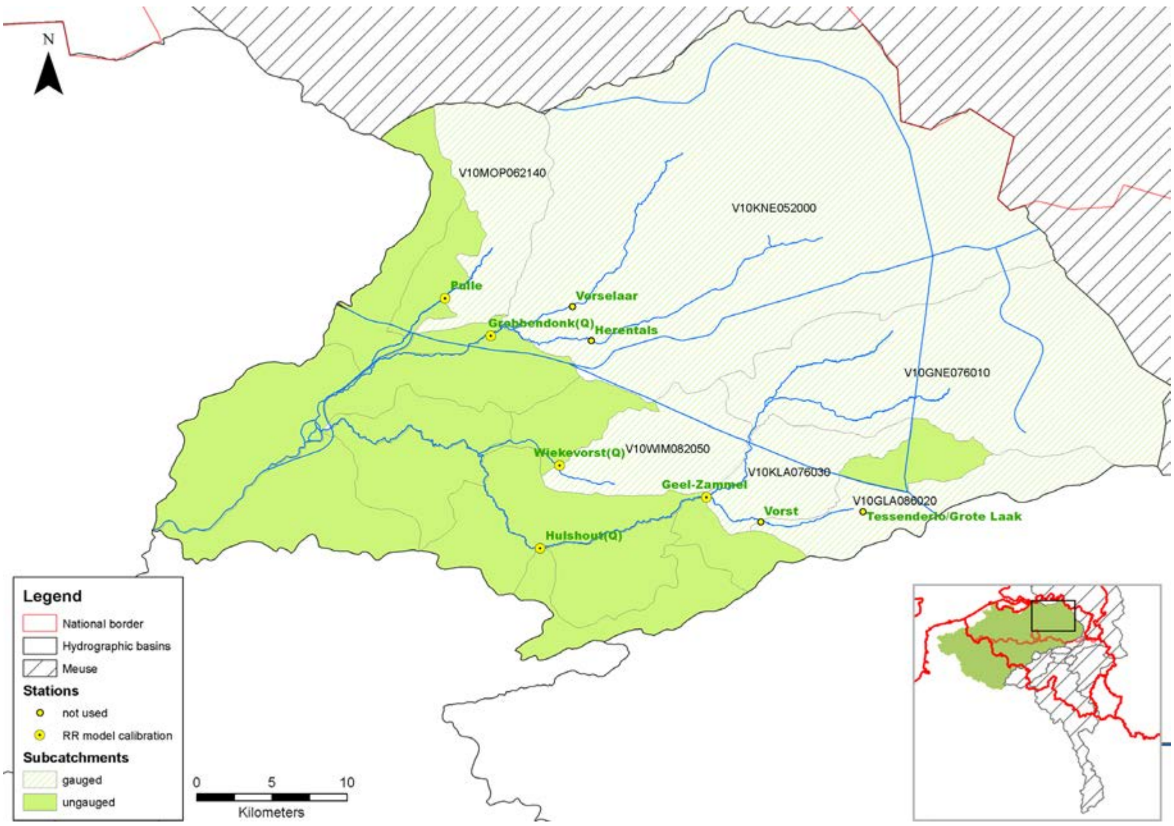
6.12 Netebekken

6.12.1 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 68 – Subcatchments and measure points for the Nete basin



6.12.2 Model performance

Table 24 and Table 25 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 **V10WIM082050** (worst model performance) are presented below (Figure 69 to Figure 74). For more detailed results on the other subcatchments is referred to Annex 12.

The model performance is good for the calibration period for most of the gauged subcatchments of the Nete basin, with NSE and Log NSE values above 0.70 and relative error below ±3% (**V10GLA086020, V10GNE076999, V10KNE052000**). For these three catchments, performance remains satisfactory in the validation period, even if goodness-of-fit statistic are significantly worse for **V10GLA086020**.

Even if goodness-of-fit statistics are satisfactory, some of the difficulties were faced when calibrating the water courses of the Nete basin that can be explained by the known abundant vegetation, which causes changes in the q(h) relationships at the gauging station. This leads to more uncertainties in the gauged discharges. In the case of **V10GLA086020** and **V10GNE076999**, there is tendency to underestimate low flows. The relative error reaches -14.3% during validation years of **V10GLA086020**. These increased discrepancies are mostly related to unusually low discharge measured in 1990, most likely from inaccurate measurements. This problem was also faced when calibrating the NAM model, thus comforting the theory of disturbances in the measurement data.

The agreement between flow simulation and observation is not as good for the catchment **V10MOP062140** as for the three catchments listed above**,** but this is mostly related to poor modelling of moderate and high flows from 2005 to 2010. Measurements show unusual behaviour during this period. The low flows are satisfactorily modelled however (log NSE = 0.67). The water balance is moderate for the calibration period but because rather poor for the validation period (RelErr = 14.5%). Flow peaks are indeed often overestimated, resulting in an overestimation of volumes.

NSE is unsatisfactory for the catchment with code **V10WIM082050**, but log NSE is reasonable for the calibration and especially validation period (Table 24 and Table 25). However, except for some years where the low flow is overestimated (i.e. 1999, 2000), the general model performance for low flows can be considered as acceptable. Moreover, the influence of this subcatchment on the larger Scheldt water allocation model is quite low (65.7 km^2 only).

Remarks on the data: Some catchments are calibrated for different periods than the one normally used (2001-2013). The gauging station **8610102 - Grote Laak** in Vorst **(V10GLA086020)** does not have discharge data from 2008 and during the years 1997 and 1998, so that the period selected for the calibration of this catchment is shorter (1999-2007). The calibration period for the catchment **V10GNE076999** is 2003-2013 since there is not data available in 2002. The catchment with code **V10MOP062140** does not have data from 23/04/2010 to 11/10/2011 and from 01/01/2004 to 31/12/2006. Rainfall was recorded in Houthulst, closest to the catchment, starting in June 2008 only. Rainfall data before then is therefore less reliable. A continuous period of 13 is thus used from 1991 to 2003. According to the gauging station 8210102 – Wiekevorst (**V10WIM082050**), the calibration period only lasts until the year 2007 due to unavailability of discharge data.

Table 24 – Overview of calibration results for gauged catchments on the Nete basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr**	**VolBias (%)**	**Calibration period**	**Approx. distance to rain gauge over calibration period (km)**
8610102 - Grote Laak, Vorst	**V10GLA086020**	62,6	0.772	0.774	-0.4%	-3.5%	1999-2007	5
7610102 Grote Nete/Geel Zammel	**V10GNE076999**	243,5	0.761	0.744	-3.3%	0.2%	2003-2013	10
5210102 - Kleine Nete; Grobbendonk	**V10KNE052000**	584,7	0.784	0.801	-0.4%	0.0%	2001-2013	10 (*large basin*)
6210102 - Molenbeek, Pulle	**V10MOP062140**	77,3	0.453	0.672	2.6%	2.6%	1997-2013	< 2001 : 8 >= 2001 : 6 2010 : 12
8210102 - Wiekevorst	**V10WIM082050**	65,7	0.142	0.603	1.4%	-7.9%	1995-2007	< 2008 :8 >= 2008 :2

Table 25 – Overview of validation results for gauged catchments on the Nete basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr**	**VolBias (%)**	**Validation period**
8610102 - Grote Laak, Vorst	**V10GLA086020**	62,6	0.614	0.452	-14.3%	-10.6%	1986-2007
7610102 Grote Nete/Geel Zammel	**V10GNE076999**	243,5	0.744	0.705	-6.3%	-3.4%	1985-2013
5210102 - Kleine Nete; Grobbendonk	**V10KNE052000**	584,7	0.798	0.834	-2.2%	-0.9%	1983-2013
6210102 - Molenbeek, Pulle	**V10MOP062140**	77,3	0.49	0.585	17.5%	10.6%	1987-2013
8210102 - Wiekevorst	**V10WIM082050**	65,7	0.015	0.556	14.5%	1.2%	1990-2007

5210102 - Kleine Nete; Grobbendonk (V10KNE052000)

Figure 69 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk (2001-2013)

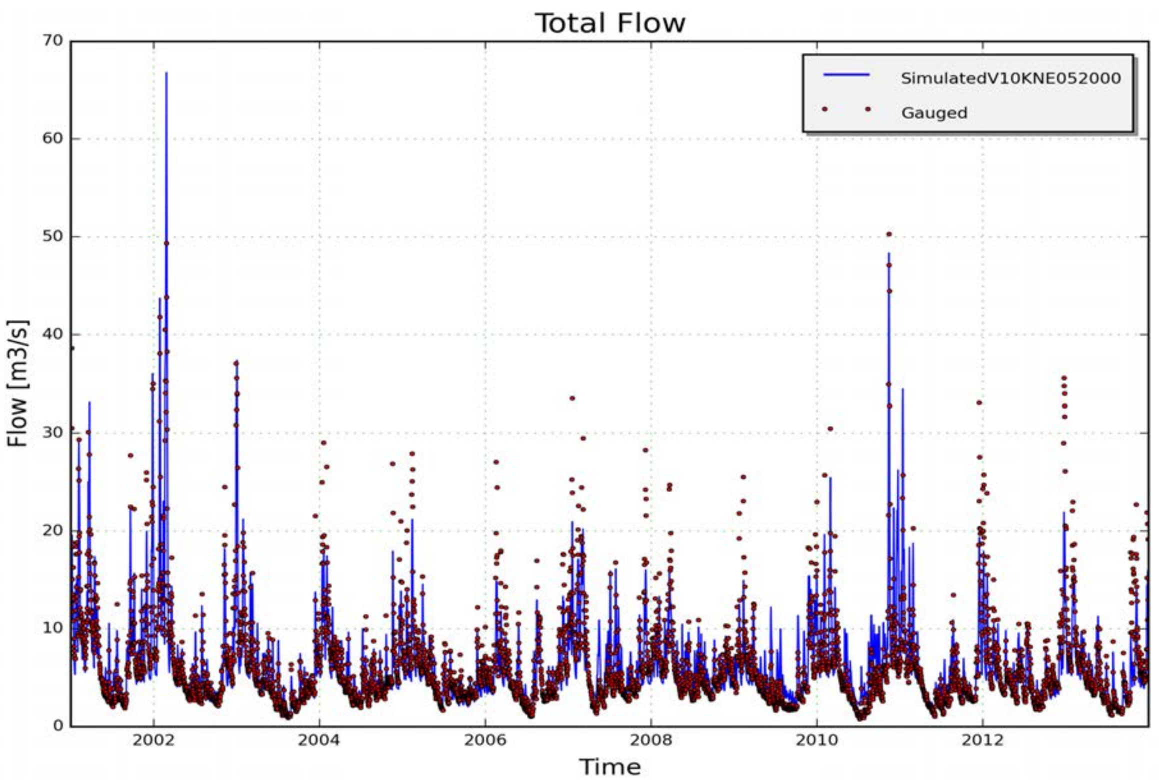


Figure 70 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk (2001-2013)

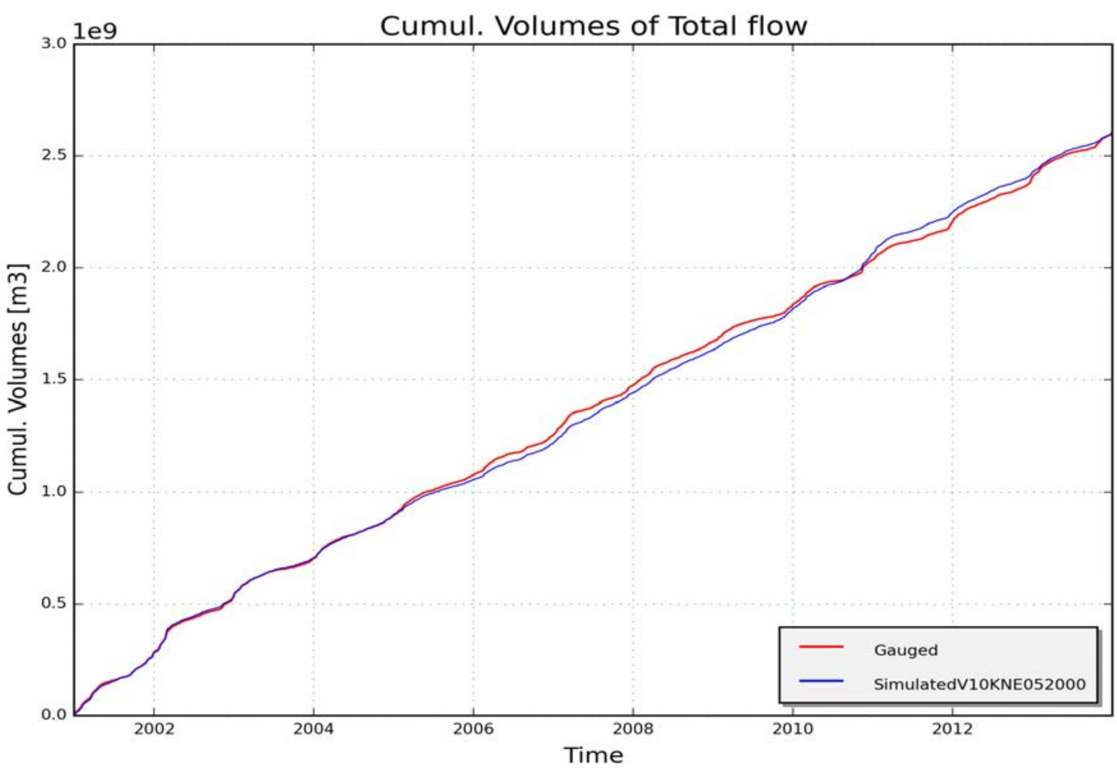
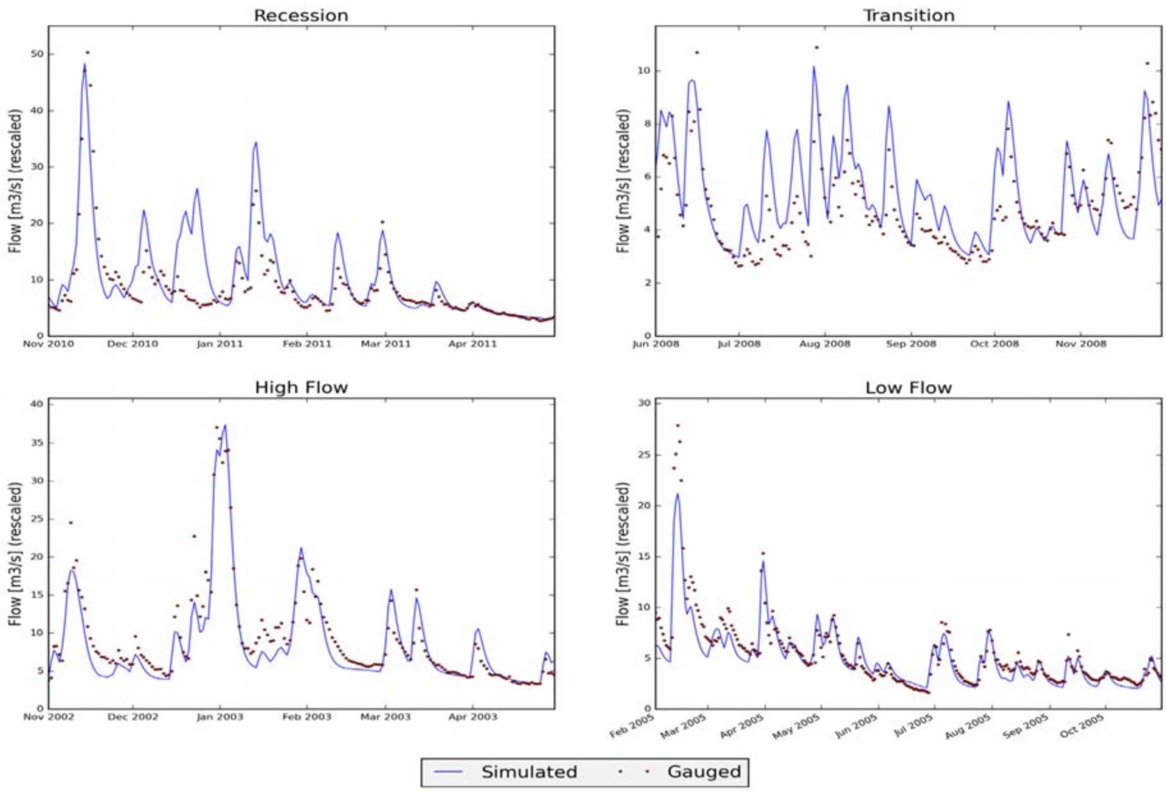


Figure 71 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events



8210102 - Wiekevorst (V10WIM082050)

Figure 72 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10WIM082050, station 8210102 – Wiekevorst (1995-2007)

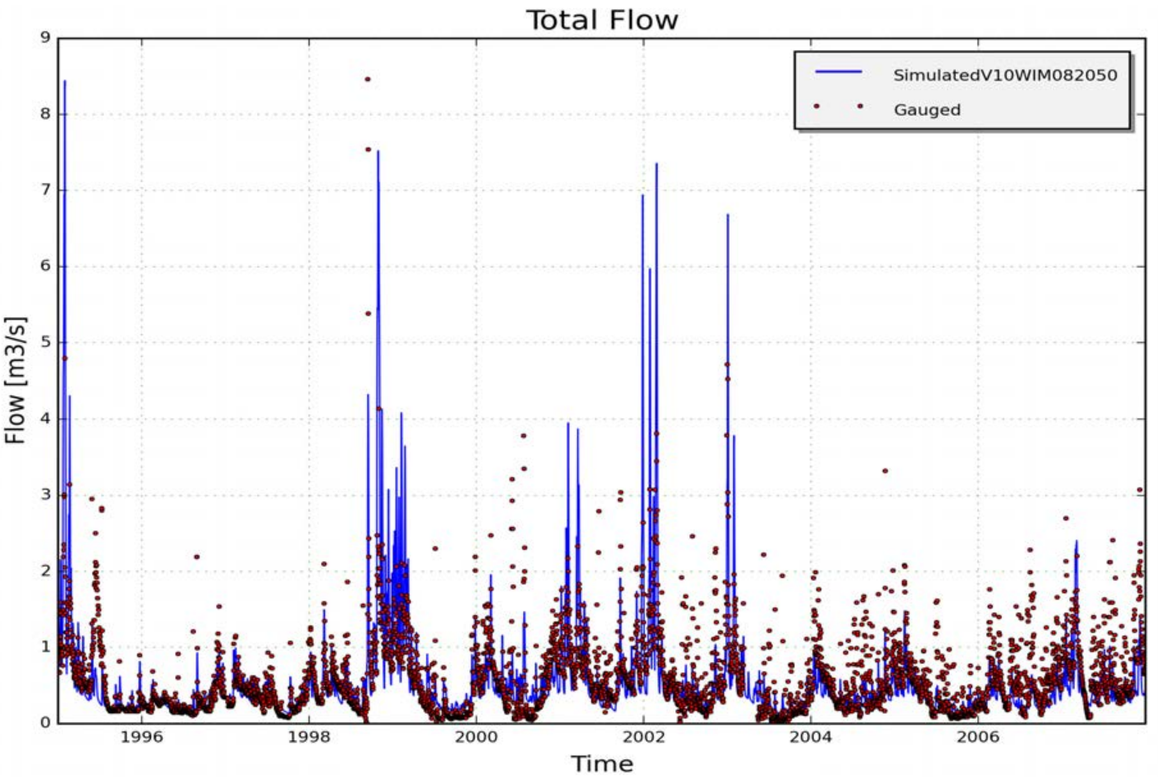


Figure 73 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10WIM082050, station 8210102 – Wiekevorst (1995-2007)

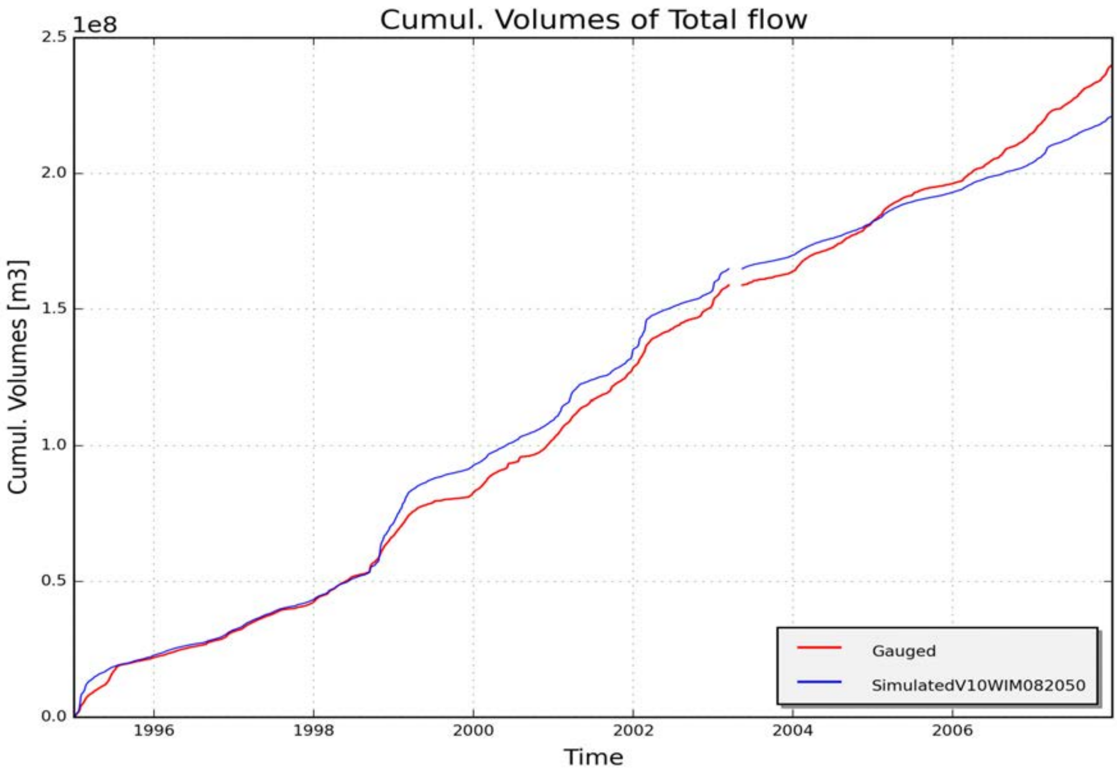
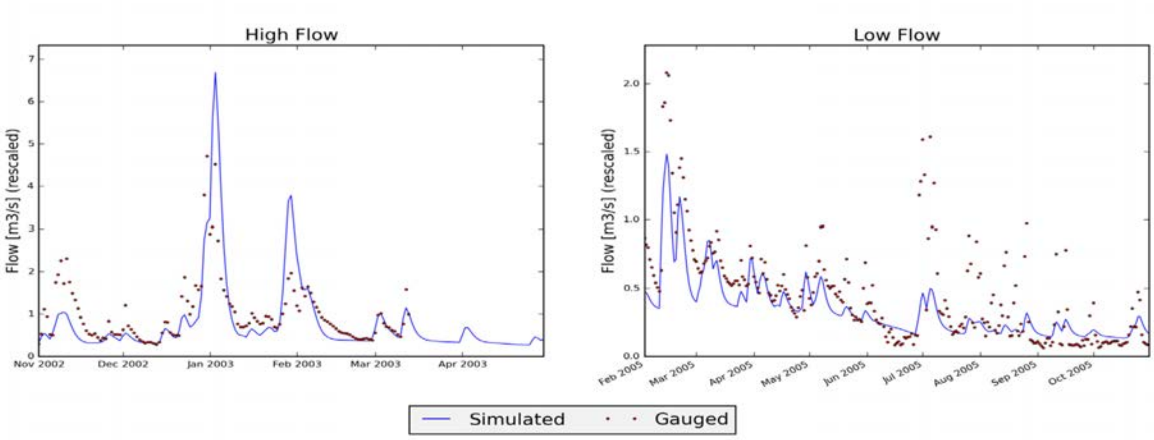


Figure 74 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10WIM082050, station 8210102 – Wiekevorst



6.13 Maasbekken

6.13.1 Context

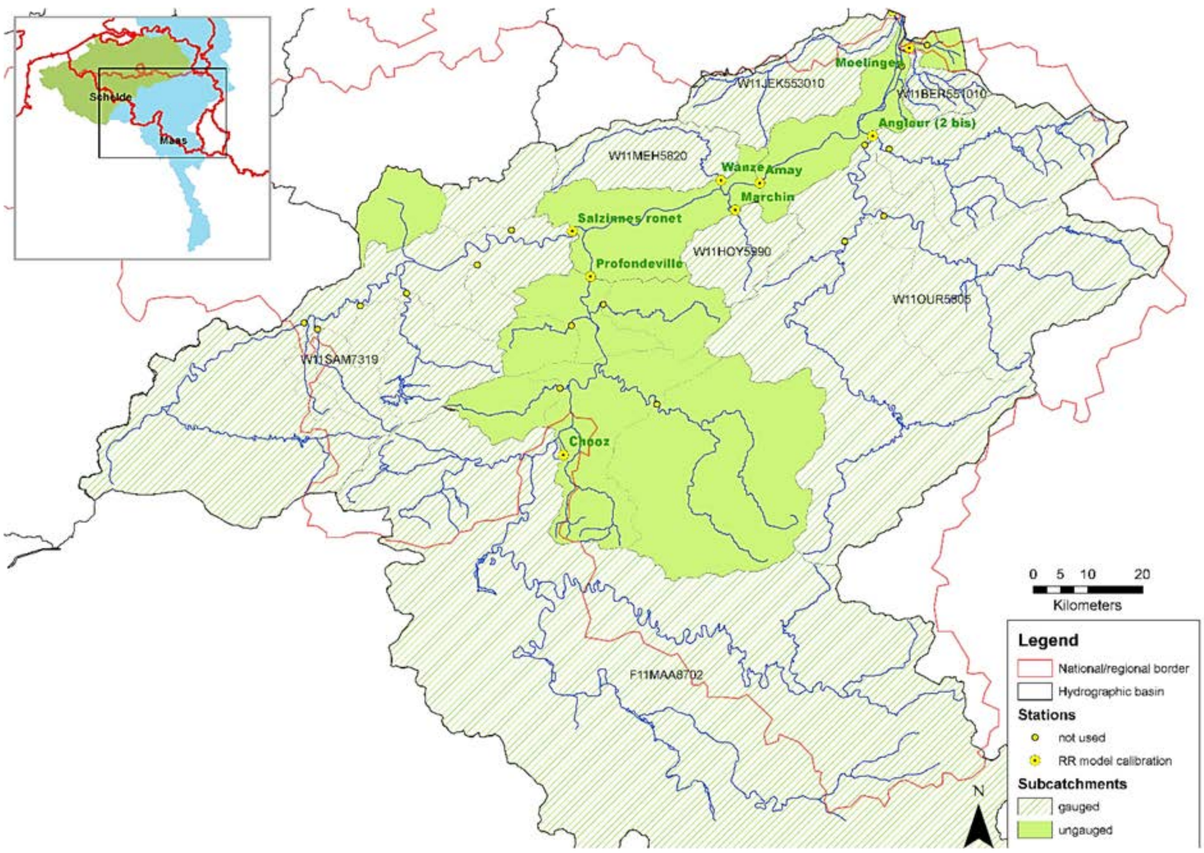
The Meuse basin is the second biggest hydrographic district of Belgium (about 20.450 km² in Visé). The Meuse river has its source in France in Pouilly-en Bassigny and enters Belgium in Agimont. The gauging station of Chooz, located in France, is the closest to the Walloon border. The main tributaries 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 1 (on the next page) shows a map of the Meuse basin in Wallonia, with a first selection of flow measuring stations (yellow dots) and their corresponding catchments. The catchment delineation was based on the GIS resources of the Walloon region (SPW). The surface area calculated based on these polygons matches closely the data published by SPW on the "Infocrue" website for each catchment (when available).

Seven stations were used to calibrate the different tributaries (Table 1). 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.

The station in Profondeville only provides water level measurements and will be used as control. The station in Amay will also be used as downstream control. A simulated time series for Amay can be constructed, aggregating together all simulation results from the 5 catchments upstream Amay ('F11MAA8702', 'W11SAM7319', 'W11MEH5820', 'W11HOY5990') and ungauged zone upstream Amay ('W11MAA0030').

Figure 75 – Subcatchments and measure points for the Meuse basin



6.13.2 Model performance

Table 26 and Table 27 present the general performance statistics for the gauged catchments of the Nete basin. Graphs of simulations of the catchments with code **W11OUR5805** (best model performance) and **W11HOY5990** (worst model performance) are presented below (Figure 76 to Figure 81Figure 69). For more detailed results on the other subcatchments is referred to Annex 13.

Table 26 – Overview of calibration results for gauged catchments on the Meuse basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr**	**VolBias (%)**	**Calibration period**
Chooz, Meuse	**F11MAA8702**	10120	0,67	0,62	-3,9%	-5,9%	2002 – 2013
Moelingen, Berwijn	**W11BER551010**	128	0,63	0,65	-0,6%	-6,3%	1994- 2006
Marchin, Hoyoux	**W11HOY5990**	242	0,29	0,63	-1,8%	-1,1%	2001 – 2013
Wanze, Mehaigne	**W11MEH5820**	12585	0,74	0,66	-3,2%	-2,2%	2004 – 2013
Angleur, Ourthe	**W11OUR5805**	3607	0,84	0,85	-0,3%	-1,0%	2001 – 2013
Salzinne, Sambre	**W11SAM7319**	2636	0,80	0,77	0,0%	-3,4%	2007 - 2012

Table 27 – Overview of validation results for gauged catchments on the Meuse basin

Gauging station	**Catchment code**	**Area (km²)**	**NSE**	**logNSE**	**RelErr**	**VolBias (%)**	**Validation period**
Chooz, Meuse	**F11MAA8702**	10120	0,70	0,64	-7,2%	-7,8%	1990 – 2013
Moelingen, Berwijn	**W11BER551010**	128	0,53	0,31	5,2%	2,2%	1992 - 2013
Marchin, Hoyoux	**W11HOY5990**	242	0,26	0,63	-0,3%	-0,4%	2001 - 2013
Wanze, Mehaigne	**W11MEH5820**	12585	0,74	0,67	-9,0%	-5,5%	2001 - 2013
Angleur, Ourthe	**W11OUR5805**	3607	0,81	0,86	0,4%	0,1%	1974 - 2013
Salzinne, Sambre	**W11SAM7319**	2636	0,77	0,76	-1,3%	-7,9%	2007 - 2013

For several subcatchments, limited time series of observed discharge are available. No validation is therefore possible on distinct years of data for those stations. This is the case for **W11HOY5990**, **W11MEH5820** and **W11SAM7319**. Control stations downstream (Profondeville and Amay) are thus useful to validate the models of the subcatchments more upstream.

Angleur, Ourthe

Figure 76 – Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W11OUR5805, station Ourthe, Angleur 2 bis(calibration period)

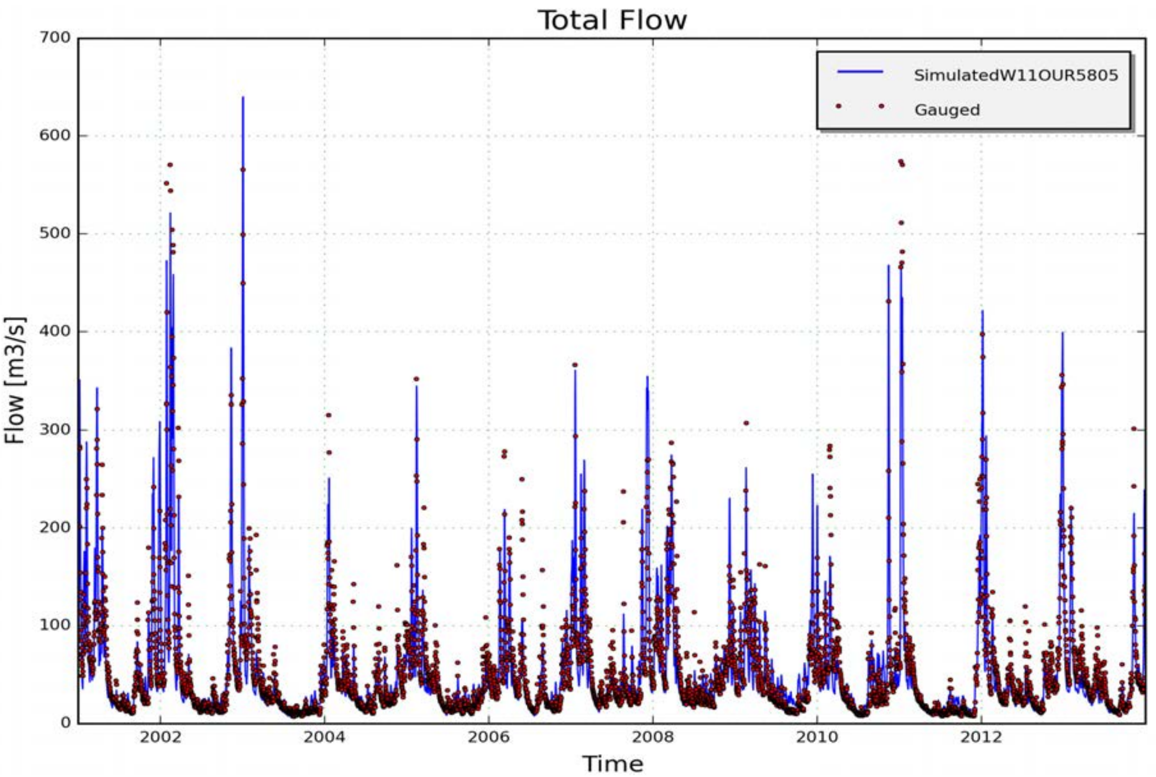


Figure 77 – Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W11OUR5805, station Ourthe, Angleur 2 bis (calibration period)

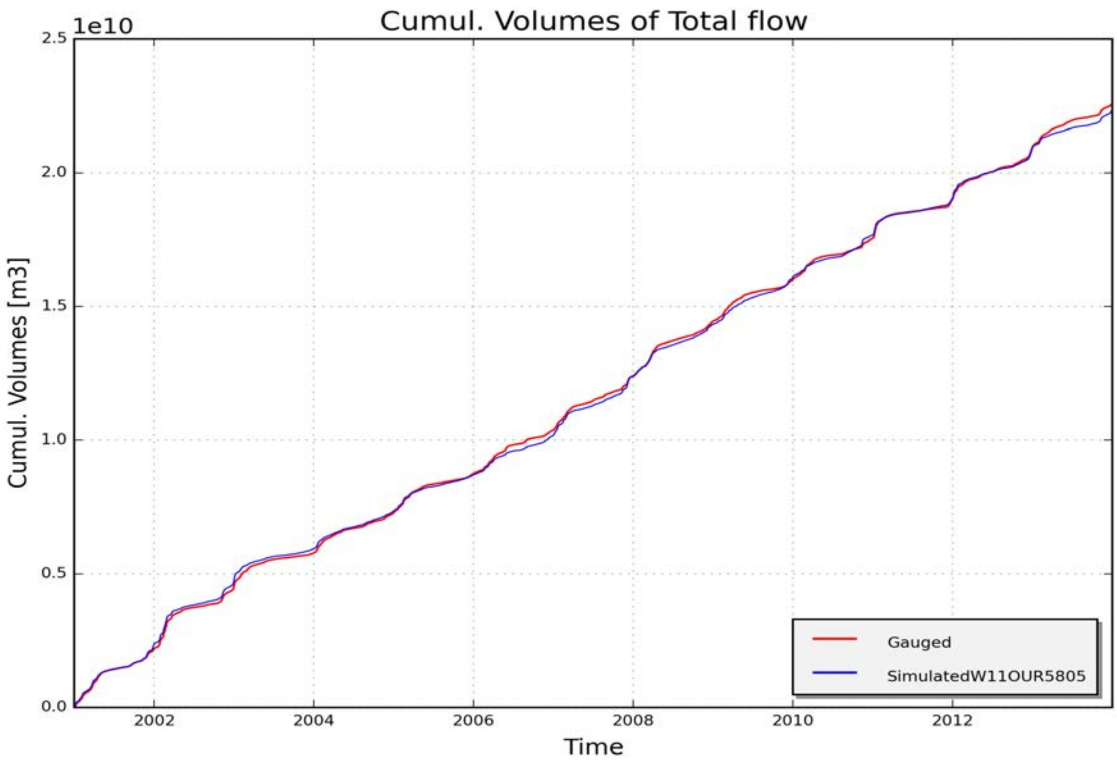
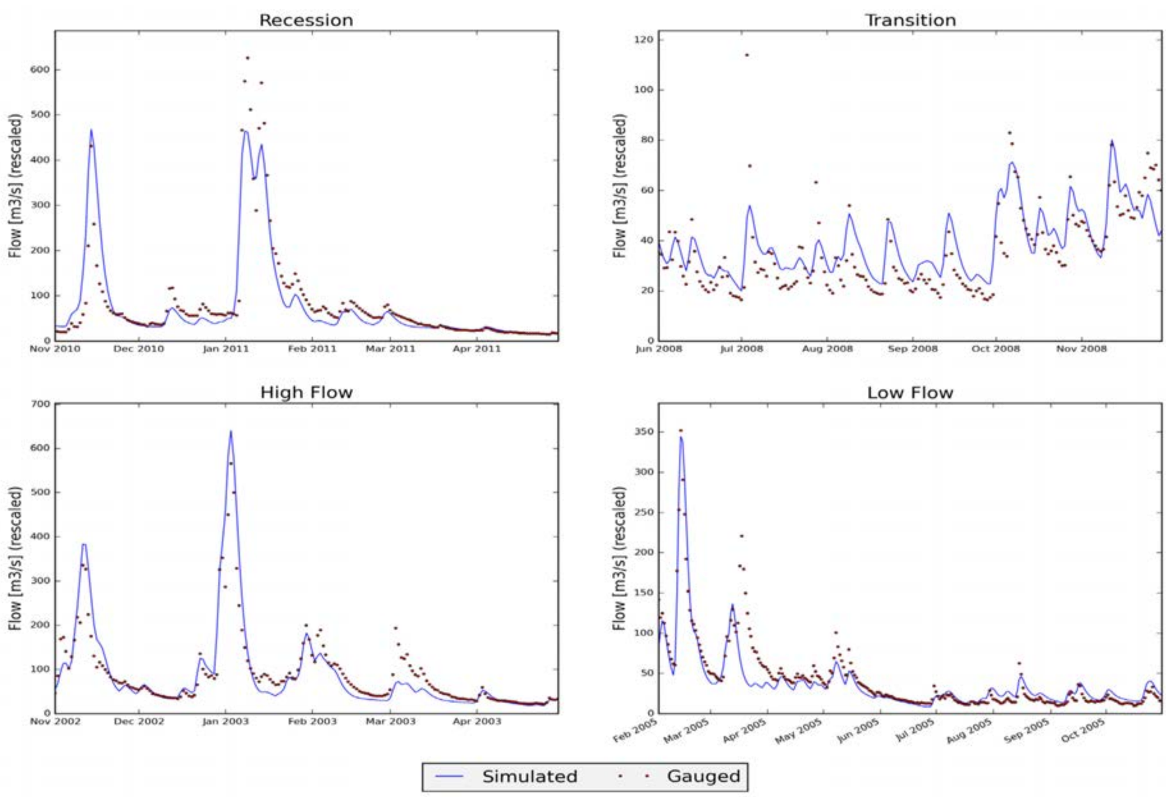


Figure 78 – Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W11OUR5805, station Ourthe, Angleur 2 bis



Marchin, Hoyoux

Figure 79 – Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W11HOY5990, station Hoyoux, Marchin(calibration period)

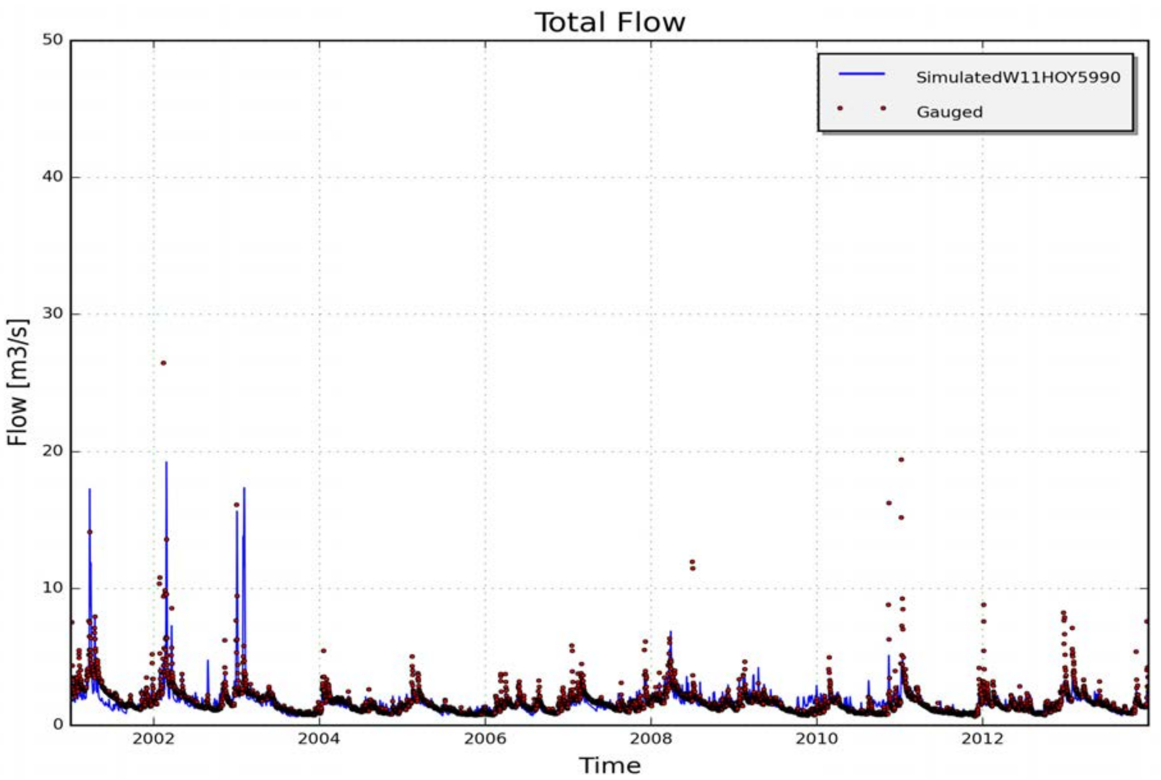


Figure 80 – Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W11HOY5990, station Hoyoux, Marchin (calibration period)

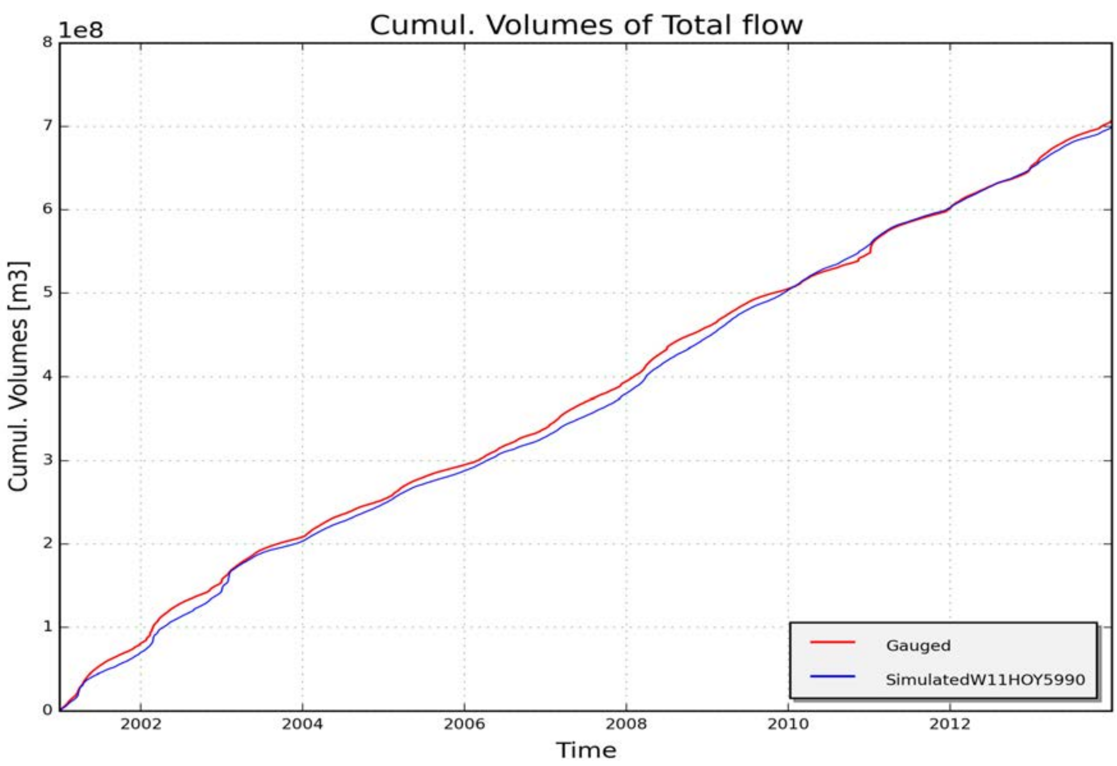
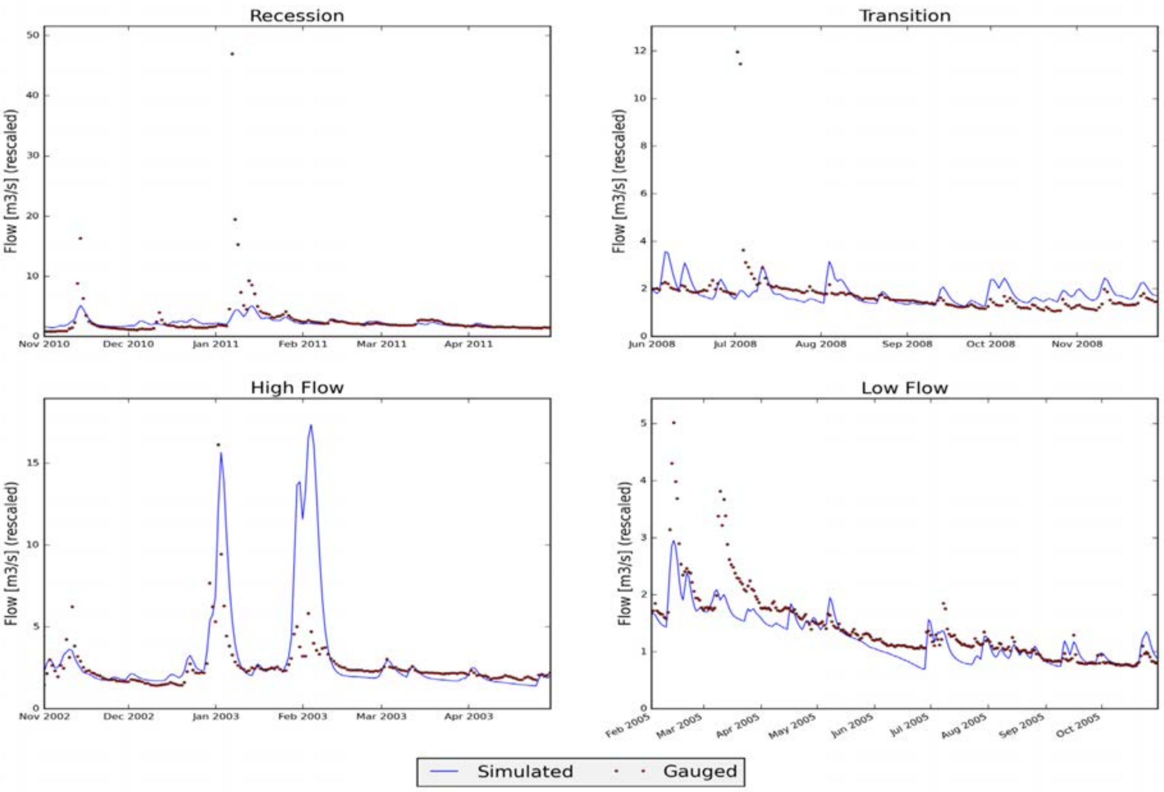


Figure 81 – Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W11HOY5990, station Hoyoux, Marchin



7 Summary

As stated before, the comprehensive results for each of the calibrated subcatchments, are attached from Annex 3 to Annex 13. In these Annexes the calibration summary, graphs and statistics are listed.

7.1 Graphical overview of the model performance

To give a quick overview of the overall result for the calibrated hydrological NAM models, a geographical summary is given in Annex 14 and Annex 15. Based on the statistics for each of the NAM models, a reclassification is performed to result in a quotation for the overall model performance. This quotation is then incorporated in a general map for the study area.

8 Conclusions and recommendations

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 subcatchments 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).

This subreport covers the calibration and evaluation of the PDM models, which are part of the InfoWorks software package (Innovyze). Hydrological PDM models for the gauged catchments (i.e. catchments upstream of a gauging station) were calibrated with the main focus on low flows. This calibration is done using an automatic optimization procedure followed by a visual control. 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.

Overall, the performance of the PDM models is equivalent to the NAM models calibrated previously (Sub report 4.2). For some subcatchments, the PDM model goodness-of-fit is much worse than NAM while for others, the flexibility of the PDM model structure seem to allow better simulation of the total flow.

As the final performance of the water balance model is directly dependent on its hydrological input, it is important to have insight in the performance of these hydrological input models. This is also the case when using the hydrological (e.g. PDM) models as input for simulations with the water balance model. The summarized results for each of the gauged subcatchments within the study area, allow the user to get insight in the performance of the PDM model for each of the involved subcatchments. Based on this information and the evaluation of the NAM, VHM and Wetspa models, the user will be able to make a well-grounded decision on which model to use for the considered objective. Therefore, this summarizing report should be consulted by any user applying the corresponding PDM models. In this way, the user gains insight in the uncertainties and performance of the hydrological models for each of the considered subcatchments.

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Annexe 1
List of optimized parameters for gauged catchments

Catchment	AreaSqM	bpareto	bevaporation	cmin	cmax	CKBF	CK1	CK2	bdrainage	kdrainage	PDM.TG
F01IJZ468000	393007000	0.15	2	0.3	153	300	40	24	1	12571	3
V01HAN488180	78558940	0.2	2	10	236	300	15	21	1	11629	7
V01IEP495080	63423128	0.15	2	5	391	300	42	22	1	19149	2
V01KEM492060	73892930	0.365	2	8.1	192	300	27	31	1	11000	3.3
V01MAR496120	76136621	0.3	2	14	202	300	26	31	1	17197	7
V01POP491030	84868207	0.09	1	11	281	300	32	33	1	36123	5
V01SSV499140	16095000	0.32	2	8	309	300	33	38	1	27441	7
V02EDE442120	45489177	0.11	2	8.38	199	300	36	27	1	21988	5.7
V02HER426010	77272201	0.1	2	8.8	274	300	34	29	1	25656	6.9
V02KER422030	62718738	0.169	1.4	10	232	300	41	27	1	18141	0.71
V02RIV425020	63980423	0.12	2	9.8	240	300	31	38	1	17086	1.9
V03POE446000	106836849	0.11	2	15	159	300	43	29	1	11807	3
V04MOL036110	32561957	0.12	2	6.3	273	300	30	35	1	14243	2
V04MOM037100	67301328	0.12	2	10	319	300	33	28	1	12666	4.3
F05LEI386001	2981779554	0.25	2	7.3	394	300	40.7	32.5	1	11466	3.4
V05HEU403210	91912331	0.236	2	3.2	167	300	34	30	1	12742	7
V05MAN401230	258441818	0.279	2	8.6	273	300	33	35	1	16690	1.3
F06BOS325001	5217586196	0.12	2	8.5	439	300	42	29	1	17574	0.4
V06MAA347160	48678191	0.05	2	8.3	325	300	14	33	1	24980	5
V06ZWA342190	112117540	0.4	2	9	365	300	34	19	1	9327	6
W06RHOL54100	161928446	0.1	2	8.3	410	300	35	25	1.1	52000	5.1
V07BEL285070	88641710	0.12	2	6.6	441	300	39	15	1	22169	3.9
V07MAR289015	173908791	0.125	2	9.7	297	300	8.3	48	1	24055	3.8
V07MOE282100	46367171	0.31	2	9.8	272	300	25	39	1	11804	2.6
V07MOG288020	23093628	0.035	2	7.5	250	300	32	16	1	37694	3.7
W07DENLES004	511840662	0.1	2	9	422	300	46	32	1	31203	4.6
V08BAR111370	70079800	0.23	2	9.7	414	300	48	31	1	12738	3.7

V08DIJ093400	861413000	0.12	2	10	886	300	28	26	1	27900	7
V08ZUU233100	64771005	0.12	2	9.9	346	300	33	30	1	32620	6.2
W08SAMRON000	134097000	0.12	2	9.6	471	300	19	27	1	17557	6.5
W08SENRON010	70364773	0.1	2	10	489	300	32	25	1	26851	4.3
W08SENTUB030	215911078	0.17	2	3	356	300	28	39	1	20181	1
V09DEM136000	255882000	0.152	2	8.6	604	300	20	30	1	16561	4.4
V09GET152080	800395376	0.08	2	10	542	300	36	35	1.02	21000	3.8
V09HER163010	274602221	0.12	2	9.6	534	300	35	36	1	24477	6
V09HUL147150	80130245	0.2	1	2	538	300	20	36	0.94	6300	3
V09LOS143300	15176294	0.06	2	7	1000	300	43	45	0.85	45000	5
V09MAN161040	103081000	0.22	2	6.33	568	300	33	23	1	10044	3
V09MOT144270	33590217	0.17	2	8.9	423	300	23	30	1	10577	3.4
V09VEL145100	96801128	0.12	2	9.8	370	300	32	35	1	25000	4.8
V09VEL145100	96801128	0.12	2	9.8	348	300	26	37	1	22264	4.8
V09WIN141310	64739169	0.16	2	8	620	300	30	25	1.03	37000	6
V09ZWA148120	96514800	0.19	2	7.9	776	300	31	37	1	16935	7.9
V10GLA086020	62621236	0.18	2	9	456	300	19	45	1	6113	1.4
V10GNE076999	359885327	0.24	2	5.8	778	300	42	46	1	12501	0.3
V10KNE052000	584669408	0.26	2	5.2	431	300	40	35	1	10171	5.7
V10MOP062140	77319091	0.12	2	6.1	459	300	45	44	1	20400	10
V10WIM082050	65701200	0.1	2	6.5	443	300	30	38	0.95	16000	6.5
F11MAA8702	10120000000	0.37	2	0.7	452	300	43	41	1	16884	1
W11BER551010	128000000	0.35	2	3.8	323	300	21	43	1	9015	1.9
W11HOY5990	242000000	0.075	2	5.6	510	300	30	38	1	16202	0.3
W11MEH5820	355800000	0.08	1	6.8	265	300	28	35	1	17236	3.7
W11OUR5805	3607000000	0.154	2	1.76	236	300	47	43	1	6081	4
W11SAM7319	2636000000	0.2	2	4.7	403	300	45	36	1	18561	1.1

Annexe 2
List of transferred parameters for ungauged catchments

Catchment	Associated gauged catchment	Area (m²)	rain fraction	bpareto	bevap	cmin	cmax	CKBF	CK1	CK2	bdrainage	kdrainage	PDM.TG	tdly	qconst
F01YSE468000	F01IJZ468000	361120000	1.0	0.15	2	0	153	1	36.3	23.7	1	12571	3	0	0
F05AAA000010	F05LEI386999	248452728	1.0	0.25	2	7	394	300	35.4	24.6	1	11466	3	0	0
F05AAA571000	F05LEI386999	374113103	1.0	0.25	2	7	394	300	36.2	23.8	1	11466	3	0	0
F05BEC386023	F05LEI386999	80086039	1.0	0.25	2	7	394	300	31.7	28.3	1	11466	3	0	0
F05BEC386025	F05LEI386999	68930969	1.0	0.25	2	7	394	300	31.5	28.5	1	11466	3	0	0
F05BOU386005	F05LEI386999	255392628	1.0	0.25	2	7	394	300	34.1	25.9	1	11466	3	0	0
F05CLA386017	F05LEI386999	36547273	1.0	0.25	2	7	394	300	30.1	29.9	1	11466	3	0	0
F05CLA386020	F05LEI386999	226006473	1.0	0.25	2	7	394	300	33.7	26.3	1	11466	3	0	0
F05DEU386040	F05LEI386999	448818370	1.0	0.25	2	7	394	300	37.1	22.9	1	11466	3	0	0
F05DEU386050	F05LEI386999	74083951	1.0	0.25	2	7	394	300	32.1	27.9	1	11466	3	0	0
F05DEU386060	F05LEI386999	116669136	1.0	0.25	2	7	394	300	33.6	26.4	1	11466	3	0	0
F05DEU386080	F05LEI386999	57192180	1.0	0.25	2	7	394	300	30.9	29.1	1	11466	3	0	0
F05DEU386090	F05LEI386999	12829199	1.0	0.25	2	7	394	300	28.8	31.2	1	11466	3	0	0
F05DEU386110	F05LEI386999	16919150	1.0	0.25	2	7	394	300	29.9	30.1	1	11466	3	0	0
F05DEU386120	F05LEI386999	39450392	1.0	0.25	2	7	394	300	30.2	29.8	1	11466	3	0	0
F05DEU386130	F05LEI386999	21724484	1.0	0.25	2	7	394	300	29.6	30.4	1	11466	3	0	0
F05DEU386140	F05LEI386999	7480581	1.0	0.25	2	7	394	300	28.5	31.5	1	11466	3	0	0
F05DEU386150	F05LEI386999	39193251	1.0	0.25	2	7	394	300	29.9	30.1	1	11466	3	0	0
F05DEU386160	F05LEI386999	27005232	1.0	0.25	2	7	394	300	29.7	30.3	1	11466	3	0	0
F05HEM000020	F05LEI386999	134010959	1.0	0.25	2	7	394	300	33.6	26.4	1	11466	3	0	0
F05LAW386018	F05LEI386999	102249474	1.0	0.25	2	7	394	300	31.0	29.0	1	11466	3	0	0
F05LAW386030	F05LEI386999	188699853	1.0	0.25	2	7	394	300	33.5	26.5	1	11466	3	0	0
F05LOI386035	F05LEI386999	113093218	1.0	0.25	2	7	394	300	32.1	27.9	1	11466	3	0	0
F05LYS386000	F05LEI386999	375288119	1.0	0.25	2	7	394	300	35.8	24.2	1	11466	3	0	0
F05LYS386010	F05LEI386999	75860338	1.0	0.25	2	7	394	300	31.9	28.1	1	11466	3	0	0
F05LYS386015	F05LEI386999	28126242	1.0	0.25	2	7	394	300	30.2	29.8	1	11466	3	0	0

F05LYS386115	F05LEI386999	168458564	1.0	0.25	2	7	394	300	33.5	26.5	1	11466	3	0	0
F05MAR386070	F05LEI386999	200520118	1.0	0.25	2	7	394	300	34.4	25.6	1	11466	3	0	0
F05MAR386100	F05LEI386999	26635692	1.0	0.25	2	7	394	300	29.6	30.4	1	11466	3	0	0
F06BOS325000	F06BOS325001	775406341	1.0	0.12	2	9	439	300	42.4	17.6	1	17574	0	0	0

Annexe 3 Ijzer

CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "F01IJZ468000" (IJZER)

Input data

Figure 1: Cumulative precipitation on catchment F01IJZ468000 (IJzer)

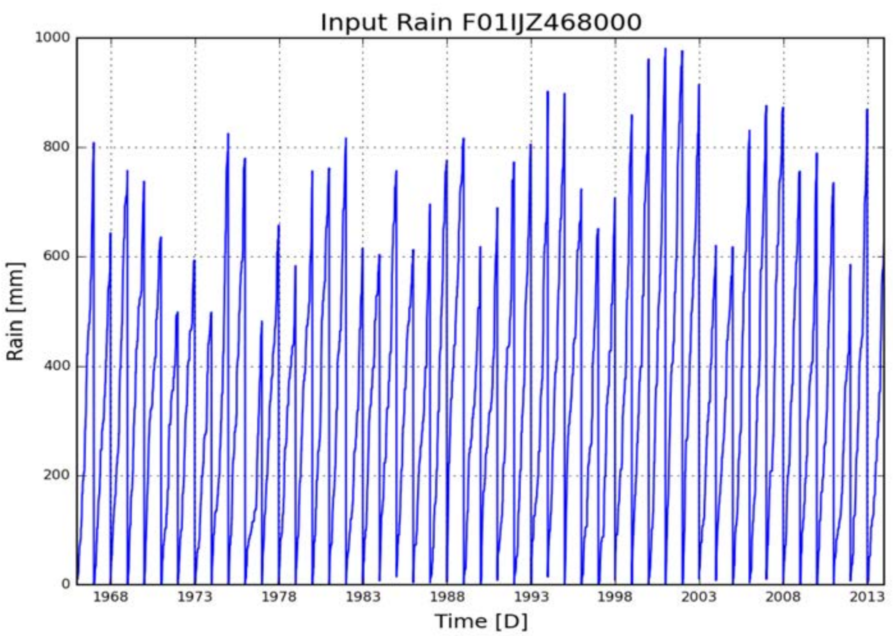
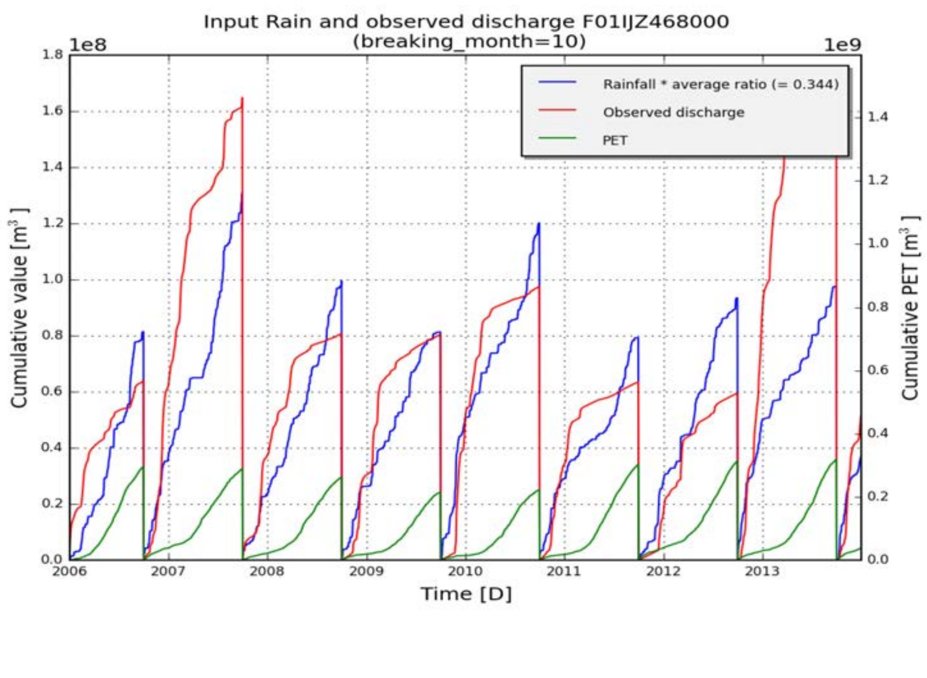


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment F01IJZ468000 (IJzer)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	F01IJZ468000
subcatchment_area [m²]	393007000
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.15), ('bevaporation', 2.0), ('cmin', 0.3), ('cmax', 153.0), ('CKBF', 300.0), ('CK1', 40.0), ('CK2', 24.0), ('bdrainage', 1.0), ('kdrainage', 12571.0), ('PDM.TG', 3.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2005 - 2013)

	Full year	Summer	Winter
NS	0.682	0.482	0.653
NS_log	0.671	-0.062	0.708
NS_rel	0.437	0.654	0.591
RelErr	-2.3 %	11.6 %	-16.5 %
VolBias	-0.051	0.144	-0.22

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.696	0.459	0.747
NS_log	0.617	-0.081	0.719
NS_rel	0.174	0.513	0.427
RelErr	9.3 %	-5.4 %	2.5 %
VolBias	0.041	-0.006	-0.06

Observed and simulated timeseries for optimum parameters

Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment F01IJZ468000, station 46810102 - Ijzer; Haringe(calibration period)

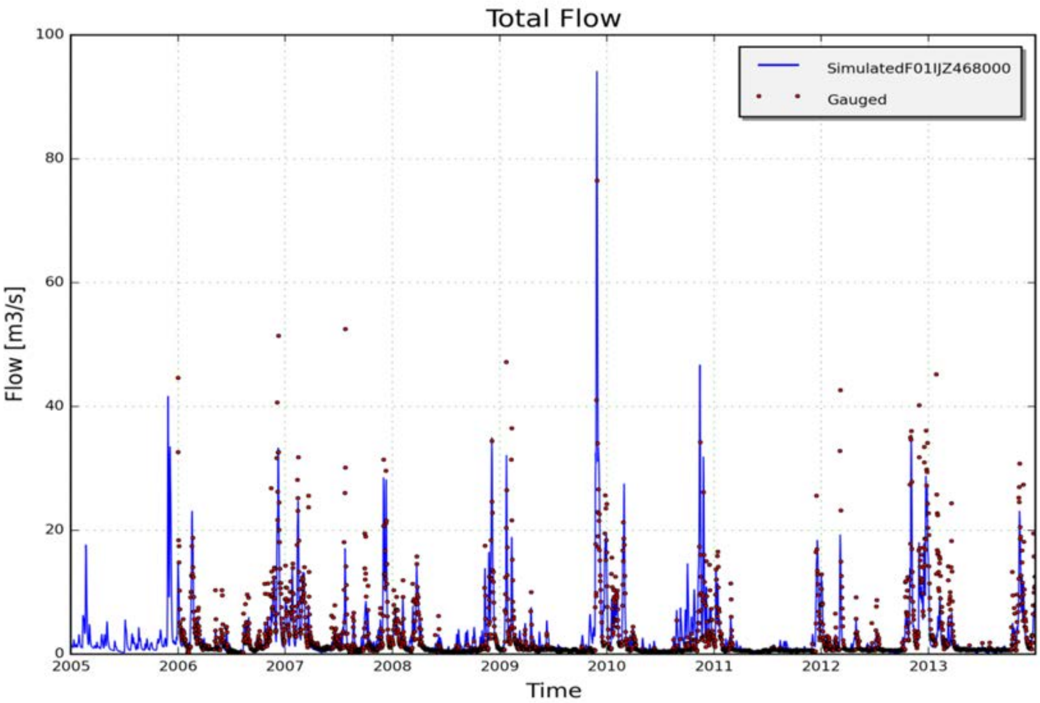


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment F01IJZ468000, station 46810102 - Ijzer; Haringe (calibration period)

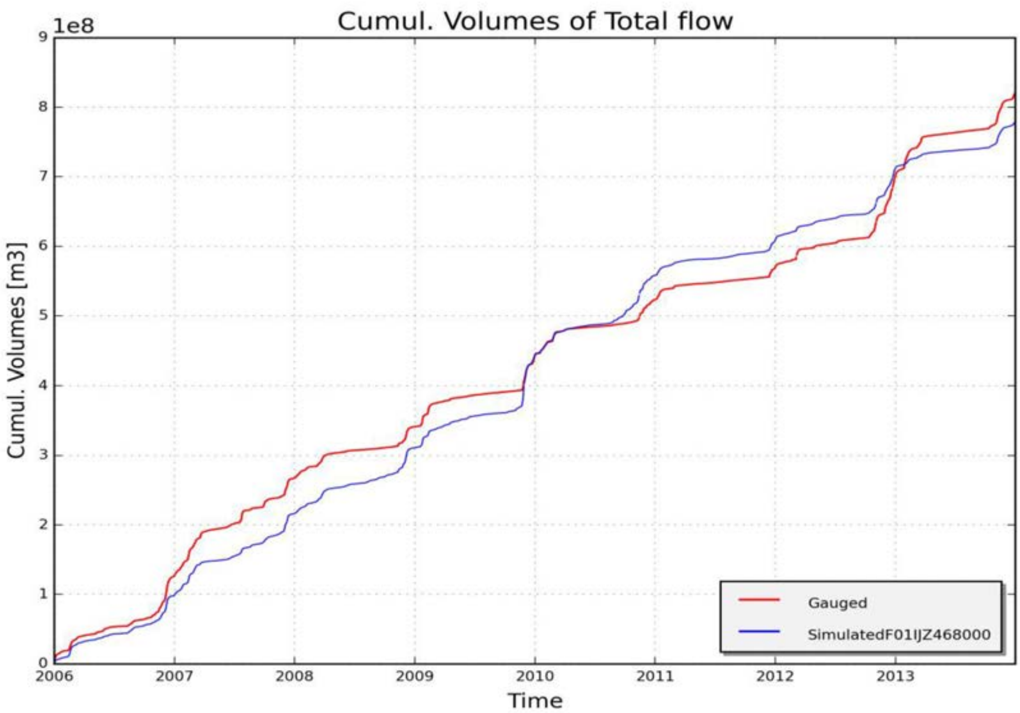


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment F01IJZ468000, station 46810102 - Ijzer; Haringe (validation period)

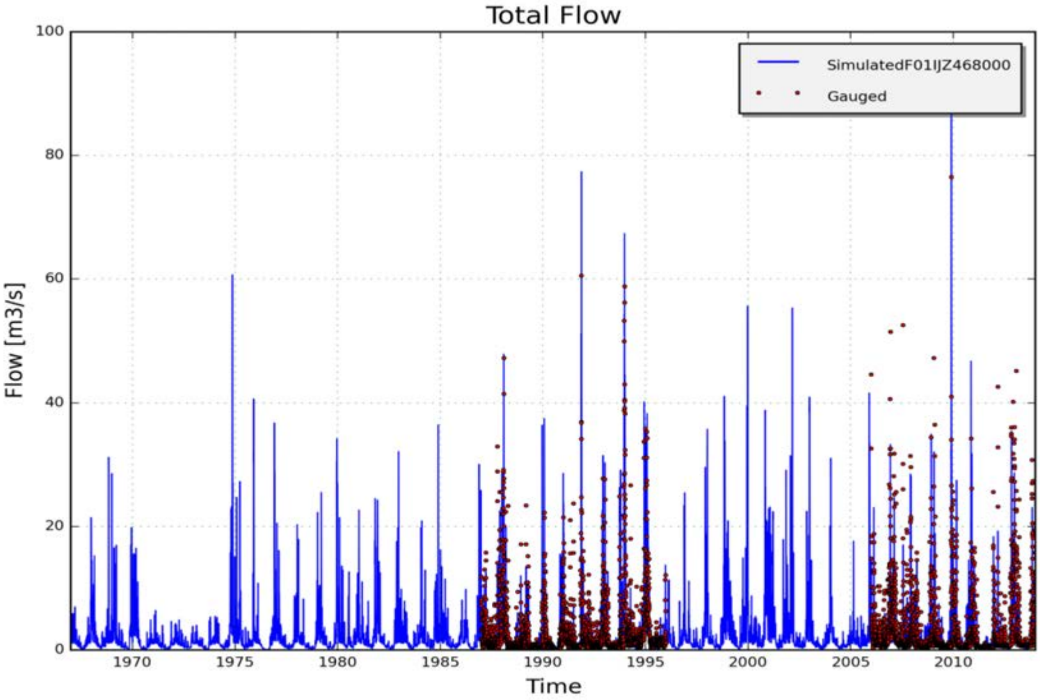


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment F01IJZ468000, station 46810102 - Ijzer; Haringe (validation period)

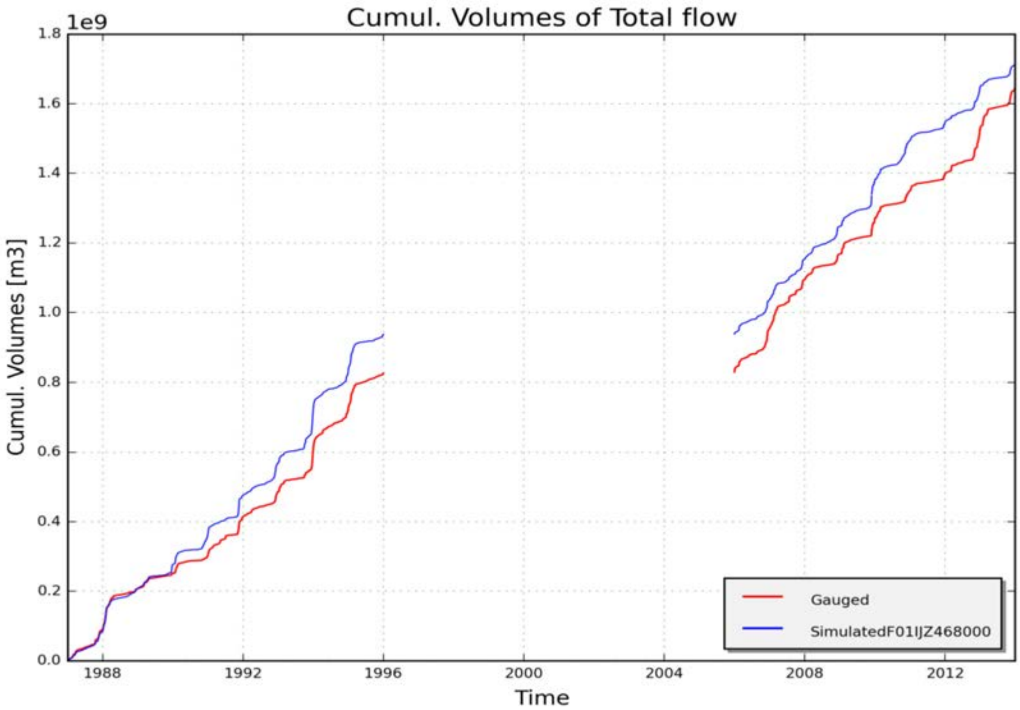


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment F01IJZ468000, station 46810102 - Ijzer; Haringe

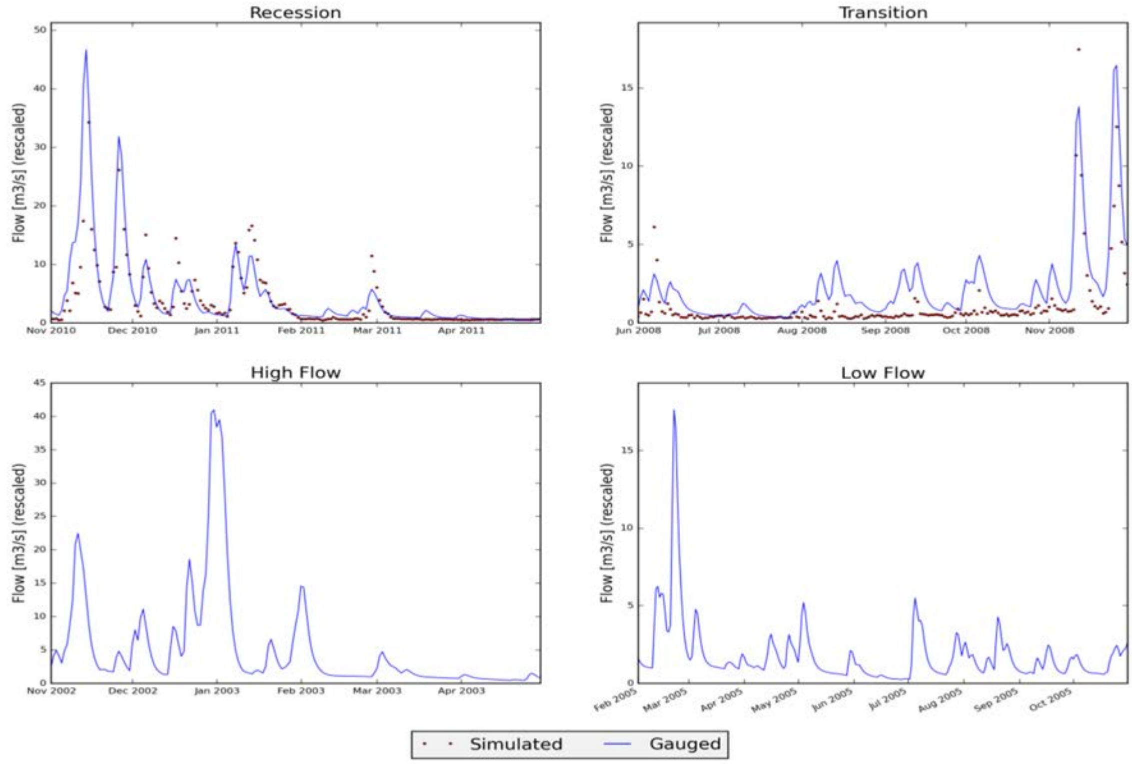


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment F01IJZ468000, station 46810102 - Ijzer; Haringe

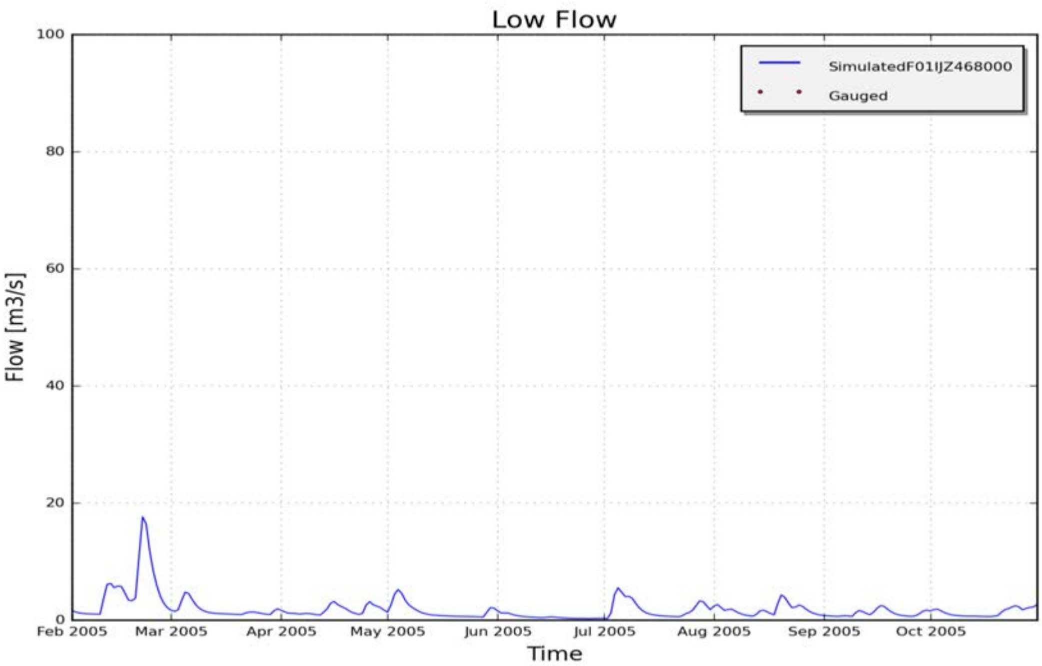


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment F01IJZ468000, station 46810102 - Ijzer; Haringe

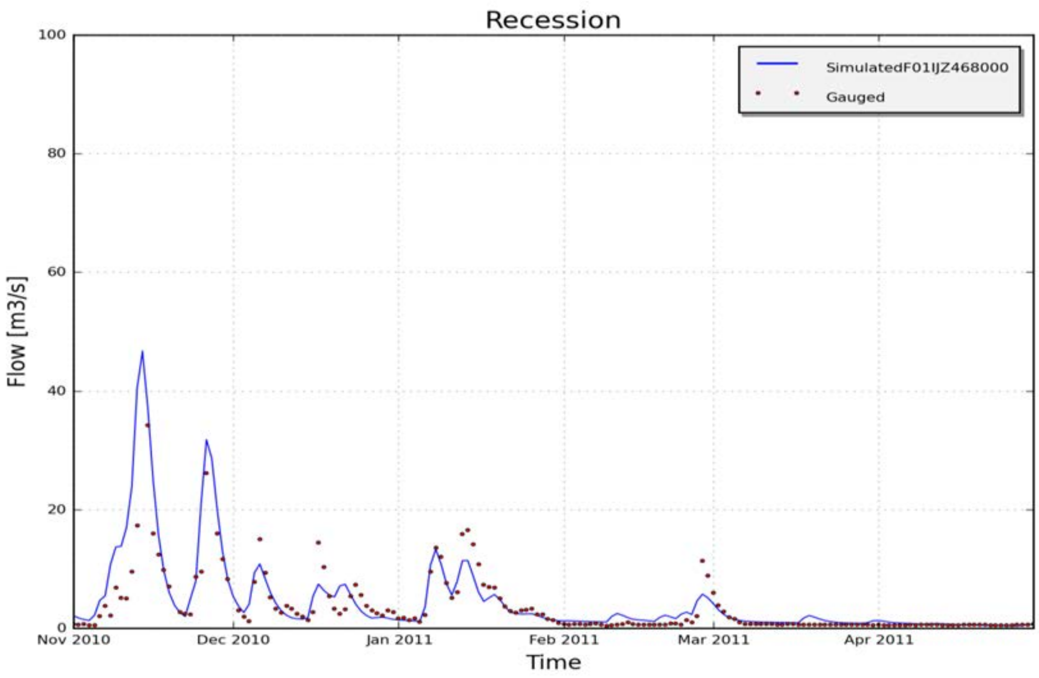
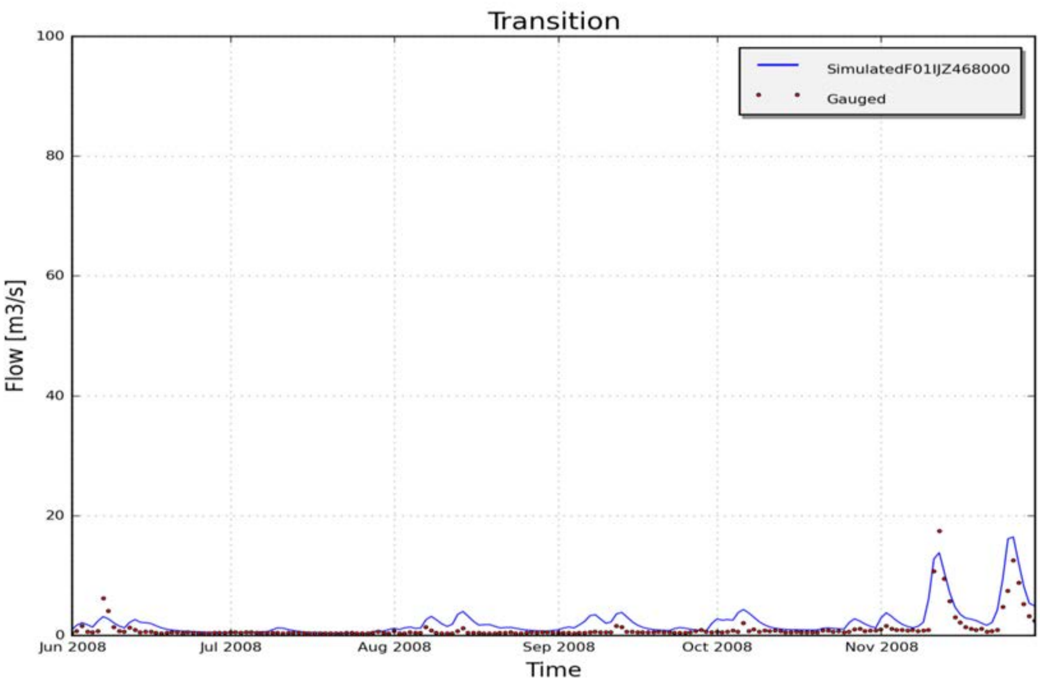


Figure 10: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment F01IJZ468000, station 46810102 - Ijzer; Haringe



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V01HAN488180" (IJZER)

Input data

Figure 1: Cumulative precipitation on catchment V01HAN488180 (IJzer)

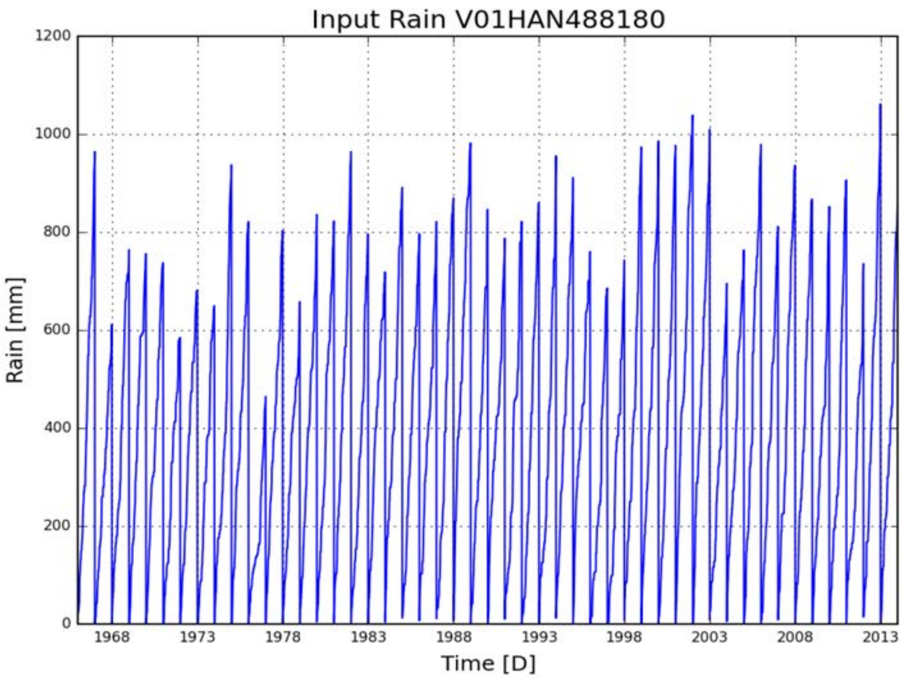
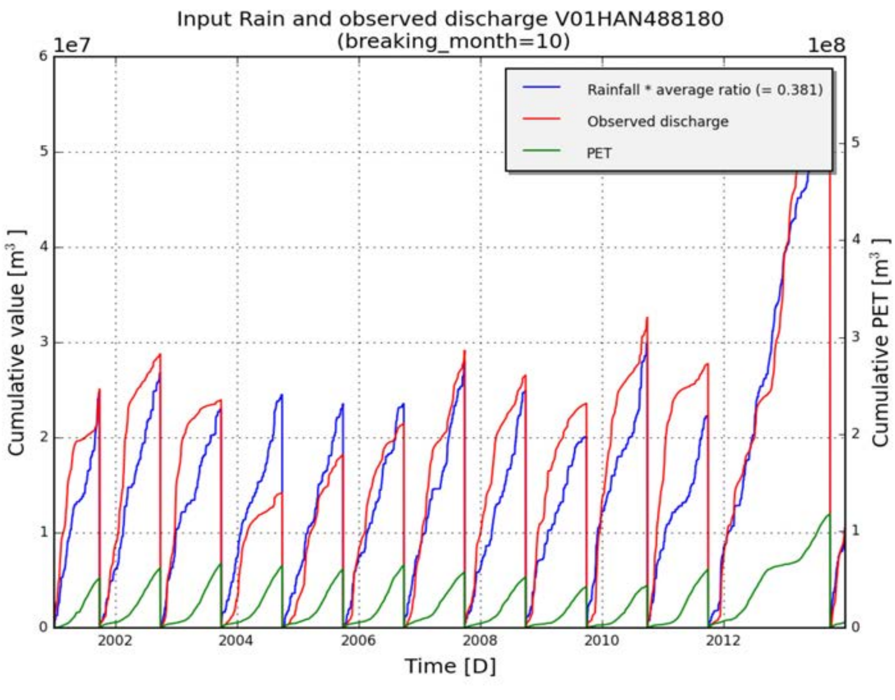


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V01HAN488180 (IJzer)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V01HAN488180
subcatchment_area [m²]	78558940
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.2), ('bevaporation', 2.0), ('cmin', 10.0), ('cmax', 236.0), ('CKBF', 300.0), ('CK1', 15.0), ('CK2', 21.0), ('bdrainage', 1.0), ('kdrainage', 11629.0), ('PDM.TG', 7.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.619	0.522	0.566
NS_log	0.784	0.614	0.657
NS_rel	0.743	0.757	0.786
RelErr	0.6 %	-4.3 %	3.0 %
VolBias	0.003	-0.083	0.001

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.626	0.513	0.567
NS_log	0.782	0.572	0.699
NS_rel	0.721	0.734	0.767
RelErr	2.4 %	-0.6 %	3.5 %
VolBias	0.017	-0.049	0.013

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)

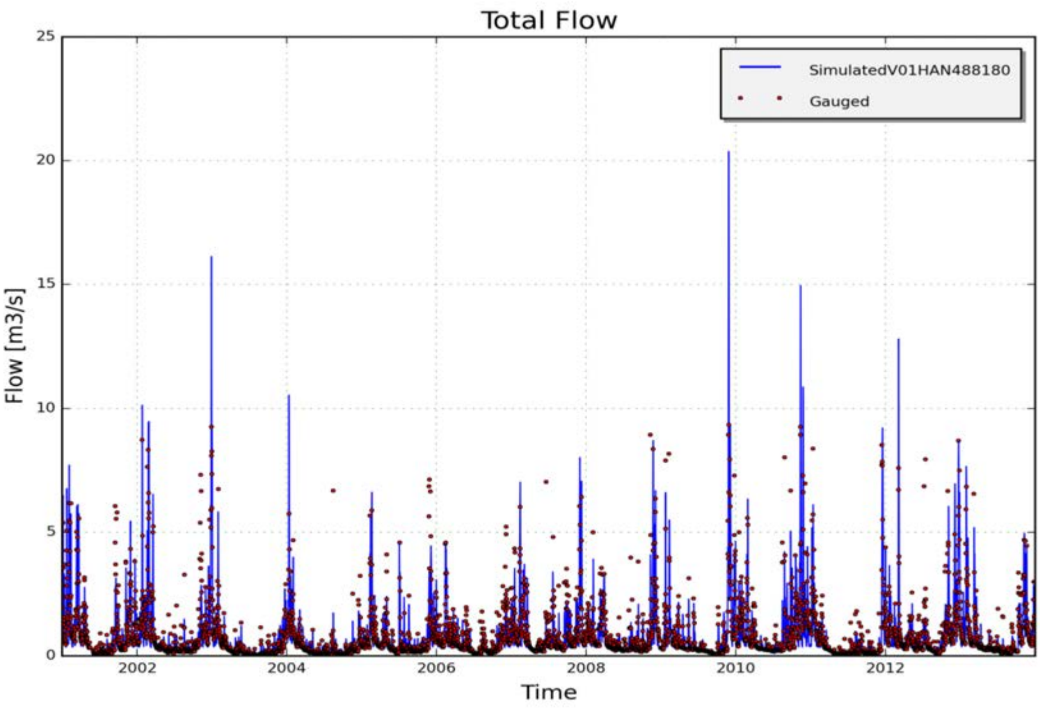


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark (calibration period)

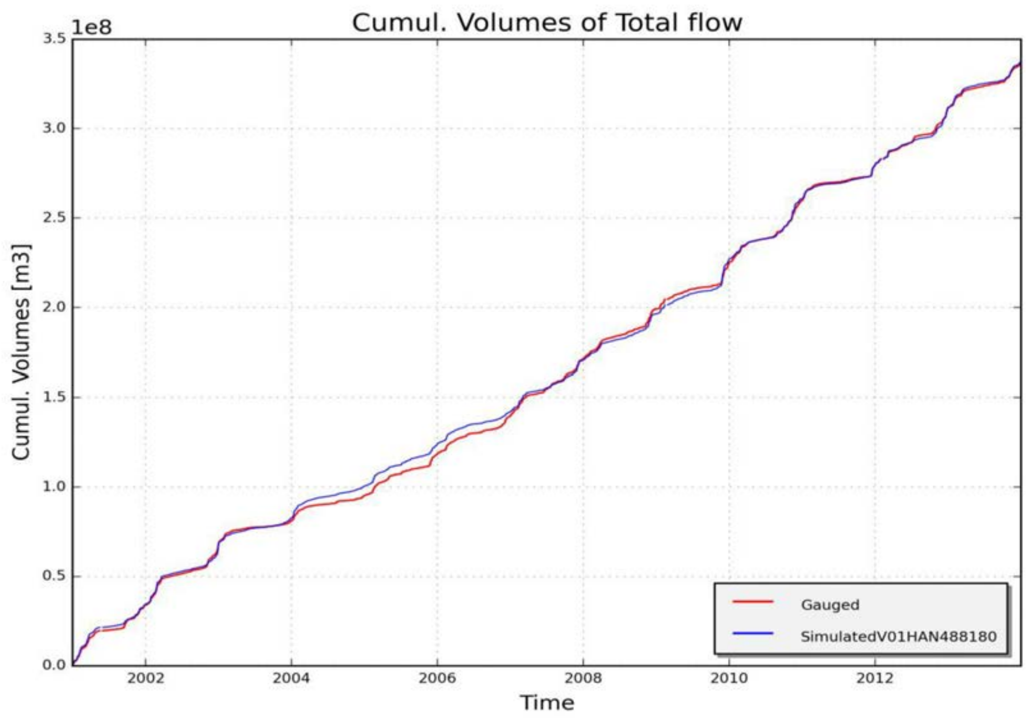


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark (validation period)

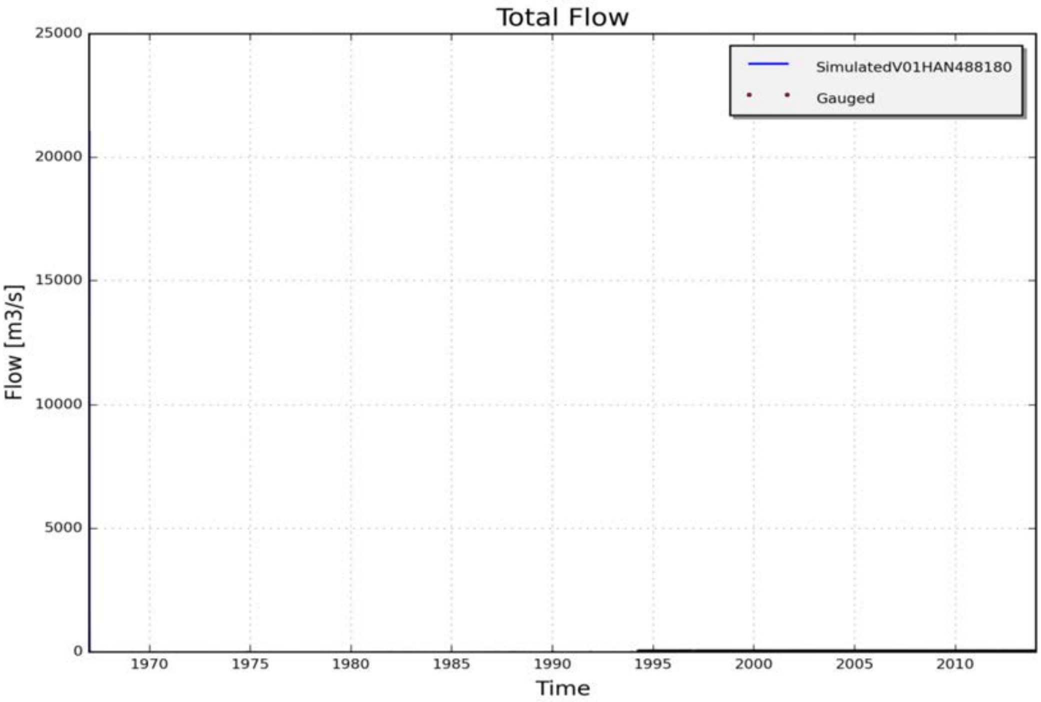


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark (validation period)

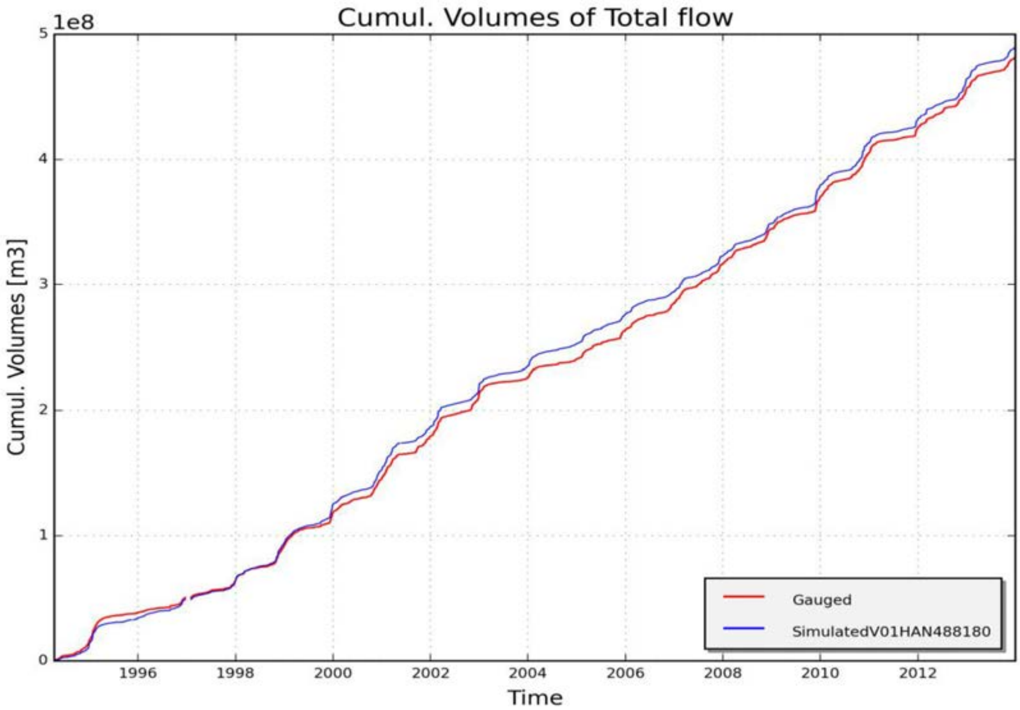
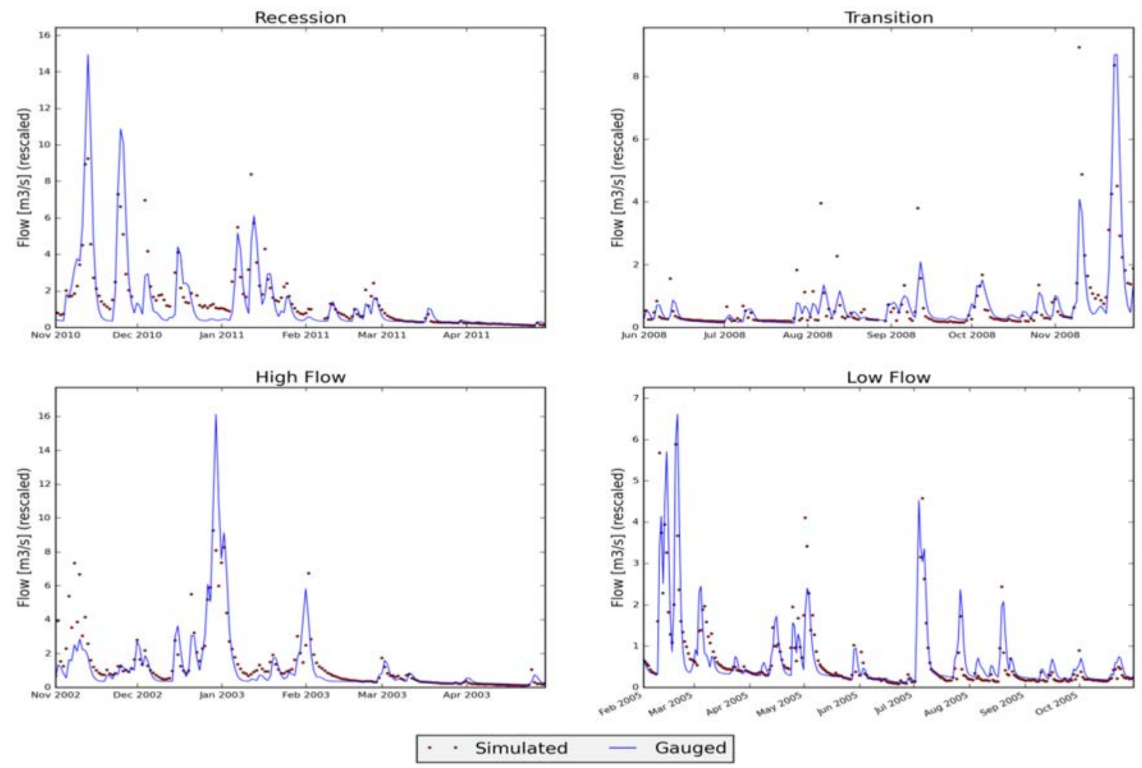


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V01IEP495080" (IJZER)

Input data

Figure 1: Cumulative precipitation on catchment V01IEP495080 (IJzer)

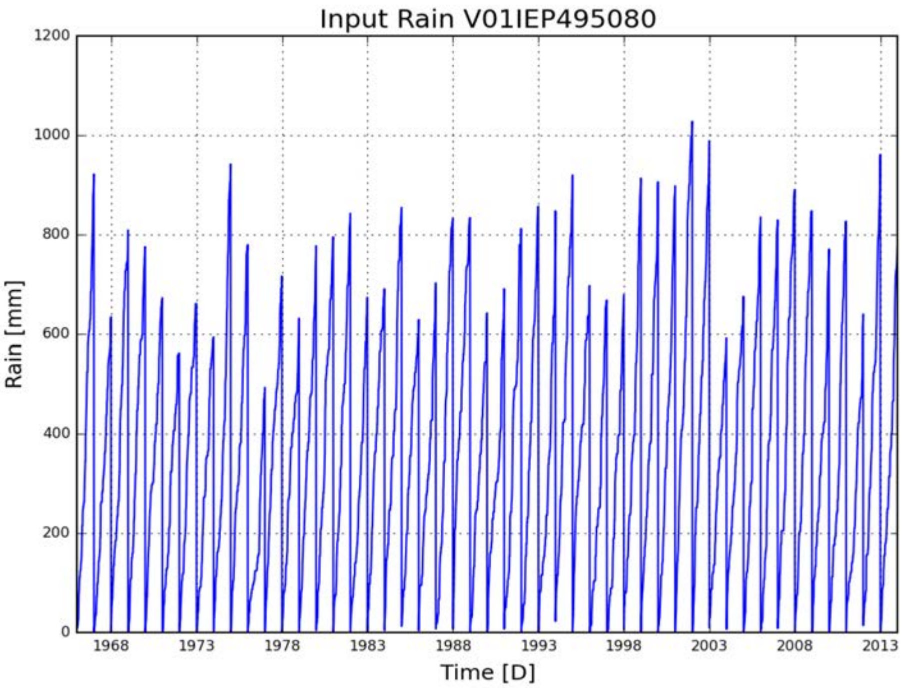
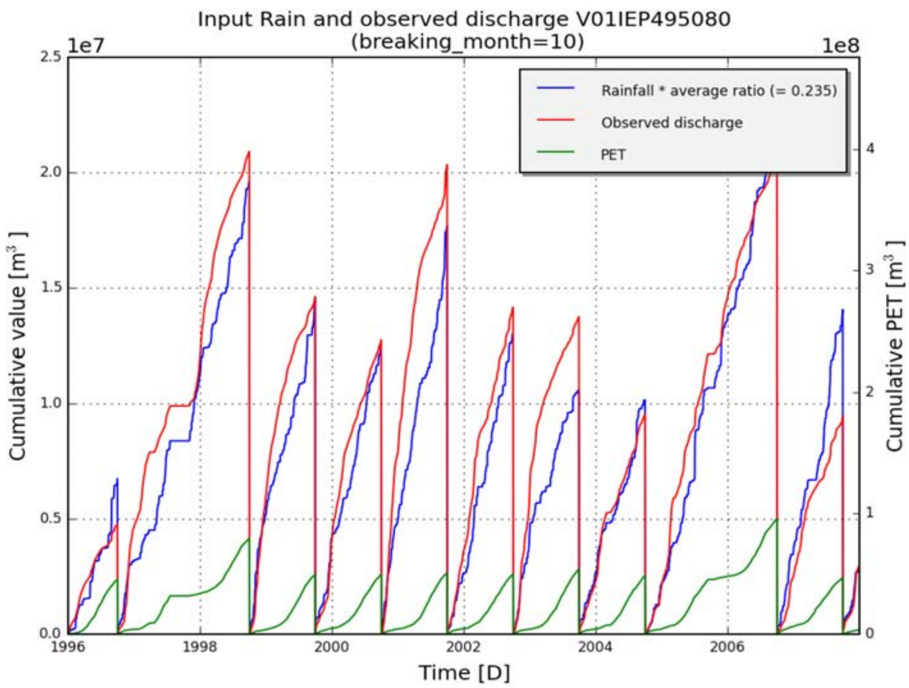


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V01IEP495080 (IJzer)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V01IEP495080
subcatchment_area [m²]	63423128
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.15), ('bevaporation', 2.0), ('cmin', 5.0), ('cmax', 391.0), ('CKBF', 300.0), ('CK1', 42.0), ('CK2', 22.0), ('bdrainage', 1.0), ('kdrainage', 19149.0), ('PDM.TG', 2.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1996 - 2007)

	Full year	**Summer**	**Winter**
NS	0.213	0.566	-0.495
NS_log	0.562	0.434	0.478
NS_rel	0.399	0.491	0.363
RelErr	9.8 %	-8.0 %	19.1 %
VolBias	0.121	-0.047	0.222

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	**Summer**	**Winter**
NS	0.247	0.567	-0.595
NS_log	0.564	0.307	0.358
NS_rel	-3.342	-11.984	0.189
RelErr	-17.0 %	-15.9 %	-16.4 %
VolBias	-0.059	-0.1	-0.018

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)

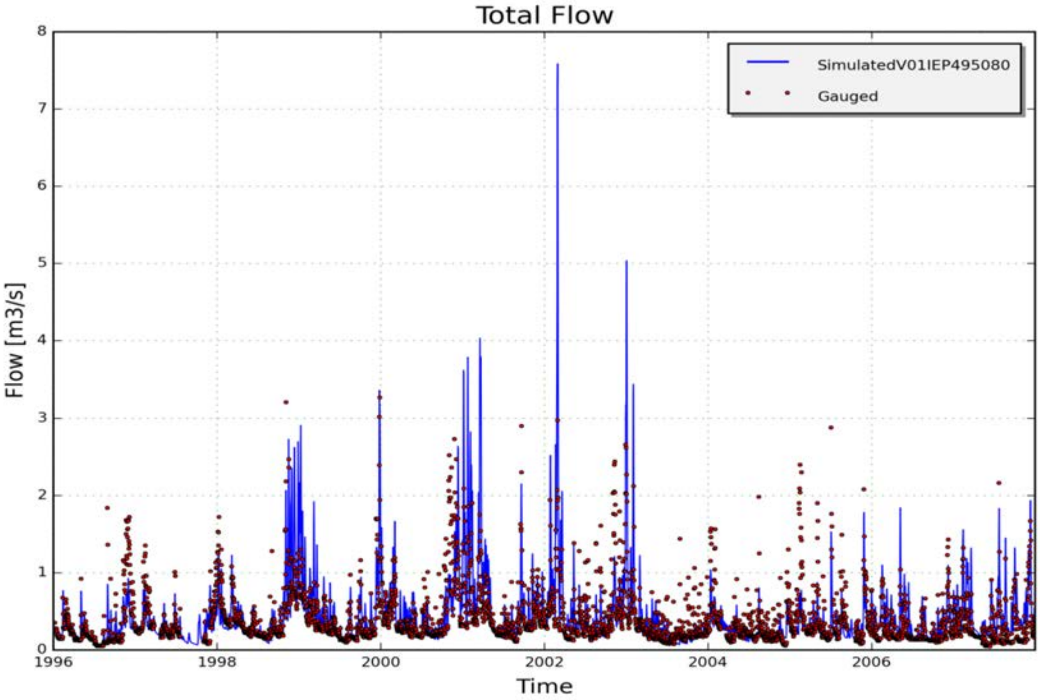


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote (calibration period)

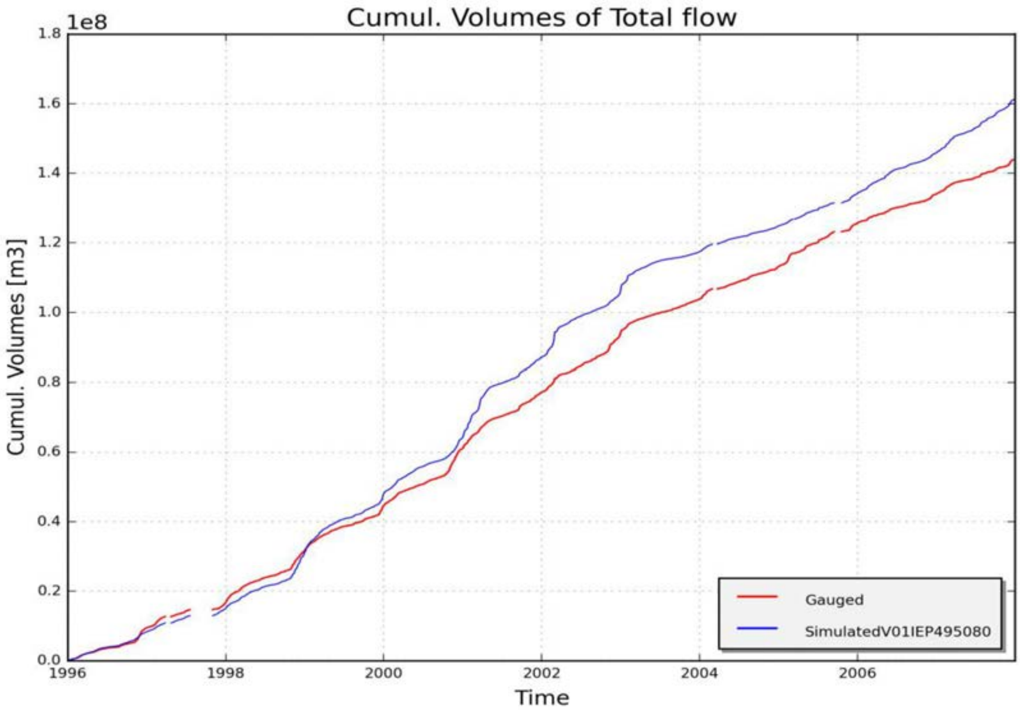


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote (validation period)

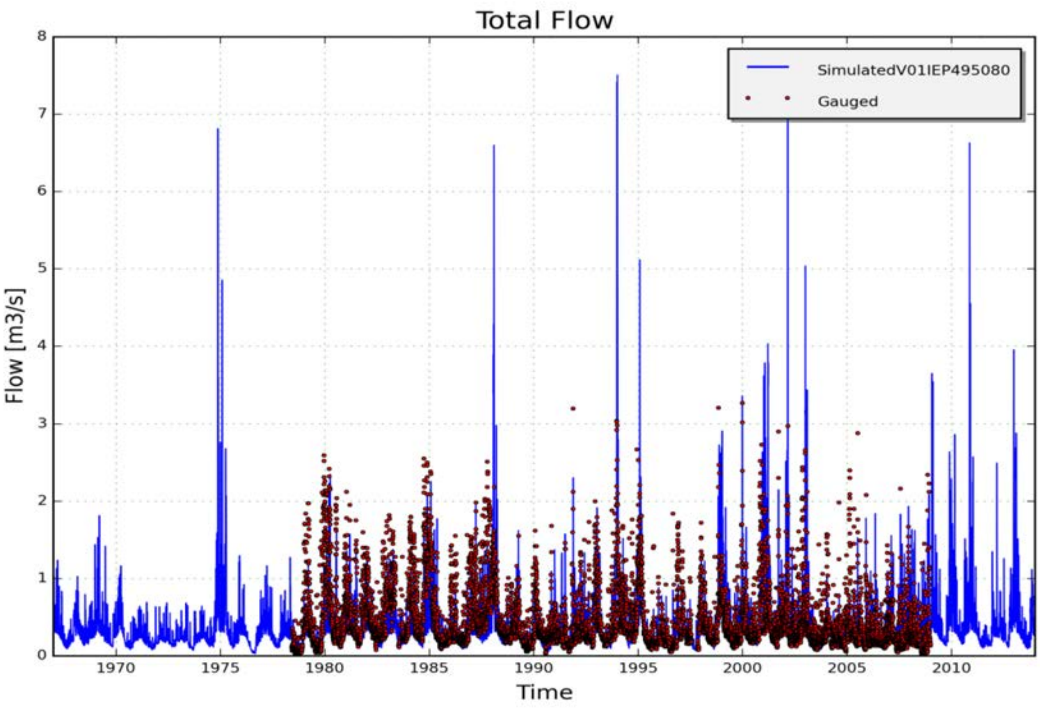


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote (validation period)

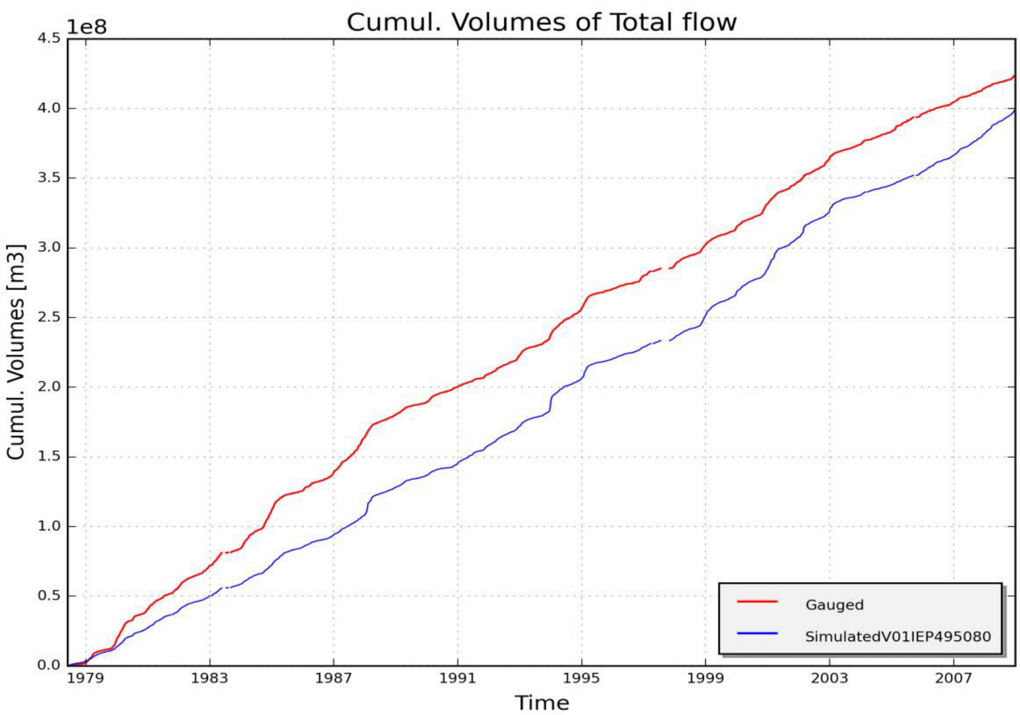


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote

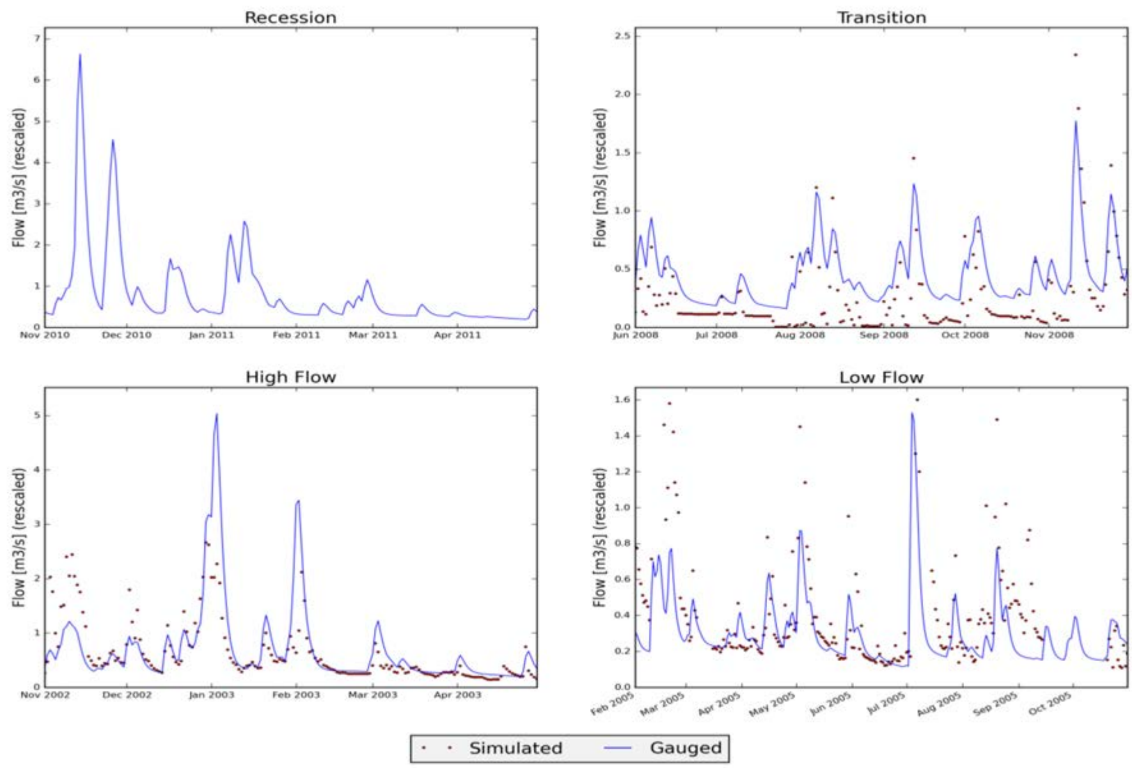


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote

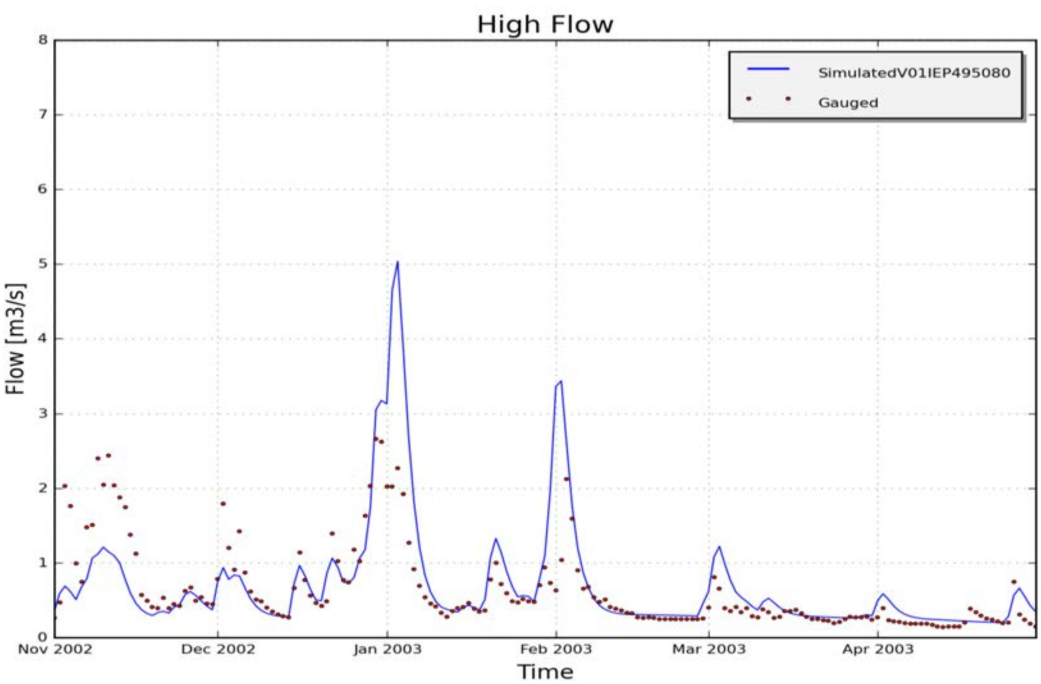
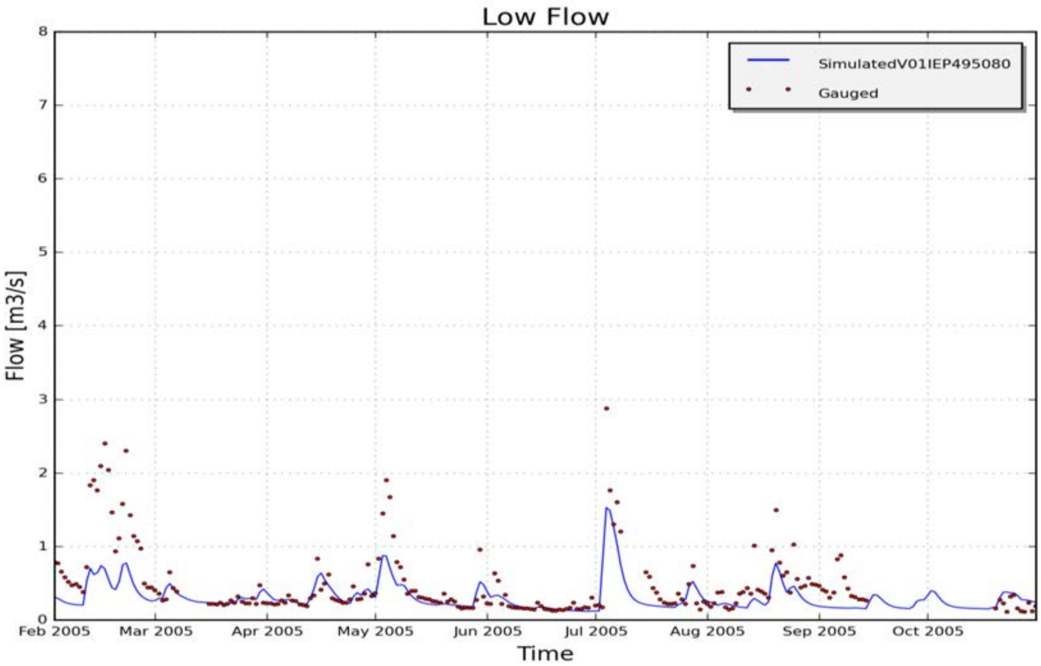


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V01KEM492060" (IJZER)

Input data

Figure 1: Cumulative precipitation on catchment V01KEM492060 (IJzer)

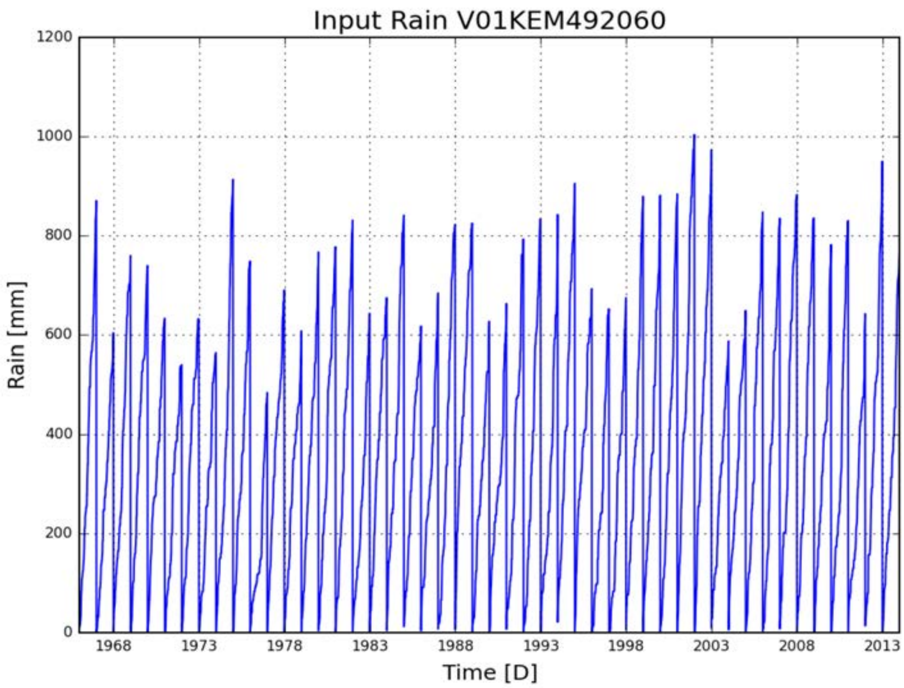
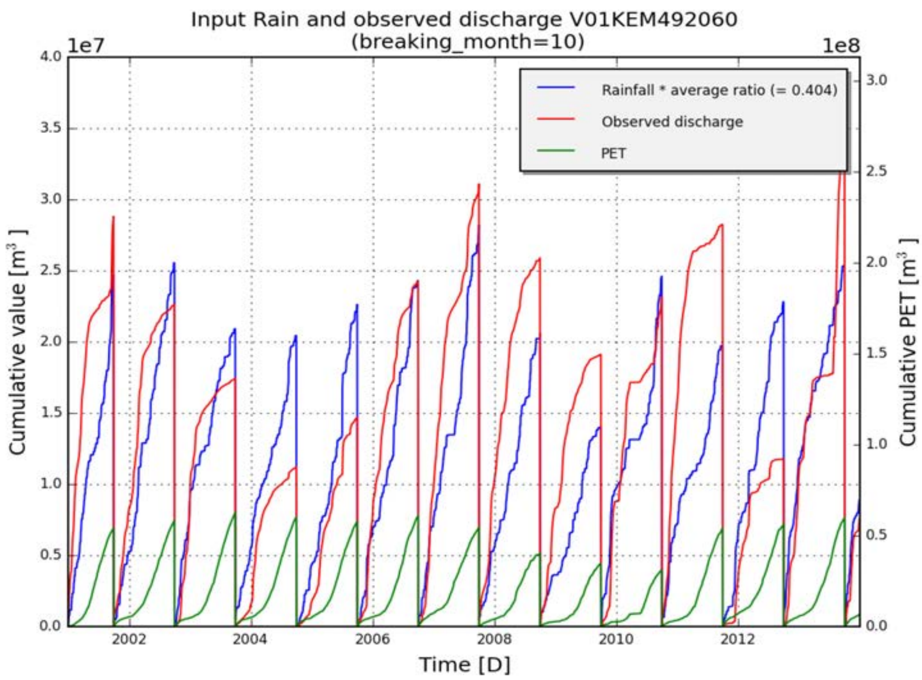


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V01KEM492060 (IJzer)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V01KEM492060
subcatchment_area [m²]	73892930
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.36), ('bevaporation', 2.0), ('cmin', 8.1), ('cmax', 192.0), ('CKBF', 300.0), ('CK1', 27.0), ('CK2', 31.0), ('bdrainage', 1.0), ('kdrainage', 11000.0), ('PDM.TG', 3.3), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	**Summer**	**Winter**
NS	0.58	0.267	0.594
NS_log	0.521	0.195	0.396
NS_rel	-20.39	-14.725	-0.045
RelErr	-0.3 %	17.8 %	-6.3 %
VolBias	-0.026	-0.169	-0.074

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	**Summer**	**Winter**
NS	0.624	0.294	0.667
NS_log	0.566	0.256	0.59
NS_rel	-9.468	-8.476	0.405
RelErr	9.9 %	23.6 %	0.3 %
VolBias	0.04	-0.032	-0.031

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)

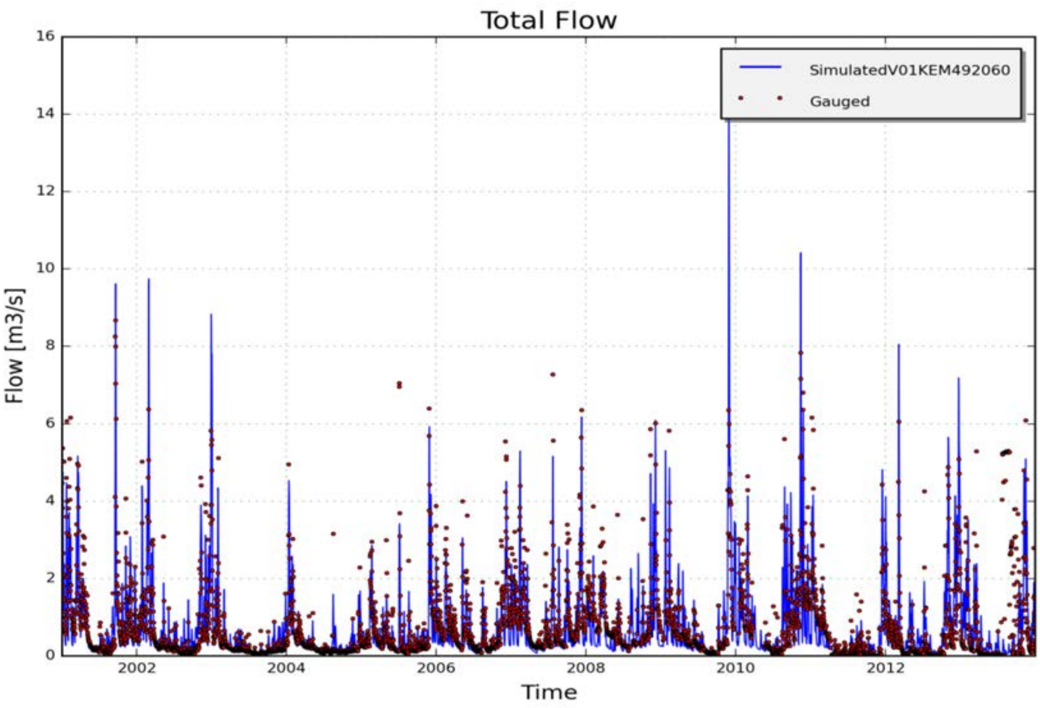


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01KEM492060, station 49270102 -Kemmelbeek; Boezinge (calibration period)

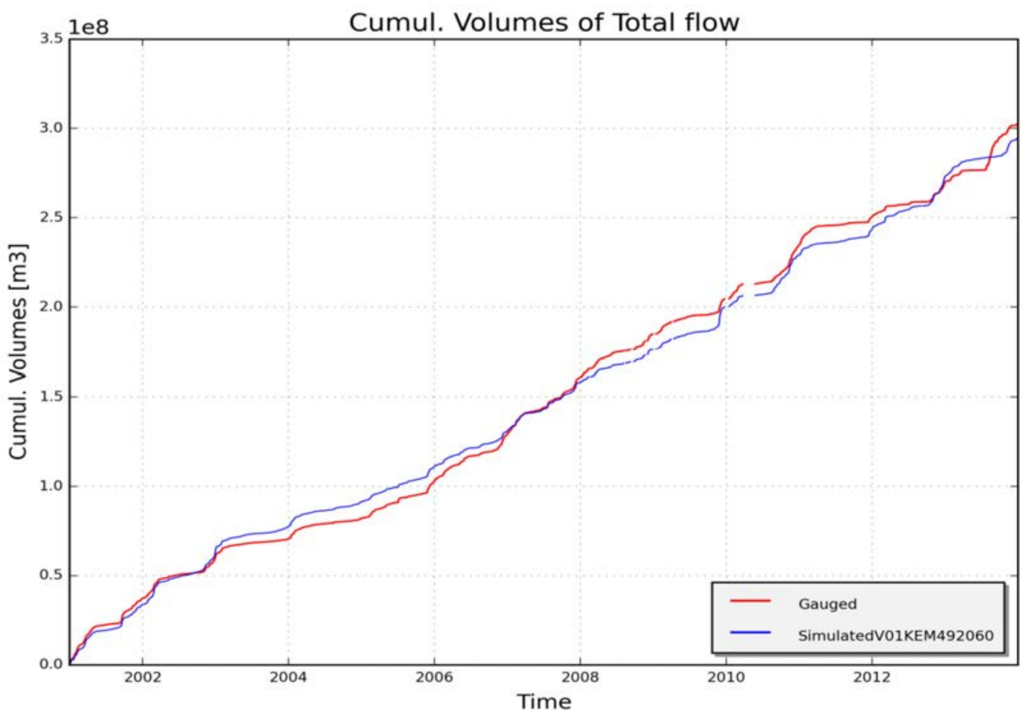


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01KEM492060, station 49270102 -Kemmelbeek; Boezinge (validation period)

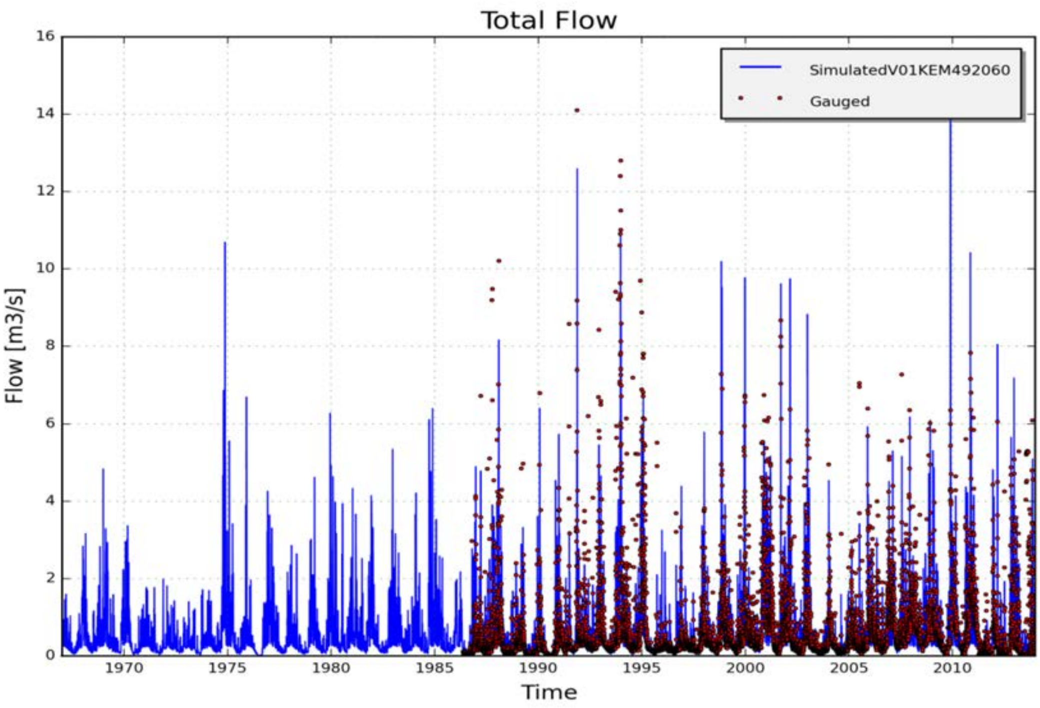


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01KEM492060, station 49270102 -Kemmelbeek; Boezinge (validation period)

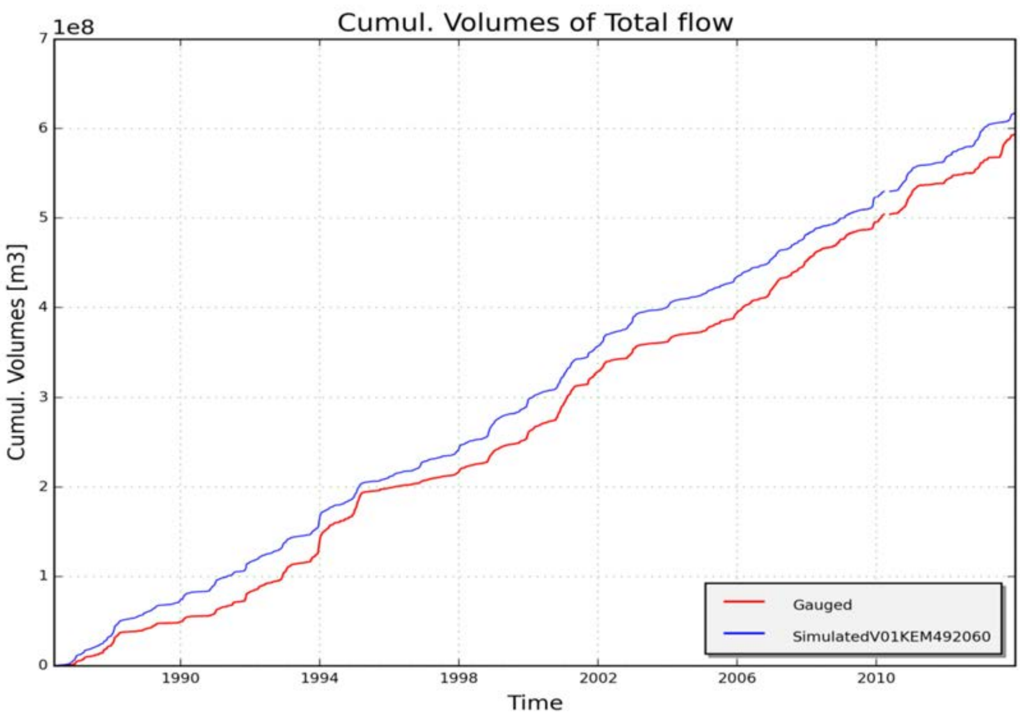
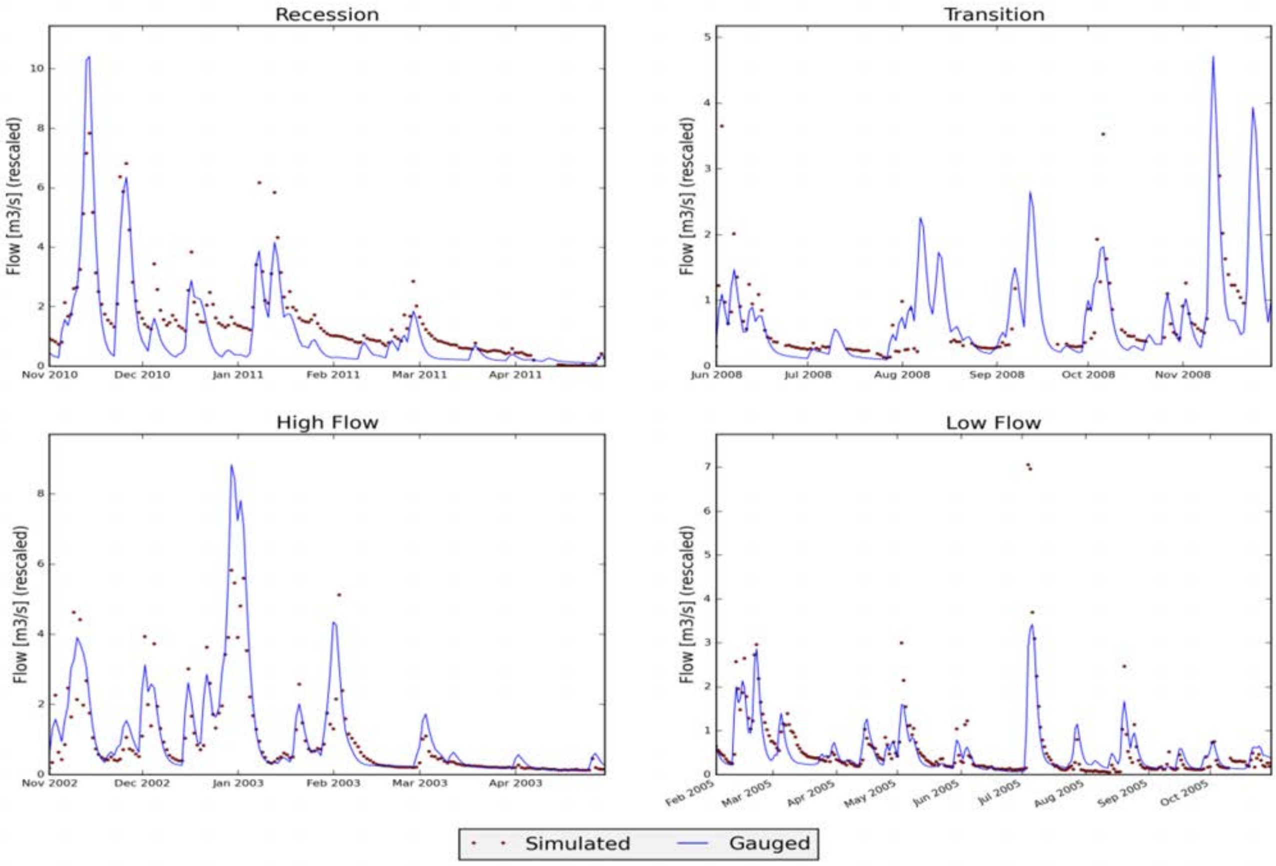


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01KEM492060, station 49270102 -Kemmelbeek; Boezinge



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V01MAR496120" (IJZER)

Input data

Figure 1: Cumulative precipitation on catchment V01MAR496120 (IJzer)

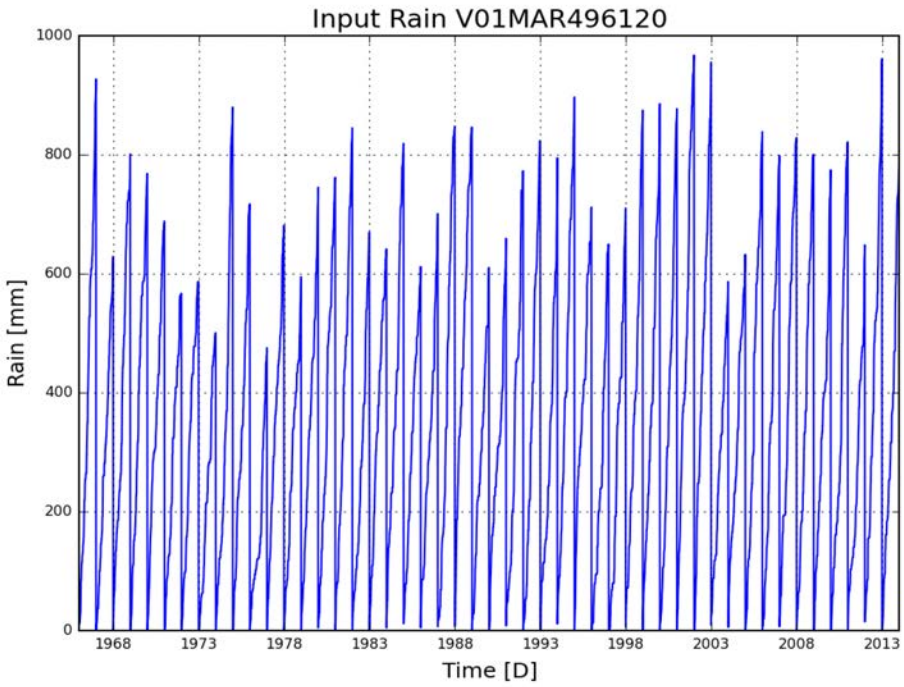
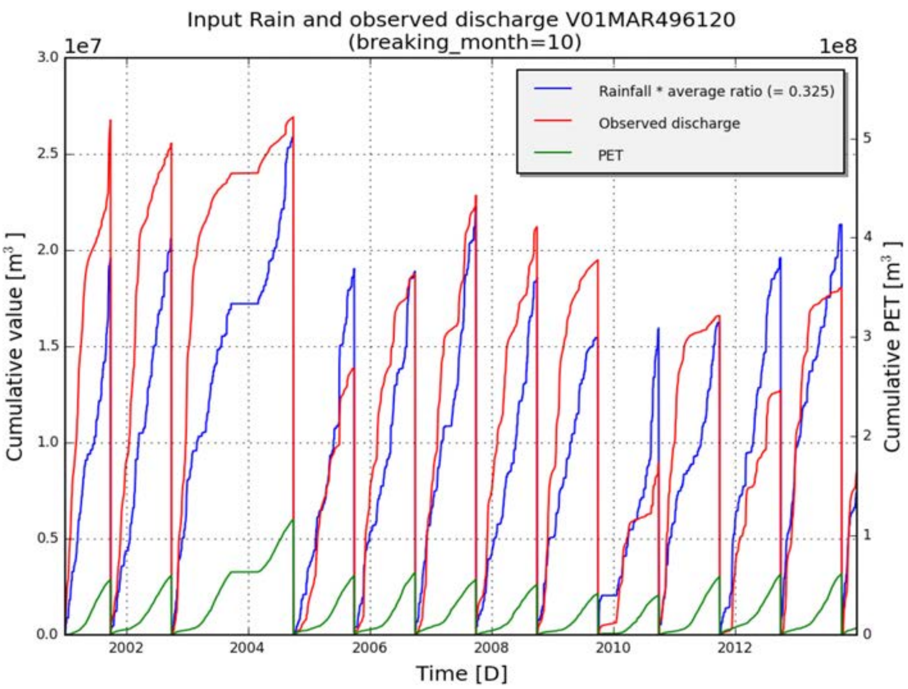


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V01MAR496120 (IJzer)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V01MAR496120
subcatchment_area [m²]	76136621
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.3), ('bevaporation', 2.0), ('cmin', 14.0), ('cmax', 202.0), ('CKBF', 300.0), ('CK1', 26.0), ('CK2', 31.0), ('bdrainage', 1.0), ('kdrainage', 17197.0), ('PDM.TG', 7.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.684	0.537	0.647
NS_log	0.683	0.386	0.687
NS_rel	-0.514	-0.33	0.333
RelErr	-4.1 %	-5.5 %	-2.2 %
VolBias	0.064	0.061	0.049

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.651	0.524	0.607
NS_log	0.644	0.446	0.665
NS_rel	-7.061	-0.786	-0.69
RelErr	7.3 %	-2.0 %	5.1 %
VolBias	0.086	0.032	0.062

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)

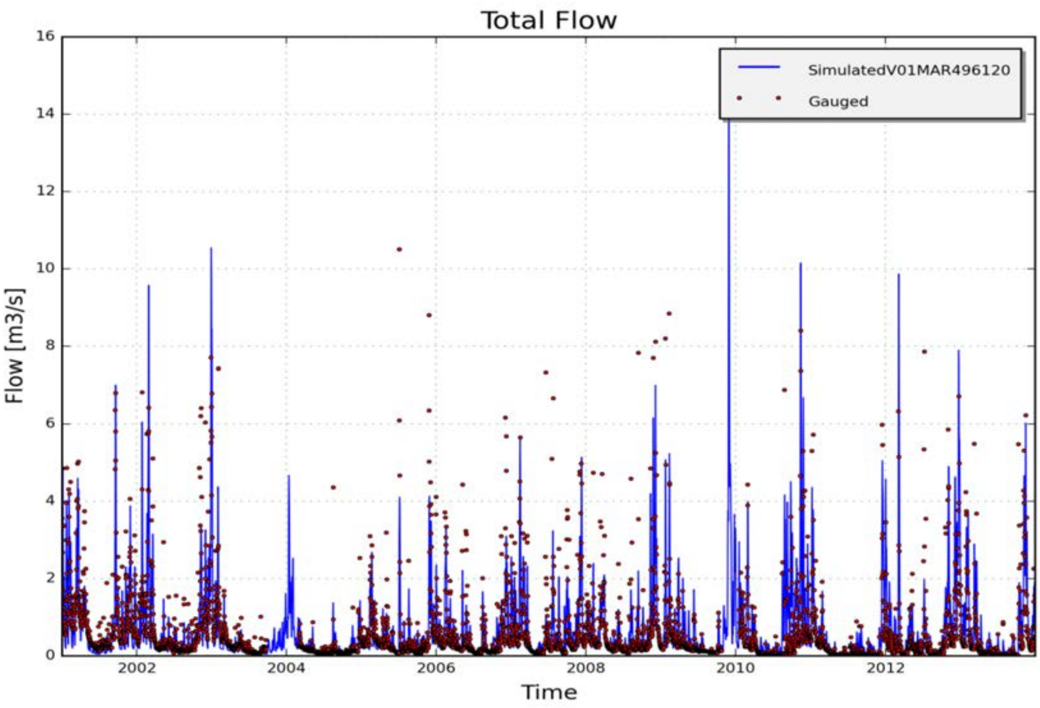


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem (calibration period)

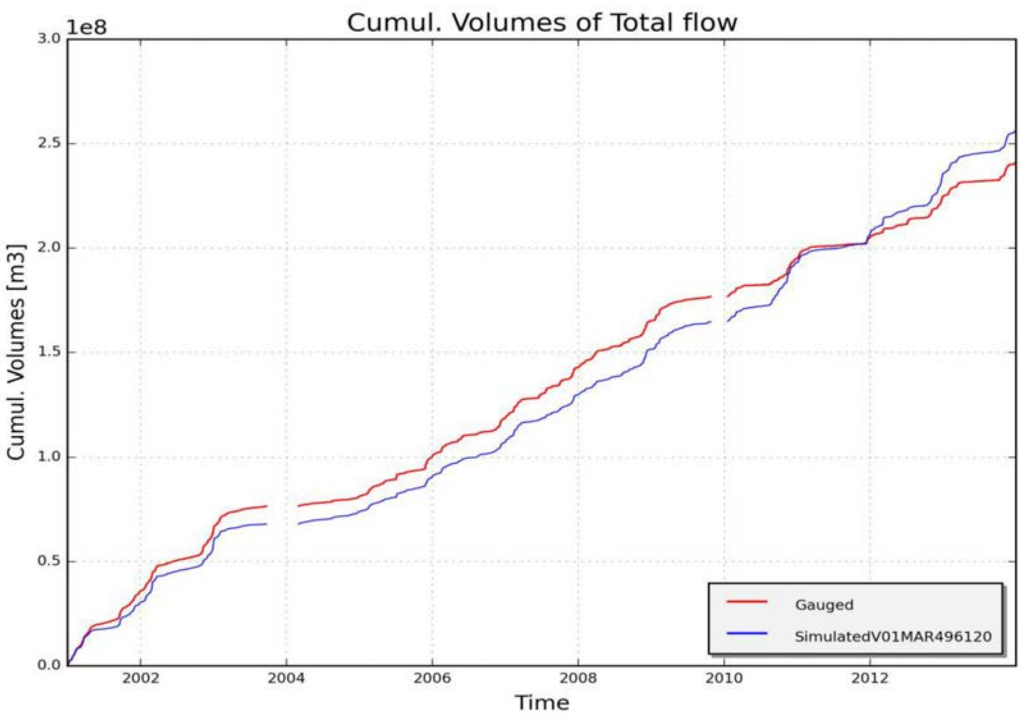


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem (validation period)

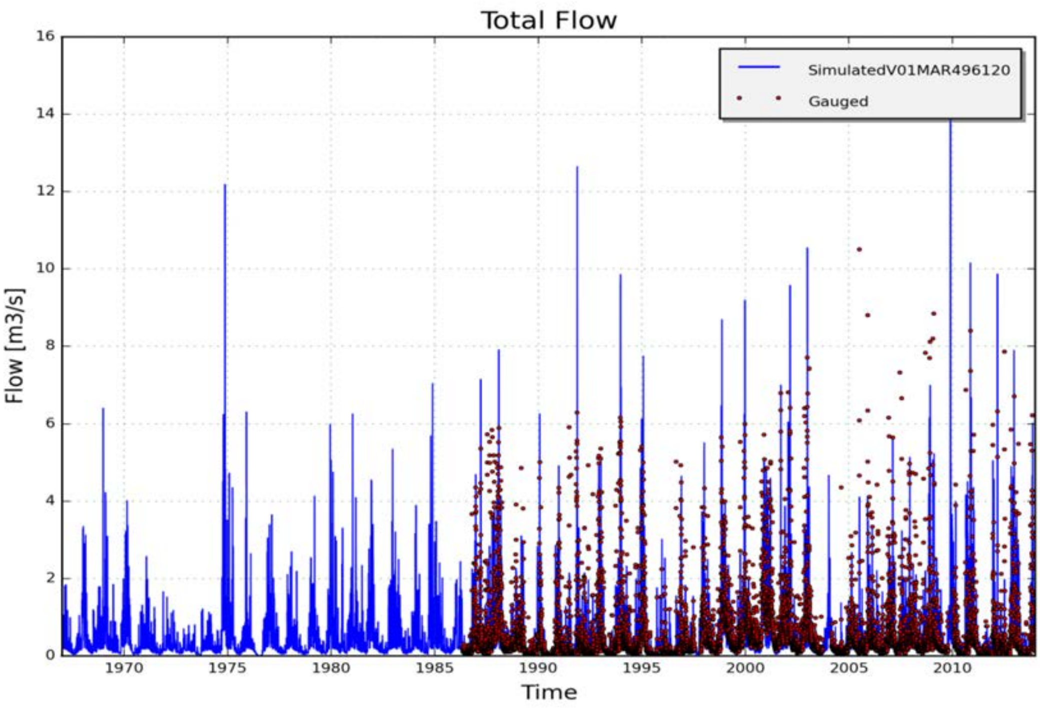


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem (validation period)

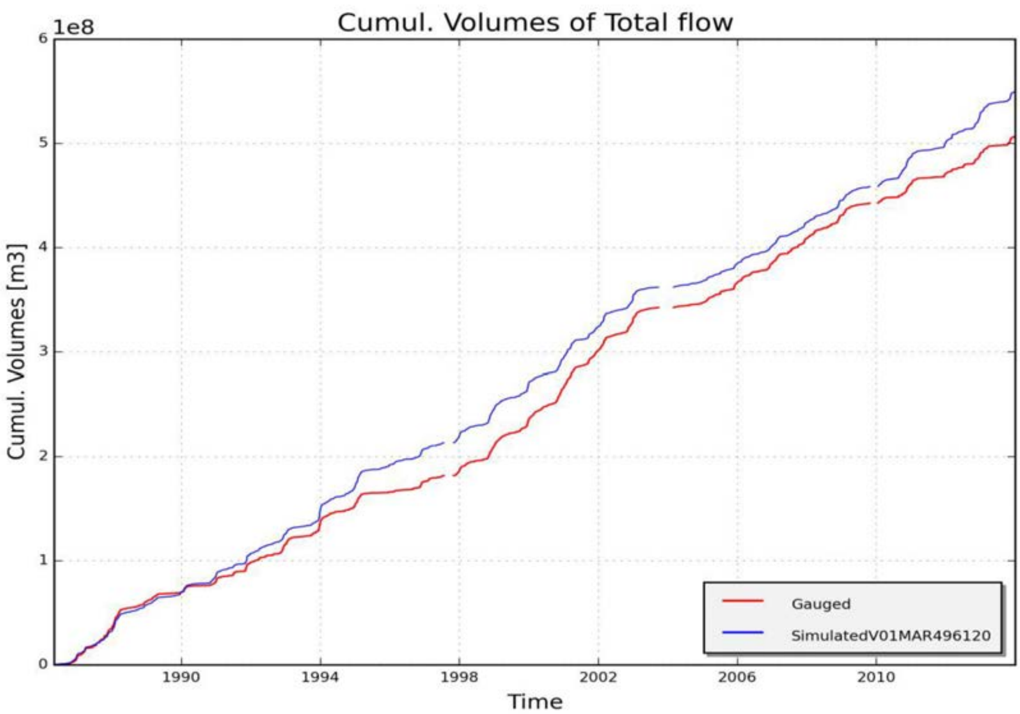
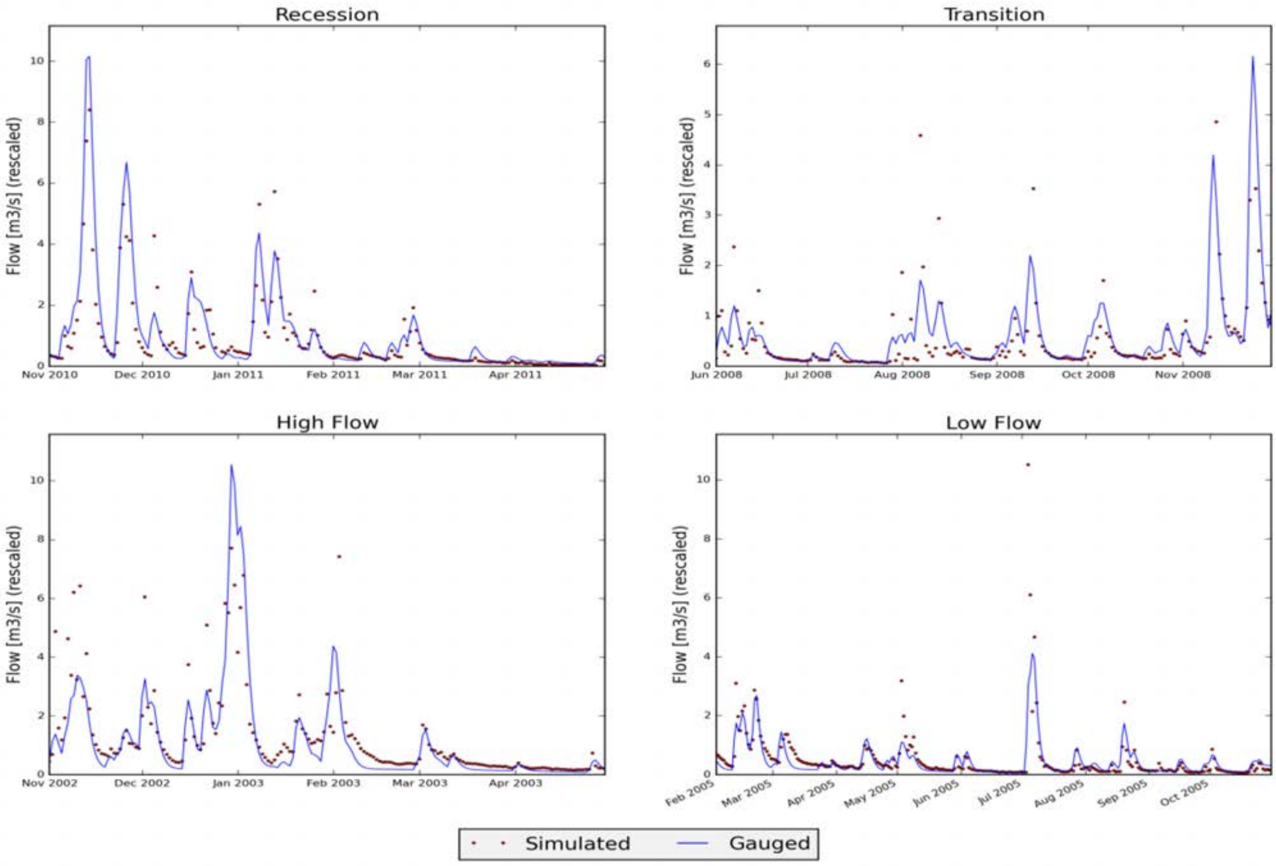


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V01POP491030" (IJZER)

Input data

Figure 1: Cumulative precipitation on catchment V01POP491030 (IJzer)

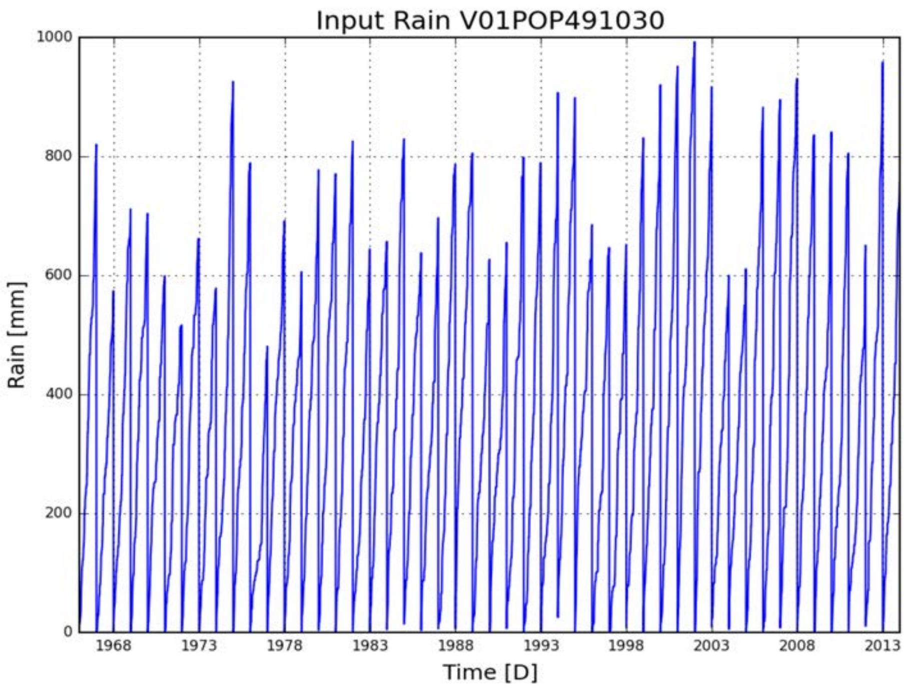
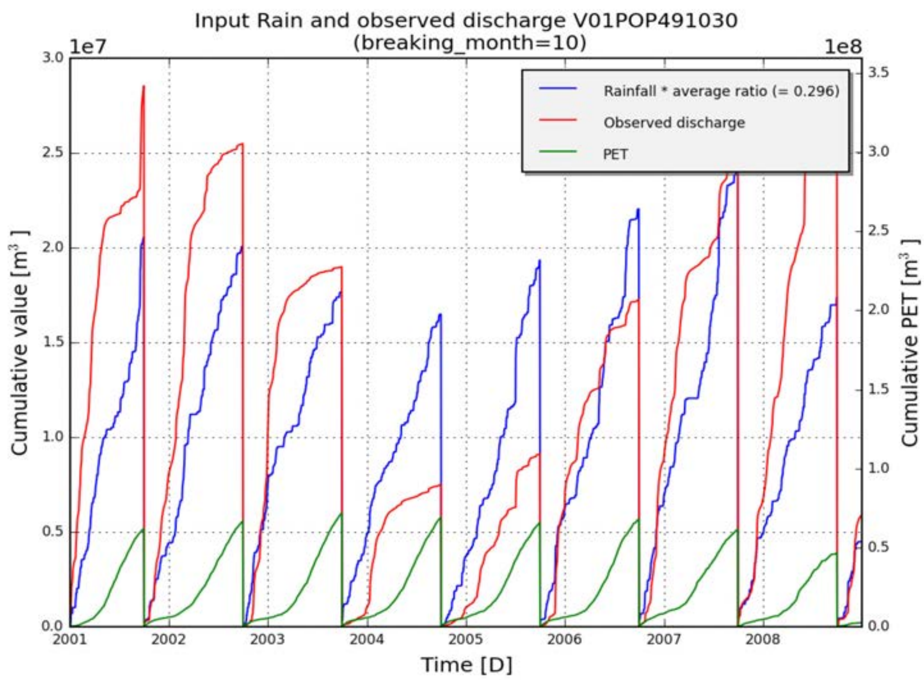


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V01POP491030 (IJzer)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V01POP491030
subcatchment_area [m²]	84868207
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.09), ('bevaporation', 1.0), ('cmin', 11.0), ('cmax', 281.0), ('CKBF', 1.0), ('CK1', 32.0), ('CK2', 33.0), ('bdrainage', 1.0), ('kdrainage', 36123.0), ('PDM.TG', 5.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2008)

	Full year	Summer	Winter
NS	0.587	0.612	0.667
NS_log	0.629	0.081	0.615
NS_rel	-0.307	0.107	0.712
RelErr	-2.2 %	8.1 %	-4.0 %
VolBias	0.003	0.162	-0.063

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.434	0.511	0.489
NS_log	0.66	0.063	0.596
NS_rel	-0.009	0.208	0.626
RelErr	-2.6 %	11.6 %	-7.0 %
VolBias	0.055	0.186	-0.01

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)

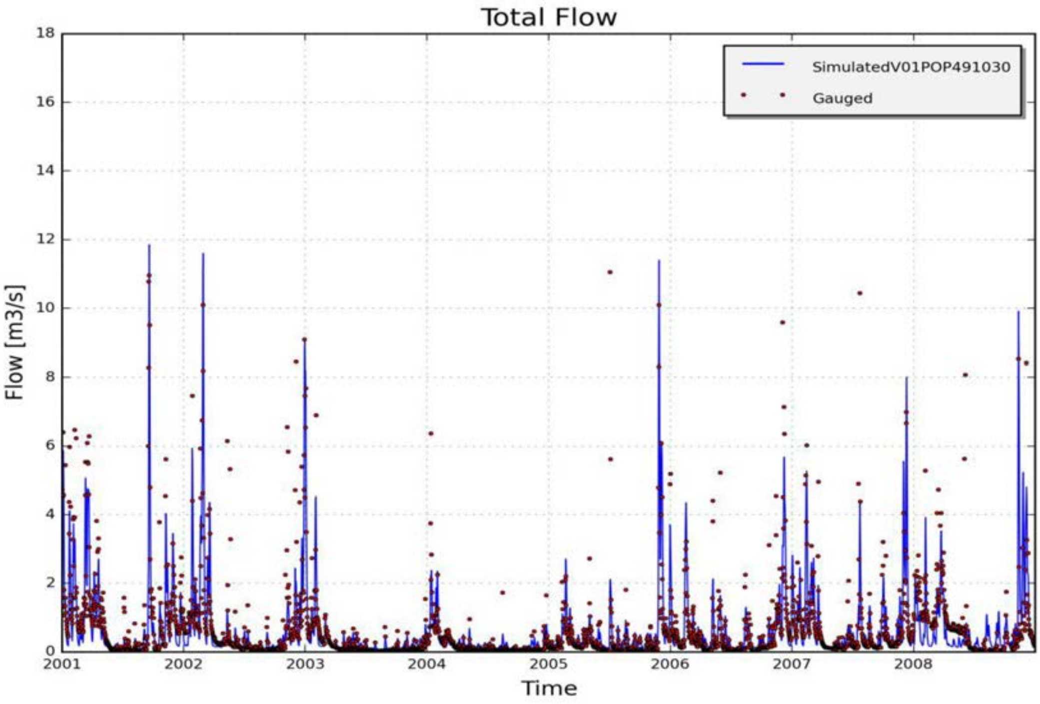


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren (calibration period)

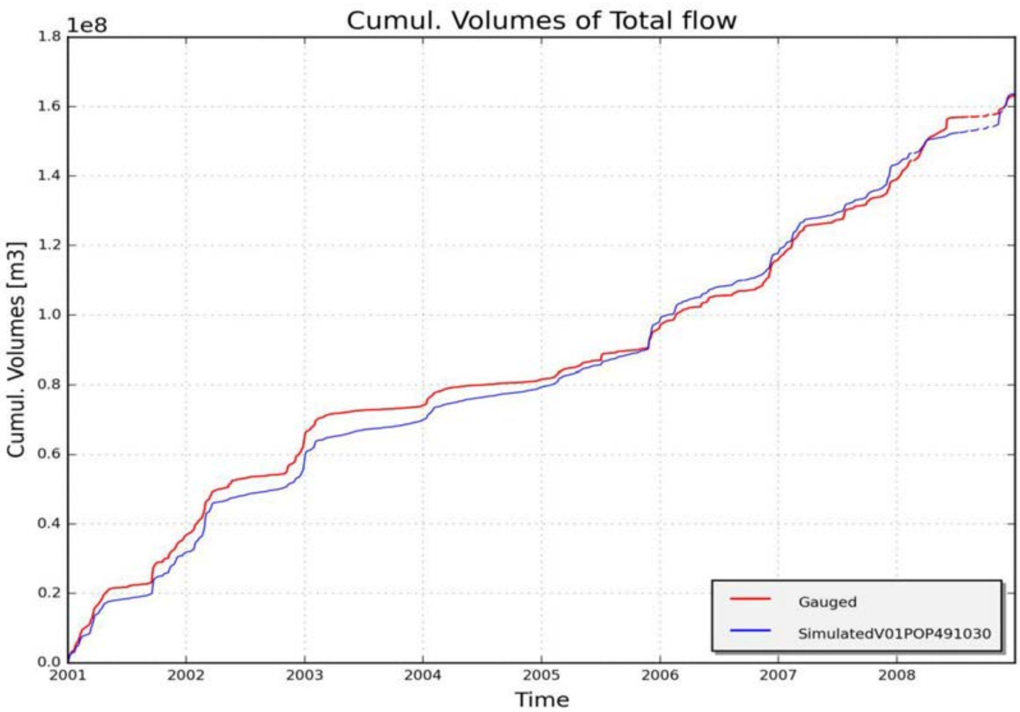


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren (validation period)

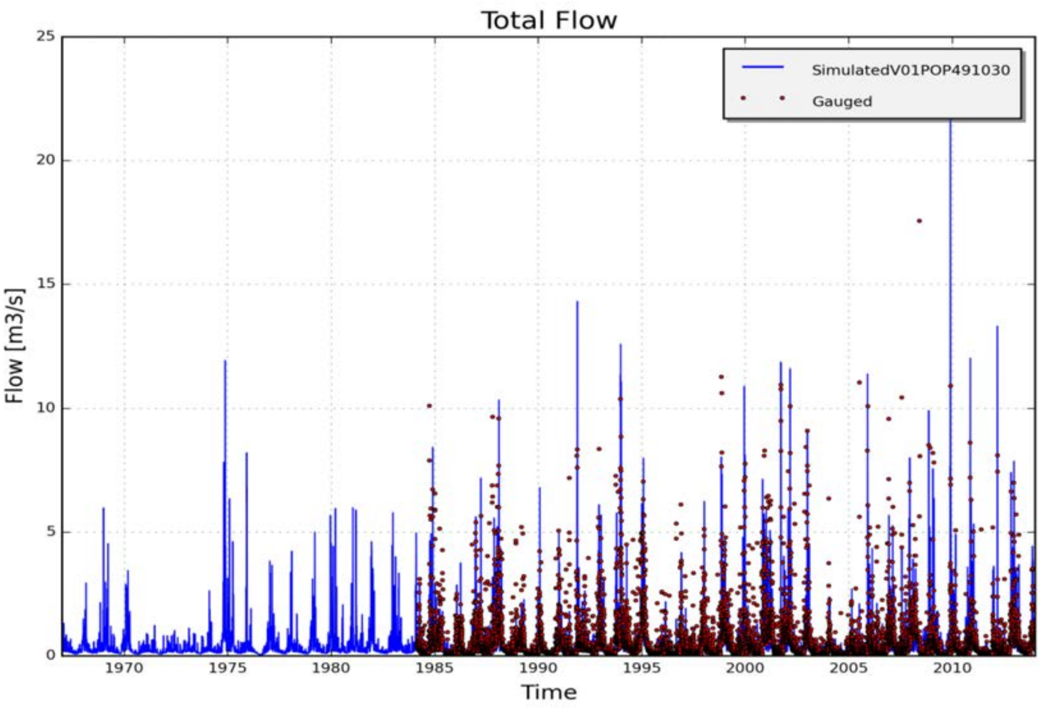


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren (validation period)

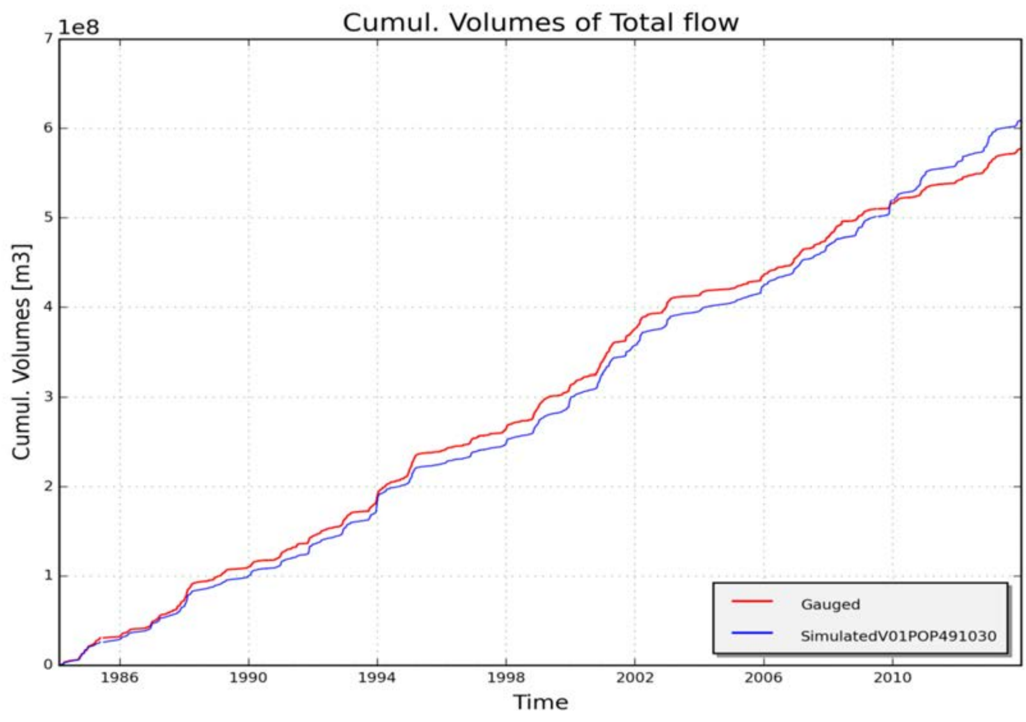


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren

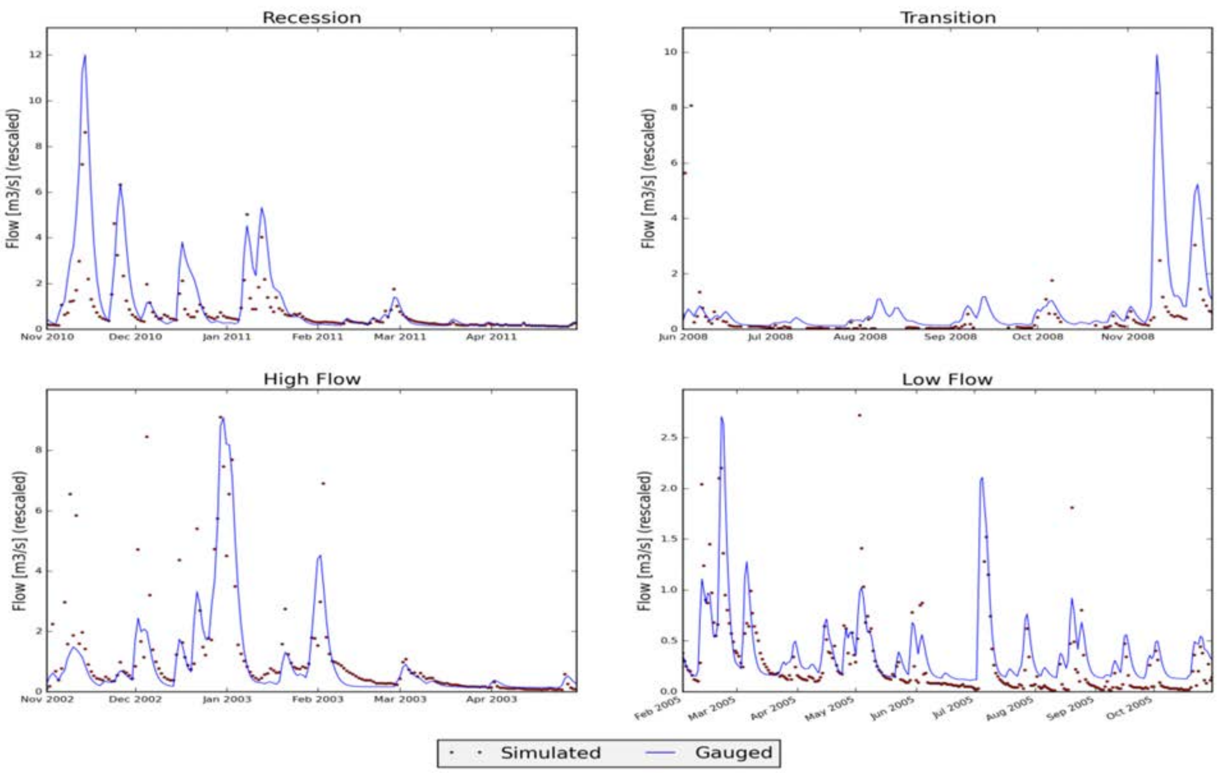


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchmentV01POP491030, station 49110102-Poperingevaart; Oostvleteren

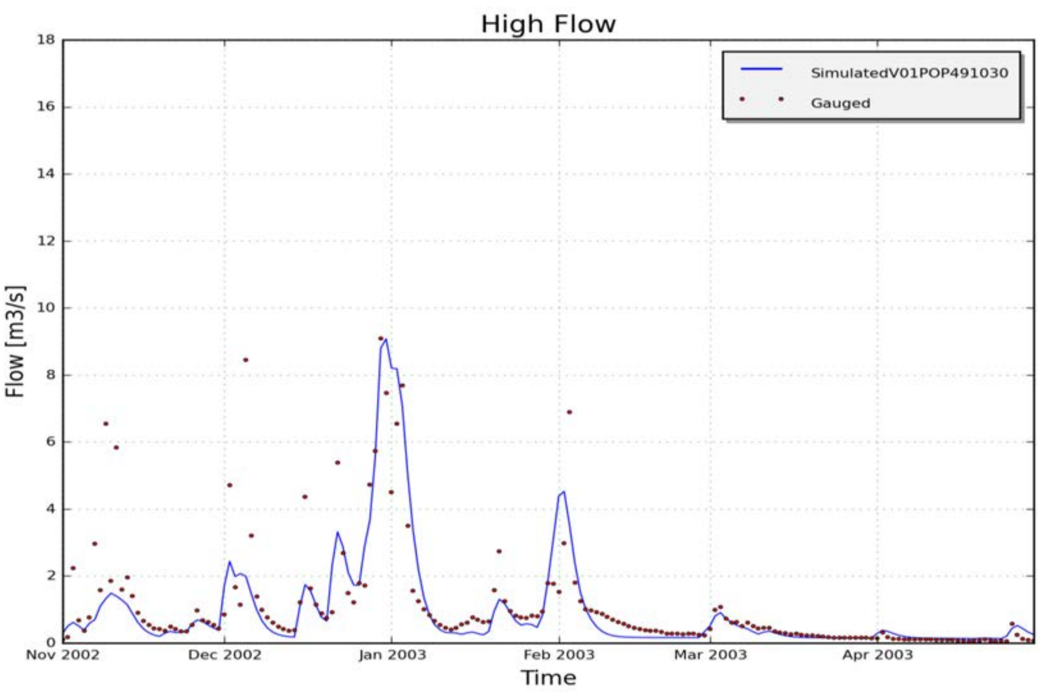


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren

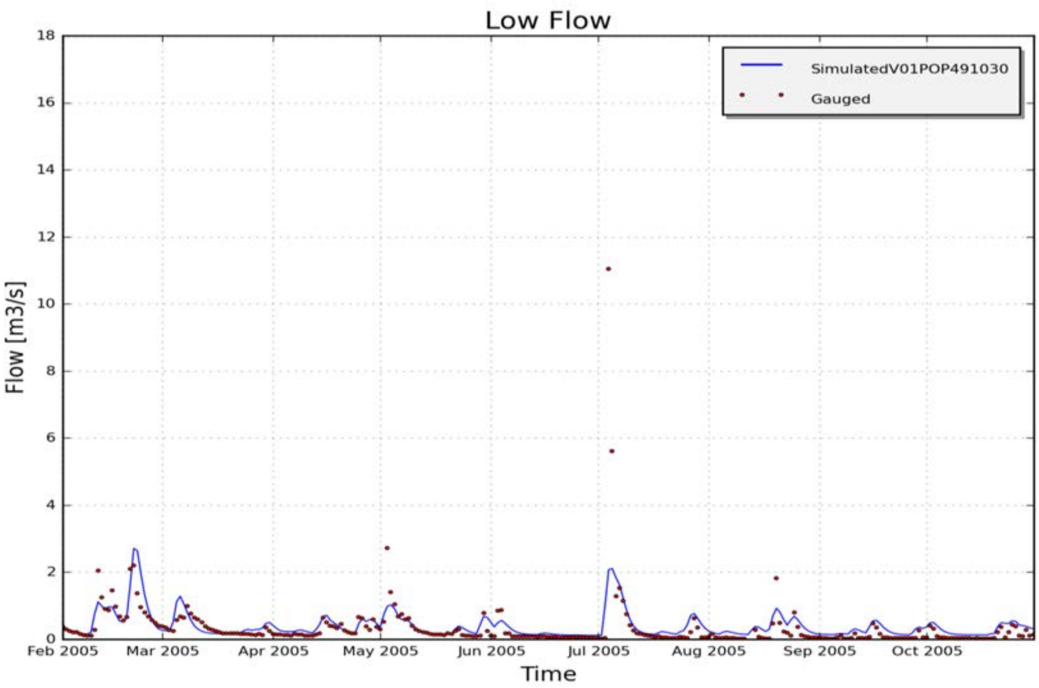
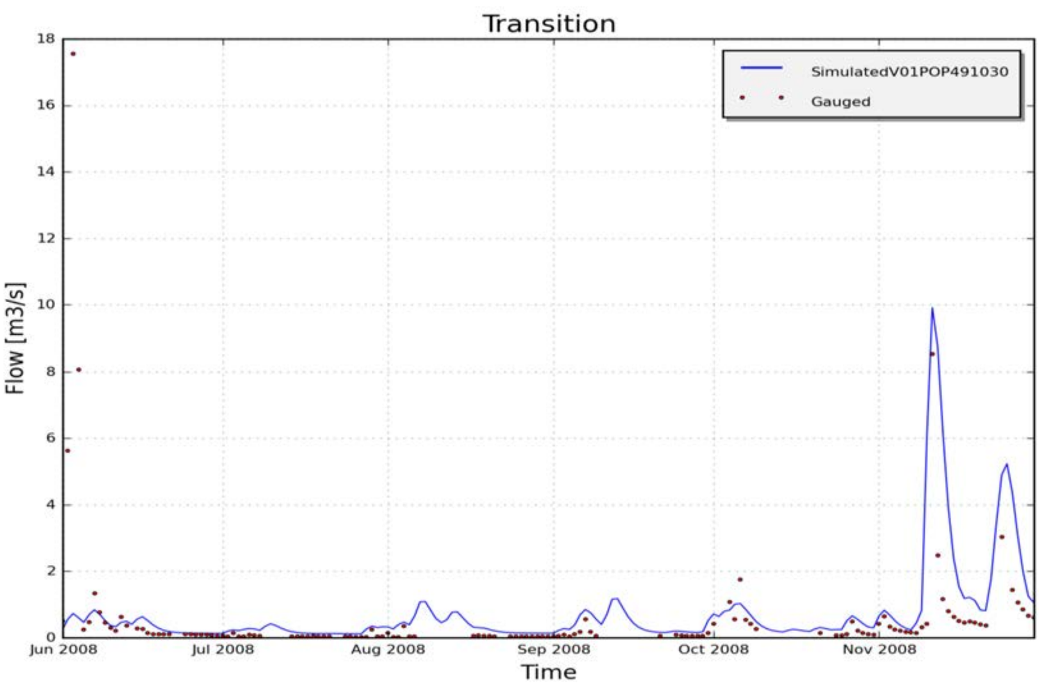


Figure 10: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V01SSV499140 " (IJZER)

Input data

Figure 1: Cumulative precipitation on catchment V01SSV499140 (IJzer)

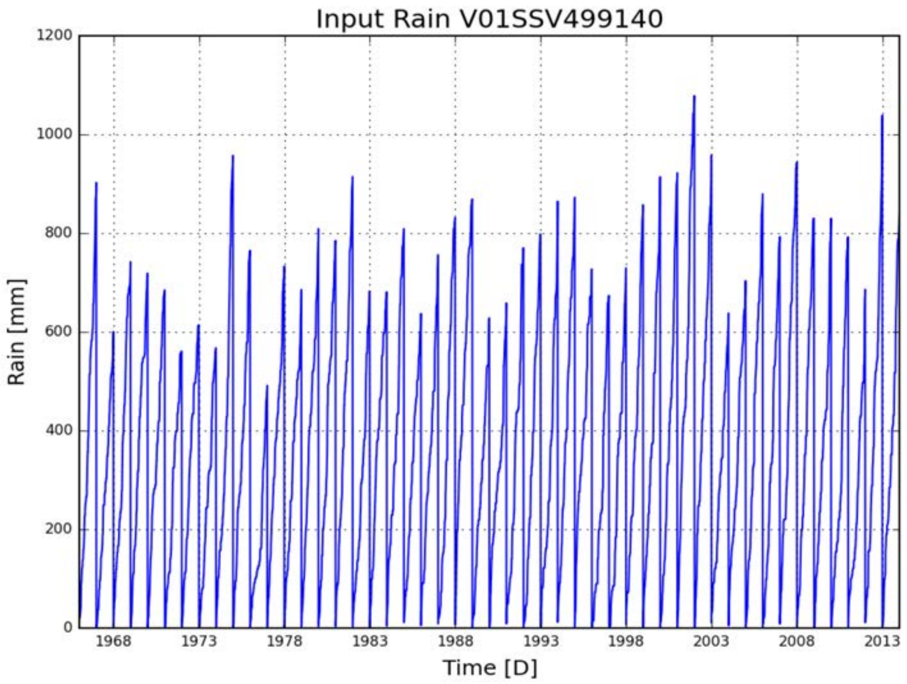
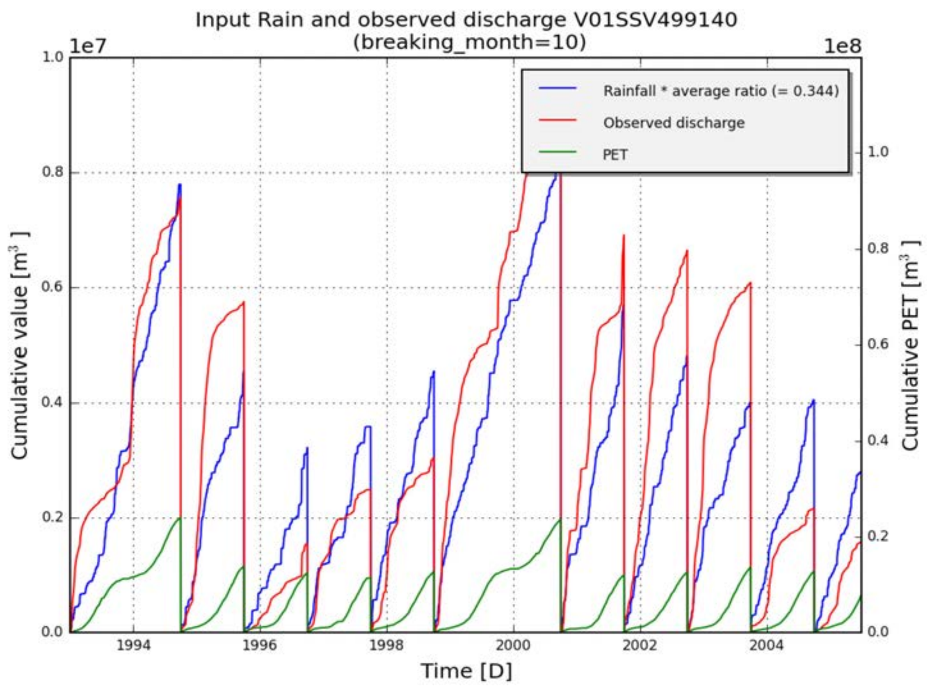


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V01SSV499140 (IJzer)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V01SSV499140
subcatchment_area [m²]	16095000
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.32), ('bevaporation', 2.0), ('cmin', 8.0), ('cmax', 309.0), ('CKBF', 300.0), ('CK1', 33.0), ('CK2', 38.0), ('bdrainage', 1.0), ('kdrainage', 27441.0), ('PDM.TG', 7.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1993 - 2005)

	Full year	Summer	Winter
NS	0.645	0.485	0.669
NS_log	0.675	0.386	0.674
NS_rel	0.491	0.729	0.691
RelErr	-3.6 %	-5.2 %	-5.8 %
VolBias	-0.046	-0.111	-0.046

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.638	0.452	0.68
NS_log	0.672	0.455	0.653
NS_rel	0.457	0.697	0.371
RelErr	-4.2 %	-19.9 %	-2.4 %
VolBias	-0.048	-0.171	-0.03

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)

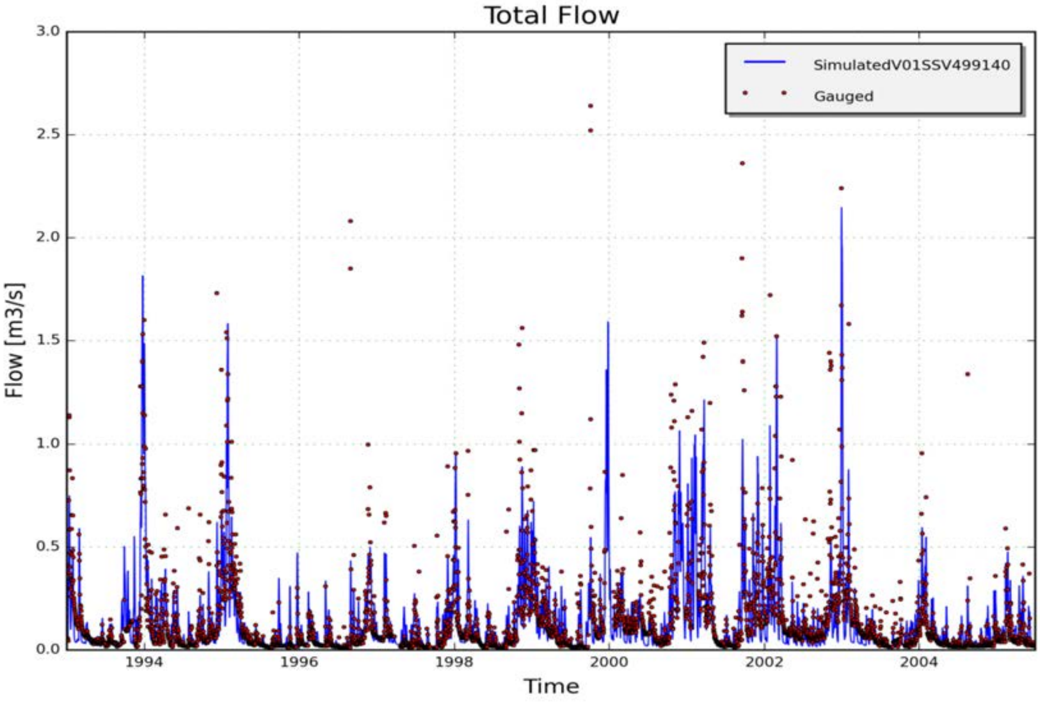


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem (calibration period)

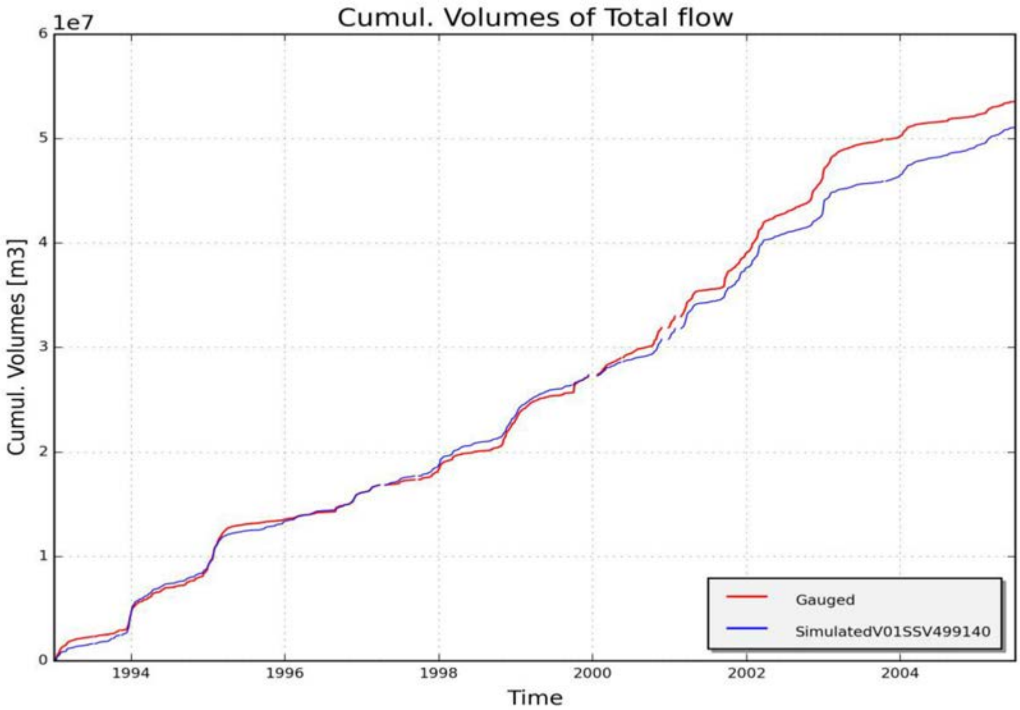


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem (validation period)

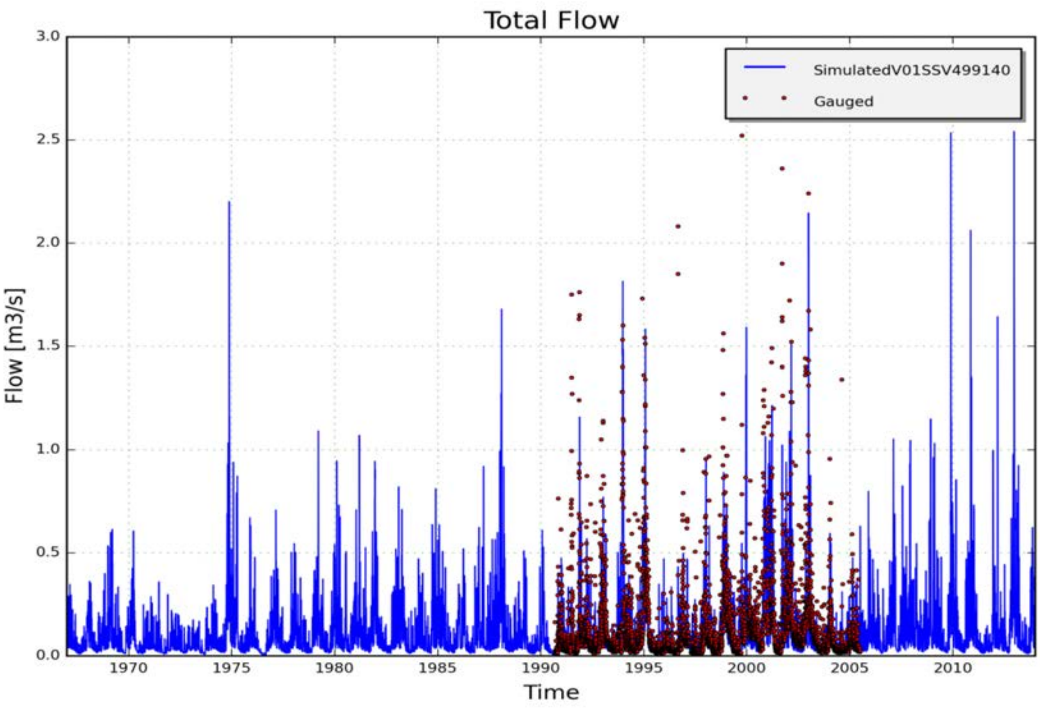


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem (validation period)

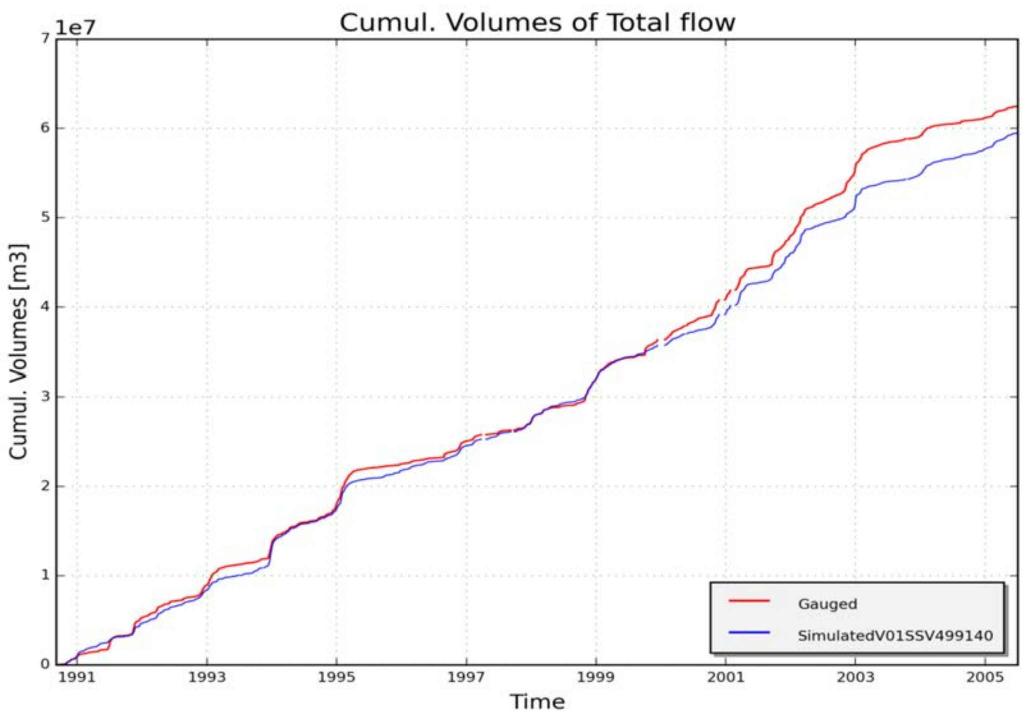


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem

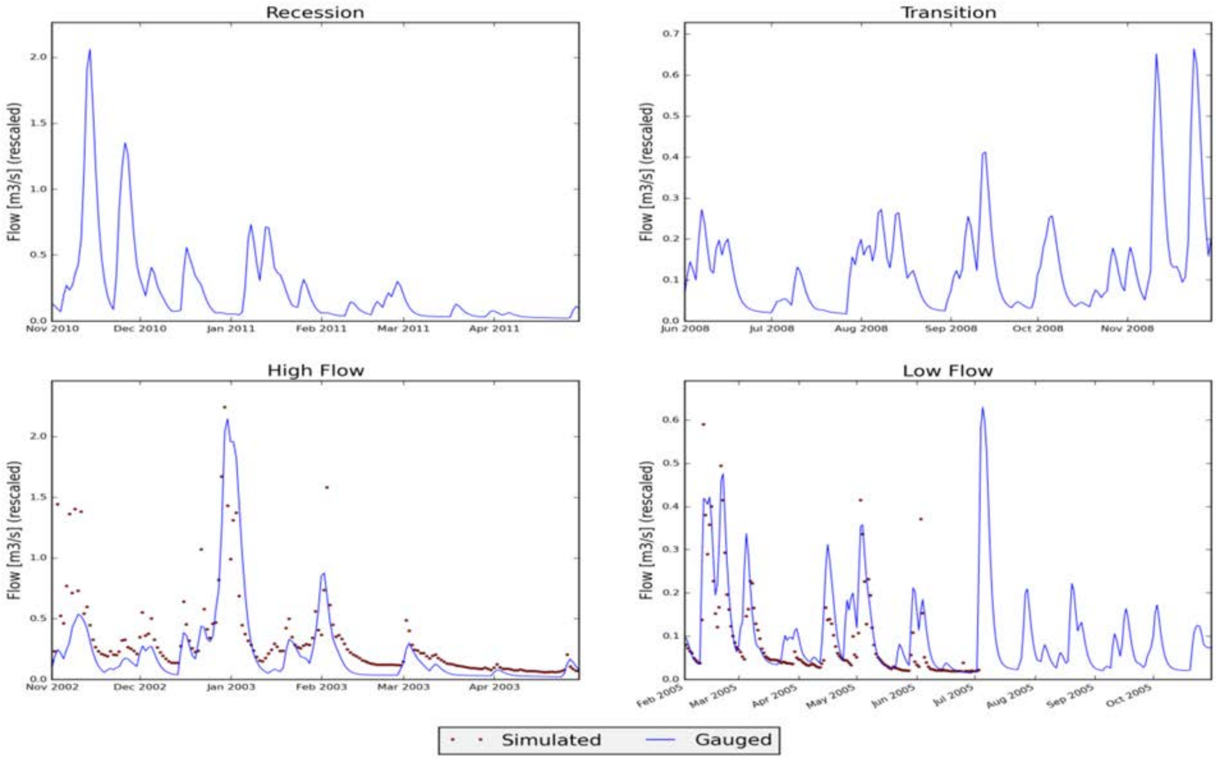
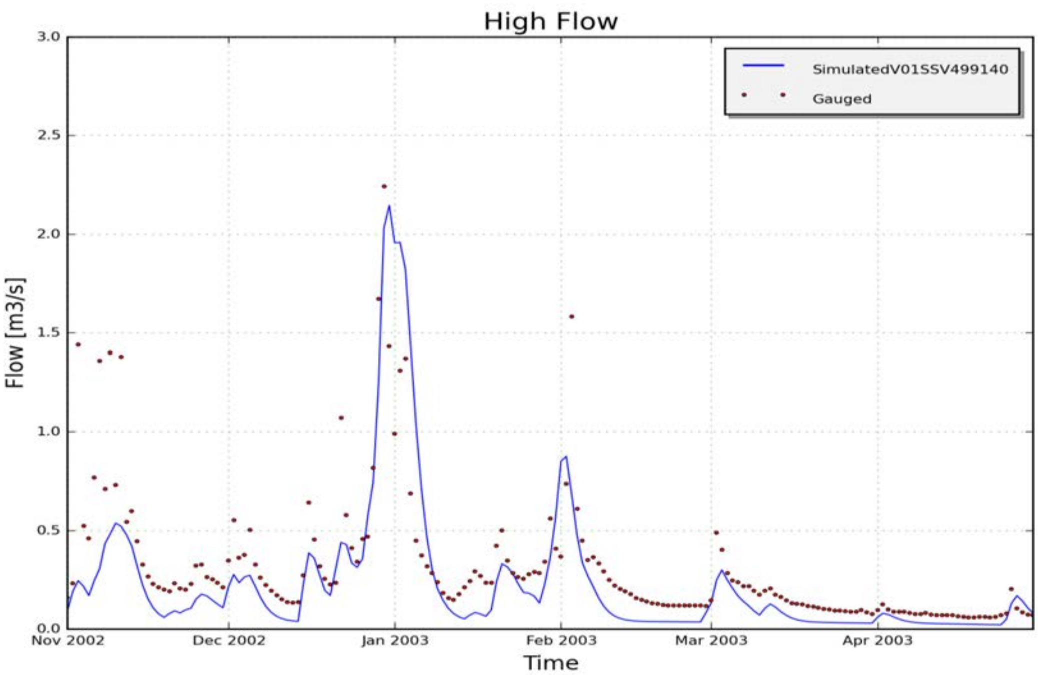


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem



Annexe 4 Brugse Polders

CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V02EDE442120" (BRUGSE POLDERS)

Input data

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

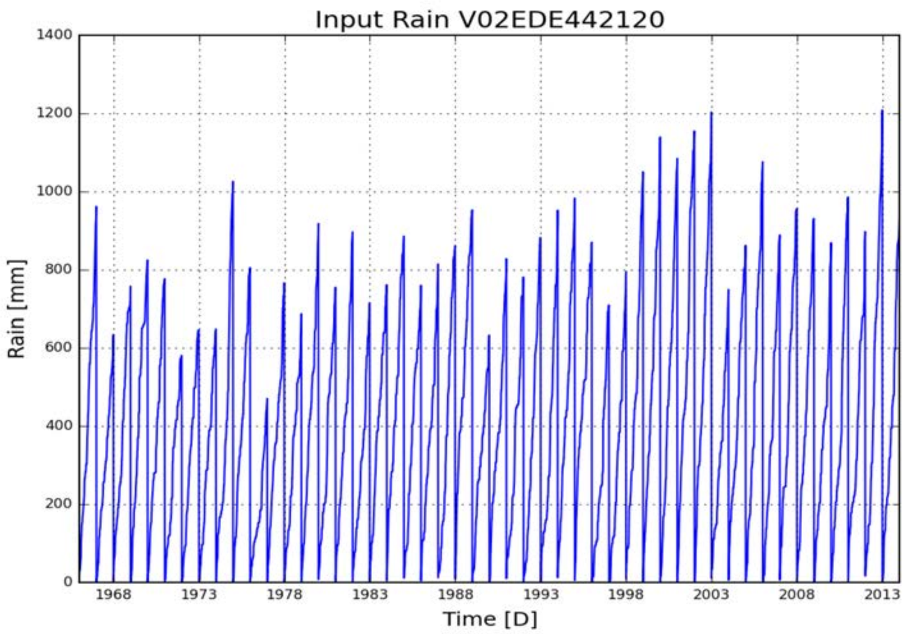
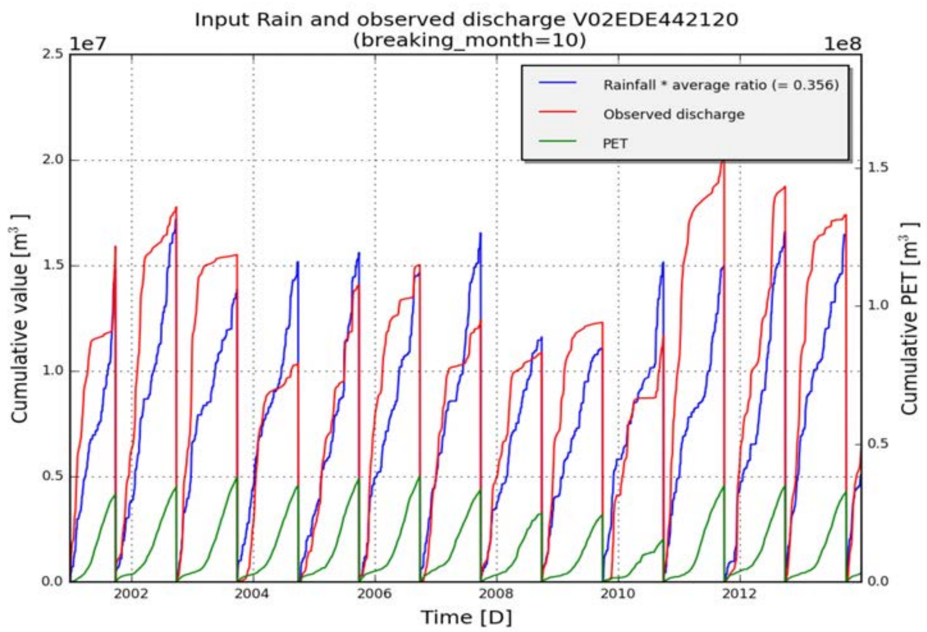


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V02EDE442120 (Brugse Polders)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V02EDE442120
subcatchment_area [m²]	45489177
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.11), ('bevaporation', 2.0), ('cmin', 8.38), ('cmax', 199.0), ('CKBF', 300.0), ('CK1', 36.0), ('CK2', 27.0), ('bdrainage', 1.0), ('kdrainage', 21988.0), ('PDM.TG', 5.7), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.727	0.544	0.779
NS_log	0.72	0.541	0.686
NS_rel	-13.744	-2.196	0.798
RelErr	0.0 %	-9.1 %	-1.1 %
VolBias	0.007	-0.137	-0.025

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.67	0.556	0.639
NS_log	0.679	0.3	0.588
NS_rel	-10.067	-4.879	0.081
RelErr	-0.8 %	1.1 %	-1.5 %
VolBias	0.004	-0.067	-0.015

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)

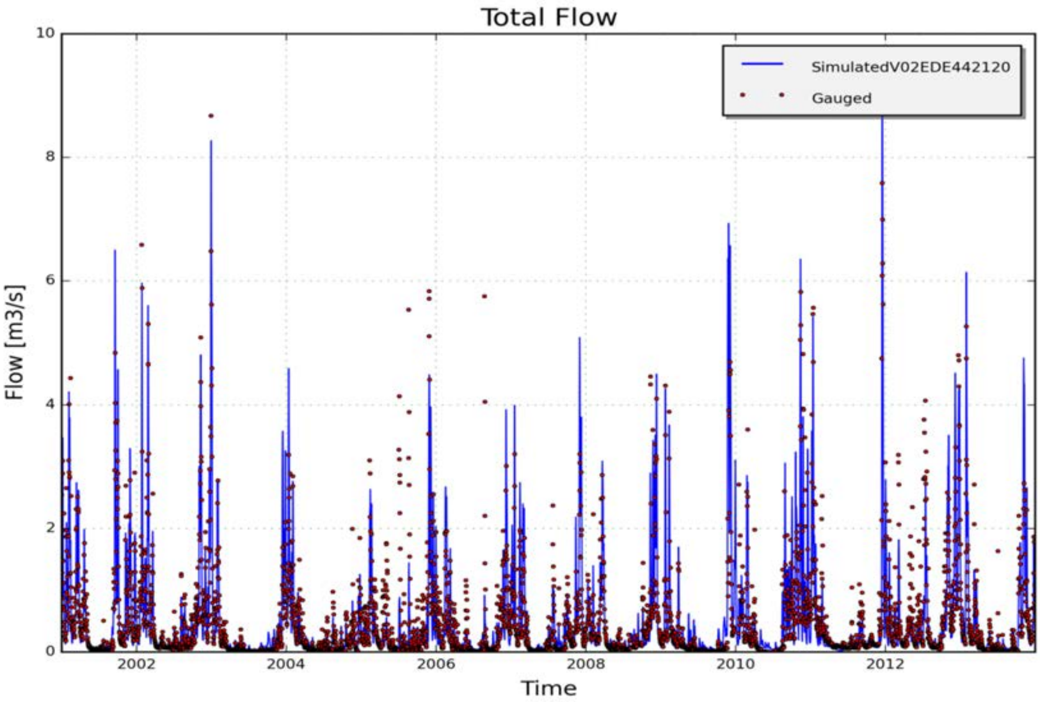


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V02EDE442120, station 44210102 - Maldegem (calibration period)

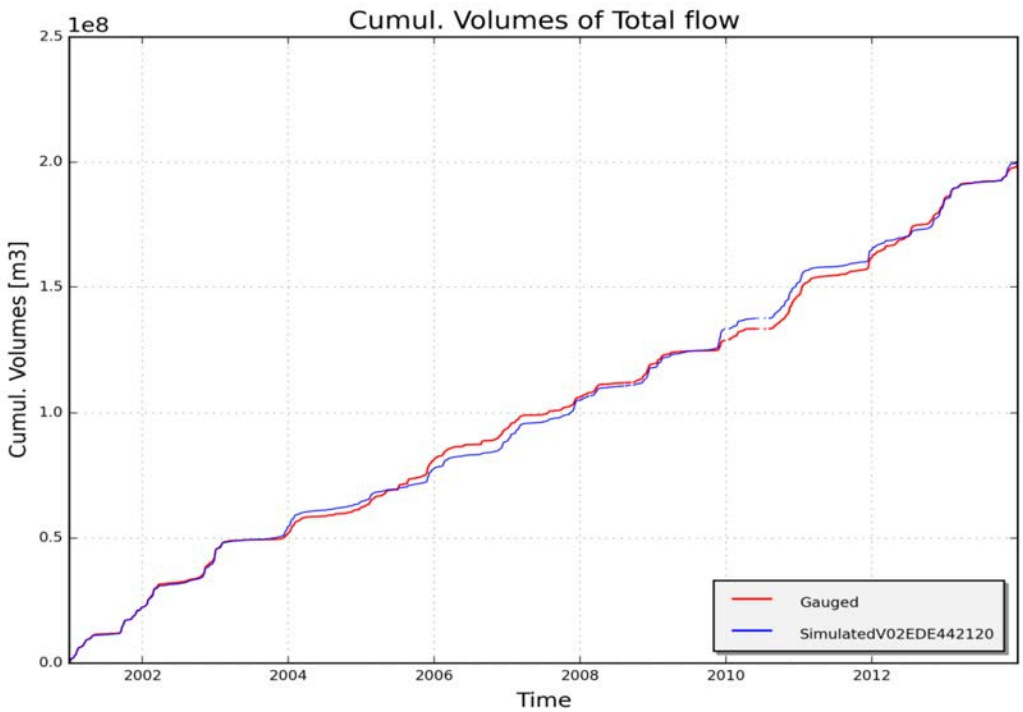


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V02EDE442120, station 44210102 - Maldegem (validation period)

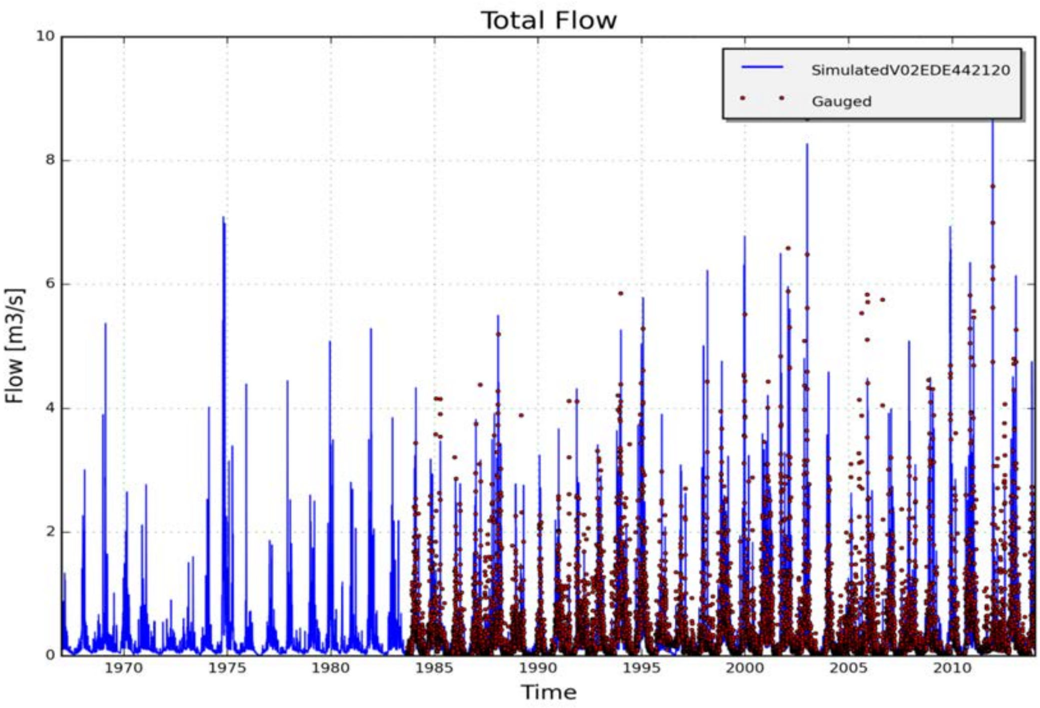


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V02EDE442120, station 44210102 - Maldegem (validation period)

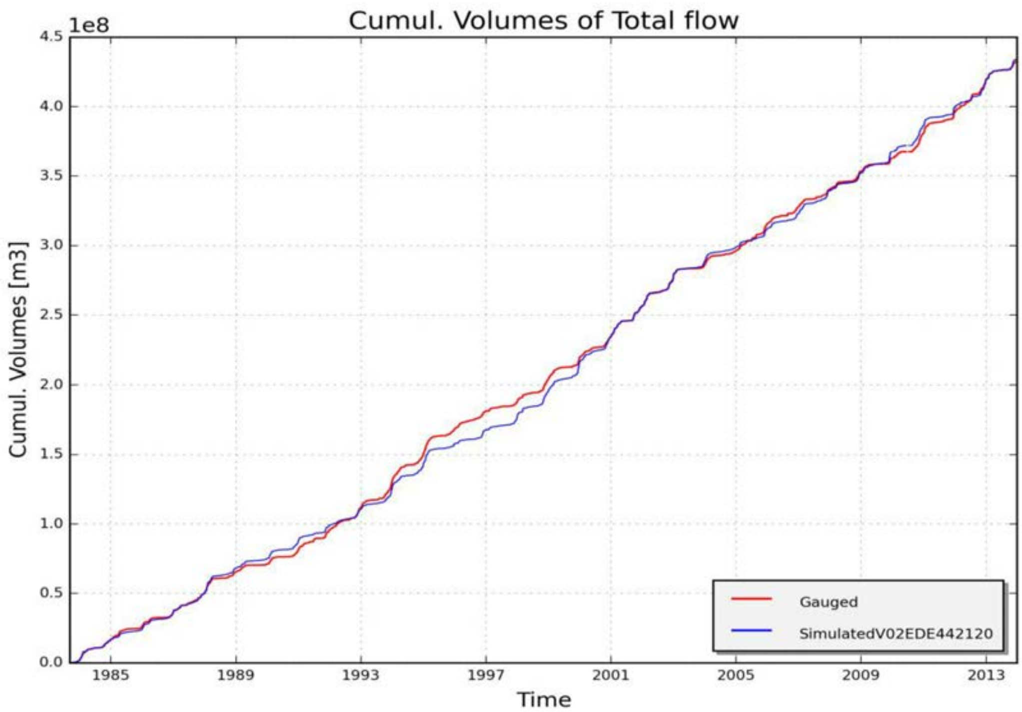
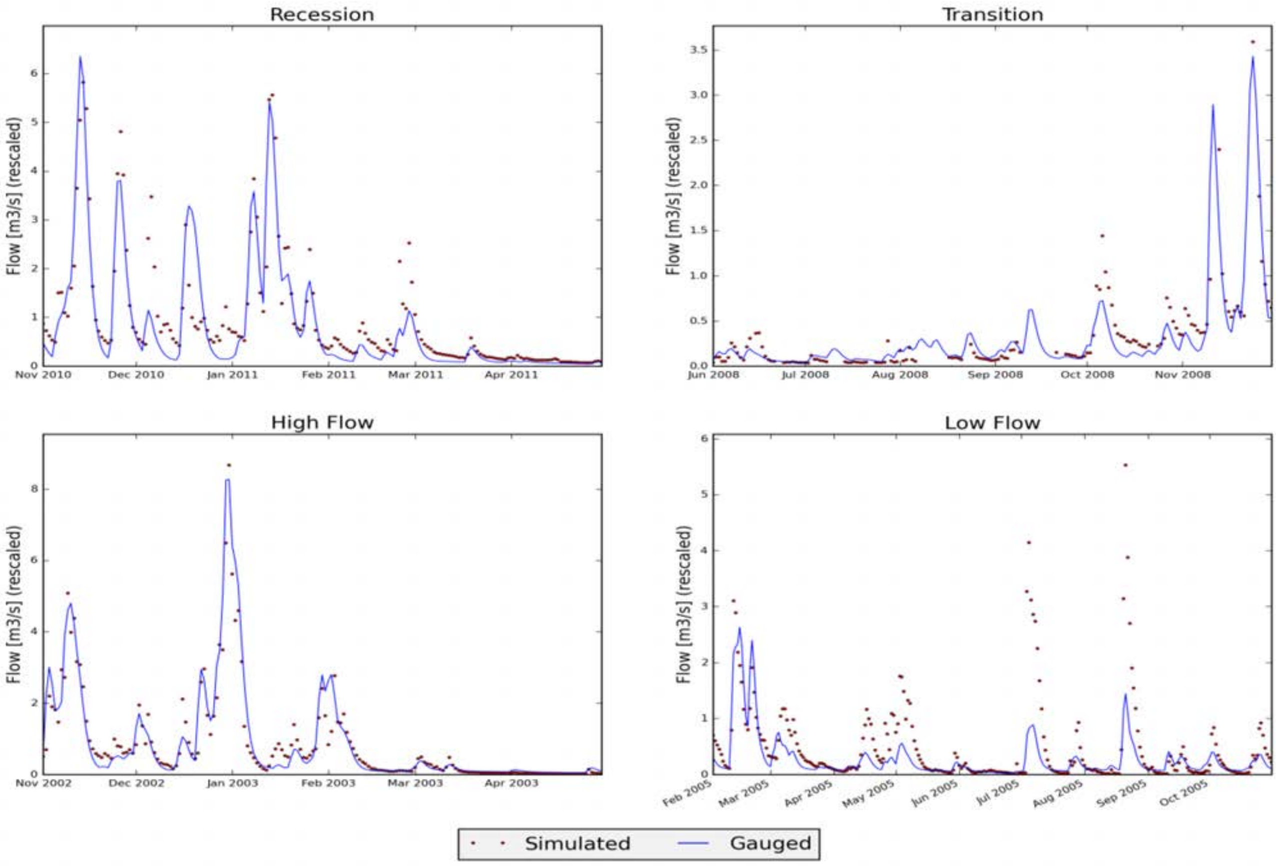


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V02EDE442120, station 44210102 - Maldegem



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V02HER426010" (BRUGSE POLDERS)

Input data

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

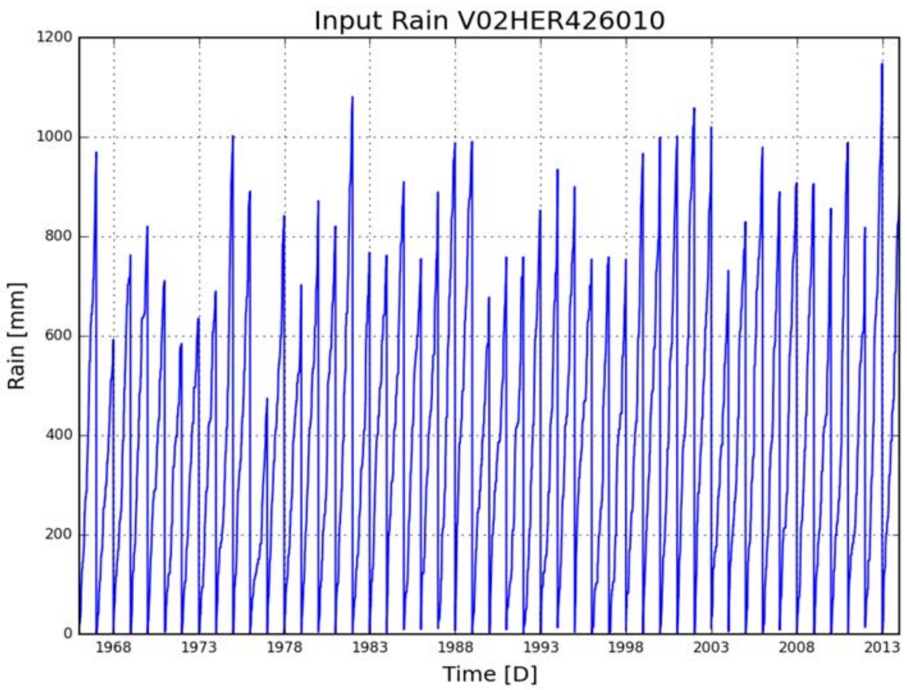
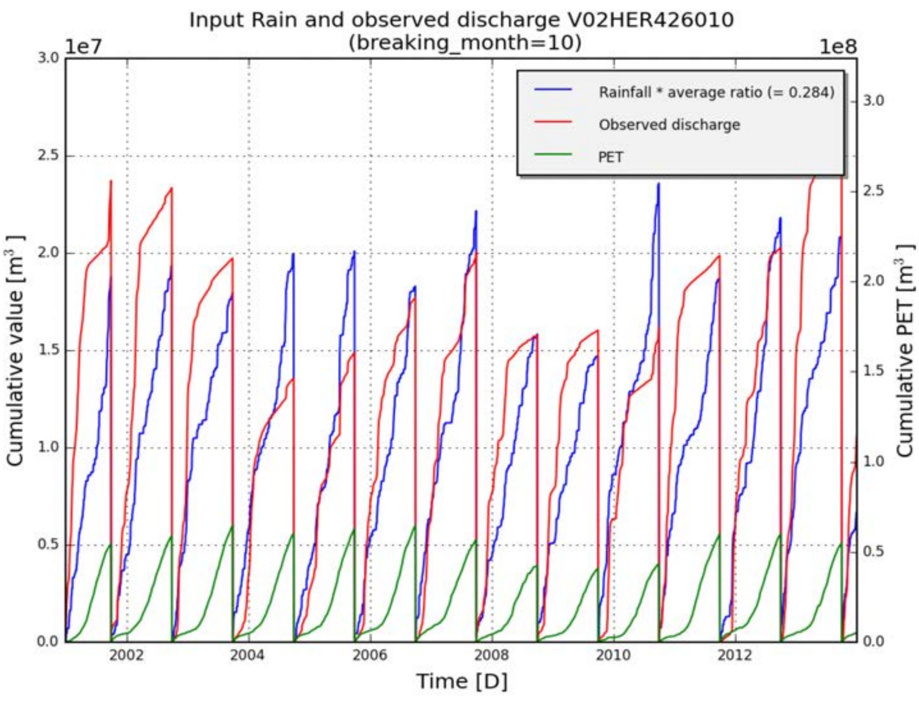


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V02HER426010 (Brugse Polders)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V02HER426010
subcatchment_area [m²]	77272201
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.1), ('bevaporation', 2.0), ('cmin', 8.8), ('cmax', 274.0), ('CKBF', 300.0), ('CK1', 34.0), ('CK2', 29.0), ('bdrainage', 1.0), ('kdrainage', 25656.0), ('PDM.TG', 6.9), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.579	0.502	0.543
NS_log	0.761	0.374	0.78
NS_rel	0.604	0.743	0.536
RelErr	5.5 %	-2.6 %	9.5 %
VolBias	0.099	0.023	0.129

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.609	0.508	0.552
NS_log	0.754	0.442	0.737
NS_rel	0.153	0.074	0.581
RelErr	3.7 %	5.2 %	5.6 %
VolBias	0.056	0.032	0.076

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)

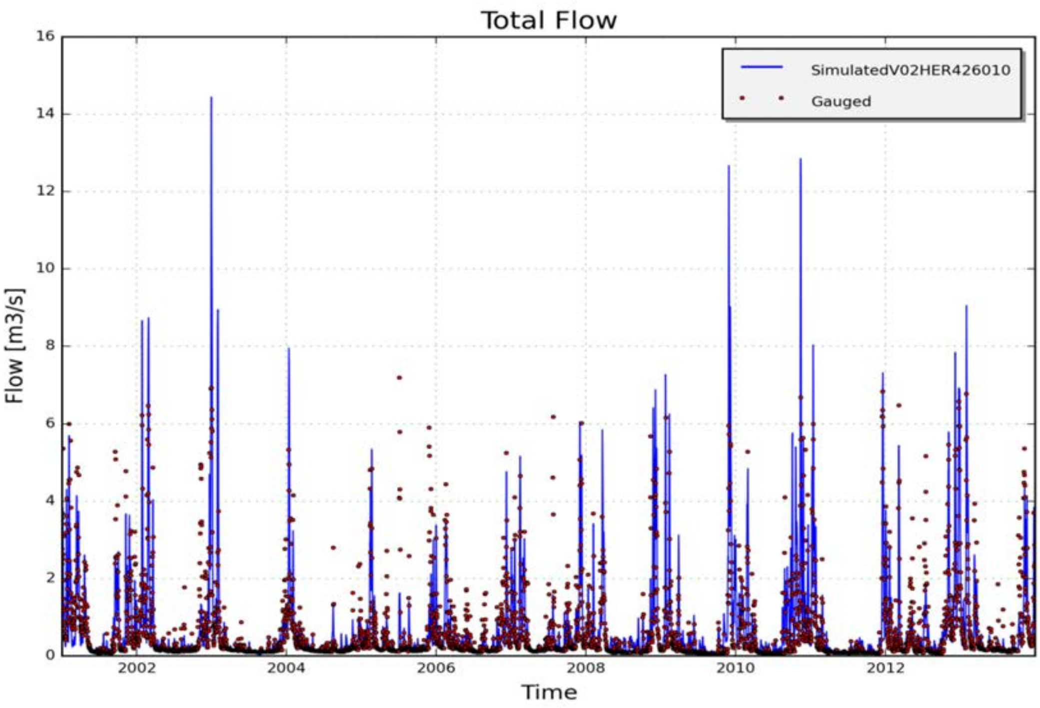


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp (calibration period)

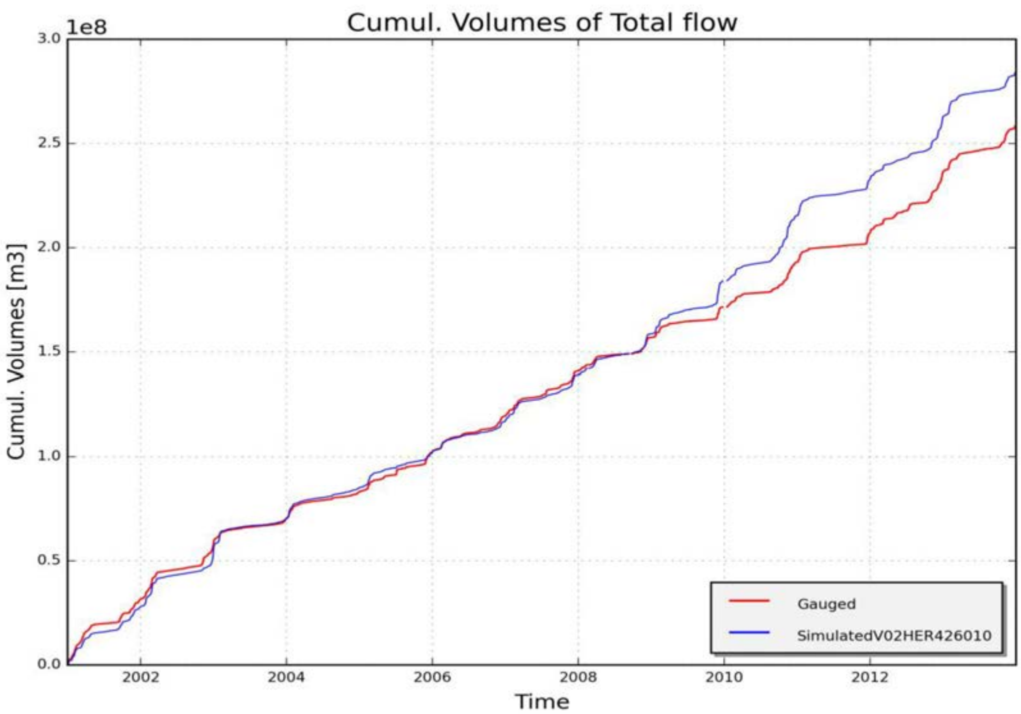


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp (validation period)

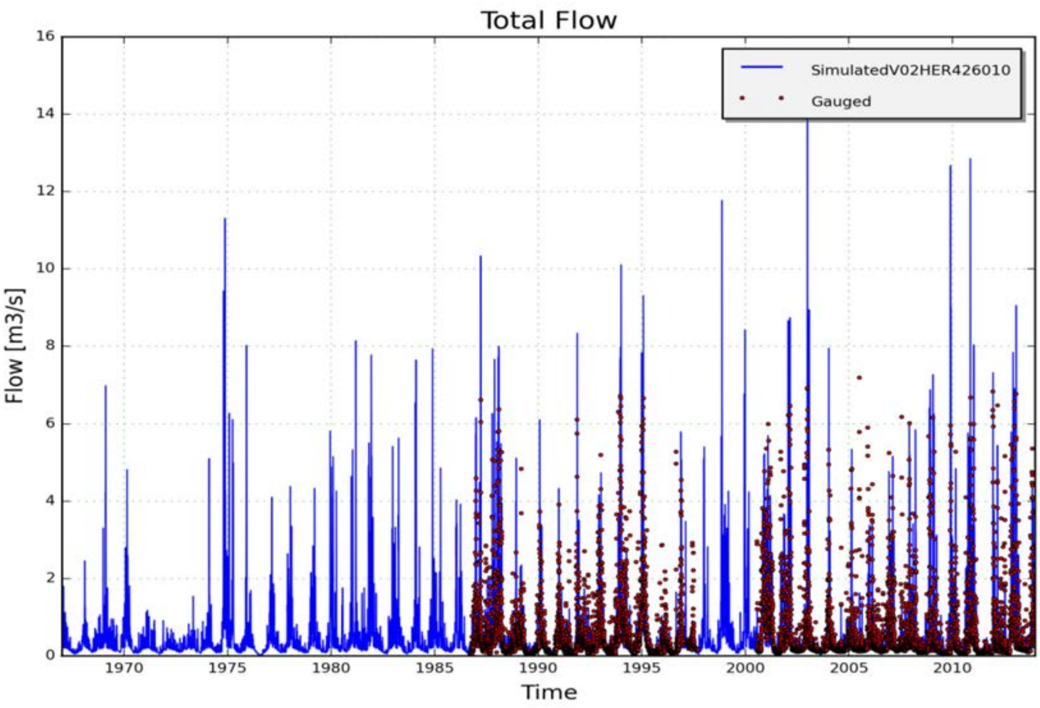


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp (validation period)

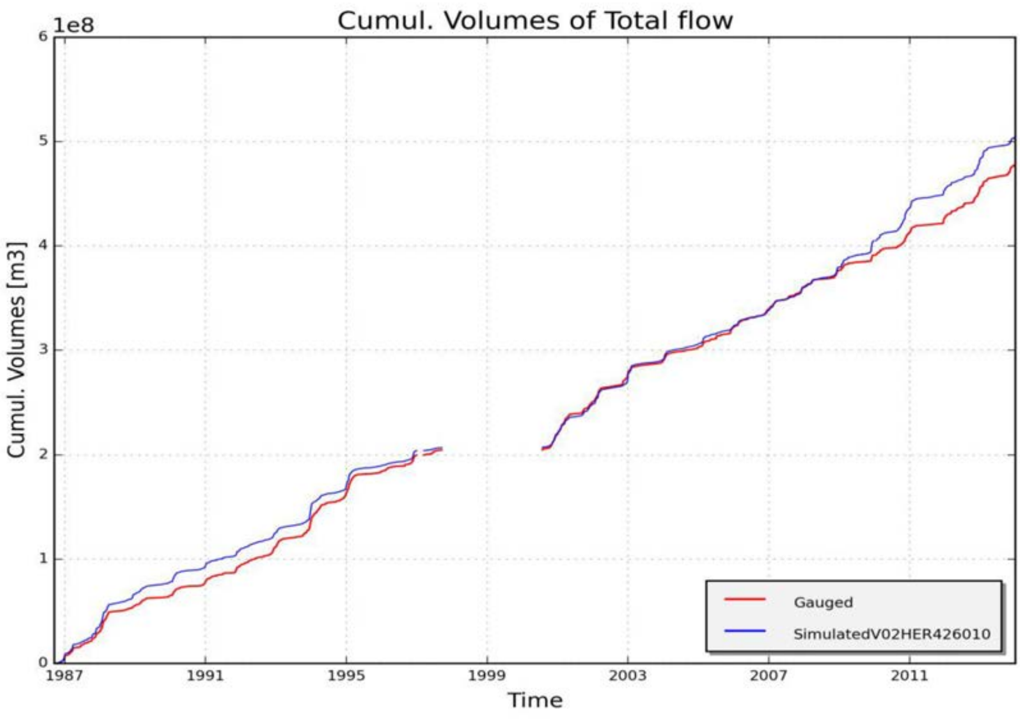
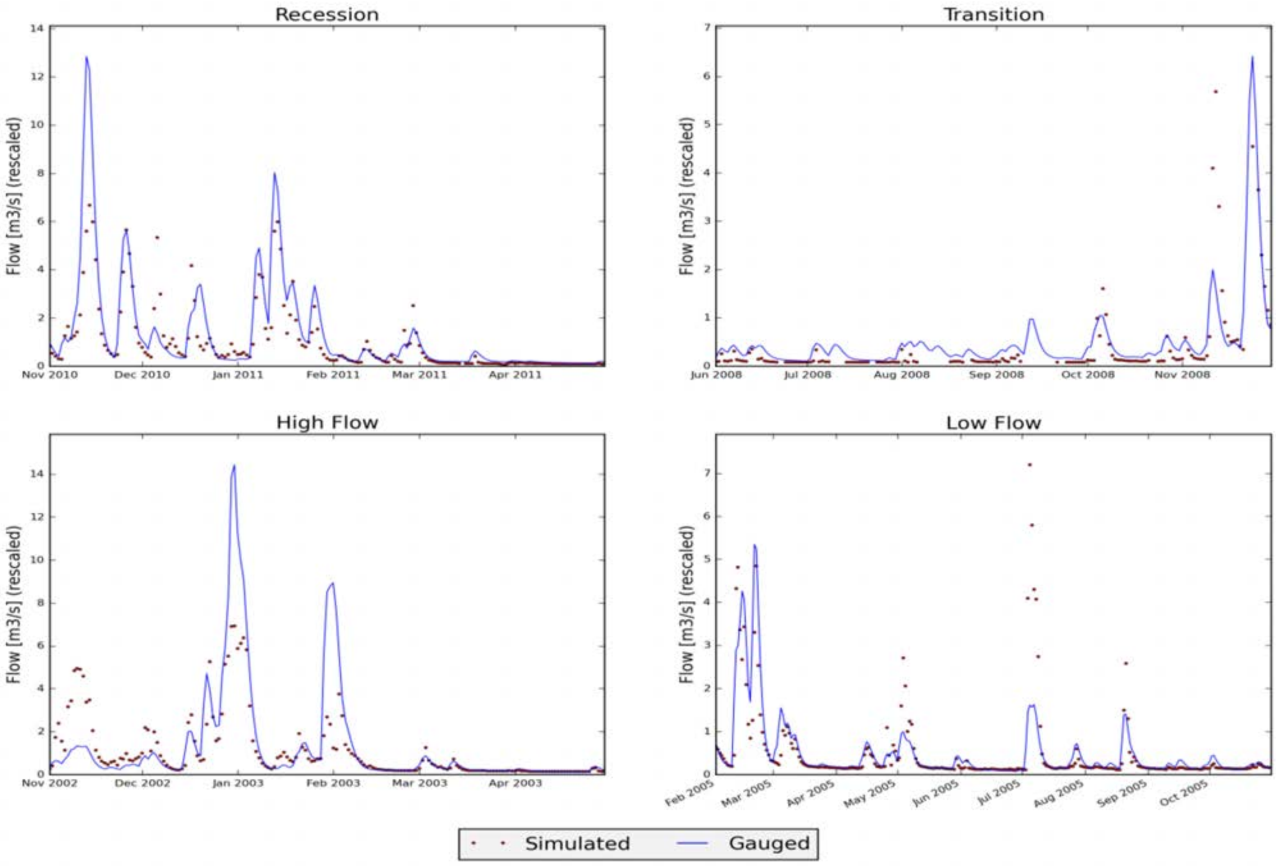


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V02KER422030" (BRUGSE POLDERS)

Input data

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

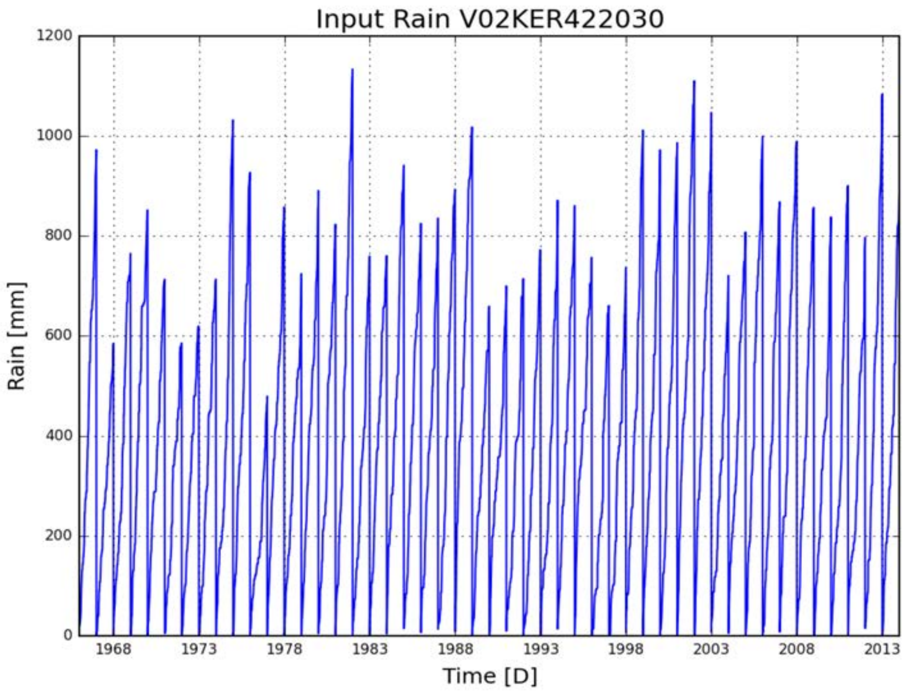
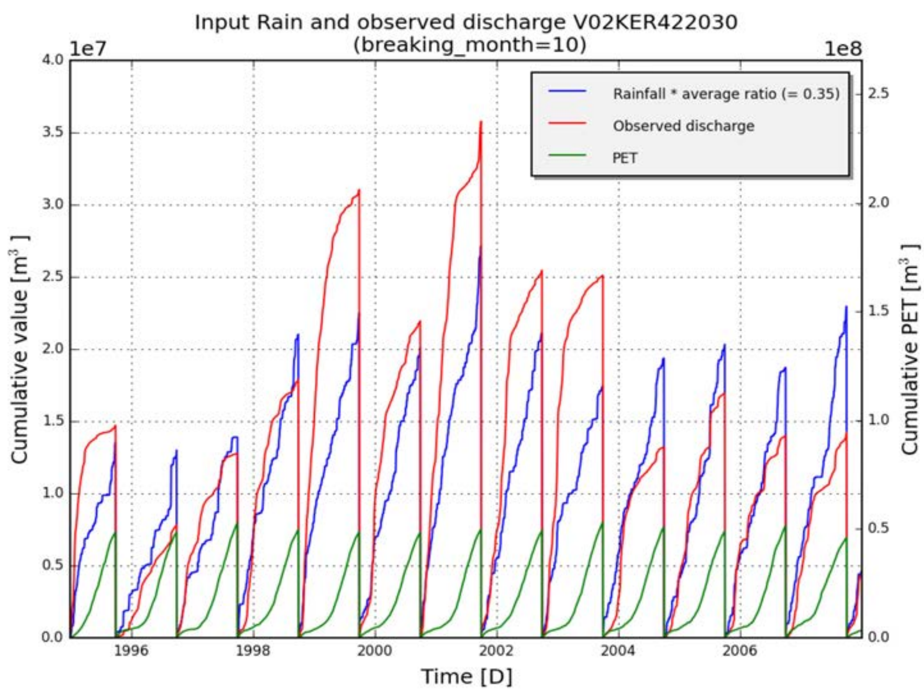


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V02KER422030 (Brugse Polders)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V02KER422030
subcatchment_area [m²]	62718738
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.17), ('bevaporation', 1.4), ('cmin', 10.0), ('cmax', 232.0), ('CKBF', 1.0), ('CK1', 41.0), ('CK2', 27.0), ('bdrainage', 1.0), ('kdrainage', 18141.0), ('PDM.TG', 0.71), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1995 - 2007)

	Full year	Summer	Winter
NS	0.606	0.487	0.606
NS_log	0.706	0.431	0.58
NS_rel	-0.784	0.744	-9.89
RelErr	-1.5 %	0.6 %	-3.8 %
VolBias	0.048	0.113	0.014

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.588	0.472	0.558
NS_log	0.669	0.285	0.545
NS_rel	-0.571	0.01	-5.029
RelErr	-5.9 %	7.6 %	-7.3 %
VolBias	-0.006	0.12	-0.026

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)

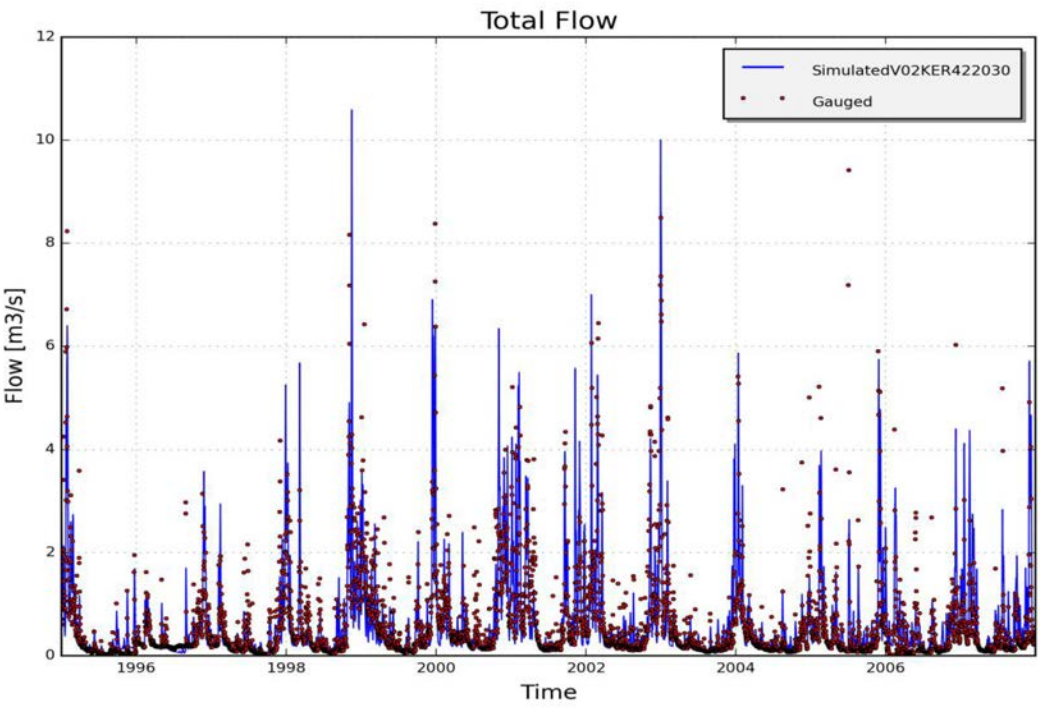


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels (calibration period)

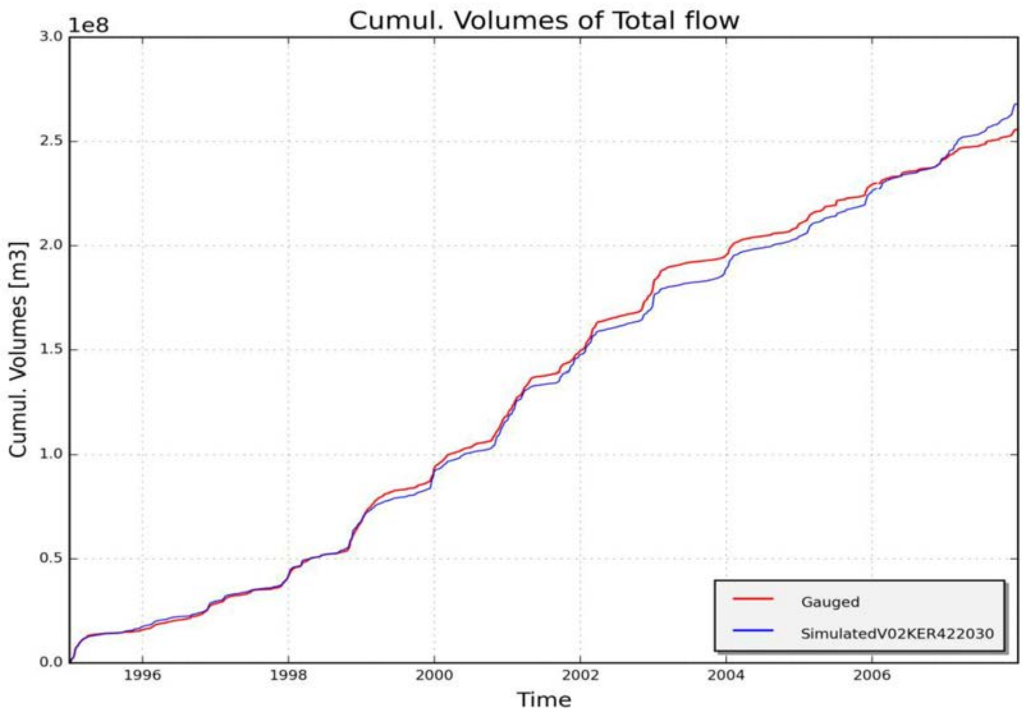


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels (validation period)

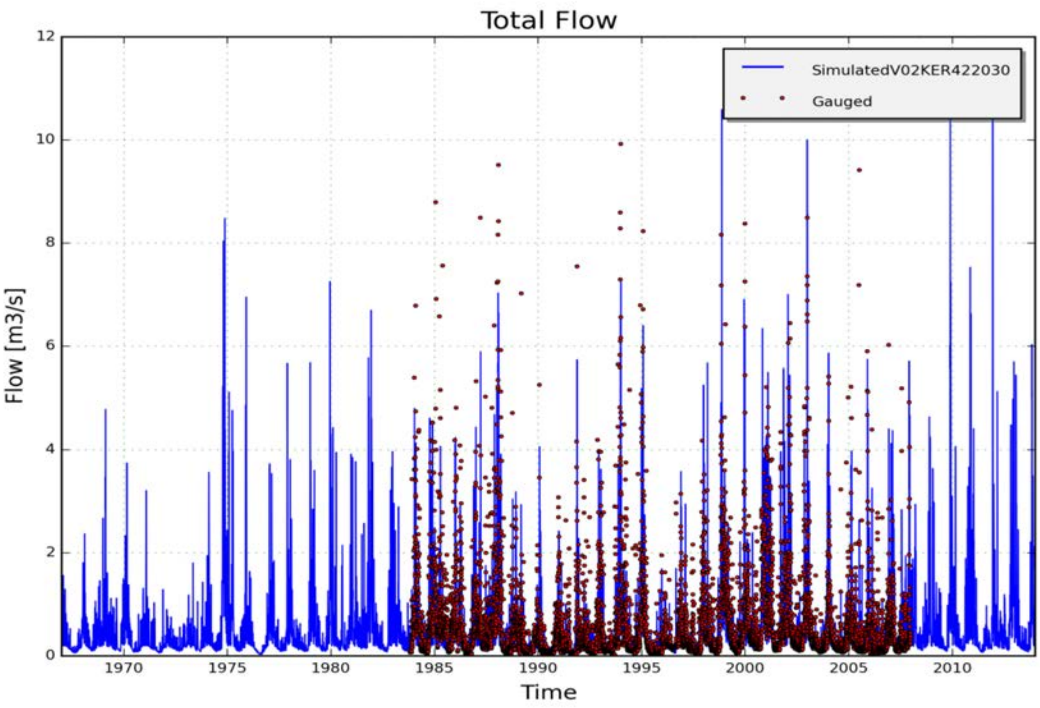


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels (validation period)

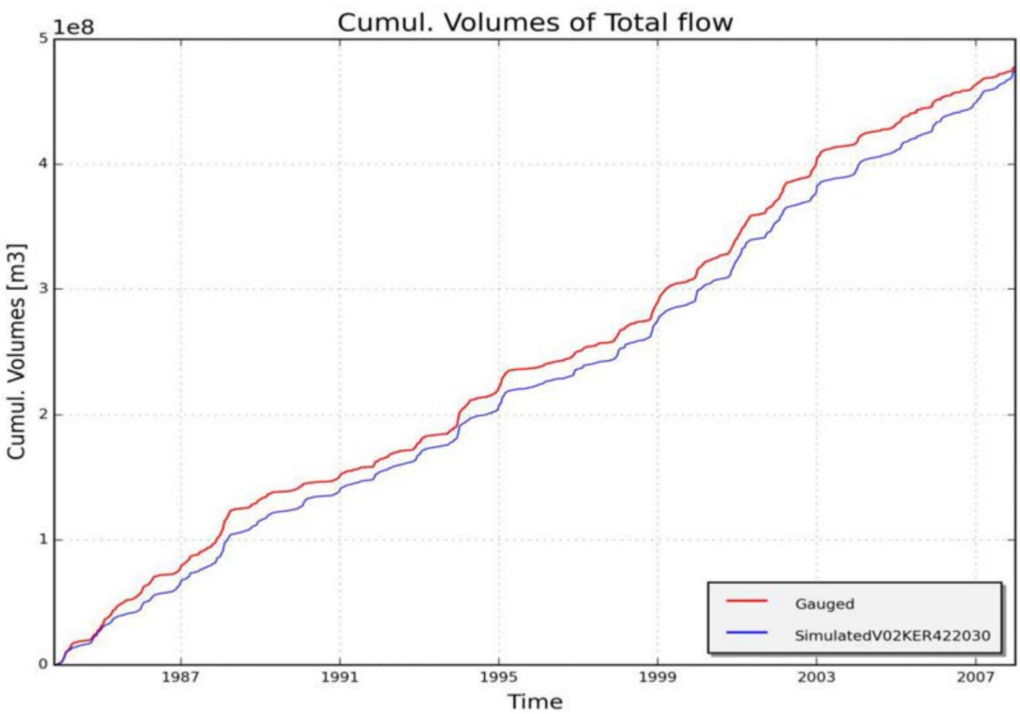


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels

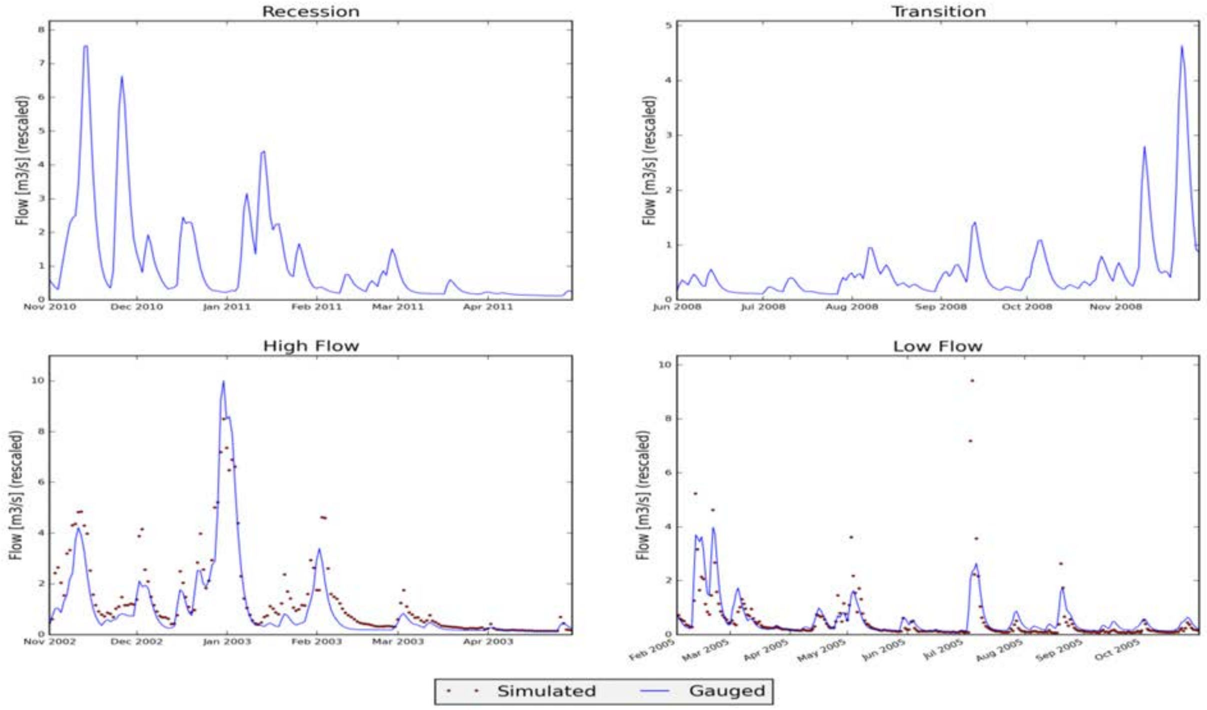


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels

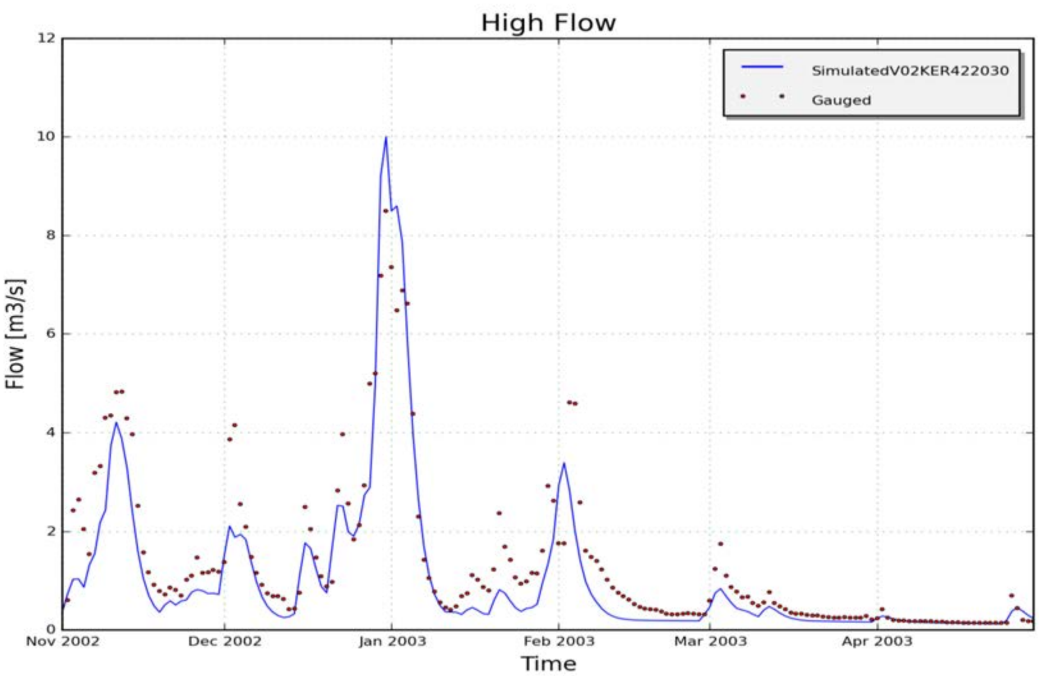
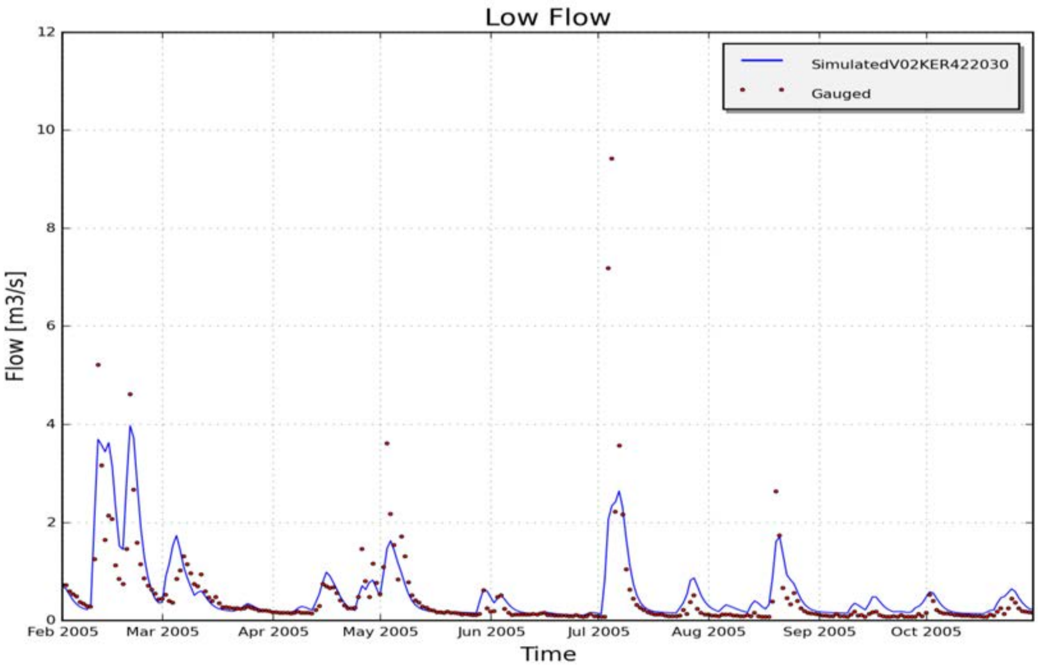


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V02RIV425020" (BRUGSE POLDERS)

Input data

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

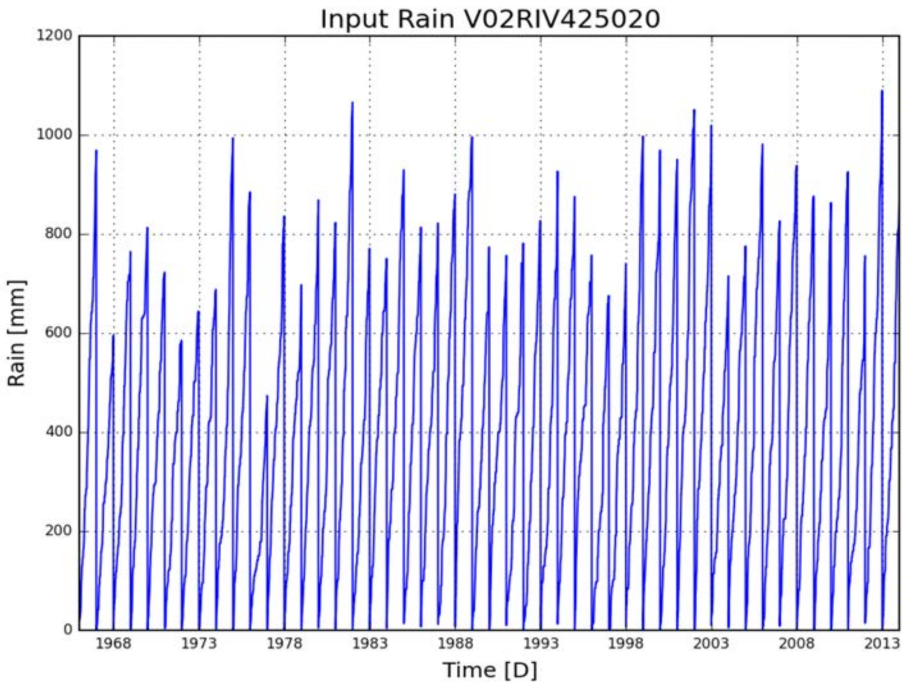
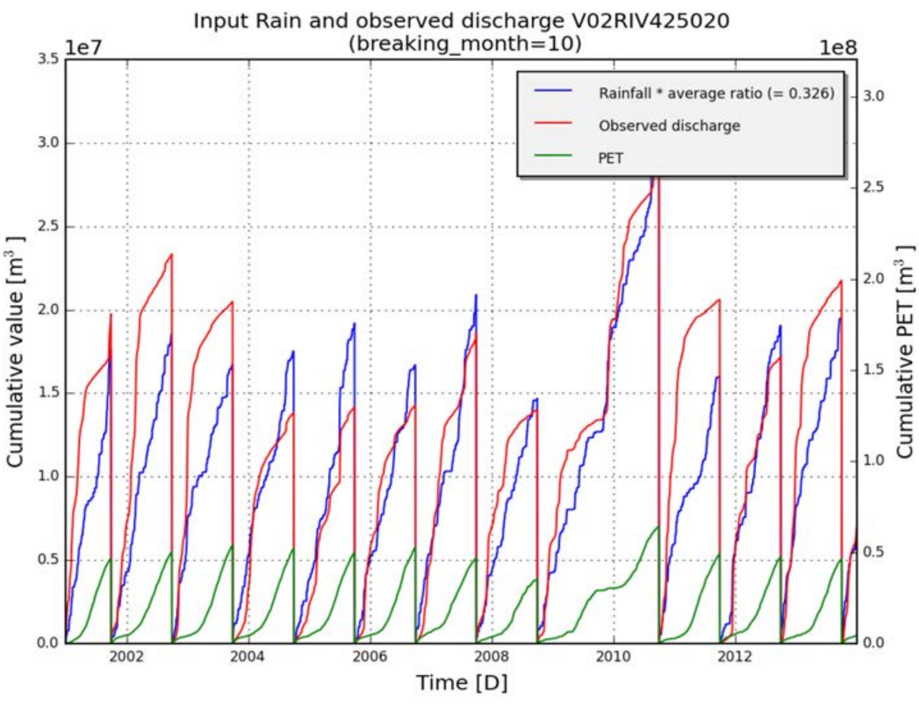


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V02RIV425020 (Brugse Polders)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V02RIV425020
subcatchment_area [m²]	63980423
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.12), ('bevaporation', 2.0), ('cmin', 9.8), ('cmax', 240.0), ('CKBF', 300.0), ('CK1', 31.0), ('CK2', 38.0), ('bdrainage', 1.0), ('kdrainage', 17086.0), ('PDM.TG', 1.9), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	**Summer**	**Winter**
NS	0.704	0.387	0.784
NS_log	0.812	0.501	0.782
NS_rel	-2.818	0.907	0.762
RelErr	-2.3 %	-18.2 %	1.6 %
VolBias	0.024	-0.144	0.055

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	**Summer**	**Winter**
NS	0.696	0.402	0.701
NS_log	0.745	0.437	0.69
NS_rel	-1.257	0.228	0.615
RelErr	-5.7 %	-8.8 %	-2.4 %
VolBias	-0.043	-0.13	-0.011

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)

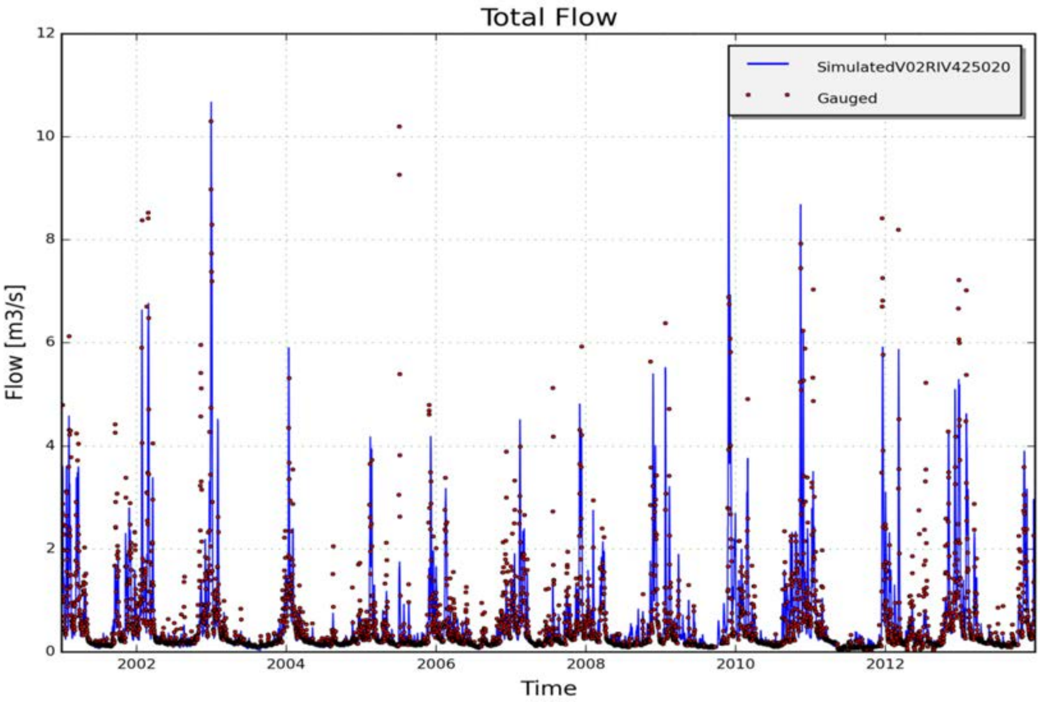


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp (calibration period)

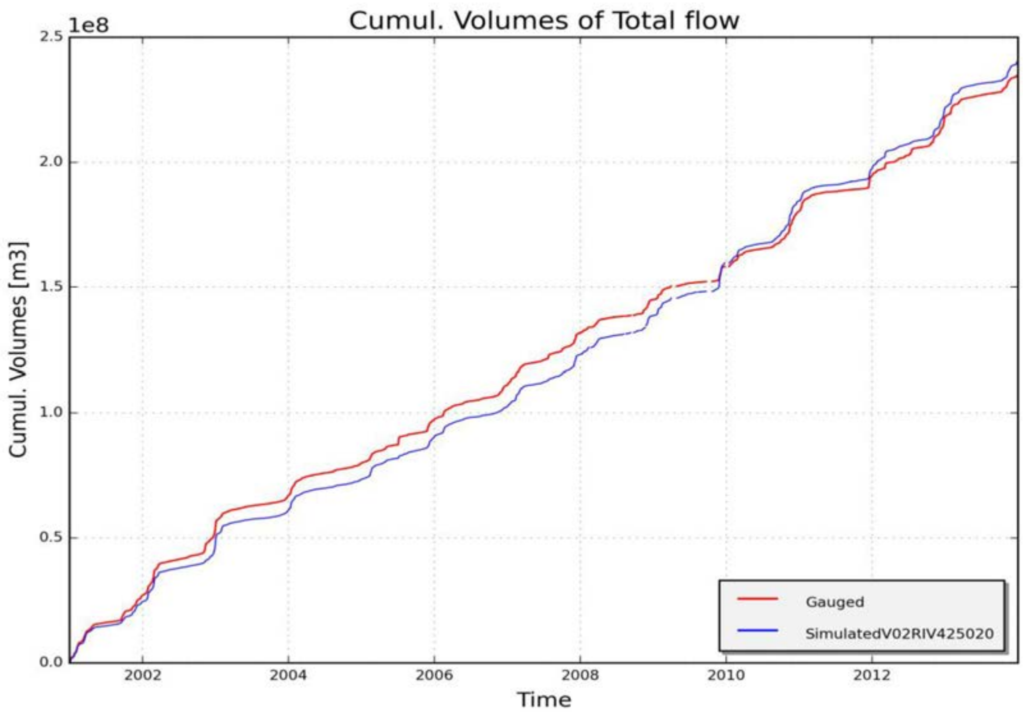


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp (validation period)

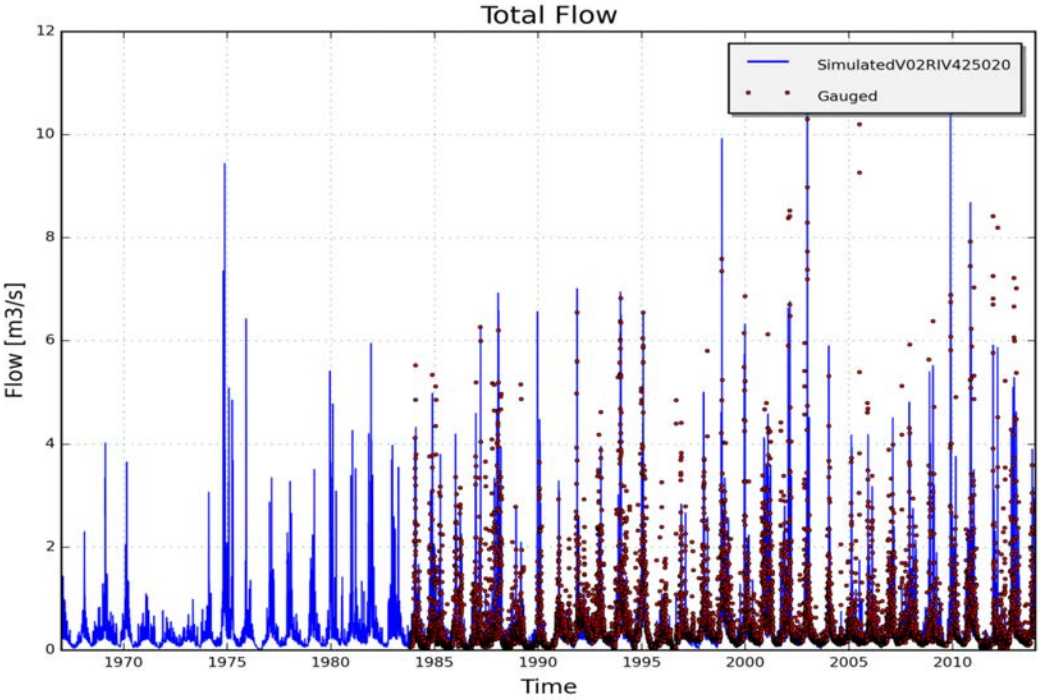


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp (validation period)

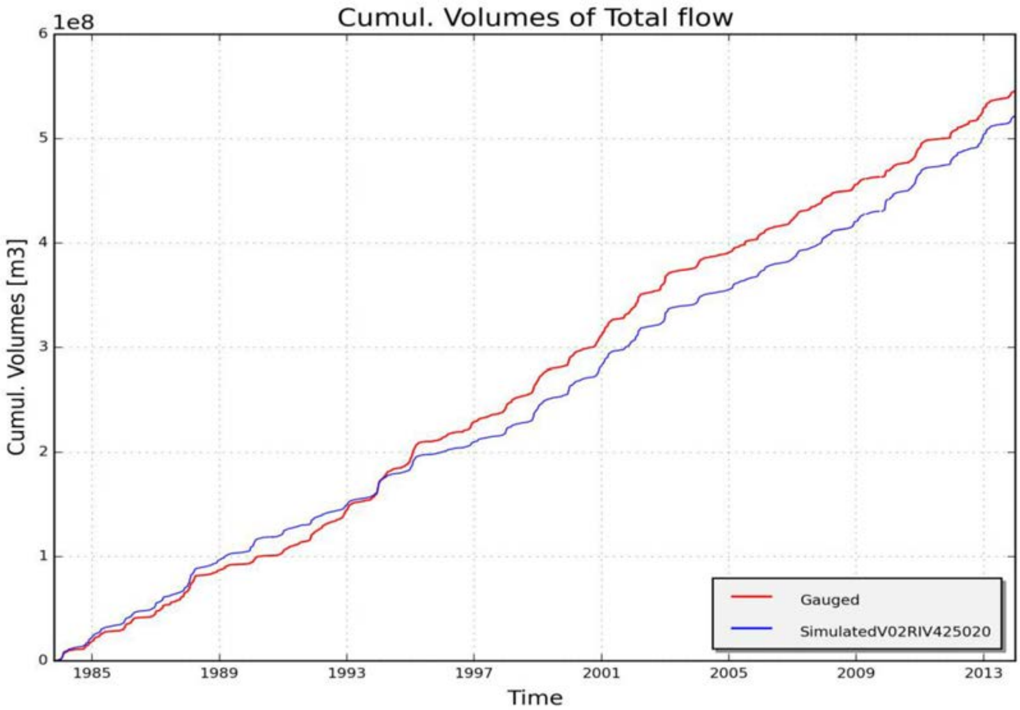
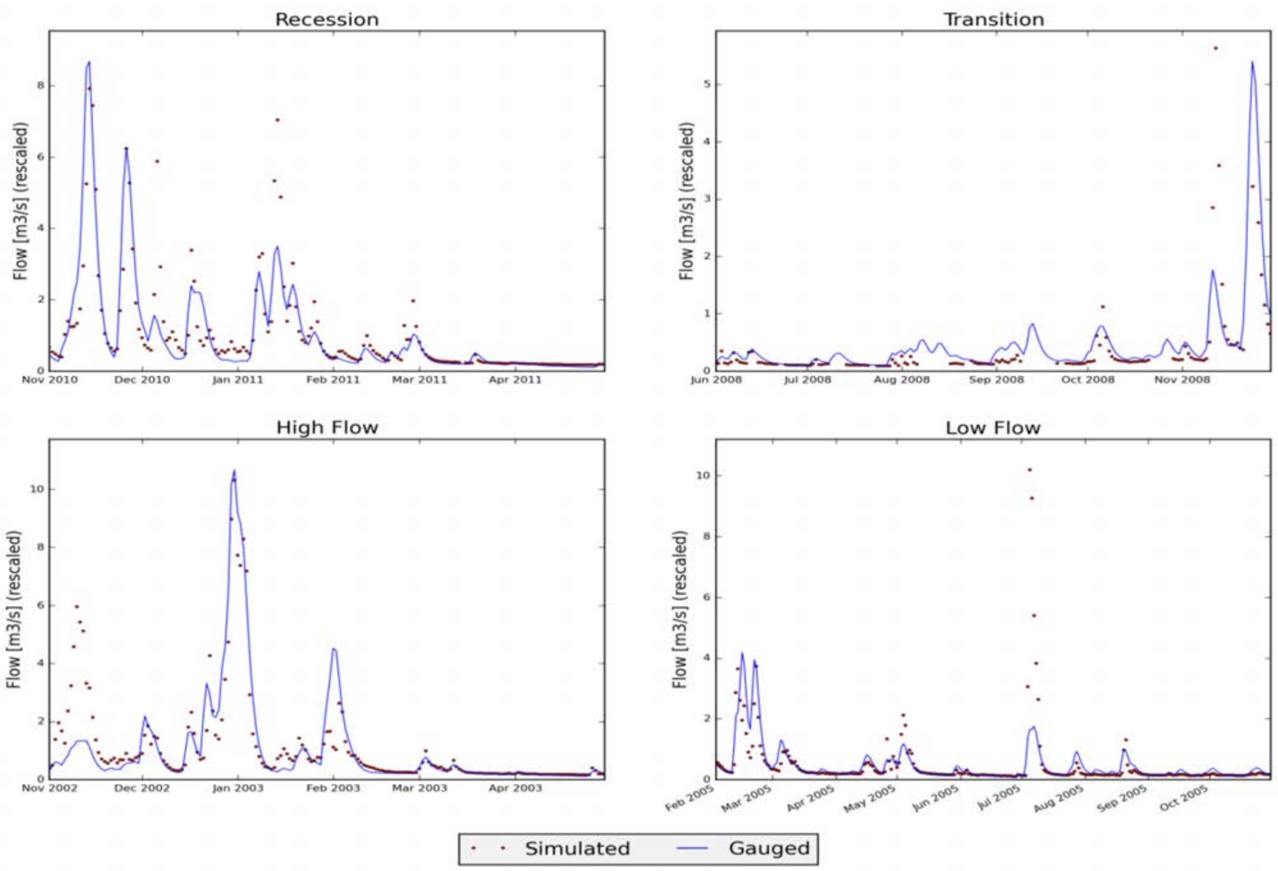


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp



Annexe 5 Gentse Kanalen

CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V03POE446000" (GENTSE KANALEN)

Input data

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

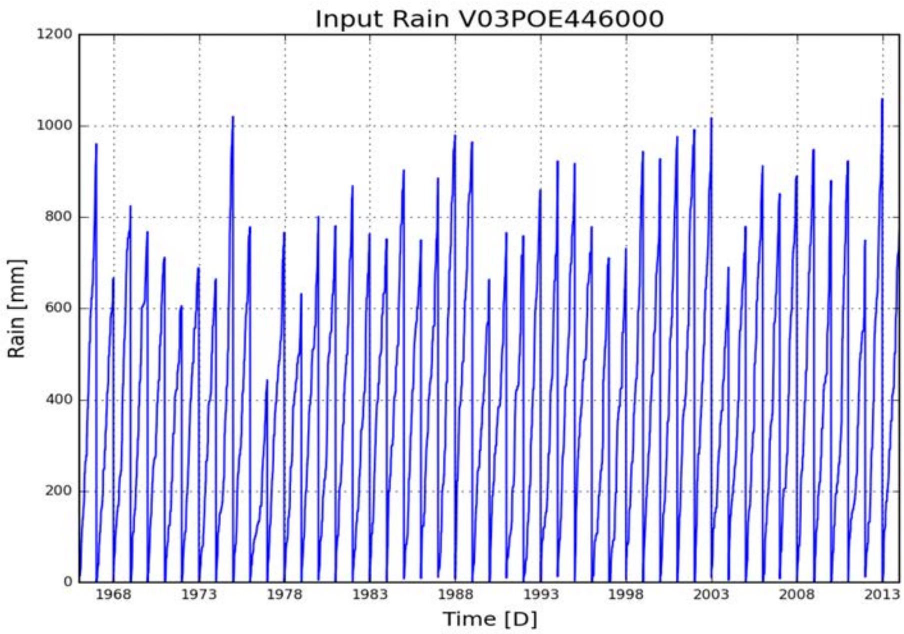
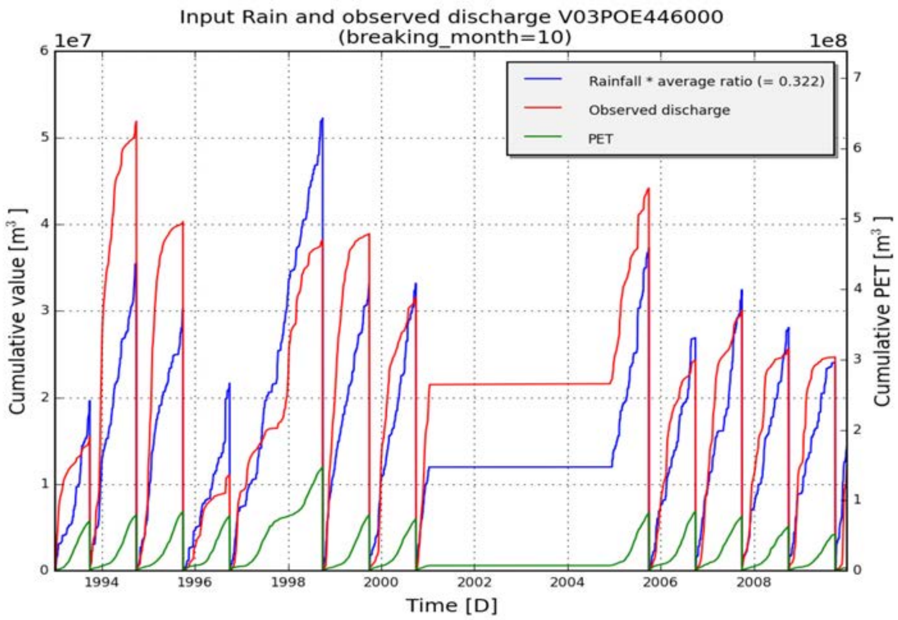


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V03POE446000 (Gentse Kanalen)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V03POE446000
subcatchment_area [m²]	106836849
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.11), ('bevaporation', 2.0), ('cmin', 15.0), ('cmax', 159.0), ('CKBF', 300.0), ('CK1', 43.0), ('CK2', 29.0), ('bdrainage', 1.0), ('kdrainage', 11807.0), ('PDM.TG', 3.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1993 - 2009)

	Full year	Summer	Winter
NS	0.711	0.414	0.823
NS_log	0.706	0.241	0.762
NS_rel	-3.872	-5.124	0.622
RelErr	-0.3 %	1.4 %	-7.8 %
VolBias	0.06	0.087	-0.079

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.671	0.449	0.735
NS_log	0.737	0.352	0.711
NS_rel	-2.052	-3.145	0.574
RelErr	9.5 %	18.2 %	2.3 %
VolBias	0.093	0.147	-0.018

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)

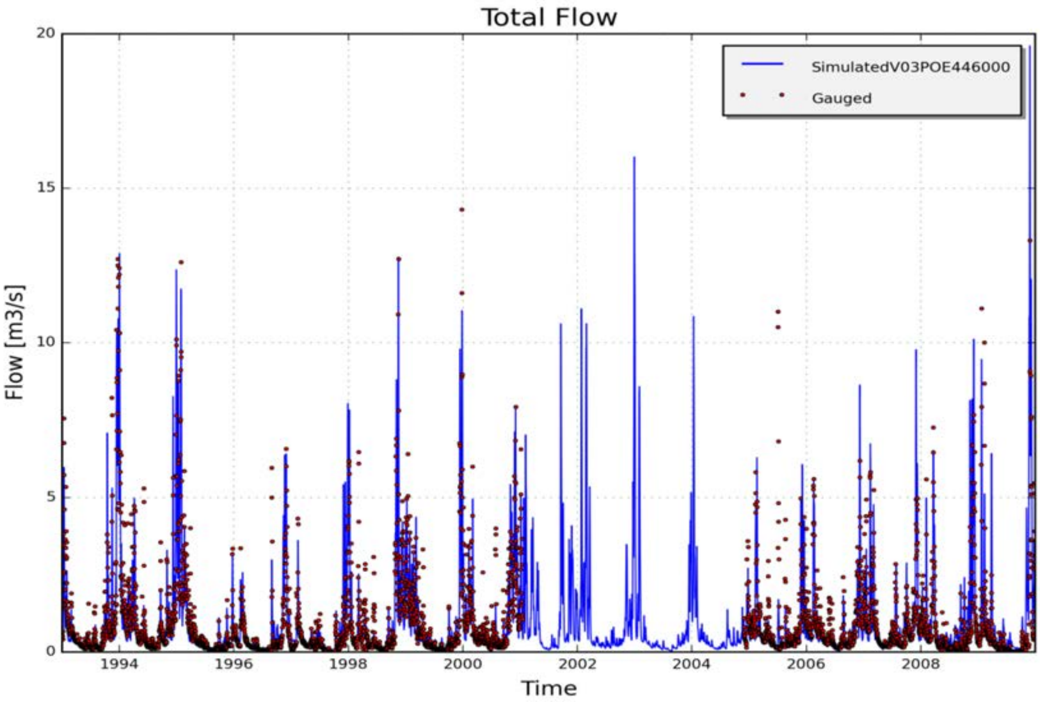


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele (calibration period)

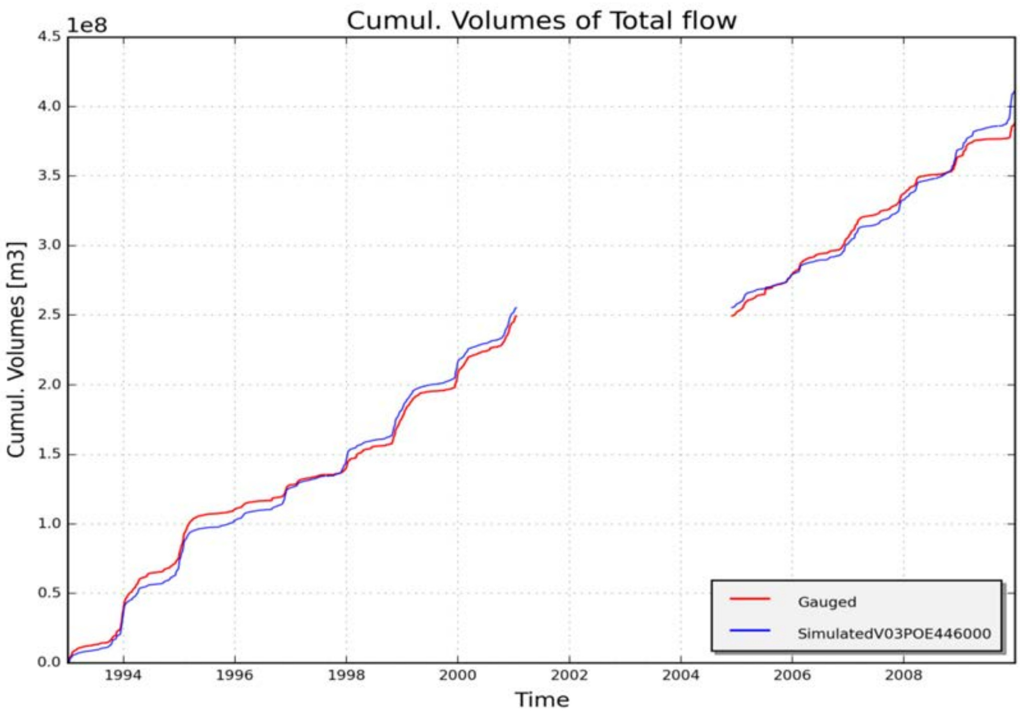


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele (validation period)

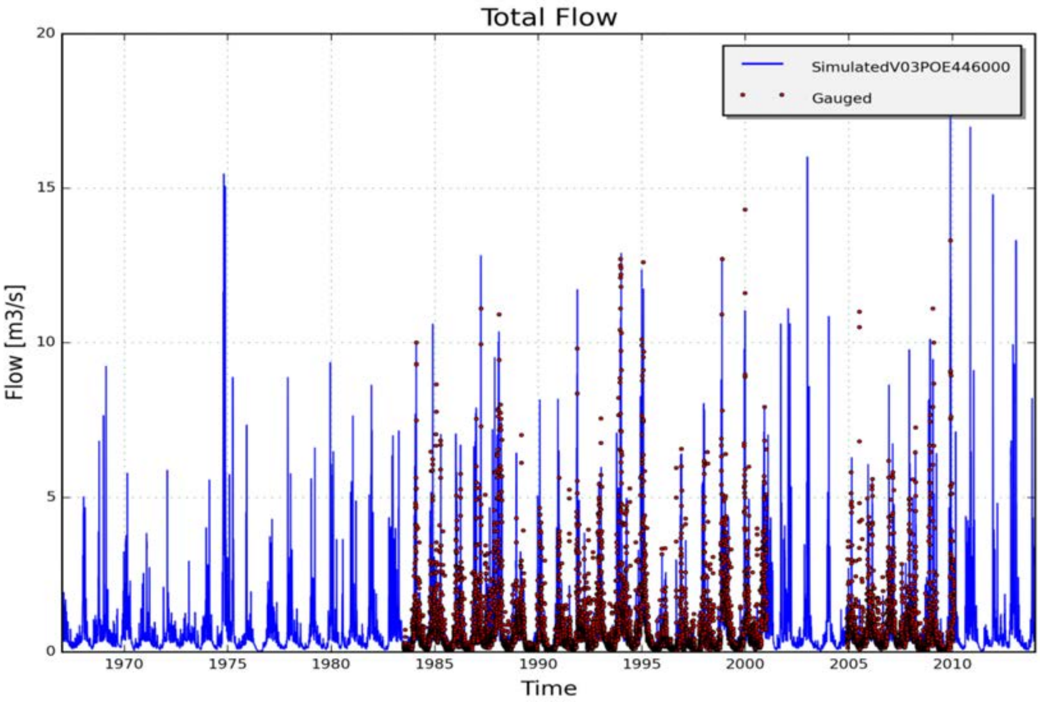


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele (validation period)

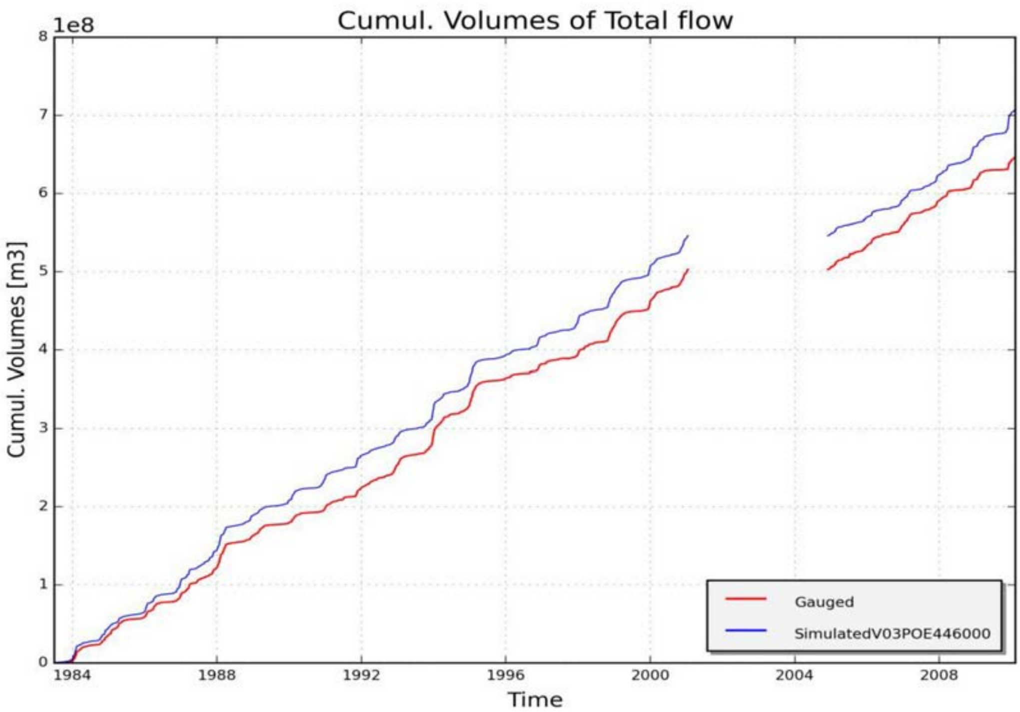


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V03POE446000, station 44656122 - Poekebeek; Nevele

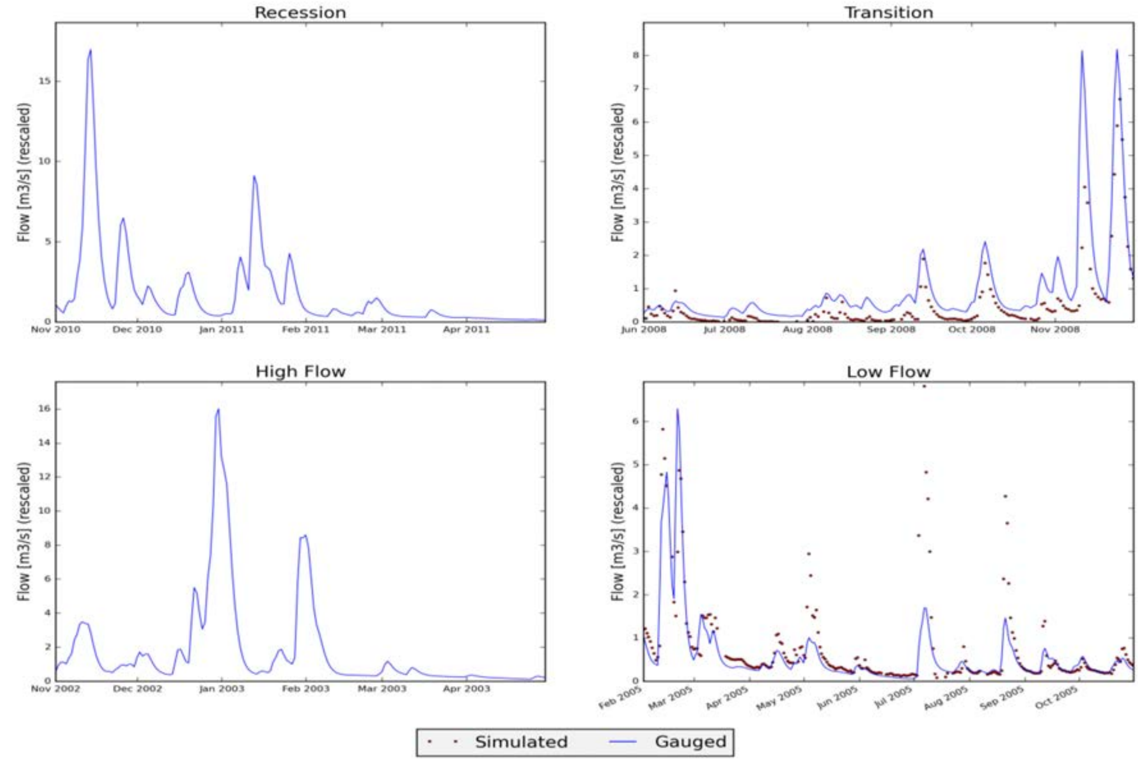


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V03POE446000, station 44656122 - Poekebeek; Nevele

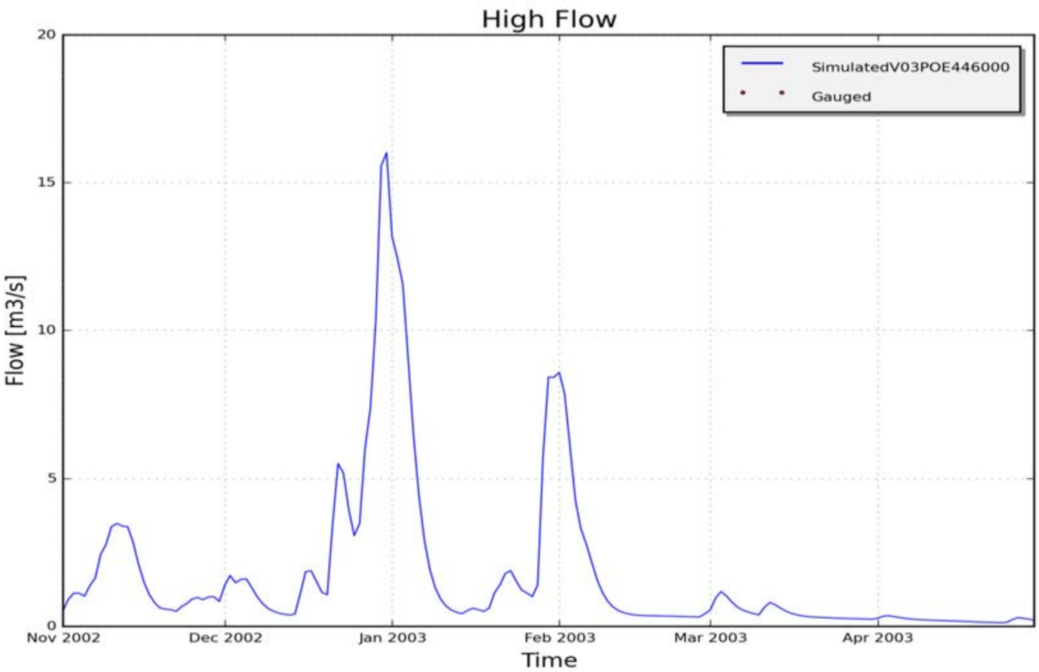


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V03POE446000, station 44656122 - Poekebeek; Nevele

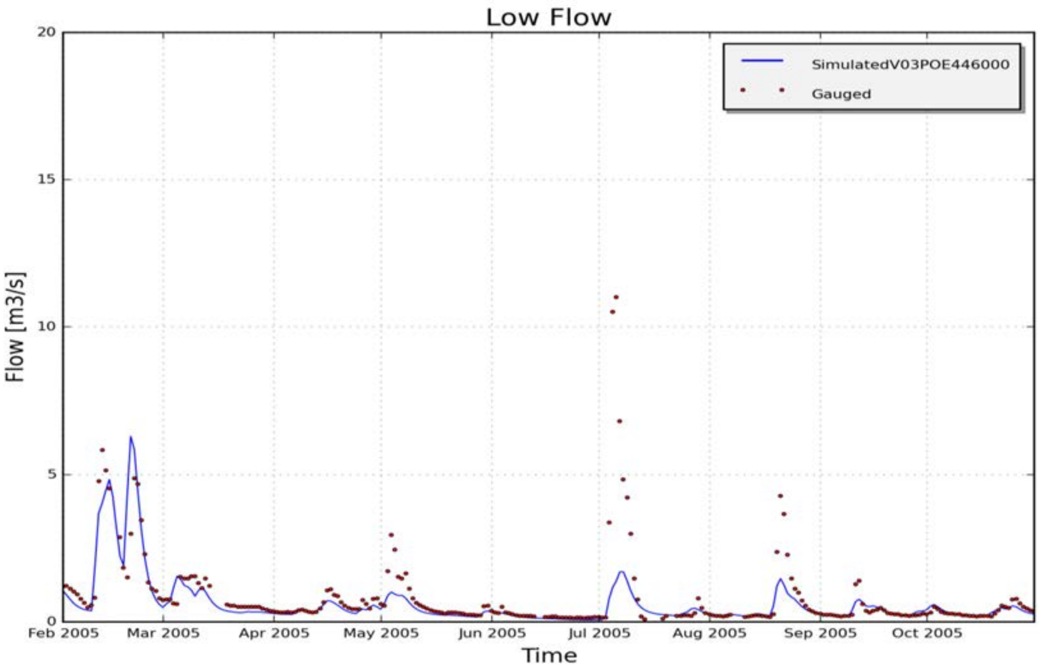
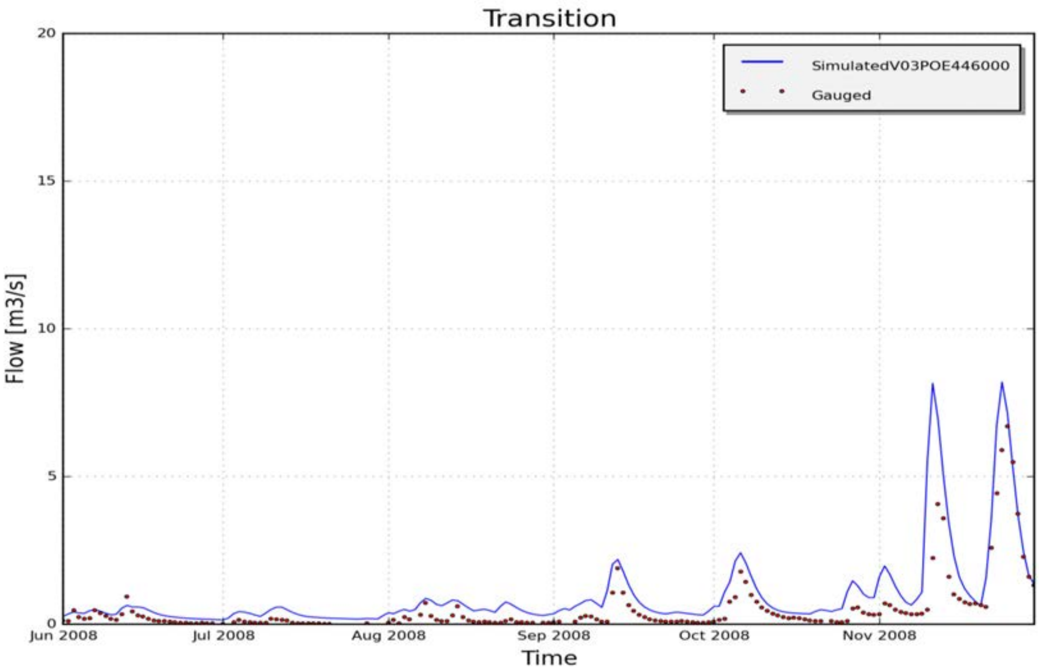


Figure 10: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment F01IJZ468000, station 46810102 - Ijzer; Haringe



Annexe 6 Benedenschelde

CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V04MOL036110" (BENEDENSCHELDE)

Input data

Figure 1: Cumulative precipitation on catchment V04MOL036110 (Benedenschelde)

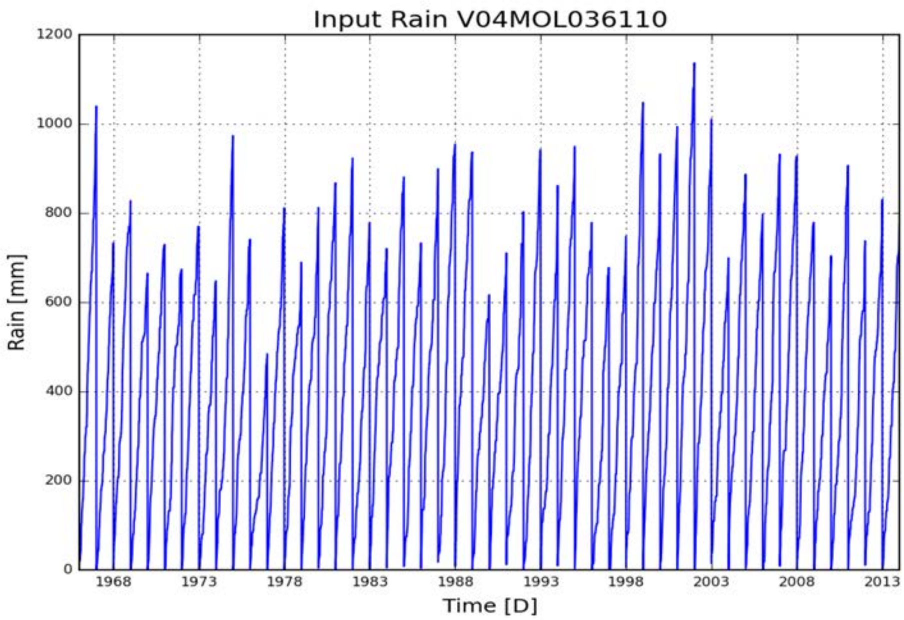
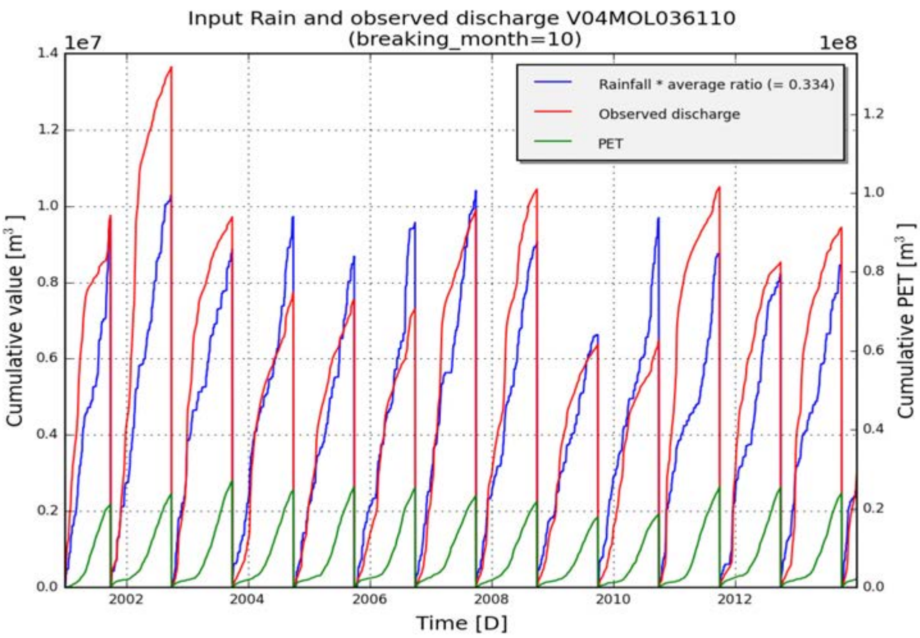


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V04MOL036110 (Benedenschelde)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V04MOL036110
subcatchment_area [m²]	32561957
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.12), ('bevaporation', 2.0), ('cmin', 6.3), ('cmax', 273.0), ('CKBF', 300.0), ('CK1', 30.0), ('CK2', 35.0), ('bdrainage', 1.0), ('kdrainage', 14243.0), ('PDM.TG', 2.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

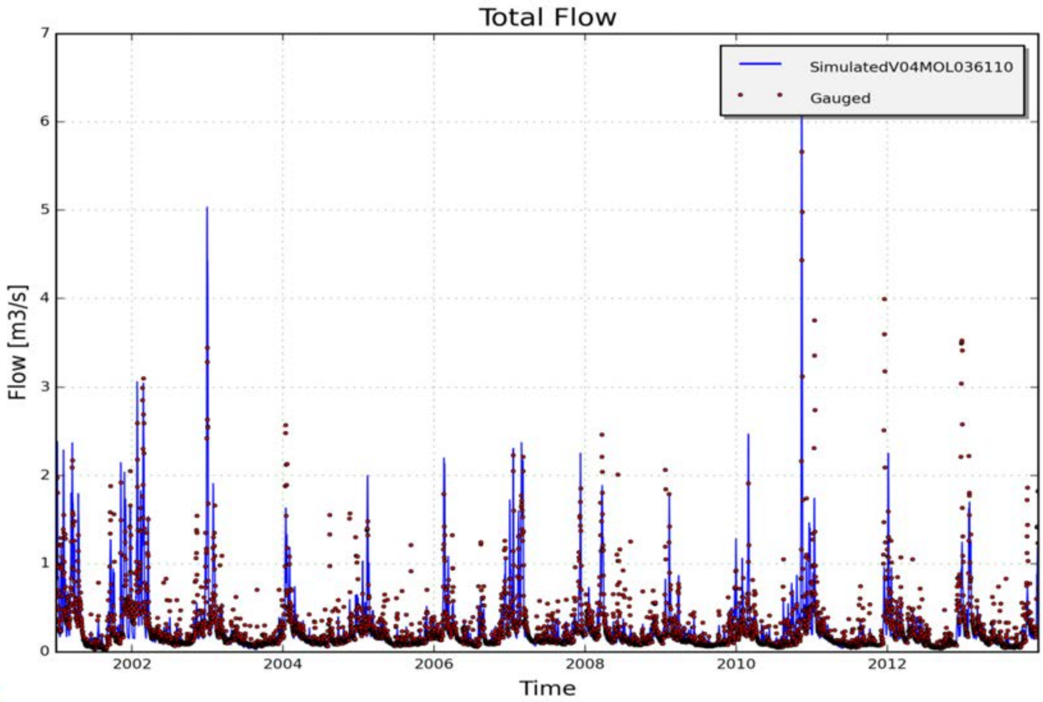
	Full year	**Summer**	**Winter**
NS	0.629	0.551	0.581
NS_log	0.781	0.561	0.73
NS_rel	0.877	0.802	0.819
RelErr	0.4 %	-8.9 %	4.5 %
VolBias	-0.031	-0.057	-0.011

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	**Summer**	**Winter**
NS	0.579	0.519	0.461
NS_log	0.69	0.265	0.676
NS_rel	-0.05	-0.567	0.688
RelErr	15.6 %	33.8 %	13.9 %
VolBias	0.115	0.203	0.109

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)



3

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

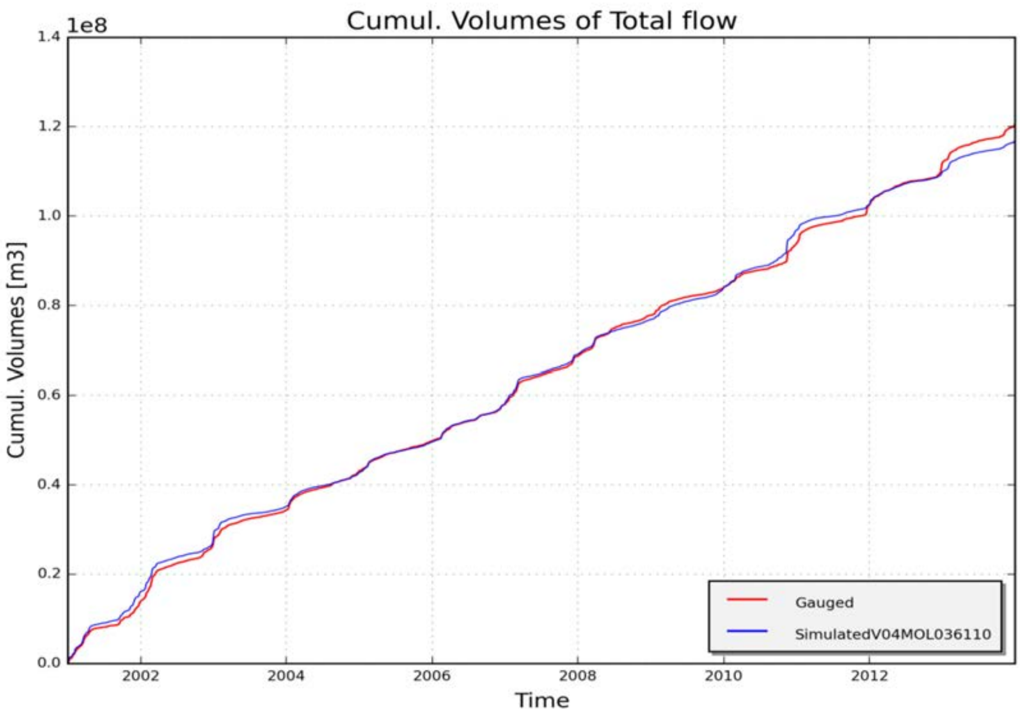


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele (validation period)

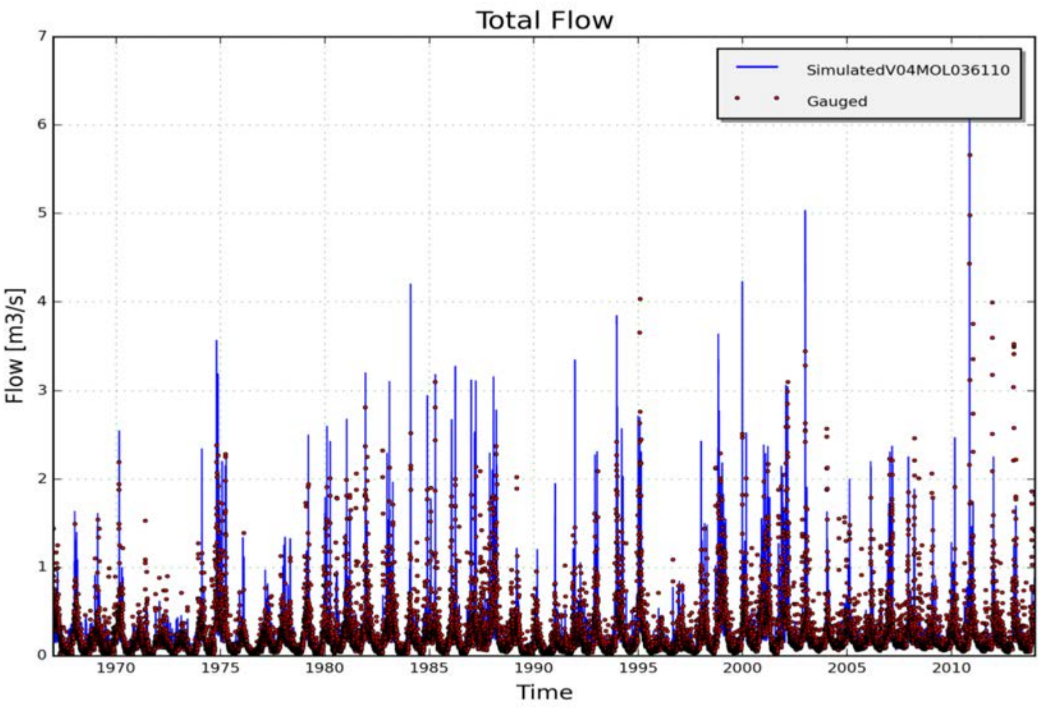


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele (validation period)

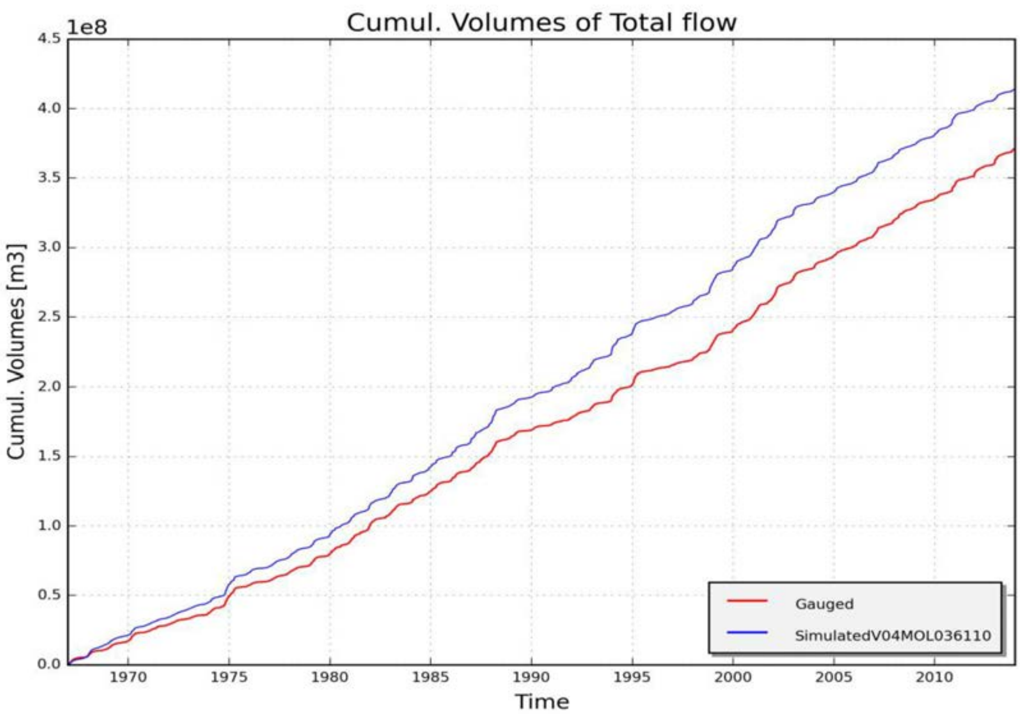
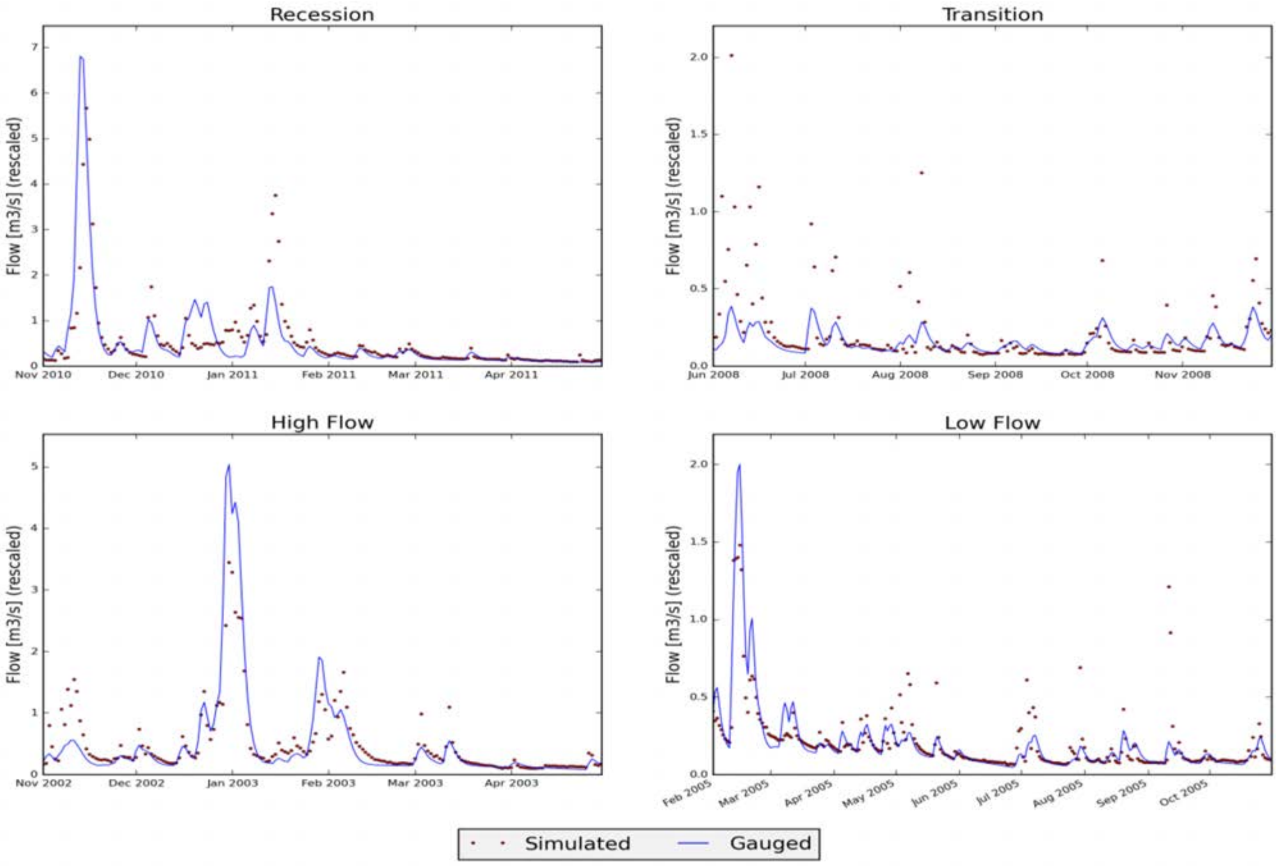


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT " V04MOM037100" (BENEDENSCHELDE)

Input data

Figure 1: Cumulative precipitation on catchment V04MOM037100 (Benedenschelde)

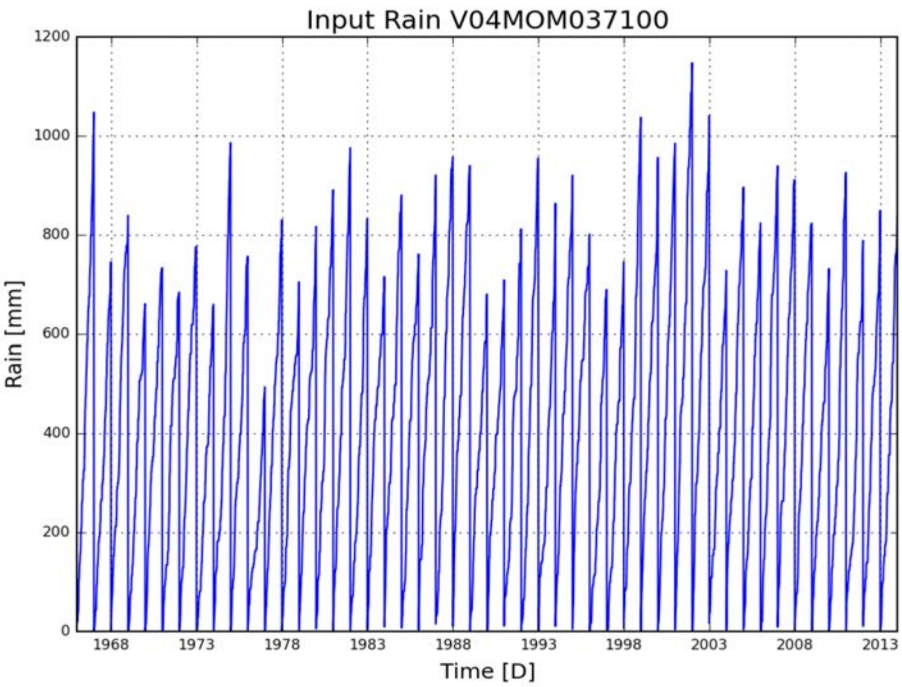
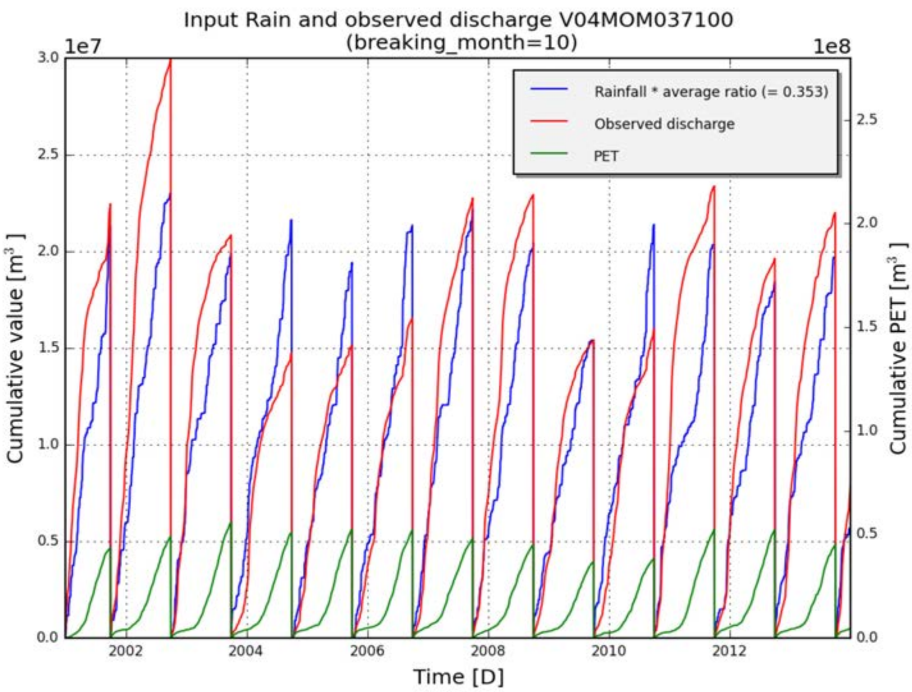


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V04MOM037100 (Benedenschelde)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V04MOM037100
subcatchment_area [m²]	67301328
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.12), ('bevaporation', 2.0), ('cmin', 10.0), ('cmax', 319.0), ('CKBF', 300.0), ('CK1', 33.0), ('CK2', 28.0), ('bdrainage', 1.0), ('kdrainage', 12666.0), ('PDM.TG', 4.3), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.406	0.596	0.318
NS_log	0.76	0.548	0.559
NS_rel	0.743	0.634	0.689
RelErr	0.3 %	0.5 %	5.6 %
VolBias	-0.039	0.005	-0.021

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.51	0.492	0.39
NS_log	0.711	0.307	0.688
NS_rel	0.081	-0.997	0.665
RelErr	13.8 %	27.3 %	10.7 %
VolBias	0.084	0.188	0.074

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)

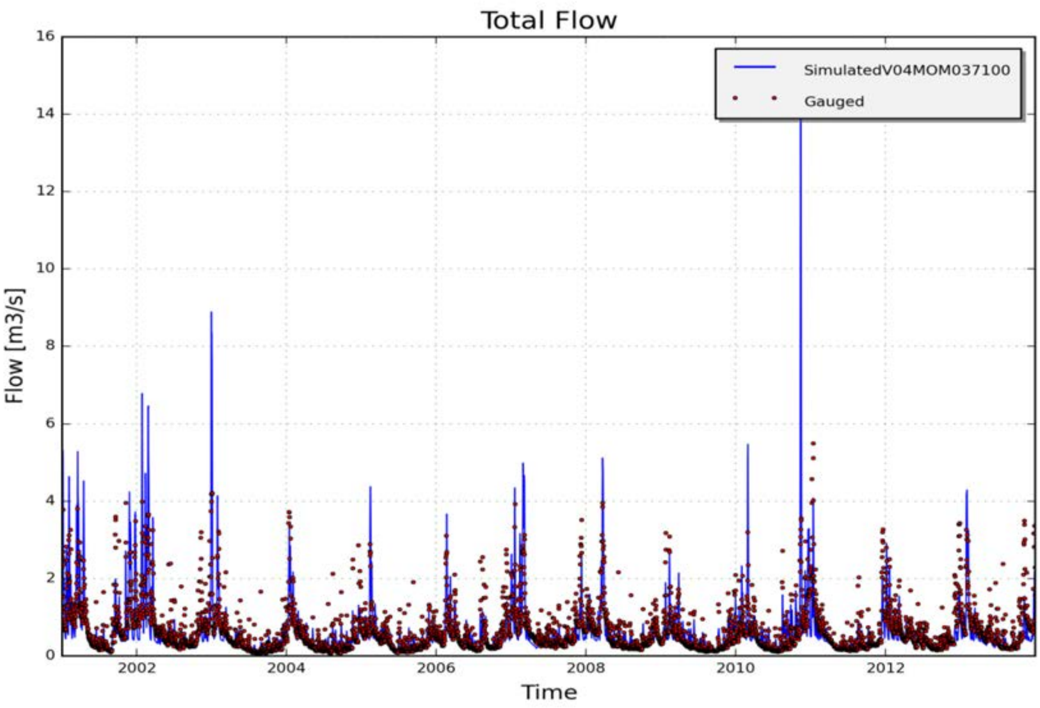


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen (calibration period)

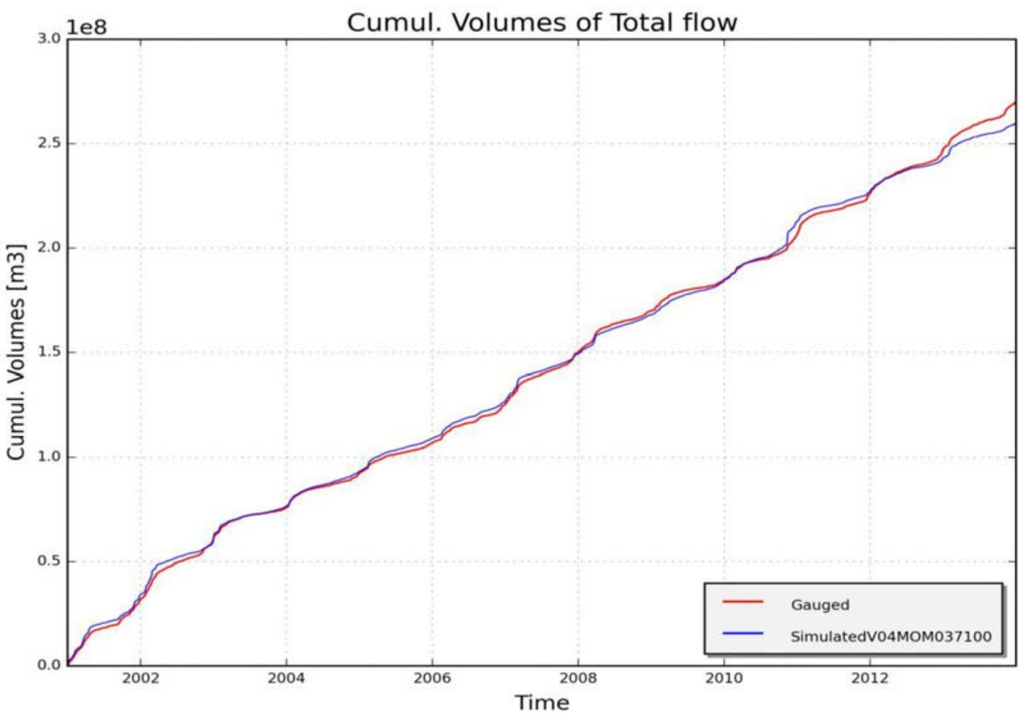


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen (validation period)

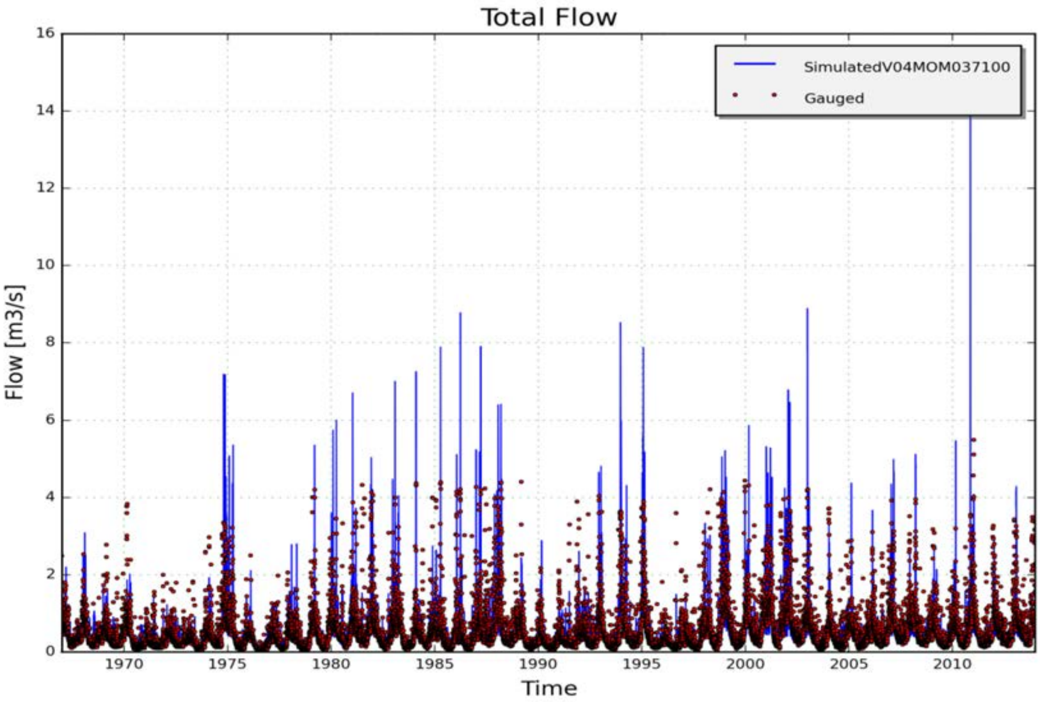


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen (validation period)

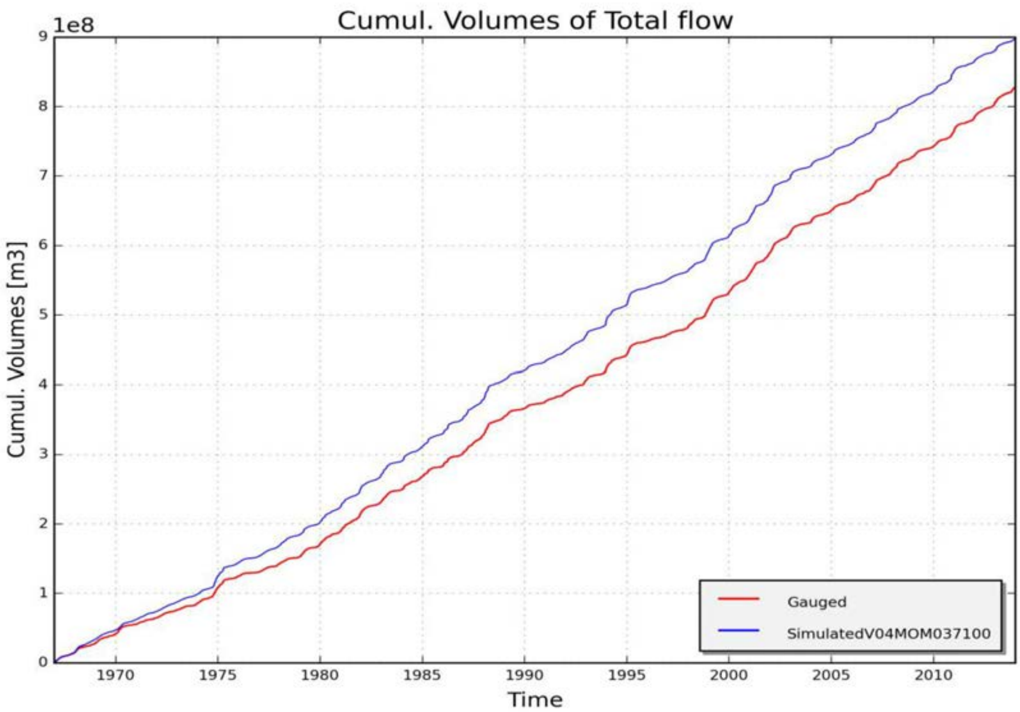
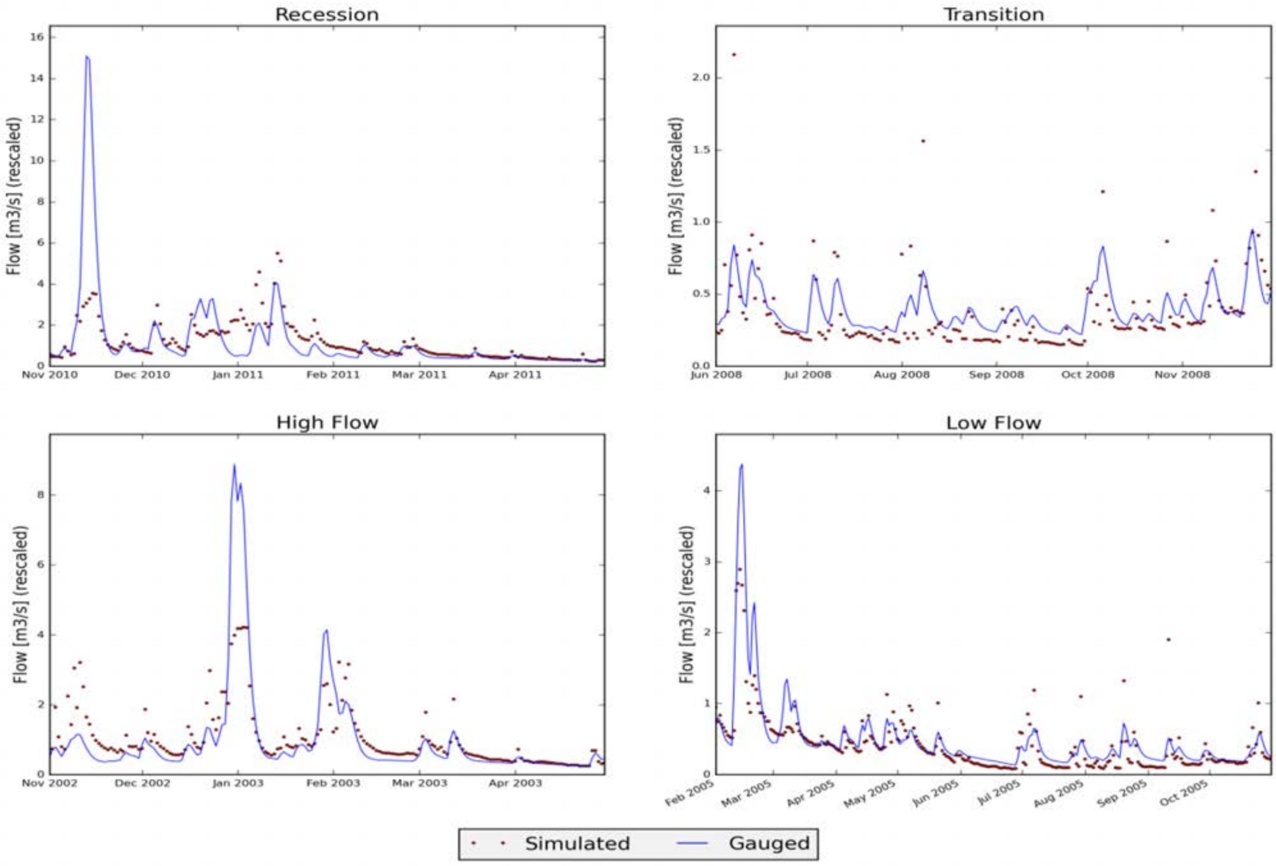


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen



Annexe 7 Leie

CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT " F05LEI386999" (LEIEBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment F05LEI386999 (Leiebekken)

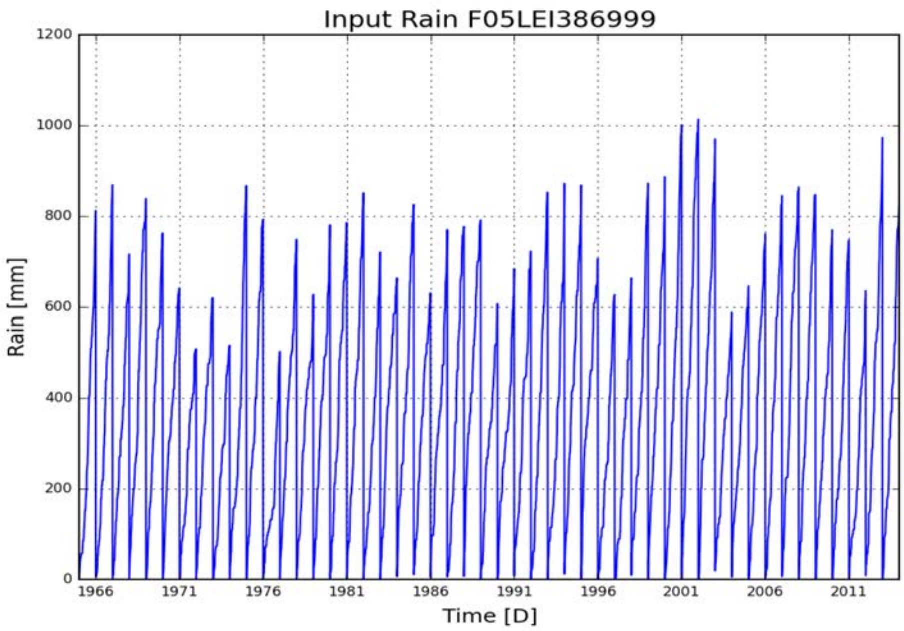
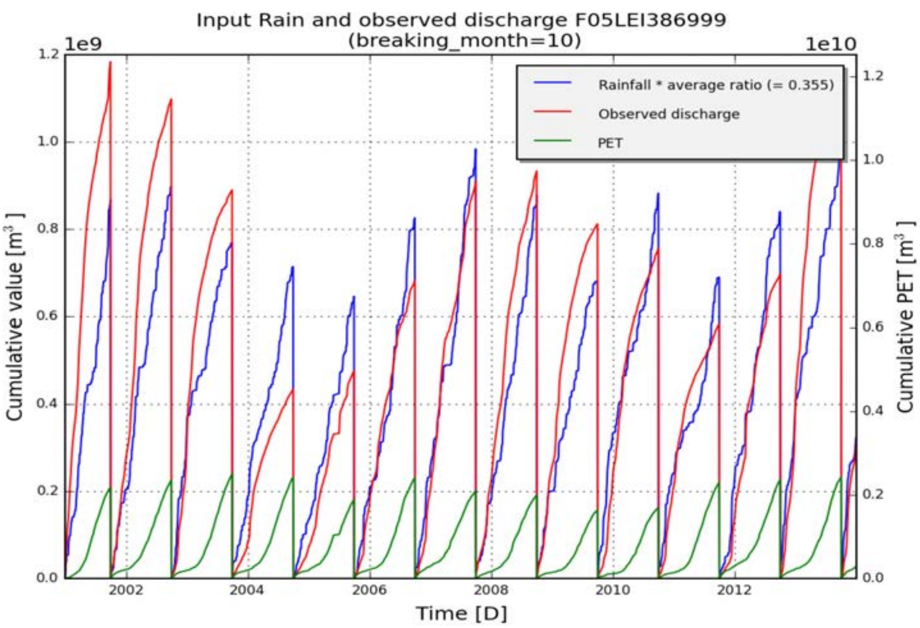


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment F05LEI386999 (Leiebekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	F05LEI386999
subcatchment_area [m²]	2981779554
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.25), ('bevaporation', 2.0), ('cmin', 7.3), ('cmax', 394.0), ('CKBF', 300.0), ('CK1', 40.7), ('CK2', 32.5), ('bdrainage', 1.0), ('kdrainage', 11466.0), ('PDM.TG', 3.4), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.802	0.68	0.781
NS_log	0.781	0.566	0.826
NS_rel	0.754	0.641	0.867
RelErr	-2.0 %	2.1 %	-3.7 %
VolBias	-0.0	0.092	-0.054

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.808	0.674	0.779
NS_log	0.795	0.563	0.821
NS_rel	0.766	0.64	0.862
RelErr	-1.6 %	3.0 %	-3.9 %
VolBias	-0.001	0.088	-0.052

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)

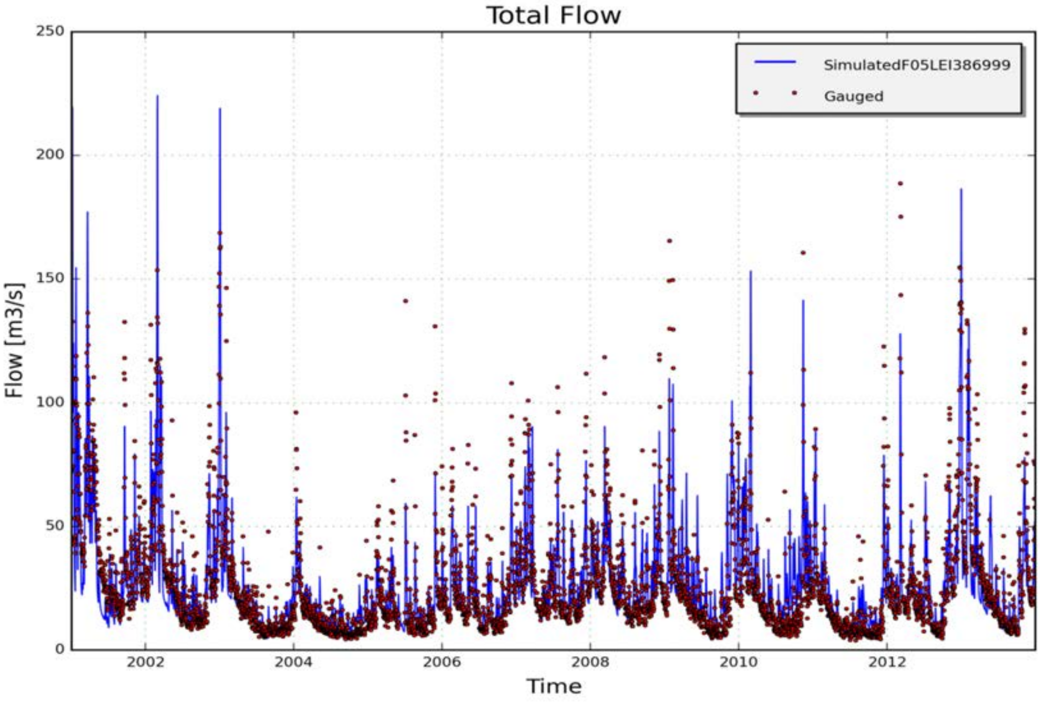


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment F05LEI386999, station unkown (calibration period)

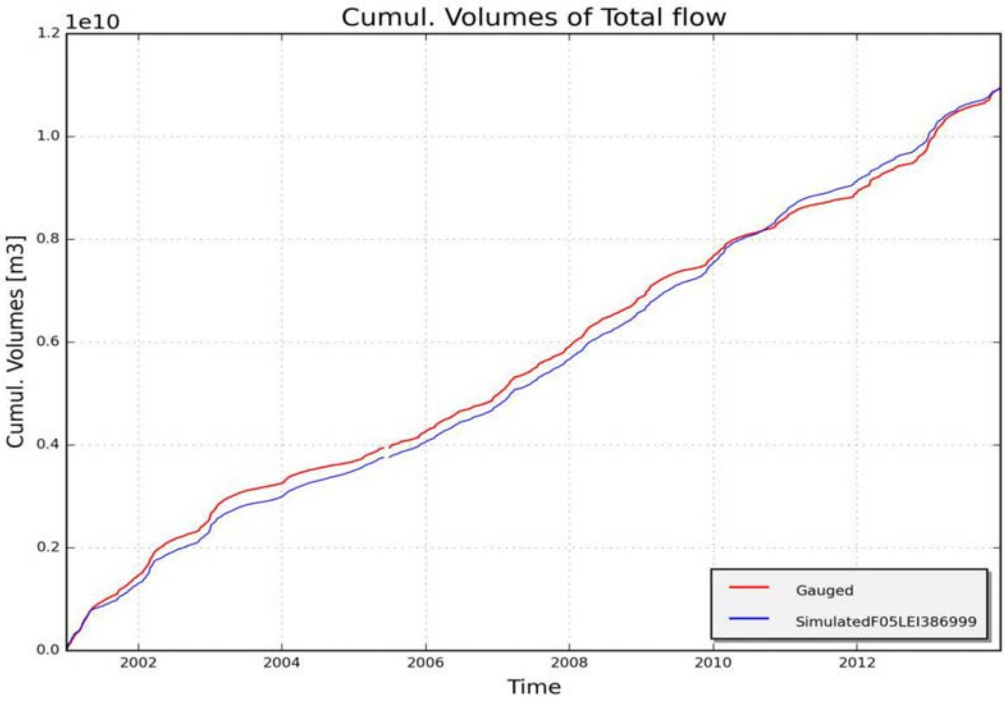


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment F05LEI386999, station unkown (validation period)

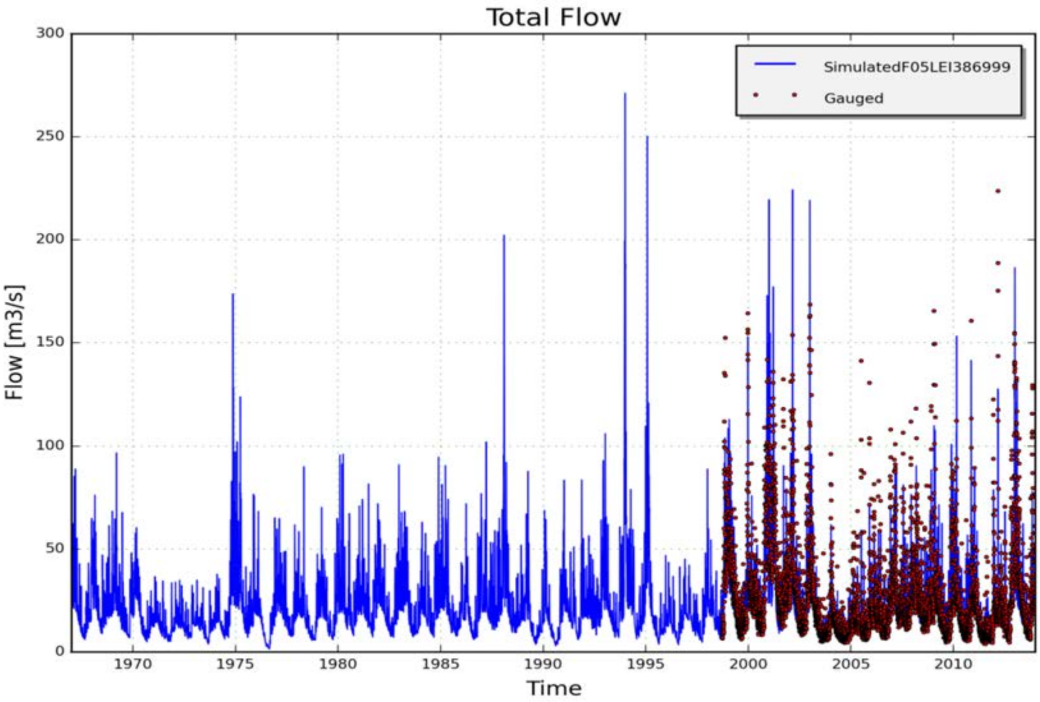


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment F05LEI386999, station unkown (validation period)

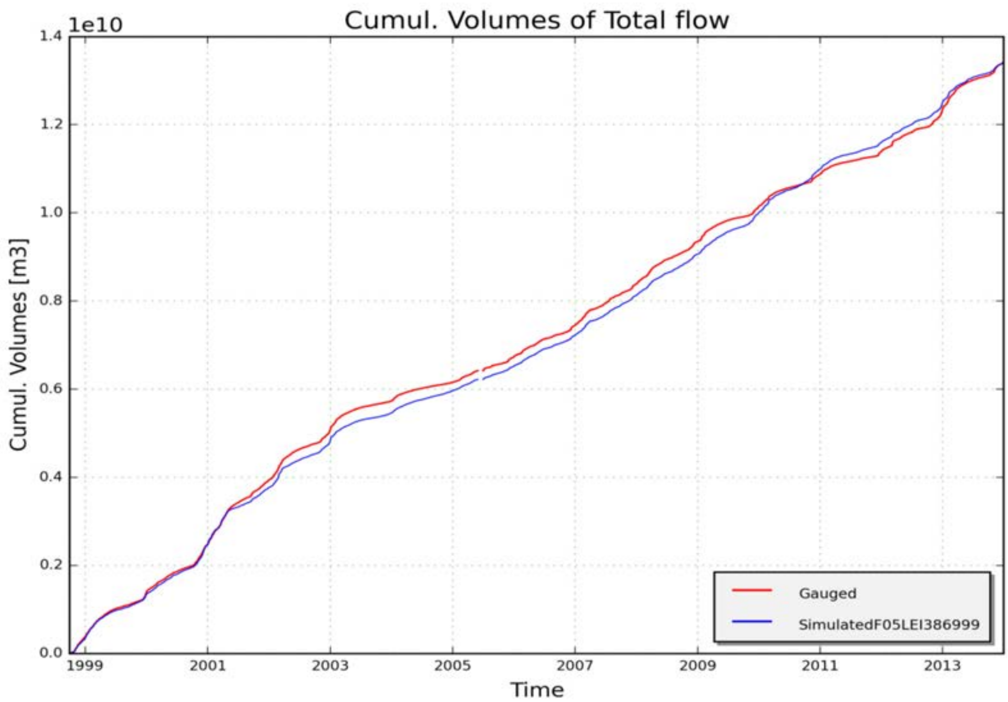
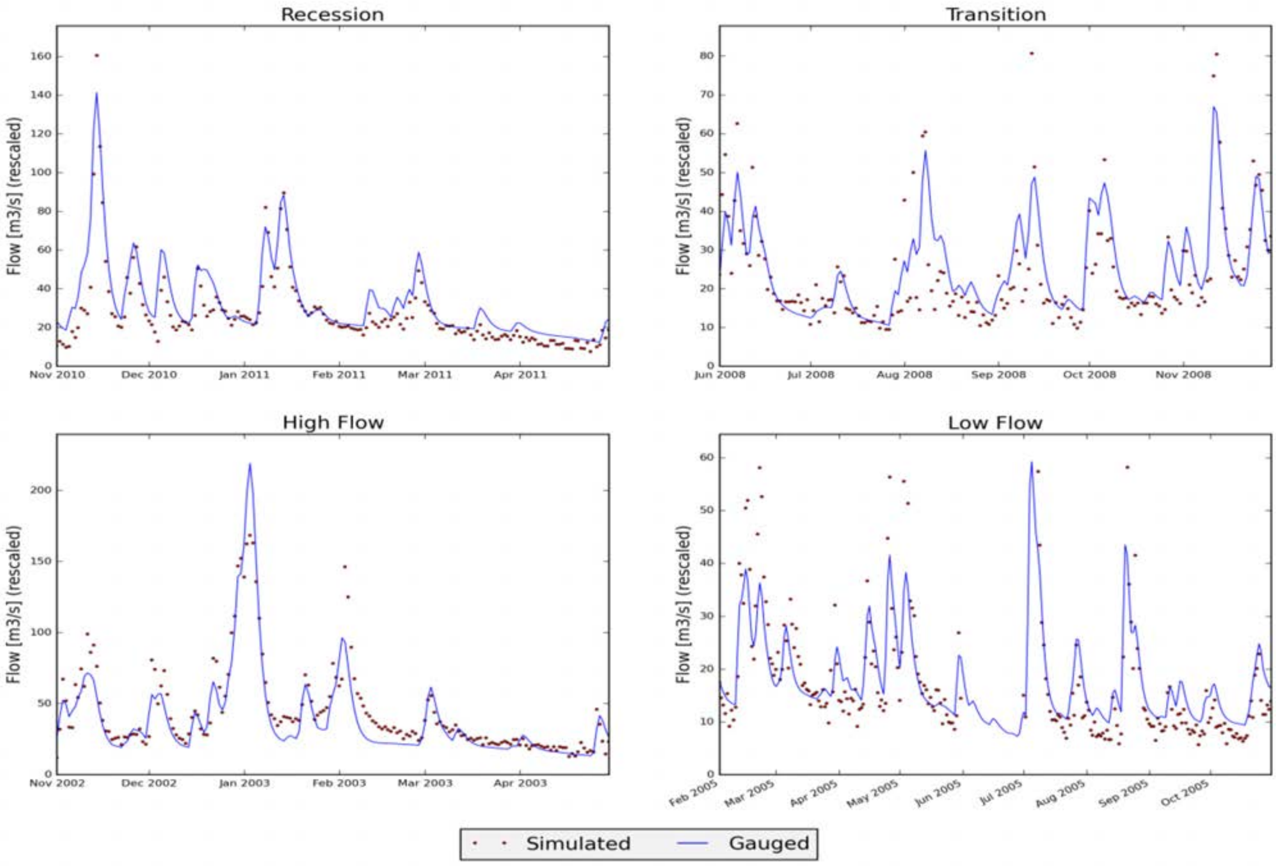


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchmentF05LEI386999, station unkown



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V05HEU403210" (LEIEBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V05HEU403210 (Leiebekken)

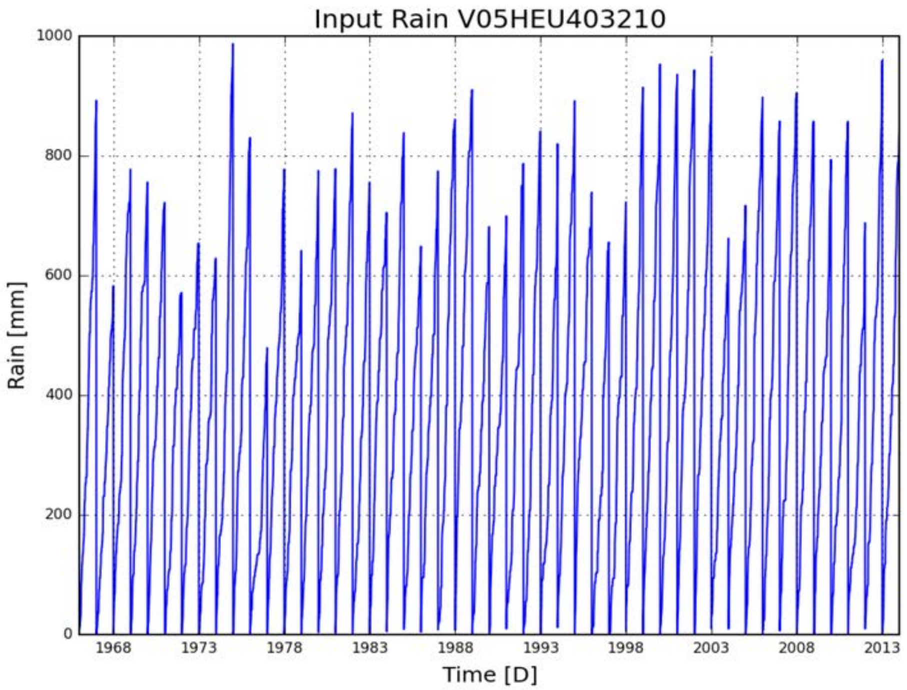
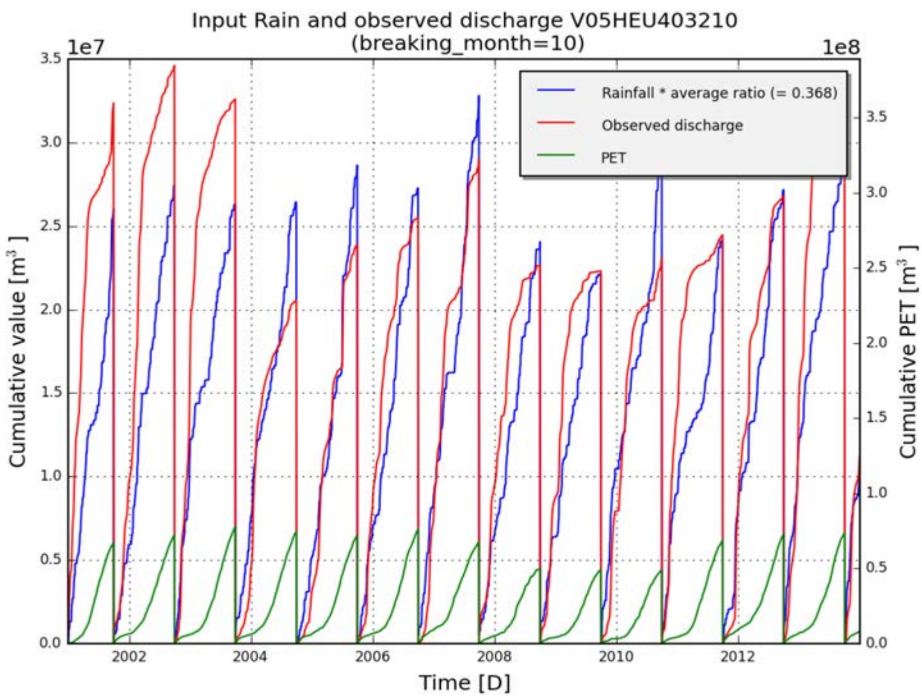


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V05HEU403210 (Leiebekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V05HEU403210
subcatchment_area [m²]	91912331
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.24), ('bevaporation', 2.0), ('cmin', 3.2), ('cmax', 167.0), ('CKBF', 1.0), ('CK1', 34.0), ('CK2', 30.0), ('bdrainage', 1.0), ('kdrainage', 12742.0), ('PDM.TG', 7.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	**Summer**	**Winter**
NS	0.758	0.656	0.787
NS_log	0.712	0.366	0.672
NS_rel	-21.003	-35.353	0.781
RelErr	-4.5 %	-4.2 %	-7.1 %
VolBias	0.009	0.04	-0.06

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	**Summer**	**Winter**
NS	0.778	0.654	0.773
NS_log	0.765	0.522	0.646
NS_rel	-6.821	-13.917	0.744
RelErr	-5.0 %	-16.4 %	-7.7 %
VolBias	-0.038	-0.115	-0.074

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)

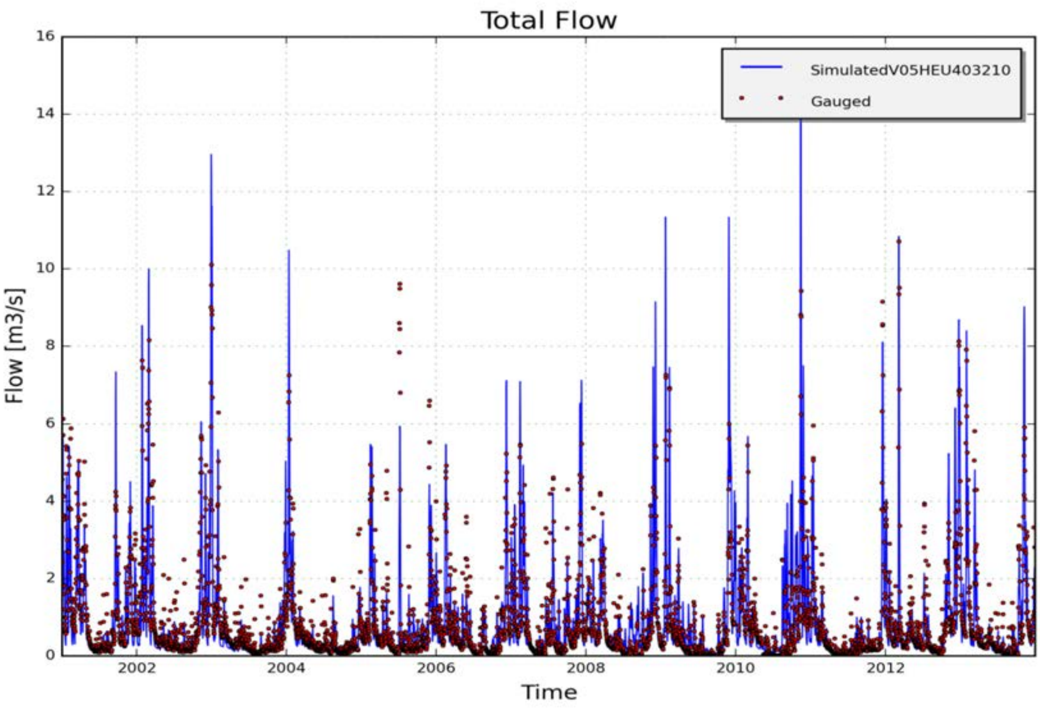


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V05HEU403210, station 40310102 - Heulebeek; Heule (calibration period)

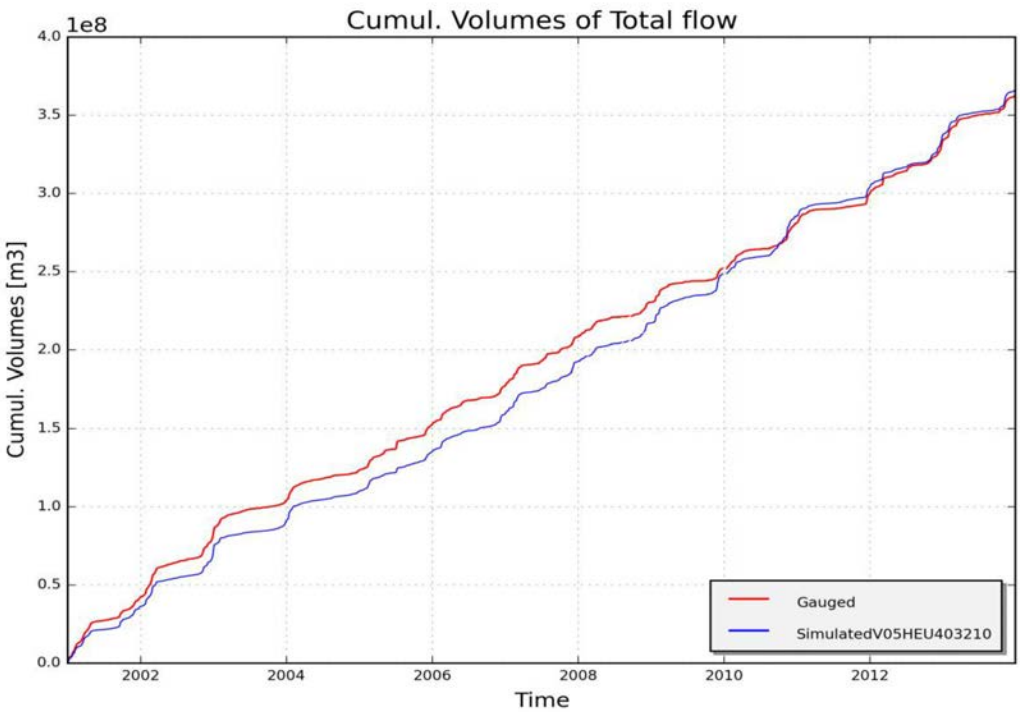


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V05HEU403210, station 40310102 - Heulebeek; Heule (validation period)

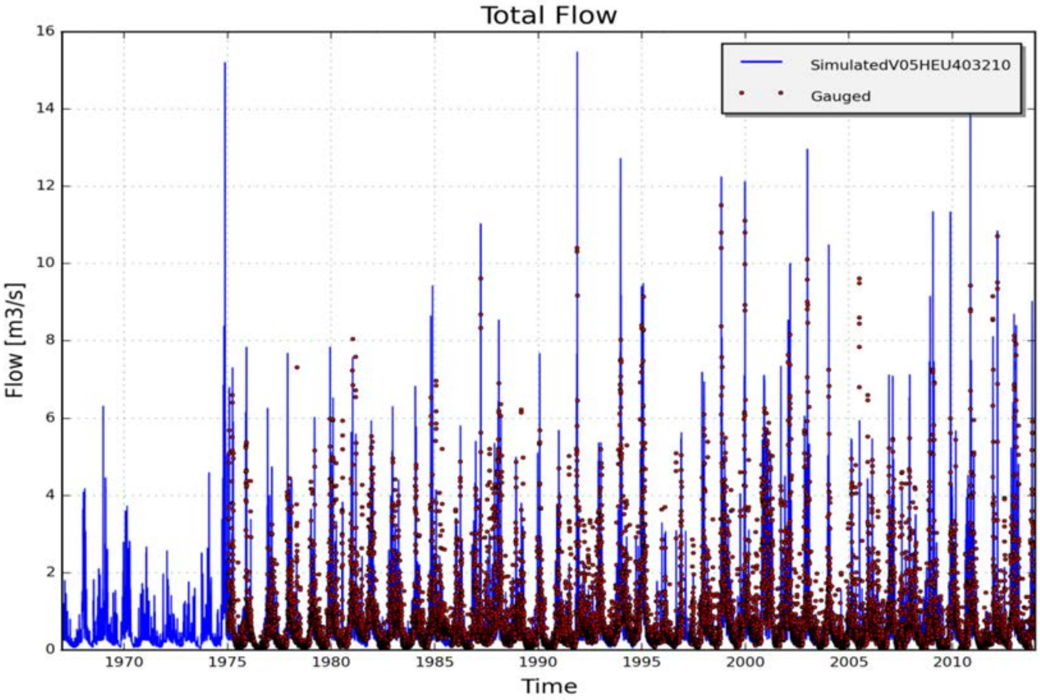


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V05HEU403210, station 40310102 - Heulebeek; Heule (validation period)

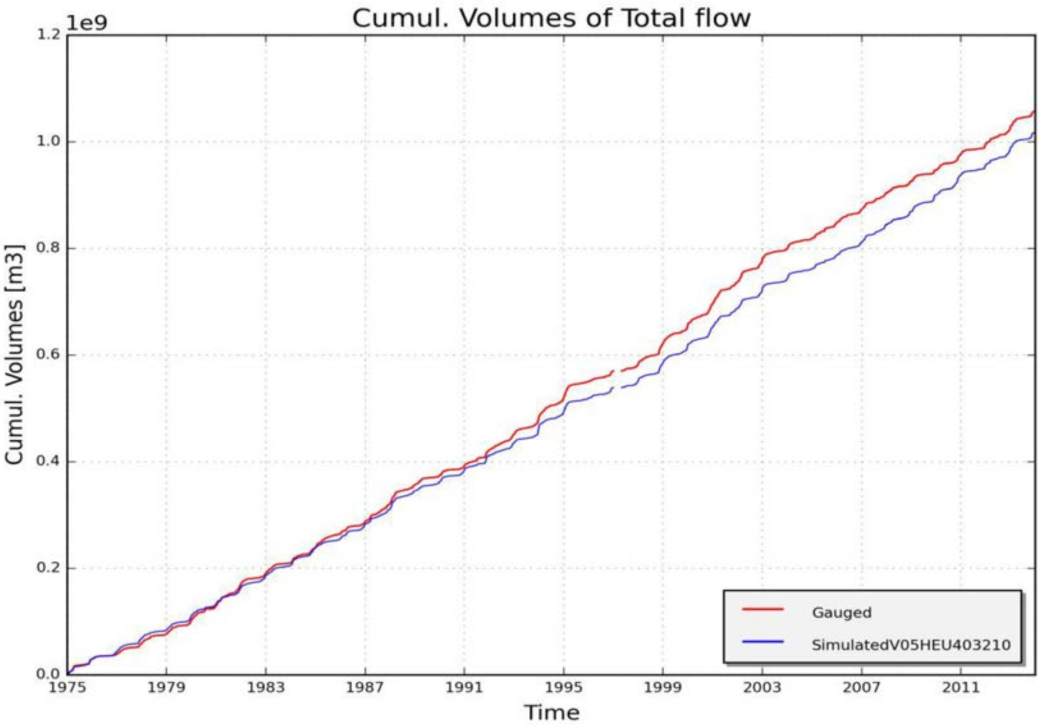
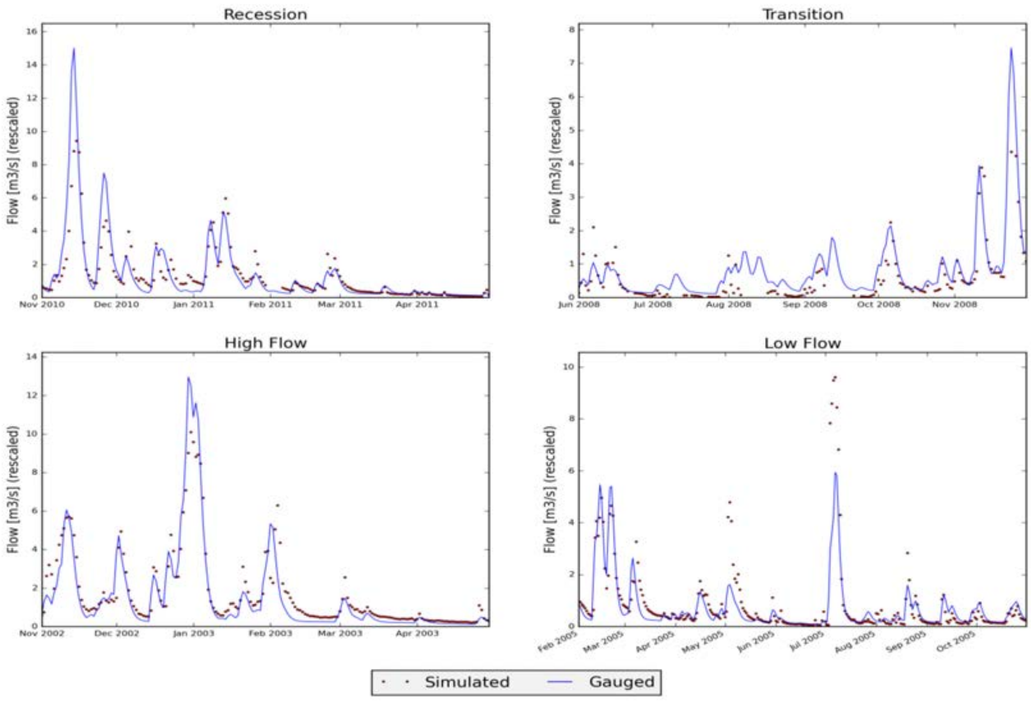


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchmentV05HEU403210, station 40310102 - Heulebeek; Heule



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V05MAN401230" (LEIEBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V05MAN401230 (Leiebekken)

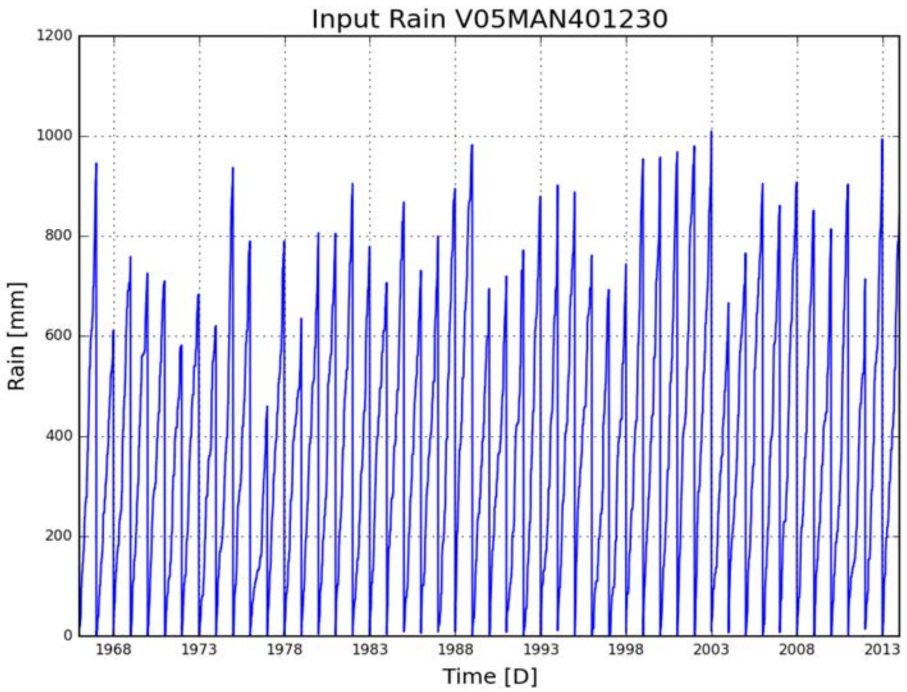
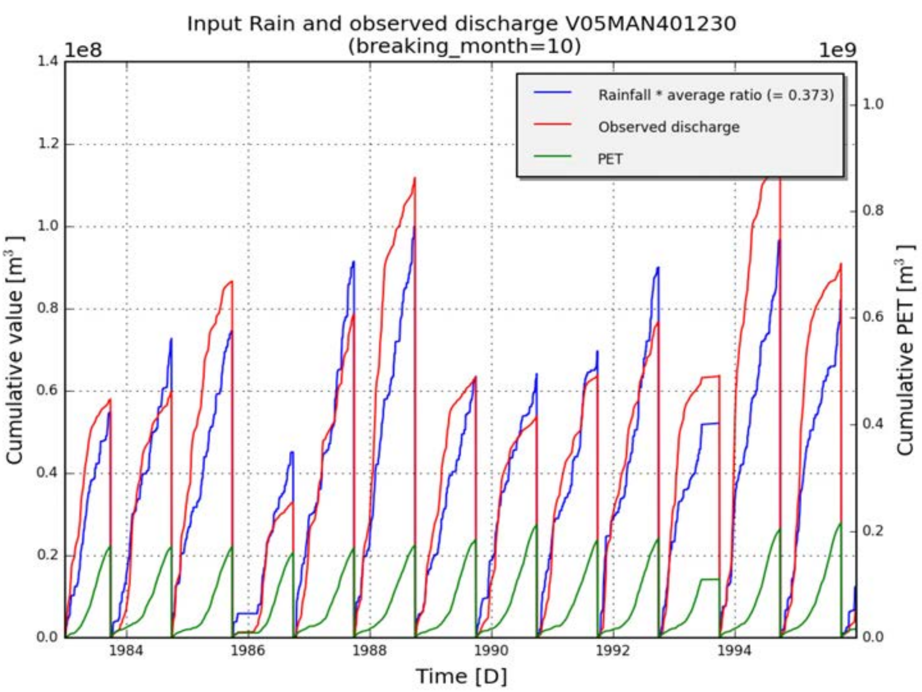


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V05MAN401230 (Leiebekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V05MAN401230
subcatchment_area [m²]	258441818
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.28), ('bevaporation', 2.0), ('cmin', 8.6), ('cmax', 273.0), ('CKBF', 1.0), ('CK1', 33.0), ('CK2', 35.0), ('bdrainage', 1.0), ('kdrainage', 16690.0), ('PDM.TG', 1.3), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1983 – 1995)

	Full year	Summer	Winter
NS	0.812	0.681	0.795
NS_log	0.831	0.705	0.768
NS_rel	0.653	0.813	0.736
RelErr	0.1 %	-0.7 %	-2.5 %
VolBias	-0.01	-0.026	-0.026

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.758	0.601	0.706
NS_log	0.735	0.427	0.657
NS_rel	0.318	0.266	0.477
RelErr	-4.1 %	8.2 %	-13.6 %
VolBias	0.01	0.122	-0.053

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)

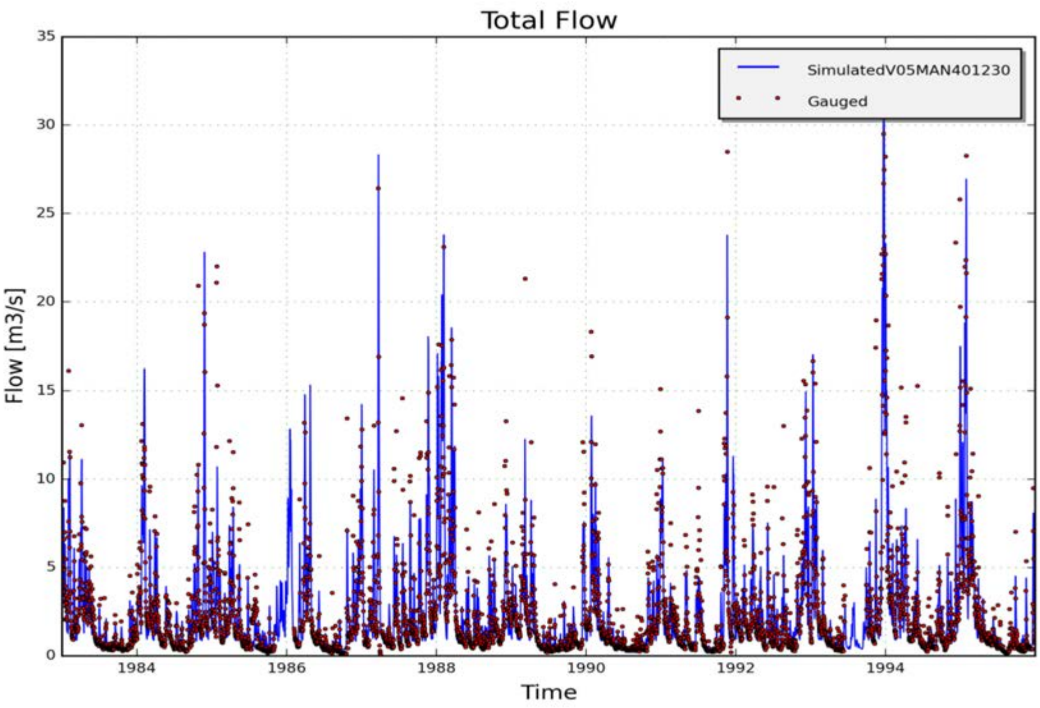


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke (calibration period)

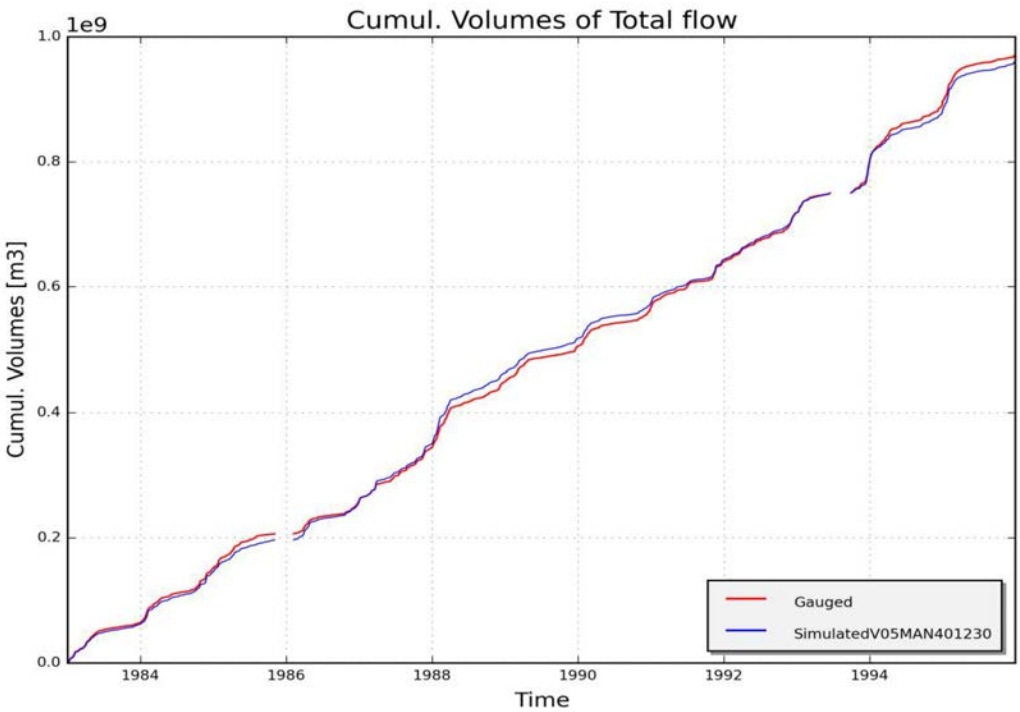


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke (validation period)

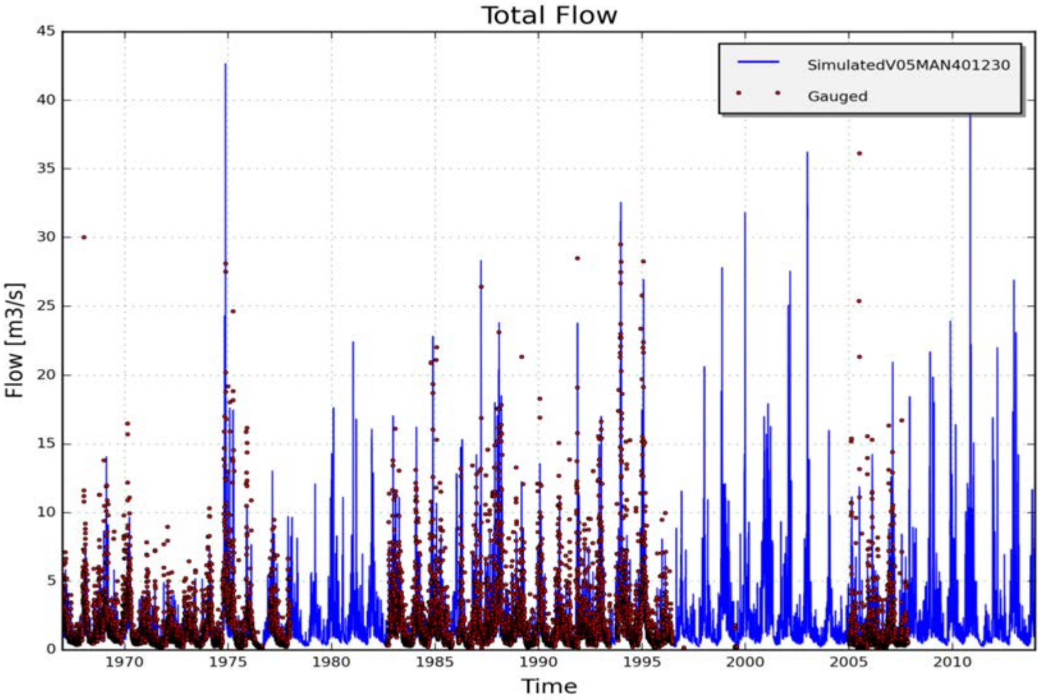


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke (validation period)

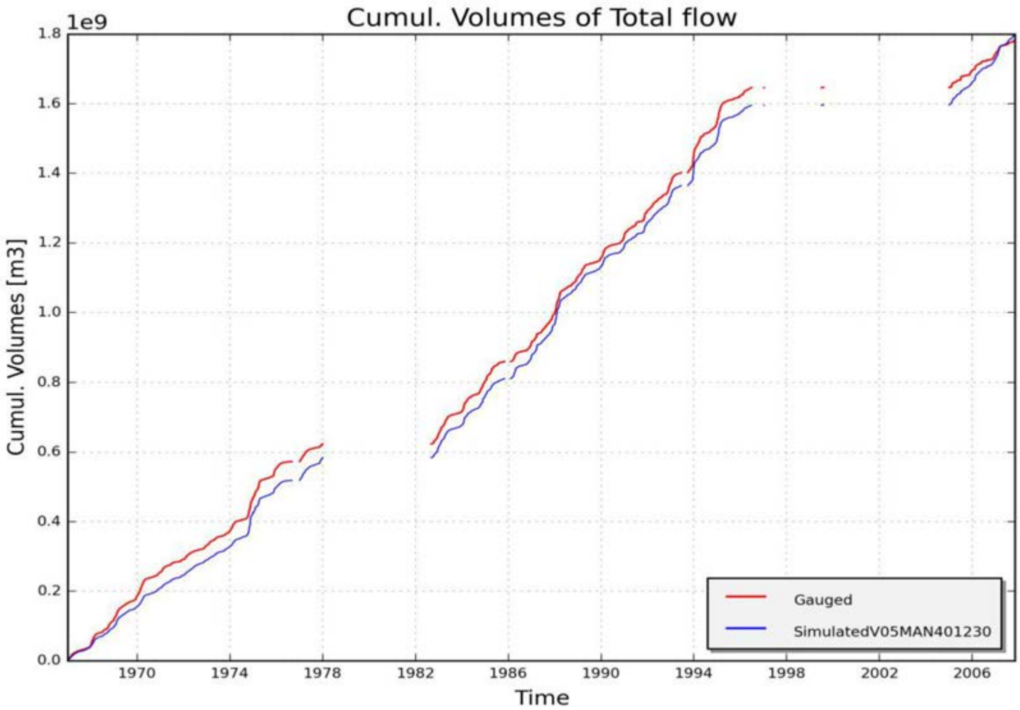
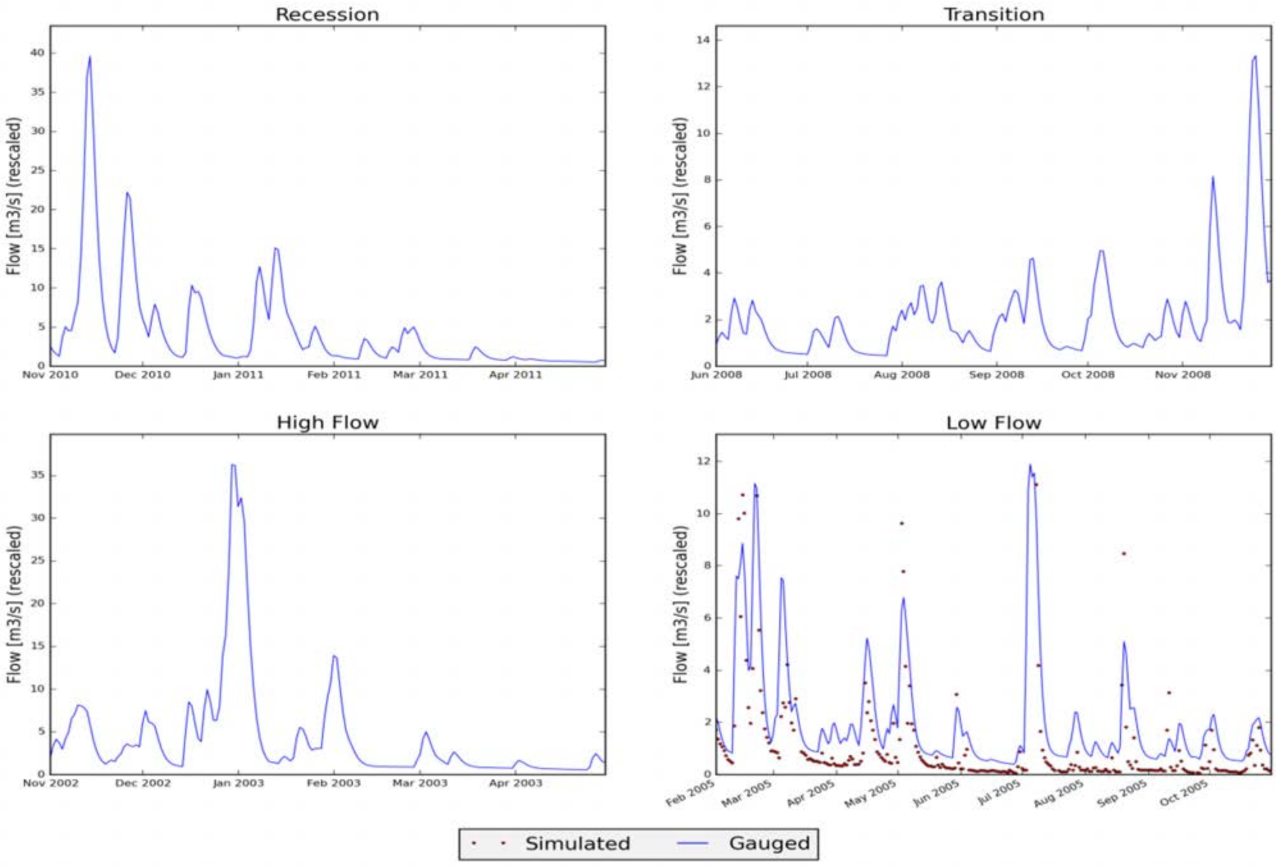


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke



Annexe 8 Bovenschelde

CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "F06BOS325001" (BOVENSCHELDE)

Input data

Figure 1: Cumulative precipitation on catchment F06BOS325001 (Bovenschelde)

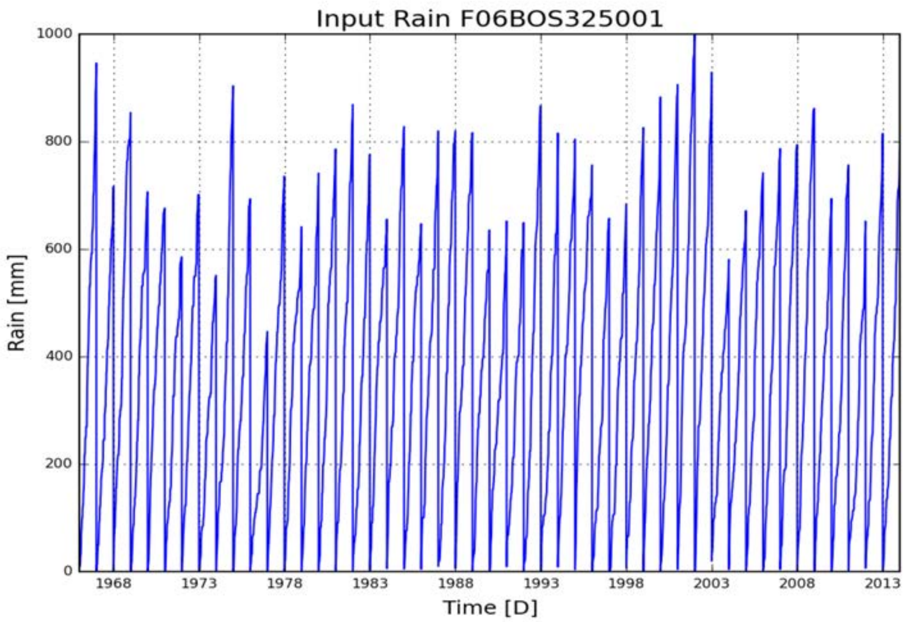
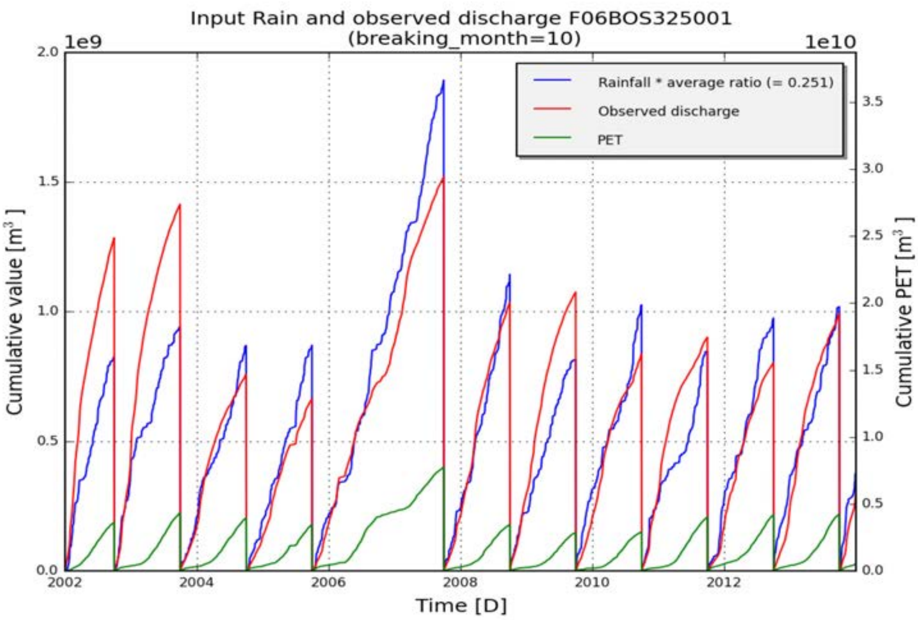


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment F06BOS325001 (Bovenschelde)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	F06BOS325001
subcatchment_area [m²]	5217586196
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.12), ('bevaporation', 2.0), ('cmin', 8.5), ('cmax', 439.0), ('CKBF', 300.0), ('CK1', 42.0), ('CK2', 29.0), ('bdrainage', 1.0), ('kdrainage', 17574.0), ('PDM.TG', 0.4), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2002 - 2013)

	Full year	Summer	Winter
NS	0.585	0.359	0.404
NS_log	0.672	0.26	0.68
NS_rel	0.731	0.302	0.744
RelErr	-4.8 %	-4.2 %	-4.9 %
VolBias	0.003	0.056	-0.042

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.583	0.409	0.389
NS_log	0.677	0.293	0.681
NS_rel	0.731	0.371	0.739
RelErr	-6.0 %	-5.2 %	-4.5 %
VolBias	-0.005	0.048	-0.039

Observed and simulated timeseries for optimum parameters

Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment F06BOS325001, station unkown (calibration period)

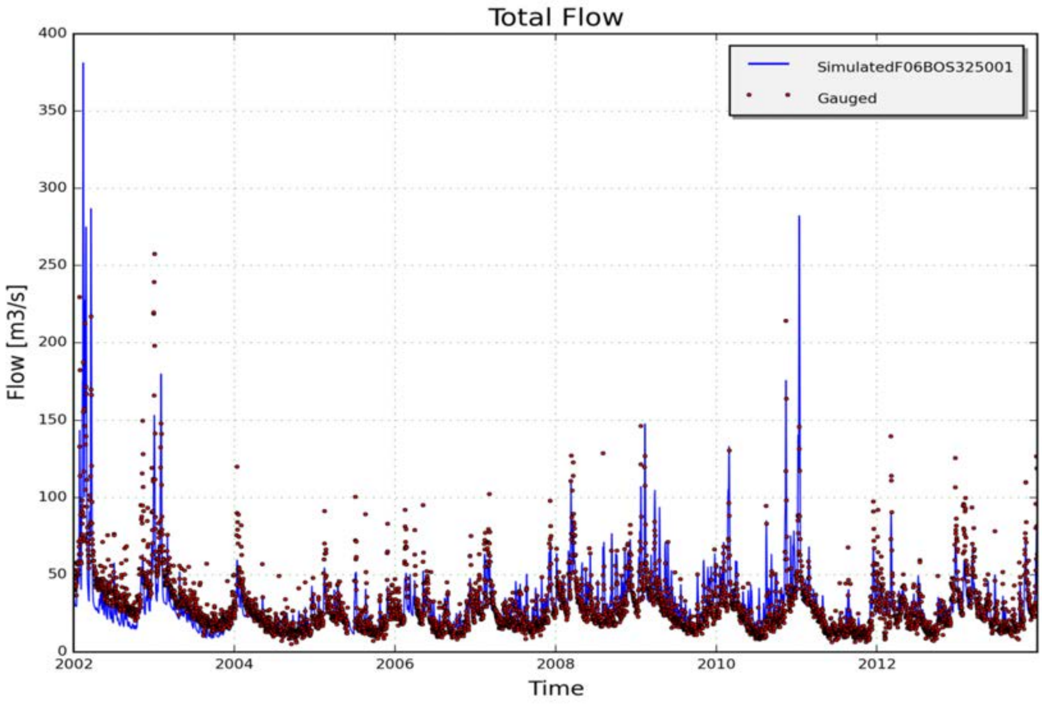


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment F06BOS325001, station unkown (calibration period)

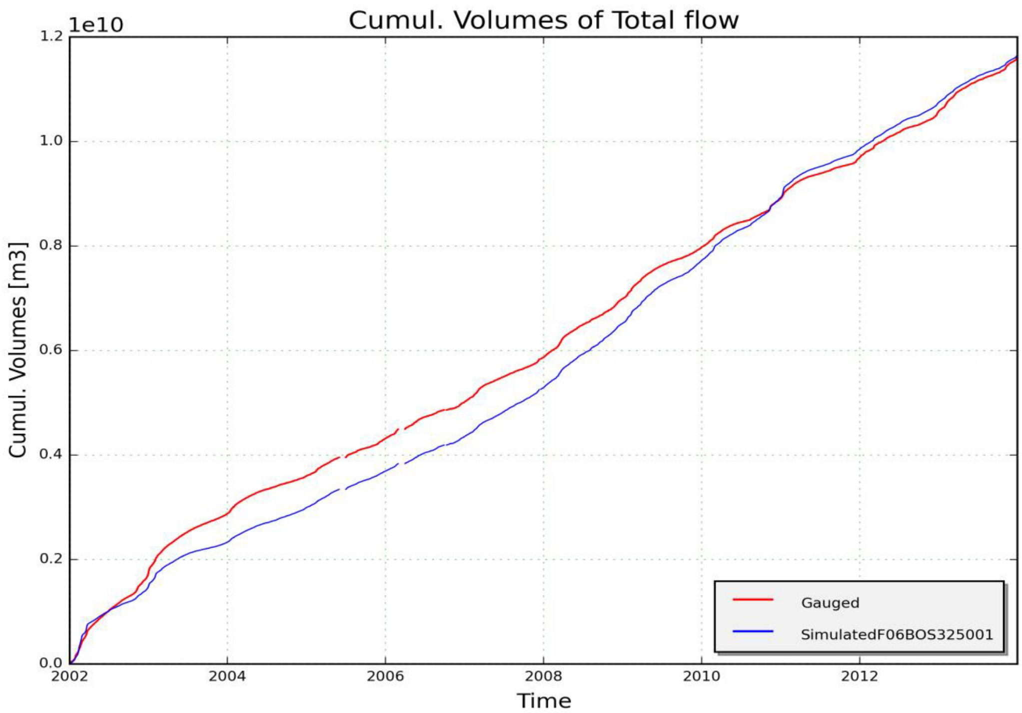


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment F06BOS325001, station unkown (validation period)

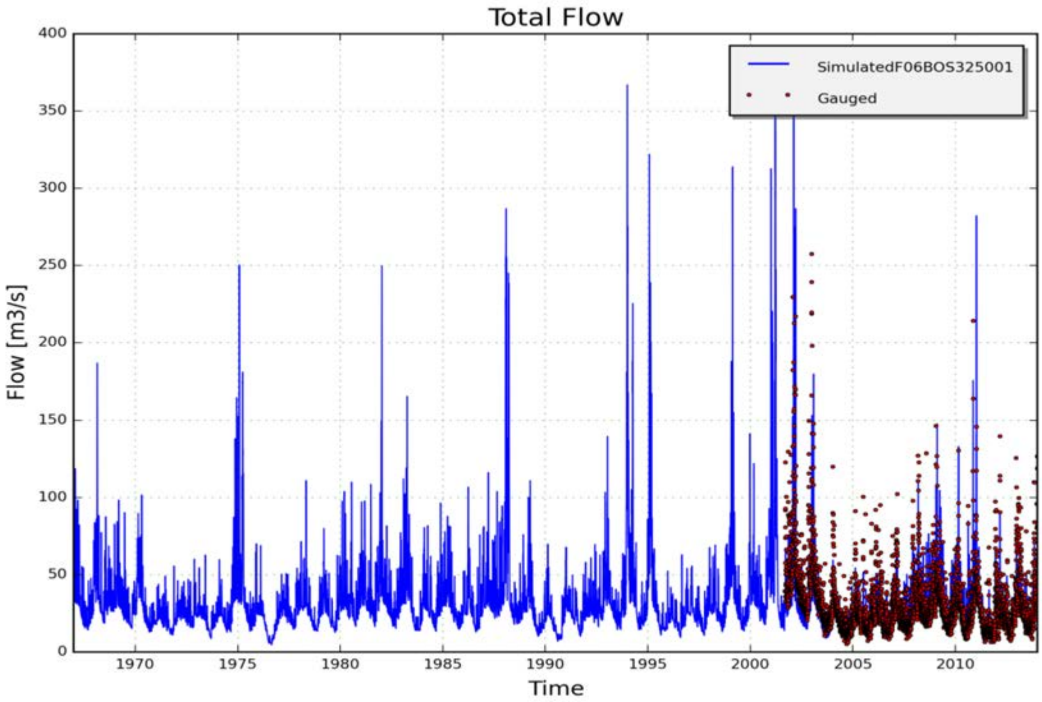


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment F06BOS325001, station unkown (validation period)

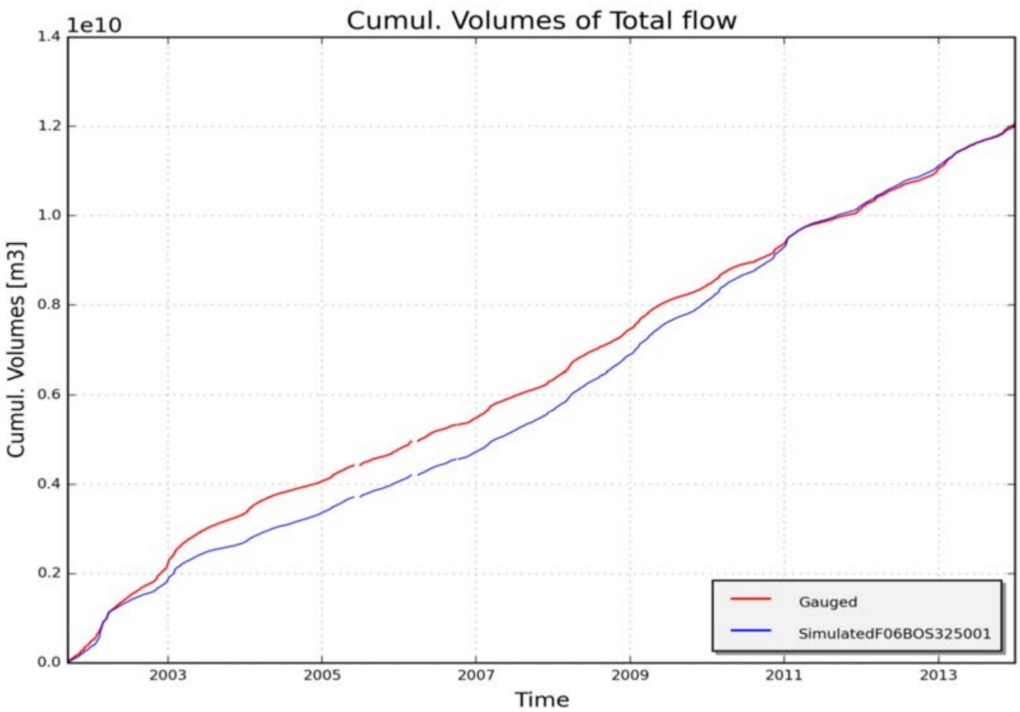
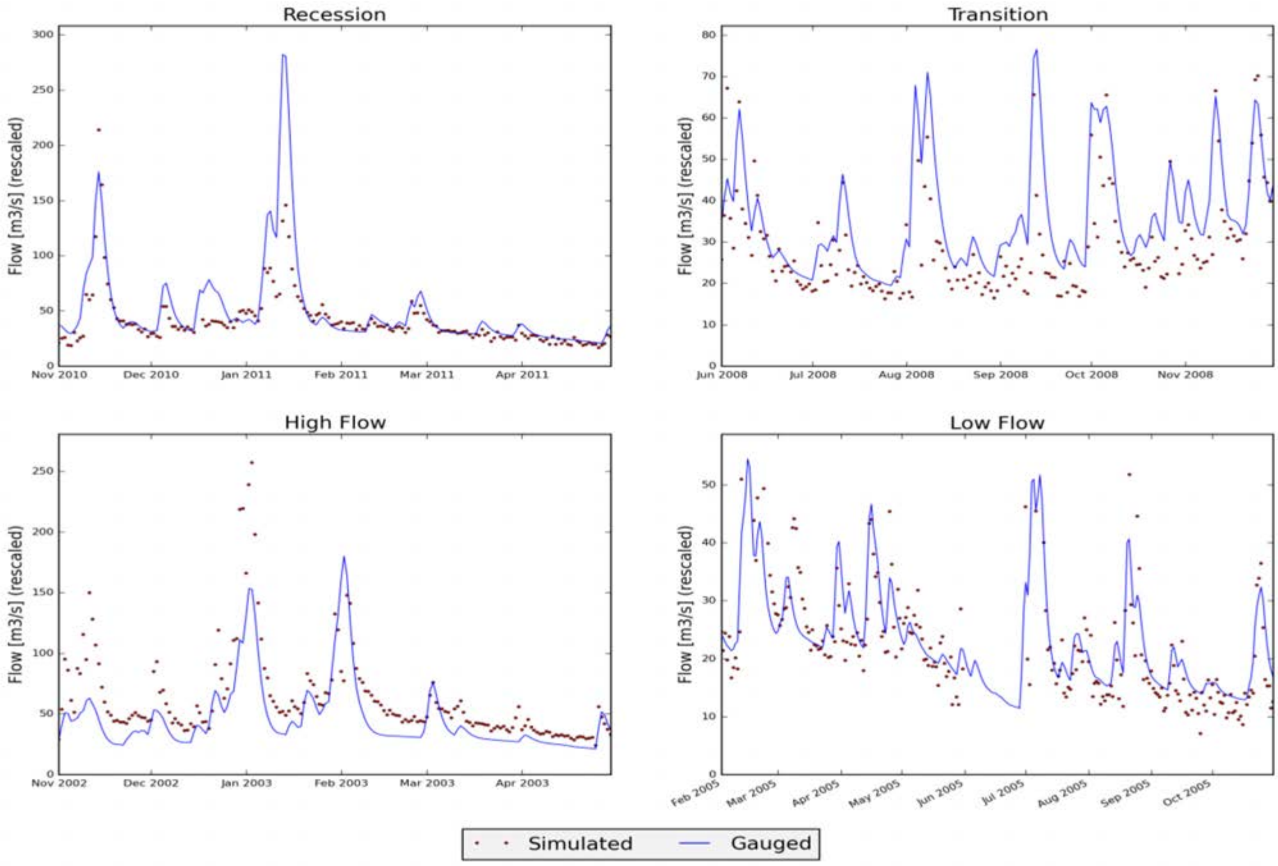


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment F06BOS325001, station unkown



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V06MAA347160 " (BOVENSCHELDE)

Input data

Figure 1: Cumulative precipitation on catchment V06MAA347160 (Bovenschelde)

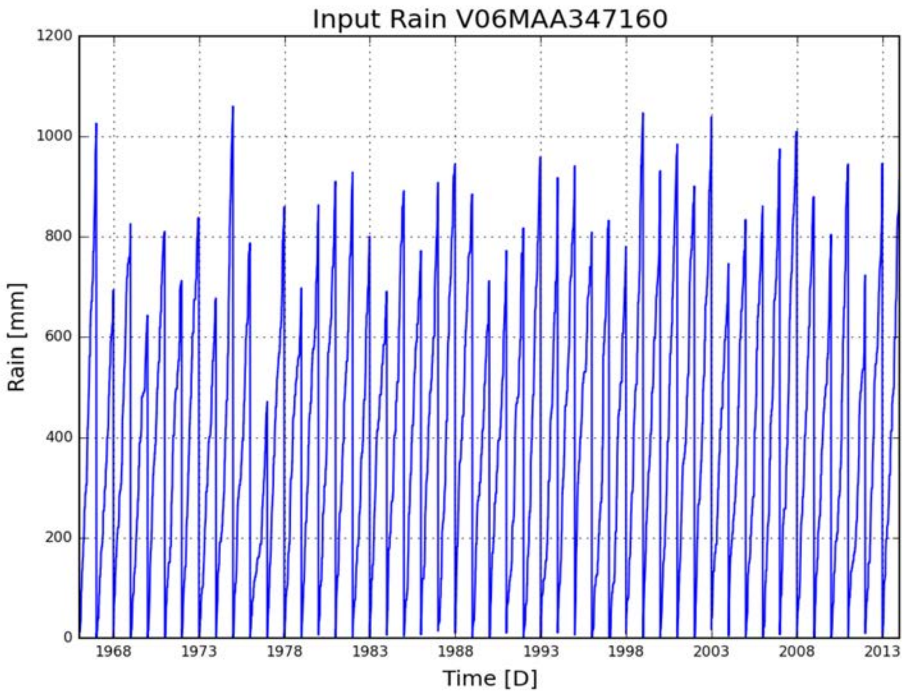
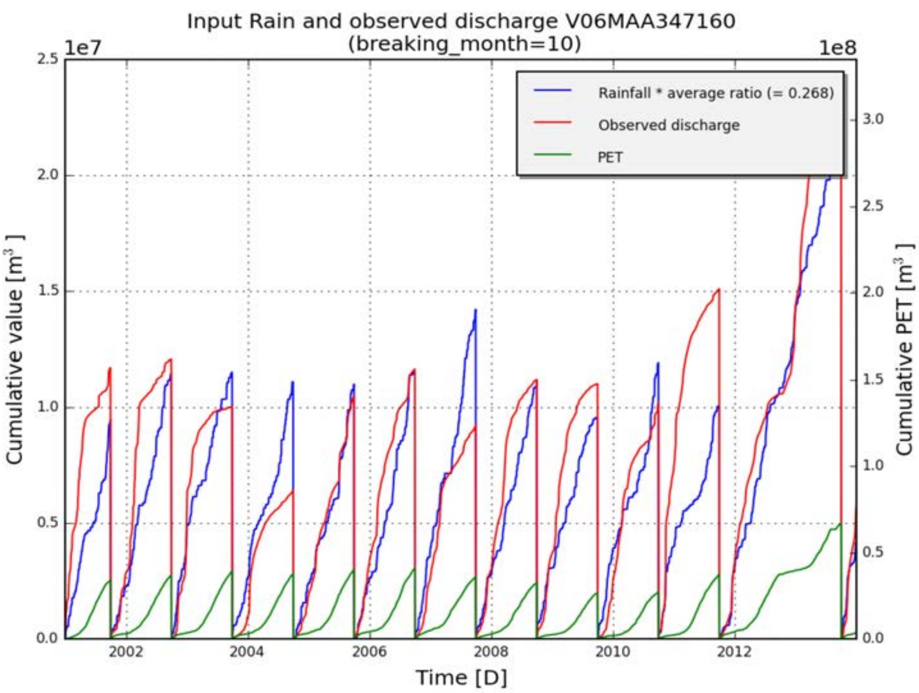


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V06MAA347160 (Bovenschelde)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V06MAA347160
subcatchment_area [m²]	48678191
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.05), ('bevaporation', 2.0), ('cmin', 8.3), ('cmax', 325.0), ('CKBF', 300.0), ('CK1', 14.0), ('CK2', 33.0), ('bdrainage', 1.0), ('kdrainage', 24980.0), ('PDM.TG', 5.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.408	0.166	0.294
NS_log	0.611	0.299	0.362
NS_rel	0.16	-0.352	0.569
RelErr	0.7 %	-20.0 %	11.5 %
VolBias	-0.011	-0.166	0.108

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.433	0.227	0.347
NS_log	0.581	0.371	0.224
NS_rel	0.531	0.225	0.54
RelErr	-19.6 %	-28.1 %	-10.1 %
VolBias	-0.175	-0.286	-0.065

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)

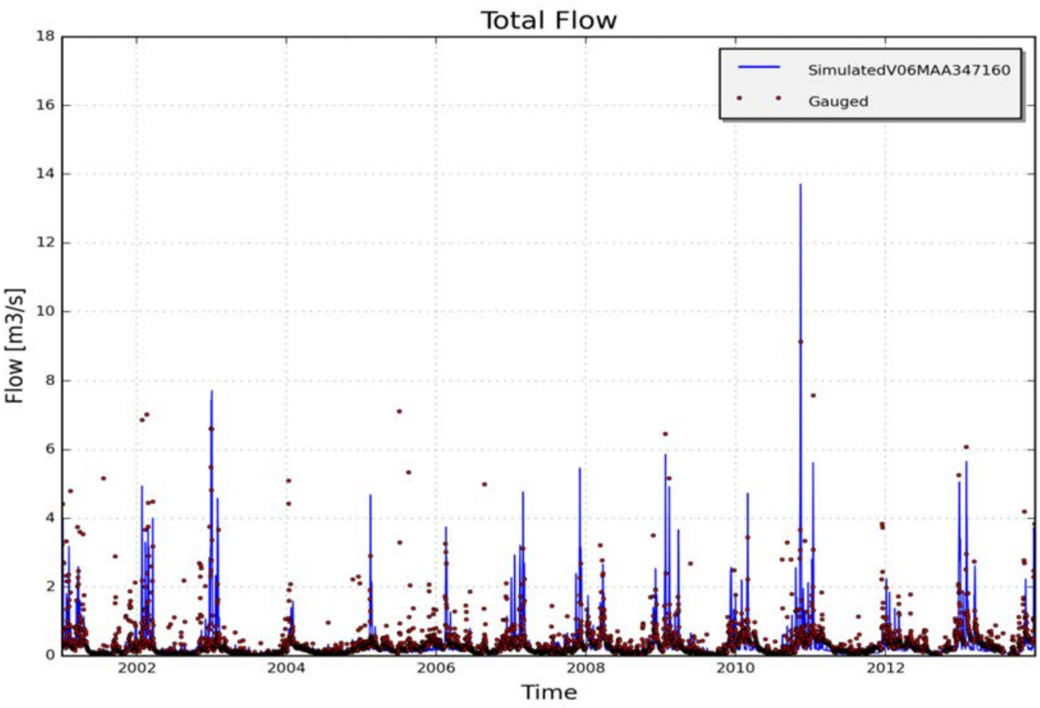


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove (calibration period)

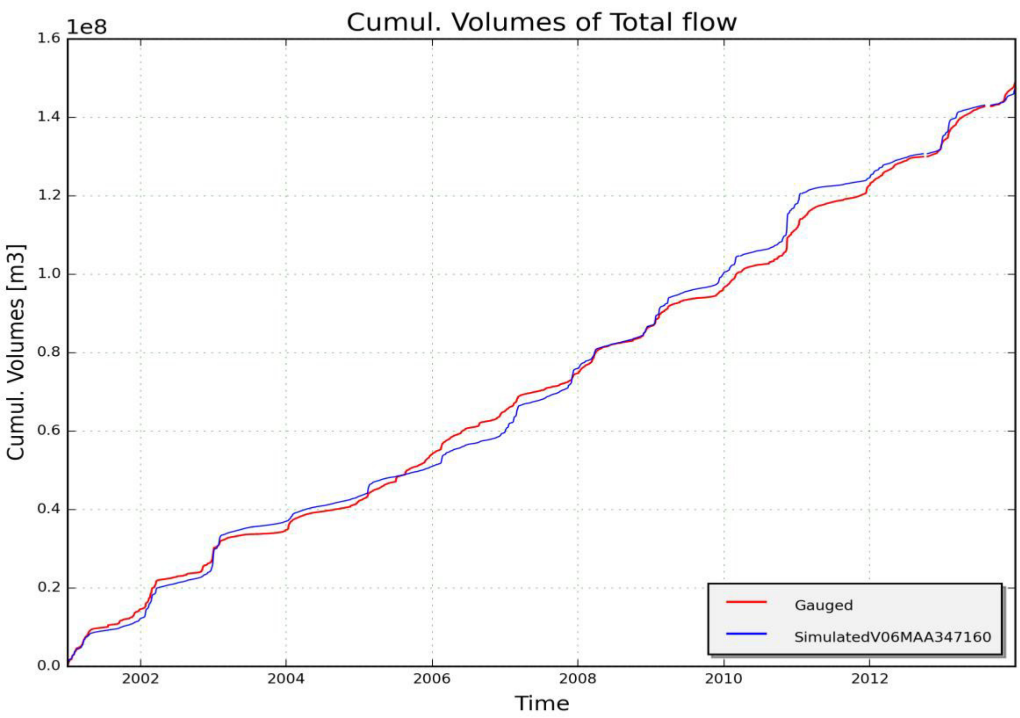


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove (validation period)

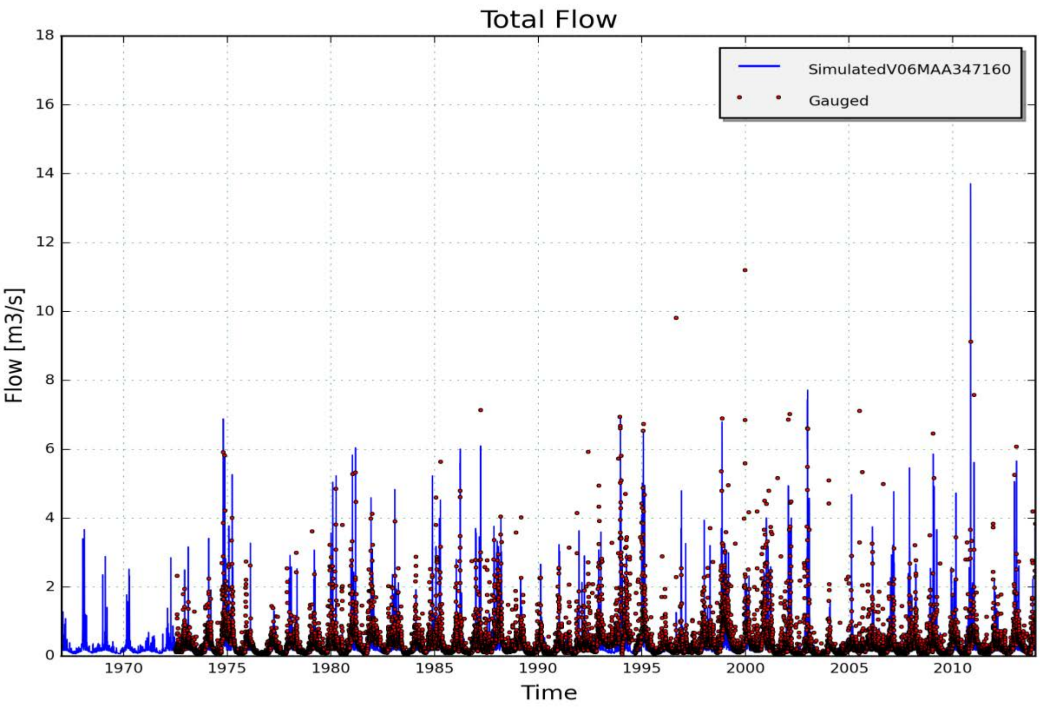


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove (validation period)

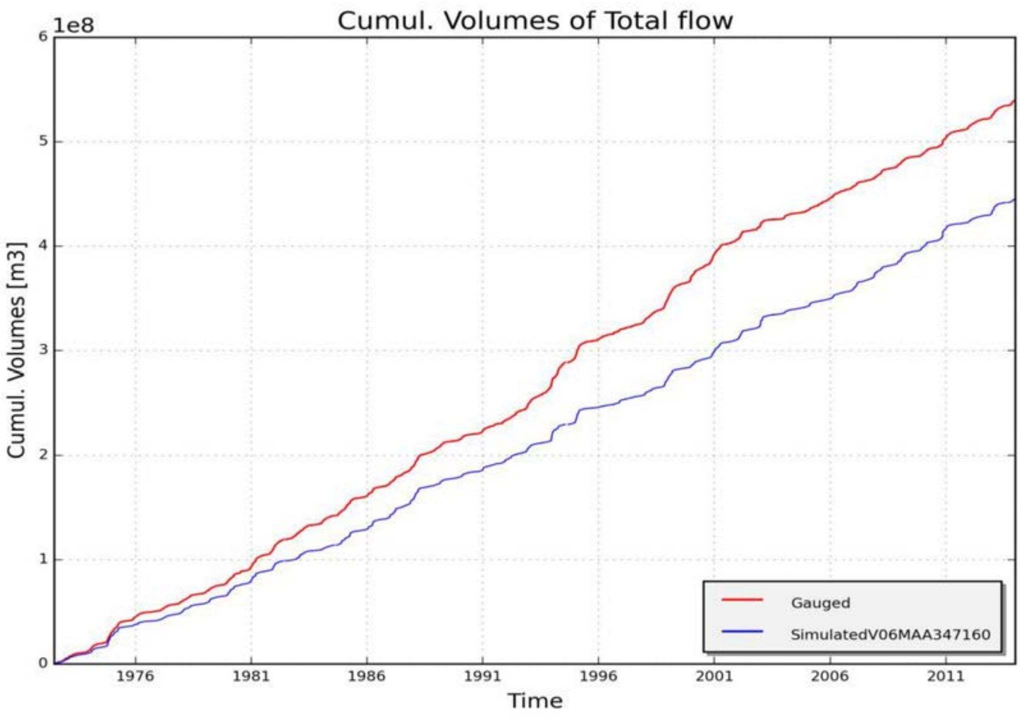
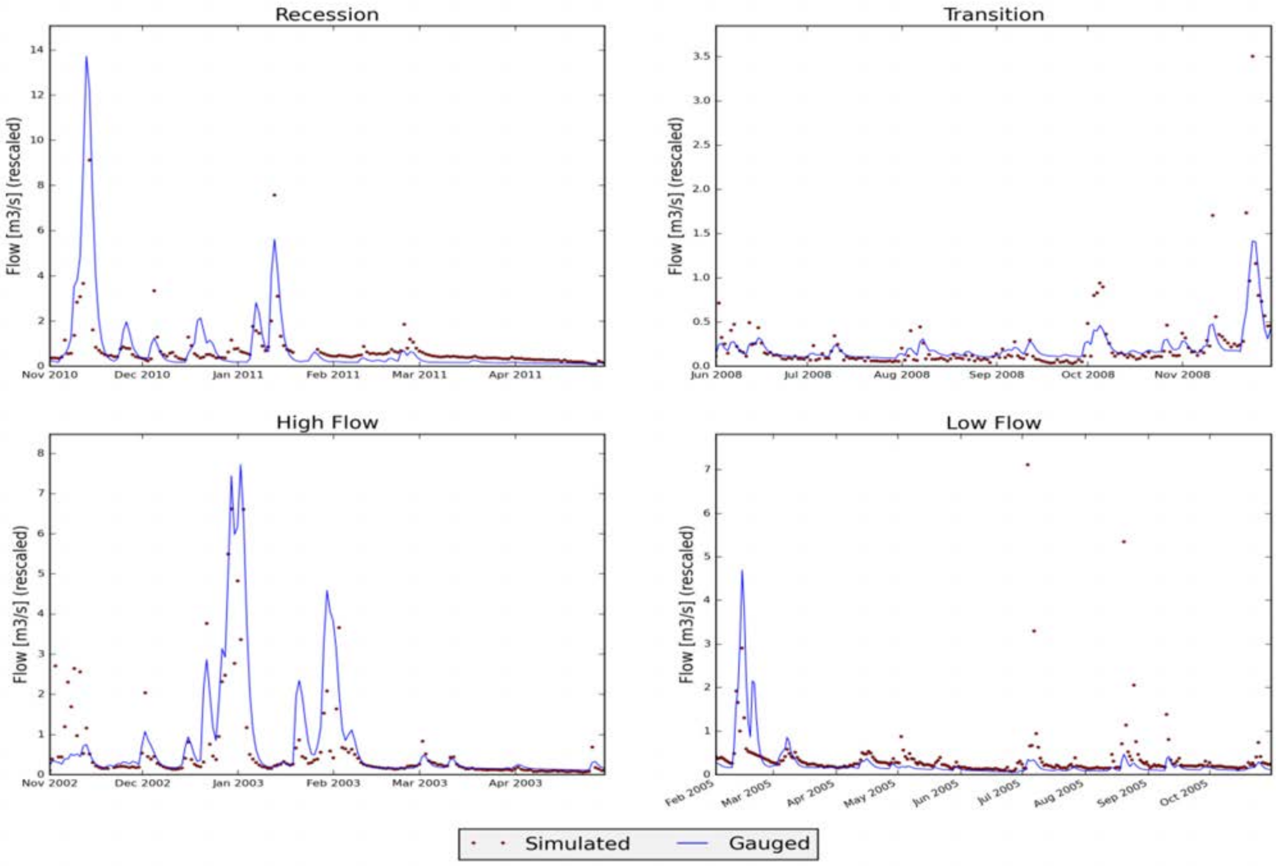


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V06ZWA342190" (BOVENSCHELDE)

Input data

Figure 1: Cumulative precipitation on catchment V06ZWA342190 (Bovenschelde)

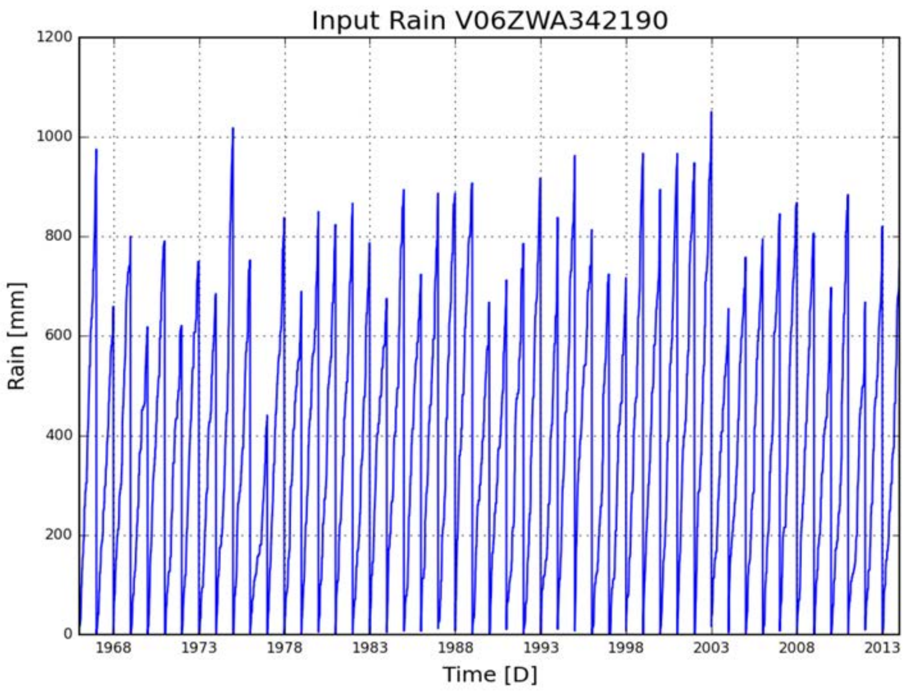
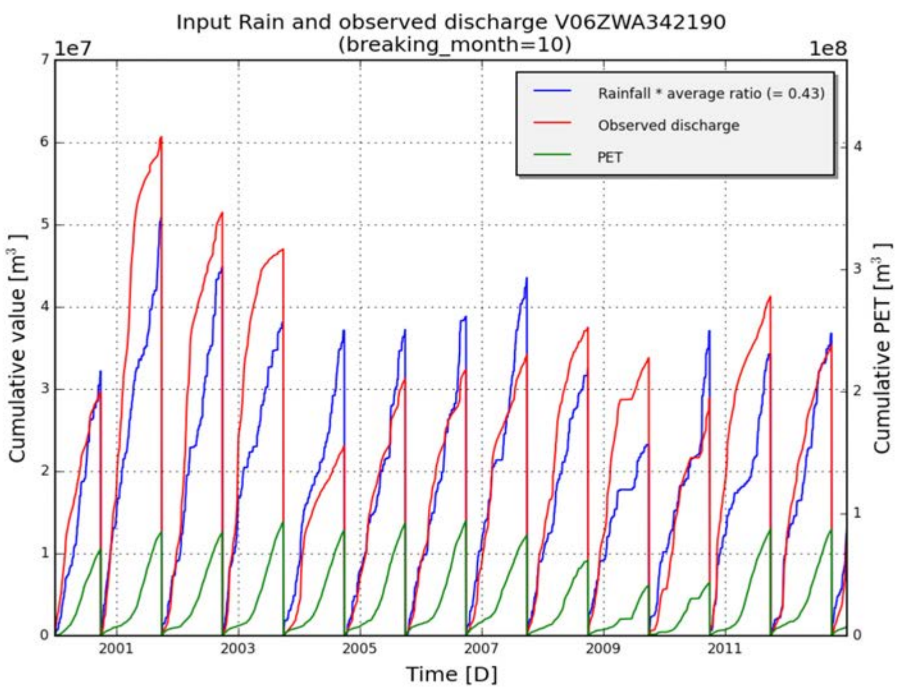


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V06ZWA342190 (Bovenschelde)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V06ZWA342190
subcatchment_area [m²]	112117540
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.4), ('bevaporation', 2.0), ('cmin', 9.0), ('cmax', 365.0), ('CKBF', 300.0), ('CK1', 34.0), ('CK2', 19.0), ('bdrainage', 1.0), ('kdrainage', 9327.0), ('PDM.TG', 6.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2000 - 2012)

	Full year	**Summer**	**Winter**
NS	0.694	0.454	0.647
NS_log	0.708	0.349	0.747
NS_rel	0.696	0.569	0.887
RelErr	-3.3 %	26.4 %	-14.9 %
VolBias	-0.029	0.245	-0.157

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	**Summer**	**Winter**
NS	0.654	0.337	0.659
NS_log	0.558	0.182	0.722
NS_rel	-34.446	-6.346	0.808
RelErr	12.2 %	36.9 %	-2.0 %
VolBias	0.06	0.305	-0.071

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)

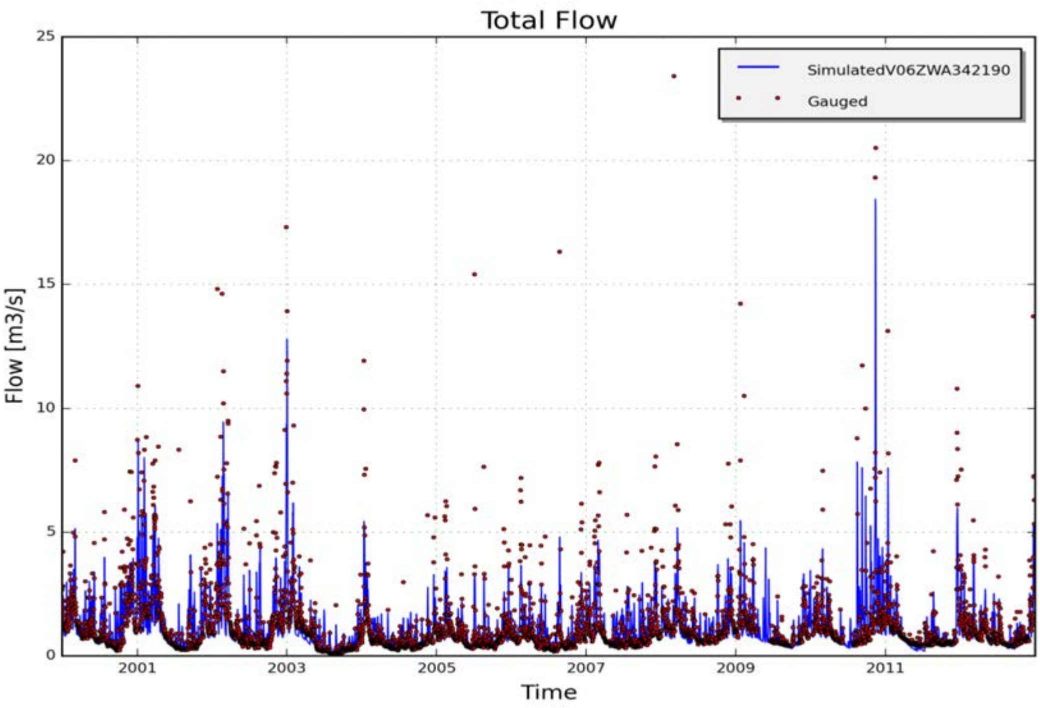


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (calibration period)

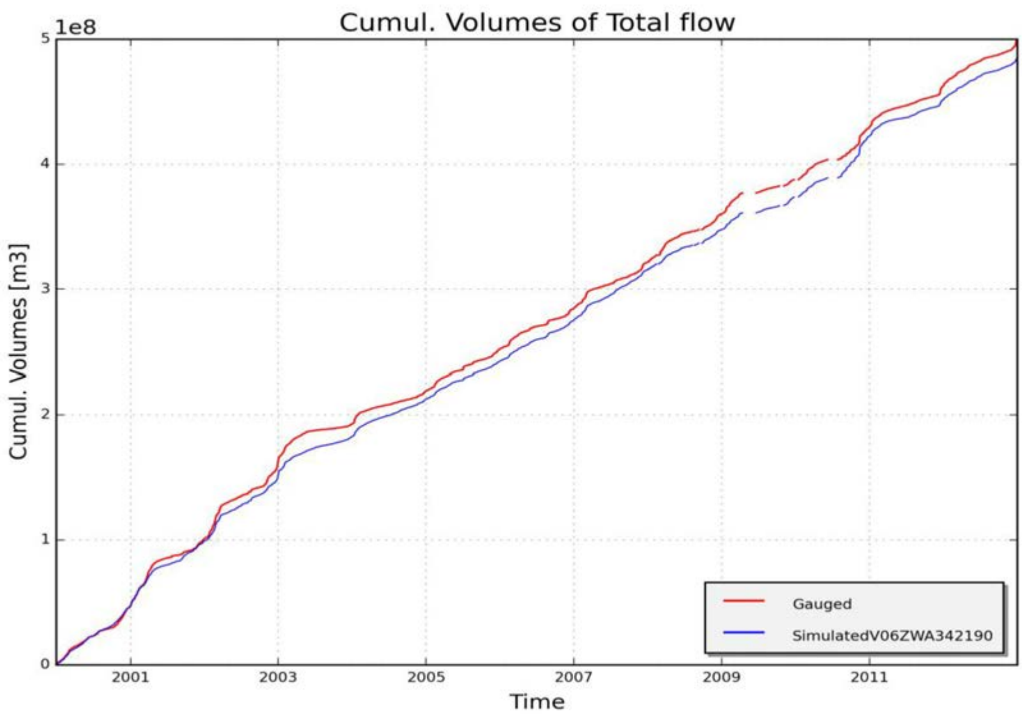


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (validation period)

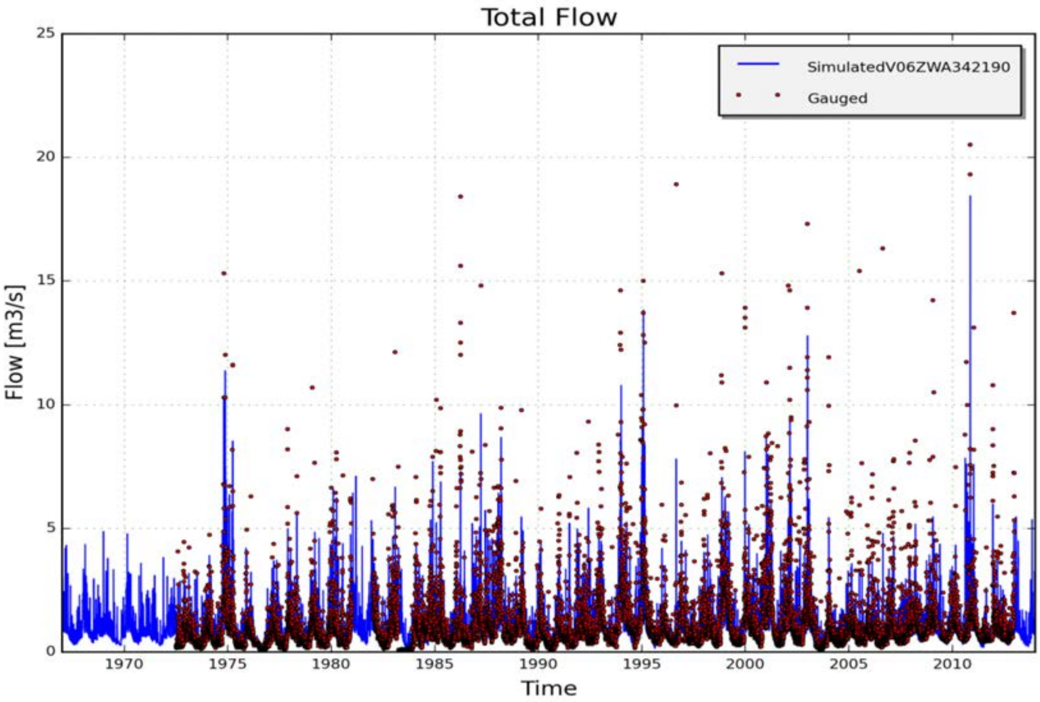


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (validation period)

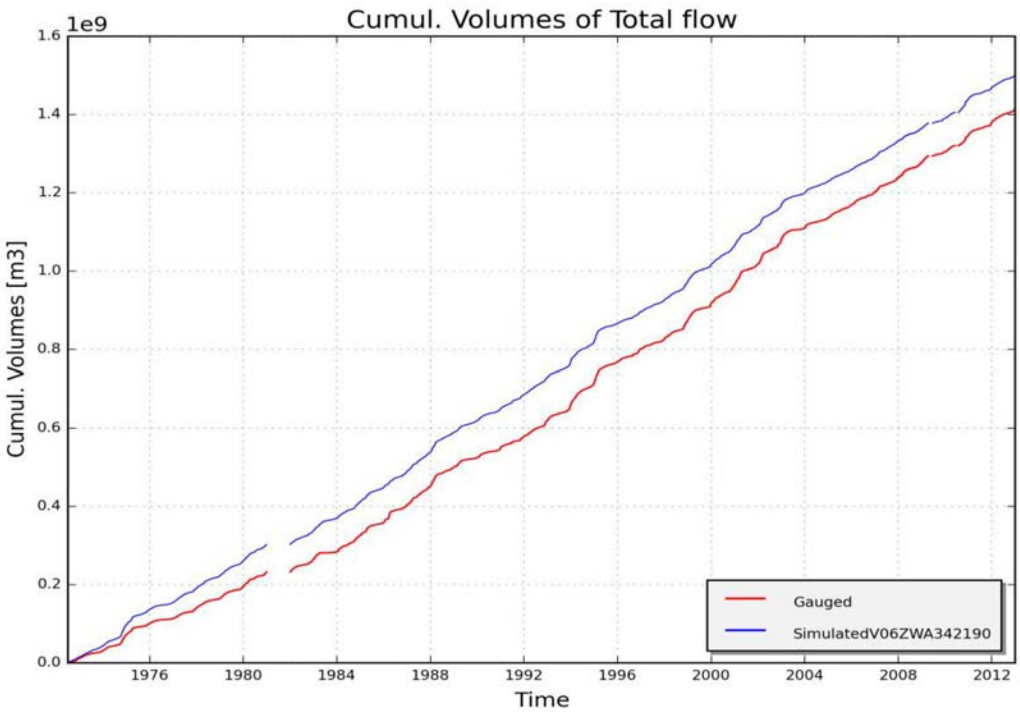
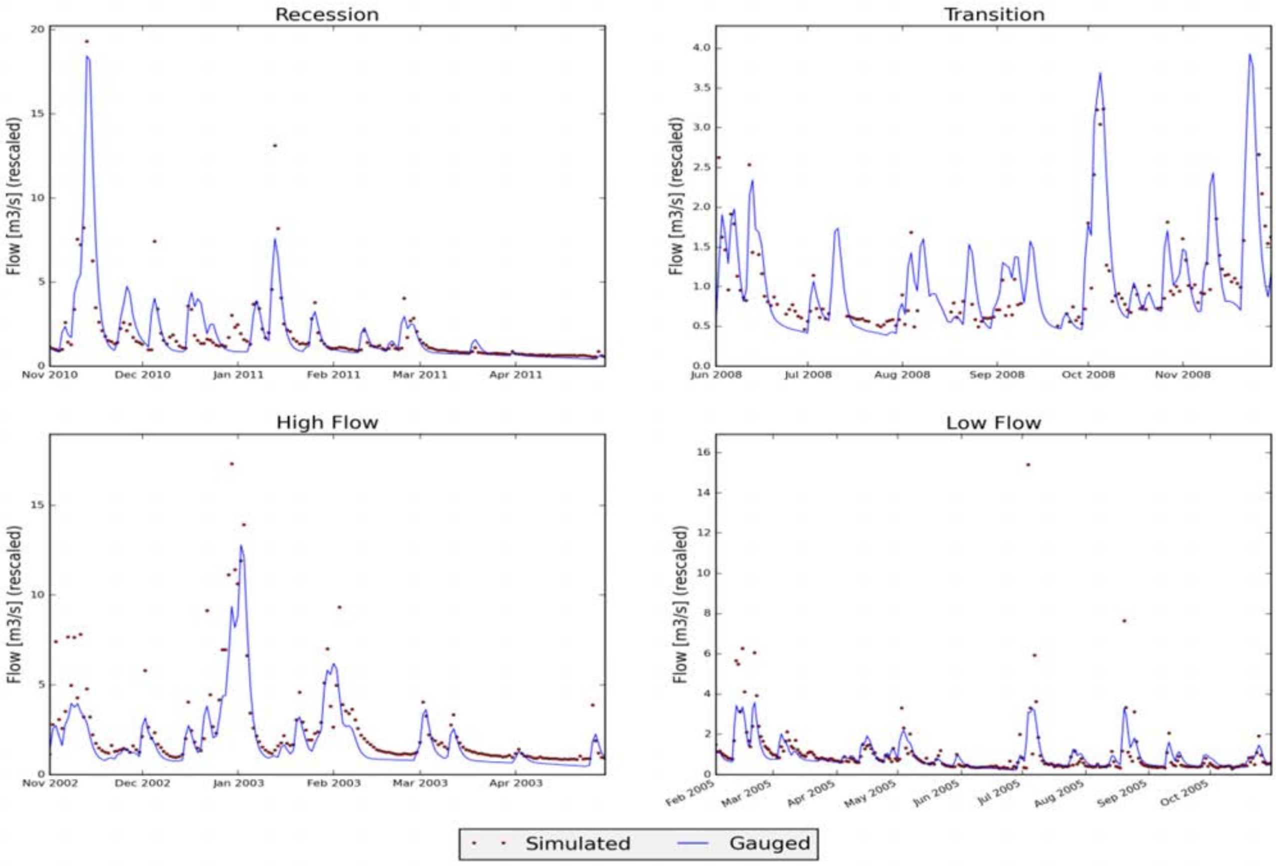


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "W06RHOL54100" (BOVENSCHELDE)

Input data

Figure 1: Cumulative precipitation on catchment W06RHOL54100 (Bovenschelde)

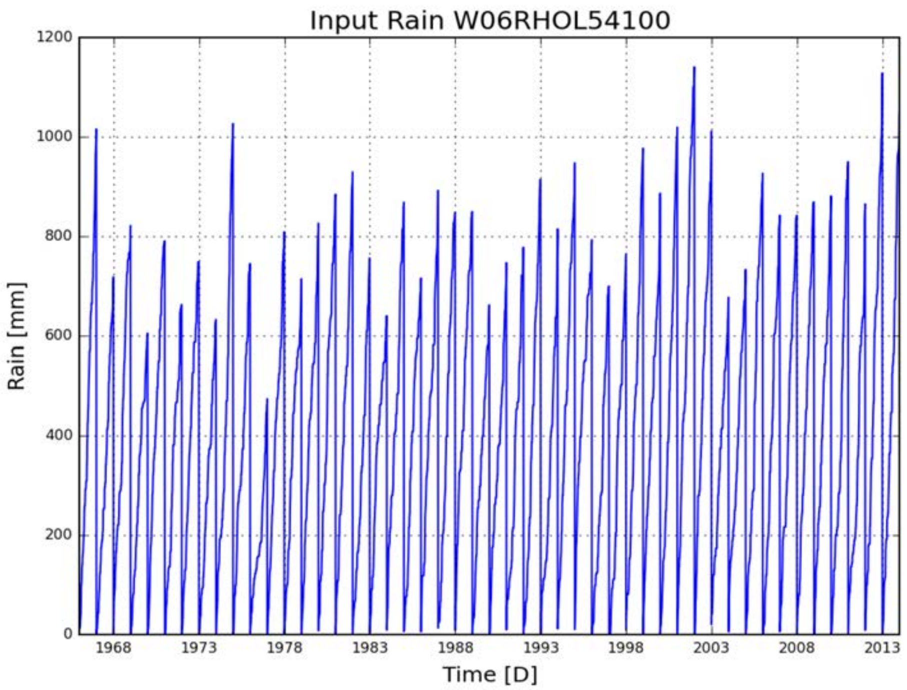
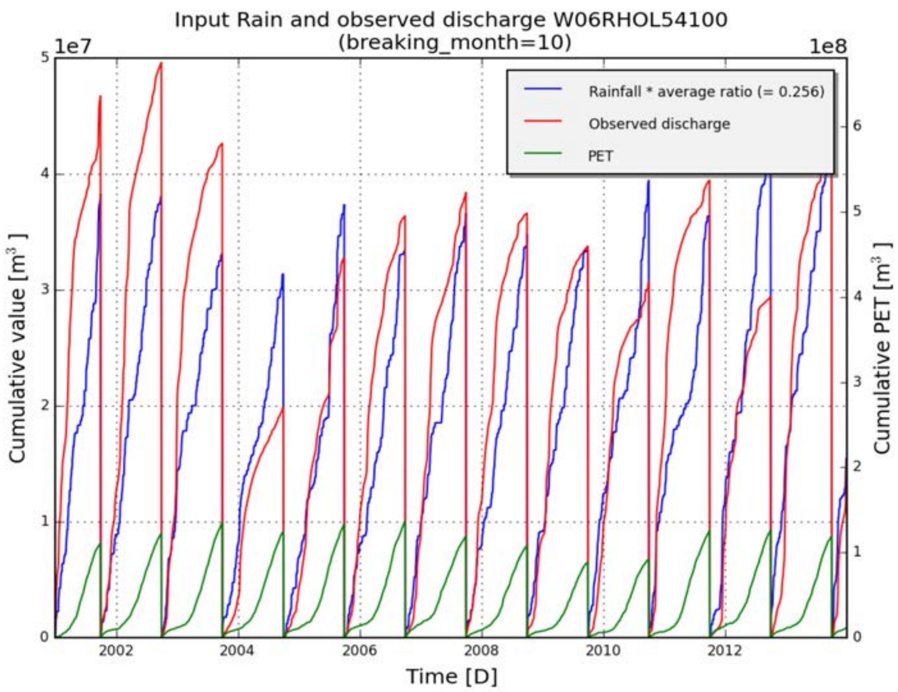


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W06RHOL54100 (Bovenschelde)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	W06RHOL54100
subcatchment_area [m²]	161928446
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.1), ('bevaporation', 2.0), ('cmin', 8.3), ('cmax', 410.0), ('CKBF', 300.0), ('CK1', 35.0), ('CK2', 25.0), ('bdrainage', 1.1), ('kdrainage', 52000.0), ('PDM.TG', 5.1), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.445	0.4	0.453
NS_log	0.604	0.181	0.462
NS_rel	0.387	0.246	0.598
RelErr	0.9 %	-8.2 %	0.5 %
VolBias	0.128	0.104	0.063

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.439	0.408	0.448
NS_log	0.612	0.227	0.454
NS_rel	0.388	0.235	0.597
RelErr	2.7 %	-7.5 %	2.4 %
VolBias	0.129	0.091	0.07

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)

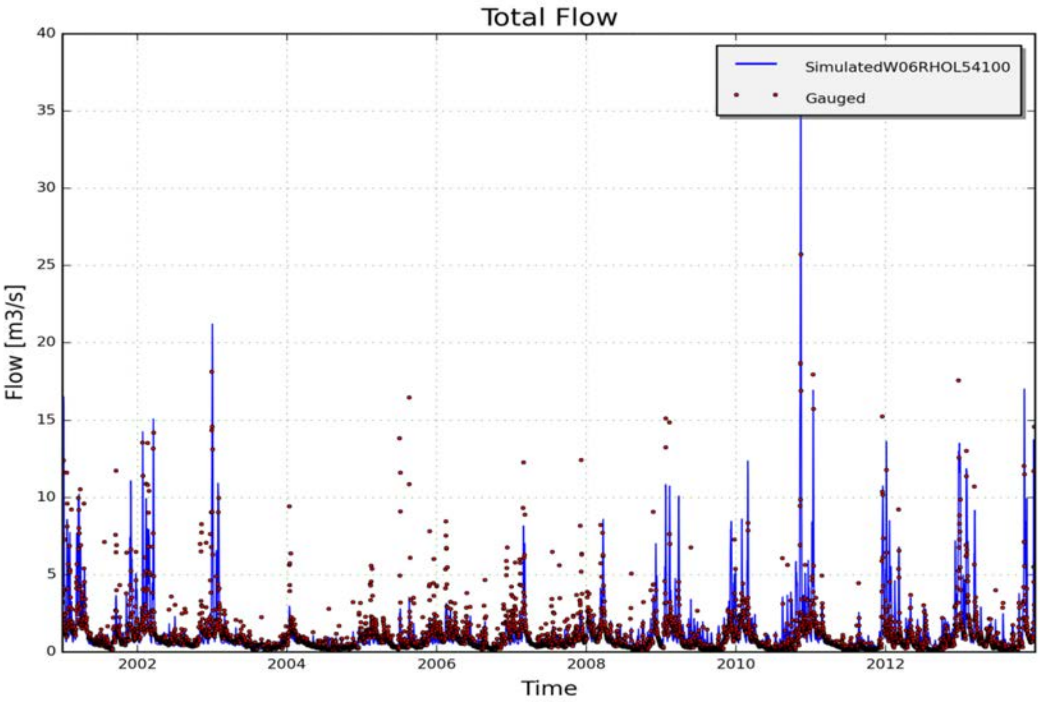


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W06RHOL54100, station L5412 Amougies - Rhosnes (calibration period)

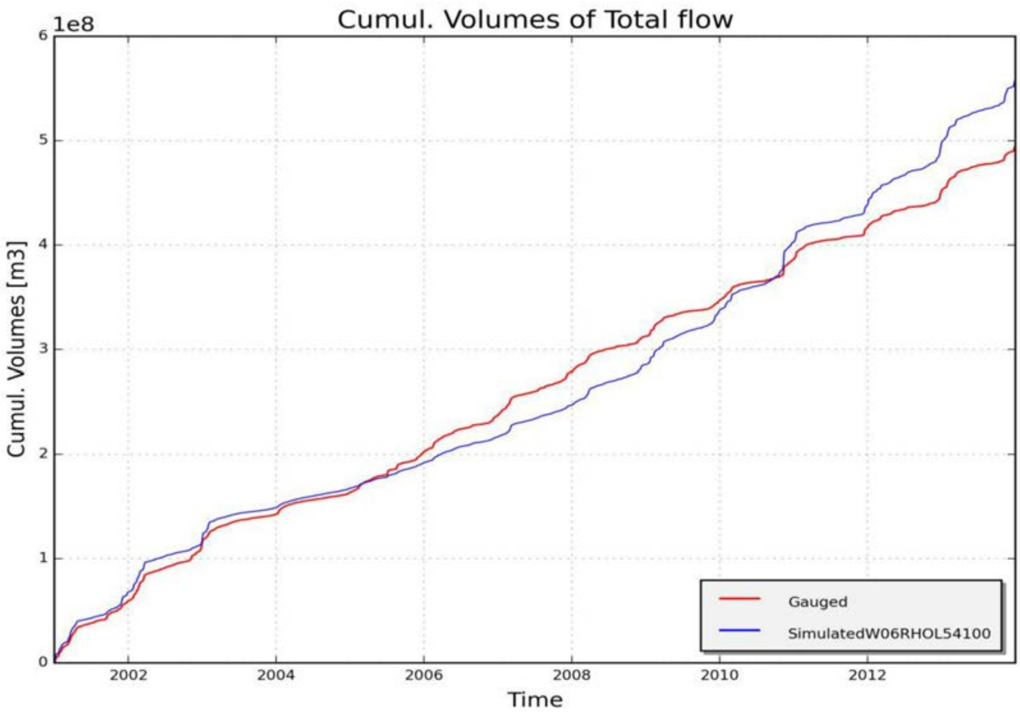


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W06RHOL54100, station L5412 Amougies - Rhosnes (validation period)

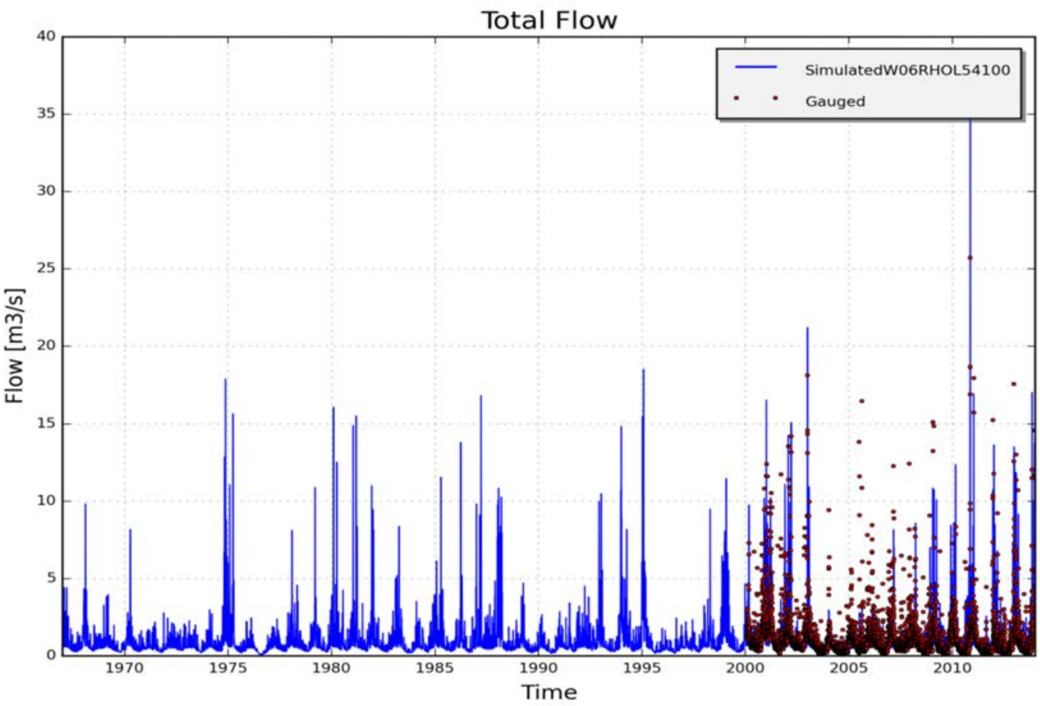


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W06RHOL54100, station L5412 Amougies - Rhosnes (validation period)

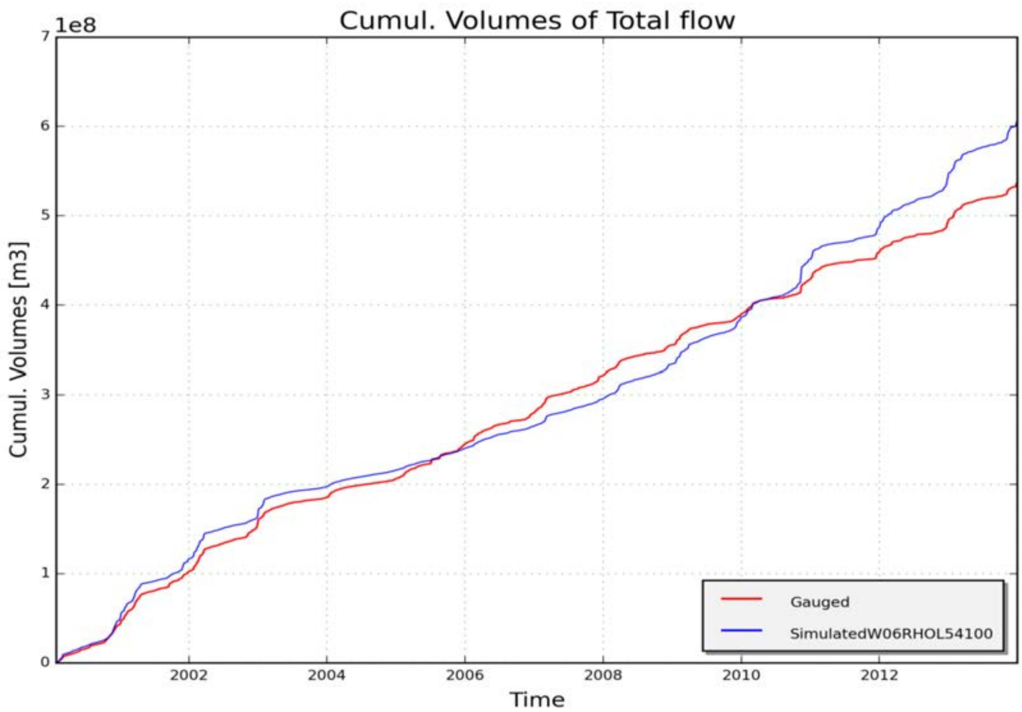
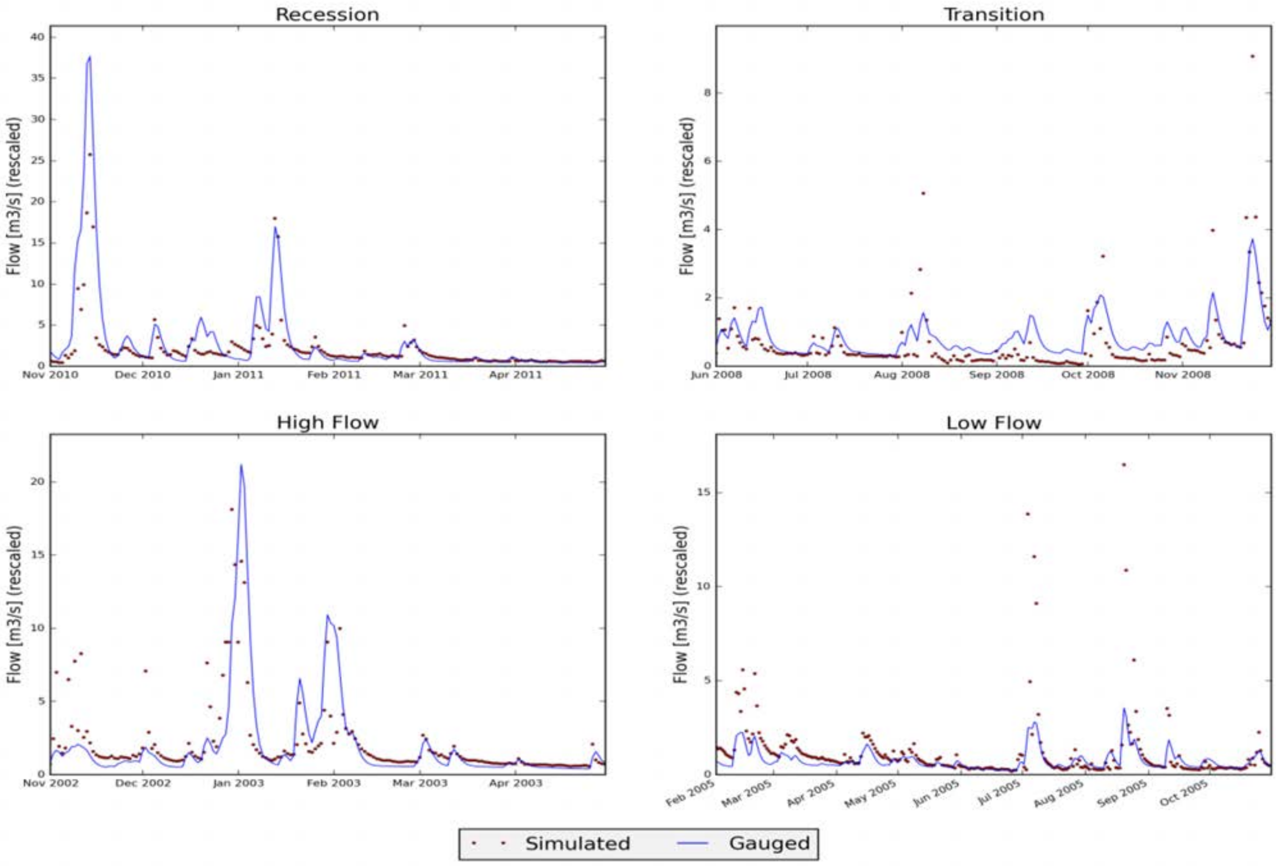


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W06RHOL54100, station L5412 Amougies - Rhosnes



Annexe 9 Dender

CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V07BEL285070" (DENDERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V07BEL285070 (Denderbekken)

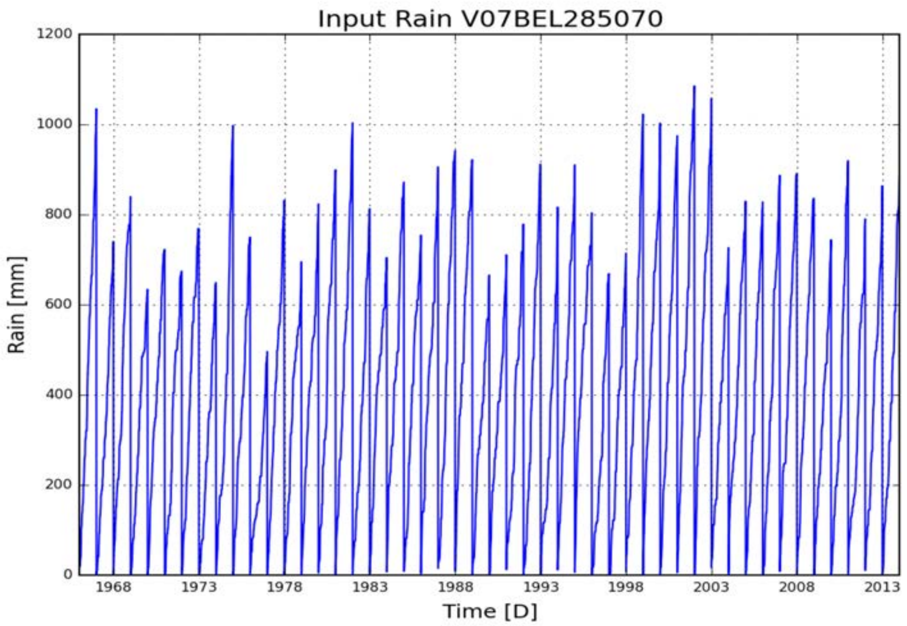
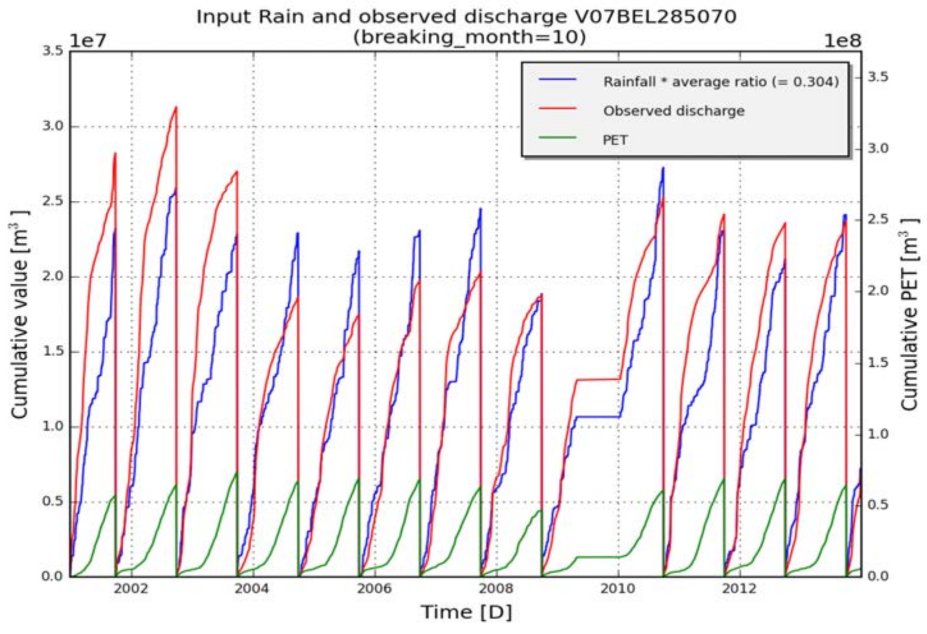


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V07BEL285070 (Denderbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V07BEL285070
subcatchment_area [m²]	88641710
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.12), ('bevaporation', 2.0), ('cmin', 6.6), ('cmax', 441.0), ('CKBF', 300.0), ('CK1', 39.0), ('CK2', 15.0), ('bdrainage', 1.0), ('kdrainage', 22169.0), ('PDM.TG', 3.9), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	**Summer**	**Winter**
NS	0.523	0.486	0.406
NS_log	0.728	0.504	0.572
NS_rel	0.757	0.686	0.694
RelErr	0.4 %	-1.4 %	4.0 %
VolBias	-0.007	0.023	0.001

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	**Summer**	**Winter**
NS	0.454	0.443	0.278
NS_log	0.644	0.359	0.54
NS_rel	-32.46	-10.038	0.522
RelErr	-7.7 %	2.1 %	-6.3 %
VolBias	-0.039	0.025	-0.011

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)

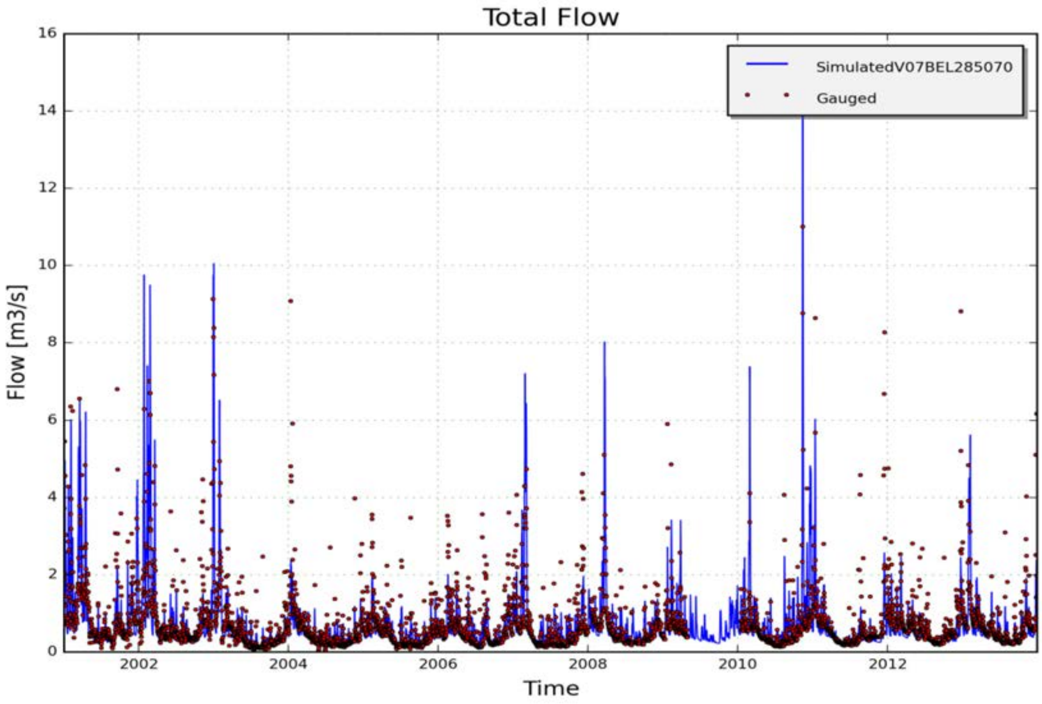


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V07BEL285070, station 28510102 - Bellebeek, Essene (calibration period)

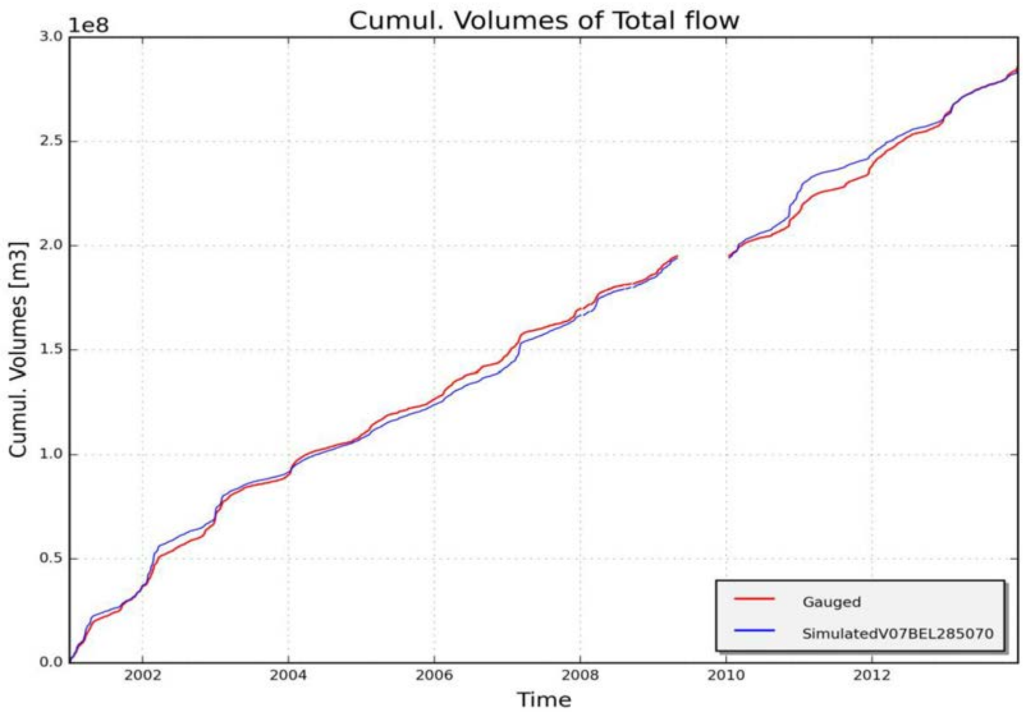


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V07BEL285070, station 28510102 - Bellebeek, Essene (validation period)

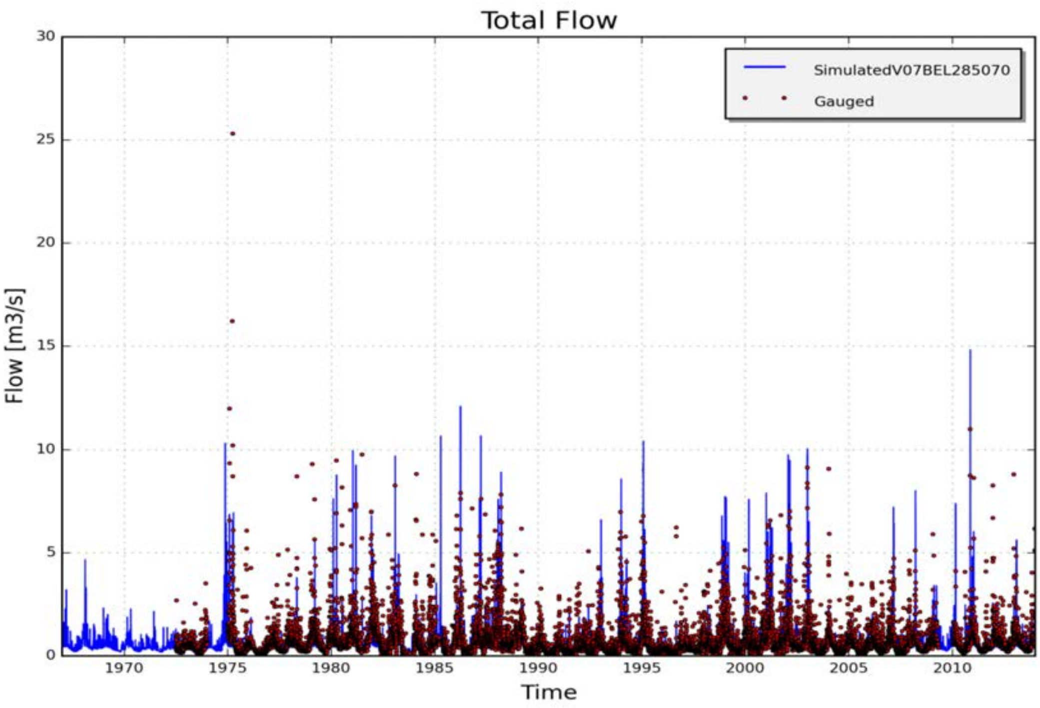


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V07BEL285070, station 28510102 - Bellebeek, Essene (validation period)

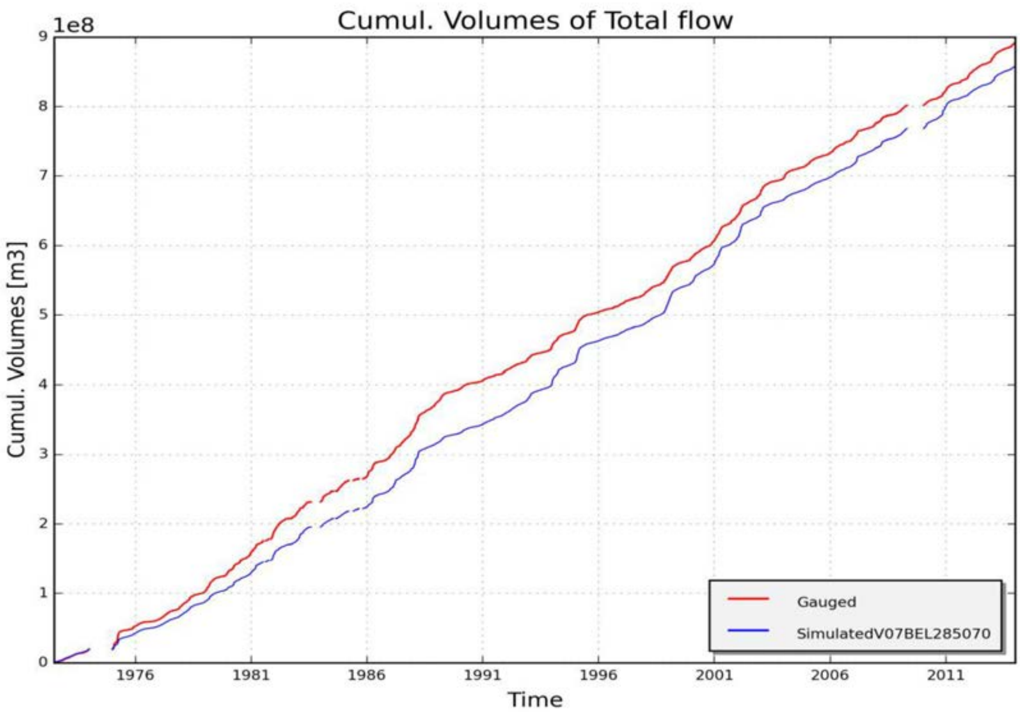
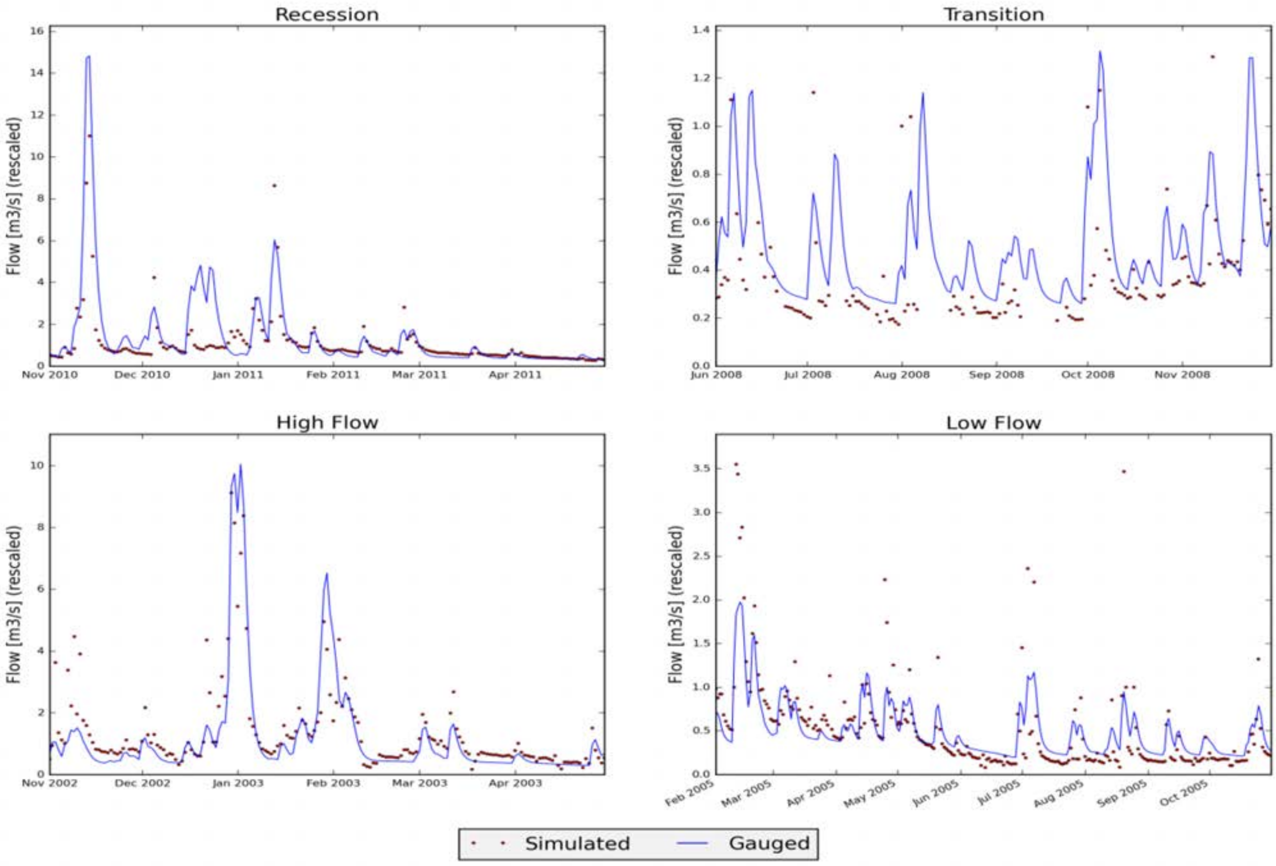


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V07BEL285070, station 28510102 - Bellebeek, Essene



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V07MAR289015" (DENDERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V07MAR289015 (Denderbekken)

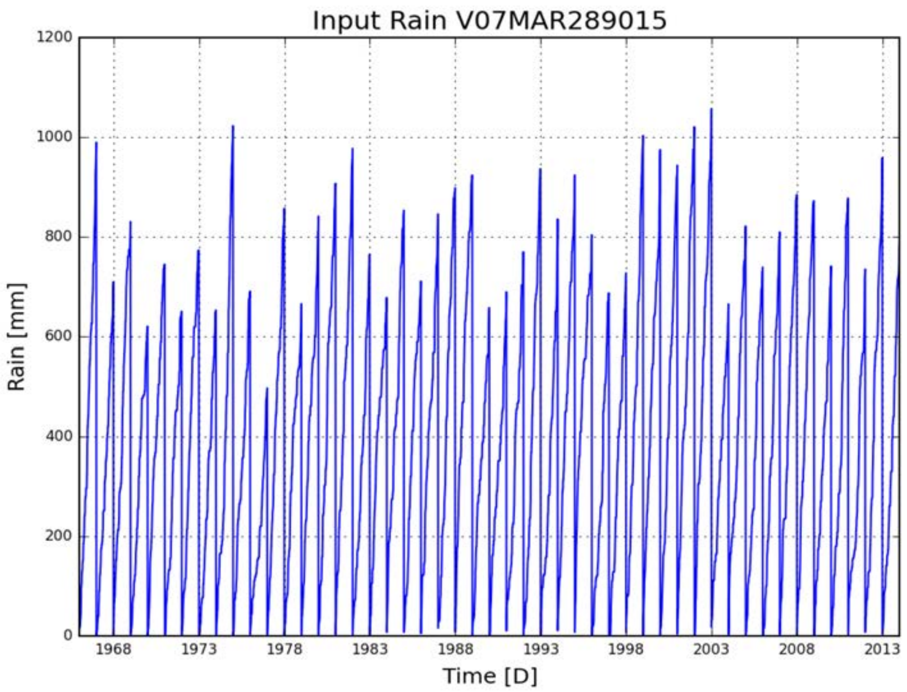
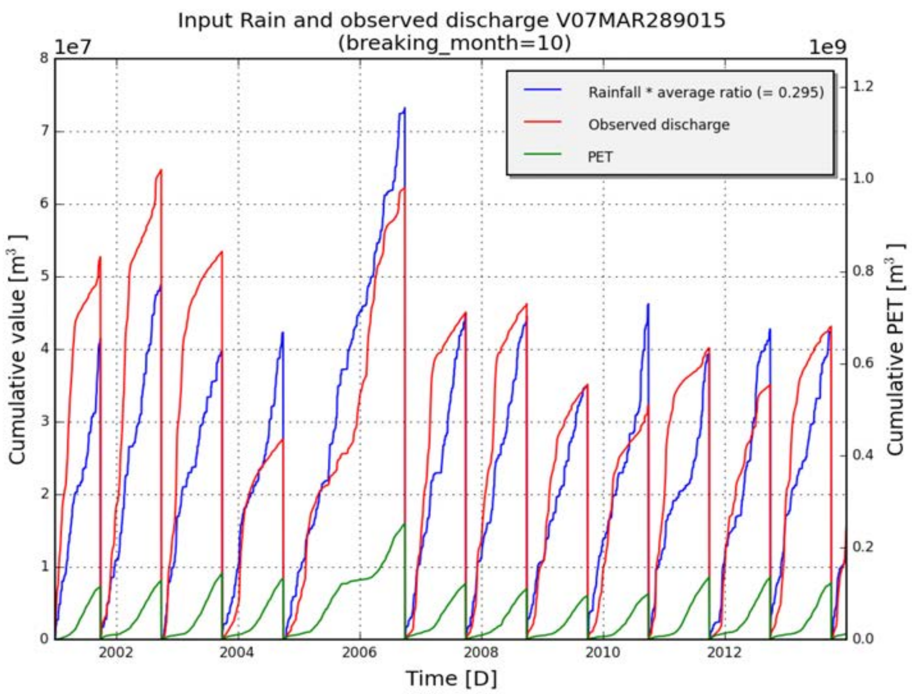


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V07MAR289015 (Denderbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V07MAR289015
subcatchment_area [m²]	173908791
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.13), ('bevaporation', 2.0), ('cmin', 9.7), ('cmax', 297.0), ('CKBF', 1.0), ('CK1', 8.3), ('CK2', 48.0), ('bdrainage', 1.0), ('kdrainage', 24055.0), ('PDM.TG', 3.8), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.585	0.257	0.563
NS_log	0.704	0.096	0.638
NS_rel	0.537	0.393	0.765
RelErr	-2.6 %	1.7 %	-2.3 %
VolBias	0.012	0.125	-0.016

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.635	0.486	0.556
NS_log	0.632	0.133	0.639
NS_rel	-8.612	-15.472	0.562
RelErr	2.4 %	11.3 %	1.4 %
VolBias	0.03	0.133	0.012

Observed and simulated timeseries for optimum parameters

Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V07MAR289015, tation 28970102 - Marke, Viane (calibration period)

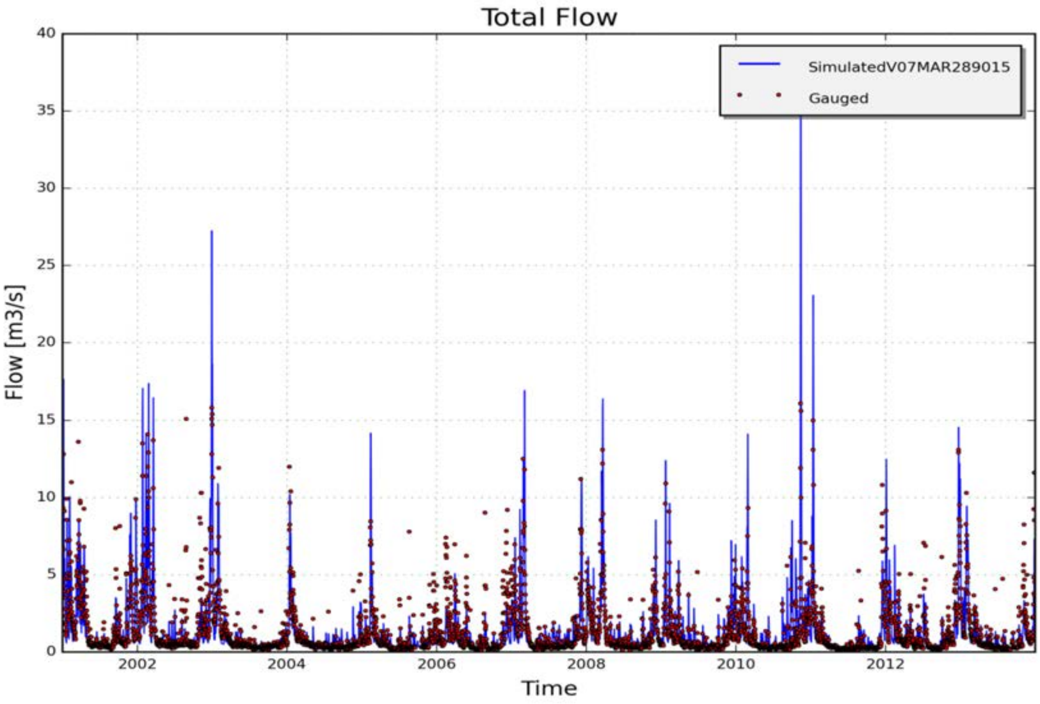


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V07MAR289015, tation 28970102 - Marke, Viane (calibration period)

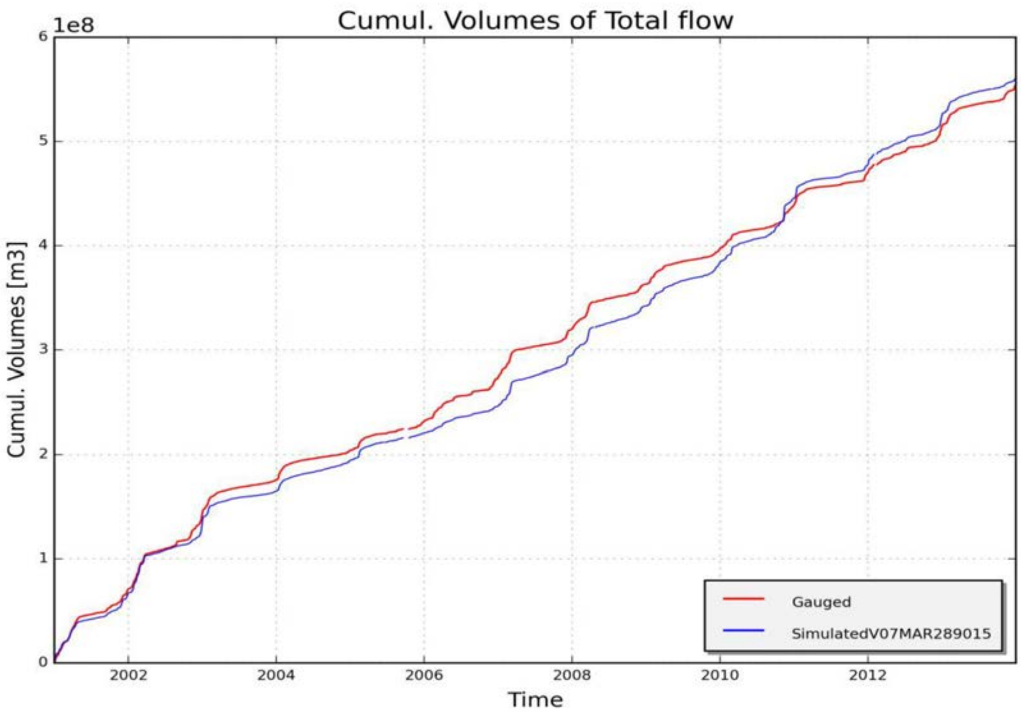


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V07MAR289015, tation 28970102 - Marke, Viane (validation period)

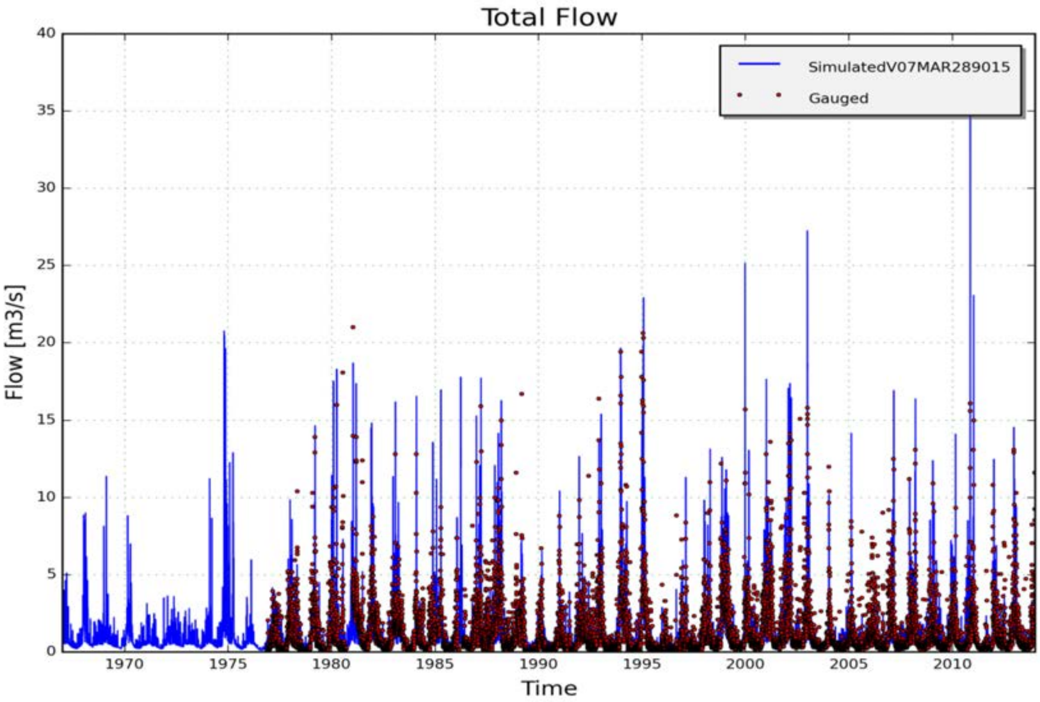


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V07MAR289015, tation 28970102 - Marke, Viane (validation period)

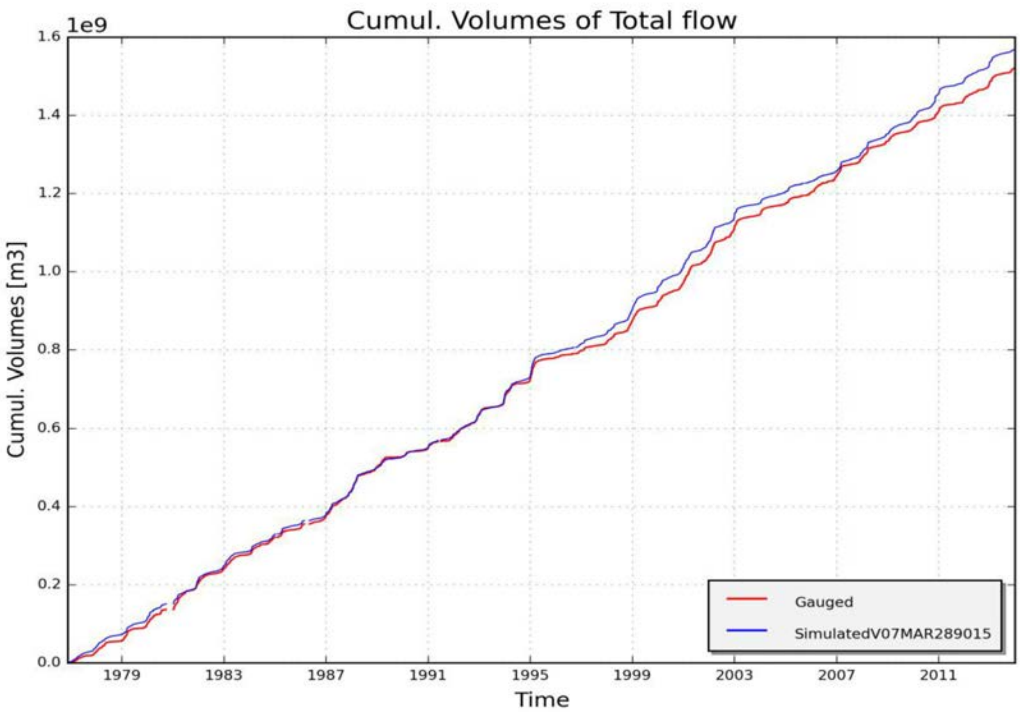
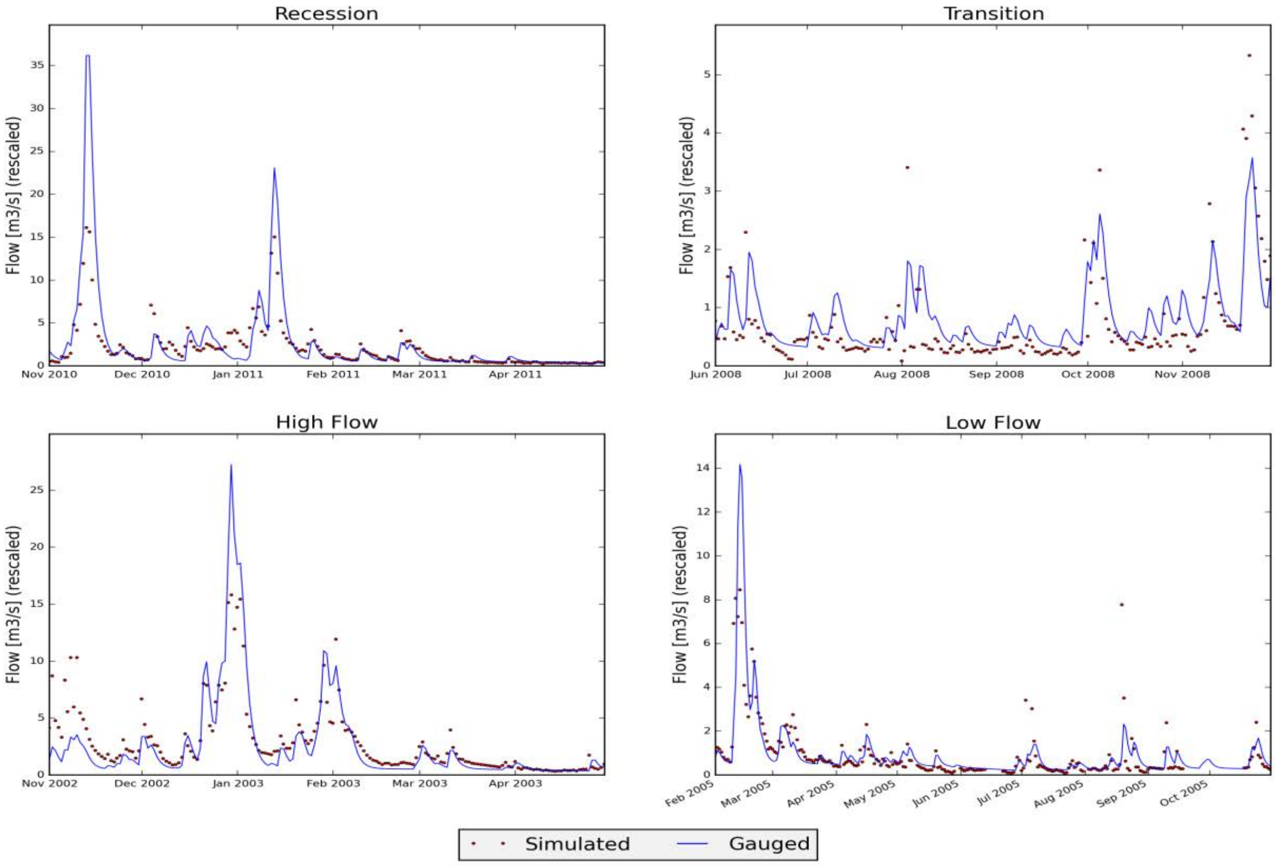


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V07MAR289015, station 28970102 - Marke, Viane



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V07MOE282100" (DENDERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V07MOE282100 (Denderbekken)

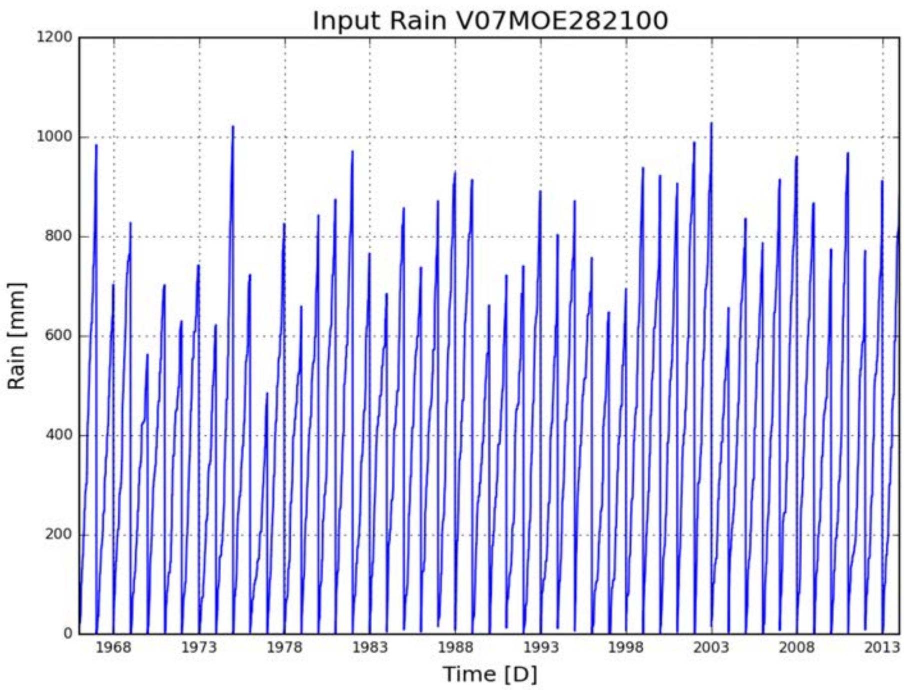
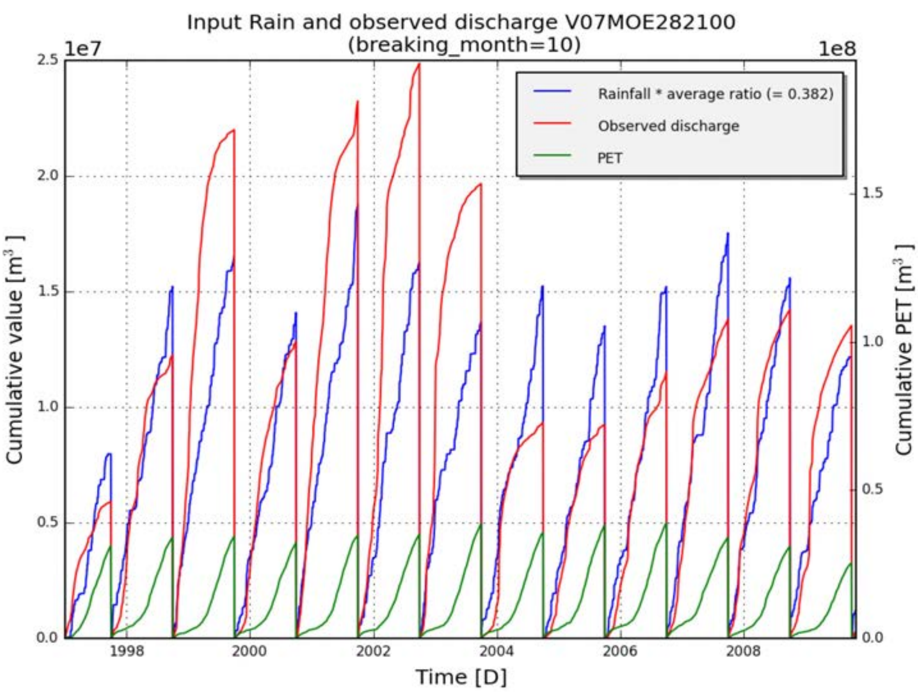


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V07MOE282100 (Denderbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V07MOE282100
subcatchment_area [m²]	46367171
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.31), ('bevaporation', 2.0), ('cmin', 9.8), ('cmax', 272.0), ('CKBF', 300.0), ('CK1', 25.0), ('CK2', 39.0), ('bdrainage', 1.0), ('kdrainage', 11804.0), ('PDM.TG', 2.6), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1997 - 2009)

	Full year	Summer	Winter
NS	0.606	0.239	0.559
NS_log	0.663	0.052	0.644
NS_rel	0.608	0.139	0.889
RelErr	-6.4 %	33.8 %	-15.6 %
VolBias	-0.006	0.382	-0.118

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.596	0.298	0.537
NS_log	0.689	0.217	0.629
NS_rel	0.653	0.506	0.843
RelErr	1.4 %	16.8 %	-2.0 %
VolBias	0.013	0.233	-0.051

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)

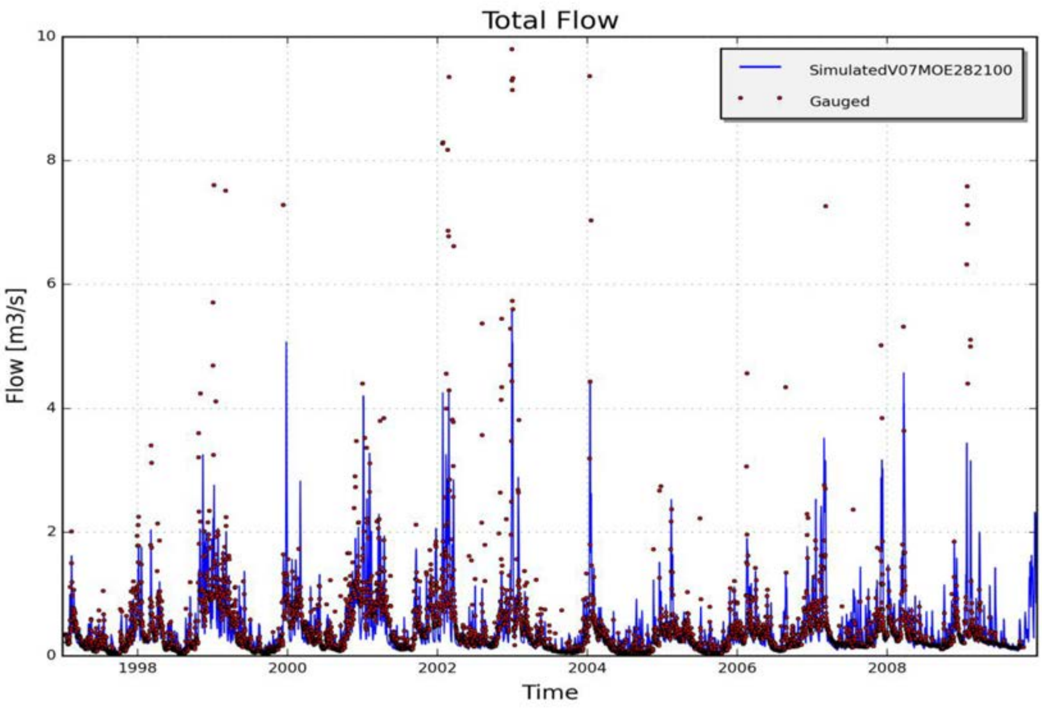


Fig b=140

Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere (calibration period)

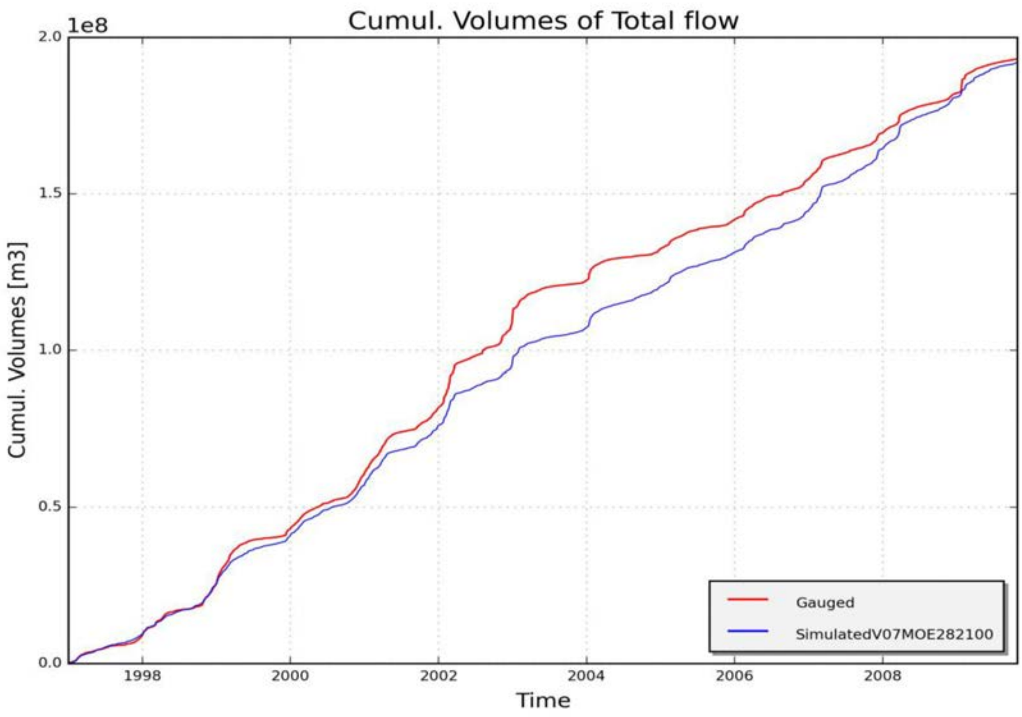


Fig b=137

Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere (validation period)

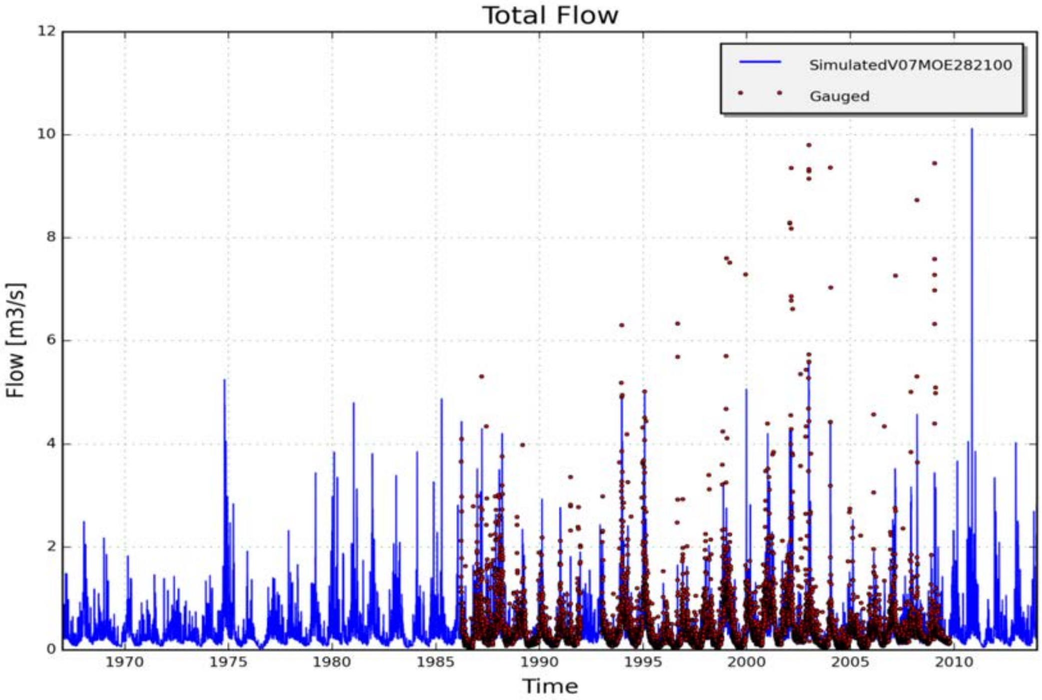


Fig b=140

Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere (validation period)

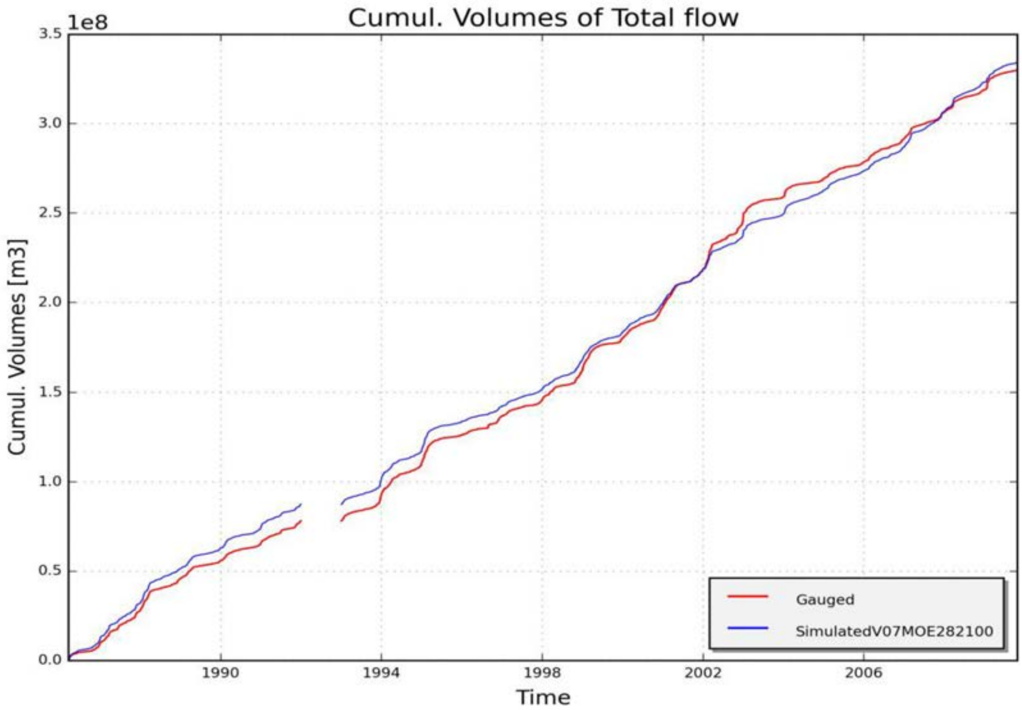


Fig b=137

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

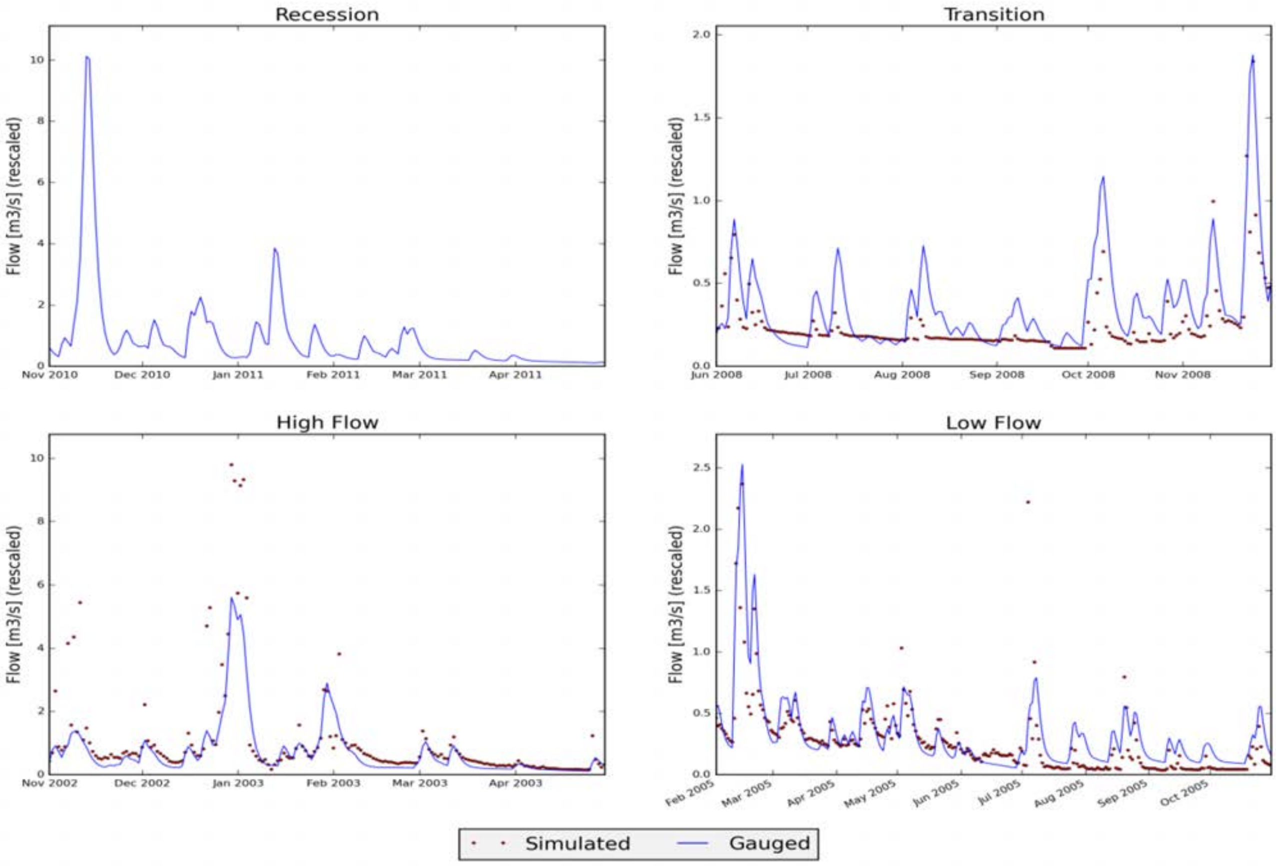


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere

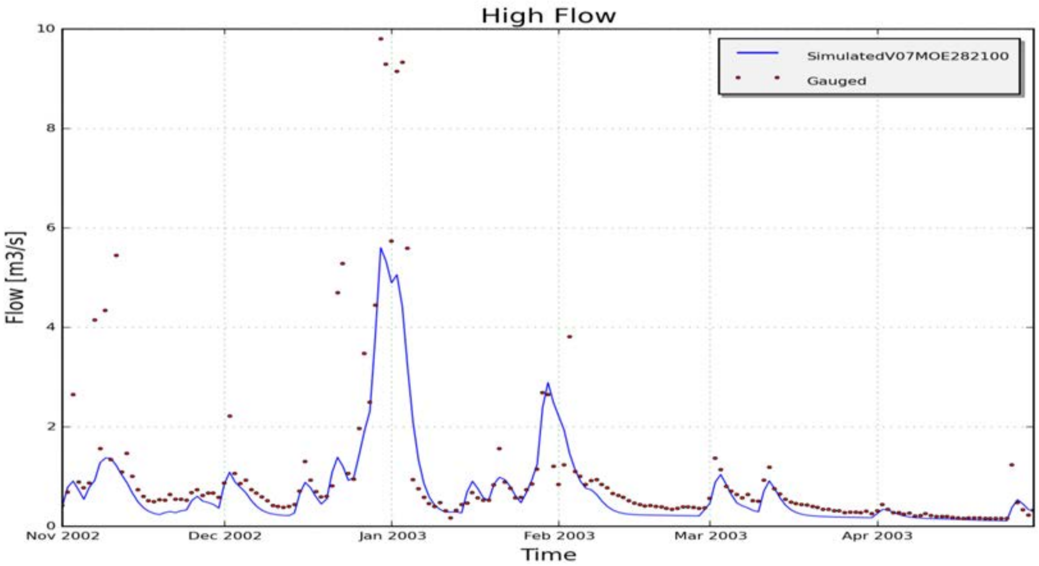


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere

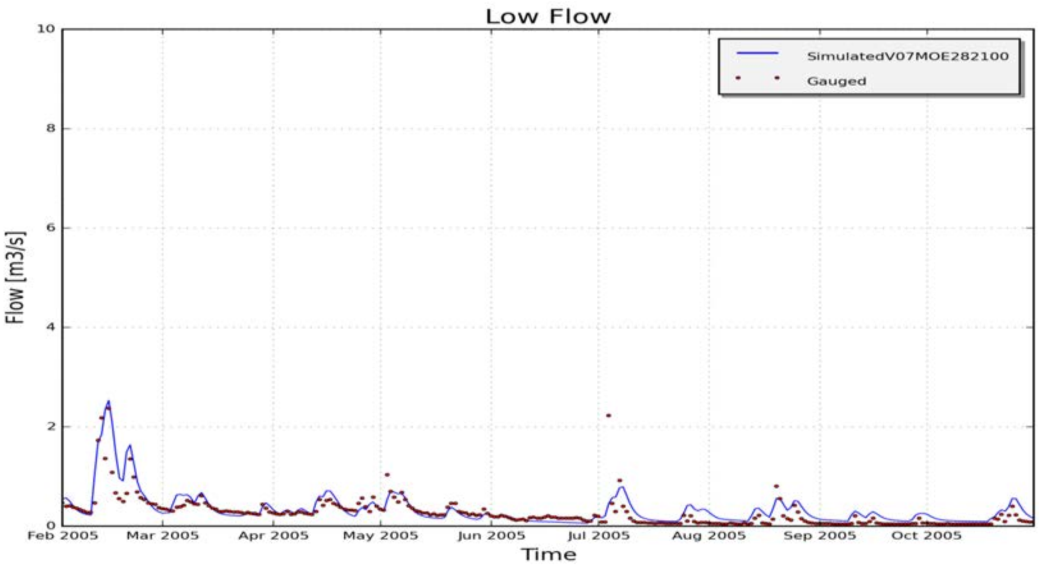
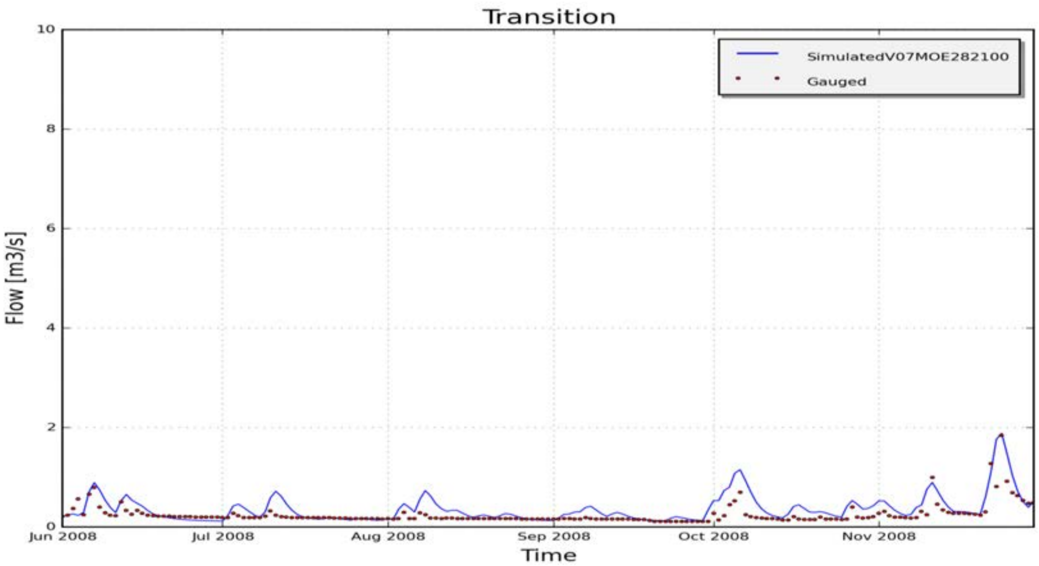


Figure 10: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V07MOG288020" (DENDERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V07MOG288020 (Denderbekken)

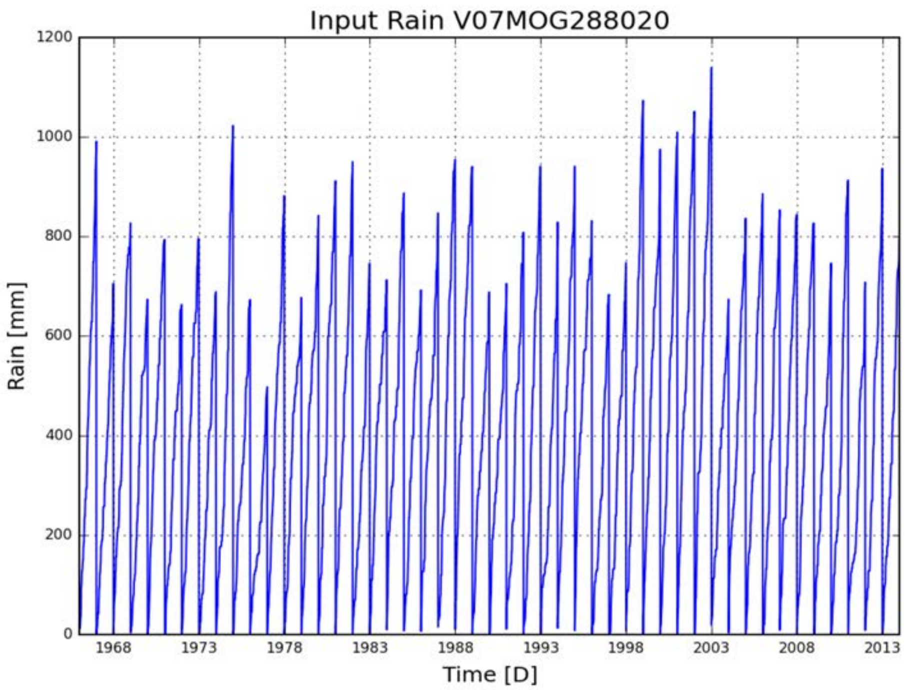
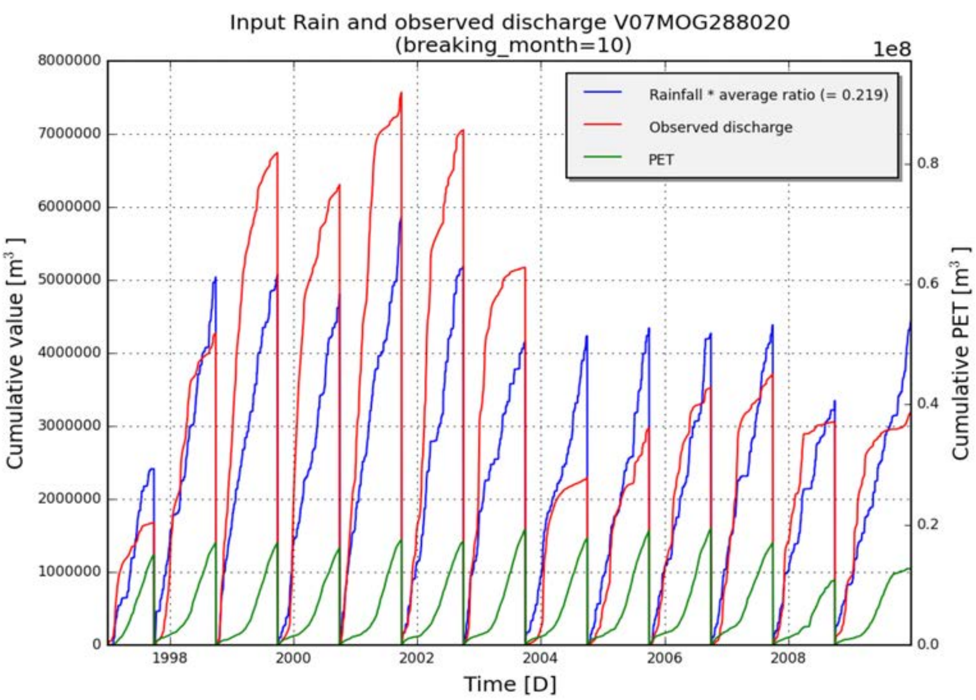


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V07MOG288020 (Denderbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V07MOG288020
subcatchment_area [m²]	23093628
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.04), ('bevaporation', 2.0), ('cmin', 7.5), ('cmax', 250.0), ('CKBF', 300.0), ('CK1', 32.0), ('CK2', 16.0), ('bdrainage', 1.0), ('kdrainage', 37694.0), ('PDM.TG', 3.7), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1997 - 2009)

	Full year	Summer	Winter
NS	0.332	0.294	0.304
NS_log	0.703	0.393	0.395
NS_rel	-0.084	-0.276	0.127
RelErr	3.0 %	-25.0 %	10.5 %
VolBias	0.066	-0.197	0.138

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.093	0.25	0.024
NS_log	0.597	0.34	0.278
NS_rel	-0.34	-0.608	0.079
RelErr	-3.2 %	-36.1 %	11.5 %
VolBias	0.031	-0.301	0.161

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)

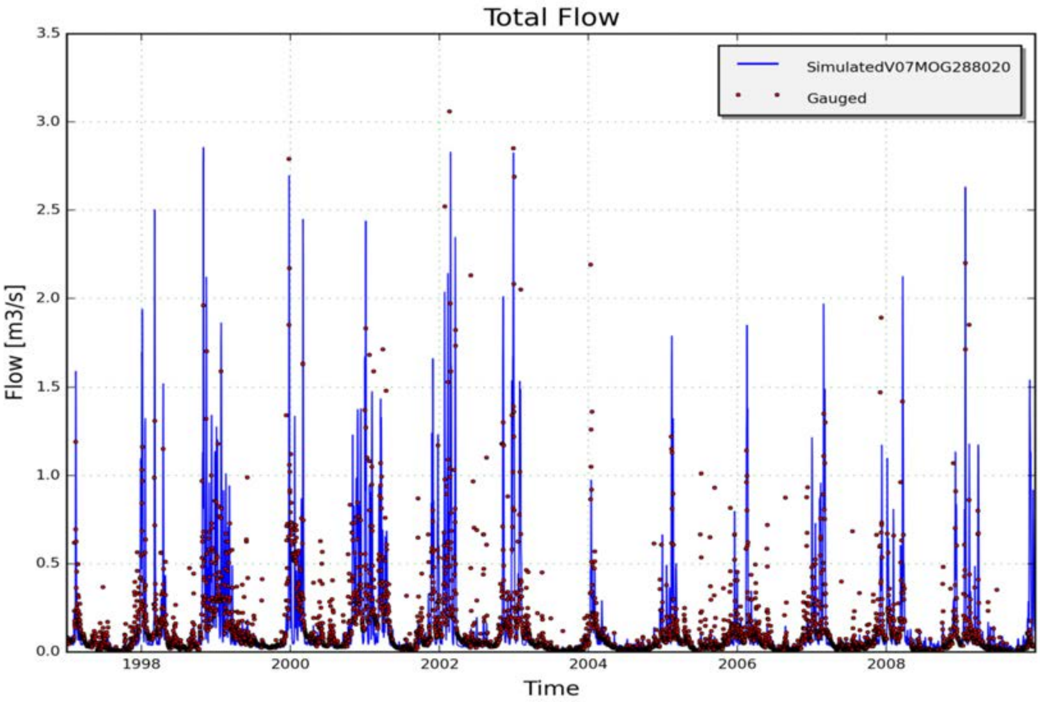


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen (calibration period)

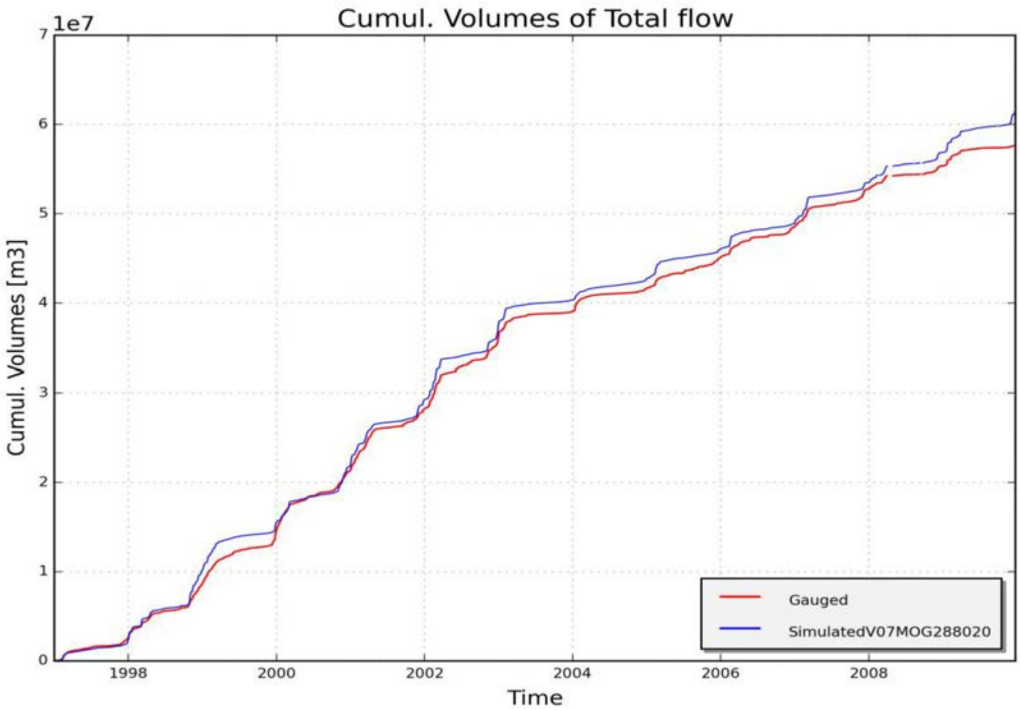


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen (validation period)

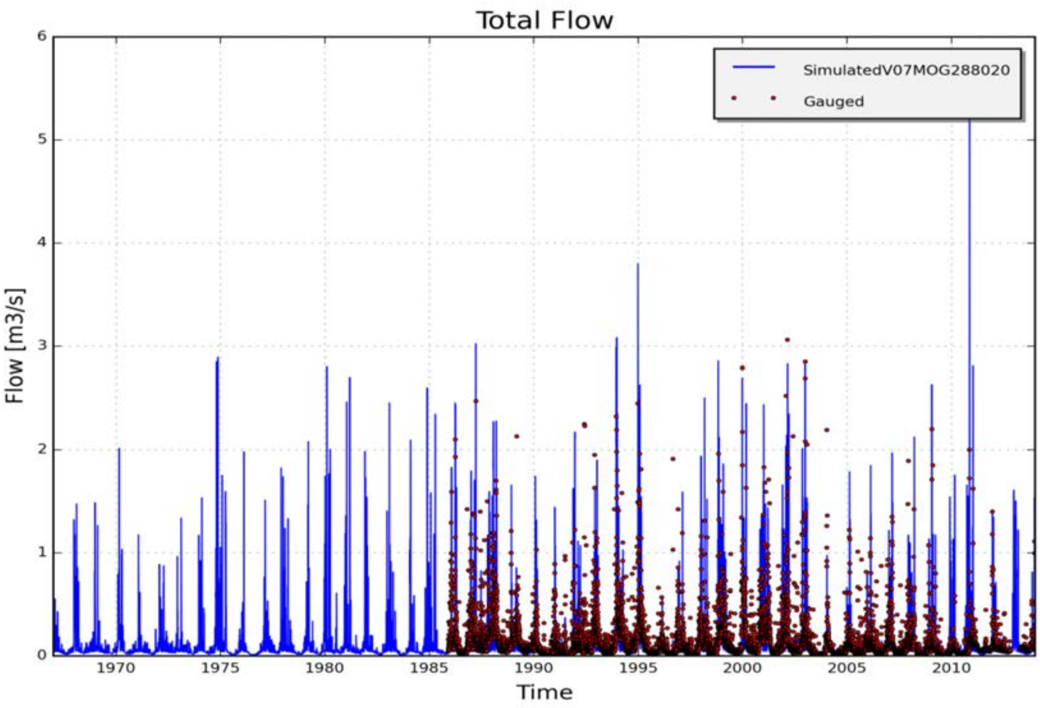


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen (validation period)

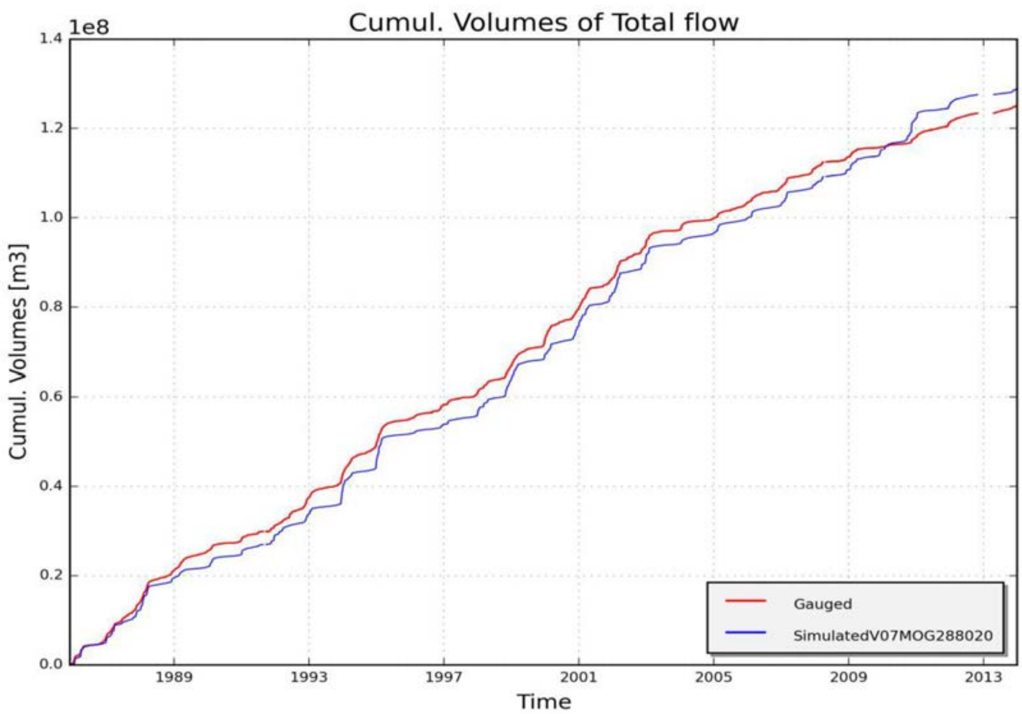


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen

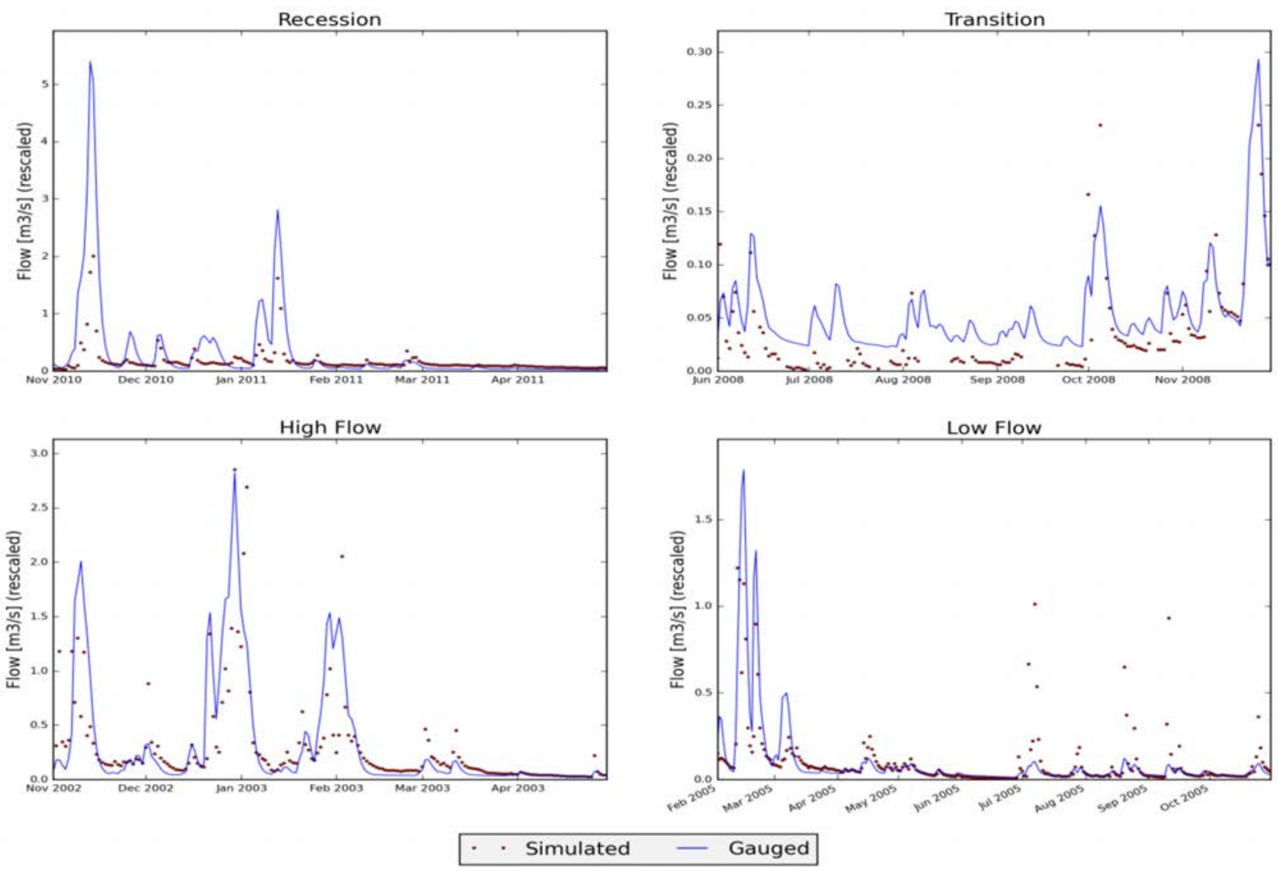


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen

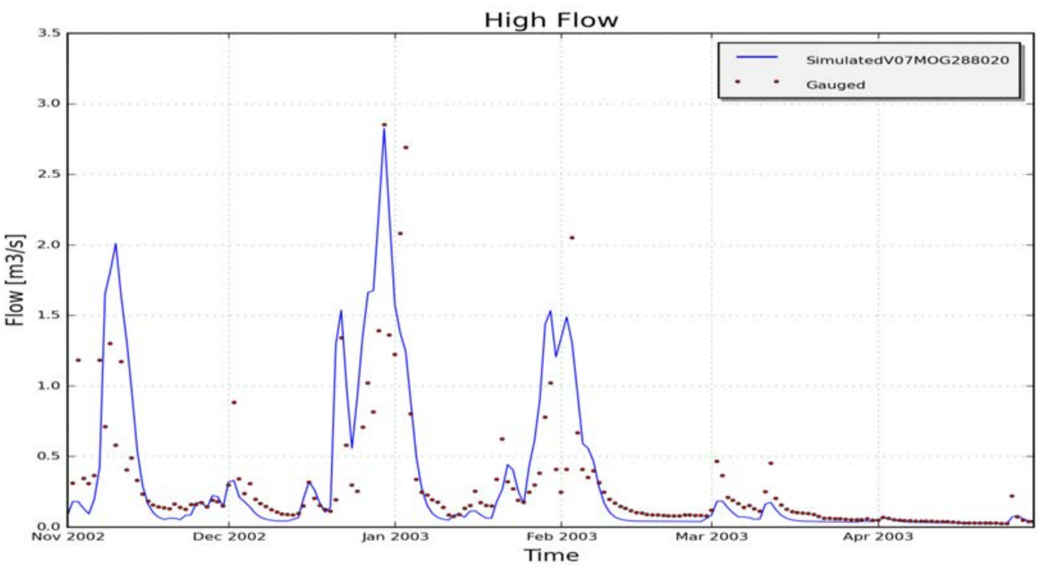


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen

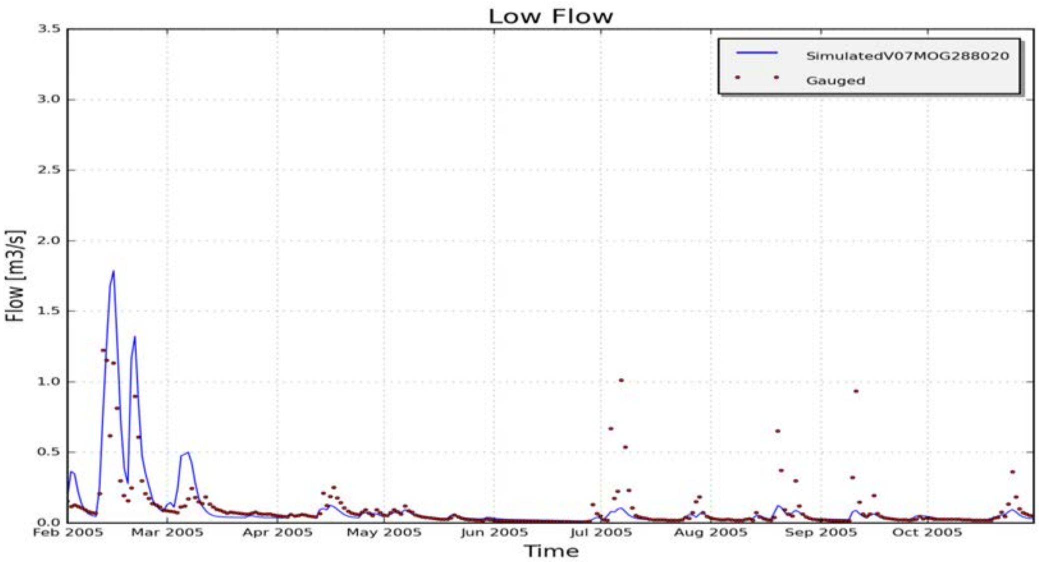
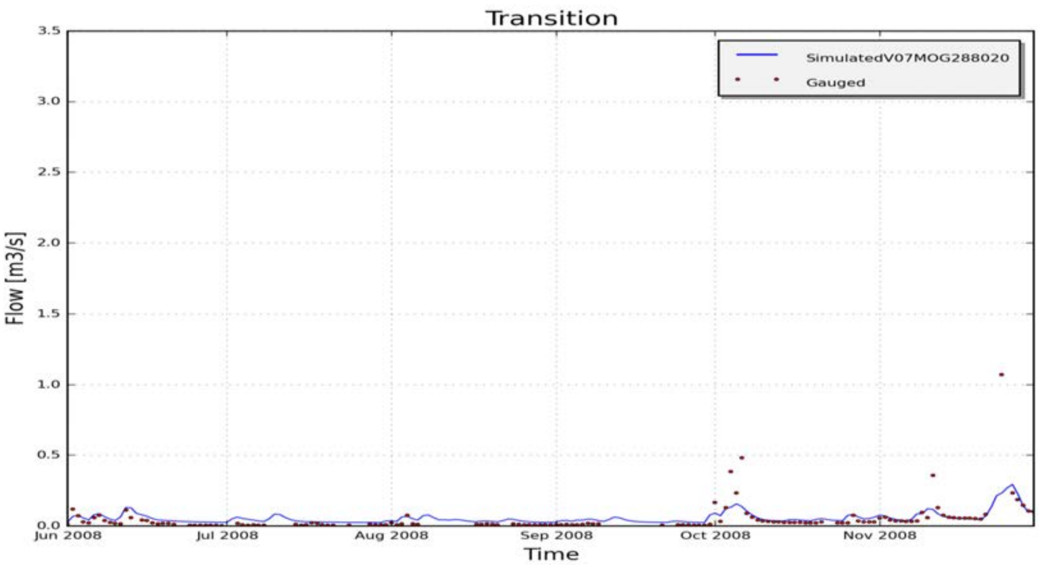


Figure 10: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchmentV07MOG288020, station 28810102 - Molenbeek, Geraardsbergen



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "W07DENLES004" (DENDERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment W07DENLES004 (Denderbekken)

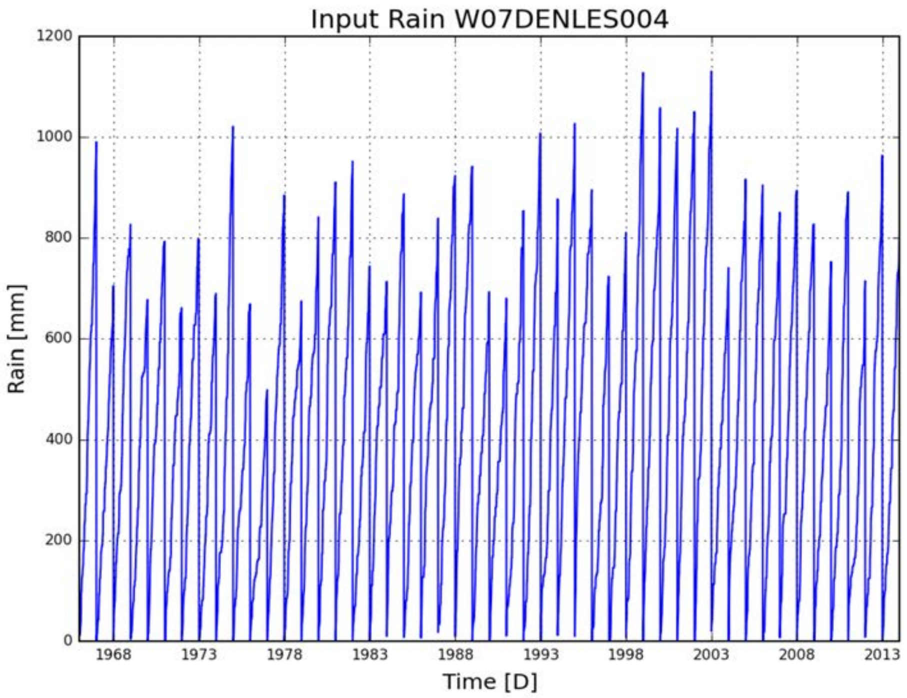
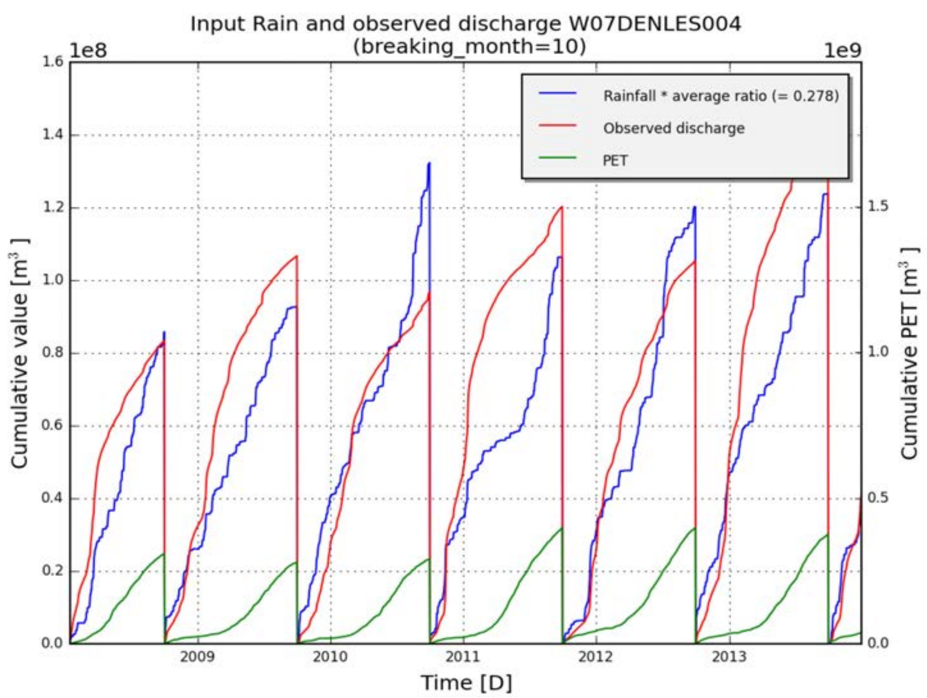


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W07DENLES004 (Denderbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	W07DENLES004
subcatchment_area [m²]	511840662
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.1), ('bevaporation', 2.0), ('cmin', 9.0), ('cmax', 422.0), ('CKBF', 300.0), ('CK1', 46.0), ('CK2', 32.0), ('bdrainage', 1.0), ('kdrainage', 31203.0), ('PDM.TG', 4.6), ('tdly', 0.0), ('qconst', 0.0)]

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

	Full year	Summer	Winter
NS	0.467	0.104	0.494
NS_log	0.659	0.202	0.394
NS_rel	0.811	0.657	0.695
RelErr	4.9 %	11.9 %	-7.6 %
VolBias	-0.014	0.085	-0.1

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.468	0.104	0.496
NS_log	0.66	0.202	0.398
NS_rel	0.811	0.657	0.696
RelErr	5.1 %	11.9 %	-7.1 %
VolBias	-0.013	0.085	-0.098

Observed and simulated timeseries for optimum parameters

Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W07DENLES004, station Lessines (calibration period)

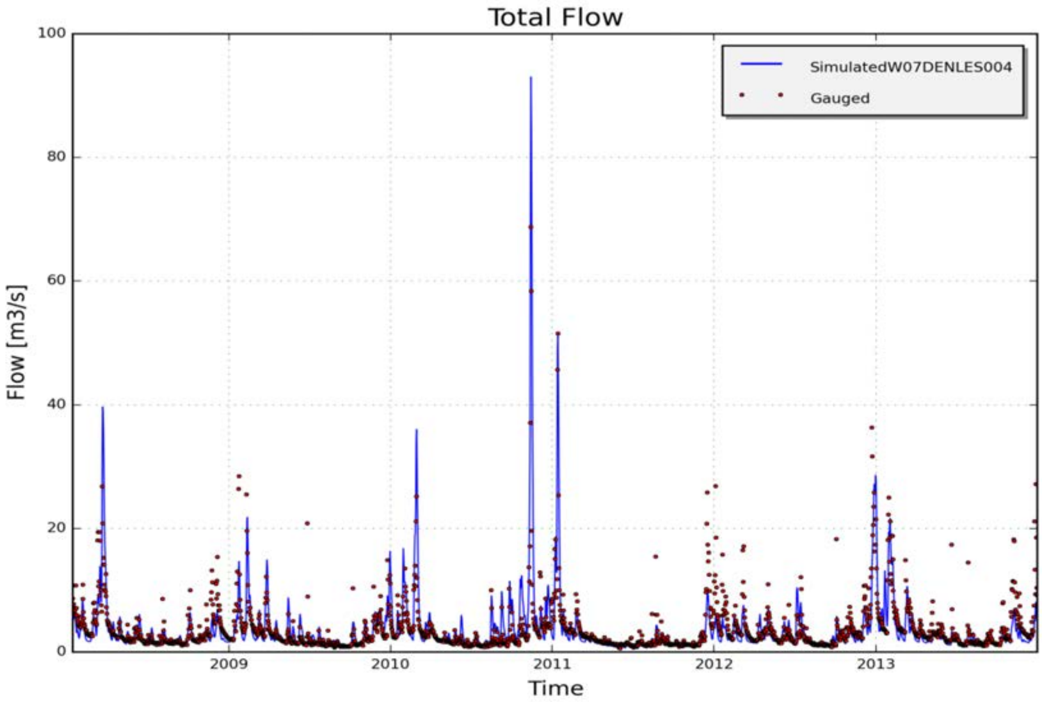


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W07DENLES004, station Lessines (calibration period)

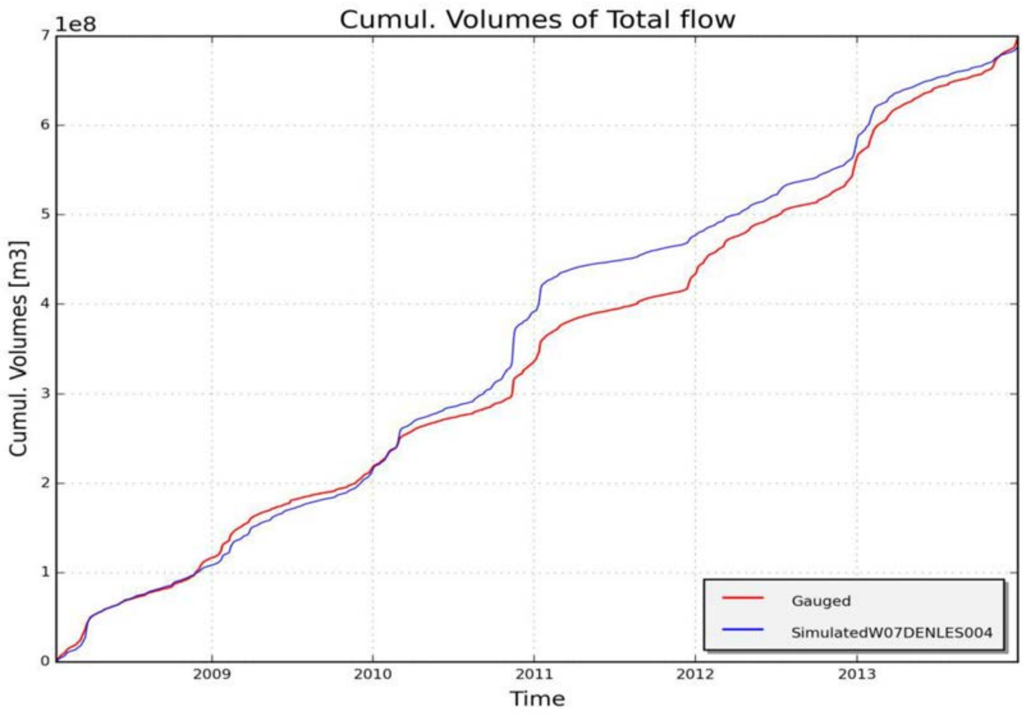


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W07DENLES004, station Lessines (validation period)

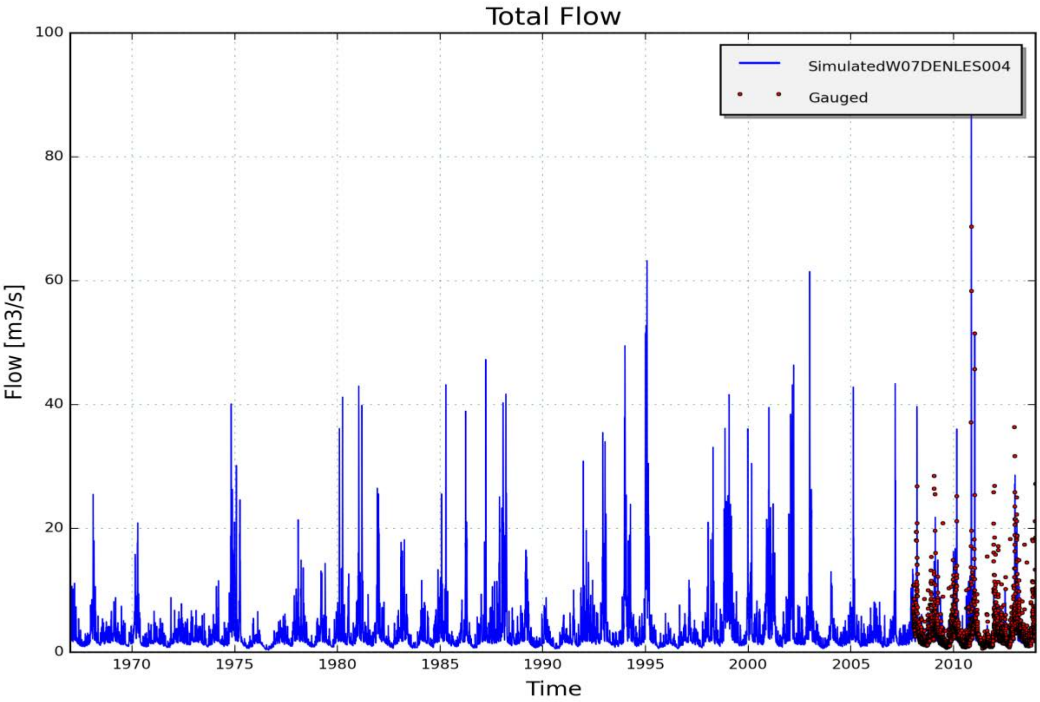


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W07DENLES004, station Lessines (validation period)

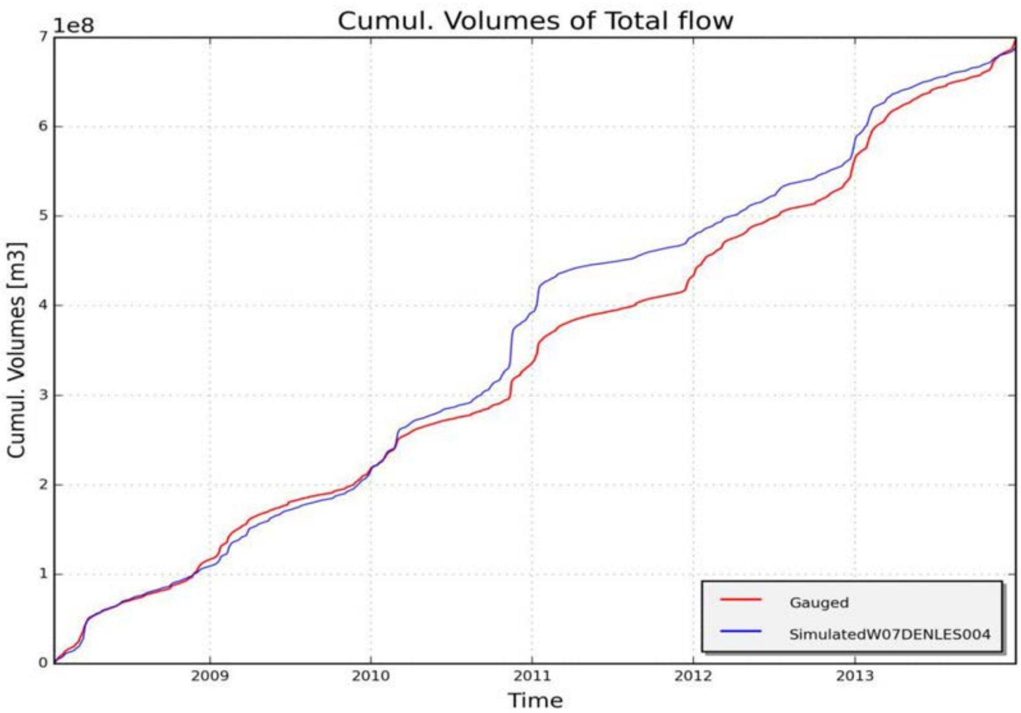


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W07DENLES004, station Lessines

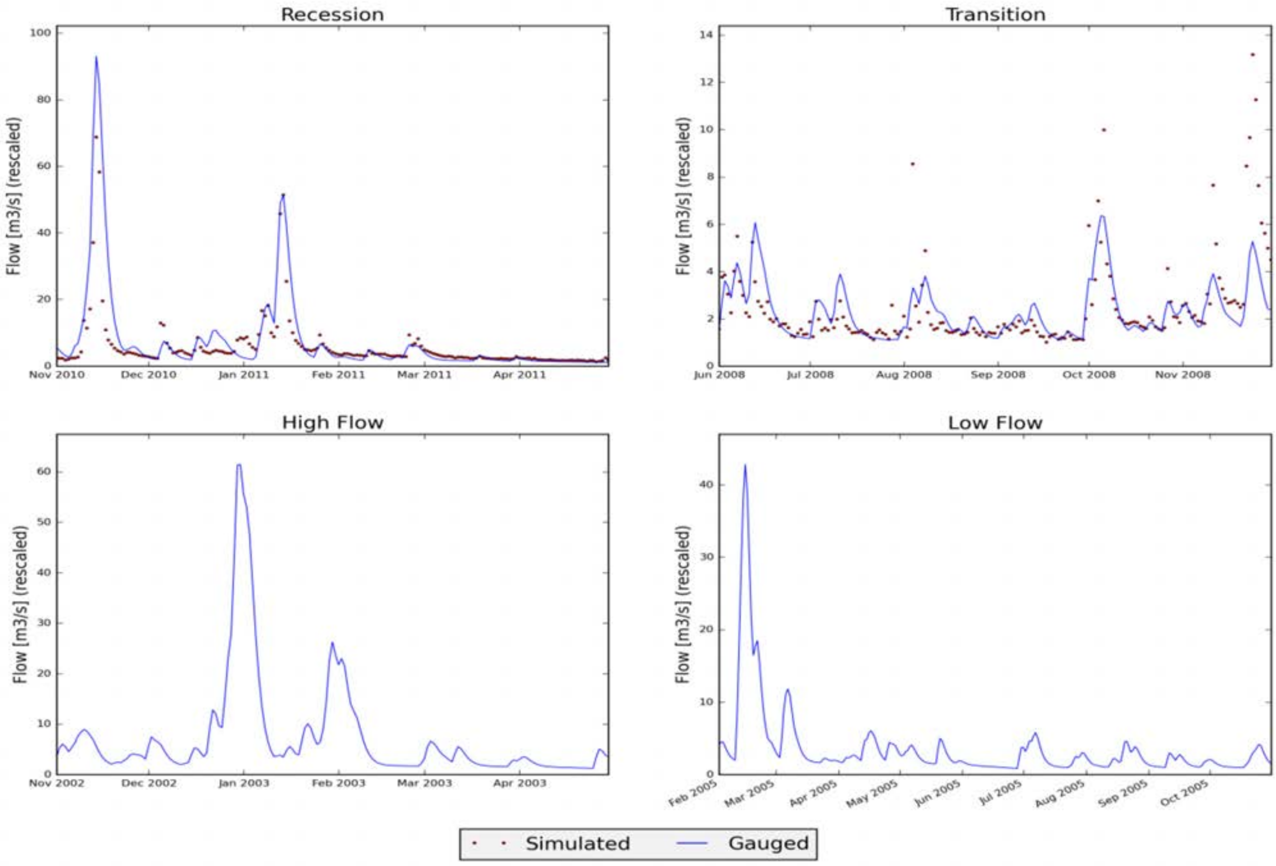


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W07DENLES004, station Lessines

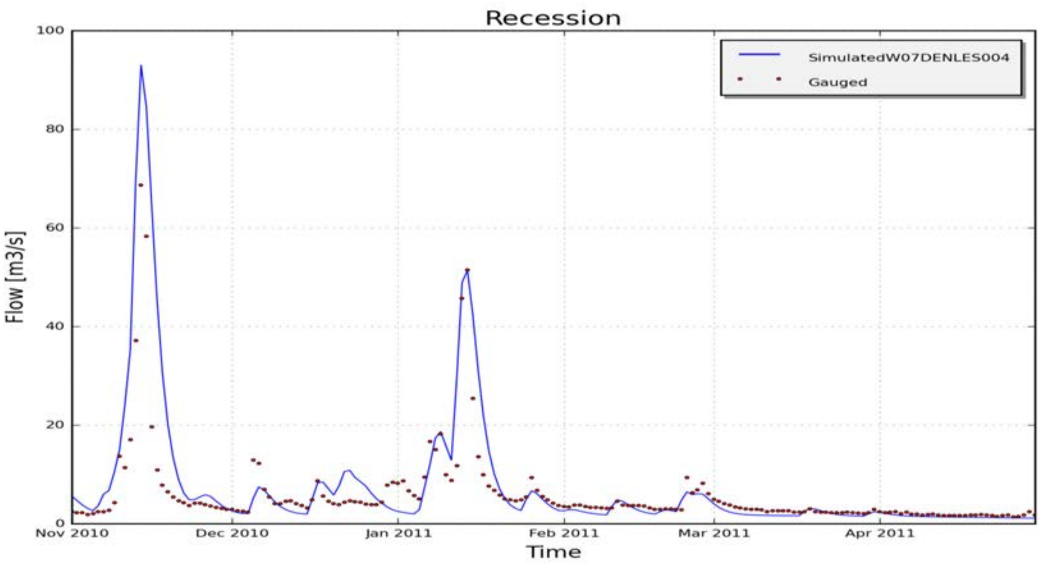
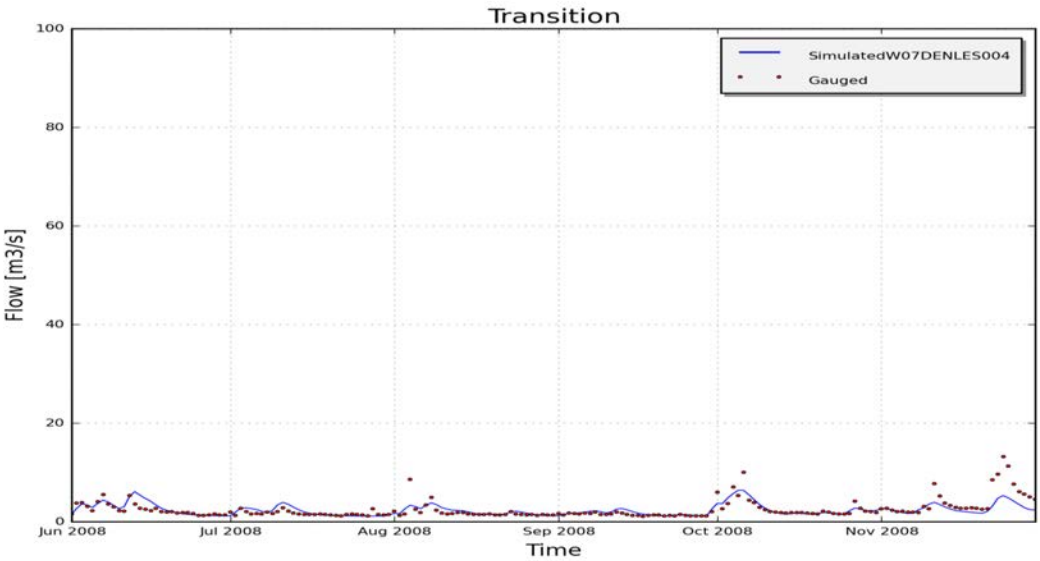


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W07DENLES004, station Lessines



Annexe 10 Dijle an Zenne

CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V08BAR111370" (DIJLE/ZENNEBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V08BAR111370 (Dijle/Zennebekken)

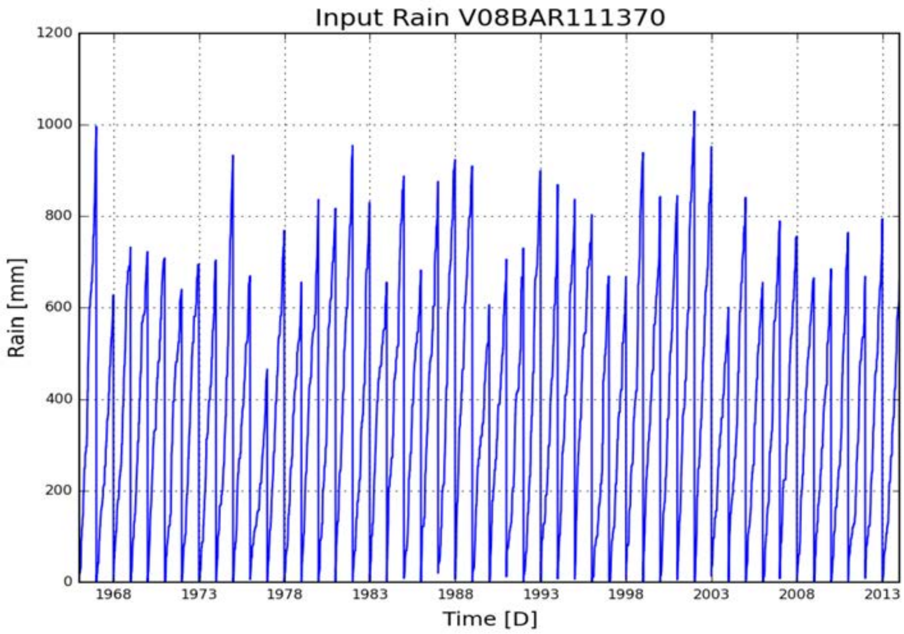
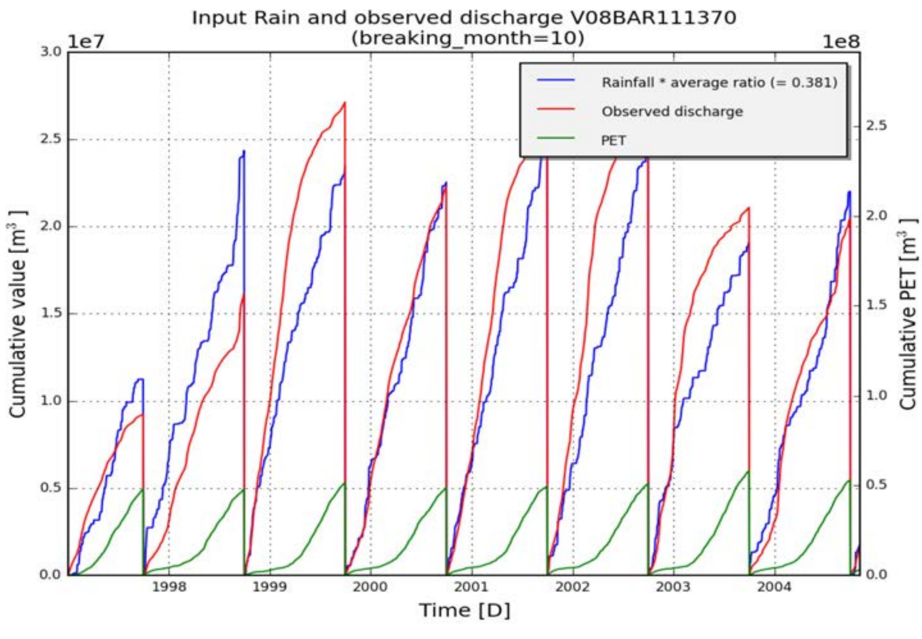


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V08BAR111370 (Dijle/Zennebekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V08BAR111370
subcatchment_area [m²]	70079800
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.23), ('bevaporation', 2.0), ('cmin', 9.7), ('cmax', 414.0), ('CKBF', 300.0), ('CK1', 48.0), ('CK2', 31.0), ('bdrainage', 1.0), ('kdrainage', 12738.0), ('PDM.TG', 3.7), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1997 - 2004)

	Full year	**Summer**	**Winter**
NS	0.721	0.64	0.613
NS_log	0.811	0.733	0.717
NS_rel	0.82	0.815	0.802
RelErr	1.4 %	3.5 %	4.6 %
VolBias	-0.043	-0.056	-0.03

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	**Summer**	**Winter**
NS	0.721	0.64	0.613
NS_log	0.811	0.733	0.717
NS_rel	0.819	0.814	0.801
RelErr	1.5 %	3.6 %	4.8 %
VolBias	-0.043	-0.056	-0.029

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)

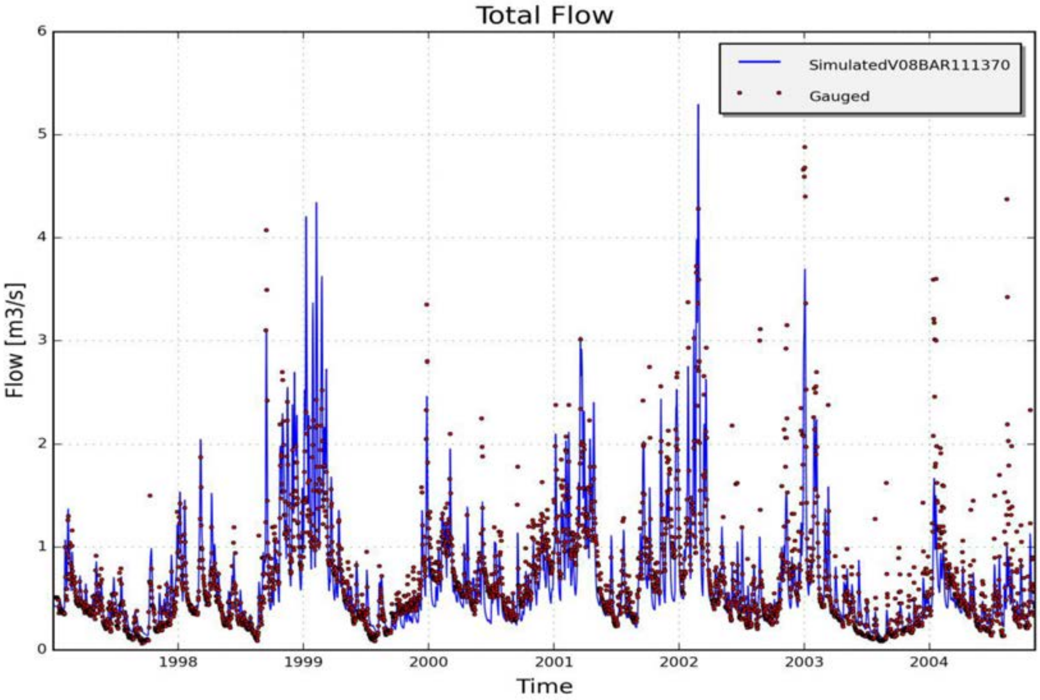


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V08BAR111370, station 11110102-Barebeek (calibration period)

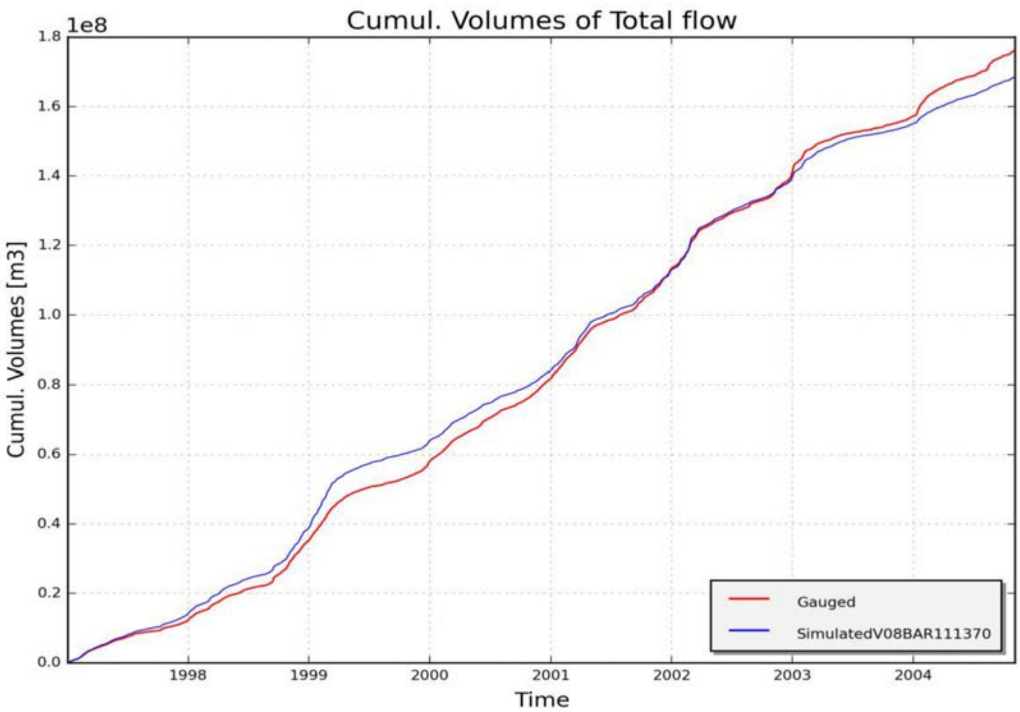


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V08BAR111370, station 11110102-Barebeek (validation period)

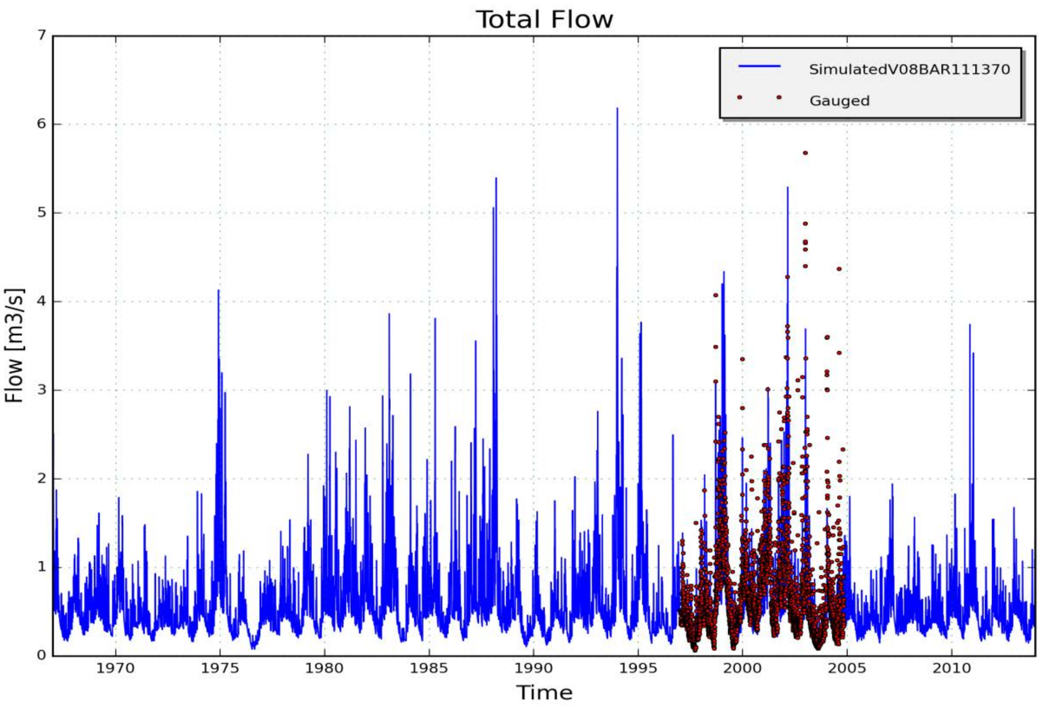


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V08BAR111370, station 11110102-Barebeek (validation period)

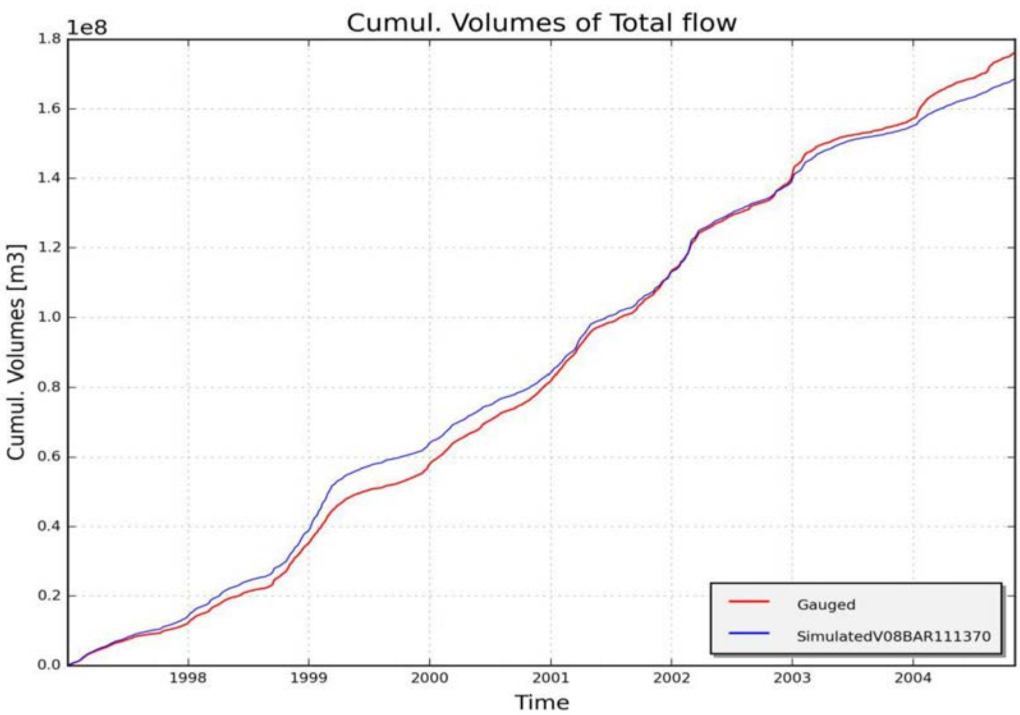


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V08BAR111370, station 11110102-Barebeek

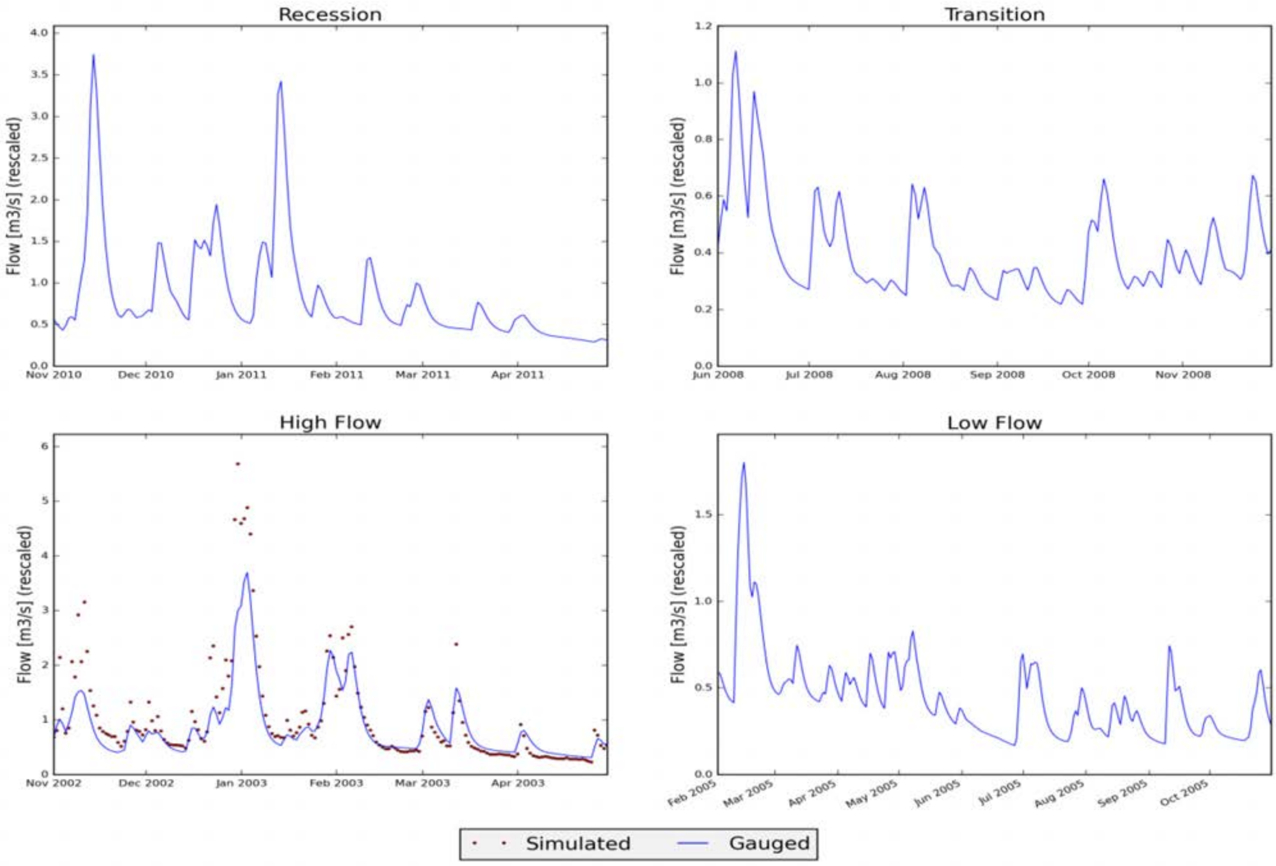
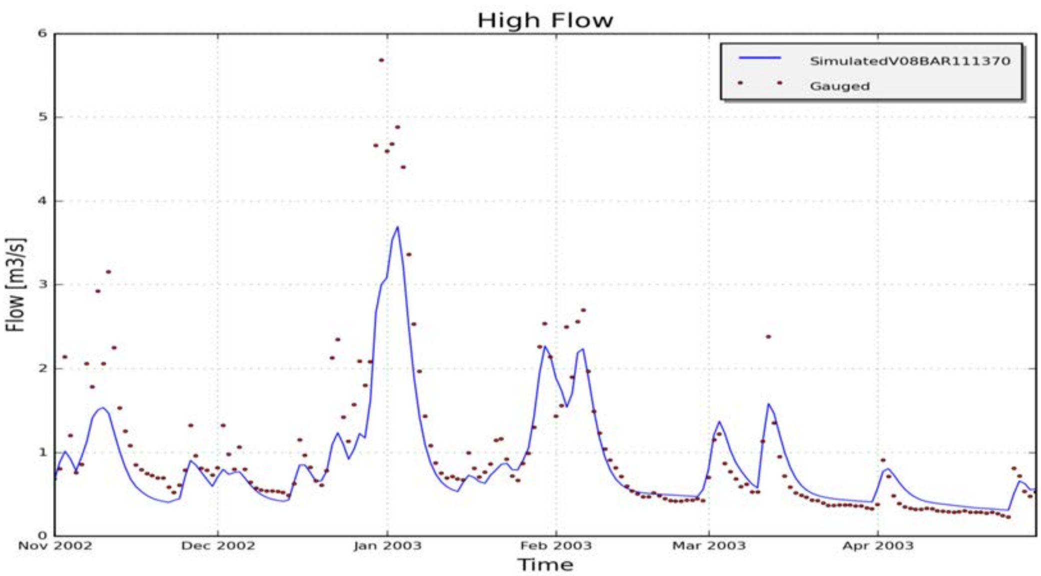


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V08BAR111370, station 11110102-Barebeek



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V08DIJ093400" (DIJLE/ZENNEBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V08DIJ093400 (Dijle/Zennebekken)

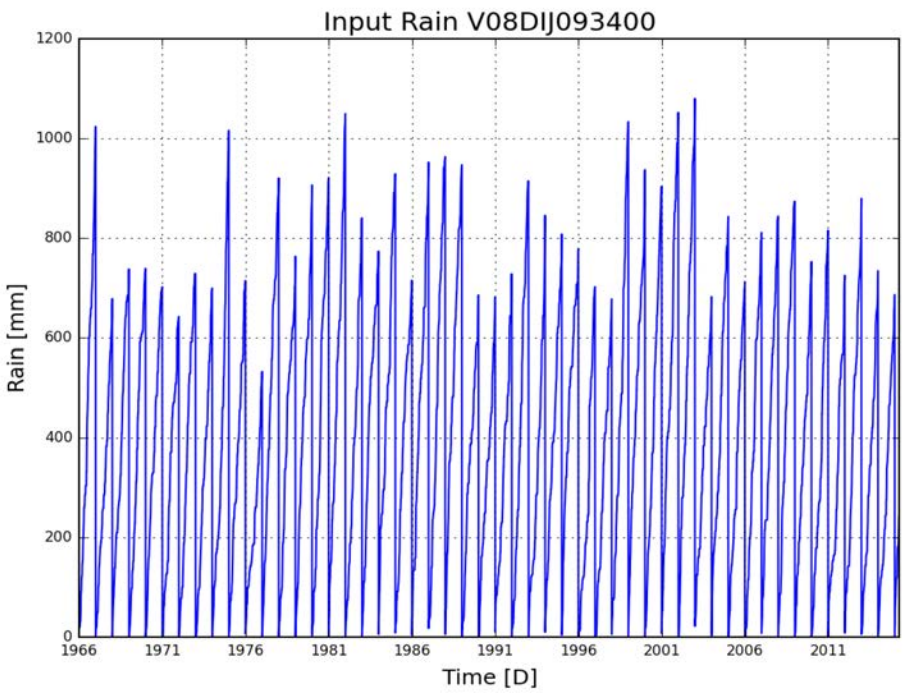
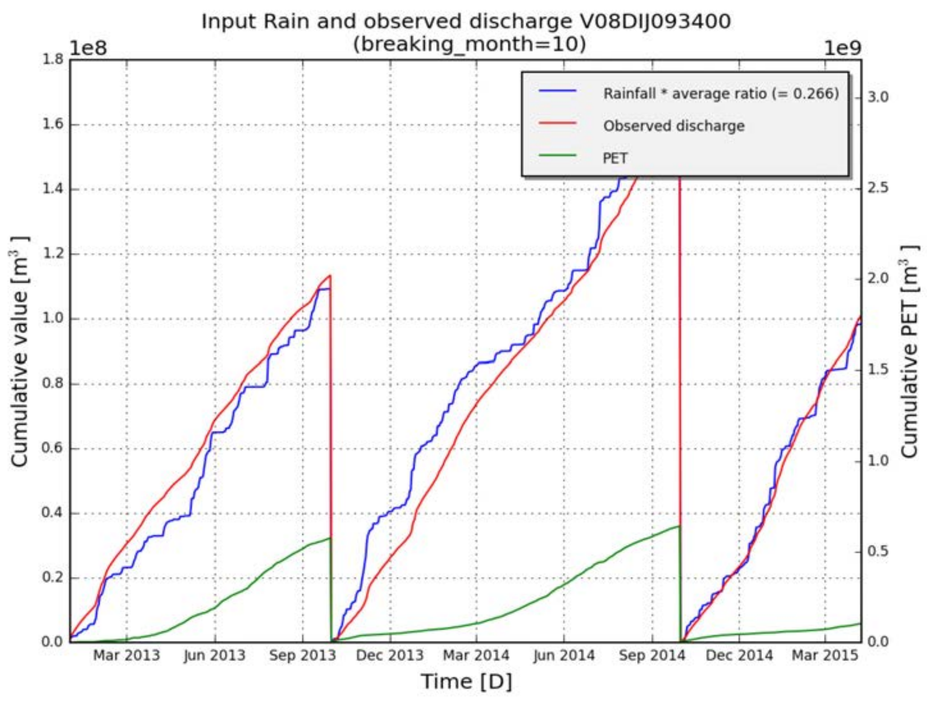


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V08DIJ093400 (Dijle/Zennebekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V08DIJ093400
subcatchment_area [m²]	861413000
Validation start_date	01-01-1967
Validation end_date	08-04-2015
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.12), ('bevaporation', 2.0), ('cmin', 10.0), ('cmax', 886.0), ('CKBF', 300.0), ('CK1', 28.0), ('CK2', 26.0), ('bdrainage', 1.0), ('kdrainage', 27900.0), ('PDM.TG', 7.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2013 - 2015)

	Full year	Summer	Winter
NS	0.619	0.489	0.663
NS_log	0.628	0.528	0.679
NS_rel	0.762	0.827	0.738
RelErr	2.5 %	-12.4 %	0.4 %
VolBias	-0.016	-0.189	-0.009

Table 2 :Goodness of fit for validation period (1967 - 2015)

	Full year	Summer	Winter
NS	0.622	0.547	0.683
NS_log	0.561	0.581	0.641
NS_rel	0.669	0.797	0.666
RelErr	-1.3 %	-10.6 %	3.2 %
VolBias	-0.009	-0.143	0.026

Observed and simulated timeseries for optimum parameters

Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V08DIJ093400, station 9310102 - Dijle, Wilsele (calibration period)

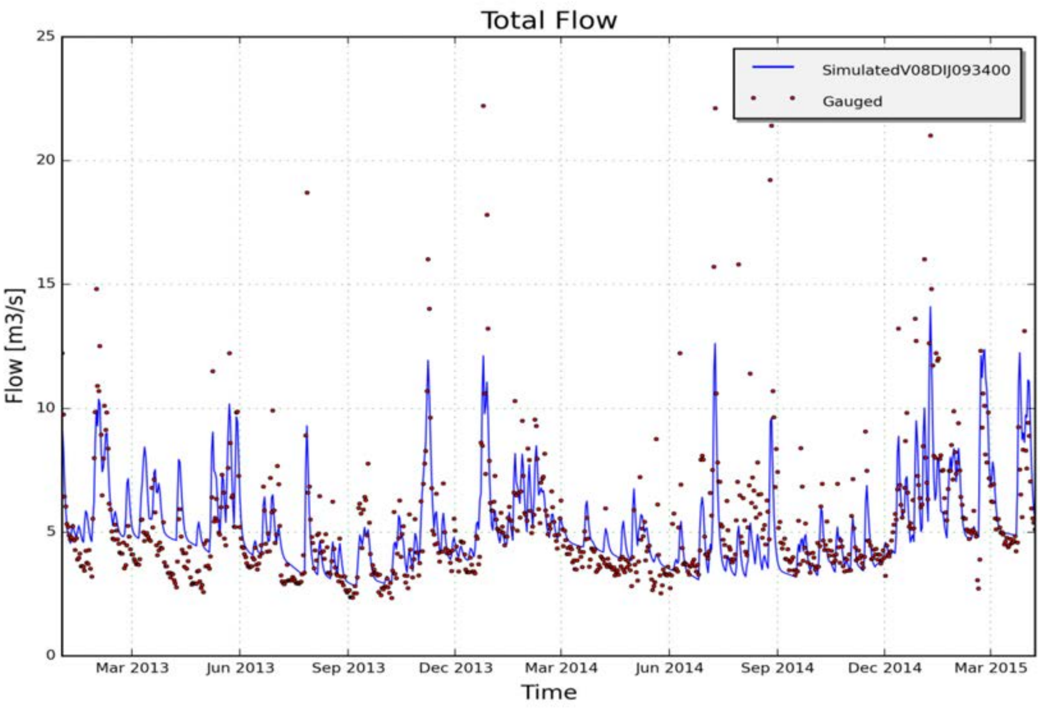


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V08DIJ093400, station 9310102 - Dijle, Wilsele (calibration period)

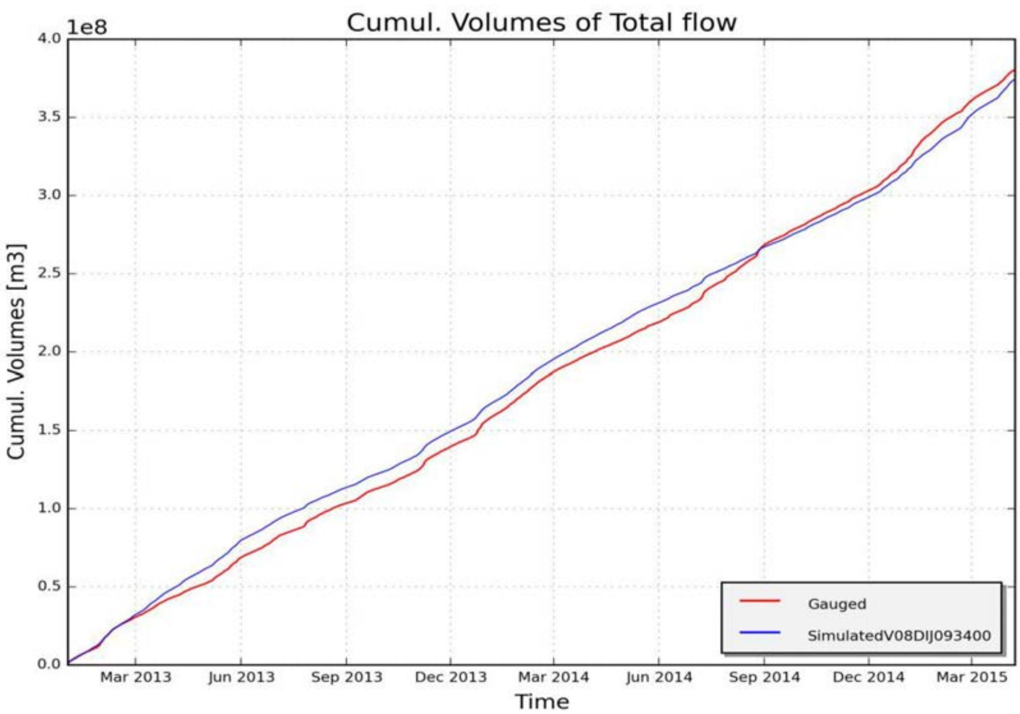


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V08DIJ093400, station 9310102 - Dijle, Wilsele (validation period)

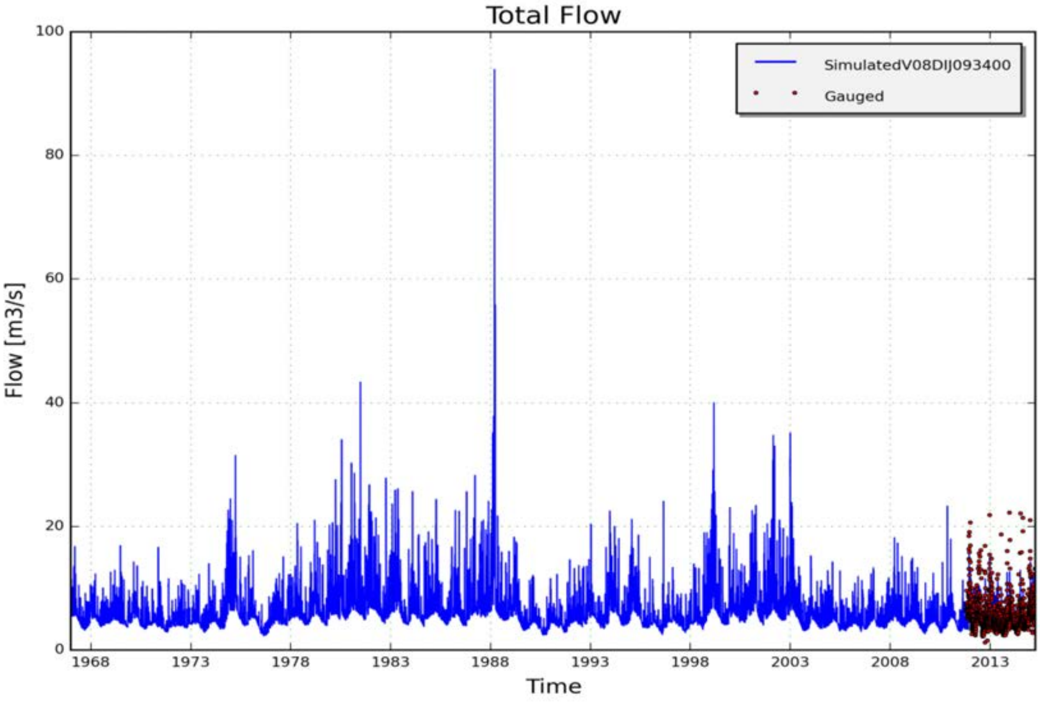


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V08DIJ093400, station 9310102 - Dijle, Wilsele (validation period)

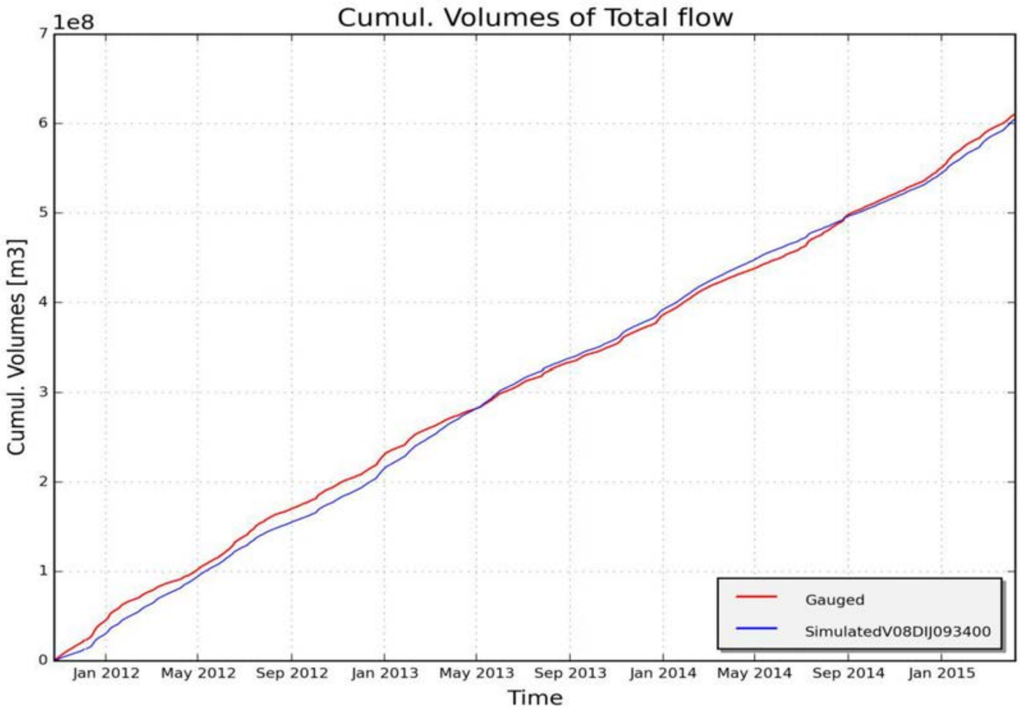
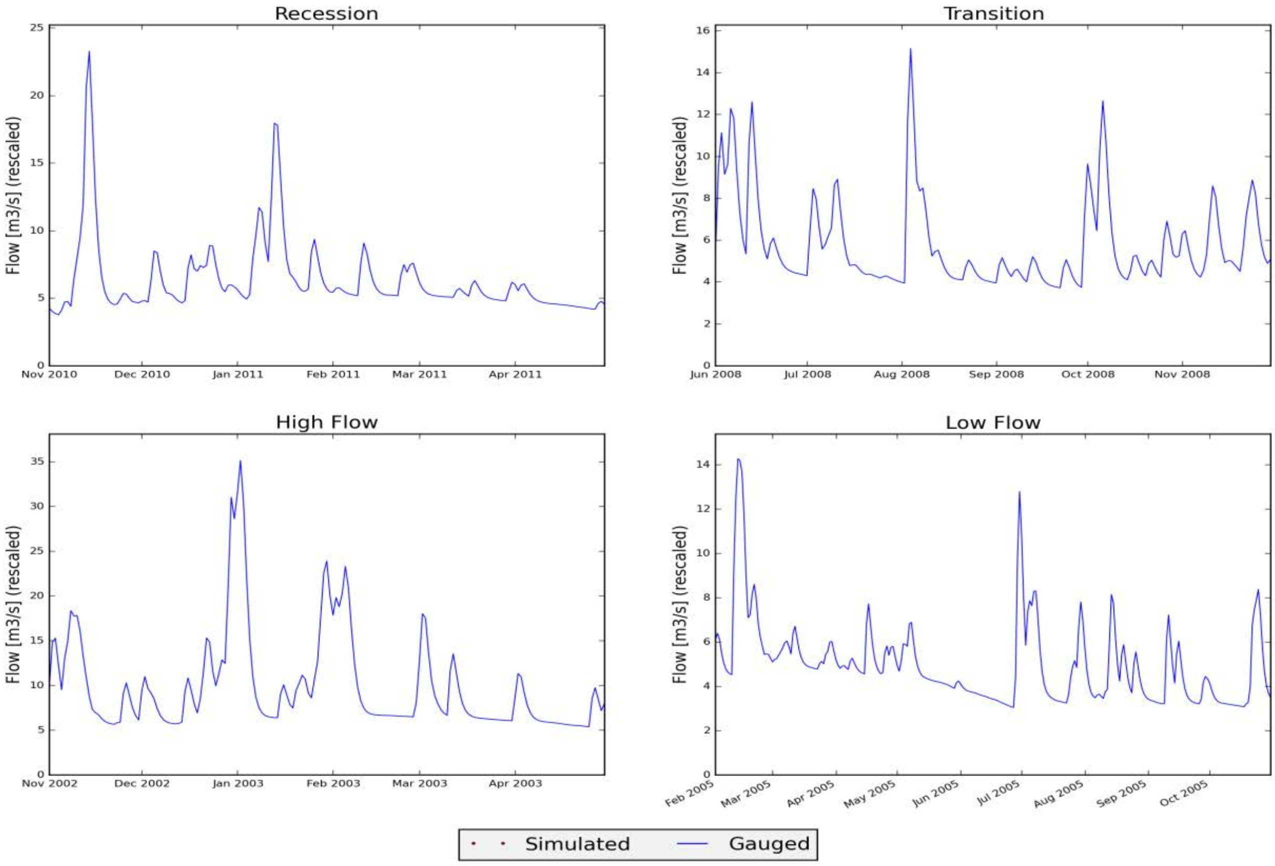


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V08DIJ093400, station 9310102 - Dijle, Wilsele



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V08ZUU233100" (DIJLE/ZENNEBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V08ZUU233100 (Dijle/Zennebekken)

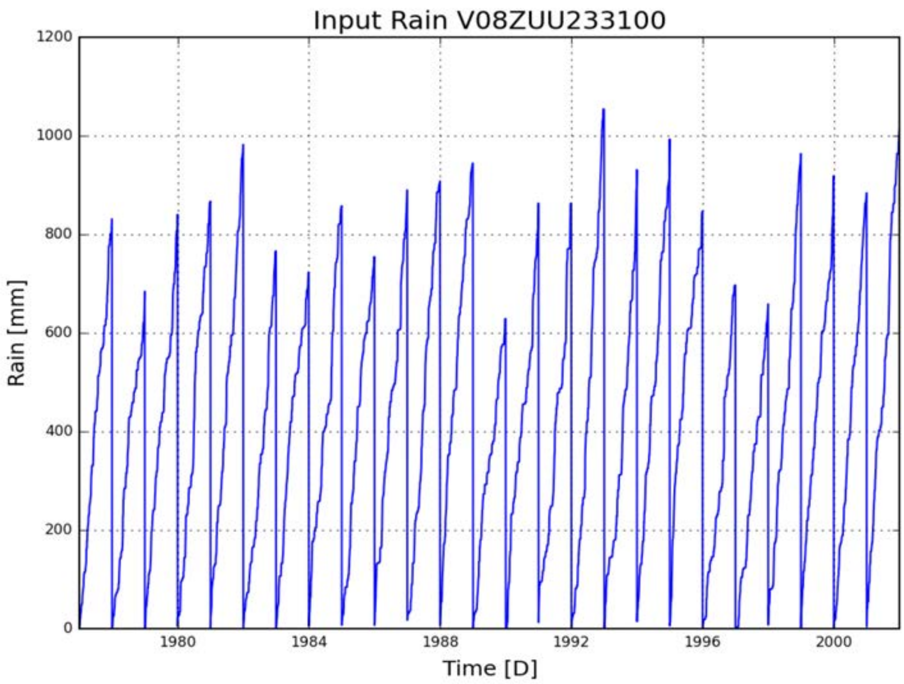
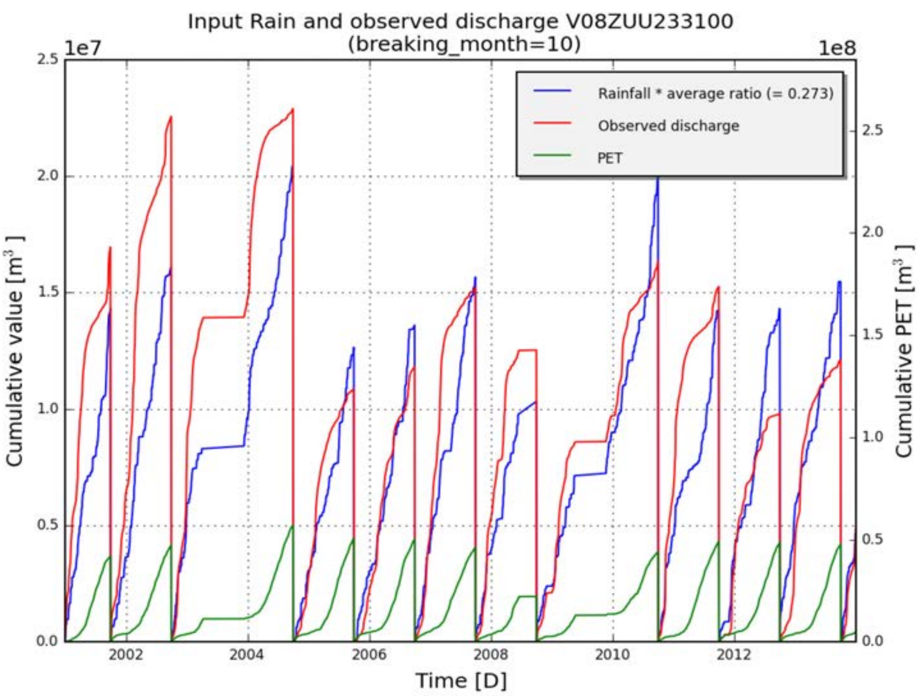


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V08ZUU233100 (Dijle/Zennebekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V08ZUU233100
subcatchment_area [m²]	64771005
Validation start_date	01-01-1978
Validation end_date	31-12-2001
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.12), ('bevaporation', 2.0), ('cmin', 9.9), ('cmax', 346.0), ('CKBF', 300.0), ('CK1', 33.0), ('CK2', 30.0), ('bdrainage', 1.0), ('kdrainage', 32620.0), ('PDM.TG', 6.2), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.487	0.274	0.449
NS_log	0.637	0.184	0.426
NS_rel	0.338	0.034	0.557
RelErr	0.9 %	-5.4 %	9.2 %
VolBias	0.075	0.116	0.116

Table 2 :Goodness of fit for validation period (1978 - 2001)

	Full year	Summer	Winter
NS	0.235	0.369	-0.15
NS_log	0.64	0.227	0.623
NS_rel	-1.75	-2.364	0.173
RelErr	27.2 %	34.4 %	31.8 %
VolBias	0.207	0.244	0.287

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 Pietersleeuw (calibration period)

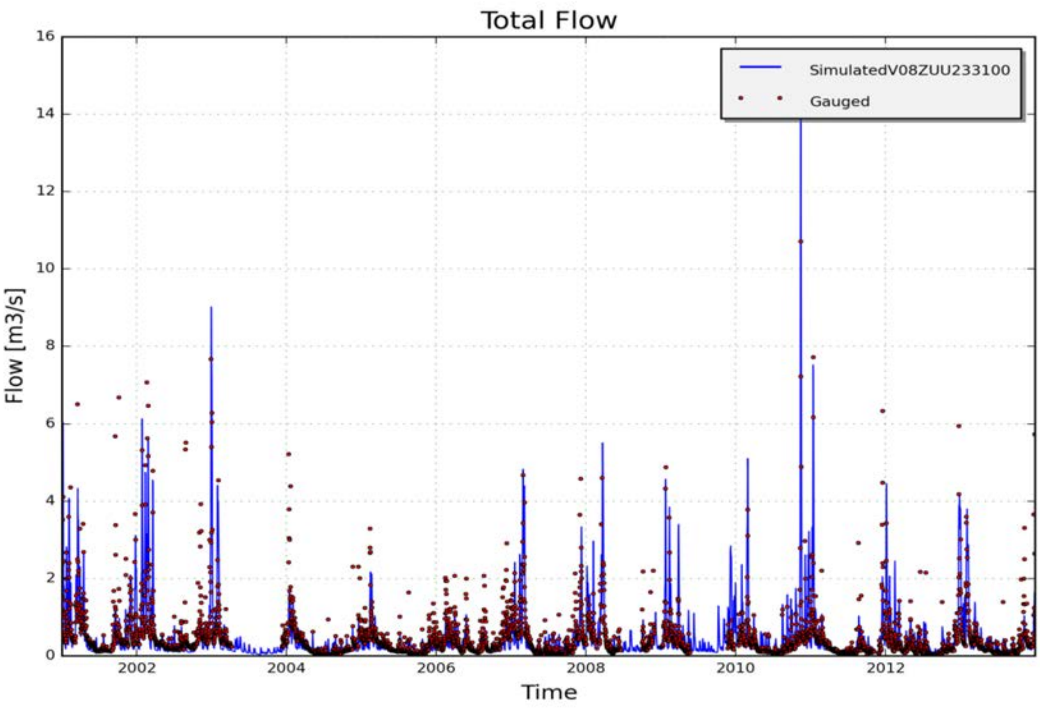


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V08ZUU233100, station 23310102 - Zuunbeek, St Pietersleeuw (calibration period)

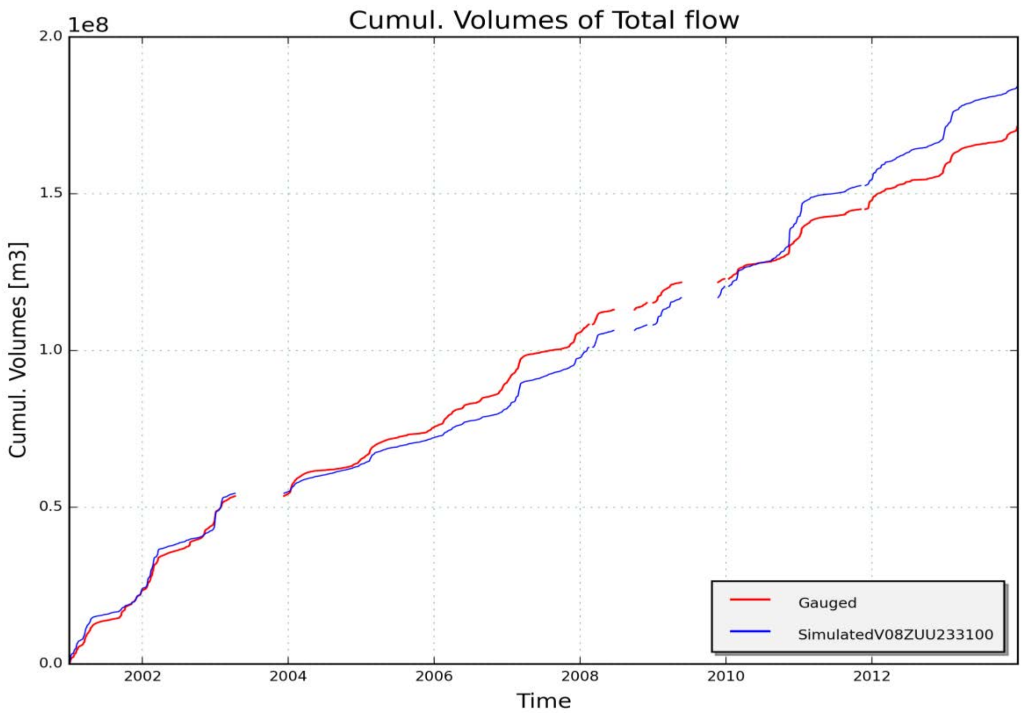


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V08ZUU233100, station 23310102 - Zuunbeek, St Pietersleeuw (validation period)

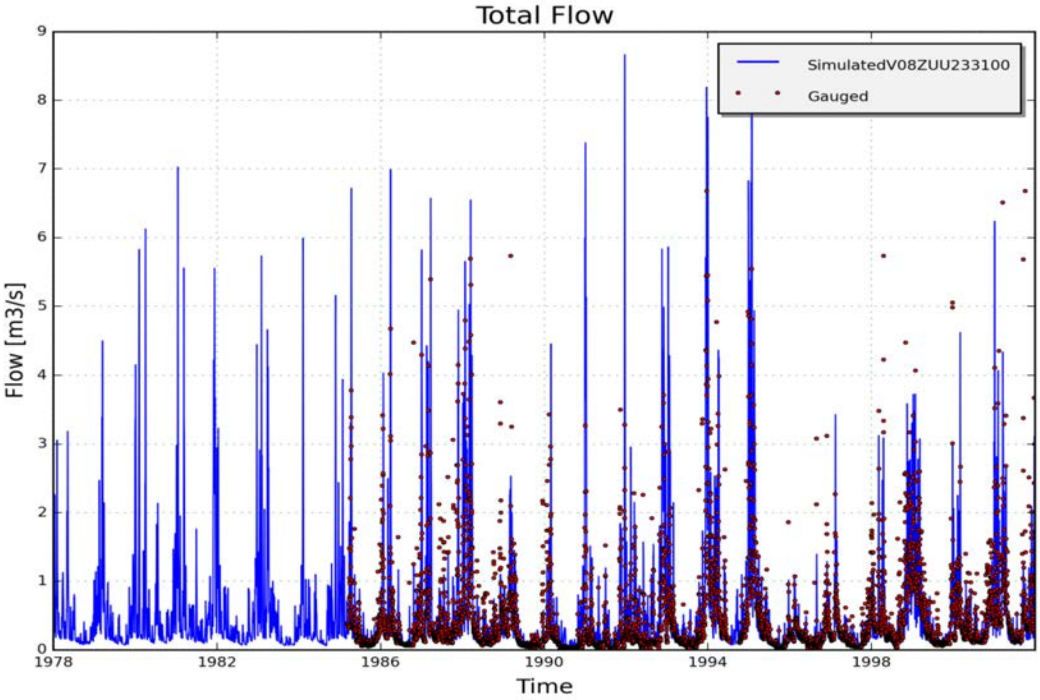


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V08ZUU233100, station 23310102 - Zuunbeek, St Pietersleeuw (validation period)

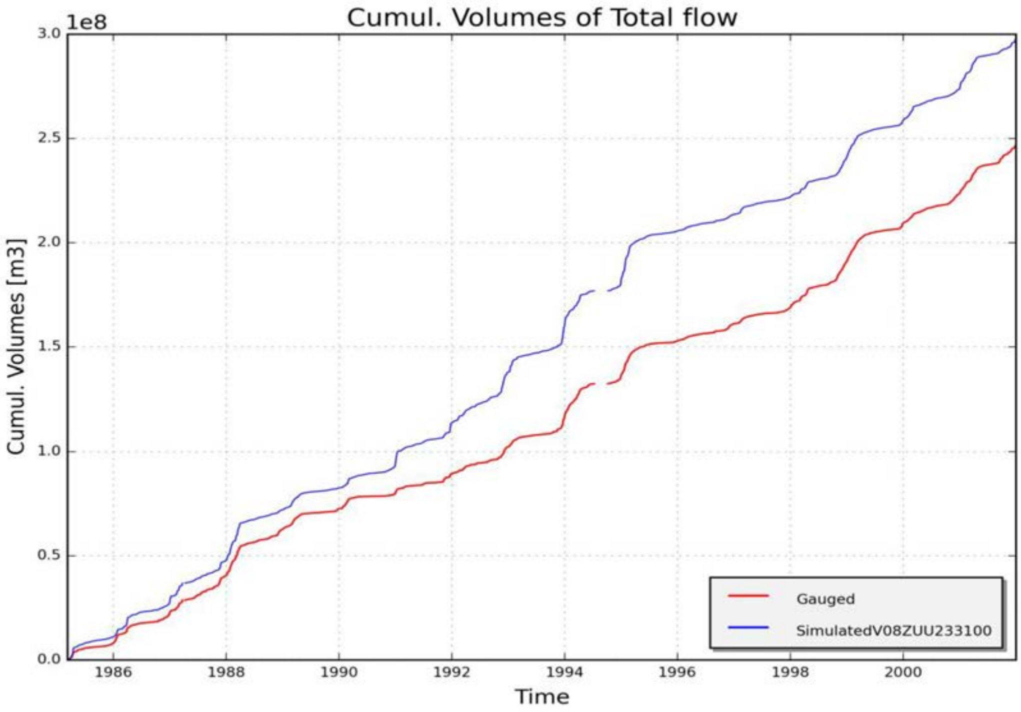
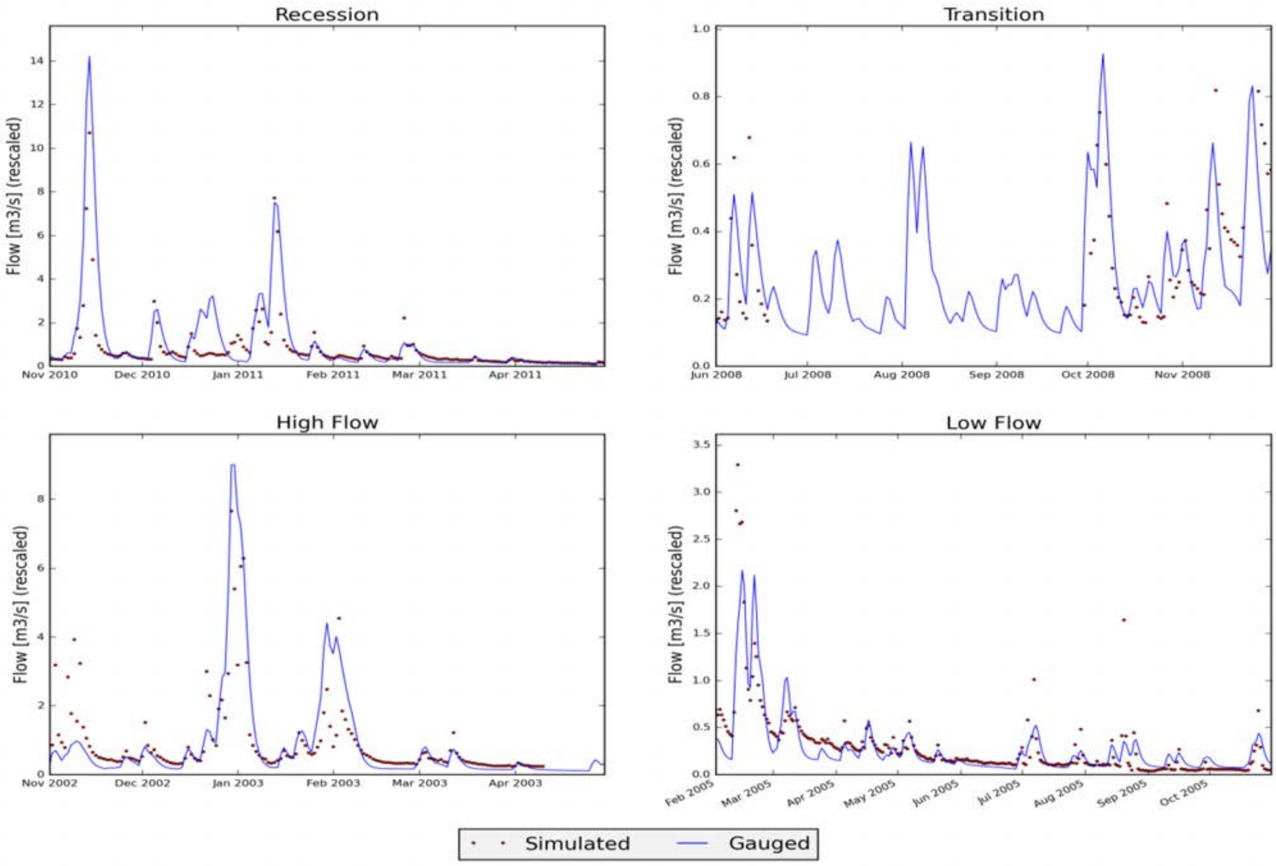


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V08ZUU233100, station 23310102 - Zuunbeek, St Pietersleeuw



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "W08SAMRON000" (DIJLE/ZENNEBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment W08SAMRON000 (Dijle/Zennebekken)

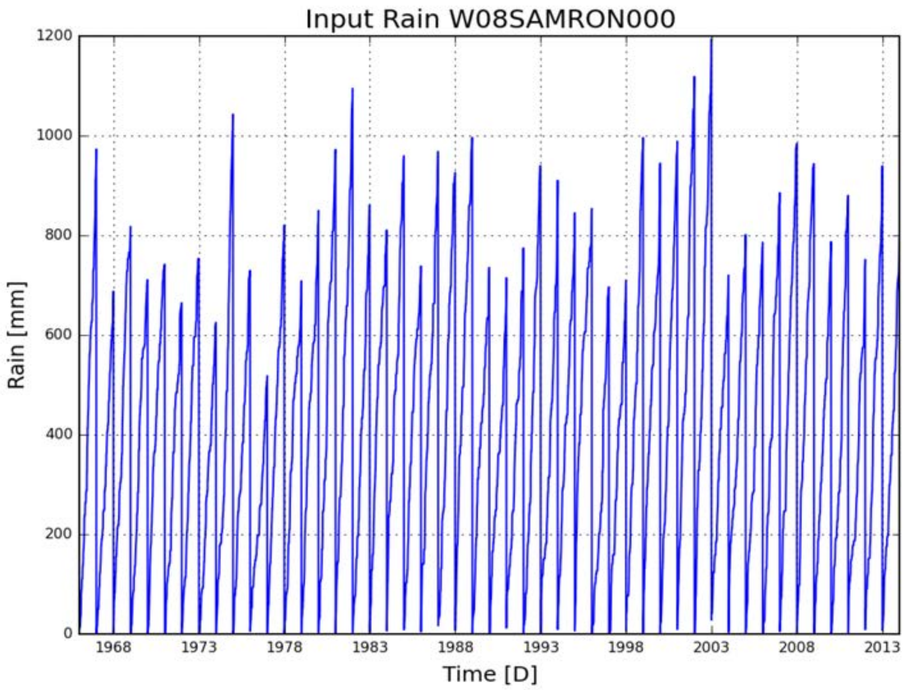
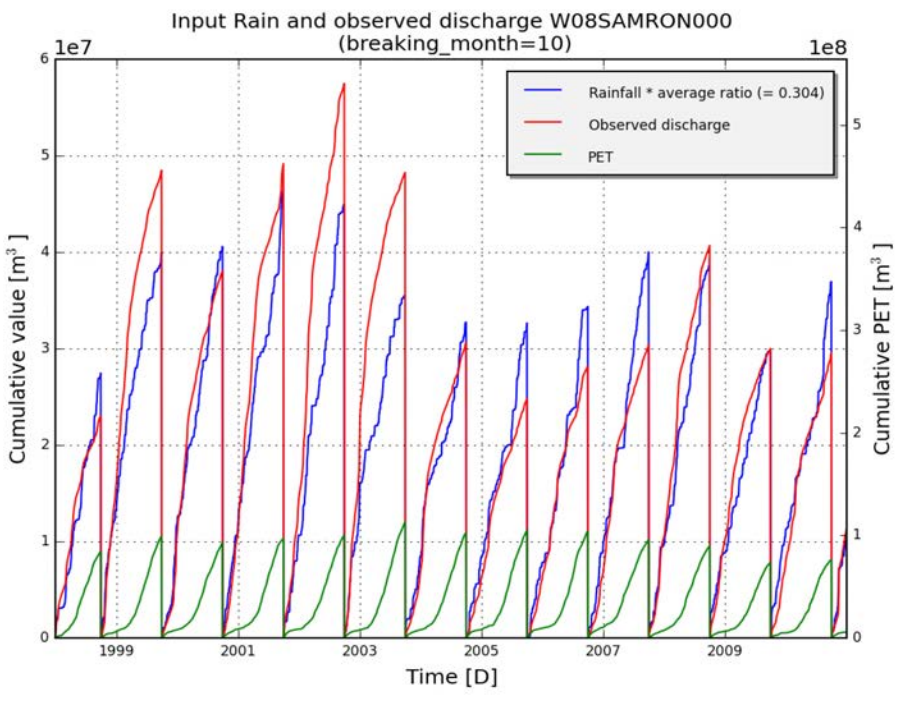


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W08SAMRON000 (Dijle/Zennebekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	W08SAMRON000
subcatchment_area [m²]	134097000
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.12), ('bevaporation', 2.0), ('cmin', 9.6), ('cmax', 471.0), ('CKBF', 300.0), ('CK1', 19.0), ('CK2', 27.0), ('bdrainage', 1.0), ('kdrainage', 17557.0), ('PDM.TG', 6.5), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1998 - 2010)

	Full year	Summer	Winter
NS	0.442	0.541	0.126
NS_log	0.702	0.504	0.619
NS_rel	0.785	0.766	0.654
RelErr	5.6 %	0.8 %	17.2 %
VolBias	0.094	0.061	0.174

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.447	0.551	0.112
NS_log	0.722	0.497	0.623
NS_rel	0.822	0.796	0.68
RelErr	-3.2 %	-10.2 %	5.3 %
VolBias	0.031	-0.025	0.112

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)

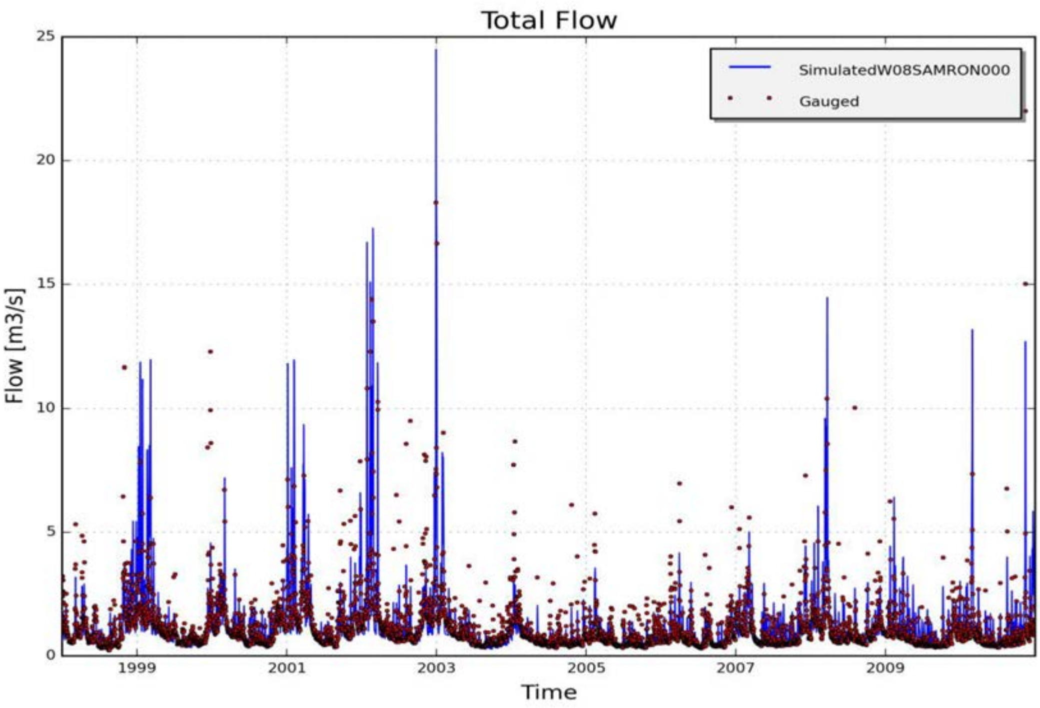


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres (calibration period)

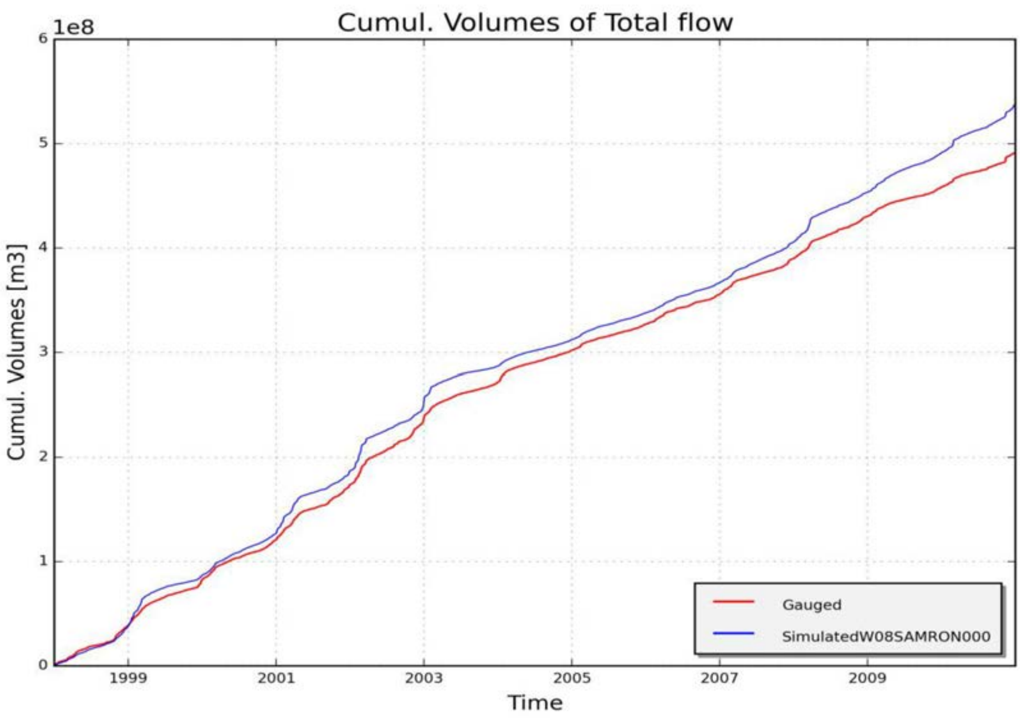


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres (validation period)

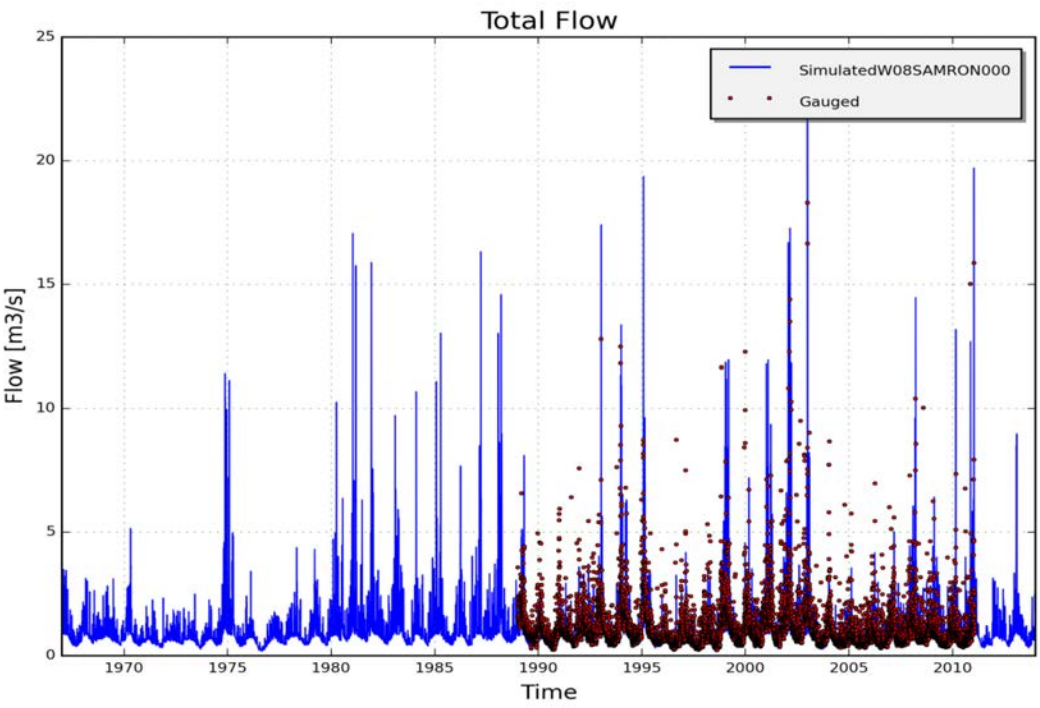


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres (validation period)

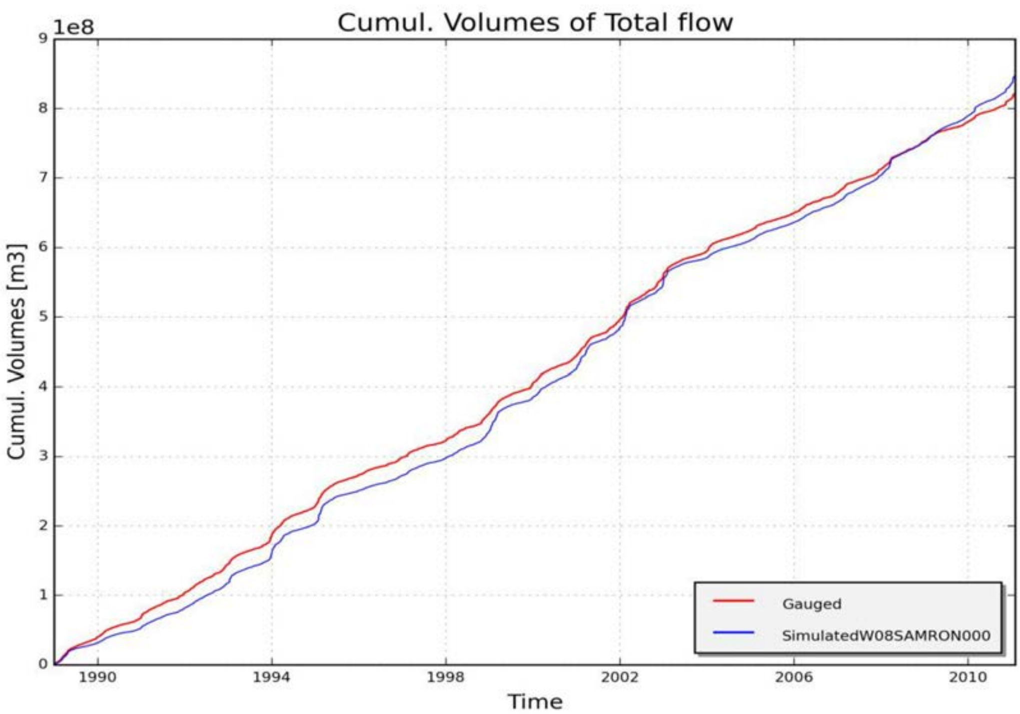


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres

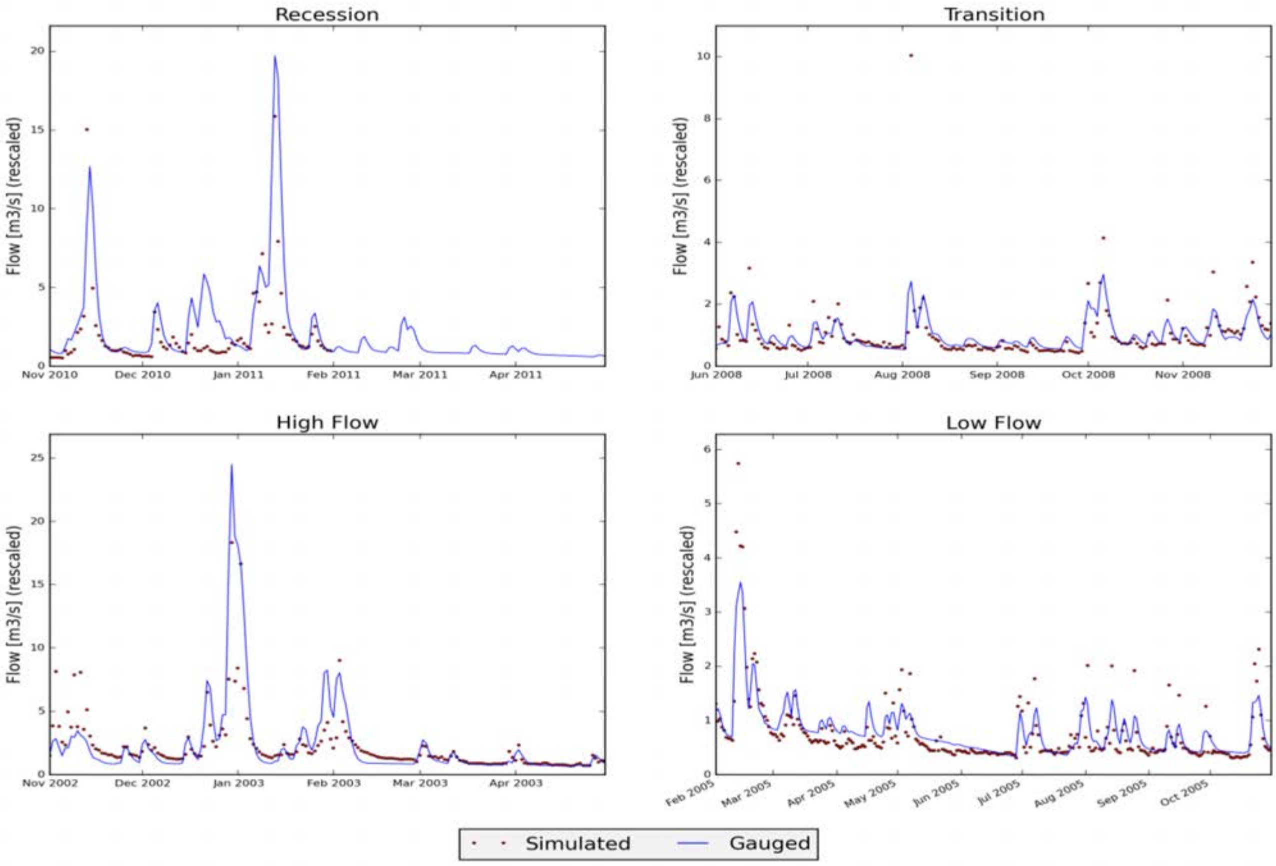


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres

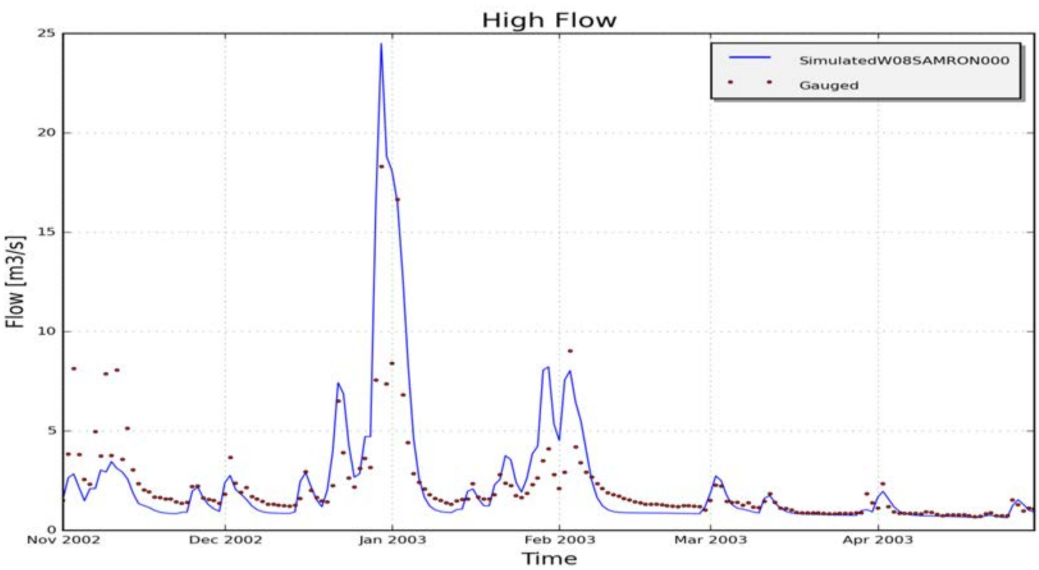


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres

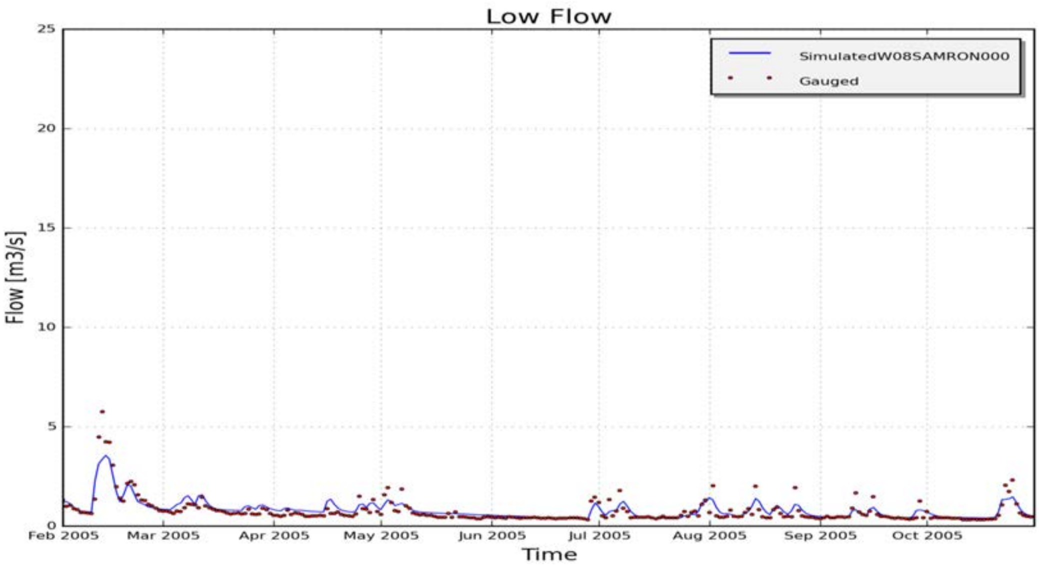
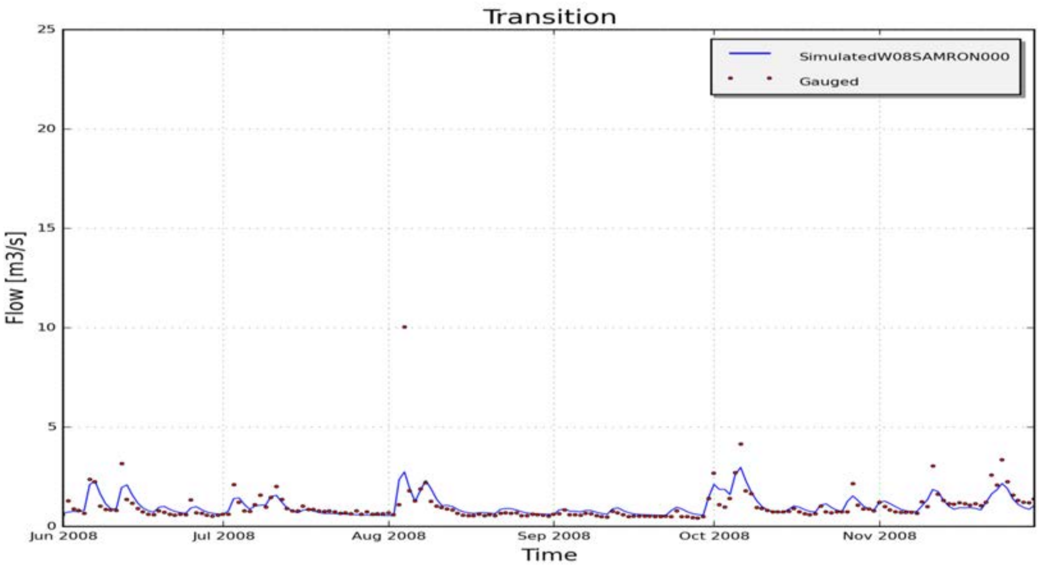


Figure 10: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment F01IJZ468000, station 46810102 - Ijzer; Haringe



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "W08SENRON010" (DIJLE/ZENNEBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment W08SENRON010 (Dijle/Zennebekken)

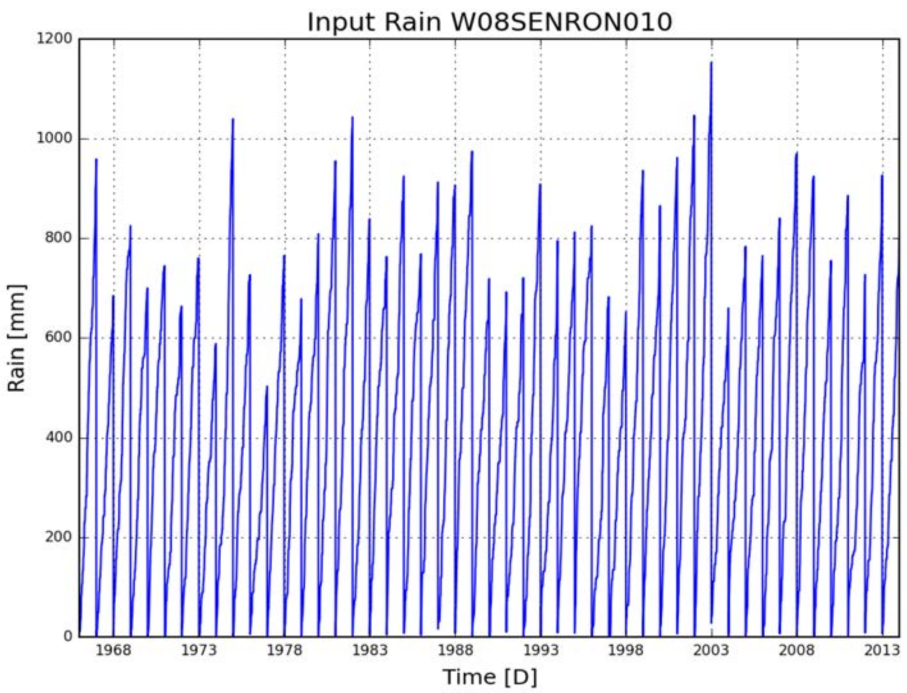
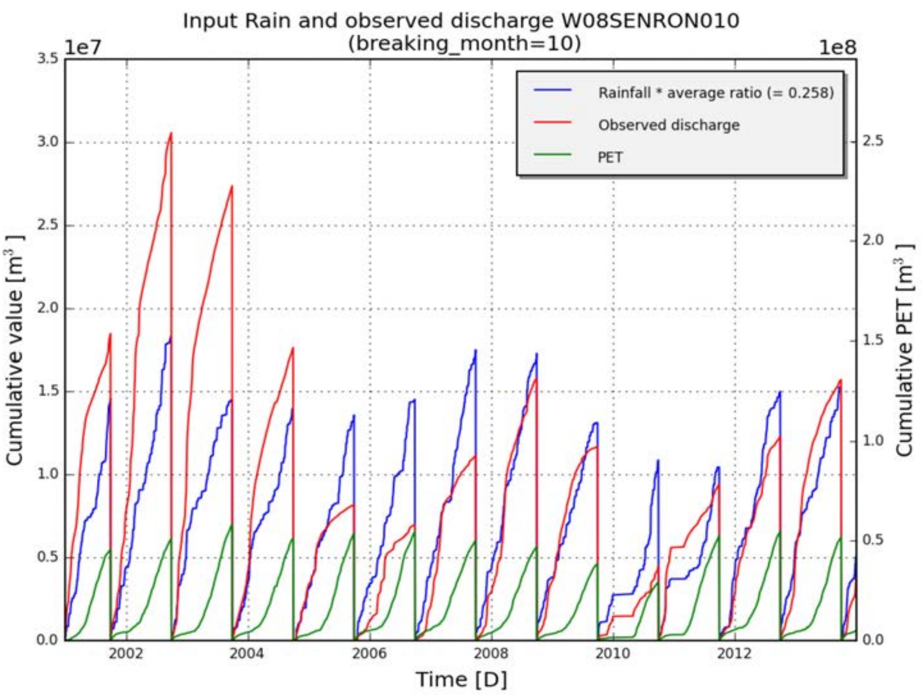


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W08SENRON010 (Dijle/Zennebekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	W08SENRON010
subcatchment_area [m²]	70364773
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.1), ('bevaporation', 2.0), ('cmin', 10.0), ('cmax', 489.0), ('CKBF', 300.0), ('CK1', 32.0), ('CK2', 25.0), ('bdrainage', 1.0), ('kdrainage', 26851.0), ('PDM.TG', 4.3), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2005 - 2013)

	Full year	Summer	Winter
NS	0.568	0.372	0.52
NS_log	0.398	-0.103	0.595
NS_rel	-0.458	-2.221	0.482
RelErr	-1.7 %	-4.6 %	1.3 %
VolBias	0.049	0.109	0.022

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.455	0.349	0.379
NS_log	0.45	0.064	0.49
NS_rel	0.091	-0.805	0.507
RelErr	-10.4 %	-30.0 %	-8.1 %
VolBias	-0.065	-0.216	-0.043

Observed and simulated timeseries for optimum parameters

Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W08SENRON010, station L5670 -Senette, Ronquieres (calibration period)

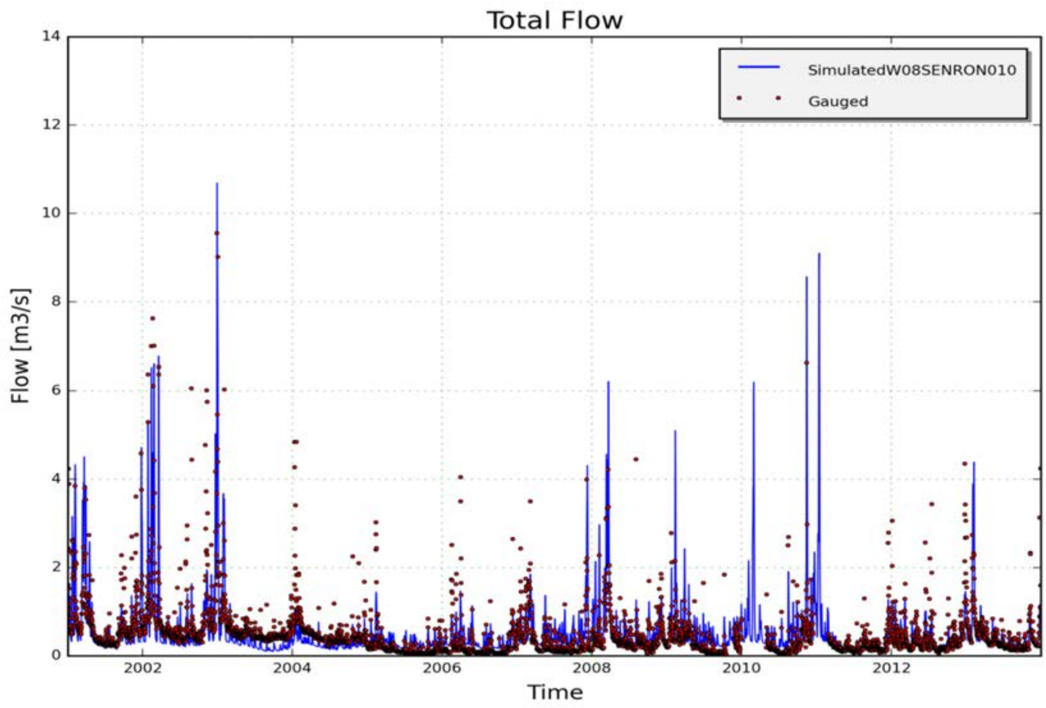


Fig b=140

Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W08SENRON010, station L5670 -Senette, Ronquieres (calibration period)

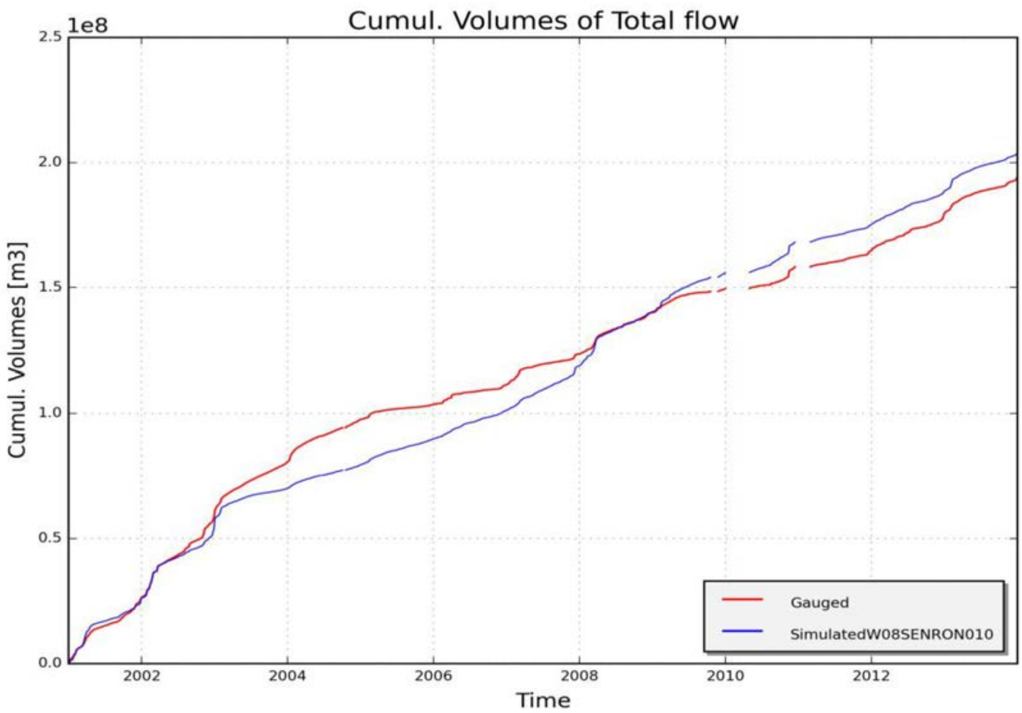


Fig b=137

Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W08SENRON010, station L5670 -Senette, Ronquieres (validation period)

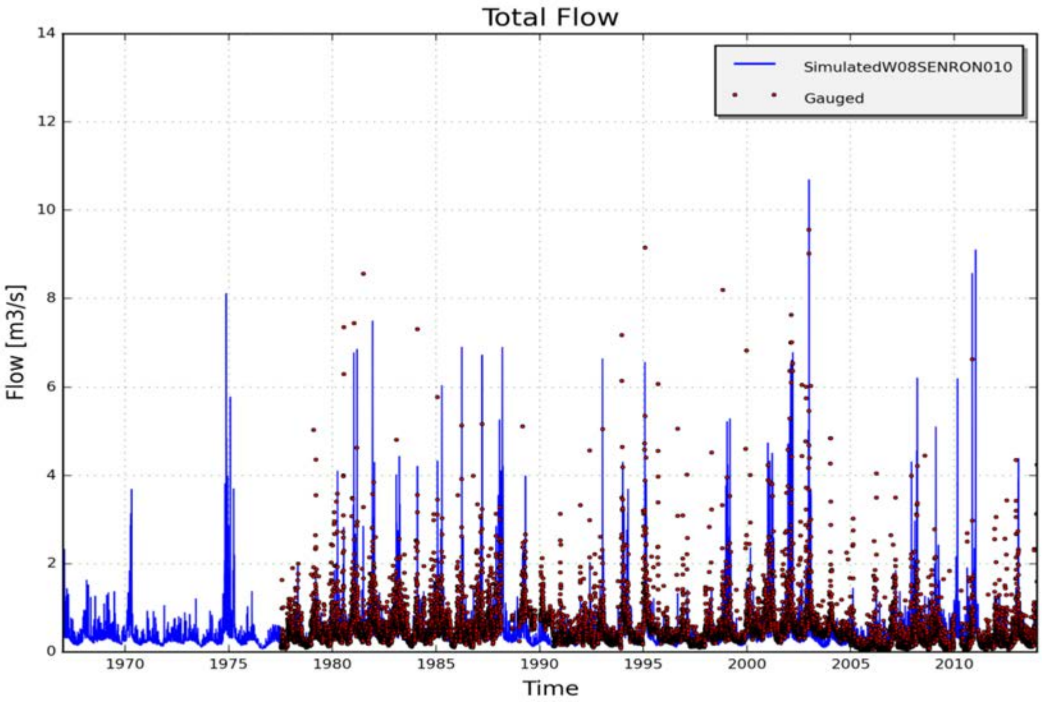


Fig b=140

Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W08SENRON010, station L5670 -Senette, Ronquieres (validation period)

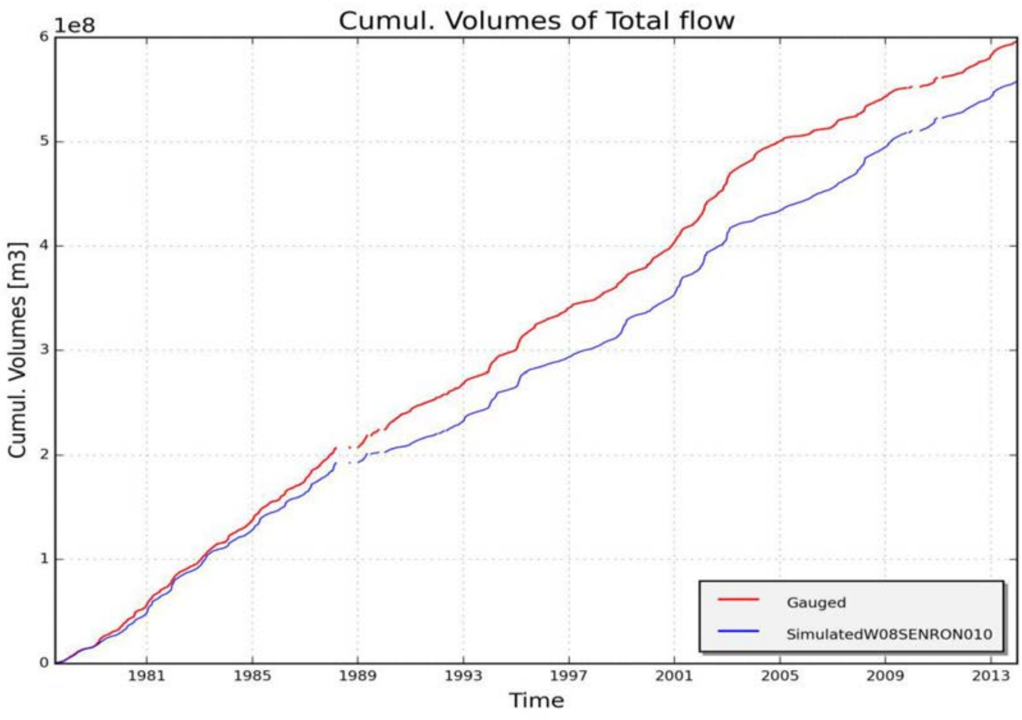
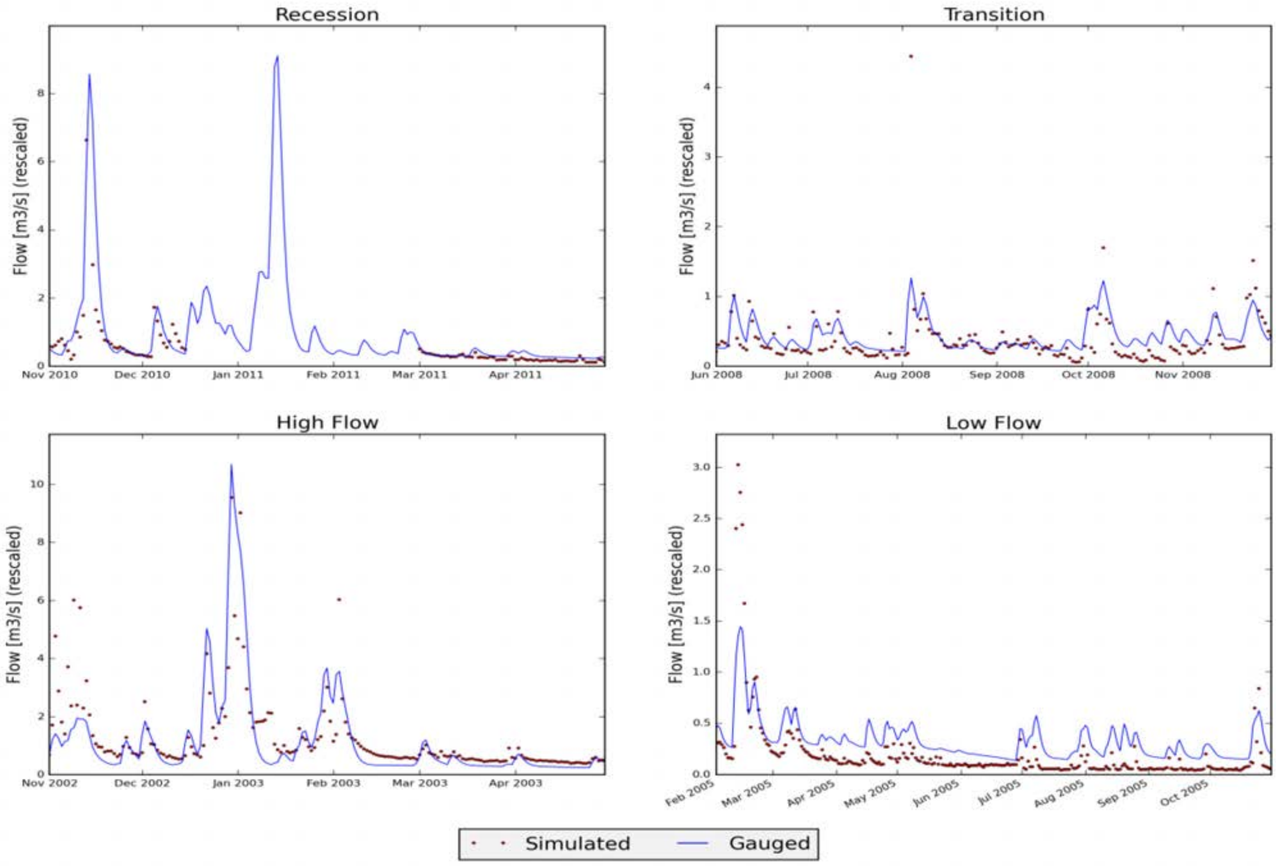


Fig b=137

Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W08SENRON010, station L5670 -Senette, Ronquieres



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "W08SENTUB030" (DIJLE/ZENNEBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment W08SENTUB030 (Dijle/Zennebekken)

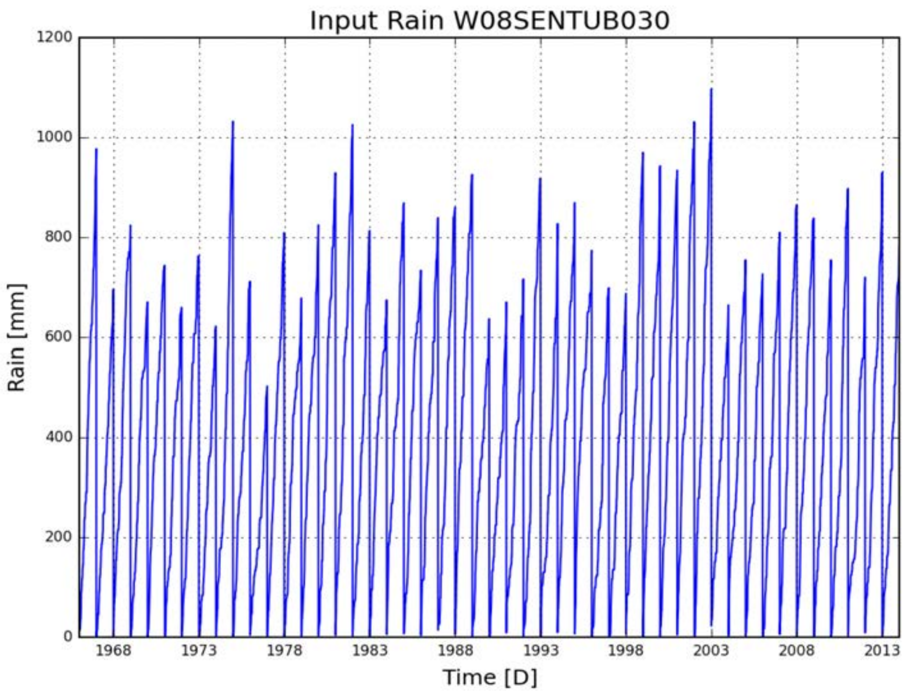
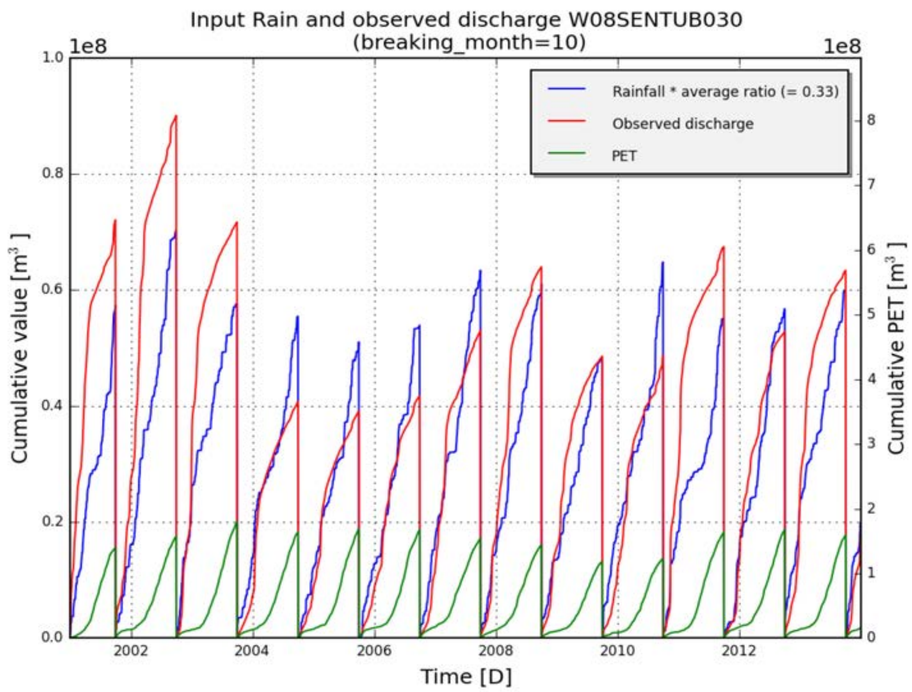


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W08SENTUB030 (Dijle/Zennebekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	W08SENTUB030
subcatchment_area [m²]	215911078
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.17), ('bevaporation', 2.0), ('cmin', 3.0), ('cmax', 356.0), ('CKBF', 300.0), ('CK1', 28.0), ('CK2', 39.0), ('bdrainage', 1.0), ('kdrainage', 20181.0), ('PDM.TG', 1.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.745	0.463	0.721
NS_log	0.758	0.28	0.731
NS_rel	0.887	0.709	0.855
RelErr	-2.1 %	12.5 %	-5.8 %
VolBias	-0.012	0.17	-0.077

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.711	0.555	0.683
NS_log	0.736	0.414	0.704
NS_rel	0.87	0.868	0.834
RelErr	-9.0 %	-20.0 %	-10.9 %
VolBias	-0.069	-0.115	-0.097

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)

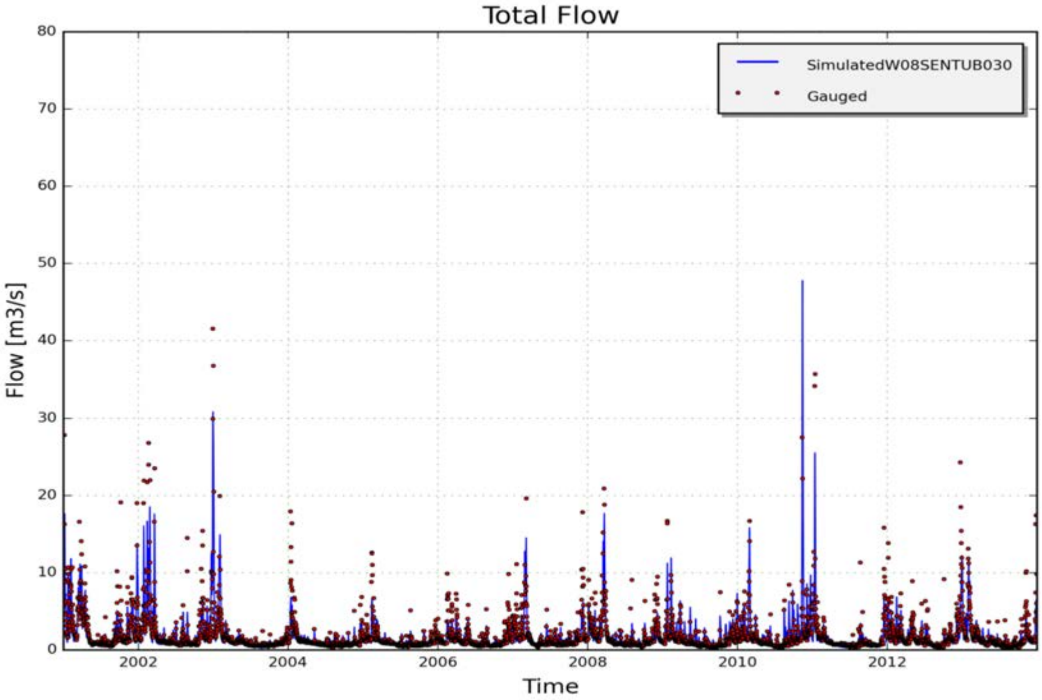


Fig b=140

Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize (calibration period)

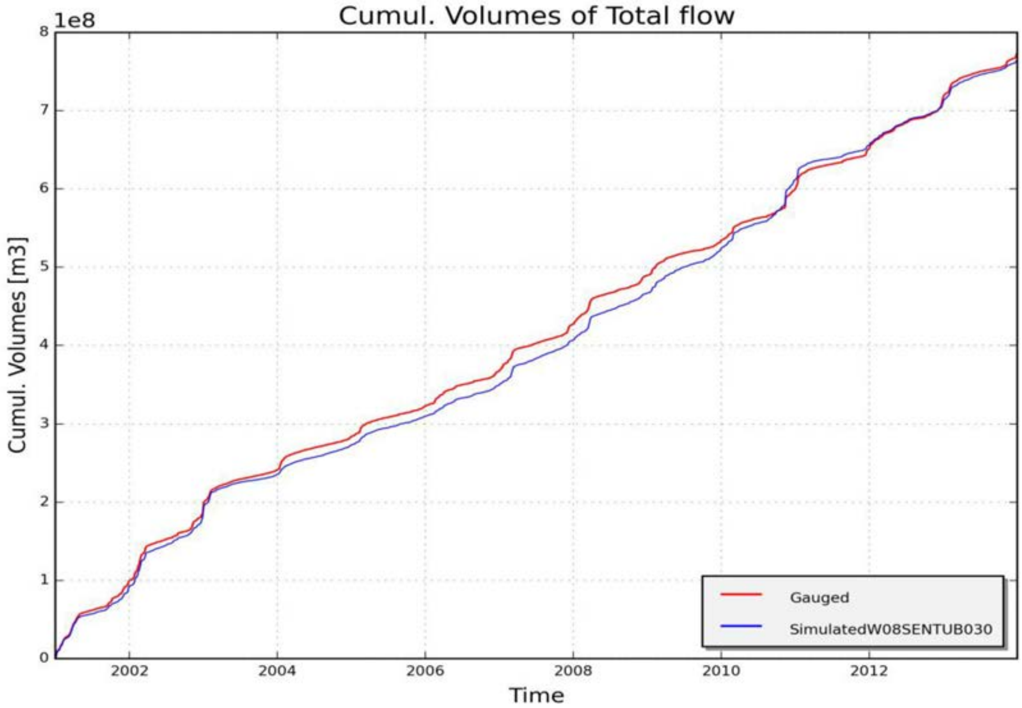


Fig b=137

Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize (validation period)

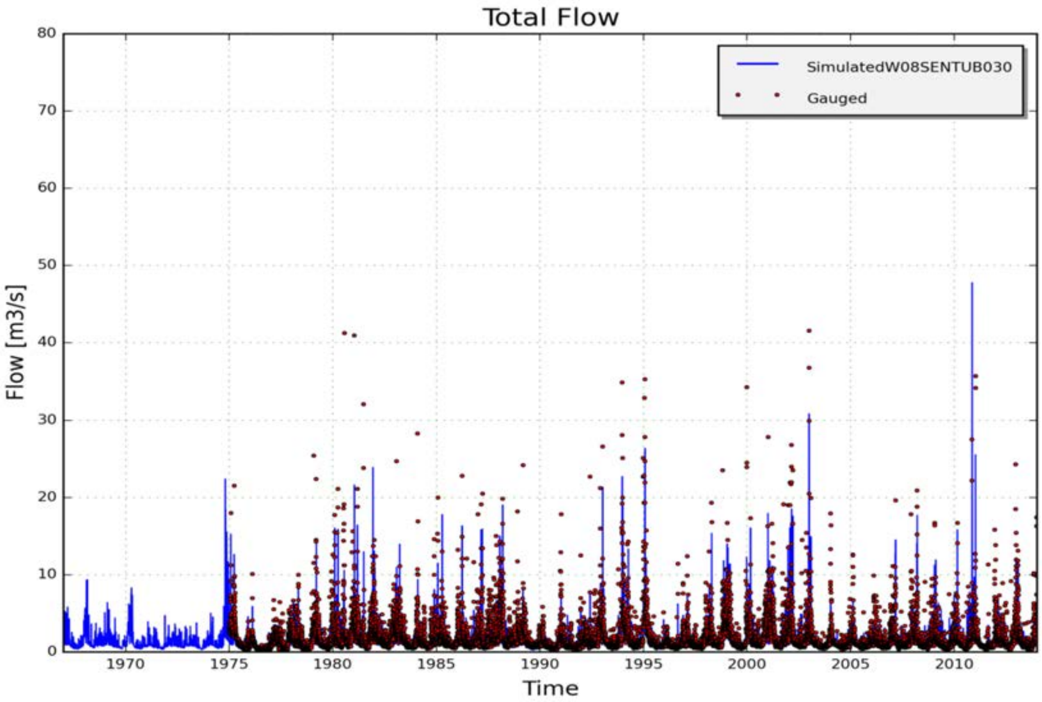


Fig b=140

Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize (validation period)

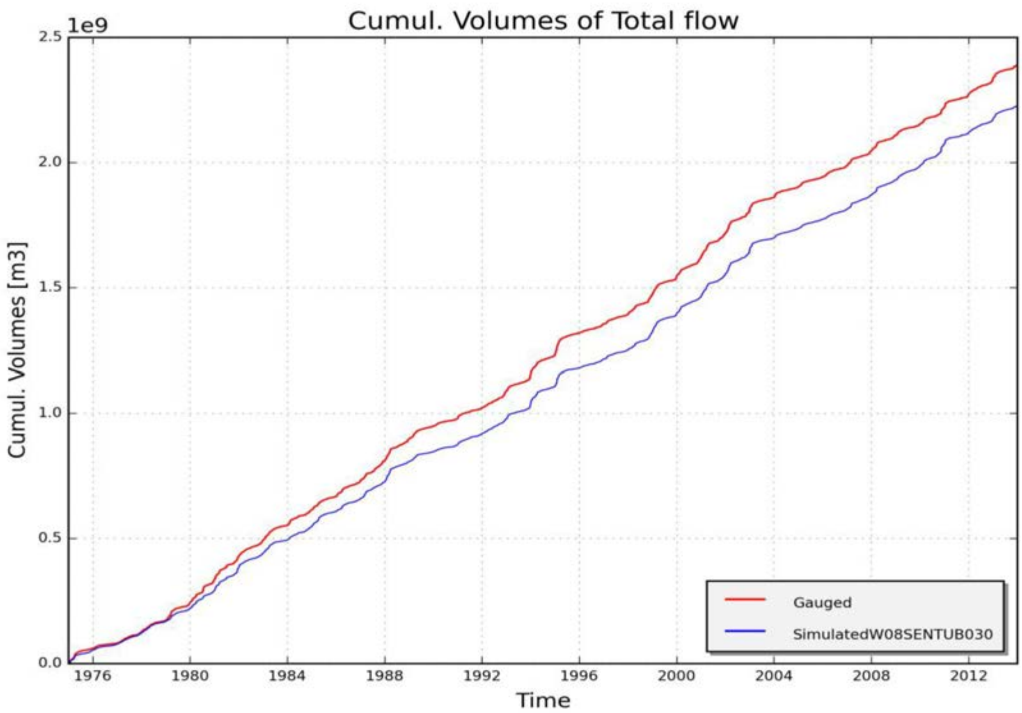
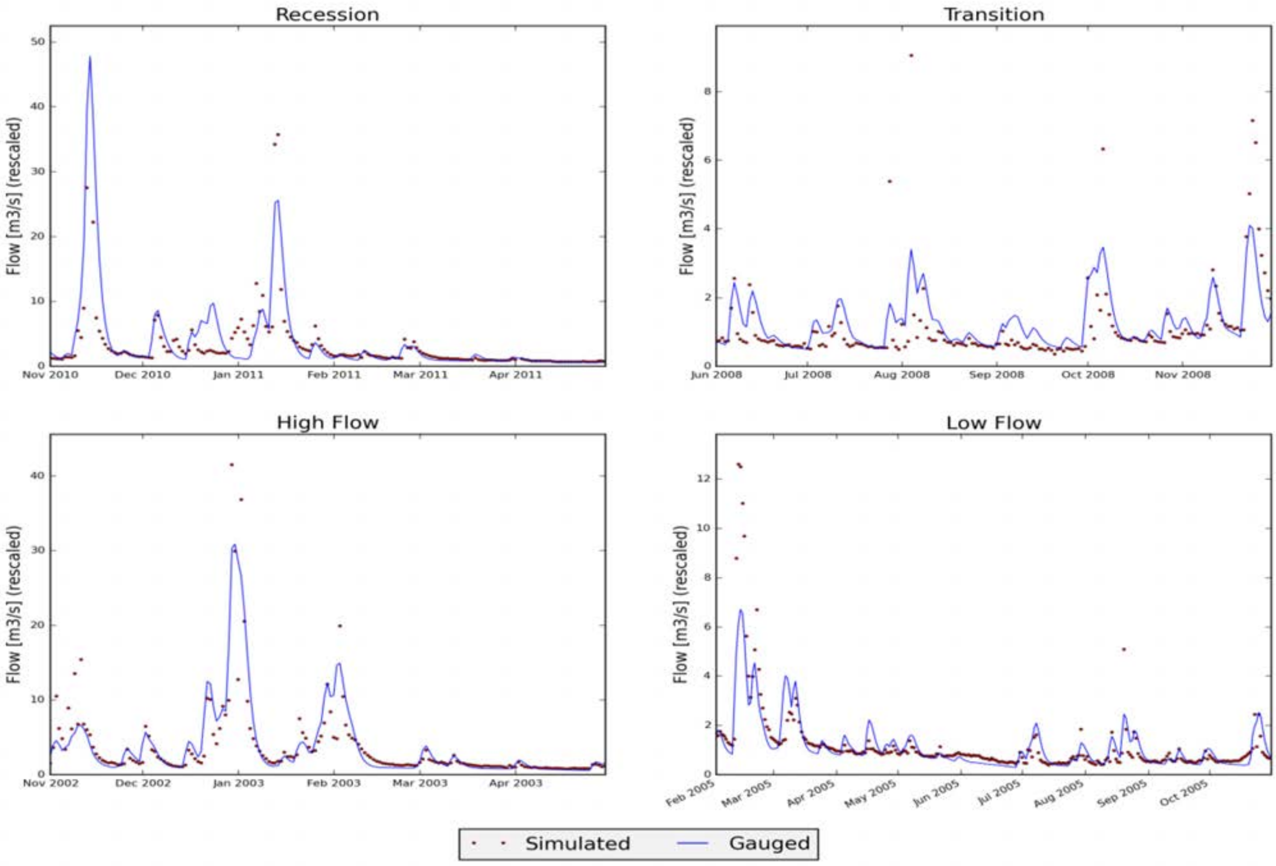


Fig b=137

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



Annexe 11 Demer

CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V09DEM136000" (DEMERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V09DEM136000 (Demerbekken)

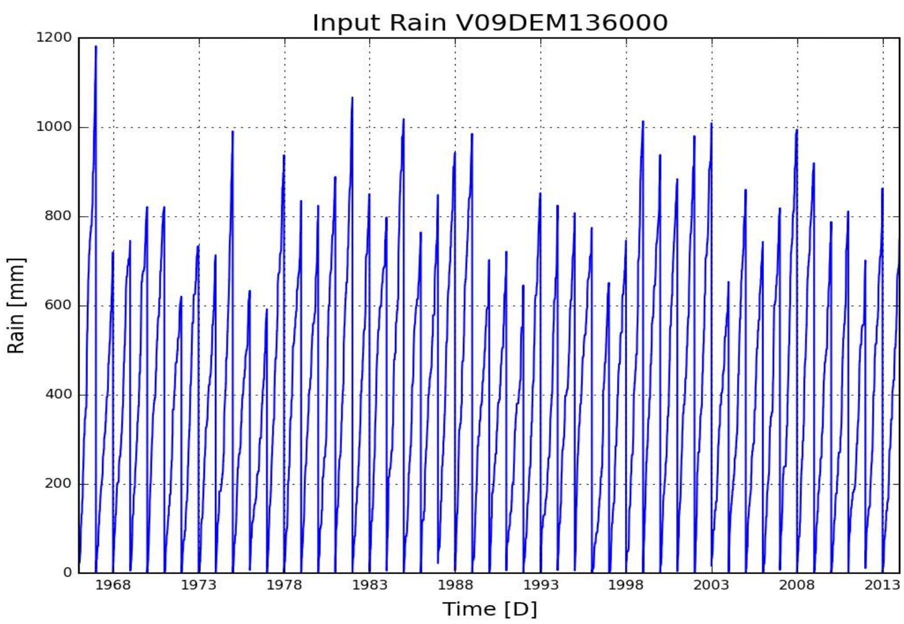
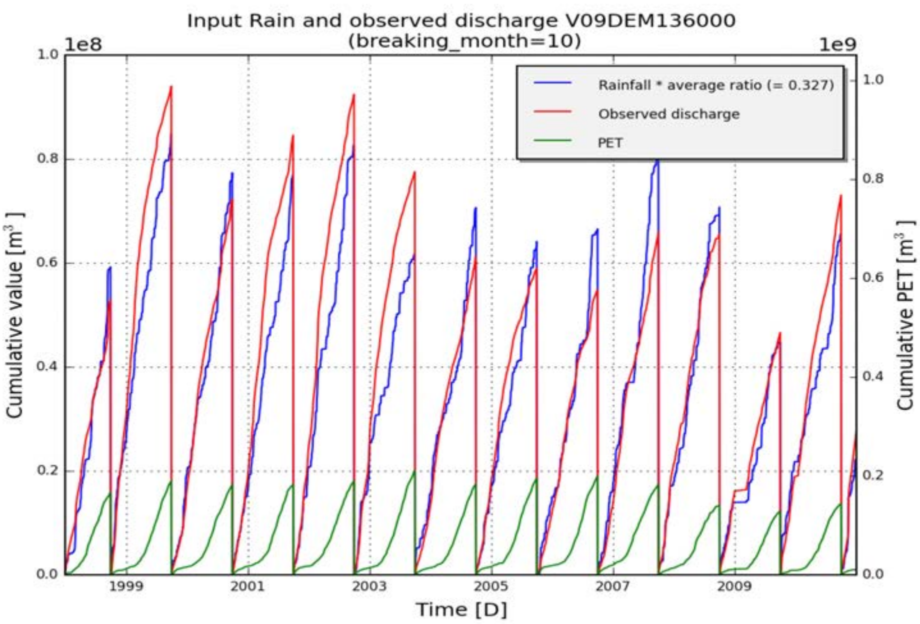


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09DEM136000 (Demerbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V09DEM136000
subcatchment_area [m²]	255882000
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.15), ('bevaporation', 2.0), ('cmin', 8.6), ('cmax', 604.0), ('CKBF', 300.0), ('CK1', 20.0), ('CK2', 30.0), ('bdrainage', 1.0), ('kdrainage', 16561.0), ('PDM.TG', 4.4), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1998 - 2010)

	Full year	Summer	Winter
NS	0.642	0.641	0.446
NS_log	0.741	0.603	0.703
NS_rel	0.804	0.772	0.777
RelErr	-0.1 %	3.5 %	-0.9 %
VolBias	0.013	0.056	-0.019

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.584	0.503	0.47
NS_log	0.636	0.445	0.667
NS_rel	0.794	0.755	0.782
RelErr	-1.2 %	0.7 %	-2.3 %
VolBias	-0.048	-0.063	-0.052

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)

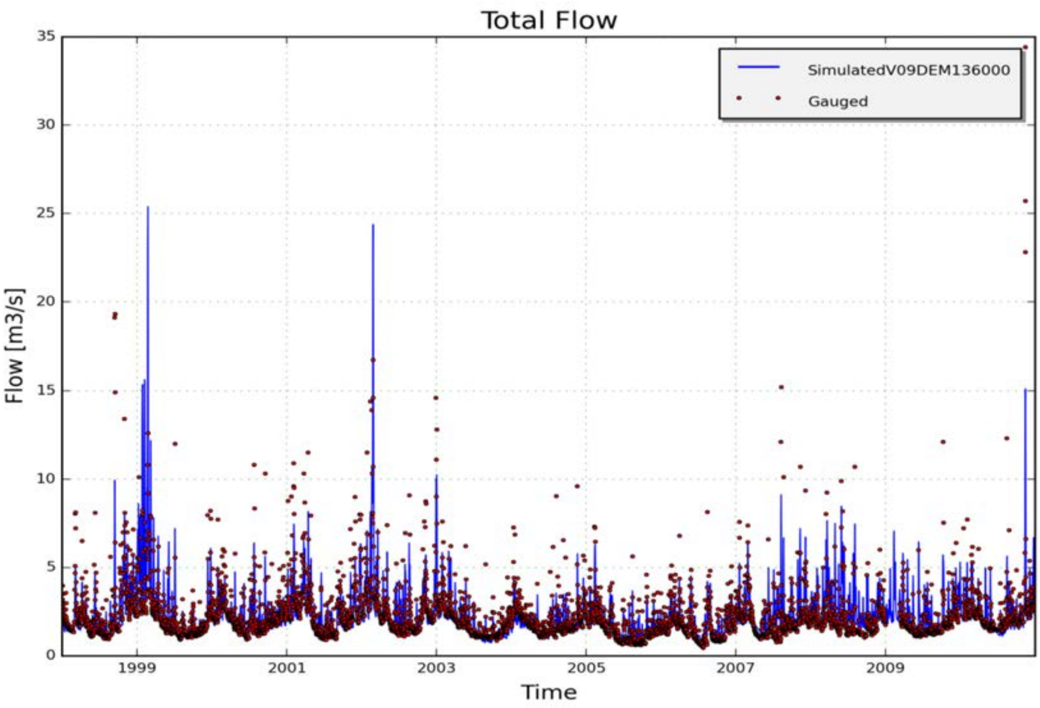


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09DEM136000, station 13610102 - Demer; Hasselt (calibration period)

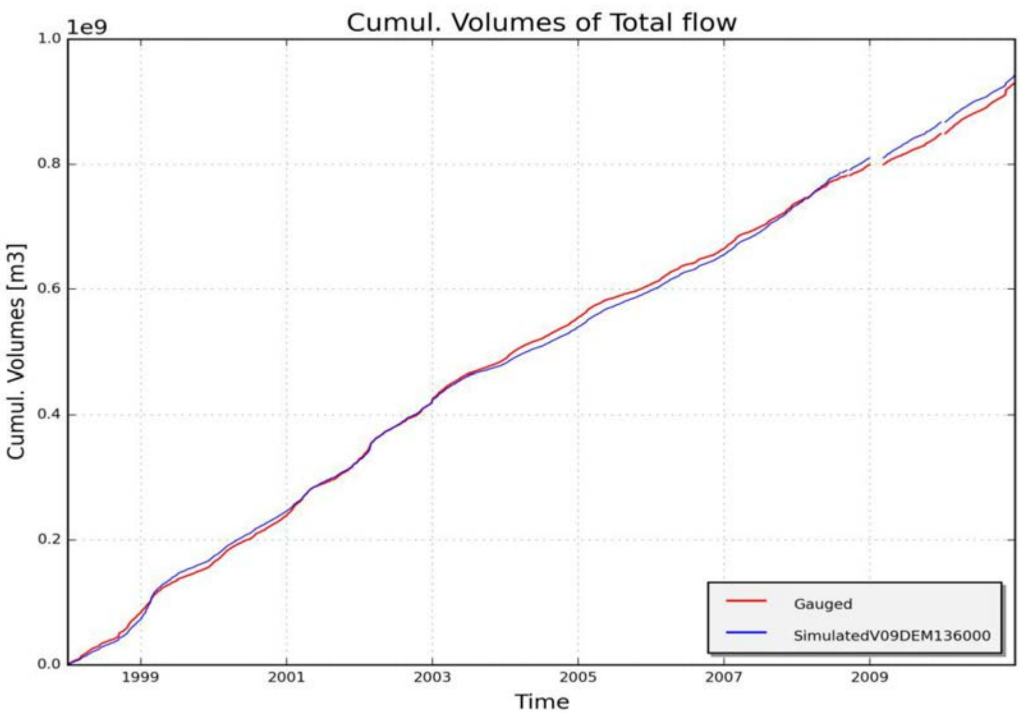


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09DEM136000, station 13610102 - Demer; Hasselt (validation period)

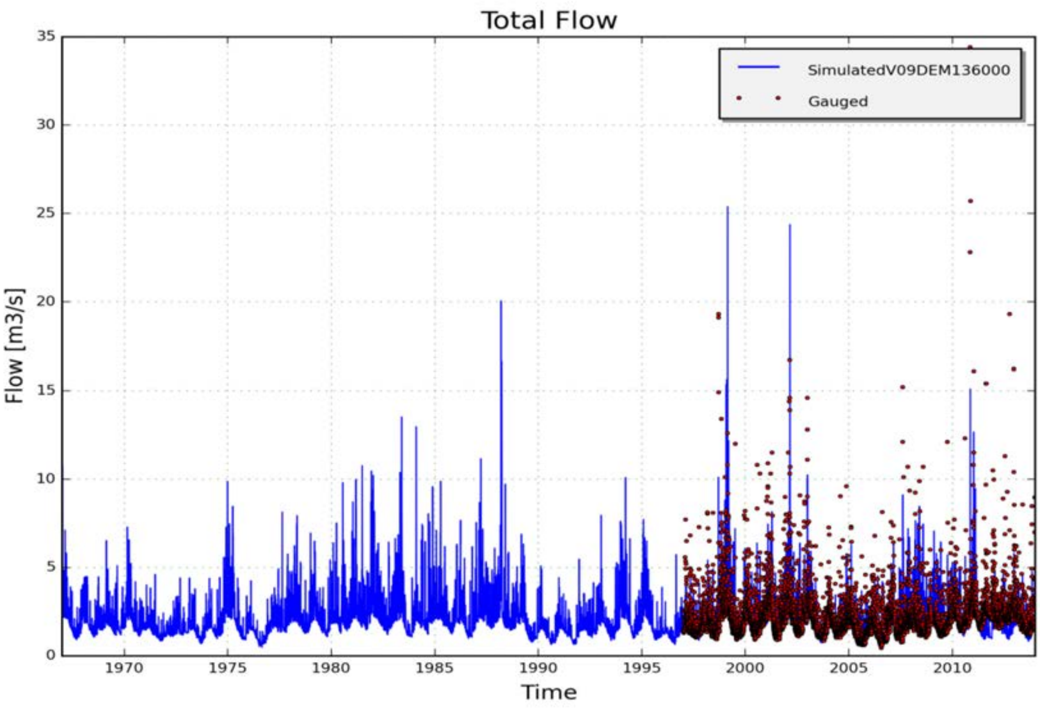


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09DEM136000, station 13610102 - Demer; Hasselt (validation period)

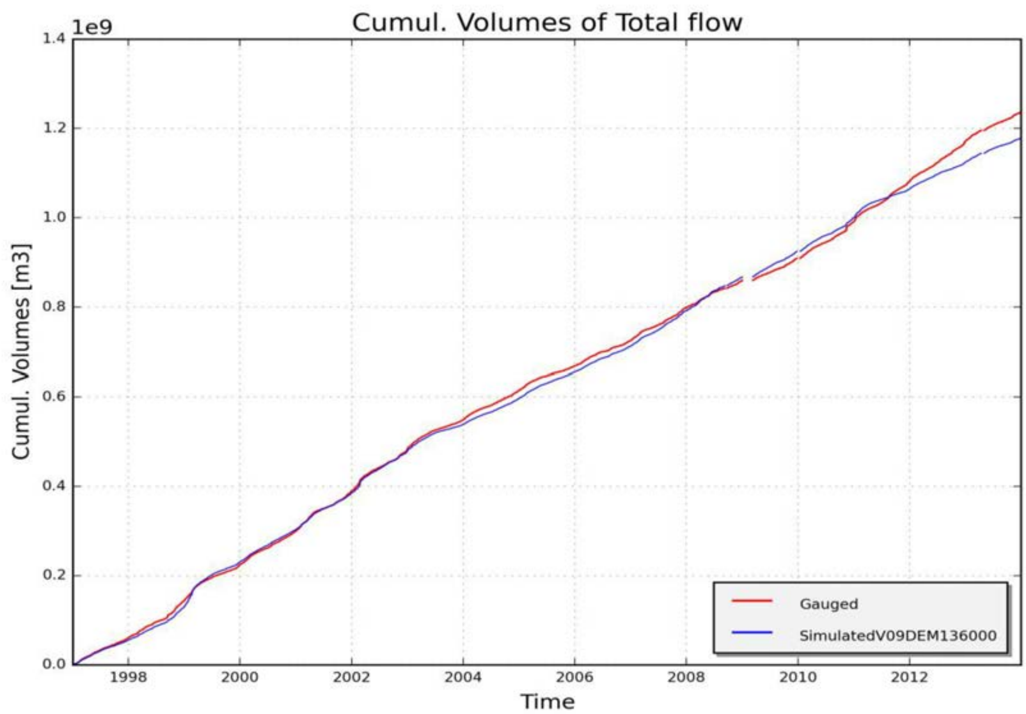


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09DEM136000, station 13610102 - Demer; Hasselt

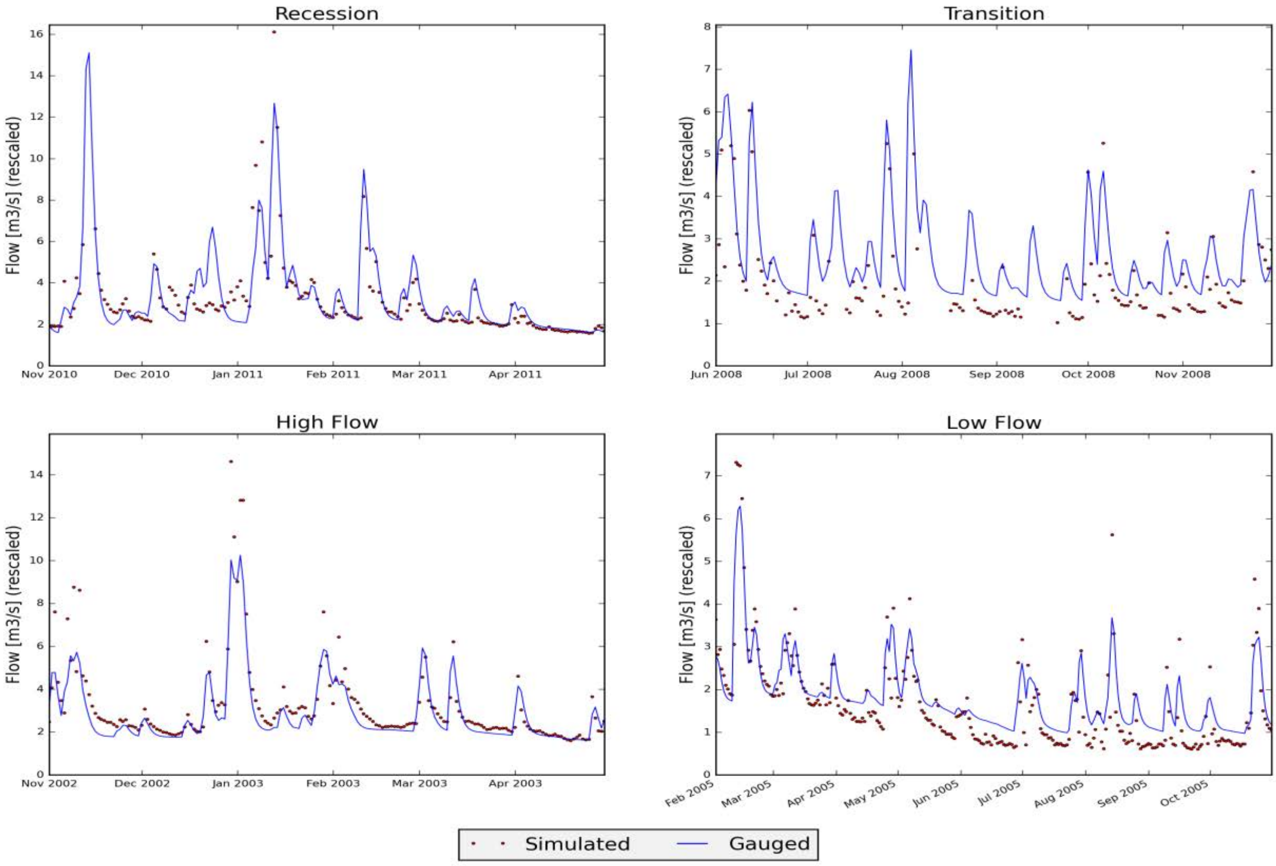


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09DEM136000, station 13610102 - Demer; Hasselt

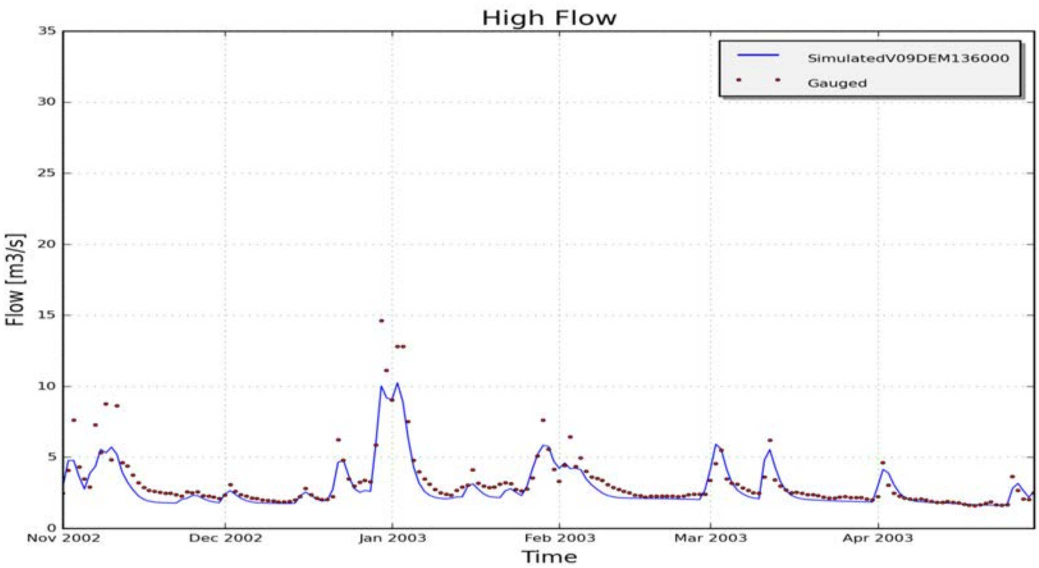


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09DEM136000, station 13610102 - Demer; Hasselt

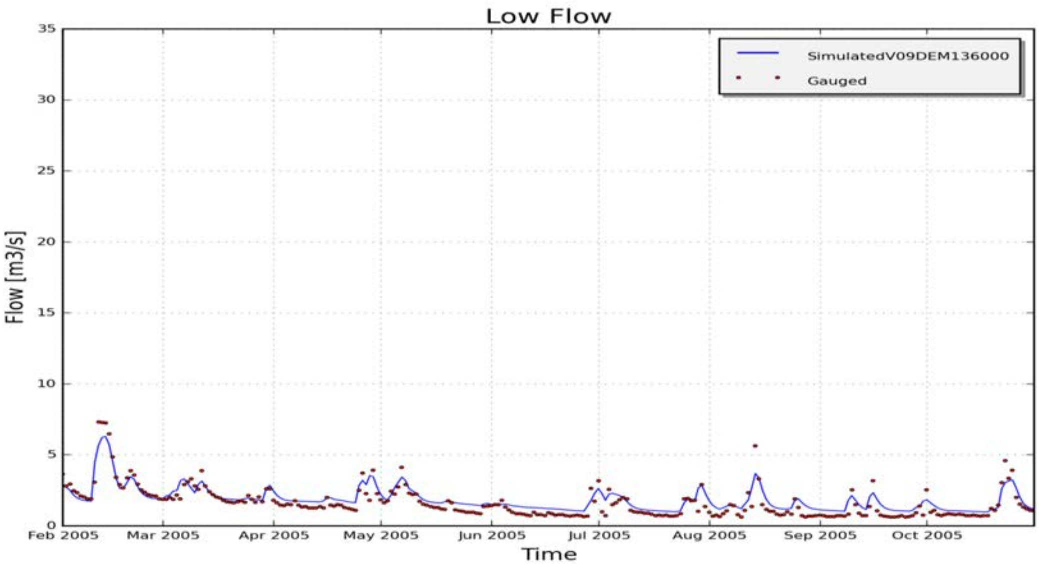
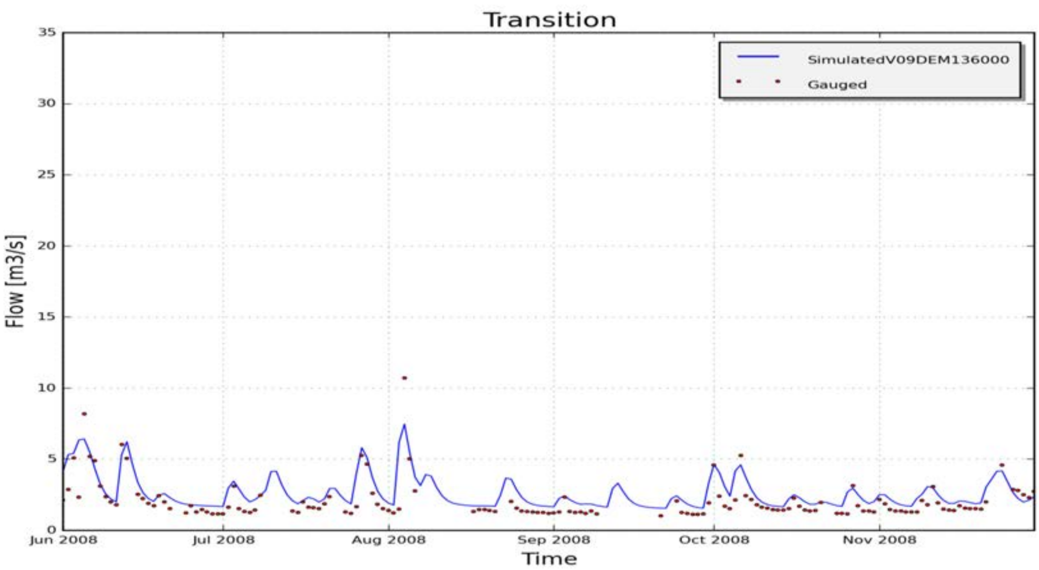


Figure 10: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09DEM136000, station 13610102 - Demer; Hasselt



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT " V09GET152080" (DEMERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V09GET152080 (Demerbekken)

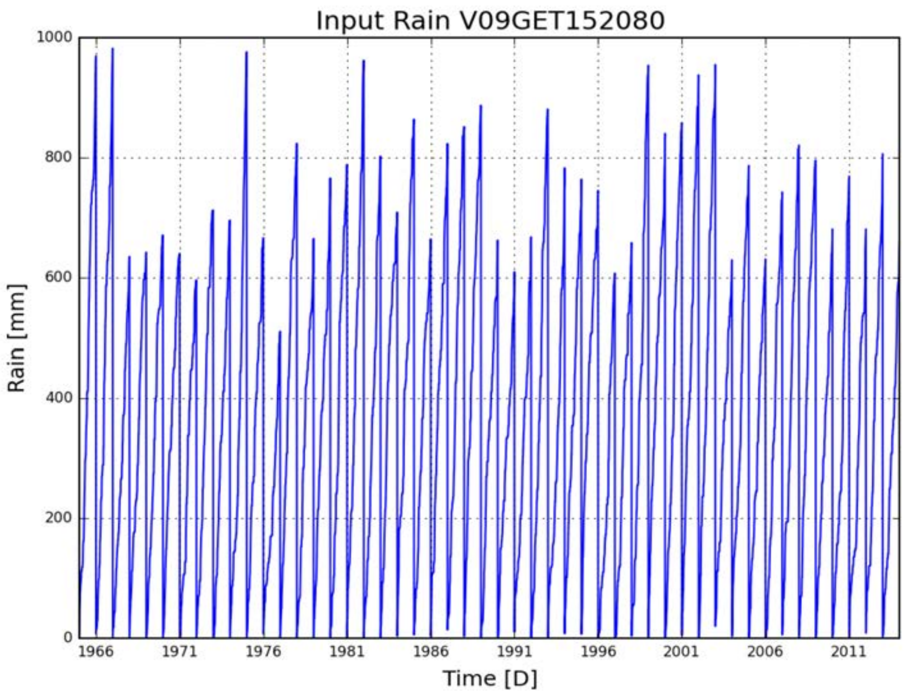
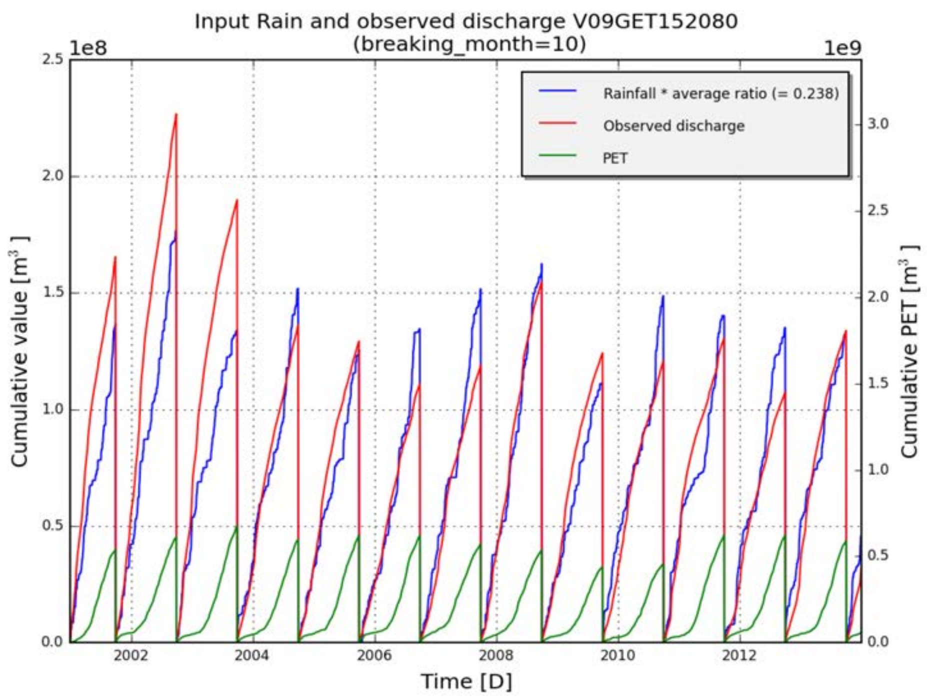


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09GET152080 (Demerbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V09GET152080
subcatchment_area [m²]	800395376
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.08), ('bevaporation', 2.0), ('cmin', 10.0), ('cmax', 542.0), ('CKBF', 300.0), ('CK1', 36.0), ('CK2', 35.0), ('bdrainage', 1.02), ('kdrainage', 21000.0), ('PDM.TG', 3.8), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.682	0.502	0.663
NS_log	0.614	0.332	0.671
NS_rel	0.687	0.486	0.741
RelErr	0.7 %	-0.0 %	-5.3 %
VolBias	0.072	0.086	-0.006

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.521	0.522	0.221
NS_log	0.652	0.295	0.662
NS_rel	0.678	0.493	0.636
RelErr	8.6 %	20.9 %	-0.7 %
VolBias	0.093	0.177	0.013

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)

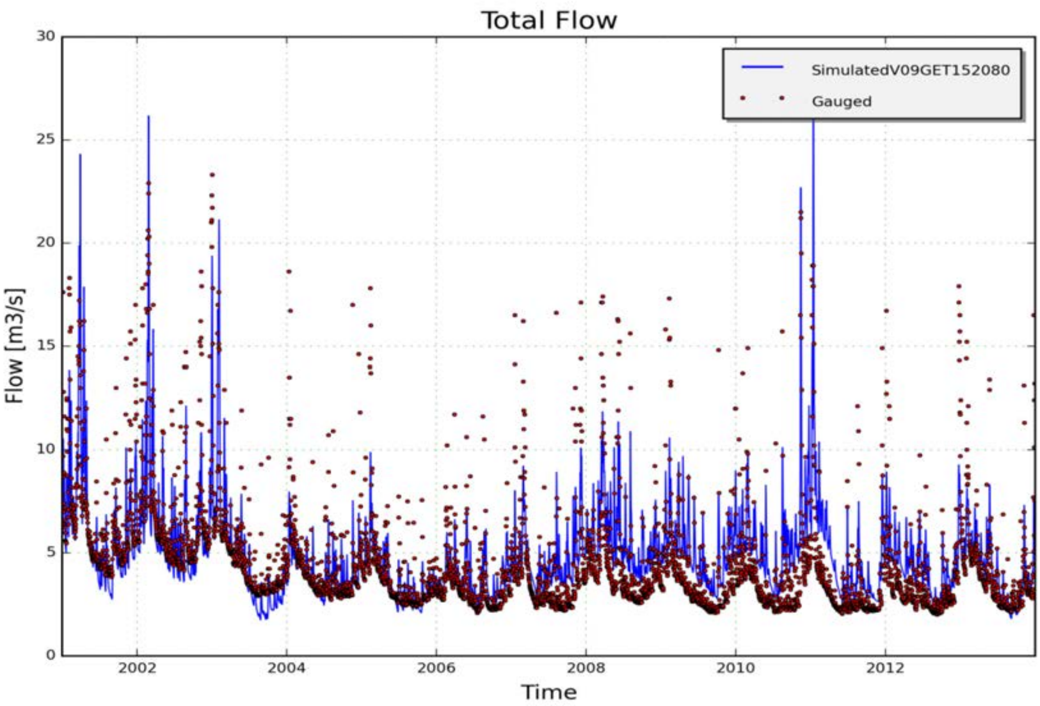


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09GET152080, station 15210102 - Gete; Halen (calibration period)

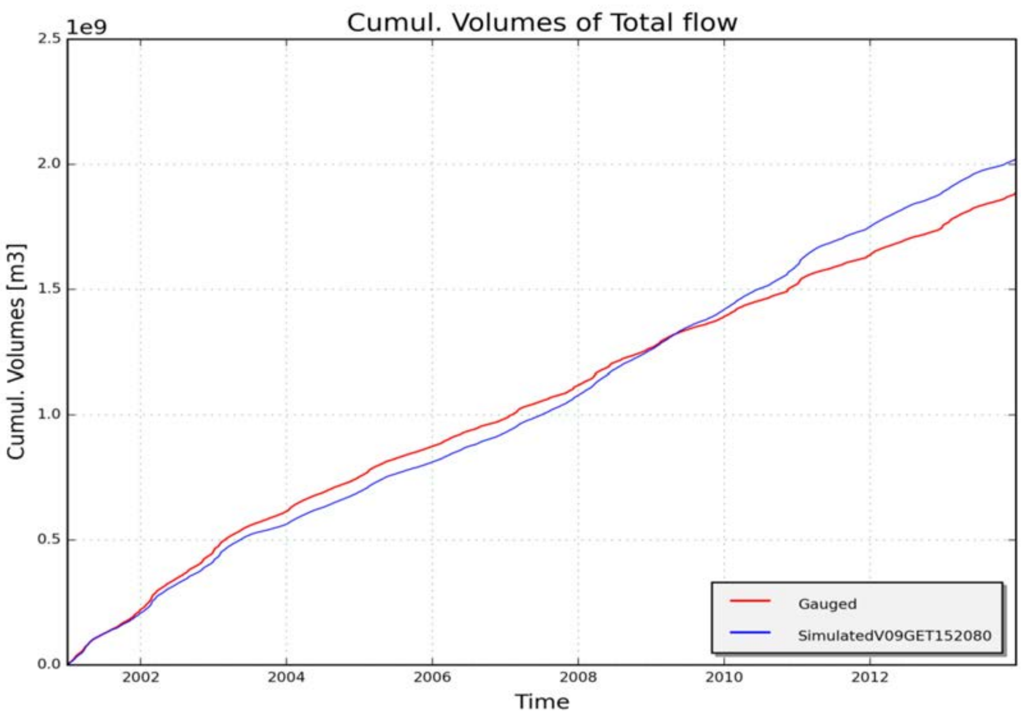


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09GET152080, station 15210102 - Gete; Halen (validation period)

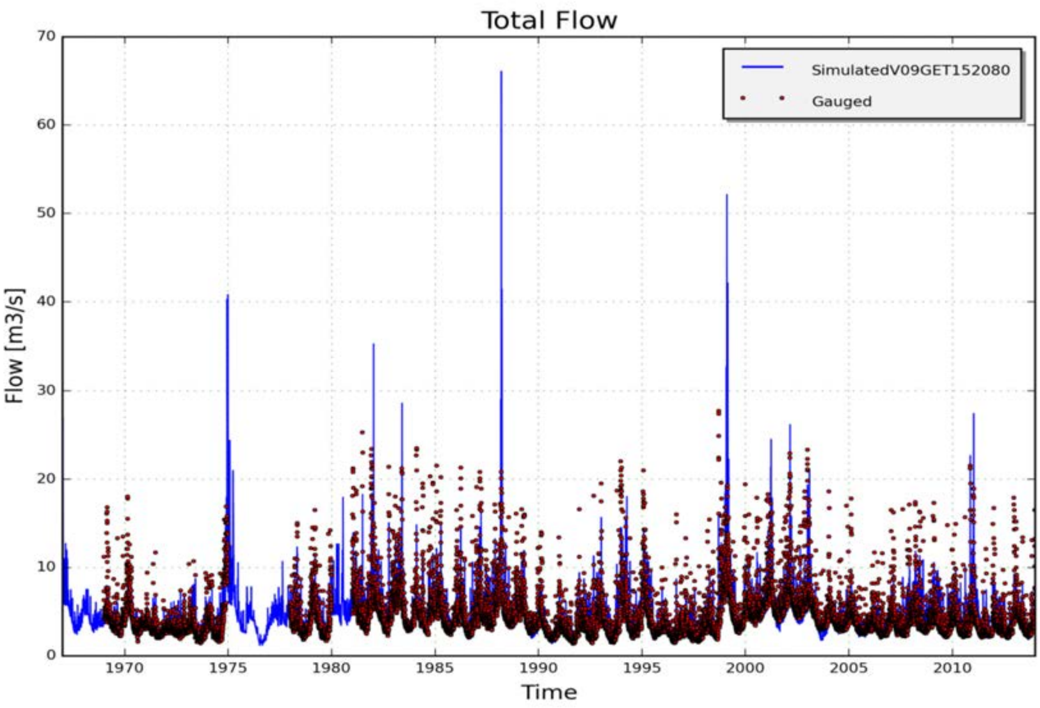


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09GET152080, station 15210102 - Gete; Halen (validation period)

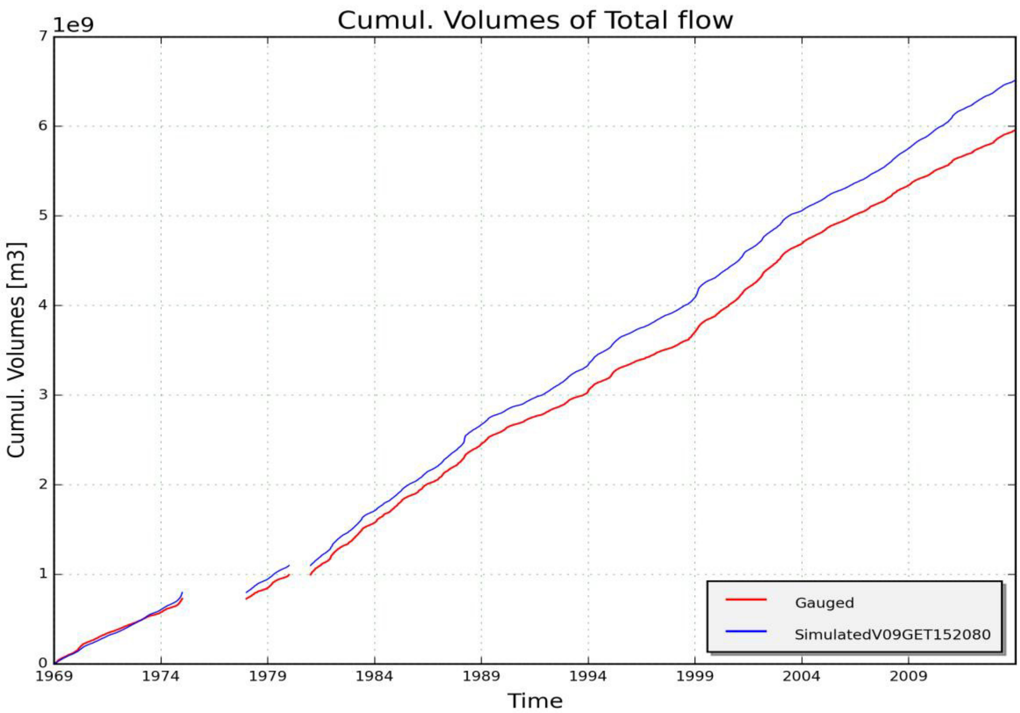
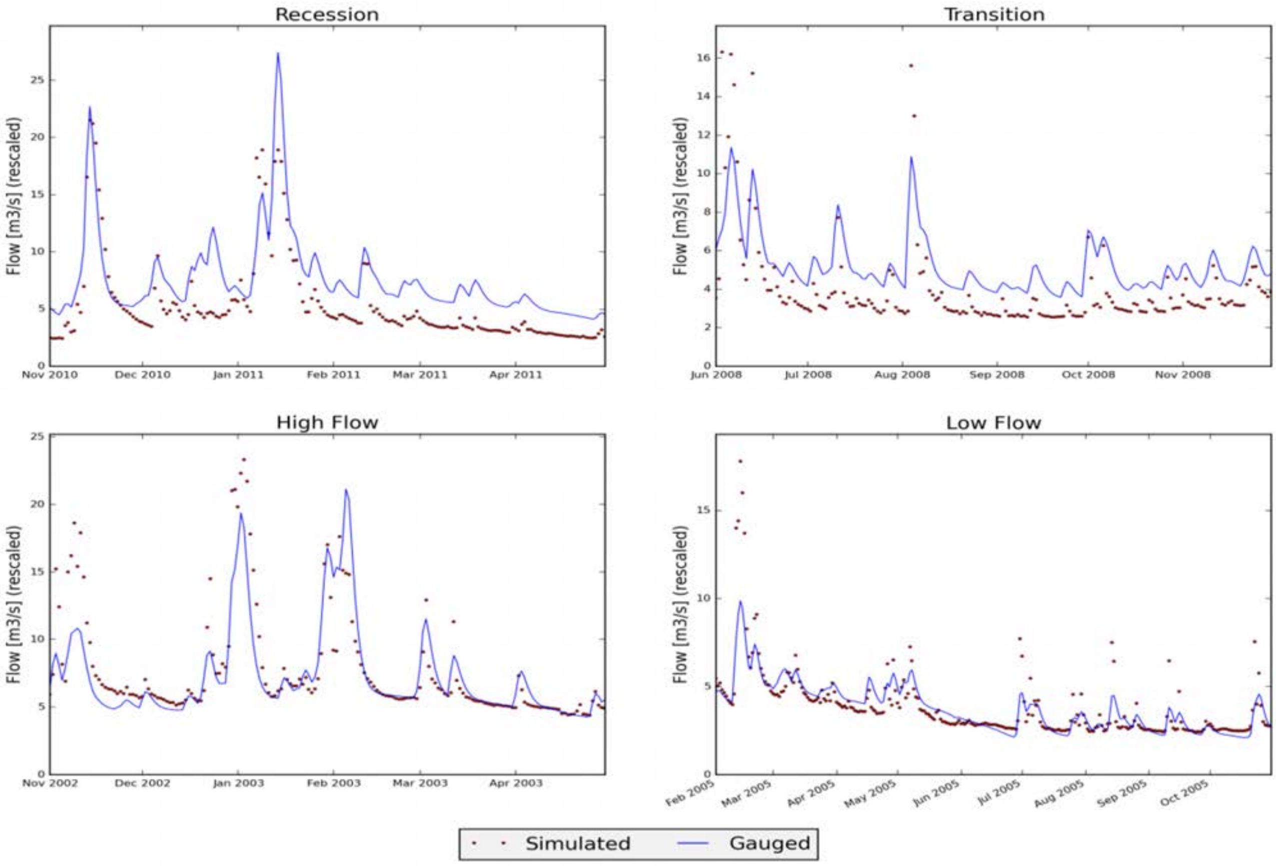


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09GET152080, station 15210102 - Gete; Halen



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT " V09HER163010" (DEMERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V09HER163010 (Demerbekken)

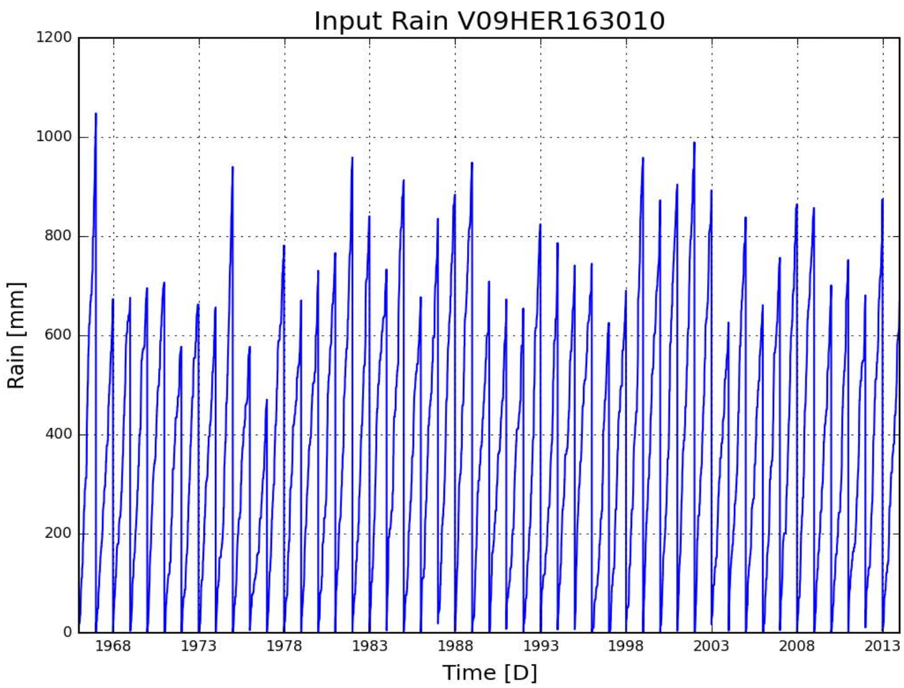
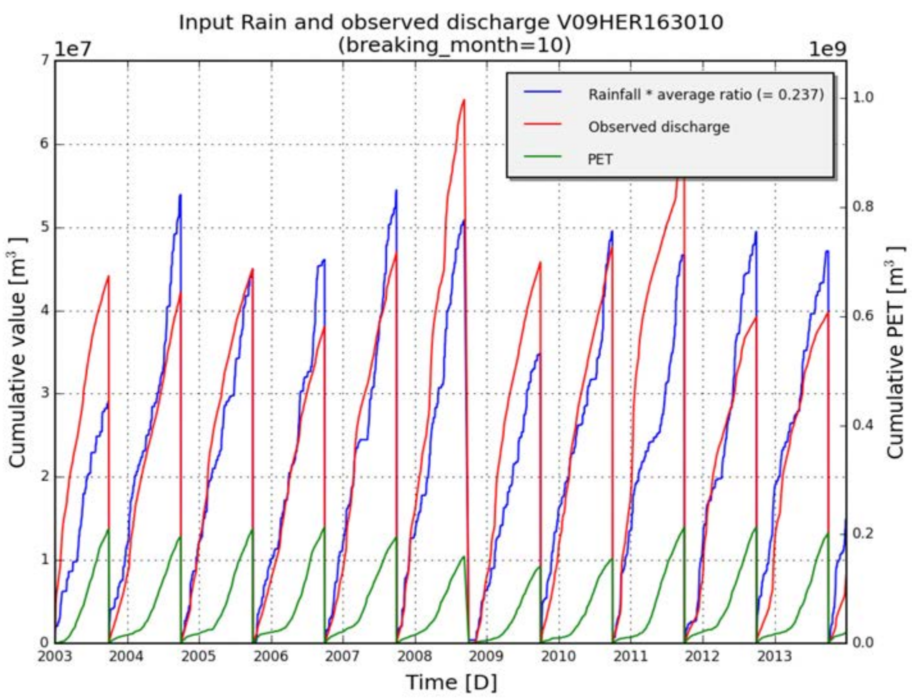


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09HER163010 (Demerbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V09HER163010
subcatchment_area [m²]	274602221
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.12), ('bevaporation', 2.0), ('cmin', 9.6), ('cmax', 534.0), ('CKBF', 300.0), ('CK1', 35.0), ('CK2', 36.0), ('bdrainage', 1.0), ('kdrainage', 24477.0), ('PDM.TG', 6.0), ('tdly', 0.0), ('qconst', 0.0)]

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

	Full year	Summer	Winter
NS	0.672	0.488	0.631
NS_log	0.636	0.29	0.72
NS_rel	0.799	0.528	0.862
RelErr	-2.1 %	0.8 %	-11.8 %
VolBias	0.035	0.085	-0.086

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.64	0.507	0.563
NS_log	0.588	0.084	0.713
NS_rel	0.391	0.229	0.68
RelErr	8.6 %	46.3 %	-10.9 %
VolBias	0.087	0.319	-0.079

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)

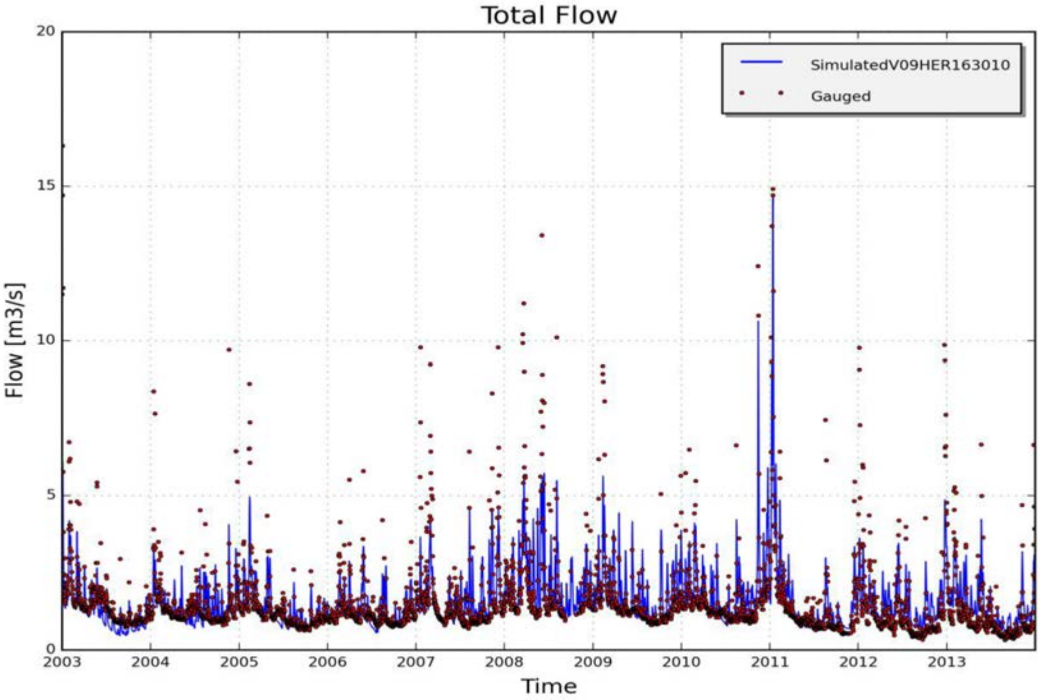


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09HER163010, station 16310102 - Herk, Kermt (calibration period)

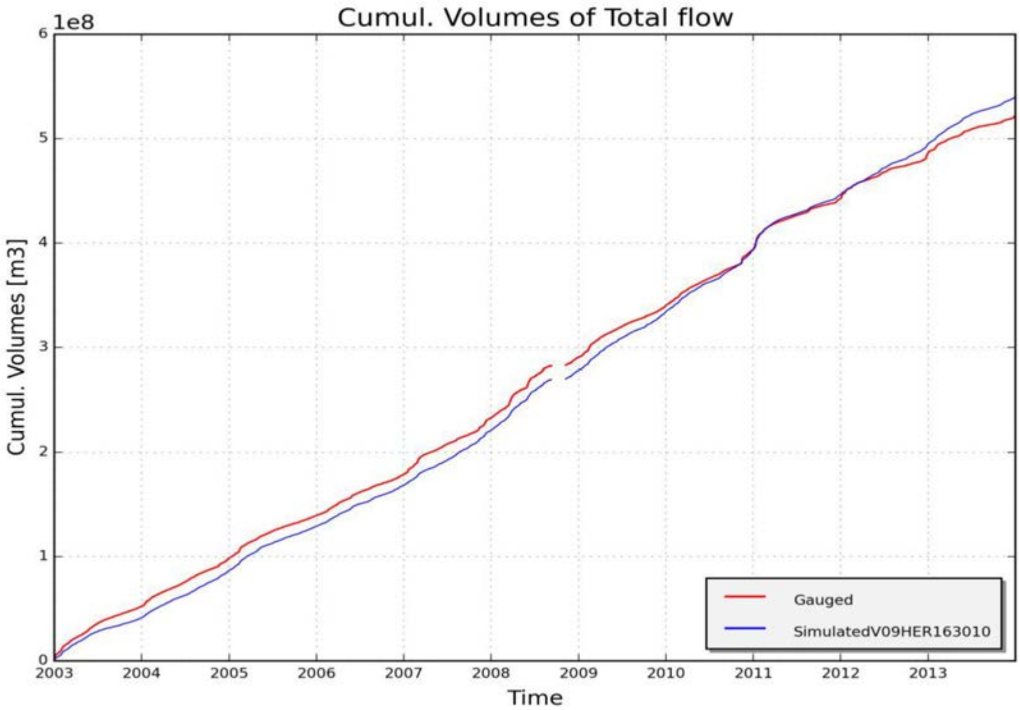


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09HER163010, station 16310102 - Herk, Kermt (validation period)

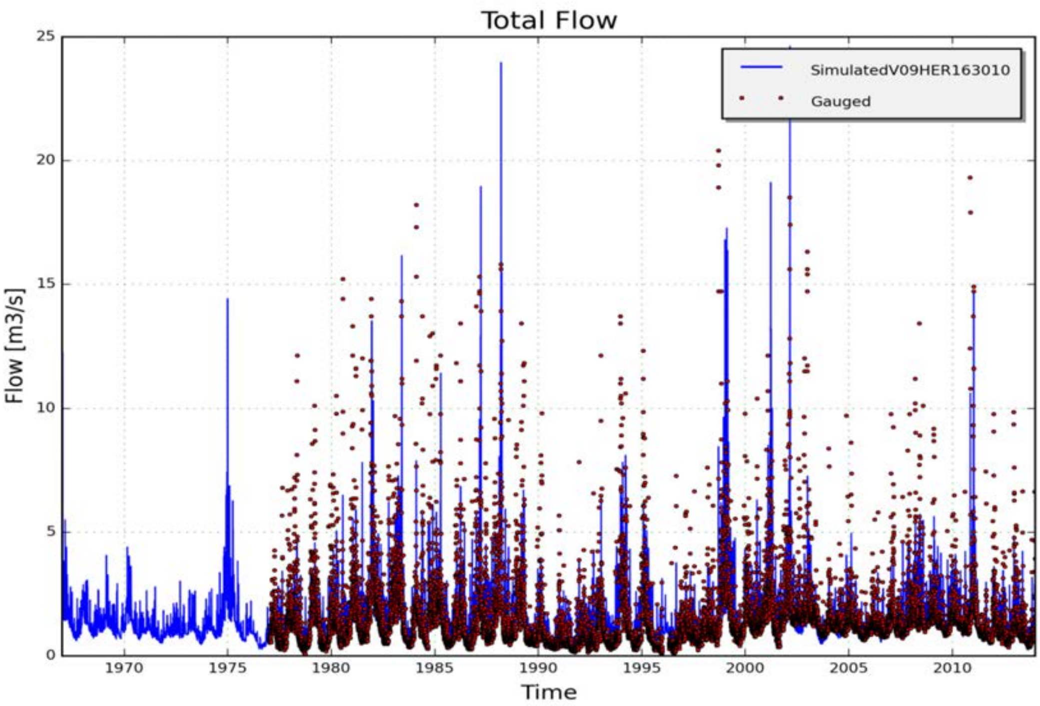


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09HER163010, station 16310102 - Herk, Kermt (validation period)

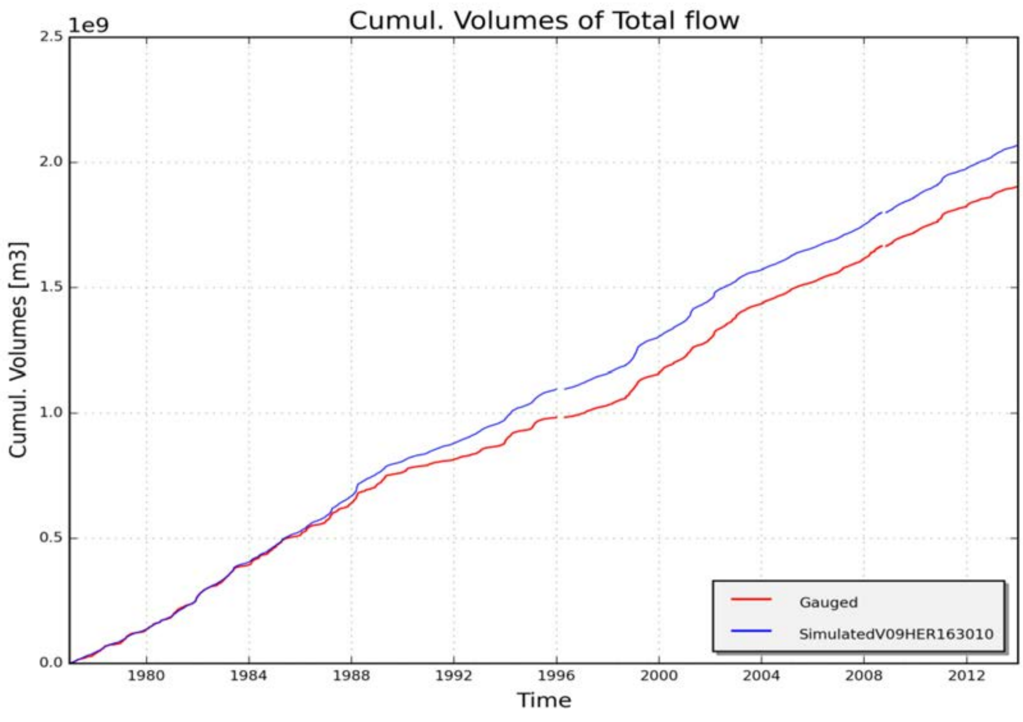
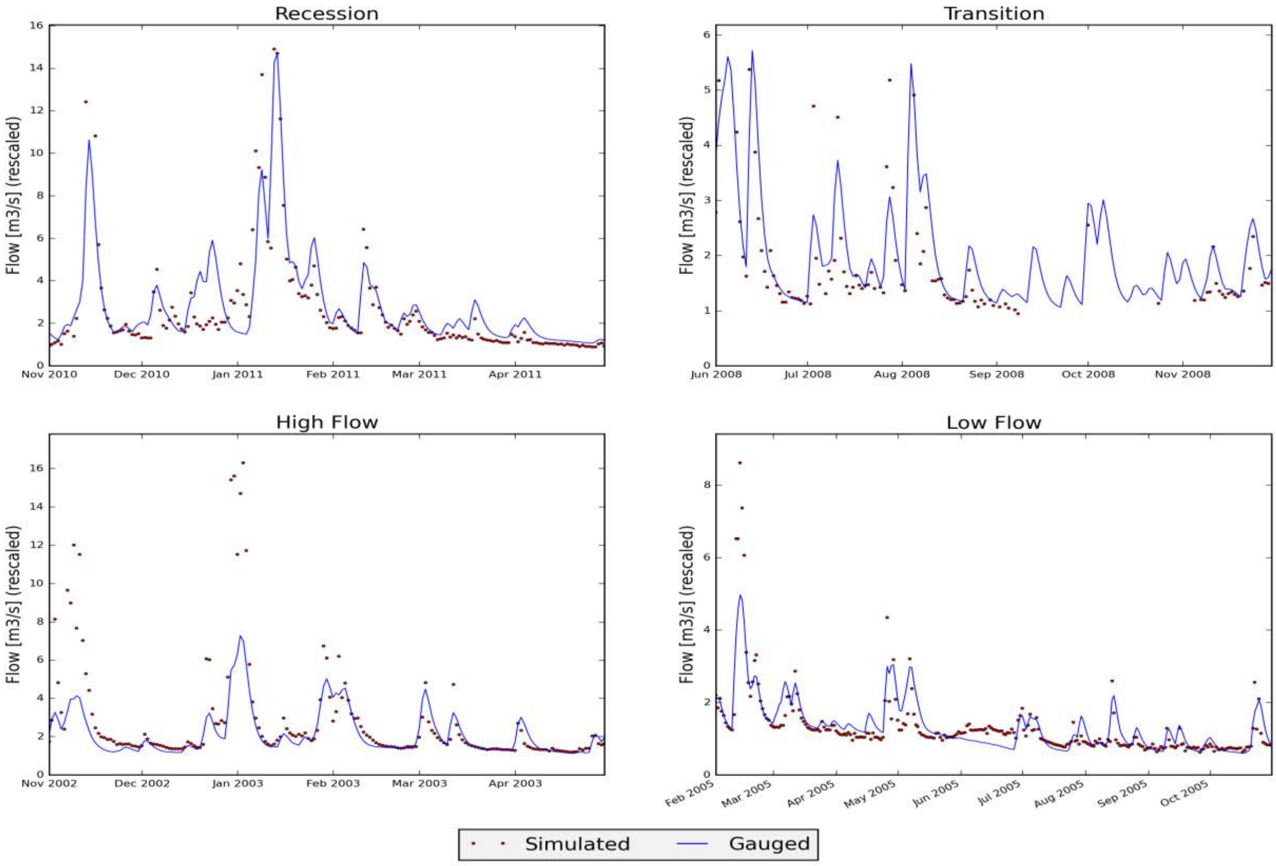


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09HER163010, station 16310102 - Herk, Kermt



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V09HUL147150" (DEMERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V09HUL147150 (Demerbekken)

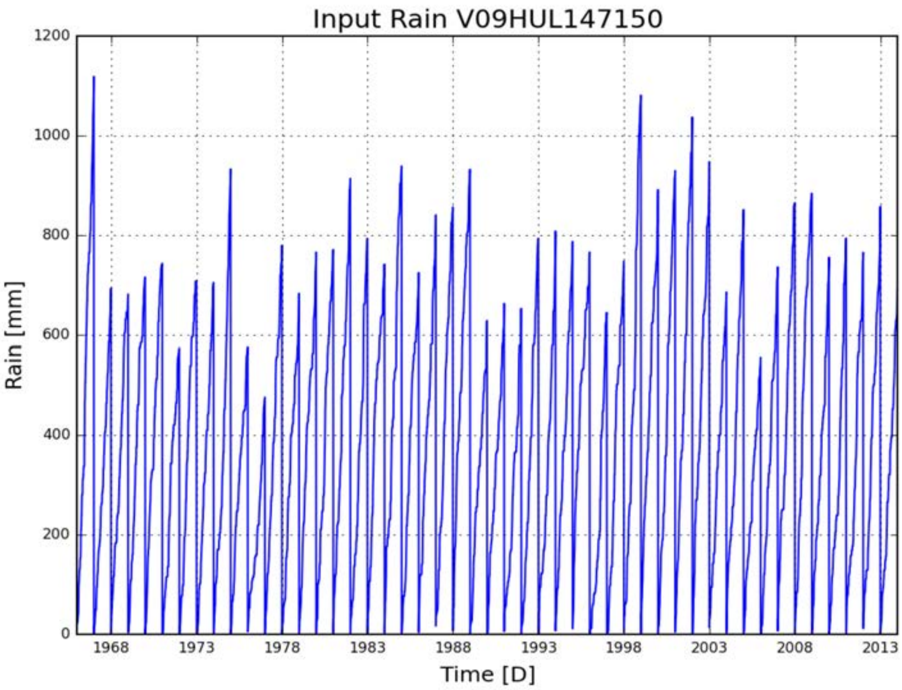
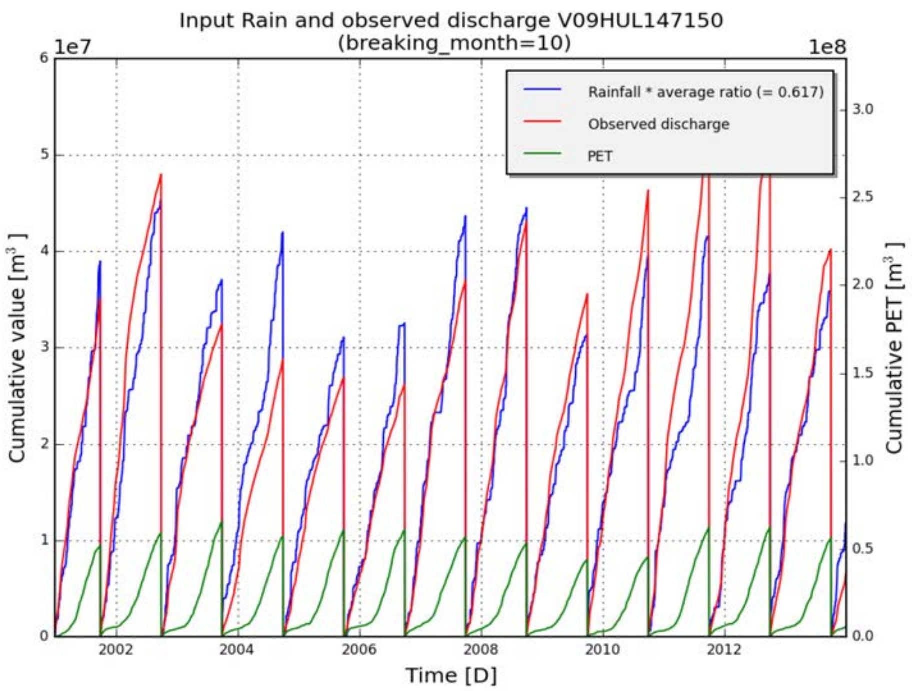


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09HUL147150 (Demerbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V09HUL147150
subcatchment_area [m²]	80130245
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.2), ('bevaporation', 1.0), ('cmin', 2.0), ('cmax', 538.0), ('CKBF', 300.0), ('CK1', 20.0), ('CK2', 36.0), ('bdrainage', 0.94), ('kdrainage', 6300.0), ('PDM.TG', 3.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.479	0.115	0.608
NS_log	0.509	0.206	0.654
NS_rel	0.762	0.683	0.81
RelErr	-10.3 %	-10.4 %	-13.8 %
VolBias	-0.164	-0.247	-0.163

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.574	0.383	0.639
NS_log	0.587	0.374	0.707
NS_rel	0.7	0.649	0.801
RelErr	0.7 %	6.8 %	-6.4 %
VolBias	-0.067	-0.089	-0.102

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)

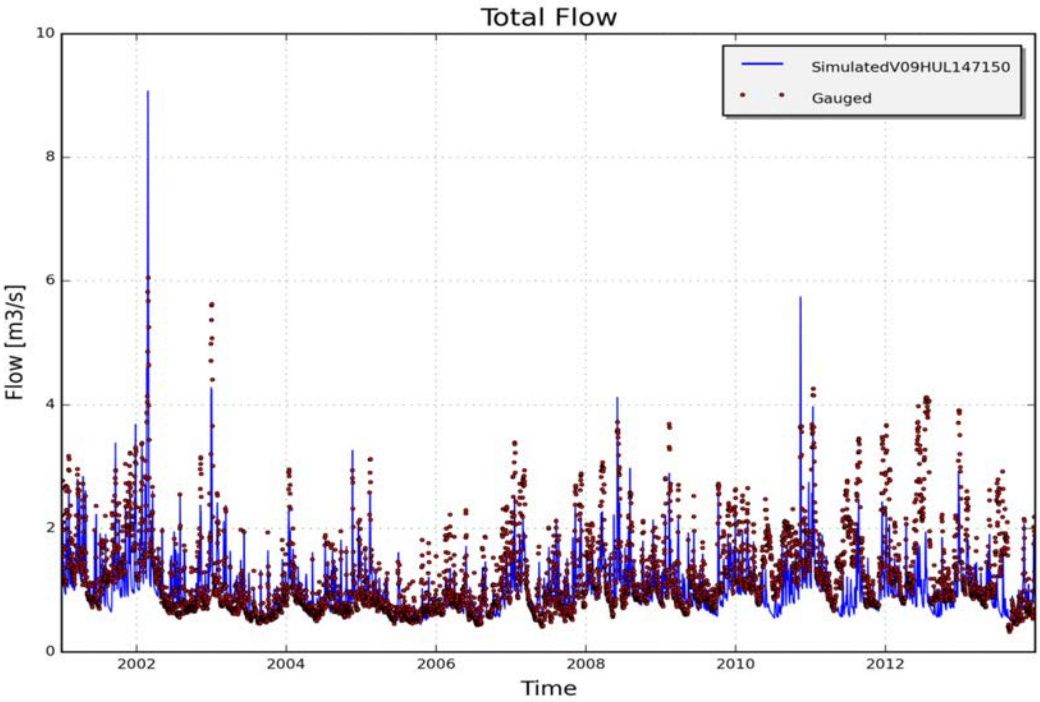


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede (calibration period)

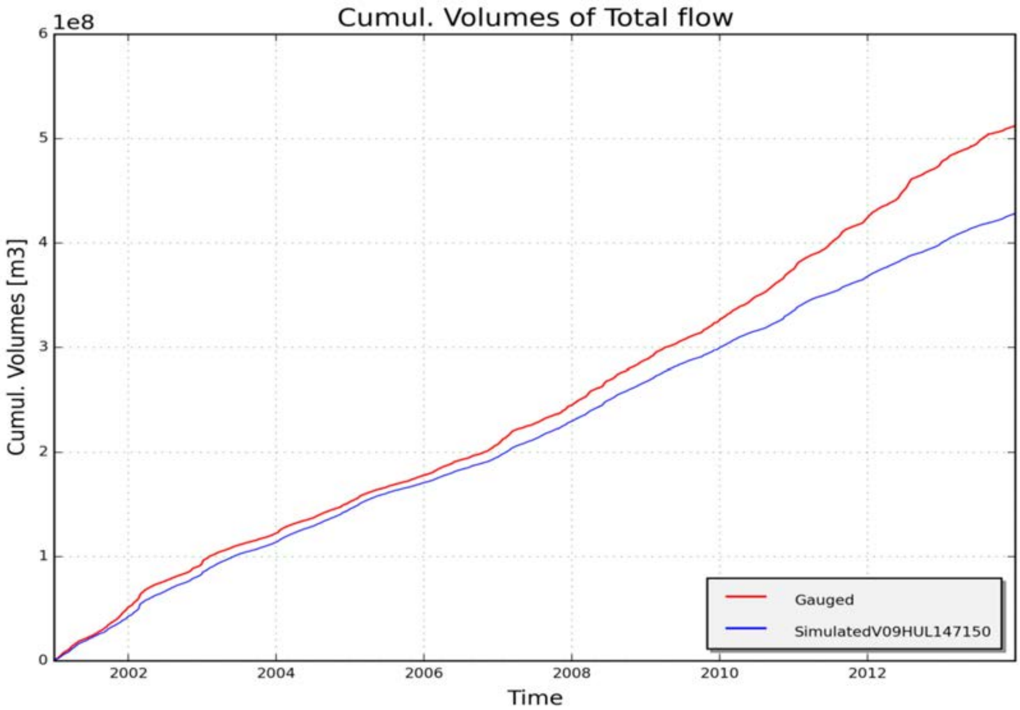


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede (validation period)

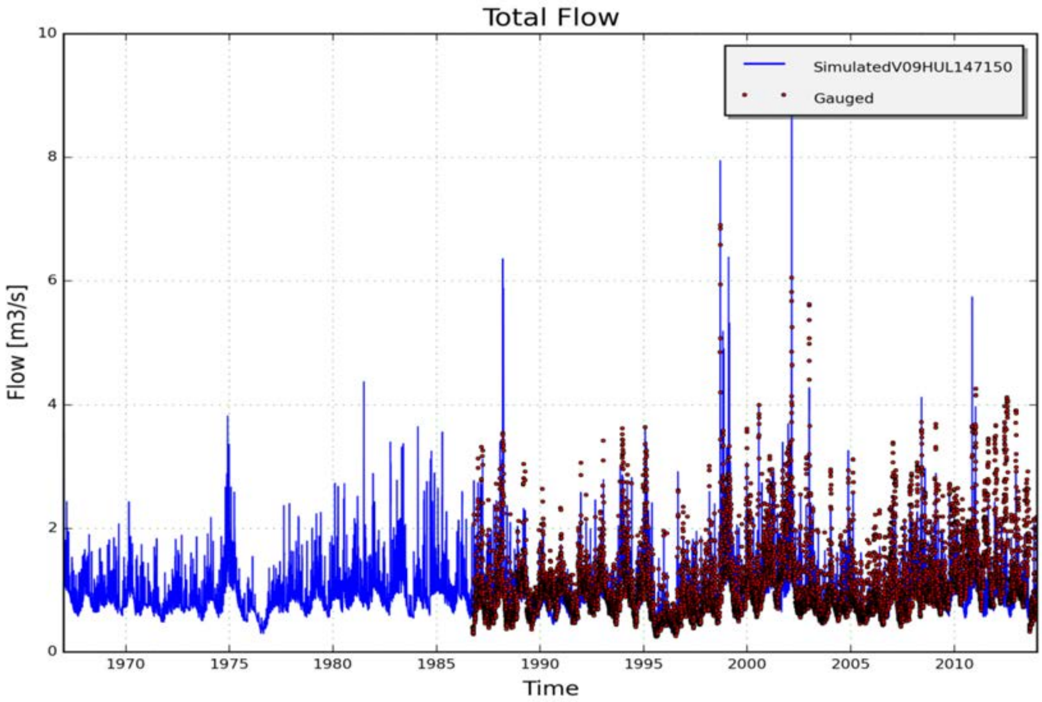


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment F V09HUL147150, station 14710102 - De Hulpe; Molenstede (validation period)

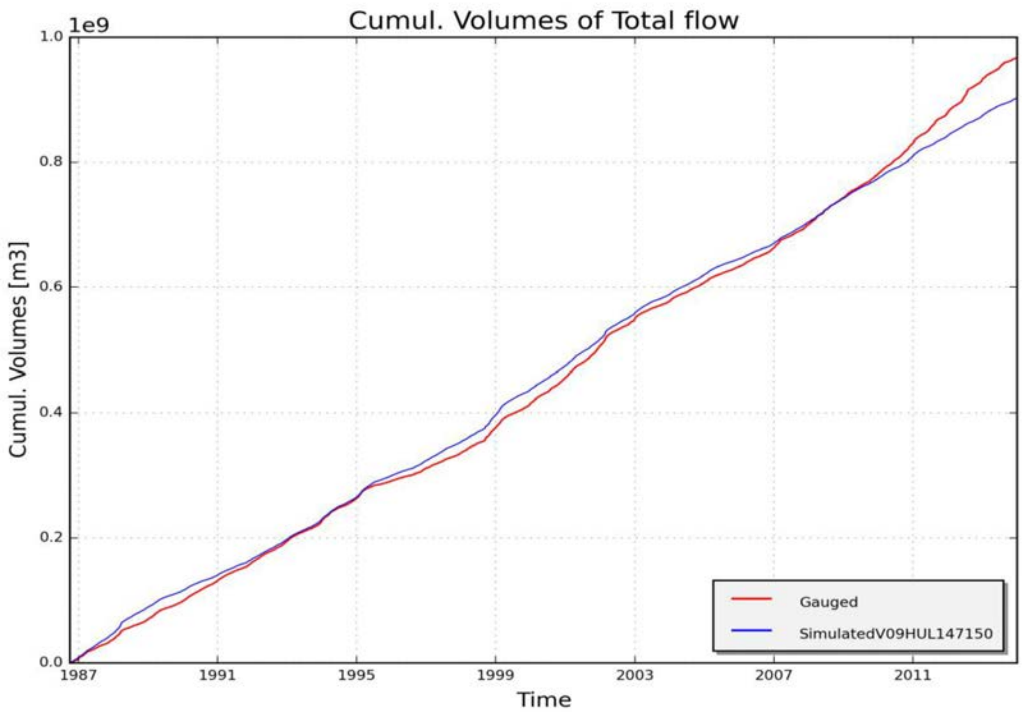
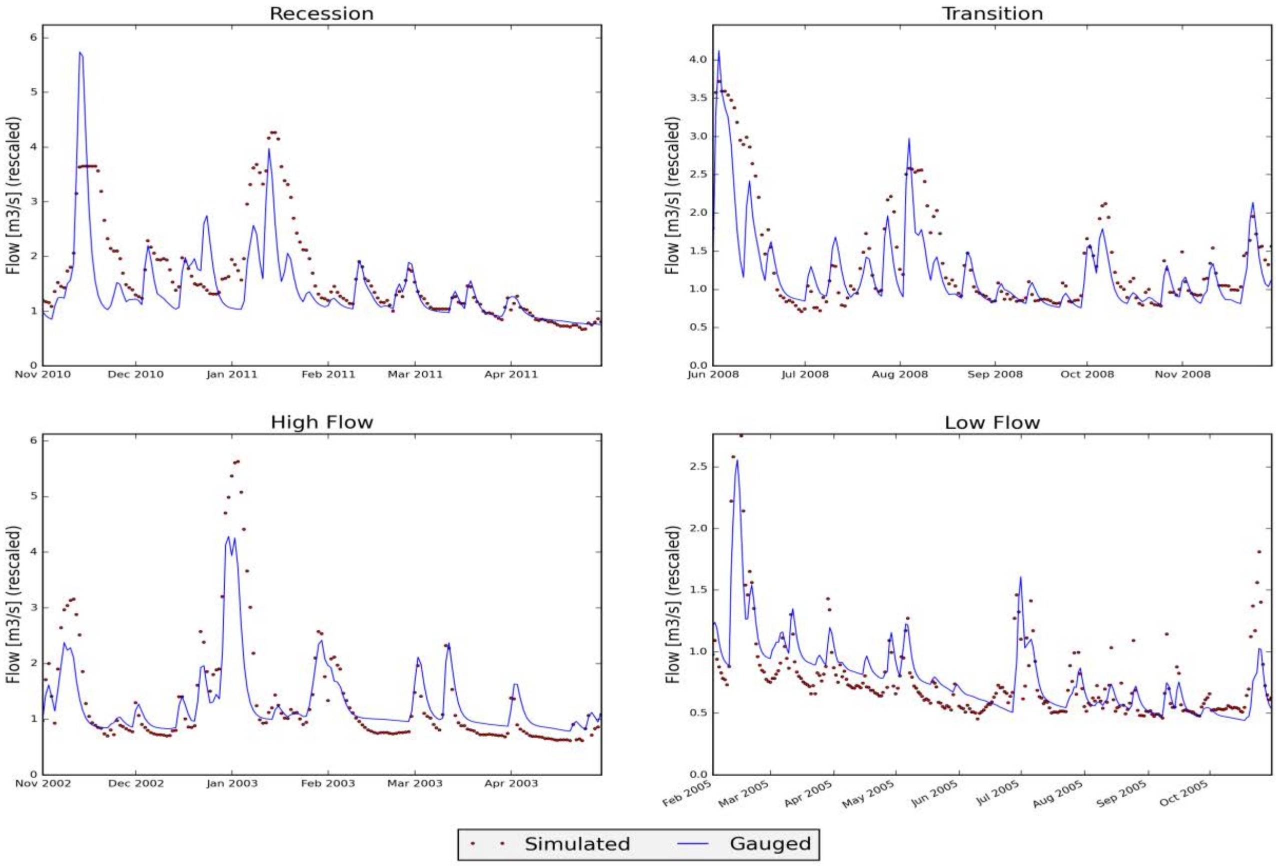


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V09LOS143300" (DEMERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V09LOS143300 (Demerbekken)

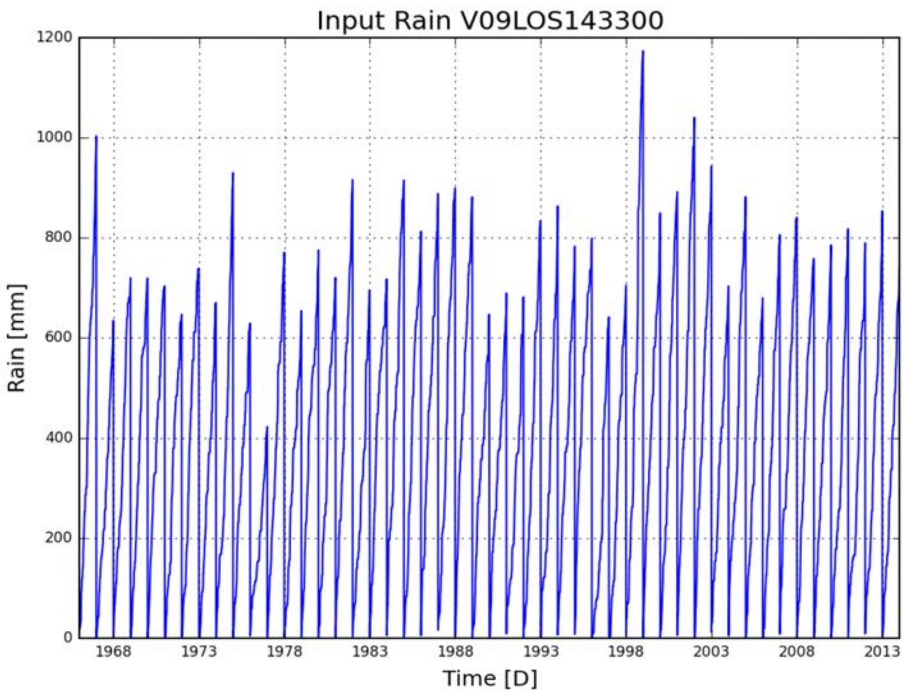
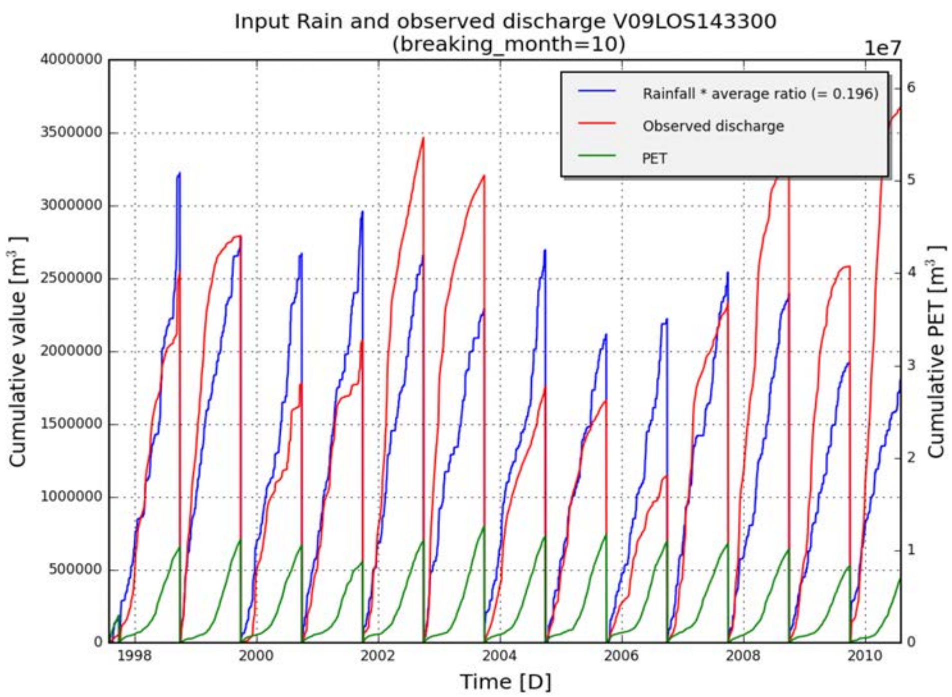


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09LOS143300 (Demerbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V09LOS143300
subcatchment_area [m²]	15176294
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.06), ('bevaporation', 2.0), ('cmin', 7.0), ('cmax', 1000.0), ('CKBF', 300.0), ('CK1', 43.0), ('CK2', 45.0), ('bdrainage', 0.85), ('kdrainage', 45000.0), ('PDM.TG', 5.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1997 - 2010)

	Full year	Summer	Winter
NS	-0.05	0.464	-0.517
NS_log	0.298	-0.242	0.11
NS_rel	-18.86	-18.733	-0.604
RelErr	11.5 %	18.3 %	13.0 %
VolBias	-0.05	0.27	-0.096

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	-0.15	0.376	-0.792
NS_log	0.342	-0.216	-0.008
NS_rel	-10.854	-12.344	-0.545
RelErr	6.4 %	42.4 %	0.2 %
VolBias	-0.036	0.353	-0.092

Observed and simulated timeseries for optimum parameters

Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09LOS143300, station 14310102 - Grote Losting; Wezemaal (calibration period)

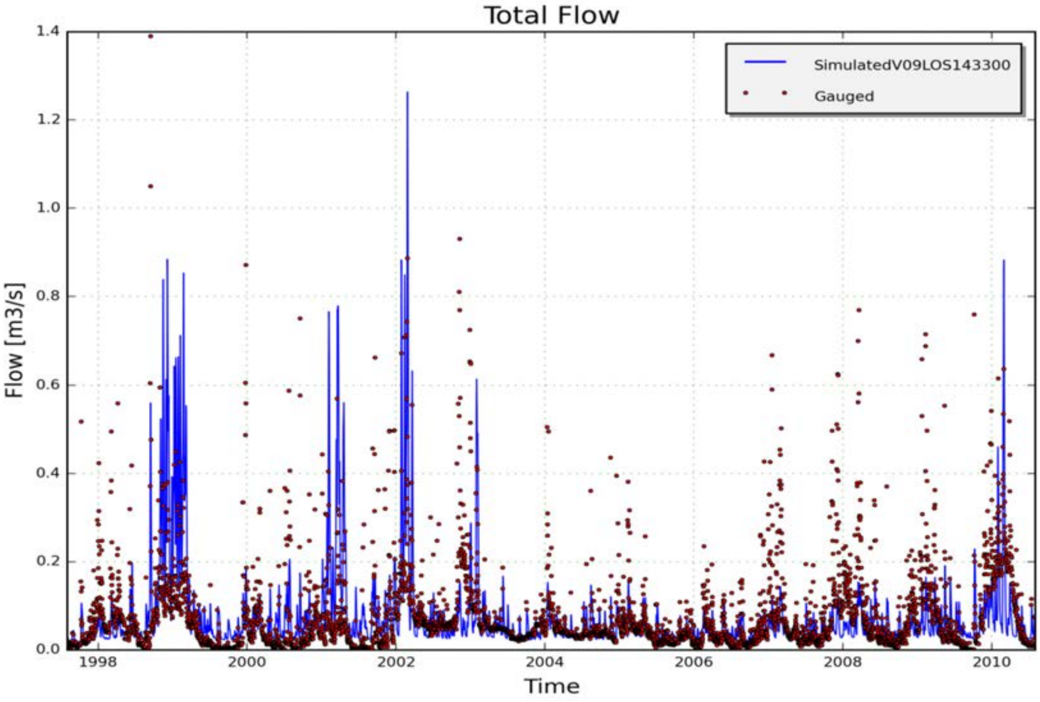


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09LOS143300, station 14310102 - Grote Losting; Wezemaal (calibration period)

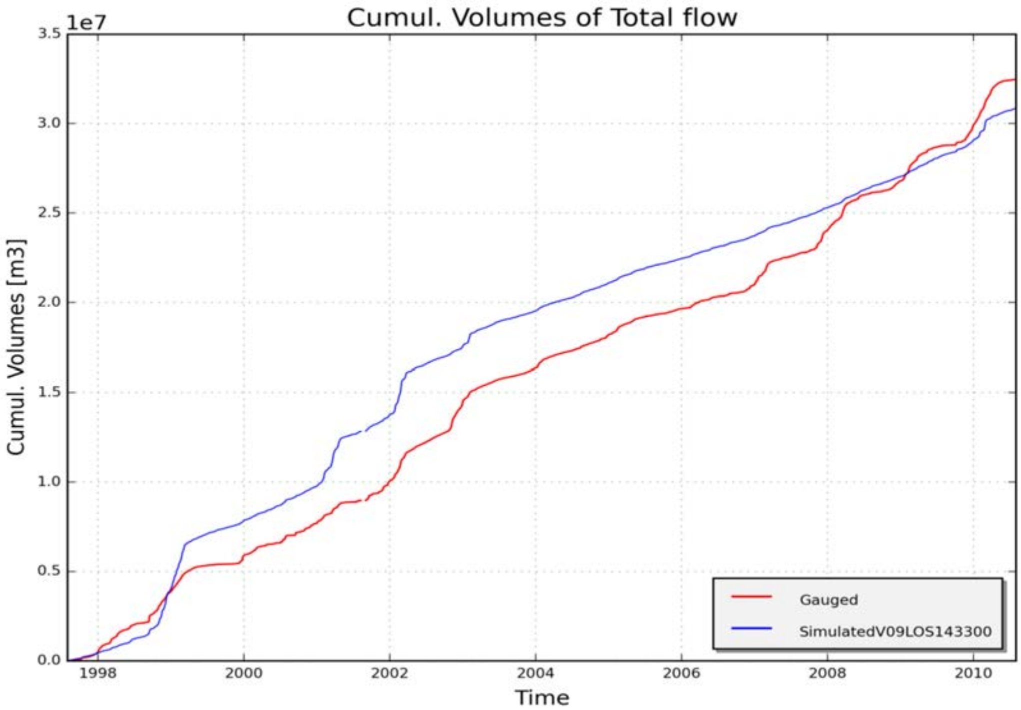


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09LOS143300, station 14310102 - Grote Losting; Wezemaal (validation period)

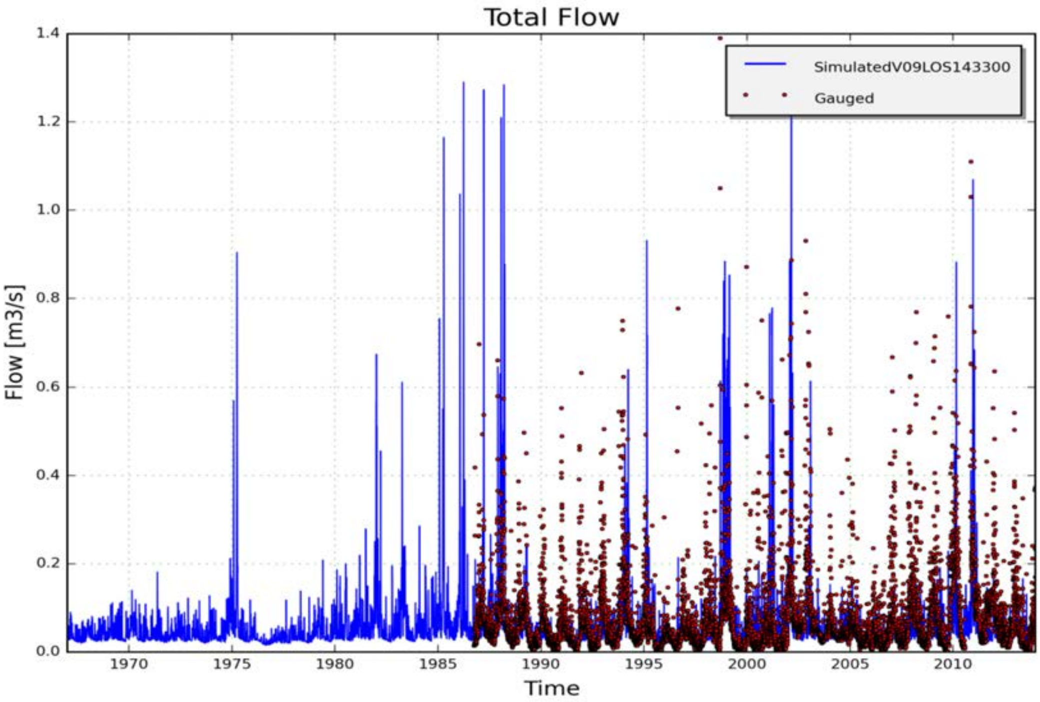


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09LOS143300, station 14310102 - Grote Losting; Wezemaal (validation period)

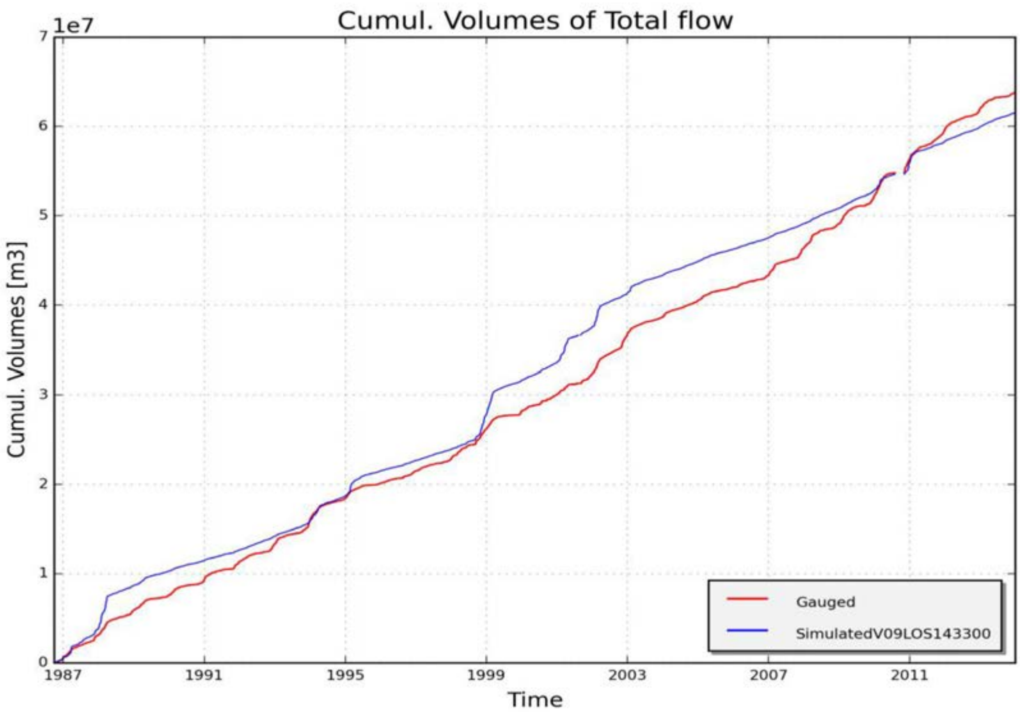


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09LOS143300, station 14310102 - Grote Losting; Wezemaal

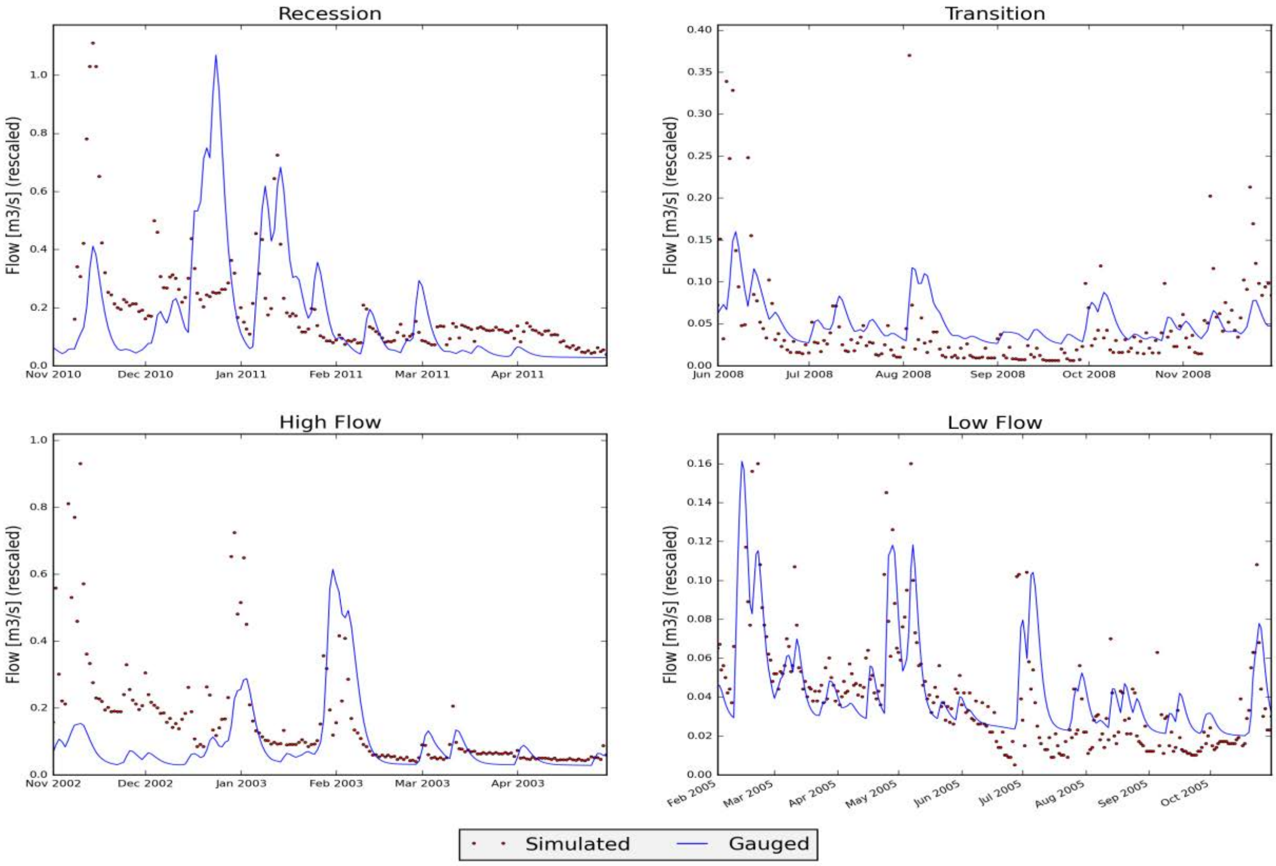


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09LOS143300, station 14310102 - Grote Losting; Wezemaal

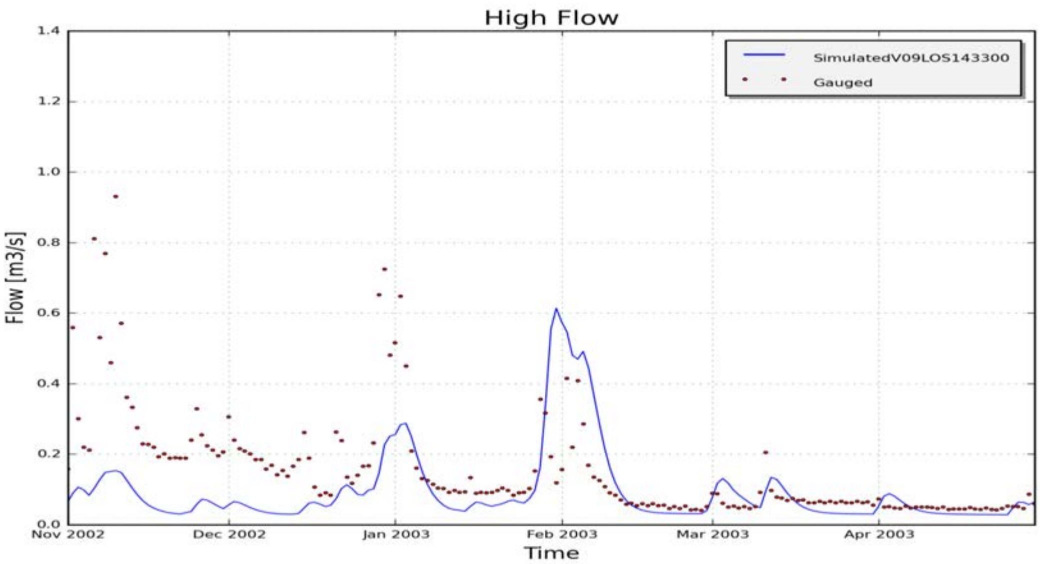


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09LOS143300, station 14310102 - Grote Losting; Wezemaal

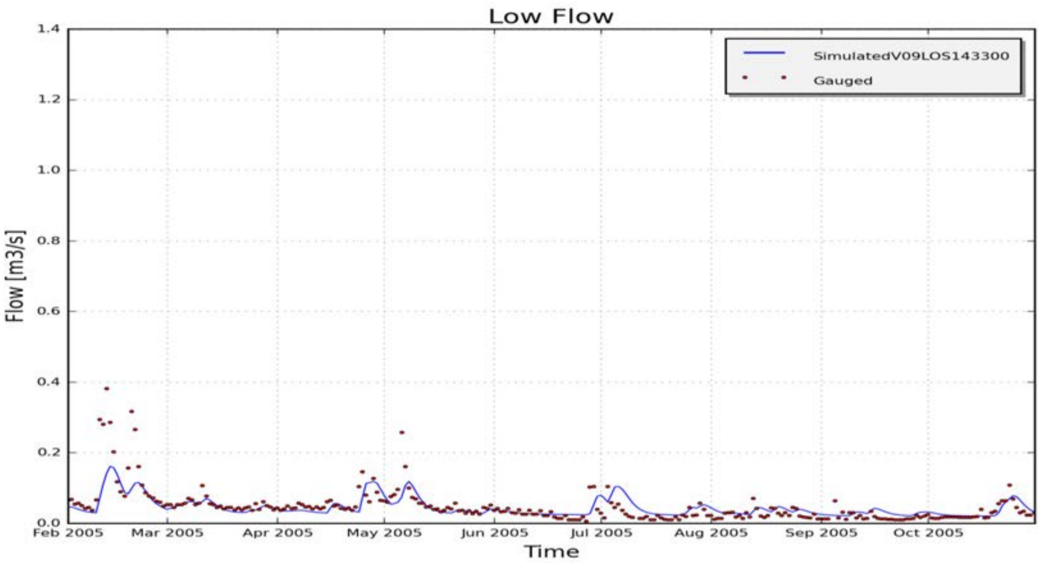
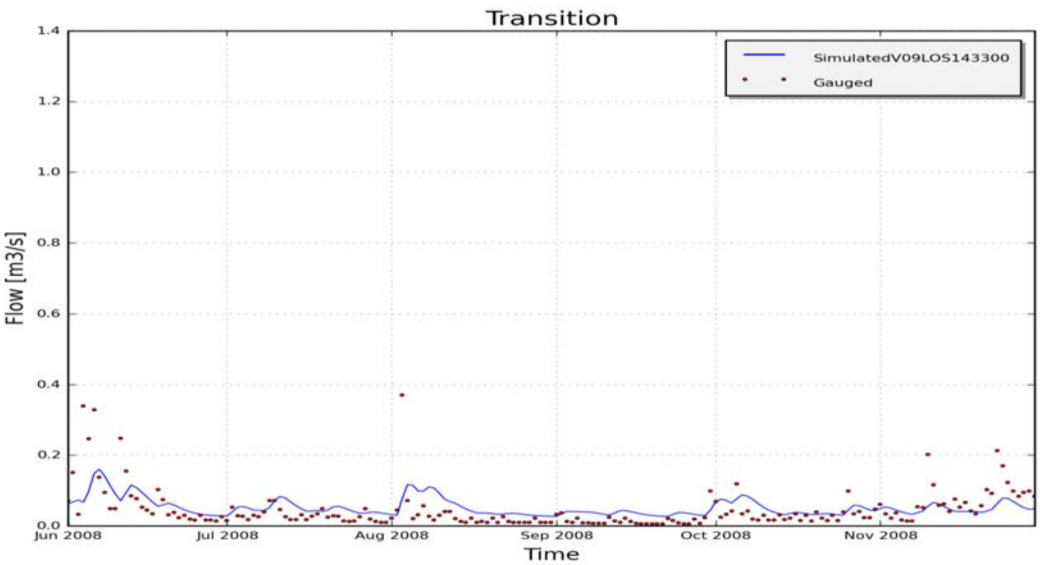


Figure 10: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09LOS143300, station 14310102 - Grote Losting; Wezemaal



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V09MAN161040" (DEMERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V09MAN161040 (Demerbekken)

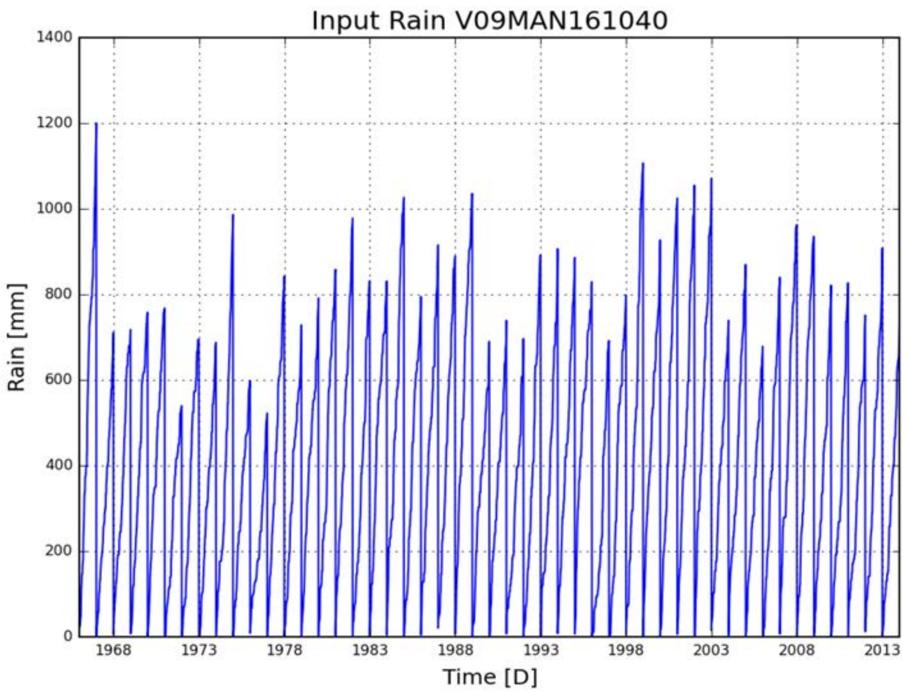
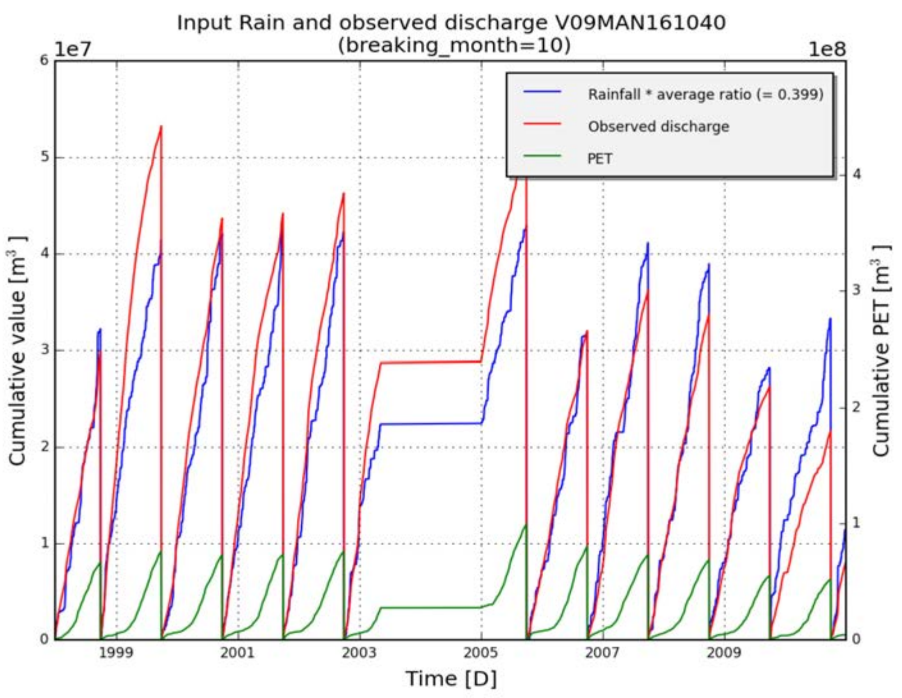


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09MAN161040 (Demerbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V09MAN161040
subcatchment_area [m²]	103081000
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.22), ('bevaporation', 2.0), ('cmin', 6.33), ('cmax', 568.0), ('CKBF', 300.0), ('CK1', 33.0), ('CK2', 23.0), ('bdrainage', 1.0), ('kdrainage', 10044.0), ('PDM.TG', 3.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1998 - 2010)

	Full year	Summer	Winter
NS	0.598	0.65	0.426
NS_log	0.599	0.535	0.568
NS_rel	0.518	0.596	0.411
RelErr	0.3 %	-4.7 %	6.4 %
VolBias	0.07	0.031	0.097

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.656	0.59	0.559
NS_log	0.637	0.438	0.652
NS_rel	0.522	0.342	0.611
RelErr	2.8 %	16.4 %	-0.6 %
VolBias	0.052	0.128	0.035

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)

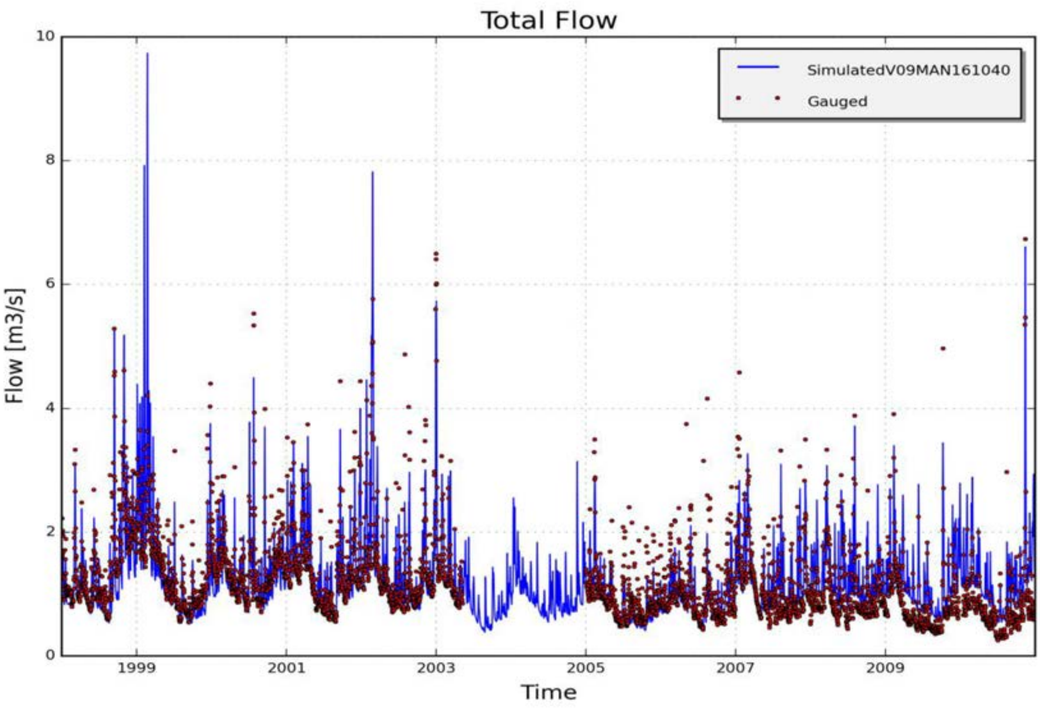


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen (calibration period)

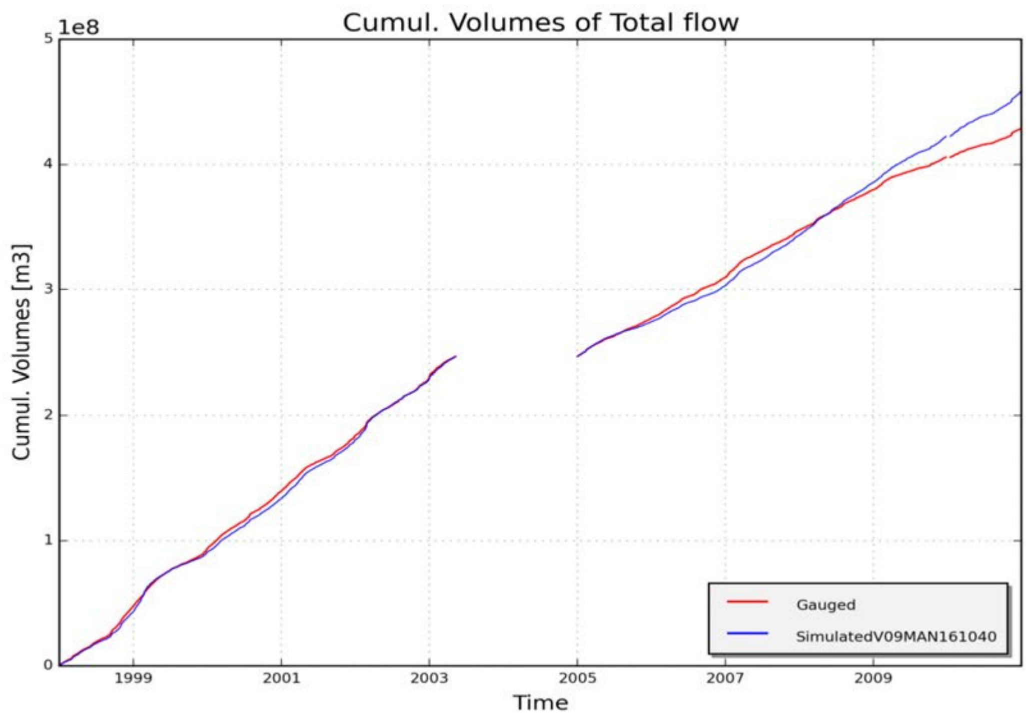


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen (validation period)

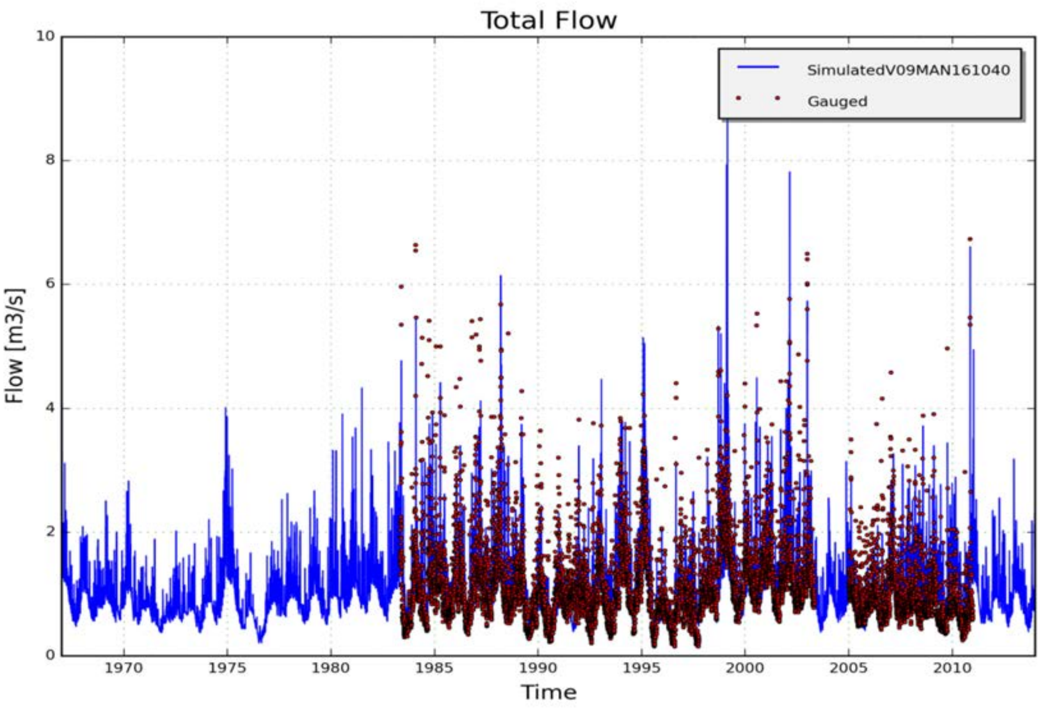


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen (validation period)

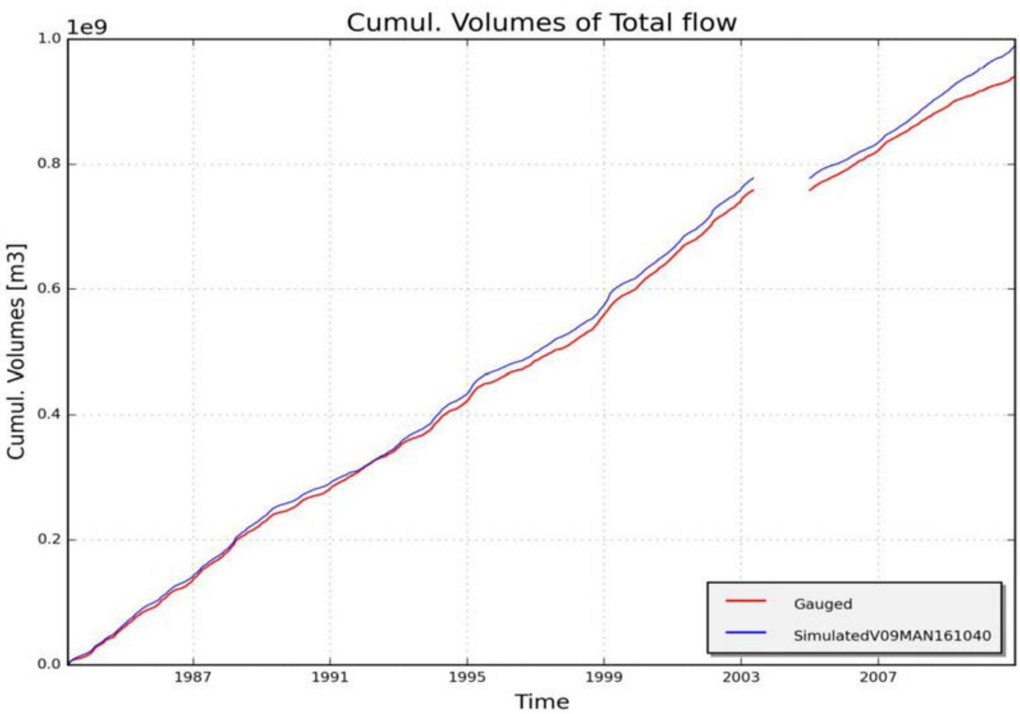


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen

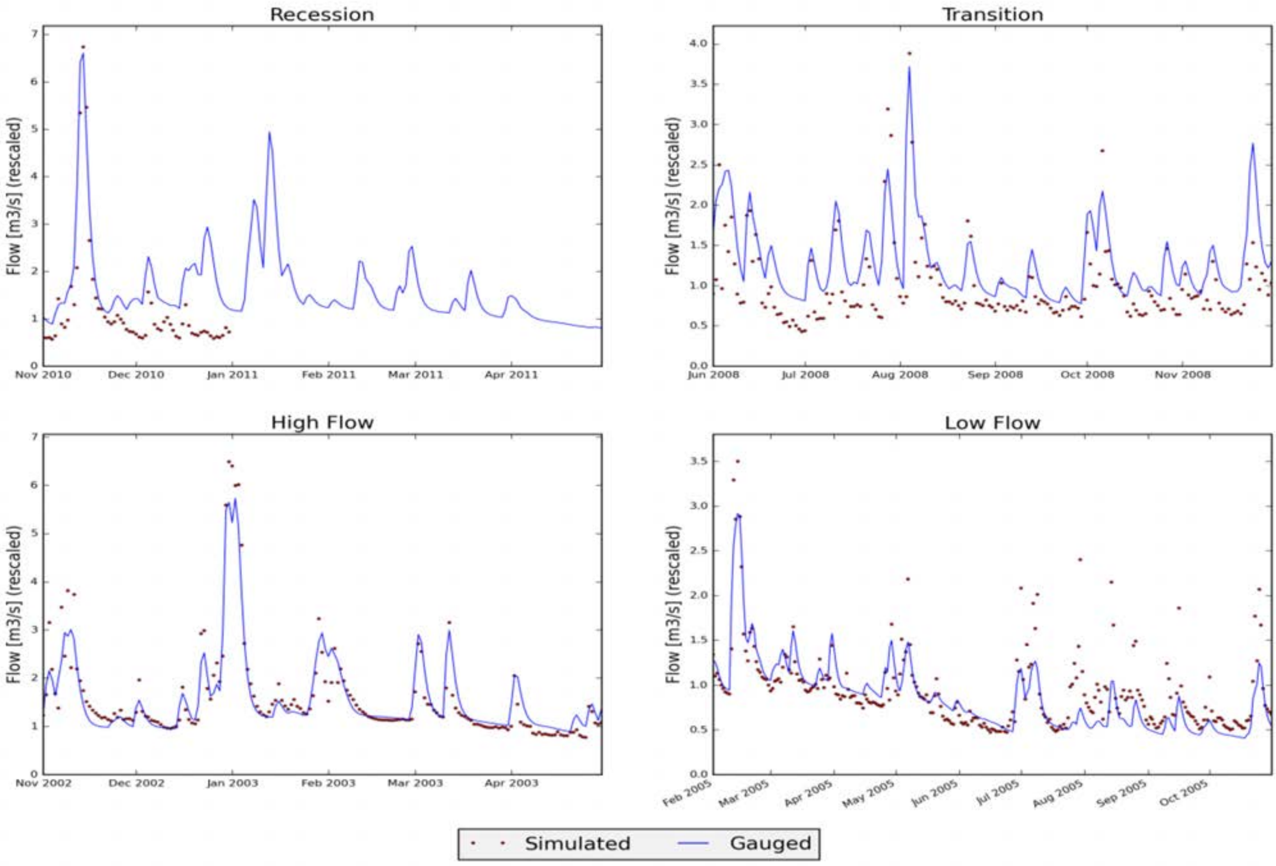


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen

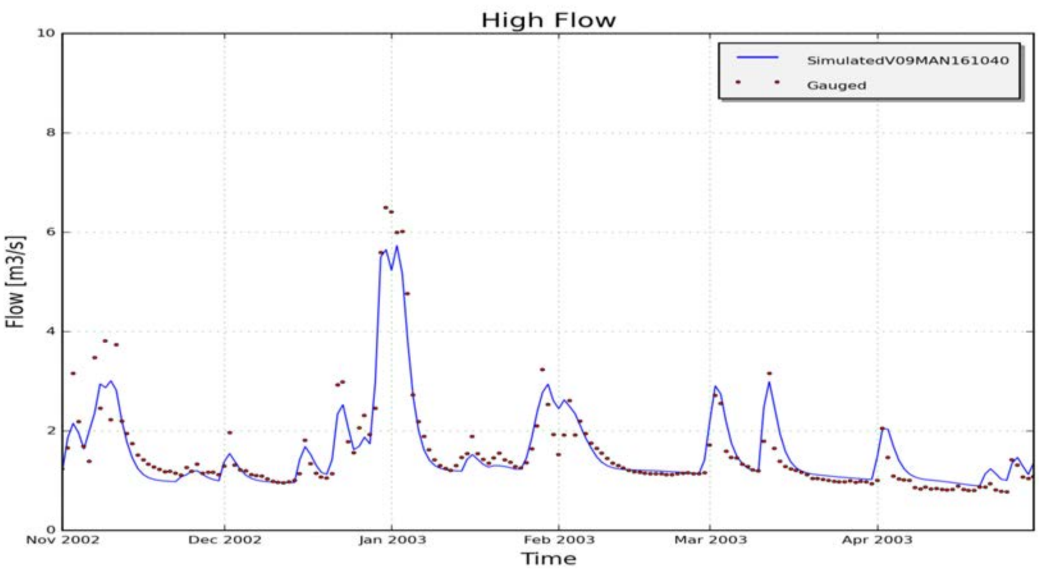


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen

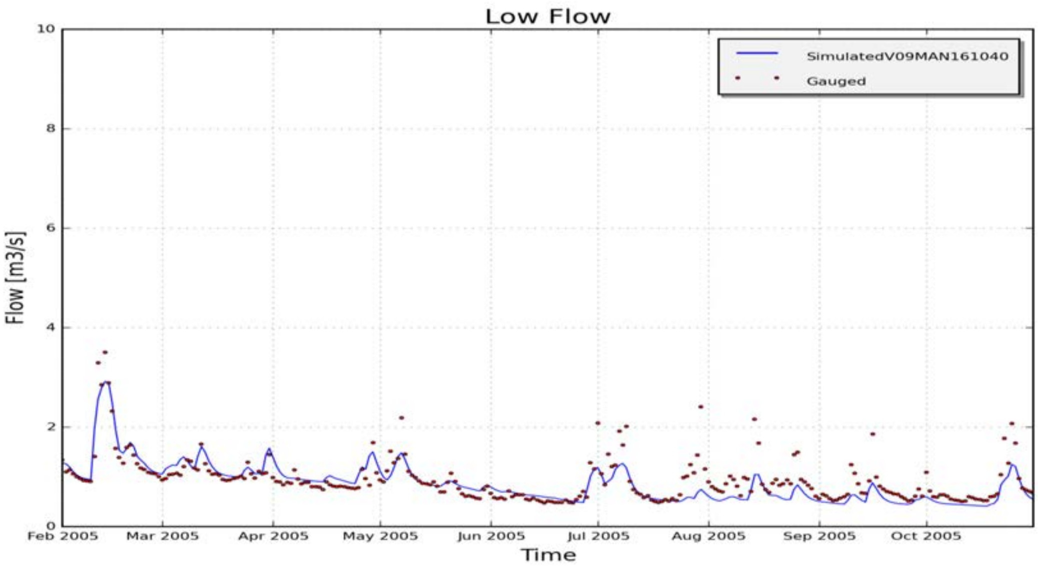
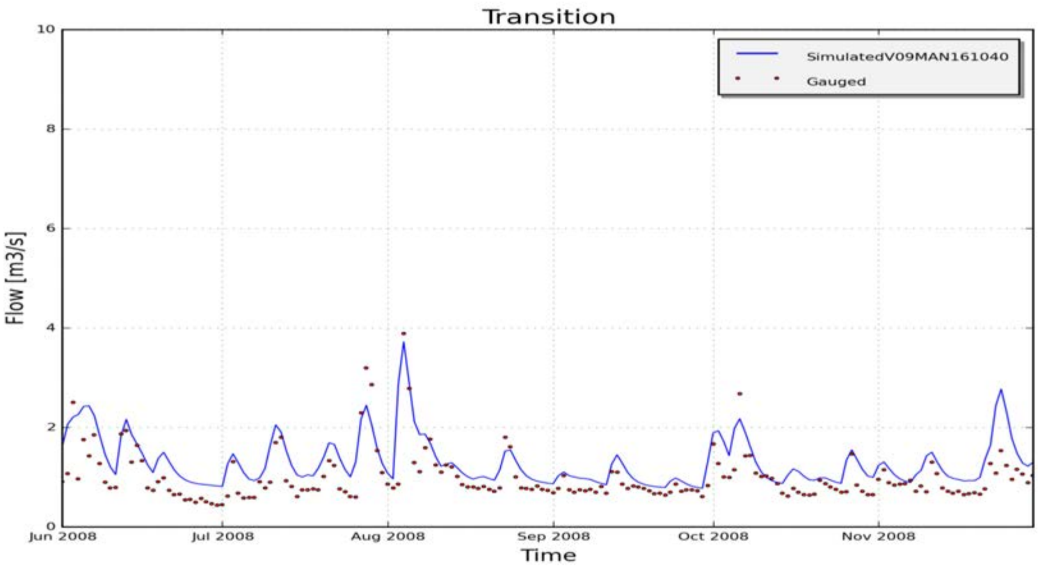


Figure 10: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V09MOT144270" (DEMERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V09MOT144270 (Demerbekken)

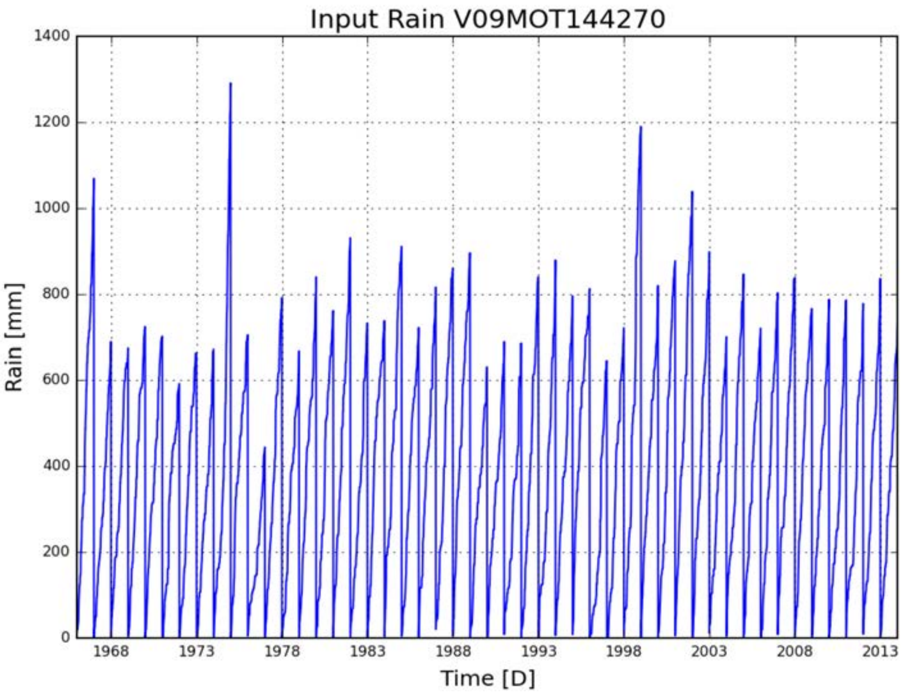
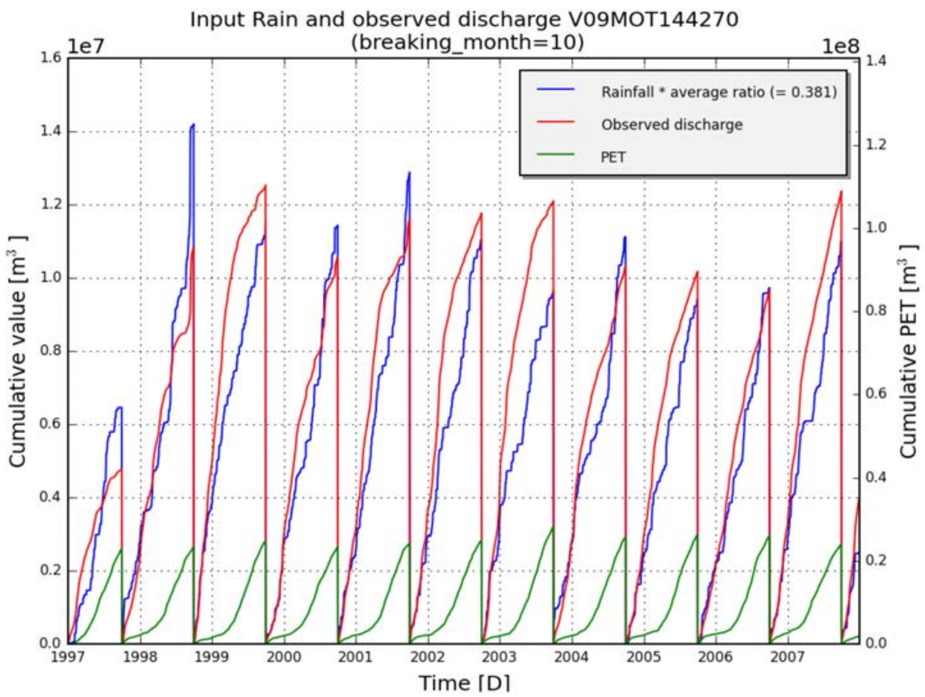


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09MOT144270 (Demerbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V09MOT144270
subcatchment_area [m²]	33590217
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.17), ('bevaporation', 2.0), ('cmin', 8.9), ('cmax', 423.0), ('CKBF', 300.0), ('CK1', 23.0), ('CK2', 30.0), ('bdrainage', 1.0), ('kdrainage', 10577.0), ('PDM.TG', 3.4), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1997 - 2007)

	Full year	Summer	Winter
NS	0.63	0.79	0.506
NS_log	0.593	0.245	0.615
NS_rel	-1.119	-1.778	0.822
RelErr	1.3 %	33.7 %	-12.2 %
VolBias	-0.074	0.16	-0.158

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.482	0.693	0.221
NS_log	0.474	0.152	0.349
NS_rel	-0.379	-1.84	0.641
RelErr	-12.4 %	-5.9 %	-12.4 %
VolBias	-0.144	-0.041	-0.165

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)

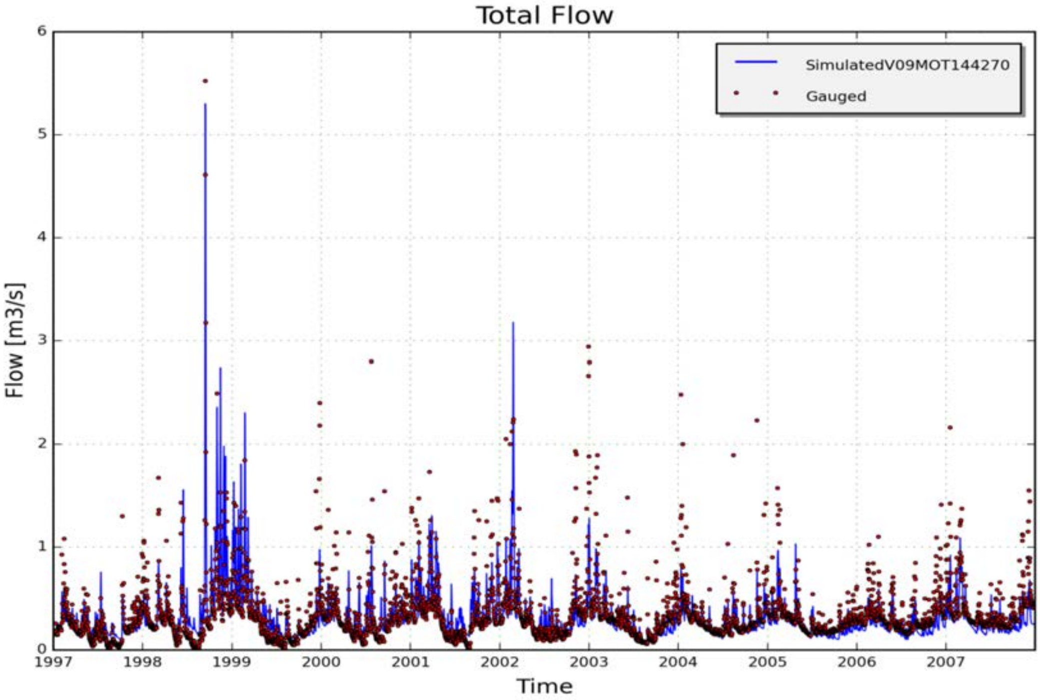


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09MOT144270, station 14410102 - Motte; Rillaar (calibration period)

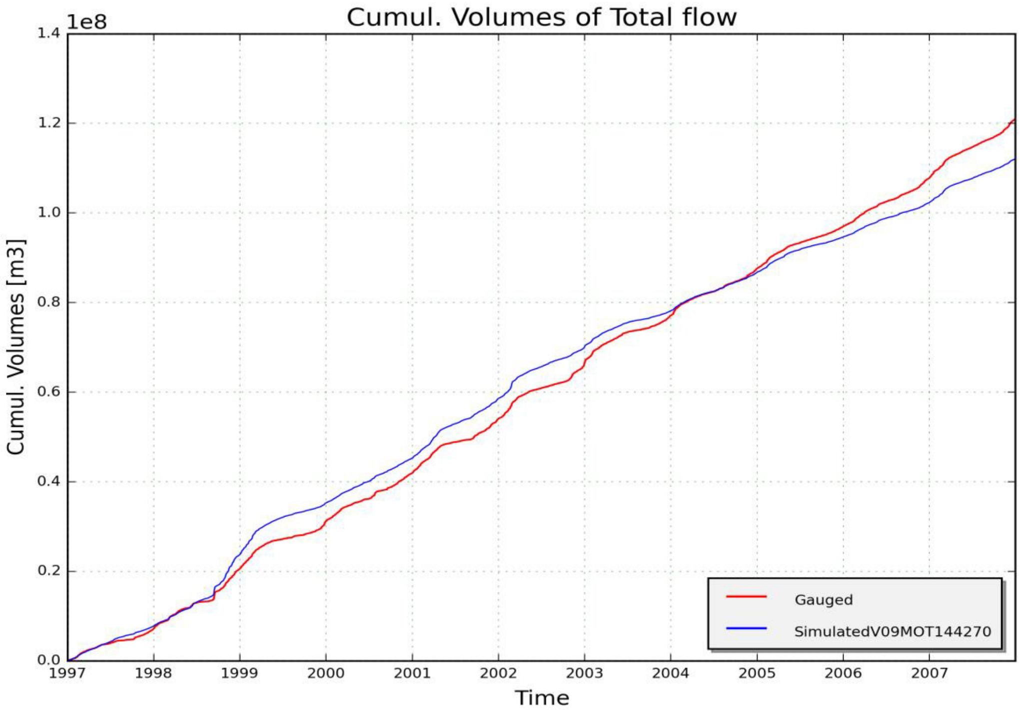


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09MOT144270, station 14410102 - Motte; Rillaar (validation period)

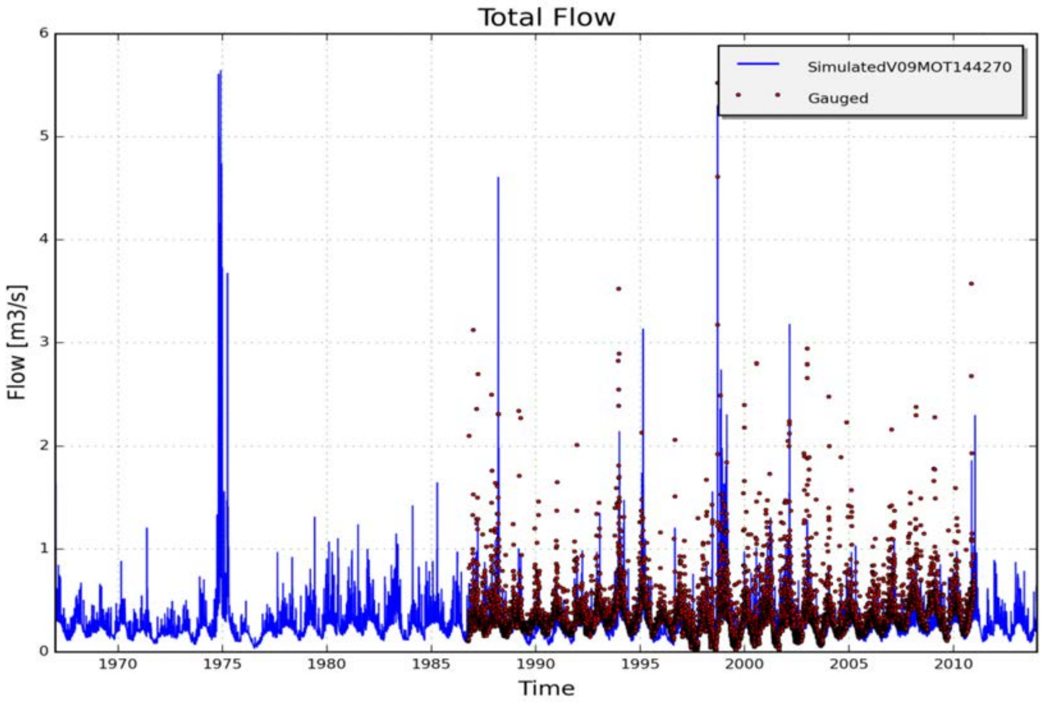


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09MOT144270, station 14410102 - Motte; Rillaar (validation period)

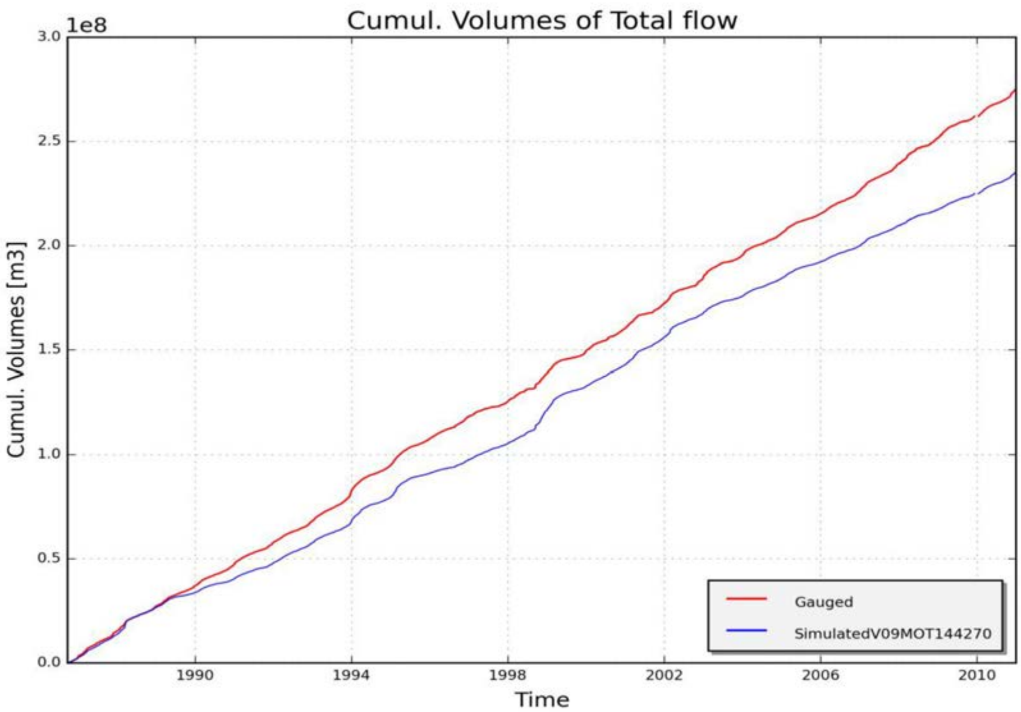


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09MOT144270, station 14410102 - Motte; Rillaar

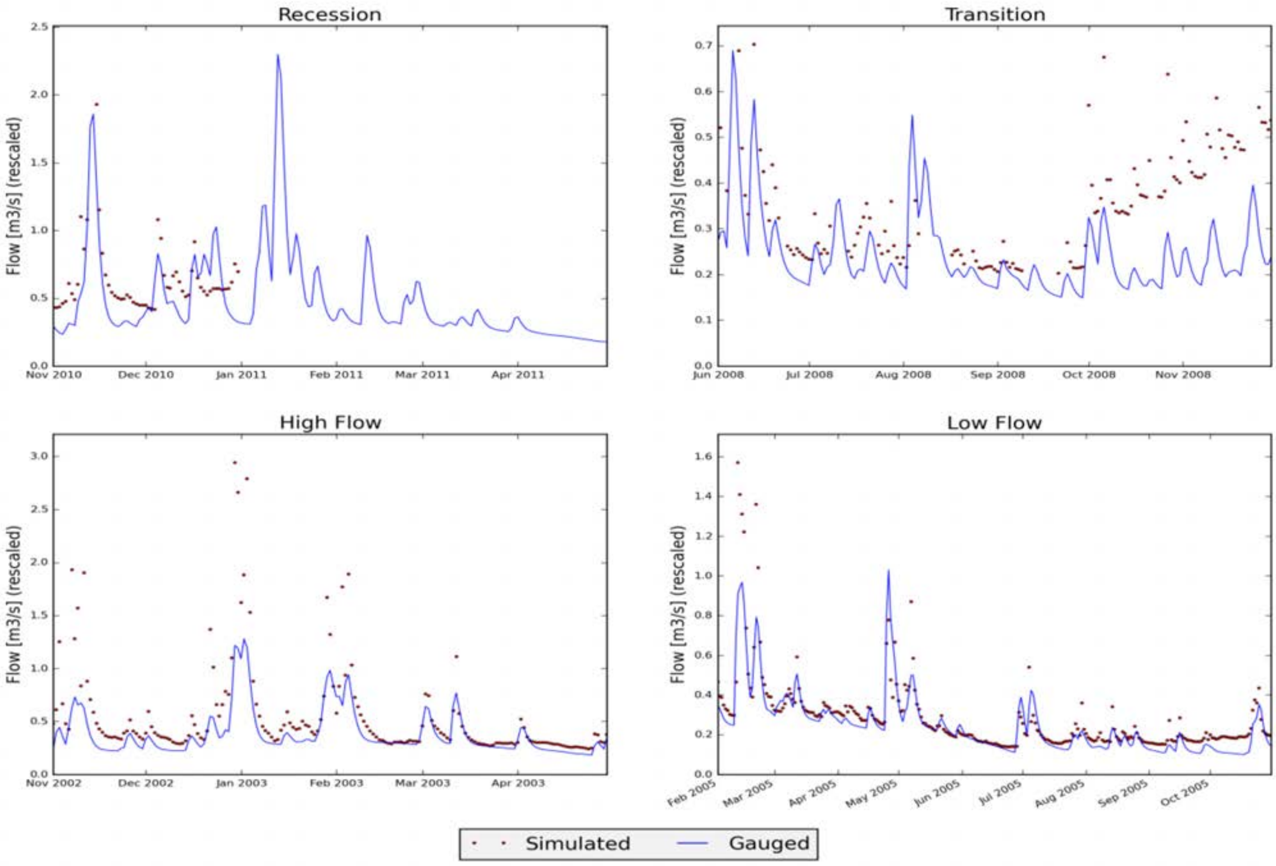


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09MOT144270, station 14410102 - Motte; Rillaar

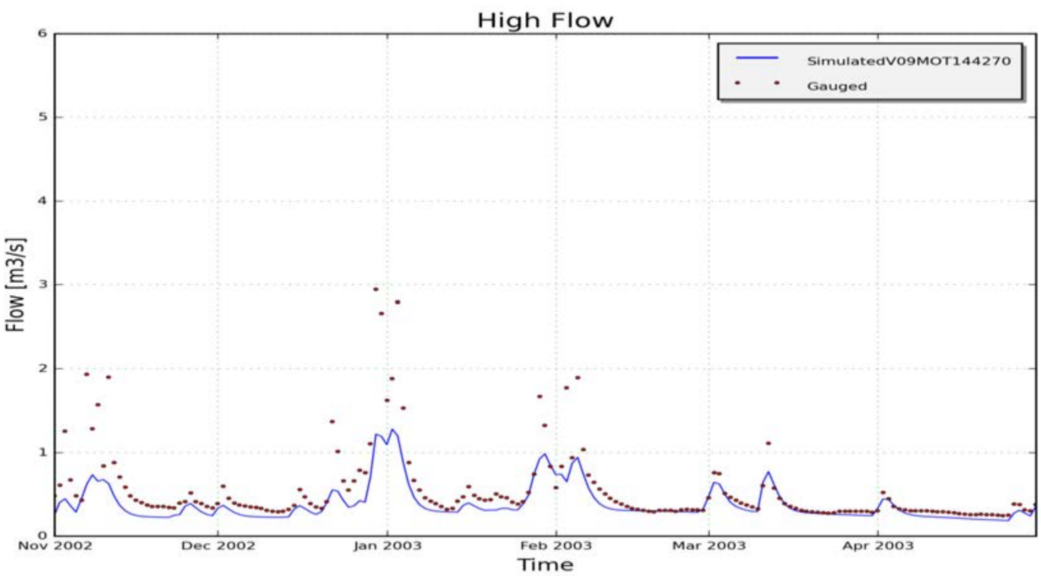
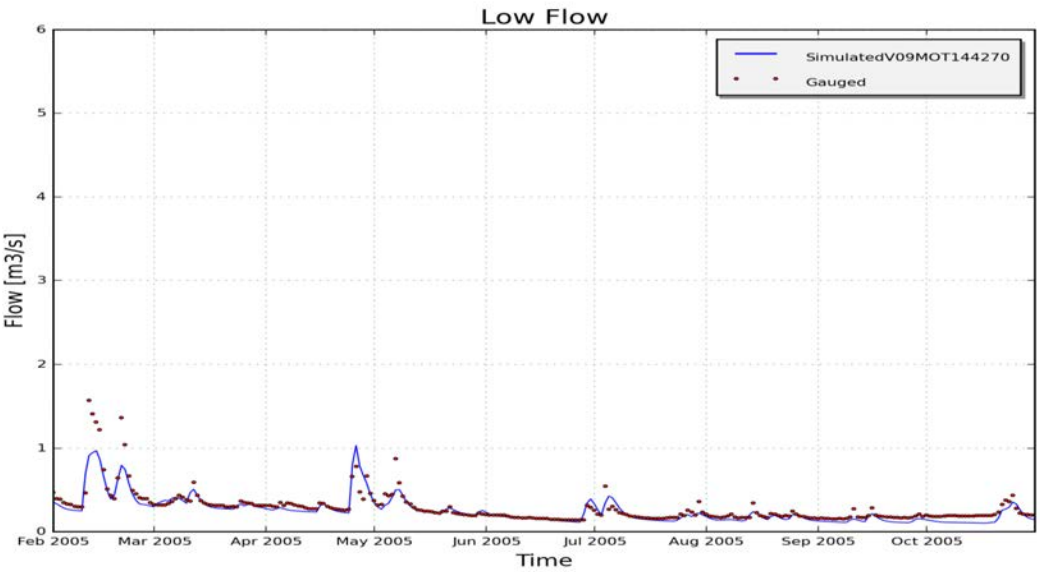


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09MOT144270, station 14410102 - Motte; Rillaar



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V09VEL145100" (DEMERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V09VEL145100 (Demerbekken)

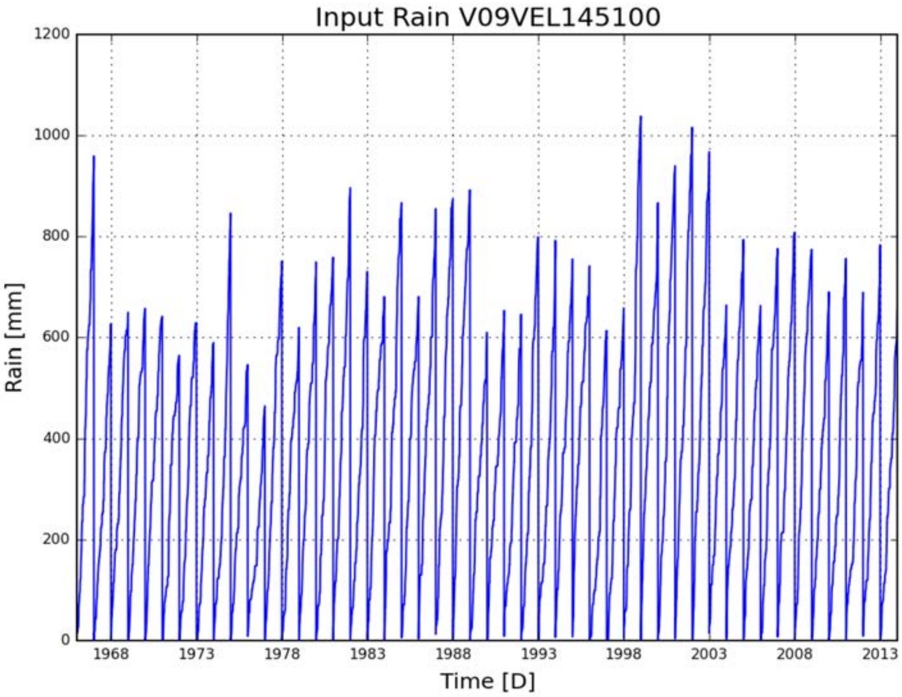
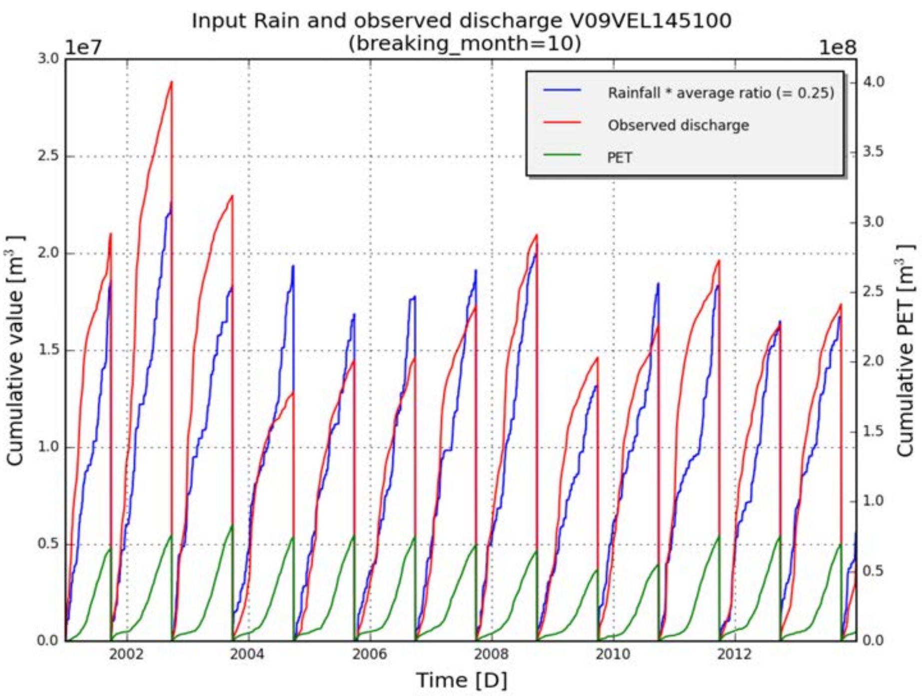


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09VEL145100 (Demerbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V09VEL145100
subcatchment_area [m²]	96801128
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.12), ('bevaporation', 2.0), ('cmin', 9.8), ('cmax', 370.0), ('CKBF', 300.0), ('CK1', 32.0), ('CK2', 35.0), ('bdrainage', 1.0), ('kdrainage', 25000.0), ('PDM.TG', 4.8), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.562	0.484	0.33
NS_log	0.743	0.335	0.563
NS_rel	0.752	0.396	0.547
RelErr	0.7 %	9.4 %	2.8 %
VolBias	-0.015	0.151	-0.041

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.475	0.542	0.254
NS_log	0.709	0.352	0.592
NS_rel	-1.43	-2.394	0.697
RelErr	-1.2 %	21.5 %	-9.8 %
VolBias	0.004	0.198	-0.057

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)

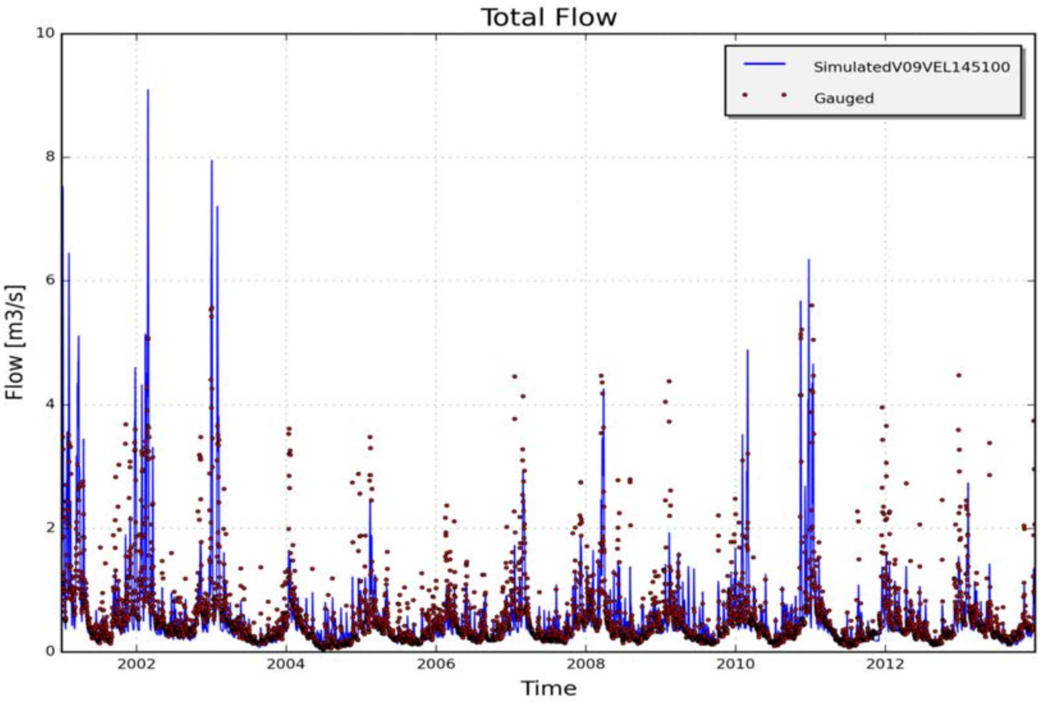


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09VEL145100, station 14510102 - Velp; Ransberg (calibration period)

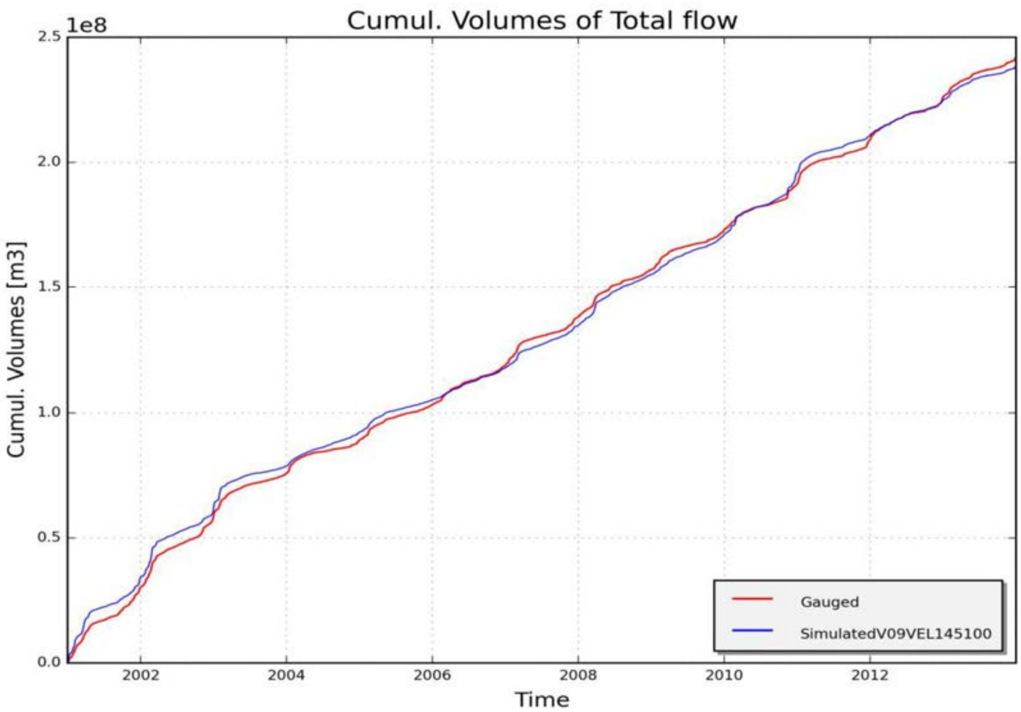


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09VEL145100, station 14510102 - Velp; Ransberg (validation period)

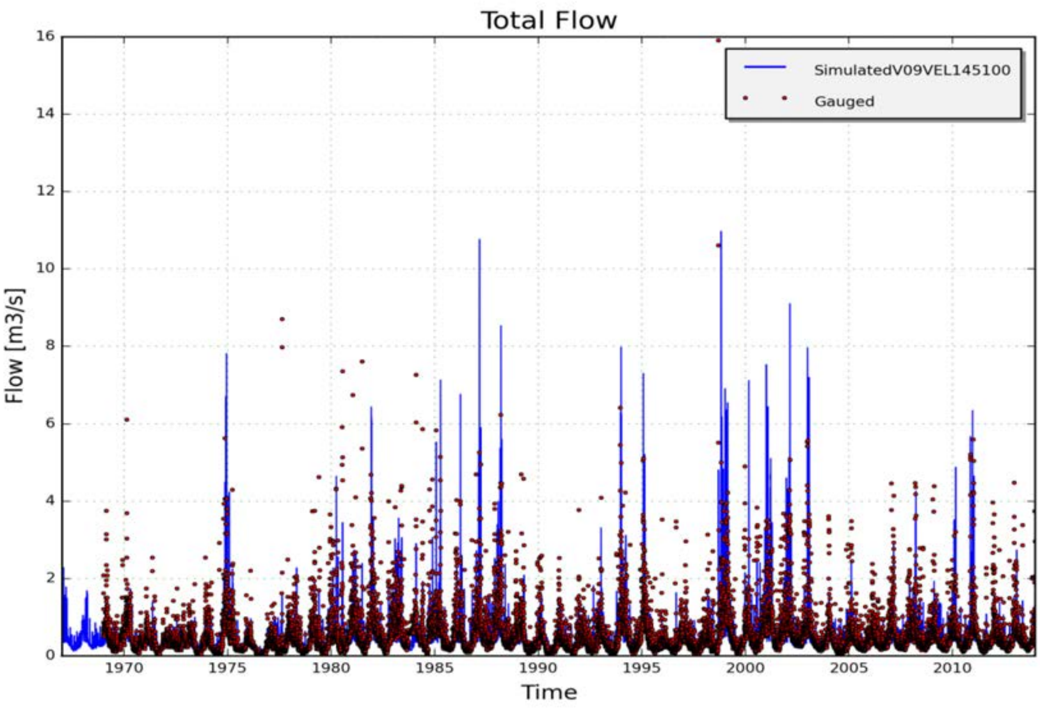


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09VEL145100, station 14510102 - Velp; Ransberg (validation period)

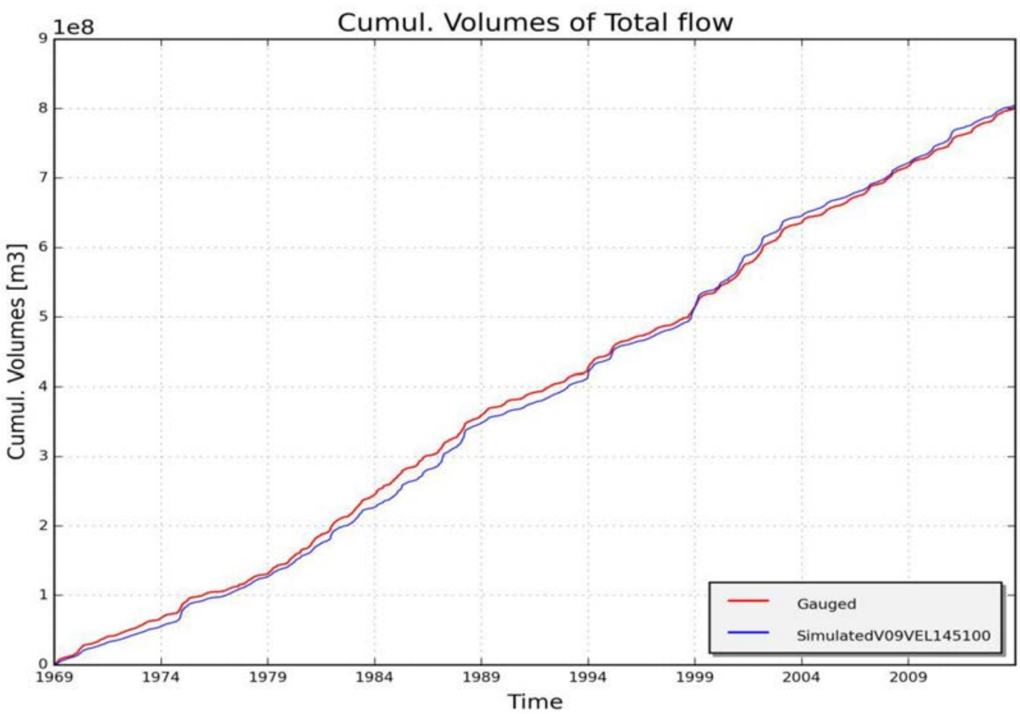
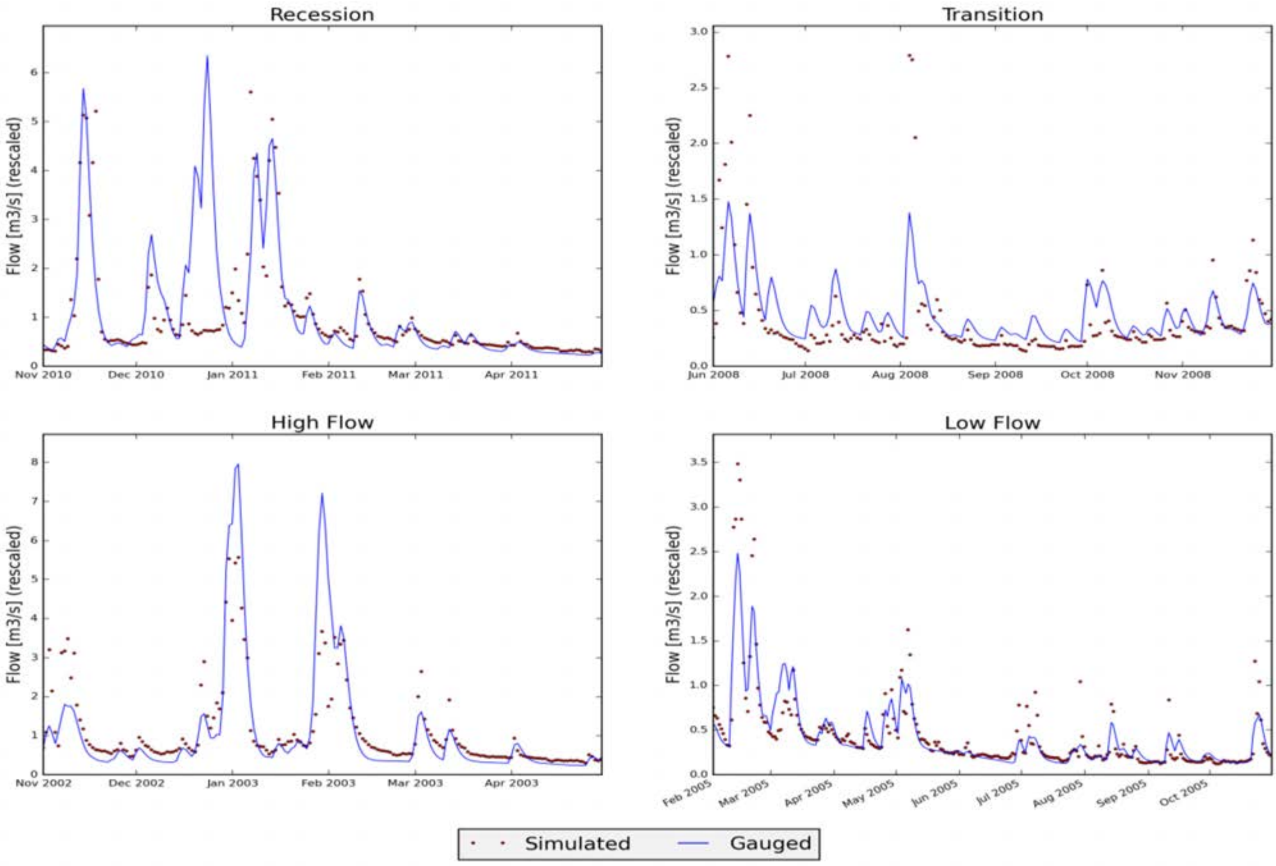


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09VEL145100, station 14510102 - Velp; Ransberg



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V09WIN141310" (DEMERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V09WIN141310 (Demerbekken)

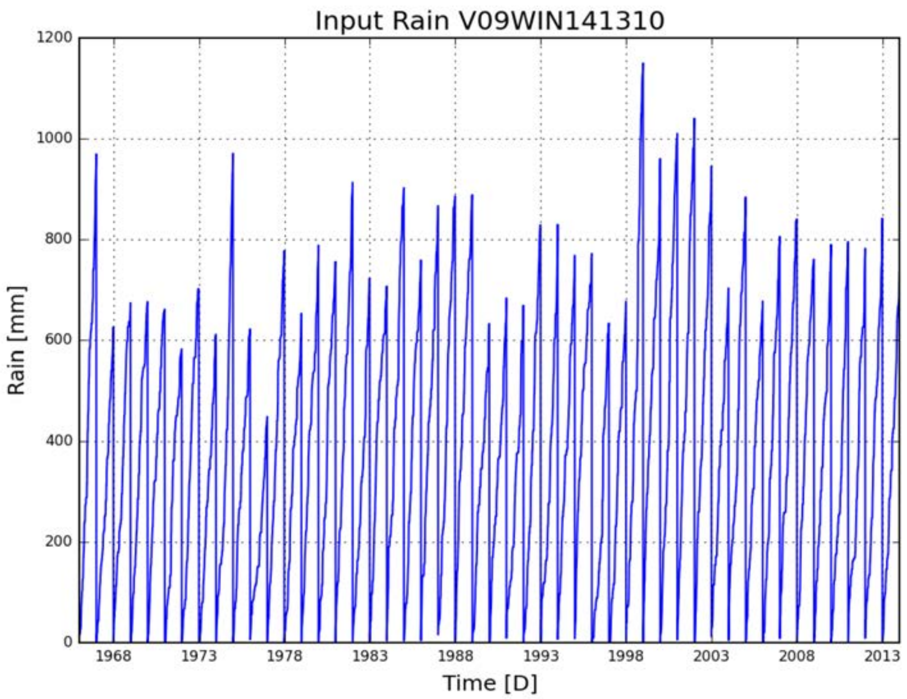
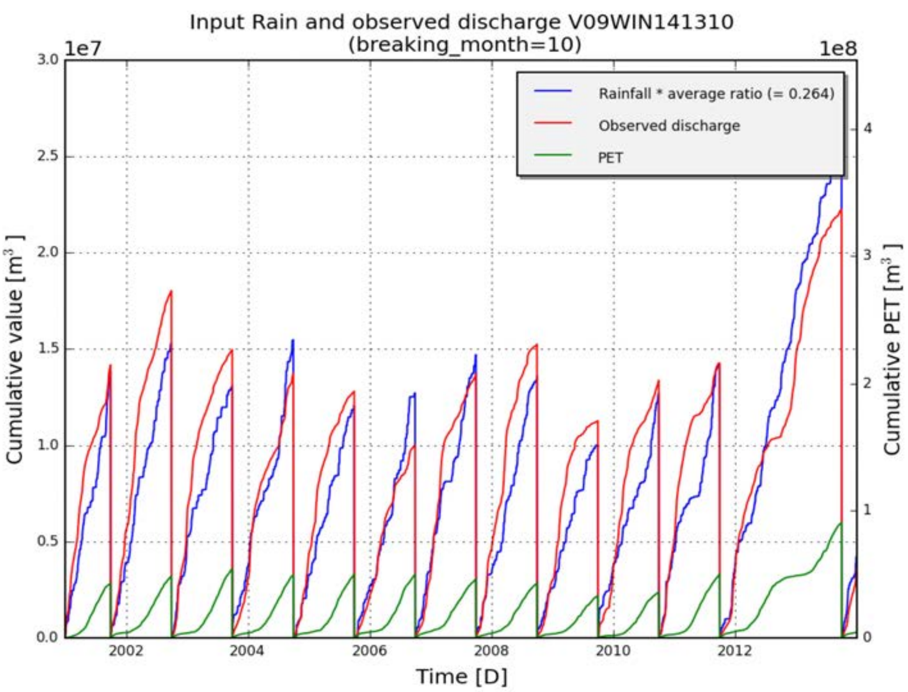


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09WIN141310 (Demerbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V09WIN141310
subcatchment_area [m²]	64739169
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.16), ('bevaporation', 2.0), ('cmin', 8.0), ('cmax', 620.0), ('CKBF', 300.0), ('CK1', 30.0), ('CK2', 25.0), ('bdrainage', 1.03), ('kdrainage', 37000.0), ('PDM.TG', 6.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.525	0.419	0.33
NS_log	0.519	0.1	0.602
NS_rel	-50.872	-54.365	0.708
RelErr	4.2 %	18.9 %	-4.8 %
VolBias	0.048	0.327	-0.085

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.344	0.608	-0.06
NS_log	0.552	0.249	0.539
NS_rel	-27.159	-18.75	0.555
RelErr	6.8 %	12.7 %	3.3 %
VolBias	0.08	0.232	0.004

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)

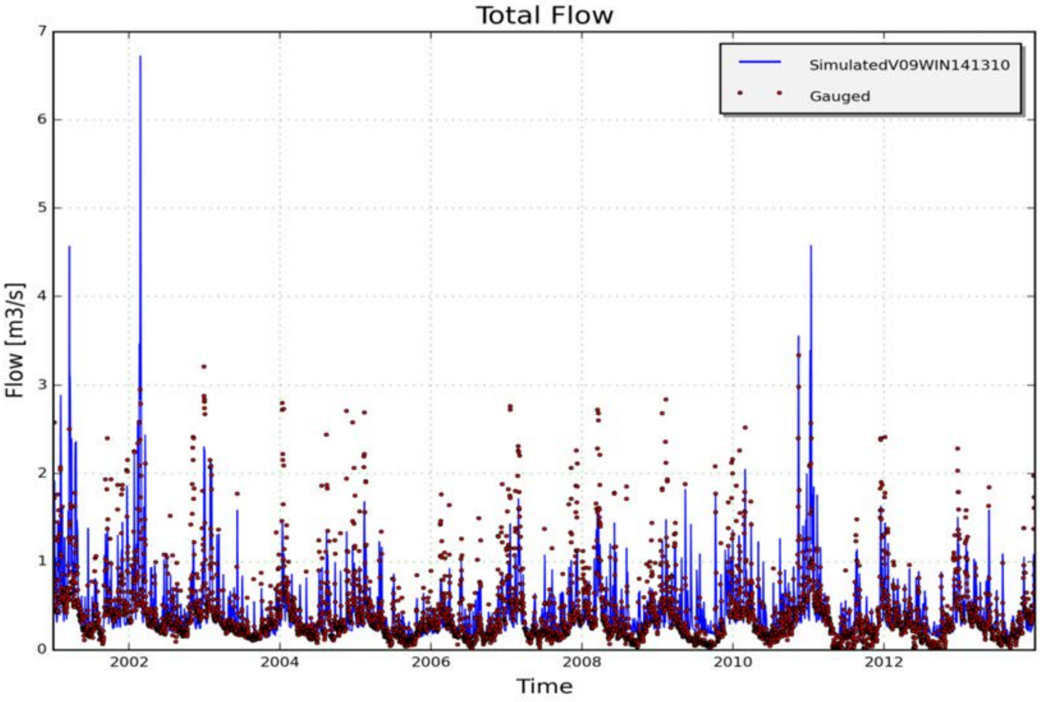


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09WIN141310, station 141 - Rotselaar ; Winge (calibration period)

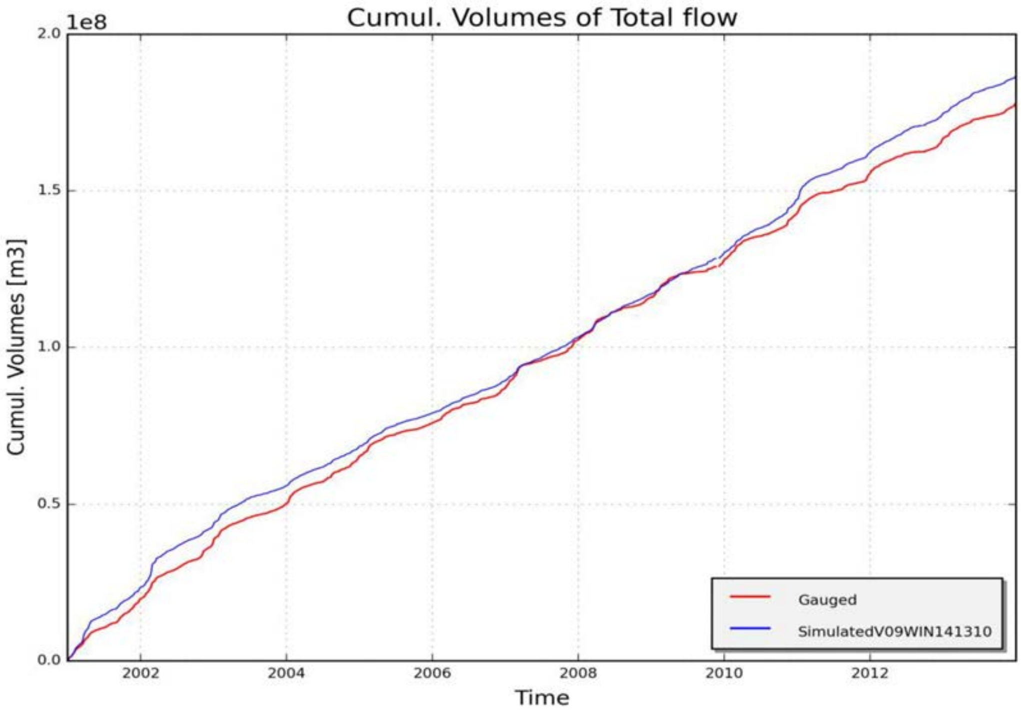


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09WIN141310, station 141 - Rotselaar ; Winge (validation period)

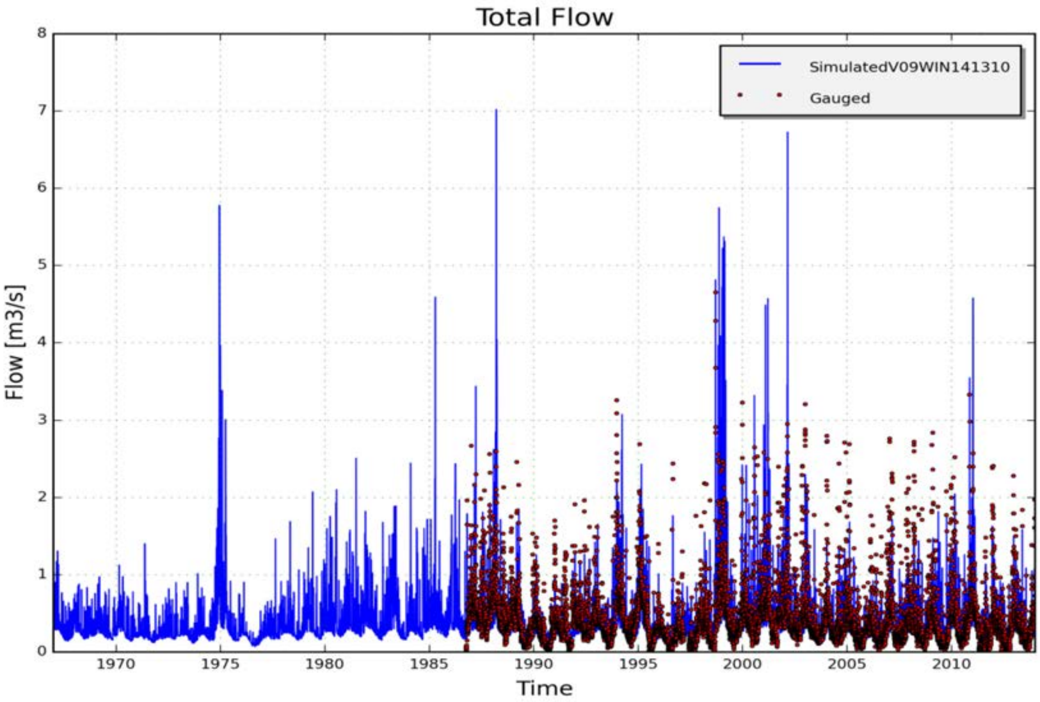


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09WIN141310, station 141 - Rotselaar ; Winge (validation period)

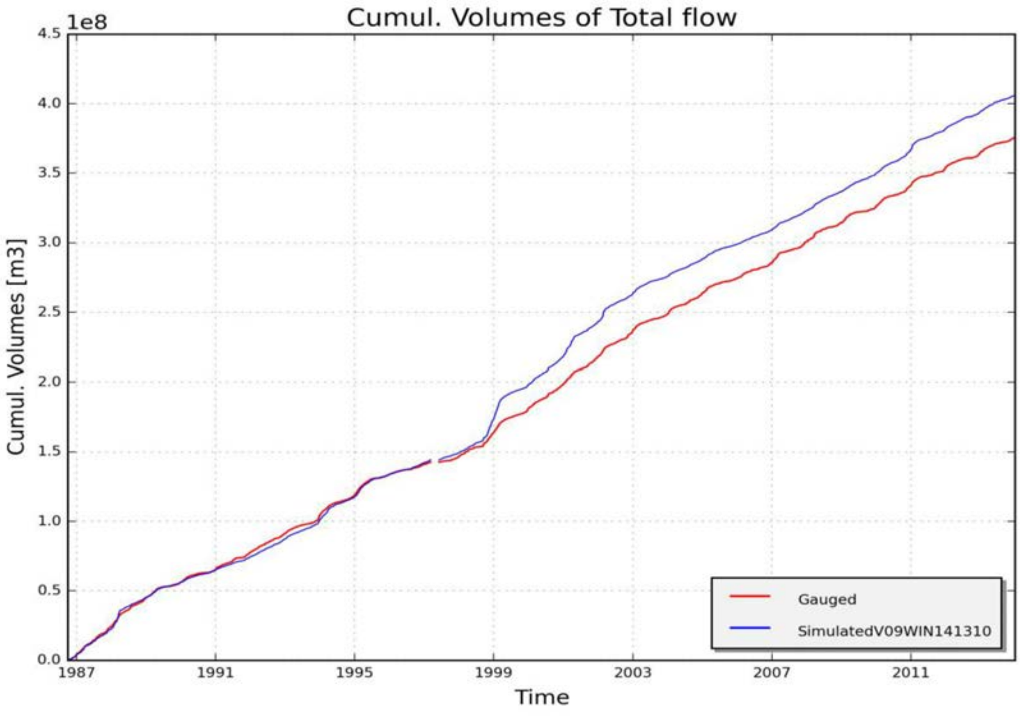
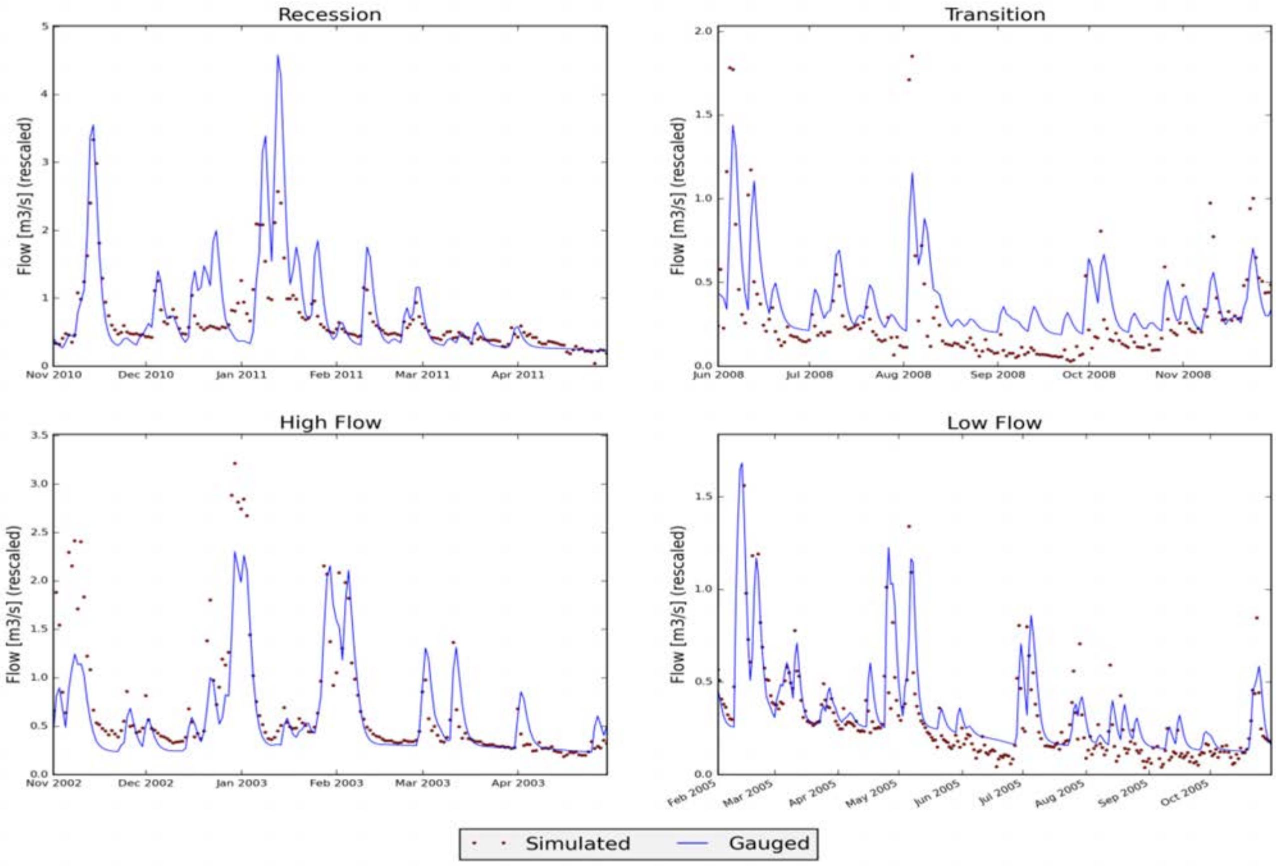


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09WIN141310, station 141 - Rotselaar ; Winge



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V09ZWA148120" (DEMERBEKKEN)

Input data

Figure 1: Cumulative precipitation on catchment V09ZWA148120 (Demerbekken)

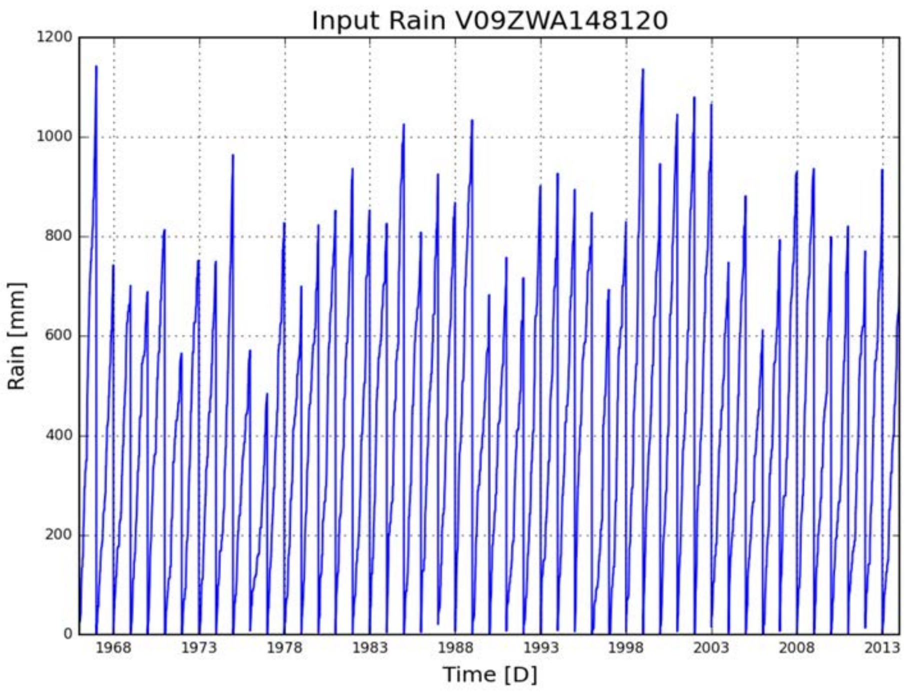
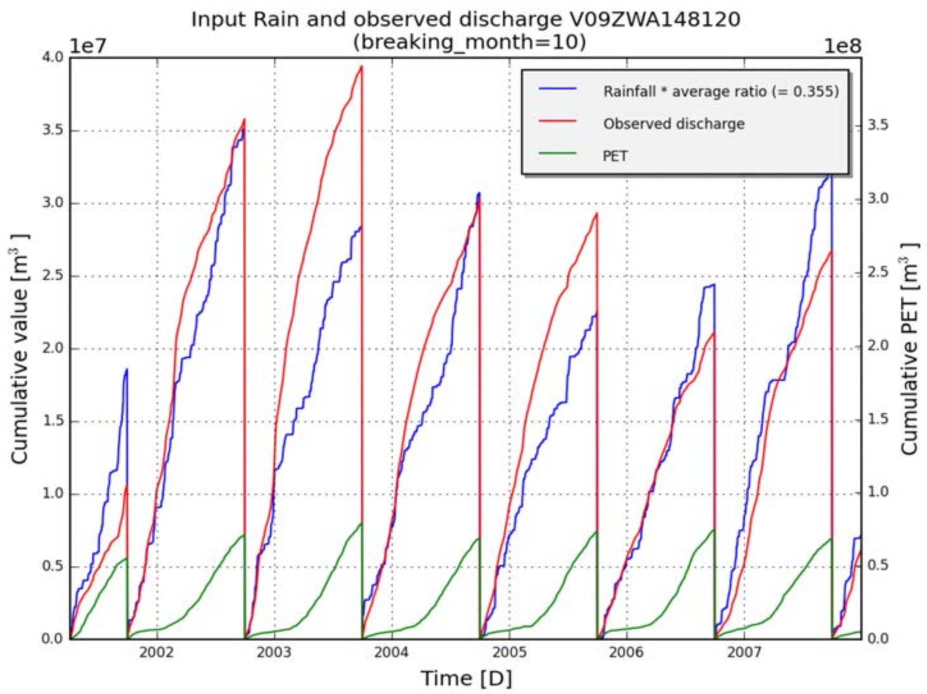


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V09ZWA148120 (Demerbekken)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V09ZWA148120
subcatchment_area [m²]	96514800
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.19), ('bevaporation', 2.0), ('cmin', 7.9), ('cmax', 776.0), ('CKBF', 300.0), ('CK1', 31.0), ('CK2', 37.0), ('bdrainage', 1.0), ('kdrainage', 16935.0), ('PDM.TG', 7.9), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2007)

	Full year	Summer	Winter
NS	0.718	0.43	0.746
NS_log	0.577	0.194	0.759
NS_rel	0.245	-1.183	0.867
RelErr	2.7 %	27.4 %	-13.4 %
VolBias	0.001	0.211	-0.145

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.559	0.306	0.627
NS_log	0.467	0.298	0.519
NS_rel	-4.909	-12.328	0.346
RelErr	-9.8 %	8.9 %	-19.4 %
VolBias	-0.089	-0.04	-0.138

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)

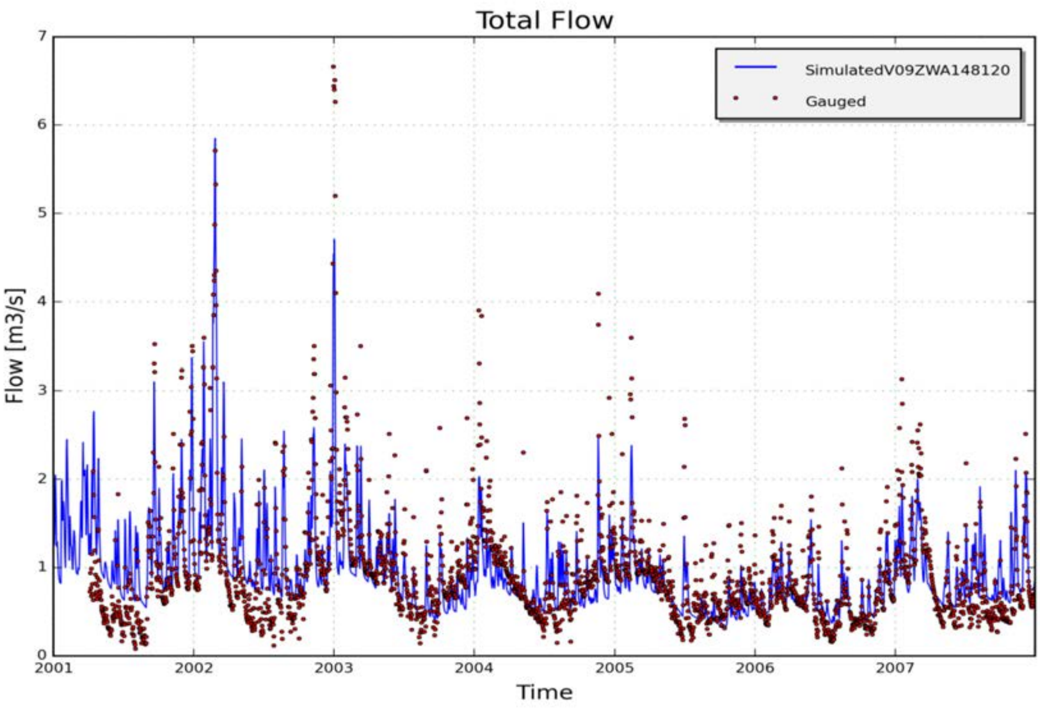


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen (calibration period)

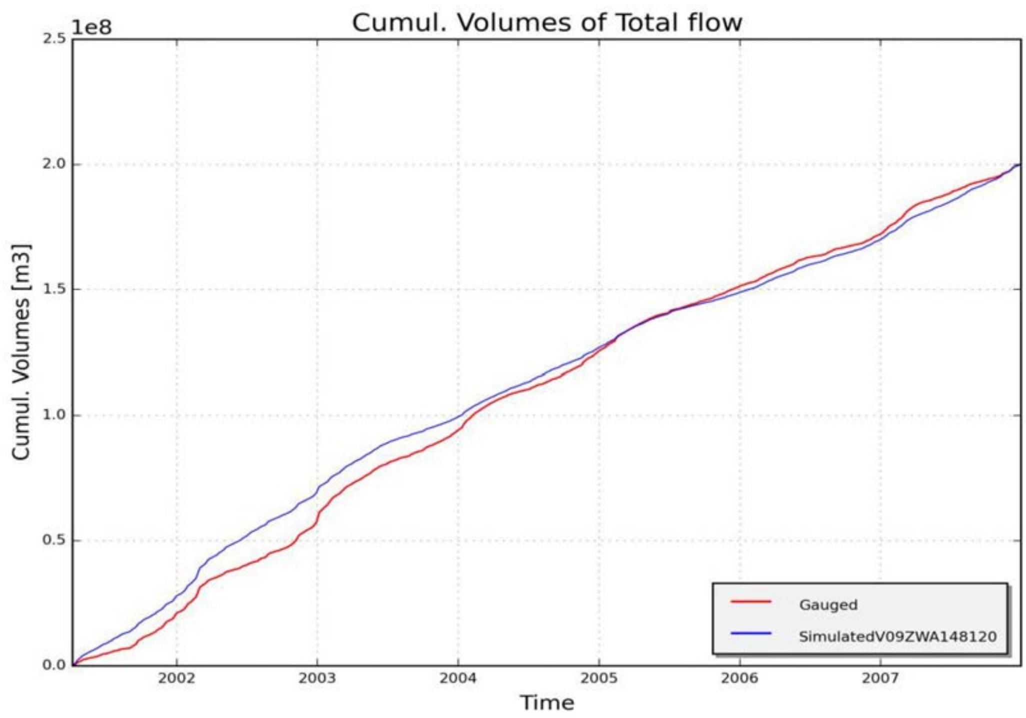


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen (validation period)

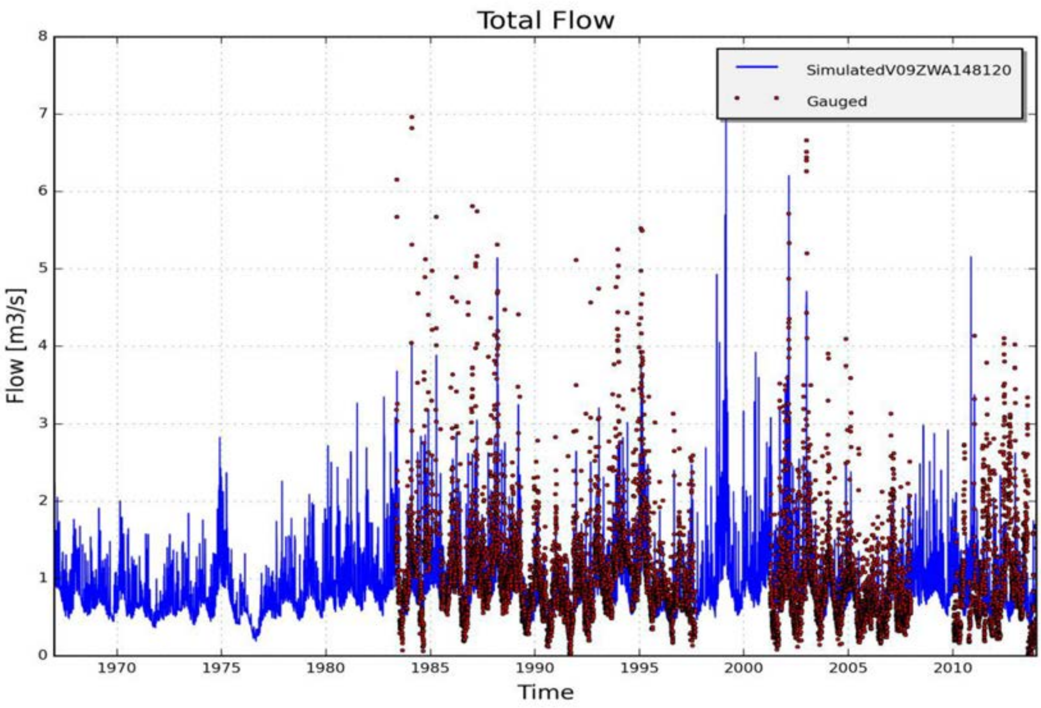


Fig b=140

Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen (validation period)

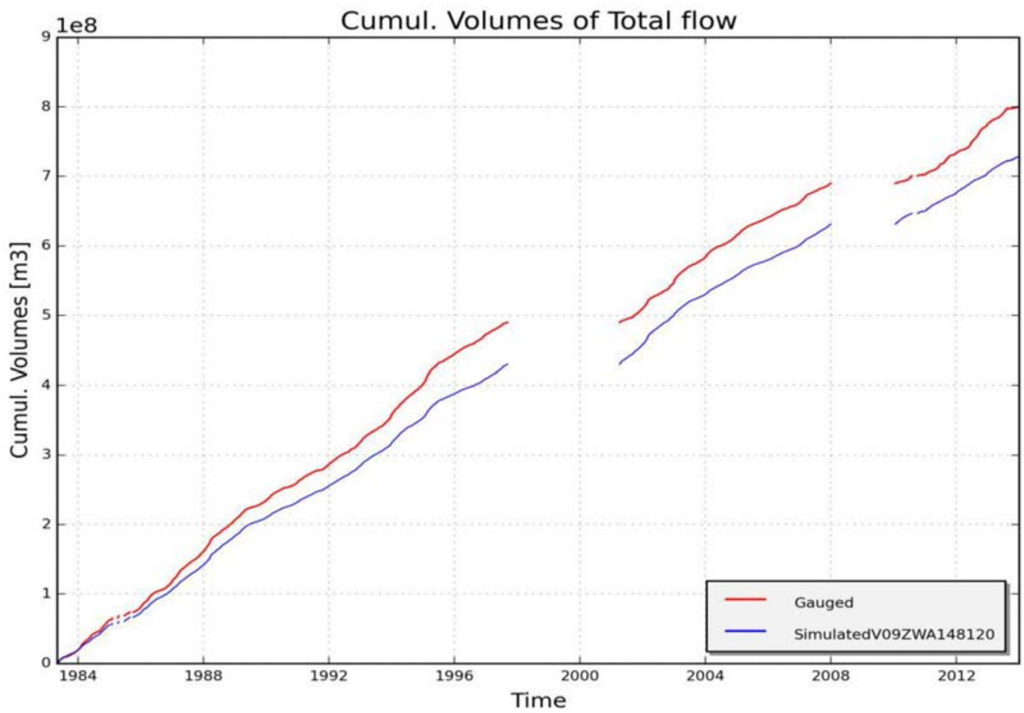


Fig b=137

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

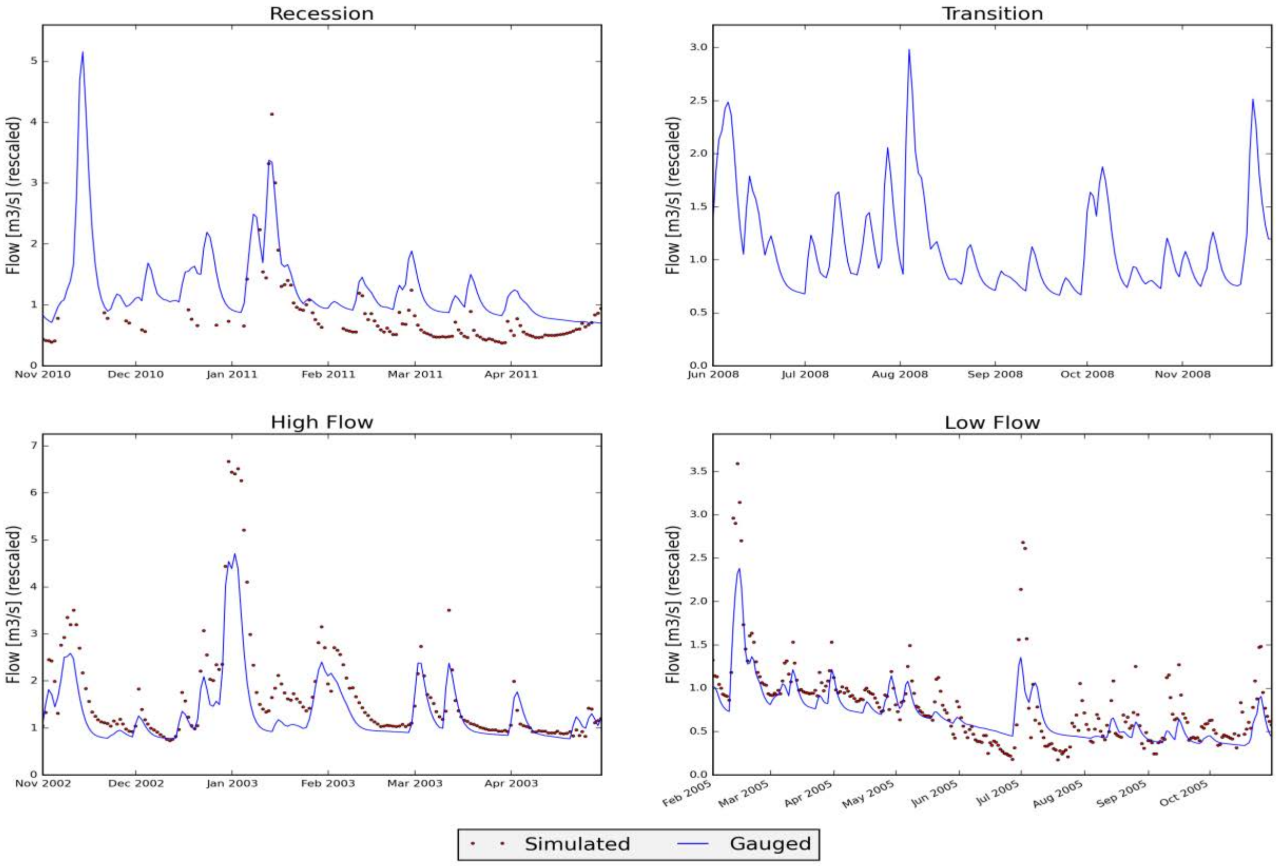


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen

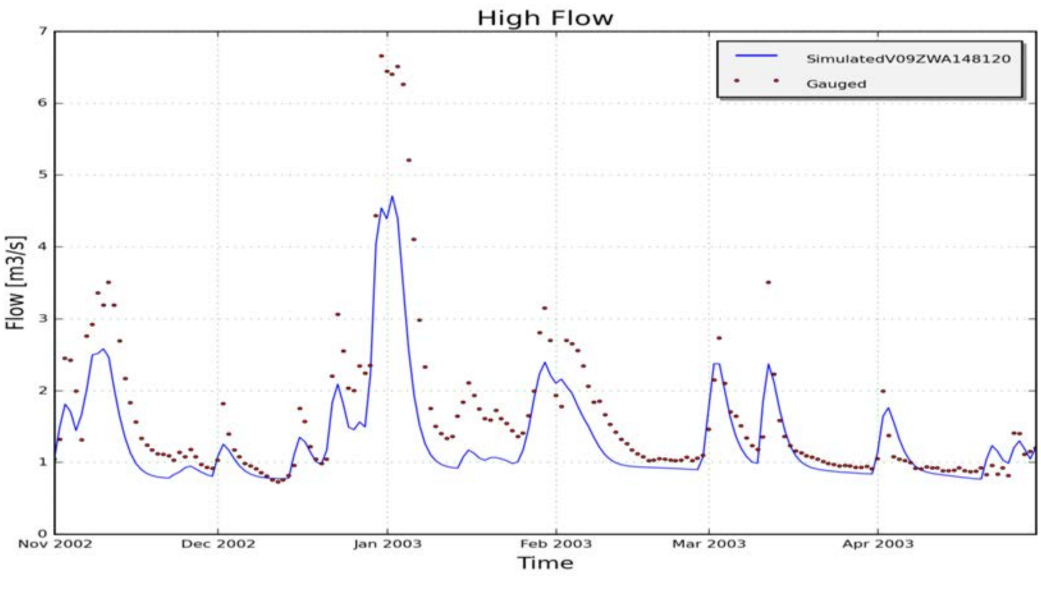
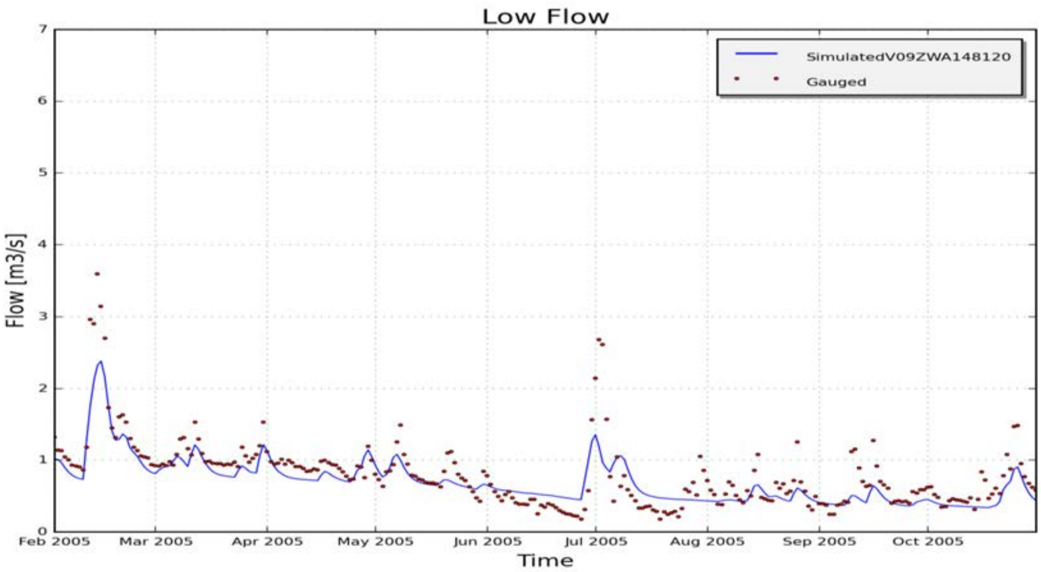


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchmentV09ZWA148120, station 14810102 - Zwarte Beek; Lummen



Annexe 12 Nete

CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V10GLA086020" (NETE)

Input data

Figure 1: Cumulative precipitation on catchment V10GLA086020 (Nete)

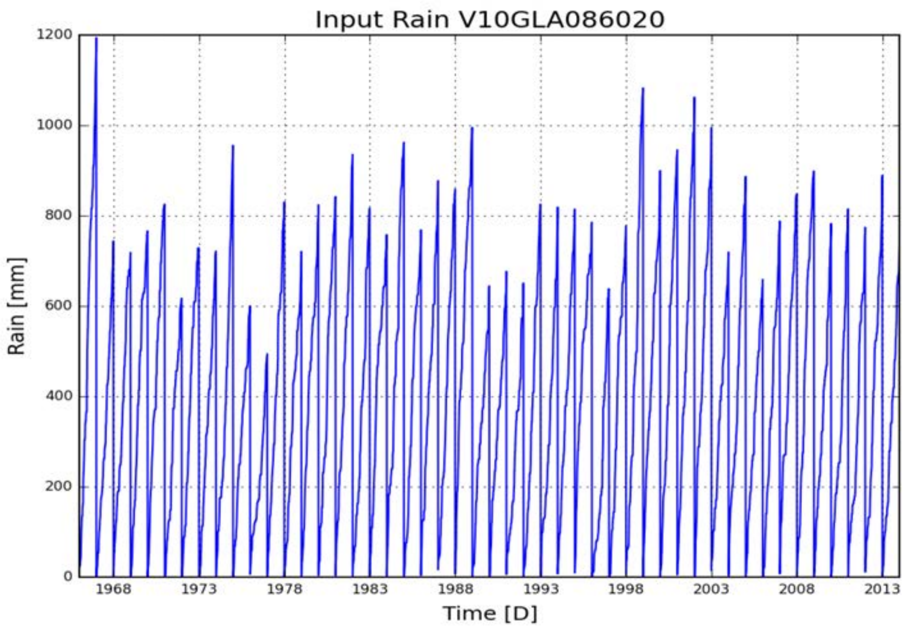
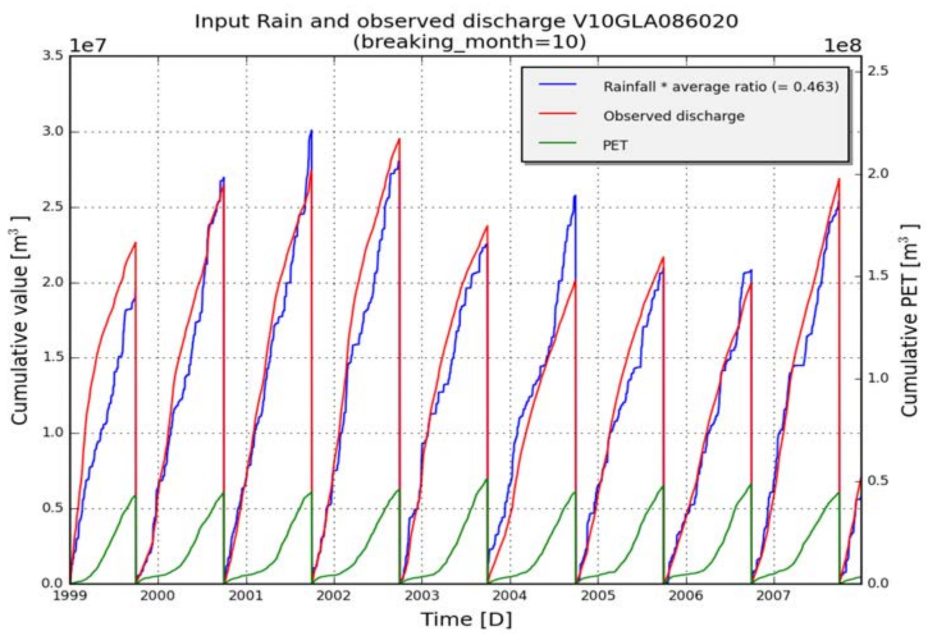


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V10GLA086020 (Nete)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V10GLA086020
subcatchment_area [m²]	62621236
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.18), ('bevaporation', 2.0), ('cmin', 9.0), ('cmax', 456.0), ('CKBF', 300.0), ('CK1', 19.0), ('CK2', 45.0), ('bdrainage', 1.0), ('kdrainage', 6113.0), ('PDM.TG', 1.4), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1999 - 2007)

	Full year	Summer	Winter
NS	0.772	0.574	0.725
NS_log	0.774	0.526	0.786
NS_rel	0.859	0.8	0.864
RelErr	-0.4 %	2.1 %	-6.0 %
VolBias	-0.035	-0.035	-0.056

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.614	0.234	0.63
NS_log	0.452	0.051	0.598
NS_rel	-7.416	-24.225	0.283
RelErr	-14.3 %	-19.6 %	-14.0 %
VolBias	-0.106	-0.147	-0.106

Observed and simulated timeseries for optimum parameters

Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V10GLA086020, station 8610102 - Grote Laak, Vorst (calibration period)

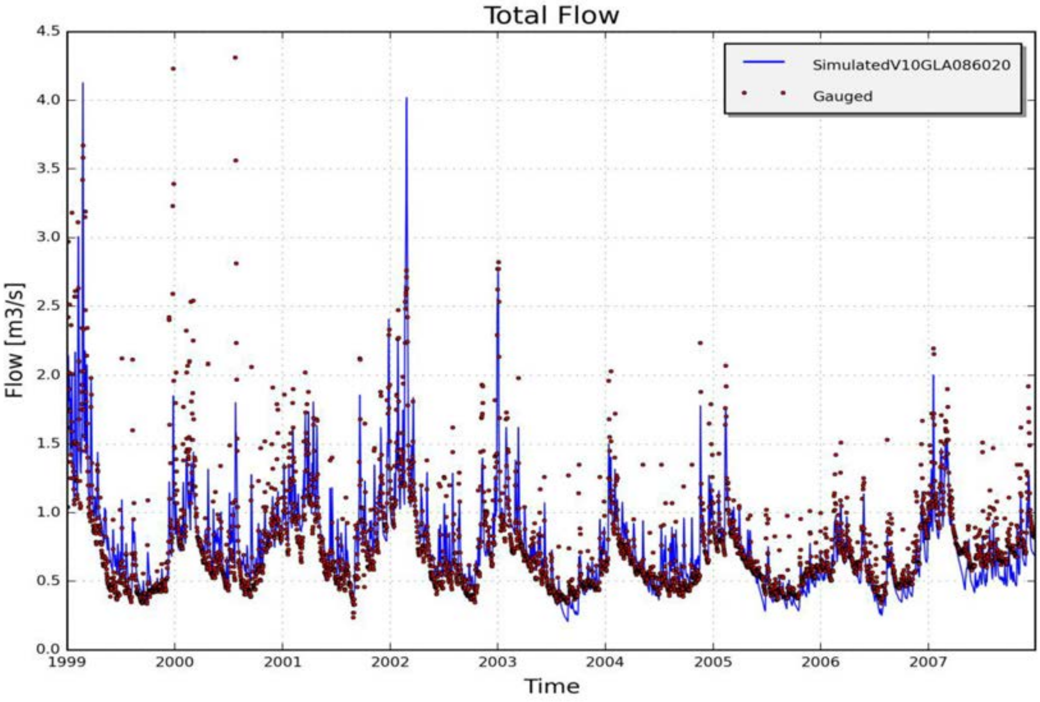


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V10GLA086020, station 8610102 - Grote Laak, Vorst (calibration period)

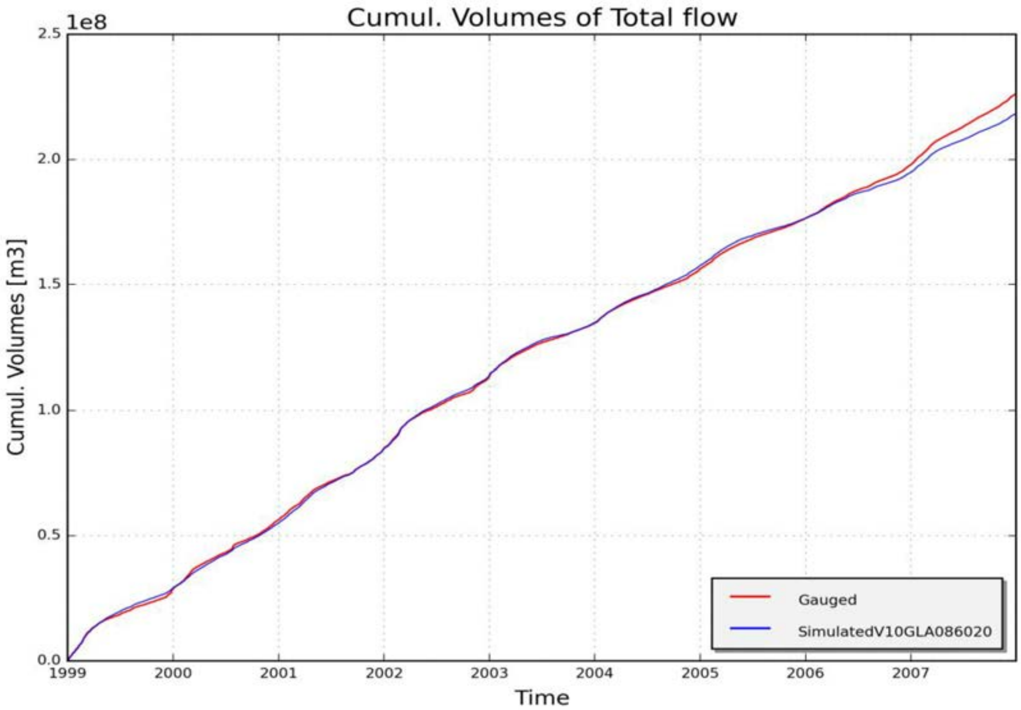


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V10GLA086020, station 8610102 - Grote Laak, Vorst (validation period)

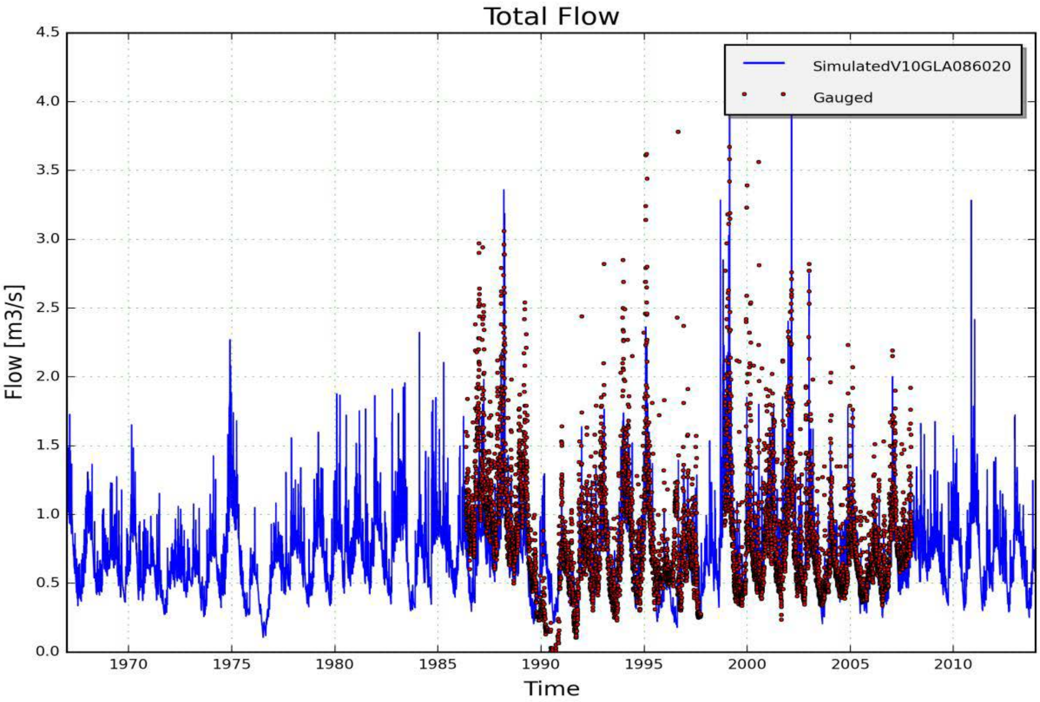


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V10GLA086020, station 8610102 - Grote Laak, Vorst (validation period)

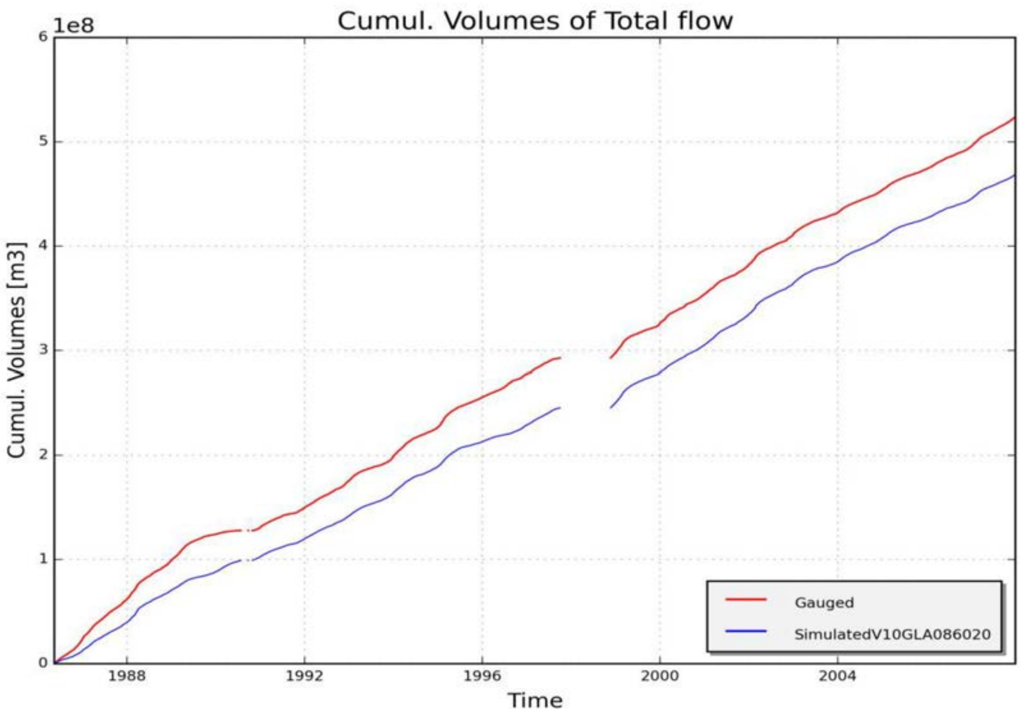


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V10GLA086020, station 8610102 - Grote Laak, Vorst

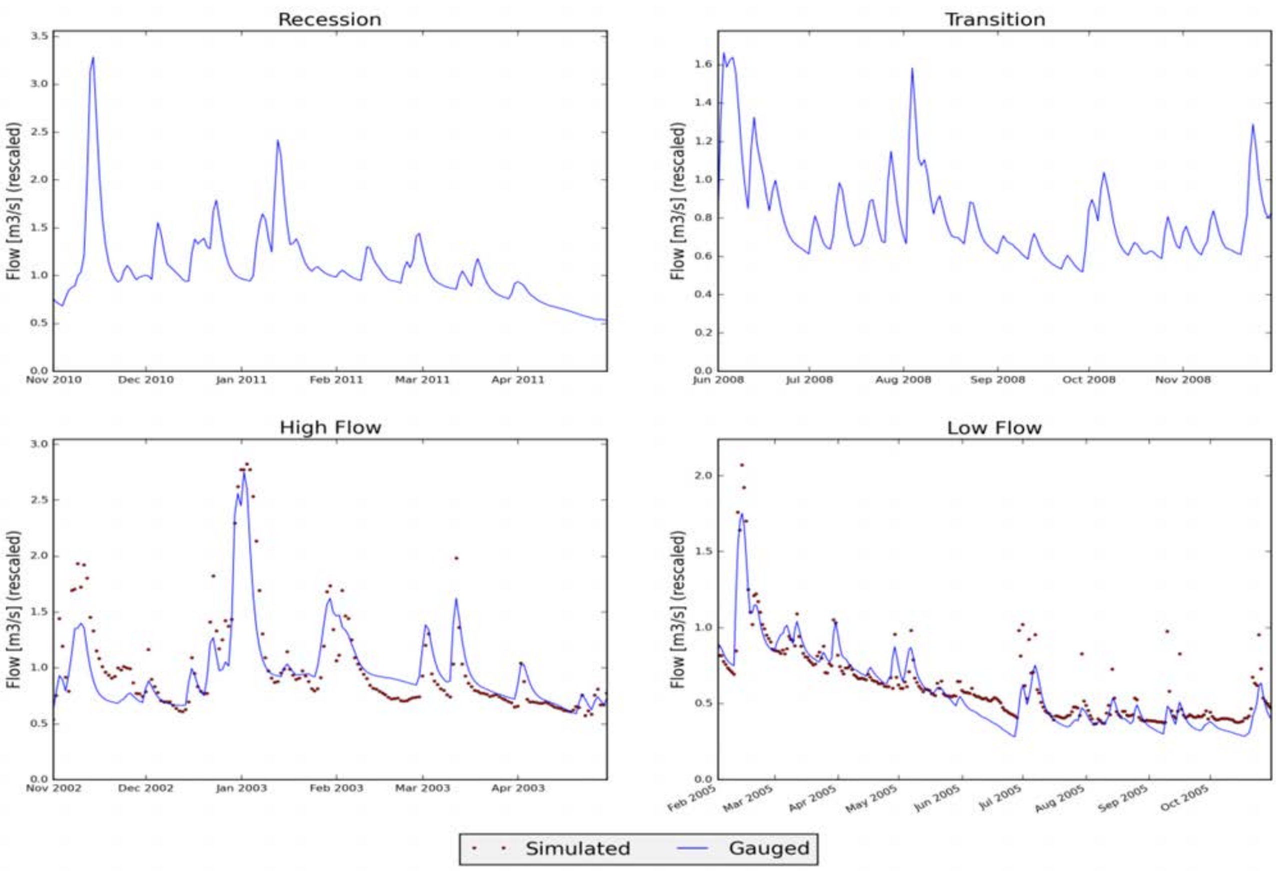


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V10GLA086020, station 8610102 - Grote Laak, Vorst

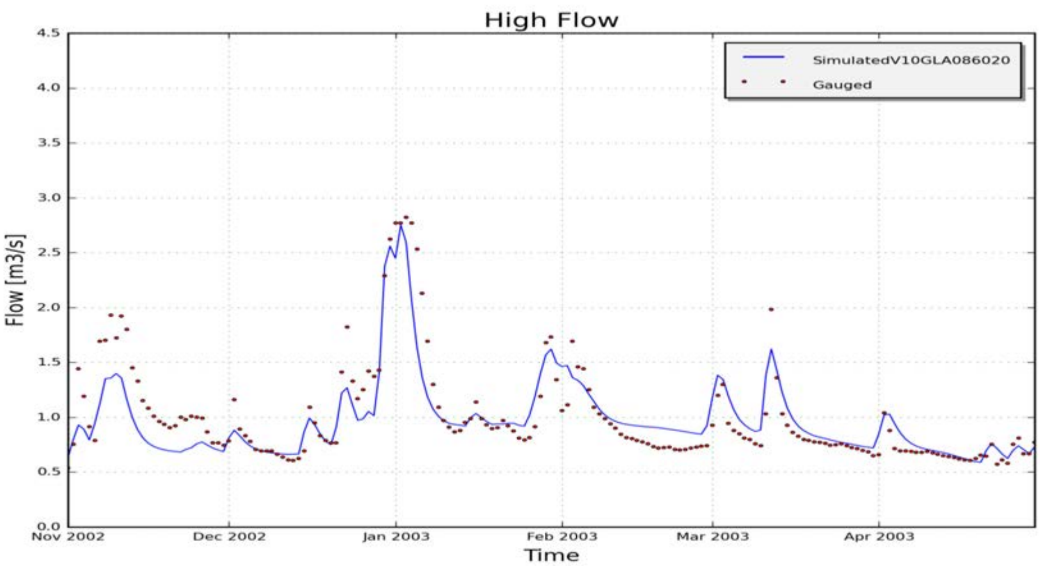
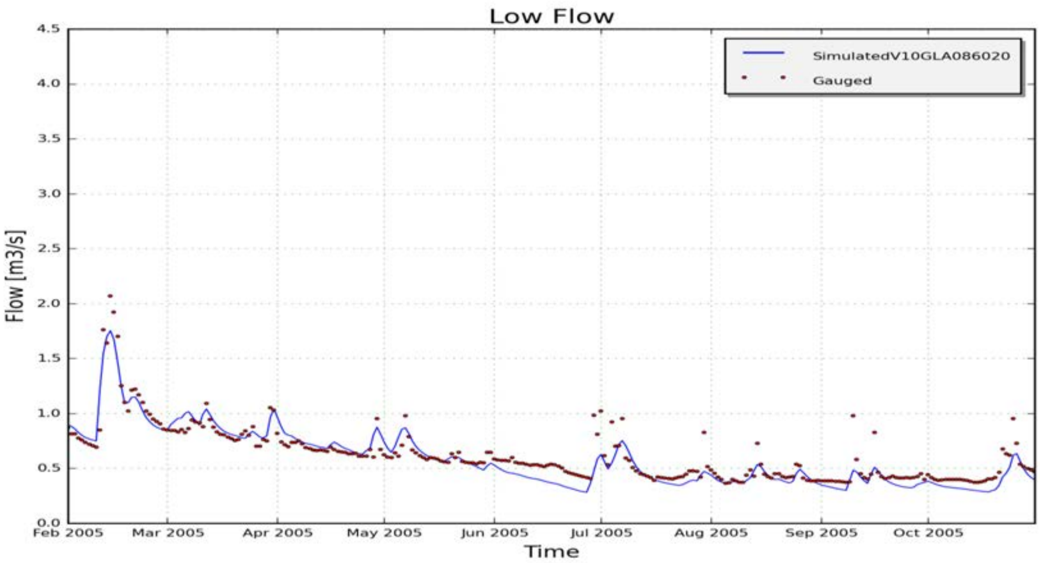


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V10GLA086020, station 8610102 - Grote Laak, Vorst



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V10GNE076999" (NETE)

Input data

Figure 1: Cumulative precipitation on catchment V10GNE076999 (Nete)

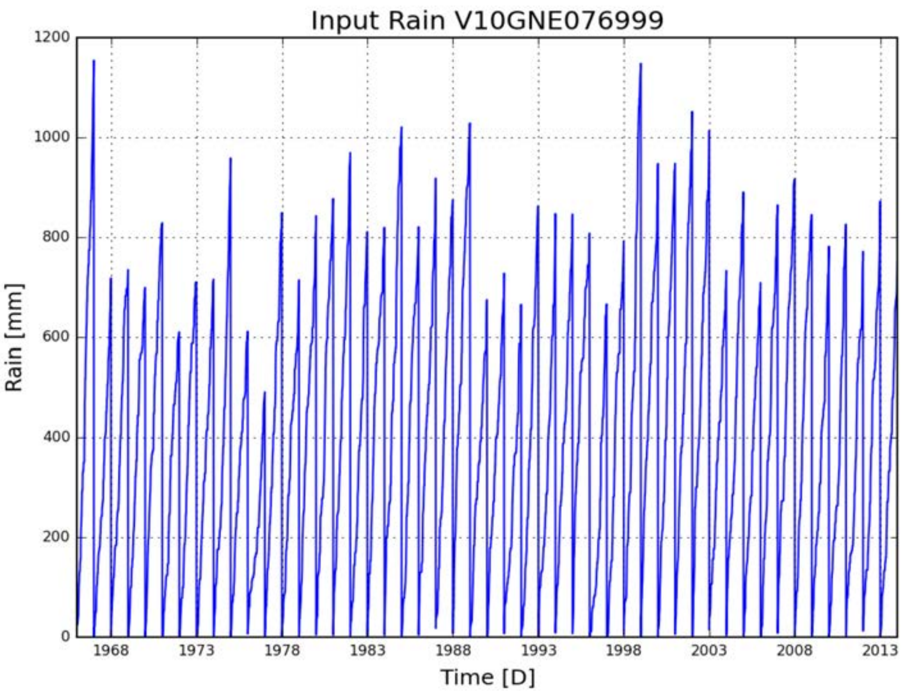
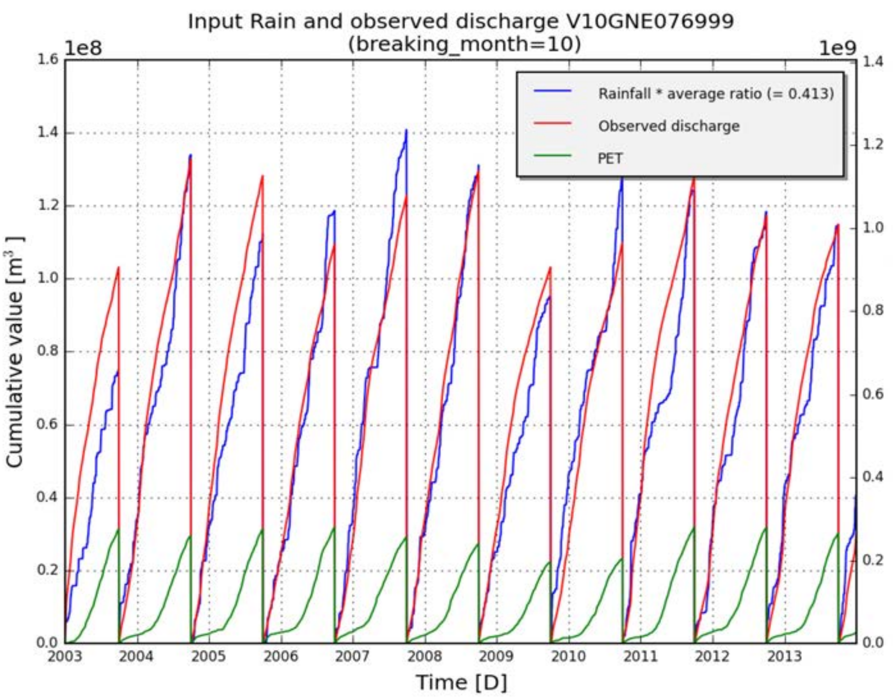


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V10GNE076999 (Nete)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V10GNE076999
subcatchment_area [m²]	359885327
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.24), ('bevaporation', 2.0), ('cmin', 5.8), ('cmax', 778.0), ('CKBF', 300.0), ('CK1', 42.0), ('CK2', 46.0), ('bdrainage', 1.0), ('kdrainage', 12501.0), ('PDM.TG', 0.3), ('tdly', 0.0), ('qconst', 0.0)]

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

	Full year	**Summer**	**Winter**
NS	0.761	0.562	0.683
NS_log	0.744	0.562	0.677
NS_rel	0.79	0.498	0.819
RelErr	-3.3 %	3.3 %	-12.2 %
VolBias	0.002	0.089	-0.093

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	**Summer**	**Winter**
NS	0.744	0.617	0.672
NS_log	0.705	0.458	0.683
NS_rel	0.743	0.483	0.809
RelErr	-6.3 %	6.1 %	-15.8 %
VolBias	-0.034	0.088	-0.131

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)

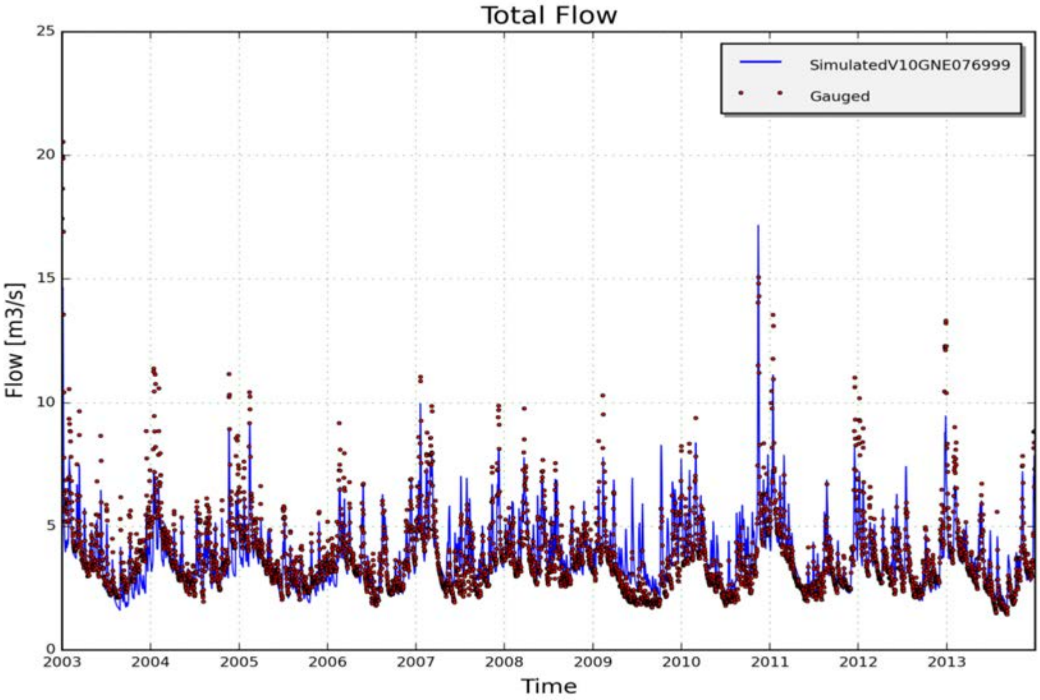


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel (calibration period)

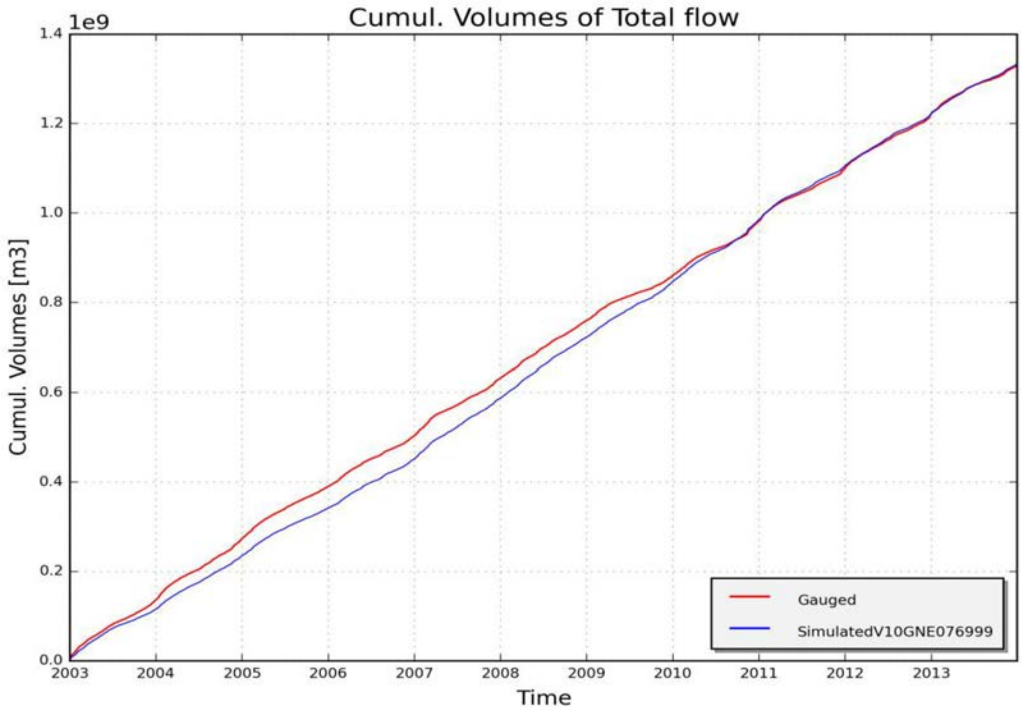


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel (validation period)

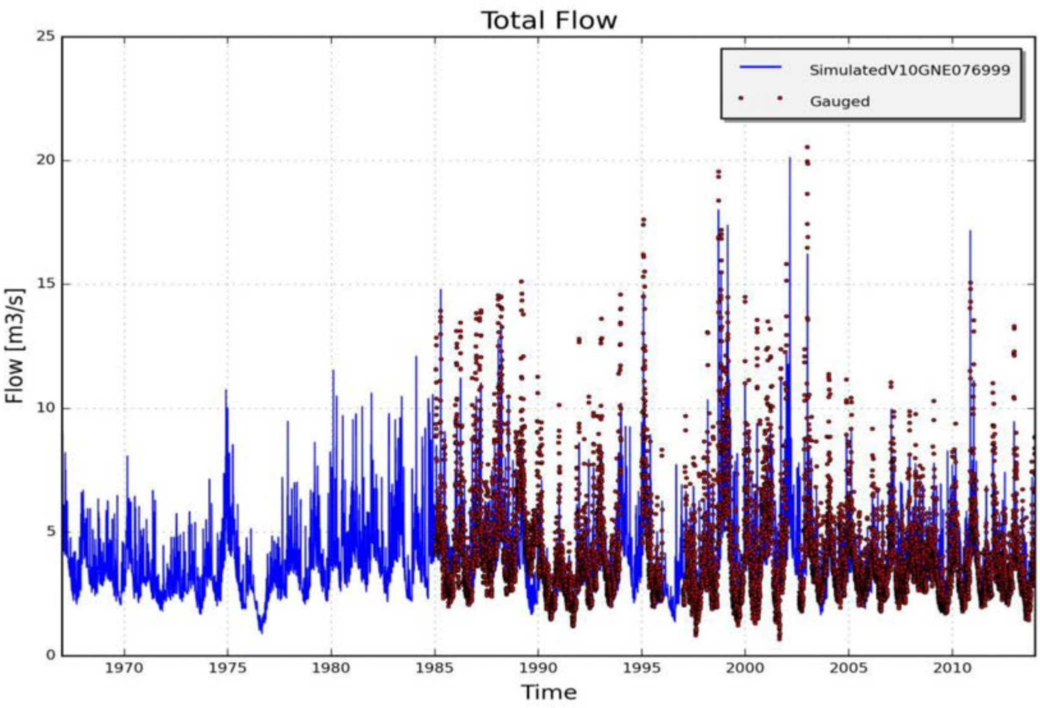


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel (validation period)

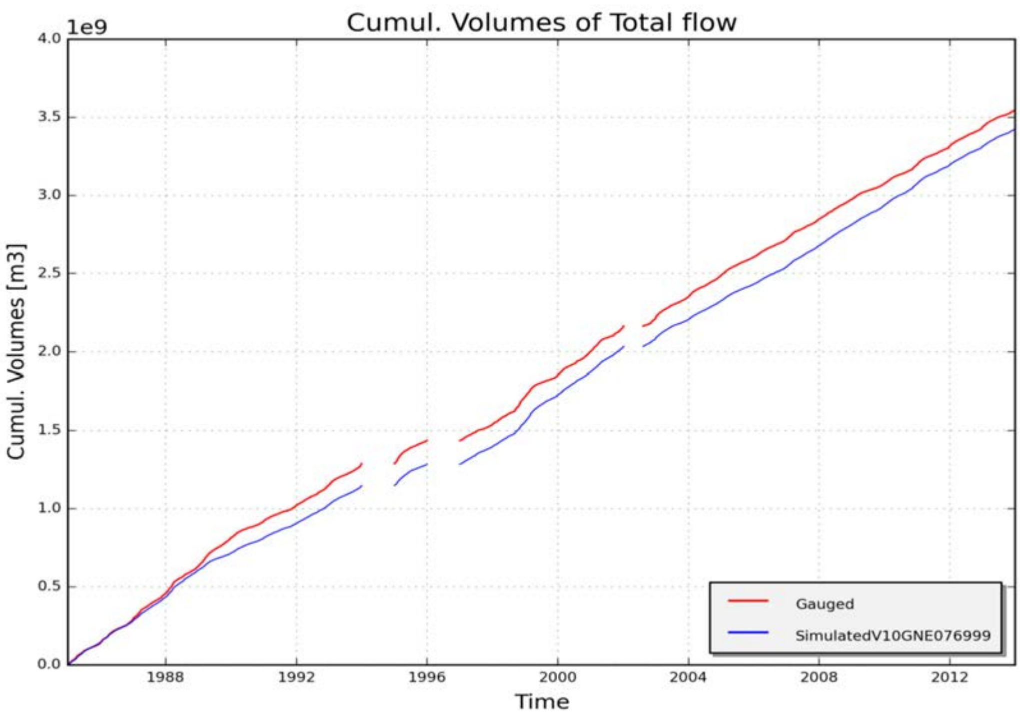
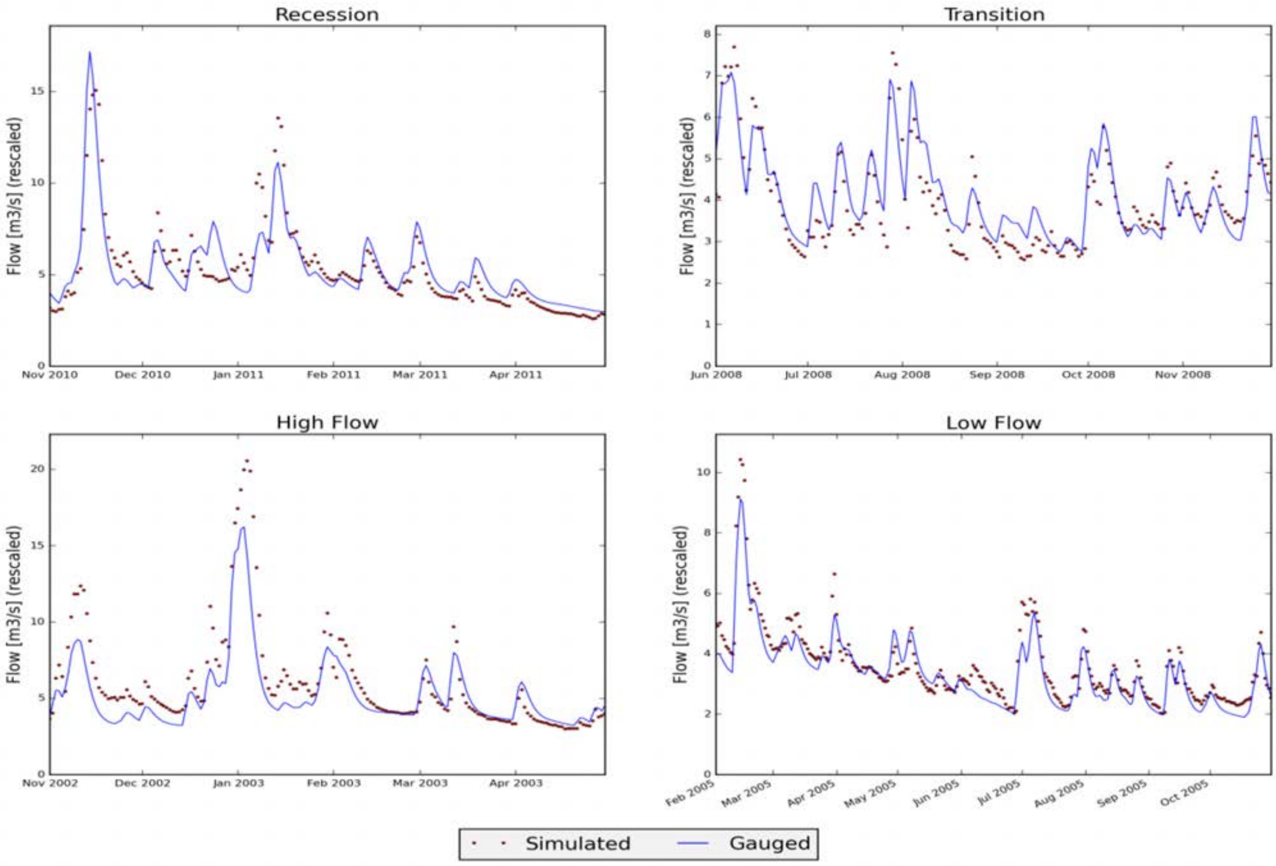


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V10KNE052000" (NETE)

Input data

Figure 1: Cumulative precipitation on catchment V10KNE052000 (Nete)

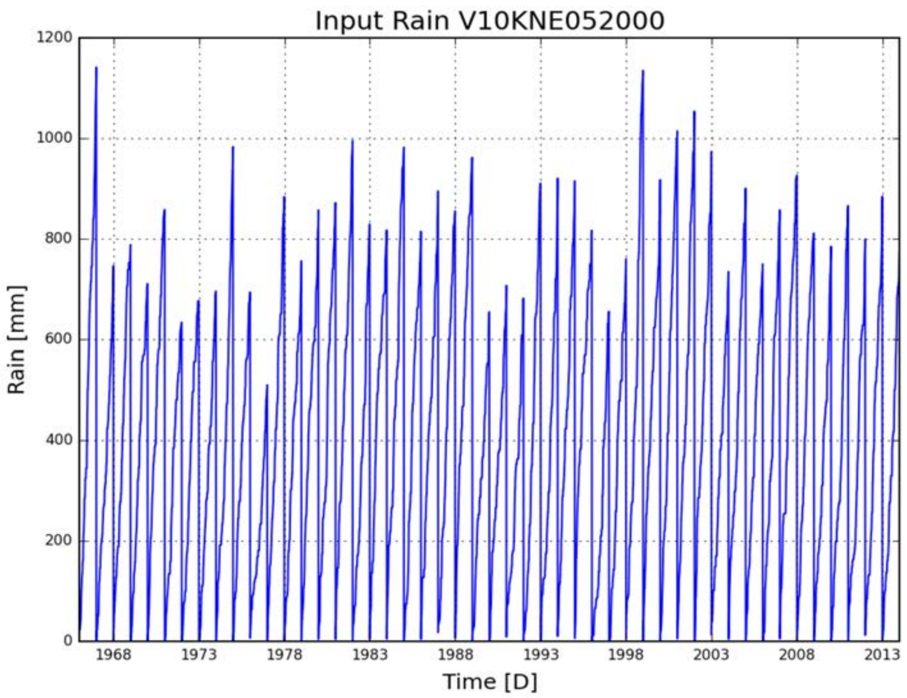
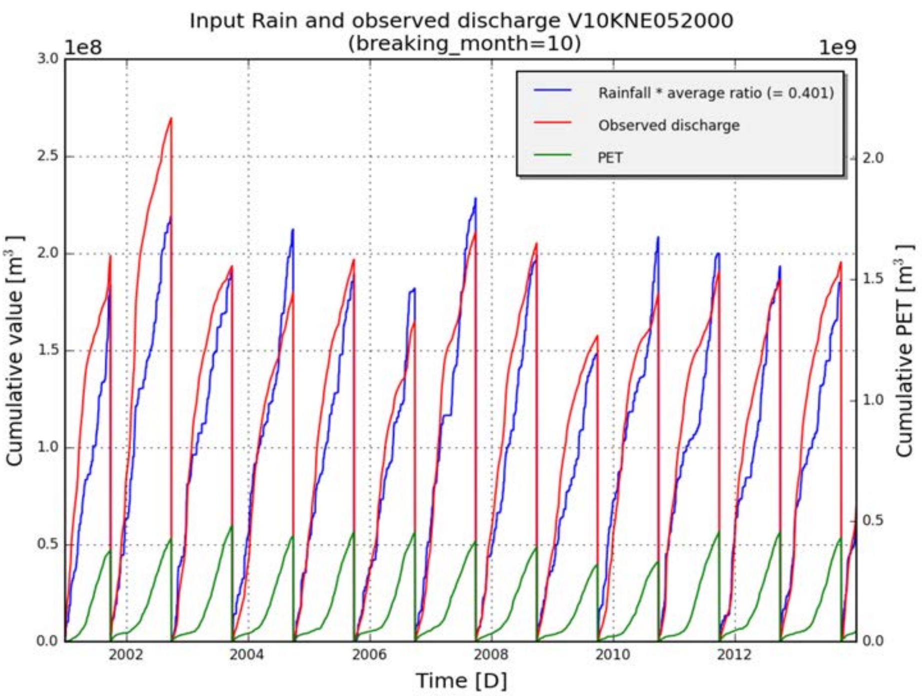


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V10KNE052000 (Nete)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V10KNE052000
subcatchment_area [m²]	584669408
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.26), ('bevaporation', 2.0), ('cmin', 5.2), ('cmax', 431.0), ('CKBF', 300.0), ('CK1', 40.0), ('CK2', 35.0), ('bdrainage', 1.0), ('kdrainage', 10171.0), ('PDM.TG', 5.7), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	**Summer**	**Winter**
NS	0.784	0.622	0.686
NS_log	0.801	0.582	0.683
NS_rel	0.783	0.371	0.724
RelErr	-0.4 %	17.0 %	-7.5 %
VolBias	-0.0	0.204	-0.089

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	**Summer**	**Winter**
NS	0.798	0.765	0.685
NS_log	0.834	0.672	0.741
NS_rel	0.833	0.693	0.794
RelErr	-2.2 %	8.9 %	-7.3 %
VolBias	-0.009	0.126	-0.069

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)

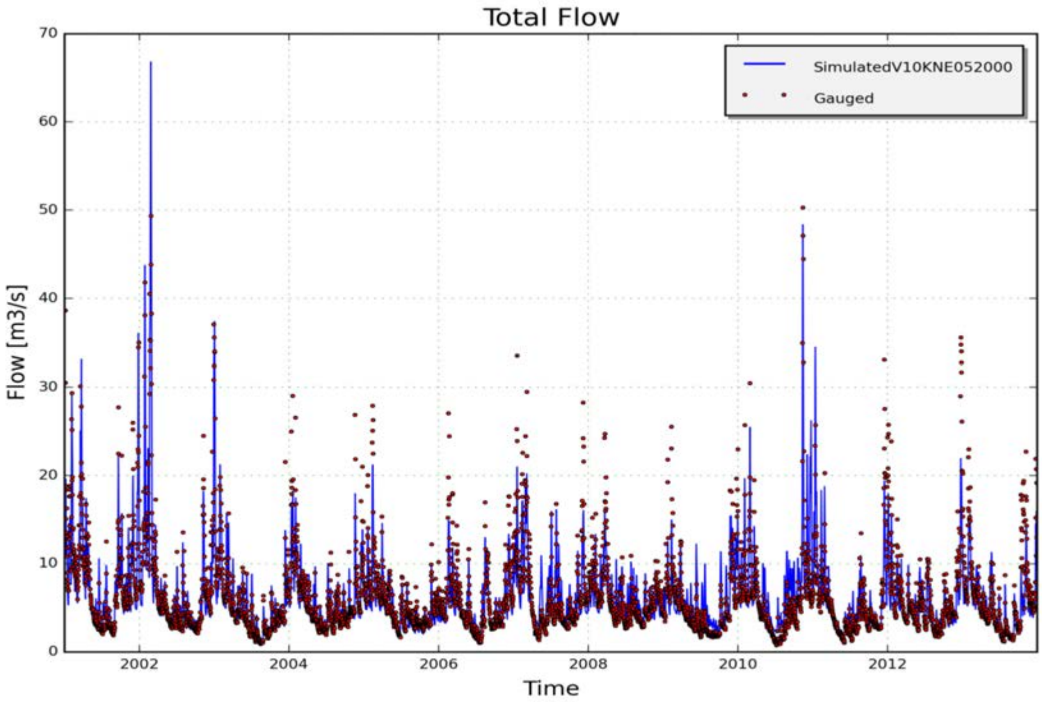


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk (calibration period)

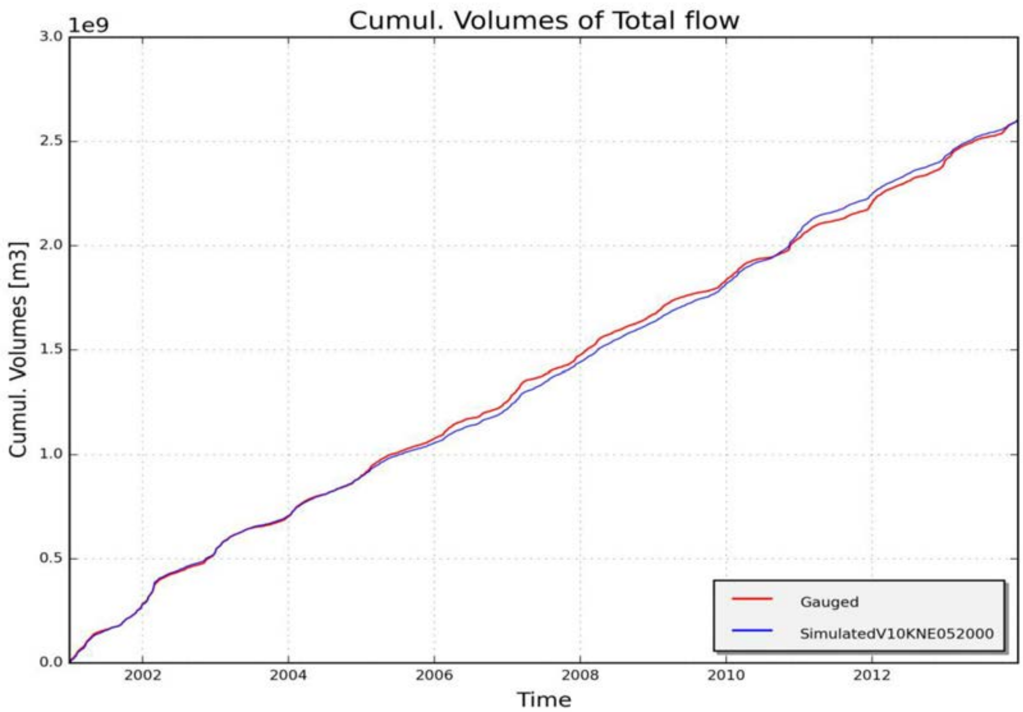


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk (validation period)

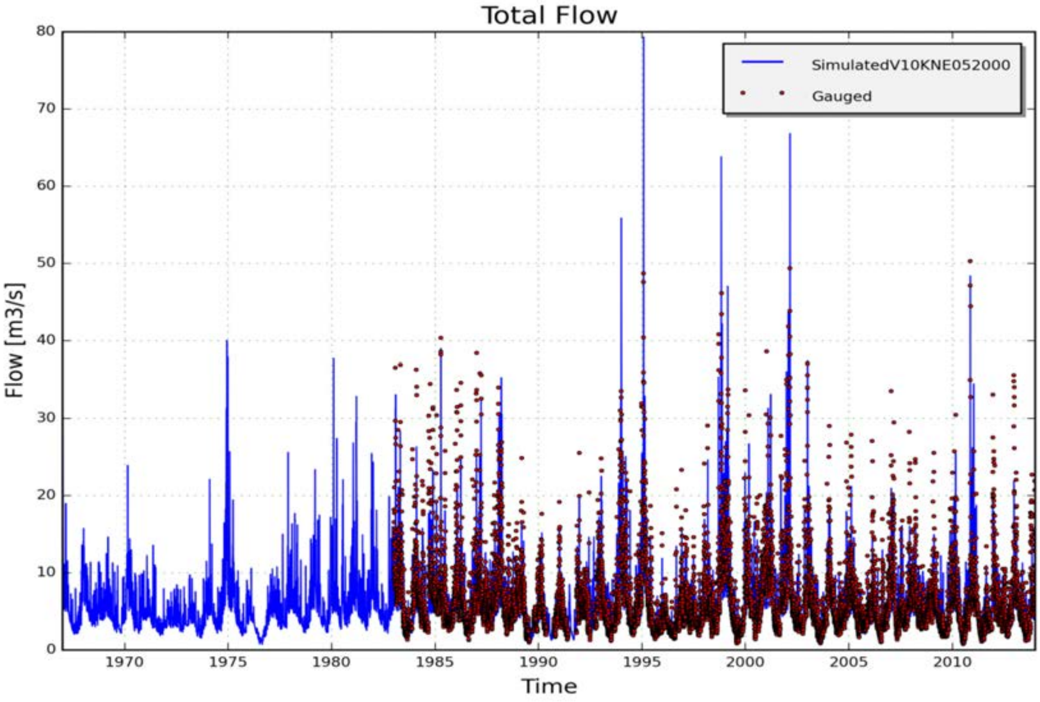


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk (validation period)

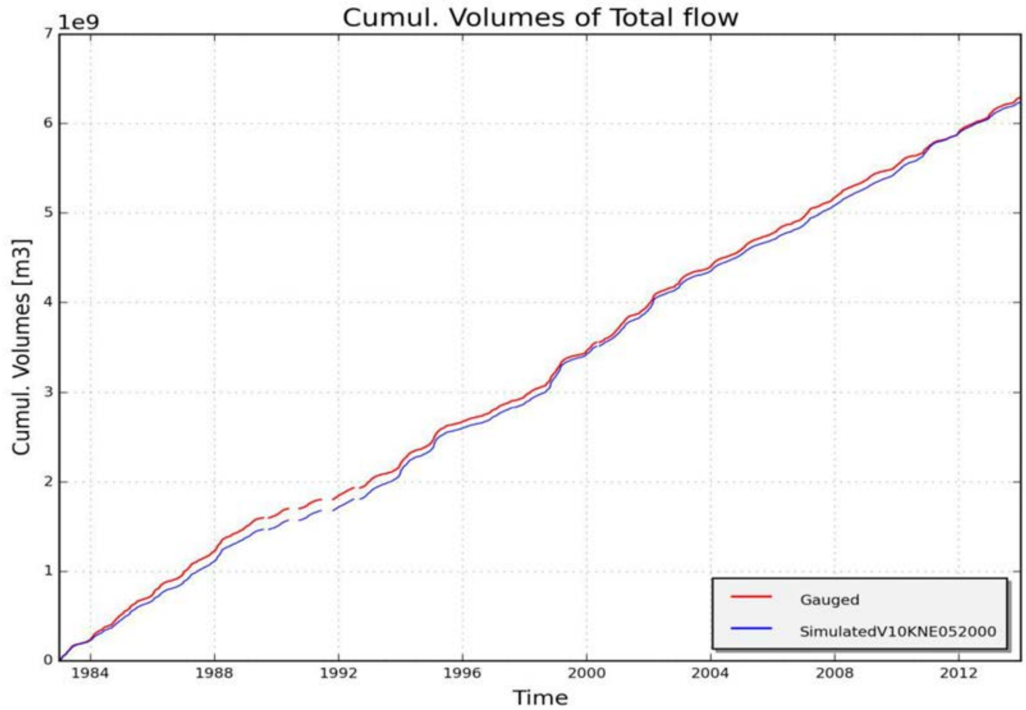
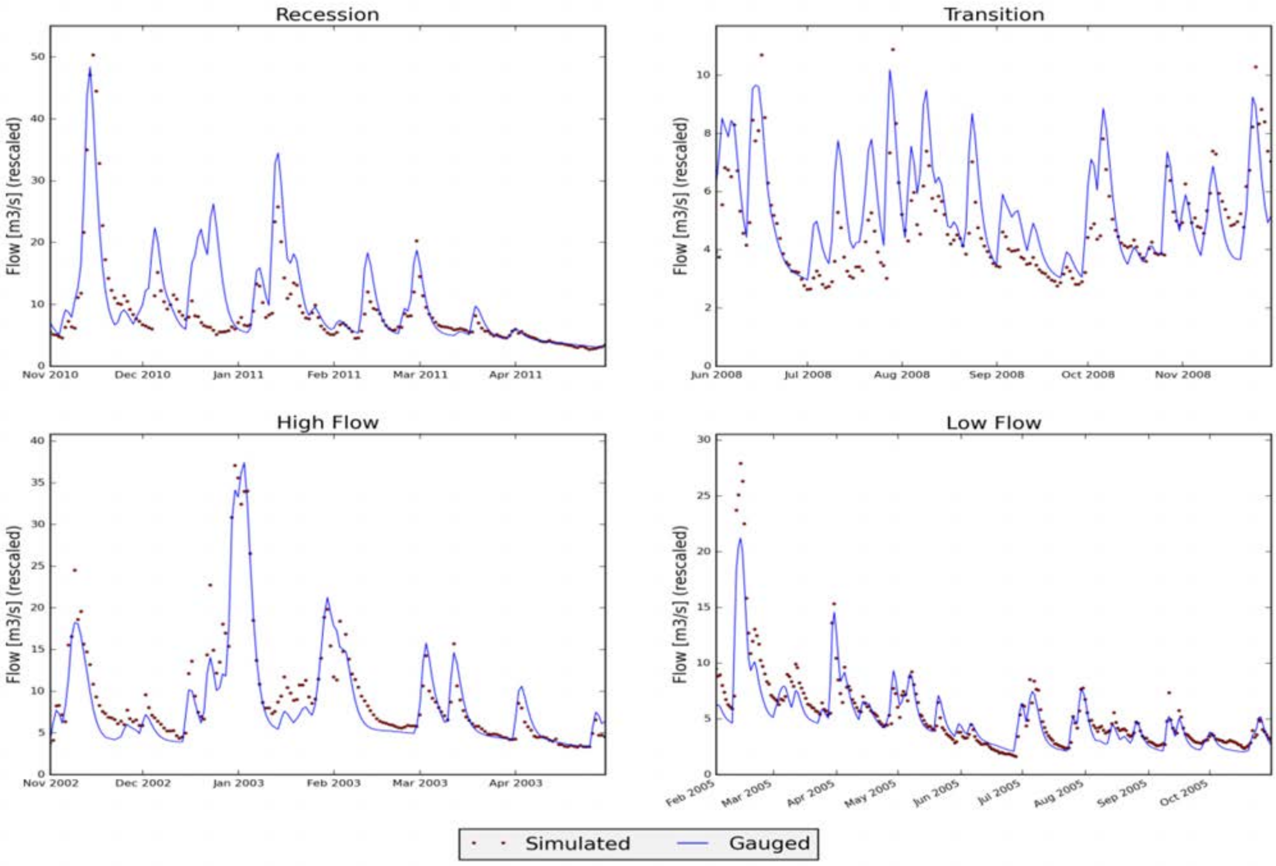


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V10MOP062140" (NETE)

Input data

Figure 1: Cumulative precipitation on catchment V10MOP062140 (Nete)

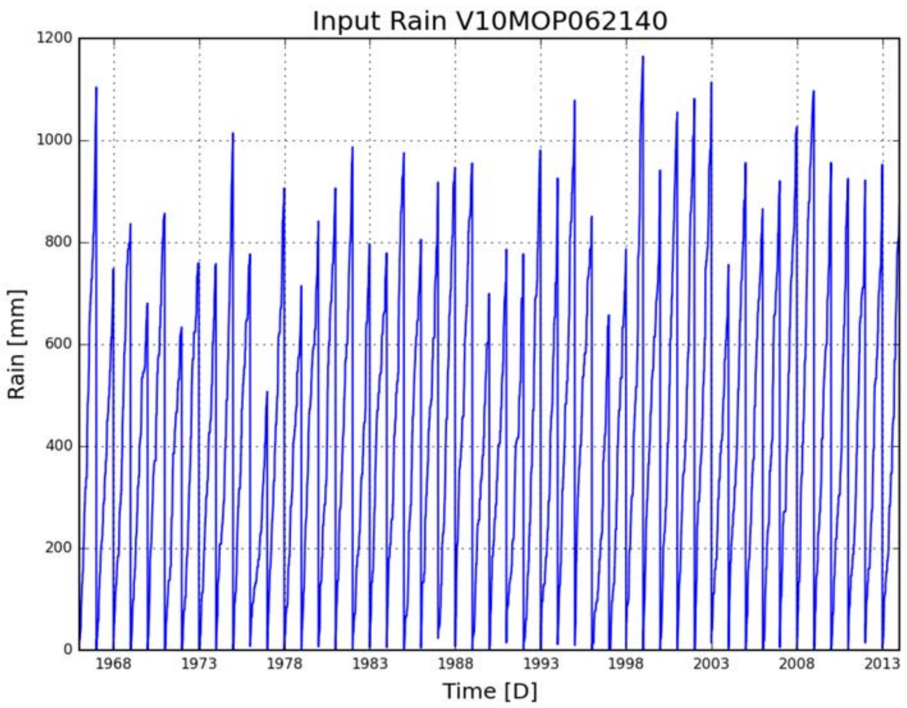
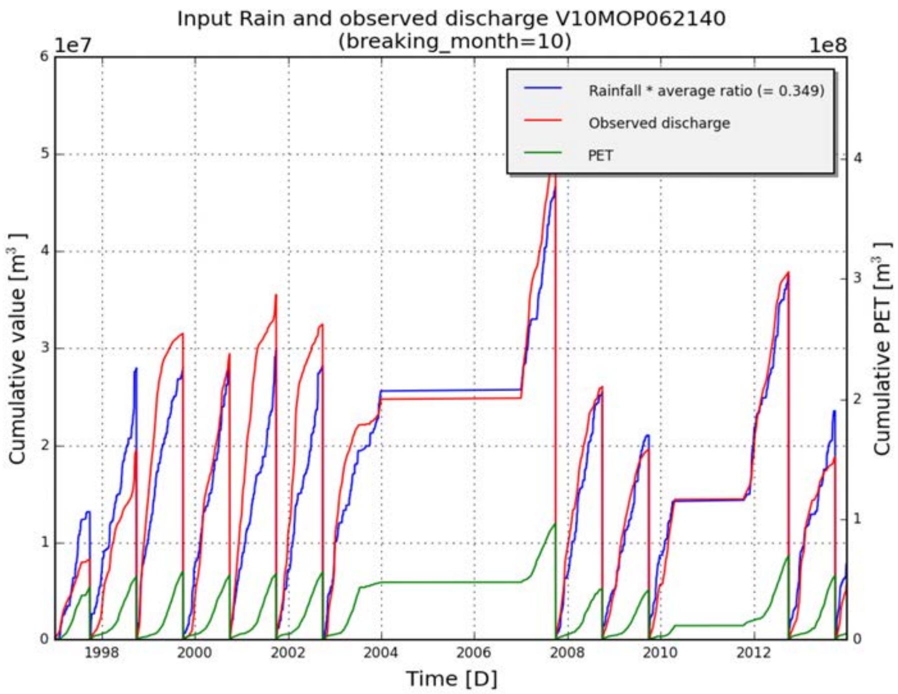


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V10MOP062140 (Nete)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V10MOP062140
subcatchment_area [m²]	77319091
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.12), ('bevaporation', 2.0), ('cmin', 6.1), ('cmax', 459.0), ('CKBF', 300.0), ('CK1', 45.0), ('CK2', 44.0), ('bdrainage', 1.0), ('kdrainage', 20400.0), ('PDM.TG', 10.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1997 - 2013)

	Full year	Summer	Winter
NS	0.453	0.496	0.291
NS_log	0.672	0.478	0.57
NS_rel	-0.45	-1.137	0.508
RelErr	2.6 %	-11.9 %	5.9 %
VolBias	0.026	-0.09	0.097

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.49	0.481	0.357
NS_log	0.585	0.242	0.688
NS_rel	-9.462	-22.25	0.597
RelErr	17.5 %	29.4 %	19.2 %
VolBias	0.106	0.115	0.159

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)

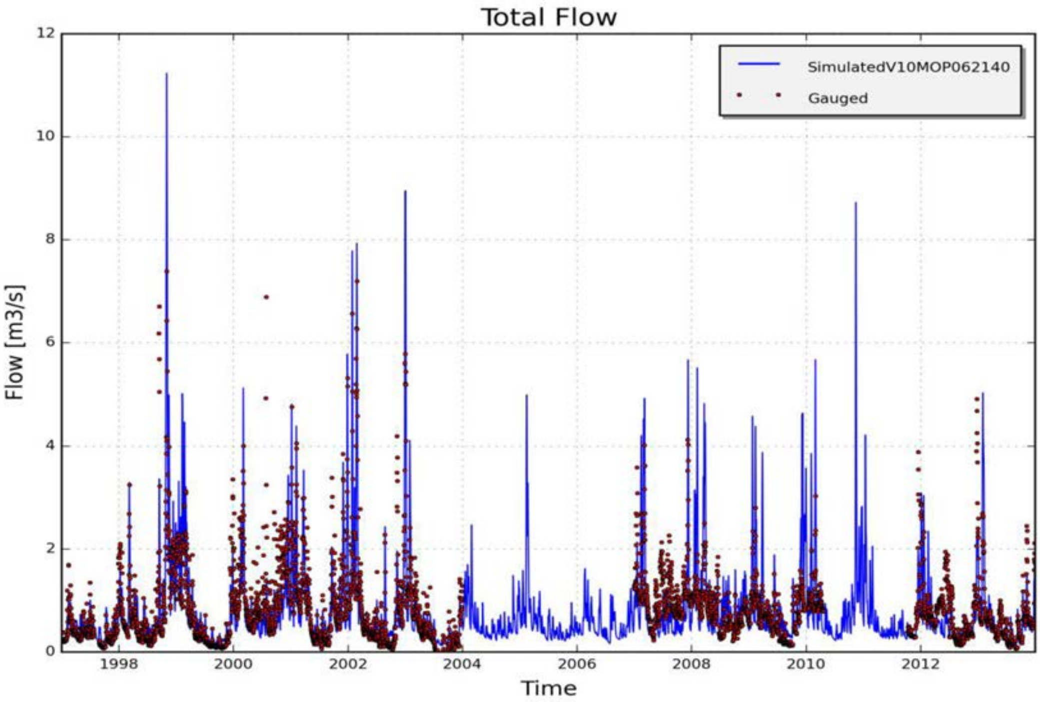


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle (calibration period)

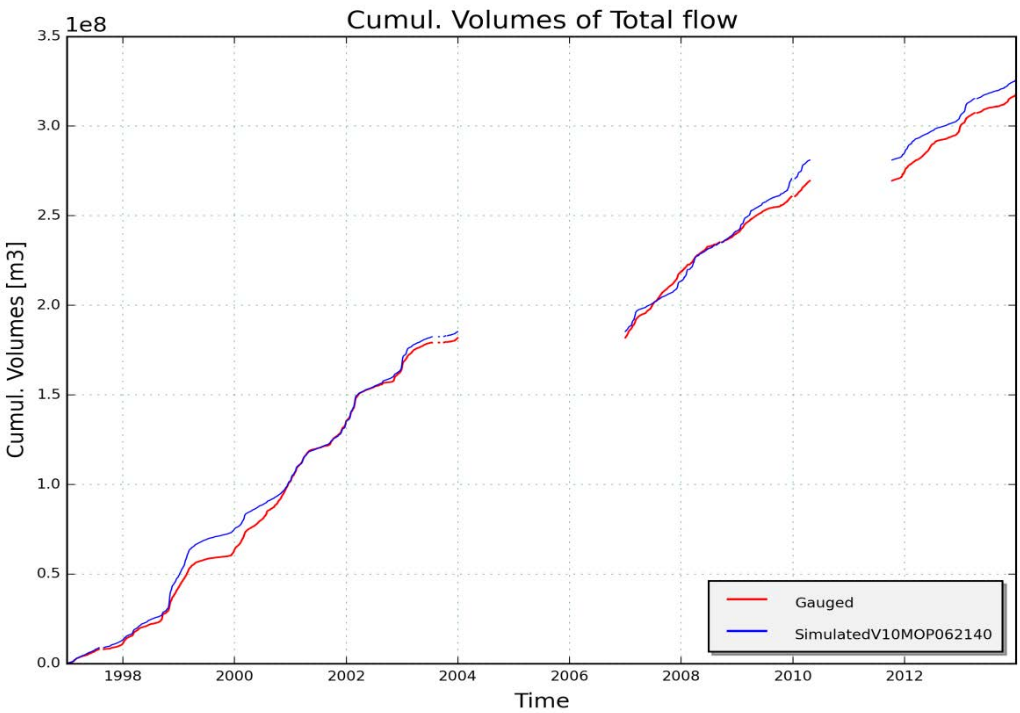


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle (validation period)

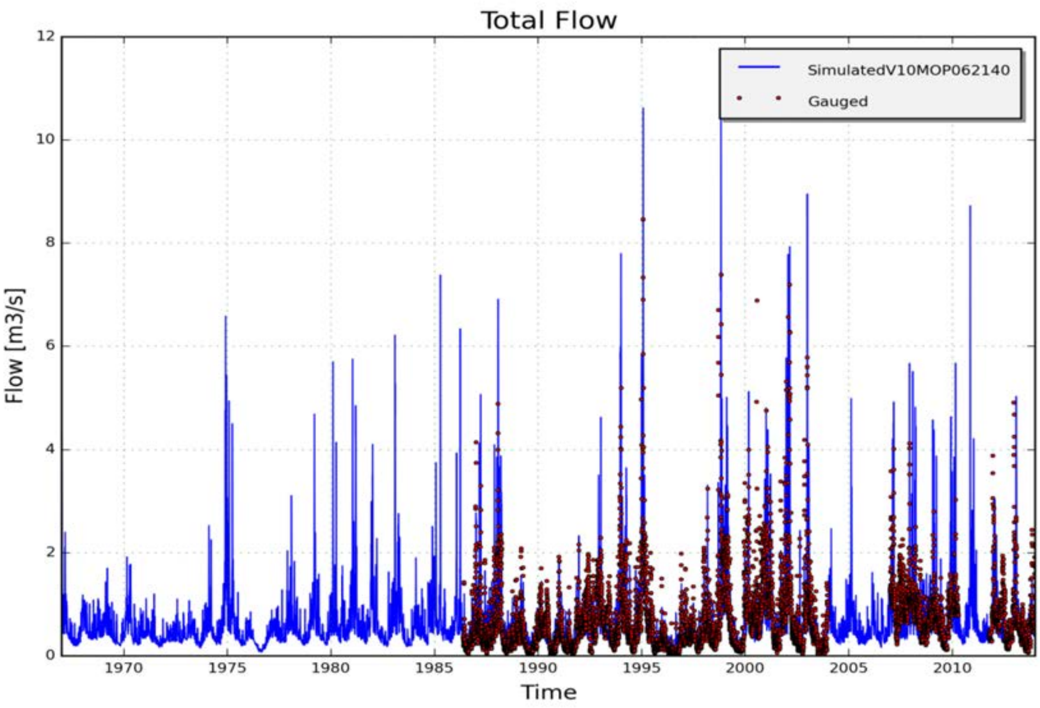


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle (validation period)

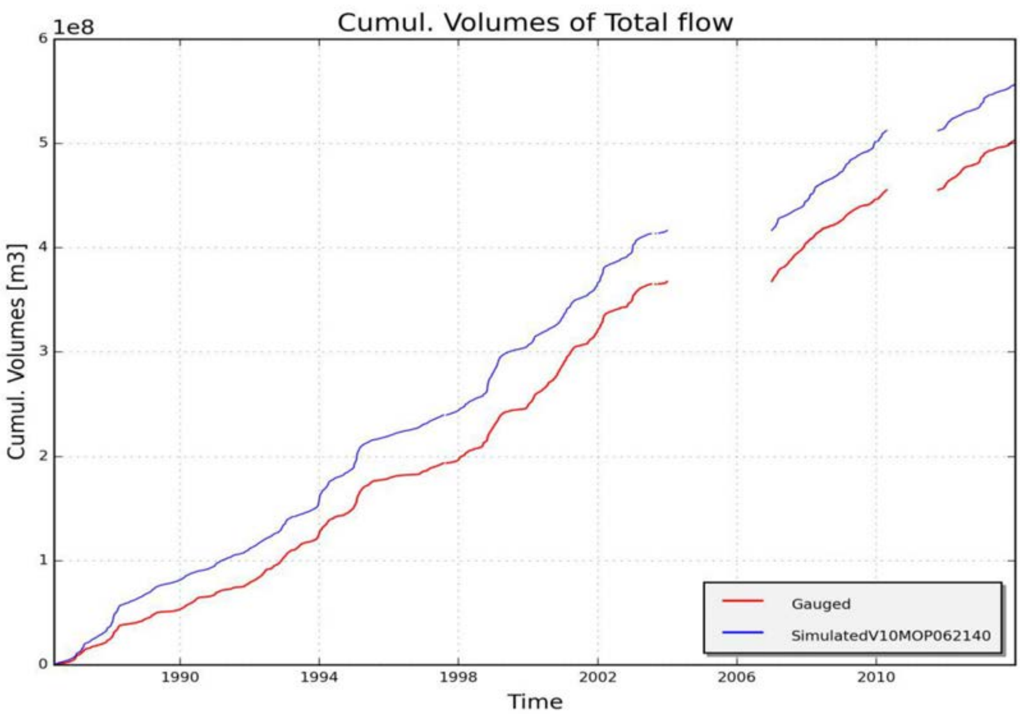
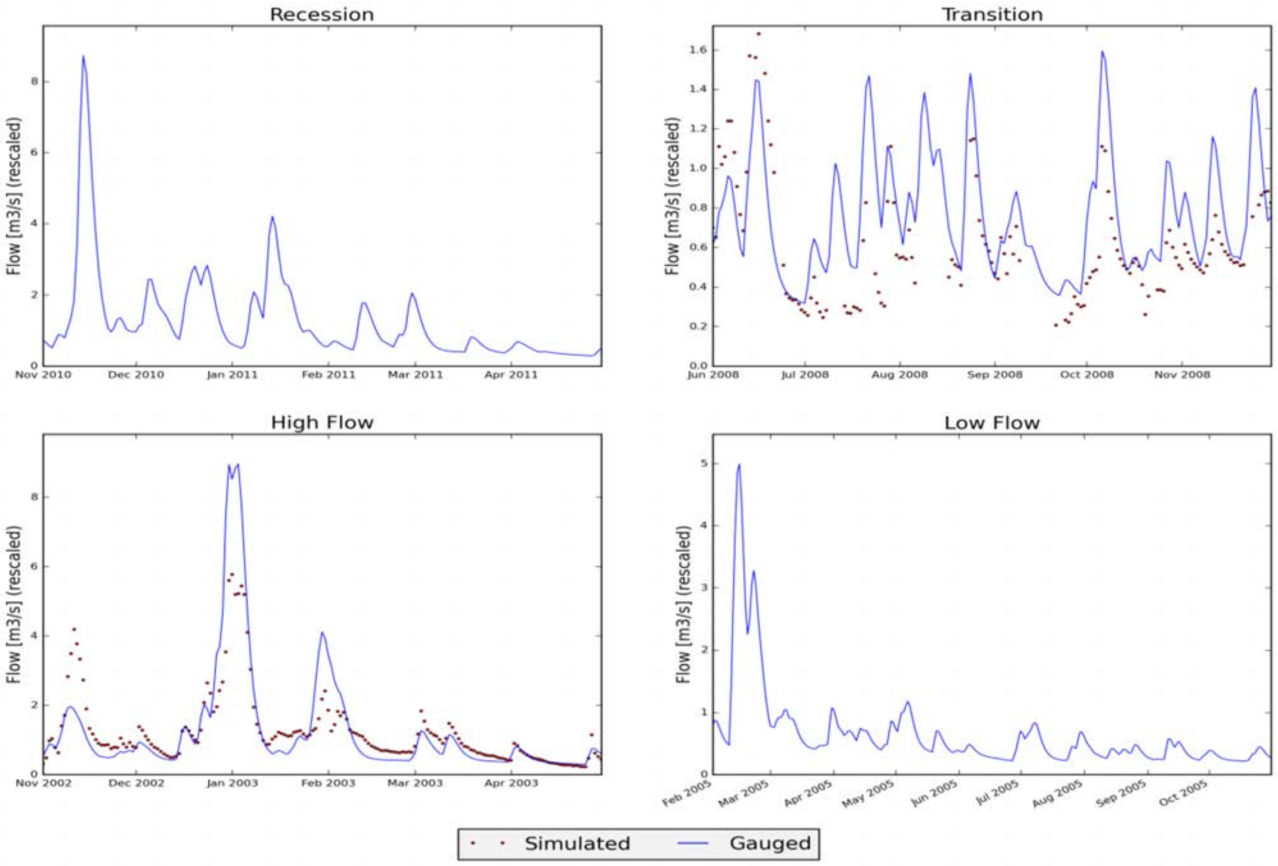


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "V10WIM082050" (NETE)

Input data

Figure 1: Cumulative precipitation on catchment V10WIM082050 (Nete)

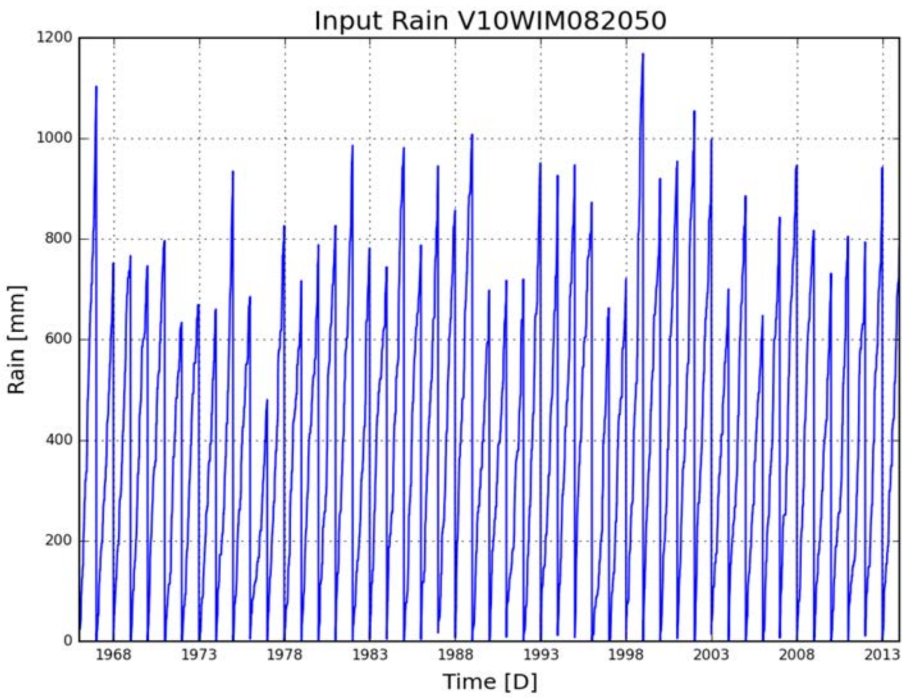
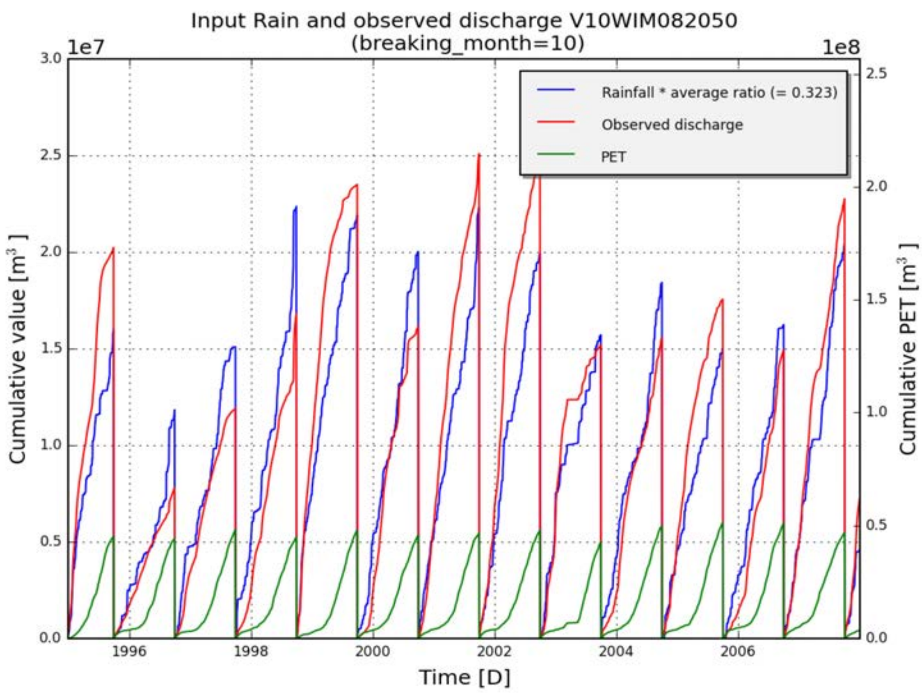


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment V10WIM082050 (Nete)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	V10WIM082050
subcatchment_area [m²]	65701200
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.1), ('bevaporation', 2.0), ('cmin', 6.5), ('cmax', 443.0), ('CKBF', 300.0), ('CK1', 30.0), ('CK2', 38.0), ('bdrainage', 0.95), ('kdrainage', 16000.0), ('PDM.TG', 6.5), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1995 - 2007)

	Full year	Summer	Winter
NS	0.048	0.473	-0.568
NS_log	0.587	0.397	0.54
NS_rel	-8.784	-17.588	0.448
RelErr	-0.4 %	-23.1 %	18.1 %
VolBias	-0.098	-0.3	0.063

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	-0.077	0.451	-0.803
NS_log	0.551	0.381	0.537
NS_rel	-5.579	-12.389	0.141
RelErr	11.8 %	-18.1 %	38.3 %
VolBias	-0.012	-0.258	0.192

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)

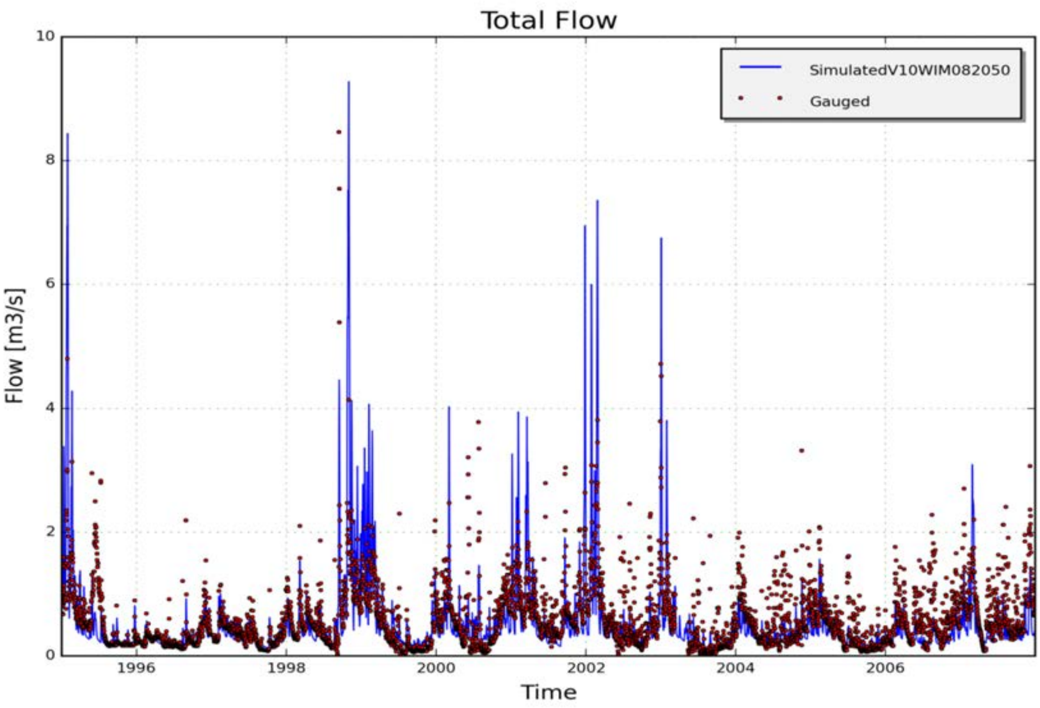


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V10WIM082050, station 8210102 - Wiekevorst (calibration period)

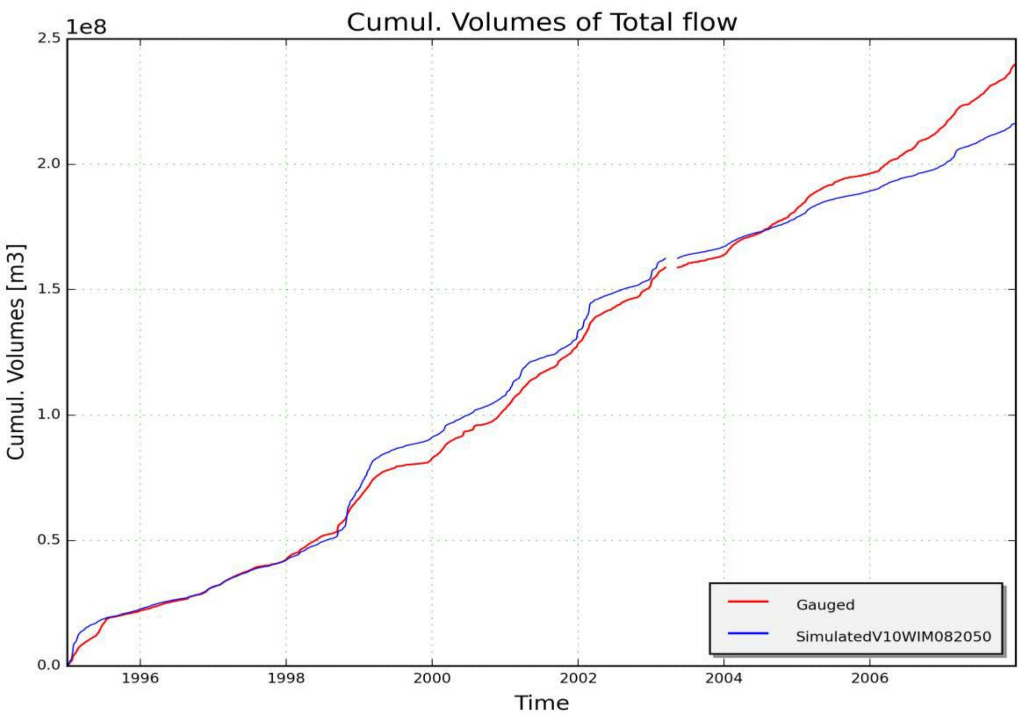


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V10WIM082050, station 8210102 - Wiekevorst (validation period)

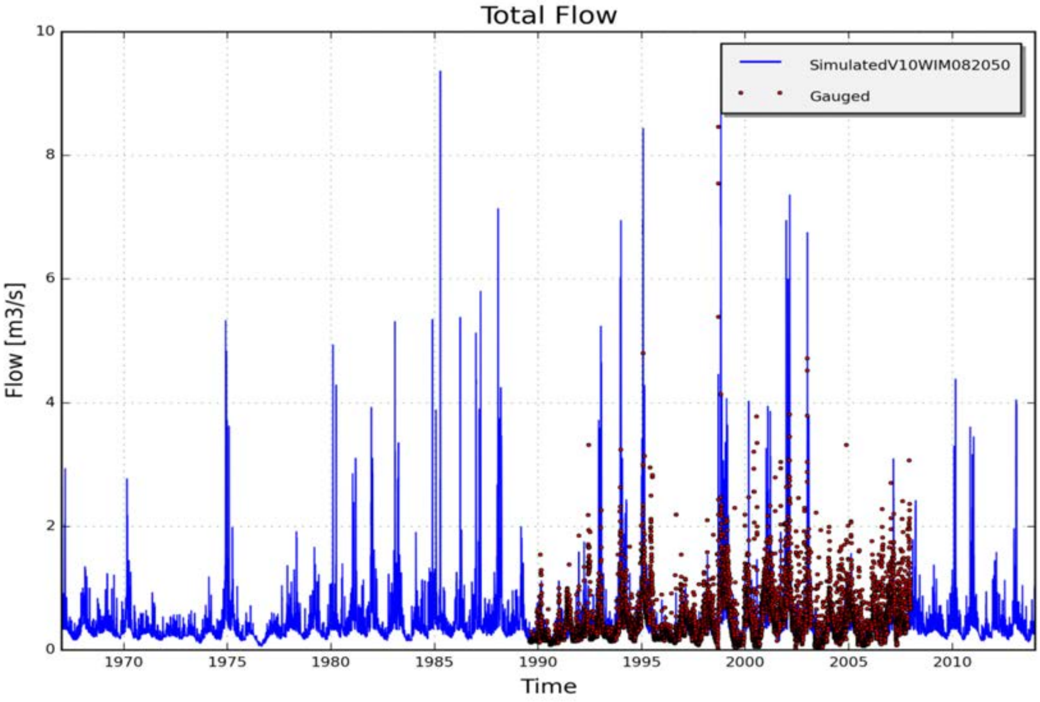


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V10WIM082050, station 8210102 - Wiekevorst (validation period)

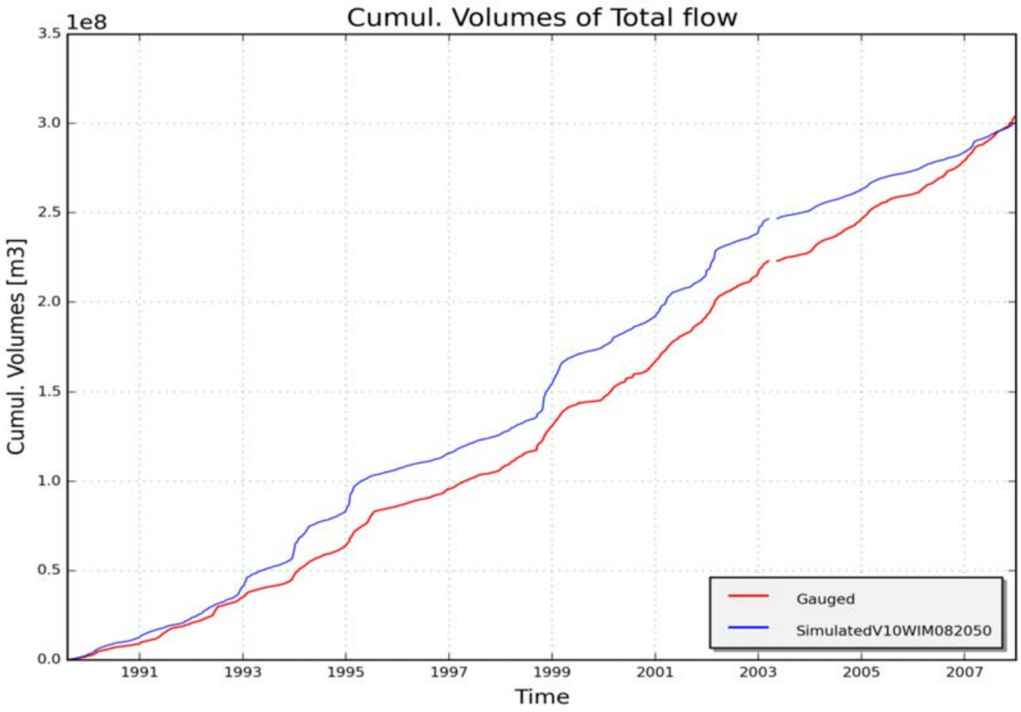


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V10WIM082050, station 8210102 - Wiekevorst

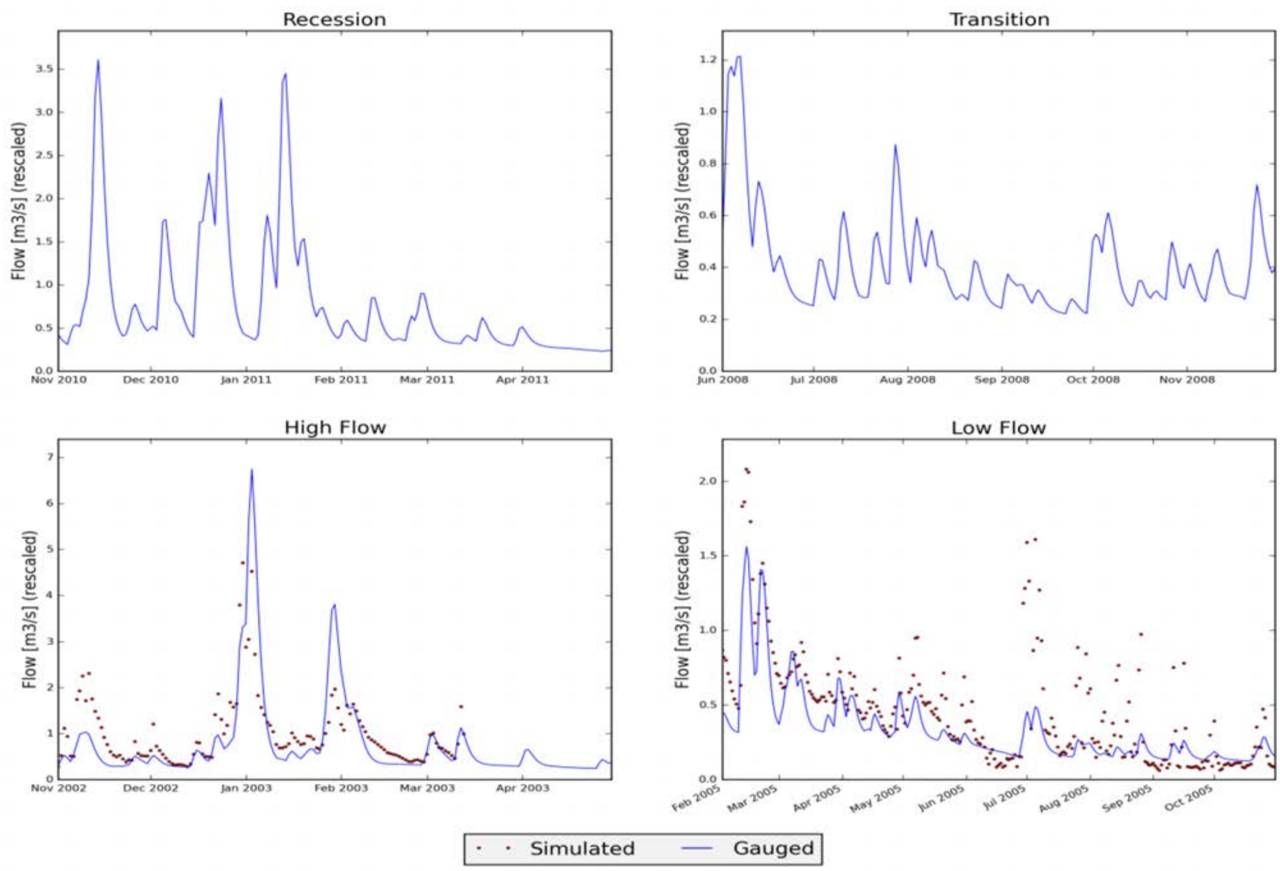


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V10WIM082050, station 8210102 - Wiekevorst

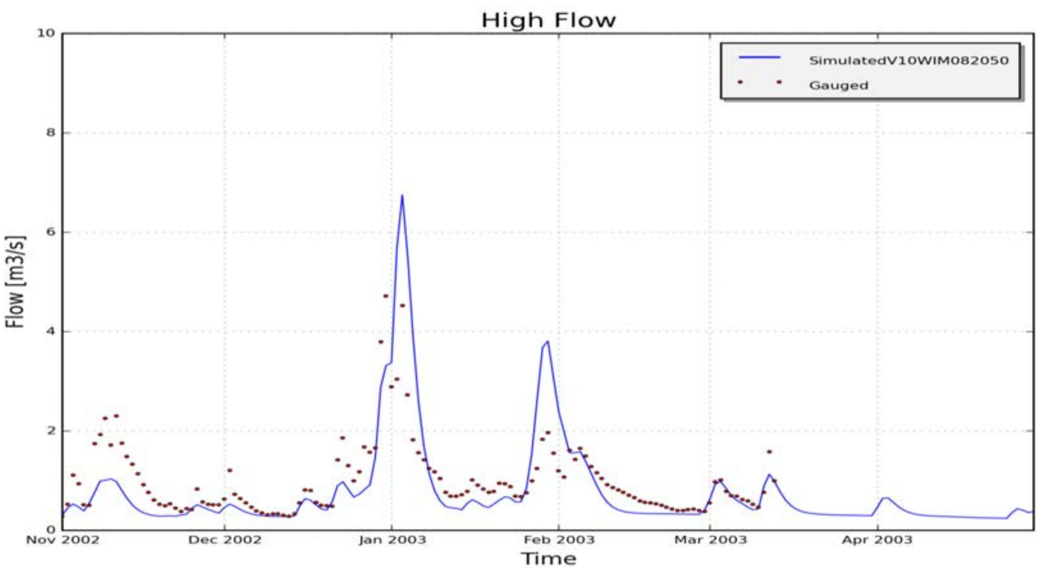
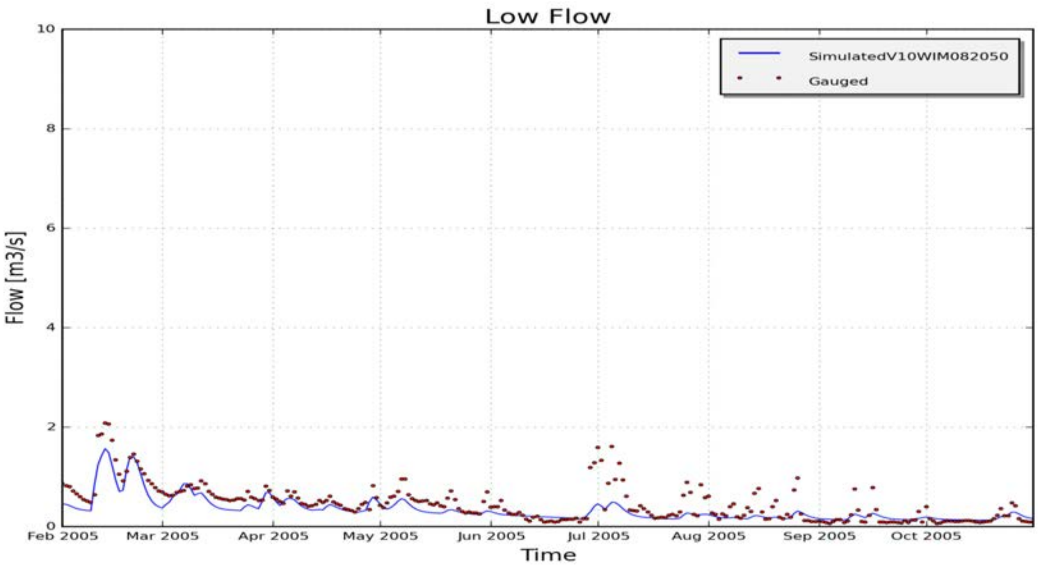


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V10WIM082050, station 8210102 - Wiekevorst



Annexe 13 Meuse

CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "F11MAA8702" (MEUSE)

Input data

Figure 1: Cumulative precipitation on catchment F11MAA8702 (Meuse)

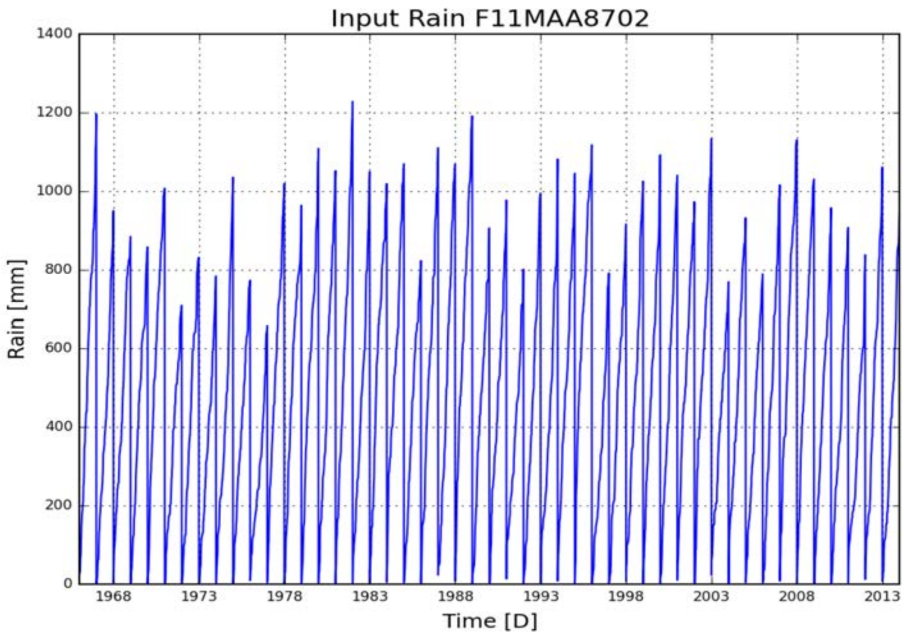
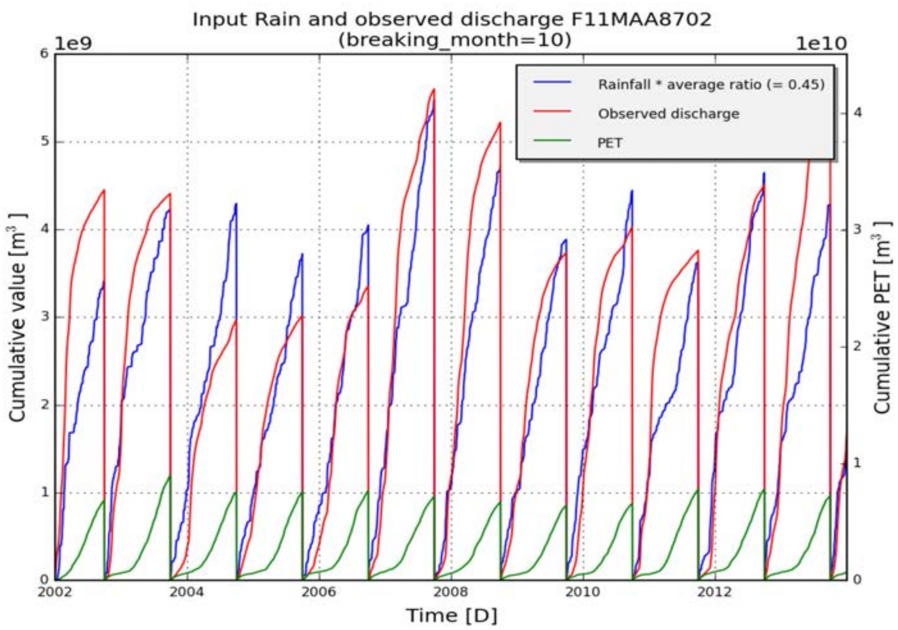


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment F11MAA8702 (Meuse)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	F11MAA8702
subcatchment_area [m²]	10120000000
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.37), ('bevaporation', 2.0), ('cmin', 0.7), ('cmax', 452.0), ('CKBF', 300.0), ('CK1', 43.0), ('CK2', 41.0), ('bdrainage', 1.0), ('kdrainage', 16884.0), ('PDM.TG', 1.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2002 - 2013)

	Full year	Summer	Winter
NS	0.673	-0.032	0.443
NS_log	0.618	-0.093	0.028
NS_rel	0.559	-0.231	0.509
RelErr	-3.9 %	40.1 %	-13.7 %
VolBias	-0.059	0.33	-0.145

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.702	-0.153	0.542
NS_log	0.642	-0.079	0.188
NS_rel	0.615	-0.313	0.583
RelErr	-7.2 %	37.5 %	-15.3 %
VolBias	-0.078	0.33	-0.152

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)

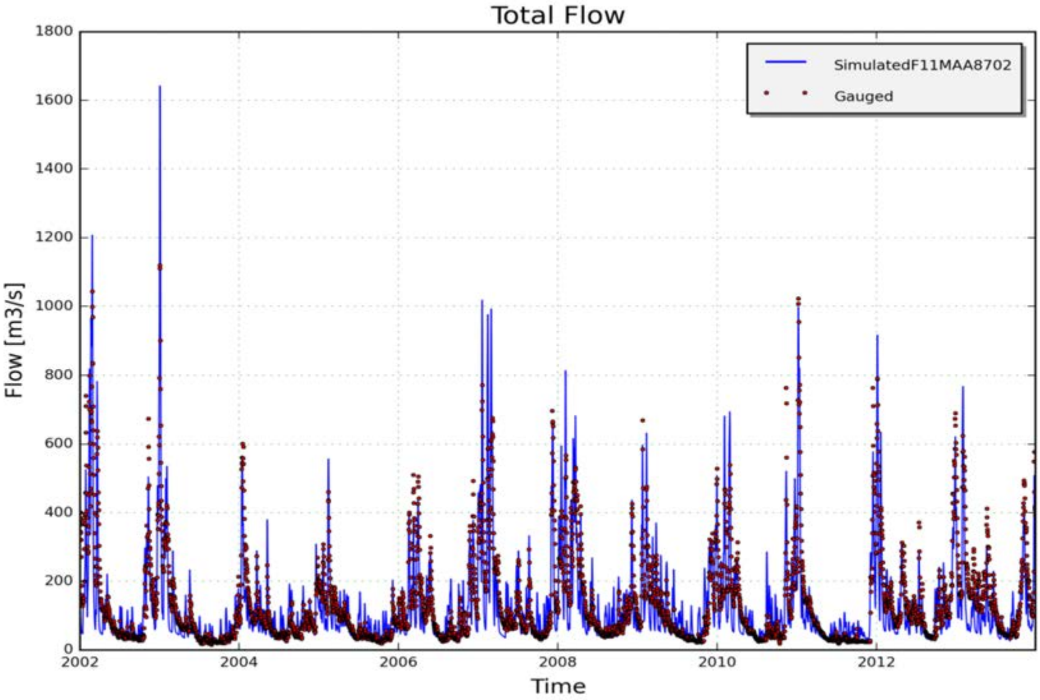


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment F11MAA8702, station Meuse, Chooz (calibration period)

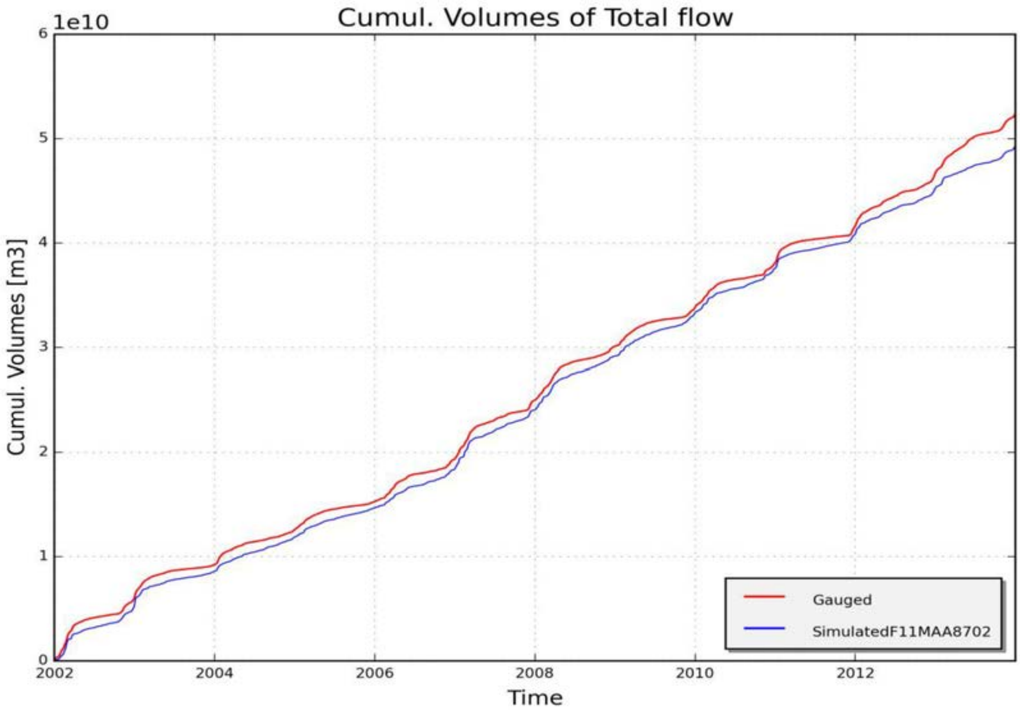


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment F11MAA8702, station Meuse, Chooz (validation period)

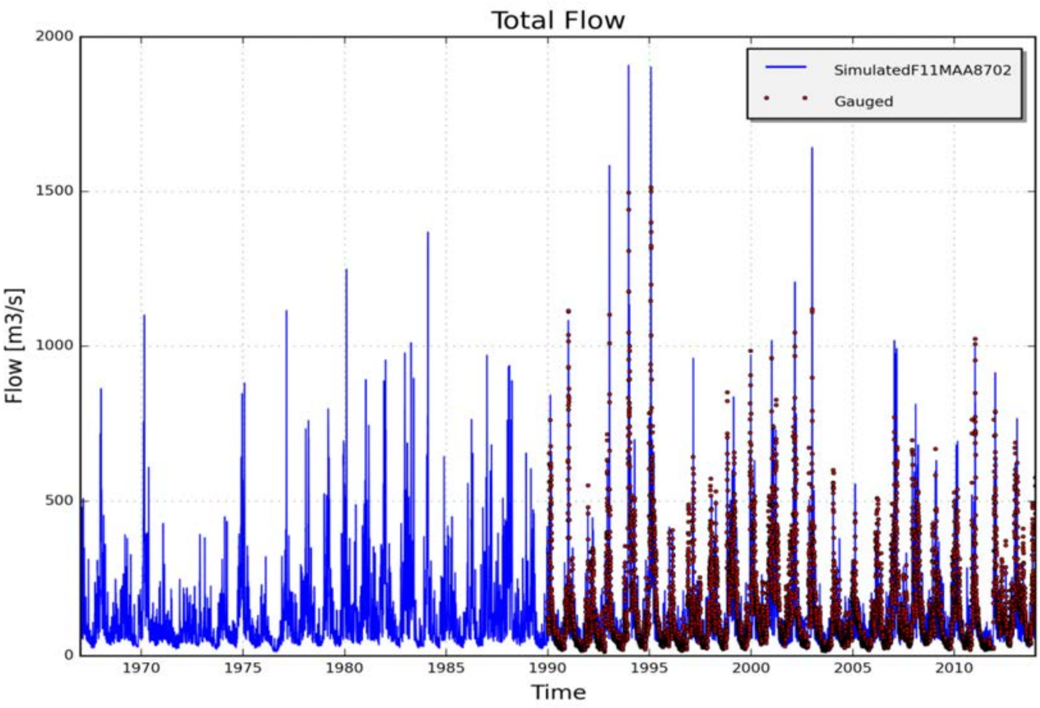


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment F11MAA8702, station Meuse, Chooz (validation period)

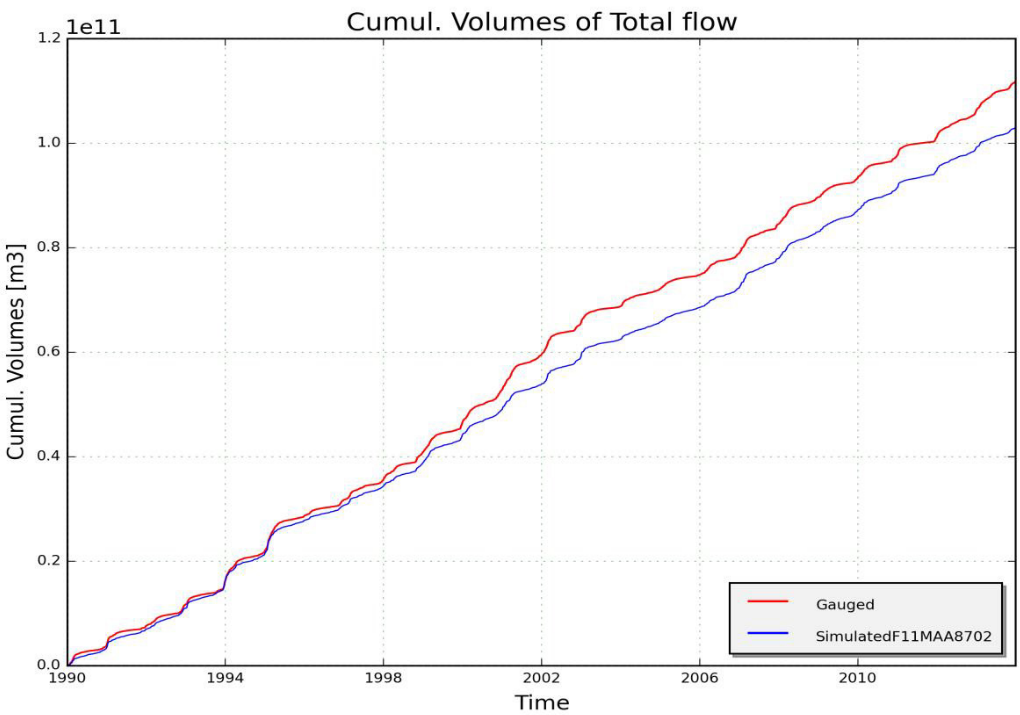
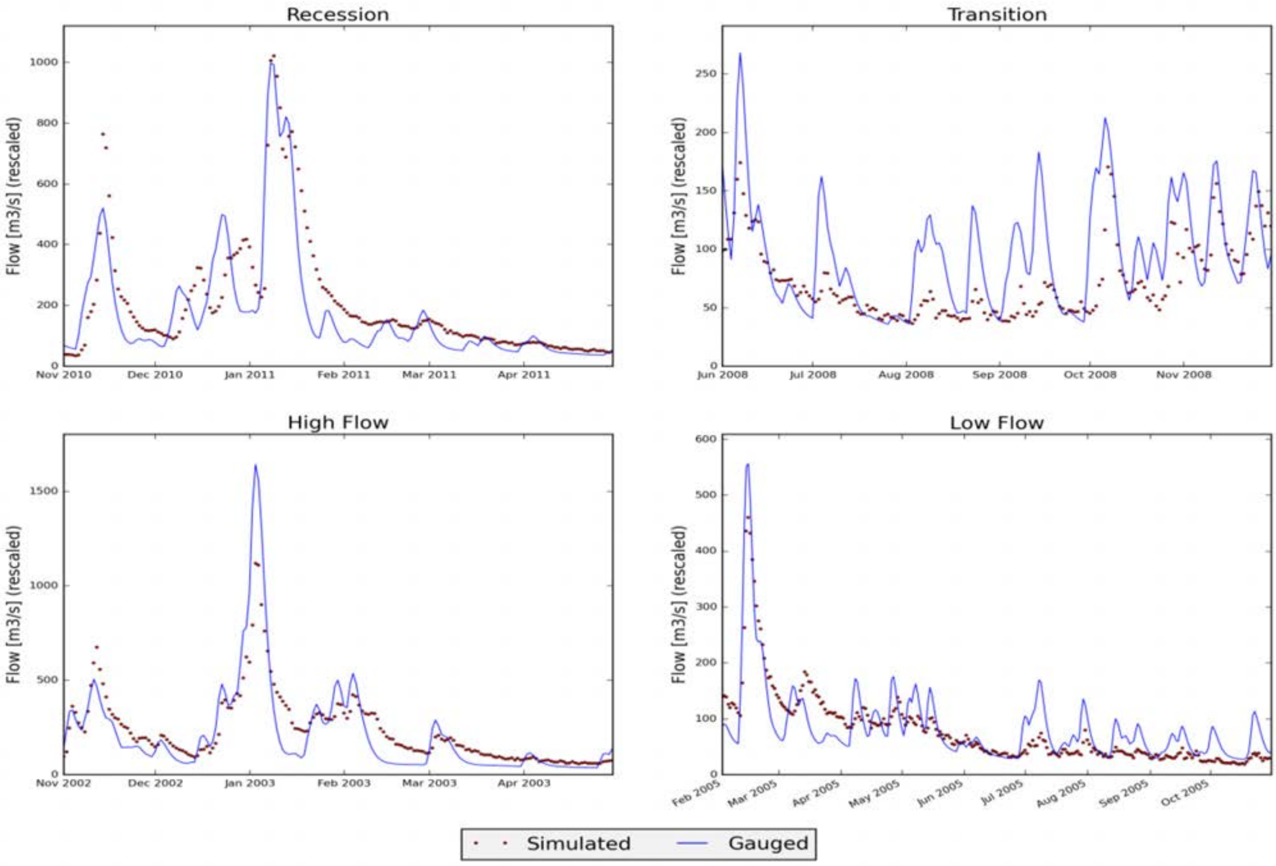


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment F11MAA8702, station Meuse, Chooz



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "W11BER551010" (MEUSE)

Input data

Figure 1: Cumulative precipitation on catchment W11BER551010 (Meuse)

Fig b=90x140

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)

Fig b=90x135

Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	W11BER551010
subcatchment_area [m²]	128000000
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.35), ('bevaporation', 2.0), ('cmin', 3.8), ('cmax', 323.0), ('CKBF', 300.0), ('CK1', 21.0), ('CK2', 43.0), ('bdrainage', 1.0), ('kdrainage', 9015.0), ('PDM.TG', 1.9), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (1994 - 2006)

	Full year	Summer	Winter
NS	0.634	0.587	0.581
NS_log	0.652	0.424	0.669
NS_rel	0.65	0.731	0.678
RelErr	-0.6 %	1.8 %	-5.0 %
VolBias	-0.063	-0.006	-0.121

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.526	0.385	0.489
NS_log	0.307	-0.203	0.432
NS_rel	-14.289	-18.594	-3.825
RelErr	5.2 %	21.2 %	-3.9 %
VolBias	0.022	0.174	-0.09

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)

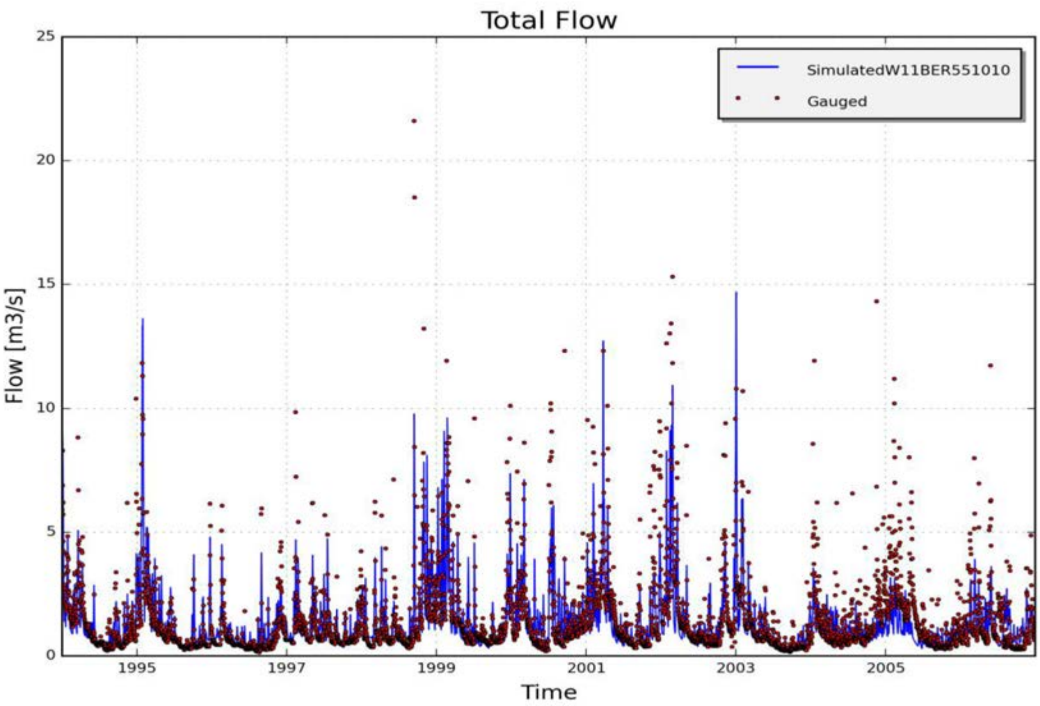


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W11BER551010, station unkown (calibration period)

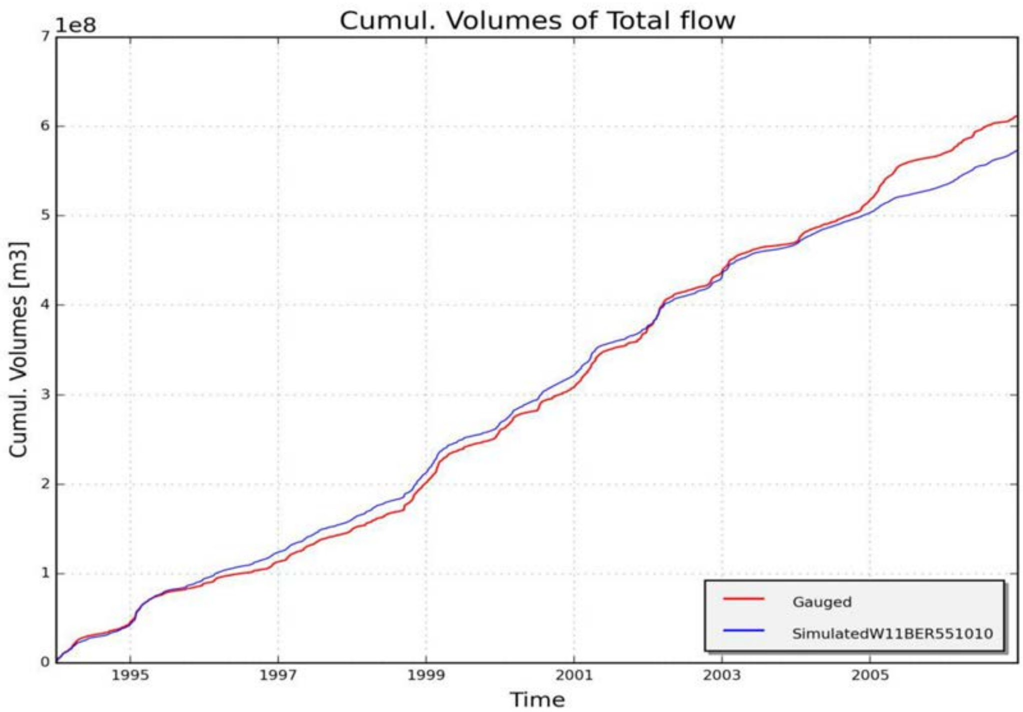


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W11BER551010, station unkown (validation period)

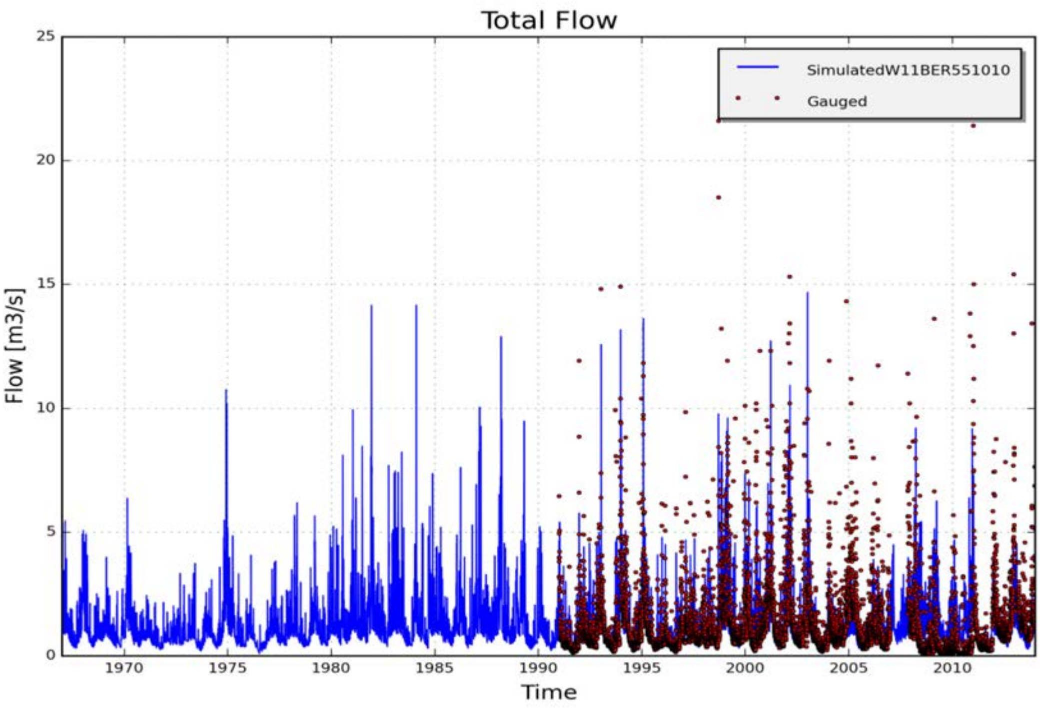


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W11BER551010, station unkown (validation period)

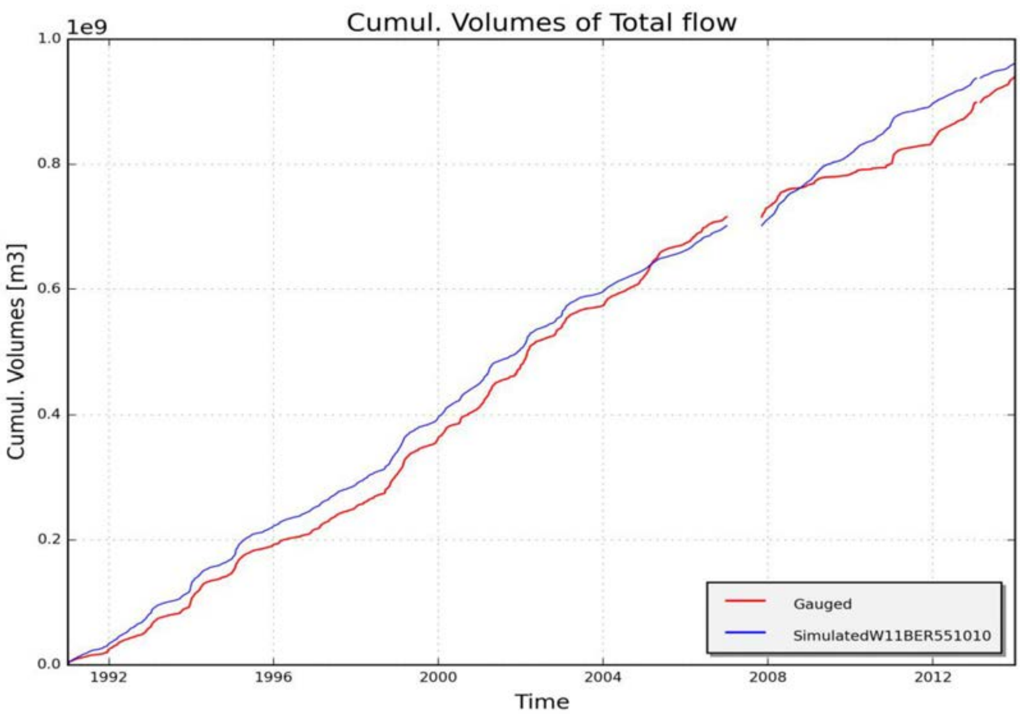


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W11BER551010, station unkown

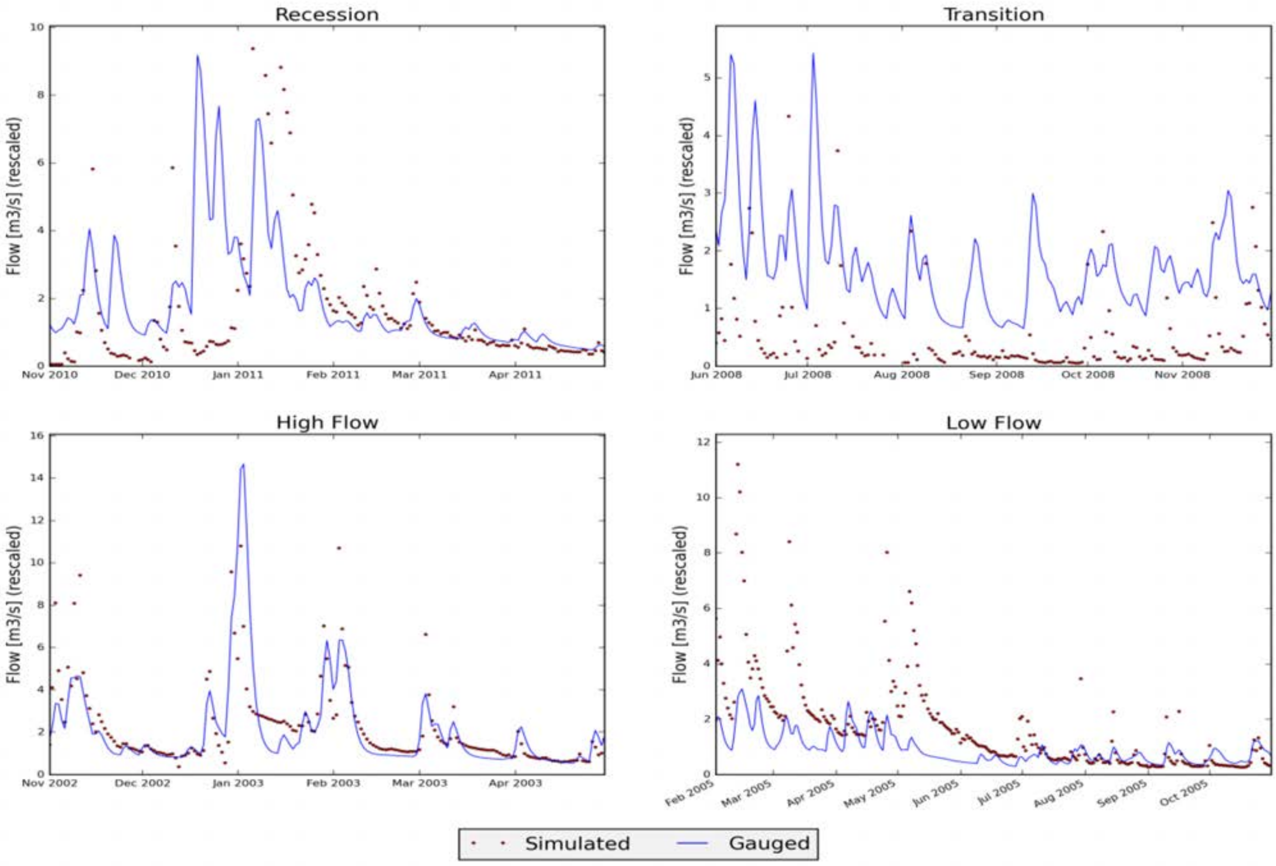


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W11BER551010, station unkown

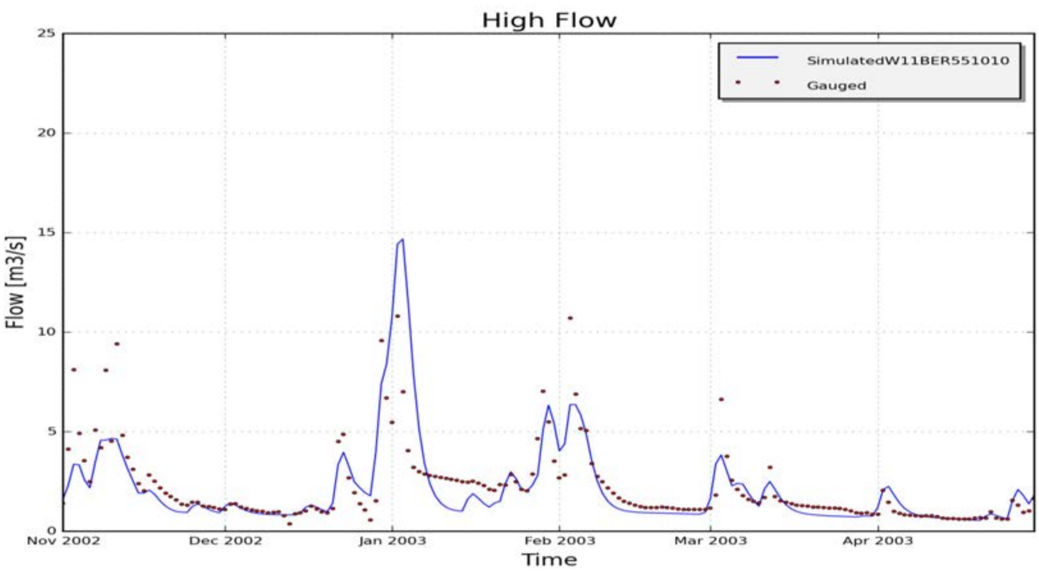
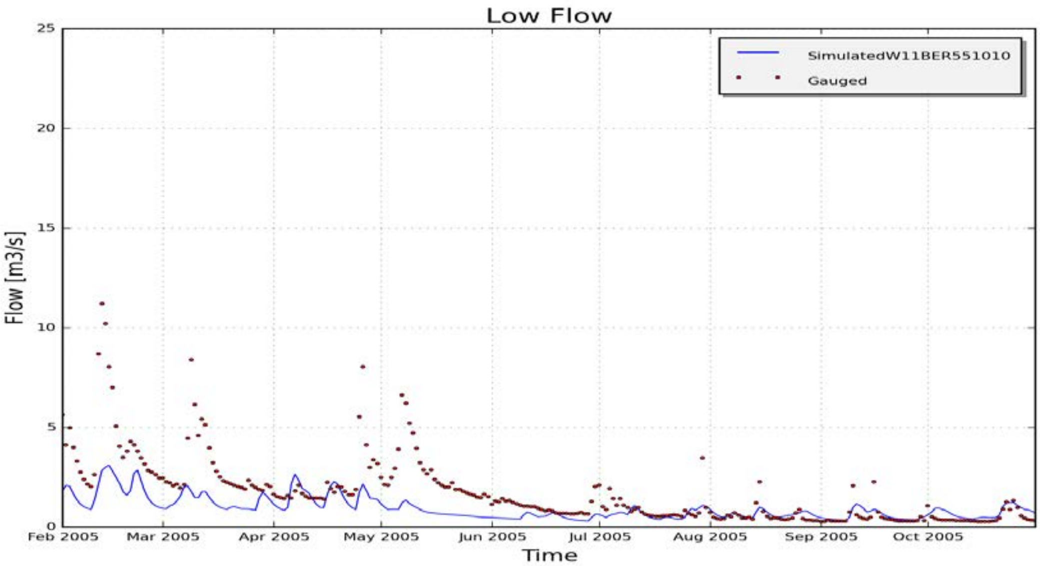


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W11BER551010, station unkown



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "W11HOY5990" (MEUSE)

Input data

Figure 1: Cumulative precipitation on catchment W11HOY5990 (Meuse)

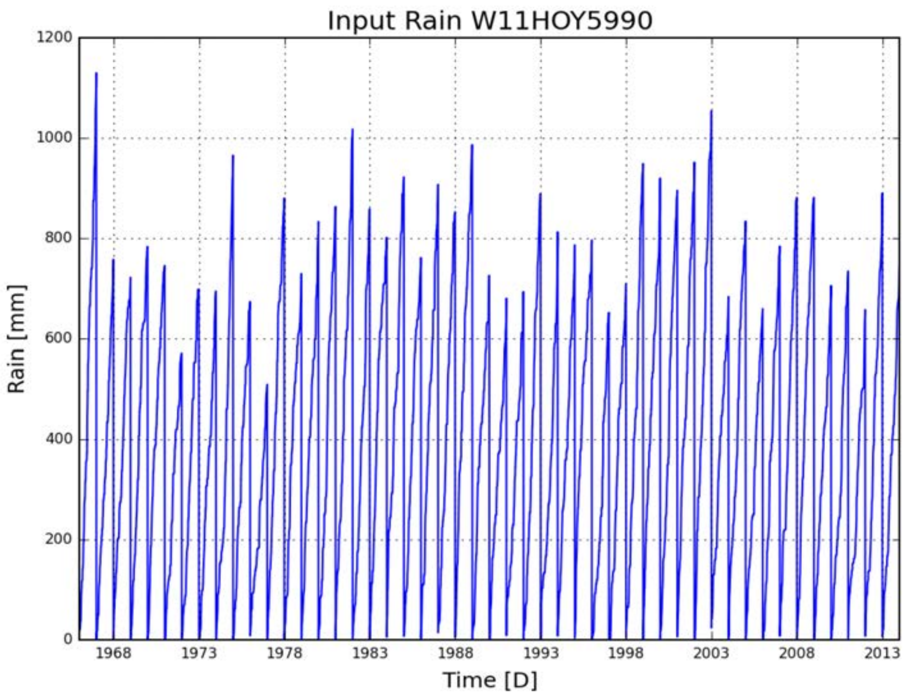
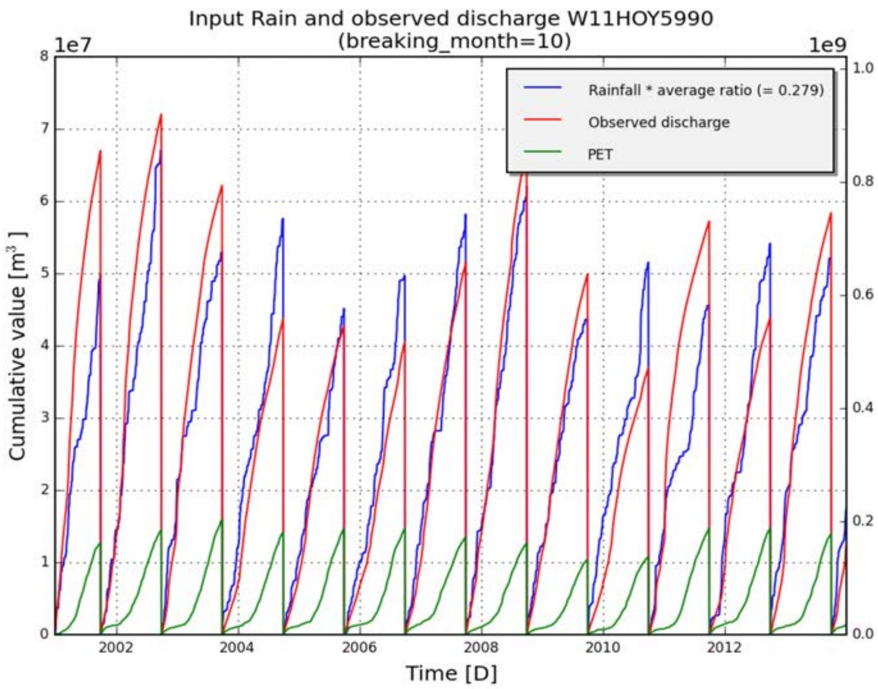


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W11HOY5990 (Meuse)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	W11HOY5990
subcatchment_area [m²]	242000000
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.07), ('bevaporation', 2.0), ('cmin', 5.6), ('cmax', 510.0), ('CKBF', 300.0), ('CK1', 30.0), ('CK2', 38.0), ('bdrainage', 1.0), ('kdrainage', 16202.0), ('PDM.TG', 0.3), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.29	0.072	0.083
NS_log	0.626	0.153	0.565
NS_rel	0.828	0.628	0.814
RelErr	-1.8 %	-6.3 %	-1.1 %
VolBias	-0.011	-0.025	-0.056

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.259	0.072	0.088
NS_log	0.626	0.153	0.574
NS_rel	0.826	0.628	0.815
RelErr	-0.3 %	-6.3 %	0.8 %
VolBias	-0.004	-0.025	-0.046

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)

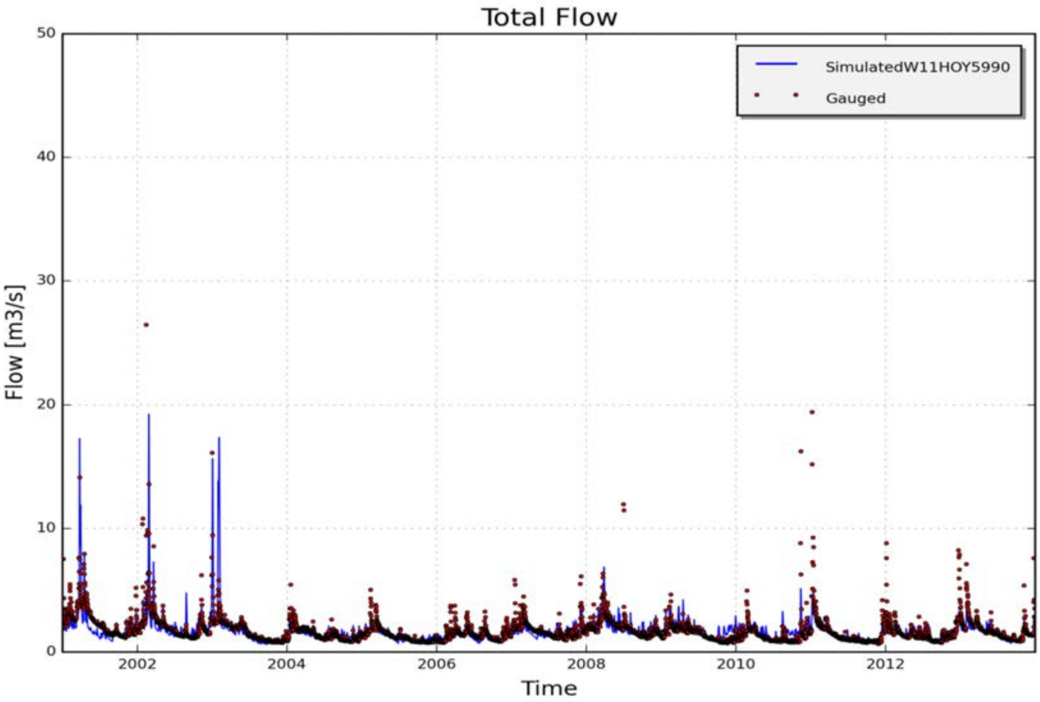


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W11HOY5990, station Hoyoux, Marchin (calibration period)

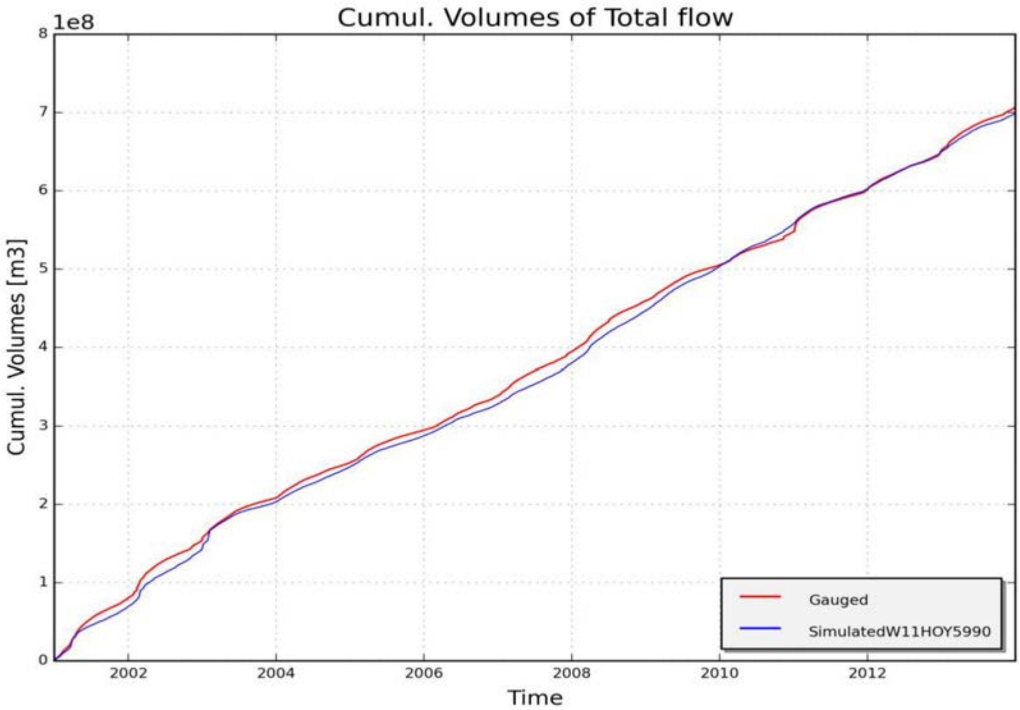


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W11HOY5990, station Hoyoux, Marchin (validation period)

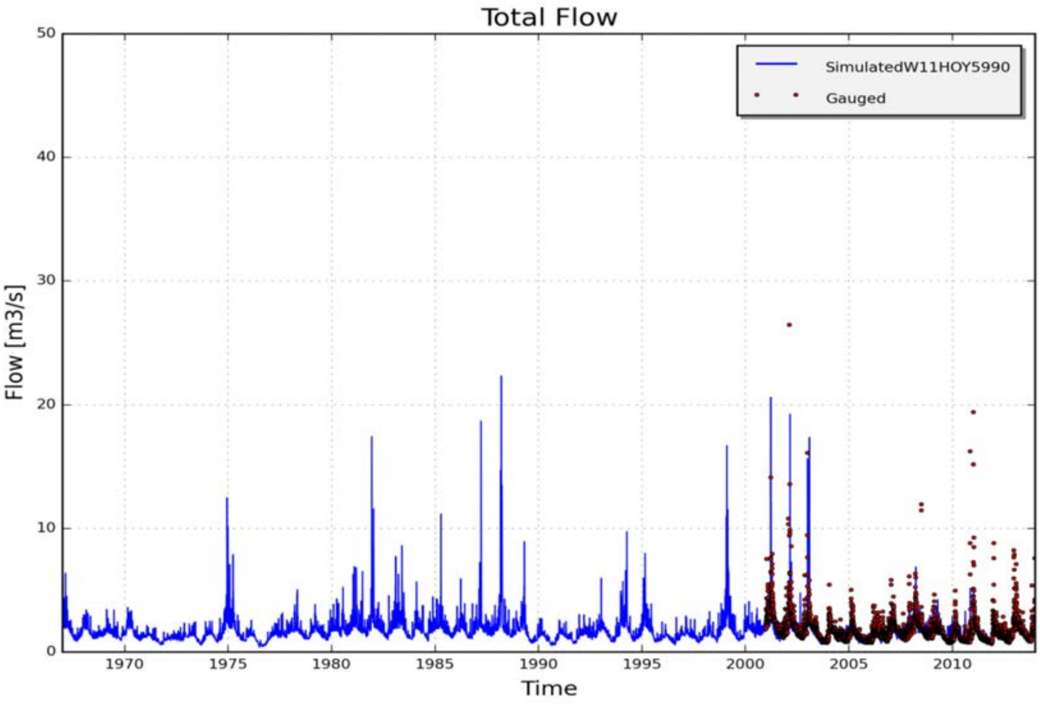


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W11HOY5990, station Hoyoux, Marchin (validation period)

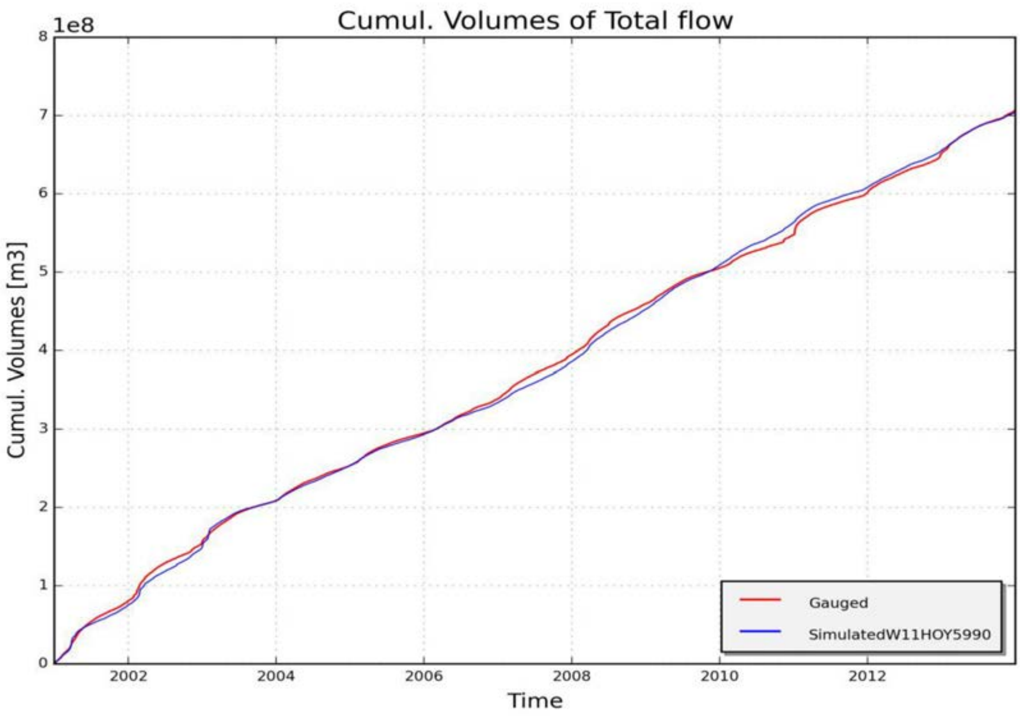
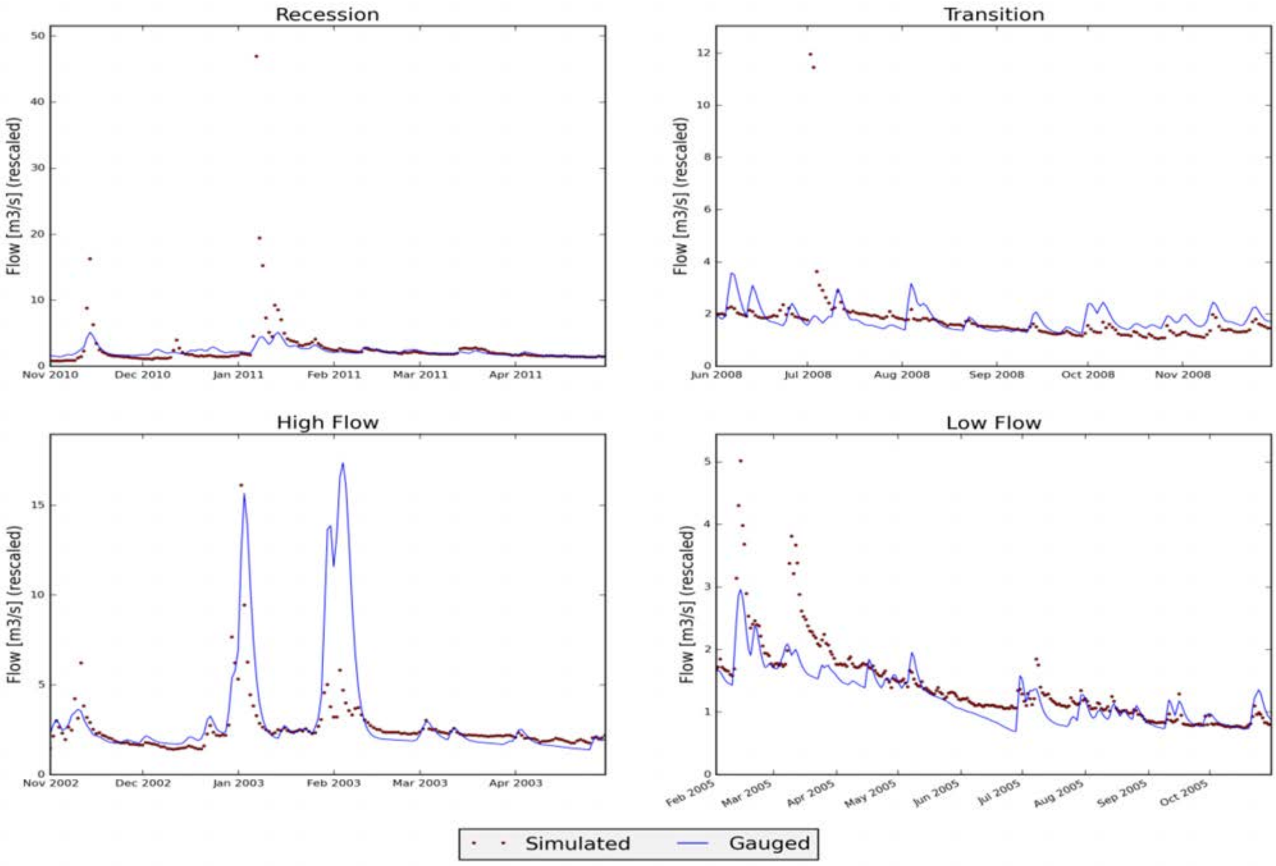


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W11HOY5990, station Hoyoux, Marchin



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "W11MEH5820" (MEUSE)

Input data

Figure 1: Cumulative precipitation on catchment W11MEH5820 (Meuse)

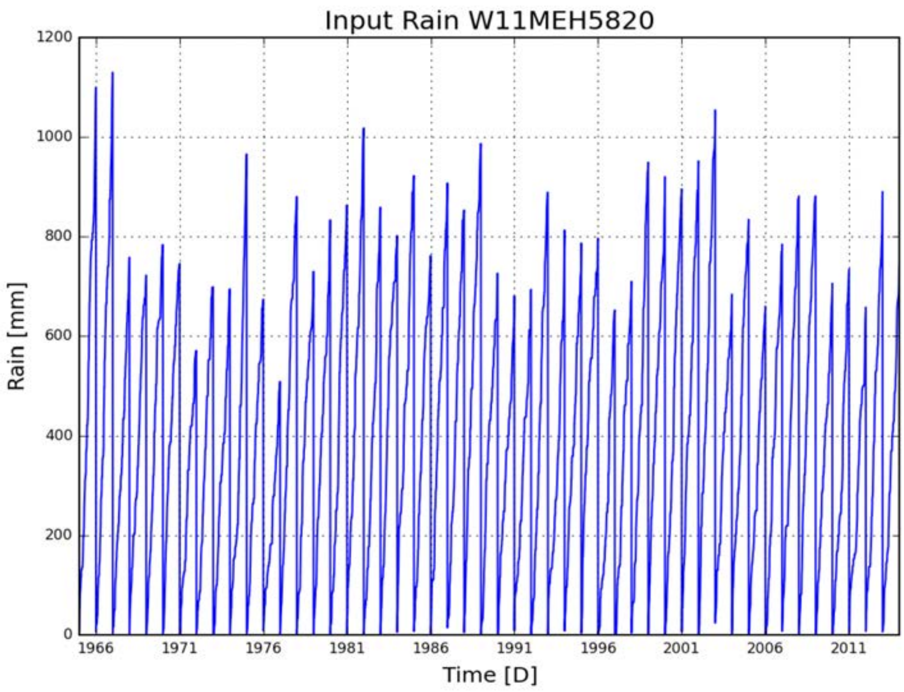
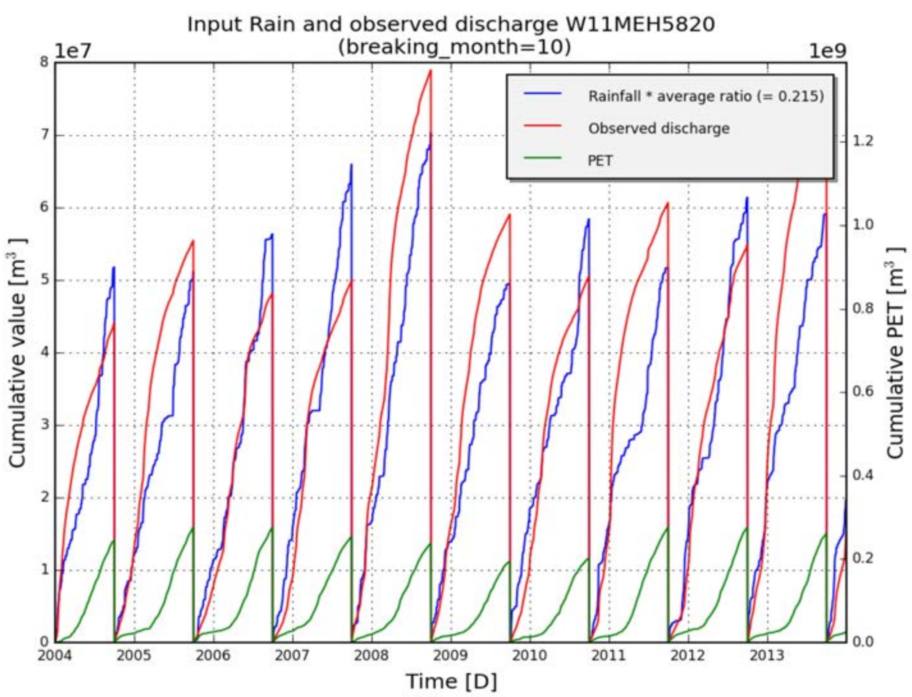


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W11MEH5820 (Meuse)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	W11MEH5820
subcatchment_area [m²]	355800000
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 0.8), ('bpareto', 0.08), ('bevaporation', 1.0), ('cmin', 6.8), ('cmax', 265.0), ('CKBF', 300.0), ('CK1', 28.0), ('CK2', 35.0), ('bdrainage', 1.0), ('kdrainage', 17236.0), ('PDM.TG', 3.7), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2004 - 2013)

	Full year	Summer	Winter
NS	0.61	0.453	0.412
NS_log	0.765	0.415	0.509
NS_rel	0.836	0.641	0.643
RelErr	-1.6 %	17.9 %	-8.5 %
VolBias	-0.011	0.136	-0.043

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.593	0.347	0.452
NS_log	0.719	0.443	0.514
NS_rel	0.863	0.894	0.709
RelErr	-10.1 %	-13.8 %	-2.5 %
VolBias	-0.066	-0.051	-0.021

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)

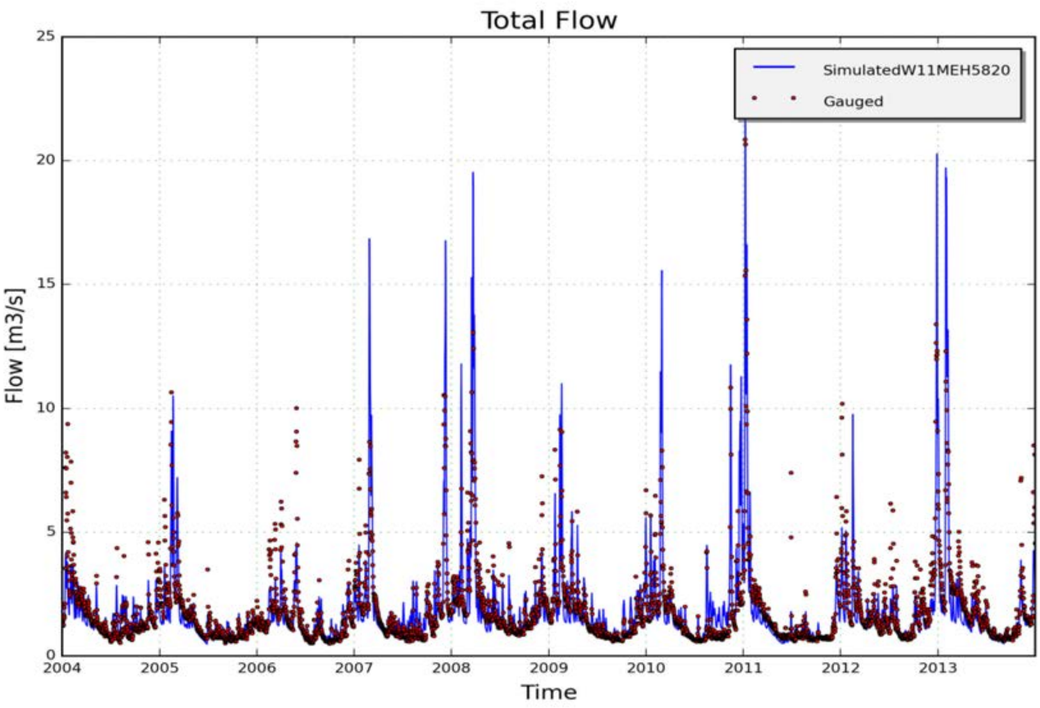


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W11MEH5820, station Mehaigne, Wanze (calibration period)

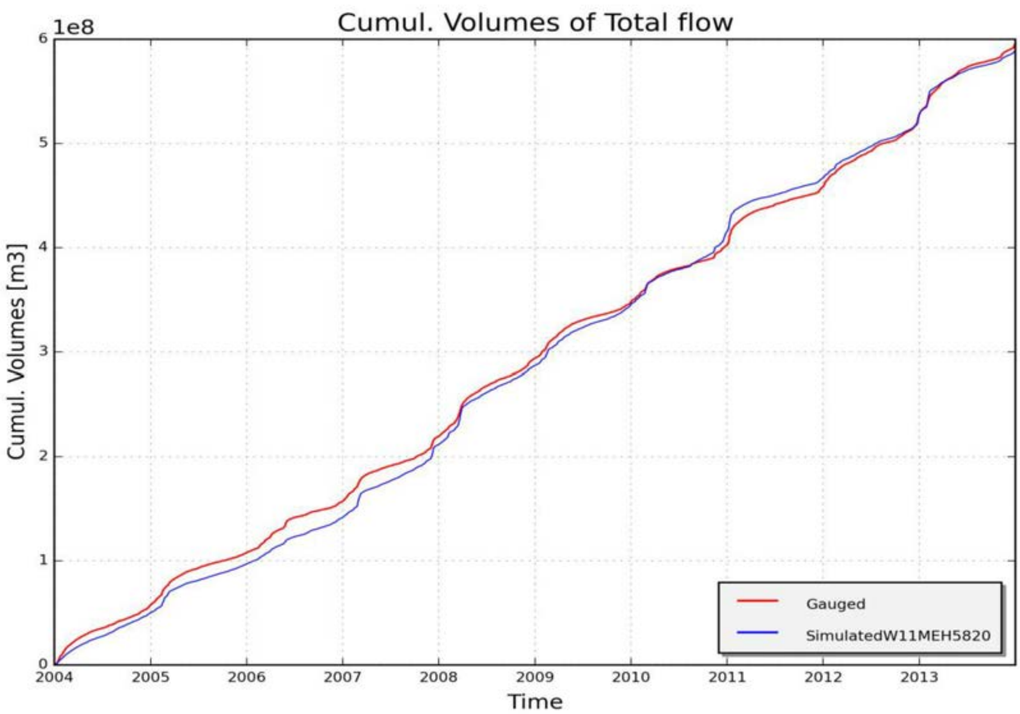


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W11MEH5820, station Mehaigne, Wanze (validation period)

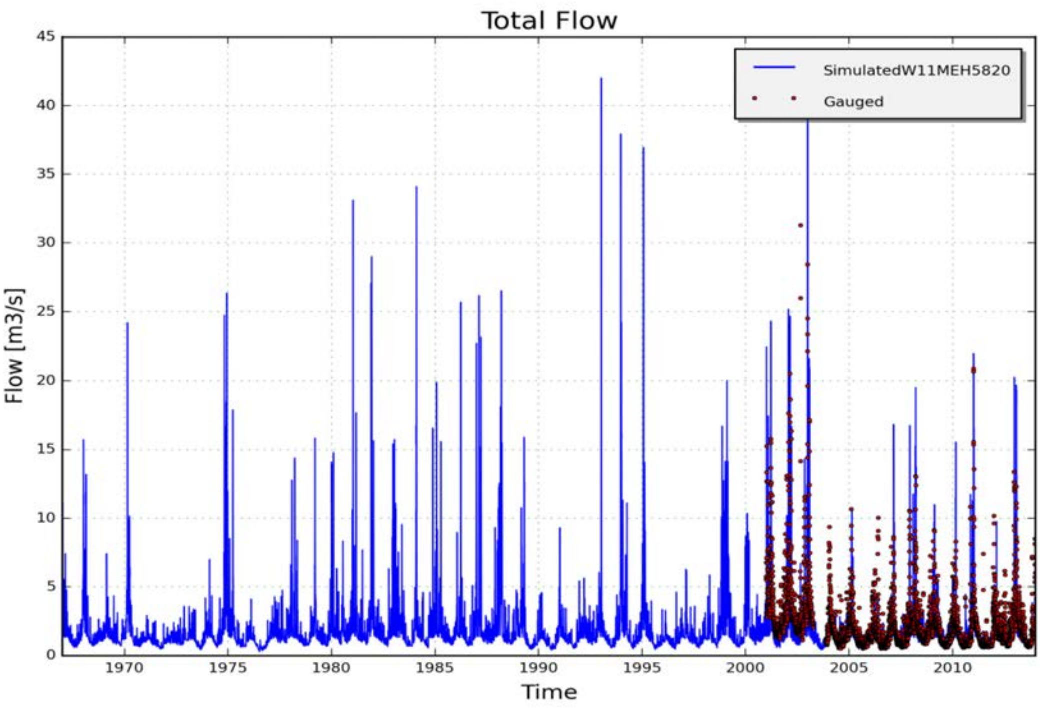


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W11MEH5820, station Mehaigne, Wanze (validation period)

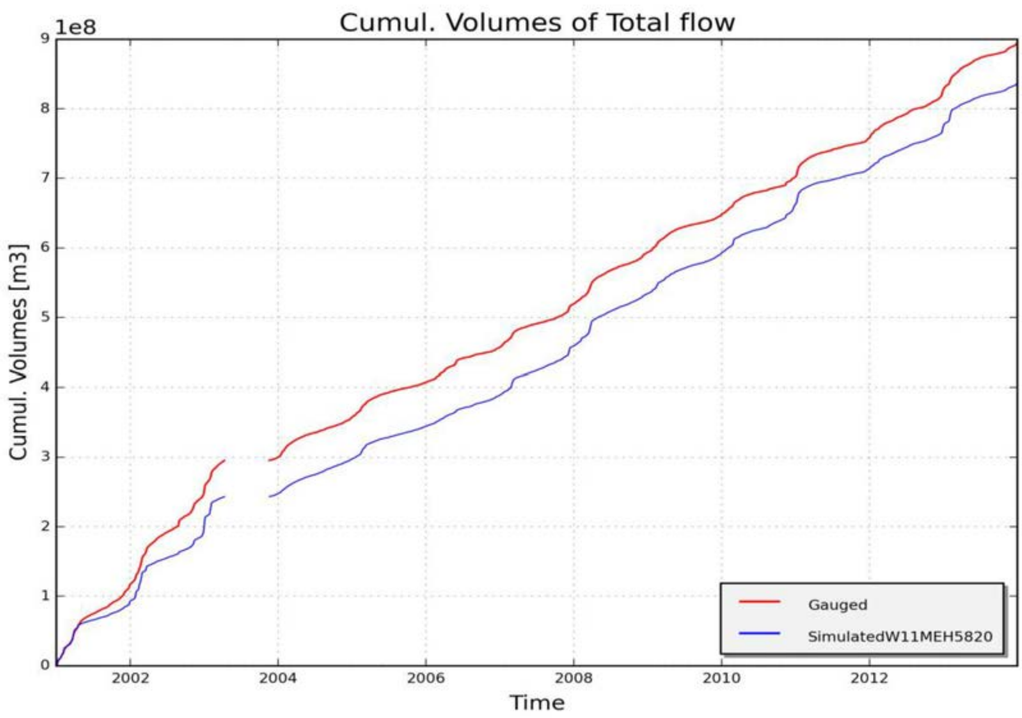
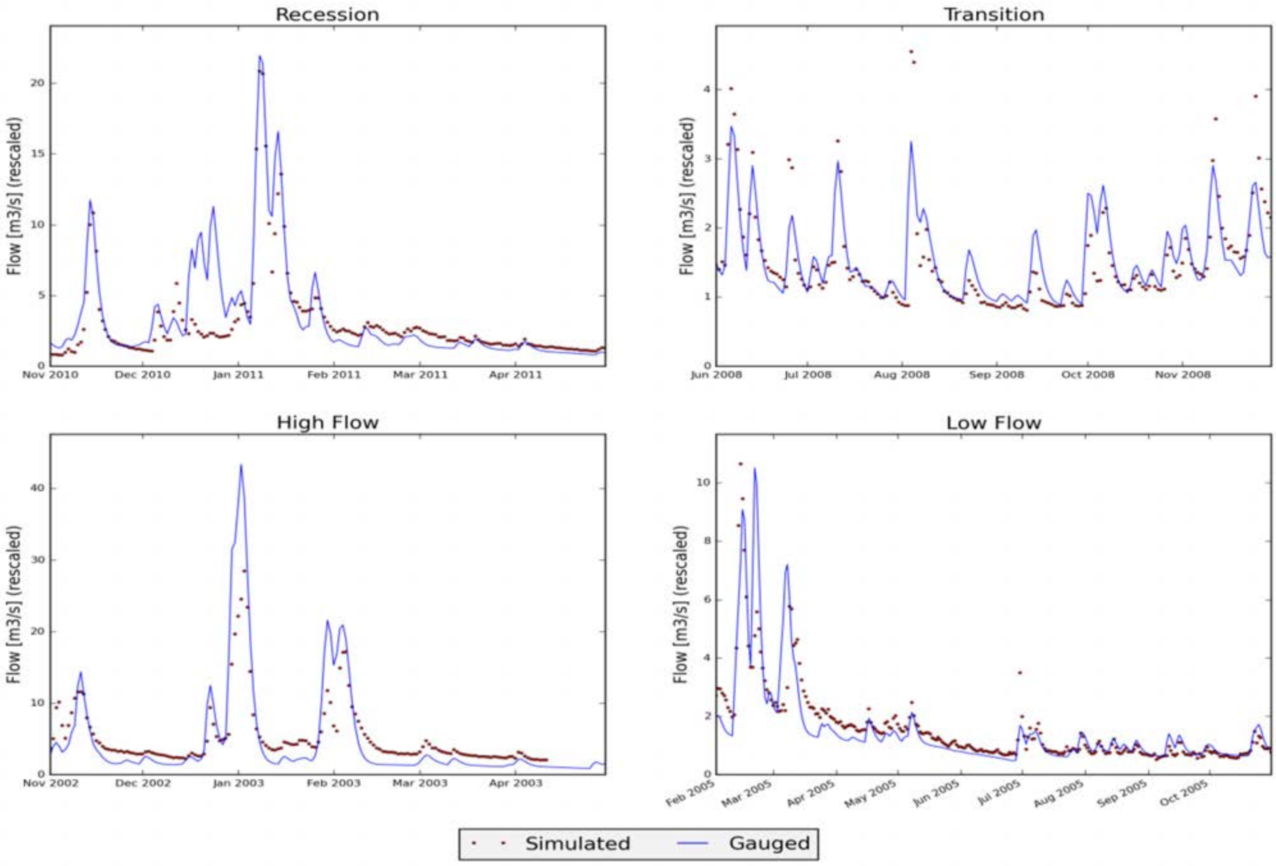


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W11MEH5820, station Mehaigne, Wanze



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "W11OUR5805" (MEUSE)

Input data

Figure 1: Cumulative precipitation on catchment W11OUR5805 (Meuse)

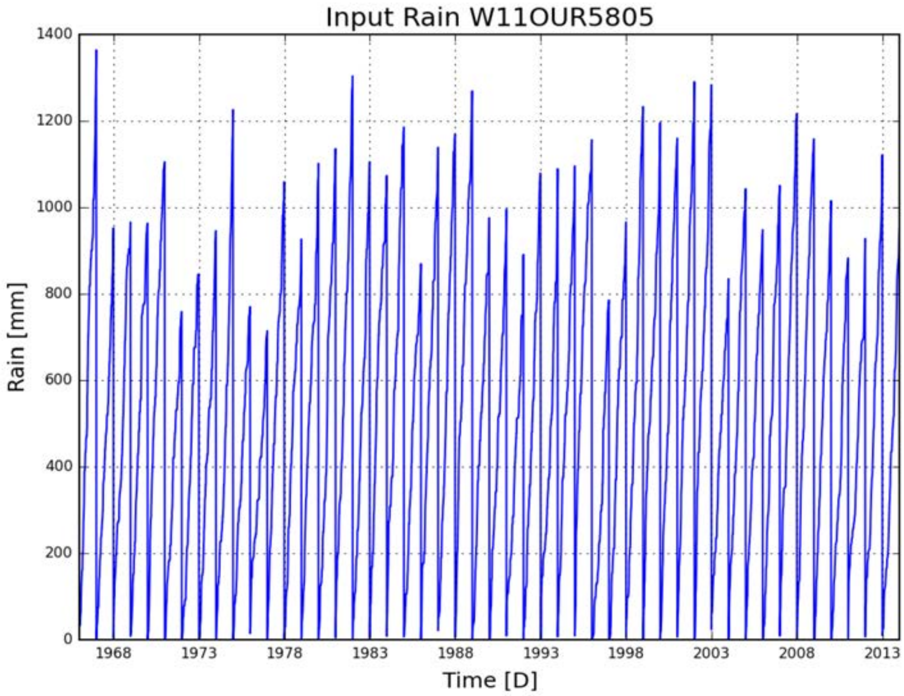
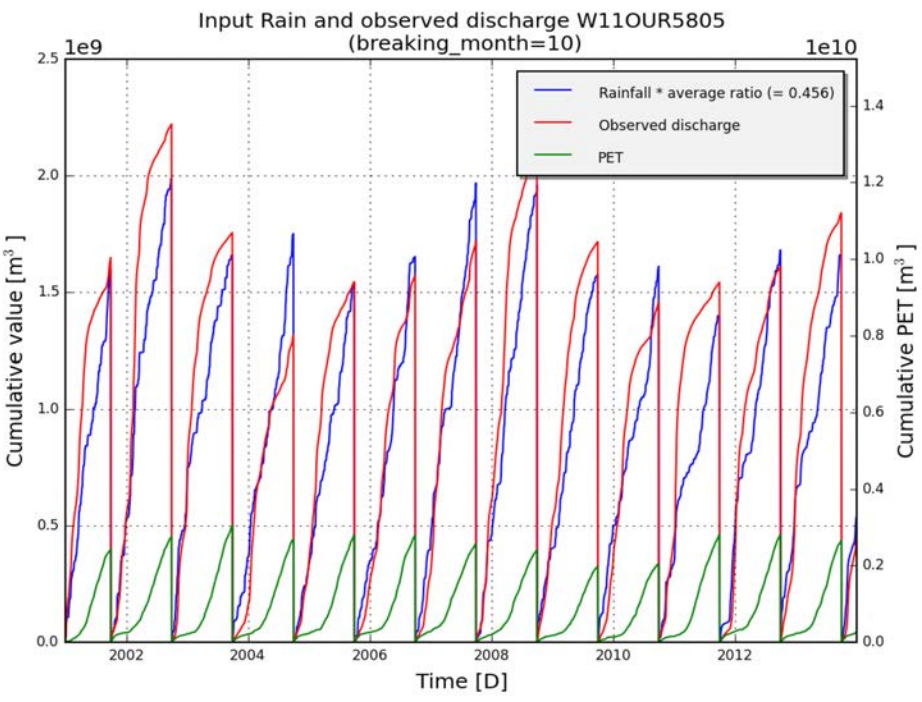


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W11OUR5805 (Meuse)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	W11OUR5805
subcatchment_area [m²]	3607000000
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.15), ('bevaporation', 2.0), ('cmin', 1.76), ('cmax', 236.0), ('CKBF', 300.0), ('CK1', 47.0), ('CK2', 43.0), ('bdrainage', 1.0), ('kdrainage', 6081.0), ('PDM.TG', 4.0), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2001 - 2013)

	Full year	Summer	Winter
NS	0.836	0.673	0.815
NS_log	0.847	0.64	0.728
NS_rel	0.88	0.737	0.828
RelErr	-0.3 %	10.3 %	-0.6 %
VolBias	-0.01	0.098	-0.037

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.813	0.77	0.767
NS_log	0.855	0.732	0.729
NS_rel	0.87	0.897	0.755
RelErr	0.4 %	5.0 %	-0.2 %
VolBias	0.001	0.064	-0.014

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)

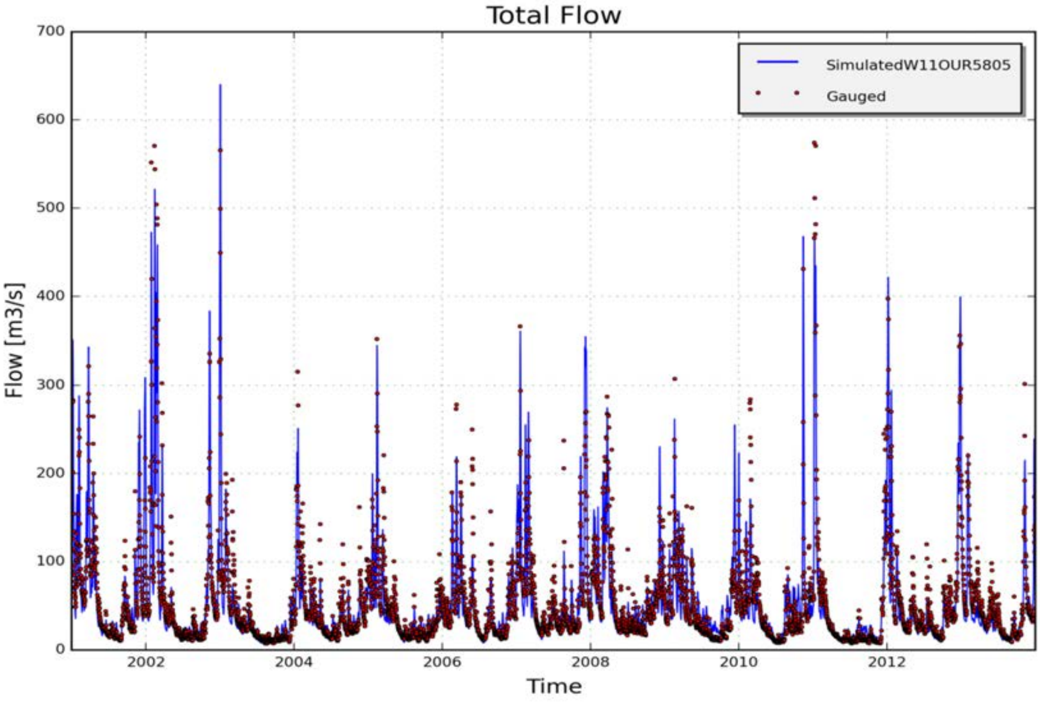


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W11OUR5805, station Ourthe, Angleur 2 bis (calibration period)

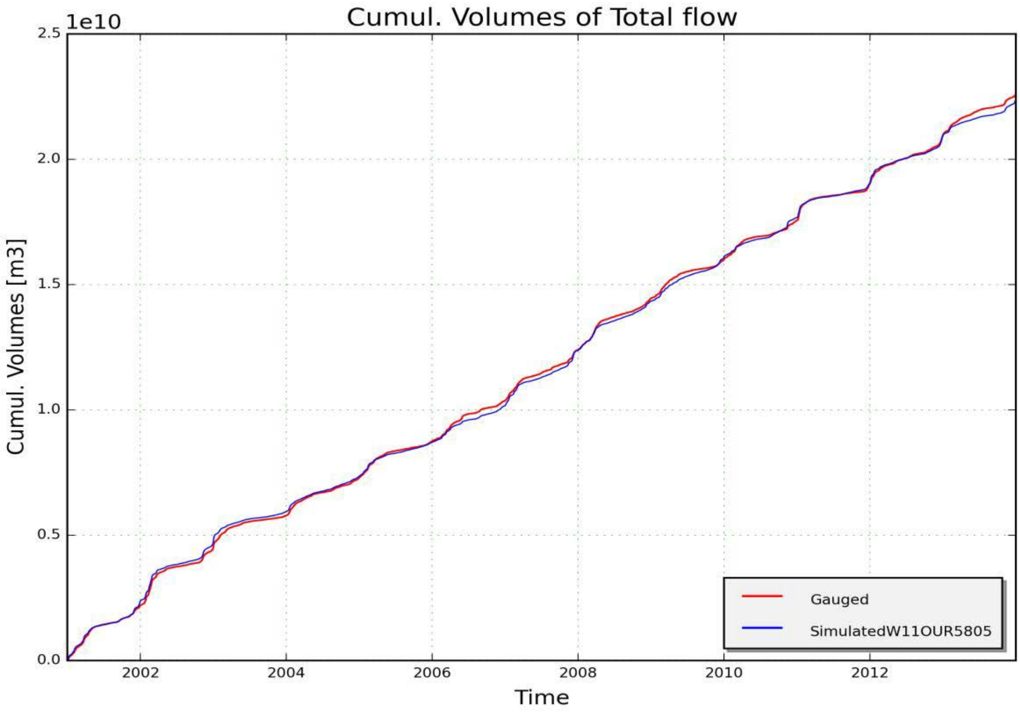


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W11OUR5805, station Ourthe, Angleur 2 bis (validation period)

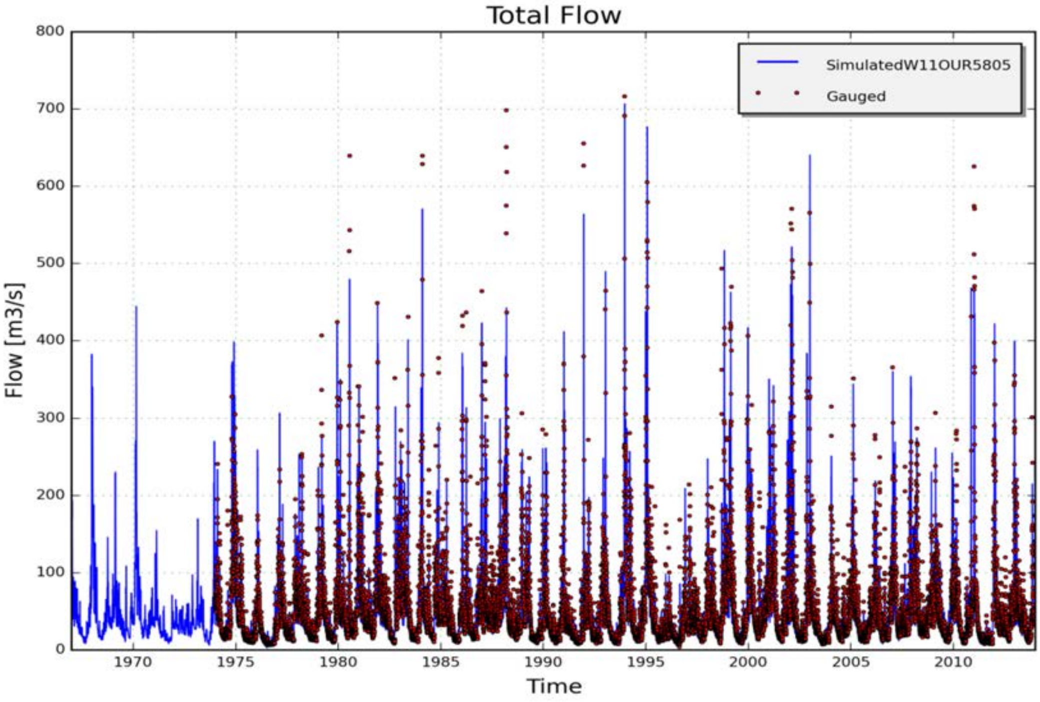


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W11OUR5805, station Ourthe, Angleur 2 bis (validation period)

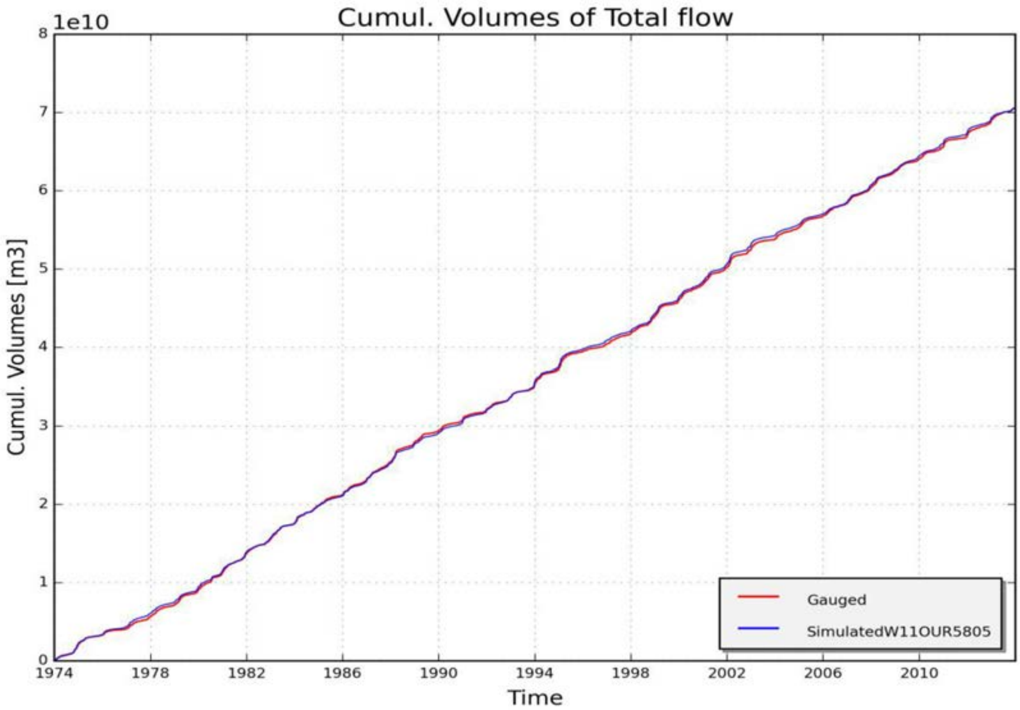
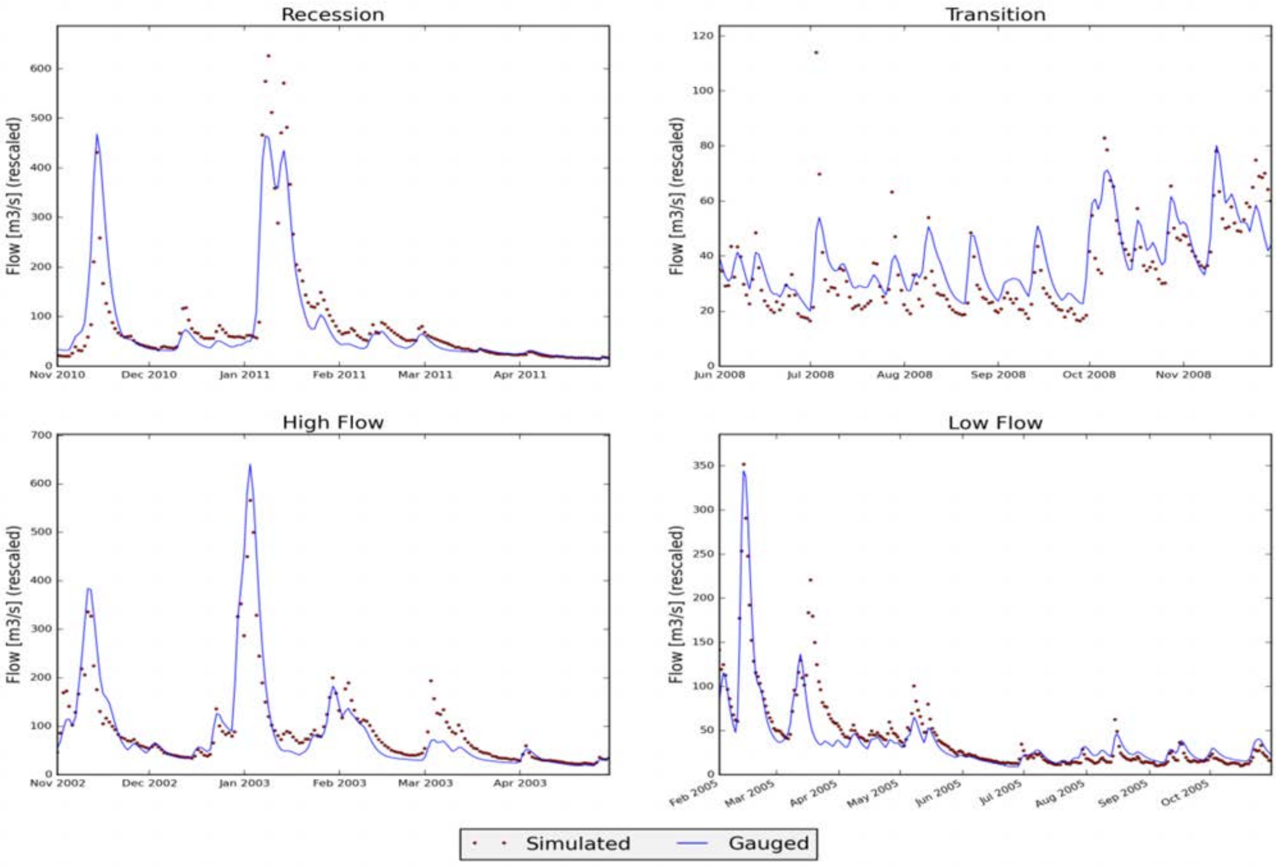


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W11OUR5805, station Ourthe, Angleur 2 bis



CALIBRATION AND VALIDATION OF PDM PARAMETERS FOR CATCHMENT "W11SAM7319" (MEUSE)

Input data

Figure 1: Cumulative precipitation on catchment W11SAM7319 (Meuse)

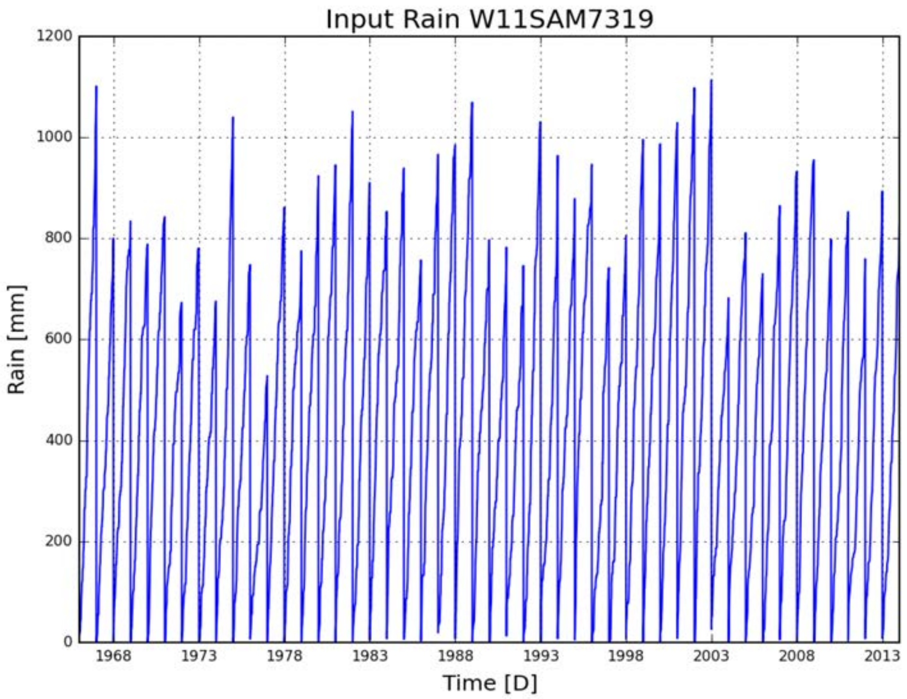
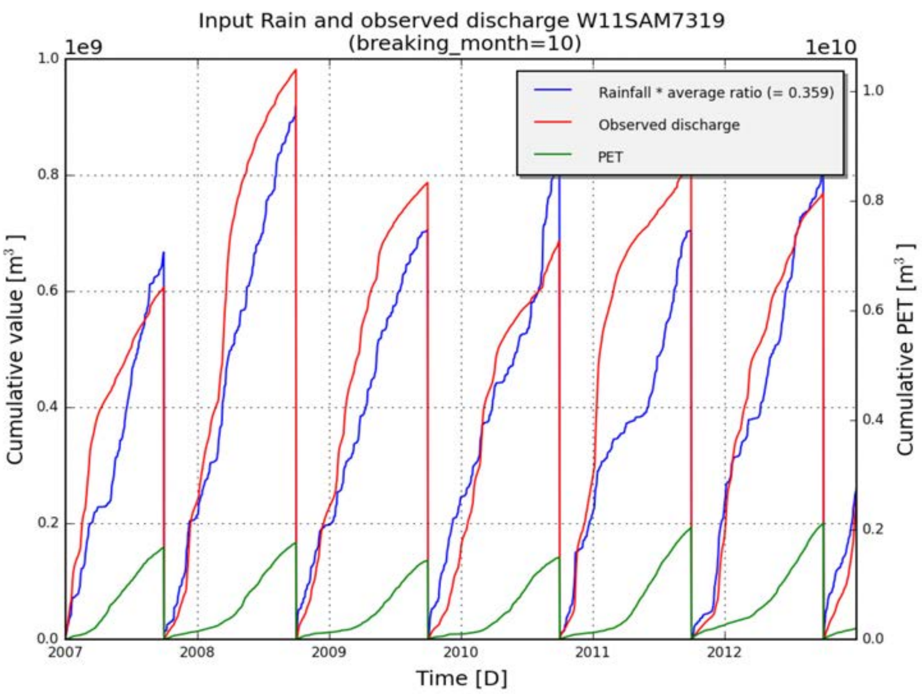


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to runoff ratio (total Q/total P) and cumulative potential evapotranspiration (green) on catchment W11SAM7319 (Meuse)



Model summary

model_structure	PDMclassic.Lumped
subcatchment_name	W11SAM7319
subcatchment_area [m²]	2636000000
Validation start_date	01-01-1967
Validation end_date	31-12-2013
frequency	daily

Optimal parameter set:

[('rainfraction', 1.0), ('bpareto', 0.2), ('bevaporation', 2.0), ('cmin', 4.7), ('cmax', 403.0), ('CKBF', 300.0), ('CK1', 45.0), ('CK2', 36.0), ('bdrainage', 1.0), ('kdrainage', 18561.0), ('PDM.TG', 1.1), ('tdly', 0.0), ('qconst', 0.0)]

Table 1: Goodness of fit for calibration period (2007 - 2012)

	Full year	Summer	Winter
NS	0.804	0.405	0.734
NS_log	0.774	0.3	0.671
NS_rel	0.826	0.353	0.83
RelErr	0.0 %	23.8 %	-6.8 %
VolBias	-0.034	0.171	-0.113

Table 2 :Goodness of fit for validation period (1967 - 2013)

	Full year	Summer	Winter
NS	0.769	0.436	0.666
NS_log	0.755	0.337	0.592
NS_rel	0.832	0.397	0.806
RelErr	-1.3 %	21.2 %	-7.9 %
VolBias	-0.079	0.123	-0.161

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)

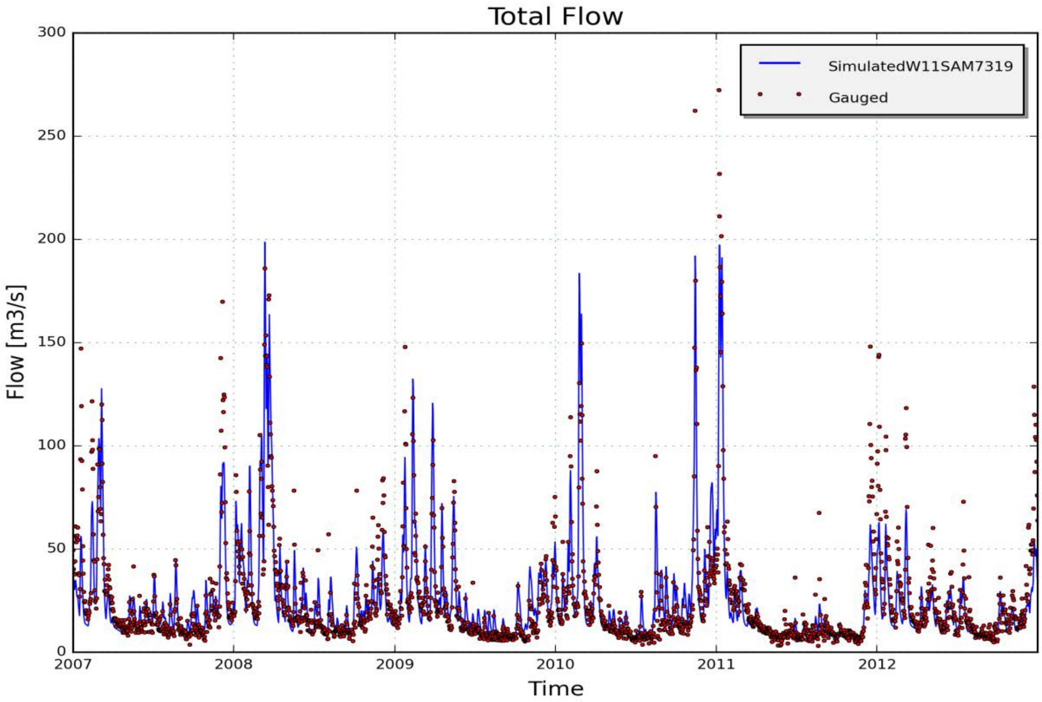


Figure 4: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W11SAM7319, station Samber, Salzinne (calibration period)

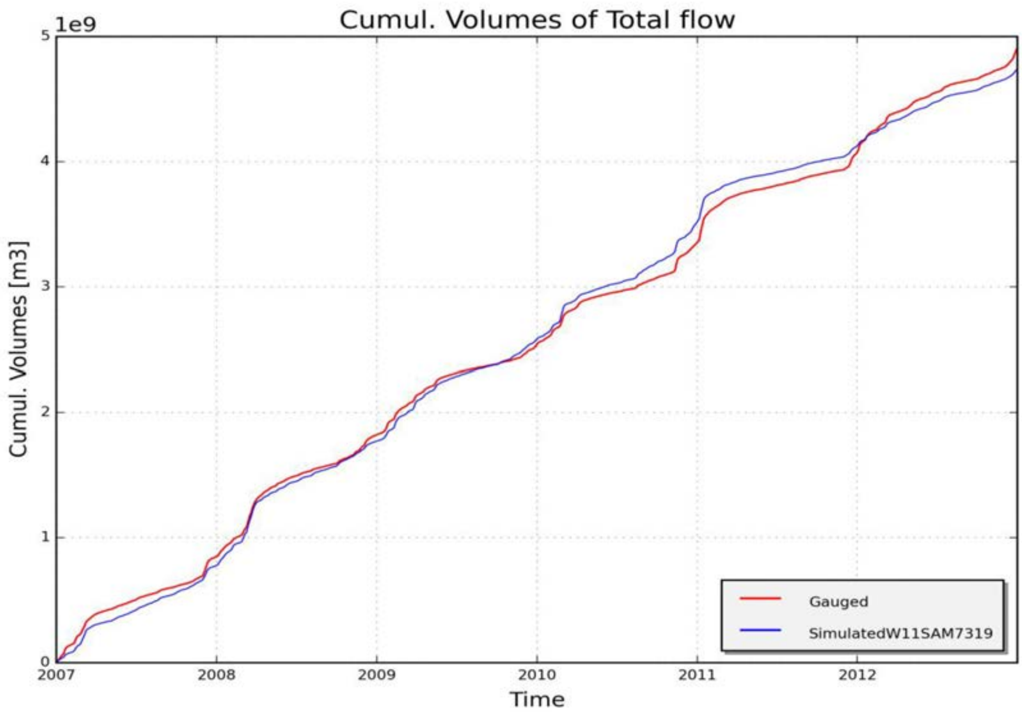


Figure 5: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W11SAM7319, station Samber, Salzinne (validation period)

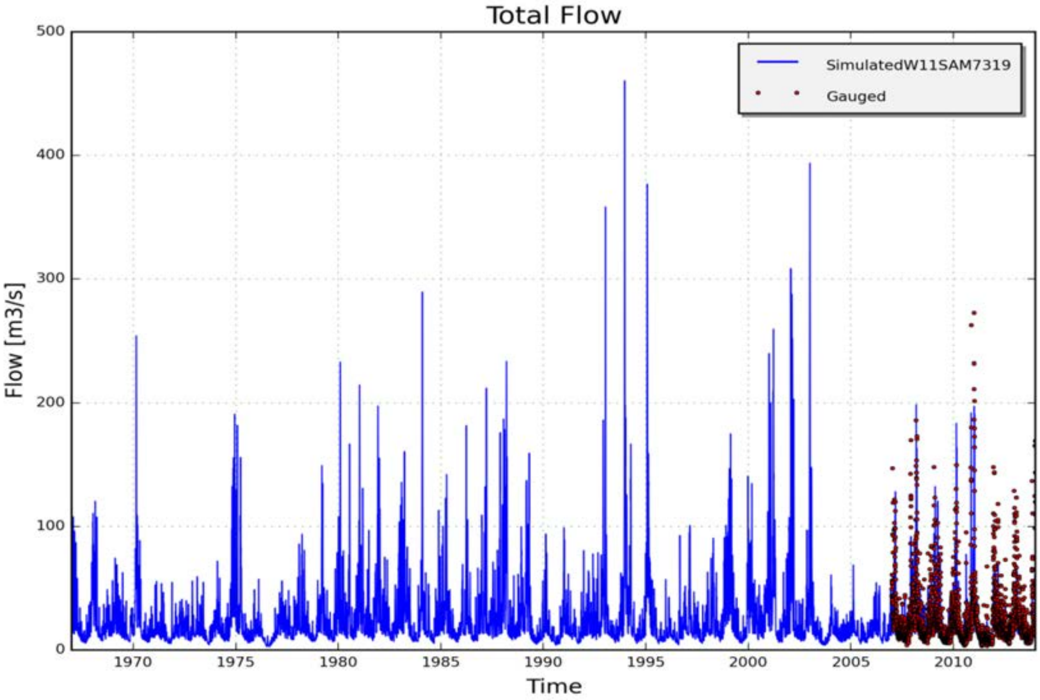


Figure 6: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W11SAM7319, station Samber, Salzinne (validation period)

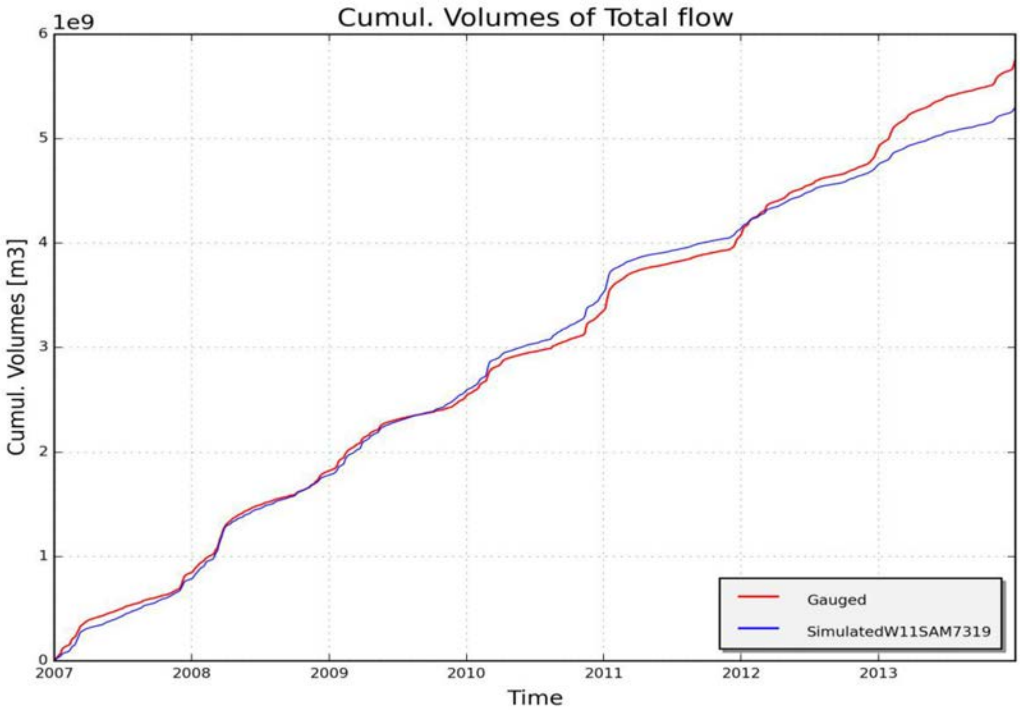


Figure 7: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W11SAM7319, station Samber, Salzinne

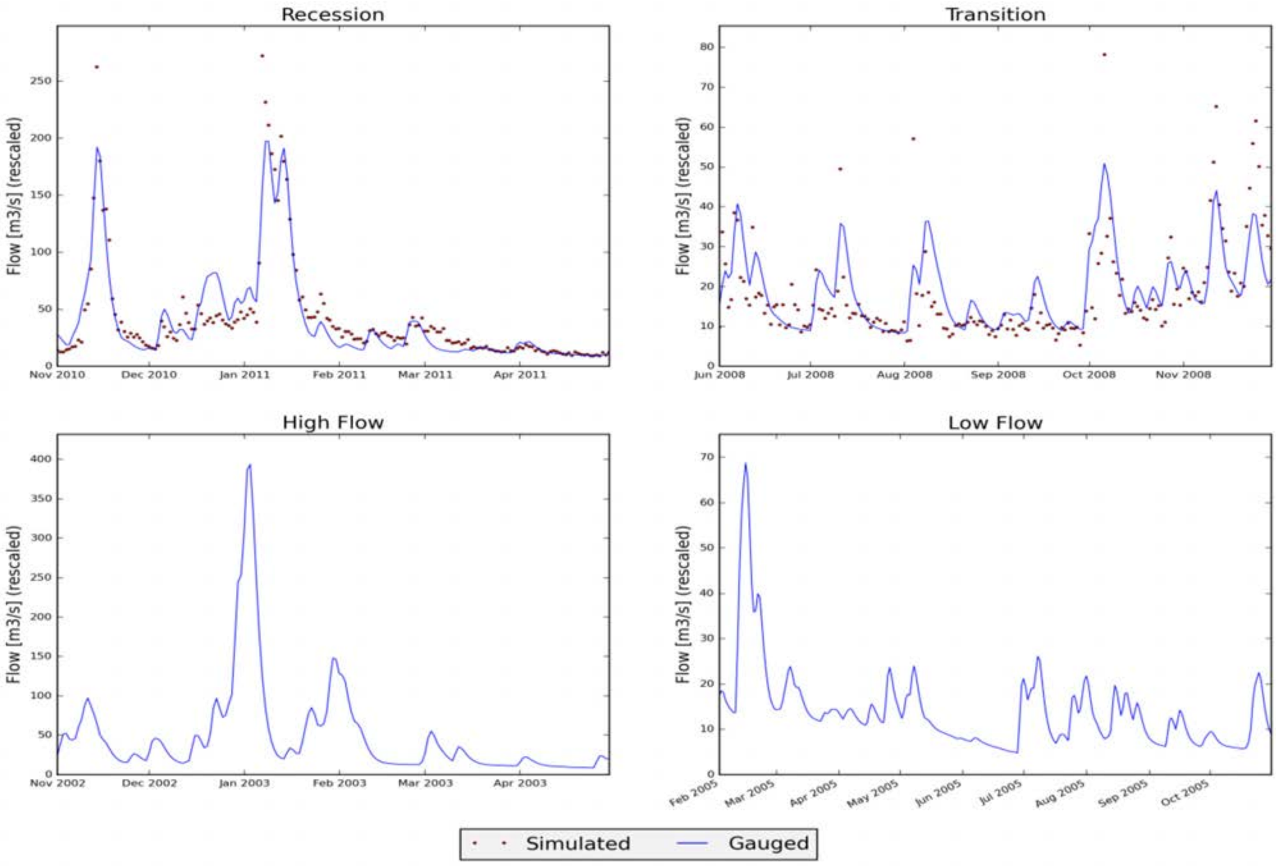


Figure 8: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W11SAM7319, station Samber, Salzinne

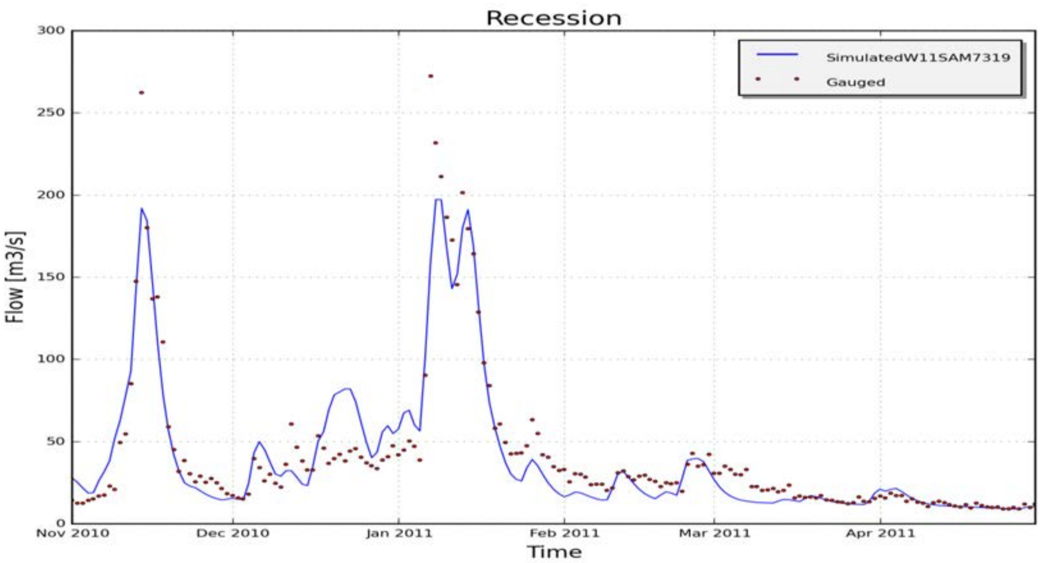
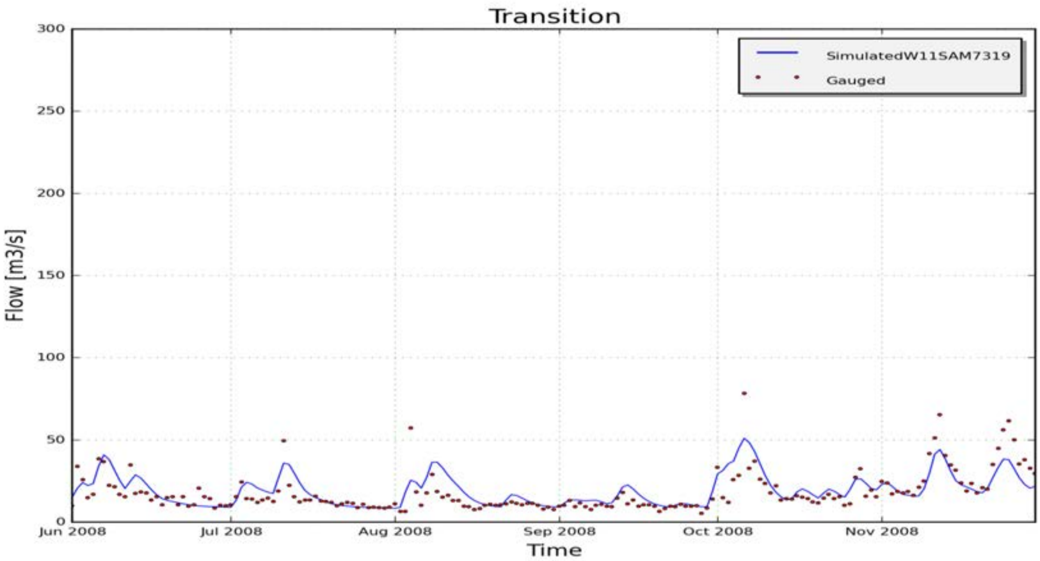


Figure 9: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W11SAM7319, station Samber, Salzinne

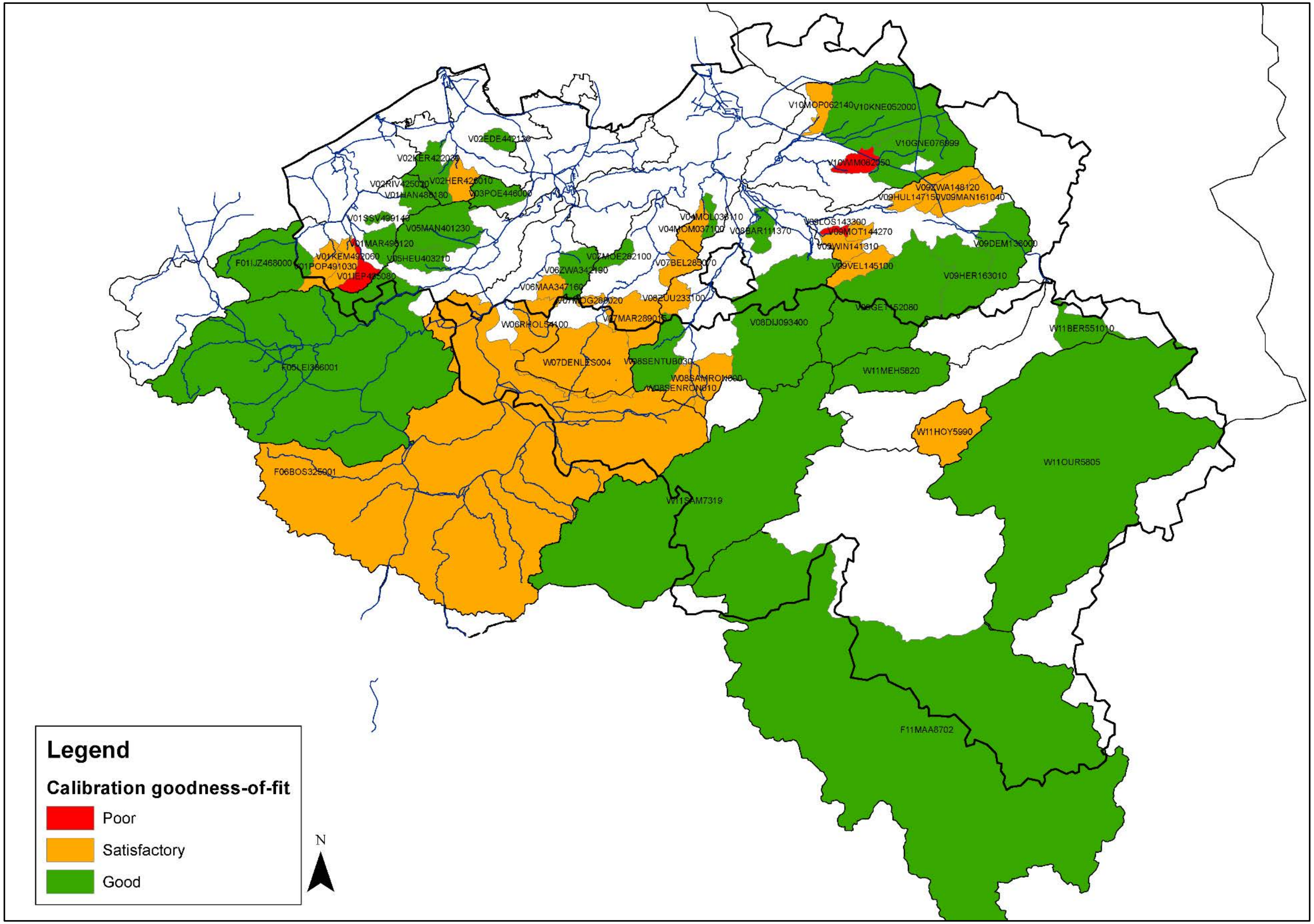


Annexe 14 Geographical overview calibration

Based on the statistics for each of the PDM models, a reclassification is performed. The table below shows how NSE, LogNSE and RelErr are combined to get a unique value for each subcatchment. This evaluation results in the map which is included hereafter.

	When value	Reclassify value
NSE		
	>0,6	3
	0,3-0,6	2
	<0,3	1
LogNSE		
	>0,6	3
	0,3-0,6	2
	<0,3	1
RelErr		
	<15	3
	50-30	2
	>50	1

Combinations				Combination statistics	Reclassification	Judgement
3	3	3		27	3	Good
3	3	2		18	2	Acceptable
2	2	3		12	2	
3	3	1		9	2	
2	2	2		8	2	
1	2	3		6	1	Bad
2	2	1		4	1	
1	1	3		3	1	
1	1	2		2	1	
1	1	1		1	1	

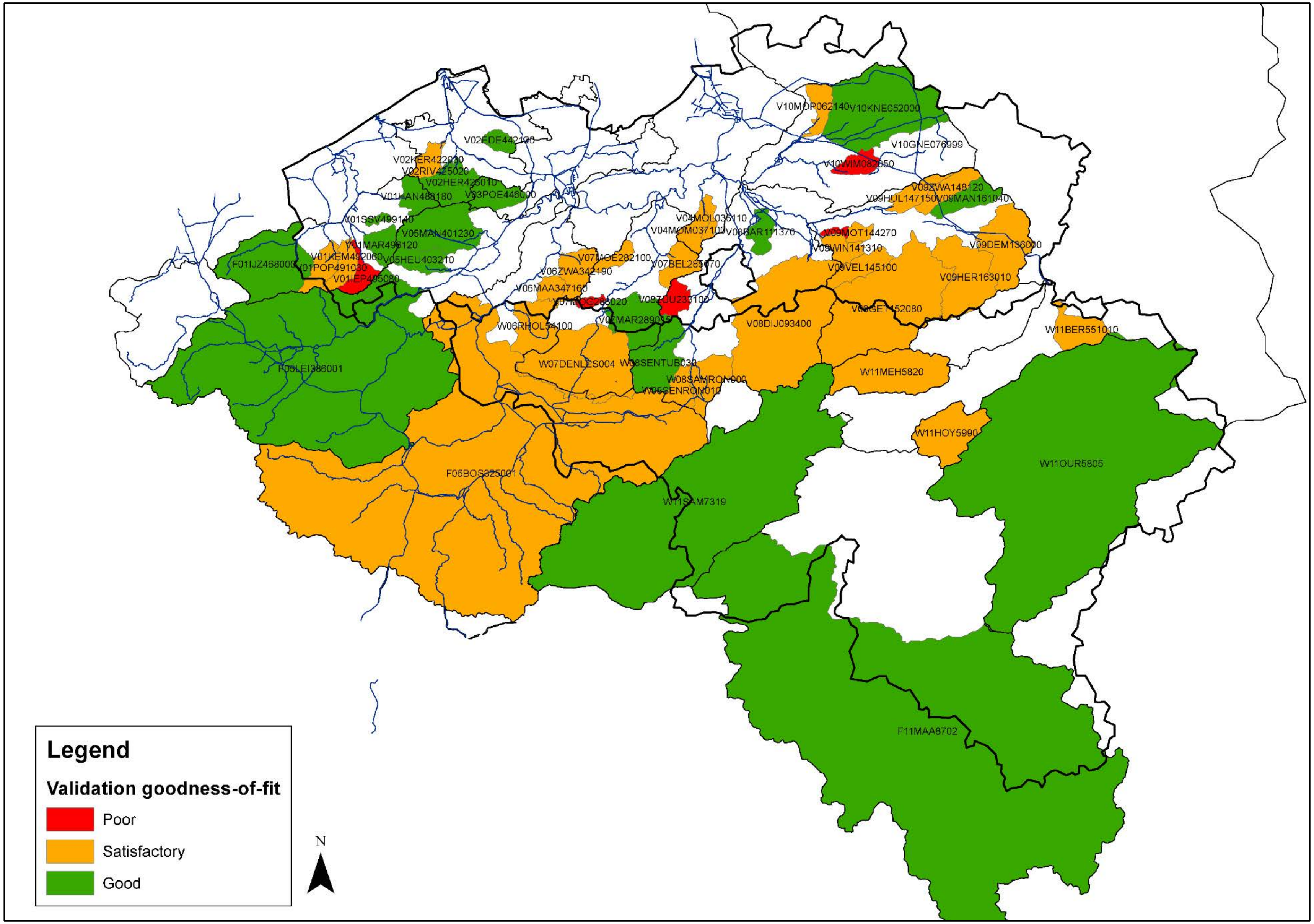

V10MOP062140
V10KNE052000
V10GNE076999
V10WIM082050
V02EDE442120
V02KER422020
V02RIV425020
V02HER426010
V01HAN488180
V03POE446000
V09ZWA148120
V09HUL147150
V09MAN161040
V01SSV499140
V04MOL036110
V04MOM037100
V08BAR111370
V09LOS143300
V09MOT144270
V05MAN401230
V09WIN141310
V09DEM136000
V01MAR496120
V01KEM492060
V05HEU403210
V07MOE282100
F01IJZ468000
V01POP491030
V07BEL285070
V09VEL145100
V06ZWA342190
V01IEP495080
V09HER163010
V06MAA347160
V07MOG288020
V08ZUU233100
V09GET152080
V07MAR289015
V08DIJ093400
W06RHOL54100
W11BER551010
W07DENLES004
W08SENTUB030
F05LEI386001
W08SAMRON000
W11MEH5820
W08SENRON010
W11HOY5990
W11OUR5805
F06BOS325001
W11SAM7319
F11MAA8702
Legend
Calibration goodness-of-fit
Poor
Satisfactory
Good
N

Annexe 15 Geographical overview validation

Based on the statistics for each of the NAM models, a reclassification is performed. The table below shows how NSE, LogNSE and RelErr are combined to get a unique value for each subcatchment. This evaluation results in the map which is included hereafter.

	When value	Reclassify value
NSE		
	>0,6	3
	0,3-0,6	2
	<0,3	1
LogNSE		
	>0,6	3
	0,3-0,6	2
	<0,3	1
RelErr		
	<15	3
	50-30	2
	>50	1

Combinations				Combination statistics	Reclassification	Judgement
3	3	3		27	3	Good
3	3	2		18	2	Acceptable
2	2	3		12	2	
3	3	1		9	2	
2	2	2		8	2	
1	2	3		6	1	Bad
2	2	1		4	1	
1	1	3		3	1	
1	1	2		2	1	
1	1	1		1	1	


Legend
Validation goodness-of-fit
Poor
Satisfactory
Good
N
V10KNE052000
V10GNE076999
V02EDE442120
V09DEM136000
V09HER163010
F01IJZ468000
F05LEI386001
F06BOS325001
W11SAM7319
W11OUR5805
W11HOY5990
W11MEH5820
W11BER551010
F11MAA8702
V08DIJ093400
V07DENLES004

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