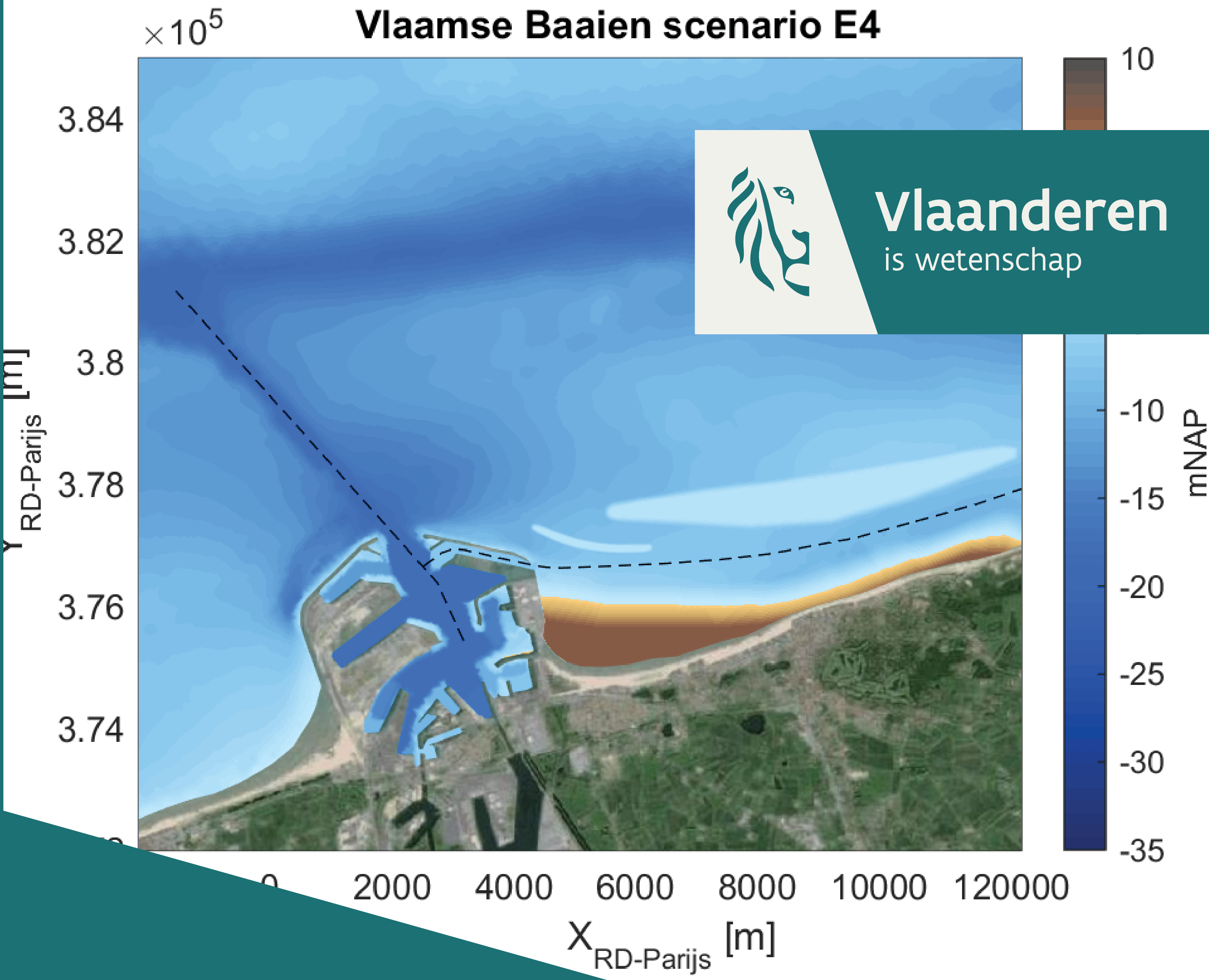

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Belgische Kustzone en Scheldemonding

Rekennota - Berekeningen golfklimaat Vlaamse Baaien scenario's E4 en F1

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Hassan, W.; Suzuki, T.; De Maerschalck, B.; Verwaest, T.; Mostaert, F.

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Samenvatting

Binnen het project Vlaamse Baaien wordt de impact van golfwerende constructies op de toegankelijkheid van de haven van Zeebrugge voor estuarine vaart onderzocht. De scenario's voorzien in een combinatie van eilanden en dammen voor de Belgische kust tussen Zeebrugge en de Belgisch-Nederlandse grens, in combinatie met een nieuwe toegang tot de haven van Zeebrugge in de Oostelijke havendam.

Onderstaande nota beschrijft de opzet van het SWAN-golfmodel voor de scenario's E4 en F1. Het scenario E4 voorziet in een overstroombaar eiland. Het scenario F1 voorziet in een groot, niet-overstroombaar eiland. De locatie van het eiland is zo gekozen dat het traject voor de nautische toegankelijkheid de historische munitiestortplaats voor de kust van Knokke maximaal ontwijkt. Voor meer informatie over de scenario's word verwezen naar De Maerschalck et al. (2016). De scenarioberekeningen in onderstaande rekennota zijn een aanvulling op eerder scenario's berekend in Suzuki et al. (2016). Voor meer details over het gebruikte golfmodel wordt eveneens verwezen naar dit rapport.

In totaal werden per scenario 3368 golfcondities brekend, dit is het volledige golfklimaat voor het jaar 2013. De golfcondities in 154 punten werden digitaal opgeleverd aan de afdeling Maritieme Technieken van de faculteit Civiele Techniek, UGent, voor verder analyse van de toegankelijkheid van de haven van Zeebrugge voor estuarine vaart.

Inhoudstafel

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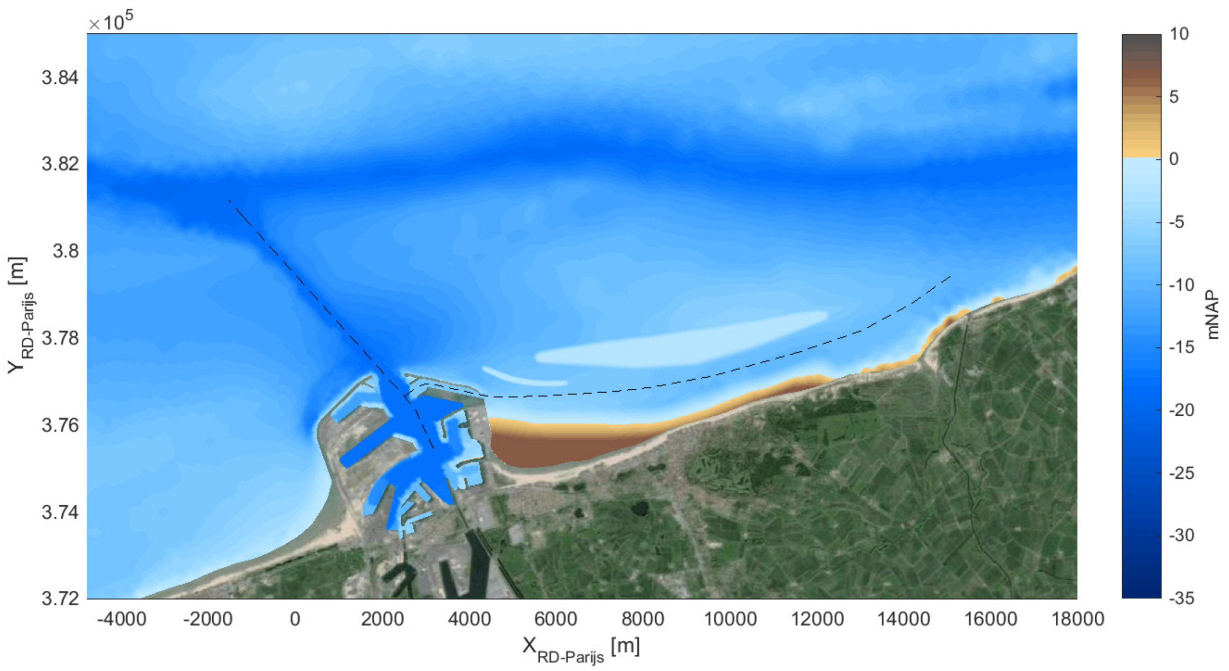
1 Introduction

The present study focuses on SWAN model set-up and calculation of the detailed wave climate between Zeebrugge and the mouth of the Western Scheldt estuary. This model calculation of scenario E4 and F1 configuration was performed under all the wind, wave and water level conditions through one year, 2013, by means of the validated numerical model (i.e. the Belgian coast model in SWAN, developed in the project R769_01). For more details on the model setup, the reader is referred to Suzuki et al. (2016). In this report also the setup of the T0, A1 and E1 scenarios are discussed.

Scenario E4 consists of a submerged island and dam in front of the coast of Knokke, Figure 1. Scenario F1 consists of an island more offshore in combination with a dam and a large extension of the beach, Figure 2. The position of the island is chosen in such a way that the navigation route avoids as much as possible the historical munition depot, marked by the black pentagon on the figure below.

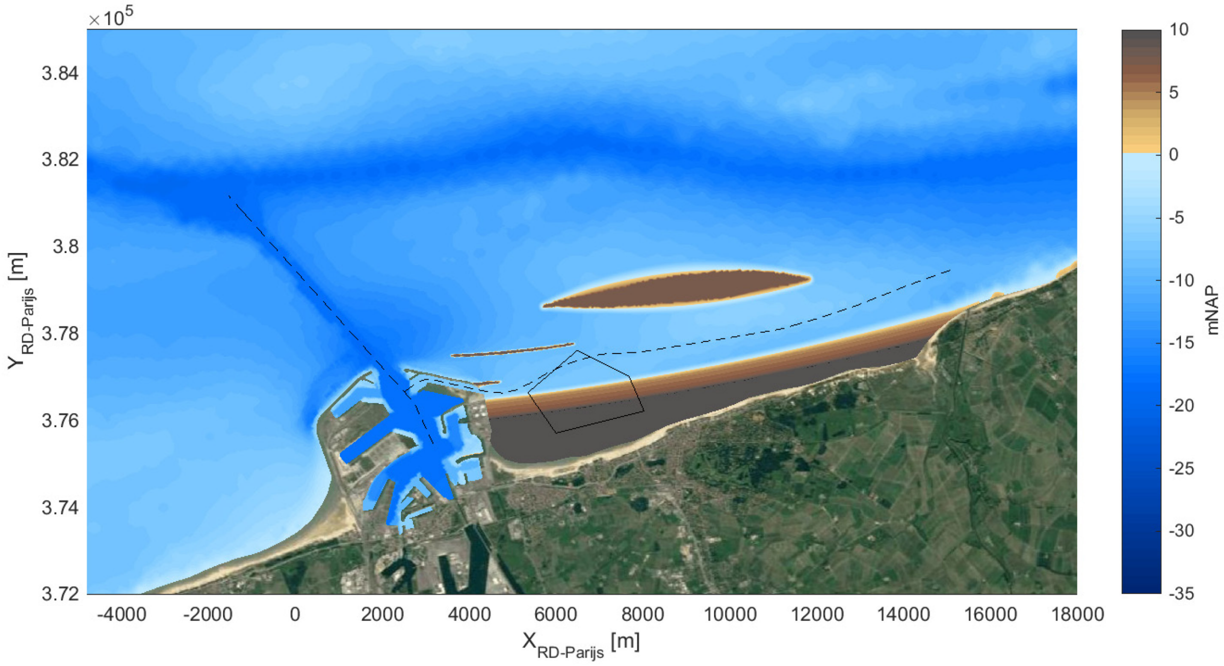
This output will be used for the further analysis for the navigation of the vessels making use of the present route and future alternative routes, and will serve as a basis to evaluate the impact of measures on the response of inland vessels sailing between the port of Zeebrugge and the Scheldt estuary. Digital data has been transferred to Ghent University, Civil Engineering – department Maritime Techniques, where the impact of the wave climate on the nautical accessibility of the port of Zeebrugge for estuarine traffic has been analyzed (Vantorre and Van Zwijnsvoorde, 2016).

Figure 1: Bathymetry scenario E4, submerged island.



The dashed line in the figure marks the navigation routes.

Figure 2: Bathymetry scenario F1



The dashed lines in the figure mark the navigation routes. The black pentagon marks the position of the historical munition depot.

2 Data source

In situ wave data and wind data are obtained through Meetnet Vlaamse Banken from the Hydrography department of the Coastal division. Normally, only wave parameters can be obtained in terms of wave data but in this study, full wave spectrum data is specially requested to Coastal division. For this study the data of 2013 (entire year) is collected and used. Bathymetry data for scenario E4 and F1 is developed from present T0 bathymetry in combination with new islands bathymetry from the Maritime access division (dx = dy = 10m).

2.1 Data format (coordinate)

Data format (coordinate) used in this study is [m in WGS84UTM31] in horizontal axis (x- and y- direction) and [m TAW] in vertical axis (z-direction). All the obtained data have been transformed into this format to proceed further with SWAN model calculations and analyses.

2.2 Waves

Measured wave data, (every 30 minutes) which have been used in the present study, is obtained by directional waveriders at three locations, at Westhinder, ZW-Akkaert and Bol Van Heist. Note that the coordinate information is extracted from the website of the Meetnet Vlaamse Banken, at the moment of 2015. The wave measurement from the Meetnet Vlaamse Banken is first processed as wave spectrum data (full spectrum; directional components + frequency components) from the measurement, and eventually translated into wave parameters (wave: height, period and direction). Normally these parameters are only used for further analysis/simulations but in this study, measured full wave spectrum is used for the input in the SWAN model since it is supposed to be more accurate (including more information). (More details can be found in Suzuki et al., 2016).

2.3 Wind

Wind measurement data (every 10 minutes) at the measuring pile 0, Wandelaar (MP0) in 2013 is obtained from the Meetnet Vlaamse Banken. Average wind speed and direction are used applying a correction factor for the height of the anemometer, because the input for the SWAN model is the average wind speed at the height of 10 m from the sea level, see Section 3.5.3.

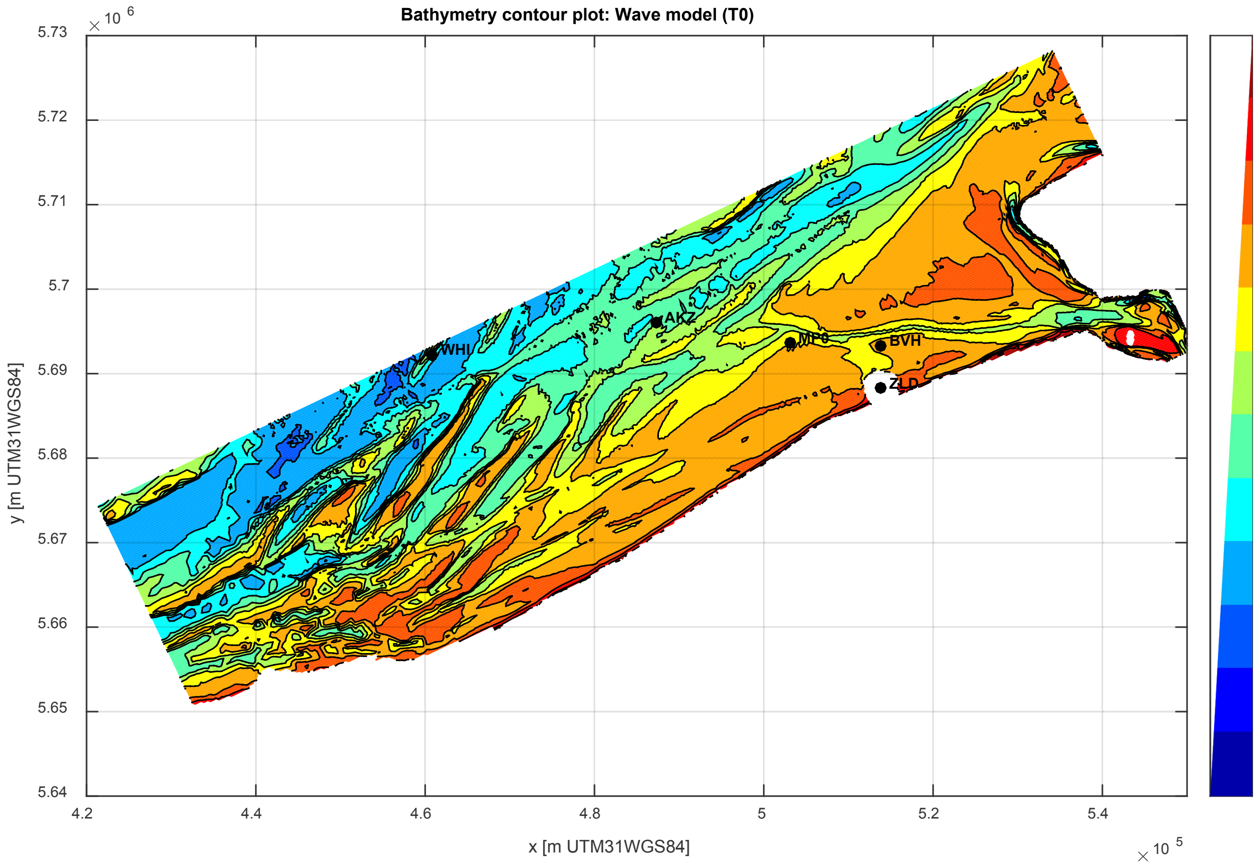
2.4 Water level

Water level data (every 5 minutes) used in this study is obtained by tide measurement station at Zeebrugge Leopold II dam (ZLD).

2.5 Locations summary

All locations used in this study (WHI; AKZ; MP0; BVH; ZLD) are shown in Figure 3.

Figure 3: Locations of in situ measurement points



3 SWAN model

SWAN (Simulating WAves Nearshore) is a third-generation wave model, developed at Delft University of Technology, which computes random short-crested wind-generated waves in coastal regions and inland waters. This model is based on the numerical solution of the wave action balance equation and accounts for physics such as wave propagation, shoaling refraction, wave generation by wind, transmission through and reflection against obstacles, and diffraction.

3.1 SWAN version

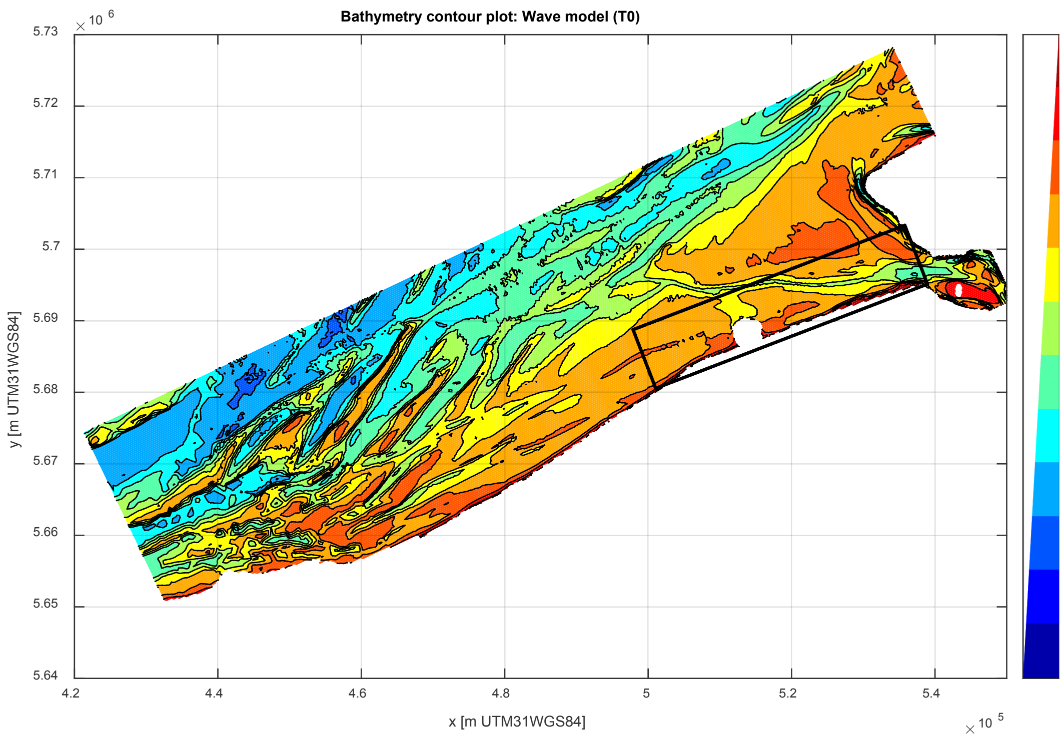
SWAN version of 40.85 is used for all calculations in this study. Note that there is no significant change between version 40.85 and 40.72, which was used earlier in the Belgian coast model.

3.2 Model domain and bathymetry

Basic settings (e.g. model domain, bathymetry, grid size) of T0 calculation are the same as used in the Belgian coast model. Only hydraulic and wind boundary conditions are the exception since the data from 2013 has been applied in this study (more details can be found in Suzuki et al., 2016).

For the calculation of future bathymetry (E4 configurations) the 'nesting' method in SWAN is used, see details in SWAN manual (2015). SWAN only calculates incident waves, and that is a reason why the nesting calculation works. The nesting boundary locations used for the scenario analyses calculations are shown as a black rectangular in Figure 3.

Figure 4: Bathymetry contour plot of T0 calculation and nesting boundary locations for E4 calculation.



3.3 Model scenario's

E4 and F1 configuration are shown in Figure 4 and Figure 5 and have been used for model calculations. Note that the scenario bathymetry files are developed based on the data provided from aMT (Renders et al., 2016). Table 1 shows the origin (x and y position in WGS84UTM31 coordinate) and the bathymetry information (rotation and number of grids for x and y direction, and dx, dy) for E4 scenario. Note that 10 m grid is not directly used in the computation since it requires a huge computational cost. Instead 50 m grid is used which has been chosen based on a model sensitivity analysis. SWAN interpolates automatically the 10m input on a 50x50m computational grid for the actual simulation.

Figure 5: Bathymetry contour plot for E4 calculation [m TAW]

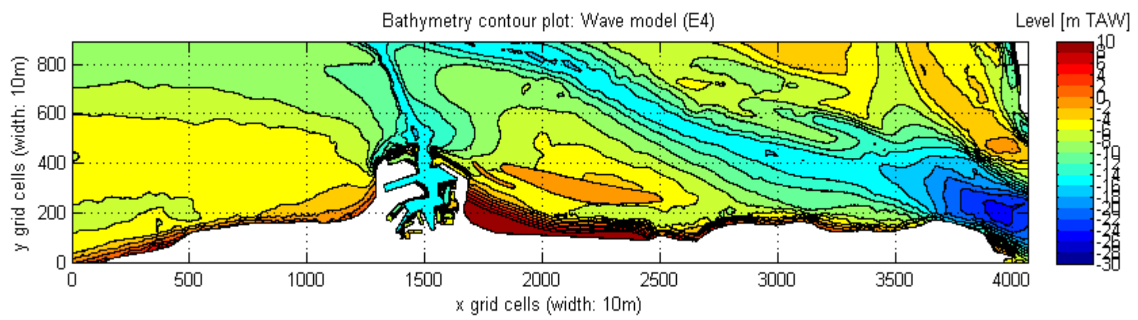


Figure 4: Bathymetry contour plot for F1 calculation [m TAW]

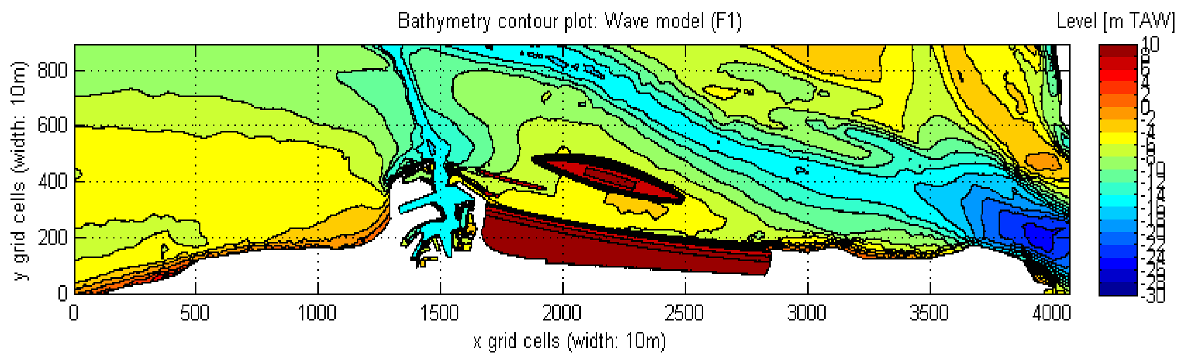


Table 1: Origin of the E4 configuration

Description	X coordinate (WGS84UTM31)	Y coordinate (WGS84UTM31)	Rotation	Number of grid in x*	Number of grid in y*
Origin of the E4 configurations	501058.00	5680545.00	21.04	4060 (dx=10 m)	880 (dy=10 m)

*Those are only used for the input in SWAN; computation is executed on a 50x50m grid.

3.4 Computational bin

Frequency band in the SWAN calculation is selected between 0.025 and 0.85 Hz (T~1.2 s to 40 s) with 37 bin (=the frequency is divided into 37 discrete energy portion). Directional resolution is set as 10 degrees. This is common for all calculations in the present study.

3.5 Boundary conditions

3.5.1 Water level

The measured water levels at ZLD are used as a boundary condition for E4 calculations.

The in situ water level data was recorded every 5 minutes. In the present study, the measured water level every 2 hours has been used in SWAN model computations.

The used data starts at +02:00 hours in 2013. This is a common setting for all scenarios calculations in this study.

3.5.2 Wave boundary condition

E4 calculation

Measured wave spectra at AKZ are used as wave boundary conditions in the T0 calculation. The available wave spectrum data was collected every 30 minutes and is filtered in the present study to obtain wave parameters every 2 hours. Averaged values of the previous 1 hour of each time step is used (2 data points before each time step). In this way, we can take into account the wave travelling time from deep water to the area of interest close to the shoreline at Bol van Heist (BVHD).

- Spec 1 e.g. 0:00
- Spec 2 e.g. 0:30
- Spec 3 e.g. 1:00
- Spec 4 e.g. 1:30
- Spec 5 e.g. 2:00 (Spec 3+ Spec 4) / 2 is used for calculation at 2:00

E4 configuration

Nesting data obtained in the T0 calculations has been applied in E4 scenario.

3.5.3 Wind conditions

The in situ wind data was recorded every 10 minutes. It was also recommended to adjust the wind speed at the model boundary by taking the averaged value of 30 minutes before each time step to take into account the time history effects of wind. This means using an average value of 3 points before the selected time step.

- Wind 1 e.g. 1:30
- Wind 2 e.g. 1:40
- Wind 3 e.g. 1:50
- Wind 4 e.g. 2:00 (Wind 1+ Wind 2 + Wind3) / 3 is used for calculation at 2:00

The wind data is obtained at the height of 25.7 m TAW. Therefore, wind speed was modified using log-law when it is applied to SWAN, in which the model input should be the wind speed at 10 m high from MSL.

In this study the correction coefficient of R=0.94 is used. The wind speed is also corrected according to the wave height (Hs). The wind speed correction factor R = 0.94 for large waves Hs > 1.0 m and R = 0.8 for small waves Hs < 1.0 m.

Wind growth was computed using WESTHUYSEN instead of the method of Komen as in the original SWAN model setting.

Those above mentioned settings are used for all calculations of E4 scenario.

3.6 Physical parameters

Wave breaking and bottom friction are activated with default values. In the scenario configuration runs (E4 calculations), diffraction and triad (wave-wave interaction) are activated with a default values.

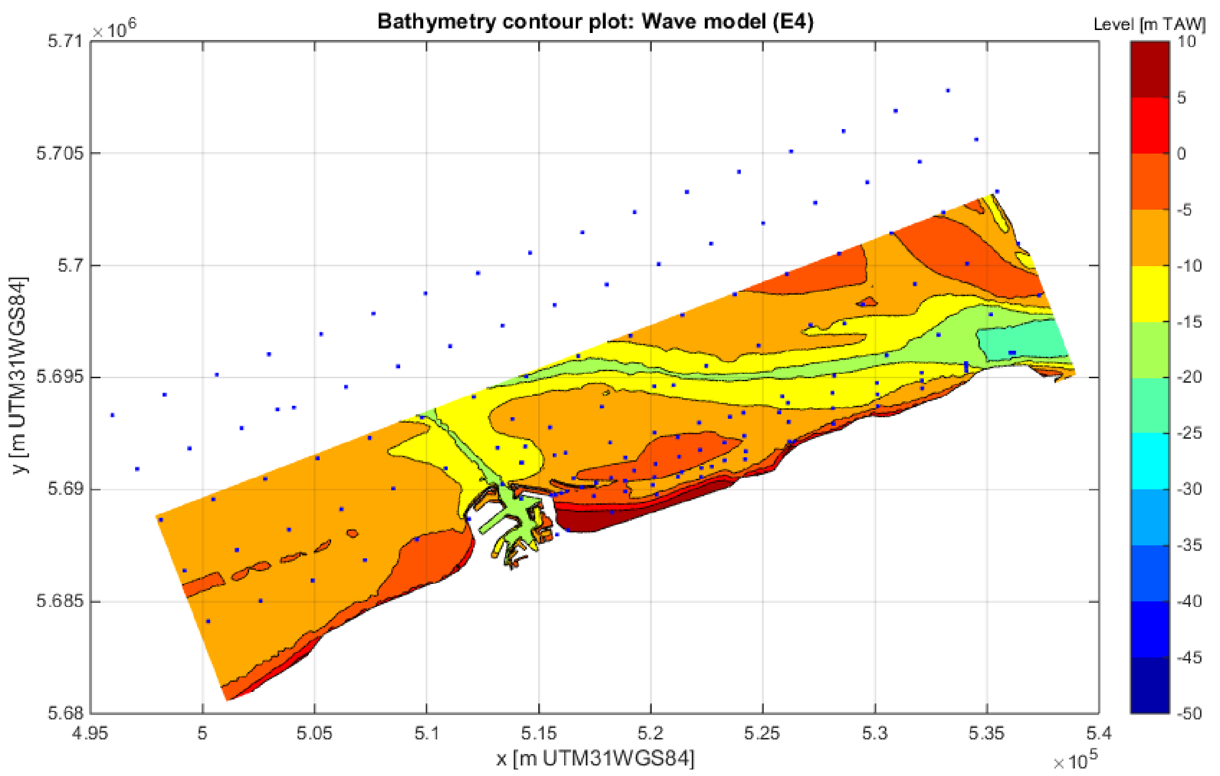
3.7 Numerical parameters

Computation is stopped after maximum 50 iteration steps.

3.8 Output locations

In total 154 locations have been selected to obtain the output results of SWAN model runs. These locations are presented in Figure 6.

Figure 6: Wave data output points



4 OUPUT

In total 3368 wave conditions were calculated and exported for 154 output points. Digital data has been transferred to Ghent University, Civil Engineering – department Maritime Techniques, where the impact of the wave climate on the nautical accessibility of the port of Zeebrugge for estuarine traffic has been analyzed (Vantorre and Van Zwijnsvoorde, 2016).

5 References

Renders, D.; De Maerschalck, B.; Vanlede, J.; Gourgue, O.; Willems, M.; Verwaest, T.; Mostaert, F. (2016). Modellering Vlaamse Baaien: Deelrapport 1 – Hydrodynamische Modellering. WL Rapporten, 15_068. Waterbouwkundig Laboratorium & afdeling Maritieme Toegang: Antwerpen, België.

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Vantorre, M.; Van Zwijnsvoorde, T. (2016). Zeewaartse binnenvaartverbinding voor Zeebrugge – Berekening van de scheepsresponsies voor scenario E4: constructie eilanden met kruinhoogte 0 m LAT op het Belgische deel van het vaartraject. Universiteit Gent, Faculteit Ingenieurswetenschappen – EA15 – Afdeling Maritieme Techniek, Gent.

Bijlage: example of a SWAN input file

Input example is shown below:

```
$
$*************HEADING****************************************
$
PROJ 'GE4_test_2317' '01'
$
$*************MODEL INPUT************************************
$
SET LEVEL  3.54
SET NAUT
MODE STATIONARY
MODE TWOD
$
CGRID REG        501058    5680545    21.04    40600    8800   812   176   CIRCLE 36 0.025 0.85 37
$
INPGRID BOTTOM     501058    5680545    21.04     4063     888    10    10   EXC 9999
$
READINP BOTTOM -1.0 'bth_E4_taw_10m_v2.dep' 4 0 FREE
$
BOUNDNEST1 NEst  'GE4_test_2317.nst' CLOSE
$
GEN3  WESTHUYSEN
BREAK CON 1.00 0.73
FRIC  JON 0.067
WIND   3.8    7.7
$
DIFFRAC
TRIADS
$
NUM STOPC STAT 50
$
$************* OUTPUT ***************************************
$
OUTPUT OPTIONS TABLE 16 BLOCK 9 6
$
```

```
POINTS 'BVHD' 514387.179 5691918.792
TABLE  'BVHD' HEAD 'GE4_test_2317_BVHD.tab' XP YP DEP HS RTP DIR TM01 TM02 WIND TMM10
SPEC   'BVHD' SPEC1D ABS 'GE4_test_2317_BVHD.sp1'
SPEC   'BVHD' SPEC2D ABS 'GE4_test_2317_BVHD.sp2'
POINTS 'out5' FILE 'out5.txt'
TABLE  'out5' HEAD 'GE4_test_2317_out5.tab' XP YP DEP HS RTP DIR TM01 TM02 WIND TMM10
SPEC   'out5' SPEC1D ABS 'GE4_test_2317_out5.sp1'
SPEC   'out5' SPEC2D ABS 'GE4_test_2317_out5.sp2'
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_xp.mat'     LAY-OUT 1 XP
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_yp.mat'     LAY-OUT 1 YP
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_dep.mat'    LAY-OUT 1 DEP
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_hs.mat'     LAY-OUT 1 HS
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_tmm10.mat'  LAY-OUT 1 TMM10
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_per.mat'    LAY-OUT 1 PER
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_rtp.mat'    LAY-OUT 1 RTP
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_tps.mat'    LAY-OUT 1 TPS
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_dspr.mat'   LAY-OUT 1 DSPR
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_dir.mat'    LAY-OUT 1 DIR
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_pdir.mat'   LAY-OUT 1 PDIR
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_ubot.mat'   LAY-OUT 1 UBOT
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_urms.mat'   LAY-OUT 1 URMS
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_dhsign.mat' LAY-OUT 1 DHSIGN
BLOCK 'COMPGRID' NOHEAD 'GE4_test_2317_drtm01.mat' LAY-OUT 1 DRTM01
$
COMPUTE
STOP
$
```

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