Process-based coastal modelling
Regional models

Calibration and validation of regional flow models

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Contents

- Requirements of a regional model
- Data collection and analysis
- Setting up the model
- Calibration
- Validation

Example case

- Flyland Project: multi-disciplinary study on the effects of an airport island in the North Sea
- Set up of a North Sea regional model as a basis for hydrodynamic, morphological and ecological effect studies
- See report:
  Z3029_11_Large scale model calibration and validation.pdf

Requirements for this example

2 Specifications

The models described in this report were set up, keeping in mind that the models (fine-grid and coarse-grid) will be used for widely varying purposes, such as the effect of the island on (1) water levels and flow velocities, (2) the coastal river, (3) exchange with Wadden Sea, (4) transport and residual velocities, and (5) North Sea wide patterns of salinity and temperature. The parameters listed below are used to quantify the ability of the models to

Criteria

Table 2.1 Specifications of the models' performance.

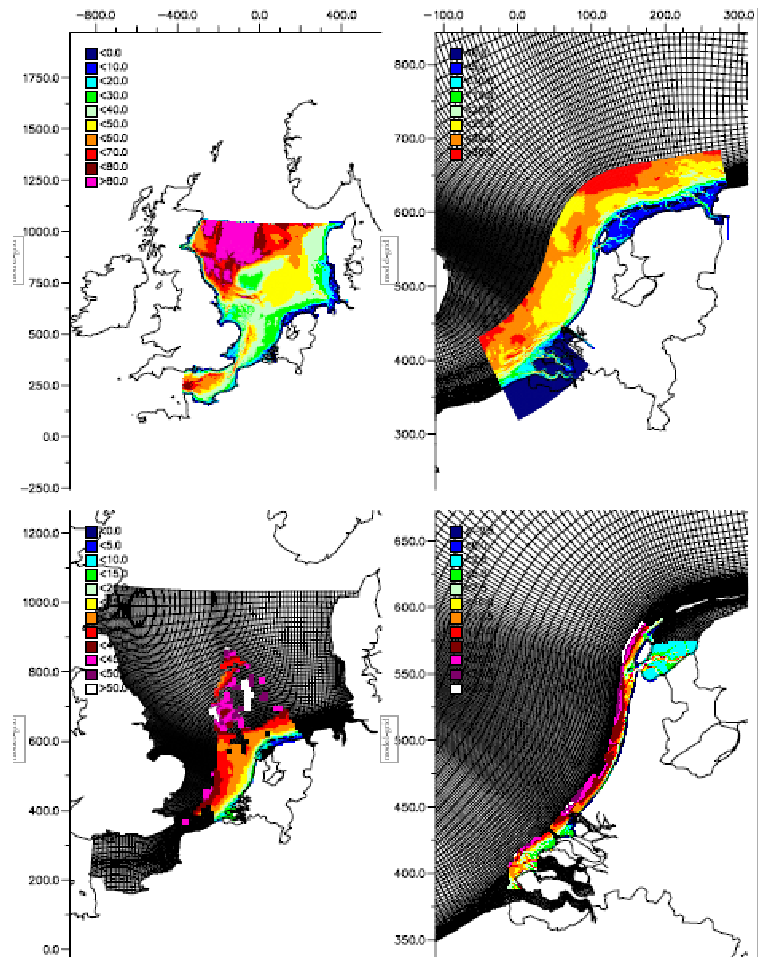
Parameter	Achieved accuracy
Water levels	
M2 amplitude	rms error <6%
M2 phase	< 10 deg.
M4 amplitude	rms error <3% of M2 amplitude
	rms error <25% of M4 amplitude
M4 phase	< 25 deg.
Flow rates Marsdiep	
rms error	< 10%
mean flow rate	< 20%
Flow rate Channel	
mean flow rate	< 30% from estimated 90,000 m^3/s
Tidal velocity area of interest	
M2 amplitude alongshore	< 10%
M2 phase alongshore	< 10 deg.
M2 amplitude cross-shore	< 20%
M2 phase cross-shore	< 20 deg.
Residual currents area of interest	
Long-term mean velocity at Scheveningen, Egmond, Noordwijk (alongshore)	< 0.01 m/s
Long-term mean velocity at Scheveningen, Egmond, Noordwijk (cross-shore)	< 0.01 m/s
Salinity	
Mean surface salinity area of interest	rms error < 1 p.s.e.
Standard deviation salinity area of interest	abs error < p.s.e.
Temporal and spatial variation during UK NERC NSP campaign	rms error < 1 p.s.e.
Temperature	
Temporal and spatial variation during UK NERC NSP campaign	rms error < 2 deg. C

Data collection and analysis

- Bathymetry
- Water levels
- Discharges
- Tidal velocities
- Wind
- Residual currents
- Salinity
- Temperature

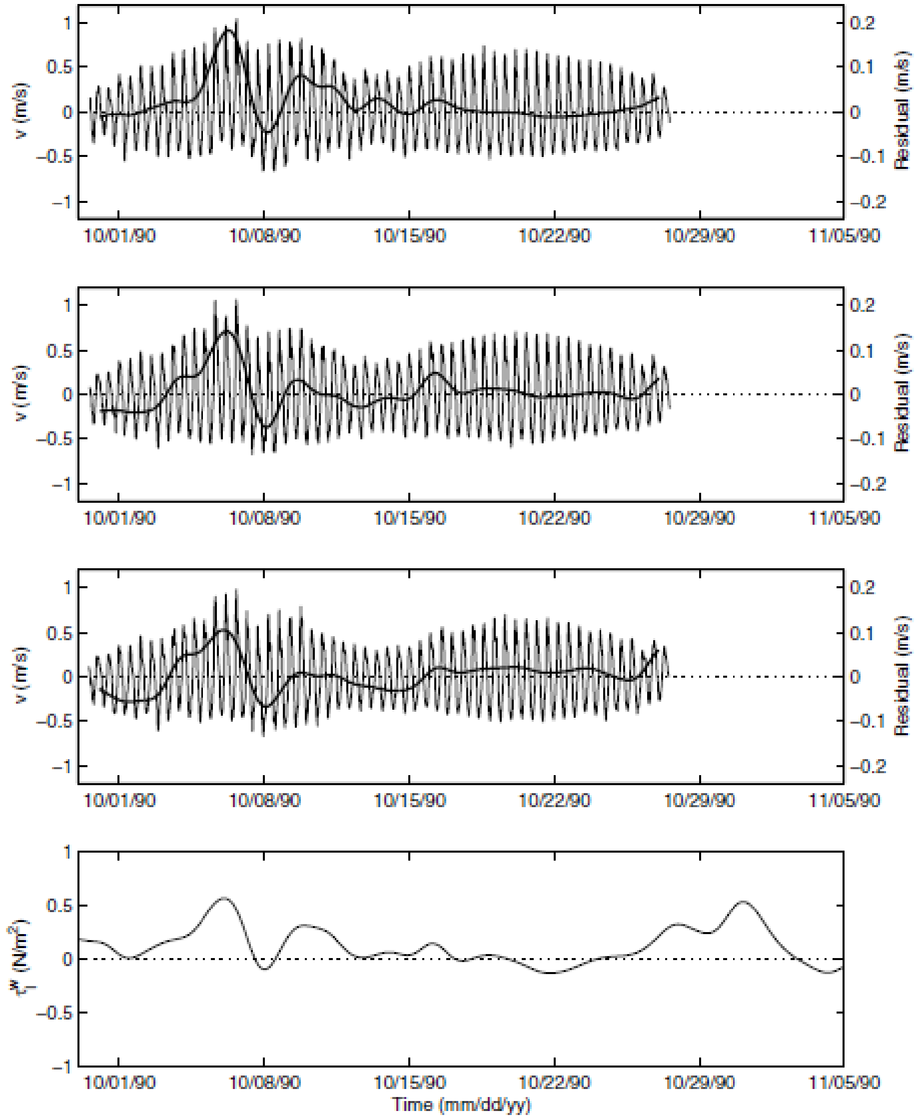
Bathymetry

- **Various sources and previous models**
- **Need to weigh and combine them**
- **Sometimes too coarse, sometimes too fine**
- **Final: 100x100m2, and interpolated to grids**

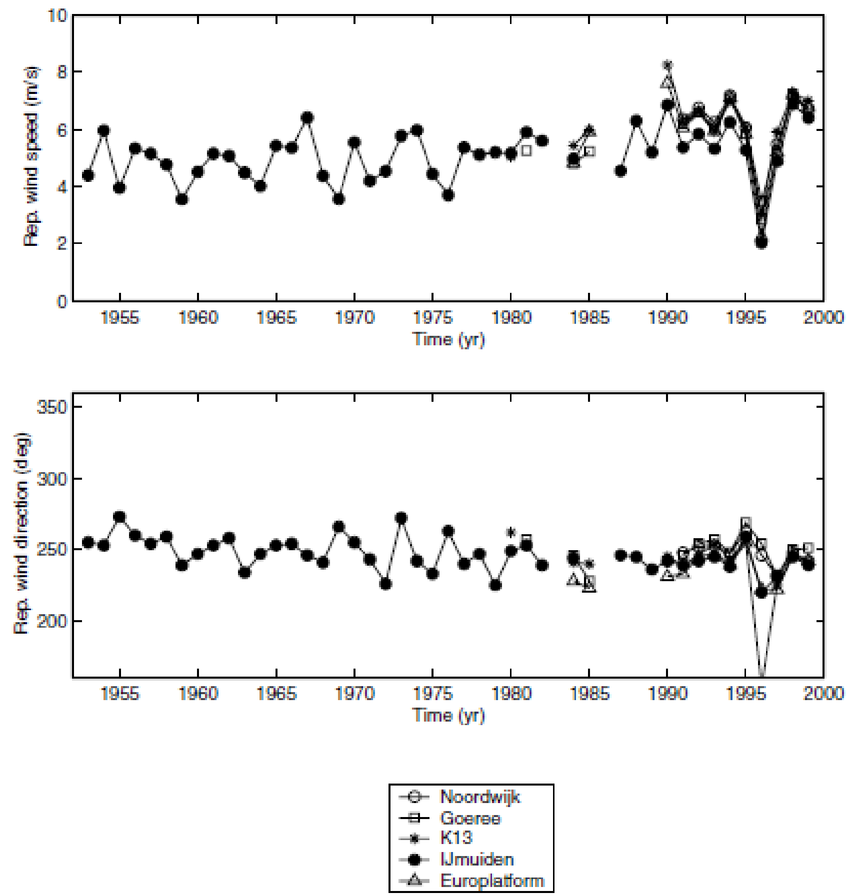


Tidal and residual currents, alongshore wind stress

- **Scheveningen 2 km**
- **Scheveningen 3 km**
- **Scheveningen 5 km**
- **Alongshore wind stress**



Representative wind speed



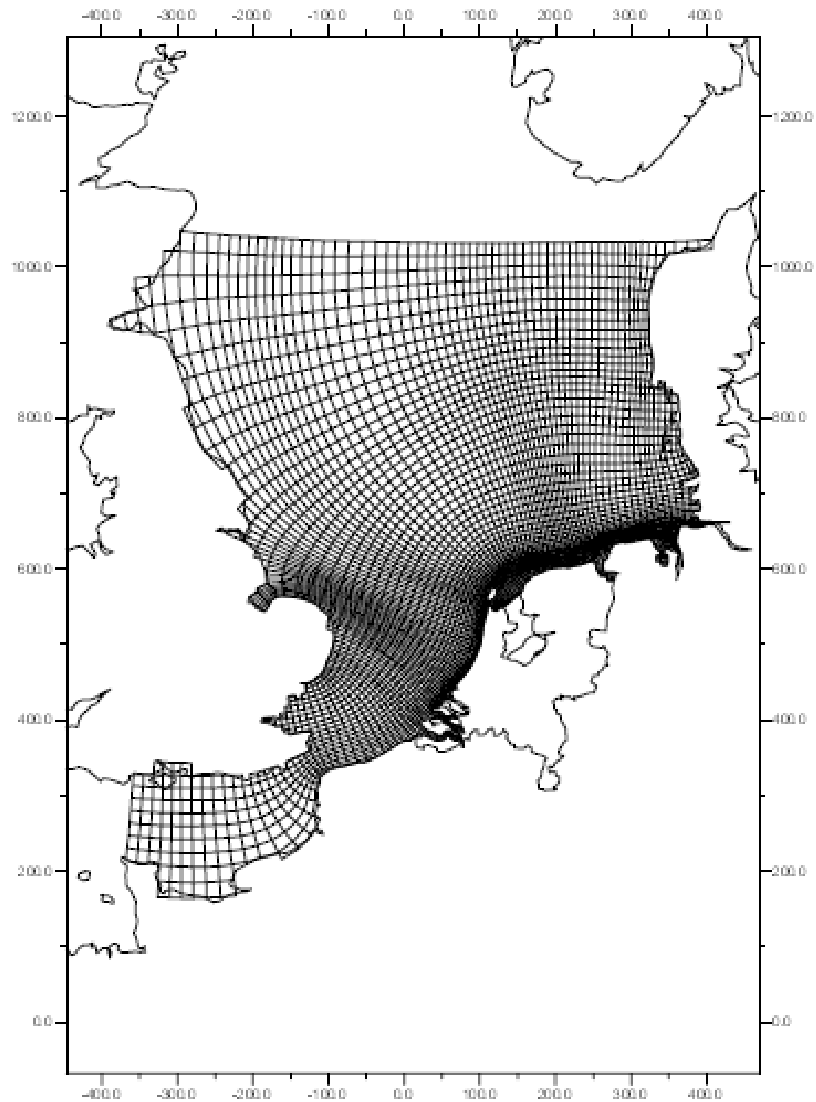
- Hourly measurements converted to cross- and alongshore wind stresses
- Yearly averaged stresses converted back to representative wind speed and direction
- About same for all stations, and all years

Table 3.5.1 Long-term representative wind characteristics

Station	Mean τ_N^w [N/m^2]	Mean τ_E^w [N/m^2]	Mean τ^w [N/m^2]	Wind speed [m/s]	Wind direction [degrees N]
Noordwijk	0.018	0.048	0.051	6.3	250
K13	0.022	0.045	0.050	6.3	244
Goeree	0.016	0.040	0.043	5.9	248
IJmuiden	0.012	0.029	0.032	5.2	247
Europlatform	0.026	0.039	0.047	6.1	236

Model grid coarse model

- **4500 grid cells**
- **Resolution 6km LS x 3km CS**

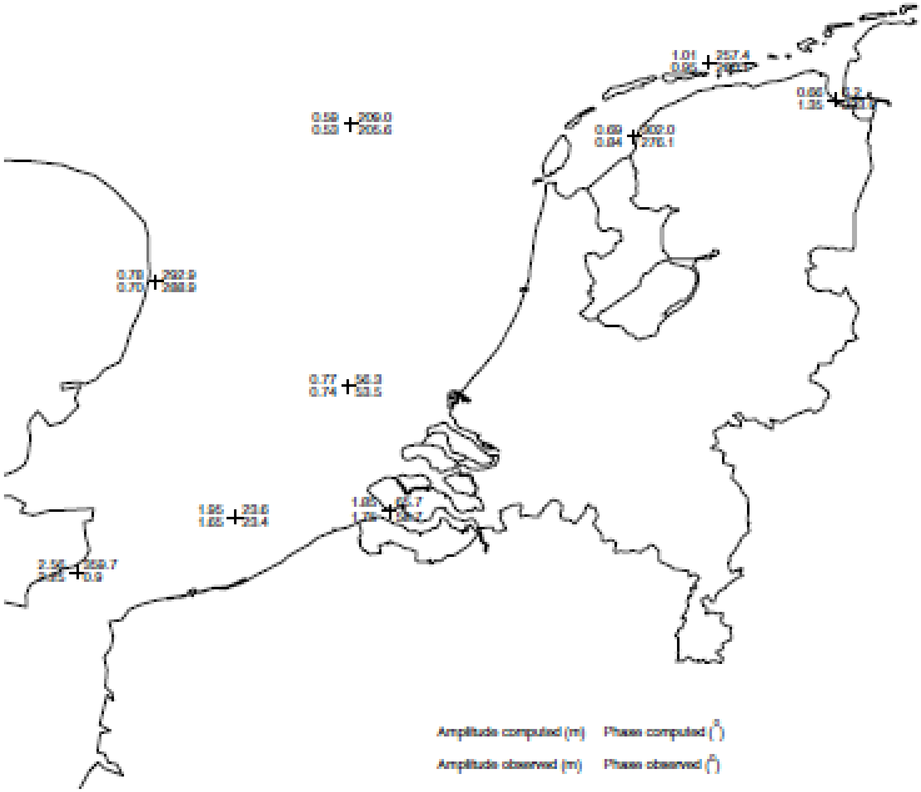


Tide stations for calibration

- Reproduction of water levels, without wind forcing
- Tidal propagation not influenced by salinity/temperature (barotropic): depth-averaged
- Tidal calibration on astronomic components, not time series!

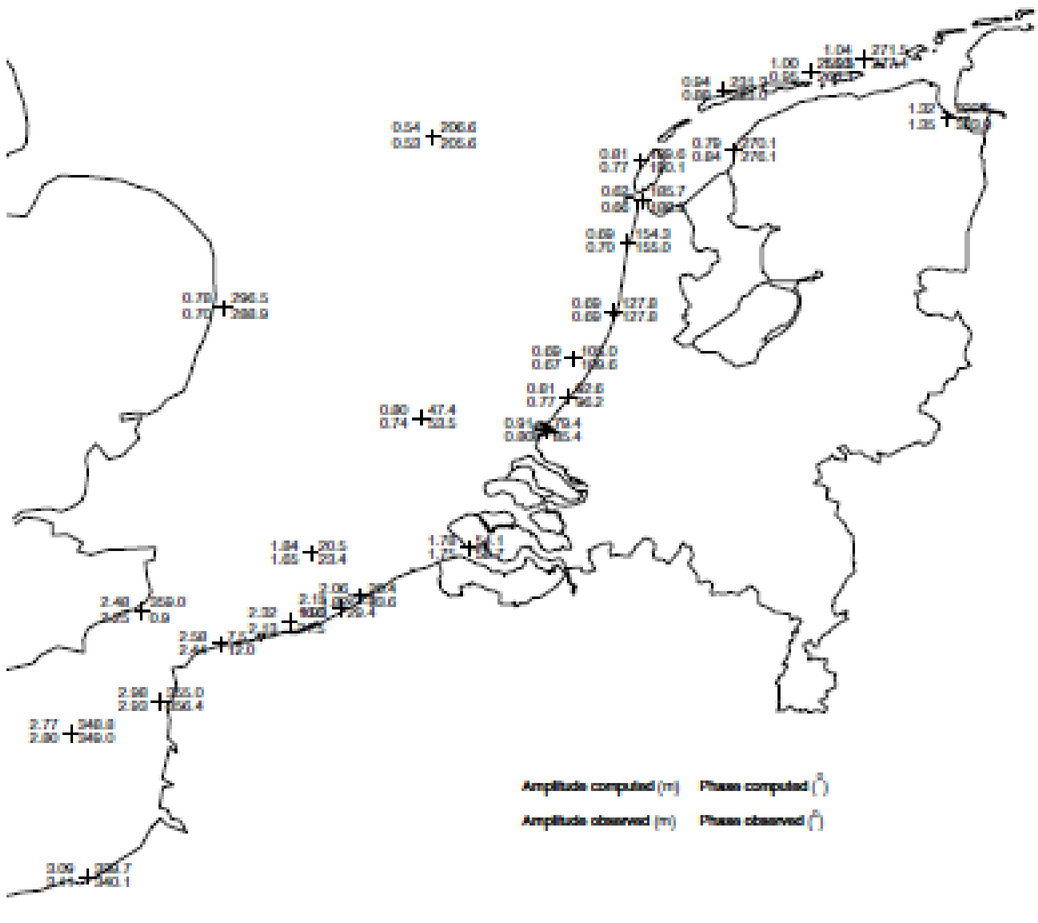
Calibration with astronomical components

- **Procedure:**
  - ✓ **Check boundary conditions**
  - ✓ **If amplitudes wrong: change roughness**
  - ✓ **If phases wrong: adapt the bathymetry**
  - ✓ **Check the influence of the timestep (might be too big)**

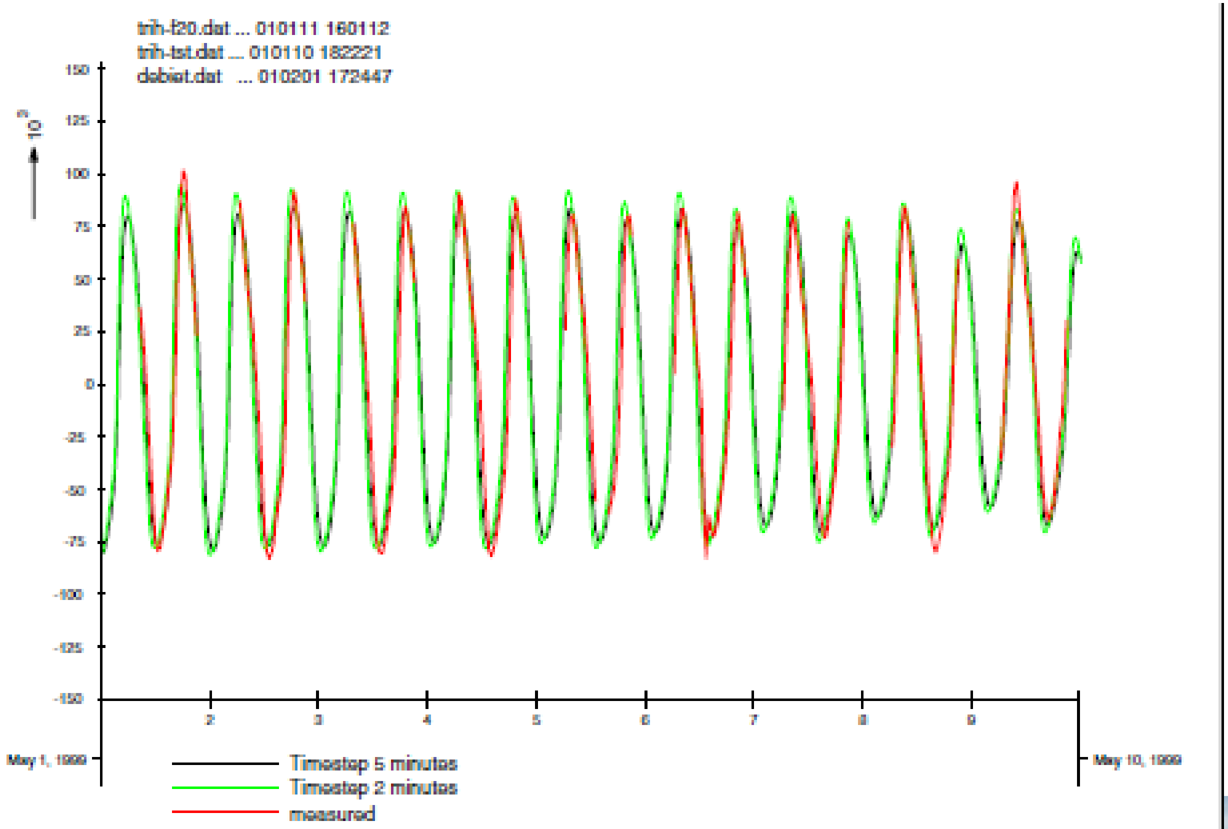


- **Roughness change can be in function of depth, or spatially varying over domain**

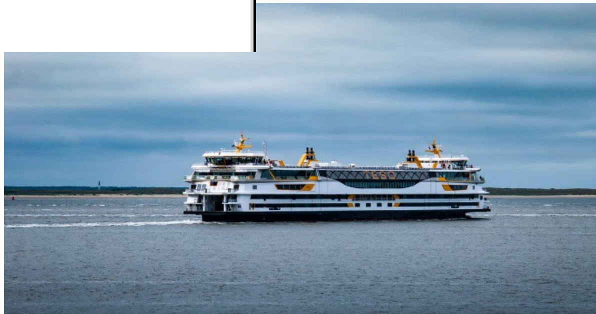
Calibration with astronomical components



Flows through Marsdiep

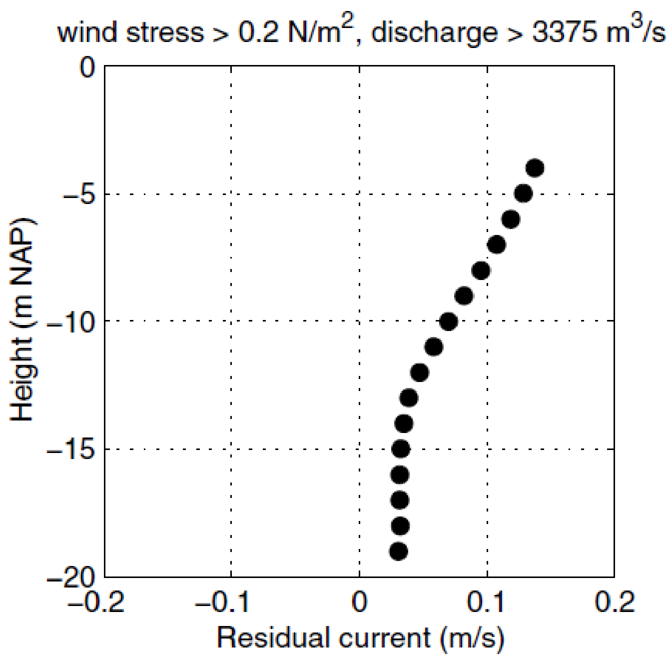


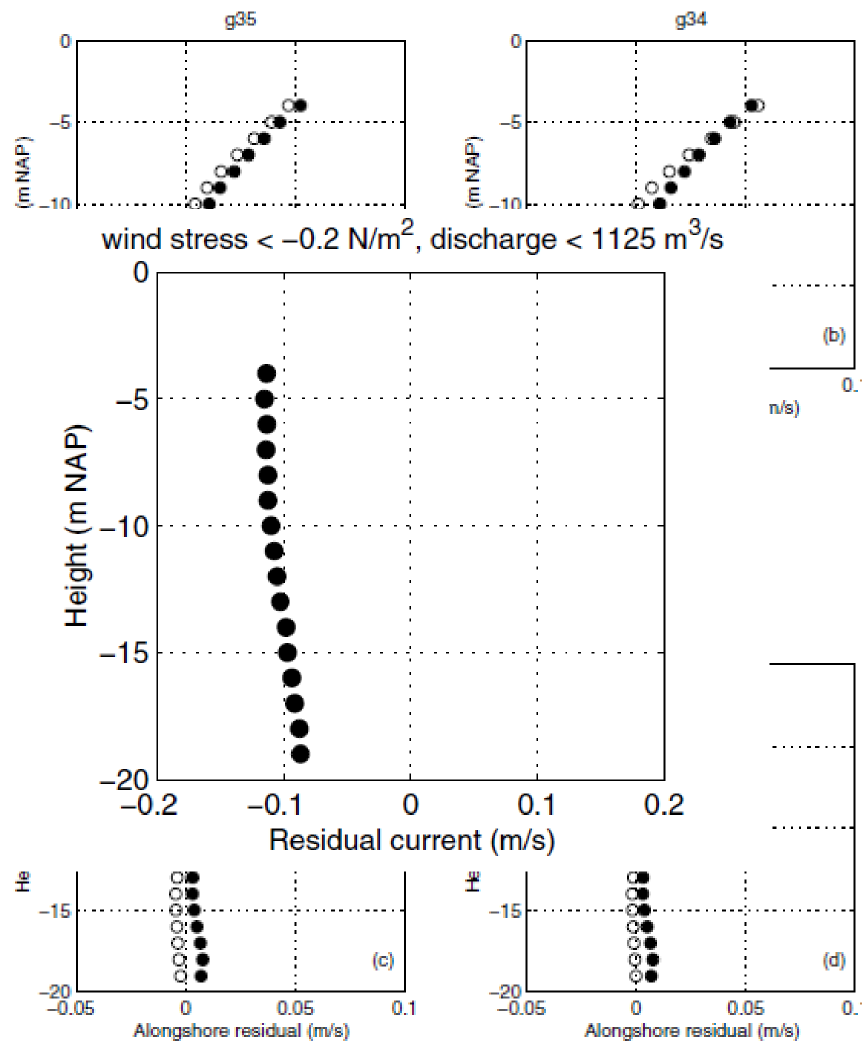
Discharges through Marsdiep Inlet



Alongshore residual flows

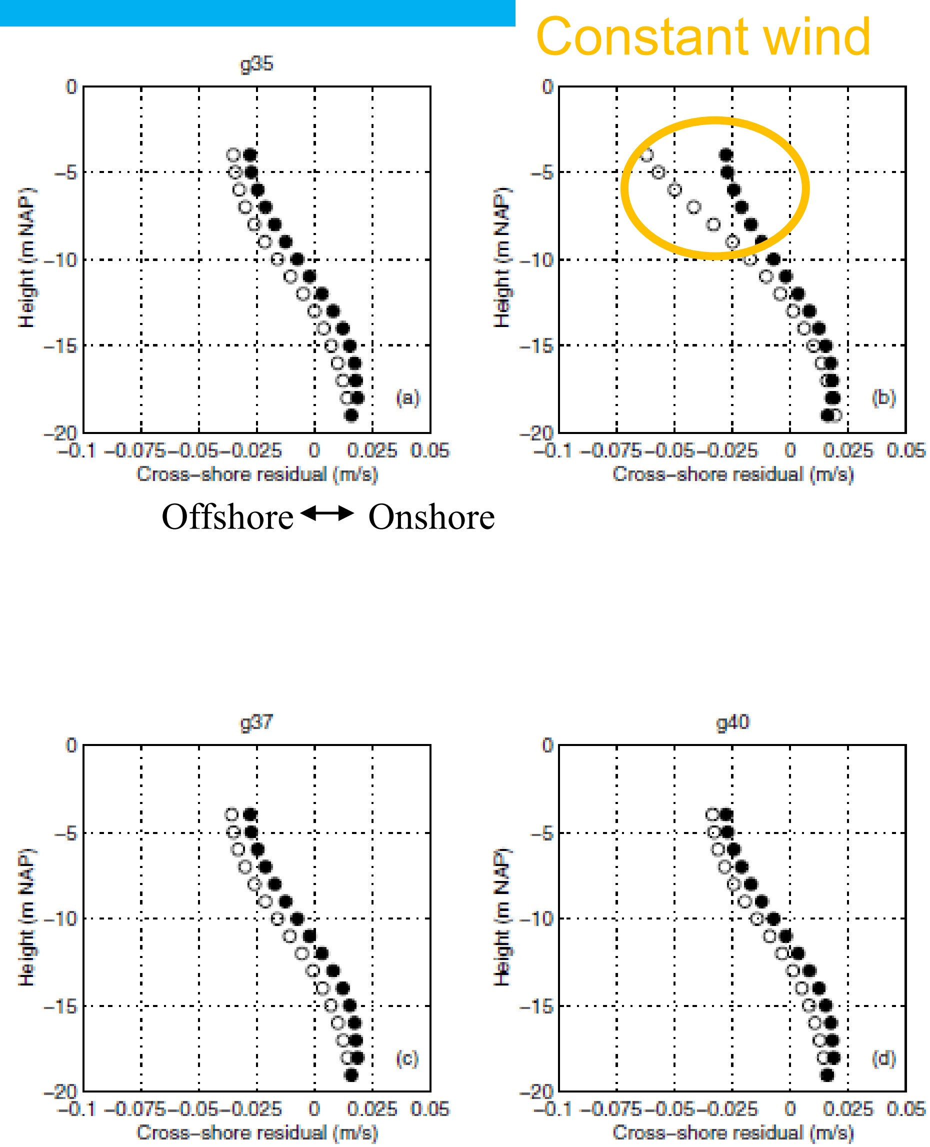
- **Very low velocities below -10m depth**



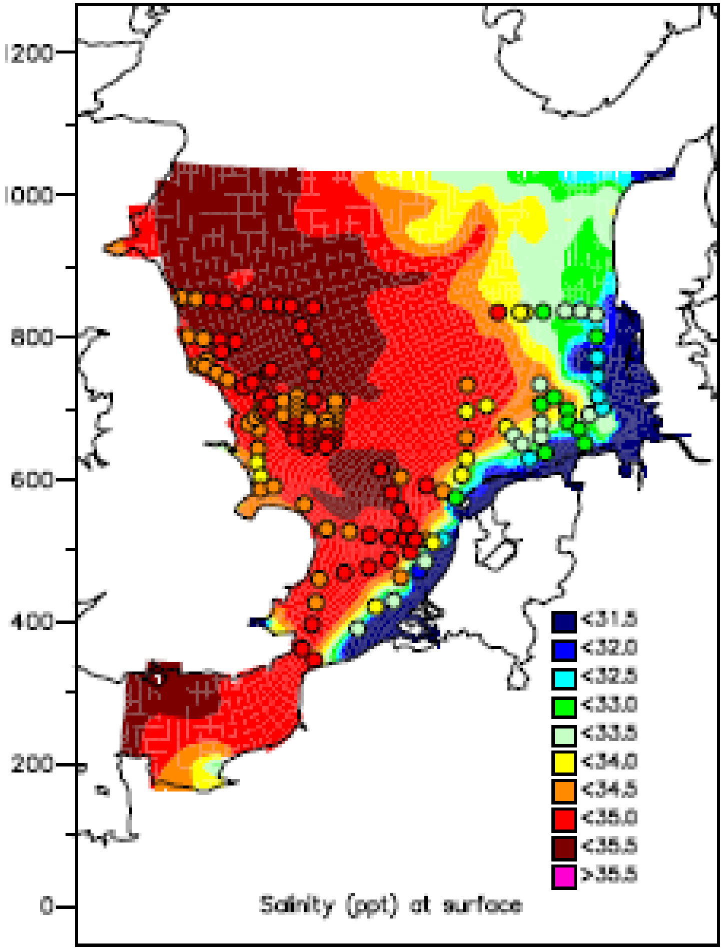


Cross-shore residual flows

- **Onshore directed below -10m, offshore directed above**
- **Estuarine circulation-type of flow**
- **Correlate also with onshore wind stress: higher onshore wind gives smaller onshore velocities near bottom**



Salinity at surface



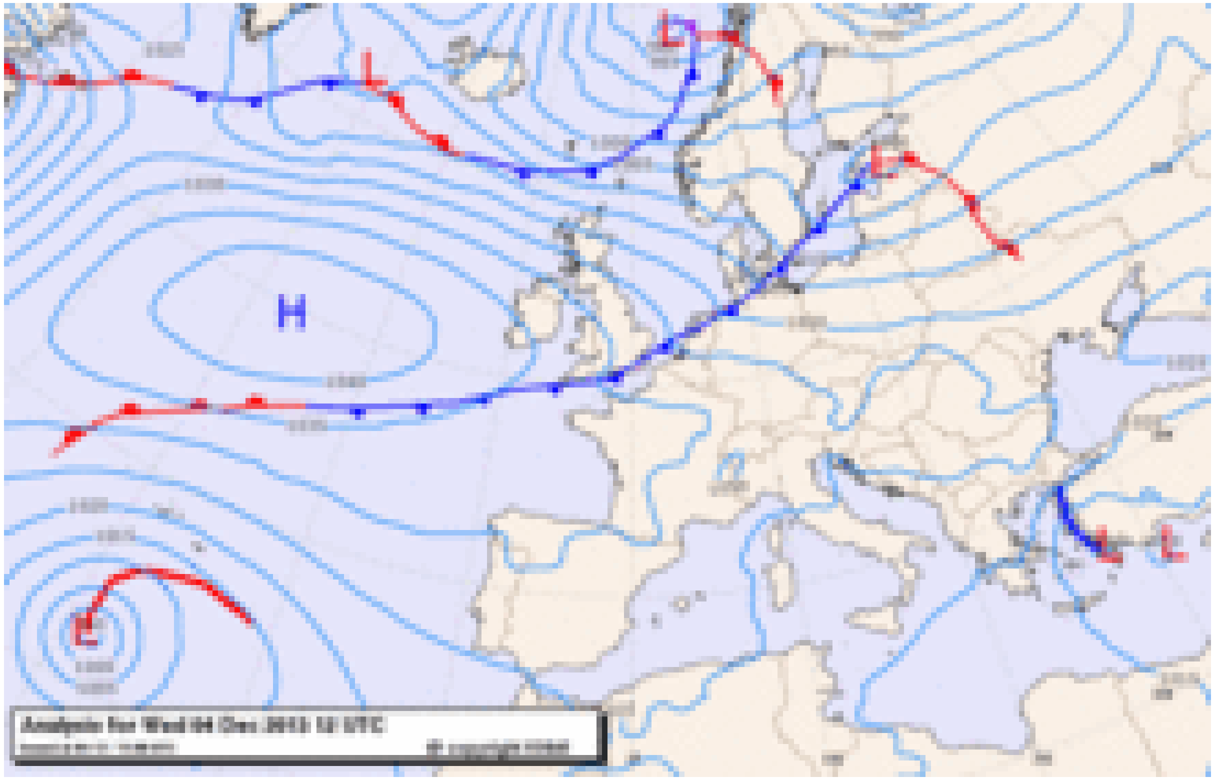
Conclusions

- Fit for purpose model
- Many applications
  - As driver for other models
  - To generate boundary conditions
- Specifically tested for different important phenomena

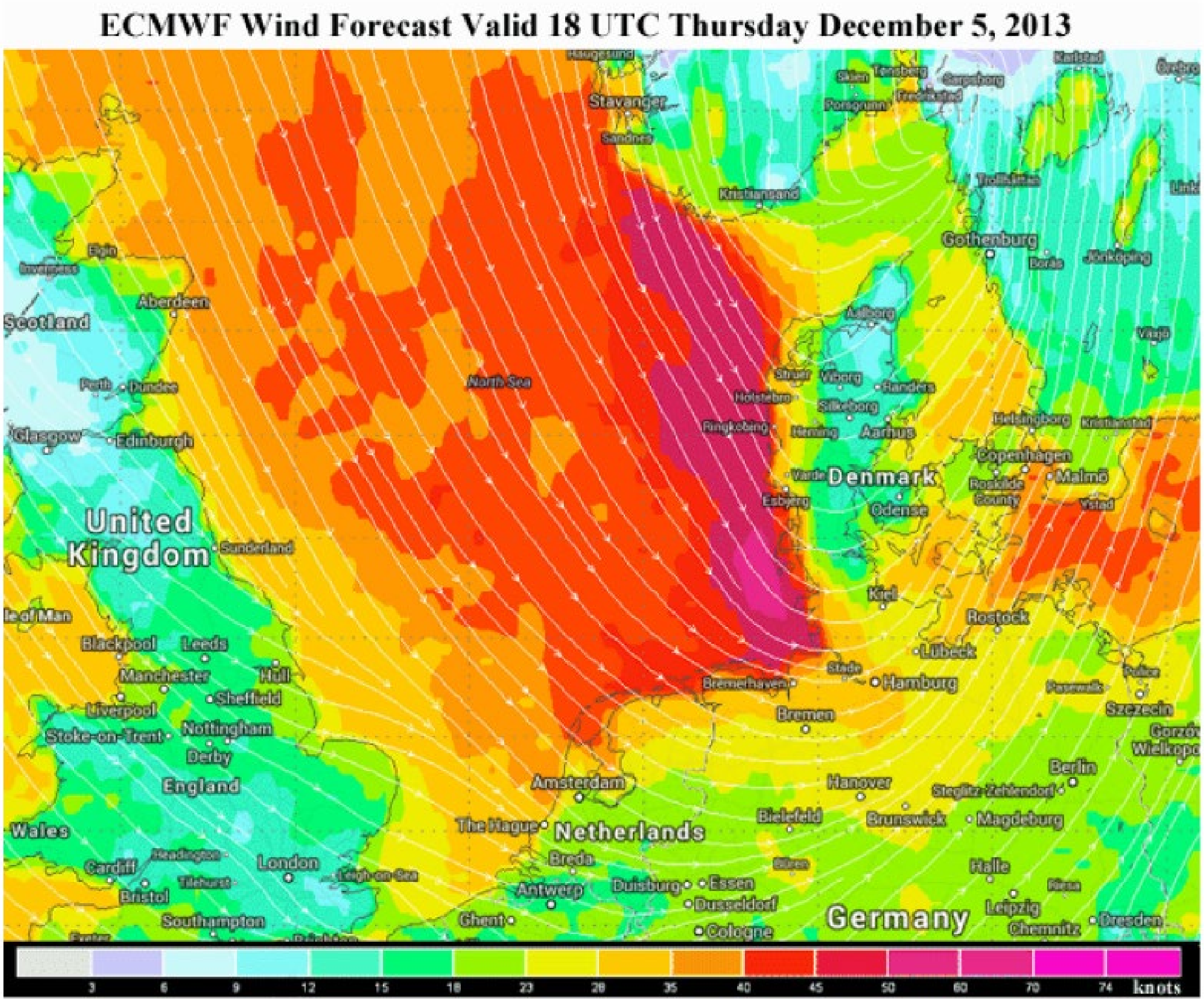
Exercise

Simulating the storm surge during the Sinterklaasstorm (5-6 Dec 2013)

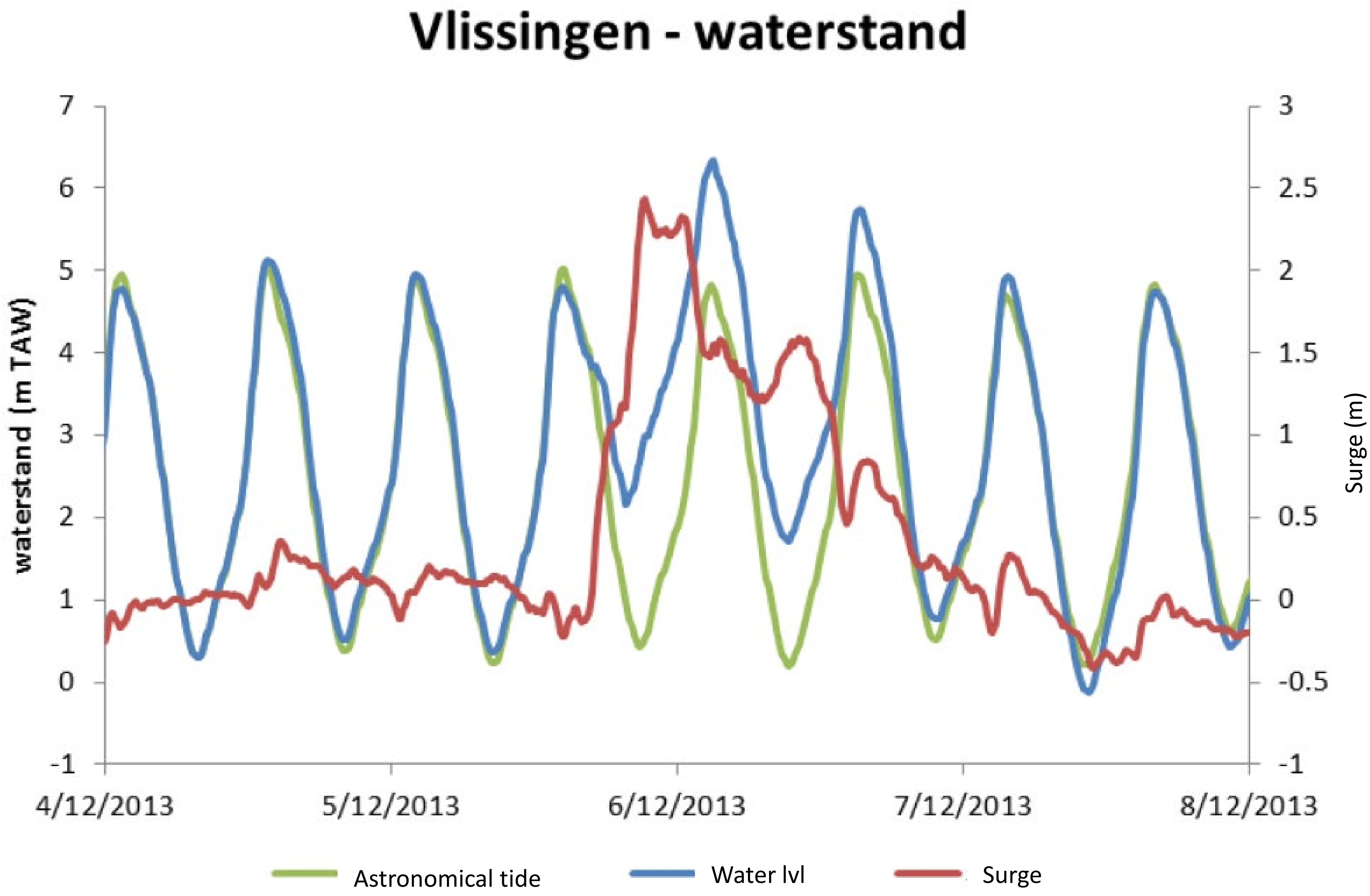
The Sinterklaasstorm of Dec 5-6 2013



The Sinterklaasstorm of Dec 5-6 2013



The Sinterklaasstorm of Dec 5-6 2013



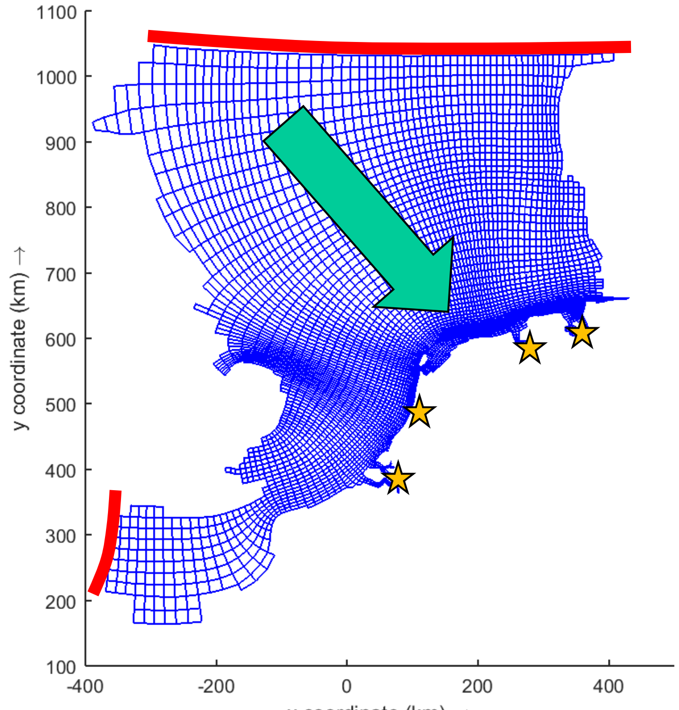
Goals of the exercise

After completing this exercise, you will be able to:

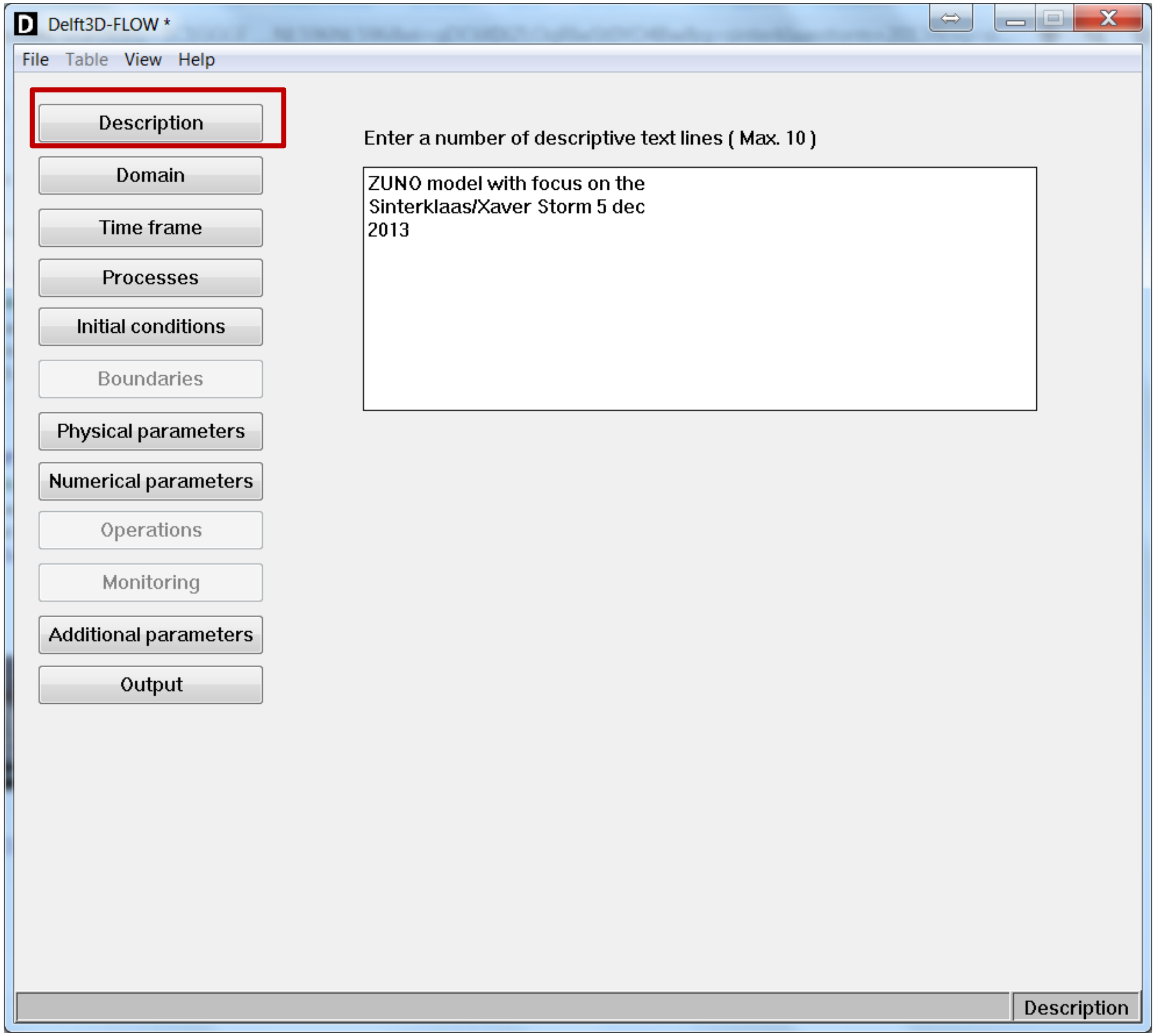
- **Set up a regional-scale Delft3D model**
- **Incorporate different kinds of boundary conditions**
- **Critically compare your model results with measured data**
- **Perform a sensitivity analysis on model parameters**
- **Find the right OpenEarth tools for pre- and postprocessing of model files.**

Setting up the Sinterklaasstorm model

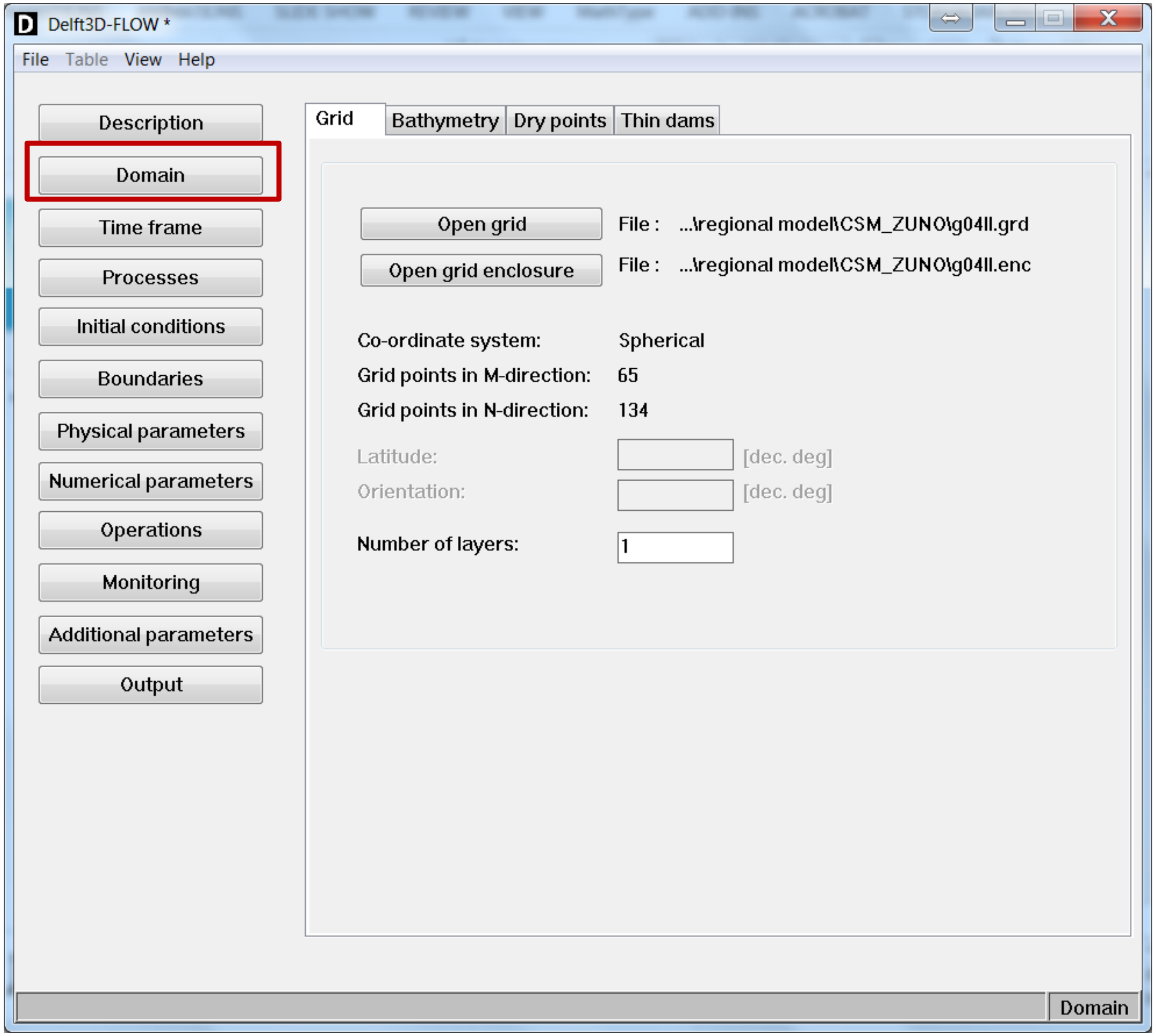
- **Hydrodynamic model covering the North Sea**
- **Forced by:**
  - **River discharges**
  - **Time- and space varying wind fields and pressure fields**
  - **Astronomical tides**



Setting up the Sinterklaasstorm model
Description



Setting up the Sinterklaasstorm model
Domain



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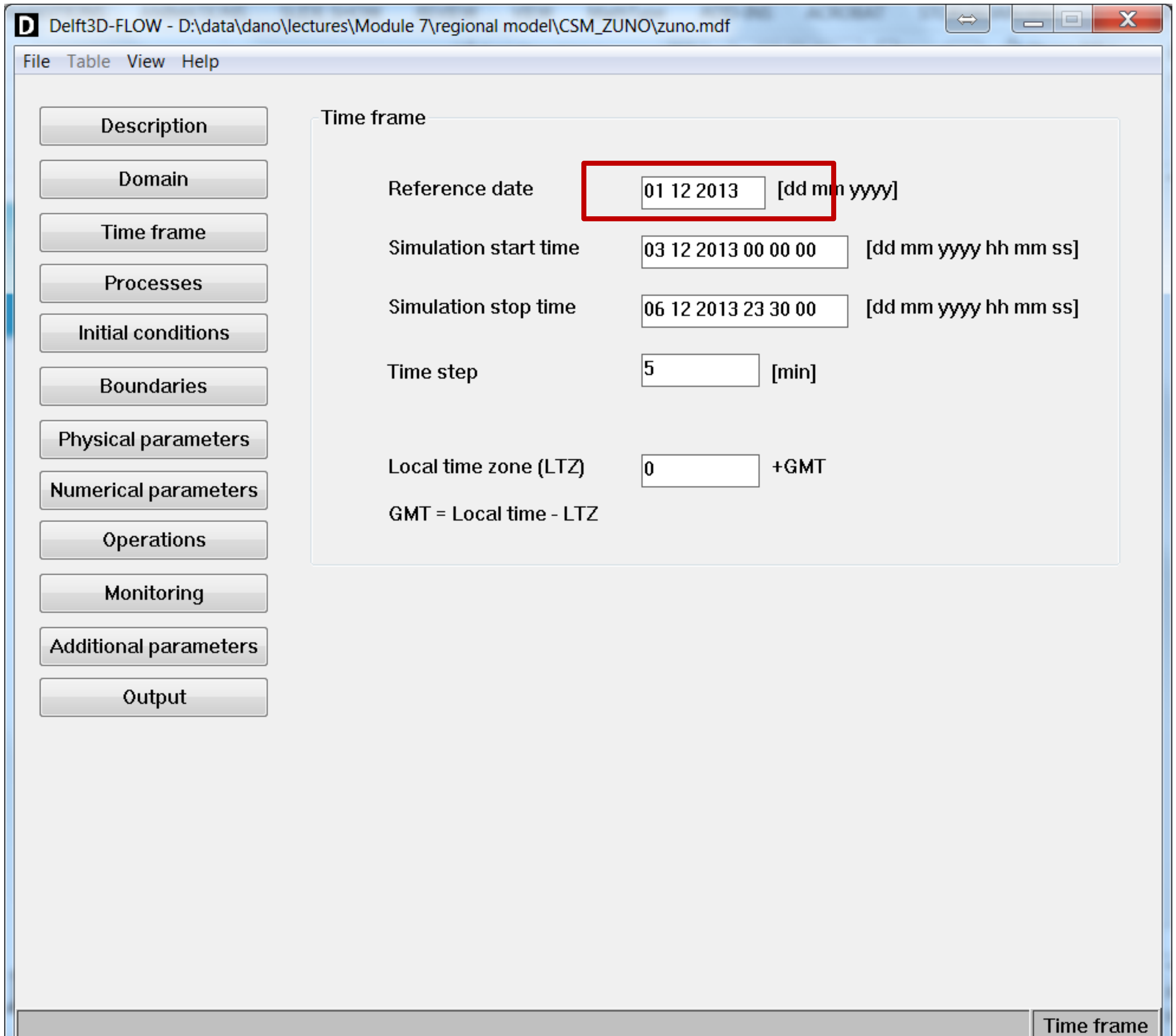
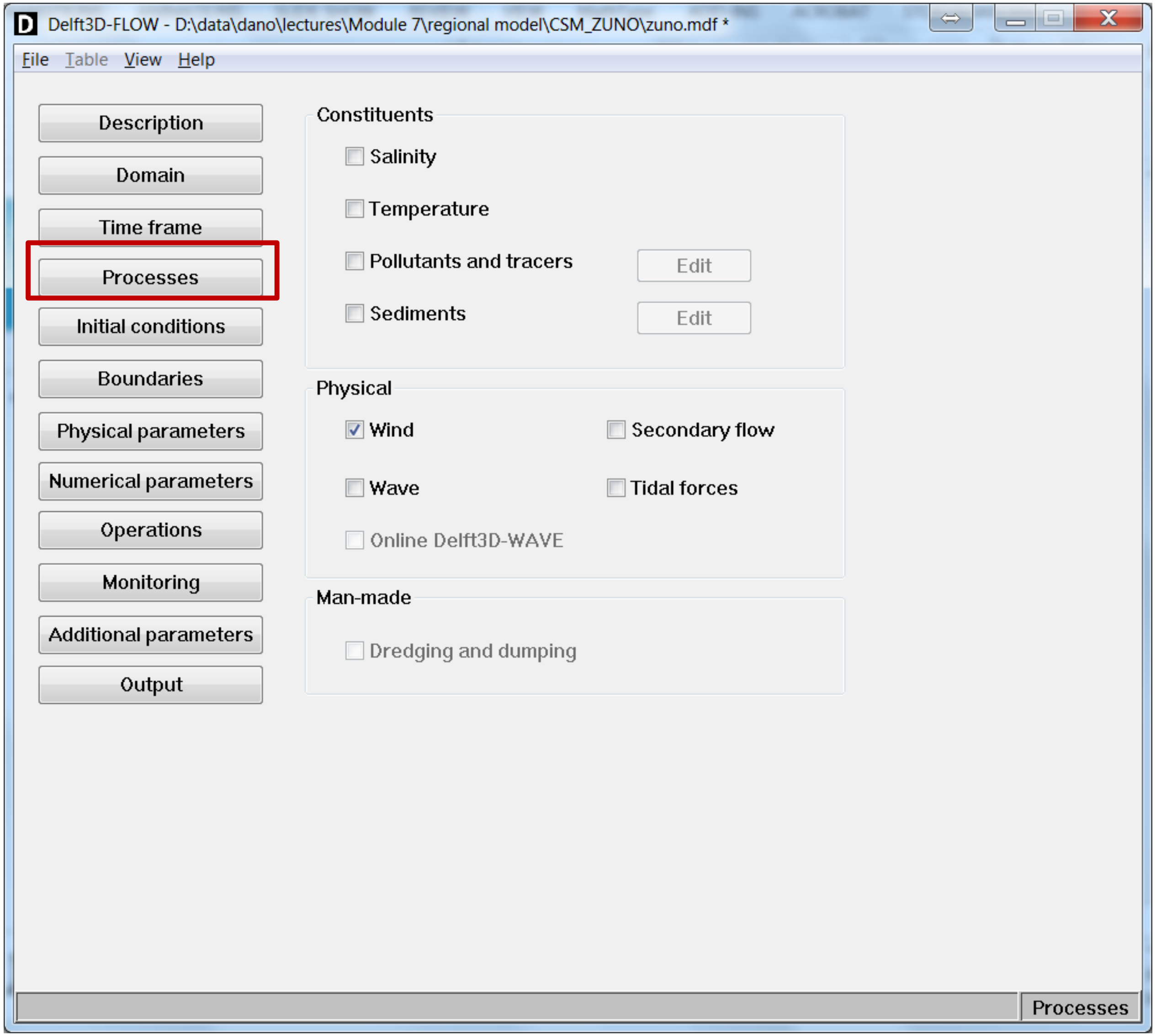
Setting up the Sinterklaasstorm model
Time frame

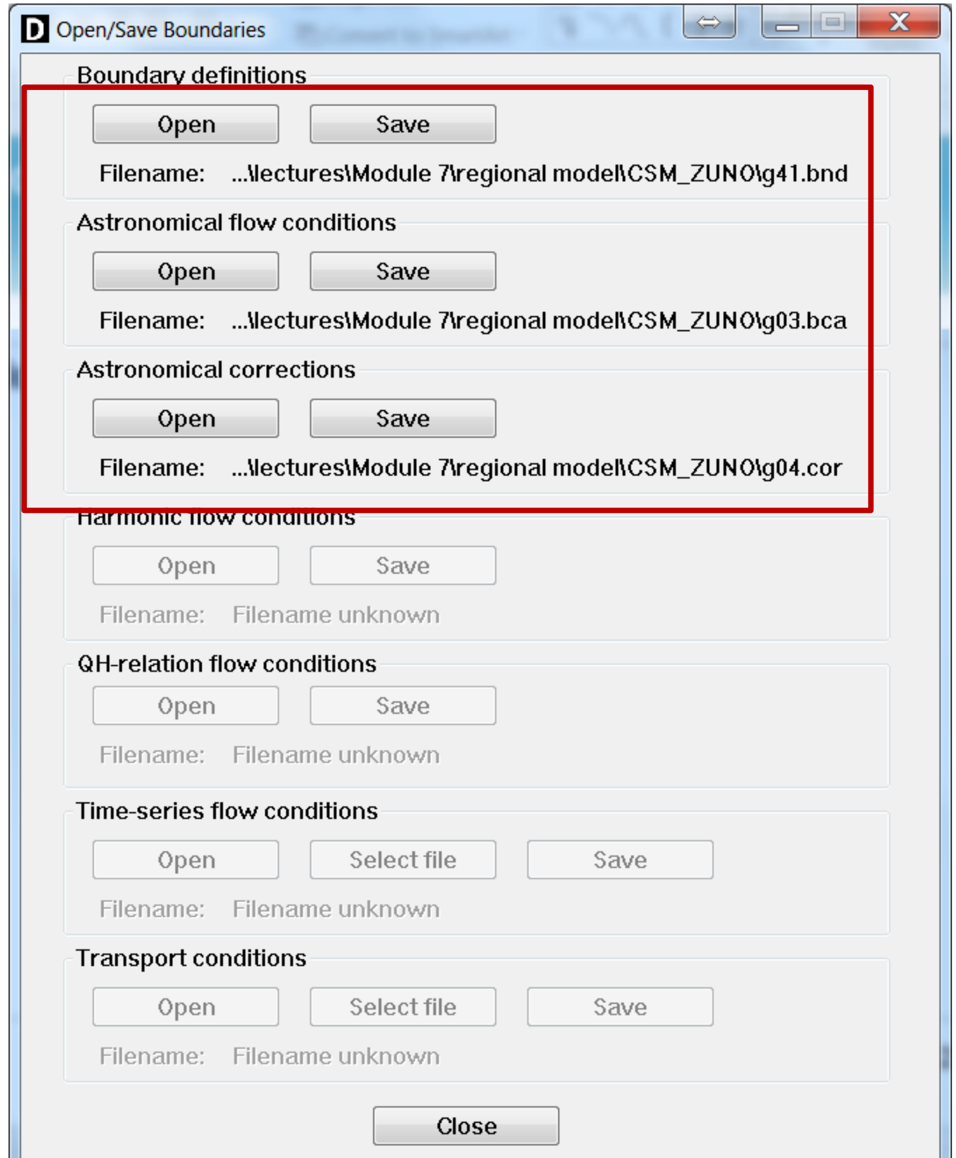


Setting up the Sinterklaasstorm model
Processes



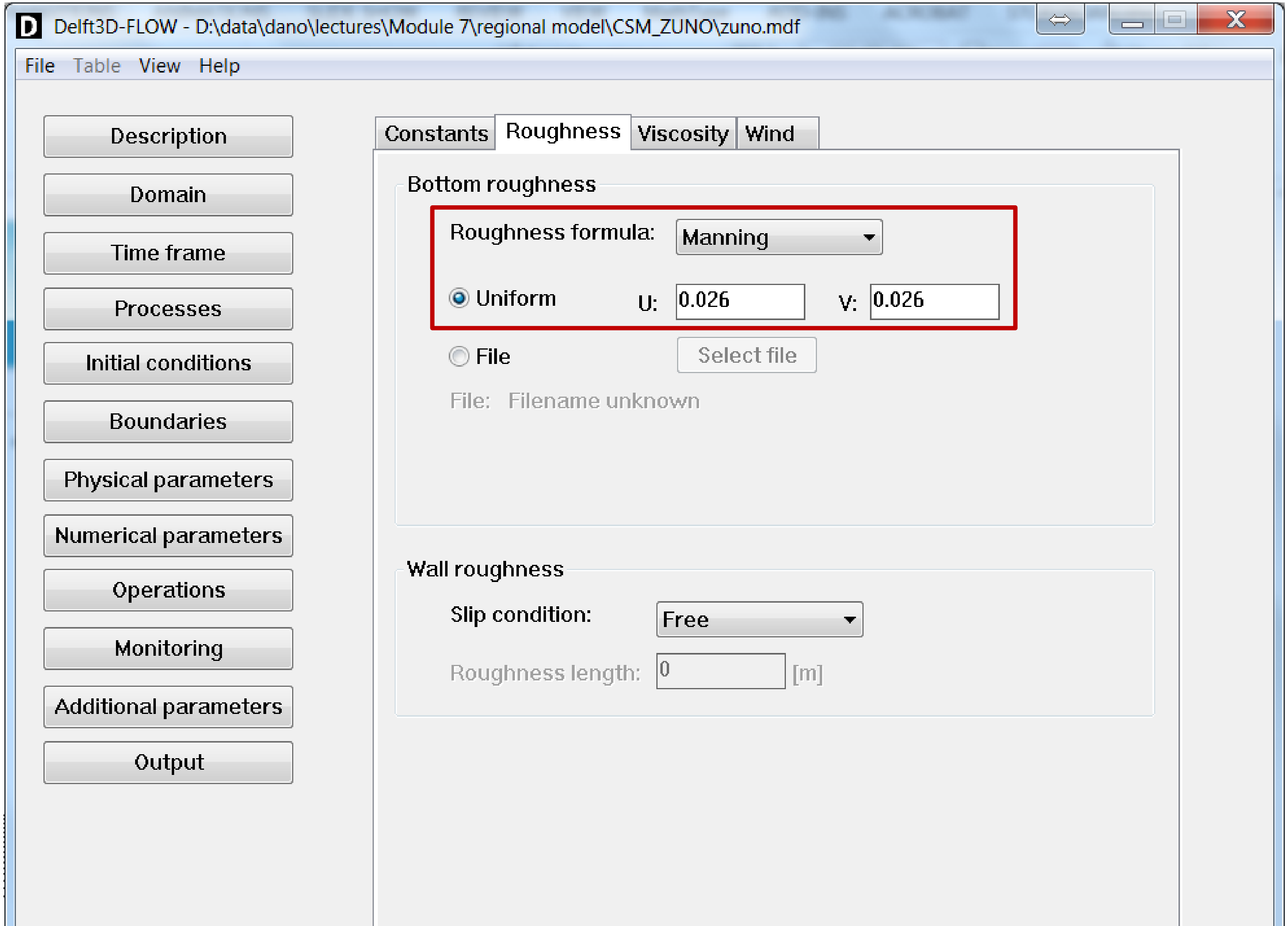
Setting up the Sinterklaasstorm model

Boundary conditions



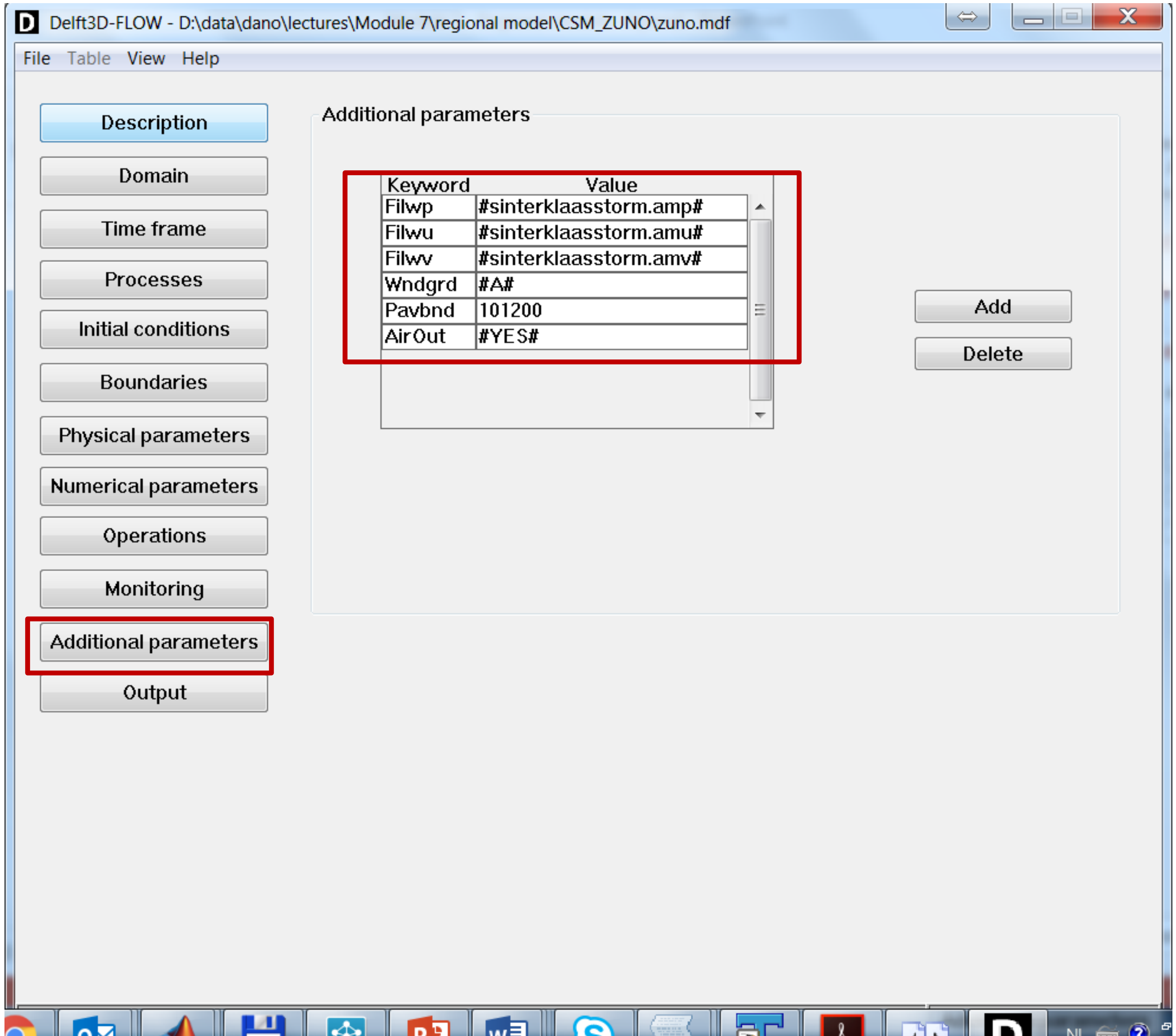
Setting up the Sinterklaasstorm model

Physical parameters



Setting up the Sinterklaasstorm model

Additional parameters



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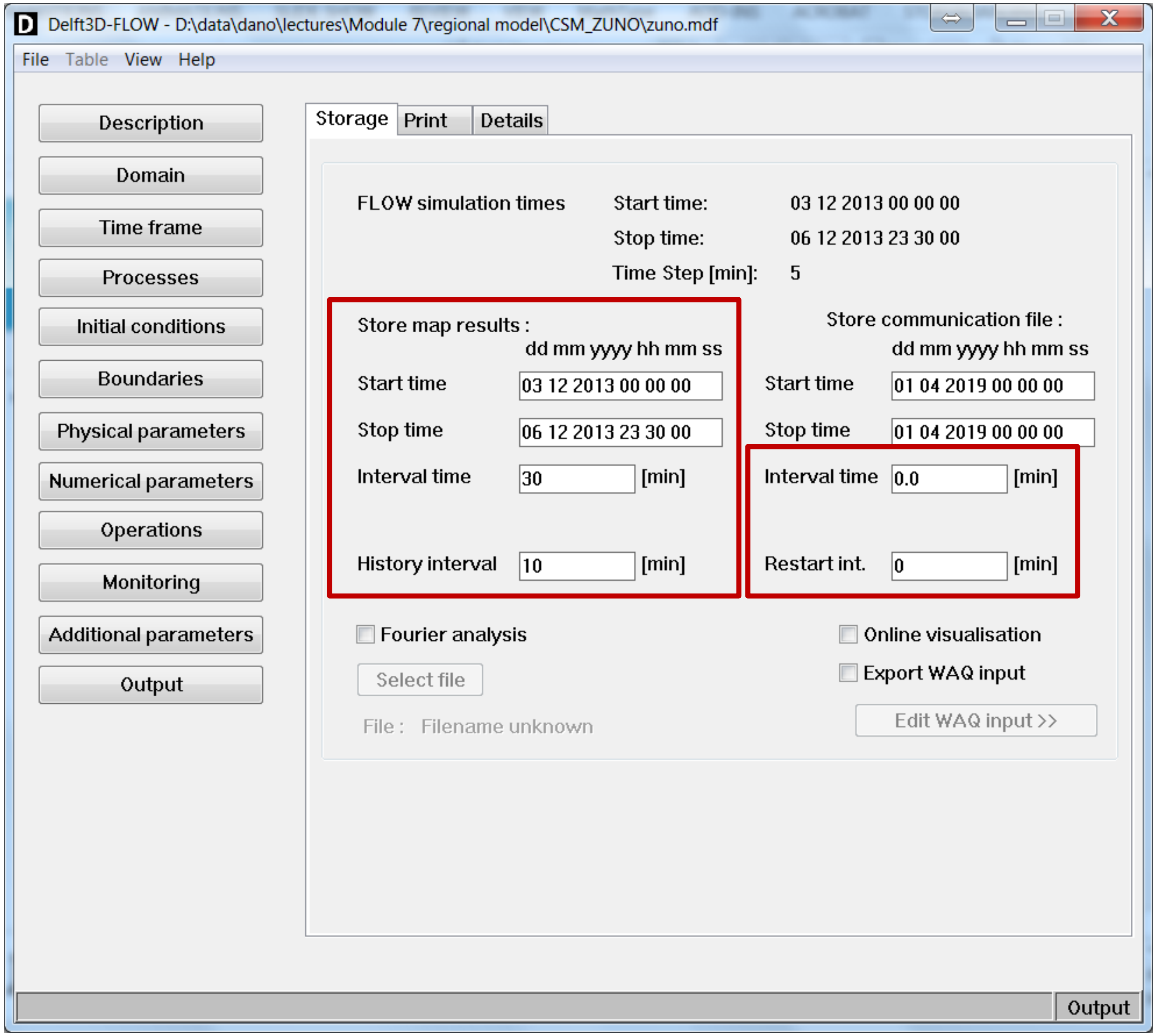
Setting up the Sinterklaasstorm model
Output



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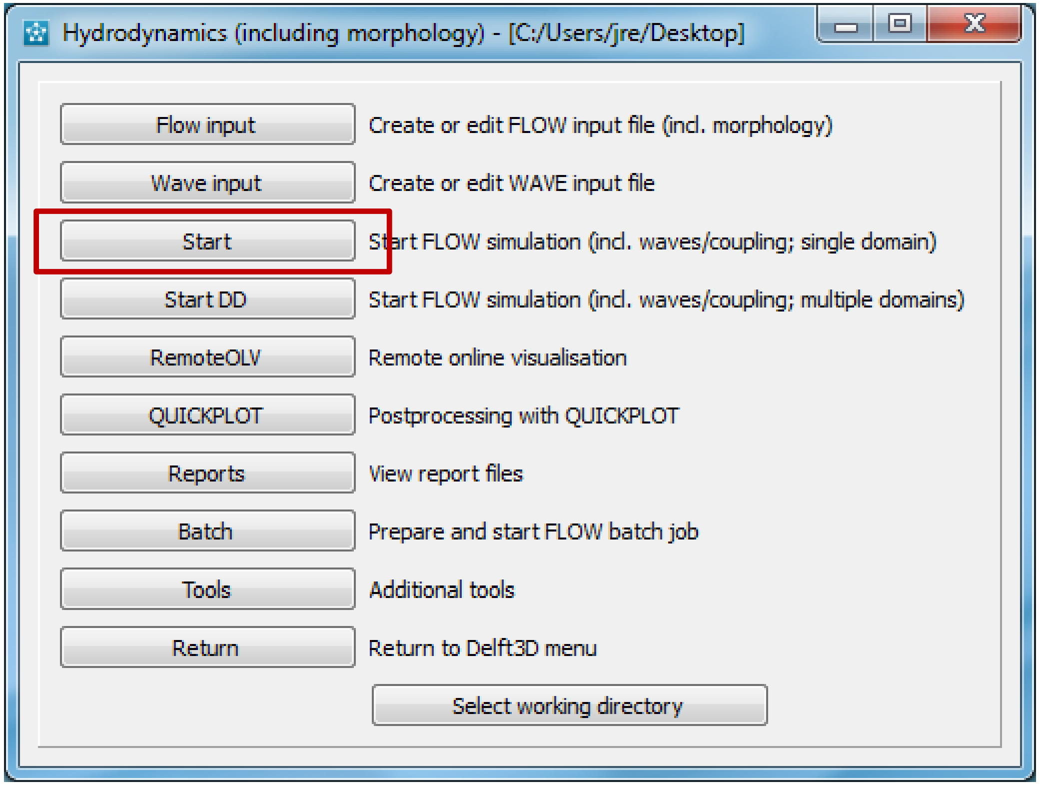
Setting up the Sinterklaasstorm model

- **Run!**



Questions

1. Run the model you just set up, and open Quickplot to load the trim-g04.dat output file
2. Check the wind fields, and check whether they look sane. Compare to the wind fields in sks_wlborgerhout.pdf, page 5-9.
3. Make a movie of the (colored) current vectors, and check that the fields are sane (specifically check for spurious circulations along the boundaries)
4. Make a movie of the water levels in the North Sea during the simulation:
    - How is the tide in the North Sea interacting with the tide in the English Channel under modal conditions?
    - Can you see the storm surge developing in the North Sea?

Questions

5. Open Matlab if necessary, and navigate to the folder where your model setup is stored.
6. We will make a Google Earth plot to check where we have stations:
   - Use the delft3d_io_obs function to load the *.obs file
   - Use the KMLscatter function to make a KML file of the stations in the model
   - Make a list of 5 evenly spaced stations along the Dutch coast, going south to north.
7. Using Quickplot, open the trih-g04.dat file
8. Make a plot with the water level of the 5 stations during December 4th. Describe the changing characteristics of the tide along the Dutch coast.

Questions

9. Using the script stormsurge.m, compute the storm surge for each of the 5 stations. Relate your results to the wind maps and the WLB report figures on slides 20-22.
10. Change the roughness of the model with +10%, and -10%. What is the influence on the storm surge estimates? Explain this using what you learned in Module 2 and Module 5.
11. Changes the wind drag coefficients with +20% and -20%. What is the influence on the storm surge estimate? Explain!