

Storm surge prediction in the Belgian coastal zone

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The water level in the southern part of the North Sea and in the Scheldt Estuary are composed of the astronomical tide and an atmospherically induced surge. These water levels can be accurately simulated with a combination of hydrodynamic shallow water models and atmospheric data. The hydrodynamic modeling train of CSMv5 (Continental Shelf Model) and ZUNOV3 (Zuidelijke Noordzeemodel) (RWS-Waterdienst & Deltares) translates the astronomical water levels at the boundaries of the continental shelf to the Belgian coast while calculating the surge generated by meteorological conditions.

Flanders Hydraulics has a hindcast modeling train installed for research purposes and a forecast modeling train coupled with inland river models for prediction purposes. Both modeling trains run on the parallelized SIMONA WAQUA shallow water software (SIMONA 2009). CSMv5 has a Cartesian grid in spherical coordinates with a resolution of 1/8° longitude (9.3-6.5km) and 1/12° latitude (9.25km). The astronomical boundary conditions consist of the 11 main tidal components. ZUNO has a curvilinear grid with a resolution of 1-4km in the Belgian coastal zone. The models are linked with water level boundaries.

A hindcast validation analysis is performed to investigate the performance of the models, compared to one year of water level measurements (Belgium, France, Netherlands, UK) (Leyssen, 2011a). The influence of the wind on the surge level is investigated during a sensitivity analysis (Leyssen, 2011b).

Wind speed, wind direction and fetch length and atmospheric pressure are the three main causes for a surge in front of the Belgian coast. Theoretically a static windspeed of 30ms⁻¹ (11 beaufort) can create a surge level of over 2.5m if it has a fetch length of 200km (Leyssen, 2011b). So an atmospheric depression above the North Sea can create a substantial increase in water level in front of the Belgian coast. This water level rise does not include the waves associated with such an event.

The propagation of the tidal waves from the continental shelf to the Belgian coast is investigated using harmonic analysis of simulation results and measurements. A good agreement is obtained for both amplitude and phase of the major tidal components.

The hindcast shows that water levels can be predicted with an accuracy between 0.1m and 0.2m in the Belgian coastal zone, both for calm and stormy periods.

The relevance of this work is reflected in the operational hydrodynamic forecasting system that runs at Flanders Hydraulics. This system consists of a nested train of SIMONA models, starting with the CSMv5 and ZUNOV3 models and further refining into Kuststrook and Kustzuid models (RWS-Waterdienst & Deltares). The predictions use atmospheric forecasts from HIRLAM and ECMWF. Data assimilation techniques are applied to ameliorate prediction quality based on observations. Forecasts are produced every six hours.

From the most detailed models, water and surge levels and current data for the Belgian and Dutch coastal zone and the Scheldt River are extracted and forwarded to the Hydrologic Information Center (Flanders Hydraulics) and Oceanographic Meteorological Station (Coastal Division) to be used in e.g. flood and storm warning systems.

References

SIMONA. 2009. Waqua/Triwaq- two- and three dimensional shallow water flow model: Technical documentation. Simona report number 99-01.

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Leyssen G., J. Vanlede and F. Mostaert. 2011b. Modellentrein CSM-ZUNO, Deelrapport 1: Opzet en gevoeligheidsanalyse. WL2011R753_12rev2_0, I/RA/11313/11.087/GLE.