Storm Surges Congress, Hamburg, Germany
13–17 September 2010
SSC2010-63-1

Impact of wind gusts on sea surface height in storm surge modeling

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Storm surges are subject of great interest to low-lying countries adjacent to oceans. In the Netherlands, modeling of storm induced surges has been performed ever since plans for a closure dike on the Zuiderzee in the early 1920s. Over time, models have become more advanced and surges are better predicted. The shallow water model WAQUA/DCSM (Dutch Continental Shelf Model) is used in The Netherlands for operational forecasting of sea level heights along the Dutch coast. The meteorological input for the model is hourly averaged wind and pressure from HiRLAM (High Resolution Limited Area Model).

The effect of high-frequent variations in the wind speed is thus far not taken into account explicitly. But as the surface wind stress that drives the model is determined by the square of the wind speed, such variations do contribute to the total driving forces. A better understanding of the impact of these variations on a storm surge is desired.

To assess the importance of these high-frequent variations, gustiness values, obtained from the ECMWF model, have been compared to the difference between sea level observations and operational model forecasts along the Dutch coast. To get a measure for the gustiness averaged over the North Sea, a district method is used that accounts for a time lag and wind direction for specific parts of the North Sea. An increasing bias between model and observations is found for increasing averaged gustiness. This is evidence for the impact of wind gusts on the storm surge height.

To understand more about the way that variations influence the sea level height, a more theoretical case has been investigated. Statistical variations have been added to a uniform wind field over the North Sea. These wind fields have been used to drive DCSM. The resulting sea levels are compared to those with undisturbed wind. Ensembles of wind disturbances in speed and direction have been generated with different temporal and spatial correlation. Added variations in wind speed (i.e. gustiness) enhance a surge whereas variations in wind direction reduce a surge. These properties have to be taken into account for storm surge modeling.