Storm Surges Congress, Hamburg, Germany
13–17 September 2010
SSC2010-95

The generation of severe surges in the Dutch Wadden Sea: insights from data, hindcasts and numerical experiments

G. Lipari and J. Adema
ARCADIS NL, Alkyon Hydraulic Consultancy and Research, Emmeloord, Netherlands (lipari@alkyon.nl, 0031527248111)

The Dutch Wadden Sea (DWS) is a North Sea sub-basin of 3,400 km2, elongated in shape and semi-enclosed by six barrier islands. The mainland shore consists of dykes protecting the low-lying areas of northern Netherlands. Tide and extra-tropical storms result into hydraulic loads on dykes through severe surge and wave action. Improved understanding of surge is essential to, and requested by, regulatory safety planning that is reviewed on a 5-yearly basis to fill knowledge gaps.

Identification of surge-generating storms in the DWS is made more complex by geographical factors. In addition to adverse meteorological and tidal conditions, the net influx of water through the tidal inlets, the accumulation of large enough water volumes, and shoreward shearing are ostensibly necessary conditions that promote severe surges in the DWS. With support of measured and computed data, we aim at highlighting the interplay of unsteady hydraulic processes, meteorological forcing and geographical constraints as a key feature of the DWS surge generation.

Firstly, the comparison of local wind measurements and wind set-ups shows that, in the past, winter storms with different speed and direction histories could generate equally alerting wind set-ups – some then powered by a conjuring tide, some remaining as ‘latent hazard’.

Then, several hindcasts of severe surges show that the storm-induced currents are in dynamical equilibrium with the wind, free surface and seabed, while being fed/relaxed through the tidal inlets and constrained by the shore. These currents can effectively redistribute the set-up hazard within the DWS. As a result, they are able to create surges that put a stress basin-wide or, rather, on either the western (e.g. Feb 1953) or the eastern (e.g. Nov 2006) part of the DWS.

Additionally, a number of synthetic storms mimicking historical severe surges strongly suggest that those historical events have been an acute moment of an unsteady, evolving process rather than a step in a progression to a steady state. Thence, severe DWS surges may be created by storms that are not necessarily remarkably intense in magnitude, but rather have, or combine with, special space- and time-scales producing exceptional accumulating-distributing-pushing combinations within the basin.

The non-uniformity and unsteadiness of these surge-generating storms is a direct consequence of the low-pressure tracks in the North Sea, which should then be taken into account. Therefore, in the case of the DWS, parametrisations between local surges and simple storm indicators (e.g. wind speed and direction at peak) overlook the effectiveness of wind patterns to mobilize massive water volumes within a semi enclosed area. The variety of ongoing adjustments that take place between the wind, current and wind set-up (with haphazard outcomes) is also missed by oversimplification. Exploratory arguments towards a more suitable parametrisation of the storm-generated hazard will be put forward.

This contribution aims at presenting and commenting on historical measurements of wind speed and direction and of total water levels for recent severe surges in the DWS. The discussion is supported by hindcasts and numerical experiments carried out with the 2D depth-averaged free-surface flow solver WAQUA endorsed by

the Dutch government for decision-making. Wind fields are provided by the Dutch Royal Meteorological Office. Possible avenues for future development will be mentioned and brought into discussion.

Acknowledgement. The research was realized in the framework of the Dutch research program “Wettelijke Toets Instrumentarium”(WTI) and partly funded by Rijkswaterstaat, Centre for Water Management on behalf of the Ministry for Transport, Public Works and Water Management of the Netherlands.