F100am04z[001-003]: Amelander Zeegat 2004

Purpose

The storm conditions important for the design of the sea defences along the mainland coasts of Friesland and Groningen are due to winds from the westerly to northwesterly directions. These conditions have been investigated in a number of recent hindcast studies. For the northwesterly storm direction, a number of wave-related physical processes are found: depth-induced wave breaking and nonlinear triad interaction are found to occur over the ebb tidal delta. Through the tidal inlet and in the tidal channel, the penetration of low-frequency waves and wave-current interaction occur. Over the shallow Wadden Sea interior, local finite-depth wave growth is found, which can occur with or without the influence of an ambient current. For westerly storm conditions, the mentioned physical processes relating to North Sea waves entering through the tidal inlet become relatively less important (although, due to the refractive turning of offshore westerly waves, not negligible). Finite-depth wave growth, on the other hand, becomes more prominent, due to the increased fetch length for westerly winds.

Situation

The shallow Dutch Wadden Sea region (Figure 3.1, top panel) is enclosed by a series of barrier islands and the mainland coasts of Friesland and Groningen. Tidal inlets are found between the barrier islands, each featuring an ebb tidal delta, one or more main tidal channels, and a complex system of smaller channels and flats extending into the Wadden Sea interior. The Amelander Zeegat (Figure 3.1, bottom panel) is found between the barrier island of Terschelling (to the west) and Ameland (to the east). The inlet is shielded from offshore wave attack by an ebb tidal delta with a minimum depth of -3 m NAP, inshore of which the Borndiep, a deep tidal channel reaching -28 m NAP, is found, ending in a complex system of tidal channels and flats in the Wadden Sea interior. Apart from the tidal channels, the Wadden Sea interior is shallow and flat, with a bed level of approximately -1 m NAP.

Case selection

Table 1 presents an overview of the 2004 storm instants and corresponding representative values for the environmental conditions considered.

Date and time	*Nr*	U_{10}	U_{dir}	Water level Nes	u_{max}, tidal phase	Grids	Source
		[m/s]	[^{o}N]	[m NAP]	[m/s]		
08/02/2004, 20:00	1	13.5	314	1.0	2.32, flood	GridCL, AZG3A	WL & Alkyon (2007b)
08/02/2004, 22:30	2	16.6	325	2.6	0.92, high w.	GridCL, AZG3A	WL & Alkyon (2007b)
09/02/2004, 01:30	3	16.3	328	1.8	1.66, ebb	GridCL, AZG3A	WL & Alkyon (2007b)

Table 1: Summary of storm instants in the Amelander Zeegat considered in recent hindcast studies, including case characteristics. The number Nr refers to the casename, i.e. f100am04z001 is case 08/02/2004, 20:00 etc.

The northwesterly storm for this case occurred on 8-9 February 2004, for which the instants 20:00 (flood), 22:30 (high water slack) and 01:30 (ebb) are considered. These storm instants have been hindcast by WL & Alkyon (2007b) and earlier studies (WL (2006b) and Alkyon (2007a)). This storm features the highest water level (+2.6 m NAP, at 22:30) of the available northwesterly cases, combined with near gale winds (according to the Beaufort scale) of 13.5 to 16.6 m/s from 314-328 ^{o}N. During this event, a single array of wave buoys was placed along a transect through the tidal inlet, starting on the seaward side of the ebb tidal delta, and following the main tidal channel into the Wadden Sea (Figure 3.2, top panel). With this buoy placement, and considering the wind direction, the following physical processes can be investigated with this field case: depth-induced breaking and triad interaction on the ebb tidal delta, penetration of low-frequency waves and wave-current interaction. For the latter, the sequential flood, slack and ebb conditions provide the opportunity to investigate wave-current interaction under both following and opposing current. These cases are therefore suited to validating for most of the wave-related processes occurring in the Wadden Sea, except for finite-depth wave growth.

Model setup

The model setup as in WL & Alkyon (2007b) has been used, thereby discarding the model setup as used in WL (2006b) and Alkyon (2007a). The computational grids used for this hindcast WL & Alkyon (2007b) are presented in the bottom panel of Figure 3.2. A series of two nested curvilinear grids was used, namely an overall coarse grid (GridCL) within which the finer grid (AZG3A) is nested. The wave boundary conditions for the AZG3A grid are obtained from the most offshore of the array of buoys presented above, namely the Directional Waverider AZB11 (no reliable information is available for the co-located buoy AZB12 for this storm). This buoy provides only the boundary conditions along the northern boundary of grid AZG3A and the North Sea part of the western and eastern boundary. The remaining boundary conditions (western and eastern boundaries in the Wadden Sea interior) are obtained from the grid GridCL, which obtains its offshore boundary values from the directional Waverider buoys at stations ELD and SON. The remainder of the array of wave buoys (Directional and omni-directional Waveriders) is used for comparison with the wave model. Non-uniform wind, waterlevel and current data are used. Note that the waterlevel and current fields have been recomputed after publication of WL & Alkyon (2007b), so that there are differences between the fields in SWIVT and the fields as presented in WL & Alkyon (2007b).

References

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Acknowledgements

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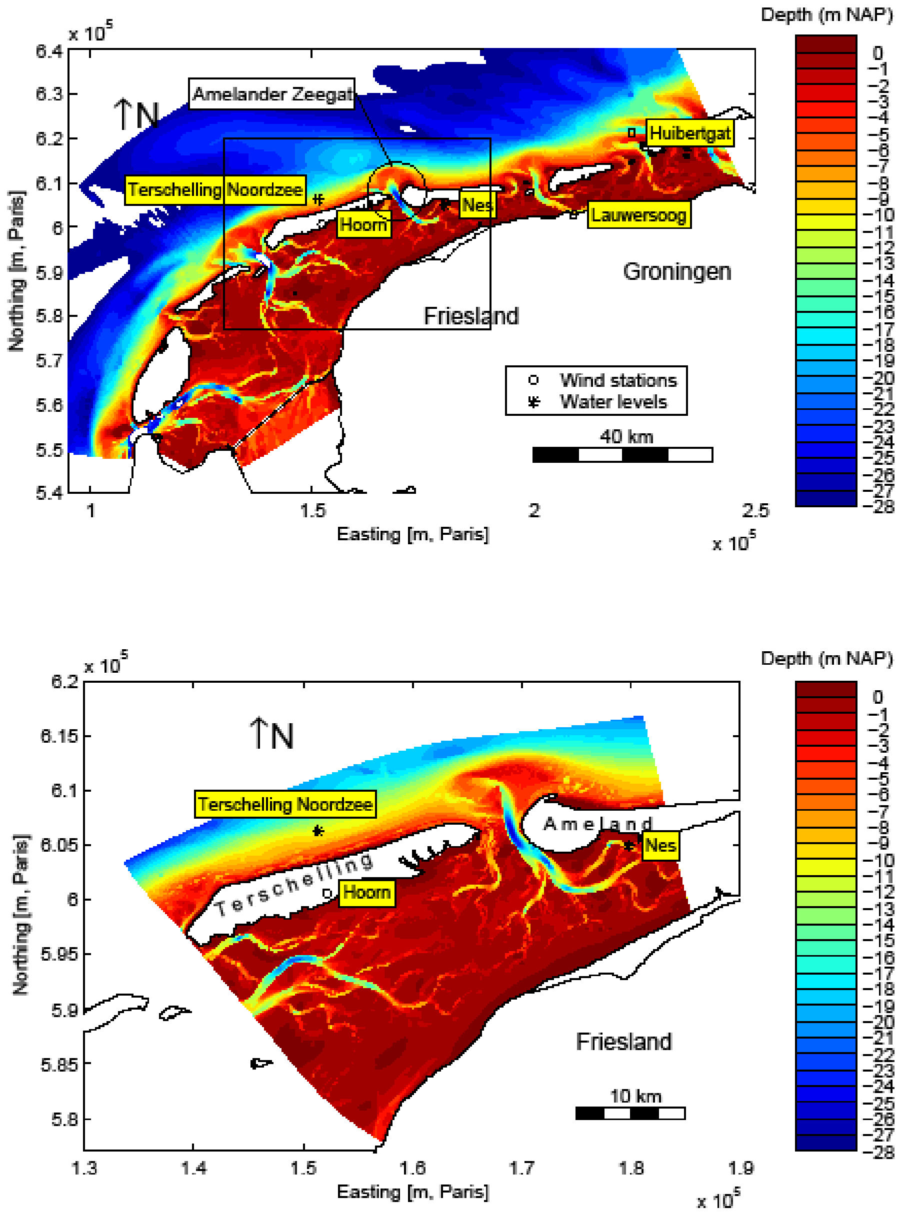
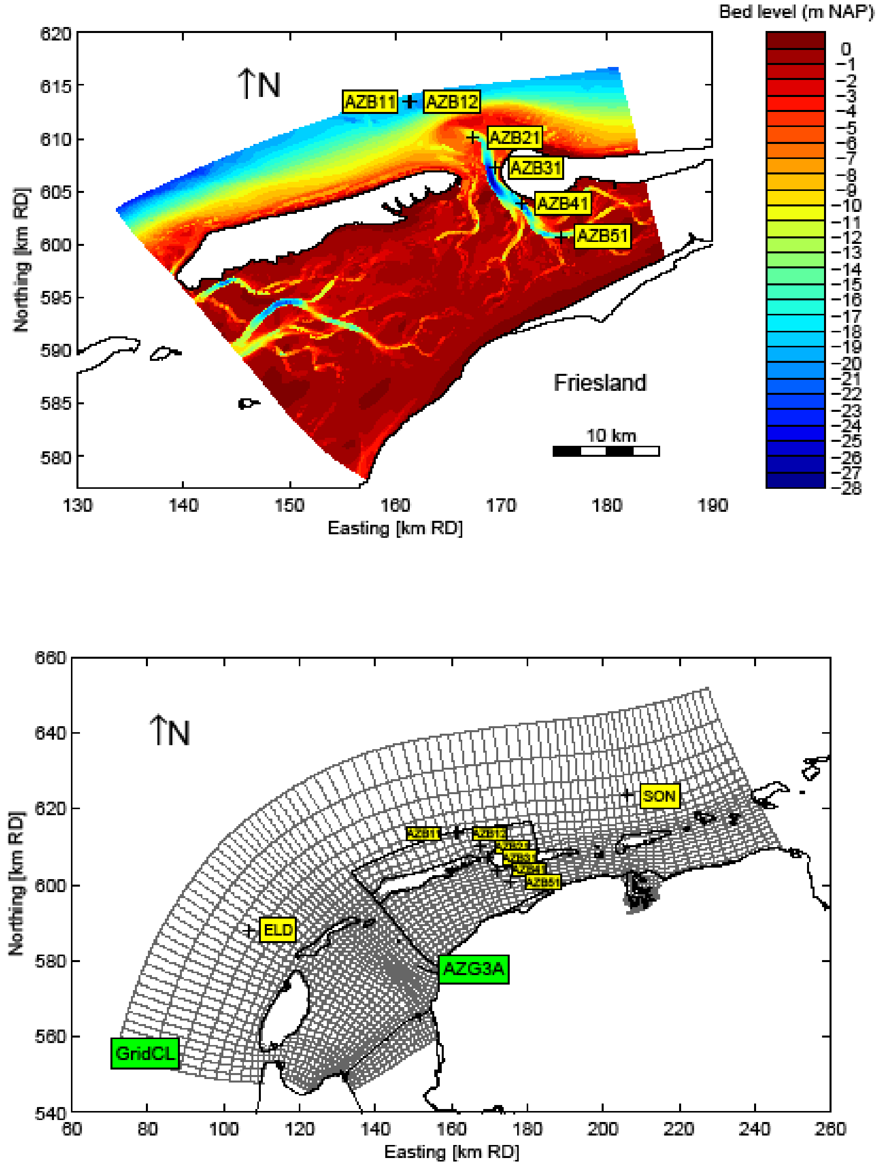
Figure



Bathymetry of the Amelander Zeegat in the Wadden Sea, the Netherlands with locations of wind, wave and water level observation stations	Validation cases SWIVT	
DELTARES	H5107.66	Fig. 3.1



Field case of Amelander Zeegat for the storm of 8−9 February 2004. Wave buoy locations (top) and computational grids (bottom). For GridCL every fifth grid line shown and for AZG3A outline only.	Validation cases SWIVT	
DELTARES	H5107.66	Fig. 3.2