F101am05z[001-009]: Amelander Zeegat 2005

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 selected 2005 storm instants and corresponding environmental conditions considered in the above-mentioned stationary hindcast studies. Also included in Table 1 are the computational grids used in the hindcast studies

Date and time	***Nr***	U_{10}	U_{dir}	**Water level Nes**	u_{max}, **tidal phase**	**Grids**	**Source**
		[m/s]	**[°N]**	**[m NAP]**	**[m/s]**		
02/01/2005, 10:00	1	20.0	277	1.0	1.99, flood	GridCL, AZG3A	WL & Alkyon (2007b), Alkyon (2007a)
02/01/2005, 12:00	2	17.8	277	2.1	1.55, high w.	GridCL, AZG3A	WL & Alkyon (2007b), Alkyon (2007a)
02/01/2005, 17:00	3	16.3	275	1.3	0.97, ebb	GridCL, AZG3A	WL & Alkyon (2007b), Alkyon (2007a)
08/01/2005, 18:00	4	19.0	270	2.3	-	Rectangular	Alkyon (2007a)
16/12/2005, 10:00	5	17.5	345	2.2	0.46, flood	Rectangular	Alkyon (2007b)
16/12/2005, 20:30	6	13.0	352	2.1	1.18, flood	Rectangular	Alkyon (2007b)
16/12/2005, 23:30	7	15.9	331	2.3	1.04, ebb	Rectangular	Alkyon (2007b)
17/12/2005, 03:00	8	15.1	339	0.8	0.96, ebb	Rectangular	Alkyon (2007b)
17/12/2005, 10:30	9	15.4	339	2.0	0.46, high w.	Rectangular	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. f101am05z001 is case 02/01/2005, 10:00 etc.

Model setup

For the January 2005 storm moments, different grids (rectangular and curvilinear) have been used in different studies. This concerns four nested rectangular grids in Alkyon (2007a), and gridCL (coarse grid) and AZG3A (fine grid) for the first three Jan. 2005 stormmoments in WL & Alkyon (2007b). The fourth moment (8 jan. 2005, 18:00) has not been considered in WL & Alkyon (2007b). Since the study of WL & Alkyon (2007b) takes recommendations of Alkyon (2007a) into account, the model settings employed in WL & Alkyon (2007b) are the ones included in SWIVT. The model domain is shown in Fig. 2.1. Two grids were used for cases 1, 2 and 3 (all on 2 Jan. 2005): gridCL and grid AZG3A, with the former providing boundary conditions for the latter.

The bathymetry is the same for case 1 – 3. The bathymetry for cases 4 – 9 is the same, and is different from the bathymetry for cases 1 – 3.

The computational grids used for case 4 (8 Jan 2005) and all the December 2005 cases are presented in the bottom panel of Figure 3.3. A series of four rectangular grids is used, namely one coarse grid (Grid 1) covering the overall model domain, and three nested fine grids (Grid 2 to 4) positioned along the main tidal channel. The wave boundary conditions are obtained from the buoys AZB11 and AZB12, and are imposed on the outer boundary of Grid 1.

Water levels and current fields for both January (only on the AZG3A grid for the first three cases) and all December 2005 cases have been provided by RIKZ, computed using the WAQUA hydrodynamical model. For cases 1,2 and 3, this corresponds to the simulations indicated by ‘fld’ in WL & Alkyon (2007b). The non-uniform wind field is the same as in WL & Alkyon (2007b). Case 4 (8 Jan. 2005) has been computed without current and water level fields. For cases 5 to 9, the water level and current fields have been recomputed at a later stage, so that they do not correspond to the data in WL & Alkyon (2007b) anymore.

References

Alkyon (2007a). Analysis SWAN hindcast tidal inlet of Ameland: Storms of 8 February 2004 and 2, 8 January 2005. Alkyon report A1725R4R3, February 2007.

Alkyon (2007b). Analysis SWAN hindcast tidal inlet of Ameland: Storms of 17 December 2005 and 9 February 2006. Alkyon report A1725R5R4, February 2007.

WL & Alkyon (2007b). Storm hindcast for Wadden Sea, Hindcasts in inlet systems of Ameland and Norderney and Lunenburg Bay. WL | Delft Hydraulics Report H4918.20, September 2007.

Acknowledgements

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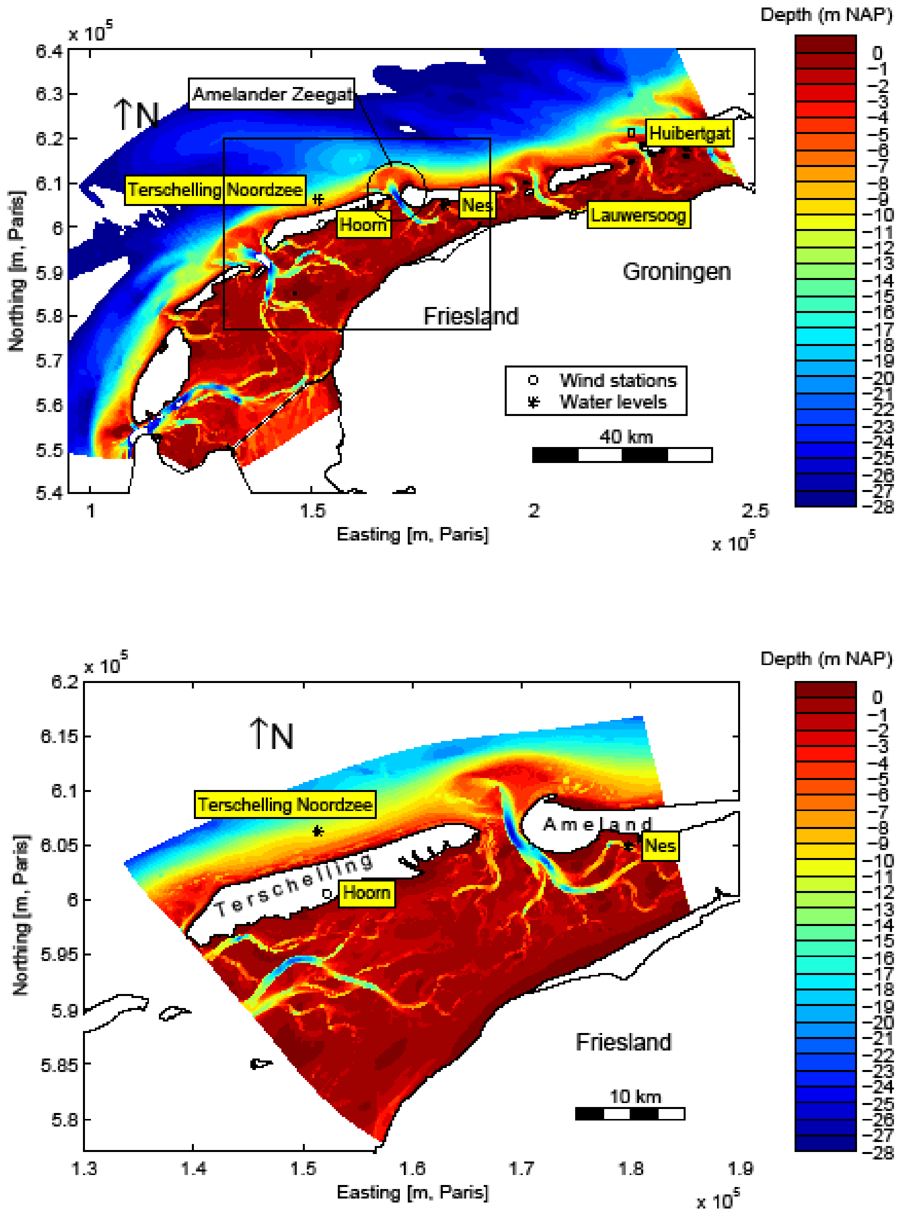
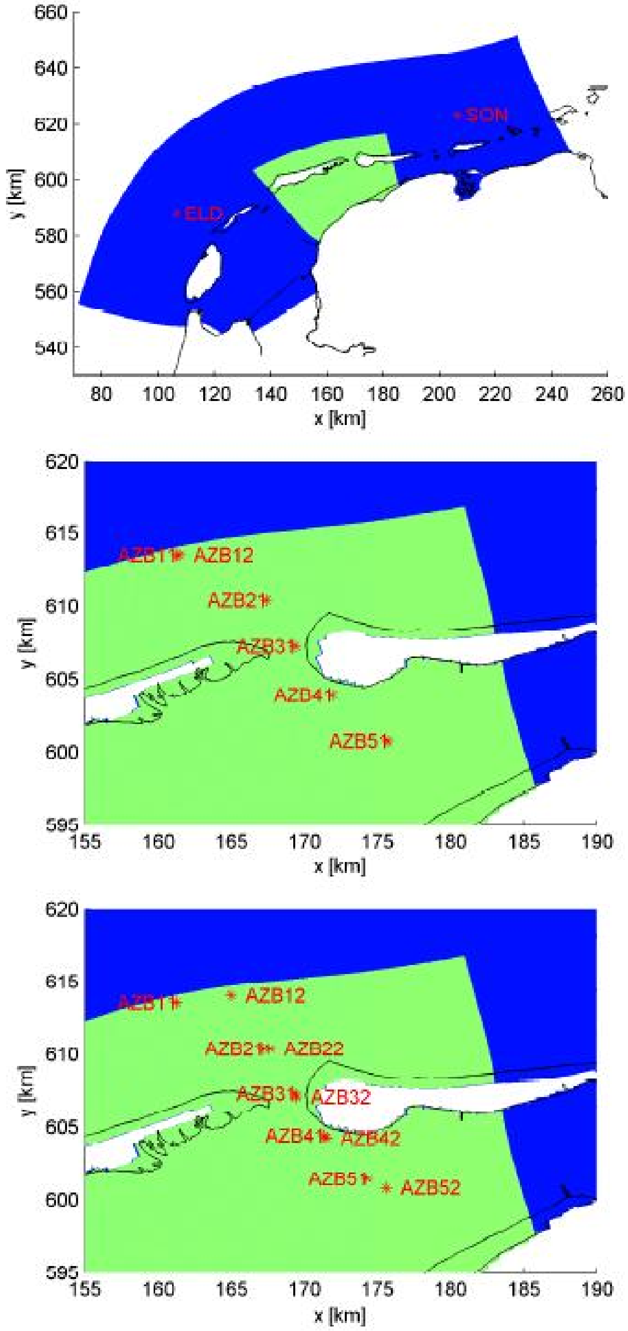
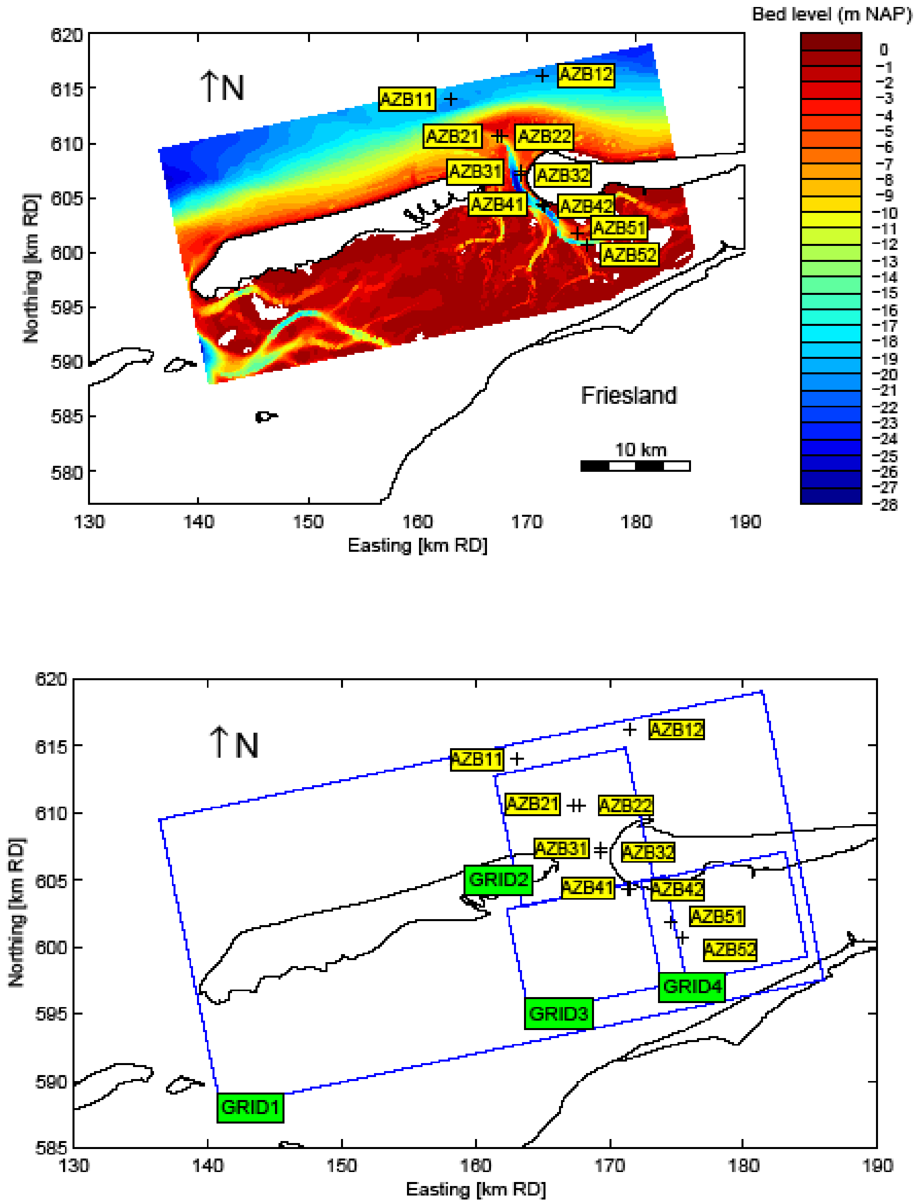
Figure



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



Computational domains (GridCL and AZB3A) and location of offshore buoys (upper panel) location of wave buoys in Ameland inlet during 2004 storm (middle panel) and during 2005 storm (lower panel)		
	Ameland Inlet	
WL | DELFT HYDRAULICS	H4918.20	Fig. 2.1



Field case of Amelander Zeegat for the storm of 16−17 December 2005. Wave buoy locations (top) and computational grids (bottom)		
	Validation cases SWIVT	
DELTARES	H5107.66	Fig. 3.3