F102am07z[001-043]: Amelander Zeegat 2007

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

As mentioned above, westerly storm conditions in the Wadden Sea provide the opportunity to study finite depth wave growth over the shallow Wadden Sea interior. Three significant westerly storms (wind speeds 8-24 m/s) were observed in the Amelander Zeegat region during the 2006-2007 storm season, namely on 11-12 January 2007, 18-19 January 2007 and 18-19 March 2007 (Table 1). A selection of 31 instants during these three storms has been hindcast by Royal Haskoning (2008). These 31 instants have been included in SWIVT. From this data set, Royal Haskoning (2008) made a selection of 13 hindcast instants which featured large H_{m0}/d ratios and high wind speeds (being uniform in time, both in speed and direction). This case selection was discussed in Deltares (2008a), where one of the 13 cases was omitted from the set on the grounds of incompleteness of wave observation data. In the storm season 2007-2008, one significant storm (northwesterly) took place: at 8 and 9 november 2009. A selection of 12 moments in this storm were hindcast by Witteveen & Bos (2008). All these moments are included in SWIVT. Therefore, we have (31 + 12) = 43 storm moments in the Wadden Sea from the year 2007.

Case selection

Information on the selected storm moments is given in the tables below (taken from Royal Haskoning (2008) and Witteveen & Bos (2008)).

The table below contains information from Royal Haskoning (2008). U10 is some representative wind velocity; the wind direction is in degrees Nautical; the waterlevels in Nes and West Terschelling are in meters.

Time	Code	U10 [m/s]	Winddir	W.level Nes	W.level W-Terschelling
01/11/2007, 04:00	f102am07z001	11.88	237	136	80
01/11/2007, 12:00	f102am07z002	19.12	224	70	72
01/11/2007, 13:00	f102am07z003	19.46	228	96	80
01/11/2007, 14:00	f102am07z004	16.95	273	101	82
01/11/2007, 15:00	f102am07z005	13.46	257	122	73
01/11/2007, 16:00	f102am07z006	14.84	265	106	61
01/11/2007, 16:40	f102am07z007	14.81	264	95	46
01/11/2007, 20:40	f102am07z008	18.17	268	44	44
01/11/2007, 21:20	f102am07z009	18.7	271	63	71
01/11/2007, 22:00	f102am07z010	17.91	275	93	102
01/11/2007, 22:40	f102am07z011	18.83	279	129	130
01/12/2007, 02:00	f102am07z012	15.52	283	306	269
01/12/2007, 05:00	f102am07z013	14.33	281	226	166
01/12/2007, 08:00	f102am07z014	10.77	271	128	88
01/18/2007, 12:20	f102am07z015	21.07	233	82	56
01/18/2007, 14:00	f102am07z016	20.24	263	60	39
01/18/2007, 17:20	f102am07z017	20.3	267	143	145
01/18/2007, 18:00	f102am07z018	20.06	268	182	169
01/18/2007, 18:40	f102am07z019	19.91	269	224	197
01/18/2007, 20:40	f102am07z020	18.85	274	281	250
01/18/2007, 21:20	f102am07z021	18.19	274	291	248
01/19/2007, 07:40	f102am07z022	13.09	271	145	137
01/19/2007, 12:00	f102am07z023	14.27	272	136	70
03/18/2007, 07:40	f102am07z024	14.78	274	110	113
03/18/2007, 09:20	f102am07z025	13.77	275	176	125
03/18/2007, 10:00	f102am07z026	13.79	279	169	121
03/18/2007, 14:40	f102am07z027	18.1	266	67	27
03/18/2007, 15:40	f102am07z028	17.91	271	63	65
03/18/2007, 16:00	f102am07z029	18.67	270	64	87
03/18/2007, 17:00	f102am07z030	17.07	268	117	141
03/18/2007, 19:20	f102am07z031	16.32	268	299	265

The table below contains information from Witteveen & Bos (2008).

Time	Code	U10 [m/s]	Wind direction	Waterlevel
08/11/2007, 18:10	f102am07z032	13.0	292	1.3
09/11/2007, 00:10	f102am07z033	16.0	324	0.7
09/11/2007, 02:20	f102am07z034	15.5	319	0.3
09/11/2007, 04:50	f102am07z035	16.7	322	1.5
09/11/2007, 08:10	f102am07z036	18.1	330	2.6
09/11/2007, 09:20	f102am07z037	17.8	330	2.4
09/11/2007, 11:00	f102am07z038	18.3	331	1.7
09/11/2007, 12:30	f102am07z039	17.7	336	1.0
09/11/2007, 14:30	f102am07z040	17.4	330	0.4
09/11/2007, 17:20	f102am07z041	16.1	330	1.0
09/11/2007, 19:10	f102am07z042	15.3	334	1.5
09/11/2007, 20:30	f102am07z043	14.8	330	1.5

However, one important change was made w.r.t. the original hindcast model data as in the report. The water level and current fields that are obtained from a Delft3D hydrodynamic model run for the storm period, were corrected before being used in SWAN. The water levels for this storm as computed by Delft3D were compared to the observed water levels at the measurement stations around the Amelander Inlet. Some parts of the time series and some locations did show a good agreement between Delft3D and the measurements. For instance near the storm peak in the morning of 9 November 2007. But in the preceding ebb the water levels are strongly overpredicted by Delft3D. The corrected water level fields are obtained from a combination of Delft3D results and the measured water levels. A time and space dependent correction is applied in such a way that the water levels in the Delft3D fields correspond to the measurements. The current velocities were corrected linearly with the local water depth. Further, also the input of wind was changed because of the more northerly wind direction.

Model setup

The computational grids used for these hindcasts (January, March, November 2007) are presented in the bottom panel of Figure 3.4. A series of two nested curvilinear grids are 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 Waveriders AZB11 and AZB12. These buoys provide 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 (lateral boundaries) 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 wave buoys in the Wadden Sea interior (Directional and omni-directional Waveriders) are available for comparison with the wave model. However, due to the limited high-frequency range observed by the Directional Waverider at AZB41, only the stations AZB51, AZB61 and AZB62 provide useful wave data for calibration for these strongly depth-limited conditions, which feature relatively short periods (Deltares 2008a). Wind data is available from the observation stations Hoorn, Lauwersoog and Huibertgat (Figure 3.1), from which a weighted averaged value is used. Royal Haskoning (2008) applied water level and current fields computed by Deltares (2008b), using the hydrodynamical model Delft3D.

Both the completeness and quality of this set of observational data is considered as being good. The data set is relevant for studying finite depth water growth in the Wadden Sea interior. Hence, it is considered to be suitable to take up as validation cases in SWIVT.

References

Royal Haskoning (2008). Hindcast tidal inlet of Ameland storms January and March 2007. Royal Haskoning Report 9T5842.A0, October 2008.

Witteveen & Bos (2008). Hindcast of the 8 and 9 november 2007 storm for the tidal inlet of Ameland. DT293-2/winb/011, November 2008.

Acknowledgements

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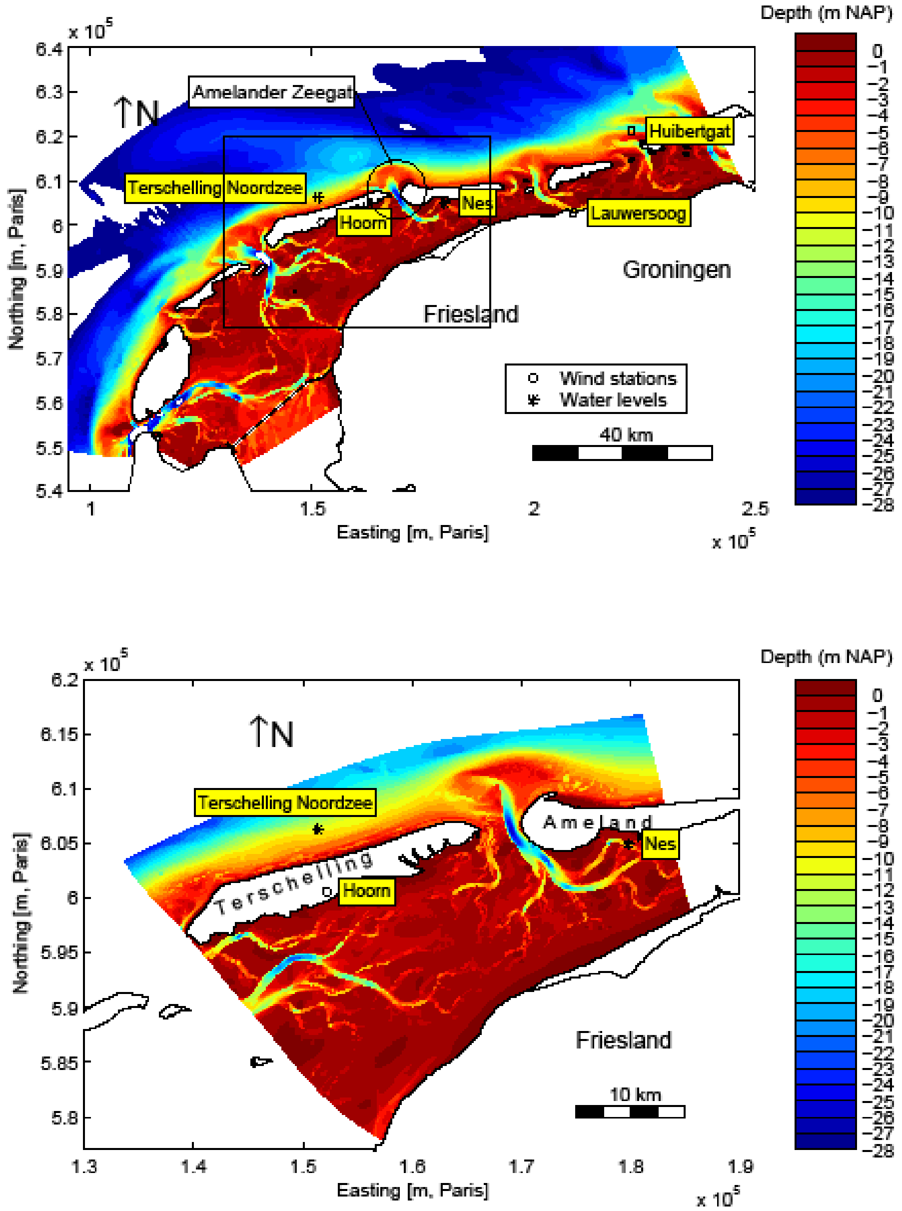
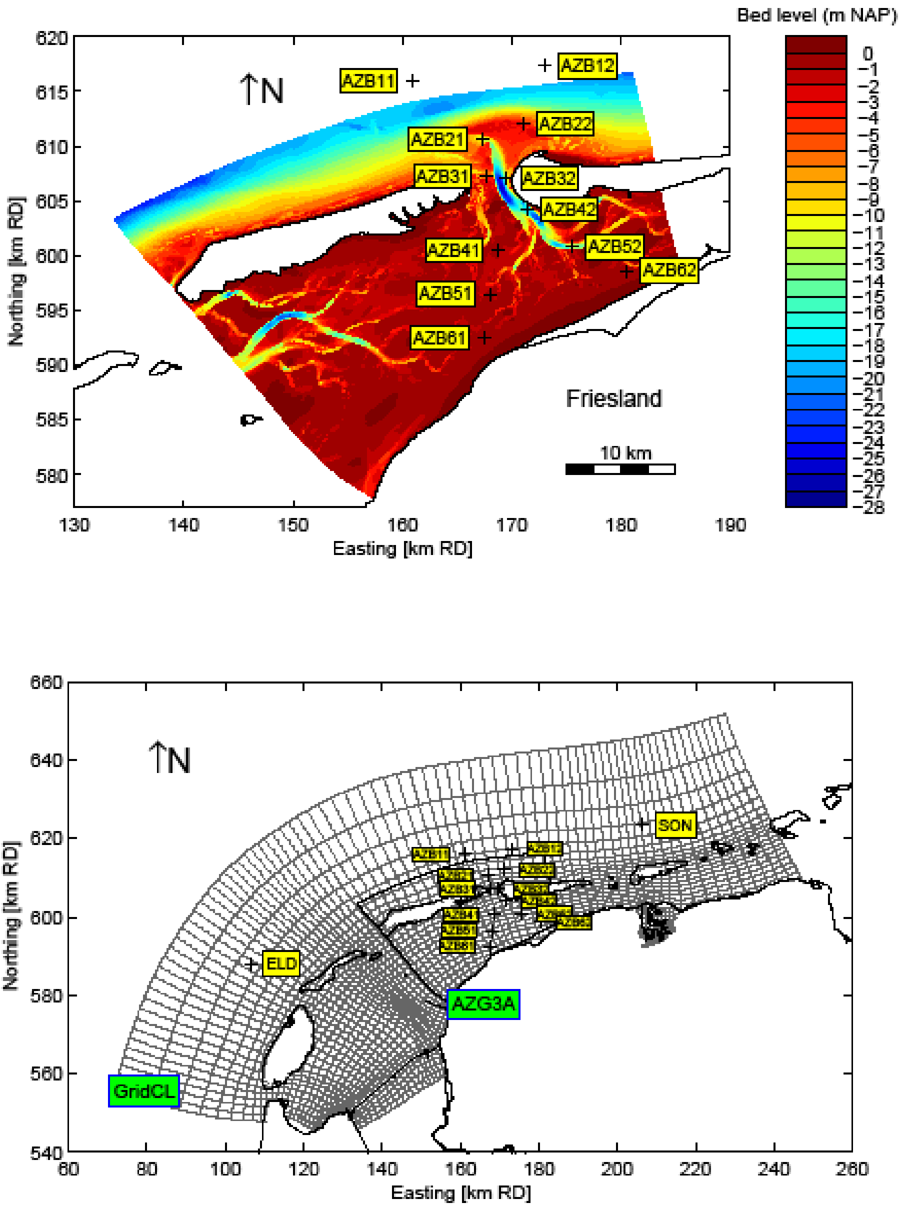
Figure



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 storms of January and March 2007. 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. 3.4