F170pettn[001-021]: Petten SWAN 1995 and 2002

Purpose

Depth-induced wave breaking is one of the most dominant hydrodynamic processes occurring in the coastal region. It not only controls the amount of wave energy impacting our coastlines and coastal defenses, but also plays a crucial role in driving many nearshore processes such as sediment transport, bottom morphology and turbulence. Wave breaking also induces radiation stresses which drive wave induced set-up and currents, both of which are of importance for coastal engineering design and management. However, despite the importance and relevance towards our knowledge of wave hydrodynamics, depth-induced wave breaking is still poorly understood, partially due to its highly nonlinear nature and is therefore heavily parameterized in most wave models.

Case selection

The Petten site is located off the west coast of the Netherlands near the town of Petten. The location represents a gently sloping beach profile with a large offshore shoal with a minimum depth of ~5.7 m and a smaller near-shore bar with a minimum depth of ~4.0 m. Wave conditions were measured along a transect normal to the beach with three to six instruments depending on when the observations were taken. Following a hindcast study to investigate the performance of the wave model SWAN (Booij et al., 1999) under instationary conditions (Groeneweg et al., 2003), a number of instances, typically four per storm, were chosen representing variations in the tide and development of the storm. Over the selected 21 cases, the offshore significant wave height varied between $3.0 < H_{m0} < 6.7$ m and the offshore mean wave period varied between $4.2 < T_{m01} < 9.9$ s, as provided in Table 1.

Run code	Date	Time UTC +01:00	$U_{w,10}$ [m/s]	θ_w [°N]	H_{m0}	T_{m01}	U_c [m/s]	θ_w [°N]
f170pettn001	01/01/1995	01:00	12.5	335.4	2.99	6.57	0.0	280.0
f170pettn002	01/01/1995	02:00	11.8	335.4	3.42	6.88	0.2	283.2
f170pettn003	01/01/1995	06:40	14.7	324.3	4.96	8.02	0.3	98.1
f170pettn004	01/01/1995	10:00	13.9	325.3	5.47	8.96	0.2	102.7
f170pettn005	02/01/1995	04:20	15.7	335.7	6.48	9.90	0.2	276.4
f170pettn006	02/01/1995	14:40	14.2	353.9	5.03	8.80	0.0	100.0
f170pettn007	02/01/1995	16:40	12.7	370.4	4.58	8.74	0.2	280.0
f170pettn008	02/01/1995	21:20	9.7	366.7	3.62	7.87	0.3	102.1
f170pettn009	10/01/1995	09:20	14.1	308.1	5.56	9.45	0.1	280.0
f170pettn010	10/01/1995	11:20	12.6	305.1	4.96	8.72	0.1	273.5
f170pettn011	10/01/1995	16:20	10.6	293.6	3.69	8.16	0.2	103.2
f170pettn012	10/01/1995	20:20	4.0	279.4	3.04	8.02	0.0	100.0
f170pettn013	23/02/2002	07:20	17.3	266.0	4.78	7.55	0.1	109.2
f170pettn014	23/02/2002	10:20	14.8	273.7	4.83	7.26	0.2	280.0

f170pettn015	23/02/2002	13:20	15.9	276.1	5.03	7.28	0.2	276.9
f170pettn016	23/02/2002	19:20	15.6	299.3	4.63	7.51	0.1	100.0
f170pettn017	26/10/2002	07:00	18.5	262.9	4.96	5.61	0.3	276.2
f170pettn018	27/10/2002	06:00	14.7	193.8	3.91	4.23	0.3	281.9
f170pettn019	27/10/2002	11:00	20.9	227.9	3.87	5.66	0.2	276.5
f170pettn020	27/10/2002	14:20	24.8	246.7	5.50	6.75	0.2	280.0
f170pettn021	27/10/2002	17:00	22.7	272.7	6.70	6.88	0.4	277.3

Table 1: Cases for Petten. Times are given in Coordinated Universal Time (UTC)+01:00. Wind velocity, $U_{w,10}$ and direction, θ_w are averaged over the entire computational domain. The offshore significant wave height, H_{m0} and mean wave period, T_{m01} are an average of the wave conditions taken at two locations (Eierlandse Gat, ELD and Ijmuiden, YMW buoys). Current velocity, U_c and direction, θ_c is taken at the most shoreward buoy location from the Petten 1995 campaign.

Model setup

The hindcast study by Groeneweg et al. (2003) was the basis for the Petten hindcasts which Salmon et al. (2015) used to study depth-induced breaking. The version of Salmon et al. (2015) is used in SWIVT. A choice was made for non-uniform water levels and depth-averaged currents, based on WAQUA computations. Also, a non-uniform wind was used. For the 1995 storms, wind speeds are estimated from three wind measurement locations in the vicinity of Petten (Texelhors, TXH; Noordwijk, MPN and K13; see Figure 1B) to estimate the wind variation both along the coast and perpendicular to it. For the 2002 storms, wind fields from HIRLAM were available and only two locations (TXH and Ijmuiden Semafoor; YMS) were used to scale the computed wind speeds.

For the 1995 storms, a fine inner computational grid is nested within a coarser outer grid to calculate the spectral boundary conditions for the inner grid. The outer grid uses 2D spectra inferred from a directional Waverider buoy near the offshore boundary of the outer grid. The same inner grid is applied for the 2002 campaign with no need for nesting, as in 2002 a directional Waverider buoy is located near the offshore boundary of the inner grid.

Model settings

The following physical model settings are applied, based on Salmon (2016). Computations were carried out in the frequency range between 0.03 Hz and 0.5 Hz with 31 discrete frequencies.

```
GEN3 KOMEN

WCAP KOMEN delta=1.

BREAK CON

FRIC JONSWAP cfjon=0.038

TRIAD
```

The numerical settings are as follows:

```
NUM ACCUR 0.02 0.02 0.02 98 STAT 50
```

References

Booij, N., et al (1999). A third-generation wave model for coastal regions: 1. Model description and validation. Journal of Geophysical Research: Oceans, 104 (C4), pp. 7649–7666.

Groeneweg, J., et al (2003). Reliability of SWAN at the Petten Sea Defence. Tech. Rep. No. H4197/A1044, WL|Delft Hydraulics & Alkyon.

Salmon, J.E. and L.H. Holthuijsen (2015). Modeling depth-induced wave breaking over complex coastal bathymetries. Coastal Engineering, Vol. 105, 21–35.

Acknowledgments

The hindcast is part of the KPP-Hydraulica project commissioned by Rijkswaterstaat-Centre for Water Management in the Netherlands.

Figures

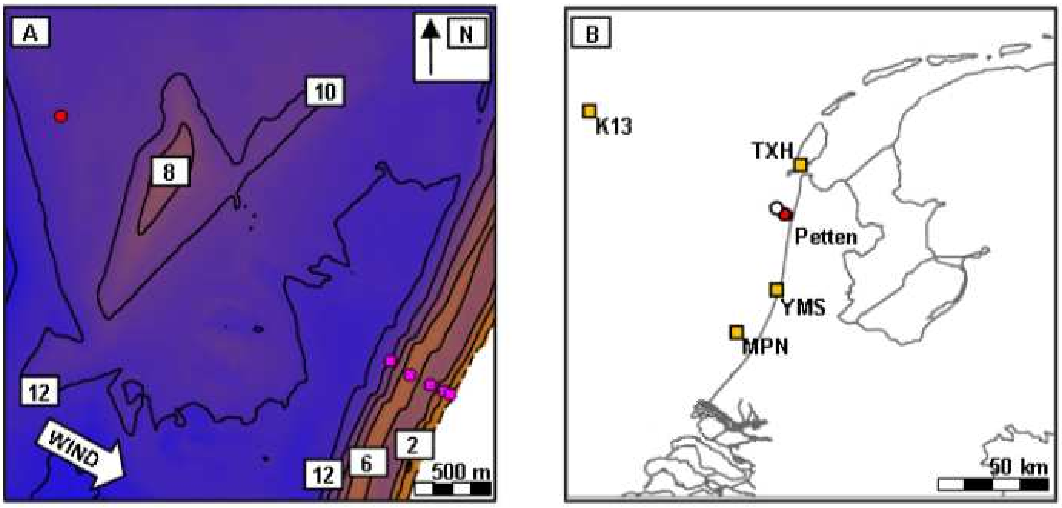

Figure 1. Bathymetry for Petten (A) +1m above Amsterdam Ordnance Datum (NAP) with the regions indicated along the Dutch coastline shown in Panel B. Contour lines are shown at 2m intervals. All buoys used to provide the boundary conditions are indicated with a red dot or an empty dot in Panel B. For the Petten 1995 campaign, the buoy used for the boundary conditions is located with an empty dot. For the Petten 2002 campaign, the boundary conditions form the buoy indicated with the red dot have been used The shoreward measurement locations are indicated in magenta (×). Wind measurement locations used for the Petten data set are indicated in Panel B as orange squares.