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Application of SWAN in the Holderness region

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1 SWAN at Holderness

Of the three regions of Lyme Bay, Carmarthen Bay and Holderness it is the wave data set from the Holderness area with its offshore vector of three waverider buoys that is most suitable for the purposes of model validation. The coastline and buoy locations are shown in Figure 1. The period studied was the 1st and 2nd of January 1995 which was the period of greatest waveheight observed by the buoys over their deployment through the winters of 1994/1995 and 1995/1996.

The Holderness bathymetry obtained from Halcrow has been used for running SWAN with the offshore boundary coincident with the N3 buoy (Figure 2). Before is could be used in the model, the bathymetry required some correction from Lowest Astronomical Tide to Mean Sea Level. The array of corrections was derived from the POL hydrodynamic model and although there was variation of 0.8m accross the model grid, for simple implementation within SWAN a correction of 3.6m was chosen for the whole grid.

A constant wavefield was input at the offshore boundary taken from the directional spectra from the N3 buoy. An example spectrum is shown in Figure 3. Cross shore boundary conditions were not required since the upwave direction was north of offshore for this test period (see Figure 2). Wind forcing to the model was provided by the 10 metre wind speed and direction at Donna Nook. The value was taken to be constant over the whole grid. Figure 4 shows the time series of wind strength over the modelled period.

The model [1] was run a stationary mode at three hourly intervals between 00:00 on 1st January and 00:00 on 3rd January.

2 Bottom Friction

In SWAN there are three possible formulations for the bottom friction term, and parameters may be set by the user for each. These parameters are influenced by the sediment grain size and the presence of ripples in the sea bed so may quite reasonably be expected to be different for different implementations of the model.

The default formulation is the empirical model of JONSWAP (Hasselmann *et al.*, 1973). Other options are the drag law model of Collins (1972) and the eddy-viscosity model of Madsen *et al.* (1988). All three formulations may be expressed in the following form

[1] The spatial grid was 78×296 points with 200 metre resolution. In the frequency domain there were 31 frequencies (0.04–0.5 Hz) and 24 directions. It took 120MB of RAM and 25 minutes per run on a Silicon Graphics R10000/195MHz (1996) workstation.

$$S(\sigma,\theta) = -C_{bottom}\frac{\sigma^2}{g^2\sinh^2(kd)}E(\sigma,\theta). \quad (1)$$

C_{bottom} is the bottom friction coefficient which depends in some functional way on the bottom orbital motion. It is the formulation of this coefficient which varies between the different models, and for which the user can change the inherent empirical constants.

3 Results

The SWAN model was run with the JONSWAP and Madsen bottom friction formulations using the default parameters. Through the European project EUROWAVES the default SWAN parameters for the Madsen bottom friction were found to be closer to the theoretical value for the estimated grain size at Holderness (Sclavo, private communication, 1998).

Figure 5 shows the waveheight results for the period of the run for buoys N3 to N1 and the JONSWAP and Madsen formulations respectively. We find that the decrease in wave height onshore is indeed better modelled by the Madsen formulation of bottom friction.

The results below show some statistics for the two cases. RMS, STDDEV and BIAS are the root mean square, standard deviation and mean of the ($Hs_{model} - Hs_{buoy}$) statistic. Note the large decrease in the bias at N2 and N1 in the Madsen bottom friction case.

	RMS(m)	STDDEV(m)	BIAS(m)	MEAN(BUOY) (m)
JONSWAP				
N3	0.06	0.06	-0.004	4.22
N2	0.55	0.48	0.30	3.38
N1	0.57	0.30	0.51	2.48
MADSEN				
N3	0.06	0.06	-0.01	4.22
N2	0.46	0.47	0.005	3.38
N1	0.36	0.29	0.22	2.48

There is some variability in the results at N1 and N2 which is not reproduced in the model. This variability has been studied in the full buoy data (as opposed to just the the hourly measurements) and found to be a signal of 12.5 hours consistent with tidal effects. The signal is weak at N3 but much stronger at N2 and N1. Since no varying water depths and currents are yet included in our implementation SWAN model it is no surprise that this variability is not seen at N2 and N1.

4 Conclusion

SWAN has been implemented for the Holderness region and run at three hourly intervals over a two day storm in January 1995. The results show that varying the bottom friction formulation can have a significant effect on the results, with the Madsen formulation producing significantly better results than the JONSWAP formulation.

It is envisaged that the next step in this study will be to include variable water depths and currents from the POL hydrodynamic model.

References

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