F120ppbay[001-006]: Port Phillip Bay Heads

Physical conditions

In the tidal inlet of Port Phillip Bay Heads, Melbourne, Australia, the near-idealised situation of swell-dominated wave field interacting with tidal currents is found. This field case is a potential validation case for wave-current interaction in SWAN, and the associated steepness-induced dissipation, found in the tidal inlets in the Wadden Sea.

The Heads of Port Phillip Bay (Figure 6.1, top panel) are subject to strong tidal currents and an energetic offshore wave climate. The tidal flows at Port Phillip Bay Heads are predictable and are approximately aligned with the approach direction of the incoming swell waves (the currents are almost unaffected by the low-lying canyon seen in Figure 6.1). Typical depth-averaged ebb and flood current velocities reach 2 to 3 m/s and offshore significant wave height is typically in the range of 1 to 4 m with a peak swell period in the range of 10 to 20 s. Shorter period wind-sea components may also be present. Two offshore directional wave buoys (Triaxys model) are permanently deployed, in close proximity to each other, approximately 10 km southeast of Port Phillip Bay Heads (see location WAVE_A in Figure 6.1, top panel). These buoys measure waves that are unaffected by the tidal flows in and out of Port Phillip Bay. Waves and currents in the tidal inlet are measured using Nortek AWAC instruments (locations RBO and RB) bolted to the rocky channel floor on the centreline of the shipping channel in approximately 18 m of water. Wave conditions within the Heads are strongly affected by the tidal streams through the inlet, and fluctuate much more rapidly than the offshore wave conditions. Wind speed and direction are recorded at the Point Lonsdale lighthouse (on the western Head) and tidal water levels are recorded at Point Lonsdale and Lorne (60 km southwest of the Heads).

This field case has been considered in the hindcast study of WL (2007a). Under opposing tidal current, Doppler shifting, steepening of waves and resulting whitecapping dissipation are found. Under following tidal current, Doppler shifting, but no additional dissipation is found. Considering the near-idealised nature of the wave and current conditions, this case is considered a valuable candidate for studying the effects of wave-current interaction in the field..

Case selection

In their hindcast study, WL (2007a) selected two storms observed in Port Phillip Bay Heads. For each storm condition, the times of peak ebb and flood tides were identified for the stationary hindcasting, along with the time of near-slack. These six storm instants, taken over for the present purpose, are listed in Table 1 below:

Case	Code	U_{10} [m/s]	U_{dir} [^oN]	u_{max} [m/s]	H_{m0} [m]	T_{m01} [s]
28/06/2006,06:30	f120ppbay001	2.6	21	2.5	3.1	14.0
28/06/2006,10:30	f120ppbay002	3.0	4	0.2	2.1	11.6
28/06/2006,14:00	f120ppbay003	5.7	44	1.8	2.4	12.0
27/10/2006,20:30	f120ppbay004	14.9	257	2.4	4.0	8.0
27/10/2006,23:30	f120ppbay005	12.3	280	0.2	4.7	8.6
28/10/2006,03:30	f120ppbay006	15.4	216	1.8	4.2	8.0

Table 1: Field cases of Port Phillip Bay Heads (and their characteristics) considered by WL (2007a). Observations presented for the offshore buoy location WAVE_A.

The two selection storm conditions have the following characteristics:

28 June 2006

This event features relatively pure, high swell waves from a distant source. The offshore significant wave height at the Triaxys buoys (WAVE_A in Figure 6.1) was on average 2.7 m with a peak spectral period of approximately 16 s. Wind at Point Lonsdale was low and approximately constant at an average of 4 m/s from 30 ^oN. These conditions were reasonably constant during this swell event. During this swell event, flood currents of up to 1.8 m/s and ebb currents of up to 2.5 m/s were observed in the tidal inlet.

27-28 October 2006

This storm occurred during a time of high distant swell coinciding with a strong local wind. Offshore significant wave height was approximately 4.4 m with a spectral peak period of approximately 12 s. Wind at Point Lonsdale was strong, at an average speed of 17 m/s, and the wind direction at Point Lonsdale gradually veering from 270 to 220 degrees during the course of the storm. Although the wind direction varies slowly, the measured offshore wave conditions were reasonably constant. During this storm period, flood currents of up to 1.8 m/s and ebb currents of up to 2.4 m/s were observed in the tidal inlet.

Model setup

The model setup features a single curvilinear grid, dimensioned such that possible inaccuracies in the lateral boundary conditions do not affect either the region of the tidal inlet or the location of the offshore wave buoys, and so that it extends far enough offshore so that offshore conditions can be assumed to be spatially constant along the offshore boundary (Figure 6.1, bottom panel). For the offshore, northest and southwest wave model boundaries, 1.5D spectra measured at the offshore buoy location WAVE_A were applied. To compensate for the offshore displacement of the observed data, the measured spectra applied at these boundaries were modified by trial and error until the observed spectra at the buoy location WAVE_A were recovered. As the wave conditions were reasonably constant during the storm of 28 June 2006, the offshore boundary conditions are held constant for all three storm instants. For the storm of 27-28 October 2006, the measured offshore wave conditions are again reasonably constant, even though the wind direction varies slowly. Therefore, despite the gradual increase in wave energy observed during the storm, the wave boundary conditions are again assumed constant for the duration of the storm.

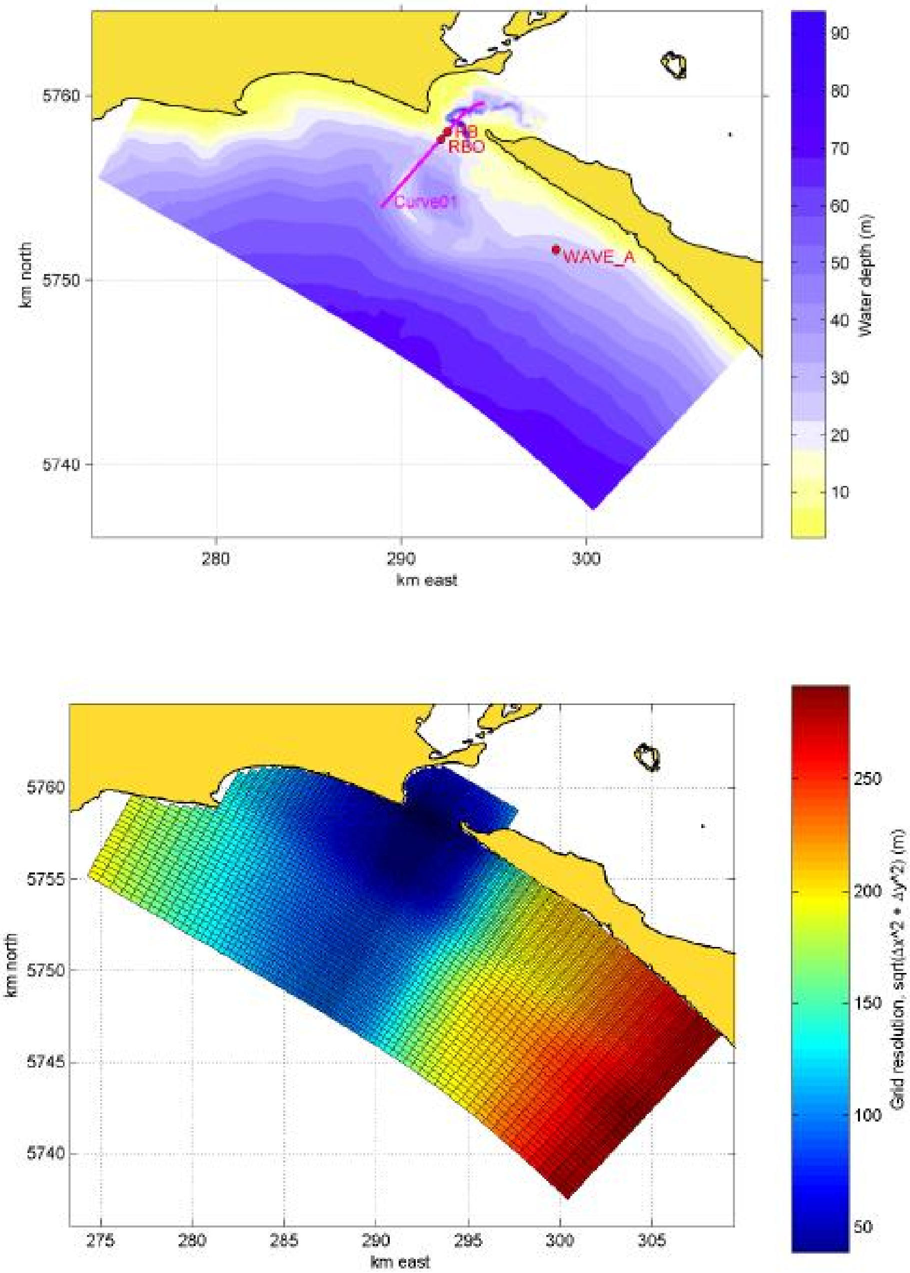
The wind speed and direction recorded at Point Lonsdale lighthouse (on the western Head) are applied uniformly over the model domain. The current fields were modelled using a three-dimensional Delft3D hydrodynamic model of Port Phillip Bay, driven using measured tidal water levels from the Lorne tide gauge, but excluding wind forcing. These results compare well with the point measurements in the tidal inlet (WL 2007a). Comparison is made between model results and AWAC wave observations at RBO and RB inside the tidal inlet.

Both the completeness and quality of this set of observational data is considered as being good (except that the absence of simultaneously measured offshore wave data is considered a drawback, see below). The data set is suitable for studying wave-current interaction, such as found in the tidal inlets of the Wadden Sea, in the field. Hence, these field cases are considered to be suitable to take up as validation cases in SWIVT. The selected hindcast instants, including their most relevant physical characteristics and SWIVT case codes, are listed in Table 1.

As mentioned above, a shortcoming of this test case is the absence of wave observations that are far enough offshore to be used as spatially uniform boundary conditions along the offshore model boundary. The boundary conditions used for the hindcasts were therefore estimated by trial and error using the SWAN version 40.51AB. This implies that the boundary conditions for this test case are valid only for this version of SWAN, and should be re-derived for use with future model versions or when applied with different numerical and/or physical model settings.

References

WL (2007a). Evalation and development of wave-current interaction in SWAN. WL | Delft Hydraulics Report H4918.60, November 2007.



Field case of Port Phillip Bay Heads for June and October 2006, with observation stations and computational grid (every 2nd grid line, WL 2007a)	Validation cases SWIVT	
DELTARES	H5107.66	Fig. 6.1