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A coupled modelling system for the Irish Sea and Liverpool Bay with application to coastal flood forecasting and beyond

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The POLCOMS-WAM coupled wave and hydrodynamic model has been implemented at 1.8km resolution for the Irish Sea and 180m in a nested model of Liverpool Bay. It can be forced with output from the UK Met Office Unified Model. This allows the use of Smith and Banke (1975) and Charnock (1955) formulations for the wind-stress. The former gives an underestimate of the wind-stress, requiring enhanced winds for accurate surge hindcasts. While the latter gives good results for the Irish Sea and Liverpool Bay, with different values of the Charnock coefficient, it also allows the inclusion of a coupled wave stress into the wind-stress (Brown and Wolf, 2009). New results have been obtained by using wind and pressures from the WRF atmospheric model, allowing further development of air-sea coupling.

The coupled model also includes bottom friction and the Doppler shift of the waves by the depth-averaged current), as well as advanced coupling procedures: use of the 3D current in the wave physics and calculation of radiation stress and Stokes' drift (Brown et al., 2011). During storm conditions it is found that the radiation stress is the most important term in this shallow water application. However, WAM runs in near real time, making this model only practical for research purposes.

The model system has been used to hindcast tides, surges and waves in Liverpool Bay. Data are readily available from the Liverpool Bay Coastal Observatory to quantify the importance of each coupled term with the aim of producing the most accurate model setup for coastal forecasting. A storm event, 18th January 2007, has been hindcast to investigate extreme tide–surge–wave condition both offshore and inshore. During storm events, wave setup in shallow regions can contribute significantly to the total water elevation. The application of a 2D method to calculate radiation stress in a 3D hydrodynamic model is thoroughly examined by comparison with observations and a 3D model (Mellor, 2003). The results show that the 2D method is not only more computationally efficient, so more relevant for operational use, than the 3D solution, but also provides a more plausible solution, especially when coupled to a circulation model to allow proper distribution of wave setup. Radiation stress is demonstrated to be of major importance at an estuary mouth and along the coast, while having lesser impact within an estuary and further offshore.

Further development of the coupled system includes modelling of SPM and water quality, both important and complex in this region of freshwater influence.

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