

The coastal ocean atmospheric boundary layer and air-sea interaction in Liverpool Bay, with application to surge and wave modeling and coastal impacts of storms

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Background

Liverpool Bay is part of the northern Irish Sea, lying between NW England and N Wales, in which an intensive oceanographic observation and modelling programme is taking place as part of the POL Coastal Observatory (<http://cobs.pol.ac.uk>). Long-term measurements of waves and currents are being made from moored instruments and shore-based radars. Measurements of the marine atmospheric boundary layer are being made at a tower on Hilbre Island, where the X-band radar is based which measures waves and bathymetry over a region of radius several kilometres. Detailed models of tides, wind-driven and density-driven currents, waves and sediments are being developed in this area and the coastal impacts of storm waves and surges have been studied over many years. As part of the EU FIELD_AC project we are further developing the POLCOMS-WAM coupled model system to include a WRF mesoscale atmospheric model which will enable examination of air-sea interaction processes and feedback from the waves into the atmospheric boundary layer.

Project

Model winds are routinely supplied to NOC from the UK Met Office mesoscale model (presently at 12km resolution). The winds are in general quite accurate, although from recent work (Wolf et al., 2011) there is a suggestion that the model winds are underestimated in the near-shore zone, and the wave model may be underestimating waves in fetch-limited (offshore-directed) winds. Also the local effects of the land-sea boundary layer and the mountains of Snowdonia will have important local effects, which are not well-resolved in a 12km model. Land-sea breeze effects will also be locally important. We are presently implementing the NCEP/NCAR WRF model which is widely used by many research groups. This is a limited-area, nonhydrostatic, terrain-following sigma-coordinate models designed to simulate or predict mesoscale atmospheric circulation. The project will investigate the capabilities of this model and its implementation for the Liverpool Bay area. Details of the atmospheric boundary layer in the coastal ocean will be the primary focus of the study, investigating the air-sea momentum exchange to waves and currents, with impacts on coastal flooding and erosion in extreme storms. The atmospheric model will be used to drive the POLCOMS-WAM hydrodynamic and wave model system and results will be compared with the available measurements to investigate the local variability of winds, waves and currents in Liverpool Bay. The project will link to the FIELD_AC project – which aims to improve nearshore oceanographic forecasts using state-of-the-art models applied to four test areas; one of which is Liverpool Bay. As part of this project we are presently setting up the WRF model for the Irish Sea and Liverpool Bay, in collaboration with the Barcelona Supercomputing Center. Supervisors at the University of Leeds Atmospheric Dynamics group working on boundary layer modeling will also assist in model setup and investigation.

The hypothesis to be tested is that there are processes of orographic interaction affecting winds in Liverpool Bay, steering the local winds, which will significantly affect the nearshore oceanographic forecasts of waves, currents and mixing. There will also be some effects on precipitation which is important for freshwater run-off and water quality modeling.

Workplan

- Background reading on ocean-atmosphere interactions
- Literature Review
- Familiarisation with POLCOMS-WAM model
- Set up WRF model
- Implement atmosphere-ocean interactions
- Validate model system against available data
- Design model experiments to investigate the importance of the wave coupling in the atmosphere-ocean momentum exchange in the nearshore zone
- Write up results

Training

The student will divide their time between Leeds and Liverpool. At least one year will be spent in Liverpool, probably after the first year which will be spent mainly in Leeds for orientation and basic research training, with short visits to NOC. The student will receive training in modelling techniques as well as basic research skills and have the opportunity to become familiar with data analysis of various instruments for measuring wind and waves. There will be the opportunity to present this work at local, national and international meetings. The supervisors will provide guidance in the development of a solid grounding in atmosphere and ocean dynamics, especially coastal oceanography and the atmospheric boundary layer. A good degree in the physical sciences as well as mathematical aptitude is required.

References/background reading

Brown, J. and Wolf, J. 2009 Coupled wave and surge modelling for the eastern Irish Sea and implications for model wind-stress. *Continental Shelf Research* 29 (10), 1329–1342.

Gill, A.E. 1982 *Atmosphere-ocean dynamics*. Academic Press.

Wolf, J., Brown, J. and Howarth, M.J. 2011 The wave climate of Liverpool Bay - observations and modelling. *Ocean Dynamics* (in press).

The Irish Sea Coastal Observatory: <http://cobs.pol.ac.uk>

The FIELD_AC project: http://lim050.upc.es/field_ac/