Particle tracking in the eastern Irish Sea

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Introduction

As part of the ARCoES project, we are investigating climate change impacts on coastal energy infrastructure. The eastern Irish Sea has sometimes been called the Energy Coast because of its high tidal range, and existing and planned conventional and nuclear power plants.

We are interested in transport pathways for various substances in the eastern Irish Sea, a semi-enclosed basin, subject to industrial pollution and excess nutrients from coastal and riverine effluent over more than 2 centuries, including radioactive discharges from the Sellafield nuclear reprocessing plant since 1952. Will these pathways change under future climate/SLR scenarios?

Figure 1: Eastern Irish Sea and particle release points (adapted from Plater and Grenville, 2011)

FVCOM Modelling

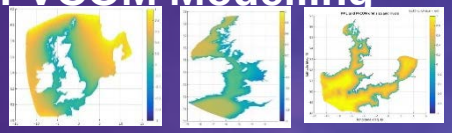

Figure 2: 3 different model grids (a) SSM, (b) ISM, (c) WCSM model resolution. Chose (c) for best near-shore resolution with least number of elements/nodes (Cazenave et al., 2016)

The FVCOM model has an unstructures triangular grids which allows good coastal resolution while not requiring high resolution everywhere (Chen et al., 2003)

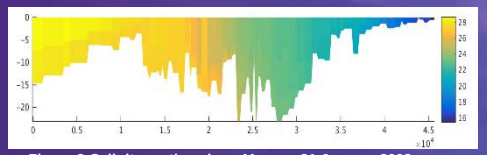

Figure 3: Salinity section along Mersey, 31 January 2008

The density-driven circulation can be important for sediment transport in the nearshore zone (Brown et al., 2015)

Particle Tracking

This is carried out by offline Lagrangian particle tracking. Advection and horizontal and vertical dispersion (random walk) are optionally included. Particle tracking was run offline in post-processing model as in Wolf et al. (2016a, b).

Two seasonally contrasting months have been run for a recent year (2008). January experienced high rainfall and several storms (Brown et al., 2016), whereas June was calm and dry.

We have also examined several future SLR scenarios: 0.259m SLR for 2050 (UKCP09), 1.9m SLR for 2100 (UKCP09 H++ scenario) for 2500 in which SLR is 5.49m (Jevrejeva, 2012). Here we show the far future 2500 scenario, this is used since the potential lifetime of management of nuclear waste after decommissioning can be several centuries and we know sea level will continue to increase even if global warming stabilises.

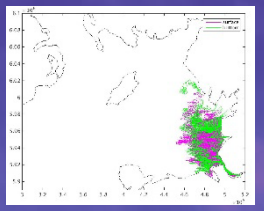

Figure 4: Particle tracks from Mersey, January 2008

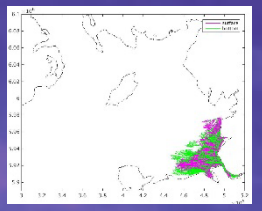

Figure 5: Particle tracks from Mersey, June 2008

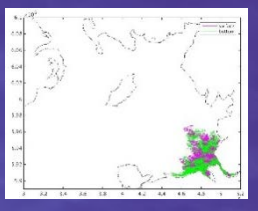

Figure 6: Particle tracks from Mersey, January 2500

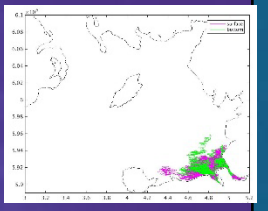

Figure 7: Particle tracks from Mersey, June 2500

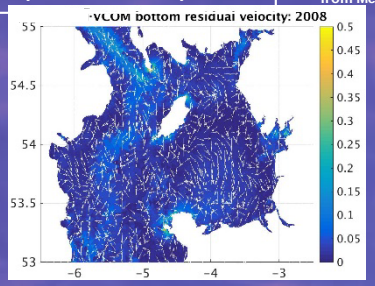

Figure 7: Surface current residuals 2008

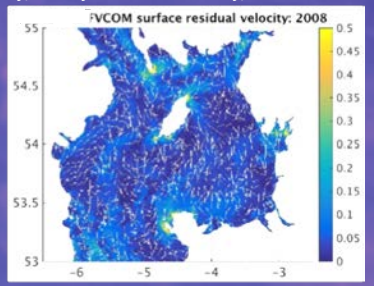

Figure 8: Bottom current residuals 2008

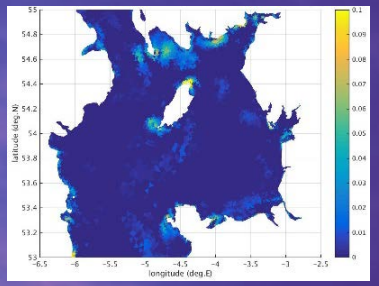

Figure 9: Difference in surface current residual 2500-2010

Mean annual residual currents do change in an increased SLR scenario (Fig. 9) but don't tell the whole story. There are significant seasonal changes from month to month

Conclusions and Future Work

The transport pathways in the eastern Irish Sea are affected by wind and density-driven circulation. In a winter month with high river run-off and several storm events the tracks extend further north. In a calm and dry summer month the pathways extend further to the west. These changes are modified in a future high-end SLR scenario.
Further work is needed to explore the dispersion and test different parameters in the model.

References

Brown, J. M., Amoudry, L. O., Souza, A. J., & Rees, J. (2015) Fate and pathways of dredged estuarine sediment spoil in response to variable sediment size and baroclinic coastal circulation. *Journal of Environmental Management*, 149, 209-221.
Cazenave, P.W., Torres, R. and Allen, J.I. (2016) Unstructured grid modelling of offshore wind farm impacts on seasonally stratified shelf seas. *Progress in Oceanography*, 145, 25-41.
Chen, C., Liu, H. and Beardsley, R.C. (2003) An Unstructured Grid, Finite-Volume, Three-Dimensional, Primitive Equations Ocean Model: Application to Coastal Ocean and Estuaries. *Journal of Atmospheric and Oceanic Technology*, 20, 159-186.
Jevrejeva S J C, Moore and Grinsted A (2012) Sea level projections with new generation of scenarios for climate change Glob.Planet. Change 80–81 14–20
Plater, A.J., Grenville, J., (2010). Linking the eastern Irish Sea to the Sefton Coast. In Sefton's Dynamic Coast, Proceedings of the conference on coastal geomorphology, biogeography and management 2008. Eds. Worsley, Lymbery, Holden and Newton, pp. 28–54.
Wolf, J., Yates, N., Brereton, A., Buckland, H., De Dominicis, M., Gallego, A. and O'Hara Murray, R. (2016a). The Scottish Shelf Model. Part 1: Shelf-Wide Domain. *Scottish Marine and Freshwater Science*, 7 (3), 151pp.
Wolf, J., Stuiver, C, Price, D. Johnson, H, Gallego, A. and O'Hara Murray, R. (2016b). The Scottish Shelf Model. Part 6: Wider Domain and Sub-Domains Integration. *Scottish Marine and Freshwater Science*, 7 (8), 150pp.

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