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Estimation of coastal density gradients

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Density gradients in coastal regions with significant freshwater input are large and variable and are a major control of nearshore circulation. However their measurement is difficult, especially where the gradients are largest close to the coast, with significant uncertainties because of a variety of factors - spatial and time scales are small, tidal currents are strong and water depths shallow. Whilst temperature measurements are relatively straightforward, measurements of salinity (the dominant control of spatial variability) can be less reliable in turbid coastal waters.

Liverpool Bay has strong tidal mixing and receives fresh water principally from the Dee, Mersey, Ribble and Conwy estuaries, each with different catchment influences. Horizontal and vertical density gradients are variable both in space and time. The water column stratifies intermittently. A Coastal Observatory has been operational since 2002 with regular (quasi monthly) CTD surveys on a 9 km grid, an situ station, an instrumented ferry travelling between Birkenhead and Dublin and a shore-based HF radar system measuring surface currents and waves. These measurements are complementary, each having different space-time characteristics. For coastal gradients the ferry is particularly useful since measurements are made right from the mouth of Mersey. From measurements at the in situ site alone density gradients can only be estimated from the tidal excursion. A suite of coupled physical, wave and ecological models are run in association with these measurements. The models, here on a 1.8 km grid, enable detailed estimation of nearshore density gradients, provided appropriate river run-off data are available.

Examples are presented of the density gradients estimated from the different measurements and models, together with accuracies and uncertainties, showing that systematic time series measurements within a few kilometres of the coast are a high priority. (Here gliders are an exciting prospect for detailed regular measurements to fill this gap.) The consequences for and sensitivity of circulation estimates are presented using both numerical and analytic models.