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Transient controls on estuarine SPM fluxes: case study in the Dee Estuary, UK.

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Estuaries are a critical interface between land and coastal ocean across which freshwater, suspended particulate matter (SPM), and consequently terrestrial carbon, nutrients and anthropogenic contaminants are exchanged. Suspended particulate matter is closely linked to estuarine turbidity; it affects water quality and estuarine ecology; and it contributes to overall estuarine sediment budgets. However, predicting the response of estuarine ecosystems to climate change and human interventions remains difficult partly due to a lack of comprehensive understanding of SPM concentrations and fluxes across time scales from intratidal to seasonal and interannual variability.

We investigate the dynamics of suspended sediment and suspended particulate matter in a hypertidal estuary with a maximum tidal range in excess of 10 m and tidal currents reaching over 1 m/s: the Dee Estuary. This estuary is located in northwest England and outflows in Liverpool Bay, itself in the eastern Irish Sea. The Dee Estuary is a funnel-shaped, coastal plain estuary, which is about 30 km long with a maximum width of 8.5 km at the mouth, and consists of mixed sediments. We focus on field observations, collected during several campaigns in the channels of the Dee Estuary from 2004 to 2009 using acoustic and optical instrumentation, which provide intratidal measurements of flow velocity and suspended sediment, and thus sediment fluxes, over approximately a month.

Measurements in February-March 2008 highlight three distinct hydrodynamic regimes: a current dominant regime at neap tides (14-21 February); a combined wave-current regime at spring tides (21-29 February); and a wave dominant regime at neap tide (1-4 March). While analysis of tidal distortion and dominance predicts weak ebb dominant channels, the observations yield flood dominant sediment transport. The net sediment flux exhibits a two-layer structure – import near the bed, export near the surface – that is consistent with the residual circulations in the estuary. Wavelet analysis provides clear evidence that such influx of sediment in the estuary is alternatively the result of periodic stratification at neap tides and of tidal asymmetry in suspended sediment concentration at spring tides. Such transient processes will be important to determine and predict estuarine responses to short-lived perturbations. Further analysis of other field campaigns will enable to determine the persistence of these processes over seasonal and annual timescales.