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Project Title: Controls on Carbon Burial Rates in Subtropical Environments: The Role of Spatial Heterogeneity of Vegetation Density and Sediment Supply

PI: Julia Mullarney, Faculty of Science and Engineering, the University of Waikato
Co-PI: Karin Bryan, Faculty of Science and Engineering, the University of Waikato

Over the past year, work has predominantly focussed on developing a numerical model for a flat-fronted deltaic system. The model is designed as an idealised version of the real Firth of Thames system. Although the key dimensions are similar to those of the real system, multiple simplifications have been made to allow us to explore the fundamental underlying dynamics of the system without the additional complexities arising from the asymmetric geometry. In particular, the first model features only a single river input at the centre of the domain (future work will explore multiple river inputs to the system). Dimensions of the real system, the model grid and bathymetry are shown in Figure 1. The model was forced with a M2 tide (of amplitude 1.3 m) and depth-uniform constant salinity at the northern open boundary and a constant freshwater input at the river boundary. A spatially varying bottom roughness coefficient was used to represent the enhanced bed roughness within the mangrove forests.

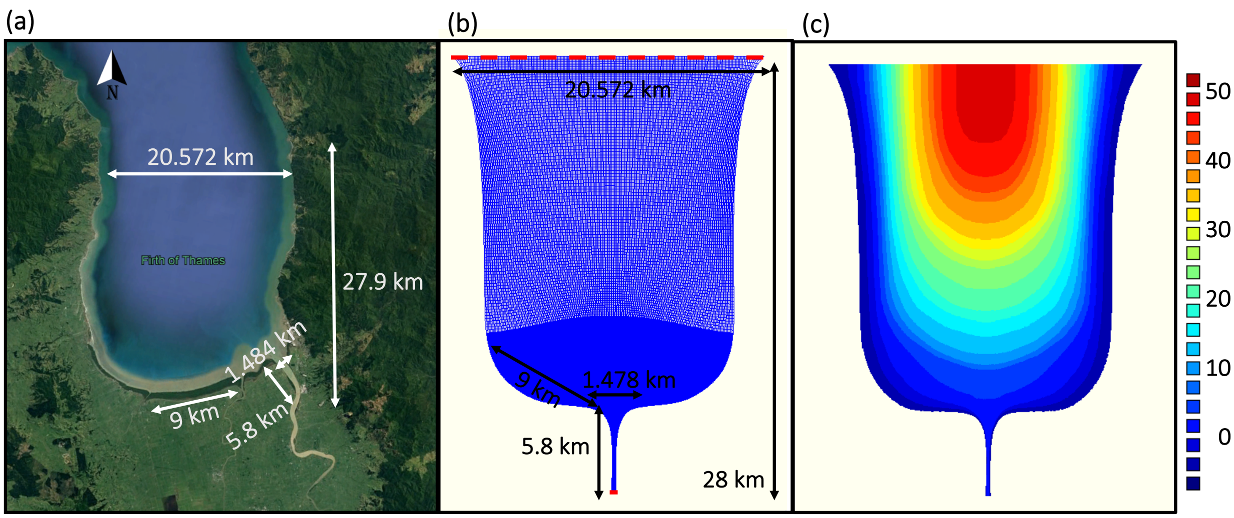

Figure 1: (a) Firth of Thames field site and key dimensions. Idealised symmetric model grid (b) with open boundary (dashed red line) and river boundary (solid red line) and bathymetry in m (c). The grid was composed of three domains with resolutions varying from 170 x 160 m in the upper grid, 15 x 6 m in the mangrove regions and 20 x 20 m in the river.

Scenarios were undertaken with spatially and temporally uniform wind forcing applied from different directions to examine the effects of wind speeds and direction on the plume propagation and interaction with vegetation. Hence, given the river plume is a key mechanism of sediment delivery to the system, plume extent will affect the eventual sediment deposition. Even under directly opposing winds, the signature of the freshwater plume extended several kilometres into the Firth, consistent with plume dimensions from in satellite images, (e.g. Figure 1a). Results also revealed that the plume was sensitive to wind direction, particularly during flood tide (Figure 2 panels c and show the plume, evident by the reduced salinity, forced into the mangrove forest lining the river by obliquely incident winds).

Additional trial model runs have also been undertaken with a constant concentration of mud input through the river boundary. The preliminary results indicate mud deposition occurs primarily along the sides of the river channel and as the plume loses momentum and debouches from the river mouth, thus forming a cuspate delta (Figure 3). However, we note these runs are not initiated from a system in morphological equilibrium. Further work will examine the deposition patterns across the mudflat-forest boundary in detail, and will explore the dependence of deposition on different parameterisations for vegetation, vegetation density and plume structure. The model will also be used to inform the instrument deployment sites for the second major field experiment.

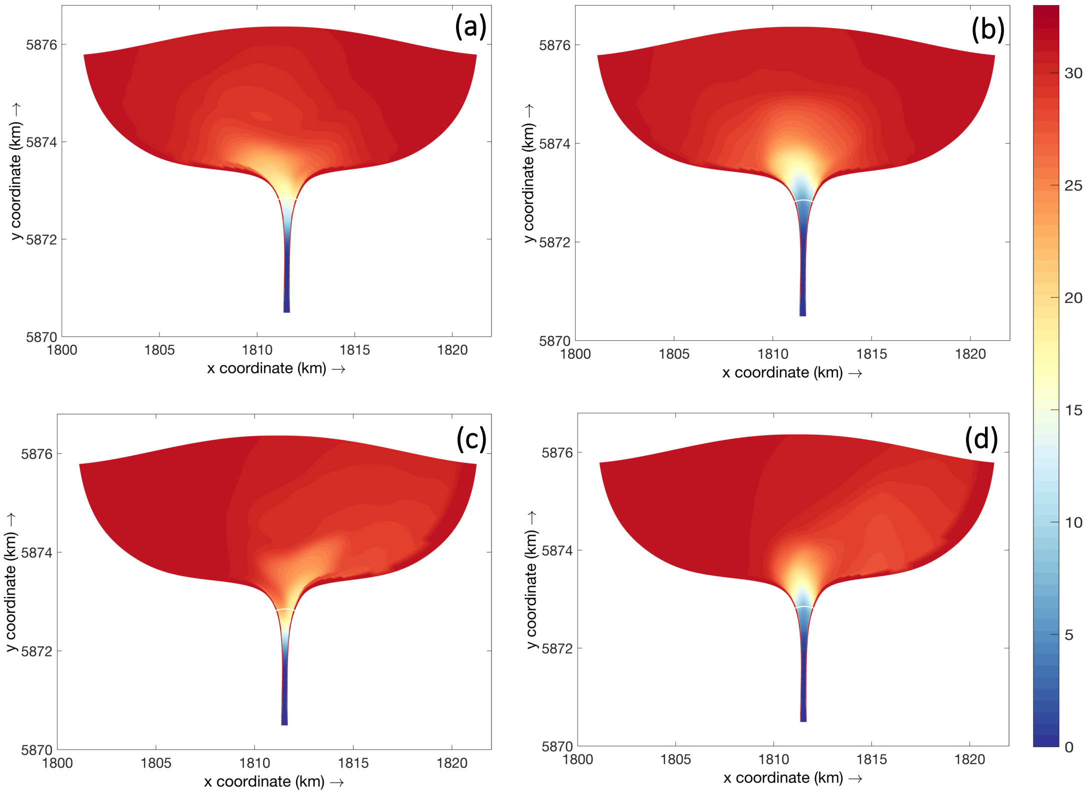

Figure 2: Salinity in ppt in the surface layer (1 of 5) showing plume exiting from the river mouth. In all simulations about, the constant wind speed was 5 m/s. (a) and (b) show winds from north, and (c) and (d) show winds from 300º. Left-hand panels (a and c) show the plume during maximum flood tide and right-hand panels show the plume during maximum ebb tide.

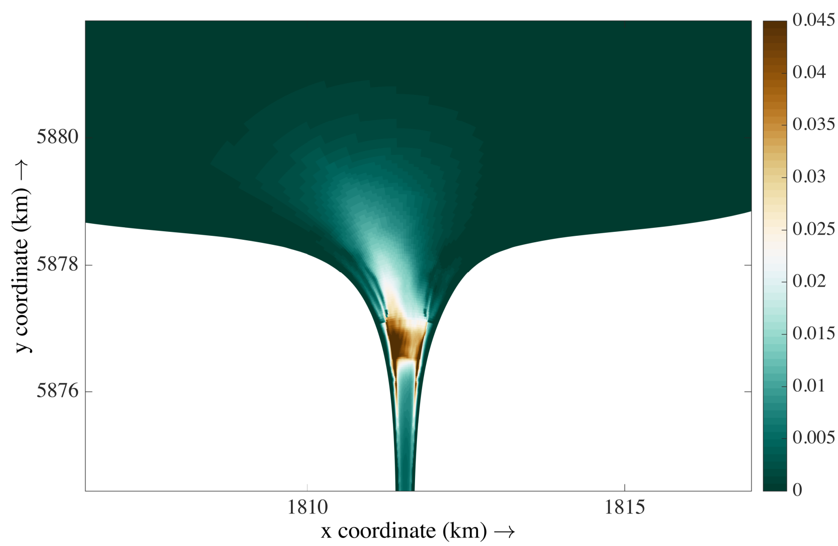

Figure 3: Preliminary results showing patterns of sediment deposition (in m) after 168 tidal cycles (~86 days) with a riverine mud input of 1 kg/m³.

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