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Large-scale scour in response to tidal dominance in estuaries

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Channel beds in estuaries and deltas often exhibit a local depth maximum at a location close to the coast. There are two known causes of large-scale (i.e. >10 river widths along-channel) channel bed scours: width constriction and draw down during river discharge extremes, both creating a local flow acceleration. Here, we systematically investigate a potential third mechanism. We study the effect of tidal dominance on the equilibrium channel bed in estuaries with a 1D-morphodynamic model. In estuaries, a morphodynamic equibrium is reached when the net (seaward) transport matches the upstream supply along the entire reach. The residual (river) current and river-tide interactions create seaward transport. Herein, river-tide interactions represent the seaward advection of tide-induced suspended sediment by the river flow. Tidal asymmetry typically creates landward transport. The main reason for scour formation is the amplification of tidal flow through funnelling of tidal energy. Only for a scouring profile the drop in river induced current magnitude reduces the river-tide interaction term, so that the net sediment transport matches the upstream sediment transport. When tidal influence is relatively large, and when channel convergence is strong, a equilibrium is only obtained with a scouring profile. We propose a predictor dependent on the width convergence, quantified as S_B, and on the ratio between the specific peak tidal discharge at the mouth and the specific river discharge at the landward boundary (q_{tide}/q_{river}). Scours develop if (q_{tide}/q_{river})/S_B exceeds 0.3. These results are independent of scale and allow the prediction of scour in estuaries under future changes.