Temporal and Spatial Scales of Autogenic Dynamics in Linked Fluvial-Marine Systems

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The role of nearshore processes in controlling the plan-view morphology of delta lobes is relatively well understood. Less clear is the potential in linked transport systems for shallow-marine processes to communicate ‘upstream’ and thus modulate autogenic processes in the attached fluvial environment. Using a combination of theory and observation, we investigated one form of this communication by considering how wave-driven longshore transport might set the tempo of distributary-channel avulsion and the length scale of individual delta lobes. We developed a semi-analytical mathematical model that couples the rudimentary dynamics of an avulsing distributary channel to diffusive longshore transport in the associated surf zone. In our simple model, sand is sequestered in distributary channels and the shoreface; the unlimited mud supply fills space on the floodplain and seaward of the shoreface. Our analysis spanned a wide range of wave energy, sediment supply, and subsidence rate. In progradation-dominated model deltas, the effect of delta lengthening with time was a reduction in sand flux at the channel terminus, thereby causing a progressive shift to a more wave-dominated state. As a result, both the channel residence time and the length scale of individual lobes (extent of smearing) increased throughout progradation. For aggradation dominated deltas, where the bulk sedimentation rate balances the subsidence rate and the mean shoreline position is stationary, our analysis points to a rich interplay between fluvial and nearshore processes that controls the overall size (radius) of the equilibrium delta. As wave energy increases, longshore smearing of fluvial sand input increases, thereby reducing channel aggradation rate and hindering avulsion; consequently, individual lobes are larger and system sequesters less sand in channel belts on the delta plain, thereby providing proportionately more sand to maintain the equilibrium shoreface at a larger overall delta radius. In addition to theory, we present data and preliminary interpretations from a suite of natural deltas; at first order, these data support our model predictions for the variation in avulsion frequency and lobe size with wave energy. It would seem that under appropriate conditions, the tail (longshore transport) can, in part, wag the dog (distributary channel).