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Mesoscale mechanics of distributive channel systems with supercritical distributaries: an experimental study of alluvial and submarine fans

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Cyclicity is a feature of distributive channel systems whereby the landform is modified by either: variation in boundary conditions, e.g., sea-level rise/fall on deltas, or feedbacks triggered and maintained by intrinsic system mechanics, i.e. autogenic processes. The intrinsic organization of coupled fluid/sediment systems is predictable over small scales, i.e. bedform development and evolution; similar relationships can be developed for sedimentary systems over the mesoscale, i.e. the channel and lobe scale. The most prevalent mesoscale process at work in a variety of settings is the avulsion cycle which takes a generic form of: distributive channel formation and basinward extension, deceleration and mouth bar deposition, flow interaction with the aggrading mouth bar and upstream retreat, and flow reorganization. Though this generic description holds in a general sense, a system's particular response is a function of several variables but is most deterministically tied to hydraulic regime relative to critical flow. Herein we describe the supercritical autogenic response of fan systems using experimental results that include data pertaining to both phases of the morphodynamic feedback cycle, the fluid flow and the mobile sediment bed. Non-invasive, image-based techniques were used to quantify the velocity field on evolving fans. Hydraulic characterization is combined with topographic scans to create a complete picture of mesoscale development. This combination makes for a unique data set in mesoscale geomorphology experiments where data is typically restricted to topography evolution with inferred hydraulic process.

Via experiments we show that supercritical distributaries experience hydraulic jump controlled backfilling and avulsion as distinguished from the backwater controlled avulsions occurring with subcritical distributive systems. Further, we consider both alluvial and submarine fan experiments to better examine the relative importance of setting (subaerial vs. subaqueous) and hydraulic regime (subcritical vs. supercritical) in explaining system mechanics.