Coupled Modeling of River and Coastal Processes: New Insights about Delta Morphodynamics, Avulsions, and Autogenic Sediment Flux Variability

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Motivation & Research Questions

- Deltas are flat & fertile \(\rightarrow\) densely populated
- Important for agriculture, resources, and transportation
- Inhabitants increasingly susceptible to natural disasters
- Humans have:
  - Decreased sediment supply (e.g., dams)
  - Altered river course (e.g., channelization, levees)
  - Relative sea-level rise rate (SLRR) increases \(\rightarrow\) aggradation & backfilling increase (morphodynamic backwater) \(\rightarrow\) avulsions assumed to be more frequent

What key feedbacks between fluvial and coastal processes drive avulsions and delta morphology? How are delta morphodynamics affected by changing forcings (e.g., sea-level rise) over long time scales?

New Delta Evolution Model

- Need to link both fluvial, deltaic, and coastal systems over multi-
  - avulsion and lobe-building timescales
- Based on couplings using the Community Surface Dynamics Modeling System framework (Basic Model Interface)
- Generalized & scale invariant
- Capable of simulating large space & time scales

Wave climate diffusivity affects morphology

- Low wave height: sign of wave climate diffusivity doesn’t matter; waves too low to affect shape
- Higher wave height: sign does matter, affects morphology & avulsion time scales
  - Diffusive (U<0.5) \(\rightarrow\) flat shorelines, progradation prohibited
  - Antidiffusive (U>0.5) \(\rightarrow\) locally smooth, but cusped shorelines

Avulsion time scales

- Diffusively-dominated: progradation slow, avulsions take longer to occur
- River-dominated or U>0.5: progradation not inhibited, avulsions happen quickly
- Increasing SLRR* only decreases avulsion time scales for wave-diffused deltas!
  \(\rightarrow\) In river-dominated or U<0.5 cases, lateral (transgressive) movement of shoreline counters base-level driven aggradation, no net affect on avulsion timing

Avulsion length scale

- Preferential length scale is a function of geometry (not varying discharge)
- Over-long-term, profile diffuses more rapidly than surrounding floodplain, becomes super-elevated at terminus concavity
- Length scales with critical SER, values scale well with lab and field data

Sediment flux variability

- Peaks represent avulsions
- River-dominated: larger cyclical peaks in flux
- Wave-dominated: less autogenic variability
- Increasing SLRR* \(\rightarrow\) more avulsions and variability for wave-diffused deltas (b/c base-level driven aggradation causes avulsions to occur more frequently)

References


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Visit https://github.com/kratliff or csmd.colorado.edu for code & more info.