Exploring delta morphodynamics with a coupled river-ocean model

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Motivation & Research Questions

- Deltas are flat & fertile → 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 → aggradation & backfilling increase (morphodynamic backwater) → avulsions more frequent

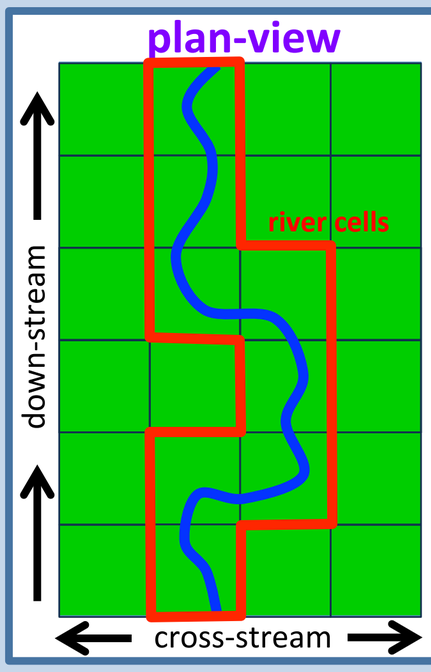
How do fluvial (river + floodplain) dynamics, wave climate, and RSLR affect delta morphology?

How do long-term delta morphodynamics depend on anthropogenic influences? (e.g., land-use and climate change)

New Delta Evolution Model

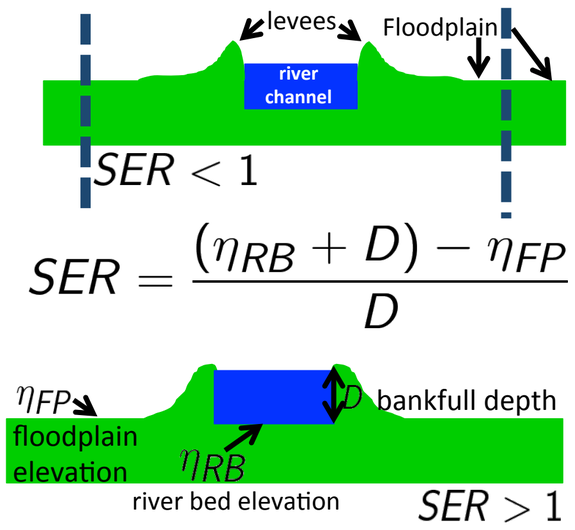
- Need to link both fluvial, deltaic, and coastal systems over multi-avulsion and lobe-building timescales
- Based on couplings using the Community Surface Dynamics Modeling System framework (Basic Model Interface)
- Generalized & scale invariant
- Capable of simulating large space & time scales

River Avulsion and Floodplain Evolution Model (RAFEM) ↔ **CSDMS Basic Model Interface** ↔ Coastline Evolution Model (CEM)



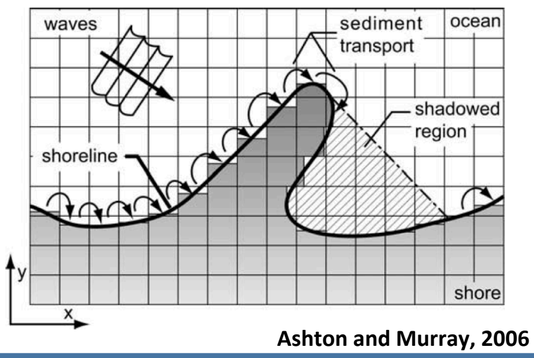
River Avulsion and Floodplain Evolution Model (RAFEM)

- **Cell width >> channel width**
- **Steepest-descent methodology** (following Jerolmack and Paola, 2007)
- **Diffusion of river profile** (Paola et al., 1992; Paola 2000)
- **River avulsions** triggered by **normalized super-elevation ratio (SER)** (Mohrig et al., 2000), **unsuccessful if not shorter** than previous path
- **Floodplain deposition** = crevasse splay (after 'failed' avulsion; steepest path longer than current course)



Coastline Evolution Model (CEM)

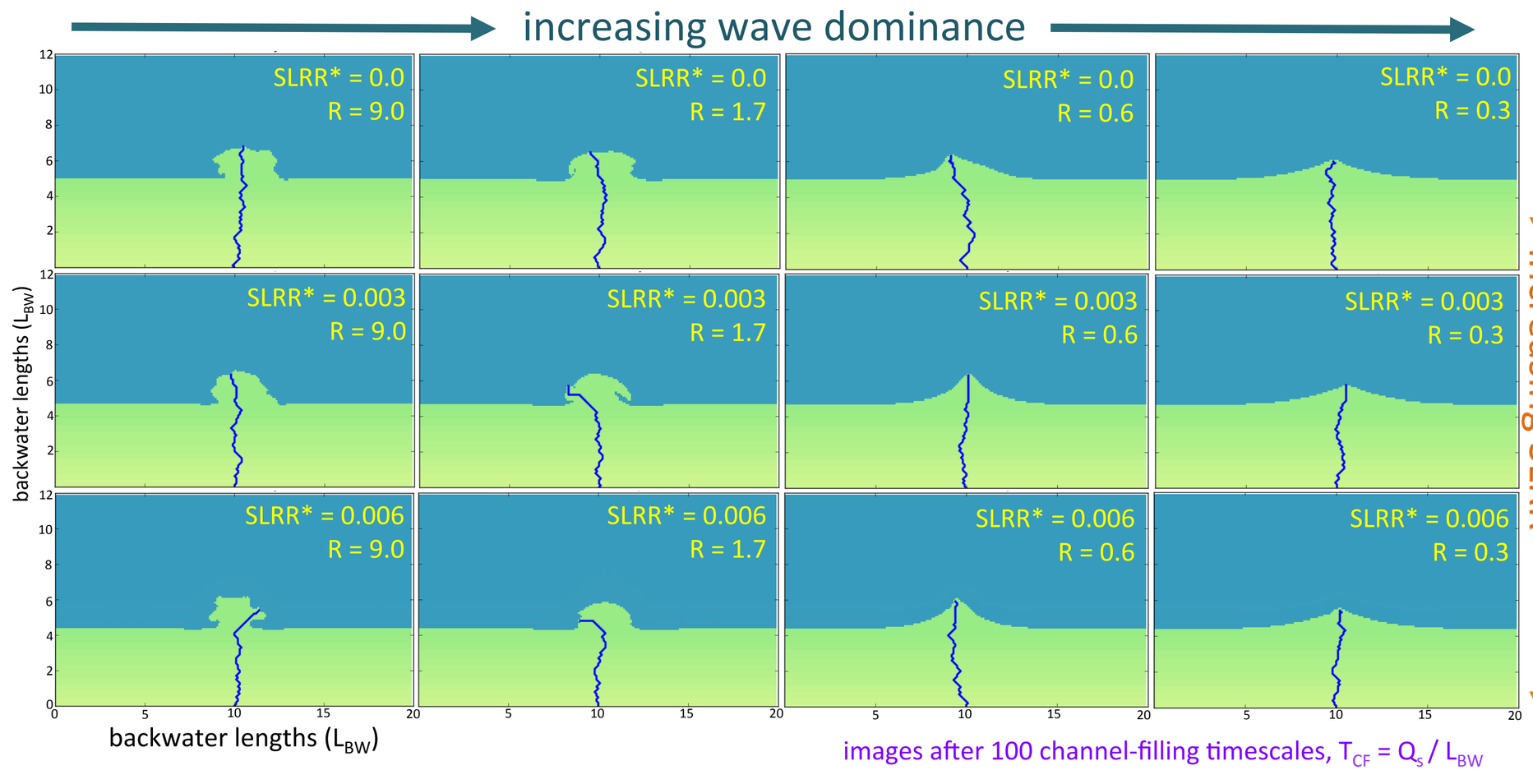
- Shoreline **erosion & accretion** driven by **alongshore sediment transport**
- **Conserves nearshore sediment**
- **Wave climate** and **shadowing**



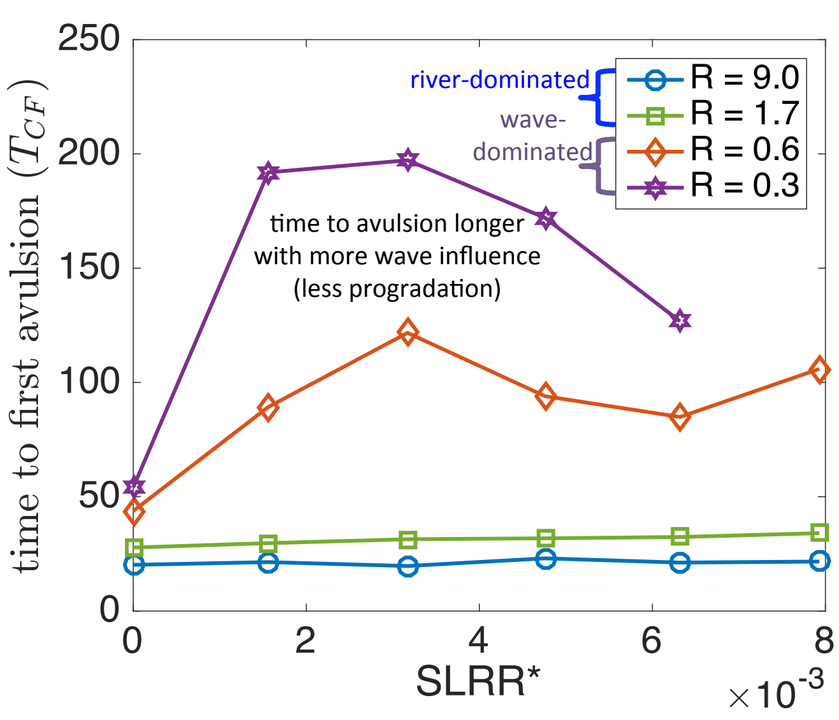
Ashton and Murray, 2006

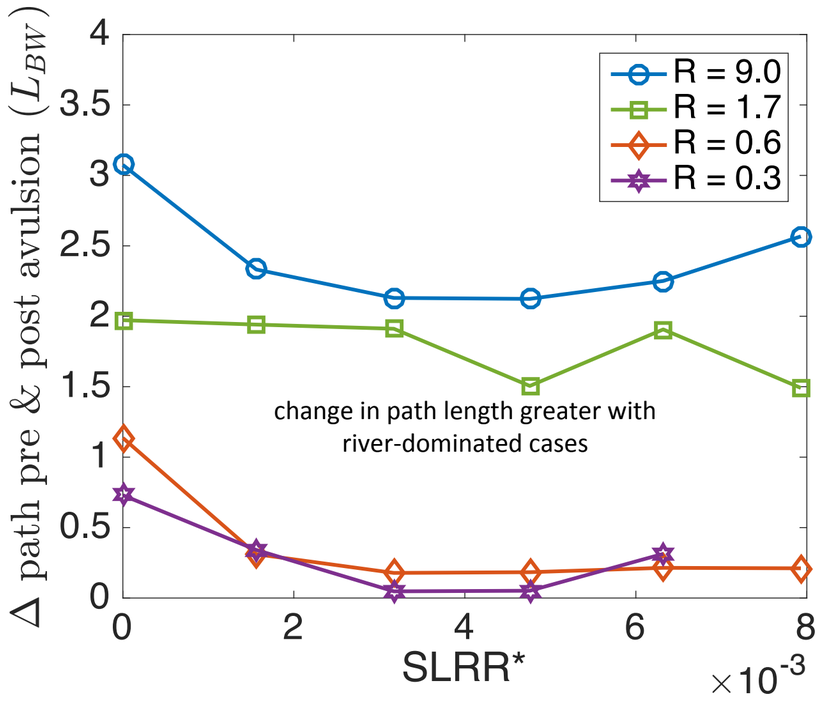
Preliminary Results

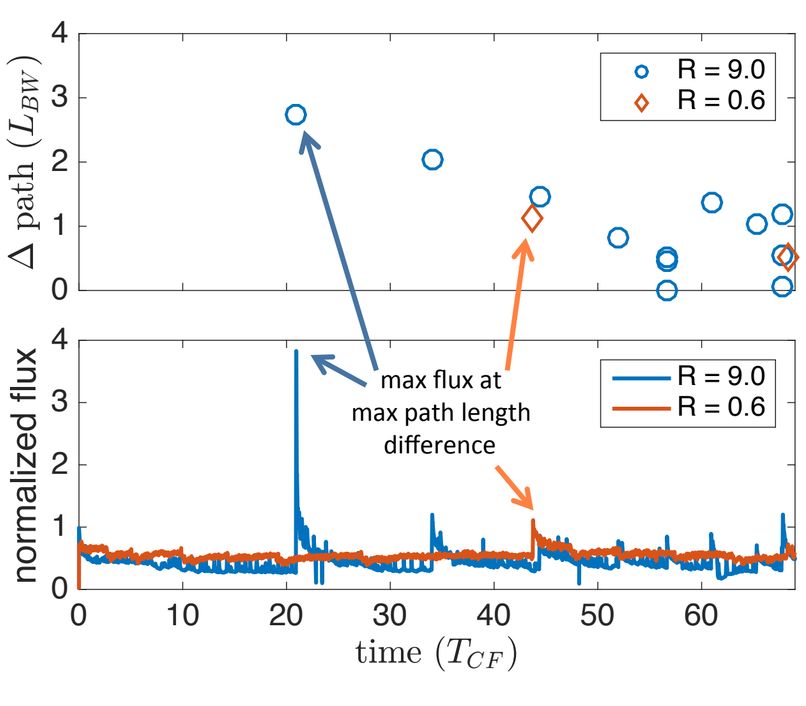
- **Increased wave dominance** (smaller fluvial dominance ratio R, where R < 1 is wave dominated [Nienhuis et al., 2015]):
  - longer time before first avulsion
  - avulsions localized, less river shortening
  - in long term, shoreline rugosity surprisingly low (even with R >> 1)
- **Higher SLRR**:
  - mostly does not accelerate avulsions
  - inhibits progradation; smaller lobes
  - only affects avulsion time scale in wave-dominated case
- **Waves affect river flux variations** with constant forcings:
  - fluxes highest with a large change in river length before and after avulsion
  - river dominance → more variance in fluxes (channel lengthens more rapidly)



images after 100 channel-filling timescales, $T_{CF} = Q_s / L_{BW}$







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Acknowledgements

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Visit https://github.com/katmratliff or csdms.colorado.edu for code & more info.