Tidal-Modulated Flow and Sediment Flux through Wax Lake Delta Distributary Channels

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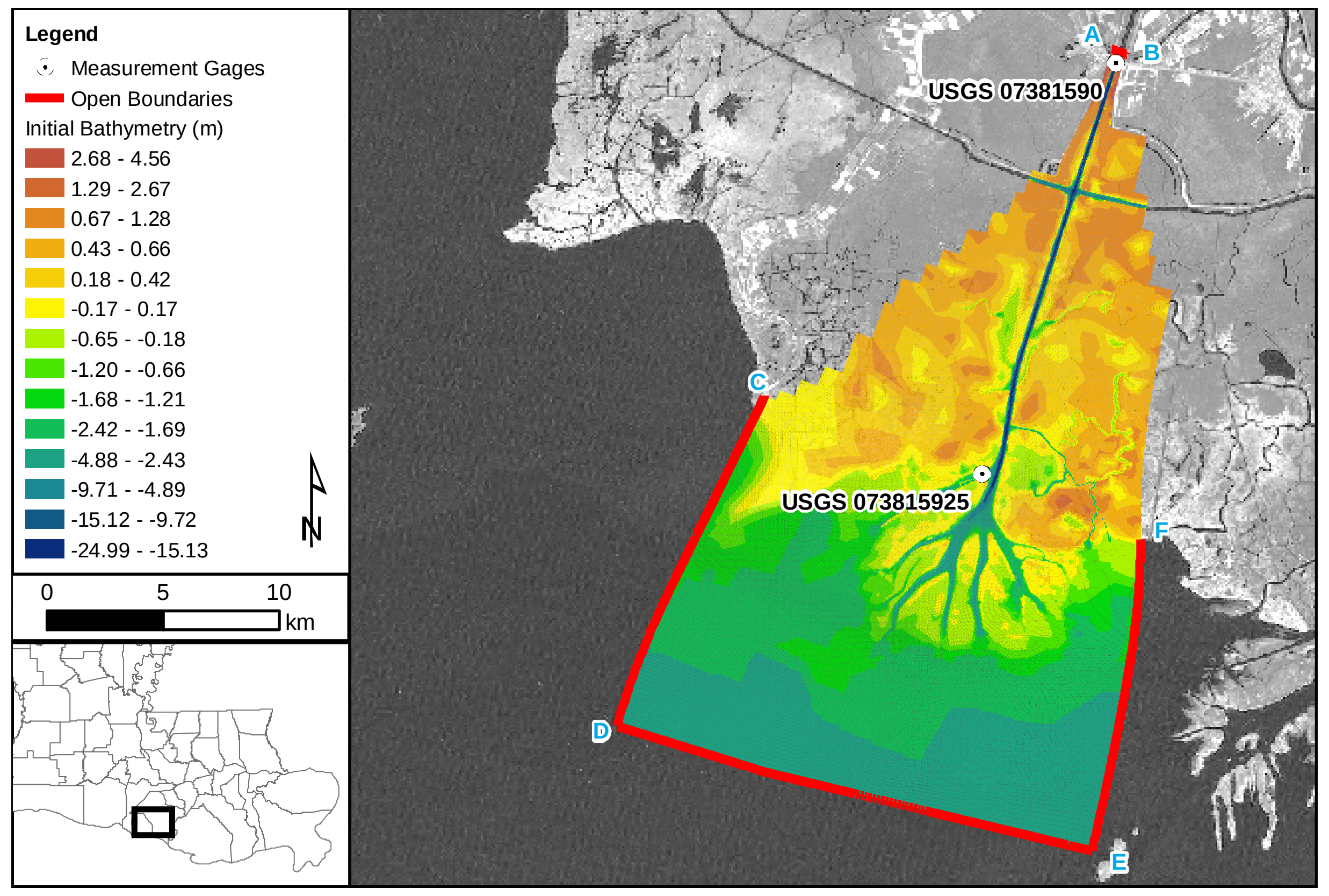
Introduction

The Wax Lake Delta (WLD) has prograded into the Atchafalaya Bay receiving basin through seaward channel extension, subaqueous river mouth bar formation, and channel bifurcation, building new land area in the form of sandy delta lobe deposits. With sediment supplied to the delta through the constructed Wax Lake Outlet (WLO) channel, the WLD is frequently cited as a natural analogue for the land-building potential of large sediment diversions from the Mississippi River.

Though traditionally viewed as river-dominant where delta progradation occurs through deposition during floods, recent work by Shaw & Mohrig (2013) documents erosive channel extension at the most distal portion of a WLD distributary channel during low flows and points to tidal modulation of flow velocities as the causative mechanism. The present study examines the hydrodynamics and sediment transport within the WLD during low flows in greater detail to both corroborate the findings of Shaw & Mohrig (2013) and gain greater insight into the potential sediment reworking in deltas during non-flood events.

Methods - Delft3D Model Development

- Delft3D simulates hydrodynamics, sediment transport, and morphology
- Depth-averaged hydrodynamics
- Upstream flow boundary forced with USGS gage data, offshore boundary forced with tidal constituents extracted from tidal databases
- Two sediment fractions: fine sand and cohesive mud



Wax Lake Delta Delft3D model domain and initial bathymetry. Model open boundaries are indicated by thick red lines.

Model Calibration

Table 1 Tidal constituent calibration results at water level gage locations

Station	*O1 η (m)*	*O1 norm. amp. ε*	*K1 η (m)*	*K1 norm. amp. ε*	*M2 η (m)*	*M2 norm. amp. ε*	*S2 η (m)*	*S2 norm. amp. ε*
07381590	0.039	-8 %	0.036	4 %	0.020	-33 %	0.001	-43 %
073815925	0.069	-8 %	0.064	3 %	0.050	-59 %	0.017	-28 %

η, measured constituent amplitude; *norm. amp. ε*, normalized error between measured and calculated constituent amplitudes

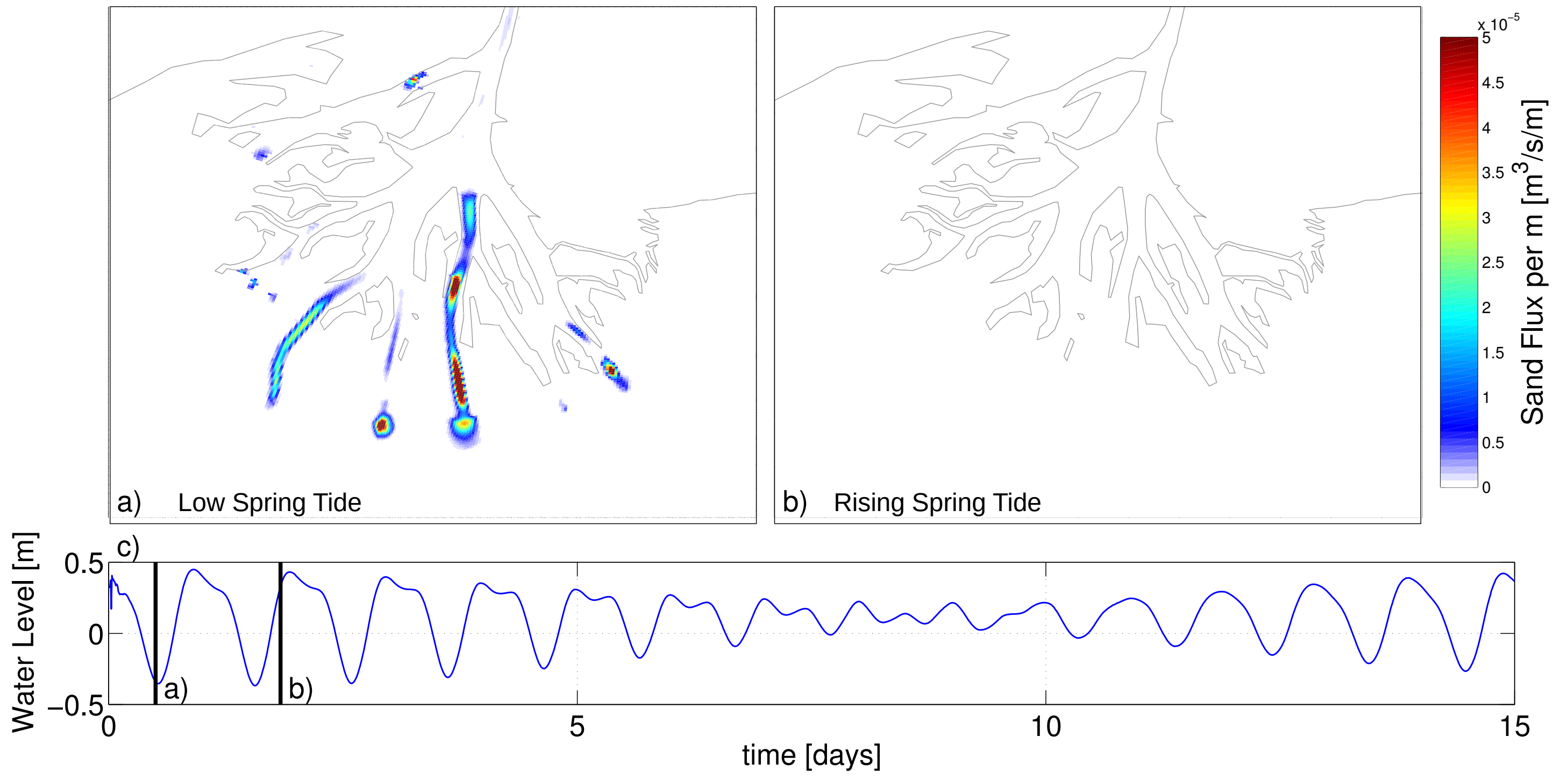
Table 2 Velocity and suspended sediment concentration calibration at transects from DuMars (2002)

Transect	*cs_8*	*cs_15*	*cs_17*	*cs_18*	*cs_21*
V norm. **ε**	-10 %	19 %	1 %	10 %	-9 %
C norm. ε	1 %	-24 %	-26 %	-16 %	-21 %

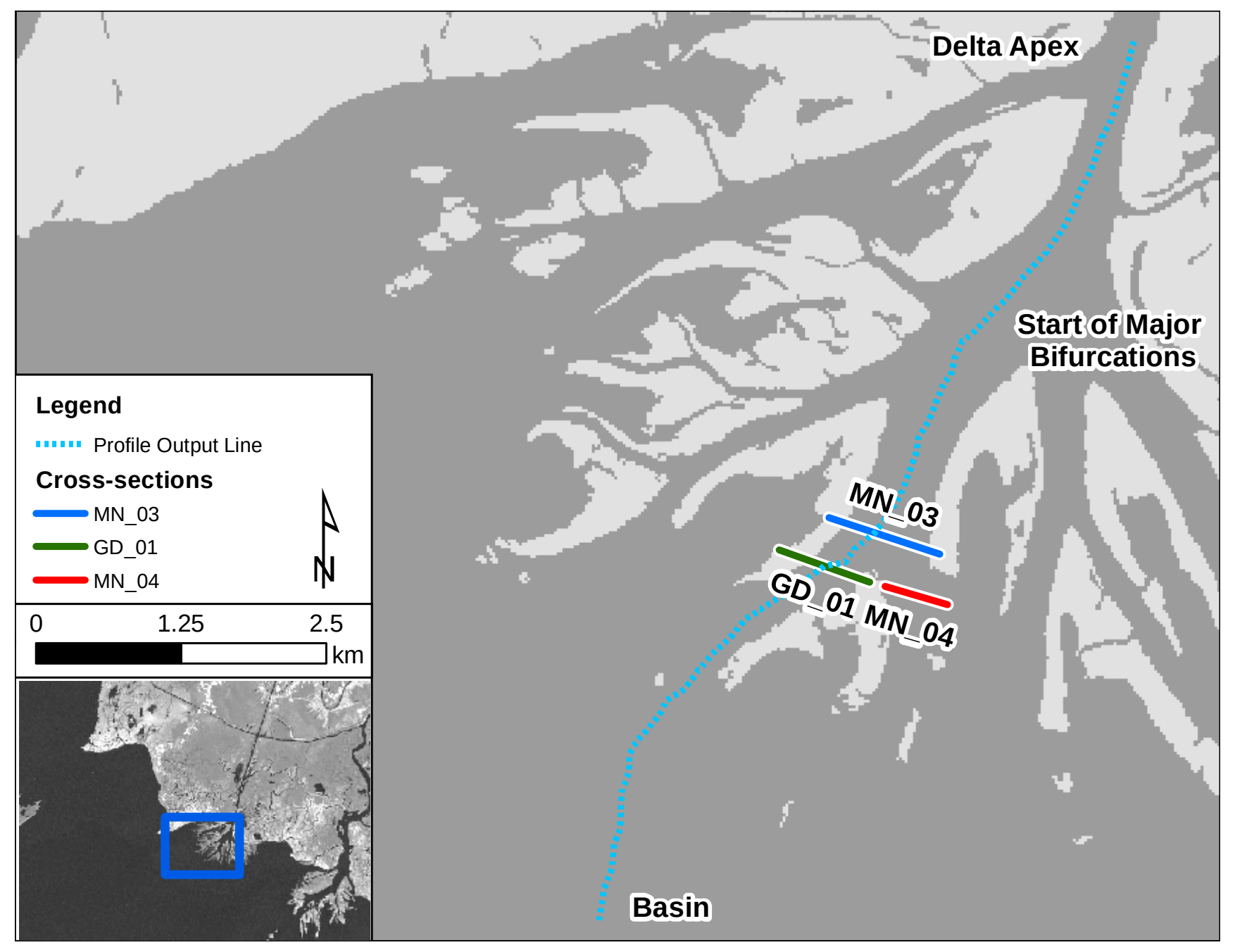
V norm. ε, error between measured and calculated channel-averaged velocity; C norm. *ε,* error between measured and calcuated channel-averaged suspended sediment concentration

Sand Flux through Distributary Channels

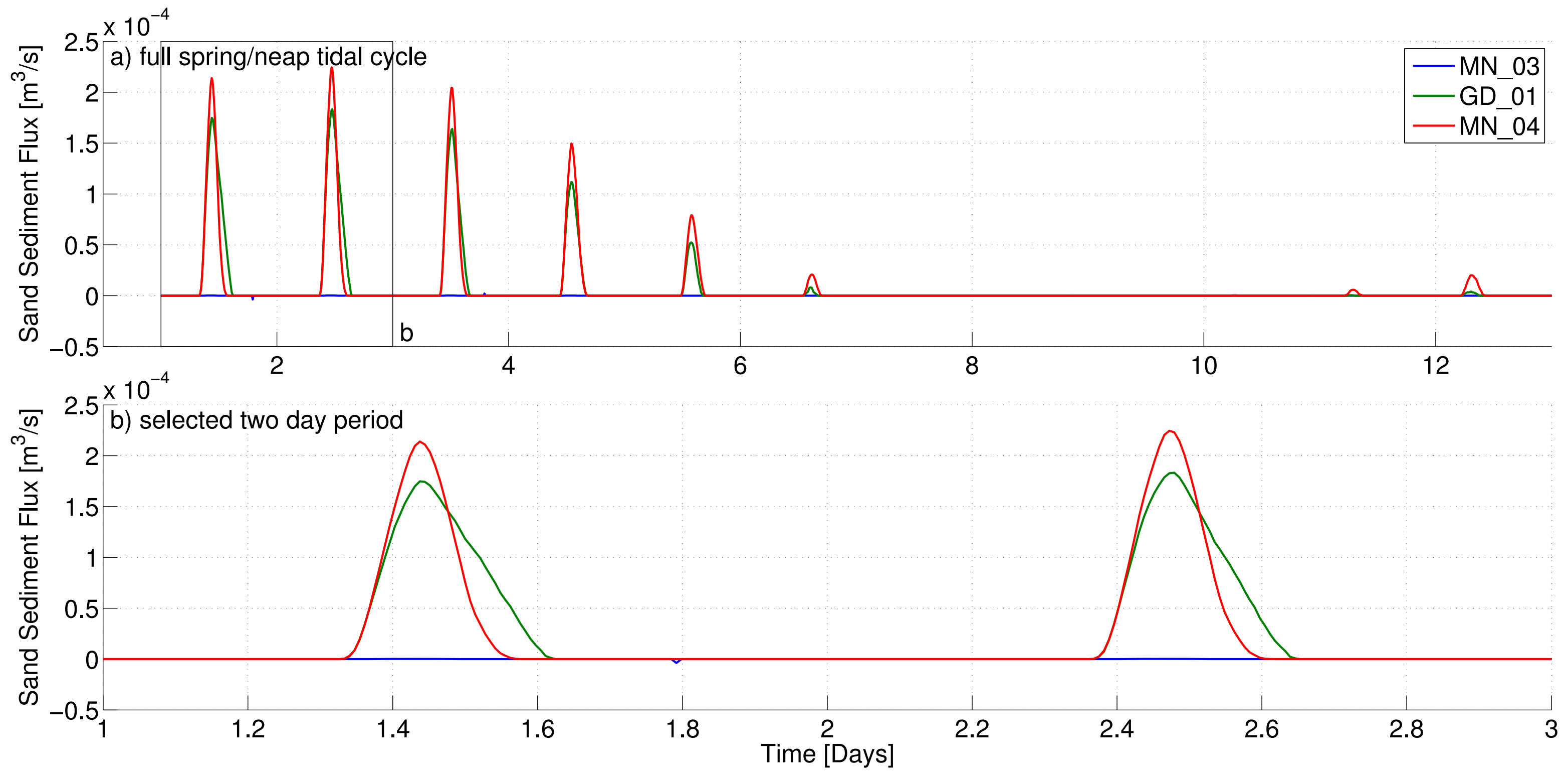
- Full spring-neap tidal cycle at four different flow levels
- This study focuses on results from **low flow** case: Q = 1149.7 m^3/s Probability of exceedance, ~82%



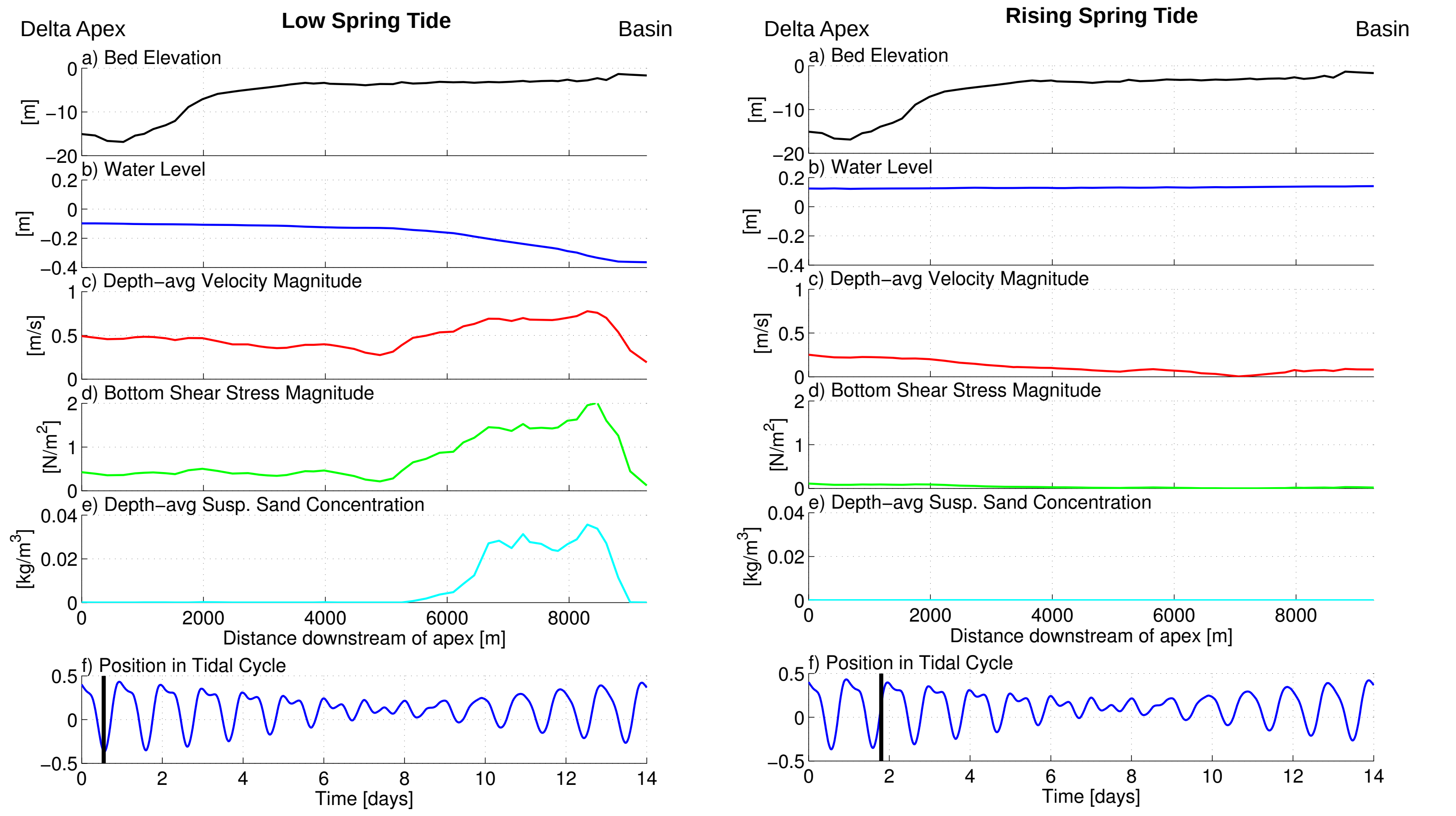
At low spring tide, sand flux only occurs in distal reaches of distributary channels and increases downstream. **Distal ends are supply-limited** such that downstream-increasing flux **erodes the bed**. Conversely, sand transport during the rising tide completely ceases.



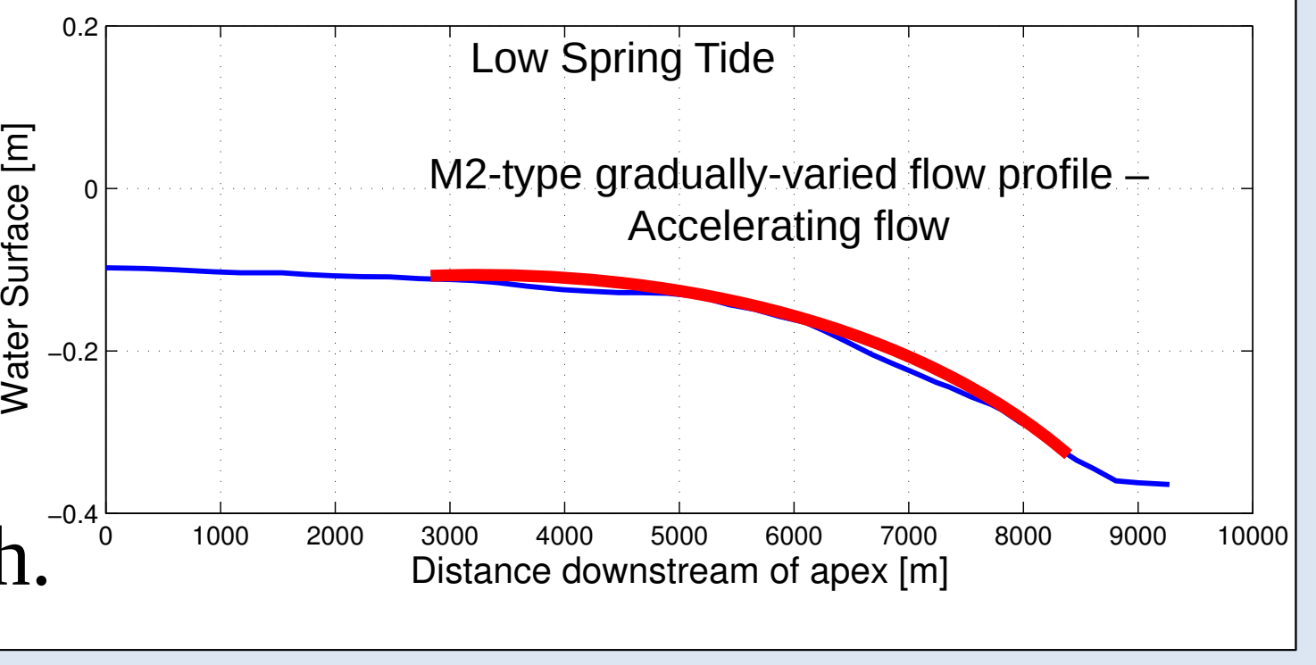
Sand flux variation with the tidal cycle is evident in the figure below, showing total sand flux through time at cross-sections **upstream and downstream of a channel bifurcation**. Across the full tidal cycle, flux through cross-section MN_03 upstream of the bifurcation is much lower than flux through the downstream cross-sections (GD_01 and MN_04). The flux through the downstream cross-sections **peaks during each spring low tide** and ceases during the rising, high tide, and falling portions of the tide. Additionally, peak sand fluxes gradually diminish to zero as the tide **cycles from spring to neap**.



Hydrodynamics and Transport along Profile



Plots of parameters along a streamwise profile (see map to left – delta apex to basin) at low tide and rising tide reveal the **mechanism** of **erosive channel extension**. For the low tide profile, **water surface drawdown** towards the receiving basin forms a convex, M2-type **backwater profile** which accelerates flow towards the channel mouth, **increasing** bed **shear stress** sufficiently to **entrain sand** in suspension. During the rising tide, the flat water surface profile results in a gradual deceleration of flow towards the mouth.



Conclusions

- Basinward-increasing sand transport throughout delta
- Microtidal environment – still sufficient to affect sand transport
- Drawdown at low tide – M2 (A2) profile accelerates flow up to channel mouth
- Supports Shaw and Mohrig's observations of erosive channel extension at low Q
- Erosive channel-extension can be an important process, with mechanisms acting during non-flood periods
- Sand deposited in delta during floods can be significantly reworked by tides
- Delta growth not solely a result of flood deposition

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