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Exploring the Role of Organic Sediment Dynamics on Channel Clustering and Alluvial Architecture

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Fluvial deltas house important groundwater and hydrocarbon reserves and provide reservoirs in which atmospheric carbon dioxide may be sequestered. Additionally, fluvial deltas are archives of past external forcing (i.e., allogenic, externally controlled processes), including sediment supply, tectonic subsidence, and sea-level variations. In order to reverse engineer the processes that led to the present fluvio-deltaic architecture, theories for stratigraphic interpretation need to be adapted to deal with internal processes (i.e., autogenic) that could play a significant role, but are to date largely unexplored, such as plant matter accumulation in floodplains. In this project, we aim to fill this knowledge gap by developing a modeling framework for the evolution of fluvio-deltaic systems under sea-level variations that account for the long-term evolution of the floodplain, including organic sediment accumulation via plant growth.

During the first year of this grant we have made progress towards this goal by developing a forward stratigraphic model that captures the dynamic behavior of the fluvial surface and treats the shoreline and alluvial-basement transition as moving boundaries (i.e., internal boundaries whose location must be determined as part of the solution to the overall morphological evolution problem). In this work, we extend a numerical technique from heat transfer (i.e., enthalpy method), previously applied to the evolution of sedimentary basins, to account for sea-level changes. We verified the mathematics of the approach by comparing predictions from the numerical model with both existing and newly developed closed form analytical solutions. Model results demonstrate the importance of the dynamics of the fluvial surface on the system response under a wide range of parameter values (Figure 1). This work was recently published in the *Computer and Geosciences* journal (Anderson et al. 2019). During year two of this project, we will work to incorporate organic sediment dynamics into this modeling framework.

Additionally, we have also studied the interplay between autogenic and allogenic forcing in barrier island environments. In particular, we have developed the BarrieR Inlet Environment (BRIE) model, which can simulate long-term barrier morphodynamics, including overwash processes, shoreface dynamics, alongshore sediment transport, inlet dynamics, and flood–tidal delta deposition (Nienhuis and Lorenzo-Trueba 2019). We are also currently exploring the interplay between pulses in the rate of sea-level rise and barrier island response. Preliminary results suggest that sea-level pulses can be preserved in the stratigraphy given the right conditions, but their signals can also be lost or "shredded" by the autogenic behavior of barrier islands. Overall, our morphodynamic modeling results motivate a need to investigate the internal dynamics of barrier systems to understand the full range of past and potential future response of barrier systems to sea-level rise.

References (* Advised students):

W. Anderson*, J. Lorenzo-Trueba and V. Voller (2019). A geomorphic enthalpy method: Description and application to the evolution of fluvial-deltas under sea-level cycles. *Computer and Geosciences*.

J. H. Nienhuis, and J. Lorenzo-Trueba (2019). Simulating barrier island response to sea-level rise with the barrier island and inlet environment (BRIE) model v1.0, *Geosci. Model Dev. Discuss.*, https://doi.org/10.5194/gmd-2019-10.

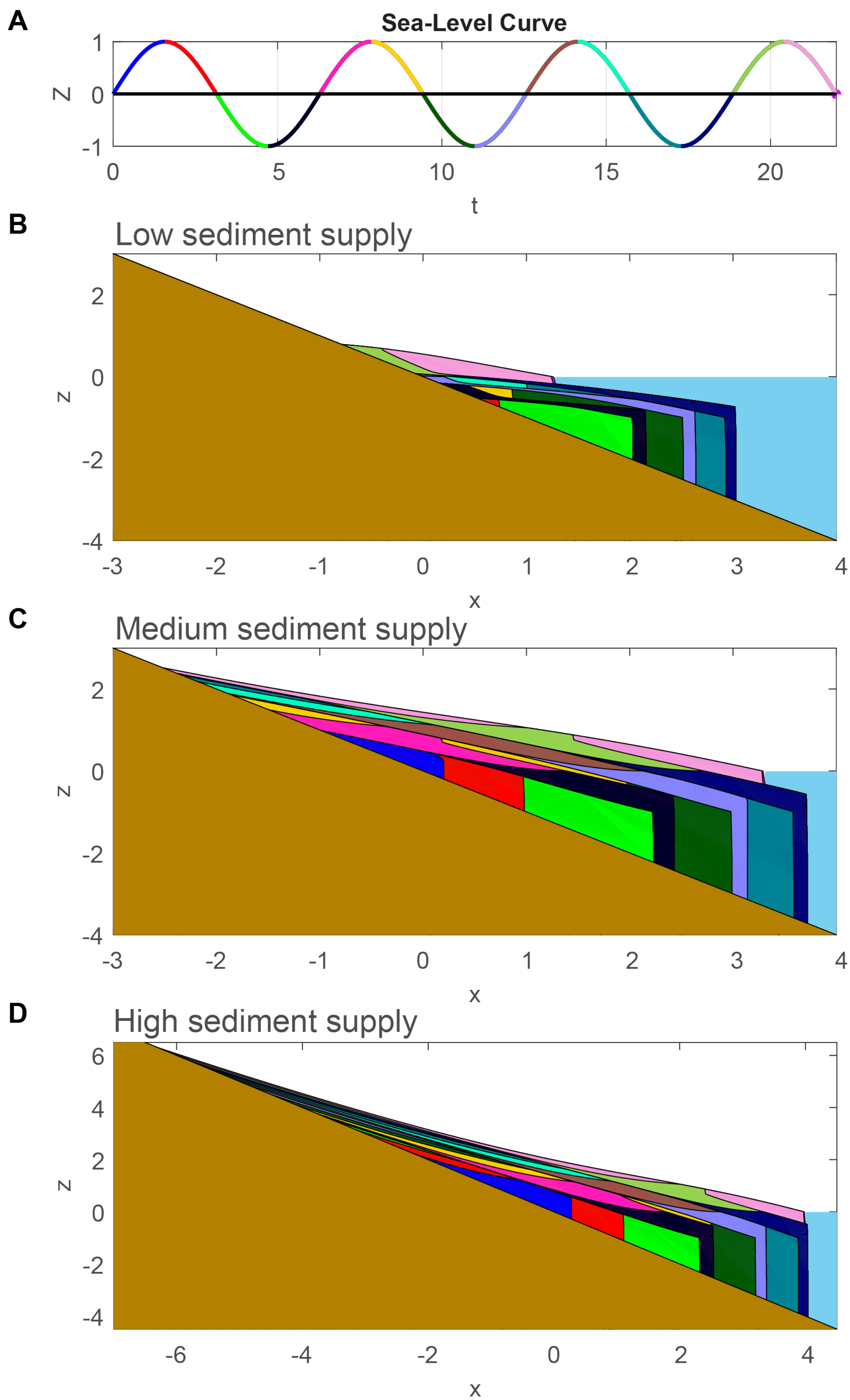

Figure 1. Stratigraphies produced under sea-level cycles for three different scenarios in terms of sediment supply.