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Signal propagation from space to time: Implications to modeling stratigraphic record
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Deltas are intricate landforms that contain complex distributary channel networks, which transport water and sediment from continents to oceans. The dynamics of such networks are complex; channels migrate laterally, avulse, divide and rejoin around bars and islands, and the flow shifts unpredictably from one part of the network to another, creating highly variable and nonlinear spatio-temporal patterns of erosion and deposition. Understanding and quantifying the dynamics of the channels and their network and physical processes operating on deltaic surfaces, in particular, is important for interpreting stratigraphic record for paleo-climatic and tectonic conditions and can provide useful predictive tools for quantifying potential locations of subsurface hydrocarbon reservoirs. Using publicly available data from delta physical experiments, the goal of this study is to quantify how the probabilistic structure of spatial patterns and processes governing the evolution of depositional topographic surfaces relates to the probabilistic structure of temporally preserved stratigraphic record.

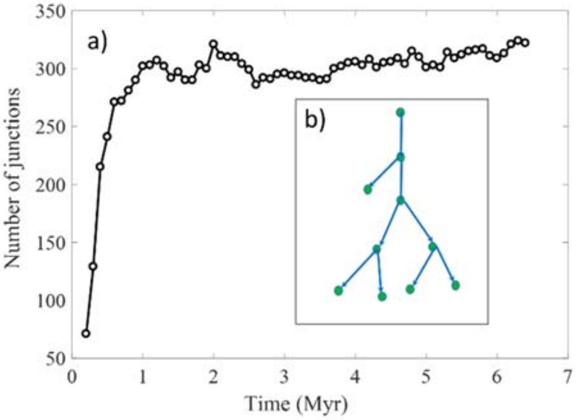

Figure 1: a) Number of junctions emerged as a function of time simulated using landscape evolution model under constant external forcings. b) Inset figure shows a schematic of a channel network represented by links (blue lines) and nodes (junctions; red solid circles).

This research is anticipated to helps us increase our ability to make quantitative predictions of how geomorphically and societally relevant variables will change under scenarios of future climatic and land-use changes. The PI and the UCF are receiving direct multiple benefits from the proposed project both in terms of their research and teaching missions. For example, this grant is providing a great opportunity to the PI for further developing these research ideas which may lead to bigger funding proposals aimed at National Science Foundation (NSF) CAREER award and other NSF sub-divisions, US Department of Agriculture, and US Department of Energy, among others. From the teaching perspective, the PI is teaching *Hydraulics* (advanced level undergraduate course) and *Stochastic river network hydro-geomorpholgy* (6000 level graduate course) which cover concepts on hydrology, hydraulics, and river network dynamics under changing environment. Depending on the level of the course (e.g., graduate students are involved in data analysis), one of the class projects is to study effect of changing hydrology on the hydraulics of channels and their network, with the intention of encouraging students to engage more in research-oriented learning and prepare them for graduate school and real-world applications.

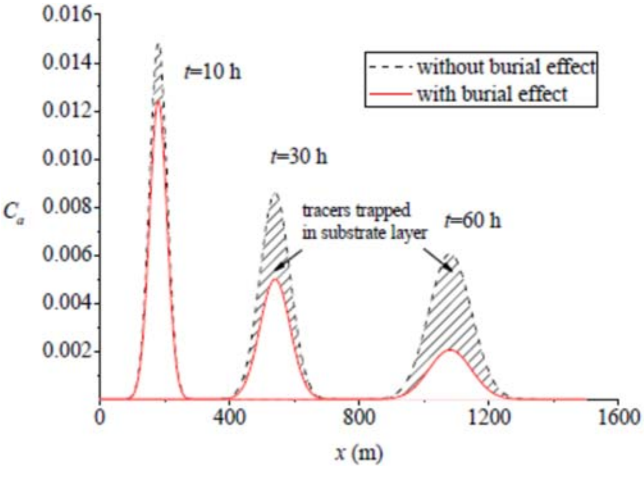

Figure 2: Spatial distribution of the active-layer tracer concentration (C_a) at three different times displaying the effect of permanent burial of tracers in the substrate layer. The parameters chosen to show the evolution are: D_d = 0.01 m^2/s, c = 0.005 m/s, χ = 5×10^{-6} s^{-1}.

This project is providing several opportunities for students and post-doctoral associates, working in PI's research group, for training and professional development. For example, two students are being trained on fundamentals of information theory and its applications in network science. They are working on developing framework for characterizing spatially distributed features (e.g. channel networks) and how these features change in temporal domain under constant and varying external forcings. Figure 1 (developed by a graduate student) shows, as an example, how channel network characteristics, such as junction (channel intersection point) density changes as a function of time over a fixed surface under constant external forcings. The students are learning advanced programming languages and platforms such as matlab and python to perform these analysis and are anticipated to be beneficial for their future career goals in academia and industry.

Among the two post-doctoral associates involved in this project, one of them has a background in fluid mechanics. As part of the academic training which helps to prepare him for the professional career, working on this project extends his research area to the new field of geomorphology with the research interest on sediment transport and hydrology. With his participation, this project benefits from a different perspective in understanding the associated physical processes. For example, the burial of sediment particles under the fluvial channel bed contributes directly to the stratigraphic records for the temporally propagating signals, which is theoretically considered and modeled in his recent work. Results in Figure 2 illustrate the small scale spatial characteristics of bedload particles transport, with the concentration distributions affected by the burial effect at different instant of times. These models will be tested for delta channel networks across a range of spatial and temporal scales.

The outcomes from the project are being disseminated through publication in the peer reviewed journals, and conference presentations. Students and postdocs are also participating in the workshops and conferences presenting their results and getting exposed to a range of disciplines which will help them in building a base for future knowledge sharing between engineering and science communities.