56

Coevolution Of River-Channel Geomorphology And Riparian Vegetation On The Lower Brazos River, Texas

Andrew Vanderheiden[1,2,3], Billy Hales[2,3], Courtney Guidry[2,3], Inci Güneralp[3,⊙], Georgianne Moore[4,⊙], Anthony Filippi[3,⊙]

[1]Presenter, [2]Graduate student, [3]Dept. of Geography, [4]Dept. of Ecosystem Science & Management, [⊙]Triad

T3: TEXAS A&M TRIADS FOR TRANSFORMATION
A President's Excellence Fund Initiative

Background

The goal of this study is to advance understanding on how scroll bars on meander bends co-form and co-evolve with riparian woody vegetation. Scroll bars, composed of ridges and swales, encapsulate the evolutionary history of a lowland meandering river. Morphology and spatial structure of scrolls have been used as a proxy to develop predictive models of channel migration[1] and floodplain classification[2]. Scroll-bar formation depends on transverse sediment transport[1], controlled by large flood events to deposit a ridge of sediment, and instream large wood[3], where deposited instream wood, as a nucleation site, decelerates the flow and forces the sediment to deposit over multiple flow events. Scroll-bar evolution is dominantly controlled by large flood events, but also impacted by the scroll-bar morphology and vegetation: Swales act as a conduits containing the erosive potential of overbank flow and woody vegetation slows down overtopping flow and stabilizes ridges with their root structures[4]. Flood inundation impacts scroll bar morphology and sedimentological architecture and contributes to soil water content within the scroll bar complex, thus creating a tapestry of conditions where grassy and woody vegetation species can grow and compete[4]. All considered, how the interactions among river hydrology, geomorphology and woody vegetation contribute to unique patterns of scroll-bar morphologies and woody vegetation patterns on meander bends is not fully understood. This knowledge is fundamental to determining how this system coevolves and responds to changes in environmental conditions. Thus, it is vital to successful management of river ecosystems and ecosystem services.

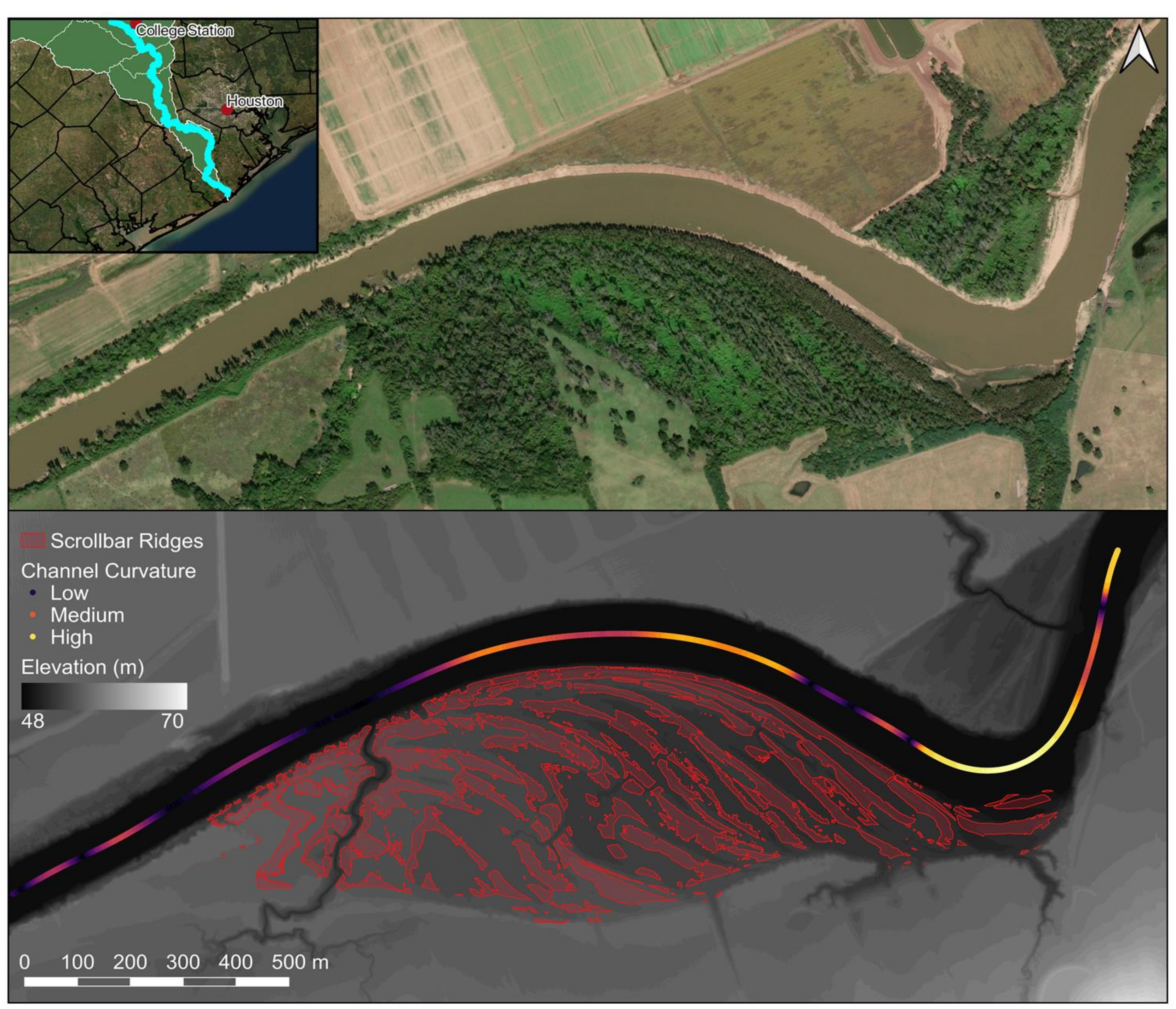

***Figure 1**: Top:* The scroll bars on a meander bend along the lower Brazos River, TX as seen on the aerial photo (source: ESRI World Imagery, acquired 2017-10-18). *Bottom:* Scroll bar ridges digitally extracted from LiDAR-derived DEM (source: USGS Lidar, acquired 2017-03-01). The higher spatial frequency of scroll bars correlate with the areas of high planform curvature.

Study Site and Methods

We examine the spatial patterns of scroll-bar geomorphology and woody vegetation on approximately 100 meander bends on the lower Brazos River, TX (*Figure 1*). We utilize remote sensing data and tools, spectral analysis, hydrodynamic modeling, and field work. We perform object-oriented image processing to delineate the scroll bars and woody vegetation densities from high resolution aerial photographs and multispectral images and LiDAR-derived digital elevation models (DEMs). We then conduct spectral analysis on delineated scroll bars and woody vegetation to quantify their spatial structures. On select meander bends, we plan to survey scroll bars and their woody vegetation with varying levels of flood inundation using Unmanned Aerial Systems (UAS) and in-situ data loggers. With these data, we plan to simulate scroll-bar inundations and determine geomorphologically and ecologically critical flows and their frequencies using a 2D hydrodynamic model. This will allow for examining the spatial-temporal relationships among hydrological, geomorphological, and ecological elements of the scroll bars (*Figure 2*).

Coevolution of meander scrolls and riparian woody vegetation

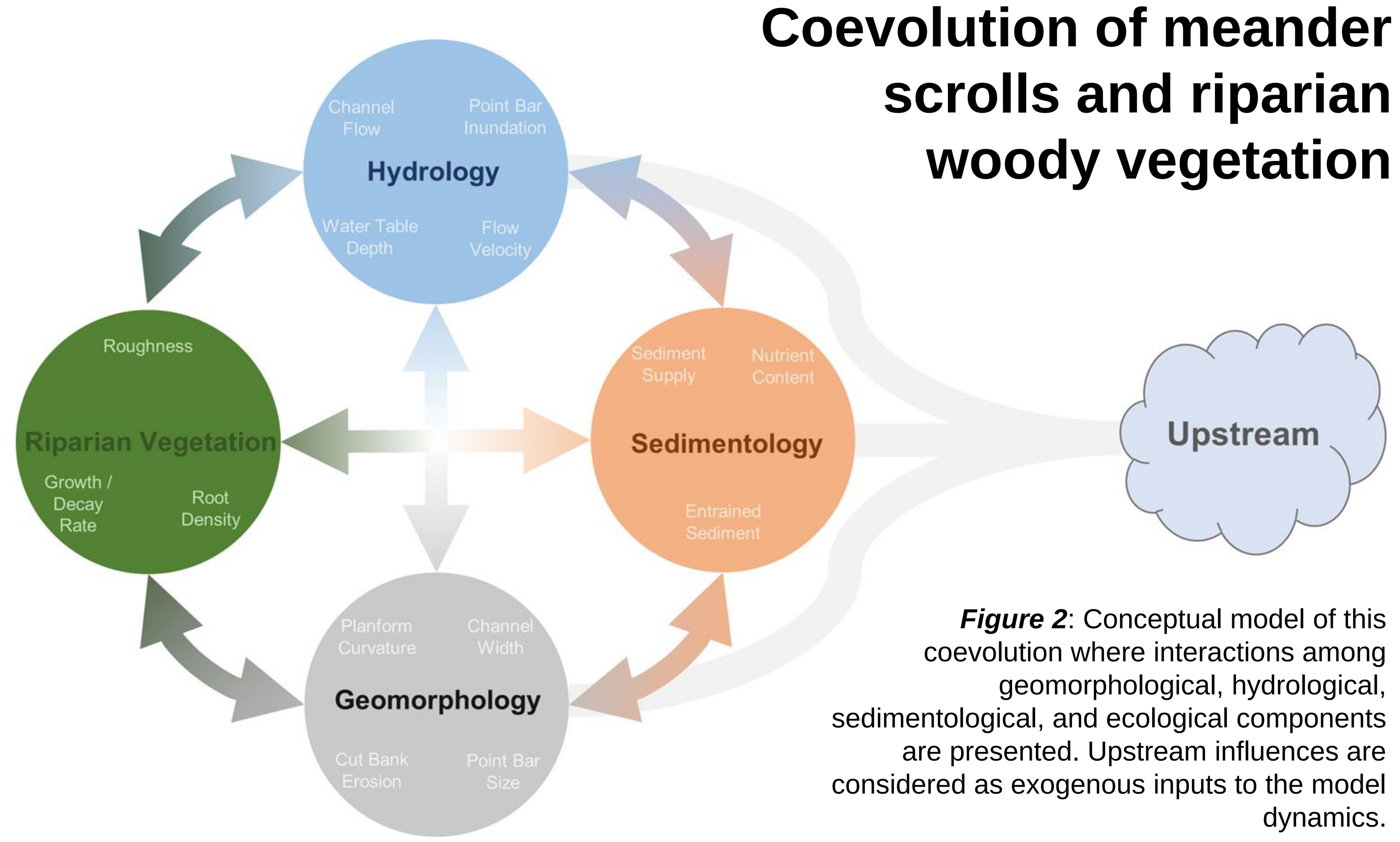

***Figure 2**:* Conceptual model of this coevolution where interactions among geomorphological, hydrological, sedimentological, and ecological components are presented. Upstream influences are considered as exogenous inputs to the model dynamics.

Major Findings

Geomorphological evolution of the existing scroll bar occurs when the flow spills over the channel boundaries and onto the scroll bar itself. This is referred to as scroll-bar activation. For the meander bend presented, the activation occurs at 80-85 percentile flow (*Figure 3*). However once this threshold is passed, large areas of the scroll bars could be inundated due to the channelized flow within individual swales (*Figure 4*). How this channelization and localized connections will occur depends on the spatial structures of scroll morphology and the connectivity of the scrolls. Because of this channelized flow, the erosivity of overbank flow returning to the main channel is restricted to the swale, maintaining the swale morphology. As the erosive flow is contained within the swales, persistent woody vegetation is allowed the time to develop atop the ridges. It is not until the 90-97 percentile flow that flow is no longer contained within the scrolls and overtops ridges where woody vegetation mitigate erosive forces of this flow, maintaining the ridge morphology[4].

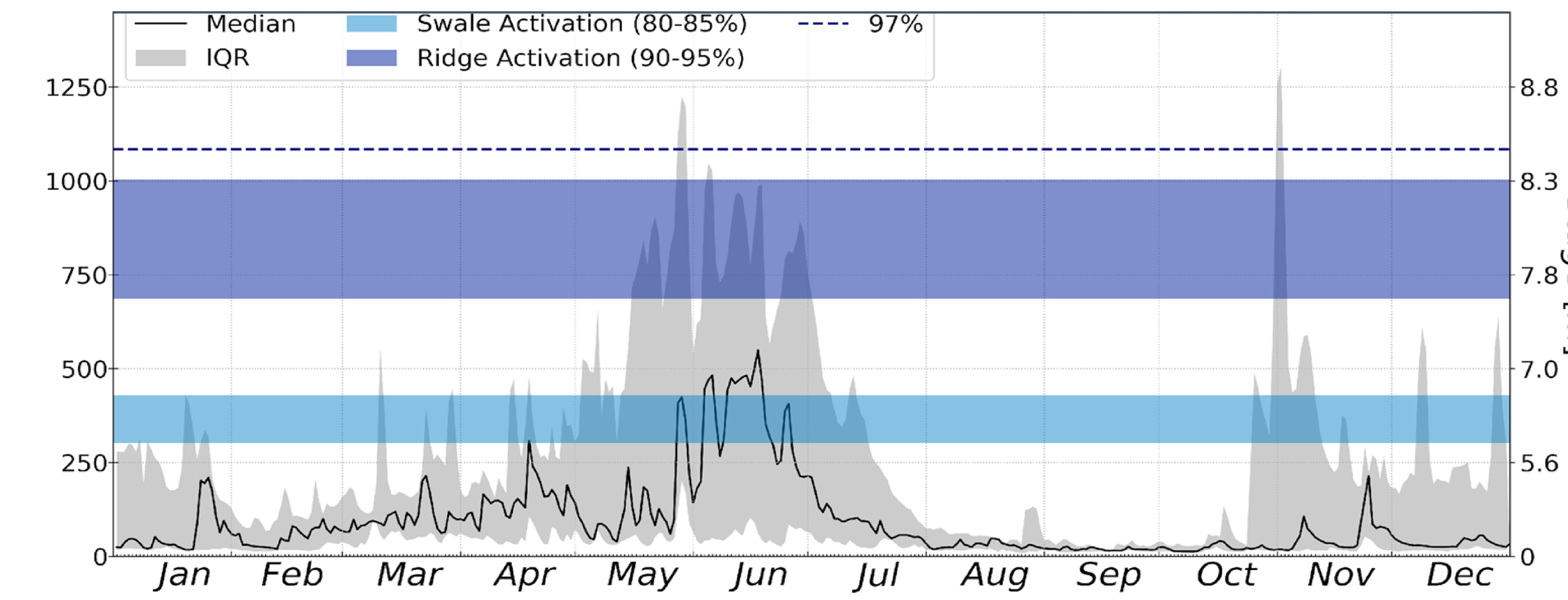

***Figure 3**:* Temporal frequency of scroll bar inundation. Daily median and interquartile range (IQR) flows and critical threshold flows to either activate or inundate the scroll bar are based on the data obtained from the nearest upstream gauge (USGS 0810700), over a period of Aug 08, 2013-May 31, 2020.

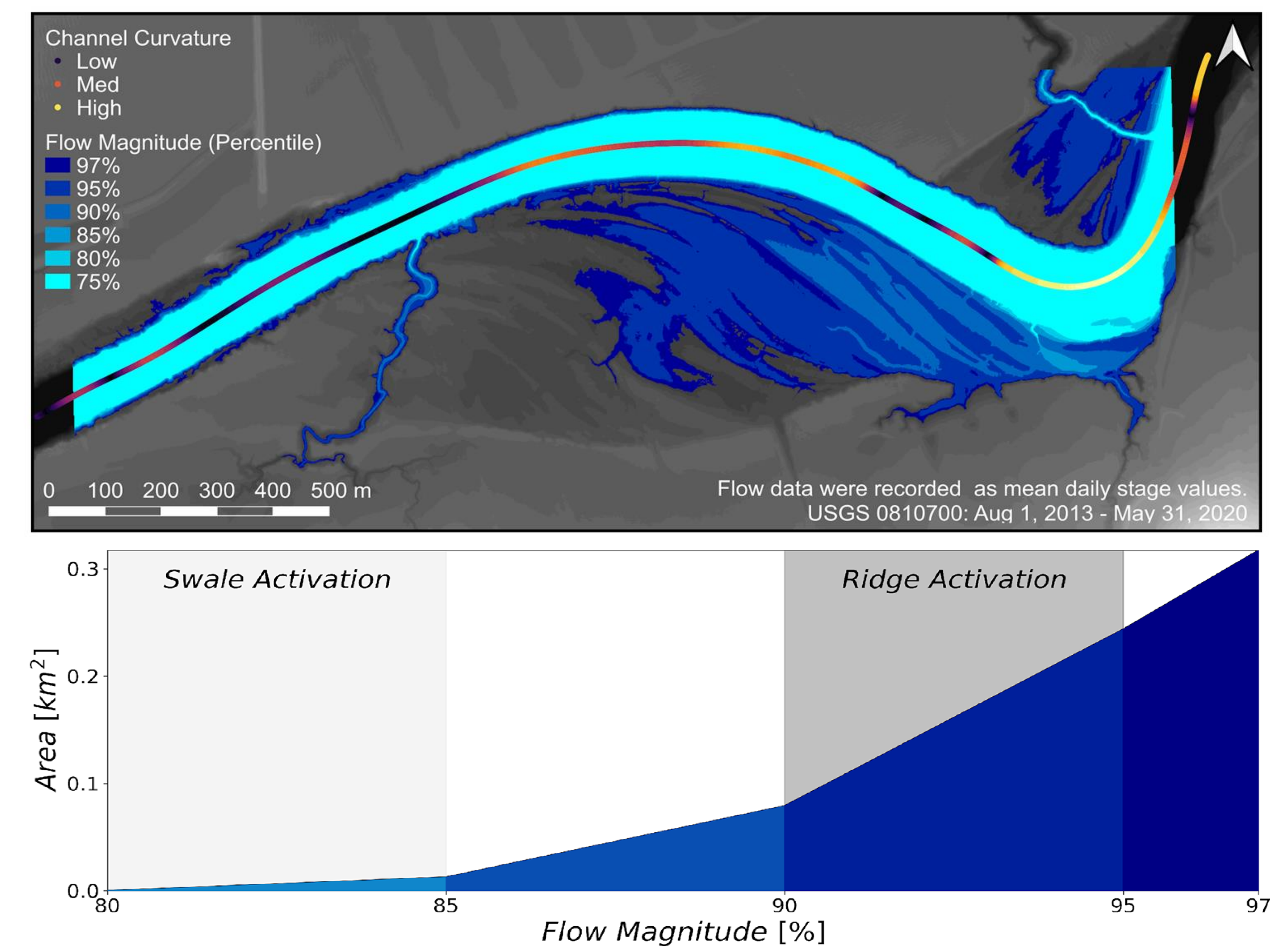

***Figure 4**:* The inundation spatial extents of critical threshold flows (Figure 2). While 80% flow is generally contained within the channel, above 85% flow leads to overbank flow. Scrolls gets activated within the range of 80-85% flow where swales gets inundated via localized connections to the channel and as a function of their spatial connectivity structure. Once 85% overbank flow threshold is passed, scrolls gets inundated dominantly via overbank flooding and the area of inundation increases with increasing flow percentile.

Ongoing work

We are developing a 2D hydrodynamic model to more accurately describe the relationship between river flow and the scroll-bar geomorphology. We are determining the framework for object-based analysis and working on the details of the field work for mapping scroll bar geomorphologies in conjunction with vegetation surveying and sediment sampling that we plan to conduct in Spring 2021.

References

1. Hickin EJ, Nanson GC (1975). The Character of Channel Migration on the Beatton River, Northeast British Columbia, Canada. *GSA Bulletin 86*(4), 487–494.
2. Nanson GC, Croke JC (1992). A genetic classification of floodplains. *Geomorphology 4*(6), 459–486.
3. Zen S, Gurnell AM, Zolezzi G, Surian N (2017). Exploring the role of trees in the evolution of meander bends: The Tagliamento River, Italy. *Water Resources Research* 53(7), 5943–5962.
4. McKenney R, Jacobson RB, Wertheimer RC (1995). Woody vegetation and channel morphogenesis in low-gradient, gravel-bed streams in the Ozark Plateaus, Missouri and Arkansas. *Geomorphology* 13(1), 175–198.