Global Riverbank Slope Patterns Inferred from SWOT-Derived Hypsometry Curves

J. Daniel Velez (University of North Carolina at Chapel Hill, United States)

Tamlin Pavelsky (University of North Carolina at Chapel Hill, United States)

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Riverbank slopes are a key geometric attribute that governs channel-floodplain connectivity, cross-sectional shape, and overbank flow behavior, with significant implications for hydrodynamic modeling and ecohydrological processes such as hyporheic exchange, riparian inundation, and floodplain residence times. However, riverbank slopes remain largely unquantified on a global scale, constrained by the limited capacity of remote sensing to capture near-bank topography and the infeasibility of applying high-resolution topobathymetric modeling across broad river domains.
The Surface Water and Ocean Topography (SWOT) satellite provides global observations of river width and water surface elevation (WSE), but not channel depth, slope geometry, or cross-sectional area. To overcome this gap, we explore the use of width-elevation hypsometry curves, monotonic relationships between SWOT-derived width and elevation, as a proxy to infer riverbank slope. This approach builds on hydraulic geometry theory, which posits that observable covariates, such as width and elevation, can inform estimates of unseen hydraulic behavior.
We applied this approach a at global scale by constructing hypsometry curves using SWOT node products at 200 m spacing across a broad set of river systems. To validate the method and assess its robustness, we focused on eight rivers in the USA, Colombia, France, and Italy, which span a range of climatic, geomorphic, hydraulic, and anthropogenic conditions, including systems with significant channel modification and hydraulic infrastructure. The shape, slope, and regression behavior of the hypsometric curves were analyzed to estimate the effective riverbank slope. This global analysis demonstrates that satellite-derived hypsometry can serve as a practical proxy for riverbank slope, enabling scalable assessments of channel geometry in support of hydrologic, hydraulic, and geomorphic applications using SWOT data alone.

Corresponding author:
J. Daniel Velez
University of North Carolina at Chapel Hill
United States
davelez@unc.edu