# Morphodynamic stage threshold for confined mountain rivers can be identified using geomorphic covariance structure analysis

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## Abstract

Does river topography have stage thresholds for maintaining fluvial landforms, and if so how can they be quantified? Geomorphic covariance structure analysis offers a novel, systematic framework for evaluating nested topographic patterns in river corridors. In this study, a threshold in mountain river stage was hypothesized to exist; above this stage landform structure is organized to be freely self-maintaining via flow convergence routing morphodynamics. A 13.2 km segment of the canyon-confined Yuba River, California, was studied using 2944 cross-sections. Geomorphic covariance structure analysis was carried out on a meter-resolution topographic model to test the hypothesis. A critical stage threshold governing flow convergence routing morphodynamics was evident in several metrics. Below this threshold, narrow/high "nozzle" and wide/low "oversized" landforms that are out-of-phase with flow convergence routing morphodynamics dominated (excluding "normal channel"), while above it wide/high "wide bar" and narrow/low "constricted pool" landforms consistent with the flow convergence mechanism were dominant. Three-level nesting of co-located base-bankfull-flood stage landforms was dictated by canyon confinement, with nozzle-nozzle-nozzle nesting as the top permutation, excluding normal channel. In conclusion, this study demonstrates a significantly different and highly effective approach to finding process-based fluvial thresholds that can complement pre-existing methods, such as estimating incipient sediment motion, to get at more powerful dynamics controlling fluvial landforms structure.

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**Morphodynamic stage threshold for confined mountain rivers can be identified using geomorphic covariance structure analysis**

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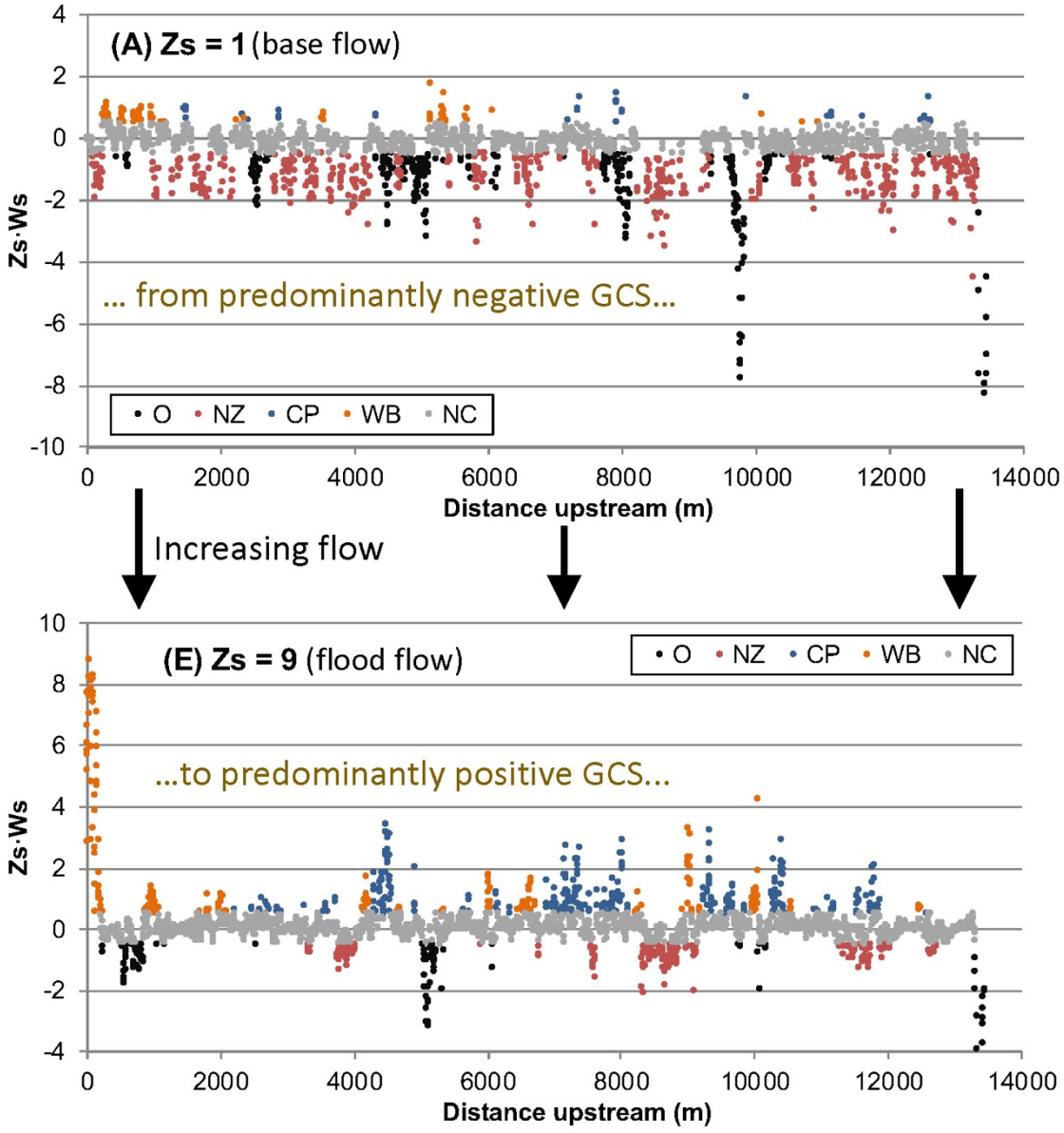
Plain-Language summary: Rivers have organized landforms. At low flows, landforms control how water moves around in the river. At a threshold flow that changes. Above the threshold, high flows push the sediment around that makes up the landforms. This results in a characteristic structure that we can detect using a novel framework called "geomorphic covariance structure analysis".

From low water stage to high water stage a mountain river's geomorphic covariance structure (GCS) shifts…




…with the threshold stage indicating the transition to flow convergence routing morphodynamics