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Continuity and discontinuity in fluvial systems: why we need both perspectives

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Connectivity is an intrinsic property of fluvial systems. Rivers evolve specifically to carry the water, sediment, wood, and other products collected, generated, and delivered by watersheds, and therefore are fundamentally connected to their co-evolving hillslopes and landscapes. Moreover, these watershed products inevitably flow downstream to their base levels under the influence of gravitational forces; on geological timescales, connectivity is destiny for rivers.

But on shorter timescales, some of the most interesting behavior of rivers occurs where the flows of mass and energy are interrupted for various reasons. Disconnectivity can occur due to blockages by dams (natural or artificial), landslides, lava flows, glaciers, or sand dunes, among other mechanisms. Such disconnections invariably result in abrupt loss of energy and momentum of moving material, leading to accumulations of mass: reservoir sediments, wood jams, organic mats, valley fills. The morphology of many rivers is an expression of the tension between states of connectivity and disconnectivity.

A richer context for understanding this tension emerges from considering the related concepts of continuity and discontinuity in fluvial systems. Where connectivity and its opposite refer to states, continuity and its antonym refer to processes. Continuity and discontinuity represent fundamental and complementary perspectives on the mechanisms that organize fluvial systems. The continuum perspective emphasizes how geomorphic features and mechanisms are expressed along continuous gradients without abrupt changes, transitions, or thresholds. Key concepts in fluvial geomorphology: -- balance of forces, hydraulic geometry, graded streams – reflect this view. This view is echoed outside of geomorphology as well in fields as diverse as ecology, paleontology, and evolutionary biology. The continuum perspective is extremely useful as an organizing principle for understanding complex systems, because it allows us to treat processes and their corresponding features as orderly progressions, or manifestations of a dynamic equilibrium of forces and overarching controls. This has immense predictive power.

In contrast, the discontinuum view incorporates non-uniform, non-progressive, and non-equilibrium thinking into our understanding of how landscapes develop and evolve. Three distinct ways in which this perspective is revealed emerge from considering: 1) discontinuous spatial arrangements of geomorphologic features or singular events; 2) process domains that reflect intrinsic or extrinsic thresholds; and 3) physical mechanisms or dynamics that involve state changes, often threshold-based. Drawing on examples from a wide range of geomorphic

landscapes, I will discuss how in moving beyond the continuum perspective, a fertile set of ideas comes into focus: thresholds, non-equilibrium states, heterogeneity, catastrophe. The range of phenomena that is thereby opened up to scientific exploration similarly expands: punctuated episodes of cutting and filling, discretization of landscapes into hierarchies of structure and control, the work of extreme events. Orderly and progressive evolution towards a steady or ideal state is replaced by chaotic episodes of disturbance and recovery. Similar to connectivity and disconnectivity, both continuum and discontinuum perpsectives are complementary and necessary views for understanding the behavior and evolution of fluvial systems.