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Laws of valley growth

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River networks incised by re-emerging groundwater flow provide a model framework for studying channelization. The underlying physical equations are well-defined and thus analytical predictions can be obtained and tested in the field. Theory of growth in such channel systems was first formed by Dunne in the early 1980s. A small bulge in the sidewall of a stream leads to the focusing of the ground water flow, and thus to a larger flux of water resulting in a higher erosion rate in this direction. In time such small perturbations grow into newly formed channels, but how they do so is unclear.

To probe this problem, we begin by relating the advancement of the tip to the discharge into the spring. If a stream advances at a rate $v \sim q^{\eta}$, where q is the discharge of water into the tip, theory of growth in a diffusive field predicts that η has to be smaller than 1 to obtain ramified networks. We test this hypothesis by measuring erosion rates in a field site of groundwater driven channels on the Florida Panhandle. Our network reconstruction yields tip growth rates, which we can directly compare to observational rates obtained from collected cosmogenic ^{10}Be data. This allows us to both verify the existence of a discharge-erosion relation, as well as better characterize growth and competition in the channelization process.