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Deformation and evolution of an experimental drainage network subjected to oblique deformation: Insight from chi-maps

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The morphology of a fluvial landscape reflects a balance between its own dynamics and external forcings, and therefore holds the potential to reveal local or large-scale tectonic patterns. Commonly, particular focus has been cast on the longitudinal profiles of rivers as they constitute sensitive recorders of vertical movements, that can be recovered based on models of bedrock incision. However, several recent studies have suggested that maps of rescaled distance along channel called chi (χ), derived from the commonly observed power law relation between the slope and the drainage area , could reveal transient landscapes in state of reorganization of basin geometry and location of water divides. If river networks deforms in response to large amount of distributed strain, then they might be used to reconstruct the mode and rate of horizontal deformation away from major active structures through the use of the parameter χ. To explore how streams respond to tectonic horizontal deformation, we develop an experimental model for studying river pattern evolution over a doubly-vergent orogenic wedge growing in a context of oblique convergence. We use a series of sprinklers located about the experimental table to activate erosion, sediment transport and river development on the surface of the experimental wedge. At the end of the experiment, the drainage network is statistically rotated clockwise, confirming that rivers can record the distribution of motion along the wedge. However, the amount of rotation does not match with the imposed deformation, and thus we infer that stream networks are not purely passive markers. Based on the comparison between the observed evolution of the fluvial system and the predictions made from χ maps, we show that the plan-view morphology of the streams results from the competition between the imposed deformation and fluvial processes of drainage reorganization.