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Tectonic Forcing and Topographic Responses Through Dynamics of Channel-Hillslope Coupling in an Extremely High-Relief Mountainous Terrain

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1.Introduction

In tectonically active regions, morphologic characteristics of channel and hillslopes, such as the average slope angle and channel-to-divide relief, reflect complex feedbacks between tectonic forcing and erosional processes (Hurst et al., 2019). The channels, hillslopes, and hilltops all have the potential to archive information about the nature of landscape development. The response timescales of these components of the landscape, however, are inherently different. This characteristic provides an opportunity to investigate the timescale of landscape response to transient signals from topographic data alone. Quantifying coupling between erosion and hillslope/channel topography provides the potential to understand the tectonic forcing conditions that have influenced landscape development (Whittaker, 2012).

2.Study Area and Methodlogy

In this study, we explored the spatial variability of topographic metrics by performing high-resolution topographic analysis of hillslopes and channels in the upstream Minjiang catchments, a part of the eastern margin of Tibetan plateau, along the Longmenshan fault zone, Sichuan, China. This area is characterized by strong tectonic activities and topography that has been deeply dissected by major rivers (Clark et al., 2006). This kind of landscapes could provide a unique sight to bring to light the tight coupling between channel parameters and hillslope metrics thought to be proxies for the complex tectonic forcing and erosion rates.

3.Result and Conclusion

We find that the concavity of channel longitudinal profiles and the drainage density varies with the distance to the faults, the drainage density increases with closer to the faults, the concavity is opposite. At the catchment scale, the hilltops (ridges) change with the distance to Minjiang river and Longmenshan fault, the topography-based erosion rate varies from approximately 0 to 2880 mm ky^{-1} in the whole area. This drastic change of erosion rate suggests that this area is a typical transient landscape influenced by the tectonic forcing and hillslopes are responding to erosion rates in the channel network.

Reference

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Hurst.M.D, Stuart W.D.Grieve, Fiona J.Clubb, Simon M.Mudd., 2019. Detection of channel/hillslope coupling along a tectonic gradient. Earth and Planetary Science Letters 522 (2019) 30–39.

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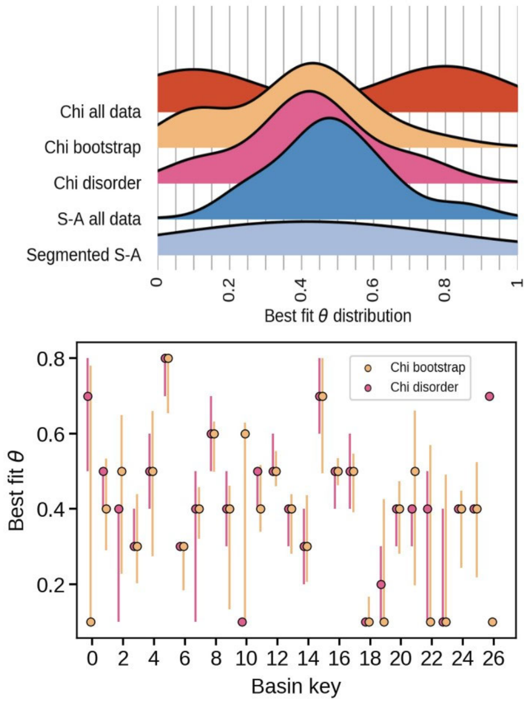

Fig.1 (a).Ridgeline plot of the most likely concavity values across all basins in the landscape (b).Summary plot of most likely concavity ratio for bootstrap and disorder methods

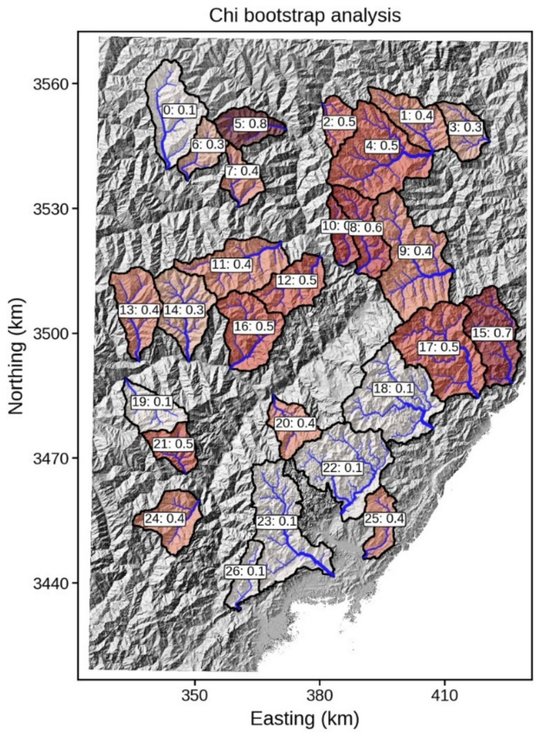

Fig.2 The plot of the best fit concavity using the disorder metric in Minjiang Catchment

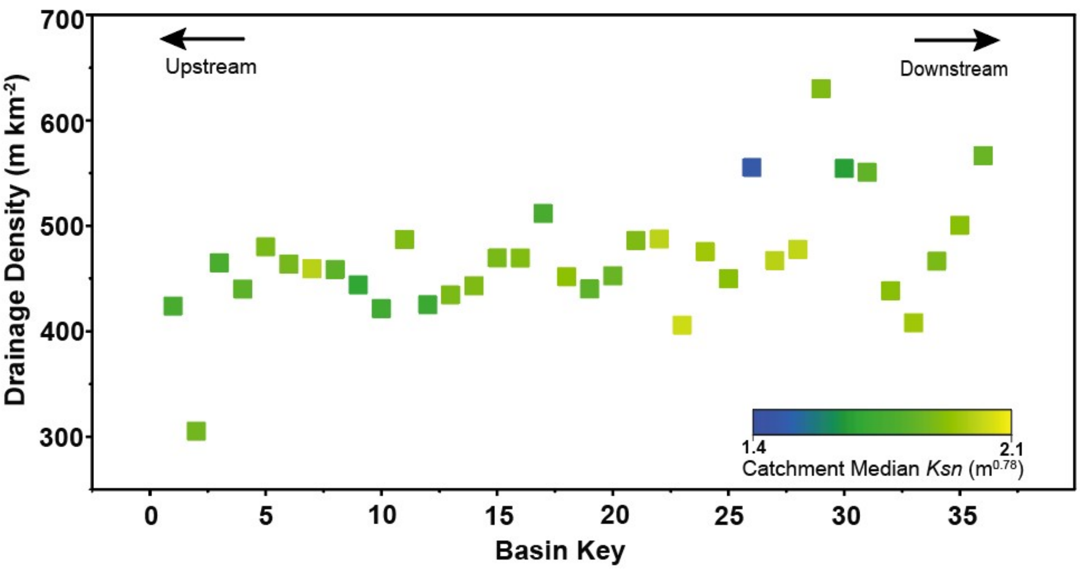

Fig.3 Variation in catchment drainage density of all selected basins, color-coded by catchment-median channel steepness index (θ*ref*=0.39).