



Fluvial signatures of modern and paleo orographic rainfall gradients

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The morphology of river profiles is intimately linked to both climate and tectonic forcing. While much interest recently has focused on how river profiles can be inverted to derive uplift histories, here we show how in regions of strong orographic rainfall gradients, rivers may primarily record spatial patterns of precipitation. As a case study, we examine the eastern margin of the Andean plateau in NW Argentina, where the outward (eastward) growth of a broken foreland has led to an eastward shift in the main orographic rainfall gradient over the last several million years. Rivers influenced by the modern rainfall gradient are characterized by normalized river steepness values in tributary valleys that closely track spatial variations in rainfall, with higher steepness values in drier areas and lower steepness values in wetter areas. The same river steepness pattern has been predicted in landscape evolution models that apply a spatial gradient in rainfall to a region of uniform erosivity and uplift rate (e.g., Han et al., 2015). Also, chi plots from river networks on individual ranges affected by the modern orographic rainfall reveal patterns consistent with asymmetric precipitation across the range: the largest channels on the windward slopes are characterized by capture, while the longest channels on the leeward slopes are dominated by beheadings. Because basins on the windward side both lengthen and widen, tributary channels in the lengthening basins are characterized by capture, while tributary channels from neighboring basins on the windward side are dominated by beheadings.

These patterns from the rivers influenced by the modern orographic rainfall gradient provide a guide for identifying river morphometric signatures of paleo orographic rainfall gradients. Mountain ranges to the west of the modern orographic rainfall have been interpreted to mark the location of orographic rainfall in the past, but these ranges are now in spatially near-uniform semi-arid to arid precipitation regimes. Indeed, despite uniform lithology and uplift history, we see patterns in river steepness values and in chi plots that are consistent with a rainfall gradient on the (former) windward side of the range and asymmetric precipitation across the range. We suggest that morphological aspects of the river networks in such regions are dominated by their history of changing climate. These morphologic signatures appear to persist for millions of years in NW Argentina, most likely because the transition from a wetter to a drier climate has prevented a rapid readjustment to new forcing conditions.

Reference:

Han, J., Gasparini, N.M., and Johnson, J.P., 2015, Measuring the imprint of orographic rainfall gradients on the morphology of steady-state numerical fluvial landscapes. *Earth Surf. Process. Landforms*, 40(10), 1334-1350.