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The role of climate change in drainage network reorganization: insights from numerical experiments

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The topography of mountain belts reflects the complex interactions among climate, tectonics and erosion, but it is often difficult to interpret the geomorphological signals of this interplay in a landscape. The continuous feedbacks among tectonics, surface processes, and climate change are reflected in the distribution of catchments on active mountain fronts. Previous studies (e.g. Hovius, 1996) have shown a certain regularity of valley spacing on several mountain ranges worldwide, but what is at the origin of such geomorphological feature of landscapes is currently not well known. Recently, studies using analogue and numerical models (Bonnet et al.; 2009, Perron et al., 2009) have attempted to explain and interpret quantitatively the formation of evenly spaced valleys along mountain fronts.

In this work, we illustrate numerical experiments of long-term landscape evolution of an active mountain range, using our TIN-based landscape evolution model, SIGNUM (Refice et. al, 2012), simulating tectonic uplift, hillslope diffusion, river erosion and climate change. In particular, building on some preliminary results (Capolongo et al., 2011), we show how the constant valley spacing, achieved at steady state on both sides of the range, is progressively restored after simulating a migration of the main drainage divide caused by a precipitation gradient applied across the mountain belt. Here, we explain how the pattern of catchments evolves on the two sides of the range, using a sequence of snapshots of the transient topography extracted from the model results. We analyze the time evolution of the spacing ratio R (Hovius,1996; Wallace, 1978), defined as the ratio between the half-width W of the belt and the spacing S of the outlets of the catchments draining from the main drainage divide. We consider R as an index describing the degree of catchment reorganization on both the windward and leeward sides of the belt. Finally, we present analogies between the synthetic landscapes extracted from the numerical simulations and real landscapes with similar tectonic and climatic conditions.

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