Uplift-driven denudation rates and associated channel response across Bhutan, Himalaya

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The Himalaya belt separates the southern edge of the Tibetan Plateau from the Indus-Gangetic Plain and is one of the most active areas in the world in terms of tectonic and climatic processes. Previous studies documented active deformation along the Himalaya in Nepal as well as major earthquakes (M>8) that have struck this area over the last centuries (e.g. Chen & Molnar 1977; Lavé & Avouac, 2000; Kumar & al., 2010). Lateral variations in instrumental seismicity may be observed from western Nepal to Bhutan with a significant decrease in rate from west to east (Drukpa et al., 2006). To better understand this major result and establish its consequences for seismic hazard assessment, observations are needed over a longer time frame.

Recently, Berthet et al. (2014) studied deformed Holocene alluvial terraces along the main front in southern central Bhutan and identified two major surface ruptures (M>8) for the last 1100 years. These first results are similar to what is observed 200 km further west in Nepal (Sapkota et al., 2013). Following this preliminary study, here we quantify the Holocene deformation through a joint approach including both the assessment of the spatial and temporal distribution of denudation rates and a detailed geomorphological analysis of drainage features (stream power, steepness index). We use ^{10}Be concentrations in river sands, along a North-South profile to quantify catchment-scale denudation over 100-1000 yr time-scale and to investigate the relationship between denudation and tectonic processes (Brown et al., 1995).

Analysis of main channel profiles reveal well defined knickpoints at 90 km and 160 km from the Main Frontal Thrust (MFT), which are not associated with a weak-to-resistant lithological transition (Fig 1A). These morphological features are marked by a significant increase in both normalized channel steepness index (Ksn) and stream power (Fig. 1B). This preliminary drainage analysis suggests that cosmogenic ^{10}Be concentrations may yield a higher denudation rate in this area.

Based on this impending result, we suggest that the regional geomorphology results from a flat-and-ramp geometry of the Main Himalayan Thrust at depth, similarly to what is observed in the Nepal Himalaya, but with different characteristics (e.g. distance from the front, depth or ramp dip angle).

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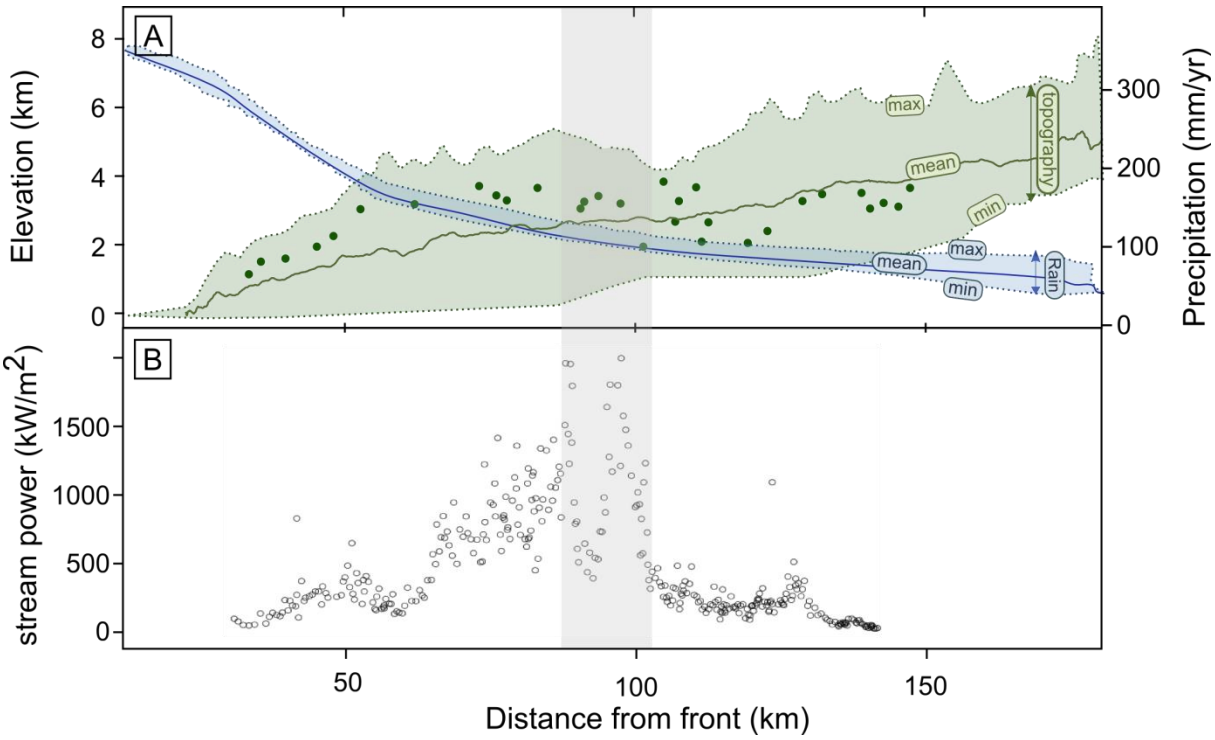

Figure 1. Cross-range section of the Himalaya in west Bhutan. (A) Topography (green) and precipitation (blue) along a 50-km-wide profile. Green dots are average elevation of sampled watershed basins. (B) Stream power. Shaded rectangles show the knickpoint section.

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