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Tectonics from topography : insights from high-resolution hillslope morphology analysis

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The spatial distribution of tectonic uplift is often investigated using river profiles, as fluvial gradient is predicted to be strongly dependent on rock uplift. A similar response is expected from hillslope morphology which is also dependent on the relative base-level lowering rate. However, the reduced sensitivity of near-threshold hillslopes and the limited availability of high resolution topographic data has often been a major limitation for their use to investigate the distribution of tectonic activity.

Here we combined high-resolution analysis of hillslope morphology and cosmogenic nuclide-derived denudation rates to constrain the distribution of rock uplift across a thrust system at the Southwestern Alpine front in France. Our study is located in the Valensole Mio-Pliocene basin, where a series of folds and thrusts has deformed a plateau surface. Using a 1-m LiDAR Digital Terrain Model, we analyzed the morphology of hillslopes and extracted proxies for the relative spatial variations in denudation such as hilltop curvature (C_{HT}) and non-dimensional erosion rates (E^*). We observed systematic variation of these metrics coincident with the location of a major underlying thrust system identified by seismic surveys. Using a simple deformation model, the inversion of the E^* pattern allows us to constrain the geometry of a blind thrust, which is consistent with available geological and geophysical data.

We also sampled clasts from eroding conglomerate at several hilltop locations for ^{10}Be and ^{26}Al concentration measurements. Calculated hilltop denudation rates range from 40 to 120 mm/ka. These denudation rates appear to be correlated with E^* and C_{HT} extracted from the morphological analysis, and are used to derive absolute estimates for the fault slip rate. This high resolution hillslope analysis allows us to resolve short wavelength variations in rock uplift that would not be possible to unravel using commonly used channel profile-based methods.