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Hillslope denudation and morphologic response across a rock uplift gradient. Insights from the Valensole Plateau, Southeastern France

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Understanding the modalities of the topographic response to tectonic and climatic forcings is a cornerstone of Earth Surface processes research. Recent methodological advances have revolutionized our ability to constrain the spatial and temporal context of these processes and quantitatively address the major questions associated with these forcings. First, the ongoing developments in high resolution topographic data acquisition and processing allow obtaining increasingly precise and detailed pictures of topographic surface properties. Second, the ability to constrain rates of landscape evolution from cosmogenic nuclides concentration measurements has bolstered our understanding of surface processes dynamics. However, major challenges still remain regarding the evaluation of the combined response of the hillslope and fluvial landscapes components to these forcings. Similarly, only a limited number of studies have convincingly combined the spatial (high resolution morphology) and temporal (cosmogenic nuclides denudation rates) perspectives on landscape evolution.

In order to increase our knowledge of the joint spatial and temporal dynamics of surface processes, we investigated the morphological response of hillslopes across a thrust structure within the Valensole Mio-Pliocene molassic basin located at the front of the French Southern Alps. A major fold and blind thrusts system has uplifted the northern edge of the Valensole Plateau during the Quaternary and is potentially still active. The Durance River has incised the Western edge of the Valensole Plateau, where a series of small catchments are directly connected to the Durance base level. These catchments are aligned along a N trending axis perpendicular to the main structures and thus ideally located to record relative spatial variations in rock uplift. We analyzed high resolution hillslopes topographic properties, using a 1-m resolution LiDAR Digital Elevation Model (IGN RGE). We extracted individual hillslope parameters and observed a significant increase in various metrics such as hilltop curvature, hillslope relief or non-dimensional denudation rates, which is consistent with the location of the main underlying thrust structure identified by seismic surveys.

Additionally, we sampled bedrock at several hilltops locations for cosmogenic nuclides concentration measurement and denudation rates calculation. The lithological diversity of the fluviatile Valensole conglomeratic formation in the studied area allows measuring different cosmogenic radionuclides (CRN) from a same sample : ^{10}Be and ^{26}Al from sandstone clasts and ^{36}Cl from carbonate clasts. Calculated hilltops denudation rates ranges from 40 to 120 mm/ka. These CRN-derived denudation rates appear to be significantly correlated with non-dimensional denudation rates extracted from the hillslope high resolution morphological analysis.

The analysis of high resolution hillslope properties highlights the possibility to resolve short wavelength variations in rock uplift, that would not be possible to unravel using commonly used channel profiles investigation methods. Our joint analysis of topography and geochronological data supports the present activity of the investigated Quaternary fault propagation fold located at the Southeastern alpine front. This kind of study is a powerful method that may bring complementary constraints to morphotectonic analysis on slip rate occurring on blind active faults. Consequently, this quantification could be critical for seismic hazard assessment related to active fault sources.