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Evaluating steady-state soil thickness by coupling uranium series and 10Be cosmogenic radionuclides

Veerle Vanacker (1), Jerome Schoonejans (1), Sophie Opfergelt (2), Matthieu Granet (3), Marcus Christl (4), and Francois Chabaux (3)

(1) Earth and Life Institute, George Lemaître Center for Earth and Climate Research, Université catholique de Louvain, Louvain-la-Neuve, Belgium (veerle.vanacker@uclouvain.be), (2) Earth and Life Institute, Environmental Sciences, Université catholique Louvain, Louvain-la-Neuve, Belgium, (3) Laboratoire d'Hydrologie et de Géochimie de Strasbourg, EOST, University of Strasbourg and CNRS, Strasbourg, France, (4) Ion Beam Physics, ETH Zurich, Zurich, Switzerland

Within the Critical Zone, the development of the regolith mantle is controlled by the downwards propagation of the weathering front into the bedrock and denudation at the surface of the regolith by mass movements, water and wind erosion. When the removal of surface material is approximately balanced by the soil production, the soil system is assumed to be in steady-state. The steady state soil thickness (or so-called SSST) can be considered as a dynamic equilibrium of the system, where the thickness of the soil mantle stays relatively constant over time.

In this study, we present and compare analytical data from two independent isotopic techniques: in-situ produced cosmogenic nuclides and U-series disequilibria to constrain soil development under semi-arid climatic conditions. The Spanish Betic Cordillera (Southeast Spain) was selected for this study, as it offers us a unique opportunity to analyze soil thickness steady-state conditions for thin soils of semiarid environments.

Three soil profiles were sampled across the Betic Ranges, at the ridge crest of zero-order catchments with distinct topographic relief, hillslope gradient and 10Be-derived denudation rate. The magnitude of soil production rates determined based on U-series isotopes (238U, 234U, 230Th and 226Ra) is in the same order of magnitude as the 10Be-derived denudation rates, suggesting steady state soil thickness in two out of three sampling sites.

The results suggest that coupling U-series isotopes with in-situ produced radionuclides can provide new insights in the rates of soil development; and also illustrate the potential frontiers in applying U-series disequilibria to track soil production in rapidly eroding landscapes characterized by thin weathering depths.