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The importance of soil properties for understanding historical environmental change in contrasting environments: a field and modelling approach

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Soil erosion and sedimentation rates are commonly linked to human impact, which has been evidenced by numerous field studies, both in Mediterranean and in central and western European environments. Field data from the Belgian loess belt indicate an increase in sedimentation rates since the first traces of human impact, with peak values in the last 1000 years. This contrasts with data from the Mediterranean Taurus mountains in southwest Turkey, where peaks in sediment dynamics can largely be found between 900 BC and 600 AD. This dissimilarity is often explained by a difference in chronology of human impact. However, temporal variability in soil properties is often not accounted for. Nevertheless, the present soil cover in both regions differs strongly, with deep loess soils marked by only minor erodibility variations in the Belgian loess belt, compared to shallow, stony soils with bedrock at limited depth in the Taurus mountains.

In order to compare the geomorphic response to historical environmental change for both contrasting environments, a spatially distributed model is applied. With this model, the temporal evolution of sediment fluxes is simulated for two small catchments in Belgium and Turkey. In both catchments, detailed sediment archives have previously been studied, yielding appropriately dated information on sediment deposition and erosion rates within the study areas, which is used for model calibration and validation. Additionally, information on Holocene climate evolution and occupation history is available for both regions, setting the model background.

As soil properties in the Belgian loess belt are relatively homogeneous up to several meters depth, variations in erosion rates are mainly related to environmental change, with human impact playing a major role. Even when significant amounts of topsoil are removed and the calcareous loess is reached, the erosion potential does not change considerably. In contrast, the shallow soils of the Mediterranean Taurus are marked by increasing stone content with depth and mostly bedrock presence at less than one meter depth, so once the topmost soil layers are removed, soil erodibility is drastically reduced. Moreover, a significant and increasing area within the catchment will yield no sediment at all, as bedrock outcrops are all too common. With the modelling results, we show that the decrease in sediment dynamics in a mediterranean mountain environment is most likely related to changes in soil properties, whilst changes in land cover are not a dominant controlling factor. In contrast, land use is the dominant driving force behind the continuous increase in sediment dynamics in temperate environments, with thick soils where soil properties remain more or less constant. Our results also imply that when modelling long-term landscape dynamics, other model approaches may be needed for different regions. Many geomorphic models are mostly focussing on the spatial variability in controlling factors, whereby long-term simulations are run by changing land use (and climate) patterns, whilst few models also incorporate the temporal dynamics of soil resources.