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Human impact on late-Holocene hillslope and fluvial sediment dynamics: a field and modeling approach

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The human impact on sediment fluxes is evidenced by numerous integrated field studies. Most of these studies, however, remain qualitative and site-specific, leaving several questions on landscape response unresolved. How intense is the landscape response to human impact compared to the response to natural environmental change ? When did humans took over control and to what extent ? What is the importance of internal catchment dynamics in regulating sediment fluxes ? How do human and natural induced environmental change interact ? Detailed field-based approaches have recently been made for several areas that now provide partial answers to several of these questions. These include time-differentiated catchment sediment budgets, catchment-wide analysis of historic sedimentation rates and cumulative density functions of colluvial and alluvial activity. However, the poor temporal resolution of the sedimentary record makes it in most cases impossible to decipher e.g. the impact of short-lasting climatic events. Spatial modelling techniques could provide a means for estimating the impact of past (and future) environmental change on hillslope and fluvial sediment dynamics. But which model approach needs to be used ? Which variables and process-interactions need to be included ?
Here, we present results from the application of the geomorphic WATEM/SEDEM model on two contrasting environments in Belgium and SW Turkey. For the Dijle catchment (Loess Belt, Belgium), this model was combined with a climate reconstruction model and a spatially distributed land use model driven by historical and archaeological data. Model results match the history of sediment dynamics as evidenced by the time-differentiated sediment budget very well. Moreover, the model approach made it possible to estimate the relative importance of human and climatic impact on the Holocene sediment dynamics. Compared to the mid-Holocene time period, human induced land use change increased sediment fluxes by 6000%, whilst climate change modified sediment flux by only 6%. Furthermore, with the model it is possible to simulate the importance of settlement density and patterns on slop-channel coupling as illustrated by changing sediment delivery ratios. Contrary to loess catchments in western and central Europe, many regions in the Mediterranean are confronted with much smaller contemporary sedimentation rates compared to Hellenistic and Roman times. Results of the WATEM/SEDEM model for a small basin in SW-Turkey shows that this is not due to an increase in erosion-reducing vegetation cover after this period (as evidenced in pollen studies), nor due to a drying of the climatic conditions, but rather due to a decrease in soil erodibility through time. Intensive land use during Hellenistic and Roman times eroded the topsoil, thereby increasing its stoniness, which prevented further erosion. The dynamic nature of soils thus needs to be taken into account when modelling the landscape response to human or climatic impact. However, this process of soil depletion is not important in catchments with thick loess cover such as in the Dijle catchment. Hence, depending in the environmental settings of the area considered, a more complex model approach may be needed.