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Facing the scaling problem: A multi-methodical approach to simulate soil erosion at hillslope and catchment scale

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Modelling soil erosion requires a holistic understanding of the sediment dynamics in a complex environment. As most erosion models are scale-dependent and their parameterization is spatially limited, their application often requires special care, particularly in data-scarce environments. This study presents a hierarchical approach to overcome the limitations of a single model by using various quantitative methods and soil erosion models to cope with the issues of scale.
At hillslope scale, the physically-based Water Erosion Prediction Project (WEPP)-model is used to simulate soil loss and deposition processes. Model simulations of soil loss vary between 5 to 50 t ha-1 yr-1 dependent on the spatial location on the hillslope and have only limited correspondence with the results of the 137Cs technique. These differences in absolute soil loss values could be either due to internal shortcomings of each approach or to external scale-related uncertainties. Pedo-geomorphological soil investigations along a catena confirm that estimations by the 137Cs technique are more appropriate in reflecting both the spatial extent and magnitude of soil erosion at hillslope scale.
In order to account for sediment dynamics at a larger scale, the spatially-distributed WaTEM/SEDEM model is used to simulate soil erosion at catchment scale and to predict sediment delivery rates into a small water reservoir. Predicted sediment yield rates are compared with results gained from a bathymetric survey and sediment core analysis. Results show that specific sediment rates of 0.6 t ha-1 yr-1 by the model are in close agreement with observed sediment yield calculated from stratigraphical changes and downcore variations in 137Cs concentrations. Sediment erosion rates averaged over the entire catchment of 1 to 2 t ha-1 yr-1 are significantly lower than results obtained at hillslope scale confirming an inverse correlation between the magnitude of erosion rates and the spatial scale of the model.
The study has shown that the use of multiple methods facilitates the calibration and validation of models and might provide a more accurate measure for soil erosion rates in ungauged catchments. Moreover, the approach could be used to identify the most appropriate working and operational scales for soil erosion modelling.