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Predicting sediment yield for catchments under pristine conditions: the role of tectonic activity

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Whereas the importance of tectonic activity in controlling long-term erosion rates is widely recognized, tectonic effects on contemporary sediment yields (SY, t/km^2/y) are generally neglected. It is implicitly assumed that the effects of tectonic activity on SY are reflected by catchment topography. Here we show that this assumption does not hold.

Analyses were based on dataset of 146 measured SY-data from "pristine" catchment in Europe, i.e. catchments that are little or not affected by humans in terms of land use and have no significant reservoirs, lakes, impoundments or glaciers in their upstream area. The selected catchments span a wide range of catchment areas (0.3 – 4,000km^2) and observed SY-values (0.5 – 3,100 t/km^2/y). Whereas climate exerts little control on the observed range of SY-values, strong correlations were found between SY and the average catchment slope and lithology. Furthermore, a very strong correlation was found between SY and the seismic activity in the catchment, expressed as the estimated Peak Ground Acceleration (PGA) having a exceedance probability of 10% in 50 years. These PGA-values were derived from a global seismic hazard map. Despite the relatively limited tectonic activity Europe, differences in PGA alone explained already more than 40% of the observed variation in SY. Partial correlation analyses further showed that SY remained significantly correlated with the seismic activity after correcting for auto-correlations with topography and lithology.

Based on these findings, a regression model was developed that allows predicting baseline SY. Model calibration and validation results indicate that this model is capable of providing robust approximations of the baseline SY, with >95% of predictions deviating less than one order of magnitude from the measured SY-values. This model allowed to further explore the role of seismic activity in explaining SY and indicated that seismic activity may contribute strongly to regional differences in SY in Europe. This effect is not entirely captured by differences in topography. Furthermore, analyses of a dataset of non-pristine SY-values from large catchments worldwide further indicated that also at a global scale, seismic activity contributes significantly to observed SY. These results clearly plead for explicitly considering tectonic activity in models that predict contemporary SY.