Sediment delivery – Limitations of empirical models in Bavaria

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Sediment input by surface runoff is an important diffuse pathway for phosphor in aquatic ecosystems. It therefore forms an integral part of nutrient models. A combination of Universal Soil Loss Equation (USLE) and simple catchment properties is commonly used to predict sediment yields at the catchment scale. However, other studies conclude that empirical approaches may not match measured yields (Boomer et al., 2008). The objective of this study is to assess the suitability and limitations of model outcomes in the hilly and mountainous terrain of Bavaria, Germany.
The study area comprised the catchments of 60 gauges with areas between 20 and 8800 km² spanning from lowland to alpine terrain. Gross erosion with 100 m raster resolution was calculated using the USLE, commonly available data and standard functionality of ArcGIS 9.2. Two calibrated lumped and one distributed (Veith, 2002) sediment delivery ratio (SDR) approaches were applied to estimate sediment yields (SY) and compare them to "critical yields" calculated for 22 Bavarian gauges according to Behrendt et al. (1999).
As the USLE is limited to sheet and rill erosion, the modeled SY of alpine catchments are below 10 % of critical SY. For non-alpine catchments, both calibrated approaches match observed yields ($R^2 > 0.8$), although outliers strongly influence the linear regression model. The uncalibrated model overestimated SY by about 50% ($R^2 > 0.7$). Four of these predictions resulted between 200 % and 500 % above observations. Although no catchment property could be singled out, short time-series of runoff and suspended solids (<5 years, SEM > 25 %), water diversion and Karst conditions in the Franconian Switzerland might be possible reasons.
Modeled SY were highly correlated (Spearman's $r_S > 0.8$), in contrast to SDR ($r_S < 0.7$). Significant correlations between SDR_{mod} / SDR_{crit} and SDR_{crit} ($r_S < -0.8$, $p < 0.001$) suggest a systematic error for all models. The same pattern was observed with an independent USLE-based erosion dataset. Power equations with exponents between -0.7 and -1.2 best described the relationships ($R^2 > 0.9$).
These first results indicate general difficulties of even calibrated empirical SDR approaches to predict sediment yields at catchment outlets. However, the influences of catchment properties, measurement uncertainties and the assumptions behind the "critical" SY have to be further scrutinized.

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