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Are runoff coefficients capable to reflect the coupled effect of upslope topography and land cover in agricultural catchments?

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The length of a hillslope plays a key role in the estimation of mean annual erosion rates of agricultural catchments. Two main properties govern the erosive slope length as used in the Revised Universal Soil Loss Equation (RUSLE) and follower models: 1) The beginning of an erosive slope length which is defined as the location where runoff usually starts. 2) The slope cutoff, which is defined by the locations where either sedimentation occurs or where the hillslope is connected to a feature of linear drainage, such as river channels or artificial flow paths. Recent studies considered land cover specific runoff coefficients in the computation of the slope length factor (L-Factor) in the RUSLE, by means of adapting the upslope contributing area with effective contributing area ratios for different land cover types, such as forest, grassland, farmland and fallow land.

In this study, we assess the effect of land cover specific runoff coefficients in the computation of L-Factor, by calibrating the RUSLE to the small (approx. 66 ha) HOAL-catchment near Petzenkirchen in Lower Austria. We compare an established grid-based approach for L-Factor computation (L_G) and a modified approach (L_M) that adapts the upslope contributing area with land cover specific runoff coefficients. Further, we evaluate the performance of the RUSLE by comparing the modelling results with measured sediment loads at the catchment outlet for a period of 11 years (2007 to 2017) and identify particular sensitive model parameters. Lastly, we aim to verify whether the modified approach (L_M) is capable to reflect the coupled effect of upslope topography and vegetation cover reliably.

Our findings indicate that the L_G-approach largely overestimates annual soil erosion rates by approx. one order of magnitude of the observed sediment load. In contrast, the L_M-approach is able to reduce the absolute predicted soil erosion rate of the L_G-approach by the half. Both approaches show similar relationships to the observed sediment load with R^2 = 0.85 (L_G) and R^2 = 0.86 (L_M) and similar trends throughout the years of observation. The direct comparison of L_G and L_M aggregated for the entire observation period show greatest differences in grassland areas, but surprisingly a recognisable variability of differences among the farmland classes (e.g. L_M is ~30 % lower than L_G in areas where cereals are cultivated but ~50 % lower in areas with maize). However, the comparison between single plots and each year of observation shows that only differences between land cover classes are observable (grassland, arable land, etc.) but not for single crops, as a direct comparison of L_G and L_M let assume.

Considering the fact that the upslope contributing area implies the highest sensitivity to the L-Factor results, it can be suggested that the L_M is not capable to reflect the topographical variabilities of surface runoff behaviour in differently managed cropland areas (e.g. cereals compared to maize). In this regard, it can be questioned whether runoff coefficients are able to represent L-Factor values reliably in differently managed cropland areas.