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Modeling climate change impact on surface runoff, erosion and sediment yield in agriculturally used catchments

Ulrike Scherer (1), Kai Gerlinger (2), and Erwin Zehe (1)

(1) TU München, Institute of Water and Environment, München, Germany (u.scherer@bv.tum.de, +49 89 28923172), (2) HYDRON, Karlsruhe, Germany

Surface runoff and soil erosion as well as many of the factors controlling both will be directly or indirectly affected by climate change impact. Increasing precipitation amounts and intensities cause non linear responses of runoff and soil loss. The variation of local precipitation and temperature regimes implicate shifts in vegetation cover, soil conditions, land use and management which will affect runoff, erosion and the translocation of sediments and environmental pollutants to surface waters. For example the adaptation of crop rotation and planting dates due to changes within temperature regimes will cause shifts in vegetation cover which might affect erosion due to decreasing cover in periods of high storm risk.

In agriculturally used catchments of Southern Germany, the susceptibility of soils to erosion is highest during spring and summer because of both, an increasing risk for thunderstorms in this season and a sparse soil cover due to the growth period of crops. Climate change scenarios for Southern Germany assume higher average precipitation rates during the winter half year, whereas precipitation rates in summer are slightly decreasing. Longer lasting rainfall events in winter will increase runoff but will have no significant impact on sediment yields, since the rainfall intensities are quite low. Despite lower rainfall rates in the summer half year it is expected that the rainfall intensity of extreme events will increase, including a higher risk for erosion. To analyse how surface runoff response and sediment yields will be affected by climate change impact the process based erosion model CATFLOW-SED was used. CATFLOW-SED is based on Richards Equation including an effective approach for preferential flow and the Saint-Venant-Equation to simulate soil water dynamics and overland flow / river flow. The erosion process is modeled using shear stress, the momentum balance of precipitation and a semi-empirical erosion resistance for predicting soil detachment. The model was validated for the database of the 3.5 km^2 Weiherbach catchment located within a loess region of Southwest Germany at various scales, showing a good agreement with observed sediment loads of large erosion events on the catchment scale. Based on these simulation results various scenarios are modeled, including the increase of rainfall intensities and shifts in vegetation cover. It could be shown that the percentage of change in surface runoff and soil erosion is significantly higher than the percentage of change in precipitation and that soil loss is more affected than runoff due to the high non linearity of the underlying processes. Additional scenarios were modeled to test the efficiency of mitigation measures e.g. conservation tillage and changes within land use to compensate for the consequences of climate change.