Soil Erosion under Climate Change – a High-resolution Projection at Catchment Scale through 2100

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The goal of this study was to quantify the impact of climate change on soil erosion rates at the catchment scale at high temporal and spatial resolutions. Simulations were run for measured and projected single rainstorm events at a temporal resolution of five minutes in three representative catchments in West, North and East Saxony/Germany.

The study is based on the A1B IPCC-scenario. Four models were incorporated in this study: ECHAM5-OPYC3 (general circulation model), WETTREG (statistical downscaling climate model), METVER (agricultural model for calculating daily initial soil moisture), and EROSION 3D as a process-based soil erosion model. The general circulation model ECHAM4-OPYC3 drives the statistical downscaling model WETTREG. In addition, the regional climate model is fed with long term measured high resolution data of the selected climate stations. It delivers simulated daily temperature, solar radiation and precipitation to the METVER-Model, as well as high resolution simulated precipitation data until 2100 to EROSION 3D. METVER determines daily soil moisture for the different soils and crops within the selected catchments. The calculated soil moistures are then transferred to EROSION 3D as model input (Figure 1).

Soil loss was simulated for two future periods from 2041 to 2050, and from 2091 to 2100. Results were compared to simulated soil loss based on 10 years of measured climate data from 1989 to 2007. Expected changes in land use, soil management due to changed crop rotations, and the influence of shifted harvest and cultivation dates of corn in monoculture were taken into account as scenario studies.

The predicted change of the regional weather circulation patterns was predicted to lead to increased or unchanged high soil erosion rates until 2050 in Saxony/Germany. For the end of the century, decreases in soil erosion rates were generally projected. Precipitation intensities of extreme events will increase, although the total number of such events was predicted to decrease. Additionally the occurrence of rainstorms within the year is predicted to change: The number of rainstorms will decrease during the summer and increase during the winter half-year periods. This trend will intensify towards the end of the century. The main reason for the decrease of soil erosion rates in the second half of the century were lower initial soil moistures due to higher temperatures, greater solar radiation and a decline of total precipitation amount.

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Figure 1. Models used and connections.
Contemporary climate change induces land use changes. This study confirms the results of Mullan et al. (2012) and Nunes et al. (2013): Soil management affects soil erosion rates much more than the impact of the predicted climate change. Chmielewski et al. (2004) and Estrella (2007) investigated the trends of the future phenology of crops. While the shift of the date of sowing will be only minor, the harvesting date of many crops will be shifted notably. For a few cases, the shift of phenology resulted in a significant increase in predicted soil loss. Certainly the amount of soil loss depends on the soil conditions after harvest (Figure 2).

Permanent conservation tillage and no-tillage proved to preserve the soil best with respect to climate change. A stable soil structure due to minimal soil disturbance and high soil surface cover all year round are of prime importance. Current soil protection measures are suitable for soil conservation under the conditions of a changing climate.

This study was conducted as a first approximation of the impact of climate and land-use changes on soil loss at a fine temporal scale. With progressing climate research and improvement of model concepts of regionalisation, the projections will become more detailed, faster and more robust.

**References**


