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From Local to Global Scale Soil Erosion Modelling – A Sensitivity Analysis of the RUSLE Model

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Human activities like deforestation and agricultural practices induce land-use changes that can trigger soil erosion on large scales. Soil erosion also influences the global carbon cycle, which may play an important role for the current climate change. The current Dynamic Global Vegetation Models (DGVMs) are designed to simulate land carbon dynamics of vegetation and soils as a result of changing climate and land-use. However, they lack the capability to account for soil erosion. This limits their usage for investigating soil carbon dynamics and the global carbon cycle. In this study a stand-alone soil erosion module for the MPI Earth system model (MPI-ESM) is developed. The particular scientific aim is to create a basic structure for the representation of erosion by water on global scale. The erosion module is based on the Revised Universal Soil Loss Equation model, RUSLE, and contains topography, soil, climate and land-use parameters. The RUSLE model, which is originally developed for the local spatial scale, is based on a large set of empirical data on soil erosion gathered under different conditions in the United States. Although RUSLE had been implemented on large spatial scales, its implementation on the global scale together with global datasets is still relatively new. Therefore, the current study presents an analysis of the sensitivity of the erosion module to different spatial resolutions of the input datasets. This is needed before the module can be used together with output from MPI-ESM millennium simulations to investigate past large scale erosion events as seen in the Middle Ages in Europe.

Firstly, global soil erosion rates were estimated for the current state of topography, soil, climate and land-use, using the original RUSLE parameterizations. The results were compared to erosion plot data from Europe from Cerdan et al., 2010, and showed a general underestimation of soil erosion on agricultural areas and low lands, while a significant overestimation in mountainous areas. The reason why soil erosion is overestimated here is twofold. Firstly, the coarse resolution input data cannot resolve small scale features in the landscape, while at the same time the original RUSLE parameterizations are not adapted to the global scale. Secondly, some important erosion-related processes are not represented in the model, such as deposition and sediment transport. This indicates that the erosion module based on RUSLE is not directly applicable at the coarse resolution of DGVM's. The current study discusses both the sensitivity of the different parameters of the erosion module to spatial and temporal resolutions of the input datasets, and to different methods of scaling up. As it is very difficult to represent local scale soil erosion processes on a large spatial scale, scaling methods are needed to gap this bridge between local and global scale in order to present a better estimation of soil erosion by water on global scale.