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Soil Erosion as a stochastic process

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The main tools to provide estimations concerning risk and amount of erosion are different types of soil erosion models: on the one hand, there are empirically based model concepts on the other hand there are more physically based or process based models. However, both types of models have substantial weak points. All empirical model concepts are only capable of providing rough estimates over larger temporal and spatial scales, they do not account for many driving factors that are in the scope of scenario related analysis. In addition, the physically based models contain important empirical parts and hence, the demand for universality and transferability is not given. As a common feature, we find, that all models rely on parameters and input variables, which are to certain, extend spatially and temporally averaged. A central question is whether the apparent heterogeneity of soil properties or the random nature of driving forces needs to be better considered in our modelling concepts.
Traditionally, researchers have attempted to remove spatial and temporal variability through homogenization. However, homogenization has been achieved through physical manipulation of the system, or by statistical averaging procedures. The price for obtaining this homogenized (average) model concepts of soils and soil related processes has often been a failure to recognize the profound importance of heterogeneity in many of the properties and processes that we study.
Especially soil infiltrability and the resistance (also called “critical shear stress” or “critical stream power”) are the most important empirical factors of physically based erosion models. The erosion resistance is theoretically a substrate specific parameter, but in reality, the threshold where soil erosion begins is determined experimentally. The soil infiltrability is often calculated with empirical relationships (e.g. based on grain size distribution). Consequently, to better fit reality, this value needs to be corrected experimentally.
To overcome this disadvantage of our actual models, soil erosion models are needed that are able to use stochastic directly variables and parameter distributions. There are only some minor approaches in this direction. The most advanced is the model “STOSEM” proposed by Sidorchuk in 2005. In this model, only a small part of the soil erosion processes is described, the aggregate detachment and the aggregate transport by flowing water. The concept is highly simplified, for example, many parameters are temporally invariant.
Nevertheless, the main problem is that our existing measurements and experiments are not geared to provide stochastic parameters (e.g. as probability density functions); in the best case they deliver a statistical validation of the mean values. Again, we get effective parameters, spatially and temporally averaged.
There is an urgent need for laboratory and field experiments on overland flow structure, raindrop effects and erosion rate, which deliver information on spatial and temporal structure of soil and surface properties and processes.