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Experimenting model deconstruction

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Physical soil erosion models describe erosion and transport of solids by flowing water as the interaction of the soils' resistivity to be eroded, the force of the water to entrain particles and its capacity to transport them in suspension. This has lead to concepts in which hydraulic parameters as flow velocity or composite parameters such as shear stress, stream power etc. are set into a direct relation to erosion and sediment transport. Soils' resistivity to erosion is in general represented as a threshold problem, in which a critical force is trespassed and the following increase of erosion depends on the characteristics of the sediments and the flowing water.
Despite considerable efforts, these model concepts have not been able to produce more reliable and accurate reproduction and forecast of soil erosion than "simple" empirical models such as the USLE and its derivates. And there is still a lack in knowledge about the reasons for this failure. A considerable number of studies have addressed the following questions:
1) What are the main parameters of soils and flowing water influencing soil erosion?, 2) What relationship do these parameters have with the intensity and different types of soil erosion?, but only few researchers have faced the consequence: 3) Are the present concepts suitable to describe and quantify soil erosion accurately?
Similar to other studies, we investigated the influence of basic parameters as grain size, slope, discharge and flow velocity on sediment transport by shallow flowing water in laboratory experiments. Variable flow was applied under different slopes on non-cohesive mobile beds. But in addition, field experiments were designed to quantify the hydraulic and erosive effects of small rills in the field. Here, small existing rills were flushed with defined flows, and flow velocity as well as transported sediments was quantified.
The laboratory flume experiments clearly show a strong interaction of flow velocity, the size of the transported grains and their concentratio, affecting them the transport of sediments. The experiments also show that hydraulic parameters are not able to predict the combination of sediment detachment and transport. Moreover, the relationship between flowing water and sediment transport is shown to be complex, depending on the morphological evolution of the bed, depending again on the characteristics of the substrate. The field experiments confirm these results, and also show that under variable conditions higher transport rates than those predicted by different model concepts are not only possible, but even the common observation.
We conclude from these results that soil erosion by flowing water is much more complex than reflected in model concepts: they neither reflect the process variability nor the interaction between the different dynamic parameters of flow and soils. Mechanistic concepts, in which simple or composite predictors define the dynamics of soil erosion, can not succeed in soil erosion modelling.