Geophysical Research Abstracts
Vol. 12, EGU2010-4249, 2010
EGU General Assembly 2010
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Soil erosion by water - model concepts and application

Juergen Schmidt
Soil and water conservation unit, TU Freiberg, Germany (jhschmidt@web.de)

Soil erosion is not a continuous process but the result of isolated surface runoff events, whose erosional effects are determined by numerous temporally and spatially varying variables. Thus the monitoring of soil loss by direct observation is extremely limited with respect to space and time. Usually observation plots cover an area of less than 100 m2 and the observation period is less than 10 years. In order to estimate soil losses by water erosion for others than empirically observable conditions, mathematical models are needed, which are able to describe the interaction of the different physical mechanisms involved either statistically or on the basis of physical algorithms. Such models are absolutely essential for risk prognoses on catchment and regional scale. Besides the aspect of soil conservation the delivery of sediments and sediment bound pollutants into surface water bodies are of increasing relevance in this context.
Based on an exemplary selection of existing water erosion models this contribution aims to give an overview over different mathematical approaches used for the description of particle detachment, transport and deposition of soil particles. According to the chronology in the development of soil erosion models empirical algorithms will be presented first based on the USLE approach. However, since purely empirical models like USLE are limited to the estimation of annual soil loss further attempts in soil erosion modelling are focussed on event based estimations considering the fact that soil erosion is not a continuous process but the result of isolated runoff events. One of the first models of this type was CREAMS using physically based algorithms in combination with empirical ones in order to describe the basic erosion processes. Today there are diverse soil erosion models available following in principle the CREAMS concept but using different algorithms in detail. Concerning particle detachment, transport and deposition alternative approaches will be discussed taking account of the models WEPP, EUROSEM, IISEM and EROSION 3D. In order to provide a better representation of spatially heterogeneous catchments in terms of landuse, soil, slope, and rainfall most of recently developed models operate on a grid-cell basis or other kinds of sub-units, each having uniform characteristics. These so-called “Distributed Models” accepts inputs from raster based geographic information system (GIS). The cell-based structure of the models also allows to generate drainage paths by which water and sediment can be routed from the top to the bottom of the respective watershed. One of the open problems in soil erosion modelling refers to the spontaneous generation of erosion rills without the need for pre-existing morphological contours. A promising approach to handle this problem was realized first in the RILLGROW model, which uses a cellular automaton system in order to generate realistic rill patterns. With respect to the above mentioned models selected applications will be presented and discussed regarding their usability for soil and water conservation purposes.