Geophysical Research Abstracts, Vol. 9, 02797, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-02797

Evaluation of sediment yield models beyond the region of origin using documented Ethiopian catchments

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Several models have been developed world-wide to estimate sediment yield. These models fall into four main classes, depending on the physical processes simulated by the model, the model algorithms describing these processes and the data dependence of the model are: i.e. (1) semi-quantitative /scoring models, (2) empirical/regression models, (3) parametric models and (4) physics-based models. So far little comparative studies were done on the performance and the degree of calibration required by these classes of models. This study evaluated the performance of these models by taking one example from each of the first three model classes in relation to predictive efficiency and the need for calibration if used beyond the region for which the model was developed.

Hence, a semi-quantitative Factorial Scoring Model (FSM) developed for the Spanish catchments, a multiple regression model developed for central Belgium and a parametric Water and Tillage Erosion/ SEdiment DElivery Model (WaTEM/SEDEM) developed for central Belgium were evaluated for 11 documented Ethiopian catchments without and with calibration.

The application of the models without calibration showed that the mean model efficiency (ME) compared to the original models goes down from 0.83 to -0.22, 0.76 to

-3 and 0.77 to 0.53 for the FSM, regression and the WATEM/SEDEM models, respectively.

The application of the models after calibration showed that the performance of the semi-quantitative and the regression models improved dramatically i.e. ME = 0.75 and 0.66, respectively. While the performance of the WATEM/SEDEM does not improve much (ME= 0.63). The low performance of WATEM/SEDEM stays as a limitation of the model irrespective of the region as gully erosion is not incorporated well in the model structure.

The regression and distributed models are quantitative in that there is very limited subjectivity during input parameters determination, unlike that of the semi-quantitative models. The WATEM/SEDEM provides information on the spatial distribution of soil erosion and sediment deposition that enables to prioritize erosion prone areas and to plan alternative management practices while the semi-quantitative and regression models provide only a lumped sediment yield data at the outlet of the catchment. Conceptual models such as WATEM/SEDEM seem relatively less region-specific as compared to the semi-quantitative and empirical models. This might be because conceptual models share some characteristics of physics-based models that use standard equations of conservation of mass and momentum for flow and the equation of conservation of mass for sediment.

We conclude that each class of models studied can be important for a specific application and an integrated application of all the three models can be useful for a holistic planning and management of soil erosion and sediment yield. Therefore, we suggest that (1) semi-quantitative models are to be applied as a first, cheap and quick assessment tool for rating catchments based on sediment yield like reconnaissance surveys, (2) the regression-model can be applied for verifying the predicted sediment yield using the semi-quantitative models and for better prediction of sediment yield like planning reservoir sedimentation rates and (3) the conceptual models may be applied for analyzing the pattern and rate of erosion-deposition within the catchment and hence to design alternative management strategies for catchment management.