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Development of Modified MMF (Morgan-Morgan-Finney) soil erosion model for various spatial and temporal scales

Muhammad Anggri Setiawan (1,3), Volker Wichmann (2), Johann Stötter (1), and Junun Sartohadi (3)

(1) Institute of Geography, University of Innsbruck, Austria (muhammad.setiawan@student.uibk.ac.at, +43-(0)512-507-2895), (2) LASERDATA GmbH, Innsbruck, Austria, (3) Department of Geography and Environmental Science, University of Gadjah Mada, Indonesia

Despite the continuous soil erosion problem in mountain areas, there is still insignificant progress in soil erosion modelling in Indonesia with its rough topography and extreme rainfall events. Moreover, most of mountain areas are extremely fertile and thus occupied by multiple agriculture activities throughout the whole year. The more intensive agriculture activities are, the more complex soil erosion processes take place thus requiring reasonable understanding of how to model these.

The main objective of this study is to adopt an applicable soil erosion model and adapt it in a simple but still robust way in order to yield reliable predictions. That model should also have a good flexibility in terms of spatial and temporal scales. In accordance to the objective, we chose Modified MMF (Morgan and Duzant, 2007) and integrated it within the SAGA environment (System for Automated Geo-scientific Analyses) as a novel module which covers all steps from data preparation, model processing until output representation. The time-span parameter was added to the evapotranspiration and interflow, which allows us to calculate soil erosion for different time scales from day to year. Another advantage of this model is the integration of a distinct channel network. Thus, calculation of total sediment from the outlet point becomes possible.

The Modified MMF-SAGA was firstly tested in two plots areas, i.e. a potato field (1940 m^2) and a forest area (219 m^2), in the upper part of Wonosobo Prefecture, Central Java Province, Indonesia. This region has been severely damaged by the intensive dry land agriculture. These plots observations were carried out during one plantation season (2.5 months) during the rainy season 2009. The observed sediment loads were collected 6 times in the potato field area and 7 times in the forest area. Each plot was equipped with automatic rainfall gauge. Terrestrial mapping was conducted to obtain a detailed topography of the plots. The potato field plot has a general slope of 15 degree and has series of ridges and furrows complemented with some ditches in the middle of the field. The forest plot has a slope of 35 degree with a relatively smooth surface. In term of input data pre-processing, the vegetation cover, ground cover and stone percentage coverage were measured using imagery supervised classification analysis. In case of the potato field area, the first month of the plantation period was assumed as bare land since during that time the vegetation parameter did not significantly affect the model results. To run the model, we used single rainfall events and summarized them at the same time with the sediment observation dates. The predicted sediment loss of the potato field and the forest area were then evaluated through Nash-Sutcliffe efficiency with logarithmic values (ln E) resulting 0.86 and 0.92, respectively, over a range of values from zero to 0.005 kg in the forest area and 3.69 kg to 1130.35 kg in the potato field. In the potato field area, the predicted Modified MMF has less accurate prediction than in forest area due to the disturbed soil surface condition by tillage activities. Nevertheless, the Modified MMF-SAGA still performs promising result for an area with such rough topography and extreme rainfall events. In the near future, this model will be tested for longer time periods and in larger areas