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www.hydrol-earth-syst-sci-discuss.net/9/C4512/2012/

Hydrology and Earth System Sciences Discussions

Interactive comment on "An efficient semi-distributed hillslope erosion model for the sub humid Ethiopian Highlands" *by* S. A. Tilahun et al.

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We would like to thank Dr. Rose for the positive evaluation (i.e., our approach has the potential to make a substantial contribution to the literature when adequately presented and defended) despite our many misprints. In answering the general reservations, we will use the same numbers as in his interactive comment and only repeat the comment in summary form.

Response to comment 1:Dr. Rose comments that the outcome of the simulations would be much more convincing if the fractional areas could be estimated independently of the calibration process. We mentioned in the response to reviewer 1 that unlike traditional parameters such as hydraulic conductivity, the exact definition of the fractional area is not known at prior when using the principles of "organized complexity". For example we do not know what the maximum soil depth is for an area to be called "degraded". One would have to follow the more detailed small scale simulations suggested by reviewer 1 to use potentially measurable parameters to obtain a priori estimates. However in the case of organized complexity once the parameter values are optimized, we will understand how they are defined and then can be validated and for the fractional area they can be compared directly with the observed field values. In Table 2 of the manuscript, the calibrated value for saturated area is 2%. This is consistent with observations in the Anjeni watershed: Piezometer readings of Legesse (2009) found that there is a deep water table throughout watershed except in very close proximity to the stream. The piezometers with a high groundwater table were located in the grassed area shown in Figure 1. The grass area is in itself an indication that it is too wet during part of the year to grow a crop. As can be seen from Figure 1 below (or Figure 4 in the manuscript), which only depict partially the watershed, the grassed area constitutes a relatively small area in the watershed and the calibrated 2% of the model is reasonable. Degraded soils have a hardpan at shallow depth and will saturate during the rain storm. To check what the degraded area are, a detailed soil survey of the watershed is shown in Figure 2 below and Table 1 below (Zeleke 2000; Legesse 2009). In Table 1 (that is included as Figure 5), there are two soil types with a soil depth of less than 25-50 cm and are called liptic Leptosols and the euric Regosols. These very shallow soils cover 12% the hillsides. In our model we use a percentage of 14% (Table 2 in the HESSD manuscript page 2147) closely resembling this information. It is also these areas that the farmers have the traditional small drainage (or cultural). In the Blue Nile Basin, the degraded areas and saturated soils are spread throughout the basin and according to Hydrosult Inc. et al., (2006) are located at Mount Choke in East and West Gojam where Anjeni is located, Lake Tana sub basin, Jema sub basin in Wolo and Abay Gorge in East Wollega. We cannot check exactly what they are but are in general agreement with other watersheds where we have tested the model in Ethiopia (Engda, 2009; Demisse, 2011; Bayabil, 2009)

A water balance is kept for all three areas on a per unit area basis (i.e., in depth units). To obtain the outflow for each of the three regions, we multiply the discharge from each unit area by the fractional area of that region. Next we sum the discharge from the three regions to obtain the discharge at the outlet. A fraction of the water leaves the watershed other than through the gage. Performing the calculation on a per unit bases avoid the difficulties as envisioned by Dr. Rose. The soils at the outlet of the watershed are over 10-20 meter deep (Table 1 only describes the top two meters and not below). These soils are very permeable as indicated by well structures soils with preferential pathways in Figure 4 below.

Response to comment 2: As noted by Dr. Rose (and reviewer 1) the description of the water balance model is too short. We have added a schematic of the water balance model (reproduced in the response to reviewer 1) and added more text. Dr. Rose noted specifically that we did not discuss the reservoirs in the model. In supplemental material to this response we give an overview over the reservoirs and added the following text in the revised manuscript concerning the subsurface "reservoirs":

"There are two types subsurface flows simulated: Interflow and baseflow. Interflow is relatively fast and is simulated as a zero order reservoir (i.e. the flow decrease as linear function of time and last for a fixed time t*, after a rainstorm. This time is landscape dependent but invariant of storm size. Baseflow is simulated as a linear reservoir with and exponentially decreasing flow with a watershed specific half-life. In order to separate interflow from baseflow, we assume that the first order baseflow reservoir fills up first to a value BSmax and then the remaining recharge is contributed to the zero order interflow reservoir."

Response to comment 3: We have responded above on the identification of the fractional areas. A land use map made by Ashagre (2009) (shown in Figure 3 below)

further confirms what the model indicates. First the grasses area can be seen in the middle bottom of the picture (indicated by Figure 3 below). There are also areas in grass that are not related to any soil type and we should investigate why that is the case. We are carrying out currently a study in small Debra Mawi Watershed to locate the runoff source regions and correlate it with remote sensing images in order to scale up to larger basin. We will report on this in a later publication when the research is completed.

The responses to the specific questions and comments are in the supplementary material that is attached electronically.

References

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Legesse E.S.: Modeling Rainfall-Runoff relationships for the Anjeni watershed in the Blue Nile Basin M.P.S Thesis. Cornell University, Ithaca, NY, USA, 2009.

Zeleke, G.: Landscape Dynamics and Soil Erosion Process Modeling in the North-Western Ethiopian Highlands, African Studies Series A 16, Geographica Bernensia, Berne, Switzerland, 2000.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/9/C4512/2012/hessd-9-C4512-2012-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 2121, 2012.

Fig. 1. Photograph of the Anjeni watershed. In the foreground the grass strip can be seen that saturates during the wet period. The area is too wet to grow a crop. The agricultural fields are on the hillside

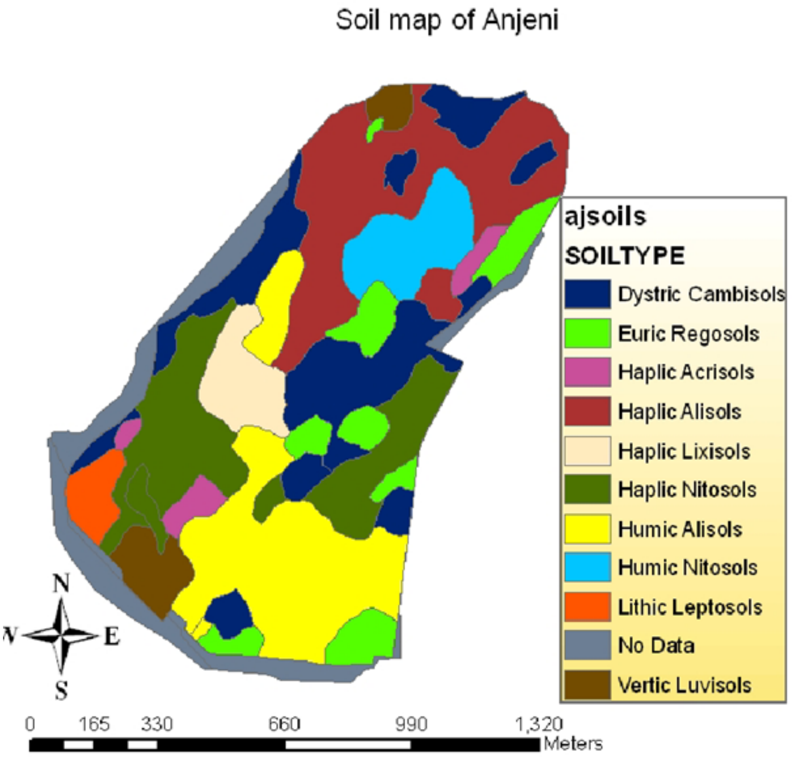


Fig. 2. Soil map of the Anjeni watershed

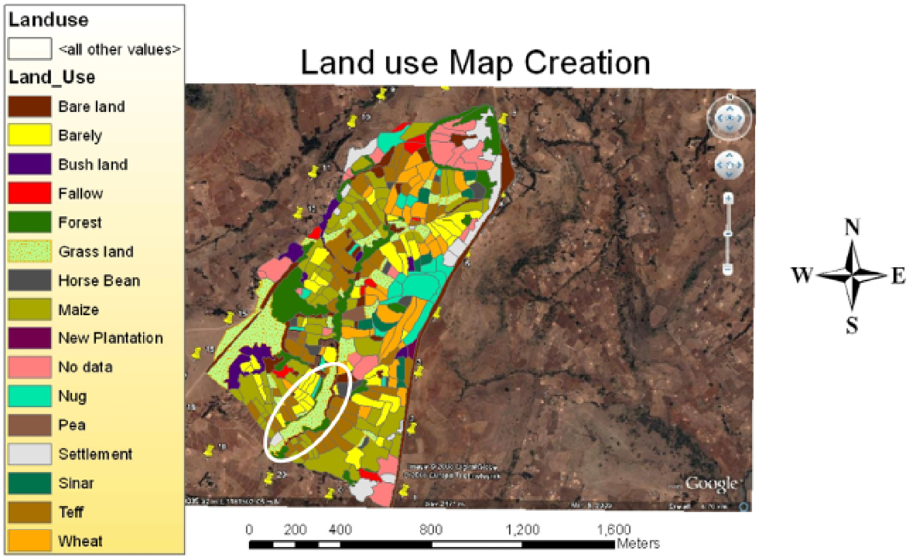
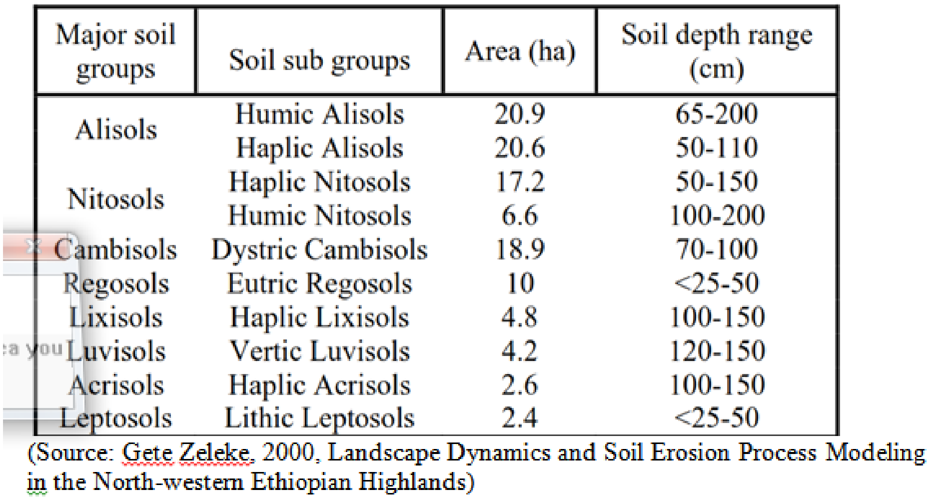


Fig. 3. Land use of the Anjeni watershed in 2008 (Ashgare, 2009). The green in the oval is the saturated grassed area.

Fig. 4. Soil profile in Anjeni clearly showing that the soil is well structured and has a high infiltration rate



Major soil groups	Soil sub groups	Area (ha)	Soil depth range (cm)
Alisols	Humic Alisols	20.9	65-200
	Haplic Alisols	20.6	50-110
Nitosols	Haplic Nitosols	17.2	50-150
	Humic Nitosols	6.6	100-200
Cambisols	Dystric Cambisols	18.9	70-100
Regosols	Eutric Regosols	10	<25-50
Lixisols	Haplic Lixisols	4.8	100-150
Luvisols	Vertic Luvisols	4.2	120-150
Acrisols	Haplic Acrisols	2.6	100-150
Leptosols	Lithic Leptosols	2.4	<25-50

(Source: Gete Zeleke, 2000, Landscape Dynamics and Soil Erosion Process Modeling in the North-western Ethiopian Highlands)

Fig. 5. Table 1: Major soil groups of Anjeni watershed