

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 fully agree with the assessment of the editor, Dr. Zehe about the weaknesses in our manuscript in HESSD. We have responded extensively (and made the requested changes in the manuscript) posted separately as a replies to the reviewers. Here we will give a short summary of our responses to the points mentioned by Dr. Zehe.

The structural uncertainty has two components: Soundness of model and equifinality. Both are addressed in the general response to reviewer 1. Soundness of model: We have observed experimentally that topographic controls dominate the runoff processes.

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The reason is that infiltration capacity of the volcanic derived soils is greater than the rainfall intensity except for very short intervals. Therefore saturation excess runoff is the dominant runoff mechanism. We have measured with piezometers that the water table comes near the surface at the end of the rainy season (Bayabil et al., 2011; Engda, 2009; Legesse, 2009). The model presented in this manuscript assumes that distinct part of the landscapes produce runoff after the (perched) water table comes to the surface. The remainder of the watershed is the source for the interflow and baseflow. Previous models that were applied in the Blue Nile Basin assumed that vegetation was the “driving force” for determining surface runoff.

Equifinality is extensively addressed in our general comments in the response to reviewer 1. We show that the shape of the outflow hydrograph strongly depends on the relative size of the regions where the rain water infiltrates and where it runs off. Small changes in runoff producing area can cause large variation in predicted hydrographs. The model is only marginally sensitive to amount of moisture that can be stored in the root zone. Equifinality for a model with two parameters (i.e., the sediment model) should not be a large issue.

The comment on whether the calibrated values for the areas have physical meaning is addressed in the response to reviewer 2 (in the beginning) and to reviewer 1 (sixth paragraph in the general response). We have shown for the Anjeni watershed that the calibrated surface runoff areas (and consequently the sediment source area) agree with the land use and soil survey map of the area. In addition we show a photograph of the watershed where grass indicates where the soil saturates during the rain storm. This was confirmed by piezometric readings. It is more difficult to verify our estimated areas for the large Blue Nile basin, but it is in general agreement with what we have measured in other watersheds by Bayabil et al (2011); Engda (2009); Legesse (2009).

In your final comment, you ask us to model land management practices. It was reviewer 1 who asked us to do this as well. As we explained in the response to his comments, it was not our intent to model land management practices in detail and was not stated as

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such in our objectives for the paper. Specifically, in our introduction of the manuscript in HESSD, we discussed the need to find better models. Current approaches to reduce soil loss have been not performing well because sediment concentration is greater than it was 25 years ago. It also reported that 40% of all erosion is caused by installing land management practices in the wrong places (Mituki et al. 2006). So there is something missing in our current scientific knowledge in sediment movement in the landscape in the Ethiopian Highlands. Our thought (obviously not well expressed) was that if we can start modeling sediment loads more realistically, we can improve our knowledge about sediment sources in the landscape and ultimately design more effective land management practices. This model is only the beginning to show the principles. Our model is different from previous models because we use topographic controls to drive the runoff processes and only to a limited degree, the land use (see Bayabil et al 2010).

In summary, we use a hydrology model that realistically predicts surface runoff. Based on discharge calculated from the hydrology model and on stream power theory, sediment concentration can be predicted realistically (with only two parameters “a1” and “a2”). Although it is impossible to model the effect of soil and water conservation practices with two fitted parameter values, it would not be that difficult to introduce the effect of land management, because the “a” parameters can be made functions of soil and water conservation practices. For example, for buffers trips the velocity will greatly decrease resulting in a much lower “a”. The exact value of “a” can be modeled with the complete Hairsine and Rose model. We are currently carrying out research to study the spatially and temporally variability of the “a” parameter and hopefully report later on this in HESS when the research is completed.

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