

Referee comment to:

Journal: HESS

Title: An efficient semi-distributed hillslope erosion model for the sub humid Ethiopian Highlands

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Hydrol. Earth Syst. Sci. Discuss., 9, 2121–2155, 2012

General comments:

This paper presents a simple modeling approach for runoff and sediment concentration in the Ethiopian Highlands for two different scales (Blue Nile basin with an area of 17.4 million ha and Anjeni watershed with an area 113 ha). In comparison to other modeling approaches in this region, the sediment sources are related to areas exhibiting saturation excess. It is stated, that a simple modeling approach, which is based on the self-organization principles of the catchments will lead to better results for this region. Therefore the watersheds are divided into three distinct functional areas which are (i) periodically saturated areas, (ii) severely degraded areas with shallow soils and (iii) hillsides. The latter were identified as no sediment source areas, since all rainfall can infiltrate. The model consists of a simple conceptual hydrologic model and an approach to model sediment concentration using runoff and calibration parameters related to the type of source area.

In general it is a targeted approach to represent the specific organization and functioning of a landscape of interest in the modeling approaches. But I do not see that this idea is consequently implemented into the modeling approaches of this study, because the extend of the different areas is a subject of calibration and the result is not validated using other information on the catchment properties. I expect that there exist different combinations of areas leading to similar results, in particular in combination with the variation of the large amount of other calibration parameters. In addition the relation between sediment concentration and runoff depends on one calibration parameter for the whole period. Using such a procedure does not allow for representing different management practices in the model (see page 2138, line 26-29). It was mentioned in the introduction, that erosion modeling will gain in importance in this region for the planning and implementation of erosion control measures. However, in my opinion, erosion control measures cannot be planned and evaluated using a model, which is not spatially explicit and which cannot represent different management practices. Therefore the presented model is not an adequate tool to reach this aim. Thus the paper should be thoroughly revised regarding the following general comments:

1. The motivation (introduction) of this study should be focused and closely related to the modeling approach presented in this paper (please see comment above). In addition the objectives should be sharpened
2. In general, the paper is not clearly structured and there are some parts which are not necessary, since they are not clearly related to the presented study:
 - a. The introduction should be shortened, better structured and focused on the objectives of the paper (see comment above and specific comments). In addition Chapter 2.1, which provides the state of the art of modeling

approaches that were applied in the Ethiopian Highlands or under similar conditions should be moved to the introduction and shortened.

- b. Chapter 2.2 presents detailed information on the properties of the study site, although the study site was not introduced yet. This information should be moved to “material and methods”. Please consider also to move the whole chapter 2 to “material and methods” (see specific comments)
3. It should be tested, if the calibrated extend of the different areas can be validated using catchment properties
4. The problem of equifinality of model parameters should be discussed in the discussion section, in particular in the light of the aim of using a simple erosion model for the planning of erosion control measures
5. The discussion section, concluding remarks and the abstract should be adapted according to the revision of the paper

Specific comments:

- Page 2122, line 2-8: This paragraph of the abstract is not clearly supported by the literature review in the introduction. Please adapt the abstract.
- Page 2122, line 25- page 2123, line 6: Please shorten this paragraph and focus on “monsoon climate”
- Page 2123, line 19 – page 2124, line 10: “However, this is problematic....”
The discussion in this paragraph is presented to motivate the aim of this paper, which is to develop a simple conceptual model for runoff and sediment loss under monsoon conditions. In my opinion, the presented discussion it is not a neutral consideration of the state of the art on the applicability of different modeling approaches. It is a series of isolated arguments, which are not clearly related and structured (please see the following examples):
 - Page 2123, line 19 – 22: On the hillslope or catchment scale, sediment loss is an integrative response of various processes such as detachment, transport and deposition. Therefore, in complex erosion models these individual sub processes are parameterized using measurements gained in small scale experiments. However, I do not see another possibility to parameterize these isolated processes. Please clarify, why this argument is presented or delete it.
 - Page 2123, line 24-29: in this paragraph a quotation of Savenije (2010) on physically based modeling is cited in relation to “upscaling plot experiments to the watershed or basin scale”. Applying a physically based model is different from simply upscaling plot experiments. Therefore the quotation of Savenije doesn’t make sense in this context.
 - Page 2123, line 29 – page 2124, line 4: In this paragraph a paper of Klaus and Zehe is cited. This paper focuses on subsurface structures and the equifinality problem associated with the parameterization of these structures. This study therefore provides an approach to deal with the deficiencies mentioned in the quotation of Savenije before. Please clarify.

- Page 2124, line 8-10: “organized complexity” should be related to the scale of interest

The whole paragraph (Page 2123, line 19 – page 2124, line 10) should be thoroughly revised regarding a clear motivation of the objectives of the paper.

I further suggest moving the paragraph on page 2125, line 9 - page 2126, line 11 (chapter 2.1) to this part of the introduction, because the relation to previous modeling approaches seems to be an adequate motivation of the objectives of this study.

- Page 2124, line 14-21: “In the model...”:
Up to now, the objectives of the paper are not mentioned yet. Therefore this paragraph is confusing
- Page 2124, line 22-26: Please sharpen the objectives
- Page 2124, line 24-27: “The sediment model...”
I do not see that the simple sediment model presented in this paper “closely” follows the Hairsine and Rose model. This comparison is confusing.
- Page 2124, line 28-29. What is related in the mentioned “regression relationship” of Steenhuis?
- Page 2125-2126: delete chapter 2.1:
 - The paragraph on page 2125, line 9 - page 2126, line 11 should be shortened, focused and moved to the introduction (see comments on the introduction).
 - Page 2126, line 12-17: this paragraph again presents objectives of the paper and should therefore be moved to the part of the introduction, where the objectives are presented. As already mentioned, the objectives should be sharpened.
- Page 2125: rename chapter 2, i.e. “model development”
Please consider also, moving chapter 2 to “material and methods”
- Page 2126-2127: I suggest deleting chapter 2.2.1
In chapter 2.2.1 many details on specific conditions and events related to the study area are provided, although the study area is not introduced yet. Please move all information related to the study area to “material and methods”.
Instead of chapter 2.2.1 there should be only a brief introduction on the properties of the conceptual model that was developed. Please shorten and rephrase the paragraph on page 2126, line 20 – page 2127, line 5 accordingly and avoid redundancies with the description of the hydrologic model in Chapter 2.2.2.
- Page 2128: At the moment there are redundancies with chapter 2.2.1. Please avoid redundancies, when rephrasing the introduction for chapter 2 (see previous comment)
- Page 2128: Please provide a brief description on the modeling approaches used in the hydrologic model (i.e. water balance, subsurface and surface flow).
- Page 2128, line 21-27: Does “parameter” mean that it is calibrated? In this case nearly all parameters of the hydrologic model are calibrated, in particular the extend of the three functional areas. In the introduction, the term “organized complexity” of the landscape was introduced. The aim was, to develop a simple model that is based on the knowledge of the

organization principles of the watershed of interest. In my opinion, organized complexity means, that the patterns and structures of the landscape explain the hydrologic functioning. But if these patterns and structures are a subject of calibration (as the extend of the three areas in the hydrologic model is) I do not see how this information can be of help to avoid equifinality. I expect that there exist different combinations of areas leading to similar results, in particular in combination with the variation of the other calibration parameters.

- Page 2129-2130: Please provide all units for the variables and parameters used in the equations in chapter 2.2.3
- Page 2129, line 2-3: Give reasons for the assumption, that the erosion process is transport limited. Under transport limiting conditions also deposition can occur due to decreasing slopes or increasing surface roughness. Why is deposition not considered?
- Page 2129, line 3-5: what is meant by the “coefficient” that depends on landscape and sediment characteristics? Please clarify. Besides, Eq. 1 has two coefficients.
- Page 2129, line 8: please provide units and more information on the influencing factor a. What about management practice?
- Page 2129, line 10-12: the linear relation due to n between sediment concentration and velocity and channel wide is unclear. Please clarify.
- Page 2129, line 13: it was not mentioned before, that “a” depends on the runoff rate, too. Please clarify, why it becomes independent now.
- Page 2130, line 9: why is it “n+1” in Eq. 5? Please explain and relate also the statement in line 12-13 to this assumption.
- Page 2134, line 6 and Table 2: delete “input” before “parameters” and clarify in the title of table 2 that the presented parameters are “calibration parameters”
- Page 2134, line 9 and 20-23: it is mentioned in line 9, that goodness of fit measures were used and in line 20-23 which were used. Please combine.
- Page 2134, line 18: since a1 and a2 are both calibration parameters I expect, that there exist different combinations of parameters leading to similar results. This should be discussed in the discussion section.
- Page 2135, line 19-21: why is Fig 3 related to this sentence?
- Page 2135, line 27: 100 mm for BSmax are not consistent with table 2
- Page 2136, line 22-24: I suggest that the extend of the calibrated areas should be validated using information on the catchment properties such as topography, vegetation cover, soil moisture etc.
In addition it would be very helpful to provide a map of the different areas, at least for the Anjeni watershed.
- Page 2136, line 24-25: this statement should be discussed regarding the problem of equifinality
- Page 2136, line 28 – page 2137, line 1: the comparison to the results of Easton should be explained and discussed in more detail. Are the same periods and watersheds compared?

Without this information it is impossible to evaluate the statement that the reason for better NSE values depends on the self-organization principles used in the modeling approach of this study (see also comments to page 2128, line 21-27 and page 2136, line 22-24).

- Page 2138, line 2-10: In this paragraph the modeling results are compared to the results of WEPP and SWAT. As mentioned before, the basis for the comparison should be explained (see also the previous comment to page 2136, line 28 – page 2137, line 1). Both models do not perform better, than the simple modeling approach in this study, although both models (in particular the WEPP model) represent the erosion process in more detail and thus need much more input parameters. However, the WEPP model is spatially explicit. In the introduction it was mentioned, that erosion models will gain importance for the Ethiopian highlands in particular for the planning of erosion control measures. I do not see, how this aim could be achieved, when using a model, which is not spatially explicit as the simple model approach in this study is? In my opinion, a model that is spatially explicit and can account for different land uses and management practices is the only way to answer questions regarding erosion control measures.
- Page 2138, line 14: delete “likely”
- Page 2138, line 26-29: It is clear, that the presented model approach cannot cope with different management practices when there is only one calibration parameter for the whole period. As already mentioned above in the comment to page 2138, line 2-10, I do not see how it is possible to plan erosion control measures with the presented modeling approach.

Technical corrections:

- Page 2122, line 23: please add “in this region” after “concentration”.
- Page 2123, line 14-15: “At the same time...”: please refine this date
- Page 2123, line 18-19: “erosion control” is redundant
- Page 2125, line 18: check wording:
“curve number” → “curve number method”
delete “the” before “hydrology”
- Page 2126, line 17: m0dels → models
- Page 2129, line 12: wide channel → channel wide
- Page 2129, line 13: please check the correctness of the “,” in this line
- Page 2130, line 7: sediments → sediment
- Page 2131, line 9: 17 400 000 ha → 17.4 million ha
- Page 2131, line 14: which “basin” → Blue Nile? Please clarify
- Page 2133, line 26: “terrace” → “terraces”
- Page 2135, line 16: “thirty four” → “34”

- Fig 1: delete “b” within the frame of the second figure.
I suggest changing the scale of the x-axis and show the event in more detail.
- Fig 2: Figure 2 needs a higher resolution, labels are not readable. Please add a scale bar and show the relation between the sub figures on the left side. It would be also helpful to label the Figures with (a), (b) and (c) and relate the labels in the Figure caption with the text.