Hydrol. Earth Syst. Sci. Discuss., 7, C1934–C1940, 2010
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Hydrology and Earth System Sciences Discussions

Interactive comment on "A multi basin SWAT model analysis of runoff and sedimentation in the Blue Nile, Ethiopia" *by* Z. M. Easton et al.

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Received and published: 23 August 2010

Reviewer 2 General Comments: The paper presents an interesting examination of the application of saturation excess runoff generation mechanism for Blue Nile Basin. The authors seem to hypothesize Ashagre's finding (Page 3840/41 line 28-29); the study supported by Liu et al. (2008) and others (Page 3841 line 22-26) which were used as the basis for developing/ applying the modified version of SWAT code (SWAT-WB). It is interesting that the paper has managed to show the ability of the revised model (SWAT-WB) to reproduce the streamflow and sediment transport in Blue Nile Basin. The manuscript then goes on further explaining about erosion processes and dynamics of erosion. But the paper consists some critical shortcomings that need to

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be addressed before publication specially in structuring what one wants to convey and what has been found/done. The paper can be a good contribution for the understanding of hydrology of the Blue Nile.

Specific Comments: Here are the areas that need to be revised prior to publication: - Comment: Define the focus of the study: It was not clear whether the authors were reporting the development of the modified SWAT version or application of the code for run-off and sediment prediction in the Blue Nile. The paper seem to introduce the development of new SWAT code at some point and then a paper by the main author (Easton et al. 2008) was also cited in the manuscript as a source of report of the development of the SWAT-WB code.

Response: We have refocused the aims of the work as per the comments from reviewer 1. We present the brief model development overview because many of the results and discussion hinges on an understanding of how the model predicts the spatial-temporal distribution of runoff and subsequent erosion in the watershed. That being said, we have tried to deemphasize the model overview section.

Comment: Ashagre's finding: Is this really the case of the Blue Nile Basin as a whole? Or it is based on study conducted on specific places. It is hard to believe the generalization of that major run off generation process in BNB is saturation excess. The problem here is; this generalization can lead to a point that overland flow occurs most often at the bottom of hillsides in the BNB but this may not be the case. Had this been true, all of the severely eroded hill slopes in Ethiopian high lands could have shown different story today (less erosion and productive hill slopes). I strongly suggest the authors to give more perspective to the previous studies.

Response: While do not pretend to know exactly and to what extent the precise runoff generating mechanism is, however, an analysis of discharge data and landscape studies in the basin, makes it relatively clear that infiltration excess runoff is likely not the dominant mechanism. Perhaps the reviewer is correct that we should be careful in

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generalizing that runoff occurs predominantly from the bottom of hillslopes, although these areas are clearly runoff saturated source areas (notice that most of these areas are managed as pasture because it is often too wet to till, and that gully formation is also associated with these areas). We have revised terminology in the manuscript and added references and data that, at least, support the contention that saturation process are important in the hydrological response. For instance: "One characteristic of Ethiopian Blue Nile hillslopes is that most have infiltration rates in excess of the rainfall intensity, thus most runoff is produced when the soil saturates (Ashagre, 2009) or from degraded, shallow soils. Indeed, data from Soil Conservation Reserve Program (SCRP) watersheds (Engda, 2009) show the probability of rainfall intensity exceeding the measured soil infiltration rate to be very low, only 7.8% of storm intensities exceeded the lowest measured infiltration rate. Of course defining sources of landscape erosion require knowledge of both where runoff is generated, and of how the landscape is managed (e.g., tillage, livestock, vegetative cover, etc)."

Comment: Can we conclude the dominance of saturation excess runoff generation mechanism based on the fact that we have got good performance of SWAT-WB simulation of streamflow prediction? If so, how does CN based SWAT model perform in the Blue Nile?

Response: We do not believe that we ever stated that saturation excess is the dominant mechanism because we got good predictions with the WB model. We based our assertions on peer reviewed science and what measured data we were able to obtain. However, we have added information on how the SWAT-CN model performed in the basin, which is quite less than the WB model. "White et al. (2010) compared the performance of SWAT-WB and the standard SWAT model in the Gumera watershed in the Lake Tana Basin, Ethiopia, and found that even following an unconstrained calibration of the CN, the SWAT model the results were between 17 and 23% worse than the SWAT-WB model."

Comment: Page 3841 line 21: Are you sure about it? Monsoon rain is rather known for

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its variable intensity. It looks that the authors are trying to make strong argument for the saturated excess runoff generation dominance in the region. It could be very good if you provide some justification or references to those kinds of remarks.

Response: Based on what high frequency rainfall data is available, which to our knowledge, the best are the SCRP sites; it is uncommon that rainfall intensity exceeds the infiltration capacity of the soils. See figure 1. We have also added to the text:

"Indeed, data from Soil Conservation Reserve Program (SCRP) watersheds (Bayabil, 2009; Engda, 2009) show the probability of rainfall intensity exceeding the measured soil infiltration rate to be very low, only 7.8% of storm intensities exceeded the lowest measured infiltration rate."

Comment: The conclusion that upland erosion is dominant in the early part of growing season is obvious. The temperature fluctuation (day and night) over long dry period on the surface soil, trampling effects of live stock and the disturbances caused by farmers (tillage) which basically starts before the onset of the rainy season are the factors to blame for more soil erosion at the early stage of the rainy period. If SWAT result has shown this it could be appropriate to present the results in clear way.

Response: The reviewer is correct that all of these processes likely contribute to the landscape contributing erosive losses early in the rainy season, but it is also the case that once crop cover is well established these rill and inter rill erosion processes from landscape sources rapidly diminish (e.g. Tebebu et al., 2010). Yet there is still considerable sediment export from the basin. It is interesting to note that the model reliably predicts the conversion of landscape based sediment to channel (or gully) sediment sources. We have added a sub figure to figure 9 (Fig. 2 below) that shows how the model predicts the basin as a whole responding. Notice that the model does predict landscape sediment to dominate the sediment yield early in the rainy season, while channel erosion or re-suspension of deposited sediment id is the dominant source later in the rainy season.

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Figure 9 (revised and uploaded Figure 2 below) caption. Observed and SWAT modeled sediment export at the Sudan/Ethiopia border (a) and the predicted landscape sediment yield and channel sediment export (b).

Comment: Page 3840 line 5 and page 3856 line 23-reread the sentences for spell-check.

Response: We have made these changes.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 3837, 2010.

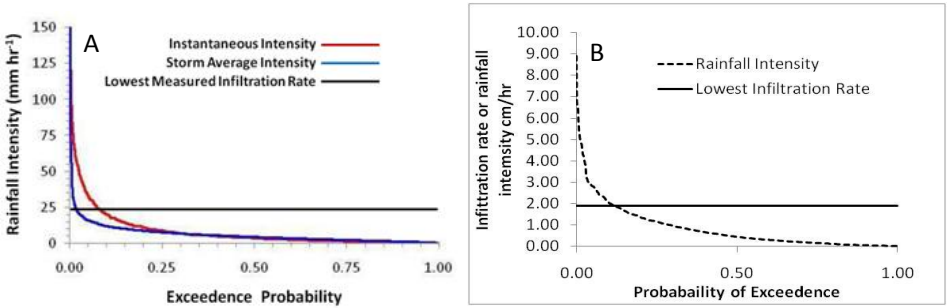

Fig. 1.

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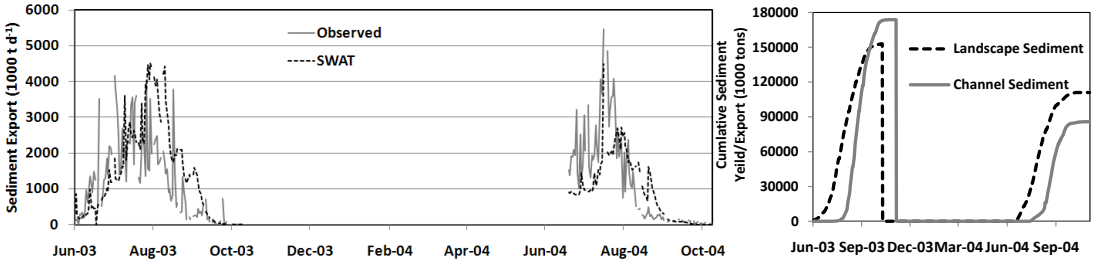

Fig. 2.

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