

Response to comments

We thank the reviewer for the positive and encouraging evaluation of the discussion paper. We appreciate the many detailed and helpful comments allowing us to improve the readability of the manuscript. We implemented all suggested changes. Below we first repeat the comment of the reviewer and follow that with our response. The changed text in the manuscript is indicated in blue.

Comment: My main concern is the P_T parameter. I could not understand from the manuscript how this parameter was determined (page 1428, line 12). The P_T is crucial for determining the stage within the rainy season and selecting the discharges to determine the end members of the 'a' parameters. The approach is illustrated in Figure 1, but this does not indicate how the parameters are determined from the data.

Response: Experimental data showed that the sediment concentration for a given amount of rainfall is greater in the beginning in the rainy phase than later on. The high concentration initially is caused by rill formation in the plowed land (Zegeye et al. 2010; Tilahun et al. (2013a, b). We assume that the sediment transport capacity of the runoff water determines the sediment concentration in the runoff. Once the rills are formed they increase in size and after the most intense storms have passed in late July the rills become stable. The sediment concentration in the water is then determined by the cohesion of the soil. The amount of effective rainfall to the point when the rills are stable (or when the most intensive storms have passed) is called P_T . It is difficult to calculate when this occurs a priori. Past modeling by Tilahun et al. (2013a, b) showed that P_T was around 600 mm. In the application to sediment rating curves in the discussion paper, we fitted the value of P_T . We found that P_T value was near the values that Tilahun found earlier.

Based on the above explanation we changed the text as follows:

“where a_s is sediment source limiting factor, a_t is the sediment transport limiting factor, P_e is the cumulative effective rainfall (mm) at a particular day, P_T is the threshold cumulative rainfall up to what point the a_c parameter linearly decreases

with cumulative rainfall, P_e , and after which the sediment concentration remains at the source limit.

When P_e is equal to and greater than P_T , the ratio becomes one, which indicates that the sediment concentration is equal the source limit. The “ a_t ” and “ a_s ” parameters depend on a number of factors such as slope length, particle size and disposability. In addition, “ a_s ” parameter varies with the cohesion of the soil (Yu et al., 1997). The threshold value was found in other simulations to be around 600 mm (Tilahun et al., 2013 a, b). The values of all three parameters are therefore difficult to predict a priori and need to be calibrated. As we will see hereafter these values fall in a relatively narrow range”

Comment: Page 1421, line 11: Please avoid abbreviations such as ‘GERD’ if you do not use them later on in the text.

Response: We removed the abbreviation ‘GERD’ from the manuscript. We did not remove the abbreviation of the models since they are usually only known by their initials

Comment: Page 1422 Line 3-5. Is there a connection between the two approaches mentioned: models and rating curves? Please discuss in a couple of sentences which models use rating curves.

Response: Based on the comments we added the following paragraph to explain connections between models and rating curves. The paragraph explained below was included in the revised manuscript page 1422 starting in between line 5 and 6.

“There is a connection between models and rating curves in sediment studies in the Ethiopian highlands. Rating curves have been used by Easton et al. (2010) and Setegn et al. (2009b) in the Lake Tana basin to generate the “observed” sediment load data and to validate the models. Our intent is to improve the prediction of sediment concentration by developing better rating curves so that sediment concentration data can be generated from observed flow.”

Comment: Page 1423 line 6-8: There are two arguments mixed up in this sentence: percentage of freshly plowed land and wetness and cohesiveness of the soil. The first is determined by the timing in the crop calendar, while the second depends on the cumulative rainfall. Please separate these two issues.

Response: We agree that our explaining the statement was poor. We improve the statements by separating in two the text by separating in to two sentences as follows:

“...the progression of the rainy monsoon phase, the value of a_c is a function of the portion of the area of newly plowed land and takes the highest value in the beginning of the rainy season when in the unconsolidated soil rills form and the soil removed is transported by runoff. Then a_c value decreases linearly with effective cumulative precipitation, P_e to the threshold value, P_T when the value of a_c becomes constant.”

Comment: Page 1423 Line 15 . . . increases.

Response: In the revised manuscript we corrected it. Thanks.

Comment: Page 1423 Line 24 word missingand aims to test how.....

Response: Corrected as proposed. We added “concentration rating curve” following the word ‘how’

Comment: Page 1423 Line 24 is not a range of scales optimistic? There are only two size groups of catchments (100's km² and 100 ha). This is hardly ‘a range of scales’.

Response: We include in the manuscripts as proposed: it was corrected as substituting “range of scales” by “two groups of watershed sizes”

Comment: Page 1424 Line 7 (see also page 1423 line 7) please be consistent in the spelling ‘plowed ‘or ‘ploughed’

Response: We used the word “plowed” consistently in the manuscript.

Comment: Page 1424 Line 19. Is P_e the cumulative effective rainfall or the daily effective rainfall? How is P_e determined (only explained on page 1427, line 26)? I can

understand the threshold for the beginning of the rainy season, but have some difficulties with the end of the rainy season. Over which time period does the P_e has to 0 to reach the end of the rainy season?

Response: P_e is the cumulative daily effective rainfall starting from the beginning of the rainy season to the end. It is obtained by subtracting the daily observed precipitation from potential evaporation and then summing the daily values starting at the beginning of the rainy phase. When the P_e become equal to maximum effective rainfall threshold (P_T), source limiting become a limiting factor in the rating curves and P_e will not be used as an input in equation 4a after this period. The end of the rainy period is not important as the threshold usually occurs before that.

Therefore based on the above explanation we changed that paragraph as follows as follows:

“Therefore, the sediment concentrations were calculated separately during the rainy monsoon phase and during the dry phase. Since the start of the rainy phase varies from year to year and from one location to another, we will use the cumulative effective rainfall, P_e , to replace the “time” parameter. P_e determined by summing the daily effective rainfall which is equal to precipitation minus the potential evaporation for that day. The rainy phase starts when the cumulative effective rainfall, P_e is greater than 40 mm (from observation) and setting each time when P_e is negative to zero. As we will see later in most of the Lake Tana basin this occurs in the beginning of July, but it begins in mid of May in Gilgel Abay because the rainy phase starts earlier in a southern direction. In all of the watersheds the rainy phase ends around the beginning of October.”

Comment: Page 1427 line 9-12. Please rephrase the sentence. There is some confusion between the years selected and the installation period of the SWC measures.

Response: We corrected as per the comment and included the rephrased sentences in the manuscript as:

“The Megech data was only available and the analysis was made for 1990–2007. The analysis for the Anjeni was made for 1996 and for Anjeni in 1994 when the

watershed were stabilized after the soil and water conservation practices that were installed in the mid 1980's."

Comment: Page 1430: line 1occurs.....

Response: Corrected as proposed and included in the manuscript.

Comment: Page 1430: line 14 Rephrase 'and in addition not very well'

Response: Thank you for the correction. It is corrected as per comment and included in the manuscript as:

"For the Lake Tana watersheds, the sediment concentrations are under predicted by the MoWIE load rating curve and indicated low prediction performance (Fig. 4)"

Comment: Page 1430: Line 16 Delete the second 'of'

Response: Corrected as proposed

Comment: P1430-1431 Sections 4.1.3 and 4.2. Please change the order of Figs. 5 and 6, as you refer to Fig. 6 first and Fig. 5 later

Response: Thanks for the comment and the Figures are relabeled as "Fig. 6" into "Fig. 5" and vice versa.

Comment: Page 1431 line 21 and line 24 . . . concentrations . . .

Response: Corrected based on the proposed comment.

Comment: Page 1432 line 2 Delete 'in the Ethiopian highlands'

Response: Thanks for the comment we deleted and corrected in the manuscript.

Comment: Page 1432 Line 12 'loads and discharge' Singular or plural, please be consistent.

Response: We corrected by removing the letter "s" from "loads"

Comment: Page 1432 Line 21 Please give the parameter in brackets that describes ‘the amount.....of the rainfall’

Response: Comment corrected as proposed by adding the parameter name and symbol in brackets as

“The amount of cumulative effective rainfall (P_e)”

Comment: Page 1432 Line 26 Please check the spelling of ‘gauge’ or ‘gage’ (used earlier in the text)

Response: Thanks for the comment. We accepted the comment accepted and corrected by using the word “gage” instead of “gauge”

Comment: Page 1433 line 4 Watersheds.....

Response: Corrected as proposed and included in the manuscript.

Comment: Page 1433 Line 10after land is plowed (or ploughed see earlier remark) and rills are formed.

Response: Corrected as proposed. The word “plowed” was used in the corrected manuscript.

Comment: Page 1433 Line 16gentle slope.....

Response: Thank you for the comment. The correction was included in the manuscript.

Comment: Page 1433 Line 17coefficient compared to the Maybar...

Response: Thank you for the comment. We included it in the manuscript.

Comment: Page 1433 Line 20the other four watersheds.....

Response: Thank you for the comment. We corrected as proposed.

Comment: Page 1433 Line 23Gumara has the greatest value.....

Response: Thank you for the comment. We corrected as proposed and included in the manuscript.

Comment: Page 1433 Line 24-25 unclear sentence. Please break up: first mention human activities, and specify them in a separate sentence.

Response: Thanks for the comment. We addressed the comment by separating the statement “This can be related to the human activities in the river for irrigation and sediment taken out from the banks” as:

“This can be related to several factors mainly increasing population and activities for natural resource competition. This includes pumping water for irrigating cash crops during the dry monsoon phase from the river. In addition, sand is being mined from the river bed.”

Comment: Page 1434 Line 2sediment concentrations.....

Response: Corrected as proposed. Thanks for the comment.

Comment: Page 1434 Line 2observation while developing.....

Response: It was corrected as proposed.

Comment: Page 1434 Line 4improves the prediction of the sediment.....

Response: The statement was corrected based on the proposed comment and included in the manuscript.

Comment: Page 1434 Line 10 Part of the sentence (and more importantly the clue of the paper) is missing after ‘might have’

Response: Thanks, we added the following phrase based on the given comment to complete the sentences:

"Although more research has to be done, there is an indication that the coefficients in the newly developed concentration rating curve can be related to landscape characteristics. These parameters might have, therefore, physical meaning which would help to generate the values from the physical catchment characteristics for the ungaged catchments."

New References Added to the Manuscript

Easton, Z.M., Fuka, D.R., White, E.D., Collick, A.S., Biruk, A.B., McCartney, M., Awulachew, S.B., Ahmed, A.A., and Steenhuis, T.S. A multi basin SWAT model analysis of runoff and sedimentation in the Blue Nile, Ethiopia, *Hydrological and Earth System Science*, 14: pp.1827-1841, doi:10.5194/hess-14-1827-2010, 2010.

Setegn, S.G., Srinivasan, R., Dargahi, B., and Melesse, A. M. Spatial delineation of soil erosion vulnerability in the Lake Tana Basin, Ethiopia, *Hydrological Processes*, 23(26), 3738-3750. DOI: 10.1002/hyp.7476, 2009.