

## ***Interactive comment on “Prediction of geomorphologic parameters of catchment without GIS to estimate runoff using GIUH model” by P. Keshtkaran and T. Sabzevari***

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Answers to referee 1

Dear Reviewer, Thanks for your efficient review. The comments were effective and lead to more scientific and well written paper. The structure of the paper has been reviewed and some reforms have been applied. The writing format has been reviewed and some changes were made. In particular, some major corrections were done in the introduction of the manuscript. The writing of the manuscript was checked and corrected by an English native speaker. The requested corrections applied and the revised version of the manuscript was sent to the referee. We tried to make our view to GIS and preparing DEM more accurate. To this end after consulting with GIS experts

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some changes in key words according to referee viewpoint applied. The reforms are as following:

Question1: One of my major concerns is that the manuscript is not well written, with lots of ill-formulated sentences that are not easy to follow. Please keep in mind that quality is paramount, schedule is secondary, and reviewers and editors really hope authors improve the quality of manuscripts as best as they can before submission. Answer 1: The writing of the paper has been reviewed and corrected by English language experts. Ill-formatted sentences were recognized and revised. Undoubtedly our corrections could be done more efficiently if these sorts of paragraphs have been identified by reviewer.

Question2: Another major concern is about the scientific merits of this work. First, I do not agree that digital elevation model (DEM) is not available in most catchments. For example, the Shuttle Radar Topography Mission (SRTM) provides global elevation maps in a resolution of 3 arc second (even 1 arc second in some countries), which has been widely used for hydrological application. The products can be downloaded without charge from websites such as <http://srtm.csi.cgiar.org/>.

Answer 2:

We agree with you in this part that some websites such as SRTM provides DEM for all parts of the world but there is a question about their quality for hydrologists. There are different ideas in this regard and our purpose in this research based on this reality that: “there are some catchments with non-qualified DEM” although we accept that we could not explain this purpose clearly and then the related sentences were corrected. For confirmation of this issue we provide some resources that do not accept the 90 meter’s DEMs for estimation of runoff.

"Hancock, G. R., Martinez, C., Evans, K. G. and Moliere, D. R. (2006), A comparison of SRTM and high-resolution digital elevation models and their use in catchment geomorphology and hydrology: Australian examples. *Earth Surf. Process. Landforms*, 31:

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"Rahman, M. M., Arya, D. S., Goel, N. K., Limitation of 90 m SRTM DEM in drainage network delineation using D8 method—A case study in flat terrain of Bangladesh, *Applied Geomatics*, (2010) 2:49–58."

It goes without saying that geomorphologic information obtained from high resolution DEM leads to more accurate runoff estimation. In this research the results obtained from GIS were considered as reference and the results of proposed method were compared with GIS results. Some of hydrologists are not familiar with GIS and related software and don't want to pay for using GIS experts and they are tend to apply easier rainfall-runoff models. The aim of this research is to provide another method to estimate geomorphologic information easier even not so accurate. To sum up, the proposed method is a new method which should be applied, evaluated and verified in more catchments in future.

Question3: Second, the authors repeatedly reiterated that it takes a long time to compute stream-order-law ratios based on DEM with GIS. My question is how long time do you think it is too long to wait, one day, one week or one month? The study catchments are all smaller than 600 km<sup>2</sup> in this work. Computing stream-order-law ratios with GIS for catchments with such a small area could take only few hours. Answer 3: The referee idea in this regard has been applied and the repeated sentence has been changed but we should mention that GIS experts in my country prefer the DEMs provided from 1/25000 topography maps to the DEMs obtained from some websites. This issue is based on their experiences and we don't want to accept or reject it but we should accept that providing high quality DEMs and then preparing geomorphologic information and sometimes writing scripts in GIS are time consuming and as told before it is not preferred by many hydrologists. We should mention again that cost and time for providing information are not our main point in this research but we want to present another method for providing geomorphologic information and stream order law for using in GIUH models.

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Question4: The authors also highlighted that some stream-order-law ratios should be calculated manually by GIS users. Actually, most GIS software (e.g., ArcGis) are open platforms to develop new toolbox. GIS users can write scripts (in Python or in Arc workstation) to calculate the related variables automatically, and transfer to following users. Laziness is not a sufficient reason to reduce the accuracy of model simulation.

Answer 4: I completely agree with the referee opinion but as it was told before, many of hydrologists and GIS users are not familiar with writing scripts (in Python or in Arc workstation). Therefore, through this research we wanted to present a more user-friendly method.

Special comments:

Question5: Line 38-40: Why are these sentences here? How do these sentences relate to the former and later paragraphs? Answer 5: The structure of introduction has been changed and the position of intended sentences has been revised.

Question6: Line 45: You have 'first' here, then where is 'second'? Answer 6: It has been corrected.

Question7: Line 49: You introduce the calculation of GP using GIS in former sentences, but here you go back to the application of GIUH Answer 7: It has been corrected in the manuscript.

Question8: Line54-76: Application of GIUH model is not the main point of this work. The main point focuses on the estimation of stream-order-law ratios when using GIUH. Hence, there is no necessary to list so many references on the application of GIUH. But please provide more references about the estimation of stream-order-law ratios in previous application of GIUH. If I am correct, the GIUH model was proposed by Rodriguez-Iturbe and Valdes in 1979, while the first study to calculate stream-order-law ratios based on DEM was introduced by Lee (1998). What methods were used to estimate streamorder- law ratios during 1979-1998? Are there any methods similar

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to the proposed one in this work? Answer 8: Many searches about other methods for estimation of stream-order-law ratios and geomorphologic data have been done but almost all of the investigations were about estimation of these ratios using GIS. During years 1979 – 1998 some researches were found which were added. Some references about the estimation of these ratios were provided as following:

"Studies on streams orderings of catchments were first introduced by Horton (1932, 1945). Later, modifications were made on Horton's method by Strahler (1952, 1957, 1964) leading to a new method of ordering. Shreve (1966) concluded that the Strahler stream numbers generally gave a better fit for natural stream networks than did the Horton stream numbers. Horton-Strahler's laws were extensively used in geomorphological applications to classify river systems [e.g., Raff et al., 2003; Reis, 2006], to establish relations with the fractal nature of channel network as detailed by Rodríguez-Iturbe and Rinaldo [1997] [e.g., Beer and Borgas, 1993; La Barbera and Roth, 1994; Rodríguez-Iturbe et al., 1994], and to characterize scale properties [Claps et al., 1996; Peckham and Gupta, 1999; Veitzer and Gupta, 2000; Dodds and Rothman, 1999, 2001]." "Using GIS tool is still one of best ways of calculating the geomorphologic parameters (Sarangi et al.2003; Obi Reddy et al.2004; Valeriano et al. 2006; Ozdemir and Bird, 2009)"

Question9: Line 77-85: This paragraph needs re-organization, taking my second major concern into account. Moreover, you list many disadvantages of the GIS-based method, but not any advantages. If it is so time-consuming, then why someone used the GIS-based method in their areas? Also, please provide a review on the application of GIS-based method in existing literatures. Answer 9: The intended sentences were corrected. Some references about using GIS in geomorphologic ratio calculation were added.

Question10: Line 86: What is the full name of SPSS software? Can you give some geo-statistical references that use this software as well? The question is why use SPSS? Answer 10: The full name of SPSS (statistical package for the social sciences) has been added. This statistical software is famous but we added two references for appli-

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cation of SPSS as below: "Mohamoud, Y. M., and Parmar, R. S. (2006): ESTIMATING STREAMFLOW AND ASSOCIATED HYDRAULIC GEOMETRY, THE MID-ATLANTIC REGION, USA1. Journal of the American Water Resources Association, 42(3), 755." "Norusis, M.J. (1999): SPSS regression models 10.0." Since the SPSS is a quit simple and commonly-used we used it to perform statistical analysis.

Question11: Line 95: It is abrupt to see this sentence here, without any related expression before. Why should analyze the sensitivity of stream ratios? What the relation between this topic and the main story of this work? Answer 11: We agree. That sentence has been deleted.

Question12: Section 3: It looks like you are introducing the equations for stream-order-law ratios, not geomorphologic parameters. Answer 12: We agree. The title of section 3 has been changed to "Horton-Strahler stream-order-law ratios "

Question13: Section 3: Listing these equations one by one makes the manuscript too prolix to read. You can summarize them in one table Answer 13: The equations of this chapter were summarized in a table 1 (In revised manuscript).

Question14: Line 176-179: There is no necessary to repeat the ideas again. Moreover, these words are hard to follow Answer 14: The sentence has been deleted.

Question15: Section 4: You just introduce the study catchments in this section, it is not 'case study'. It is better to summarize all study catchments in Table 1, including the size, reference, and geographical extent. Answer 15: I agree. The title of "CASE STUDY" has been deleted and related information transferred to table 2.

Question16: Figure 1: Why only Kasilian and Gagas? If you do not have the map for Heng-Chi, please delineate it from the SRTM DEM. The maps of Kasilian and Gagas could be originally delineated from DEM as well. Answer 16: The map of Heng-chi has been added as figure1(In revised manuscript).

Question17: Line 212-216: What are the 80 watersheds and 37 catchments mentioned

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here? You told that you obtained these equations based on nine catchments listed in Table 1. Answer 17: Relation between catchment area and bifurcation ratio (Eq. 12) was obtained from information of 37 catchments. Equations 13 to 16 were derived based the information of 9 catchments because there was not all needed information in the 37 catchments.

Question18: Line 212-216: What is the input data for the software? Did you use the calculated stream-order-law ratios from DEM to determine the coefficients in the equations? If yes, then DEM data is needed to apply your method in other catchments, as you cannot expect that these equations can be applicable to any catchments in the world

Answer 18: In equation 12 bifurcation ratio obtained based on catchment area. For this purpose area (as input data) and Rb information of 37 catchment (as output data) have been used and regression equation as follow has been obtained. Figure2 added in this part to show linear regression between bifurcation ratio and the area of the catchment.

If catchment area is available, Rb obtained from the regression equation and DEM is not needed. Eqs. 12 to 16 the SOLR coefficients of which were estimated using their DEMs are first derived based on the data of the representative catchments. Then the equations are applied to the catchments without DEM. Given Eq. 12 and the catchment area coefficient RB is first estimated. Next coefficient RL is calculated from Eq. 13 using the length of the main stream and catchment area. Then the value of RA is obtained from Eq. 14. Finally Eqs. 15 and 16 give the values of Rs and Rso.

Question19: Section 5: Same to comment 9, there is no need to list the equations one by one, but summarize in one table Answer 19: Each equation needs to be referred and described individually so the title of parts related to equations have been omitted but according to our opinion it is better not to put these equations in a table.

Question20: Section 5: So many assumptions adopted here. Are there any references to support your assumptions? Answer 20: Some references were introduced for as-

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sumptions in part 4.

Question21: Section 5: You just write out these equations followed by correlation coefficients, without any figures to show the match between the estimated and GIS-based stream-order-law ratios and GP. I really doubt the credibility of the correlation coefficients. Answer 21: You are correct. Figure3 (In revised manuscript) shows the GIS-based stream-order-law ratios versus predicted SOLR

Question22: Line 252: What is "simple topographic maps of the catchment", do you think this kind of map are of course available for most catchments? My concern here is how to calculate the area and river length for the application of your regression equations in other places

Answer 22: By simple topographic maps of the catchment we meant topographic catchments maps (Scale 1:25000 to 1:50000). The word "simple" which seemed confusing was deleted from the text. Usually topographic maps with mentioned scales are available for all catchments and the first step of each hydrologist work is catchment delineation according to these maps and then calculating catchment area and length.

Question23: Line 252-262: Add a sub-section 5.6 for these words. Answer 23: A section with this title "5. Prediction of catchment's geomorphological information" added.

Question24: Line 252: You often have a mixed use between subcatchment and catchment. Please check the manuscript thoroughly and make sure all the using are appropriate. Answer 24: This issue has been reviewed and corrected. Our purpose in figure 4 were sub-catchment.

Question25: Line 328: The word 'observed' is not appropriate here. How to observe the stream ratios? Answer 25: I agree. The word "observed" has been deleted.

Question26: Section 7: There are two points in this section. One is the comparison between estimated and GIS-based GP. The other one is the comparison of GIUH performance using estimated and GIS-based stream-order-law ratios. I think it is better

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to divide this section into two sub-sections. 23. Table 2: How to calculate the Error here? Answer 26: Validation part has been divided to two sections: 7.1. Validation of stream-order-law ratios 7.2. Validation of catchment's direct runoff

Question27: Line 409: How did you calculate the average error? Answer 27: Simple mean has been used in 4 events and there is no need to provide the formula.

Question28: Captions for tables and figures are too simple to explain the implied information. Give full names of all the abbreviations in captions. Answer 28: This issue has been corrected.

Please also note the supplement to this comment:

<http://www.hydrol-earth-syst-sci-discuss.net/hess-2016-153/hess-2016-153-AC2-supplement.zip>

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-153, 2016.

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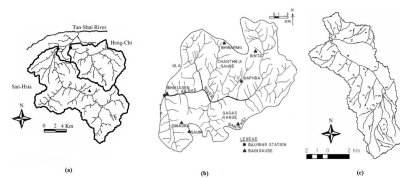


Fig. 1: Drainage network map  
a)Heng-Chi catchment b) Gagaa catchment c) Kasilian catchment

**Fig. 1.** Fig. 1: Drainage network map a)Heng-Chi catchment b) Gagaa catchment c) Kasilian catchment

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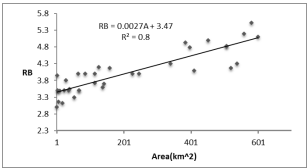


Fig.2: Linear regression between bifurcation ratio and the area of the catchment

**Fig. 2.** Fig.2: Linear regression between bifurcation ratio and the area of the catchment

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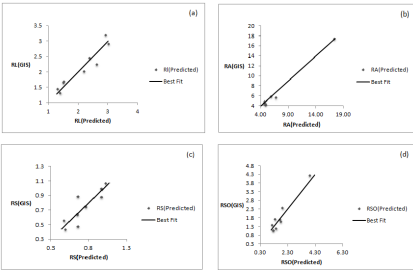


Fig3: GIS-based stream-order-law ratios versus predicted SOLR

**Fig. 3.** Fig3: GIS-based stream-order-law ratios versus predicted SOLR

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