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Comment

## ***Interactive comment on “Streamflow simulation methods for ungauged and poorly gauged watersheds” by A. Loukas and L. Vasiliades***

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The authors would like to thank the reviewer for his/her constructive and useful comments. All comments made by the reviewer have been addressed in the final revised paper (see supplement in Final Author Comment)

The reviewer wrote: 1. “The paper presents the procedure for dealing with gauged or poorly gauged watershed in order to simulate streamflow data. As a modelling tool, the UBC model is used which is a continuous conceptual model. The description of model and its parameters is too detail, in my opinion but I cannot say that it needs to be rewritten. In general, the paper is interesting because there are many papers discussing the efficiency of different models using data for well gauged watersheds. It

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is common that physically based models are used for ungauged watershed and I see the importance of this paper mainly in the application of conceptual model for given purpose. On the other hand, I would find interesting if the methodology is verified deeper for some watershed as the first step despite there are references to papers presenting the application of UBC watershed model worldwide”.

The authors would like to thank the reviewer for his/her comments. The extended description of the UBC watershed model is necessary for explaining the structure of the model and the model parameters for its application to ungauged watersheds. The authors wanted to apply the methodology in more watersheds in order to generalise the results obtained in this study. However, a serious constraint in the application of UBC model at other watersheds was the data availability. Data for only five different river basins located in Canada, Cyprus and Pakistan were available in this study. The different runoff producing mechanisms and the climate conditions at the study watersheds make the application of the method quite interesting. Furthermore, as the results show in watersheds with limited information about the distribution of precipitation over the watershed elevation range or even regional information about the orographic precipitation gradients of a watershed (e.g. Yermasoyia, Astor and Hunza watersheds) the UBC ungauged application (UBCREG method-Table 4) was quite successful given the large uncertainties in the precipitation distribution and the small number of precipitation stations used. Application of the method for poorly gauged watersheds in these watersheds (UBCANN method-Table 6) shows a vast improvement in runoff simulation when compared with the conventional calibration approach (UBCCLA method-Table 7). In watersheds where previous scientific knowledge exists on the precipitation distribution of the study watersheds (Upper Campbell and Illecillewaet watersheds) all methods perform similar for daily runoff simulation.

2. The reviewer wrote: “I have some comments to the paper which could in my opinion improve its comprehensibility. First, parameters V0FLAS and V0FLAX are mentioned to be characteristics of a given watershed (pg. 1047, lines 19-20) but it is not said

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to which watershed characteristics they are related. I think that it would make further parts of paper clearer.”

This comment of the reviewer has been fully addressed and explained in page 12 of the revised paper (lines24-26). The V0FLAS and V0FLAX model parameters are parameters of the flash flood runoff and they take constant values (Table 3) for the study watersheds. These model parameters are characteristics of the flash flood runoff generation mechanism and they depend on the geomorphologic characteristics of the watershed (e.g. land slope, impermeable areas, etc.).

3. The reviewer wrote: “It is also stated in section 3.2 (pg. 1048, lines23-24) that some parameters were set to default values while others were estimated. It is necessary, in my opinion, to define which parameters were estimated and how.”

This comment of the reviewer has been fully addressed and explained in page 13 of the revised paper (lines 4-19). The precipitation distribution parameters are POSREP(i), PORREP(i), P0GRADL, P0GRADM, P0GRADU, E0LMID and E0LHI where (i) is the number of available meteorological stations in each study watersheds. These precipitation distribution parameters are estimated in the present study (Sections 3.2.1 – 3.2.5). The water allocation parameters (namely, P0AGEN, P0PERC, P0DZSH, V0FLAX and V0FLAS), and the flow routing parameters (namely, P0FSTK, P0FRTK, P0ISTK, P0IRTK, P0UGTK, P0DZTK, and P0GLTK) are assigned constant values in this study (Tables 2 and 3). The total number of model parameters for Upper Campbell and Astor watersheds are 19, for Illecillewaet and Yermasoyia 23 and for Hunza 21.

4. The reviewer wrote: “In section 3.3.2 (pg. 1059, lines 12-14), the analysis of maximum annual peak flows is mentioned which was carried out based on two methodologies for four catchments. I think, that it should be mentioned which of three discussed methodologies are considered. It seems to me that all three methods were used for frequency analysis (fig. 9). Furthermore, it is not mentioned at this part which of five watersheds was not analysed and why although it is described later”

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This comment of the reviewer has been fully addressed and explained in the revised paper (page 22, lines 17-28 and page 23, lines 1-3 ). We thank the reviewer for his/her comment. The authors fully agree with the reviewer and all three methods are used for frequency analysis. In the revised manuscript the Page 1059 and lines 12-14 will contain the following text “Finally, the streamflow simulation results of the applied methods for ungauged and poorly-gauged watersheds were used for frequency analysis of the annual maximum peak flows. This analysis was performed only for the watersheds which have streamflow data for at least six (6) consecutive years. Based on these criteria, Hunza watershed is excluded for this comparison. The estimated peak flows were compared with the observed peak flows of the four study watersheds (Upper Campbell, Illecillewaet, Yermasoyia and Astor). . . .”

5. The reviewer wrote: “In general, the results are comparable for all three applied methods and the differences are not very high mainly when comparing UBCCLA and UBCANN. In this sense, the combination of UBC model in combination with ANN doesn’t seem to be a significant improvement and it is properly called as an alternative in the conclusion section.”

This comment of the reviewer has been fully addressed and explained in the revised paper. We thank the reviewer for his/her comment. The results for the poorly-gauged watersheds show that when limited information of the distribution of precipitation over the elevation range of the watershed is available (in Yermasoyia, Astor and Hunza watersheds) the UBCANN method outperforms the UBCCLA method (Table 6 and Figs. 6-8). When previous scientific knowledge exists on the precipitation distribution of the study watersheds (Upper Campbell and Illecillewaet watersheds) both methods show similar performances (Figs. 4 and 5). However Table 8 and Figure 9 shows a marginal superiority of the UBCANN over the UBCCLA method especially for large return periods ( $\geq$ years). Overall the UBCANN method is considered as an improvement to UBCCLA method especially in watersheds where limited information exists for the study watershed. But this has to be proven and in other study watersheds to generalise the

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results.

6. The reviewer wrote: “Additional comments: Pg. 1044, line 1: missing word “watershed” (UBC watershed model) Pg. 1044, line 5: word “in” is missing in the sentence (. . . can be divided IN up to . . .) Pg. 1044, line 19: I think that the word “routine” should be inserted (after . . . soil moisture . . .) Pg. 1067, line 6: “developed procedures” should be used instead of “develop” procedures Pg. 1068, line 6: I would be careful with the use of term “physical modelling” as the model applied is not physically based”

We thank the reviewer for his/her additional comments. All the above corrections have been made in the revised paper (see supplement).

7. The reviewer wrote: “Pg. 1092: I don’t know why the frequency distributions are drawn using plot of flood discharge against frequency factor. I would prefer if frequencies are used instead of frequency factor or if the Gumbel plot is used but it is perhaps only my personal opinion.”

We thank the reviewer for his/her comment. This comment of the reviewer has been fully addressed and explained in the revised paper. Figure 9 has been re-drawn and the flood discharge as been plot against the flood frequencies.

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 2, 1033, 2014.

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