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Hydrology and Earth System Sciences Discussions

Interactive comment on "Simulation of high mountainous discharge: how much information do we need?" *by* B. Schaefli and M. Huss

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Response to Reviewer 3

We would like to thank the reviewer for the very detailed comments that will help to make our manuscript more concise and easier to read.

As mentioned in our response to reviewer 1, we will modify the title of our paper. Our current suggestion is:

"Integrating point glacier mass balance observations into hydrologic model calibration"

We will re-write the introduction to more clearly state our research objectives and reorganize the methods and results section. Answers to the additional specific comments are given hereafter; we first answer the comments referring to the content of the paper and then the comments referring to its language and structure.

Comments referring to the content

1)- 3) Clearer introduction and map

Thanks for the detailed suggestions about how to improve the introduction. We will more clearly state the research question and the knowledge gaps in the following fields i) the combined use of point observations and integrated continuous data, ii) the problem of compensating sources and sinks in models and iii) the use of glacier mass balance data to calibrate hydrological models (comment from reviewer 2).

We will include a map (see Fig. 1 hereafter) showing the topography and include some information on the range of elevation of the catchment (the outlet is at 1760 m asl, the glacier ranges from 2109 to 3615 m asl). The used elevation bands for the glacier are given as inset in fig. 1 of this comment.

10) Comment: p.8680 line 11 I cannot see that ' there is still too much discharge in spring (..)

Something went wrong during the production process, we uploaded a figure with two different panels, one of them showing discharge simulations; the correct figure is added hereafter (fig. 2).

13) Comment:p. 8683 last sentence. The authors claim that water retention in firn is the most plausible explanation for the spring peak that wasn't observed. Without displaying temperature or discharge components it's difficult to judge (..)

This sentence refers only to the the period of model initialization, during which the model simulates a spring peak, which does not exist. We would like to thank the reviewer for this comment; we should in fact be talking here about water retention in

the snow pack in general. (A further comment on the importance of firn is giving in our response to reviewer 2.) Of course, it is the lowest part of the catchment that contributes to melt water production first. (There is no direct data to constrain snow accumulation in the parts of the catchment where there is no glacier).

13 b) Comment: If I count days correctly (please use date on axis) this over estimated 'spring event' was as early as March or beginning of April in 1977 (..). Could it also have to do with consequences from the extreme dry year 1976 (refill of depleted storage in talus, moraines, englacial drainage, pro-glacial lake, etc. after the dry year 1976)?

We will provide the dates in the revised version. Fig. 6 b shows the year 1976 and the overestimation corresponds to March.

This pattern of overestimation is recurrent at the beginning of the simulation period, independent of the starting year (see fig. 3 hereafter that shows the same effect for a simulation that started 4 years later); this reflects the time the model needs to initialize its state variables. If there was a systematic overestimation of snow accumulation during winter or of snowmelt in spring (e.g. due to the simple degree-day method not considering slope and aspect), this overestimation would be visible in many simulation years and not grouped at the beginning of the simulation period.

The state variable initialization can have different effects:

i) glacier-free part: initialization of the slow storage for rainfall-runoff transfer; here, the storage is assumed empty at the start; its filling, therefore, abstracts some meltwater and rainfall at the beginning of the simulation, which results in an underestimation of the flow during initialization (contrary to the suggested explanation of the reviewer);

ii) initialization of the snow routine: simulation starts without initial snow height, which means that the snow pack is underestimated during the first winter in all elevation bands; this has as effect that any snow falling during the winter will too quickly flow off if temperatures rise; in addition, the glacier becomes quickly exposed to melt in all

elevation bands.

If we start the simulations in the year 1972, the snow routine takes quite some time to initialize because the years 1972-1976 where relatively dry (see fig. 4 that shows mean annual precipitation over the observation period). This initialization effect is well visible in the first years of the snow height plots (see fig. 5 of this comment showing the snow accumulation patterns in the two highest bands).

We will update the corresponding paragraph in the paper to reflect the above.

Comments referring to structure and language

4) Section 2.1 last paragraph, section 2.2 last sentence and entire section 2.3

We will follow the suggestions of the reviewer and present the validation data in a more concise way and avoid the early reference to the very last figure (figure 6d).

5) Comment: The model/optimization descriptions in Sections 2.2 and 2.4 are not specific to the 'case study' (heading) and should be part of the Methods

We adopted the perspective that the optimization algorithm is just a tool (at the same level as all other algorithms used to run the model) and do not present it in the methods part. Since this choice might appear to be unusual, we will move it to the methods section.

6) Comment: The heading " Merging Data and Model" alone may suggest to a browsing reader something like a climate reanalysis or a mass balance reconstruction from a combined model and observation

We will change the title; "merging" evokes in fact different meanings depending on the field of specialization of the reader. Our current suggestion is to simply call this section "method".

7) Comment: 3.1 I suggest to integrate the lead paragraph and some general aspects of MOO and sequential merging into the Introduction and here introduce it directly

followed by the context of this particular study.

Thanks for this suggestion. We will re-organize this part together with the introduction.

8) and 11) Comment: Methods and Results section need to be separated more clearly.

This point was already made by reviewer 1. Since two reviewers insisted on this, we will re-think the organization of the corresponding paragraphs.

9) and 12) We will integrate the paragraph on p.8679 line 18 following and paragraph 4.6 into the discussion section

14) Comment: I found section 5.3.2 a bit redundant and too general. What do the authors mean by 'assimilated' in the last sentence?

We will consider this comment during the revision; thanks for pointing out the wrong use of "to assimilate" in English (in French, this verb can be used to say "something can be considered as being similar to something").

15) Comment: Figures need to be reorganized. Use multi-panel figures only where direct comparison is facilitated

We will re-organize the figures and follow the detailed suggestions 16-19) of the reviewer.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 8661, 2010.

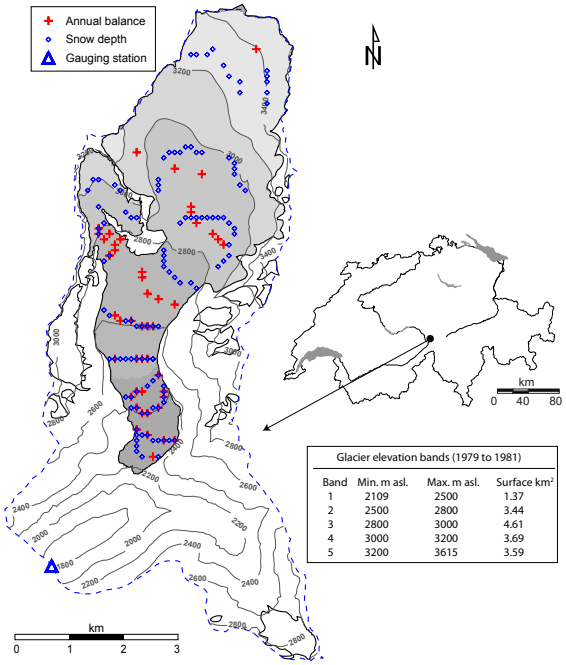

Fig. 1: Location of the case study in Switzerland and map of the catchment showing the studied Rhone glacier in gray shades and the measurement locations for 1979/1980 (glacier geometry of 1980)

Fig. 1.

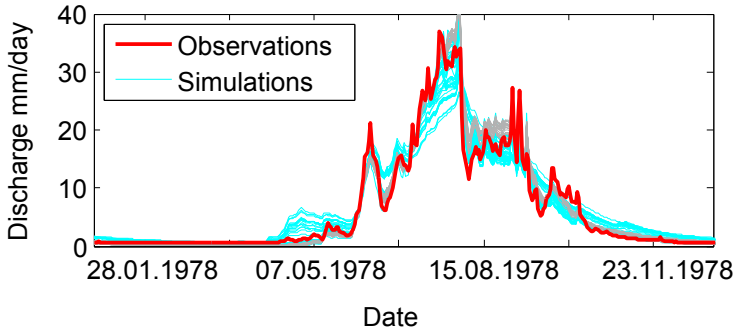

Fig. 2: Correct manuscript fig 4b showing all discharge simulations corresponding to the 13 parameter model

Fig. 2.

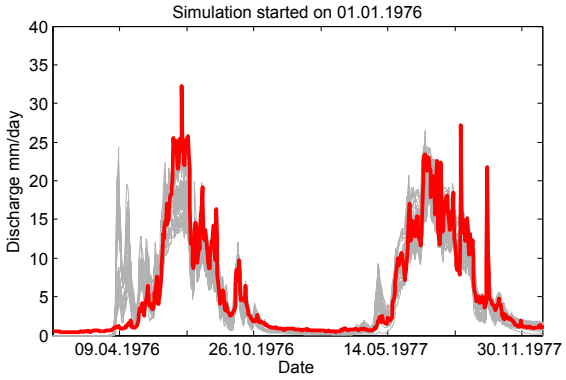

Fig. 3: Effect of model initialization: Observed discharge (red line) and simulations (gray lines) corresponding to all parameter sets on the Pareto front for the final model structure; the plot shows the first two years of simulation (see also fig. 6b of the manuscript)

Fig. 3.

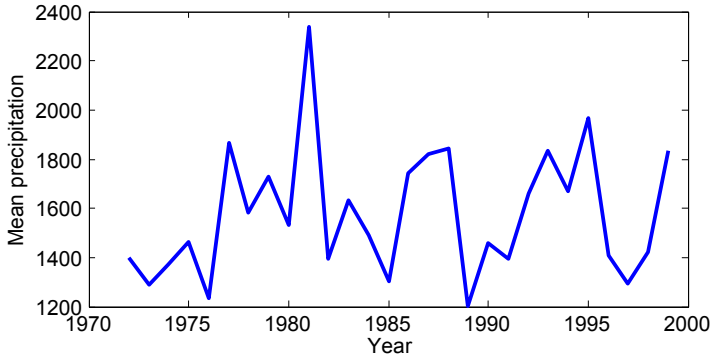

Fig. 4: Mean annual precipitation observed at the meteorological station (Oberwald)

Fig. 4.

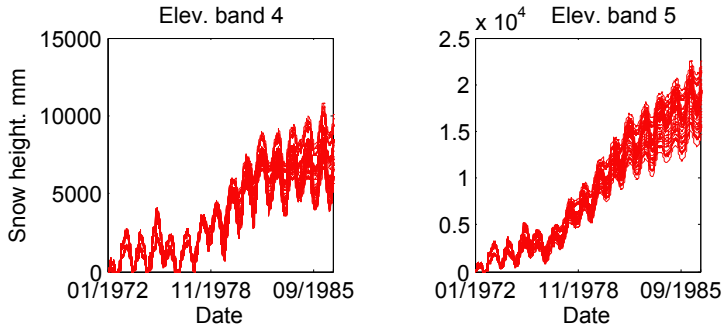

Fig. 5: Effect of model initialization on the filling of the snow store on the two highest elevation bands of the glacier (see fig. 1), simulation started on 01/01/1972

Fig. 5.