

Interactive comment on “A conceptual glacio-hydrological model for high mountainous catchments” by B. Schaefli et al.

Anonymous Referee #1

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General comments:

The manuscript presents the development and application of a conceptual glacio-hydrological catchment model in three Swiss catchments. The model has been developed for climate change impact studies and it is calibrated on daily discharges and -if available- on annual glacier mass balance. The complexity of the presented model is compatible with the amount of hydrological information available in the target area (parsimonious conceptual model for data scarce catchments) and the use of additional glacier mass balance data is a good example of using all available information about the hydrological behaviour of a catchment for the modelling procedure. The authors discuss interesting points of modelling high alpine catchments. However, I have difficulties with some of the arguments put forth and some of the conclusions do not seem to be supported by the data.

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I find this manuscript acceptable for publication in Hydrology and Earth System Sciences with major revisions and re-review by the reviewers.

Specific comments:

The most interesting point of the paper is the multi-signal calibration on discharges and additionally on annual glacier mass balance. However, the benefit of using glacier mass balance data is not really shown. First, only for one out of three catchments this calibration procedure is used and no observed glacier mass balance data are available for validation. As long as no mass balance data is available for validation any improvement of the water balance simulation can not be shown (see Klemes, 1986). If this data is not available, a comparison of model performance and calibrated parameter values using only discharge data and parameter values using additional glacier mass balance for calibration would at least support the assumption that additional data is helpful. The model performance in the validation period should be better than when only using runoff data or at least the parameter values should be more reasonable.

Page 80, line 5-17: The authors argue that threshold temperatures can not be found by calibration, because any errors in input or calibration data can be compensated by these parameters. I think this argument is not valid, as every model parameter can compensate for model or data errors to some extent. Parameters of open systems, such as glaciers, may be particular sensitive to overparametrisation, however, the soil can also be seen as an open system if maximum storage capacity is set to a very large value. A better way of getting a parsimonious model would be to preset those parameters, for which information about the parameter value is available (from data or from theoretical considerations) ? i.e. threshold temperatures. The authors should consider these arguments and revise the paper accordingly.

Page 92, line 2: The authors assume that for the Drance catchment the lower data quality explains the different performances in the calibration and validation periods. Swapping the periods (using 1990-94 for calibration and 1995-99 for validation) and

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comparing the difference in performance would shed light on this assumption.

Page 92, line 25: Due to the model assumption of an infinite available stock of ice, the mass balance of the Rhône catchment in winter 1981/82 is considerably underestimated. The sum of the observed mass balance in three years is 600 mm/yr, while the simulated mass balance is -160 mm/yr. This is a significant error and questions the authors' statement, that the total mass balance is well simulated. A limited stock of ice as an initial condition should be introduced which is assumed to improve the mass balance simulation and may have a significant impact on the performance of the simulation of the daily discharges.

Technical corrections:

Page 75, line 16 ".. the model uncertainty has to be quantifiable." This is a little misleading, fewer parameter do not imply that the uncertainty is quantifiable.

Page 75, line 26: "In Switzerland .. " This sentence disrupts the flow of thought.

Page 77, line 14-16: Please add information on how the ice-covered and bare areas in the catchment were separated.

Page 76, line 6 to 10: same as page 75, 15. Please remove sentences.

Page 78, line 15: What is the "considered station"?

Page 78, line 17: Please explain term "interannual mean precipitaion" or use "mean annual precipitation" if applicable.

Page 82, line 2: What is the input to the glacier store if covered by snow? It can not be rainfall as supported by the text (equation 4).

Page 83, line 1-21: This section is very long, but contains little relevant information. Please shorten and say instead how the glacier mass balance data were observed.

Page 85: The data collection section should be moved to earlier in the paper before

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model description.

Page 87, section 4.1: How are the calibration criteria used in detail? Are they based on a subjective selection of those parameter sets that have a good performance according to Nash efficiencies and discharge bias? Are they based on a visual comparison of simulated and observed time series? Are they based on an objective function? Is one initial parameter set for every catchment used for local refinement? Much more information needs to be provided here.

Page 89, line 20: If no glacier mass balance data are available, Nash efficiencies and discharge bias appear to have been used for local refinement. What is the difference to the selection of the initial parameter set? Please clarify.

Page 88, line 14: no bracket after "Braithwaite and Oelsen, 1989"

Page 90, line 13-19: The motivation of using glacier mass balance for calibration should be placed at the beginning of the chapter.

Page 91, line 2: "for the other two catchments" (typo)

Page 92, line 8: replace "critical" by "High flow", as the situations are not critical if they can be easily managed (line 11).

Page 93, line 10: " 2003 for an attempt " (typo)

Page 104, Table 4: The headers of Table 4 seem to be wrong. They should be read: First "Discharge calibration" then "Discharge validation" then "Mass balance calibration", otherwise inconsistent with text.

Page 108, Table 7: Please remove glaciation rates, as they are not a criterion for calibration.

Page 112, Fig.4 & page 114, Fig. 5. Please add that these figures are for the Rhône catchment.

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Recommendations:

I find this manuscript acceptable for publication in Hydrology and Earth System Sciences with major revisions and re-review by the reviewers. The major points that need to be changed are:

The analysis of the Rhône catchment would have to be expanded to also use glacier mass balance data for the validation period to check "multi-signal" model performance. I would also suggest that the authors tone down the claims of multi-signal testing as it is limited to one of the three catchments.

For the Drance catchment the calibration period and the validation period should be swapped in an additional analysis.

References:

Klemes, V. (1986) Operational testing of hydrological simulation models, *Hydrological Sciences Journal*. 31(1),13-24.

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