Hydrology and Earth System Sciences Discussions

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Review of hess-2022-205

Anonymous Referee #2

Referee comment on "Climate sensitivity of the summer runoff of two glacierised Himalayan catchments with contrasting climate" by Sourav Laha et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2022-205-RC2, 2022

This is a well written manuscript on a very relevant topic regarding the contribution of streamflow generated in the glacier-covered part of a catchment to catchment-scale water resources. It uses two contrasting glacierised Himalayan catchments, one of which is winter-precipitation dominated, Chandra (the western Himalaya), and the other one summer-precipitation dominated, upper Dudhkoshi (the eastern Himalaya). For these catchments, climate sensitivities of simulated streamflow is obtained by regressing the simulated variability of streamflow to the one its meteorological drivers. The used model is a the Variable Infiltration Capacity (VIC) model, augmented with a glacier melt module.

The analysis is model-based; , the used precipitation-glacier-melt-streamflow model is very simple for the glacier-covered catchment part; as far as I see, it sums up the ice melt and the snowmelt (and rainfall) and routes it through a single (or perhaps two, unclear) linear reservoir, i.e. the corresponding streamflow response has a single time scale stemming from icemelt and snowmelt and no baseflow, thus the model can most likely not simulate a water carry-over effect from month to month for the glacier part. This model structure might have a different impact on the estimated sensitivities for the different analysed catchments. Furthermore, we do not have information on how large the (ignored) debris cover is nor on how important snow redistribution is, we simply know that it is ignored.

Only two parameters of the hydrological model are calibrated, the ones that affect the water balance the most strongly (melt factor for ice and precipitation scaling factor). The calibration is on streamflow and glacier mass balance; there is an empirical weight factor to combine the performance with respect to both quantities; despite a clear lack of giving any formal statistical framework, the parameter estimation approach is called a Bayesian inference.

Accordingly, I am rather skeptical about the added value of this model study; I think that this is essentially a modelling exercise without clear indications that it actually

corresponds to how nature reacts; moreover, the conclusion is very general with new insights that can be inferred from general process knowledge such as e.g. the sentence "the temperature sensitivity of the glacier runoff and the precipitation sensitivity of the off-glacier runoff are critical determinants of the future changes of summer runoff and its variability in these two catchments".

I therefore recommend rejection of this version. The work could become more valuable if it was more critical about the value of the model, if it discussed what we miss with the simplifications and if it provided more insights in what we can learn from the two different types of catchments.

Detailed comment:

- what do you mean by runoff? there are usages of this term where it does not include groundwater-fed baseflow; accordingly: if we mean total flow leaving a catchment, we might want to use streamflow;
- it needs to be very clear also what is meant by "glacier runoff": runoff generated in the glacier-covered part of the catchment? including baseflow? Including runoff from lateral moraines that are not glacier covered?
- Methods, calibration: I do not think that 5% or 10% error on summer streamflow observations is a realistic value; since summer is the period of high flow, this values is certainly, much higher; furthermore, in the chosen formulation, the error should correspond to the total model error and not just to the observational error (see e.g. an Bayesian inference paper by Dmitri Kavetski); the Bayesian formulation for the mass balance is based on very few obs. values; what assumption do you make about the distribution of the residuals for streamflow and mass balance? i.e. what motivates the chosen form of the likelihood? How did you compute the posterior (you did not use any sampling method that would yield a sample for the posterior; I guess you did some kind of rescaling?)
- Methods, other: i) what is the used temporal time step of the VIC model on the glacier part ? why is it reasonable to keep the bias correction constant in space? I would expect that biases depend on elevation? Why does the glacier melt model not use the energy-balance approach? Is the glacier melt coded by the authors of the study or someone else?
- Methods: the computation of glacier mass balance sensitivity is not clear to me; did you run the model with modified precipitation input?
- Methods: how did you compute the deltaP and deltaT values (anomalies)?
- Results: please reword "the present calibration strategy resolved the equifinality problem that is usually encountered while calibrating glacio-hydrological models using only discharge data"; using two data sets does not remove equifinality; you built a single performance metric with an empirical factor to sum up two performance measures and then you report only the best value; it does not mean that there is no equifinality
- Fig. 1: the legend (not the caption) should also include what the dashed lines are
- Fig. 3: the glacier scheme is probably wrong, the text states that there are two linear

reservoirs, rainfall is missing

- Fig. 6: what is the y-axis (equation 1 is the calibration equation, something is wrong?)?
- Fig. 7: should be improve, I cannot see much about the circles
- Table 1: is there snowfall occurring in summer and if yes, what is the amount of sommer snowfall? Caption could say how summer is defined (it is in the text though); how high is ET?
- The following reference which is certainly relevant is missing: van Tiel et al : https://hess.copernicus.org/articles/25/3245/2021/; probably their review on glacier modelling is also relevant: https://wires.onlinelibrary.wiley.com/doi/10.1002/wat2.1483