Hydrology and
Earth System
Sciences

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Discussions

Interactive
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Interactive comment on "Contribution of snow and glacier melt to discharge for highly glacierised catchments in Norway" *by* M. Engelhardt et al.

Anonymous Referee #1

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General comments

This contribution describes the application of a conceptual hydrological model to three different glaciated catchments in Norway. For model validation, runoff, mass balance data and melt measurements are used. The model output is used to examine changes in the runoff regimes. The discharge is divided into the water sources snow melt, glacier melt and precipitation and the differences in between the different catchments and over time are analyzed. The model does not contain new findings, but the use of corrected seNorge temperature and precipitation data and the analysis of discharge changes over time in areas with different climate characteristics show interesting insight into the local runoff characteristics of the different catchments. The contribution is well written and most working steps are well documented.

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Specific comments

The model structure should be described in a more detailed way. Also, the available data allow more detailed validation of the results which should be made up, as explained in the comments below. I recommend changing the order of the paragraphs in the result section. Start with model performance (page 11496, line 21-29) and then show the modeling results.

Introduction:

P. 11487

Line 3-4. Please specify data source: "In Norway, 98% of the electricity is generated by hydropower of which 15% is based on discharge from glacierised basins"

Line 16-19. Hock 2005 uses the phrase "melt models"

Line 17-21. Please rewrite phrase. As precipitation and temperature are also meteorological data, point out that temperature-index models need significantly less data than energy-balance models.

Line 22. I recommend to use "parameter" instead of "variable"

Page 11488

Line 1. In my opinion "discharge models" should be replaced by "hydrological models", as this is the commonly used term

Line 1f. Better results compared to what? As far as I see, the model used in this study is grid based, but on a grid resolution of 1km. I am wondering if this scale really gives better results than lumped models which divide a catchment into different elevation and exposition classes.

Line 5. how are the seasonal mass balance data derived?

Line 7. Maybe "hydrological model" is possible here?

Line 9f. Points (1) and (2) do not belong to the calibration approach but to the model structure. For calibration, you should mention your Monte Carlo runs and the used objective functions, Nash-Sutcliffe coefficients and the coefficient of variation. There are plenty of years with runoff and mass balance data available, why don't you validate using runoff and mass balance additionally to the point measurements of ablation?

Study sites

Line 20. Why did you choose just these catchments?

Line 22. Missing word: "carried <u>out</u>"

Line 21. Please add some more information about the measurement method of the seasonal mass balances

Line: 24f. "Discharge data are <u>available</u> at daily resolution"

Page 11489

Line 23: "catchment<u>s</u>"

Methods:

Page 11490

Line 10f: "<u>to</u> account"

Line 22ff. Please give more information why evaporation is not relevant in glacierised areas

Page 11491

Table 2: Should it be possible to recalculate runoff based on the CFg and CFng values in this table? I tried but got different results using the glacier coverage presented in table 1. Is this caused by updated glacier areas? Please clarify.

Model Setup

Line 18. You should talk about the models grid size at this point (see comments on Line 16 below)

Line 22. Mass loss is caused by melting of snow and ice, runoff is just a consequence

Page 11492

Line 2. Not completely clear: Is the percental share of rain, and snow respectively, linearly increased within the temperature interval?

Line 16. Is the model calculating in grid resolution of 1km because of the resolution of the meteorological input data? Is each pixel either glacier or not glacier? Two of your glaciers only have an area of about 8km^2. Why don't you calculate more detailed using temperature lapse rates and a topographic input? Then, the potential clear sky solar radiation would be more efficient than only giving a radiation difference over the course of the year.

Line 21. Braces at (glacier) are not necessary, particularly as you don't allow ice development outside of glacier areas

Line 28ff. I don't understand what you did here. Please explain more detailed how area changes are considered.

Page 11493

Line 11. (seNorge precipitation > Ts): precipitation is bigger than the threshold temperature?

Calibration and validation of model parameters

Line 26. You write on page 11492 that R$_{firn}$ is assumed to be the mean of R$_{snow}$ and R$_{ice}$. Here it looks like you calibrated this parameter. Please clarify.

Table 3. Please check the units of the storage constants.

Page 11494

Line 14. Did you consider all years with runoff and mass balance data during calibration?

Line 22 and Table 3. To show how representative the ensemble mean for the 100 values of each parameter is, the range of each should be presented. Also, the possible ranges of the different model parameters would be interesting. Instead of calculating Nash-Sutcliffe coefficient and coefficient of variation of the ensemble mean, the maximum and minimum values of these objective functions within the 100 best sets would have more information content.

Page 11494

Line 21f. I'm not sure if using the mean parameter values really gives you good simulation results. Why don't you calculate the melt rates at the points for all sets of your ensemble as done for monthly and annual discharge as described in the results section? As already mentioned in the introduction section, I would recommend using some years of runoff and mass balance data to perform a split sample for validation of the model. The melt rates can be used as additional verification.

Page 11495

Results

Line 6. Are these values the ensemble means of all ensemble parameter sets, as described in the last section? That should be mentioned (in text and figure 3).

Line 6-13. At Nigardsbreen, runoff data for nearly the whole period exists. These should to be used here to validate your results.

Page 11496

Line 14. Why did you choose the period 1996-2012 at Alfotbreen for model validation? At Nigardsbreen, this data is also available. Why don't you show these results? Maybe this can be presented at monthly scale together in figure 8? It seems that some results

are presented twice.

Figure 7. Scale figure axes equal for easier understanding

Page 11497

Line 1. Explain the choice of the time periods. Which parameter set is used for the calculations? Here, also the measured runoff data from Nigardsbreen should be used for comparison as they are available for both periods (Alfotsbreen in the second period).

Discussion

Page 11498

Line 13 and 24. Table 4 and 5 should be mentioned in the results section.

Page 11499

Line 1. "that with"

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 11485, 2013.