

Interactive comment on “Projected cryospheric and hydrological impacts of 21st century climate change in the Ötztal Alps (Austria) simulated using a physically based approach” by Florian Hanzer et al.

Anonymous Referee #1

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The authors present a very interesting and thorough study of the effects of a changing climate on cryospheric and hydrologic processes in the Austrian Alps over the next century. The authors use a well-established physically based model, which employs a full energy balance approach to simulate snow cover evolution, and a comprehensive future climate data set to look in detail at several processes in the Ötztal Alps. Additionally and commendably, the modelling method used in the study considers the change of glaciers in terms of ice thickness and areal extent throughout the modelling period. Results are presented for the development of the glaciers in the study area, the

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changing depth and length of the snow covers, and for the amount and timing of the runoff in the area.

While comparable studies have been carried out in other parts of the European Alps (particularly Switzerland) this seems to be the first comprehensive study in the Eastern (Austrian Alps). This along with the already mentioned fact that the current study employs an energy balance model and includes glacier evolution in their analysis make this study very interesting for a larger readership. Overall, the paper is very well written. In total, it seems to be a bit on the long side. Maybe the authors could go over the paper again, trying to find some sections that could be shortened a bit. Especially the Method section seems to have some potential for shortening (in my opinion). Furthermore, some of the individual sentences seem to rather long which makes it a bit hard to read at times. It would probably be better to simply subdivide these sentences into two or three separate ones. Again I would encourage the authors to have one more look at the manuscript with this problem in mind.

The Abstract seems to me to be very concise while addressing all the major important points of the chosen method and the most significant results of the study. The introduction provides an adequate overview of previous studies in this field. The actual goals of this study are mentioned in one (rather short paragraph) at the end of the introduction. Here I would encourage the authors to maybe expand this part a little, explaining why this study area and this method was chosen and what sets this study apart from others before. The study site and data presentation are good and complete. The “Methods” section is very thorough, maybe even, as mentioned, a little on the long side with some potential for shortening. The “Results and Discussion” has a very logical setup and presents all relevant results clearly and concisely. Also included are appropriate comparisons of the results of the current studies to previous related studies. I especially applaud the authors for including an extensive section about the uncertainties in the modelling. Especially in modelling studies of the impact of future climate scenarios, such a section is highly valuable. Finally the “Conclusions” present the major results

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of the study in a concise form. The conclusions are well based on the results and give the reader a good summary. The Tables and figures are adequate and present the information in an easily understandable form.

Overall, this is in my opinion a well thought out and well presented study. It covers a topic that is one of the most pressing questions of the coming decades not only in a scientific sense, but also for society as a whole (winter tourism, freshwater availability, etc.). The chosen geographic location, which to this date has not been studied in this context and the use of a completely physically based hydro-climatological model along with an algorithm tracking the evolution of the glaciers throughout the model period present, in my opinion, a significant new addition to the overall scientific knowledge. The paper's topic falls well within the scope of the journal and is of interest to other scientists, but also to the general public and political decision makers. I would therefore recommend publication after minor revisions. As noted above, these revisions could address the overall length of the paper and the sometimes excessively long sentences, as well as the following minor specific comments.

Specific Comments:

I'm guessing that the layout of the article is not the final version, but as it is now, some of the Figures are quite far away from where they are discussed in the text. This makes it somewhat hard to follow the discussion. I would make sure that the Figures are placed closer to the text discussion of them in the final version.

p.1 line 7-9: I would cut this sentence into two by putting a period after "century" and describing the situation below 1500m asl in a second sentence.

p.2 line 7-9: This sentence ("These general...") reads very awkward. Please try to rephrase.

p.4: The authors mention three climate scenarios. However, the scenarios are not explained any further until in the results section. Maybe you could add a small paragraph

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explaining these scenarios i.e. what assumptions they make, how they are situated in the overall "scenario ensemble" (high, medium or low change assumptions)

p.6 line 15: Was terrain orientation and slope included in the calculation of the incoming solar radiation or were the model grid cells assumed to be "flat"?

p.6 p.32 Could you add one more sentence as to what modifications for climate conditions under forest canopies were applied?

p.7. Line 1: How was ground heat flux considered? Did you have ground temperatures (either measured or modelled) or was a constant value used?

p.8 line 20 and following: Is this paragraph really needed? It mainly discusses a method that is not needed for the current study. Maybe you could just explain what you did and omit the rest.

p. 13 line 19: "This is partly explainable from the fact" reads very awkward. Maybe replace with "This can be attributed to the fact"

Results Section: Generally, comparable studies start out by showing that the chosen model "system" start out by showing that the model system was able to simulate the current state (here 1997 to 2006) adequately. There is a Table (Table 3) much later, where some model efficiency values for the modelling of the current state are shown. However the focus of this Table is on showing original versus disaggregated values. I would welcome a short section showing how well the employed model system does for the historic phase at the start of the results section.

p.13 and 14: It is not entirely clear to me why observed data was used for the 1997 to 2006 period of the "regular" model runs, while RCM data was used for the 1971 – 2005 "snow cover model runs". Is this due to a lack of observed data from 1971 to 1997 or what is the reason for this procedure? Please explain.

p. 15 line 17: "Comparing" should be "Compared"

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p. 15 line 30: End sentence after “century”.

p.15 line 32: “However, also for the ...” is not a correct English sentence. Please rephrase.

p. 15 line 35: For “the” station Obergurgl. ...

p. 17 line29: “occur already” should be “already occur”

p.24 line 13: End sentence after (Huss et al 2010)

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