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The Cryosphere
Discussions
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Interactive comment on "How much can we save? Impact of different emission scenarios on future snow cover in the Alps" *by* Christoph Marty et al.

Anonymous Referee #2

Received and published: 4 December 2016

Recommendation: minor revisions

GENERAL COMMENTS

This paper represents a detailed study of possible future snow pack changes in two mountainous regions in Switzerland. The authors use a very high-resolution (200 m) surface process model (Alpine3D) specifically designed for simulation of snow conditions in complicated mountain topography. They (i) first force this model for the 1999-2012 baseline with an AWS-observation-based analysis of hourly surface weather conditions and (ii) then modify these input data using a height-sensitive Bayesian kriging analysis of RCM-simulated seasonal mean temperature and precipitation changes. By using climate changes derived from RCM simulations for three different emission scenarios and lower and upper estimates of change derived from the variation of the RCM

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results, they assess the sensitive of their findings to the forcing scenario and climate modelling uncertainty.

The paper fits very well in the scope of the journal. Although there are several earlier studies on future changes in snow conditions in the European Alps and some of them use a similar methodology, this paper adds to the field (i) by providing a more comprehensive uncertainty assessment of the future changes and their sensitivity to the emission scenario, and (ii) by including a range of impact-oriented statistics, tailored to inform (e.g.) the winter tourism industry.

The paper is clearly structured and written in generally good English. However, some parts of the methodology are not very clearly described. Furthermore, the analysis of the changes in interannual variability might not be very informative because the delta change method only takes into account changes in long-term seasonal mean temperature and precipitation. Some of the figures also need improvement, particularly in the supplementary material. On the whole, however, the paper only appears to require relatively small revisions.

COMMENTS ON SCIENCE

1. Beginning of section 2.4. The method in which the climate change scenarios were obtained should be described in some more detail. From the description that is available now, the casual reader gets the impression that the RCM-simulated temperature and precipitation changes were used nearly as such. Howerer, Zubler et al. (2014) reveals that they were based on a rather complicated Bayesian methodology. In particular, the “upper and lower bounds of this dataset” are not the minima and maxima of the 20 RCM simulations, but are based on the Bayesian model of Buser et al. (2009). An important and debatable feature of this Bayesian model is that it in some cases contracts the uncertainty range from that derived directly from the variation of the original RCM simulations (see Figs. 1 and 2 in the supplementary material of Zubler et al. (2014)). Therefore, the uncertainty ranges derived in this paper should also be seen

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as indicative only.

2. The simple delta change method with constant absolute changes in temperature and constant relative changes in precipitation neglects changes in climate variability on both sub-seasonal and inter-annual time scales. However, it is a common feature in climate model simulations that temperature variability in midlatitudes decreases in winter but increases in summer (e.g. Holmes et al. 2016). Such changes in climate variability almost certainly affect the change in interannual variability of snow conditions (Section 3.3). They might also have some effects on the average change in snow conditions, because the phase of precipitation and snowmelt both depend nonlinearly on temperature.

3. P12L23-24. Is this because the amount of snowfall is more sensitive to temperature when the precipitation is larger?

4. P14L2-3. Is this just common knowledge or can you support the statement with a reference?

COMMENTS ON PRESENTATION

1. P2L28-30. Why are most of the results only shown for the Aare region? This should be mentioned and motivated in the text.

2. P3L1: eastern Atlantic? (western Atlantic = east coast of North America)

3. P4L19-22. Instead of describing the socioeconomic pathways, please indicate the end-of-century CO_2 concentrations which give a much more tangible idea of the magnitude of climate forcing.

4. P6L7-8. “the uncertainty of model set up” should rather be “model fidelity”.

5. P6L15. observed or simulated snow depth above 0.01 m?

6. P6L26 and 29. Replace “uncertainty” with (e.g.) “error” or “discrepancy”

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7. P7L21-23. Would it not be simpler to directly compare the interannual variability (characterized e.g. by the coefficient of variation of snow depth or by the relative difference between the maximum and the minimum) in the baseline and future climates?

8. P8L9. What is the height range covered by the 500 m elevation zone?

9. P8L14. “The decrease of the affected years with elevation ... is caused by the lower inter-annual variability” does not make sense. The results show that the overlap between the baseline and future distributions is larger at higher elevations, most likely because the colder baseline climate make snow conditions at higher elevations less sensitive to warming.

10. P8L30. Always snow-covered in winter?

11. P8L32. winter months

12. P9L1. the fact that

13. P9L4. How do you define the beginning and end of the snow season if the first continuous snow melts away or individual days with continuous snow occur after the main snow season?

14. P9L6-7. As Figure 7 shows, the time shifts depend on elevation. What elevation do you refer to in this text?

15. P9L12 and 13. ”months” in plural.

16. PL20-22. This complication could have been avoided by using the baseline period glacier mask for all periods.

17. P10L6. Note that the ...

18. P10L10-11. Please specify the emission scenario to which this result applies.

19. P11L8. Note that this is ...

20. P11L14. snow cover or snow water equivalent?

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21. P13L8-9. expected snow volume reduction ... in which season?

22. P13L32. “summer months” in plural.

23. P14L9. “which might have worse consequences than the same amount of snow today”? While the preparedness will be most likely reduced, it is not obvious why the future preparedness for future’s snow extremes should be worse than today’s preparedness for today’s more severe snow extremes.

24. Table 2. Please mention the emission scenario in the caption.

25. Figure 2. It would be simple to include the results for the Grisons region by adding a parallel set of bars with a different colour.

26. Figure 3. The headings “Aare” and “Grisons” could be inserted above the figure panels for easier reference.

27. Figure 4. How wide are the elevation zones in terms of their height ranges?

28. Figure 4. The dashed lines are too faint.

29. Figure 6. Please specify the emission scenario in the caption and increase the size of the labels.

30. Figure 8. Please increase the size of the figure panels and the size of their labels, and reduce the unnecessary empty space between them. It would also be helpful to describe the interpretation of the box plots in the caption.

31. Caption of Table S1. The values suggest that this is not a “relative error” (which would be expected to be large at stations with little snow” but rather the absolute root mean square error. In addition, please spell out the station acronyms.

32. Figure S1. Please use colours and increase the size of the headings and the labels. Also, as this figure is in the supplementary material, there is no need to squeeze the three panels on the same row.

33. Figure S2. This figure is difficult to understand. If the purpose is to illustrate the change in interannual variability, scatter plots with the yearly values of the baseline snow depth on the X axis and the corresponding future yearly values of snow depth on the Y axis would be more informative. Besides, the figure is too small.

34. Figure S4. Better in colour and with larger X and Y labels

35. Figure S6. The lines are far too faint and the labels (as well as the figure panels) far too small. Use colours for a better separation of the lines.

REFERENCES

Buser CM, Künsch HR, Lüthi D, Wild M, Schär C (2009) Bayesian multi-model projections of climate: bias assumptions and interannual variability. Clim Dyn 33:849–868.

Holmes, CR., Woollings, T., Hawkins, E, de Vries, H. (2016) Robust future changes in temperature variability under greenhouse gas forcing and the relationship with thermal advection. Journal of Climate: 29, 2221–2236

Zubler, E.M., Fischer, A.M., Liniger, M.A. et al. (2014) Localized climate change scenarios of mean temperature and precipitation over Switzerland. Climatic Change 125: 237-252

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