The Cryosphere

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Discussions

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**Interactive
comment**

Interactive comment on "Snowfall increase counters glacier demise in Kunlun Shan and Karakoram" *by* Remco J. de Kok et al.

Anonymous Referee #2

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General comments

In this study, a 20-km WRF downscaling of ERA-Interim is performed over High Mountain Asia over 1980-2010. The resulting data is much more representative of the temperature and snowfall trends over the mountains over this period than the reanalyses. Unlike previous studies, the WRF simulations include moisture in the land surface to reflect increases in irrigation over the simulation period, in particular over the Tarim Basin, in western China. The WRF output is used to force a glacier mass balance model over the given period and thus addresss the meteorological impacts on glacier mass balance in recent decades, in particular to address the Karakoram anomaly. It is shown that some glaciers have advanced in the western Kunlun Shan and Karakoram (WKSK) due to increased snowfall. By tracking the moisture that leads to precipitation

over the WKSK, the authors identify that increased evapotranspiration over the Tarim Basin and to a lesser extent over other areas has contributed to this increased snowfall. Therefore, the increased irrigation may have been a factor in the Karakoram anomaly.

This study is highly novel in: 1) using high-resolution model data, which incorporates the meteorological effects of increased irrigation, to force a glacier model; 2) reproducing the observed patterns of glacier mass balance. As such it should be published and will be of great interest to both meteorologists and glaciologists. I just have a few comments that I would suggest the authors consider before the manuscript is suitable for publication.

Specific comments

1) In various figures (2,4,8,10,11,12), concise panel labels would be very helpful to allow the reader to immediately see what each panel shows, without having to read the caption.

2) Similarly, in Figs. 6 and 7, a legend would be very helpful so the reader can immediately see what each line represents.

3) L54-55: By "the amount of irrigation needed to compensate evapotranspiration", do you mean, after subtracting actual precipitation?

4) L55: PCR-GLOBWB should be defined/spelled out.

5) L71-73: How are these concentrations of the various greenhouse gases fed into the model? Is it through the radiation scheme?

6) L76: What is meant by "convergence between months"?

7) L92: What is meant by "both deltas"?

8) L152-154: In this sentence, it sounds like the implicit assumption is that the measurements are biased, but assuming these biases are constant in time, then we can use them to evaluate WRF's interannual variability. This should be made explicit.

9) L156: GHCN has not been defined.

10) L159-160: Please explain the relevance of many of these stations being situated in urban environments.

11) L166-167: Implicit in this sentence is that the stations measure snow less reliably than rain. Please make this explicit and provide a reference.

12) L185: How do you know that the discrepancy is only in part due to the different spatial resolution? Have you quantified the effect of the spatial resolution?

13) Figure 6 is never referenced in a meaningful way. This figure shows nicely that there is no clear distinction between growing and shrinking glaciers in terms of temperature trends, but that there is a clear distinction in terms of snowfall trends. It would be nice to have some words to this effect in the text.

14) Figure 6 caption: how is representativeness of the bins determined?

15) L230-232: It is quite confusing when you say "our simulations only go out to 2010, but we compare our results for 2000-2008". Why not compare results up to 2010? If 2008 is as far as the observations go, then the limitation is in the observations, not the simulations.

16) L232-233: As well as the model showing too little growth for the growing glaciers, it shows different glaciers growing to the ones in the observations (Fig. 9). Are the growing glaciers in the model and observations at least in the same areas?

17) L259: Presumably the low glacier temperature sensitivity in the WKSK is because, even with warming, temperatures in in the WKSK are still generally below freezing? This could be clarified. Or if there is a different reason?

18) I am slightly confused about Fig. 10b. Is temperature kept constant (similarly to snowfall being constant in Fig. 10a)? Please clarify in the caption.

19) L279-280: The increases in the Tarim basin are just on the very edge of the basin.

Can you confirm that the specific grid points that exhibit increases in moisture contributions have undergone an increase in irrigation?

20) L280: You say that the contribution is mainly in May to July, but only May is shown in Fig. 12.

21) L306-307: Do you mean the correlation is weaker because surface fluxes are lower in winter?

22) L335: After "Once the groundwater is depleted, the glaciers in WKSK will also receive less snowfall from this region", you should insert, "according to our results", or something similar.

Technical corrections

1) L122: if → of

2) L126: "less than 1%" should be "more than 99%", unless I misunderstand?

3) L147: rare → sparse

4) L153: of → from

5) L185: extremes → maxima

6) Figure 5 caption: insert "annual" before snowfall. Same in other figures.

7) L214: think → thin

8) L215: northwestern → southwestern. Same on L295.

9) L229: Fig. 3a → Fig. 8a

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