The manuscript by A. J. Witshire describes the present status and future changes in air temperature, precipitation, and snowfall along the Hindu-Kush, Karakoram and Himalayan mountains projected by two GCMs, which are downscaled using a high resolution regional climate model. Although this manuscript does not deal with energy and mass balances over glaciers, the two drivers are mainly projected and discussed in detail, air temperature as a proxy of glacier ablation and snowfall amount as a proxy of glacier accumulation. Some previous studies have projected changes in glaciers and/or
C1736
associated glacier runoffs using GCM outputs as boundary conditions for their massbalance or runoff models. However, those previous studies have not depicted how the input drivers affected the calculated changes in glaciers or runoffs. This manuscript by Witshire therefore helps us to understand the climate conditions, which are the driving force for changes in glaciers, in this high mountain region where the basic information is scarce. On the other hand, it is unclear how the author deals with altitudes of individual sub-regions, which affect both air temperature and snow accumulation. I request the author to make this point clear.

Major comments

Altitude information

Altitude settings affect air temperature and thus snow accumulation. Each sub-regions discussed in this study should have different altitude distribution, but no relevant information was given. Average, minimum, maximum, distribution, and representative altitudes have to be provided in detail. In particular, the "representative altitude" is important because air temperature and snow accumulation depicted in this study should be calculated at a given altitude for a sub-region. As the author mentioned in the discussion paper that the impact of warming on "positive degree days" differed along the altitude, it is important to disclose which altitude is dealt with.

Mean regional changes are calculated as area-averages over the defined sub-regions. The summary elevation statistics for these regions are provided in a table. In addition figures on hypsometry, and the sub-grid variation in elevation are included.

At the inception of this study I did attempt to mask for glacier area, however it was clear this wasn't possible without further downscaling of the RCM data. I felt it more defensible to look at these regions as a whole in terms of the projected climate from which inferences could be made on future mass balance given appropriate caveats. I agree a future study should analyse these simulations in more detail to gain better appreciation of these caveat and enable better inferences on mass balance to be made.

Besides altitude settings of RCM, the author can analyze the hypsometry (altitude-area distribution) of each sub-region using the Randorph glacier inventory together with high resolution digital elevation models (gap filled SRTM-v4.1 or ASTER-GDEM2). It is important to provide information how the altitude distributions modeled in this analysis are different from/consistent with the latest glacier distributions.

Presented in the paper is the mean elevation difference between the RCM gridbox and mean glacier elevation as provided in GLIMS. **Furthermore, a comparison of the model area-altitude distribution against the GMTED2010 high resolution data product is also included. The discussion is extended to include a section on the caveats and limitations including the models ability to sample the distribution of glaciers.**

Present climate

More detailed descriptions of present climate (Figs. 6 and 7) and its implications for the present glacier distributions are appreciated.

An additional section on this has been included in the results. This study doesn't include recent trends and it is therefore difficult to compare mean climate against mass balance data from Kaab, etc. However, a short discussion is included on the implications of different climate.

C1737

Climate changes at different altitudes

Some studies asserted that the higher altitude, the more rapid warming. It will affect future changes in glaciers if it is real. If such phenomena are found in the models in this study, which mechanisms drive it? How much degree? If not, what is the author's idea?

A section of this is included in the discussion. The model simulations do not reveal a strong elevation linked rate of warming relationship. Instead, we find uncertainty in the seasonal rates of warming and suggest this is linked to circulation changes.

Does larger PDD imply more sensitive glacier?
As the author cited, Fujita (2008a, b) discussed the sensitivity of glacier mass balance, in which glacier mass balance will more sensitively respond to the same degree of warming if the glaciers are situated in the summer accumulation environment. Because the regions analyzed in this discussion paper cover wide regions in terms of precipitation seasonality (summer accumulation in the Himalaya to winter accumulation in the Karakorum), I suppose that the degree of changes in PDD associated with warming cannot be simply implicated to that of glacier sensitivity. Any discussion is required about it.

This section has been revised for clarity. Rather than talk about sensitivity, given different regional levels of warming and the absence of any glacial processes, this section now refers to the vulnerability of warming and possible impact on mass balance.

Other but non-minor points
P3729L12: I do not understand how this degree-day factor was obtained. Need more detailed description.

Agreed. Unfortunately, the units were incorrect in the original manuscript. This has been corrected and a more detailed description included.

Minor comments
Chapter structure
"1.1 Baseline regional climate" does not seem Introduction because this part consists of the modeled results.
In the earlier part of "2 Methods", definitions of sub-regions ("2.2" and altitude information too) have to be presented. The relevant figure is too unclear to find those sub-regions.
I request for the author to reconsider the order of chapters.

Agreed. The manuscript has been restructured as recommended.

C1738
Snow to rain probability
It is appreciated how the GCMs/RCMs calculate phases of precipitation, snow or rain.

This has been included. It has also been made clear this is one of the processes with the largest uncertainties.

Reference list incomplete
Scherler et al (2011), Hewitt (2005, 2011), Matsuo and Heki (2010), Bhutiyani (1999), and Fujita (2008a, b) are not found in the reference list. Copland (2011) and Kääb (2012) seem to be just missed "et al", but Cogley (2010) is cited for glacier inventory but Cogley et al (2010) in the reference list does not provide any glacier inventory.

Thank you. Corrected. The two Cogley (2010) references are now correct.

By the way, Scherler et al (2011) concluded that the terminus changes in heavily debriscovered glaciers were equivocal, but they did not dealt with changes in glacier mass.
I suppose that it is unnecessary to cite this study so many times in this study. In this regards, Bolch et al (2011) and Nuimura et al. (2012) revealed that the thinning rate of debris-covered glacier surface have been comparable to that of debris-free glacier surface.

This section has been revised. The point of this section was to highlight the importance of glacial processes that may moderate the response to climate drivers. Hopefully, this is now clearer.

Bolch T, Pieczonka T, Benn DI (2011) Multi-decadal mass loss of glaciers in the Everest area (Nepal Himalaya) derived from stereo imagery. Cryosphere, 5, 349–358.
Nuimura T, Fujita K, Yamaguchi S, Sharma RR (2012) Elevation changes of glaciers revealed by multitemporal digital elevation models calibrated by GPS survey in the Khumbu region, Nepal Himalaya, 1992–2008. Journal of Glaciology, 58(210), 648-656.
Positive degree days (PDD) is generally used than the just degree days (DD).

Thank you. This was an oversight. Corrected throughout.

P3719L19: I do not catch why the author can say "and thus" here. If the author wants to say "and thus", aridity/humidity or precipitation contrast or contrast of melt and precipitation seasonality along the catchment have to be described in the earlier part, and then the author can emphasize the importance of glacier meltwater contribution.

Clarified.

P3720: "Karakorum anomaly" seems to be mentioned too many times. I suppose that
C1739
the author can make this part more simple. Matsuo and Heki (2010) did not particularly mention the "Karakorum anomaly".

Section restructured.

P3721L22-: I do not catch where this "possibility of future mass increase" comes from even under the current trends observed worldwide. We have to keep it mind that the Karakorum glaciers are currently slightly gaining mass, but it is unnecessary to persist this phenomena because the many other glaciers are shrinking in the Himalayan range.

This is agreed. However, I think it is a valid point that climate induced shifts in precipitation may negate future warming effects on mass balance. I have revised section.

P3723L9-: I do not catch the feature of precipitation gradient in Figs. 5, 6 and 7. Please rethink the presentation.

Changed.

P3724L14: Ohmura (2001) is more appropriate than Hock (2003).

Changed. Thankyou.

Ohmura A (2001), Physical basis for the temperature-based melt-index method, J. Appl. Meteorol., 40, 753–761
Misc
Capital letters have to be used appropriately in the reference list. I found TRMM, GCMs ERA-Interim, IPCC and others are written in small letters. Please check carefully.

Changed. This was actually the default setting in the Copernicus reference style.

P3721L4: Need any reference for avalanche contribution, Hewitt (2011) for instance.

Incorporated.

P3721L16: Radi´c

Changed.

P3721L27: Please rethink the word "Himalaya Hindu-Kush".

Changed in this instance

P3722L18: "degree C" after "zero".

Changed

P3722L19: I do not catch the written feature in Fig. 2. Fig. 1?

Figures now correctly labelled.

P3723L4: Is Fig. 4 really needed? This is an impressive and beautiful picture, but providing little information.

Possibly. I was hoping it conveyed the role of the Himalaya as a moisture barrier, which we are attempting to capture in the RCM. I have kept it in for now.

P3723L5: I do not catch the written feature in Fig. 5.

Switched to correct figure

P3724L26: general circulation models?

Changed

C1740
P3728L29: I do not catch the greater winter warming in Fig. 10.
P3729L8: HKKH?

Corrected

P3729L23: Sentence incomplete. "across the."?

Corrected

Table 1: Need descriptions what the scenario ab is. Kääb (2012) should be Kääb et al (2012). What is the last "scenario ab"?

Corrected

Figs. 1 and 5: Depicted domain is too wide. The same domain in Fig. 2 seems more appropriate.

The reason for the larger domain is show the RCM can capture the large-scale circulation features which are essential to accurately modelling the Himalaya. I have therefore kept these as they are. Where more detail is required additional figures are included.

Please rethink color bars in many figures because the current version is too difficult to see.

All figures have been redrawn and colour bars and scales improved.

Fig. 2: Definition of sub-regions has to be depicted in more simple way. No Cogley (2010) is found in the reference list, which should be different from Cogley et al (2010).

Reference now included. I'm not sure how best to do this in a simpler way, so I have improved the figure included and summary stats added to the table.