

Review of “PDO-driven interdecadal variability of snowfall over the Karakoram and Western Himalaya” by Bharati, Deb and Hunt

Submitted to WCD

This manuscript explores the relationship between the Pacific decadal oscillation (PDO) and snowfall over the Karakoram and Western Himalaya during the period 1940-2022 using the ERA-5 reanalysis. Understanding the drivers of snowfall variability in the region is important. In particular, could snowfall trends explain the “Karakoram anomaly” where glaciers in the Karakoram region have been stable unlike most other mountain glaciers globally in large part due to winter snowfall preserving the glacier mass balance. Western Disturbances (WD) contribute significantly to winter snowfall in this region, and so PDO impacts on WDs provides a mechanism by which PDO can drive snowfall variability. This is a difficult problem to study as there are few long-term snowfall observations in the region and both satellite retrievals and reanalysis show biases over the mountainous terrain of the Karakoram and Western Himalaya. Long datasets are required to study decadal oscillations such as the PDO. The result is that I am not completely confident in the robustness of the results, and this at least needs mentioning in the discussion section in the manuscript.

Comments:

- 1) As noted, it is hard to get good long-term observations of snow fall, but figure 1 shows that the reanalysis datasets consistently overpredict precipitation compared to the satellite datasets (though which is “correct” is not completely clear). In terms of variability then all the datasets (with the possible exception of CMAP) are reasonably well correlated with ERA5 (although this is DJF precipitation averaged over quite a large box so not the toughest of tests). Maybe this correlation is enough if you are looking at how snowfall variability is modulated with the PDO, but it would be good to explicitly discuss this.
- 2) Why did you choose the green box in figure 2 for averaging over? I can appreciate the simplicity of using a box, but it includes regions where snowfall is negatively correlated with PDO over the mountains, while it is positively correlated with PDO in both the foothills to the SW in the box and in the NE of the box. This potentially complicates the interpretation of later results.
- 3) What are the thin black lines on Figure 2 (and other figures). State boundaries? These are helpful in terms of comparing figures, so it would be good to explain and refer to them in the text.
- 4) Is the record of 1940-2022 long enough? The record only contains two periods of negative PDO and one short (11 year) period of positive PDO. Comparing PDO+ and PDO- periods is therefore not very robust. I am not sure what else you can do given data availability (perhaps 20th century reanalysis project?), but at the very least this limitation needs discussing.
- 5) In general, there is some blurring between results and discussion (e.g. lines 234-236 feel more like discussion not results).
- 6) Figure 2b – what is shown here? If this is a difference in snowfall, then it should presumably be a depth with units of length? Please clarify and include the proper units.
- 7) The interpretation of figure 2c (lines 248-249) talks about the interdecadal variability of KH snowfall depending on the PDO phase. I am not sure you can say that from the results. The power in the 6-15 year band is only significant in the PDO- phase, and so what the results suggest is that in the PDO- phase PDO and KH snowfall are related on a decadal timescale,

but again this is only over a 30 / 16 year time frame for the 1st and 2nd PDO- periods and so it is not clear that this is significant.

- 8) Figure 6b. The additional moisture convergence is relatively modest over the region where there is significant additional snowfall (figure 1b), so how can you be confident this is driving the additional snowfall? Much larger convergence is seen elsewhere.
- 9) It would be good to mention the uncertainties of the research in the discussion and conclusion, for example the uncertainties in the snowfall datasets and the challenges of a relatively short timeseries for studying decadal oscillations. If models capture the coupling between PDO and snowfall then potentially large ensembles or longer climate simulations could be used to confirm these conclusions? I'm not suggesting you need to do this, but it would be worth mentioning as future work.