Final author comments

Anonymous Referee #1

We thank the reviewer for the useful recommendations.

1) My first comment is about the observed trend in Eurasia/North America snow cover in November. The CanSISE observations you use stop in 2010, but it is notorious that snow cover in fall has had a tendency to increase since 2010, roughly. See the timeserie of snow cover from the Rutgers University Global Snow Lab for November, that shows the Eurasia and North America snow cover extent for the 1966-2022 period. There is a clear positive trend in both domains. This is for 1966-2022, but even over the 1979-2010 period that you use in your study, I do not see a decreasing trend as shown in your Fig. 5. Could you elaborate on this discrepancy? Is this due to uncertainties in observations, periods, both?

Link to the Rutgers Univ. snow extent timeseries:

https://climate.rutgers.edu/snowcover/chart_anom.php?ui_set=1&ui_region=nhland&ui_month=112)

We also find this discrepancy between the NOAA-CDR snow cover extent and the snow extent found from CanSISE or other datasets. We interpret it as an important uncertainty in observation. Brown and Derksen (2013) already pointed at this discrepancy between NOAA-CDR and other dataset in October. The singular trend of NOAA-CDR was also described in October and November in Mudryck et al. (2017). The reason for this discrepancy is not known. Brown and Derksen (2013) or Mudryck et al. (2017) did not provide any hypotheses to explain it. To the best of our knowledge, we do not find any explanation for this discrepancy, but we will continue to explore recent assessments of observational dataset.
We will consider adding more information on the spread found in observation in our results and the two papers cited above.

2) In link to my previous comment, section 3.4 shows there are large differences between the observed datasets in November. This is something that could be discussed further. Which dataset is more reliable in fall? NOAA-CDR, because it consists of direct satellite measurement of snow cover?

The spread in observation will be further discussed in link with the past assessment published. We will explore recent work to better discuss the difference in these datasets, and to provide hypotheses to explain the spread shown.

Presently, we do not understand the different variability obtained (see first comment). We speculate that many snow datasets are needed to sample some of the observational uncertainty. This is why we include the snow cover and snow depth from four different datasets in this manuscript.

3) The most interesting result of the study, other than highlighting the limited impact of SIC on snow cover variability, is the potential feedback of January snow cover anomalies on polar vortex warming events (section 4.3). You find that snow cover $EOF1_{int}$ is preceded then followed by a significant weakening of the polar vortex, and you hypothesize that snow may act as a feedback in increasing the persistence, possibly amplitude, of the anomaly in the stratosphere. This is interesting but only speculation since no analyses are shown to demonstrate it. I think this is where the paper can be improved, and I have a few suggestions. In the analyses of LMDZOR6, you could select winters that exhibit persistent polar vortex weakening (similar to Fig. 15), and differentiate these events between those that also exhibit high snow cover $EOF1_{int}$ anomalies, and those that do not (composite analyses). This would be a way to verify whether snow cover $EOF1_{int}$ anomalies are indeed necessary

to enhance the persistence and amplitude of the polar vortex warming. If possible, it would also be nice to see how snow cover $EOF1_{int}$ affects the stationary wave structure over Eurasia, and wave activity, that could potentially cause a higher persistence of polar warming anomalies. This section needs improvement to be more convincing.

We will conduct a composite analysis (as suggested) or a multi-variate regression (as in Simon et al. 2020) to better assess the linkages between the snow cover, the stratospheric polar vortex and the following Arctic Oscillation. Nevertheless, the conclusion from such analysis could be limited, as the causality cannot be assessed without more advanced statistics, as discusses at the very end of the discussion (L641-642).

We will investigate the stationary wave and the wave activity, as suggested. We will discuss the results and consider including a new figure in section 4.3.

Reference:

Simon, A., Frankignoul, C., Gastineau, G., & Kwon, Y. O. (2020). An observational estimate of the direct response of the cold-season atmospheric circulation to the Arctic Sea Ice Loss. *Journal of Climate*, *33*(9), 3863-3882.