Review of WCD-2021-18, Revision 3
WCD-2021-18

Title: Identification, characteristics, and dynamics of Arctic extreme seasons

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General comments:
The authors evaluate the atmospheric conditions during anomalously extreme seasons in the Arctic. This is performed using a regional principal component (PC) analysis (PCA) from ERA5 data of the first two PCs of all seasons from 1979-2018. The PCA uses six key surface variables and divided spatially into 9 Arctic sub-regions subjectively chosen based on climatological sea ice conditions in either the Nordic Seas, Kara and Barents Seas, and the rest of the Arctic. Results identify 2-3 extreme seasons for each season and in each sub-region. The PCA applied here provides a quantification of how anomalous a season is relative to another season, which variables contribute most to the extreme conditions of the respective season, and how consistent those conditions are during those particular seasons. The authors then choose two extreme or anomalous seasons in the Kara-Barents sea during winter (DJF) and one extreme DJF season over the "High Arctic" to further investigate the synoptic weather conditions that were occurring. The chosen seasons are picked based on their orthogonal, yet anomalous or extreme, projections onto the PCs, as well as their diverse processes.

This research nicely demonstrates how PCs can be used to identify seasonal anomalies and extremes in certain regions of the Arctic. It furthermore demonstrates how to use that information to provide an expectation of how an extreme season was characterized with regard to of one of the six variables and how consistent those conditions were. It is certainly a notable method to identify extreme seasons that might be worth analyzing in further detail at shorter time and space scales if desired. I again thank the authors for their consideration of my comments from the previous version, and now there is a more clear description of the two winter cases (DJF 2011/12 and 2016/17). However, given this extra clarity, I am not sure I agree that the two seasons are "fundamentally" different as stated on line 502. Otherwise, I don't see any issues and think this should be published once this remaining issue is addressed as described below:

1) Thank you for elaborating on the preconditioning of DJF 2011/12 in the review response. I have re-included my figure from the last revision (Fig. 1), which I think clearly shows the atmospheric response directly over the region of anomalously low SIC would be confined to mainly the KBI region and to some degree KBM during SON. I also included an additional figure showing the SIC anomaly and that the temperature anomalies persist and extend deep in the troposphere almost directly over the region of anomalous SIC through February (Fig. 2). Perhaps due to combining the 3 regions, figure R1 does not capture the negative E_s^* due to the more limited area of the surface fluxes while the temperature anomalies more broadly surrounded the region because of a lack of other dynamics moving the air masses elsewhere. Thus, combined with all of the other information, I do not necessarily think the two winters are fundamentally different and share many similarities.

   I do think these extreme cases are an interesting story and should be in this paper. My suggestion would be that since the stories do not end up being very different in my view, that sections 5.1-5.3 could be condensed. I think this is interesting and is a great demonstration of how sensitive seasonal extremes are to blocking (and how there is still a lot to learn about the onset of blocks). It seems that there was similar preconditioning (positive SST anomalies and negative SIC anomalies) present at the beginning of the season in both cases. In 2011/12, this pattern set up in early autumn following the second lowest September sea ice extent (up to that time) and in 2016/17 it started in the previous late winter or spring. The primary difference appears to be in the atmospheric response. For whatever reason, the synoptic patterns were such that they did not favor CAOs in DJF 2011/12 while they did in DJF 2016/17, resulting in different surface fluxes and strong but non-consistently signed temperature anomalies in 2016/17 (i.e., surface cyclone tracks were different because the larger-scale flow pattern was different). Persistent blocking in 2011/12 did not provide a way for heat flux introduced into the atmosphere to be advected elsewhere, while 2016/17 was much more of a transient pattern with less frequent blocks. It is interesting that the larger-scale pattern and block more resembled the SIC anomalies in 2011/12 while not so much in 2016/17, and while these differences are interesting and should be noted, there could be many possible reasons as for why they occurred and therefore I think any additional explanation or speculation is beyond the scope of this study.

Other specific comments:

1) Lines 490-494: Cyclones also contributed to the low sea ice during the summer of 2016 (e.g., Finocchio et al. 2020; Lukovich et al. 2021).

2) In the DJF 2016/17 case study (Section 5.2), the results about that sea ice transport from several cyclones pushes the sea ice edge further north is a little strong with the given evidence. The PIOMAS data in Figure S7 is simply showing the transport vectors. While it looks quite plausible, there are still other factors that can not be ruled out, such as the impact of waves or upwelling. So I think this part of the discussion on sea ice can be shortened to say that there is an an apparent association with sea ice transport and the passage of cyclones.

References

Finocchio, P. M., J. D. Doyle, D. P. Stern, and M. G. Fearon, 2020: Short-term impacts of Arctic summer cyclones on sea ice extent in the marginal ice zone. *Geophys. Res. Lett.*, **47 (13)**, e2020GL088 338.

Lukovich, J. V., J. C. Stroeve, A. Crawford, L. Hamilton, M. Tsamados, H. Heorton, and F. Massonnet, 2021: Summer extreme cyclone impacts on arctic sea ice. *J. Climate*, **34 (12)**, 4817–4834.

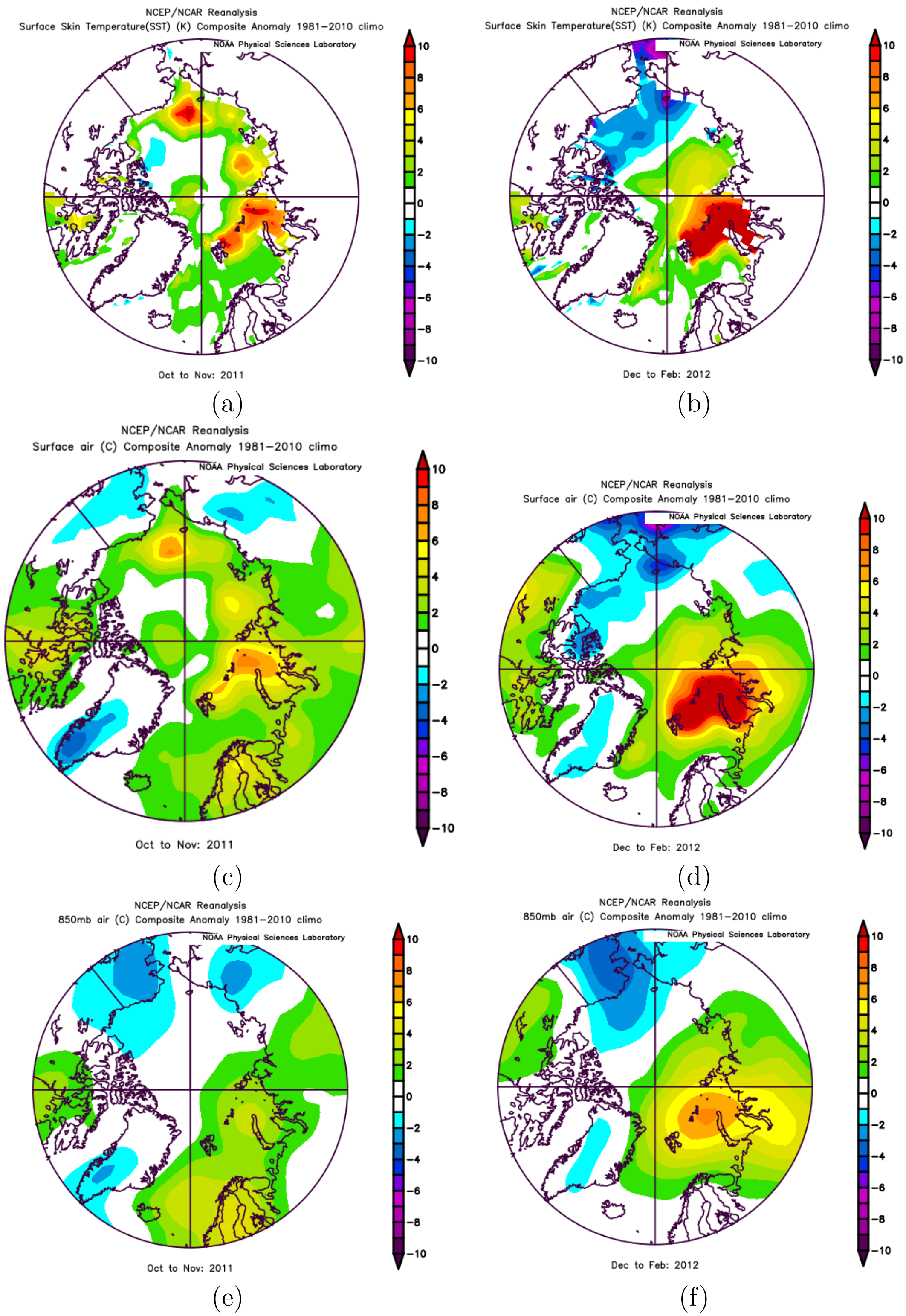
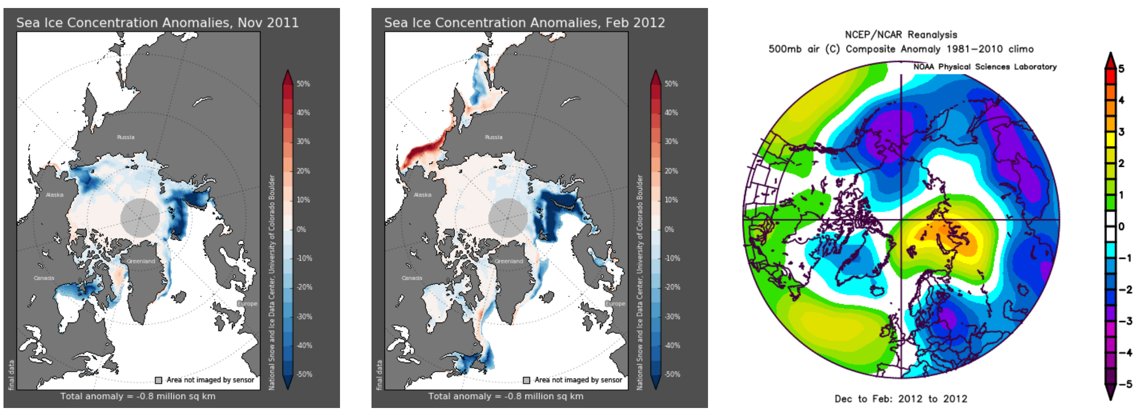


FIG. 1. Anomalies in monthly mean (a), (c), (e) October-November 2011 and (b), (d), (f) December - February 2011/2012 (a)-(b) surface skin temperature, (c)-(d) 2-m air temperature, and (e)-(f) 850 hPa air temperature. NCEP/NCAR reanalysis data are freely available from https://psl.noaa.gov/cgi-bin/data/composites/printpage.pl.



(a) (b) (c)

FIG. 2. Anomalies in (a) November 2011 and (b) February 2012 sea ice concentration and (c) anomalies in monthly mean December - February 2011/2012 500 hPa air temperature. Data in panels (a)-(b) are from the NSIDC available from https://nsidc.org/data/seaice_index/archives/image_select and data in panel (c) are from NCEP/NCAR reanalysis data and are freely available from https://psl.noaa.gov/cgi-bin/data/composites/printpage.pl.