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Comment on wcd-2021-41

Anonymous Referee #2

Referee comment on "Winter thermodynamic vertical structure in the Arctic atmosphere linked to large-scale circulation" by Tiina Nygård et al., Weather Clim. Dynam. Discuss., https://doi.org/10.5194/wcd-2021-41-RC2, 2021

Review of the manuscript
'Winter thermodynamic vertical structure in the Arctic atmosphere linked to large scale circulation'
by Tiina Nygård, Michael Tjernström, Tuomas Naakka
submitted to 'WCDD' (WCD-2021-41)

The current climate change in the Arctic is characterised by an unprecedented near-surface warming exceeding the warming in the mid-latitudes by about 2 K and related sea-ice retreat (Arctic Amplification). Arctic Amplification is both a consequence and a driver of local and remote feedback processes specific to the Arctic, but currently there is no consensus on how much the individual feedbacks contribute to AA nor consensus on how AA is linked with the weather and climate in the lower latitudes. Recent studies (e.g. He et al., 2020) suggest that the mid-latitude response to AA depend on the depth of Arctic warming.

Given this background, the submitted manuscript is very valuable since it studies the wintertime thermodynamical structure of the Arctic atmosphere and the impacts of local processes (cloud processes and associated radiative cooling) and large-scale processes (in terms of specific atmospheric circulation patterns) on temperature and specific humidity profiles in the circumpolar Arctic. In addition the manuscript includes a valuable evaluation of the ERA5 reanalysis over the Arctic with respect to cloud cover and temperature and humdity profile metrics at about 30 selected sounding stations.

Therefore, the study should be published in 'WCD'. Nonetheless, at this stage, the submitted manuscript needs careful and major revision.

Major comments:

(1) The SOM clustering algorithm has been applied for the classification of the preferred atmospheric circulation pattern. During the last years, this method has been well established for that purpose, but as as all clustering algorithms, it requires the prescription of different parameters.

The authors have to better explain, which criteria they have used to determine the quality of the clustering, and how sensitive are the results of the SOM clustering to the choice of the region (e.g. in comparison to a region north of 50 degrees N) and the choice of the SOM parameters. In particular I wonder why a 3x4 SOM array was choosen, and why only 4 circulation patterns were discussed at a time in sections 4.2 to 4.5. I understood that the 4 patterns analysed in section 4.2 to 4.4 have been choosen to cover the whole range of sensitivities to circulation changes, assuming that this is best covered by the corner patterns of the 3x4 SOM array. I think this assumes implicitely, that the corners of the 3x4 SOM array map to the corners of the corresponding Sammon map (which visualizes the closeness of nodes in a 2D space). I wonder whether the authors have proven that.

In 4.5 (the analysis of two specific Arctic stations) the 4 circulation pattern which have been chosen to cover a wide range of circulation sensitivities have been selected with respect to the specific position of the station (as far as I understood). I recommend that the autors explain this in more detail, and discuss if this selection of the 4 circulation patterns out of the 3x4 SOM array could be done in a more objective manner.

(2) I appreciate the efforts of the authors to divide the Arctic into 5 regions with specific characteristics, and to summarize the results in this way. To make the linkages to the circulation patterns even clearer and easier to follow for the reader,I recommend to describe the linkages more explicitely throughout the whole section, not only for region (4) at L507.

Furthermore I wonder, if the temporal variations of temperature inversions over Greenland (see L 521) would show a stronger association with specific circulation patterns, if other circulation patterns than the corner patterns would have been included in the analysis. I assume a stronger association of temperature inversions over Greenland with the circulation pattern typ 4 which displays a strong Icelandic low, probably as part of a NAO+ pattern.

(3) It is clearly stated in the manuscript that the effects of large scale circulation are manifested as heat and moisture advection. So far, anomalous heat and moisture transport related to the different circulation changes are discussed only implicitely on the basis of the mean sea-level pressure patterns. I suggest to include an additional metric which quantifies the anomalous advection more directly (anomalous horizontal wind fields or, if feasible, even anomalous temperature and moisture fluxes).

(4) I recommend to improve the figures for the gradient profiles. For me it was very difficult to see the differences between all the profiles (and therefore to follow the description and arguments in section 4.5), and I wonder, whether they could be moved to the supplement.

Minor comments

(1) The authors should give a brief explanation why they analysed the period 2009-2018 only.

(2) L89-91: Another approach for comparing station data with reanalysis is to use the average of reanalysis data from the 4 closest grid points surrounding the station instead of using the closest grid point only. Why did the authors used the latter approach? And just for my curiosity: in the case that the autors compared the two approaches, what was the outcome of that excercise?

(3) L134-145: Please mention the region used for the SOM clustering explicitely here.

(4) L213-214: "...in which he Icelandic low has a relatively western location." This statement is not valid for type 10, please correct.

(5) L249: Fig. 3e and i --> please correct to Fig. 3e and m!

(6) L363-364: Please be more precise on the region (westward from 60N over land or ocean??), otherwise it is difficult to follow the discussion.