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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Characteristics of Arctic low-tropospheric humidity inversions based on radio soundings" *by* T. Nygård et al.

Anonymous Referee #2

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Nygård et al. (2013), "Characteristics of Arctic low-tropospheric humidity inversions based on radio soundings" (ACPD)

The authors present a study on specific humidity inversions over the pan-Arctic region during the year 2000-2009. Using radiosondes and similar methodology to a study in the Antarctic, the authors are able to present a climatology of Arctic humidity inversion characteristics, comparing with other studies in the Arctic region as well as with the results from the Antarctic. The main results indicate the frequent presence of multiple humidity inversions across the Arctic, with a substantial seasonal cycle in many inversion properties. These results broadly agree with other Arctic studies, but the actual numbers of humidity inversion properties differ. These differences are related primarily to differences in methodology.

I find the study to be very well written, the results are presented openly (for the most part, see detailed comment #5 below) and the Arctic atmospheric research community would greatly benefit from this brief climatological study of thermodynamic properties. My suggestion is to publish this paper in ACP after the following concerns have been sufficiently addressed.

Major concerns:

The methodology of humidity inversions (from here on referred to as q-inversions) identification from radiosondes becomes a philosophical question. In this study, as in Nygård et al. (2013), there is no restriction on the depth/strength of a negative q-lapse rate between inversion layers; statistics presented in Nygård et al. (2013) showed little impact of such a restriction on the statistics and so it was motivated that this restriction was unnecessary. Have similar tests been done for this study. Secondly, in a thermodynamic and radiative sense, the question emerges: Which q-inversions are most important? Are a number of thin and relatively weak q-inversions important for the radiative impact of the atmosphere? Are these weak q-inversions generated by cloud formation (Qv becomes Ql)? Yes, it is true they can potentially indicate vertical variation in meridional flux distributions, but are the main advective q-inversions containing the majority of the column integrated water vapor more important? These questions further arise when reading pages 22582-83 regarding the differences between the strongest inversions and the median statistics of all inversions. I am not sure of the answer to these questions, but I hope the authors can elaborate more on the importance of observing multiple q-inversions over the Arctic.

The above concerns could be better quantified if the study included, as one of the 1st figures, example profiles of temperature and humidity, showing cases where both temperature and q-inversions coexist, are separated vertically, and cases where multiple q-inversions are present. I am particularly interested in cases where there is a deep, strong q-inversion present, with variable advection vertically such that additional, thin q-inversions are present within the large-scale q-inversion. These structures seem to

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occur quite frequently, for example, see the specific humidity profiles in Fig. 7 of Shupe et al. (2013, ACP). Examining these profiles begs the question: should individual, small increases/decreases in q within a deeper q-inversion be considered separate inversion structures? After all, the q-values within these thinner, more frequent inversions are still larger than the main q-inversion base level.

Additionally, the majority of these radiosonde stations are central land stations, with extremely different climatology than the interior central Arctic for which results from Devasthale et al. (2011) were focused. This is likely also causing the Russian stations, most "interior" stations in this study, to have systematic differences compared to the other stations with a closer footprint to the Arctic Ocean. Yet there is little to no description of the potential biases that may be a result of the station location.

Detailed comments

(1) Table 1 shows a wide range of radiosonde sensors, yet there is not text considering the potential uncertainties/errors in humidity observations relative to each sounding system.

(2) Have the humidity profiles been averaged vertically using, for example, a 3-point vertical averaging window? It seems the requirement of a 10 m thick inversion layer, with subsequent inversion separated by negative humidity lapse rates, should be very easily passed with rather noisy radiosonde profile data. As mentioned above, see the specific humidity profiles in Fig. 7 of Shupe et al. (2013, ACP).

(3) Pg. 22584, Line 13-14: What does "markedly different" mean here? It would help if the authors added another panel to Fig. 5 showing the clear-sky inversion number RFD.

(4) Pg. 22584, Final paragraph: It is difficult to follow the results discussion when so many of the stated results are "not shown". Either remove those not shown from the discussion or include the necessary figures.

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(5) Pg. 22586, Line 10 as well as Lines 10-25 on Pg. 22587: This is an interesting result, and one that seems to contradict recent studies that show inversions of temperature and humidity coincide near cloud top and potentially are the source for cloud moisture (e.g. Sedlar and Tjernström 2009; Solomon et al. 2011; Sedlar et al. 2012). These aforementioned studies are focussed over the remote, sea-ice covered Arctic Ocean. The analysis in this study comes from profiles that are more representative of the high latitude pan-Arctic land mass. Could you comment on the potential differences and how thermodynamic advection over sea ice may lead to more coordinated temperature and humidity inversions over the Arctic Ocean?

(6) Pg. 22588, Lines 8- : It is important to note that the radiosonding analysis in Devasthale et al. (2011) differed from the AIRS results in terms of frequency of inversion presence and inversion strength, and agreed much more closely with the radiosonding analysis performed in this study.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 22575, 2013.