

## Response to Reviewer 1 Amy Solomon

Thank you very much for your time and effort dedicated to our manuscript! With the help of your advices, we have prepared an improved version of the manuscript. Our responses to your comments are marked in red below.

This study makes an important contribution to the understanding of humidity inversion characteristics in the Arctic. In addition, this paper identifies how using sounding data produces different results from studies that used satellite data. Also, this study employs a methodology that allows for a clean comparison with the observed characteristics of Antarctic humidity inversions. This paper is very well written and I recommend that it is acceptable for publication after minor revision.

### Major Comments:

1) Is there a way to test whether there is a bias in statistics of humidity inversions at cloud top due evaporation on the sensor when the radiosonde emerges from saturated conditions?

We admit that this may generate a bias, as the humidity sensor may be wet when rising above the cloud top. We have added a note on this on Section 2.2 in the manuscript. In practice it is, however, impossible to quantitatively estimate the bias in this study. This is because the amount of condensate in the sensor depends on the cloud particle concentration, phase, and size distribution, as well as on the level of turbulence both inside and above the cloud.

Some radiosonde instruments take care of the issue effectively. For example, Vaisala Radiosonde RS92 has two humidity sensors, of which one is pulse heated. The purpose of the heating is to minimize condensation that may occur during the flight. This results in reliable humidity measurements also when emerging from a cloud. In general, if a radiosonde humidity sensor experiences condensation while emerging from a cloud, the condensate gets fast frozen in freezing temperatures. That leads into unrealistic constant large humidity values for the rest of the flight, which are removed in the quality control of the data. We did not see this type of behavior in our vertical profiles of humidity.

2) How meaningful are the statistics presented in Figure 4? Figure 5d shows that base heights in North America of 1000m are as frequent as 2500m and the most frequent base heights are closer to 200m. The statistics for median base heights in Figure 4 may not be physically meaningful. It is possible to make a contour plot as a function of RFD for the statistics shown in Figure 4 (as was done in Devasthale et al. 2011).

It is true that the median value of inversion base height, shown in previous Figure 4e (now Figure 5e), does not tell everything. It is, however, not clear for us what kind of contour plot of RDFs the reviewer was meaning; if only the base height is to be presented, the plots would be similar to the present Figure 6d (except that RDFs from all 36 stations could be shown, but it would either make the plot hard to read or take too much space). Devasthale et al. (2011) showed contour plots with two variables (their Figures 7, 8, 9, and 11), but without the inversion base height. We considered it most relevant to add discussion in Section 3.1, in the paragraph where the present Figure 6 is first referred to. There we explain how Figure 6d provides additional information to help interpreting the

present Figure 5e. (We also added a-e to figure references in the manuscript to help the reader to look at the correct subfigure.)

3) Much of the discussion about this study is in the past tense. I think the authors need to go through the paper and reword the discussion in the present tense.

We have changed the tense from past to present in suitable places. Our principle is to write about results based on the data set from 2000-2009 in the past tense, and use the present tense for discussions and conclusions that are more generally valid.

Minor Comments:

- 1) Page 22576, line 9: "...are present on multiple levels nearly all the time..."
- 2) Page 22576, line 14-15: Properties are both relatively weak and systematic? Adding specific examples will help clarify the meaning of this sentence.
- 3) Page 22576, line 22: "...encourage further..."
- 4) Reword the introduction and methods sections so that reference to this study is in the present tense.
- 5) Page 22577, line 10: "keeping"
- 6) Page 22577, line 11: "..., which implies that humidity inversions extend to large spatial scale."
- 7) Page 22577, line 12-13: "...influence longwave..."
- 8) Page 22578, line 3: "...data that the fraction of humidity..."
- 9) Page 22578, line 8: "...inversions is lower than..."
- 10) Page 22578, line 9-10: "...did not show a seasonality in the frequency of occurrence..."
- 11) Page 22578, line 17: "...a 10yr..."
- 12) Page 22578, line 13: "...from linearity..."
- 13) Page 22581, lines 2-4: "...a selection criteria was used where a humidity inversion..."
- 14) Page 22581, lines 6-8: The meaning of the sentence starting with "The latter correlation..." is unclear.
- 15) Page 22587, lines 27: "...vertically separate..."
- 16) Page 22588, lines 8: "...differ remarkably..."
- 17) Page 22589, lines 9: "...in both polar..."
- 18) Page 22589, lines 12: "...in most..."

We thank the reviewer for the advice, and have modified the text accordingly.