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Reply on RC2

Tiago Silva et al.

Author comment on "A 25-year climatology of low-tropospheric temperature and humidity inversions for contrasting synoptic regimes at Neumayer Station, Antarctica" by Tiago Silva et al., Weather Clim. Dynam. Discuss., <https://doi.org/10.5194/wcd-2021-22-AC2>, 2021

We would like to thank RC2 for the thorough review and constructive comments. In the following we address them point by point:

- *I am not convinced that using the terms cyclonic and non-cyclonic is truly accurate given the way that the synoptic weather observations are used to define these two weather types. While the conditions used to identify the cyclonic type most likely occur during periods of low pressure that may not always be the case. Similarly, the non-cyclonic conditions could occur when the station is under the influence of an area of low pressure. I suggest renaming these two synoptic classifications - maybe precipitating and non-precipitation would be more accurate (although this is problematic due to the inclusion of diamond dust in the current non-cyclonic category, which I think is appropriate). But I do think this better reflects the distinction between the two synoptic categories being used for this work.*

This point was also of concern for RC1 and we realize that we have to explain our choice of definition and terms in more detail. "Cyclonic vs. non-cyclonic" was not our first try, but we came to the conclusion that it describes our defined synoptic situation as closely as possible. "Precipitation vs. non-precipitation", as the referee states, too, is difficult because diamond dust is also precipitation, but definitely falls into the non-cyclonic class. Also, "fair weather" vs. "bad/stormy weather" is not a good choice since fog would not belong to the bad weather category while it is not exactly what one would call fair weather. Non-cyclonic conditions would not occur when the area is under the influence of low pressure (except for a short transition period, we discussed this difficulty already in the original text).

Neumayer weather conditions are strongly determined by cyclonic activity in the circumpolar trough. The weather is characterized by cyclones passing from west to east with the general westerly flow, with anticyclonic conditions for shorter or longer periods between two cyclones. The semi-annual oscillation can lead to longer anticyclonic periods in summer and winter when the trough and thus the position of the frontal zone moves northwards. This is also indicated by the main wind directions. For the majority of the time Neumayer Station experiences relatively strong easterly, to ENEly winds, related to the clockwise rotation of the passing cyclones. The center of the cyclones is always north of the coast since the topography (increasing elevation) blocks further southward

movements of the low-pressure systems. Weaker winds from southerly or SWly directions prevail under high pressure. We add a figure of the mean Neumayer wind direction in the supplemental material (Fig. S1). Also, clouds are of much less importance for inversions at Neumayer than at Arctic or interior Antarctic stations. A study by Hirasawa et al. (2000) showed that at Dome Fuji, advection of relatively warm and moist air lead to formation of low clouds, which were not sufficient to produce precipitation but increased downward longwave radiation, which, together with increased wind speed destroyed the prevailing inversion. At Neumayer, the increased wind speeds, thus turbulence associated with an approaching cyclone remove an inversion very quickly.

We explained our definition of the two-weather situation typical at Neumayer in more detail in the Data and Methods section and also gave more general information about the climate of Neumayer as an Antarctic coastal station in contrast to interior Antarctica or most Arctic stations in the introduction.

- *I have some concern about the use of a fixed humidity threshold to define humidity inversions. Given the strong dependence of absolute humidity on temperature it will be much harder to meet the humidity threshold for a humidity inversion in colder conditions (aloft or in winter). It might be better to define a humidity inversion threshold as a percentage of the humidity at the inversion base or top instead.*

We found that the use of absolute values of specific humidity to define inversions has been widely used in similar studies, mainly in the Arctic (e.g., Devasthale et al. 2011, Kilpeläinen et al. 2012, Vihma et al. 2011), but also in the Antarctic (Nygård et al. 2013). We thus assume that it is an accepted method for studies of humidity inversions. Concerning lower humidity in colder seasons or at higher levels: Saturation vapor pressure is a function of temperature, and this usually leads to lower absolute humidity when the temperature is lower. However, this is only part of the story. First of all, we do not always have saturated conditions, and more important, warm air advection in winter can lead to temperatures similar to the temperatures of warmer seasons, even summer, so the humidity should be not necessarily lower, particularly since at Neumayer warm air advection usually means advection of moisture, too. Only southerly winds bring dryer air, but those are generally cold. We added these considerations in the paper (Section 2.5 and Discussion of Fig. 10).

- *The inversion composite figures are interesting but it may be better to create these composites using a varying height scale rather than one fixed relative to sea level. Specifically, it might make sense to create composites with the 0 height taken as the inversion base. In this way varying heights of inversion will not "smear" the inversions in the composite and a more robust signal of the inversions and their relationship to wind is likely to be seen. I would also suggest using the temperature (or humidity) at the inversion base as the 0 value so that variability in the value of temperature or humidity can be removed from the composites. Taken together these two changes should produce much more robust composites.*

We thank the referee for this constructive suggestion. We created new figures with normalized height and temperature (humidity) axes for both surface based and 2nd/level inversions. Furthermore, we included the profiles for surface-based inversions under non-cyclonic conditions (Fig. 15a) and for 2nd-level inversions under cyclonic conditions (Fig. 15b) in the main manuscript and kept the original Figures 11-14 in order to be able to show the entire height profile. In Fig 15 we discuss change of wind direction and speed with height within the inversion. All figures with normalized axes including a short discussion are found in the supplemental material (Fig. S4-S7).

- *Line 5: What "both" refers to in this sentence is unclear. I assume it is cyclonic and non-cyclonic conditions, but please clarify this text or explain what two synoptic*

classifications are being presented in this work before this sentence.

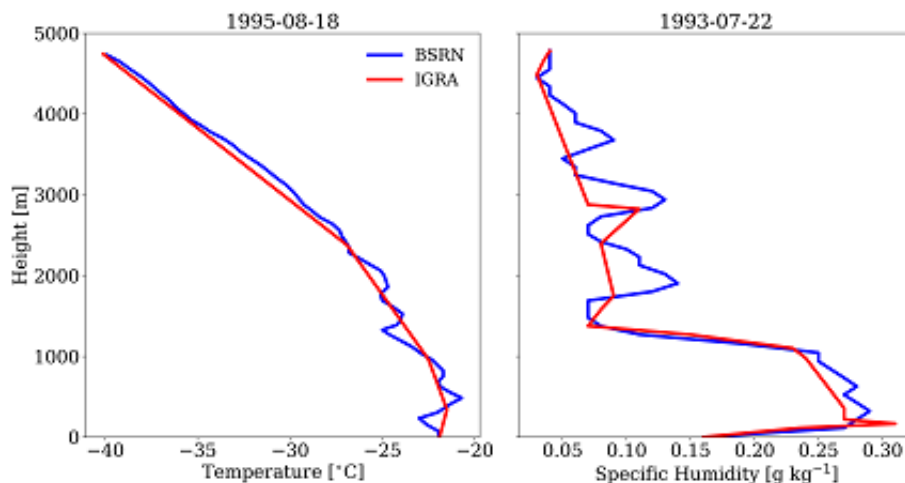
We agree that this formulation was not exact, and we corrected this in the abstract.

- *Figure 1: It would be useful to also indicate what percent of all possible days in each month during the study period the total radiosonde count for each month represents. This could be listed below the monthly radiosonde count at the top line of this figure.*

We fully agree, and we added this information in Figure 1.

- *Section 2.5: It would be good to indicate the typical vertical resolution of the sounding data either here or when the radiosonde data is first introduced. This impacts what depth inversions can be reasonably identified. It might also be worthwhile to discuss why the BSRN radiosonde data is used rather than IGRA data here rather than in the discussion section.*

This is also a good suggestion, which we followed. We changed the text in the Data and Methods Section accordingly. Given the 25-year period, three types of radiosondes were used where the latest version has always higher vertical resolution than the previous. Moreover, the weather conditions severity can also affect the vertical resolution. One of a few IGRA corrections during the quality control procedure is the removal of pressure levels where relative humidity is exceeded 100% with respect to ice. Supersaturation is remarkably important to account when making analysis over polar areas. Here, we add a figure with arbitrary dates comparing BSRN with IGRA data:



However, a statistical analysis of differences among upper air sounding archives due to distinct quality control procedures and associated impacts on inversion detection go beyond the scope of our study.

- *Line 172: It would be useful to more explicitly state how the 5 point moving average profile is used. The text states that this moving average profile is used to detect the inversion base and top positions. Is this done for both absolute humidity and temperature profiles? Also, are the top and bottom inversion values of humidity and temperature taken from the unsmoothed profile data or do these values also come from the moving average profile?*

Exactly. We wrote this in the manuscript already but tried to change the formulation to make it better understandable for first reading.

- *Figure 4 and all similar figures: Please indicate what the boxes, whiskers and open circle symbols indicate in the figure caption. The figure caption should fully explain what is plotted in each figure without the reader needing to refer to the main text for this information.*

Principally we agree that figure captions should have the full explanation of the figure. We tried to follow this request, but it turns out that adding the (same) explanation to all figure captions for Fig. 4-Fig. 10 would reduce the size of the figures if we wanted to keep the caption on the same page as the figure. This would also reduce the legibility of the figures. Thus, for practical reasons, we gave the full explanation of the box plots only in the first Figure where box plots occur (Fig. 4). (You will notice that here the page number gets aligned with the caption already. The layout done by the journal might have a reduced figure size.) We would like to avoid having this for all box plots. In the following Figure captions, we refer to this explanation in caption of Fig. 4. We hope that this will be sufficient, also taking into account that box plots are actually textbook knowledge.

- *Paragraph starting at line 299: The change in humidity gradient across the three height ranges and seasonally is driven by changes in the magnitude of absolute humidity as a function of temperature. It is not surprising that gradients are smaller at upper levels or in winter where colder, and thus drier, in an absolute sense, conditions, occur. This point should be made when discussing Figure 10.*

As stated above, it is true that saturation vapor pressure is a function of temperature, and this usually leads to lower absolute humidity when the temperature is lower. However, we do not always have saturated conditions, and more important, warm air advection in winter can lead to temperatures similar to the temperatures of warmer seasons, even summer, so the humidity should be not necessarily lower, particularly since at Neumayer warm air advection usually means advection of moisture, too. Only southerly winds bring dryer air, but those are generally cold. We added these points in the discussion of Fig. 10., also referring to the revised Section 2.5.

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