Comment on amt-2022-22
Anonymous Referee #2


Chellini and Ebell compare statistics of moisture inversions in the Arctic between datasets of the nadir thermal IR sounding instruments IASI and AIRS, the ECWMF ERA5 reanalysis data and radiosoundings as reference measurements. They draw as their main conclusions (a) that the nadir-sounders strongly underestimate inversions in specific humidity and, (b) that the reanalysis datasets characterize such profiles quite well when compared to radiosonde profiles with adapted vertical resolution.

In my opinion, this is a valuable and clear study expressing the limitations of satellite moisture data with a focus on specific features of moisture vertical profiles in Arctic regions. Thus, it helps also to prevent inappropriate use of those datasets. My main criticism concerns the method applied to adapt the vertical resolution of radiosonde data to that of the nadir-sounders. As the authors state themselves, the correct method would have been the application of the satellite instruments’ averaging kernels to the radiosonde profiles. In this study, only a vertical interpolation and averaging is performed which does by no means simulate typical nadir sounding averaging kernels. That this is wrong can be seen by the fact that the statistical analysis of humidity inversions when applying their averaging to the radiosoundings (Fig. 4) is largely different from the analysis on the satellite data themselves (Fig. 5). If the real averaging kernels were applied, the differences should be much smaller. Thus, this exercise only shows that the wrong ‘resolution-reduction’ has been applied to the radiosonde dataset. Therefore, I would draw the conclusion that the related sections (3.2,4.2) should better be omitted since they do not really contribute any new insights and rely on a very inaccurate method.

Similarly, this would apply to the comparison of resolution reduced radiosoundings and ERA5. However, this may be more appropriate due to the presumably better behaved vertical ‘kernel’ and resolution of ERA5 compared to nadir-sounding instruments.
In summary I would recommend this work for publication in AMT, if the major comment, as expressed above, is taken into consideration.

Specific comments:

L265:

Please specify if IASI/AIRS data is also assimilated in ERA5.

L375, 'Standard Product (7 between 1000 and 400 hPa) is close to the typical number of degrees of freedom of the IASI retrievals (e.g., ranging between 2.5 and 7.2, according to Ebell et al. (2013))':

It is not close but at the upper, optimistic end of the typical degrees of freedom reached by IASI retrievals.

L451, 'IASI seems to be able to capture better inversion frequency below the 800-hPa level in winter.', also L15 (abstract) 'A better agreement has been found for IASI below the 900-hPa level and in particular for winter':
Considering the fact, that thermal IR nadir sounders generally have a very low sensitivity on the lowermost atmospheric layers (due to the small thermal contrast between surface and lower atmospheric temperature), I doubt that this ‘better’ achievement is due to real information from the measurement but may stem from retrieval artefacts. At least this should be a part of the discussion.

L566, ‘... If ERA5 showed a similar good performance, the data could also be used as a reference to be compared to the satellite retrievals across the whole Arctic region’:

It should be emphasized here that this argument is valid only in case the radiosoundings used for comparison are really independent from the reanalysis, have not been assimilated and are locally distinct from radiosoundings used in the assimilation.