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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Probabilistic description of ice-supersaturated layers in low resolution profiles of relative humidity" *by* N. C. Dickson et al.

Anonymous Referee #1

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A review of 'Probabalistic description of ice-supersaturated layers in low resolution profiles of relative humidity' by N. C. Dickson, K. M. Gierens, H. L. Rodgers and R. L. Jones.

This manuscript addresses the use of a radiosonde database to quantify the frequency of occurrence of ice-supersaturated regions (ISSR) relative to a coarser grid (50 or 100 hPa layers). The coarser grid is a proxy, for instance, for the vertical resolution that a climate model may resolve or for the vertical resolution of an operational temperature and water vapor sounder (HIRS, AIRS, IASI, AMSU, etc). For these thicker layers, there could be a subsaturated value of RHI reported (or retrieved) but only because a more complex vertical structure of supersaturated and subsaturated layers is smoothed over. The frequencies of ISSRs are obtained for several different stations and are compared

between different years, seasons, and vertical levels. The authors develop an analytical model based on an "S" shaped curve obtained from the observations observed in all radiosonde stations and it may be useful for the parameterization of ISSR frequency in coarsely gridded climate models. Furthermore, this analysis is useful for contrail prediction and quantification.

This is a straightforward paper that is a logical follow-on of a recent paper by Lamquin et al. (2009, ACP). That paper presented a similar analysis except the context was radiosonde comparisons to the vertical binning of AIRS RHI. Overall, there is a sufficient amount of new information presented in this paper using an independent data set. The technical approach is sound and the discussion and interpretation of the results also appear to be fine. Although this work isn't a major breakthrough, it does add to some of the analysis that Lamquin et al. performed with a limited comparison of radiosonde/AIRS data. The reviewer has some suggestions for further improvement below that the authors should consider before this paper is published.

Introduction

The issues of RHI in the context of the thickness of temperature, water vapor, and cloud structures is addressed in detail in several studies previous to this paper. The following paper:

Maddy, E. S., and C. D. Barnet (2008), Vertical resolution estimates in version 5 of AIRS operational retrievals, IEEE Trans. Geosci. Remote Sens., 46, 2375 – 2384, doi:10.1109/TGRS.2008.917498.

addresses the vertical sensitivity of AIRS temperature and water vapor. Although AIRS data is not explicitly discussed in this paper, it does give some additional context to the problems encountered in assessing vertical structure from remote sensing retrievals and relating them to the structures seen in radiosondes.

A few more papers related to AIRS:

Kahn, B. H., A. Gettelman, E. J. Fetzer, A. Eldering, and C. K. Liang (2009), Cloudy and clear-sky relative humidity in the upper troposphere observed by the A-train, J. Geophys. Res., 114, D00H02, doi:10.1029/2009JD011738.

Kahn, B. H., C. K. Liang, A. Eldering, A. Gettelman, Q. Yue, and K. N. Liou (2008b), Tropical thin cirrus and relative humidity observed by the Atmospheric Infrared Sounder, Atmos. Chem. Phys., 8, 1501 – 1518.

Lamquin, N., C. J. Stubenrauch, and J. Pelon (2008), Upper tropospheric humidity and cirrus geometrical and optical thickness: Relationships inferred from 1 year of collocated AIRS and CALIPSO data, J. Geophys. Res., 113, D00A08, doi:10.1029/2008JD010012.

give some additional context to the vertical resolution problem, and also present climatologies of RHI for thin and thick cirrus as well as clear sky. Some of the lessons learned from these papers could apply to this work or to future applications by the authors if they fold in remote sensing data sets into their research.

Section 2

With regard to the radiosonde observations of temperature and water vapor, what are the effective vertical resolutions? Are they the same for temperature and water vapor? Are the measurements essentially instantaneous or do they have some 'time memory' that smoothes them in the vertical, perhaps differently for temperature than water vapor? If so, how does that affect the vertical structure of RHI from radiosondes? What about problems with horizontal advection as the balloon ascends? Will it smooth over horizontal features increasingly so with higher wind speeds, or are the ISSRs so thin that this does not matter? Some discussion of the radiosonde capabilities and sampling characteristics in the horizontal and vertical is warranted.

p. 2364, line 4: In the case of radiosondes (which is the focus of this work), it probably makes sense to simply average the RHI values. However, what about averaging the

temperature and water vapor individually and THEN calculate RHI? Which approach is more robust and justified, or do they yield the same results? Furthermore, going back to the Maddy and Barnet paper, you will see that this is probably not justified for satellite retrieval comparisons because the averaging kernels have a complex structure with height thus implying each point should not be weighted evenly.

p. 2364, line 20: 'relationship for each'

p., 2364, line 20 to p. 2365, line 7: There is no such need for complex language for something that is essentially quite simple. Please make it clearer to the reader. For instance, what is 'the ISS event indicator function'?

p. 2365 onwards: The authors may want to touch on the issue of skewness in the temperature, water vapor and RHI data from the radiosondes, and also the skewness in the derived frequency distributions of ISSRs. Quantifying skewness will explain why, for instance, if 50% of radiosonde points are ice supersaturated (and 50% are not), yet the average in the 50 hPa layer is supersaturated (skewed towards large positive RHI) or subsaturated (skewed towards smaller values of RHI).

Section 5

Do the authors have some physical insight as to why there is some inter-annual variability in the frequency of ISSRs with respect to RHI in the thicker layers? This behavior seems consistent between most of the stations (Fig. 6, 2006 has a less sharp S curve). The authors note that the radiosonde instruments used changed at this time, but could there be a physical reason? How does a change in the 'response time' affect the vertical resolution of the radiosonde observation? Why don't the authors use data from 2007 and onwards, which would provide additional insight on determining the cause of the change from either atmospheric processes or a possible instrument change?

Figure 9 is confusing because the same curves in the left column are repeated on the right. The only difference the reviewer could see is the addition of the two 100 hPa curves. Why not simply plot the right column?

p. 2368, lines 20-21: It is true that the tropopause is colder and drier, but that does not mean RHI is smaller. See, for instance, Kahn et al. (2009), or search for some UARS/Aura MLS papers on this.

p. 2371, lines 28-29: Have the authors used any of the high quality radiosonde data from the Atmospheric Radiation Measurement program (ARM) sites in the tropical western Pacific? Could be a nice contrast to the single tropical station shown here.

p. 2373, lines 12-14: Here the authors address skewness of RHI, could expand on with the other figures of ISSR frequency as a function of RHI.

Figure 4: Why not make a 2-d contour plot of the frequency? It would be much easier to see which combinations of RHI and ISSR frequency are the most/least populated.

Fig. 14: 250-300 and 200-250 colors are too similar, can't tell apart.

Could the authors elaborate a bit more on how this work could be used to parameterize contrail formation in climate models?

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 2357, 2010.