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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Quantifying the clear-sky temperature inversion frequency and strength over the Arctic Ocean during summer and winter seasons from AIRS profiles" *by* A. Devasthale et al.

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We would like to thank the referee for his thoughtful review and helpful comments. The point by point reply to the referee's comments is given below.

My first concern is with possible sampling effects (also brought up by the first reviewer), though I believe this is a minor concern and can be resolved with some careful book-keeping and careful wording of the text. The occurrence rates cited in this study are conditioned on at least three criteria. The first criterion is the AIRS quality flagging,

which reject a certain fraction of cases before they are averaged into the L3 products. Second is the requirement that cloud fraction be identically zero. Third is the definition of an inversion. The effect of each of these can (and should) be better stated in the manuscript. For example, what fraction of total AIRS observations do the PDFs in figure 3 represent if they are highest quality retrievals, stringently clear, and meet the criterion of a temperature inversion? This is a more representative measure of frequency that the fraction inversions in Level 3 data. That said, this a really minor point: it is difficult to imagine a serious sampling issue when the phenomenon of interest occurs 70-90% of the time. (Note that Gettelmen et al. (2006), The global distribution of supersaturation in the upper troposphere from the Atmospheric Infrared Sounder, J. Clim. used to AIRS data to describe supersaturation in 1% of the data.) The results shown in this study are some of the most robust I have seen in any AIRS study.

- The referee's concern regarding the sampling effects is duly noted. The three criteria that have influence on the occurrence rate are discussed below.

- 1) Since we have directly used Level 3 (L3) data, it is not possible for us to assess how the aggregation of L2 to L3 would have an impact on the occurrence rate. However, as the referee has rightly pointed out, for a phenomenon like inversion that occurs 70-90% of the time over the Arctic, the sampling of L2 data to L3 will not induce a serious bias.

- 2) Since we have focused only on clear-sky conditions, spatio-temporal variations in cloud cover would have an impact on the number of observations used for the analysis. This issue is also raised by the first referee. As we have pointed out before (in our reply to the first referee), we have actually highlighted this aspect in the Supplementary figure in original manuscript that shows the spatial pattern of the total number of AIRS profiles used for the analysis. It can be seen that the sampling pattern is not uniform, and the number of observations are high in winter (due to less cloudy conditions compared to summer). However, it is important to note that spatial patterns of inversion frequency and strength (Figs. 2 and 5) do not show footprints of such different sampling, thus hinting at the robustness of our results. About 10 to 40% of all AIRS profiles are used

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for the analysis. This number differs from region to region and month to month as it is influenced by cloud cover.

- 3) At each pressure level, we recursively search for the warmer temperature at lower pressure level above (up to 400 hPa), and if such condition occurs, we consider inversion to be present in the retrieved profile. This means that we include all types of inversions in our analysis (e.g. elevated, surface based, near isothermal situations in the lowermost troposphere etc).

-Additionally, there are two aspects that are worth mentioning here in support of the robustness of the large scale statistics derived from these L3 data; a) only good quality retrievals are used when aggregating L2 data into L3, and b) the sun-synchronous orbital configuration of Aqua satellite results into data being available from multiple orbits (14 per day) at very high latitudes, thus increasing the statistical significance of L3 averages.

Another concern is the use of descending and ascending as proxies for daytime and nighttime. A longer discussion of the diurnal sampling is needed. Using day and night instead of ascending and descending (or it the other way around?) is much easier on the reader unfamiliar with the Aqua orbit.

- We used terminologies “ascending/descending” instead of “day/night” because of the fact that, at very high latitudes, the sun is permanently above the horizon during the summer months and below during the winter months. Thus, the conventional definitions of “day/night” for “ascending/descending” passes of satellite do not hold true at these latitudes. We agree that more clear description of these aspects is needed for a reader unfamiliar with the Aqua orbit and is now provided in the revised manuscript.

Here are other comments: p. 2838, line 20. More discussion of diurnal effects is needed here.

- It is added in the revised text.

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p. 2838, line 25. The requirement of zero cloud fraction is a bit draconian. Figure 1 of Fetzer et al. (2004), Satellite remote sounding of atmospheric boundary layer temperature inversions over the subtropical eastern Pacific, JGR, shows that physically plausible inversion can occur in the AIRS data under visibly obvious cloud cover. The identically zero cloudiness requirement here could be increased to 10 or 30% cloud fraction without adding significant uncertainty. This should also increase the inversion occurrence rate.

- Please note that the focus of the present study is on quantifying the characteristics of inversions under clear sky conditions. Hence, we have used a stringent threshold of zero cloud fractions. In future, it will indeed be interesting to relax this threshold and investigate slightly cloud contaminated profiles. Our preliminary assessment suggests that when cloud cover criterion is relaxed to 10%, we additionally have about 8 to 17% profiles available for the analysis (depending upon the region and month in question). We will assess an accuracy of AIRS retrievals under such conditions (i.e. partly cloud covered) extending previous validation studies using in-situ data from the special campaign, Arctic Summer Cloud Ocean Study (ASCOS), which was carried out during Aug-Sep 2008 in the inner Arctic (more information here: http://www.ascos.se). The work for such evaluation will start soon next month. Once we analyse the results from such evaluation and bracket the potential bias under partly cloudy conditions specifically over the Arctic, we would expand our study further.

p. 2839, line 1 forward. Something should be said about the relative frequency of surface based versus elevated inversions, since they presumably form under different conditions. p. 2842, line 3 forward. This sentence is readable but runs on, and the 'also not expected' construct is unnecessarily complicated.

- Corrected.

p. 2843, line 2. The "was" can be deleted.

- Corrected.

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p. 2844, line 15. Delete “the” so it reads “in every AIRS profile.”

- Corrected.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 2835, 2010.