Atmos. Chem. Phys. Discuss., 10, C3383–C3388, 2010
www.atmos-chem-phys-discuss.net/10/C3383/2010/

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.

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Received and published: 31 May 2010

The authors would like to thank anonymous referee #2 for comments, the author responses are detailed below.

Comment 1 - The abstract seems a bit too long. I suggest to leave a large part of the first paragraph, approximately from line 6 to 12 to the introduction.

Response 1 - Agreed, the abstract is too long. The authors will shorten the abstract in-line with the referee's comments.

Comment 2 - Section 2.2, p. 2362 l.12 ff. I do not understand why the authors did not derive the tropopause altitude from the radiosonde data (i.e. the temperature profile) themselves, which is a straightforward task. This would significantly improve the anal-

ysis since the quality check that were carried out would be more robust and could also be applied for the tropics.

Response 2 – In terms of applying the sensor icing criteria a notional altitude was chosen (100hPa for mid-latitudes) above which RH values should be lower than 90%. This altitude was high enough to pick out those radiosondes which still showed large values of RH (>90%) in the lowermost stratosphere. When this criteria was fulfilled the humicap sensor was assumed to have experienced icing, and therefore these profiles were considered erroneous, and as such they were excluded from the analysis. In this section an accurate definition of the tropopause is not critical to the analysis because the notional sensor icing altitude was high enough to always be in the lowermost stratosphere. Given this it is suggested that references to a tropopause definition (in the sensor icing criteria only) are misleading, and the following text (from p.2362, Line 12 – p2363, Line 3) will be modified.

'An additional problem is that the RS80-H radiosondes are known to experience instrument sensor icing during some operations [Miloshevich et al., 2004]. This could occur if the radiosonde passed through either super–cooled liquid water (T < 0ËŽC) or an ice cloud. If this happened then ice formed on the sensor could remain even after the icing event, and as a result ice super-saturation could be measured for the remainder of the profile, even into the stratosphere [Miloshevich et al., 2004]. To detect such erroneous events, all RS80-H radiosonde profiles which had RH>90% above the tropopause were excluded from the analysis. In mid-latitudes, the tropopause is expected to be at pressures between 225 and 300 hPa, depending on season [Hoinka, 1998b], although three-sigma standard deviations from this mean suggested that the tropopause could be at pressures as low as 100 hPa. To ensure that only anomalous data were excluded, the sensor icing criterion was only applied for the parts of all radiosonde profiles below a pressure threshold of 100 hPa. In the tropics the tropopause can be at pressures below 100 hPa [Hoinka, 1998b], so that actual tropospheric ISS events below 100 hPa are feasible. Therefore, to mitigate the risk of removing genuine ISS events, the sensor icing criterion was not applied to any of the St. Helena radiosonde profiles. The RS92 radiosonde, in addition to improved calibration accuracy and faster sensor response time, eliminates sensor icing through alternately heated dual humidity sensors, which allows one sensor to be heated while the other makes the observation [Paukkunen, 1995]. Therefore, for the RS92, the application of a sensor icing criterion to observed profiles is unnecessary.'

The following text is now included on p2362, Line 12 – p2363, Line 3. 'An additional problem is that the RS80-H radiosondes are known to experience instrument sensor icing during some operations [Miloshevich et al., 2004]. This could occur if the radiosonde passed through either super–cooled liquid water (T < 0ĚŽC) or an ice cloud. If this happened then ice formed on the sensor could remain even after the icing event, and as a result ice super-saturation could be measured for the remainder of the profile, even into the lowermost stratosphere [Miloshevich et al., 2004]. To detect such erroneous events, all RS80-H radiosonde profiles which had RH>90% at high altitudes well into the lowermost stratosphere (the sensor icing criterion) were excluded from the analysis. To ensure that only anomalous data were excluded, the sensor icing criterion was applied to mid-latitude radiosonde profiles below a pressure threshold of 100hPa. This altitude threshold is high enough (in mid-latitudes) to identify erroneous radiosonde profiles because mid-latitude tropopause altitudes have been shown to be at a mean altitude of 225-300hPa and with three-sigma standard deviations from this mean of around 100hPa [Hoinka, 1998b] In the tropics the tropopause altitude can be at pressures below 100hPa and, therefore, to mitigate the risk of removing genuine ISS events, the sensor icing criterion was not applied to any St. Helena radiosonde profiles. For all observations made with the RS92 instrument the application of the sensor icing criterion is unnecessary. This is because, in addition to improved calibration accuracy and faster sensor response time, the RS92 eliminates sensor icing through alternately heated dual humidity sensors, which allows one sensor to be heated while the other makes the observation [Paukkunen, 1995].

In this paper the most important use of a tropopause height definition (derived from radiosonde observed temperatures) was the identification of the tropopause within pressure layers (50hPa and 100hPa). This was achieved (as stated in section 3 of the paper) by identifying those pressure layers which have only a negative lapse rate throughout (i.e. are fully within the troposphere). Pressure layers including a positive lapse rate where assumed to include the tropopause and were excluded from the analysis. This means that radiosonde temperature data was used to account for the tropopause height. It is suggested that the text in section 3 sufficiently describes this.

Comment 3 - Section 5.3, p. 2370 line 2: It is not quite clear to which entity the figures are related to.

Response 3 – To clarify this, the following text will be modified:

'The occurrence frequency of ice super-saturation shows a seasonal signal. During the winter 15–25% of radiosonde observations are ISS and in the summer 5–15% are ice super-saturated (Radel and Shine, 2007). Therefore, it is expected that the s-shaped curve will be influenced by season.'

The new text is the following:

'Radel and Shine (2007) showed (using standard resolution radiosonde data) that during the winter 15-25% of RHi observations showed ice supersaturation and during the summer 5-15% of RHi observations were ice supersaturated. Given this, it is expected that the s-shaped curve will be influenced by season.'

Comment 4 - Section 5.4, p.2371, l.13: The tropics are generally defined as the region between the tropic of cancer (23.4_N) and the tropic of capricorn (23.4_S). I suggest to use these figures instead of -30_ to 30_.

Response 4- Agreed, this correction will be made.

Comment 5 - Climatologically, things are more complicated since the border between tropical and arid zones are not at a constant latitude. This is of particular importance with regard to the discussion of the data from St. Helena, since there is a large number of observations suggesting that the frequency of occurrence of ice clouds and ISSR in the tropical tropopause layer is particularly high (e.g. Winker Trepte, GRL, 1998, 25, 3351-3354, Sandor et al. GRL, 2000, 27, 2645-2648, Immler, et al. J. Geophys. Res., 2007, 112, D03209) in contrast to the results reported in the current paper.

Response 5 – Agreed. Please see response from comment 6.

Comment 6 - It would be interesting to know whether this is because St. Helena's climate is dominated by subsidence (arid climate zone) and is therefore low in water vapor up to the tropopause, or whether this is a problem of the radiosonde data or the analysis algorithms. In the first case the paper would greatly benefit if data from a truly tropical station was used. In any case the authors should be more cautions with the conclusion that the derived S-shaped function is applicable for all climatic regions.

Response 6 – The tropics are not a homogeneous region with respect to the occurrence frequency of ice supersaturation, for instance as shown by the MLS derived maps in Spichtinger et al. (2003). There it is shown that St Helena is in a region where ice supersaturation is very rare on 215hPa (less than 2% frequency of occurrence) and rare (less than 10%) on 147 hPa, with strong seasonal variations. At least on the 215hPa level it looks as if St Helena is dominated by subsidence. With only one tropical station used in the study presented in this paper any conclusions regarding the applicability of the s-function to every climate zone should be made with caution. Importantly, St. Helena has no clear counterexample, and in order to confirm the findings from St Helena presented in this paper further analysis using more tropical radiosonde data is recommended. This is also in line with comments by (and responses to) referee #1, where the US ARM TWP site is mentioned as an example.

The following text is suggested in section 5.4, line 18:

'The findings from this tropical analysis should be treated with caution because St Helena has no clear counterexample, and in order to confirm these findings further

analysis using other tropical radiosonde datasets is recommended.'

This will also be included in the conclusions along with the response to comment 10 by referee #1 (regarding recommendations of further use of tropical radiosonde data)

Comment 7 - Fig. 9 2nd line: replace '(' with 'in '

Response 7 - This correction will be made.

Reference (to be included in the paper)

Spichtinger, P., K. Gierens, W. Read, 2003: The global distribution of ice-supersaturated regions as seen by the Microwave Limb Sounder. Q. J. R. Meteorol. Soc., 129, 3391-3410.

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