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Atmospheric Measurement Techniques
Discussions

Interactive comment on "Characteristics of tropopause parameters as observed with GPS radio occultation" *by* T. Rieckh et al.

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We thank the referee for the review and the helpful and constructive comments. We will implement the following changes according to the referee's suggestions. We have answered all comments below (for easier comparison the referee comments are included in italic).

1. Page 4696, lines 14–15: *After my knowledge the first RO-tropopause study was from Nishida et al. (2000) using GPS/MET data.*
   Thank you for this input, we will change the sentence to: “First studies using GPS RO data for tropopause determination have been conducted by *Nishida et al.* (2000), *Randel et al.* (2003), and *Schmidt et al.* (2004) for the tropical region.”

2. Page 4698, lines 1–10: *The authors should describe on which vertical grid the temperature profiles are interpolated.*
   Before applying the algorithm the profiles are interpolated to a 20 m grid, using spline interpolation that passes through all initially given data points.

   We will include the following sentence at page 4699: “Before applying the algorithm the profiles are interpolated to a 20 m grid using spline interpolation.”

3. Page 4698: *Tropopause algorithm: Here the authors must give more details. The WMO (lapse rate) tropopause definition is very simple, but the application to high vertical resolution datasets (as RO) is not straightforward. How are outliers handled within the 2 km interval? A discussion of these features and an according tropopause algorithm can be found in Birner (2006) for radiosonde data that could be also applied for RO data.*
   Within the RO processing chain, WEGC performs several quality checks to remove outlier profiles. These quality checks, which are described in detail in *Schwärz et al.* (2013), comprise bending angle, refractivity, and temperature profiles. Furthermore, RO data processing from raw measurements to temperature profiles includes two integrals: the Abel integral from bending angle to refractivity and the hydrostatic integral from density to pressure. Due to these integrals, atmospheric information is vertically correlated and outliers usually do not occur. Thus the algorithm can simply be applied to the profiles without further restrictions (apart from water vapor variations in the lowermost couple of kilometers, which is discussed in the paper).

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On page 4697, line 25 we will write: "...we use quality controlled atmospheric profiles ..."

4. Page 4698: *Tropopause algorithm: How is the lower bound of the tropopause height defined exactly? Son et al. (2011) e.g., define this altitude also latitude dependent using the relation* $\text{TPH}_{\text{min}} = 7.5 + 2.5 * \cos(2 * latitude)$*. Beside the definition of the upper and lower bound on the basis of heights I would recommend a definition by pressure, e.g. searching a tropopause between 500 hPa and 70 hPa.*
   We found that the algorithm proposed by *Son et al.* (2011) cuts off many profiles well above the tropopause in some regions. This problem frequently occurs close to the subtropical jet in winter and results from the sharp transition of tropical to extra-tropical tropopause characteristics. While *Son et al.* (2011) cut off profiles at approximately 9 km at subtropical latitudes, Fig. 3 of the AMTD manuscript clearly reveals that many tropopauses occur well below 9 km.

   Thus we developed an empirical algorithm, which is based on the comparison of tropopauses altitudes from dry RO temperature profiles (which include water vapor variations) and from physical RO temperature profiles (which do not include water vapor variations). Based on this analysis we identified lower bounds for every 10° latitude band and every season. Detailed information of these lower bounds can be found in *Rieckh* (2013). We will also include this information in the manuscript.

   Concerning the use of pressure levels, we do not think that this will have an additional effect as potential tropopauses at pressures greater than 500 hPa do not occur due to the altitude restriction anyway.

5. Page 4698: *Tropopause algorithm: Another detail in lapse rate tropopause determination is the vertical resolution of the used dataset. Supposing a 100 m vertical grid and applying the WMO definition gives the tropopause height at the*

lowest level where the condition is fulfilled, that means only on the according sampling point. But the lapse rate tropopause could be also between this level and the level below (see also Birner, 2006 or the tropopause algorithm from Reichler et al., 2003). Both tropopause algorithms consider this and define the tropopause level at the intersection between the temperature profile from above and below the possible tropopause height(by consideration of a useful number of data points)

We applied a spline interpolation on a 20 m grid to avoid finding a spurious tropopause on the original grid level (see item 2). The algorithm searches tropopauses on the interpolated spline function.

6. Page 4698: *Tropopause algorithm: Why did the authors only search for three tropopauses? The so-called "second" tropopause in this context should be the last tropopause in the according height range. This is also the general definition in the literature.*

   Since we do not use third tropopauses in this work, will change the sentence on Page 4699, lines 10–11 to: "Furthermore, we restrict the algorithm to a top altitude of 22 km."

References

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Interactive comment on Atmos. Meas. Tech. Discuss., 7, 4693, 2014.