Atmos. Chem. Phys. Discuss.,
doi:10.5194/acp-2016-576-AC2, 2016

Atmospheric Chemistry and Physics
Open Access
EGU
Discussions

ACPD

Interactive comment

Interactive comment on "Tropical temperature variability and Kelvin wave activity in the UTLS from GPS RO measurements" *by* Barbara Scherllin-Pirscher et al.

Barbara Scherllin-Pirscher et al.

barbara.pirscher@uni-graz.at

Received and published: 26 October 2016

We thank the reviewer for the review and his/her helpful and constructive comments which we fully took into account in the revision of the paper. Please see our detailed response below (the original remarks of the referee are in italics).

General comments

1. *The authors use the phrase "high frequency" throughout the manuscript which they define (Section 2.3) as those waves with periods shorter than 100 days. This*

is quite misleading given the usual definition of "high frequency" waves refers to gravity waves, or perhaps, waves irresolvable in your data binning . Kelvin waves and gravity waves are known to drive the QBO, thus you should change this phrase to "Kelvin-wave band" or "monthly – seasonal band" or similar. And then your "low frequency" band could be referred to as "seasonal" or similar. Please change notation in Figures to reflect these changes in terminology too.

Thanks for pointing at this miswording! We agree with the reviewer and will replace "high-frequency" variability by "sub-seasonal" variability in the entire manuscript (text and figures). Since "low-frequency" variability does not only include to "seasonal" variability but also inter-annual variability, we will not change this notation.

2. *Usually upon using the Hayashi (1971) space-time spectral analysis method, authors retain Kelvin wave information in wavenumber-frequency space based on equivalent depths derived from Matsuno's (1966) shallow water equations. For example, see Wheeler & Kiladis (JAS 1999) for OLR and Ern et al. (ACP, 2008) for SABER and ECMWF temperatures in the stratosphere. Some comments on why a simple $k = 1$,2 and $7 < T < 30$ day periods filter is chosen in this manuscript is necessary. Also note that the wavenumber-frequency spectrum will change between the troposphere and stratosphere. Specifically, the spectrum will move to peak at higher frequencies in the stratosphere because higher frequency Kelvin waves propagate into the stratosphere more easily. Please investigate and discuss the wavenumber-frequency results at higher & lower altitude to confirm the validity of your filter limits and/or consider using equivalent depth filters instead.*

   We thank the referee for highlighting this important issue. We reassessed the definition of atmospheric Kelvin waves and decided to filter Kelvin waves with wavenumbers $k = +1$ to $+6$ and periods from 4 to 30 days. These filter widths are determined by our sampling strategy as well as by the spatial resolution of our daily-mean fields. Furthermore, we will follow Kim and Son (2012) and filter equivalent depths from 8 m to 240 m. Our new filter will be able to also capture local enhancements of Kelvin wave power, which is of particular importance in the tropical tropopause layer. We will replot Fig. 1 (where we will include maximum and minimum equivalent depths of 8 m and 240 m, respectively, and use logarithmic contour intervals instead of linear ones) as well as Fig. 2b, Fig. 5c, and Fig. 6 to Fig. 10.

In the manuscript, we will add the following sentence in Sect. 2.3:

We isolate Kelvin wave activity by selecting wavenumbers $k = +1$ to +6, periods from 4 to 30 days, and equivalent depths from 8 m to 240 m.

3. *Figure 2a: What role might the lapse-rate tropopause gradient play in the zonal anomalies shown here? That is, are you confident that you are removing all effects of the tropopause itself from this anomaly plot? I wonder in Figure 4b how or if the sharpness of the tropopause might influence these mean annual cycles of temperature anomalies – noting that the maximum positive and negative anomalies are right on the tropopause altitude? Do these maximum anomalies change in altitude following the seasonal cycle of tropopause altitude itself?*

   We agree with the reviewer. There could be some effect of temperature variability due to the seasonal cycle of tropopause characteristics. Figs. 4b,c, which show the vertical structure of seasonal temperature anomalies, reveal, however, that the amplitude of DJF anomalies is notably larger than that in JJA. Furthermore, the seasonality shown in Fig. 4b is still distinctive even if we follow tropopause-relative coordinates.

   We also tested the possible influence of the change in tropopause altitude on Kelvin wave activity by comparing temperature anomalies in altitude coordinates and tropopause-relative coordinates. We find that temporal variability of Kelvin wave variance at the cold-point tropopause is in very good agreement with vari-

Printer-friendly version

Discussion paper

ability at 17 km. Furthermore, Kelvin wave variance 2 km above the cold-point tropopause is very similar to Kelvin wave variance at 19 km. Therefore, the change of tropopause altitude seems to have minor effect. We will include both timeseries of Kelvin wave activity at cold-point tropopause and 2 km above as new Fig. 9 in the manuscript and will add a discussion in Sect. 3.3:

To assess whether this temporal variability should be attributed to temporal variations of the tropopause rather than to Kelvin wave activity itself, we calculated Kelvin wave variance in cold-point tropopause coordinates. Figure 9 shows results at the cold-point tropopause and two kilometers above. Comparison to Fig. 8 shows very similar temporal evolutions. The time series at the tropopause and 2 km above (Fig. 9) are virtually similar to those at 17 km and 19 km in altitude coordinate (Fig. 8), respectively. Again, no clear periodicity of Kelvin wave activity can be found.

Minor comments

1. *P7 line 20: What are you defining as "high frequency" here?* .

   "High-frequency" amplitude variations were meant to be temporal variations in the waves' amplitude.

   We will rewrite this sentence to make it more clear. It will read:

   Kelvin wave variance in Fig. 7a shows temporal variations in the waves' amplitude that are strongly modulated by the QBO, with enhanced wave activity in periods of transition from easterly to westerly stratospheric wind (westerly shear zones).

2. *Figure 3: Worth noting that W=westerly, E=easterly to avoid confusion between westerly/westward.*

Printer-friendly version

Discussion paper

We assume that the referee refers to Figure 5, where we will add in the figure caption:

E and W in the top panel refer to easterly and westerly wind.

3. *Figure 10: Replot the boxes on top of the green, red, blue lines as it's not well presented at the moment.*

   Since different colors were chosen subjectively, we will remove red and blue lines in this figure (remark of reviewer 1). In order to indicate peaks in Kelvin wave variance outside of one standard deviation, we will only plot green lines. We will plot boxes on top of these green lines.

Technical corrections, grammar, etc.

1. *P2, Line 10: "were theorised by Matsuno"*—done
2. *P2, Line 16: "important role in the stratosphere – "*—done
3. *P3, line 13: "Due to the RO measurement"*—done
4. *P3, line 16 & 17: change "are" to "were"*—done
5. *P3, line 24: "information on convection"*—done
6. *P3, line 27: "vertically-resolved"*—done
7. *P4, line 18 "Gaussian filter (with. . . "*—done
8. *P8, line 4 & 5: Boreal or austral spring 2003 & 2004?*—in boreal spring. We added "boreal" in these sentences.
9. *P9 line 6 "these data ideal for characterizing"*—done

References

J. Kim and S.-W. Son. Tropical cold-point tropopause: Climatology, seasonal cycle, and intraseasonal variability derived from COSMIC GPS radio occultation measurements. *J. Climate*, 25(15):5343–5360, doi:10.1175/JCLI-D-11-00554.1, 2012.

Interactive comment on Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-576, 2016.