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Atmospheric Measurement Techniques Discussions

Interactive comment on "An intercomparison of stratospheric gravity wave potential energy densities from METOP GPS-radio occultation measurements and ECMWF model data" *by* Markus Rapp et al.

Anonymous Referee #1

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This paper investigates whether the data set of METOP GPS radio occultations can be used for the analysis of gravity waves. Gravity wave potential energy derived from the radio occultations is compared to ECMWF IFS and ERA-Interim data. Qualitatively, good agreement is found for global distributions. Some shortcomings are discussed. For example, enhancements in the lower stratosphere in the tropics are attributed to effects of the tropopause, and a correction method for monthly averaged data is proposed. Comparison to gravity wave observations by lidar shows good correspondence in temporal variations. However, potential energies seen by lidar are higher by a factor

of two, which is explained by the better sensitivity of lidars for gravity waves of short horizontal wavelengths.

Overall, the paper shows that METOP GPS-radio occultations are a promising data set for gravity wave analysis. The paper is very well written, and publication in AMT is recommended after addressing my minor comments.

My main comment is that some more discussion is needed regarding the separation of temperature altitude profiles into background and temperature fluctuations due to gravity waves. The selected method is a vertical filter with cutoff at 15km vertical wavelength. The main idea is that all variations with wavelengths shorter than 15km are assumed to be gravity waves. This, however, is not stated clearly enough, and the pros and cons of this approach should be briefly discussed as detailed in my specific comments.

For specific and technical comments see below.

SPECIFIC COMMENTS:

(1) about Sect. 2.2: Please clarify that the spatial resolution mentioned in this section corresponds to the horizontal grid spacing. Atmospheric waves that are resolved by these data sets have scales that are considerably longer. According to Skamarock (2004) only scales exceeding the grid spacing by several times are resolved.

Skamarock, W. C.: Evaluating Mesoscale NWP Models Using Kinetic Energy Spectra, Mon. Wea. Rev., 132, 3019-3032, 2004.

(2) p.5, l.12, Sect. 2.3 Here, you call the reduced scatter of RO-wet temperatures a reduced "uncertainty range". Is this justified, or are RO-wet temperatures too smooth?

Above 30km RO-wet temperatures show a reduced scatter with respect to ECMWF IFS. However, at these altitudes the influence of a priori data should be increasing, and it is known that at high altitudes ECMWF is known to suffer from hyper-diffusion. Could it therefore happen that temperature fluctuations are suppressed in RO-wet temperatures because of an increasing influence of relatively smooth a priori data?

(3) p.5, l.28 The idea behind using a Butterworth filter should be stated more clearly, and shortcomings mentioned.

As far as I understand, variations in the vertical with scales longer than 15km are assumed to be the "background" (climatological structure plus planetary waves), while shorter scales are assumed to be fluctuations due to atmospheric gravity waves. This separation of scales will work well with a few exceptions. One exception is the tropopause region, which has been discussed in detail in the current paper. Another exception is the tropical stratosphere. While vertical wavelengths of planetary waves in the extratropics are quite long, this is different in the tropics where Kelvin waves usually have vertical wavelengths that are comparable to those of gravity waves. See also (5).

(4) p.5, l.28 Please mention that the use of the Butterworth filter in vertical direction has the advantage of being applicable in the same manner to all data sets considered, thus allowing a fair comparison.

(5) p.6 l.10-14 Epot close to the equator will be high-biased due to Kelvin waves

Kelvin waves in the tropics can have quite short vertical wavelengths, comparable to those of gravity waves. Kelvin waves can have considerable temperature variances of a few K^2 on zonal average, and corresponding zonal average values of Epot could easily reach values of around 5 J/kg, which is non-negligible. This is particularly important because Fig.6 represents a case of tropical easterlies. Under these conditions the amplitudes of Kelvin waves will be amplified.

A climatology Kelvin waves in the tropical stratosphere is given, for example, in Ern et al. (2008)

Ern, M., Preusse, P., Krebsbach, M., Mlynczak, M. G., and Russell III, J. M.: Equatorial wave analysis from SABER and ECMWF temperatures, Atmos. Chem. Phys., 8, 845-869, 2008.

(6) p.9, about the Epot correction Do you think that monthly average temperatures are sufficient for deriving a correction, as proposed? Or may there be changes in the background on shorter time scales that would require averaging over shorter time intervals? Of course, this may be beyond the scope of the current paper, but should be carefully considered before making this correction operational.

see also p.11, l.16+17

(7) p.11, l.22 Please include the information that Kelvin waves could produce a high-bias of Epot in the tropics.

TECHNICAL COMMENTS:

p.2, l.7 GW are a major means to couple the -> GW are an important mechanism that couples the

p.2, l.30 please correct: ECMWF = "European Centre for Medium-Range Weather Forecasts"

Fig.1a Is the red dot at 90N an artifact, or is this a real accumulation of ROs?

p.3, l.18 The expression in parentheses is confusing; suggestion

a corresponding gridding (i.e., 36 $\times$ 36 5deg latitude $\times$ 10deg longitude bins) -> a corresponding gridding of 36 x 36 grid points (i.e., 5deg latitude $\times$ 10deg longitude bins)

p.4, l.8 Please check whether it is correct that T1279 corresponds to a horizontal resolution of 8km

To my knowledge, the ECMWF grid uses 2560 points at the equator, corresponding to 15km grid spacing. The numbers of T255/80km that given for ERA-Interim should however be correct.

p.4, l.12 from -> starting from

p.7, l.23 wavelengths if the phase fronts are perpendicular to the line of sight, -> wavelengths than is the case if the phase fronts are perpendicular to the line of sight,

p.8, l.33 cleat -> clear

p.13, l.33 stratopsphere -> stratosphere

p.13, l.34: Ern et al., 2016 -> Ern et al., 2017

p.14, l.12: LOVE -> Love ??

p.14, l.15 Hei, H., T., T. T., and Hirooka: -> Hei, H., Tsuda, T., and Hirooka, T.:

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