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Atmospheric Chemistry and Physics Discussions

Interactive comment on "First continuous ground-based observations of long period oscillations in strato-/mesospheric wind profiles" *by* R. Rüfenacht et al.

Anonymous Referee #1

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The paper describes the oscillating modes of the middle atmospheric flow as measured with the ground based radiometer WIRA at different latitudes. Such observations are important since the instrument is sensitive to the altitude range 5 hPa to 0.03 hPa where few observations exist and none on a routinely basis. To my knowledge, WIRA is the first ground-based microwave radiometer designed for wind measurements and provide good quality data described in previous papers. It is the complement to the upper atmospheric observations derived from radar systems. The analysis presented in this manuscript shows the detection of well known atmospheric oscillation modes with periods near 5, 10, 16, and 25-50 days. The quasi-2day oscillations and the tidal oscillations are not detected because of the data daily sampling used in the spectral

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analysis. The results are a good demonstration of what can be done with this new system.

The manuscript presents important results that should be published but I think the discussion is too short to match ACP journal requirements. Therefore, I would recommend minor changes before publication. My main concerns are:

1) There are extensive theoretical and experimental studies related to the observed oscillations and their connections with atmospheric waves or atmospheric states. The reference to previous works is not enough. The main oscillation characteristics derived from the WIRA observations (latitudinal and seasonal variations, period variability, life time) should be compared with those from previous studies. I can not really figure out if WIRA observations are in agreement with what it is supposed to be known. Also they are some features in the plots that are not mentioned.

2) The impacts of the characteristics of the measurements and of the periodogram (spectral features broadening, time resolution of the periods, measurement vertical resolution, possible spectral artifacts) are not sufficiently taken into account in the discussion. - The spectral features seen in the periodogram are broadened by the analysis because of the limited lifetime of the oscillations ($\sim$30 days?) and of the spectral window (3T). For instance, the spectral broadening for a long-period oscillation (T>20 days) should be large (Delta_T >10 days, FWHM). - The vertical wavelengths of the waves associated with some of the stratospheric oscillations are similar to the retrieval vertical resolution. The latter may have a significant impact on the results. - I believe that some spectral features discussed in the manuscript can be artifacts. If I am right, their interpretation has to be presented with more cautions.

I think these comments are minor since they are simply a demand for more information and do not require any modifications of the data analysis presented in the manuscript. The details are given in the specific comments section herebelow.

Specific comments

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P35038, L11: Is the vertical resolution derived from the FWHM of the averaging kernels as explained in Rüfenacht2014? If yes I would expect such estimation to underestimate the actual vertical resolution because of the strong asymmetric shape of the averaging kernels and the presence of negative lobs. Should a better estimation of the retrieval vertical resolution be used?

The wind averaging kernels depends on the O3 abundance and tropospheric conditions. I am wondering if the change of the averaging kernels due to the seasonal change of these parameters may have enough impact on the retrieved wind profiles to make a spectral signature in the results?

P35039, L15: Why the authors use percentage to express the differences? I think it is better to express the differences between ECMWF and WIRA in term of velocity (m/s). For instance, the differences between the observations and ECMWF are expected to be larger in the Tropics (Reunion) than at higher latitudes (other stations) though the stratospheric wind mean velocity is smaller above la Reunion. Also it is interesting to compare the differences with the measurement errors which do not depend on the wind velocity.

Is the statement "mesospheric zonal wind overestimated by the model ... " derived from Fig18 in Rüfenacht et al., 2014? If yes, it should be indicated that it is applicable to only mid/high latitudes sites and not for La Reunion (not given in Fig18). Note that wind measurements with JEM/SMILES (Baron et al., 2013, cited in the Supplements) clearly show a large underestimation of ECMWF forecast in the Tropical mesosphere. The data also shows the overestimation at higher latitudes such as that reported in Rüfenacht et al., 2014.

P35040, L1: Why a width of 3T ? How does the width of the window compare to the expected lifetime of the oscillations? The spectral broadening of the spectral features induced by to the size of the window and of the oscillation life time should be discussed. I think it is relatively large (periods of 30 days are spread over a 10-20 days period-

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range depending on the oscillation lifetime) and should be taken into account in the discussion of the results. (see the supplement file uploaded with my report)

P35040, L10: add “s” to “more detail”

P35042, L09: The Figures S2 and S3 should be added to the main manuscript. They should be used to discussed the impacts of the retrieval vertical resolution and missing data in the periodogram. For instance, the 5 days oscillation in the Meridional wind above Provence (Fig 3, mid-stratosphere) is strongly reduced in the unaltered ECMWF data (S2). Is the Fig3 spectral feature an artifact due to missing data? If yes, this should also be the case of the measured one (Fig2)? The mesospheric 10day oscillation in the Provence meridional wind (S2) vanishes in Fig3. Is it due to the measurement vertical resolution? I am surprised to see that in general upper stratosphere and mesospheric oscillations are much stronger in Fig3 than in S2. Altering the data should decrease the oscillation amplitude?

P35042,L16: “seasonal averages” means that all seasons are averaged which is not the case since the mean periodogram is more representative of winter conditions.

P35042,L21: The 50day period is also a systematic feature in the results. I would expand the period range to 20–50 days and indicate that 50 days is the upper limit of the period estimation.

P35042,L23: The limitations due to the spectral analysis and measurement characteristics should be taken into account in the discussion of the quasi 30day oscillations. For instance separate modes such as 30day and 50day periods may overlap because of the spectral broadening and be seen as single “blob” with period ranging from 20 to above 50 days (except for the zonal wind above Provence).

P35043,L5: The discussion about the long oscillations is too short. There are clear features in Fig2 that are not mentioned. Mid-latitude oscillations between 20-35 days seems to expand from the mid-stratosphere to the top of the retrieval range (mid/upper

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mesosphere) while the oscillations larger than 35/40 m/s are blocked at ∼0.02 hPa. At high latitudes, the oscillation is predominant in the lower mesosphere with a period very close to 27 days but it is not seen in the stratosphere. Are these behaviors compatible with what it is expected? More references about studies on 27day oscillation and more generally those describing periods between 20 and 50 days should be provided (the one provided in the manuscript is not enough). (e.g, Huang et al., observational evidence of quasi-27-day oscillation propagating from the lower atmosphere to the mesosphere over 20N, Ann. Geophys., 33, 1321-1330, 20, 2015, Fedulina et al., Seasonal, interannual and short-term variability of planetary waves in Met Office stratospheric assimilated fields, Q. J. R. Meteorol. Soc., 2004).

P35043, L13-15: The 5-day oscillation of the meridional wind above la Reunion is more significant (alpha near 0.01, white contour) than above Provence (alpha > 0.1, grey contour). Is alpha > 0.1 a reliable value? Can we trust a large peak but with low significance?

P35043, L16: Over la Reunion, the zonal wind oscillations with periods larger than 10 days vanished in the mesosphere. Is-it expected based on other radar and satellite measurements or is-it a lack of measurement sensitivity/resolution that could explain the oscillations decrease?

Similarly, Day et al. 2012 (cited in the manuscript) clearly shows a 16-day signal in winter mid-latitude at high altitudes. In Fig.2, above Bern and Provence, the 16day oscillation signal strongly decreases at 0.1 hPa and increase slightly again at the top of the retrieval range. I have the same questions as previously for La Reunion site.

My general feeling on this section is that the behaviors of the 5/10/16day periods should be described in more detailed and, their main characteristics should be compared with previous studies in the middle and upper atmosphere.

P35043, L24: This result is compatible with other measurements and theoretical studies. Previous works should be cited. (e.g., Fedulina et al., Seasonal, interannual and

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short-term variability of planetary waves in Met Office stratospheric assimilated fields, Q. J. R. Meteorol. Soc., 2004, ...).

P35044, L6-10: As already mentioned, the comparison with results from other observations should be improved.

P35045, L20: The interpretation of the spectral features is too fast (I don't say wrong). The period variation (35-25 days) is in the same order that the spectral broadening (period resolution (FWHM) is ∼10-20 days for a period of 30 days). The effect has to be taken into account in the discussion.

P35045, L24: The 16day period is too quickly attributed to atmospheric wave. The period resolution has to be taken into account (as stated in my previous comment). Also the 16day oscillation signature can be reproduced as an artifact at the beginning and the end of a long-period monochromatic oscillation event. The authors should check if such artifacts can explain the spectral signature seen in their observations. (see the supplement file I uploaded with my report).

P35046, L1: Note that if the 16day spectral features are artifacts, they are still a good indication of the beginning and termination of the long-period oscillation event. A value of the measured oscillation lifetime should be provided for Bern and La Reunion (it is difficult to infer it from the plots) and compared with other studies.

P35046, L21-26: "... extra long period (20-40 days)" → (20-50 days) P35046, L26: The 16day spectral feature might be described with cautions if the authors agree with my comment in the previous section.

Supplement TextS1, second paragraph: HRDI has also measured wind in the stratosphere over a long period (∼10 years). The observations started from ∼30 km (e.g., Ortland D. A, Rossby wave propagation into the tropical stratosphere observed by the High Resolution Doppler Image, GRL, 24, 16, 1997)

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Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/15/C11896/2016/acpd-15-C11896-2016-supplement.pdf

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