Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2017-350-RC1, 2017


Atmospheric Measurement Techniques Discussions
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# *Interactive comment on* "Derivation of horizontal and vertical wavelengths using a scanning OH(3-1) airglow spectrometer" *by* Sabine Wüst et al.

**Anonymous Referee #1**

Received and published: 3 November 2017

We would like to thank the anonymous referee for his valuable comments. We tried to include them all. Please find our comments below.

Due to the comments of all three reviewers, I made the following general changes in the manuscript:

- The calculation of the vertical wavelengths from SABER data was limited to one wavelength for each profile in the range of the vertical wavelength derived from GRIPS +/- the error. As I re-calculated the approximation for the height range 70–90 km (instead of 60–80 km) for comparison reasons, I found out that the original approach

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might deliver not the best results. The SABER profiles show two to three waves. If I restrict the adaption to one more or less specific oscillation, which might not be the dominant one, the harmonic analysis provides a kind of compromise between both waves. Therefore, I provided less restrictions to the harmonic analysis: it searched for two oscillations with a wavelengths between 2.5 km (minimal vertical wavelengths detectable in SABER measurements according to Trinh et al., 2015) and 20 km (height interval length) and I used the one which fits better to the GRIPS vertical wavelength. Applying this approach, the difference between the vertical wavelengths derived from both approaches halves.

- When adding additional information to former table 2, I found out, that I included one wave with a rather long wavelength (33 km) in the subsequent analysis. This is not consistent with the exclusion of waves with vertical wavelengths longer than 20 km. Therefore, I corrected it.
- I used the Brunt-Vaisala frequency calculated directly from the SABER profiles

These leads to different figures compared to the previous version. However, the main message of the paper does not change.

This manuscript describes the investigation of medium and long period gravity waves (GWs) observed at mesospheric altitude using a spectrometer instrument. Though this instrument only measures temperature variations within a limited field-of-view, it is possible to assess GW horizontal parameters by looking in 3 or 4 different directions. This technique has been previously published. The authors analysed 22 nights of data obtained from a mid-latitude site between July and November 2015. Using meteor wind radar data, they calculated the vertical wavelengths and compared their results with SABER observations. This paper is clear and well-written, nevertheless, I would suggest that the authors address the following comments:

- The title should be changed to: "Derivation of mesospheric gravity waves horizontal and vertical wavelengths using..." Done.

- The error on the very long horizontal wavelengths must be really large. Wachter et al., 2015 give Lx up to ~1300 km and obtain already large uncertainties. I don't think val- ues >1500 km make any sense. You should limit your study to the events with Lx<1500 km.

Wavelengths larger than 1500 km are only addressed in three cases (2x1801 km, 1x2054 km). Therefore, their effect on the mean values is not very large. The errors are approximately 420 km and 580 km (ca. 20–30%) in these cases.

I checked the analyses results; the mentioned cases do not produce outliers and the large error bars are taken into account for the calculation of the error bar of the vertical wavelength. Therefore, I included your suggestion as follows: in the text, I provided the (mean) results for waves with horizontal wavelengths of 1500 km at maximum, the (mean) values including all events are given in brackets, if they disagree. In the figures, the values referring to waves with horizontal wavelengths larger than 1500 km are marked in light grey.

- Many papers using airglow imagers to measure medium scale GWs are not mentioned in this paper: Takahashi et al., 2009; Paulino et al., 2011; 2012; Suzuki et al., 2013; Liu et al., 2015. Chen et al., 2013, and 2016 also investigated mesospheric large scale waves or inertial GWs using Fe lidar and radar data. The authors might



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not cite all these references (some of them only concern individual cases), but at least they should be aware of them. Thank you for this hint. I included the ones which use a larger data basis (Paulino et al., 2011 and Che et al., 2016).

- What is the largest time difference between SABER measurements and GRIPS measurements? The GRIPS measurements are performed during night, therefore the use of SABER data is limited to nightly satellite overpasses. The exact times are given in table 1 (former table 2). The length of a GRIPS measurement depends on the length of the night and therefore on the day of the year and on the meteorological conditions. In our study, we only used nights with a very good signal to noise ratio (in order to identify the phase shift properly) with 7 h measurement time at minimum. The SABER measurements took place while GRIPS measured.

- Maybe you should have an extra figure to show the geometry of the observations. Something similar to Wachter et al., Figure 1, but for the configuration used in this study. I inserted such a figure as new figure 1 and changed the text in section 2.1 slightly (description of GRIPS).

- Table 2 should include the other parameters: Lh and c (and maybe also direction of propagation and wind speed in the GW direction).

I included two further parameters, horizontal wavelength derived by GRIPS and vertical wavelength derived by SABER. I provided exclusively these two in order to keep it clear. However, they can be used for the derivation of additional information like the phase velocity.

Minor points:

p. 1:

l. 18: mesopause level or altitude Done

l. 20: frequencies Done

l. 21: remove "afterwards" Done

l. 22: ...Oberpfaffenhofen, by a meteor radar. Done

p. 2:

l. 2: "is observed" or "is monitored" instead of "is addressed" I took “studied”, it was the proposition of another reviewer whose corrections I read earlier.

l. 9: something wrong with this sentence Corrected

l. 14: a few 100s km Done

l. 15: of a few 10s km Done

l. 31: constructed Done

p. 3: l. 2: "operates" instead of "measures" Done

p. 4: l. 27: "um" has to be changed with micron character (maybe it’s just a problem of conversion to pdf format) Done

p. 5:

l. 24: 2-element Done

l. 33: that applied I am not a native speaker but are you sure? Shouldn’t it be “the same than applied” or “the same that was applied”?

p. 6: l. 3: components Done

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p. 7:

l. 11: the maximum measurable period should be half the measurement time

If we used the FFT, I would agree with you. However, we are using the harmonic analysis. Here, the spectral resolution is not determined by the length of the data series. In principal, it would be sufficient, if half the oscillation was included in the time series. However, since we use the phase information, we need to be more careful here and use the full length of the data series. In addition, we apply several further criteria in order to check the consistency of the results based on this analysis step (see section 3.1).

Another point is that the harmonic analysis assumes a stationary signal. If the oscillation is much shorter than the time series and not stationary during the measurement time, the results (amplitude, phase and period) become uncertain, too.

So, the choice of these criteria is a compromise.

However, at least on average the measurement time is a little bit more than twice the period.

l. 21: 3600km is huge!!!! See comment above

p. 8: l. 6: For medium and low-frequency waves, you always have N»sigma, so it works for your approximation, but maybe you don't need to talk about f since you don't use its relation with sigma or N. You should also explain why you can get rid of 1/4H2

I inserted "The term $\frac{1}{4H^2}$ can be neglected since it is small compared to the squared vertical wave number".

l. 14: monthly basis Done (I corrected this mistake also in section 4.2, last paragraph before section 5)

p. 10:



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l. 2: change subtitle to 4.1 Horizontal parameters Done

l. 20: the night Done

p. 11:

l. 6: the value for the scale height is surprising, usually at this altitude it's 6-7 km To

JANUARY ZONAL MEAN TEMPERATURE (K)

| Scale Height | Pressure (mb) | Geom. Height (km) | 0 | 5N | 10 |
|---|---|---|---|---|---|
| 13.00 | 2.29E-3 | 89.2 | 190.1 | 190.2 | 190 |
| 12.75 | 2.94E-3 | 87.7 | 192.7 | 192.9 | 193 |
| 12.50 | 3.78E-3 | 86.3 | 195.7 | 196.0 | 196 |

To be honest, I was not able to read the CIRA properly. I am sorry. Even if the parameter listed in the first column (see figure above) is called scale height, it is the log-pressure scale height (-ln(p/p0). Therefore, I deleted this part of the manuscript.

l. 8: investigated Done

p. 12:

l. 2: remove "," after only Done

l. 3: ... and subsequently of the vertical... Done

p. 13: l. 3: (1-10h, 100-1000s km) Done

The authors should use other expressions for "ca." (about, approximately, ~). It's a little bit repetitive! Indeed, we use it 29 times. I tried to mix it a little bit.



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