

Interactive comment on “Observations of OH-airglow from ground, aircraft, and satellite: investigation of wave-like structures before a minor stratospheric warming” by Sabine Wüst et al.

Anonymous Referee #2

Received and published: 3 January 2019

We would like to thank the anonymous referee for his valuable comments. We answered all of them and changed the manuscript accordingly. Please find the details below in orange.

General Comments The authors present a selection of results from a campaign of observations on OH-airglow emissions recorded from the ground, and from an aircraft flown inside the Arctic Circle during January and February 2016. The ground-based observations were made using infrared spectrometers deployed at ALOMAR and Kiruna, while the aircraft measurements were made with a “Fast” airglow imager taken over

flight paths that included both observing stations.

These observations were supplemented with the inclusion of temperature and OH* VER profiles from the TIMED-SABER satellite instrument near the time and location of the observations, in addition to horizontal and meridional wind data from the ECMWF.

The SABER data have been used to calculate the mean height and thickness of the OH* layer during the period of the observing campaign. There is good correspondence between the variation of the OH* layer brightness measured by the ground based spectrometers and that obtained from the SABER VER measurements. The Brunt-Väisälä (BV) frequency during the observing campaign was calculated for the OH* layer by weighting it by the VER measurements. It showed a steady decrease throughout the observing period – which was interpreted to imply a reduction in the static stability of the atmosphere during that time interval.

Combining the OH*-layer averaged temperature data from the infrared spectrometers with the SABER temperature profiles, enabled the authors to calculate the gravity wave potential energy density (GWPED) contained in the spectrometer temperatures. Results were separated into those with periods > 60 and ≤ 60 minutes. GWPED for waves with $T < 60$ min were in the range 7 - 15 J/kg, whereas those waves with $T > 60$ mins were in the range 10 - 150 J/kg. A relatively clear maximum in the GWPED for the former group occurred around January 27th, which is close to the time of a minor stratospheric warming event. The authors interpret this coincidence as possible evidence that these longer period waves originate at tropospheric altitudes. The cubic spine fitted to the two wave groups is of doubtful value.

Images from the FAIM camera were used to calculate wavelengths and propagation directions of the waves and ripples detected in the images. These were separated into those with $\lambda > 15$ km and those ≤ 15 km. In the case of flight 1 (Kiruna – Alomar and back making a triangle) waves with $\lambda > 15$ were either NW or SE, whereas those with $\lambda \leq 15$ km tended to be SW or NE. The highest occurrence rate of waves occurred in both legs when the plane was passing over the highest mountain peaks.

The manuscript is well organised and the data is clearly presented. The methods used

to identify the gravity waves in the image sequences are correct and the description of the methods used are clear. The text includes an appropriate set of references. The work is suitable for publication in ACP, provided that the minor points highlighted in the specific comments and in the technical corrections below are addressed.

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Interactive
comment

Specific Comments

On page13, the authors attempt to use the airglow brightness images to deduce something about whether static and dynamic instability is the dominant mechanism generating the ripples in flight 1 or flight 5. This is an interesting idea, but it is based entirely on assumptions which may or may not be true. In the absence of horizontal wind and temperatures data (see page 12, lines 31-33), we cannot say. This passage also assumes a relation between airglow brightness and temperature, which does not always hold strictly as pointed out in lines 17-19 on page 13. Yes, that's true but as reviewer 3 pointed out, at least during this time of the year this assumption holds on average (Garcia-Comas et al., 2017; Shepherd et al., 2006). I integrated this information in the manuscript. I also pointed out the assumptions and used wind measurements at ALOMAR (Stober et al. 2017) in order to motivate at least the argumentation.

A really useful reference on this point is the recent paper by Li et al. (2017), in which the authors study statistically the relation between ripples and the background atmosphere. Some of the statements made in the current manuscript are not supported in the work by Li et al. (2017), e.g., line 30 on page 11 states (referring to ripples) "They move with the background wind . . .". Li et al. (2017) report that less than half of the ripples examined moved with the background wind, and were in fact real wave structures that are difficult to distinguish from real instability features.

The authors should read Li et al. (2017) and revise the current manuscript in the light of the results presented there.

Thank you very much for bringing this paper to my mind. I revised abstract, discussion



Technical corrections

It seems to me that some of the technical corrections refer to the manuscript before it was improved during the quick review process. In this case I only mention "already corrected" as answer to the comment.

Page 1, line 27; "evolvement" -> "evolution". **Already corrected**

Page 1, line 29; "Special emphasize is put . . ." -> "Special emphasis is placed . . .".
Done

Page 2, line 29; insert "(BV)" after "Brunt-Väisälä". **Done**

Page 3, line 18; insert "(GWPED)" after "density". **Done**

Page 3, line 24; omit "of" in "on board of the DLR". **Done**

Page 4, line 22; omit "certainly". **Done**, additionally I think it must be "are" instead of "is" just before the (now-deleted) "certainly"

Page 6, line 10; replace "looked up" by "found". **Done**

Page 6, line 18; insert " for the calculation of N" after "necessary". **Done**

Page 6, line 24; "catches" -> "includes". **Done**

Page 7, line 8; replace "The used 2D FFT algorithm needs equidistant data." by "The 2D FFT algorithm employed requires equidistant data.". **Done**

Page 9, line 21; insert ";" after "also. **Already corrected**

Page 9, line 28; "cut" -> "reduced". **Done**

Page 11, line 15; year of reference (2009) is inconsistent with line 7 on page 17. **Already corrected**

Page 12, line 17-18; suggest "Therefore, we conclude that gravity waves with periods longer than 60 min are more likely to could to a larger part be generated in the

Interactive comment

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troposphere than gravity waves with periods shorter than 60 min." **Done**

Page 14, line 7; "In the same time" → "At the same time". **Already corrected**

Page 14, line 10; "could not be observed." → "were not observed." **Done**

Page 17, lines 5-7; year of reference (1995) is inconsistent with line 15 on page 11.

Already corrected

Page 20, line 10; "preceding" → "subsequent". **Already corrected**

Page 21, line 6; "stand for" → represent. **Already corrected**

Page 24, Figure 6(a) and 6(b); dashed grey line is very faint. Use a darker colour.

Already corrected during the quick review. Is it still too faint?

Page 26, Figure 8(a); the grey line that shows the orography is so faint that it is almost

impossible to see it. **Already corrected during the quick review. Is it still too faint?**

Page 29, Figure 11(a); the grey line that shows the orography is so faint that it is almost

impossible to see it. **Already corrected during the quick review. Is it still too faint?**

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Interactive
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References Li, J., T. Li, X. Dou, X. Fang, B. Cao, C.-Y. She, T. Nakamura, A. Manson, C. Meek, and D. Thorsen (2017), Characteristics of ripple structures revealed in OH airglow images. *J. Geophys. Res. Space Physics*, 122, 3748-3759, doi:10.1002/2016JA023538

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