

Interactive comment on “Investigation of inertia-gravity waves in the upper troposphere/lower stratosphere overnorthern Germany observed with collocated VHF/UHF radars” by A. Serafimovich et al.

A. Serafimovich et al.

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Reply on the interactive comments of an anonymous Referee #2

In the revised version we considered all constructive and critical topics made in the review. Furthermore, in the revised version we tried to remove all apparent contradictions. In detail we will now answer on the topics of the interactive comment made by the anonymous Referee 2.

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1) We agree with the referee that this paper is an extension of a paper of Peters et al, Met. Zeitschrift, 2003, (hereafter P2003). The main aim of the first paper P2003 was to study and to describe the generation and appearance of inertia gravity waves downstream of a jet in the upper troposphere where the wind streak was induced during the second phase of a pole ward Rossby wave breaking event north-eastwards of an anticyclone.

Basing on these ideas and on the discussion of the meteorological background in P2003, the main objectives of this continuative study based on detailed analyses of the data of two continuously running VHF/UHF radars located in Northern Germany are directed to get more insight in the structure of gravity waves with shorter periods in the upper troposphere which cannot be resolved by 3 hourly radiosondes.

Furthermore we have included a detailed analysis of the data of both VHF/UHF radars at Kuehlungsborn and Lindenberg, separated by about 265 km in order to investigate temporal and spatial differences of the observed waves and to identify common wave events by a cross-spectral-analysis, and last but not least, we would like to apply different methods and newly developed algorithms for the estimation of the main characteristics of inertia-gravity waves.

We changed the introduction in the revised version to emphasize these above statements.

2) We agree with the reviewer and improved Figure 3 to get more clearly separated waves to justify the investigation of gravity waves of different temporal scales with different filtering processes.

In the revised version, the new Figure 3, based on the results of previous detailed wavelet analyses, shows in its upper panel the wavelet power spectra of the time series of zonal and meridional winds, now averaged over the altitude ranges 5.45-5.75 km (for Kuehlungsborn) and from 5.25 - 5.75 km (for Lindenberg). The presentation has been reduced to periods from 2 to 25 h for the time from 16-20 December. Especially for the Kuehlungsborn data, with these reductions both waves are now more clearly

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separated than in Fig. 3 of the previous submitted paper, where the wavelet spectra were smoothed too strong due to the applied averaging in height.

3) The wind perturbations shown in Figures 4 and 5 are characterized by a superposition of atmospheric waves with different frequencies in the selected frequency band. We decided here to present the figures with the clearest signatures of gravity wave's phase propagations.

However the estimation of all wave parameters itself shown in the following sections is based on both components evaluated by different methods, e.g., with the hodographs, rotary spectra, and the especially with the Stokes parameter spectra. We added a general remark to the end of Sect. 3.1.

Furthermore, we agree with the reviewer, that the downward directed phase propagation shown in Figs. 4 and 5, and determined by a negative sign of the ratio between vertical wave number and observed frequency according to Eq. 8 in time-height coordinates, cannot be used to conclude directly on a downward or upward directed wave. The information of the direction of the vertical wave propagation are derived from hodographs, rotary spectra, Stokes parameter spectra (see Sect. 3.2) as well as by the vertical group velocities derived from Eq. 37 (see Table 6 on page 4370 or Table 4 in the revised version), in every case determined by a common evaluation of both wind components.

As we have later discussed in Sect.3.3, we have to note that in the case of Fig 4, the intrinsic and observed frequencies must have different signs, whereas we adopt here a positive intrinsic frequency (see page 4344 of the submitted manuscript).

4) As we have mentioned above, we didn't repeat the discussion made in P2003 on the connection between the generation and appearance of gravity waves during a Rossby wave breaking event. The results at both locations shown in this paper are in agreement with the findings in P2003 and Figures 6 and 10 therein, where the authors have shown, that the main source of these waves is located in the region of the zonal

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wind jet just below the tropopause. Unfortunately the restricted stratospheric altitude range from the UHF wind profiler data does not permit a significant estimation of rotary spectra above the tropopause.

To avoid misunderstandings and over-interpretations, in the revised version the corresponding sentences at the end of sect 3.2.1 have been changed.

5) We thank the referee for the suggestion to use the data for the investigation of long period waves with periods of about 2 days.

A first attempt to investigate the variations of the zonal and meridional winds derived from VHF Radar measurements at Kuehlungsborn after the removal of mean profiles for 7 days from 15 -22 Dec1999 and for 3 days from 17 - 20 Dec 1999, respectively, is shown in Fig.http://www.iap-kborn.de/radar/Mitarbeiter/Serafimovich/acpd/uv_KB_349.gif.

There is a hint especially in panel c and d, that this long period wave occurred at first in the lower troposphere. This coincides with the results of the rotary spectrum without band pass filtering shown in Fig. http://www.iap-kborn.de/radar/Mitarbeiter/Serafimovich/acpd/roto_kbn.gif averaged for the same periods as in Figs. 6 and 7. The maximum peaks of the vertical wave number corresponding to vertical wavelengths of about 8 km are probably determined by a dominating long period wave with upward directed energy propagation, as indicated by larger negative parts corresponding to stronger clockwise rotational power. However, the energy of this wave is much larger than the energy of gravity waves.

To give a detailed description of these long period wave with periods of about 2 days, a common analyses of the radar and radiosonde data in combination with ECMWF reanalysed data should be an interesting topic for a new study, but goes beyond the scope of the main aim of this paper to investigate inertia gravity waves.

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 4339, 2004.