

Interactive comment on “Short vertical-wavelength inertia-gravity waves generated by a jet–front system at Arctic latitudes – VHF radar, radiosondes and numerical modelling” by A. Réchou et al.

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Received and published: 27 March 2014

Journal of Atmospheric Chemistry and Physics

Please find the list of corrections of the manuscript entitled “Short vertical-wavelength inertia-gravity waves generated by a jet–front system at Arctic latitudes – VHF radar, radiosondes and numerical modelling ” by Anne Réchou, Sheila Kirkwood, Joel Arnault and Peter Dalin “

C13061

Replies to reviewer 1 comments/suggestions

At the outset, we would like to thank the reviewer for his constructive suggestions and comments, which we feel improved the manuscript significantly.

1) REFERENCE: I suggest to include Zülicke & Peters (2008) into the references: they showed combined observations and modellings studies of jet-generated waves. They also include the Lagrangian Rossby number as an indicator for potential wave-generation regions. Perhaps, it helps the interpretation of results with the model data.

Reply : Thanks to the reviewer to give us the references, which will be added in the text.

2) PROPAGATION: The authors describe the wavepackets in the 10-to-14-km height region. In the discussion they should mention, that the wave packets are remaining there and do not propagate further up. If they are captured there (Bühler & McIntyre, 2005) or absorbed in a critical layer, remains to be discussed.

Reply: we can't see the wave well higher up with the radar, but the model sees them going higher up – Fig 6b for example.

3) APPENDIX: For my taste this justification to study the Brunt-Vaisala frequency N is not necessary. The authors describe what they have done, and that is sufficient. It is pretty technical information.

Reply : The editor asked us to put such information

4) FIGURES: The figures should all re-processed. The axes are difficult to read, may be the

Reply : We will process the figures carefully to make them as clear as possible.

Further below, some specific comments are added.

TECHNICAL CORRECTIONS

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At many places in the text the authors refer to waves - perhaps they might abbreviate inertia-gravity waves with IGWs.

Reply : It is done, thanks !.

31252-19: "+" → "+/-" : done, thanks !.

31253-2: "inertia gravity" → "inertia-gravity" :done, thanks !.

31253-20: "Eckermann" :done, thanks !.

31253-10: Include here reference to Zülicke & Peters (2008) for study of jet-generated IGWs with 10 field campaigns and modelling at 54 N : done, as follows :

“ In the stratosphere, the waves were dominated by upward energy propagation (clockwise rotation of the wind vector) and in the troposphere by downward propagation, consistent with the dominant source for IGWs being at tropopause level. Zülicke & Peters (2008) showed combined observations and modellings studies (MM5 mesoscale model) of jet-generated waves over northern Germany (54°N). They also include the Lagrangian Rossby number as an indicator for potential wave-generation regions. At high southern latitudes, Guest et al. (2000) . . . ”

31254-18: "and al." → "et al." :done, thanks !.

31255-12: Include Zülicke & Peters (2008) : done, as follows :

“ Another possibility might be to use modelling, as in case studies (e.g. O’Sullivan and Dunkerton, 1995; Wu and Zhang, 2004; Zhang, 2004; Plougonven and Snyder, 2007; Zülicke and Peters, 2008). However, it is not . . . ”

31255-21: Here, I guess you refer to horizontal wind speed - but I do not understand why these should be small. I would expect the opposite due to the shallow inclination of the waves. However, this remark could also be taken out.

Reply: The fluctuations in horizontal wind speed are seen in the radiosonde data and

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they are small. A comment to this effect will be added in the text.

31255-23: "buoyancy-frequency" → "buoyancy frequency" :done, thanks !.

31256-5: "spectral analysis (FOR observations)":done, thanks !.

31256-6: "analysis (FOR radiosonde)" :done, thanks !.

31256-8: Perhaps, a linout-of-the-paper section can be given here. :done, thanks !.

31256-25: "N" has been defined before - should be used here. :done, thanks !.

31257-4: Please, specify value and unit of A. ??

Reply: Value and units depend on the value and units of Pr. Here we use comparison with radiosondes to find A, with arbitrary units for Pr, so arbitrary units for A (for absolute values see Kirkwood et al 2010a). A comment to this effect will be added in the text.

31257-12: "this ISSUE can", but it need not (see above). ???

Reply : Sorry, We don’t understand this comment.

31257-14: "for THIS study":done, thanks !.

31258-25: Please add an information on the used moisture scheme and orography : done, thanks !.

We add : “ Convection is explicit and microphysics is parameterized with the 3-class liquid and ice hydrometeors scheme of Hong et al. (2004) ”

31259-8: "westerly-north-westerly" → "west-north-westerly":done, thanks !.

31260-8: "cross sections" → "cross-sections" :done, thanks !.

31260-9: "north westerly" → "north-westerly" :done, thanks !.

31260-15: "waveS" : done, thanks !.

31260-20: "Leningrad" → "St. Petersburg" :done, thanks !.

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31260-22 delete "/wind" :done, thanks !.

31261-14: This forward-inclined wave packet is also not in Zülicke & Peters (2008). :done, as follows : \hat{A} The waves directly over the main jet, tilting equatorward with height, are very similar in morphology and location (relative to the jet) to those found in the simulations by Lane et al., 2004, Plougonven and Snyder, 2007 and Zülicke and Peters, 2008. However... \hat{A}

May be this is an effect of extraordinary strong upper-front activity?

Reply: We see these waves very often at ESRAD – so they can't need 'extraordinary' conditions.

31261-24: "waveS" 31263-1: "7.5 h, of" \rightarrow "7.5 h is of":done, thanks !.

31264-9: Please, give here an information how the mean profile has been eliminated.

Reply : The mean of the vertical profile of the function is first determined by fitting and subtracting a 3rd-order polynomial over the height interval shown: A comment to this effect will be added in the text

31264-29: "inertia gravity" \rightarrow "inertia-gravity":done, thanks !.

31266-13: "Gaussian weighted" \rightarrow "Gaussian-weighted":done, thanks !.

31267-14 (eq. 10): If you defined u' and v' in eq.s (8, 9) for the wind components, you should use the two components of the momentum flux.

Reply : We have written that u' and v' are parallel and perpendicular to the wave propagation direction and that this is the momentum flux in the direction of wave propagation, i.e. in the direction of u' , so there should not be any contribution from v' .

31267-17: The formula should read " $(u'^2)_{\text{mean}} = |u'|^2/2$ ", shouldn't it?

Reply : Sorry for this error, it should indeed say " $(u'^2)_{\text{mean}} = |u'|^2/2$ " In the text it is $(u'w)_{\text{mean}} = |u'|^2k / (2m)$

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31267-18 (eq. 11): See two items above!: so it is ok like it is

31268-6: "Ern et al." \rightarrow "They" : done, thanks !.

31268-21: "wave driven force" \rightarrow "wave-driven forces (also referred to as gravity wave drag)" done, thanks !.

31268-25: "per day" \rightarrow "d \hat{E} -1" 31268-27: "and the wavefronts distorted, by" \rightarrow "and distorted by" : done, thanks !.

31269-21: "short vertical wavelength" \rightarrow "short-vertical-wavelength" : done, thanks !.

31269-23: "2 day" \rightarrow "2-day" done, thanks !.

31270-13: Here, a remark should be added that the waves in the present case do not propagate further up into the middle atmosphere. In other situations, with more wind, they well could.

Reply : in the models, the waves propagate further up.

31270-22: Include Zülicke & Peters (2008) : done, thanks !.

31271-11: Delete ", in the parameter which is to be used" : done, thanks !.

31271-17: "signal power to noise power" \rightarrow "signal-to-noise ratio" : done, thanks !.

31272-12: Define "UTLS" : done, thanks !.

31273-2: I would insert a coma after "winds" : done, thanks !.

31273-6: I have my problem with "SNR > 0.5". Going into fig. A1, I see for $\sigma_w = 0.1$ m/s an SNR of 0.5, for 0.2 m/s 0.25 and for 0.3 m/s just 0.20 - or am I wrong.

Reply : this is a correct interpretation of Fig A1. We have reasoned that, to look at fluctuations due to the waves, you would need σ to be less than the amplitude of the fluctuations by at least a factor 2. To make this clearer, the phrase \hat{A} (assuming that σ should be less than half the amplitude of the fluctuations to be detected) \hat{A}

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can be added to this sentence

31273-8: "that" → "than". Further, a SNR information on N^2 should be given: for 0.1 I take from fig. A1 a SNR of 0.2 - right? Reply : The solid black line in fig. A1 should be taken for the relation between SNR and standard deviation for N^2 , so that $\sigma_{N^2} = 0.1$ corresponds to SNR = 0.1. 94% of observations have SNR > 0.1. However, here we have been inconsistent with the comment about limits for detecting fluctuations in vertical wind. The sentence "Wave signatures as small as 10% in N^2 could be detected more than 90% of the time" should be changed to "Wave signatures as small as 20% in N^2 could be detected more than 90% of the time (SNR > 0.1)"

31279 (fig. 1): Please, superimpose the radar mean wind in order to distinguish weak-wind and strong-wind periods as done for fig.s 5 and 6.

Reply : The strong winds are not seen at the radar location – the mean winds at this location are everywhere less than 15 m/s and do not change much over the interval plotted. The jet seen in Figs. 5 and 6 does not reach this location. Adding wind contours to Figs 1 and 2 does not add anything useful.

31280 (fig. 2): Please, add mean model wind. :

Reply : same comment as for Fig. 1.

31281 (fig. 3): Please, add wind (for intercomparison with fig.s 5 and 6).

Reply : the wind speed is shown by the length of the arrows – adding contours would make the plot very hard to read

31283 (fig. 5): Please, control the wind arrows for the cross-sections. Looking into the map, I would expect there arrows pointing to the left (into southerly directions).

Reply : Sorry there was a programming error - the figure has been corrected.

31284 (fig. 6): See item above.

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Reply : as for Fig 5 - the figure has been corrected.

31288 (fig. A1): delete "all measured" : done, thanks !

OTHER CORRECTIONS

Typing errors in equations 6, 8 and 9 have been pointed out to us by Dr. Gubenko. These should read

$$ae = [2 (1-f^2/\omega^2)^{0.5}] / [1+(1-f^2/\omega^2)^{0.5}] \quad (6)$$

$$|u'| = (2 - ae) \lambda z N / 2 \pi \quad (8) \quad |v'| = (1 - ae) 0.5 \lambda z N / \pi \quad (9)$$

Please also note the supplement to this comment:

<http://www.atmos-chem-phys-discuss.net/13/C13061/2014/acpd-13-C13061-2014-supplement.pdf>

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 31251, 2013.

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ISOALT-ECMWF-ML-P on the wrf grid

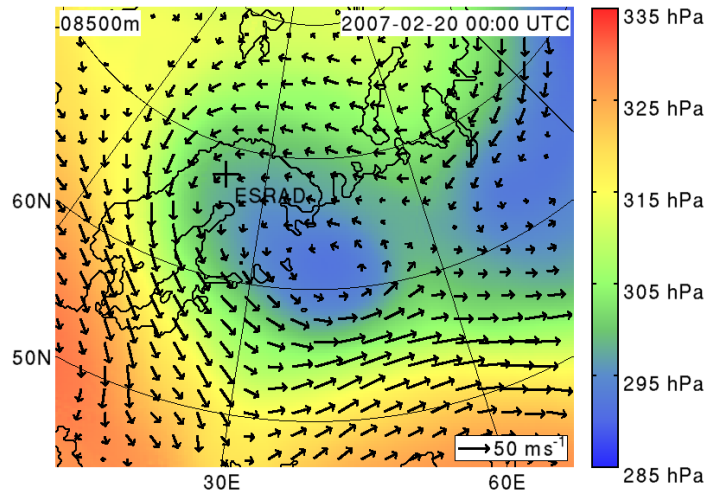


Fig. 1.

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ISOALT-ECMWF-ML-P on the wrf grid

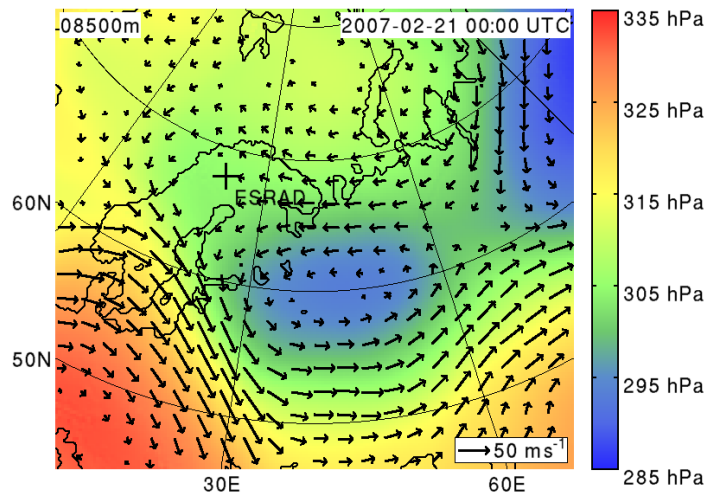


Fig. 2.

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ISOALT-ECMWF-ML-P on the wrf grid

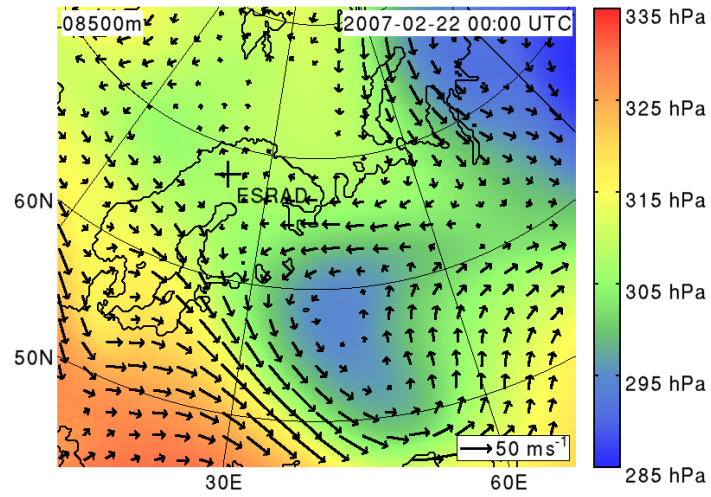


Fig. 3.

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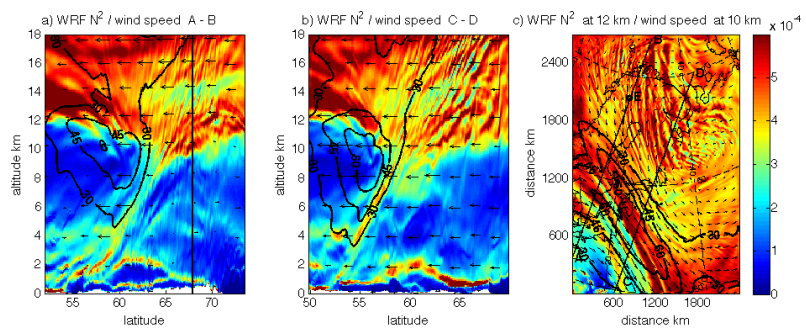


Fig. 4.

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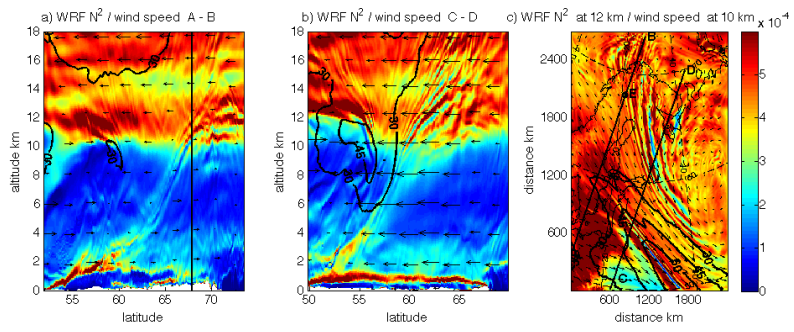


Fig. 5.

C13073

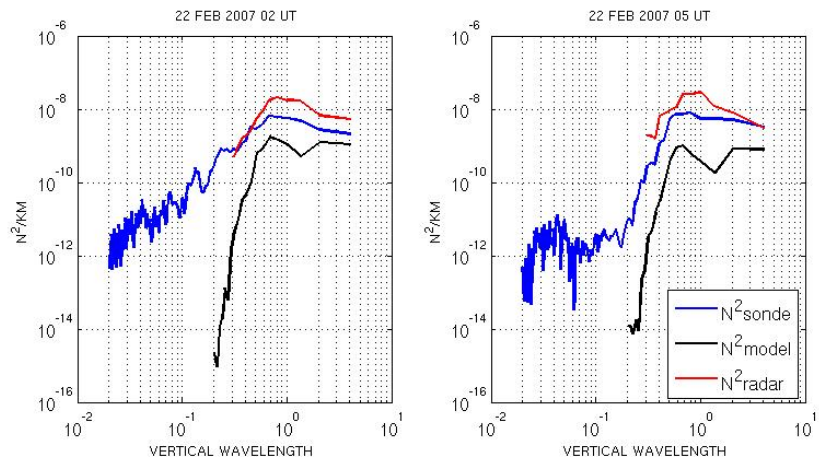


Fig. 6.

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