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Interactive comment on "Wind-profiler observations of gravity waves produced by convection at mid-latitudes" *by* Y. G. Choi et al.

Y. G. Choi et al.

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In recent years there have been significant advances in our understanding and modelling of gravity wave generation by convection. Observations are required to test the models and to constrain the results since there is, as yet, no satisfactory way of relating storm intensity to wave amplitudes. VHF wind profiler observations of stratospheric vertical velocities and momentum fluxes provide a potentially important way of constraining the models. However, while the results in this paper are qualitatively plausible they need to be backed up by more quantitative analyses.

We agree that the reviewers comments about a greater amount of quantitative analysis in the draft paper is necessary and have made considerable changes to the text. In particular, the Discussion section has been rewritten and extra quantitative analysis has been performed in an attempt to provide more useful information to the modelling community. See the first portion of Section 4 (page 7 to page 9).

Specific Comments:

The discussion of the convective event itself is particularly weak and the paper would benefit from a more extended analysis of the convection, including estimates of the depth of latent heat release, the horizontal extent of the heating and the passage of the storm relative to the position of the profiler. For example, if UKMO weather radar and rainfall data are available then they can be used to provide such information in a similar manner to that described in Alexander et al (JGR, 109, doi:10.1029/2004JD004729, 2004).

We agree that this extra information about the form of the convective region is useful and we have added a section of text to improve this description. However, the lack of relevant data, in particular UKMO weather radar data, means that limitations in this description still exist. The lines added are indicated below:

Ancillary information from satellite and radiosonde soundings (not shown) suggests that the interpretation of the large vertical velocity fluctuations in the troposphere as convective signatures is valid. In particular, thermal infrared imagery shows an approximately NW-SE aligned band of cloud which corresponds to the trailing edge of an occluded front approximately 600 km to the NE of the radar site. The position of this front shifts only slightly during the course of the day and so the radar site was within the cold air sector behind the front throughout. Convective activity is confirmed by evidence of high-topped cumulus clouds in this satellite imagery (not shown). However, the convection observed by the VHF radar is associated with a trough which moved several hundred kilometres from west to east during the course of the day and which is responsible for the clouds covering much of the British Isles. Imagery suggests that the British Isles were virtually cloud free at 03:56 UT, but that low cloud was beginning

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to pass over the radar site at 09:58 UT, and higher cloud by 11:39 UT.

The period of the vertical velocity enhancements are also related to a period of particularly heavy surface rainfall at Aberystwyth. A radiosonde launch at 05:00UT on 1st March 2003 suggests that the atmosphere examined is close to instability and could easily produce convective clouds later in the day. UK Met Office mesoscale unified model data has also been used to derive values of the Convective Available Potential Energy (CAPE). Examination suggests regions with values of CAPE greater than 500 Jkg$^{8722;1}$ are observed close to Aberystwyth previous to the period of interest. It should be noted that because of the difficulty in modelling the precise location and intensity of convection in mesoscale models this information is only indicative, but does confirm the expectation that the radar is observing a mildly convectively active region. Examination of thermodynamic data from a radiosonde at Camborne (approximately 270 km to the south of Aberystwyth) launched at 11:00 UT suggests that the depth of the layer in which condensation can release latent heat is approximately 5 km. Many previous modelling studies have also indicated the importance of the horizontal extent of the heating and the requirement to adequately represent the horizontal scale of the updrafts (Holton et al., 2002; Lane and Knievel, 2005). However, the ancillary information required to identify the horizontal extent of the heating is either of too low a horizontal resolution, for example the mesoscale model data is defined on a 12 km by 12 km gird, or is not available, in the case of UKMO weather radar data. Therefore it is not possible to identify this important criterion. However, a simple analysis based on the theory indicated in Holton et al. (2002) allows us to identify possible upper limits of this value in Section 4.

Such results can then be used to inform the discussion in a more quantitative manner concerning vertical wavelengths and periods.

The Discussion section has been rewritten and extra quantitative analysis has been performed in an attempt to provide more useful information to the modelling community. This includes determination of the horizontal wavelength and the vertical and horizontal

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group velocities of the waves. See the first portion of Section 4 (page 7 to page 9).

The concluding paragraph notes that this storm seems unique in terms of the gravity wave response compared with other convective events. An analysis such as that described above would help understand why this is so and make the results more useful to theoreticians and modellers.

To improve this portion of the work a brief qualitative examination of the incidence of this type of wave was made. The following lines have been added in the text to deal with this qualitative analysis and to indicate that this needs to be an area of future work:

It is interesting to note that a number of other convective events have been observed in the radar data and that only one other event shows similar signs of gravity waves above the tropopause perhaps suggesting that this event is unusual in the magnitude of the waves observed. Initial analysis of the seven other convective events observed by the MST radar, one of which is discussed in Hooper et al. (2005), suggests that this event occurs during a period of low wind shear relative to the other events.

This suggests that the modelling and observational studies described in Beres et al. (2002) and Bohme et al. (2004) which indicate the importance of wind shear on the propagation of short period gravity waves could potentially be the reason for this feature. This conclusion seems to be supported by the orientation of the horizontal momentum flux which suggests that the waves observed propagate roughly orthogonally to the background wind and are therefore unlikely to be trapped. Further study will focus on identifying more convective regions using the aforementioned signature in uncertianties and examining the frequency of gravity wave events.

Finally, more use could be made of the information already at hand. For example, the almost north-south orientation of the momentum fluxes suggest that waves are propagating almost orthogonal to the background winds at heights near 13 km, so ground-based and intrinsic periods should be very similar. This will simplify the use of the dispersion and polarization relations in trying to determine

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the relationship between the heating depth and vertical wavelengths etc.

The Discussion section has been rewritten and extra quantitative analysis has been performed in an attempt to provide more useful information to the modelling community. This includes use of the disperson relationship to determine of the horizontal wavelength and the vertical and horizontal group velocities of the waves. Comparison of the heating depth taken estimated from radiosonde soundings with the vertical wavelength observed has also been discussed. See the first portion of Section 4 (page 7 to page 9).

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 11029, 2005.