

Interactive comment on “The thermal and dynamical state of the atmosphere during polar mesosphere winter echoes” by F.-J. Lübken et al.

F.-J. Lübken et al.

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Response to the reviewers reports on the paper:

‘The thermal and dynamical state of the atmosphere
during polar mesosphere winter echoes’

by F. J. Lübken, B. Strelnikov, M. Rapp, W. Singer, R. Latteck, A. Brattli, U.-P. Hoppe,
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General remarks:

We thank both referees for their positive and encouraging reports. We appreciate their comments and have taken their suggestions for improvements into account when preparing the final version of our manuscript. We have addressed the specific comments point by point (see below) and have corrected the typos.

There is one common aspect in both reports which we would like to address here, namely the question how PMWE changes if the atmospheric conditions are different from those observed in our campaign. In chapters 4 and 5 of our paper we have extensively discussed the sensitivity of the radar echo power (more precisely the volume reflectivity, η) on atmospheric background parameters, in particular on the mean electron density, $\overline{N_e}$, turbulence energy dissipation rate, ϵ , and on the dissipation rate of fluctuations, N_θ . We have demonstrated that η can vary drastically if some of these parameters change. We consider it an important strength of our paper that most of the atmospheric background parameters have been measured during our campaign. It is rather difficult or even impossible to speculate about meaningful values for these parameters if observations are not available. We therefore hesitate to conjecture about the magnitude of η during periods when no measurements are available. Still, we have addressed some of the issues raised by the referees in this context (see below).

Referee #1 (M. Jarvis):

Response to the specific comments:

According to our own measurements and those published in the literature all PMWE

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have been observed in a period of solar and/or geomagnetic disturbed conditions suggesting enhanced electron number density. This emphasizes the importance of electron number density to create PMWE and excludes the possibility to study PMWE ‘... during periods when there is no electron enhancement’. This is probably not surprising since a typical value for $\overline{N_e}$ during undisturbed conditions in the winter lower mesosphere during daytime is $10^8/\text{m}^3$, i. e., two orders of magnitude less than during disturbed conditions. Since $\eta \sim \overline{N_e}^2$ this implies that PMWE should be smaller by 40 dB, assuming all other parameters to be unchanged. This is much too small to be detectable by our radar.

Regarding a comparison of η during our two salvoes we would like to point out that the maximum detected backscatter signal is similar in both periods (24 dB above noise floor). However, we also find some short time intervals and/or height ranges with very small reflectivity (just above the noise floor) during both salvoes. Generally speaking, the radar backscatter during our PMWE salvoes is rather variable and we have observed volume reflectivity in the entire range of $5 \cdot 10^{-17}/\text{m} - 10^{-14}$. We are therefore reluctant to relate PMWE echo power to background parameters (or vice versa) at times when we don’t have reliable measurements. To improve the comparison between the two salvoes and also with other campaigns and radars, we have replotted Figure 1 with a scale in dB and in volume reflectivity, respectively.

7616, I21: We mean that a PWME being as large as 24dB above noise floor (volume reflectivity on the order of $4 \cdot 10^{-15}/\text{m}$) is observed rather seldom with our radar. We have added a note in the text.

p7614, I5: We did say ‘large solar proton fluxes’ and not ‘large solar proton events’.

7614, I21: We have replaced ‘absolute magnitude of backscatter’ by ‘radar backscatter’.

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More quantitative values are given later in the text.

620, I2-14: We have added a note of caution to make clear that the evidence for turbulence from the measurements on both instrumented rockets presumably comes from one single event.

7622, I:15 A value of $\epsilon=0.1\text{W/kg}$ was chosen since it is a moderate value and it is consistent with model results (see paper by E. Becker, JASTP, Vol. 66, p683, 2004.) We have added a note and this reference.

7624, I:25 We have added a note in the revised version on the range of riometer absorption values detected during the electron measurements presented in Figure 9 and the range of values observed during the salvo.

7625, I:1-2 We have changed the wording. As far as ‘PMWE’ in summer 2002 is concerned, our radar did not cover the lower mesosphere at that time, i. e., we don't know whether an echo would have been observed. In the year 2004 we have expanded the height coverage of our radar (now from 50 to 115 km) but have not observed any echo from the lower summer mesosphere in the last 2 years. We present a brief discussion on this topic in the revised manuscript.

p7629, I4: We have replaced the word ‘particles’ by ‘aerosols’.

We have taken the technical corrections mentioned by the referee into account.

Referee #2 (anonymous):

Response to the specific comments:

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We refer to our response to referee #1. PMWE during enhanced electron densities is normal, not an exception. Note that we have improved Figure 1 by showing a scale in dB and in volume reflectivity, respectively.

We fully agree with the referee that the PMWE statistics indicates that some background turbulence is likely to persist in the lower winter mesosphere. In fact, this is an interesting consequence of our findings. We note that our experimental knowledge about mesospheric turbulence during winter is very limited. Regarding modeling we refer to recent results by E. Becker (JASTP, p. 683, 2004) about gravity wave saturation which indeed suggests the presence of turbulence in the lower winter mesosphere. This paper also elucidates the role of gravity waves in producing turbulence in the upper atmosphere. We have added a further reference to a review paper by Fritts & Alexander (Rev. Geophys., 2003) on gravity waves and instabilities.

We hesitate to relate the strength of PMWE to turbulence indicators on a one-to-one basis considering the important effect of other parameters on radar backscatter (e.g. $\overline{N_e}$, see above). In the future we intend to make a statistical correlation analysis using improved remote sounding capabilities and a larger data base.

We have addressed some of these topics in the revised version of our manuscript. Furthermore, we have taken the technical corrections mentioned by the referee into account.

Kühlungsborn, 15. November 2005.

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(F.-J. Lübken, for all authors)

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 7613, 2005.

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