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

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General comments:

This paper presents a thorough examination, using rocket-based data, radar data and theoretical estimates, of the causal mechanism behind Polar Mesosphere Winter Echoes (PMWE). It is central to the scope of ACP and presents original data and solid scientific argument. It reaches the substantial conclusion that, contrary to peer community literature, charged aerosols are not required (or present) for the generation of PMWE and that turbulence is the key requirement. The paper demonstrates analytically that, with an average polar electron density profile, weak PMWE could be produced through turbulence alone, and that in the height regime in which PMWE are

observed (68-75 km) turbulence is observed to be present. It also demonstrates that more powerful PMWE will be generated if, in addition to the turbulence, there is a strong enhancement in electron density above the norm. The observed PMWE presented are assumed to be occurring during both turbulence and electron density enhancement, based upon observation of both turbulence and electron density on one day (18 January), and the lapse rate and solar activity on the other days.

The paper is lucidly written, well-organised and very clear.

Specific comments:

The results are sufficient to support the conclusions and are very convincing; they effectively rely, however, on data from a single day to prove turbulence exists at PMWE heights. A minor criticism is that the paper neglects to observationally compare the PMWE volume reflectivity between periods when there is an enhanced electron density profile and periods when there is not - the analytical calculations imply that weak PMWE should still be present through the action of turbulence during periods when there is no electron density enhancement.

One critical observational test of this analytical result regarding the comparative contributions of turbulence and electron density appears to be available but not presented in the paper. The two plots of Figure 10 indicate that with a 'normal' electron density profile and moderate turbulence the volume reflectivity will be about a factor of 100 less than it is during the much higher electron density of the two rocket profiles in Figure 9 (red solid lines). This is equivalent to a change of about 20dB. Is this apparent in the data?

If the left panel of Figure 2 is reproduced for 18 January (i.e. when RWMM01 and RWMM02 were launched and the only occasion when both turbulence and high electron density were directly measured) does it show the same volume reflectivity of approximately 2x10**-13 as was seen on 20 January? If the same plot is produced for days when there is no electron density enhancement (based on solar and geomag-

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netic activity, or possibly riometer data) are PMWE with about 20dB weaker reflectivity observed just above the noise (as implied from Figure 10)?

P7616, line 21. Fig. 1 shows a “strong PMWE”. What is meant by “strong” - i.e. how typical is it?

P 7614, line 5: What does “large” mean in “during large solar proton events”? A different adjective indicating either flux, duration or energy might be better.

P7614, line 21: Can one have an “absolute magnitude” of backscatter, because the backscatter is dependent on transmitted power etc. etc.? The paper does not actually calculate the backscatter but it calculates the reflectivity.

P7620, lines 2-14. The comparison of turbulence “inside” and “outside” the PMWE is central to the discussion of the paper. It should be made clear therefore that this evidence is taken from only 2 rockets and that these were launched just 30 minutes apart. Thus this evidence really comes from a single event. [Other evidence presented in Fig. 3 is more circumstantial].

P7622, line 15. At this point in the paper, it is not indicated why the energy dissipation rate constant of 0.1W/kg has been chosen (although it is made clear later that it is for moderate turbulence). A note to that effect at this point might make the logic behind the calculation clearer.

P7624, line 25: Fig. 9 shows electron density profiles for a host of rockets in the auroral zone, but there is no indication of whether these were launched under typical or active conditions. Perhaps it would help to mark the Kp index on the profiles?

P7625, line 1-2: There cannot be an “exception to the rule” of “never”. These two sentences should be re-worded. Also, this paragraph begs the question as to whether PMWE were observed by the radar during the summer of 2002 - any evidence of this should be stated.

P7629, line 4: The word “particles” could be confusing. I assume that here the authors

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mean “aerosols”. Electrons are particles, also, and these are definitely needed (P7627, line 13-14).

Figure 3. The lapse rate should read “+9.8 K/km” and not “-9.8 K/km” as lapse rate is defined as a decrease in temperature with increasing altitude.

Technical corrections:

P7622, line 9: “, n on electron” should read “, n, on electron”

P7627, line 9: “Wether” should read “Whether”

Figure 8. The caption is slightly confusing. It would read better as “Same, but for changes in electron density and turbulent. Ě..”.

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