

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

### **Anonymous Referee #2**

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The thermal and dynamical state of the atmosphere during polar mesosphere winter echoes, by F.-J. Lübken et al.

#### General comments:

This paper reports on a rocket payload campaign that monitored the thermal and dynamical environment in the altitude range where PMWE were simultaneously observed using MST radar (within 30–50 km) above Andoya (69°N). The most significant finding of the paper is that neutral air turbulence (sourced from gravity wave breaking) when coupled with sufficient free electrons (sourced from solar proton events and magnetosphere sub-storms) during daytime, more than adequately accounts for the existence

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for PMWE! This is in contrast to previous works that suggested that aerosols (other than water ice) in the lower mesosphere (yet to be categorically observed!) might contribute to PMWE analogous to the role of water ice aerosol with PMSE at higher altitudes.

An excellent set of rocket launches probed the atmospheric volume during PMWE which was a most remarkable experimental success, given the relative rarity of their occurrence compared to the more ubiquitous PMSE. The experimental evidence for turbulence, viz., ion density fluctuations, steep temperature gradients, low Richardson number, and PMWE (SNR) spectral broadening are irrefutable for the case studies presented. Similarly the in situ electron density measurements, albeit during an interval following a coronal mass ejection (when ground geophysical observation on this occasion would have sufficed) overwhelmingly support the authors hypothesis. The authors also present a plausible explanation of their proposed PMWE turbulence theory.

This paper is a scholarly and a well written piece of experimental and theoretical science, that is recommended for publication in ACPD after consideration of the following comments.

Specific comment:

Since PMWE is a little documented phenomenon I am surprised that this near definitive paper on the theoretical interpretation of PMWE is presented ahead of the experimental observations from Andoya (the authors did reference a submitted paper here). Nonetheless the works of Kirkwood et al. (2002) and Stebel et al. (2003) do provide the necessary characteristics of PMWE for the unfamiliar reader.

Although the authors suggest that evidence for the presence of aerosols in the altitude 55-75 km in the winter mesosphere is not currently substantiated, they do remain open should future observations detect aerosols < 10 nm in diameter. Nonetheless, the authors have presented a convincing argument that aerosols are not needed to account for PMWE.

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It is apparent that the sequence of PMWE events on 20 January 2005 are very intense and as discussed are related to the enhanced solar proton event and intense X-ray flare on this day. Thus PMWE on this day are the exception rather than the typical - so the authors need to convince the reader that the solar influences on this day did not contribute to the PMWE generation beyond that of turbulence expected for more typical PMWE days! It would be useful for the authors to comment on whether the various indicators of turbulence measured on 18 January are likely to be present during intervals with weak PMWE reflectivity (or intensity). Turbulence indicators for weak PMWE would be useful - perhaps some results for the weaker PMWE for 18 January 2005 (as posted on the IAP web site) might be beneficial.

Although the seasonal and diurnal statistics for PMWE occurrence, intensity, altitude, etc, are not given in this paper, they were reported to occur at a rate of 1-3% compared with 80% of the time for PMSE. Nonetheless their mere observation would suggest that some background turbulence threshold level must persist throughout the winter (spring/autumn!) interval to enable the ostensibly random solar events (or source of electrons) to produce PMWE!

Very little is mentioned in the paper other than a reference to gravity waves on the nature of the source for the atmospheric turbulence in this region of the atmosphere! Perhaps some additional material or appropriate reference on atmospheric turbulence mechanisms could be given.

Technical corrections:

P7614 line 5: PMWE are much = PMWE occur much

P7614 line 16: : Viscosity = : viscosity

P7614 line 25: solar protons. = solar proton events.

P7616 line 23: above noise = above noise floor

P7617 line 2: and can = but on occasions can

P7617 line 2: We summarise = we found

P7617 line 15: thousands of small = thousand small

P7618 line 2: appearance = occurrence

P7618 line 23: We allocate = We designate

P7618 line 25: We thereby = We also

P7619 line 24: taken = considered

P7621 line 14-16: Several terms introduced earlier are spelt out again!

P7621 line 19: Fig. 6 = Fig. 5

P7621 line 20: viscosity  $\check{\check{E}}$  and = viscosity,  $\check{E}$  , and

P7622 line 1: show energy = show turbulent energy

P7622 line 1: rates = rates (dT/dt)

P7622 line 9: on electron = , on electron

P7623 line 28: include the latitude of Ft. Churchill

P7623 line 28: spell out PCA (Polar Cap Absorption)

P7624 line 3: particles = aerosols

P7624 line 3: conditions = conditions,

P7624 line 16: strengths = strength

P7624 line 17: two effects: = two effects.

P7624 line 17: viscosity = Firstly, viscosity

P7625 line 1-5: These sentences need to be rewritten to distinguish the turbulence observations below 76 km during the 2002 summer stratospheric warming event, from

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other more typical summers!

P7625 line 7: detects = detected

P7625 line 11: turbulence = turbulent

P7625 line 13-14: that flight, more precisely in a period = these flights, or more precisely for an interval [perhaps rewrite this sentence]

P7625 line 21: in perfect agreement = in agreement

P7625 line 27:  $R_i$  smaller as  $i_j$ ) =  $R_i$  as small as  $i_j$ )

P7625 line 28: observed = shown

P7625 line 29: “roughly” should be replaced by “approximately” or “ ” throughout the manuscript!

P7626 line 4: probing. = probing volume.

P7626 line 21: water ice particles = water ice particles or aerosols

P7627 line 4: particles = aerosol particles

P7627 line 9: Wether = Whether

P7627 line 25: measurements = measurement

P7627 line 25: generation etc. = generation, etc.

P7628 line 4 7 10: particles = aerosols

P7630 line 23: Nonneutral = Non neutral multiconstituent = multi constituent

P7634 line3: universal time = Universal Time

P7635 : / km = [km] etc for the respective axes unit labels

P7637 : There is a 3 hour temporal difference between chaff wind observations

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(RWCH14) and the falling sphere temperature observations (RWFS17) - what effect is this likely to have on the derived turbulence value? Also need to explain this in the text on P7619!

P7638 : font size of axes labels too small (compared with earlier figures)

P7639 :  $[1/m] = [m^{-1}]$

P7640 : check figure labels for consistency: altitude [km]; 9.9

P7641 : text on colour needs to be bolder Right panel text needs to be rewritten  $[/m^3] = [m^{-3}]$

P7642 line5: need to define “disturbed conditions”

P7643 : altitude = altitude [km]  $[1/m] = [m^{-1}]$  for figure labels line2: 1. = 1.0

P7644 :  $/km = [km]$   $/K = [K]$   $/dB = [dB]$

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

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