

Interactive comment on “Coincident measurements of PMSE and NLC above ALOMAR (69 N, 16 E) by radar and lidar from 1999–2008” by N. Kaifler et al.

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We thank the referee for providing his comments already in his first review, enabling us to apply all corrections already into this discussion paper. We address all points by listing the changes that we have made prior to the ACP discussion:

> 1. Some of the statements concerning the PMSE and NLC need further work for better clarification. For example, it is clearly stated in the abstract and the text (line 304-305) that the PMSE lower boundary is below NLC, which should be the case for bright NLC only. Most of the cases, according to table 3, case I to VI, "on average", show that the bottom of the PMSE is higher than the NLC lower boundary, DZbot

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(NLC-PMSE) = -0.88 km, as stated in line 270-271 on page 9.

We have rephrased three passages in the hope to make our statements more clear. The rephrased passages are:

Abstract:

—————before

"We confirm the coincidence of the lower boundaries of overlapping PMSE and NLC layers and find a standard deviation of 1.26 km. Besides hinting at very fast sublimation rates, this coincidence also implies that the lower boundary of PMSE reaches to altitudes 900 m below average in the case of NLC displays."

—————after

"The PMSE occurrence rate is with 75.3 % considerably higher than the NLC occurrence rate of 19.5 %. For overlapping PMSE and NLC observations, we confirm the coincidence of the lower boundaries and find a standard deviation of 1.26 km, hinting at very fast sublimation rates."

Introduction:

—————before:

"... evidence about smaller ice particles that might still generate PMSE. However, the observation of NLC is directly linked to the presence of ice particles. When speaking of NLC in the following, we ..."

—————after

"... evidence about smaller ice particles that might still generate PMSE. When speaking of NLC in the following, we refer to lidar measurements of NLC. Consequently, the observation of NLC is directly linked to the presence of ice particles larger than about 15 nm."

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—————before

"The mean layer width of PMSE is 4.4 km, the layer width of NLC 1.7 km. On average of all simultaneous measurements in our dataset, the bottom of the PMSE layer is located ~ 900 m above the NLC lower boundary, as was already indicated in Section 3.2."

—————after

"In average of all measurements (case I to VI), no matter if NLC were present or not, the mean layer width of PMSE is 4.4 km. The bottom of the PMSE layer is then located ~ 900 m above the NLC lower boundary, as was already indicated in Section 3.2. In case of NLC (no matter if PMSE were present or not) the layer width is 1.7 km."

> 2. Use of the terms, such as "overtake" and "force" are descriptive but not scientifically meaningful and need to be qualified.

We have rephrased and eliminated the use of the words "overtake", "force" and "obvious".

> 3. Although it mentioned that measurements were made 24 hour, the only examples given in figure 2 are night time events. It would be helpful to see some examples of NLC and PMSE measurements during the day.

We have added a daytime measurement to our list of examples and mentioned it in the text (Fig. 2 f).

————— changed

"We have selected six examples of joint observations of PMSE and NLC extending over several hours that demonstrate some common features (Fig. 2). All times displayed are Local Time (LT), which corresponds to UT + 1h and is close to Local Solar Time at the location of ALOMAR (Fiedler, 2005). NLC is typically located in the lower part of the PMSE layer (a and f), ..."

> 4. How do these results compare with the recent presentation by Rapp et al., (2009 Fall AGU talk) which compared PMC measurements by SOFIE onboard of AIM satellite with PMSE and NLC measurements at ALOMAR? My understanding was that SOFIE detects more NLC events than the radar detections of PMSE, possibly as SOFIE can measure smaller size ice particles and also because (as stated in this paper) the PMSE occurrence depends on not only the ice particle but also the electron density and turbulence while the NLCs exist when there are ice particles, whether or not the lidar can measure them. So in this paper, it must be clarified that the occurrence of NLC as measured by lidar instrument is less than PMSE measured by radar.

—————before:

"Lidar measurements are sensitive to ice particles larger than 10 to 20 nm \citep[e.g.]{}{BaumgartenJGR2008}, and cannot give evidence about smaller ice particles that might still generate PMSE."

—————after:

"We note that the satellite experiment SOFIE observes ice clouds more often than PMSE is measured by radar \citep{}{HervigJASTP2010}. Lidar measurements are sensitive to ice particles larger than 10 to 20 nm only \citep[e.g.]{}{BaumgartenJGR2008}, leading to smaller occurrence rates, and do not give evidence about smaller ice particles that might still generate PMSE."

> 5. Additional references to previous published work on the relation between PMSE and NLC should be included, such as Kirkwood, S., Cho, J., Hall, C.M., Hoppe, U.-P., Murtagh, D.P., Stegman, J., Swartz, W.E., van Eyken, A.P., Wannberg, G., Witt, G., 1995. A comparison of PMSE and other ground-based observations during the NLC-91 campaign. *Journal of Atmospheric and Terrestrial Physics* 57, 35–44. Taylor, M.J., van Eyken, A.P., Rishbeth, H., Witt, G., Witt, N., Clilverd, M.A., 1989. Simultaneous observations of noctilucent clouds and polar mesospheric radar echoes: evidence for noncorrelation. *Planetary and Space Science* 37, 1013–1020.

We have mentioned the additional references in the text:

—————before

"The first observation of simultaneous and common-volume observations of PMSE and NLC were published by \cite{NussbaumerJGR1996}, "

—————after

"Several attempts to investigate NLC and PMSE simultaneously were made using camera observations from ground \citep{Taylor1989, KirkwoodJASTP1995}. The first observation of simultaneous and common-volume observations of NLC measured by lidar and PMSE were published by \cite{NussbaumerJGR1996}, "

> Some minor points (plus others) need to be addressed: > > The use of LT and UT needs to more consistent.

LT is now consistently used. We use LT rather than UT because at the location of ALOMAR it is very close to solar time and is also used by others since it is better suited when discussing e.g. tides. Fig. 2 and the describing text was changed from UT to LT.

> Line 23: monostatic radar?, Line 38: possible to be observed by naked eye, Line 115: lidar sounding volume: 10mx10kmx500m?

These corrections were applied to the manuscript

> Line 250-252: I can only conclude that near the lower boundaries of PMSEs, most of the ice particles are large in sizes compare to the those at higher altitudes. There still can be smaller size ice in this region, not detectable by the lidar. Please change the word "complete" to something not so strong.

—————before

"A sedimentation velocity of NLC particles of ~ 1 km/h restrict the lifetime of particles

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fallen below the lidar detection threshold to several minutes until they can no longer sustain PMSE. In consequence, a small or zero separation between lower boundaries of PMSE and NLC implies that the lidar observes in fact the complete ice particle population, in contrast to higher altitudes where all or part of the ice particles are below the lidar detection threshold."

—————after

"A sedimentation velocity of NLC particles of ~ 1 km/h restricts the lifetime of particles fallen below the lidar detection threshold to several minutes until they can no longer sustain PMSE. In consequence, a small or zero separation between lower boundaries of PMSE and NLC implies that the lidar measurements of the NLC lower boundary represent the lower boundary of the ice layer well.

> Line 273: to be visible as NLC "by the lidar"

done.

> Line 297-298: the bottom altitude does not decrease with increasing threshold. As the bright clouds sit at lower altitudes than the dimmer ones, increasing threshold removes the dim clouds from your sample set. It is the brightness of the cloud that affects the altitude not the threshold. Please rephrase.

—————before

"As mentioned before (see Figure 5 and discussion) a higher NLC threshold includes only bright NLC, and as those tend to be at lower altitudes \citep[anti-correlation of altitude and brightness, e.g.]{ChuJGR2006}, the bottom altitude decreases with increasing threshold. Fig. 6 a) shows how this correlation also effects accompanying PMSE."

—————after

"As mentioned before (see Figure 5 and discussion) a higher NLC threshold removes

dim NLC from the sample set, and as those are usually located at higher altitudes \citep[anti-correlation of altitude and brightness, e.g.]{ChuJGR2006}, the NLC bottom altitude decreases with increasing brightness. Fig. 6 a) shows how this correlation also effects accompanying PMSE."

> Line 317-319: reducing the lidar threshold to 0 does not improve the lidar sensitivity. This result is still limited by the fact that lidar can't detect ice <20nm.

—————before

"Inclusion of all detectable NLC (beta_thr=0), also does not improve the coincidence of lower boundaries further, meaning this result is not limited by the sensitivity of the lidar measurements."

—————after

"Inclusion of all detectable NLC (beta_thr=0) also does not improve the coincidence of lower boundaries further, meaning this result is not limited by the detection threshold chosen here."

> Line 354-355: missing PMSE during NLC = $P(\text{NLC}/\text{no PMSE}) = \text{prob.5?}$ so, remove the word "missing"?

The phrase "missing PMSE during NLC" was misleading in conjunction with the next sentence and was therefore removed.

—————before

"The probability of PMSE measured during NLC displays also decreases with solar zenith angle, such that most observations of missing PMSE during NLC displays occur at very low solar elevations (prob. 3.)."

—————after

"The probability of PMSE measured during NLC displays also decreases with solar

zenith angle (prob. 3.).

> Line 394: PMSE layer "can" extends to lower altitudes with the presence of NLC, not always (for 204 h out of 438 h, nearly half of the time, PMSE above and inside NLC as listed in table 1).

—————before

"NLC mostly is embedded into the lower part of the PMSE layer. This implies that the PMSE layer extends to lower altitudes than usual in the presence of NLC. In most cases, the lower boundaries agree exceptionally well. 27 % of all cases agree within $|\Delta z| < 250$ m, the mean of the distribution being -50 m and the standard deviation 1.26 km."

—————after

"In case of NLC presence, PMSE is located 880 m lower than its average altitude. For overlapping PMSE and NLC observations, we confirm the coincidence of lower boundaries. 27 % of all cases agree within $|\Delta z| < 250$ m, the median of the distribution being -50 m and the standard deviation 1.26 km."

> Line 405: "As NLC sees large particles...". The NLC do not "see" ice particles, they are made of a distribution of ice particles. This sentence needs further clarification.

—————before:

"As NLC only sees large particles and PMSE is additionally influenced by electron density and turbulent activity, it is useful to combine both observations."

—————after

"As lidar measurements of NLC are restricted to the larger ice particles and PMSE observations depend the ice particles and electron density as well as turbulent activity, it is useful to combine observations of NLC and PMSE."

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