

Authors response on “Simultaneous observations of NLC and MSE at midlatitudes: Implications for formation and advection of ice particles” by Michael Gerding et al.

Anonymous Referee #1

We thank the reviewer for careful reading and the positive feedback. Answers to the specific comments are given below (in italics). New line numbers refer to the manuscript with marked changes.

General comments

The title describes well what is shown in this manuscript, so I will not try to formulate it better. The authors use a large dataset from collocated, simultaneous radar measurements of MSE and lidar measurements of NLC. They select cases when MSE and NLC were present at the same time to characterize these two different, but related middle atmosphere phenomena. In the Introduction and the Discussion, the authors summarize well our present knowledge of the phenomena, and they show where their findings agree with existing knowledge, and where they can add new knowledge. The figures are excellent, clear and well described. The text is generally formulated clearly. The authors describe well how they selected and analyzed the data.

Specific comments

What is new knowledge in this manuscript? - This can be found in the second paragraph of section 6 Summary and Conclusions, the first 2/3 of that paragraph. Section 5 Discussion and the excellent Figure 7 explain what this means, and why the differences between the combination PMSE/NLC at high latitudes and MSE/NLC at intermediate latitudes are as observed. I can imagine Figure 7 being used in lectures and review talks in the future.

We thank the reviewer for this comment. This is indeed the main conclusion of the paper, taking the limitations because of the complex origin of MSE into account.

The mechanism that creates MSE or PMSE is a complex one involving the existence of aerosol particles (ice particles), turbulence and the presence of free electrons and ions - three ingredients. The authors describe this well and with sufficient detail for this manuscript on lines 4/5 on page 13 in the Summary and conclusions. At other places in the text, the authors understandably shorten this already brief description, for instance on p. 2 l. 12, p. 2 l. 25, p. 8 l. 1, p. 10 l. 3, and p. 12 l. 1. They mention only the fact that particles must be present, but not the other two "ingredients", except on p. 10 l. 3, where they add turbulence but omit free electrons and ions. The authors, this reviewer, and many readers of the published paper know that all three ingredients are necessary, but scientists new to MSE and PMSE most likely do not. They may learn "small ice particles make MSE or PMSE", which is not a true statement. It would be clumsy to repeat the sentence from p. 13 l. 4/5 every time. Therefore I do not know an easy solution to the problem that I am trying to point out.

We apologize for explaining the complex origin of MSE and the limitations for the interpretation of the signal too late in the manuscript. Following also the suggestions of Referee #2, we added a short description of the origin of MSE in the beginning of Section 1 (p. 2 l. 6-8) and repeated the issue throughout the manuscript (e.g., p. 7 l. 1-5).

As a tentative suggestion, the instance on p. 2 l. 12 could be formulated like this: "... (NLC), while radar echoes ((P)MSE) require ice particles, large or small, where smaller particles may be freshly formed in the ...". The word "require" seems to include the meaning that something else is required, too (turbulence and ionization).

Many thanks. Inspired by this formulation we changed the phrasing to "... radar echoes ((P)MSE), ionization and turbulence provided, indicate small or large ice particles, where smaller particles may be freshly formed in the ..." (p. 2 l. 21).

For the case of p. 8 l. 1, my tentative suggestion might be a small addition: "... visible for radars (signal strength proportional r^2 , if turbulence and ionization in addition allow)."

We rephrased to "... if turbulence and ionization allow)" (p. 9 l. 3).

For p. 10 l. 3, my tentative suggestion is: "... turbulence is needed to create radar echoes (Rapp and Lübken, 2004), as well as sufficient ionization.

We want to make another point here and rephrased: "and continuous turbulence is needed to create radar echoes in contrast to intermittent turbulence being sufficient in combination with larger ice particles (Rapp and Lübken, 2004). Additional ionization is needed in both cases." (p. 11 l. 17/18)

I ask the authors to kindly understand this paragraph of mine as a suggestion, no more. I leave it to them to find brief but complete solutions for the other instances that I have pointed out earlier in this paragraph.

We hope, the complex issue of (P)MSE and the influence on the interpretation are much better described now.

Technical corrections

"to allow" is a verb with a distinctly different meaning than "to allow for", see Oxford, Cambridge, or Webster dictionaries. On p. 1 l. 4 (twice) and p. 5 l. 5, it seems "to allow" is what is really meant.

Rephrased or corrected

p. 1 l. 17 "... respectively, have been performed since..."

Changed (cf. Reviewer #2)

p. 1 l. 19 and 20: Consider "equatorward" instead of "south" to make the statement global.

Done

p. 2 l 10/11: The subject and the verb of this sentence do not agree logically. I suggest "give additional information", which is better, or perhaps "From simultaneous observations by lidar and radar, we gain additional..."

Done (p. 2 l. 18)

p. 2 l. 15 The verb "to sediment" is intransitive. Therefore I recommend to delete the "been".

Corrected

p. 2 l.18/19: Consider adding "During darkness and outside the auroral oval, the ionization..."

Done

p. 3 l. 1: Replace "like" with "such as"

Done

p. 3 l. 19 I recommend "is achieved by a narrow field of view of the telescope". "Field-of-view" with dashes is an adjective. Without dashes, it is a noun.

Corrected

p. 3. l. 33 Here, I would recommend adding a dash in "phased-array" because "phased" and "array" belong together, but "phased" is not a qualifier for "field".

Corrected

p. 4 l. 2 and l. 8: "For receiving, ..." (comma)

Corrected

p. 4 l. 12 might be better formulated like this: "As we do not have an absolute calibration of the radar, we use SNR as an approximation for the echo intensity..."

Rephrased. Many thanks for the suggestion.

p. 5 l. 18 "The MSE quickly grew...";

Corrected

p. 5 l. 26, p. 13 l. 8 and elsewhere: Just a comment from my side: Usually in everyday life and in laboratory physics, "high" is often used as synonymous with "large" and "low" as synonymous with "small". Here is a case where it becomes ambiguous, because we are writing about the atmosphere: Is the ionization too small, or is it too low in altitude? I know the former is meant, but there is a slight ambiguity.

Checked throughout

p. 6 l. 5 "1 km bins" (no dashes) p. 6 l. 7 lowercase "figure", as it is not a name in this case.

Corrected

p. 11 l. 1 and l. 13: "... in our observations suggest that the layer of only small particles..." ; "(Hervig et al., 2016), suggesting different cloud formation mechanisms..."

Rephrased

p. 13 l. 10 "understanding of quickly sublimating..." . "Fast" does not form an adverb by adding "-ly". Correct the "grew" as well.

Corrected

p. 13 l. 18 "extent"

Corrected

p. 13 l. 21 "descent"

Corrected

I do not understand the very last sentence with the verb "acknowledged". Perhaps "This formation process must be taken into account..." is meant or "This formation process must be allowed for" (here in the correct meaning of this verb).

Yes, this was meant. Rephrased.