Authors' response to reviewers' comments on "Electron-Driven Variability of the Upper Atmospheric Nitric Oxide Column Density Over the Syowa Station in Antarctica" by Verronen et al.

Please find below our answers (in blue) to the comments (in black).

Response to the comments of Referee #3

General comments:

This study looks at the changes in nitric oxide density in the MLT region over a years-long time duration and compares WACCM simulation results with the observations to understand the model's accuracy for capturing the NO variability. The results show that EPP forcing is driving much of the day-to-day variability, during which time the NO changes correlate well with geomagnetic indices. Using Arase data, the study also looks at the usefulness of providing inputs from satellite observations. This is a very timely study in that the research on EPP-produced NOx is gaining traction and the use of new data sets like Arase should be explored more.
Response to general comments: We would like to thank the reviewer for the comments and appreciate the time devoted to the evaluation of our paper.

Moderate comments:

Line 133: Is the scatter plot showing data for all times, summer and winter? If not – if you break it up seasonally is there a different dependence?
Response: Yes, Figure 2 includes all daily values, i.e. we have not separated the data by season. In general, based on Figure 1 in the manuscript, the higher values are measured (and simulated) in the winter periods. In summer, the radiometer data gets noisier when NO amounts are low. This could masks some of the natural variability, and result in a weaker correlation between the measurements and WACCM simulations. As a test of robustness, we repeated the scatter plot analysis, this time including only the winter data (April – September). We find only marginal changes in the relation between the radiometer and WACCM (see Figure 1 of this response). We added a brief note of this in the manuscript (Section 3.1).

Lines 136-139: Is it true that the lower values "saturate"? Perhaps this is a physical lower limit on the densities. Comparing these to the simulations, which show negative lower values, is not reasonable since the negative values are certainly unphysical. Unless there is a reason you think the measurement saturates at this lower value, perhaps explain that it's unclear what causes this lower value of 0.25e15 - perhaps it is measurement capability but perhaps it is due to physical processes.
Response: We have revised this part of the text, replacing "saturate" with "stagnate" when describing the lowermost simulated values. As seen in our Figure 4b, in WACCM the ionization by auroral electrons at altitudes above 100 km is never less than 10^3 $\mathrm{cm}^{-3}\mathrm{s}^{-1}$. We think that this is what defines the lower bound of NO column density in the simulations. We now mention this in the manuscript.

Lines 145-146: In Figure 3b,d, I don't see where the 50% contour ever gets down to 94 km altitude. Is it perhaps a mistake in the lower altitude boundary range? There is no 50 contour exactly to see for sure, but extrapolating between 40% and 60%, I don't see the "50%" ever getting to 94 km. It seems more like 100 km to me. Can you check the data please? Or explain better, since I might be missing something.
Response: The 50% contour level: the minimum altitude of 94 km is reached in 2015 only. While there is no 50% contour line in Figure 3b, the 94 km lower altitude limit is clear in Figure 3d in the intersection of the dashed black line (50%, vertical) and the red line. On average, the 50%/50% limit is higher in altitude. This is reflected in the median value of 109 km. We have revised the text for more clarity.

Lines 149-150: It's not obvious to me where the SEPs are in the plot. Can you describe them more or somehow point them out?
Response: The SPE events are best seen in Figure 3b as sharp downward peaks in the 5% contour line. We point this out in the revised text.

Line 225: Can you explain why the correlation might be stronger with AE (in the Discussion)? Also please here explain the two different indices (how they are calculated and what they are a proxy for).
Response: Different indices correspond to different magnetospheric process which drive EEP with different characteristics (*e.g.* duration and a extent of the forcing). In Section 3.2, we have added a general explanation of the indices with some citations. In the case of St. Patrick's Day storm, as we explain in the text (revised), the temporal behavior of NO column density is more consistent with the Dst and AE indices than with the Ap index.

Minor comments:

Line 103: "Van" Allen should be capitalized
Line 151: "ration" —> "ratio"
Line 161: Do you mean figure 3b?
Line 289: "exist" —> "exists"
Response to minor comments: Corrected as suggested.

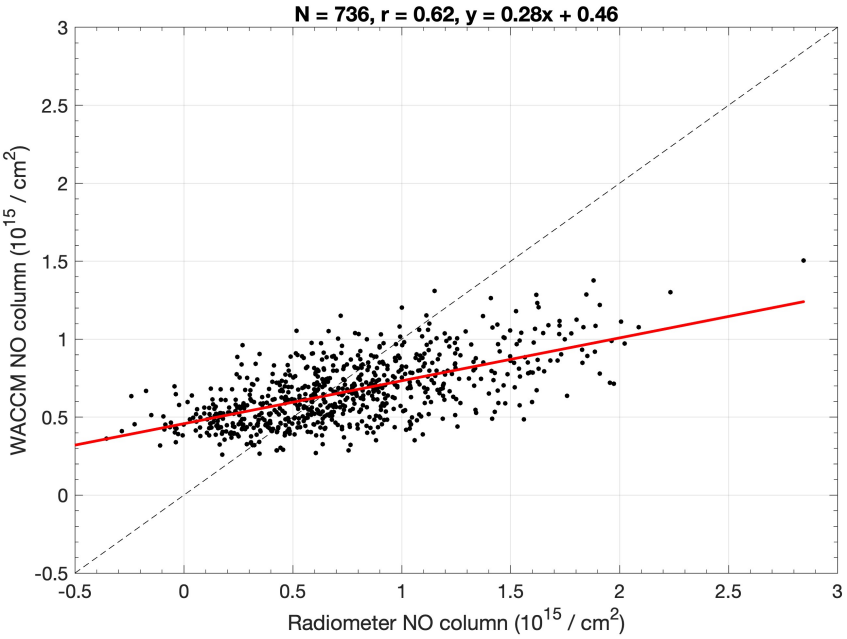

Figure 1. Comparison between Syowa observations and WACCM: relation between the daily NO column densities over the period 2012–2017. Only wintertime data between April and September are inluded.