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Interactive comment on "Magnetic local time dependency of radiation belt electron precipitation: impact on polar ozone" *by* Pekka T. Verronen et al.

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

Response to the comments of Reviewer #2

This paper analyses the impact of magnetic local time (MLT) resolved ionization rates

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Discussion paper

in the mesosphere lower thermosphere region on the chemical state in this altitude region. It addresses a problem related to recent and on-going climate simulation which study the role of the external forcing by solar-terrestial connections, specifically uncertainties of the applied ionization rates which do not account for local time dependency of the flux of mid-energy electrons (MEE). The organization of the paper is straightforward: three model experiments without MEE contribution, a zonal mean and a MLT resolved one are compared to each other. As a specified dynamics experiment is performed, the paper concentrates on the chemical impact under the assumption that any climate response is driven by resulting changes in the radiatively active trace gases, i.e. mainly ozone, to be studied in free-running experiments. From their analysis the authors conclude that resolving ionization rates to magnetic local time has only a minor impact on monthly averaged ozone changes caused by particle precipitation. The paper is generally well written, the conclusions are clear, the figures allow the readers to follow the authors analysis. The paper is timely as it supports the rational of the model experiments in CMIP6. Besides minor comments (see below) I find the paper ready to be published.

Response to the general comments: We thank the reviewer for the constructive comments. We also appreciate the time devoted to the evaluation of our paper.

Minor comments:

– Please check the use of articles in your text carefully. Often articles are missing.

We have made a full check of the articles in our text, taking particularly into account the errors pointed out by both reviewers.

– in the title specify the altitude domain, perhaps "Impact of magnetic local time resolved ionization rates on ozone in the polar middle atmosphere"

We have revised the title to specify the altitude domain. The new title is “Magnetic local time dependency of radiation belt electron precipitation: impact on ozone in the polar middle atmosphere”.

– p2,l30: give reference to ionization models which include LT dependency (eg. the AIMOS model) and which have been used in many studies so far

We revised the text to give reference to the AIMOS model which indeed includes MLT dependency. We are not aware of other global MEE models designed for atmospheric simulations that would have MLT dependency.

– specific comments are given in the commented pdf. Please also note the supplement to this comment: https://www.ann-geophys-discuss.net/angeo-2020-14/angeo-2020-14-RC2-supplement.pdf

We have revised the manuscript text according to the reviewer's suggestions that were given in the supplement to the comment. **Below we list the most substantial comments from the supplement, and answer them individually.**

P2, lines 42-48. You are mixing somewhat primary and secondary factors. The primary cause is the MLT dependence of the forcing, modulated by other factors as SZA eg. which change the efficiency.

We have revised this paragraph. The role of MLT is made clearer by starting: "Any MLT-dependency in EPP ionization affects the short-term HOx and ozone responses in the mesosphere." We have also re-organized the other sentences.

P3, Lines 85-86. The term ZERO is misunderstandable as there is no forcing. "No input" is even worse. Instead, specify: reference, EPP from auroral and p only. 2) as 1) plus ..

We revised the text and figures, replacing the notation "Zero/no input" with "REF/no MEE". To clarify that only MEE was different between the simulations, we added a sentence: "All simulations included the standard aurora and SPE forcing, along with the NAIRAS GCR forcing."

P4, Line 7, Figure 3. Figure title: percentage is a unit as ppm and '100x' is unneces-

sary; d) log10 of ozone / cm-3

We changed the panel titles of Figures 3-8 and 10, removing “100 x” and using “log10” instead of “log”.

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