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Comment on angeo-2021-25

Anonymous Referee #1

Referee comment on "Simulated seasonal impact on middle atmospheric ozone from high-energy electron precipitation related to pulsating aurorae" by Pekka T. Verronen et al., Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2021-25-RC1, 2021

The article "Simulated seasonal impact on middle atmospheric ozone from high-energy electron precipitation related to pulsating aurorae" by Verronen et al. presents the results of model simulation on the impacts of the energetic electron precipitation related to pulsating aurorae (PsA-EEP) to the middle atmospheric ozone. However, there are several issues need to be addressed before the consideration of the publication.

1. Regarding "There is also an open question of the relative contribution of PsA-related energetic electron precipitation (PsA-EEP) to the total atmospheric forcing by solar energetic particle precipitation (EPP)" in the abstract, why did you choose the pulsating aurora over the ordinary diffuse or discrete aurorae to investigate the EPP impact on ozone chemistry in the polar mesosphere? What makes the pulsating aurora special over the ordinary aurorae, in particular, with regard to their atmospheric impacts? How are PsAs distinguished from the ordinary diffuse aurora or discrete aurora in terms of energy, occurrence rate and duration, latitudinal extent etc. to affect the atmospheric chemistry and possibly dynamics? It is critical to justify the results of the study especially when the simulation impacts of PsA-EEP seem to be similar to typical EPP impacts.

2. How was the PsA-EEP taken into account within the model as an energy inputs during the simulation period of 18 months in comparison with other EPP energy inputs? Please describe it specifically. In Section 2, the PsA-EEP ionization rates applied in the study were described such as its application of every other night at the local time hours of 00 MLT to 06 MLT, homogeneously between 60 and 72 deg geomagnetic latitude. I am wondering how this application of PsA-EEP forcing is realistic and how different it is from regular diffuse and discrete auroral forcing. Authors mentioned that all simulations included the background EPP forcing used in WACCM, i.e. solar protons, auroral electrons, and galactic cosmic rays. How the applied PsA-EEP forcing is distinguished from these background EPP forcing? This seems to be critical to explain the difference between the full-PsA and no-PsA simulations in Figure 2, assuming that the no-PsA simulation includes all the background EPP forcing.

3. At the end of Section 1, authors raised a few questions as "The question that remains whether PsA is common enough to cause an appreciable longer-term effects over a wider range of latitudes and local times, and whether these could be detected by satellite-based observations. Furthermore, an outstanding issue in simulations is the shortcomings in EPP-related enhancement of wintertime odd nitrogen. In this context, understanding the PsA-EEP-driven odd nitrogen production could be particularly useful because PsA events are most common in wintertime. Finally, the PsA-EEP high-energy end can directly increase the mesospheric NOx production which should enhance the indirect ozone impact in the upper stratosphere." Are these questions answered by this study? What are the fundamental differences of the current study from previous studies?

4. Regarding thermo-PsA simulation, it was mentioned to separate the impacts from thermospheric and mesospheric forcing. However, it seems very unrealistic and artificial to me. Can it be regarded as the pulsating aurora with relatively low-energy electrons? If so, why didn't you set two different PsA EPPs with high and low energy, instead of artificially setting the zero-ionization below 85 km? This way should be more physically consistent within the model.

5. Regarding the solar activity effects in the study, authors mentioned as "Note that the simulation period is in the ascending phase of the solar cycle right after a record minimum in solar activity, thus the background EPP forcing was relatively low, making it easier to identify the PsA-EEP impact." Does it mean that the occurrence of PsA is not affected by solar activity while the background EPP forcing is weak during low solar activity? Is PsA different from background EPP in terms of solar activity dependence?