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Reply on RC1

Stefan Bender et al.

Author comment on "Validation of SSUSI-derived auroral electron densities: comparisons to EISCAT data" by Stefan Bender et al., Ann. Geophys. Discuss.,
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We thank the reviewer for the comments that helped to improve the manuscript, we have answered the concerns and indicated the changes to the manuscript.

The study describes a validation of SSUSI derived electron density profiles using ground-based electron density measurements by Eiscat incoherent scatter radar in Tromsø, Norway. The data were collected over 2 years and analyzed in 2 magnetic local time sectors separately: 03–11 & 15–23 MLT. Despite all averaging the agreement of the two data products is good within the analyzed height range of 90–150km. Thus, the results provide a promising outlook for spatially extending Eiscat electron density measurements with the help of SSUSI data.

Comment: The only bigger concern I have is the lack of description of the magnetic activity during the analyzed time periods. A brief look into a magnetic index data, as an additional parameter for Table 1, would provide some background on Eiscat location with respect to the auroral oval, i.e. what kind of precipitation the Eiscat radar was pointing to.

Reply: We thank the reviewer for this suggestion, which is a valid point. We are not sure that a single number such as the average Ap or Kp over all coincidences would be helpful, similarly for a list of geomagnetic index data for each single orbit. For SSUSI to observe sufficient UV emission to infer the average energy and flux, some geomagnetic activity is required, and to compare to EISCAT observations, the activity should not be too high because then the auroral oval would be south of the EISCAT radar. Thus the activity ranges from low to moderate Kp (0–4), with the most coincidences around a Kp of 2 for both MLT sectors.

Action:

We updated figure 1 to show the geomagnetic Kp index instead of the solar zenith angle in the middle panels. We also reduced the data shown therein to the data that were used in the comparison to reduce the complexity. The EISCAT experiments are now indicated by different symbols, and we added a legend, to also address one of the minor points the reviewer raised below.

Minor commentary:

- line 9: "derive" instead of "drive"?

Reply: We mean to "drive" as in using the data as input to the ionization and recombination parametrizations.

Action: To avoid confusion in this expression, we changed that phrase to: "...[energies and fluxes] as input to [standard parametrizations]..."

- line 25: more sporadic compared to what?

Reply: More sporadic than auroral electron precipitation with lower energies.

Action: We changed the sentence to read: "..., but those occur more sporadically and have lower flux levels than typical lower-energy auroral electrons."

- lines 27–30: so far only particle precipitation and their energies have been talked about. Should this have an introductory sentences to say something about where NO_x comes from?

Reply: We thank the reviewer for this suggestion, indeed there is a transition sentence missing. NO_x is created by the reaction of the ionized or dissociated species with other ions or neutrals.

Action: We have added the following sentence: "Subsequent chemical reactions result in auroral particle precipitation being a major source of thermospheric NO_x (Brasseur and Solomon, 2005), which can directly and indirectly influence the atmospheric ozone (Randall, 2005; Randall et al., 2009; Funke et al. 2005). To date, ..."

- lines 32-47: These few paragraphs are very detailed to be in the introduction. It would be more important to describe the Aksnes et al. results in more detail here and move some data and instrument details to the next section.

Reply: We thank the reviewers for this suggestion.

Action: We have shortened these introductory sentences to the essentials and moved the detailed description of the SSUSI data to Sect. 2.1, and of the EISCAT data to Sect. 2.2.

We added the following details about the Aksnes et al., 2006 study:

"In their study, Aksnes et al. (2006) compared the FUV-derived electron density profiles from 105 km to 155 km, with generally good agreement between UVI and EISCAT. They achieve that by individually choosing the precipitating electron spectrum for the UVI profiles that best reproduces the EISCAT profiles during that single substorm event."

- line 34: not sure if there is a point in giving time spans in both 0–12 and 0–24 time ranges..

Reply: They were intended to list the ascending and descending passes in the 00–24 time range, but we accidentally listed the UT times of the morning and evening coincidences with EISCAT.

Action: The times have been corrected to state the local equatorial crossing times of the ascending node of the satellites, 17:34 (F17) and 20:00 (F18).

- line 69: "at" seems misleading here

Reply: The reviewer is correct, its use is confusing in that sentence.

Action: We removed "at" from the sentence.

- line 70: I would not call experiments the same as pulse codes, as the latter is just one part of the experiment setup

Reply: We thank the reviewer for pointing that out, indeed they are not the same thing, and here we don't separate the pulse codes from the experiment.

Action: The sentences have been separated (see previous reply), and that part has been changed to: "In addition, the "experiment" run and pulse code used determine the altitude and time resolution."

We also changed "pulse codes" to "experiments" in (original) L73 to clarify that.

- line 72: what is the reasoning behind the analysis time window?

Reply: The 5 minute window was introduced to be long enough to have several EISCAT profiles to average, and short enough to avoid substantial changes in auroral activity.

Action: We added the following clarification:

"This time window was chosen so that several EISCAT profiles could be averaged to characterize the mean level of auroral ionization in the larger comparison region."

- line 74: were scanning experiments also included in this study?

Reply: Yes.

Action: We indicate which ones are scanning experiments in the caption of Fig. 1, and in the mentioned sentence in parentheses after "experiments": "experiments (including scanning experiments)..."

- footnote 1: the latter sentence could well be in the actual text

Reply: Thank you for the suggestion.

Action: We have included the whole footnote mentioned in the main text.

- section 3.1: The beginning of this section reads a little backwards. Following the data processing logic until the Fang et al. parametrization would probably be more logical..

Reply: We believe that introducing the bigger picture first, i.e. the parametrizations used, is the better approach. But we agree with the reviewer that the logical flow could be improved.

Action: We have swapped the order of the second and third sentence of that paragraph to put the description of the spectra before the details about the <E> to E0 conversion.

- line 120: what was the desire to be consistent with Aksnes et al. in the first place?

Reply: The consistency was not our main motivation, but it is a welcome side-effect.

Action: We changed that sentence to: "We use Eq. (5) as the better choice for the altitude range over which we compare the data, 90–150 km, and this is also consistent

with Aksnes et al. (2006)."

- Figure 1: a legend to describe the experiments in the panels c & f would be helpful.

Reply: We thank the reviewer for this suggestion.

Action: We have updated the figure and included the legend as suggested. The 3 panels per satellite are now also consistent in that they use the same symbols for the different experiments.

- line 186: "is" instead of "are"

Reply: The phrase "a number of models" is used for denoting "several models" or "many models".

Action: To avoid confusion, we have changed the sentence to read: "..., numerous models are available ..."

- line 194: "study" instead of "studies"

Reply: Changed as suggested.

- line 200: "blindness of SSUSI" for the sake of completeness

Reply: We thank the reviewer for this suggestion, the term "blindness" was also misleading.

Action: We changed the sentence to: "...indicate the limits of the unambiguous energy range for the FUV-derived electron characteristics as described in Sect. 2.1."

- line 239: "short temporal and spatial scales" with respect to what? Although Eiscat provides data in high resolution it does not allow a high resolution extrapolation, so this is a confusing statement.

Reply: The reviewer is correct here, and the sentence did not convey the intended meaning.

Action: We have removed the phrase "short temporal and spatial scales" from the mentioned sentence.

New references:

Brasseur, G. P. and Solomon, S.: *Aeronomy of the Middle Atmosphere*, vol. 32 of *Atmospheric and Oceanographic Sciences Library*, Springer-Verlag, <https://doi.org/10.1007/1-4020-3824-0>, 2005.

Funke, B., López-Puertas, M., Gil-López, S., von Clarmann, T., Stiller, G. P., Fischer, H., and Kellmann, S.: Downward transport of upper atmospheric NO_x into the polar stratosphere and lower mesosphere during the Antarctic 2003 and Arctic 2002/2003 winters, *J. Geophys. Res. Atmos.*, 110, D24 308, <https://doi.org/10.1029/2005JD006463>, 2005.

Randall, C. E.: Stratospheric effects of energetic particle precipitation in 2003–2004, *Geophys. Res. Lett.*, 32, L05 802, <https://doi.org/10.1029/2004gl022003>, 2005.

