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Interactive comment on "Electron precipitation characteristics during isolated, compound and multi-night substorm events" *by* Noora Partamies et al.

Anonymous Referee #2

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The authors use a combination of ground based and space based observations to investigate energy spectra and flux variations of precipitating electrons during expansion and recovery periods of substorms. The results are very interesting, but I recommend some clarifications to the paper before it is accepted for publication.

The DMPS and POES electron measurements are only presented one figure (Figure 7) and the discussion in section 3.2 focuses on contrasting the DMPS energy ranges to the pulsating aurora fluxes. What about the POES observations? Why does there appear to be a large discrepancy between the DMPS and POES fluxes between 1-10 keV energies? What about higher energies? Note that the value of the top energy

range is cut off from the left panel in Figure 7.

The authors relate the substorms under investigation to the potential atmospheric impacts throughout the paper. I note that the atmospheric impact in the paper is used to discuss both the ionisation impact and referring to NO_x and HO_x production/ozone loss and often it is initially not clear to the reader which one is meant. I recommend reading the text through carefully and clarifying where needed. Substorms are indeed one of the main unknowns in the existing proxies for electron precipitation particularly when considering the eV to tens of keV vs. hundreds of keV energy precipitation. Global atmospheric models that extend to the thermosphere usually include the lower energy range via parameterisation that is driven for example by the Kp-index, while the higher energies are implemented via a POES/MEPED based precipitation model that is driven by the Ap-index (for both, see Matthes, K. et al. (2017), Solar forcing for CMIP6 (v3.2), Geoscientific Model Development, 10(6), 2247–2302, doi:10.5194/gmd-10-2247-2017). The authors touch on this in the discussion section (lines 360-362) where they write in the context of their results that: *These findings emphasise the atmospheric influence of the compound and multi-night substorm events, which may explain why the global geomagnetic activity indices serve us so well as energetic particle precipitation proxies, despite their poor temporal and spatial resolution.* and again the in conclusions: *This would explain why the geomagnetic indices have been good energetic particle precipitation proxies despite their poor temporal resolution and spatial coverage.* Unfortunately I found no explanation or background of the use of global indices in proxies – for anyone unfamiliar with the details of electron precipitation proxies, this important result will likely be lost and thus I recommend revising the text to make the context clear. Can you comment on the relation of indices like Ap and Kp to the ones used in this study - this again would be useful context for the users of those global indices.

On several occasions the impacts on NO_x and HO_x production are referred to as this a direct atmospheric consequence of electron precipitation. For example in the discus-

sion: *Compound and multi-night substorms will, however, be significant contributors to the direct production and HO_X and NO_X radicals in the atmosphere.* I agree that this might be the case, but a statement like this should either be backed up by suitable references or toned-down (e.g. *. . . likely be significant. . .*) as the present work does no involve any direct analysis of the production. Please check these aspects in the text and clarify where needed.

Lines 151-152: Are the locations of the Abisko and Sodankylä riometers the same as the magnetometers in section 2.1? No location is given for the two, only Ivalo.

Line 294: Wording check: Does this mean events with IL< -300 nT are excluded? or ones with IL> -300 nT?

Line 306: First mention of HSS?

Lines 370-373: In the context of the atmospheric impact, do you mean when contrasted to the likely impact from the expansion and recovery phases?

Line 380: What is M-I?

Line 396: *deplete the mesospheric ozone* indicated the process is destroying all mesospheric ozone. Suggest *cause depletion of mesospheric ozone* instead.

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