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Reply on RC1

Christos Katsavrias et al.

Author comment on "On the semi-annual variation of relativistic electrons in the outer radiation belt" by Christos Katsavrias et al., Ann. Geophys. Discuss.,
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Katsavrias et al. in their work "On the semi-annual variation of relativistic electrons in the outer radiation belt" thoroughly investigate the reasons which produce the variations of the electron intensities. The results can be helpful for the adjustment of the future radiation belt models. The manuscript is well written and structured. I would recommend this study for publication after considering the following minor comments/suggestions:

Specific comments:

lines 59-60: How did you derive that background correction rate was less than 75%? Is that specified in the Level-2 data? What do you mean under "only similar to Boyd et al. (2019)"?

Response: The background correction error is included in the level 2 files of both MagEIS and REPT as FESA_CORR_ERROR. We have only used flux values which have errors less than 75%. The same limit (less than 75%) in the background correction error was also used in Boyd et al. 2019.

line 65, Were both RBSP-A and RBSP-B observations used in this study? How well are the observations from these two spacecraft cross-calibrated?

Response: Yes, we have used both RBSP-A and B measurements. There is no cross-calibration study (to our knowledge so far) between the two spacecraft. Nevertheless, the two spacecraft have identical instruments, which allows assuming that the technical characteristics of the measurements are identical.

line 106, please specify the interpretation of values of 0 and 1.

Response: The text has been amended as follows:

"The measure of wavelet coherence closely resembles a localized correlation coefficient in time–frequency space and varies between 0 and 1, corresponding to non-coherent and highly coherent phase relationship, respectively".

lines 121-122, It is not quite clear what do you mean under "the secondary peaks". Is that the second enhancement after the second islet? And "peaks" mean that those are seen in

different energy channels?

Response: We refer to the maxima during March and September, which appear with lower flux values than the primary maxima. The text has been amended as follows:

"Moreover, these peaks are accompanied by secondary maxima (peaks at all energies but with lower flux values than the aforementioned maxima), which occur almost simultaneously with the equinoctial and axial maxima during March and September, respectively."

lines 157-158, about the presence of the significant semi-annual fluctuations for years 2013-2014 and year 2019 we cannot really judge because they are in the cone of influence for this period.

Response: The reviewer is right. We have modified the sentence accordingly:

"Furthermore, the SAV seems to be completely absent during the late maximum of the SC24 (2013--2014) as well as 2019; nevertheless, most of the aforementioned time-period falls inside the cone of influence."

Figure 4, why different time spans are used in panels on the left and right sides?

Response: As we mention in section 2.1, we have excluded all MagEIS data up to September 1st, 2013 due to several major changes to energy channel definitions, operational modes, and flux conversion factors. Thus, even though REPT spans the 01/2013 – 07/2019 time period, MagEIS starts from 09/2013.

line 189, Could you please clarify what does "90 degrees lead of the first data-set" mean?

Response: It means that the first dataset occurs earlier in time and the second follows. The text has been amended accordingly.

lines 200-201, Could you please specify how the phase degrees are transformed in to day's time lag.

Response: The degrees provide us with a fraction of the full cycle which corresponds to the specific period under consideration. For example, let's consider that we have a 90 degrees phase relationship between variables x and y at the semi-annual periodicity. First it means that x is leading y (x precedes y). Furthermore, 90 degrees correspond to a quarter of a full circle and a full circle corresponds to a 6-months period; thus 90 degrees correspond to a quarter of the 6-months, i.e. to 45 days.

line 220, "primarily driven by the theta angle" --> The electron fluxes are not driven by the theta angle. They correlate with the theta angle.

Response: The reviewer is right. The text has been amended as follows: "...primarily driven by the RM effect, which in turn is controlled by the theta angle."

lines 228-241, in study by Smirnov et al., on "Electron Intensity Measurements by the Cluster/RAPID/IES Instrument in Earth's Radiation Belts and Ring Current", JGR, 2019 a clear correlation between AE index, the solar wind dynamic pressure and the electron fluxes at energies of 40 to 400 keV and L-shells 4 to 6 was derived. The enhancement of the solar wind dynamic pressure and AE index occur during the descending phase of the solar cycle. Therefore, these results are also in agreement with those in the manuscript. Namely, they support the scenario of HSS (high speed --> high solar wind dynamic pressure) that drive substorms injections (correlation with AE-index) which populate the

radiation belts.

Response: A reference is added in the corresponding paragraph.

"McPherron [2009] provided further evidence on the validity of the aforementioned scenario highlighting the importance of the azimuthal electric field (E_y). Similar results were reported by Smirnov [2019] using Cluster data."

lines 265-272, There is a new model based on the machine learning approach of the electron intensities in the radiation belts at energies 120–600 keV and L-shells ~ 4 to 7 which is pretty dynamic, depends on the solar wind and geomagnetic conditions and gives high prediction rate: "Medium Energy Electron Flux in Earth's Outer Radiation Belt (MERLIN): A Machine Learning Model", Smirnov et al., 2020, Space Weather. I think it is worse discussing in the outlook. The solar wind electric field does not appear to play highly important role for the electron flux enhancements in this model.

Response: Thank you for this information. The following sentence has been included in the conclusions:

"A new category of models that has emerged in the latest years are machine learning models such as the very recent MERLIN model (Smirnov et al. 2020). These are typically built on many years of data and thus probably include the effects of all such variabilities, but in a way that is difficult to disentangle from all the other effects and variations. Even in these cases though, our study can help in the choice of input parameters, which, when included in a machine learning model, will assist it in properly representing this type of phenomena."

Technical comments:

- The affiliations 3 and 4 should be added to the affiliation list.

Response: Duly amended.

- Through the manuscript there is a lot of confusion with definition of abbreviations. They are often defined too late, or several times or not defined at all. For example, HSS(ICME) on line 8 are not defined, fully spelled in line 24, 126, 164 and defined in line 165; MagEIS can be defined either in line 2 or line 52; RM is not defined in line 71; EPS should be defined before line 250.
- Figure 3, in the horizontal label, "20015"--> "2015"

Response: Duly amended.

- Please add in line 159 at the end of sentence "(not shown)".

Response: Duly amended.

- Please acknowledge the data source of GEO data.

Response: Duly amended.