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Interactive comment on "Semiannual Variation in radiation belts particle fluxes: Van Allen probes observations" *by* Facundo L. Poblet and Francisco Azpilicueta

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We are very grateful to the anonymous reviewer. Beyond all the corrections, the reviewer has suggested many points that will significantly improve the quality of our work.

Below there is an answer to each comment of the reviewer. We hope we could submit an improved version of the manuscript to ANGEO.

In their manuscript, 'Semiannual variation in radiation belts particle fluxes: Van Allen Probes observations', Poblet & Azpilicueta revisit the seasonal dependence of energetic and relativistic electron fluxes in the outer radiation belt using the Van Allen

Probes data covering multiple energy channels. In particular, they analyse more than five years of data from the Van Allen Probes covering the period 2012-2018 to demonstrate electron flux peaks that are, however, not well aligned with equinoxes, similar to past results of Li et al. (2001) and Kanekal et al. (2010), from SAMPEX electron flux measurements. When they repeat the superposed epoch analysis with ring current ion flux measurements (for H+ and O+), a seasonal variation is not however clearly observed.

Though part of their study of energetic and relativistic electron fluxes using the new Van Allen Probes data set could complement and inform previous work, the manuscript is missing sufficient support for the statements made in the Summary and conclusions.

- Section 2 should be enriched with more explanation of the experimental data used for this study. Van Allen Probes have instruments designed to measure the relativistic electrons in both the inner and outer radiation belt. Radiation Belt Storm Probes (RBSP) was the name of the mission prior to launch, after which it was designated in honor of James Van Allen. The acronym RBSP is still used for the two spacecraft of the Van Allen Probes mission. The REPT experiment on board RBSP-A and RBSP-B has offered unprecedented observations of radiation belt electrons whose kinetic energy can reach up to 10 MeV - not up to 20 MeV [Baker et al. 2014, 2016] and an elaborate set of data products. For the MagEIS data set, a new release was announced on 25 May 2018 (please see https://www.rbsp-ect.lanl.gov/rbsp_ect.php) which has significant differences from the previous. Which data set have the authors used for this study, whether they analyse differential or integral flux, omnidirectional or directional flux and other essential information of the data set selected are not specified.

ANSWER: We utilized pitch angle resolved differential fluxes for RBSP data. The release of 25 May 2018 were processed for MagEIS data. We will expand this Section including more detail on the data employed.

- In Section 3, the authors introduce what should be the McIlwain L-parameter or L-shell and not the dipole L. The model used for the calculation of the L-shell is not specified. Figure 1(b) – (d) suggest that an inner belt is seen at energies higher than 1 MeV which should be incorrect as the Van Allen Probes have revealed that the inner belt is largely devoid of relativistic electrons [e.g. Claudepierre et al., 2017]. Observations at L-shells lower than 2 should be omitted in Figure 1 and 2, as they have been in Figure 3. On page 6, lines 4-7, the description of Figure 2 needs to be revisited as it suggests Earthward swift of the outer belt around the autumn equinox while the spring equinox (DOY 79) is seen more than 40 days later. Electron flux variations are highly energy dependent in the outer radiation belt. How different is the electron flux variability seen at higher than 1.8 MeV energies?

ANSWER: The reviewer is correct. We used the McIlwain L-parameter calculated for 90 degree pitch angle particles with the OP77Q Olson & Pfitzer magnetospheric model. We were not aware of the results regarding the absence of relativistic electrons in the inner belt. We will correct Figures 1 and 2 to remove flux values below L = 2.5. Also the description of Figure 2 will be modified. We will add a similar analysis for higher energies.

- In Section 4, on page 8, the manuscript does not make clear whether the mean or median of flux is shown in Figures 3 and 4. As noted by the authors, the electron fluxes vary over orders of magnitude especially during geomagnetically disturbed periods. During storms, relativistic electron fluxes are expected to abruptly drop and gradually increase more than three orders of magnitude as in the case of the January 1997 storm [Reeves et al. 1998]. As a result of the high variability in electron fluxes in the outer belt, the results of superposed epoch analysis should be characterised by significant spread around the median/mean. It would worthwhile to provide readers an indication of the spread, for example by choosing two different L-shells at which to quantitatively compare the distribution of electron flux values. In Figure 3, it should be the SAMPEX electron fluxes in the 1.5 MeV < E < 6 MeV energy range that are shown but this is specified. An alternative for the study of electron flux changes in the

radiation belts in the total radiation belt electron content (Baker et al. 2004 included in the manuscript references list) which could remove reversible adiabatic changes observed during periods of geomagnetic activity and possibly improve the presented results.

ANSWER: Thanks for this comment. The many suggestions could significantly improve the manuscript. In Figure 3 and 4, mean values were calculated.

- Without sufficient information about the data set used for the superposed epoch analysis of proton fluxes in the ring current, it is difficult to evaluate the suitability for the problem at hand or the validity of the results presented in Section 5. A combination of RBSPICE data for high energy protons and HOPE data for lower energy protons could be also be used. Communication with each experiment PI is necessary to get insights into the suitability of each data set as well as possible limitations that could have an effect on the analysis results. My concerns about the results regarding the ring current variability stem from the semiannual variation observed in the Dst index [e.g. Mursula & Karinen, 2005; Svalgaard, 2011] as well as the occurrence and intensity of storms [e.g. Temerin & Li, 2015], both of which are well established. And as the authors note on page 12, the Dst global 'ring-current' index is a measure of geomagnetic activity.

ANSWER: We have already made contact with an ECT PI for REPT and MagEIS data and we will do the same for RBSPICE data. As the reviewer suggests, a combination of RBSPICE and MagEIS data could change our results of the apparent absence of a semiannual pattern in the fluxes of the ring current principal components which is very well known in the geomagnetic activity.

Previous studies on the electron radiation belts variability include:

Miyoshi et al. (2004), Solar cycle variations of electron radiation belts: Observations and radial diffusion simulation, Space Weather, doi:10.1029/2004SW000070 Emery et al. (2011), Solar rotational periodicities and the semiannual variation in the solar wind, radiation belt and aurora, Solar Physics, doi:10.1007/s11207-011-9758-x

References not included in the manuscript list:

Baker et al. (2014), Gradual diffusion and punctuated phase space density enhancements of highly relativistic electrons: Van Allen Probes observations, GRL, doi:10.1002/2013GL058942 Claudepierre et al. (2017), The hidden dynamics of relativistic electrons (0.7–1.5 MeV) in the inner zone and slot region, JGR, doi:10.1002/2016JA023719 Mursula & Karinen (2005), Explaining and correcting the excessive semiannual variation in the Dst index, GRL, doi:10.1029/2005GL023132 Temerin & Li (2015), The Dst index underestimates the solar cycle variation of geomagnetic activity, JGR, doi:10.1002/2015JA021467

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