Referee #2

This paper, entitled "Outer radiation belt and inner magnetospheric response to sheath regions of coronal mass ejections: a statistical analysis", shows the immediate response of inner magnetospheric plasma waves and electron fluxes to the driving of sheath regions preceding interplanetary coronal mass ejections. Through a superposed epoch analysis, the study shows the enhancements in wave powers of ULF, EMIC, chorus, and hiss waves during the sheaths compared to those during the preceding solar wind in both geoeffective and non-geoeffective events; source and seed populations often exhibit flux enhancements in the outer belt, while core and ultrarelativistic populations most exhibit flux decreases at high L region; and non- geoeffective sheaths can cause significant changes in the outer belt electron fluxes as well. This study enriches and advances the results of previous studies on the effects of ICME/sheath on the inner magnetosphere by more strictly focusing on the sheath region, and the results shed light on the important effects of the sheath to the inner magnetosphere dynamics. This manuscript is overall well-written. However, there are still some concerns regarding the analysis method and interpretation of the results that I would like the authors to consider and address.

We thank the referee for the constructive comments and corrections that will improve the manuscript. Please find below our detailed responses.

1. In the introduction, it is stated that "Our study includes sheaths that caused only a weak geomagnetic storm (-30 nT > SYM-H min > -50 nT) or no geomagnetic storm at all (SYM-H > -30 nT)" (line 27-28 on page 3). However, from Figure 4, it seems like the sheaths in some events did trigger stronger geomagnetic storms with SYM-H < -50 nT. Please check whether this is an inaccurate statement or Figure 4 needs to be corrected.

The study includes events that caused weak or no storms, as well as events causing stronger geomagnetic activity. We have clarified the statement on page 3.

2. In this study, data from GOES-15 spacecraft were used for ULF and EMIC wave activity. However, the major results from this study focus on the dynamics of the inner magnetosphere at L<6. Since the wave distributions are L-dependent and localized, why not include measurements also from Van Allen Probes and other GOES satellites to enhance the spatial coverage?

Calculating ULF wave power from RBSP data can be good for analysing local wave characteristics on shorter timescales, but the Van Allen Probes are not ideal for looking at long-term ULF wave statistics over the course of an event. The RBSP spacecraft move relatively fast through highly different plasma environments, observing vastly different regions of the inner magnetosphere over the course of one half-orbit. GOES has the advantage of remaining at the same distance. We will look into the possibility of including ULF observations from more than one GOES satellite.

We have now discussed the effect of using ULF observations from a geostationary GOES satellite and referenced to Georgiou et al. 2018 and Engebretson et al. 2018.

3. On the other hand, the chorus and hiss wave activities were measured by the Van Allen Probes. Since chorus wave distribution is MLT-dependent, sampling may cause some bias in the statistical analysis. A plot of satellites' orbits in the statistical analysis will be helpful to reveal more detailed information.

We have considered the referee's suggestion, but feel that there is no feasible way to provide orbit information for this type of statistical analysis. In the statistical superposed epoch analysis, the median wave power is calculated from the data of 37 events at each time step, which most likely averages out MLT dependence.

4. The results of this study mainly focus on the electron flux variations. However, it is hard to isolate the effects of external drivers (i.e., sheath/ejecta) from adiabatic effects due to pure magnetic field configuration changes by only looking at electron fluxes. More discussions regarding the potential effects of adiabatic variations should be further discussed in the manuscript for both the event study and the statistical analysis.

The referee makes an excellent point, but we would like to reserve electron phase space density analysis for a more detailed study in the future. The method has been contemplated on a general level in the Discussion.

5. Line 6-8 on page 17, "Since the sheaths cause enhancements in source electrons but mostly depletion of more energetic seed electrons and the core population, they cannot, statistically, produce the so-called killer electrons (> 1–2 MeV), at least not under the studied timescales": From Figures 7 and 8, and also from the discussion earlier in this page, it seems like the seed electron fluxes enhanced in at least half of the cases. Especially during geoeffective events, despite the enhancements of both seed electron fluxes and chorus wave activity during sheaths, core population fluxes did not show enhancements. This indicates that the wave-particle interaction between chorus waves and seed populations may need a longer time to accelerate those electrons to MeV energies.

This was indeed written unclearly. We have reformulated the sentence to reflect that sheaths cause enhancements of the seed population but that depletion dominates at the highest > 500 keV seed energies.

Minor issues:
1. It may be helpful to include some discussion on the results of previous studies on the ultrarelativistic electrons in the introduction. Only a small portion of geomagnetic storms in the Van Allen Probes era caused flux enhancements of ultrarelativistic electrons (e.g., Zhao et al., 2019), which may explain the results in this study that ultrarelativistic electrons often have little response to the sheaths.
Reference: Zhao, H., Baker, D. N., Li, X., Jaynes, A. N., & Kanekal, S. G. (2019). The effects of geomagnetic storms and solar wind conditions on the ultrarelativistic electron flux enhancements. Journal of Geophysical Research: Space Physics, 124. https://doi.org/10.1029/2018JA026257.

We have now discussed the results of Zhao et al. 2019 in the Discussion.

2. Line 3 on page 3, “The most important drivers of geomagnetic activity are interplanetary coronal mass ejections. . .” -> One of the most important drivers of. . .

Corrected

3. About the solar wind data used in this study: have these observations been propagated to the bow shock nose?

Yes, thank you for noticing this. We have added this information to Section 2.1.

4. Line 11-12 on page 5, “The resampled data was acquired with linear interpolation”: Were electron fluxes also derived from linear interpolation? It makes more sense to linearly interpolate the logarithm of electron fluxes.

Thank you for this suggestion. We have now interpolated the logarithm of electron fluxes as well as the logarithm of wave power.

5. Section 3.2 and Figure 4: Some descriptions and discussions are needed for Figure 4(l) hiss waves. Also, it is confusing whether the mean or median of electron fluxes was used in this figure. From the text, it seems like the median of fluxes was used here, but the figure caption says the mean electron fluxes.

We have added a discussion of hiss waves in Section 3.2. Figure 4 shows median electron fluxes. Thank you for noticing the typo, we have now corrected the caption of Figure 4.

6. Line 8-9 on page 19, “. . .Reeves et al. (2013) showed that local acceleration, i.e., energization via wave-particle interactions, dominate in the heart of the outer belt” -> . . . during an intense geomagnetic storm of October 2012.

Added