Reply to Review 1

We thank the reviewer for their careful read of our manuscript and have replied to the comments below. The reviewer comments are shown in italic font.

Have the authors considered how sensitive the magnetic field model used in the calculations of mass density is to fluctuations in the field, and how this might impact the results? Since the manuscript considers storm time, it is highly likely that the field model will almost always be wrong for each particular instance in time (since the model is an empirical average), but accurate in a statistical sense. Can the authors please consider inserting a few lines about why using such a model is justified. Yes, more of this is in the Takahashi study, but a few lines could also be included here to inform the reader.

The model used in the Takahashi study was a storm-time magnetic field model (TS05). We have added this note to our description of how the mass density is estimated (in the introduction).

Unfortunately, the Takahashi study does not discuss magnetic field model sensitivity and we have not considered it either. As noted by the reviewer, the model will likely not capture rapid fluctuations. We think that a good experiment to perform for future mass density estimates would be to incorporate some of this uncertainty into the modeling to allow error bars to be determined for mass density estimates.

In the case of the manuscript, we do not believe that one-directional bias or large error bars would have a significant influence on our conclusions, because we looked at threshold crossings.

One other part of the paper that I felt could benefit from improvement was discussion of the implications of the results which is currently very weak. It is generally considered that most of the mass density will result from outflow from the ionosphere. The F10.7 variation supports that. It would be nice to see more discussion of the implications of the results on such wider issues. For example, the strong variation with F10.7 implies a connection with enhanced outflows but what about composition issues regarding the effect of the ratio of O+/H+ on the mass density?

We agree with this statement. When starting the work associated with what was presented in this manuscript, our ultimate goal was to be able to both identify the solar wind drivers and provide additional insight into the internal composition processes that lead to equatorial mass density increases.

We have added a few sentences in the second-to-last paragraph of the summary and conclusions in an attempt to provide additional insight into the driving physics:

> “Denton et al. [2016] showed that the ratio of O^+/H^+ changes greatly with solar cycle, with larger amounts of O^+ occurring during solar maximum (when $F_{10.7}$ is elevated). The dependence of the mass density response on $F_{10.7}$ suggests that the process responsible for enhancing ρ_{eq} during geomagnetic storms may have a strong sensitivity to the O^+/H^+ ratio.”

Based on the limitations on the database considered, we were not able to find any additional statements about implications beyond those presented in the paper. We have considered analysis that would include mass density ratios, but concluded that there just was not enough data for firm conclusions to be drawn using event-style statistical analysis as was considered in the manuscript. From our perspective, to answer such questions with event-style statistical analysis would require a much longer and much less sparse set of measurements.