Ann. Geophys. Discuss.,
https://doi.org/10.5194/angeo-2019-125-RC1, 2019

Annales Geophysicae Discussions

Interactive comment on "Estimating the fate of oxygen ion outflow from the high altitude cusp" *by* Patrik Krcelic et al.

Anonymous Referee #1

Received and published: 18 September 2019

General comments

This paper studies oxygen ion escape from the polar cusps and determines which region ions ultimately reach (dayside magnetosheath, plasma sheet, or solar wind through the distant X-line in the magnetotail), and in which proportions. The authors use measurements from the EDI and CODIF instruments aboard Cluster to obtain statistics of cusp and plasma mantle convection speed and oxygen ion fluxes and parallel speeds, respectively. They trace the trajectories of oxygen ions from their initial location in the cusp in the geomagnetic field using the Tsyganenko and Stern T96 model, with a simple parametrisation for particle acceleration along geomagnetic field lines depending on the region in the cusp/lobe. The conclusions are that, overall, 69% of the oxygen escaping from the high-latitude cusps reaches the solar wind

(19% through the dayside magnetosheath, 50% through the magnetotail distant X-line), whereas 31% reaches the plasma sheet. When separating driving conditions as a function of geomagnetic activity given by the Dst index, the authors find that enhanced activity (Dst < –20 nT) increases the amount of oxygen ions returning to closed field lines in the plasma sheet.

The paper is pleasant to read, as it is well-organised and has clear figures. The authors carefully justify their choices such as the magnetic field model version or the cusp latitudinal extent. My comments below are therefore mostly minor ones, except perhaps regarding the choice of Dst ranges for binning according to geomagnetic conditions.

Specific comments (major)

The only major comment I have is related to the choice of Dst values used in the data separation according to geomagnetic activity. Indeed, positive values of Dst can be associated with so-called sudden commencement, which is generally triggered by solar wind pressure pulses (see for instance https://doi.org/10.1029/2006JA012141; https://doi.org/10.1029/2011JA017255). This seems consistent with the fact that, in Table 1, the solar wind dynamic pressure has its highest average value for the Dst > 0 condition. Therefore, it seems a bit strange to me to call this category "quiet conditions" since they may include sudden commencement events.

On the other hand, the threshold of Dst < –20 nT to define "active" conditions would need to be justified. Indeed, Dst = –20 nT is considered by some authors to belong to the category of "quiet conditions" (see for instance https://doi.org/10.1029/2008JA013095 paragraph [30] in sect. 5.3.1).

I would therefore recommend to either modify the Dst thresholds when studying the effects of geomagnetic activity on the fate of oxygen ions, or to add a justification for choosing these values as well as a discussion on potential effects of sudden commencements in the Dst > 0 situation.

Specific comments (minor)

- p. 2, l. 21: It could be helpful for the reader to give a range of values for "high altitudes", since it is a recurring concept in this paper.
- Figure 2: Perhaps it would be nice to add the lines showing the boundaries of cusp and plasma mantle from Fig. 1 on both panels of Fig. 2, for the reader to be able to relate it to the discussion on p. 5, l. 3.
- p. 8: I would suggest that, whenever writing acceleration units, a space be added (m s^{-2}) to avoid any possible confusion with "per squared millisecond".
- Figure 4: I would recommend slightly increasing the line thickness as well as the font size to improve the legibility of this figure.
- p. 12, l. 8–9: Strictly speaking, the lower (upper) quartile is not defined as one standard deviation below (above) the average. I would therefore recommend to rephrase the corresponding sentence.
- Figure 9: I am intrigued by the isolated black pixel in the right panel (near X = 1.5 R_E, R = 8.5 R_E). It is mostly curiosity, but would it be possible to briefly explain the reason why the oxygen from this bin reaches the dayside magnetosheath rather than the plasma sheet?
- p. 14: Would it be possible to add, perhaps as supplementary material, a figure showing the coverage of EDI and CODIF data for each of the three geomagnetic activity conditions, in a similar way as shown in Fig. 2? This could prove useful when discussing the results shown in Fig. 11. While the rather poor coverage for "quiet" and "active" conditions is unlikely to affect the overall results (as stated on p. 14, l.3), it would be valuable to discuss to what extent conclusions on the oxygen fate under those two types of conditions might be affected by the lack of data.

- p. 18, l. 1: The third point given in conclusions has not been mentioned above. I think it would be better to introduce the corresponding result and explain how it was obtained in one of the previous sections (Results or Discussion).

Copyediting and typesetting

- p. 5, l. 11: ware → were
- p. 7, l. 17: consider → considered
- p. 11, l. 10: an measurements → a measurement / measurements

---

Interactive comment on Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2019-125, 2019.