Answer to the referee #1

We would like to thank the referee for his/her comments. We hereby answer the comments in green.

By going through the revisions, we found some errors in the automatic routine as well as the value of the perpendicular velocity in equation 1. The perpendicular velocity used in the submitted manuscript has been the bulk perpendicular velocity calculated from CODIF instrument. However, this perpendicular velocity is dominated by the ExB drift velocity, to what we added an additional initial ExB at the start of the tracing. Even though this was done, the velocity was underestimated compared to the thermal velocity of ions (for CODIF, the estimated thermal velocity is significantly higher than the bulk perpendicular velocity). We should have used the thermal velocity to begin with. We therefore reran all our events with the thermal velocity instead of the perpendicular velocity. We consequently updated all figures accordingly to the new simulations. The results are very similar but slightly different.
Please also note that we removed "cusp" from the title to avoid confusion, since our observations are mainly in the plasma mantle region.

1. Implementation issues

The model is based on tracing test particles in a magnetosphere described by the T96 and Weimer 2001 models for magnetic field and potential, respectively. It is implied, but not directly stated, that the authors use the actual solar wind conditions for the events they study. Both T96 and Weimer 2001 are statistical models based on averages of observations under particular solar wind and IMF conditions. Some of the T96 input parameters take into account the history of relevant solar wind and IMF conditions. However, the Weimer models are known to have unphysically rapid responses to shocks and other interplanetary transients, as well as Alfvénic fluctuations in the IMF. Some caveats will be needed in cases where a shock or other interplanetary transient impacts the magnetosphere during the period covered in the modelling.

We use indeed the actual solar wind for the events studied. Most of strong disturbed conditions are removed from the data by Tsyganenko model requirements. Additionally, we looked at shocks through the Cfa interplanetary shocks database (https://www.cfa.harvard.edu/shocks/) simultaneously with the solar wind data. After a cross-check of these data, we removed 5 events. If a shock appeared in the next hours (after our events), we did not remove the event considering that if the solar wind conditions were too extreme at the initial time of our event, Tsyganenko requirements does not take the event into account. See clarifications in lines 132-133 of the revised manuscript.

The model is a test particle model which, as noted in the manuscript, neglects wave-particle interactions. This is a reasonable approximation in the outer magnetosphere but not in the inner magnetosphere, where some combination of chorus, EMIC, and ULF waves can produce pitch angle scattering and therefore affect loss rates (precipitating ions should not be considered losses in the context of this paper). Some caveats on this issue are also needed.

Our simulations are done mainly in the plasma mantle, which is considered to be in the outer magnetosphere (and very few events from the high-latitude cusp). In our automatized routine, we used a criteria of R > 6 Re in order to remove the inner magnetosphere. Therefore, we believe that our code is valid and gives reasonable trajectories for the ions observed in the plasma mantle. Also, our main purpose is to confirm that majority of the O^+ in the plasma mantle are directly escaping into the solar wind or in the distant tail. Should our tracing lead the particles to the inner magnetosphere, we consider them as not lost, as discussed in the paper.

The simulation domain covers 60 <= X <= 10 Re . The justification for the upper limit is the magnetopause location. But X = 10 Re is merely the average location of the subsolar magnetopause; the actual location can move inward or outward depending on solar wind dynamic pressure. The simulation box should therefore be extended a bit sunward to cover the case of reduced solar wind pressure.
The simulation box is used for the electric field calculation along the magnetic field lines. Since we are tracing the ions from the plasma mantle and very few in the cusp, the limit of the electric field box is enough at X = 10 Re. The Y and Z directions are more important from X = 0 Re to approximately X = 5 Re, in order to include the moving magnetopause in the Y and Z directions. This aspect is covered by our limits in |Y| and |Z| directions that equals approximately 20 Re. The ions traced in the dayside plasma mantle are escaping almost directly through the magnetopause and never reach distances higher than the simulation box limit in the dayside. Therefore, the limit at 10 Re in X direction is enough for our study and extending the box would require more computational time without providing more accurate trajectories.

The authors treat the boundary of the inner magnetosphere as spherical and constant in time at a distance of 10Re. The real boundary is neither static nor spherical: when solar wind dynamic pressure is elevated the nose of the magnetopause can be pushed inside 10 Re, which is its nominal location, and the relevant coordinate in the inner magnetosphere is the McIlwain parameter L rather than the radial distance R used in the manuscript.
We agree that the representation we used do not represent the real boundary. However, we only want a parameter that defines the boundary where the ions escape. In our case, we believe a spherical and static boundary for average conditions is good enough for statistics. For slightly disturbed conditions, the whole magnetosphere is compressed and our boundary is then overestimated and ions escape anyway. Please also note that strong disturbed conditions are removed by Tsyganenko model requirements.

2. Clarifications about the model

Equation (1) as written in the manuscript is not correct, because it has a scalar quantity on the left-hand side and a mixture of scalars and vectors on the right-hand side. If this was intended to be a vector equation, then all terms in the equation should be vectors. If the left-hand side was intended to be a scalar, then the right-hand side should be the square root of the sums of the squares of the components.
We are sorry for the confusion, equation (1) is a vector. We have corrected the equation in the new manuscript. Please note that we have updated the equation according to our new simulations (thermal velocity instead of bulk perpendicular velocity), lines 150-154. See also explanation at the beginning of the review.

Although the reader can deduce this from the subsequent figures, there should be an explicit statement in section 3.1 that the code traces the full 3-D velocity vector rather than using the guiding centre approximation.

We slightly changed the text, see lines 150-154. Additionally, equation (1) has been rewritten and therefore clarify the 3 dimensions of the velocity vector.

The authors do not give the X location for the listed magnetopause location of |Y | = 13 Re and |Z| = 13R E. The magnetopause can be approximated as cylindrical in the deep tail but still usually has some flaring at the X = 0 plane, which is where I think the quoted numbers are supposed to apply.
Yes, the numbers for Y and Z apply for X=0. We have added this detail in the new manuscript, see line 162.

In section 3.2, the authors should be explicit about using time-varying solar wind and IMF inputs.
We added a precision in the sentence saying that the solar wind conditions for each corresponding event are taken at the initial time (start time of the event). See lines 171-172 in the reviewed manuscript.

3. Miscellaneous issues

The result that the O^+ outflow increases by 1.5 orders of magnitude during active times compared to quiet times (specifically using Kp as an activity indicator) is not original with Slapak et al. (2017). The same result was obtained from DE data by Yau et al. (1985), JGR 90, 8417, doi:10.1029/JA090iA09p08417, which paper should be cited in that paragraph.
We have added this reference and Yau et al. (1988) as well, see lines 43-46. Slapak et al. study is actually based on their flux equations. The main difference between Slapak et al (2017) and Yau et al. (1985, 1988) is altitude. Slapak et al. examined the O+ ions in the plasma mantle whereas Yau et al. examined lower altitudes (accordingly, the energy range is different) and this is why our simulations start from the plasma mantle rather than DE altitude that all past models used.

In the data selection thresholds given at line 119, I think the "and" should be an "or", since the intent is to exclude a velocity range in which the O + channel is contaminated by protons.
Yes, indeed the “and” should be changed in “or”. We have corrected this in the new manuscript.

The quantity plotted on the X axis of Figure 4c is described as "minimum X distance" in the text, the figure caption, and the axis label. I do not think this is an accurate description of the quantity being plotted, since it covers the full range of the simulation box. A clearer description of this quantity would provide better insight into its physical significance.
We defined the minimum distance Xmin as the minimum value in the X direction of the trajectory length. So in a trajectory of 280 steps, we take the minimum value in X direction within the 280 points. The maximum number of steps for a trajectory is 10000 and the shortest trajectory we obtained has 7 steps, the average trajectory steps is 1029. So, figure 4c represents the minimum value of each trajectory length, which indicates that most of the ions reach distances between X = -10 Re and X = -20 Re. These ions might end their journey at that distance or may go back towards Earth after interacting with the plasma sheet. For most of the particles the minimum distance is their ending position. The peak at X = -60 Re includes the particles stopped at the limits of our model.
We have now clarify this “minimum X distance” in the new manuscript, see lines 224-227.