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Reply on RC1

Zhanrong Yang et al.

Author comment on "Width of plasmaspheric plumes related to the level of geomagnetic storm intensity" by Zhanrong Yang et al., Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2022-20-AC1, 2022

In their paper, Yang et al. address the question of the width plasmaspheric plumes and how it correlates with the intensity of the geomagnetic storm. Previous work (Borovsky et al, 2008) already showed that there are no correlation (confirmed by this work when looking at the whole event), but this work showed that a negative linear correlation can be found when focusing only on the recovery phase of the storm.

To reach this conclusion, this paper used spacecraft data from the Van Allen mission (ranging from 2012 to 2019), used different definition of the plasmaspheric plume width and excluded extreme events to create a set of events in order to perform statistic analysis. It also use simulation data to explain its results, explaining in particular the inverse correlation by a stronger erosion of the plasmasphere during the initial and mains phase of the geomagnetic storm, resulting in narrower plumes in the recovery phase.

The results of this paper are clear and well explained. The use of simulation offers a nice development of the observation results, offering a new result of use for the community working on plasmaspheric plumes. I would recommend this paper for immediate publication if not for minor comments listed below, my main issue being some lack of clarity when manipulating the statistic tools.

Main comments:

L. 121 —> the set of data used for the Spearman (and Pearson) correlation has a strong constraint:

it needs set of data with the same number of data. This first point is already unclear, as you don't say what is N (the number of data point). And then, given the constraint, it is also important that you develop clearly later how you define those set of data so that you can apply these methods.

In Fig 3 (and the text associated), you explain quite clearly how you select your events, and why you make those choices. However, it is interesting to see that purple point events (extreme events) always match quite well with orange points event (not in the recovery phase). A sentence or two about this and the possible explanation of this correlation would be interesting in the discussion.

Answer:

Thanks for your suggestion. We calculated the Pearson correlation between the average plume width in every 5 nT interval and the median Dst in the corresponding interval. Obviously, they have the same data length with N equals 15.

We notice the interesting phenomenon about the orange points and purple points event. For statistical results, this paper only analyzes the plume events with Dst value ranging from -90 nT to -15 nT during the recovery phase. The analysis of plume events in too weak magnetic storms will be our further work. And there are few plume events from -90 nT to -209 nT in the range of excessively negative Dst values (less than 12% plume events in the range of 57% Dst values), so analyzing this portion of the plume events would bring about a chance result. Therefore, we exclude the events with excessively negative Dst values (less than -90 nT).

More information about N is supplemented in the new manuscript:

On Lines 120-123:

‘As described above, we use the averaged width of the detected plume in steps of 5 nT (Dst index) to represent the plume width in the corresponding Dst range. N is equal to 15 if the geomagnetic activity levels from Dst~-15 nT Dst~-90 nT are considered in the study.’

The discussion about your suggestion is supplemented in the Discussion and Conclusion part of the new manuscript:

On Lines 158-162:

‘This paper analyzes the plume events with Dst value ranging from -90 nT to -15 nT during the recovery phase. In the future study, we will use other geomagnetic activity indices to analyze the relationship between plume width and magnetic storm intensity, such as Kp, and AE, thus studying the correlation between the plume width and substorm activity.’

L.229 —> The F, G and VS functions are not detailed later. You need more precisions. If this is too long for the core of the paper, maybe in annex.

Answer:

Thanks for your suggestion. The specific expressions and modulation effect on SAPS of F(r,φ), G(φ) and $V_S(t)$ are supplemented in the revised manuscript:

On Lines 234-243:

‘The detail formulas of functions are as following:

[1]. The function F(r,φ) treats the SAPS flow channel as a potential drop centered at radius R_S:

$$F(r,\varphi) = \frac{1}{2} + \frac{1}{\pi}\tan^{-1}\left[\frac{2}{\alpha}\{r - R_s(\varphi)\}\right] \qquad (5)$$

where $R_{S,\alpha}$ are represented as:

$$R_s(\varphi) = R_0\left[\frac{1+\beta}{1+\beta\cos(\varphi-\pi)}\right]^{\kappa} \qquad (6)$$

with β=0.97 and κ=0.14. And R_0:

$$R_0/R_E = 4.4 - 0.6(K_P - 5) \qquad (7)$$

here R_E is the radius of the Earth, 6380 km.

α is expressed as:

$$\alpha = 0.15 + (2.55 - 0.27K_P)\left[1 + \cos\left(\varphi - \frac{7\pi}{12}\right)\right] \qquad (8)$$

[2]. Based on the magnitude of the SAPS potential drop decreases eastward across the nightside, azimuthal modulation of SAPS magnitude G(φ) is set to:

$$G(\varphi) = \sum_{m=0}^{2}\{A_m\cos[m(\varphi-\varphi_0)] + B_m\sin[m(\varphi-\varphi_0)]\} \qquad (9)$$

[3]. The $V_S(t)$ function describes the time regulation of SAPS:

$$V_S = (0.75kV)K_p^2 \quad (10)$$

’

Minor comments:

L.92: MLT (Magnetic Local Time, I guess) is not defined before use.

Answer:

Thanks for your suggestion. The definition of MLT has been added to the first mentioned position of MLT in the revised manuscript:

On Lines 93-94:

‘Second, the width is considered the difference between the magnetic local times (MLTs) of the two plume ends (ΔMLT).’

L.209: I’d prefer if you give the meaning of PTP, even if this is related to the quoted works.

Answer:

Thanks for your suggestion. The meaning of PTP and the difference between PTP and our particles simulation have been added in the revised manuscript:

On Lines 210-212:

'In this study, this process differs from the plasmapause test particle (PTP) simulation which only provides the evolution of the plasmapause and plasmaspheric plume boundaries in Goldstein et al. (2004; 2014a; 2014b);'

L.253: typo: EIM —> E_{IM}

Answer:

Thanks for your reminder. This spelling mistake has been corrected in the revised manuscript:

On Lines 265-266:

'..., the maximum E_{IM} index reached 0.4684 mV/m.'

L.340: probably a typo (.javascript:void(0))

Answer:

Thanks for your reminder. This mistake has been corrected in the revised manuscript:

On Line 353:

‘..., width during the recovery phase of geomagnetic storms.’

L.363: I think you can merge the financial support with the acknowledgment

Answer:

Thanks for your suggestion. The acknowledgement and the financial support have been merged in the revised manuscript:

On Lines 375-380:

‘**Acknowledgments and financial support.**

This research is supported by the National Natural Science Foundation of China (Nos. 42064009). The data of EMFISIS onboard Van Allen Probe are from (http://emfifisis.physics.uiowa.edu/Flight/. The Dst and KP data are provided by OMNI at http://cdaweb.gsfc.nasa.gov. This research has been supported by the National Natural Science Foundation of China (grant nos. 42064009).’

L.490. Maybe detail the different units used in abscissa of the plot.

Answer:

Thanks for your suggestion. It is obviously more standardized for the paper after indicating the different units, so the units have appear in the Figure 1, Figure 8i and Figure 10i in revised manuscript:

Figure 1.

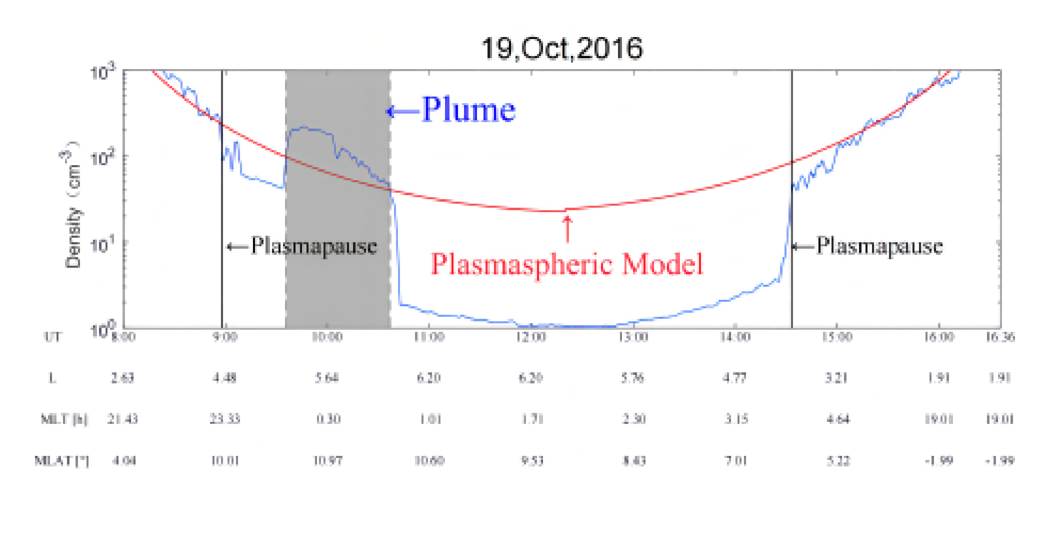


Figure 8.

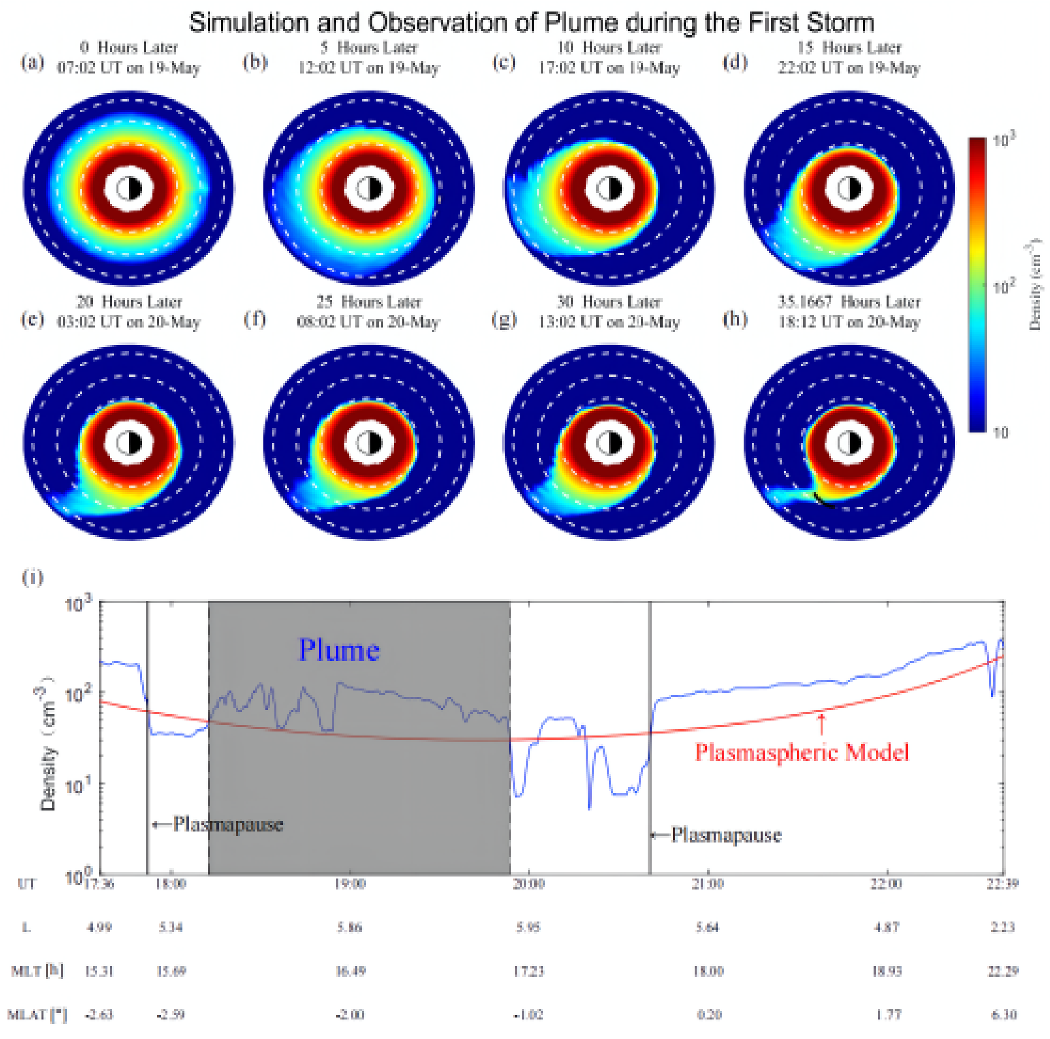
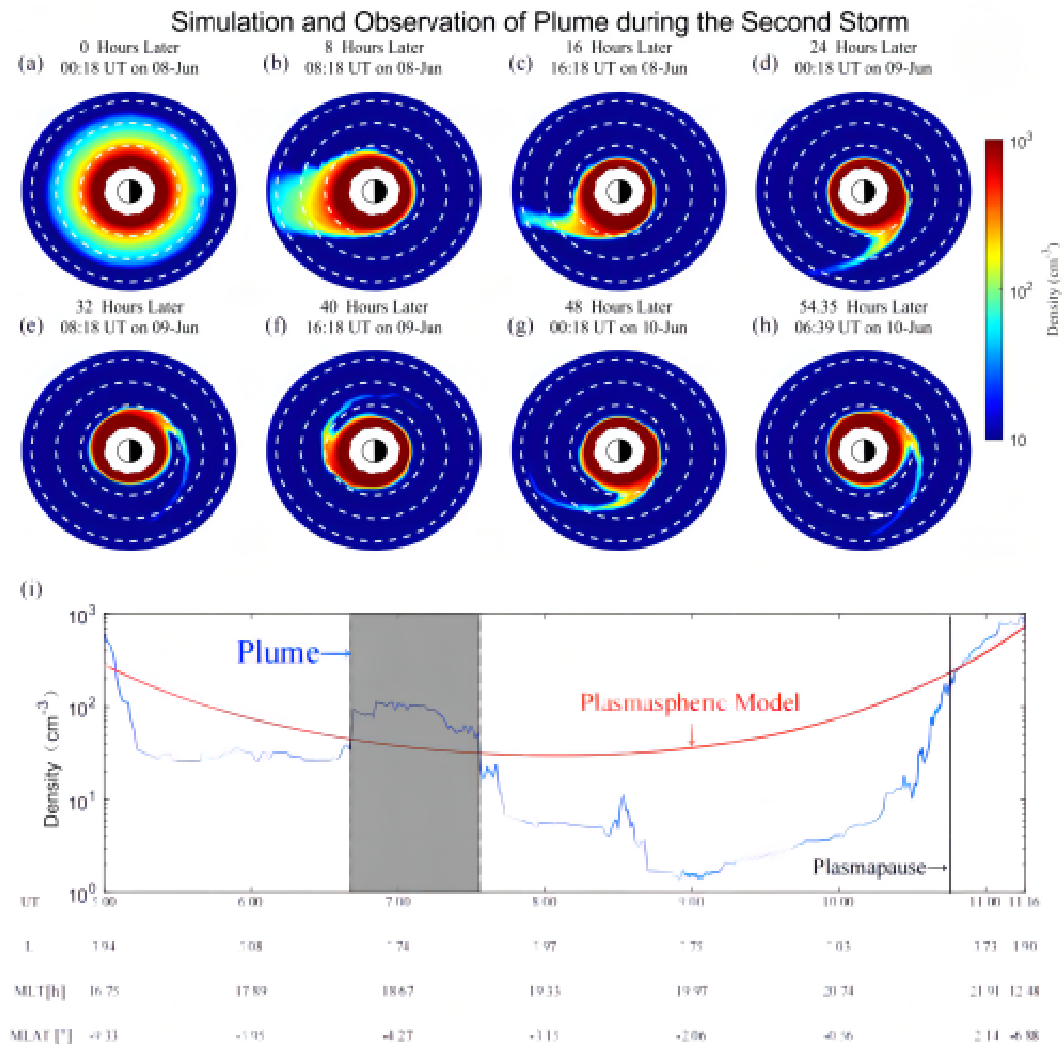

Simulation and Observation of Plume during the First Storm
(a) 0 Hours Later 07:02 UT on 19-May
(b) 5 Hours Later 12:02 UT on 19-May
(c) 10 Hours Later 17:02 UT on 19-May
(d) 15 Hours Later 22:02 UT on 19-May
(e) 20 Hours Later 03:02 UT on 20-May
(f) 25 Hours Later 08:02 UT on 20-May
(g) 30 Hours Later 13:02 UT on 20-May
(h) 35.1667 Hours Later 18:12 UT on 20-May
Density (cm⁻³)
(i)
Plume
Plasmapause
Plasmaspheric Model
Density (cm⁻³)
UT 17:36 18:00 19:00 20:00 21:00 22:00 22:39
L 4.99 5.34 5.86 5.95 5.64 4.87 2.23
MLT [h] 15.31 15.69 16.49 17.23 18.00 18.93 22.29
MLAT [°] -2.63 -2.59 -2.00 -1.02 0.20 1.77 6.30

Figure 10.


Simulation and Observation of Plume during the Second Storm
(a)
0 Hours Later
00:18 UT on 08-Jun
(b)
8 Hours Later
08:18 UT on 08-Jun
(c)
16 Hours Later
16:18 UT on 08-Jun
(d)
24 Hours Later
00:18 UT on 09-Jun
(e)
32 Hours Later
08:18 UT on 09-Jun
(f)
40 Hours Later
16:18 UT on 09-Jun
(g)
48 Hours Later
00:18 UT on 10-Jun
(h)
54.35 Hours Later
06:39 UT on 10-Jun
Density (cm⁻³)
(i)
Plume
Plasmaspheric Model
Plasmapause
Density (cm⁻³)
UT
L
MLT[h]
MLAT [°]
6:00
7:00
8:00
10:00
11:00
11:16
16.75
17.89
18.67
19.33
19.97
20.74
21.91
12.48
-4.27
+2.06
+6.88