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Interactive comment on "A New Perspective and Explanation to the Formation of Plasmaspheric Shoulder Structure" *by* Hua Zhang et al.

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Dear anonymous Referee1:

I am very happy to receive your recommendation and very grateful for your advice. We have followed your comments to revise this manuscript. Then, due to the stupid organization and poor English make readers understand difficulty, we have made efforts to revise and hope that you could be satisfied. In the resubmitted paper, new text is emphasis as red text.The Referee Comments is abbreviated to "RC", and Authors' Response is abbreviated to "AR".

The following are the response of each major comment: RC 1: The manuscript is poorly written, and the expressions in many sentences are confusing. These mistakes

made the manuscript hard to understand. However, it is highly recommended that the authors carefully proofread the manuscript. AR 1: I am agree with the advice, and have revised this problem in my manuscript. We will call for professional company to polish the manuscript before formal publication.

RC 2: Figure 3 illustrates the comparison between the observations and the TPM model, which is essential to the main conclusions. However, the authors provided only the processed plasmapause location (red curves) every 3 hours. It is recommended that the authors (1) show the raw images from the EUV/IMAGE observations for comparison, (2) show the simulations at higher temporal resolution (e.g., 1 hour) so that the evolutions are clear. AR 2: To recommendation (1): the raw images of the EUV/IMAGE observations are color drawing and have serious light contaminates (see in left panel of Figure 1), so no processing to superpose the simulations of TPM is not good effects. We submit the raw images of the EUV/IMAGE observations in the supplementary material. To recommendation (2): In this case, there are 8 panels output in Figure 3. If 1 hour temporal resolution is used to simulate, there are 24 panels outputs in Figure 3 results in crowds and poor typesetting. During two adjacent panels of the TPM output, the plasmasphere corotates approximately 3MLT, and spatial resolution enough is used to study evolution of plasmaspheric structures.

RC 3: The authors discussed the formation of the double Plumes in the TPM model. However, they did not provide any observations to validate the existence of the double Plume. AR 3: The double Plumes firstly arises in Figure 3(e), but the IMAGE satellite is too close to the Earth to provide any global view of the plasmasphere during this period of time. The double Plumes structure has been simulated in Pierrard and Cabrera [2006] (has been listed in References). In this paper, the author indicates the double plumes derives from the Shoulder evolution based on sequential panels of TPM simulation.

RC 4: The proposed theory of the plasmaspheric shoulder involved the dawn-dusk convection electric field. It is recommended that the authors provide the comparisons be-

tween the Weimer electric field and the EUV/IMAGE observations and the TPM model, which is essential to support the conclusion. AR 4: I am sorry that I cannot understand the referee's meaning. The Weimer electric field maps into magnetosphere as the dawn-dusk convection electric field, and then is used to simulate evolution of the plasmasphere in the TPM model.

RC 5: Captions for Figures 2 and 3 need further improvement. The red circles in Figure 2 are barely visible. The definition of the black/white filled contours in Figure 3 are missing. Some legends are missing from Figure 3 (e.g., Plume2 in line 158). AR 5: Thank you for your recommendation, I have revised Figures 2 and 3 according to your advice in the resubmitted manuscript. And the definition of the black/white filled contours in caption of Figure 3 rewrite.

RC 6: Line 191-197 and Figure 4 are very confusing. Are these test particles placed in a static electric field at a specific time (the same as Figure 1)? Or are the electric field changing during the substorm event (from 0600 UT to 2100 UT)? Is the x-axis time-dependent (UT) or location-dependent (MLT)? AR 6: I am sorry for indistinct presentation in Line 191-197 to confuse the referee. These test particles placed in a static electric field and the electric field changing with 3-minute time resolution (same as describe in line 109-110). The x-axis is both time -dependent(UT) and location-dependent (MLT). I have rewrite the caption of Figure 4 .

RC 7: Figure 4b is very confusing and hard to understand. I suggest that the authors consider a contour plot (w/w) with the x-axis (either UT or MLT) versus the y-axis (L-shell). AC 7: I have rewrite the caption of Figure 4. The legend illustrates various initial location of test particles. The Formation of Shoulder derived from the rotation of differential motion withÂăL-shell, so the y-axis label as rotation rate is necessary .

RC 8: Line 277-281 (conclusion 3): The third point is more of a result from the TPM model rather than a scientific conclusion. The authors should provide (1) a scientific intensive in the introduction section, (2) provide observational evidence to support

the formation and evolution of the Plume (or double Plume, or second-Plume), and (3) show a comparison between the observations and the simulation to support their conclusion. AC 8: I am agree with the advice, and have revised this problem in my manuscript. I have introduced Pierrard and Cabrera (2006) to the introduction in line 33-34, who also simulated the double Plumes in paper, but not explained origin of second-Plume. I also revised Figure 3 (f) to produce the observations and the simulation of the double Plume.

RC 9: Line 119-120. The reasons also include the limitation in the TPM model and the unrealistic Weimer electric field model. AC 9: I revised this problem of manuscript according to your advice. Please see revised content in Line 122-123.

Technical corrections: Confusing sentences or grammatical errors

RC 1) : 'a', 'an', 'the' are missing throughout the manuscript. AC 1) : I have try my best to revise grammar and usage in the resubmitted manuscript. I originally wanted to ask a professional service to solve the grammatical problems, but I am not sure whether this revision is the last version. If the Referee think that there is only a grammatical problem in final version, I will ask a professional agency to solve it again. Please understand my difficulties.

RC 2) : The sentence in lines 16-18. AC 2) : Lines 14-18, the sentence "The analysis indicated that the Shoulder is created by a dawn-dusk convection electric field intensity, sharp reduction and spatial nonuniform manifested. As, combination of the plasmaspheric rotation rate speed up with L-shell increase and plasma flux do radial outflow in the predawn sector to interact, and produce an asymmetric bulge that rotates eastward. " is replaced by "The analysis indicates that the Shoulder is created by sharp reduction and spatial nonuniform of a dawn-dusk convection electric field intensity. Combined action of the plasmaspheric rotation rate speeding up with L-shell and plasma flux doing radial outflow in the predawn sector, results in an asymmetric bulge rotating eastward to reproduce the Shoulder structure. "

RC 3) : The sentence in lines 73-74. AC 3) : Lines 73-74, the sentence “Subsequent pictures show that the Shoulder-like structure remaining and corotating with main plasmaspheric body by discussion in the next section.” is replaced by “ Comparison sequential observations with the simulation pictures, show that the Shoulder-like structure keeping and corotating with the main plasmaspheric body can be seen in Figure 3, and is discussed in the next section”.

RC 4) : The sentence in lines 79-80. AC 4) : Lines 79-80, the sentence “ In the next section, we would discuss simulation of Shoulder and Plume evolution on 8 June 2001 case base on the TPM method ” is replaced by “ In the next section, we take the case of 8 June 2001 observation as an example, to discuss the simulation of the Shoulder and the Plume evolution based on the TPM method. ”

RC 5) : Line 105: Word->World AC 5) : Line 106, the word “Word” is replaced by “ World ”.

RC 6) : The sentence in lines 79-80. AC 6) : The same as RC 4).

RC 7) : Line 109: run-> runs AC 7) : Line 110, the word “run ” is replaced by “ runs ”.

RC 8) : Line 110: which-> whose AC 8) : Line 111, the word “which ” is replaced by “ whose ”.

RC 9) : The sentence in lines 148-150. AC 9) : Lines 148-150, the sentence “The Shoulder1 firstly arises at 12 UT in the morning sector(see in Fig.3(a)), and then corotates with the Earth reaching to the afternoon region at 18 UT (see in Fig.3(c)), on 8 June 2001. At this time, Kp index increases to 3+ ” is replaced by “ The Shoulder1 firstly arises on Fig.3(a) in the morning sector (at 12 UT, 8 June 2001), and then corotates with the main body of the plasmasphere to the afternoon sector on Fig.3(c)(at 18 UT, 8 June 2001). During this period, Kp index increases to 3+ from 1”

RC 10) : Line 156: the infantile Plume2. What does ‘infantile’ mean? AC 10) : ‘the infantile Plume2’ means the Plume2 just appear, not mature Plume structure in line

158.

RC 11) : The sentence in lines 168-169. AC 11) : Lines168-169, the sentence “The plasma refilling from plasma sheet results in the Notch structure disappear (Gallagher et al., 2005). The results of simulation show the Channel structure in Fig.3(e)-(f) ” is replaced by “Plasma refilling originating from plasma sheet, result in the Notch structure disappearance (Gallagher et al., 2005). The results of simulation reproduces the Channel structure in Fig.3(f) ”.

RC 12) : The sentence in lines 148-150.. AC 12) : The same as RC 9).

RC 13) : The sentence in lines 175. AC 13) : Lines173-175, the sentence “ due to the fact that the potential structure does not cause the inward convection of plasma in the afternoon sector, and the low disturbance time is maintained for no long enough time. ” is replaced by “ due to the fact that the potential structure not cause the inward convection of plasma in the afternoon sector, and the low disturbance time is maintaining for not long enough.”

RC 14) : The sentence in lines 184-187. AC 14) : Lines184-187, the sentence “The Bz value must lower than previous 24-hours value, due to the intensity of the convection electric field lower than previous level, so the last closed equipotential line (LCE) would close to the Earth and result in plasmapause of peeled off in the predawn sector (Zhang et al., 2013). One can see that no shoulder appearance in the results of the simulation, produced at 02:00 UT, 05:00 UT, and 08:00 UT on 9 June 2001 respectively. ” is replaced by “ One can see that no shoulders reproduced in the results of the simulation, at 02:00 UT, 05:00 UT, and 08:00 UT on 9 June 2001 respectively. The Bz value of southward component must less than previous 24-hours mean value. The intensity of the convection electric field is greater than previous 24-hours level. So the last closed equipotential line (LCE) would closer to the Earth and results in plasmapause of peeled off in the predawn sector (Zhang et al., 2013). ”

RC 15) : The sentence in lines 208-210. AC 15) : Lines208-210, the sentence “ So,

the Shoulder has a sharp eastern edge about 0.5Re∼0.7Re in radial extension and in a range of 3 MLT." is replaced by " So, the Shoulder has a sharp eastern edge about 0.5Re∼0.7Re in radial extension and across a narrow 3-5 hours MLT region "

RC 16) : The sentence in lines 218-220. AC 16) : Lines218-220, the sentence "The previous researchers analyze the EUV observation and propose the Shoulders structure have MLT sharpening in the angular direction, which indicate the outer edge of the Shoulder rotates faster than the inner edge, resulting in the gradual increase of MLT-profile of the Shoulder (Goldstein et al., 2002) " is replaced by " The previous researchers analyzed the EUV observation and proposed the Shoulder structure has MLT sharpening in the angular direction. It indicates that the outer edge of the Shoulder rotates faster than the inner edge, resulting in steepening of the MLT-profile of the Shoulder (Goldstein et al., 2002). "

RC 17) : The sentence in lines 239-240. AC 17) : Lines 239-240, the sentence "So, we suggest that the physical mechanism of shoulder formation is the result of plasma extrusion in the predawn sector, caused by outer plasmasphere drifts radial outward and rotates faster." is replaced by " So, we propose that the physical mechanism of the shoulder formation is plasma extrusion of outer plasmasphere in the predawn sector, due to outer plasmasphere both drifts radial outward and rotates faster. "

RC 18) : The sentence in lines 244-246. AC 18) : Lines 244-246, the sentence " The first reason is that the level of Kp index and the convection of magnetosphere is increase, so the value of these parameters driven convection field in this case is greater than the previous study articles in the geomagnetic quite case" is replaced by "The first reason is that this is a substorm case, so the convection of magnetosphere is greater than the previous study articles of the geomagnetic quiet case. "

RC19) : Line 255:downside-> dawnside AC 19) : Line 255, the word "downside " is replaced by " dawnside ".

RC 20) : The sentence in lines 218-220. AC 20) : The same as RC 16)

You can see the detailed changes in the resubmitted manuscript. If you have any problems, please contact me immediately. I am very grateful for your comment. Thank you very much.

Best Regard Hua Zhang The 1th author of this manuscript

Please also note the supplement to this comment:
https://angeo.copernicus.org/preprints/angeo-2020-86/angeo-2020-86-AC1-supplement.pdf

Interactive comment on Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2020-86, 2020.