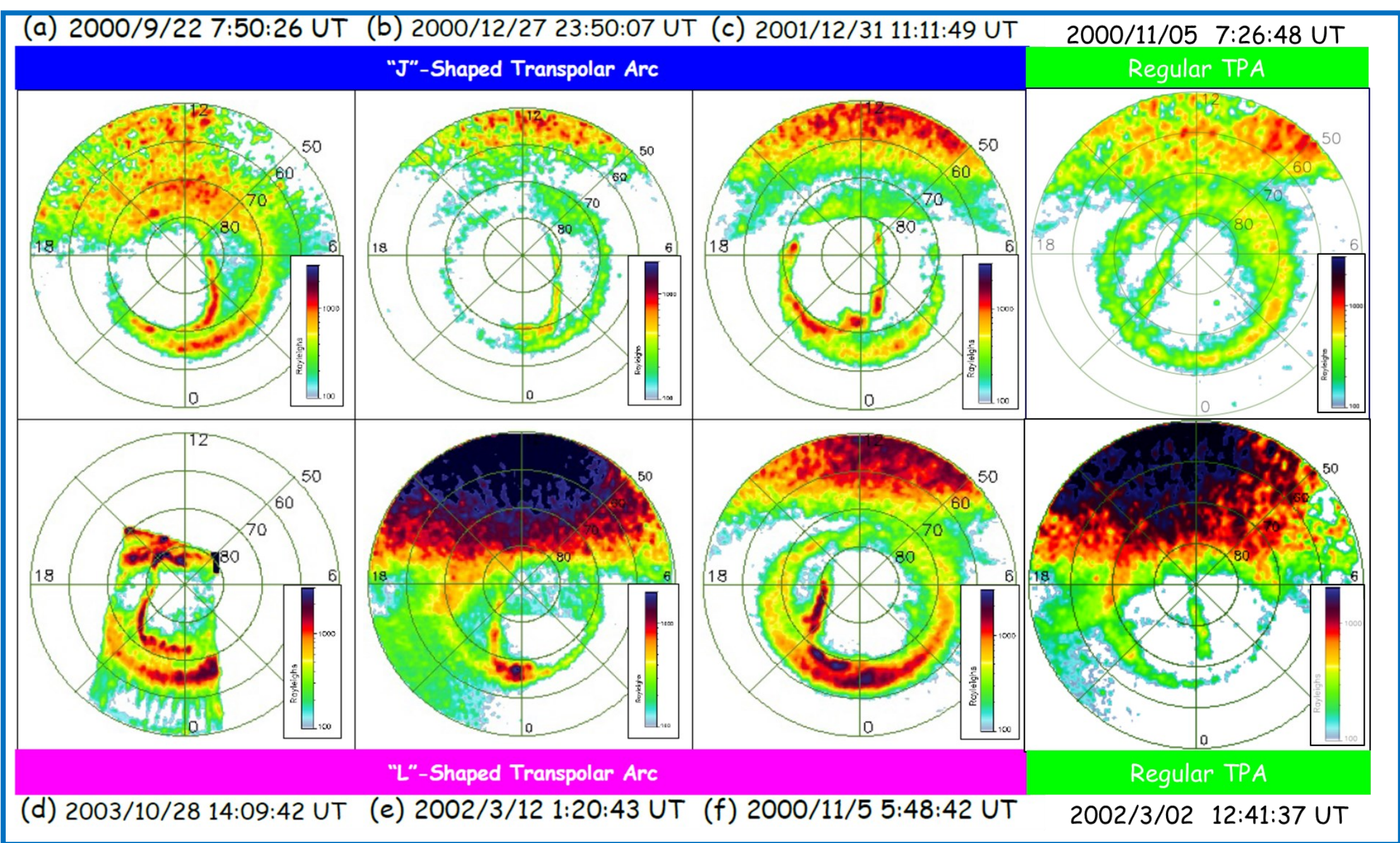# A Significant Finding of New Morphological Type of Transpo-lar Arc: Nightside Distorted Transpolar Arc

Motoharu Nowada(野和田 基晴)[1], Jun Yang[2], Qiu-Gang Zong[2], Quan-Qi Shi[1], Yong-Fu Wang[2], Hua-Yu Zhao[2], and Xu-Zhi Zhou[2]

All questions on this presentation: moto.nowada@sdu.edu.cn
ePosters available or see my Twitter @Moto_Diablo666 and can download the poster.

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[2]Institute of Space Physics and Applied Technology, School of Earth and Space Sciences, Peking University, People Republic of China.

(a) 2000/9/22 7:50:26 UT (b) 2000/12/27 23:50:07 UT (c) 2001/12/31 11:11:49 UT 2000/11/05 7:26:48 UT
"J"-Shaped Transpolar Arc / Regular TPA
"L"-Shaped Transpolar Arc / Regular TPA
(d) 2003/10/28 14:09:42 UT (e) 2002/3/12 1:20:43 UT (f) 2000/11/5 5:48:42 UT 2002/3/02 12:41:37 UT

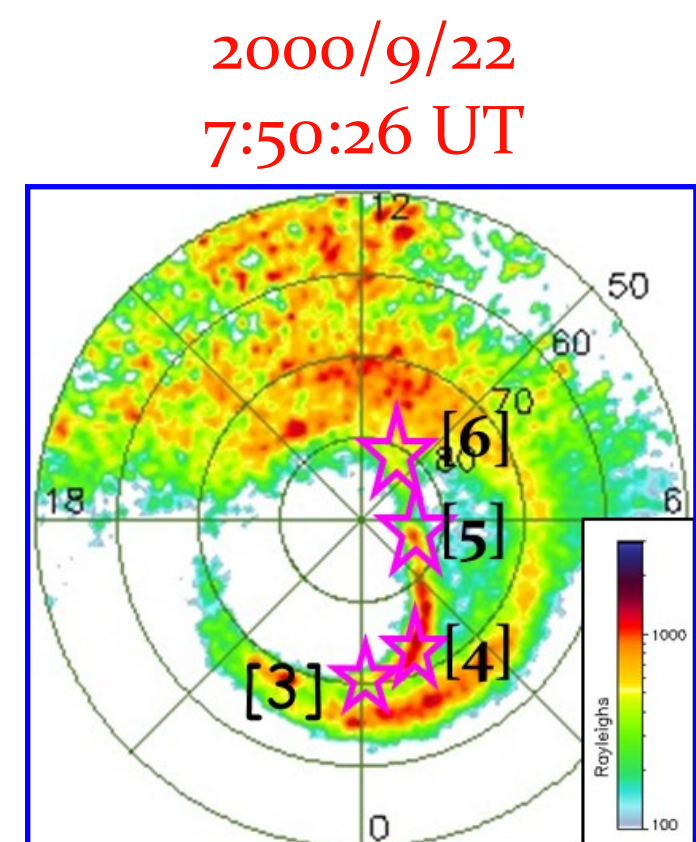## Key Question 1 What is "nightside distorted TPA"?

- "Nightside distorted TPAs" are the dawnside (duskside) TPAs with the nightside ends distorted toward pre- (post-) midnight sector. Because these TPAs look like the shape of an alphabetical letter of "J" or "L", we further distinguished the nightside distorted TPAs from "J"- and "L"-shaped TPAs.
- The "J"-shaped TPAs are the dawnside TPA with the nightside end distorted toward the pre-midnight sector. The TPAs in the duskside, whose nightside parts got distorted toward the post-midnight sector, are referred to as "L"-shaped TPA.

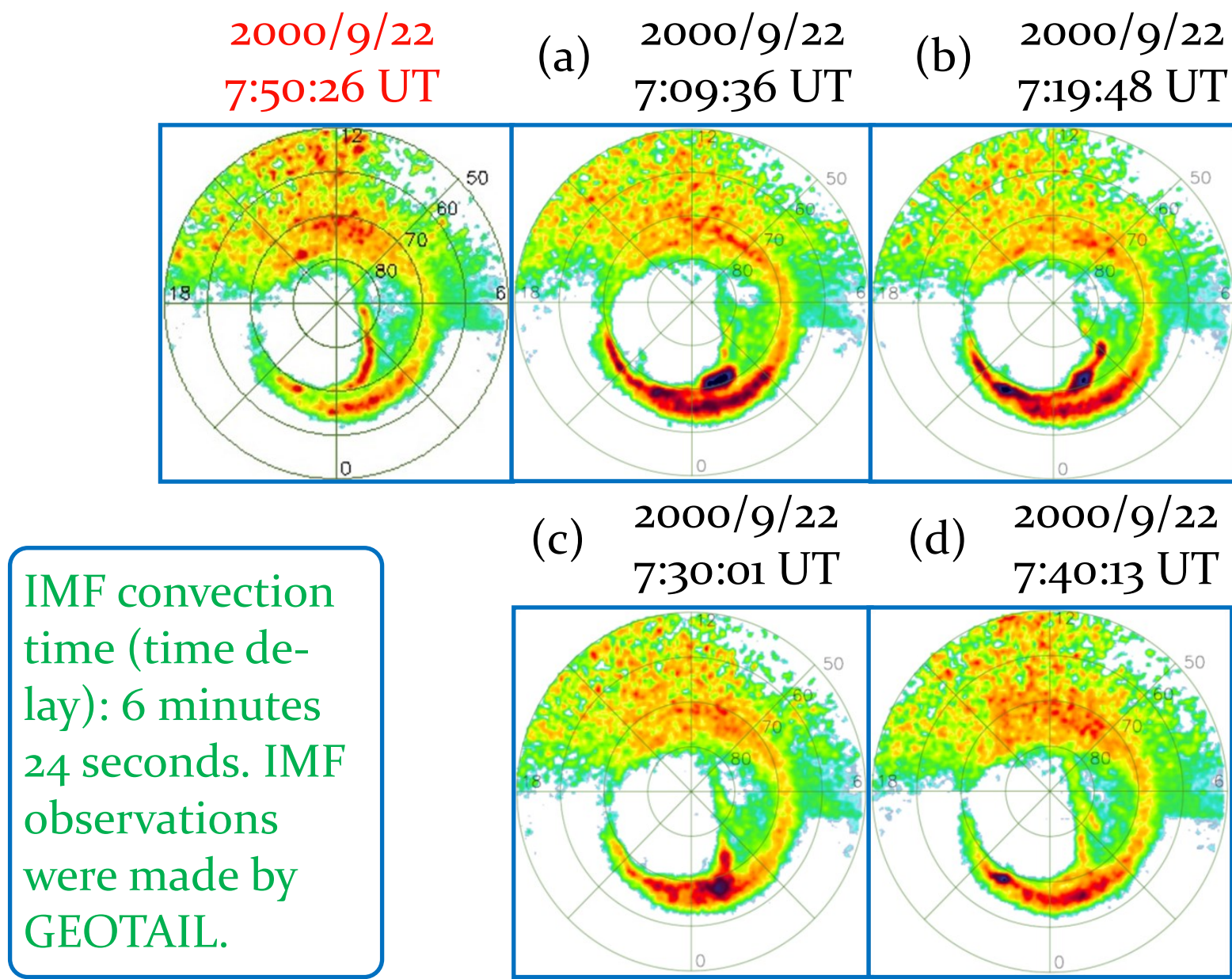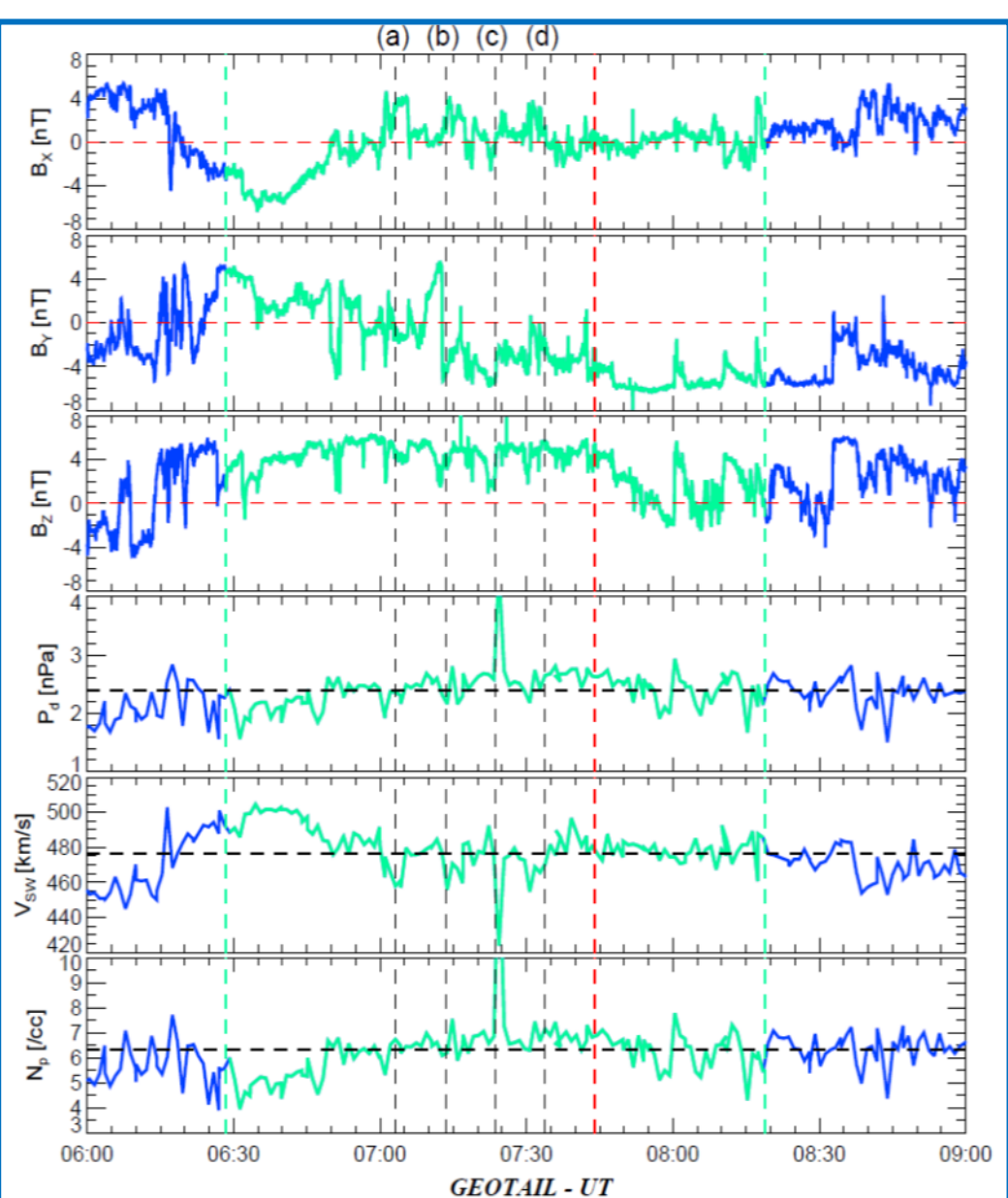## Key Question 2 How is the relation with the IMF condition?

- In most of cases, the nightside distorted TPAs can dominantly be found under the northward Interplanetary Magnetic Field (IMF) conditions.
- Furthermore, when the IMF-By component pointed to the dawnward (duskward) direction, the "J" ("L")-shaped TPAs were frequently observed, suggesting that the relation between the IMF-Bz and By orientations, and the locations of the nightside distorted TPAs would be consistent with that between the IMF conditions and regular TPA, previously reported.

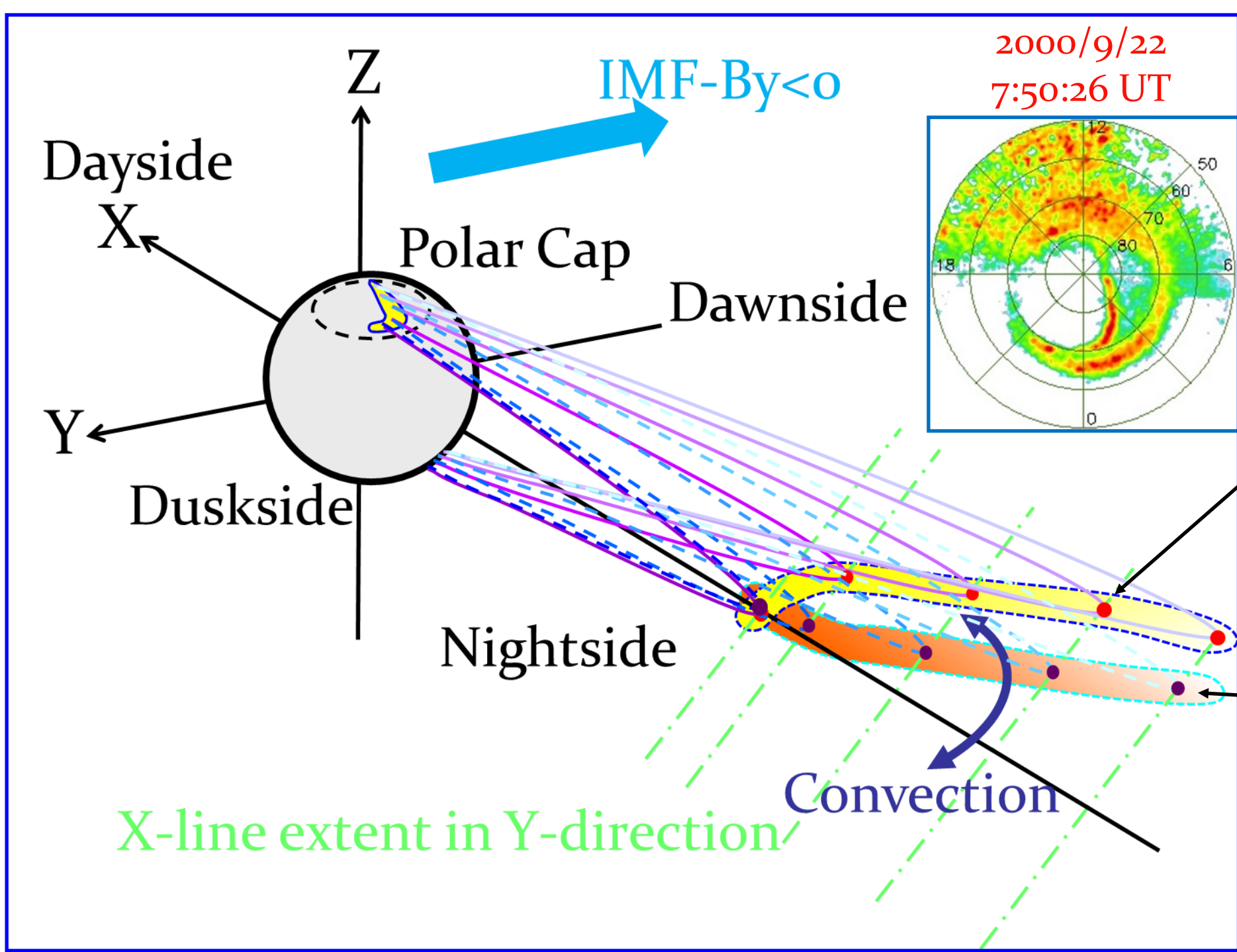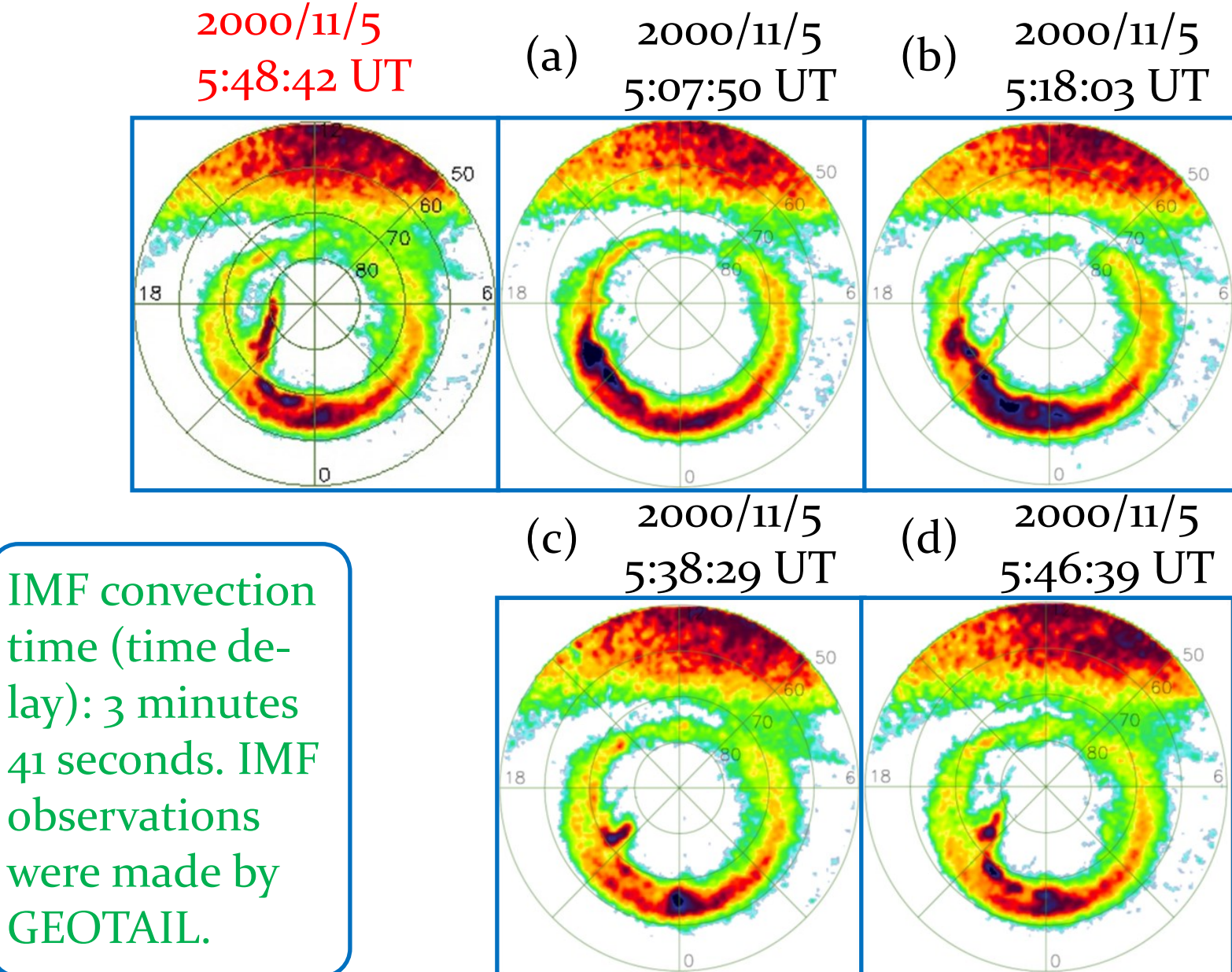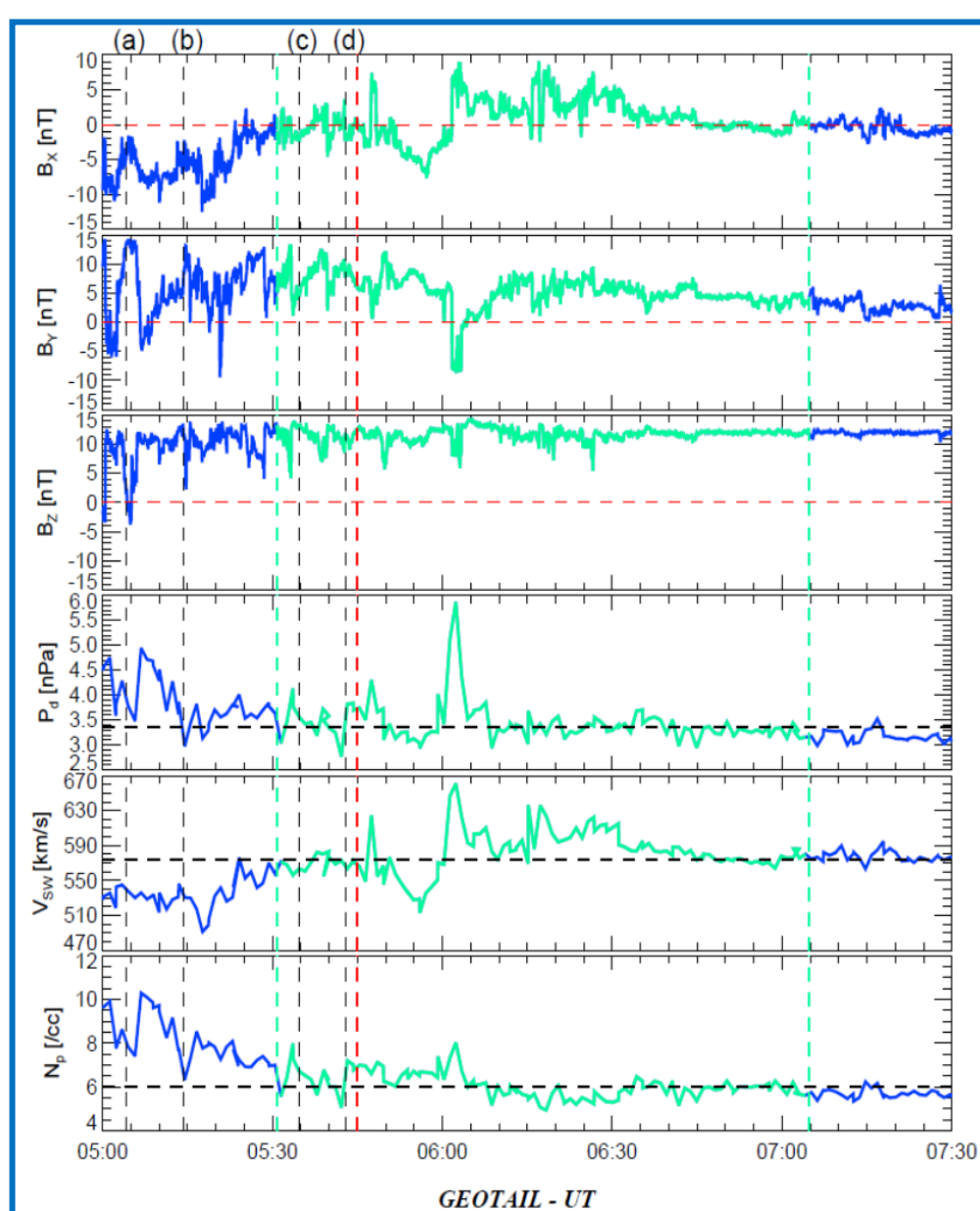### "J"-Shaped TPA Event on September 22nd 2000

Event #	GSM-X [R_E]	GSM-Y [R_E]	GSM-Z [R_E]
[1]	-10	0	±1,2,3,5
[2]	-20	0	±1,2,3,5
[3]	-35	-3.4	±1,2,3,5
[4]	-37	-8.2	±1,2,3,5
[5]	-56	-4.1	±1,2,3,5
[6]	-54	-4.6	±1,2,3,5
[7]	-65	0	±1,2,3,5

2000/9/22 7:50:26 UT

GSM-Z > 0 Case | GSM-Z < 0 Case
OMNI IMF-By
[1] [2] [3] [4] [5] [6] [7]

"J"-shaped TPA : 2000/9/22 6:34:53 UT – 8:25:08 UT (IMAGE-FUV-WIC)

2000/9/22 7:50:26 UT
(a) 2000/9/22 7:09:36 UT (b) 2000/9/22 7:19:48 UT
(c) 2000/9/22 7:30:01 UT (d) 2000/9/22 7:40:13 UT

IMF convection time (time delay): 6 minutes 24 seconds. IMF observations were made by GEOTAIL.

L"-shaped TPA : 2000/11/5 5:34:24 UT – 7:08:24 UT (IMAGE-FUV-WIC)

2000/11/5 5:48:42 UT
(a) 2000/11/5 5:07:50 UT (b) 2000/11/5 5:18:03 UT
(c) 2000/11/5 5:38:29 UT (d) 2000/11/5 5:46:39 UT

IMF convection time (time delay): 3 minutes 41 seconds. IMF observations were made by GEOTAIL.

"L"-Shaped TPA Event on November 5th, 2000

Event #	GSM-X [R_E]	GSM-Y [R_E]	GSM-Z [R_E]
[1]	-5.0	5.9	±1,2,3,5
[2]	-10	0	±1,2,3,5
[3]	-21	4.4	±1,2,3,5
[4]	-30	0	±1,2,3,5
[5]	-40	0	±1,2,3,5
[6]	-50	0	±1,2,3,5
[7]	-59	16	±1,2,3,5
[8]	-57	1.8	±1,2,3,5

2000/11/5 5:48:42 UT

GSM-Z > 0 Case | GSM-Z < 0 Case
OMNI IMF-By
[1] [2] [3] [4] [5] [6] [7] [8]

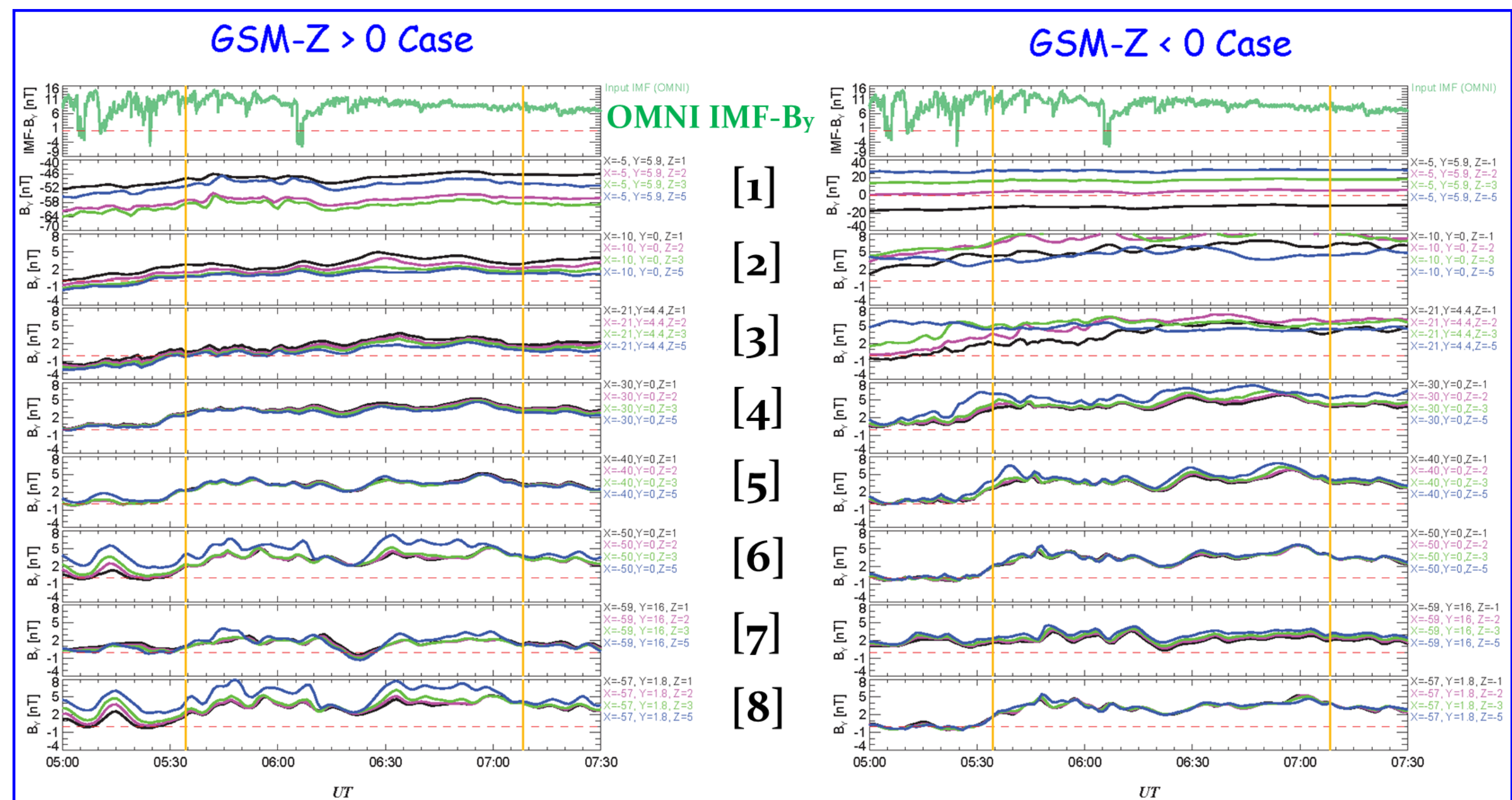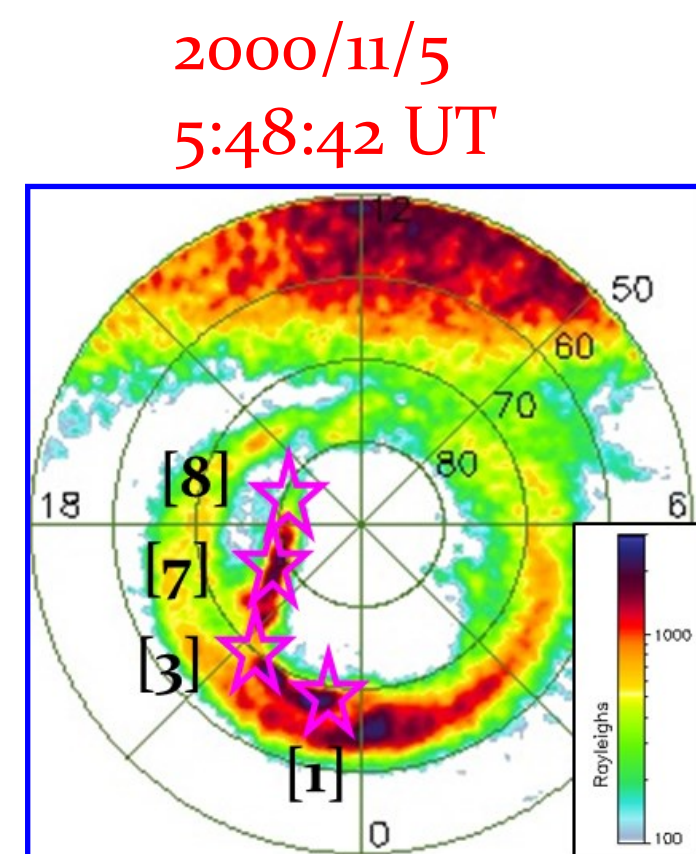

IMF-By<0 2000/9/22 7:50:26 UT
X-line Retreat(Stagnant) points in case the convection is faster than the retreat
X-line Retreat(Stagnant) points in case the convection is slower than the retreat
IMF-By>0 2000/11/5 5:48:42 UT
X-line extent in Y-direction
Convection

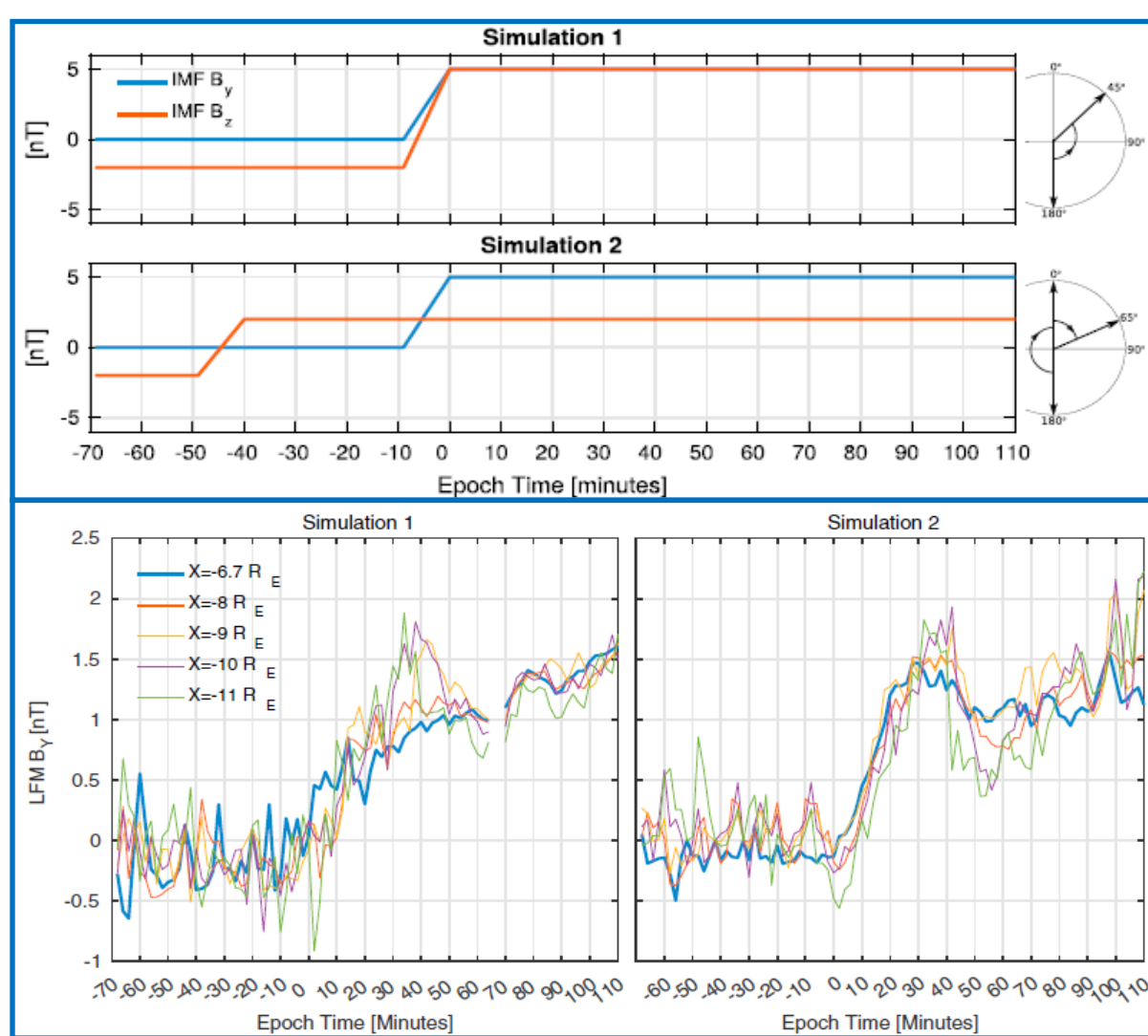## Key Question 3 How are the nightside distorted TPAs formed ?

We followed the time sequence of the nightside distorted TPA evolution with the IMAGE FUV-WIC imager data. The "J" and "L"-shaped TPAs mostly started to grow from the nightside main auroral oval, and protruded to the dayside region with being distorted.
—>Formation process of the nightside distorted TPAs would basically be explained by "nightside magnetic reconnection model", which was proposed by Milan +2005 ?

Key Question 4 How do you verify that the formation processes of the "J" and "L"-shaped TPAs could be explained by "nightside magnetic reconnection" model ?

No clear "in-situ" observational evidence for magnetotail reconnection during the intervals of the nightside distorted TPA brightening could be obtained. The observational examples, where the low-latitude orbiters were crossing over the distorted parts of the TPA, cannot also be found. —>Even though performing an MHD simulation, it is hard to specify the locations where nightside magnetic reconnection occurs (e.g., Kullen and Janhunen +2004). However, if the nightside distorted TPA formation was followed by the models proposed, the magnetotail magnetic field profiles would be controlled by the IMF-By components.

Supportive Evidence

- IMF-By penetration to magnetotail should occur during the nightside distorted TPA formation. —>Verifying the IMF-By control to the magnetotail By profile based on an MHD simulation using the BATS-R-US code.
- The IMF penetration to the near-earth tail was confirmed by Tenfjord +2018 based on an LFM simulation.

Tenfjord +2018

Conclusion

1. New morphological type of transpolar arc, that is, nightside distorted TPA ("J"- and "L"-shaped TPAs) is found.
2. Formation process of the nightside distorted TPA can basically be addressed by the nightside magnetic reconnection model. The nightside end of the TPA might get "distorted" due to the "crooked" X-line retreats, whose lines were convected dawn- or duskward.
3. With a help of the MHD simulations using the BATS-R-US code, the IMF-By component controlled the By profiles in the magnetotail; the IMF-By penetration to the tail was evident, implicitly verifying that the reconnection-formed closed flux (TPA-associated flux) convected dawn- or duskward during the nightside distorted TPA intervals.