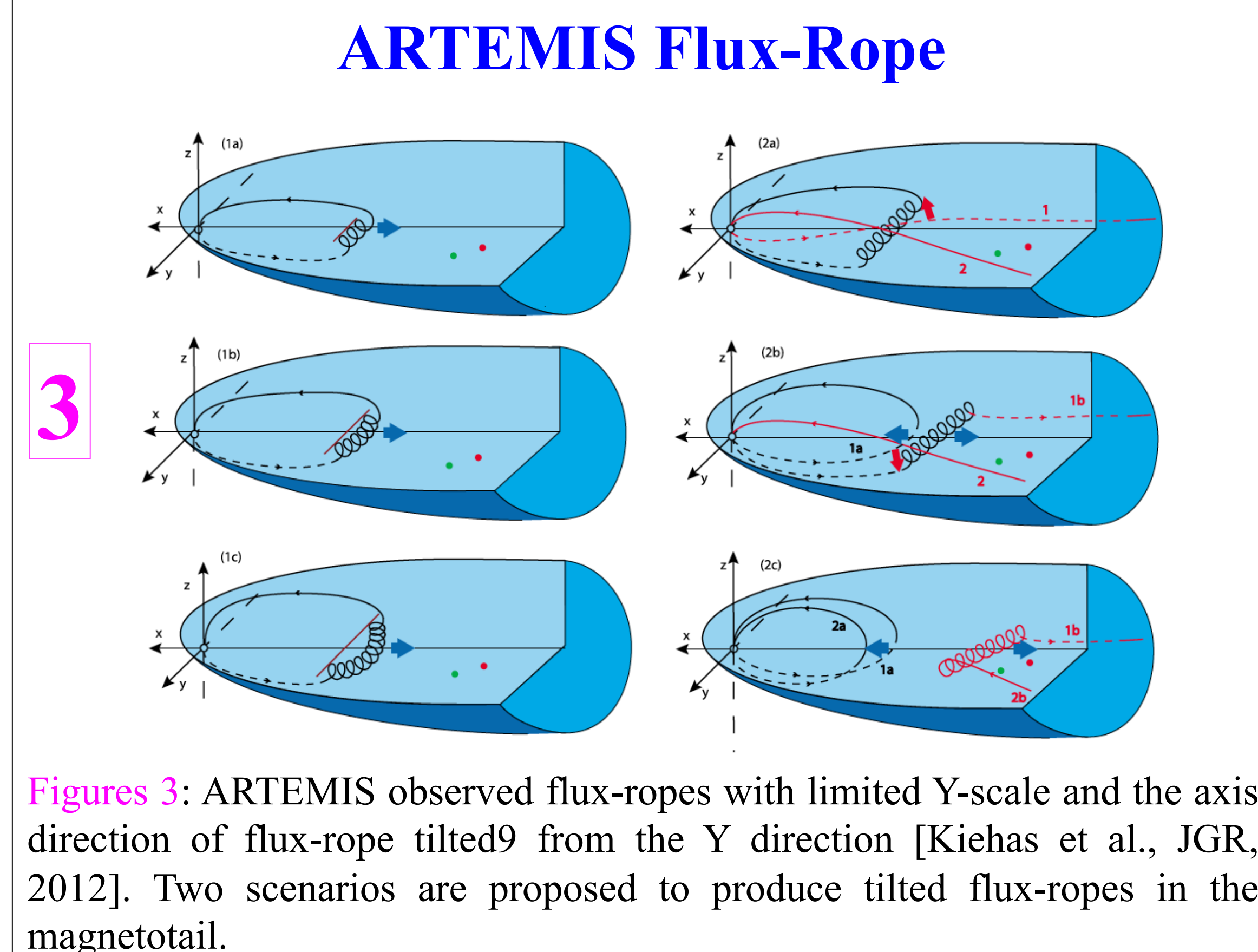


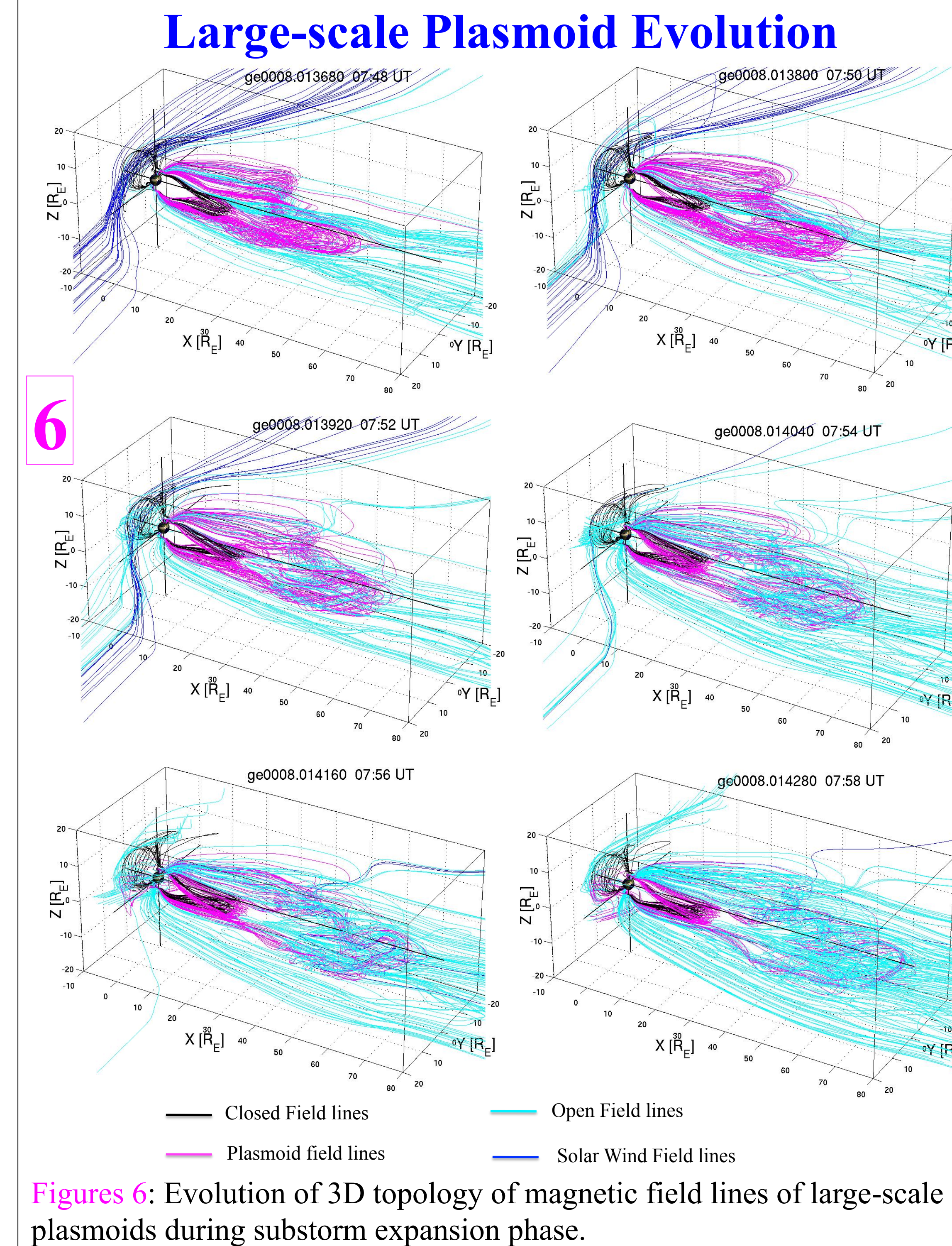
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Abstract

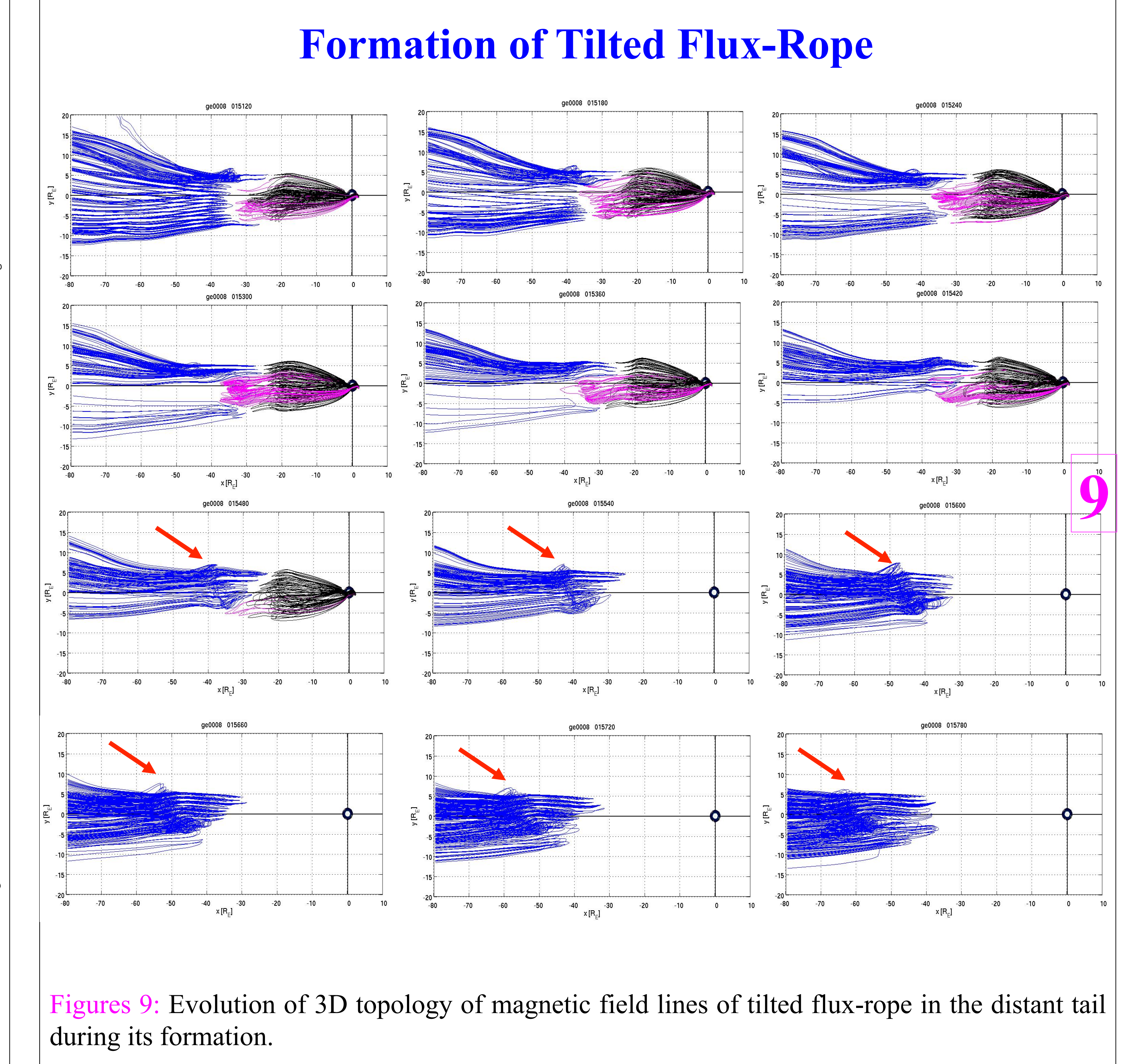
The observation of plasmoids and flux-rope in the Earth's magnetotail was crucial to establish the simultaneous presence of multiple x-lines in the tail, and has become the basis for the Near Earth Neutral Line (NENL) model of substorms. While the "classical" NENL model envisions x-lines that extend across the entire tail, recent observations have shown that neither do the x-lines and resulting plasmoids encompass the entire tail, nor do the x-lines have to lie along the y-axis. Furthermore, several x-line/plasmoid/flux-rope structures can exist simultaneously. The fragmentation of the tail by spatially and temporally limited x-lines has important consequences for the mass and energy budget of the tail. Recent ARTEMIS observations have shown that the plasmoids in the distant tail are limited in the Y direction and some flux ropes are tilted during their tailward propagation. In this study we simulate plasmoids and flux-rope in the Earth's magnetotail using the Open Global Geospace Circulation Model (OpenGGCM). We investigate the generation mechanisms for tail plasmoids and flux-rope and their evolution as they propagate in the magnetotail. The simulation results show that the limited extent of NENL controls the length or the Y scale of tail plasmoid and flux rope. In addition, by studying their 3D magnetic topology we find that the tilted flux rope forms due to a progressive spreading of reconnection line along the east-west direction, which produces and releases two ends of the flux rope at different times and in different speeds. By constructing a catalogue of observational signatures of plasmoid and flux rope we compare the differences of their signatures and find that large-scale plasmoids have much weaker core fields than that inside the small-scale flux ropes.



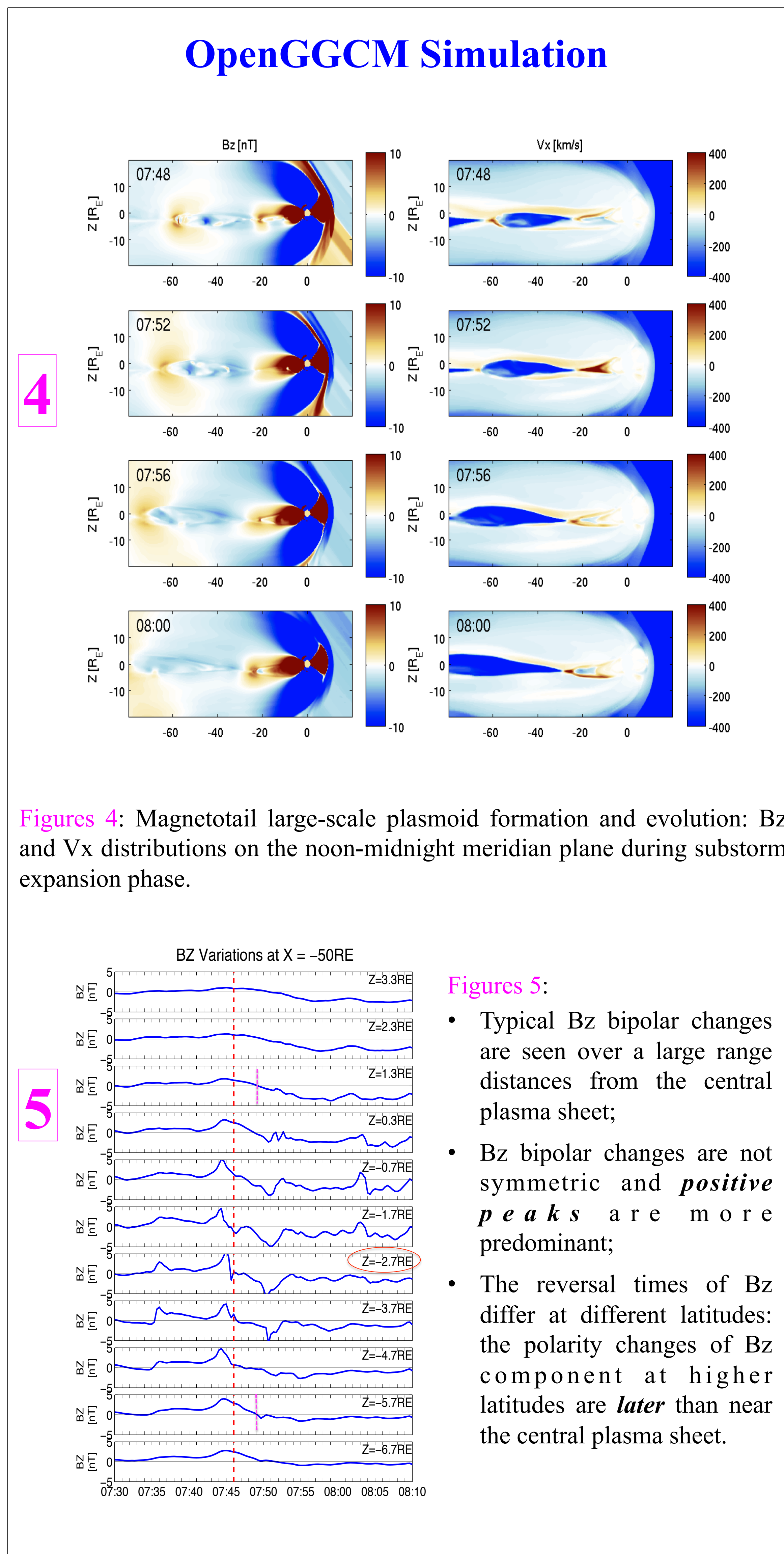
Figures 3: ARTEMIS observed flux-rope with limited Y-scale and the axis direction of flux-rope tilted from the Y direction [Kiehas et al., JGR, 2012]. Two scenarios are proposed to produce tilted flux-rope in the magnetotail.



Figures 6: Evolution of 3D topology of magnetic field lines of large-scale plasmoids during substorm expansion phase.



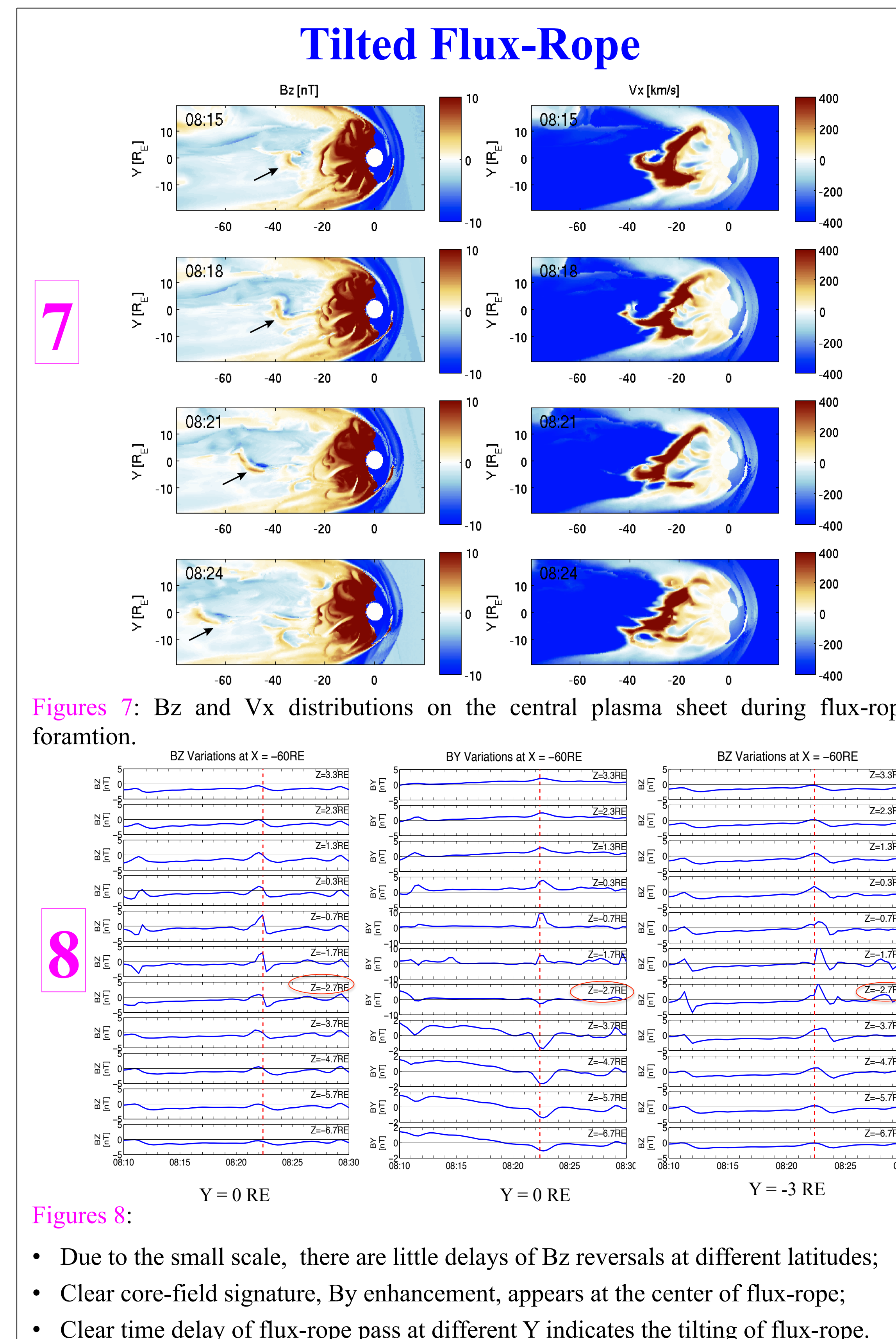
Figures 9: Evolution of 3D topology of magnetic field lines of tilted flux-rope in the distant tail during its formation.



Figures 4: Magnetotail large-scale plasmoid formation and evolution: Bz and Vx distributions on the noon-midnight meridian plane during substorm expansion phase.

Figures 5:

- Typical Bz bipolar changes are seen over a large range distances from the central plasma sheet;
- Bz bipolar changes are not symmetric and **positive peaks** are more predominant;
- The reversal times of Bz differ at different latitudes: the polarity changes of Bz component at higher latitudes are **later** than near the central plasma sheet.

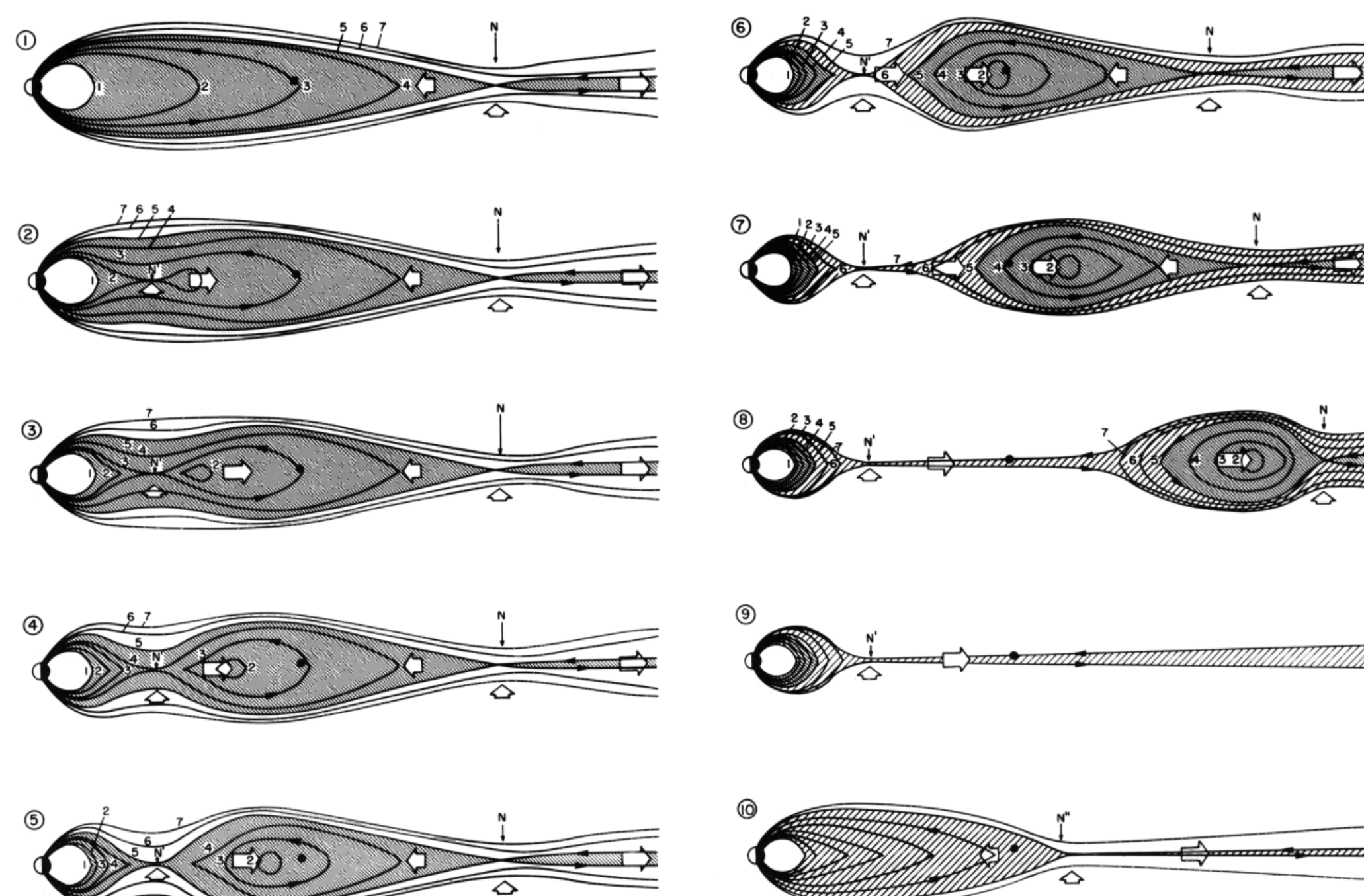


Figures 7: Bz and Vx distributions on the central plasma sheet during flux-rope formation.

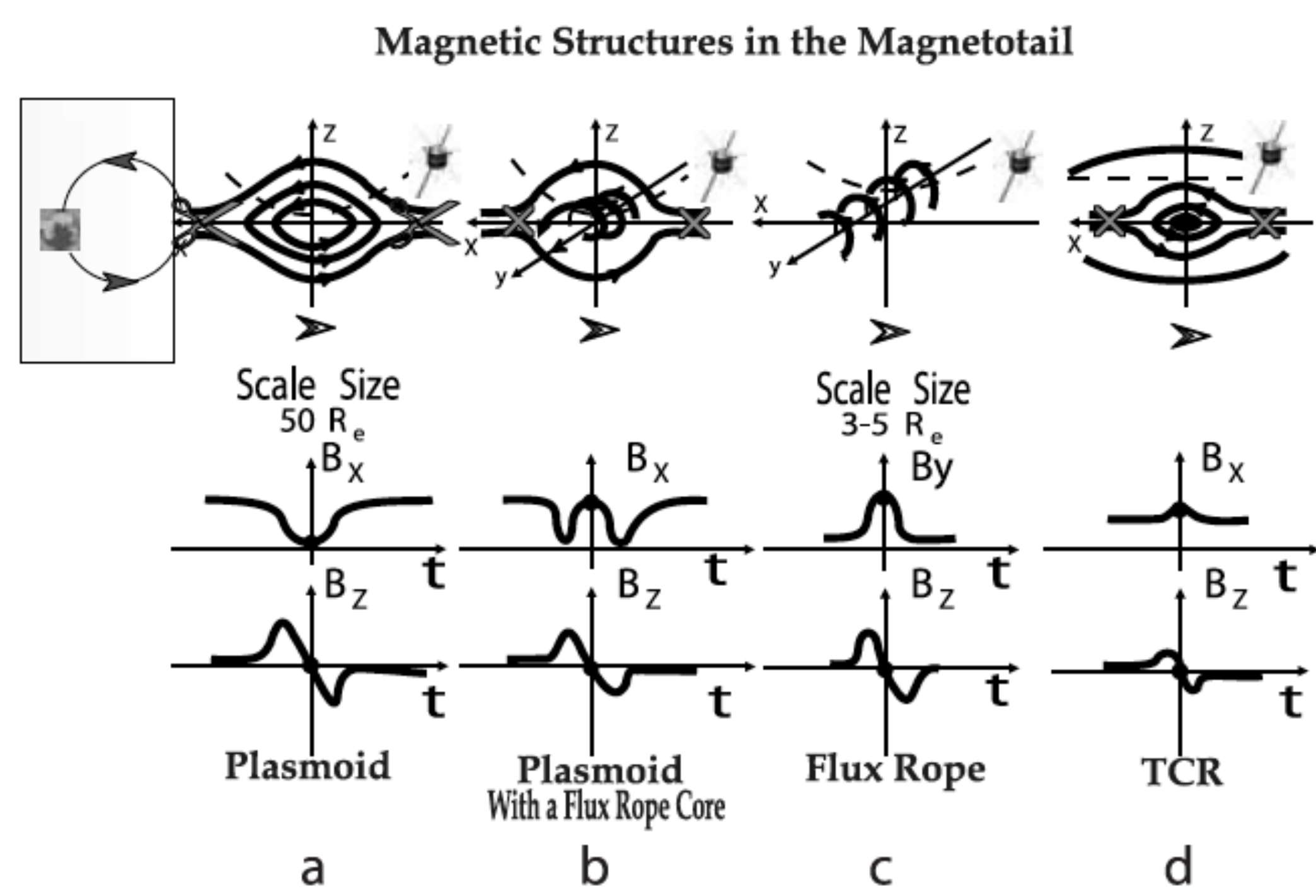
Figures 8:

- Due to the small scale, there are little delays of Bz reversals at different latitudes;
- Clear core-field signature, By enhancement, appears at the center of flux-rope;
- Clear time delay of flux-rope pass at different Y indicates the tilting of flux-rope.

Introduction: Plasmoid Signatures



Figures 1: Observations of plasmoids in the Earth's magnetotail were crucial to establish the simultaneous presence of multiple x-lines in the tail, and has become the basis for the Near Earth Neutral Line (NENL) model of substorms [e.g., Slavin et al., 1989].



Figures 2: Signatures of plasmoids/flux-rope differ with different passings of S/C through the structures [e.g., Zong et al., 2004]

Summary

- ◆ Persisting multiple reconnection produces large-scale plasmoids which is usually associated with geomagnetic activities, while tail flux-rope can be generated by localized reconnection.
- ◆ Plasmoids can be very large in X direction (up to several tens RE), while their width is determined by width of X-line and can be limited into several RE.
- ◆ Besides the lower core-field, plasmoids also differ from the small-scale flux-rope by their delayed signatures as away from the center.
- ◆ At higher latitudes, the TCR signatures are produced mainly by the Bx enhancement during plasmoid passing, while during flux-rope passing the field enhancement comes from both Bx and By components.
- ◆ The tilting of tailward-moving flux-rope is caused by the asymmetric reconnection process at different local time sectors.

Future Work

1. Reproduce ARTEMIS observed events of plasmoids and flux-rope.
2. Compare in situ ARTEMIS observations with simulations.
3. Establish a comprehensive catalogue of plasmoids/flux-rope signatures in different locations with various S/C passings.

Reference

- Slavin, J. A., et al. (1989), Doi 10.1029/JA094ia11p15153.
- Zong, Q. G., et al. (2004), Doi 10.1029/2004GL020692.
- Kiehas, S. A., V. Angelopoulos, A. Runov, M. B. Moldwin, and C. Mostl (2012), Doi 10.1029/2011JA017377.

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