磁気圏電離圏結合対流生成機構
—magnetopauseとはなにか—

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Simulation study of the Magnetosphere-ionosphere coupling convection —What is the magnetopause?—

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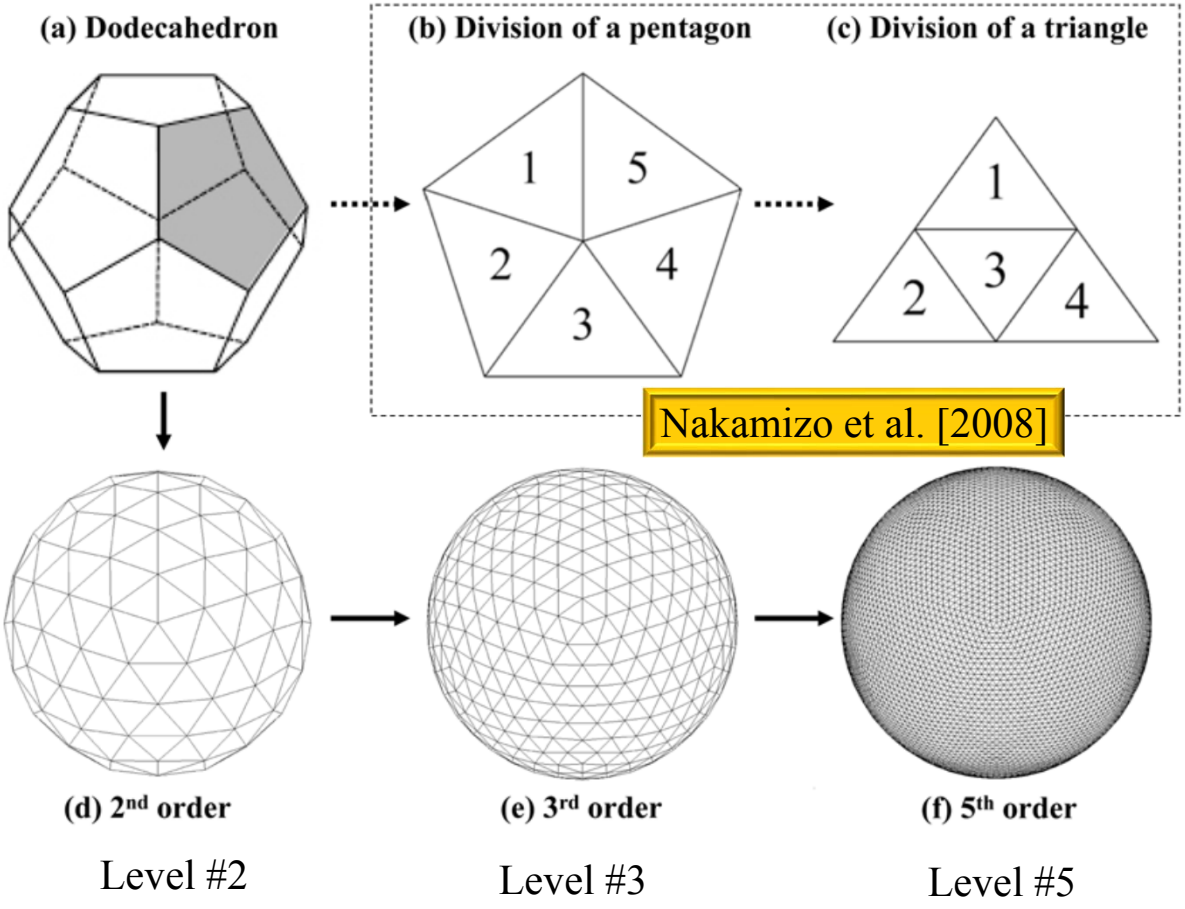
contents

- (The link between the solar wind energy and the dynamo of the R1FAC)

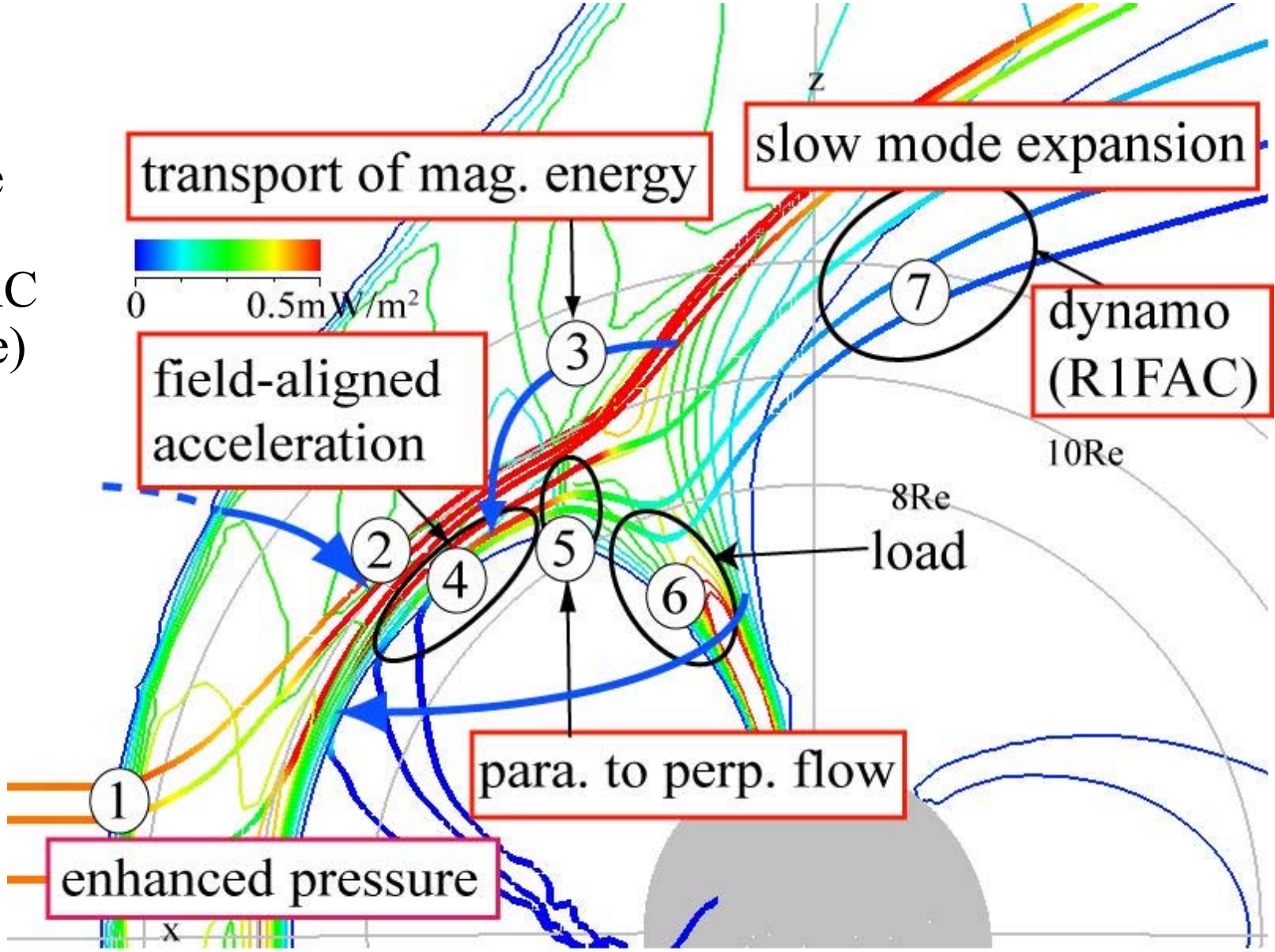
- What is the magnetopause in the southward IMF condition?
  - Two MHD definitions of the magnetopause
  - The “reconnection” in the null-separator structure
  - The rotational discontinuity

The spherical coordinate code and the REPPU code（level #6, # of r nodes=240）

- The spherical coordinate code is employed by Tanaka et al (2010). 0.25Re (r) x 0.35Re (lat) x 0.75Re (long)
- REPPU code (level #6). 0.22Re (r) x 0.20Re (lat) x 0.31Re (long)
- The magnetic diffusion parameter in REPPU code is reduced. (1/10 of the spherical coordinate code) The magnetic Reynolds number is as large as 10^7.



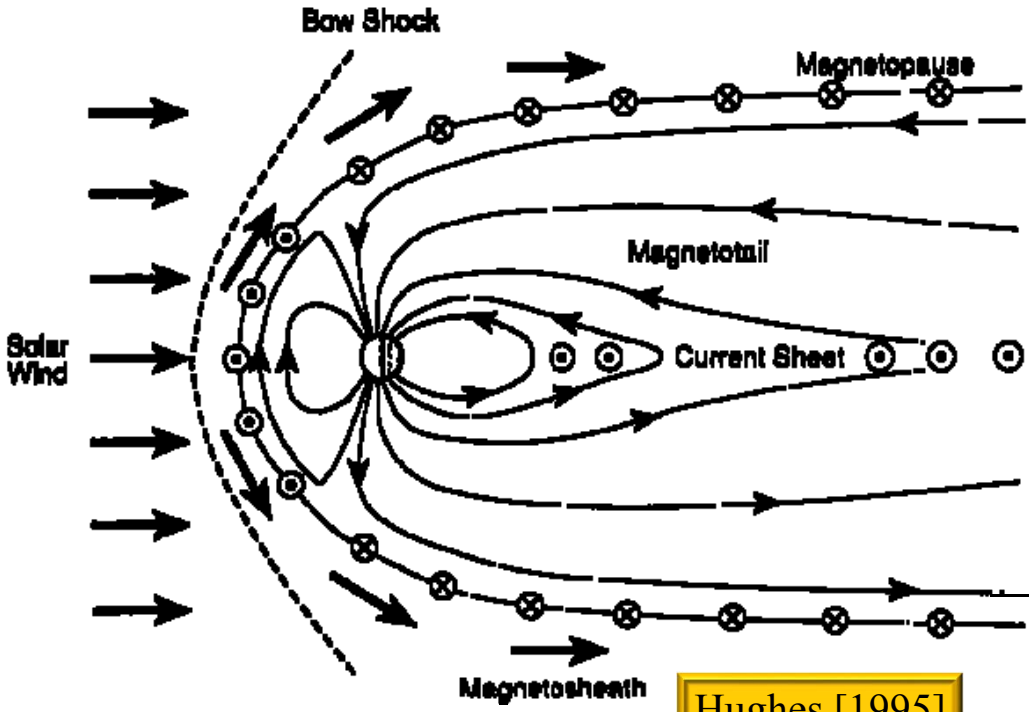
- The link between the solar wind and the dynamo of the R1FAC (southward IMF case)



What is the magnetopause?

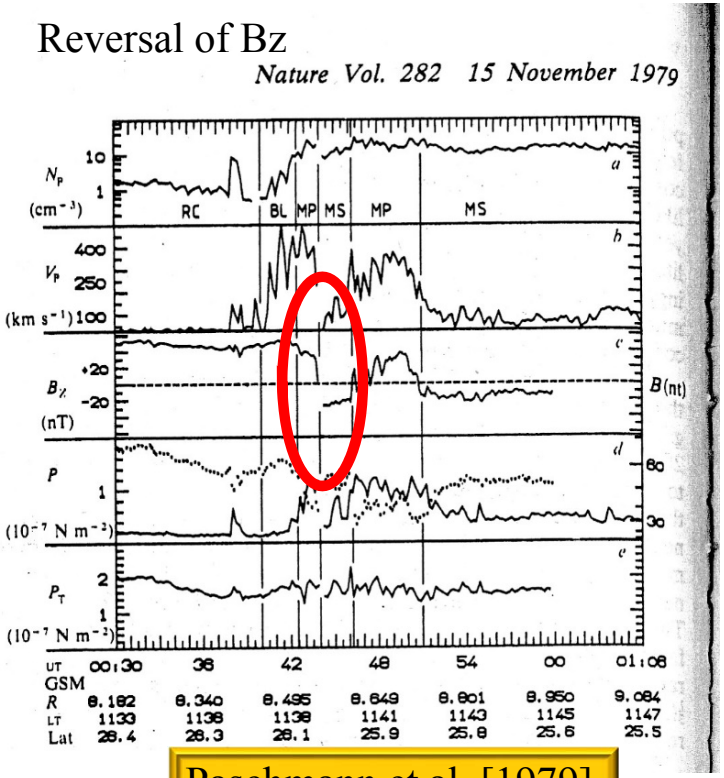
- Two MHD definition of the magnetopause : force balance or magnetic field deflection

Thermal pressure=magnetic pressure

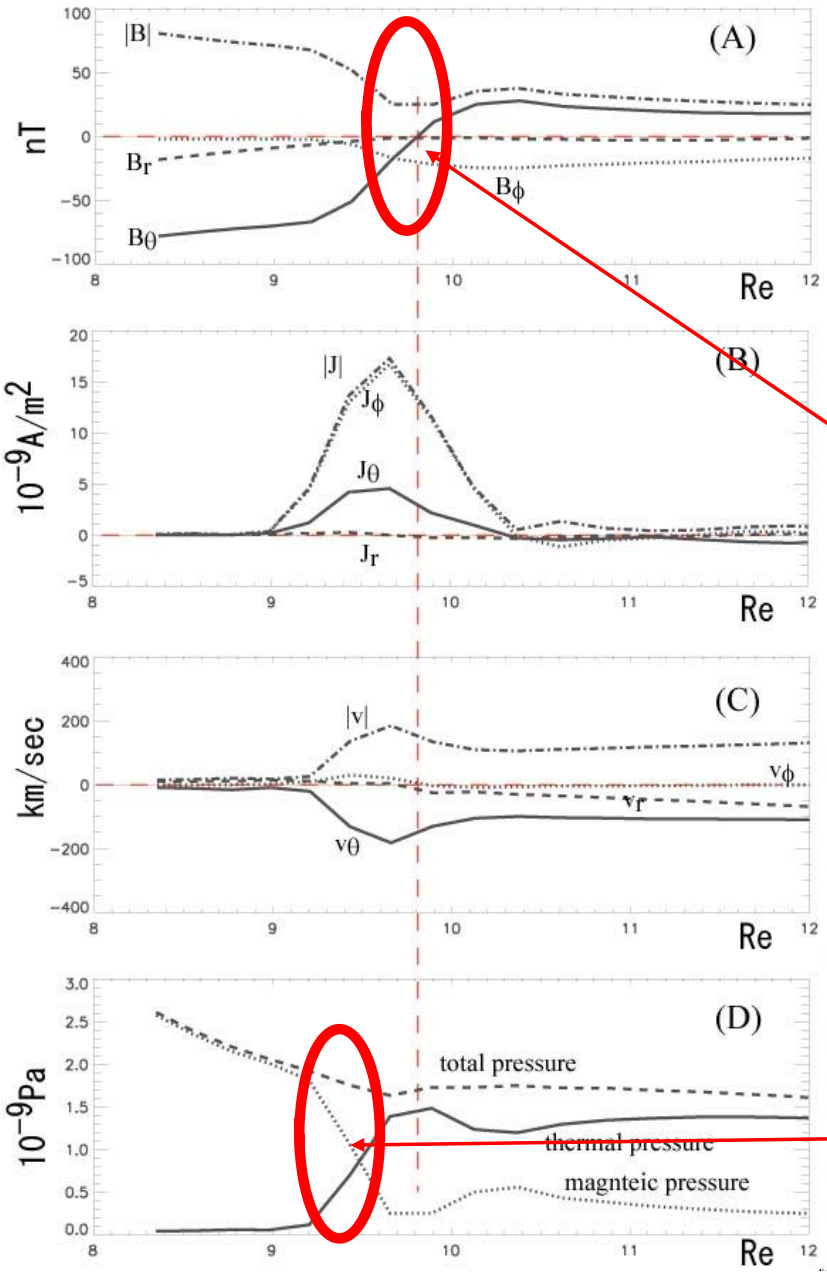


Hughes [1995]

Reversal of Bz

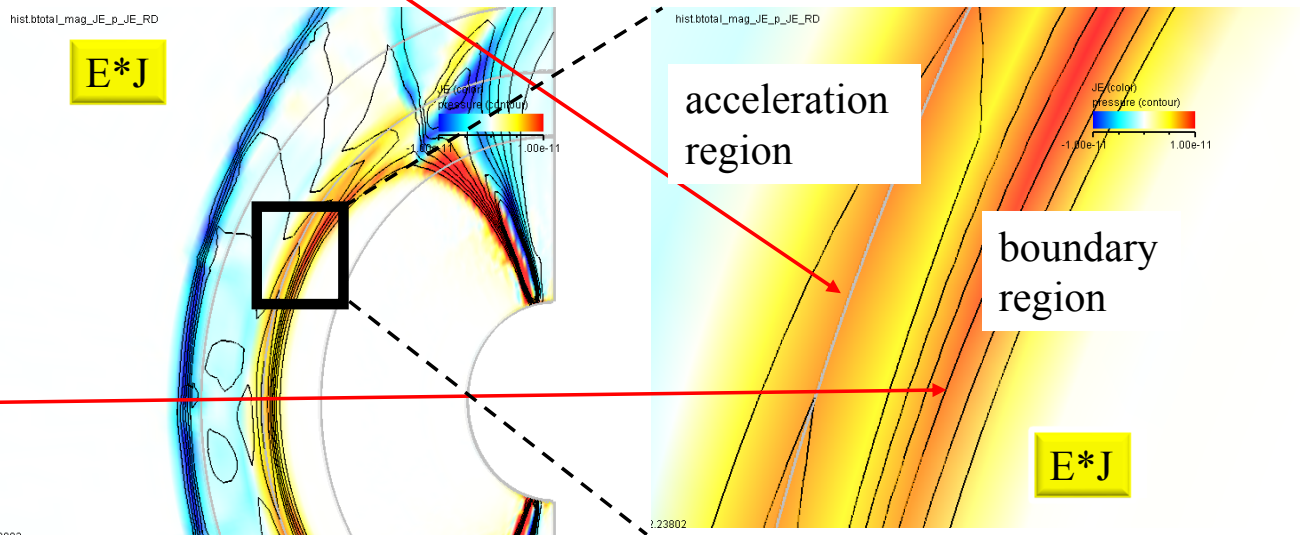


Paschmann et al. [1979]

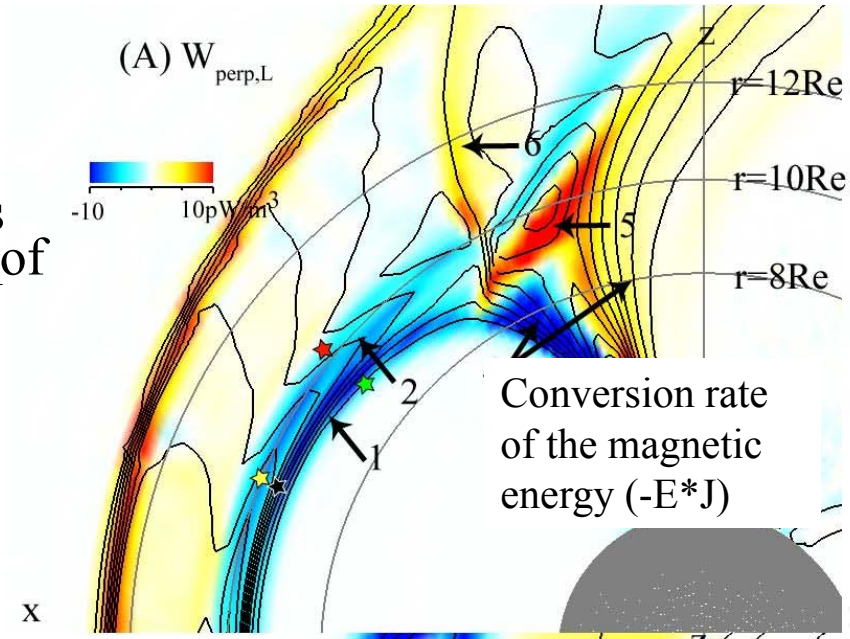


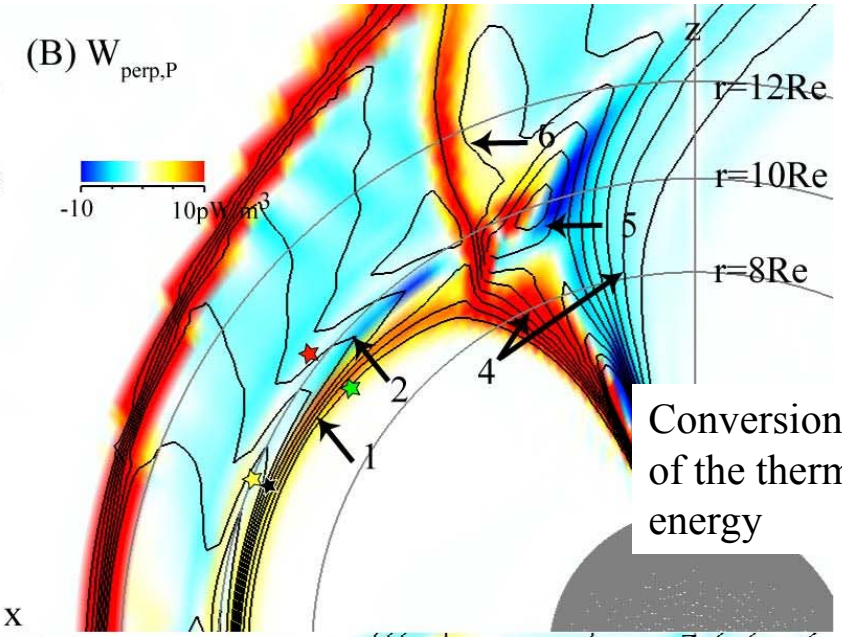
What is the magnetopause?

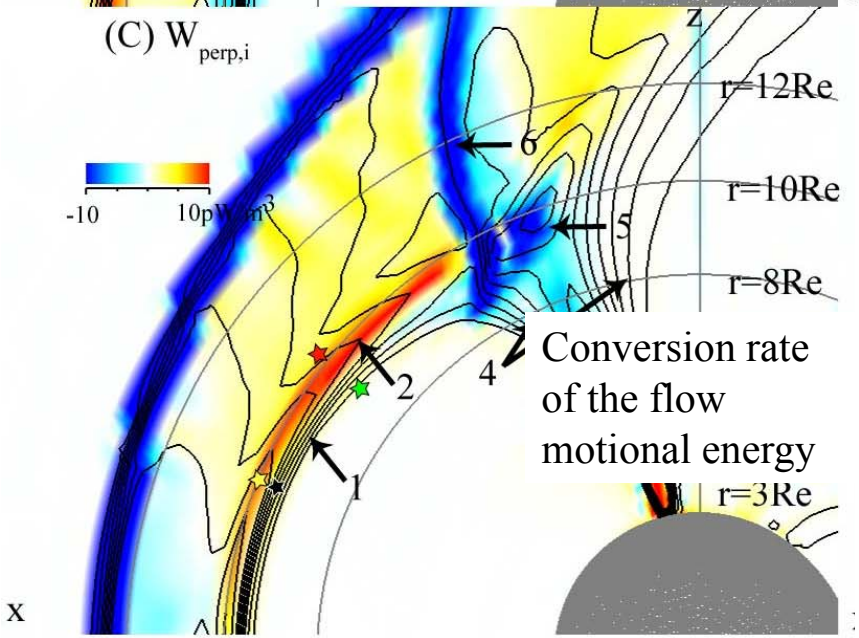
- *force balance* and *magnetic field deflection* occur in different regions.



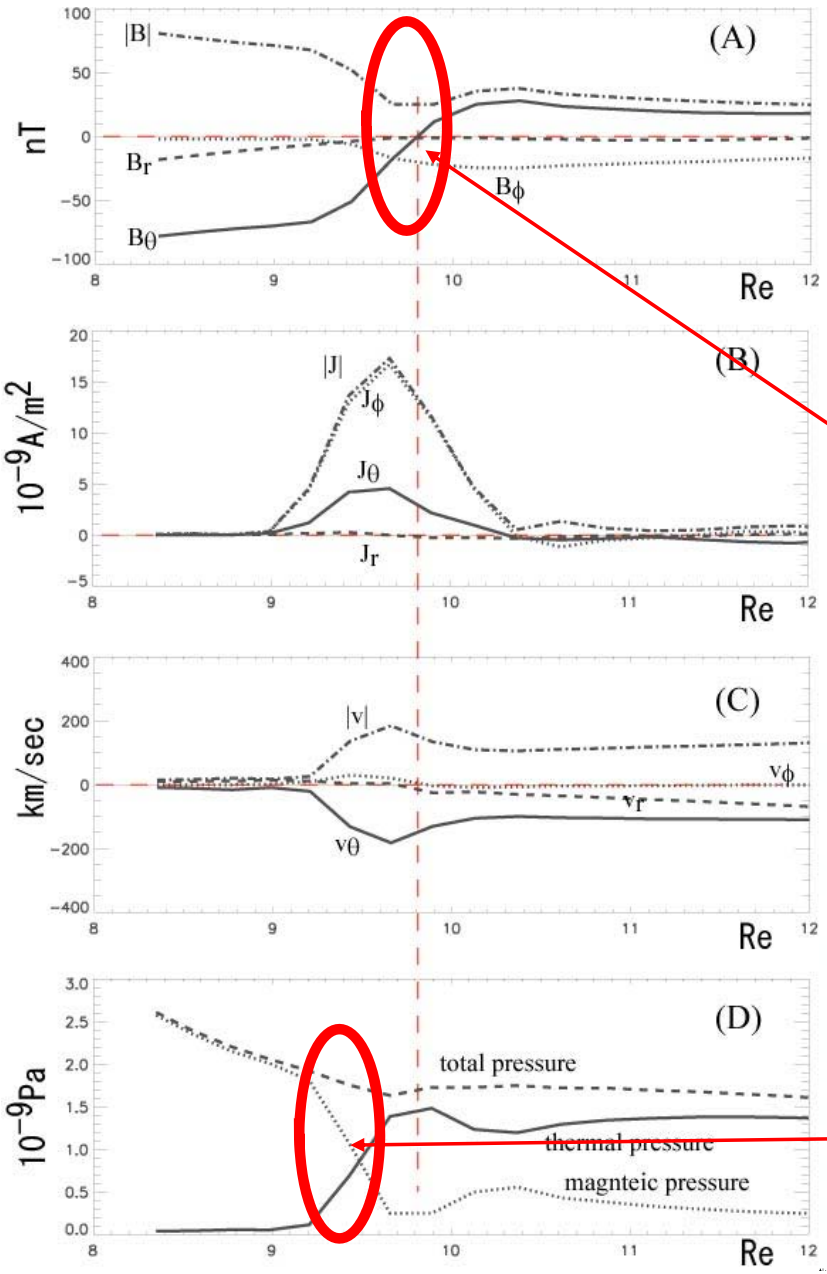
Two regions (#1 and #2) of positive E*J (negative W_perp,L)







- 1: boundary region
  magnetic energy ➡ thermal energy
- 2: acceleration region
  magnetic energy + thermal energy ➡ flow motional energy



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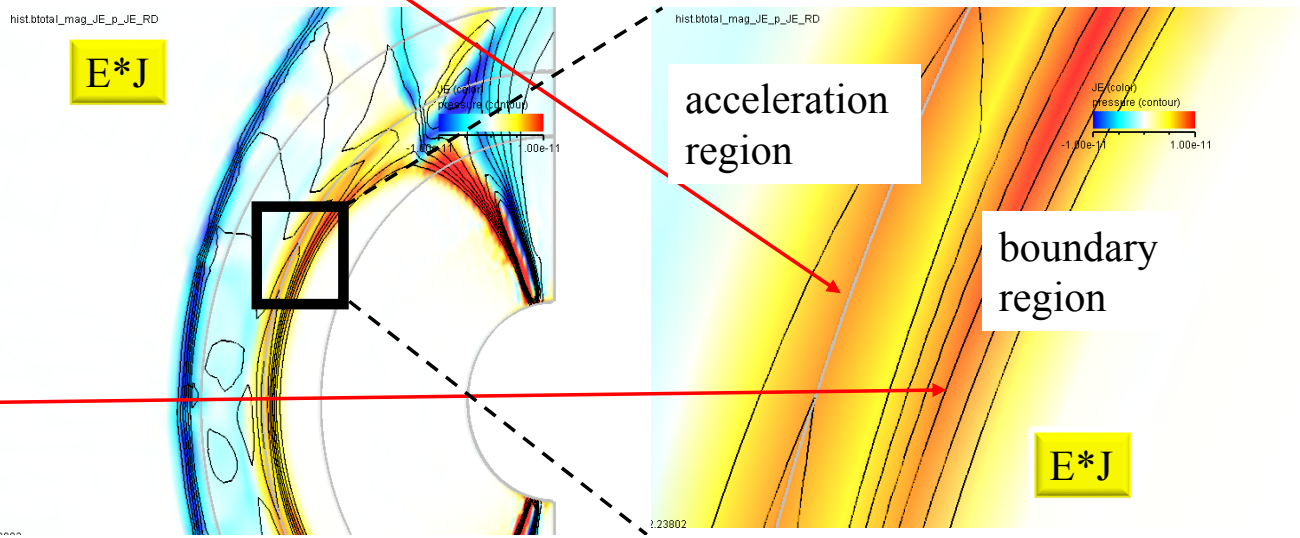
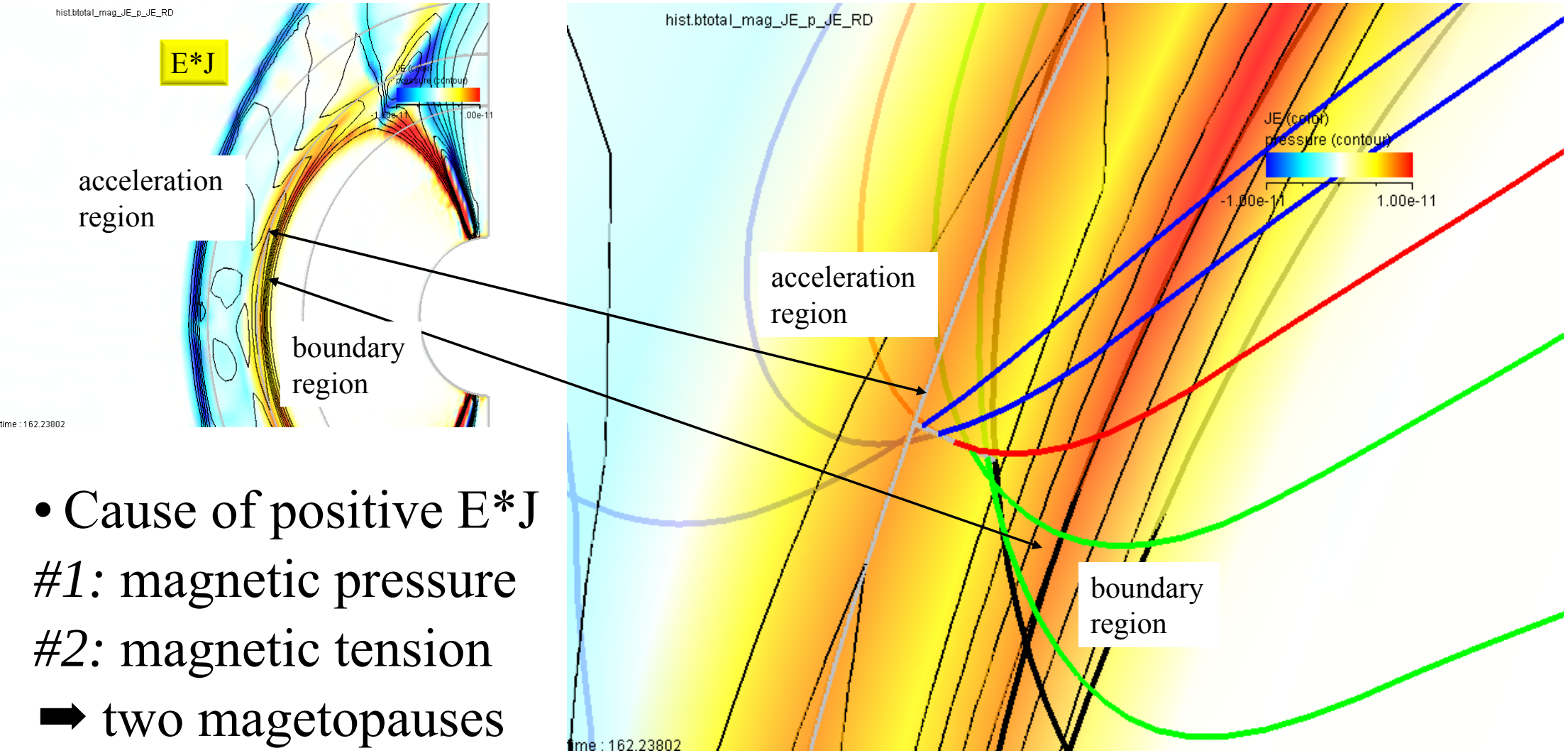




- Cause of positive E*J

#1: magnetic pressure

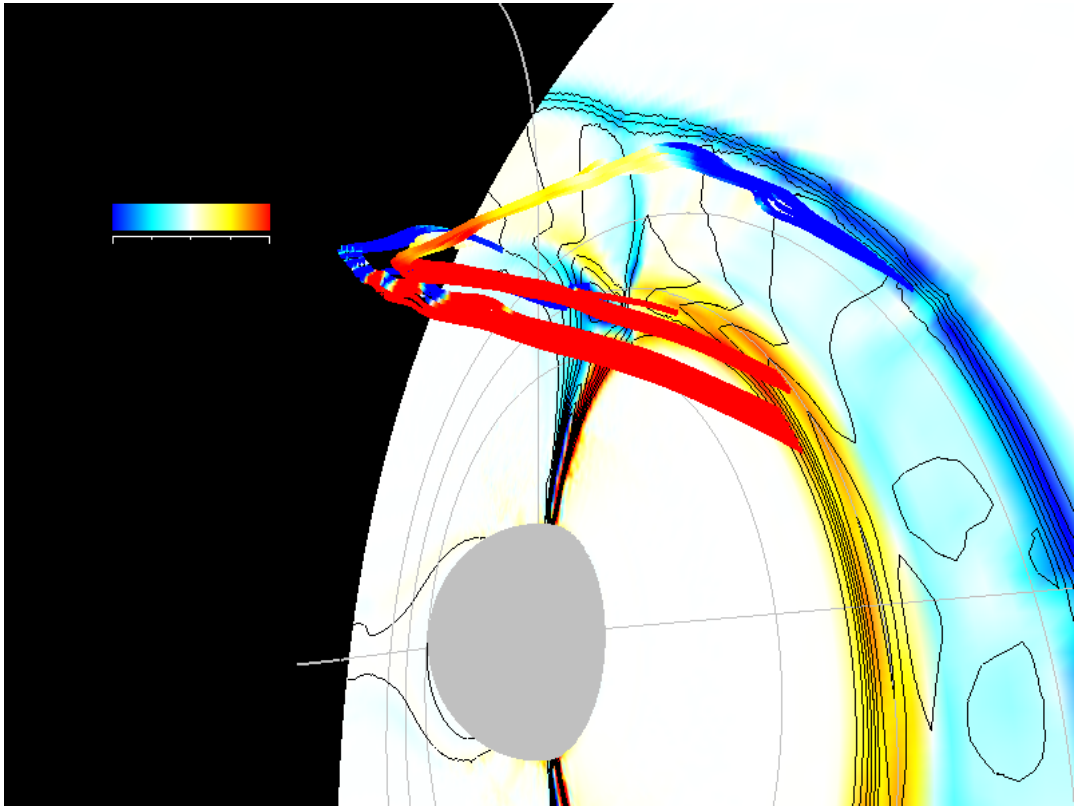
#2: magnetic tension

➡ two magetopauses

Two magnetopauses seen from the current system

- #2: The magnetopause defined as the magnetic field deflection (satellite observation)➡ bow shock current. That is to say, the magnetic field deformation from the pure null-separator structure is caused by the bow-shock current.

- #1: The magnetopause defined as balance between magnetic pressure and thermal pressure ➡ Chapman-Ferraro current

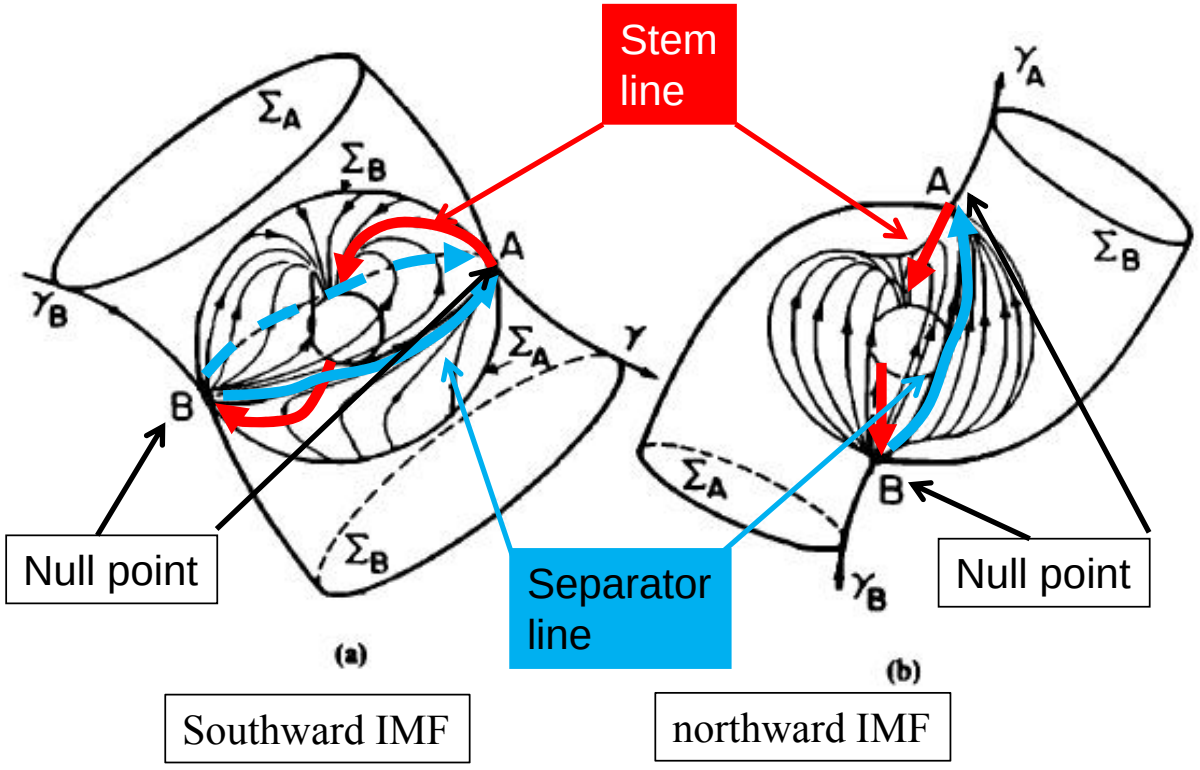


What is the magnetopause reconnection?

- The null-separator structure provides the original merging between the IMF and Earth's magnetic field
- Parallel Rx (no anti-parallel Rx, no component Rx)
- Kinetic effect (diffusion) does not play any essential role in the reconnection. Diffusion appears as a secondary effect.
- Null-separator structure (no free energy) + SW compression of M'sheath ➡ deformation of plasma structure and field structure = generation of free energy = generation of current system

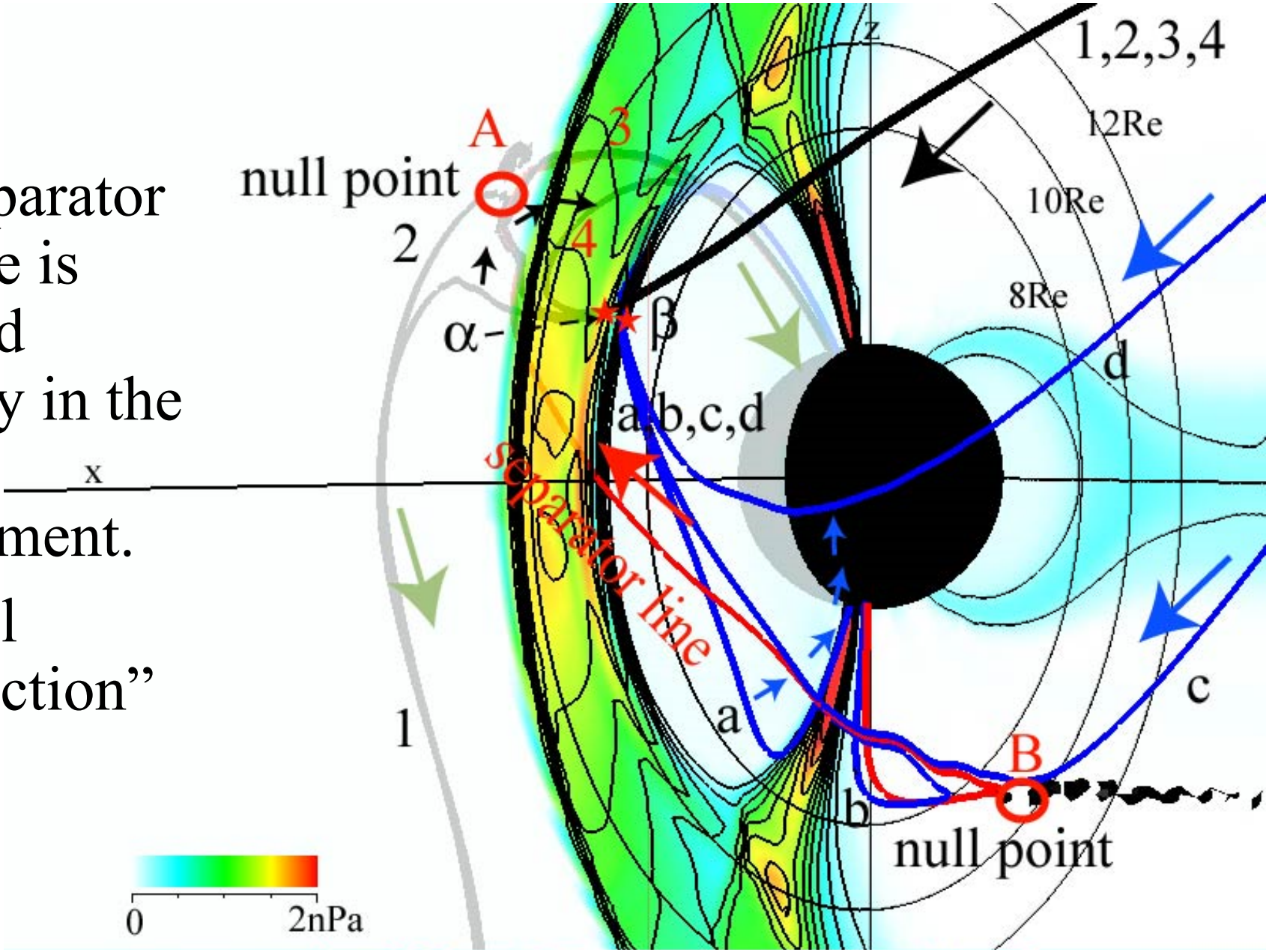
What is the magnetopause reconnection?

- null-separator structure = superposition of two force-free magnetic field systems
- The magnetic field configuration of the null-separator structure does not have free energy.
- The two magnetic field lines are connected through the null point. The kinetic effect (diffusion) is not required for the "reconnection".

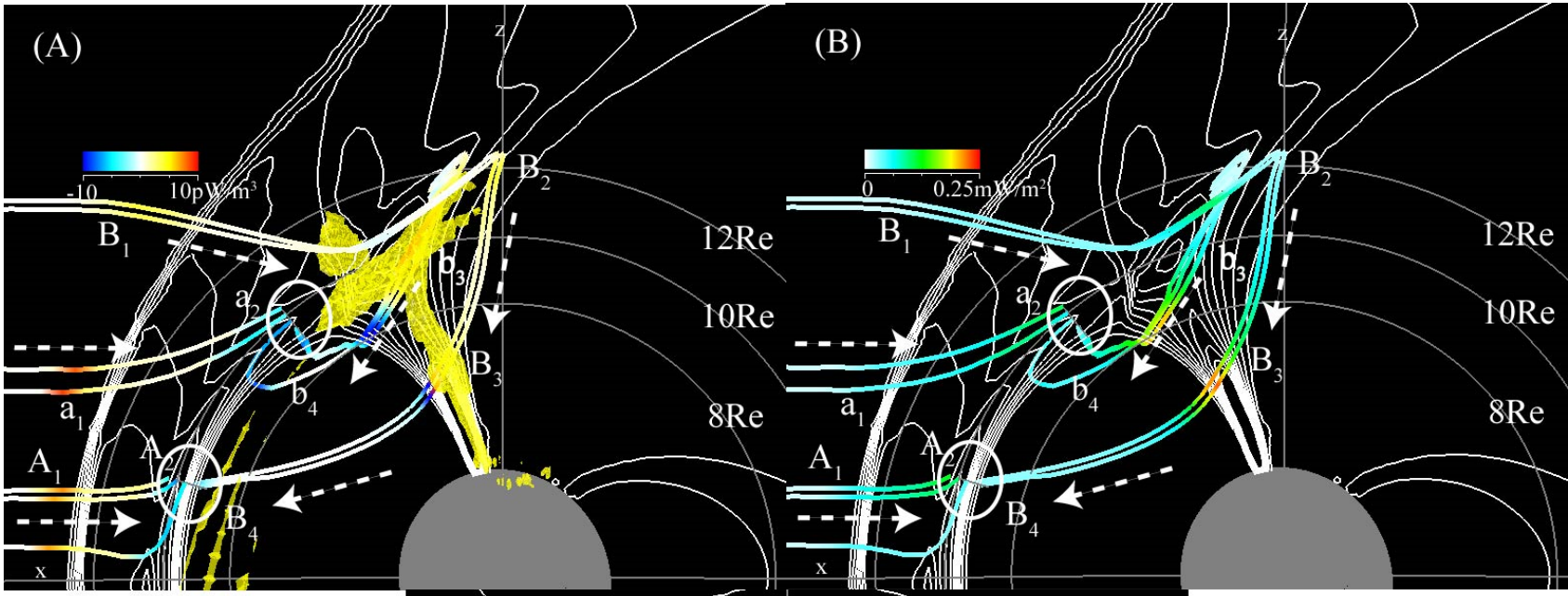


Wang and Bhattacharjee [1996]

- Null-separator structure is achieved basically in the plasma environment.
- “parallel reconnection”



Streamline of Poynting flux

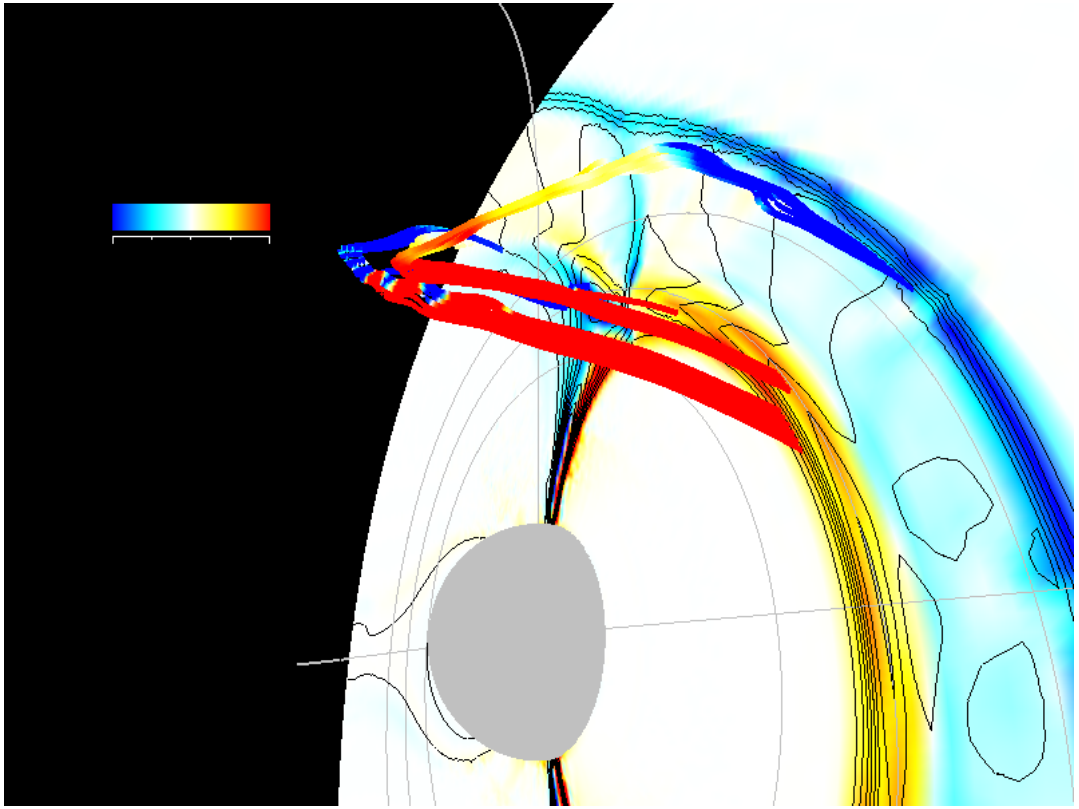


- The magnetic energy in the acceleration region (the magnetopause defined as the magnetic field deflection) is supplied from the bow shock.
- This result stands for compression of the magnetosheath by the solar wind plays an essential role in the "reconnection" in the dayside magnetosphere.
- ➡ then we recall….

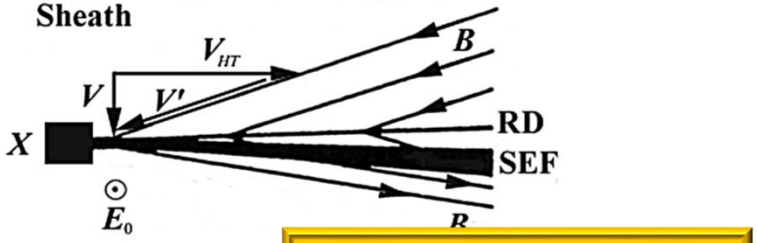
Two magnetopauses seen from the current system

- #2: The magnetopause defined as the magnetic field deflection (satellite observation)➡ bow shock current

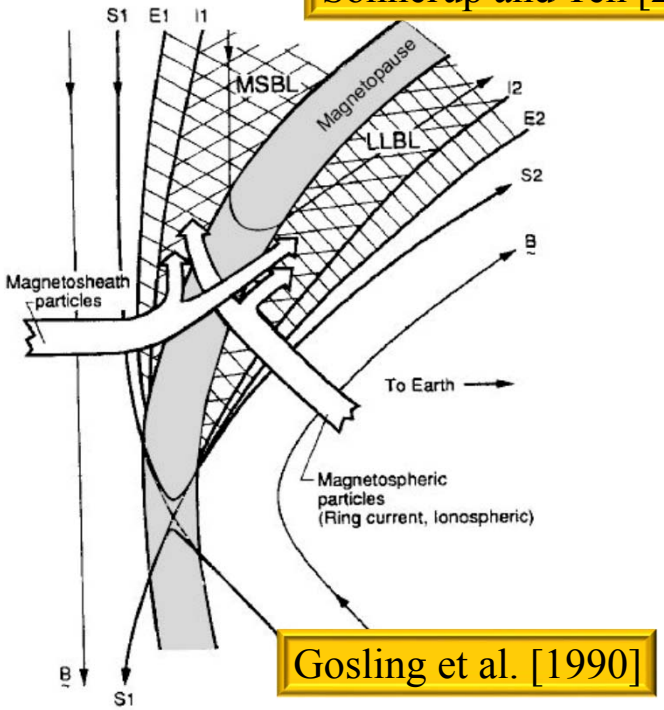
- #1: The magnetopause defined as balance between magnetic pressure and thermal pressure ➡ Chapman-Ferraro current



Discussion: but, the satellite observations insist the magnetopause as the rotational discontinuity…

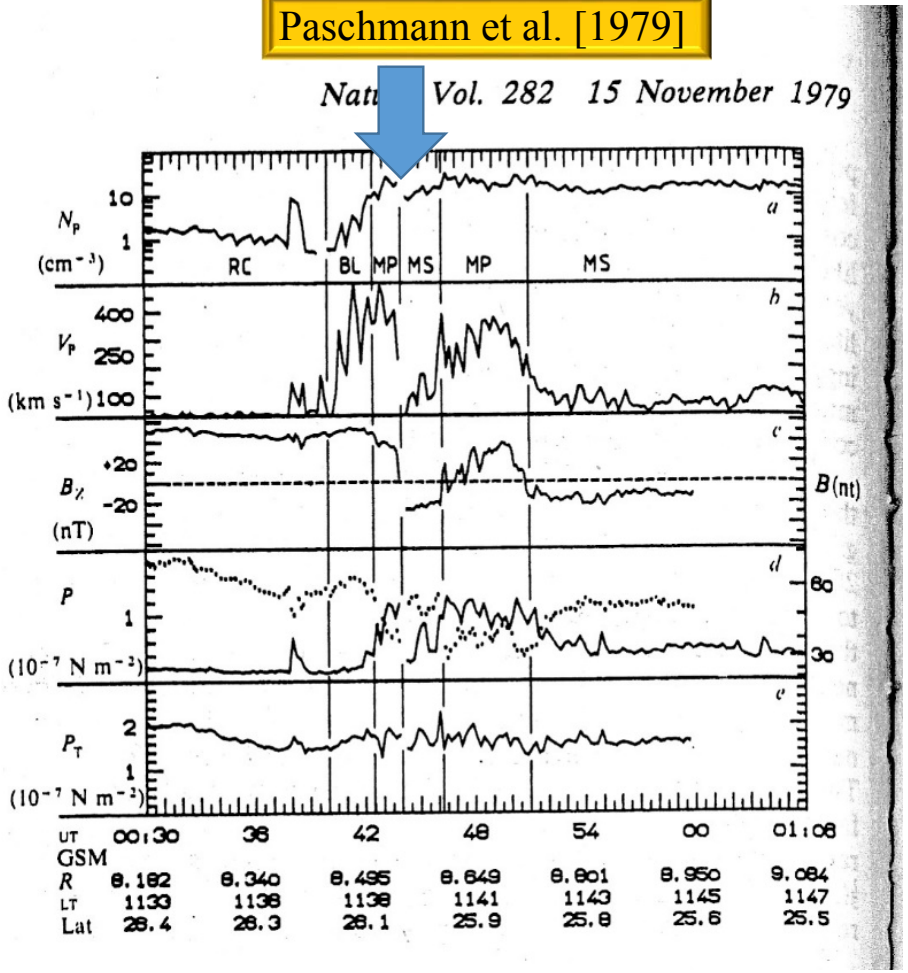


Sonnerup and Teh [2008]



Gosling et al. [1990]

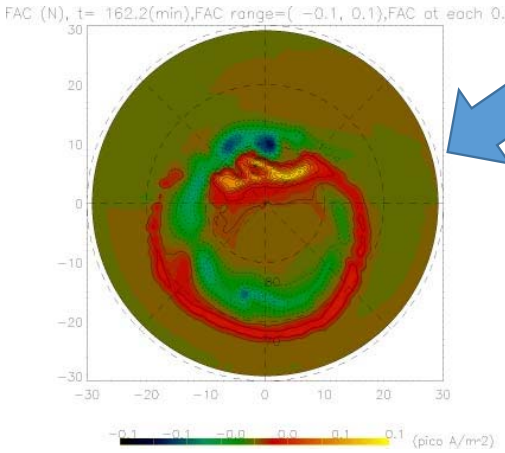
Paschmann et al. [1979]

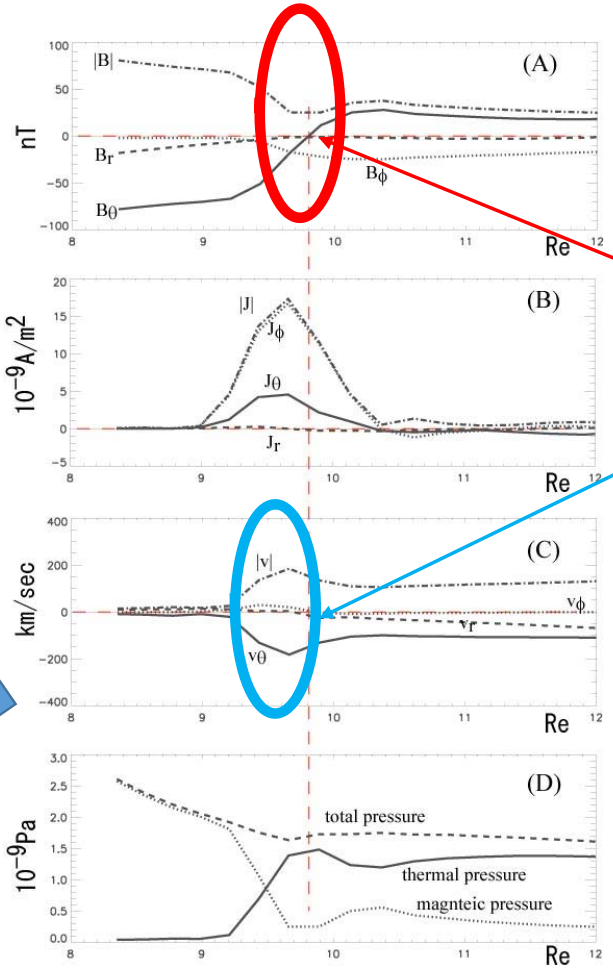


- High-speed plasma flow: simulation and observation are consistent.
- Magnetic field deflection: simulation and observation are essentially consistent. But with of the simulated "magnetopause" is wider than the observed one.

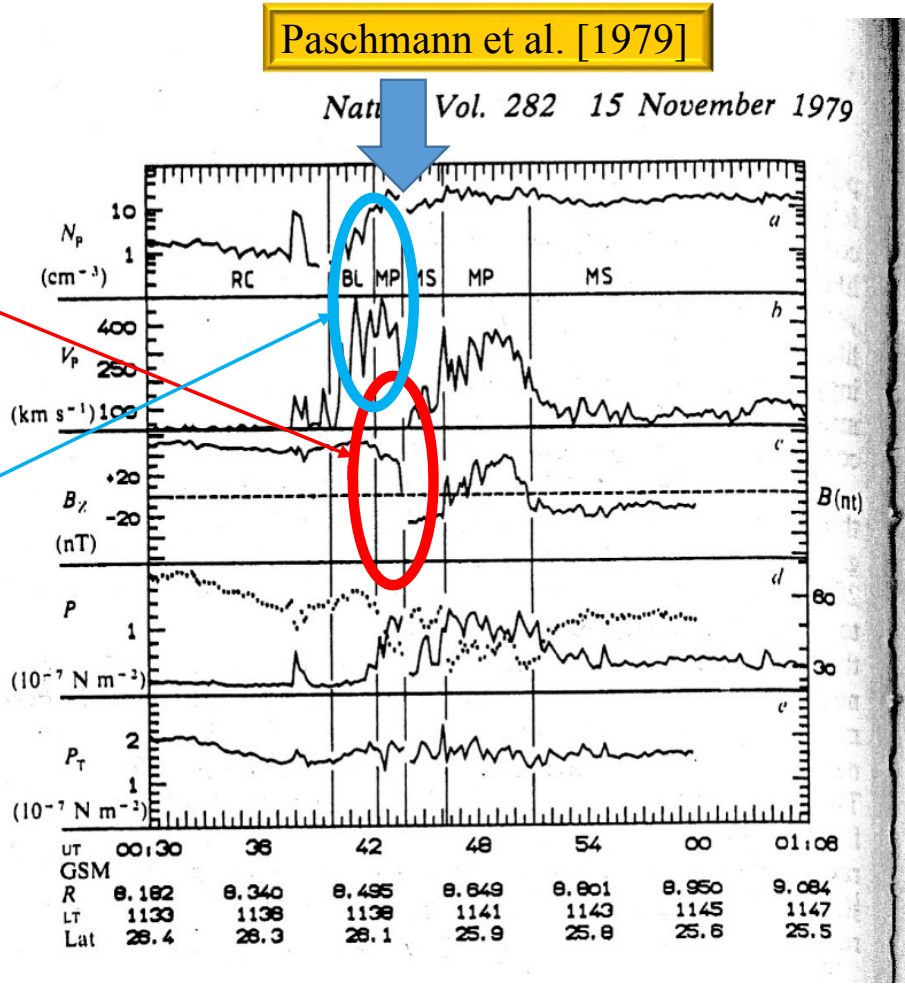
Observation: 400-1000km

Simulation : ~0.5Re





Paschmann et al. [1979]



- The RD is not correctly reproduced in the simulation. But the global R1FAC distribution is realistically reproduced.

The issues about the rotational discontinuity are …

- The RD is not reproduced in the MHD simulation. This is because of a coarse mesh system (0.23Re) employed by the simulation. However, probably, the simulation with much finer mesh system will not reproduce the RD. Some anomalous diffusion will be required for the RD.
- The RD will not play an essential role in producing global phenomena such as the R1FAC. The RD may drive local disturbances in the magnetosphere and ionosphere.

Conclusions

- The null-separator system provides the fundamental structure of the magnetic field in the solar wind-magnetosphere interface.
- The kinetic effect does not play an essential role in the reconnection in the dayside magnetopause. The “reconnection” occurs in the compressed plasmas due to the solar wind dynamic pressure. Thus, the magnetic energy is transported from the bow shock to the magnetopause, as well as the bow-shock current makes the magnetic field modification in the magnetopause.
- Plasma behaviors in the simulated magnetopause are essentially consistent with those in the observations. However, the RD is not reproduced in the simulation.

Acknowledgments

- S. F. is very much thankful to H. Hasegawa of ISAS for discussions about the satellite observations of the magnetopause.