Observational Analysis of In Situ Ring Current Density

A Multi-Mission, Multi-Perspective, and Multi-Spacecraft Approach

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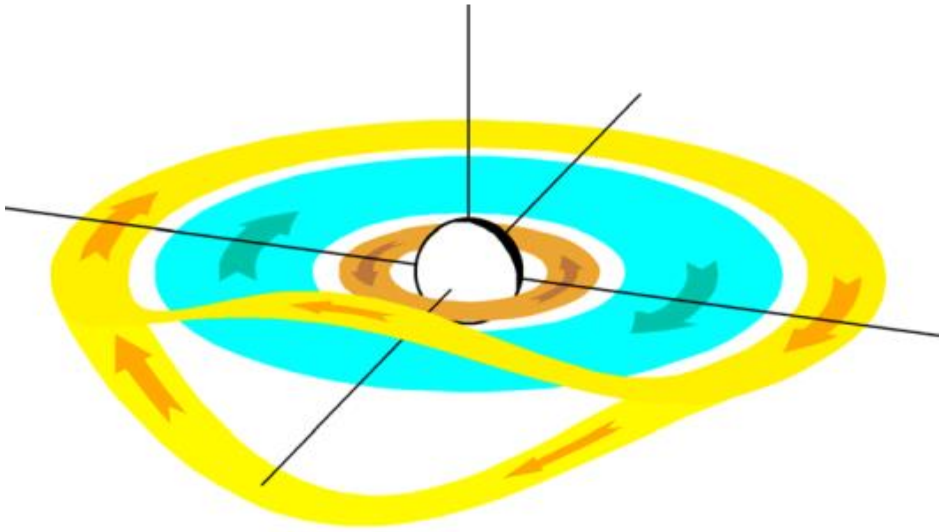
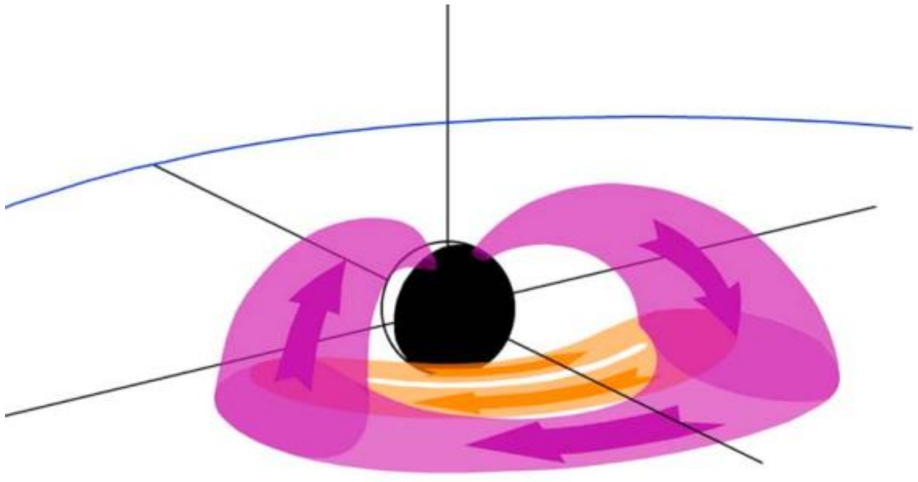
The ring current system in Earth’s magnetosphere





(Ganushkina, Liemohn et al. 2018)

Symmetric ring current (eastward and westward) including cut ring currents on the dayside + Partial ring current and region 2 field-aligned currents

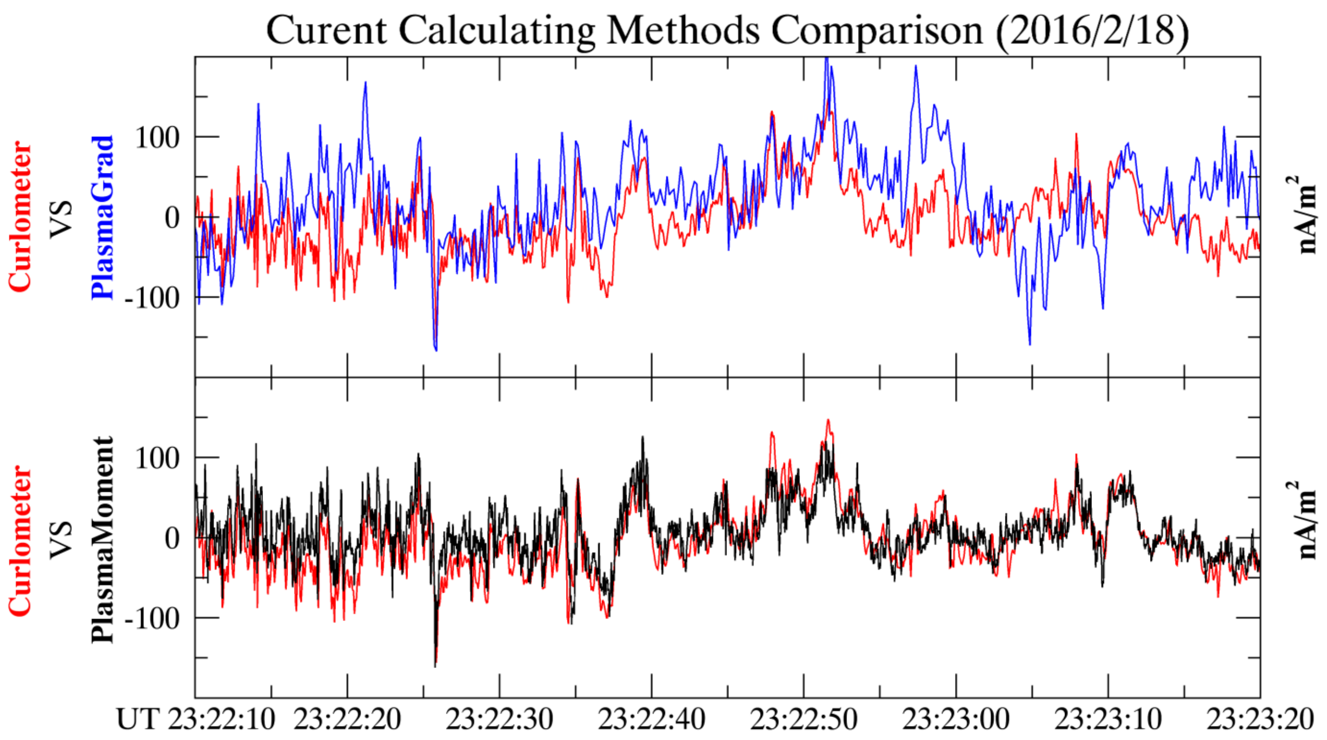
Methods of in-situ current density calculation

Data from MMS FGM & FPI

$$\boldsymbol{J} = \frac{\nabla \times \boldsymbol{B}}{\mu_0} - \epsilon_0 \frac{\partial \boldsymbol{E}}{\partial t}$$

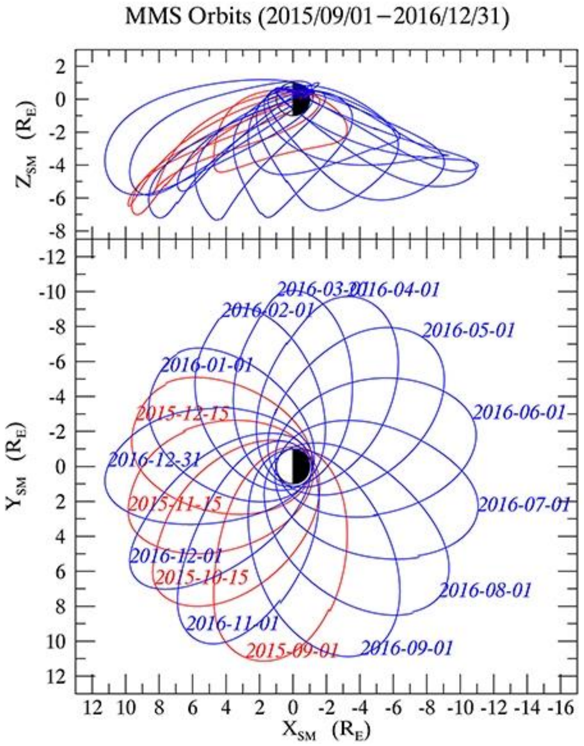
$$\boldsymbol{J} = \frac{\boldsymbol{B}}{B^2} \times \left(\nabla P_\perp + \frac{P_\parallel - P_\perp}{B^2} (\boldsymbol{B} \cdot \nabla) \boldsymbol{B} \right)$$

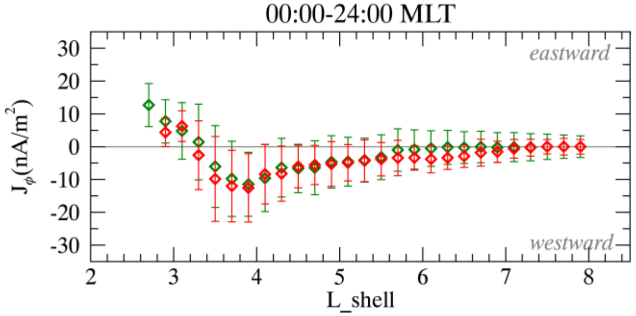
$$\boldsymbol{J} = q(n_i \boldsymbol{v}_i - n_e \boldsymbol{v}_e)$$

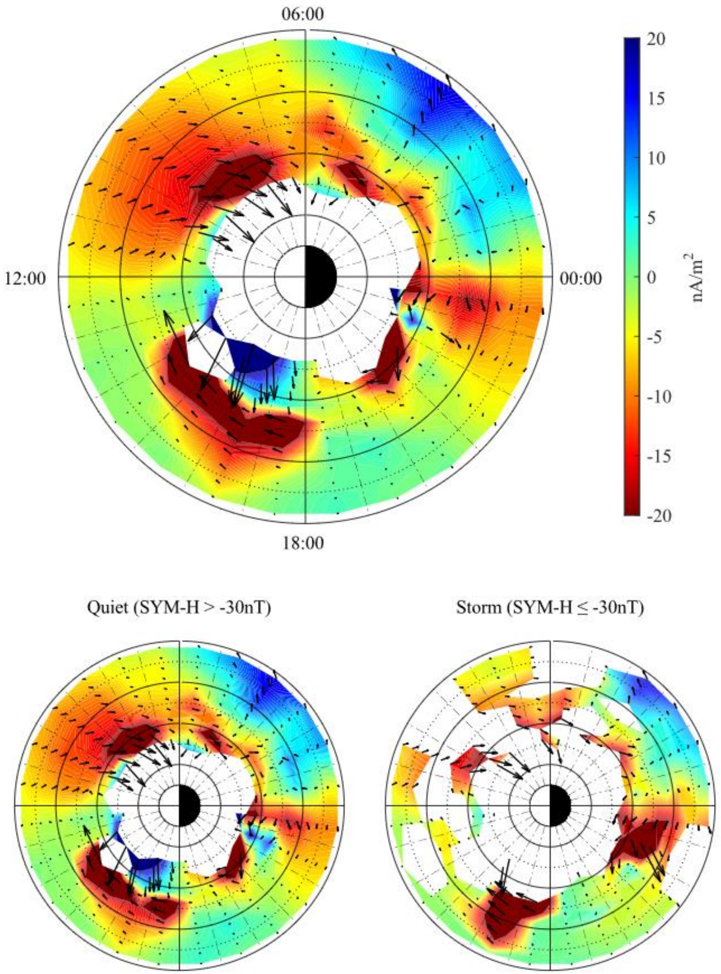


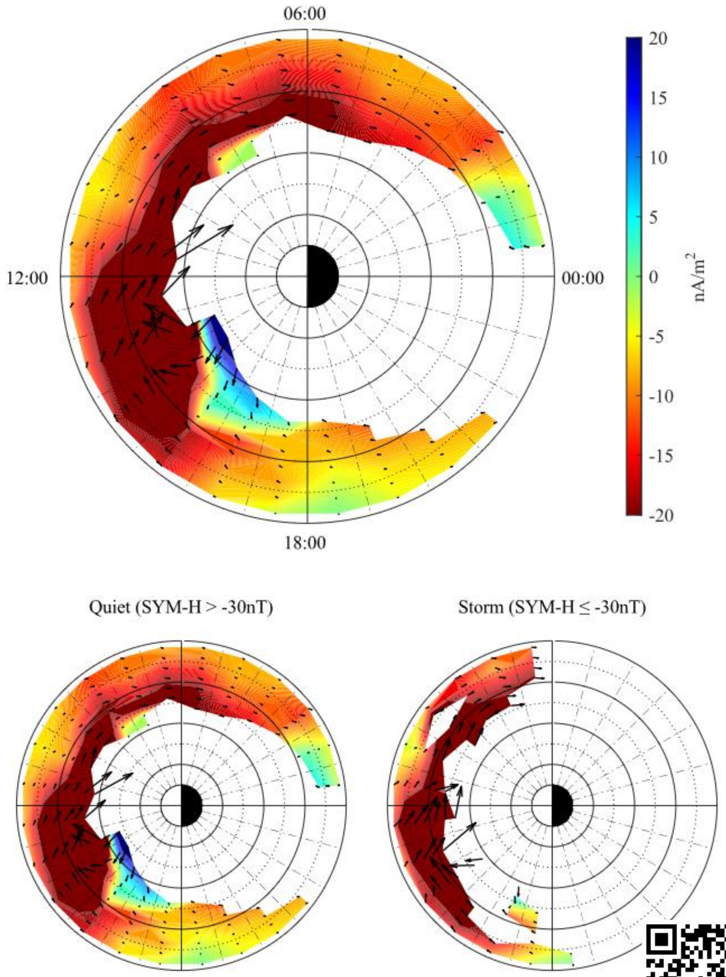
Ring current morphology from MMS observations

Data from MMS FGM 2015-2016

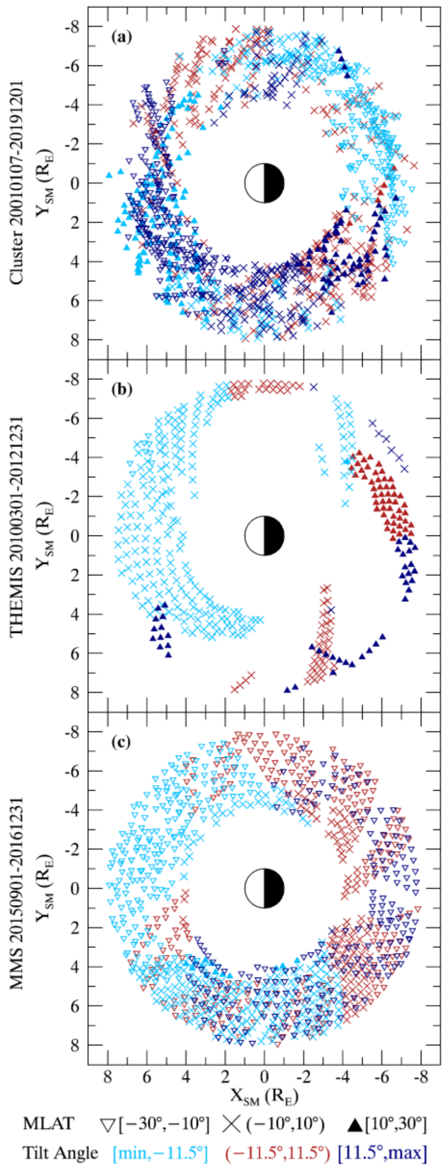


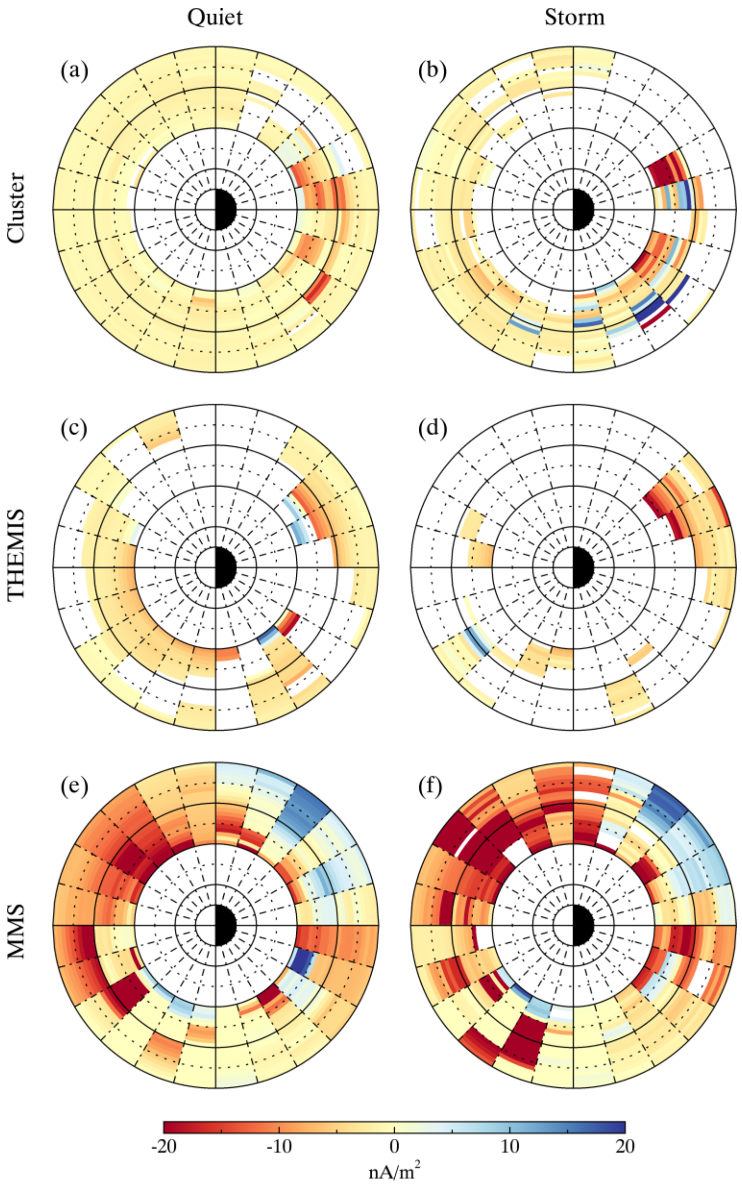




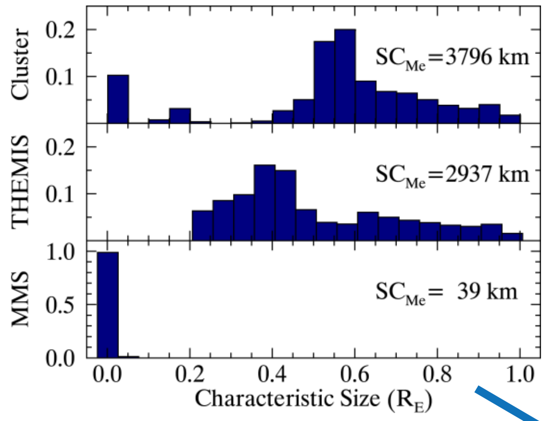


(Tan, Dunlop et al. 2023)





Comparison of Cluster, THEMIS and MMS

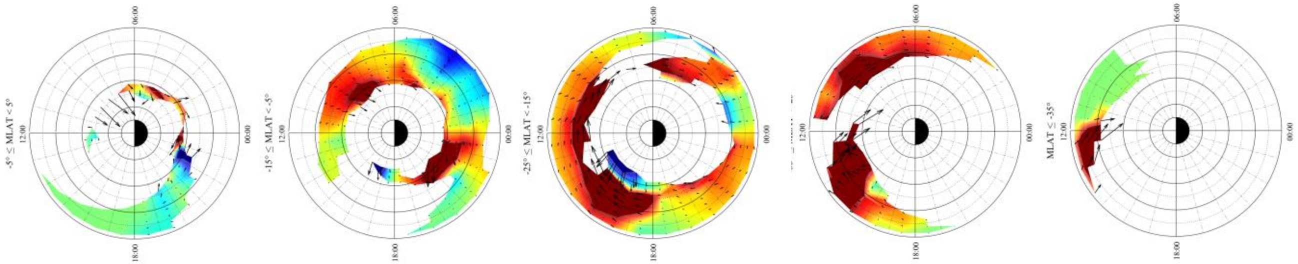


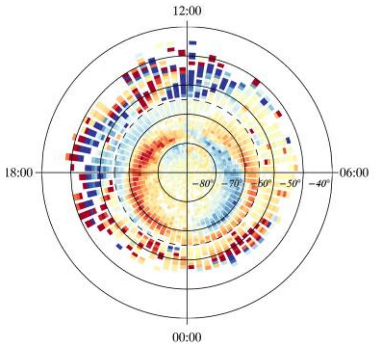
$$\oint \boldsymbol{B}\cdot d\boldsymbol{l} = \mu_0 \boldsymbol{I} = \iint \boldsymbol{\nabla}\times\boldsymbol{B}\cdot d\boldsymbol{S} \approx \mu_0 \tilde{\boldsymbol{J}}\cdot\tilde{\boldsymbol{S}}$$

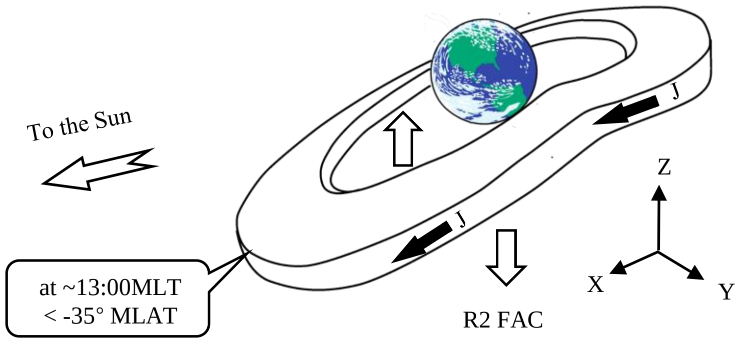
(Under Review)

Layered structure of near equatorial, ring current density and its ionospheric coupling

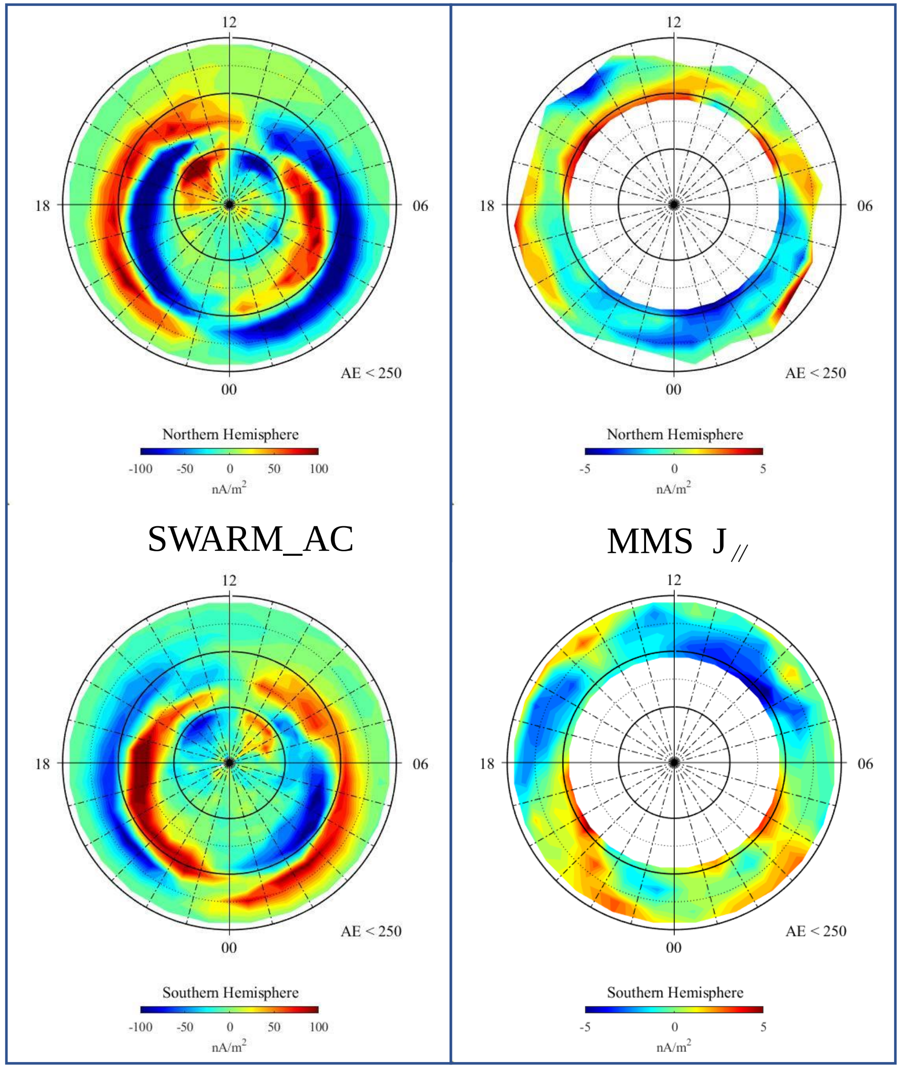
Data from MMS FGM & SWARM FAC 2015-2016







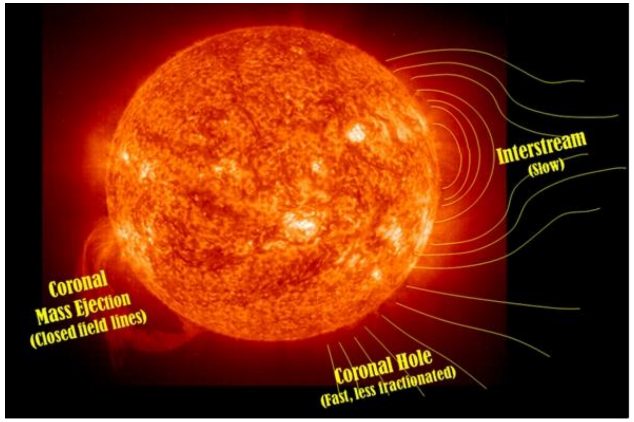
(EGU23 X4.254)

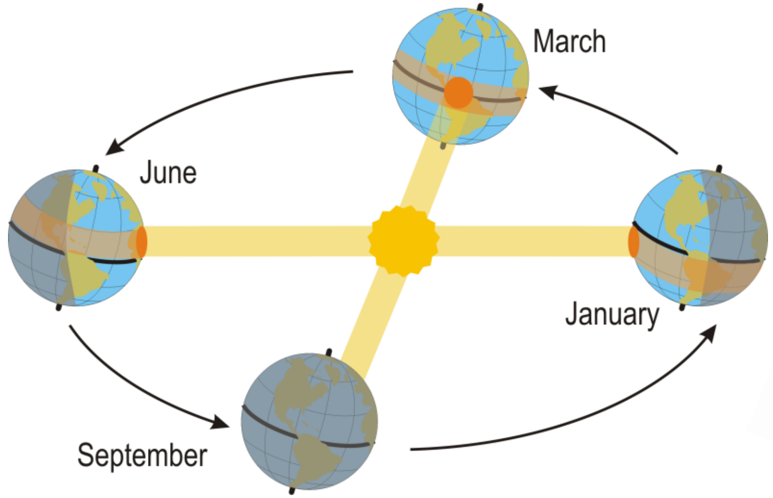


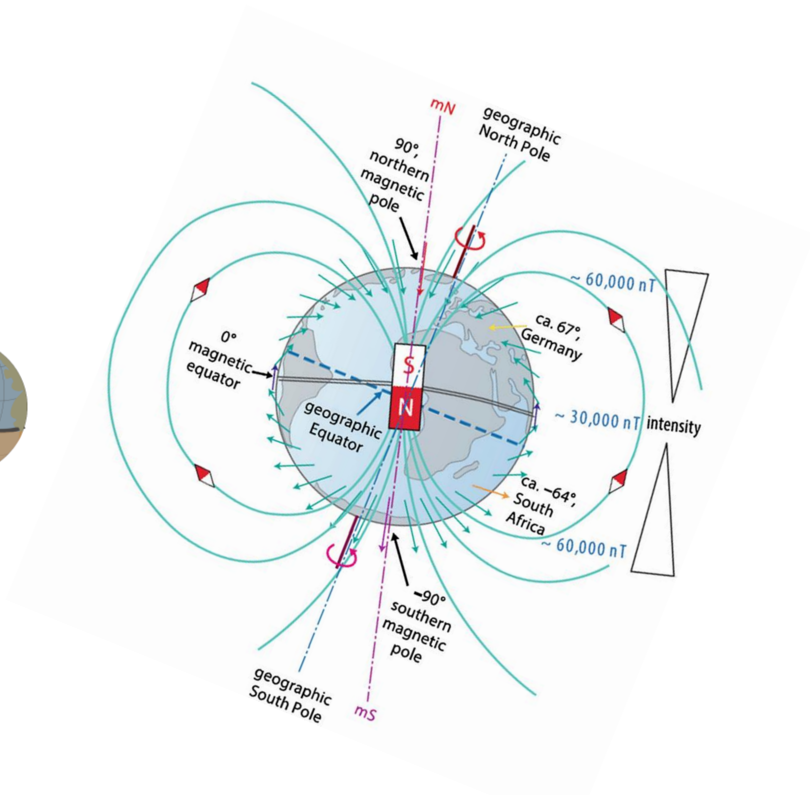
Data from
MMS FGM
&
SWARM FAC
2015-2022

Polar region mapping

Changes of upstream solar wind conditions



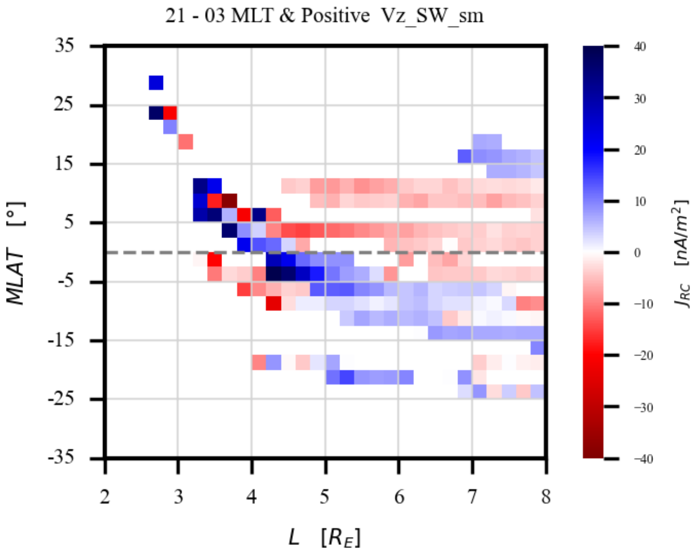


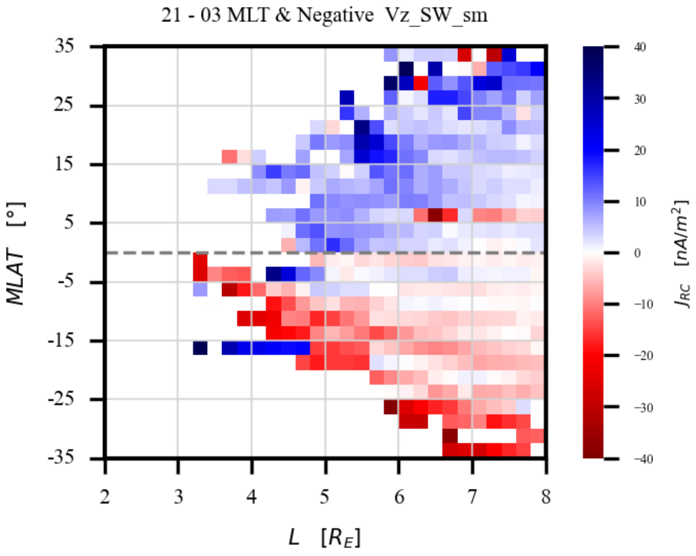


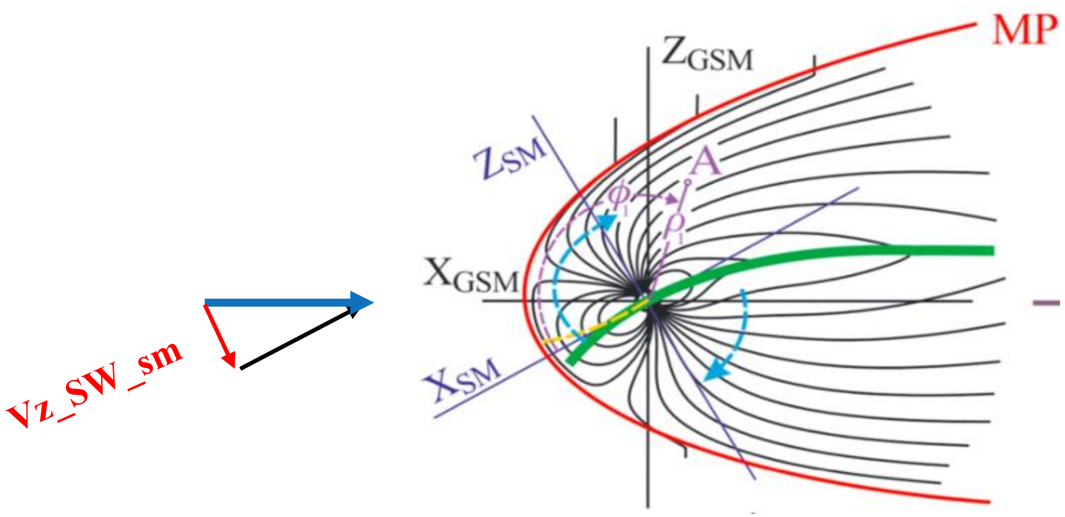
Generation and evolution of the solar wind + The annual change in the tilt of the geographical axis caused by the Earth's revolution + The diurnal change in the tilt of the magnetic axis caused by the Earth's rotation

MMS J_{RC} @ MidN Side 21:00 - 03:00 MLT

Vz_SW_sm

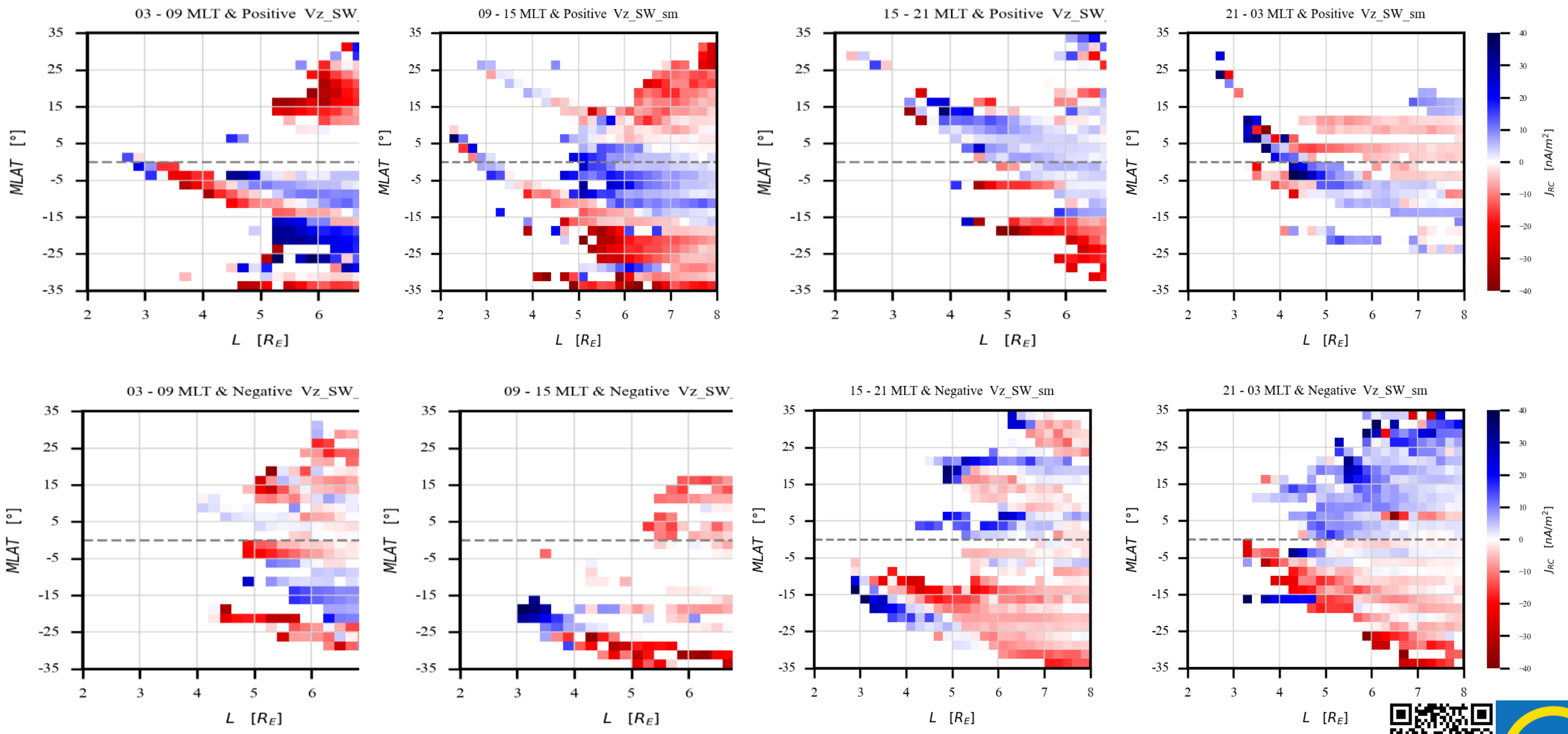






(Tsyganenko 2014)

Vz_SW_sm



Dawn **Noon** **Dusk** **MidN**

Summary

- Analysis of in-situ current density is a helpful and powerful tool for us to expand our understanding of the ring current. The curlometer method is reliable and effective in the ring current region, where for MMS plasma information is limited.

- The basic ring current structure is always present; the westward current is enhanced during magnetic storms. Banana currents exist in both clockwise and counterclockwise directions in the ring current region. The cause can be traced to plasma pressure peaks and valleys.

- The spatial spacecraft separation scale affects the analysis of current density. This is relevant to compare observations from missions with different sampling scales and to determine the spatial scale of the ring current sheet or some other space current sheets.

- The spatial structure of the ring current makes it behave differently at different MLT and magnetic latitudes, and the most important factor is the Vz component (with respect to Earth's magnetic field) of the upstream solar wind. Current density observations have provided a preliminary look at this effect.

THANK YOU