ÖAW IWF

ISEE 宇宙地球環境研究所
Institute for Space-Earth Environmental Research



# MMS-ARASE Conjuction observations during Phase 8d

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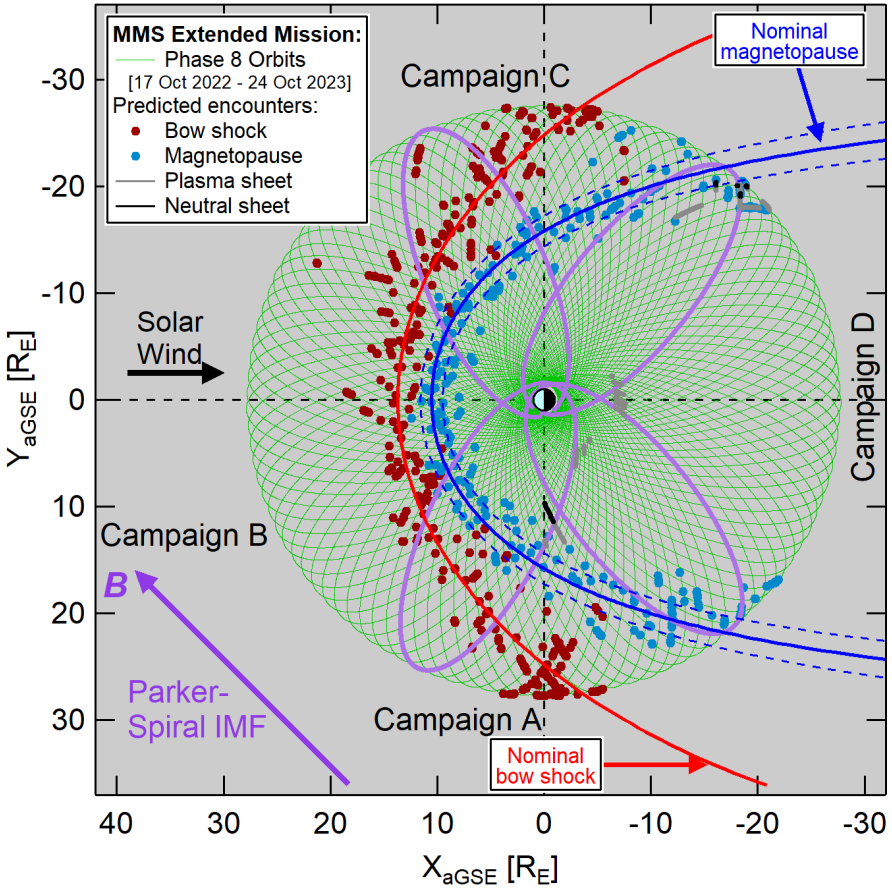
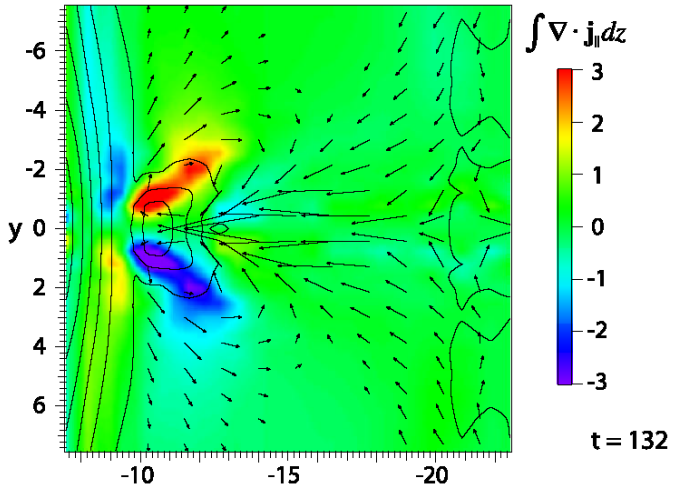
# 2023 Summer-Autumn

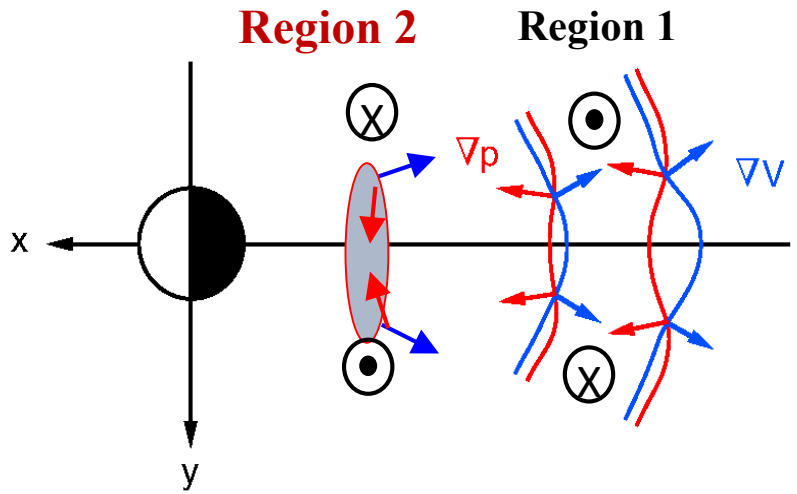
- MMS current sheet crossings take place in inner magnetosphere during Phase 8D  (apogee in lobe)
- >12 inner magnetospheric (inside GEO) conjuction with ARASE spacecraft
- Most of them are >3 missions conjuctions with MMS, ARASE, THEMIS or Cluster, and some with foot point in North-American sector
- Opportunities for night-side sciences: flow braking, FAC, injection, instabilities/waves around the transition region, wave-particle interaction related to pulsating aurora



# Parallel current and Pressure gradient in Flow Braking region



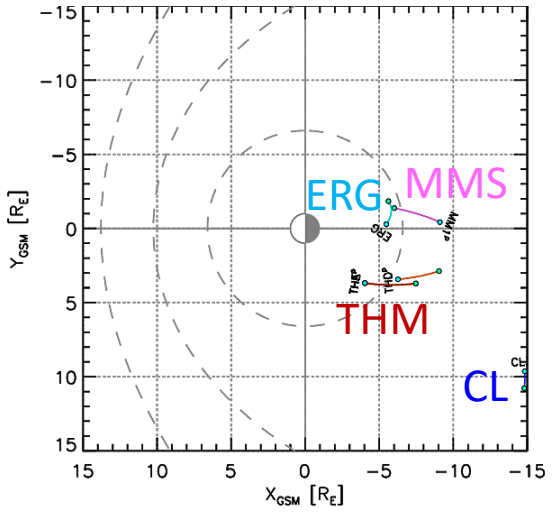

(adapted from Birn et al., 2011)

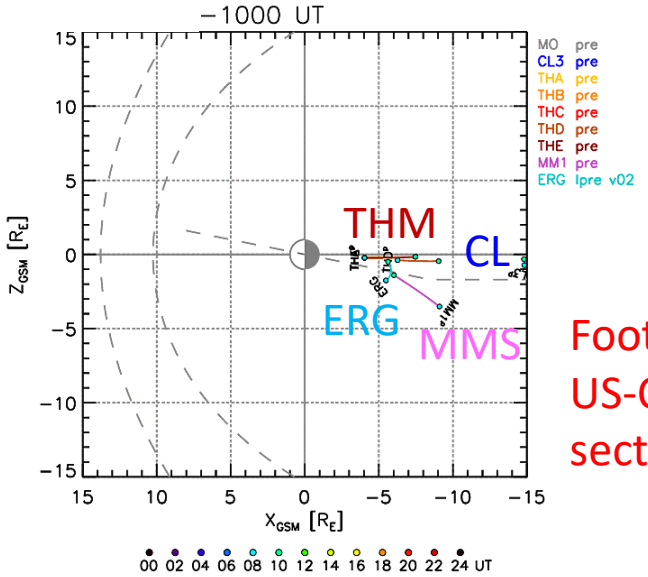



$$\int_{equator}^{ionosphere} \frac{j_{//}}{B} ds = -\frac{\mathbf{B}}{B_{eq}^2} \cdot \nabla p_{eq} \times \nabla V$$

$$V = \int_{eq}^{io} \frac{ds}{B}$$ flux tube volume

- Multi-point gradient measurements
- FAC



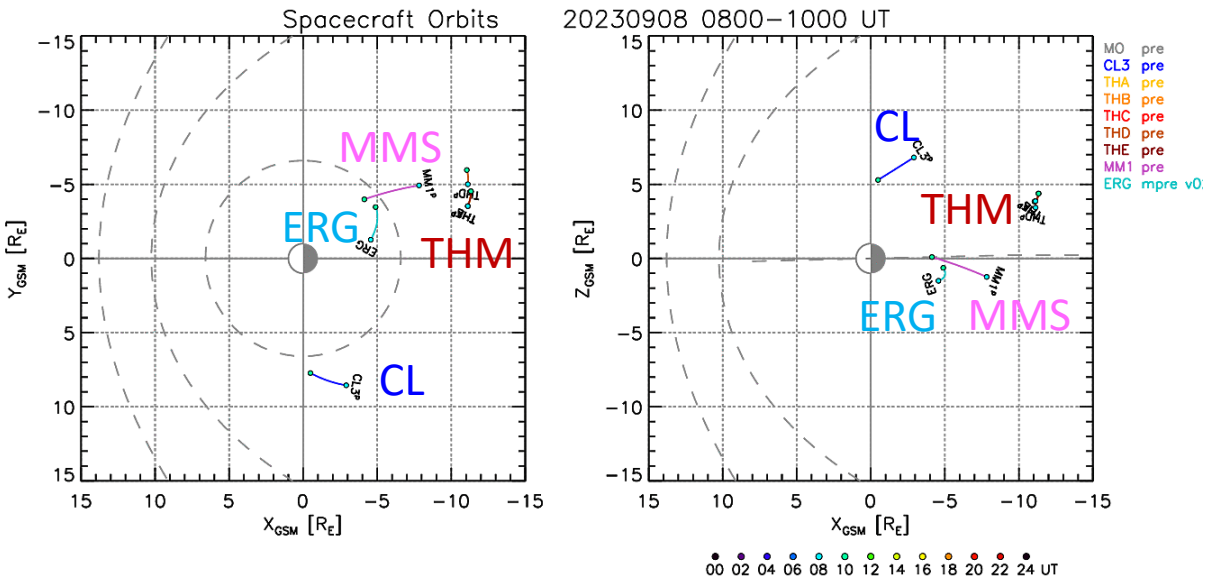

Footprint: US-Canada sector

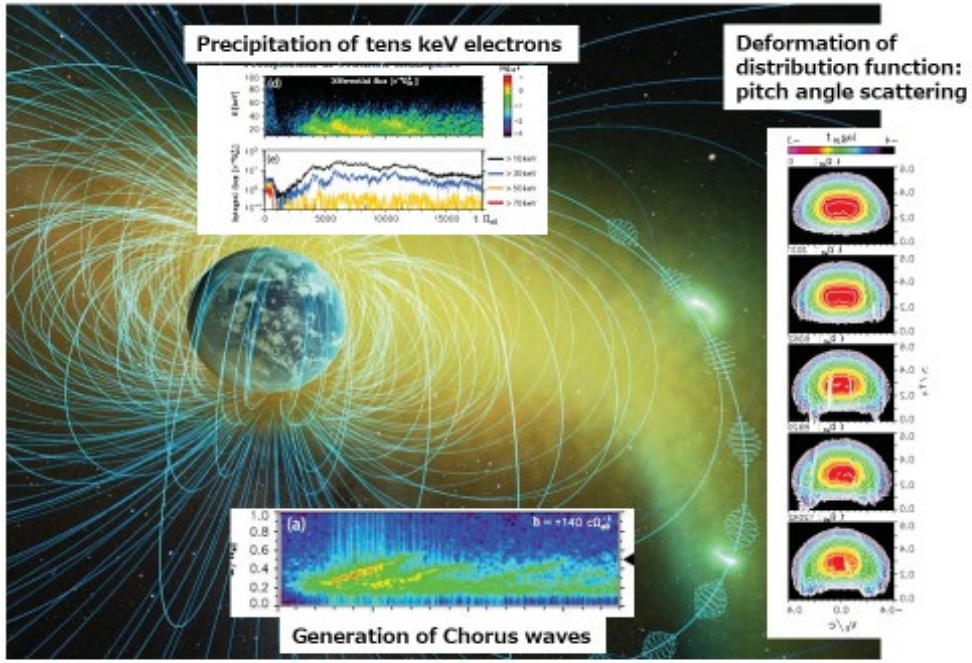
## Pitch angle scattering by wave-particle interactions

# Pulsating aurora

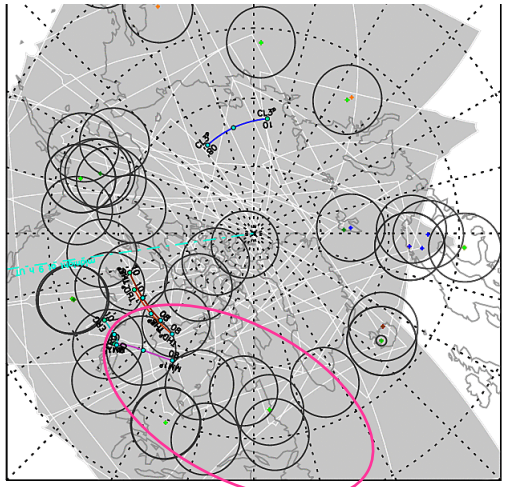
- Monitoring all ingredients:

injection, density irregularities, wave-particle interaction, auroral precipitation




Hikishima+, GRL, 2010



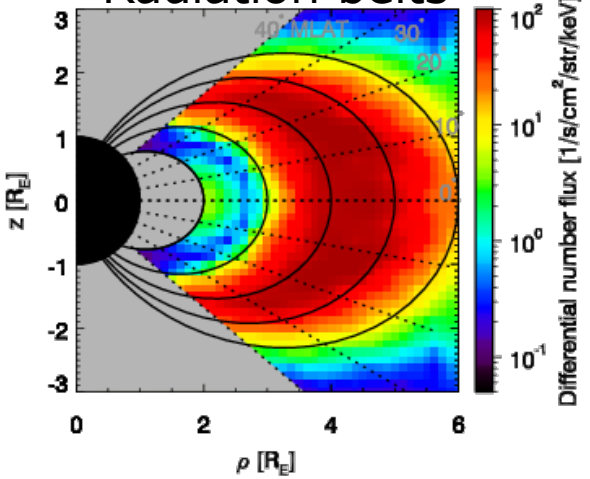
Foot-point in northern american auroral stations

# Arase/ERG

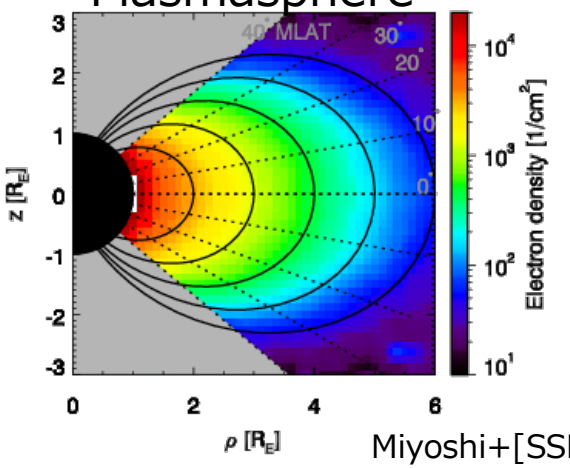
**Orbit:**

| | |
|---|---|
| -Apogee: | 32,000 km |
| -Perigee: | 460 km |
| -Orbital period: | 9.4 hours |
| -Inclination | 31 deg |
| -Spin period: | 8 sec |

Radiation belts




Plasmasphere




Miyoshi+[SSR, 2022]

**Particles:** Ion (w/ mass discrimination): 10 eV/q – 180 keV/q (3D distribution function)
Electrons: ~100 eV - ~ 5 MeV (3D distribution function)

**Fields/waves:** Electric fields: DC – 10 MHz
Magnetic fields: DC – 100 kHz
(DC-256 Hz: waveform, -64 kHz: wave burst)

**WPIA** (direct measurements of phase between electrons/ions and waves) has been operated.

**Data & Analysis tool:**

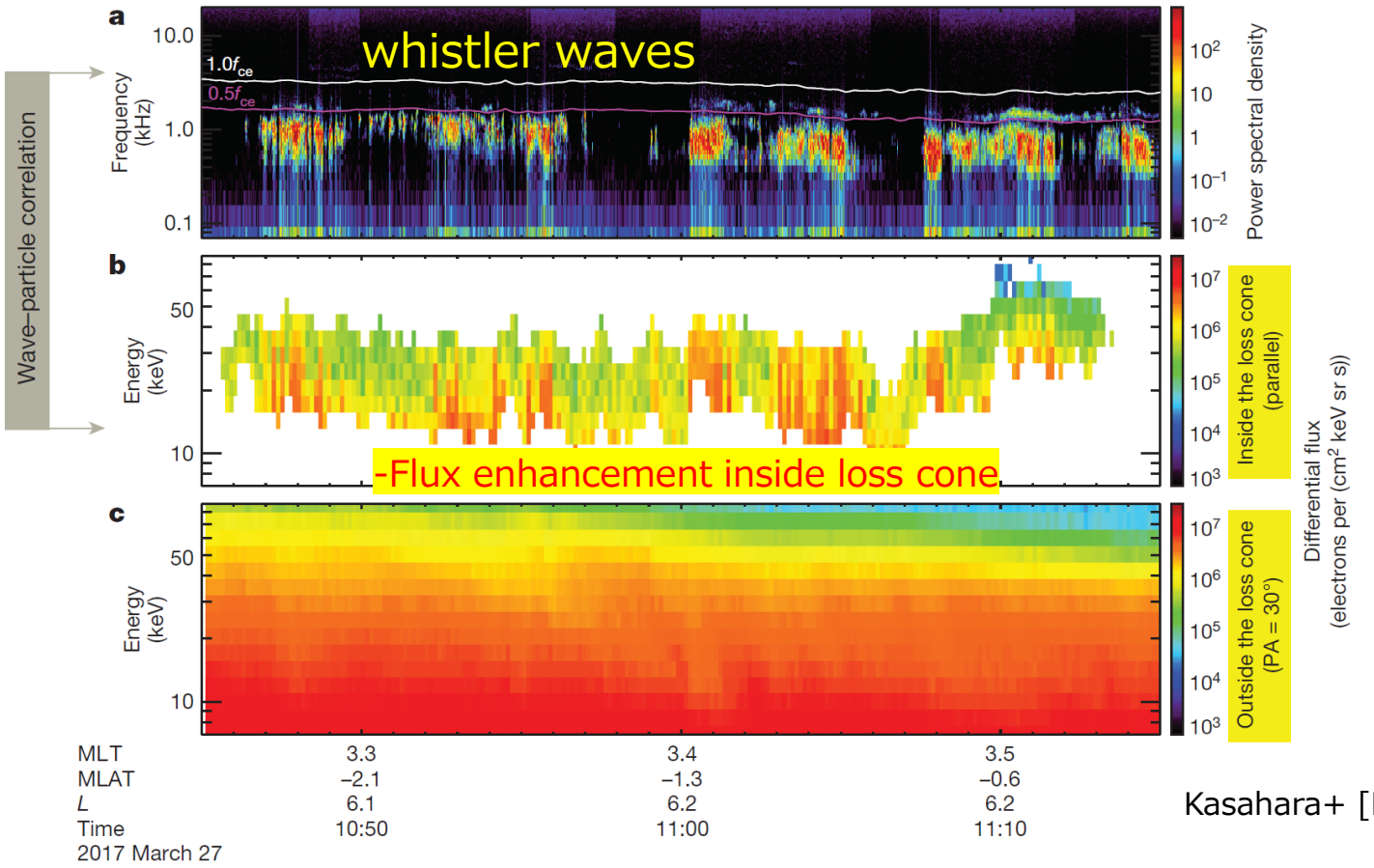
Data are available at ERG Science Center (https://ergsc.isee.nagoya-u.ac.jp/index.shtml.ja)
SPEDAS/PySPEDAS are available for the Arase data and ERG-ground based data (ASI, magnetometer, high-speed camera data etc).

# Example of observations by Arase

VLF waves:

Electrons:
Inside loss cone

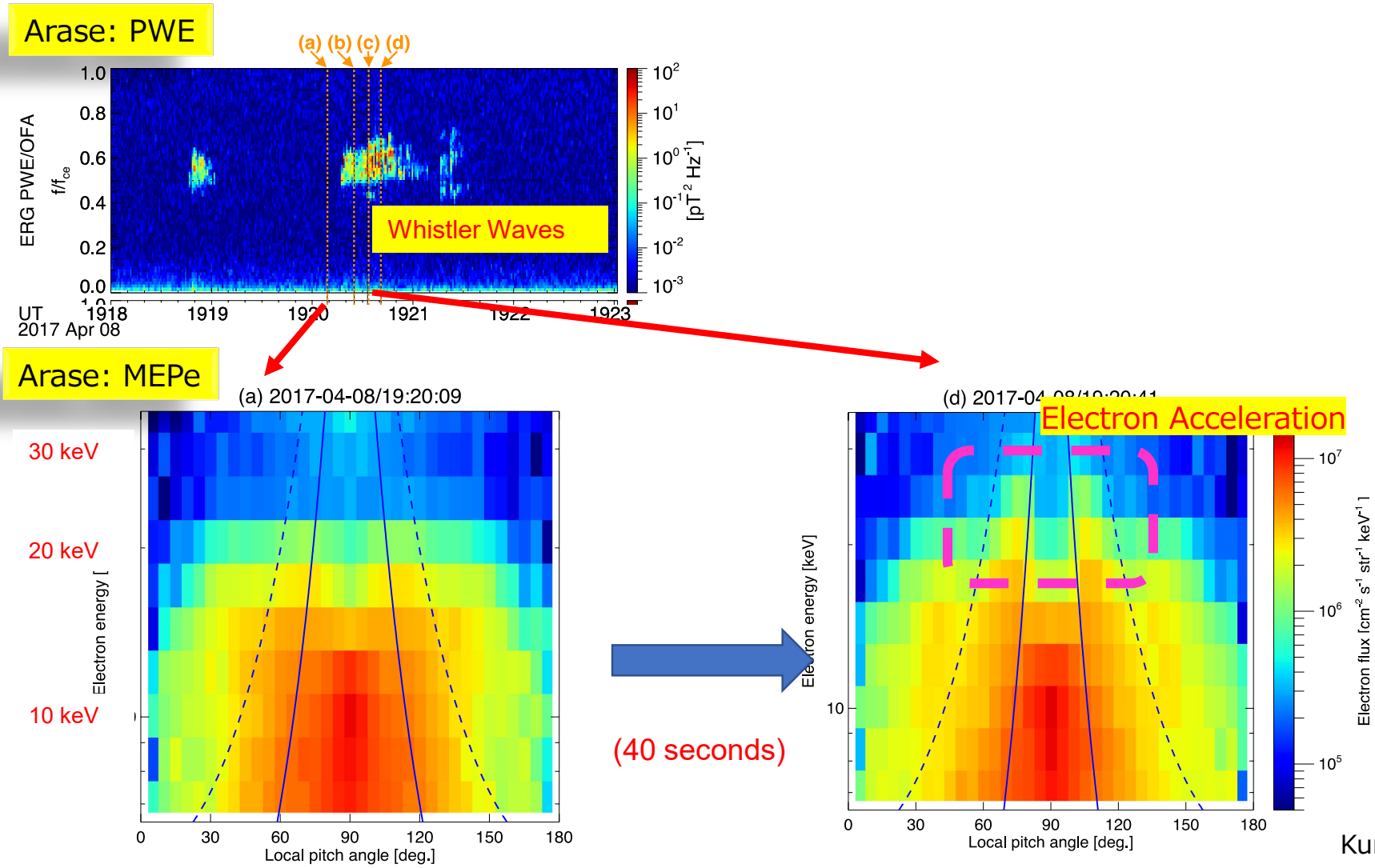
Electrons:
Outside loss cone




Kasahara+ [Nature, 2018]

The Arase satellite can sometimes observe electrons inside loss cone (~100 eV – 90 keV), and discuss how much electrons actually precipitate into the thermosphere through the pitch angle scattering.

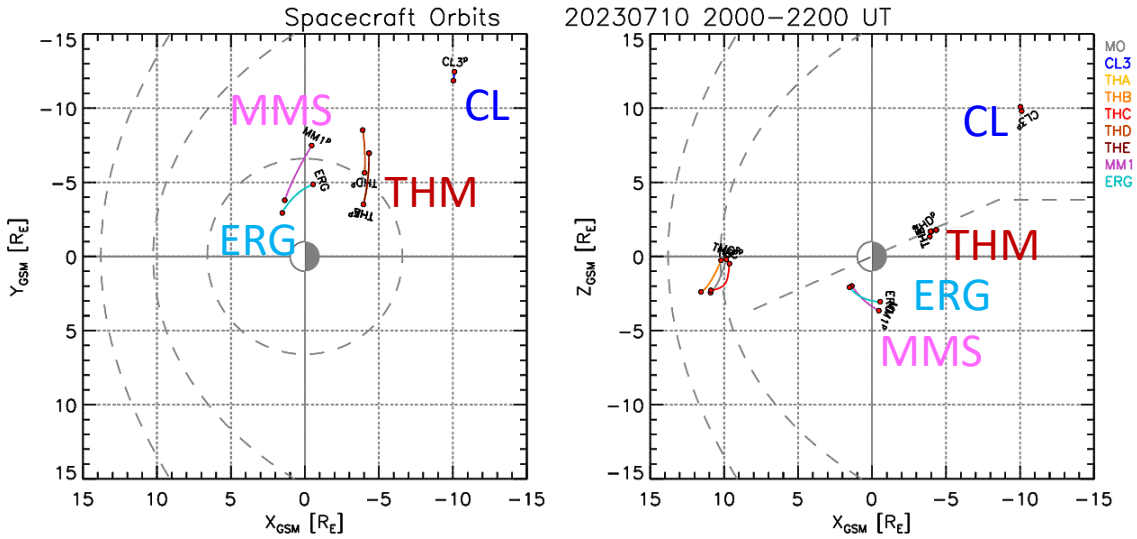
# Example of observations by Arase




Kurita+ [JGR, 2018]

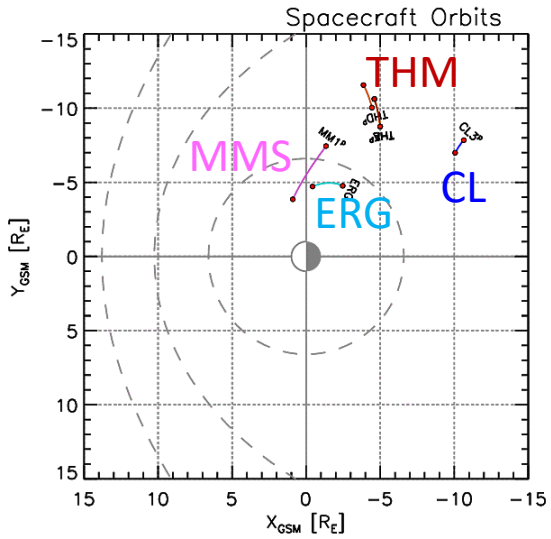
Arase observes 3-D distribution function every 8 sec (spin period) and found the deformation of the distribution function of electrons through chorus wave-particle interactions.

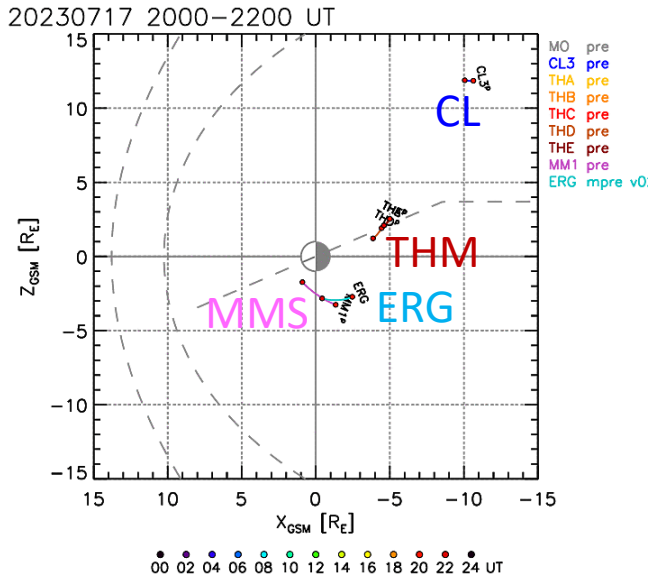
# 4 (Moderate) Conjunctions from Jul. 10 to Jul. 21

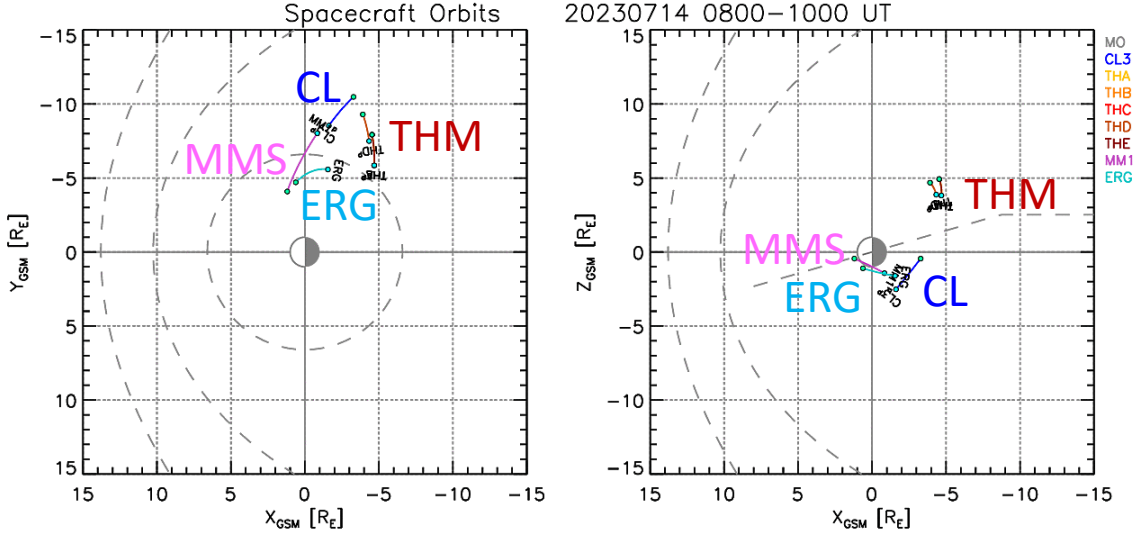






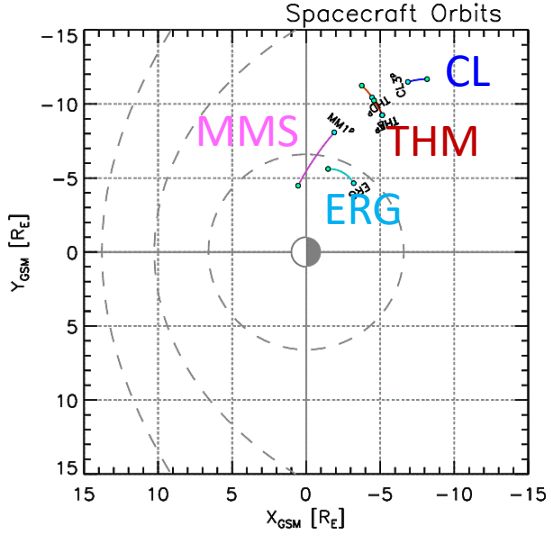


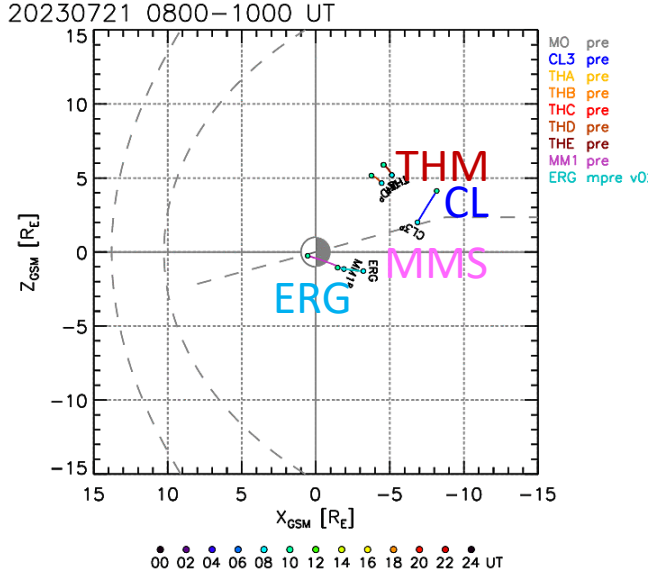



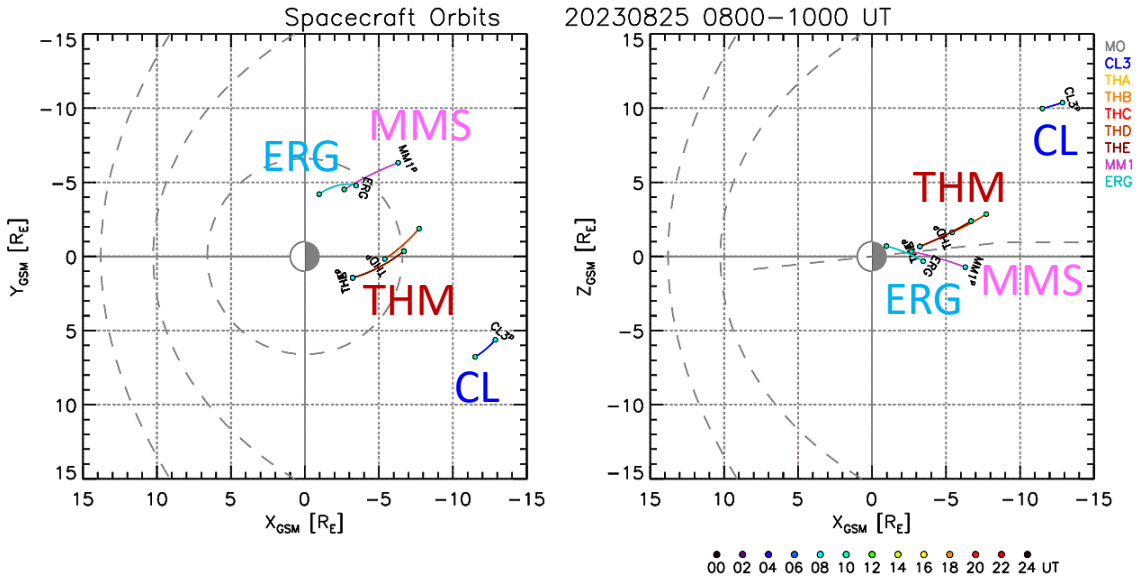






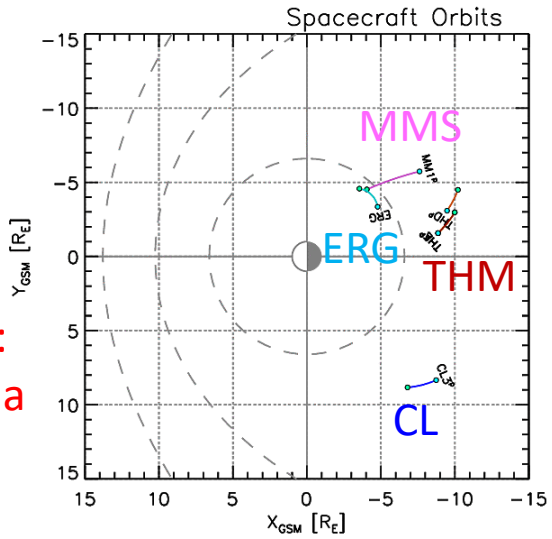
# 5 Conjunctions from Aug. 25 to Sep. 8

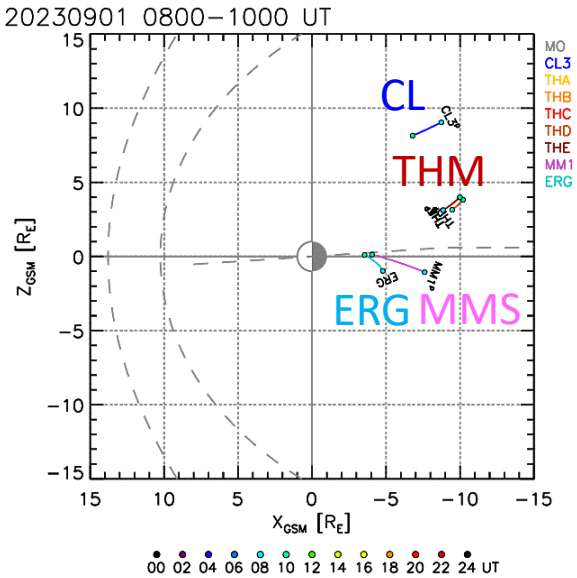


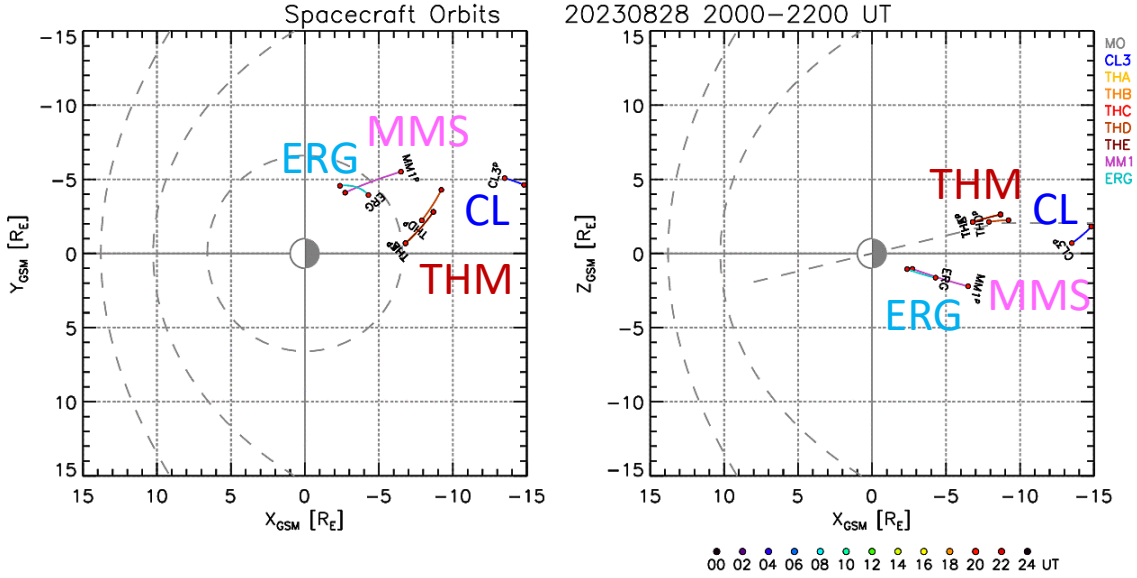




Footprint: US-Canada sector



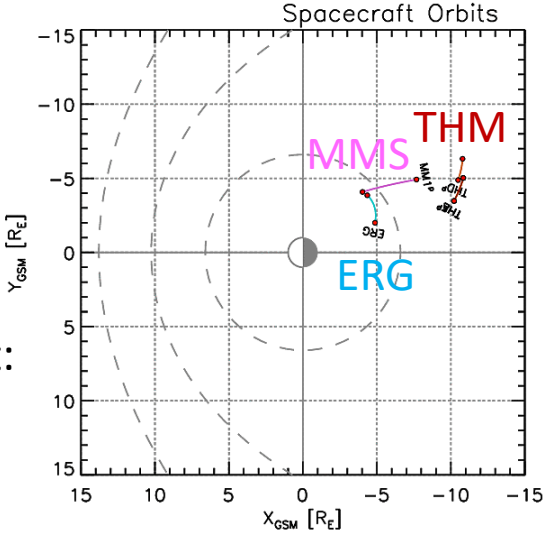



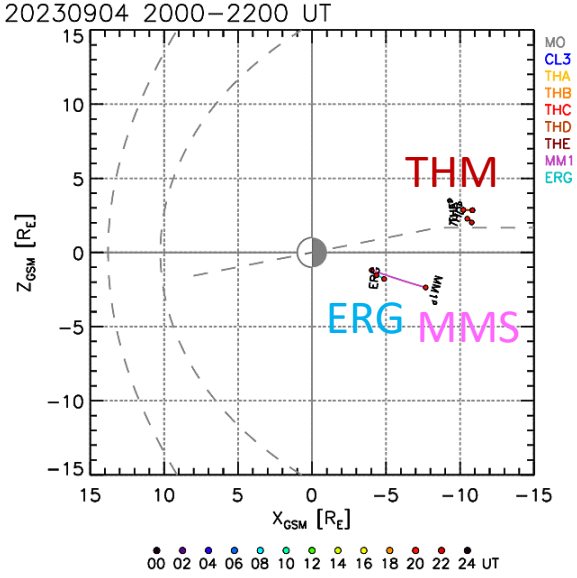







Footprint: Russia sector



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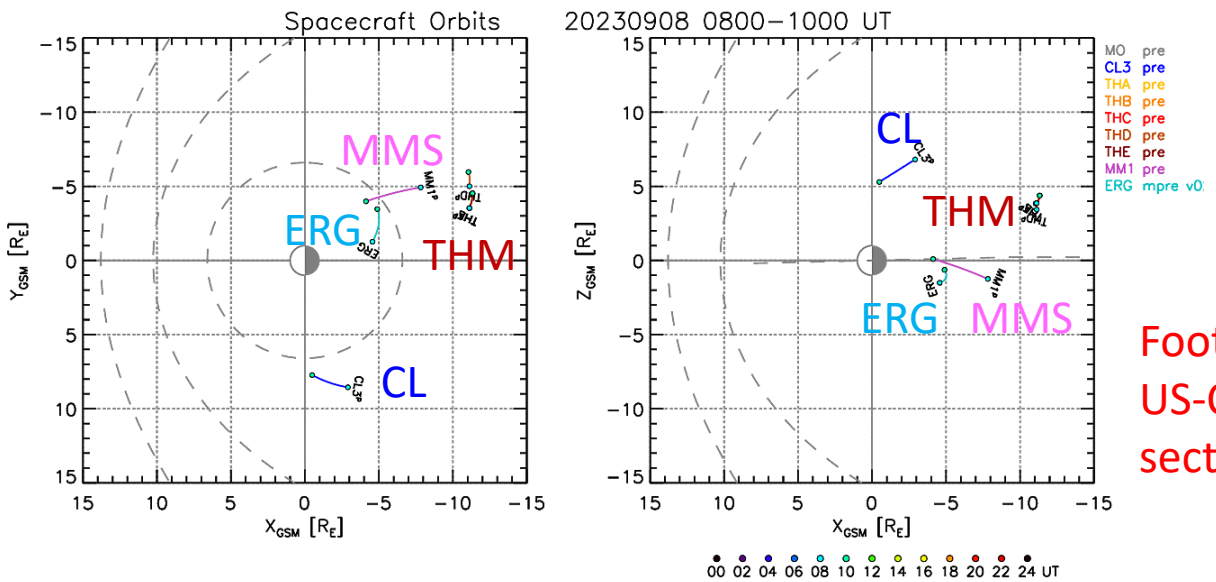
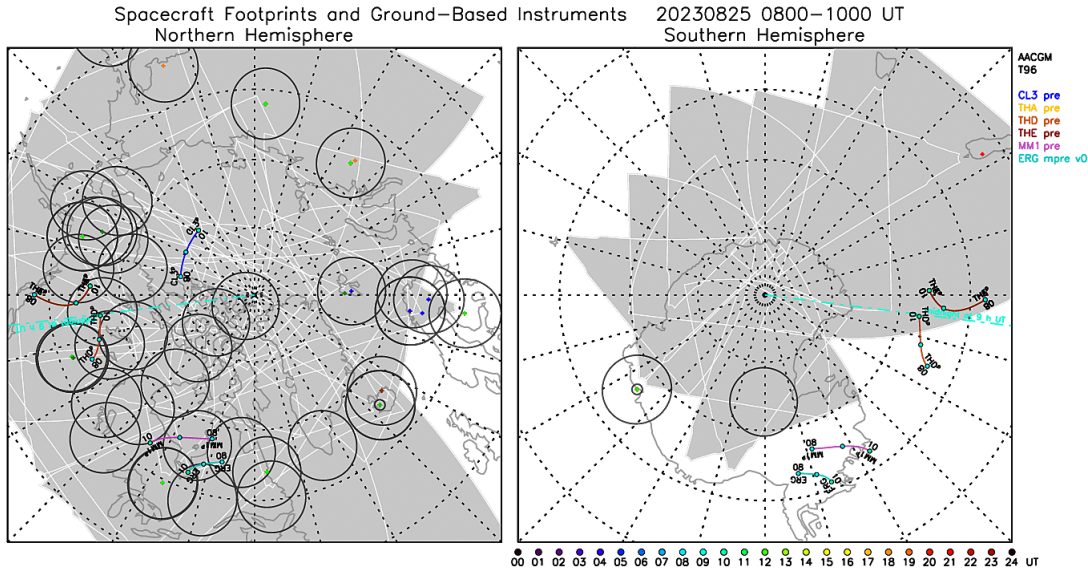
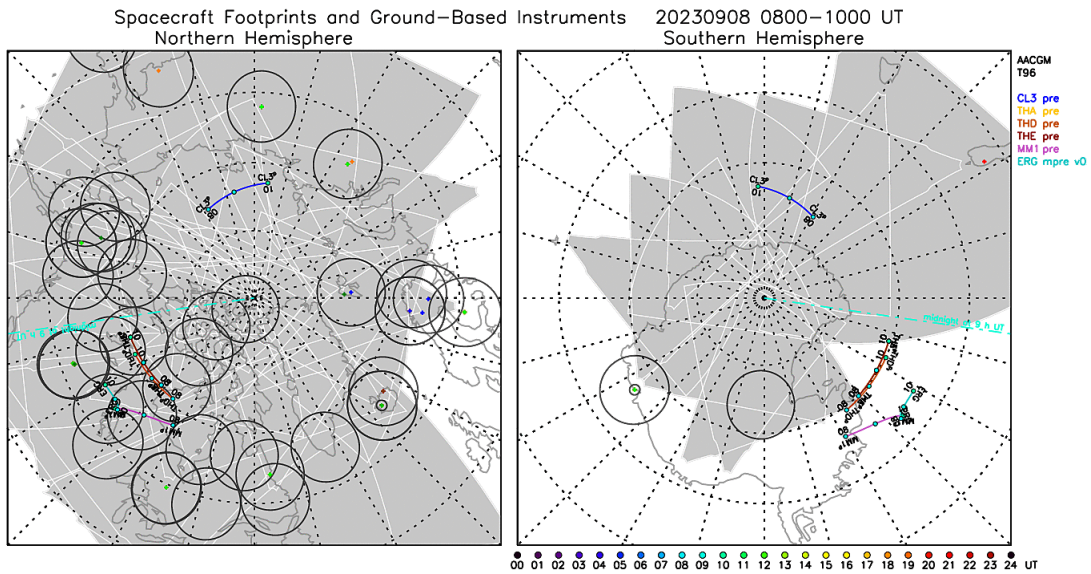
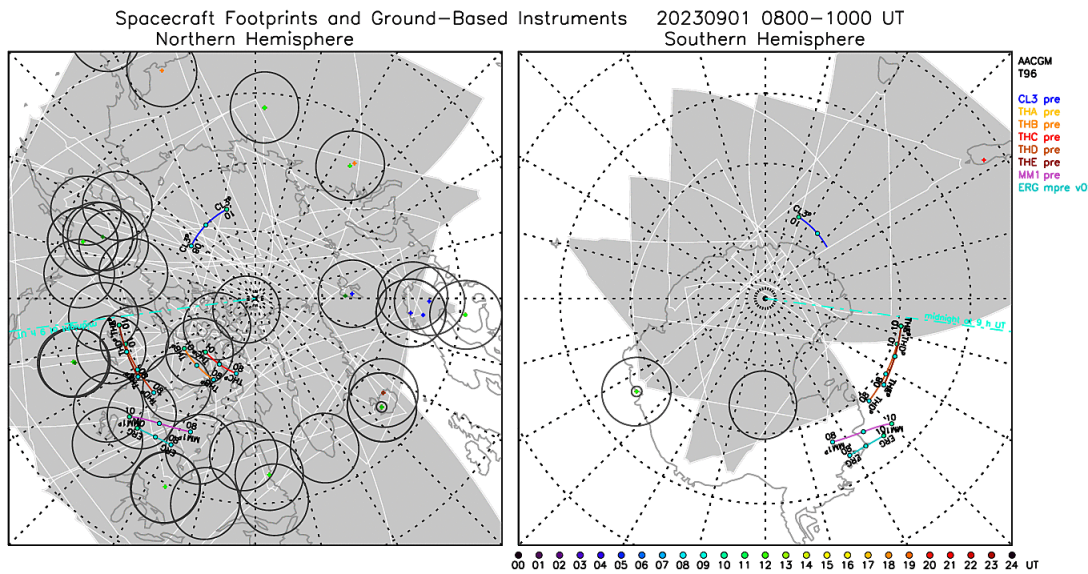


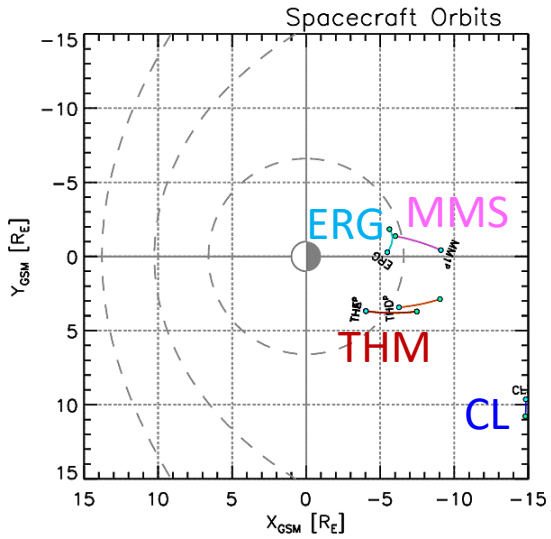

Footprint: US-Canada sector

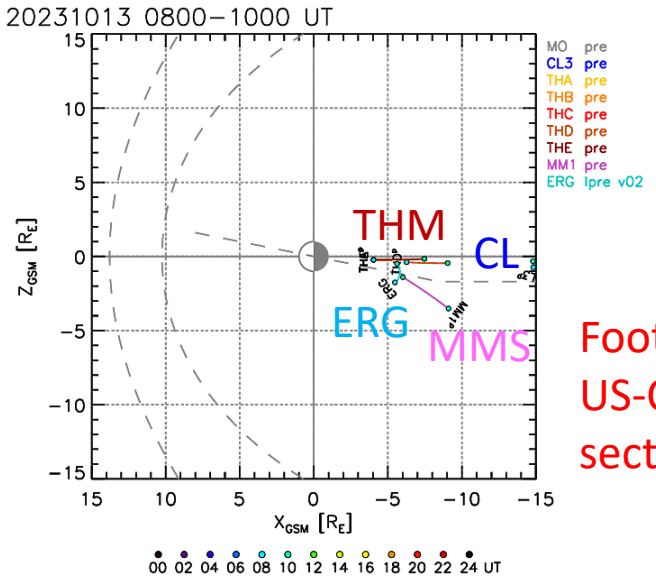


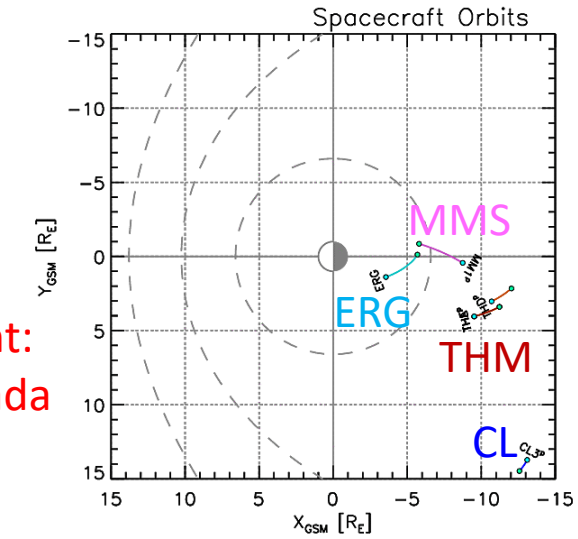



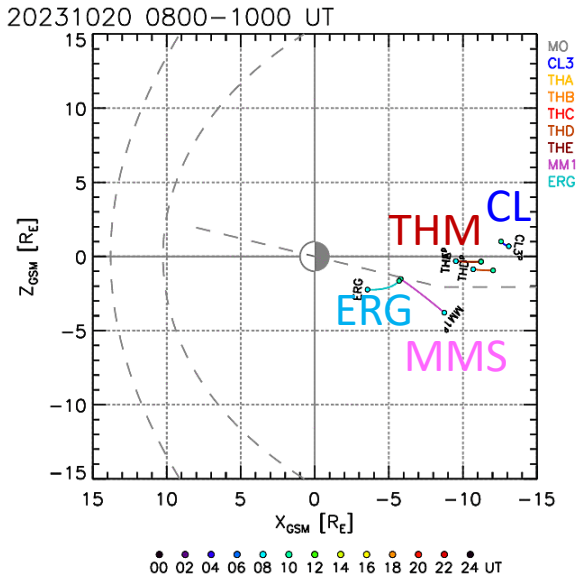
# >3 Conjunctions from Oct. 13

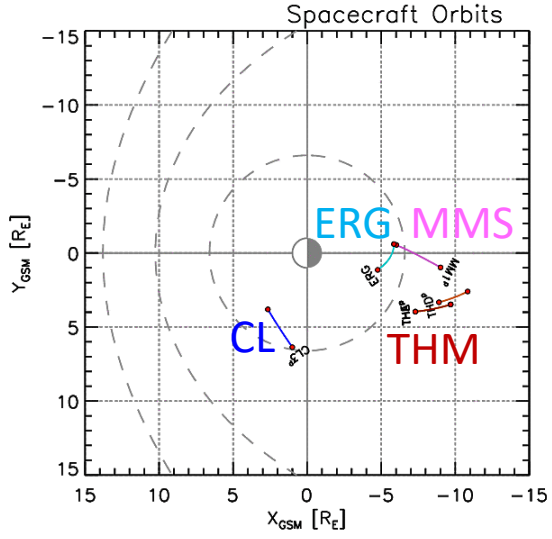


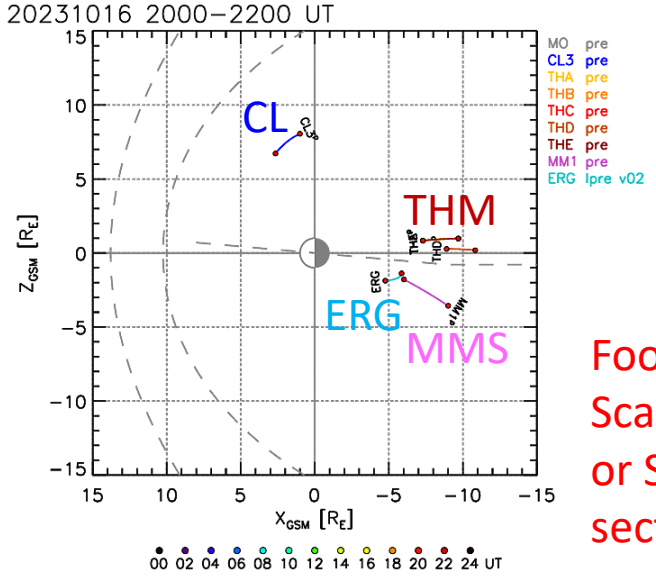




Footprint: US-Canada sector

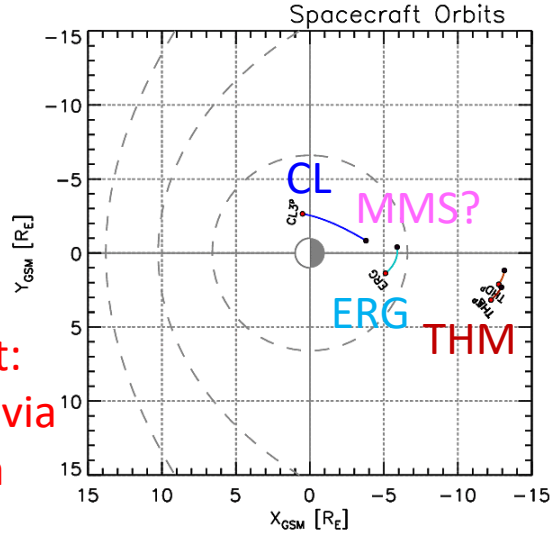


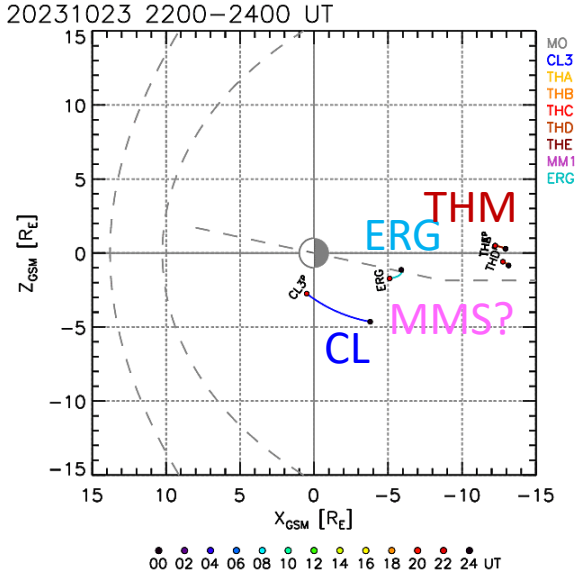



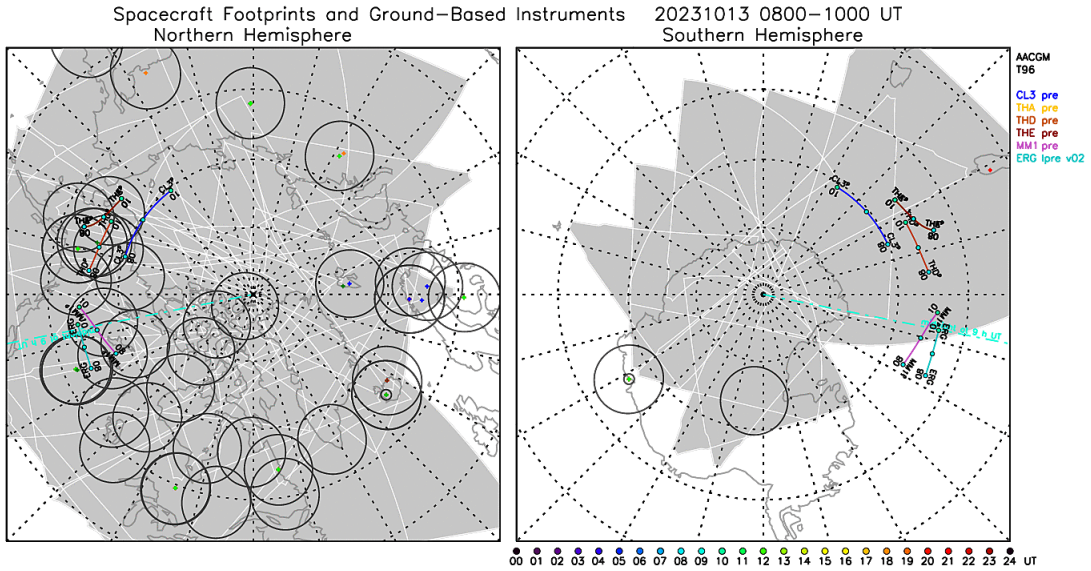




Footprint: Scandinavia or Syowa sector

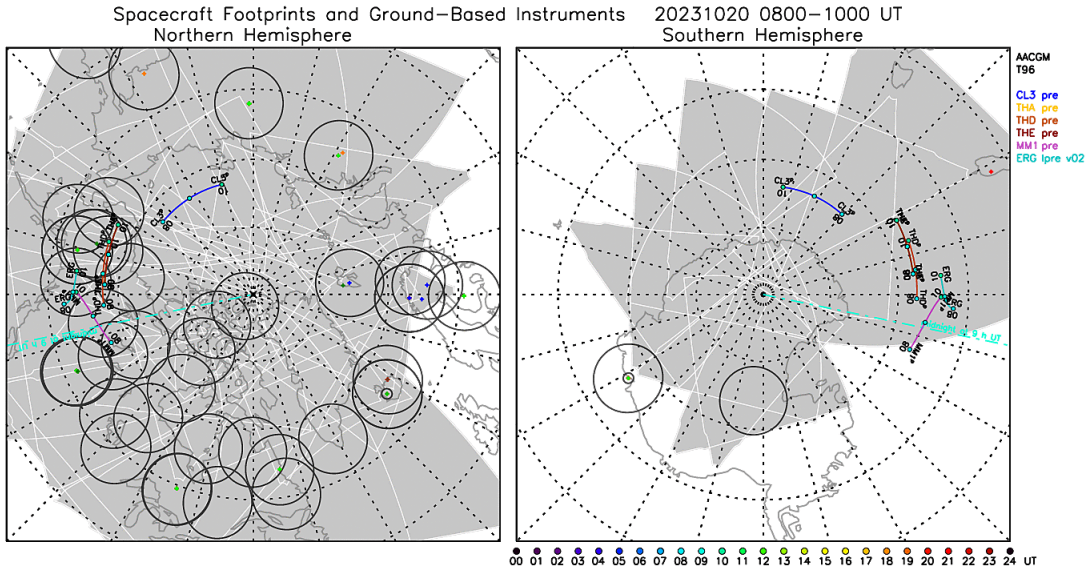


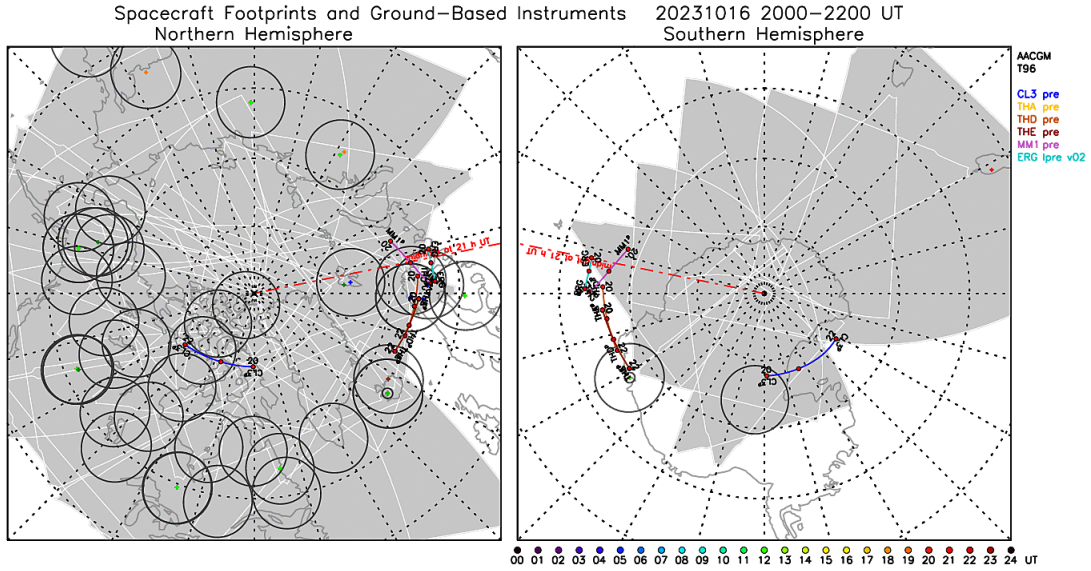



# >3 Conjunctions from Oct. 13

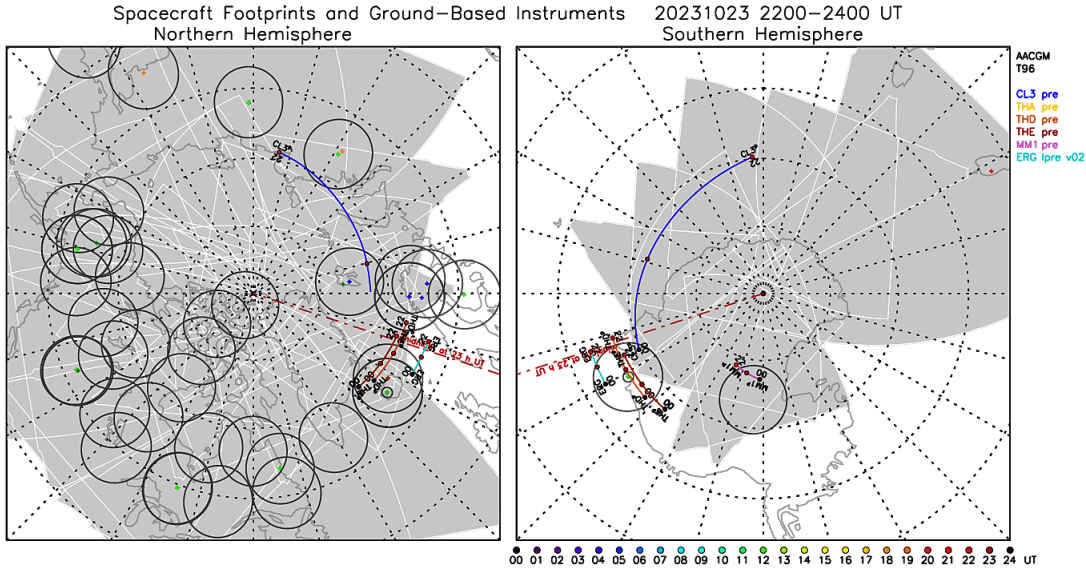



Footprint: US-Canada sector




Footprint: Scandinavia or Showa sector



# Discussion points

- Conjunction events include  $L < 10$
- Is it possible to extend SROI region toward inner magnetosphere ?
- Interest from ground-based community ?