

Multi-Satellite Geostationary Observations of Recent Space Weather Events

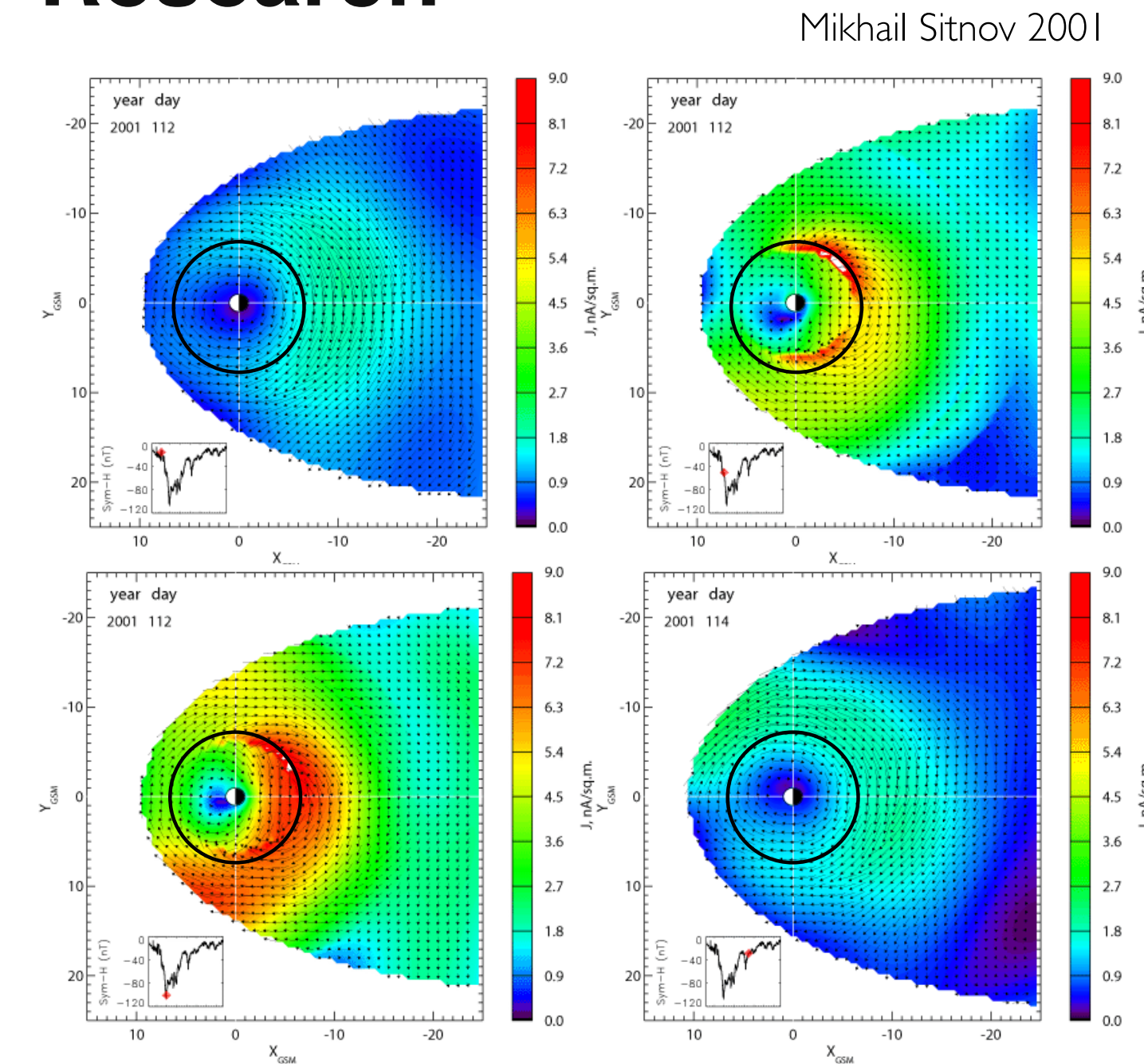
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Background and Motivation

Multi-Point Observations in Geostationary Orbit for Space Weather Research

- CMEs & solar HSS can compress the magnetosphere and expose geostationary satellites to interplanetary space.
- During such events, the response of satellites varies significantly depending on their position along the geostationary orbit (Borodkova et al., 2006; Wing and Sibeck, 1997; Dong et al., 2014).
- These variations reflect the spatial complexity and asymmetry of magnetospheric dynamics during disturbed periods.
- Although location-dependent responses to magnetopause compression on GEO orbit have been expected, simultaneous observations from multiple satellites have been limited.
- Simultaneous observations at different local times provide rare and direct evidence of how magnetospheric responses vary by position during space weather events.



In-situ data from GEO satellites

1. GK2A KSEM

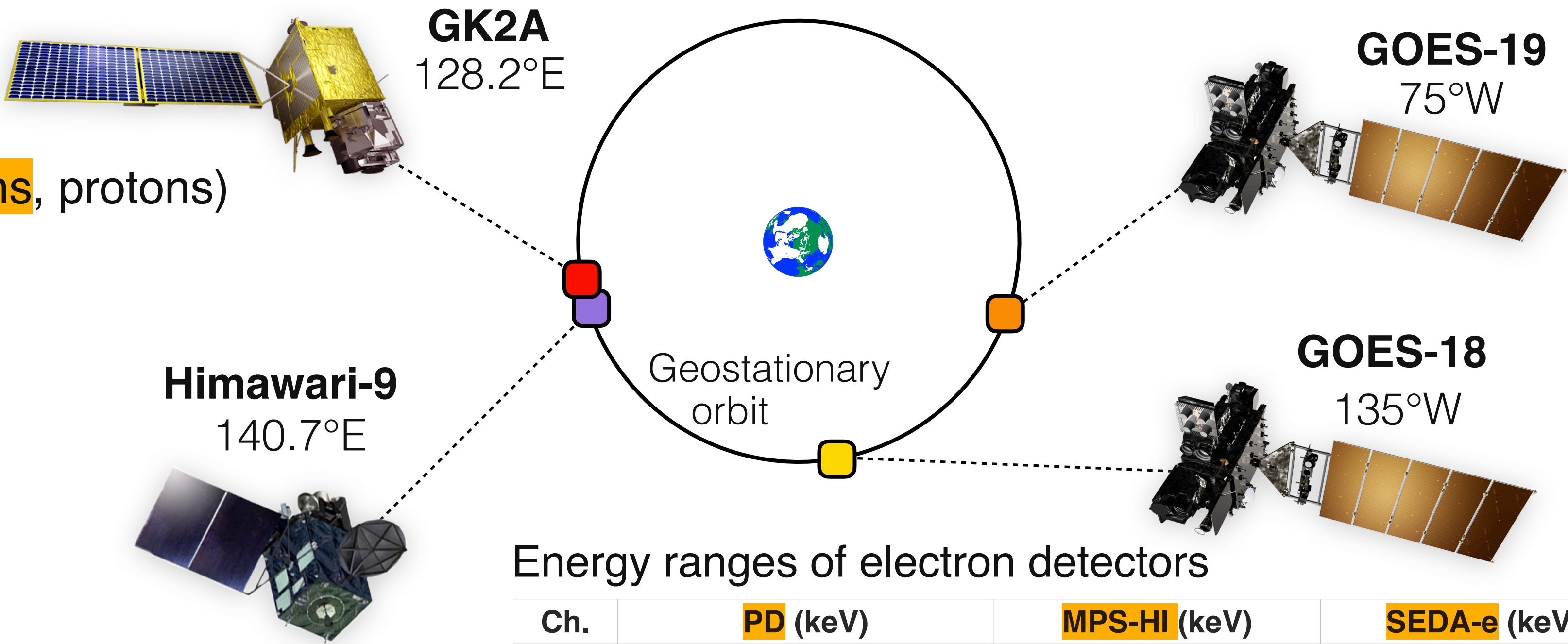
- KMA/NMSC
- Instruments
 - ▶ **PD**: Particle detector (**electrons**, protons)
 - ▶ **MG**: Magnetometer
 - ▶ CM: Charging monitor

2. Himawari-9 SEDA

- JMA, NICT
- Instruments
 - ▶ **SEDA-e**: Electron detector
 - ▶ SEDA-p: Proton detector
- ✓ No magnetometer

3./4. GOES-18/16 SEISS & MAG

- NOAA
- Instruments
 - ▶ **MPS-HI/LO**: Particle detector (**electrons**, protons)
 - ▶ SGPS: Solar & galatic proton detector
 - ▶ EHIS: Heavy ion detector
 - ▶ **MAG**: Magnetometer



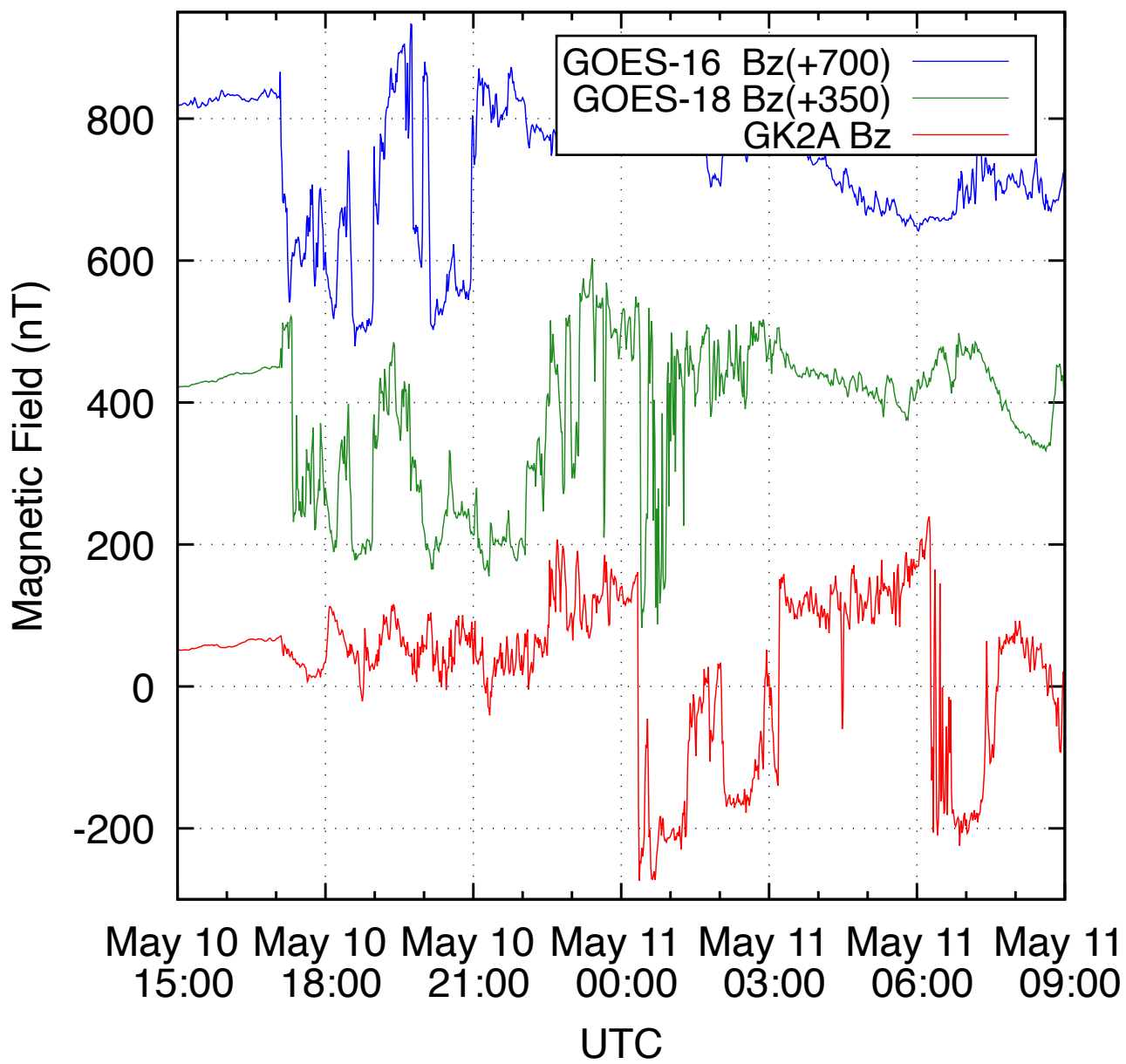
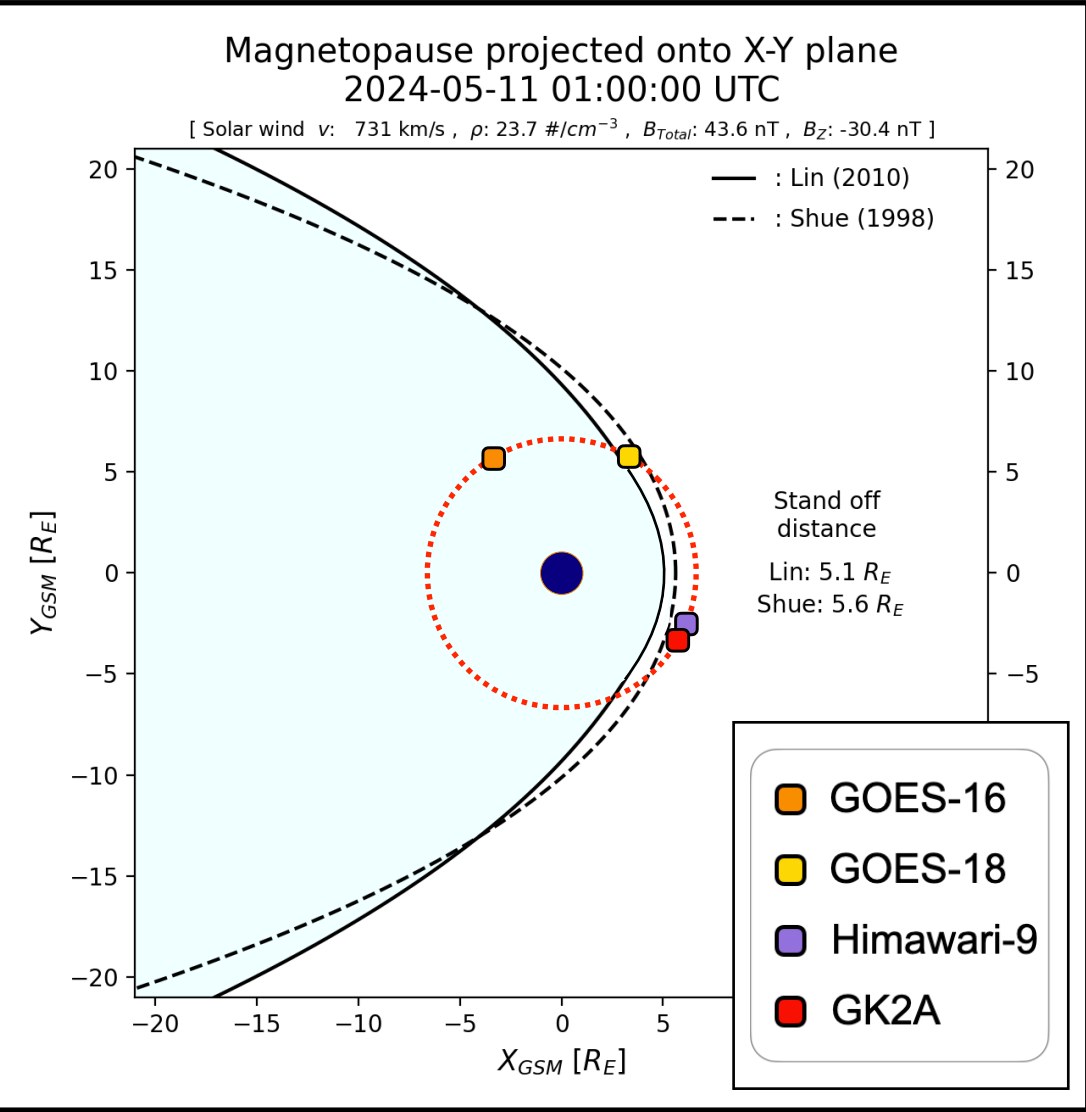
Energy ranges of electron detectors

Ch.	PD (keV)	MPS-HI (keV)	SEDA-e (keV)
1	100-150	90-145	
2	150-225	145-230	200
3	225-325	230-325	300
4	325-450	325-460	450
5	450-700	460-705	650
6	700-1350	705-1360	1000
7	1350-1800	1360-1785	1500
8	1800-2600	1785-2685	2000
9	2600-3800	2685-4345	4500
10	2000-3800	>2000 (integral)	

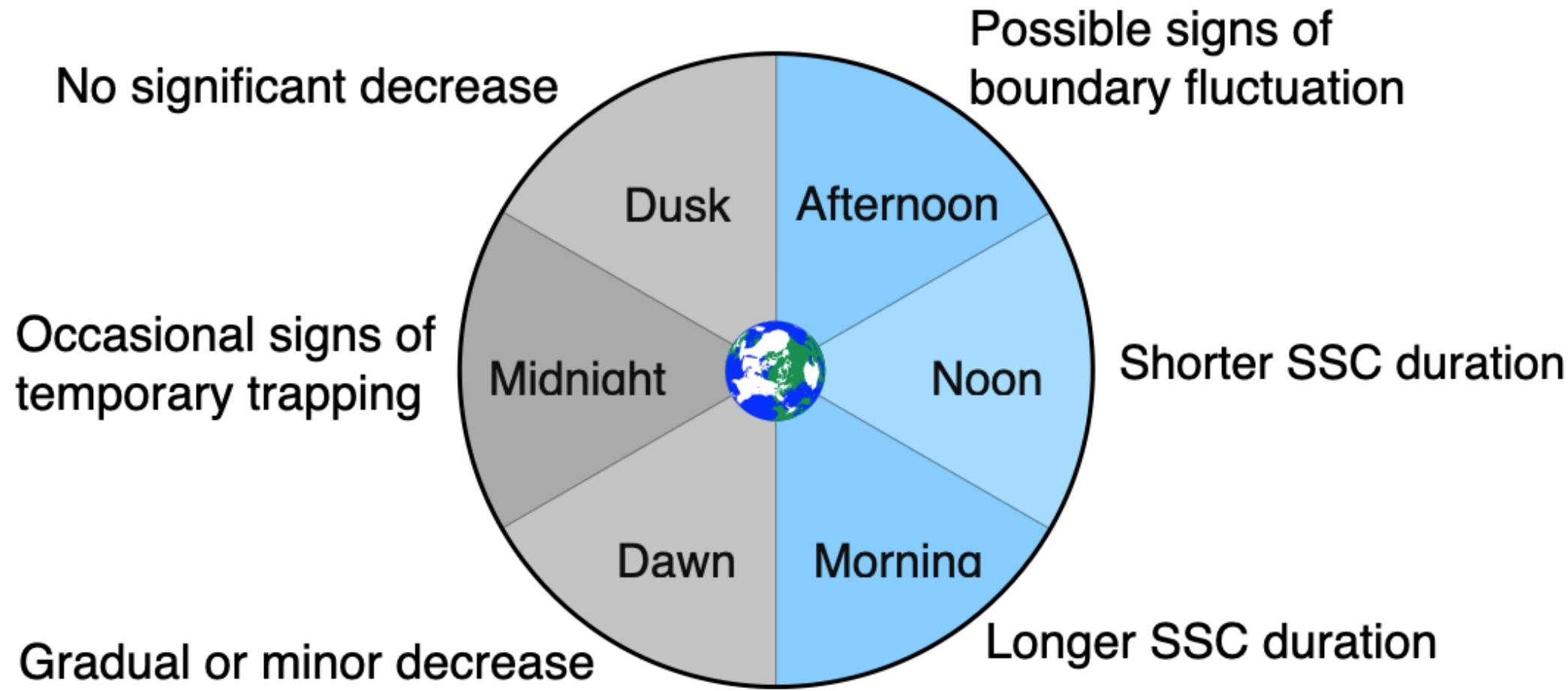
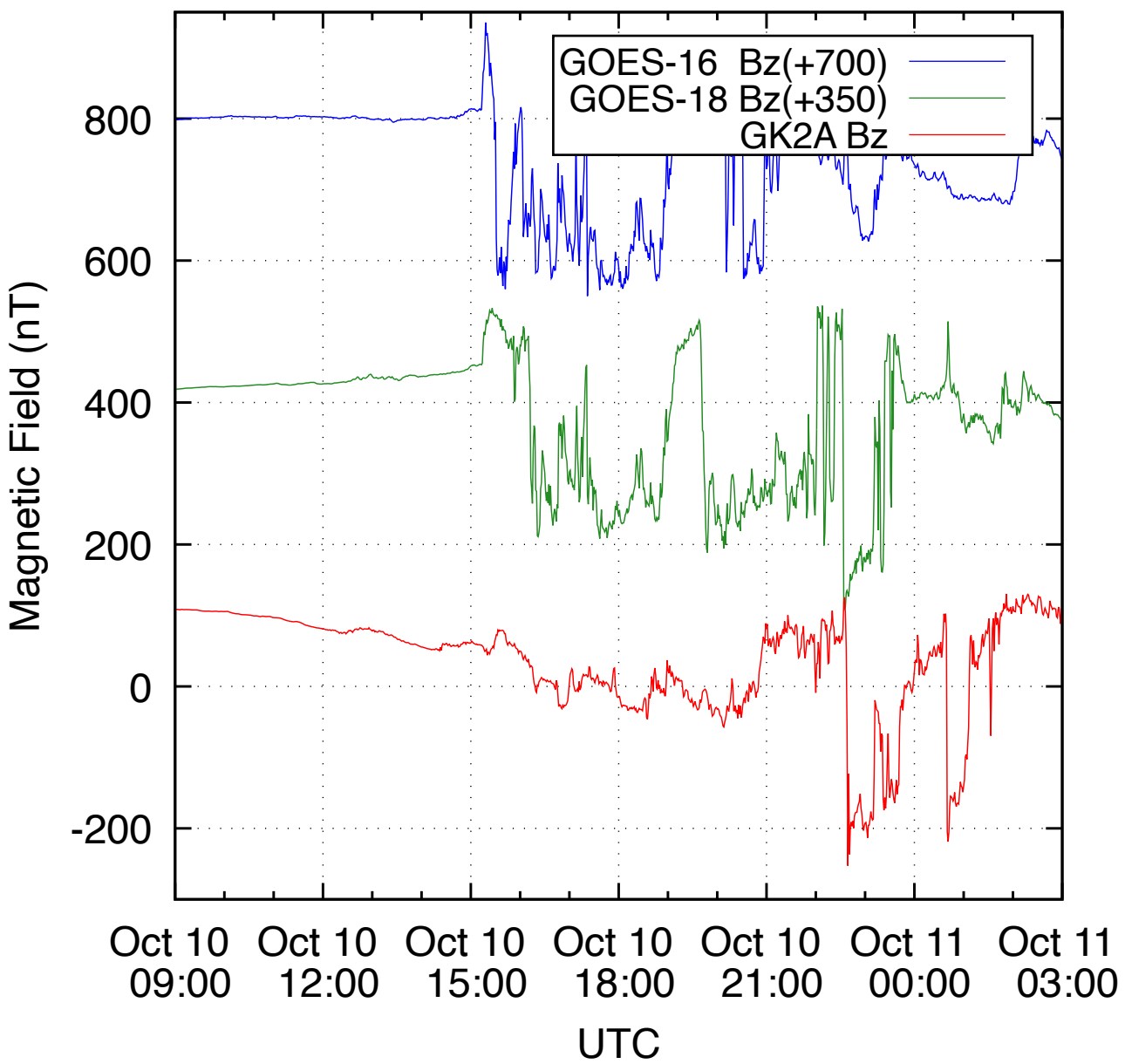
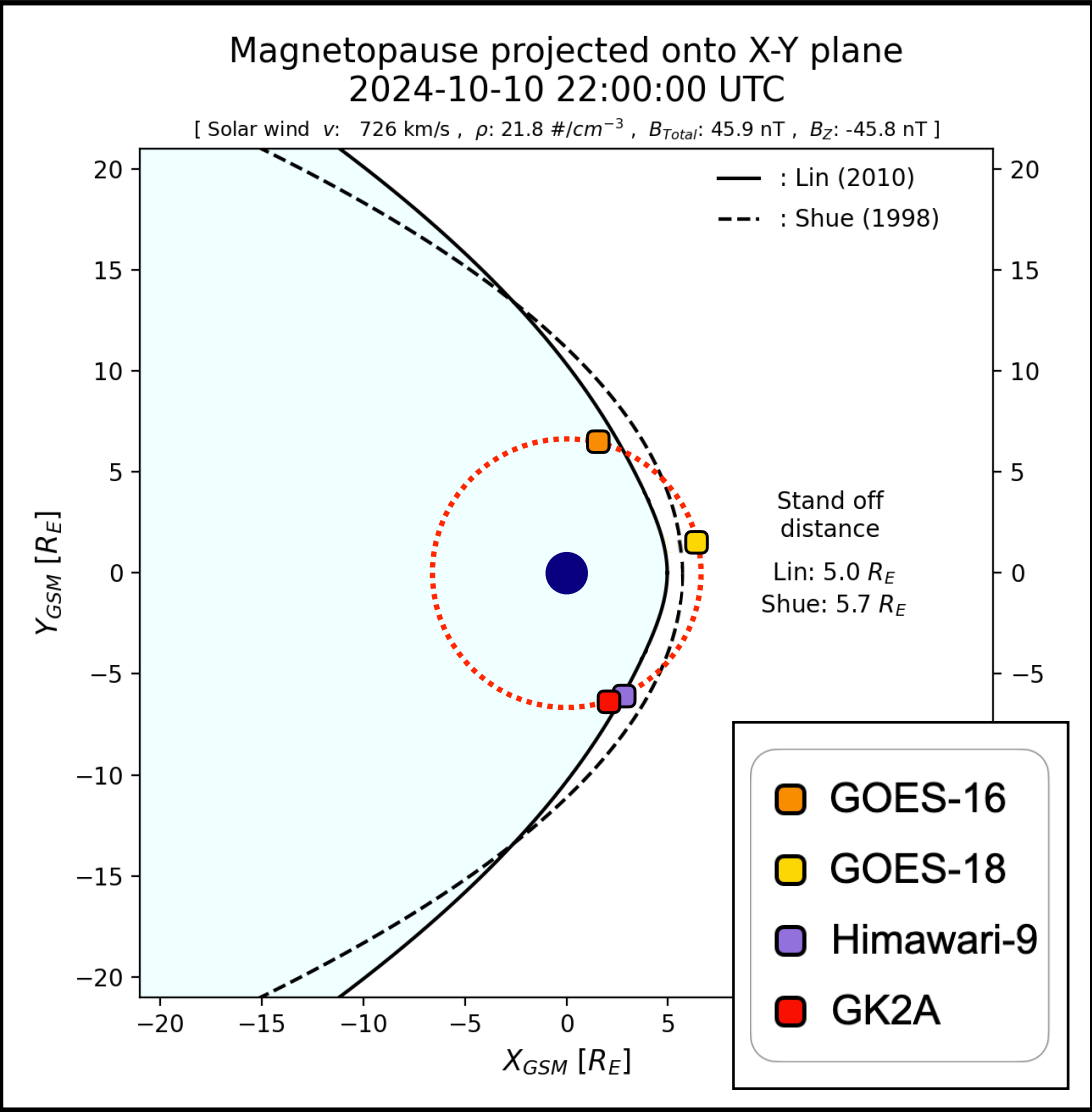
Magnetic field and electron flux observed at GEO often respond within minutes of solar wind shock arrival, providing some of the earliest in-situ indicators of magnetopause compression (e.g., Dmitriev et al., 2011; George et al., 2022; Kang et al., 2018).

Previous results from multiple GMCs in 2024

Multiple GMCs in May 2024



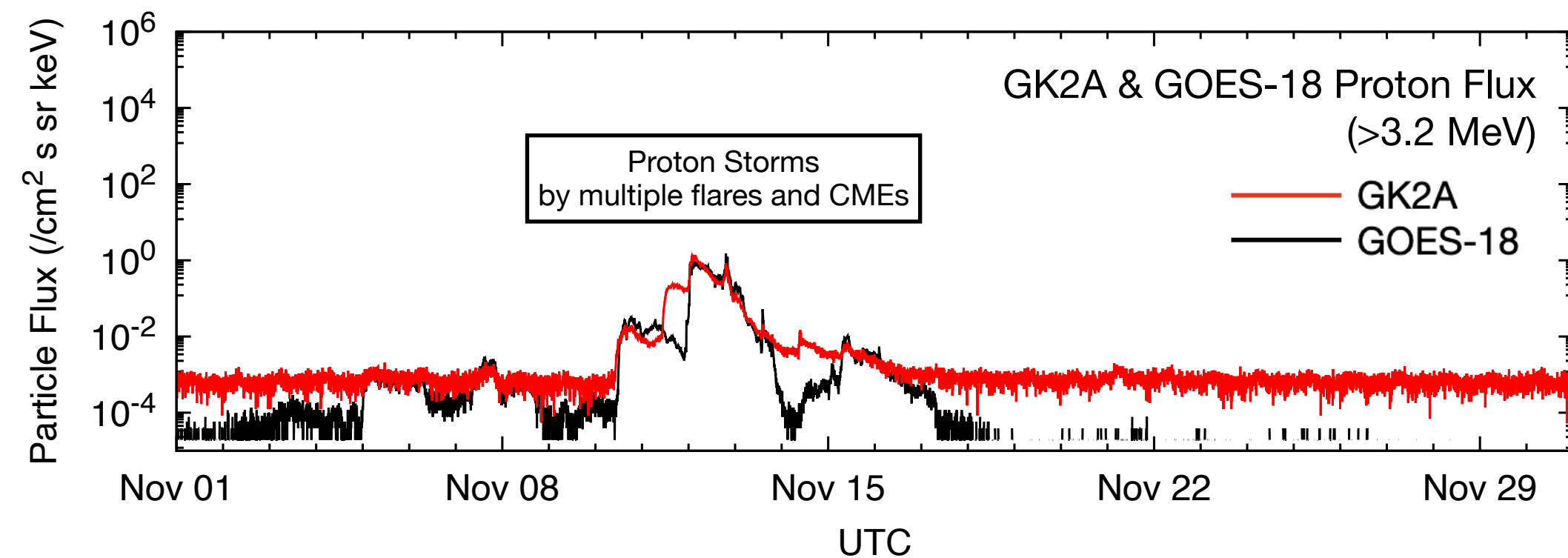
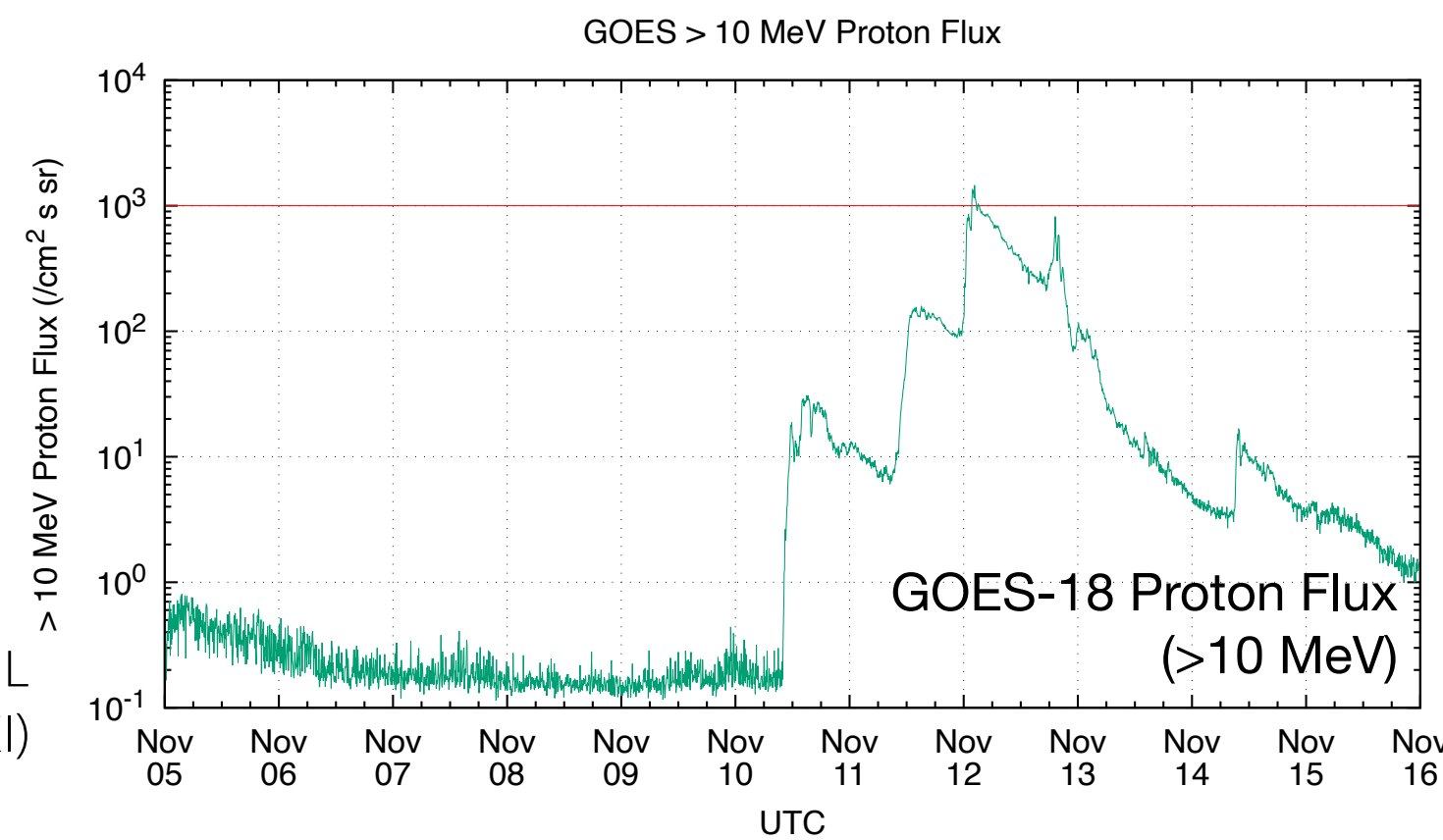
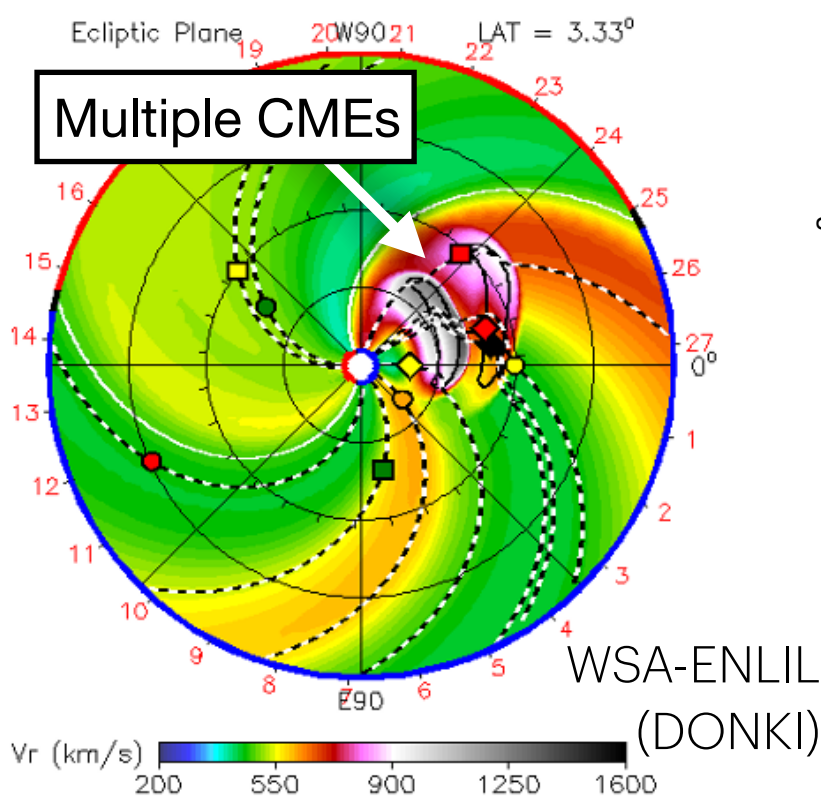
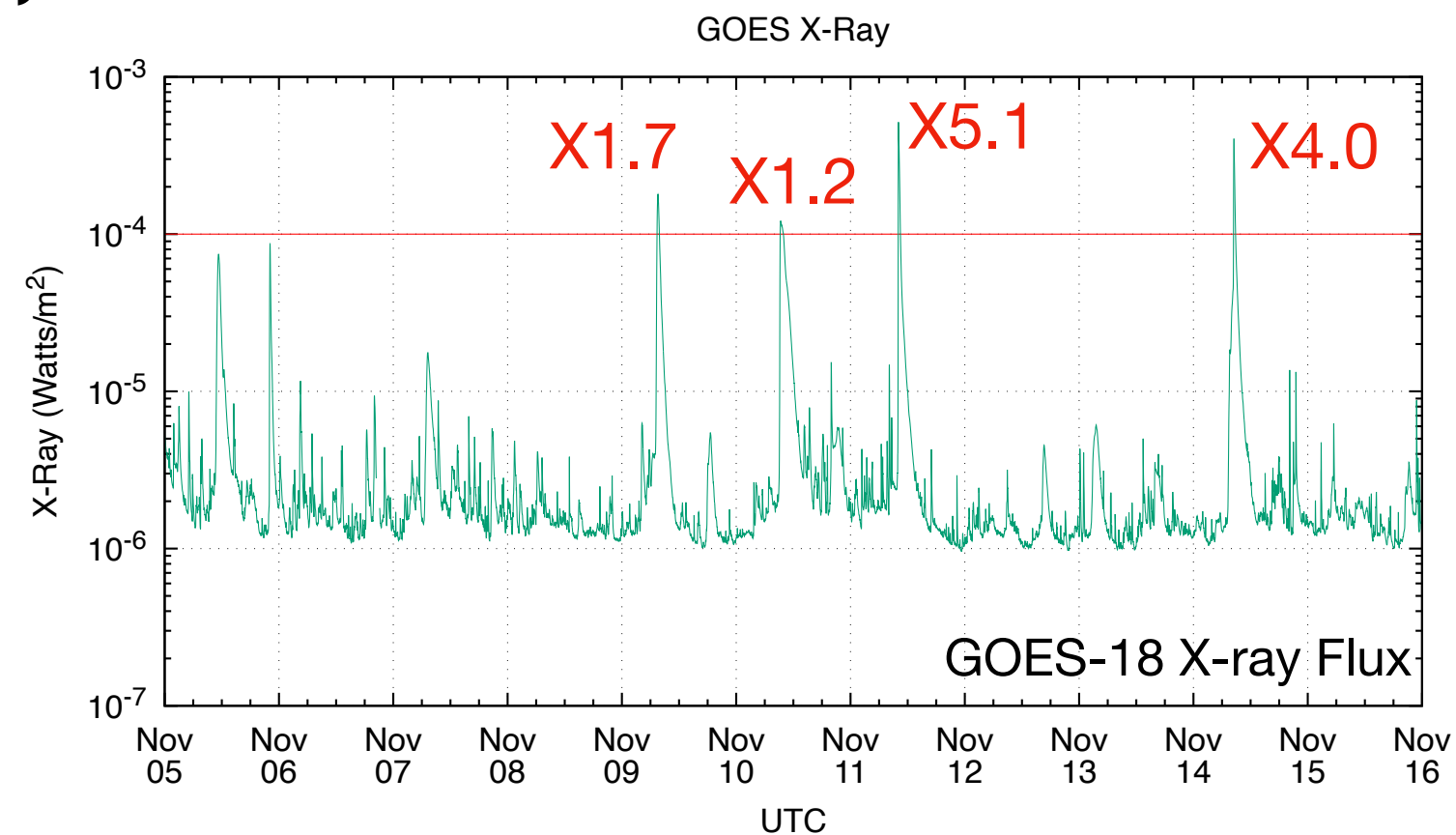
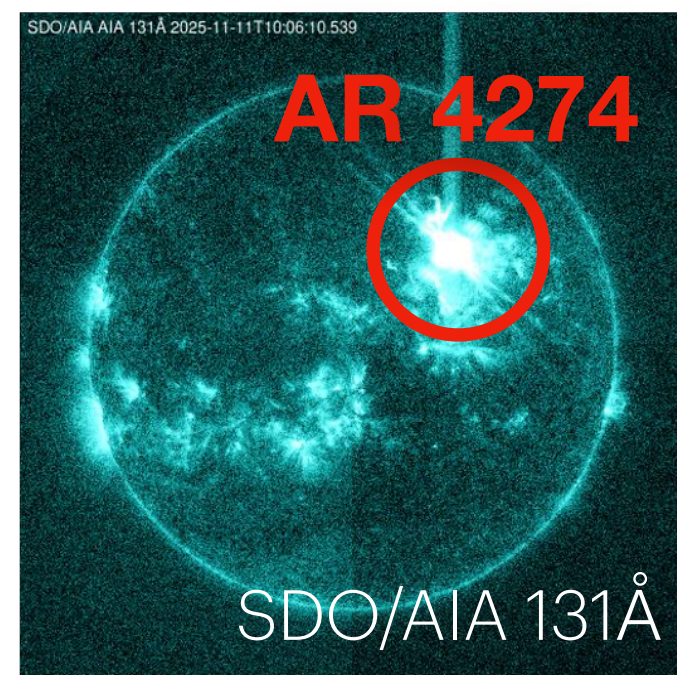
Multiple GMCs in Nov. 2024



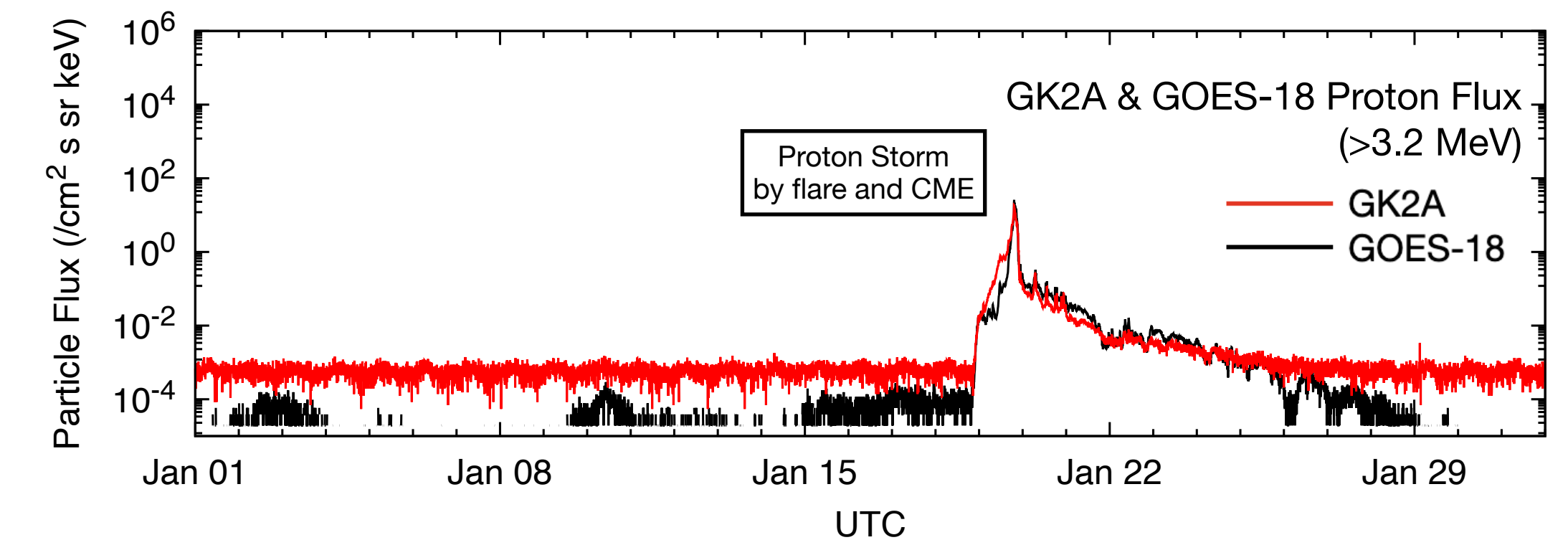
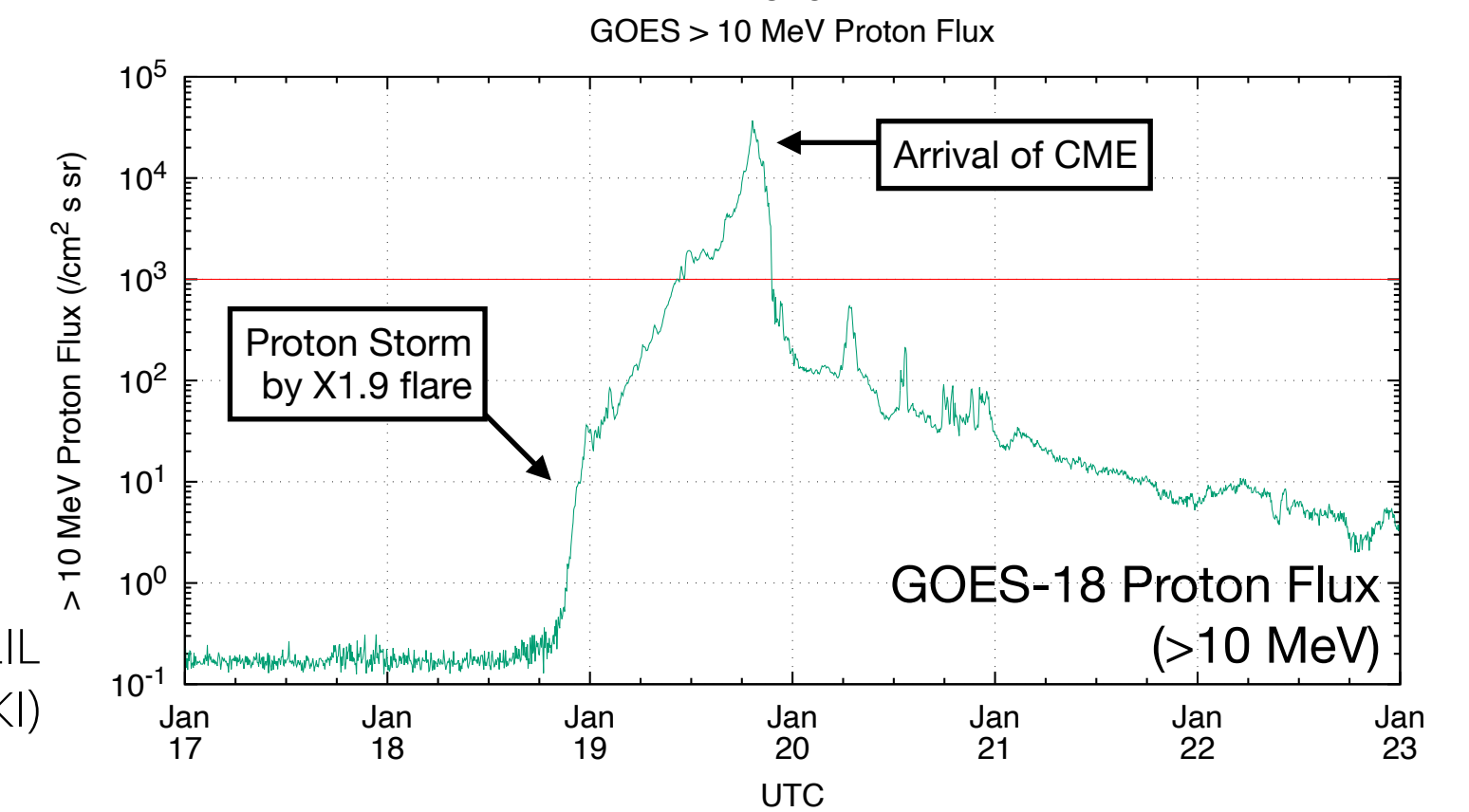
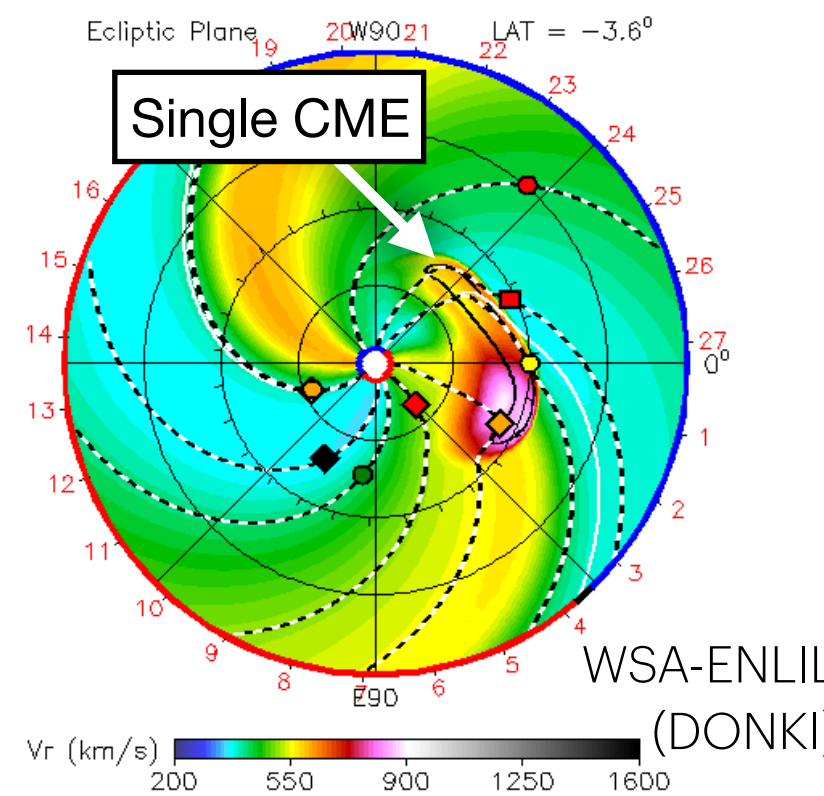
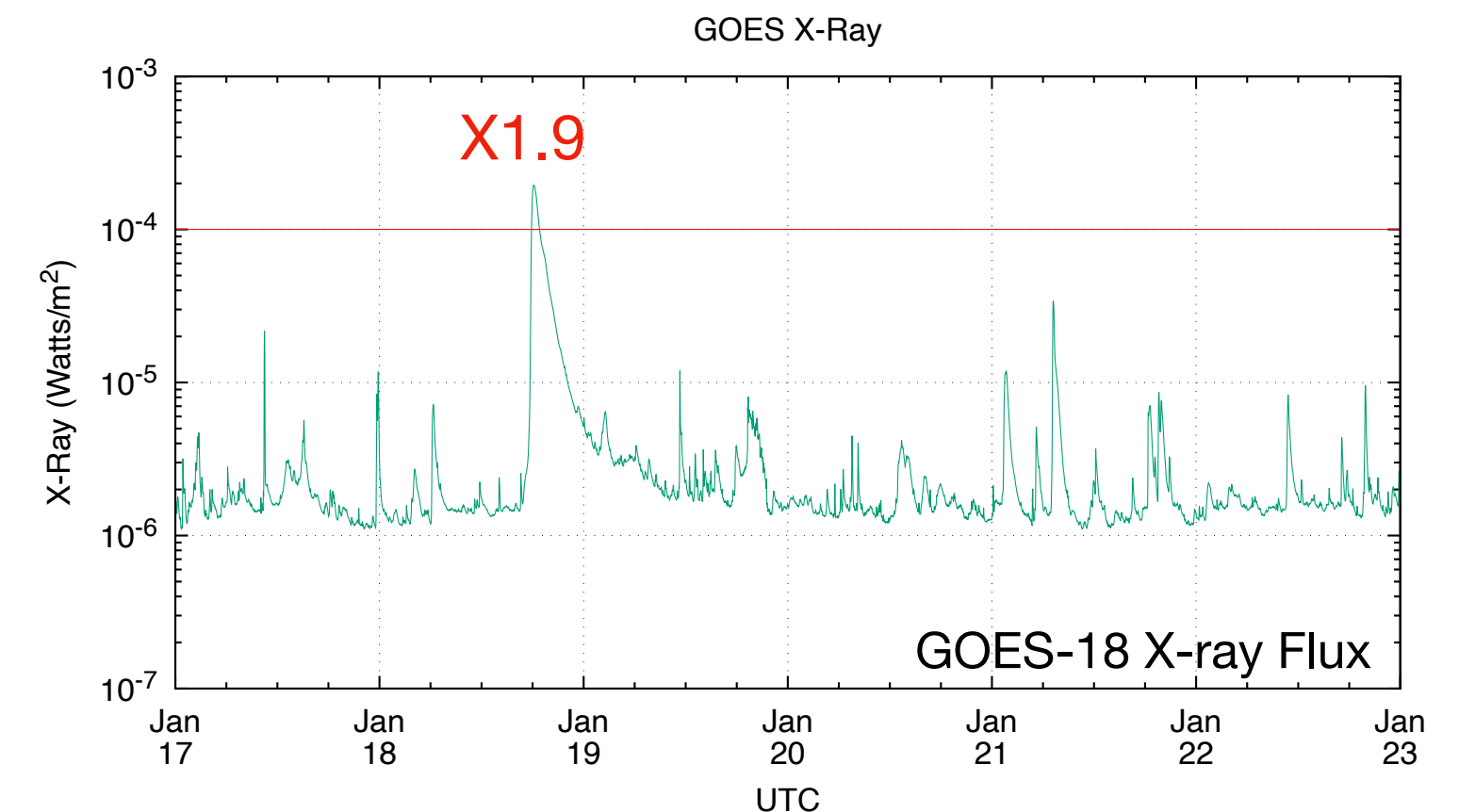
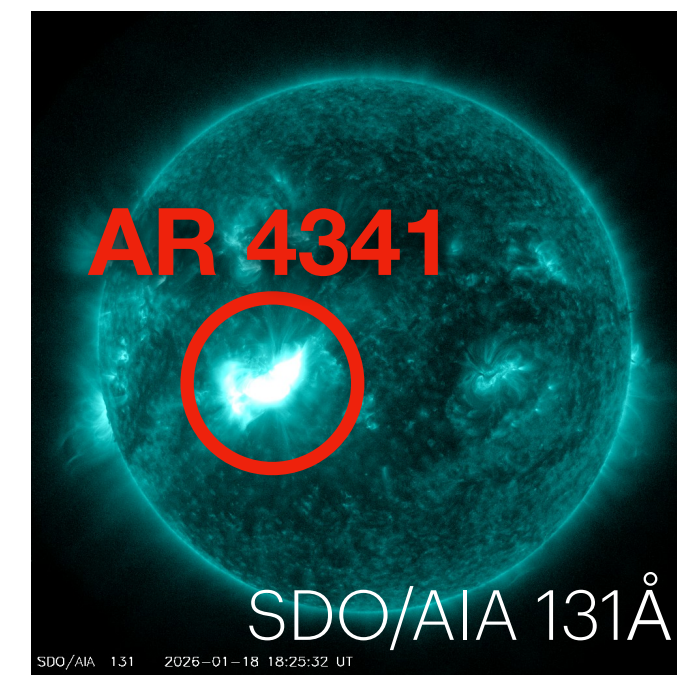
Local Sector	Bz Behavior	Electron Flux (E)
Dusk (18:00–22:00)	No significant decrease	No significant decrease
Midnight (22:00–02:00)	No significant decrease	No significant decrease Occasional signs of temporary trapping
Dawn (02:00–06:00)	Gradual or minor decrease No clear reversal; SSC unclear	Gradual and minor decrease
Morning (06:00–10:00)	Sharp decrease and reversal Longer SSC duration	Gradual to sharp decrease
Noon (10:00–14:00)	Sharp decrease and reversal Shorter SSC duration	Sharp initial decrease Gradual secondary decrease
Afternoon (14:00–18:00)	Sharp decrease and reversal Possible signs of boundary fluctuation	Sharp initial decrease Gradual secondary decrease

Extreme Space Weather Events in Nov. 2025 and Jan. 2026

November 9-14, 2025

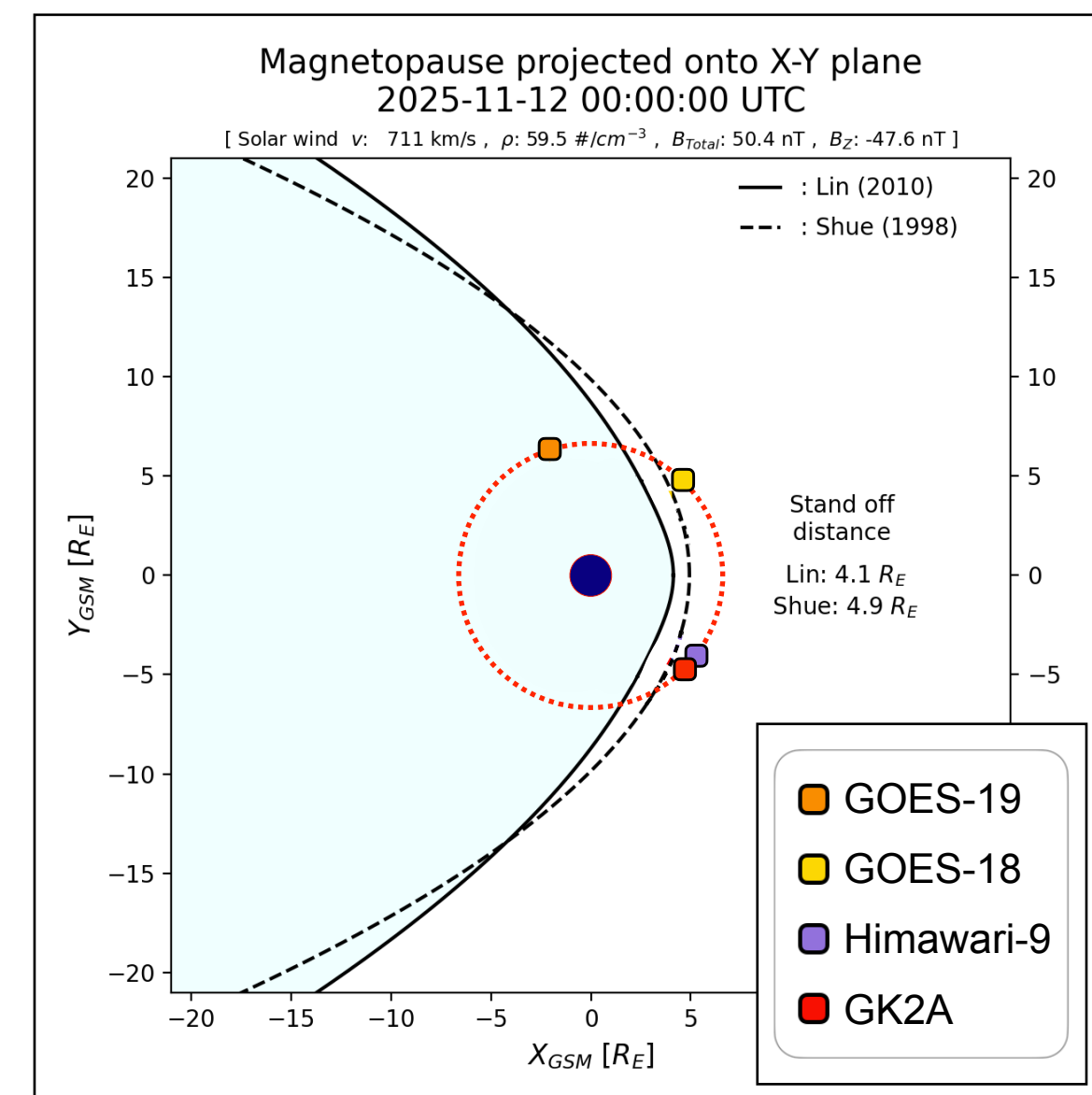
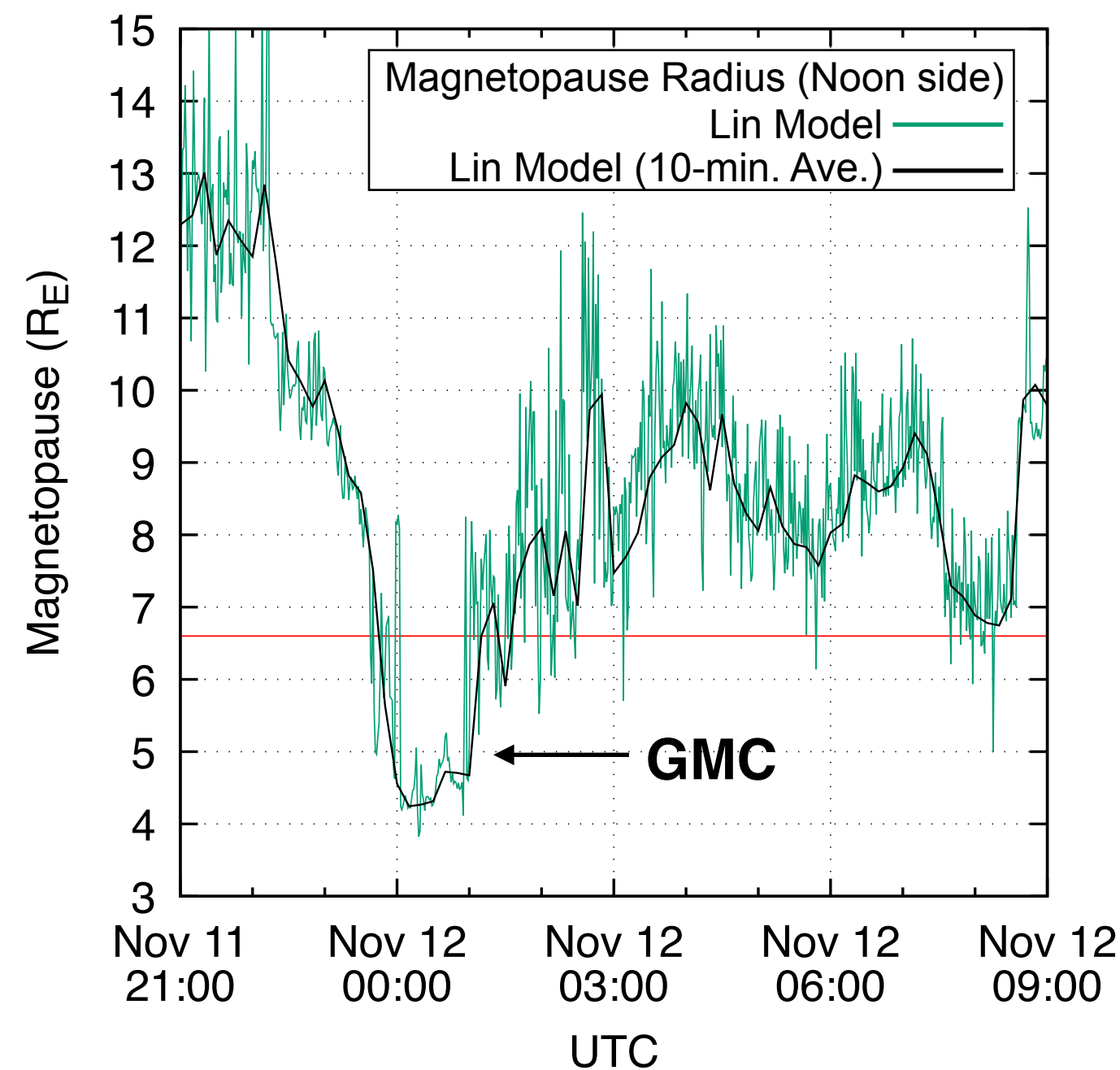
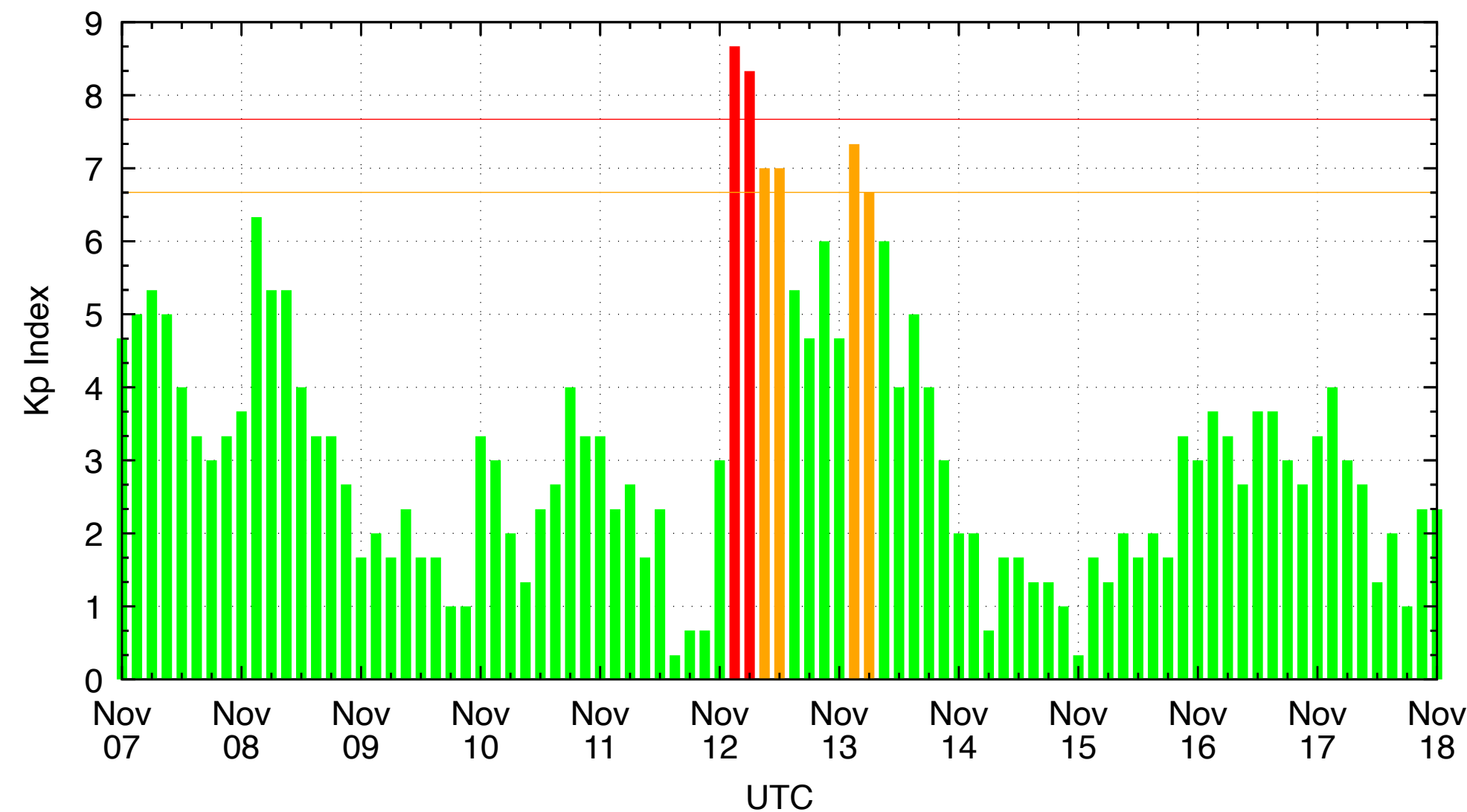


January 19-21, 2026

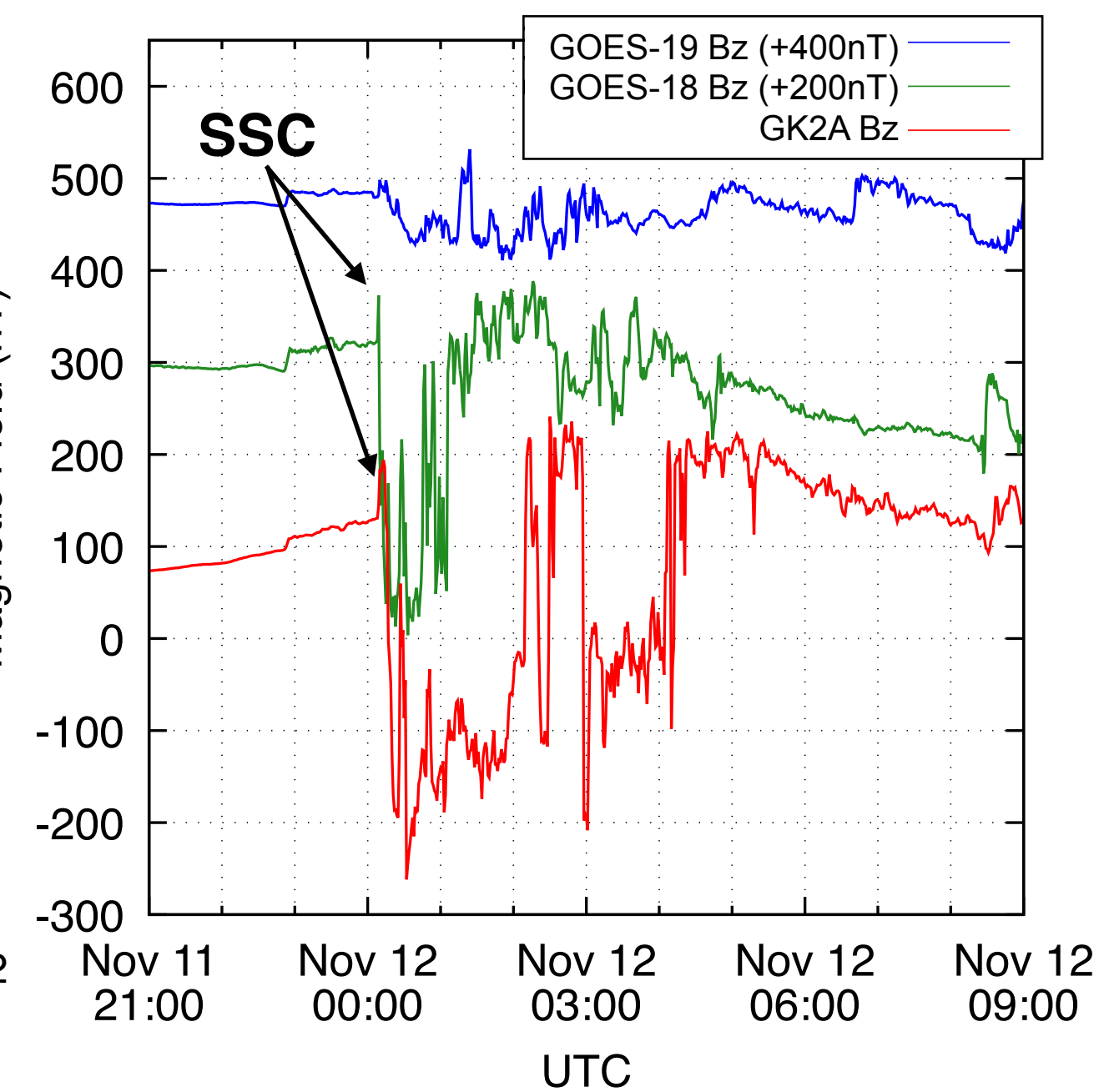
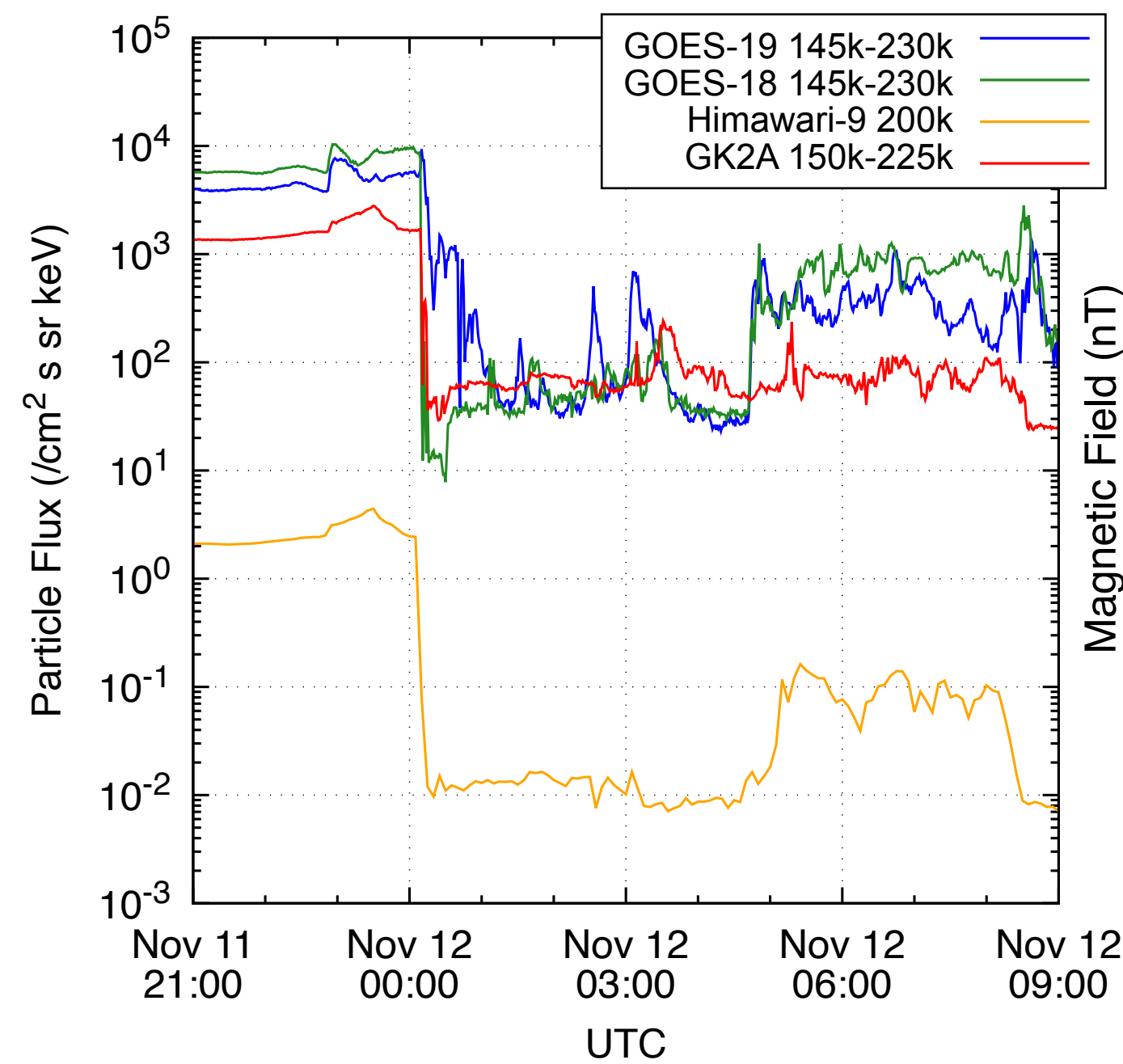


Case 1: 2025, November 12

Max. Kp: 9-
Min. Dst: -209 nT

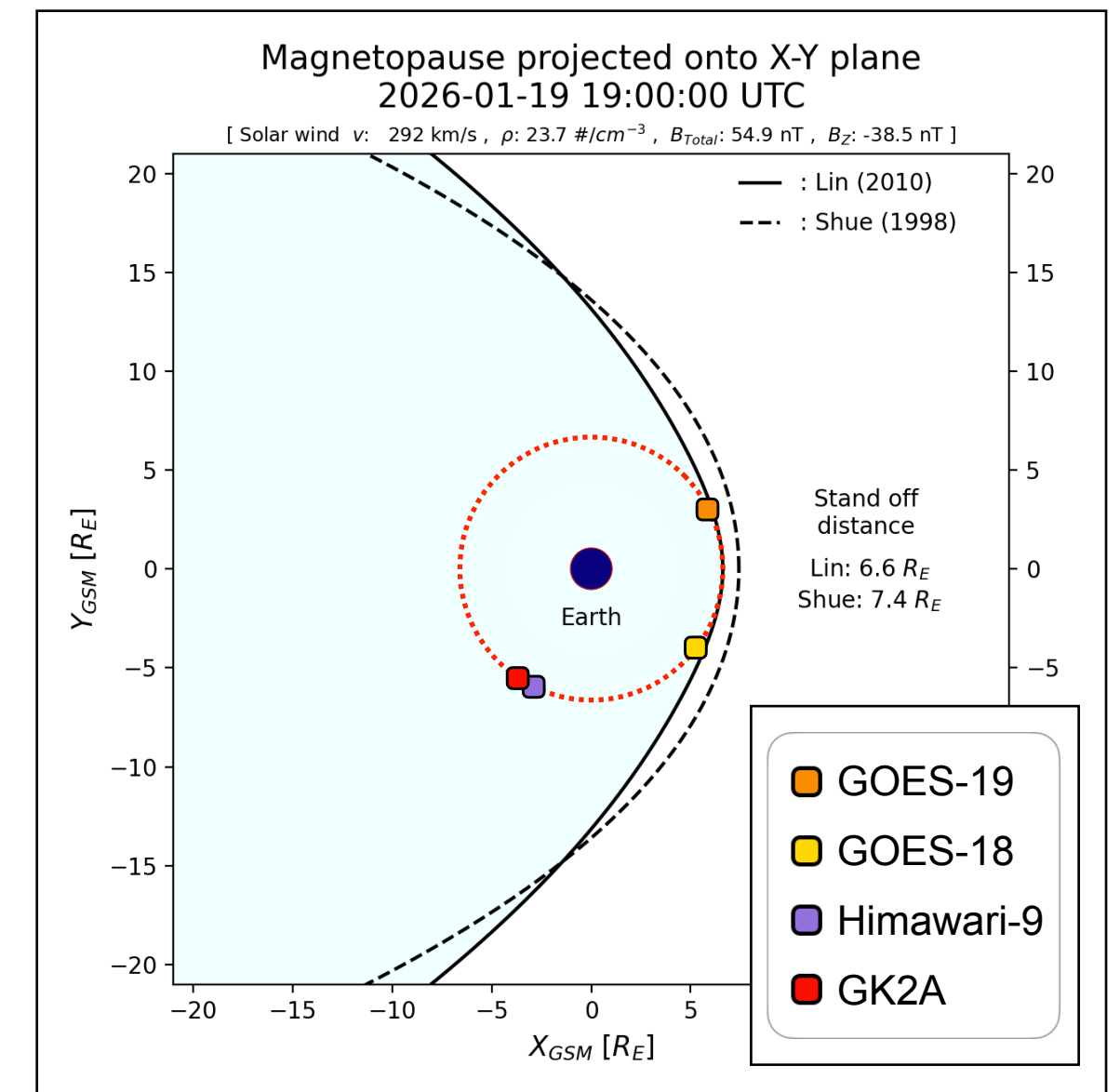
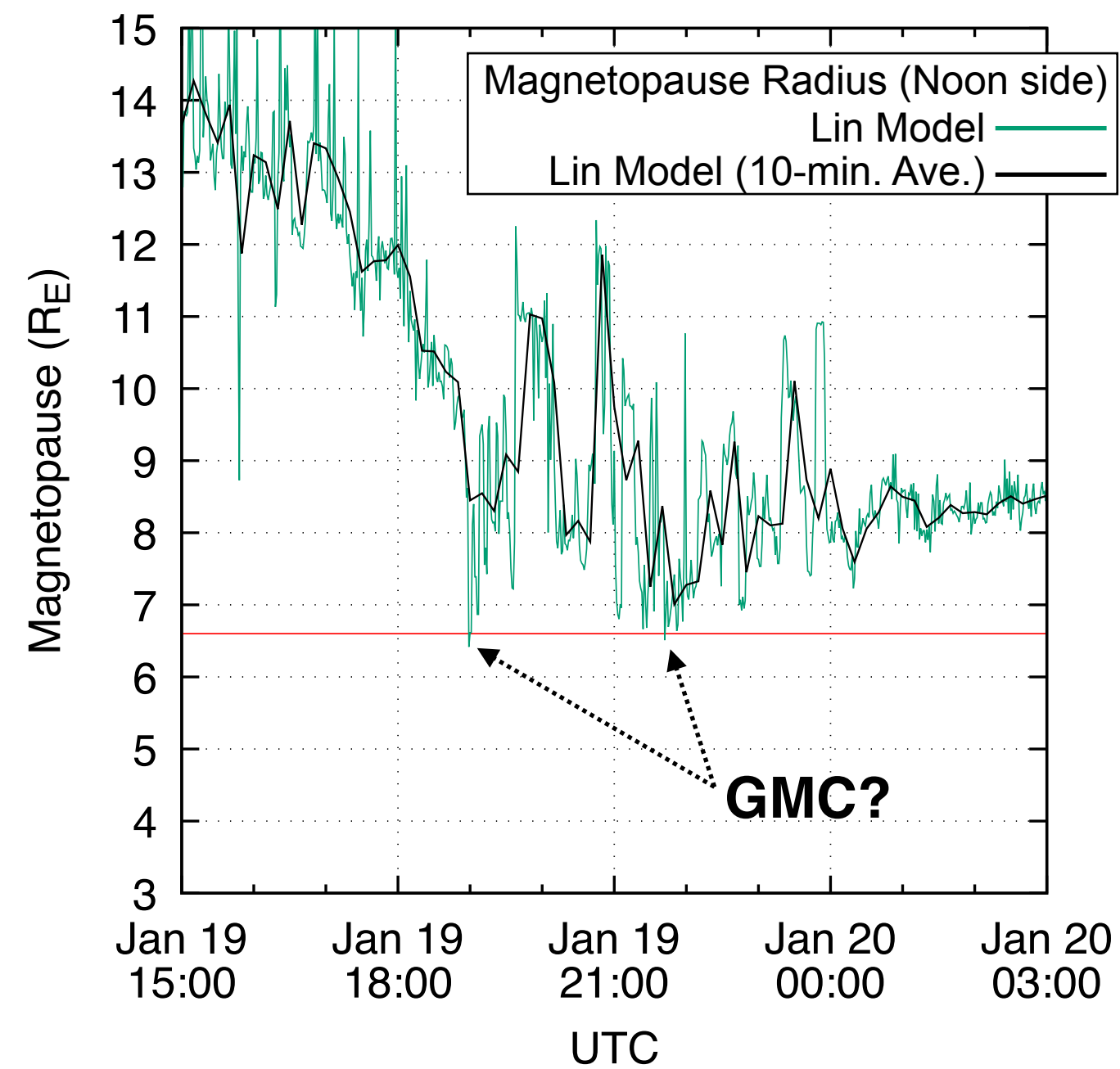
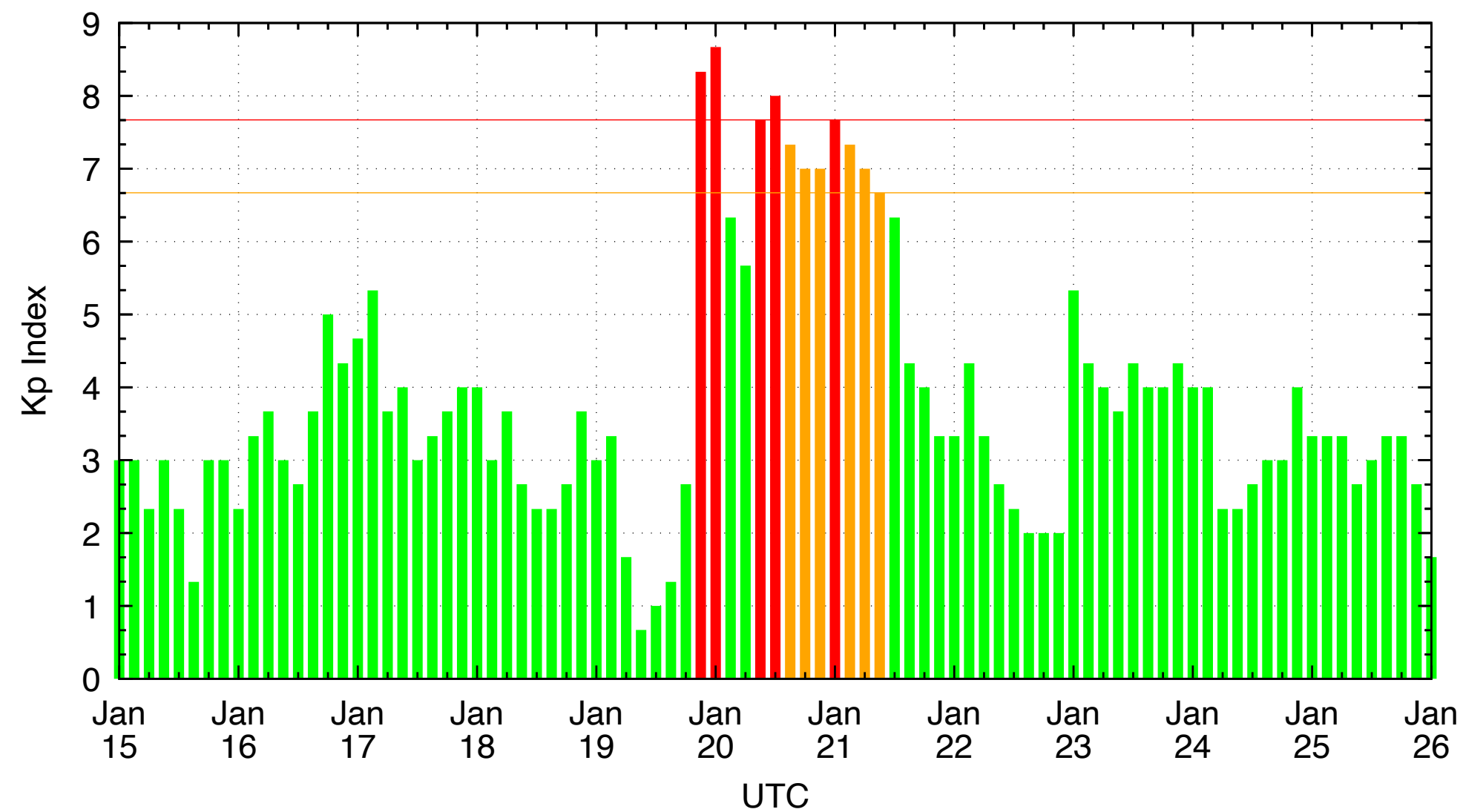


Satellite	Sector	Electron Flux	Bz Field	SSC
GOES-19	Dusk	Late & gradual drop	No reversal	-
GOES-18	Afternoon	Rapid drop	Sharp reversal	09:00 short duration
GK2A	Morning	Rapid drop	Sharp reversal	09:00 - 09:13 Long duration
Himawari-9			-	-

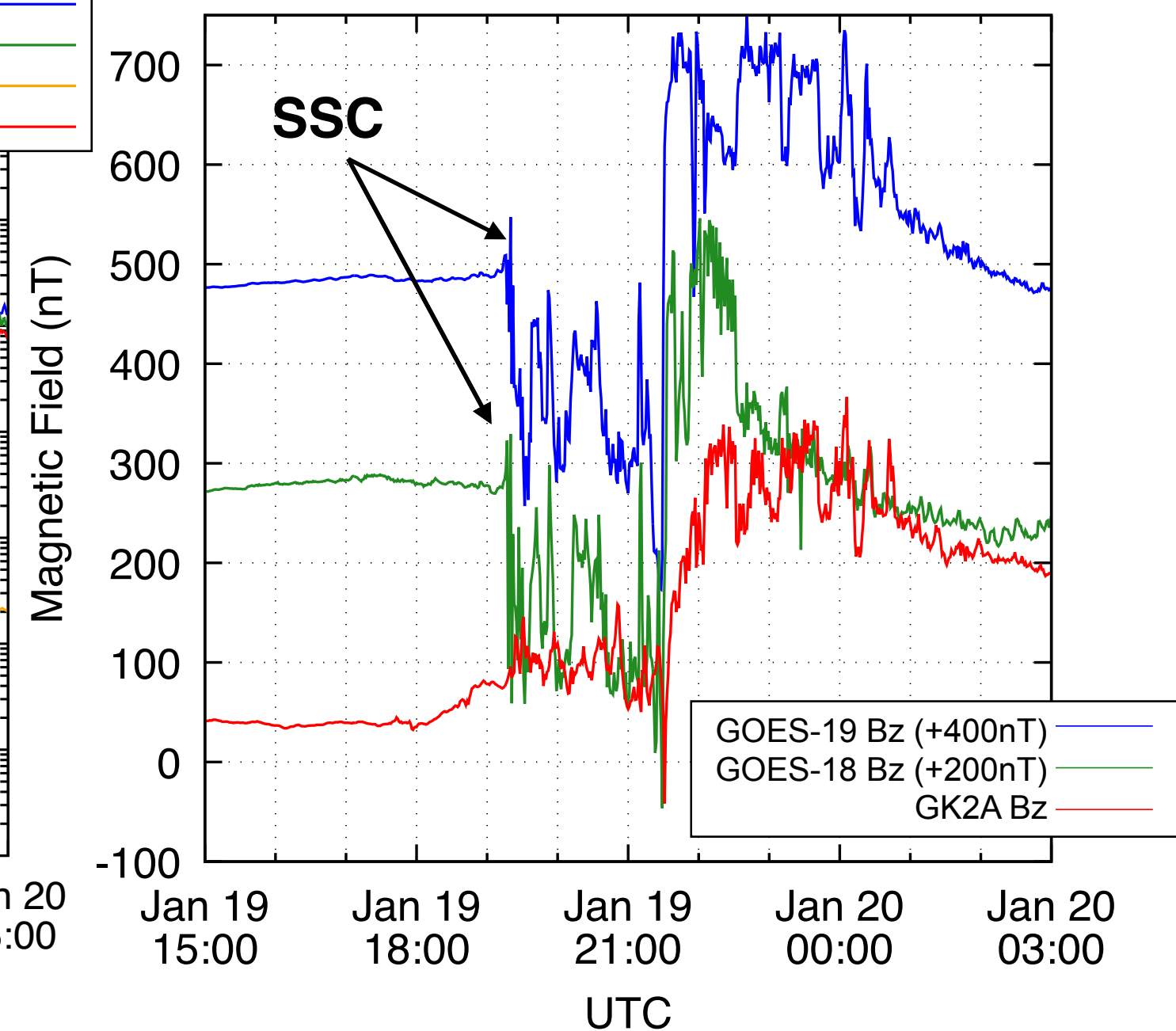
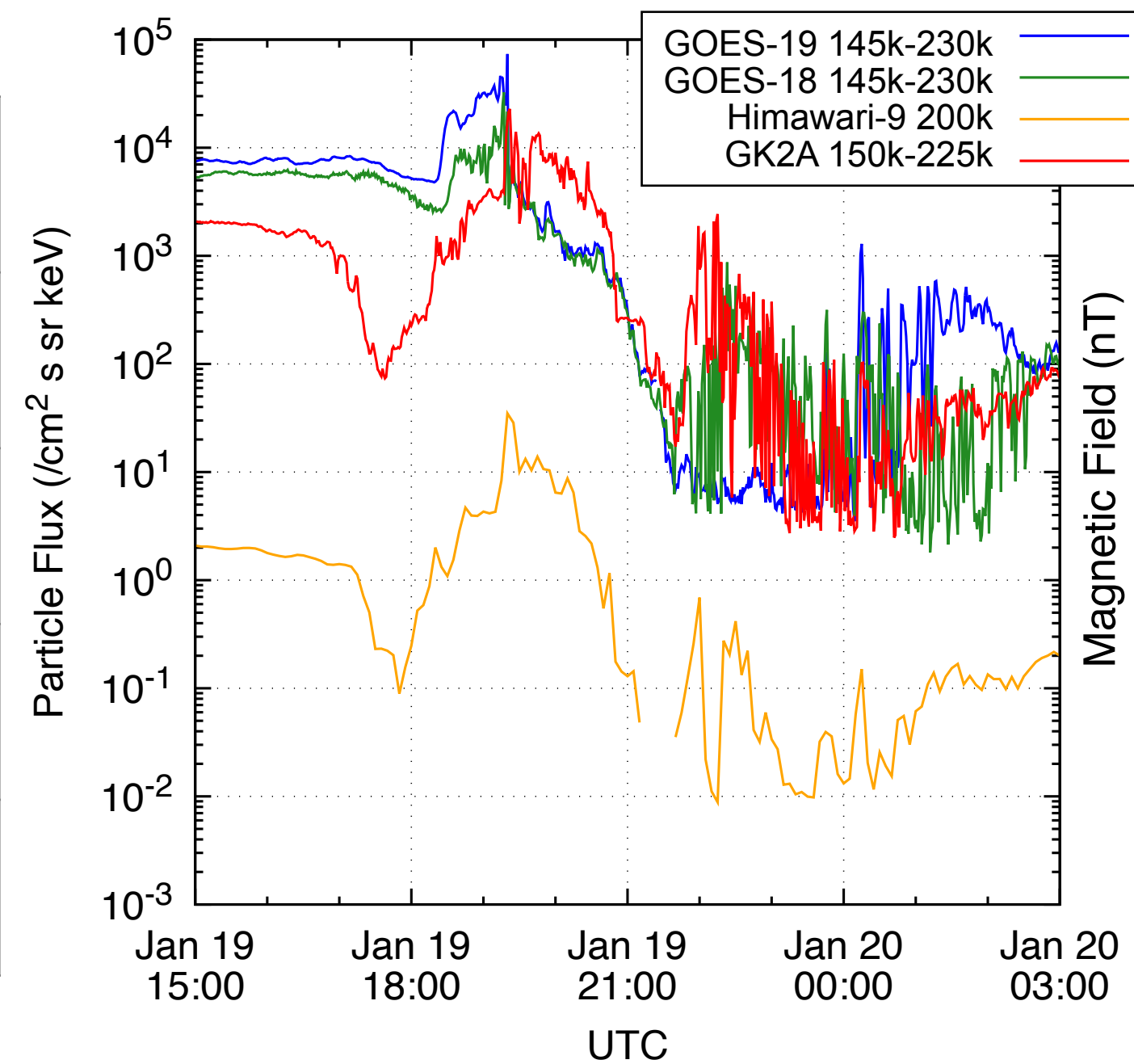


Case 2: 2026, January 18

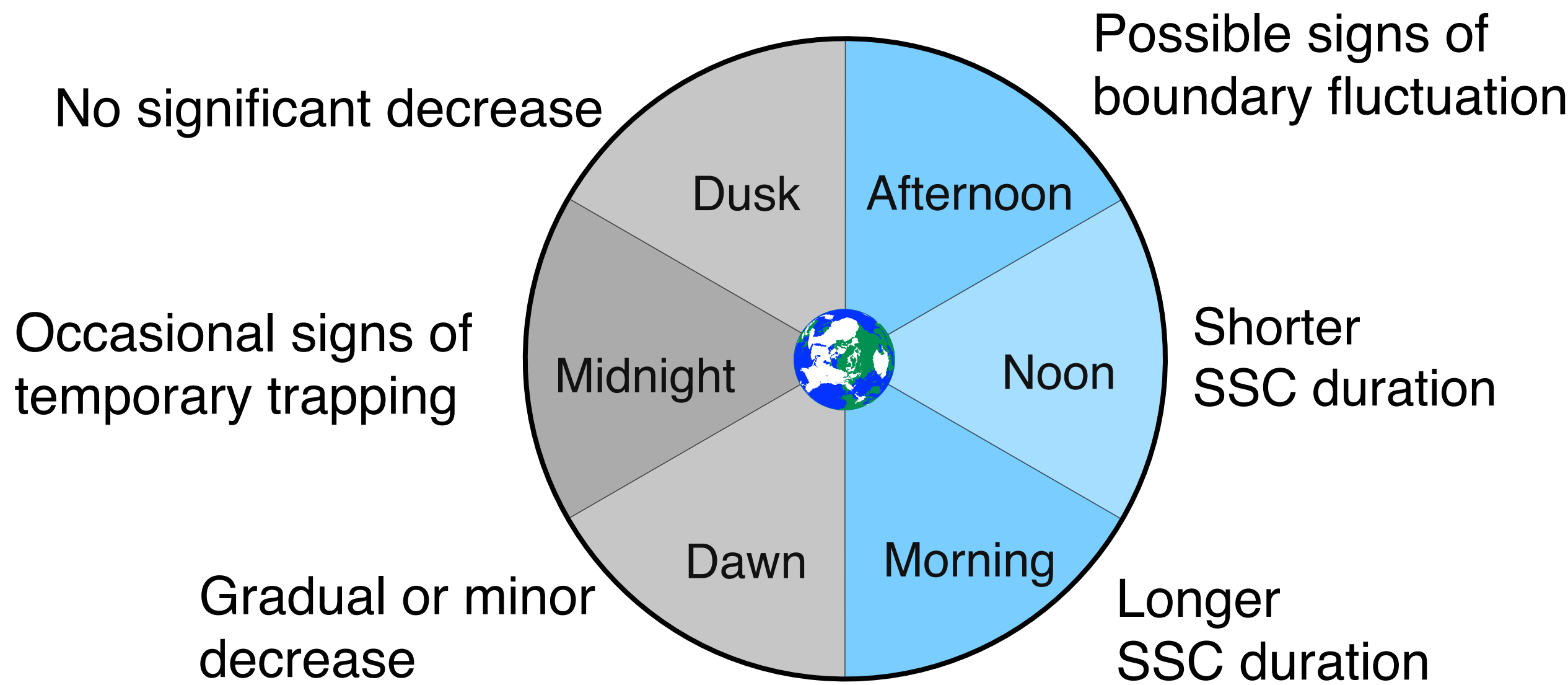
Max. Kp: 9-
Min. Dst: -235 nT



Satellite	Sector	Electron Flux	Bz Field	SSC
GOES-19	Afternoon	Increased after weak & gradual drop	Sharp & repeated reversal	19:17, 19:20 multiple durations
GOES-18	Morning	Increased after weak & gradual drop	Sharp reversal	19:14 - 19:16 Long duration
GK2A	Dawn	Increased after early gradual drop	No reversal	-
Himawari-9			-	-



Characteristic Behavior on local time



- Magnetic field (B_z) and electron flux responses to magnetopause compression show notable asymmetries across local time.
- These patterns suggest that:
 - The magnetospheric response is not spatially uniform.
 - Satellite position along the geostationary orbit significantly influences observed signatures.

Local Time Sector	B_z Behavior	Electron Flux (E)
Dusk (18:00–22:00)	No significant decrease	No significant decrease
Midnight (22:00–02:00)	No significant decrease	No significant decrease Occasional signs of temporary trapping
Dawn (02:00–06:00)	Gradual or minor decrease No clear reversal; SSC unclear	Gradual and minor decrease
Morning (06:00–10:00)	Sharp decrease and reversal Longer SSC duration	Gradual to sharp decrease
Noon (10:00–14:00)	Sharp decrease and reversal Shorter SSC duration	Sharp initial decrease Gradual secondary decrease
Afternoon (14:00–18:00)	Sharp decrease and reversal Possible signs of boundary fluctuation	Sharp initial decrease Gradual secondary decrease

- This is based on a limited number of independent GMC events.
- More events need to be analyzed
 - Higher-resolution data (sub-minute) should be utilized for detailed comparison.

Summary

- Using GK2A, Himawari-9, GOES-18 and -19, we analyzed 8 magnetopause crossing events since May 2025.
- Magnetospheric responses to compression events show local time–dependent asymmetries, with distinct variations in timing, intensity, and duration across sectors such as noon–midnight and dawn–dusk.
- This provide, multi-point observational evidence confirming spatially structured magnetospheric responses on GEO orbit to compression, as previously inferred from modeling and single-point measurements.
- This shows the value of multi-point observations in providing a more comprehensive view of magnetospheric responses in space weather events.

Future Works

- Collect and analyze additional GMC events to confirm local time–dependent patterns
- Use higher-resolution data to refine SSC timing and flux/Bz variation
- Improve boundary identification for ambiguous crossings
- Compare observations with model simulations for spatial interpretation
- Strengthen cross-calibration across GEO platforms

Any questions or comments:
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Thank you

