

# Drivers of Intense Geomagnetic field Variations



**Chigo Ngwira**

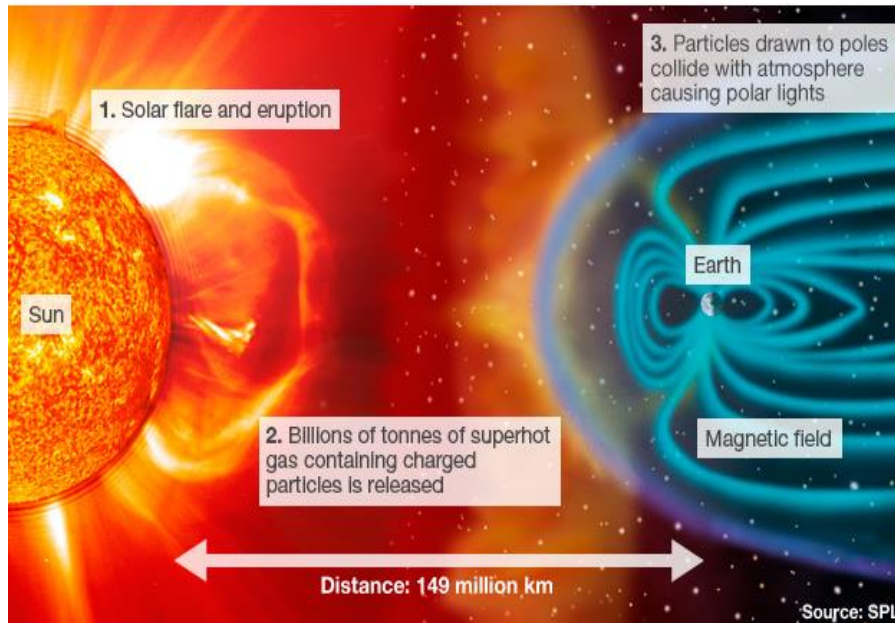
**Catholic University of America and NASA Goddard Space  
Flight Center**

**United Nations/Germany Workshop on the ISWI:  
Preparing for the Solar Maximum, June 10-14 2024,  
Neustrelitz, Germany**

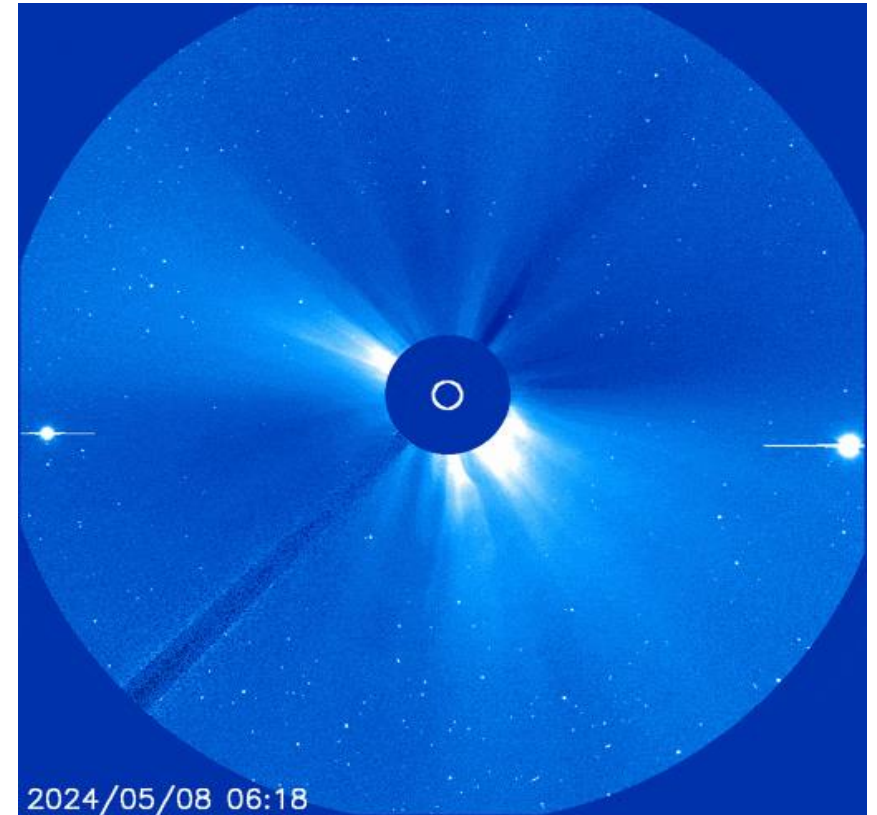
# Content

- Introduction
- Identification of Localized Events
- Magnetosphere-Ionosphere (MI) Driving
- Interplanetary Solar Drivers
- Summary

# Space Weather

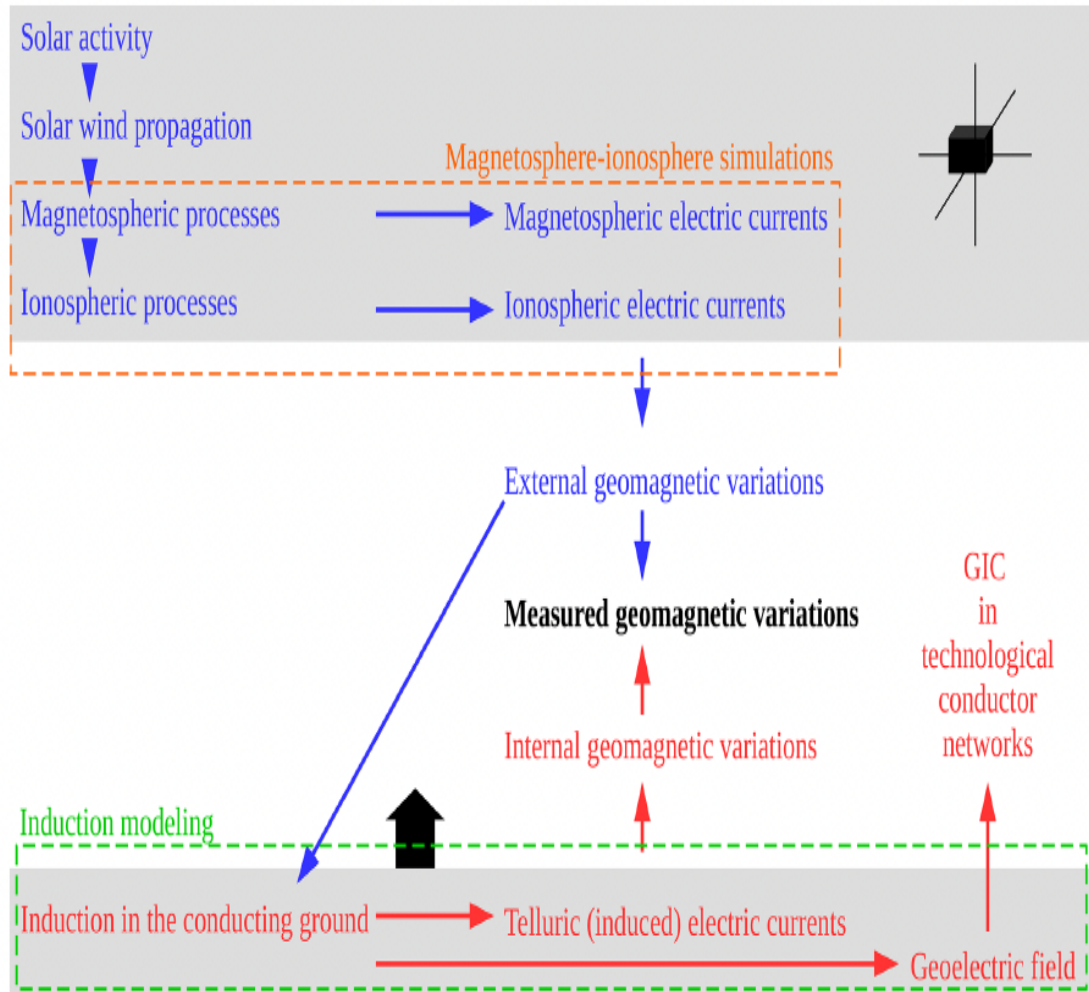


- Our Sun is the primary space weather driver.
- Comprising activity like solar flares, SEPs and CMEs etc.
- Solar wind-magnetosphere coupling leads to geomagnetic storms.
- Space weather as potential to impact human-made technologies and national security.



CMEs are major concern for Geomagnetically induced currents (GICs)

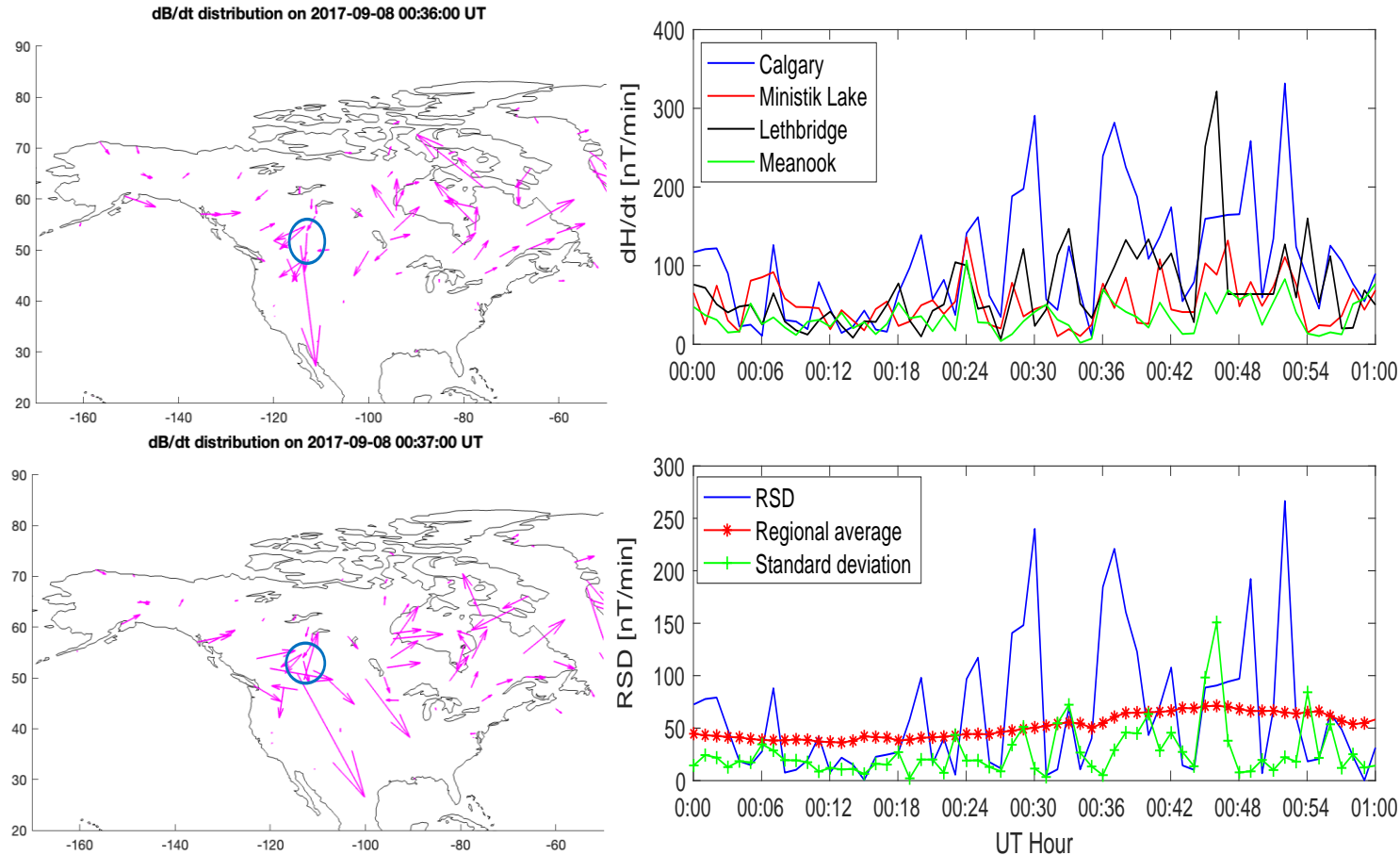
# The GIC Chain of Events : Sun – Mud



- CMEs drive the largest geomagnetic field variations and GICs on the ground
- Availability of geoelectric field and GIC data a major challenge
- We focus on the ground geomagnetic field response instead
- Use the GIC proxy  $dB/dt$  for analysis

[Credit: Juusola et al., 2023]

# Identification of Localized dB/dt features?

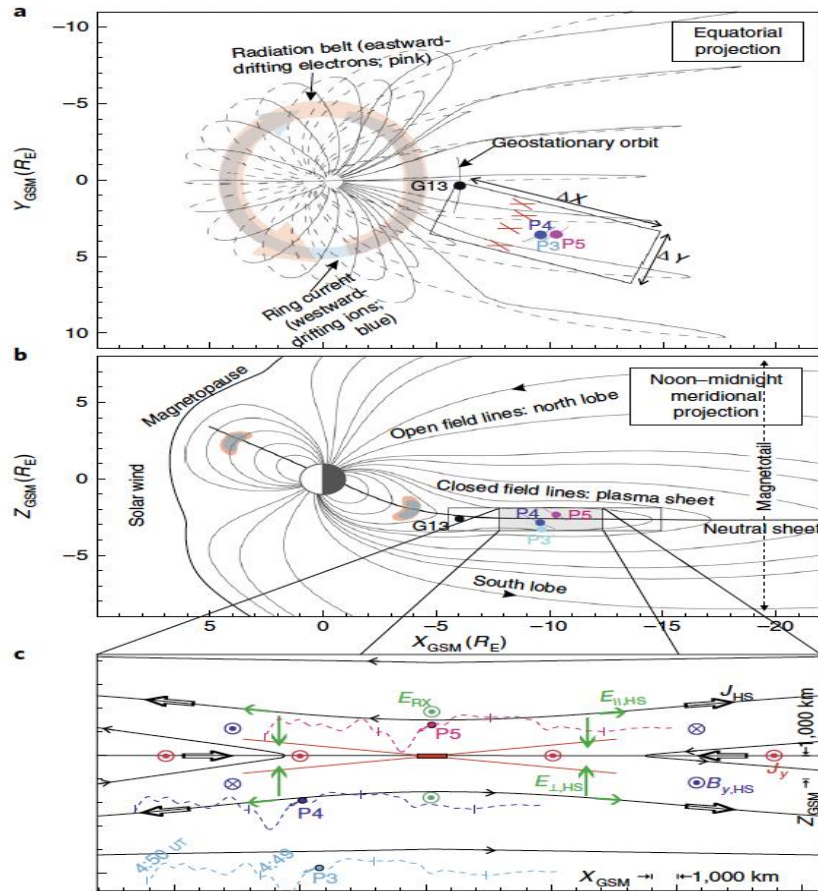


- We first visually identify the localization
- Then quantify it using the regional-to-specific difference (RSD) method by [\[Dimmock et al., 2020\]](#)
- A ratio  $> 3$  is applied.

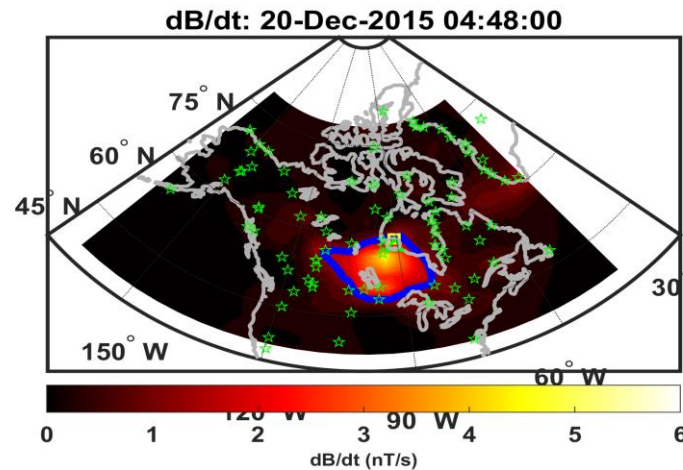
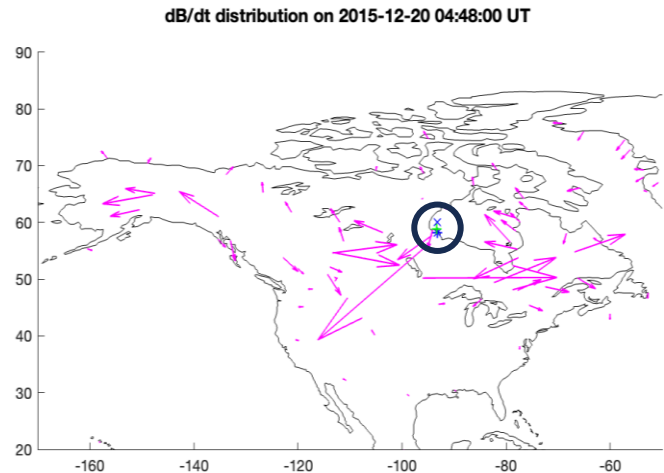
**\*This is a potential area that will be addressed by upcoming missions like GDC, EZIE, SNIPE, and TRACERS**



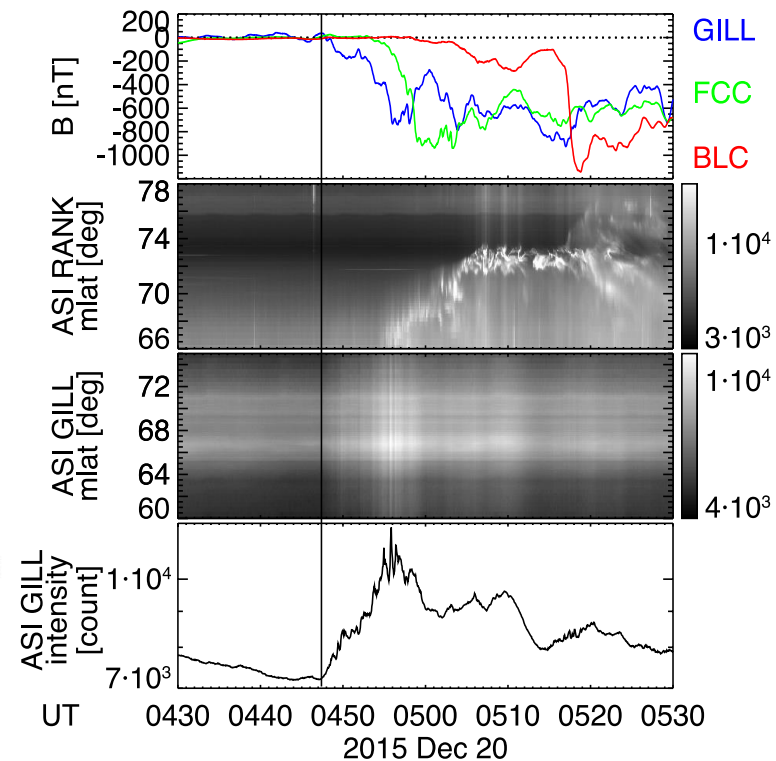
# MI Coupling and the Ground Response



[Angelopoulos et al., 2020]

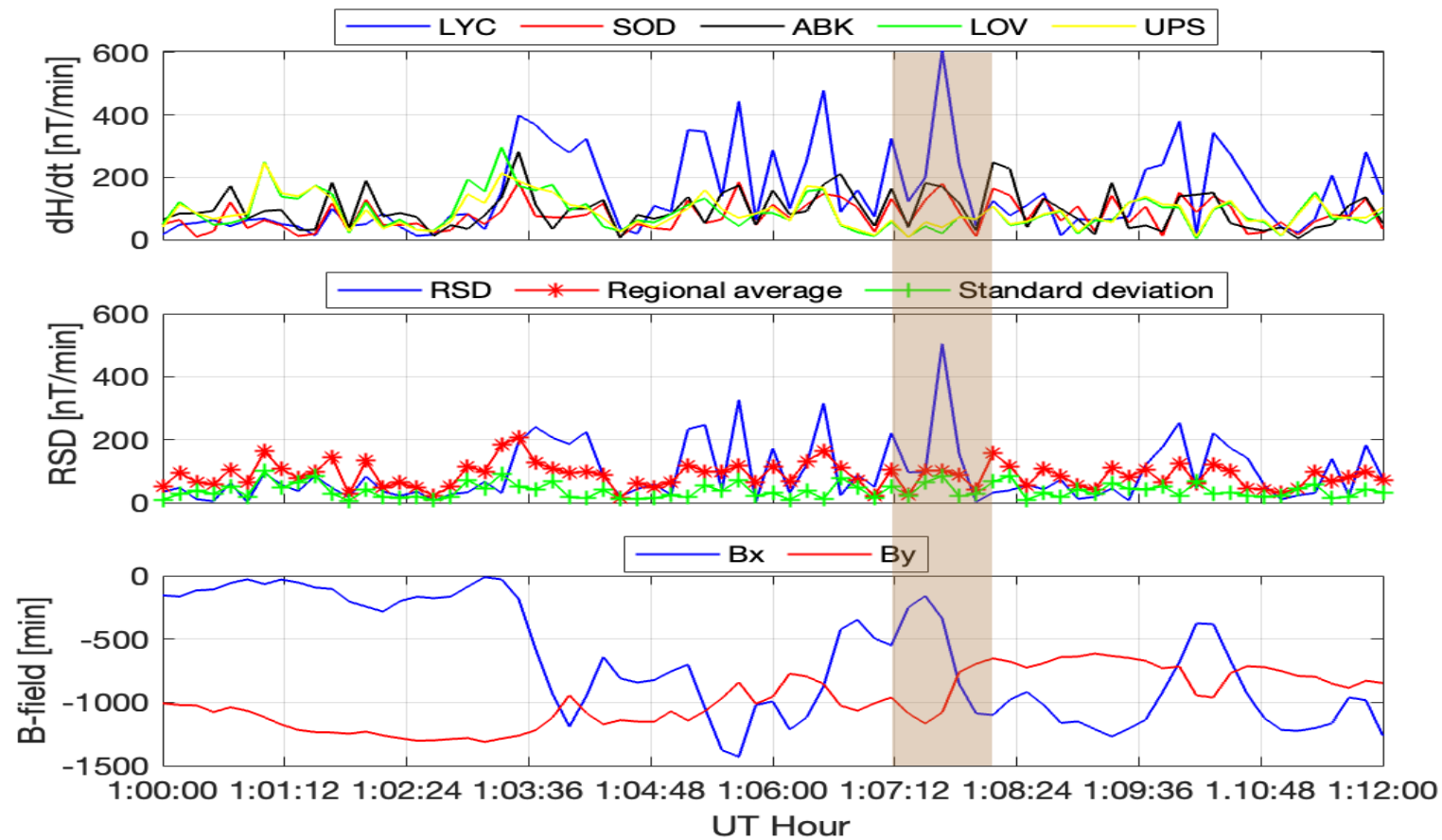


Substorm onset key  
to the localization



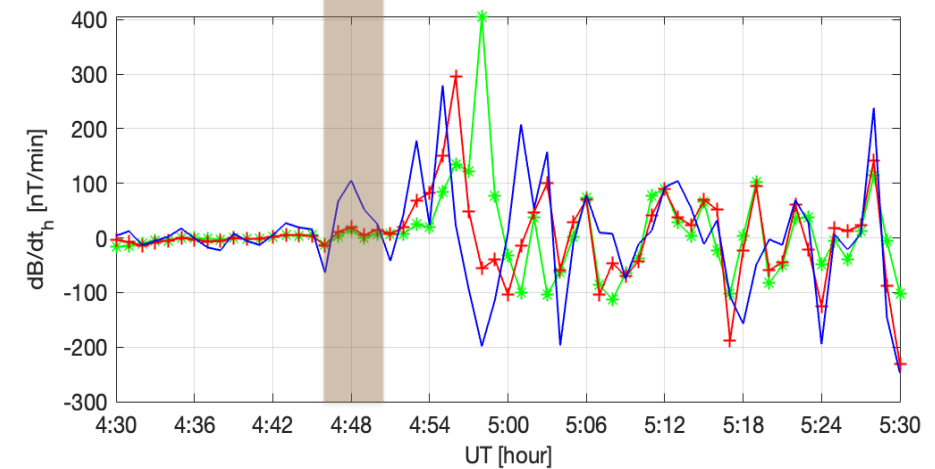
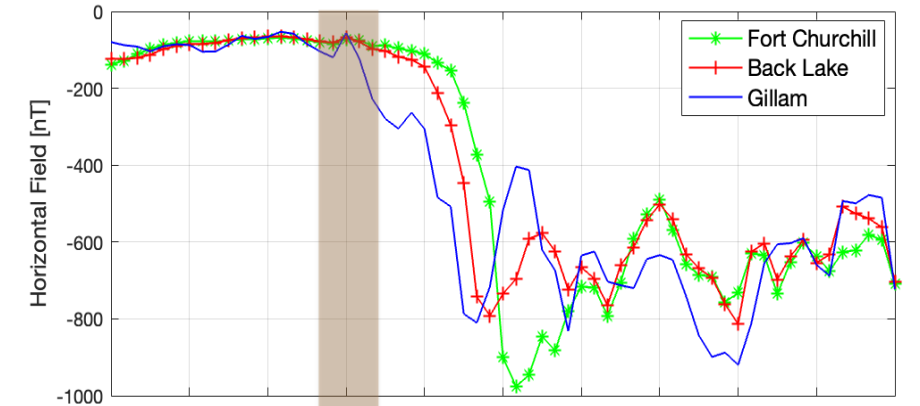
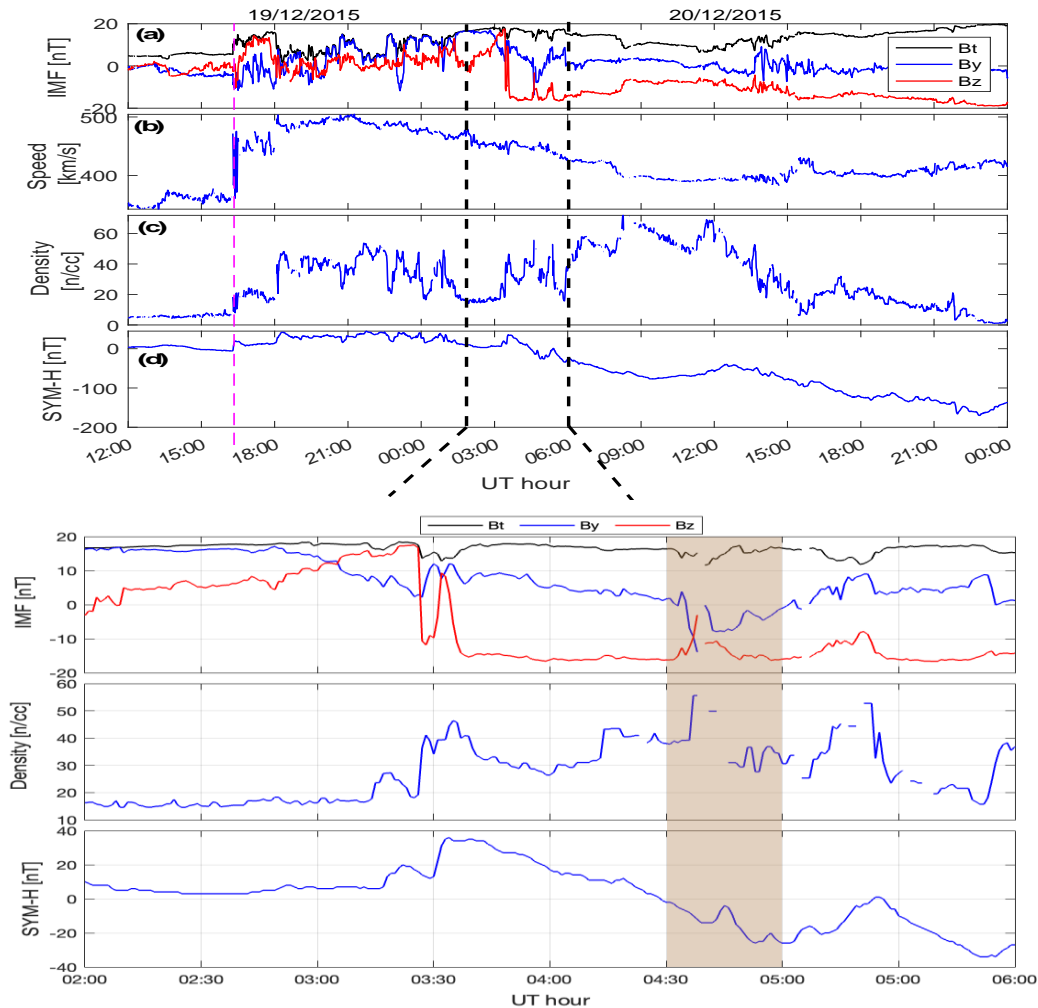
[Ngwira et al., In preparation, 2024]

# Localization from MHD Models



\*Space Weather Modeling Framework: University of Michigan code

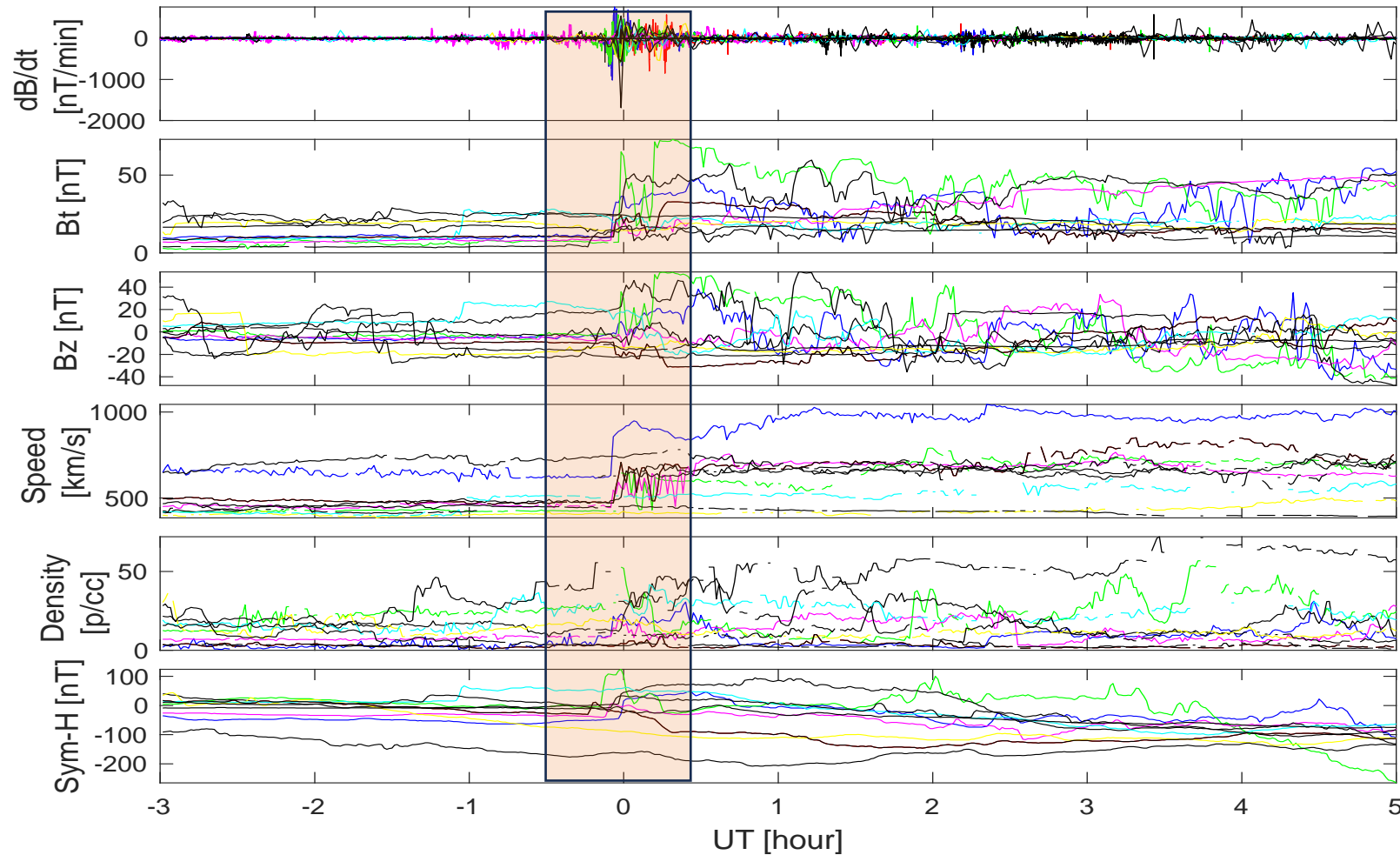
# Solar Wind Connection: Example Event on 20 December 2015



[Ngwira et al., In preparation, 2024]



# Superposed Analysis of Solar Wind and dB/dt



There is a close relation between solar wind perturbations and dB/dt variations

# Summary

- Space Weather is an important part of today's technology dependent society.
- Understanding of the Solar wind-magnetosphere-ionosphere physical processes is required to fully appreciate the GIC phenomena.
- MHD model show promise in capturing the localized geomagnetic feature.
- Preliminary analysis of solar wind perturbations and localized ground dB/dt variations shows a close connection exists
- More analysis to follow in terms of separating the events with respect to storm phase.

# Acknowledgements

- This work funded by NASA and NSF Grant awards
- **Collaborators:** Antti Pulkkinen, James W. Weygand, Toshi Nishimura, Mark Engebretson, and Pete Schuck

