

# CENTER FOR GEOSPACE STORMS

Transforming the understanding and predictability of space weather

— INNOVATE

— EMPOWER

— DISCOVER

**Understanding stormtime geospace as a complex, coupled system:**

**Recent progress from the Center for Geospace Storms**

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& the CGS team



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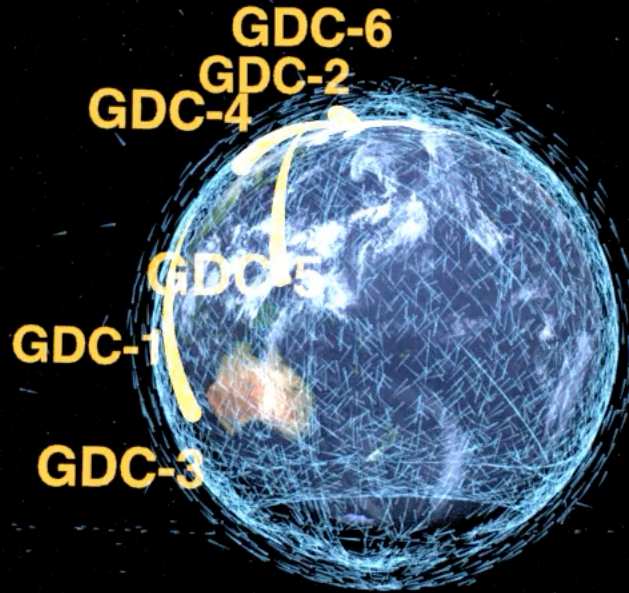


# Geospace is a *complex system*

It exhibits strong coupling across many domains and scales

## CGS Mission

- **Innovate** space weather modeling
  - **Empower** the scientific, academic, operational communities, and the broader public
  - **Discover** together how stormtime geospace responds to solar disturbances
- 
- **Treat geospace as a whole**
  - **Resolve mesoscale processes**
  - **Couple to the atmosphere**



MAGE simulation, 10-11 May 2024

NASA Science Visualization Studio

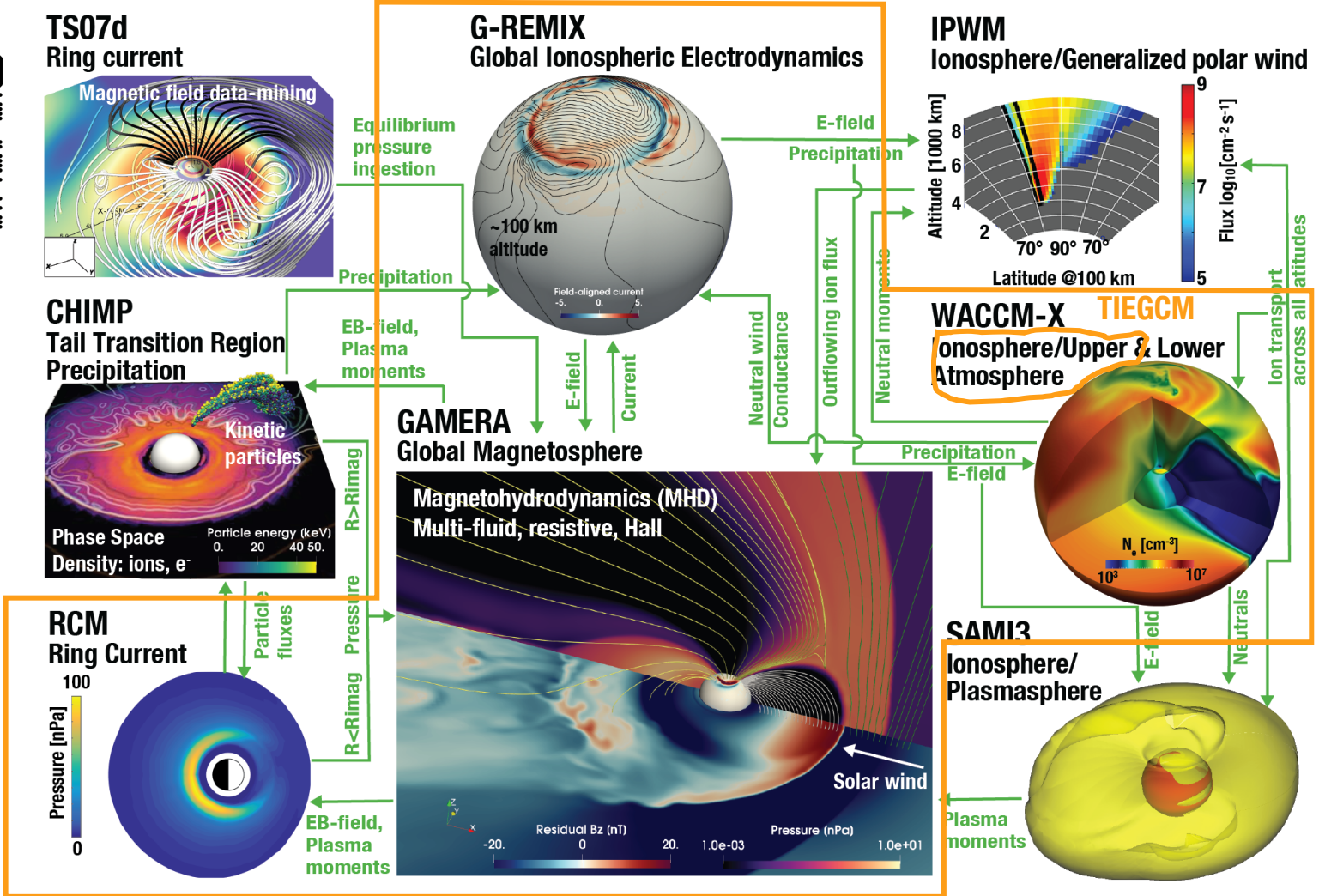
Credit: A. J. Christensen (NASA/SVS) | Kevin Pham (NCAR/HAO)

# Innovating space weather modeling & Empowering the community

## Multiscale Atmosphere-Geospace Environment (MAGE)

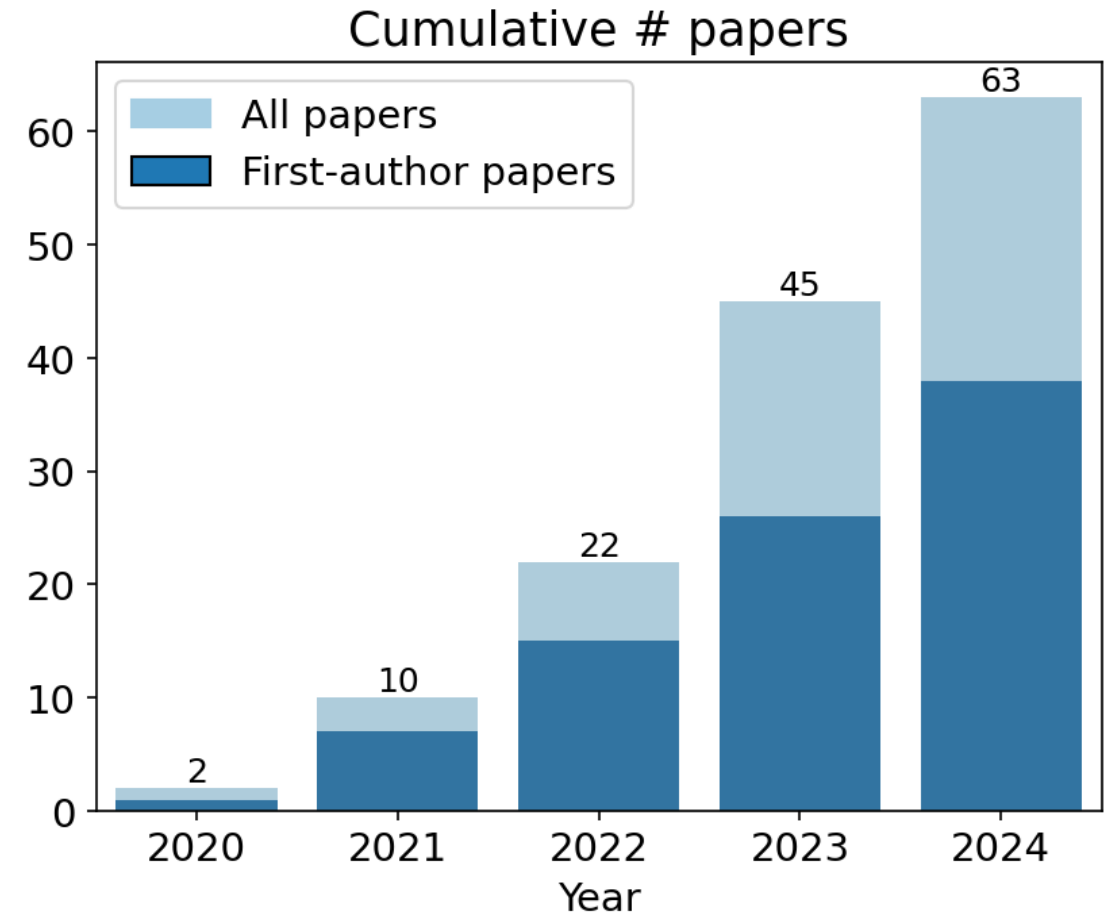


- MAGE 0.75 (GAMERA+REMIX+RCM)
  - Available for runs on request at the NAS CCMC
- MAGE 1.0 (GAMERA+REMIX+RCM\*+TIEGCM)
  - Science production since 2020
  - Delivered to CCMC in December 2024
  - Expecting runs on request and OSS release this year
- Open-source post-processing and analysis suite
  - `pip install kaipy`



# Discovering together how geospace responds to solar disturbances

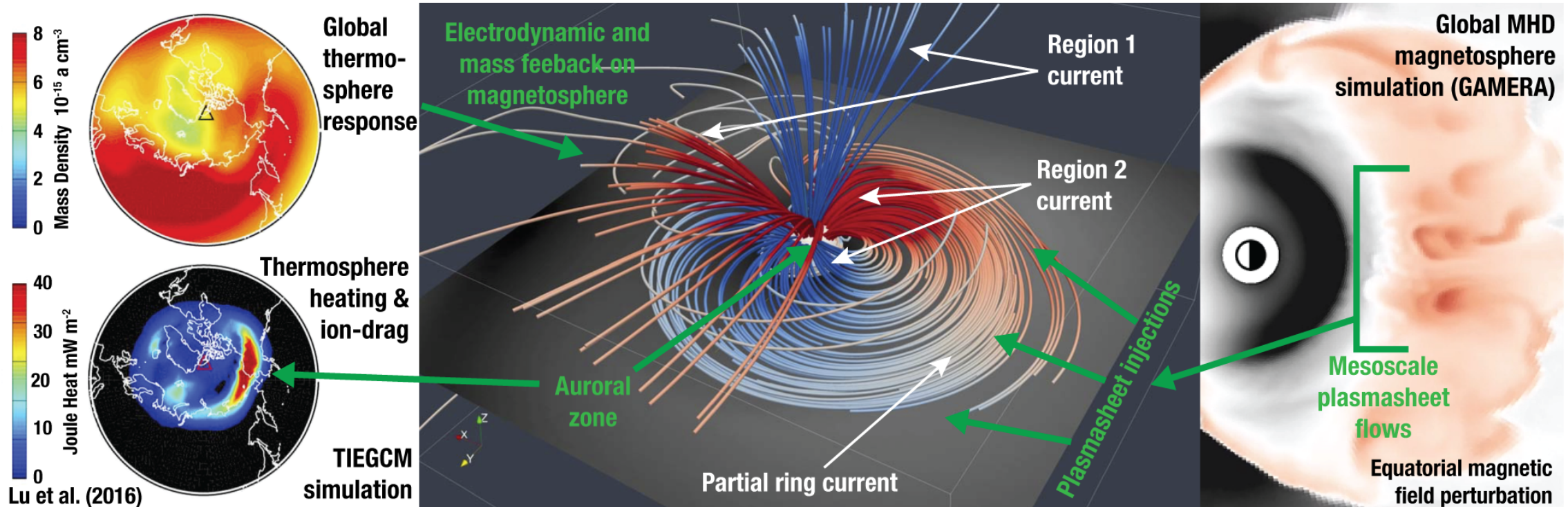
- A steadily growing publication list.
- One first-authored paper per month in the last two years.
- 5 GRLs and 1 AGU Advances out of total 12 first-authored papers last year.
- Growing fraction of collaborative papers each year.





# CGS Science Theme 1

Multiscale plasma sheet transport, ring current build-up, and their global impacts throughout stormtime geospace



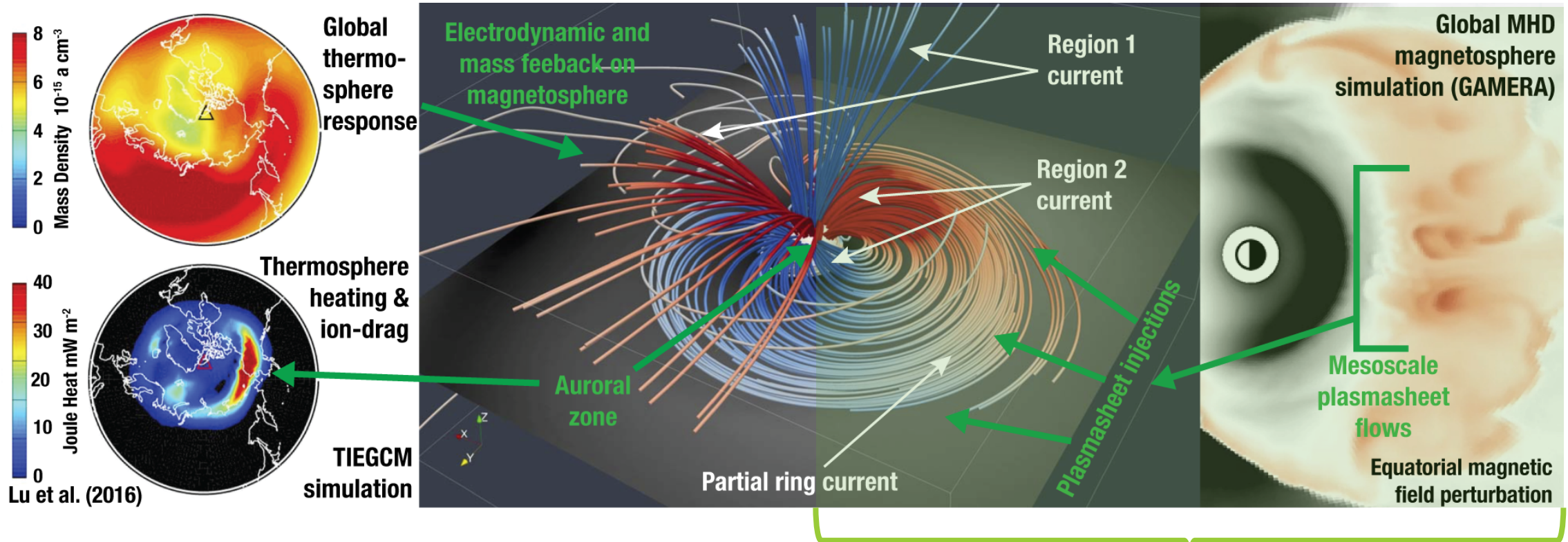
Today we'll highlight

- 3 published works (2 in 2023 and one last summer)
- 1 ongoing effort



# CGS Science Theme 1

Multiscale plasma sheet transport, ring current build-up, and their global impacts throughout stormtime geospace



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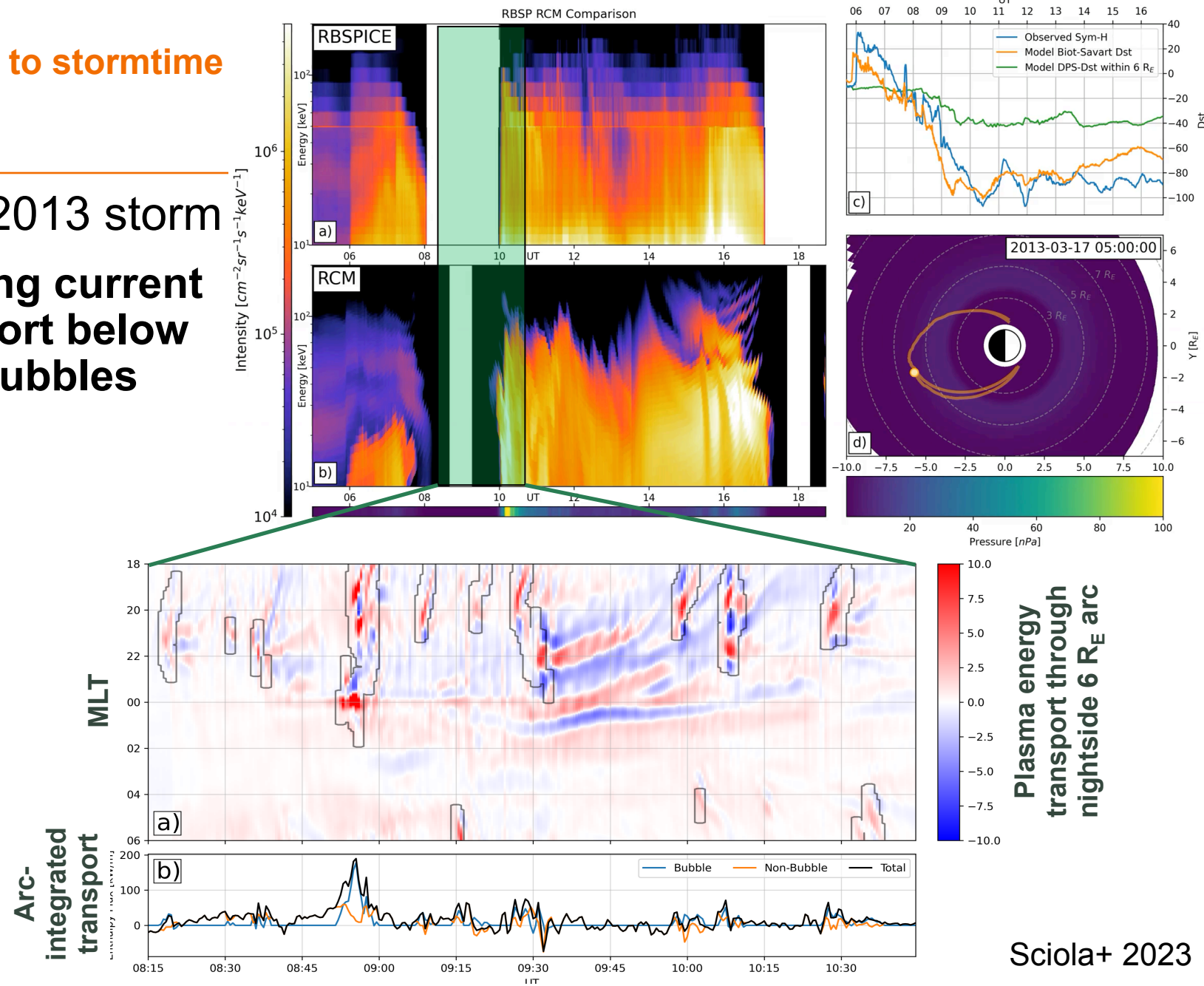
Plasmasheet/Magnetotail



# Contribution of plasma sheet bubbles to stormtime ring current buildup

- Case study of the March 17, 2013 storm
  - During initial buildup of the ring current at least 50% of the net transport below  $6 R_E$  is due to plasma sheet bubbles
  - The return flows that accompany bubbles as a result of interchange transport outwards an average of 40% of the plasma energy
  - The evolution of the modeled ring current energy spectra is due to both an evolving source population and energy-dependent losses

Full paper →



Sciola+ 2023



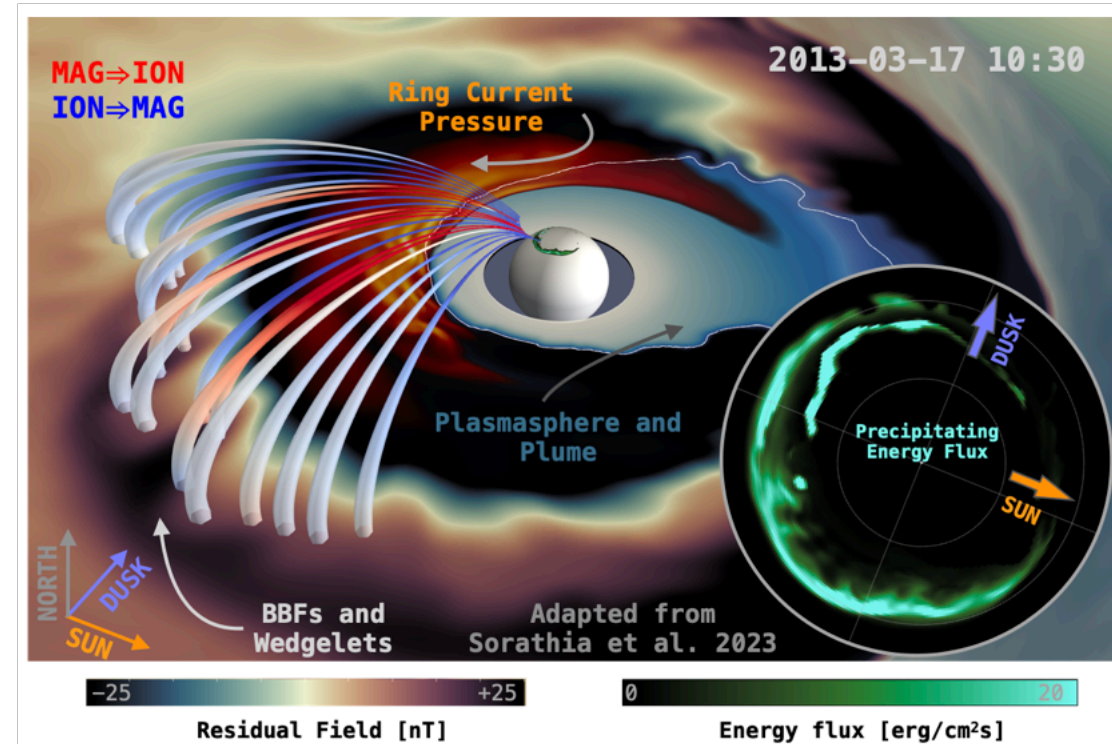
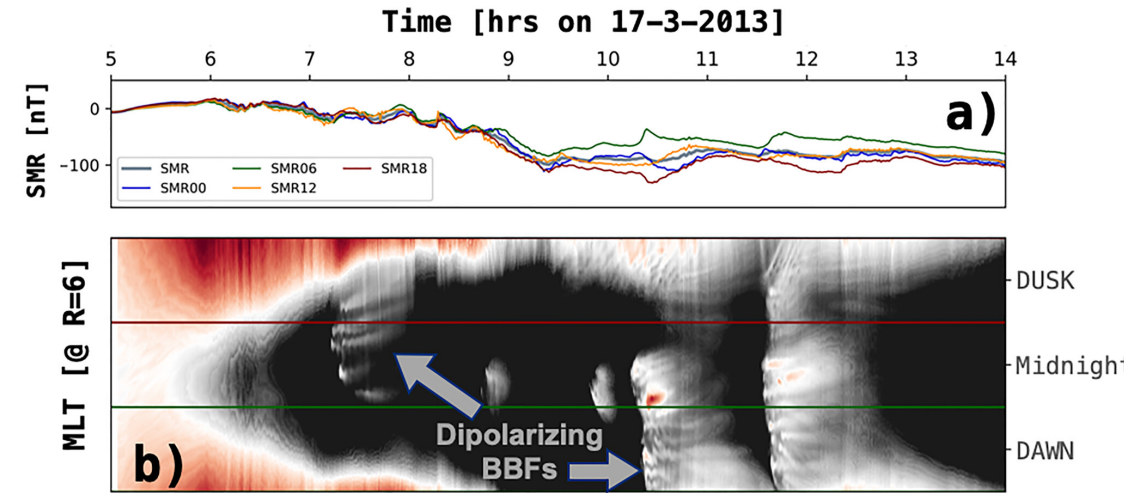
# Modeling GMDs w/ MAGE

## Stormtime MI Coupling

- Dawnside current wedge
  - Ohtani '21 and '23, Sorathia+ '23
- Modeling shows dawnside BBFs during stormtime create multiscale enhancement of the dawnside AEJ
  - BBFs connect to omega bands & large dB/dt

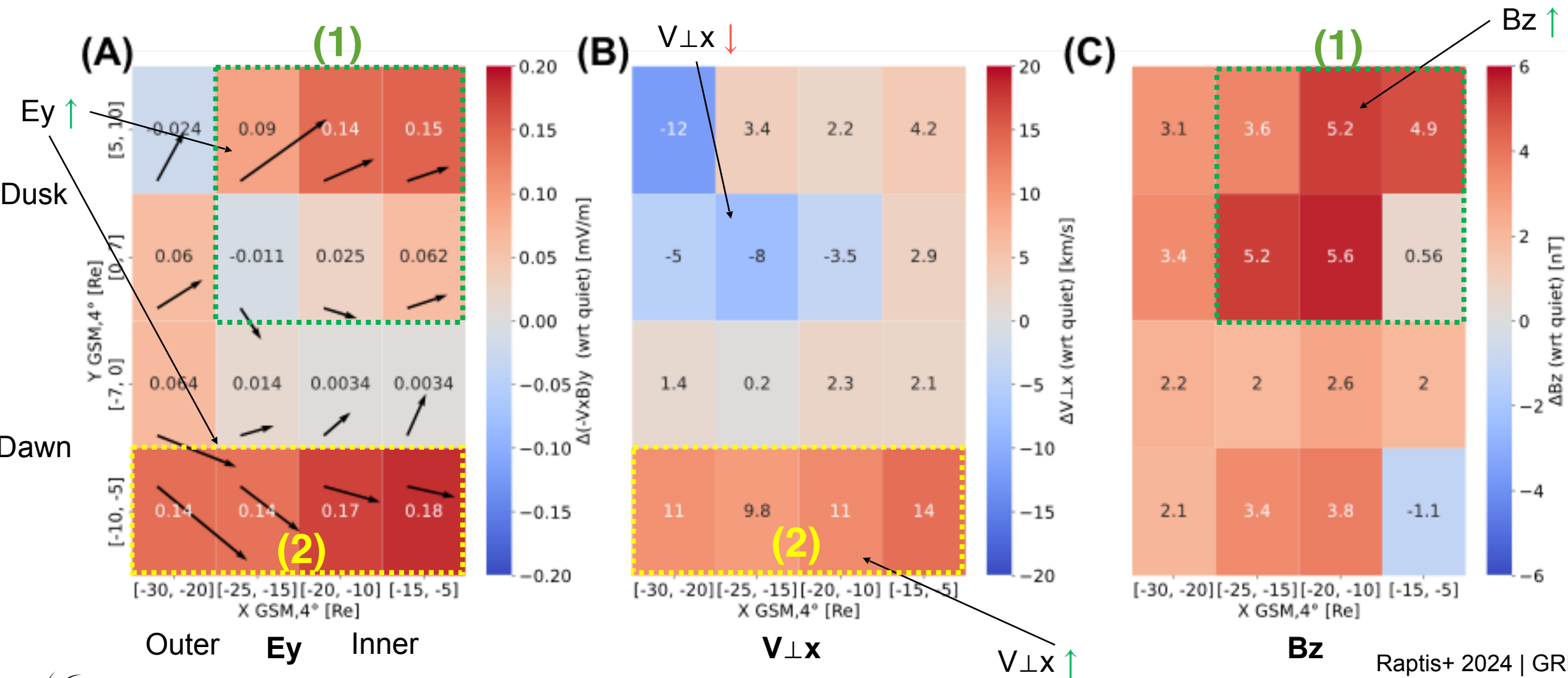
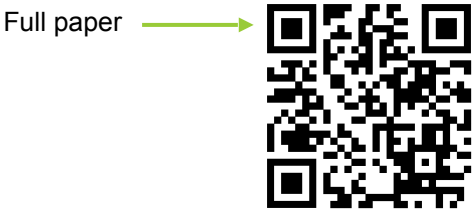
## Dawnside GMDs

- dB/dt skewed towards dawn (Schillings+ '22)





# Stormtime Global Convection - Geotail (1994 – 2022)

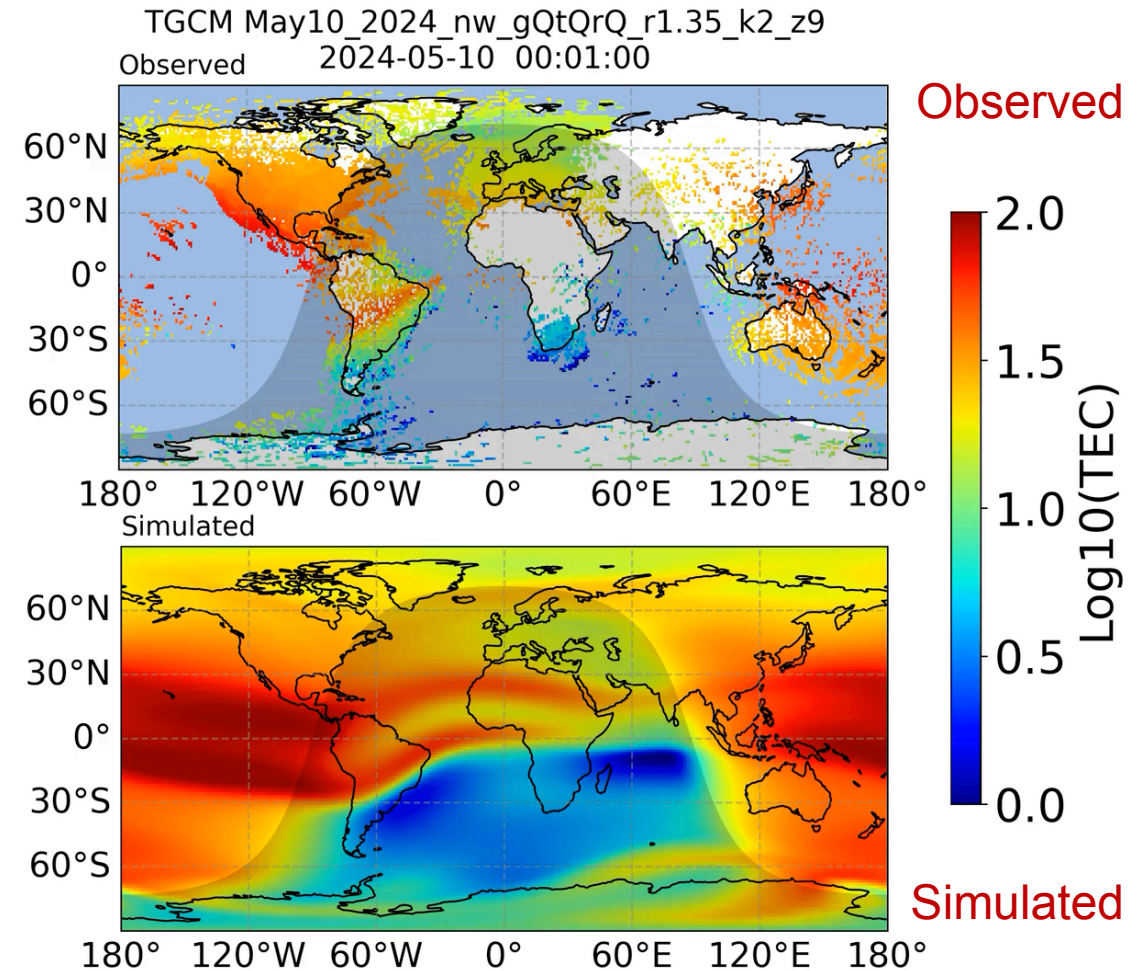




# Summary

- CGS vision is to transform the understanding and predictability of space weather
- CGS mission is to:
  - **Innovate** space weather modeling
  - **Empower** the scientific, academic, operational communities, and the broader public
  - **Discover together** how stormtime geospace responds to solar disturbances
- CGS is building the Multiscale Atmosphere-Geospace Environment (MAGE) model
  - MAGE 0.75 available at CCMC
  - MAGE 1.0 is a fully coupled magnetosphere-ionosphere-thermosphere model
    - slated for OSS release next year

Stay tuned for more discoveries from the CGS team and let us know if you'd like to collaborate!



May'24 superstorm MAGE 1.0 simulation by K. Pham (NCAR/HAO)