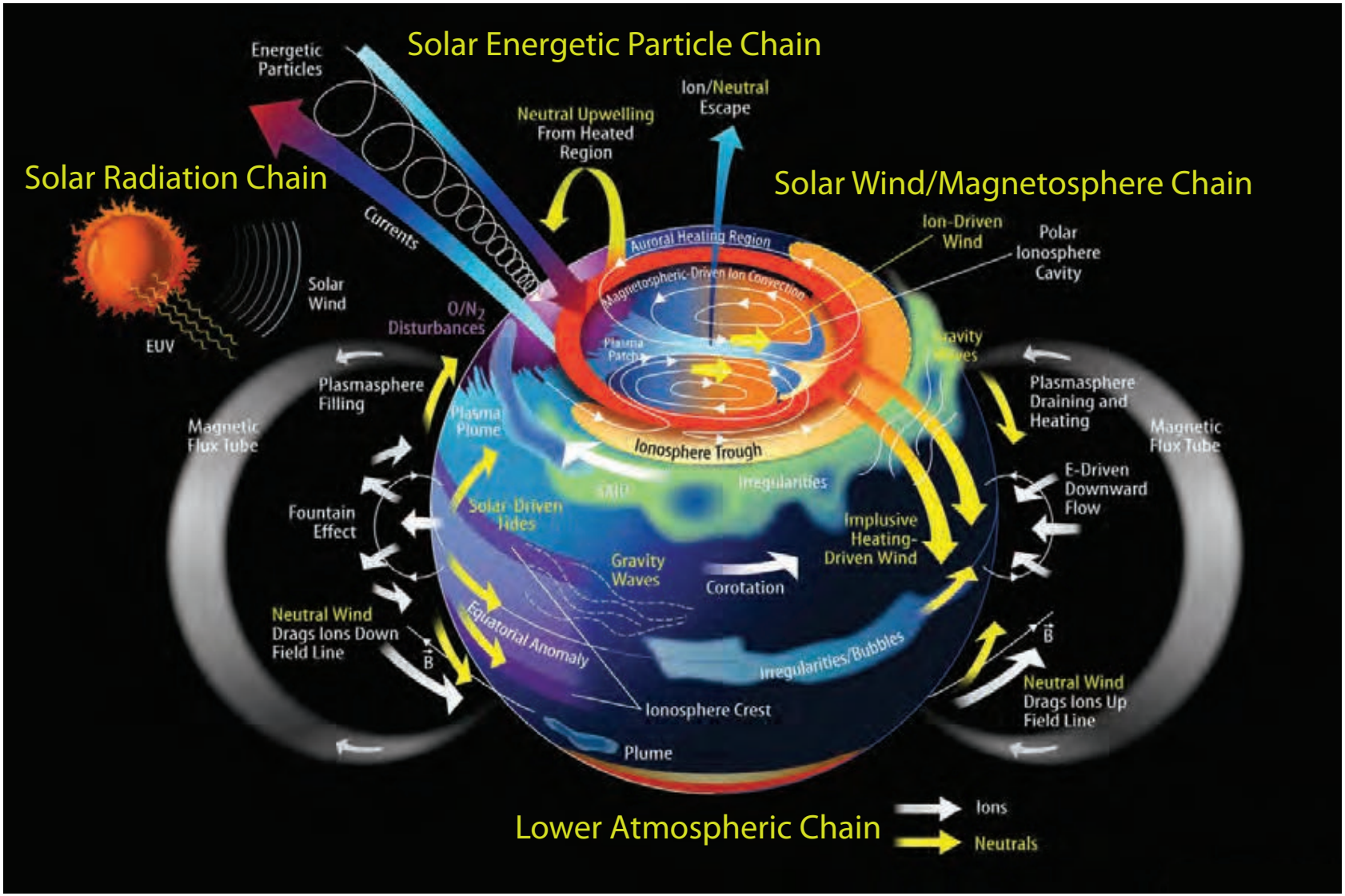
Challenges in Aeronomy Research

Nick Pedatella

High Altitude Observatory, NCAR
COSMIC Program Office, UCAR

This talk will provide an overview of the big-picture CEDAR research questions. What are we trying to answer by studying the detailed processes below?



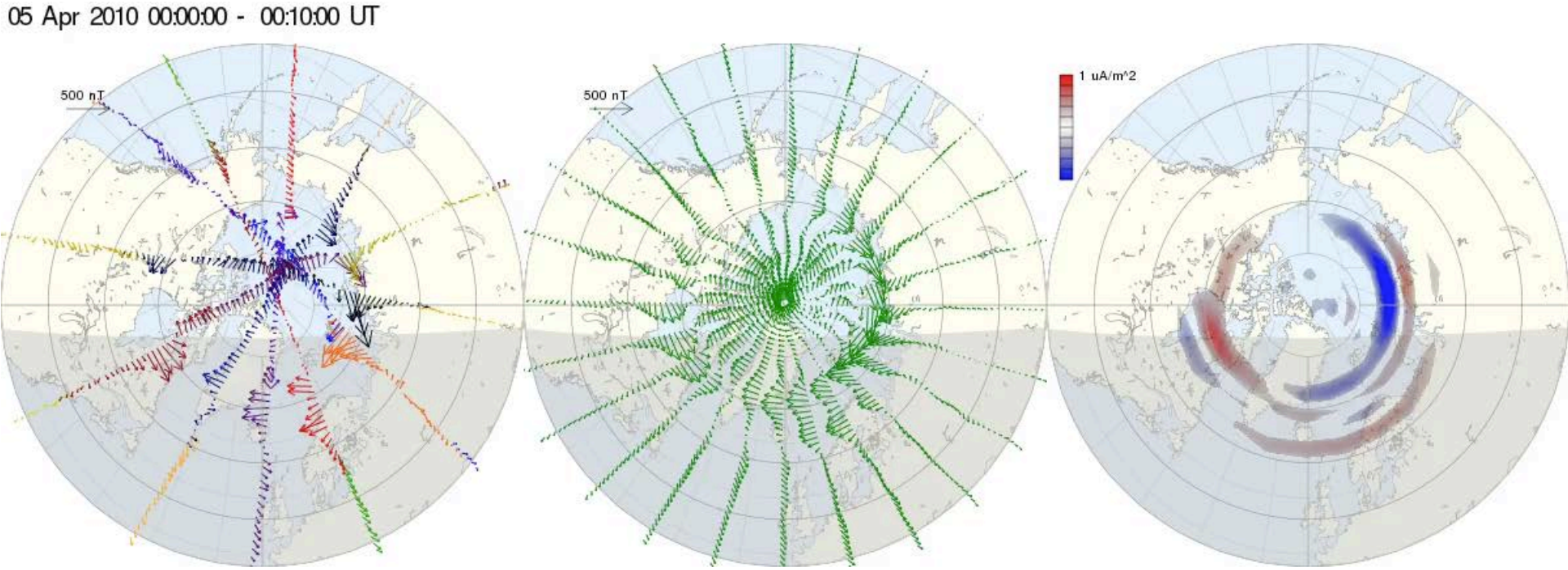
(NAS, 2013)

Areas to be (briefly) discussed

1. High latitude forcing and the MTI response
2. Meteorological driving of the MTI
3. The growing number of observations
4. ~~Simulating the above in numerical models~~

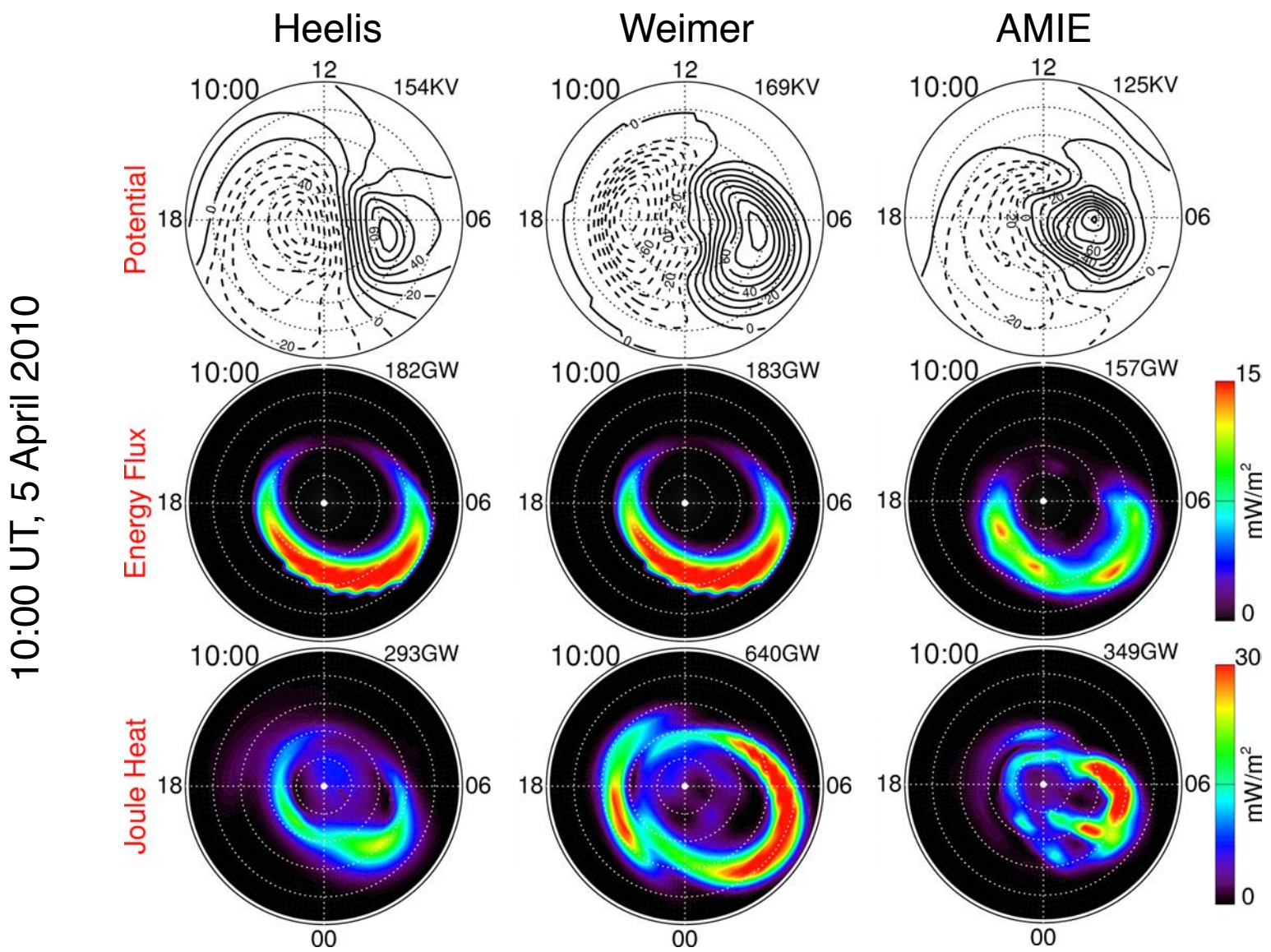
MTI – Mesosphere, Thermosphere, and Ionosphere

High-latitude forcing and MTI response



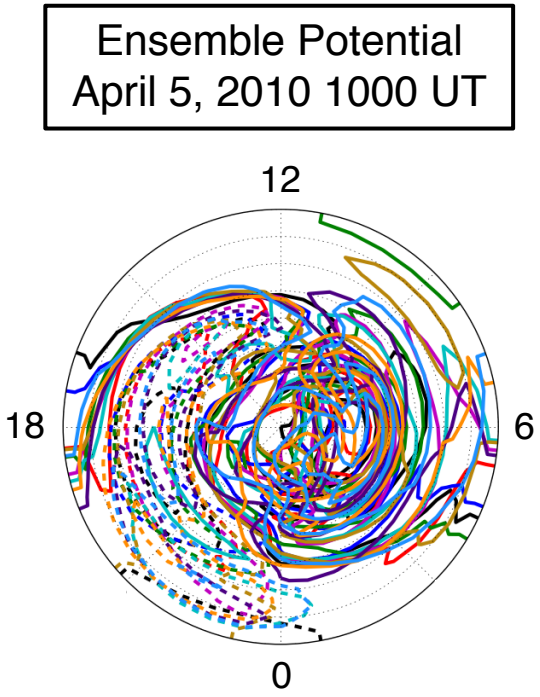
http://ampere.jhuapl.edu/

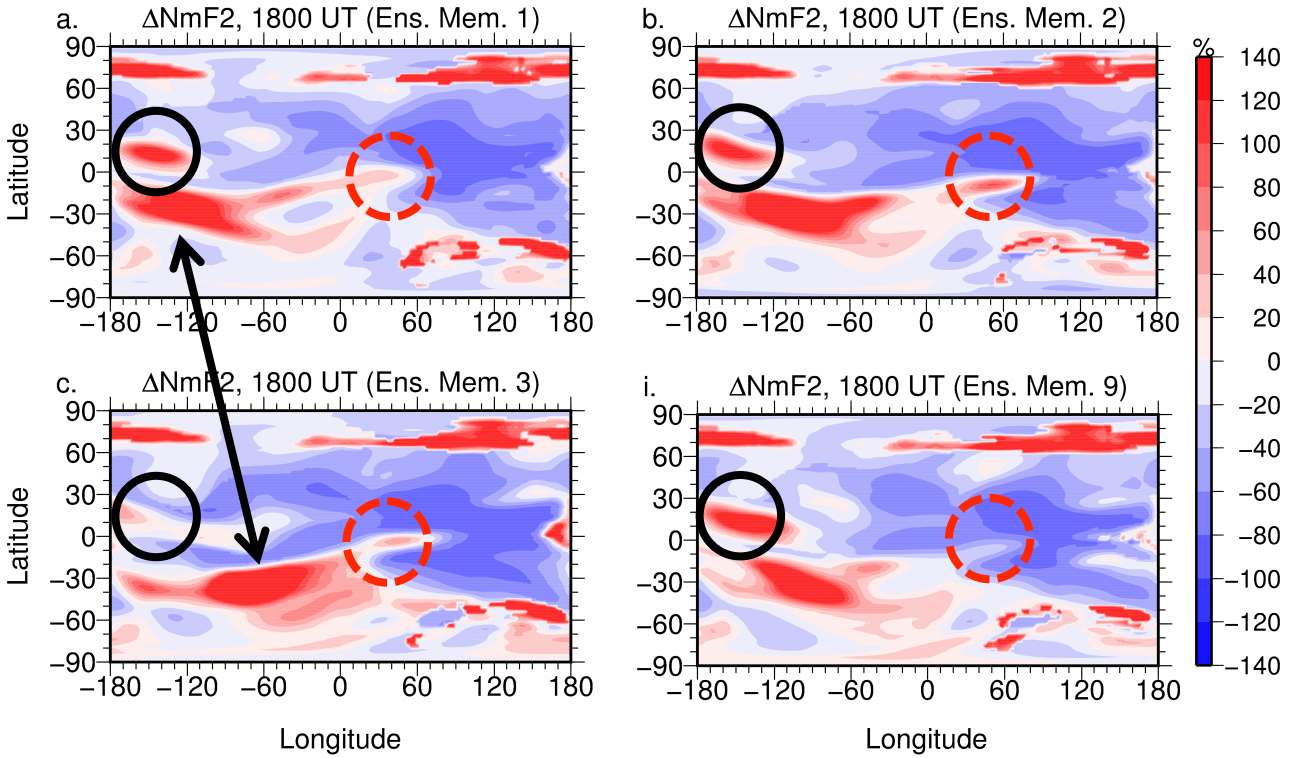
What is the distribution in space and time of the high-latitude energy inputs?



(Courtesy of Gang Lu)

What is the distribution in space and time of the high-latitude energy inputs?

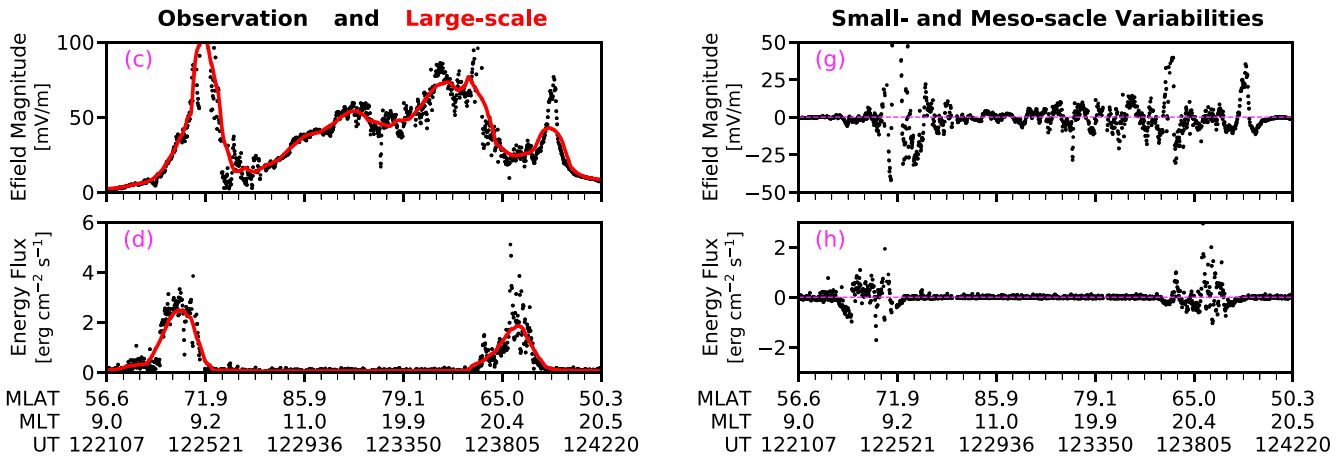


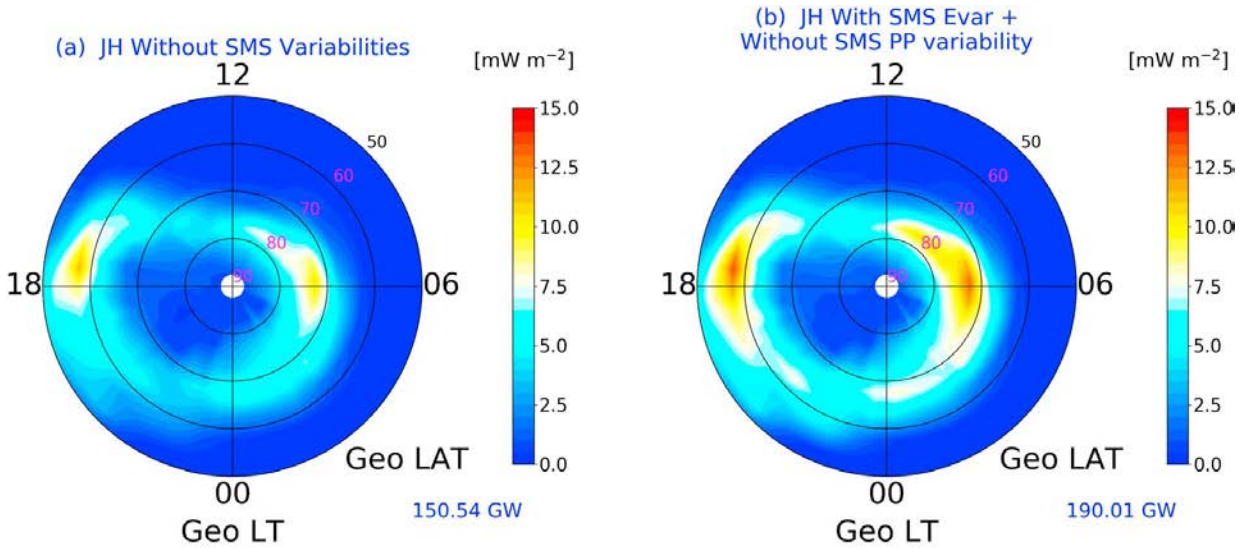


uncertainty in high-latitude forcing ⟶ uncertainty in TI response

(Pedatella et al., 2018)

What is the distribution in space and time of the high-latitude energy inputs?



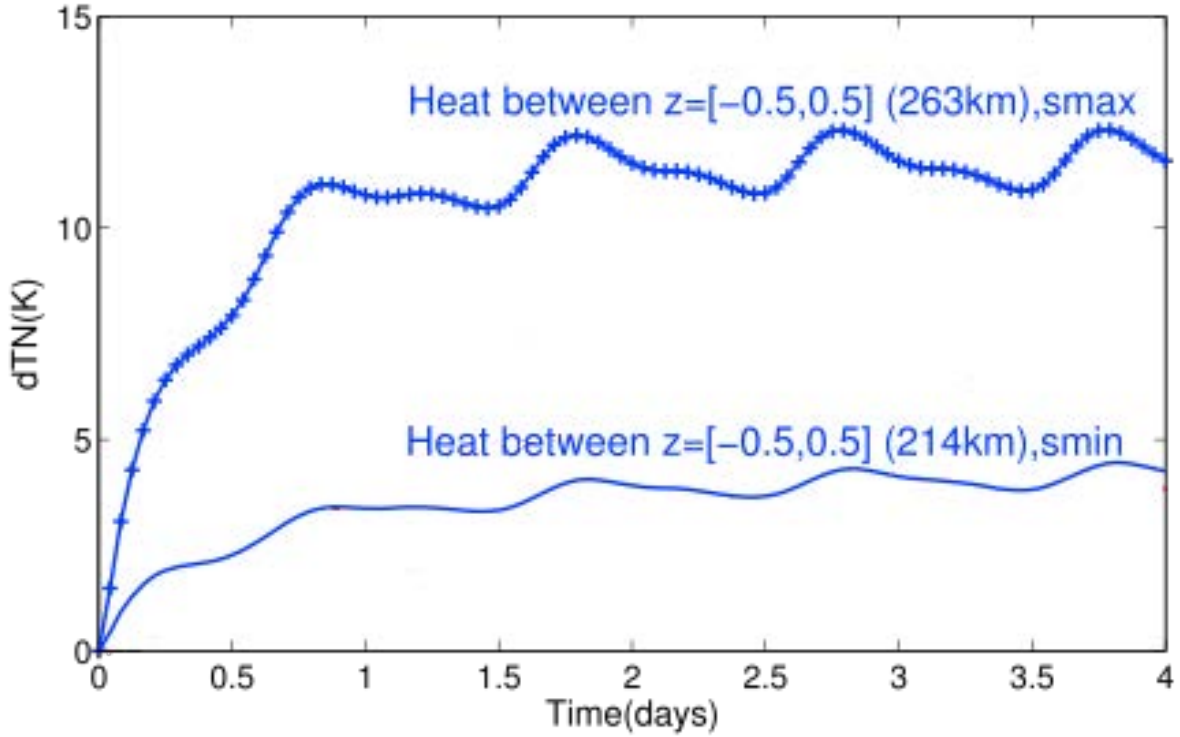


What is the energy input due to small-scales?

(Zhu et al., 2018)

What is the distribution in space and time of the high-latitude energy inputs?

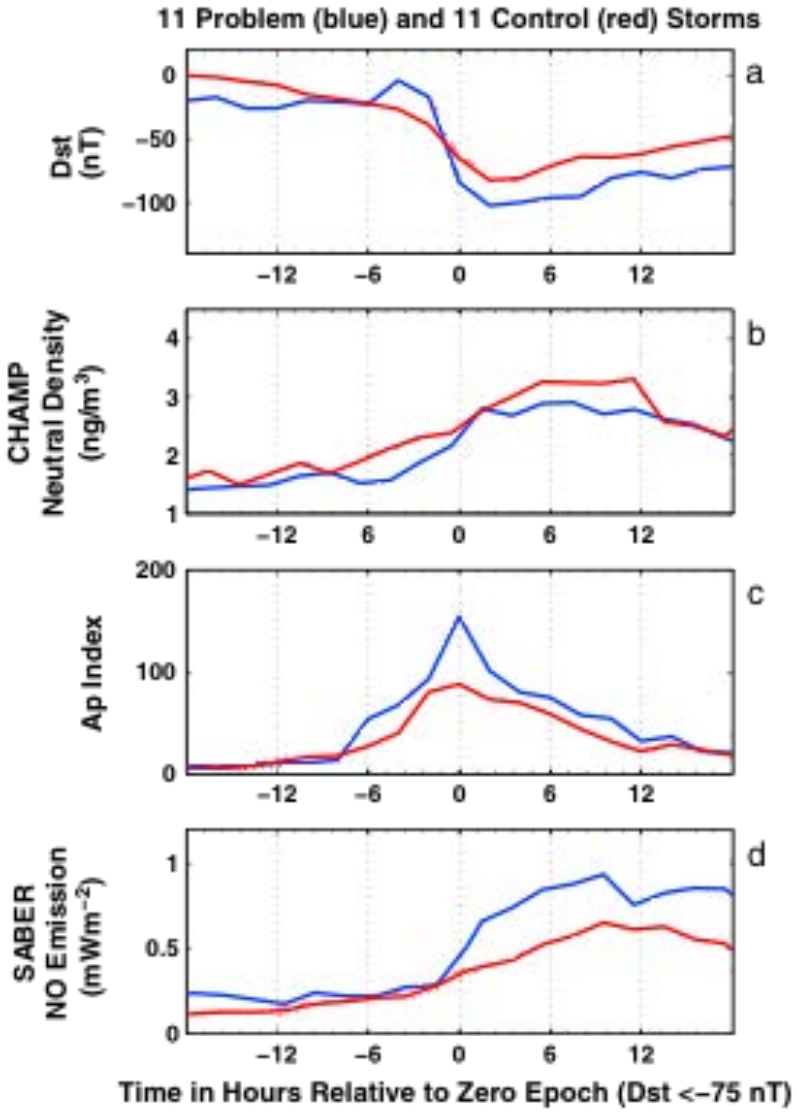
Neutral temperature response at 400 km due to Joule heating at different altitudes.



What is the conductivity in the high-latitude ionosphere?

(Huang et al., 2012)

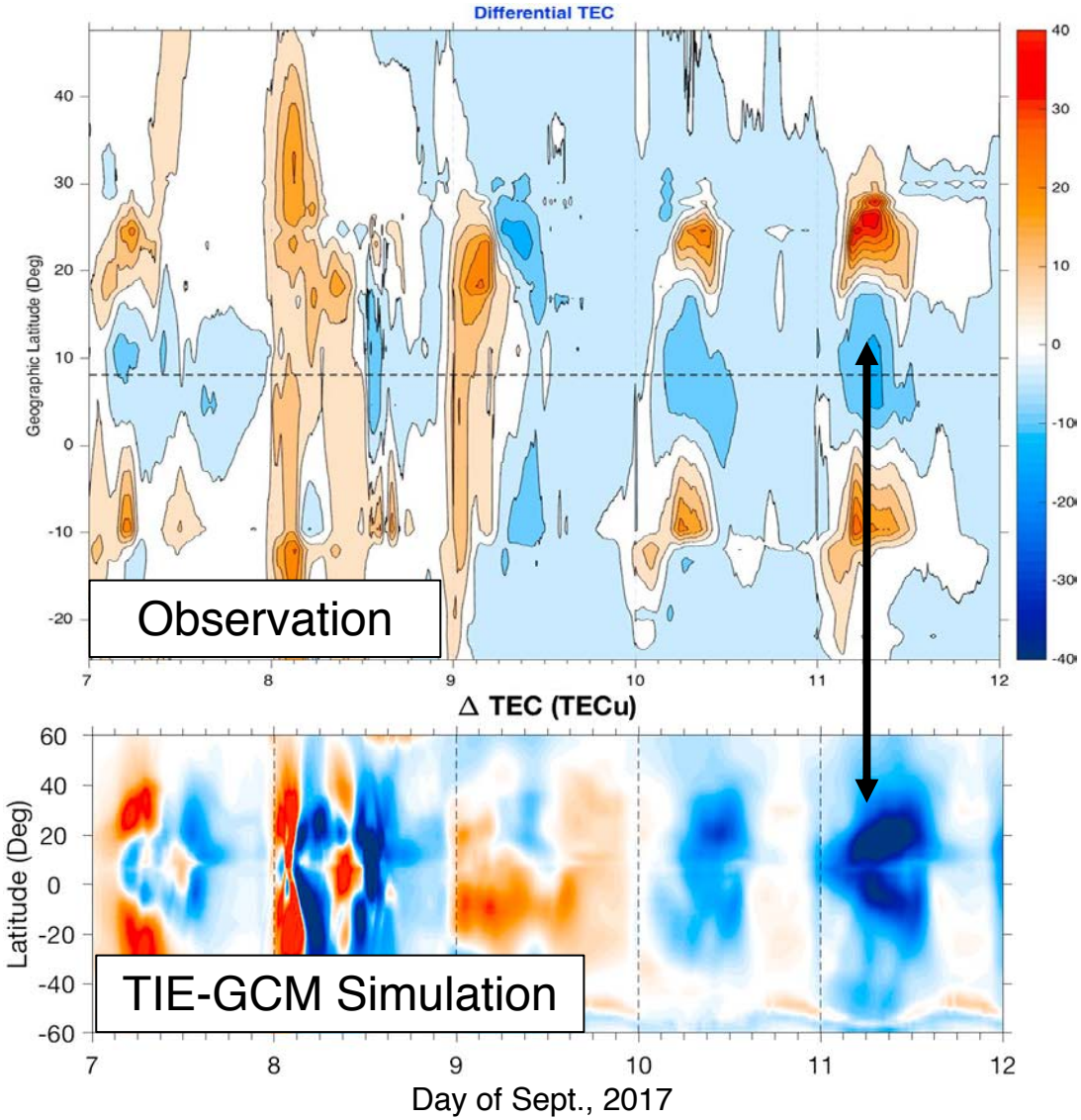
What is the MTI response to geomagnetic storms?



Why are some storms “anomalous” in our ability to model the MTI response?

(Knipp et al., 2013)

What is the MTI response to geomagnetic storms?



Why are some storms “anomalous” in our ability to model the MTI response?

(Lei et al., 2018)

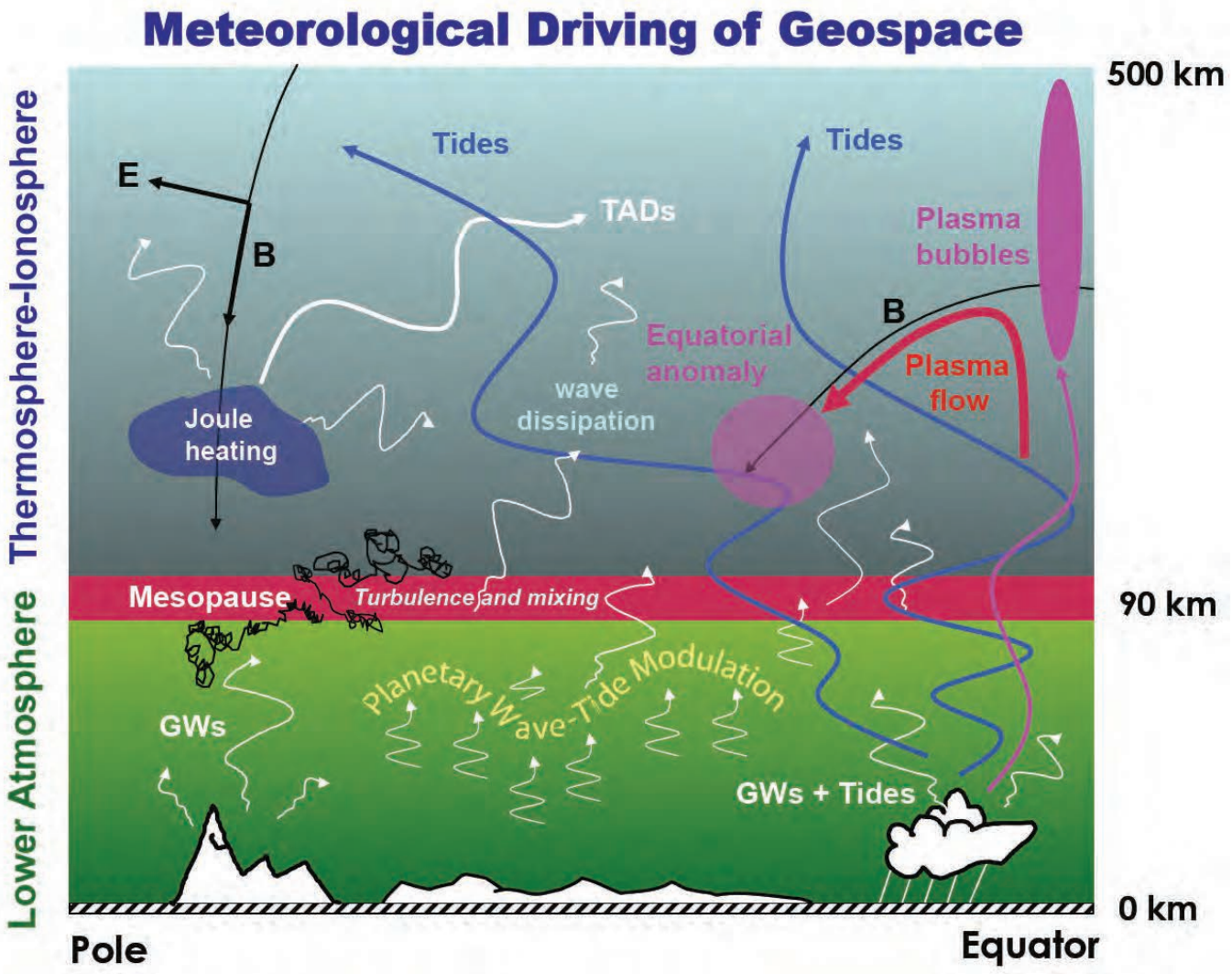
What is the MTI response to geomagnetic storms?

The MTI response to geomagnetic storms is driven by changes in:

- Heating
- Neutral winds (large scale and TADs)
- Electric fields
- Composition

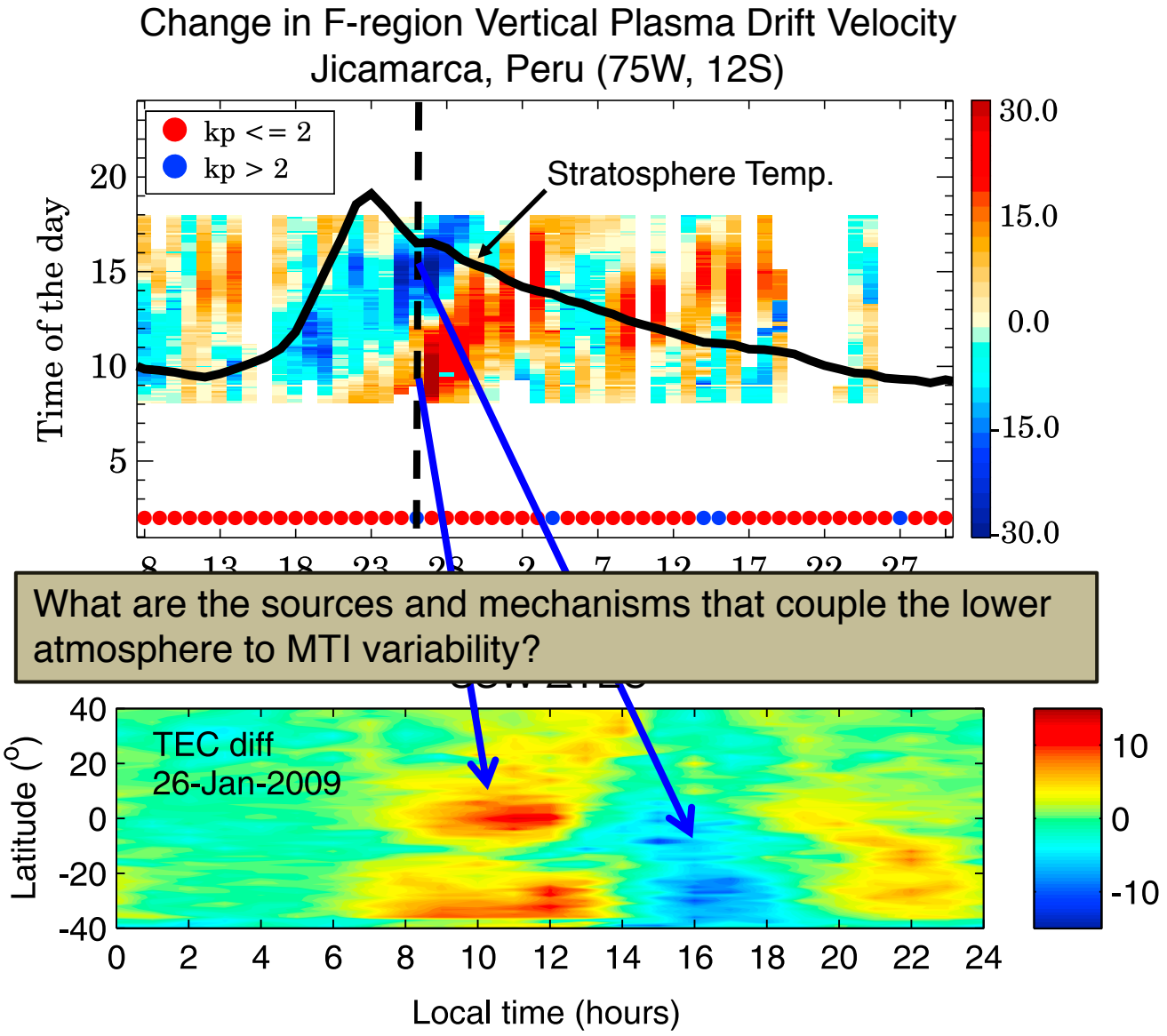
What drives the IT variability during storms on different spatial and temporal scales?

Meteorological Influence on the MTI



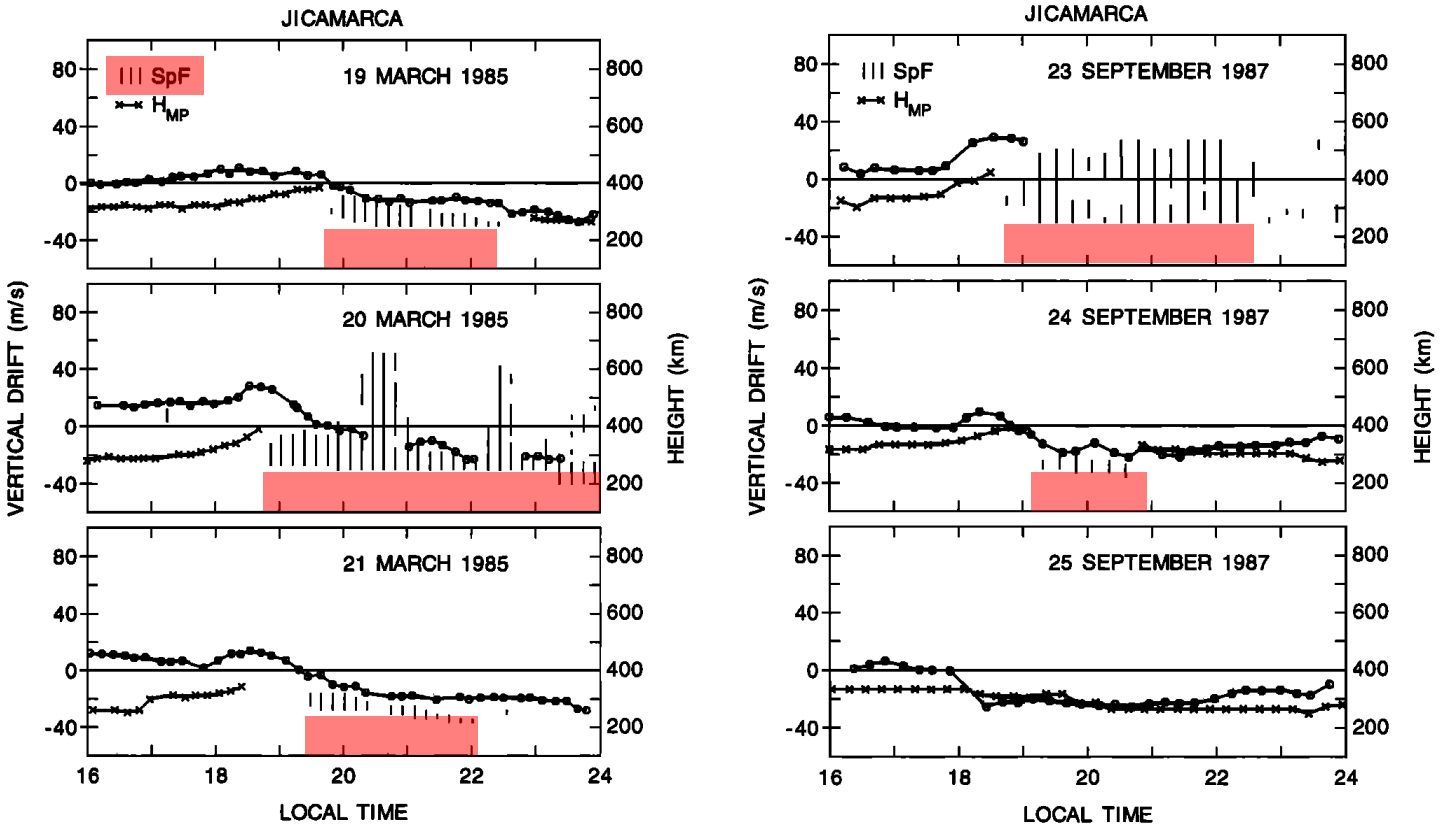
(NAS, 2013)

What is the lower atmosphere contribution to variability of the MTI?



(Chau et al., 2010; Goncharenko et al., 2010)

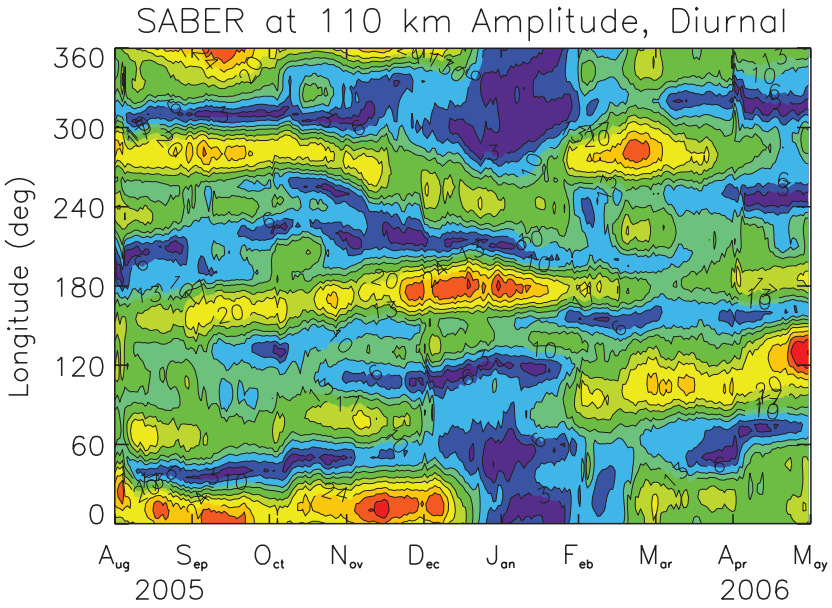
What is the lower atmosphere contribution to variability of the MTI?

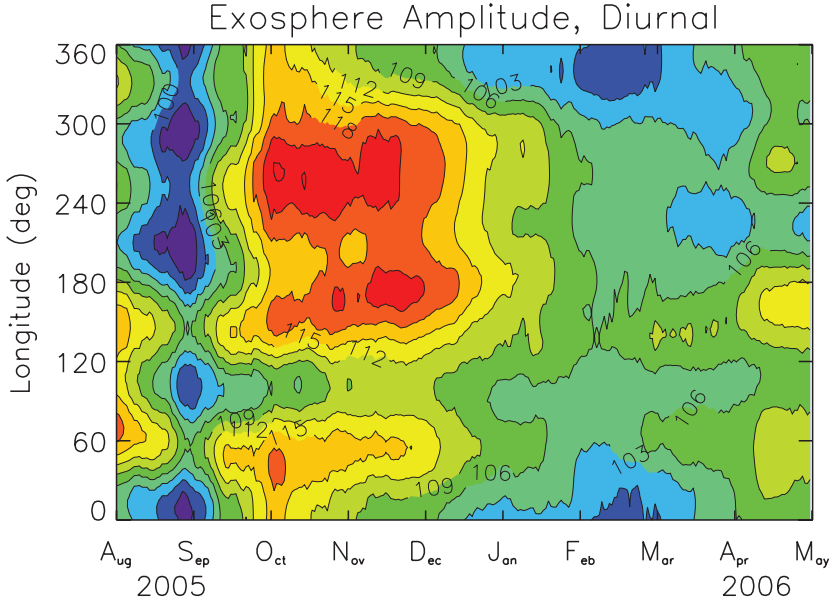


What is the role of the lower atmosphere on the day-to-day variability and seeding of ionosphere irregularities?

(Fejer et al., 1999)

How does the wave spectrum evolve with height?

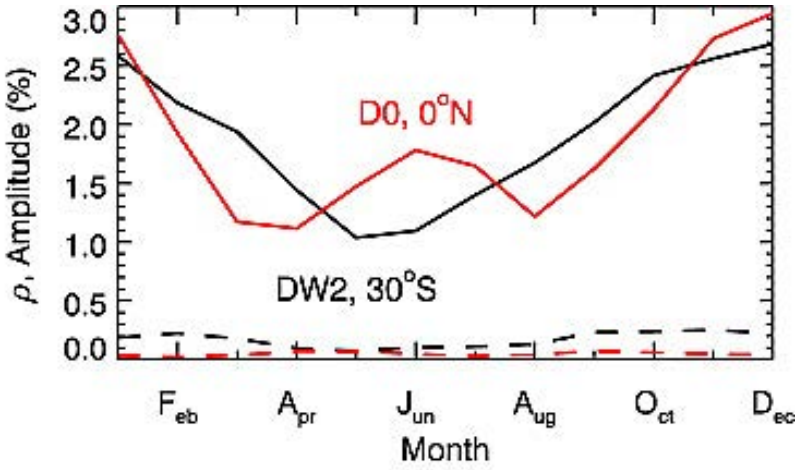


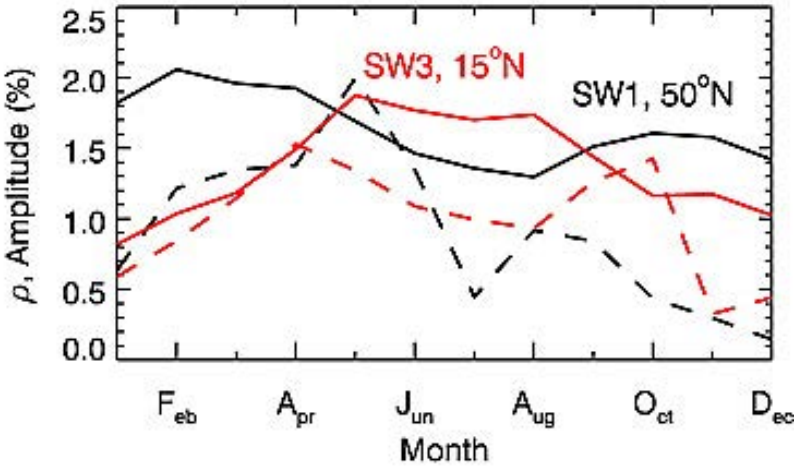


How are waves dissipated and generated in the lower thermosphere where there are few existing observations?

(Forbes et al., 2009)

How does the wave spectrum evolve with height?



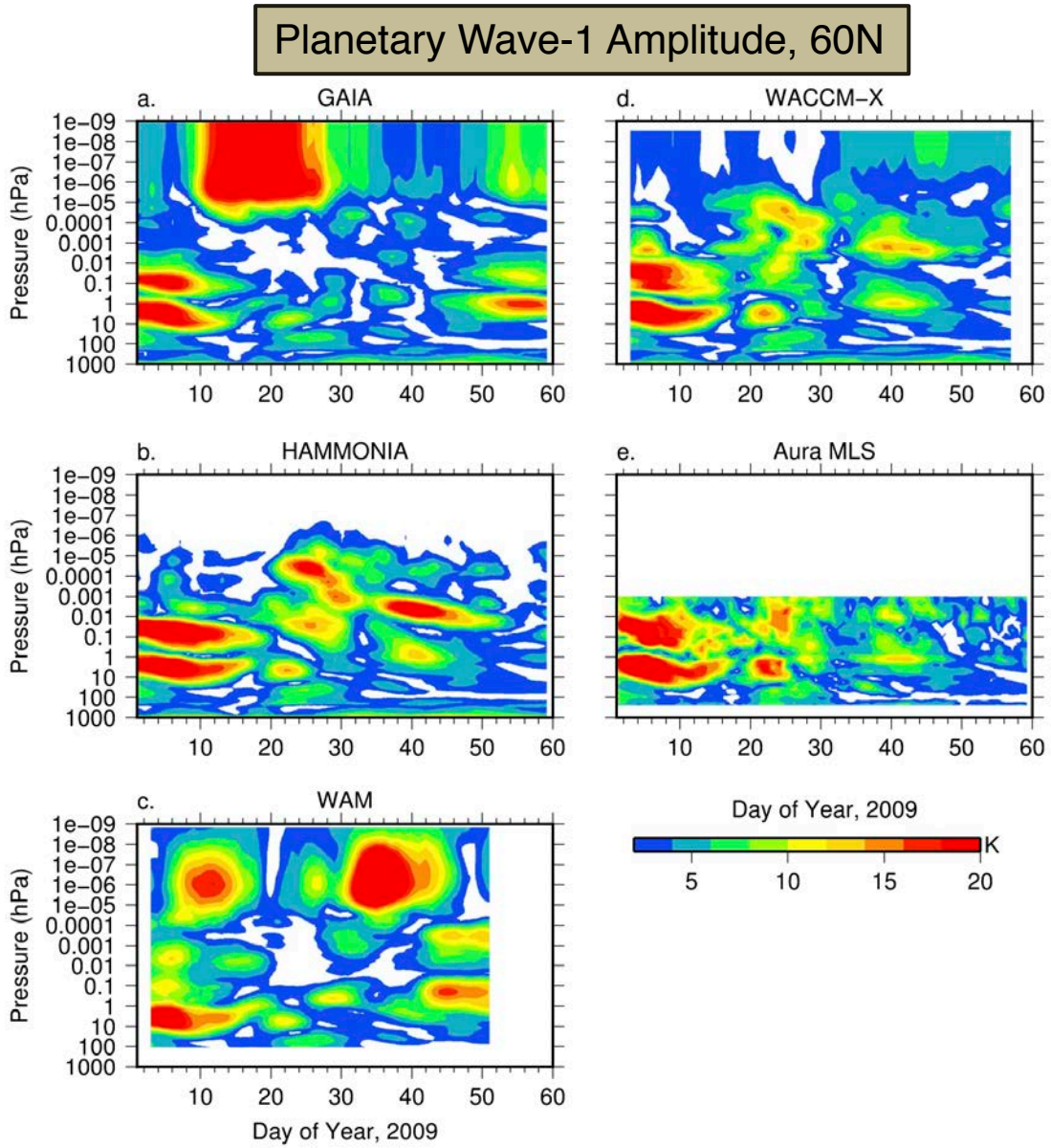


Sold – Observed tide from CHAMP satellite
Dashed – Extension based on observations below 100 km

How are waves dissipated and generated in the lower thermosphere where there are few existing observations?

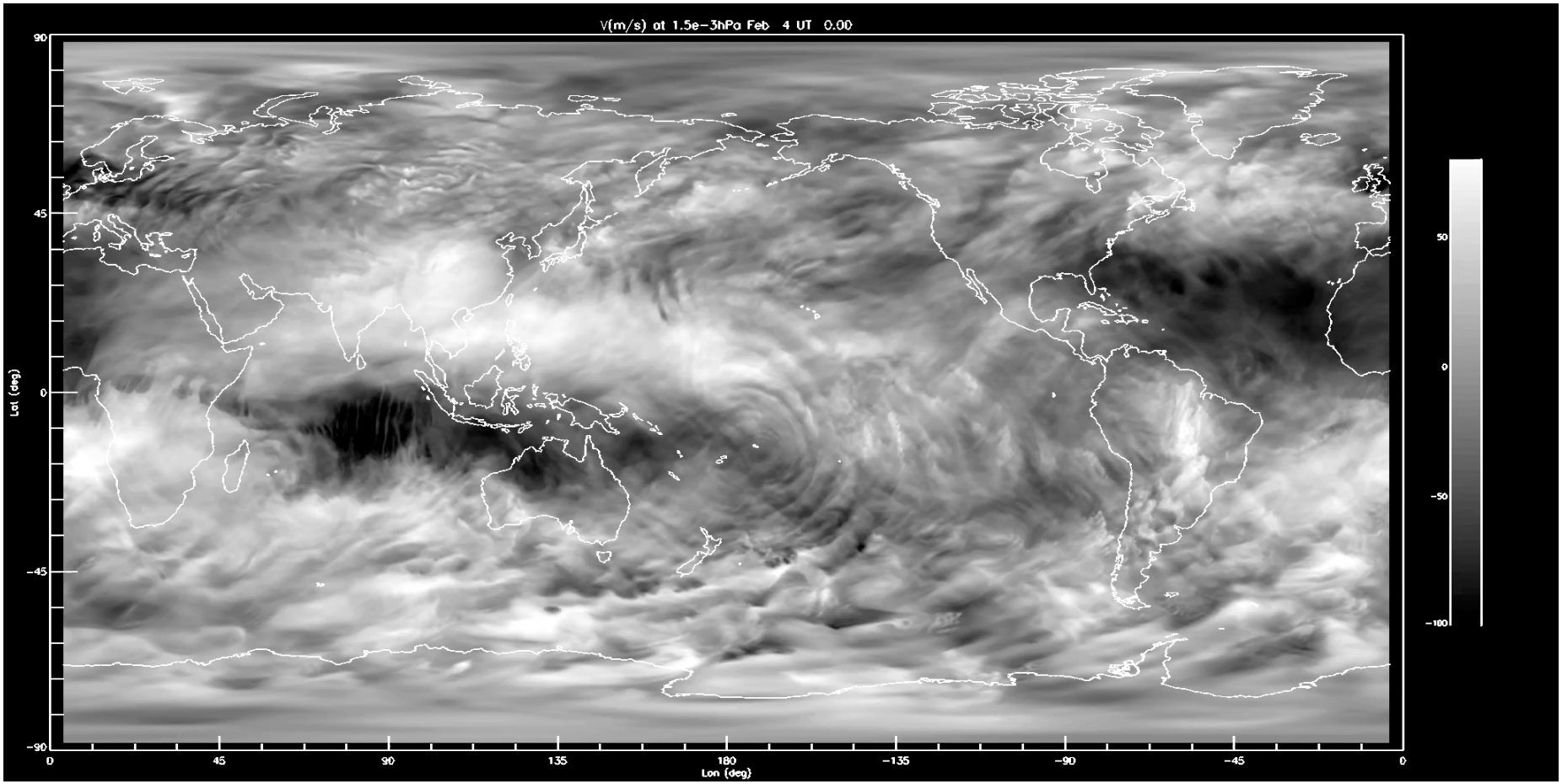
(Oberheide et al., 2011)

How does the wave spectrum evolve with height?



(Pedatella et al., 2014)

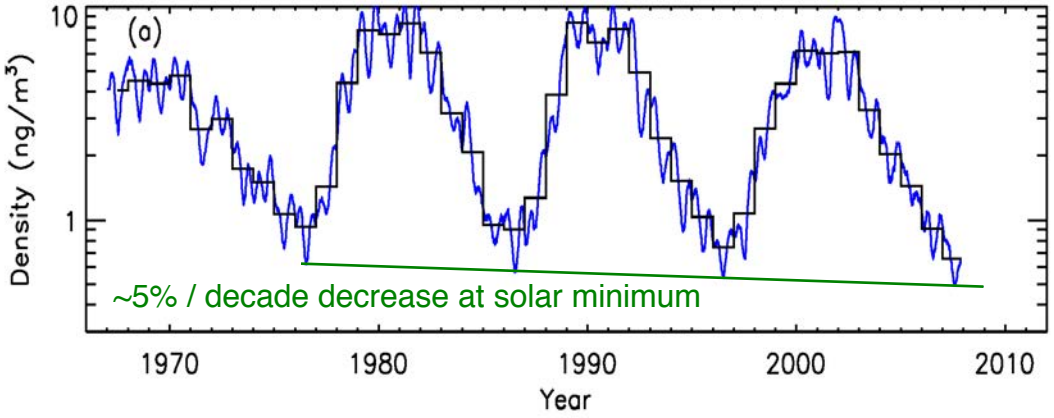
How does the wave spectrum evolve with height?

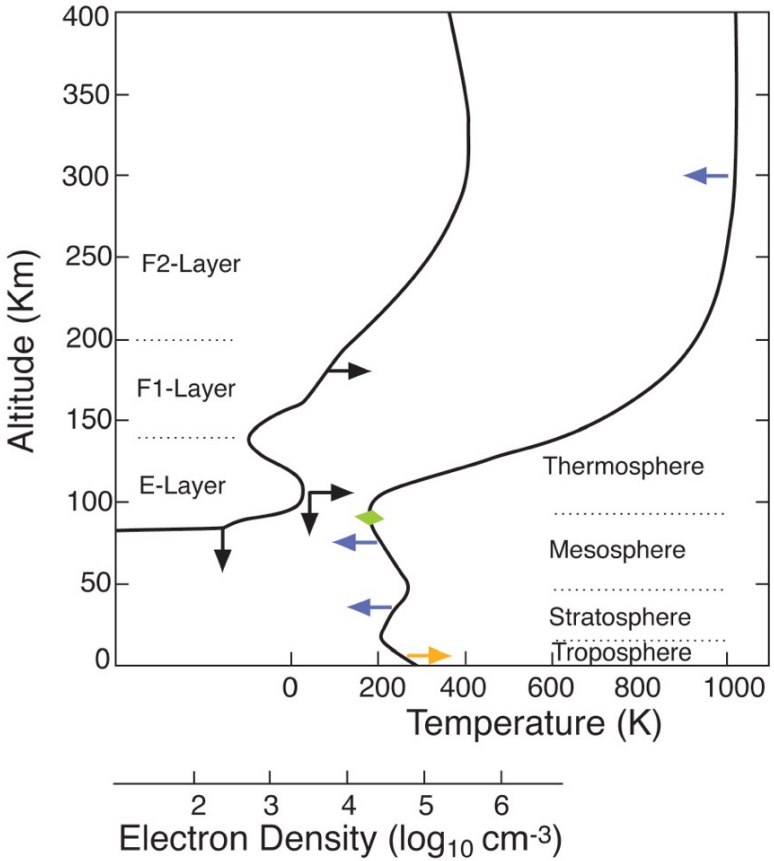


What is the interaction between small-scales (gravity waves) and large-scales (tides and planetary waves)?

(Liu et al., 2014)

What are the drivers of long-term changes in the MIT?





How do anthropogenic, geomagnetic field, and solar variability contribute to long-term variability in the MTI?

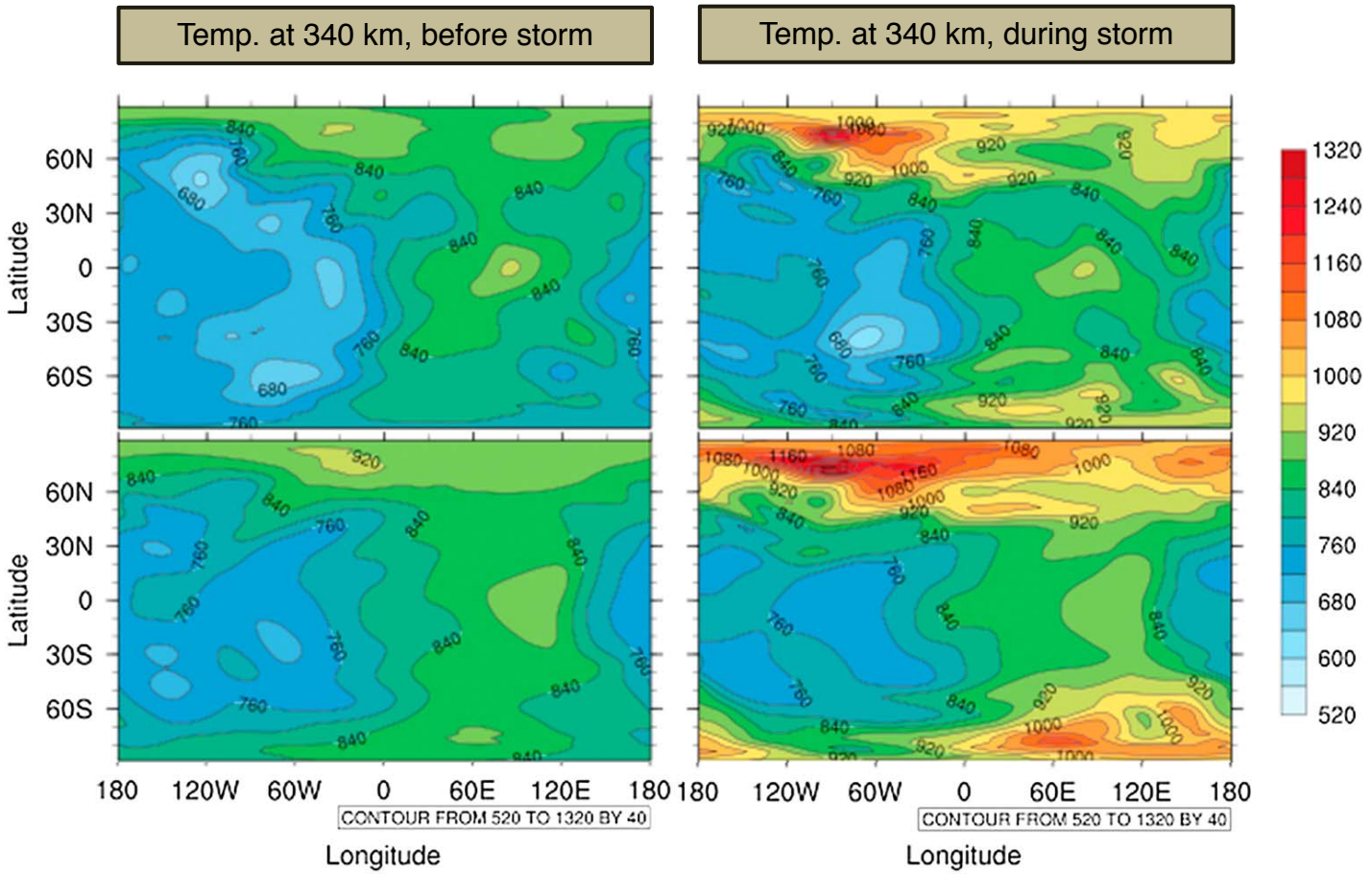
What influence do long-term trends have on the MTI response to geomagnetic/solar and lower atmospheric variability?

(Courtesy of Stan Solomon)

What is the interaction between lower atmosphere variability and geomagnetic/solar variability?

Realistic Lower Atmosphere

Climatological Lower Atmosphere



(Hagan et al., 2015)

The growing number of geospace observations

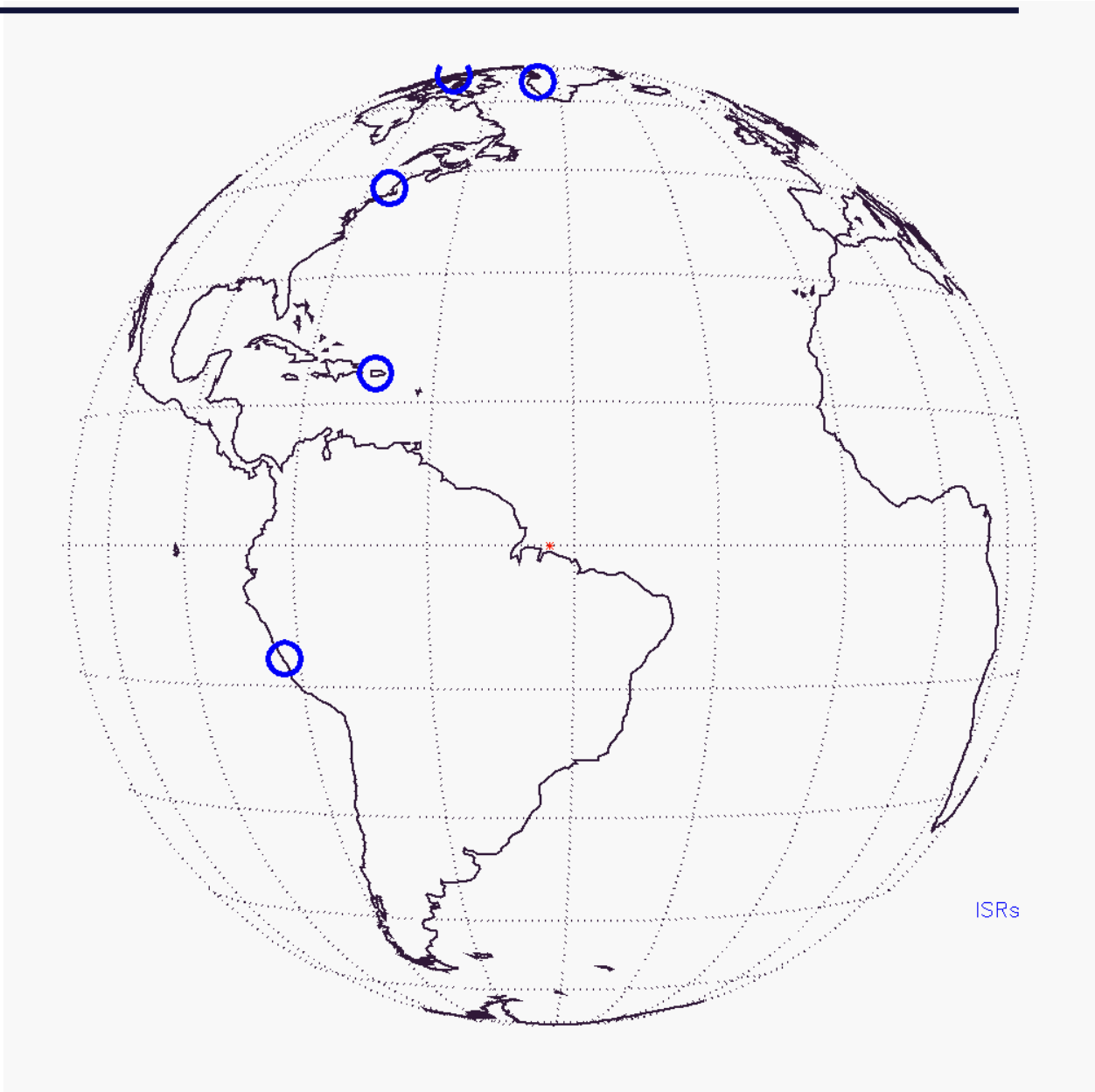
Current and upcoming satellite missions:

- GOLD (data since Oct. 2018)
- COSMIC-2 (launch June 24, 2019)
- ICON (launch TBD)
- TIMED, Swarm, DMSP, …

Ground-based observations:

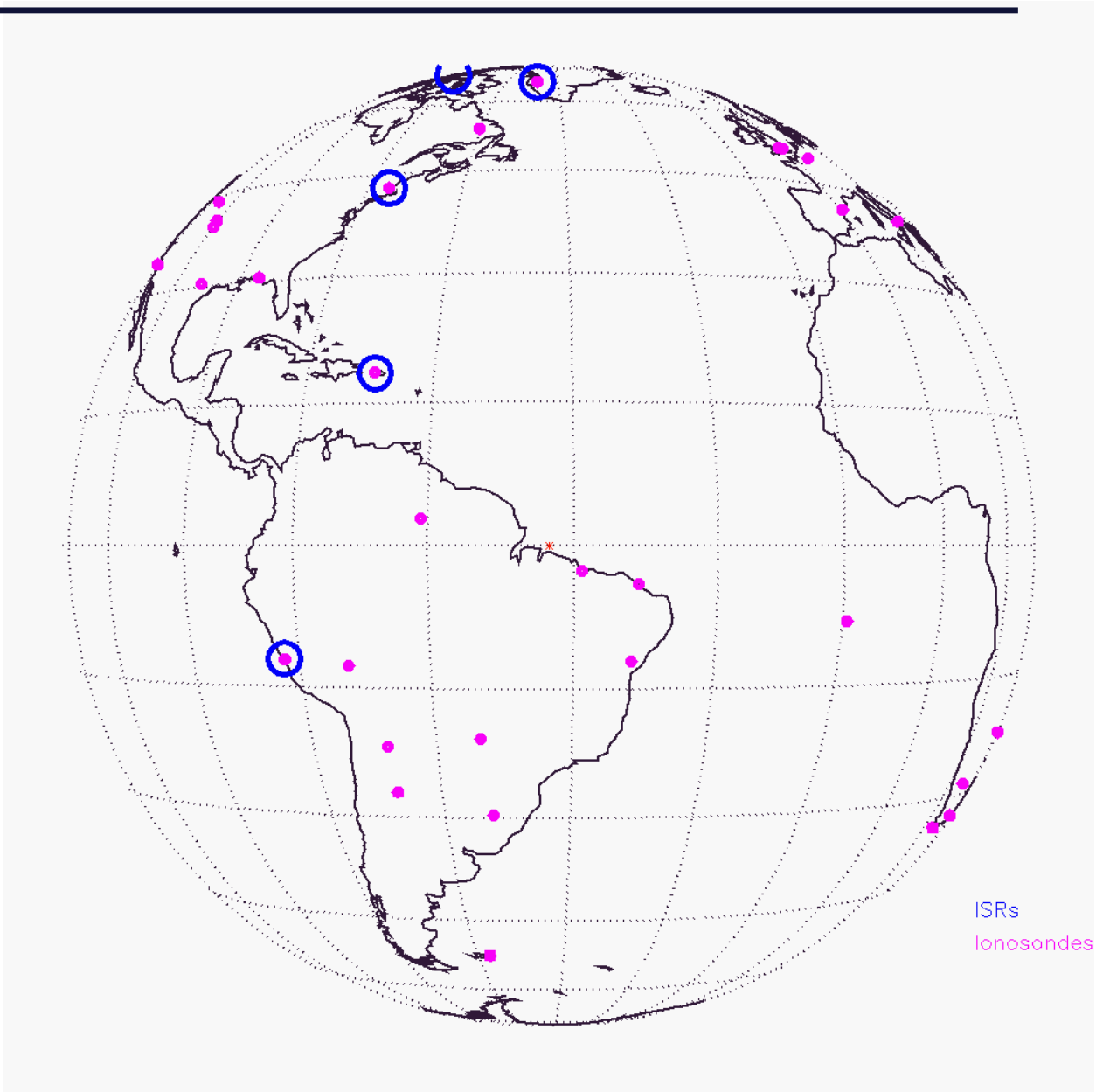
- SuperDARN
- Incoherent Scatter Radars
- GPS total electron content (TEC)
- Auroral Imagers
- Lidar
- Radars
- Fabry-Perot Interferometers
- …

The growing number of geospace observations



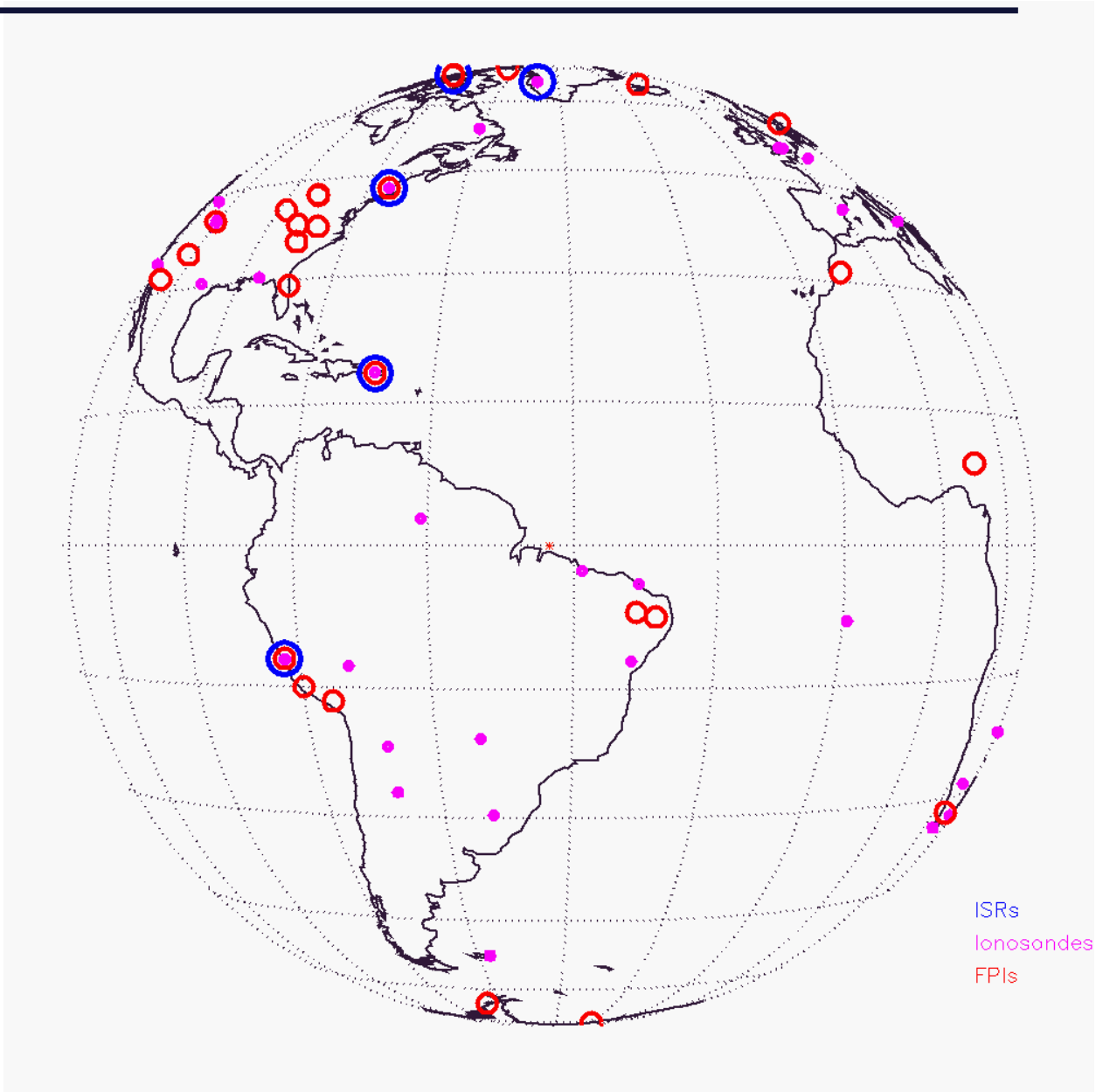
(Stan Solomon)

The growing number of geospace observations



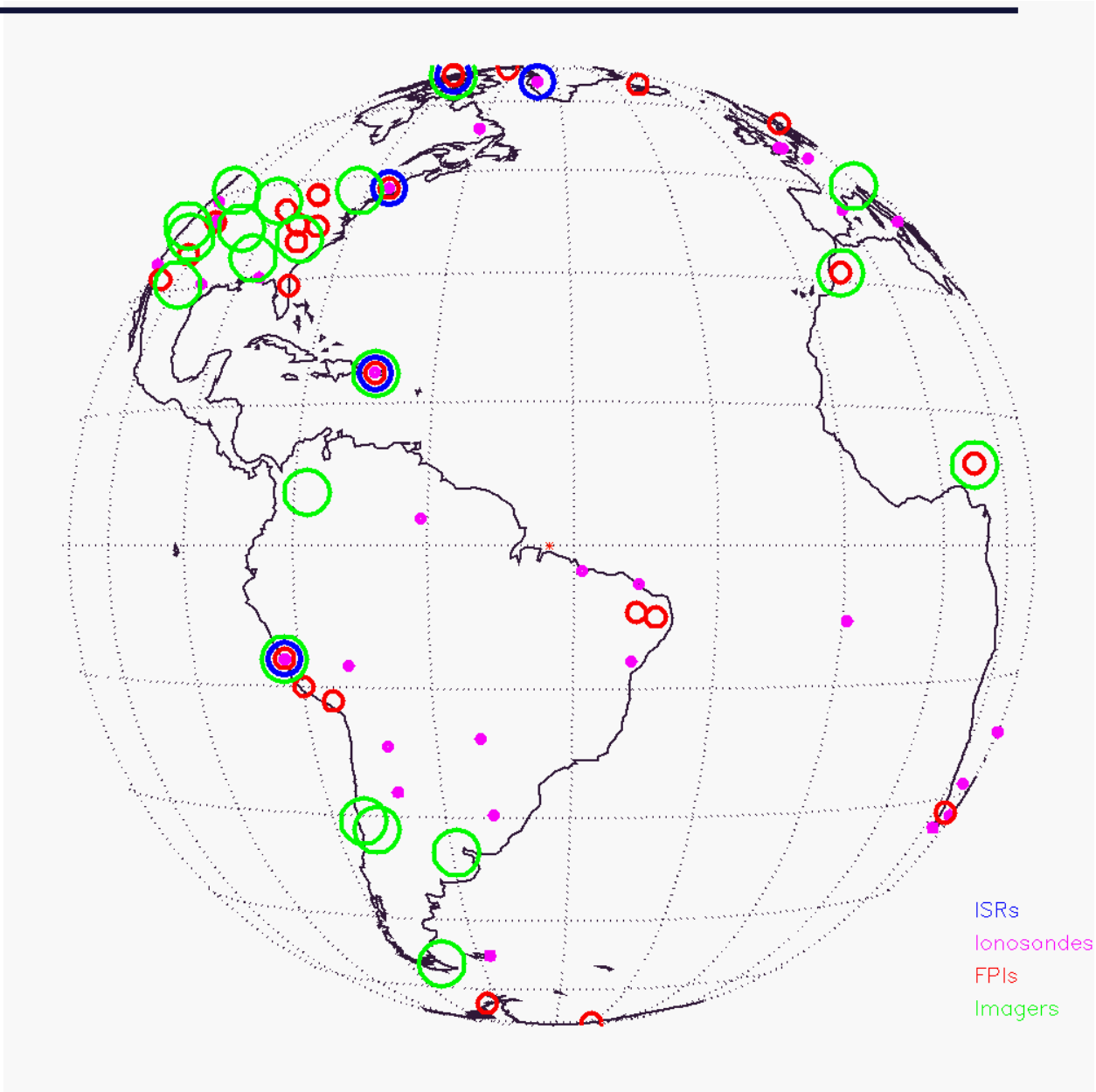
(Stan Solomon)

The growing number of geospace observations



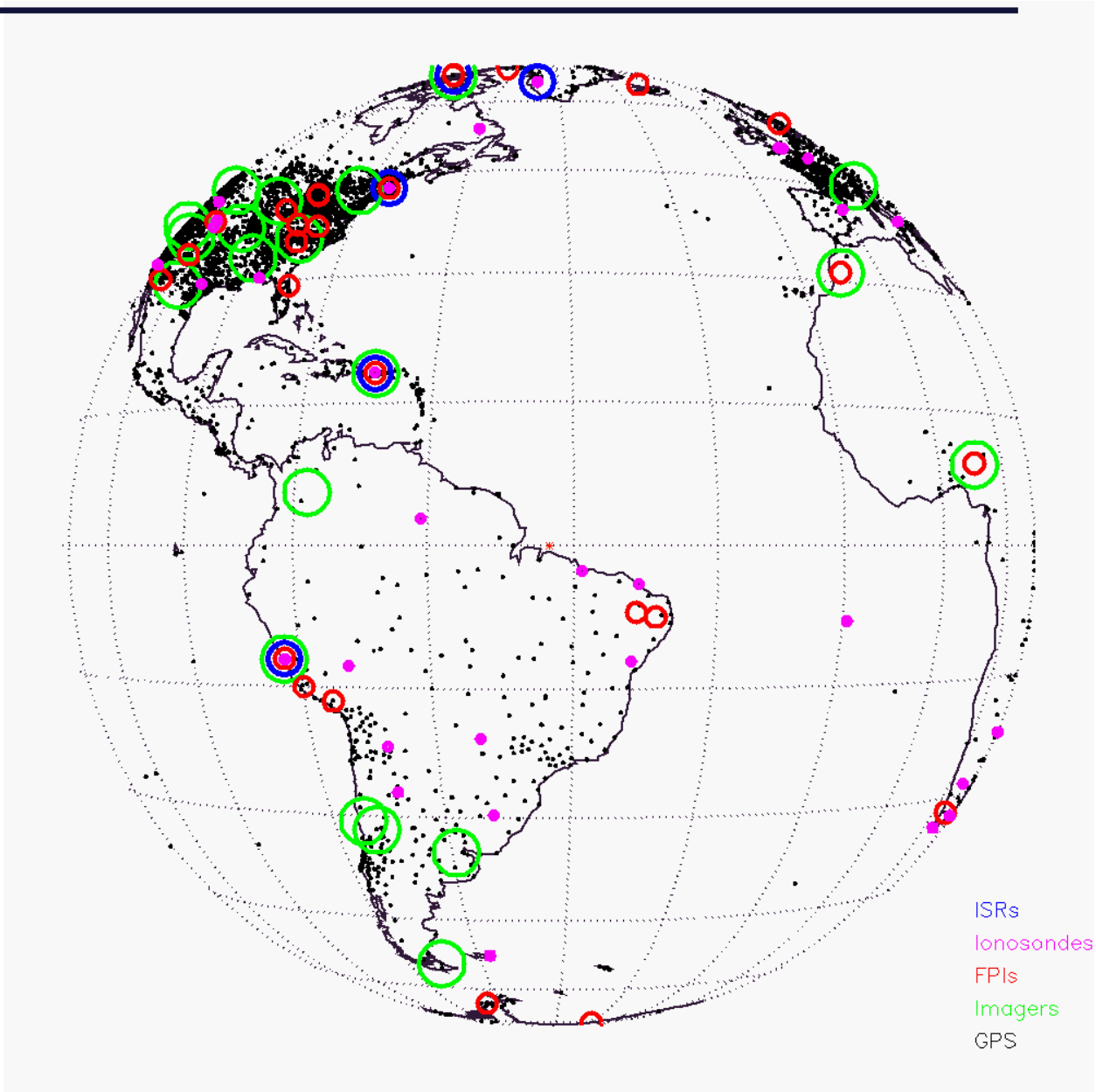
(Stan Solomon)

The growing number of geospace observations



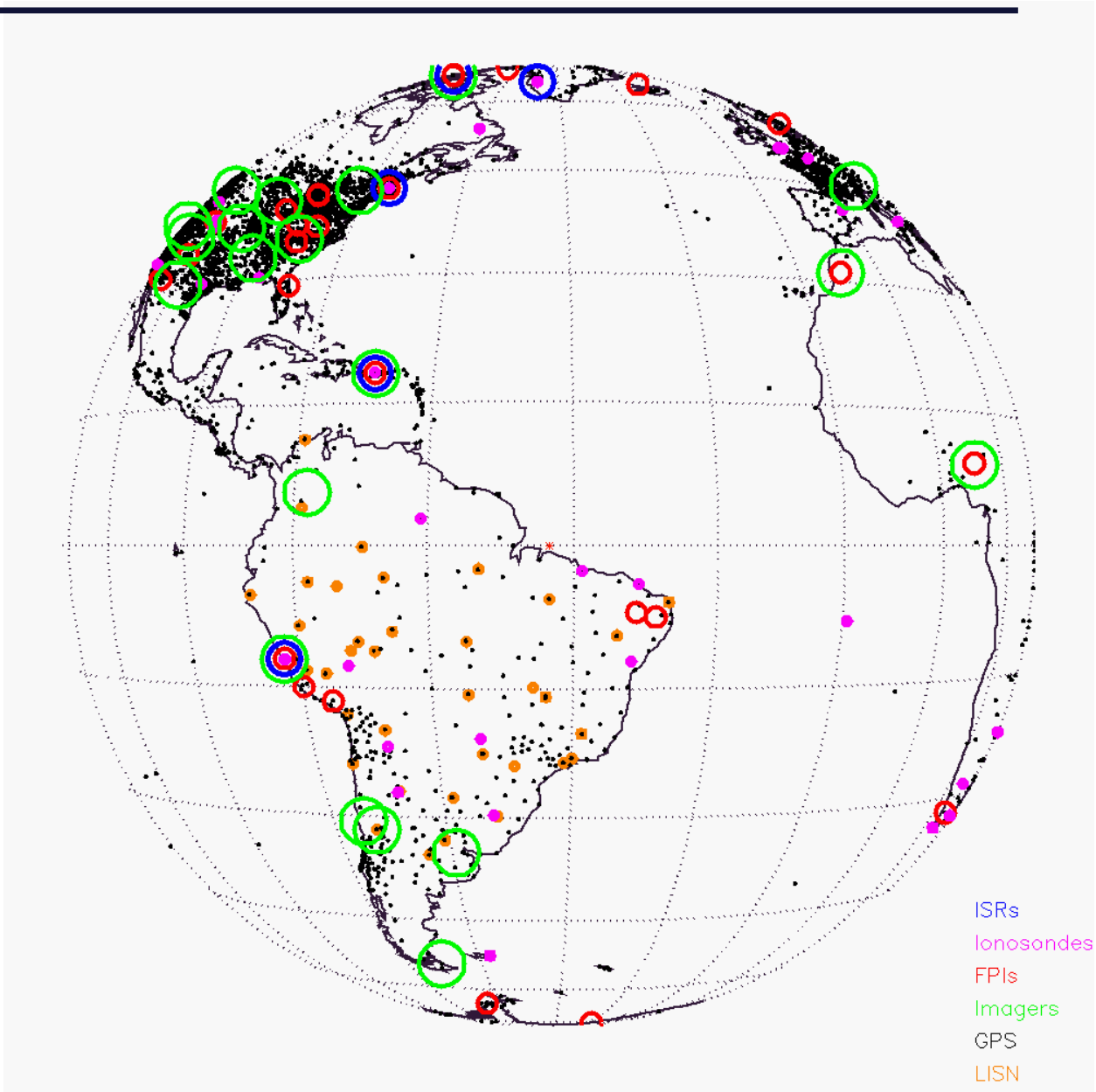
(Stan Solomon)

The growing number of geospace observations



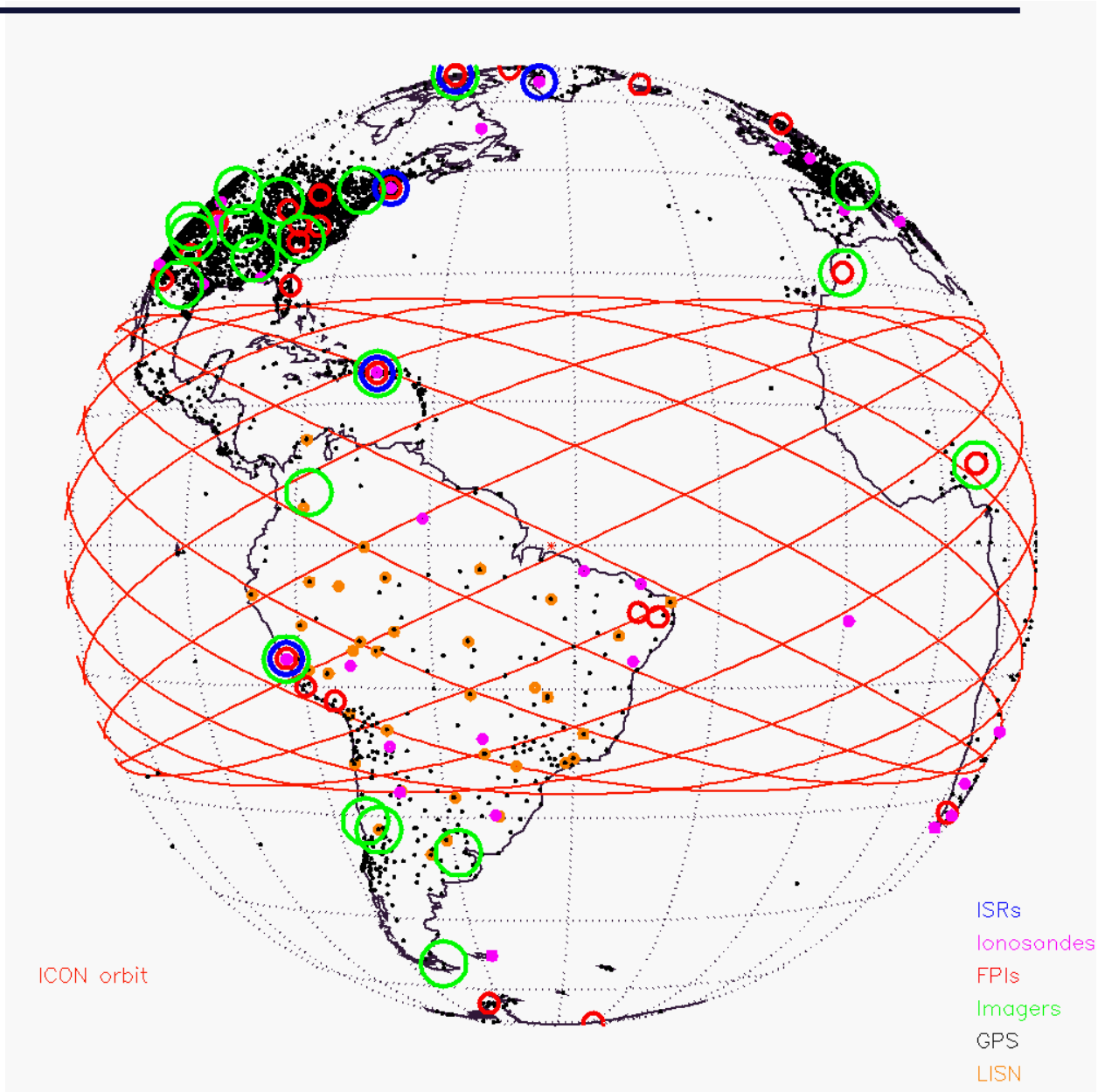
(Stan Solomon)

The growing number of geospace observations



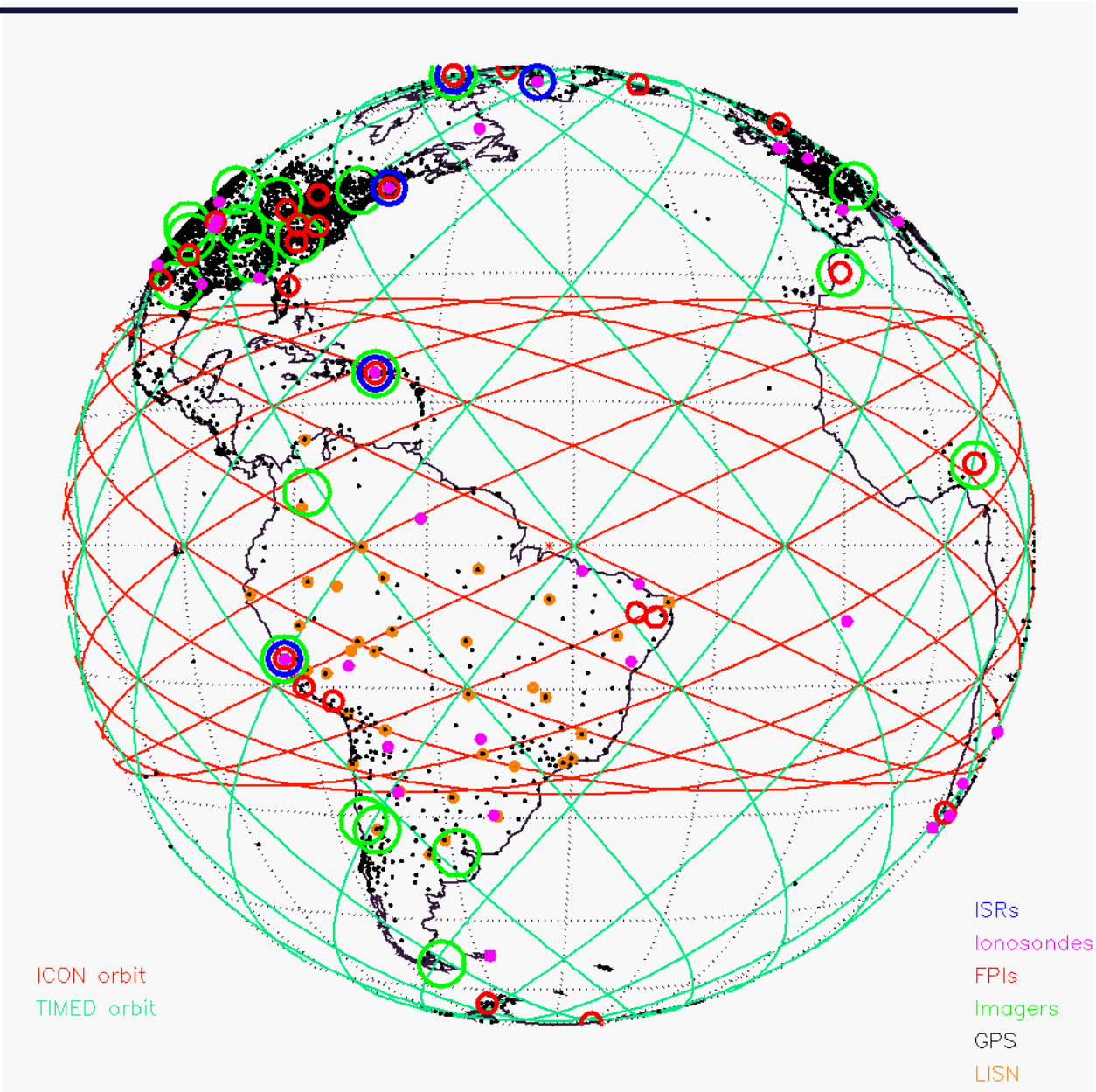
(Stan Solomon)

The growing number of geospace observations



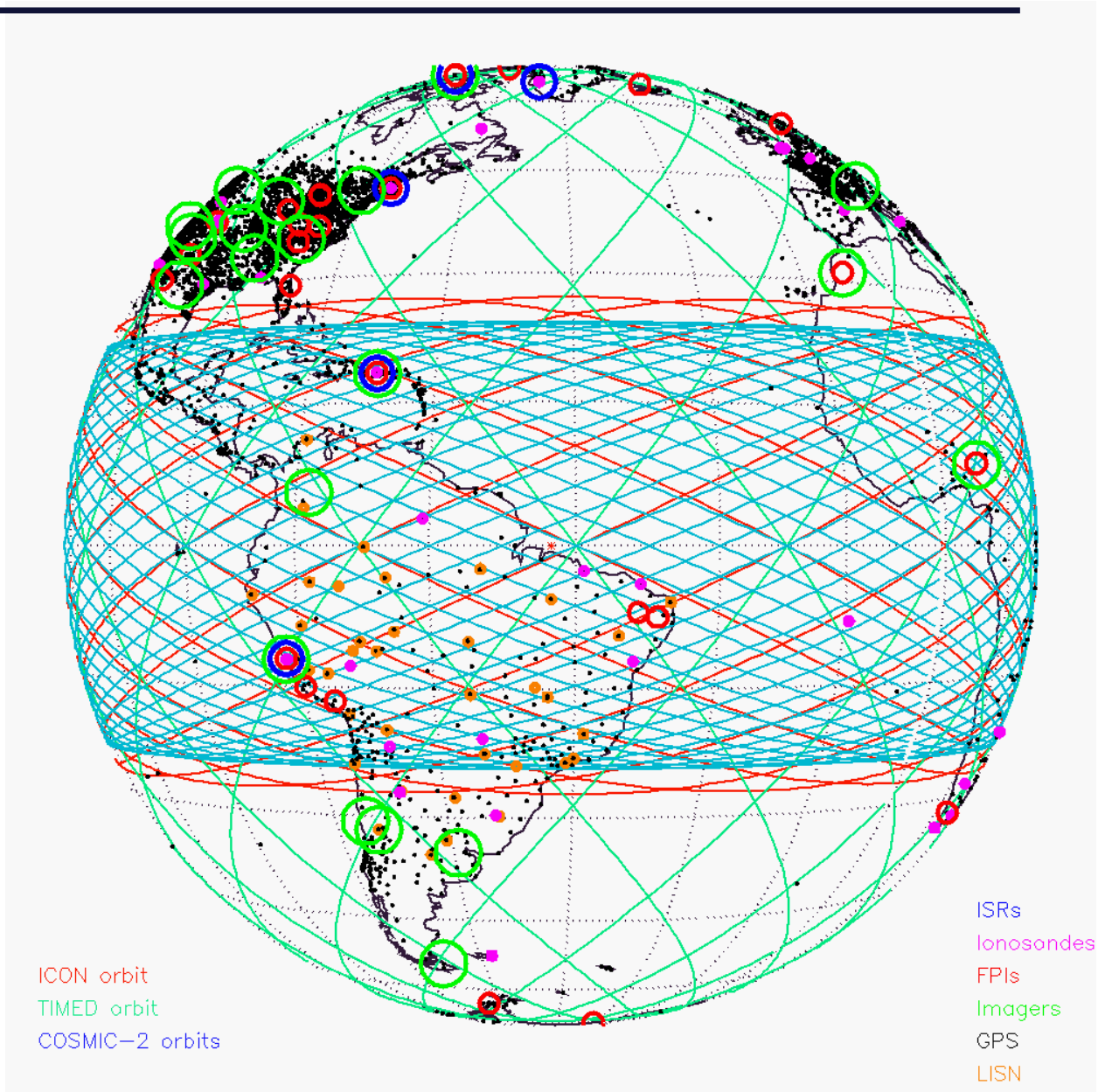
(Stan Solomon)

The growing number of geospace observations



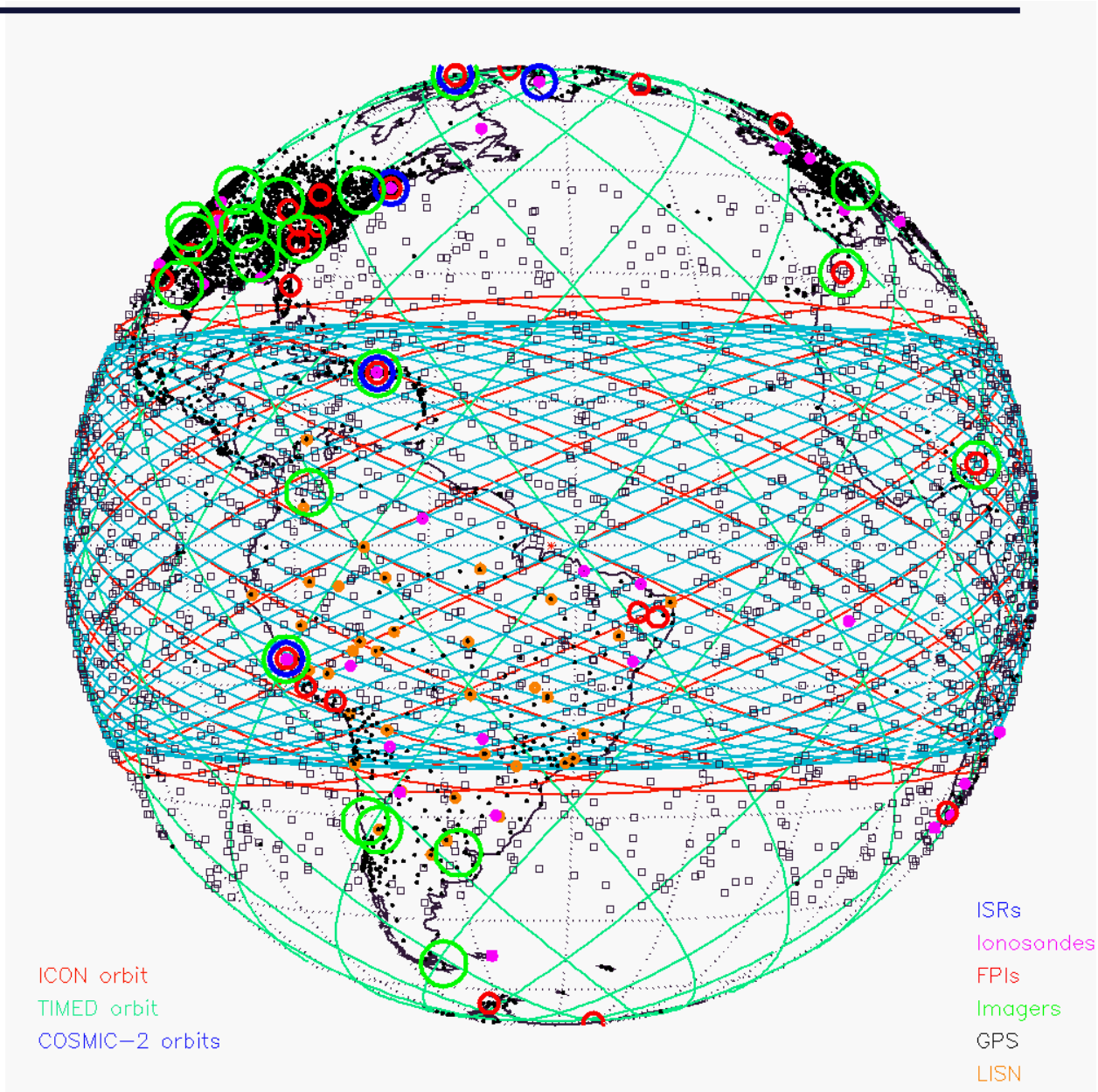
(Stan Solomon)

The growing number of geospace observations



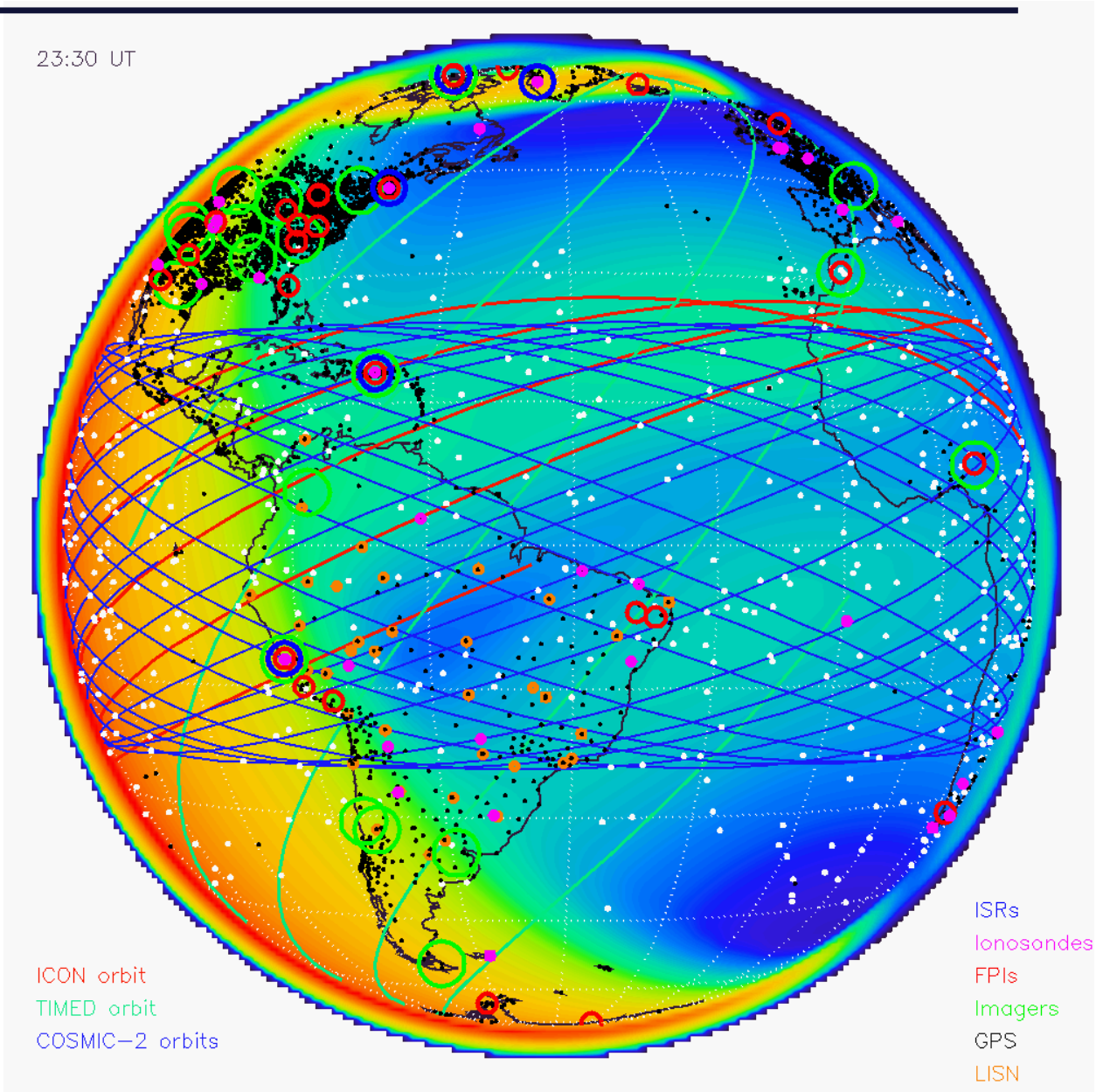
(Stan Solomon)

The growing number of geospace observations



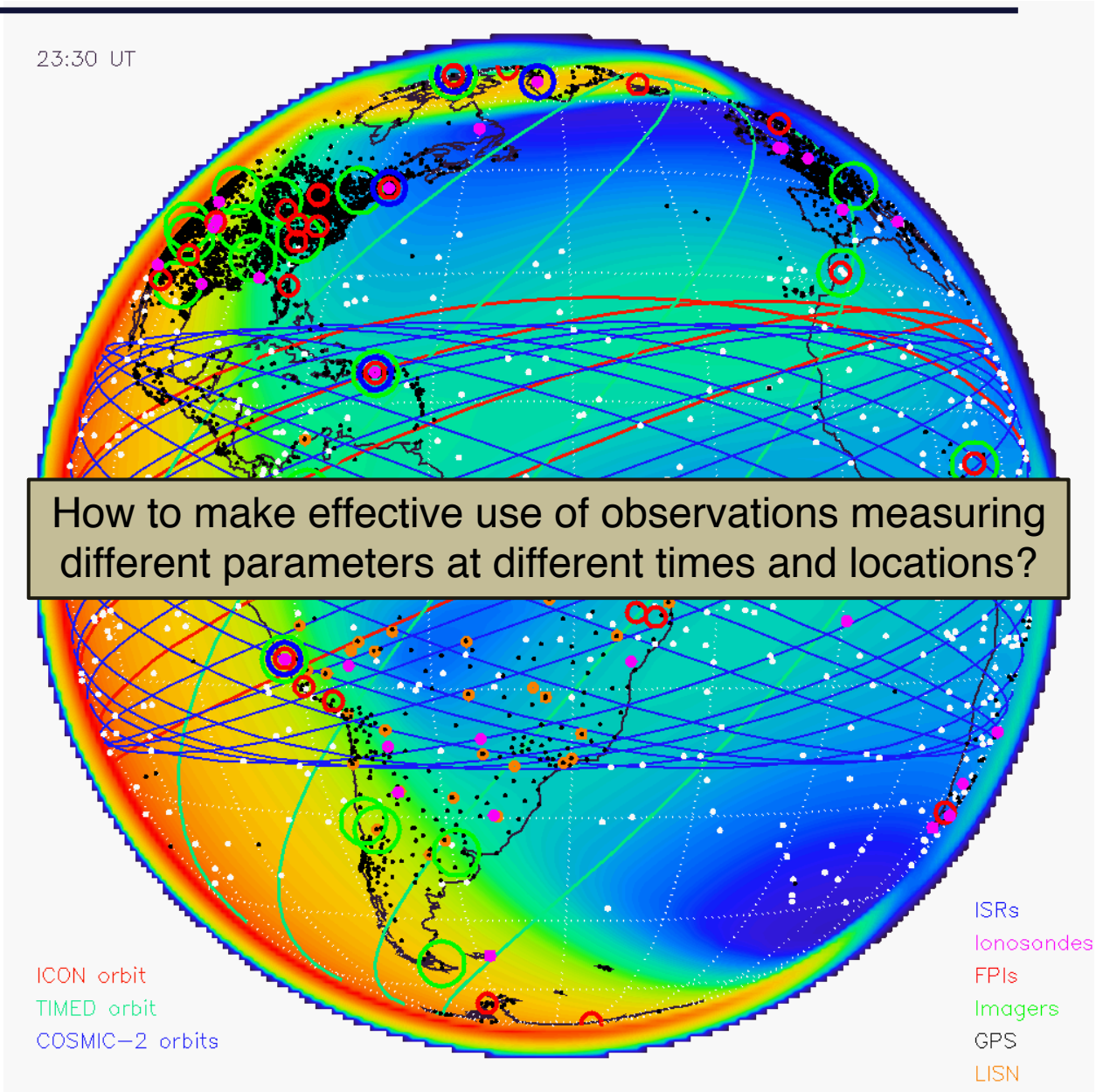
(Stan Solomon)

The growing number of geospace observations



(Stan Solomon)

The growing number of geospace observations



How to make effective use of observations measuring different parameters at different times and locations?

(Stan Solomon)