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Radiation Belt Storm Probes (RBSP): Partnerships with Other Missions

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NASA/GSFC

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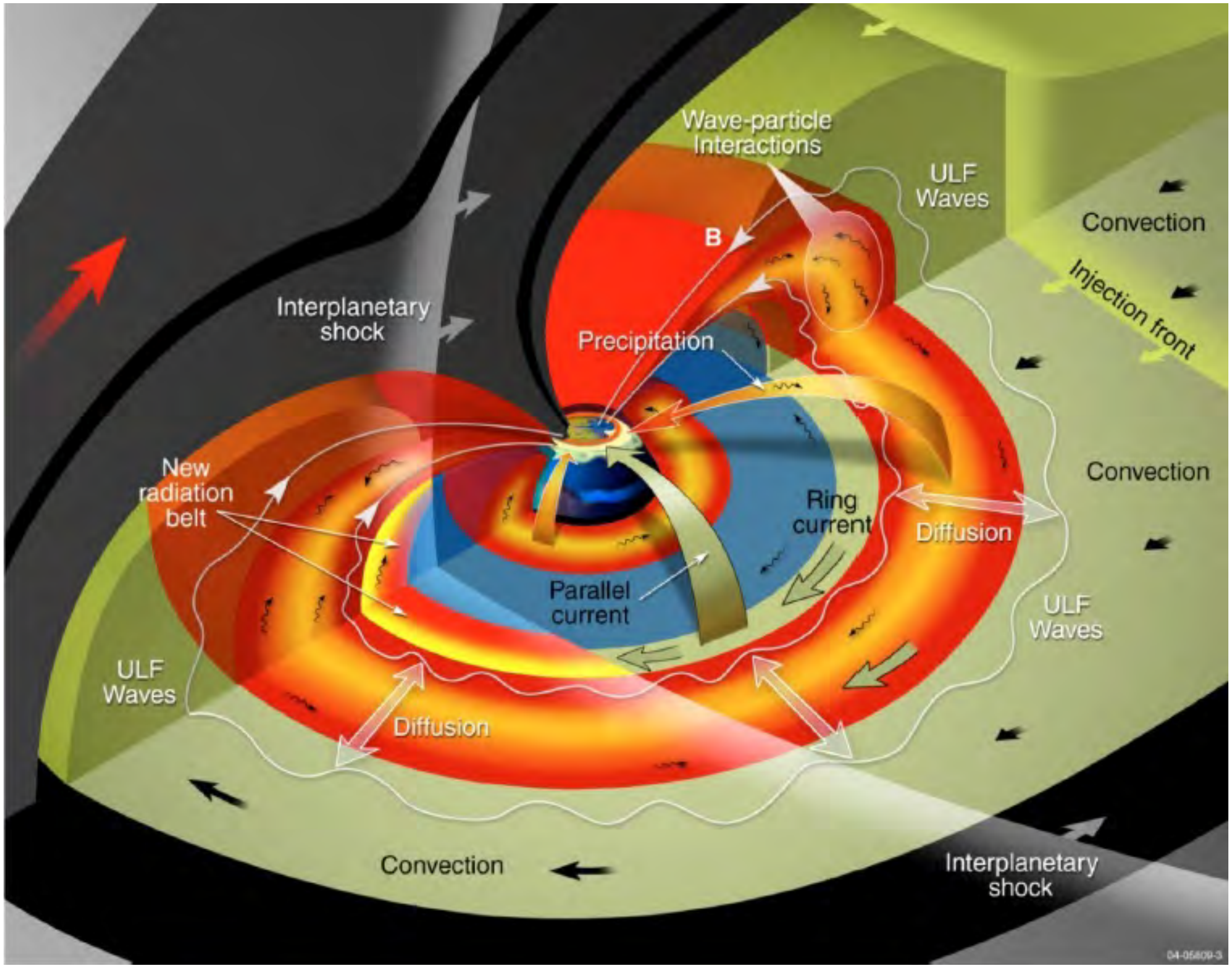
JHU/APL



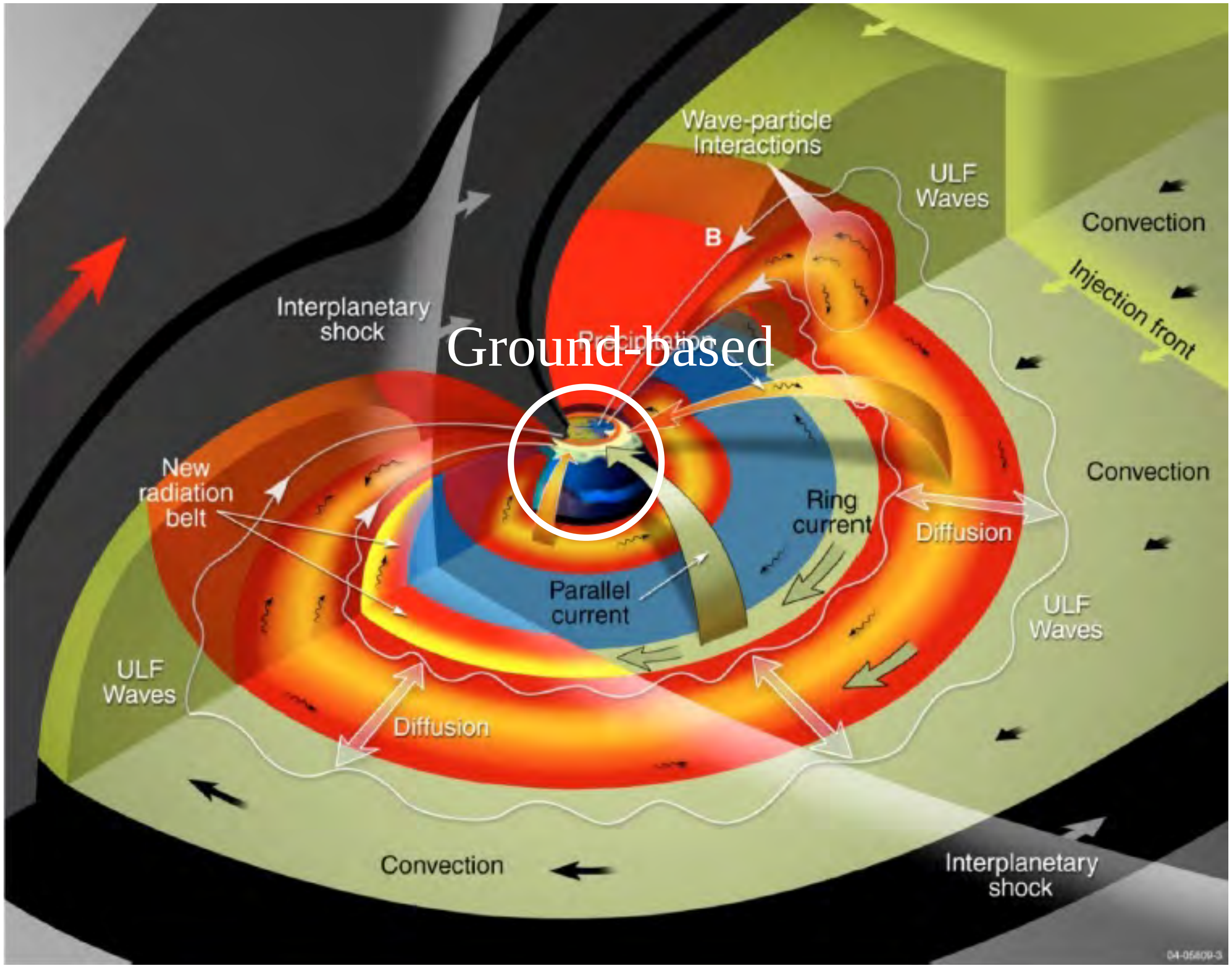
Many processes sculpt the inner magnetosphere:
Correlative studies help quantify their importance

RBSP Science Questions

- Which physical processes produce radiation belt enhancement events?
- What are the dominant mechanisms for relativistic electron loss?
- How do ring current and other geomagnetic processes affect radiation belt behavior?

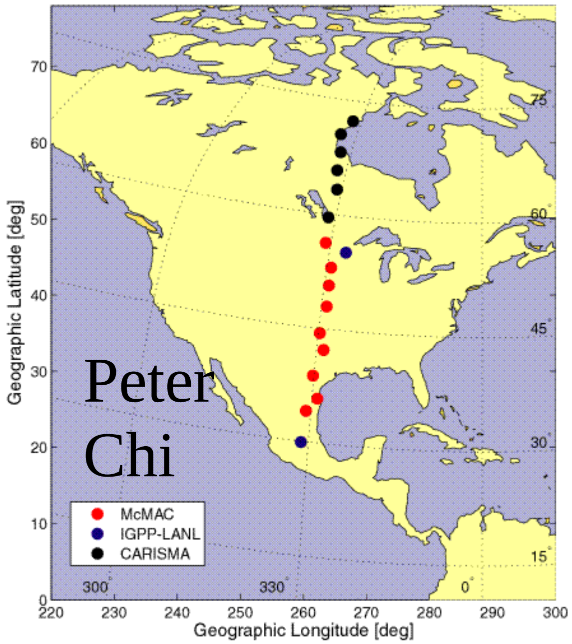
Correlative Measurements for RBSP

- Ground-based
- Balloons
- Low-altitude spacecraft
- High-altitude spacecraft

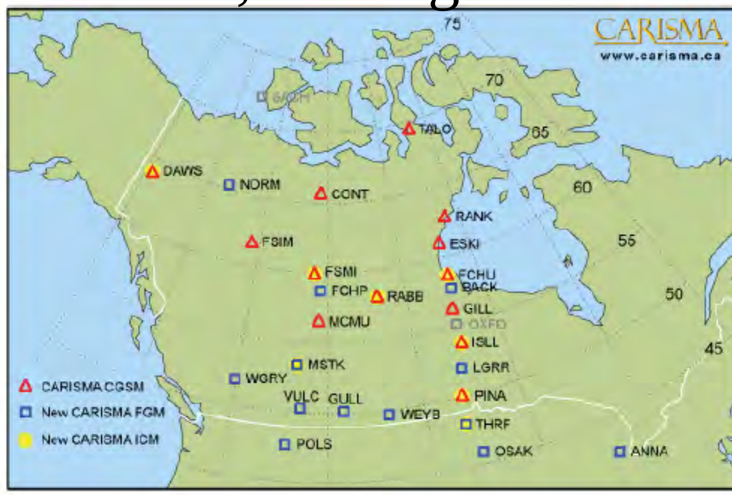


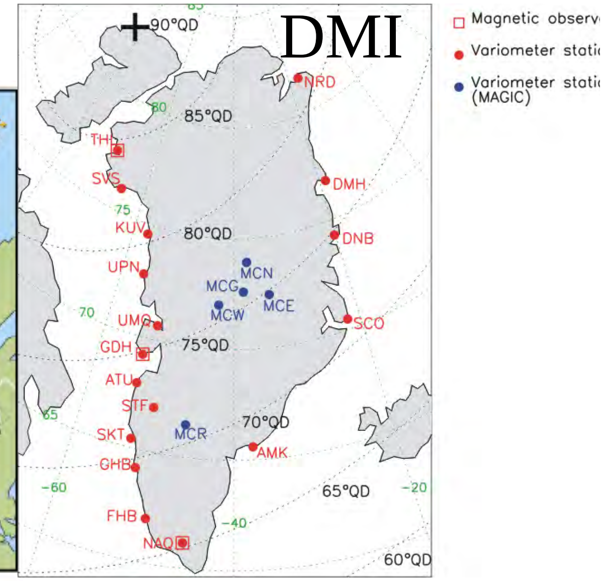
Ground-based observations at the footprints of magnetospheric magnetic field lines

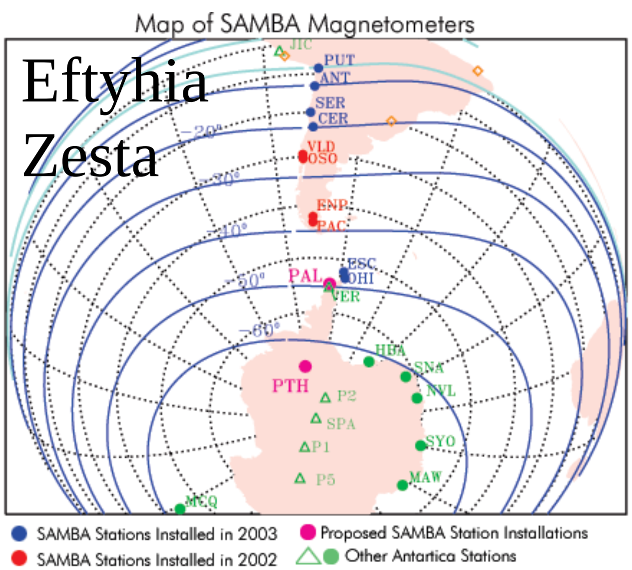
Extensive Ground Magnetometer Coverage

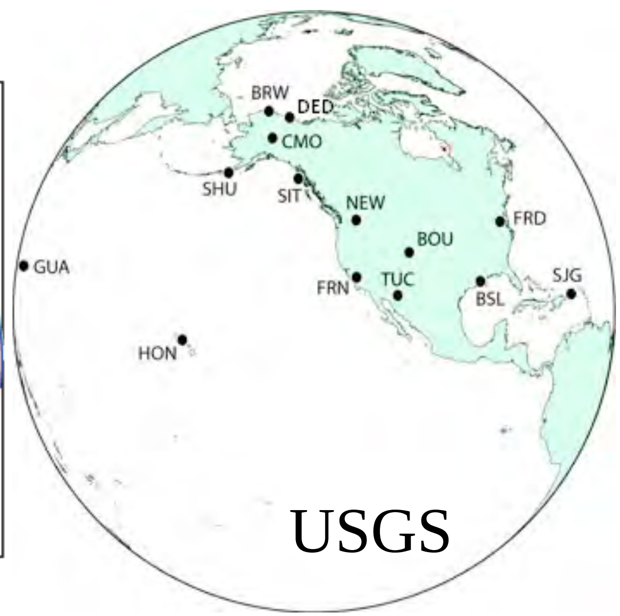


I. Mann, M. Engebretson





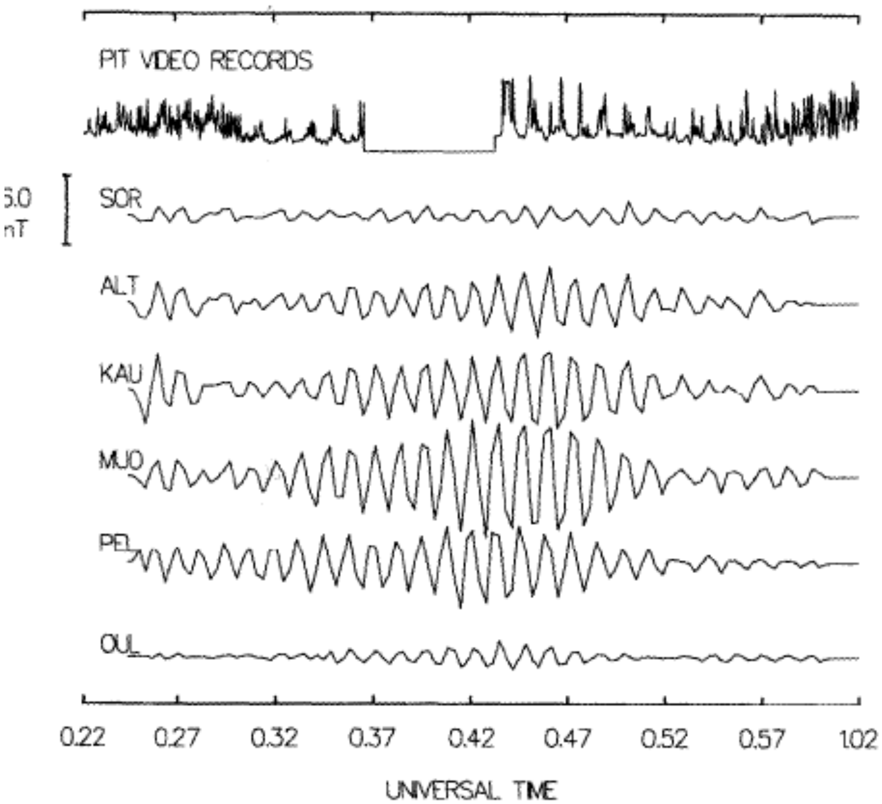




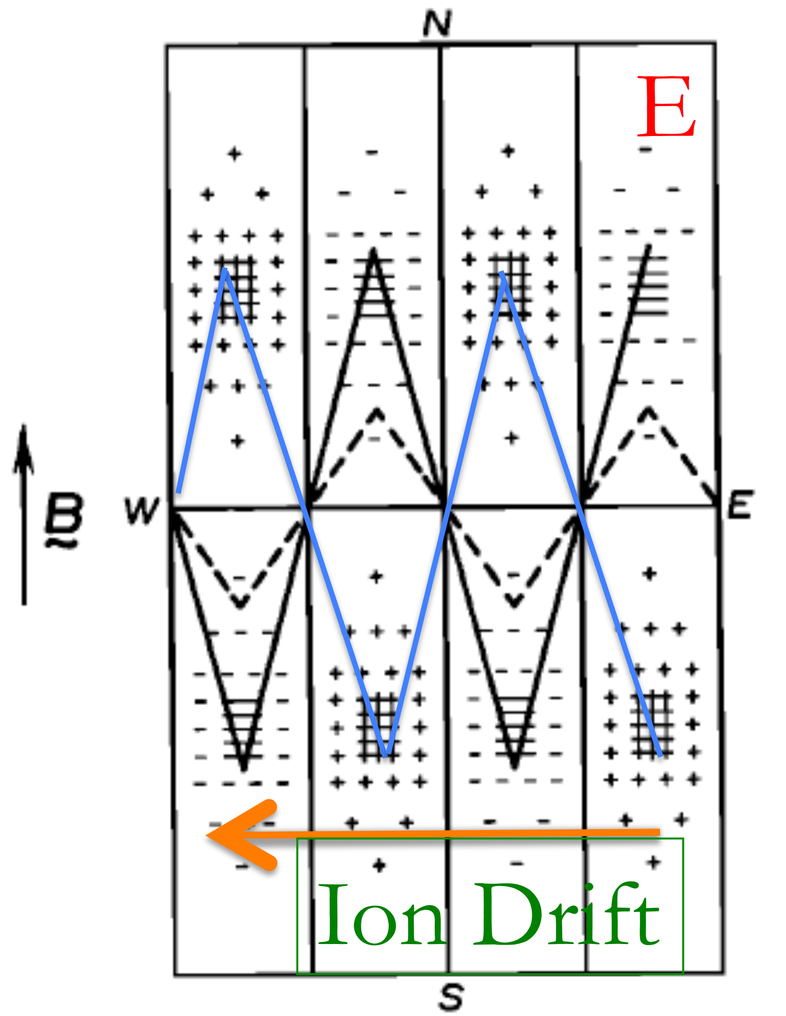
1. Pc pulsation power
2. Substorm onset
3. Magnetoseismology
   Use pairs of stations
   to determine
   msphere densities

Poloidal Pulsations:
Symmetric low ‘m’ scatter, energize electrons
Antisymmetric high ‘m’ energize ions

Chisham et al. [1990]



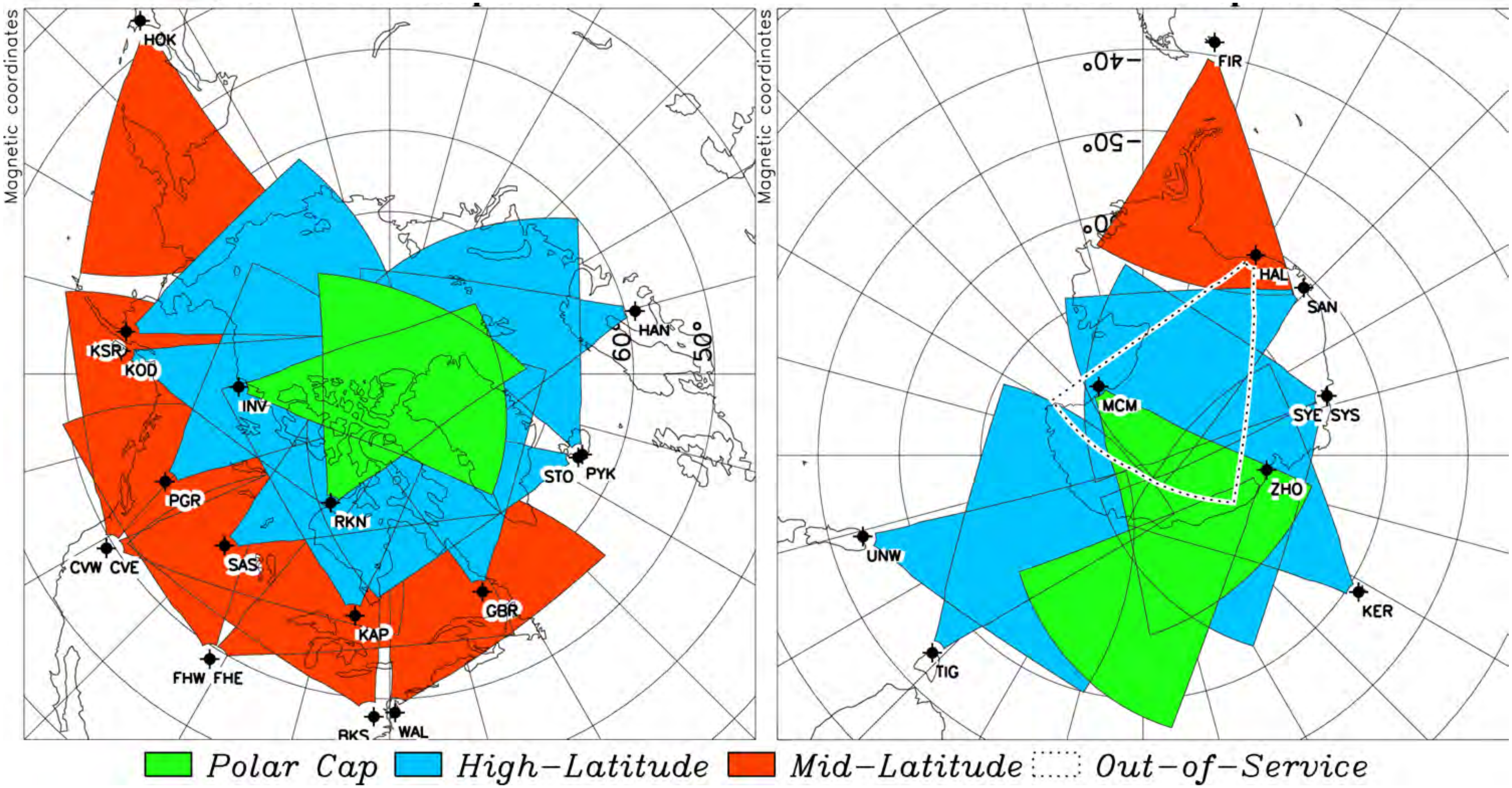
Southwood and Kivelson [1982]



$m = 2\pi R/\lambda$, where R = radius,
λ = wavelength

SuperDARN Radar Convection Patterns Provide Global Context for RBSP Electric Field Measurements

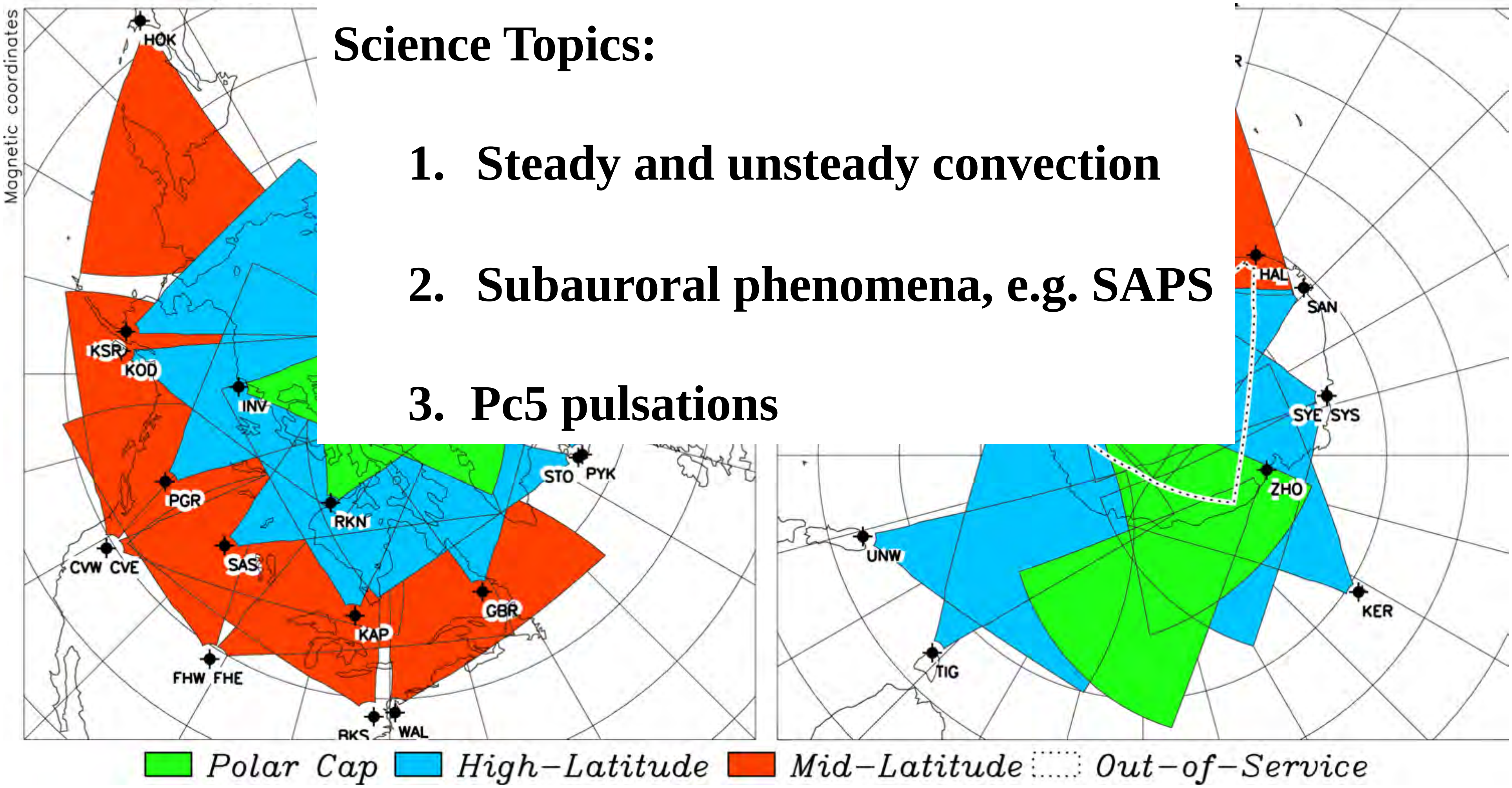
Arctic Antarctic



Elsayeed Talaat

SuperDARN Radar Convection Patterns Provide Global Context for RBSP Electric Field Measurements

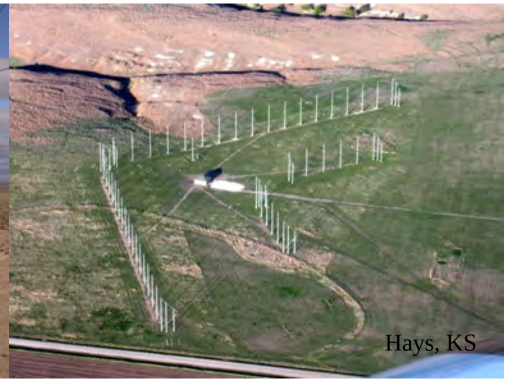
Arctic | Antarctic



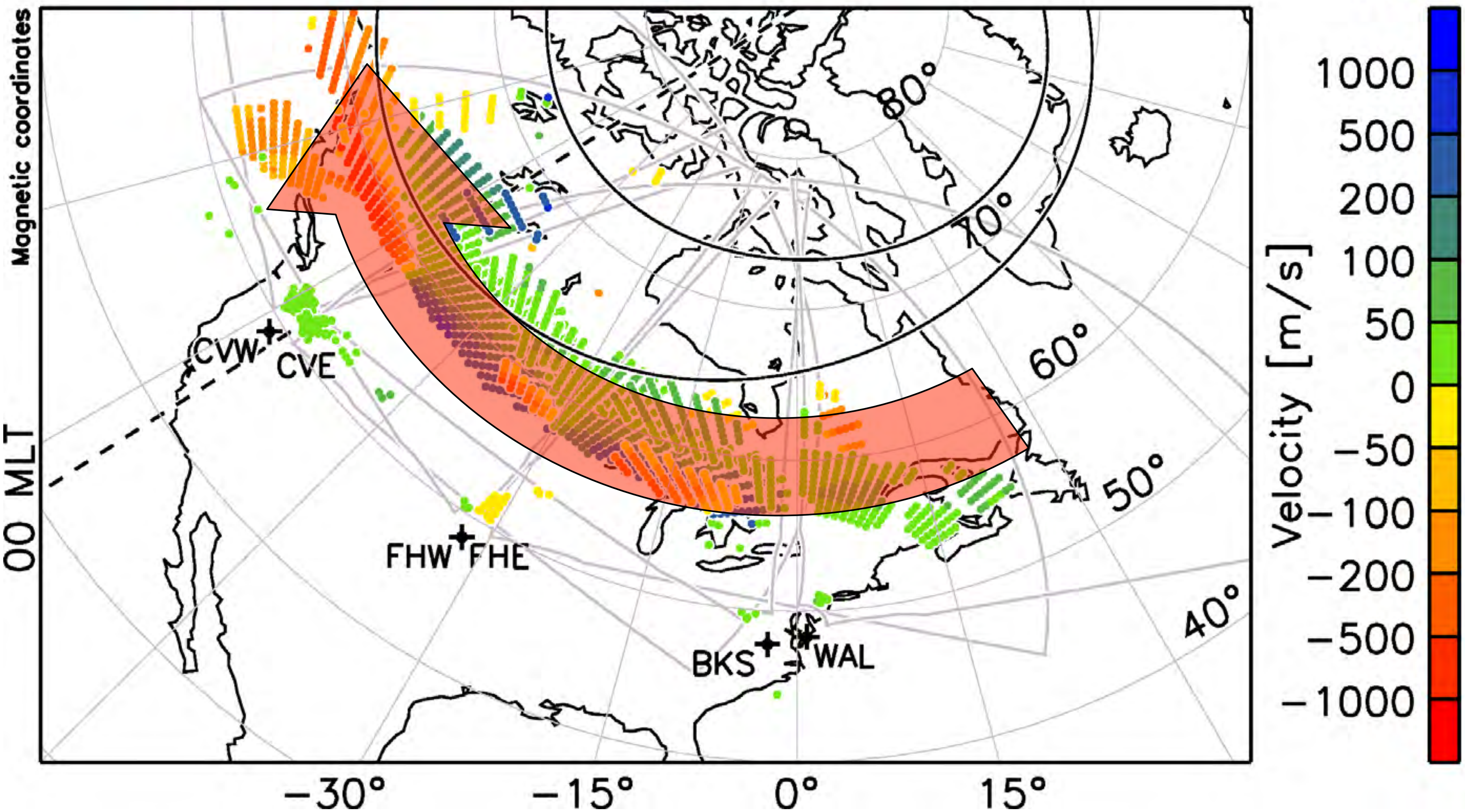
Science Topics:

1. **Steady and unsteady convection**
2. **Subauroral phenomena, e.g. SAPS**
3. **Pc5 pulsations**

Elsayeed Talaat



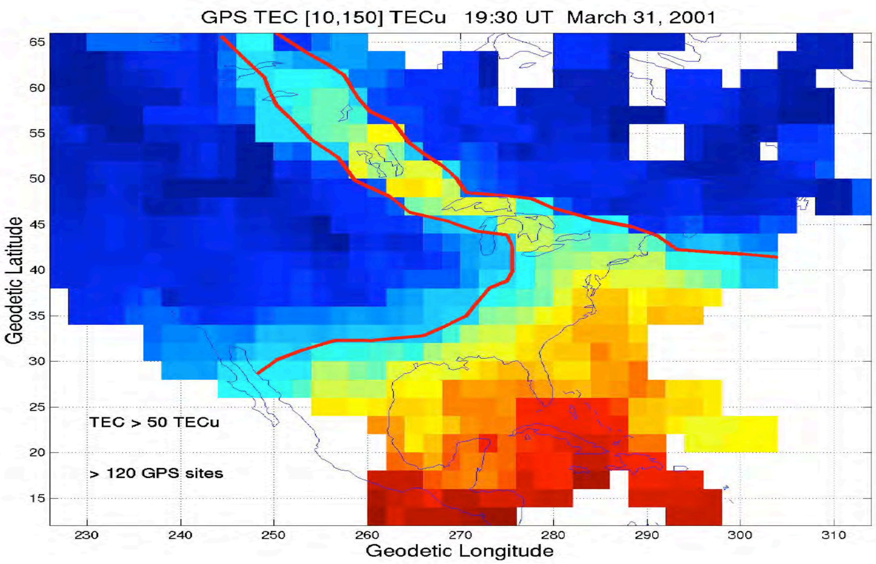
SuperDARN images SAPS flow channel→ maps to strong E at inner edge of dusk ring current



Map of Line-of-Sight Velocities for 08:40 UT, March 9th, 2011

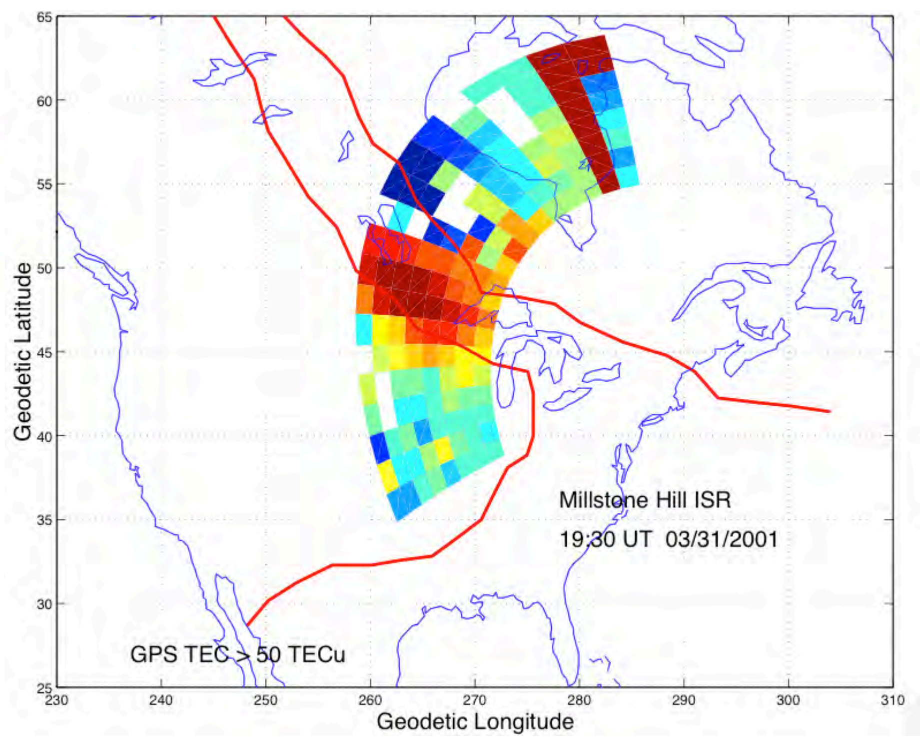
GPS and Incoherent Scatter Radars

GPS Observations of Plasma Plume



Tony Manucci

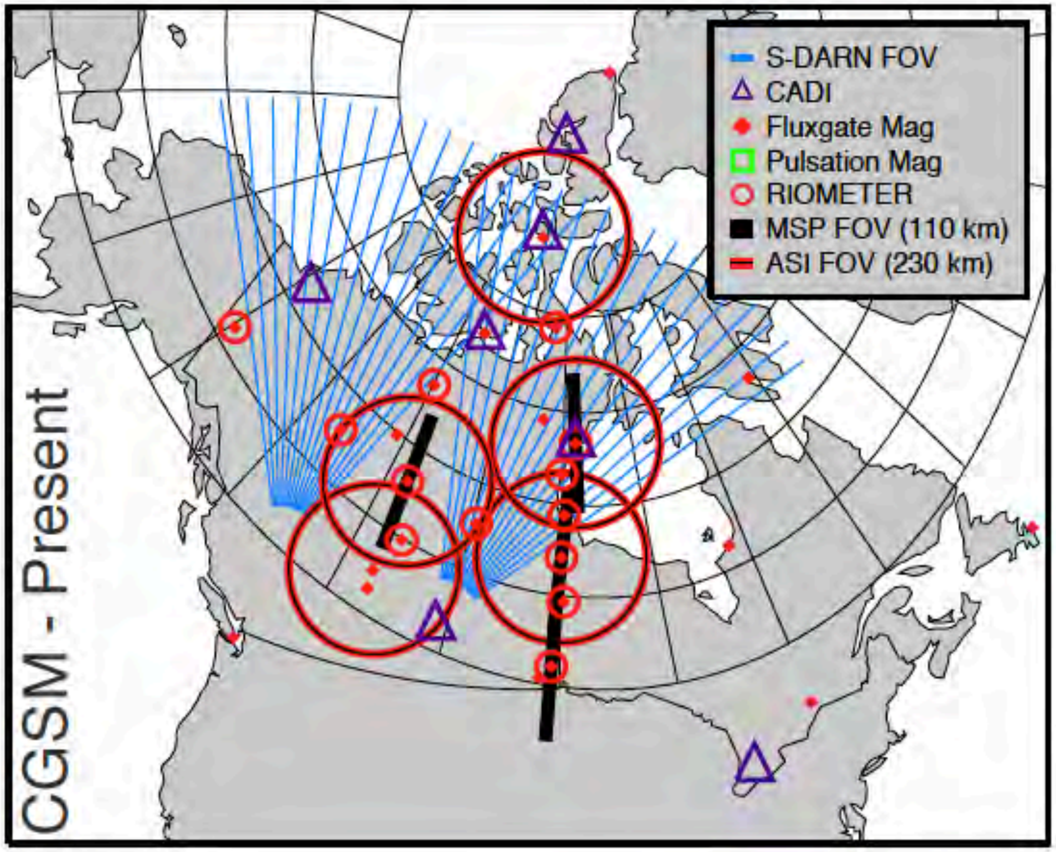
ISR Observation of Plasma Plume



John Foster

Dayside plasmaspheric plume → EMIC/hiss waves → ion loss

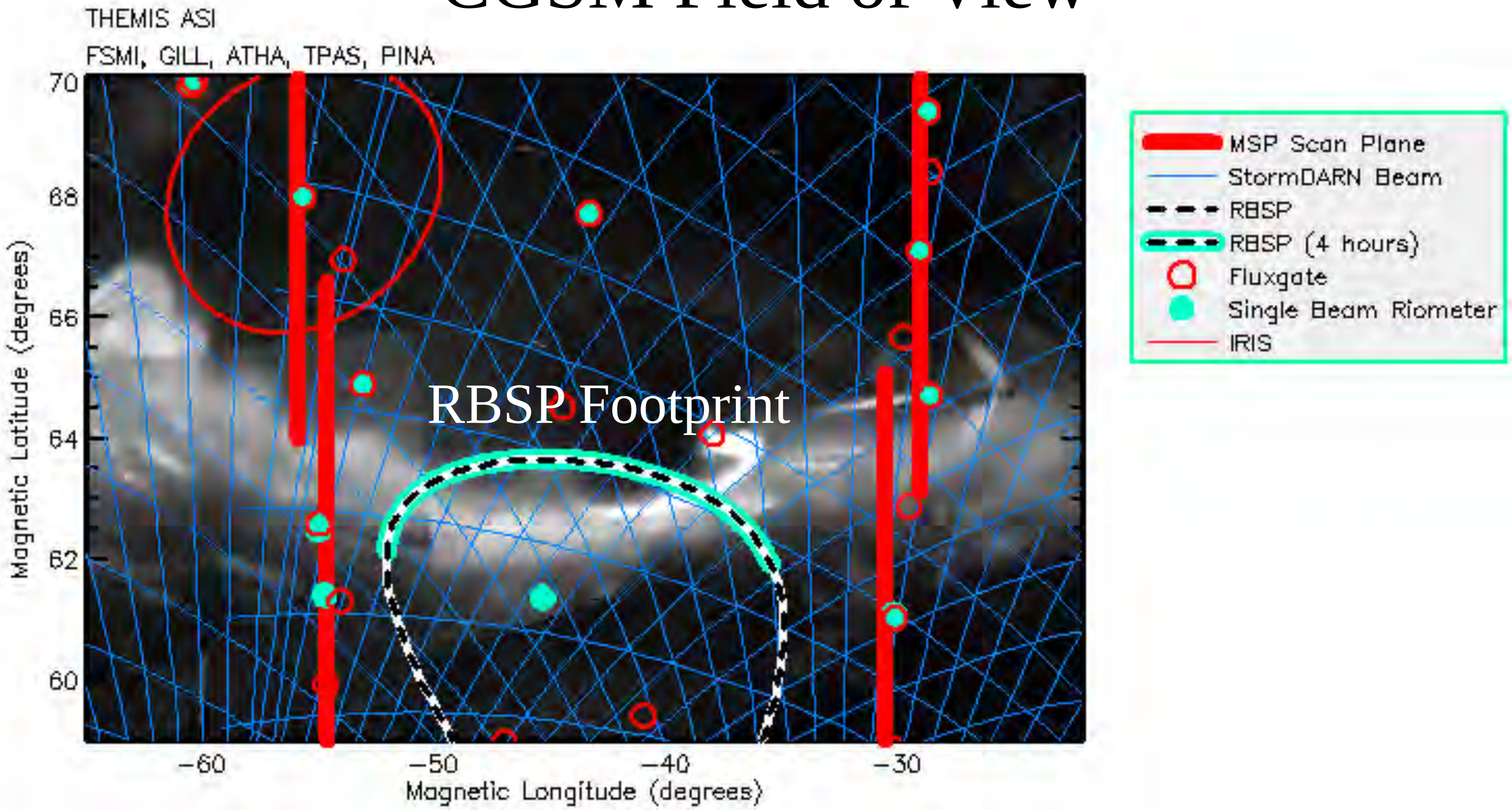
Canadian Geospace Monitoring Array



1. Radar→ steady/transient convection
2. Riometer → 10's kev electron injections and loss
   L = 4.2, 5.5, 6.7…
3. MSP/ASI →substorm auroral activity
4. CADI Ionosonde

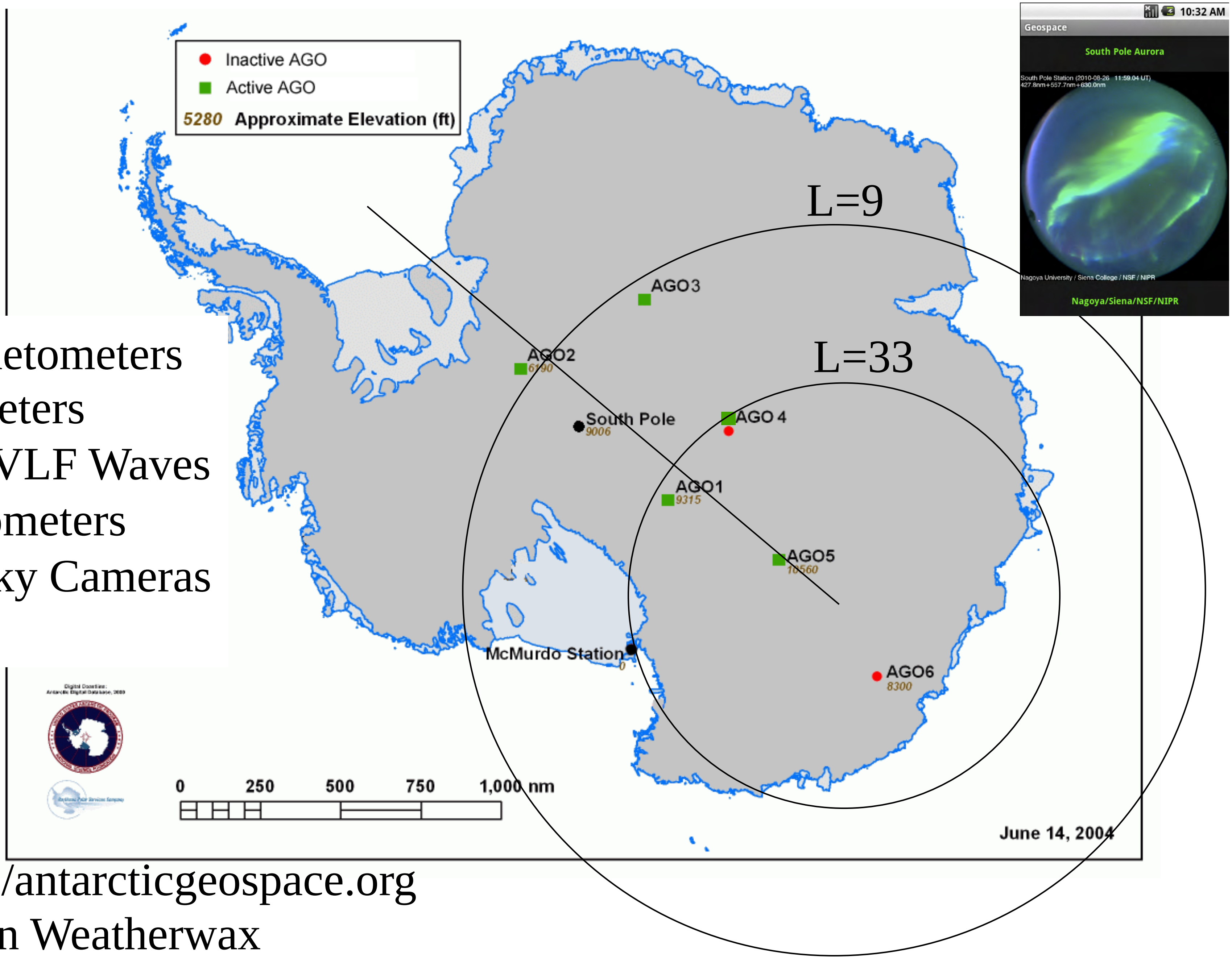
E. Donovan and I. Mann

Footprint of RBSP lies Well within CGSM Field of View



Storms, substorms, and pulsating aurora/chorus studies

Antarctic Ground-based Support for RBSP



Magnetometers
Riometers
ELF/VLF Waves
Photometers
All Sky Cameras

http:/antarcticgeospace.org
Allan Weatherwax

BARREL Project Overview

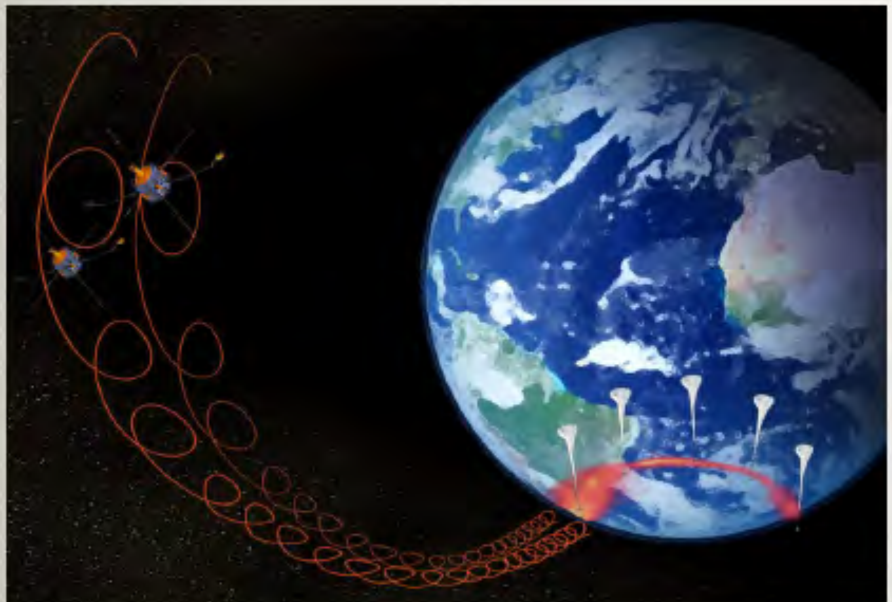
Robyn Millan, Dartmouth

- BARREL is a multiple-balloon experiment designed to study relativistic electron precipitation

- Two Antarctic Science Campaigns during RBSP Mission
  - 20 small balloon payloads in each campaign in 2013 and 2014
  - Launched successively to set up slowly drifting array
  - Long duration balloon flights => 30 day campaign
  - >3000 hours of data in radiation belt region (L<7)
  - Launch sites planned: Halley Bay and South African Antarctic station (SANAE)

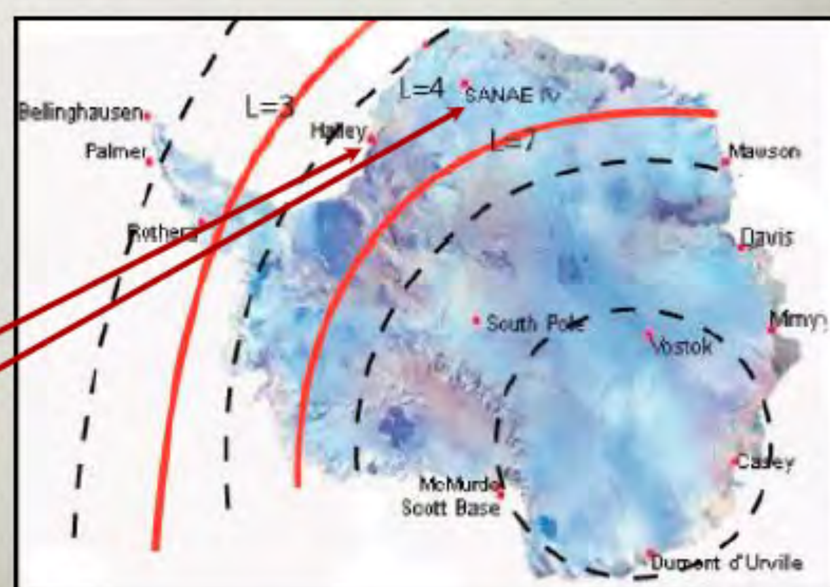
Observe brehmsstrahlung generated by electron-neutral collisions resulting from precipitating MeV electrons

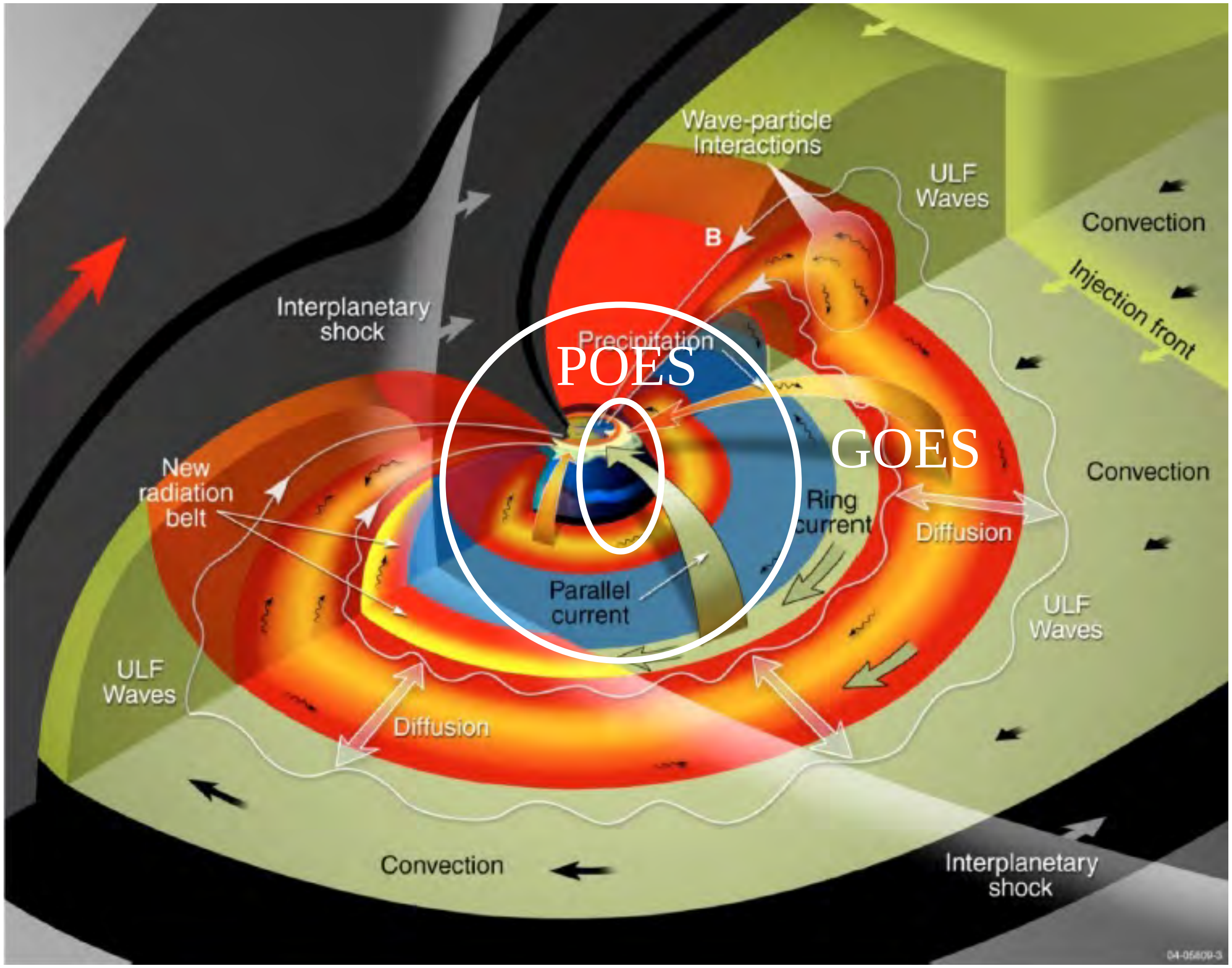
Platform - Balloon Array



- BARREL uses an array of balloons to achieve its science
- 4-5 balloons aloft simultaneously
- separation 1-2 hours of MLT
- flight durations ~7 days
- 20 balloons per campaign

- Two launch sites:
-Halley Bay
-SANAE





NOAA Spacecraft:
POES and GOES

NOAA Resources

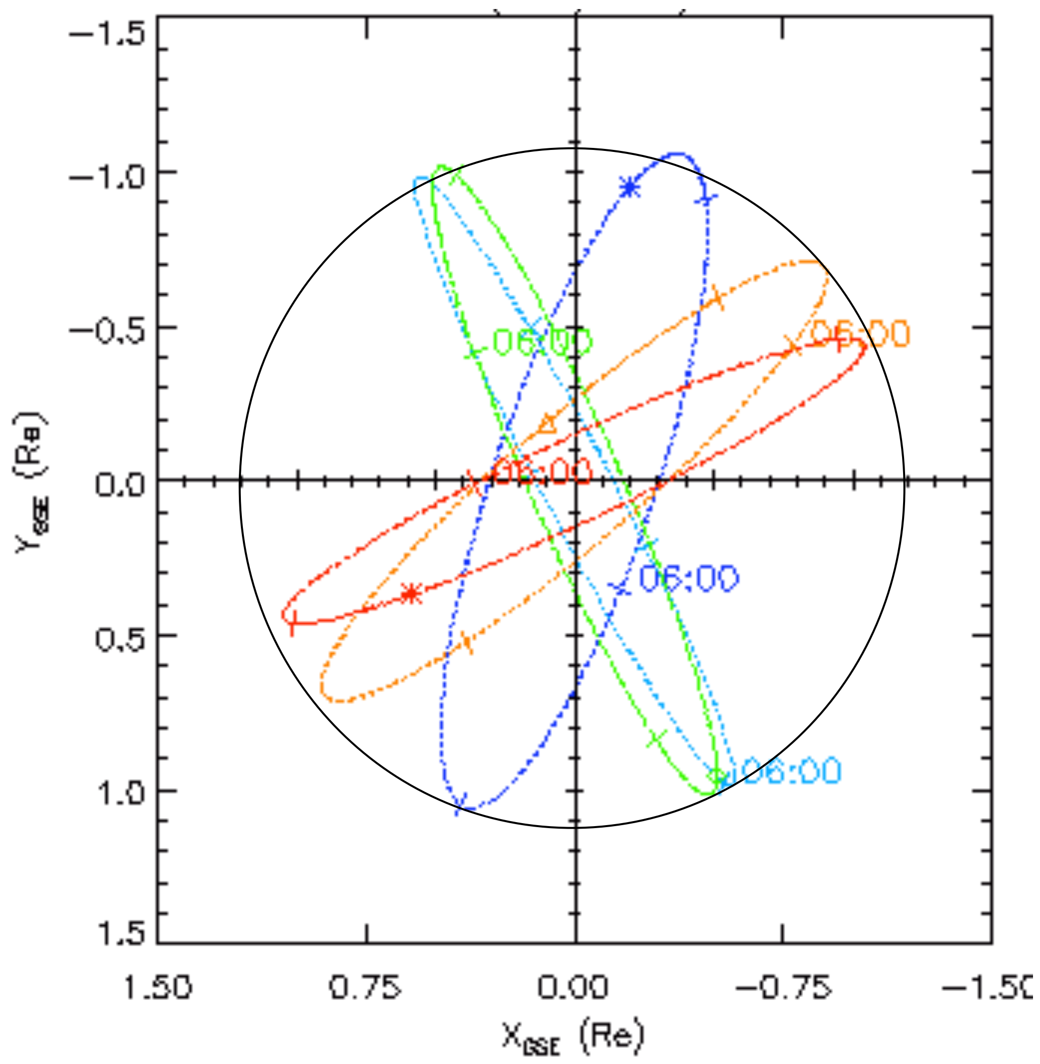
POES observations of

50 eV to 2.5 MeV electrons
50 eV to 6.9 MeV ions and
16-140 MeV protons

at 830-870 km with 2s cadence

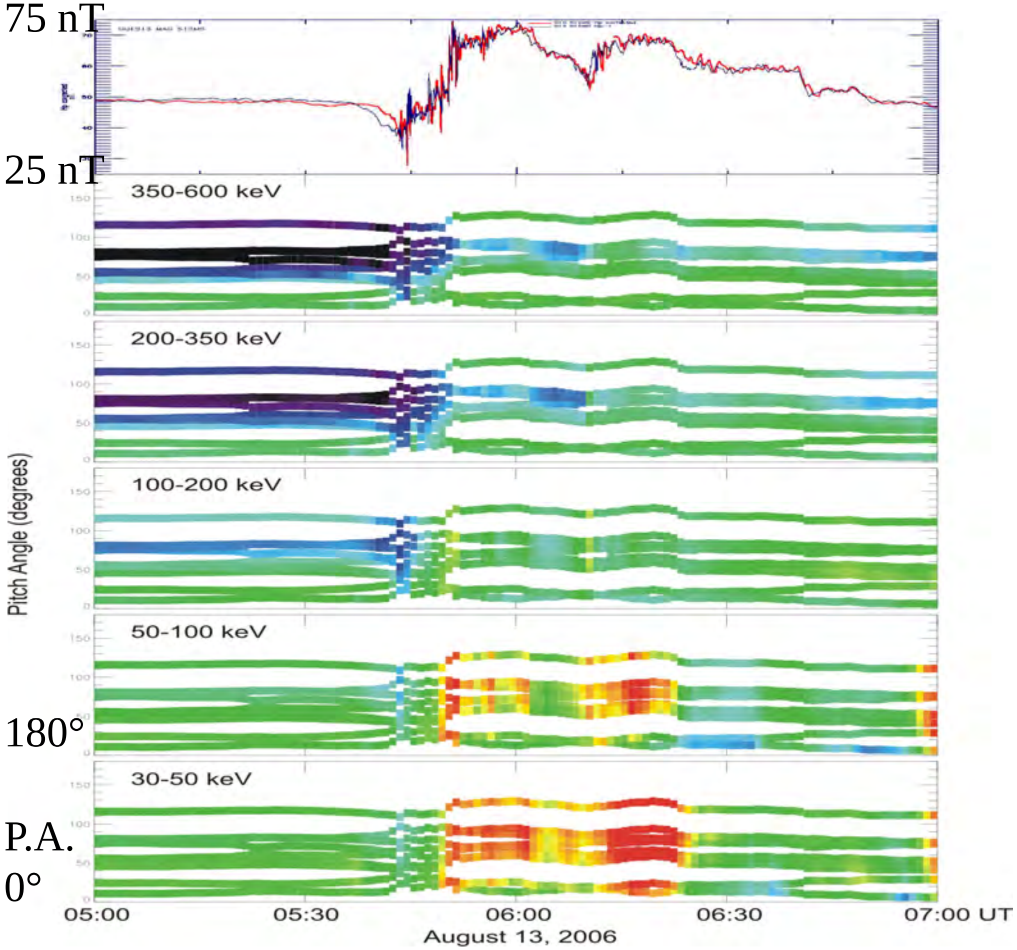
provide information on:

1. Magnetosphere topology
2. Precipitation or the lack thereof [e.g. Turner et al., 2012]



NOAA Resources

GOES-10/13



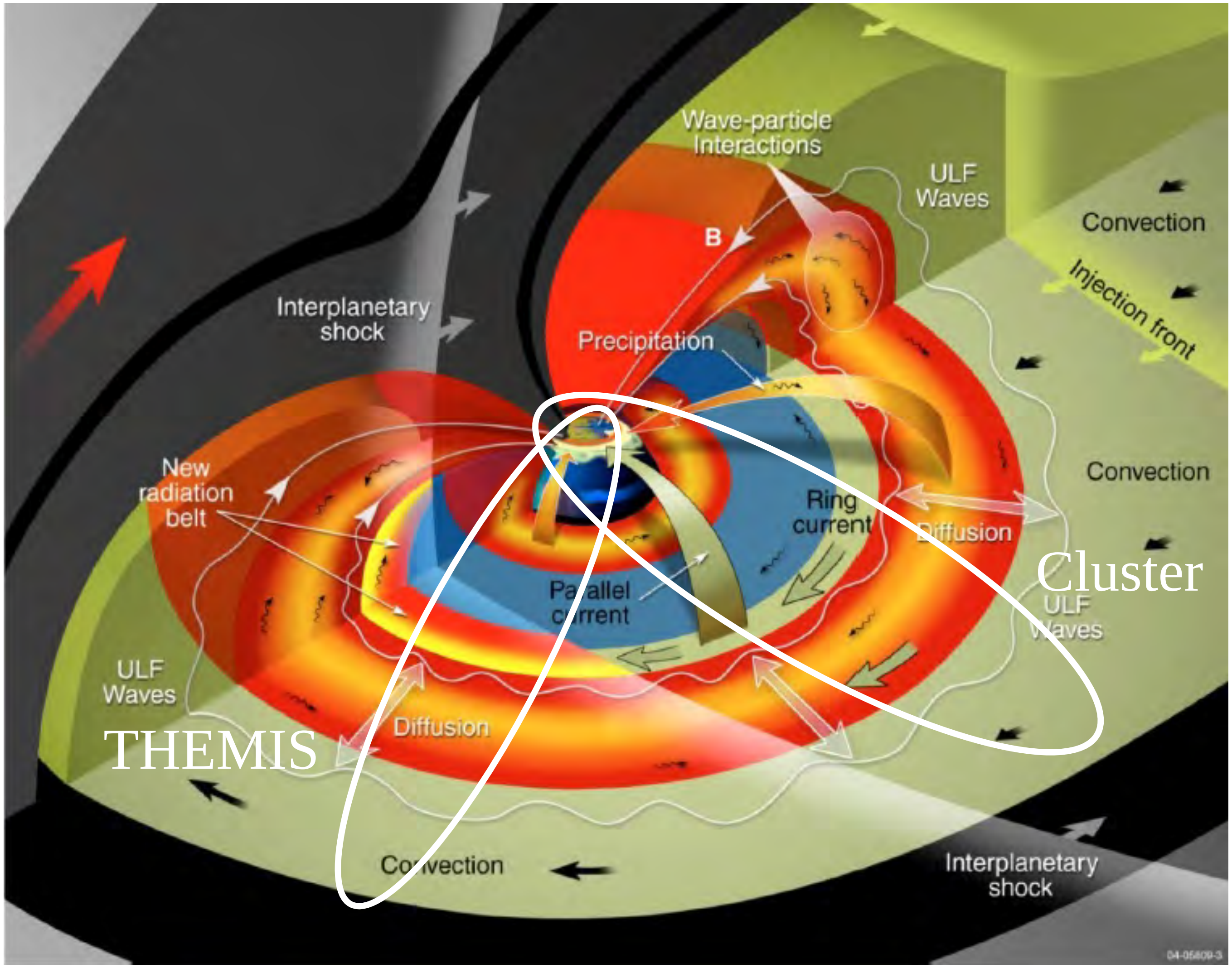
Substorm Stretching, Onset

The 2 GOES geosynchronous spacecraft provide information on:

1. Magnetosphere structure
2. Substorms
3. Injected ions

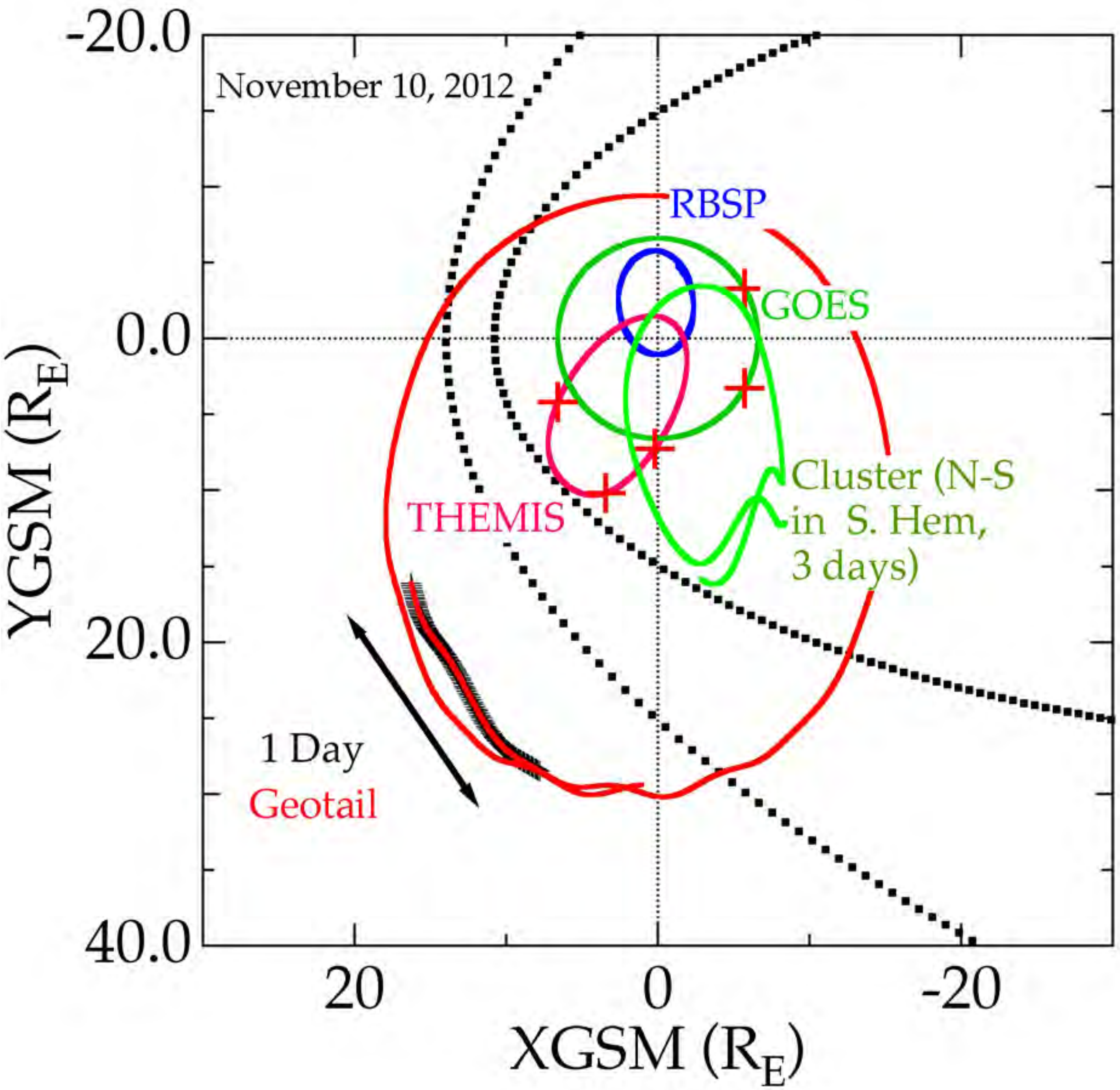
Magnetic field (0.5s cadence)

Electrons 30 keV → > 4 Mev
Protons 80 keV → 900 MeV
Alphas 4 MeV → 3400 MeV



Cluster and THEMIS

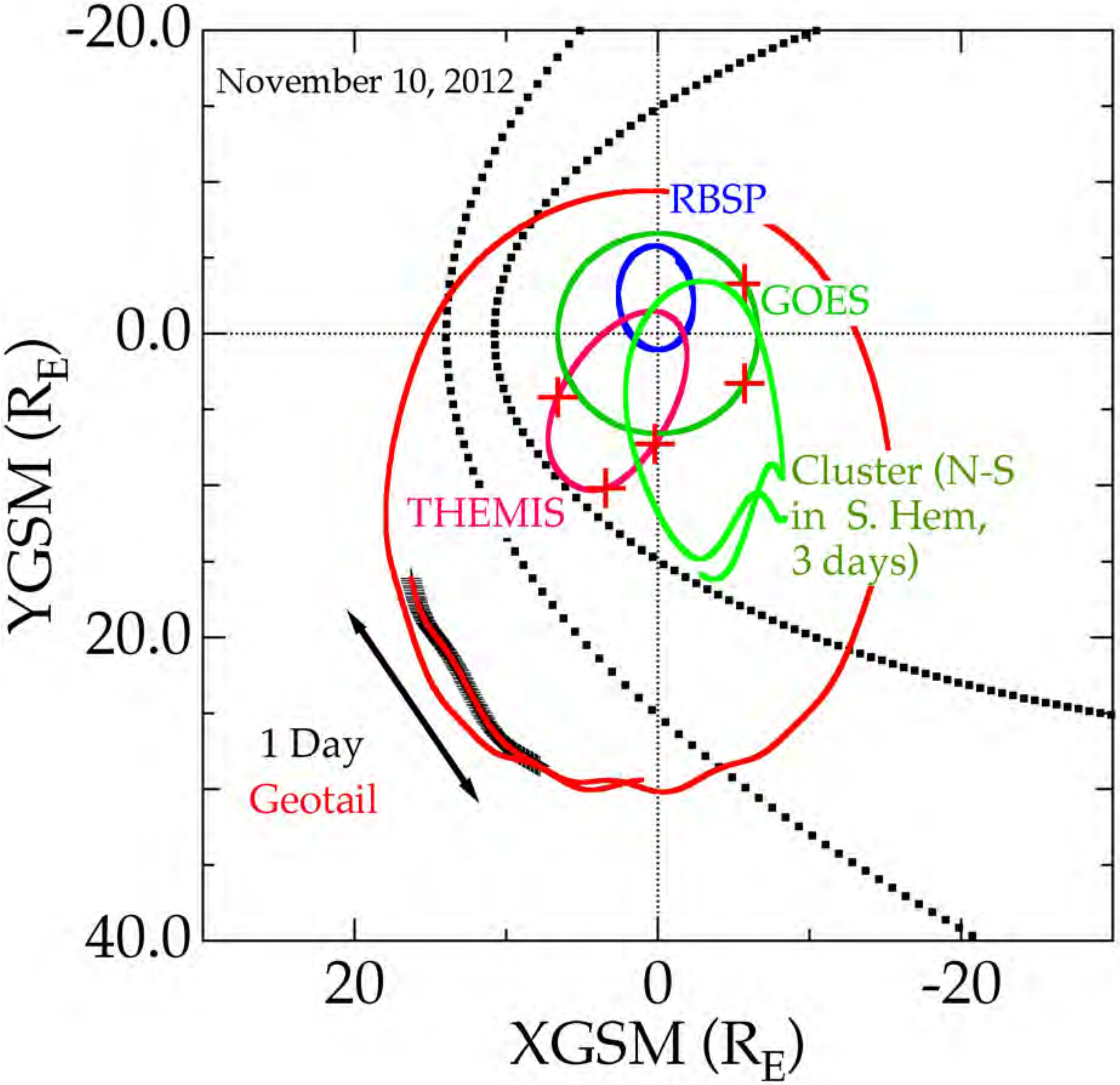
November 10, 2012



Early Mission Locations:

1. RBSP near dawn
2. Cluster near dusk
3. THEMIS at post-noon magnetopause
4. Geotail in solar wind

November 10, 2012



Early Mission Science:

Roles of chorus/EMIC

RBSP/Cluster → chorus at dawn

THEMIS → EMIC at dusk

Roles of Chorus/Hiss

RBSP → Chorus at apogee

THEMIS/Cluster → Hiss at perigee

Ring current asymmetry

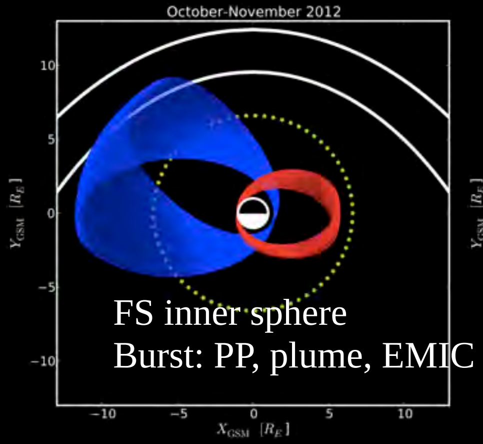
RBSP →dawn ring current

THEMIS → dusk ring current

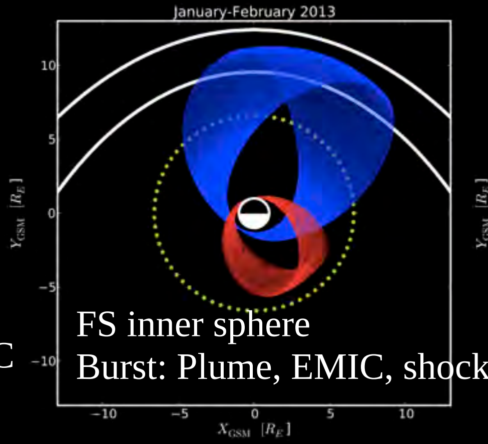
8 Science Campaigns

4-8-12 hrs sep along orbit

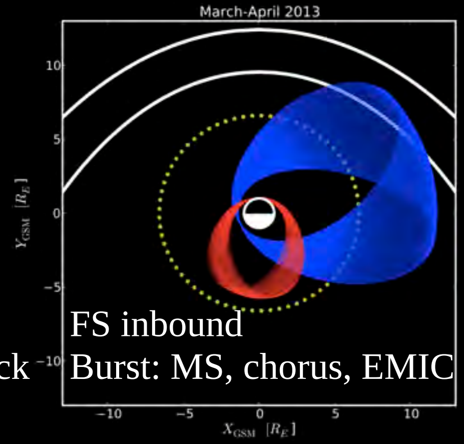
Dawn-Dusk Differences
(Fall 2012)



Magnetopause Losses
(Winter 2012-2013)

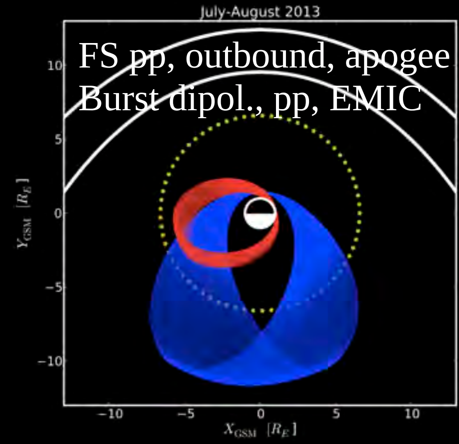


Dawnside Waves & Electron Drift
(Spring 2013)



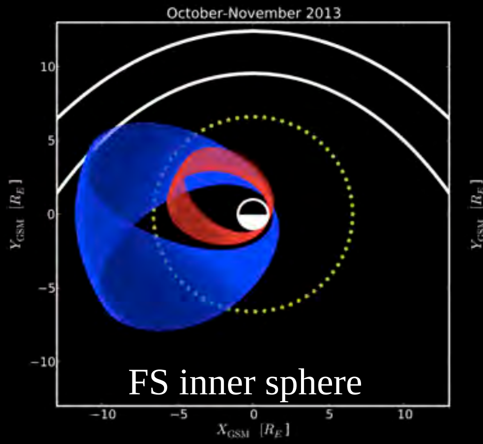
4-8-12

Ion Injection & Energization
(Summer 2013)

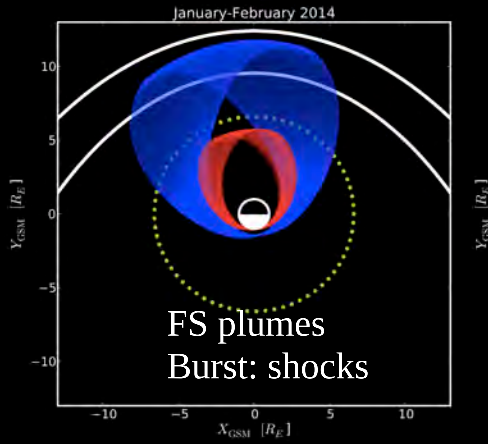


8-8-8

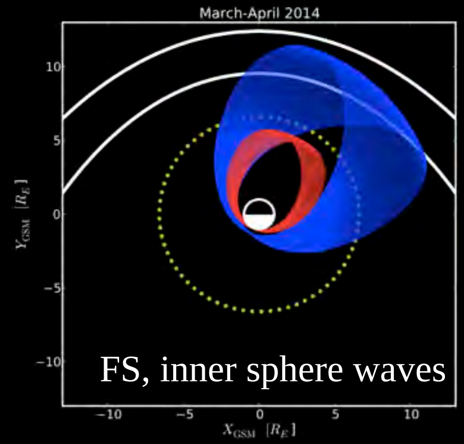
Duskside EMIC Waves
(Fall 2013)



Effects of SW Pressure Variations
(Winter 2013-2014)

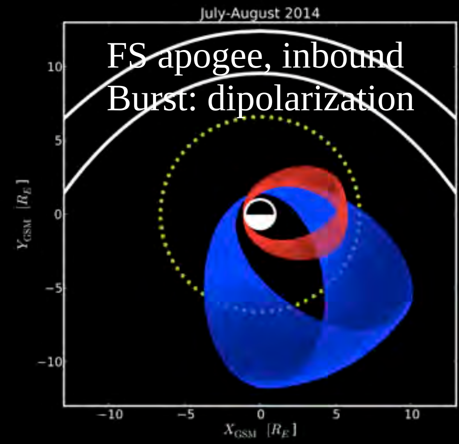


ULF Waves
(Spring 2014)



8-8-8

Electron Injections
(Summer 2014)



Many thanks to S. Ukhorskiy for graphics!

Summary

- 1. RBSP welcomes your participation in the mission. More information: http://rbsp.jhuapl.edu/

- 2. For data, ephemeris, software, tools:
  - http://athena.jhuapl.edu/home_overview

- 3. Please ask me for my white paper describing detailed science plans as a function of mission phase.

- 4. Thank you for your kind hospitality!

Geosynchronous GOES-13/15
(Separation: 4 Hrs LT)

Magnetometer
- 0.5s time resolution

Magnetospheric Electron Detector (MAGED):
- 9 look directions for (5 azimuth and 5 elevation with shared center)
- 5 energy channels in each look direction: **30 keV – 600 keV**

Magnetospheric Proton Detector (MAGPD):
- 9 look directions for (5 azimuth and 5 elevation with shared center)
- 5 energy channels in each look direction: **80 keV – 800 keV**

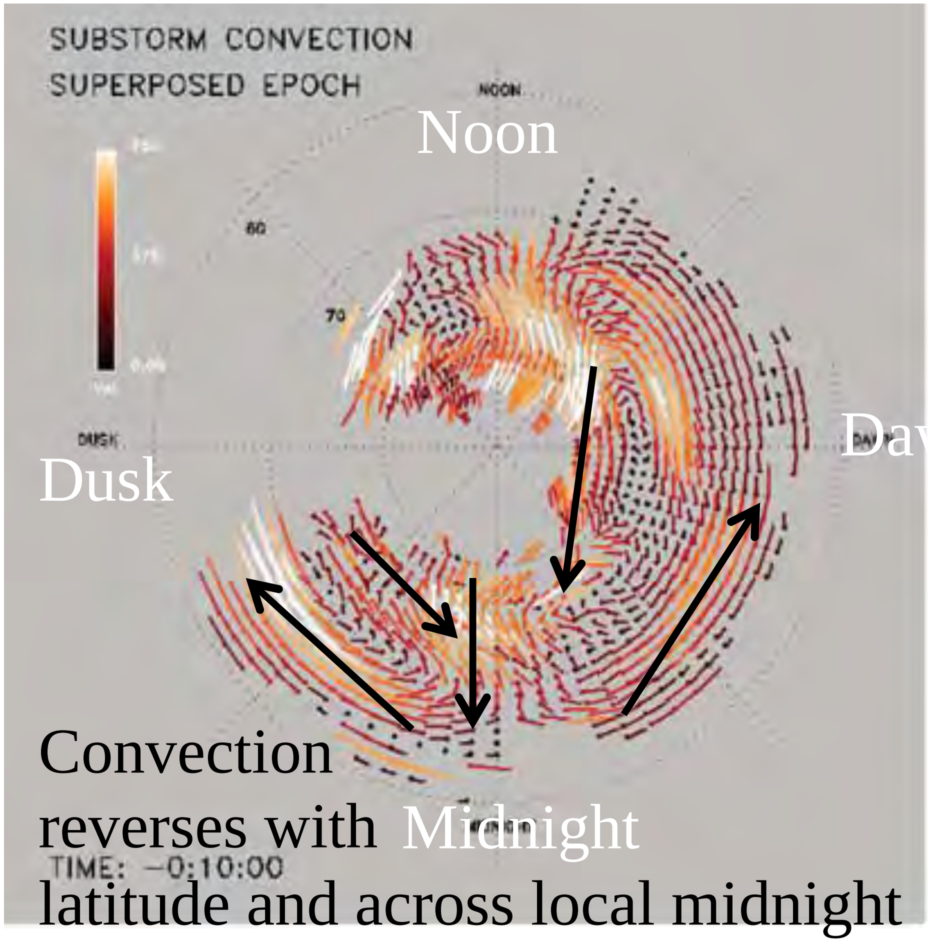
Energetic Proton Electron and Alpha Detector (EPEAD):
- 2 look directions (East and West)
- 3 electron energy channels: **> 0.8 MeV, > 2 MeV, > 4 MeV**
- 7 proton energy channels**: 0.7 – 900 MeV**
- 6 alpha particle energy channels: **4 – 500 MeV**

High Energy Proton and Alpha Detector (HEPAD):
- 1 look direction
- 4 proton energy channels: **330 – >700 MeV**
- 2 alpha particle channels: **2560 – >3400 MeV**

Janet Green

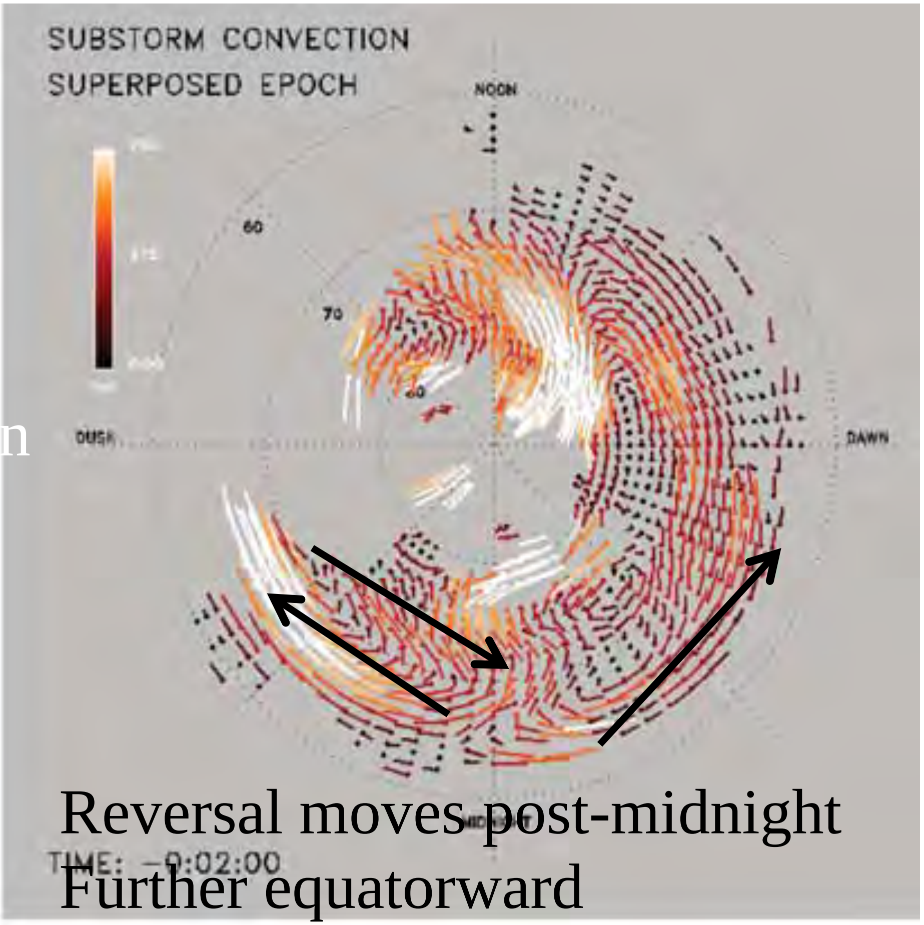
Radars and Substorms

Growth Phase: Two Cell Pattern



Convection reverses with latitude and across local midnight

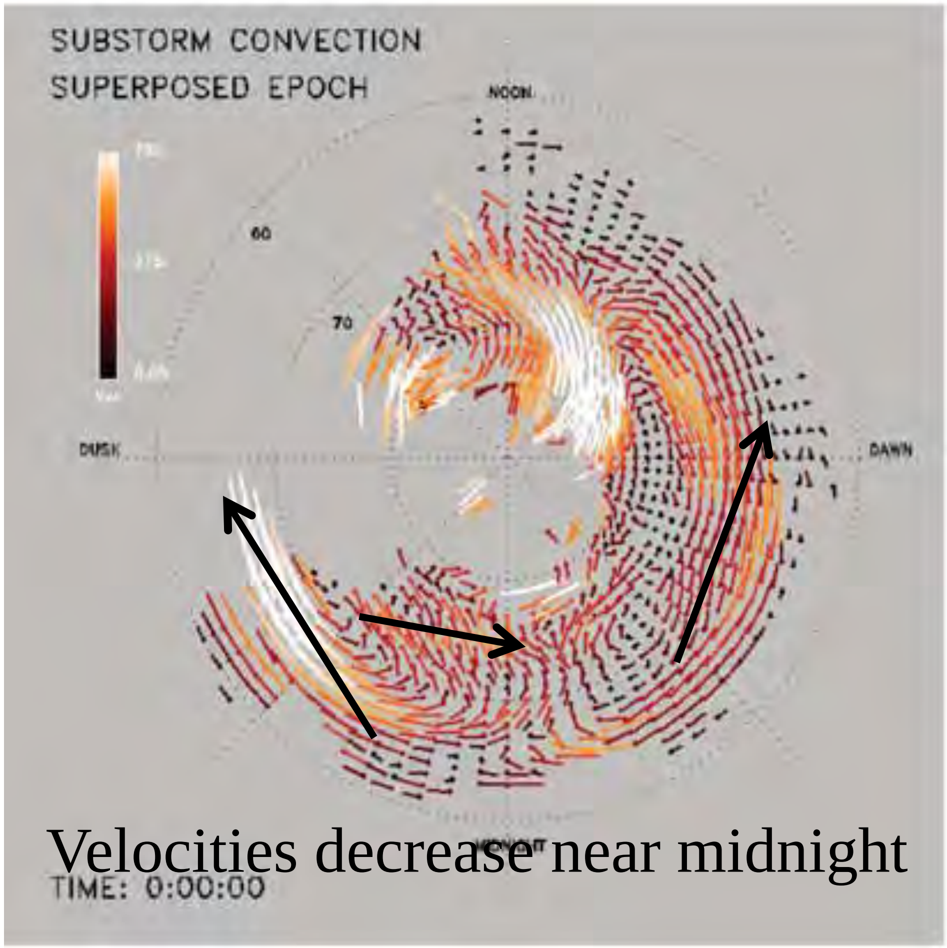
Just Prior to Onset



Reversal moves post-midnight
Further equatorward

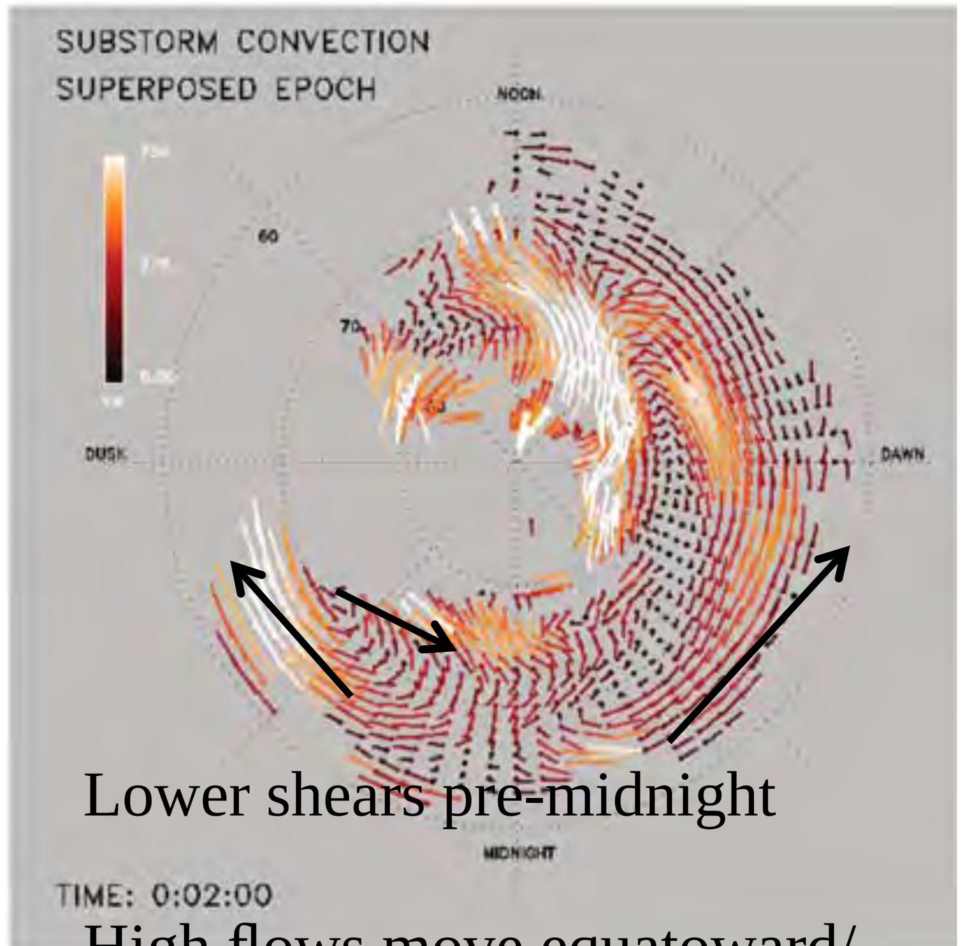
Radars and Substorms

Onset



Velocities decrease near midnight

Onset + 2 min

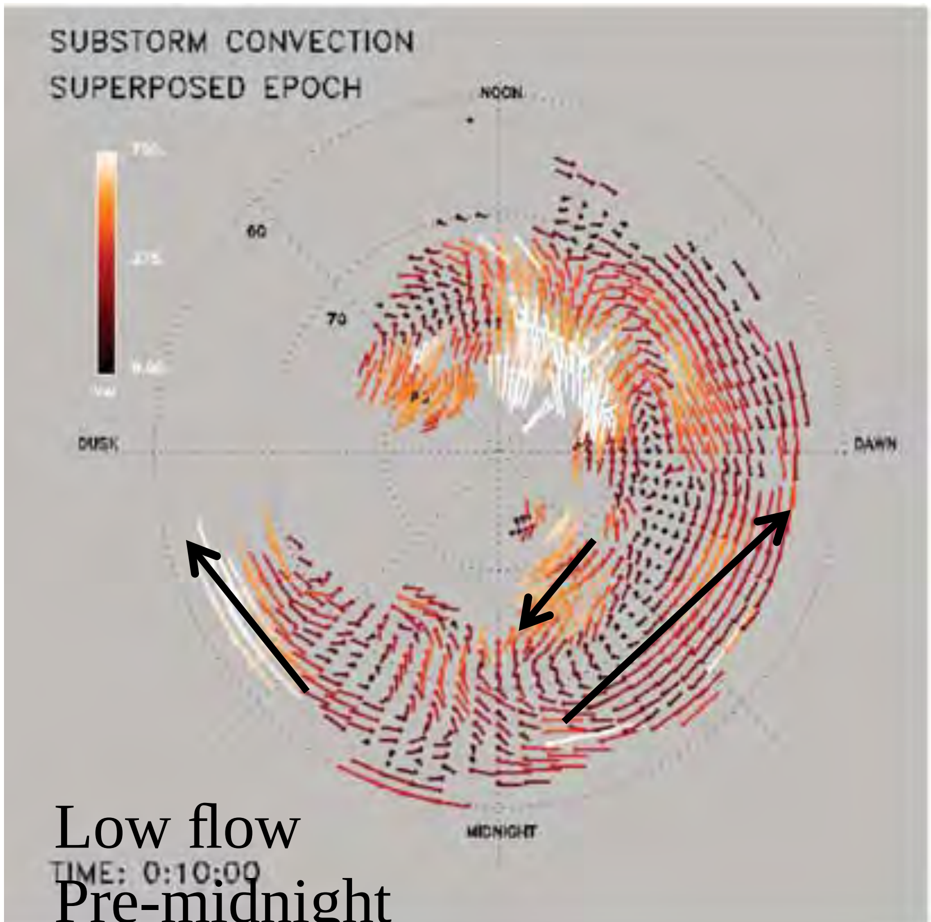


Lower shears pre-midnight

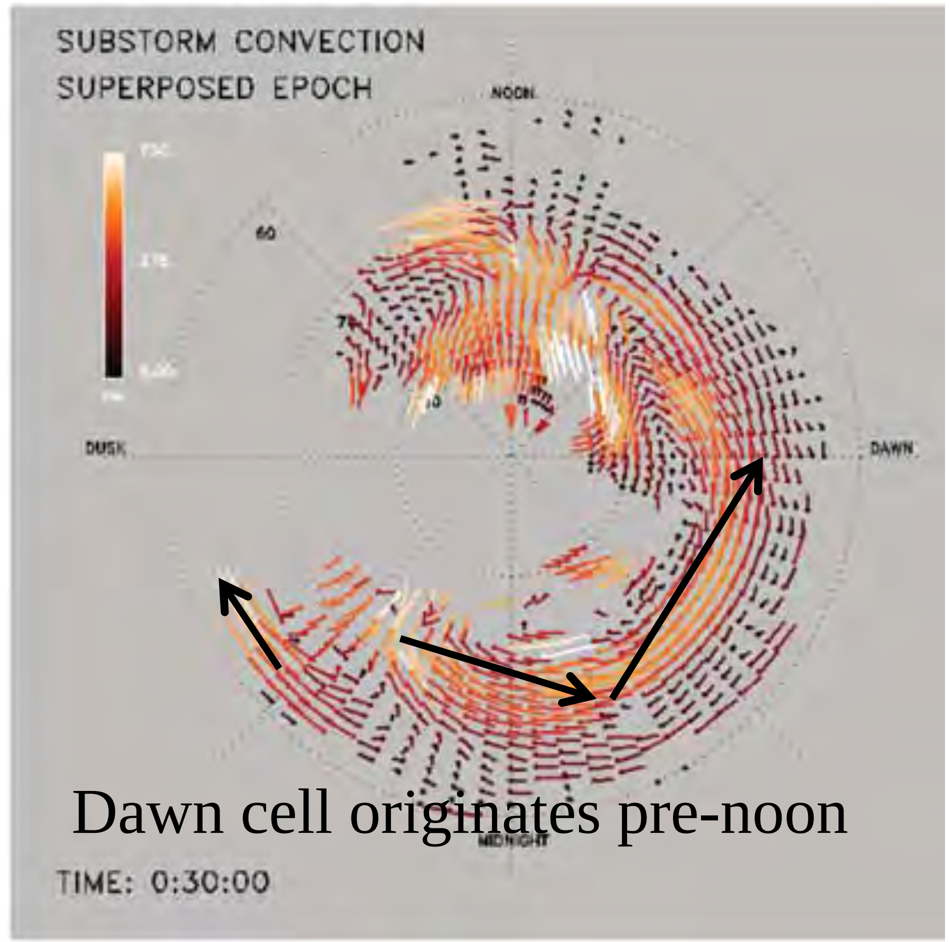
High flows move equatoward/ duskward

Radars and Substorms

Onset + 10 min



Onset + 30 min



Bristow et al. [2007]