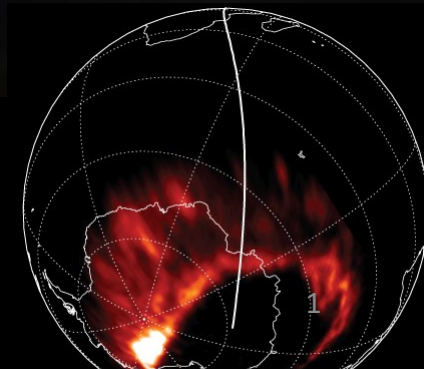
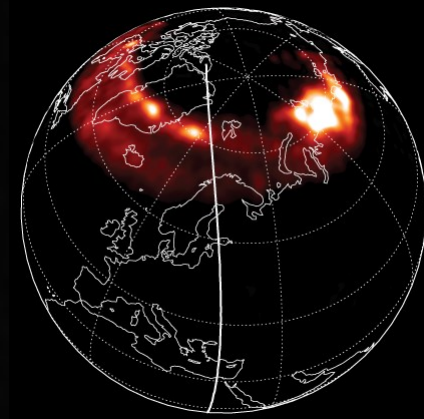
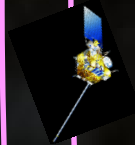


Conjugate Ground-based Magnetic Observations for Hemispheric Asymmetry Research in the Next Decade

Peter J. Chi (UCLA)

Thanks to contributions from
C. T. Russell, M. Connors, R. J.
Strangeway, T. Wilson,
UNAVCO

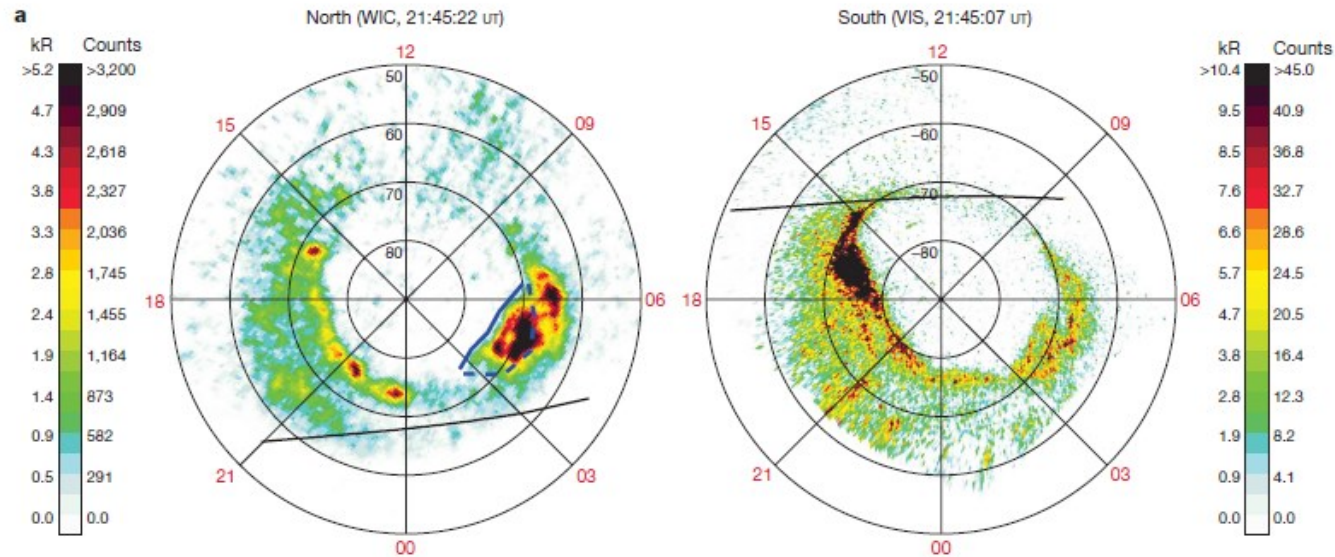


Solar and Space Physics Decadal Survey White Papers
Workshop #3:
The Future of Ground-Based Research for
Magnetospheric and ITM Physics
March 15–16, 2022

Hemispheric Asymmetry of the Geospace

Examples:

- Aurora intensity
- Ionospheric conductivity and currents
- Field-aligned currents
- Sub-auroral Polarization Streams (SAPS)
- Sudden Impulse magnitude
- Etc.

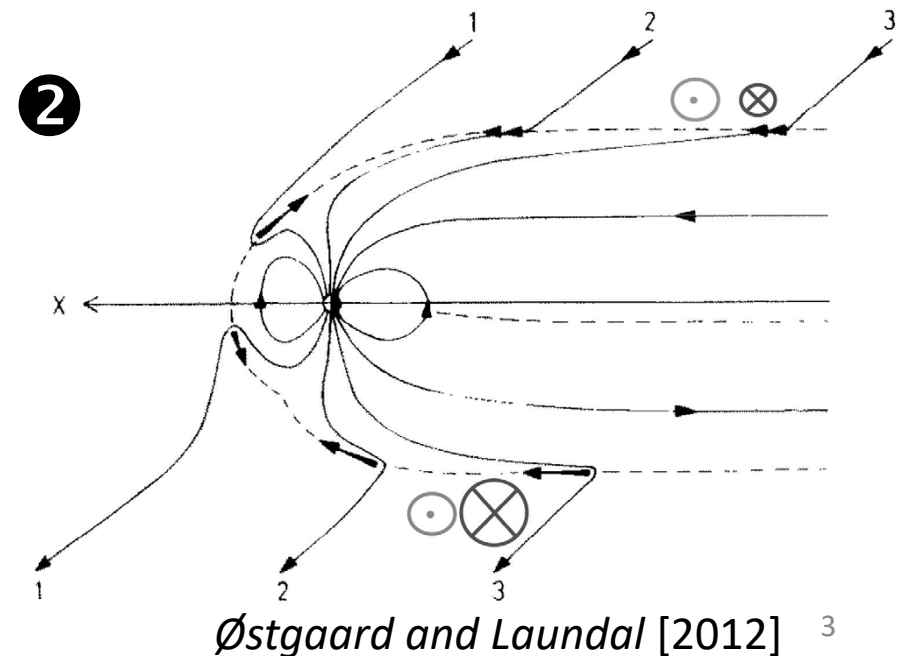
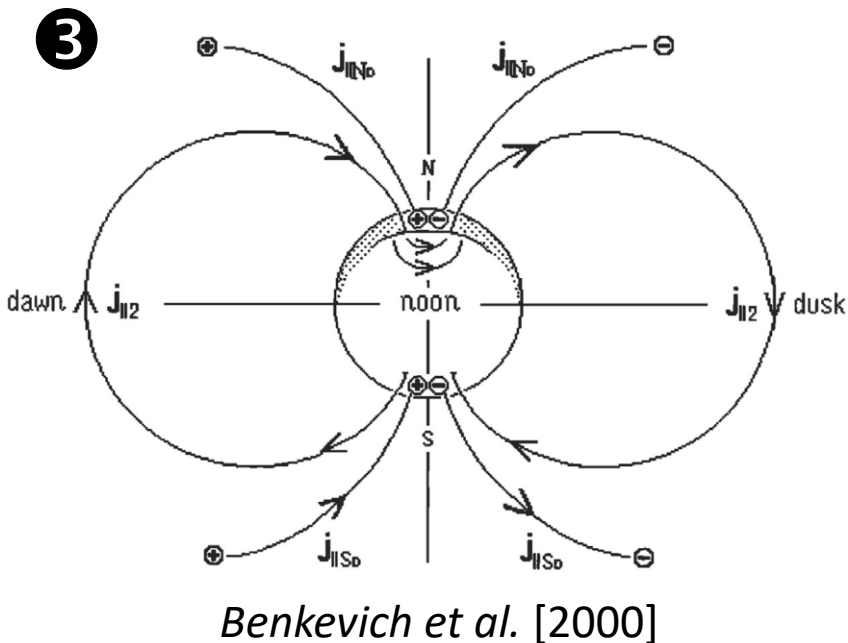
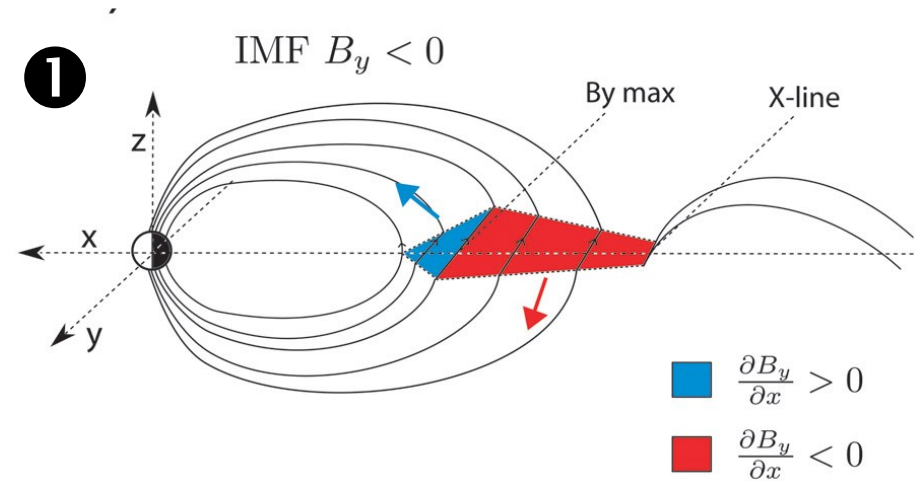


Laundal and Østgaard [2008]

It can be argued that most if not all components of the Geospace possess some level of hemispheric asymmetry.

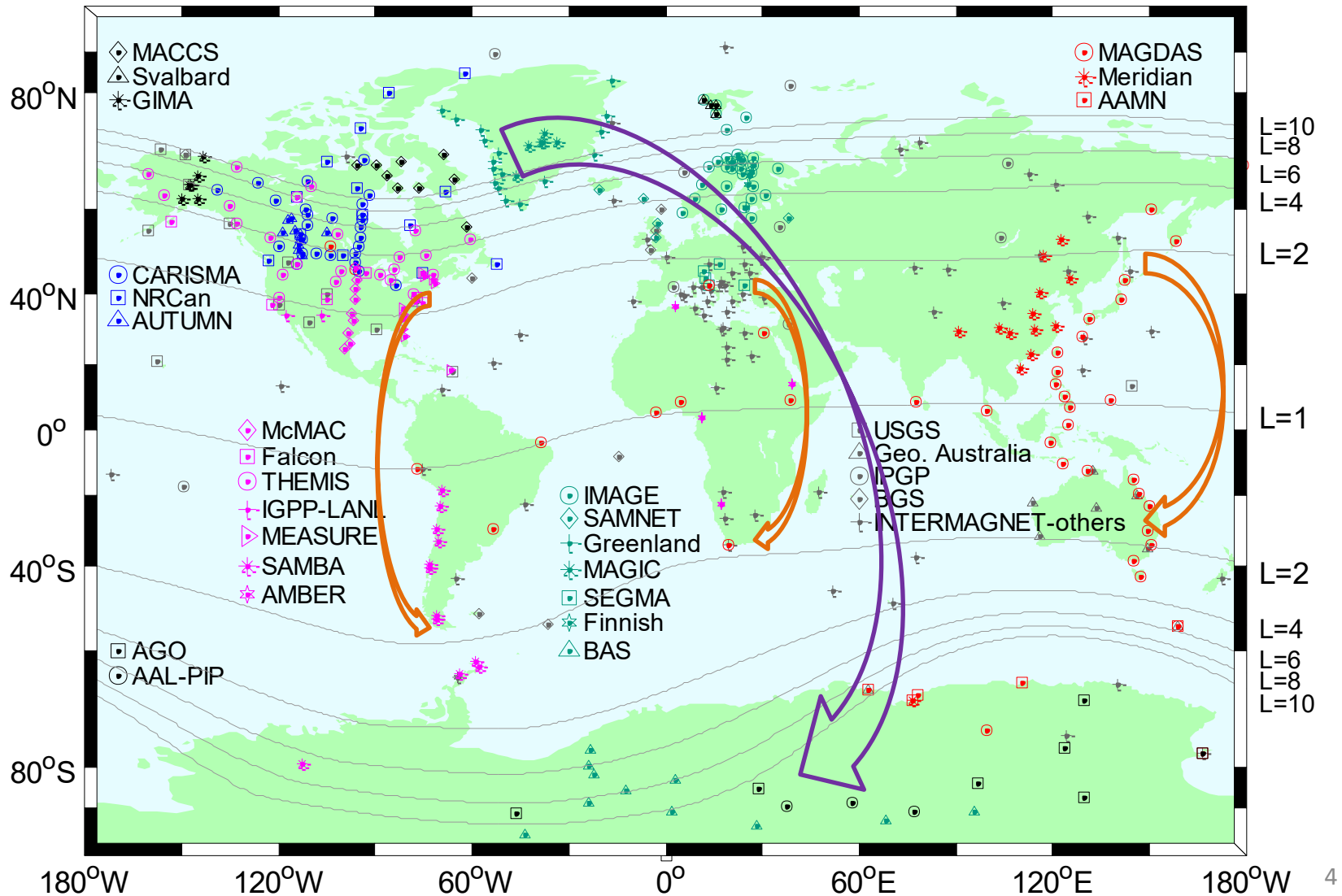
Possible Mechanisms Producing Hemispheric Asymmetry of Aurora

1. Interplanetary magnetic field (IMF) B_y penetration into the magnetotail
2. Dynamo due to strong IMF B_x
3. Interhemispheric currents
 - Tilt of magnetic pole
 - Solar illumination



Conjugate Magnetic Observations Available at High and Low Latitudes

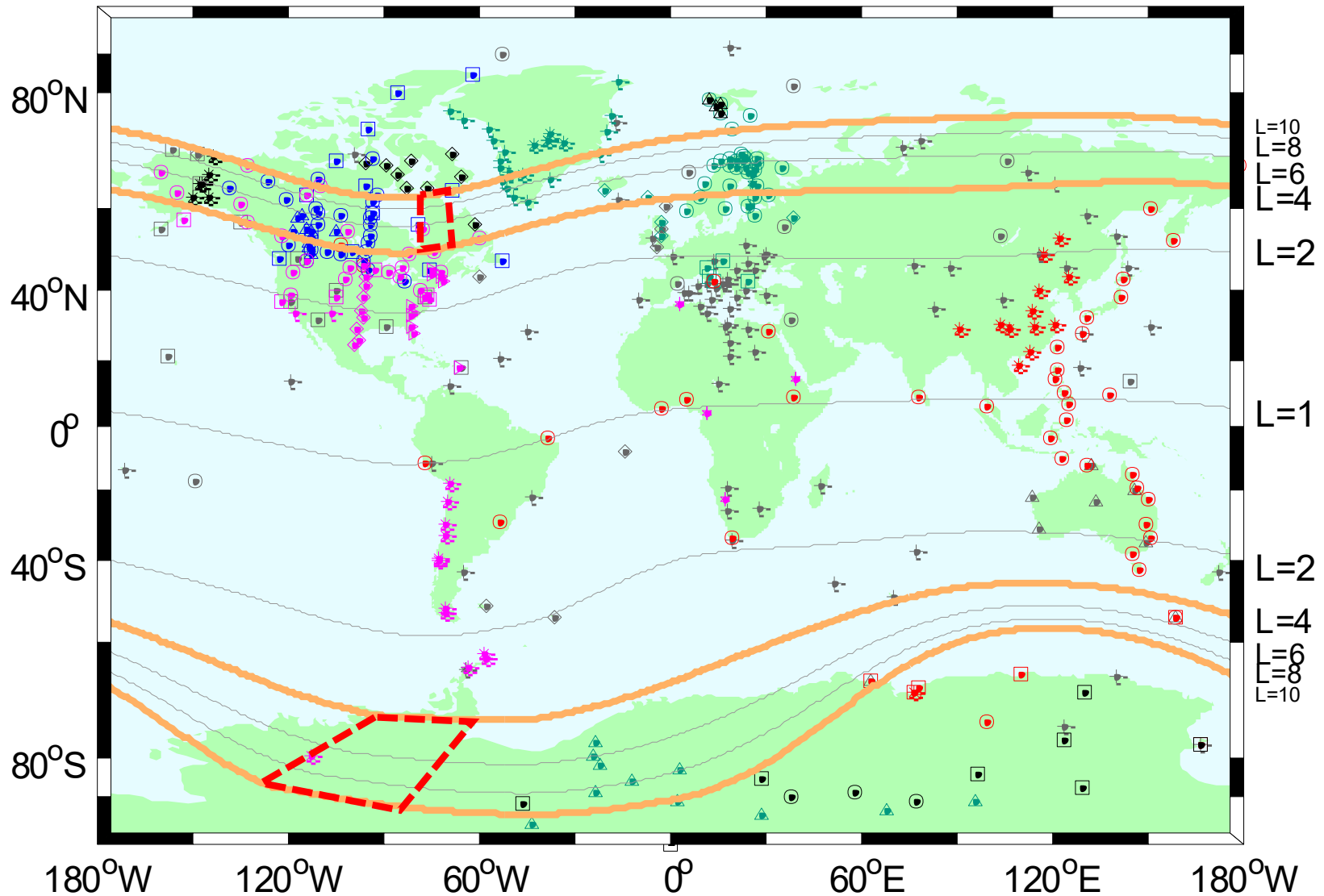
Locations of Ground-based Magnetometers



Conjugate Magnetic Observations

The Only Conjugate Lands with Full Range of Auroral Latitudes

Locations of Ground-based Magnetometers



Polar Region Interhemispheric Magnetic Observations (PRIMO)

- To fill the gap in conjugate magnetic observations.
- $L = 4-8$ (or even better $4-10$; auroral oval can contract or expand)
- Conjugate *chains* are designed to bracket the movement of the auroral electrojet.

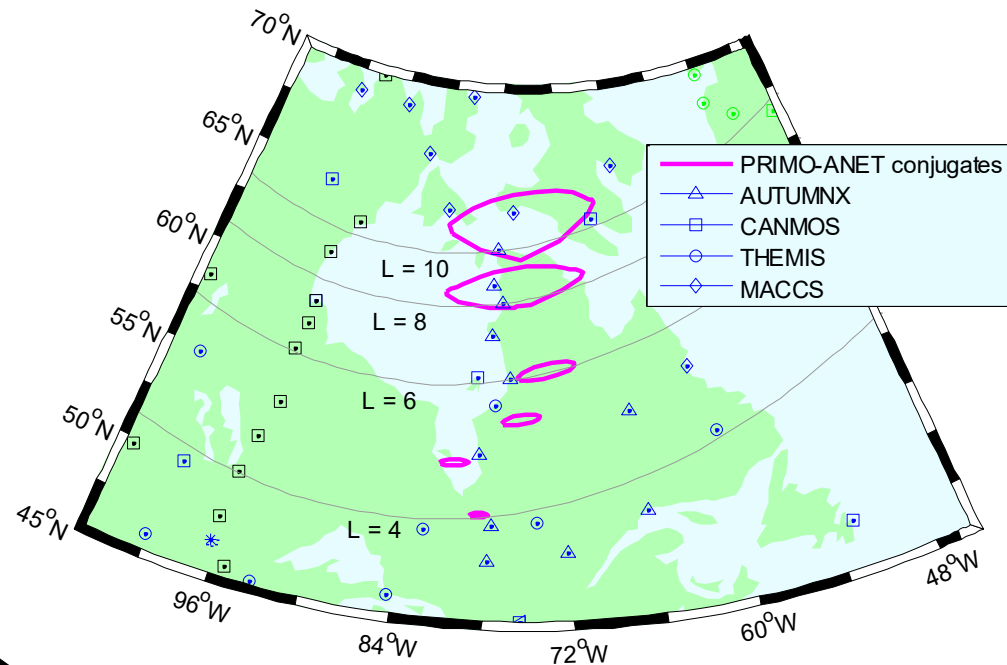
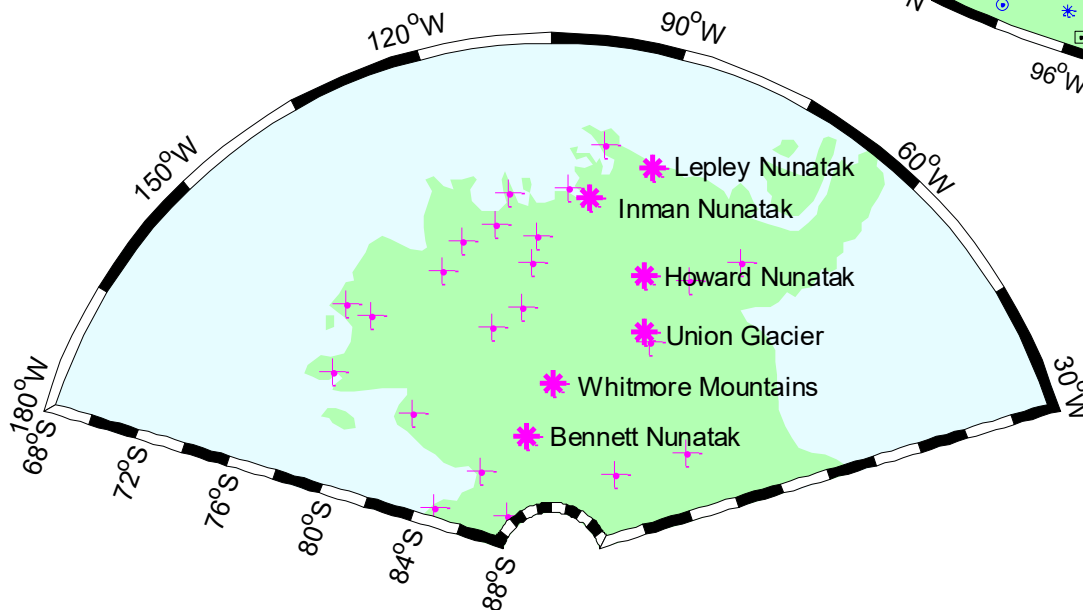


Observations between Quebec, Canada and West Antarctica

PRIMO-AUTUMNX Conjugate Observations

PRIMO in West Antarctica

- Co-located with six ANET sites, enabling substantial logistic synergies
- $L = 3.9 - 10.1$
- Mean latitudinal spacing: 2.3°



- The conjugate point can drift with local time, season, and geomagnetic activity. Plotted is the daily variation.
- Overlap with AUTUMNX sites along the east shore of the Hudson Bay

Scientific Objectives

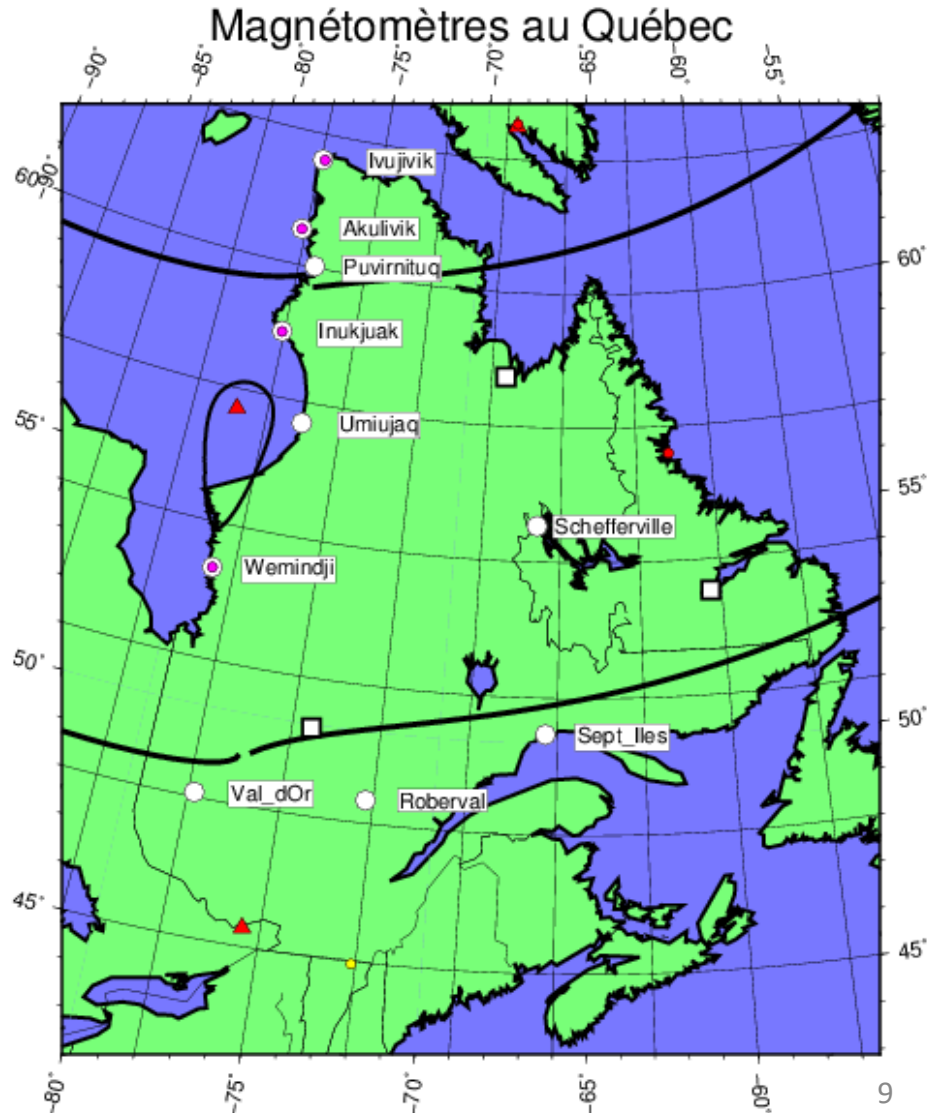
from the view of magnetic field measurements

- **Hemispheric asymmetry in magnetic induction of auroral zone currents**
 - Conjugate PRIMO and AUTUMNX **chains** can monitor auroral electrojet movement.
 - To investigate the controlling factors of hemispheric asymmetry as a test of predictions by Geospace models
- **Hemispheric asymmetry in oscillations of closed magnetospheric field lines**
 - *Quarter-mode waves* can occur when ionospheric conductivities at the two ends of a closed field line differ significantly; Conjugate observations can confirm phases of quarter-wave oscillations.
 - Hemispheric asymmetry of impulsive signatures (e.g., sudden impulses, substorm onsets): Conjugate observations of effects due to differences in propagation path (and thus travel time) and in ionospheric conditions.

Canada: AUTUMNX

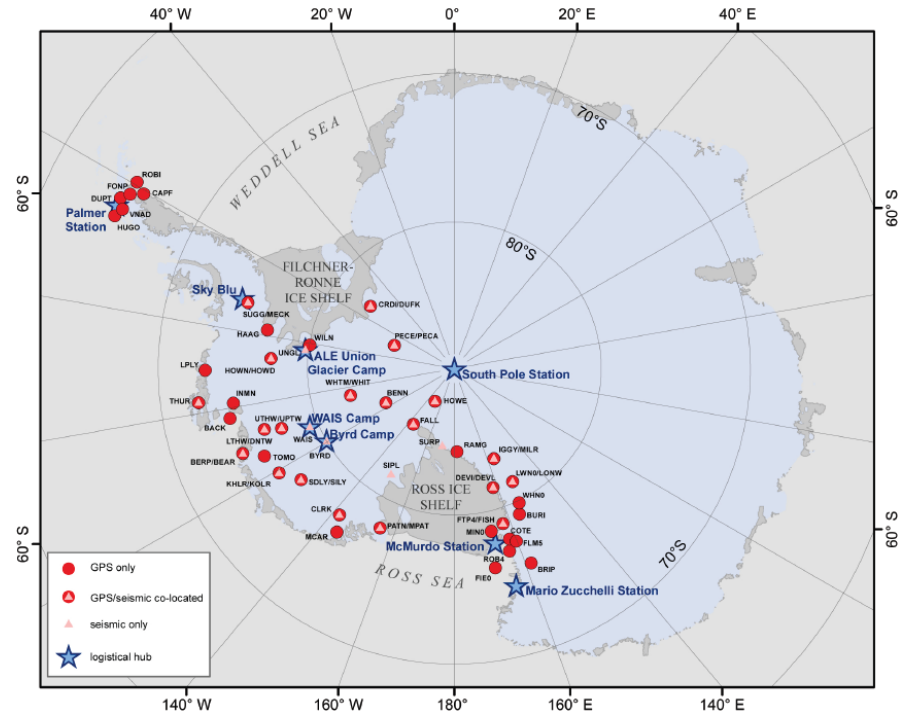


- Motivated by conjugate observations
- PI: Martin Connors (Athabasca U., Canada)
- 11 magnetometer stations (mostly in Quebec) extending the AUTUMN array
- Funded by Canadian Space Agency
- The low-power BeagleBone magnetometer with ruggedized design greatly facilitates the implementation in the targeted region.



PRIMO in Antarctica: Building from ANET Experience

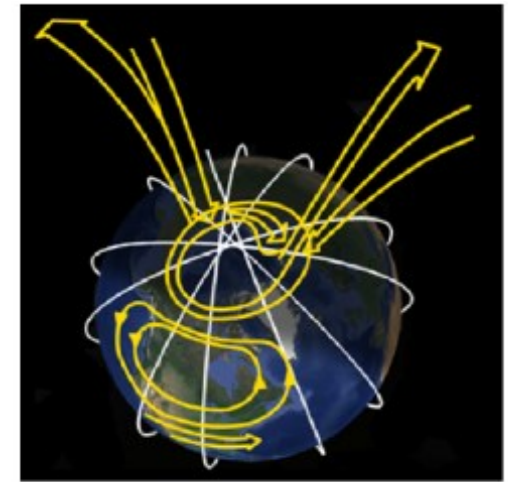
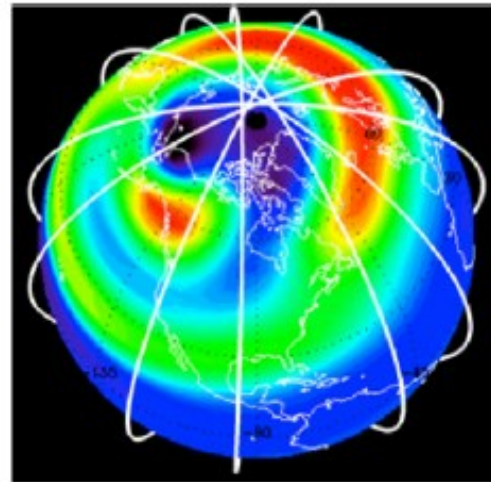
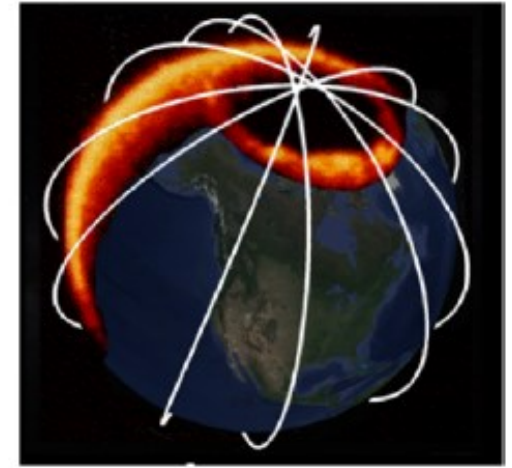
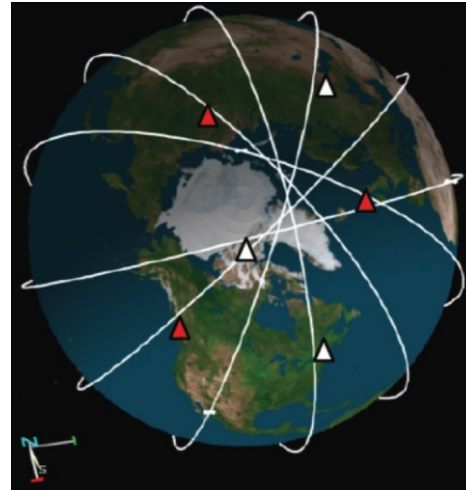
- ANET: POLENET initiative in Antarctica; GPS/seismic network
- One of the greatest achievements of the International Polar Year (IPY)
- Power system and Iridium data comms for continuous operation
- NSF-sponsored UNAVCO handles logistics and operation
- PRIMO proposal passed NSF science review with high marks, but NSF did not fund the proposal due to budget considerations.



*ANET at
Whitmore
Mountains*

New Opportunities in Joint Geospace Observations

- **AMPERE**: Global field-aligned current system inferred from Iridium
- **SuperDARN**: Ionospheric conditions on both hemispheres
- **GDC, MMS, THEMIS**: *In situ* observations of fields and particles in the geospace



NASA Geospace Dynamics Constellation (GDC)

Summary

- Interhemispheric asymmetries of the geospace has become one of the most important unresolved problems in the solar terrestrial system.
- West Antarctica and Quebec are the only conjugate pair of lands with a continuous range of auroral latitudes.
- The PRIMO and AUTUMNX chains can bracket the auroral electrojets that produce the strongest type of magnetic perturbations on the Earth's surface.
- Conjugate observations are valuable in differentiating between magnetospheric and ionospheric contributions.
- PRIMO leverages previous efforts in ground-based magnetometry and field experiments in Antarctica.