# Space Physics

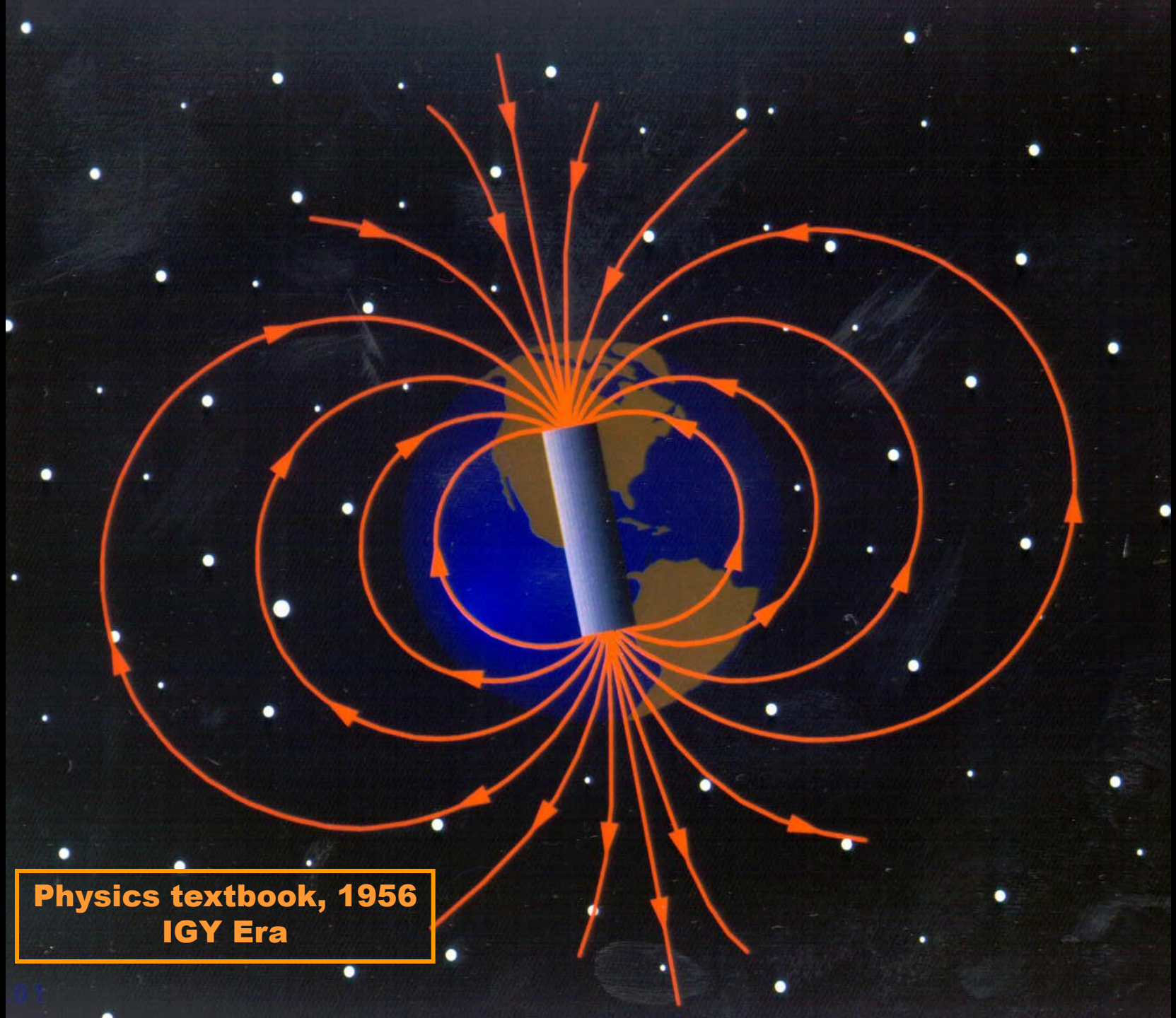
**Louis J. Lanzerotti**
**Center for Solar Terrestrial Research**
**New Jersey Institute of Technology**

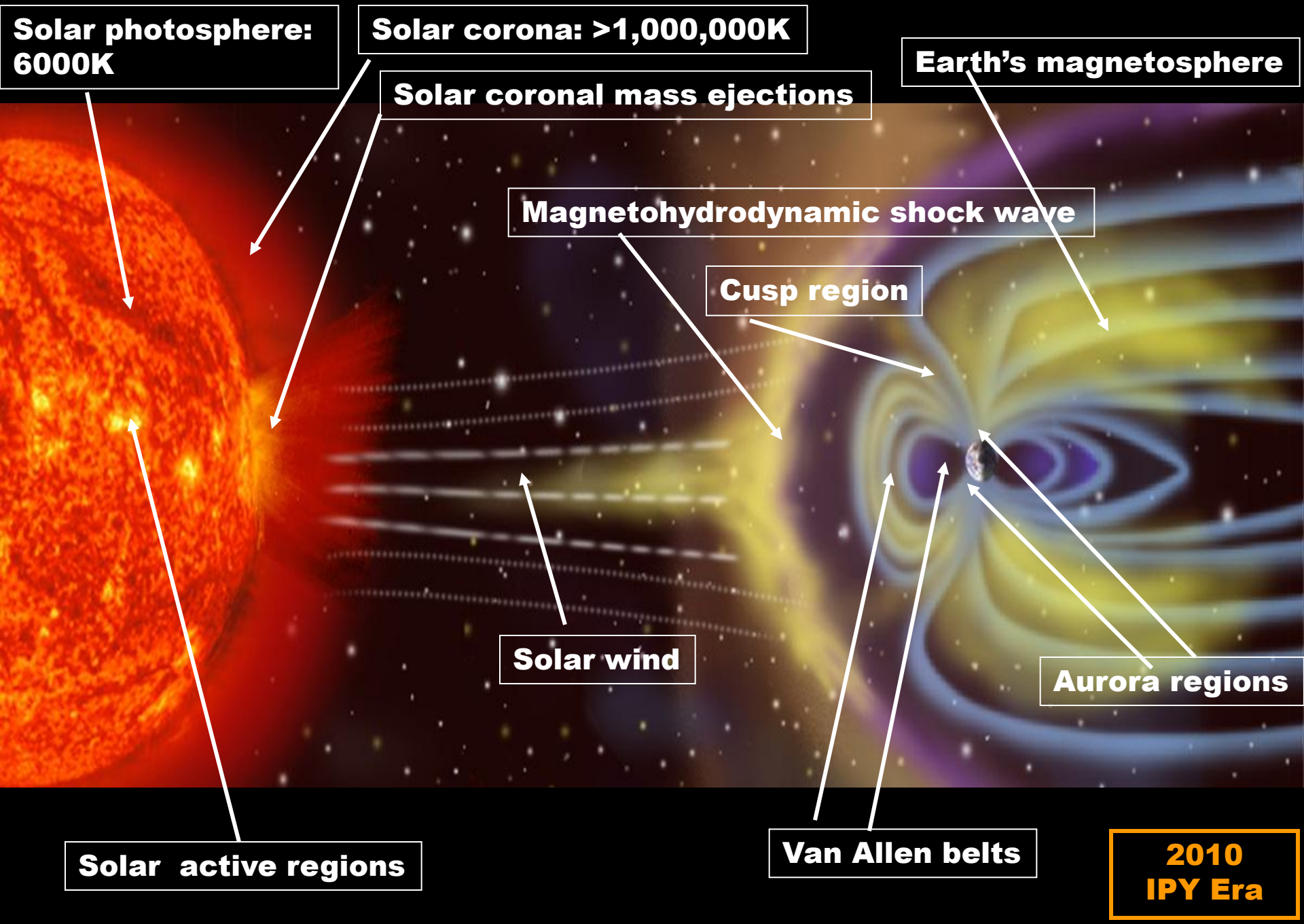
**Autonomous Polar Observing Systems Workshop**
**United States National Science Foundation**

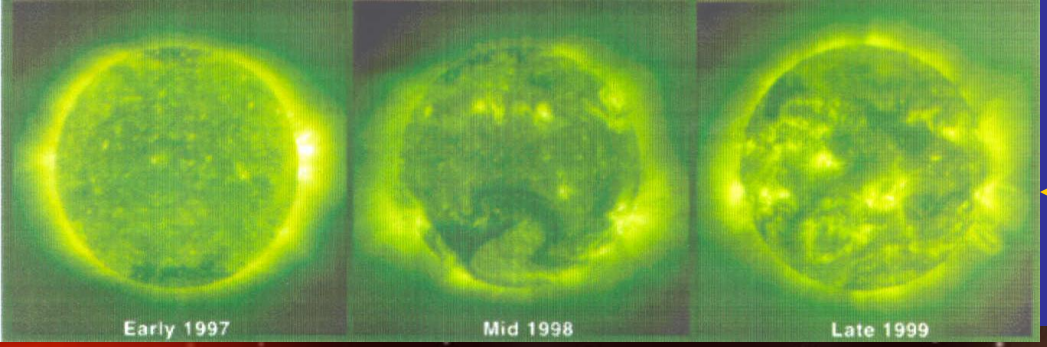
**Potomac, Maryland**
**30 September – 1 October 2010**

# Space Physics

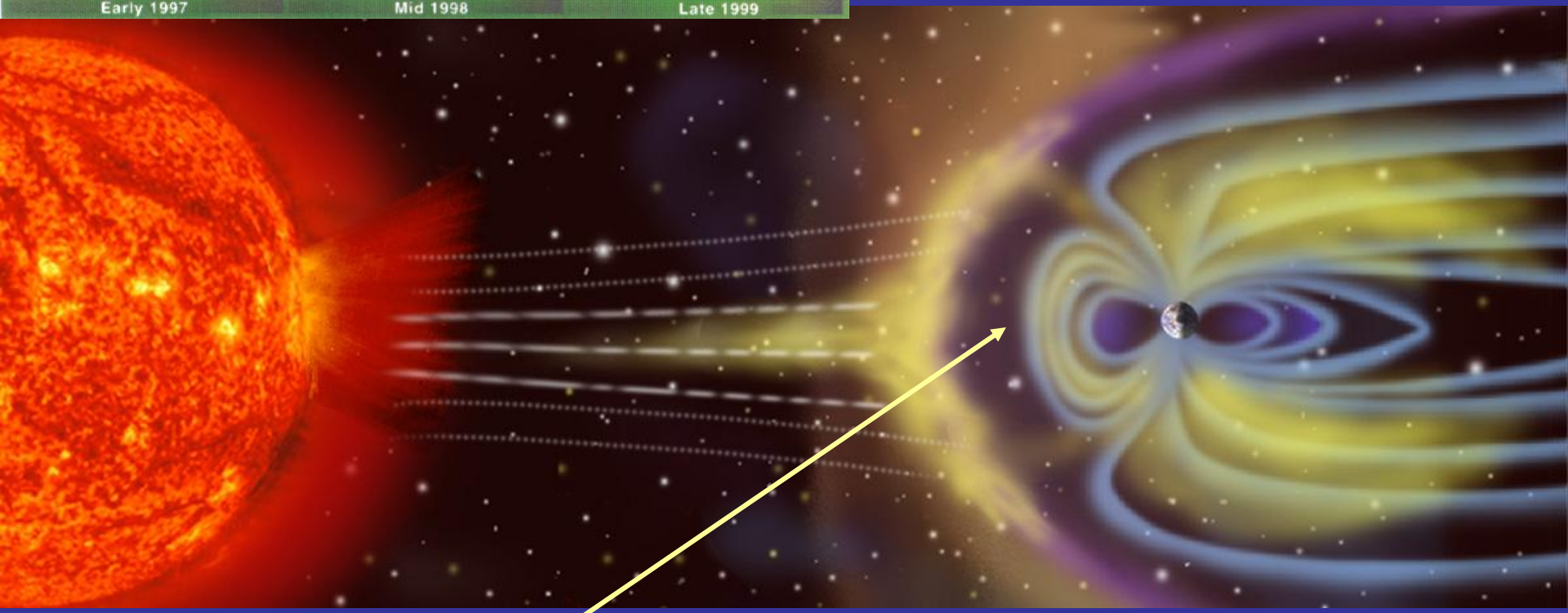
- IGY to IPY: Understandings of Earth's Space Environment
- Important Relevance for Operations of Many Modern Technologies
- Siple Station, Antarctica, to Cross Polar Cap Automatic Geophysical Observatory (AGO) Array: 1970s to Today
- Science and Model Validation: Example


Physics textbook, 1956
IGY Era


Solar photosphere: 6000K
Solar corona: >1,000,000K
Earth's magnetosphere
Solar coronal mass ejections
Magnetohydrodynamic shock wave
Cusp region
Solar wind
Aurora regions
Solar active regions
Van Allen belts
2010
IPY Era




**The Sun in ultra violet, solar minimum to near solar maximum (left to right)**

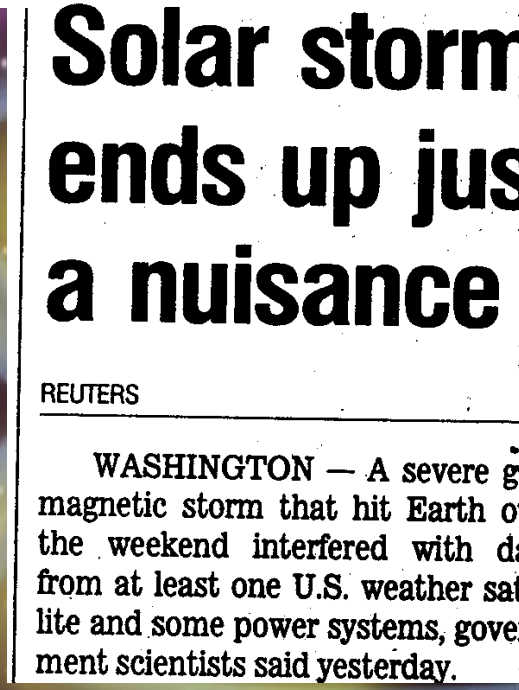


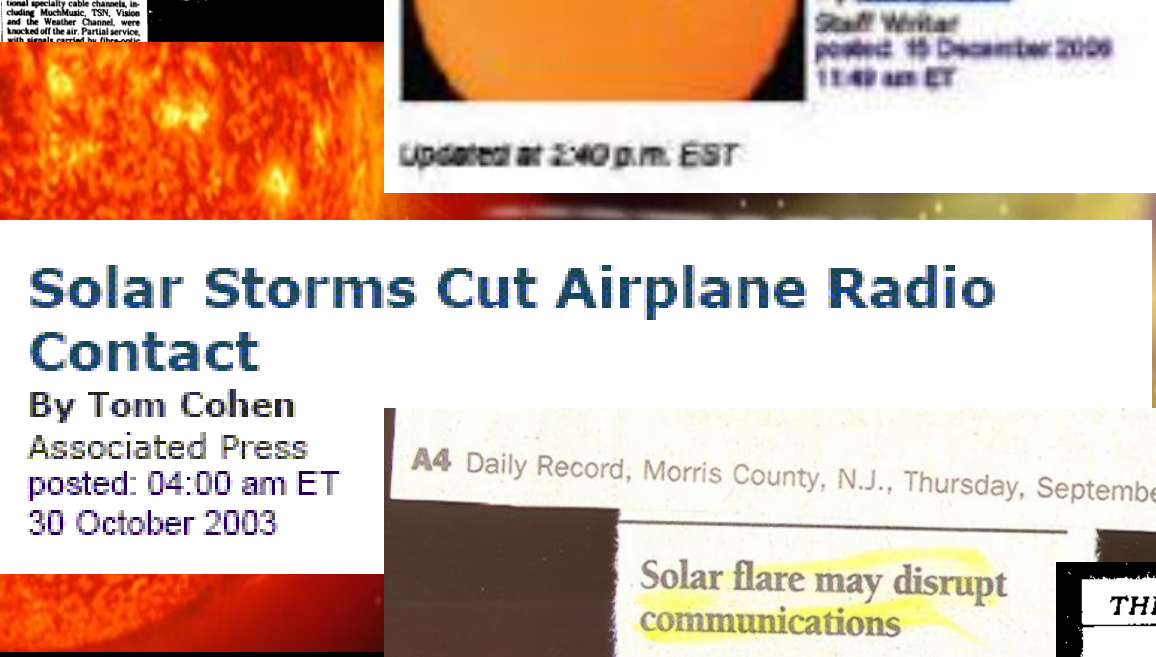
**Solar wind at Earth: about 10 particles per cubic cm**
**average velocity about 400km/sec**
**imbedded magnetic field about 0.0003 Earth's field at surface**


e Hamilton Spectat
Established 1846
P-ANIK!
High-tech chaos as satellites spin out of control
Plug pulled on phones, TV, radio, papers


Italy Blames Disruption of Comsat NATO Uses on Strong Solar Activity
PETER B. de SELDING, PARIS
Space News, January 15, 2007


Space Station Glitch Possibly Caused by Solar Flare
By Tariq Malik
Staff Writer
posted: 15 December 2006
11:49 am ET
Updated at 2:40 p.m. EST


MONDAY, JULY 17, 20
Solar storm ends up jus a nuisance
REUTERS
WASHINGTON — A severe g magnetic storm that hit Earth o the weekend interfered with da from at least one U.S. weather sat lite and some power systems, gove ment scientists said yesterday.

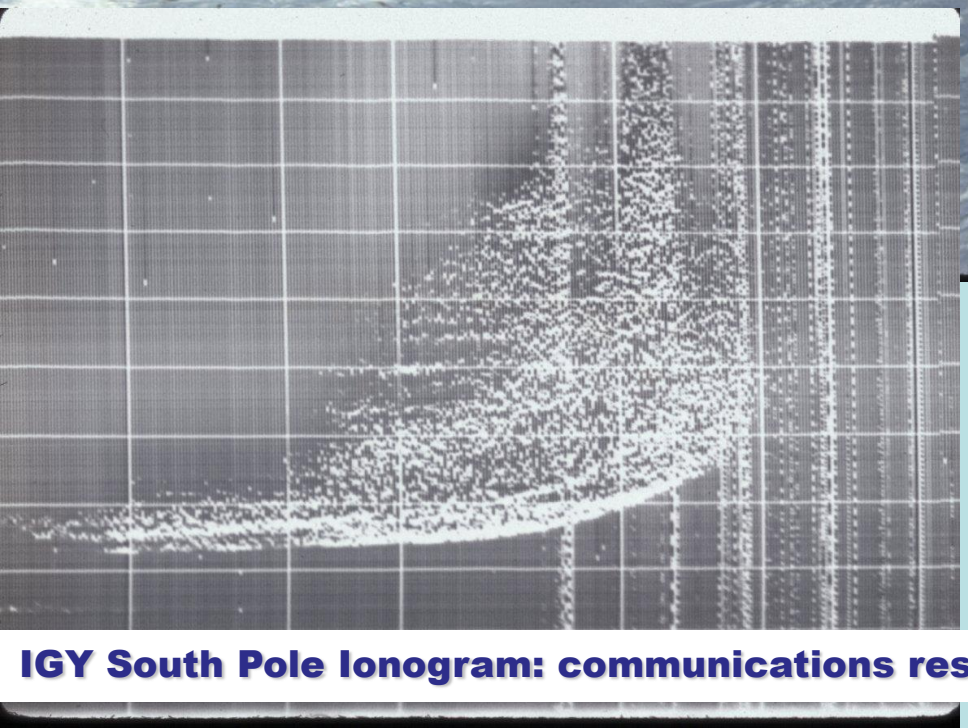

Solar Storms Cut Airplane Radio Contact
By Tom Cohen
Associated Press
posted: 04:00 am ET
30 October 2003


A4 Daily Record, Morris County, N.J., Thursday, September 8, 2005
Solar flare may disrupt communications
WASHINGTON (AP) — A large solar flare was reported Wednesday and forecasters warned of potential electrical and communications disruptions.
The flare was reported by

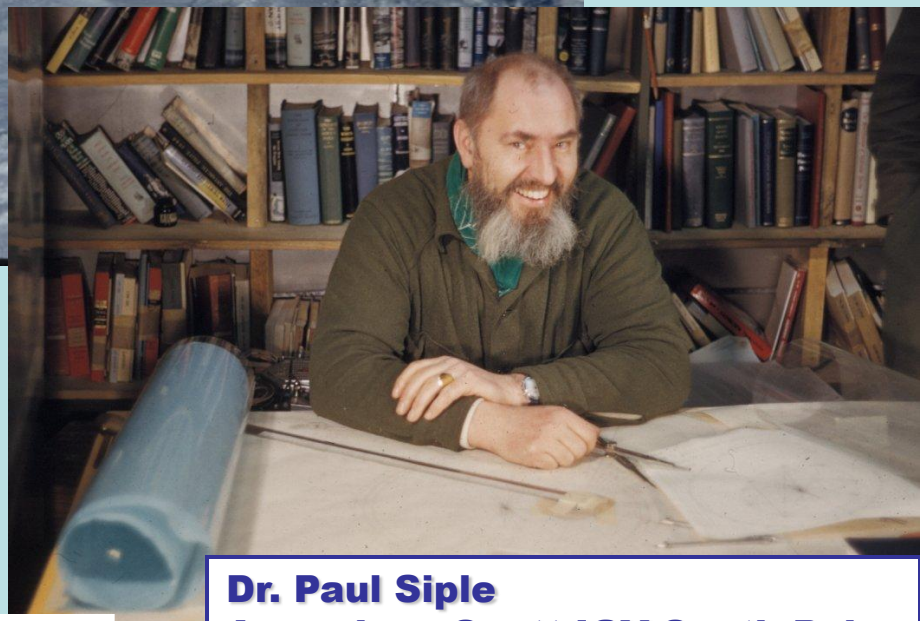

THE NEW YORK TIMES, WEDNESDAY, MARCH 8, 1989
Largest Solar Flaring in 5 Years Could Break Up Communications
By WILLIAM K. STEVENS

# Amundsen-Scott IGY South-Pole Station 12 February 1957

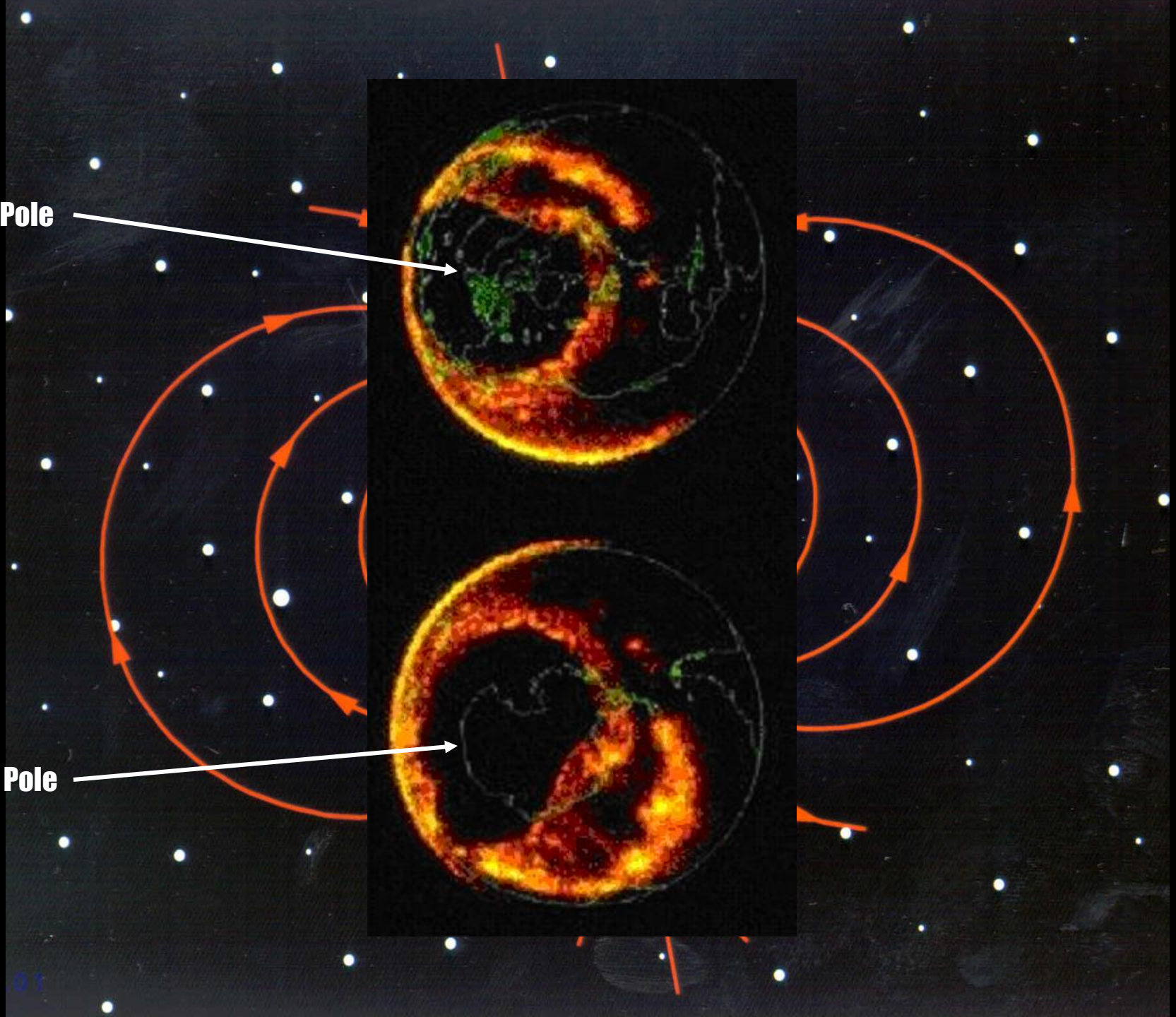
(All pictures courtesy of Dr. Robert Benson, IGY South Pole winter over)



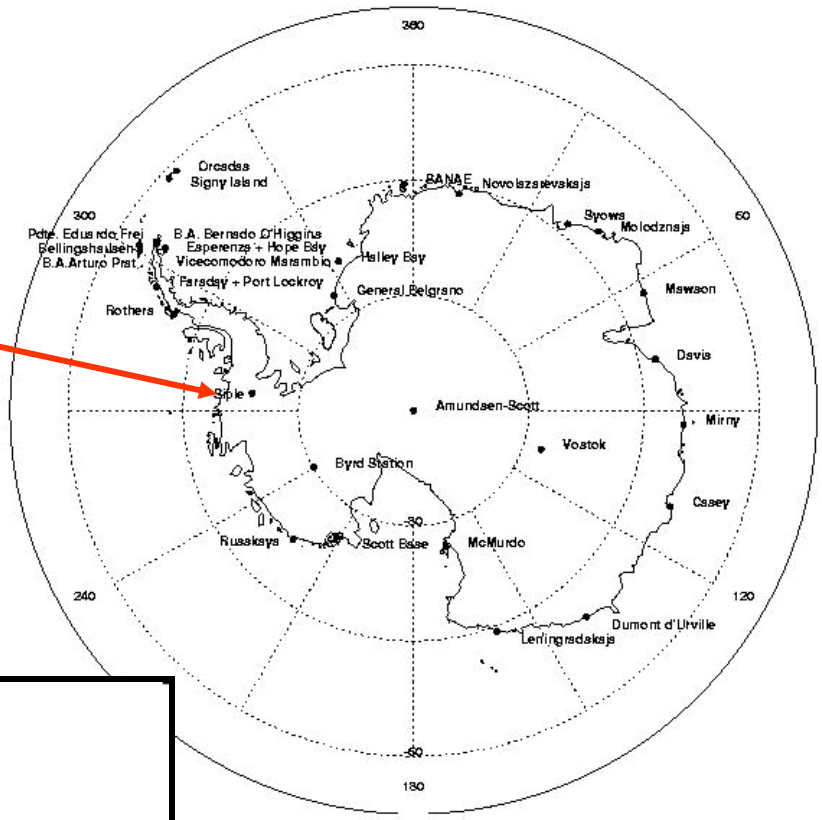
IGY South Pole Ionogram: communications research

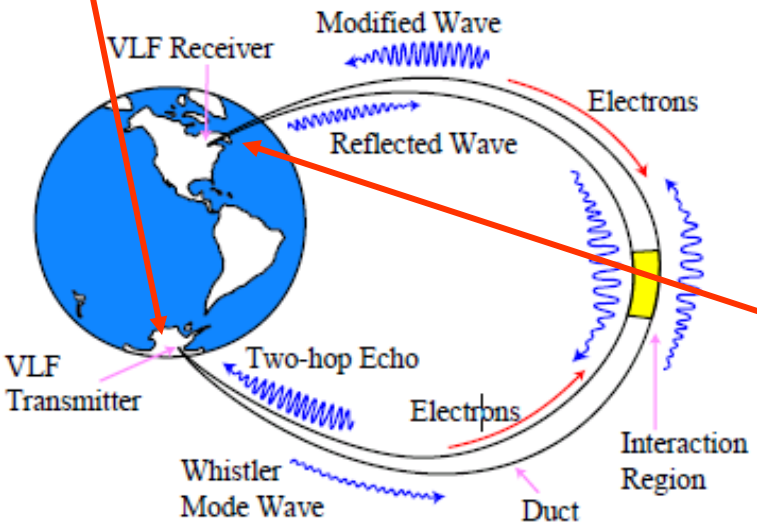


Dr. Paul Siple
Amundsen-Scott IGY South-Pole Station Leader


North Pole
South Pole

# The beginnings: early 1970s onward .....


**Four stations spaced in latitude around northern hemisphere conjugate area**

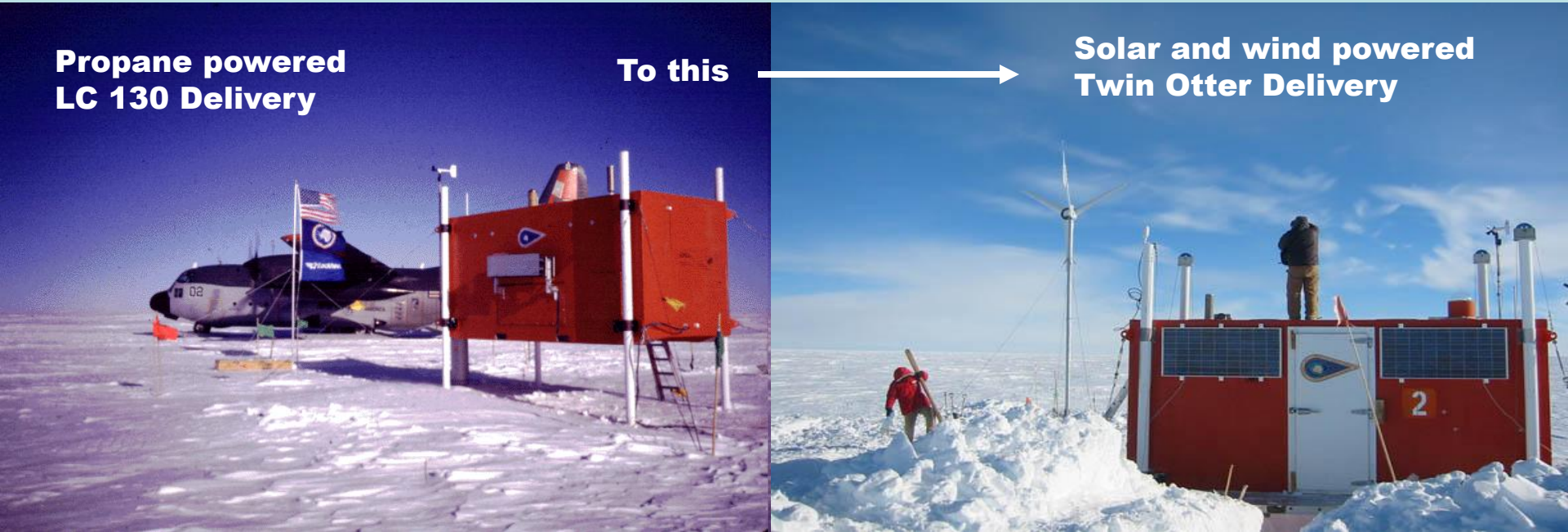
## Very brief, incomplete, personal "history":

Move instrumentation to South Pole: magnetometers (fluxgate and induction coil), photometers, all-sky camera, VLF receivers: Early 1980s
U. Maryland, Stanford, U. New Hampshire, Bell Laboratories, Tohoku U.

Close to magnetosphere boundary at certain times of day and under certain solar/geomagnetic activity conditions
South Pole conjugate site near Iqualuit, Nunavut, Canada

Recognized importance of latitude studies and conjugate studies with comprehensive set of low power instrumentation

Began workshops and design studies for comprehensive experimental program in Antarctica: Late 1980s onward ……



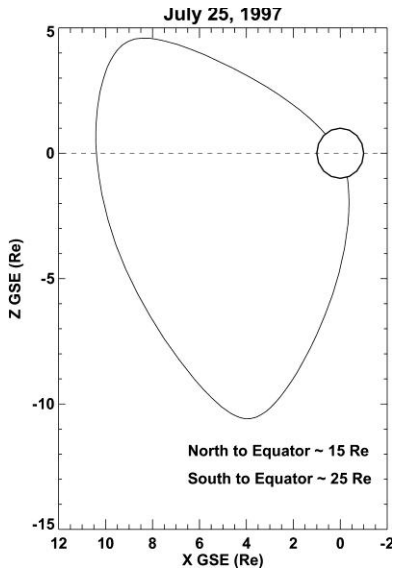
# Global arrays of instruments provide one of the best resources for investigating the Atmosphere-Ionosphere-Magnetosphere system and validating models

- **Geomagnetic poles are intrinsically asymmetric against the Earth's rotation axis: shifted by ~ 9° toward central Canada in the north and ~15° in the Antarctic.**

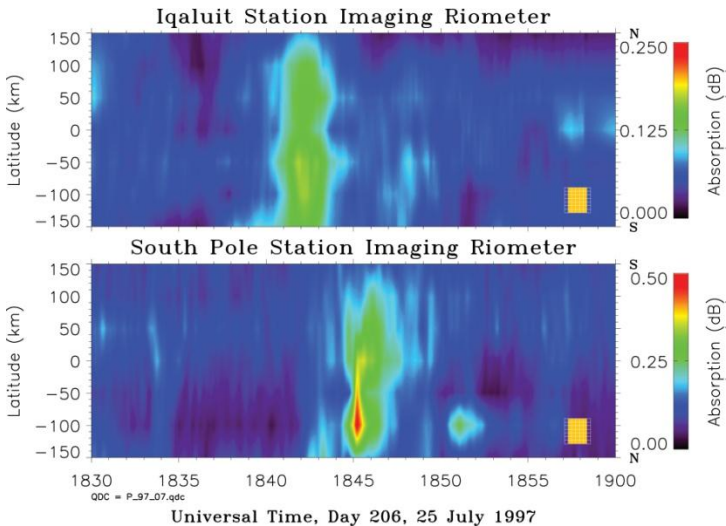
- **Large asymmetries introduced in the distribution of physical quantities and characteristics in the two polar regions.**

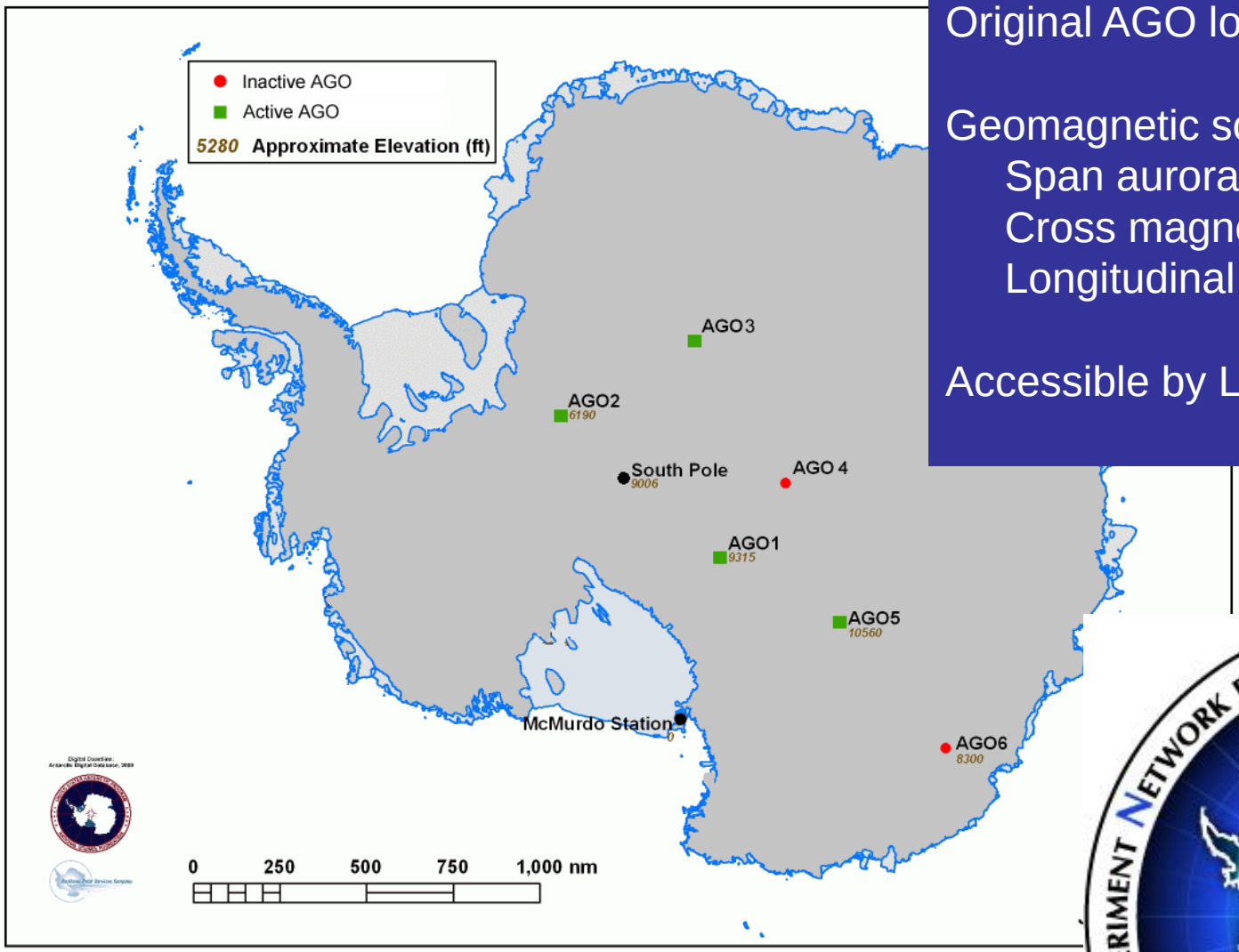
- **Intense scientific and practical interests to investigate both polar regions to achieve global understanding required for accurate space weather models and space environment forecasts.**

- ***Only Antarctic continent has land mass for extended geomagnetic range of investigations***




*Murr et al, JGR, 2002*





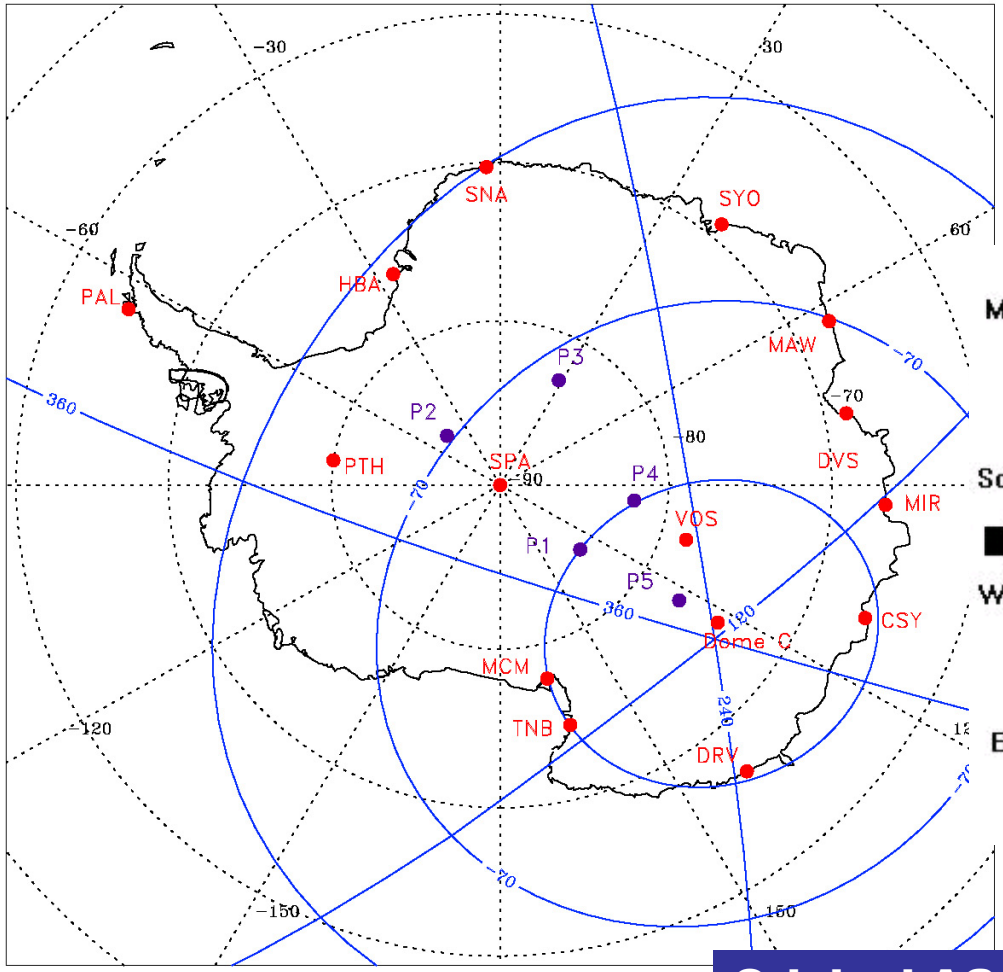

Original AGO locations determined by:

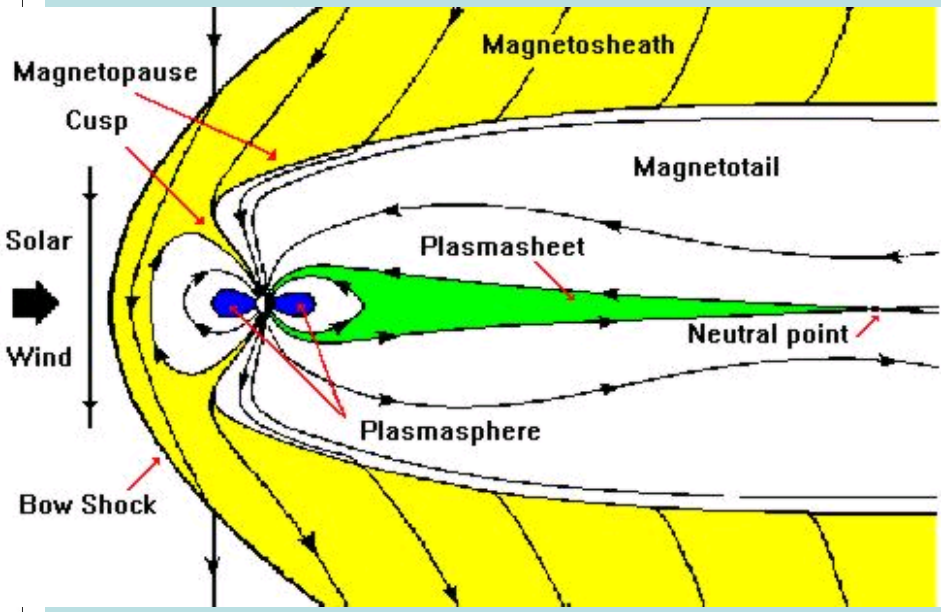
Geomagnetic science requirements:

- Span auroral zone to the pole
- Cross magnetosphere cusp latitude
- Longitudinal spacing as feasible

Accessible by LC130 Hercules

POLAR EXPERIMENT NETWORK FOR GEOSPACE UPPER-ATMOSPHERE INVESTIGATIONS
PENGUIN

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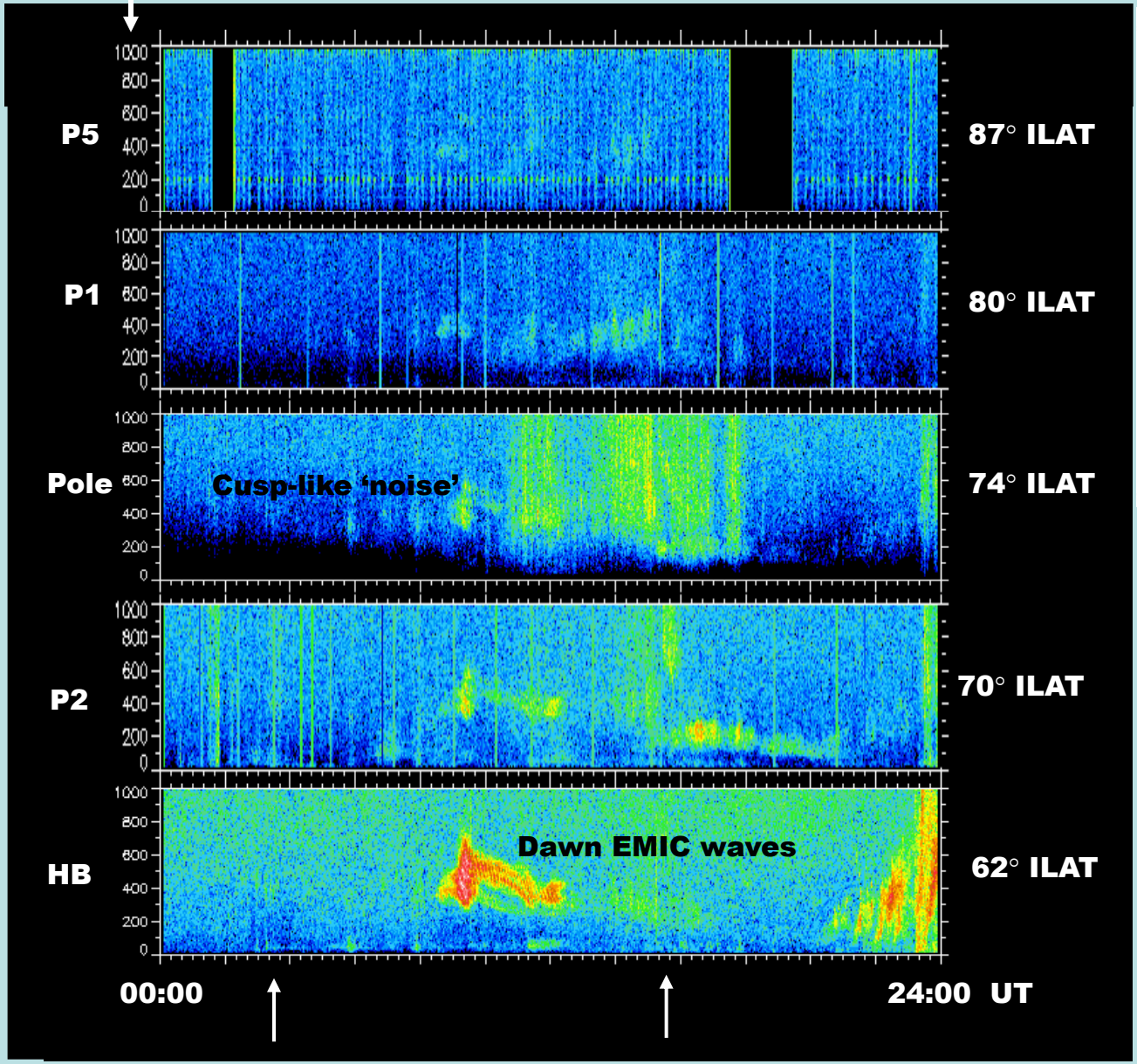
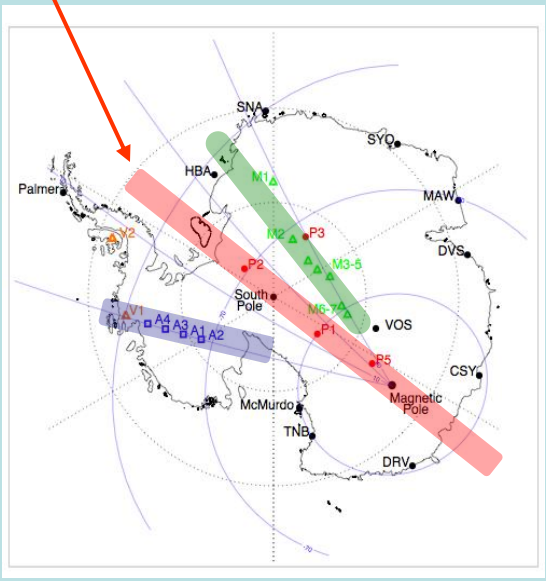
**Accessible by LC130 Hercules**

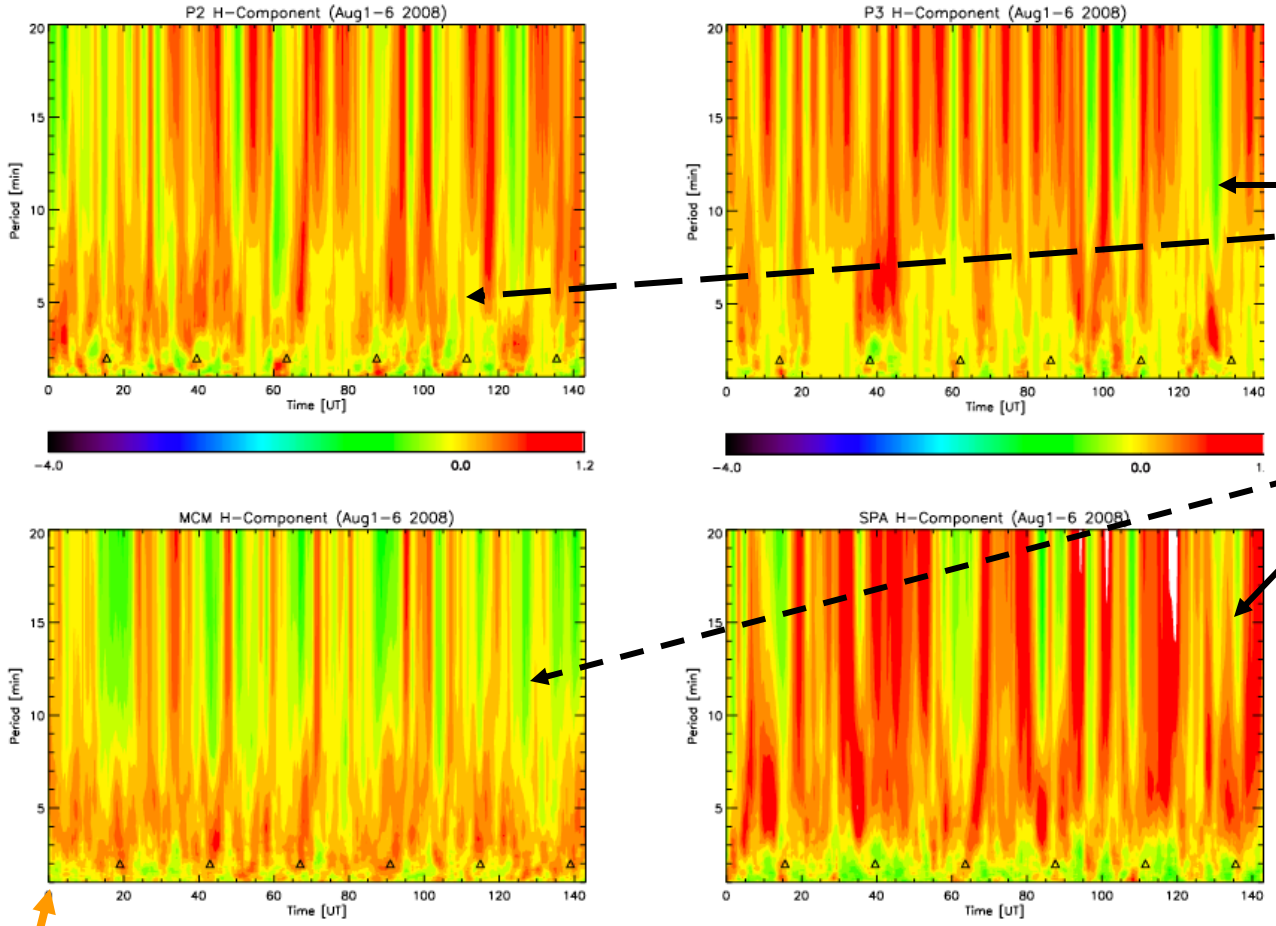
**Induction coil magnetometer data, acquired along the "red line"**
**Left hand vertical scale: frequency in mHz**

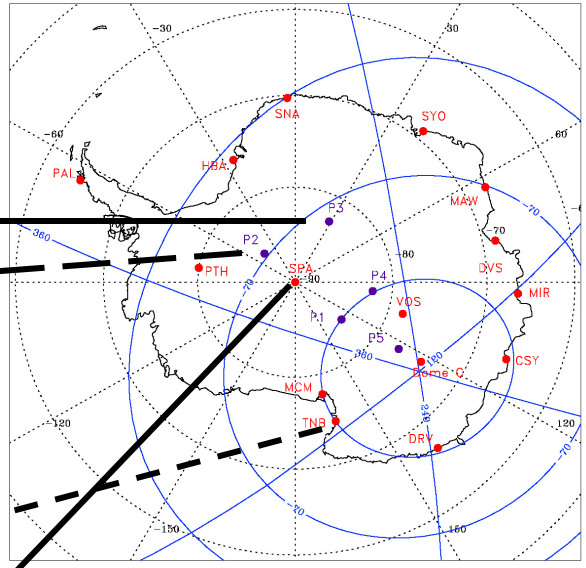


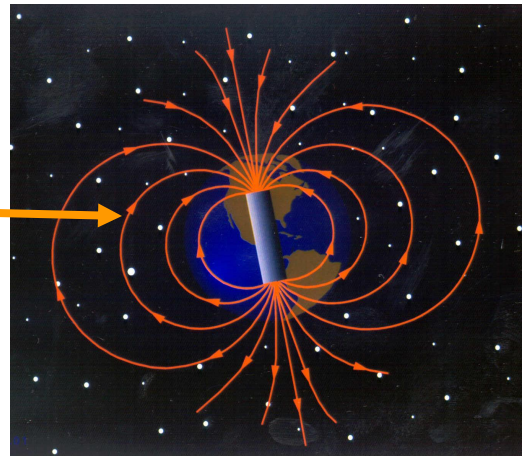

**Example:**
Latitude dependence of space plasma waves:
Only feasible in Antarctica.

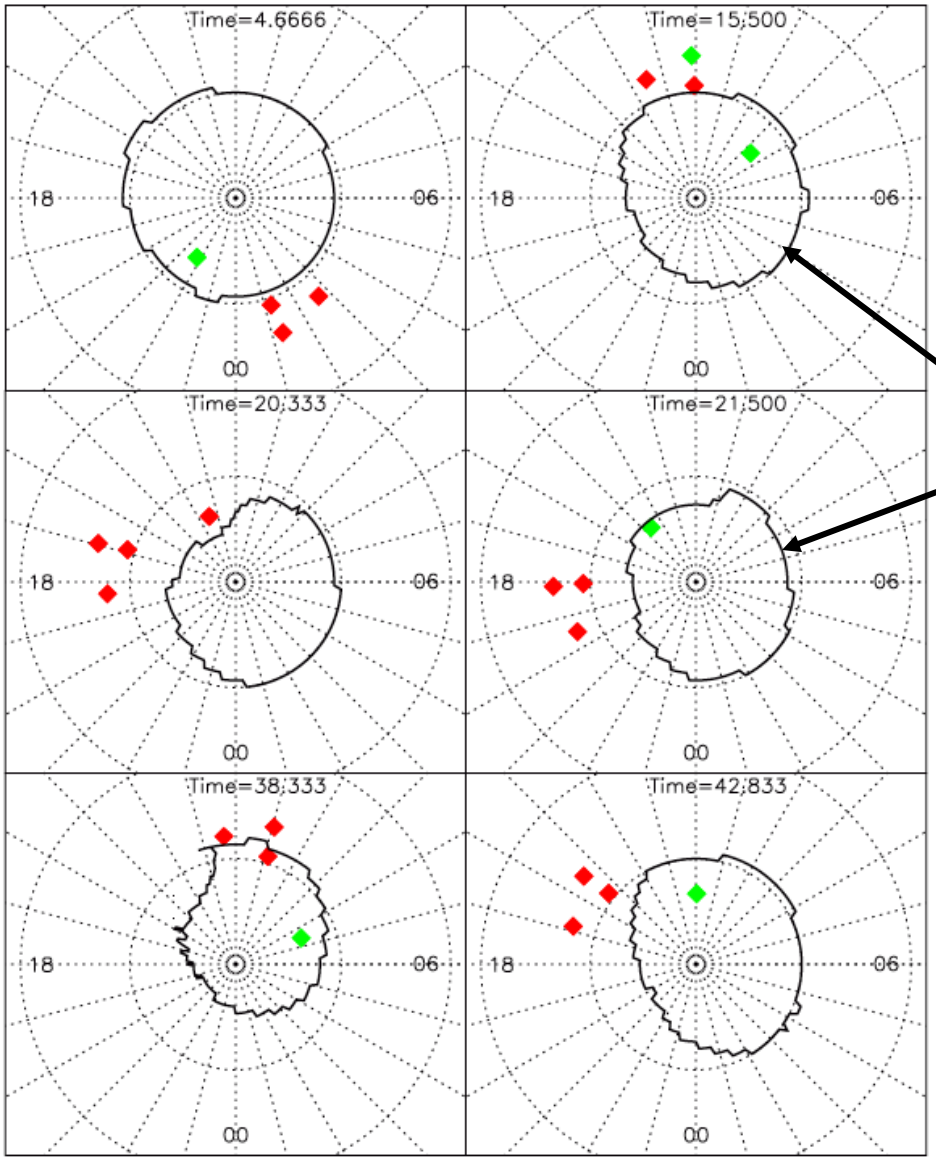
# Determine magnetosphere boundary: observation and model validations




**Standing plasma waves (Alfvén Waves) on geomagnetic field lines. Spectral analysis of geomagnetic field fluctuations provides measurements of field line lengths and thus open and closed lines.**



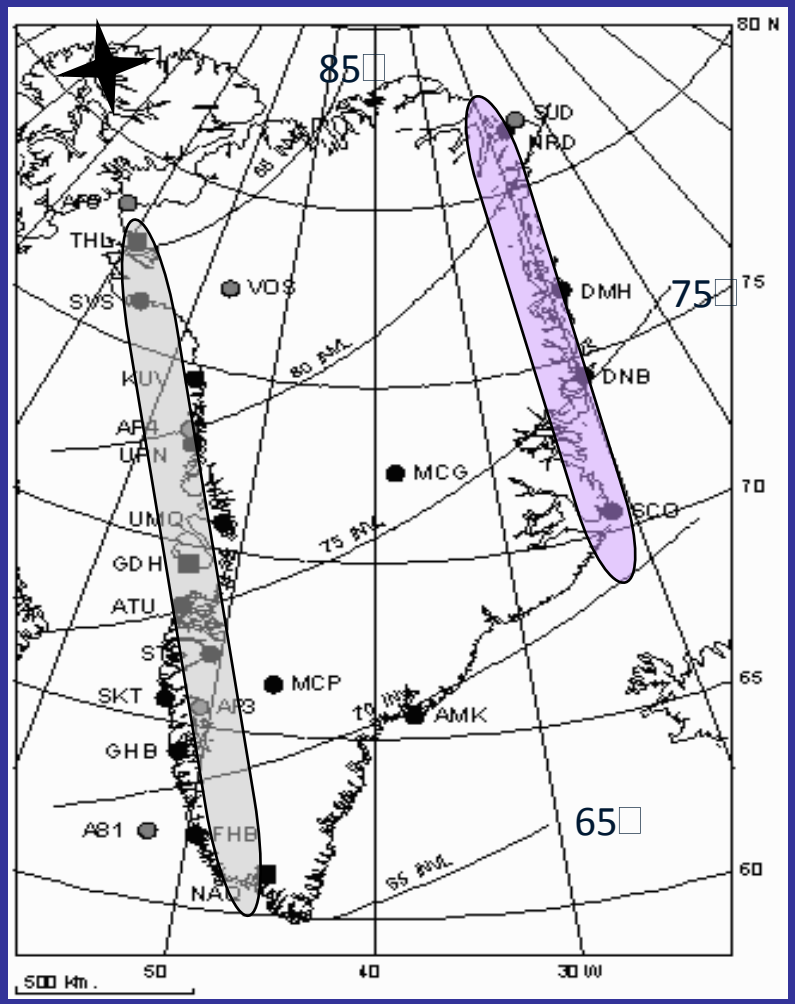



**Comparison of experimentally-determined open field lines [green] and closed field lines [red] as measured by the presence of "Pc5" magnetic field oscillations (plasma waves to the predicted open-closed boundary by the BATSRUS (U. Michigan) model.**

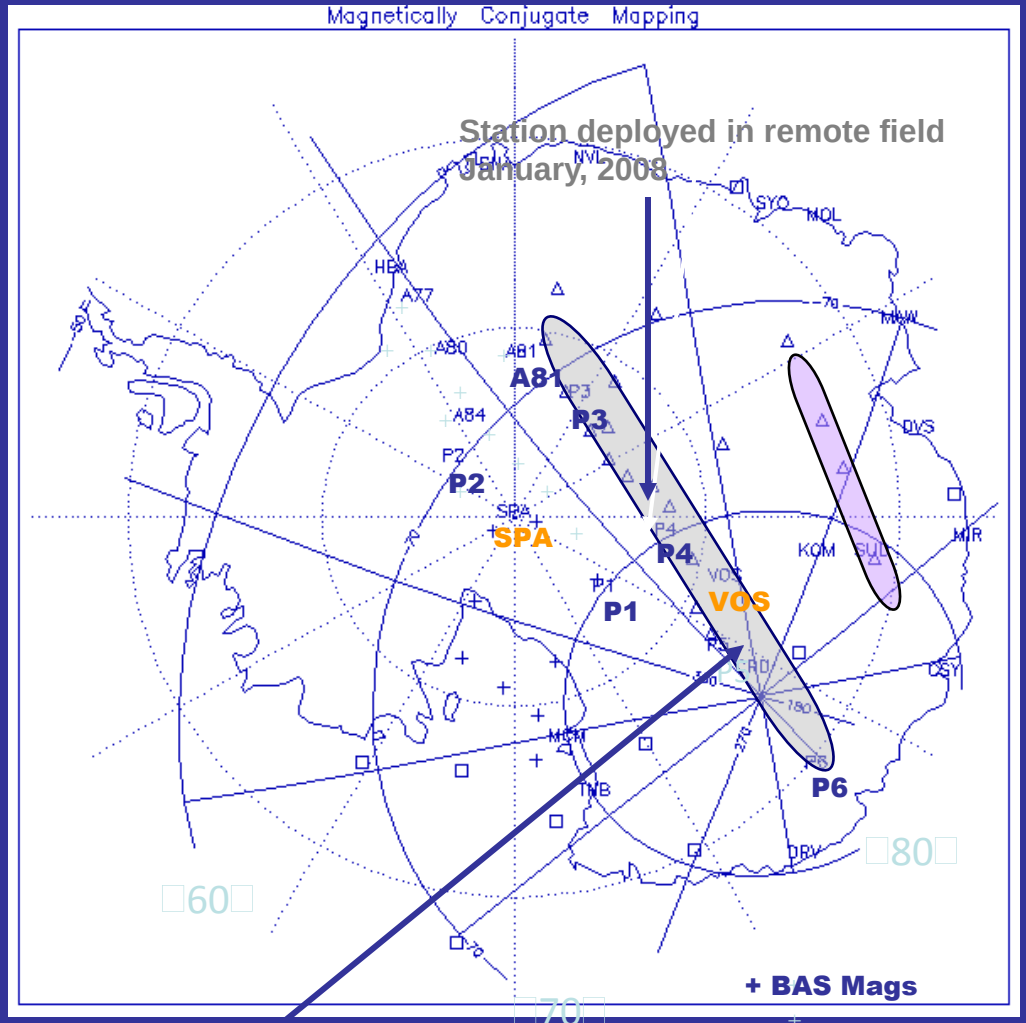
**Pre-magnetic storm period.**
**Model uses measured interplanetary solar wind data at each of the event time intervals.**

**K. Urban et al., J. Geophys. Res., 2010**

# Polar Regions Geomagnetic Conjugacy
## Greenland and Eastern Antarctica: Global Space Environment




Greenland Magnetometer Chains
West: ~40° CGM meridian (12)




Eastern Antarctica Magnetometer Sites
~40° CGM meridian (6)

C. R. Clauer. Virginia Tech, 2010

## THUS Antarctica is a ***Geospace Observatory Platform:***

- **Geomagnetic activity and substorms at the highest geomagnetic latitudes**
- **Determination of dynamics of magnetosphere boundary**
- **Dayside physical processes (such as magnetic impulse events and traveling convection vortices) that transfer energy from interplanetary medium to Earth's space environment**
- **Auroral zone dynamics driven by solar activity**

## LEADING to better understanding and prediction of ***space weather*** processes that impact technologies on Earth and in near-Earth space, including:

- **Radiation belt particle energization and loss into ionosphere**
- **Effects of solar particles incident on polar cap ionosphere**
- **Enabling kinetic and MHD modeling of physical processes**

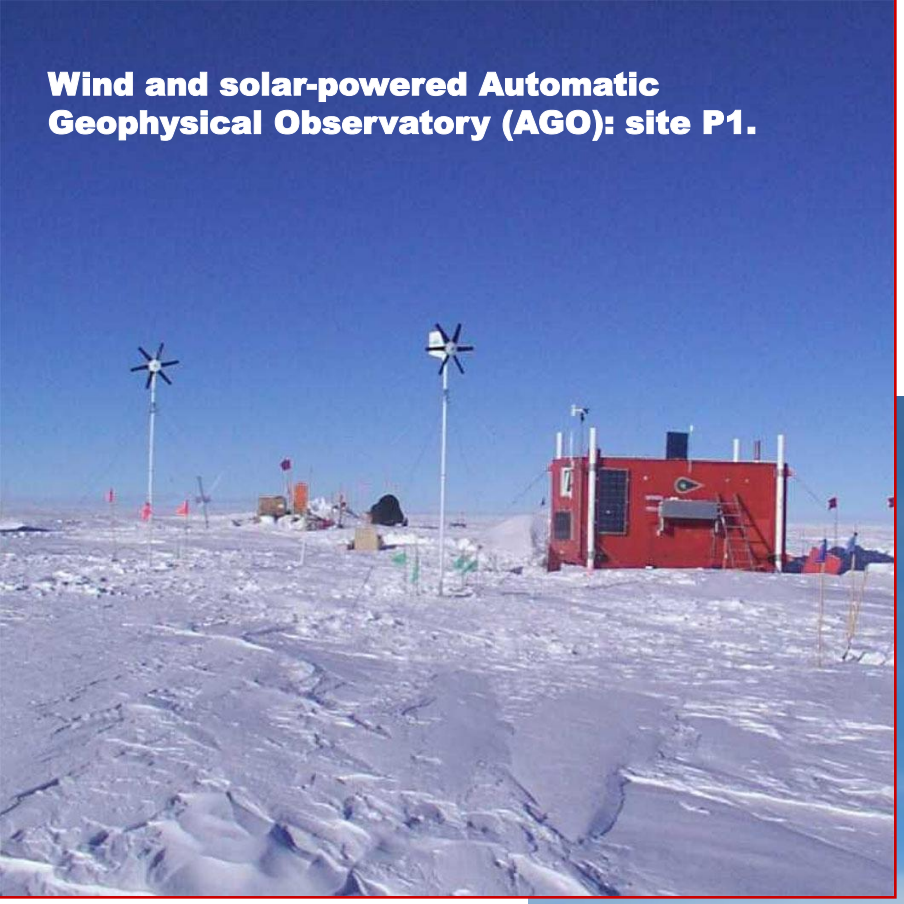
# Space Physics

## SUMMARY

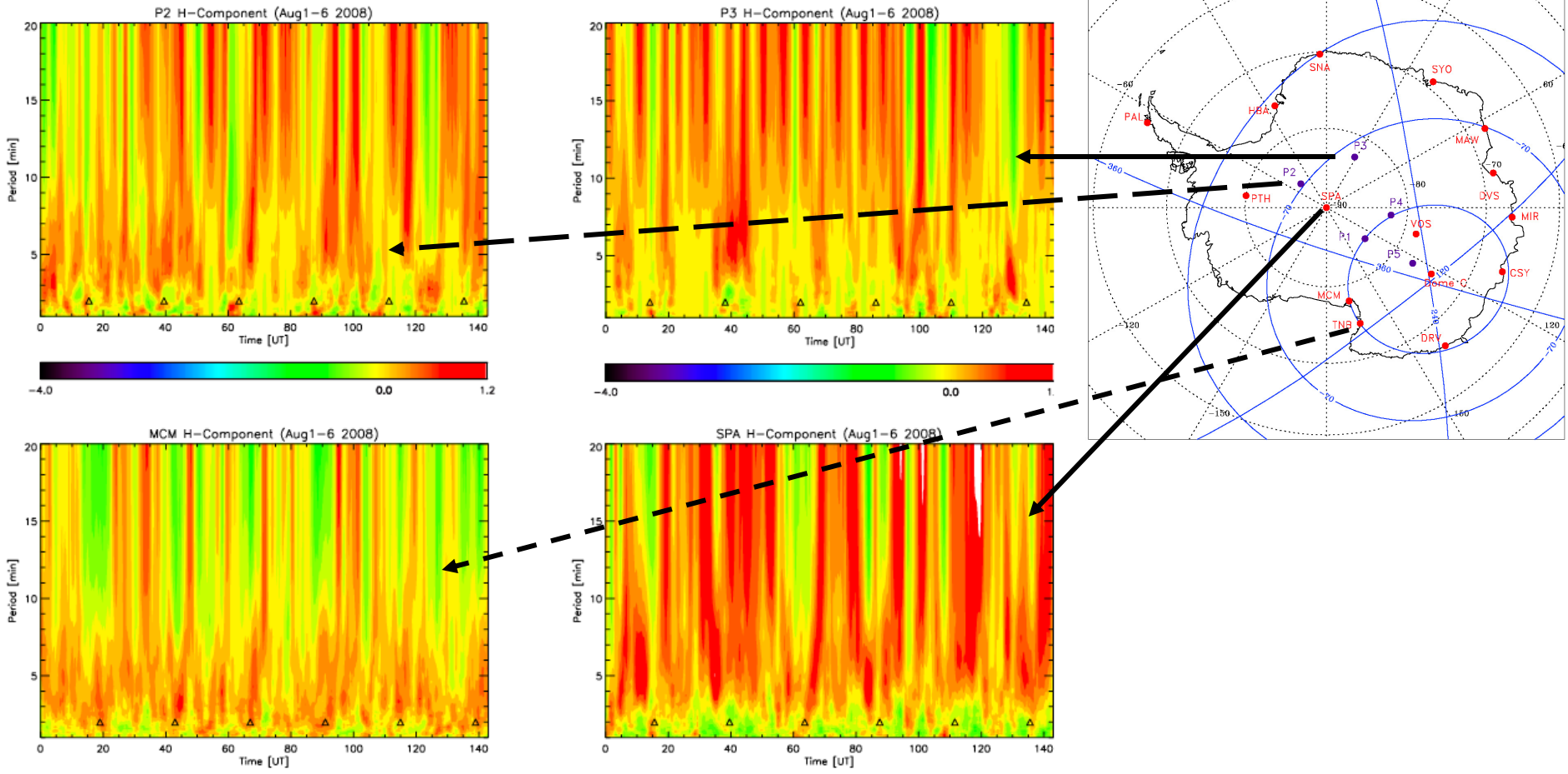
- IGY to IPY: Understandings of Earth's Space Environment
- Important Relevance for Operations of Many Modern Technologies
- Siple Station, Antarctica, to Cross Polar Cap Automatic Geophysical Observatory (AGO) Array: 1970s to Today
- Science and Model Validation: Example
- The Future: Denser Conjugate Arrays; Close Coupling of Models and Observations; Model Validations;
  Space/Ground Observations and comparisons; Better Forecasts
  Presentation Today by Bob Melville


Thank You!

**Wind and solar-powered Automatic Geophysical Observatory (AGO): site P1.**



# Determine magnetosphere boundary: observation and model validations




**Residual power spectral density of fluxgate magnetometer north-south variations from P2, P3, MCM, and SPA, beginning 7 August 2008. Solar wind disturbance hits Earth's magnetosphere on the UT morning of August 9 (i.e., hour 48). Frequency components change after storm time.**