

# Geospace Measurements from the Antarctic Polar Cap: Efforts Enabled by the Polar Engineering Development Center (PEDC)

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# What is the PEDC?

The PEDC, housed at the New Jersey Institute, consists of a highly skilled group of collegiate professors, research scientists, electrical and mechanical engineers, and technicians that have decades of experience in instrument and hardware design for deployment at high latitude/polar regions.

Now supported by NSF and reaching out to serve the broader astrophysical and geospace scientific communities conducting research in polar environments by providing support in the areas of:

- (a) sustainable “green” power generation in the 10-W to 500-W range,
- (b) power conditioning and control,
- (c) robust engineering for polar climates,
- (d) data acquisition techniques, units, and transmission services, and
- (e) general polar field support.

The original group was formed in the 1980’s as part of the NSF-supported Automatic Geophysical Observatory (AGO) program which operates to this day on projects active across the Antarctic ice shelf. ***And which we are most known for...***

# US AGO Program



AGO at SPA in 1983.



AGO at McMurdo in 1991.

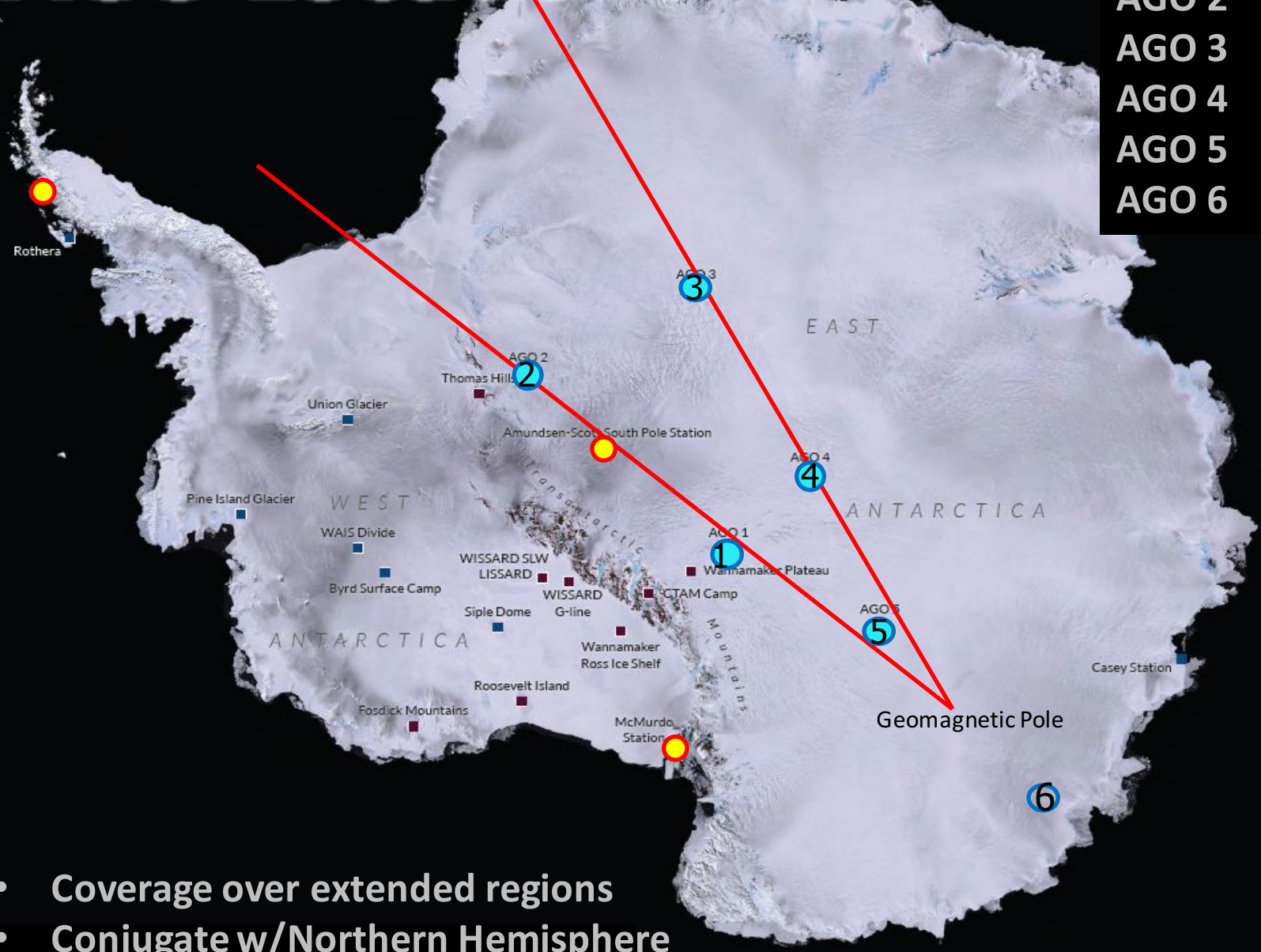


AGO	Date established
AGO-1	January 1994
AGO-2	December 1992
AGO-3	January 1995
AGO-4	January 1994
AGO-5	January 1996
AGO-6	February 1997



# AGO Locations

AGO 1	9,400 ft.
AGO 2	6,102 ft.
AGO 3	9,554 ft.
AGO 4	11,696 ft.
AGO 5	10,118 ft.
AGO 6	(8,300 ft.)



- Coverage over extended regions
- Conjugate w/Northern Hemisphere
- 24-hour darkness in dayside auroral zone

# Current Power



## Solar Panels

Four total (2 x 2)

Each rated 240-W

50-W shaded side

## African Windpower 3.6 Turbine

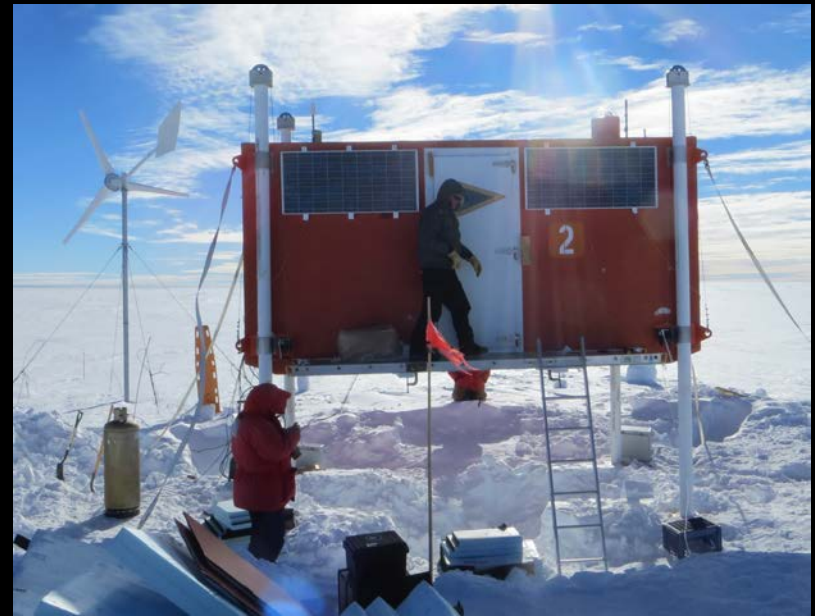
Permanent magnet alternator

Can supply over 1,000 watts

***THE ENGINEERING TO KEEP  
THESE SYSTEMS ALIVE IS  
NON-TRIVIAL!***

# AGO Instrumentation

- All AGOs:
  - Fluxgate Magnetometers (Augsburg)
  - Search Coil Magnetometers
  - Imaging Riometer
  - Auroral All-Sky Systems
- Select AGOs:
  - GPS
  - VLF (Stanford)
  - HF



AGO data is available from individual PIs. AGO fluxgate data will be available from [antarcticgeospace.njit.edu](http://antarcticgeospace.njit.edu) very soon.



# McMurdo & South Pole Data

- Fluxgate Magnetometer
- Search Coil Magnetometer
- Photometer
- Riometer
- VLF Receiver



*McMurdo Station*



*South Pole Station*

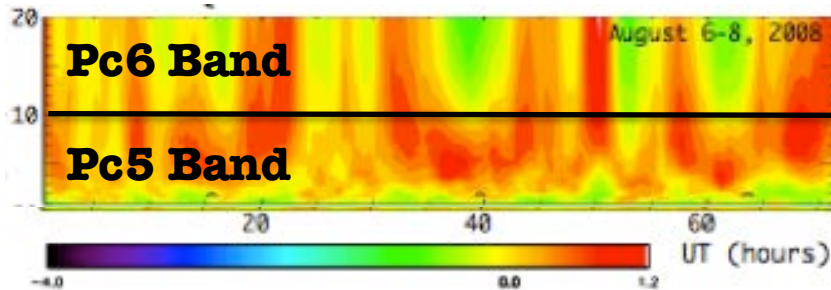
MCM and SPA data are available at [antarcticgeospace.njit.edu](http://antarcticgeospace.njit.edu).

**WHAT HAS THIS ENABLED?**



# 1. Automating Open/Closed Field Line Determinations

To automate open/closed field line determinations, we looked at band integrations over the Pc5 and Pc6 bands at each site, using the distribution at the highest-latitude site to define the open/closed threshold in each band.

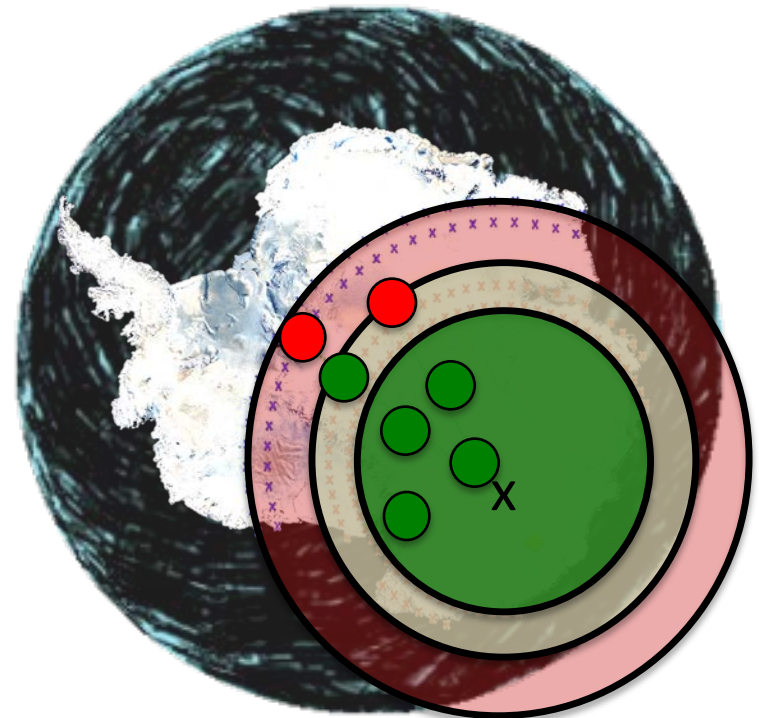


Open or Closed: Does wave power exceed threshold in both bands?

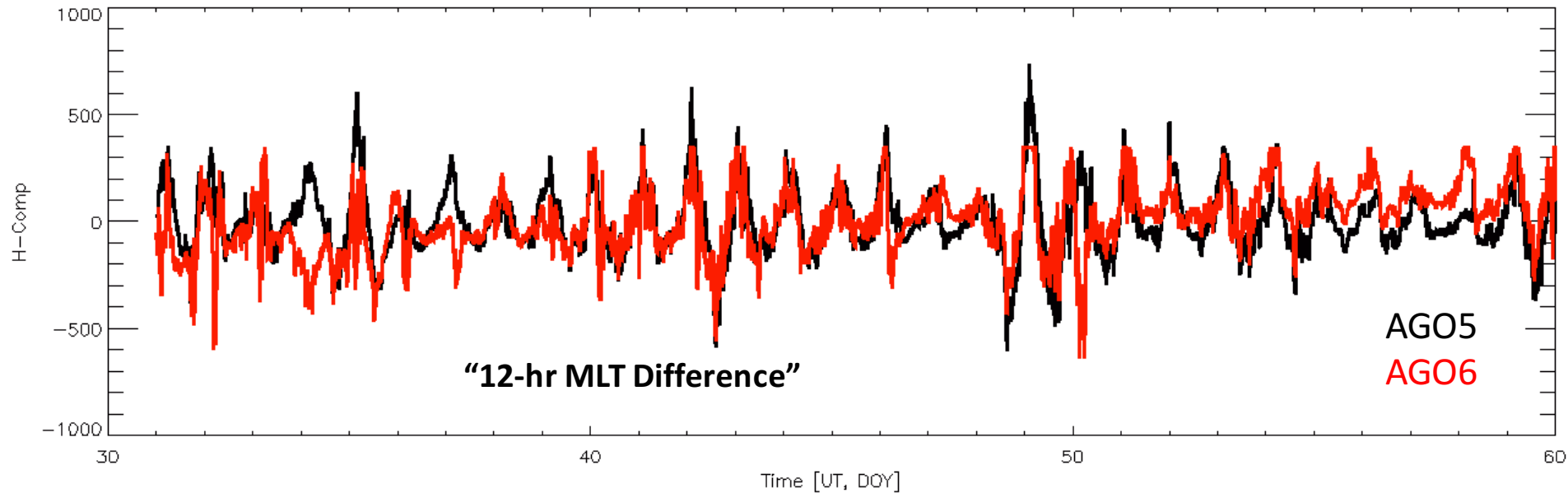
	Pc6	Yes	No	Yes	No	Yes	No	Yes
			<b>OPEN</b>	<b>CLOSED</b>				
	Pc5	Yes	No	Yes	No	Yes		

*ALL 5 AGOS + SPA + MCM ARE CURRENTLY REPORTING SYNOTPIC FLUXGATE DATA!!!*

Urban, K. D., A. J. Gerrard, Y. Bhattacharya, A. J. Ridley, L. J. Lanzerotti, and A. T. Weatherwax (2011), Quiet time observations of the open-closed boundary prior to the CIR-induced storm of 9 August 2008, *Space Weather*, 9, S11001, doi:10.1029/2011SW000688.

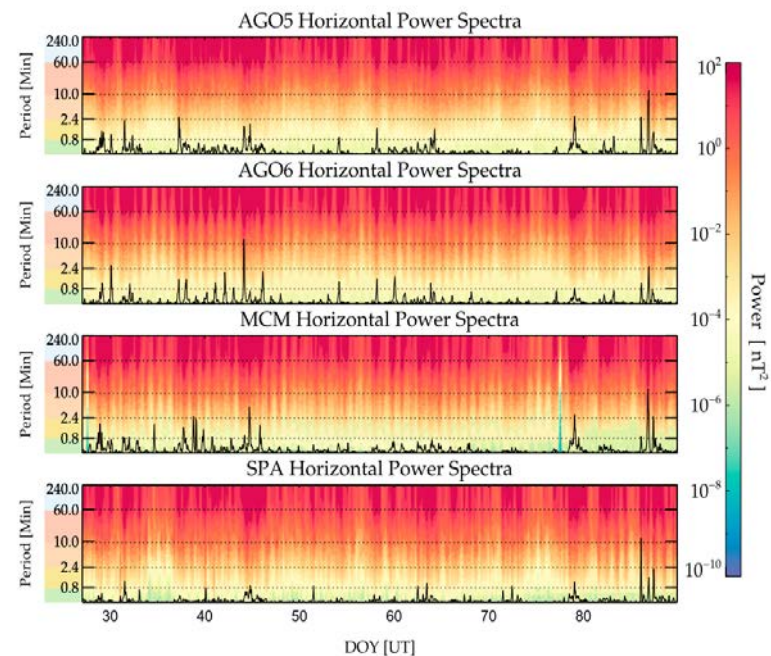


## 2. Where is the Geomagnetic Pole?



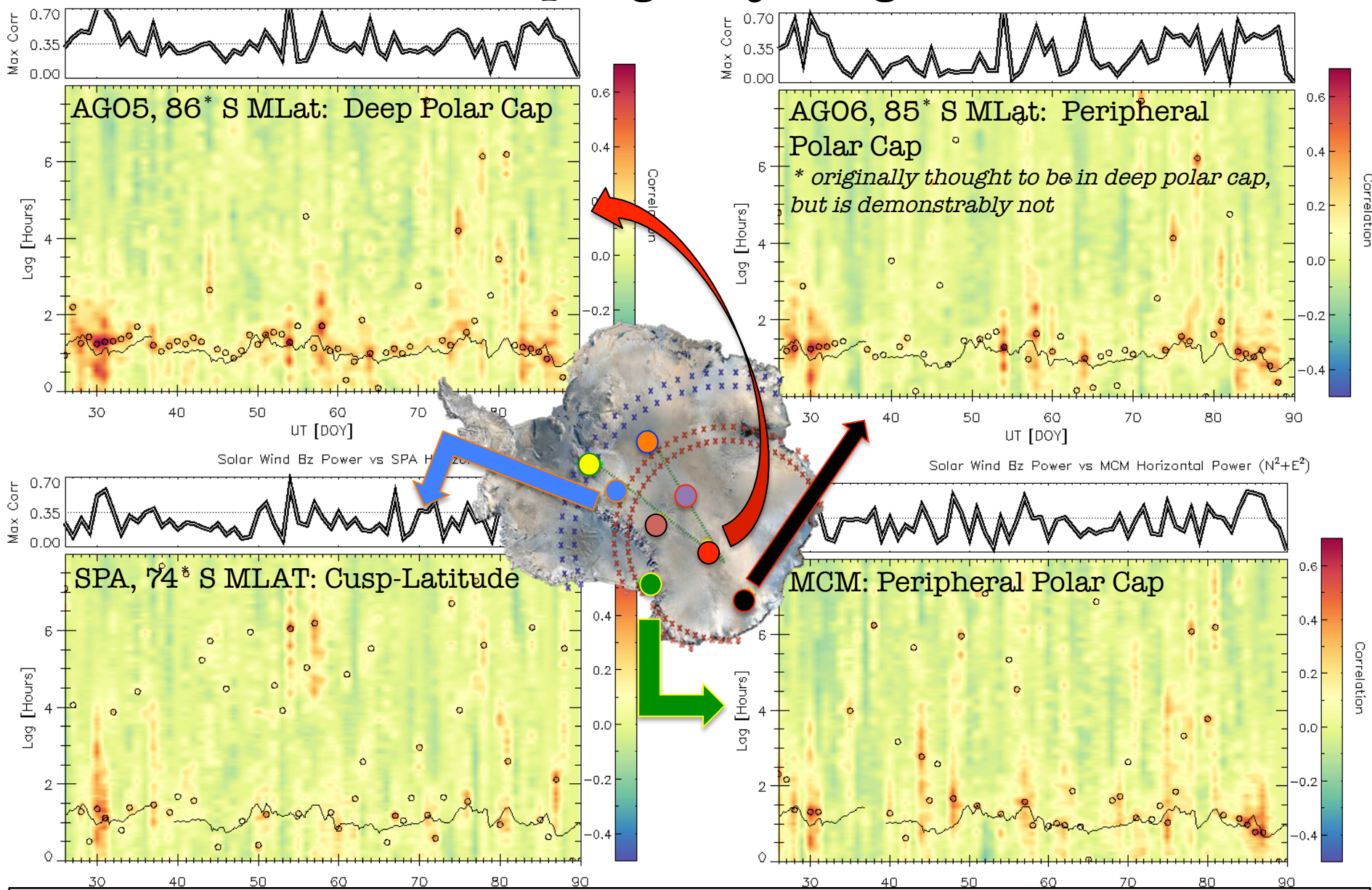
*CGM latitudes cannot be used to infer the local-time ULF power observed at sites distributed in and around the nominal polar cap*

Urban, K. D., A. J. Gerrard, L. J. Lanzerotti, and A. T. Weatherwax (2016), Rethinking the polar cap: Eccentric dipole structuring of ULF power at the highest corrected geomagnetic latitudes, *J. Geophys. Res. Space Physics*, 121, 8475–8507, doi:10.1002/2016JA022567.





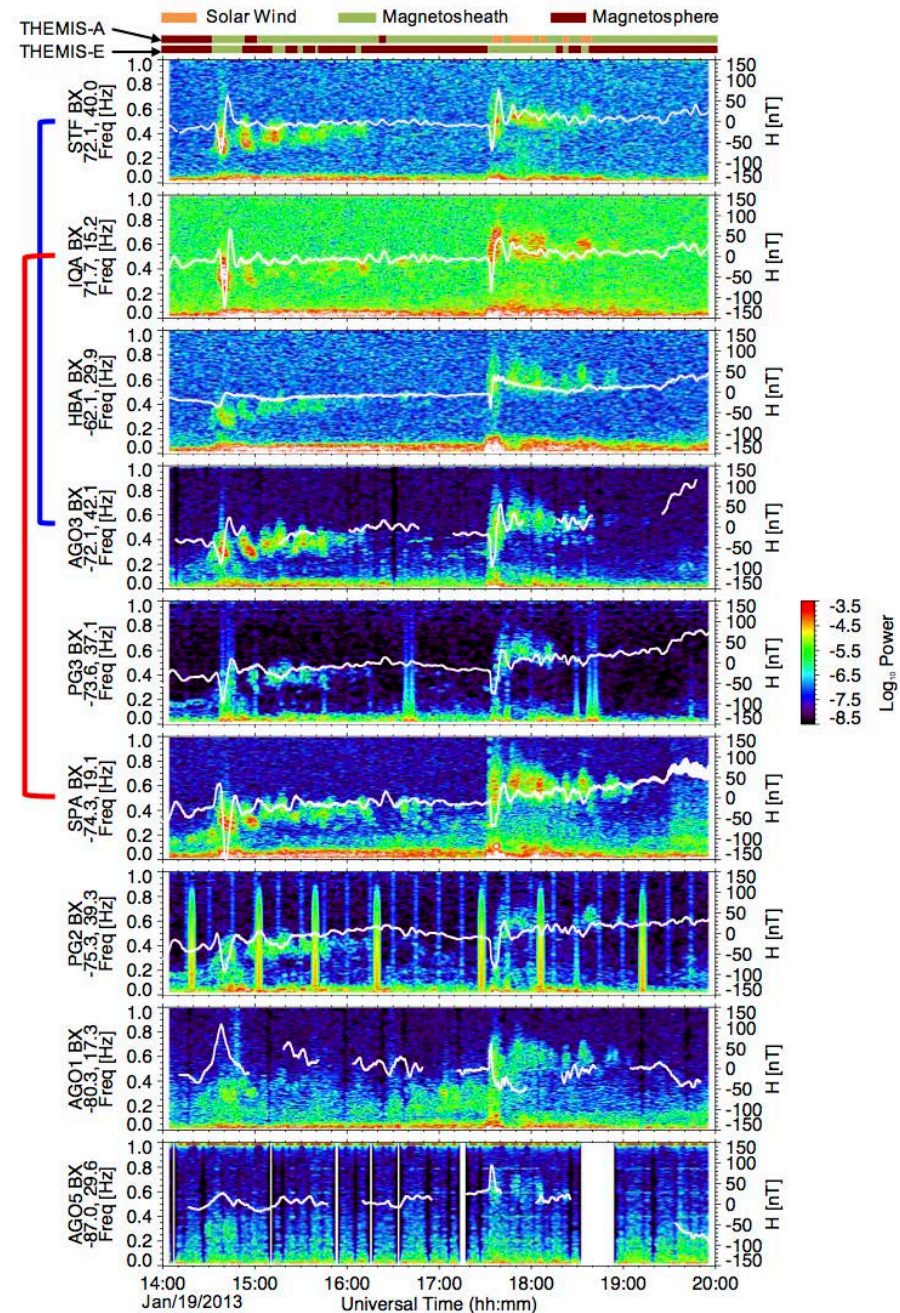
### 3. Solar Wind ULF Coupling: Poynting Flux Calculations



Urban, K. D., A. J. Gerrard, L. J. Lanzerotti, and A. T. Weatherwax (2017), Solar wind ULF coupling into the polar cap ionosphere, J. Geophys. Res. Space Physics, in preparation.

# 4. Interhemispheric Conjugate Observations of EMIC Waves Associated with TCV events with TCV events

- Interplanetary shock-associated transient events were observed by the THEMIS spacecraft that were positioned near the magnetopause.
- Travelling Convection Vortices (TCVs) were observed by high-latitude interhemispheric ground magnetometer network (fluxgate + induction) during the events [Kim *et al.* 2015].
- The network also detected electromagnetic ion cyclotron (EMIC) waves associated with the TCV events: Wave source region is estimated to be near STF/IQA and SPA.
- The confluence of space-borne and ground instruments including the interhemispheric, high-latitude, fluxgate/induction coil magnetometer array allows us to constrain the EMIC source region while also confirming the relationship between EMIC waves and the TCV current system.
- The network is now called “Magnetic Induction Coil Array (MICA) – North & South” (UNH, NJIT, VT, KHU, NRCan, DTU and BAS).



Kim *et al.* [2017]

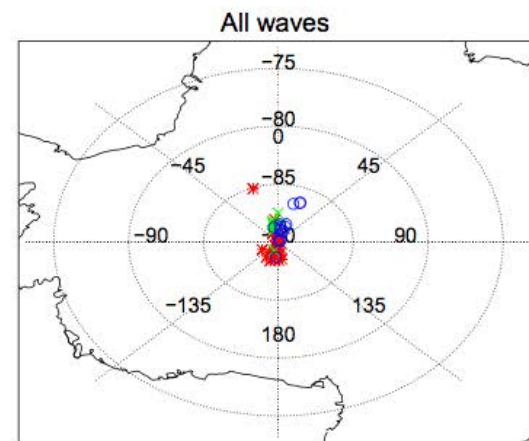
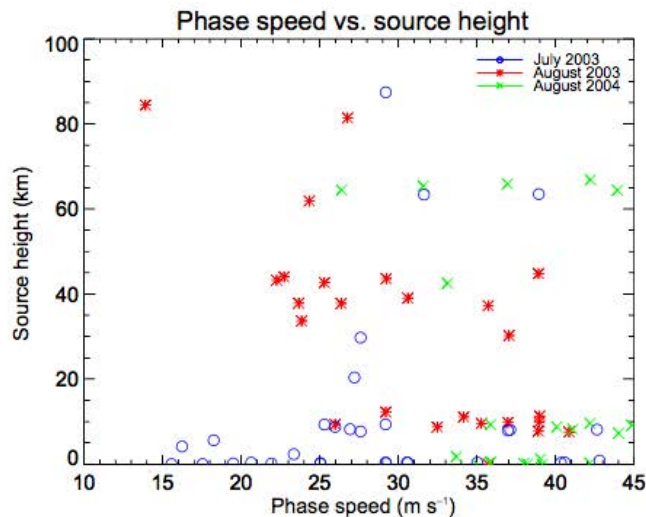
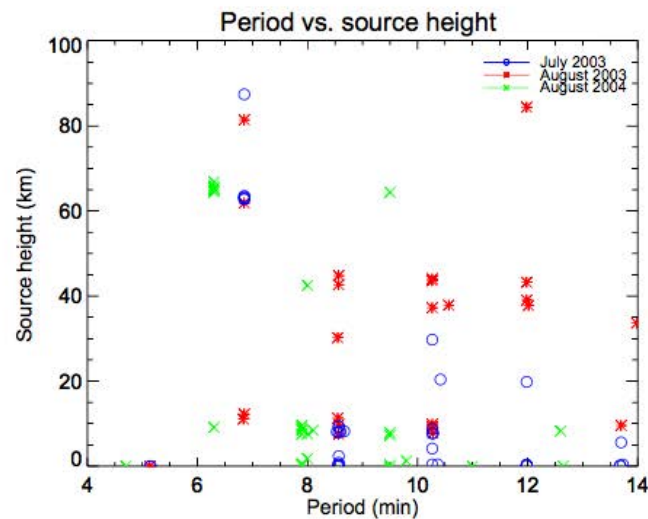
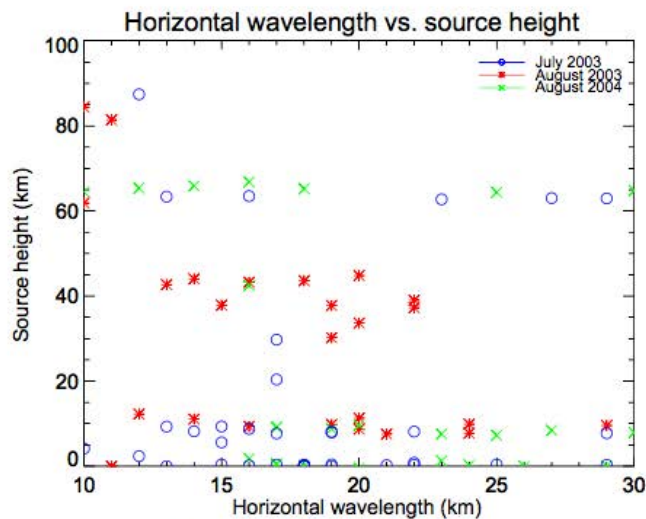
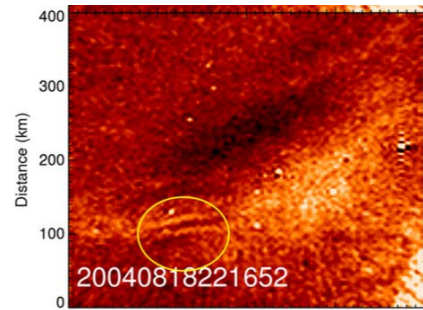


# 5. Short-period Mesospheric Gravity Waves Observed at SPA

*Short-period gravity waves observed over SPA originate from baroclinic zones formed by the polar vortex.*

Mehta, D., A. J. Gerrard, Y. Ebihara, A. T. Weatherwax, and L. J. Lanzerotti (2017) Mesospheric gravity waves and their sources at the South Pole, Atmos. Chem. Phys., 17, 911-919, doi:10.5194/acp-17-911-2017.

**Now at MCM!**



# More Information At:

- [antarcticgeospace.org](http://antarcticgeospace.org).... Or for data: [antarcticgeospace.njit.edu](http://antarcticgeospace.njit.edu)
- ***Future Science Opportunities in Antarctica and the Southern Ocean***  
National Academies of Science [2011]
- ***Solar-Terrestrial Research in Polar Regions: Past, Present, and Future***  
NSF Workshop Report [2014]
- Mende, S., W. Rachelson, R. Sterling, H. U. Frey, S. E. Harris, S. McBride, T. J. Rosenberg, D. Detrick, J. L. Doolittle, M. Engebretson, U. Inan, J. W. Labelle, L. J. Lanzerotti, and A. T. Weatherwax (2009), Observations of Earth space by self-powered stations in Antarctica, Review of Scientific Instruments 80, 124501; doi: 10.1063/1.3262506.
- Melville, R., A. Stillinger, A. Gerrard, A. Weatherwax (2014), Sustainable energy at the 100-W level for scientific sites on the Antarctic Plateau: Lessons learned from the PENGUIn-AGO project, Review of Scientific Instruments, 85, 4, id.045117.



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## Solar-Terrestrial Research in Polar Regions: Past, Present, and Future



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# Thank you!