Ground observations from Antarctica: Substorm And Radiation belt Array (SARA)

A project proposed to NSF consisting of remote observations at auroral and radiation belt latitudes

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WHY ANTARCTICA????

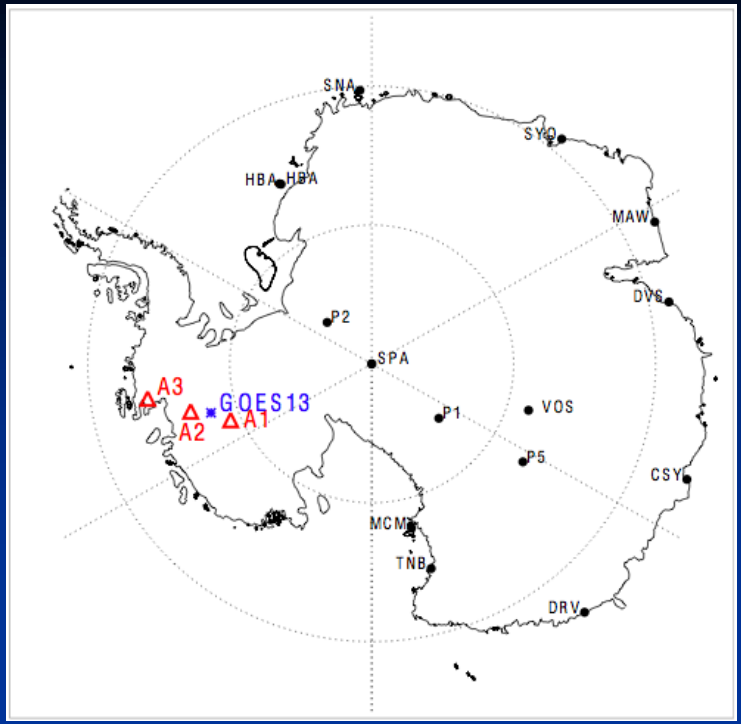
Excellent conjunctions with RBSP and BARREL.

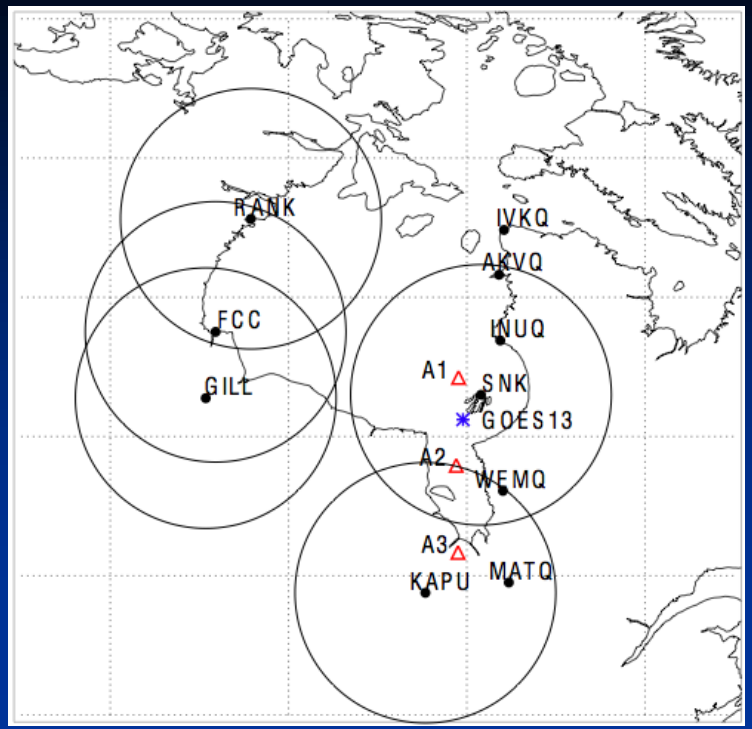
Supports 3-point conjugacy with GOES 13, taking advantage of ice-coring facility at WAIS Divide.

Conjugacy studies with northern hemisphere (supports observations of FLRs - Pc5, “bounce” studies of waves - Pc1-2, etc).

Total darkness and/or daylight:
24 hour allsky camera observations, even at latitudes as low as 4+.

Extended range of geomagnetic latitudes from the ground; OR, extended longitudinal coverage for low L shells.

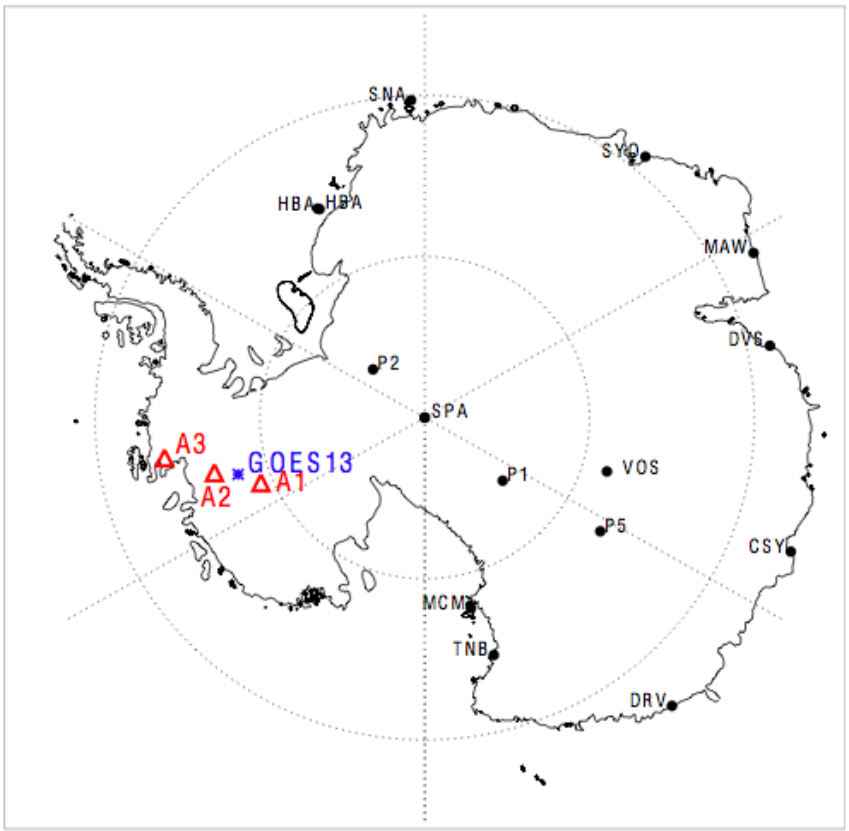


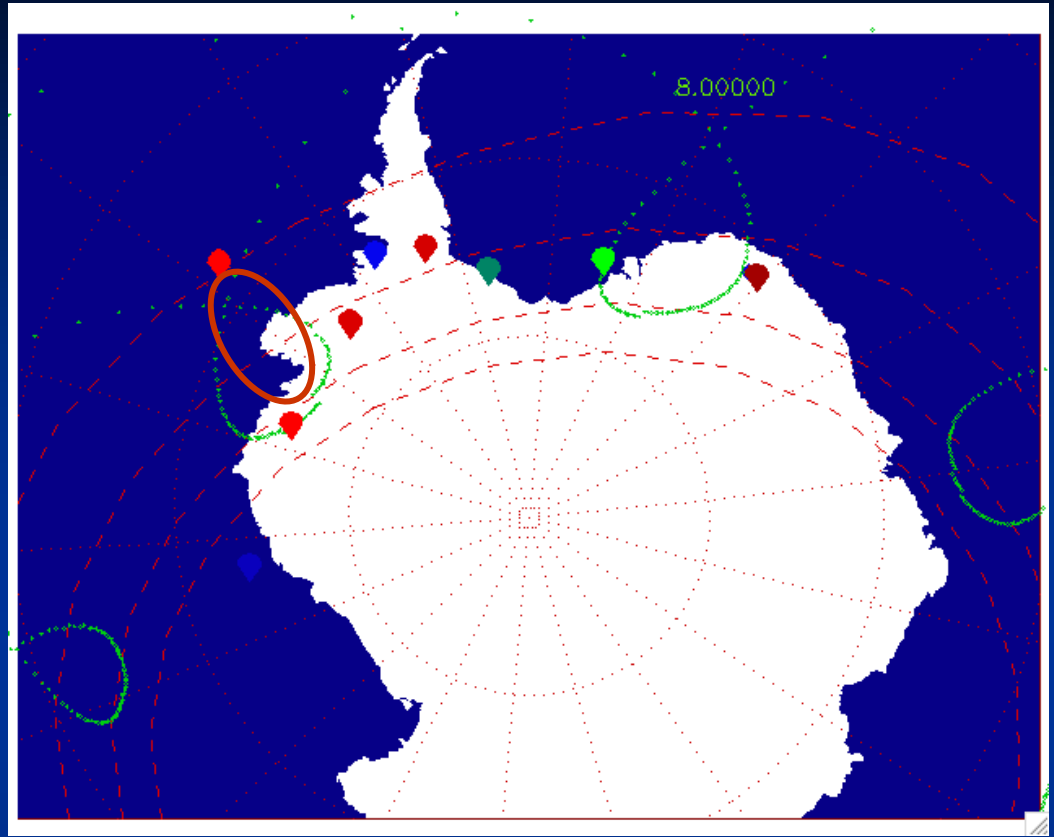


Left: Map of Antarctica showing proposed ARRO sites (co-located with the footprint of the GOES 13 satellite), as well as various ground stations and existing AGO sites.

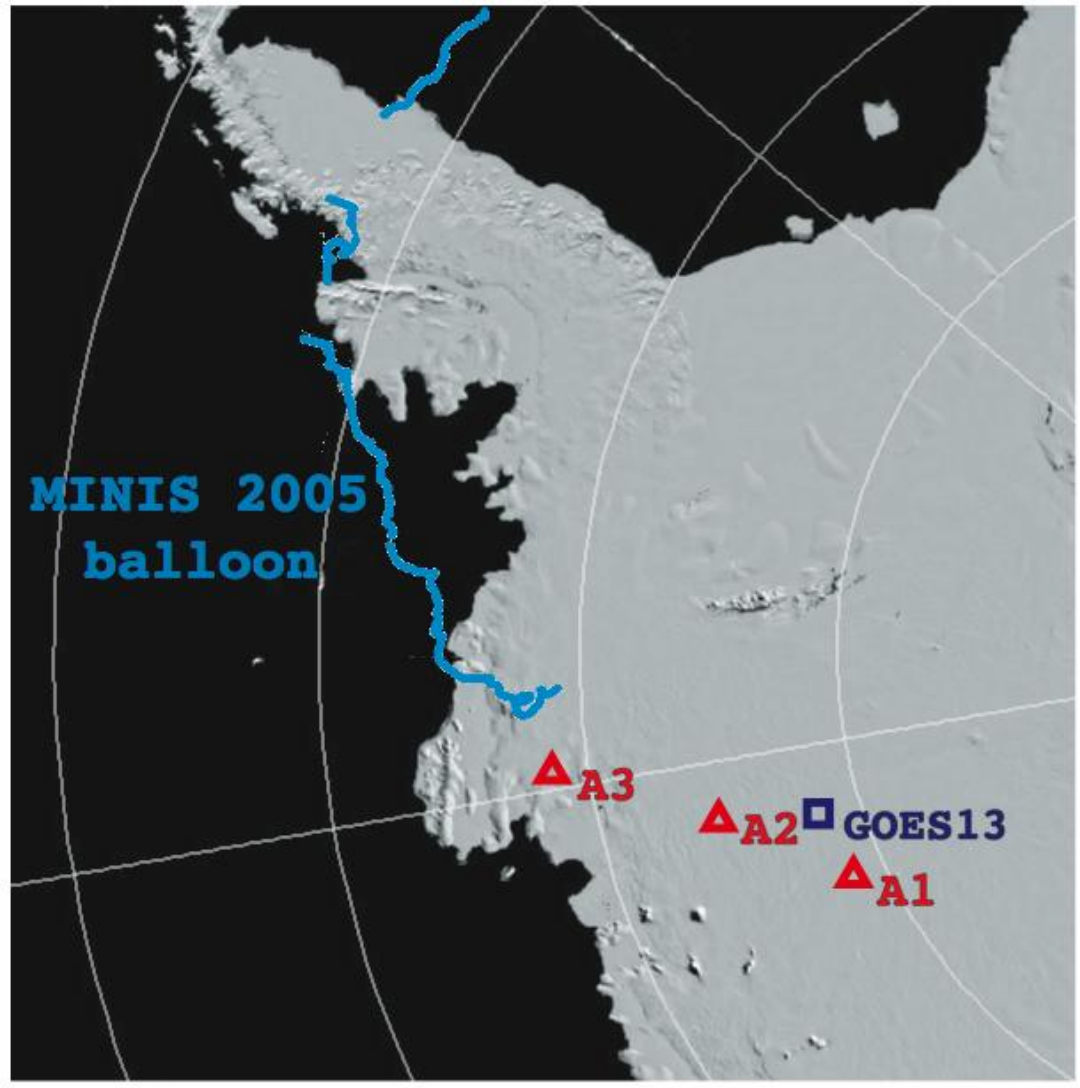
Right: Map of Canada (near Hudson Bay), showing conjugate sites of ARRO locations. Note that the footprint of GOES 13 is in close proximity to the conjungate sites as well as to Sanikiluaq (SNK) in Quebec.

Season	Observatory	Geographic Lat	Geographic Lon	ILAT	MLT	L shell
11/12	ARRO-1	79.28S	247.88E	-67.0	5.15	6.46
12/13	ARRO-2	76.82S	255.60E	-64.0	5.15	5.28
13/14	ARRO-3	74.03S	261.00E	-61.0	5.15	4.21





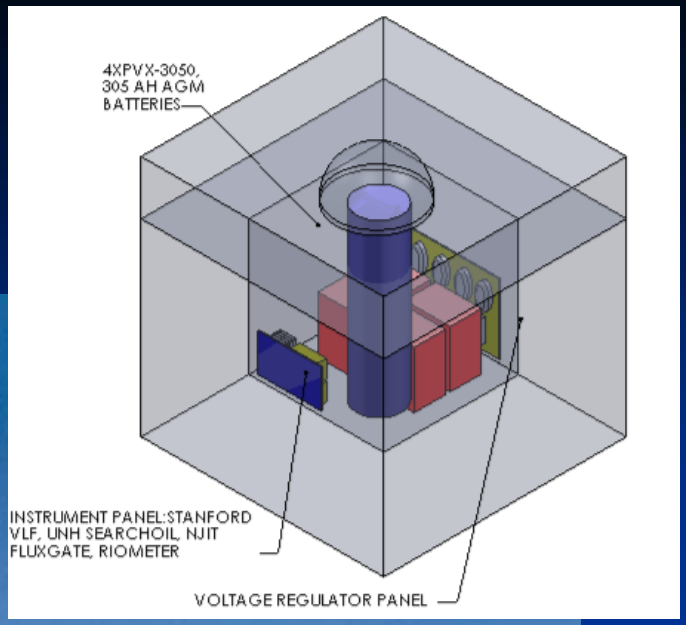
Green curve is example of RBSP spacecraft pass. Red dashed lines are lines of constant IGRF L between 3-6. From BARREL fact sheet, R. Millan.

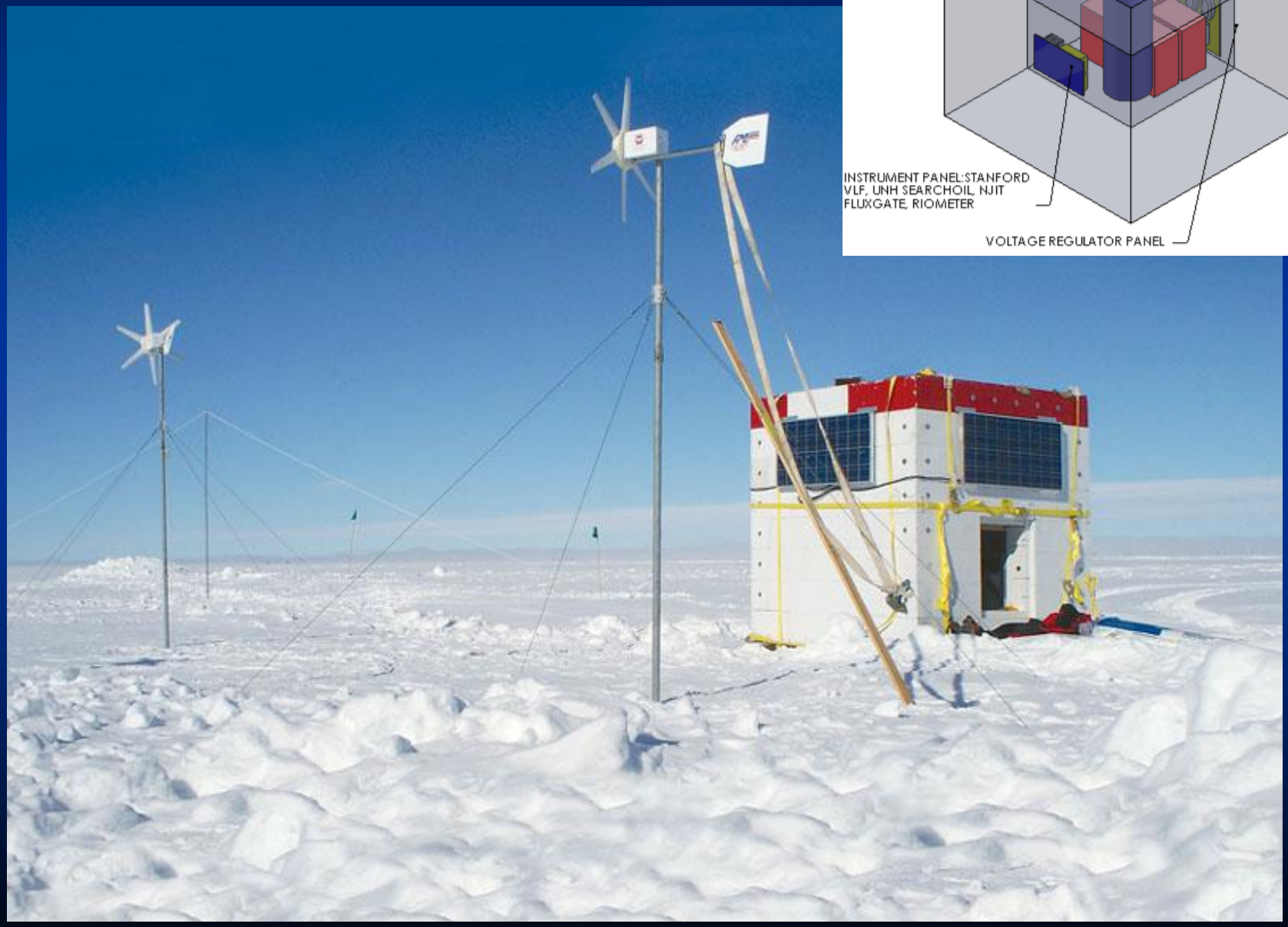


In more detail, synthetic aperture radar map of Antarctica, showing specific locations of the proposed observation sites in red, the GOES13 footprint in blue and the MINIS balloon trajectory in light blue.

RBSP SWG, Aug 2010

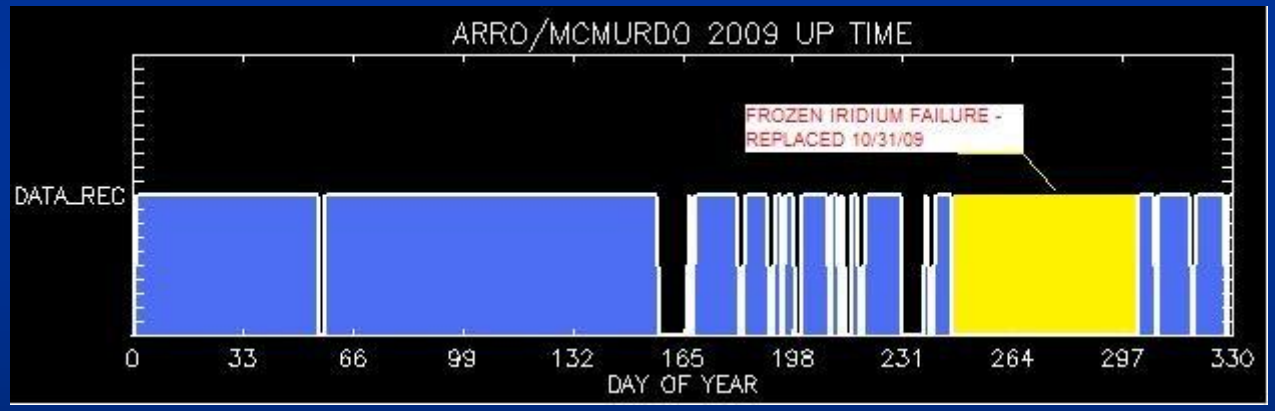
Autonomous Remote Real-time Observatory (a modular design) undergoing field tests at McMurdo Station last winter. The enclosure in the photo is 8 ft^3; the enclosures for SARA will be 5 ft^3, as shown to the right.





Energy in the system is stored both electrically and thermally. Batteries provide electrical power to the instruments and to heat the enclosure to its operating temperature of 0C. Water jugs provide a very effective means of storing thermal energy, exploiting the high latent heat energy associated with the phase change between water and ice.

Recent test installation at McMurdo Station: used three Marlec Rutland 910 wind turbines (100 watts each, placed in parallel for redundancy) and four 120-watt Kyocera solar panels. This power system operated throughout two winter seasons at McMurdo with excellent results, including continuous operation during storms in April, 2010, with winds gusting to 78 knots (90 mph) and with sustained winds of up to 55 knots.



The horizontal axis shows Day of Year; the vertical axis (when blue) shows when data were received by the Iridium modem. Gaps in data acquisition (e.g., during cold soak periods) appear as the black background, occurring primarily in the winter, as expected.

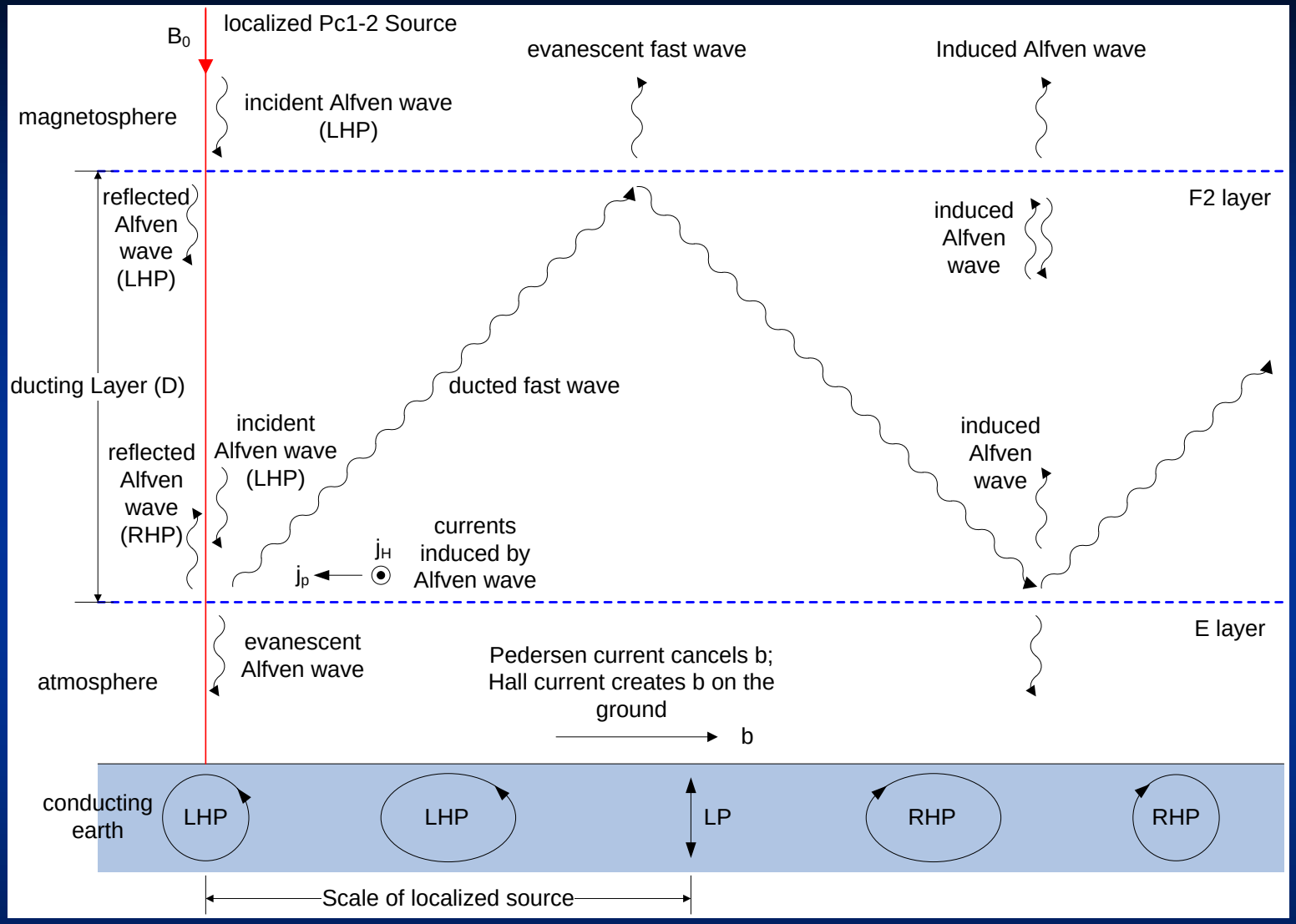
SARA Instruments (in each ARRO)

Fluxgate magnetometer	DC mag field, at 1 Hz	NJIT
Induction Coil magnetometer	ULF waves at 10 Hz	UNH
ELF/VLF receiver	Amplitude in 4 bands (0.5-8 kHz) Wideband at 20 kHz	Stanford
Riometer	Broadbeam, 60 degree FOV	UNH
Allsky camera	557.7, 630.0 and 427.8 nm, at 6 seconds, and well-calibrated	UNH

Data are both stored “onboard” and transmitted in near-real time via Iridium modems (providing bi-directional communications). Not all of the allsky camera Images can be transmitted over the modems.

Data will be accessible in various ways, including through Autoplot (we will Provide the requisite CDF files)

Relevant to RBSP: EMIC Wave Propagation in Ducting Layer



[Fujita and Tamao, JGR, 1988]; [Popecki, Ph.D. Thesis, 1991]

First developed by Dessler JGR (63), 1958.
Expect a cutoff near 0.5 Hz cutoff (Greifinger and Greifinger , JGR (73), 1968)

Ground observations of ducting of Pc1-2 ULF "Pearl" event, 3/23/2007

(Kim, H., M.R. Lessard, M. J. Engebretson, and H. Luhr (2010), Ducting Characteristics of Pc 1 Waves at High Latitudes on the Ground and in Space, JGR, doi:10.1029/2010JA015323, in press)

Bx (N-S) By (E-W)

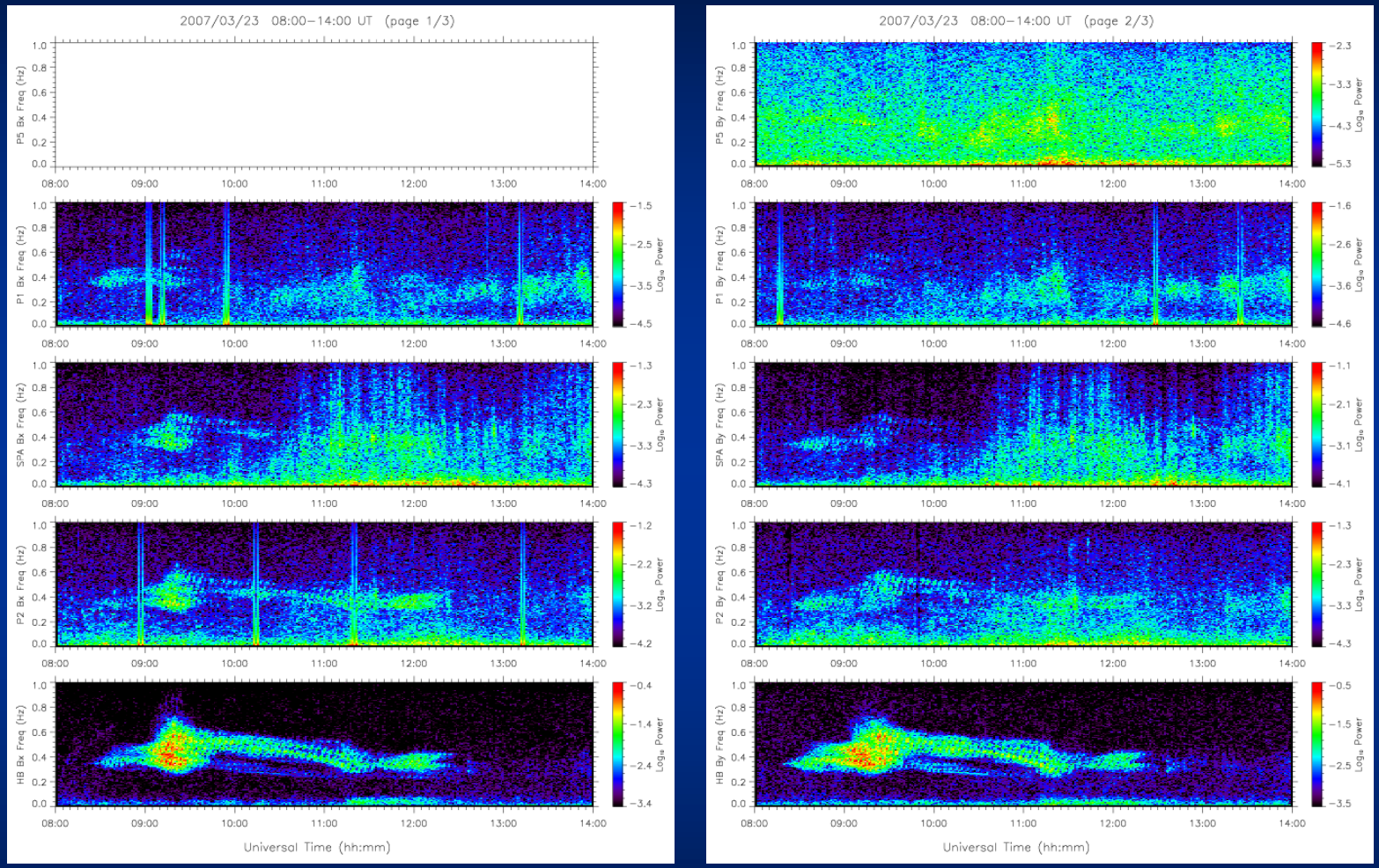
2920 km P5 (-87º)

2252 km P1 (-80º)

1610 km SPA (-74º)

1170 km P2 (-70º)

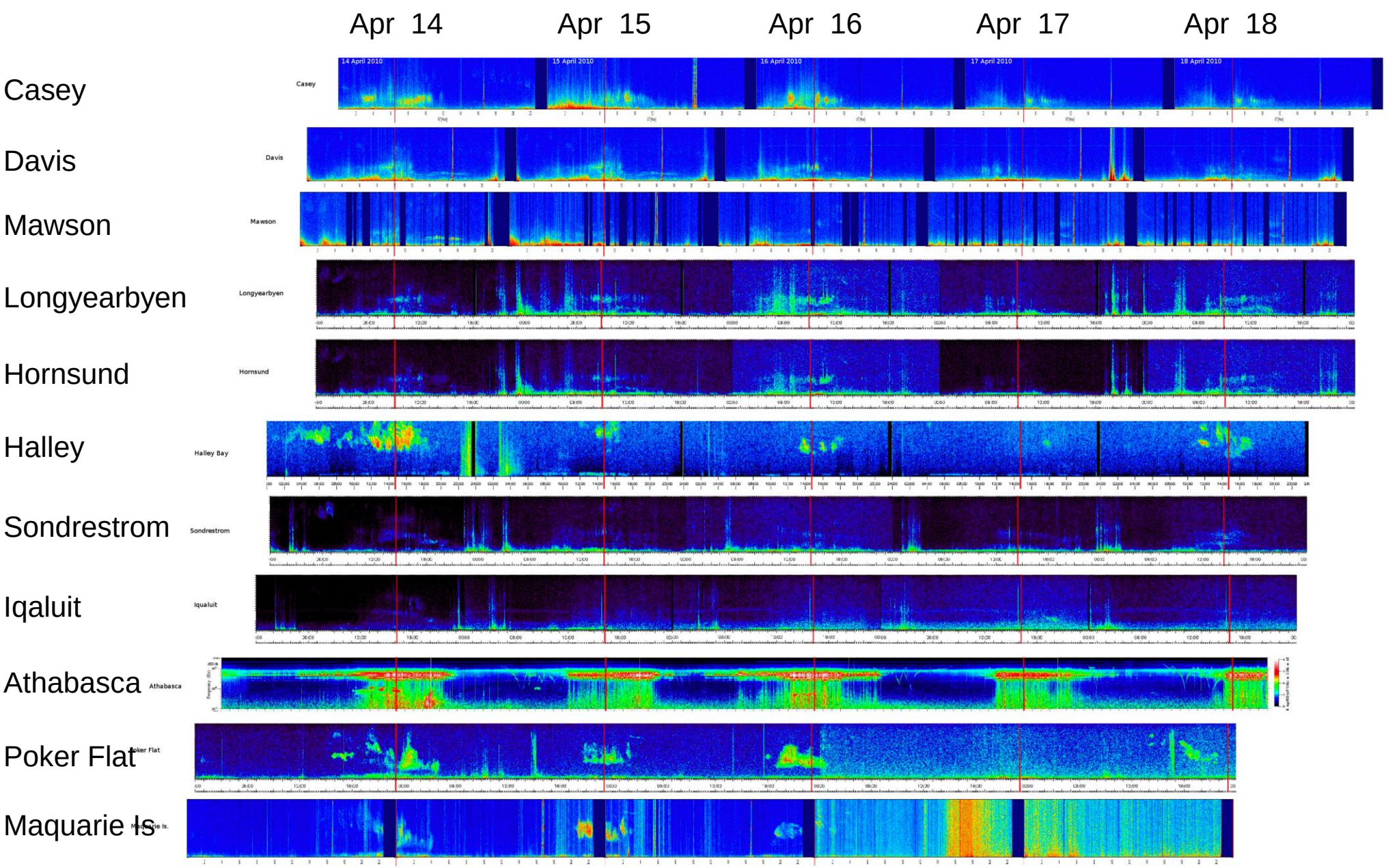
0 km HB (-62º)



6 MLT 10 MLT

- Band-limited ULF waves over ~0.3-0.6 Hz over the course of 4 hours.
- Attenuation of ~10 dB/1000 km; speed of 160 km/s

Persistent EMIC generation from stream interaction region (Carol Weaver)



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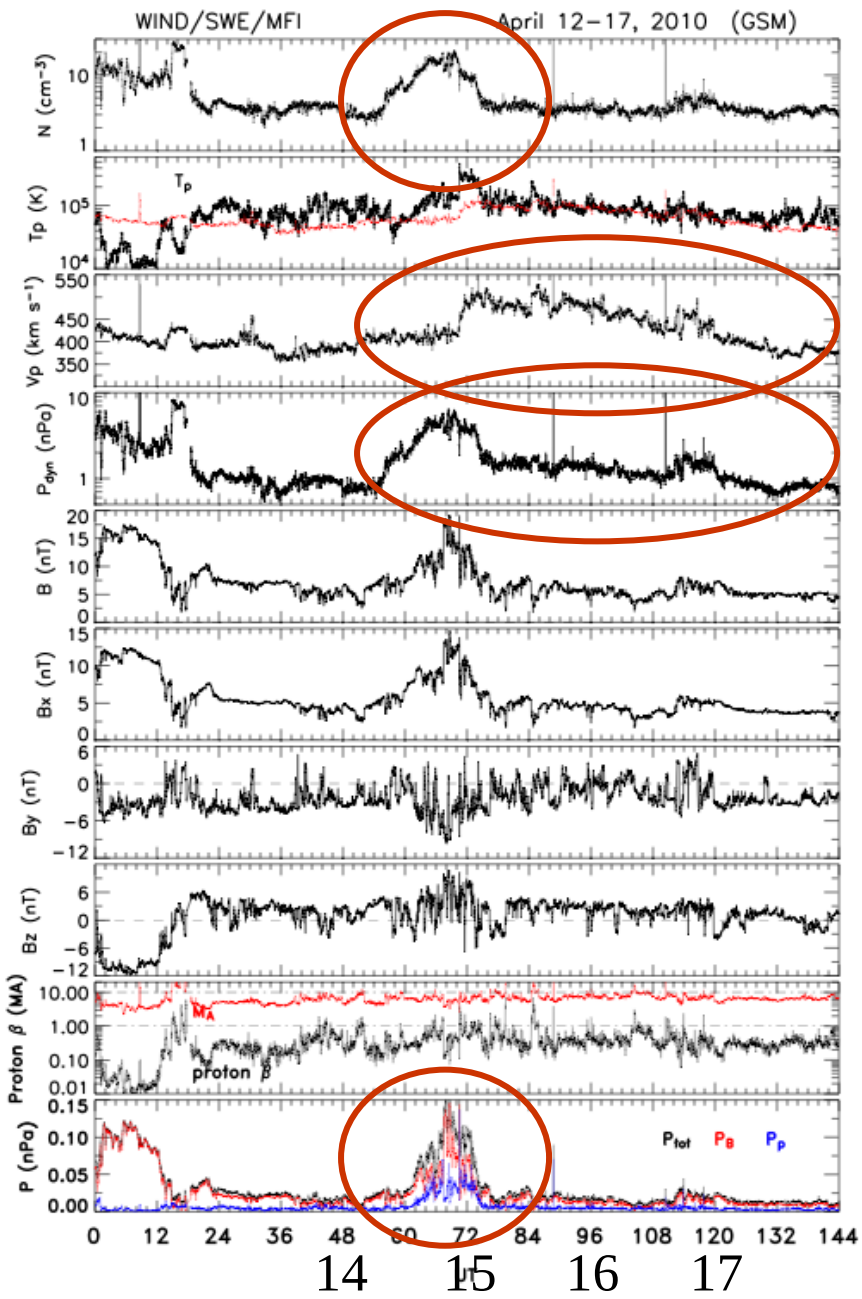

Data from the WIND satellite, showing the high speed stream interaction region and extended pressure pulse (thanks to Charlie Farrugia).

Enhanced pressure, extending for several days, with EMIC waves generated intermittently - very geo-effective!!

RBSP SWG, Aug 2010

Questions, comments and requests about the SARA project are very welcome.

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