The Automatic Geophysical Observatories: Science and Implementation

SRI Polar Technologies Conference

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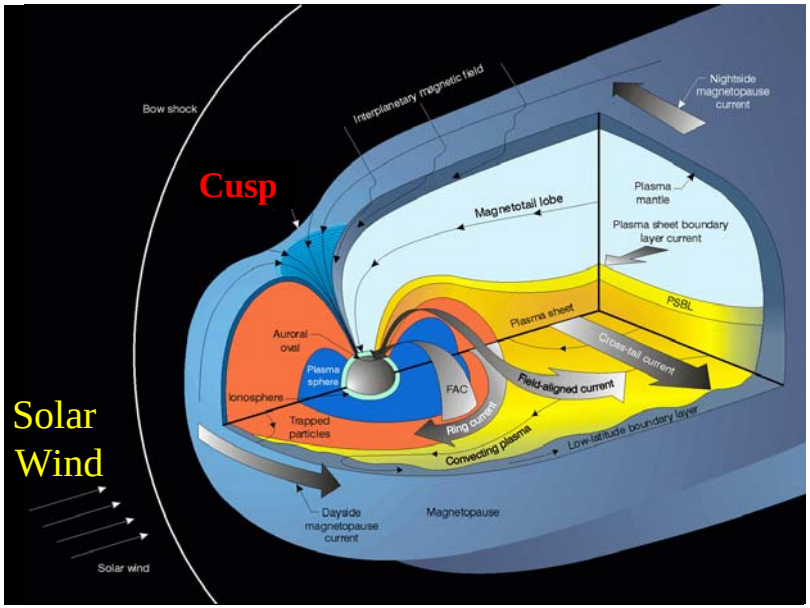
The people

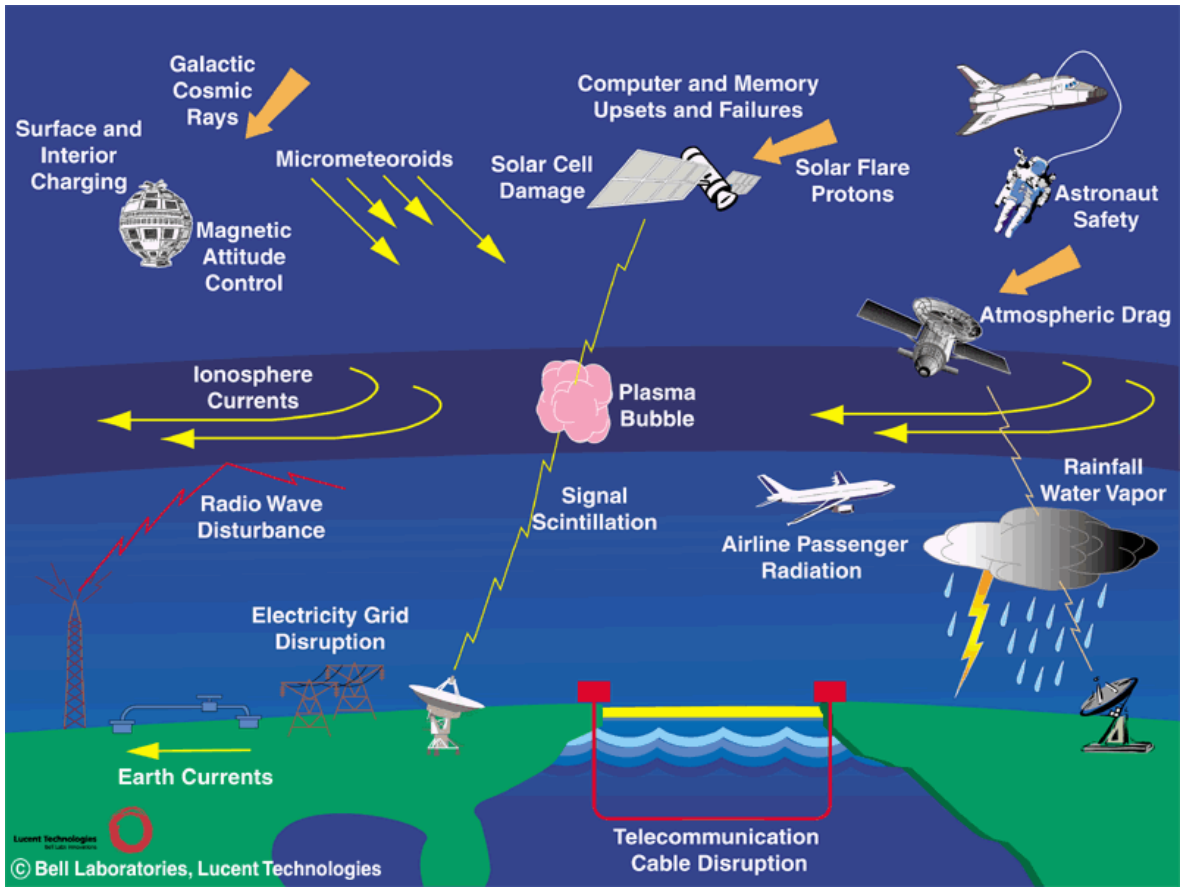
- Al Weatherwax
- Steve Mende
- Andy Gerrard
- Lou Lanzerotti
- Mark Lessard
- Mark Engebretson
- Umran Inan
- Will Rachelson
- Jeff Chang
- Alec Plauche
- Dan Detrick
- Bob Melville (Fingee)

Space weather

- Ionosphere and magnetosphere
- Interaction of magnetic fields of the Sun and Earth
- Aurora
- The *Solar Wind*
- Study the impact on ground resources, aircraft, satellites, communications, the power grid, etc.



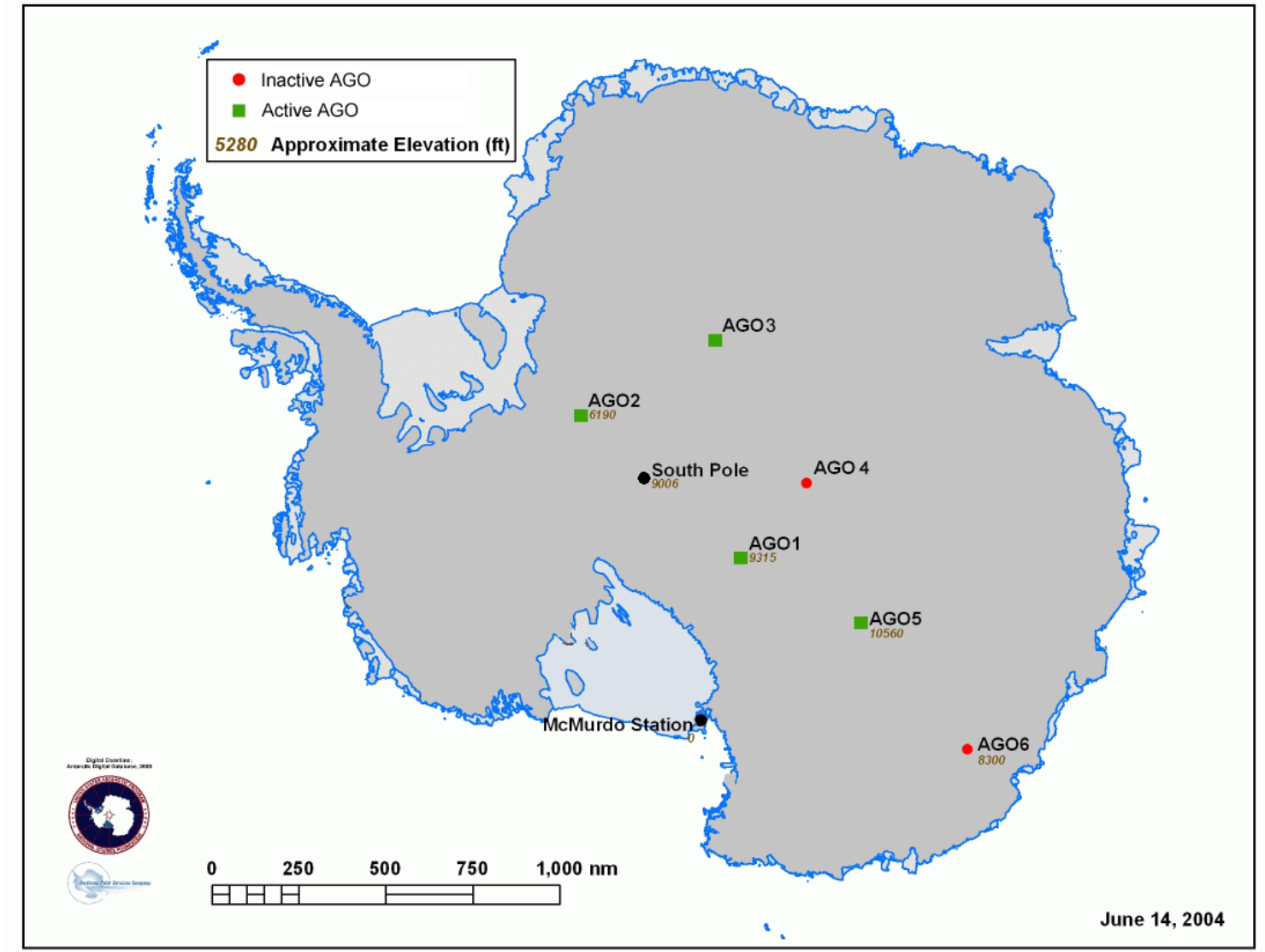
Practical impact of Space Weather phenomena



Early publications …

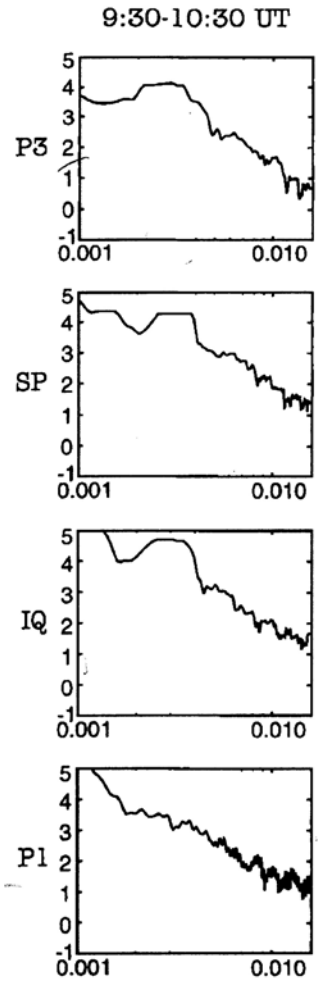
- *First AGO Observatory Installations*, Doolittle, J., Mende, S., Paschal, E., Trimpi, M. and M. Anderson, Antarctic Journal 28(5), 1994.
- *Studying the Polar Ionosphere and Magnetosphere with Automatic Geophysical Observatories*, Rosenberg, T. and J. Doolittle, Antarctic Journal, 29(5), 1995.

AGO Locations

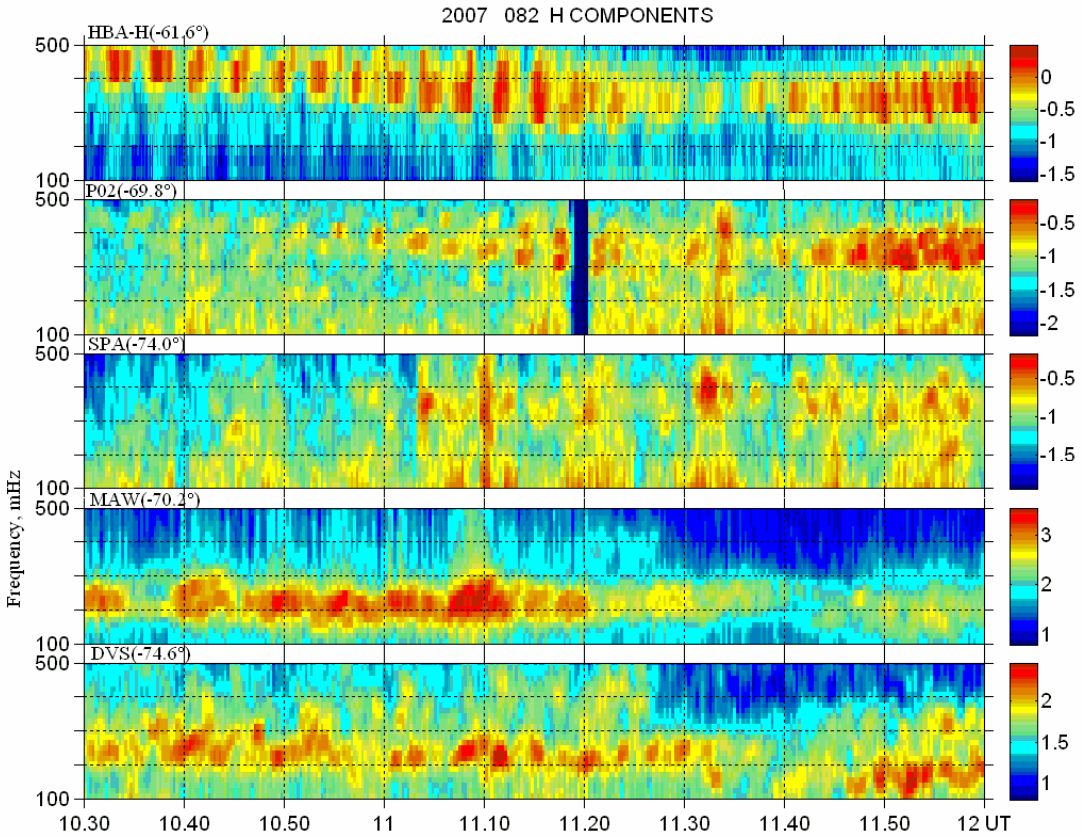


Two examples of AGO observations …

- Observe in Antarctica because boundary of magnetosphere touches down on the continent
- Accurate location and timing of boundary gives information about space weather
- Space-based platforms (satellites or sounding rockets) are moving (fast), hence do not stay in one place long enough to get a good picture
- Ground-based stations are ideal for such measurements, and must be spaced closely enough to bracket the boundary of the magnetosphere

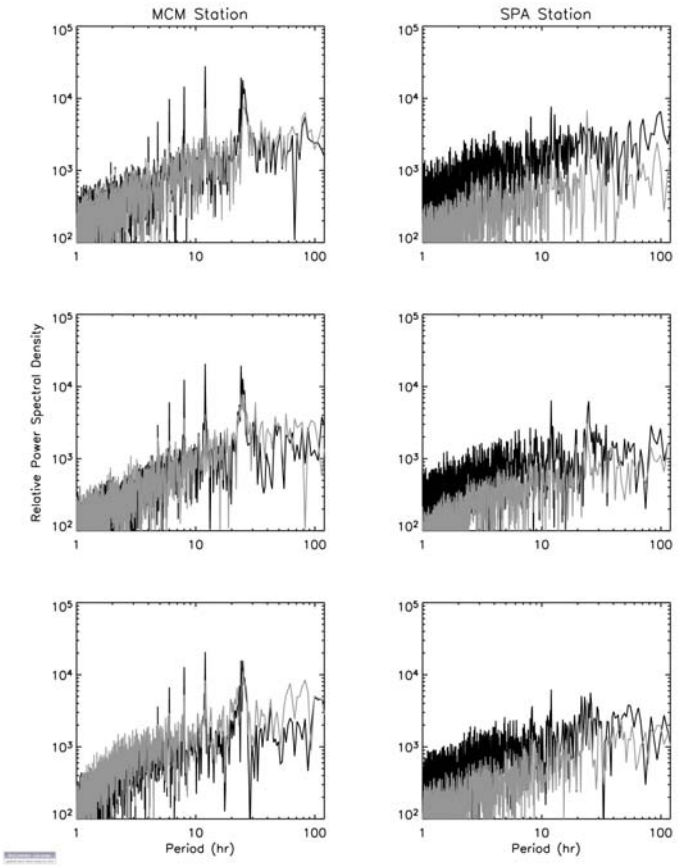


ULF magnetic waves at various sites in Antarctica

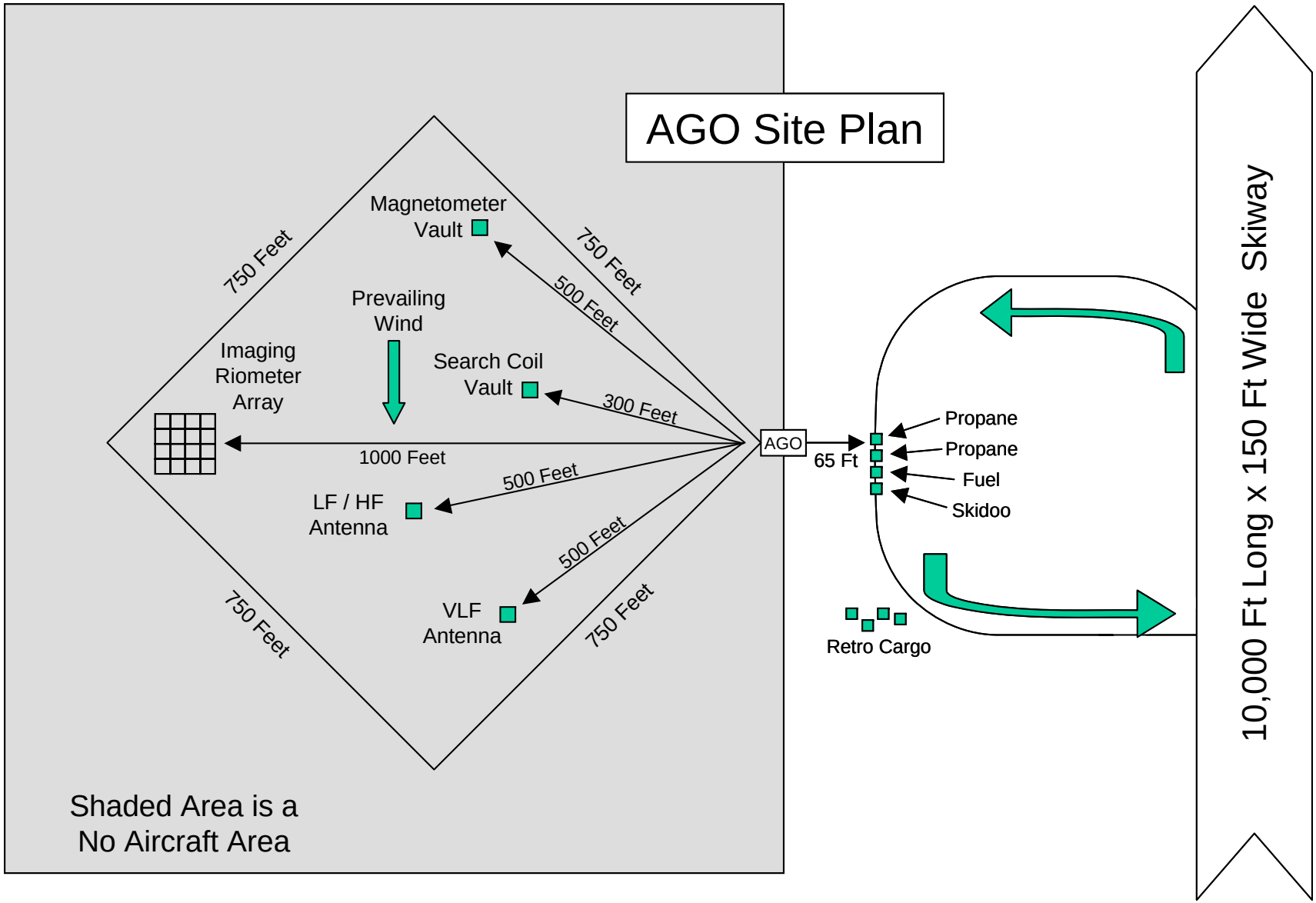


Add photometers at AGOs

- Measure light intensity at two wavelengths
- Study neutral dynamics of middle and upper atmosphere
- Tidal amplitudes have changed between two sites (SPA and McM)
- Photometers at AGOs would allow further resolution



Site Layout / Instrumentation



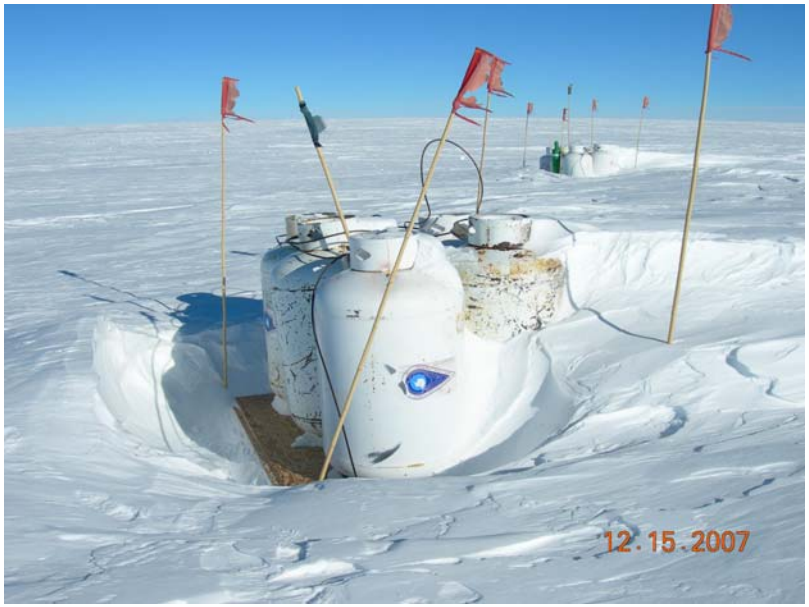
Science Instrumentation

1. Allsky Camera
2. Data Acquisition Unit
3. Iridium Comms
4. VLF

5. Fluxgate Magnetometer
6. Imaging Riometer
7. LF/HF
8. Searchcoil Magnetometer

First efforts at a power system …

- Early system (starting 1992) used propane-fired TEG
- Reliability was poor and required LC-130 support (!)
- Circa 2002, switched to solar and wind-power with 120 W generator at P2



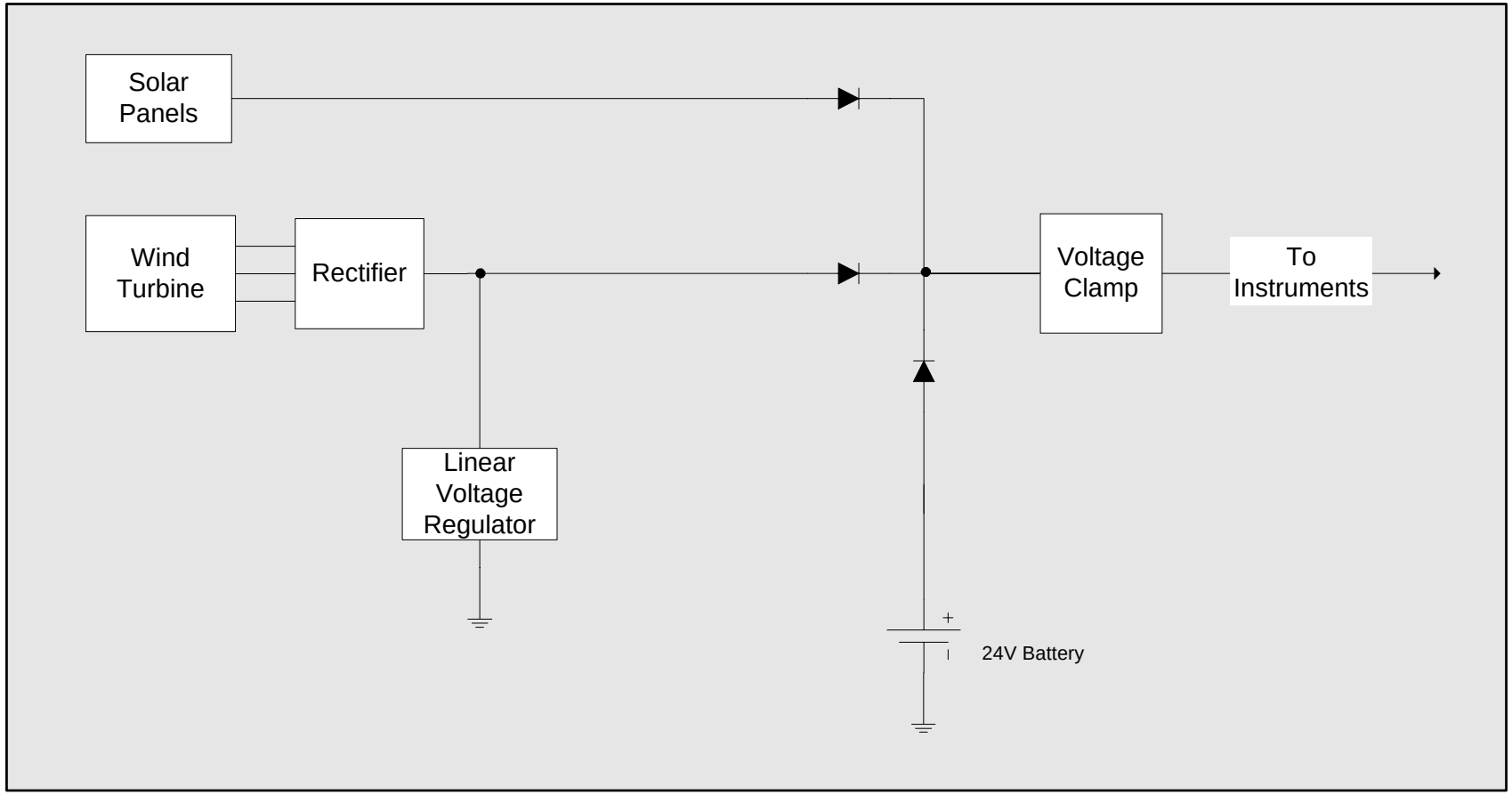
continued upgrades …

- Bearings of wind turbine made loose to avoid freeze-up; not much field experience with these at –80 C (!)
- Circa 2004, upgrade to 850 W wind turbine (pictures later)
- Weibull distribution of wind; average is close to 20 MPH
- Also upgraded on-site storage mechanism to commercial flash memory cards; these have proved quite reliable

Power System

- Top Level Diagram
- Design Requirements
- Novel Components
  - AWP Wind Turbine
  - System Architecture
  - Linear Voltage Regulators / Heaters
- Specifications

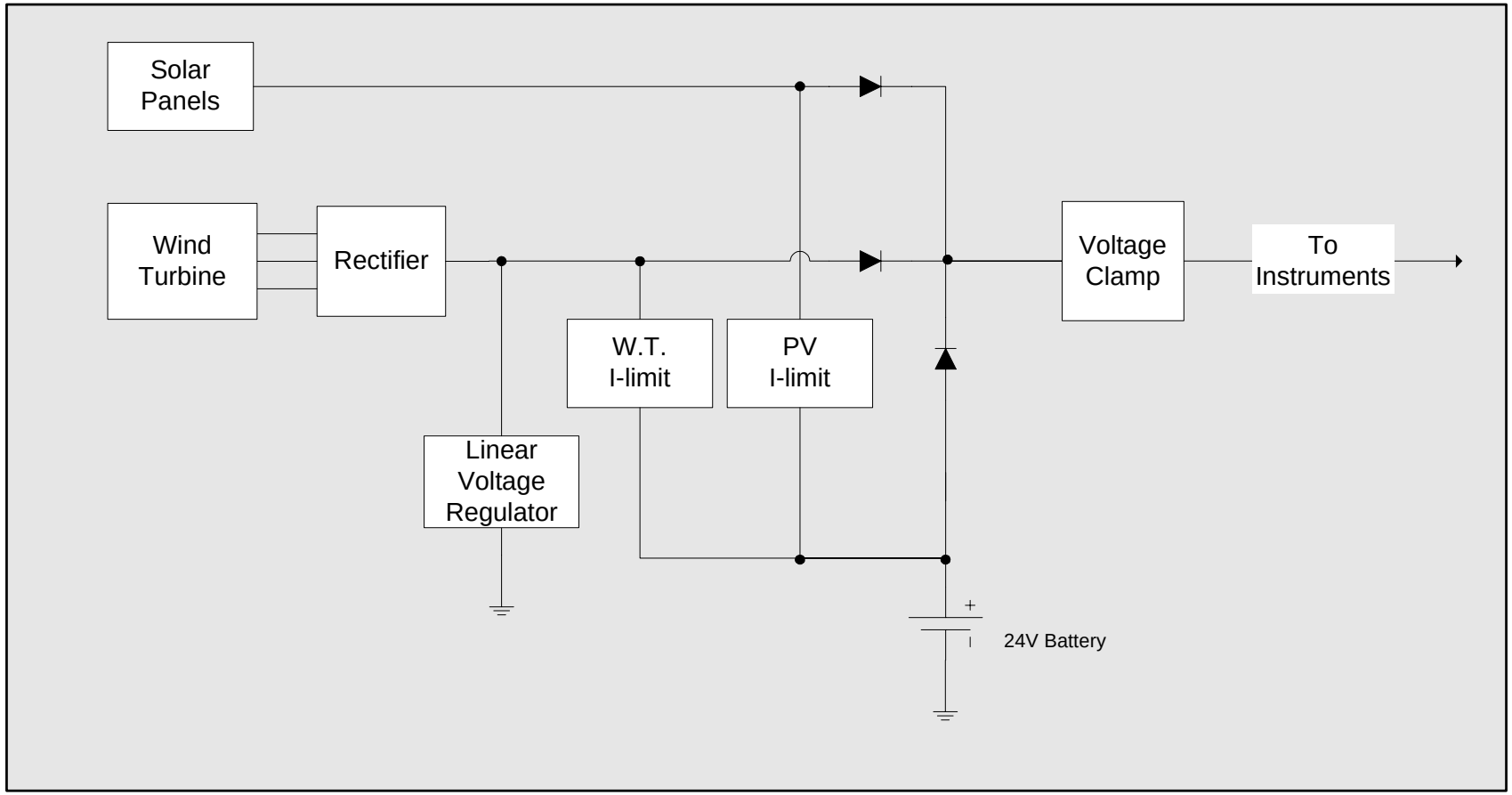
Power System – Top Level



Power System Requirements

- Must operate with battery fault: short/open
- Must operate when sun up, regardless of battery condition or wind
- Must operate unattended
- Must not damage instrumentation in fault conditions
- Maintain temp > -40C
- Supply ~3A @ 30V

Power System – Top Level 2



African Wind Power 3.6

- 3.6m^2 Swept Area
- 24V, ~1000W @ 23mph
- Low cut-in speed (~6mph)
- No slip-rings or brushes
- Indestructible
- Cheap ($2500 USD)
- Hard to acquire

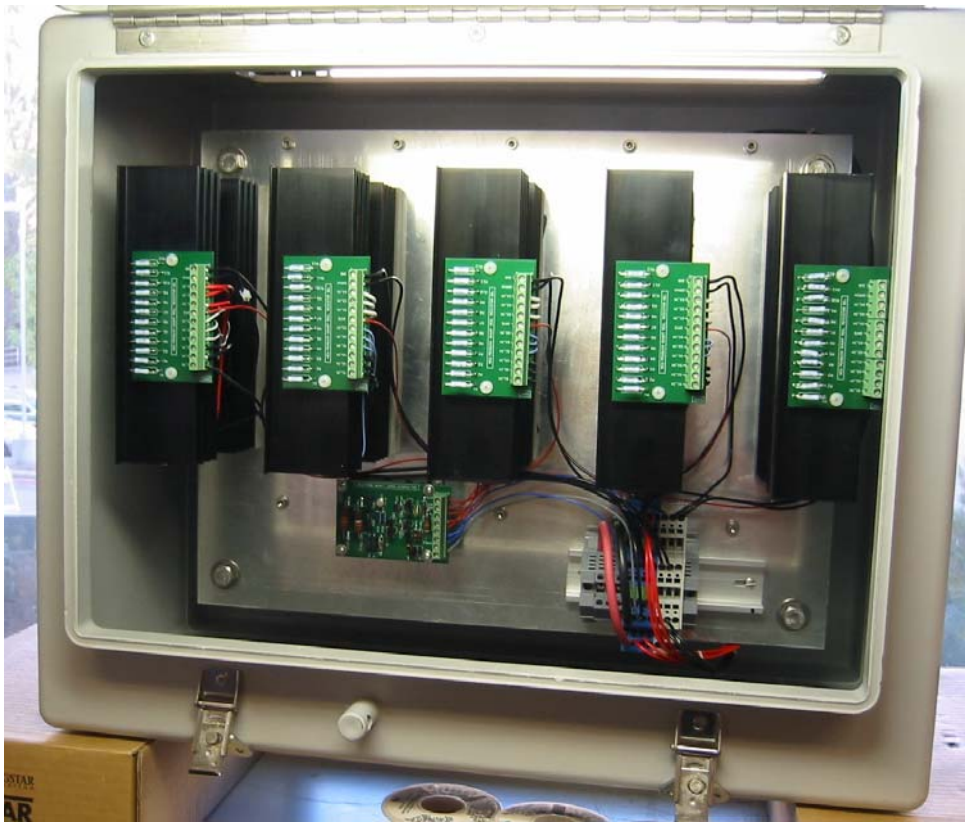
AWP

Alternator survives falls

Blades don’t

Voltage Regulators

- 30Vdc Regulated output
- 1500 Watts Max
- Switched among 3 locations:
  - Rack
  - Hut
  - Outside

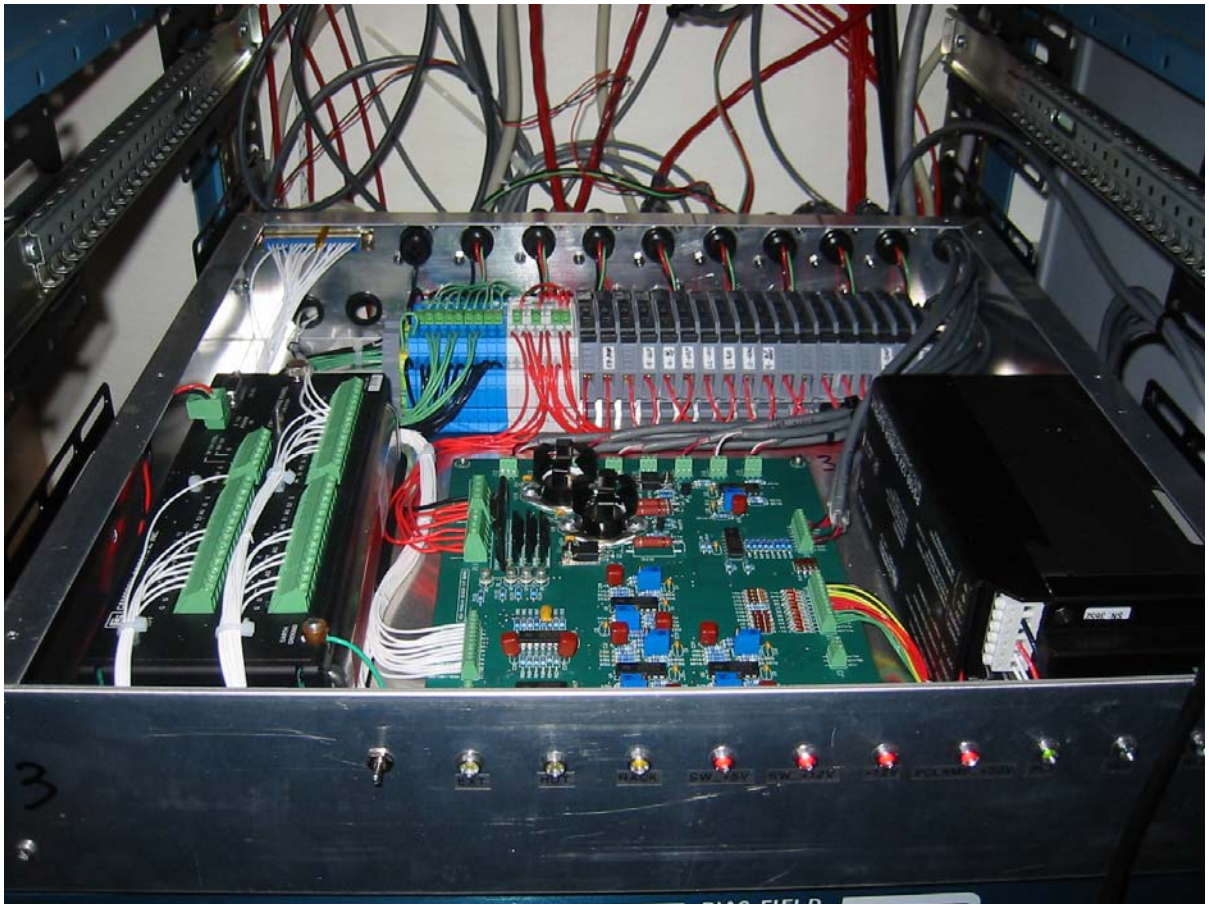


15 IRFP250 FETs, 300W per heatsink

Voltage Regulators

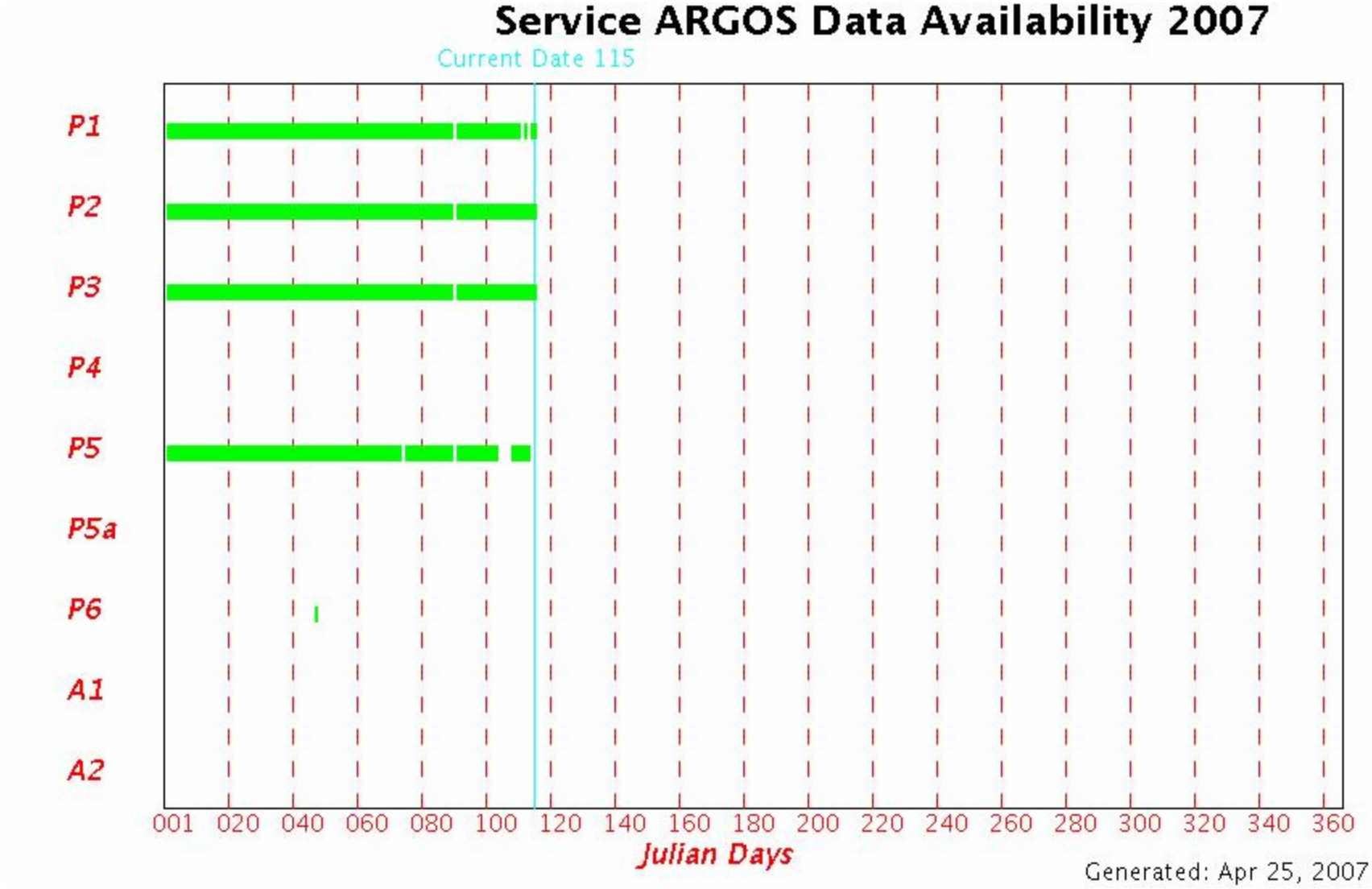
Power System Control

- cr10x-based
- Simple state machine
- Duties:
  - Switch Heat
  - Turn on/off Instruments

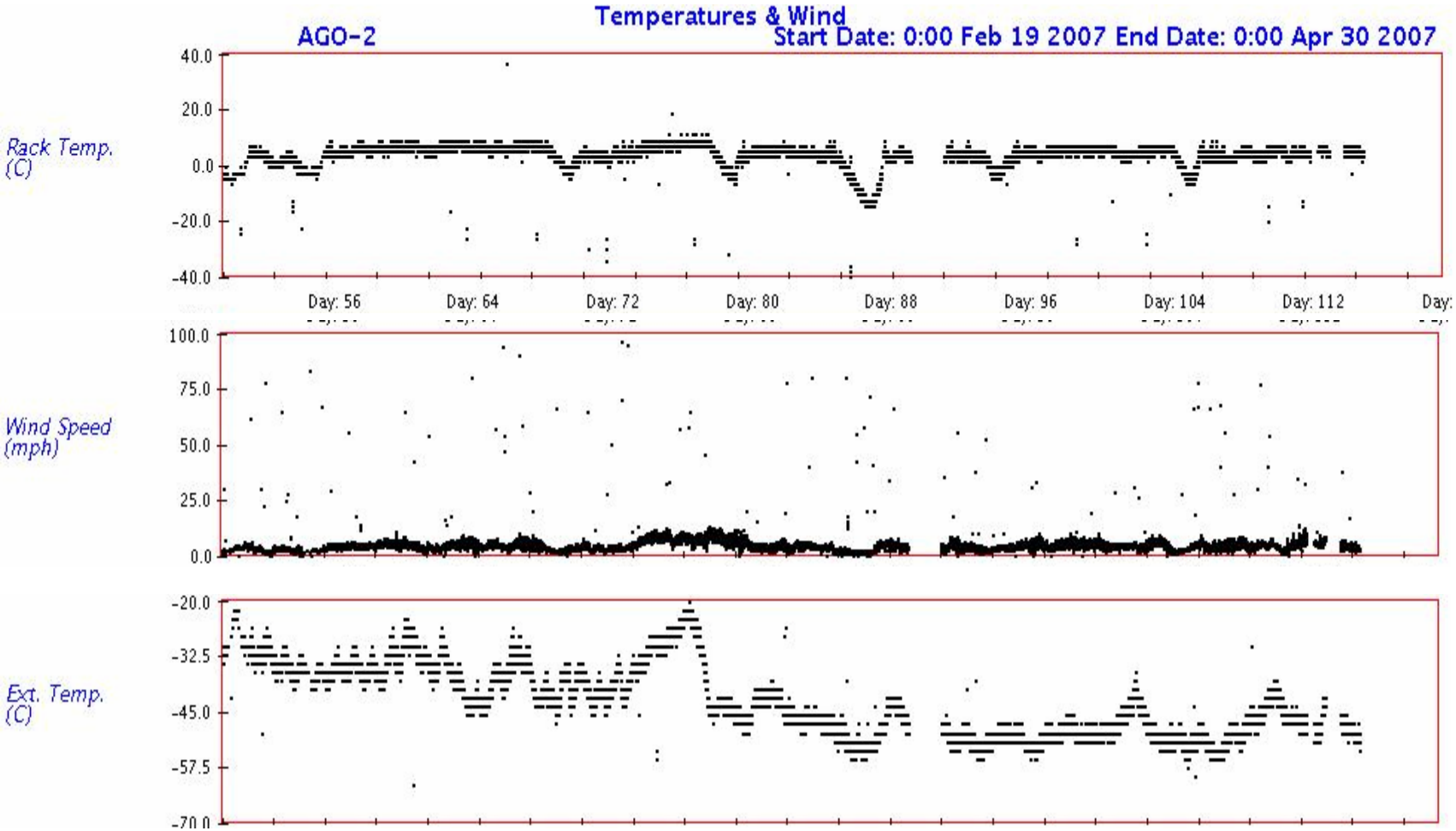


cr10x with housekeeping and instrument power connectors

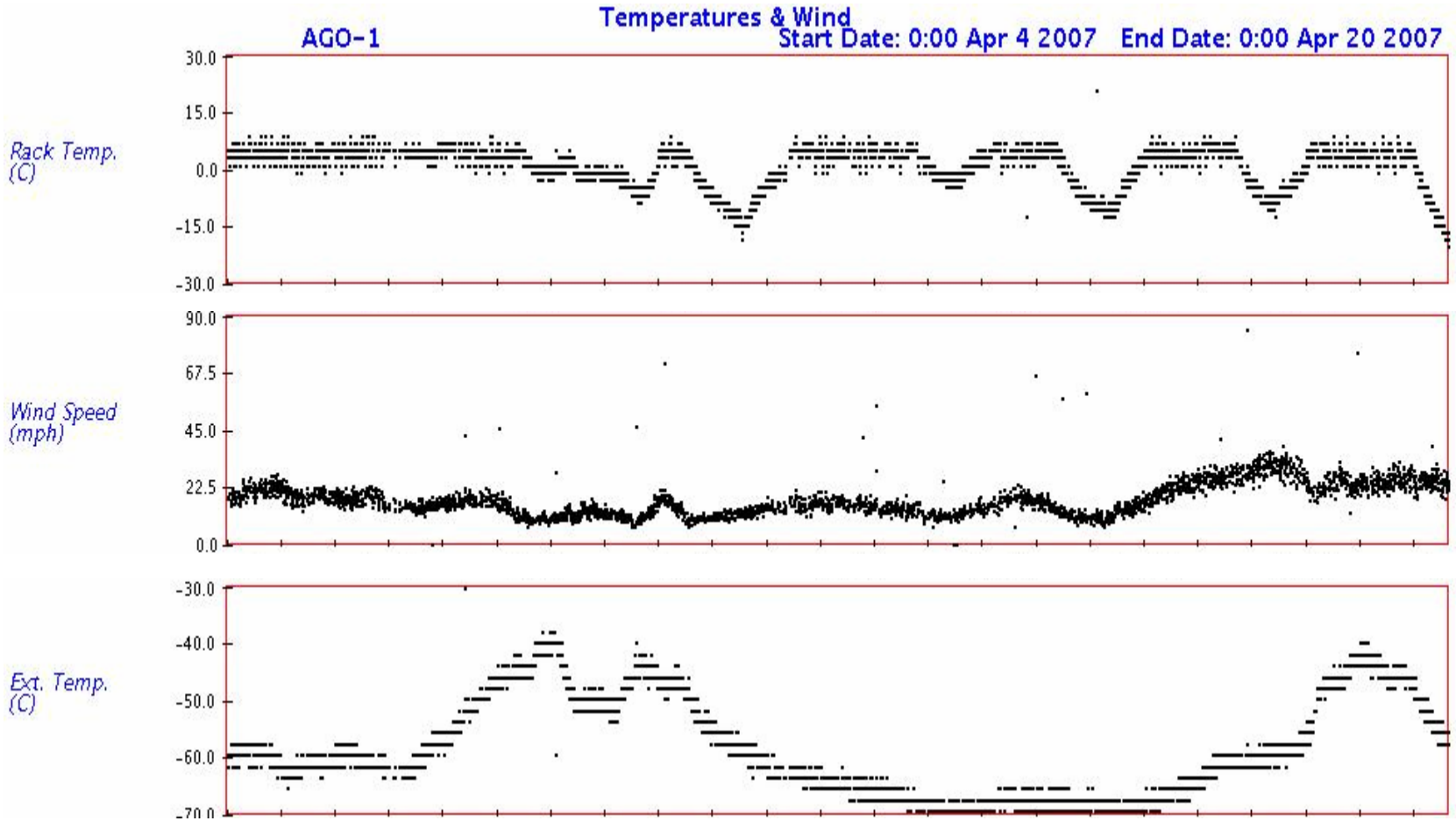
AGO Status


Service ARGOS Data Availability 2007
Current Date 115
P1
P2
P3
P4
P5
P5a
P6
A1
A2
001 020 040 060 080 100 120 140 160 180 200 220 240 260 280 300 320 340 360
Julian Days
Generated: Apr 25, 2007

AGO Status


Temperatures & Wind
AGO-2
Start Date: 0:00 Feb 19 2007 End Date: 0:00 Apr 30 2007
Rack Temp. (C)
40.0
20.0
0.0
-20.0
-40.0
Day: 56
Day: 64
Day: 72
Day: 80
Day: 88
Day: 96
Day: 104
Day: 112
Wind Speed (mph)
100.0
75.0
50.0
25.0
0.0
Ext. Temp. (C)
-20.0
-32.5
-45.0
-57.5
-70.0

AGO Status


Temperatures & Wind
AGO-1
Start Date: 0:00 Apr 4 2007
End Date: 0:00 Apr 20 2007
Rack Temp. (C)
30.0
15.0
0.0
-15.0
-30.0
Wind Speed (mph)
90.0
67.5
45.0
22.5
0.0
Ext. Temp. (C)
-30.0
-40.0
-50.0
-60.0
-70.0

Power System Specifications

- **Solar Panels**: 4x Kyocera 120W 12V
- **Wind**: AWP 3.6 Turbine, 1kW 24V, 20’ tower
- **Batteries**: 4x Sun Xtender AGM PVX-2120L, 212Ah 12V Sealed Lead Acid
- **Power Controller**: Campbell Scientific cr10x
- **Charge Control**: Morningstar Tristar TS-60
- **Battery LVD**: Morningstar Sunsaver 24V
- **Comms**: Iridium (h/k + science), ARGOS (h/k only)

A day in the life of the AGO field team …

Possible improvements

- One-piece tubing for “stilts”
- Cache heavy items, like spares of AWP turbine, blades and PV panel, rather than carry them from site to site; up-front cost recovered in cheaper air support
- Power all support equipment and laptops from DC buss (rather than use a DC-AC inverter)
- Get rid of snow mobiles(!)

Contacts

- AGO Engineering:
  - Bob Melville (bobmelville1@gmail.com)
- AGO P.I.:
  - Al Weatherwax – aweatherwax@siena.edu
  - www.antarcticspacescience.org
- Status Plots: http://yspace.augsburg.edu/ago/index.html
- Web page: https://themisgbo-2.ssl.berkeley.edu/ago
- AGO Photos: https://themisgbo-2.ssl.berkeley.edu/~will/photos/