Technical Challenges in Antarctic Seismology

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Overview

- Key parameters.
- Technical issues.

Appendix A

Workshop Action Items and Recommendations

Action Item #1: Identify an organization responsible for maintaining an interactive web site for the promulgation and discussion of new ideas, and develop a means for funding it.

Action Item #2: Prepare and maintain an experimenter's handbook that includes a compilation of proven technologies, lessons learned and other information relevant to designing and deploying autonomous systems to extreme environments.

Action Item #3: Principal Investigators deploying systems to the field should make an effort to include meteorological instruments in their systems and the data obtained from said instruments should be added to a database maintained on-line.

Action Item #4: Provide federal funding for a study to research the political and economic feasibility of a federally funded and administered RTG power source program for extreme environment research applications.

Action Item #5: Solicit and fund a proposal to develop a simple-to-use, computer based thermal model of the Antarctic environment for system design purposes.

Action Item #6: Compile and maintain on the web site, a list of government and university test facilities, their capabilities, and a point of contact to discuss their use by researchers funded by NSF grants. Consider the implementation of a national program of shared test facilities in which member institutions would gain mutually enhanced access to other facilities.

System Design Recommendations:

1. Keep system electrical loads as low as possible. Use micro-powered devices whenever available.

2. When selecting batteries for use in cold conditions, use standard 12VDC, Gel-Cell electrolyte type batteries.

3. Take maximum advantage of solar energy sources and utilize multi-crystalline silicone solar cell technology. Select panels with demonstrated robustness such as those produced by Solarex, Inc.

4. Extensively test all wind generator designs prior to deployment to the field.

5. For other than video data, set data sampling rate and retrieval interval to permit the use of commercially available Flash memory cards for data storage.

6. Include some form of telemetered data whenever possible, even if it consists of nothing more than a system health signal. Incorporate a processor and a compression routine into system design if it will permit the telemetry of greater amounts of data.

7. Include provisions for passive thermal regulation and static discharge in packaging design.

8. Ensure that overall design, and particularly the packaging, is compatible with the equipment to be used in transport and deployment of the system to the field.

9. Provide redundancy for critical instruments and data storage.

System Development and Testing Recommendations:

1.

Extensively document all system components at all stages of system design, testing and deployment. Implement a method for documenting and tracking revisions and subsequent changes.

2.

Modularize system design to permit isolated component testing, replacement repair and upgrading.

3.

Test all component manufacturers' specifications that are relevant to the intended field location.

4.

Invest in testing to the greatest extent possible and strive to subject integrated system components to combined condition testing in so far as practical.

Recommendations on the Research Infrastructure:

1.

Provide longer-term grants to proposals that require the development of new technology. The review of such proposals should ensure adequate provisions for testing are included.

2.

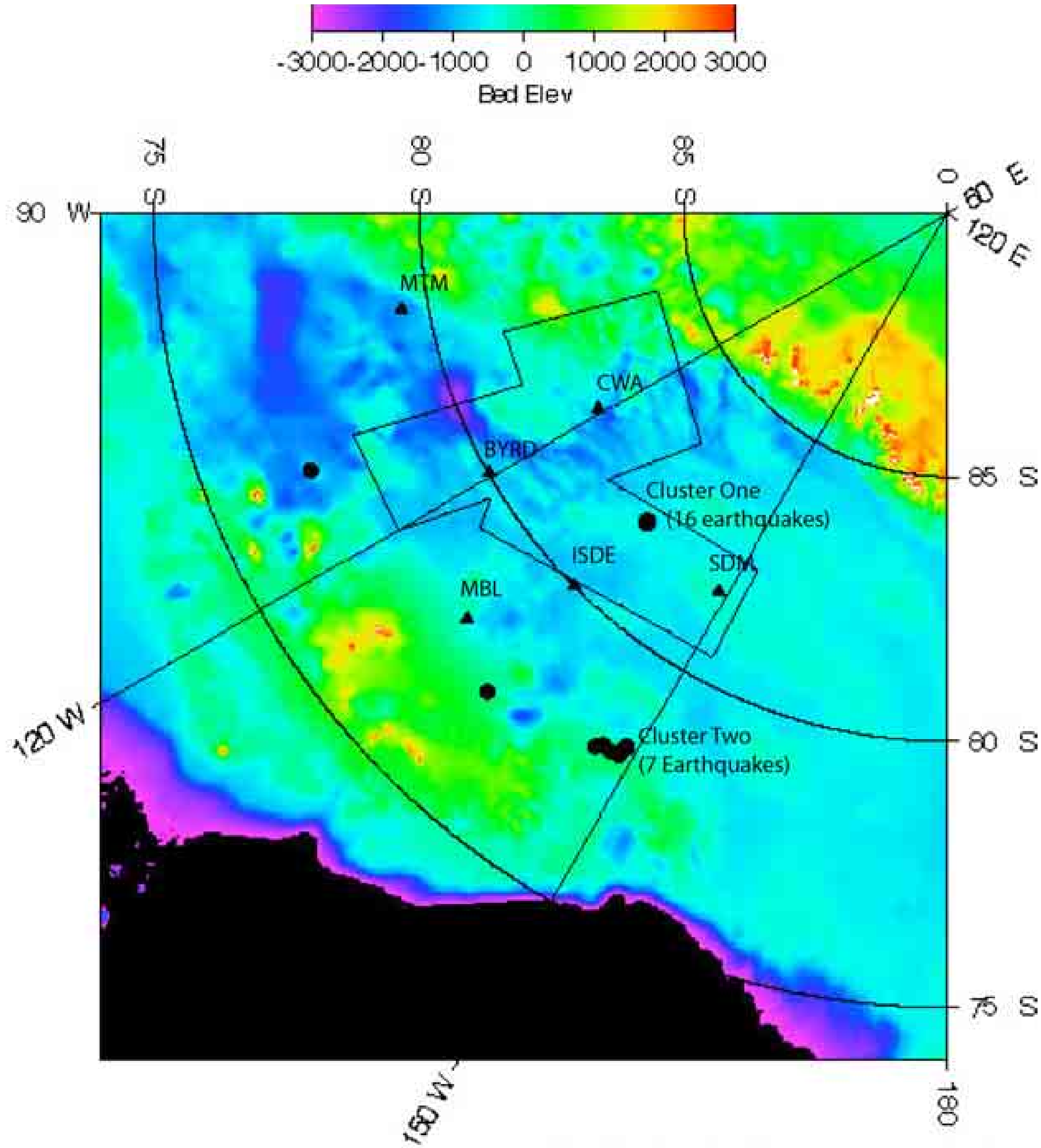
Create a grant program for technology development to specifically complement extreme environment research needs.

3.

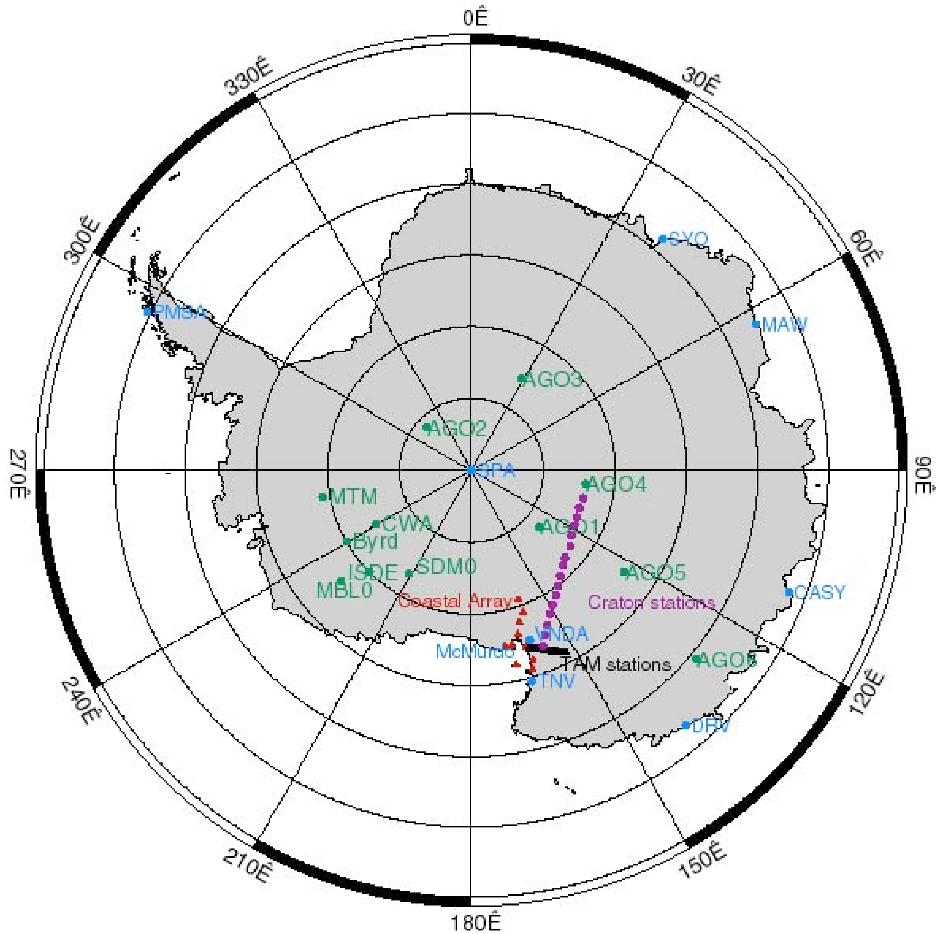
Empower an organization to facilitate technology transfer, focus funding and development efforts, approve quality standards for industry and guide our future efforts to explore our frontiers.

Prior (and ongoing) work

- Active seismics
  - Ice stream imaging and upper-crustal imaging
- Passive seismics, local, high frequency
  - Ice stream dynamics, icequakes, tidal forcing
- Passive, broadband
  - WARS
  - TAM, EA



Bed Elevation data from SPRI, SOAR, UW, others
SOAR/CASERTZ aerogeophysical data boundary
ANUBIS Seismic stations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Coastal Array
Craton stations
VNDA
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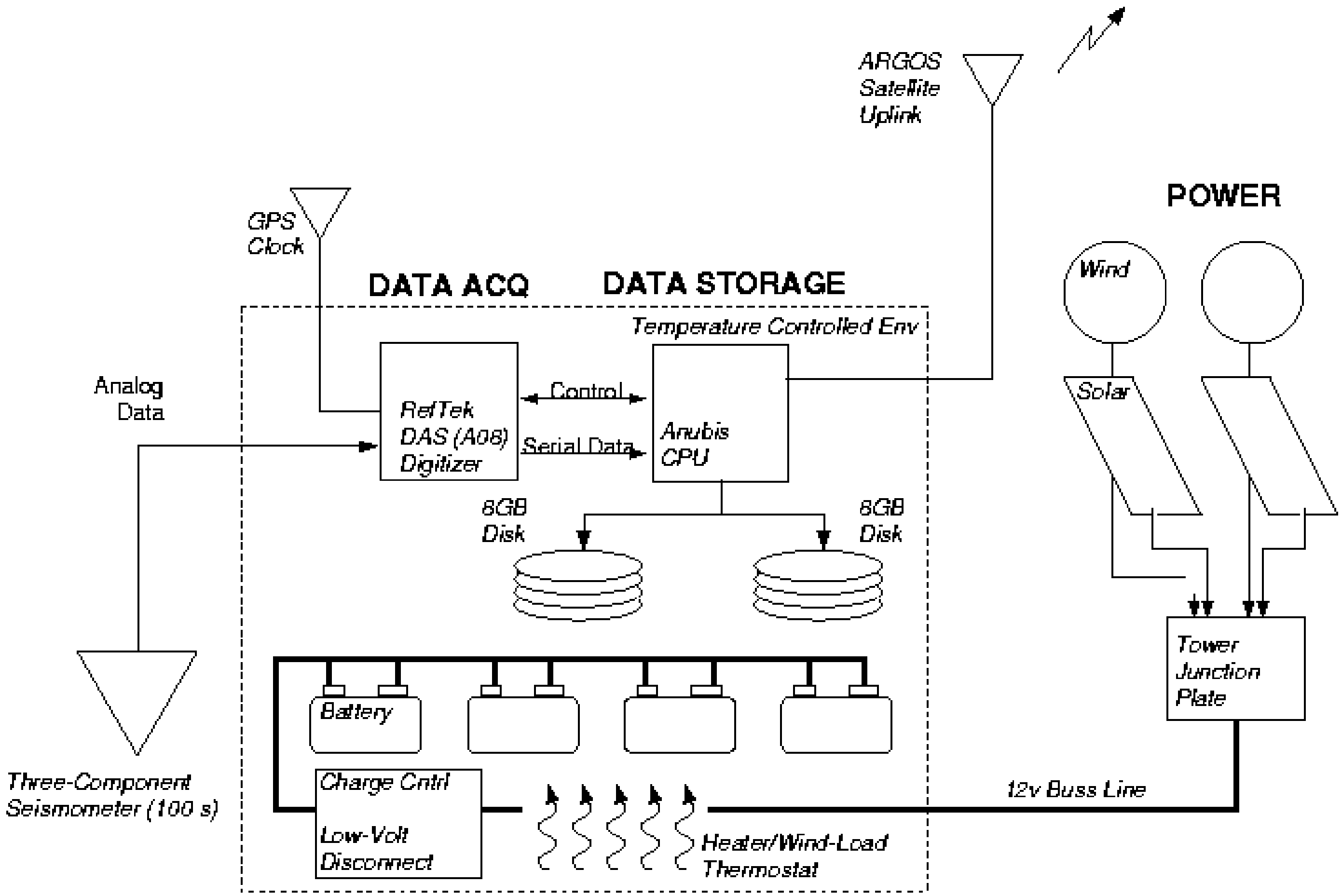
TAM stations
AGO6
TNV
DRV

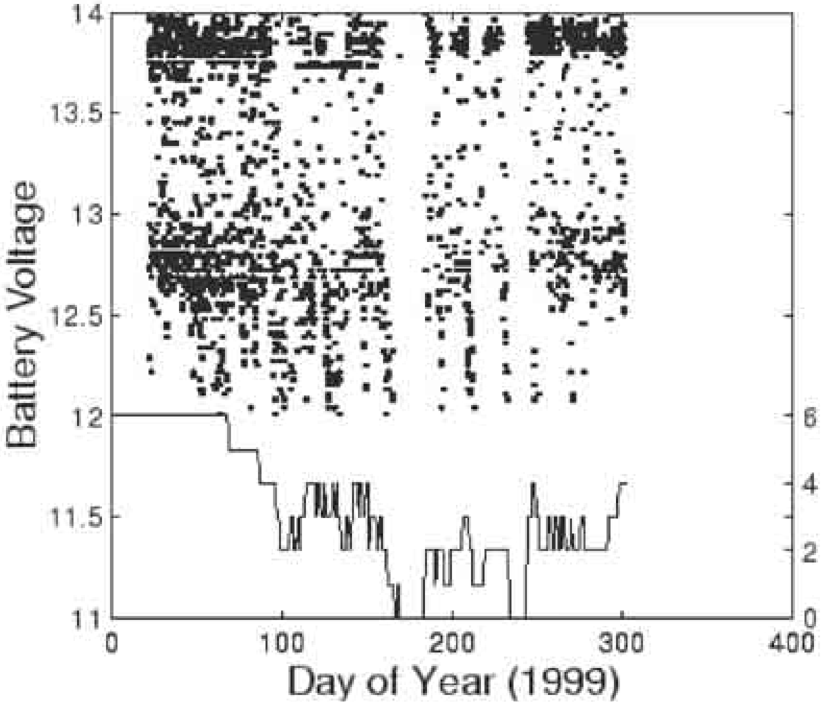
Schematic of a seismic station

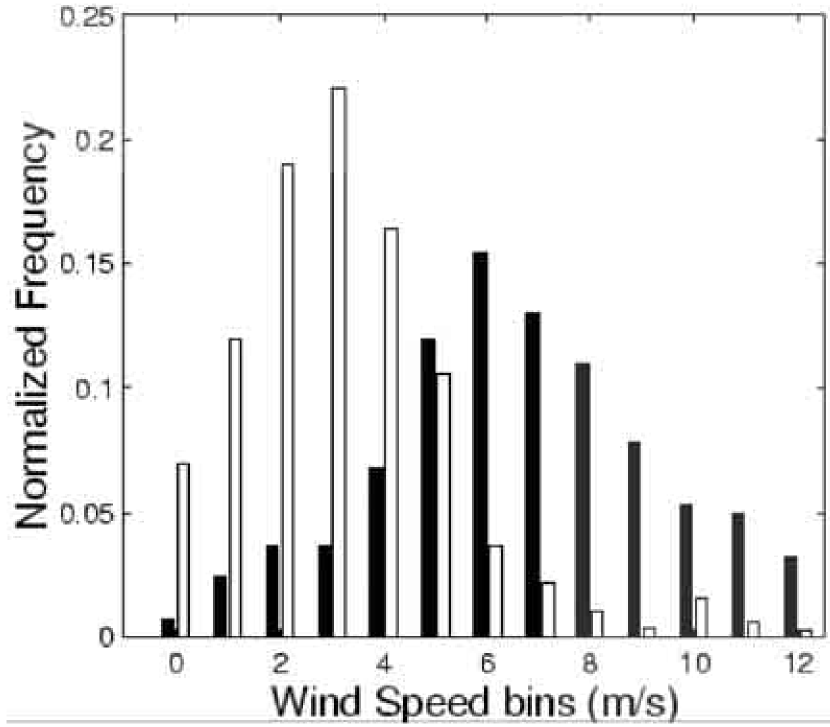


“Bruce board”

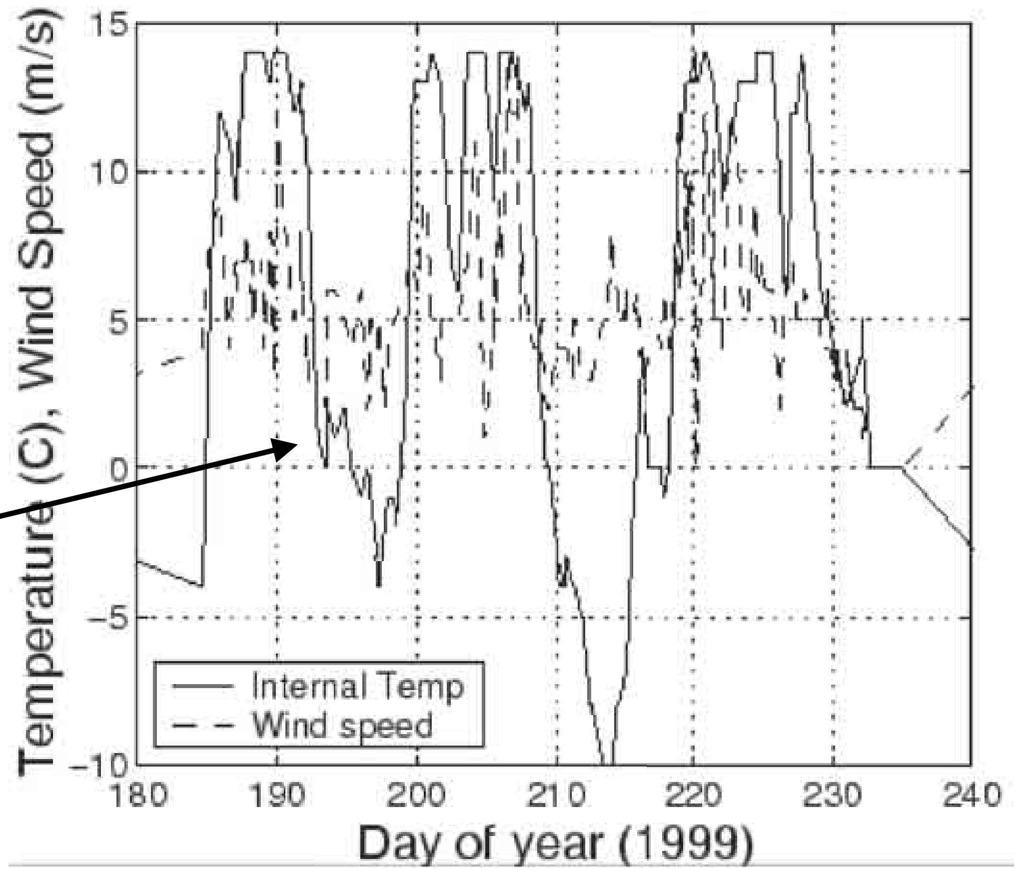
- 56 stations installed
  - One plate (on which the batteries sit)
  - 4 connectors (all different)
    - PV/wind input
    - Battery charging leads (with temp sensor)
    - Load (with LVD - temp compensated)
    - State of health - cable to outside
  - Multiple heating resistors underside of plate (+10C)

Winter performance from wind generators





Internal Temperature



5 l of water
freezing...

Autonomous stations

- Cost
- Power
- Data download
- Reliability
- Temperature control

Power

- Power budget is ≈1W per channel
  – Plus complementary geophysics (GPS).
  – Plus temperature control, if needed.
- PV is fine for 1/3 to 1/2 of the year
- Remaining part of year…
  – Accept downtime and trade off with deployment-time to achieve SNR
  – Less-reliable power sources (wind)

Cost

- $C = C_{deploy} + C_{retr} + N_{yrs} \times C_{maint} \times f$
- Deployment costs go with size & complexity
- Retrieval costs go with re-use potential and depreciation
- Maintenance goes with complexity
- f = fraction of stations to refuel/maint per year
- ***f* goes with data communication**
- N years goes with science requirements/sensor sensitivity

Cost = Deploy + Retrieval + Servicing

- Manual data retrieval
  - One visit per station per year (at least)
  - f=1

Cost = Deploy + Retrieval + Servicing

- Remote data retrieval
  - Now we have *maintenance* visits only.
  - *f* = fraction of stations that require refueling/PM per year
  - *f* is now an engineering issue (0.3? 0.5?)

Temperature control

- Sensors are generally the most sensitive to low temperature.
  - Equipment designed for operation at extremes will reduce power consumption.
- Minimize surface area.
- Consolidate equipment (sensor, electronics, ancillary GPS, etc.)

Reliability

- Minimize f_{visit}
- Minimize N_{yrs} of expt. to achieve SNR

Critical problems

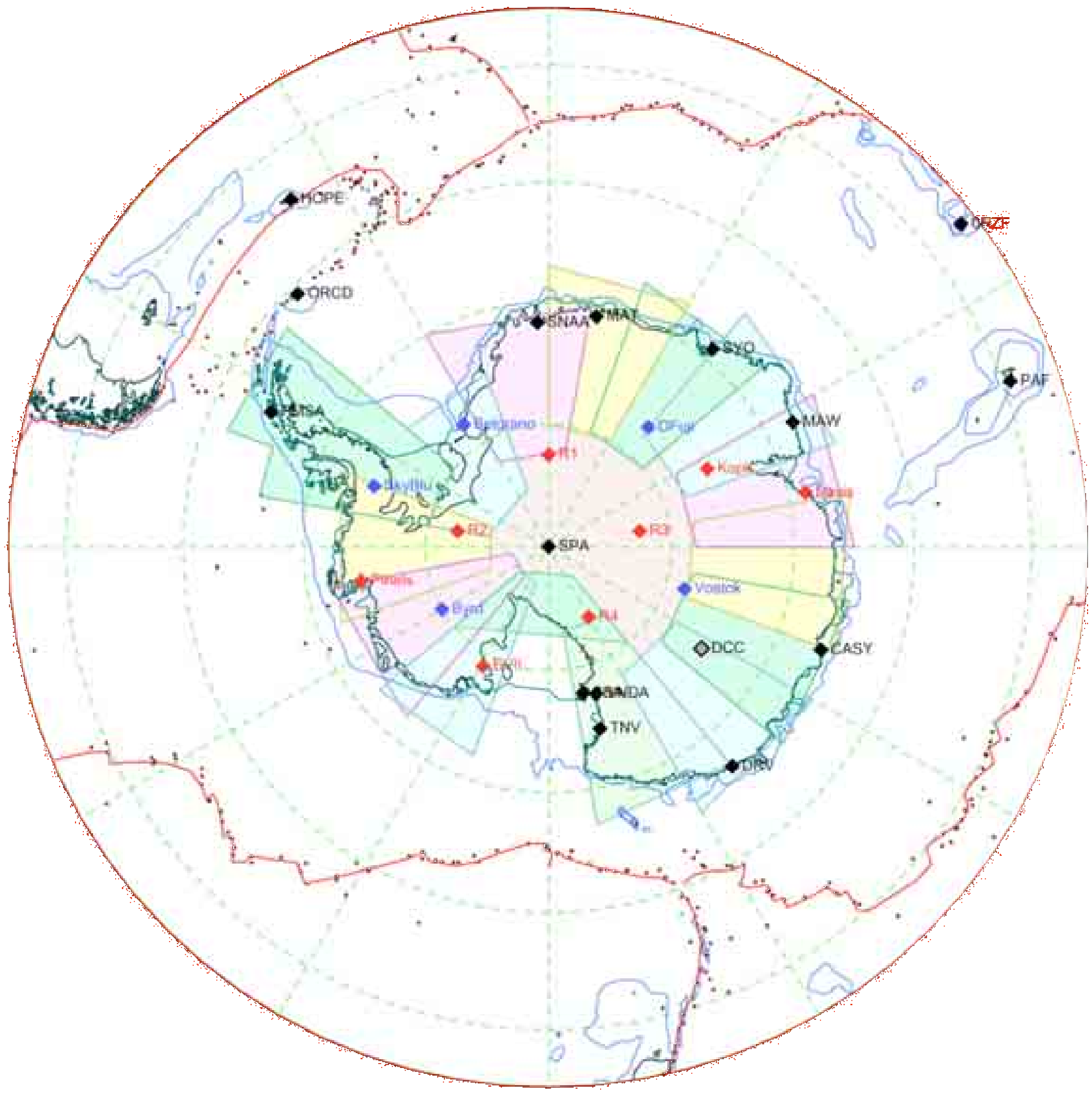
- Power overwinter (3W continuous)
  - Reduce N_{yrs}
- Remote data download ($10\text{-}10^2$ kB/s)
  - $f_{visit}<1$
- Bespoke packaging of systems
  - Reduce size for Temp control, reduce interconnections for reliability, better f_{visit}

One center of expertise

- Dedicated field engineers to do the deployment and maintenance in partnership with science
- One place to do the design and construction and maintenance
- “Corporate memory”

AntarcticArray

- like USArray
- 10 countries
- some permanent stations
- evolving pinwheel array



Field camp Logistics

- New *designed* instead of *ad-hoc* field facilities
  - Current Antarctic field camp facilities are heavy & inefficient.
  - Require trades to install.
  - Activation energy for a medium-size (10+ pax, summer) camp is 4-6 LC-130 flights.