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Remote ARA Power Systems 2010-2011 Season

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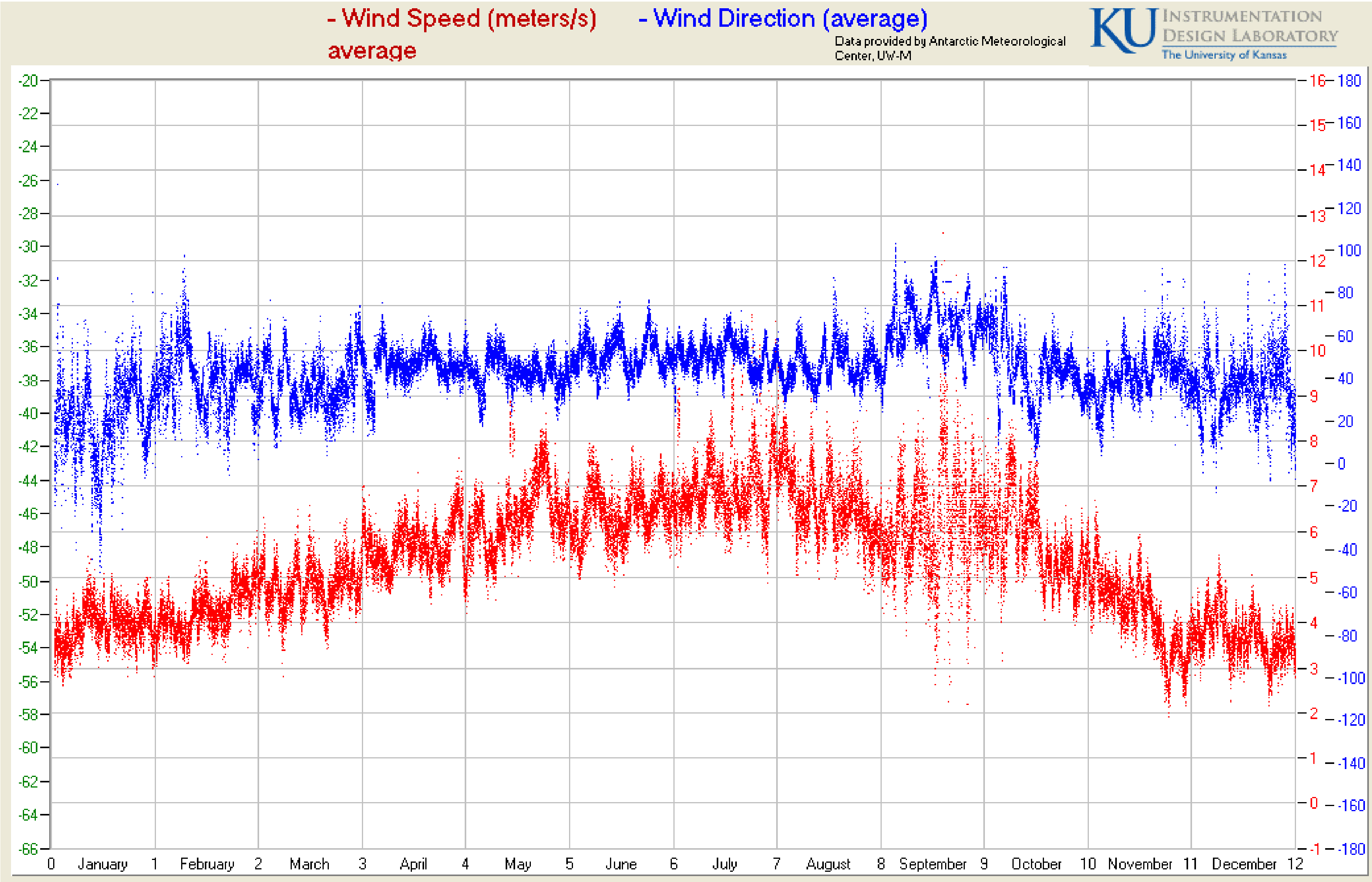
Long-Term Autonomous Power Station Goals

- Manageable deployment & Scalable design.
- ~~100~~ 200 watts (for 3 holes.)
- Continuous operation.
- 24-7-365 health monitoring.
- Orderly hibernation and restart in case of wind outage or failure.
- 2-person Deployment.
- Minimal maintenance (max=annual).
- Long lifetime (>= 5 yrs).

Challenges

- Low wind availability, especially in Austral summer.
- Gaps in wind.
- No photovoltaic capability in Austral winter.
- Temperatures to -80C
- FORTUNATELY:
  – Sun & wind are complementary
  – Wind from nearly constant direction

Averages (1993-2009)



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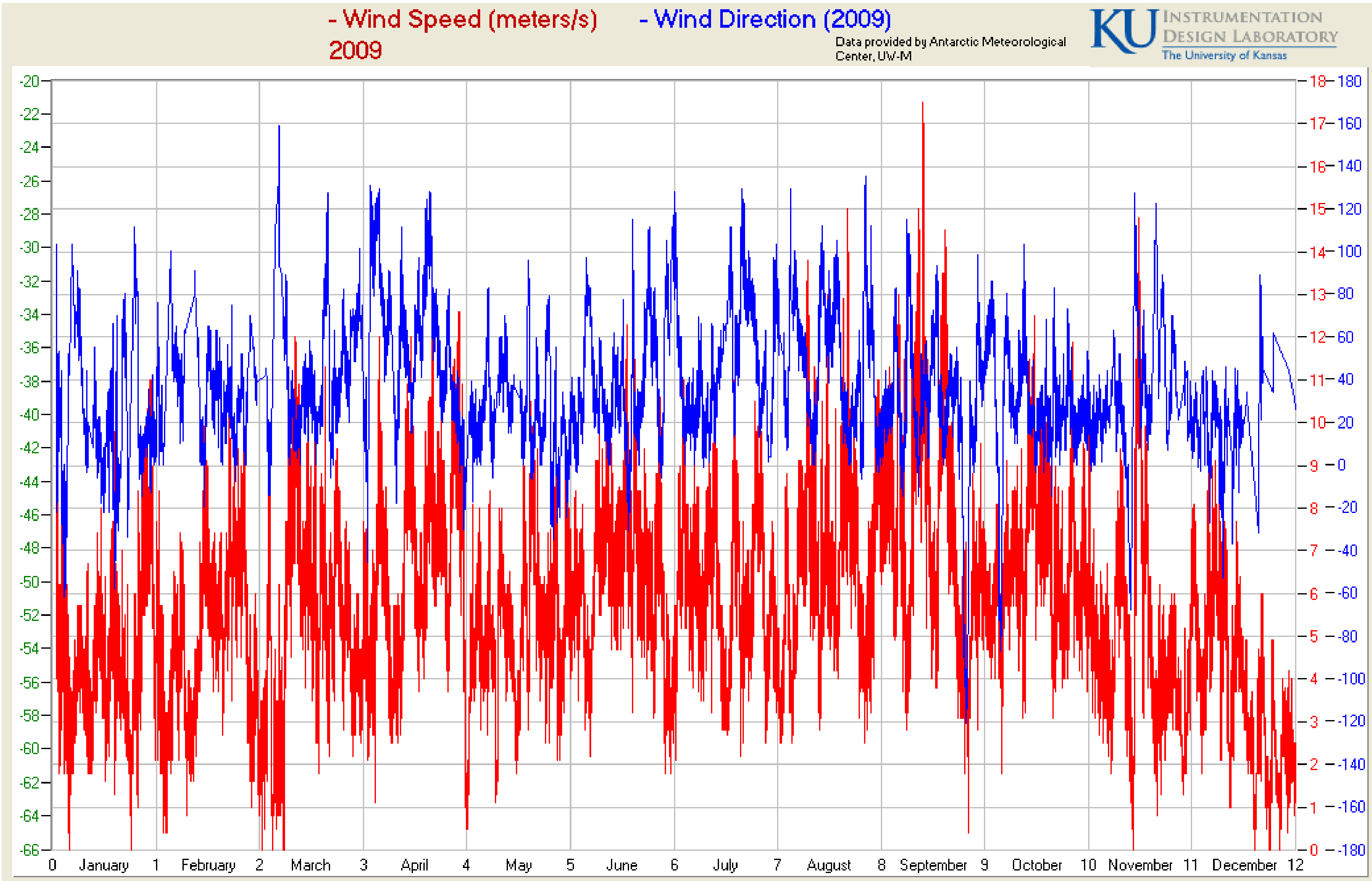
Typical Annual Wind Speed



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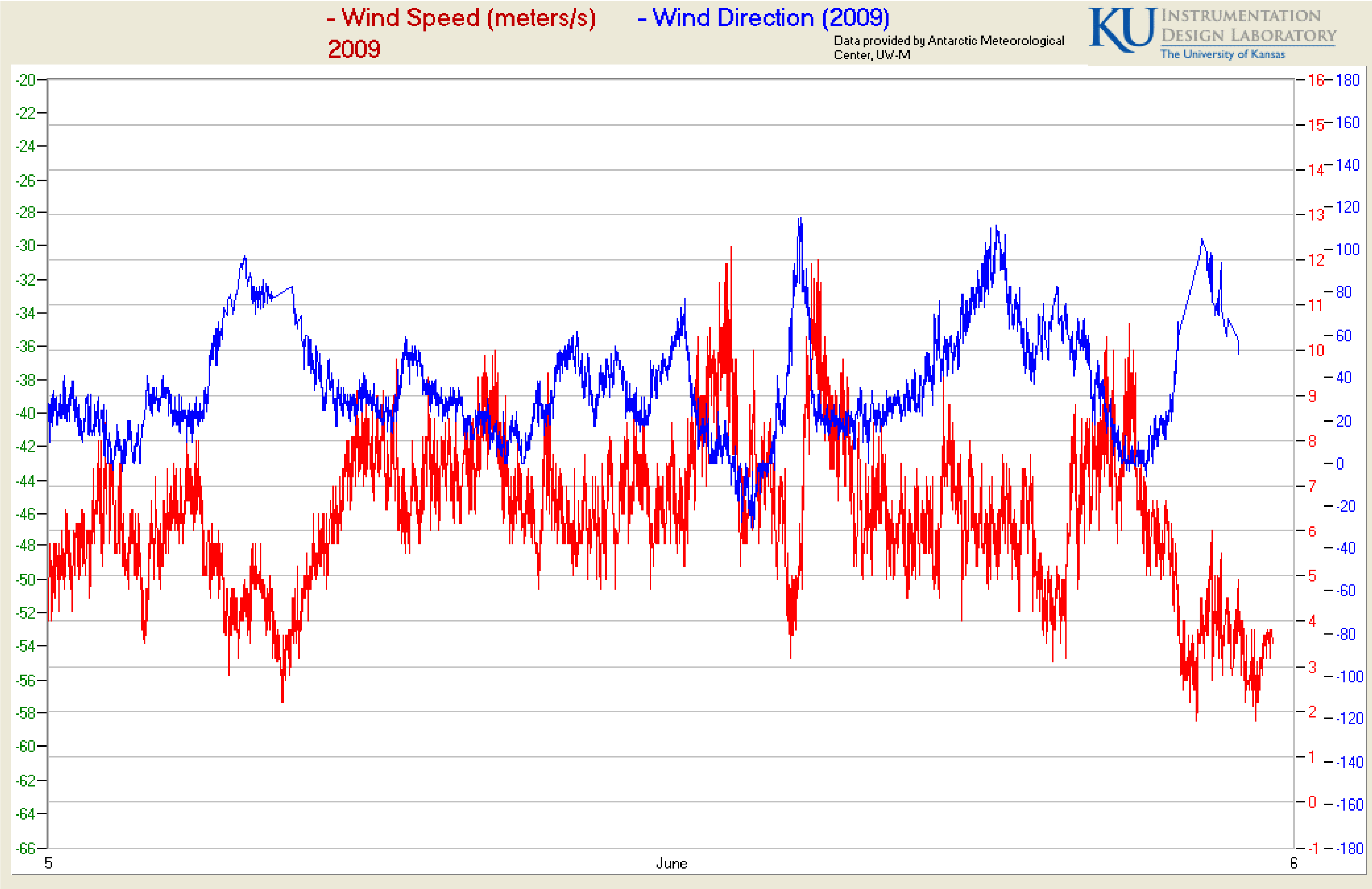
Typical Month



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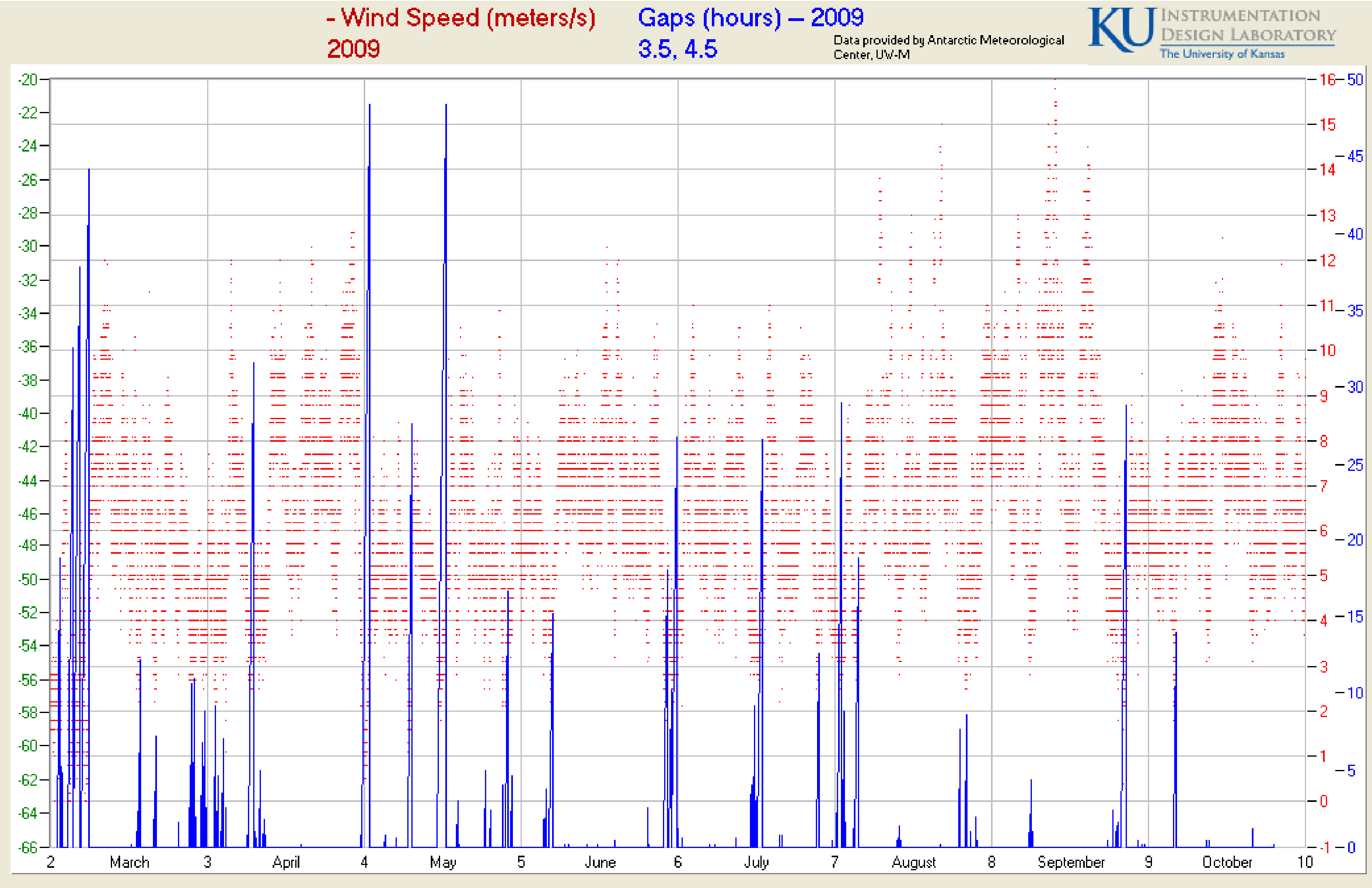
Gaps



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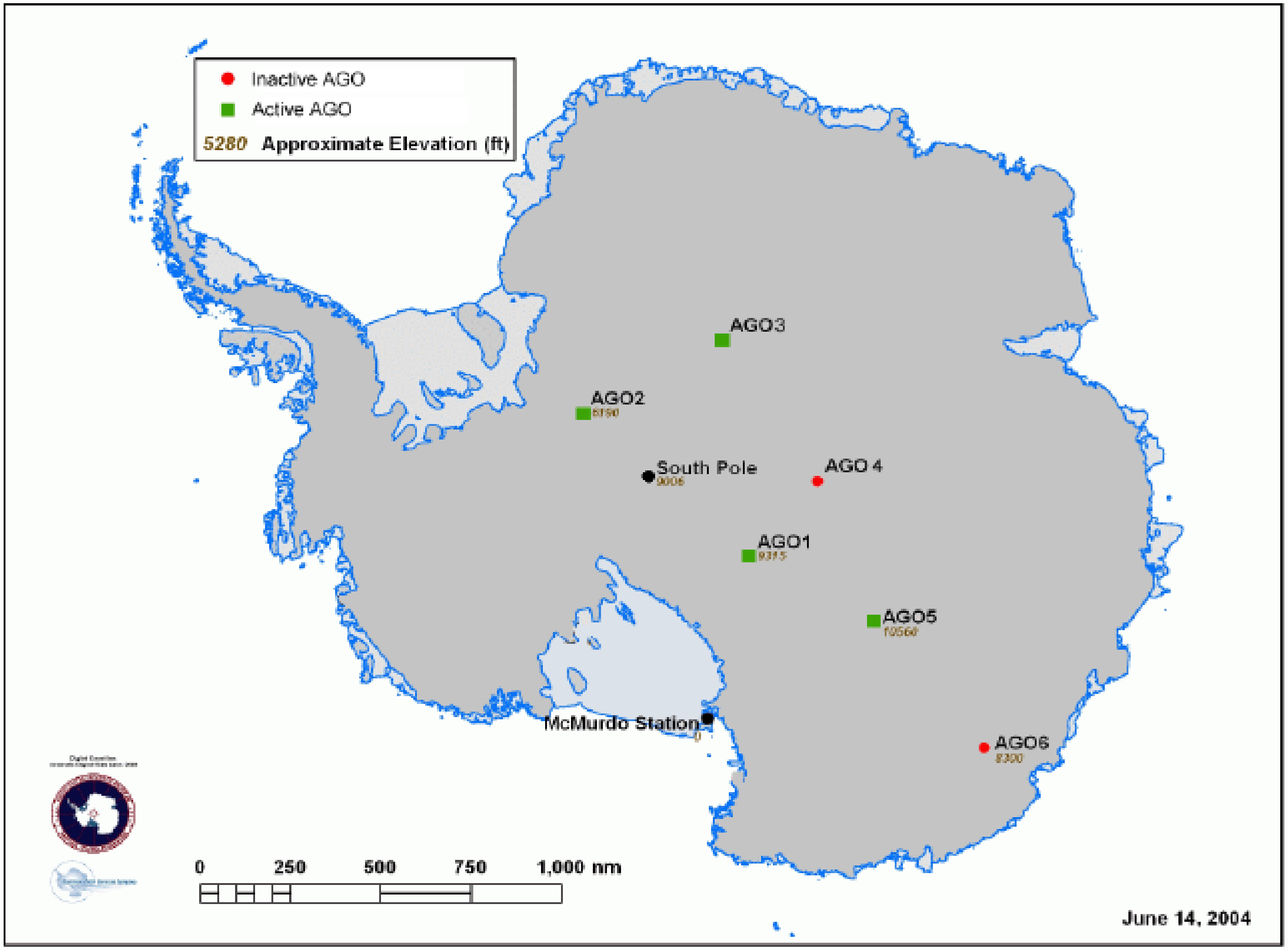
Evaluating Previous Experiences

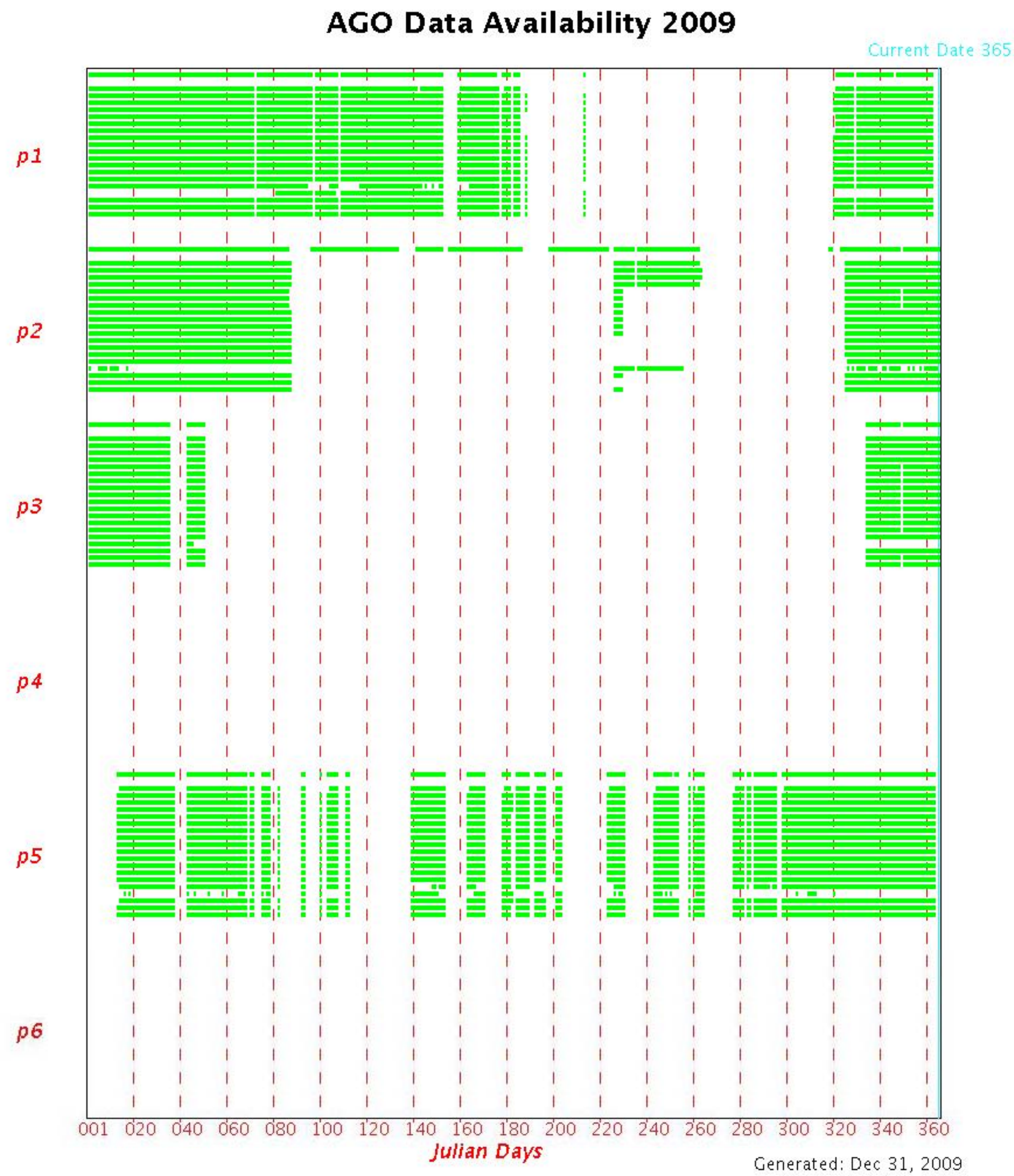
- Plateau experience is relevant; margin experience is not.
- AGO: Automatic Geophysical Observatories
  - Relatively high power requirement
- ARRO: Related to AGO
- UNAVCO:
  - Low Power
  - Mostly GPS monitoring

AGO Locations



Recent installations use AWP 3.6 1kW turbines plus 4 solar panels.

Melville, 2008 PTC



AGO Data Availability 2009
Current Date 365
p1
p2
p3
p4
p5
p6
001 020 040 060 080 100 120 140 160 180 200 220 240 260 280 300 320 340 360
Julian Days
Generated: Dec 31, 2009

Lessons

- Points of failure:
  - Bearings (replace with Class C)
  - Lubricants (use low temp lubricants)
  - Procurement problems (AWP not a dependable source)
  - Power Connections
- Power requirements much greater than for ARA

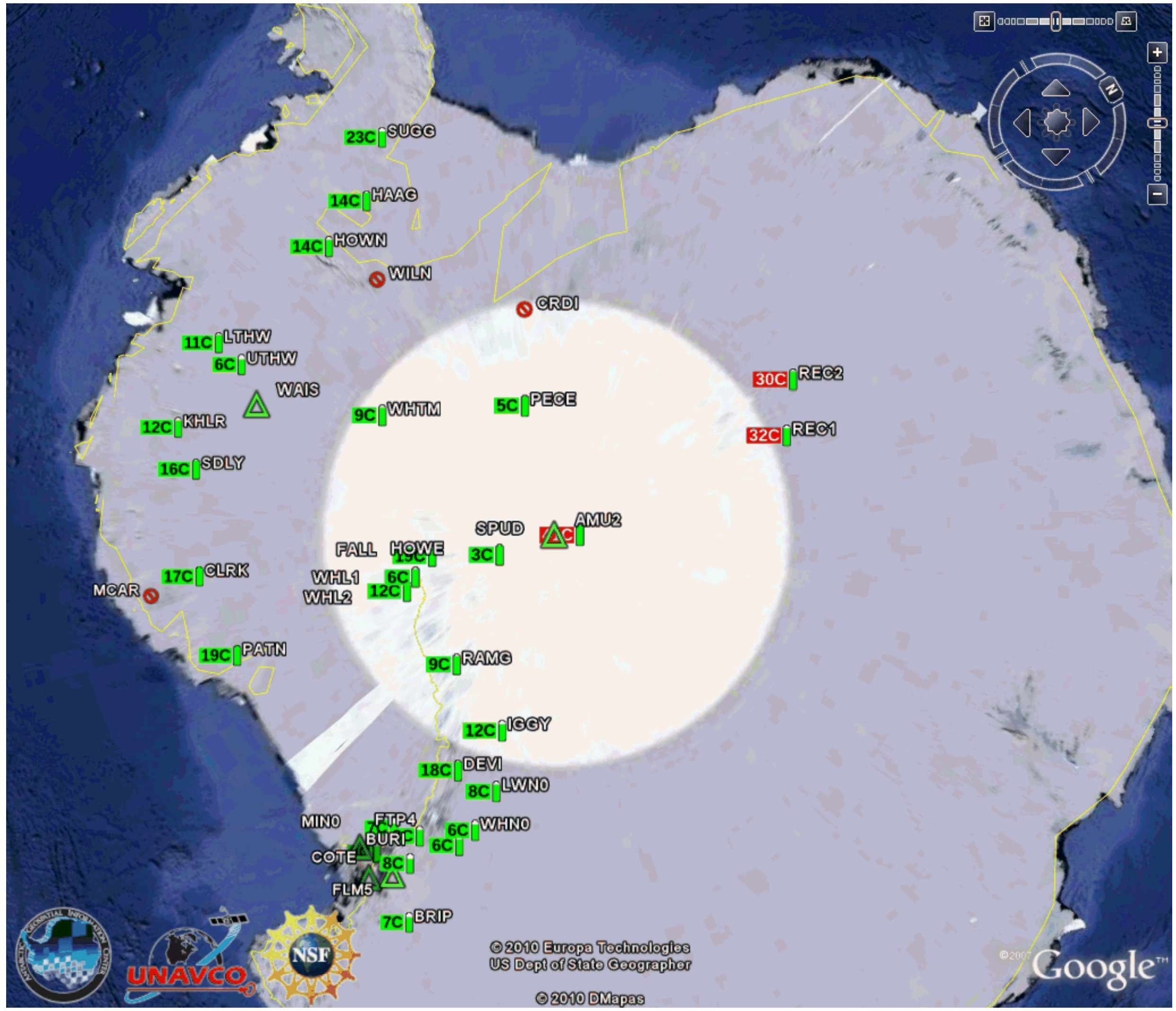
Contacts:

- Engineering: Bob Melville (bobmelville1@gmail.com)
- PI: Al Weatherwax (aweatherwax@siena.edu, www.antarcticspacescience.org)
- Status plots: http://yspace.augsburg.edu/ago/, http://www.polar.umd.edu/ago.html

UNAVCO Locations

Successful stations on Plateau

- SPUD (near Pole)
- REC1
- REC2



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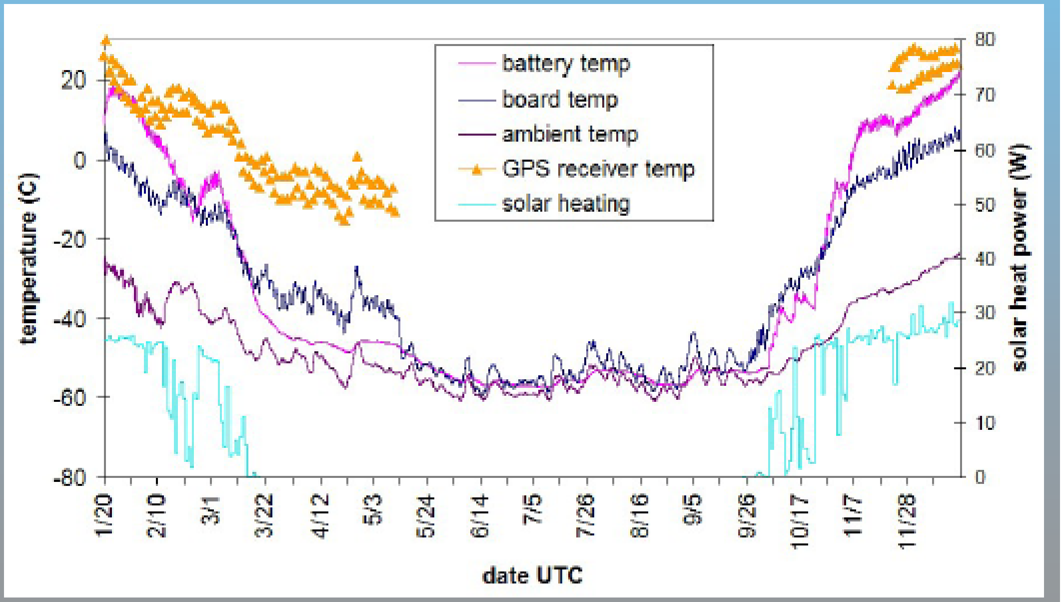
Plateau GPS System: Version 1

- Installed January 2008
- 3 solar panels + 900 AH SLA batteries + 2 Forgen 1000 wind turbines
- Vacuum-panel insulation, Iridium comms
- 12 channels engineering data recorded: voltage, temperature, current
- System lost power in May, restarted in October
  - Forgen 1000: too little power, bearings not OK for plateau cold
  - Electronics not damaged by cold soak



UNAVCO

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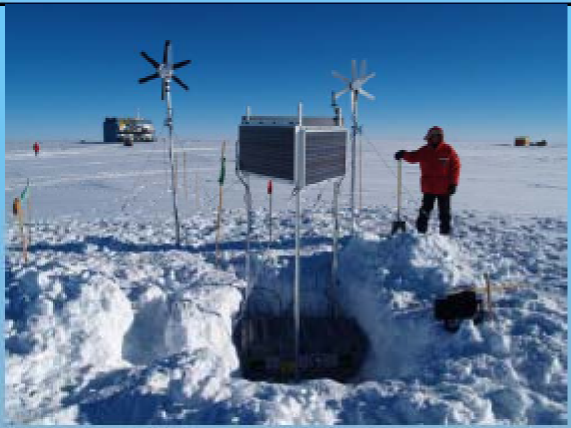
Plateau GPS System: Version 2

- Improved vacuum-panel insulation: ~40% better than Version 1
  - Double layer of 1" panels where possible. Panels from Nanopore.
  - Tighter fit. Edge effects can reduce enclosure's overall thermal efficiency by ~50%
  - Vacuum panels are very fragile and assembly is extremely labor-intensive. Panels can also fail over time, or during transport.
  - We may prototype a very thick-walled foam box. Same insulation but cheaper, easier, and tougher. Larger volume but still deployable via traverse or Twin Otter.
- Electronics now inside vacuum-panel enclosure with batteries to conserve heat
- New wind turbine
  - Aerogen 4 non-furling
  - Manufactured with custom bearings: C3 clearance and LG68 lubricant
    - Identical bearing specs to turbines used with success on plateau by AGO group with AWP
    - Blade and yaw start torque cold-chamber tested to -70C
  - Aerogen turbine won out in lab tests vs. Ampair 100 and Rutland 910-3
    - Two Plateau sites (Recovery Lakes) have Aerogen 4
    - South Pole runs with Aerogen 4. Also testing modified Ampair 100 (improved yaw bearing)

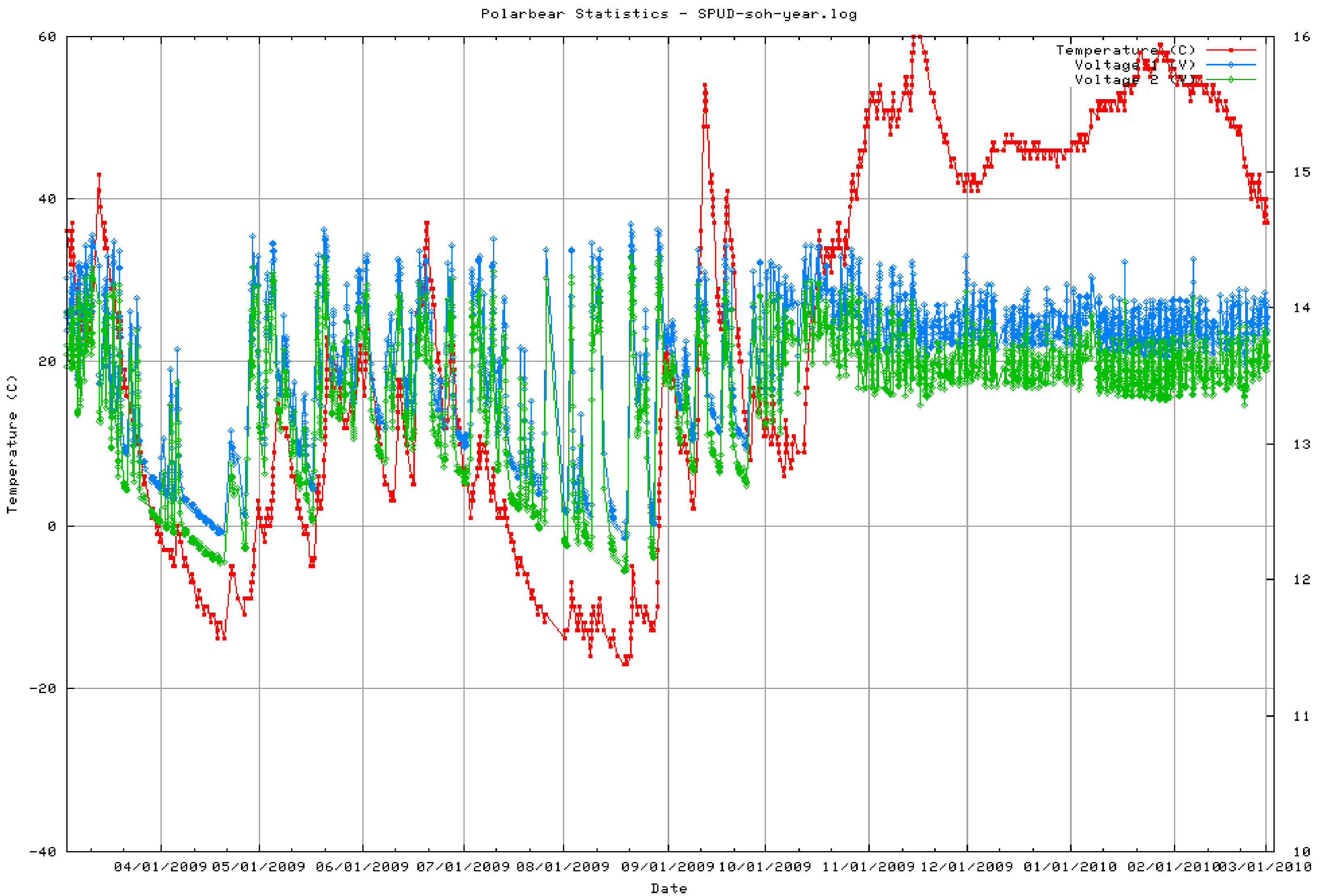
Plateau GPS System: Version 2

Aerogen 4 turbine



Plateau GPS system at South Pole

Electronics + batteries in vacuum enclosure



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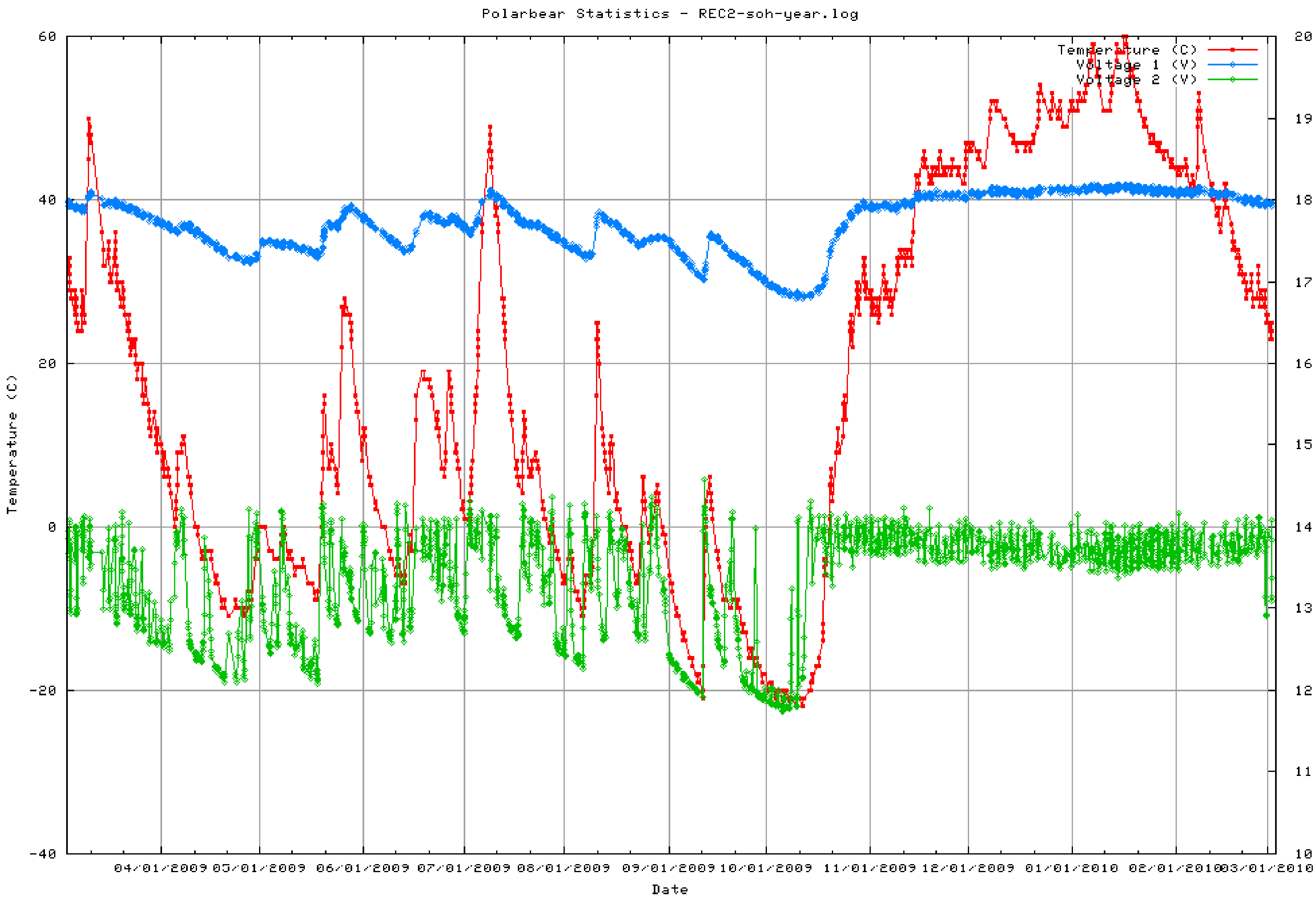

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UNAVCO Lessons

- Points of failure in past years
  - Bearings
  - Lubricants
  - Infant mortality
- Successes: Aerogen 4-based operated through winter at S.P. and Recovery Lakes (2).
- Plateau recommendations available for lubricants, PhotoVoltaics, boxes, insulation, batteries, etc.
- Will learn more at Polar Technology Conference, Boulder

ARA 2010-’11 Goals

- Test candidate turbines.
- Look for rf interference.
- Evaluate a PhotoVoltaic system.
- Monitor environmental and operational parameters
- Test independent health-monitoring system.

Notes from ARRO Report, 2006

Began a study of a selection of turbines.

They found Rutland to cut in quickest. Windside, Whisper not usable. AWG became available and comparisons ended.

Ampair also under consideration.

Ampair Pacific 100
Used on polar plateau by both ANUBIS project and AGO project
Cut-in speed: ~3 m/s
Produces up to 100 W/hr
Weighs 13 kg
Recommended by Rick Sterling (Berkeley) and Hugh Piggot (Scoraig Wind)

Bergey XL.1
No known Antarctic usage
Cut-in speed: 2.5 m/s
Weighs 34 kg
Produces up to 1 kW/hr
Bergey products in general recommended by Paul Gipe (author)

LVM Aero6gen-F
Claims use in Antarctica, but no proof
Cut-in speed: ~2.6 m/s
Weighs ~13 kg
Produces approximately 100 W/hr
Recommended in Chelsea Green article

Marlec Rutland 910-3F
Used on polar plateau by ANUBIS project
Cut-in speed: 3 m/s
Weighs 17 kg
Produces approximately 100 W/hr
Recommended by Chelsea Green article

Southwest Windpower Whisper H40
Previous model (Air 403) used by Mt. Erebus and ANUBIS projects
Cut-in speed: 3.4 m/s
Weighs 21 kg
Produces approximately 900 W/hr
Former models recommended on Chelsea Green article

Windside WS 0,30A
U of Michigan plans to use one on polar plateau, one supposedly in use at McMurdo
Cut-in speed: 3 m/s
Weighs 80 kg
Produces approximately 108 W/hr
Interest expressed by several Antarctic scientists

Marlec Rutland fm1803-2: 1.8m, 36kg

Marlec Rutland 910-3F: 0.91m, 17kg

Aerogen 6: 1.221m 16kg

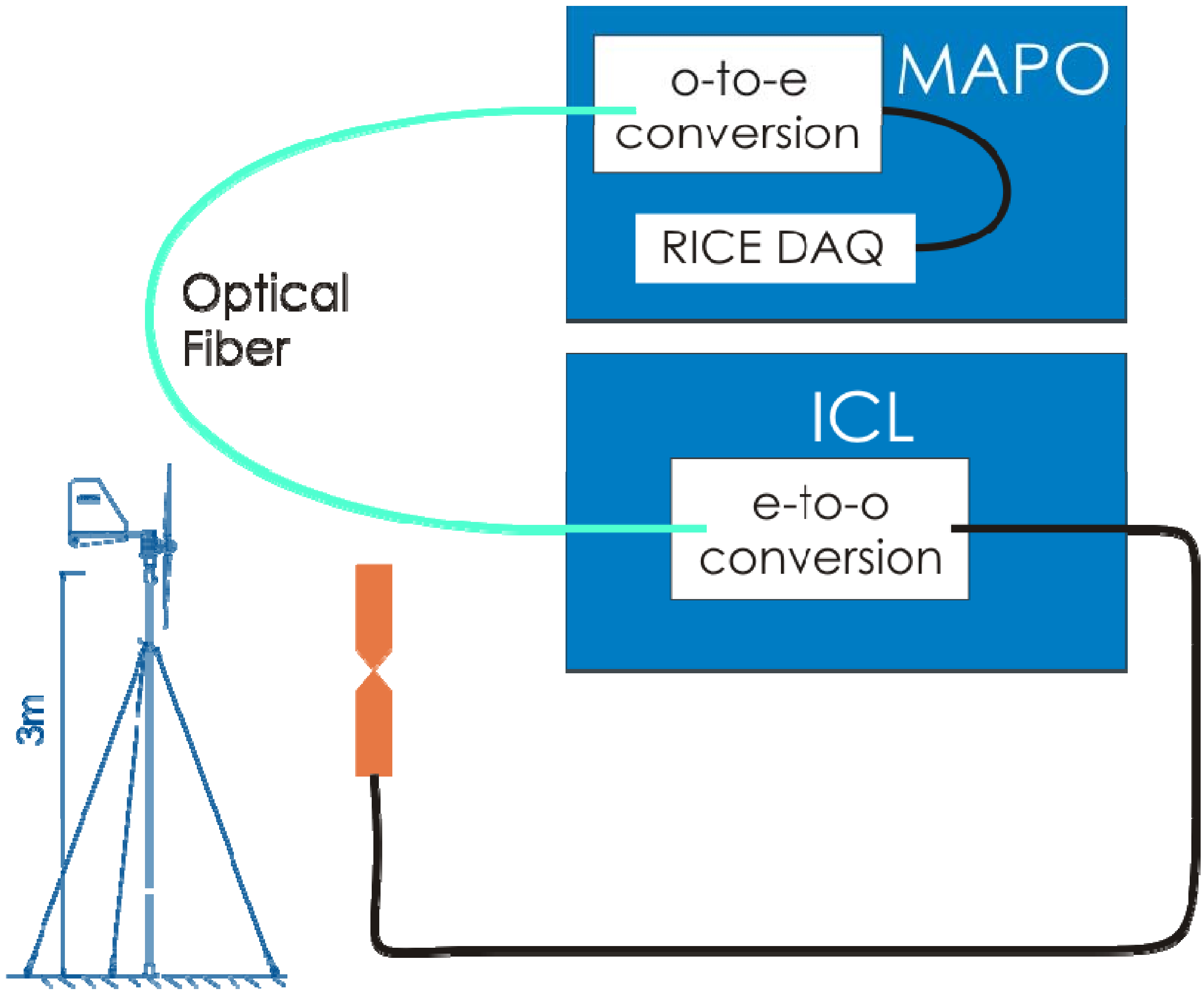
Forgen 1000 used by UNAVCO pre-2009. Vertical axis style.

2010 Turbine Installations

- Candidates TBD based on AGO/ ARRO/ UNAVCO experiences.
- Possibly Aerogen 6, Rutland 910-3:
  – 6-8 blades, optimized for low-wind.
  – Non-furling types.
- Modifications:
  – C3 (loose) bearings
  – Low Temperature greases per recommendations.
  – No furling mechanism.
- Install mast on a hinged plate with guy wires.
- Location(s): TBD

Test for rf interference

- Expected sources:
  - Aerogen 6 is brushless; slip-rings to be removed.
  - Rutland "89/336/EEC compliance ensures no radiated interference."
  - Wind-generated emi.
- Rf detection:
  - SATRA detectors?
  - Testbed detector?
  - RICE? (Turbine near ICL; e-o link to MAPO.)


o-to-e
conversion
MAPO
RICE DAQ
Optical
Fiber
ICL
e-to-o
conversion
3m

Photovoltaic

- One site only, to determine power density, possibly to test power controller.
- Use Sharp devices proven by UNAVCO with UNAVCO structure design.

Health Monitoring System (HMS) Monitoring System

- Very low power; in future, implement as a mesh.
- Independent of Super-Cluster comms.
- Will run on a dedicated battery.
- Meteorological measurements with solid-state Vaisala module.
- Measure meteorological and power parameters at 10-min intervals. (Anything else?)
- Data Handling:
  - Telemeter to ICL via low-power 900MHz Zigbee.
  - Stored in flash memory.
  - Possibly send data through a surface quad.

Power Storage

- Probably 2 SLA batteries per station
  - One with dummy load.
  - One to run zigbee comms.
- For this season, a simple power control system.
- Plan to use UNAVCO-style equipment box, buried.

Storage Controller

- Must monitor charging
  - Report status (10s intervals) to Health Monitor System (HMS)
  - No over-charging
  - Shut down system if batteries get low. Orderly startup when power returns.
- Monitor Instrumentation Box
  - Warm before charge
  - Switch to external sink if warm.

Data Comms Notes

- Options:
  - 900 MHz
  - Laser
- Plan 900 MHz (900-928) with separate frequencies for the first 7 channels. (Maybe extend freq. range in future?)
- Use Yagis, pointed toward 1 or more receivers.

Today’s ‘10-’11 Questions

- Where to place turbines
- How to look for emi from turbines (or turbine structures)
- Where to place Zigbee antenna (and penetrate ICL)