Autonomous Polar Observing Systems:

Mike Rose
& Many co workers at BAS.

Developments at British Antarctic Survey

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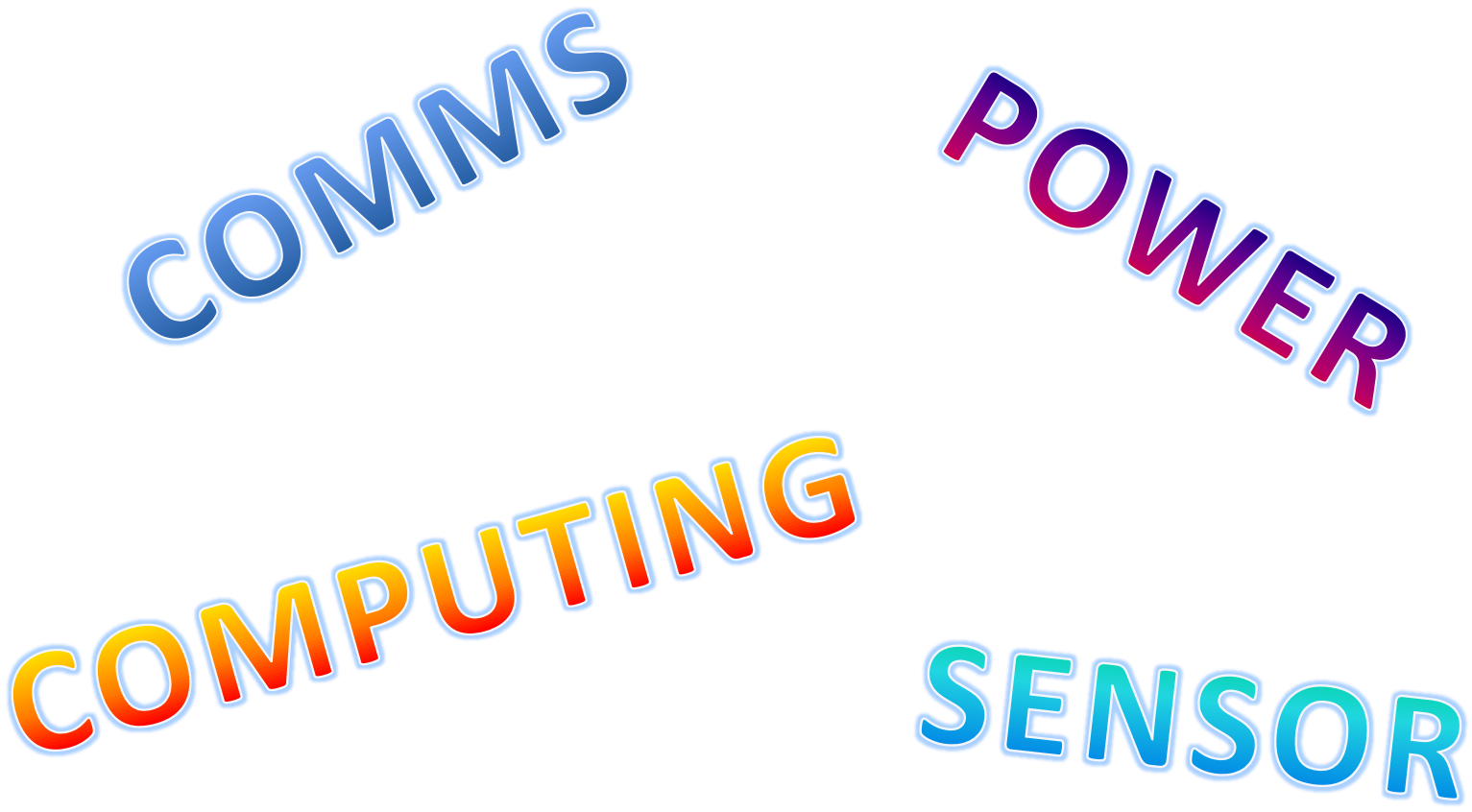
m.rose@bas.ac.uk



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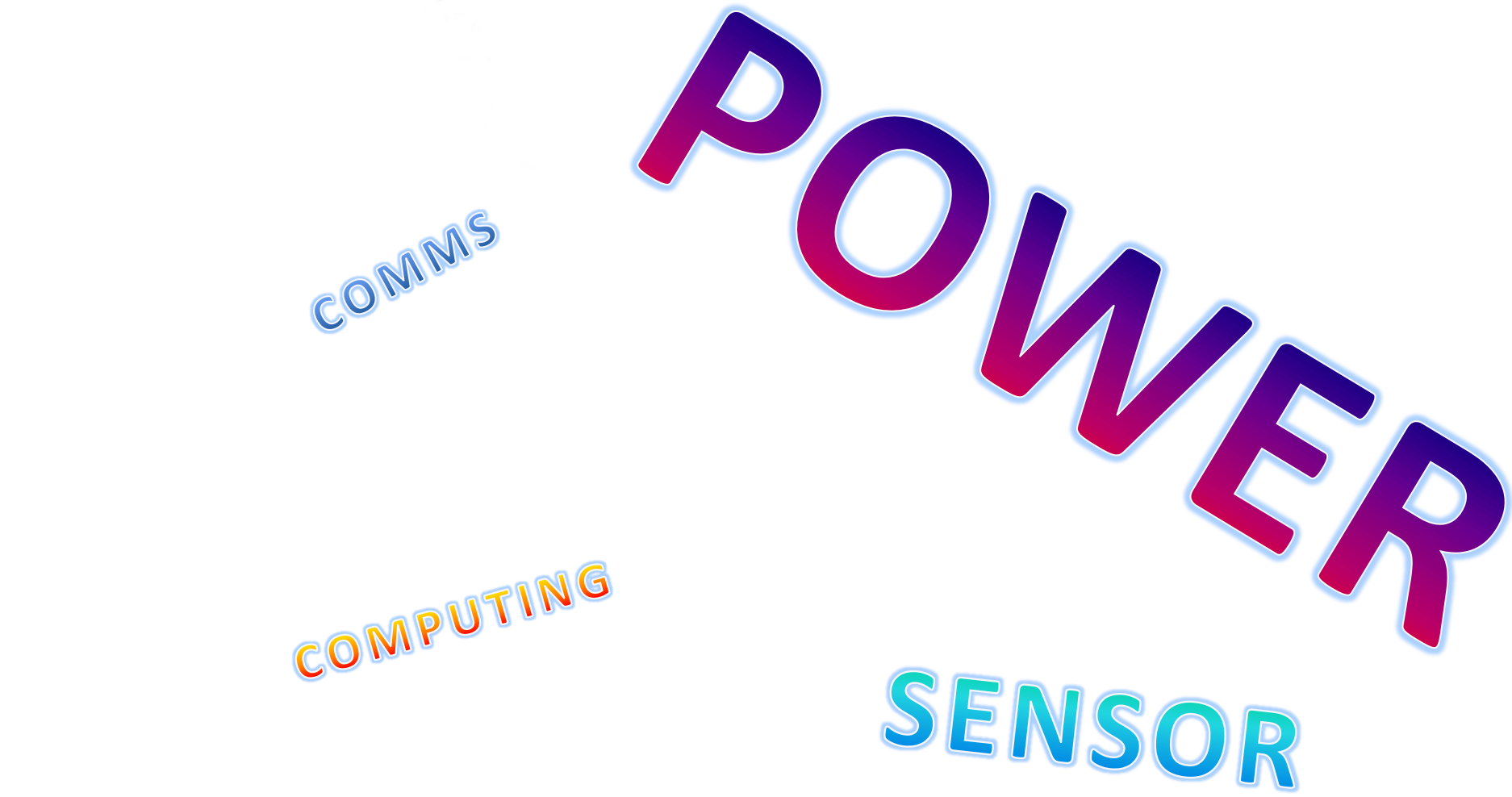

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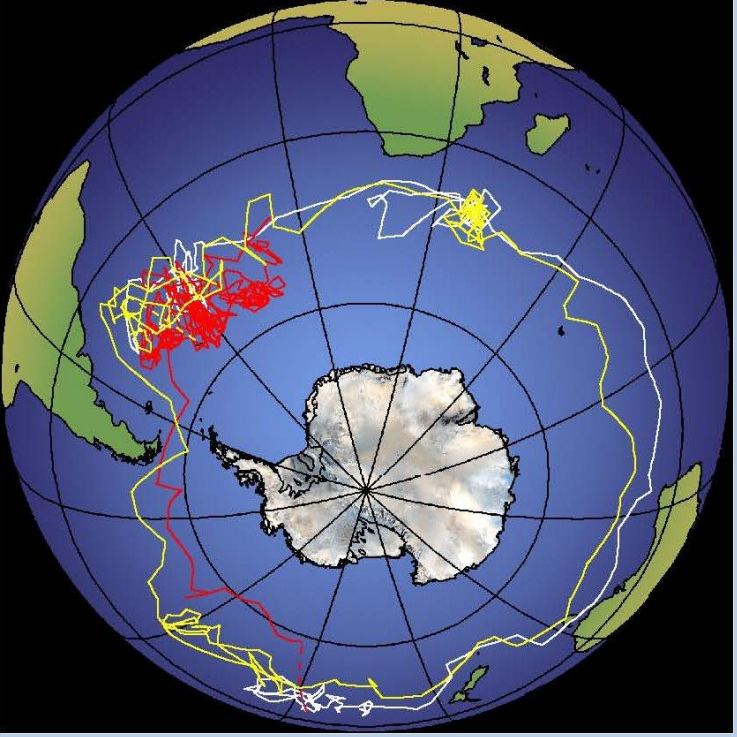
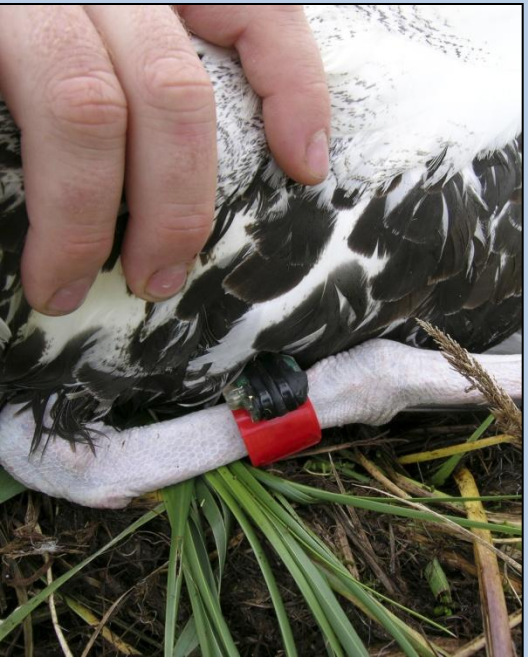
UAS for Boundary layer studies

philip.s.anderson@bas.ac.uk



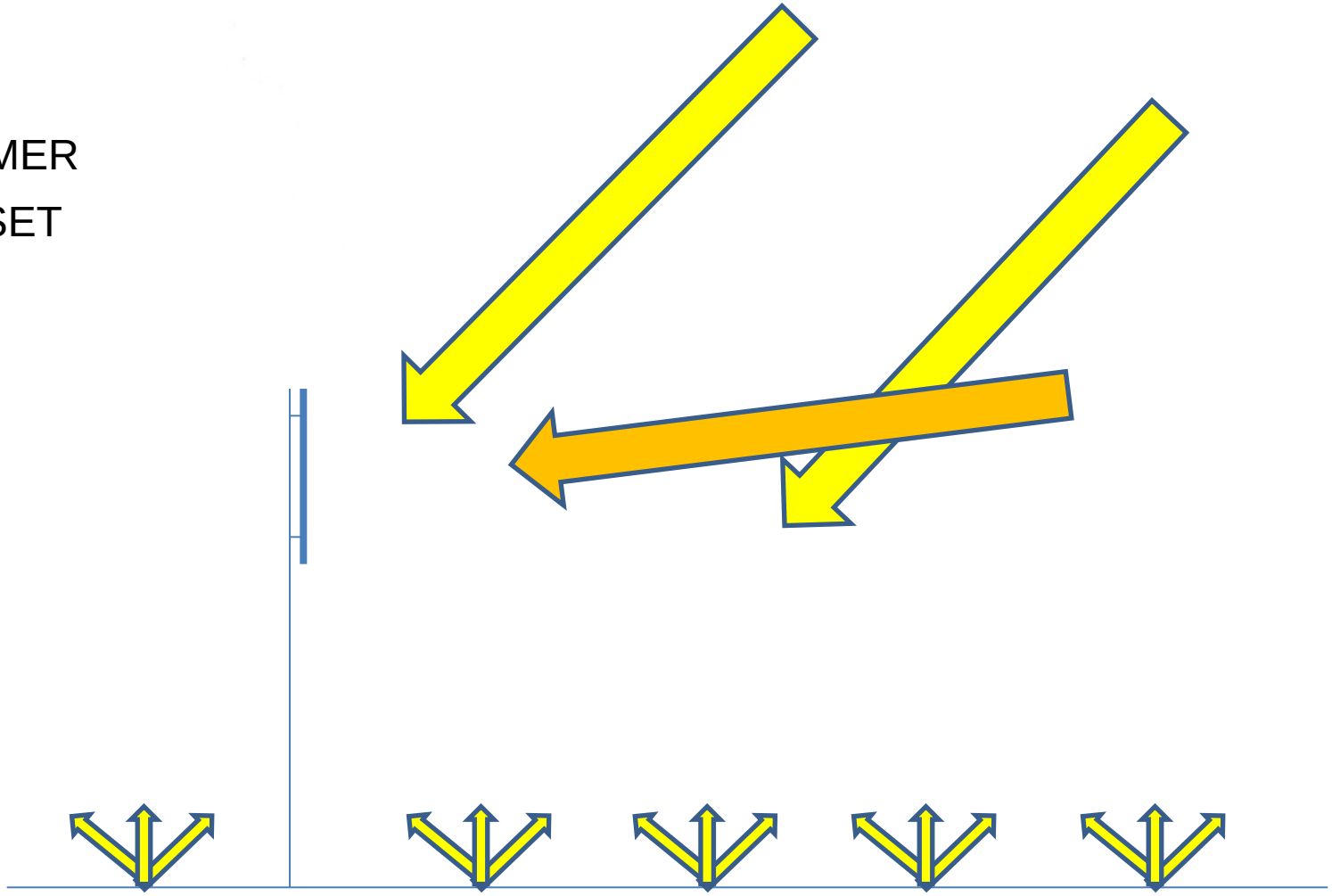


Bird Loggers:
Position of bird and immersion (feeding) information relayed via Argos.

Jim.Fox@bas.ac.uk Richard.Phillips@bas.ac.uk

SUMMER

SUNSET



SNOW ALBEDO >0.9

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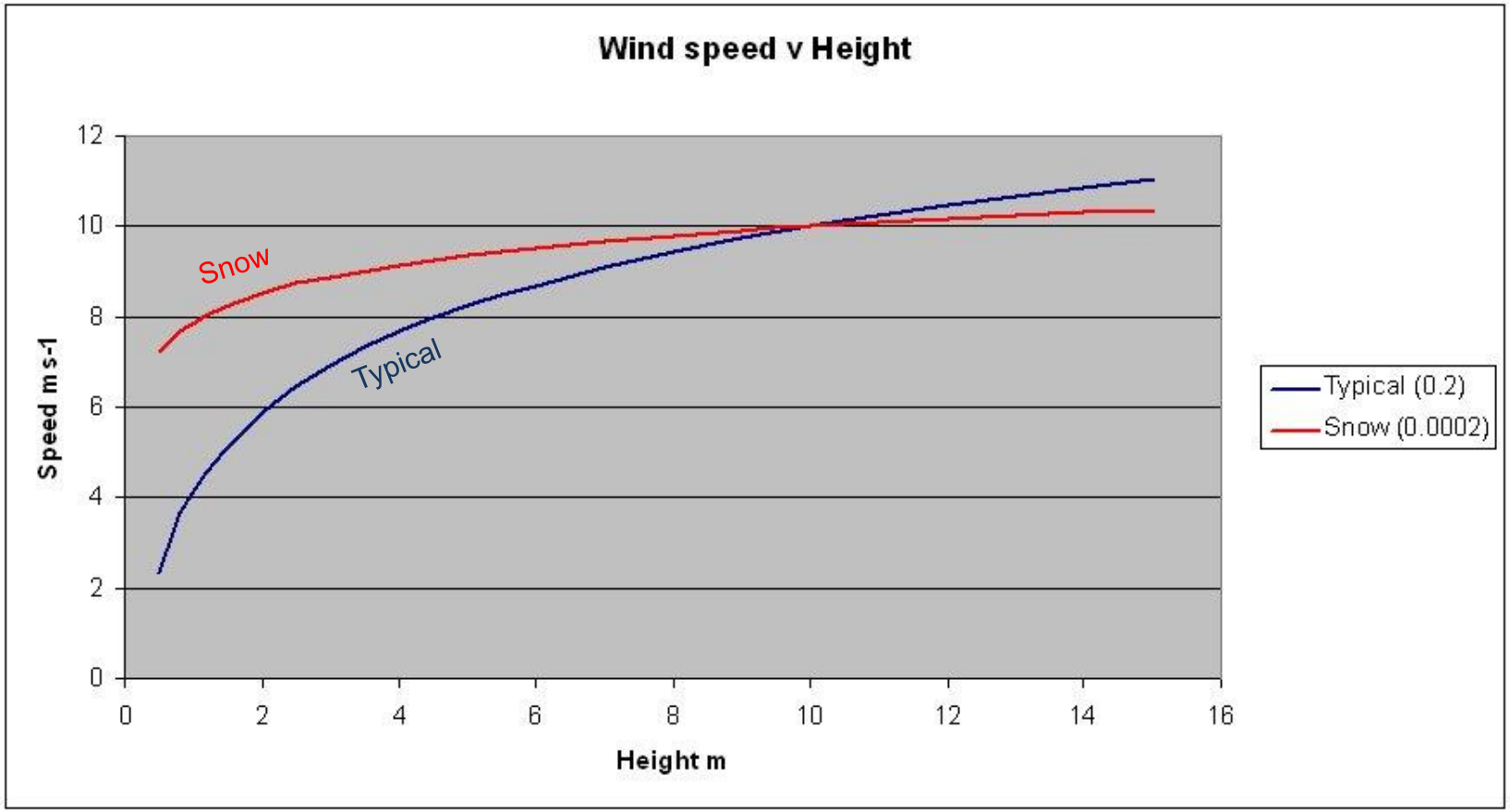
Roughness length (z_0) implications



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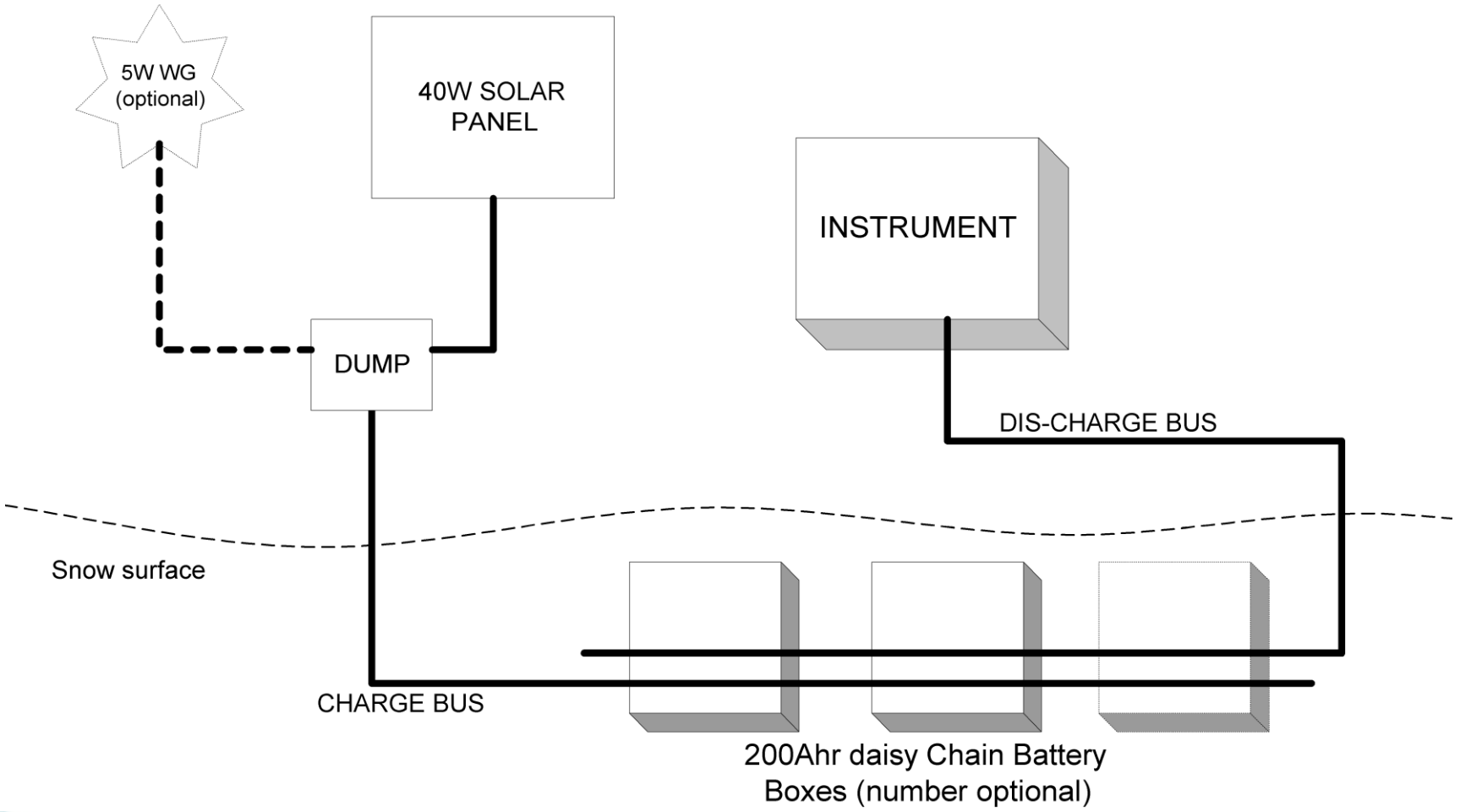
LPM Power system



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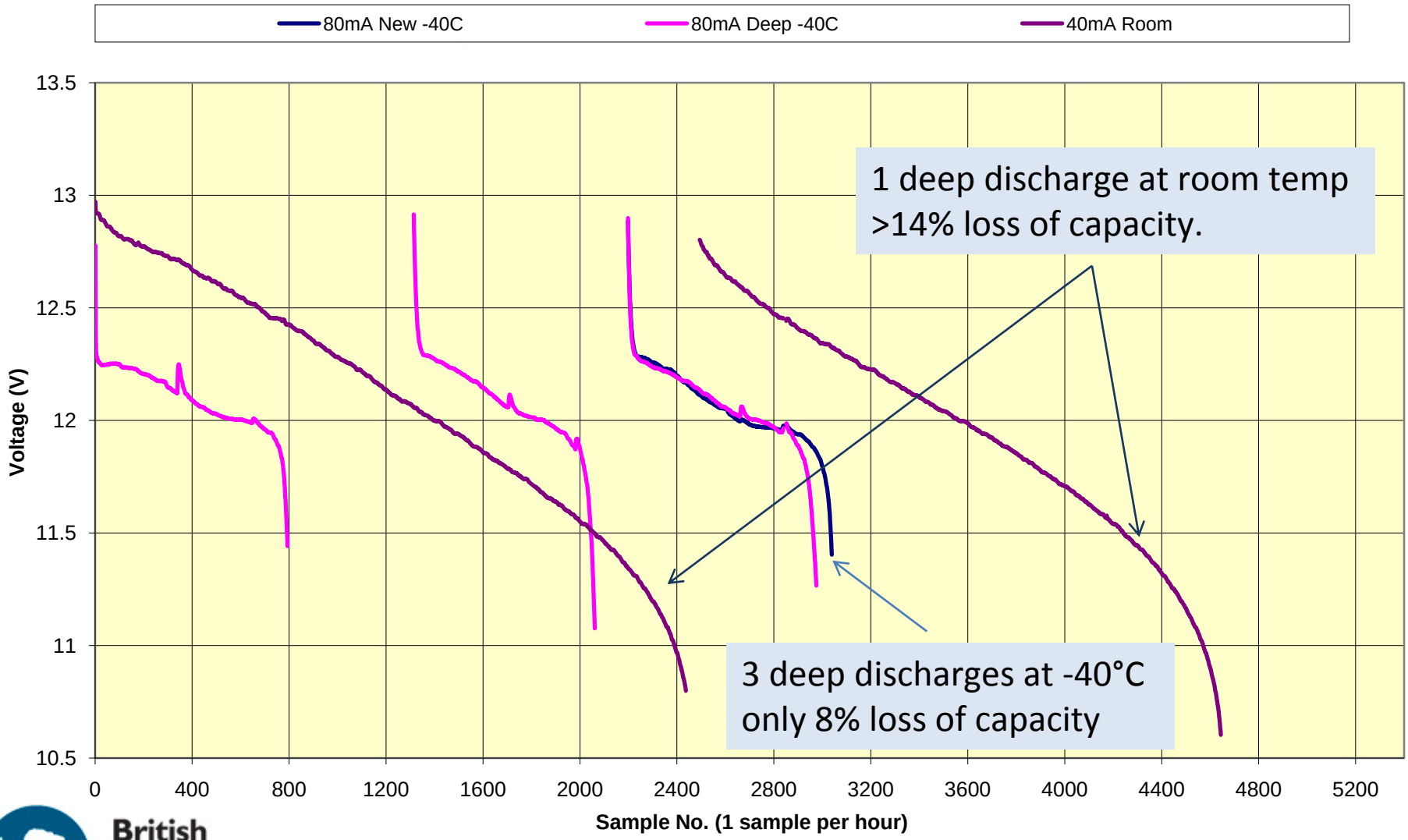
Long Term Battery Tests



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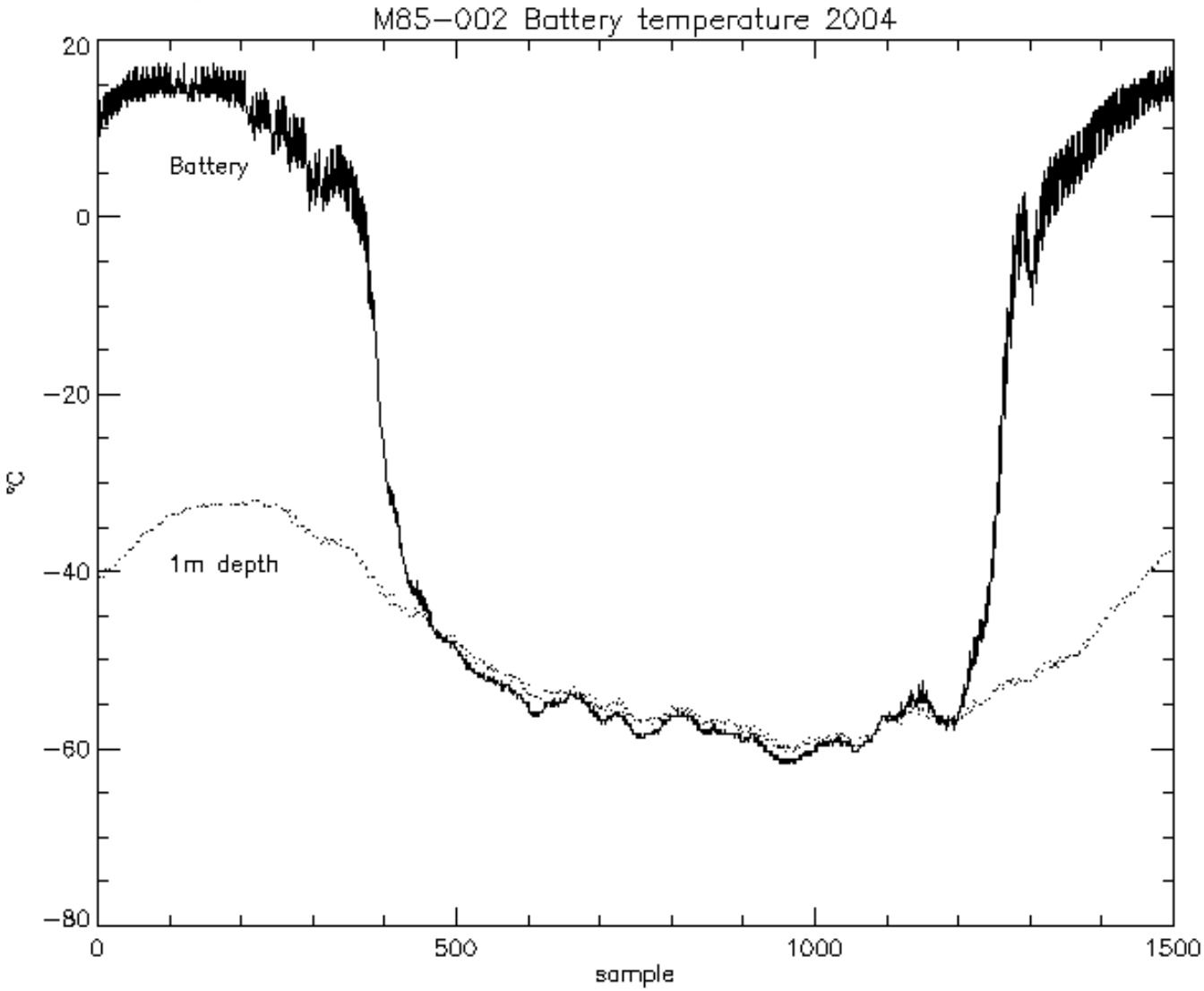
Expected duration for 100Ahr Lead Acid AGM Cell at -40°C

Discharge current	Rating	Expected Duration For 100Ahr
10mA	82%	341 days
20mA	75%	156 days
40mA	67%	70 days
80mA	50%	26 days



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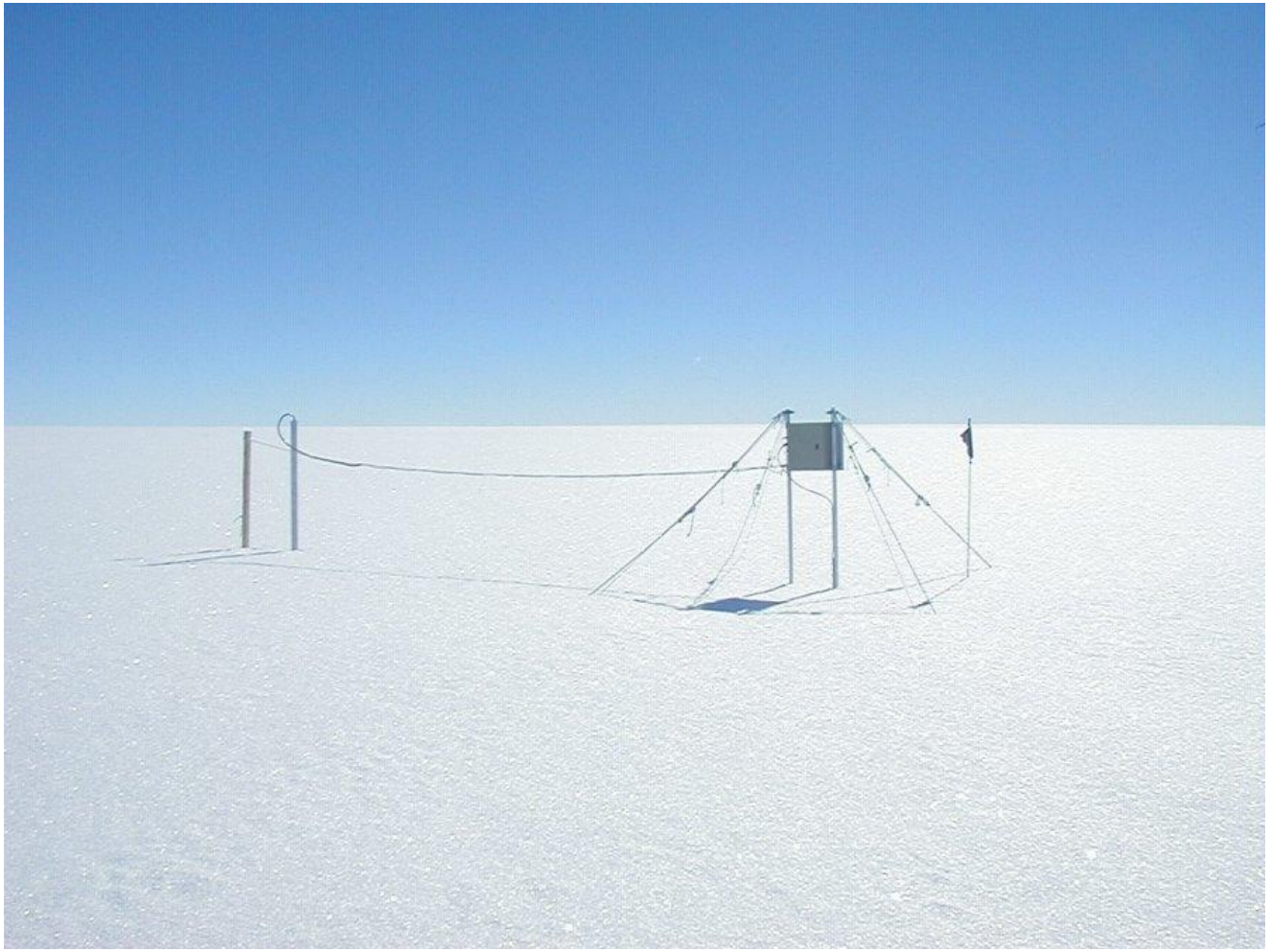
BAS LPMs



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BAS LPMs

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POWER SAVING

TURN ON – Make a MEASUREMENT – TURN OFF

Time spent on/off is defined mainly by:

- Sampling interval
- Anti- alias filter

POWER SAVING

TURN ON – Make a MEASUREMENT – TURN OFF

Average noise power
10^3 fT/√Hz @ 1s
Peak – allow 10X more.
Sensor is 10^4 fT/√Hz @ 1s
Allow 10^5 fT/√Hz @ 1s
With 100Hz LP this is 1nT

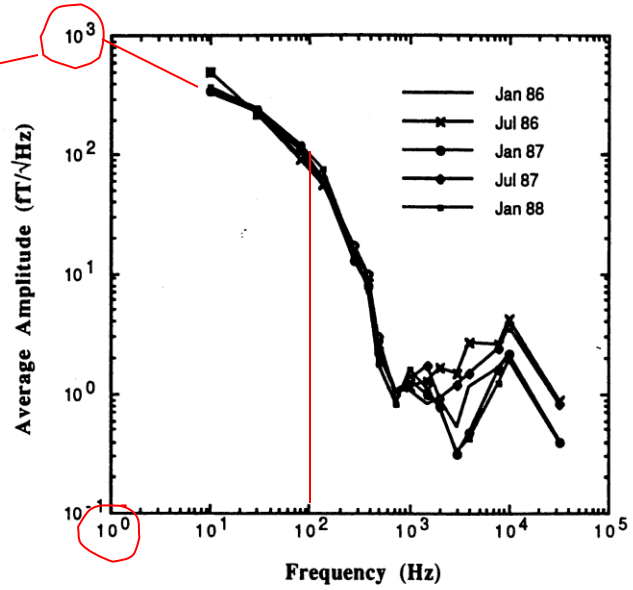

Figure 12.3.1 Variation of the Arrival Heights ELF/VLF noise amplitudes for the months of January 1986, 1987, and 1988 and July 1986 and 1987. Overall average amplitudes for each of the 16 narrowband frequencies are shown. For frequencies less than 1 kHz the amplitudes show little variation over the 2-year interval. (From Fraser-Smith, A. C. et al. *Environmental Space Electromagnetics,* H. Kikuchi, Ed., Springer-Verlag, Tokyo, 1991, 191. With permission.)

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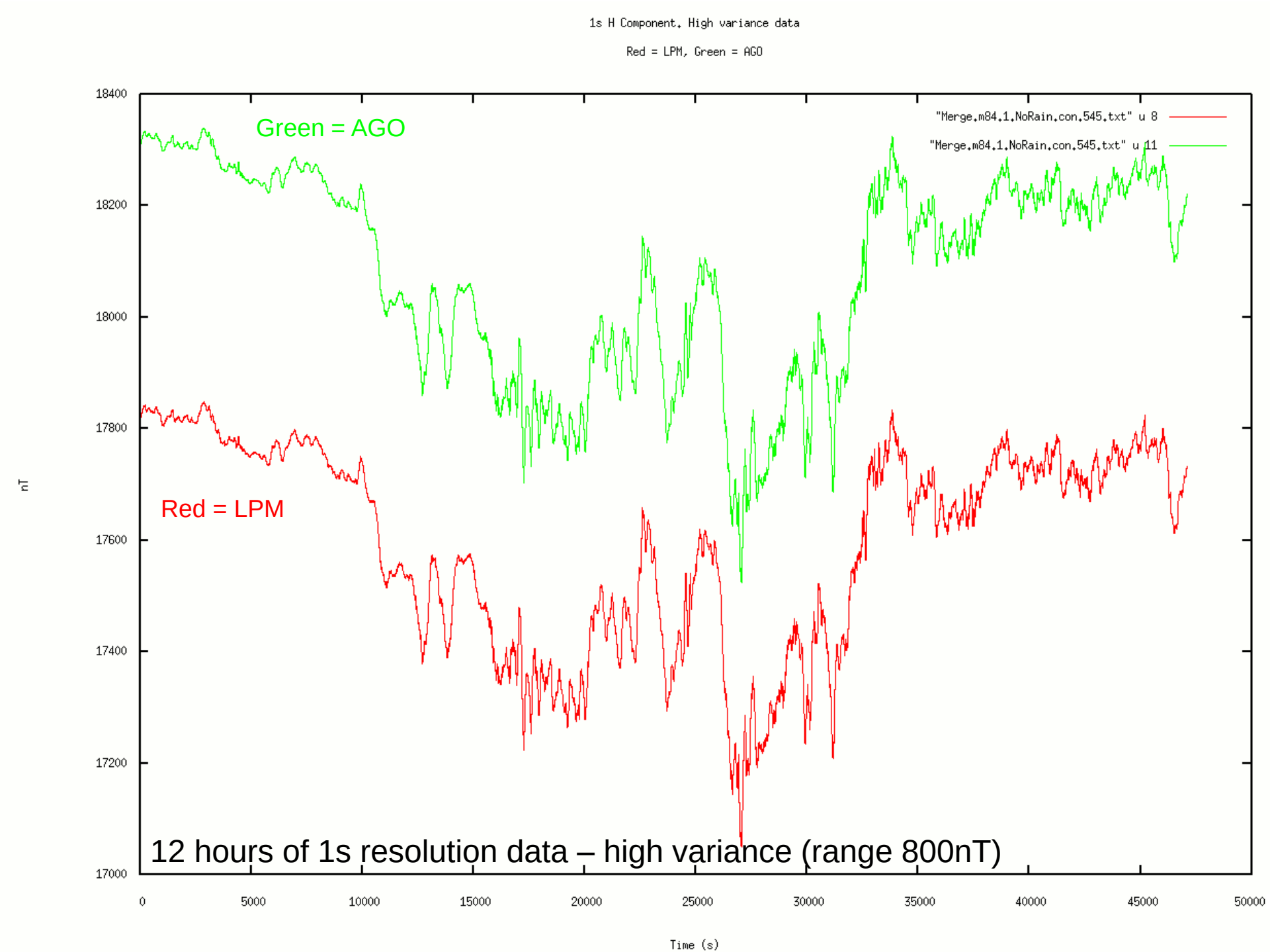
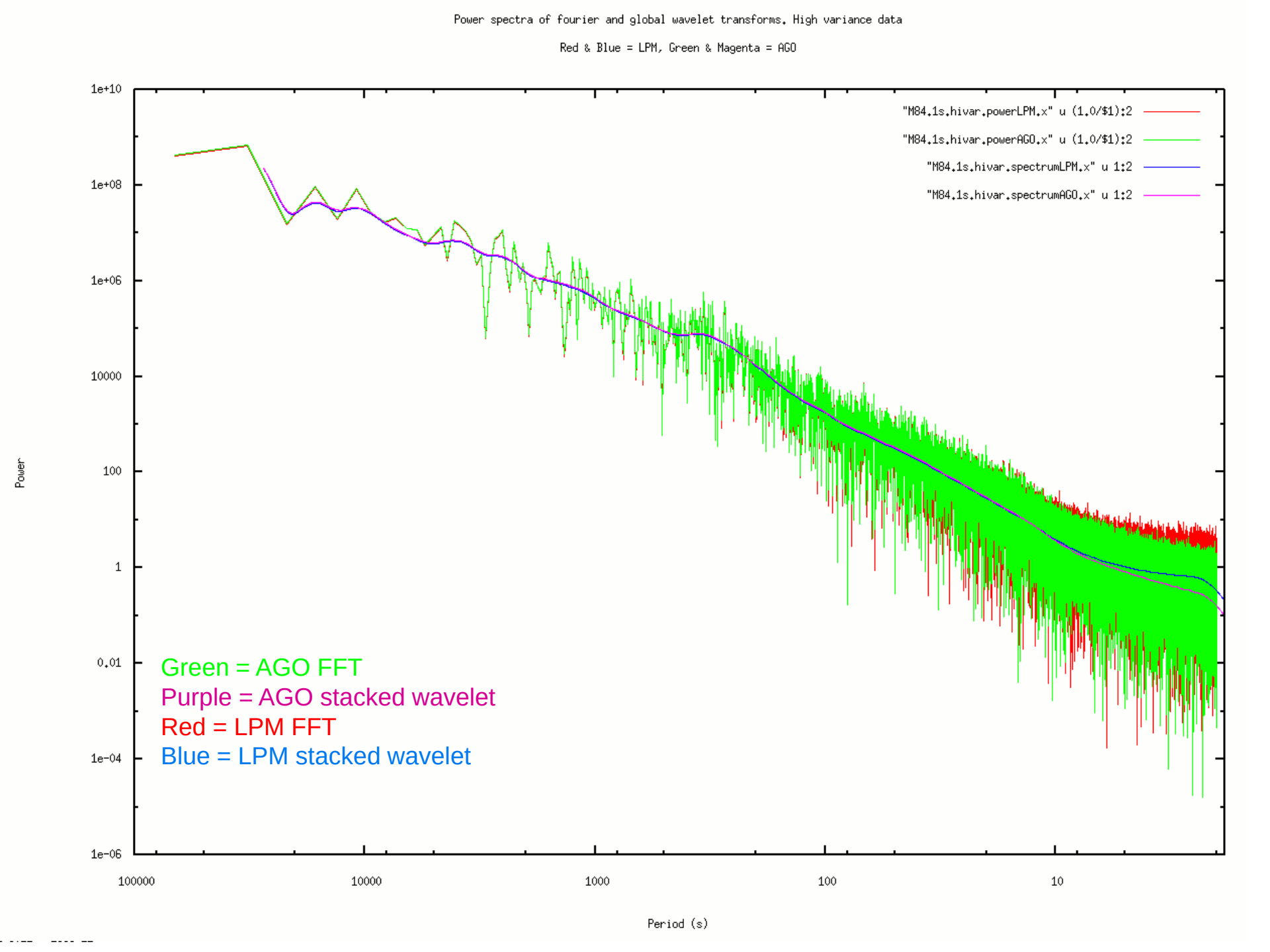
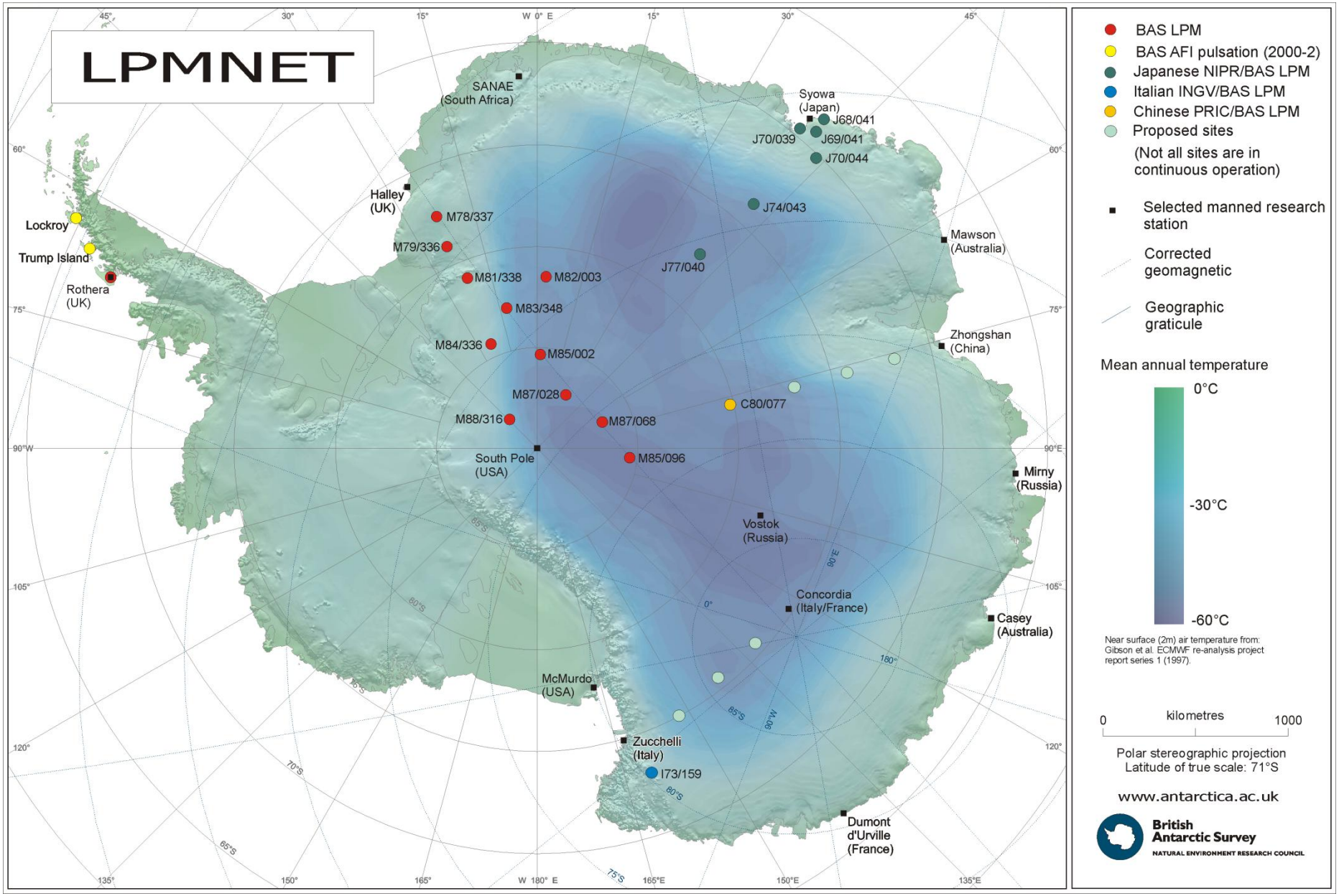

1s H Component, High variance data
Red = LPM, Green = AGO
"Merge.m84.1.NoRain.con.545.txt" u 8
"Merge.m84.1.NoRain.con.545.txt" u 11
Green = AGO
Red = LPM
12 hours of 1s resolution data – high variance (range 800nT)
nT
Time (s)
18400
18200
18000
17800
17600
17400
17200
17000
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000


Power spectra of fourier and global wavelet transforms. High variance data
Red & Blue = LPM, Green & Magenta = AGO
"M84.1s.hivar.powerLPM.x" u (1.0/$1):2
"M84.1s.hivar.powerAGO.x" u (1.0/$1):2
"M84.1s.hivar.spectrumLPM.x" u 1:2
"M84.1s.hivar.spectrumAGO.x" u 1:2
Green = AGO FFT
Purple = AGO stacked wavelet
Red = LPM FFT
Blue = LPM stacked wavelet
Power
1e+10
1e+08
1e+06
10000
100
1
0.01
1e-04
1e-06
100000
10000
1000
100
10
Period (s)


LPMNET
SANAE
(South Africa)
Syowa
(Japan)
J68/041
J70/039
J69/041
J70/044
Halley
(UK)
M78/337
J74/043
Lockroy
Trump Island
Rothera
(UK)
M79/336
J77/040
Mawson
(Australia)
M81/338
M82/003
M83/348
M84/336
M85/002
Zhongshan
(China)
M87/028
C80/077
M88/316
M87/068
South Pole
(USA)
M85/096
Mirny
(Russia)
Vostok
(Russia)
Concordia
(Italy/France)
Casey
(Australia)
McMurdo
(USA)
Zucchelli
(Italy)
I73/159
Dumont
d'Urville
(France)
BAS LPM
BAS AFI pulsation (2000-2)
Japanese NIPR/BAS LPM
Italian INGV/BAS LPM
Chinese PRIC/BAS LPM
Proposed sites
(Not all sites are in continuous operation)
Selected manned research station
Corrected geomagnetic
Geographic graticule
Mean annual temperature
0°C
-30°C
-60°C
Near surface (2m) air temperature from: Gibson et al. ECMWF re-analysis project report series 1 (1997).
0
kilometres
1000
Polar stereographic projection
Latitude of true scale: 71°S
www.antarctica.ac.uk
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LPMNET

- International Low Power magnetometer network operating on Antarctic Plateau.
- Data freely available at: dabs.nerc-bas.ac.uk/lpm from 2001 to date.
- 20 in total: 11 BAS systems, 4 Operated by Japan, 4 Operated by China and 1 by Italy.
- Data validation, system performance, processing code and other technical information at: www.antarctica.ac.uk
- Commercially available from www.extreme-instrumentation.com

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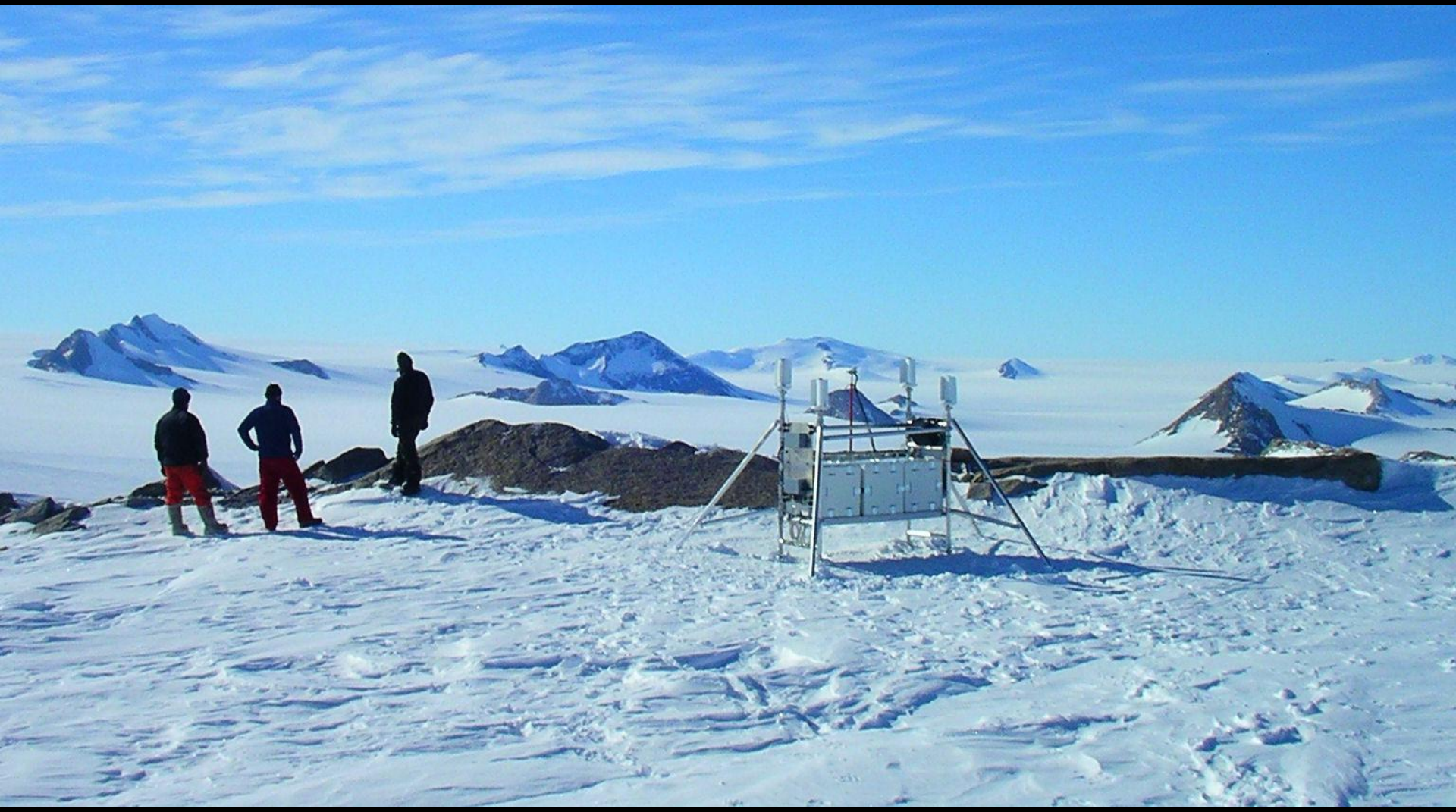
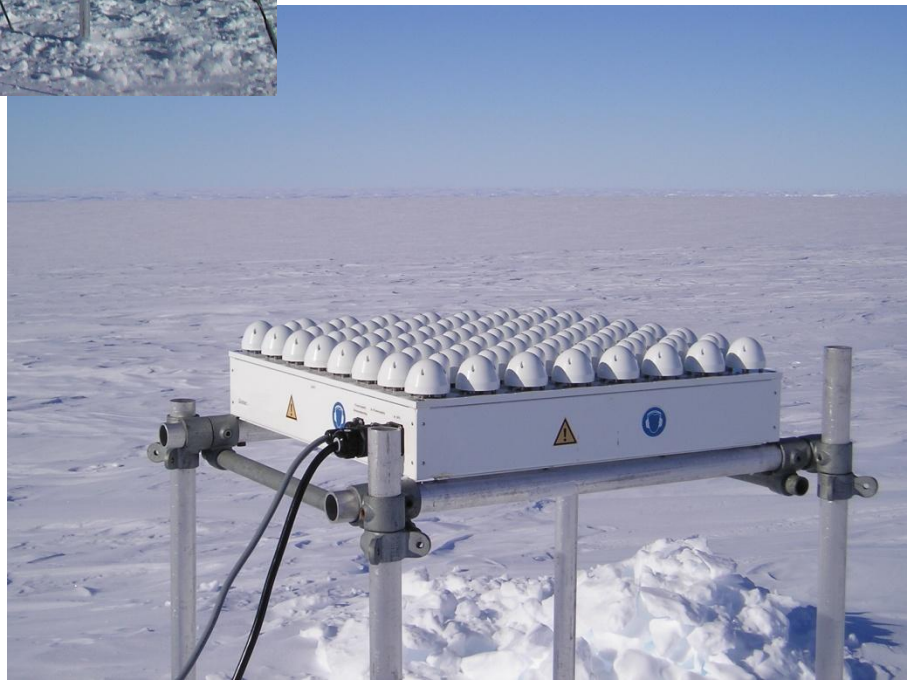



FORGEN

rsla@bas.ac.uk



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5
Bottom

(small) variable speed wind generators

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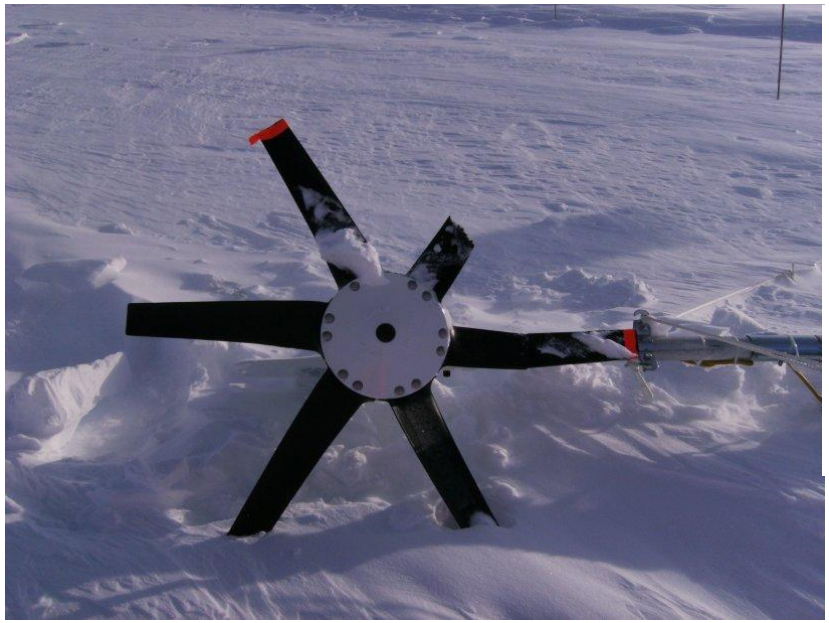
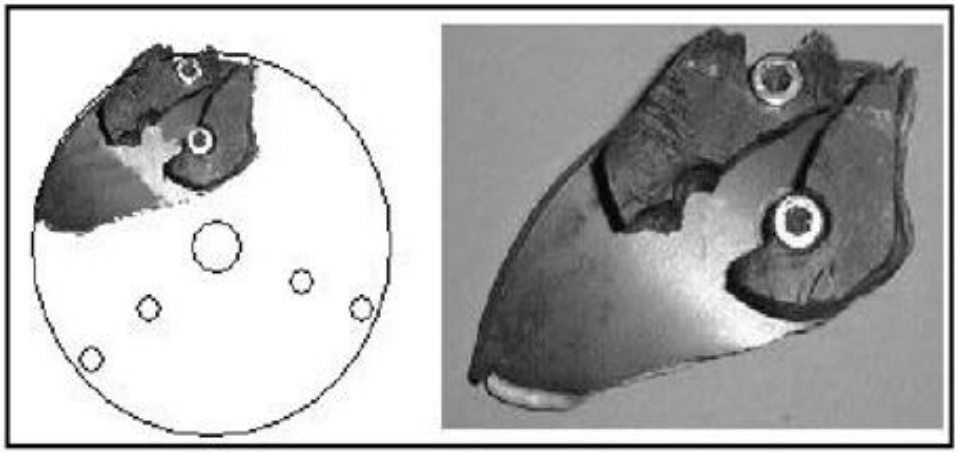
Wind Generators fail in Antarctica





Antarctica

- Wind regime dominated by storms and katabatics.
- Many sites with average wind speeds of 10ms^{-1} or greater.
- Calms are rare – low windspeed and startup are unimportant.
- Sites may be remote and rarely visited >1year.
- Cold – many implications, but especially for chemical and mechanical systems.
- **Survivability and MTBF is most important.**

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'Controllers' do more than 1 job

- Govern the operating conditions of the turbine
- Protect down stream systems from the energy available in the wind
- Report back status, knowledge etc
- Regulate the batteries – arghh
- Megalomaniacs – assume they are THE controller.

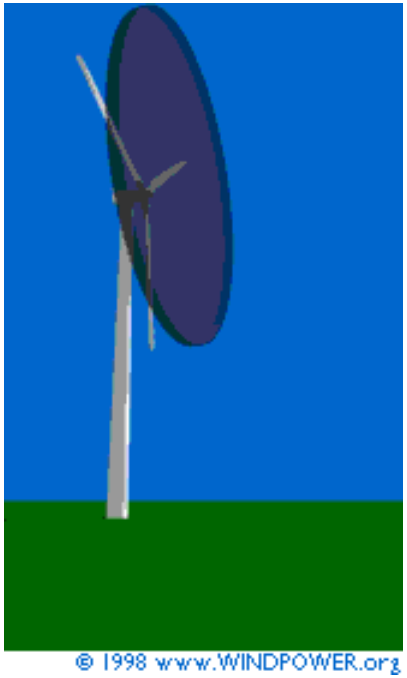
Basic – but important

$E=\frac{1}{2}\ mv^2$

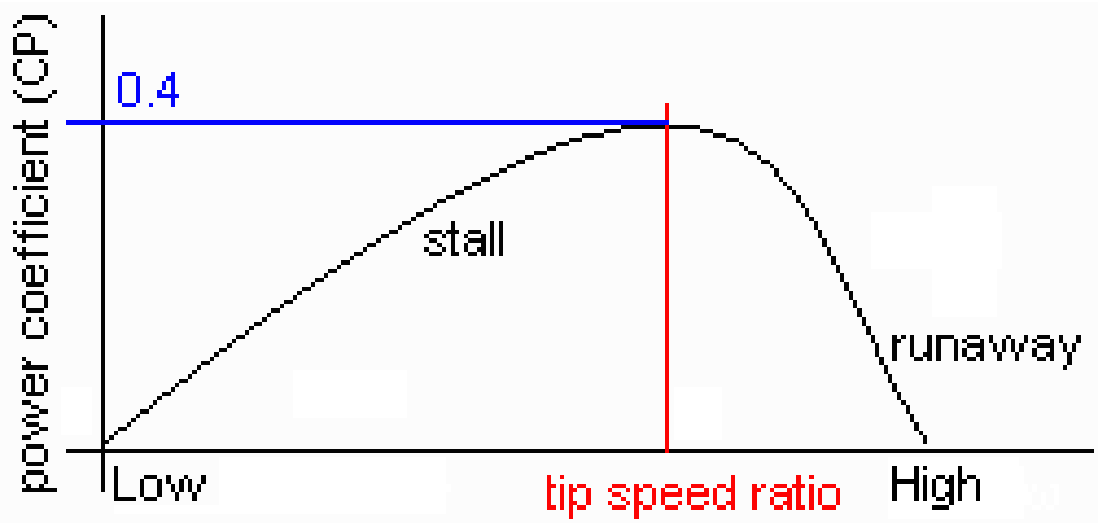
$m=\rho\pi r^2 v$ (for a tube of air in 1s)

(and remembering E=PxT)

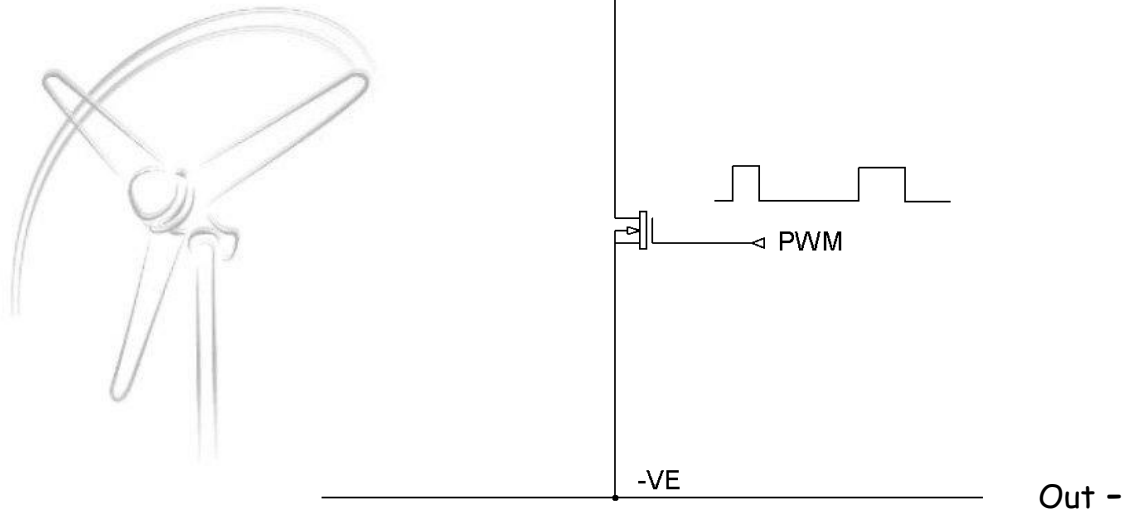
Therefore $P=\frac{1}{2}\ \rho\pi\ r^2\ v^3$



Tip Speed Ratio - λ - tip speed /wind speed



Control method – PWM shunting.



Control method – PWM shunting.

- High frequency (4.5KHz) energy loss
- Removes energy from:
  - Stored in inductance of windings.
  - That being supplied by the wind.
  - Momentum of the blades etc.
    (this is the big one!)

Modular system considerations

- Multiple manufacturers - redundancy
- Scaleable – more generators, more batteries
- Standard controllers in system – one per generator
- Maintenance – log history of performance

BAS Wind Generator Controller

Regulates on:

- **Output voltage**
- **Output Current**

Shuts down on:

- **Input I (ave and peak)**
- **Hardwired input (OTSW)**
- **RS485 command**

Transmits:

- **Input I&V, Output I&V, PWM, RPM, Temp, etc**

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Turbine survivability

		2008	2009	2010	Notes
SG1 913	Generator	✓			Only 1 year of operation
	Controller	✓			Only 1 year of operation
SG1 Ampair	Generator	×			Only 1 year of operation
	Controller	×			Only 1 year of operation
SG1 Windside	Generator	✓			Only 1 year of operation
	Controller	✓			Only 1 year of operation
SG2 913	Generator	✓			Only 1 year of operation
	Controller	✓			Only 1 year of operation
SG2 Windside	Generator	✓			Only 1 year of operation
	Controller	×			Only 1 year of operation
A77 913	Generator	✓	✓	✓	
	Controller	✓	✓	✓	
A77 Ampair	Generator	×	✓	✓	New turbine in 08/09 season.
	Controller	✓	✓	✓	
A77 Windside	Generator	✓	✓	?	
	Controller	✓	✓	?	
A80 913	Generator	✓	✓		System removed in 09/10 season
	Controller	✓	✓		System removed in 09/10 season
A80 Ampair	Generator	✓	✓		System removed in 09/10 season
	Controller	✓	✓		System removed in 09/10 season
A80 Windside	Generator	✓	✓		System removed in 09/10 season
	Controller	✓	✓		System removed in 09/10 season

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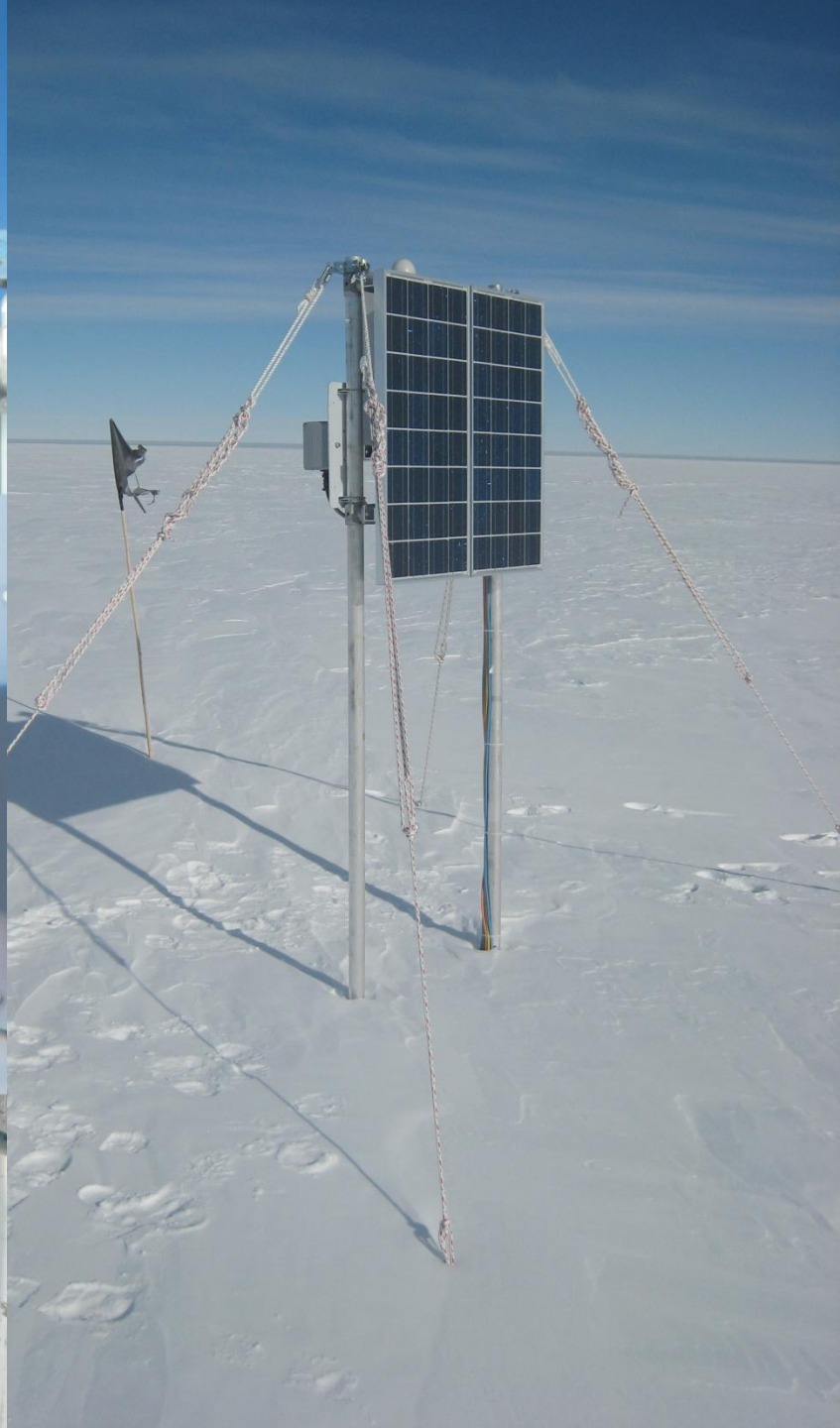
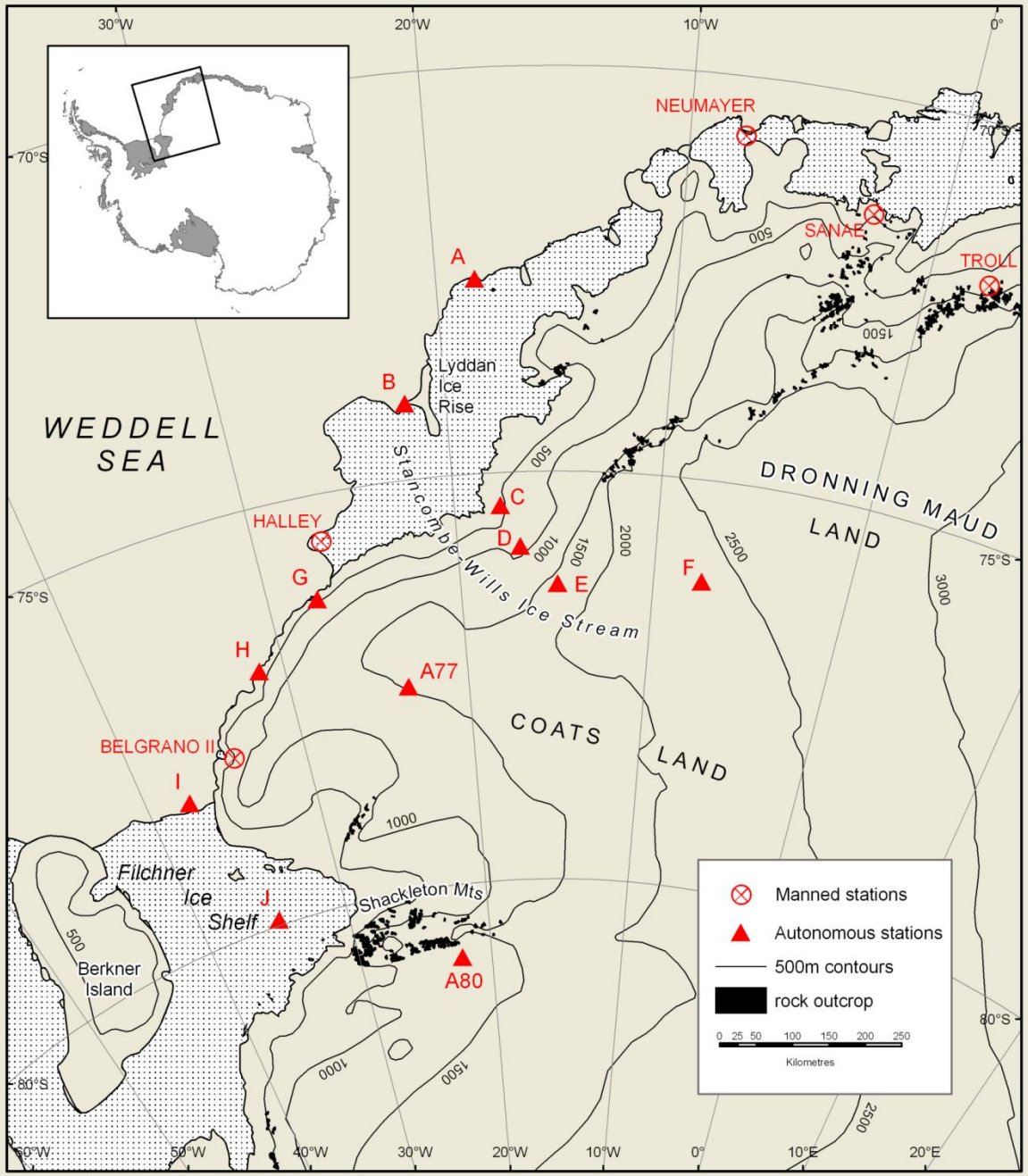
GEFPOD
00018



Surface ozone monitoring network during IPY



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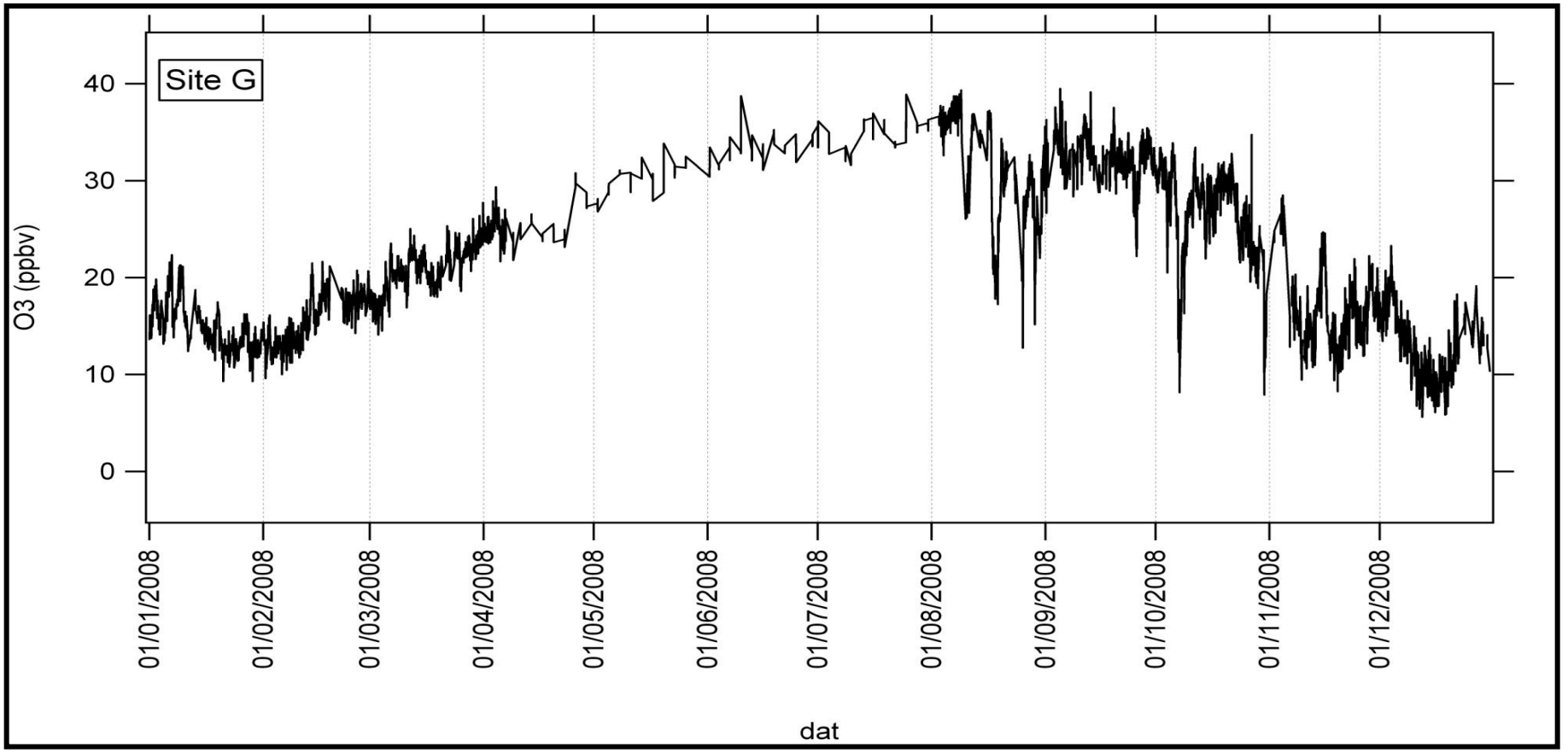
Site G 2008 Tropospheric Ozone Data



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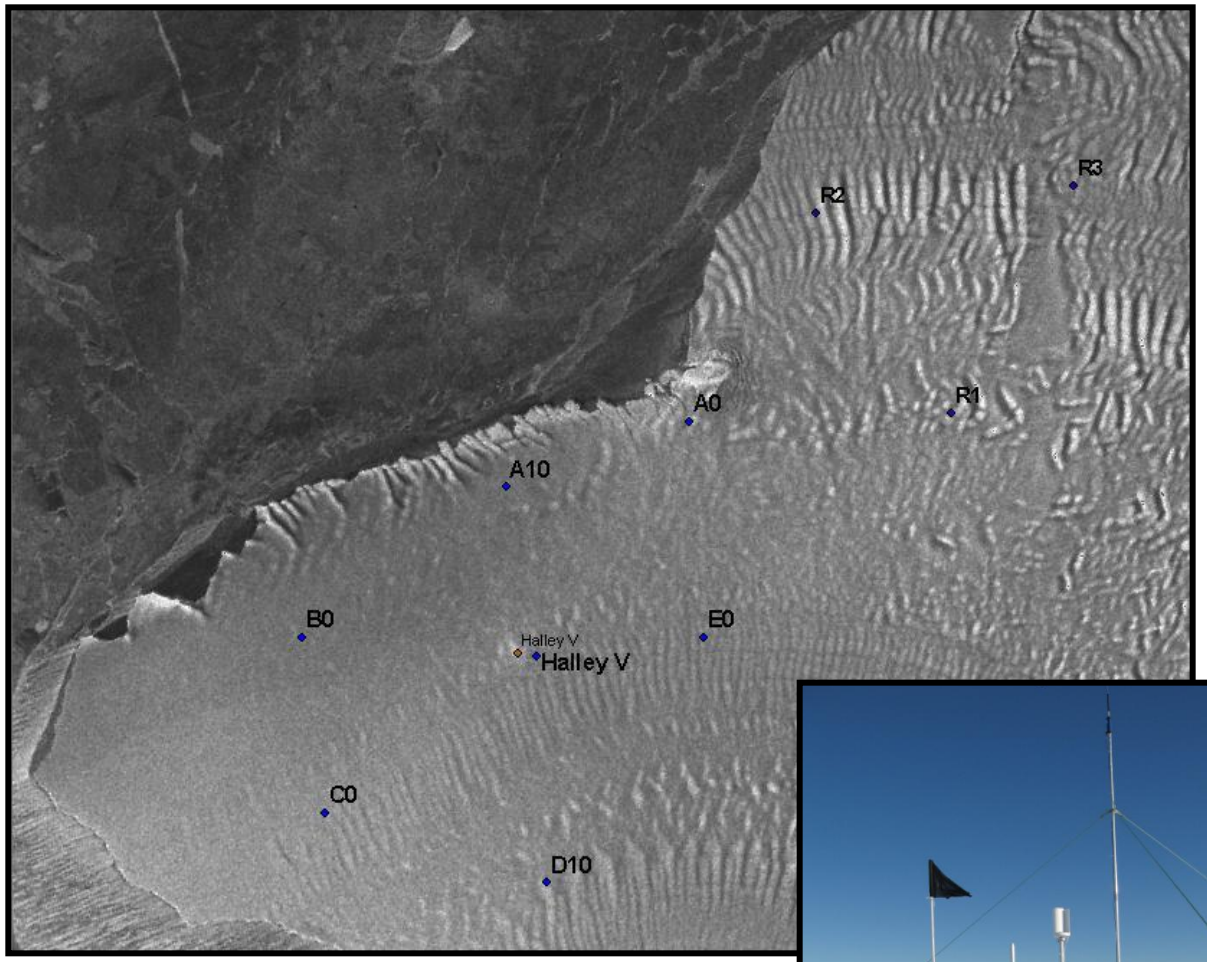
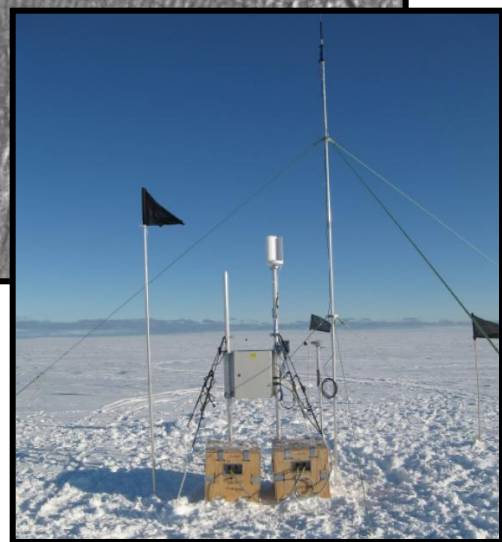
Monitoring Program: GPS network

- Survey-quality GPS stations have been installed around Halley to watch for a natural calving event.
- Each station collects two hours of GPS raw data daily and transmits it back to Halley via radio modem.
- Our network has shown that the Brunt Ice shelf is currently stable.





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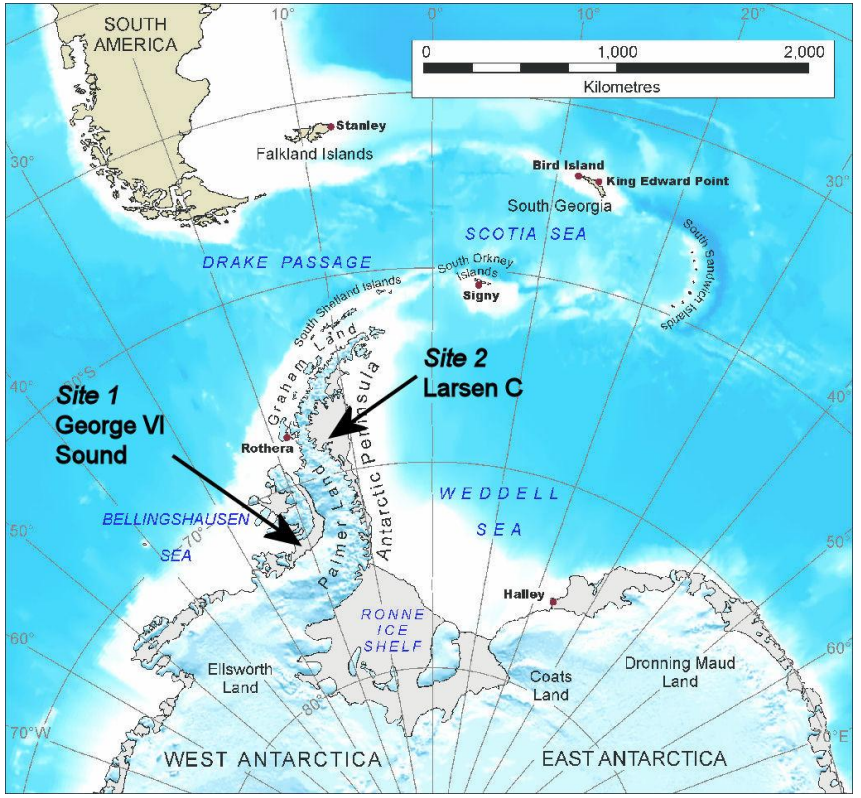
SIBLEX
Sea Ice Boundary Layer Experiment

- Logging of
  - Water current
  - Upward looking sonar
  - Depth
  - Atmospheric pressure

- Battery powered
- Solar recharging
- Iridium SBD
- GPS
- Persistor 1 – raw logger
- Persistor 2 – data processing and comms

- Designed for Peninsula iceshelf conditions
- IP67 rated logger and battery boxes



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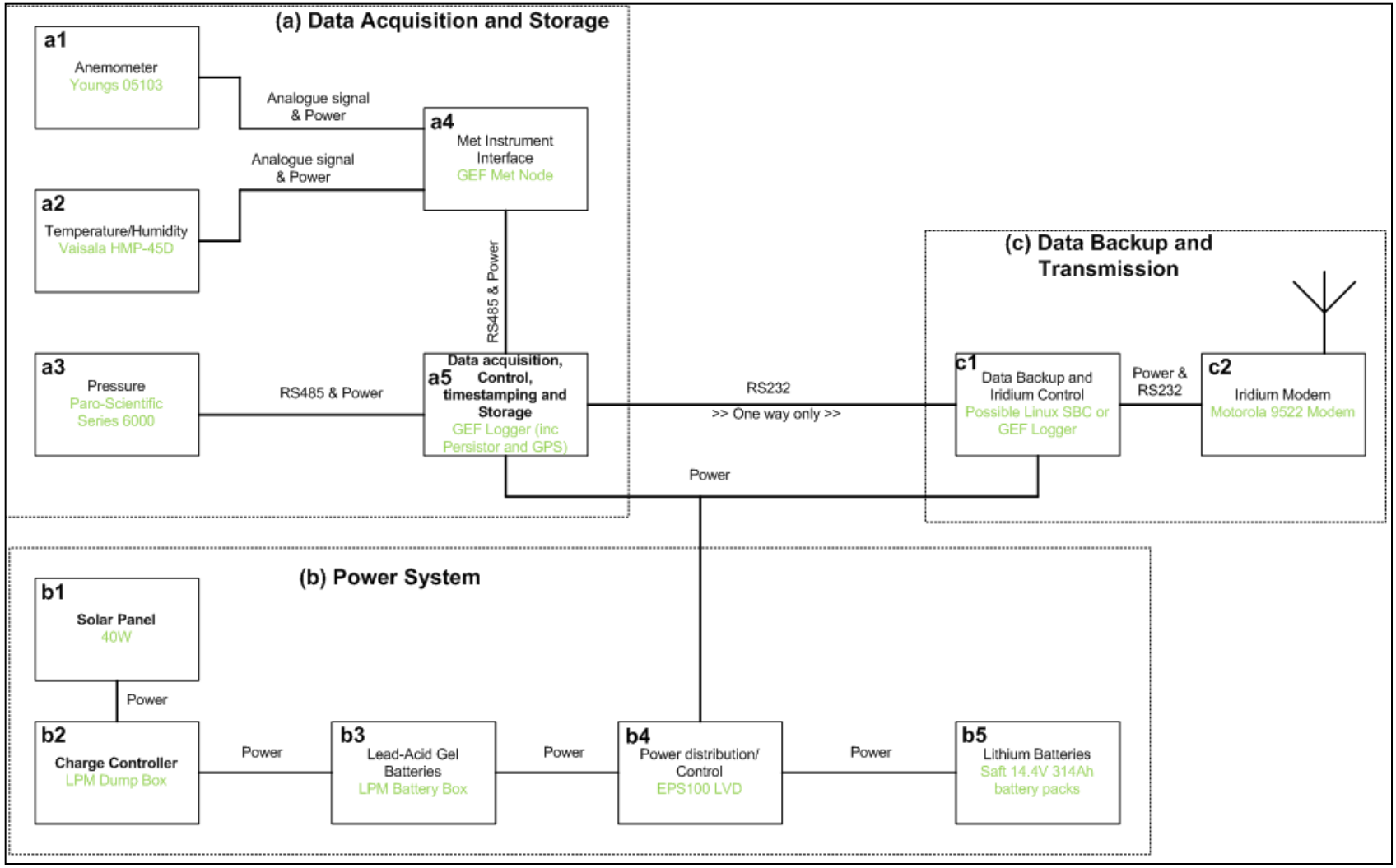

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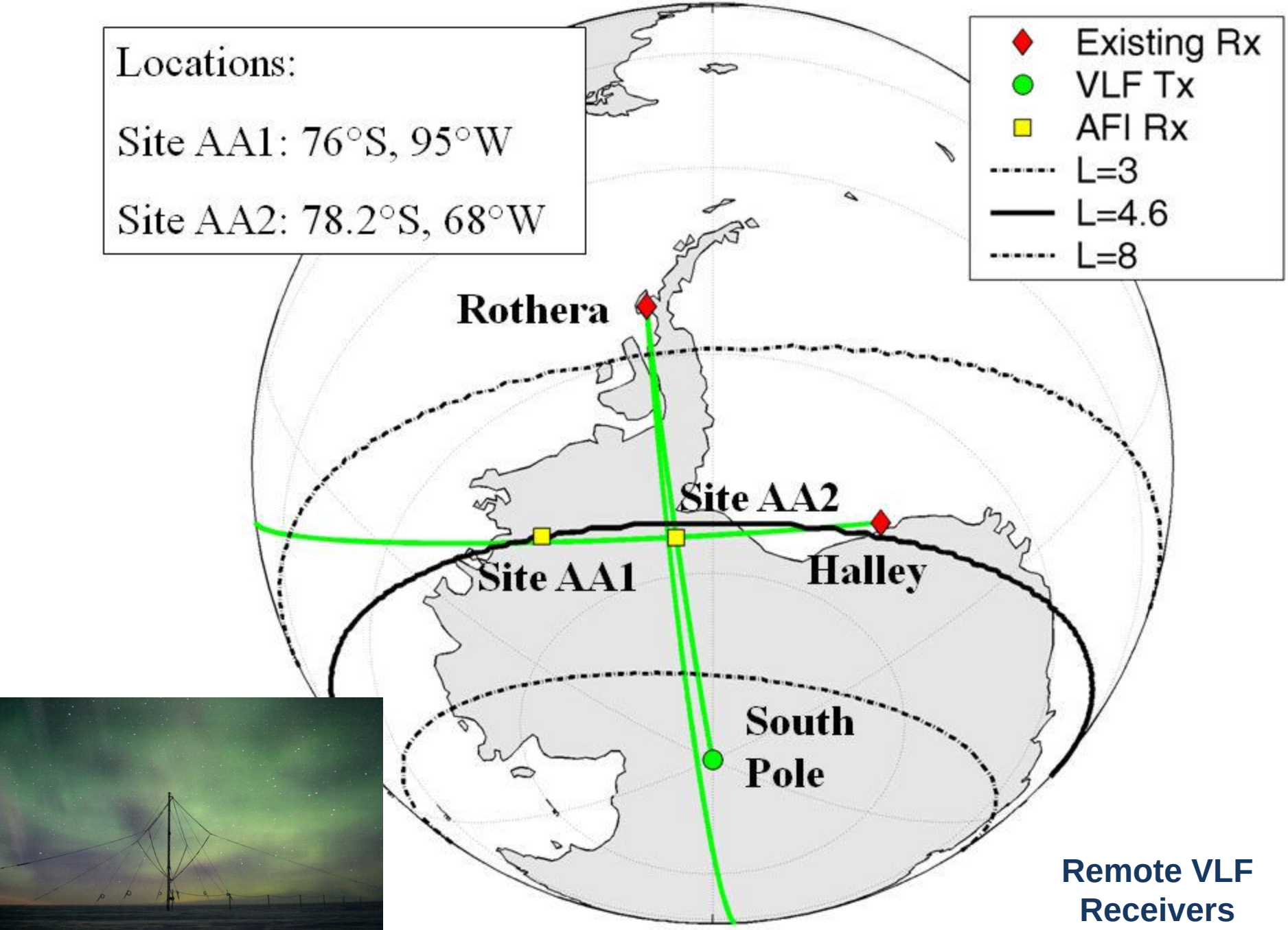
Locations:

Site AA1: 76°S, 95°W

Site AA2: 78.2°S, 68°W

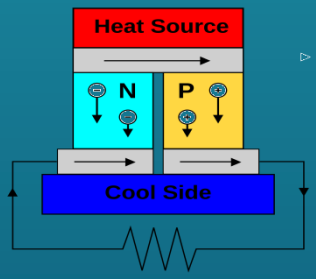


Remote VLF Receivers

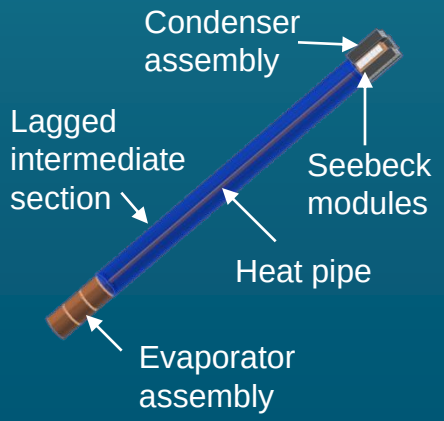
Powering sea-ice equipment via the Seebeck effect

- Problem powering sea-ice instruments during polar winters;
  - No solar power, wind generators unreliable.

- Thermoelectric energy harvesting;
  - Seebeck effect: temperature → electricity.
  - Exploit thermal gradient across sea-ice.



- Prototype device;
  - 2m long, 6” dia, rugged construction,
  - Heat pipe (thermal superconductor),
  - No moving parts (reliability),
  - Output: ≈ 5V, 300mW (ΔT=30°C).



Bryn Jones, Keith Jackson, Alistair James, David Meldrum, Mike Rose (BAS)

Project funded by NERC grant NE/H002839/1v

SCOTTISH ASSOCIATION for MARINE SCIENCE

Scottish Marine Institute,
Oban, Argyll
PA37 1QA
Scotland, UK

Closing remarks

- Modular systems allows reuse at design and in the field.
- Simplicity in the field, eases maintenance, lowers logistic cost.
- Clustering instruments lowers logistics cost.
- Suggestion: Multiple networks – share maintenance by location rather than equipment originator.
- Much BAS kit available from www.extreme-instrumentation.com primarily as means to support collaborations.
- Knowledge exchange – collaborations, job swaps, sabbaticals, etc.
- EGU usually has a session on polar instrumentation.

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