Geophysical Data:
"Real data has real warts"

Dale Chayes

Lamont Research Engineer

Instrument Lab

Lamont-Doherty Earth Observatory of Columbia University

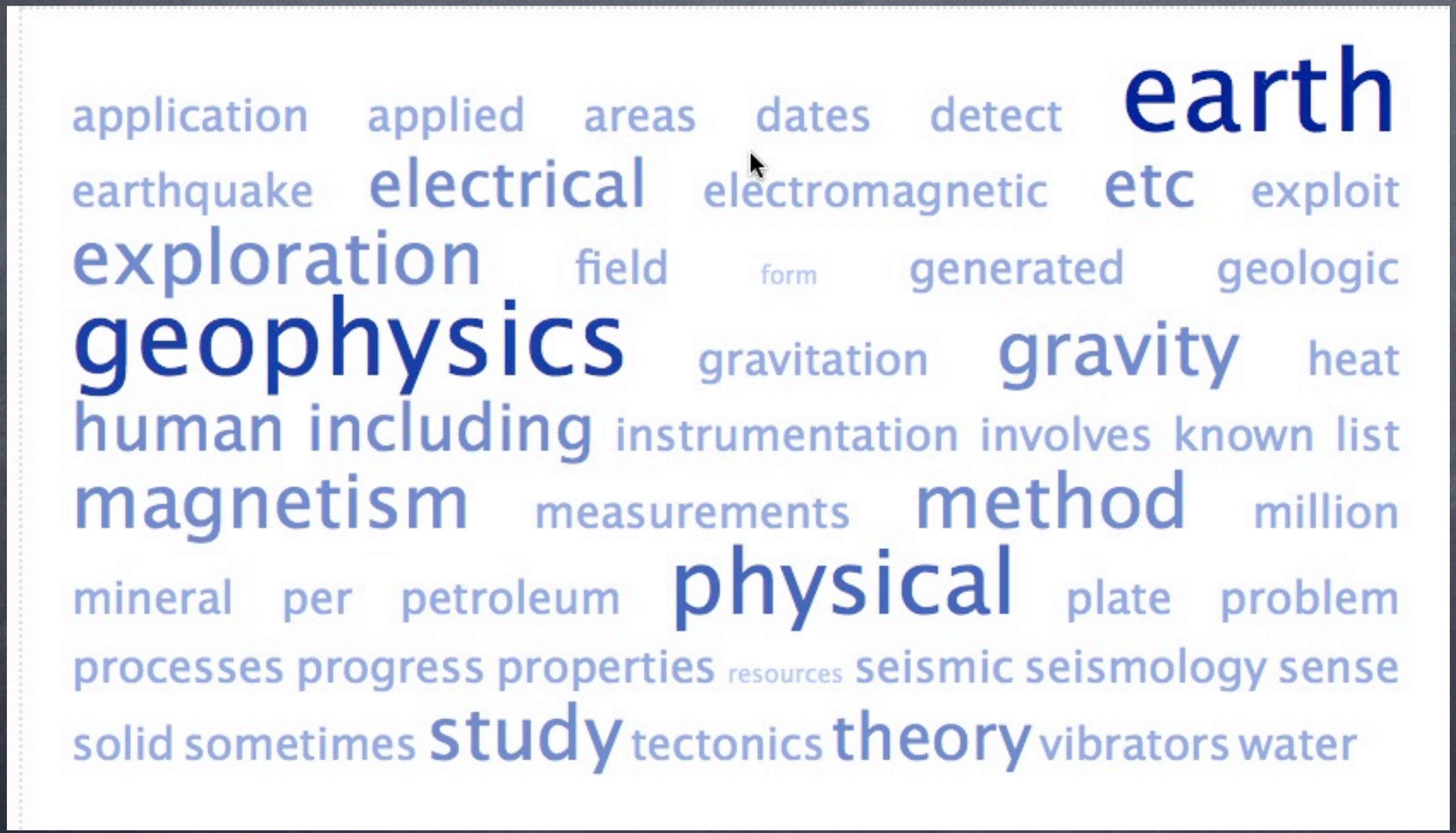
Columbia University Department of Earth and Environmental Science (DEES) Noon Balloon Tuesday November 9th

12:15-1:00pm

Room 417 Schermerhorn **Hall**

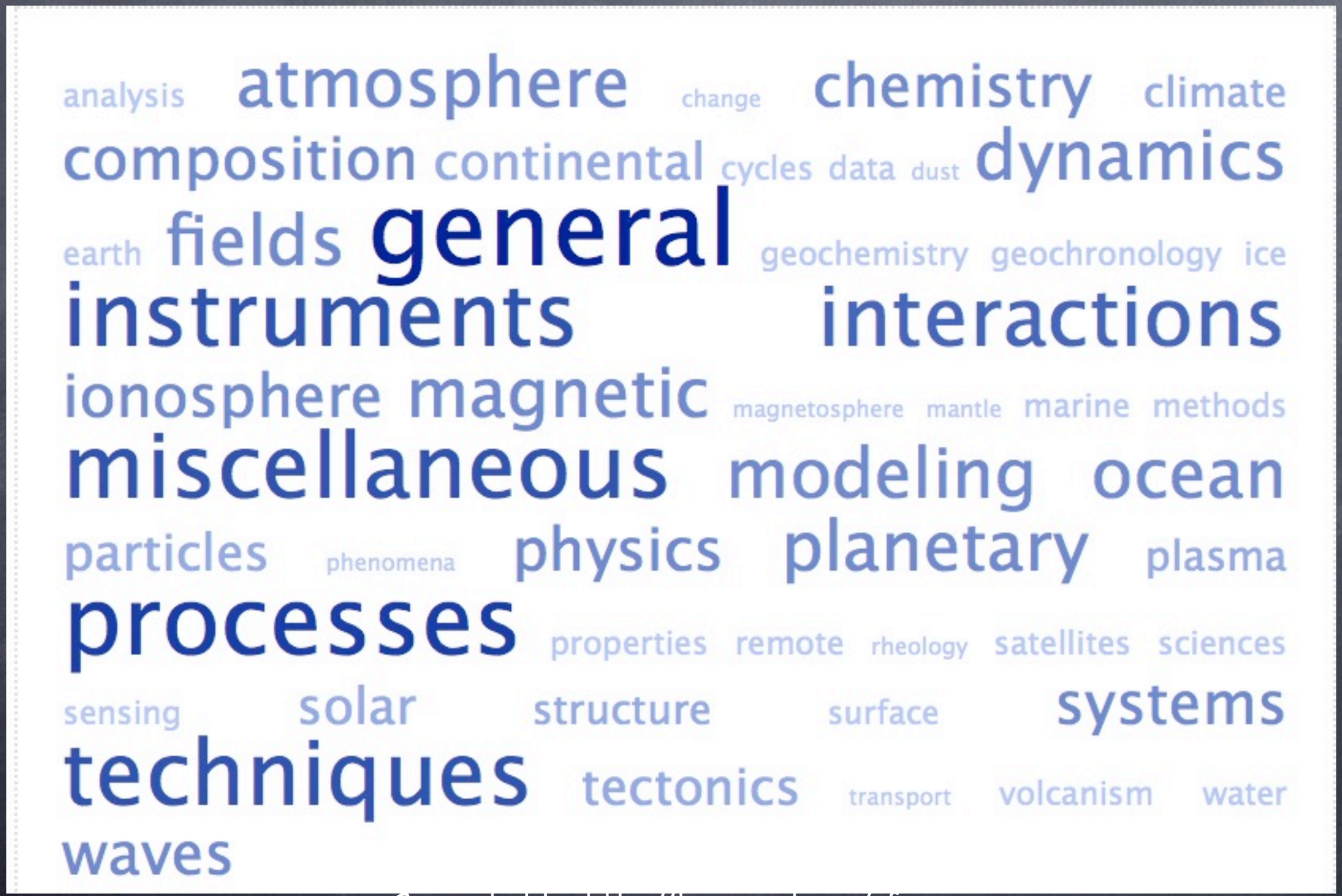
http://eesc.columbia.edu/news-events/news/tuesday-noon-balloon-dale-chayes

What is Geophysics?



Generated by http://tagcrowd.com/ from http://www.seg.org/ (what is geophysics)

What is Geophysics?



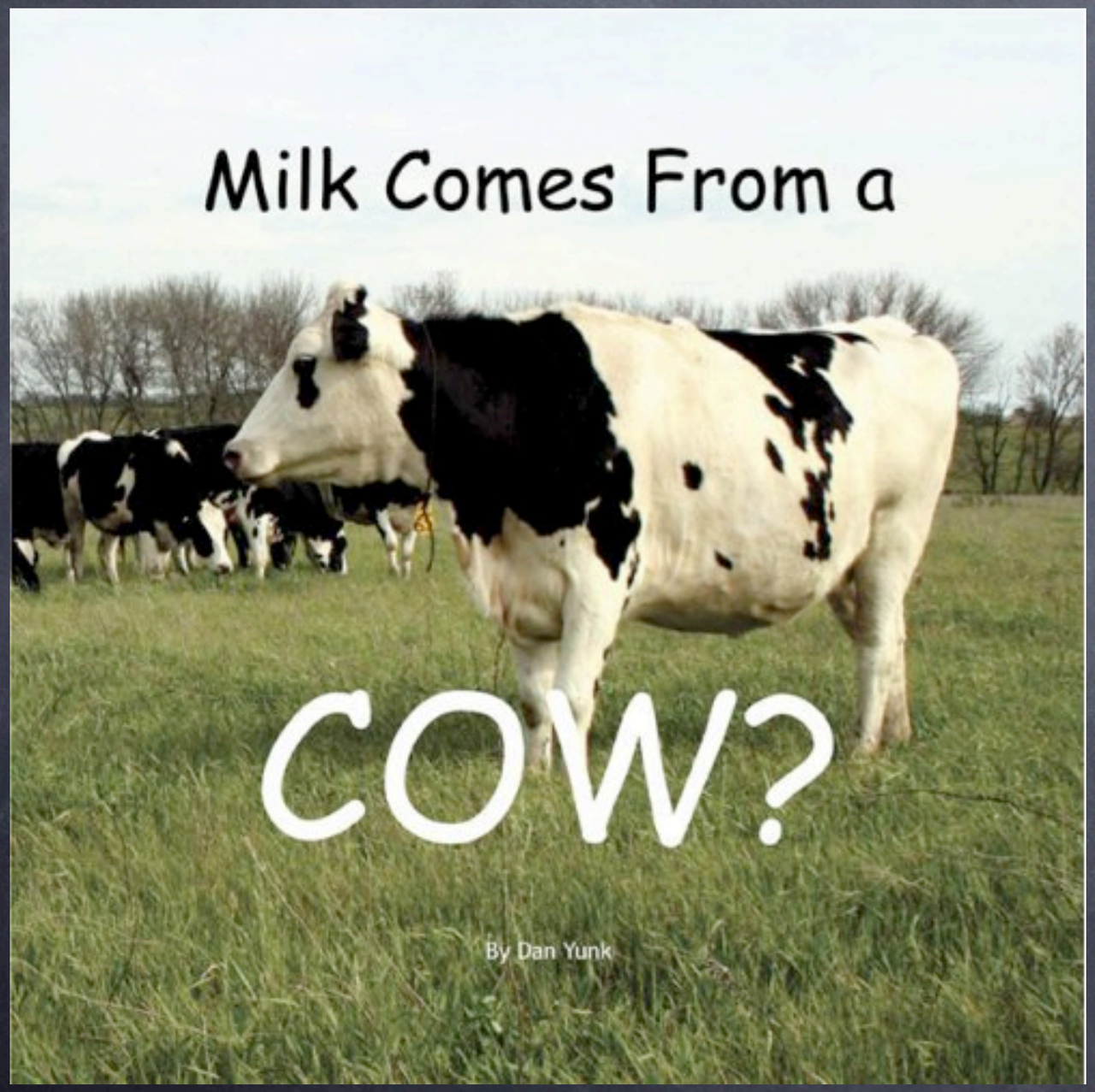
Generated by http://tagcrowd.com/ from
http://www.agu.org/pubs/authors/manuscript_tools/journals/index_terms/AGU_index_terms.txt/

What is Geophysics?

Gravity
Heat flow
Vibrations
Radioactivity
Electricity
Electromagnetic waves
Magnetism
Fluid dynamics
Condensed matter physics

http://en.wikipedia.org/wiki/Geophysics

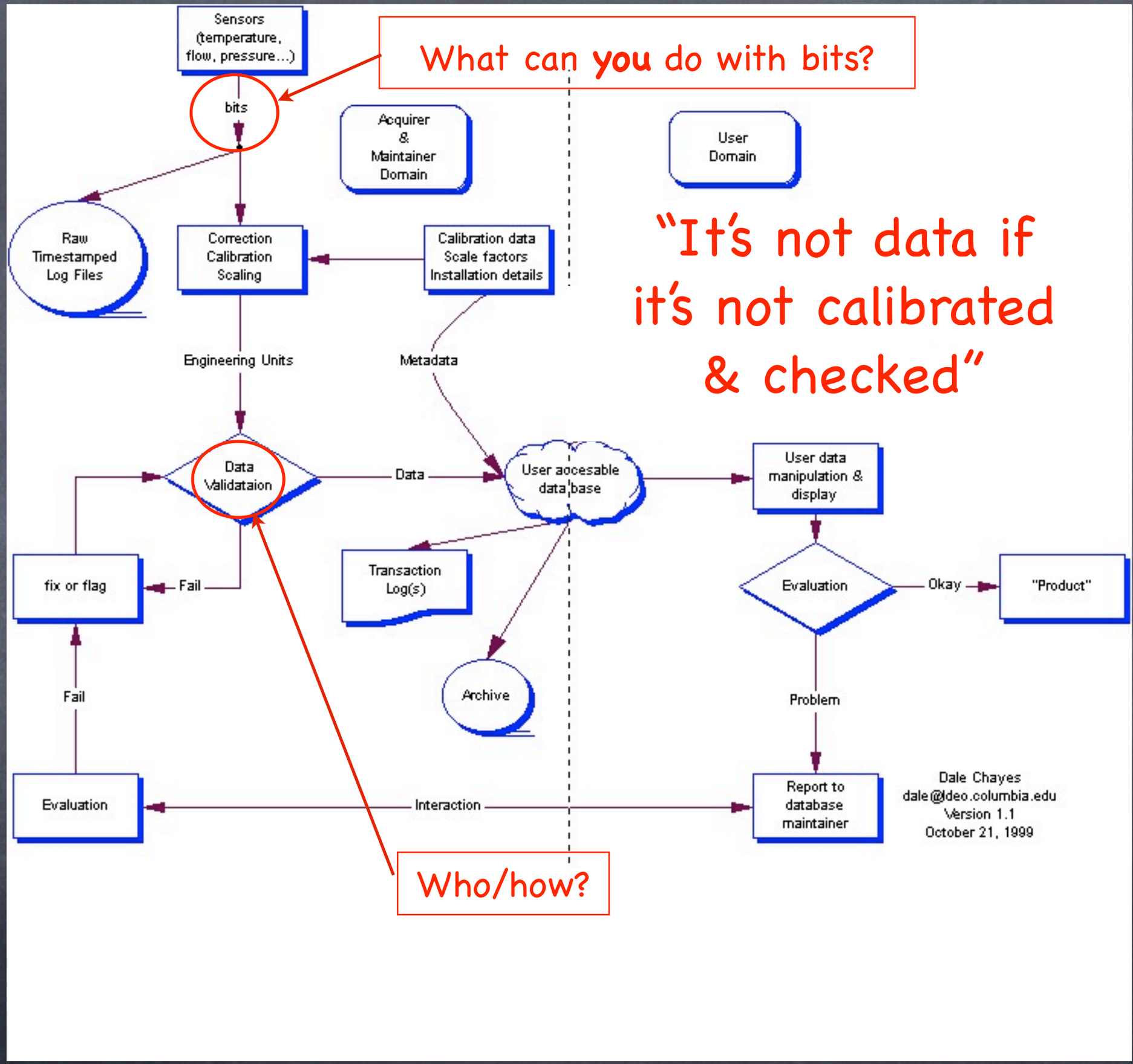
And Data?



http://www.amazon.com/Milk-Comes-COW-Dan-Yunk/dp/0979765307

If milk really comes from animals (cows, mares, goats, camels ...) and not from the store,

What about data?



Design, development and operation of a

Through-ice CTDs

(from a fixed wing aircraft)

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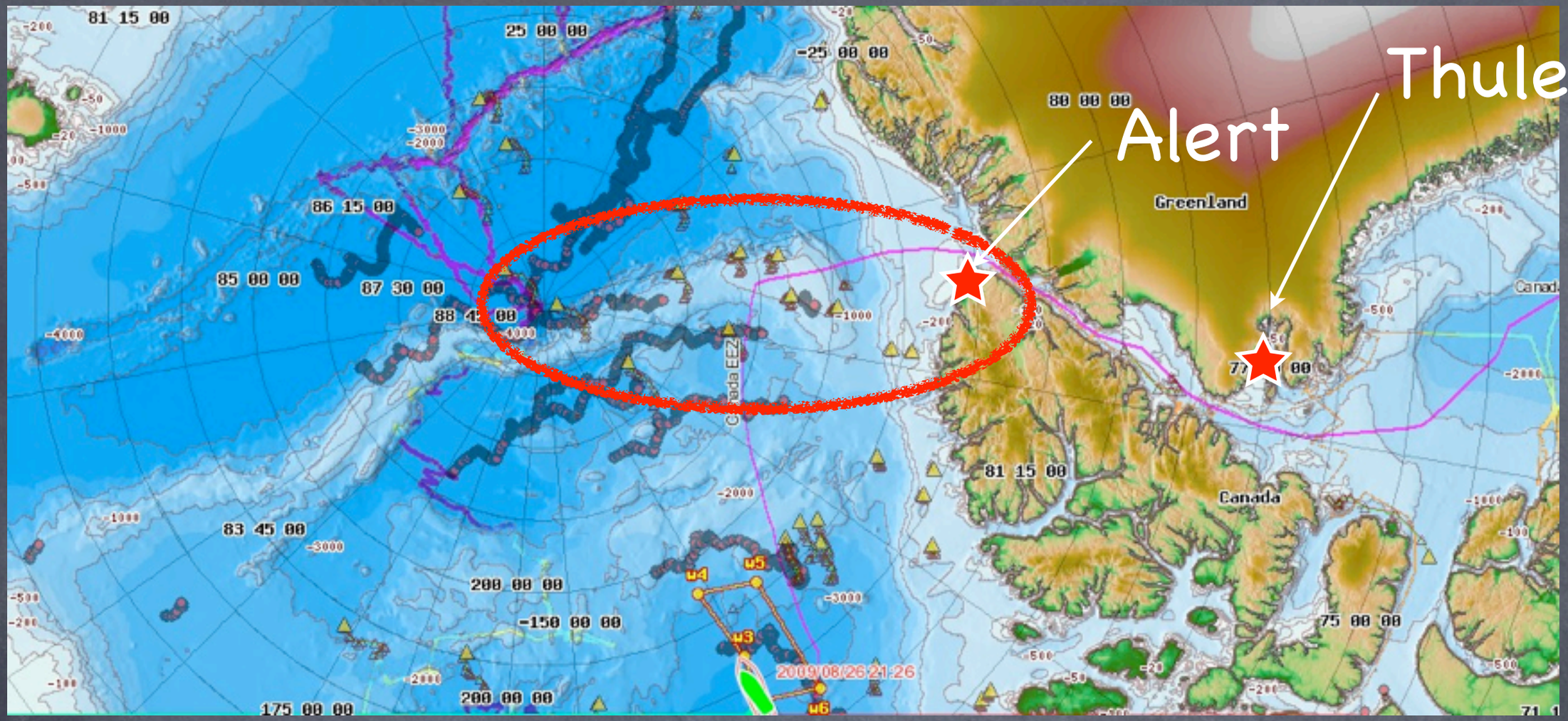
INSTRUMENT LABORATORY

Science Objectives

- Real-time data from the CTD
- Precision located (depth) water samples
- Samples for chemical analysis to:
  - Track fresh water sources
  - Investigate temporal variability (composition and circulation)
  - Estimate "age" using trace gas techniques

Design Goals

- Transect from Alert to the Pole
- Trace gas tight (to the lab at 1ppb) samples
- 2 liter (useable) samples
- 12 bottles per station
- 3 stations per day
- Depth: 600m minimum, 1km desirable
- Cheap, quick, with inexperienced operators…



- Can't reliably get there w/ icebreakers (even nukes)
- Submarines aren't available (and can't sample deep)
- Hoover craft can't get the samples back fast enough
- So we fly.....

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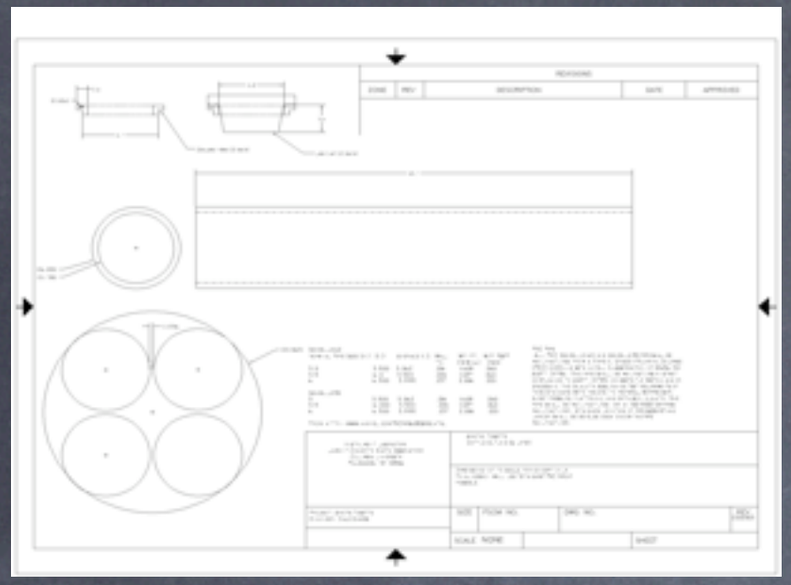
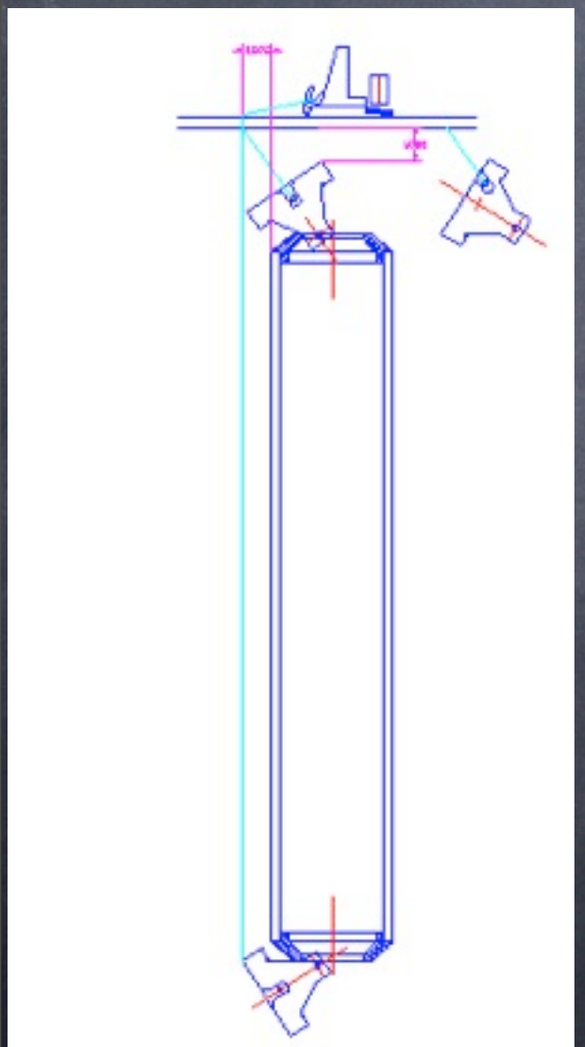
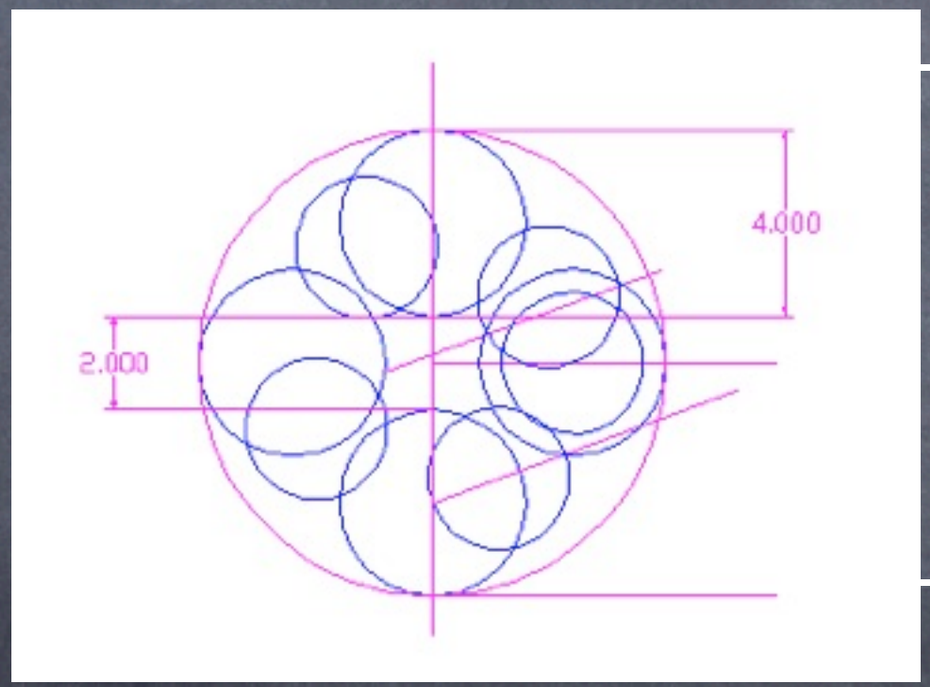
Concept #1

(With a standard (COTS) SBE release)







- No chance in a 10” hole without radical redesign
  - No time for re-design
  - Concerns about mixing of water
- Very long release wires w/ a standard release mechanism

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Concept #2 custom release

Project: Arctic Rosette
Subject: Water bottle sizes
Date: November 23, 2002
Eng: Dale Chayes

Station holes will be drilled with a 12" auger in a Jiffy Drill or perhaps with an electric drill powered from the same (diesel) generator used to run the winch. Some allowance for non-straight holes and for ice chips and junk in the hole will be allowed.

$Diameter_{max} := 10 \cdot in$

$Bottle_{OD} := \frac{(Diameter_{max} - 0.25 \cdot in) \cdot .9}{2}$

We have to allow some material around the outside of the bottle circumfrence for support. The exact amount depends on the design and the materials. The current estimate allows 1/8" for material and has a 10% tolerance.

$Bottle_{OD} = 0.111\,m$

$Bottle_{wall} := 0.3 \cdot in$

$Bottle_{ID} := Bottle_{OD} - 2 \cdot Bottle_{wall}$

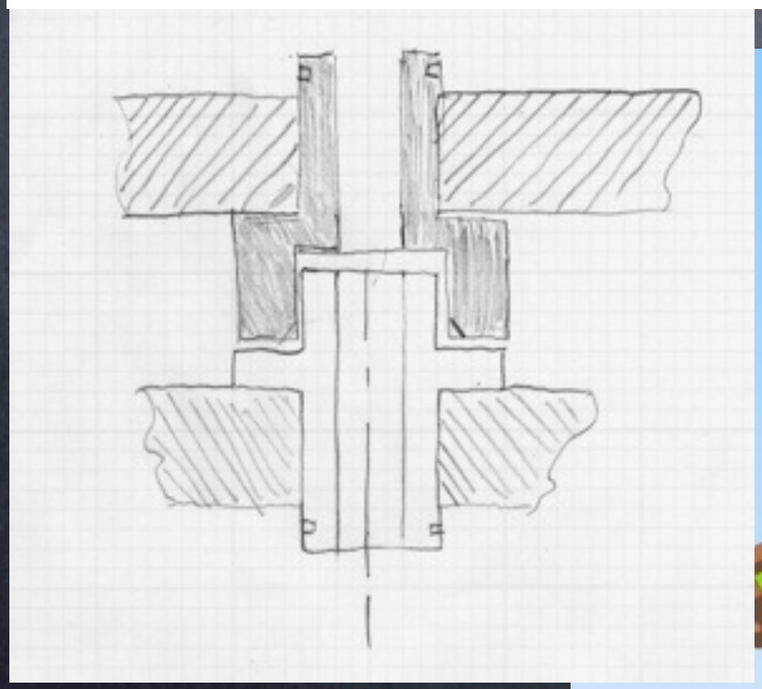
$Bottle_{ID} = 3.788\,in$

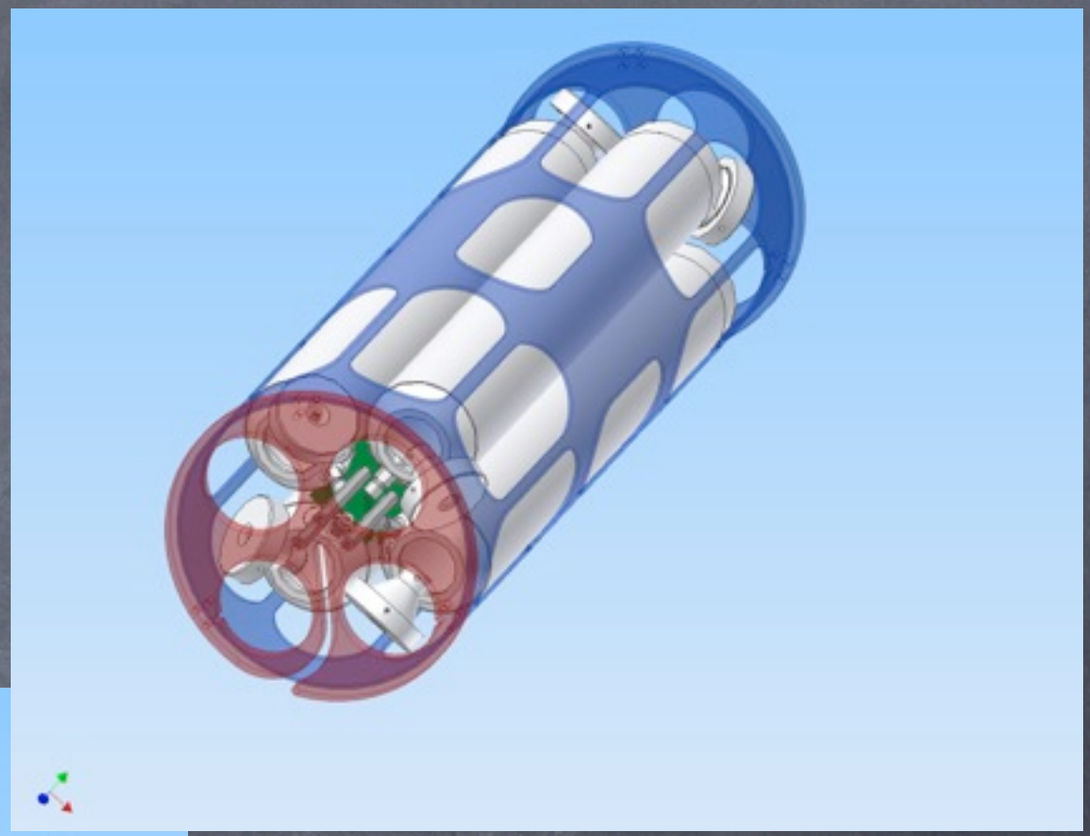
$Volume_{required} := 4 \cdot L$

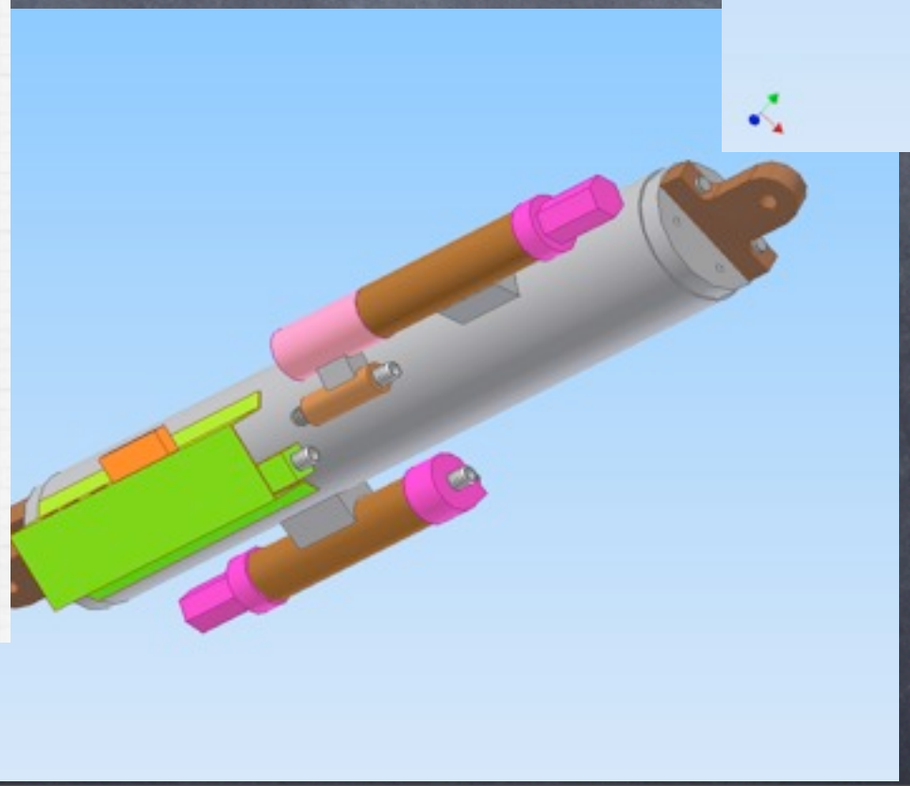
The mimimum acceptable sample volume seems to be three liters. The range goes up to four liters.

$$Bottle_{length} := \frac{Volume_{required}}{\pi \cdot \left(\frac{Bottle_{ID}}{2}\right)^2}$$

$Bottle_{length} = 21.665\,in$







November 9, 2010

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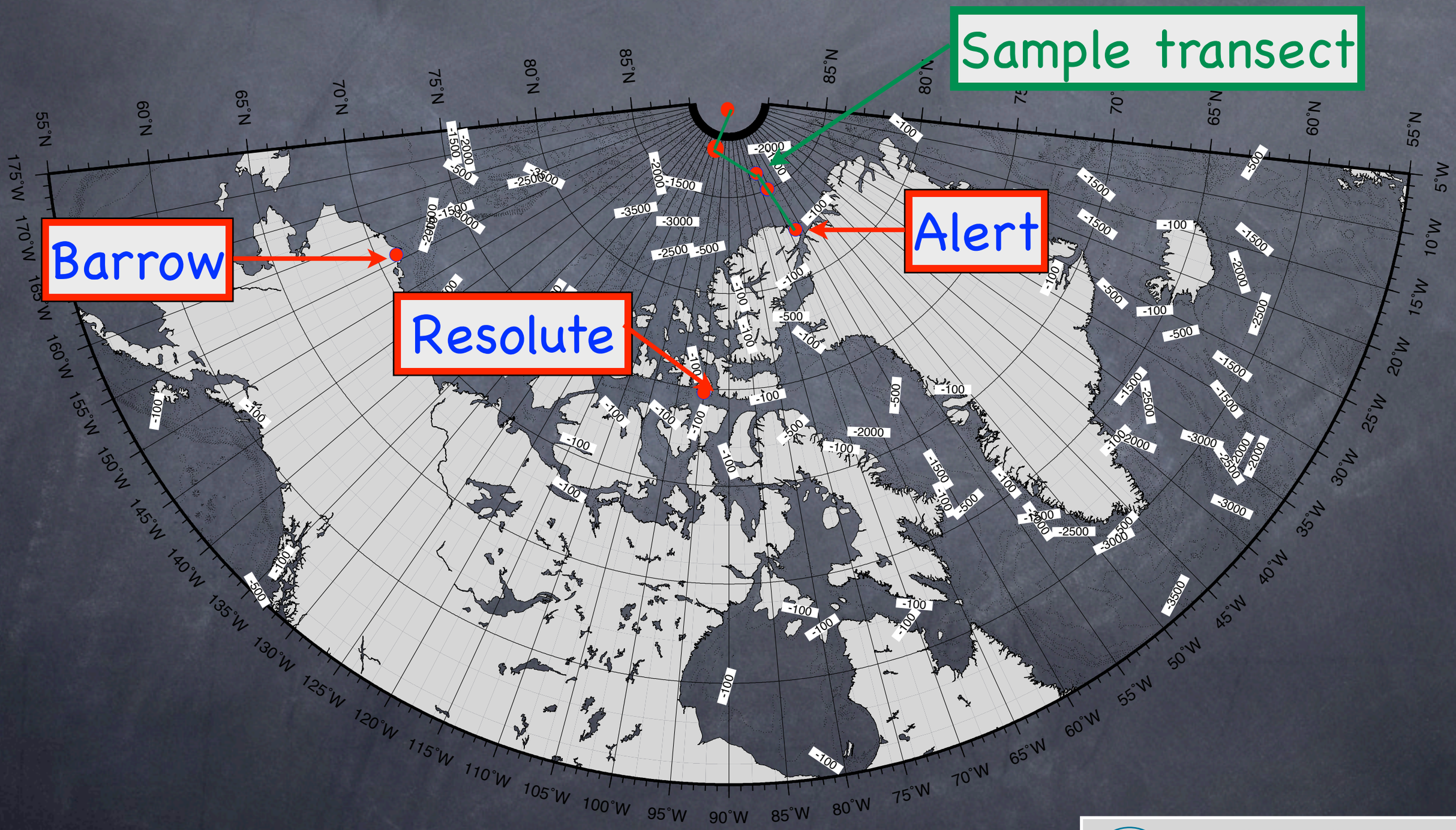
ski-doo


ON YOUR PACKING LIST

Engineer for scale

Where is Alert?



GMT 2004 Jun 18 22:46:19
November 9, 2010

Switchyard 2004 Lambert Conformal Conic Projection with GSHHS Coastline and GEBCO IBCAO Bathymetry

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How do you get there (and back)?

- Comair + Charter:
  - New York->Ottawa->Iqaluit->Resolute
  - Then charter to Alert (via Eureka)
- US Air National Guard (109th)
  - Scotia NY -> Kangerlussuaq -> Thule -> Alert

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Chartered Hawker 748
Resolute -> Alert

Switchyard 2003 Team

Switchyard 2008 Team


U.S. AIR FORCE
0491


VICTORIA 2695
COLLINGWOOD
TORBAY
4315KM
NORTH STORMORT
P.S 4166KM
STE-BEATRIX 4235KM
BRUNO SK
BORDER
LONDON ENGLAND 250
ALMONTE
QUEBEC 2500
FERGUS 4432 KM
NORTH 82 30
STE-JULIENNE
HAYSYLLE 4393
SAINT JOHN
4143KM
PLESSISVILLE QC
4030 KM
SARNIA ONT 4426 KM
ELLIOT LAKE ONT 4082KM
ALER
N
W
MOST NO
TION
BAGOTVILLE 380
TARNAPOL SASK 219
WINNIPEG 2390
ANGSTA
VAL D'OR QC
ST-MARC
HALIFAX
4216KM
TORONTO 2720
WHEATLEY
4562
PE TORMENTINE
BOW SASK 2375
SAINT-LAMBERT P.Q. 405 km
TISDALE, SK
LAISE AU CLAIR
PRONO 7 BES
4135 K.
GASPE 2180
BERMUDA
SHERBROOKE
YARMOUTH


THE WALL OF
SHAME


DRDC 1
JUSTRITE
FLAMMABLE
KEEP FIRE AWAY
INFLAMABLE
MANTENGA ALEJADO DEL FUEGO
INFLAMMABLE
PRODUITS INFLAMMABLES


TWIN OTTER
EXIT
EXIT
REMOVE THIS COVER
PULL HANDLE DOWN
PUSH WINDOW OUT
Attention: BOX

A long one-station flight:

4 coolers (CTD +3)

Ice drill & flights

Tripod & tent

Heater

Electronics

Winch & wire

Generator

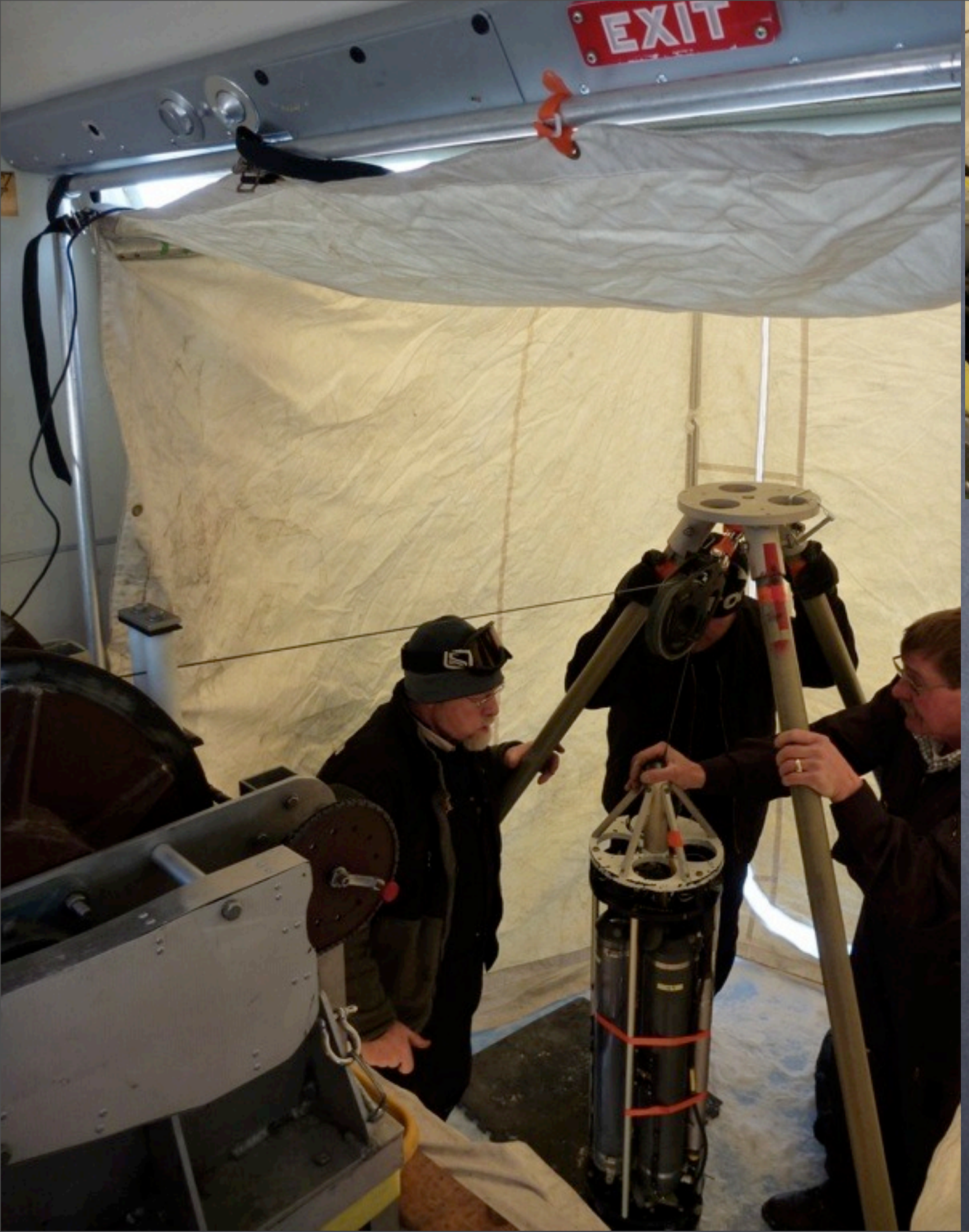
Fuel, tools, emergency gear

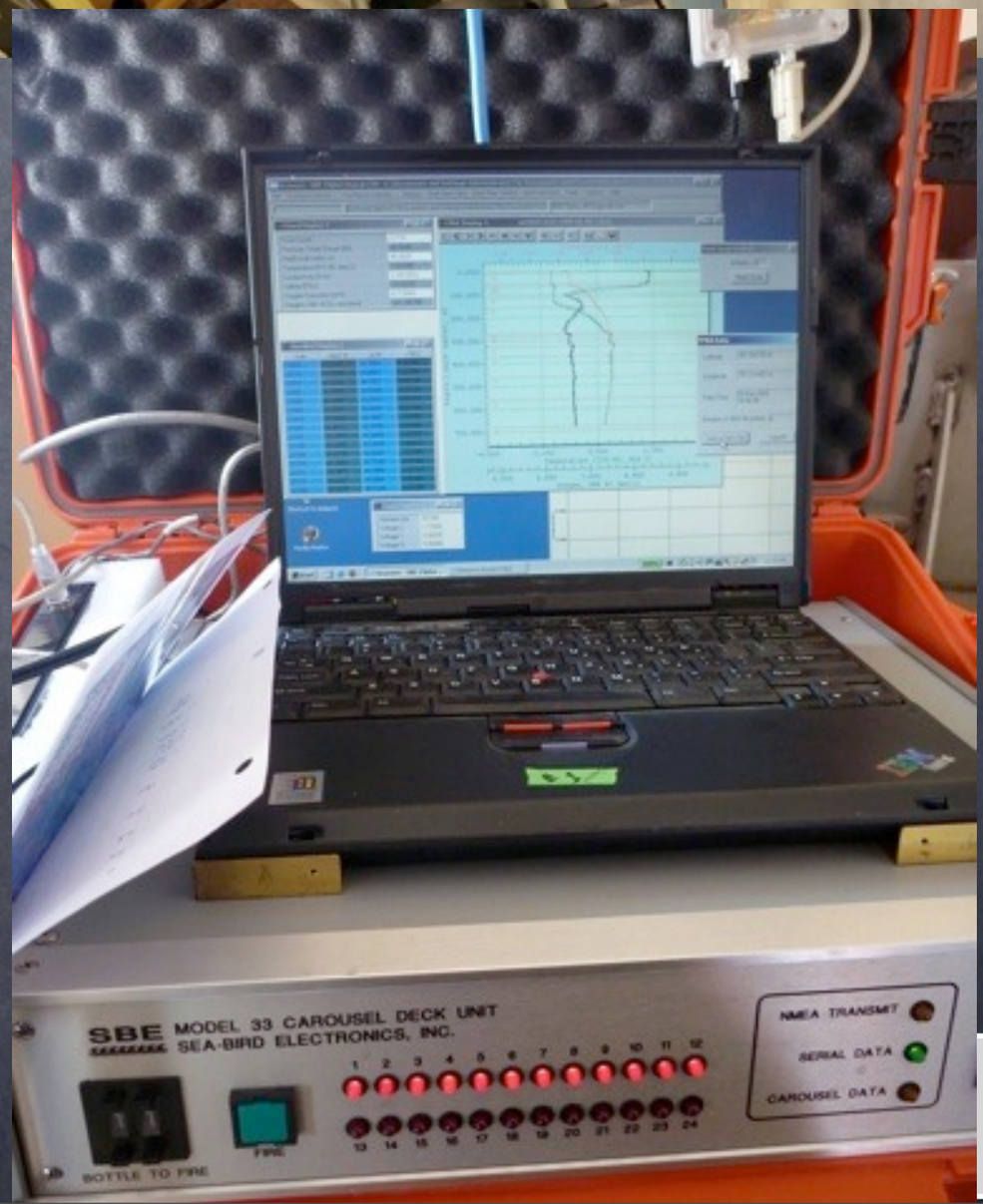
Four souls:

- Pilot, copilot,
- Richard & Dale


EXIT


C-GCKB


EXIT


SBE MODEL 33 CAROUSEL DECK UNIT
SEA-BIRD ELECTRONICS, INC.
NMEA TRANSMIT
SERIAL DATA
CAROUSEL DATA
BOTTLE TO FIRE
FIRE

Drawing and preserving water samples for transport to Lamont and analysis

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Ice tracking buoys

November 9, 2010

Year	Stations	Duration (Days)	Weather & Aircraft Days
2004	3	8	~3
2005	4	6	~2
2006	3	6	~3
2007	5	11	~4
2008	5	11	~3
2009	9	17	6
2010	4	12	7
2011			
2012			
2013			
?			

Science Systems on USCGC Healy

The US research icebreaker in the Arctic

Installed Science Equipment

- Science (TCP/IP) Ethernet Network
- Time of day (very precise) via satellite
- Navigation, Attitude & Heading (GNSS)
- Sonars (bottom mapping & currents)
- Physical properties sensors (weather, water)
- Winches+ to lower sensors and samplers
- Labs, reefers and freezers
- Visiting equipment

Navigation Sources

- Rockwell Collins P-Code (HNV1000)
- Trimble Centurion P-Code
- Ashtech ADU-5 3D-GPS
- Furuno WAAS GPS
- Applanix POS/MV-320 (2)
- Trimble AG132 DGPS
- Ashtech Glonass/GPS
- Simrad MX512 DGPS (2)
- C-Nav GC-DGPS (2)

ADU5(4)

Time

P-Code

AG132

Long Wave Radiation
Short Wave Radiation

L-Band

PAR

CNav (2)

MX512

POS/MV (2)

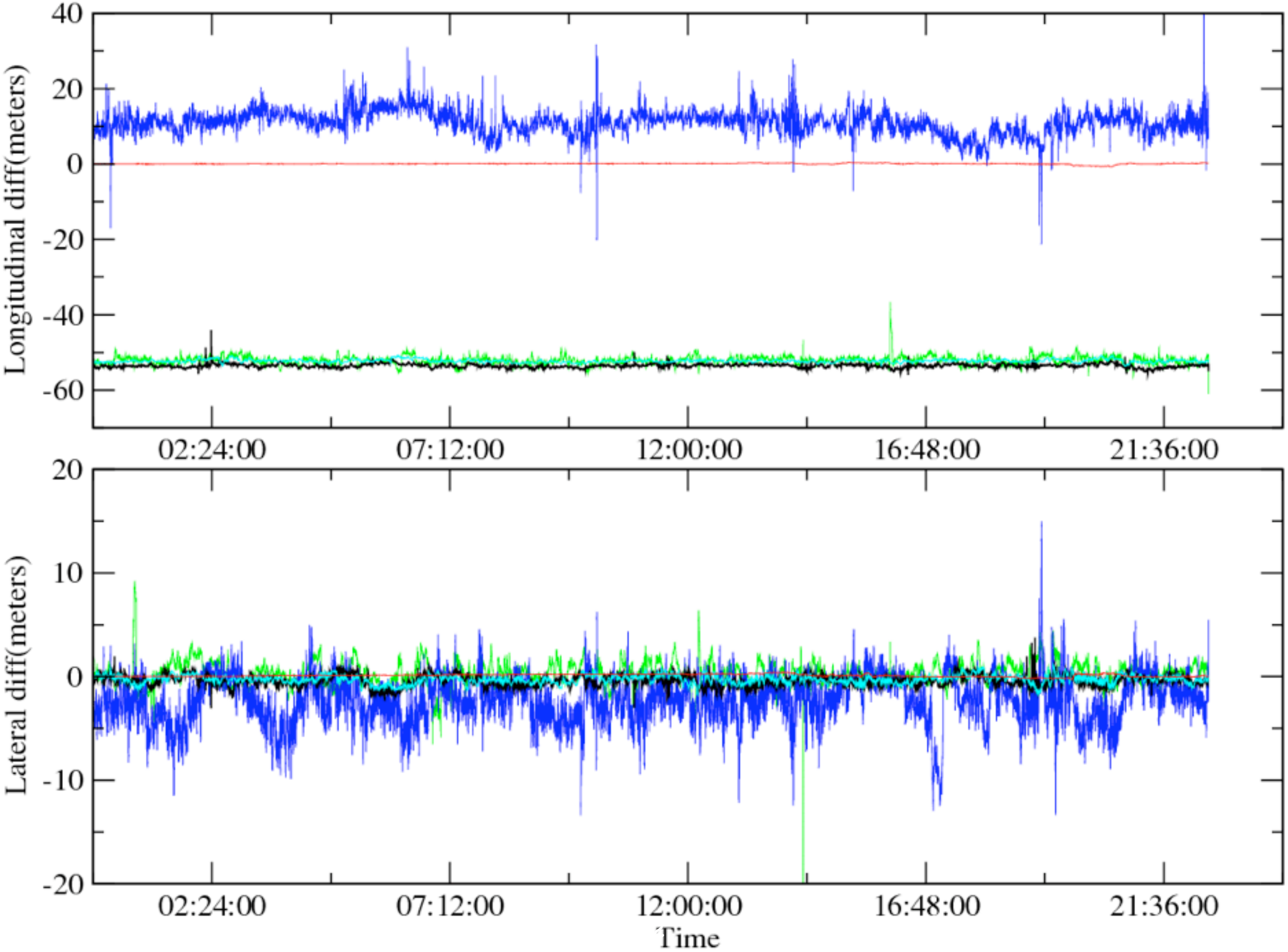
AIS

Met

Summer Student for scale

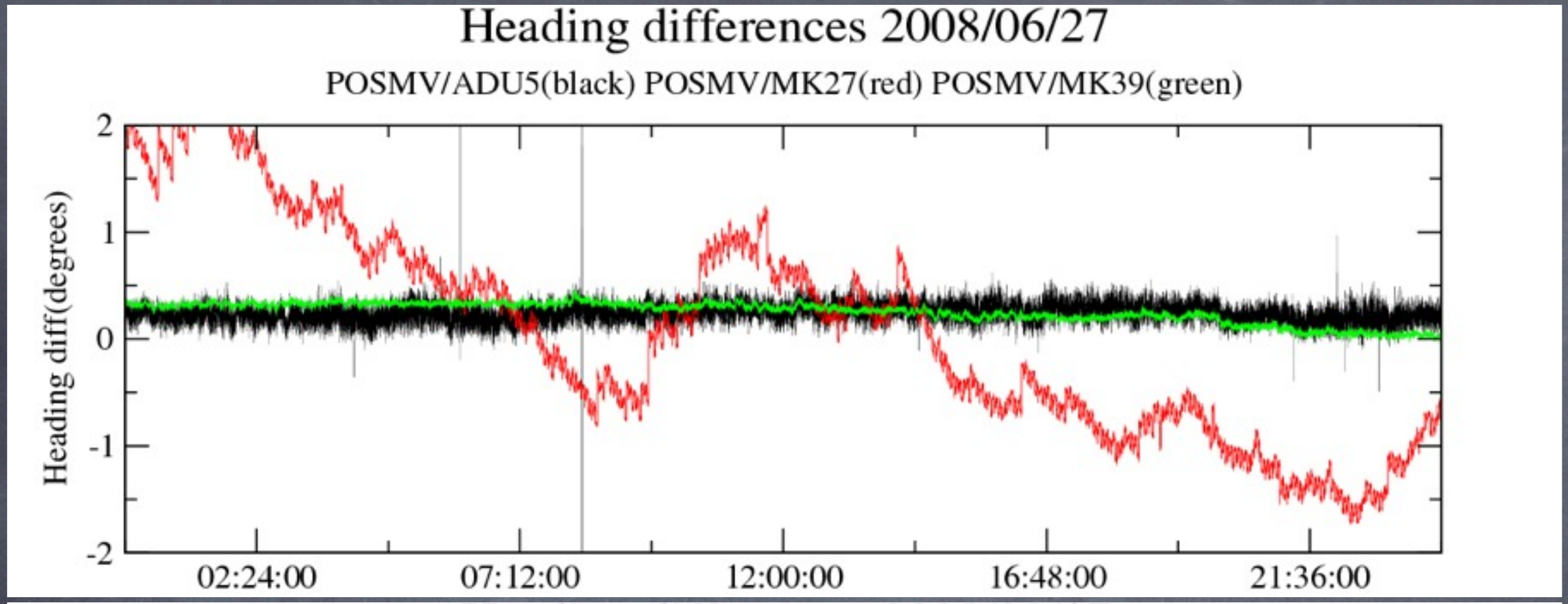
GPS differences 2009/08/12

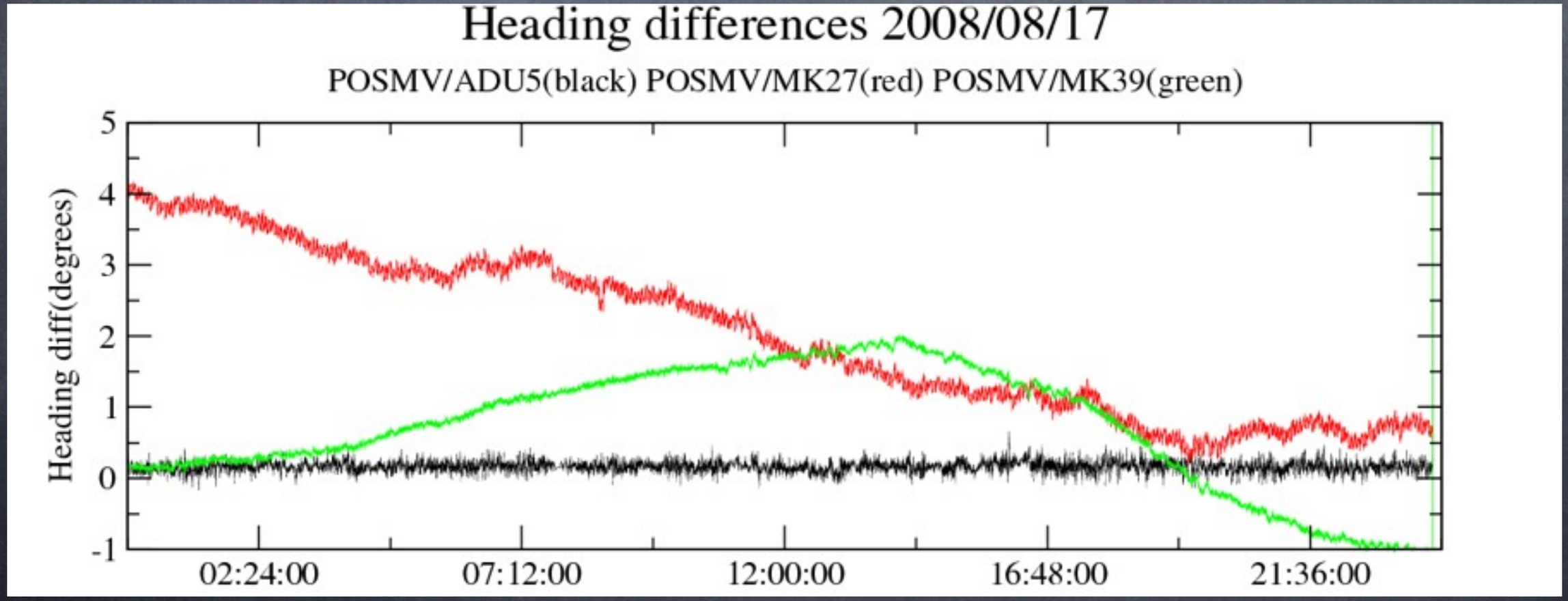
POSNAV(red:reference) ADU5(black) Pcode_aft(green) Pcode_bridge(blue) AgGPS(cyan)



Attitude & Heading

- Applanix POS/MV-320 (primary) (2) GNSS aided Inertial navigation system
- Thales (Ashtech) ADU5 (part of IBS/VMS)
- Sperry MK-27F gyrocompass
- Sperry MK-39 Mod3A gyrocompass


Heading differences 2008/06/27
POSMV/ADU5(black) POSMV/MK27(red) POSMV/MK39(green)
Heading diff(degrees)
2
1
0
-1
-2
02:24:00
07:12:00
12:00:00
16:48:00
21:36:00


Heading differences 2008/08/17
POSMV/ADU5(black) POSMV/MK27(red) POSMV/MK39(green)
Heading diff(degrees)
5
4
3
2
1
0
-1
02:24:00
07:12:00
12:00:00
16:48:00
21:36:00

Sonars

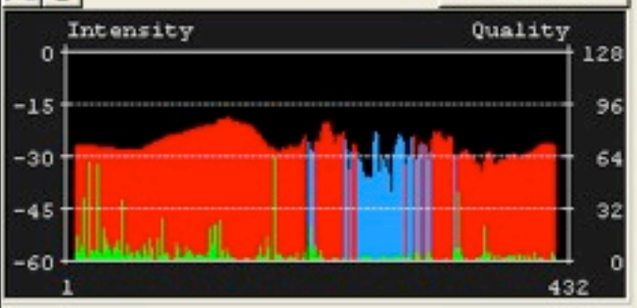
- Kongsberg EM122 multibeam sonar (maps the shape & reflectivity of the seafloor and water column)
- Knudsen 320B subbottom profiler (senses sediment layers below the bottom)
- Two Acoustic Doppler Current Profilers (measures ocean current relative to the ship)

Image courtesy of Jill Heinerth, Bermuda: Search for Deep Water Caves 2009.

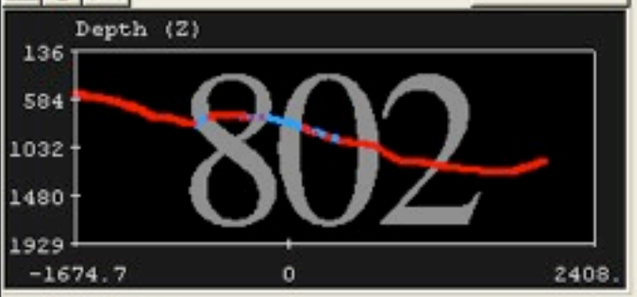
File View Tools Help

Healy_SAT | None | Rescan | EM122_106 | WCL | Logging | Pinging | Line cnt. | 0009 | 11 | HLY_10TC_Survey2a_2010-06-09

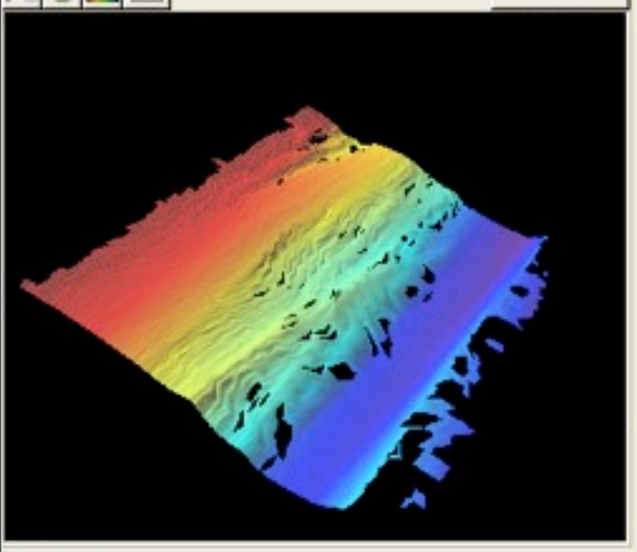
Beam intensity



Cross track

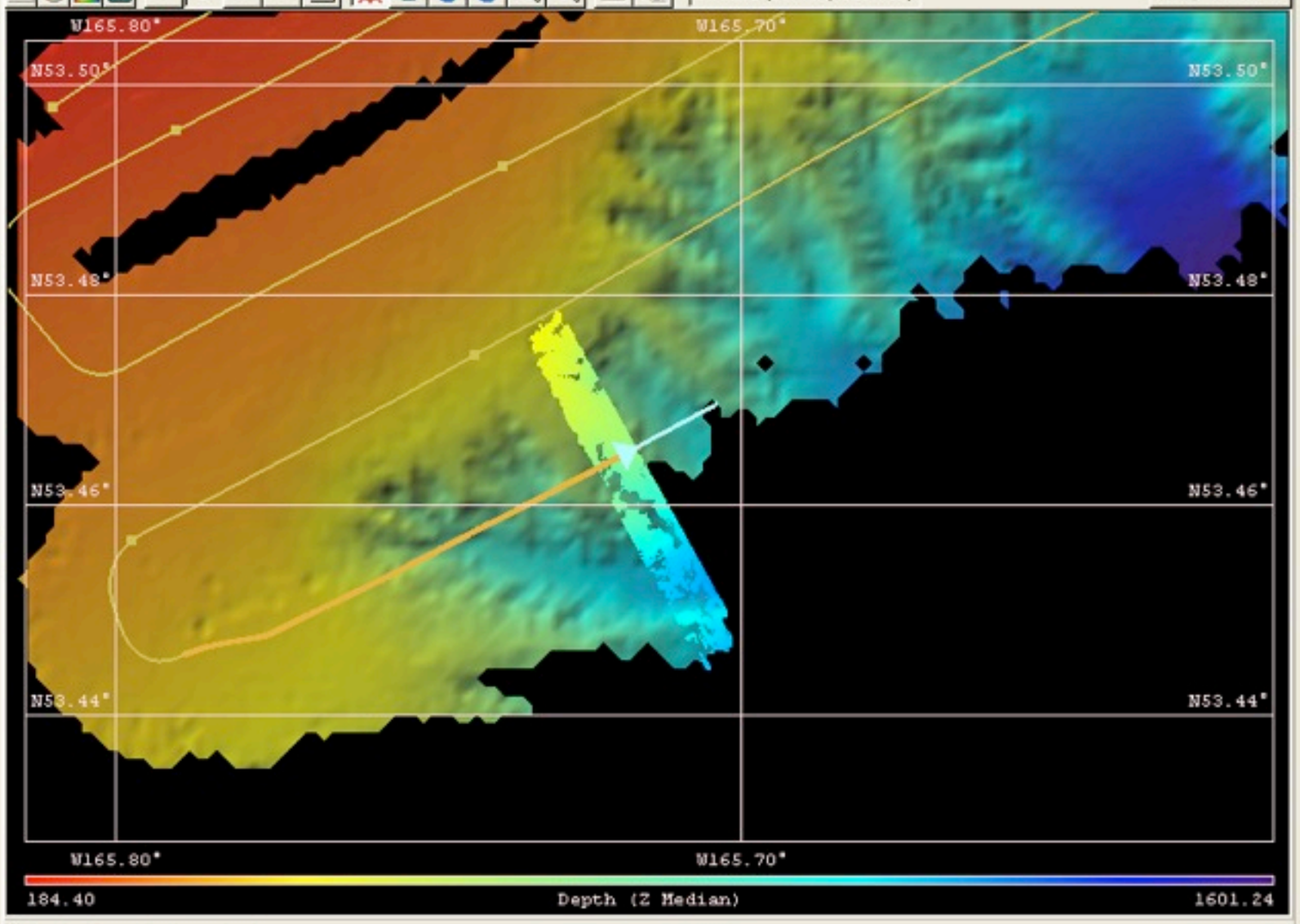


Waterfall

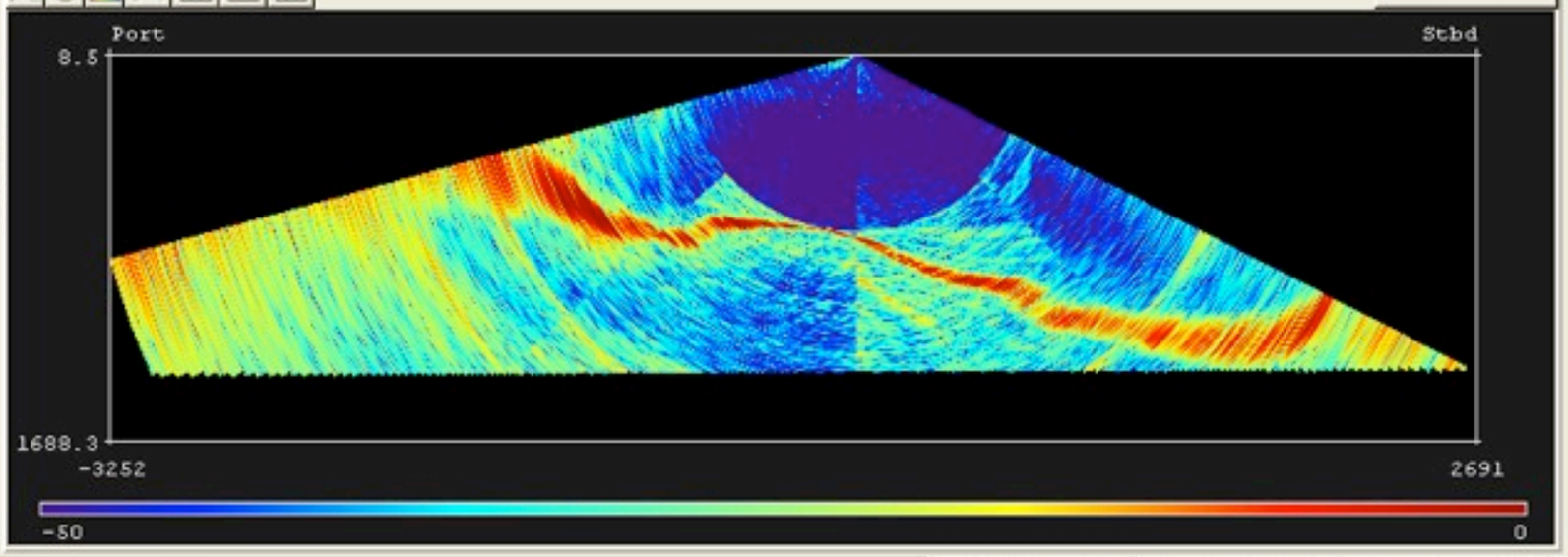


Seabed image

D S 3D I | 1:99200 (53.46N,-165.71E) | Geographical



Water Column

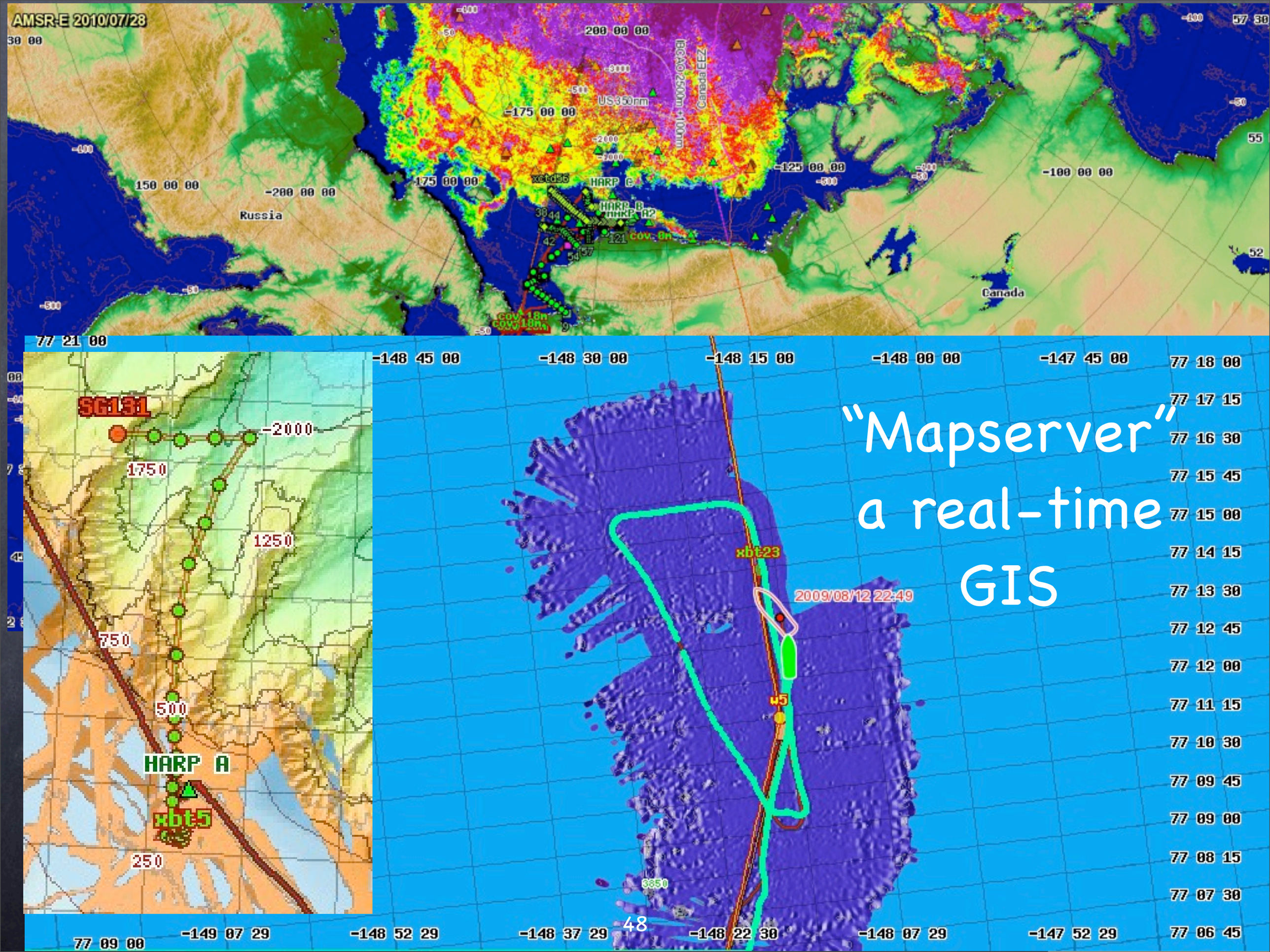


Numerical display

N 53.46559	North DD.DD
W 165.71644	East DD.DD
61.28	Heading
0.15	Pitch
0.36	Roll
0.07	Heave
8.71	Speed kn
2010 6 9	Date
10:39:31	ZDA Time
10:39:31	PU Time
1	PU - ZDA
152	PU - POS
801.96	Depth
MEDIUM	Mode
HIDENS EQDIST	Beam sp.
410/432	Beams
75/61	Coverage
1718/1934	Port/Stb.
1475.50	SV Profile
1478.10	SV Used
1478.2	SV sensor
0.21	Ping Hz
1.10	HDOP
8059	Pingno.
CW	FM mode
Dyn.	Dual swath
10	No. sat.
-0.04	AttVel downward
4.47	AttVel forward
0.06	AttVel starboard
0.21	Ping Hz
5.0	TX pulse (ms)
8.71	Speed kn
3653	Across
7.7	Temp. probe C

Satellites

Ready. | Mode: MEDIUM | Depth: 801.96 | Across: 3653.18 | Soundspeed: 1475.50



"Mapserver" a real-time GIS

Data

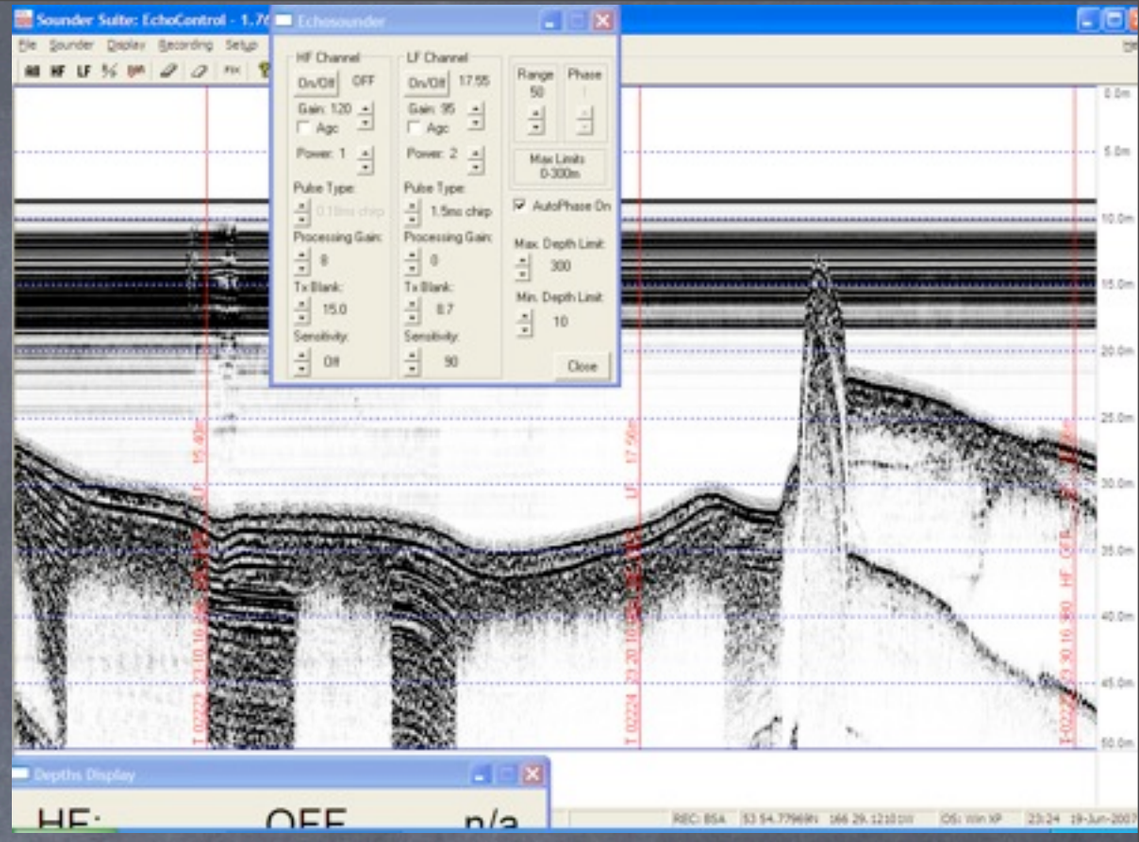
Gravity Meter

```
bgm221 2009:218:12:52:54.7920 04:025486 00
bgm221 2009:218:12:52:55.7820 04:025351 00
bgm221 2009:218:12:52:56.7820 04:025367 00
bgm221 2009:218:12:52:57.7858 04:025337 00
```

POS/MV-320

```
posnav  2009:224:23:40:06.1274  $PASHR,234006.002,351.85,T,-0.82,-0.06,0.00,0.018,0
posnav  2009:224:23:40:06.1854  $PRDID,-0.06,-0.82,351.85*7F
posnav  2009:224:23:40:06.2454  $INGST,234006.002,,2.3,1.1,5.5,2.7,1.4,6.9*56
posnav  2009:224:23:40:06.3034  $INGGA,234006.002,7716.20000,N,14816.39637,W,1,10,0
posnav  2009:224:23:40:06.3035  $INHDT,351.9,T*2B
posnav  2009:224:23:40:06.3334  $INVTG,353.7,T,,M,3.0,N,5.6,K*72
posnav  2009:224:23:40:07.0693  $INZDA,234007.0019,12,08,2009,,*7C
```

Sub-bottom Profiler



- Knudsen 320B/R
  - CW and FM modulated transmission
  - 3 to 6 KHz subbottom
  - 12 KHz echo sounder
  - Only one set of transducer arrays for each frequency
  - No 12 KHz w/ multibeam

Acoustic Doppler Current Profilers (ADCP)

- RDI OS75 Ocean Surveyor (76.8 kHz)
- RDI OS150 Ocean (new for 2010) Surveyor (153.6 kHz)

Science Seawater System & TSG*

- Sea-Bird Electronics SBE-45, DO, flourometer
- Biochem Lab
- Remote temperature probe (SBE-3) near the intake
  - About the time lag....

* Thermosalinograph

HLY07TD TSG temperature difference for day 174 (June 23)

Temperature (degrees C)

11.5
11
10.5
10
9.5
9
8.5

0
200
400
600
800
1000
1200
1400

Time (minutes)

HLY07TD TSG temperature difference for day 174 (June 23)

Temperature (degrees C)

11.2
11
10.8
10.6
10.4
10.2
10
9.8

950 960 970 980 990 1000 1010 1020 1030 1040 1050

Time (minutes)

HLY07TD internal temperature -0.35C and advanced 22 minutes

Temperature (degrees C)

11
10.8
10.6
10.4
10.2
10
9.8

950 960 970 980 990 1000 1010 1020 1030 1040 1050

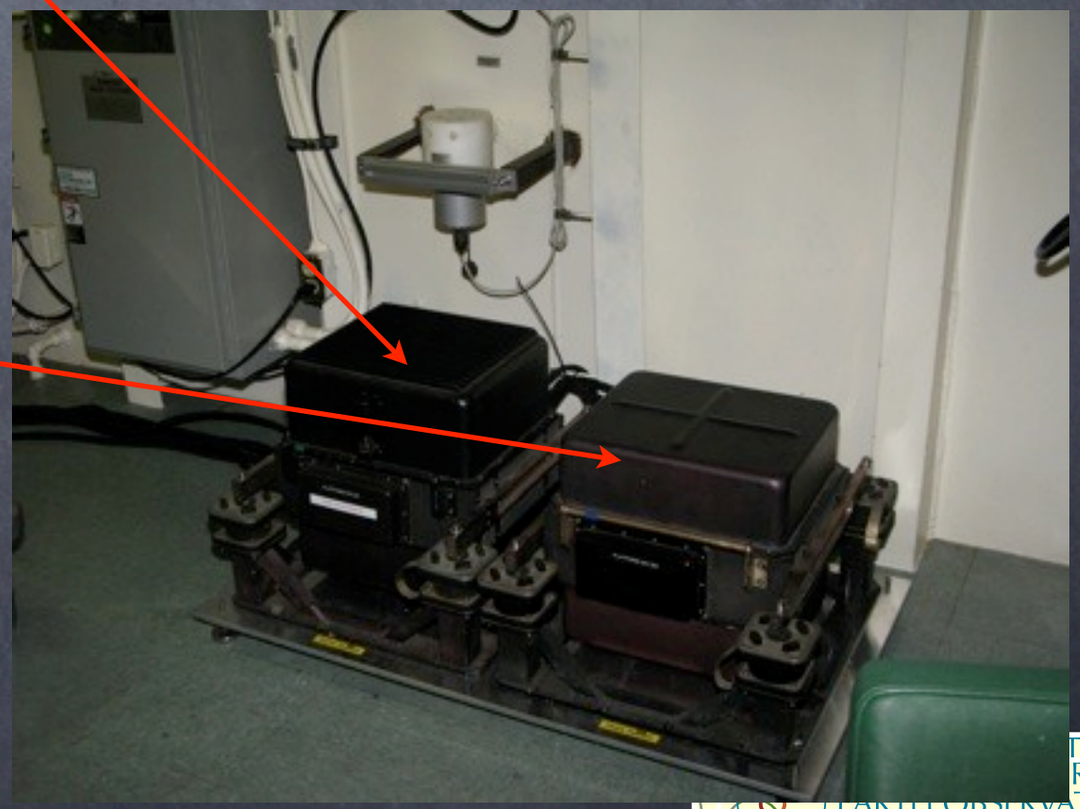
Time (minutes)

Red is external

Blue is internal

Gravity

- Bell BGM-3 Marine Gravity Meter (x2)
- In IC/Gyro (by the lower gym)



Weather

+

- Wind speed & Direction
- Temperature
- Humidity
- PAR, LW, SW radiation
- Atmospheric Pressure
- Terascan

High quality meteorological measurements from ships is hard, and harder from icebreakers is hard, BUT: high latitude weather observations are rare and important so we try harder.

Water sampling

Water sampling rosette
SBE "911" CTD

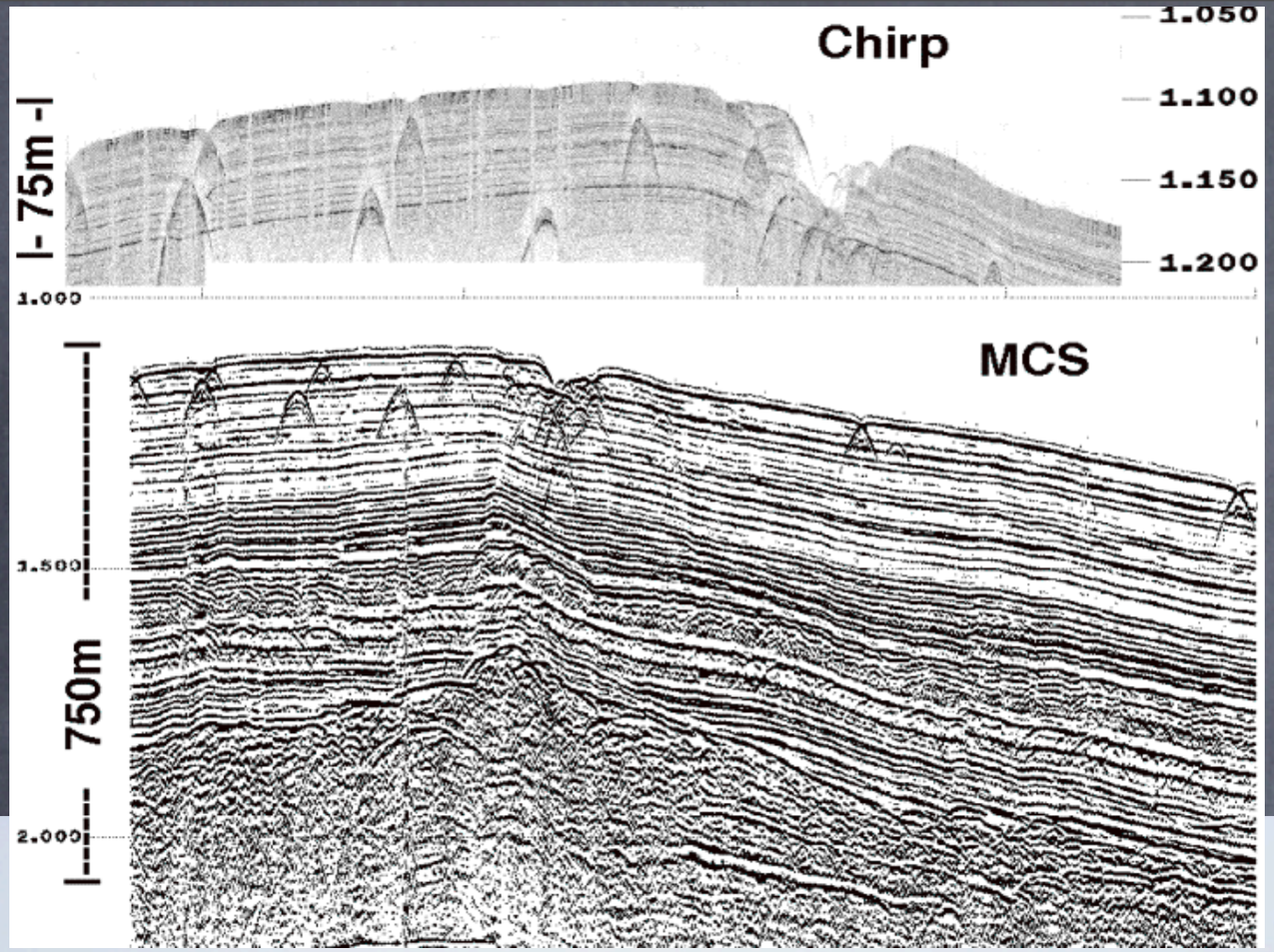
Bow Tower


Small Core
(aka gravity core)

Visiting Science Equipment

- Remotely Operated Vehicles (ROV) and Autonomous Underwater Vehicles (AUV)
- Towed sonars
- Deep seafloor sounding systems (seismic)
- Nets, cores, grabs samplers, dredges
- Ice profilers (EM, radar, laser)
- ~~Gravity meters~~ (now permanent)
- Gliders, moorings, transponder navigation

Remotely Operated Vehicle



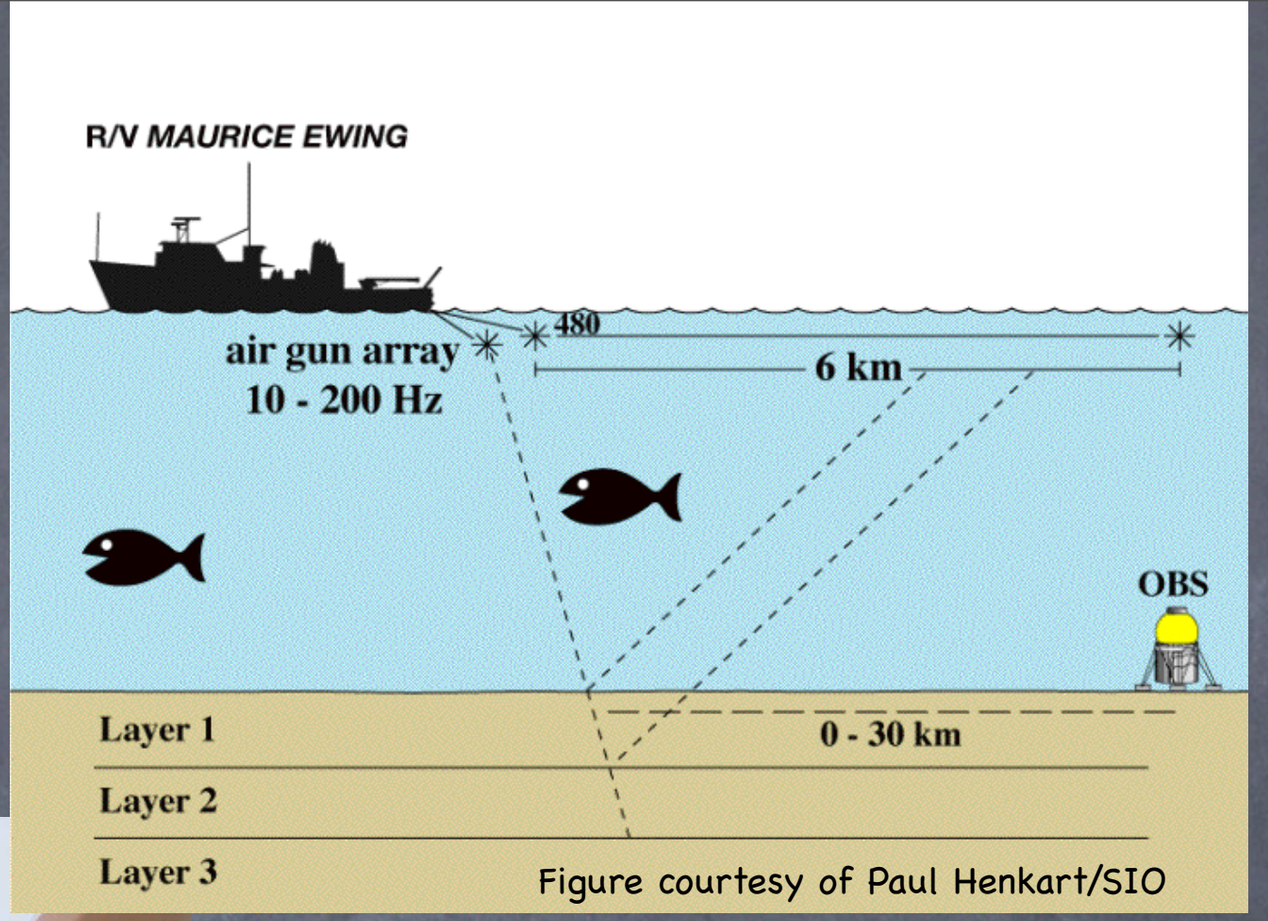


Figure courtesy of Paul Henkart/SIO

Multichannel Seismic Profiling

Healy Acknowledgements

- Many people contributed to this effort including but not limited to: Steve Roberts, Bob Arko, Richard Perry, Tom Bolmer, Scott Hiller, Will Handley, Val Schmidt, Chip Maxwell, Steve Hartz, Ryan Harris, CG Healy crew, and ESU Seattle folks.
- Most but not all of this work is funded by the Arctic Section of the Office of Polar Programs of the US National Science Foundation.
- This work does not represent the opinion or position of any organization.

This talk represents the work of many individuals including engineers, technicians, aircraft and ship crews, and scientists from many organizations and institutions world wide

It is dedicated to the makers and the doers who make these things happen, particularly those who aren't with us any more.

A significant fraction of this work was funded by the Arctic Section of the Office of Polar Programs US National Science Foundation

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INSTRUMENT LABORATORY

Questions?