

New surface-based observations of the environment beneath Pine Island Glacier ice shelf

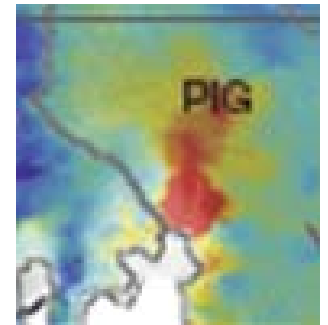
Robert Bindshadler, Martin Truffer, Tim Stanton, Sridhar
Anandakrishnan, Leo Peters, David Holland, Miles
McPhee, David Vaughan, Michael Shortt, Jim Stockel, Bill
Shaw, Kiya Wilson, Einar Steinarsson, Alberto Behar,
Cedric Cocaud, Christina Stam, Mitch Bushuk



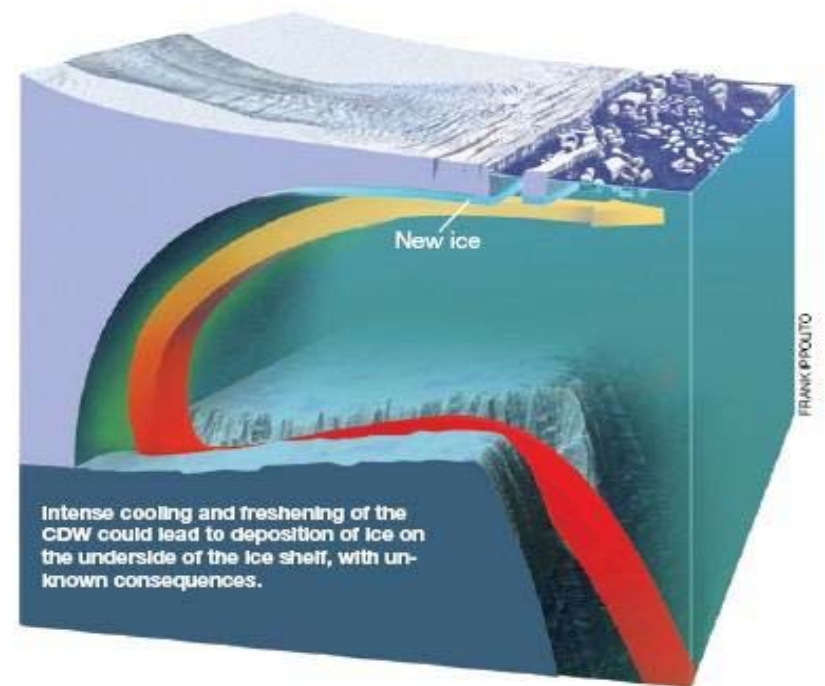
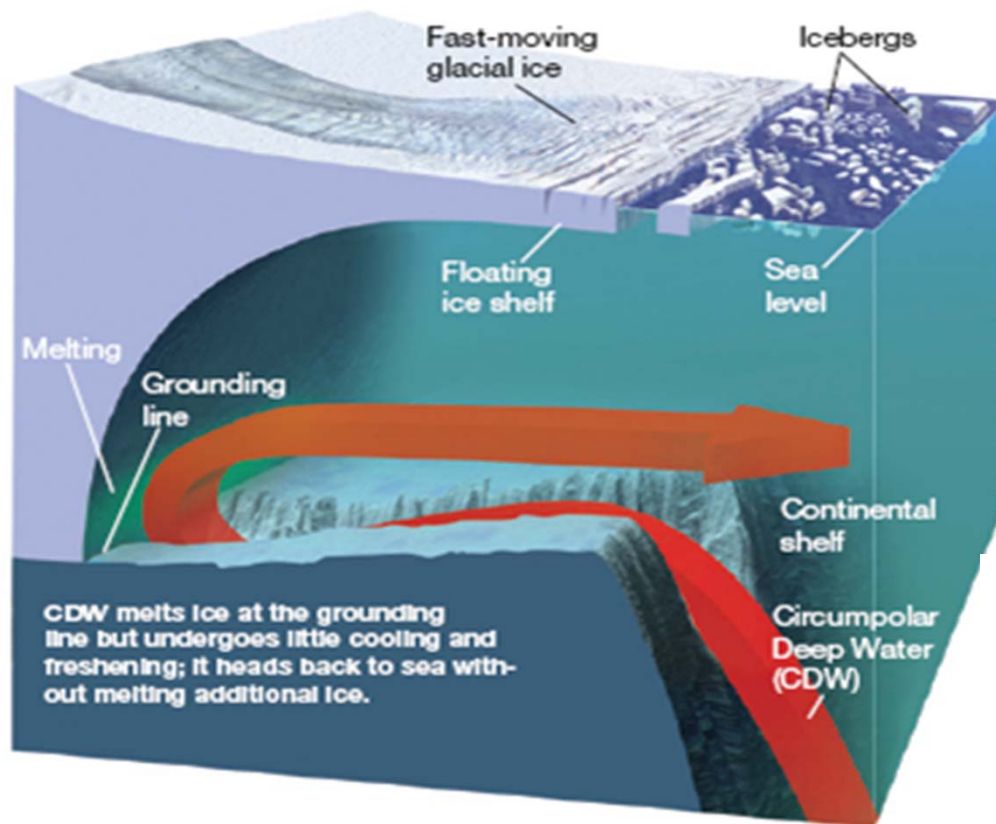
Community “call” for this work came
in this room 7 years ago

Warm ocean is eroding West Antarctic Ice Sheet

Andrew Shepherd,¹ Duncan Wingham,² and Eric Rignot³ , 2004



“If we don’t do this (PIG) research will we be better
able to quantify West Antarctica’s contribution to sea
level in 5 years?”



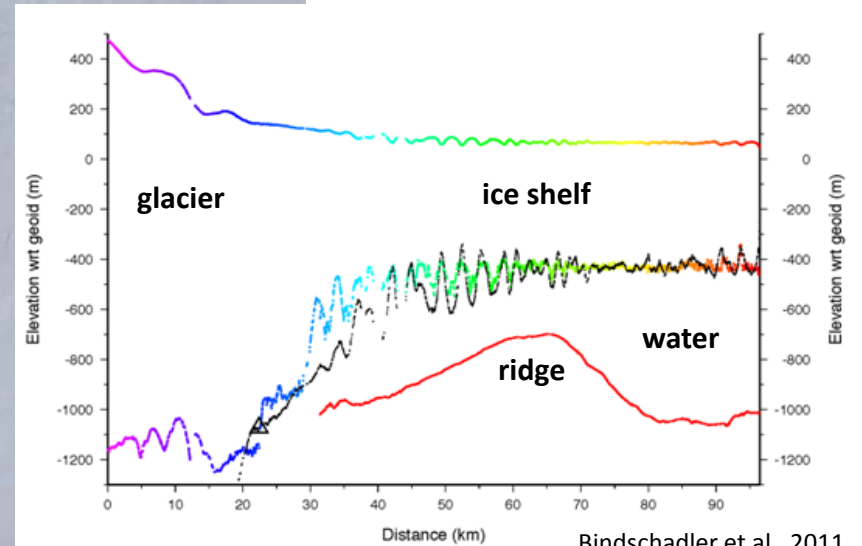
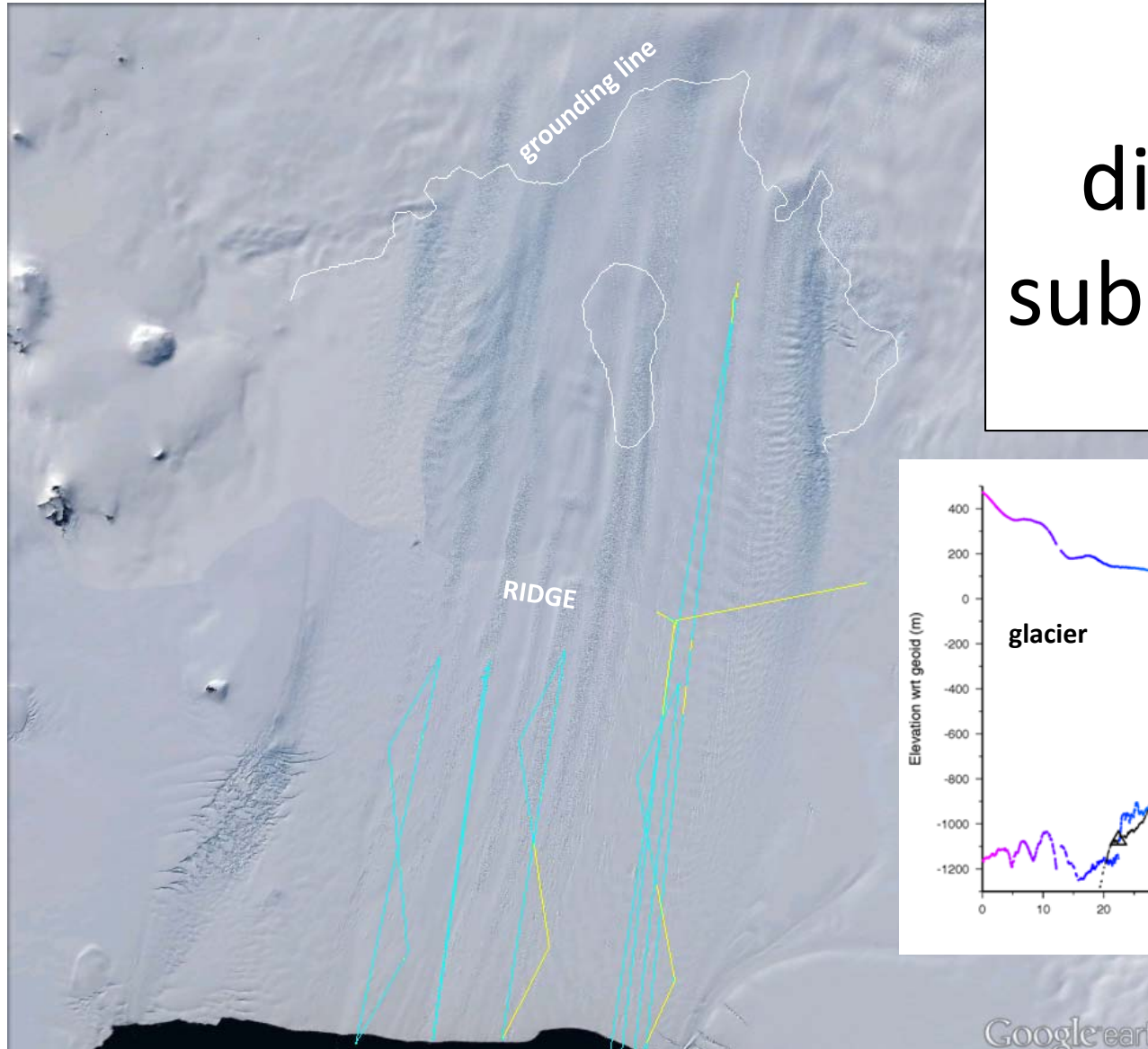
Massive Logistic Support



Thanks to: NY Air National Guard, Kenn Borek Air,
British Antarctic Survey, PHI, & Raytheon Polar Services

Autosub discovered a submarine ridge

(Jenkins et al., 2010)



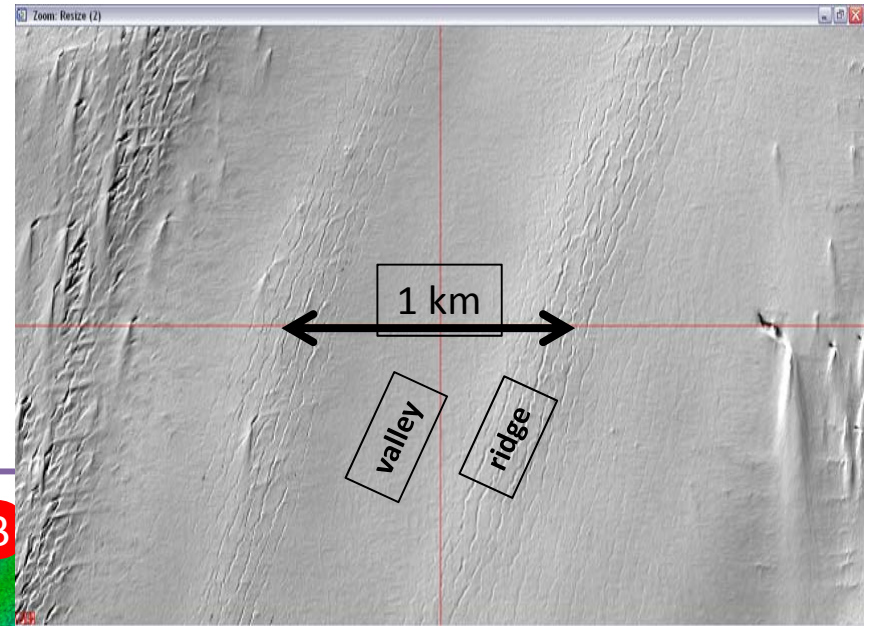
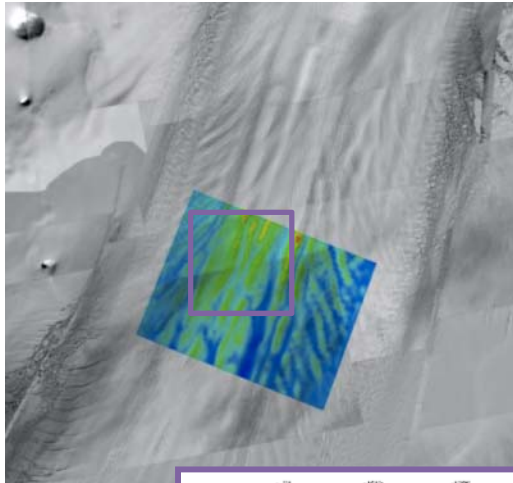
Bindschadler et al., 2011

2009 Autosub
tracks

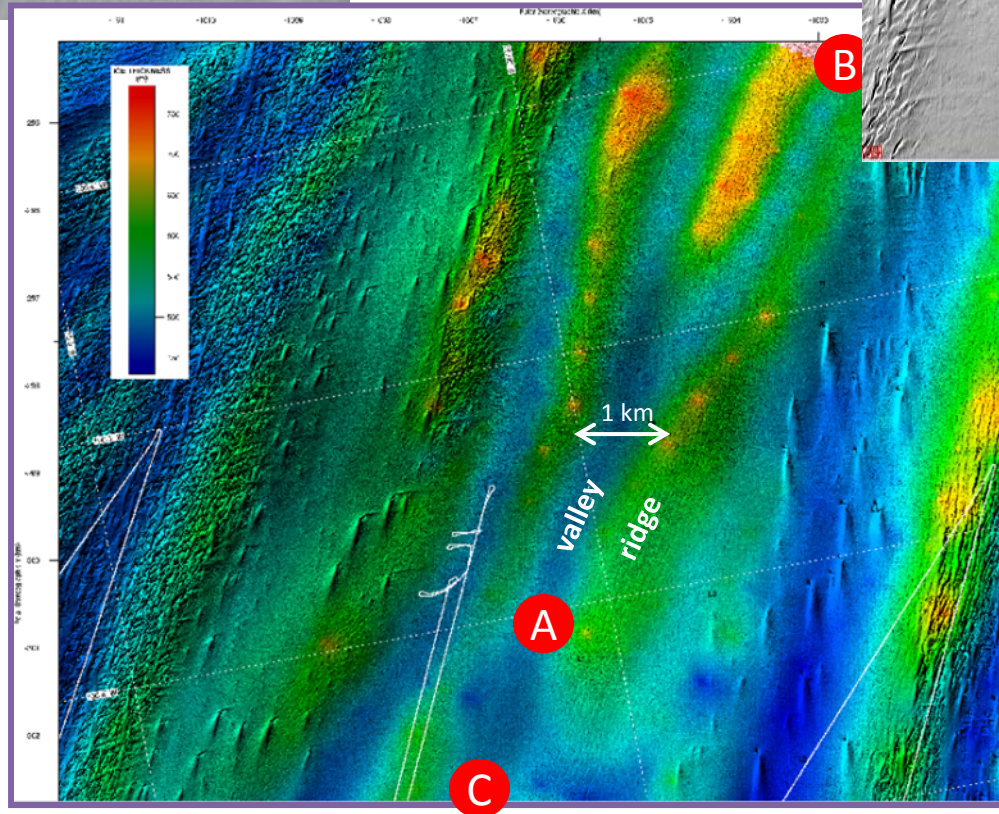
2011 BAS Airborne Survey

Vaughan and others, 2012

Documented a
dominant
valley/ridge
morphology

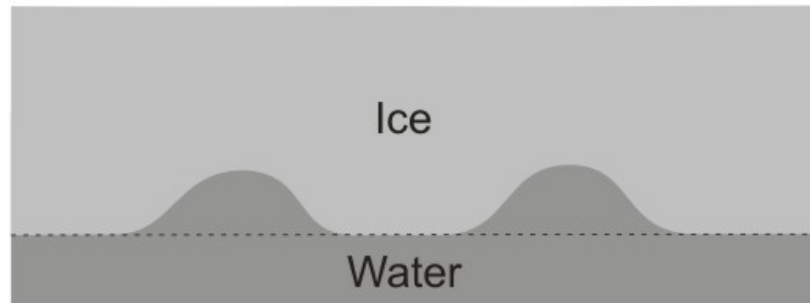


Imagery from Polar Geospatial Center

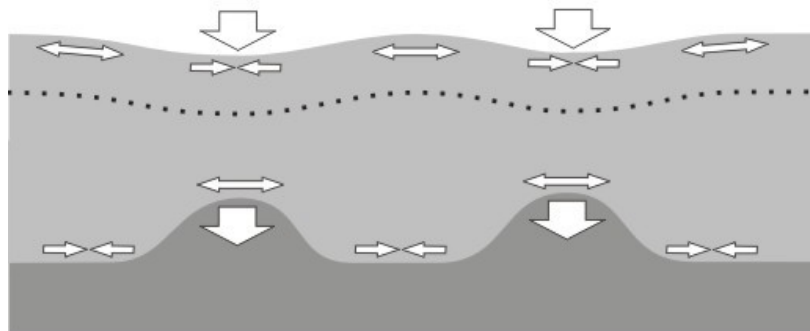


Helped us target
valleys as sites of
largest melt rates
AND greatest
safety...

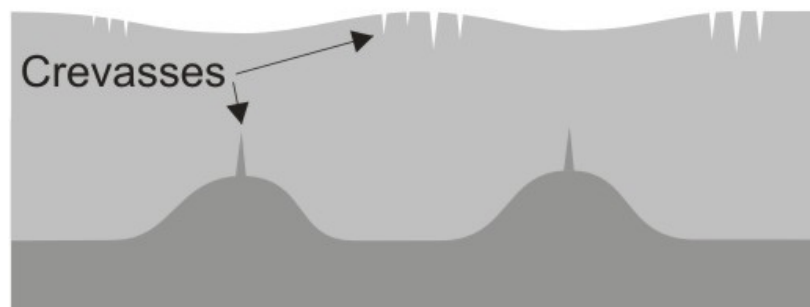
a. Undeformed ice shelf



b. Flexing response



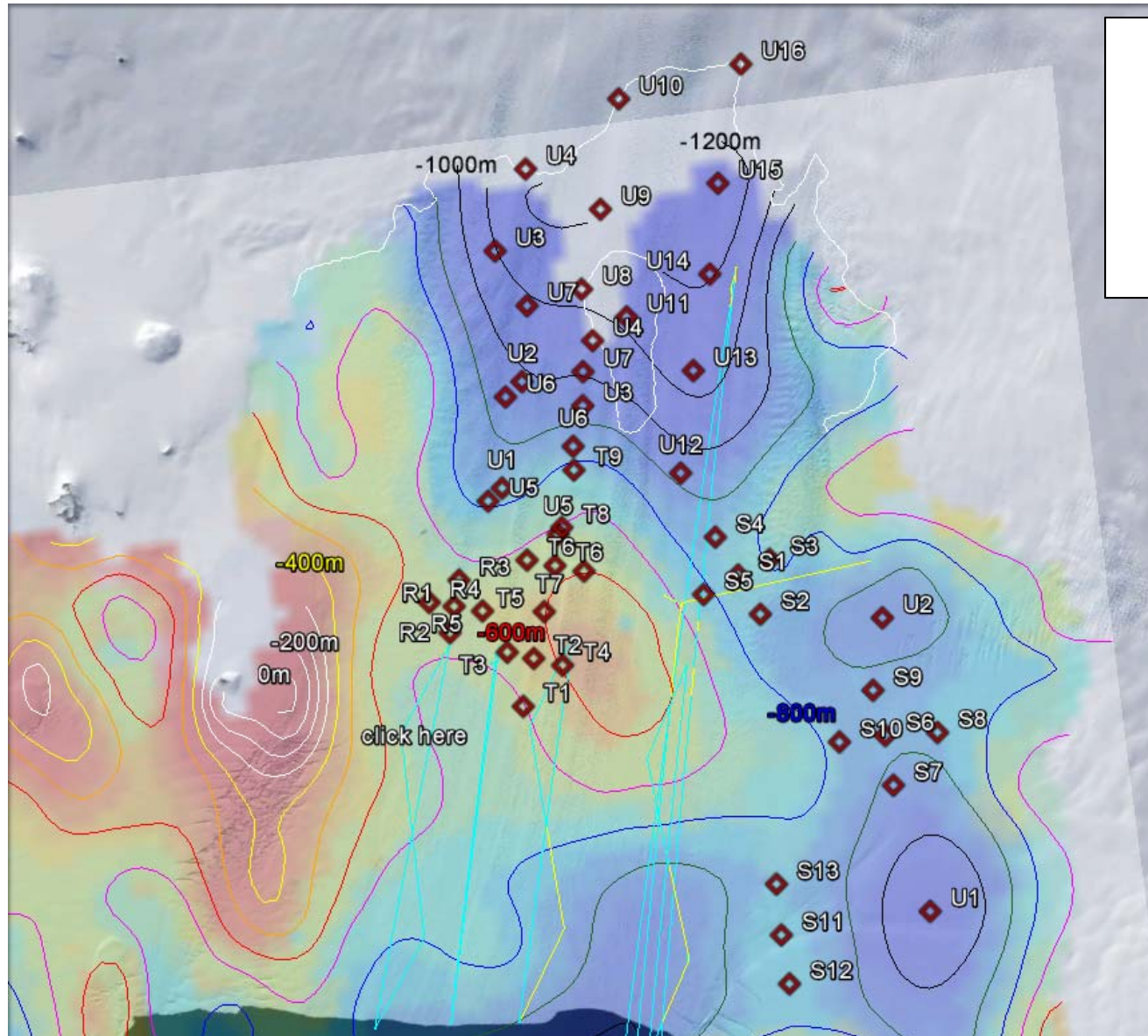
c. Zones of possible failure



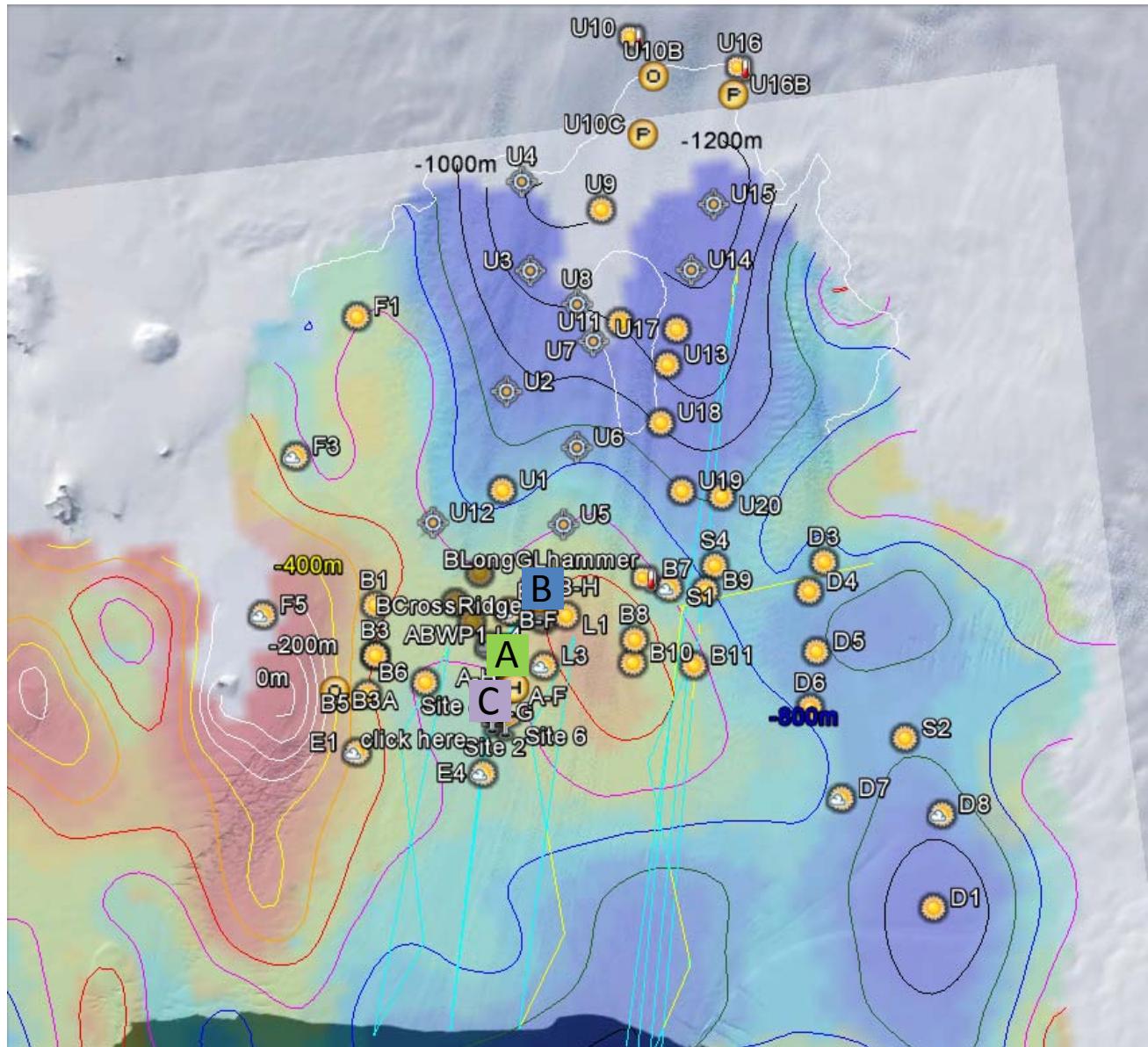
(from Vaughan et al., 2012)

2012-13 Field Plan

Bathymetry from
inverted IceBridge
airborne gravity
(courtesy of M. Studinger)



2012-13 Field Sites



Hammer



Explosives + Hammer



Explosives + Hammer
+ pRES



Explosives + Hammer
+ pRES (repeated)



pRES (repeated)



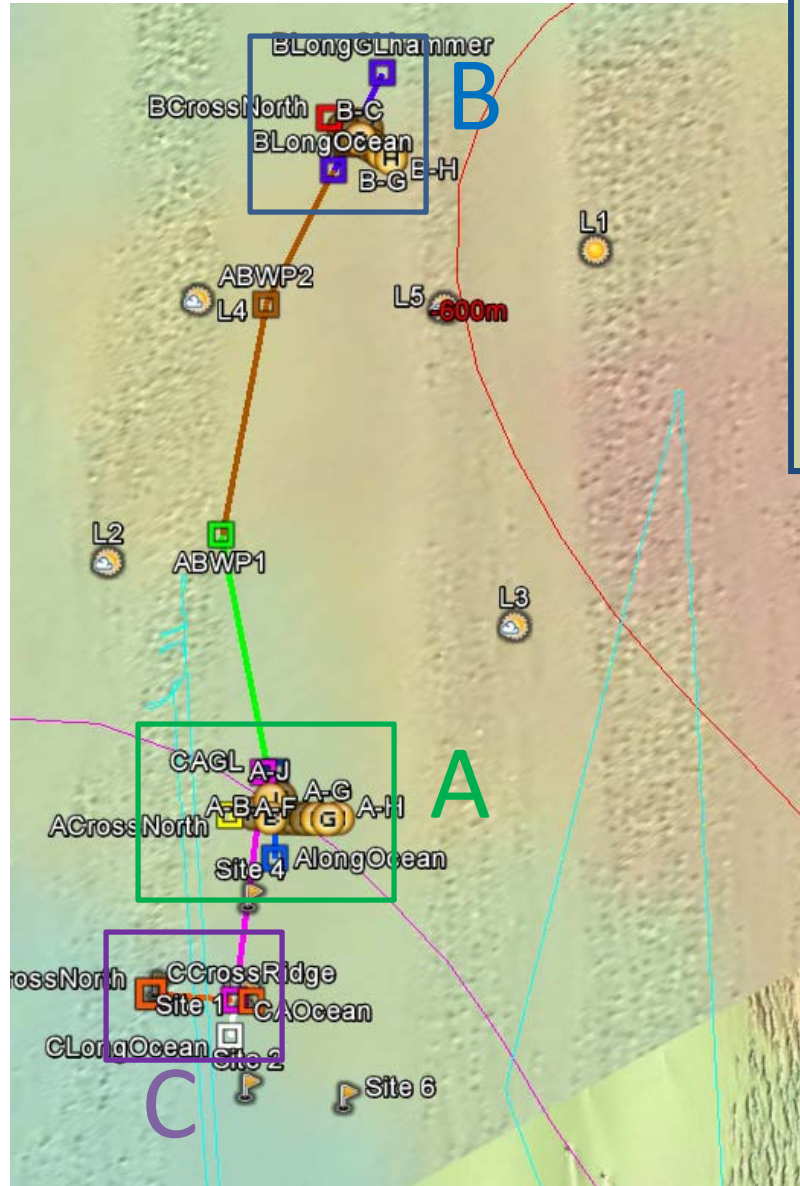
pRES (repeated) +
Winterover GPS and
Passive Seismic



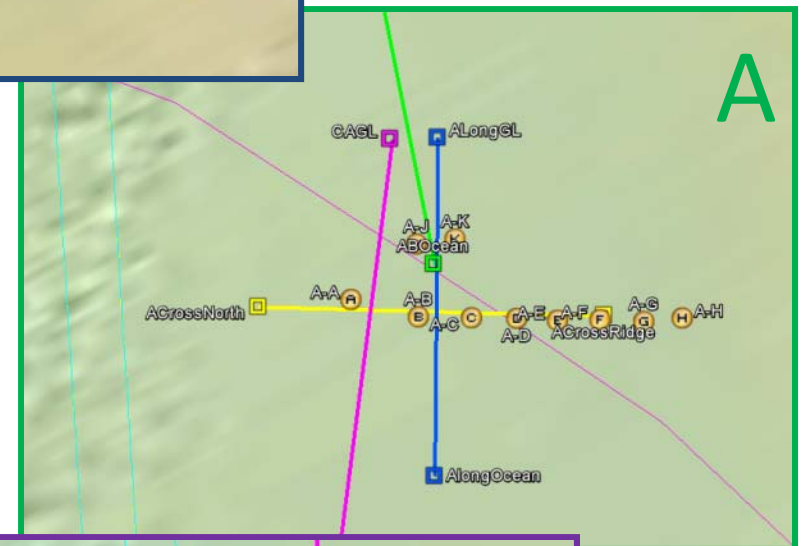
Drill Sites

Drill Sites

Hot-water drilled holes to permit deployment of oceanographic sensors



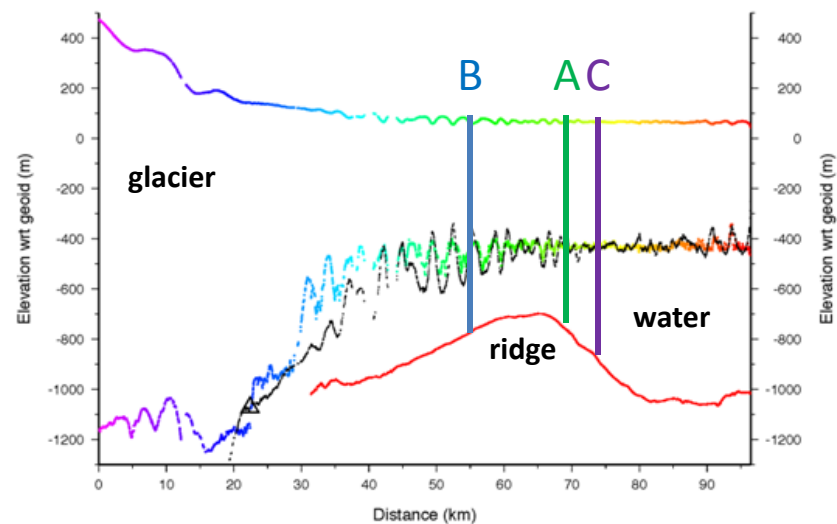
ABC valley is 460 m thick, 10 m deep and overlies an inverted channel 80 m deep



Oceanographic Measurements



- 3 Profilers (one each at Sites A, B & C)
 - Only site B profiler actually profiles, other two are anchored at seabed to sample deepest water
- 3 ice-bottom packages (one each at Sites A, B & C)
 - All working but will eventually melt out (masts frozen in a few meters)
- All measure CTD
- Ice-bottom packages also measure bottom melt rate directly

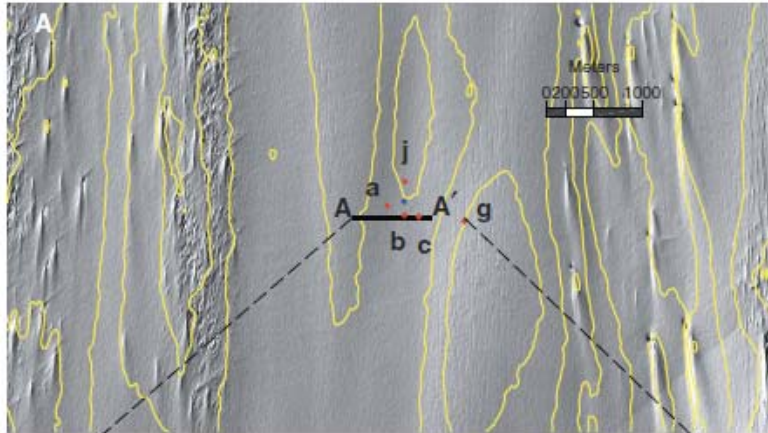


Just published!

Channelized Ice Melting in the Ocean Boundary Layer Beneath Pine Island Glacier, Antarctica

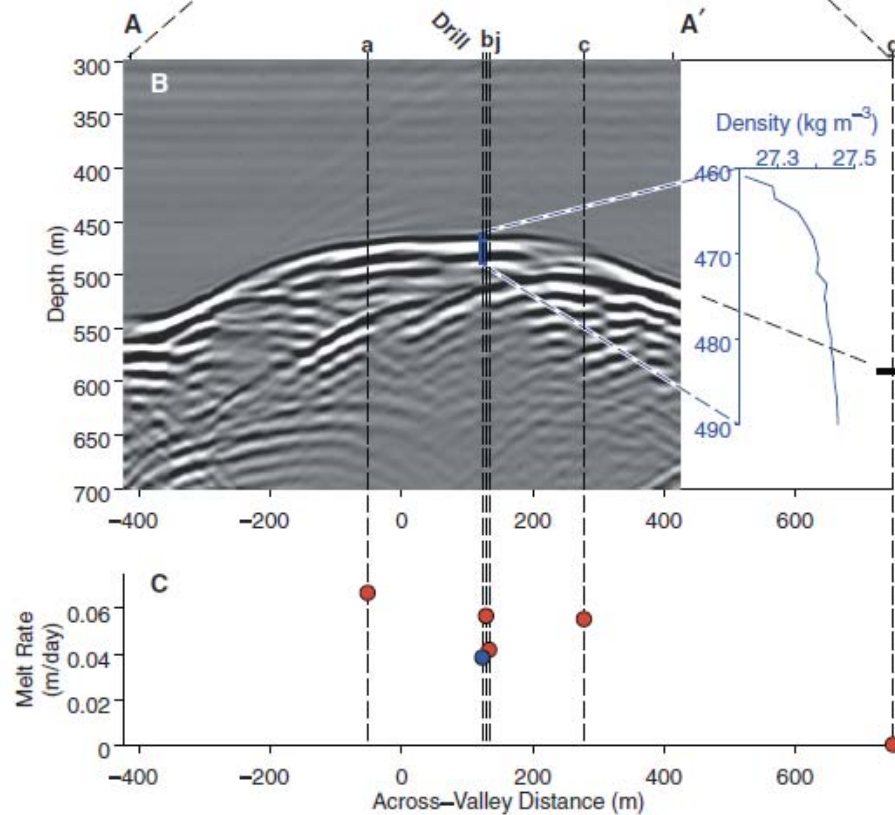
T. P. Stanton,^{1*} W. J. Shaw,¹ M. Truffer,² H. F. J. Corr,³ L. E. Peters,⁴ K. L. Riverman,⁴
R. Bindshadler,⁵ D. M. Holland,⁶ S. Anandakrishnan⁴

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Measurements in valley and on ridge*

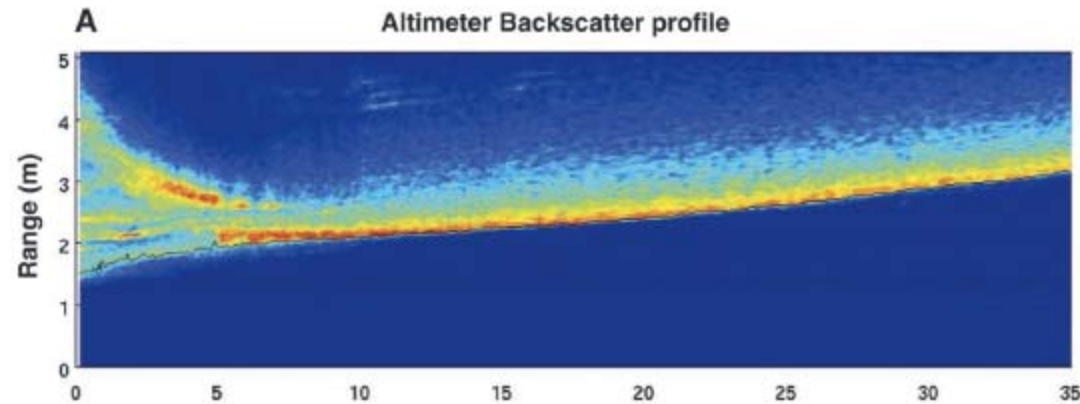
*20 km downstream of grounding zone



Boundary Layer well
characterized

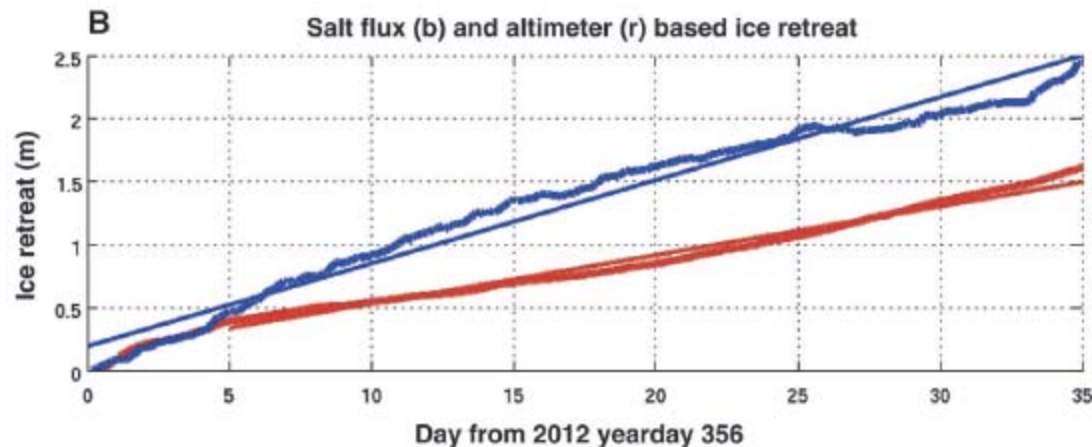
Strong melt in channels;
no melt under ridges

Melt Rates In Channel



from Altimeter:
3.9 cm/day

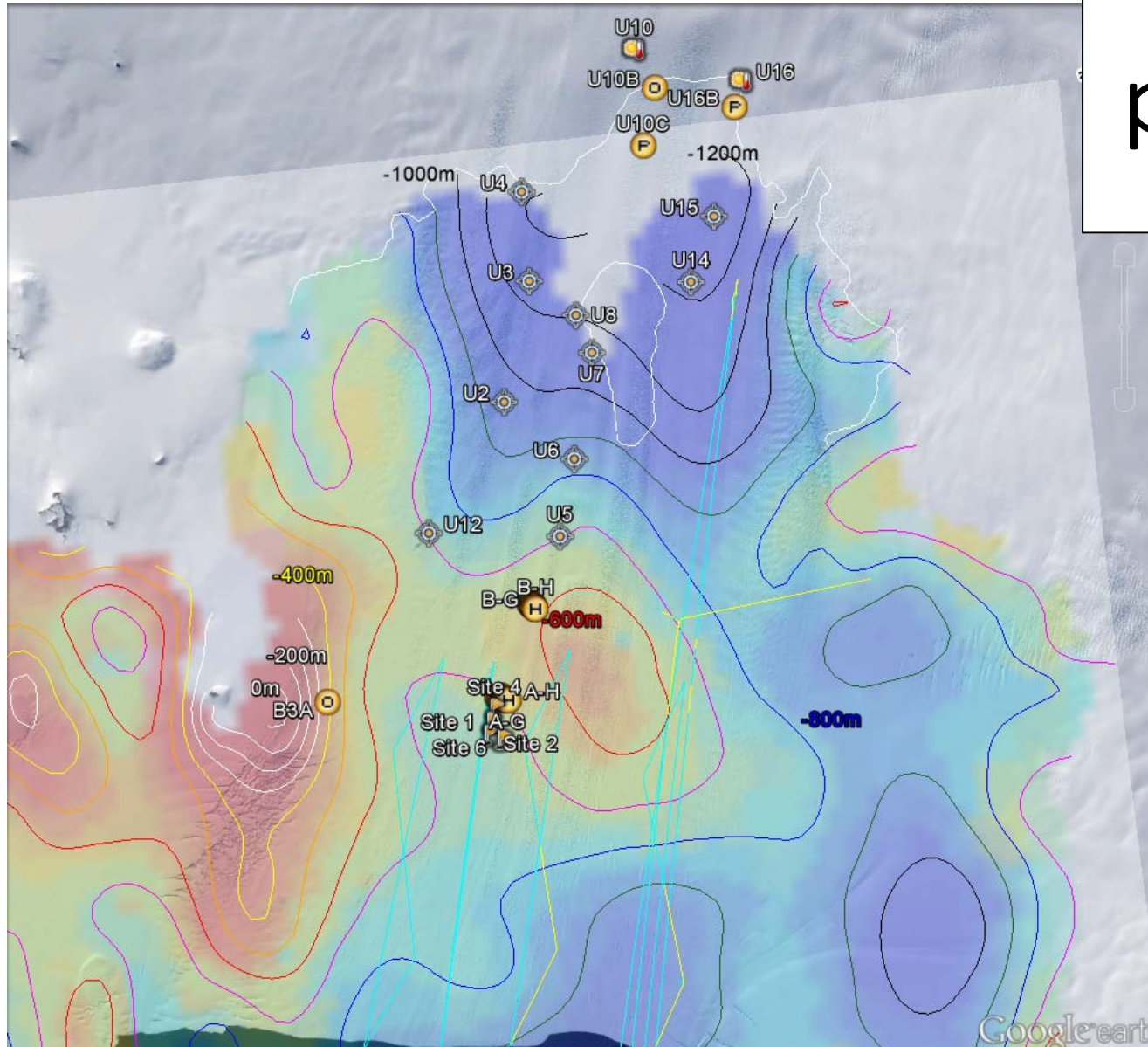
From Salt flux:
6.6 cm/day



From pRES:
6.7 cm/day
5.5 cm/day
5.7 cm/day
4.2 cm/day

Average melt rate: 5.4 cm/day (20 m/year)

pRES Sites

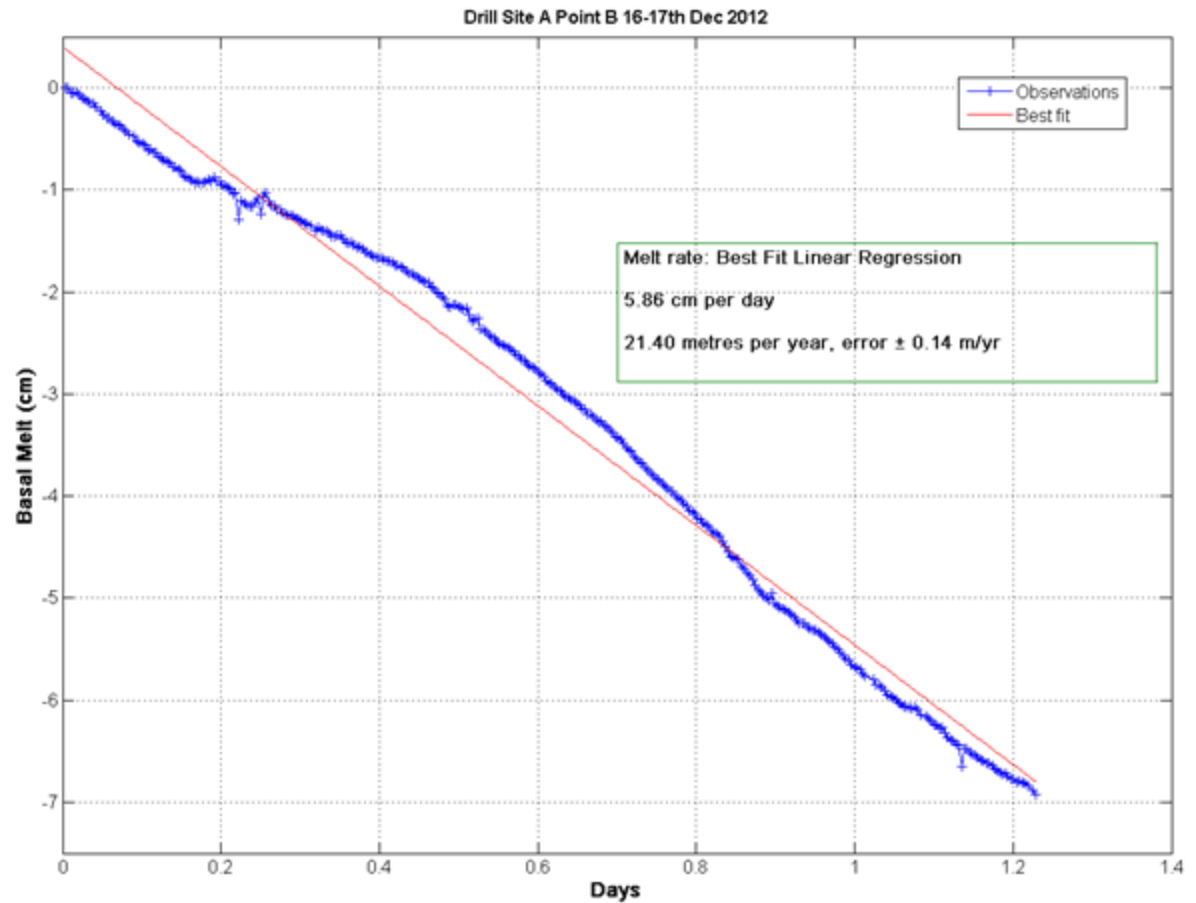
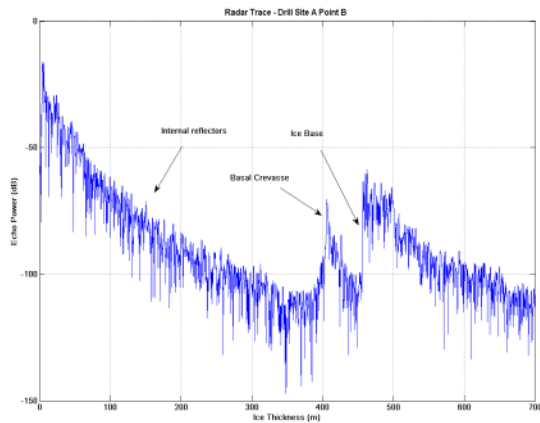
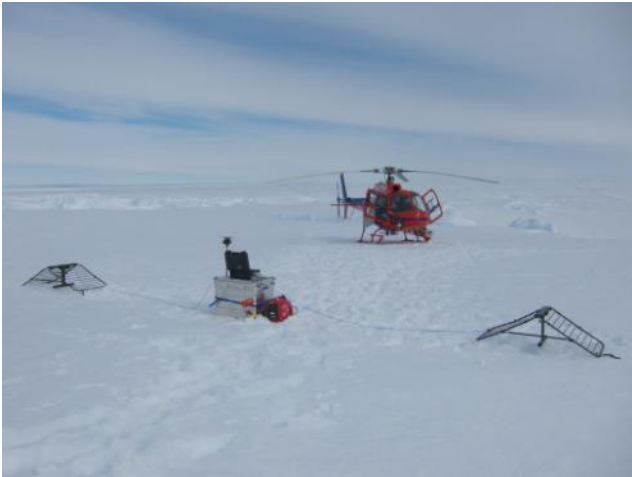


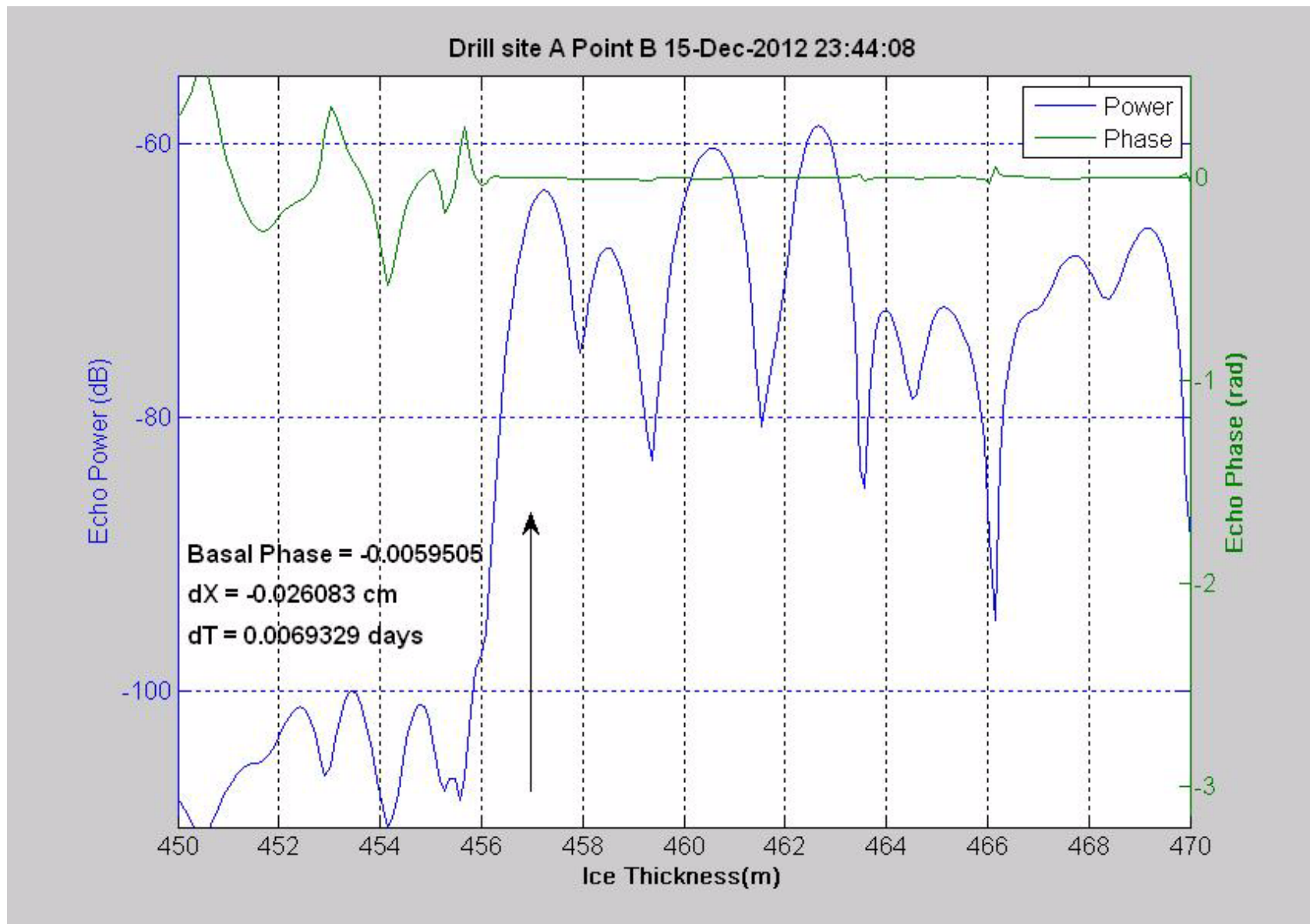
Phase-sensitive
radio echo sounder
used to measure
basal melt rate

Revisit required

First pRES Results (Site A)

347 measurements over 29 hours





**British
Antarctic Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

Change in **Echo Phase** measures decreasing range to rising ice shelf bottom to a fraction of the 0.558 m wavelength

Sediment corer



- 1+ meter core at site A
- 1+ meter core at site B
- ~0.3 meter core at site C



courtesy of James Smith

Summary

- Field work on PIG ice shelf is possible, even pleasant
- Sustained, high-quality measurements of ice motion and ocean characteristics are now being collected
 - (not mentioned) passive seismic and weather data also being collected
- “High” melt rates in channels quantified
 - Results from 3 independent methods broadly consistent
 - slightly less than inferred by others
- No melt outside channels
- Analysis of sediment cores, active seismology and more pRES yet to come
- Data will help answer outstanding questions such as:
 - Shape of cavity
 - Temporal variations of oceanic heat in/out of cavity
 - Enable detailed modeling of cavity circulation

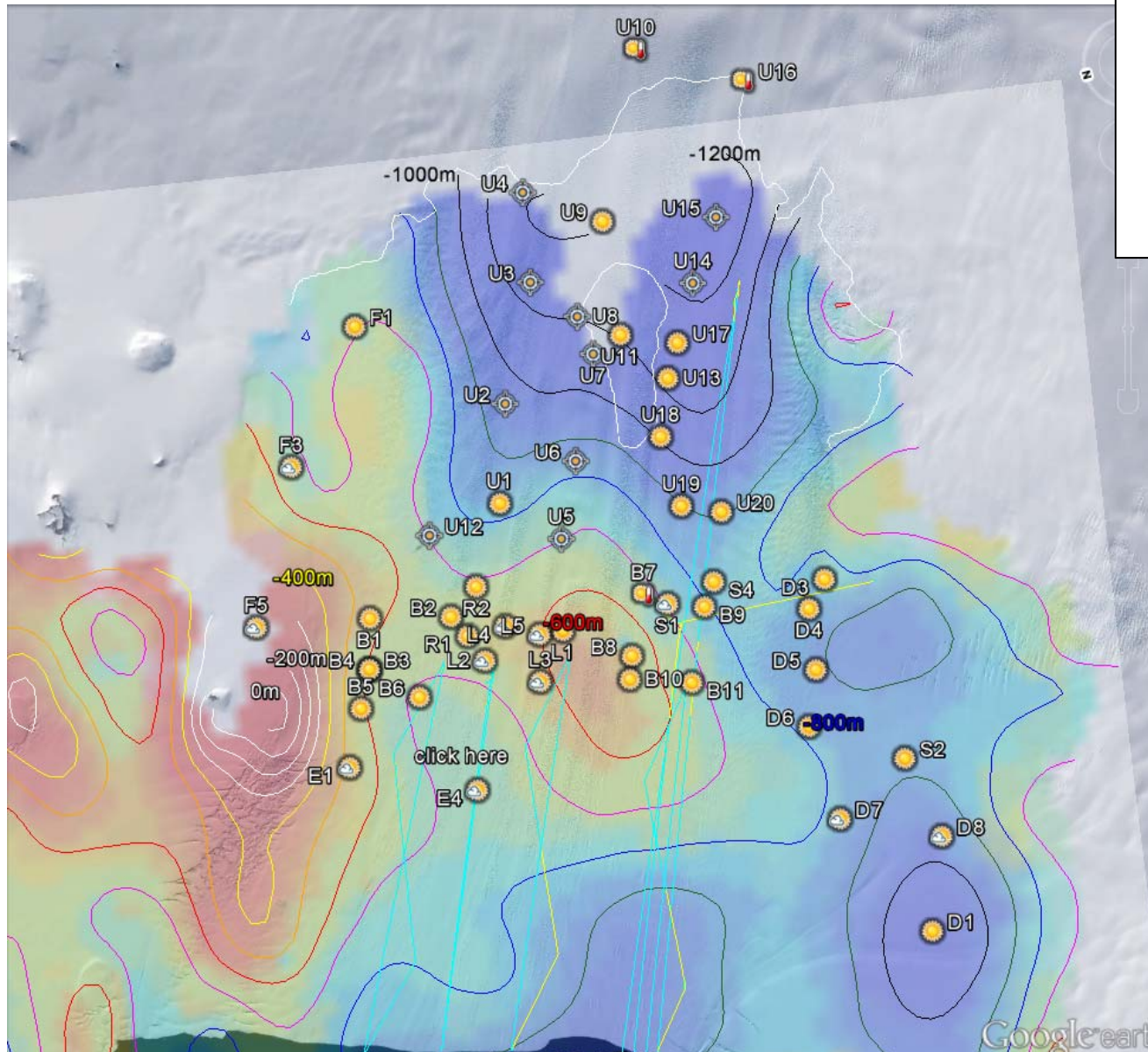
Thank you!

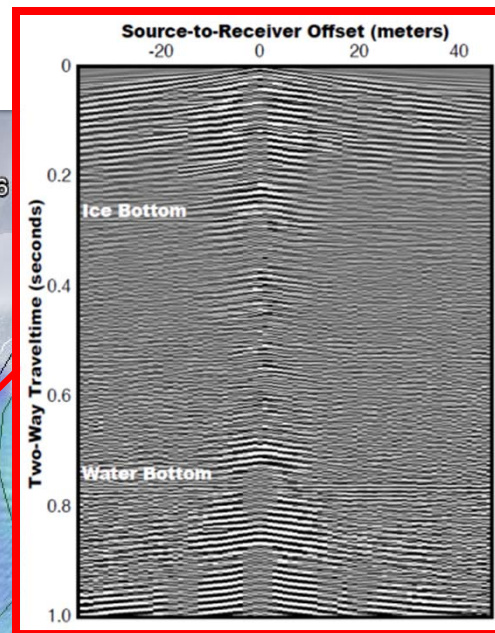
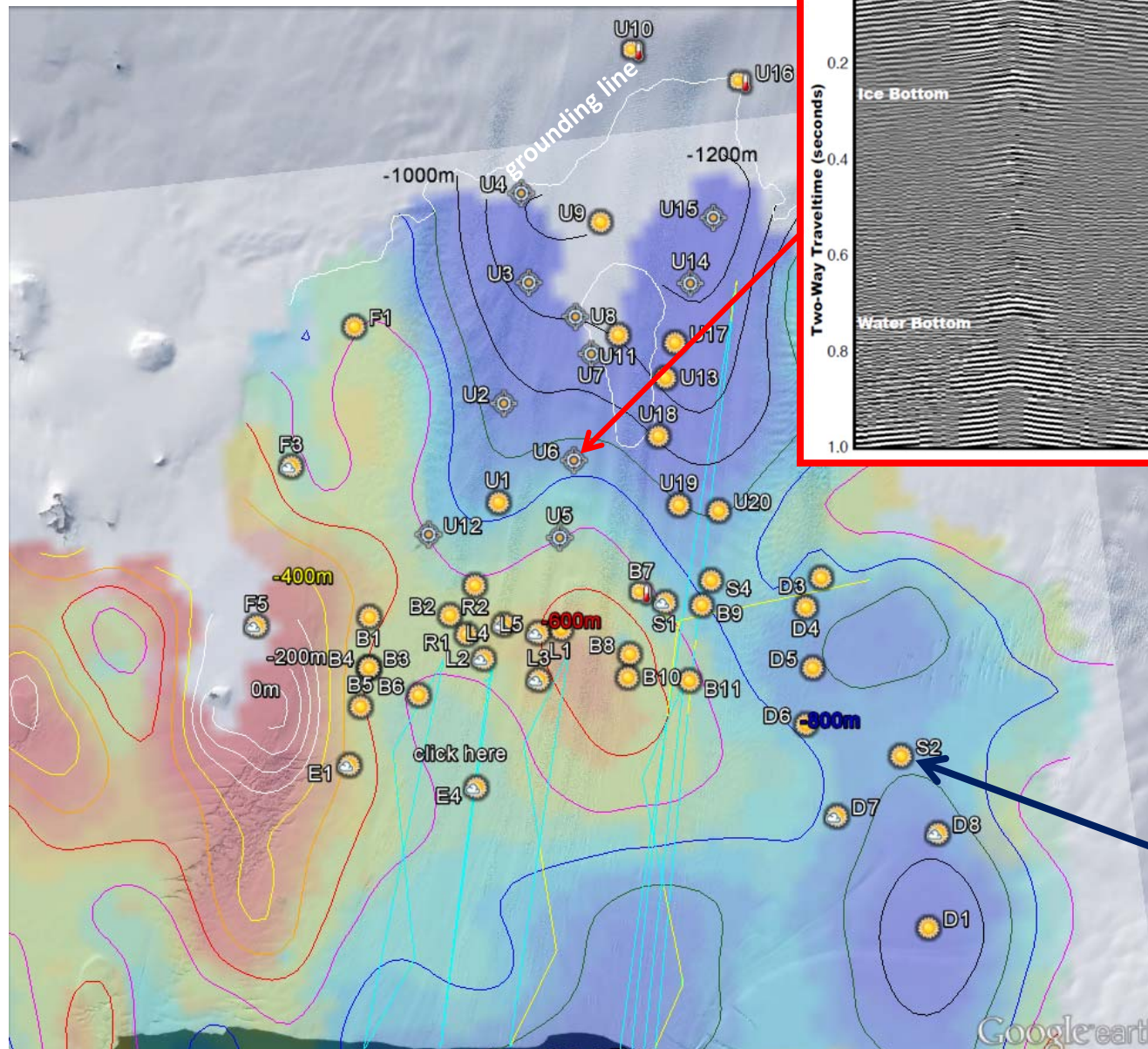


Questions?

Seismic sites

Active seismics used to measure water column thickness and seabed properties





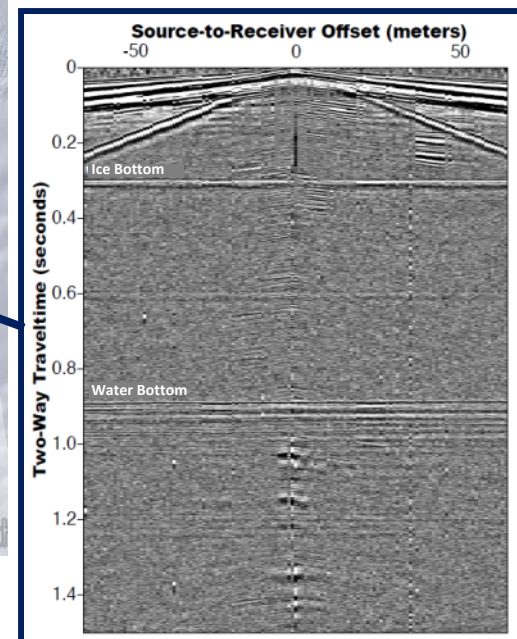
Seismic sites

$H_{ice} = 530\text{m}$

$H_{water} = 360\text{m}$

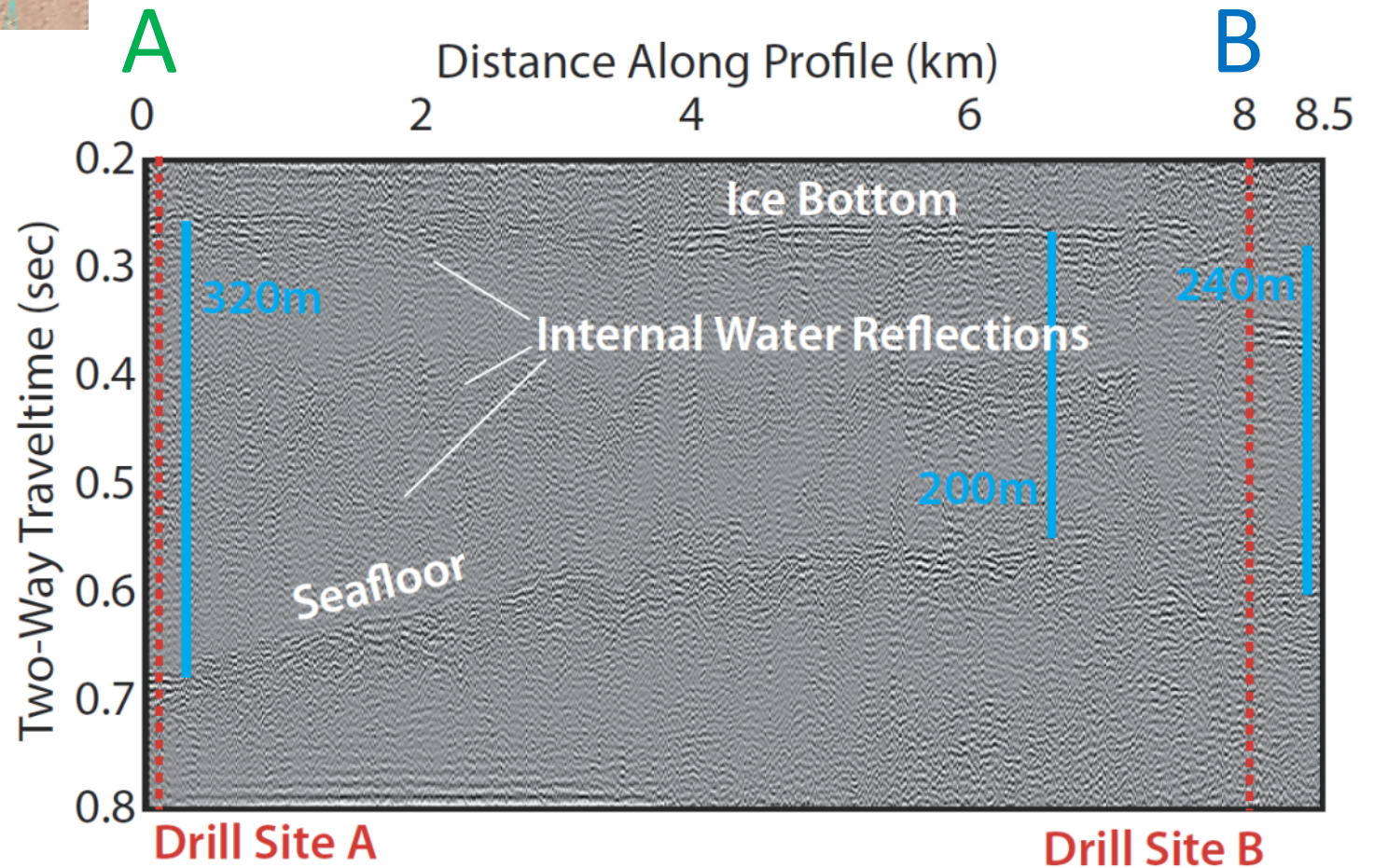
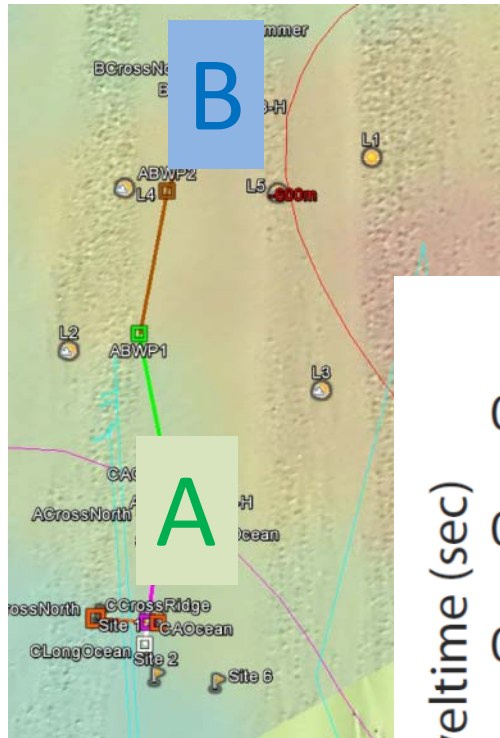
$H_{ice} = 570\text{m}$

$H_{water} = 450\text{m}$



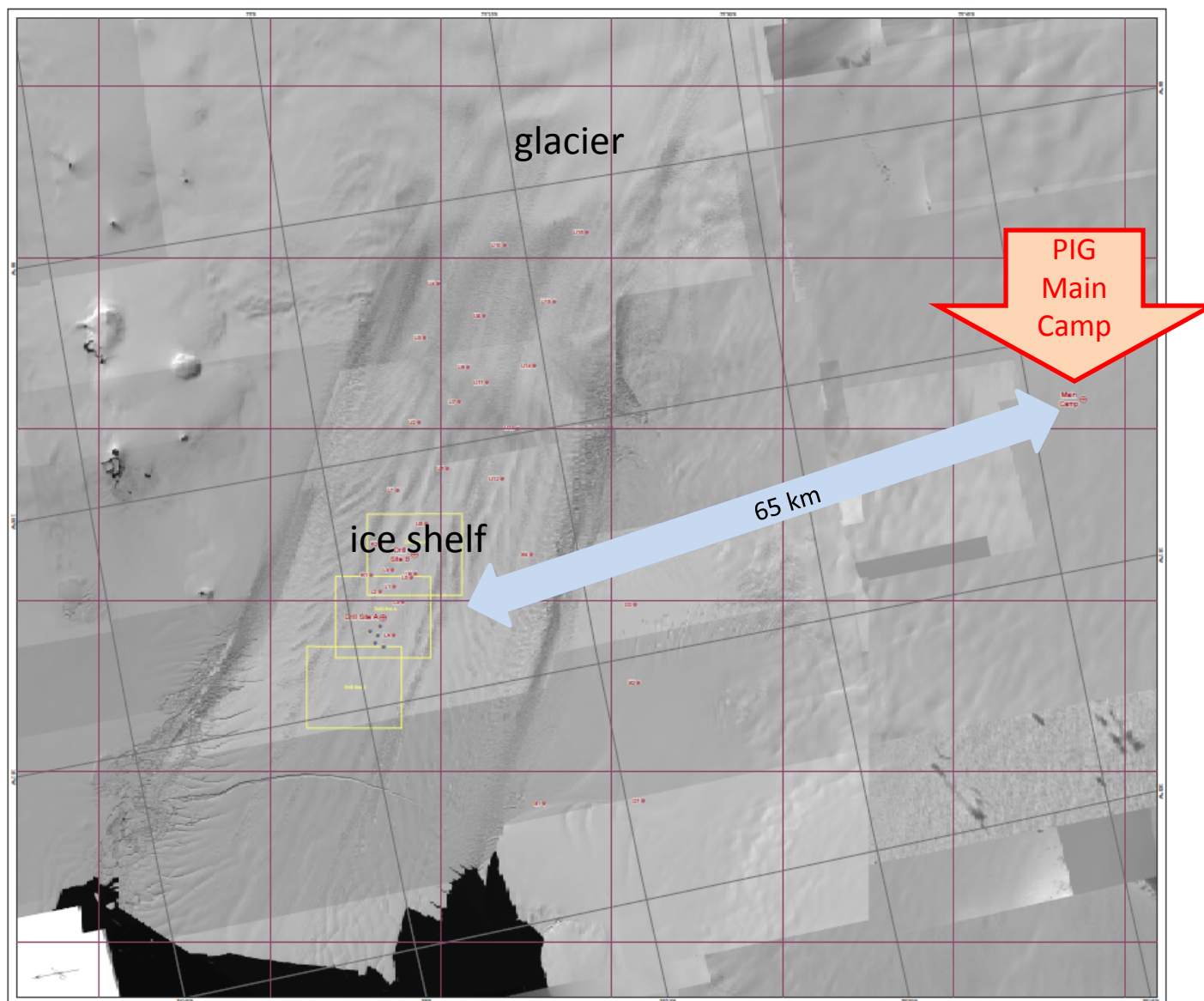
courtesy of Leo Peters

Seismic Profile: A to B



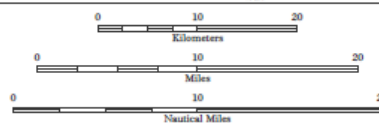
Profile traverses "Autosub Ridge"

courtesy of Leo Peters



WGS84 Antarctic Polar Stereographic Projection
Central Meridian: 0° (Grid North)
Standard Parallel: 75° South
Lines of Longitude Indicate True North

0.5m resolution imagery from multiple platforms
© DigitalGlobe Inc. 2011 - 2012 Antarctic Field Season
Imagery shifted to reflect epoch date: January 1, 2013

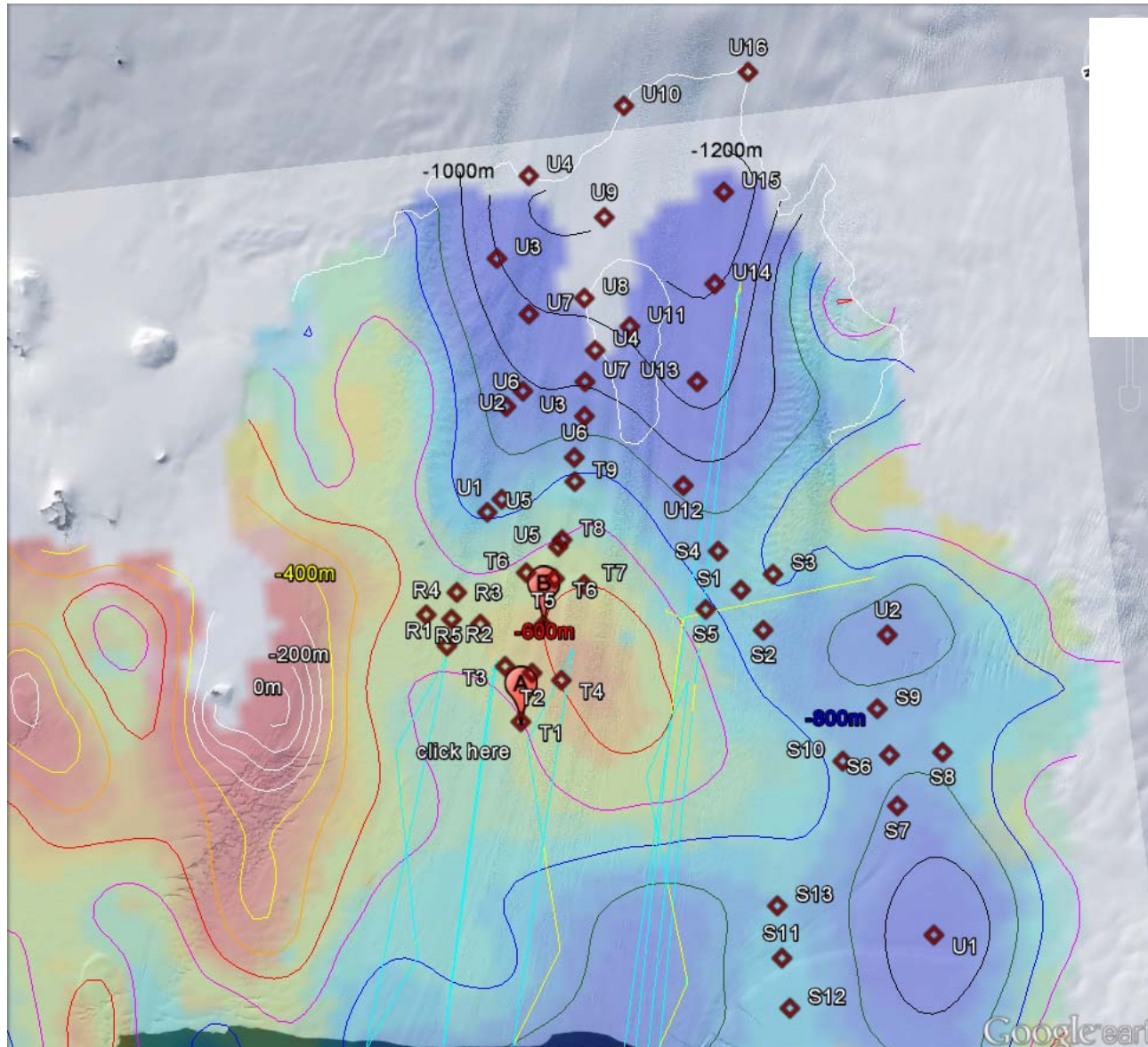


- Remote Site
- FWD 2011 Location/Station
- Fixed Wing Landing Site
- 20 km Grid

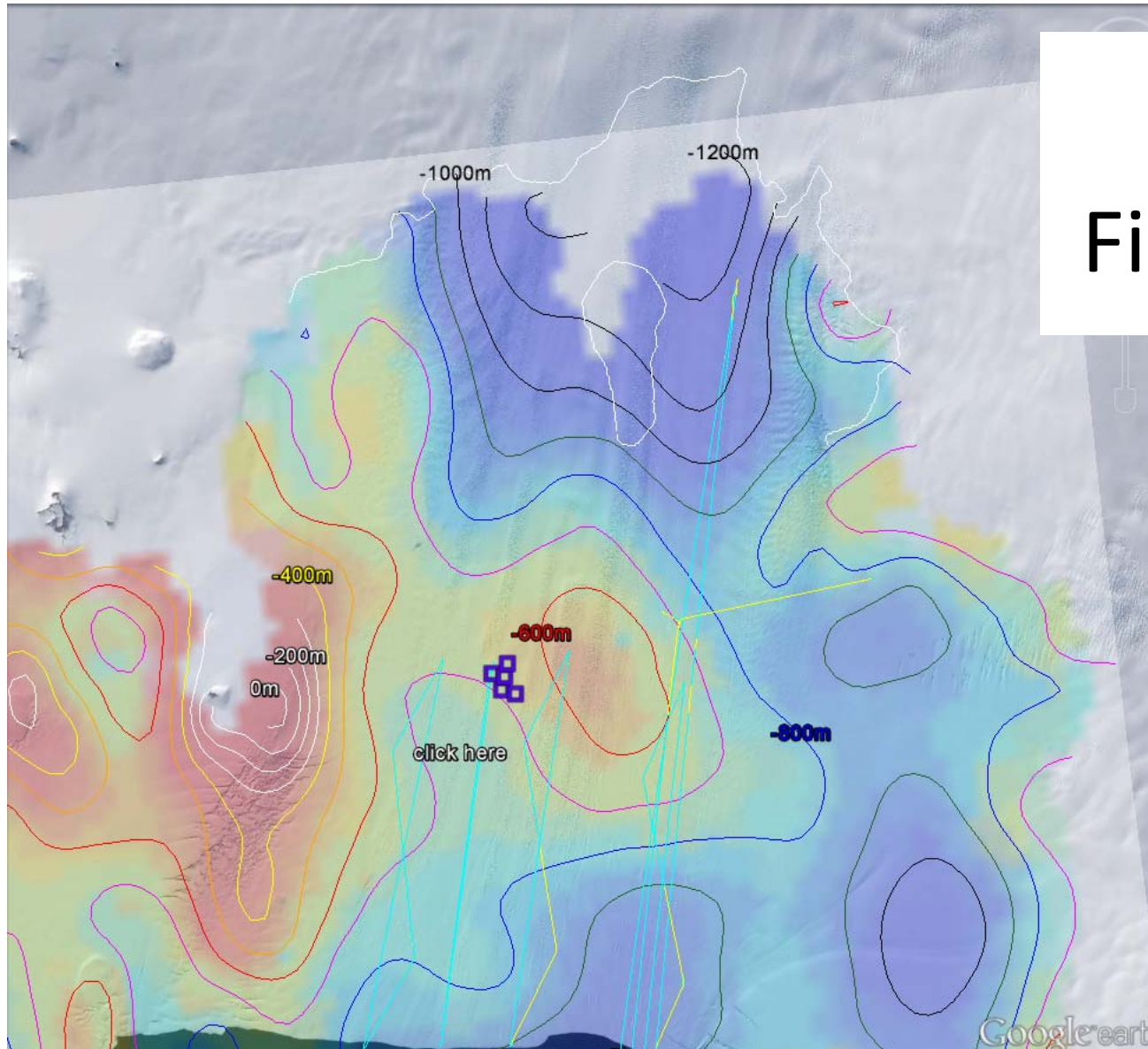
Cartography by Cole Kallender
Image Processing by Clark Probst
Polar Geospatial Center
version 1.0 - 10/04/2012



2011-12 Field Plan



2011-12 Field Stations



Meter-scale satellite imagery has been extraordinary

