

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

Robert Bindschadler, 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 Coraud, Christina Stam, Mitch Bushuk



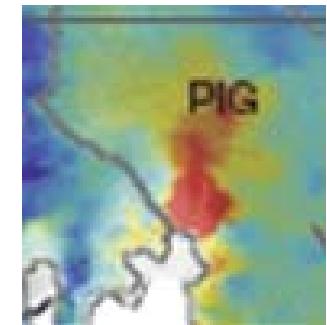
**British
Antarctic Survey**
NATIONAL ENVIRONMENT RESEARCH COUNCIL



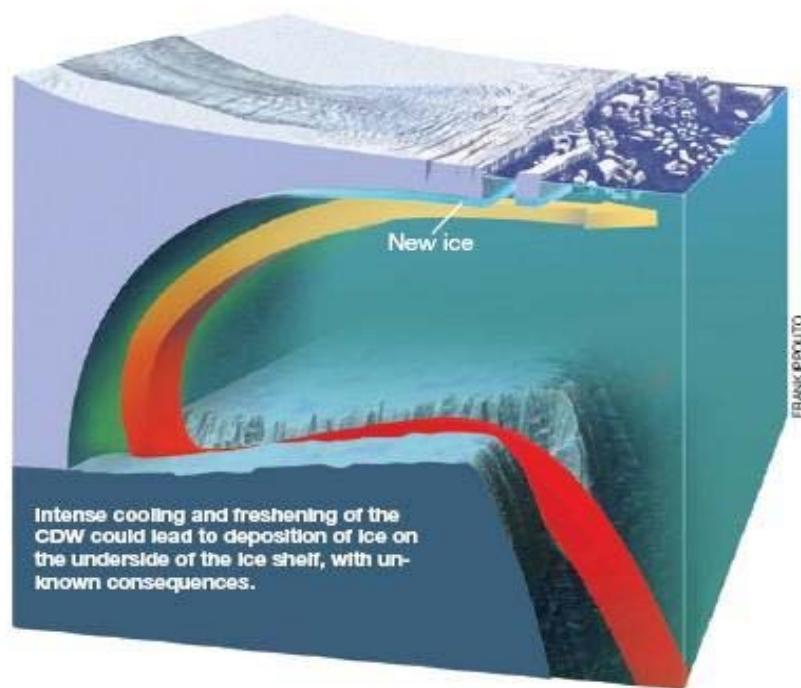
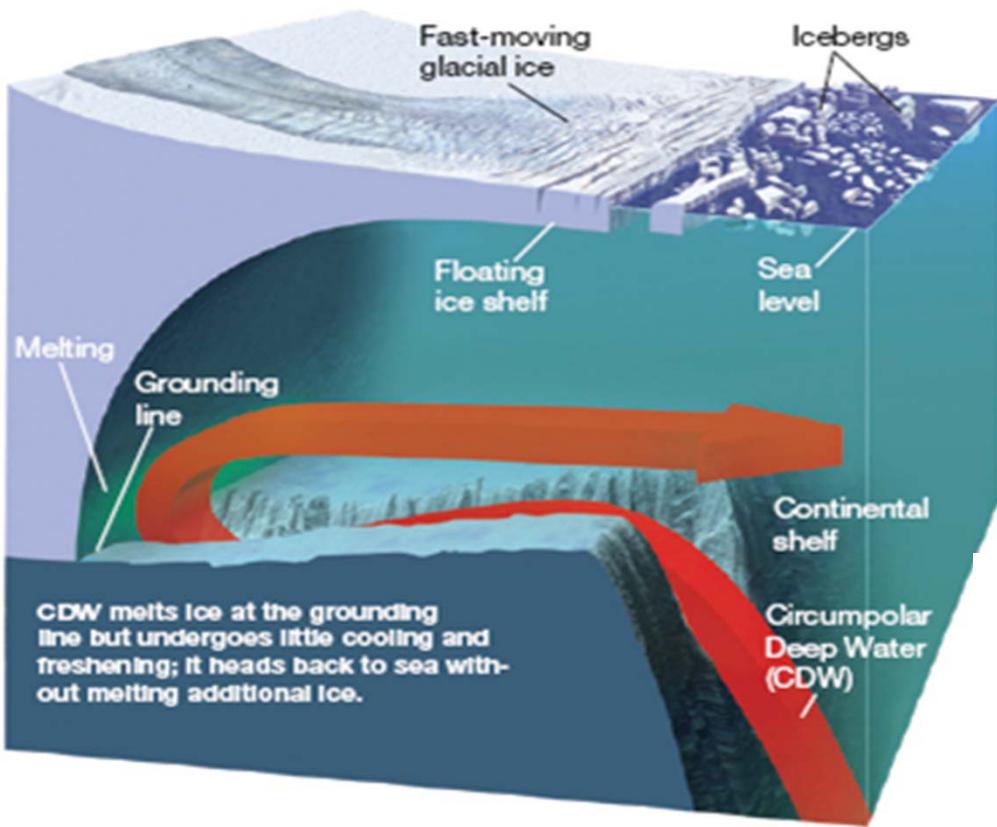
Community “call” for this work came in this room 7 years ago

Warm ocean is eroding West Antarctic Ice Sheet

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



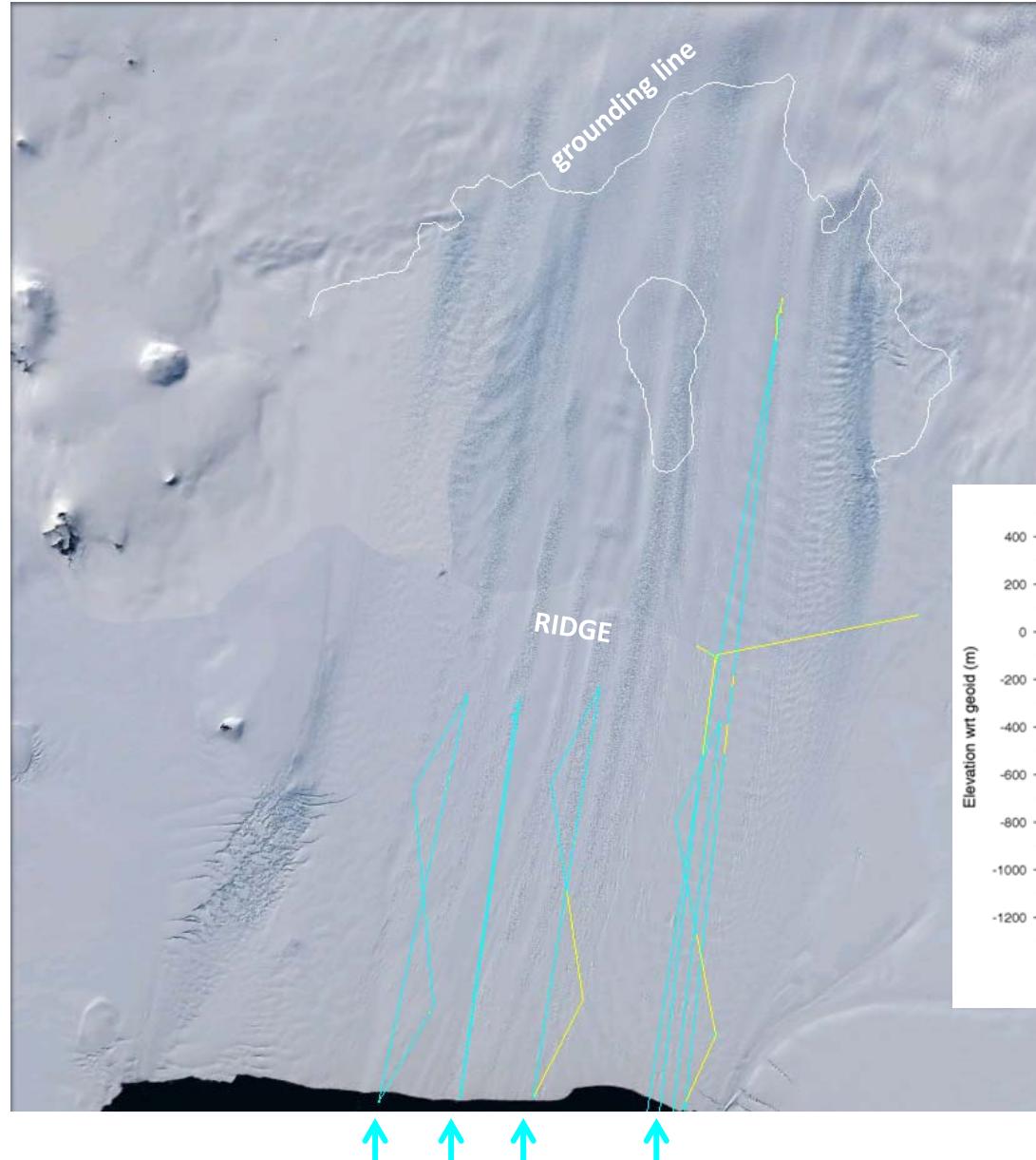
“If we don’t do this (PIG) research will we be better able to quantify West Antarctica’s contribution to sea level in 5 years?”



Massive Logistic Support

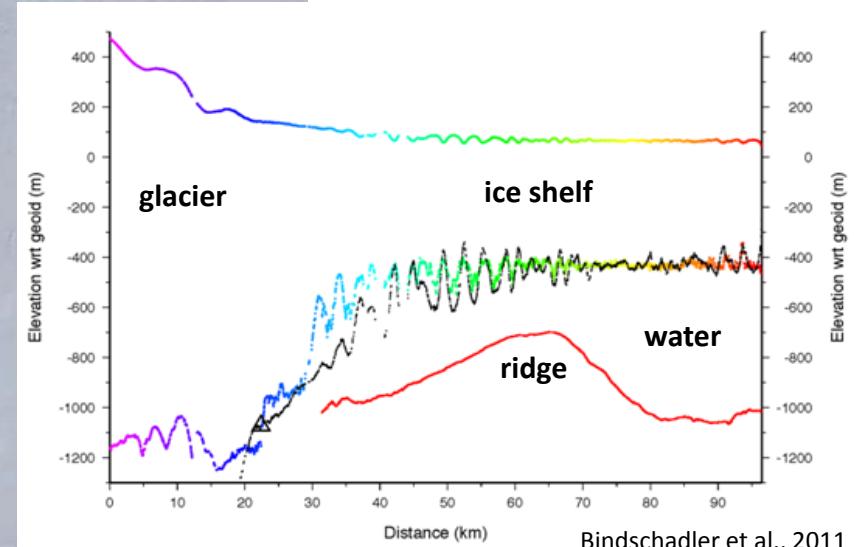


Thanks to: NY Air National Guard, Kenn Borek Air,
British Antarctic Survey, PHI, & Raytheon Polar Services



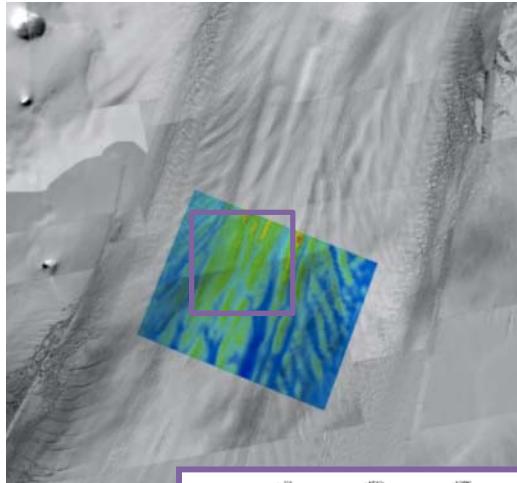
Autosub
discovered a
submarine ridge

(Jenkins et al., 2010)



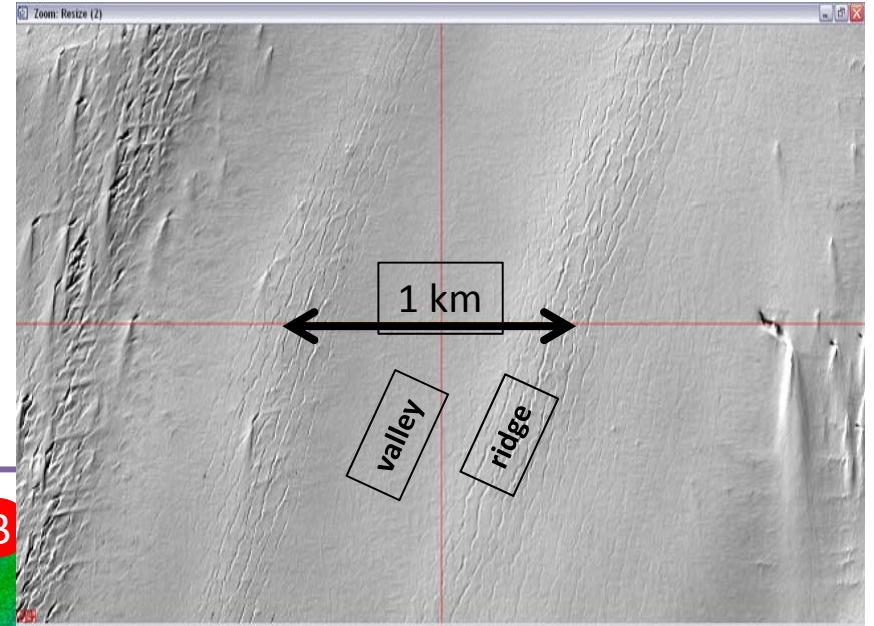
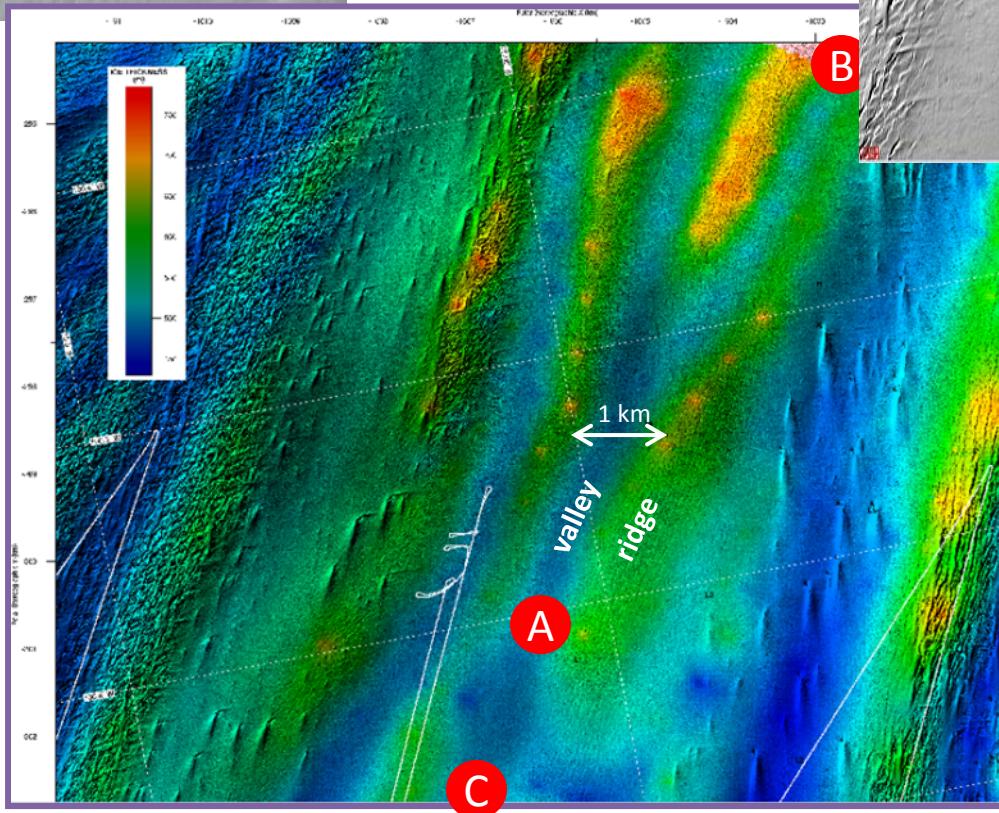
2009 Autosub
tracks

2011 BAS Airborne Survey



Vaughan and others, 2012

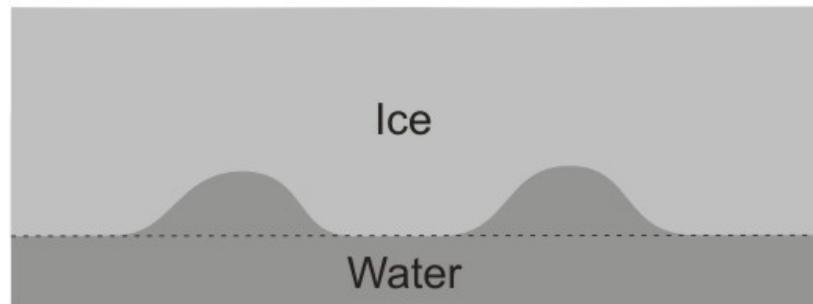
Documented a
dominant
valley/ridge
morphology



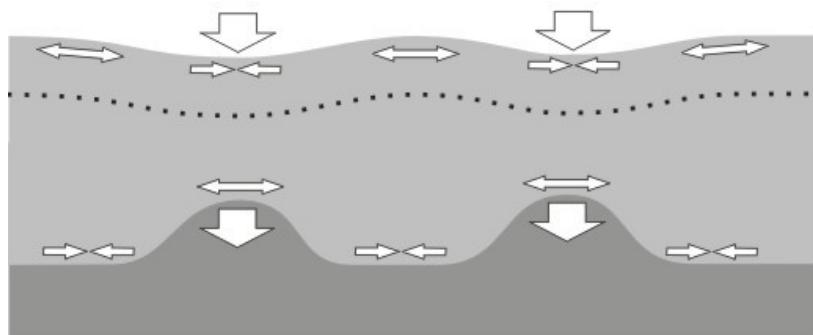
Imagery from Polar Geospatial Center

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

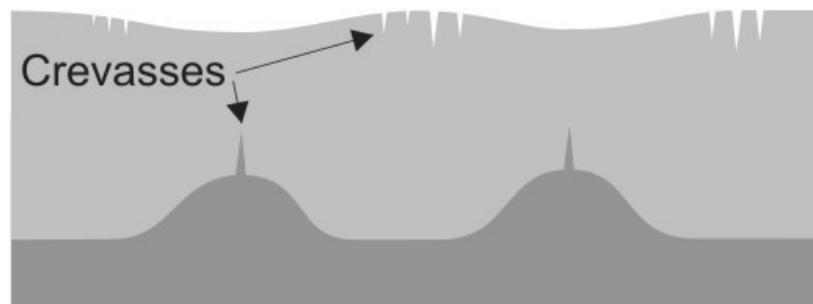
a. Undeformed ice shelf



b. Flexing response

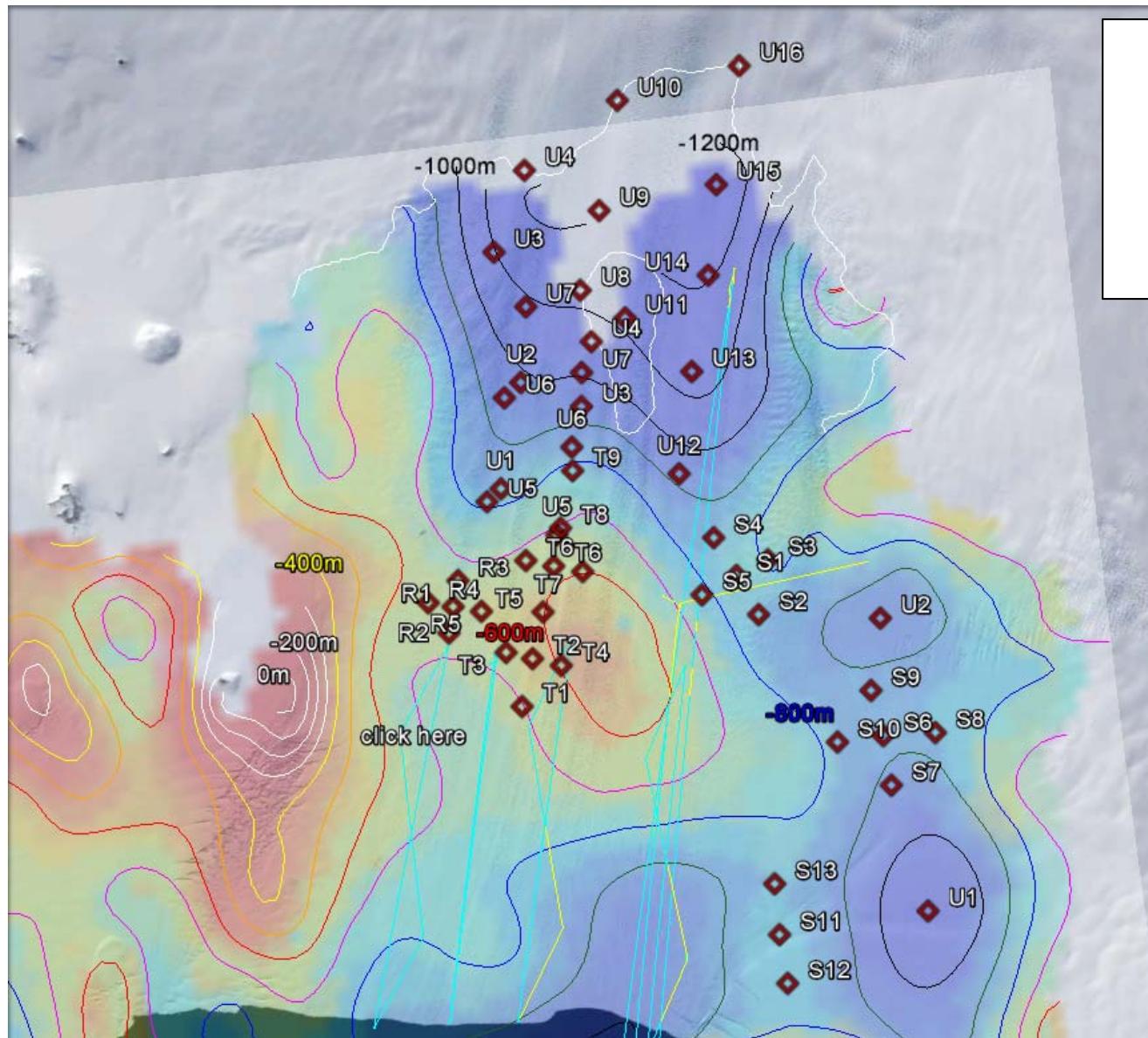


c. Zones of possible failure

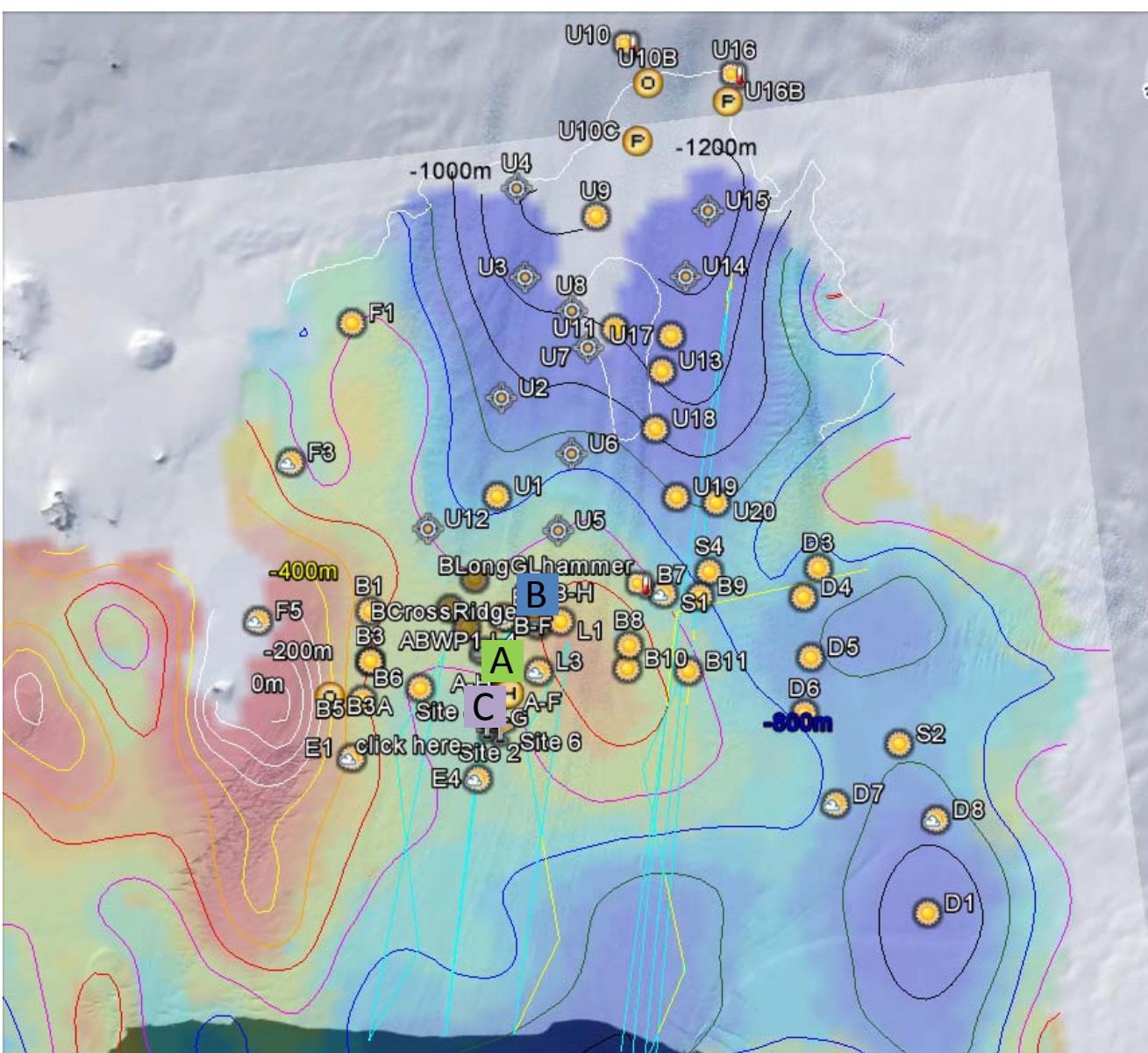


(from Vaughan et al., 2012)

2012-13 Field Plan



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

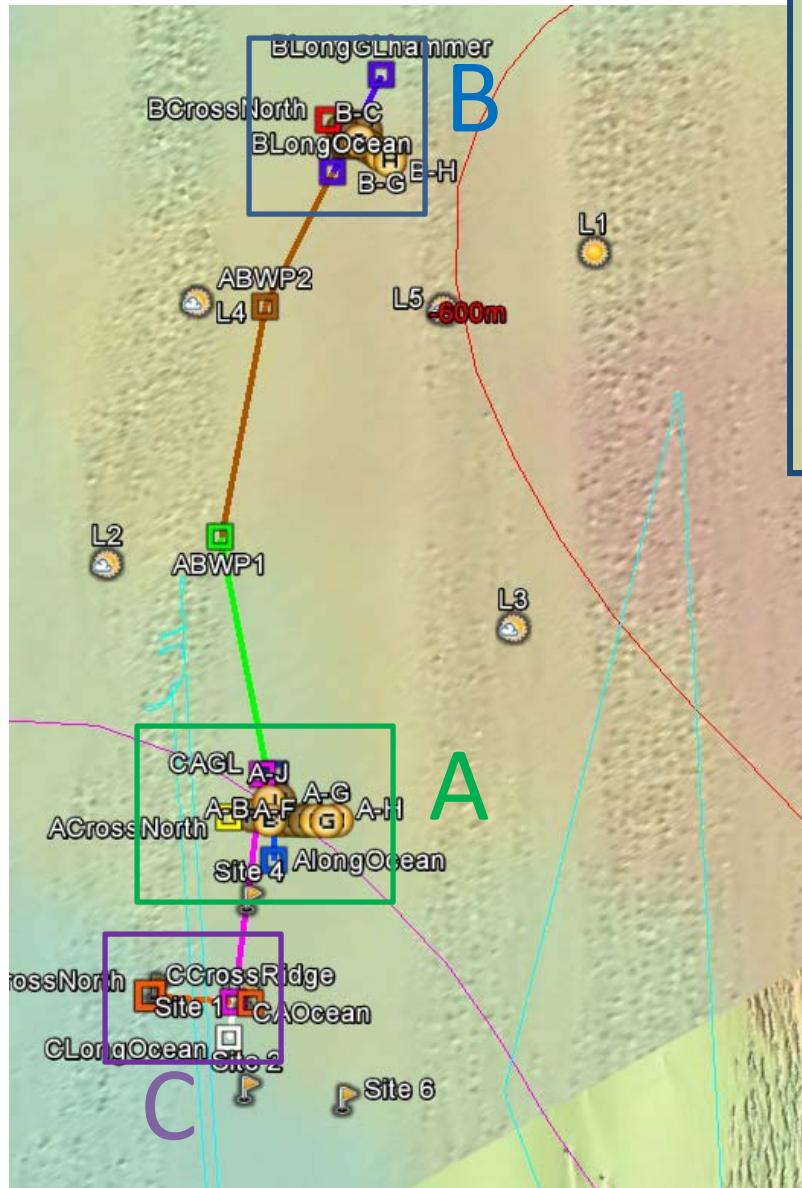


2012-13 Field Sites

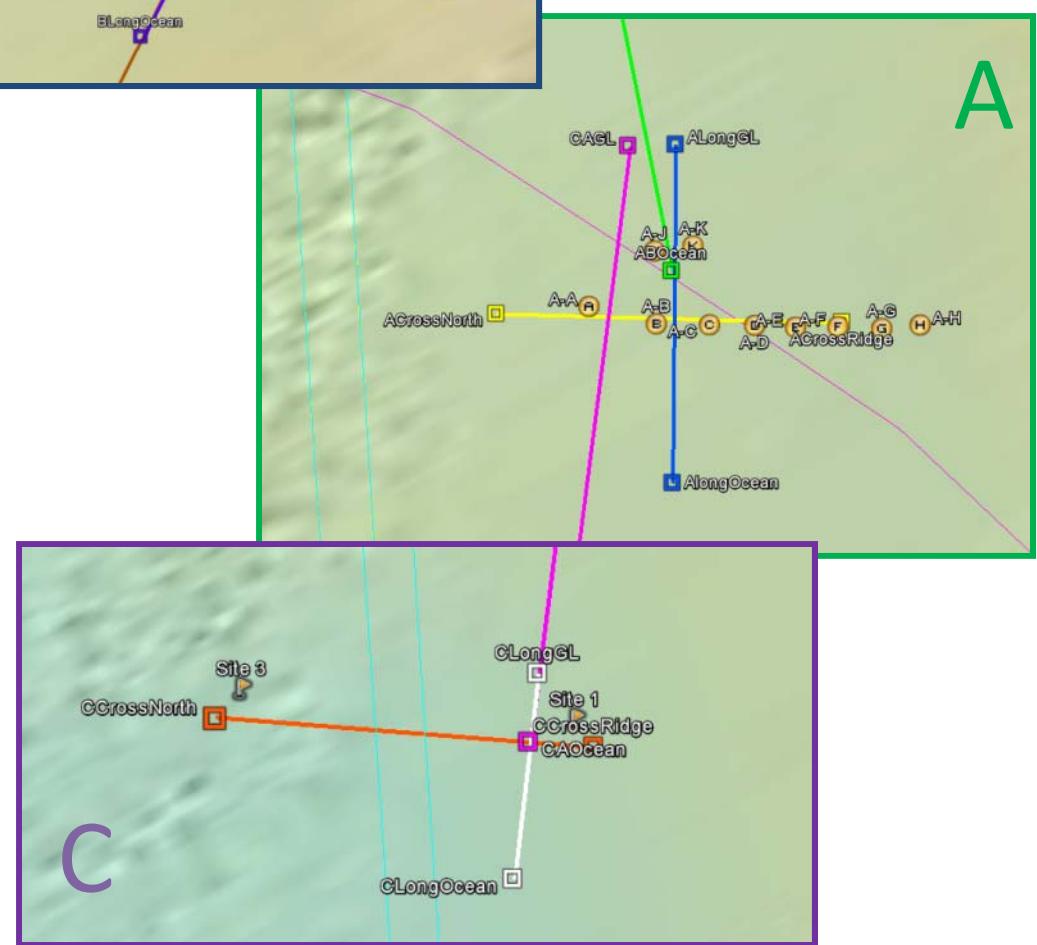
- Hammer
- Explosives + Hammer
- Explosives + Hammer + pRES
- Explosives + Hammer + pRES (repeated)
- pRES (repeated)
- pRES (repeated) + Winterover GPS and Passive Seismic
- Drill Sites

Drill Sites

Hot-water drilled holes to permit deployment of oceanographic sensors



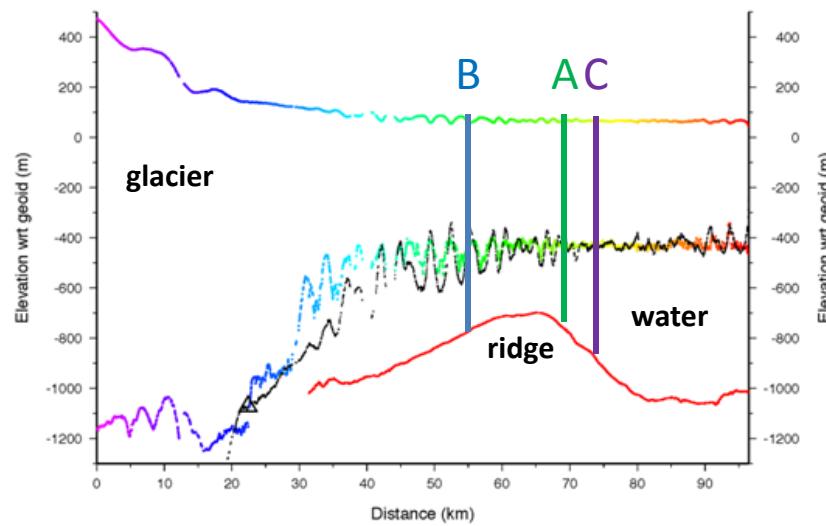
ABC valley is 460 m thick, 10 m deep and overlies an inverted channel 80 m deep



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

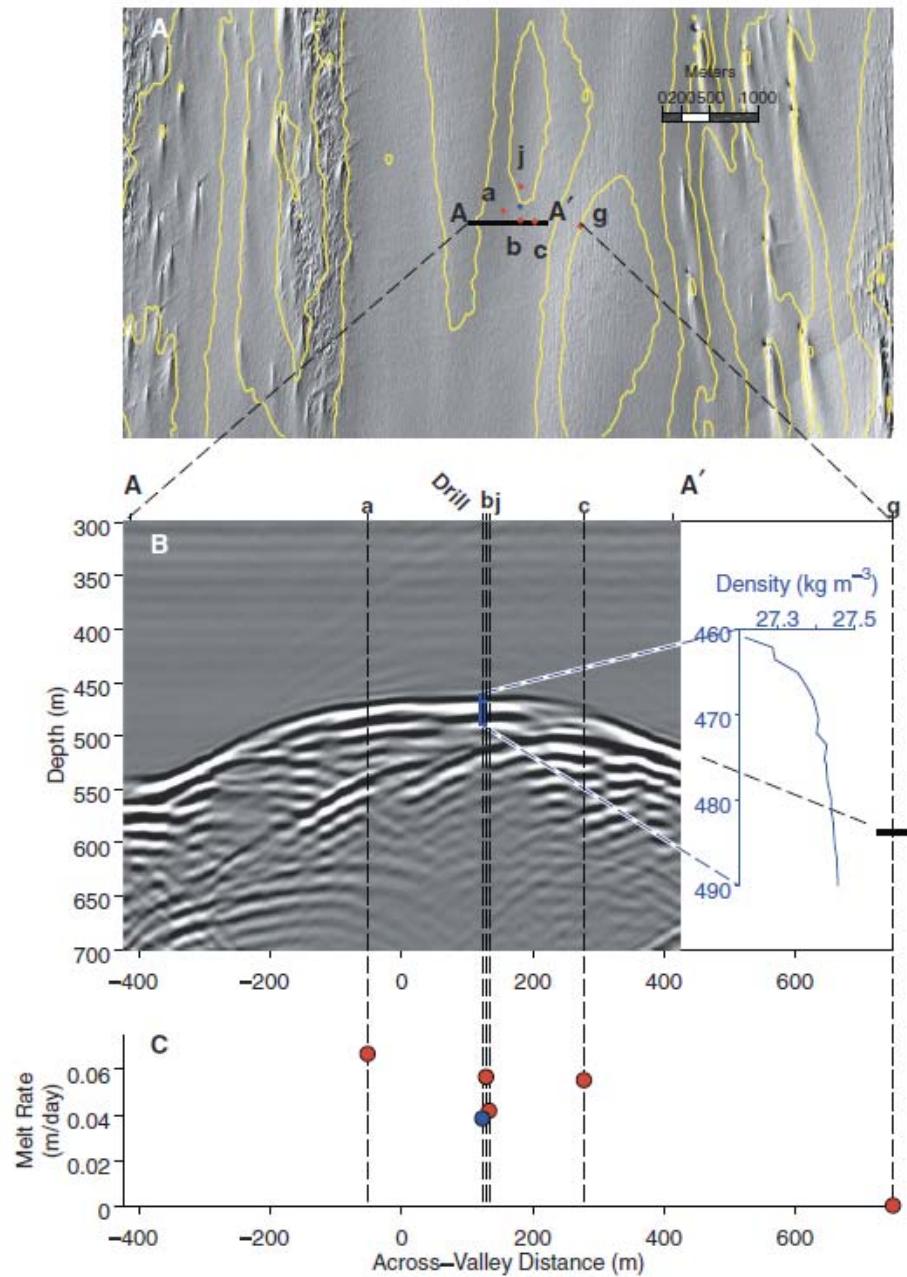


Just published!

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. Bindschadler,⁵ D. M. Holland,⁶ S. Anandakrishnan⁴

13 SEPTEMBER 2013 VOL 341 SCIENCE www.sciencemag.org



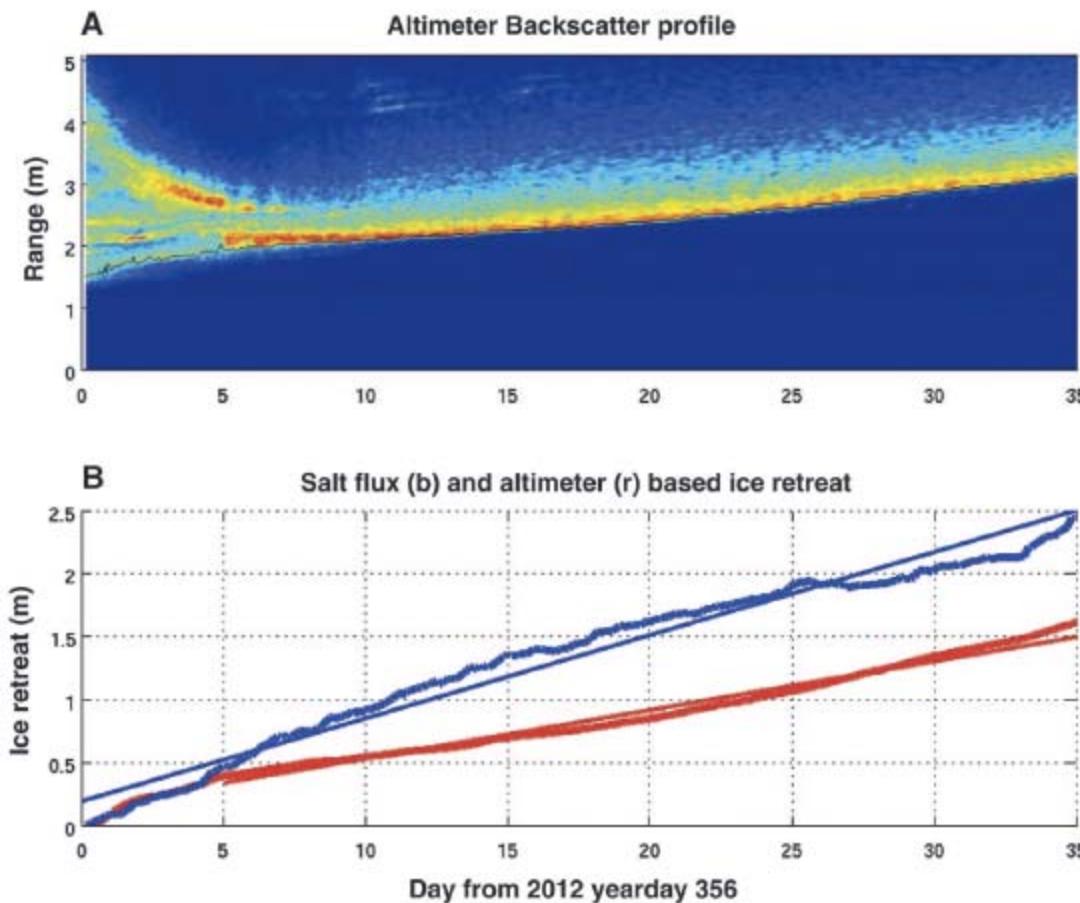
Measurements in valley and on ridge*

*20 km downstream of grounding zone

Boundary Layer well
characterized

Strong melt in channels;
no melt under ridges

Melt Rates In Channel



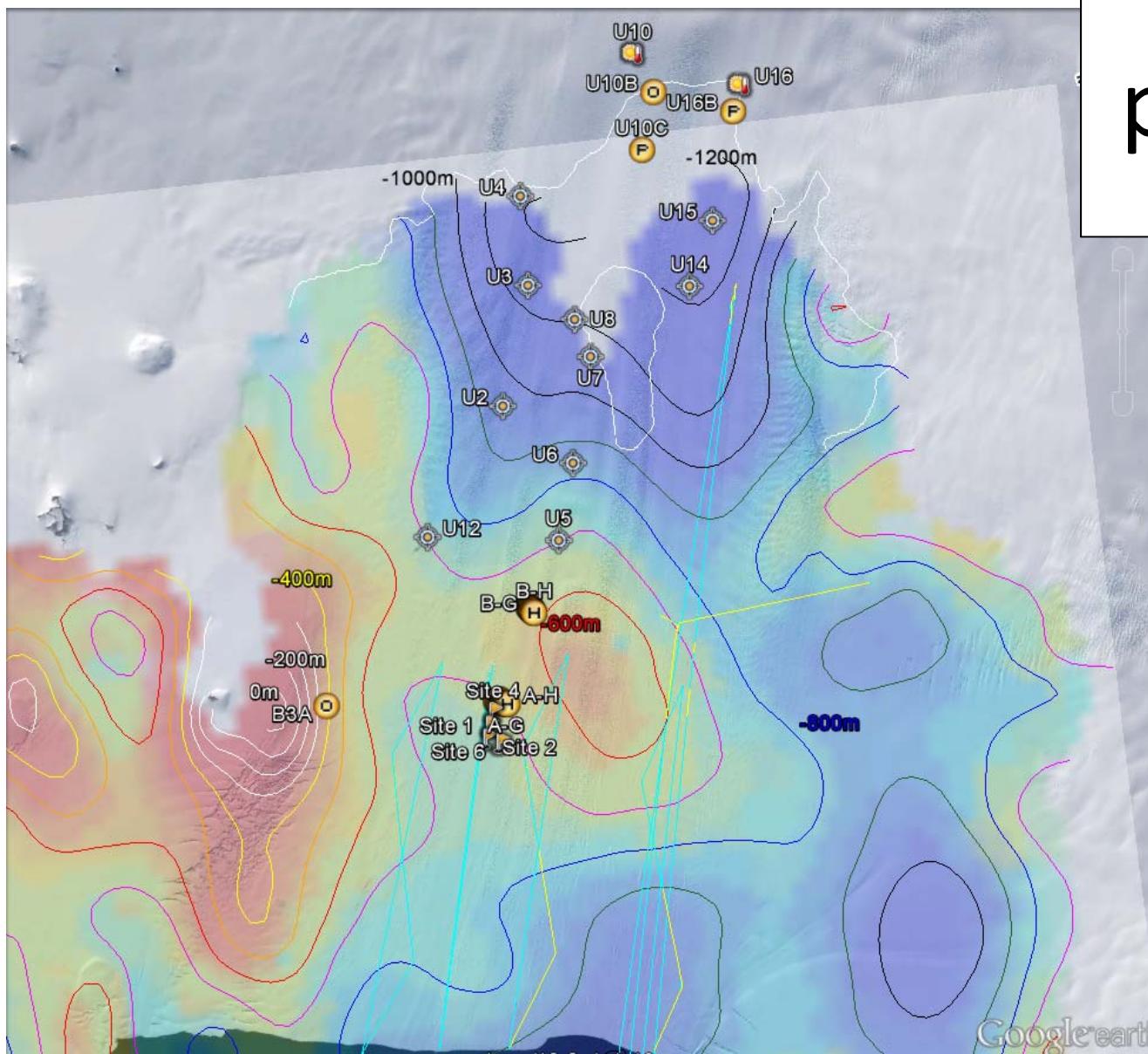
from Altimeter:
3.9 cm/day

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



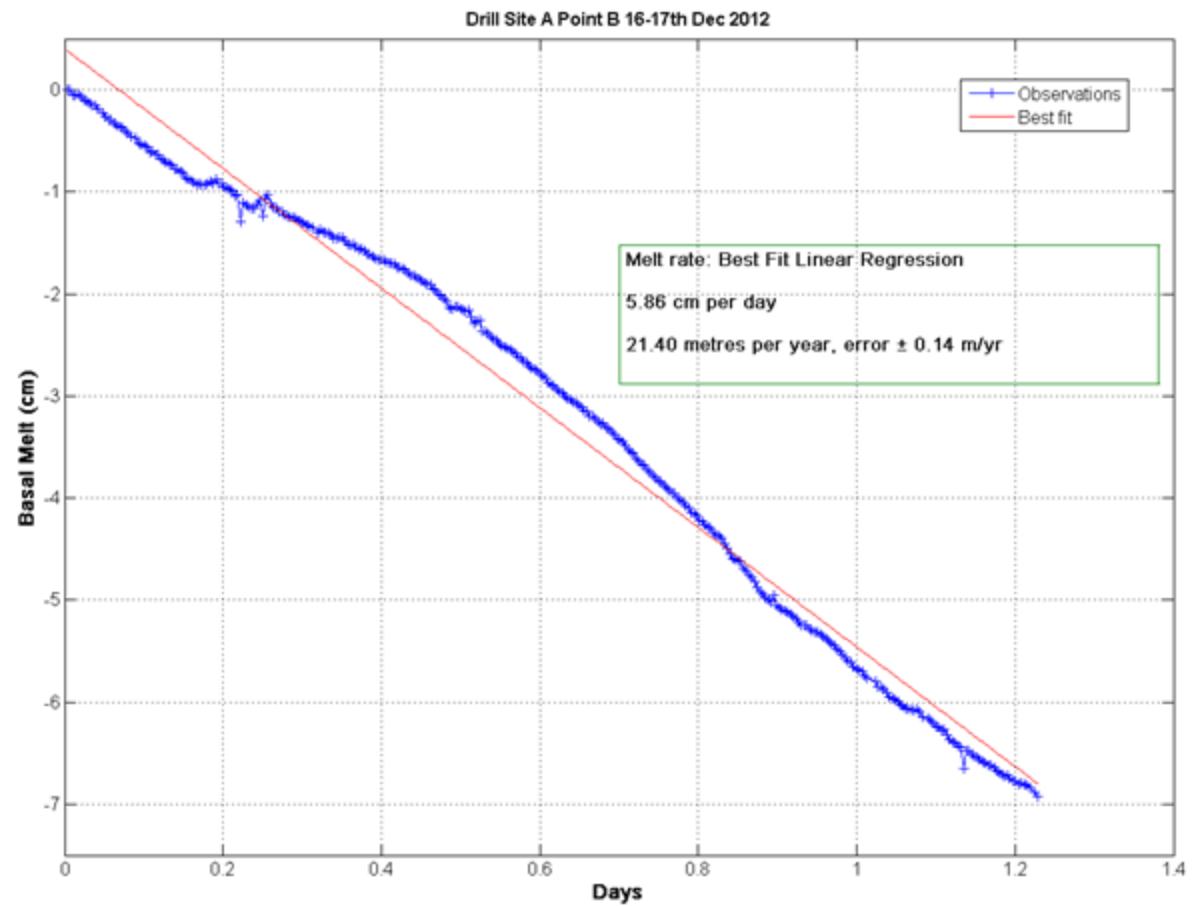
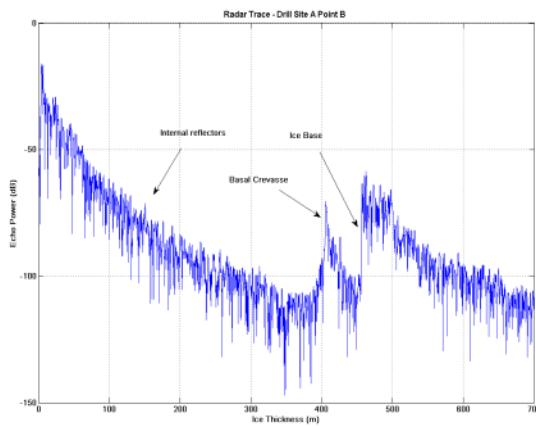
Phase-sensitive
radio echo sounder
used to measure
basal melt rate

Revisit required

First pRES Results (Site A)



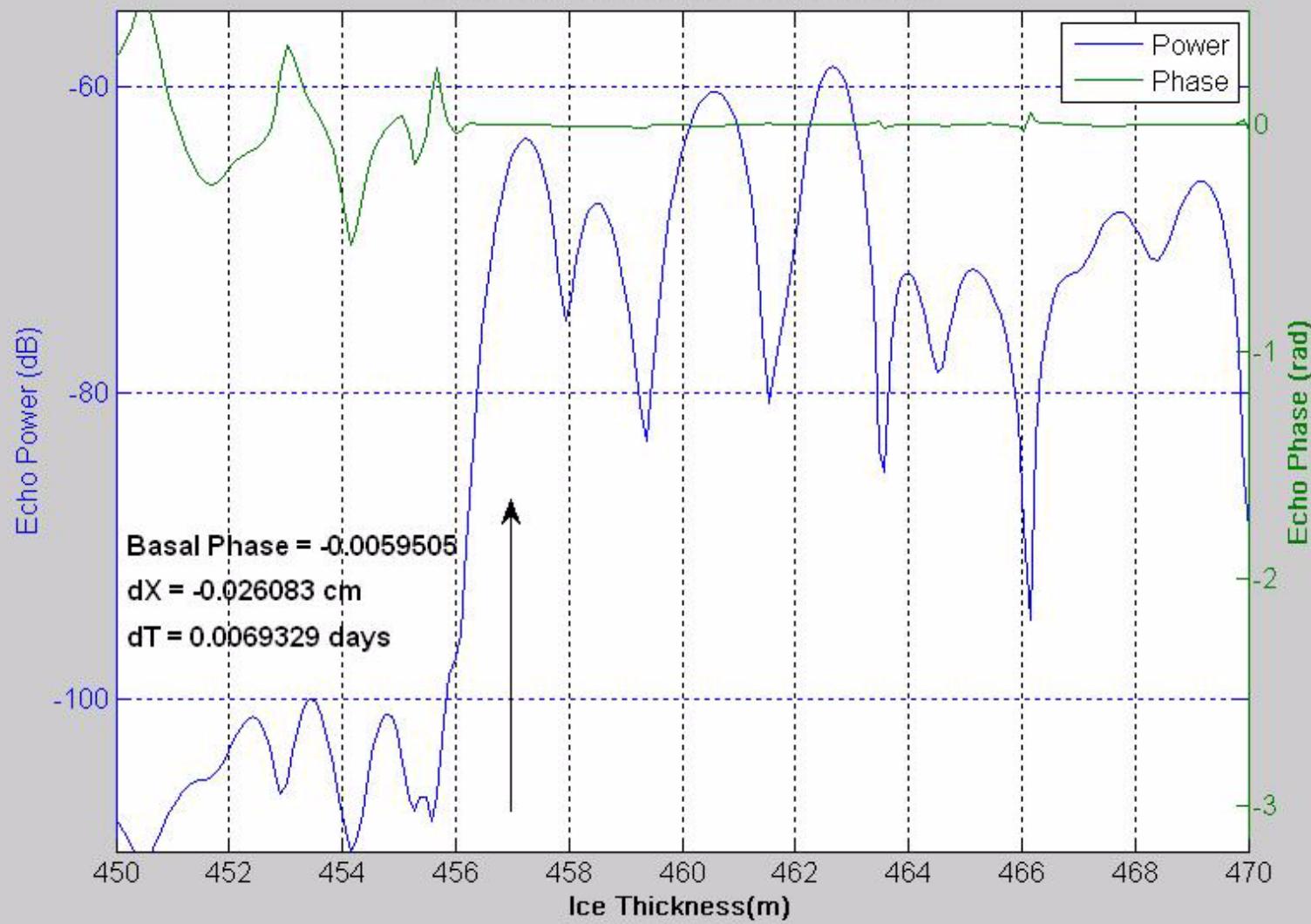
347 measurements over 29 hours



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courtesy of H. Corr and M. Shortt

Drill site A Point B 15-Dec-2012 23:44:08



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



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Summary

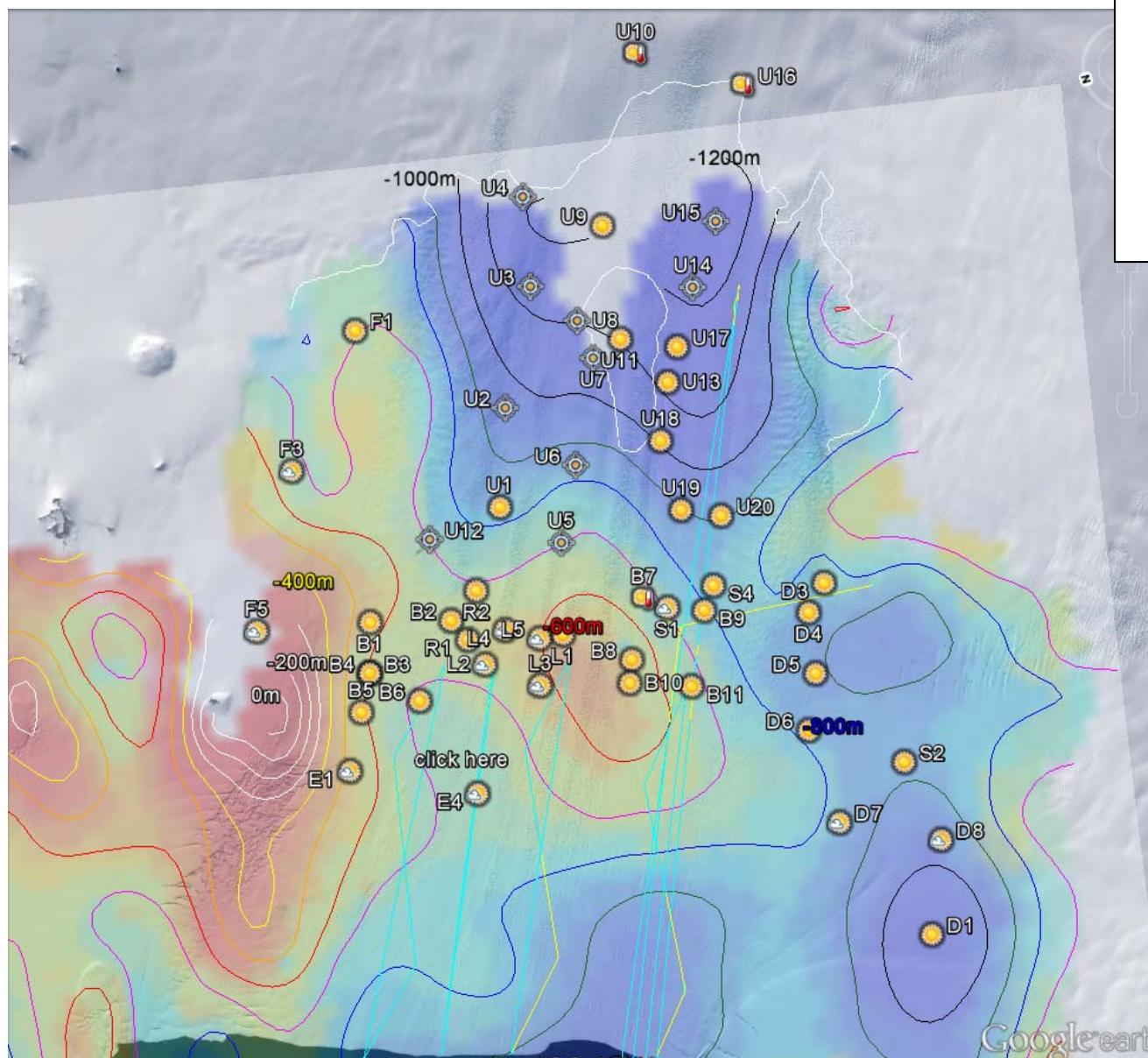
- Field work on PIG ice shelf is possible, even pleasant
- Sustained, high-quality measurements of ice motion and ocean characteristics are now being collected
 - (not mentioned) passive seismic and weather data also being collected
- “High” melt rates in channels quantified
 - Results from 3 independent 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!



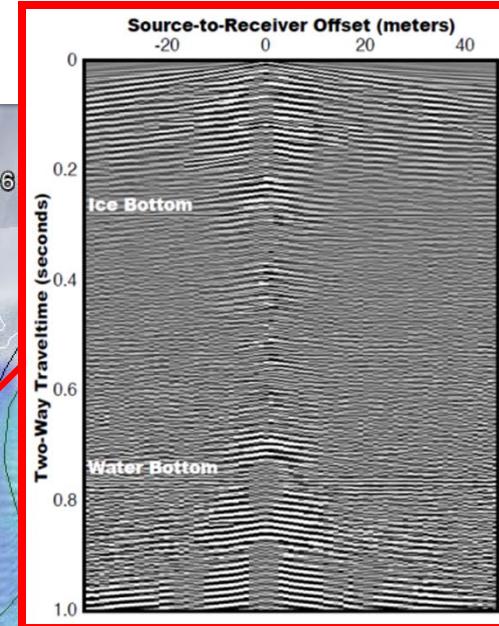
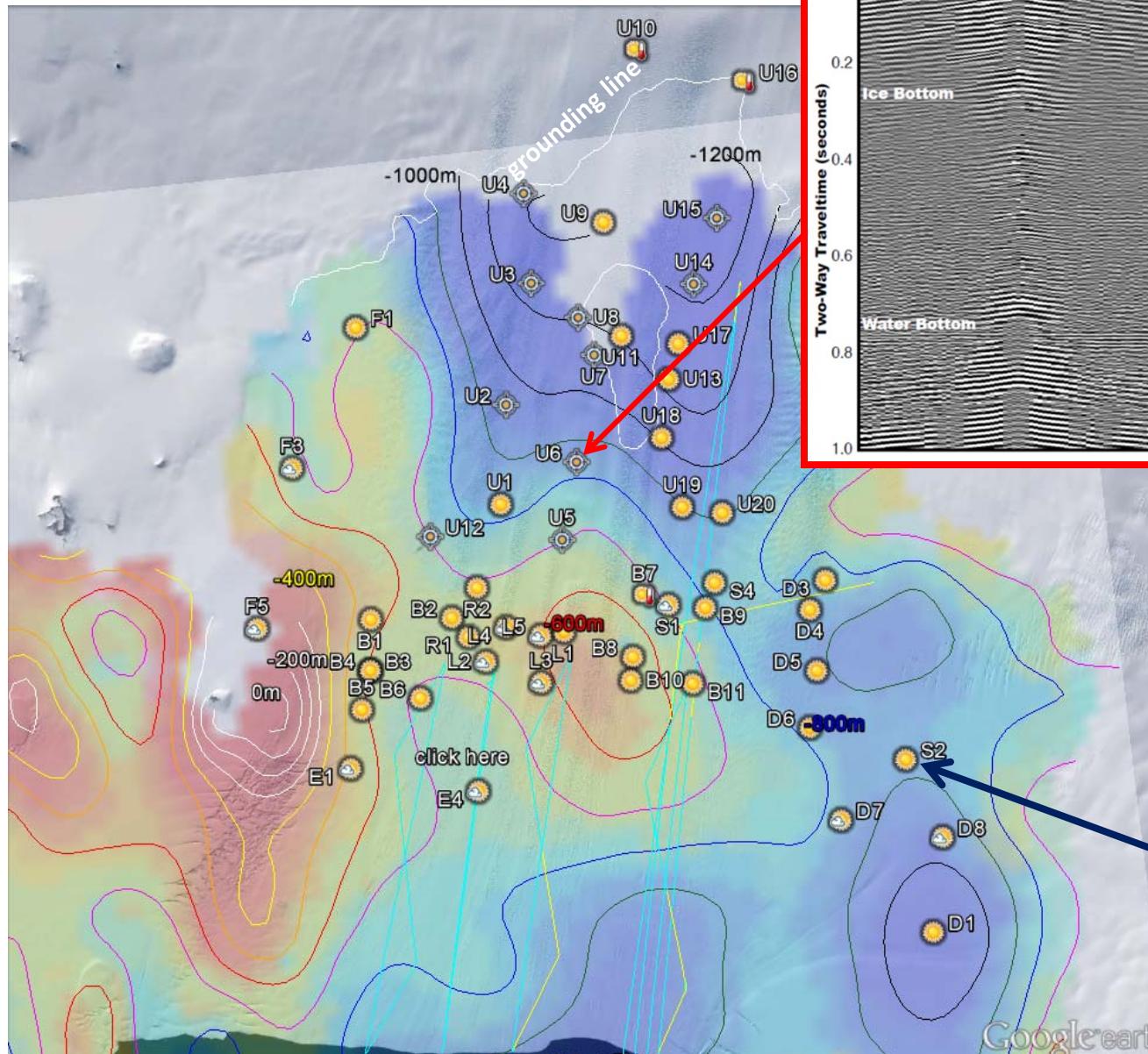
Questions?

Seismic sites



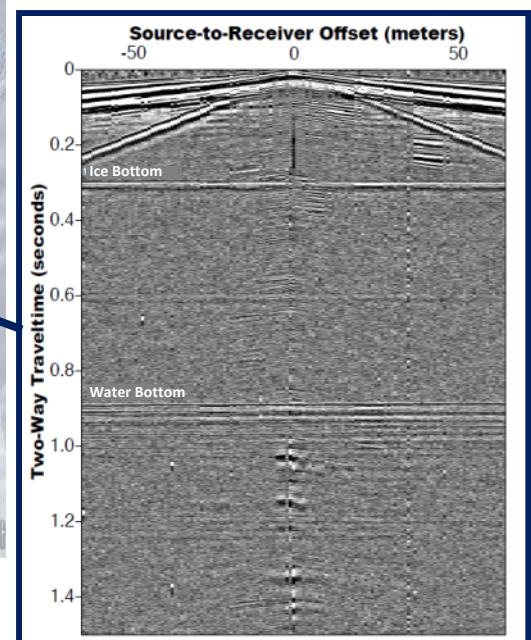
Active seismics
used to measure
water column
thickness and
seabed properties

Seismic sites

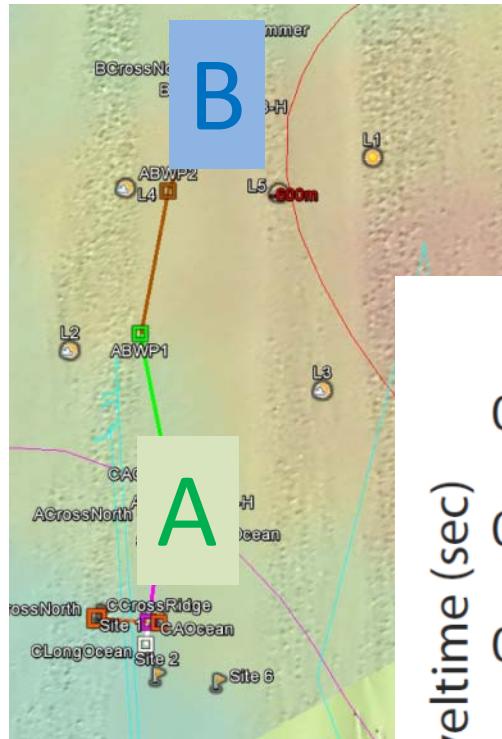


$$H_{\text{ice}} = 530 \text{m}$$
$$H_{\text{water}} = 360 \text{m}$$

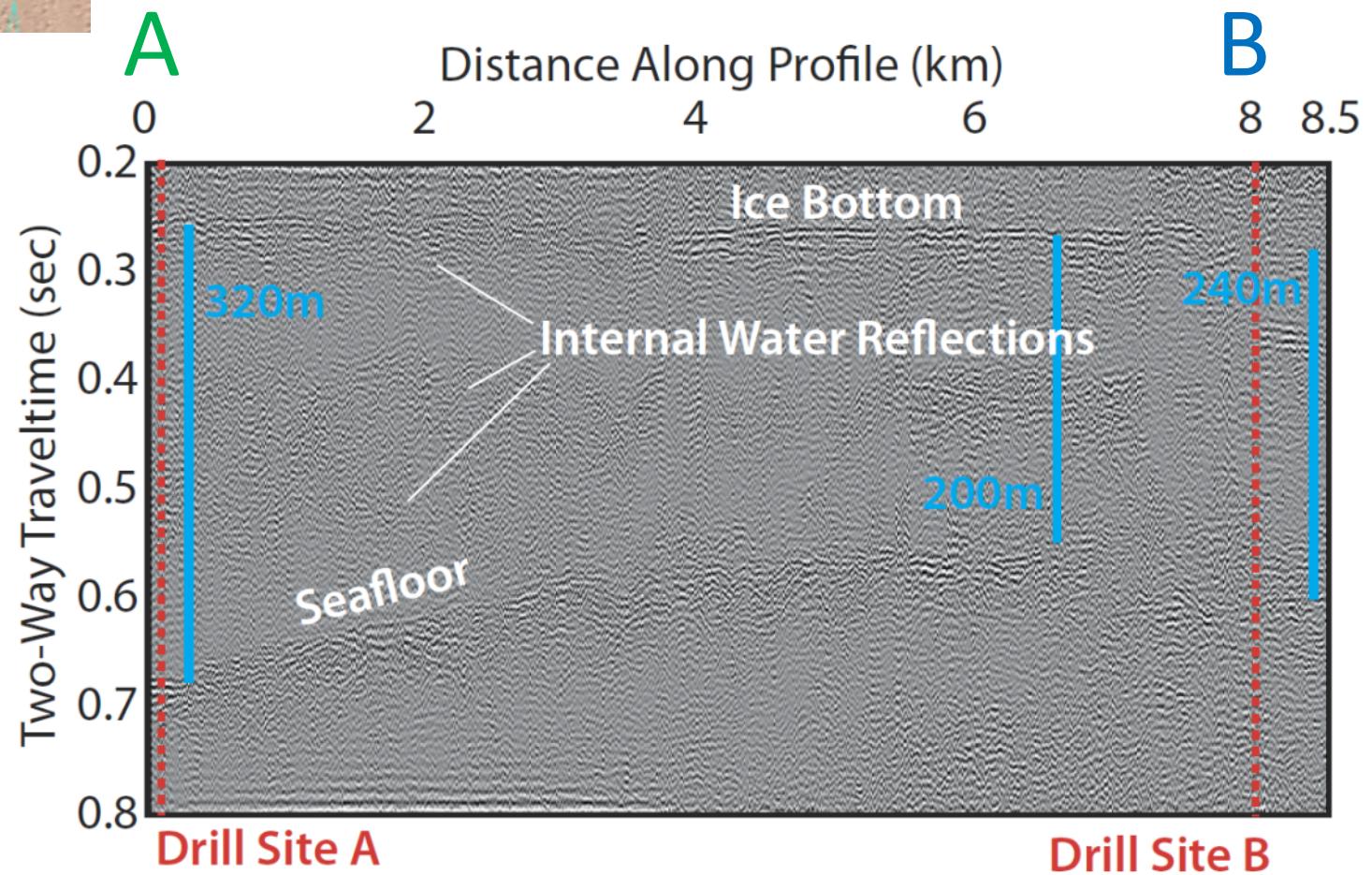
$$H_{\text{ice}} = 570 \text{m}$$
$$H_{\text{water}} = 450 \text{m}$$



courtesy of Leo Peters



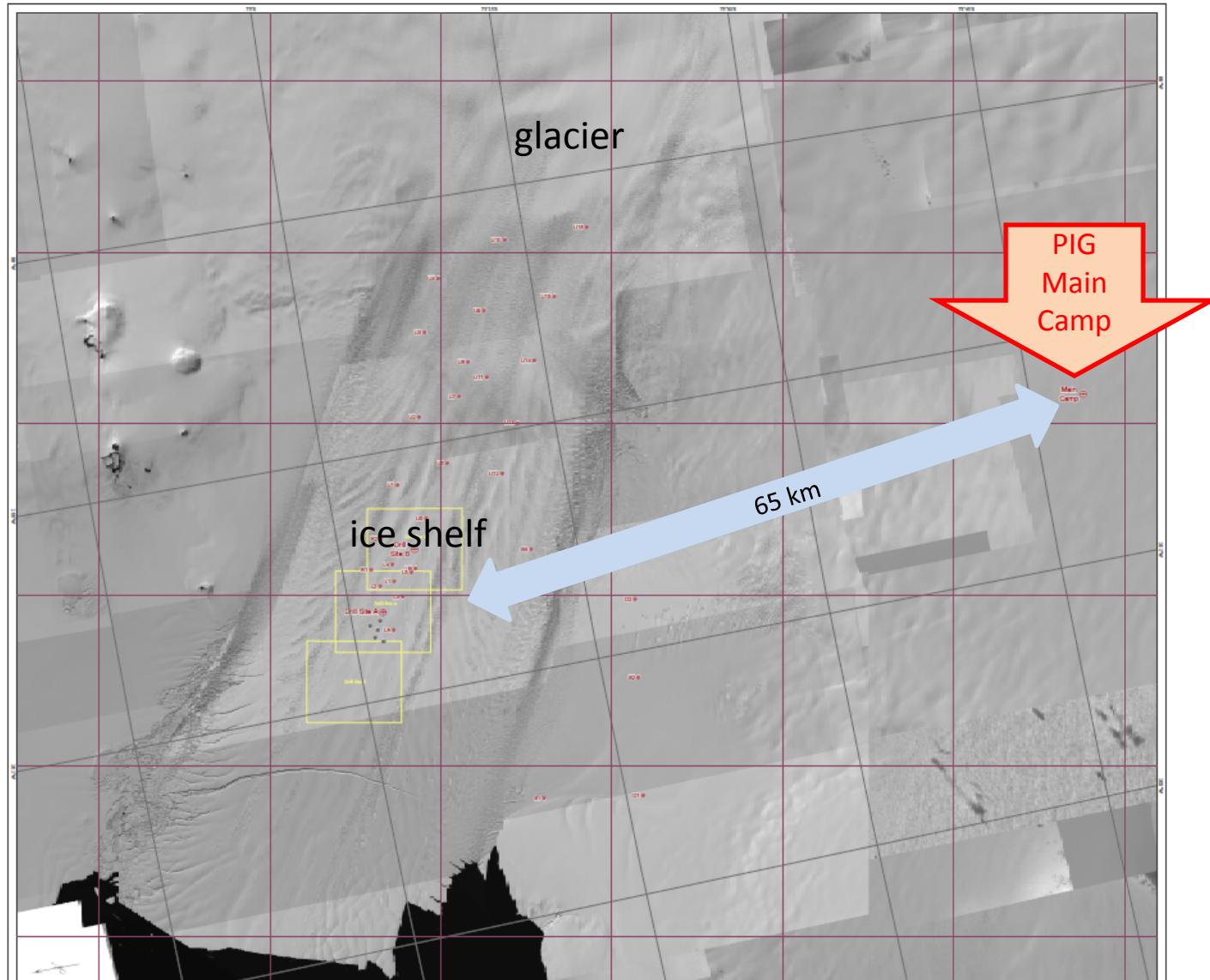
Seismic Profile: A to B



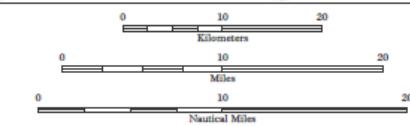
Profile traverses "Autosub Ridge"

courtesy of Leo Peters

Pine Island Glacier



WGS84 Antarctic Polar Stereographic Projection
Central Meridian: 0° (East/West)
Standard Parallel: 71° 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

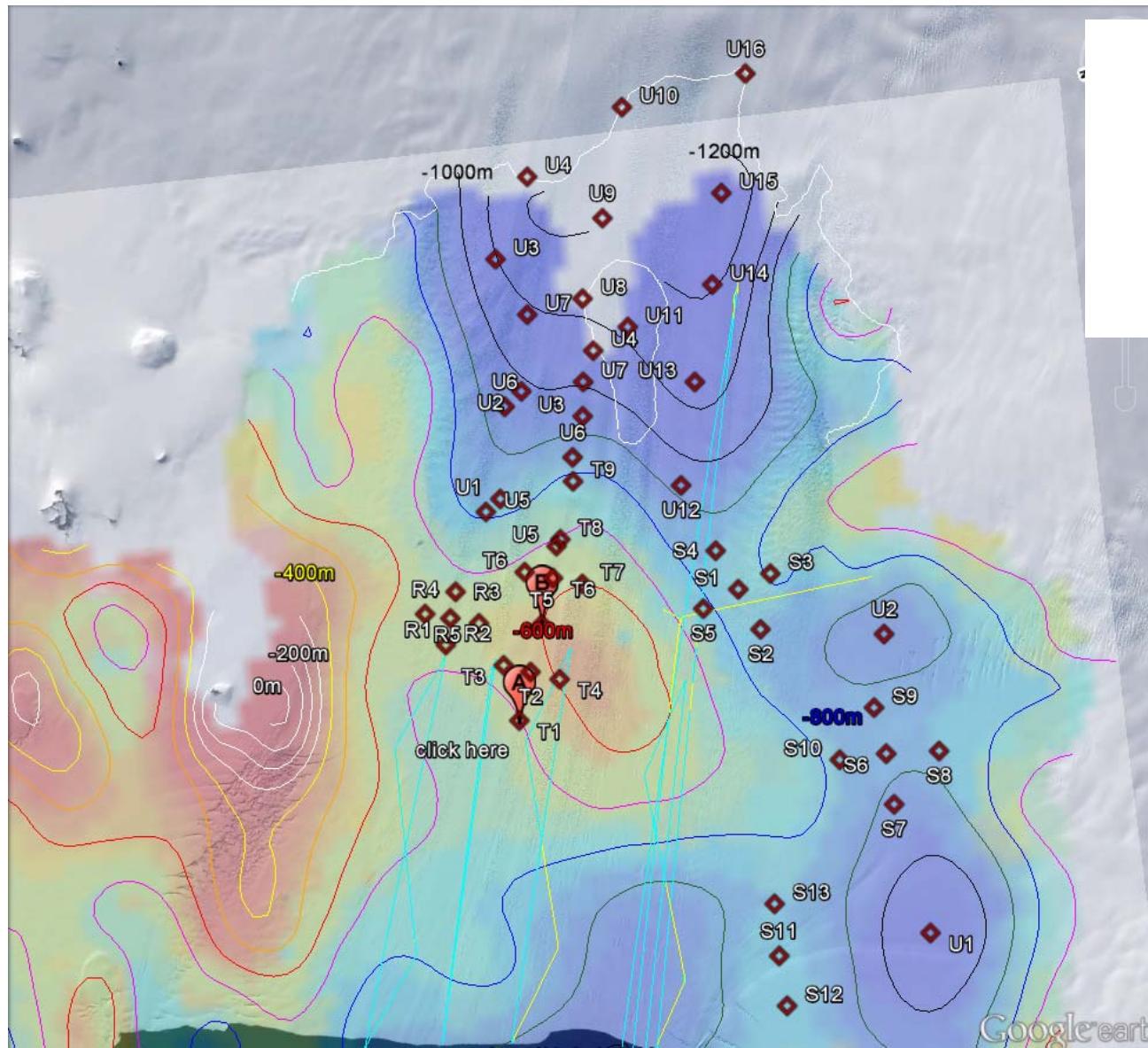


● Remote Site
● PIG 2012 Instrumentation
● Hard Wing Landing Site
— 20 km Grid

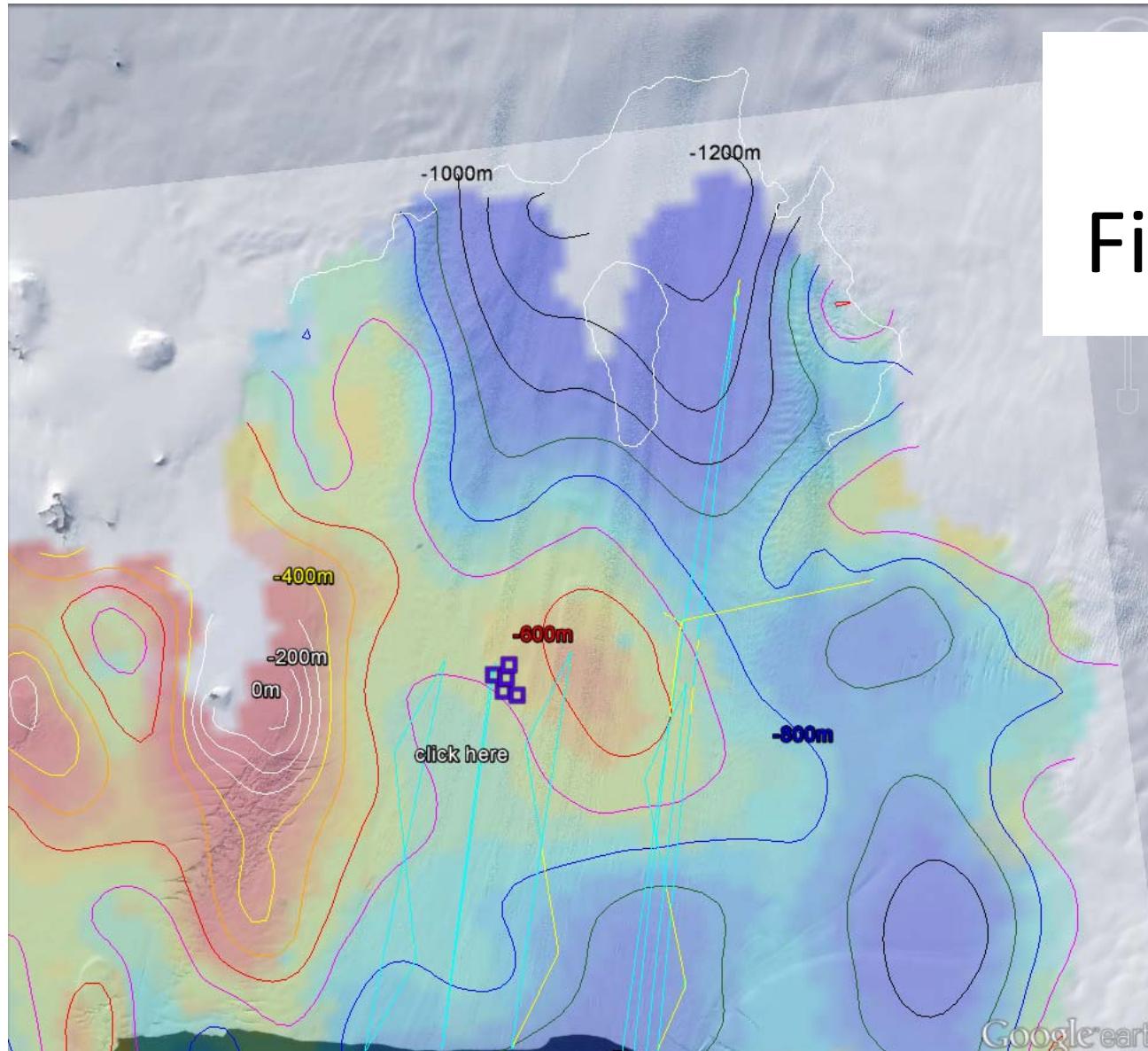
Cartographic by Gabe Kiebler
Image Processing by Gabe Kiebler
Polar Geospatial Center
version 1.0 - 10/26/2012



2011-12 Field Plan



2011-12 Field Stations



Meter-scale satellite imagery has been extraordinary

