Using pressure-sensor equipped inverted echo sounders (PIESs) to measure heat and ice in a Greenland fjord

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Thursday, April 16, 2015
New England Glaciology Meeting

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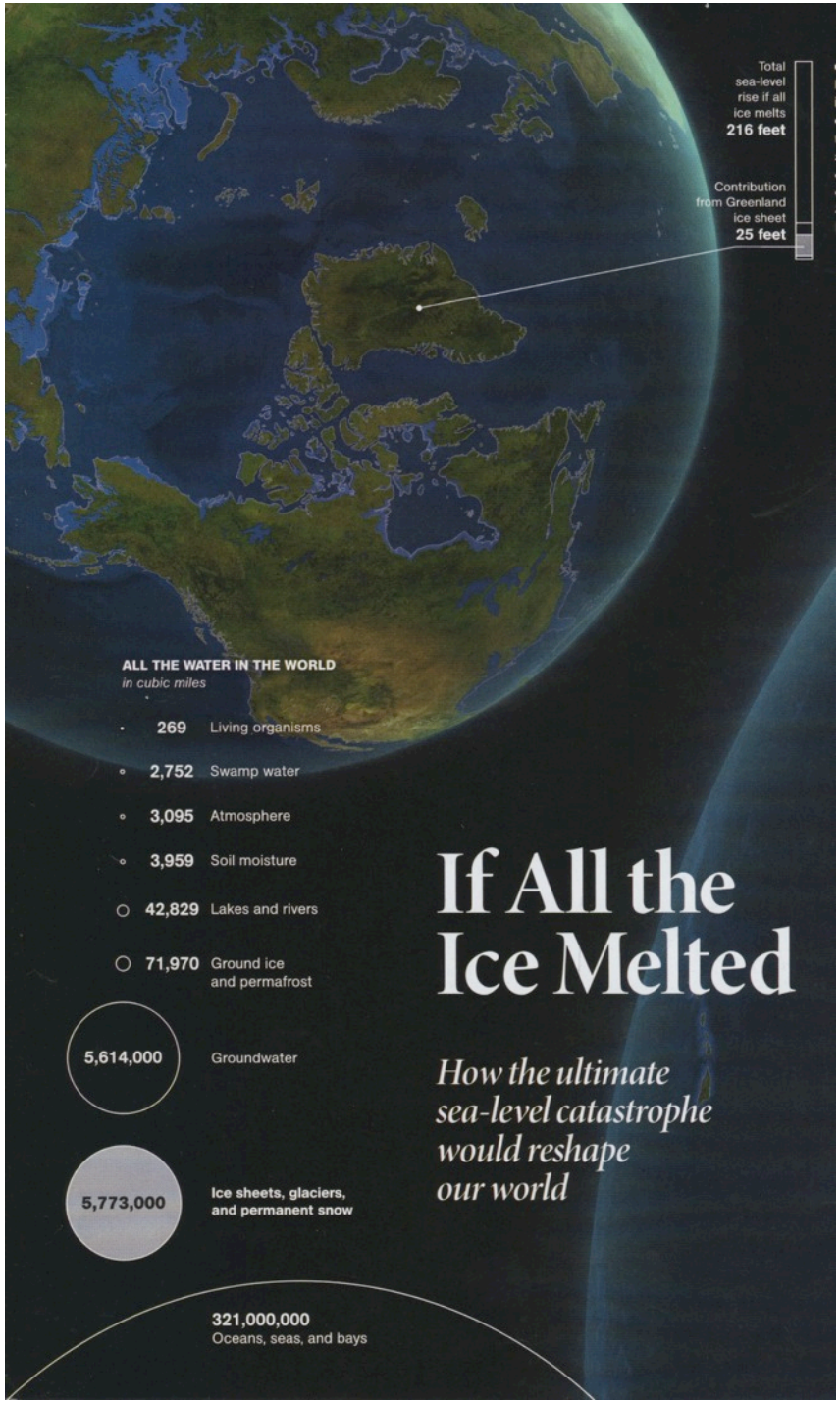
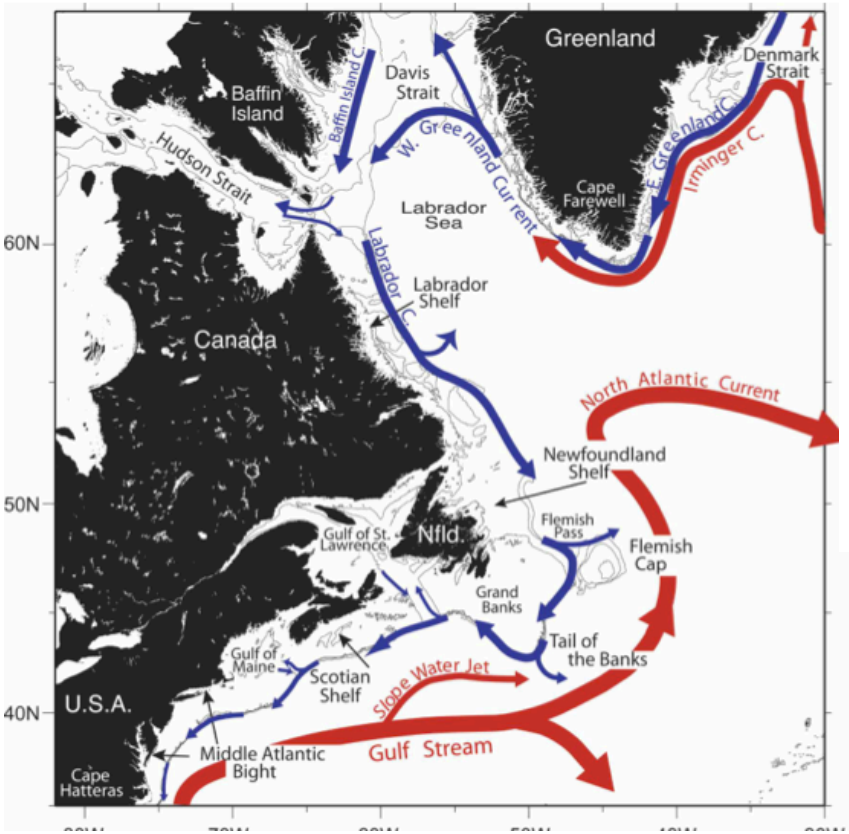


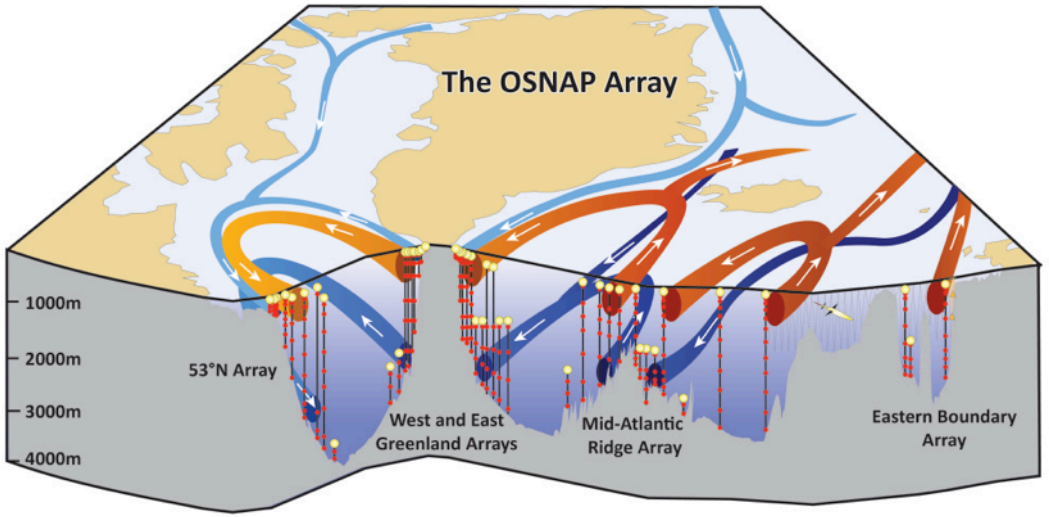
Folger, National Geographic, Sept. 2013.

"…the mean flow in the Middle Atlantic Bight is part of a 5000 km-long **buoyancy-driven, coastal current** which originates along the southern coast of Greenland." Chapman and Beardsley, 1989, *JPO*, 19.



Fratantoni and Pickart, 2007, *JPO*, **37**.

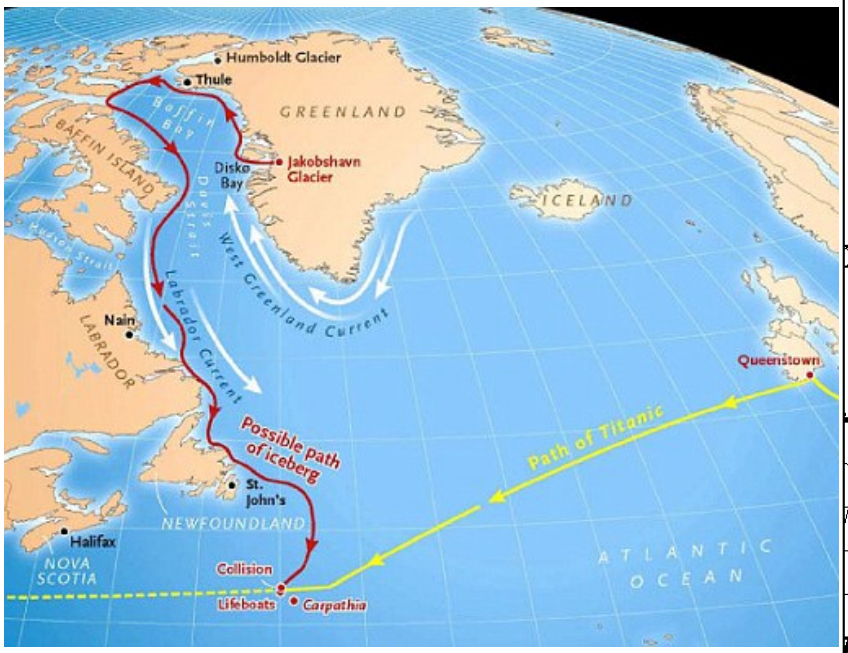
Deep convection in the Labrador and Irminger Seas.

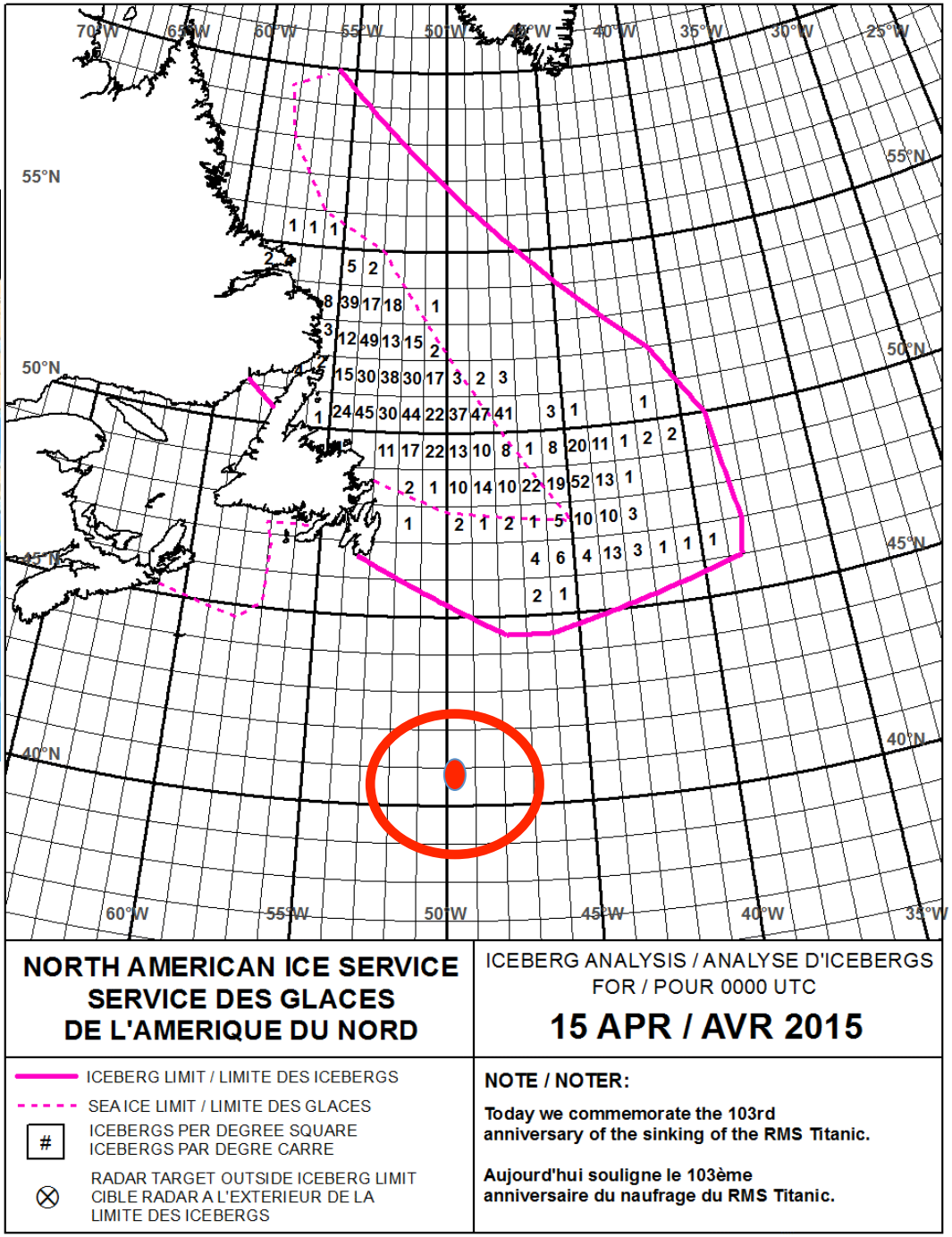


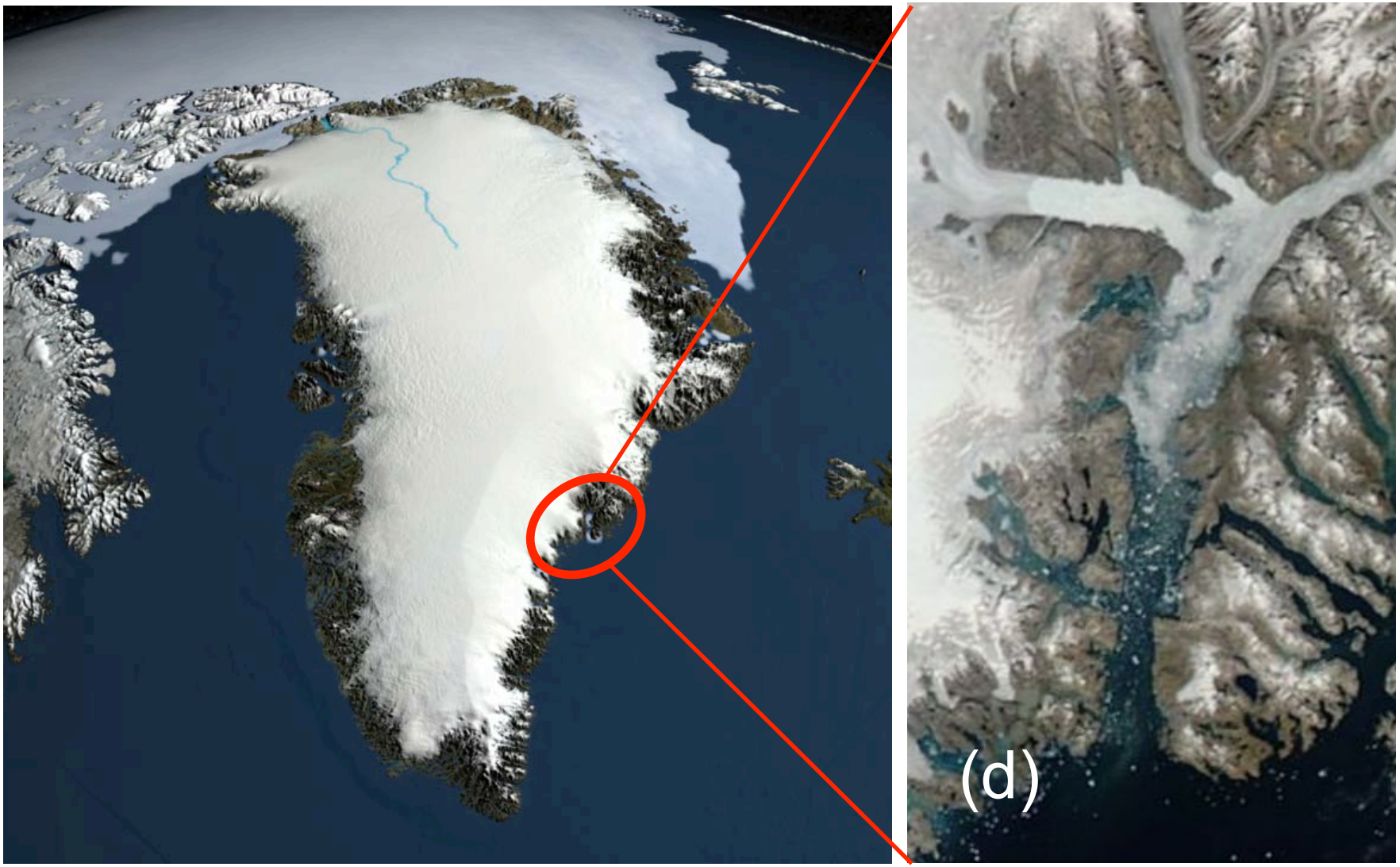
A schematic of the OSNAP array. (Credit: Penny Holliday).

http://www.o-snap.org/news-events/blog/

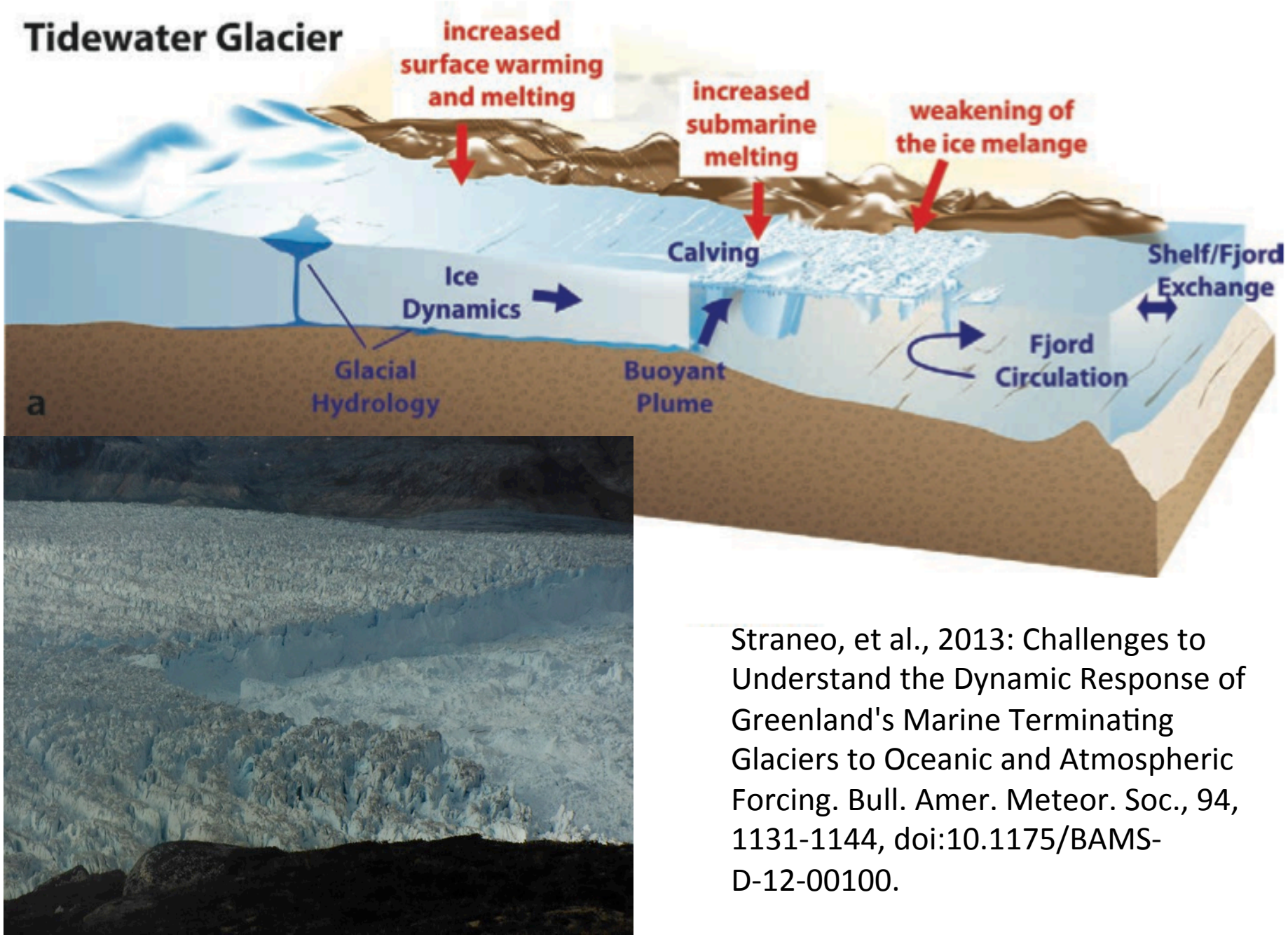
The ice report for yesterday (the 103rd anniversary of the sinking of the Titanic)



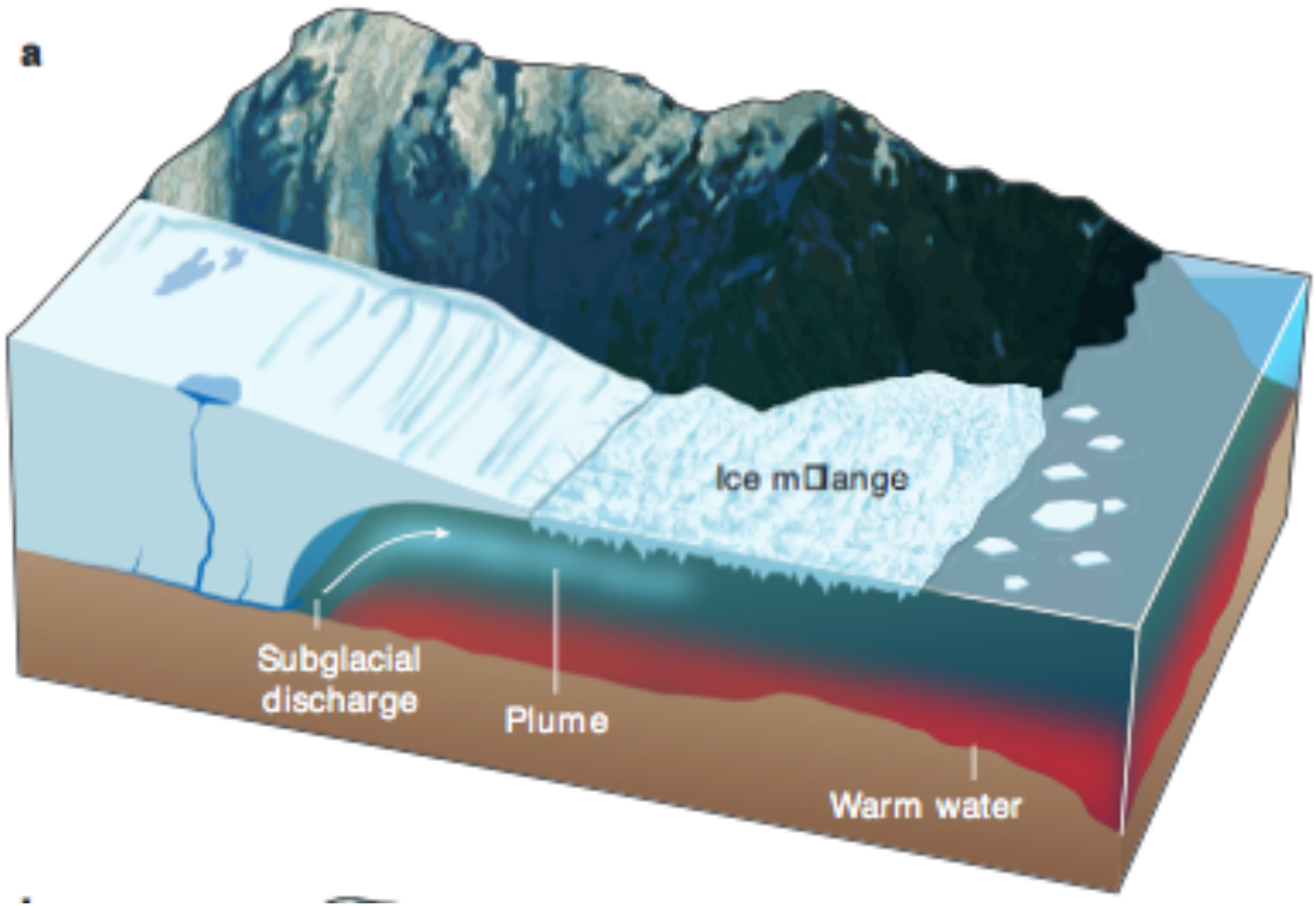




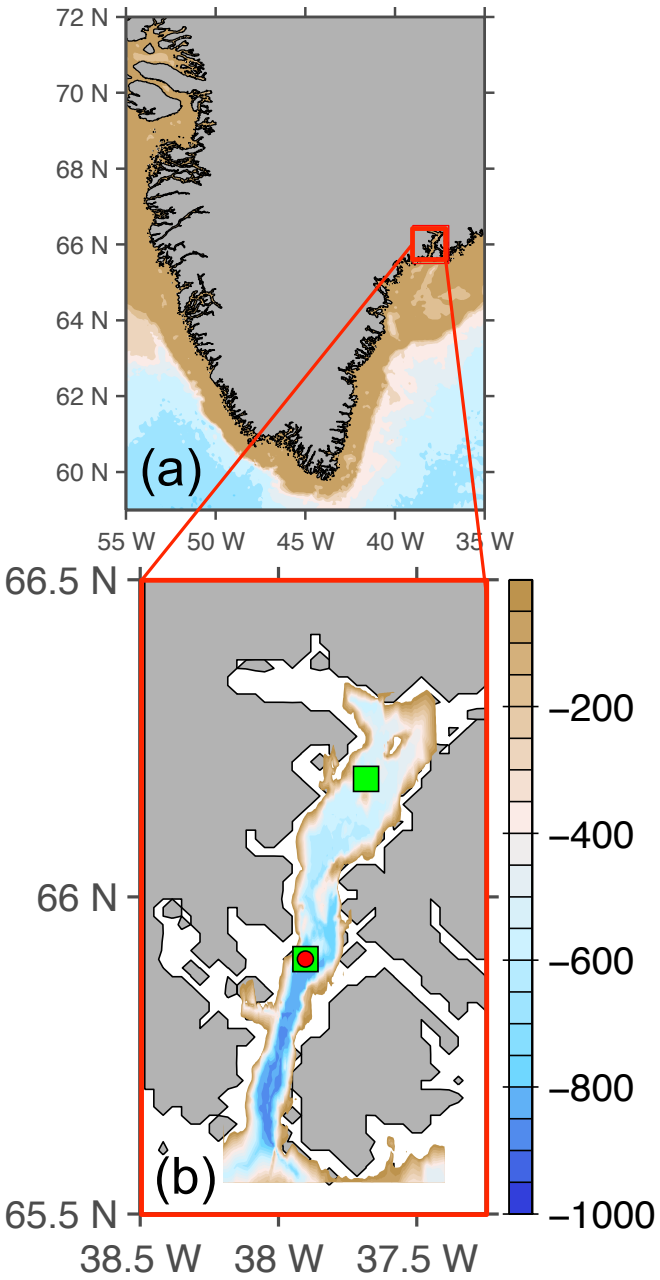
Jonathan Bamber / University of Bristol / NASA's Goddard Space Flight Center Scientific Visualization Studio) - See more at: http://www.astrobio.net/topic/solar-system/earth/climate/greenland-ice-sheet-vulnerable-climate-change-previously-thought/#sthash.2dcikEt4.dpuf



Straneo, et al., 2013: Challenges to Understand the Dynamic Response of Greenland's Marine Terminating Glaciers to Oceanic and Atmospheric Forcing. Bull. Amer. Meteor. Soc., 94, 1131-1144, doi:10.1175/BAMS-D-12-00100.

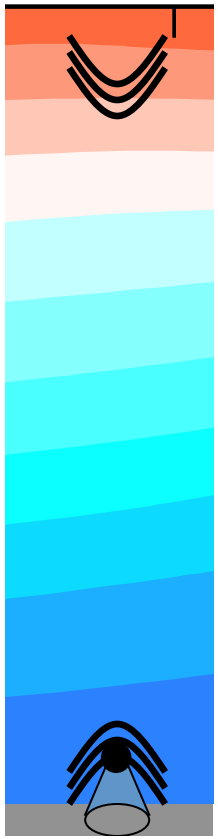


Straneo, F. and P. Heimbach, 2013: North Atlantic warming and the retreat of Greenland's outlet glaciers. *Nature*, **504**, 36-43.



Sometimes the icebergs win:

A PIES measures round-trip-acoustic-travel-time (τ)



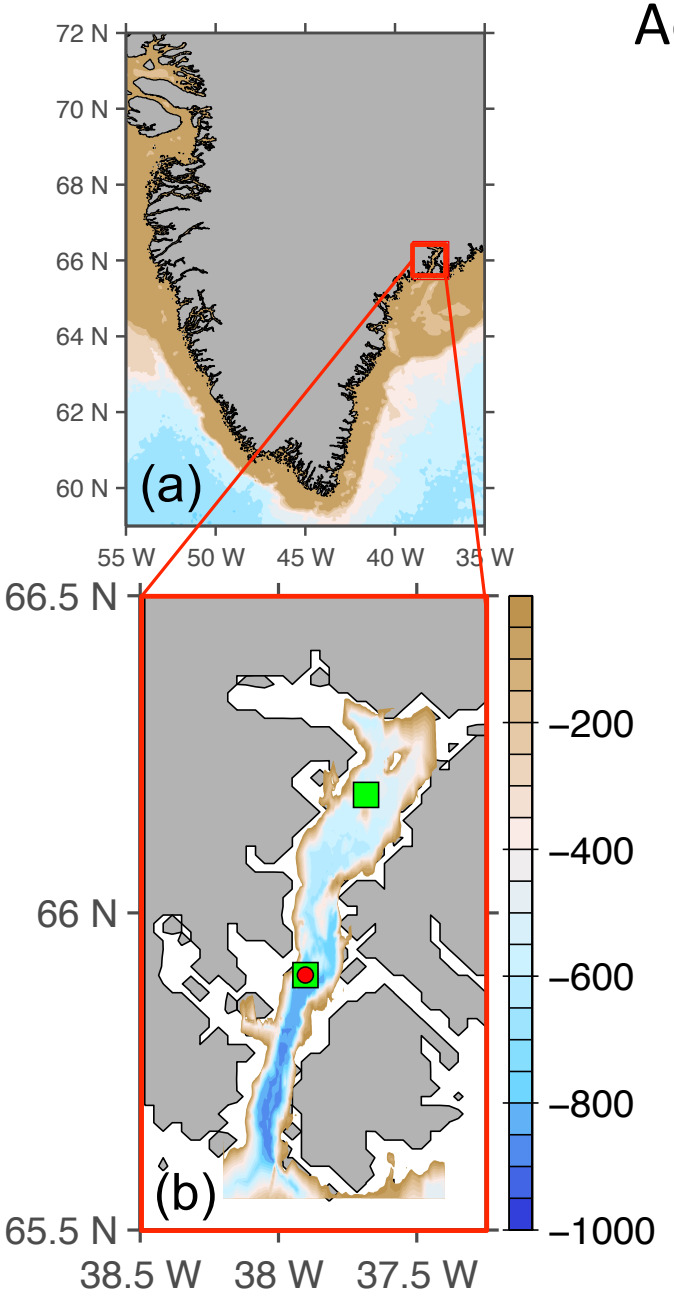
Emits sets of 4 12-kHz pings every 10 minutes over an entire hour (24 pings).

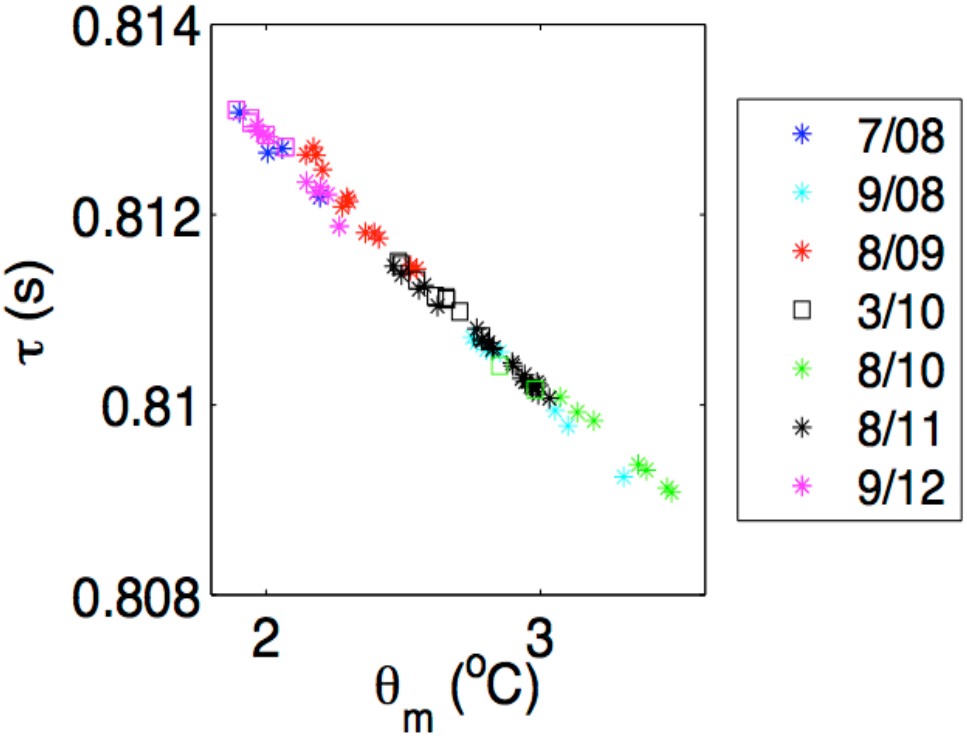
0.06 millisecond resolution

Speed of sound in water is ~1,500 m/s

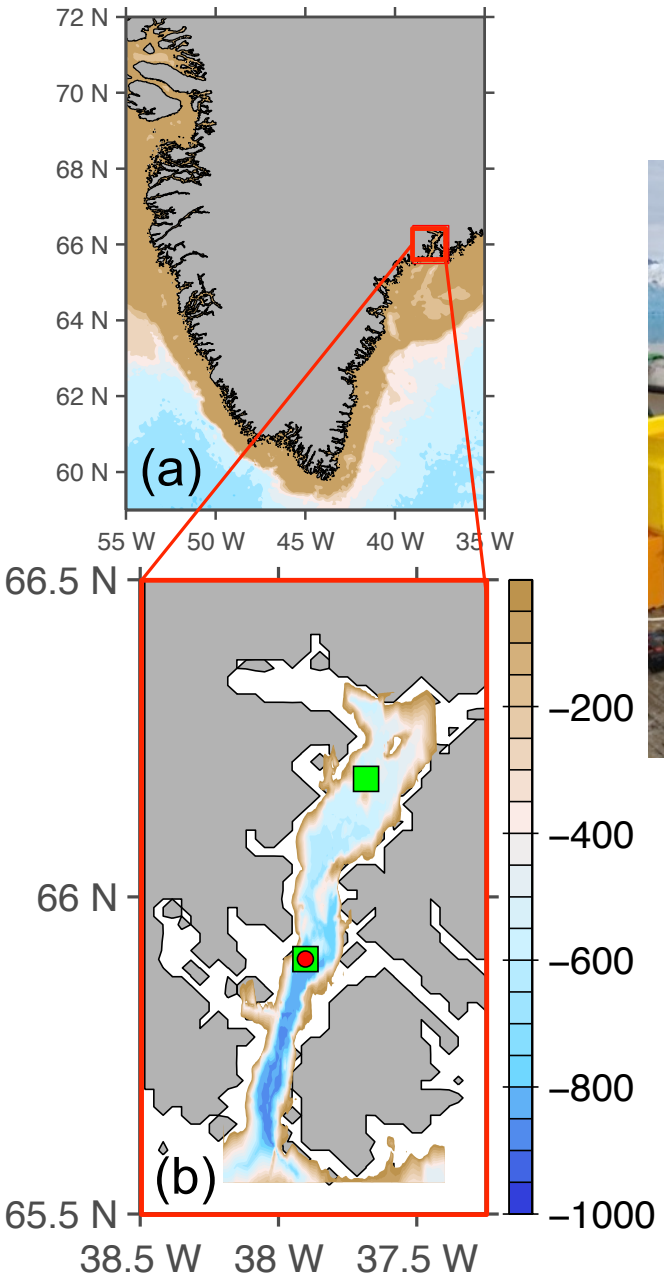
So for a 1500 m deep ocean:
1 second for the pulse to travel 1500 m
2 seconds for the pulse to travel up and back

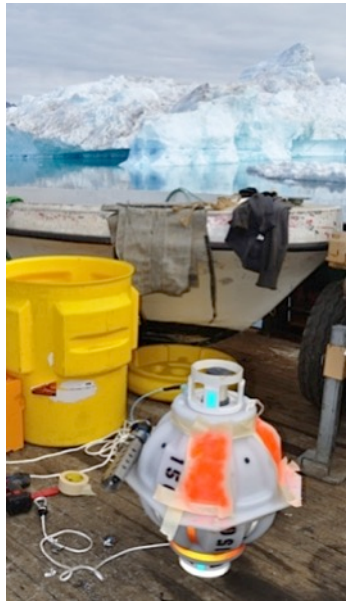
Acoustic-travel time (τ) is well-correlated with heat content.

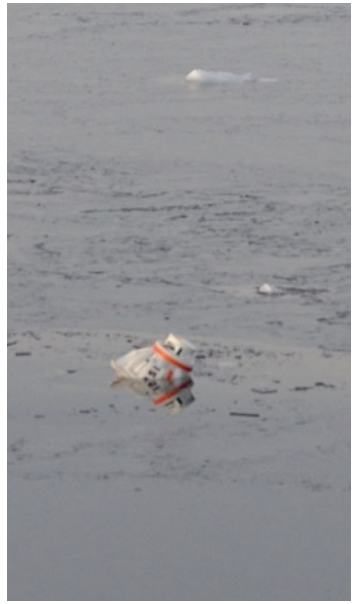


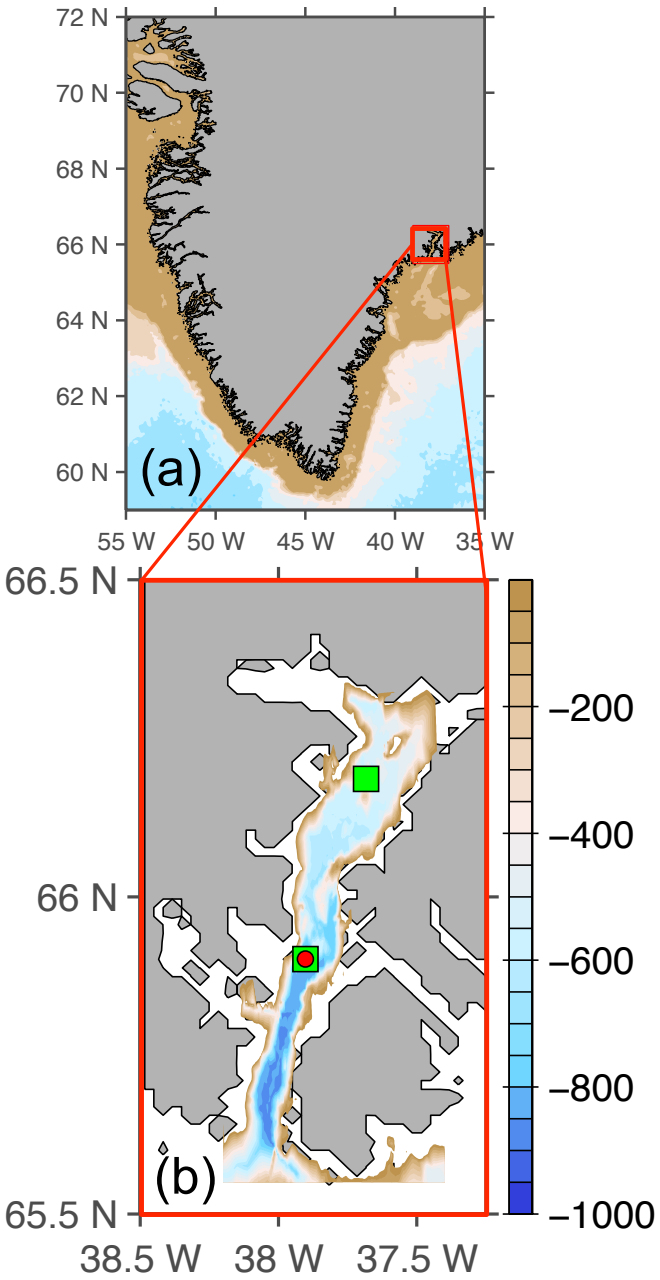


A 1-year pilot study:

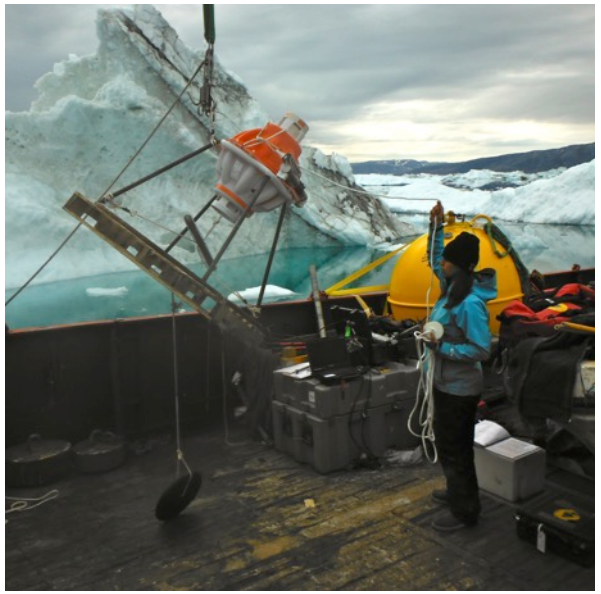


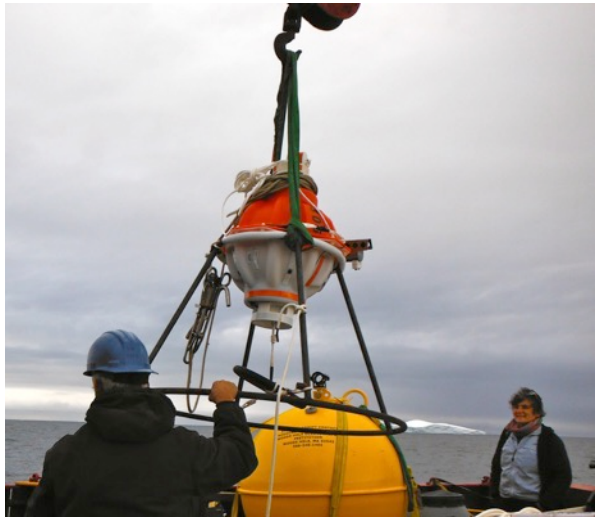




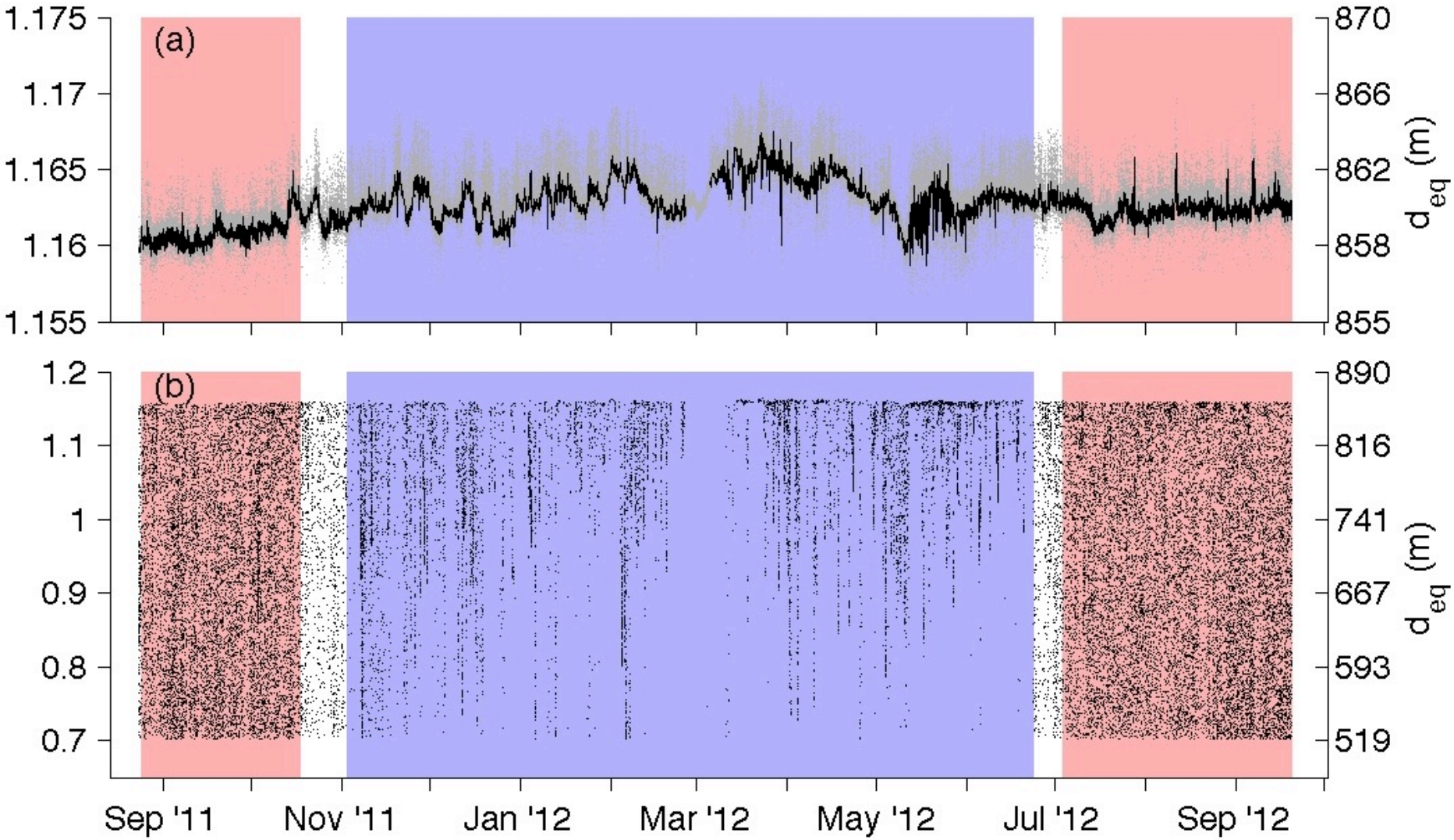


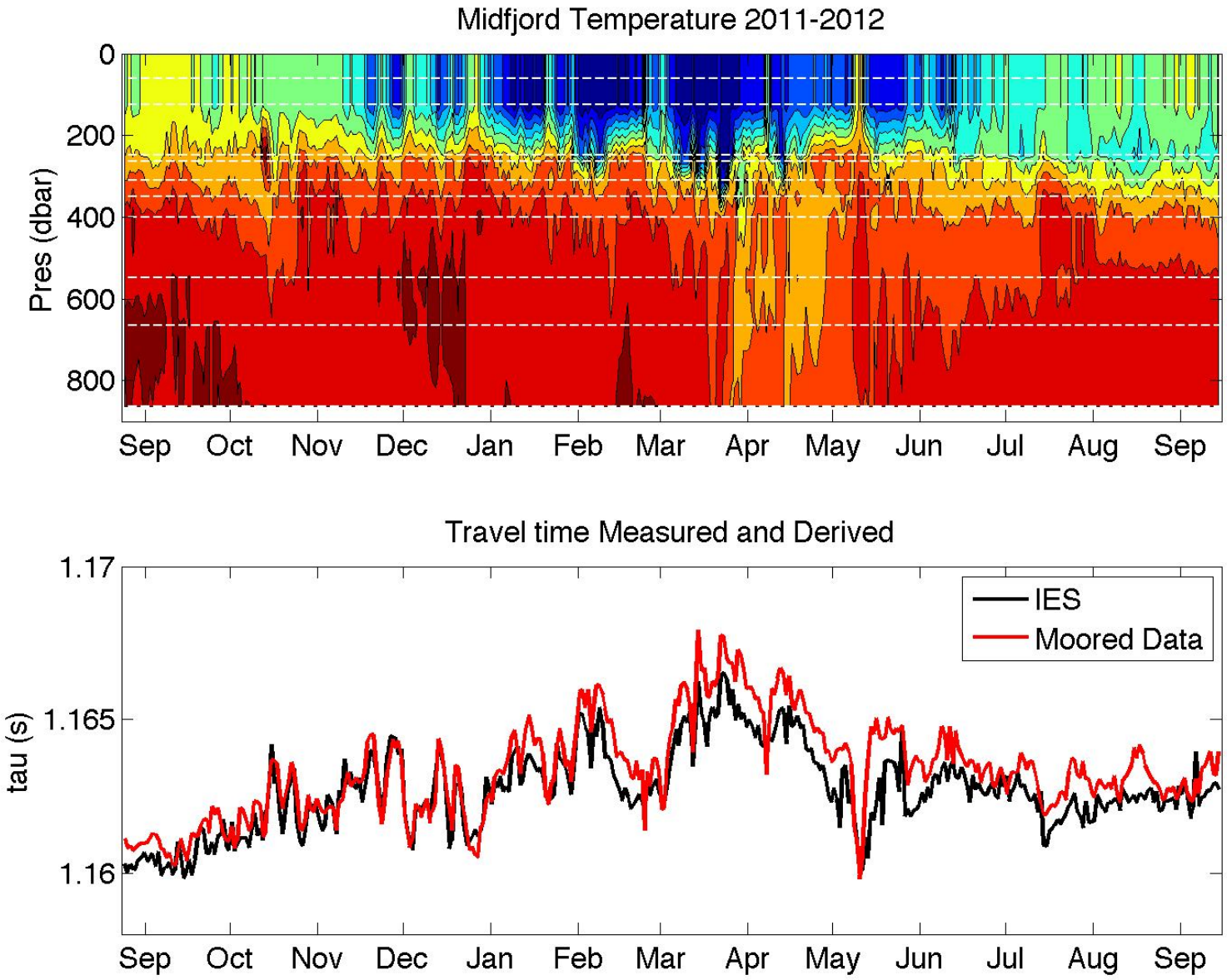
A 2-year deployment of 3 PIESs in the fjord:



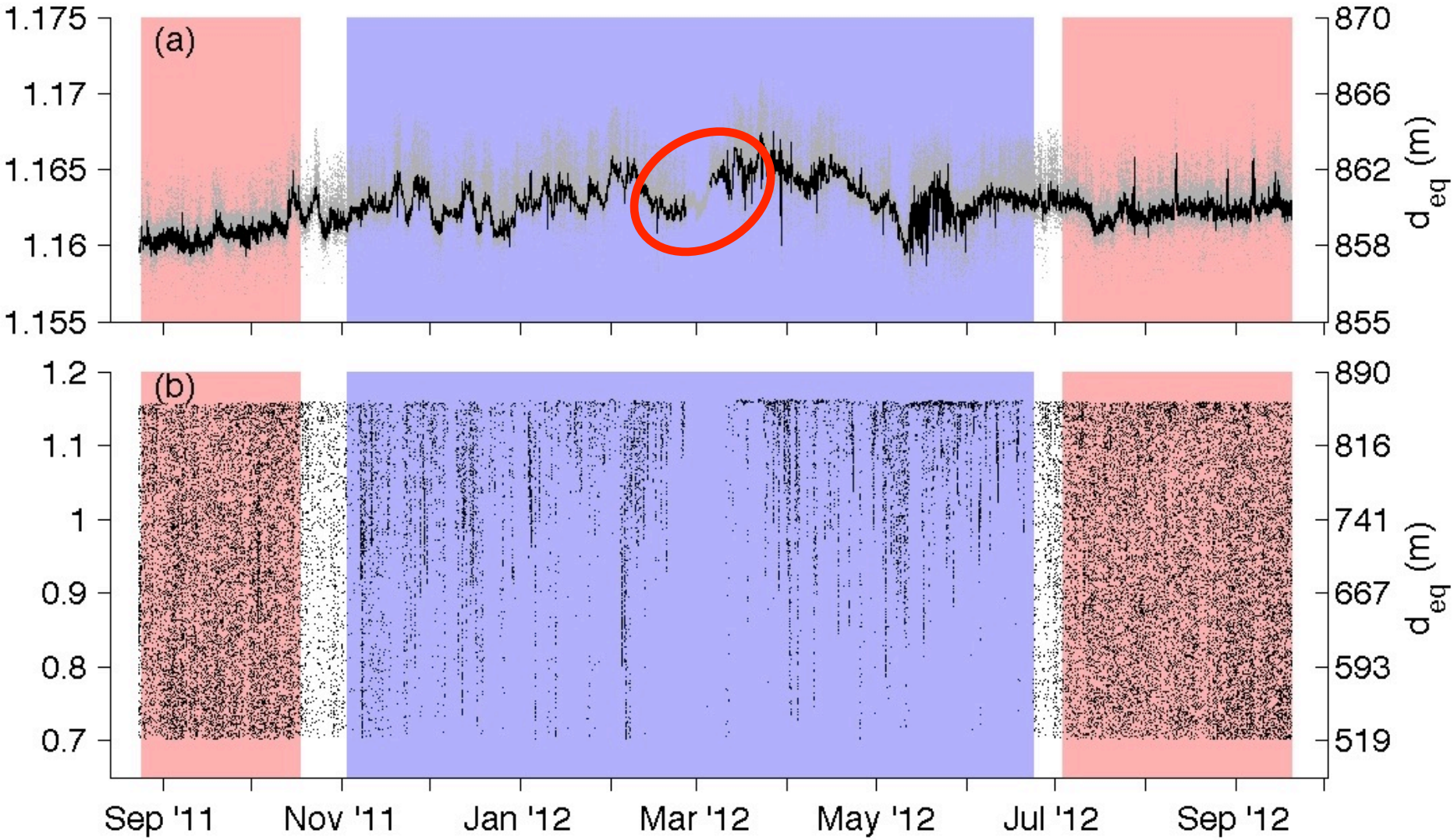


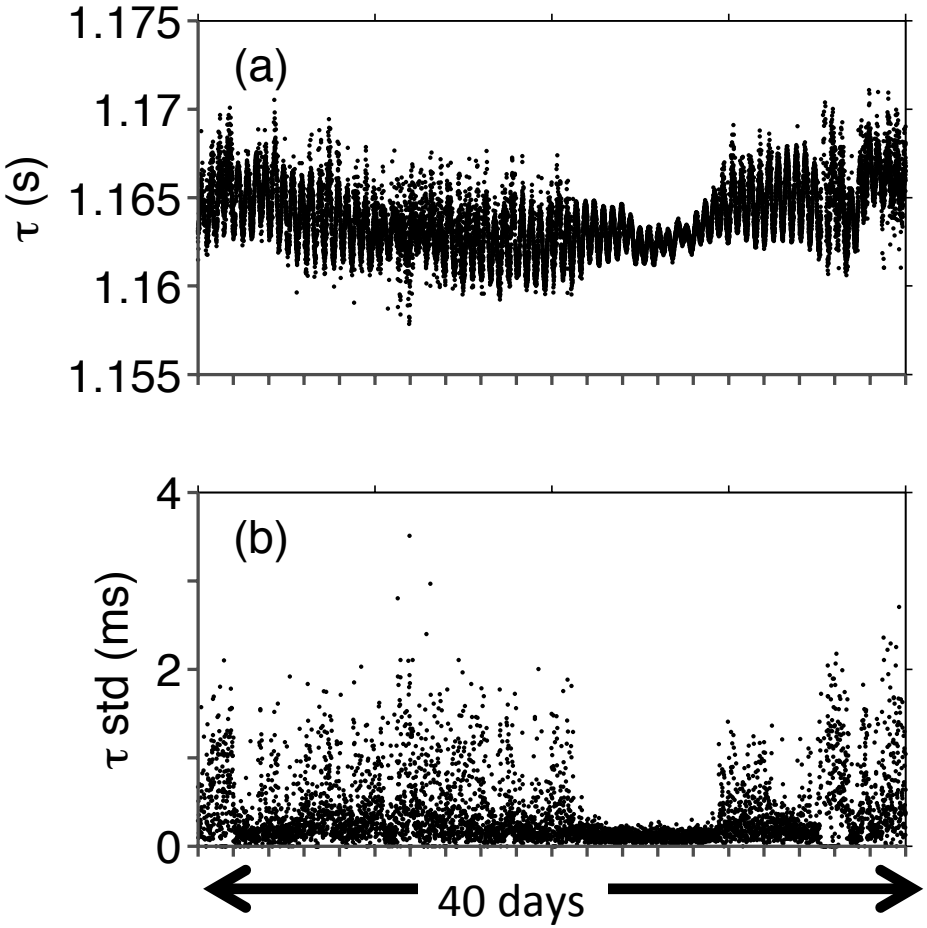
Some results from the pilot study:



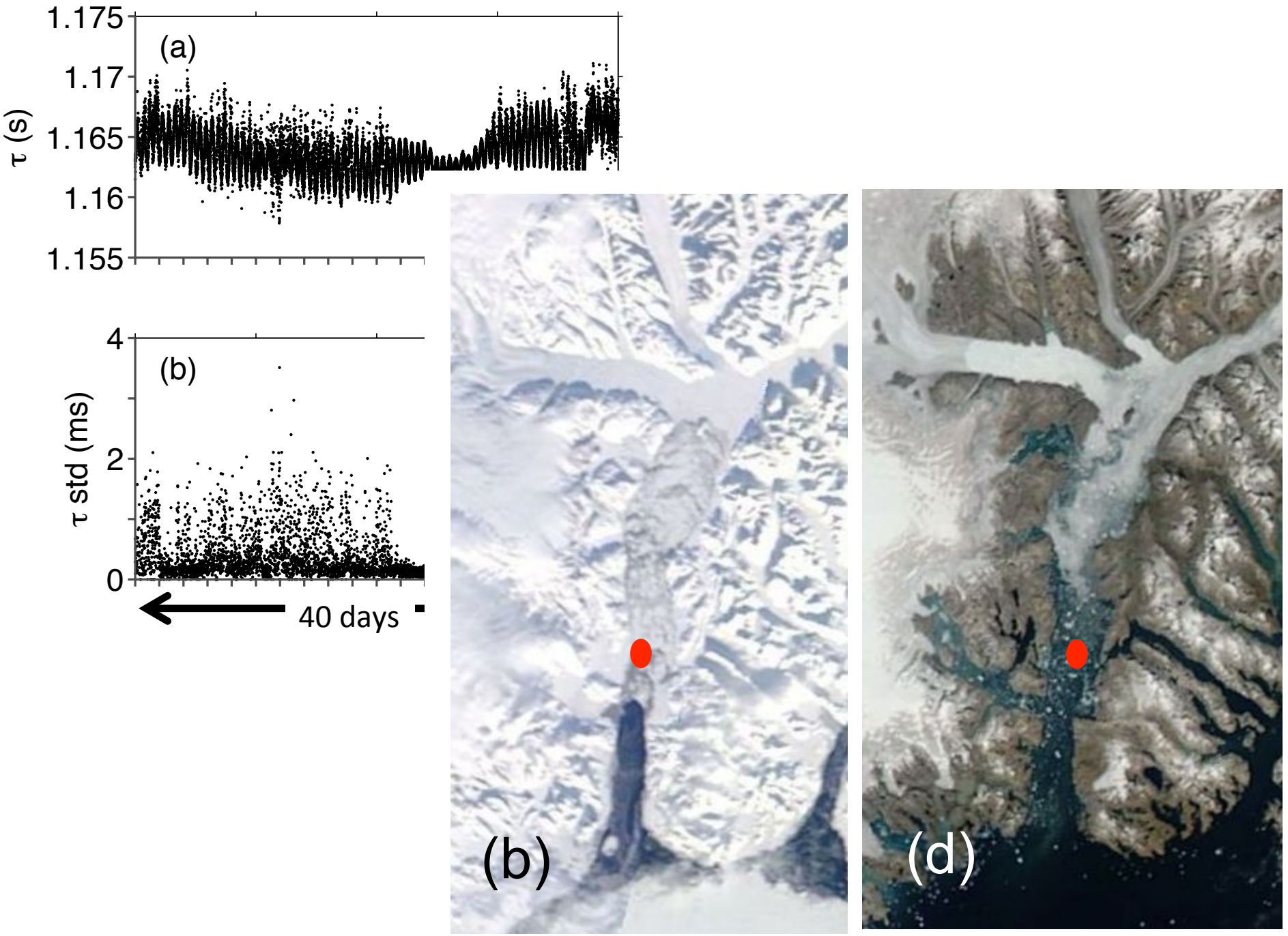

Midfjord Temperature 2011-2012
Pres (dbar)
0
200
400
600
800
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Travel time Measured and Derived
tau (s)
1.17
1.165
1.16
IES
Moored Data
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

Some results from the pilot study:

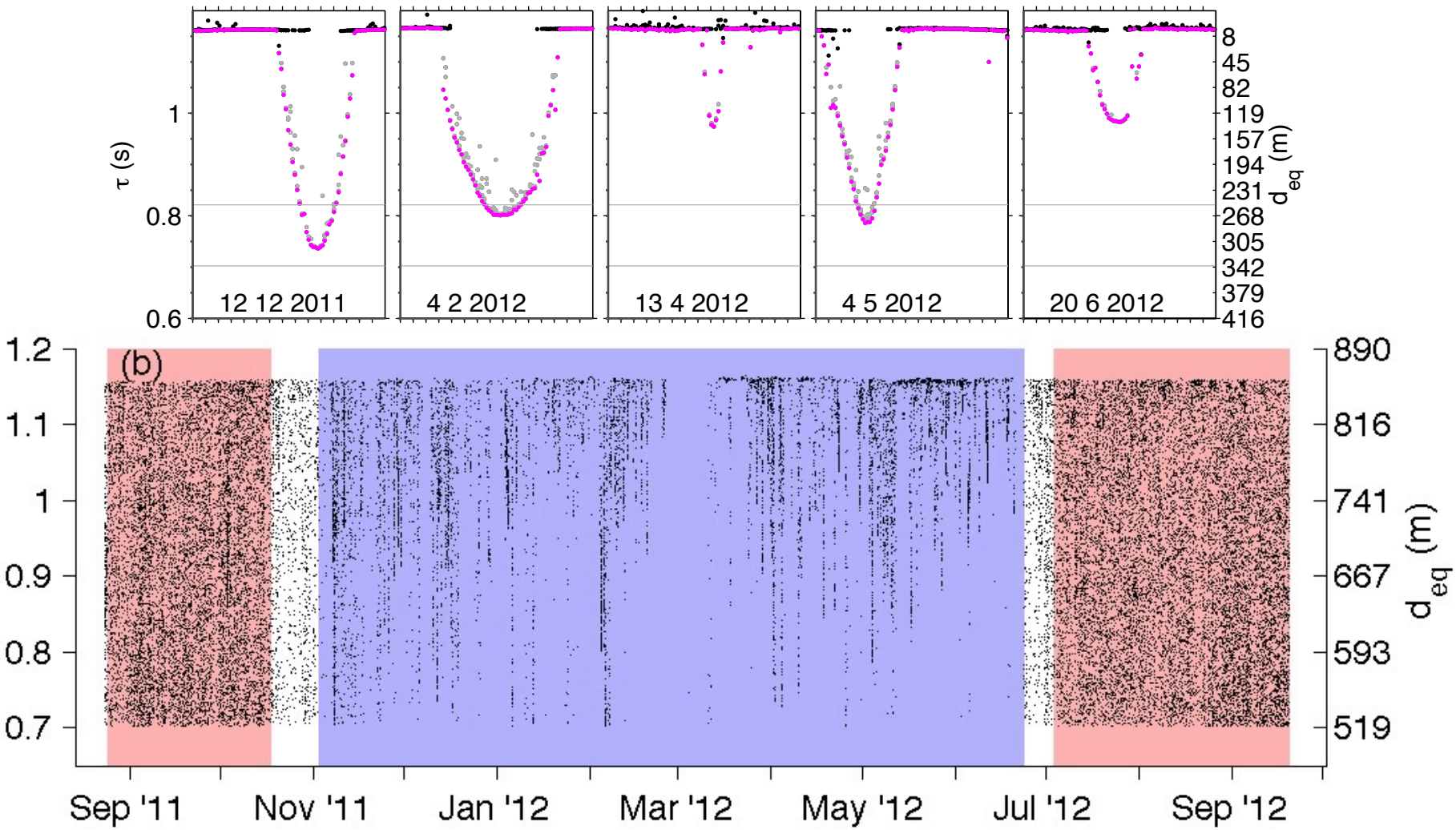


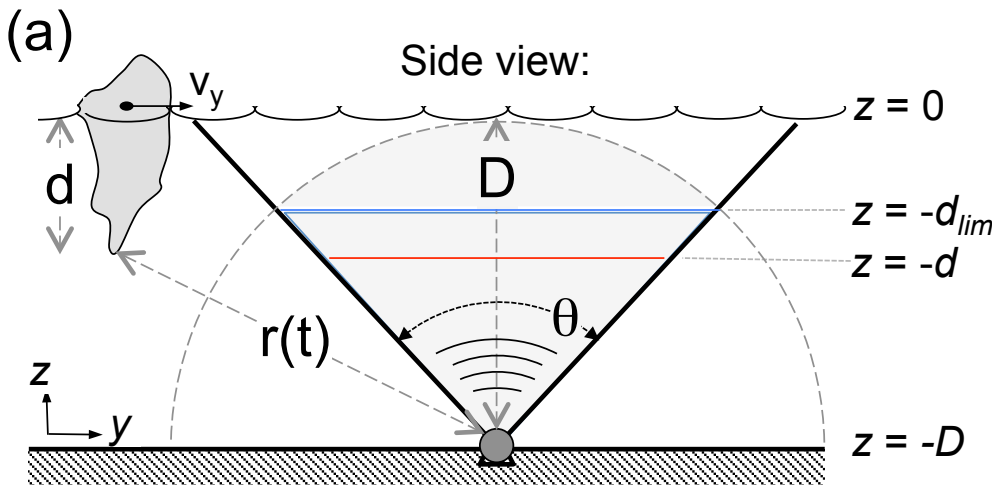

(a)
1.175
1.17
1.165
1.16
1.155
τ (s)
(b)
4
2
0
τ std (ms)
40 days

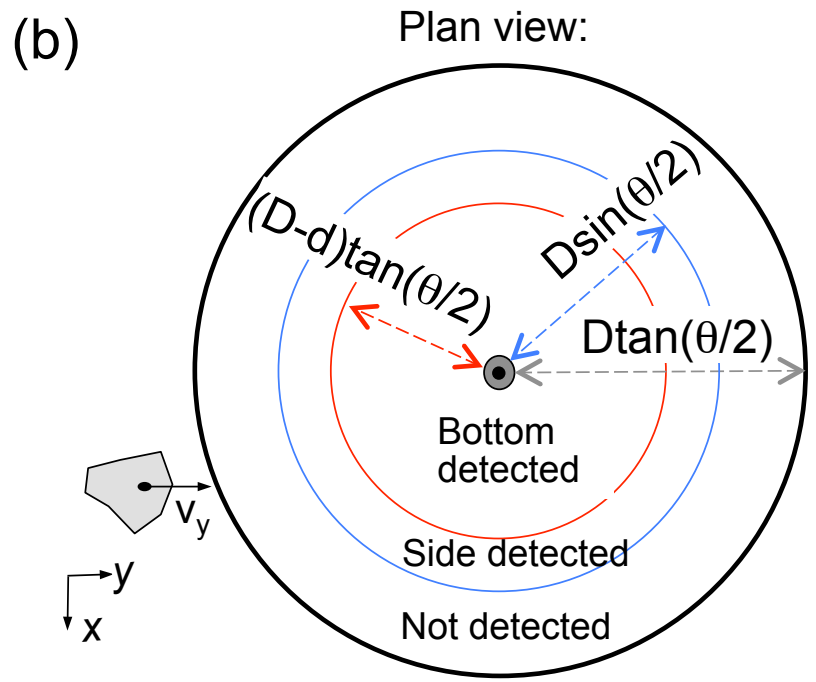
(d)


1.175
1.17
1.165
1.16
1.155
τ (s)
(a)
4
2
0
τ std (ms)
(b)
40 days
(b)
(d)

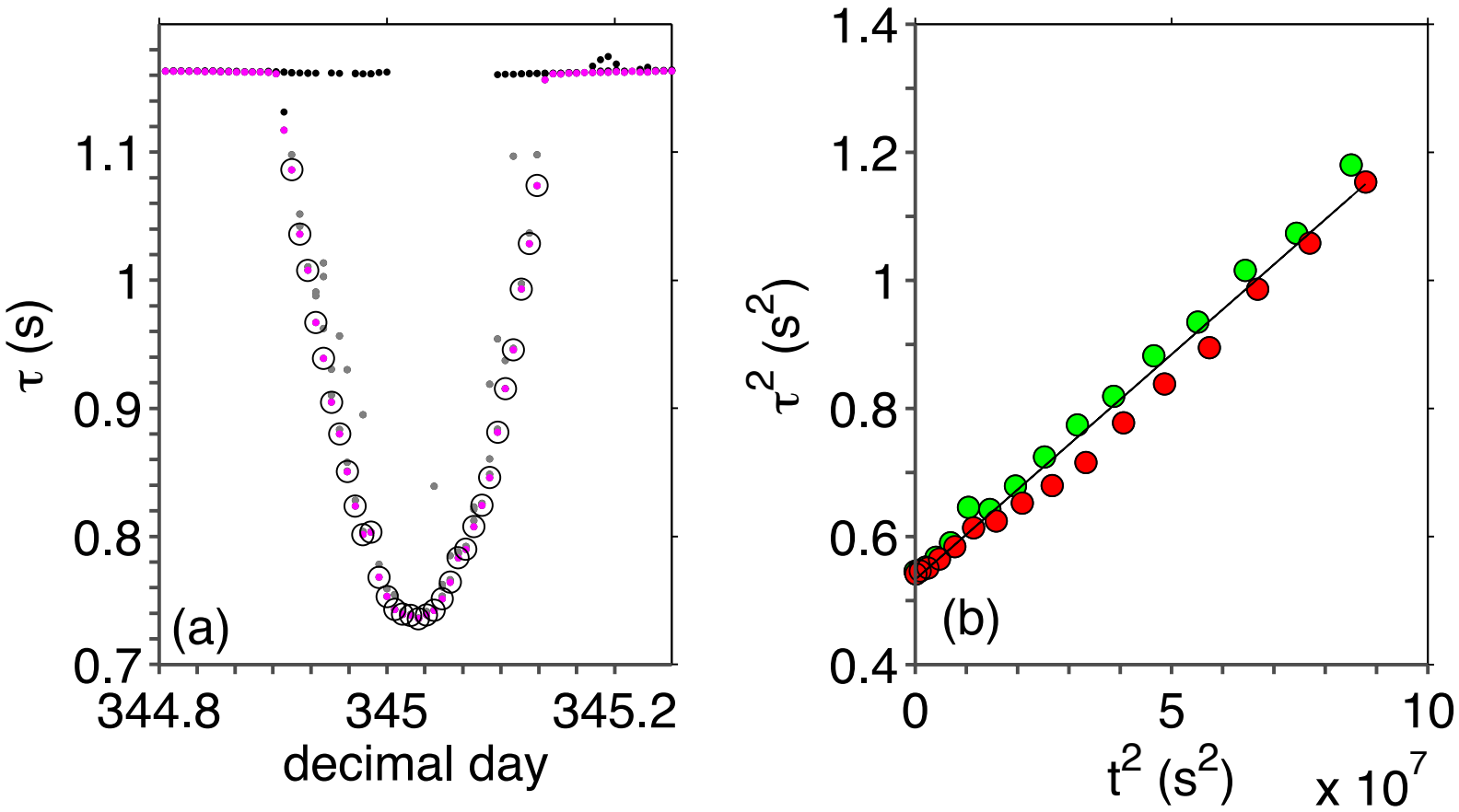
Signature of iceberg events:





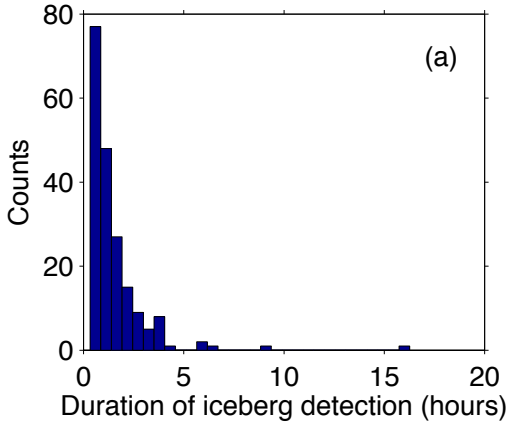


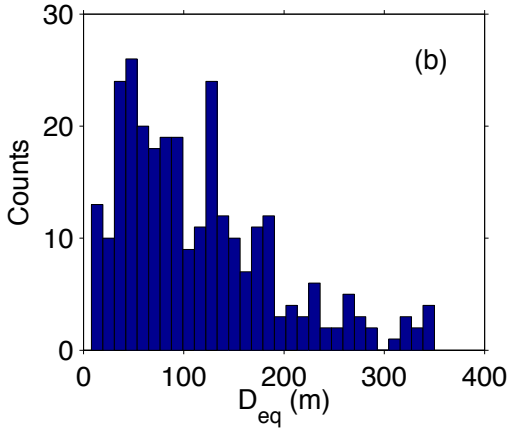
$$r(t) = \sqrt{[x_o + v_x(t - t_o)]^2 + [y_o + v_y(t - t_o)]^2 + (D - d)^2}$$

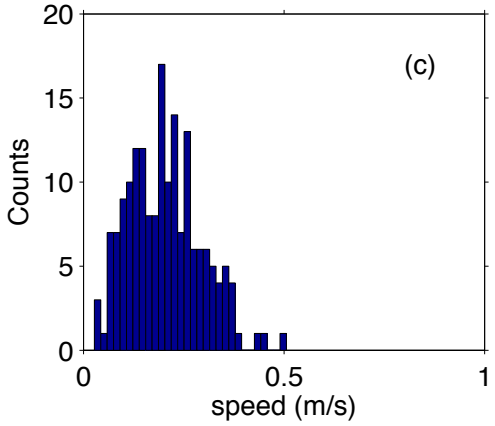


Estimate of the keel's draft.
Measure of the iceberg's speed.

Andres, M., A. Silvano, F. Straneo, and D.R. Watts, 2015. Icebergs and sea ice detected with inverted echo sounders, JTECH, in press.





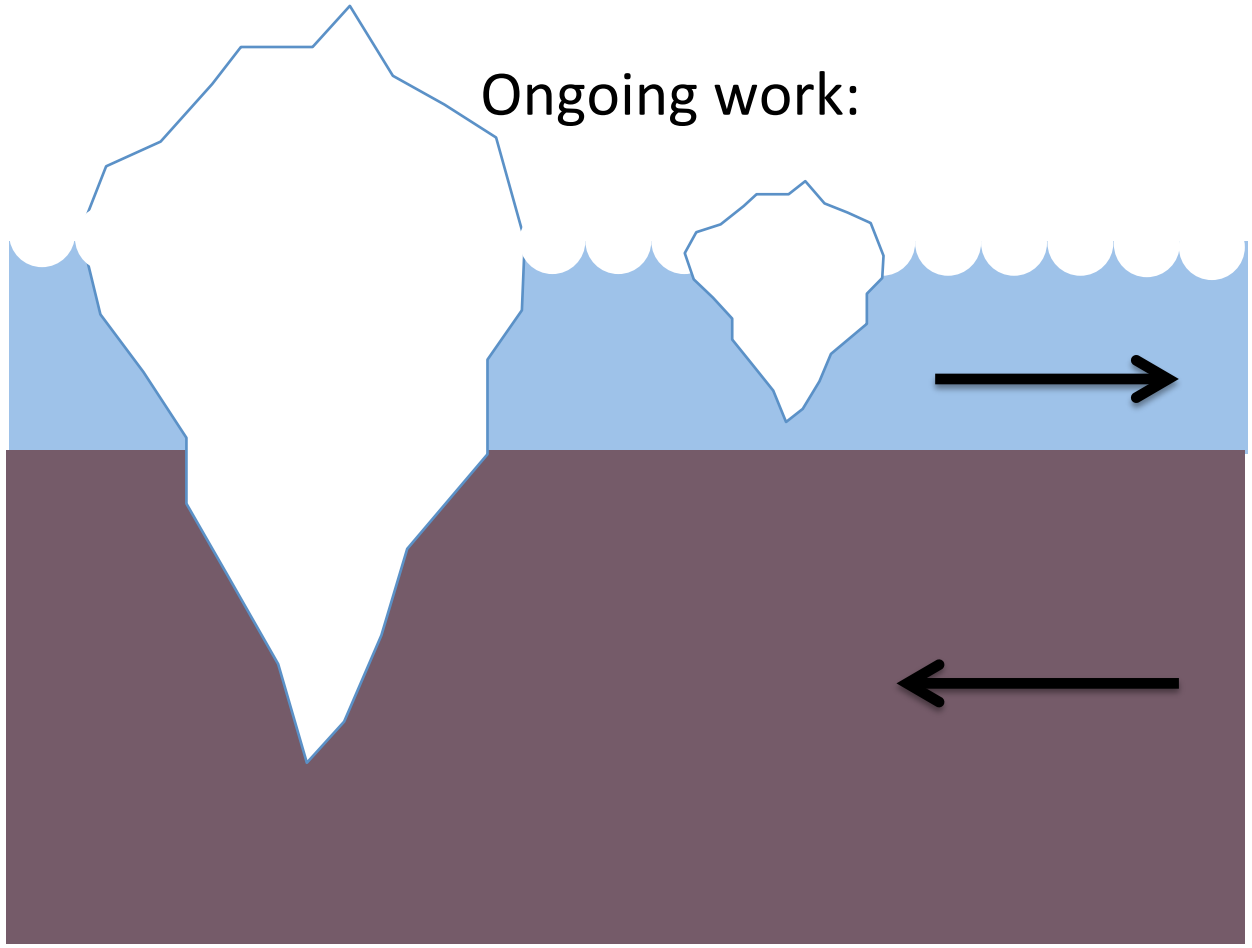


For winter 2011/2012 in Sermilik Fjord:

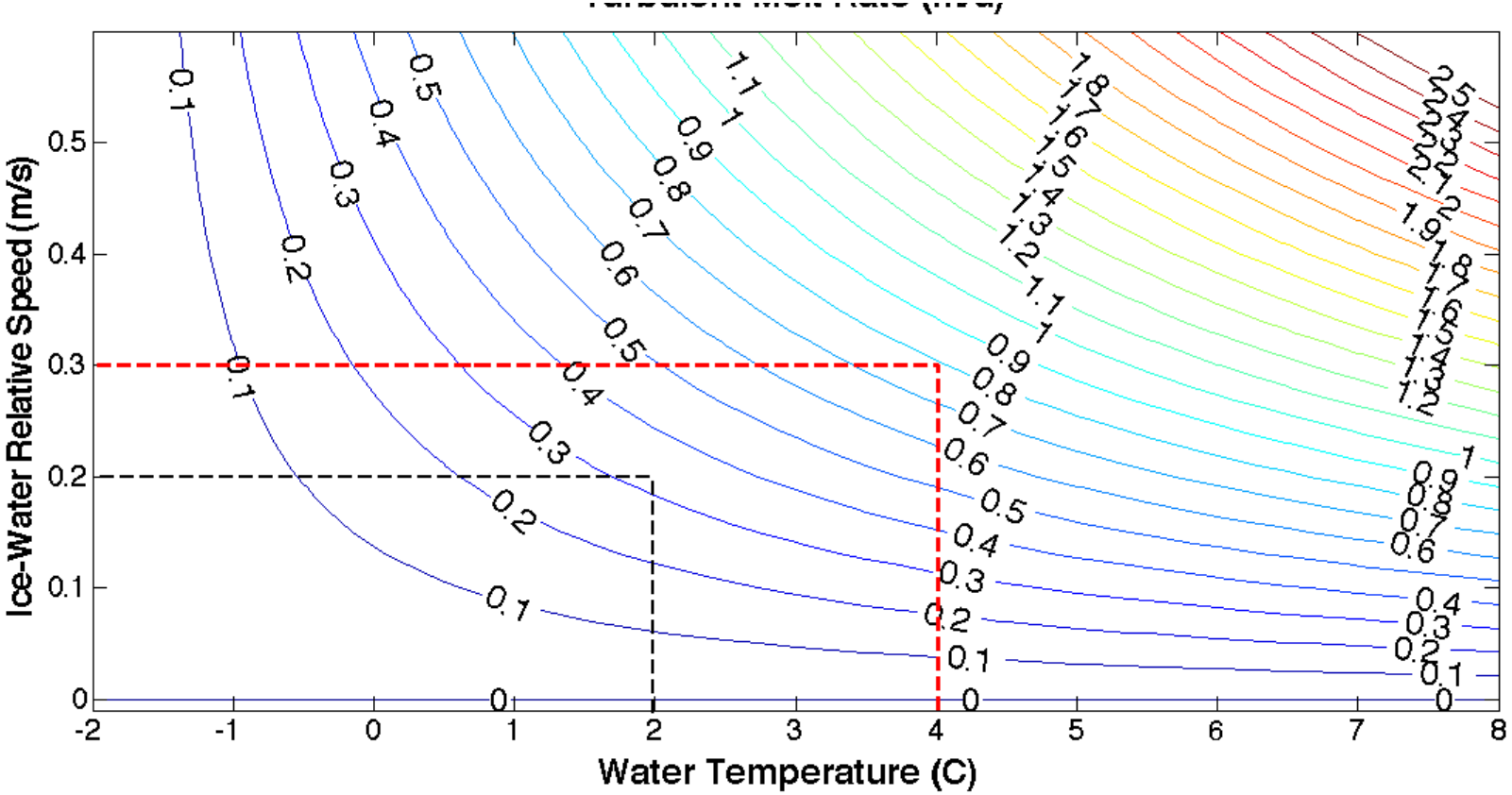
- ~300 iceberg detections.
- Longest detection was 16 hours (minimum is 30 minutes).
- Draft of the deepest keel is > 350 m.
- For 178 detections, we could also determine the speed:

  0.2 - 0.5 m/s (17 - 43 km/day).
- Speeds are not correlated with tides.

Ongoing work:



Water currents are the main forcing on iceberg motion. Wind is important when it is strong > 15 m/s or when currents are weak (< 5 cm/s). Strong winds are rare (Katabatic wind events occur about 8-10 times per year with a duration of 1-2 days, Oltmann et al., 2014) and typical water speed is around 20 cm/s in the first 150-200 where most of icebergs live. Wind can be important for icebergs deeper than 300m because of the fjord circulation (inversion of the water speed at 150m -200m). However these icebergs are rare.



Turbulent melt rate as function of temperature and iceberg relative speed to water (w/out wave erosion). Typical values are around 0.1-0.2 m/day, but it's possible to find even values bigger than 0.5 when iceberg are very deep.

Helheim glacier during winter has a melt rate estimated of about 0.2 m/s (Sciascia et al, 2013), therefore fresh water flux due to iceberg melting is a primary source in Sermilik Fjord in winter (in summer glacier produces a bigger contribution to freshwater discharge than icebergs due to runoff), considering the high number of icebergs in SF. Black box represents typical values for not small icebergs; red box is for icebergs deeper than 300 m.
Silvano et al., in prep., Roth master thesis (2014)

VIKING MADSALEX
SVENDBORG