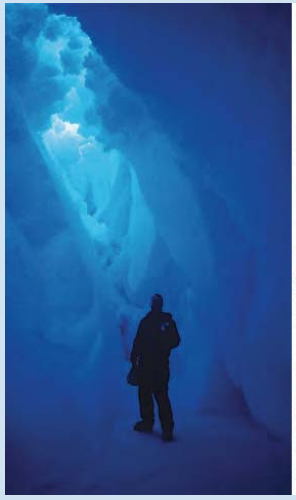
National Snow and Ice Data Center
Supporting Cryospheric Research Since 1976



LARISSA Glaciology and Early Results from the AMIGOS Stations

Ted Scambos

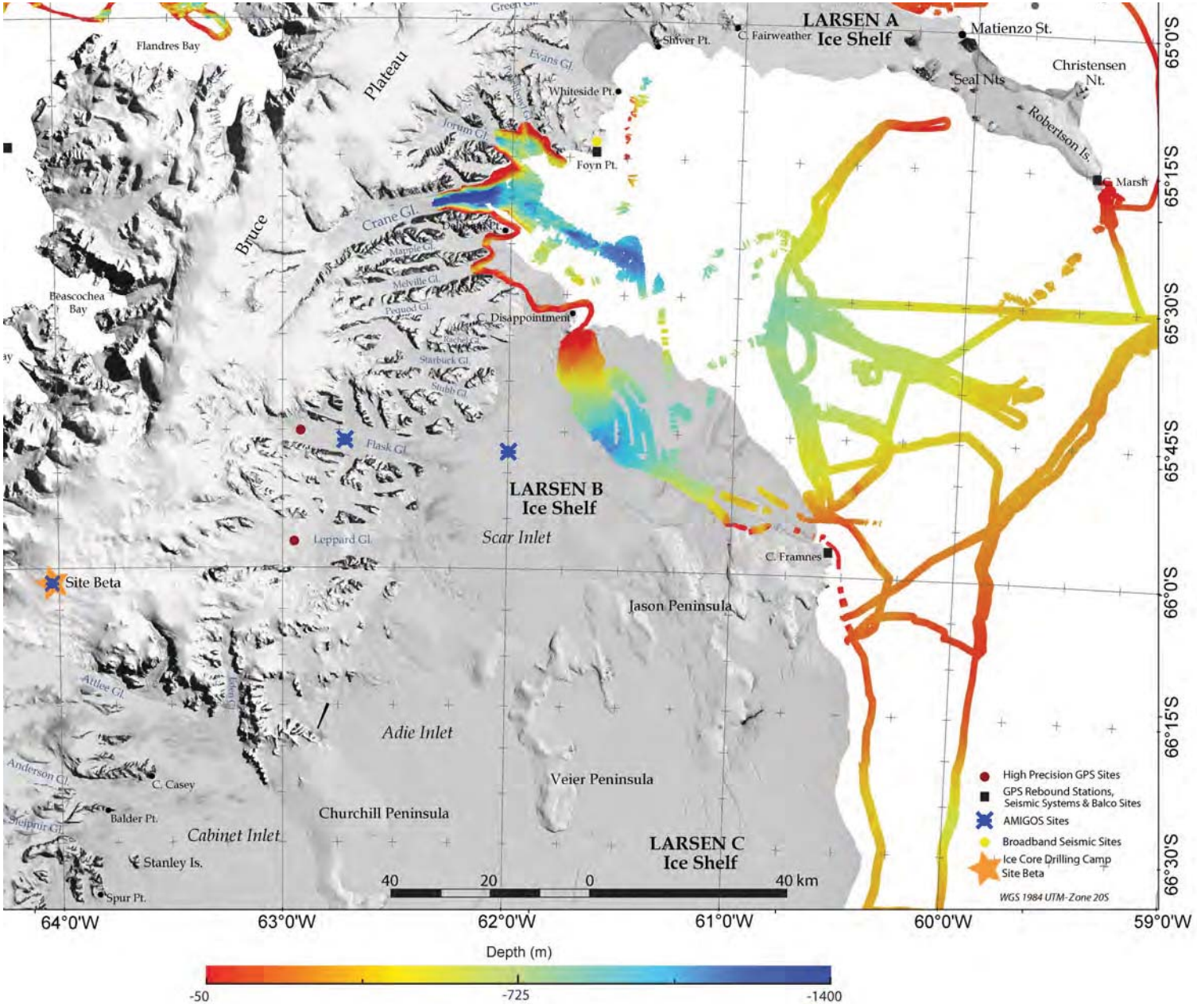
National Snow and Ice Data Center, CIRES, University of Colorado, Boulder

Ronald Ross **Terry Haran** **Anika Petach**

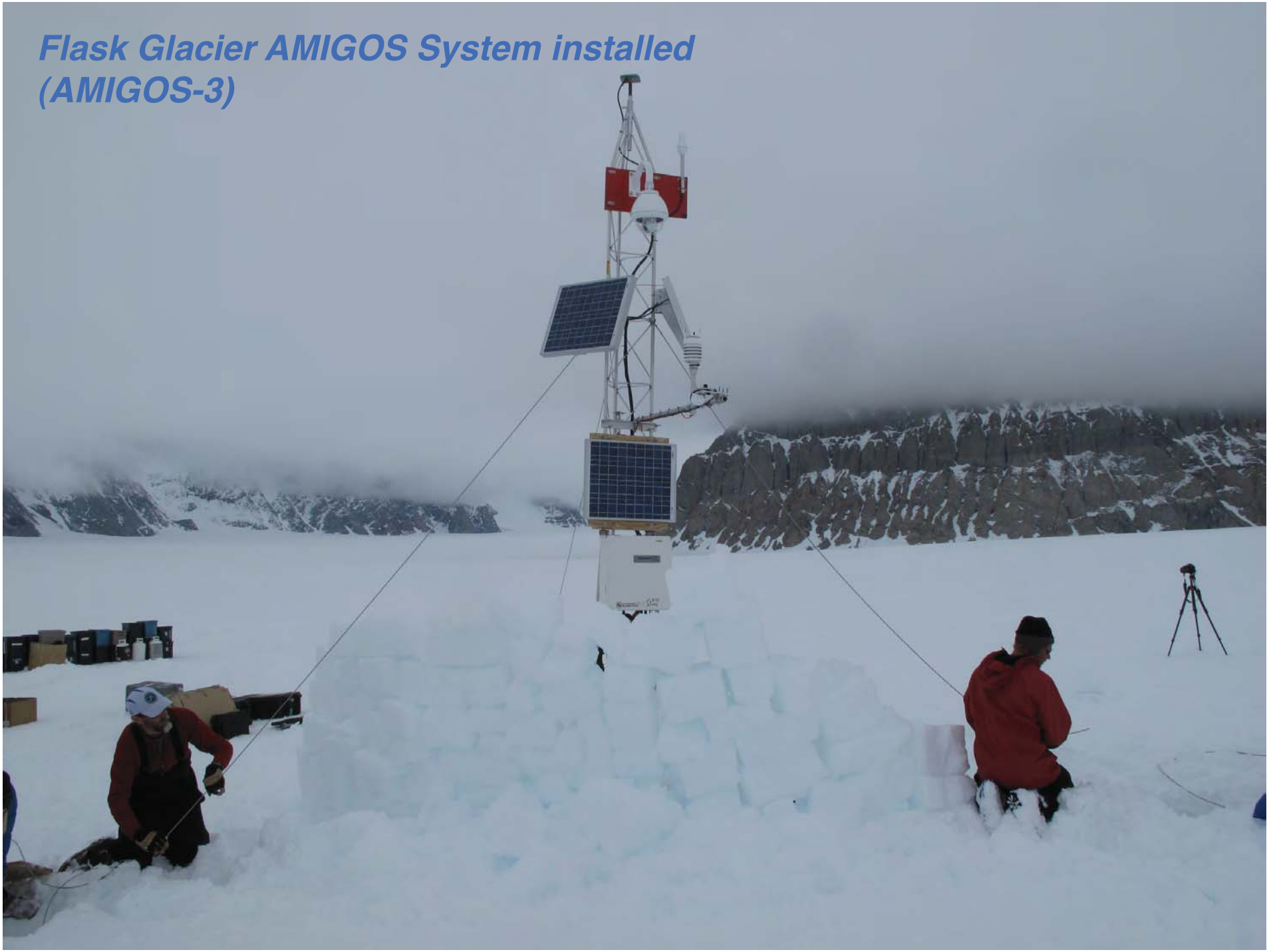
Avega Systems, Sydney Aus.; NSIDC/CIRES, Univ. of Colorado; Harvard University

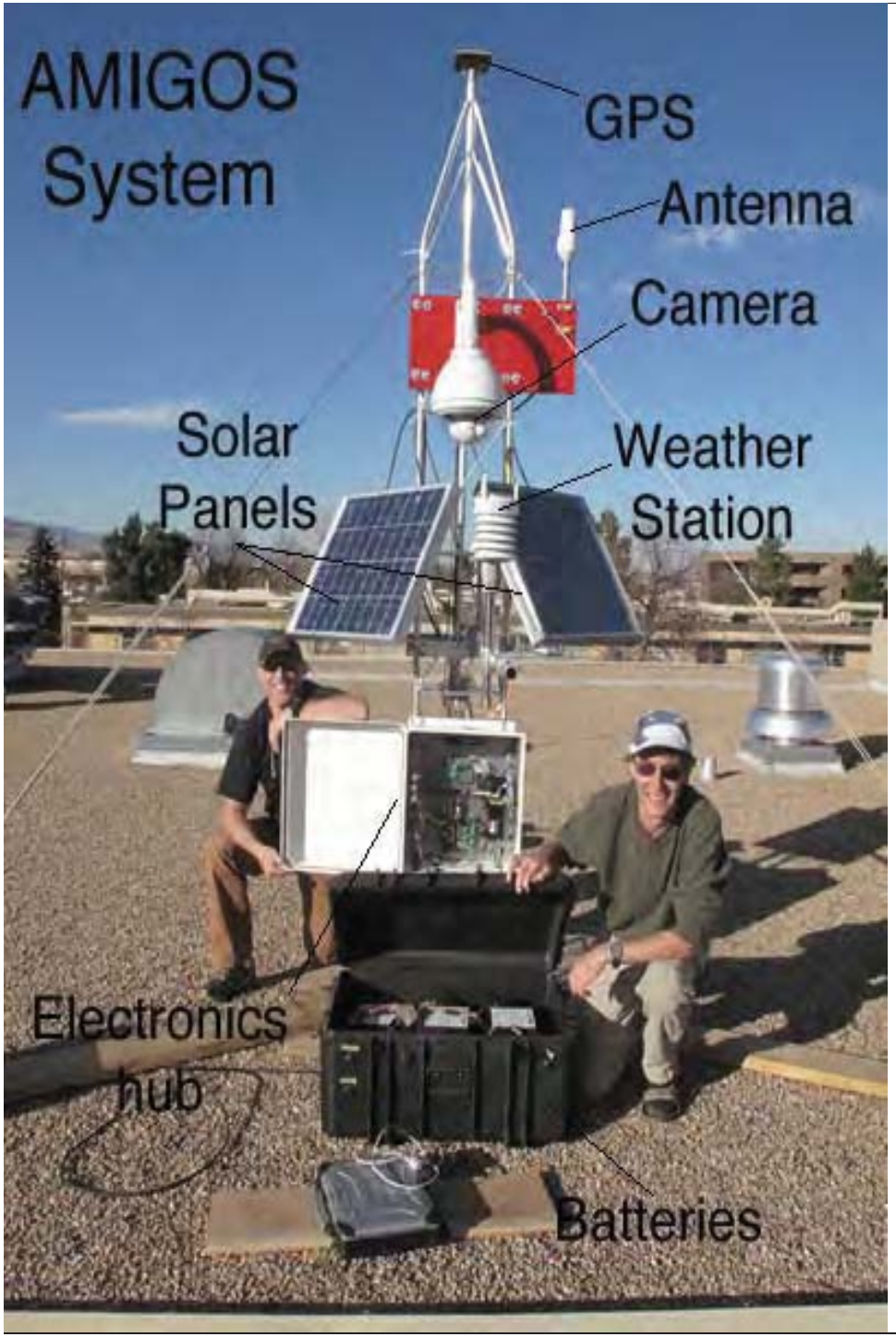
Field work supported by NSF-OPP awards 0732921 and 0540915
Remote sensing supported by NASA award NNG06GA69G

LARISSA Project: 2010 AMIGOS, GPS, and Seismic Installations



Flask Glacier AMIGOS System installed (AMIGOS-3)





Control:
Triton ETN-LP Linux computer
Campbell CR-1000 data logger
INS Spider 5TX-EEC ethernet hub

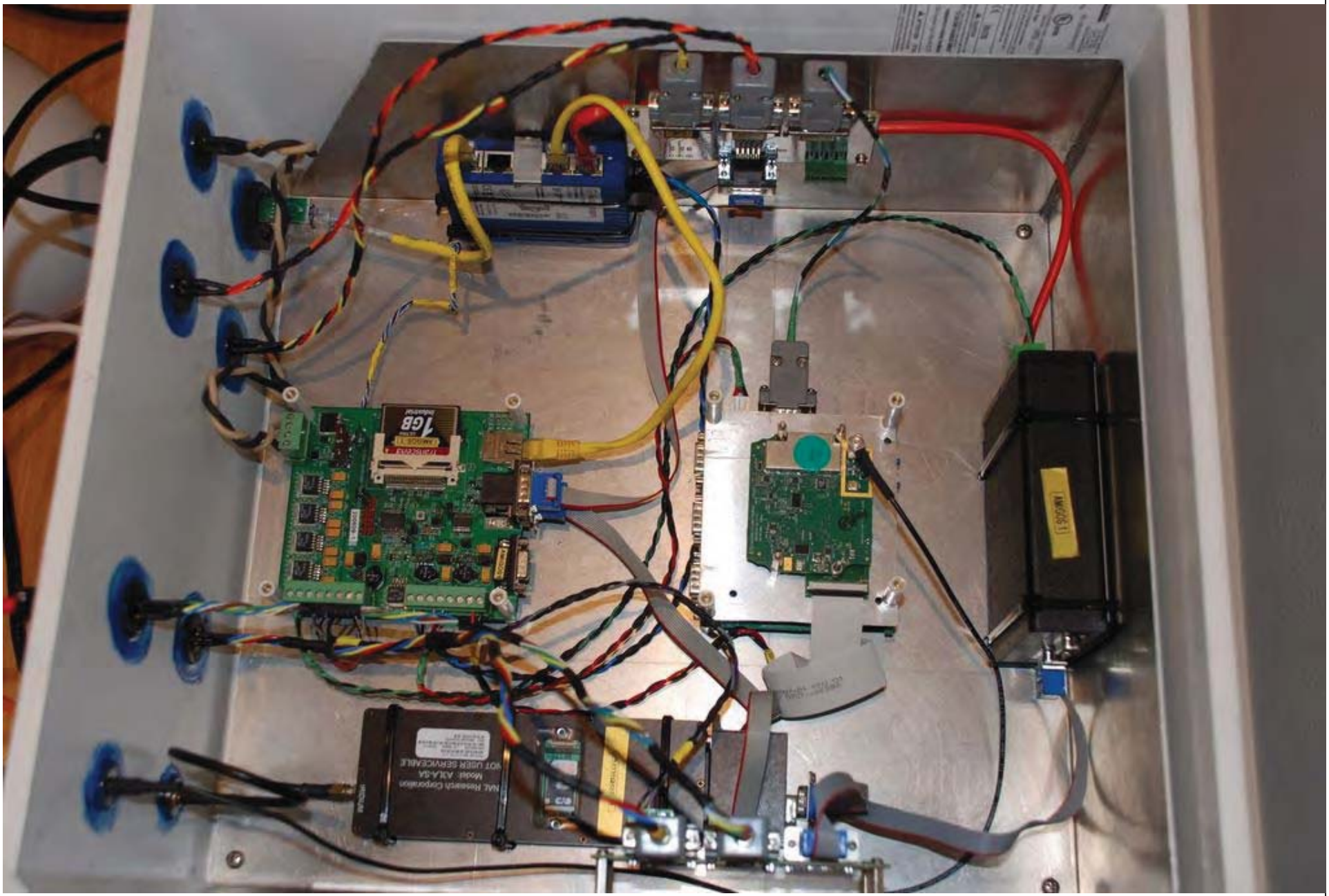
Communications:
NAL A3LA-SA Iridium modem
DCB IP6600 router

Scar and Flask Sensors:
Vaisala WXT510 weather sensor
Apogee SP-212 pyranometers (2)
Sony PTZ color camera*
Topcon GRS-1 precision GPS*
Platinum thermistors (4)*

Site Beta Sensors:
Vaisala WXT510 weather sensor
Apogee SP-212 pyranometers (2)
Campbell SR50A Sonic ranging*
Garmin 17-HVS WAAS GPS*
Platinum thermistors (17)*

Scar and Flask Power:
Flexcharge 20NC12L12F charger
BP-340J 40 watt solar panels (3)
E31SLDGST Deka 12V batteries (4)*

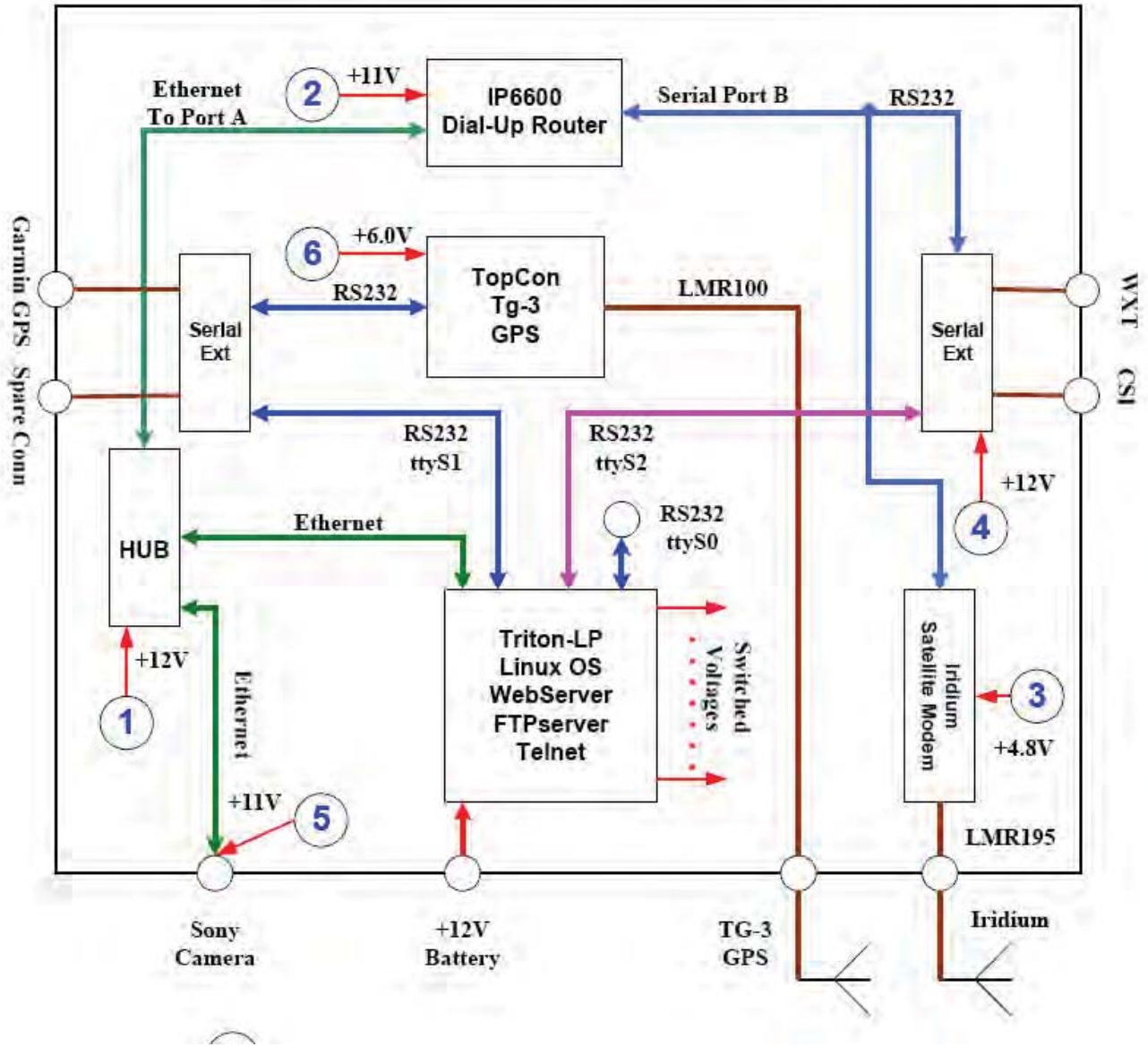
Site Beta Power:
Flexcharge 20NC12L12F charger
BP-340J 40 watt solar panels (3)
E31SLDGST Deka 12V batteries (3)*


1GB
NAL Research Corporation
Model: A3LA-BA
NOT USER-SERVICEABLE

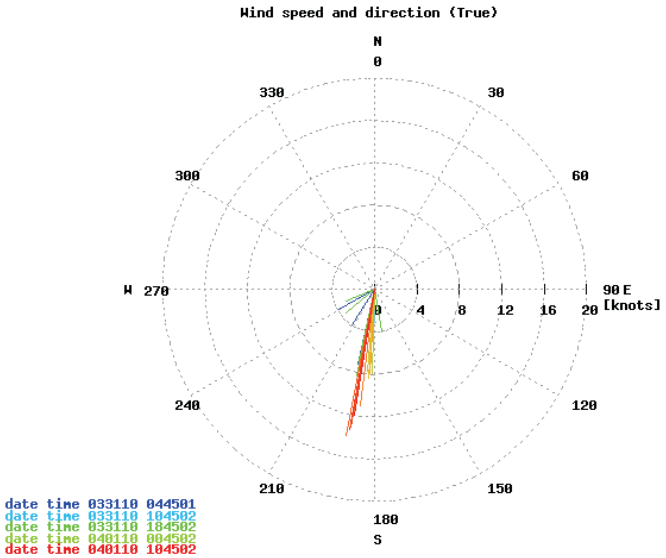
File Edit View Document Tools Window Help

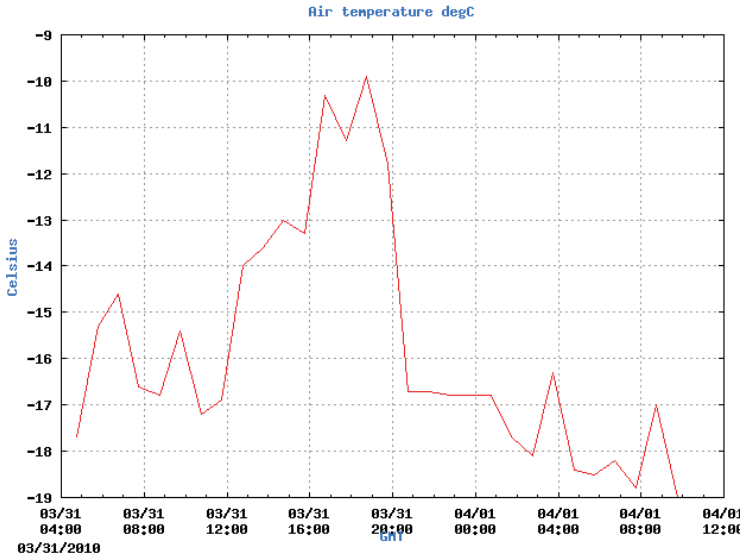
7 / 8 119%

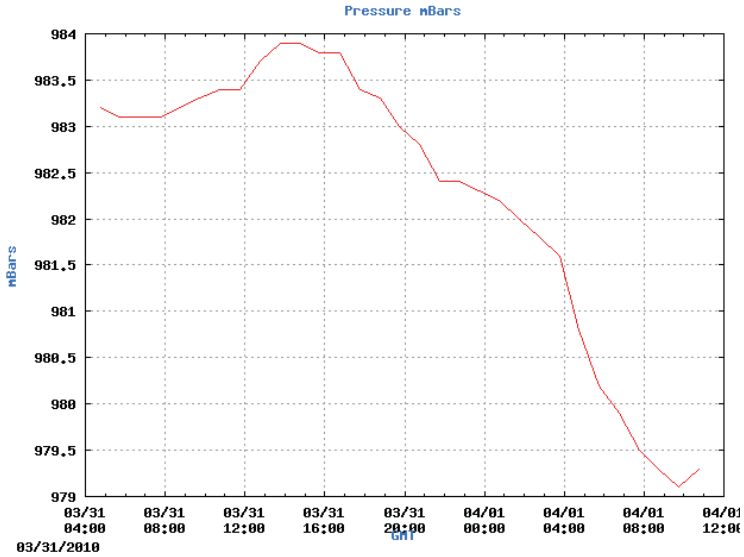
Shelter box wiring diagram

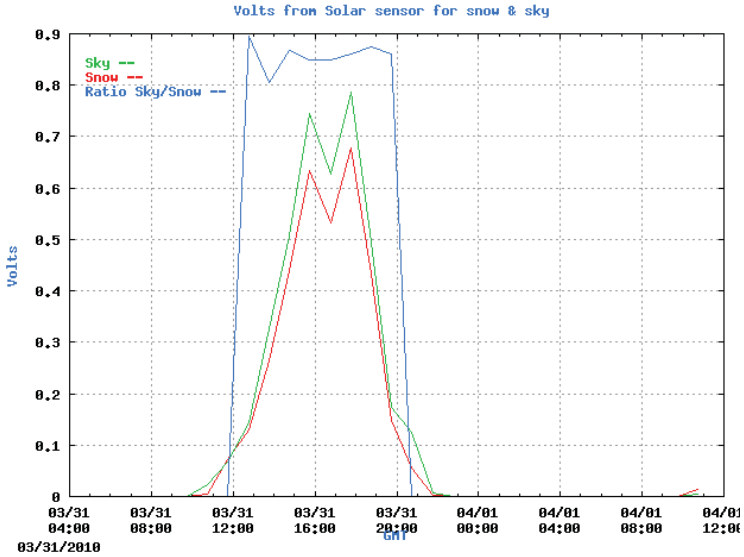


Weather and albedo data from AMIGOS-2, single day









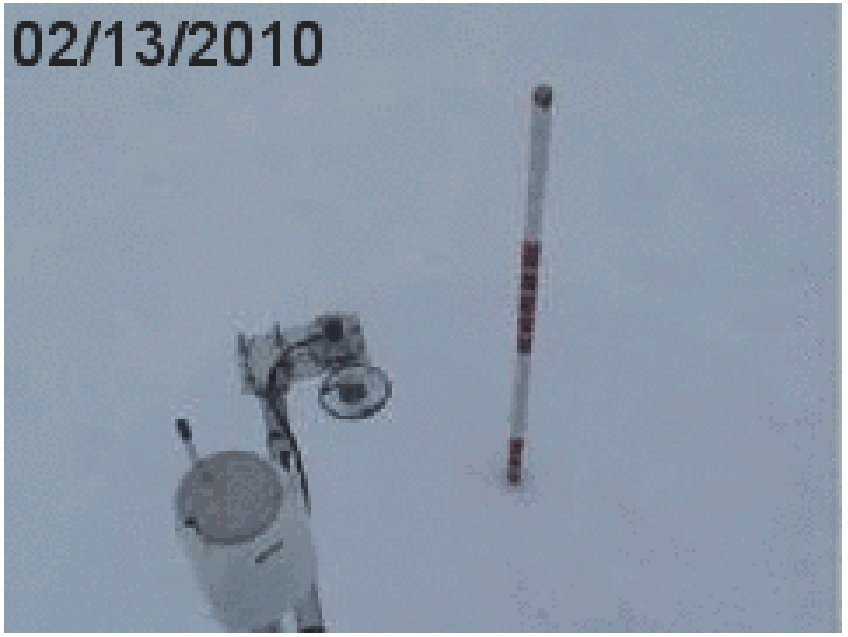
Flask Glacier AMIGOS-3 image set





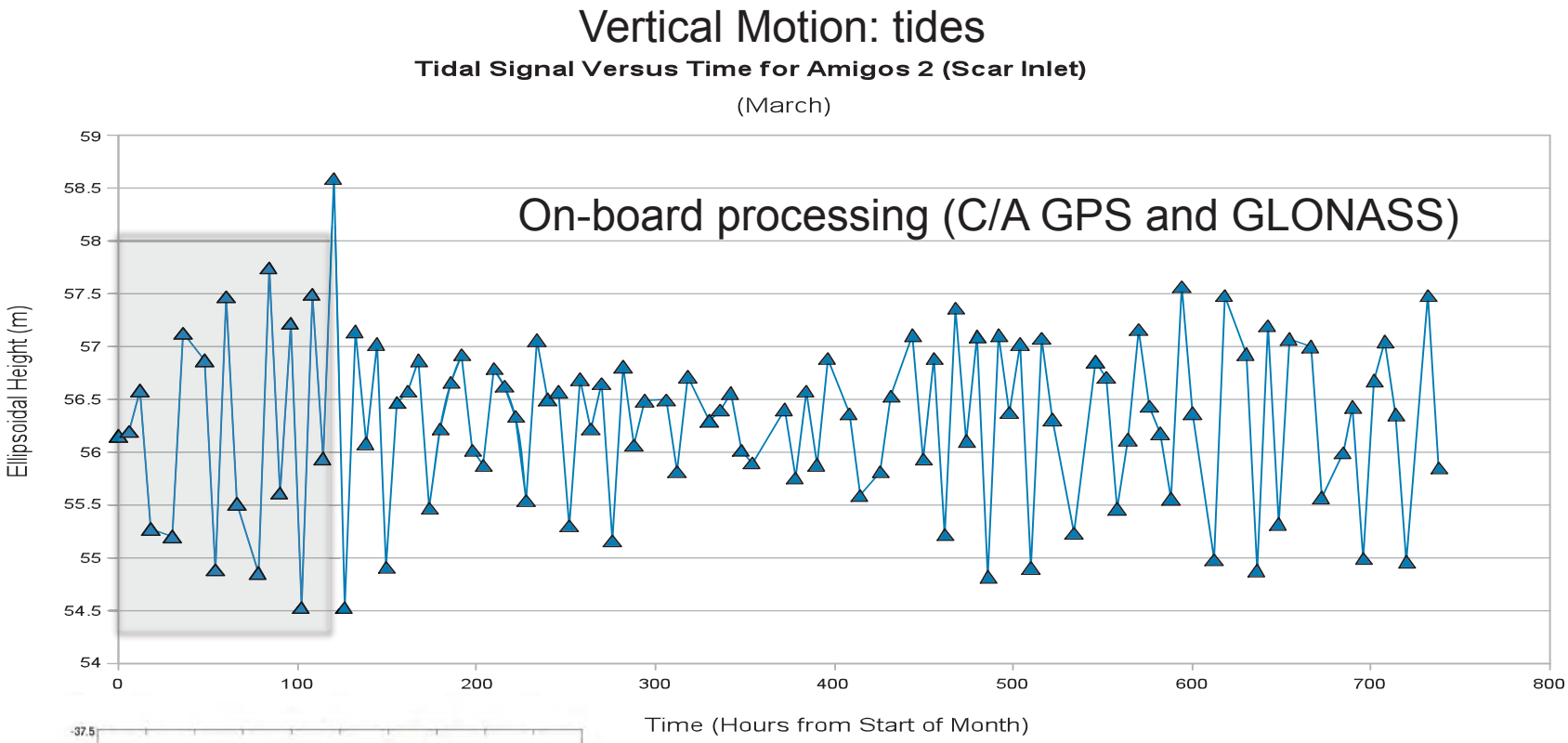

AMIGOS System camera on Scar Inlet and Flask Glacier: accumulation pole movies

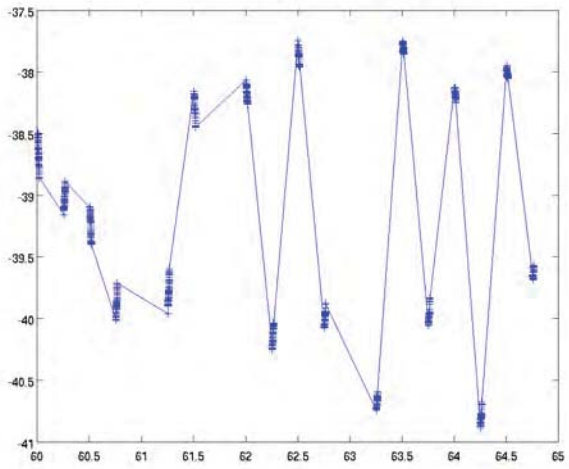
SCAR Inlet:
Near-zero net accumulation in 6 months



Flask Glacier:
~0.7 m net accumulation in 6 months

Precision GPS results for AMIGOS -2 Scar Inlet





Differential processing (GAMIT Track);

Geoid height

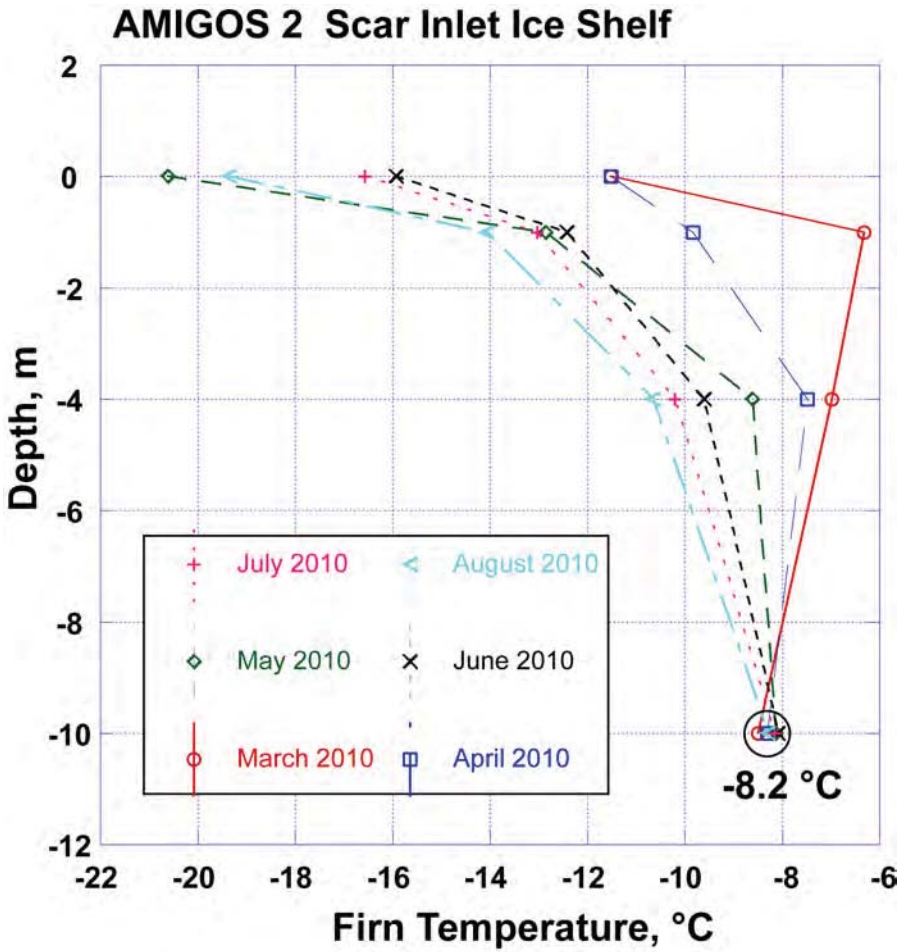
March 2010 ice flow speeds:

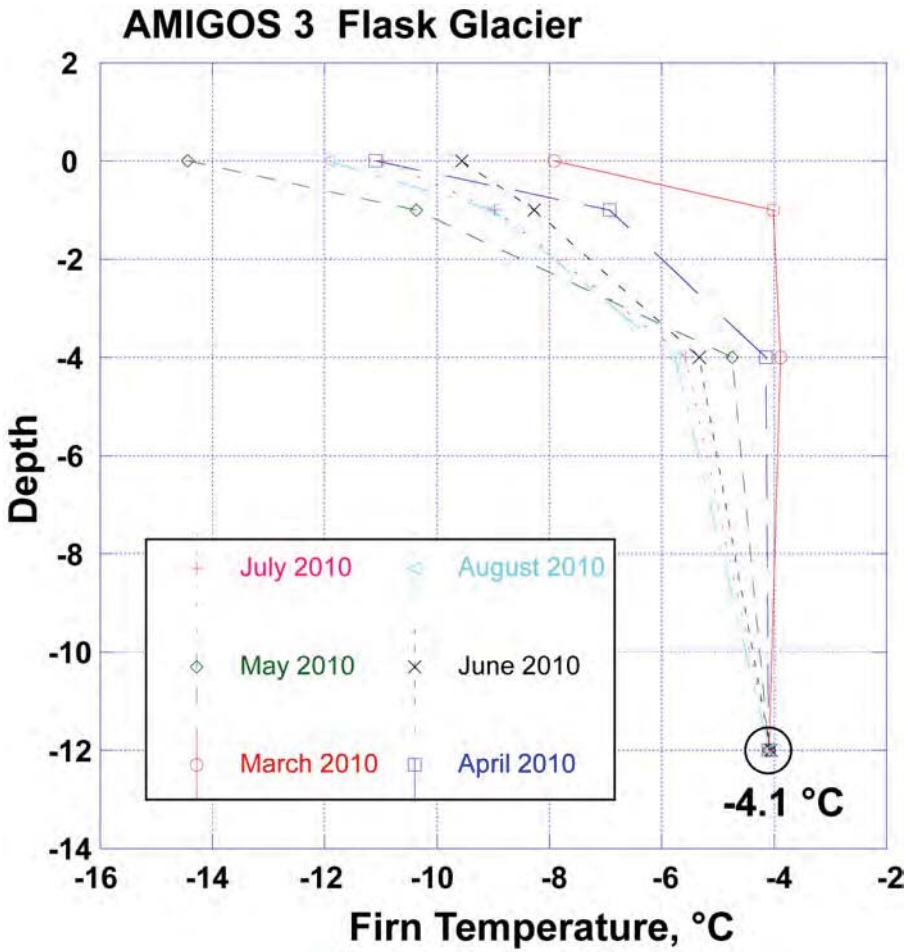
Scar Inlet: 641.0 m/yr
Flask Gl.: 258.4 m/yr

Little change since 2006;
Some acceleration since 2002?

AMIGOS 2 and 3 Firn Temperature profiles:

Scar Inlet near the shelf stability limit; Flask is even warmer

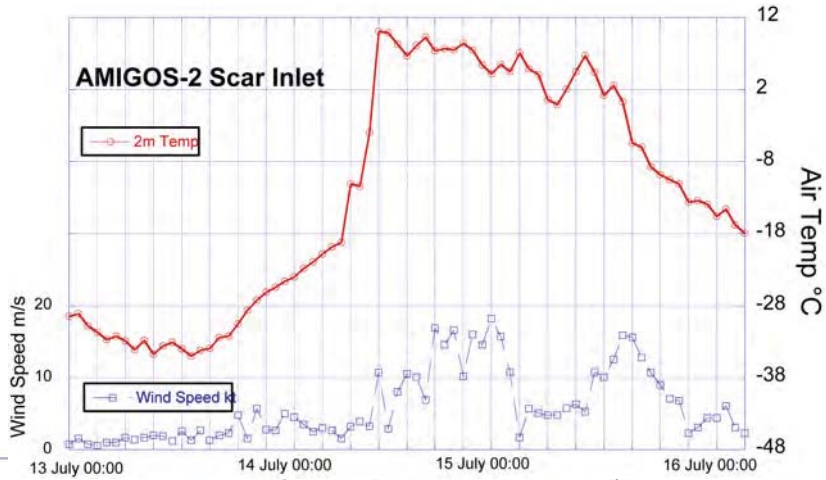




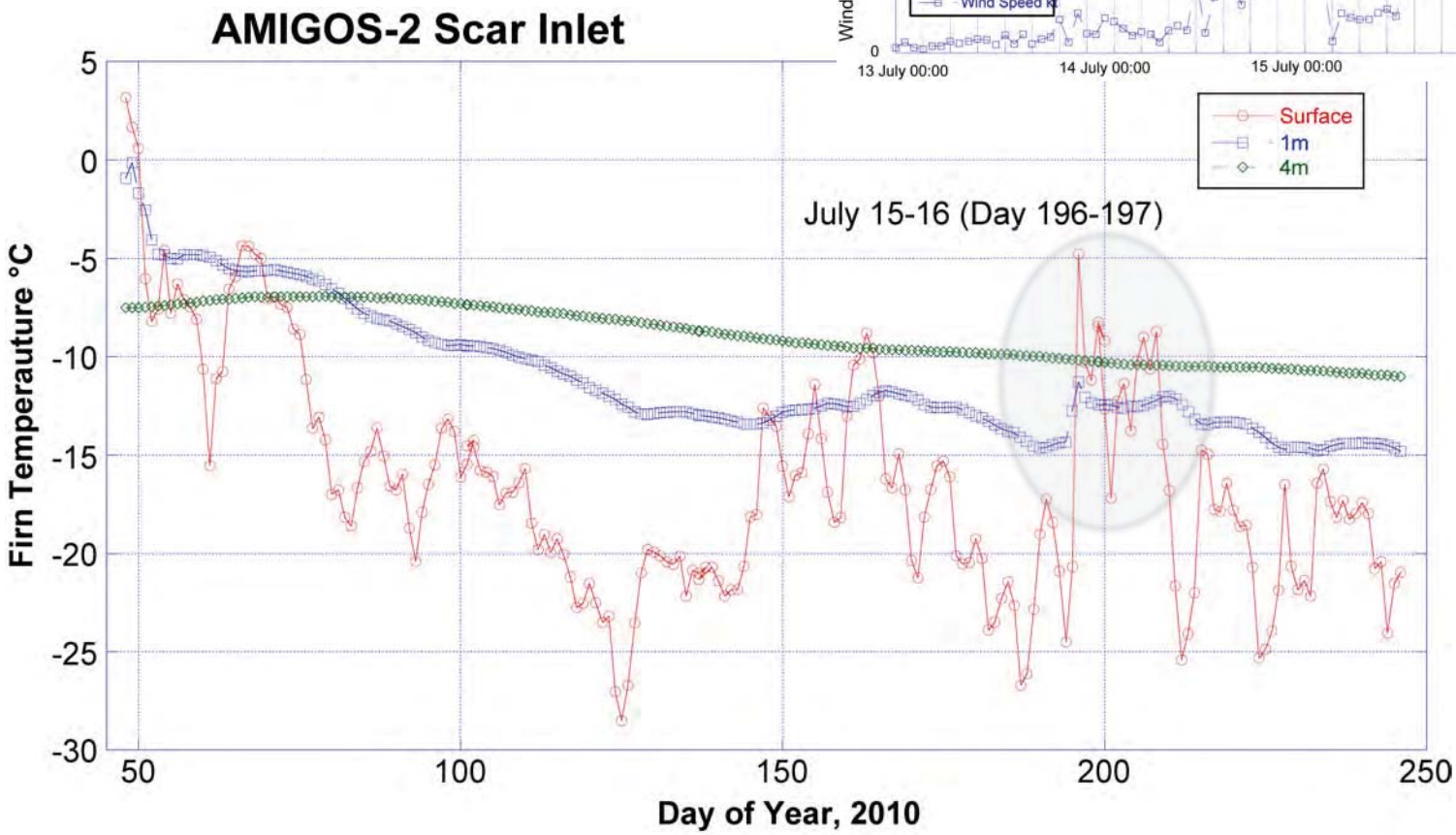
AMIGOS 2 Temperature: melt detection

Mid winter melt event – July 14-15-16

Weather data:



Firn thermistor data:

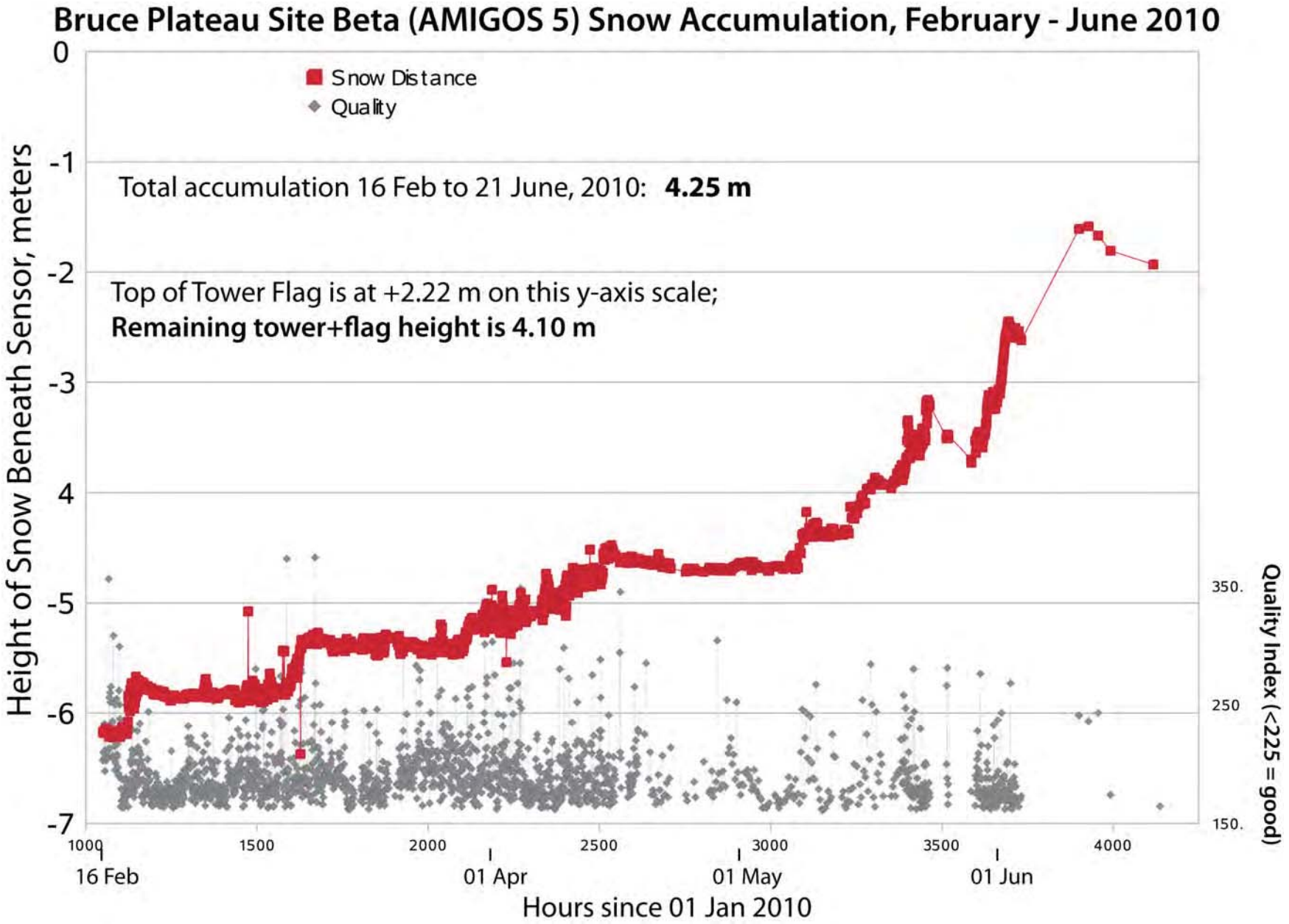


Bruce Plateau AMIGOS System

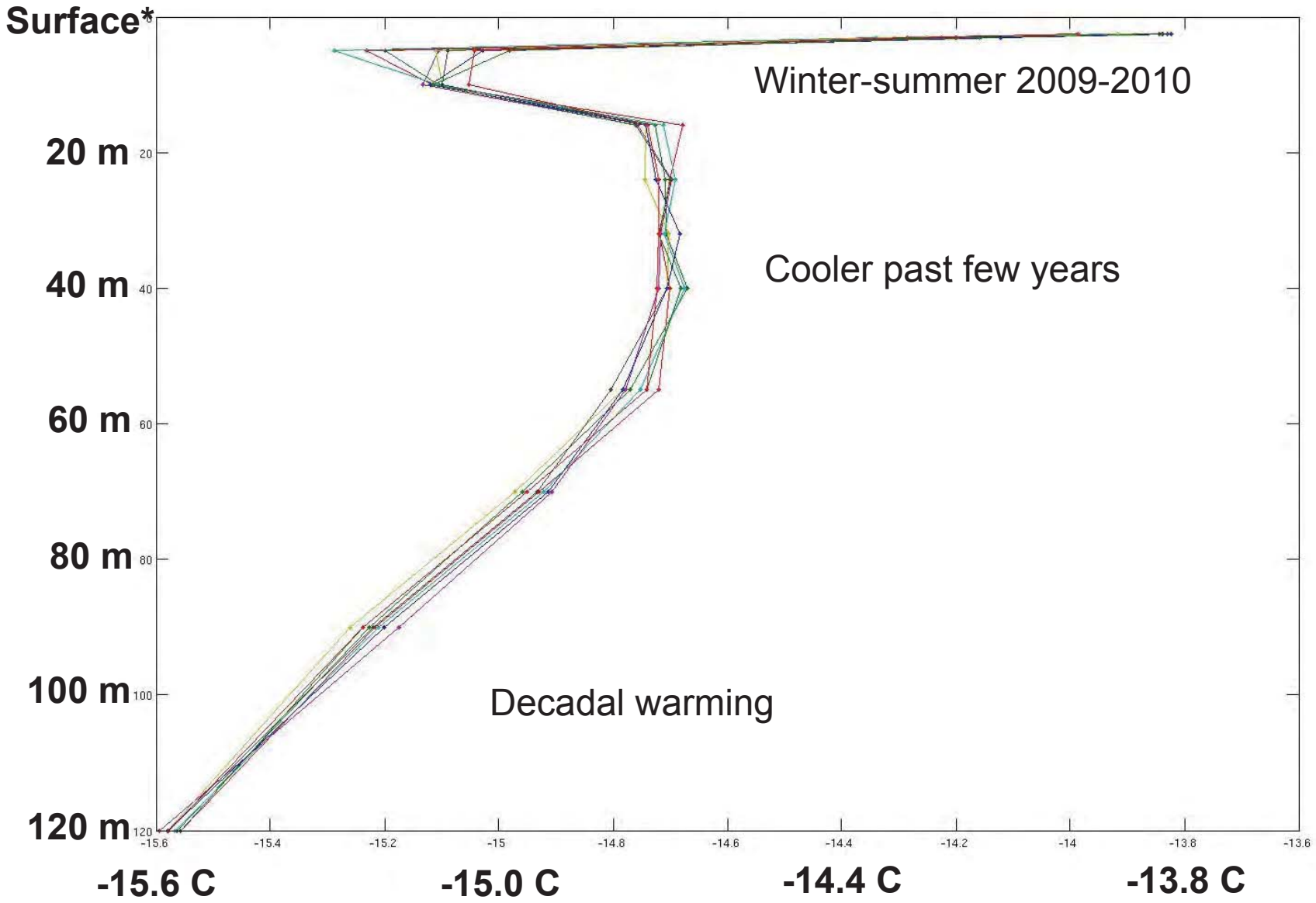
- Sonic snow height sensor
  accumulation rate
- Weather data
  Vaisala system:
  wind, temp, press, humid
- Albedometer
  solar power, surface melt onset
- Thermistor string (120 m)
  mean annual temperature
  temperature history for past 10-20 yrs.

NO LONGER TRANSMITTING:

SNOW BURIAL RATE ~1m/month


Bruce Plateau Site Beta (AMIGOS 5) Snow Accumulation, February - June 2010
Snow Distance
Quality
Total accumulation 16 Feb to 21 June, 2010: 4.25 m
Top of Tower Flag is at +2.22 m on this y-axis scale;
Remaining tower+flag height is 4.10 m
Height of Snow Beneath Sensor, meters
0
-1
-2
-3
4
-5
-6
-7
Quality Index (<225 = good)
350.
250
150.
1000
1500
2000
2500
3000
3500
4000
16 Feb
01 Apr
01 May
01 Jun
Hours since 01 Jan 2010

Bruce Plateau 120 m firn thermal profile, March-April 2010



'Ridge Cam' AMIGOS System, for high-resolution images overlooking the glaciers or ice shelves

AMIGOS:
Automated **M**et-**I**ce-**G**eophys.
Observing **S**tations

- Hi-Res Camera
  three 12 megapixel images,
  2x /day
  surface processes,
  crevassing, calving

- Weather data
  Vaisala system:
  wind, temp, press, humid

- Albedometer
  solar power, surface melt onset

NOT YET INSTALLED;

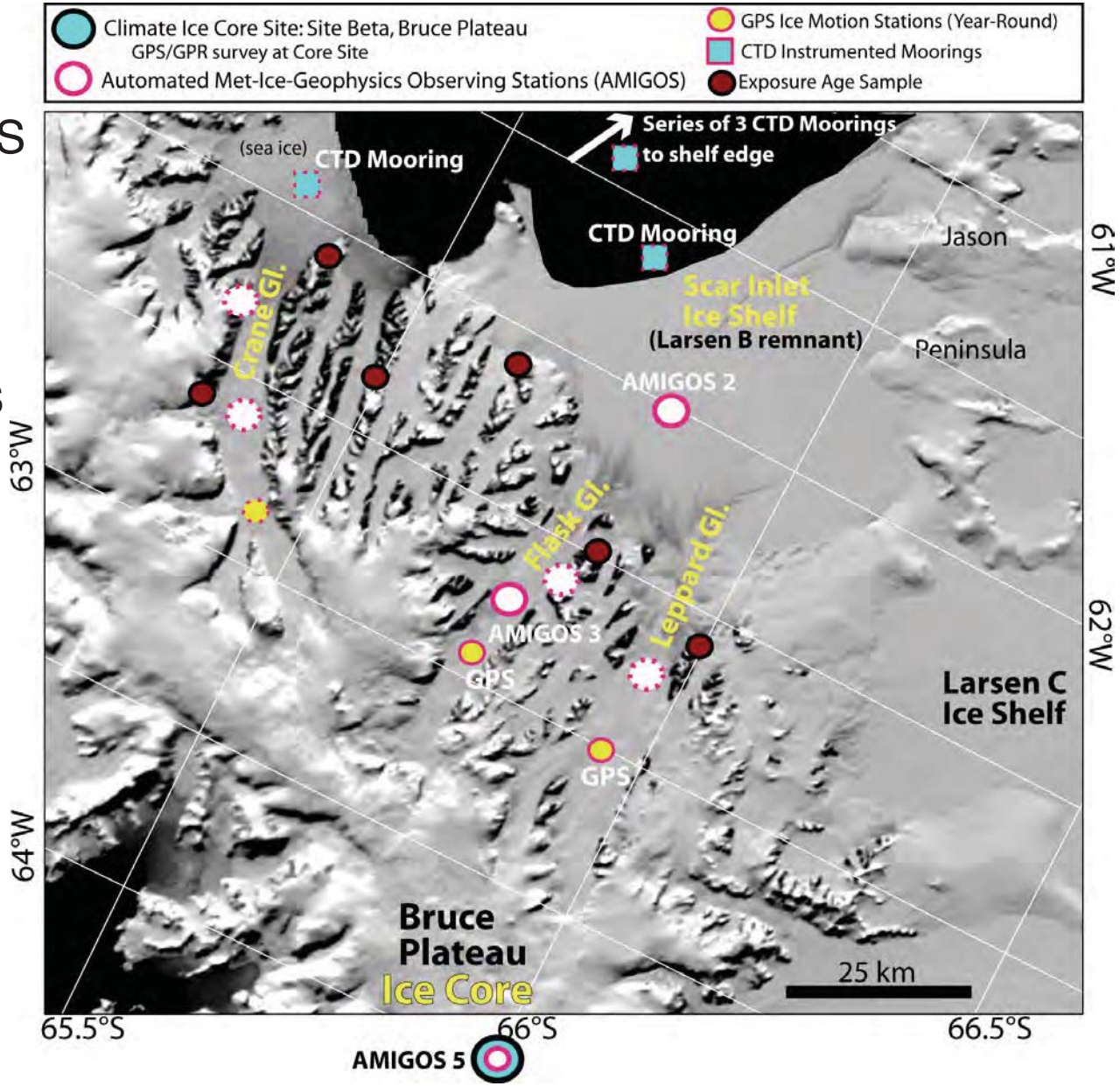
REQUIRES HELICOPTER TO INSTALL AND REMOVE
4 Hours Ground Time

Plans for Further Installations in 2011/2012

- **Crane Glacier**
  Ice front Hi-Res AMIGOS
  Glacier AMIGOS
  Precision GPS

- **Flask Glacier**
  Ridge-top Hi-Res AMIGOS

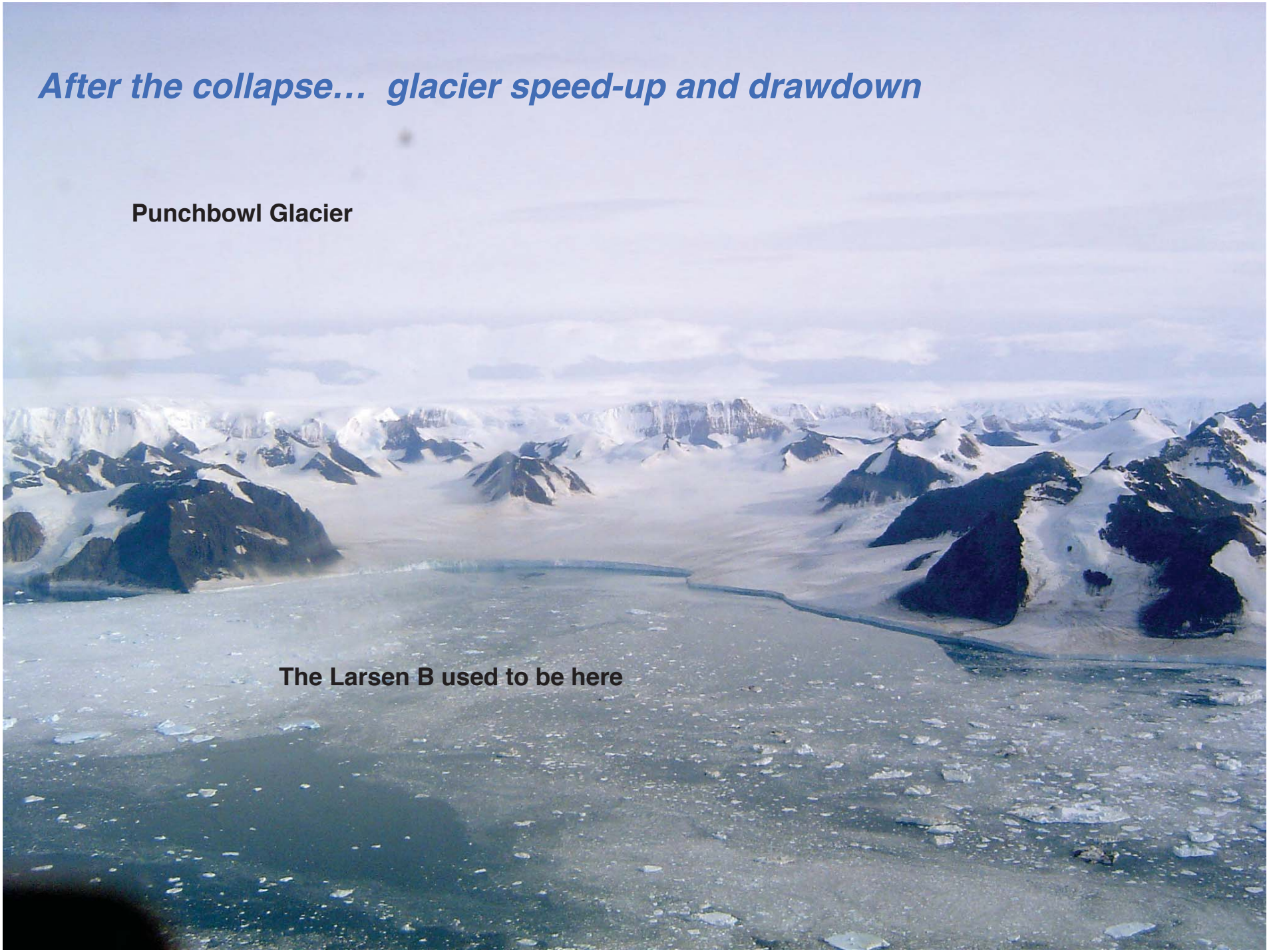
- **Leppard Glacier**
  Glacier AMIGOS




Crane Glacier - new AMIGOS and GPS sites in 2013
Thank you
Questions?


Thank you
Questions?

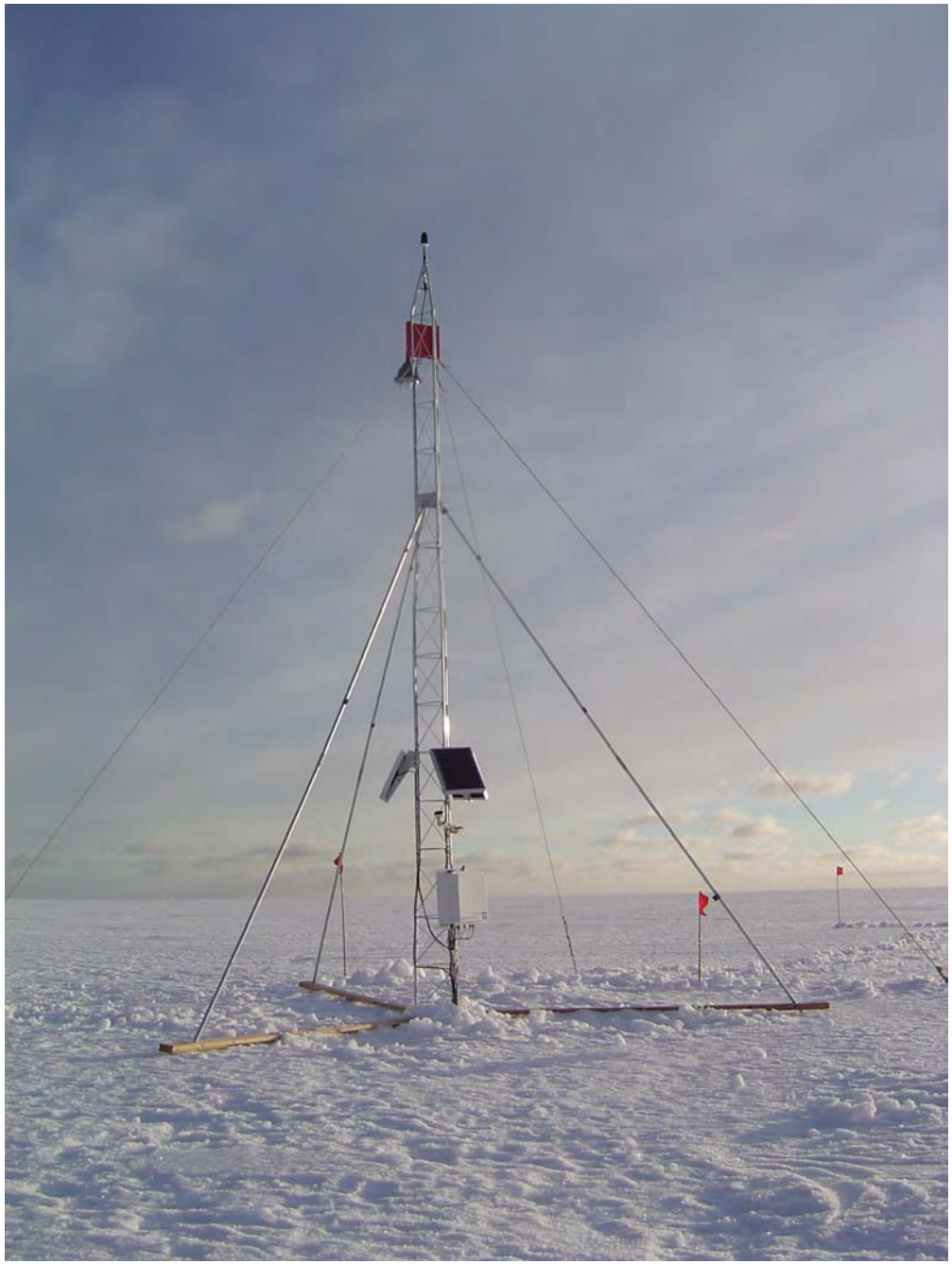
After the collapse… glacier speed-up and drawdown



Iceberg evolution during drift -

AMIGOS:
Automated
Met-**I**ce-**G**eophys.
Observing **S**tations

- GPS
- Camera
  - flag lines
  - accum/ablate
  - surface events
- Weather data
- Ice thickness and melt rate
  - didn't work…



Iceberg evolution during drift - Automated station science results

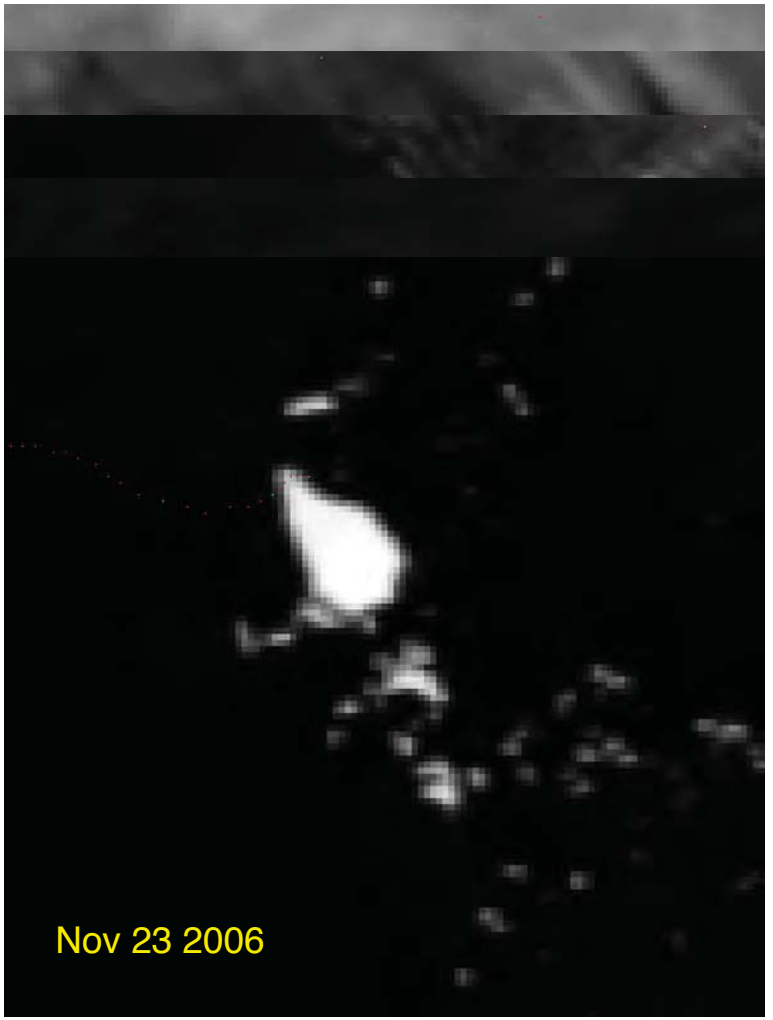

A22a station, March 19 2006

Lots to look at --

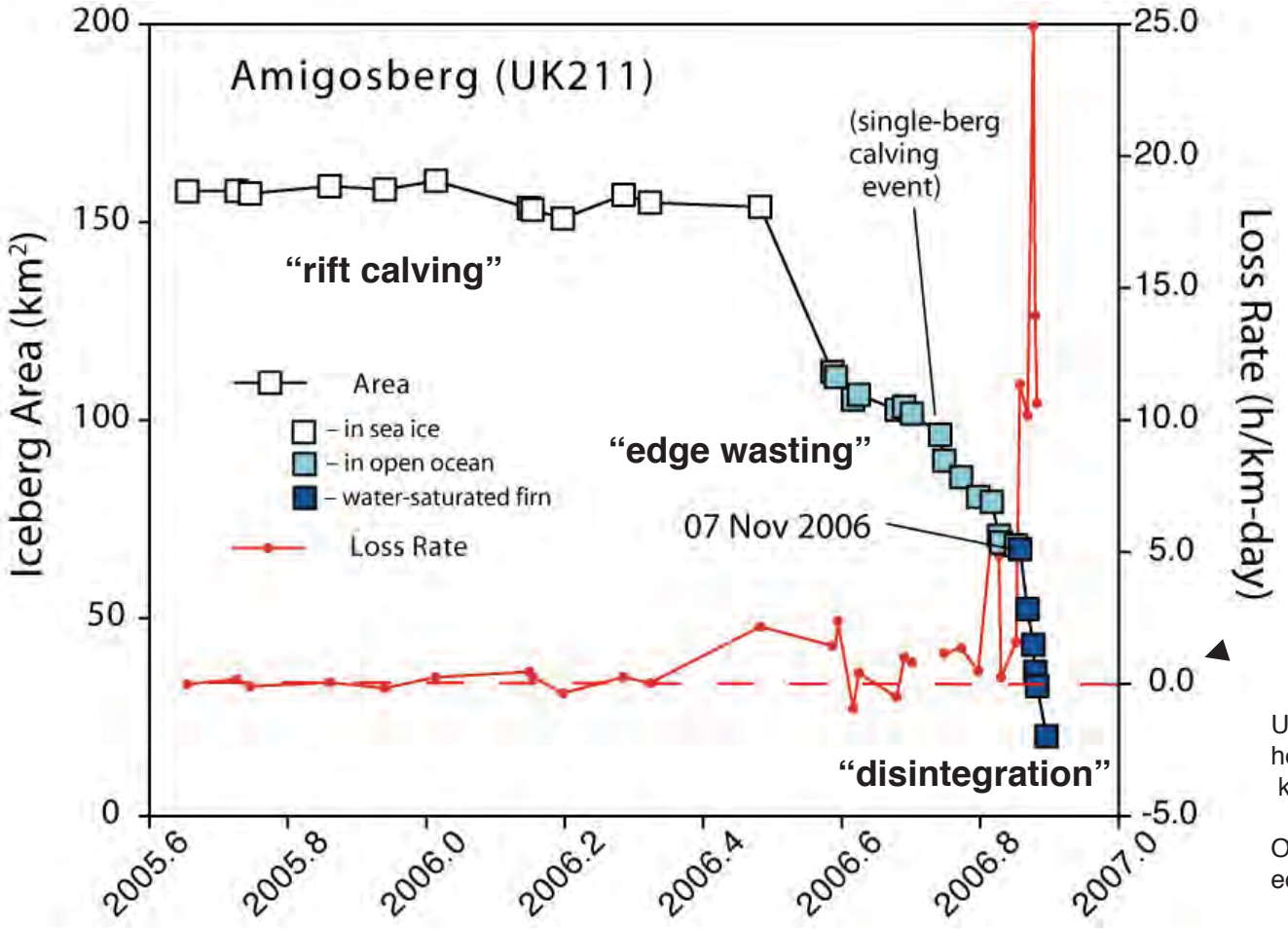
- accumulation mast
- flag line
- (barrel)
- your feet
- yourself

..and record the weather and GPS position

Iceberg evolution during drift - AMIGOSberg disintegration: water



Iceberg 'edge-wasting' loss rates - three stages



Units here:
hectares per day per kilometer ice edge

Or -- 1 unit equal 10 m edge retreat per day

Scambos et al., 2008 J. Glac.

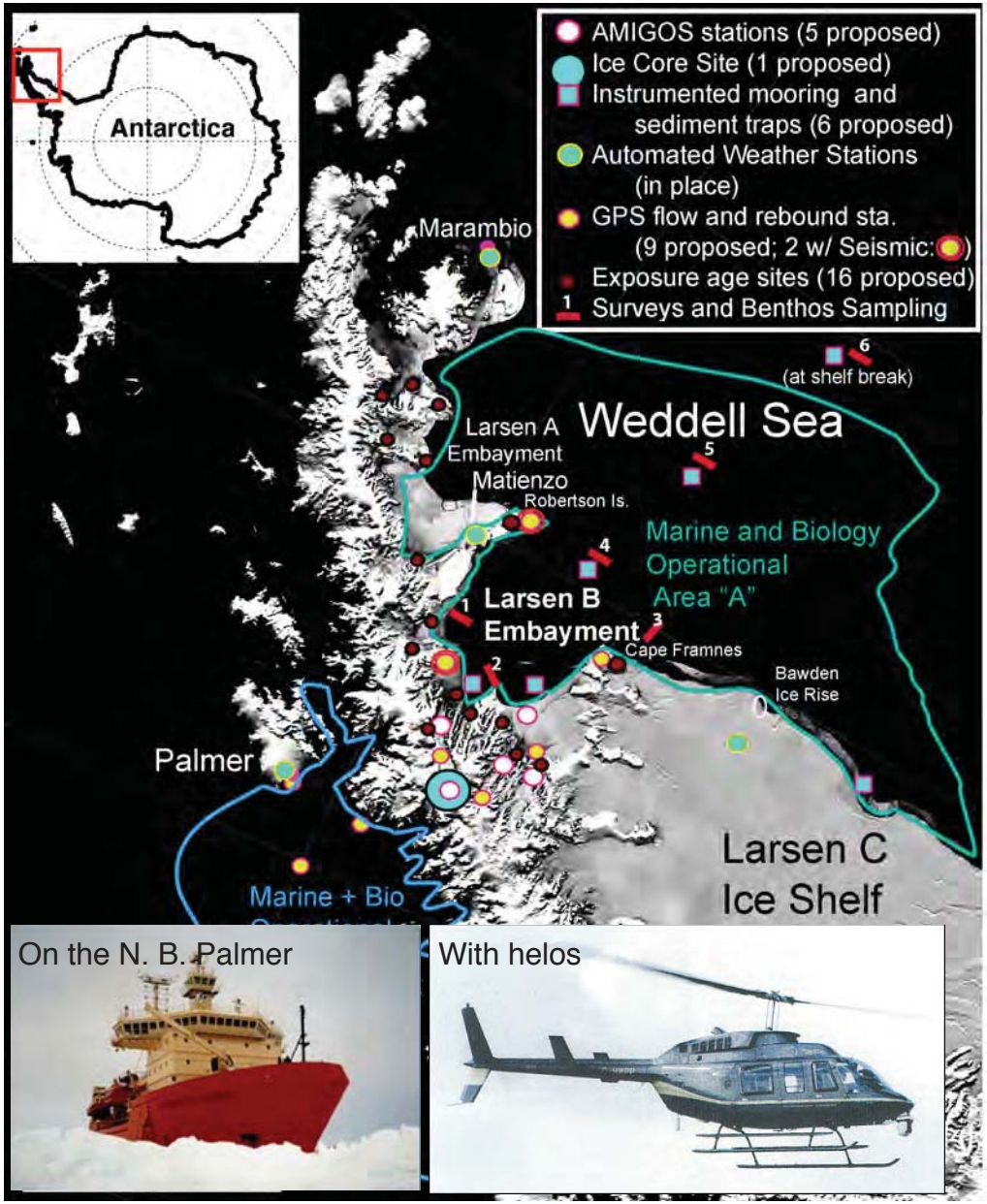
LARISSA: Larsen Ice Shelf System, Antarctica

3 linked studies:

Marine Geology
E. Domack*, A. Leventer, S. Brachfield, et al.

Cryosphere and Oceans
T. Scambos, M. Truffer, E. Pettit, B. Huber
L. Thompson and E. Mosley-Thompson

Ecosystems
M. Vernet, C. VanDover, C. Smith, , et al.



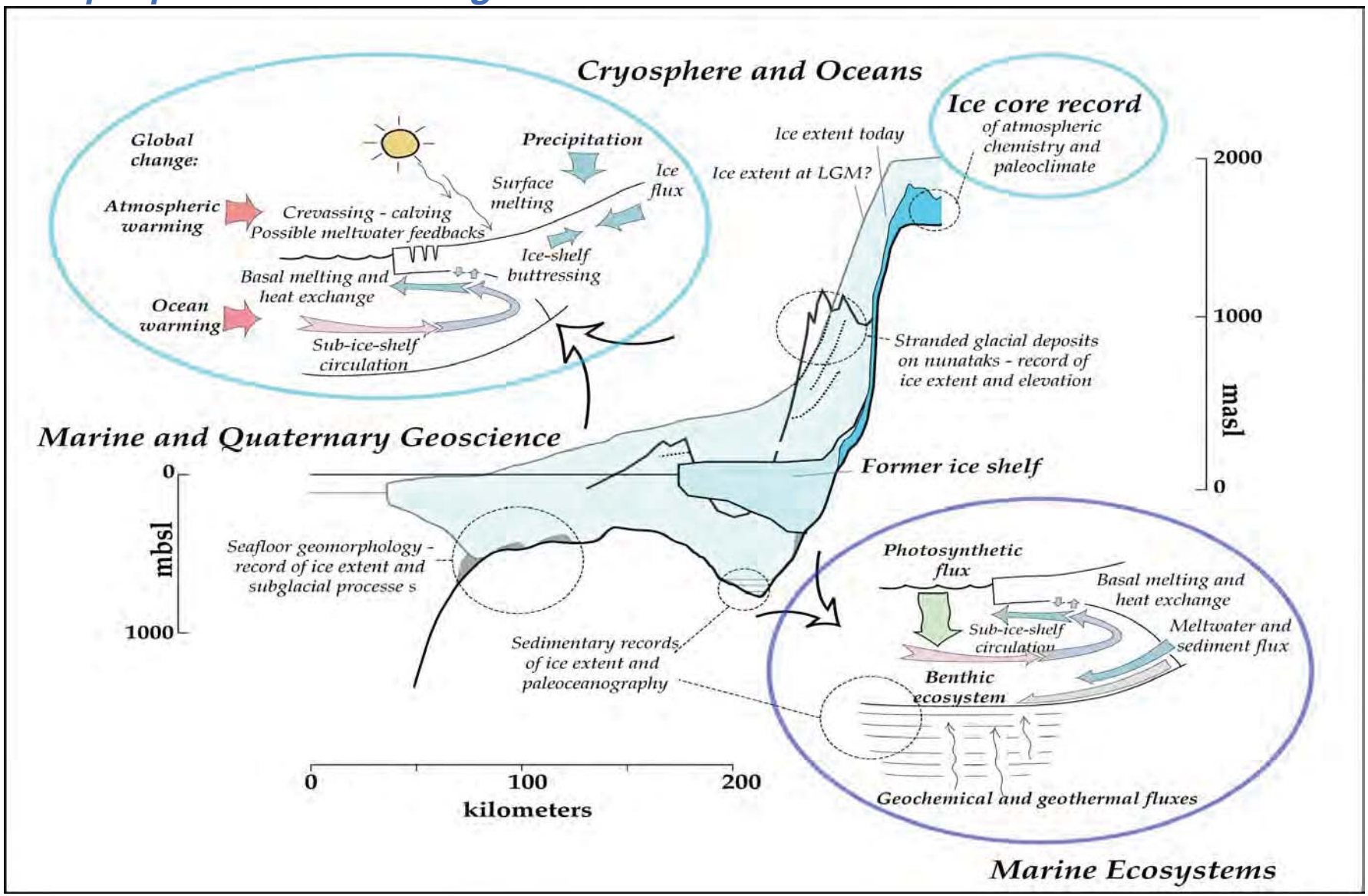
CRYOSPHERE AND OCEANS:

- Ice core on Bruce Plateau (~400m)
  (L. Thompson, E. Mosley-Thompson)

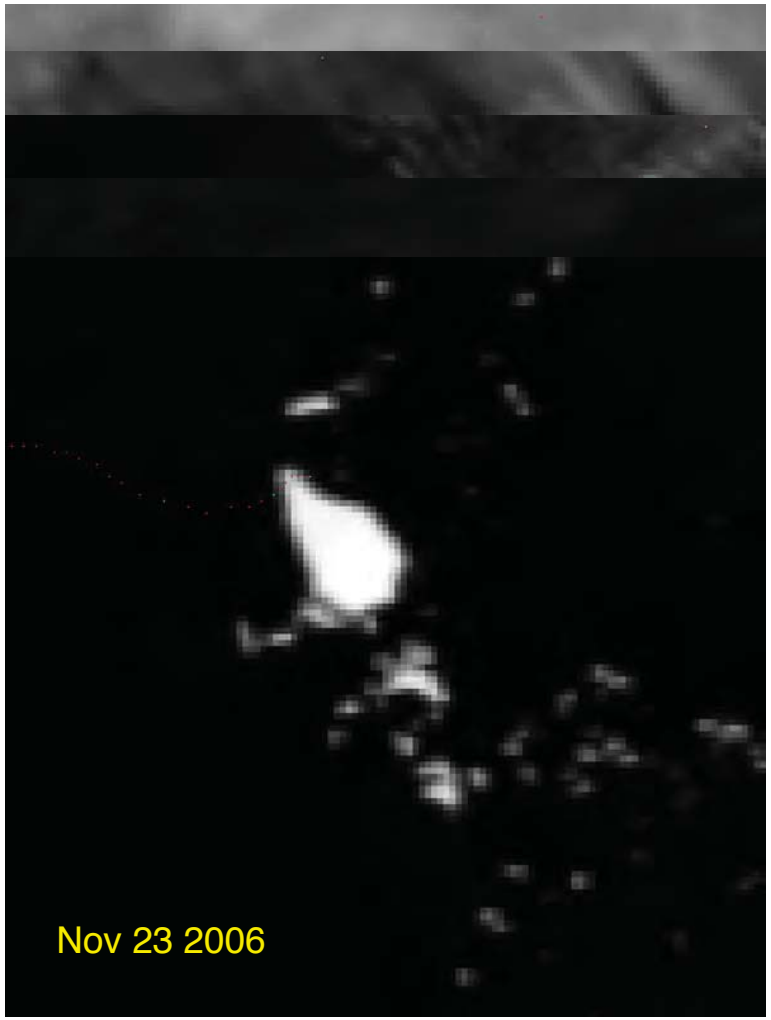
- Met data and ice geophysics, ('AMIGOS'); GPR surveys; flowline models and others
  (T. Scambos, M. Truffer, E. Pettit)

- Ocean circulation, exchange
  (A. Gordon, B. Huber)

LARISSA: how ice sheets, marine geosystems, and the biosphere respond to rapid polar climate change



Iceberg evolution during drift - AMIGOSberg disintegration: water



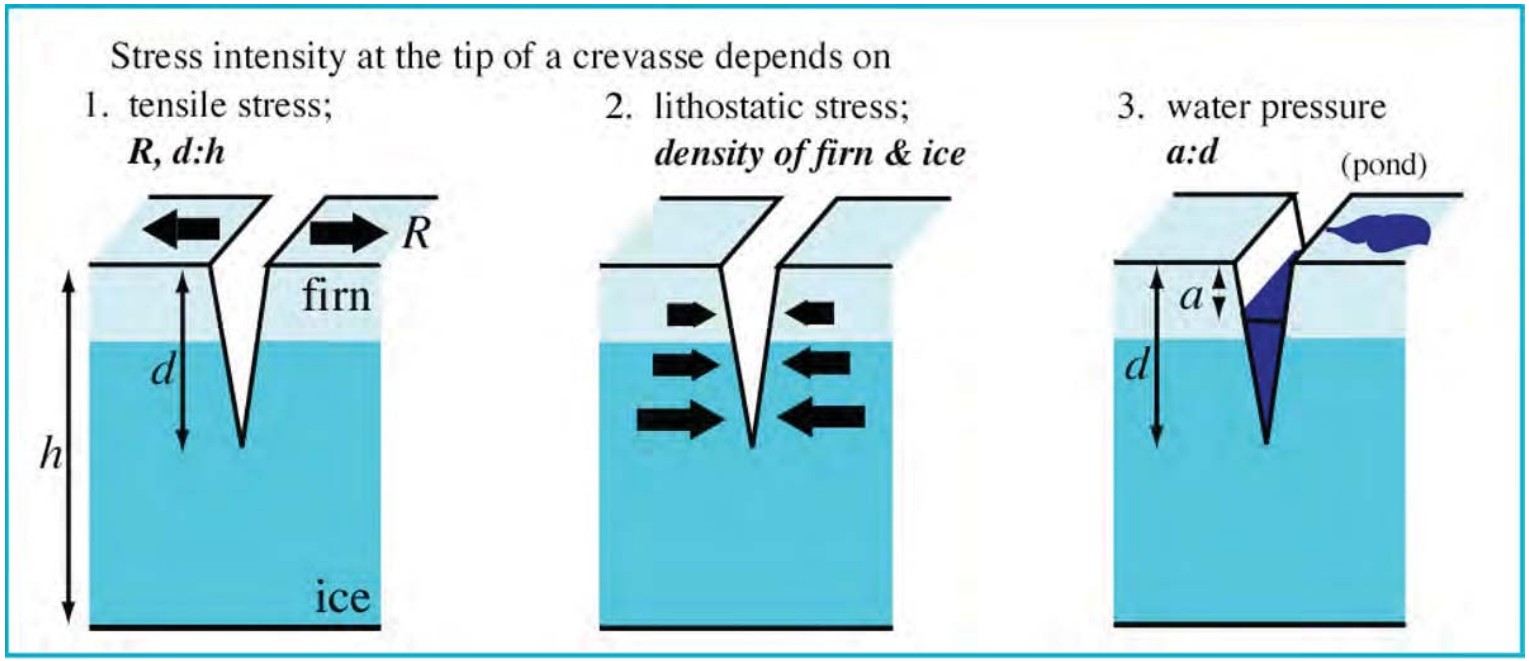
Saturated firn can initiate a 'disintegration-style' break-up

Scambos et al., 2008 J. Glac.


NATHANIEL B. PALMER


NATHANIEL B. PALMER

How a small amount of melt has a magnified effect…
(Weertman, 1973)

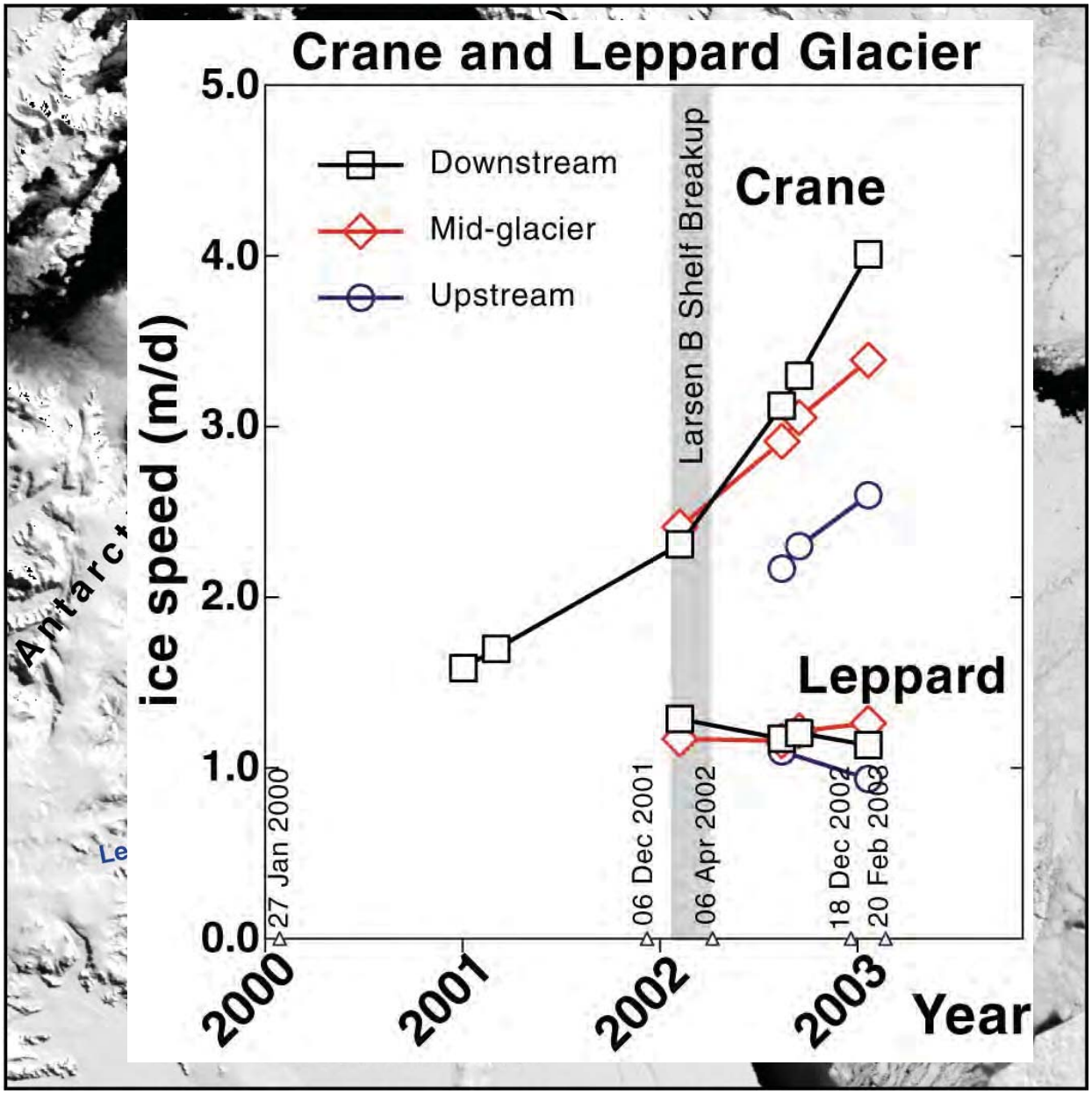


Other components of a ‘disintegration’-style collapse:

- pre-existing crevasses, e.g. from glacier stresses or ice front stresses;
- low compression within the shelf (explains George VI, Amery)
- a surface reservoir of water to fill the as fracture as it deepens (e.g., ponds)

Scambos et al., 2003 Ant. Res. Series

After the shelf was lost, glaciers began to accelerate.



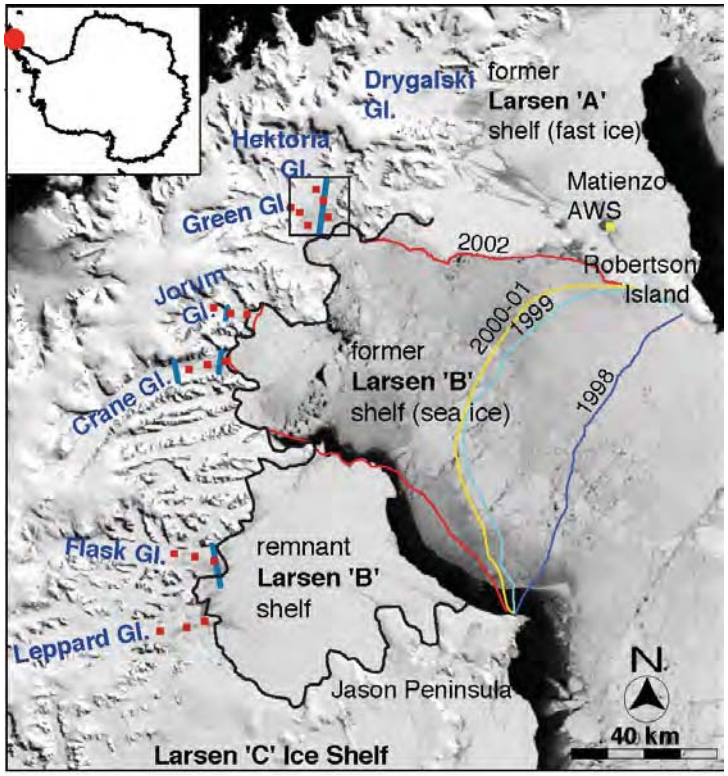
Larsen B Embayment:

A significant speed increase occurred for all glaciers feeding the breakup areas.

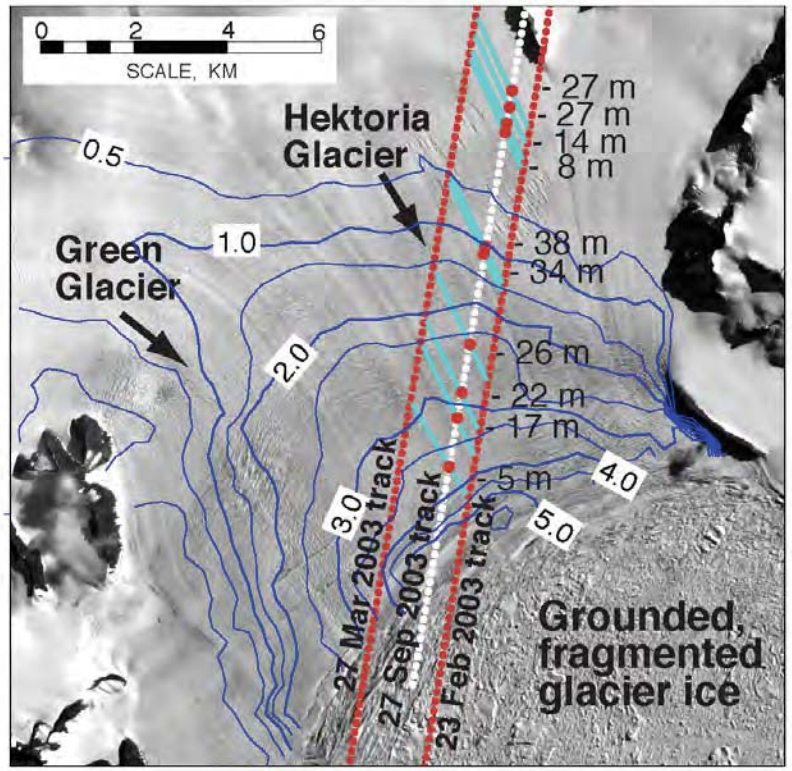
No ice speed change was observed in glaciers south of the break-up zone.

Ice shelves - the gatekeepers of mass balance change

Glaciers feeding the Larsen B accelerated and thinned after disintegration of the ice shelf --



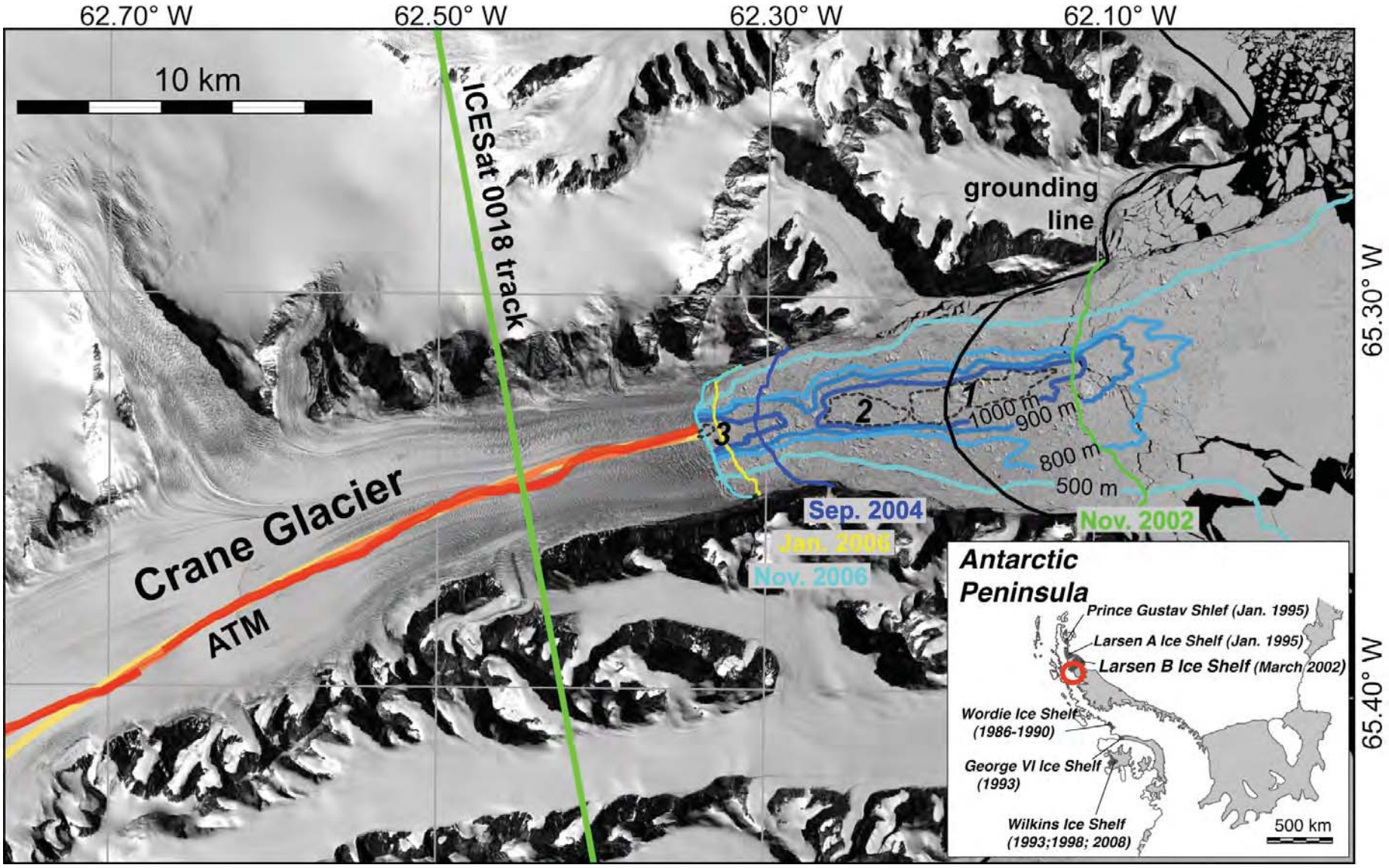
MODIS image, November, 2002



Landsat-7 image, February 2003

Scambos et al., 2004, GRL

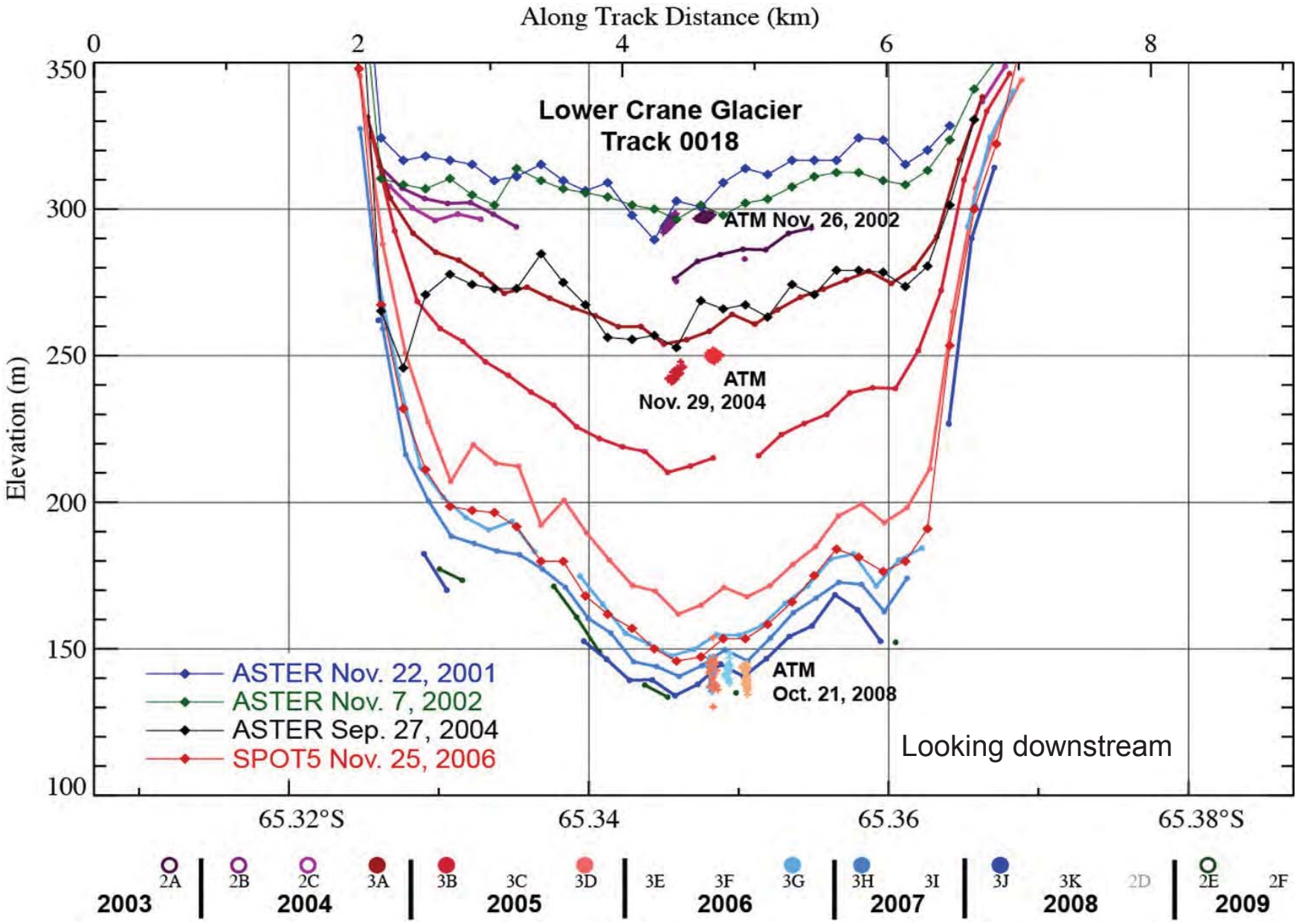
Study area, and altimetry / bathymetry data sets



SPOT-5 image, 25 November 2006

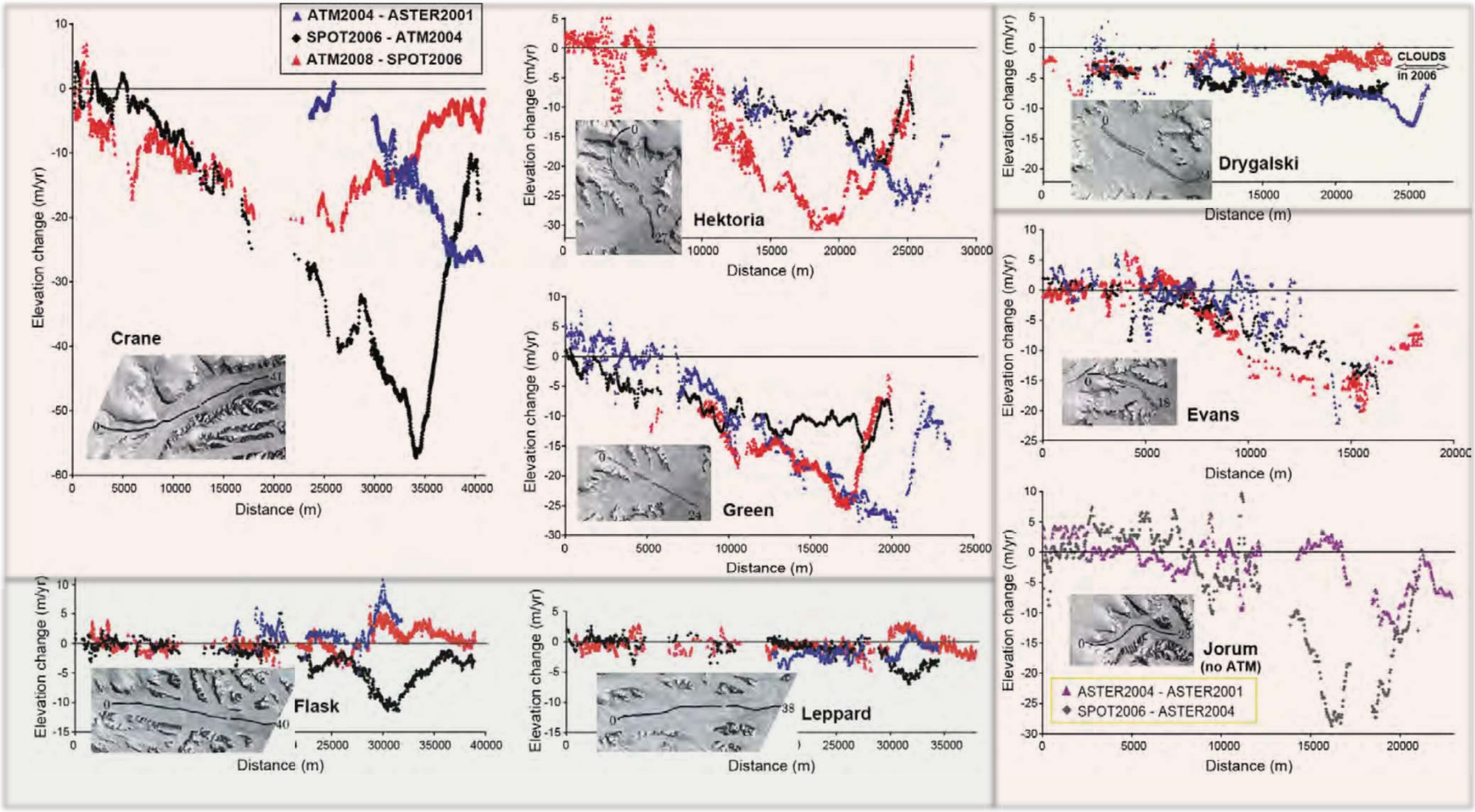
Scambos et al., 2010, J. Glac.

A brief period of rapid elevation loss ('drawdown'): late 2004 to late 2005



Shuman et al., 2010 in prep.

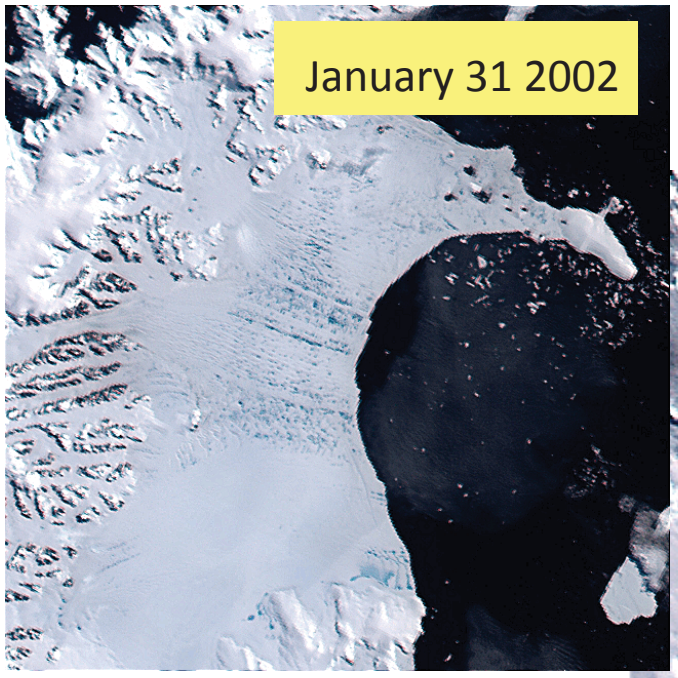
All glaciers in the region of shelf disintegration show major speed and elevation effects; where the shelf remains, there is little change.

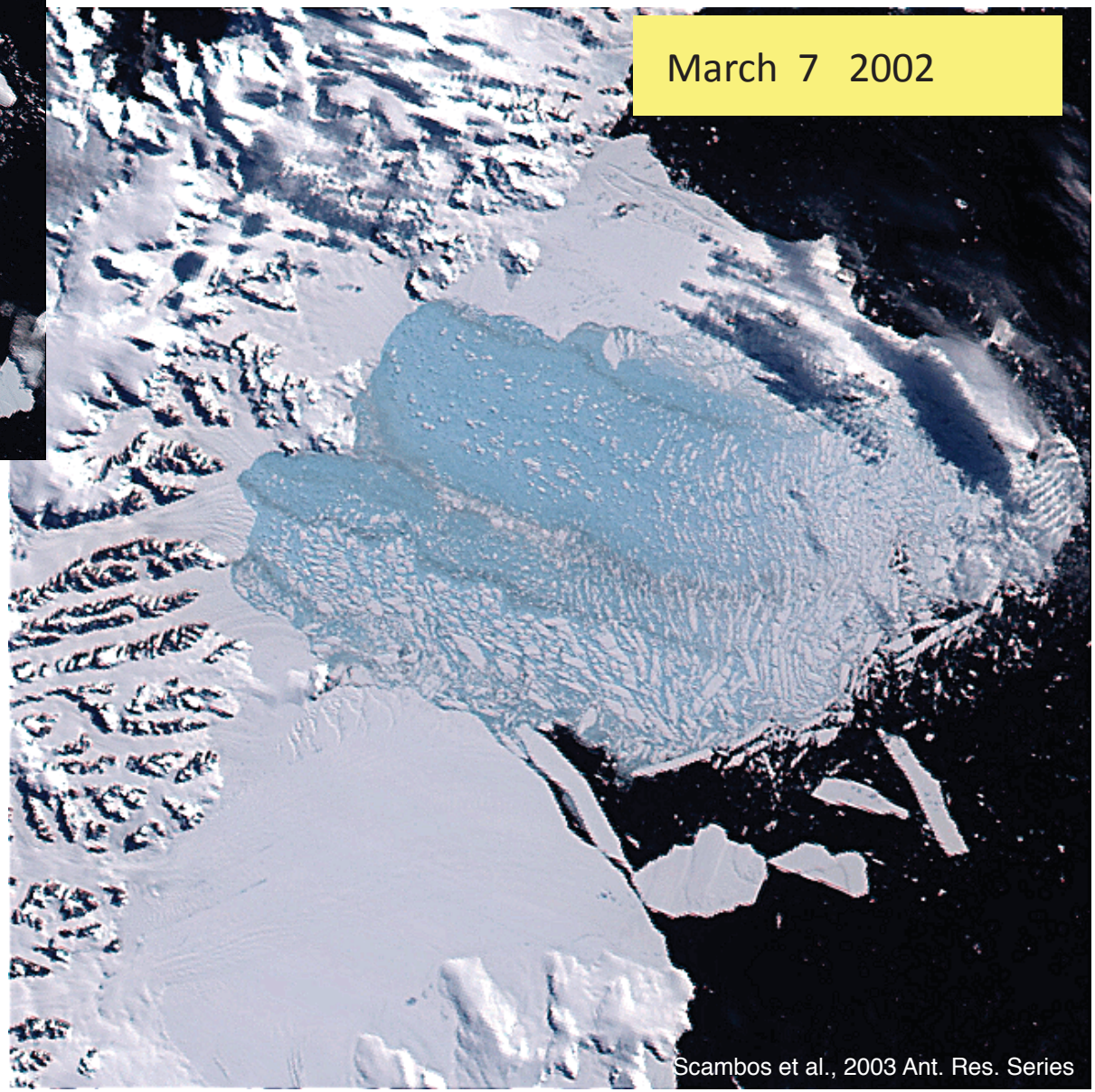


Shuman et al., 2010 in prep.

Along-flow elevation difference profiles of the Larsen B glaciers

Larsen B Ice Shelf disintegration, February-March 2002





‘Disintegration’ style break-up

Not all retreat events are disintegrations

Climate – change driven; rapid increase in surface melting; hydro-fracture.

Above, melt ponds cover the area of subsequent break-up;

Sliver icebergs, ice-front-parallel

At right, blue areas are toppled ice; brown streaks are entrained debris exposed by the break-up.

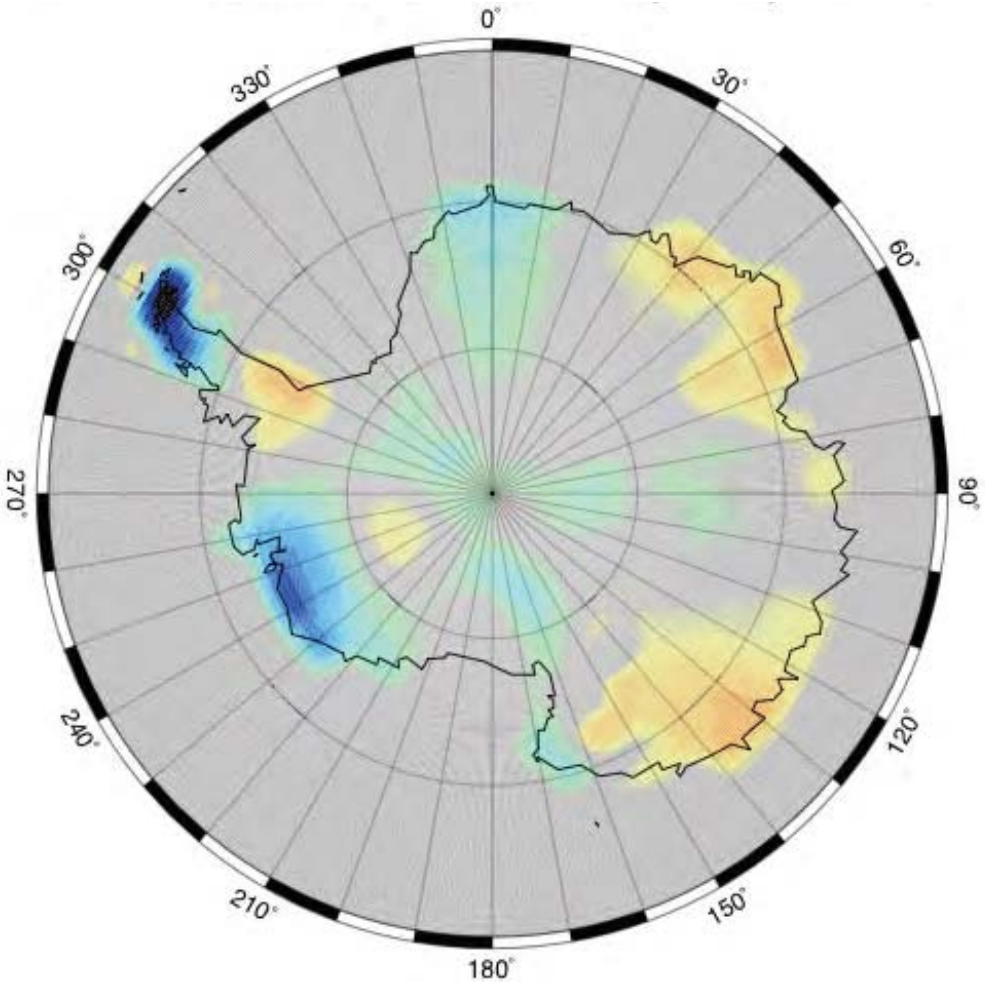
Mass loss of the Larsen B tributary glaciers and Drygalski Glacier: Total is ~62.3 Gtons

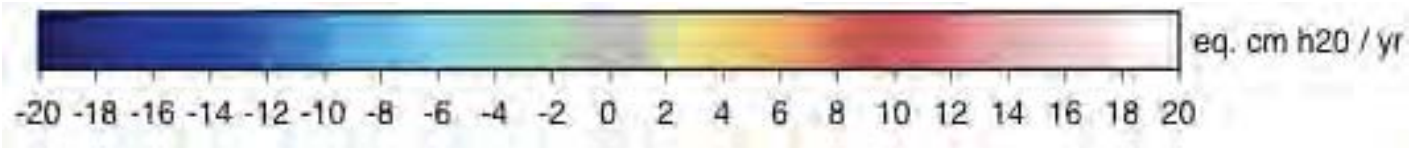
Plus some significant amount (1 to 3 Gt?) from grounded ice that has calved and drifted away

	Grounded ice that calved				Grounded ice losing elevation			
	Area Loss (km^2)	Elevation change (m)	Volume Loss (km^3 ice)	Standard Error (km^3 ice)	Area (km^2)	Elevation change (m)	Volume loss (km^3 ice)	Standard Error (km^3 ice)
Drygalski	0.0	x	0.0	0.0	1015	-15.2	-15.4	5.1
Hektoria/Green	72.8	-79.9	-5.8	0.4	752	-28.9	-21.7	3.8
Evans	11.5	-46.1	-0.5	0.1	266	-33.3	-8.9	1.3
Jorum/Punchbowl	25.1	-39.8	-1.0	0.1	351	-9.0	-3.2	1.8
Crane	33.8	-80.0	-2.7	0.2	470	-28.1	-13.2	2.4
All glaciers			**-10.0***	**0.7**	**2853.7**		**-62.3**	**14.3**
Rate of ice loss (Gt ice /yr)			**-2.0***	**0.1**			**-12.5**	**2.9**

Shuman et al., 2010 in prep.

Antarctica Ice Sheet GRACE Mascon Solution 2003-2008





	GRACE mascon - ICE5G (Gt / yr)	GRACE mascon - IJ05 (Gt / yr)
< 2000 m	-96 ± 39	-87
> 2000 m	-8 ± 13	6
WAIS	-120 ± 11	-96
EAIS	16 ± 24	15
Antarctica	-105 ± 26	-80
Tip of Penn.	-43 ± 4	-39 ± 4

Luthke, 2009 GSFC, pers. comm.