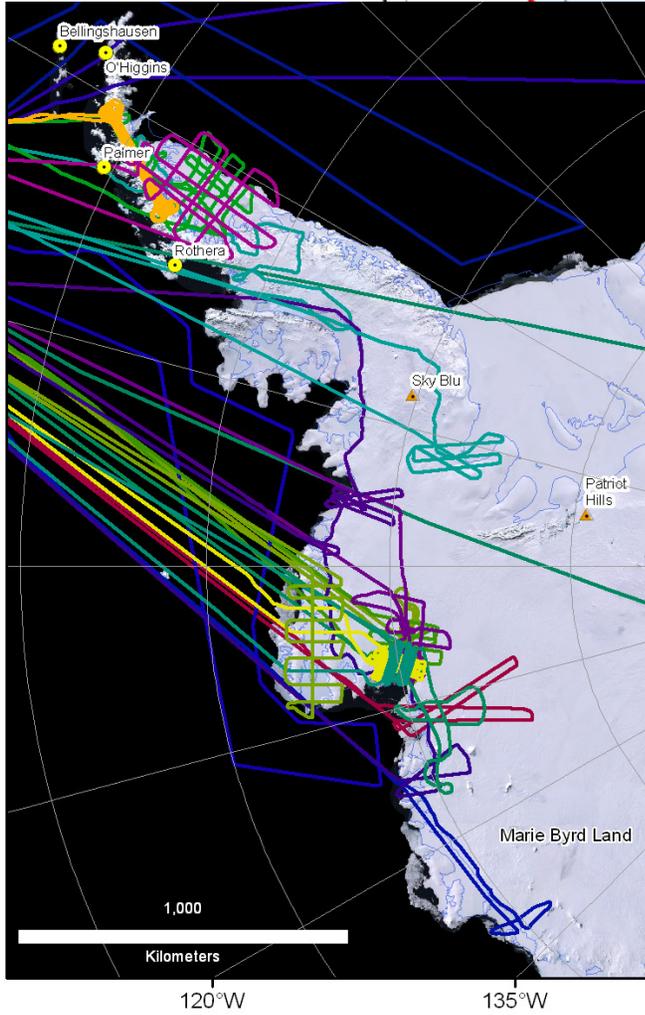
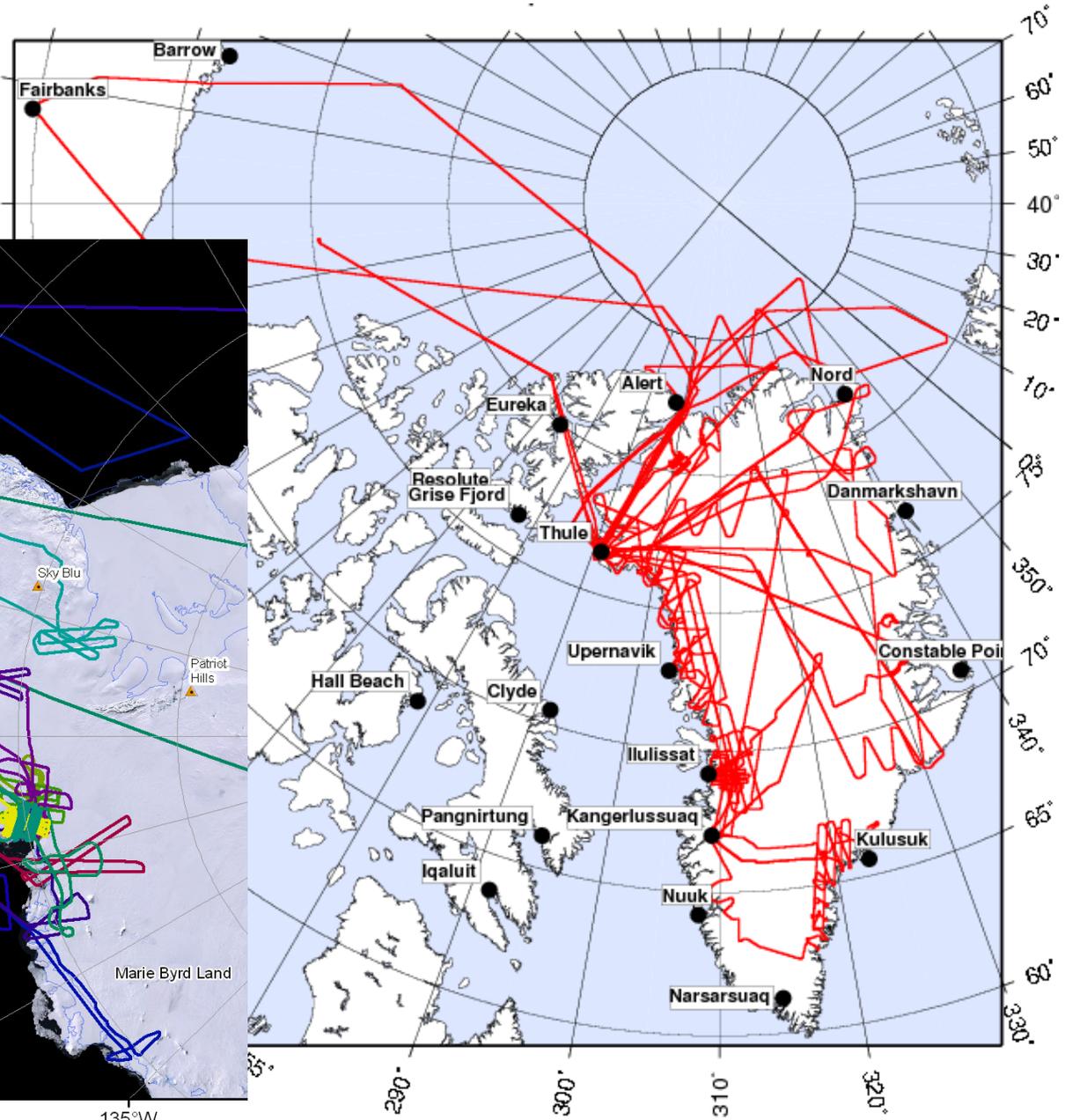




# Operation ICE Bridge 2009



Map compilation: Michael Studinger





Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
Image © 2010 TerraMetrics  
Image IBCAO  
© 2010 Cnes/Spot Image

©2009 Google

1646 km

lat 74.687834° lon -86.046791° elev 0 m Merewether Crater Eye alt 3828.15 km

## ATM Data Processing Stages

### Preliminary “quick look” field processing

- Uses course GPS trajectories and estimated ATM biases
- Provides a quick indication of ATM data quality

### First stage- (Preliminary)

- Uses single station GPS trajectories
- Provides processed data from calibration site and crossing points used to improve ATM biases
- Used to identify regions where additional ATM data filtering may be required (ice fog, clouds, etc)

### Second stage (Processed, Filtered and an ATM ICESSEN product produced)

- Uses best GPS trajectories based on multiple stations and other refinements.
- Uses filtered ATM T2 data (using ATM T3 data to fill in ATM T2 data gaps)
- Produced a ATM ICESSEN data product (multiple surface planes summary file)

Final Product- All possible data processing improvements completed

## **Timeline for processing 2009 Greenland Operation IceBridge ATM data**

100% already processed to stage 2 level (ICESSN product available)

~60 % finalized with no further data processing improvement required

Remaining missions should be finalized by June 1, 2010

ATM3 files will be processed to fill remaining data gaps due to clouds at aircraft altitude.

## **Timeline for processing 2009 Antarctic Operation IceBridge ATM data**

Multiple mission days have preliminary processing; results look very promising.

Missions are now undergoing first stage processing to accurately determine mounting and range biases, and single and multi ground station GPS processing.

Remaining missions will be processed thru second stage by approximately Sept 1, 2010.

All data products finalized by Dec 2010.

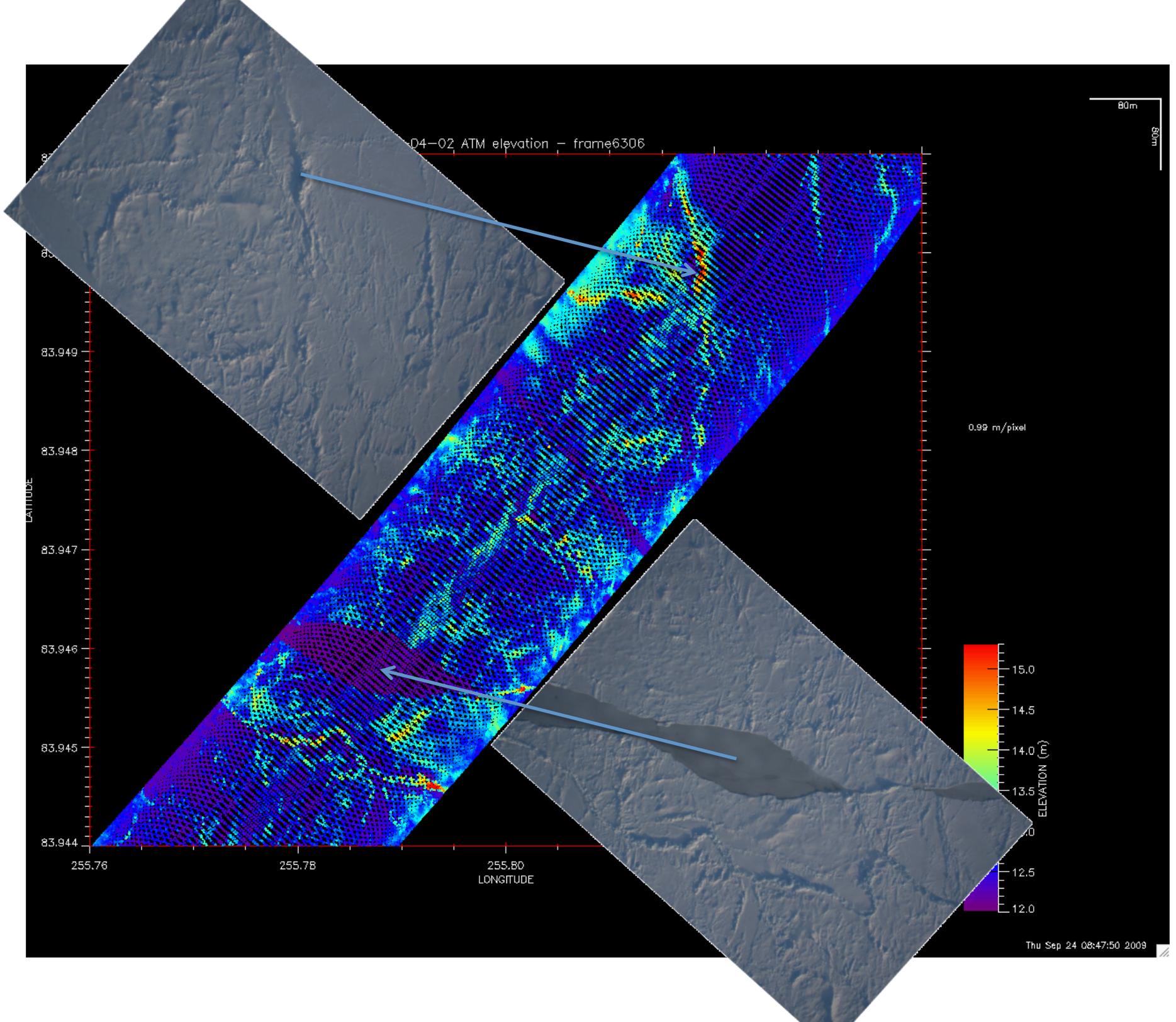
# ATM IceBridge Data Quantity Summary

## Greenland/Arctic Sea Ice Campaign 2009

Date	Flight #	hours	Target	ATM T2	ICESSN	ATM T3	ICESSN	ATM QTY	CAMBOT	CAMBOT QTY	JH-APL-PAF	PARIS QTY
3/31/09	718	8.1	Arctic Sea Ice	34.3 Gb	X	34.3 Gb		68.6 Gb	X	6.5 Gb	X	5.7 Gb
4/1/09	719	7.7	E. Greenland	35.5 Gb	X	36.4 Gb		71.9 GB	X	6.5 Gb	X	14.3 Gb
4/2/09	720	8.2	Cross Arctic Sea Ice	41.0 Gb	X	40.8 Gb		81.8 Gb	X	8.2 Gb		
4/5/09	721	8.7	Cross Arctic Sea Ice	43.9 Gb	X	43.8 Gb		87.7 Gb	X	2.1 Gb		
4/6/09	722	7.7	NW Greenland Glaciers	49.5 Gb	X	48.3 Gb		97.8 Gb	X	9.8 Gb	X	23.8 Gb
4/17/09	730	7.7	NW Greenland Glaciers	57.9 Gb	X	30.6 Gb		88.5 Gb	X	10.8 Gb	X	57.5 Gb
4/20/09	731	9.3	NE Greenland	68.7 Gb	X	41.1 Gb		109.8 Gb	X	12.7 Gb	X	29.2 Gb
4/21/09	732	7.7	Sea ice-envisat overflight NOAA	39.8 Gb	X	23.5 Gb		63.3 GB	X	9.7 Gb		
4/22/09	733	8.0	NW Greenland Glaciers	62.5 Gb	X	36.3 Gb		98.8 Gb	X	10.3 Gb	X	32.2 Gb
4/23/09	734	7.9	East Central Greenland	59.7 Gb	X	35.4 Gb		95.1 Gb	X	9.9 Gb	X	8.3 Gb
4/24/09	735	7.8	Eastern Greenland	60.1 Gb	X	36.0 Gb		96.1 Gb	X	10.0 Gb	X	5.8 Gb
4/25/09	736	6.7	Sea ice- Greenarc overflight- NOAA	40.5 Gb	X	23.8 Gb		64.3 Gb	X	10.4 Gb		
4/27/09	737	7.5	W. Greenland/Jacobshaven	55.4 Gb	X	33.3 Gb		88.7 Gb	X	7.9 Gb	X	29.1 Gb
4/28/09	738	7.4	Jacobshaven	55.3 Gb	X	34.1 Gb		89.4 Gb	X	10.2 Gb	X	20.1 Gb
5/1/09	746	7.3	E. Greenland	50.0 Gb	X	33.0 Gb		83.0 Gb	X	9.5 Gb	X	6.1 Gb
5/2/09	747	6.4	S. Greenland	44.5 Gb	X	26.9 Gb		71.4 Gb	X	6.8 Gb	X	27.7 Gb
5/5/09	757	4.1	W. Central Greenland	29.3 Gb	X	17.6 Gb		46.9 Gb	X	5.0 Gb		

## Antarctic/ Sea Ice Campaign 2009

Date	Flight #	hours	Target	ATM T2	ICESSN	ATM T3	ICESSN	ATM QTY	CAMBOT	CAMBOT QTY
10/16/09		11.8	Getz Ice Shelf	26.1 Gb		22.8 Gb		48.0 Gb	x	5.8 Gb
10/18/09	DC8-100110*	10.6	Pine Island Area	27.6 Gb		26.7 Gb		54.3 Gb	x	7.7 Gb
10/21/09	DC8-100112	11.0	Sea Ice, Bellingshausen ad Amundsen Seas	43.9 Gb		42.4 Gb		86.3 Gb	x	20.0 Gb
10/24/09	DC8-100113	11.4	Sea Ice, Weddell Sea	56.1 Gb		55.4 Gb		111.5 Gb	x	16.7 Gb
10/27/09	DC8-100115	10.9	Pine Island Glacier	31.3 Gb		30.6 Gb		61.9 Gb	x	10.0 Gb
10/28/09	DC8-100116	10.6	Thwaites, Smith, Koehler Glaciers	30.7 Gb		29.6 Gb		60.3 Gb	x	15.1 Gb
10/29/09	DC8-100117	11.7	Pine Island Glacier	41.3 Gb		40.4 Gb		81.7 Gb	x	12.1 Gb
10/30/09	DC8-100118	11.0	Sea Ice Weddell Sea	51.1 Gb		54.8 Gb		105.9 Gb	x	17.0 Gb
10/31/09	DC8-100119	9.4	Antarctic Peninsula	34.7 Gb		32.2 Gb		66.9 Gb	x	11.5 Gb
11/2/09	DC8-100120	10.9	Thwaites, Smith, Koehler Glaciers	33.8 Gb		31.7 Gb		65.5 Gb	x	9.5 Gb
11/3/09	DC8-100121	10.5	Antarctic Peninsula	39.8 Gb		38.7 Gb		78.5 Gb	x	12.0 Gb
11/4/09	DC8-100122	11.3	Antarctic Peninsula-Atlee, Flask, Crane, Hektor	56.4 Gb		54.7 Gb		111.1 Gb	x	17.3 Gb
11/7/09	DC8-100124	11.0	Pine Island Glacier- Abbot Ice Shelf	40.1 Gb		38.6 Gb		78.7 Gb	x	12.0 Gb
11/9/09	DC8-100125	11.3	Pine Island Glacier	33.2 Gb		31.1 Gb		64.3 Gb	x	11.3 Gb
11/12/09	DC8-100126	10.4	Abbot Ice Shelf	32.2 Gb		30.8 Gb		63.0 Gb	x	8.8 Gb
11/15/09	DC8-100127	10.6	Antarctic Peninsula-Drewry and Evans Ice Strea	35.3 Gb		32.6 Gb		67.9 Gb	x	10.0 Gb
11/16/09	DC8-100128	10.4	Antarctic Peninsula- Larsen C- Starbuck, Sumner	48.4 Gb		47.2 Gb		95.6 Gb	x	14.3 Gb
11/18/09	DC8-100129	10.8	Thwaites, Smith, Koehler Glaciers	25.1 Gb		24.6 Gb		49.7 Gb	x	11.0 Gb



# NADIR PHOTOGRAPHY & ATM TOPOGRAPHY

2003-04-02 ATM 516-01

53.200  
53.250  
53.300  
53.350  
53.400  
53.450  
53.500  
53.550  
53.600

125.75

125.75

125.75

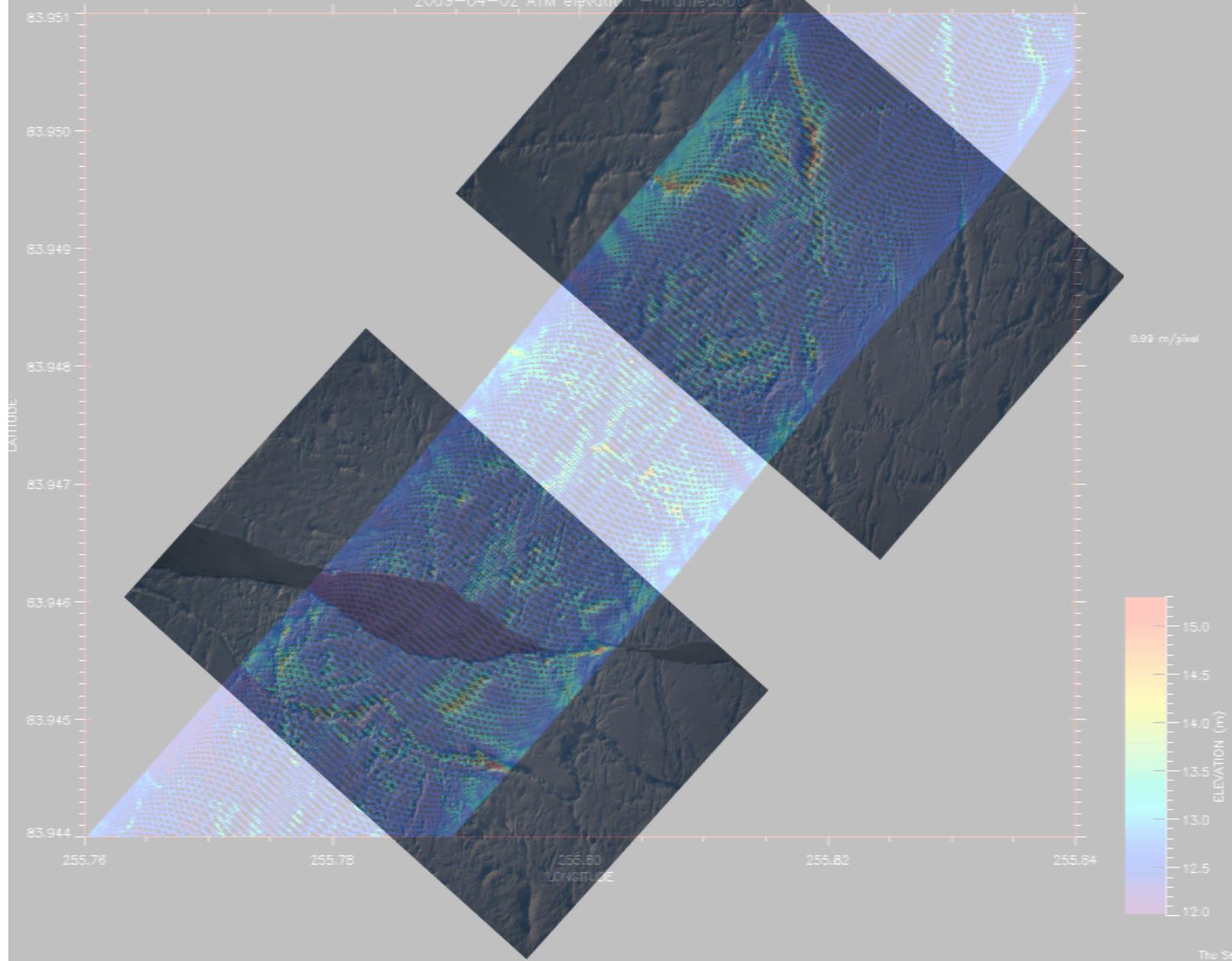
125.75

5000



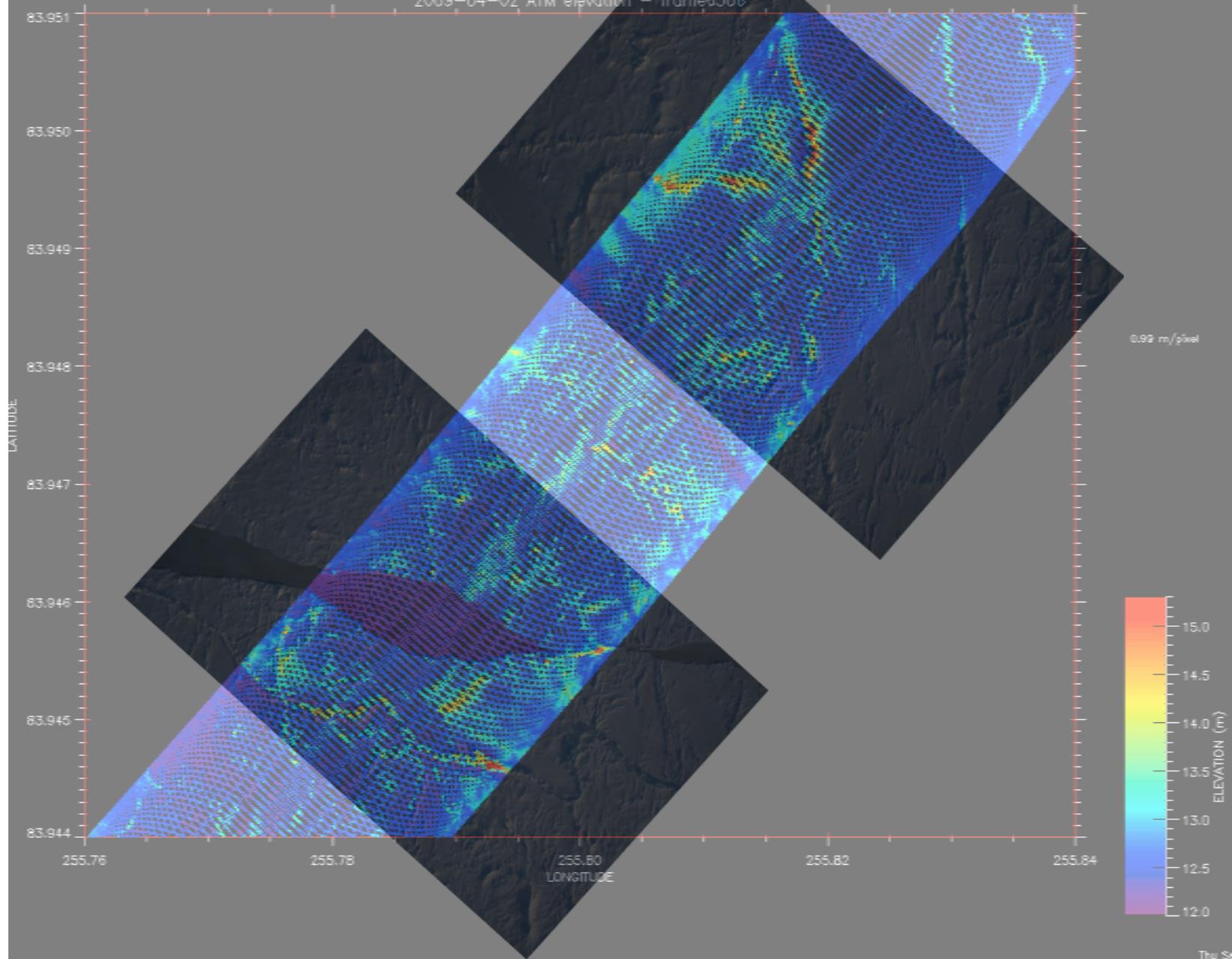
# NADIR PHOTOGRAPHY & ATM TOPOGRAPHY

2009-04-02 ATM elevation - frame6306



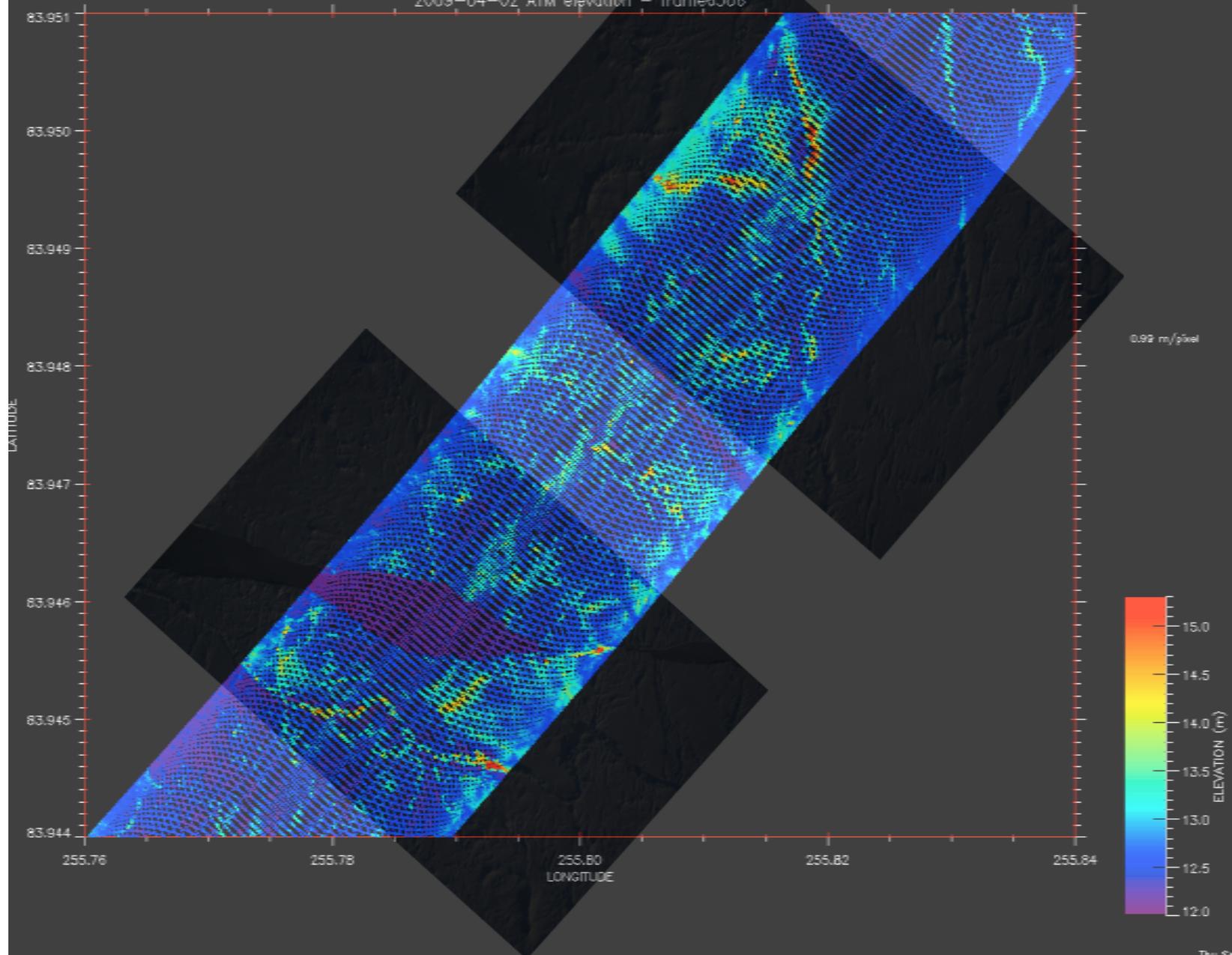
# NADIR PHOTOGRAPHY & ATM TOPOGRAPHY

2009-04-02 ATM elevation - frame6306



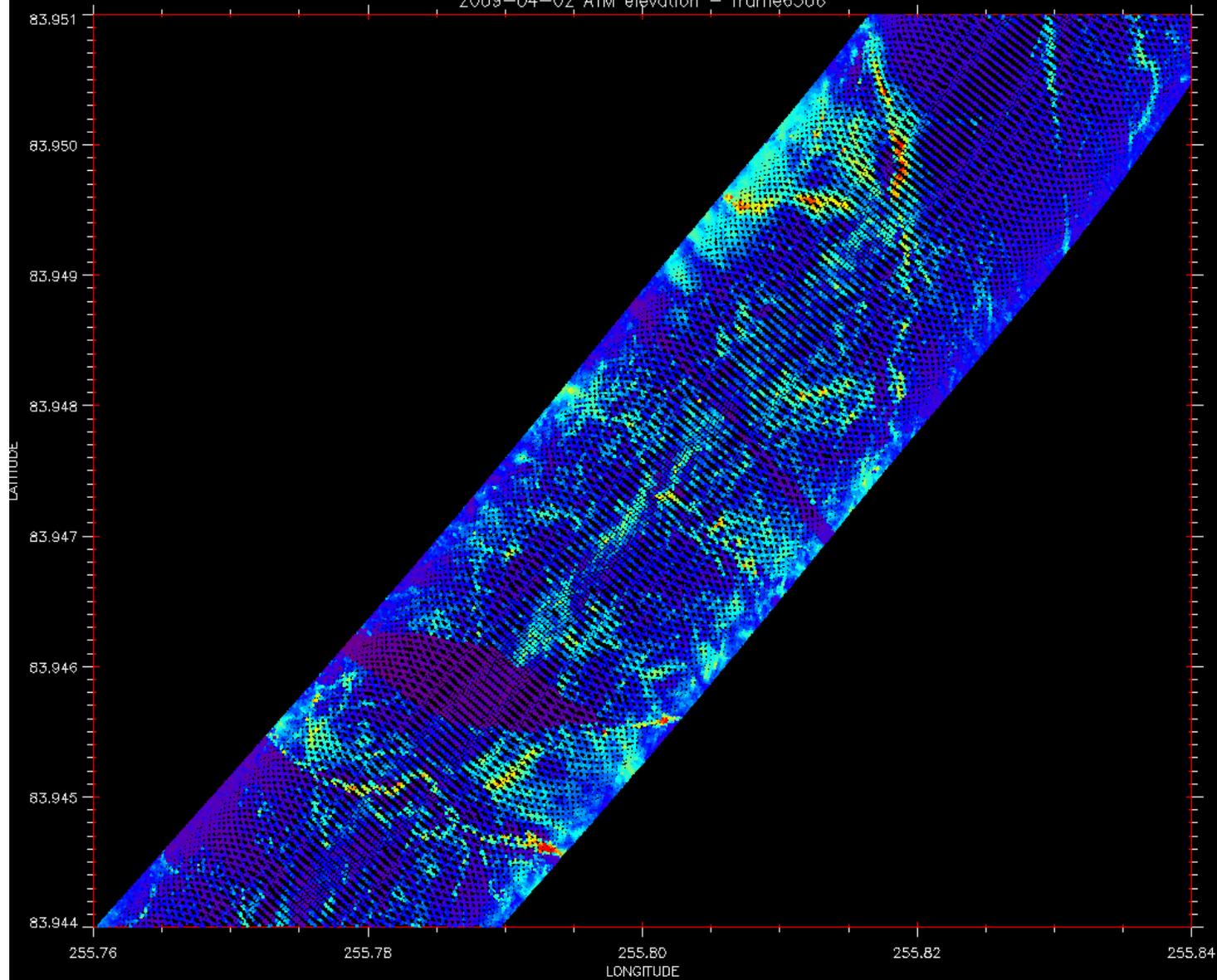
# NADIR PHOTOGRAPHY & ATM TOPOGRAPHY

2009-04-02 ATM elevation - frame6306

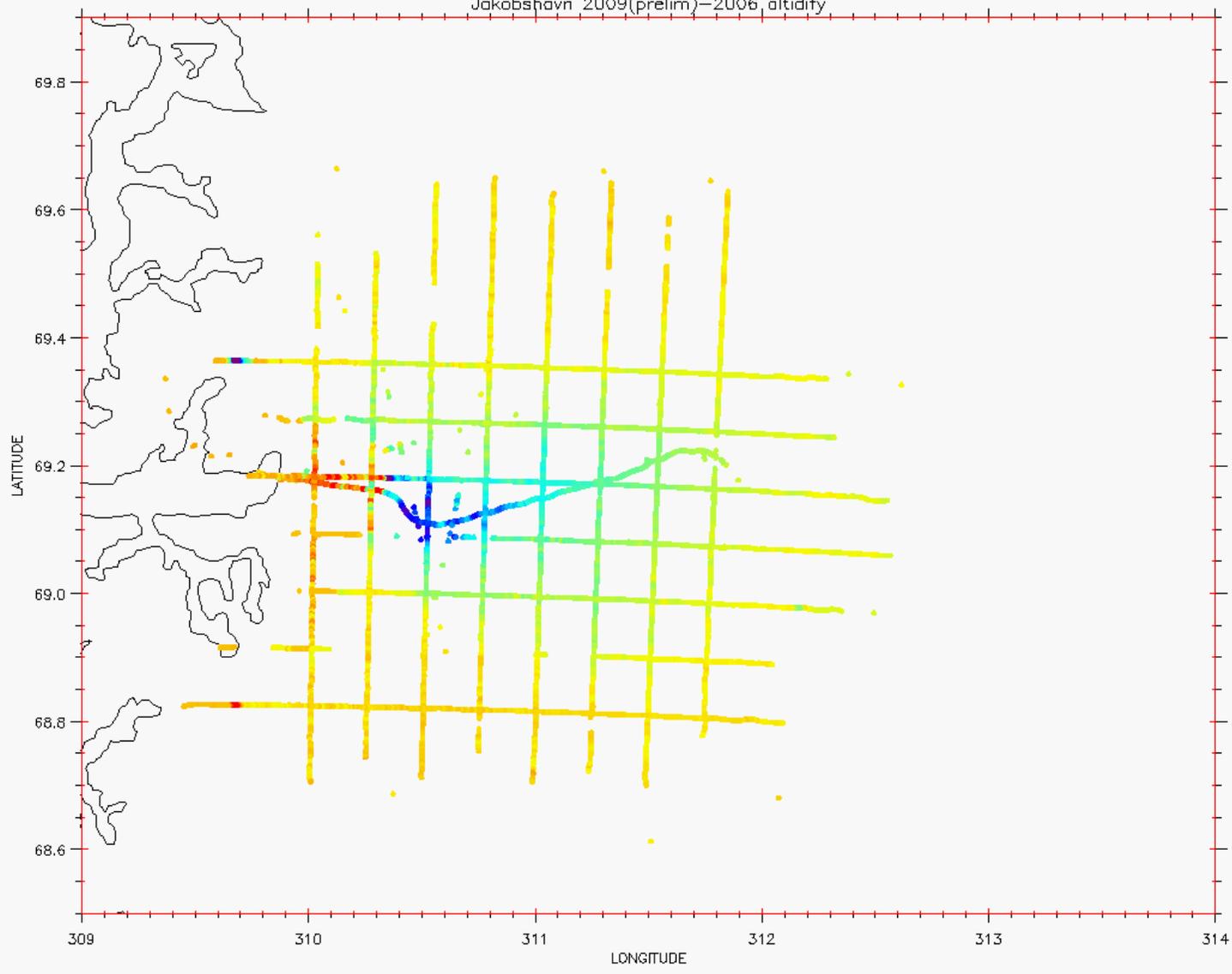


# & ATM TOPOGRAPHY

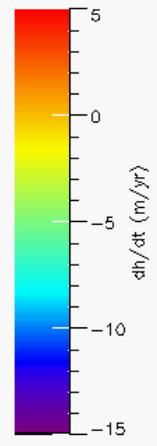
2009-04-02 ATM elevation - frame6306

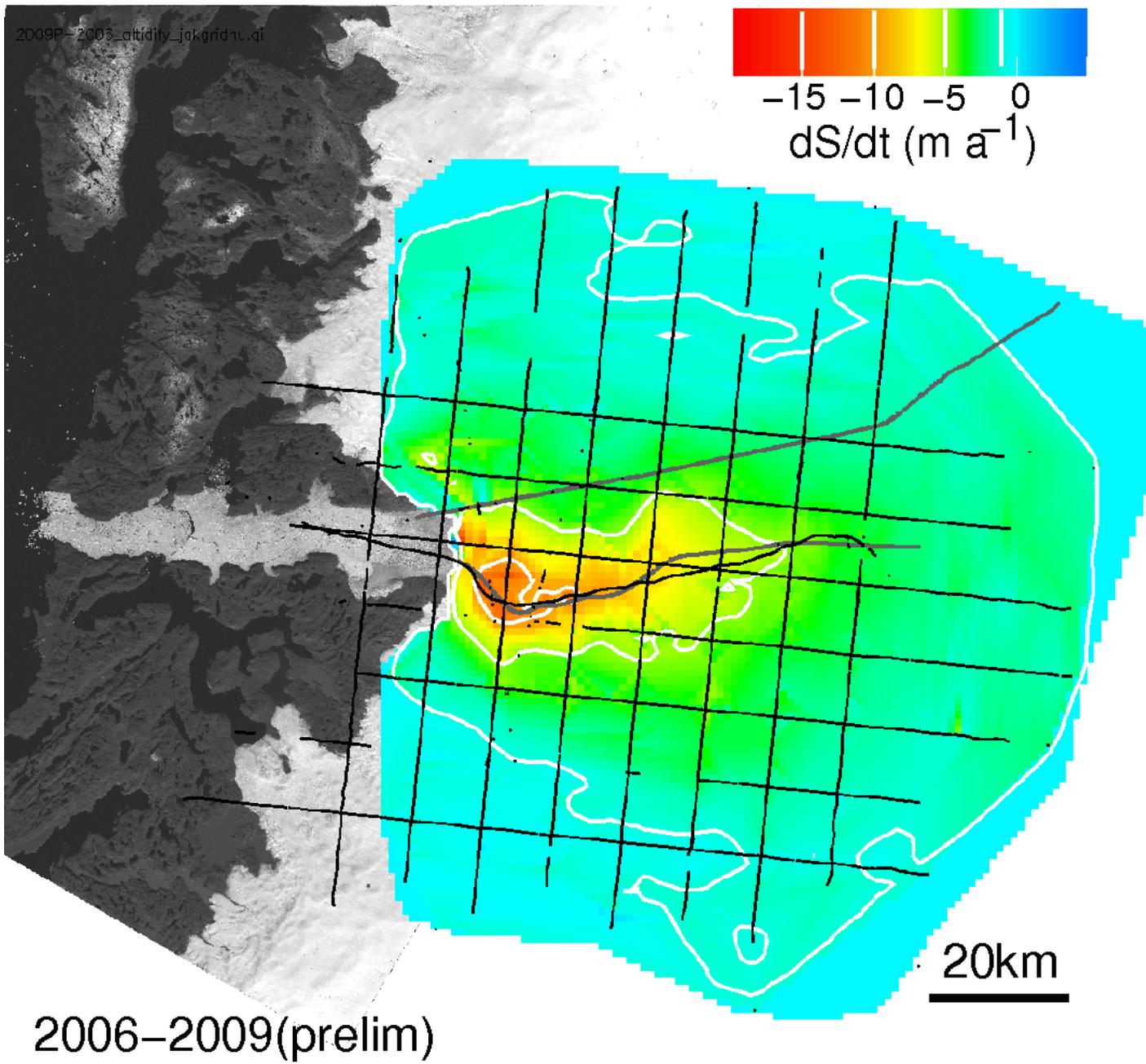


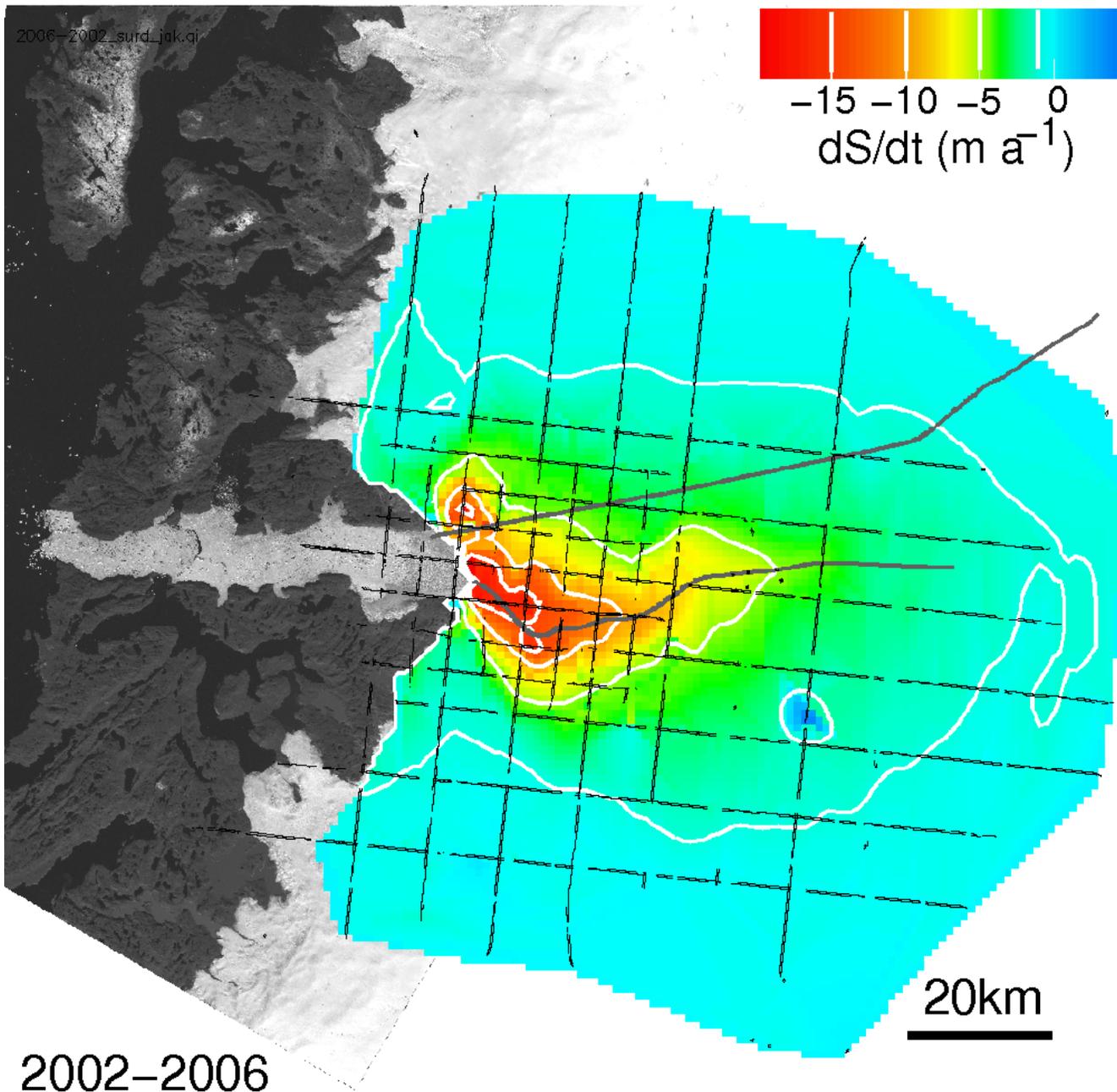
Jakobshavn 2009(prelim)-2006 altidify



208.58 m/pixel





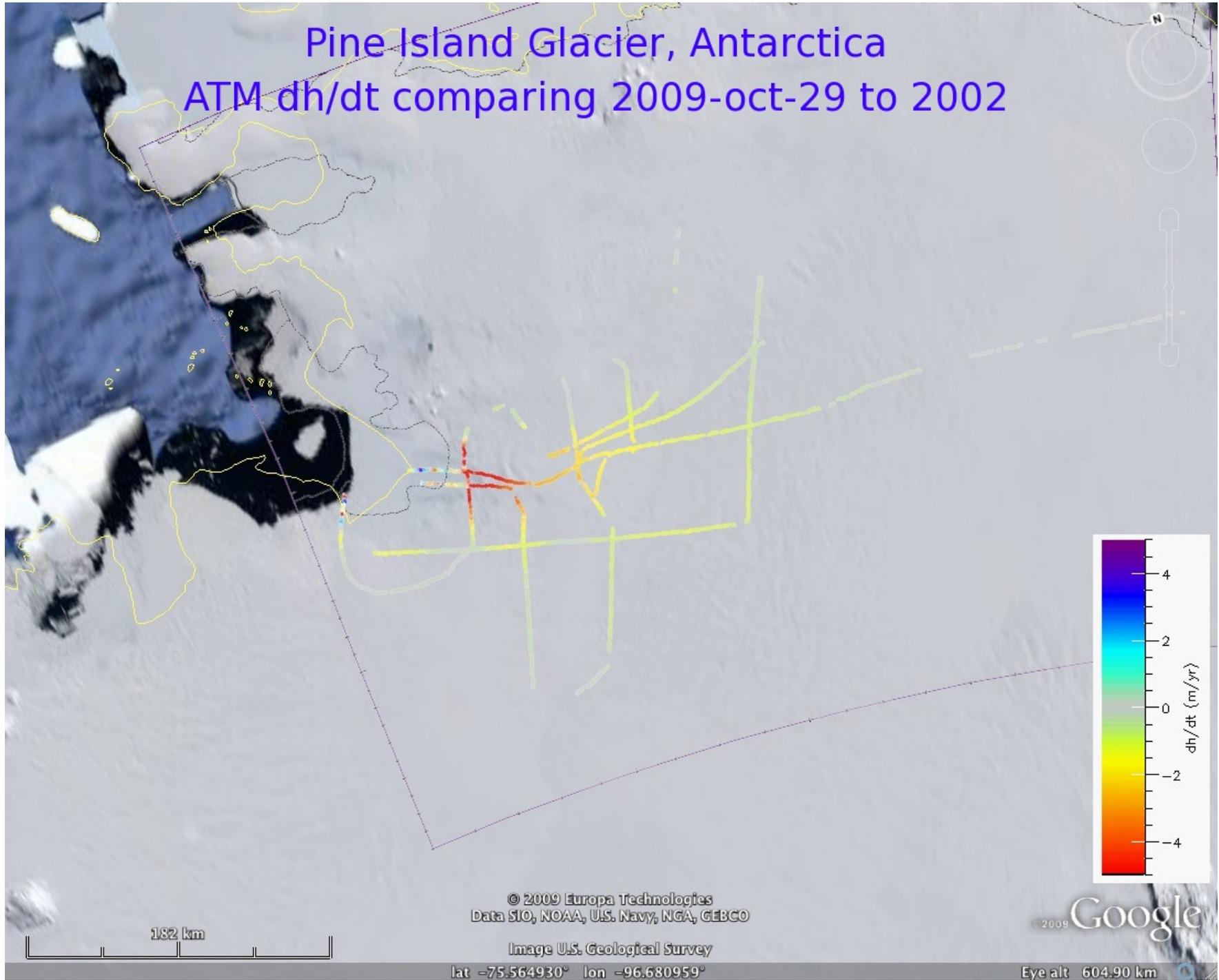






# Pine Island Glacier, Antarctica

## ATM dh/dt comparing 2009-oct-29 to 2002



# ATM dh/dt 2002-2009 Pine Island, Thwaites, Smith, & Kohler Glaciers

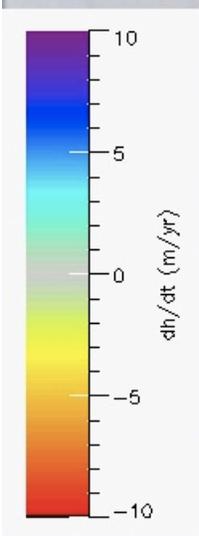
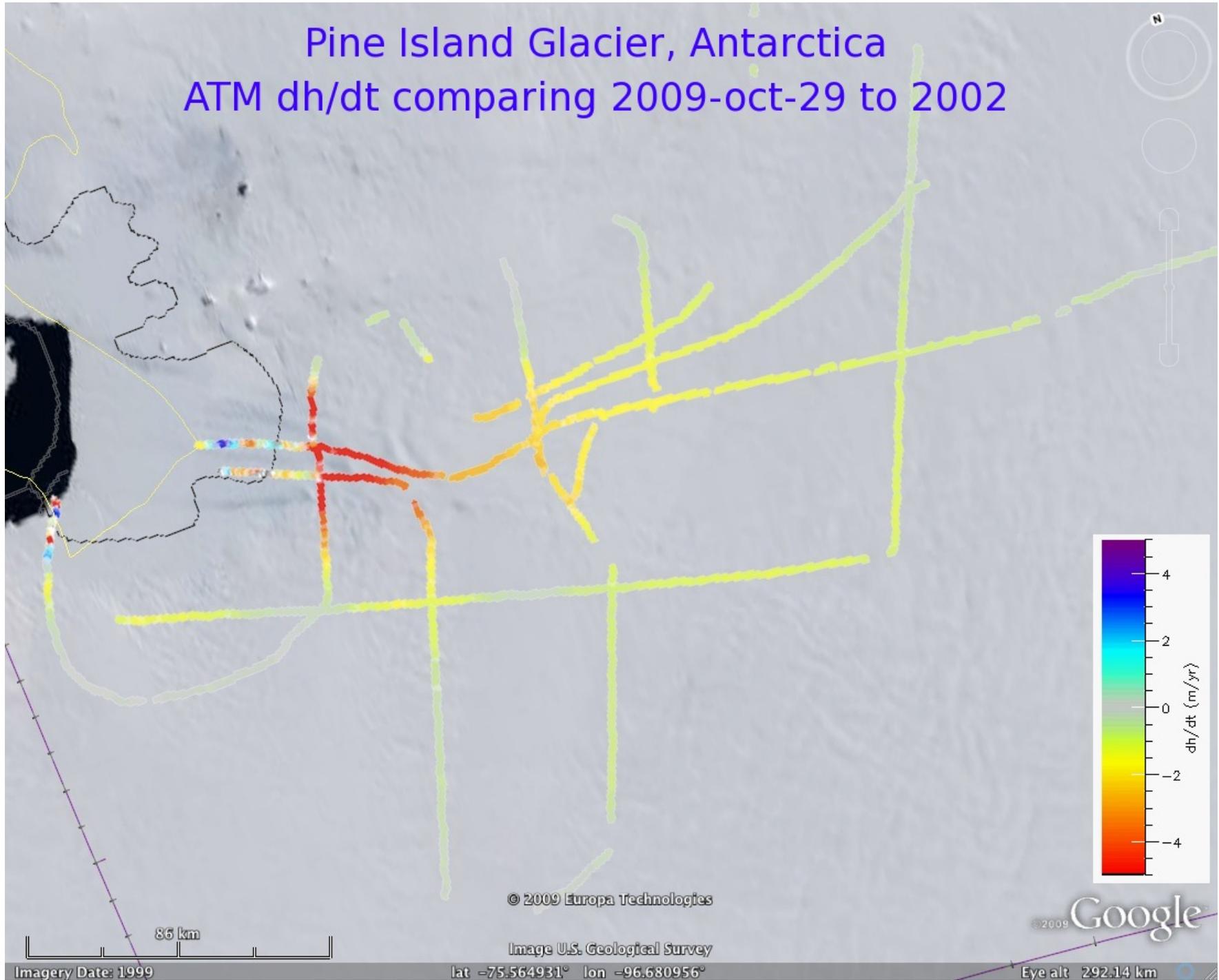


Image NASA  
Image U.S. Geological Survey  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO



# Pine Island Glacier, Antarctica

## ATM dh/dt comparing 2009-oct-29 to 2002



© 2009 Europa Technologies

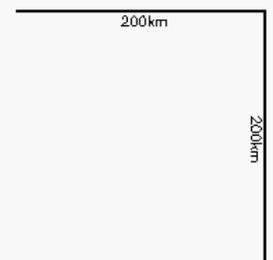
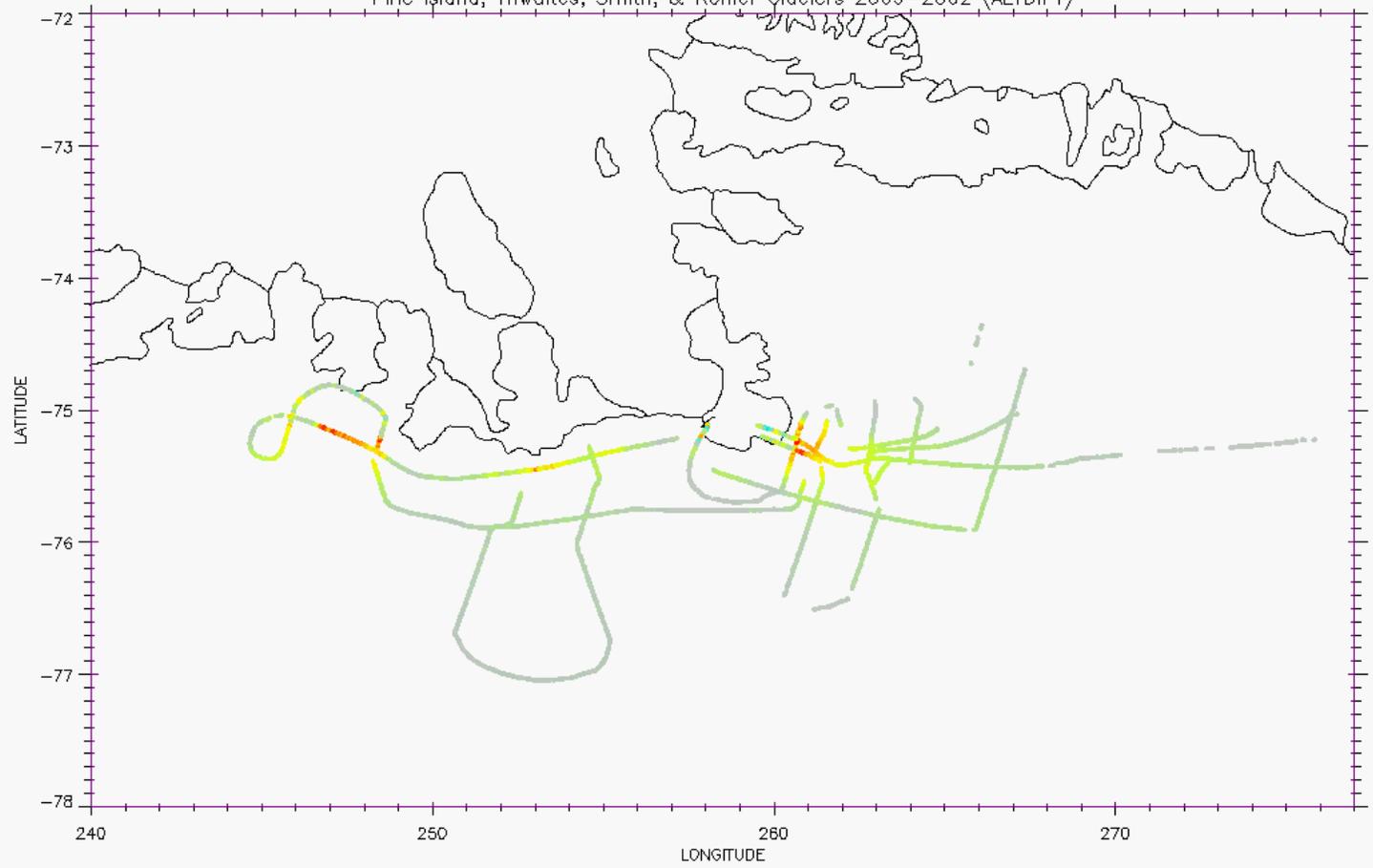
Image U.S. Geological Survey

Imagery Date: 1999

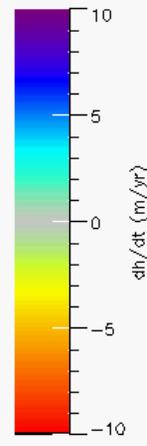
lat -75.564931° lon -96.680956°

Eye alt 292.14 km

Pine Island, Thwaites, Smith, & Kohler Glaciers 2009-2002 (ALTDIFY)



1124.96 m/pixel



# ATM dh/dt 2002-2009 Pine Island, Thwaites, Smith, & Kohler Glaciers

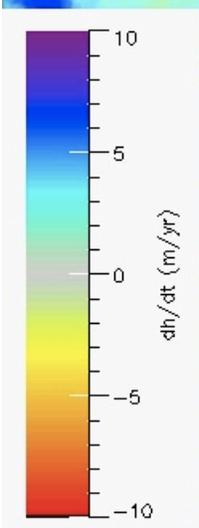


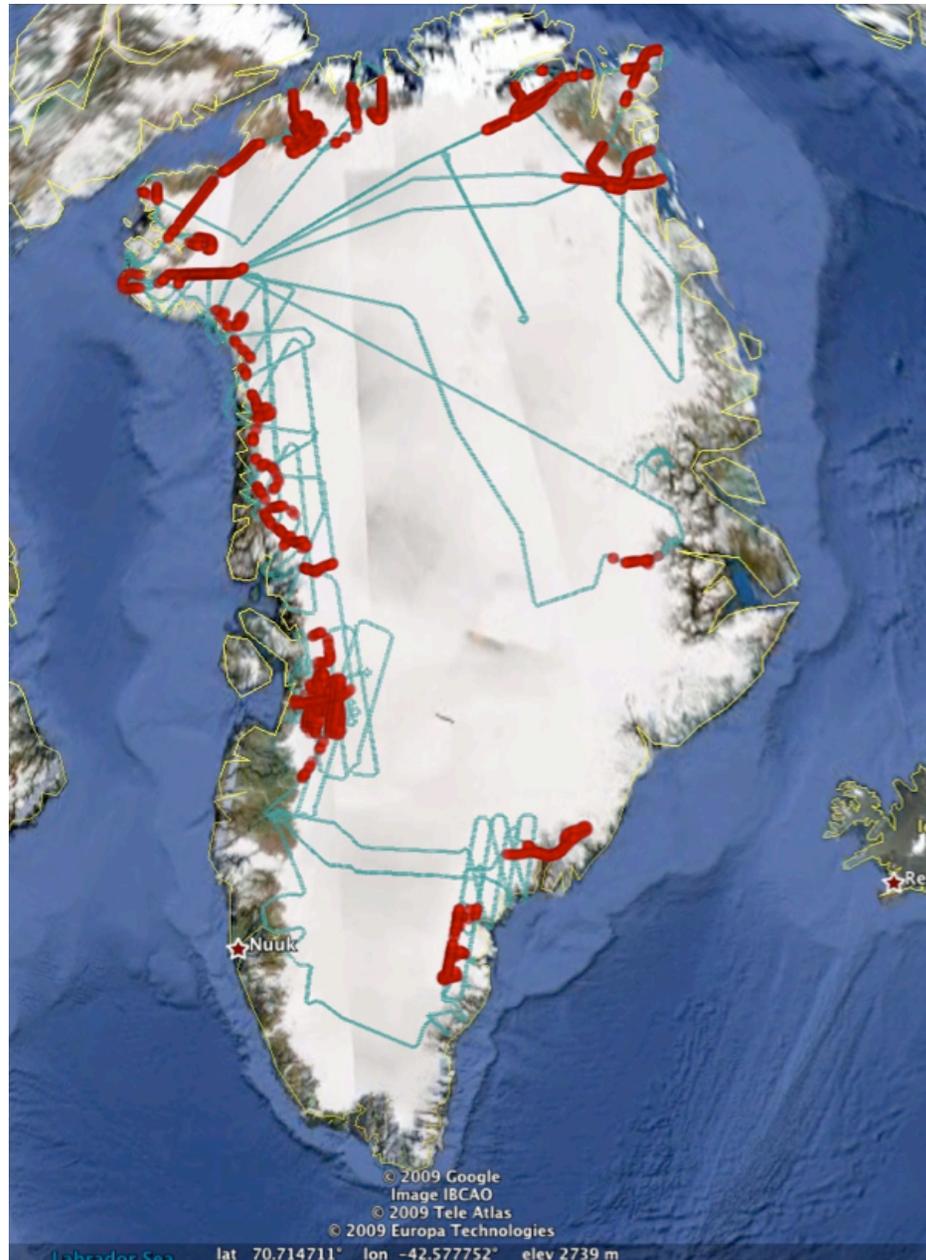
Image NASA  
Image U.S. Geological Survey  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO



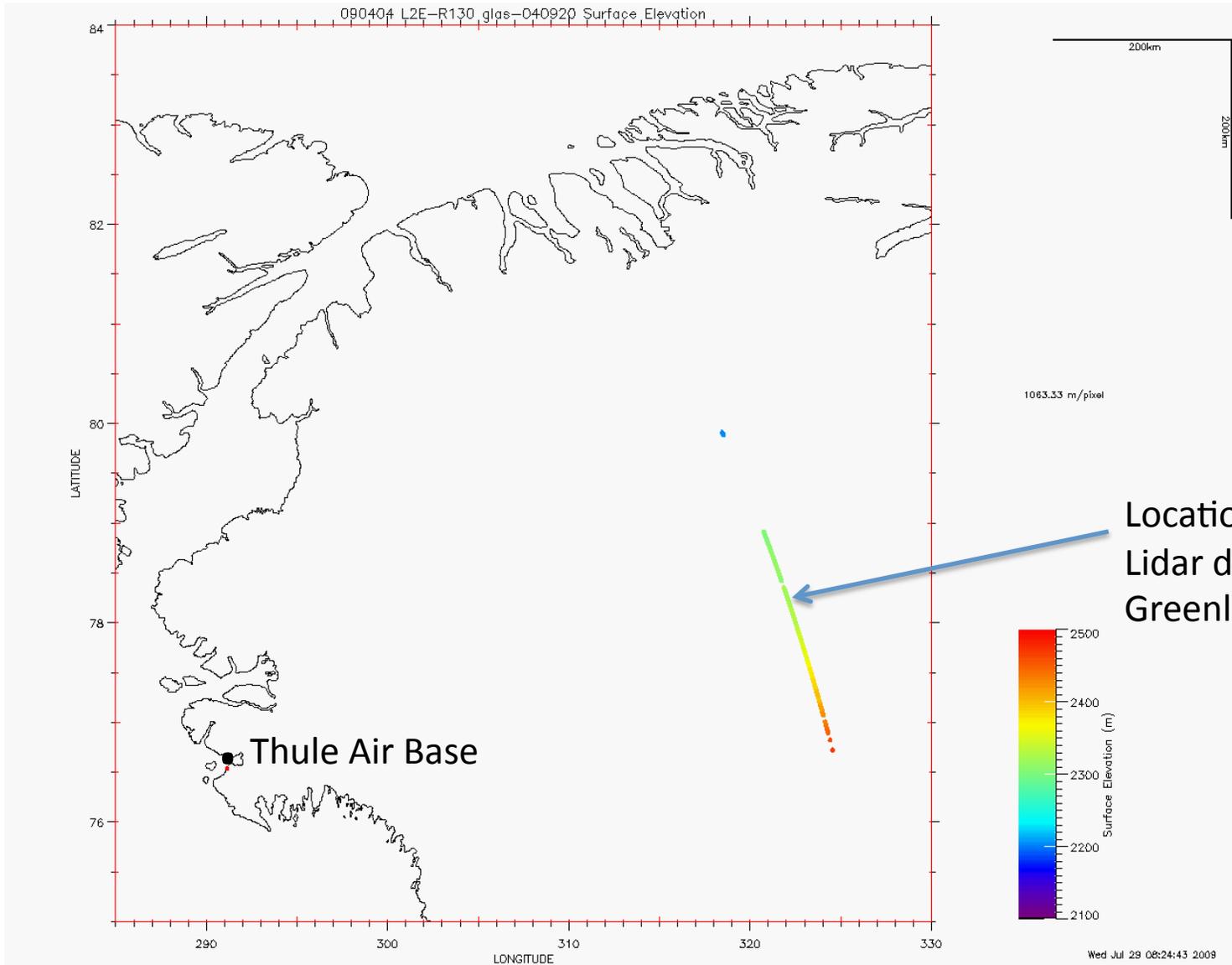
lat -75.316214° lon -101.088263° elev 0 m

Eye alt 923.86 km

# PARIS Ice Sounding Radar data availability 2009

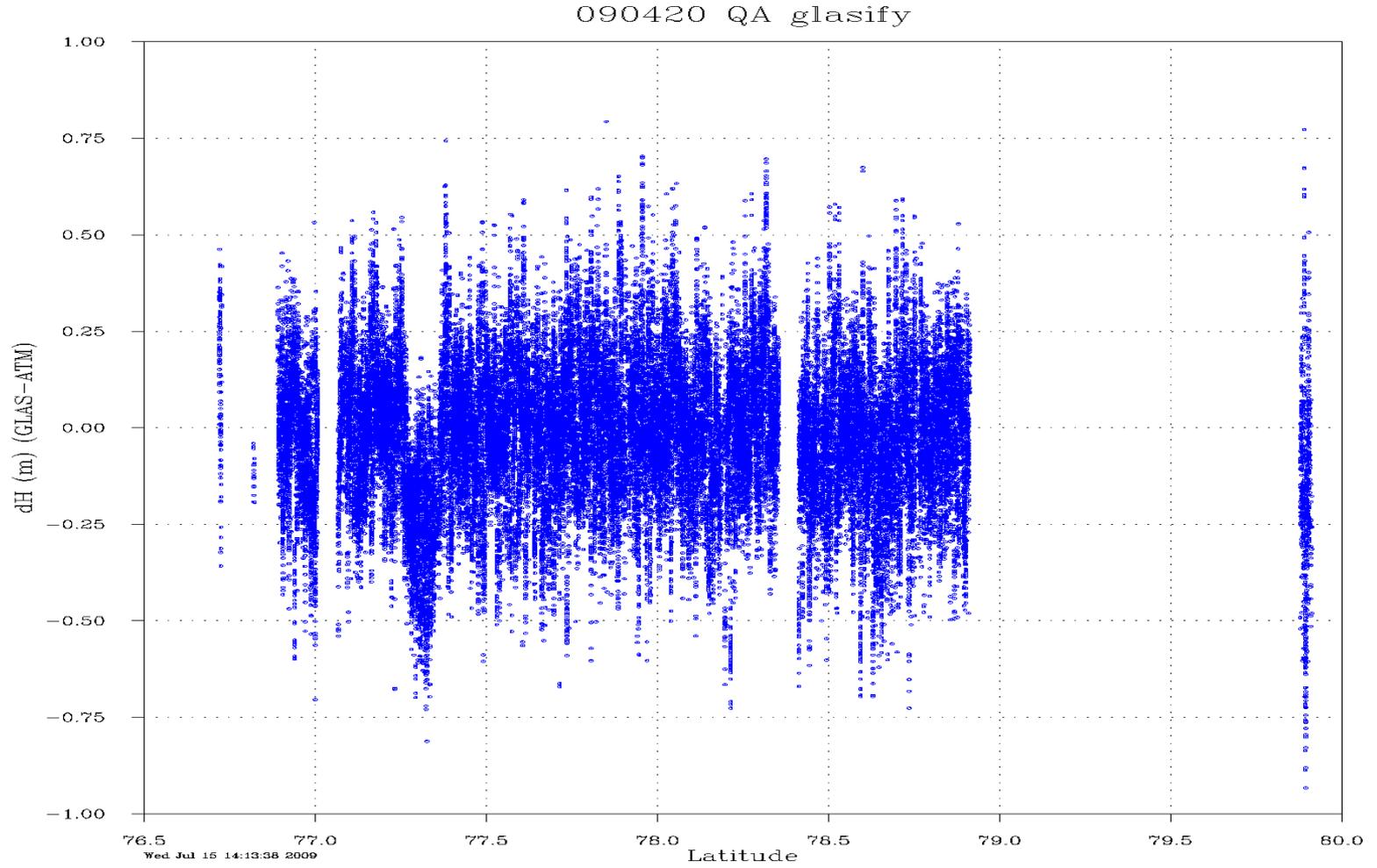


# Early Ice Bridge – ICESat Results



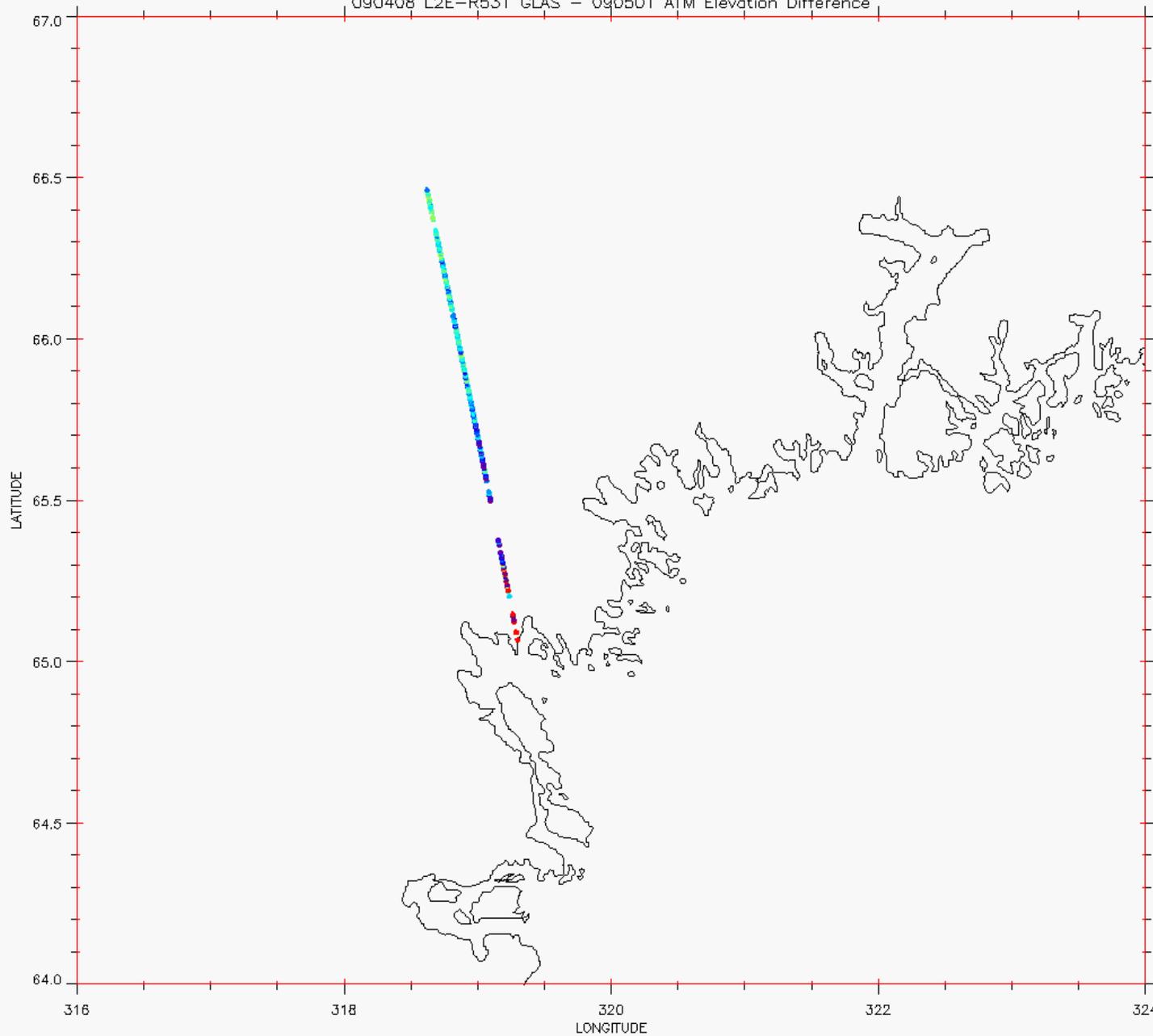
Location of ICESat and ATM Lidar data in North Central Greenland

ICESat data collected April 4, 2009  
ATM data collected April 20, 2009

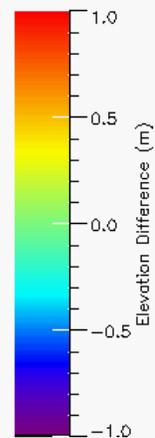




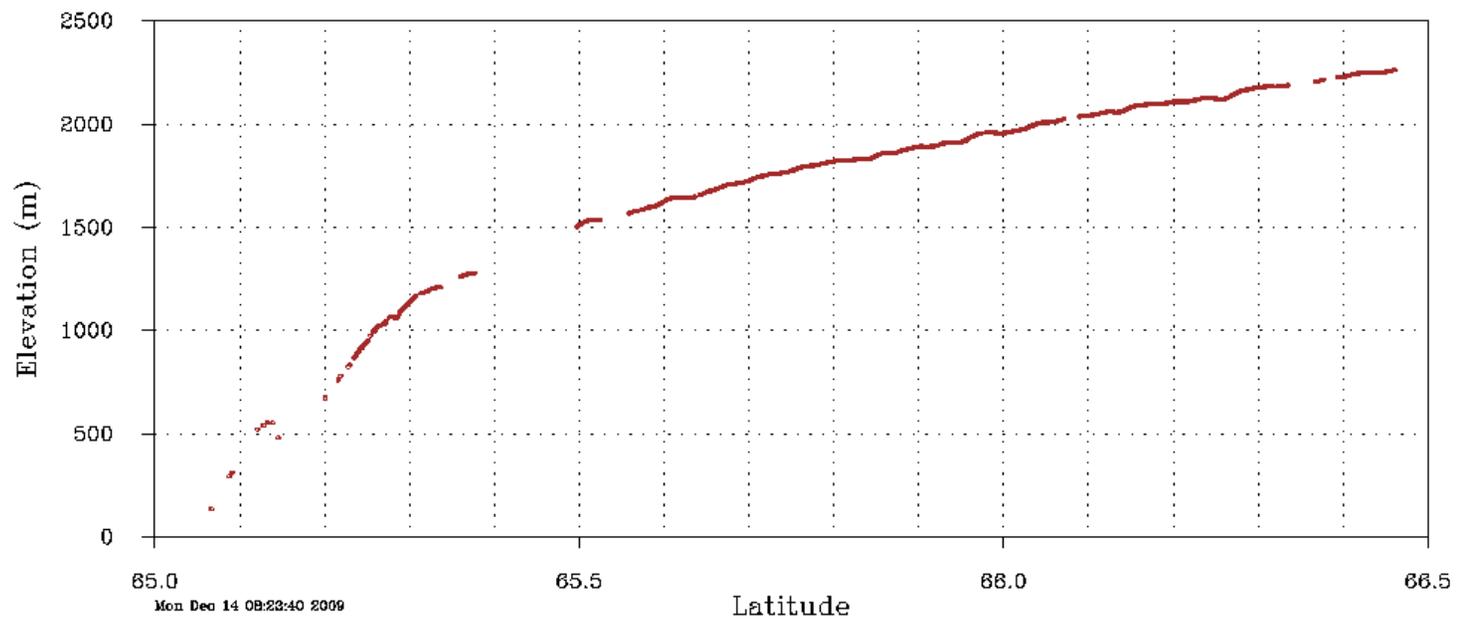
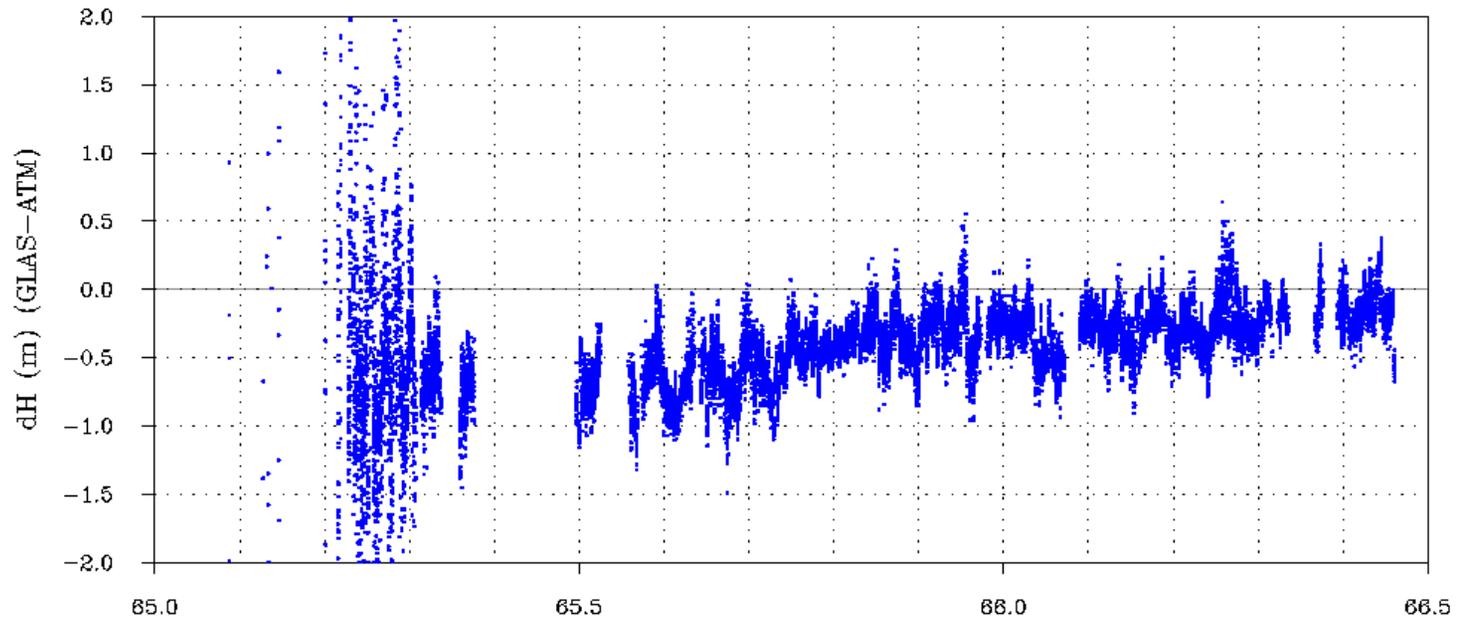
090408 L2E-R531 GLAS - 090501 ATM Elevation Difference



389.72 m/pixel



090408 (R531) GLAS - 090501 ATM QA altdify



Mon Dec 14 08:23:40 2009

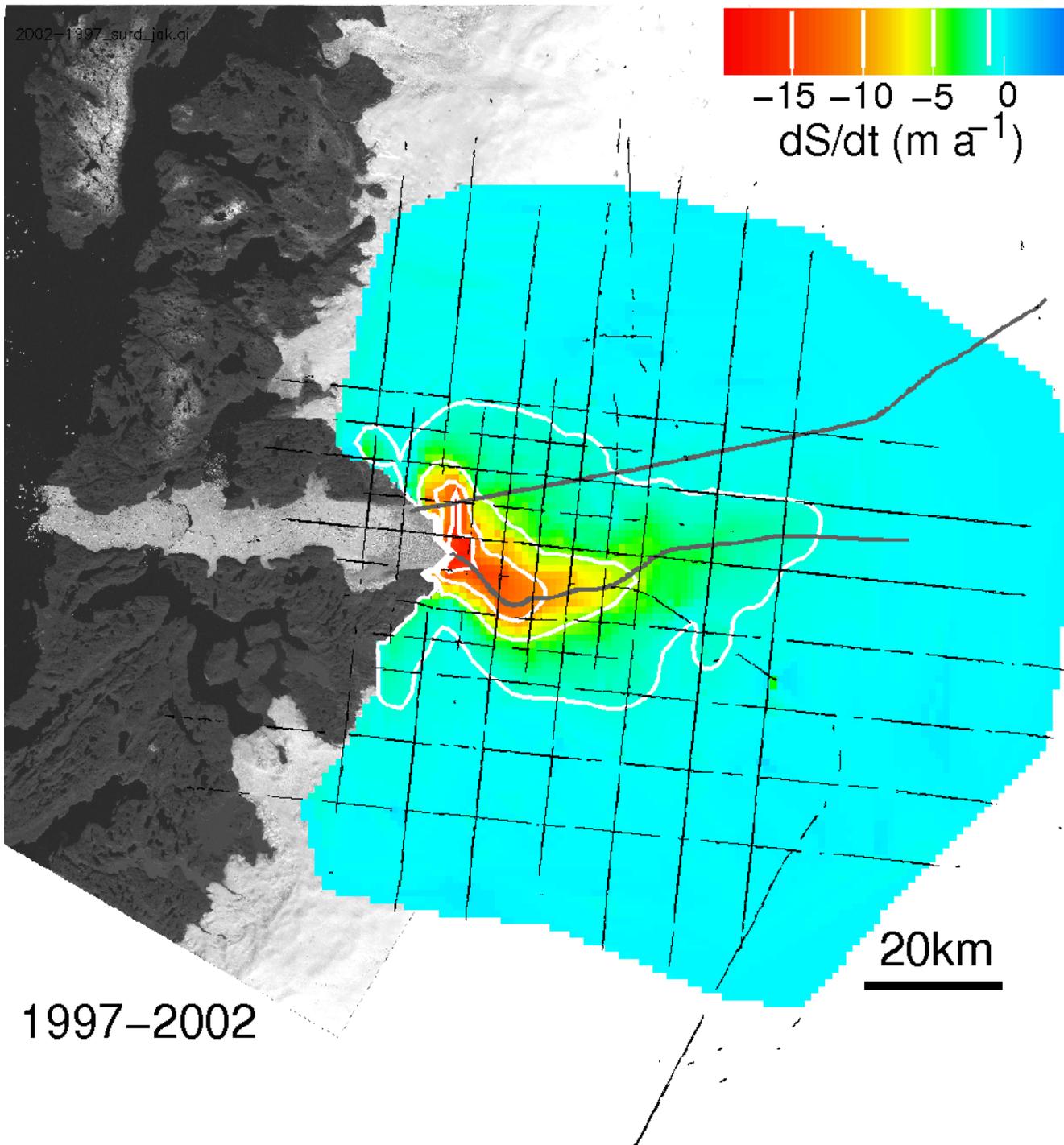


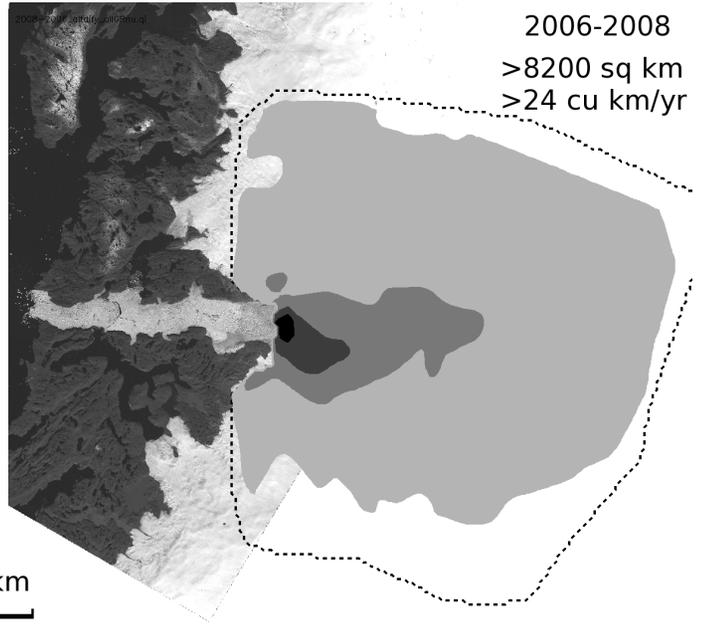
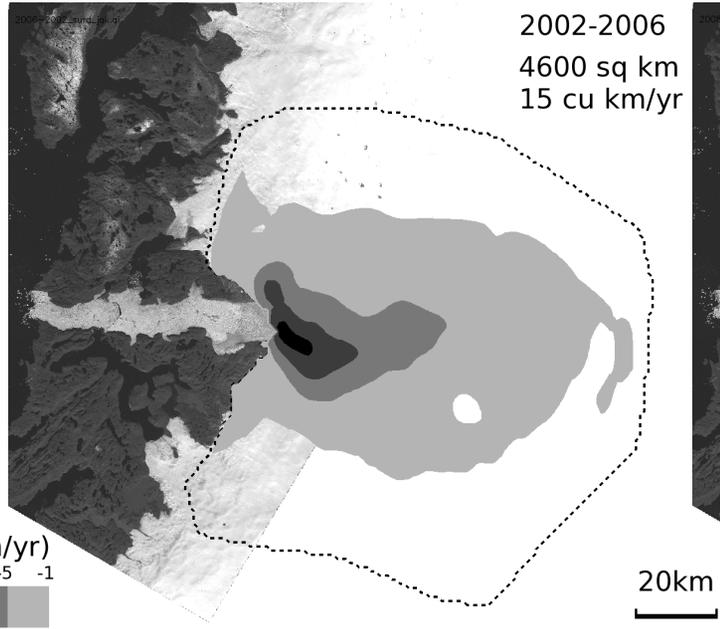
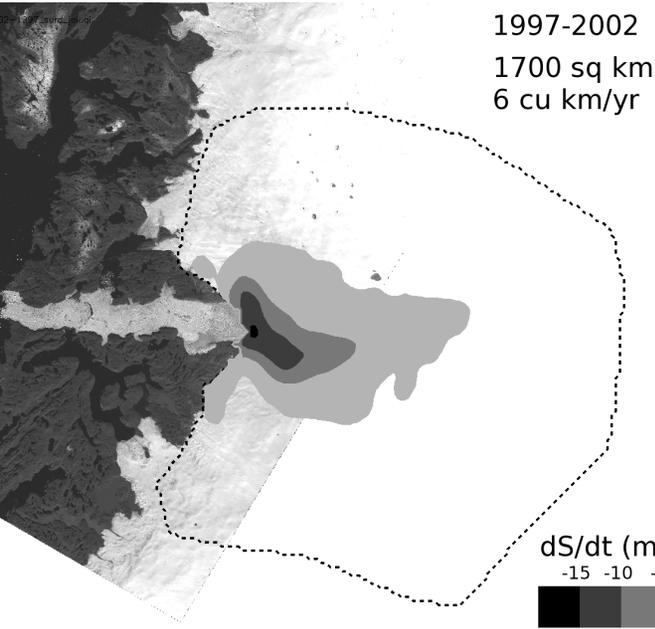
Arve-prinsens Eiland

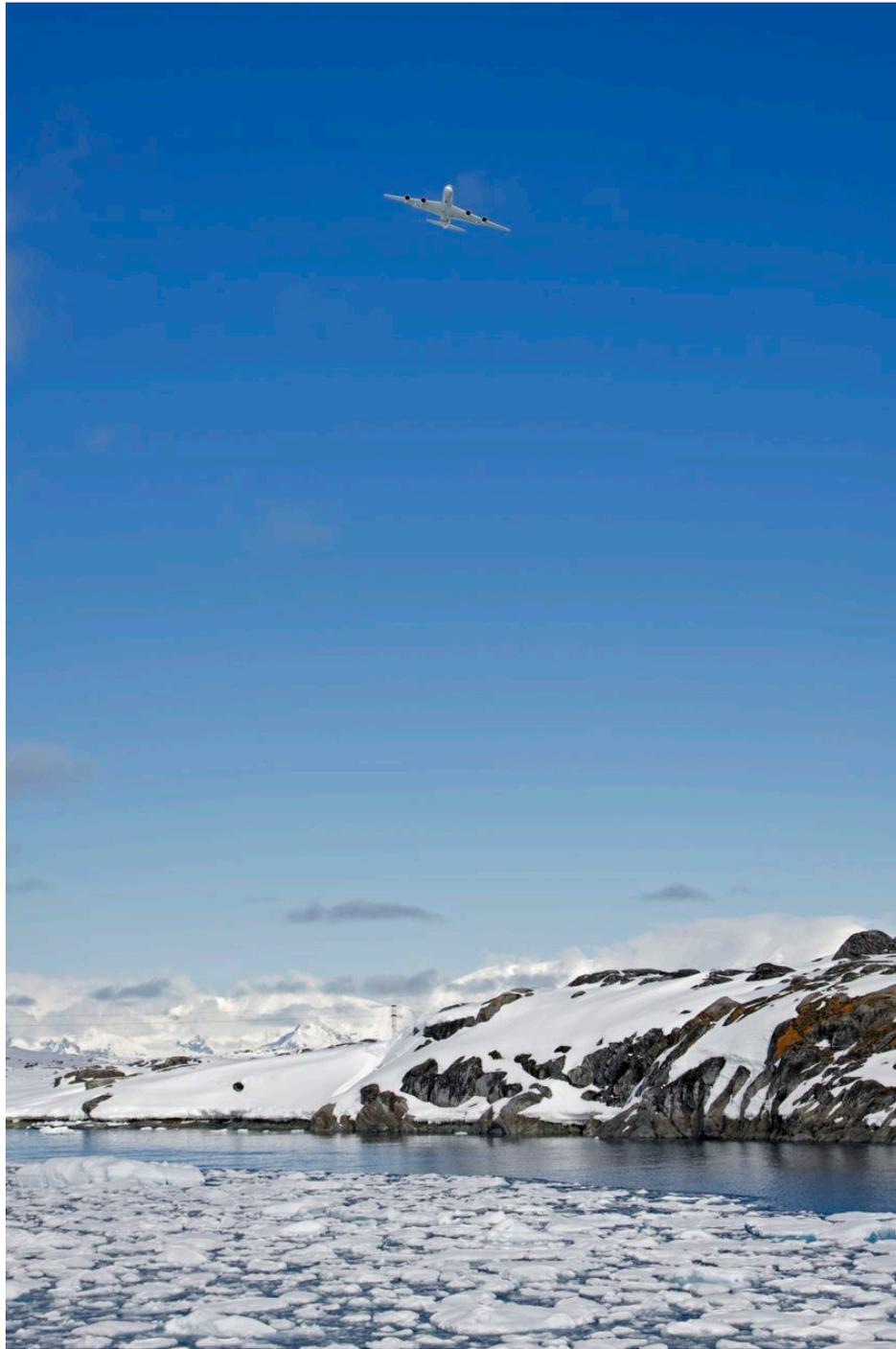
Ilulissat

Jakobsholm

Jakobshavn GI

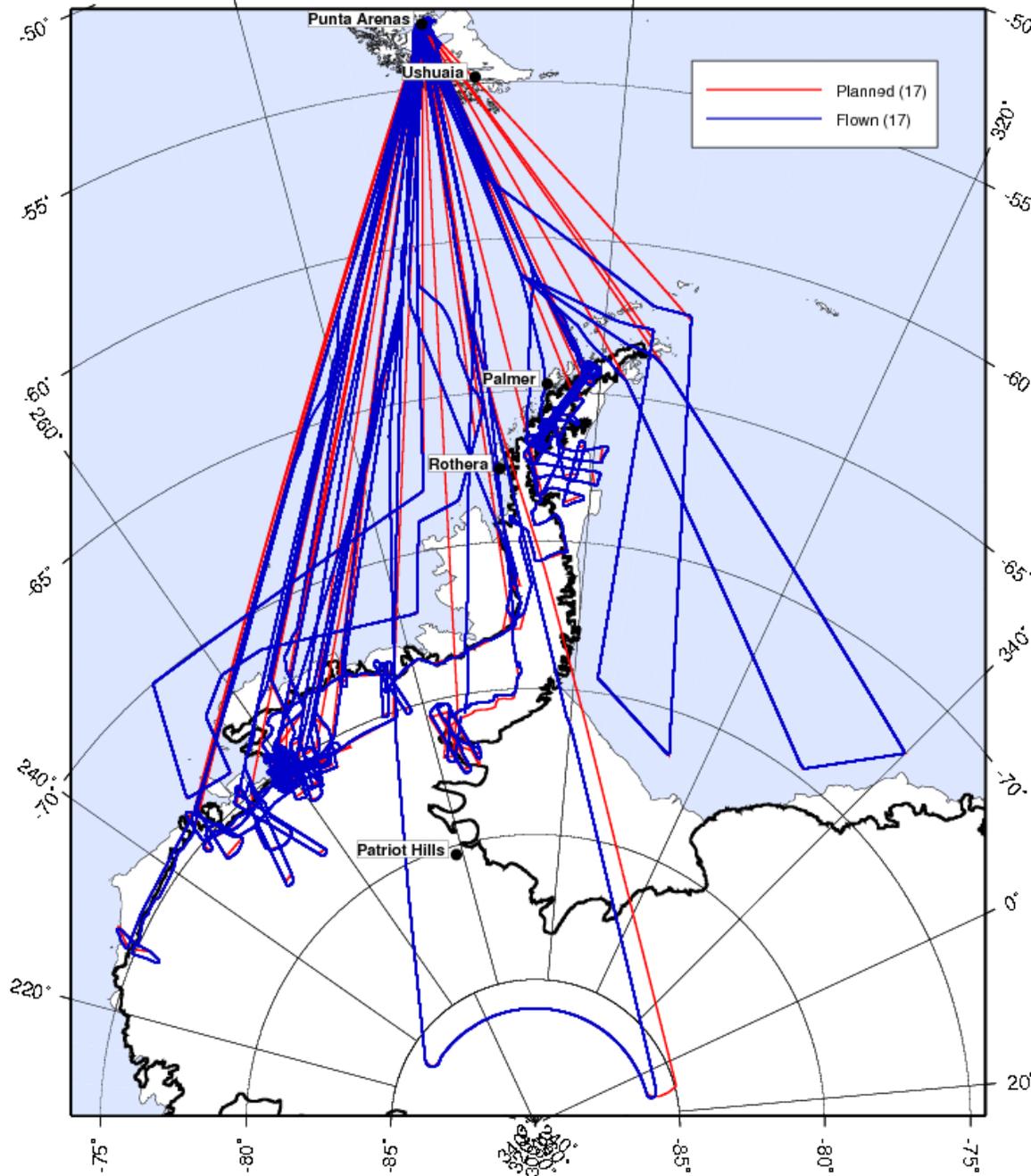






# Fall 2009 IceBridge Campaign

Updated 16 November



21 missions  
227.4 flight hours  
83,858 nautical miles  
flown  
(about 4 times  
around the Earth at  
the equator)

Thanks for your  
interest!

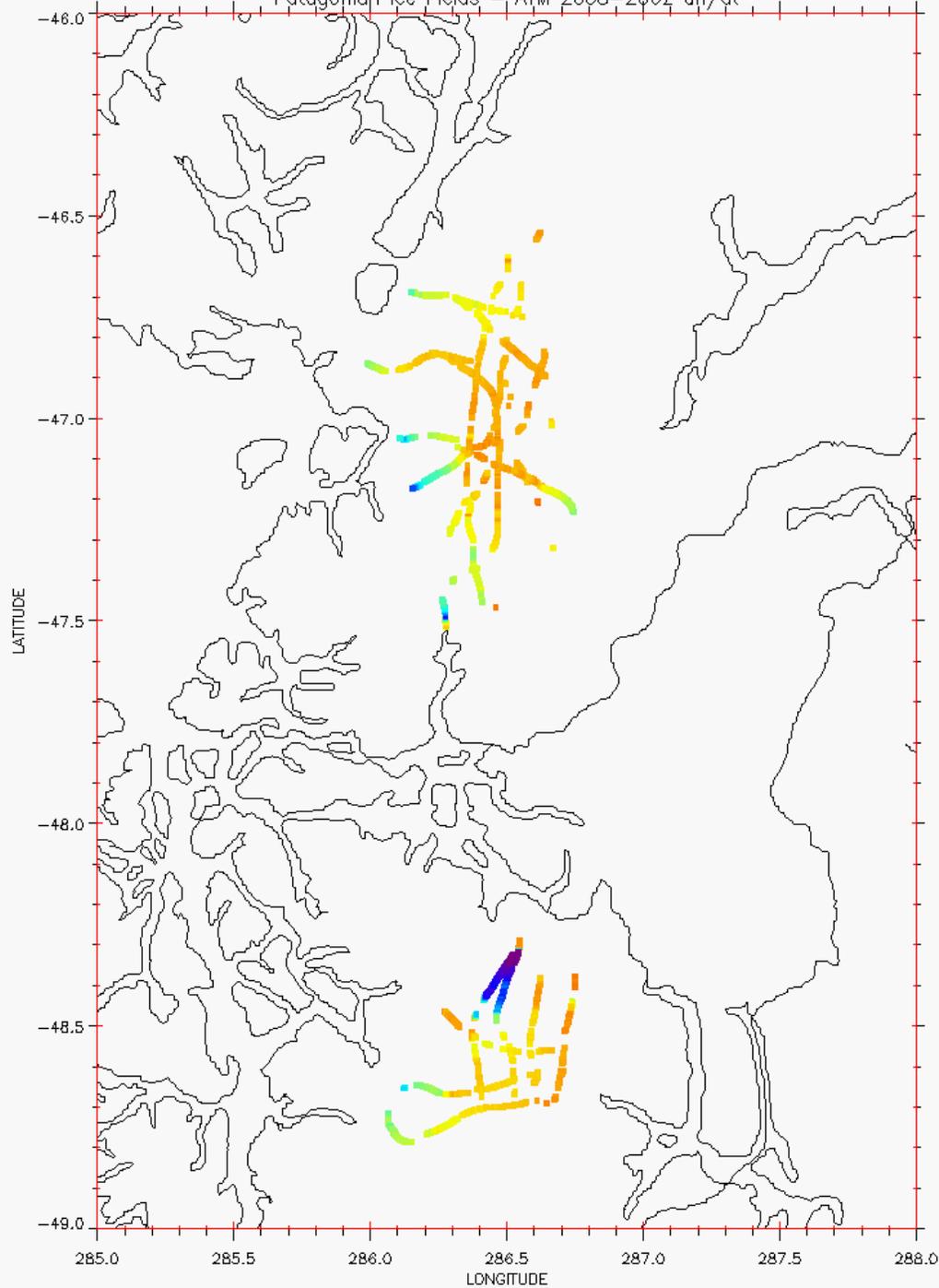


## Armada de Chile P3

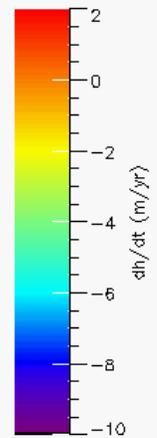


Collaborations with  
Centro de Estudios  
Científicos in 2002, 2004  
and 2008

Patagonian Ice Fields - ATM 2008-2002 dh/dt



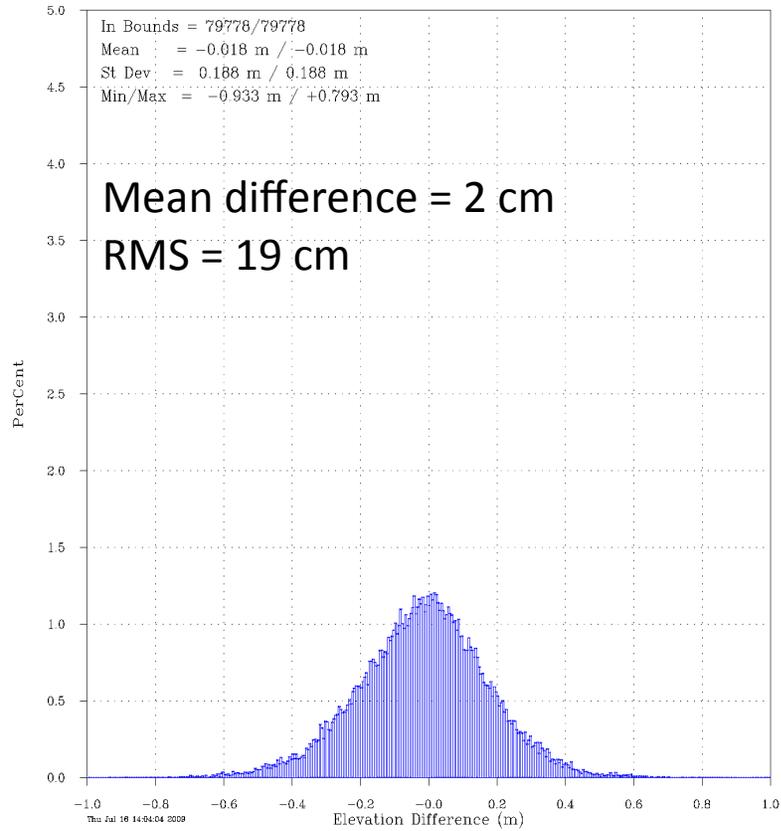
364.44 m/pixel



# Histograms of differences

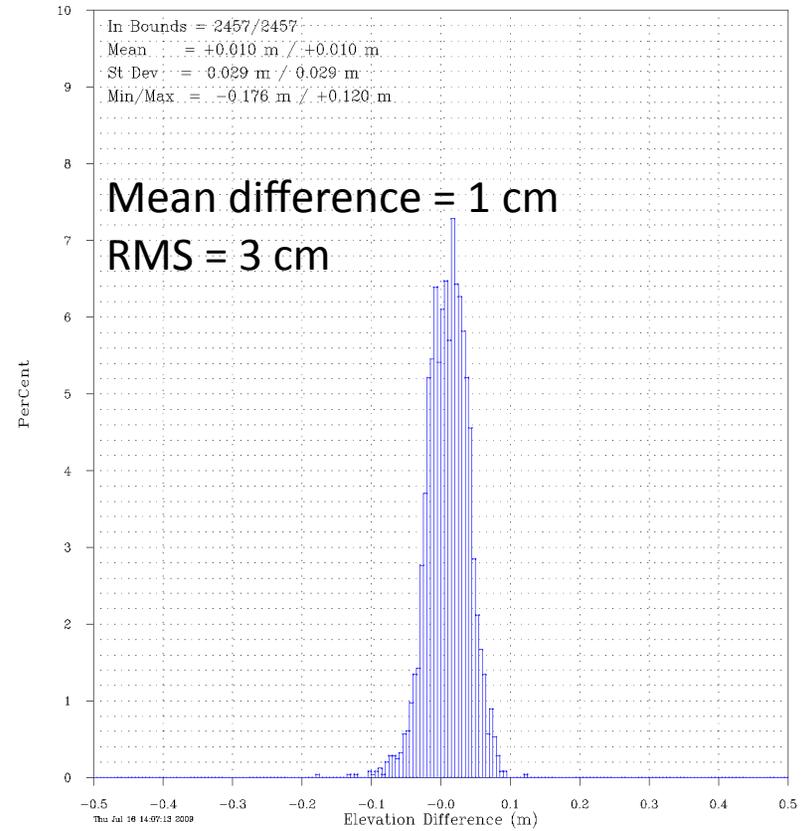
## ICESat – ATM

GLAS 090404 – ATM 090420

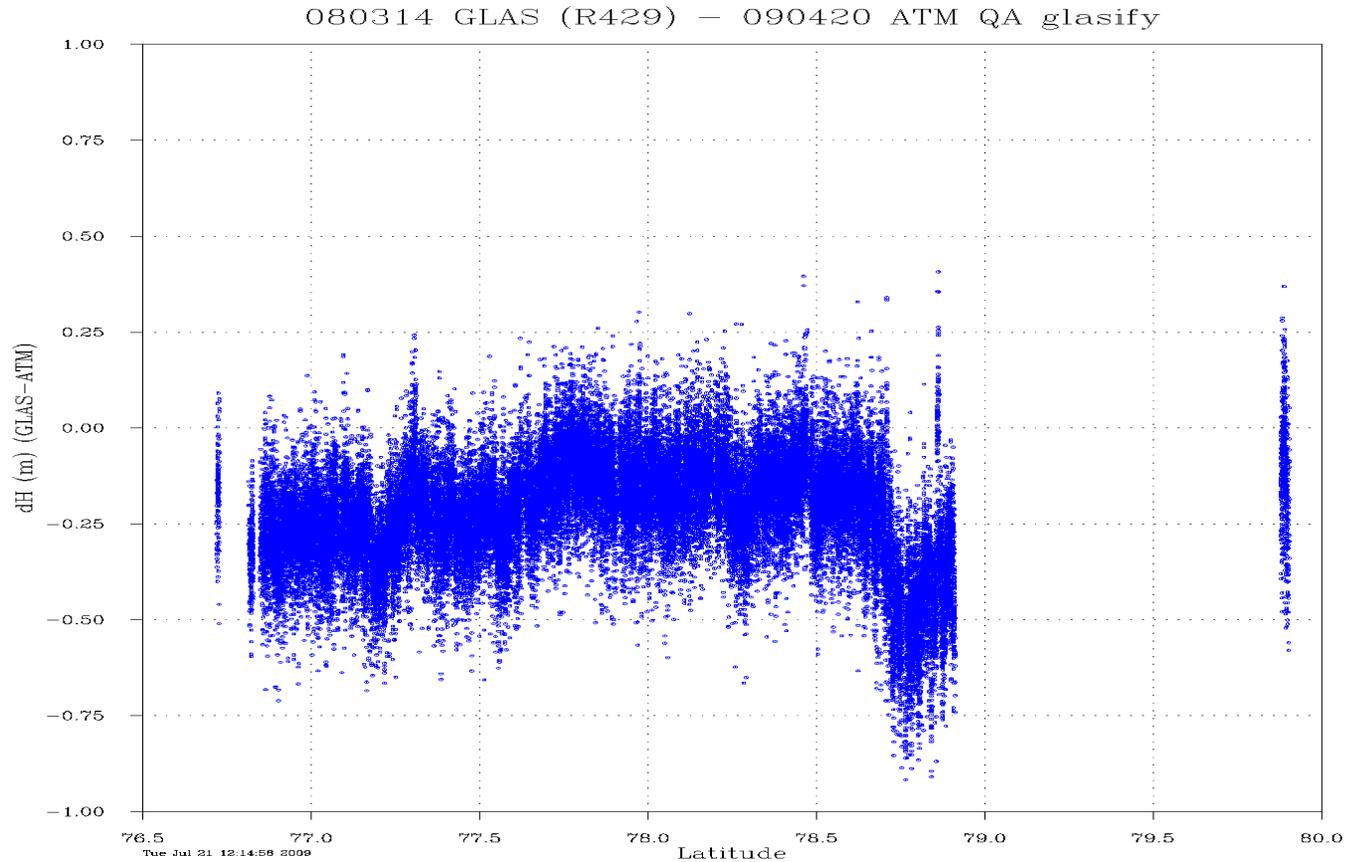


## ATM N\_S – ATM S\_N

090420 northbound – 090420 southbound

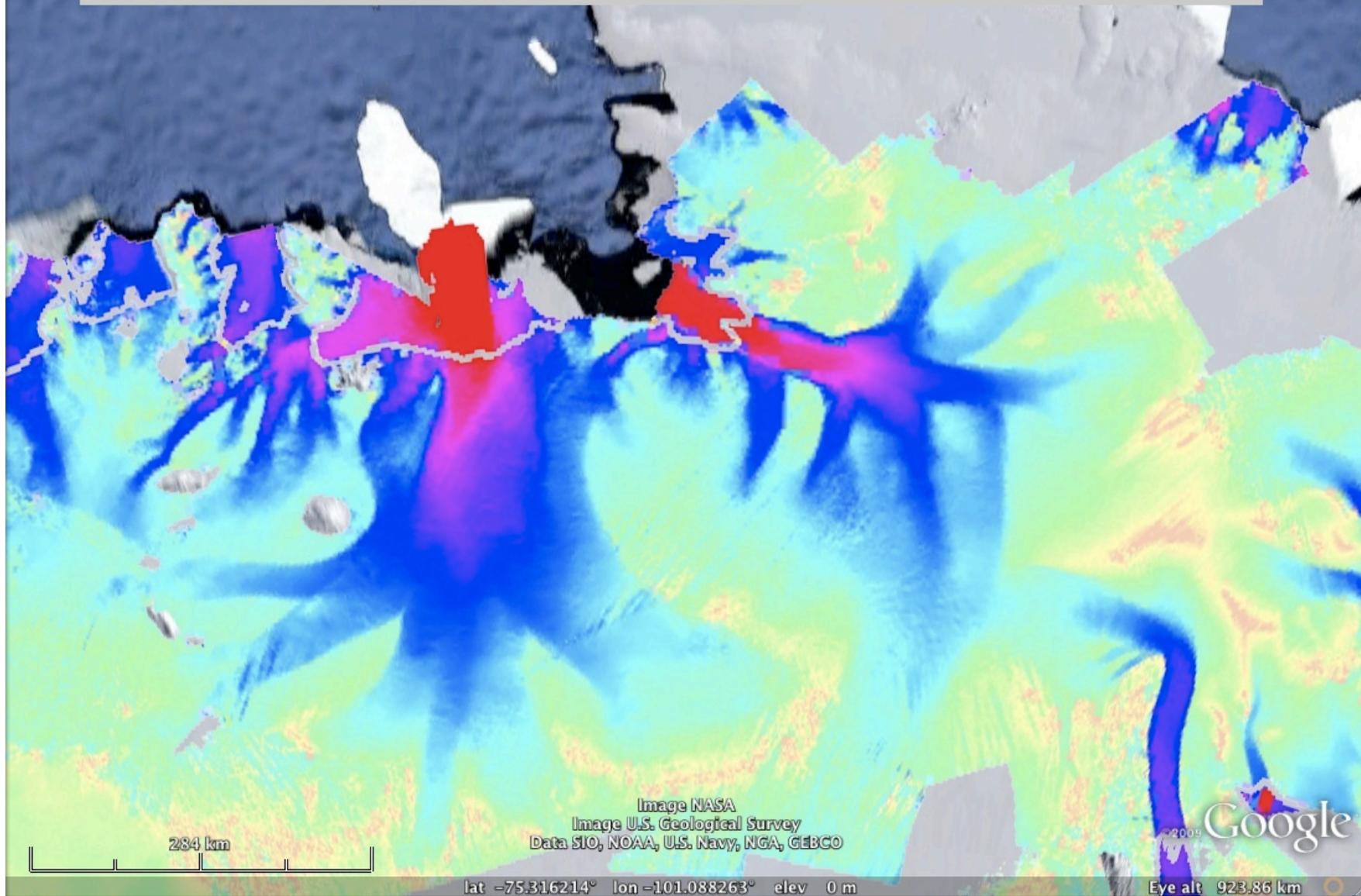


As an additional check we compared to a different ICESat pass from the previous year  
(March 14, 2008)

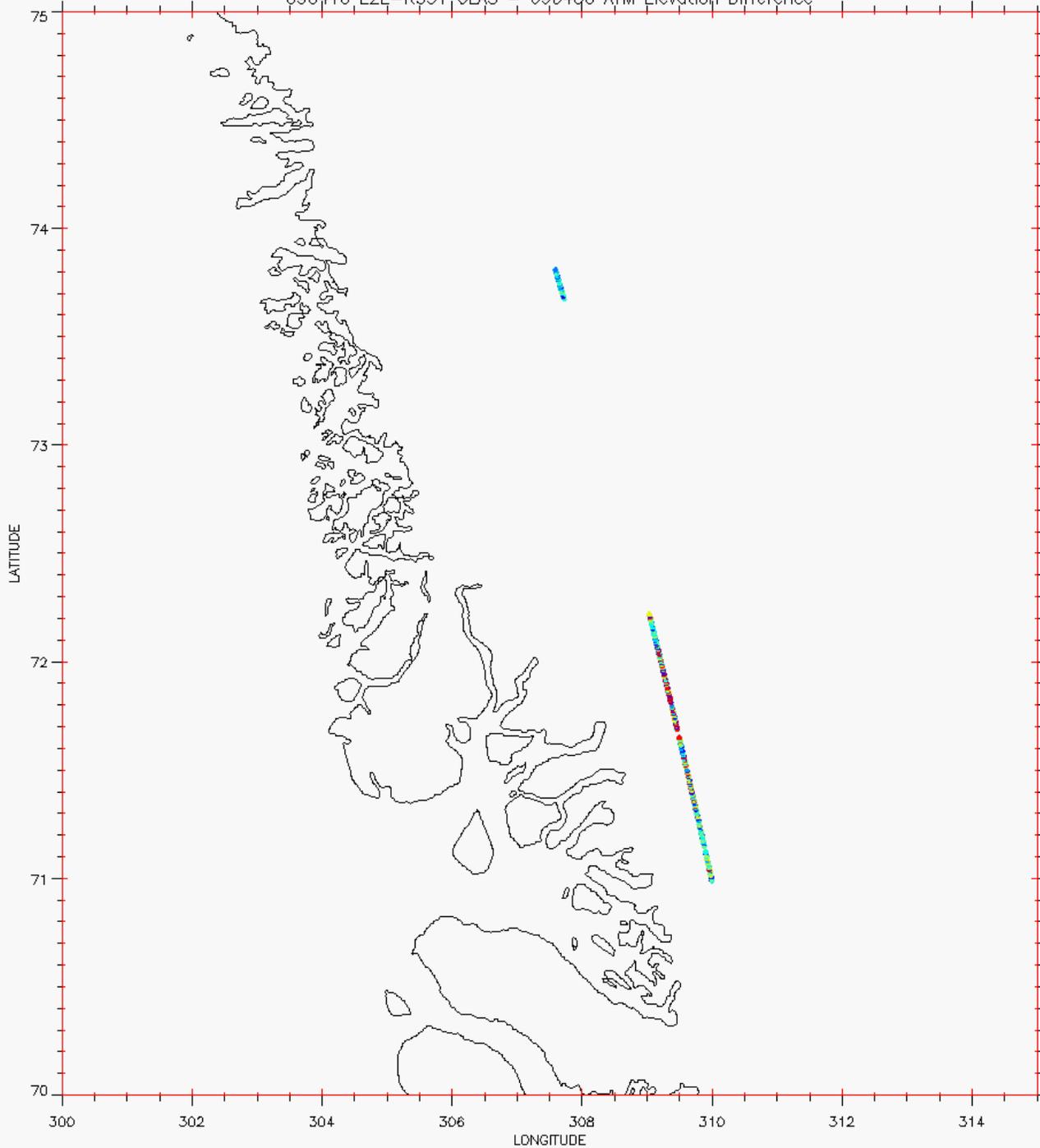


The scatter is  $\sim$  half that of the recent low-power data. The negative differences suggests thinning has taken place between March, 2008 and April, 2009.

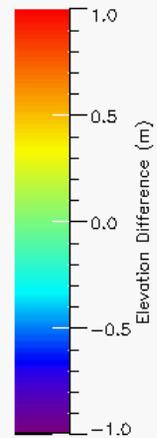
# Glacier velocity map (Joughin) Pine Island, Thwaites, Smith, & Kohler Glaciers



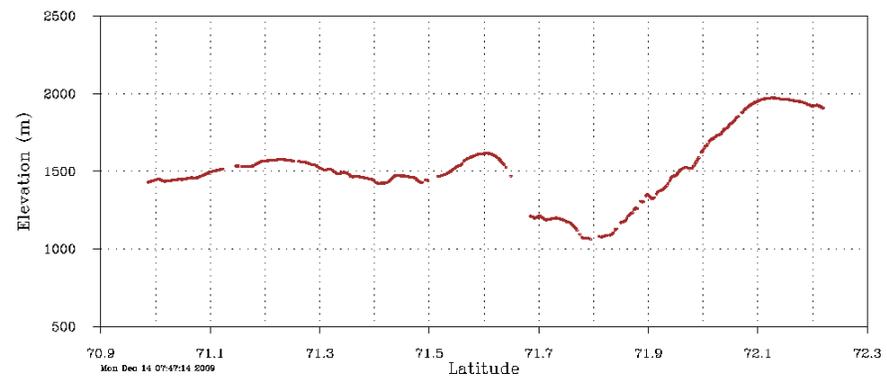
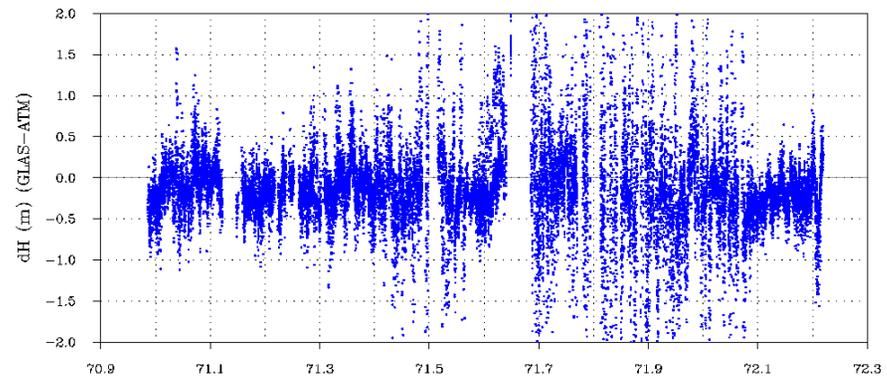
090410 L2E-R531, GLAS - 090406 ATM Elevation Difference



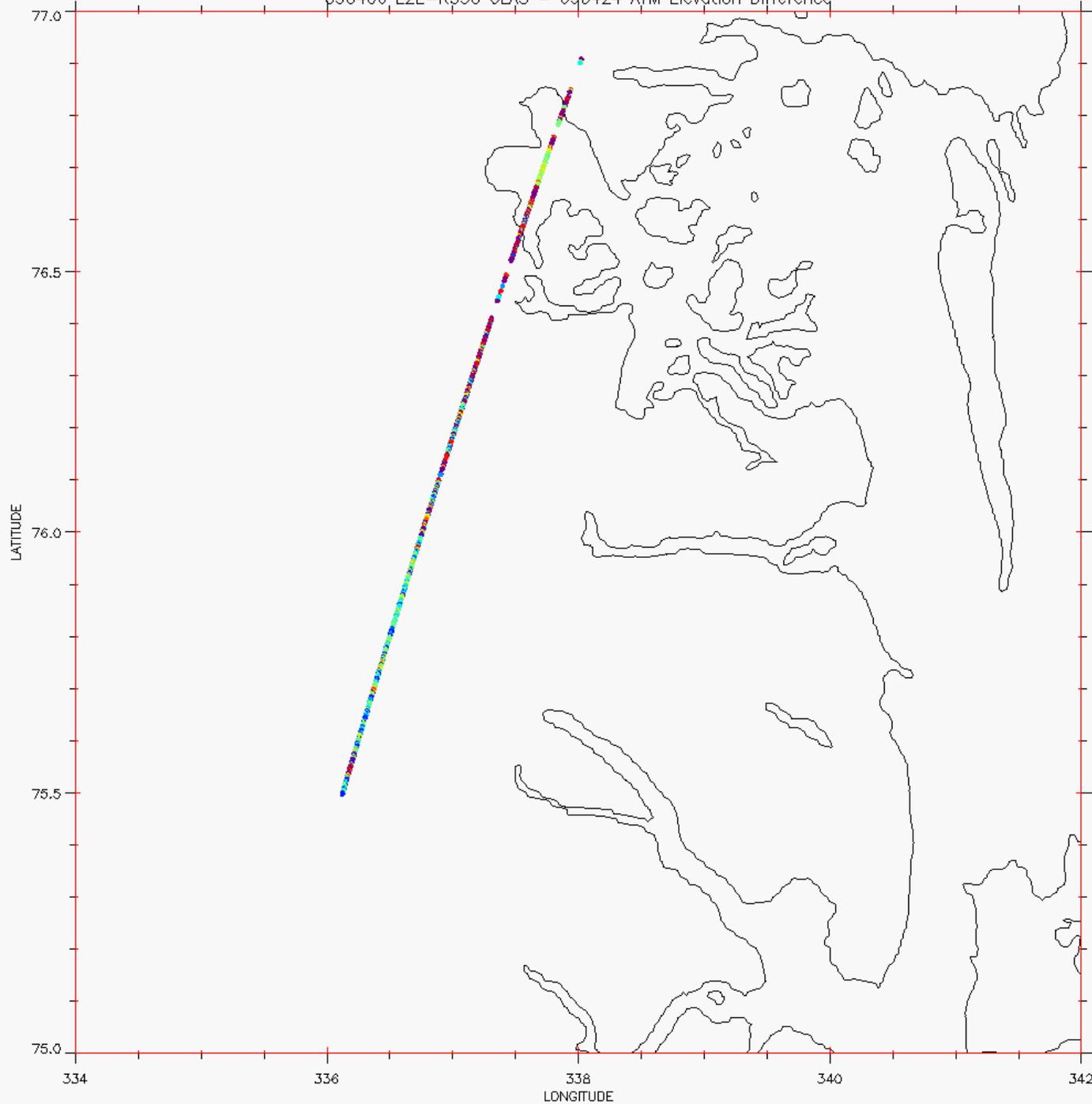
590.74 m/pixel



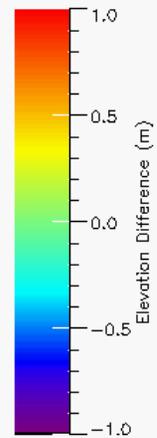
090410 (R531) GLAS - 090406 ATM QA altdify



090406\_L2E-R530 GLAS - 090424 ATM Elevation Difference



236.30 m/pixel



090406 (R531) GLAS - 090424 ATM QA altdify

