Patterns and Possible Drivers of Rapid Glacier Change Around Greenland

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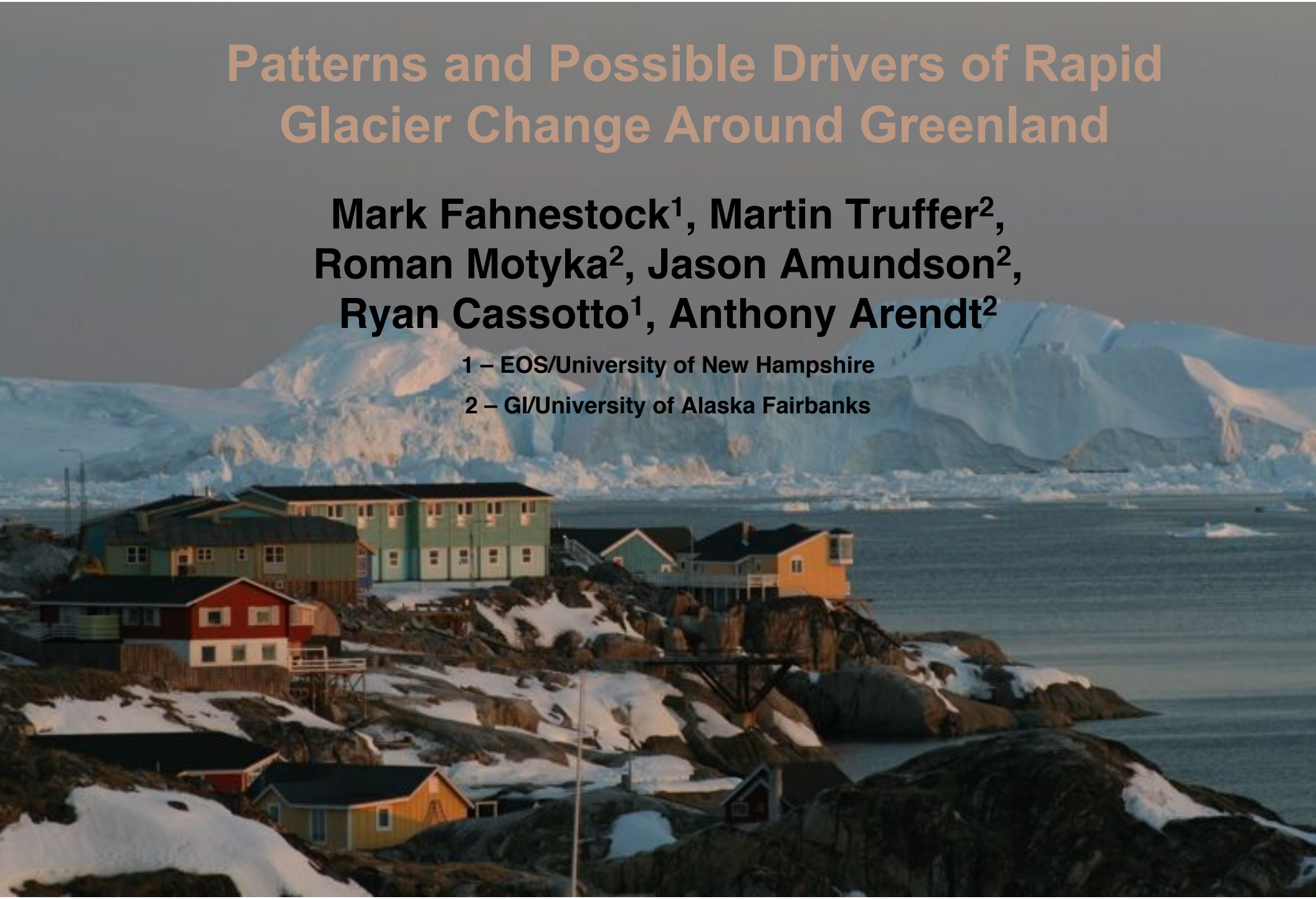
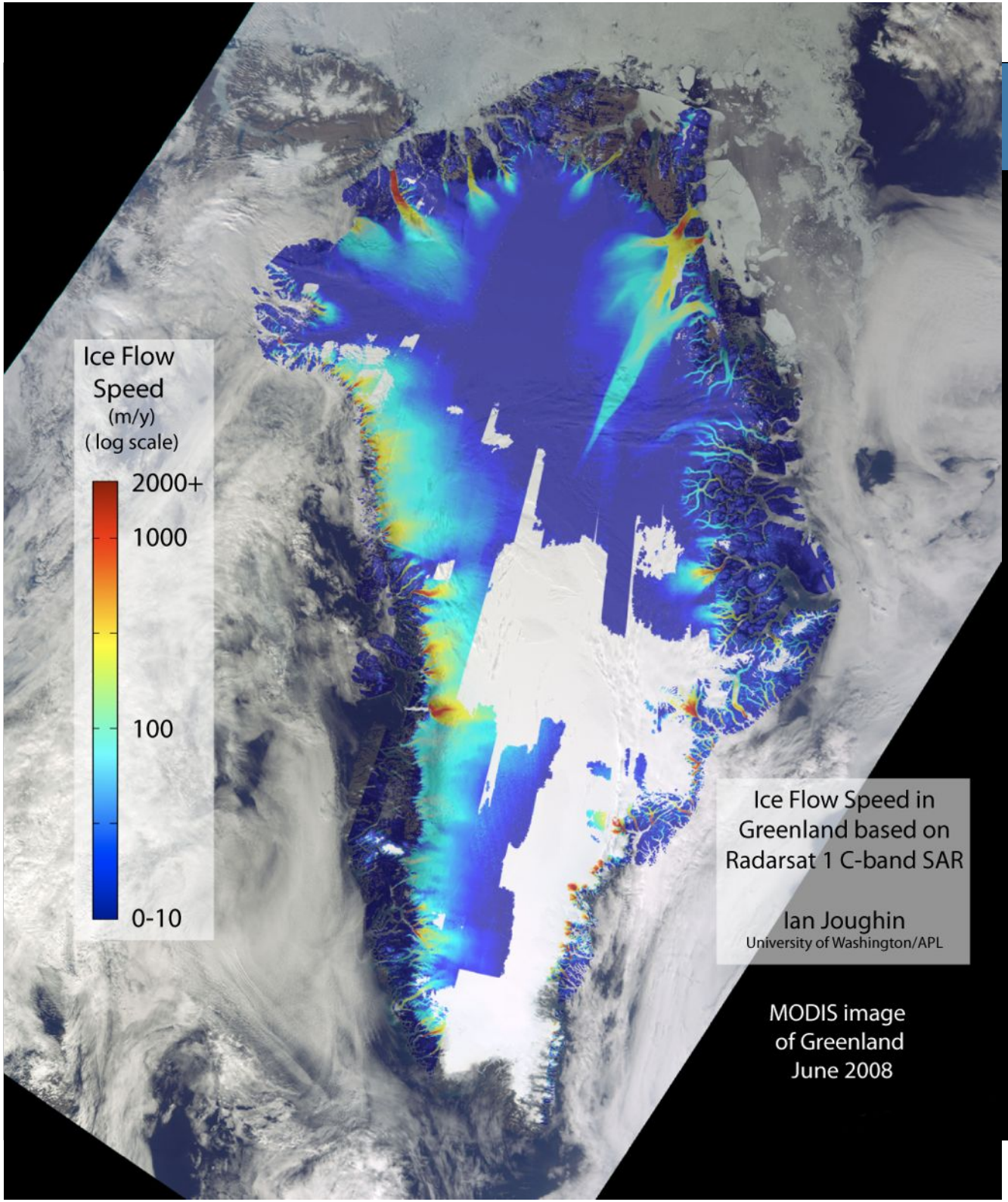
1 – EOS/University of New Hampshire

2 – GI/University of Alaska Fairbanks



Greenland


Ice Flow
Speed
(m/y)
(log scale)
2000+
1000
100
0-10
Ice Flow Speed in
Greenland based on
Radarsat 1 C-band SAR
Ian Joughin
University of Washington/APL
MODIS image
of Greenland
June 2008

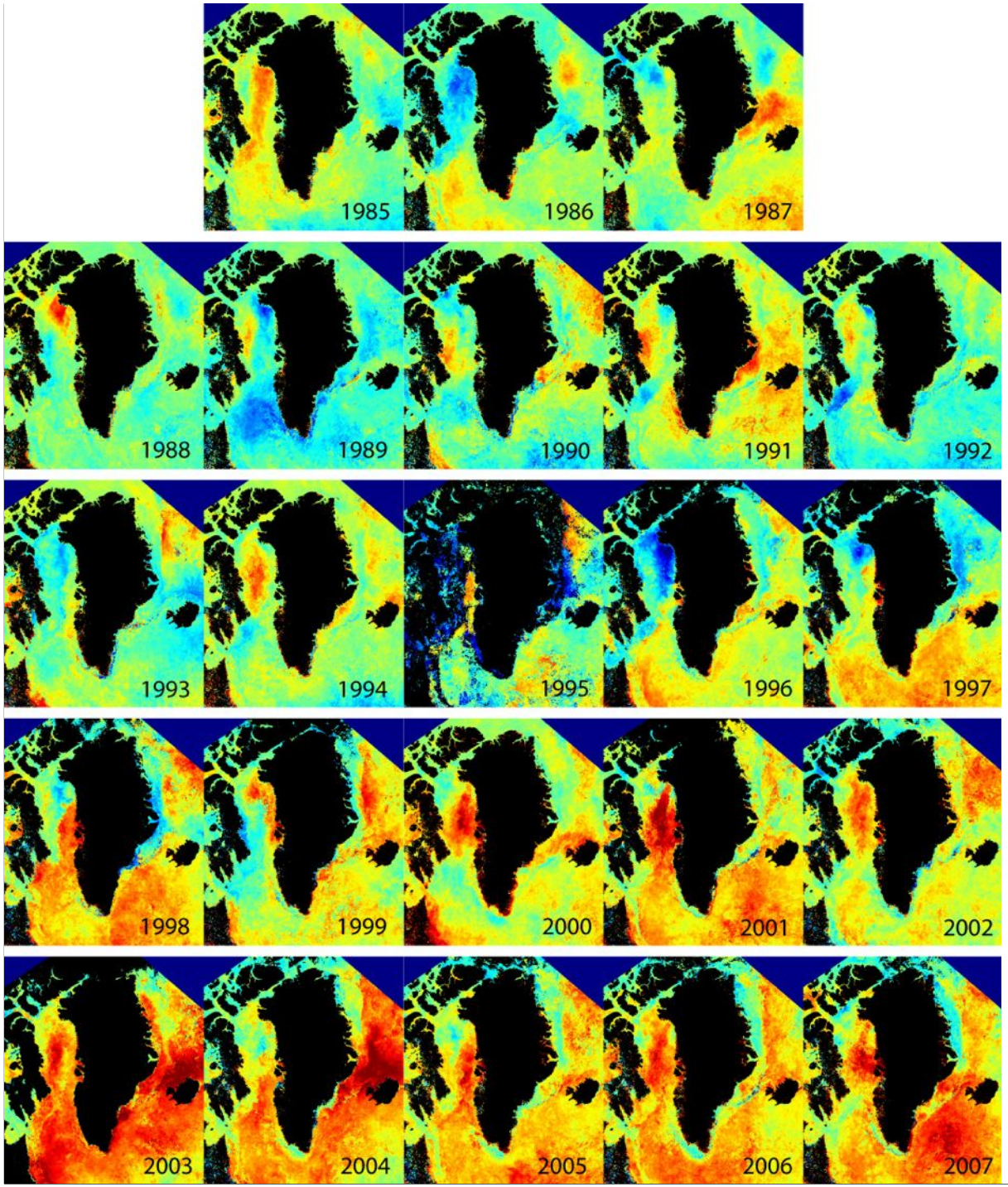
The Greenland Ice Sheet in a warming Arctic

In the last decade:

Outlet glaciers around Greenland have accelerated and surface melting has increased

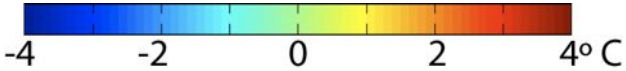
More ice has been discharged into the ocean than has fallen as snow

The ice sheet is presently tens of percent out of balance as a result of these changes



The ocean around Greenland has warmed

Here we show surface temperature; Holland et al. (2008) have shown changes in shelf currents in SW Greenland

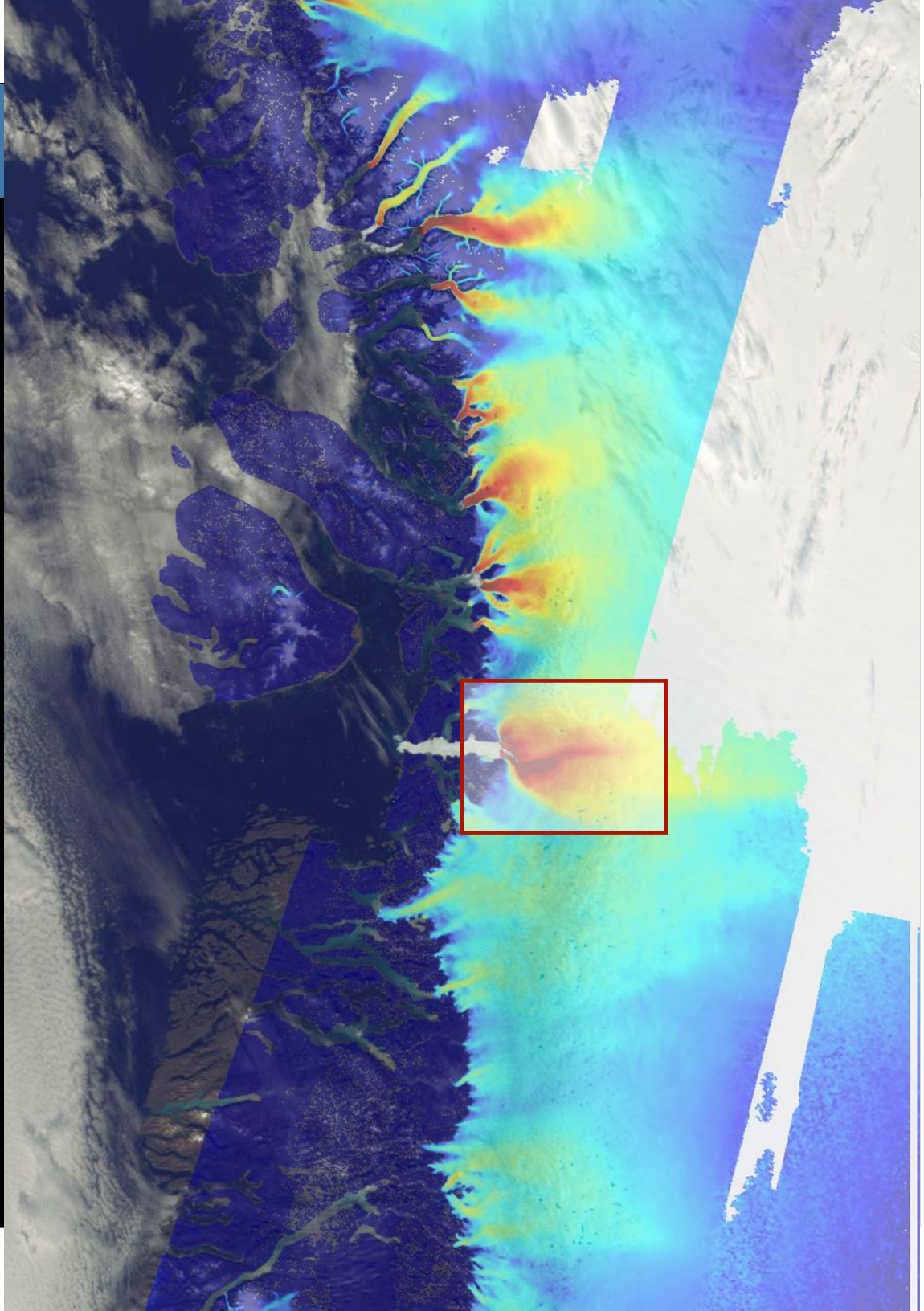


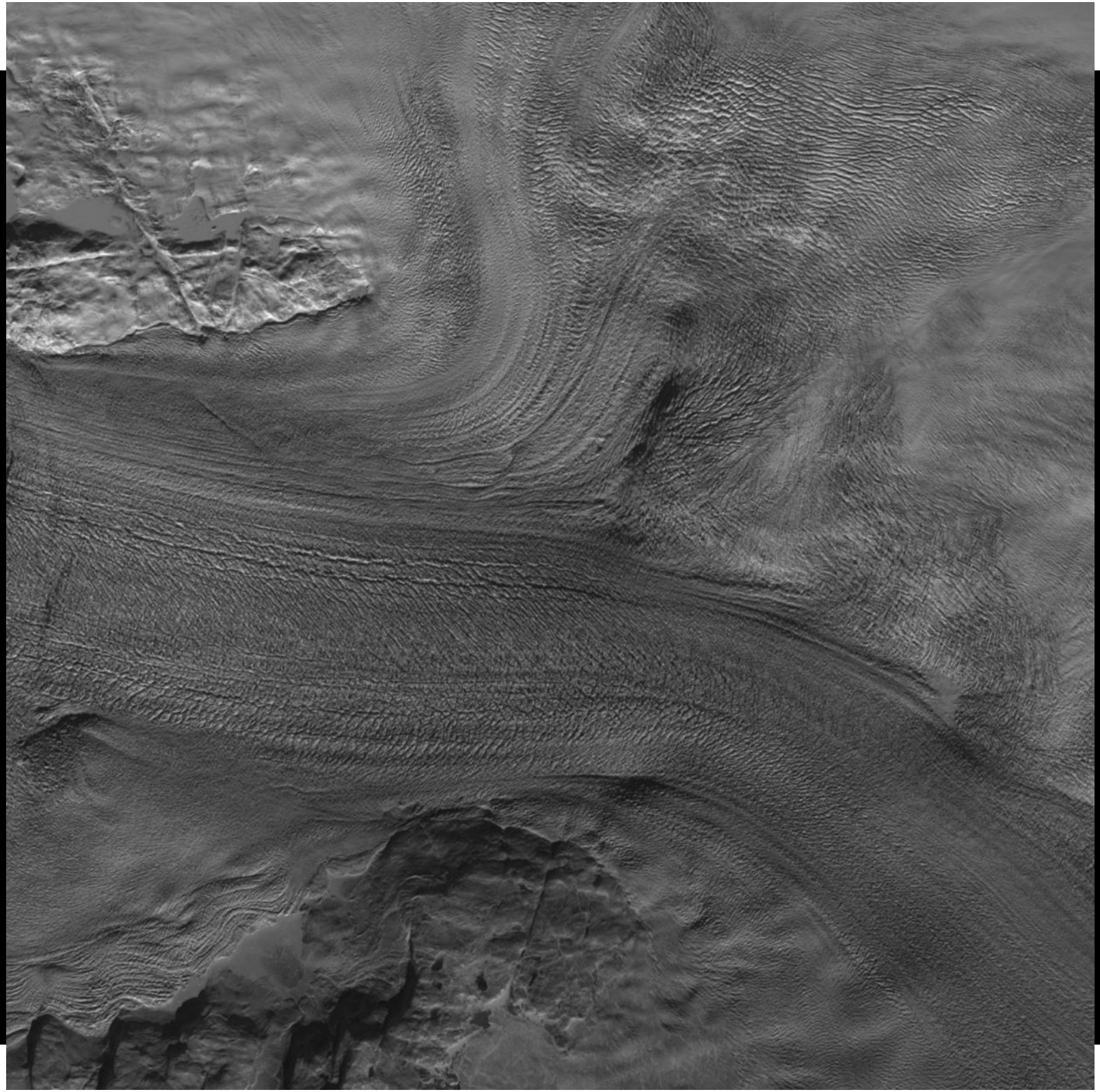
Summer Maximum SST Anomaly
(relative to 1985-89 mean)

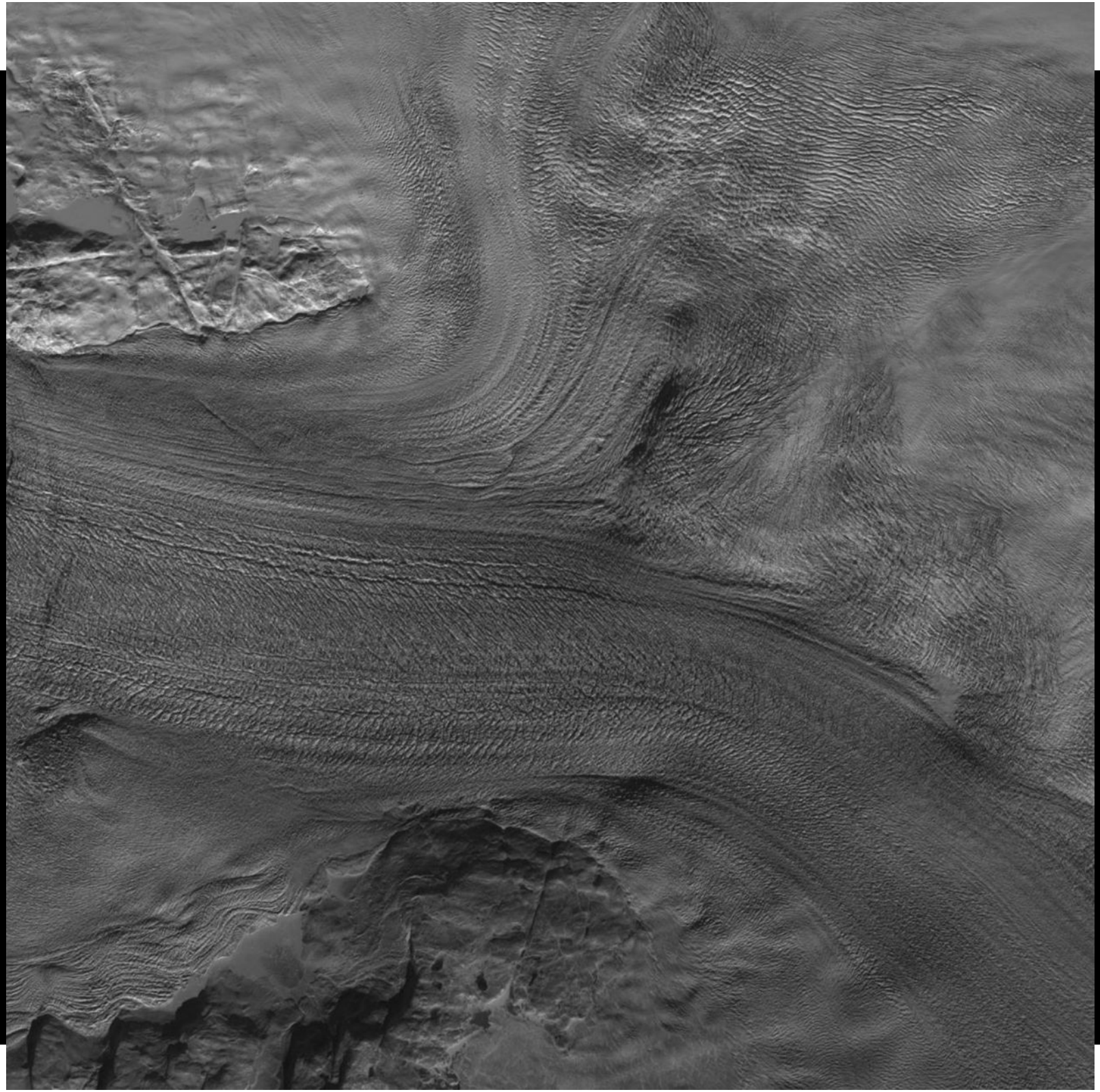
Jakobshavns Isbrae

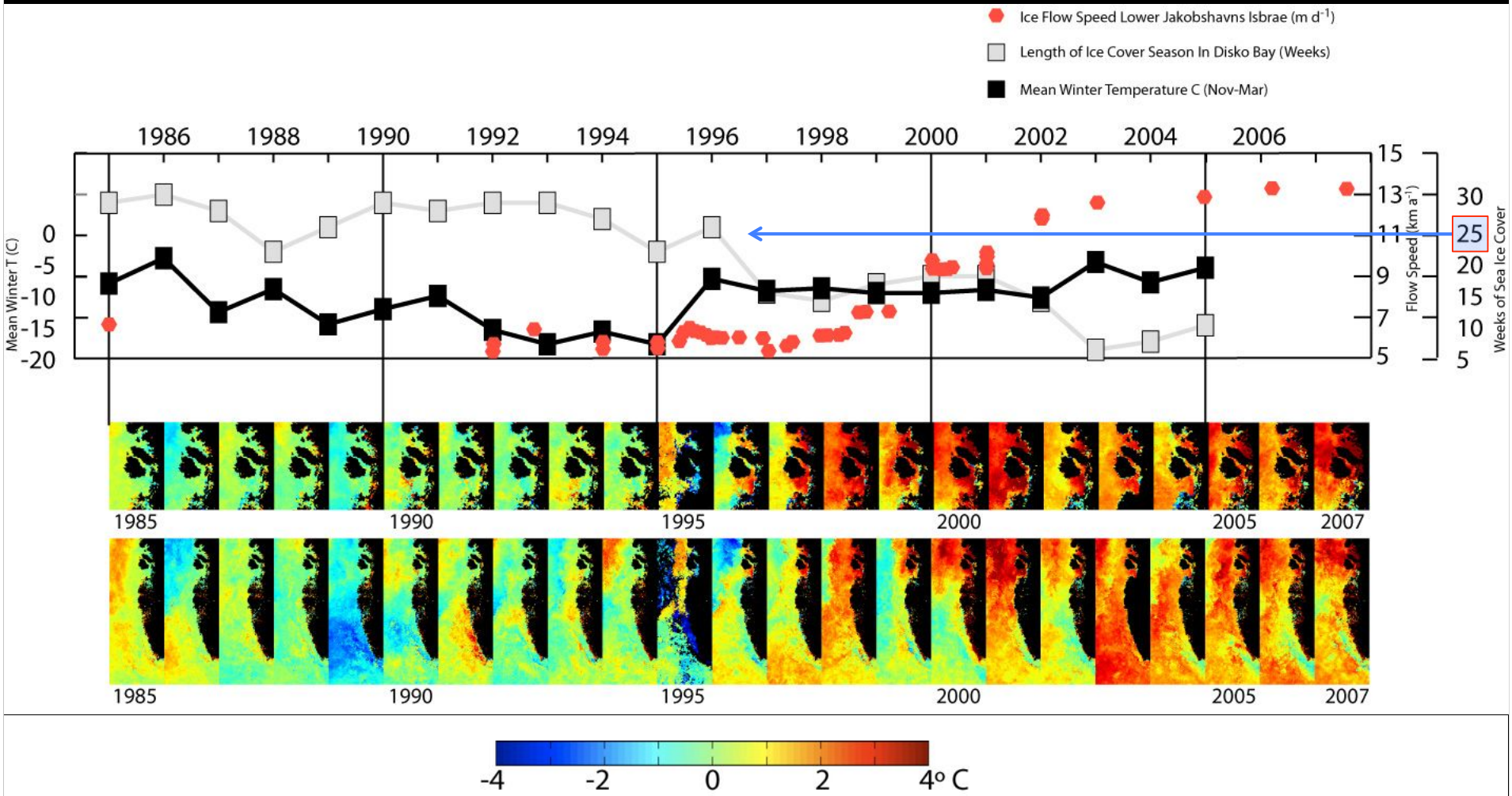
This glacier lost a large floating tongue and doubled its speed at the beginning of the decade

It has doubled its speed and thinned by hundreds of meters as a result

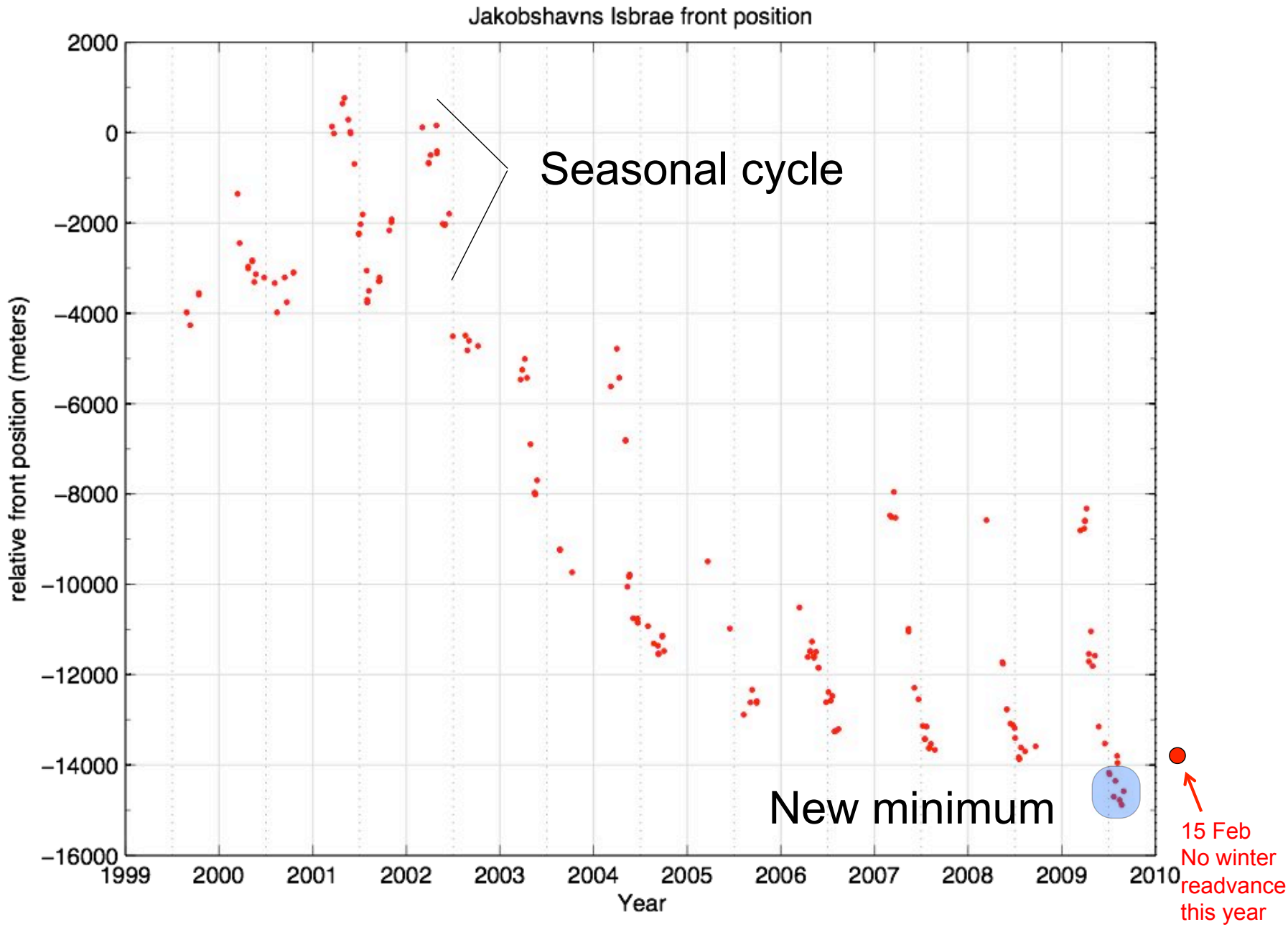


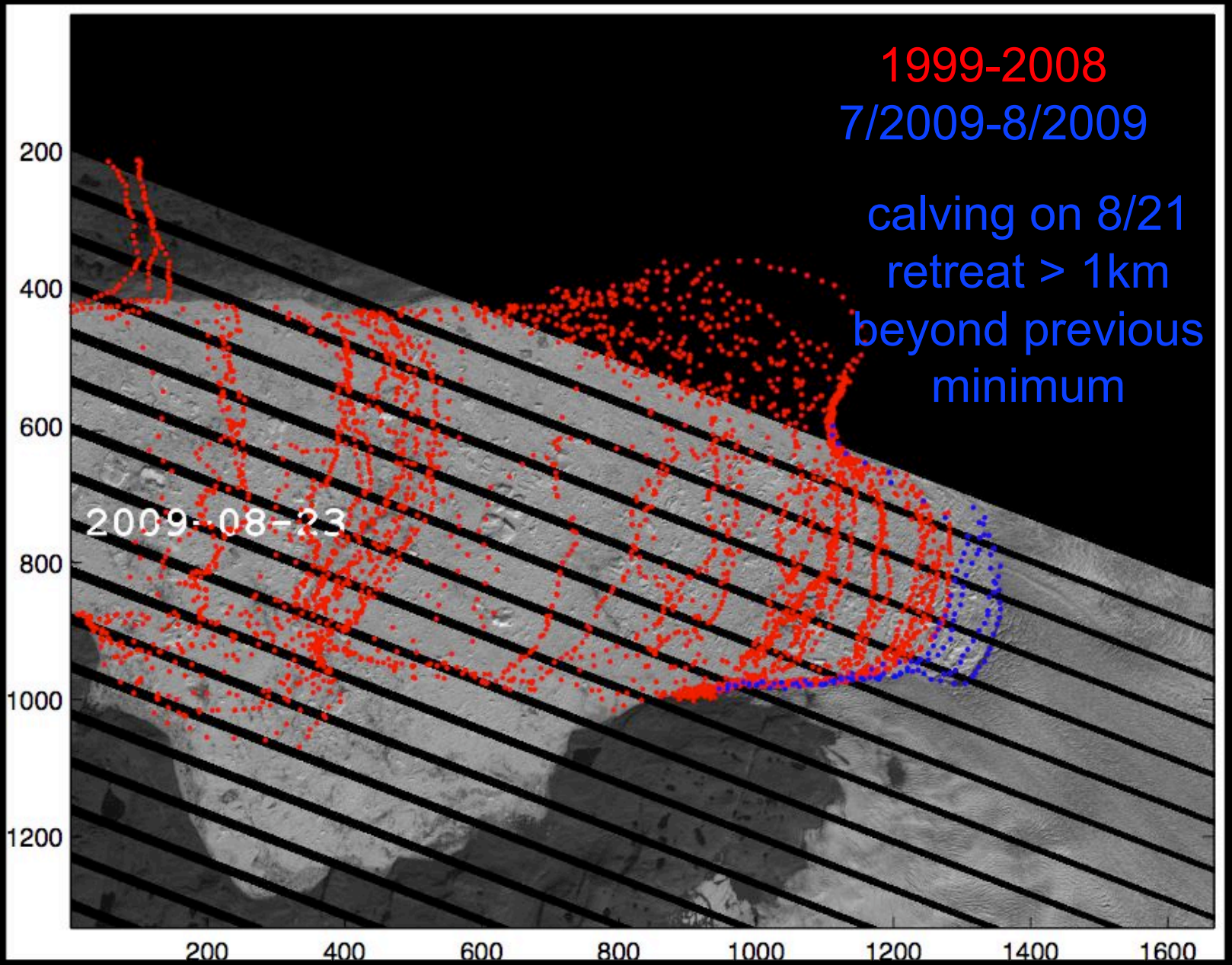




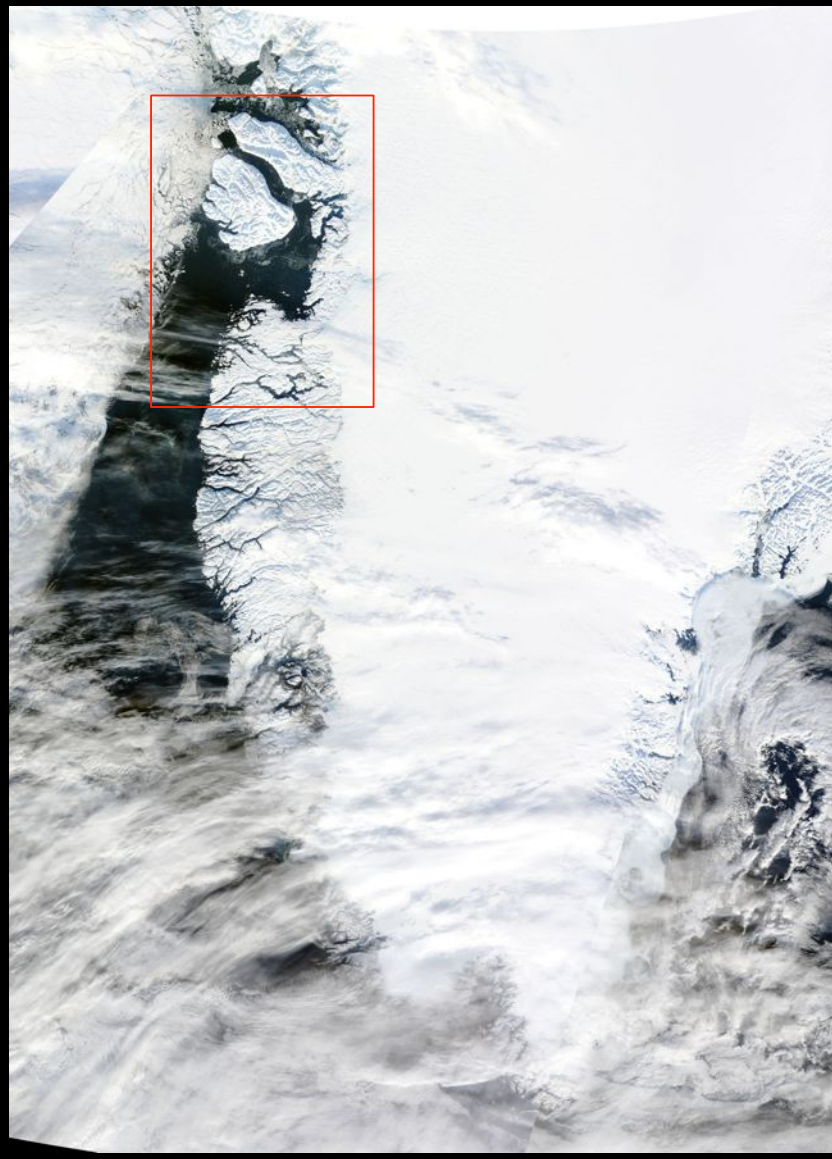


Summer Maximum SST Anomaly (relative to 1985-89 mean)

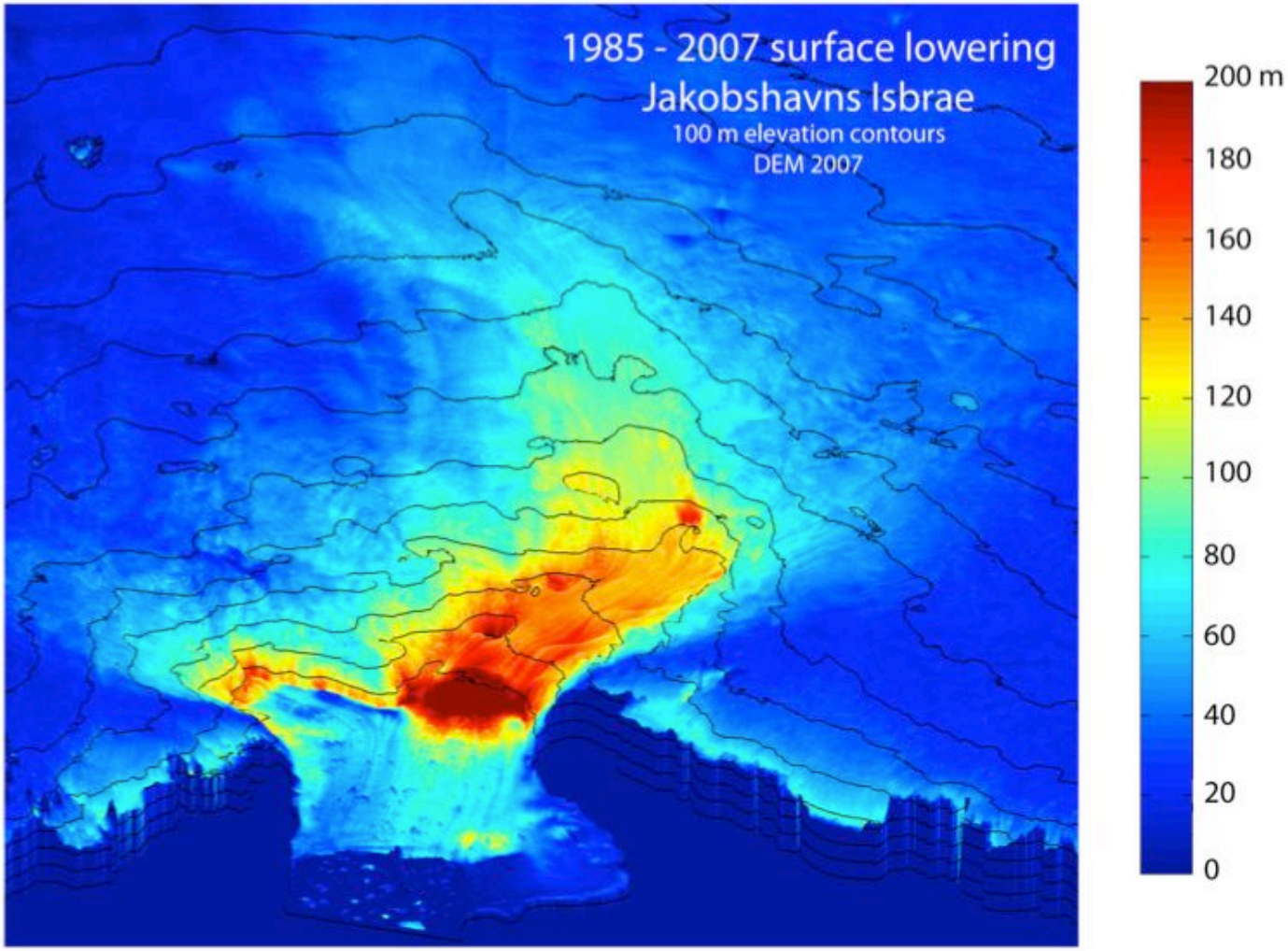

Jakobshavns Isbrae front position
relative front position (meters)
2000
0
−2000
−4000
−6000
−8000
−10000
−12000
−14000
−16000
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year
Seasonal cycle
New minimum
15 Feb
No winter
readvance
this year


1999-2008
7/2009-8/2009
calving on 8/21
retreat > 1km
beyond previous
minimum
2009-08-23
200
400
600
800
1000
1200
200
400
600
800
1000
1200
1400
1600

Disko Bay 15 February 2010

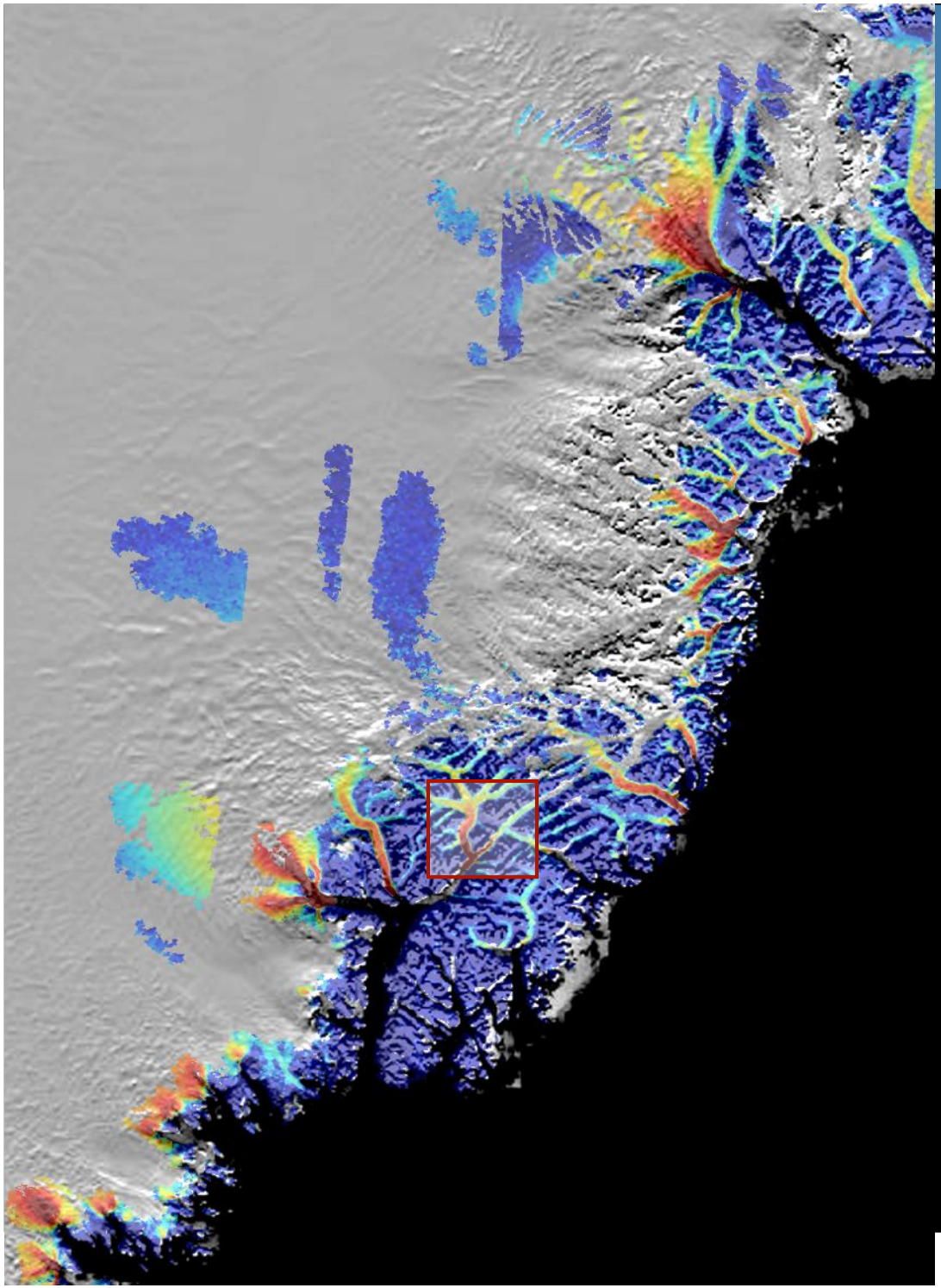


Comparison 1985 (Brecher) to 2007 (SPOT)

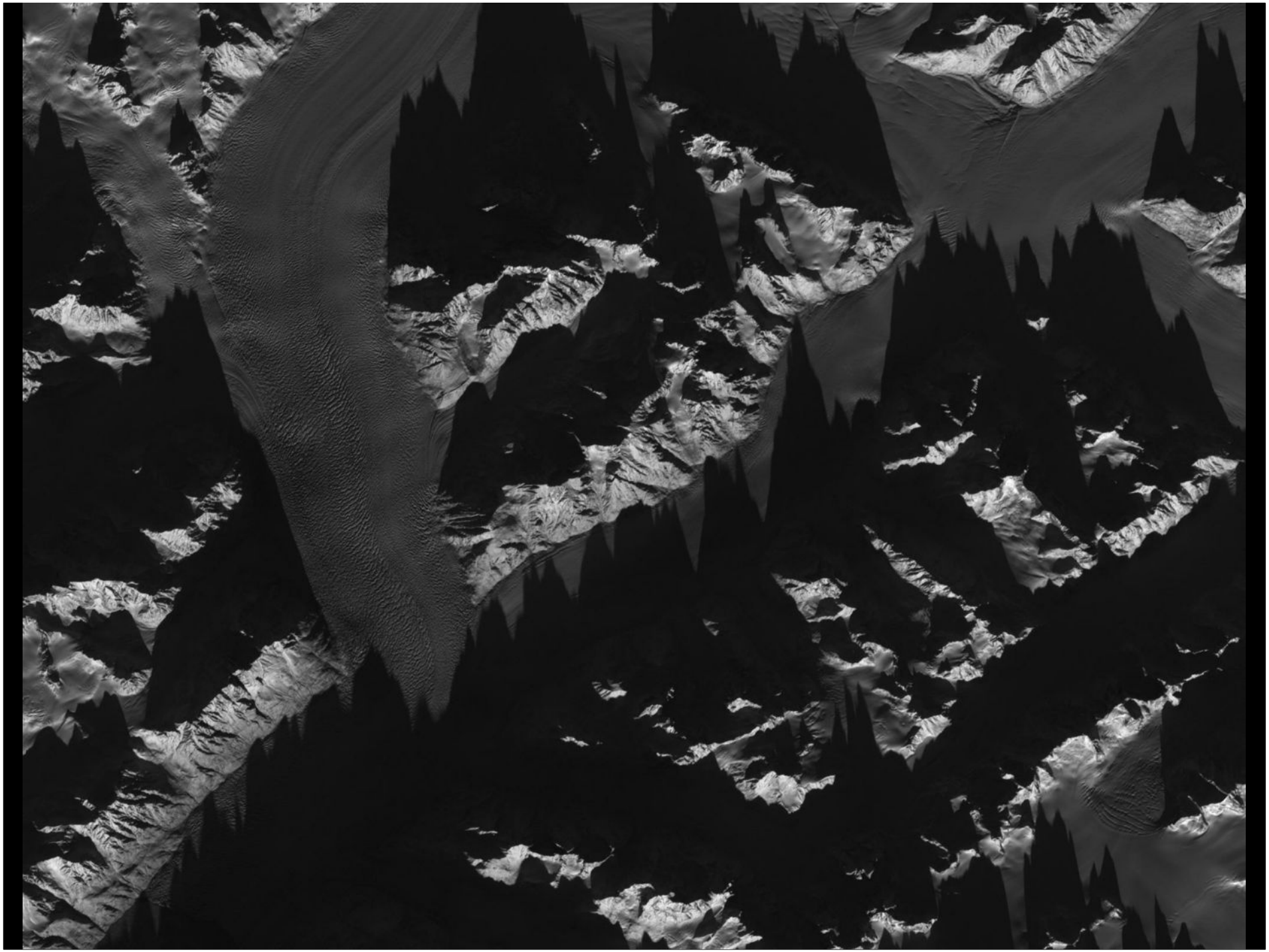


Total drawdown: $\sim 120\,\mathrm{km}^3$

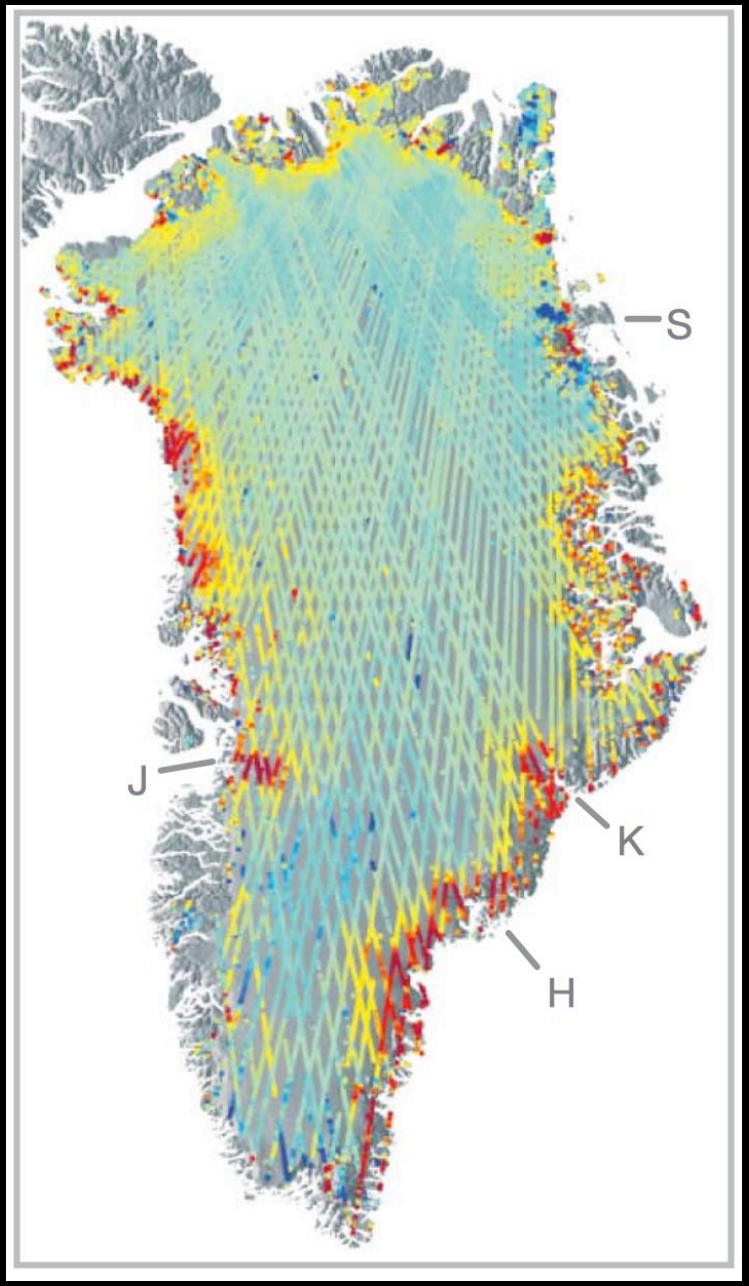
Motyka et al., in prep.



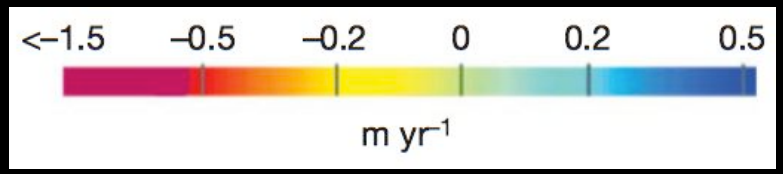
Midgardsgletscher near Helheim



How much ice is actually being lost?

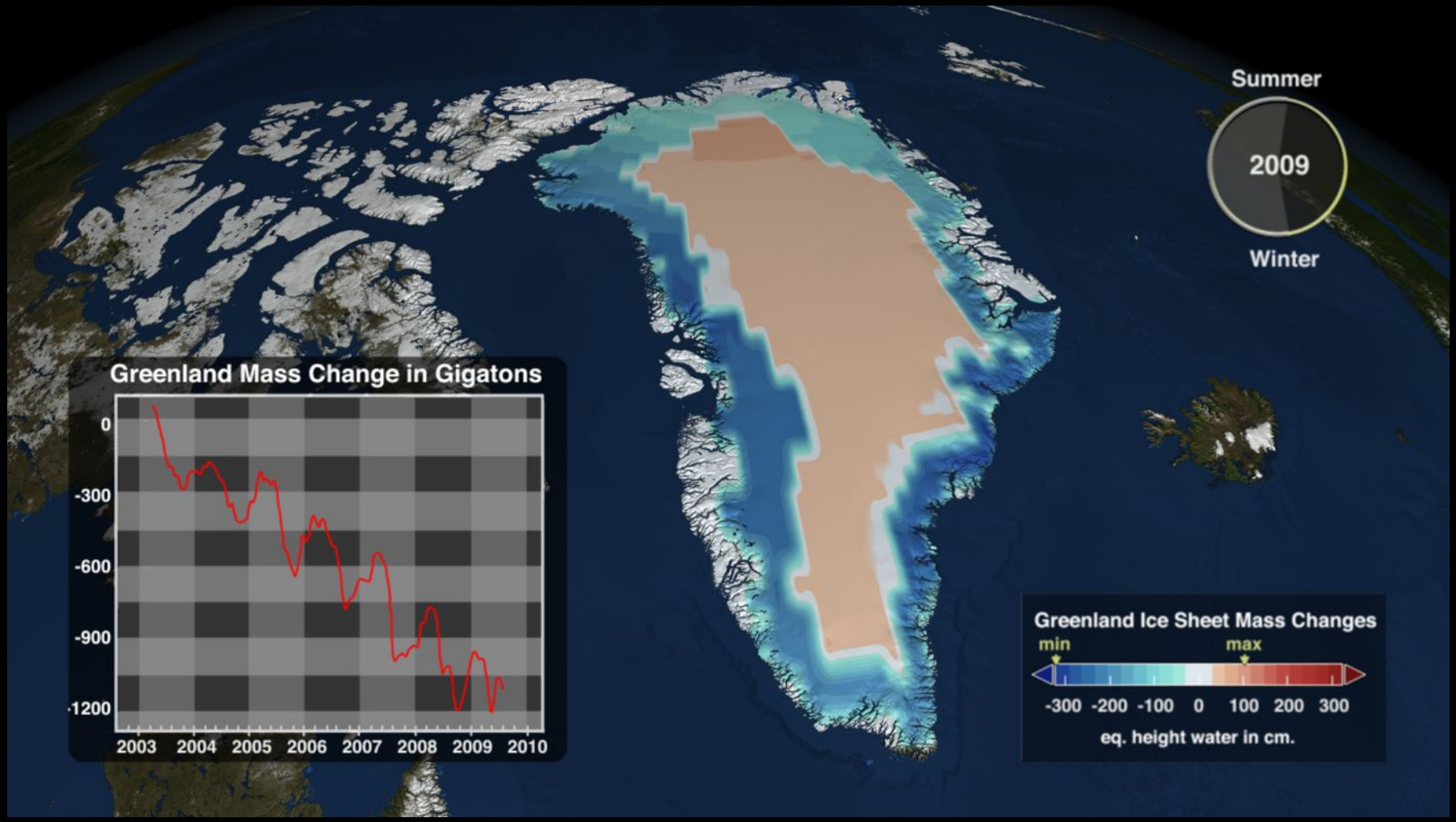


Greenland Surface Height Change measured by ICESat

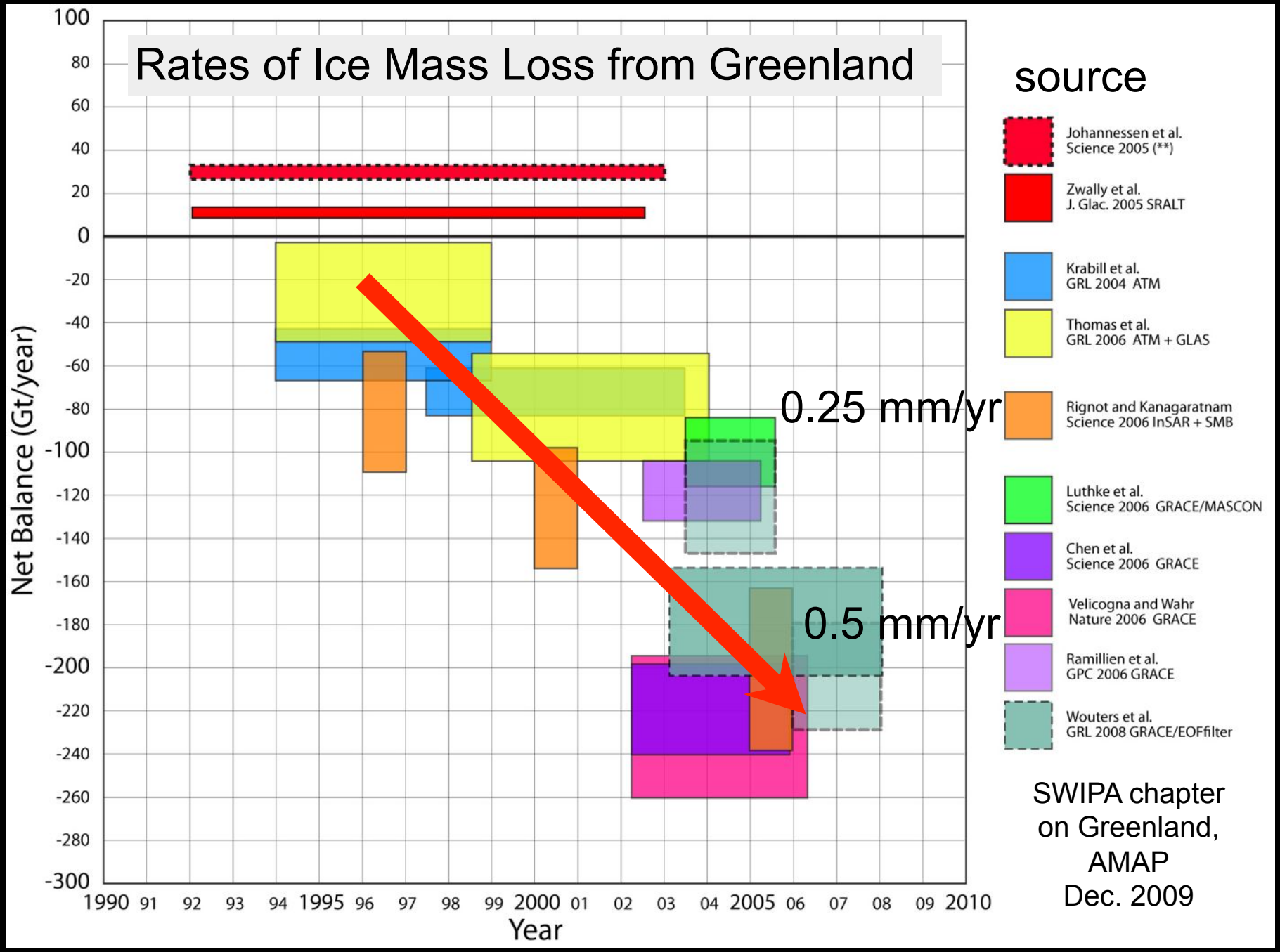


From Figure 1 in
Pritchard et al., Nature, 15 October 2009 |
doi:10.1038/nature08471

Greenland Mass Loss measured by GRACE



GRACE data analysis S. Luthke, NASA/GSFC – graphic: http://svs.gsfc.nasa.gov

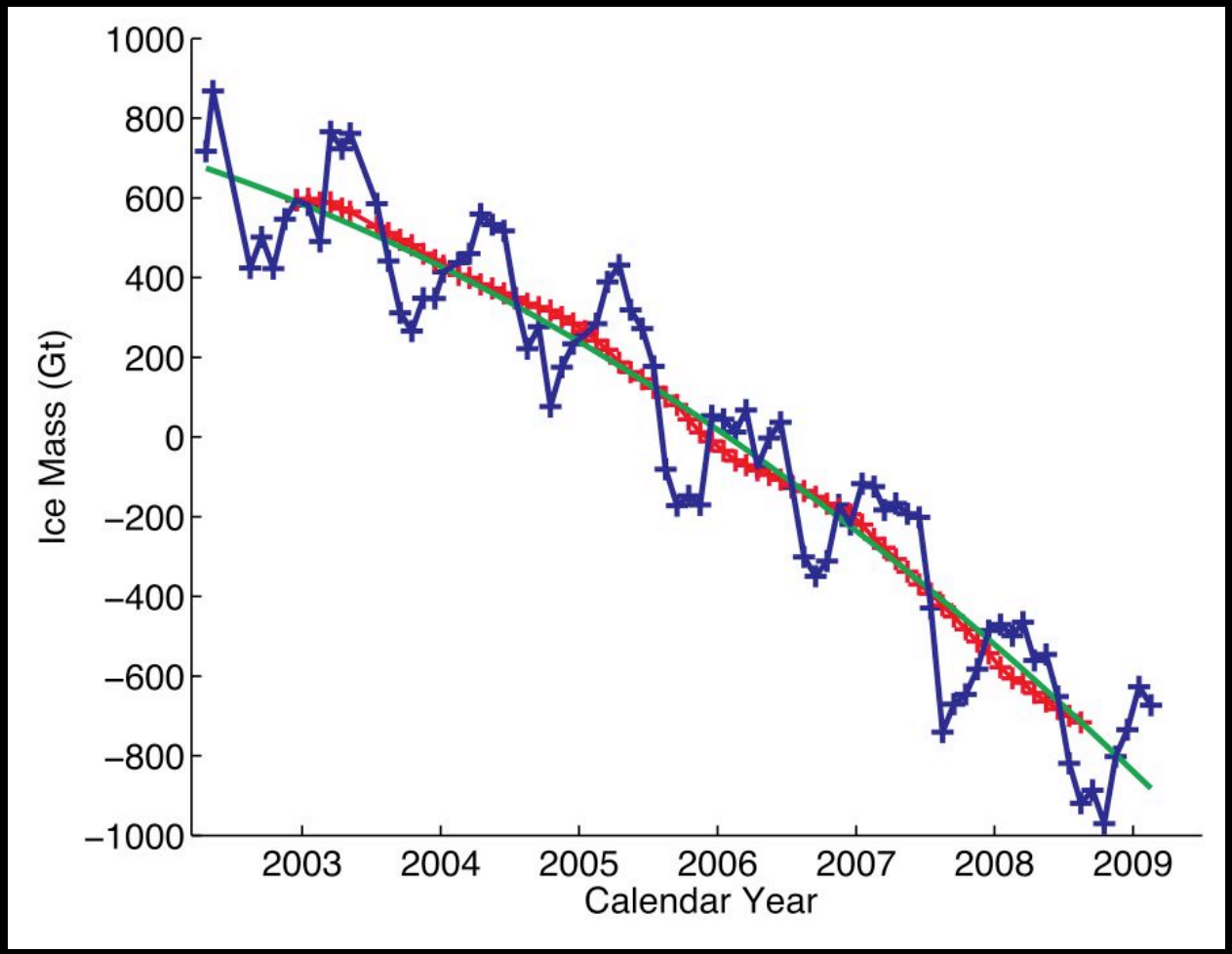

Rates of Ice Mass Loss from Greenland
source
Johannessen et al.
Science 2005 (**)
Zwally et al.
J. Glac. 2005 SRALT
Krabill et al.
GRL 2004 ATM
Thomas et al.
GRL 2006 ATM + GLAS
Rignot and Kanagaratnam
Science 2006 InSAR + SMB
Luthke et al.
Science 2006 GRACE/MASCON
Chen et al.
Science 2006 GRACE
Velicogna and Wahr
Nature 2006 GRACE
Ramillien et al.
GPC 2006 GRACE
Wouters et al.
GRL 2008 GRACE/EOFfilter
0.25 mm/yr
0.5 mm/yr
Net Balance (Gt/year)
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
-300
1990 91 92 93 94 1995 96 97 98 99 2000 01 02 03 04 2005 06 07 08 09 2010
Year
SWIPA chapter
on Greenland,
AMAP
Dec. 2009

Glaciers in Greenland are changing rapidly in response to warming; at present they are losing roughly 200-250 Gt per year to the ocean

Glaciers and Ice Caps around the Arctic, not discussed here, are estimated to be making an even larger contribution in the last decade

Land-based ice in the Arctic is a significant contributor to present sea level rise

Greenland Mass Loss measured by GRACE



Velicogna GRL, 2009 (Figure 1)