

Earth's ice from space

Andrew Shepherd



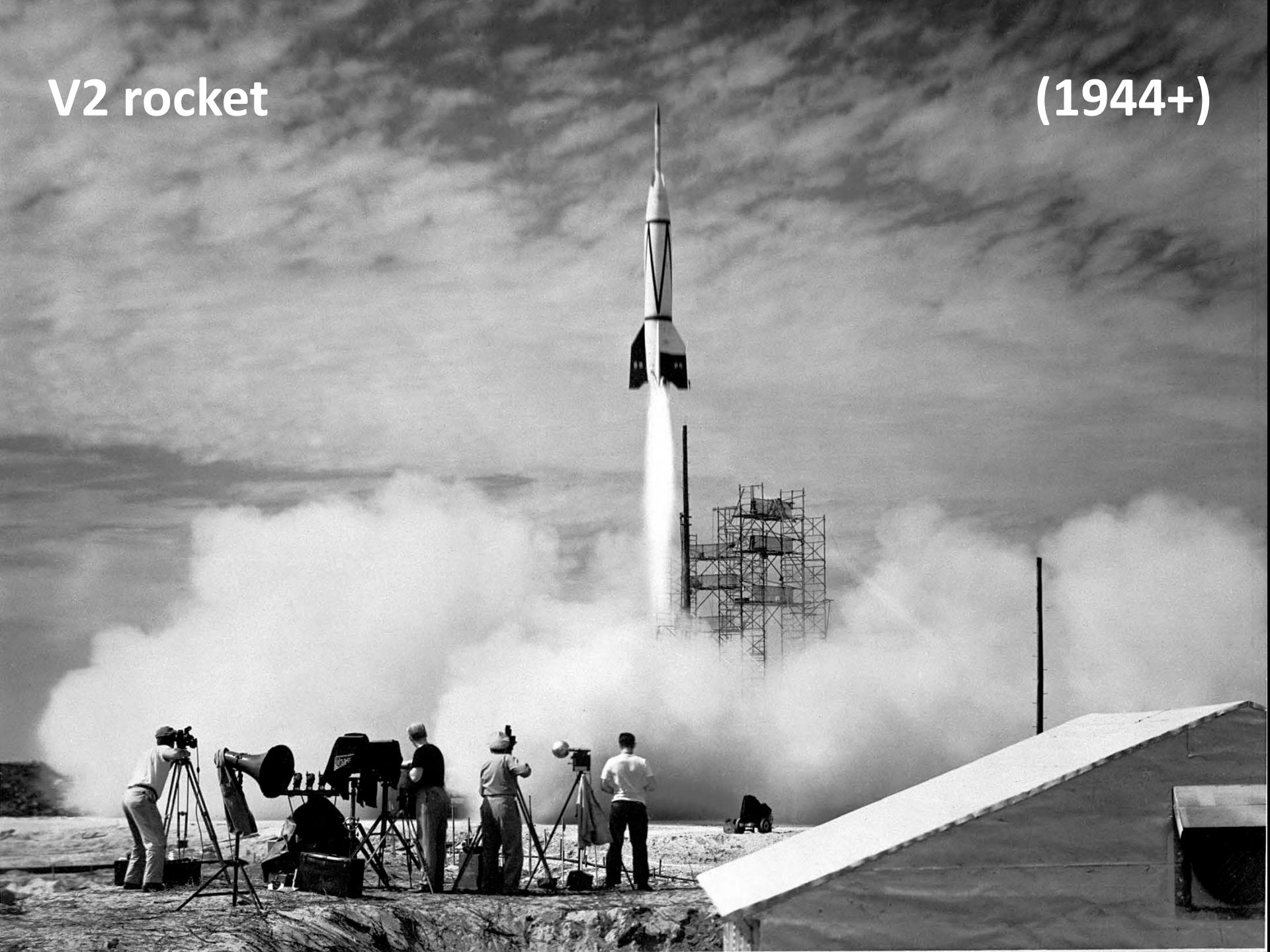


Earth Observation
Optical
Passive Microwave
Synthetic Aperture Radar
Interferometric SAR
Altimetry
Gravimetry
Future Missions

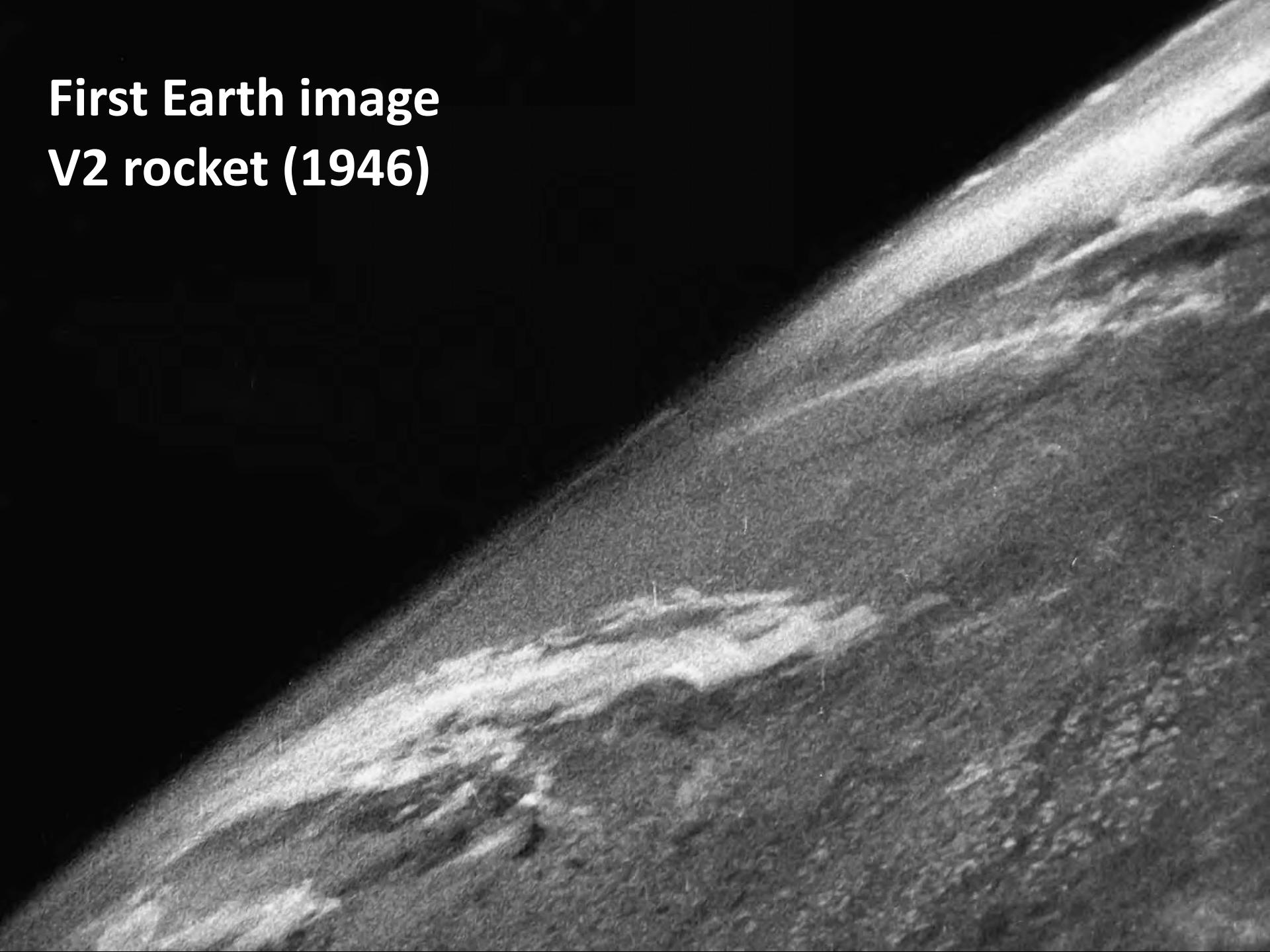
Earth Observation

V2 rocket

(1944+)



**First Earth image
V2 rocket (1946)**



First telemetry

C119 & DMSP (1959)



First weather satellite

TIROS (1960)



Earthrise

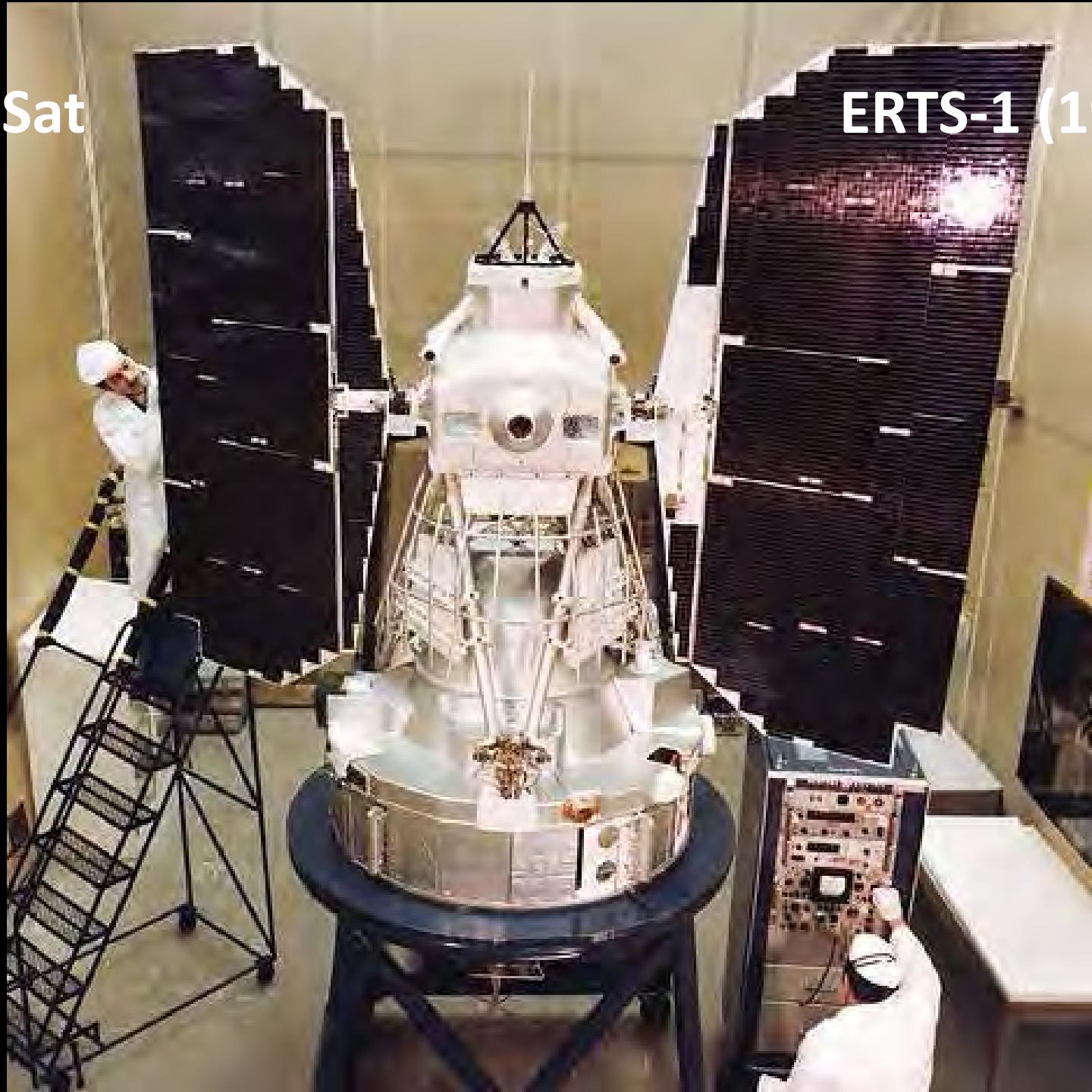
Apollo 8 (1968)



Optical

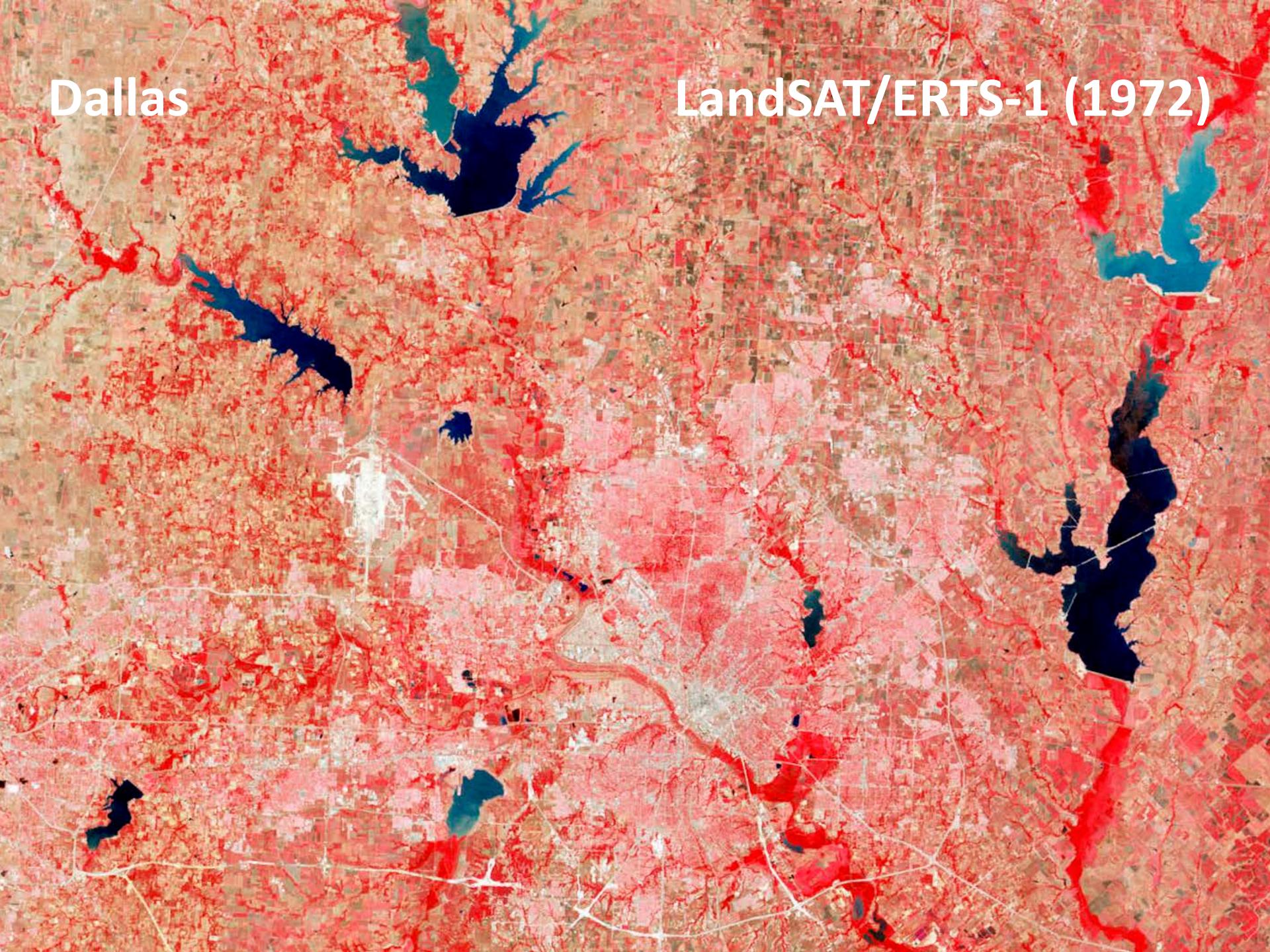
LandSat

ERTS-1 (1972)



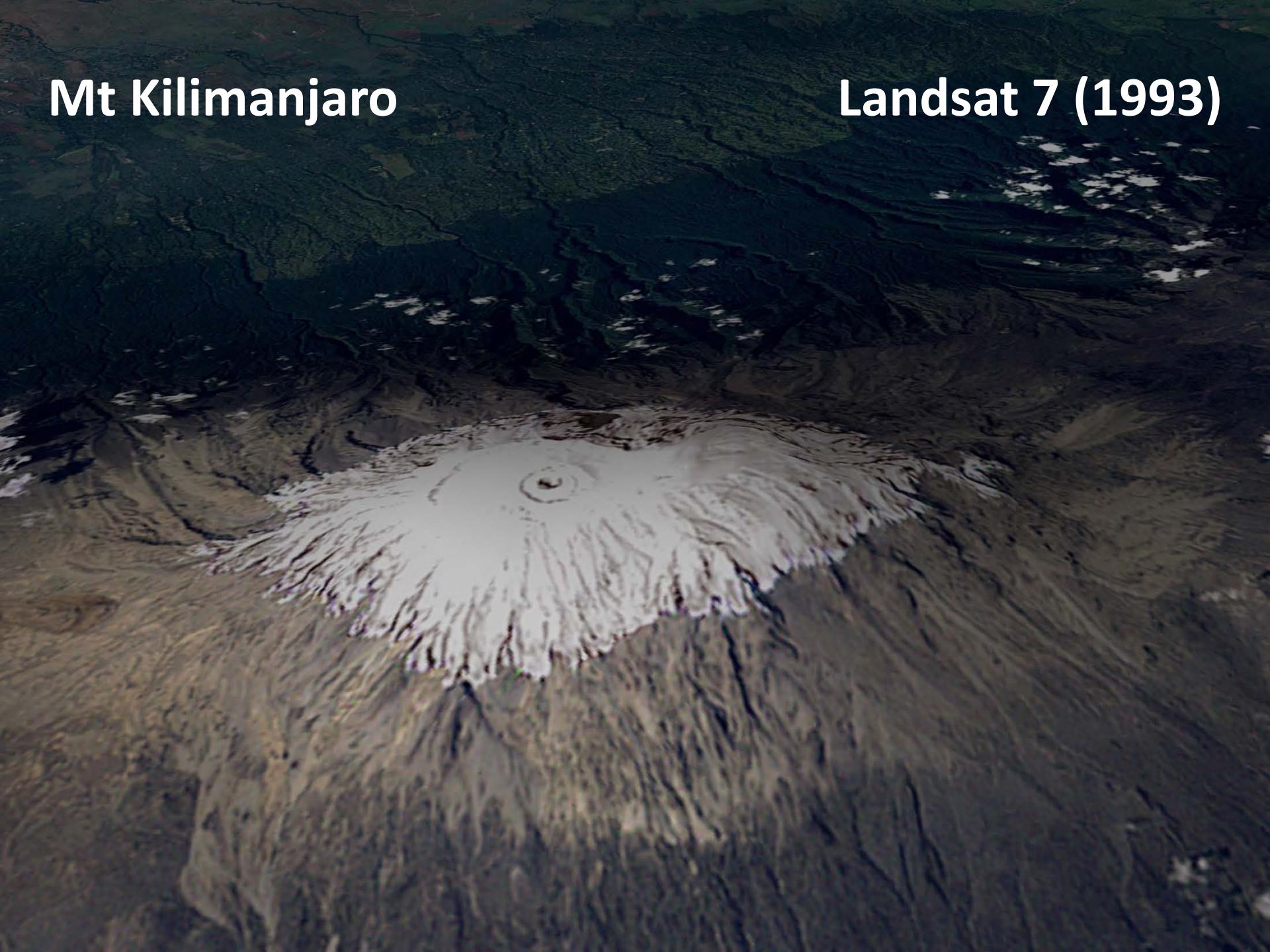
Dallas

LandSAT/ERTS-1 (1972)



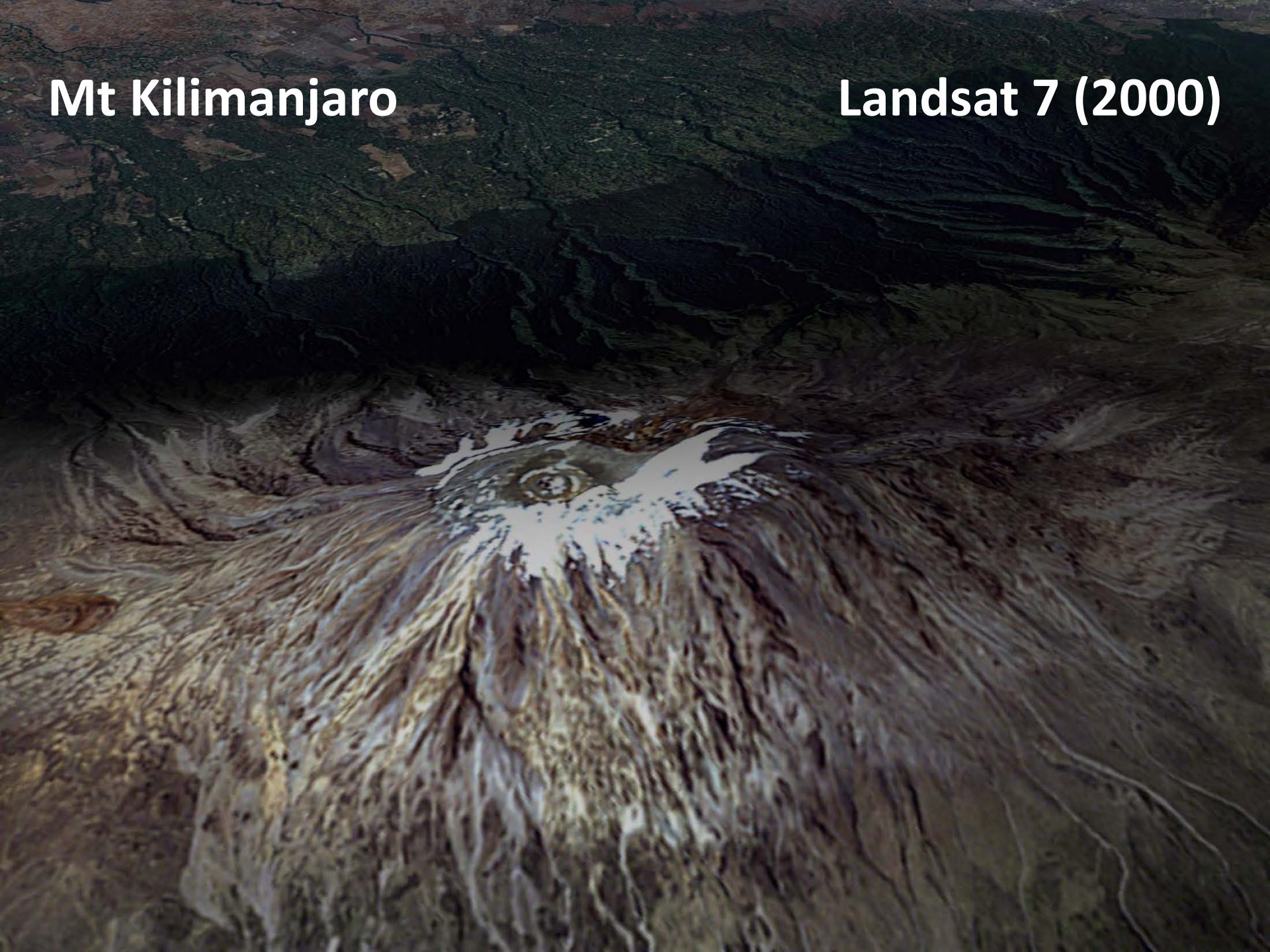
Mt Kilimanjaro

Landsat 7 (1993)

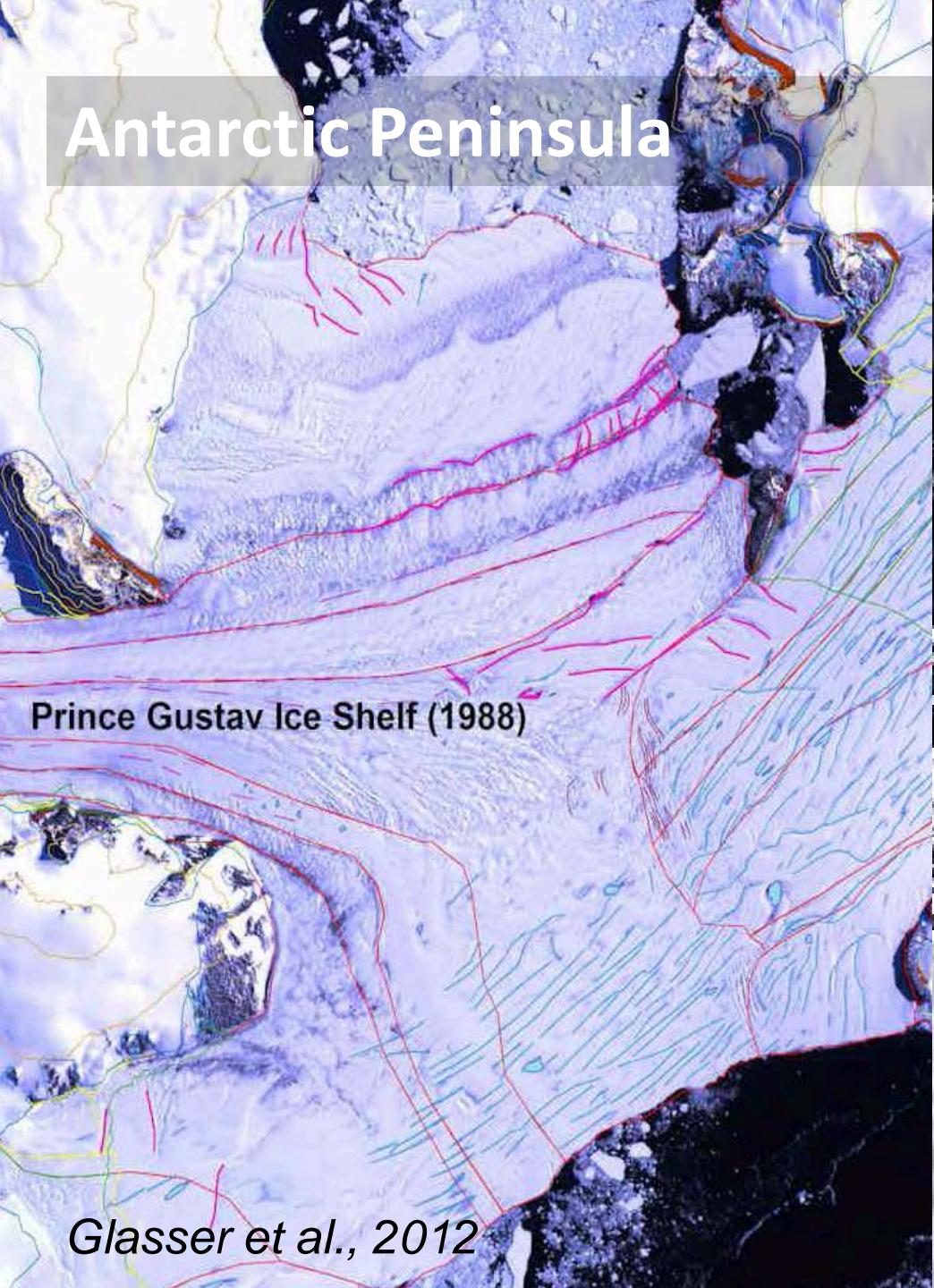


Mt Kilimanjaro

Landsat 7 (2000)

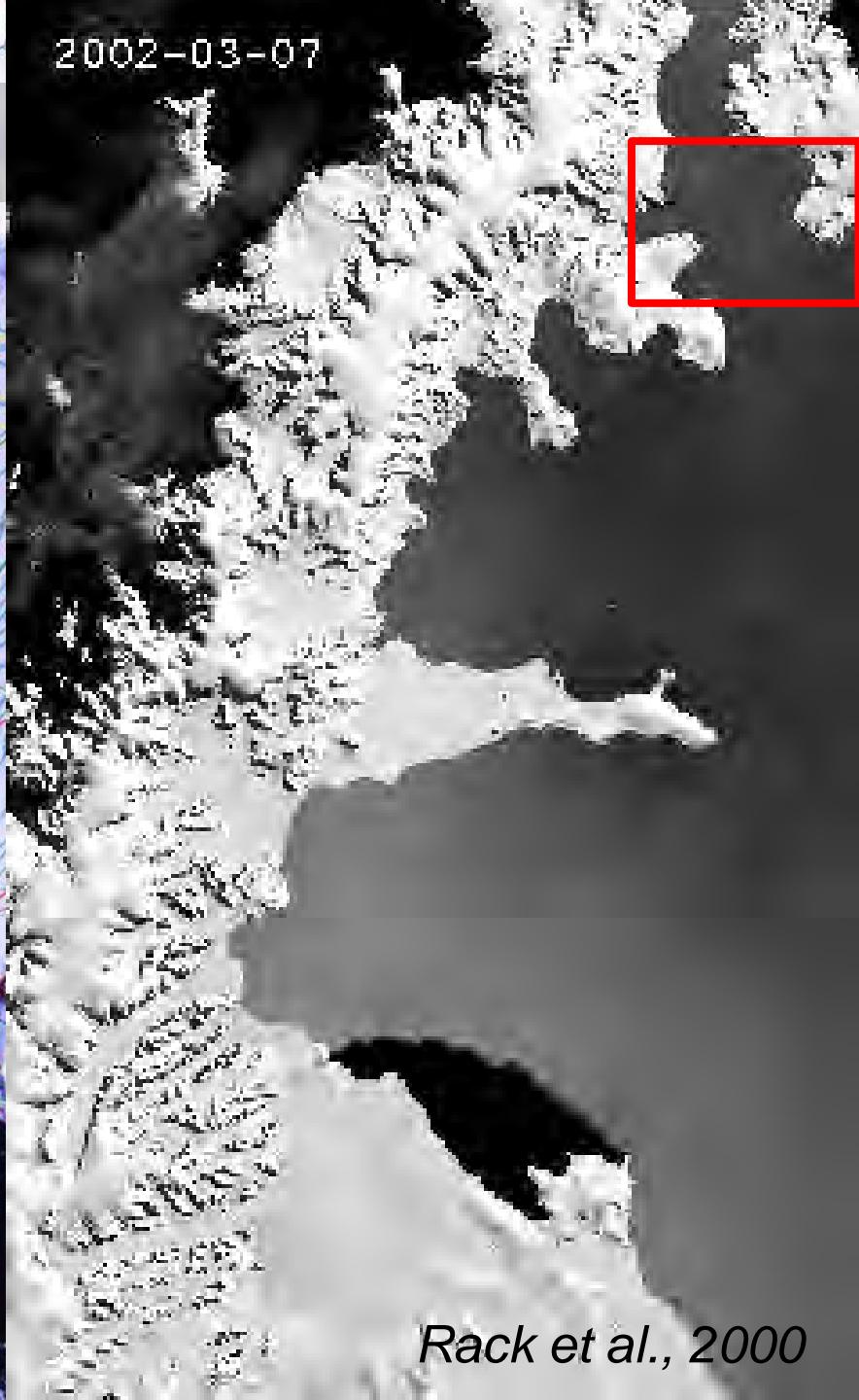


Antarctic Peninsula



Glasser et al., 2012

2002-03-07



Rack et al., 2000

Space shuttle

(1981)



Greenland

SS (1992)



Kolka Glacier

SS (2002)



International Space Station

(1998)



Upsala Glacier

ISS (2001)



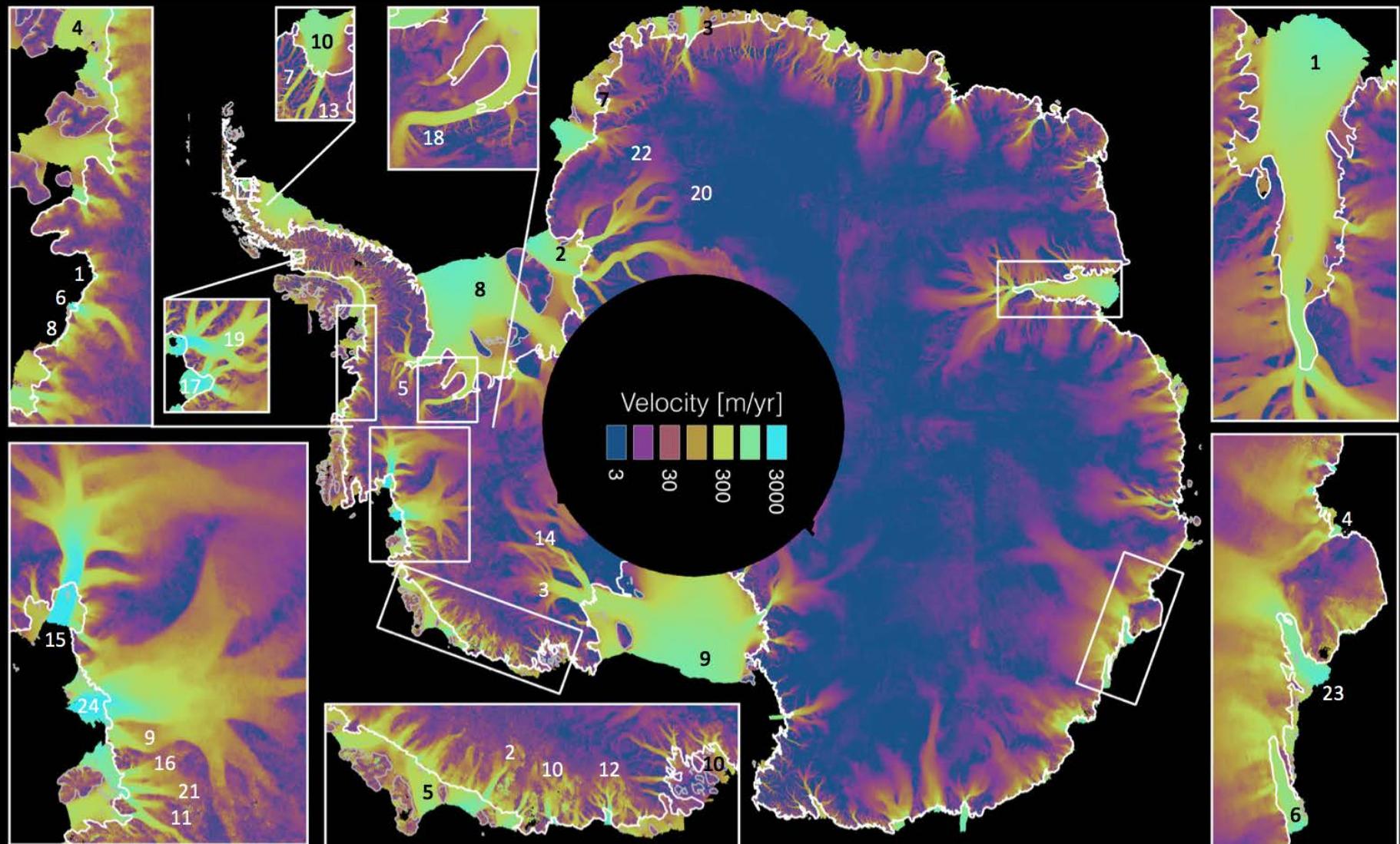
Upsala Glacier

ISS (2004)



Antarctic ice motion

LandSAT-8 (2013+)

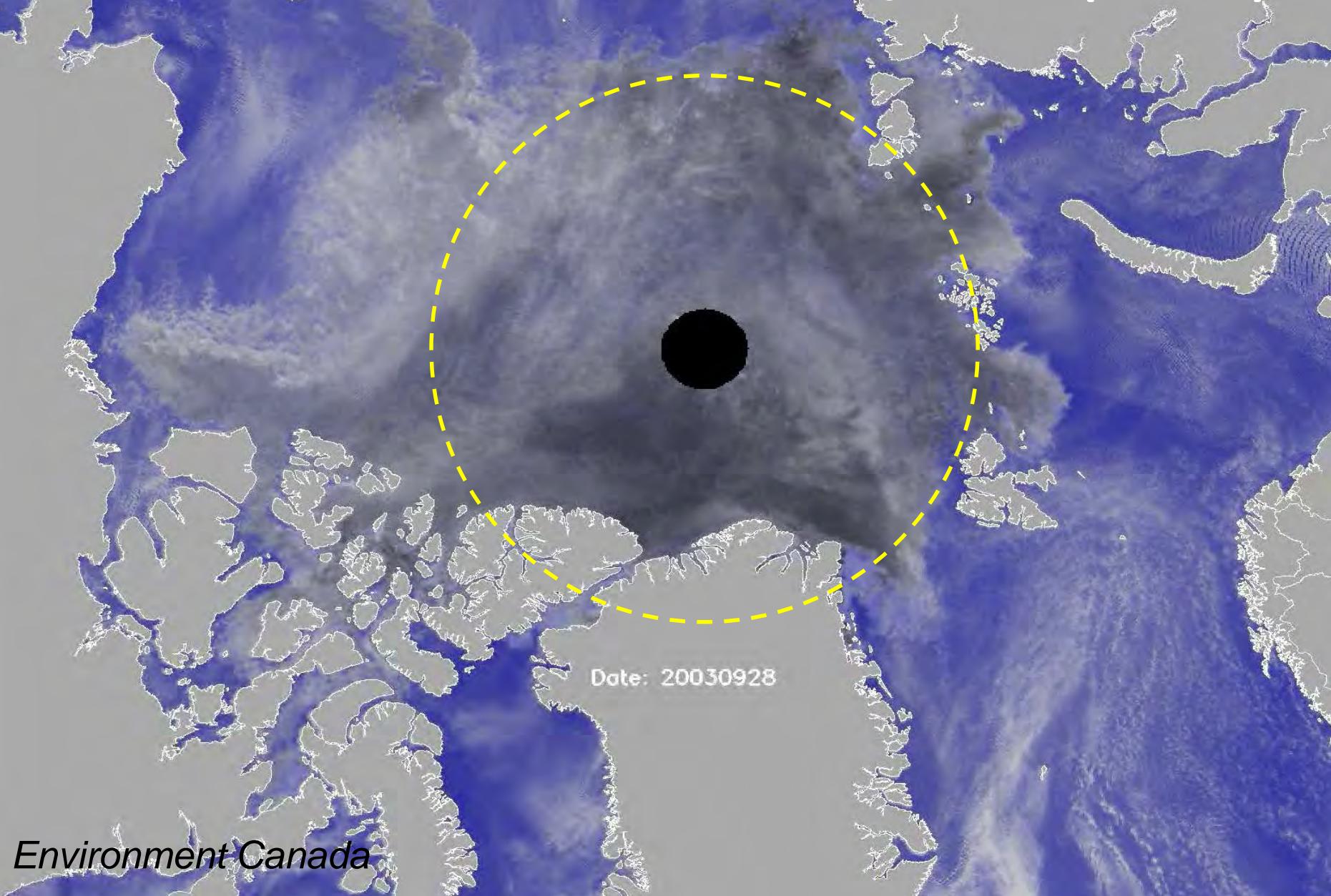


Gardner et al., 2018

Passive Microwave

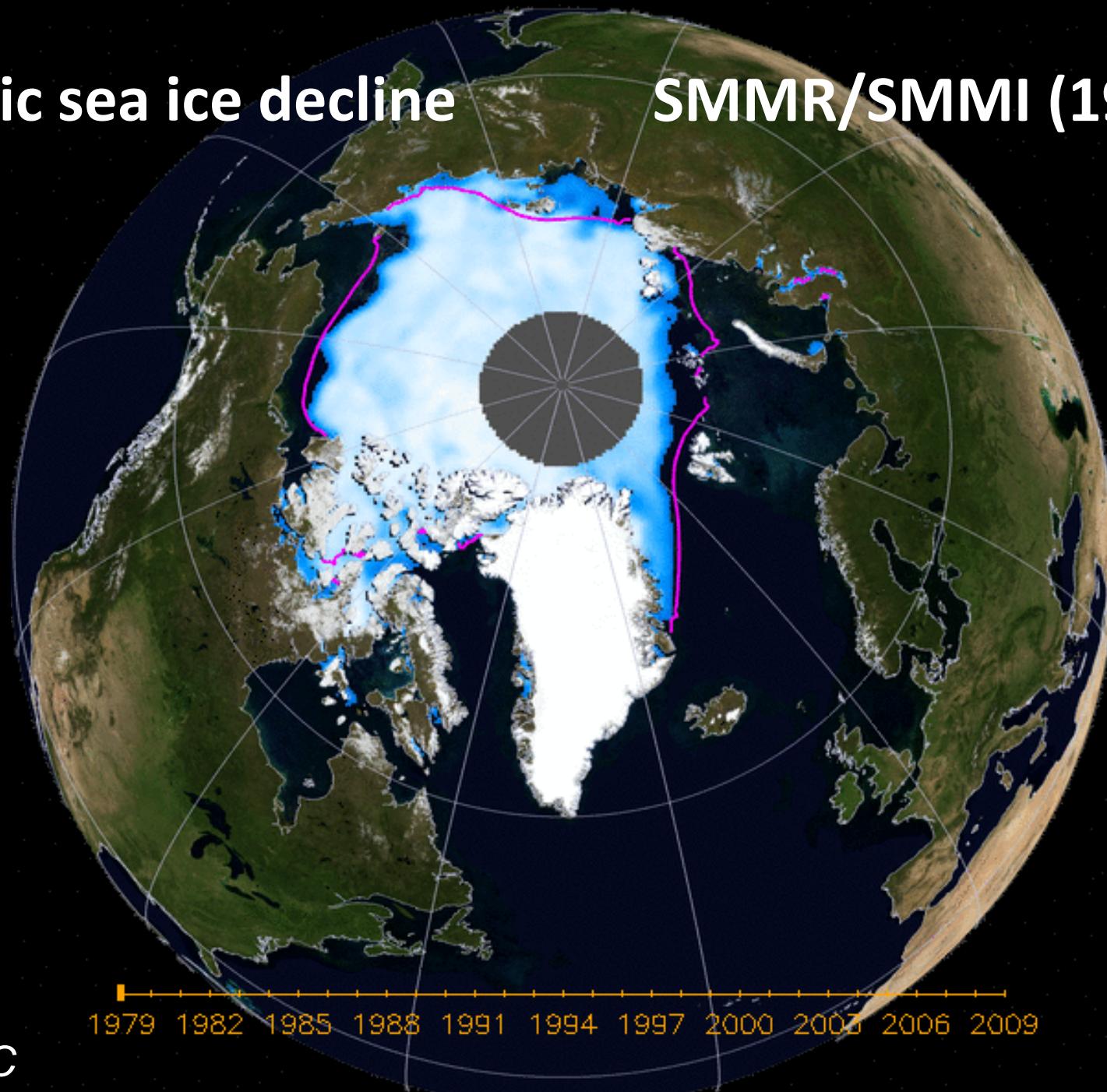
Sea ice drift

SMMR/SMMI (1978+)



Arctic sea ice decline

SMMR/SMMI (1978+)



Greenland melt

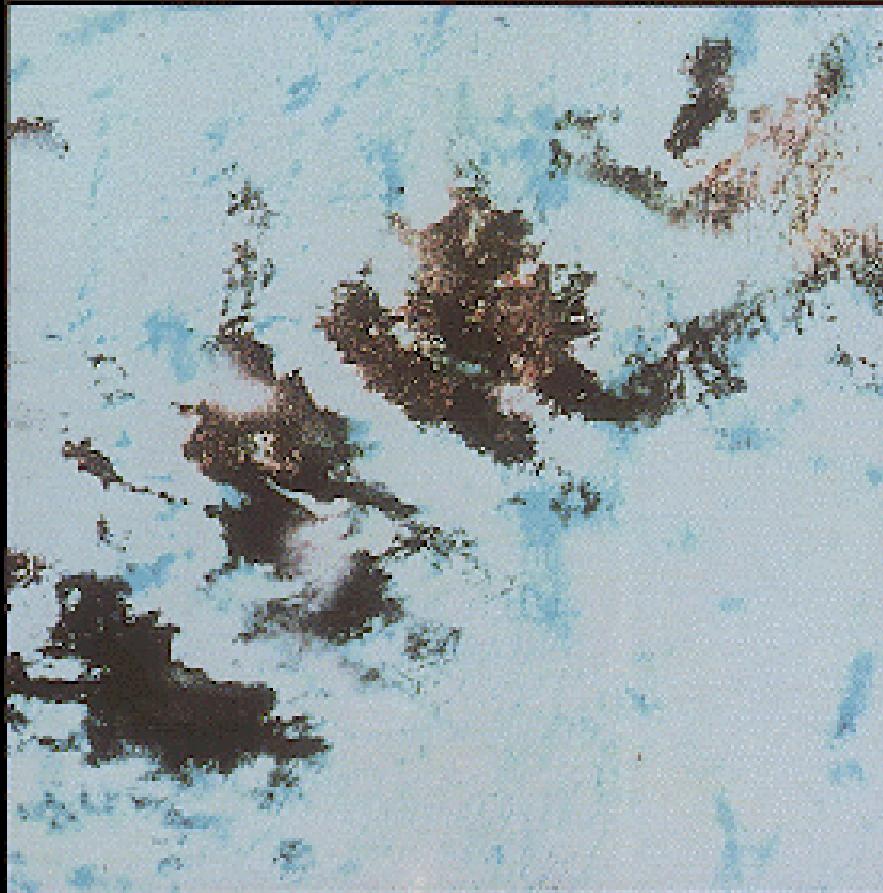
SMMR/SMMI (1978+)

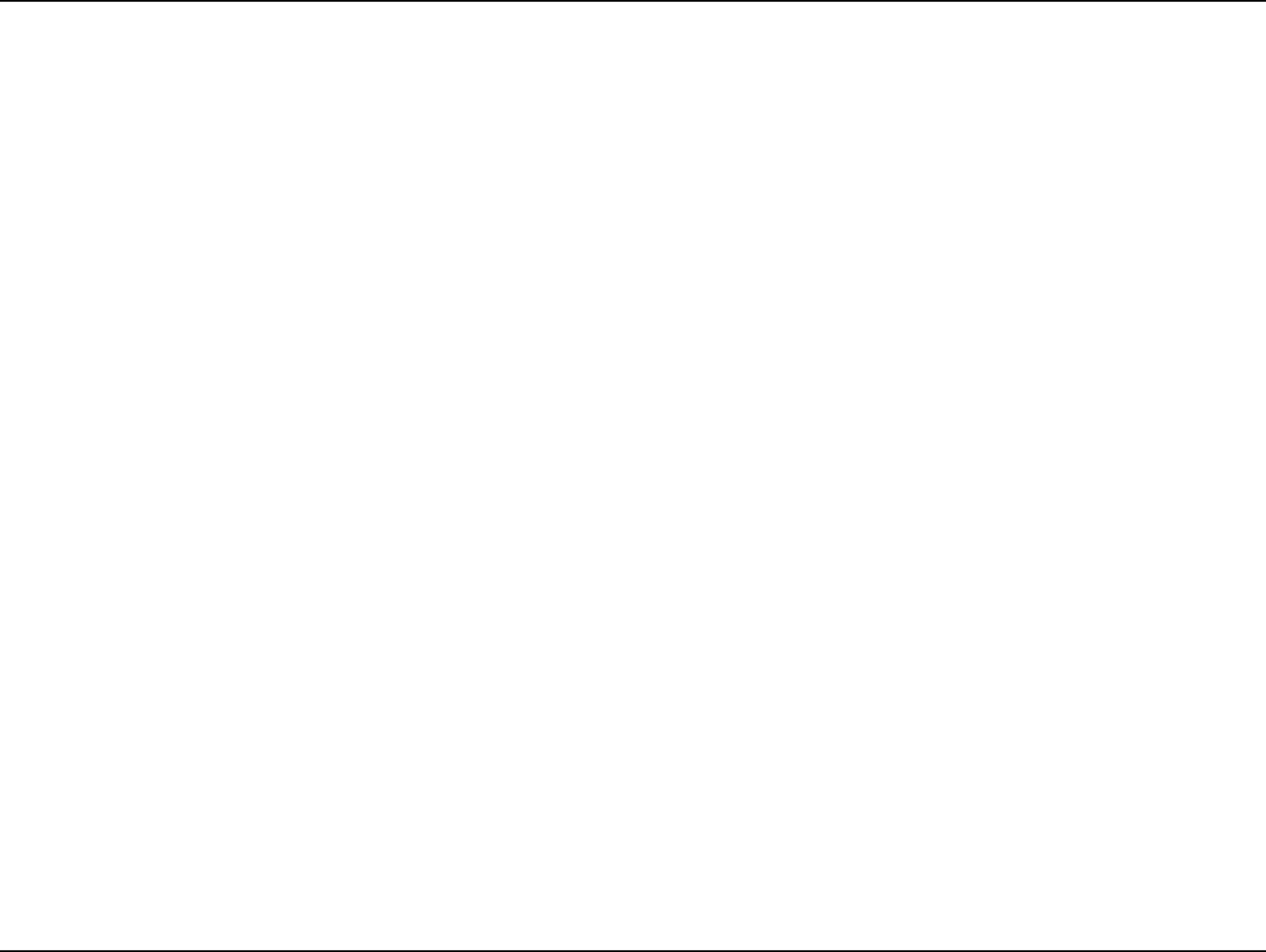


Synthetic aperture radar

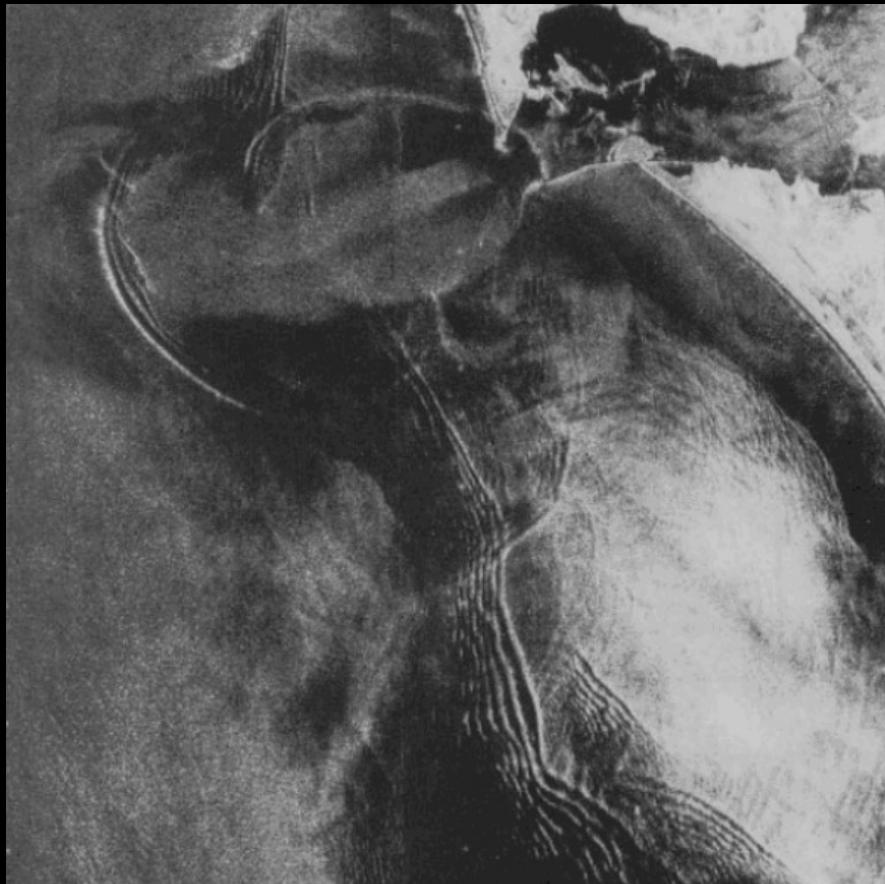
Imaging radar

(1978+)

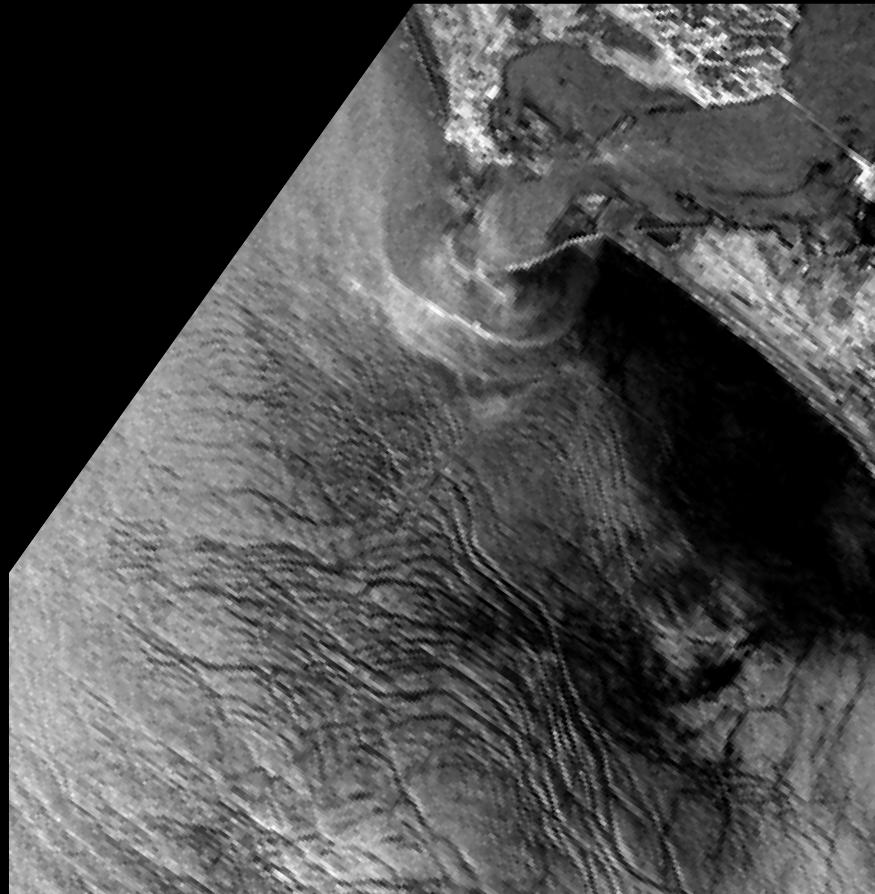




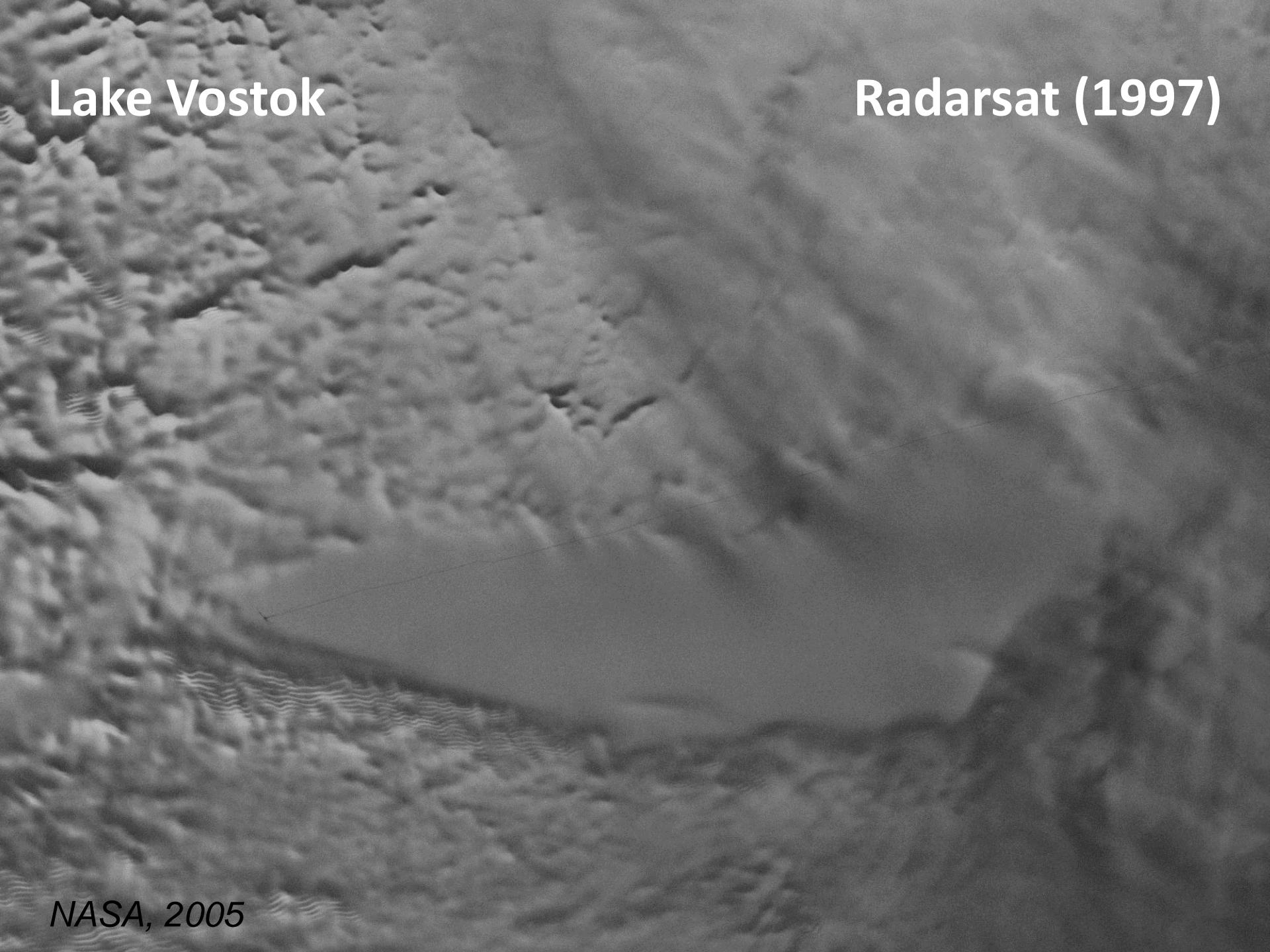
Pacific Northwest



SeaSat (1978)



Alaska SAR Facility

A grayscale satellite radar image showing a large body of water, identified as Lake Vostok, surrounded by a thick, textured ice shelf. The image has a grainy, high-contrast appearance typical of radar imagery.

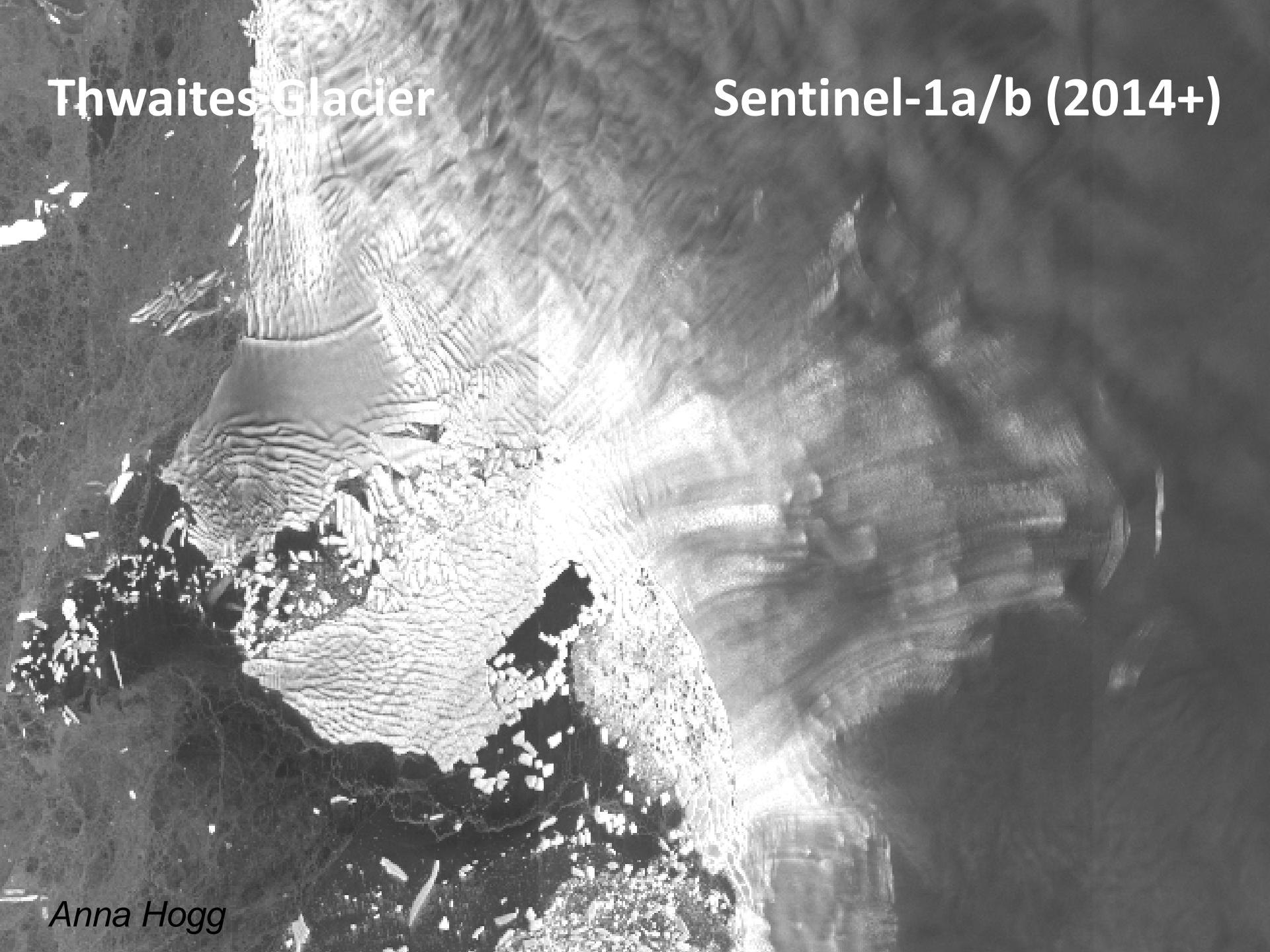
Lake Vostok

Radarsat (1997)

NASA, 2005

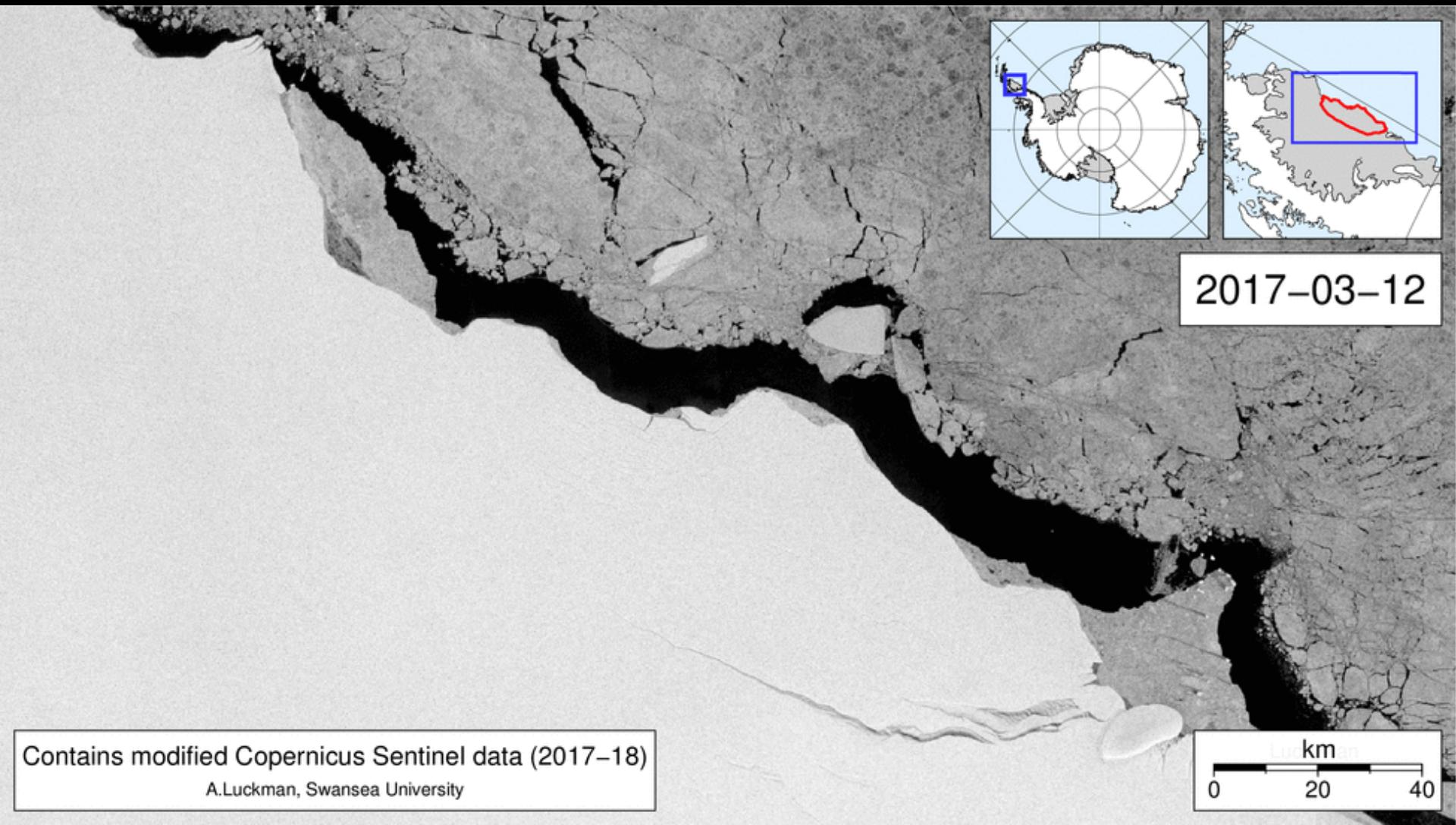
Thwaites Glacier

Sentinel-1a/b (2014+)



A68 Iceberg

Sentinel-1a/b (2017+)

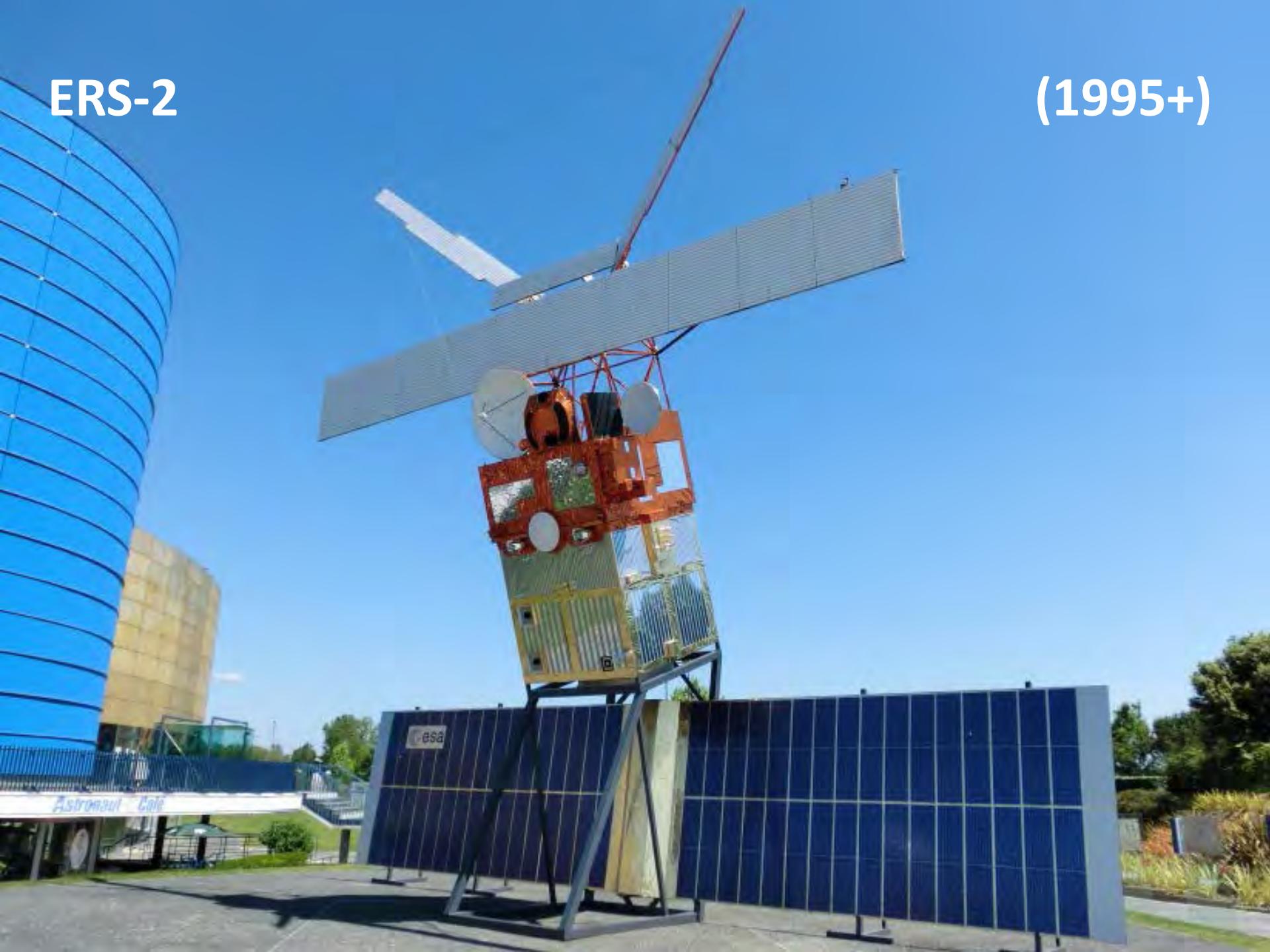


Adrian Luckman, 2018

Interferometric SAR

ERS-2

(1995+)



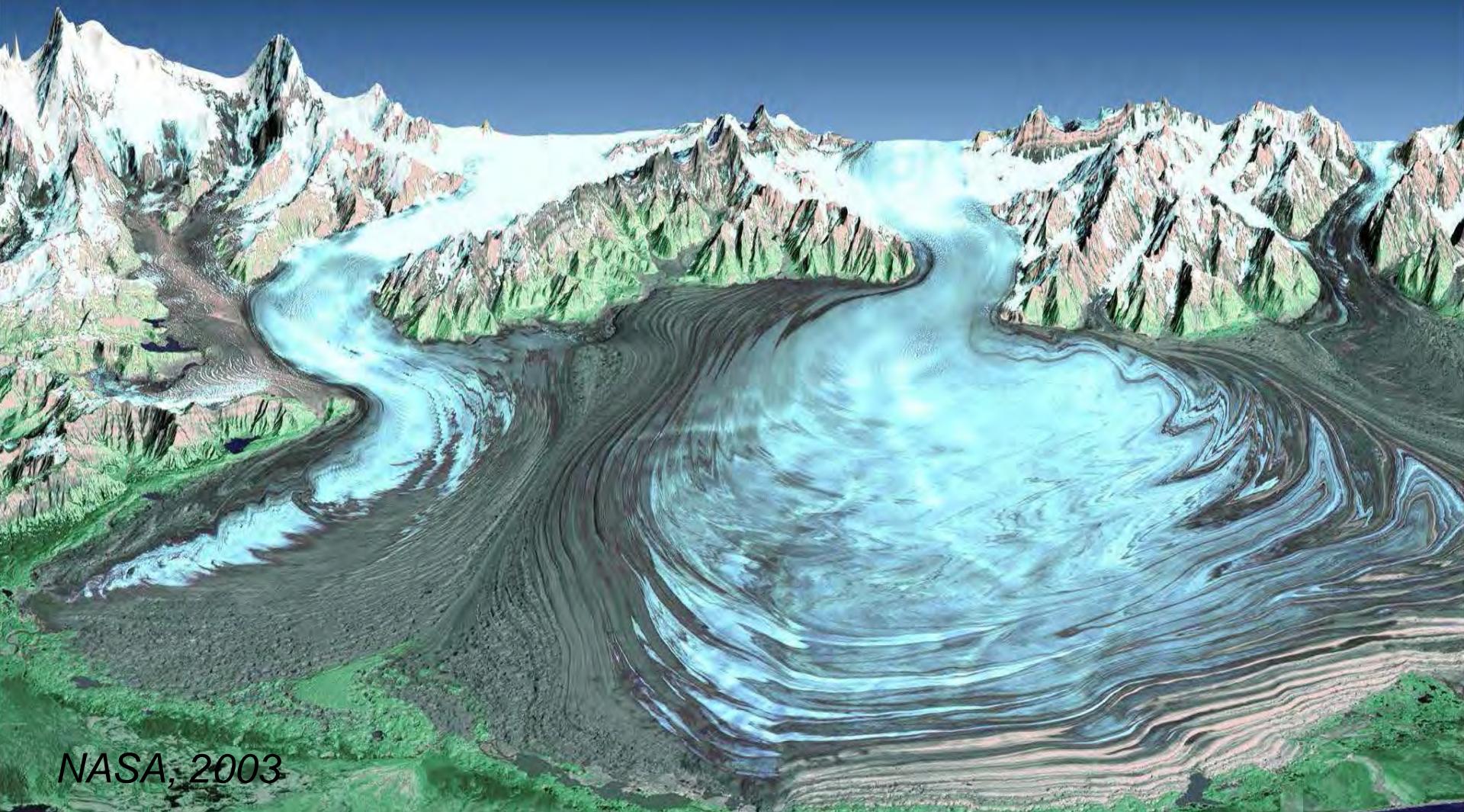
InSAR

ERS-1/2 (1995)

Goldstein et al., 1993

Malaspina Glacier

SRTM/LandSat (2000)



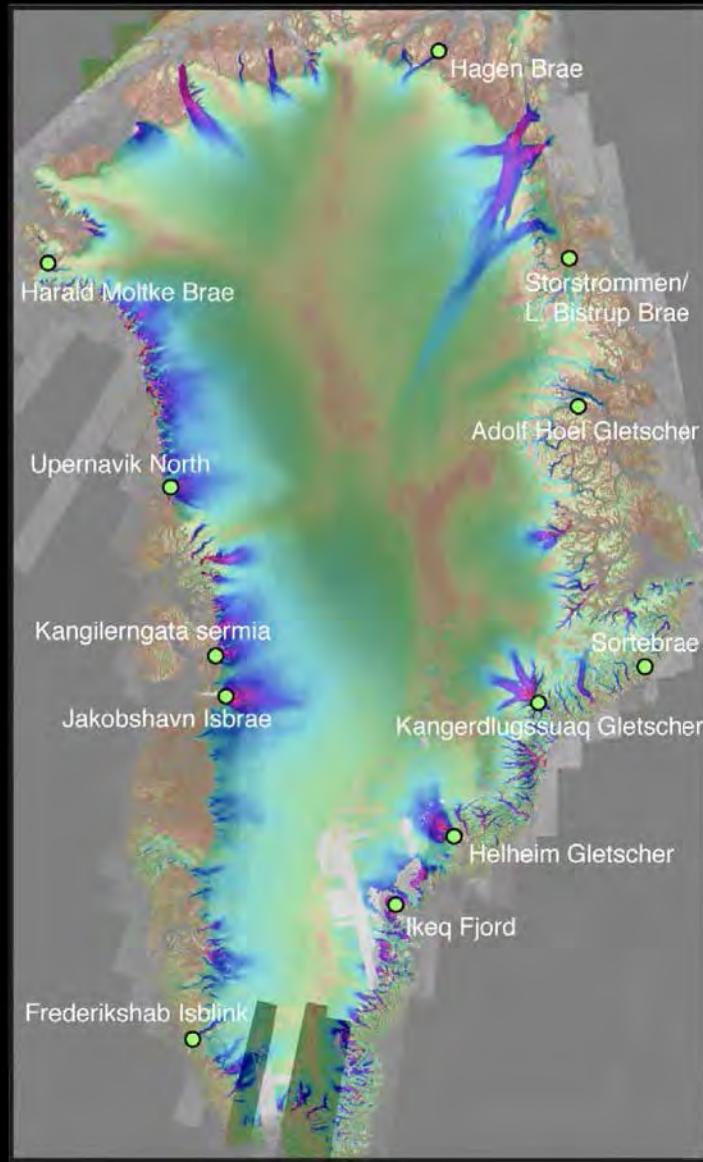
NASA, 2003

Antarctic ice flow

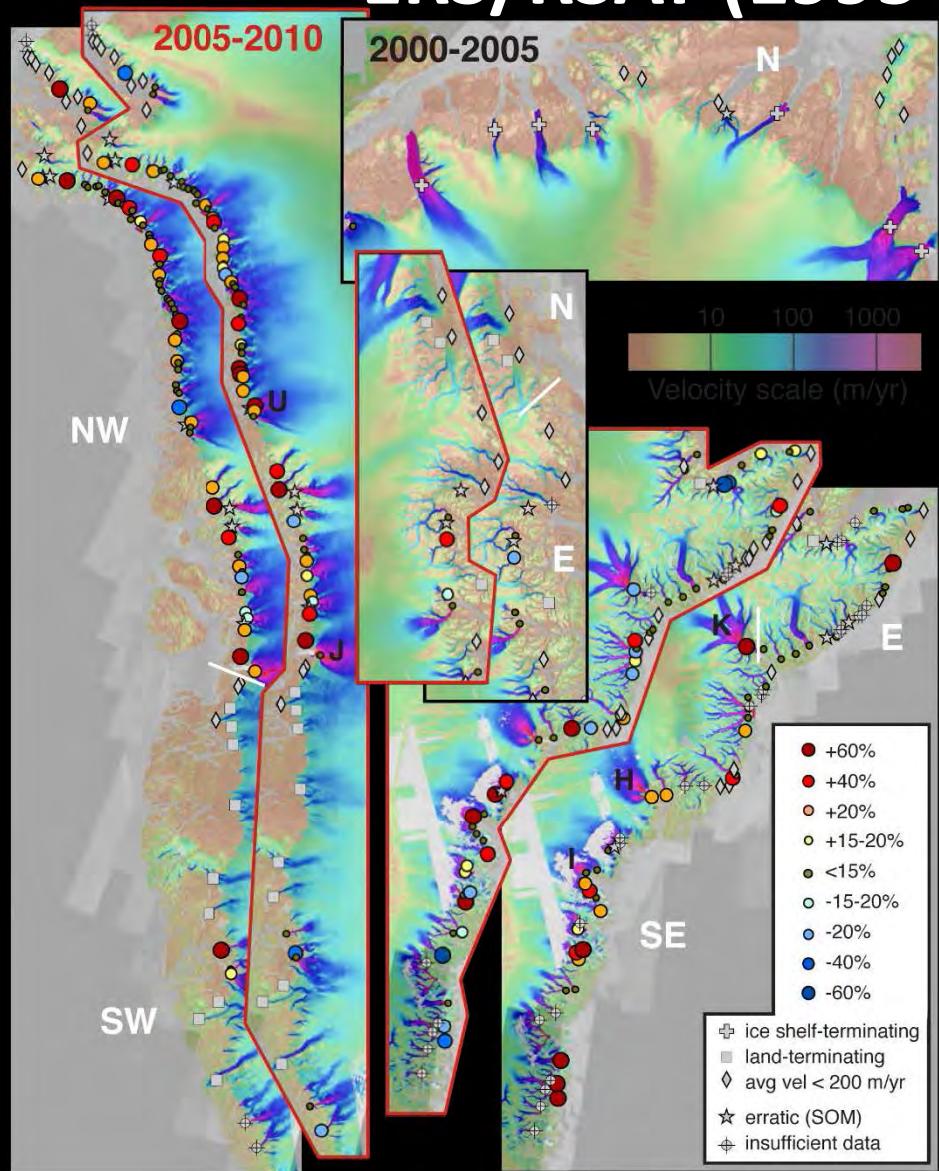
LSAT/ERS/RSAT (c. 2008)



Greenland ice flow



ERS/RSAT (1995+)



Moon et al., 2012

Greenland ice flow

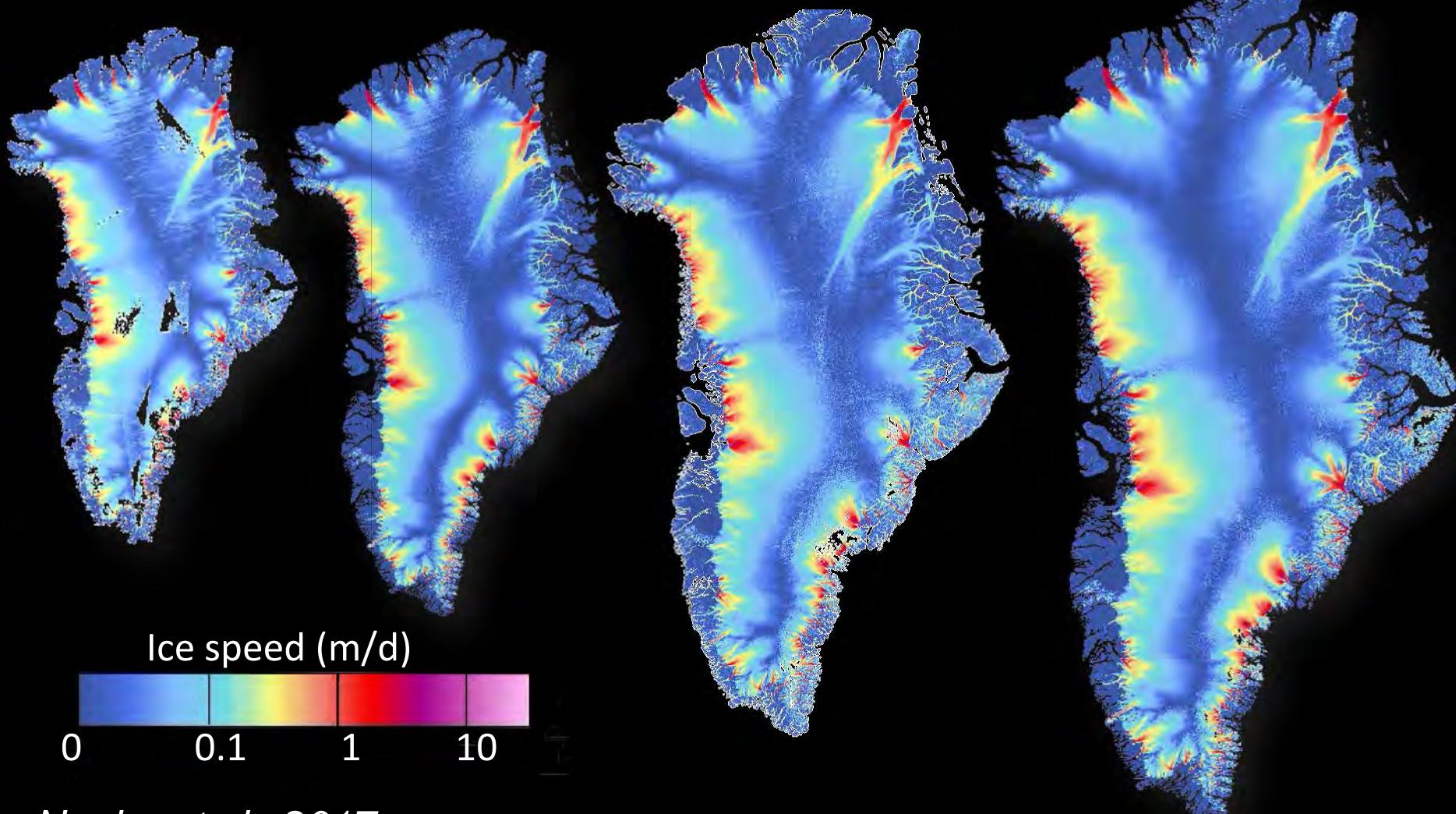
S1a/b (2014+)

2014/15

2015/16

2016/17

2017/18



Jakobshavn Isbrae

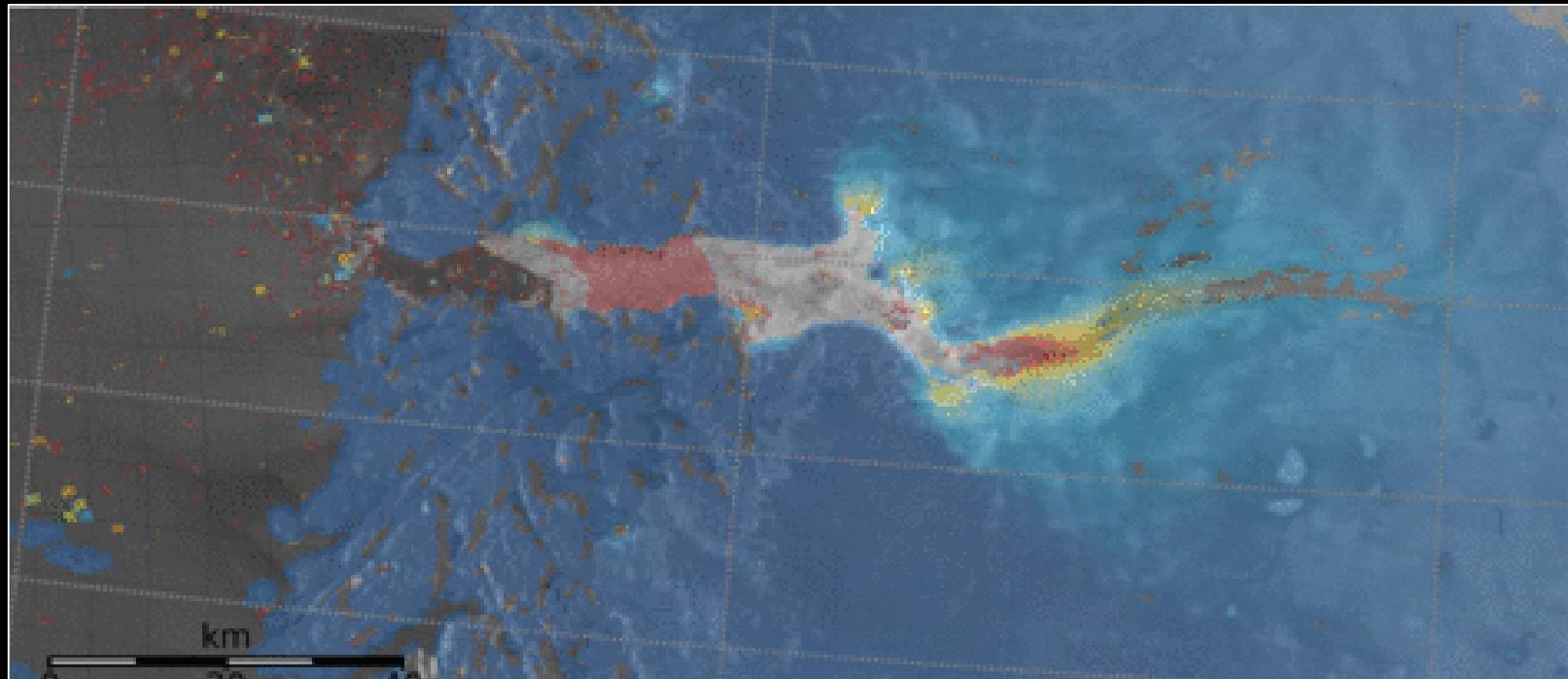
S1a/b (2014+)

2014

2015

2016

2017



Ice speed (km/yr)

0

4

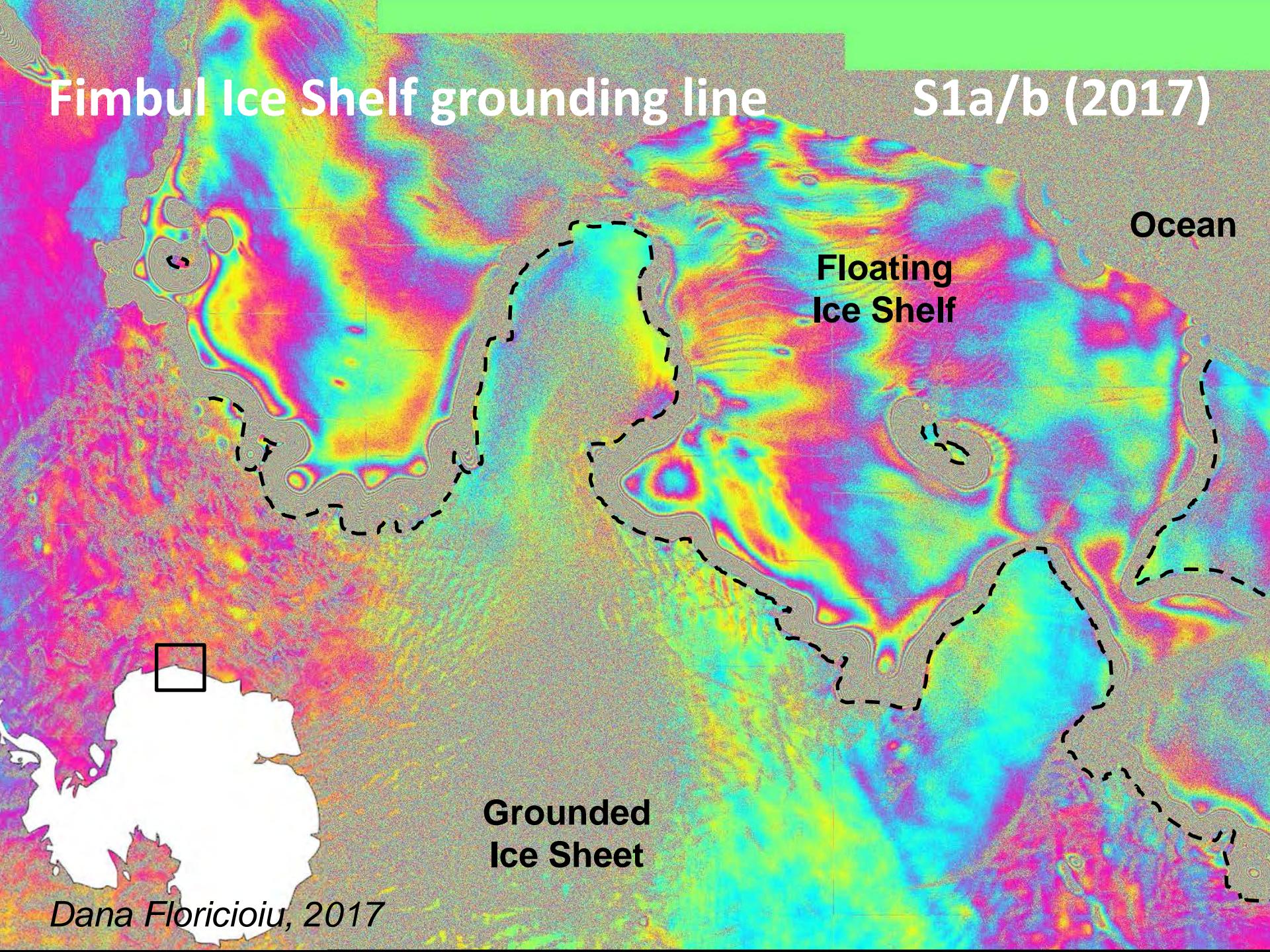
Antarctic grounding line

(1992+)



Fimbul Ice Shelf grounding line

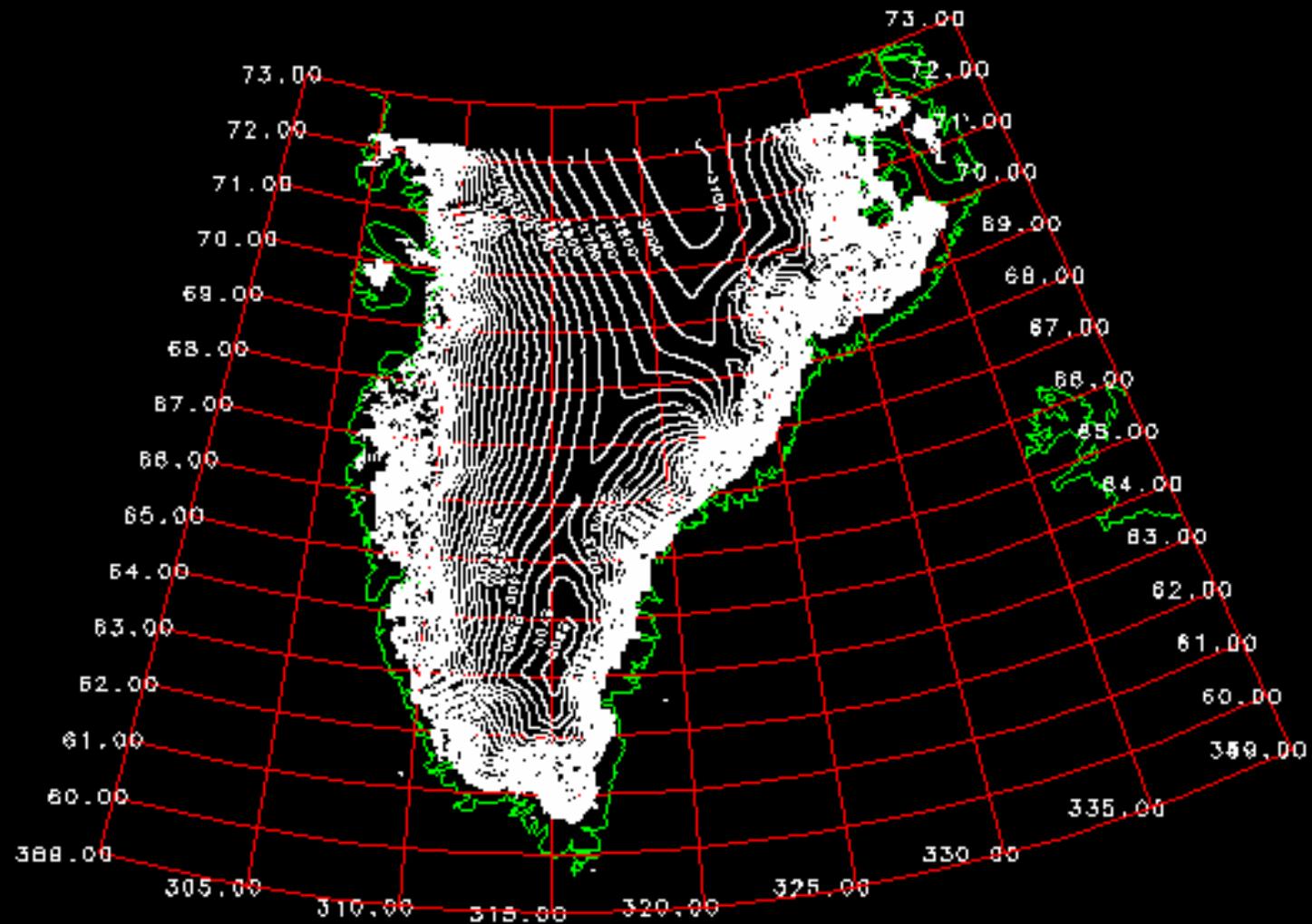
S1a/b (2017)



Altimetry

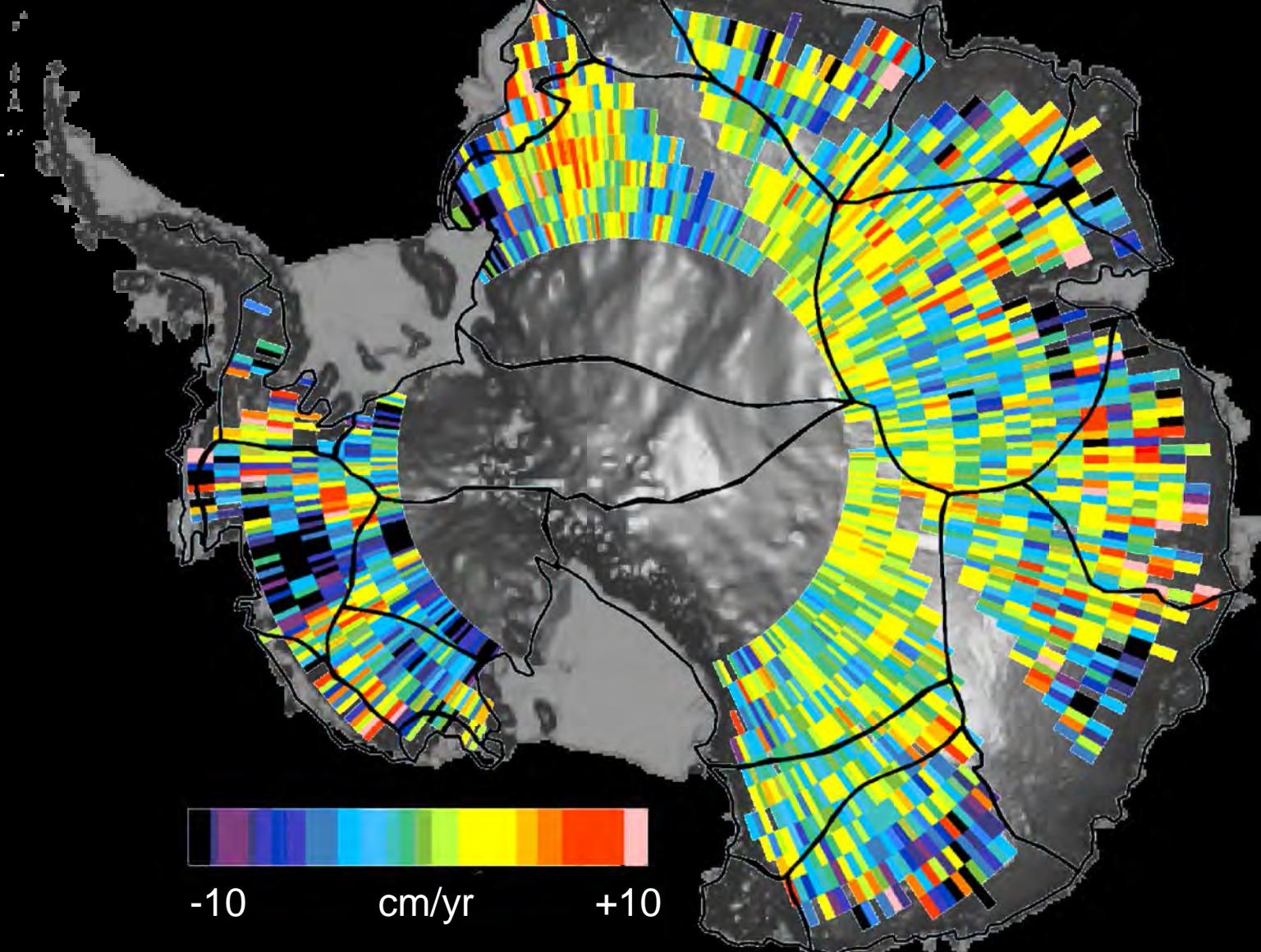
Altimetry

SeaSat (1978)



Radar Altimetry

ERS-1 (1991-2000)

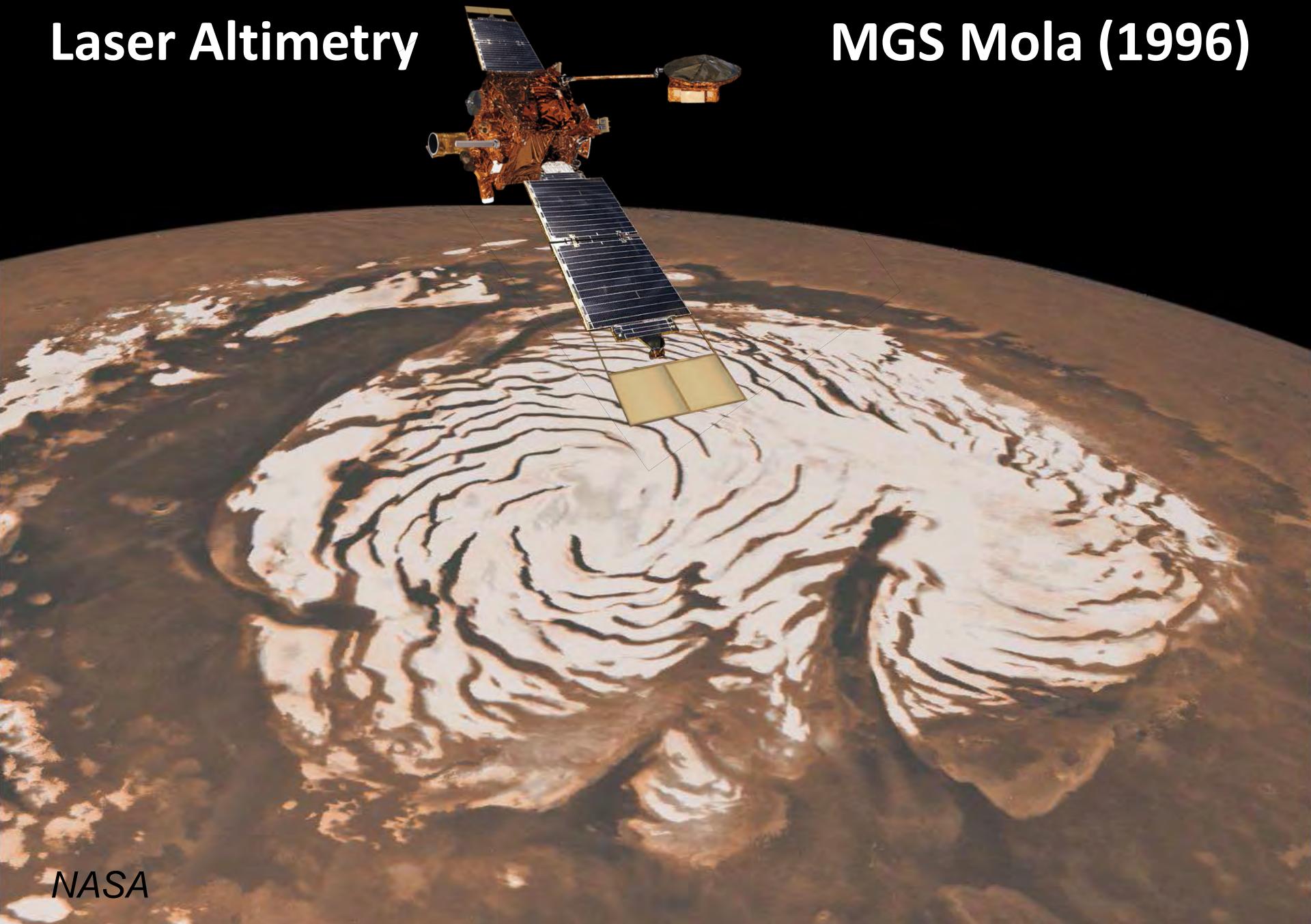


Bamber and Bindschadler, 1991

Wingham et al., 1998

Laser Altimetry

MGS Mola (1996)

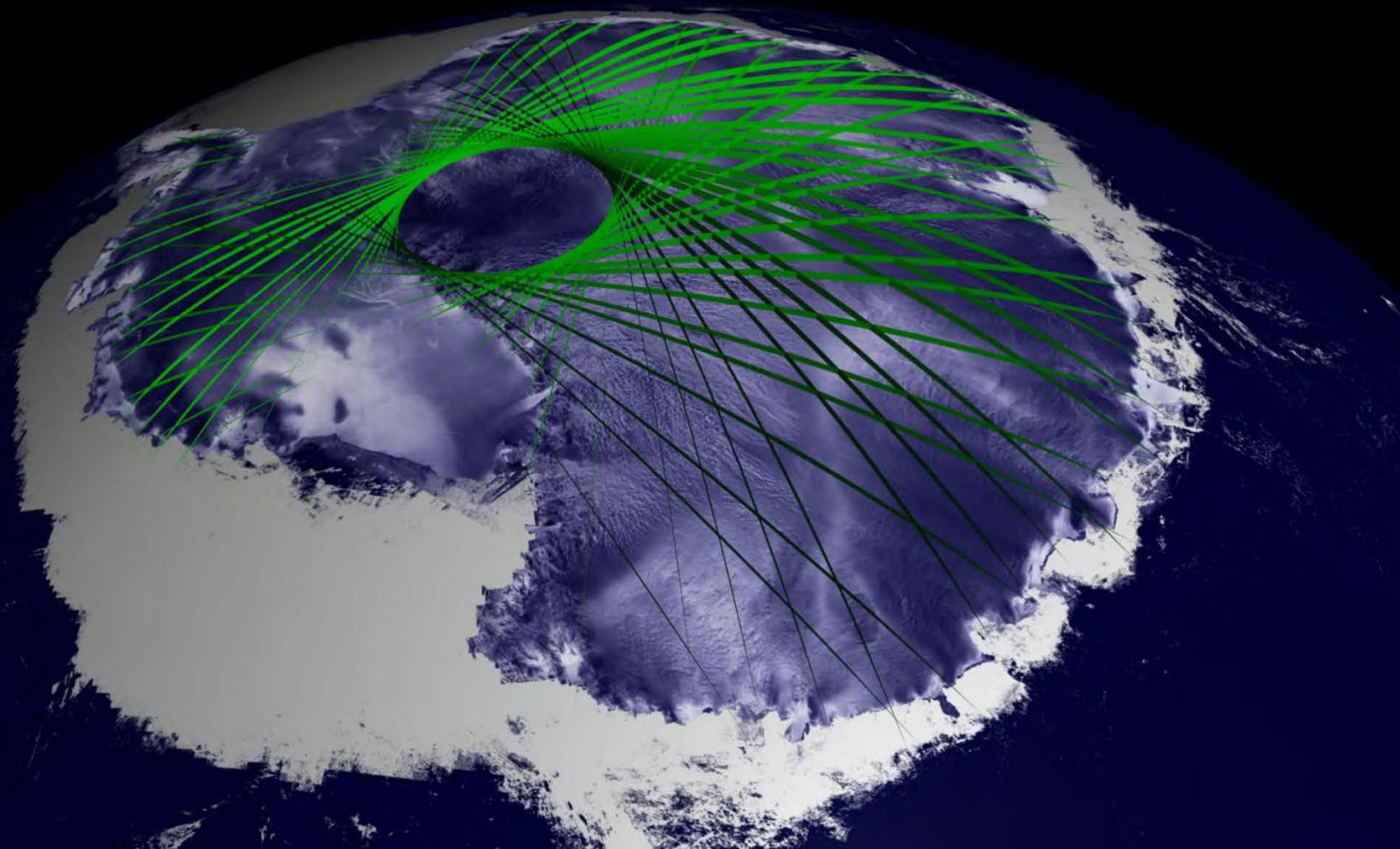


NASA

Laser Altimetry



ICESat (2003-8)



NASA

Subglacial lakes

(2006+)



Fricker et al., 2007

CryoSat-2

(2010+)



CryoSat-2

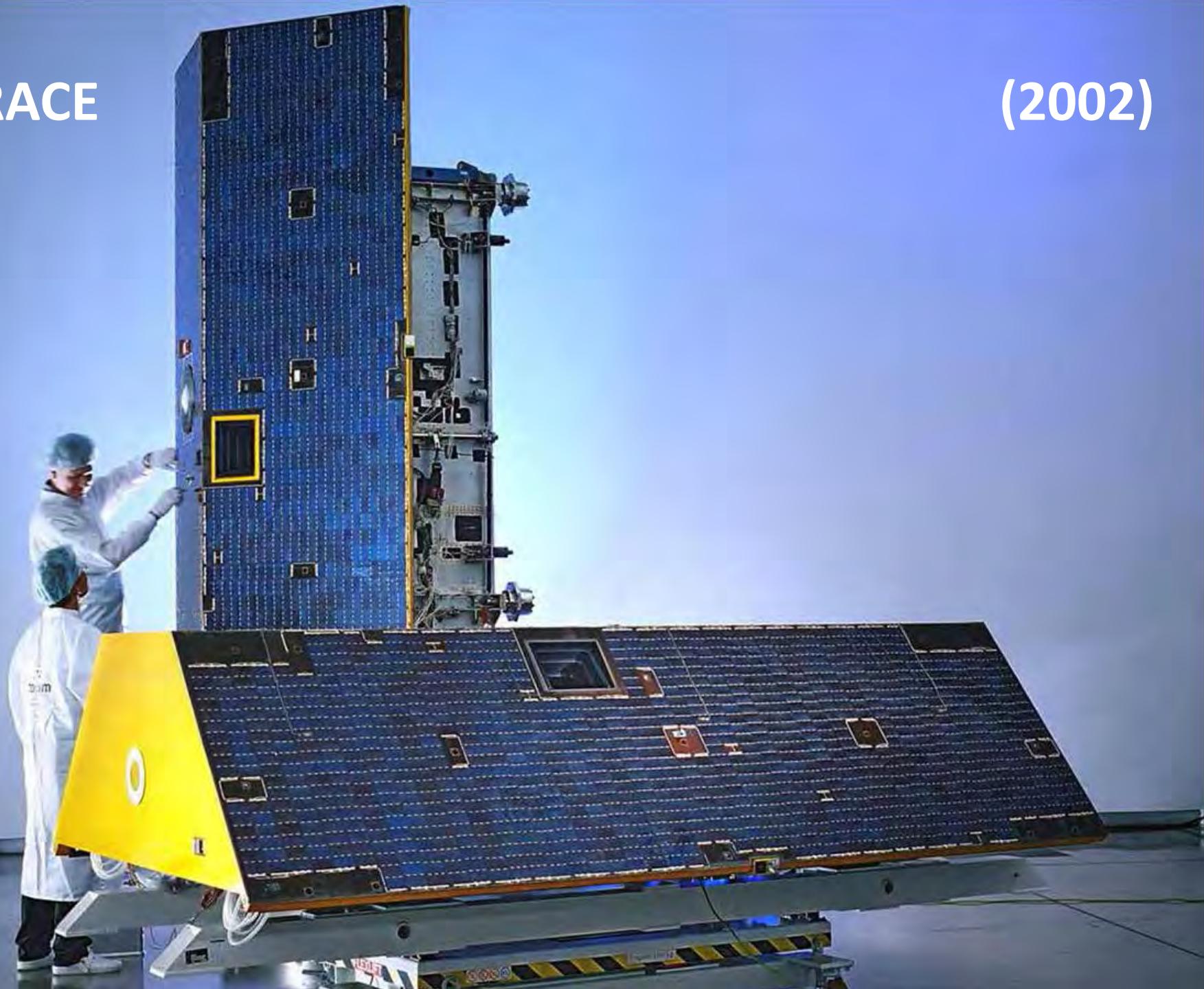
(2010+)



Gravimetry

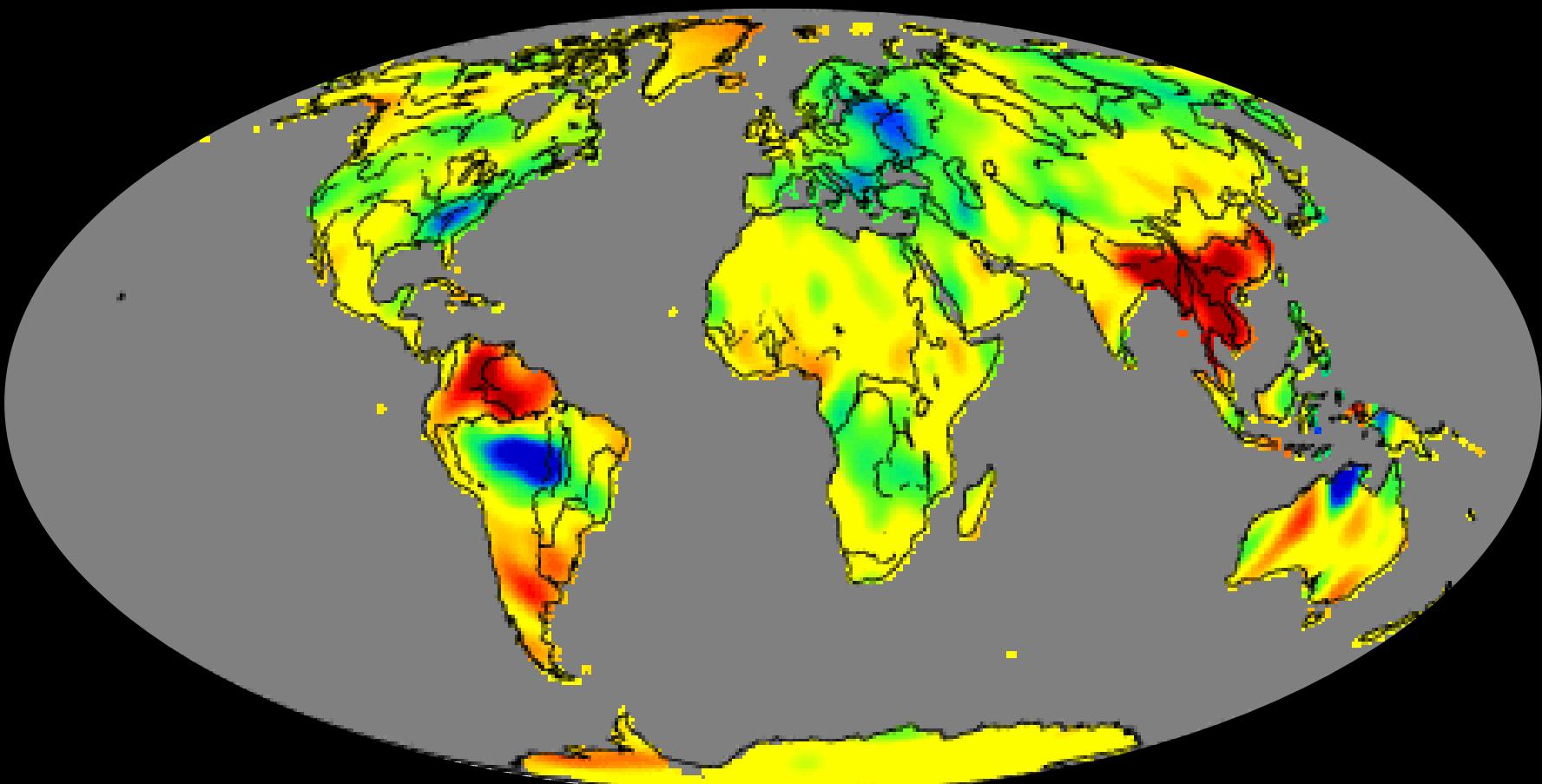
GRACE

(2002)



Mass transport

GRACE (2009)



Gravimetry (2003+)



Future missions

