# Physical Changes in the Arctic

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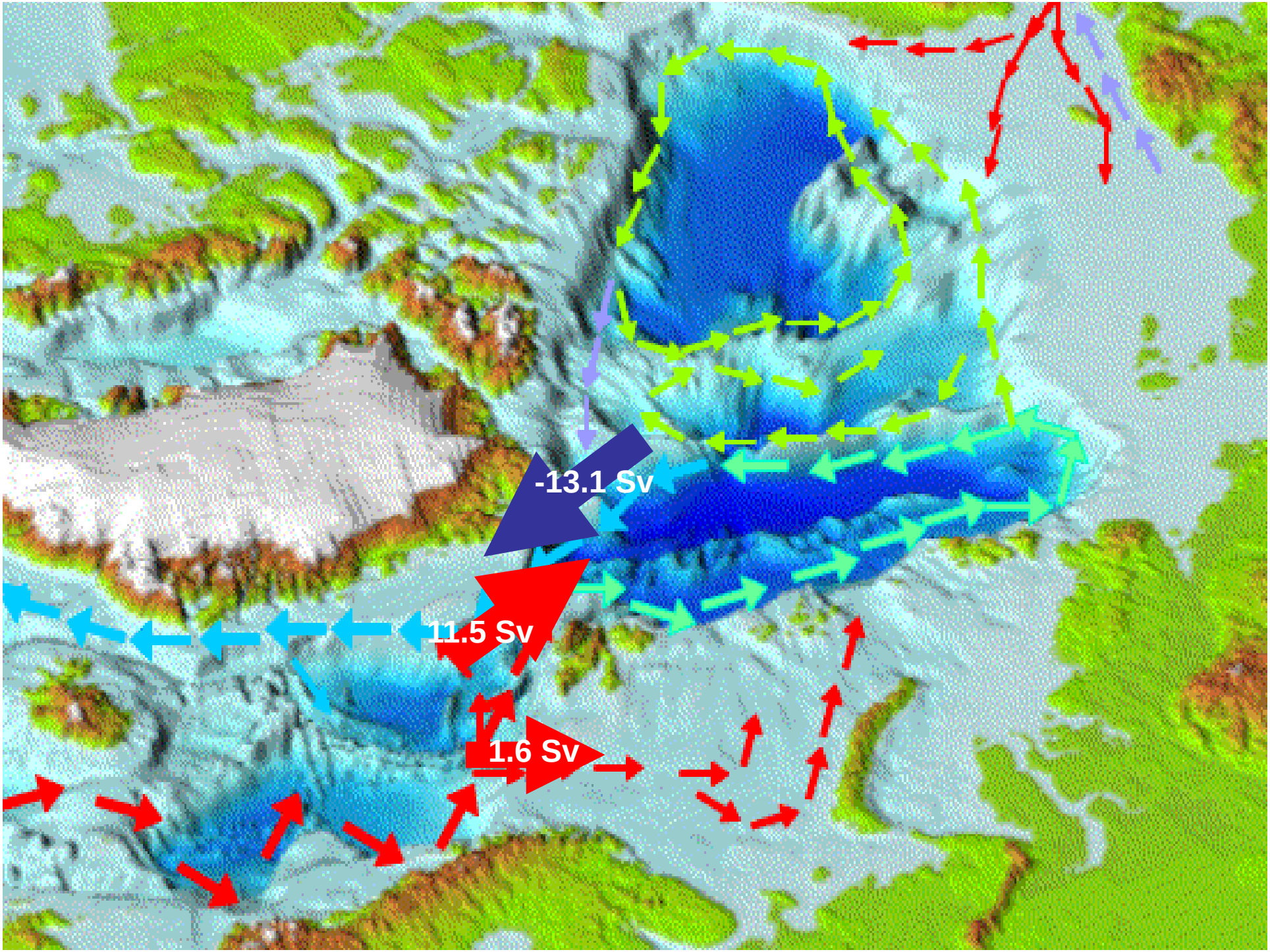
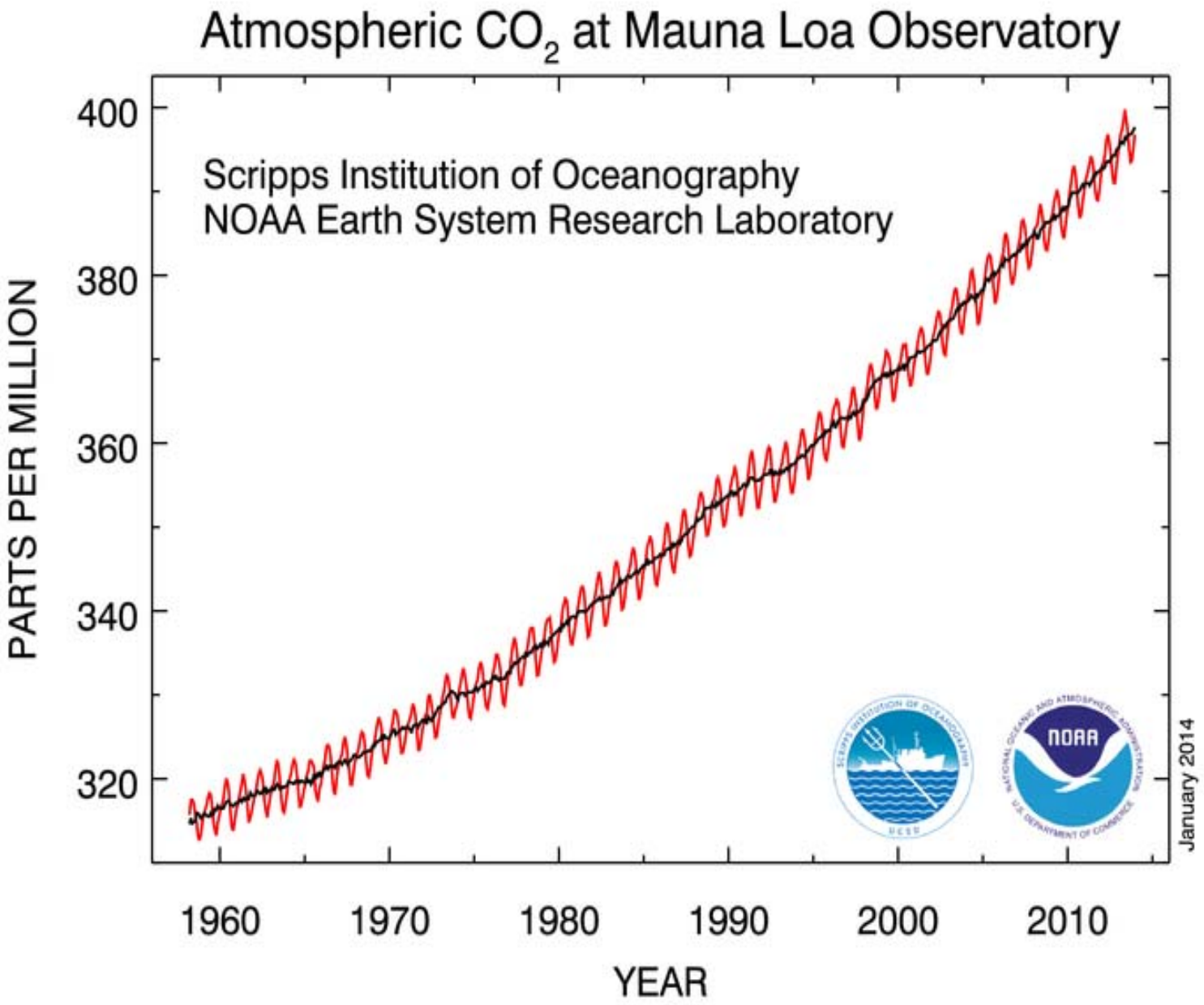
**Svalbard:**

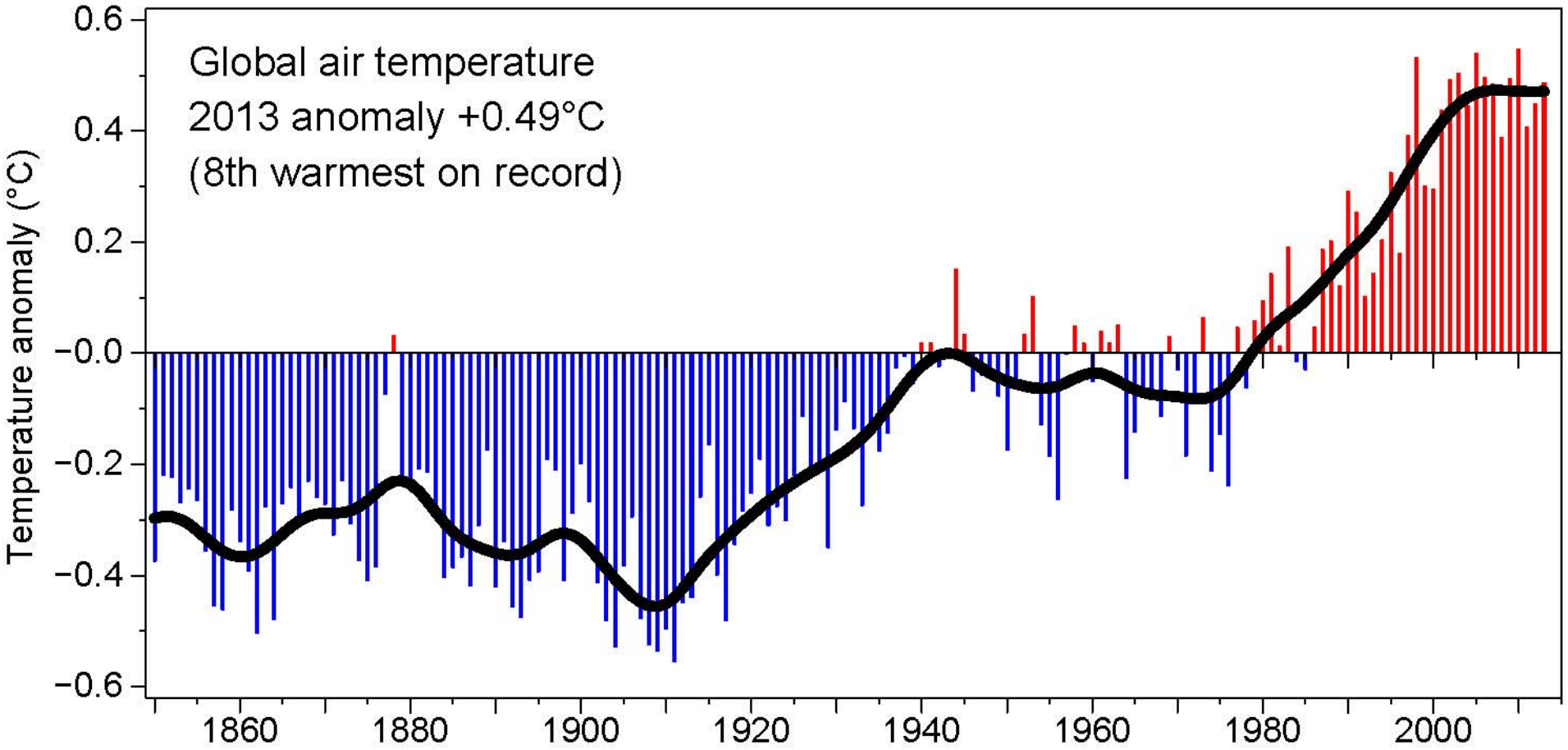
**Norwegian Arctic**


-13.1 Sv
11.5 Sv
1.6 Sv

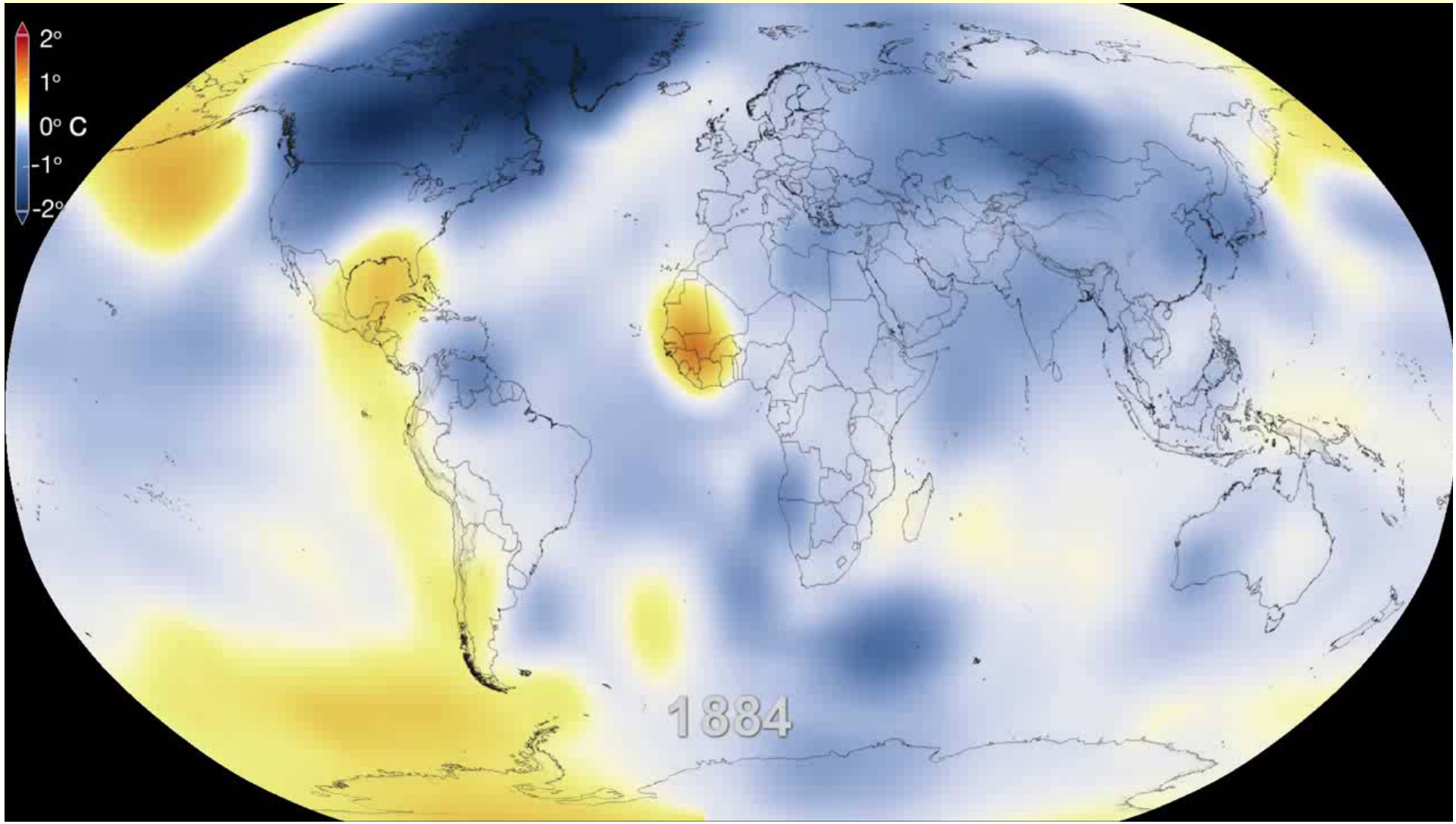

Atmospheric $CO_2$ at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
400
380
360
340
320
1960
1970
1980
1990
2000
2010
YEAR
NOAA
January 2014

# Climate Research Unit, University of East Anglia

http://www.cru.uea.ac.uk/cru/info/warming/

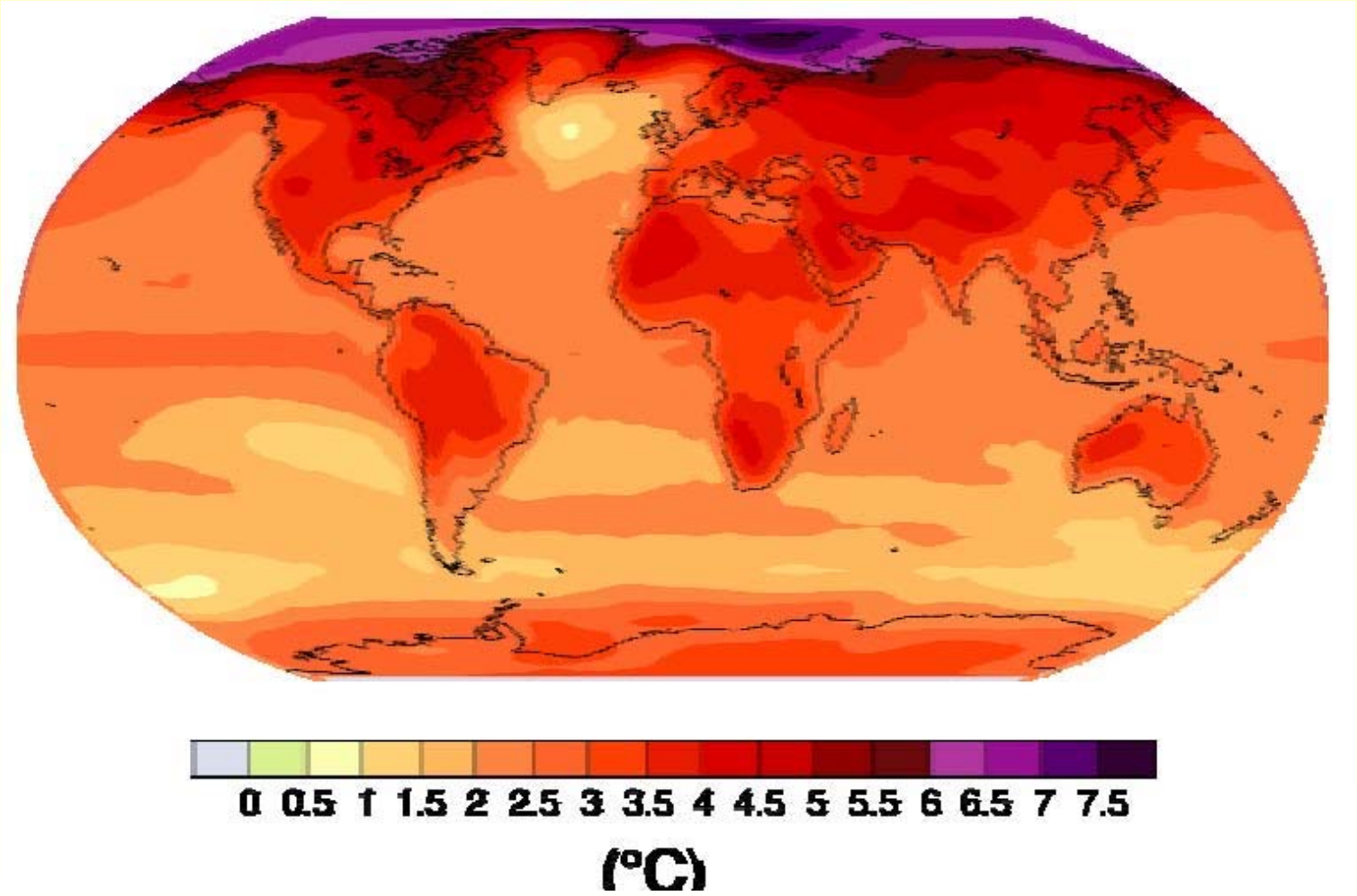


National Aeronautics and Space Administration
Goddard Institute for Space Studies




http://data.giss.nasa.gov/gistemp/animations/

# Geographical pattern of surface warming

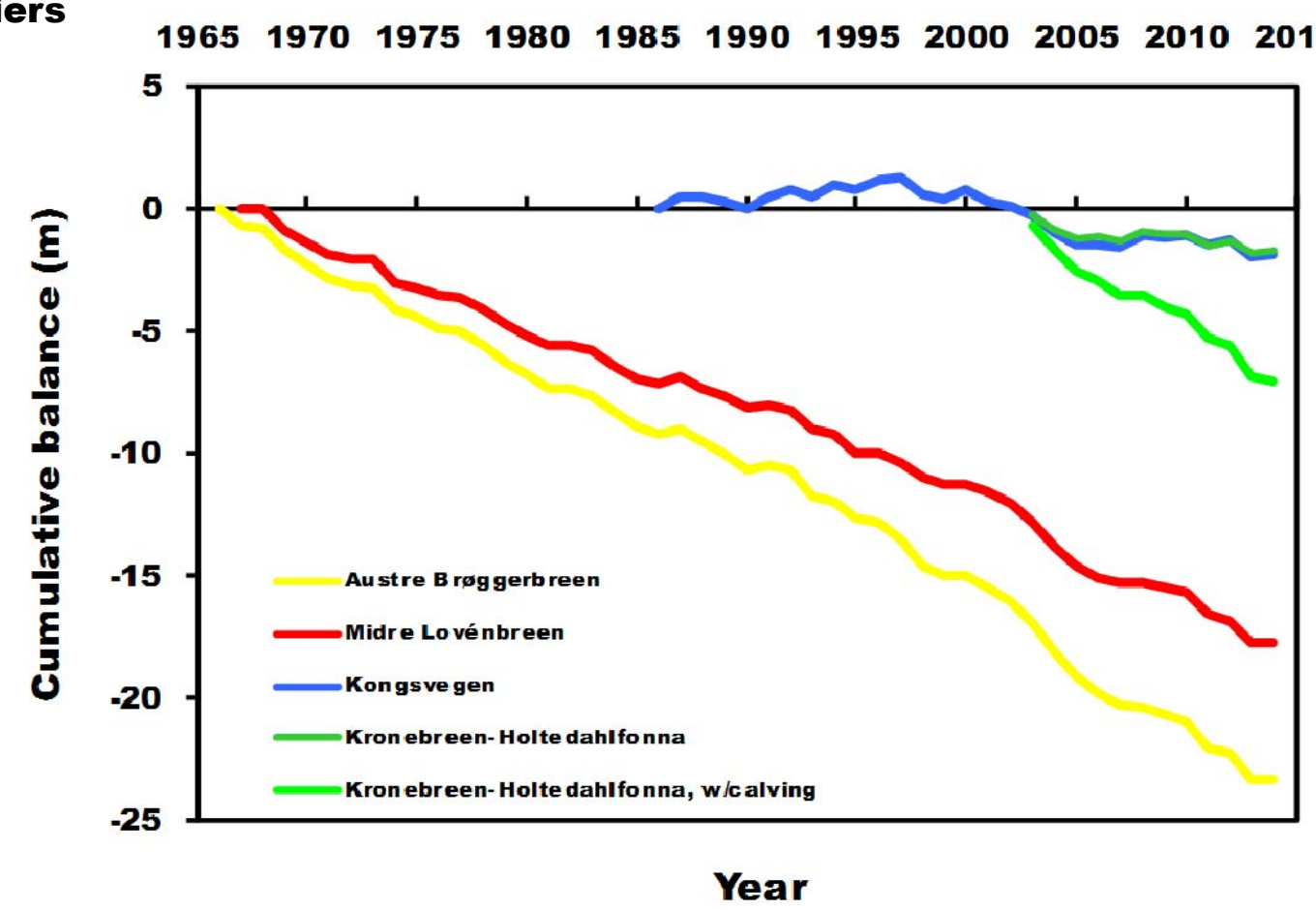



Projected surface temperature changes for the late 21st century (2090-2099). The map shows the multi-AOGCM average projection for the A1B SRES scenario. All temperatures are relative to the period 1980-1999.


1922
1939
2002
June 21, 2010

# Summed mass balance ≈ volume change

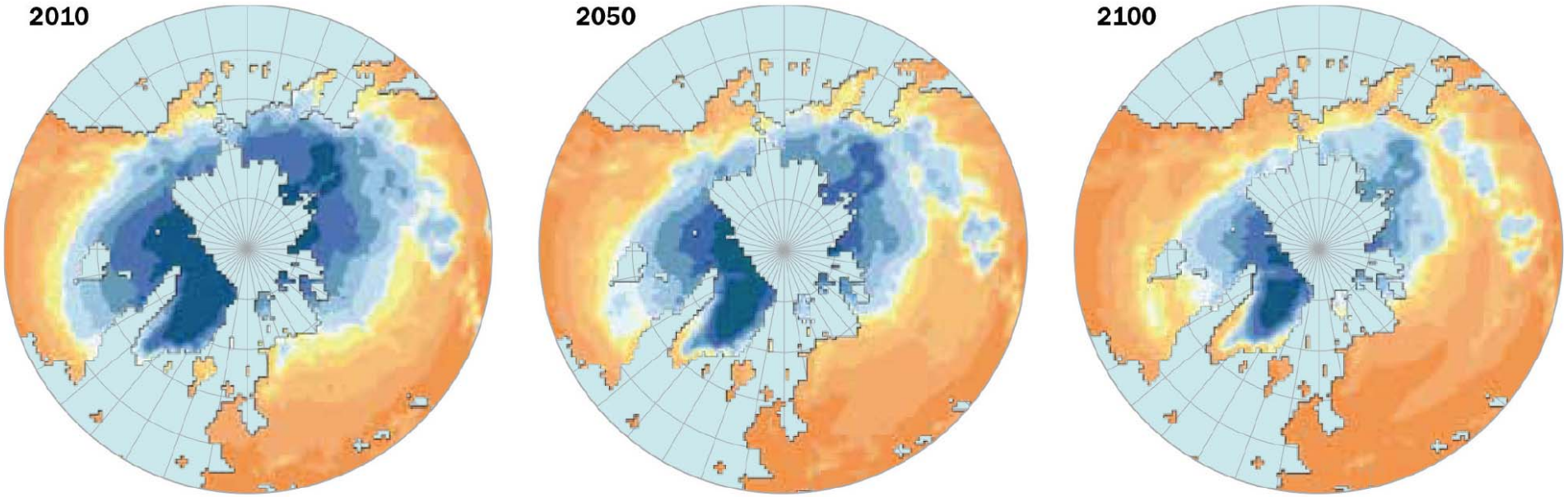
- Small glaciers BRG and MLB steadily retreating, accelerated 2001-2007
- More negative balances after 2000 lead to net loss since 1986 for KNG
- KRB-HDF surface mass balance similar to KNG
- When calving and front retreat is added, KRB-HDF considerably more negative than all other glaciers




Jack Kohler, NPI

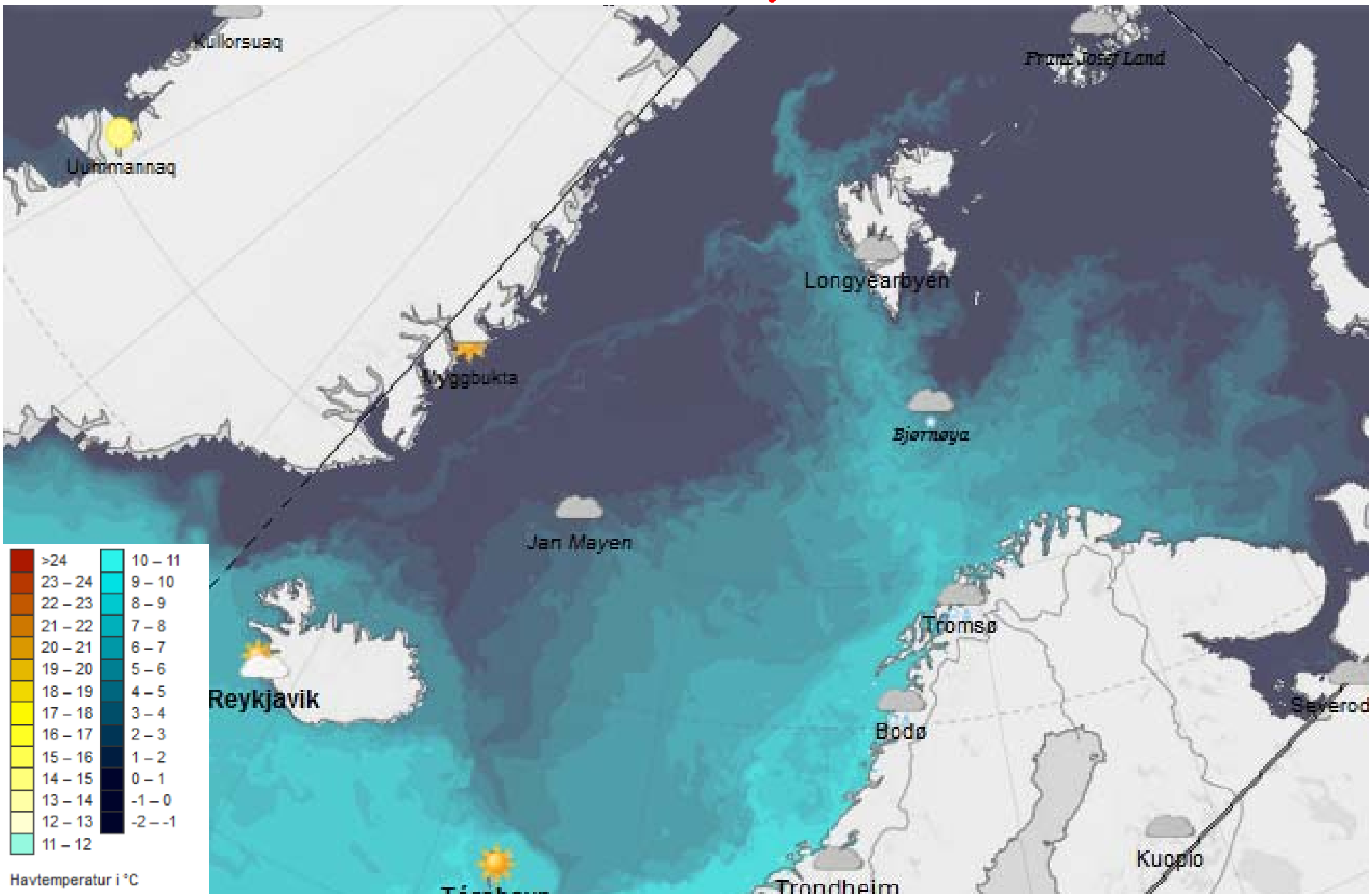
# Arctic Monitoring and Assessment Programme

Arctic Climate Issues 2011



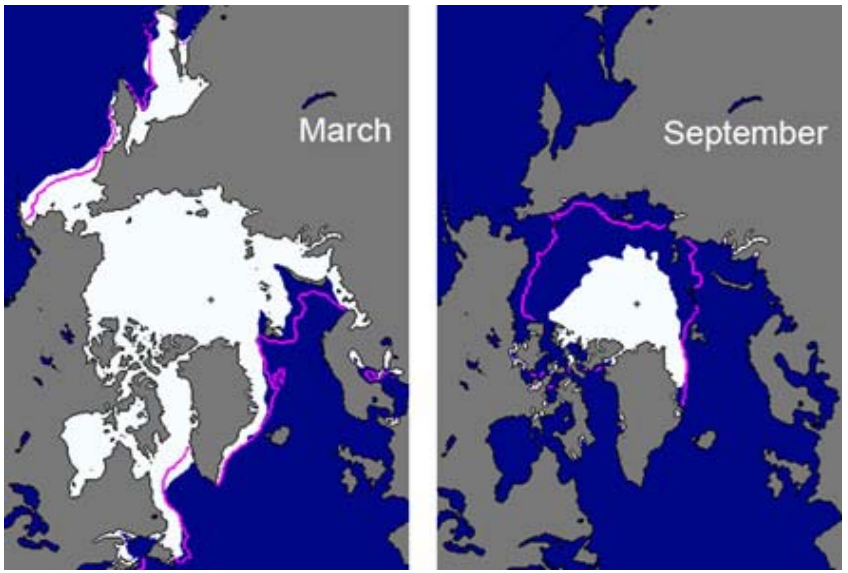
# Sea surface temperature
# December 8, 2014

yr.no

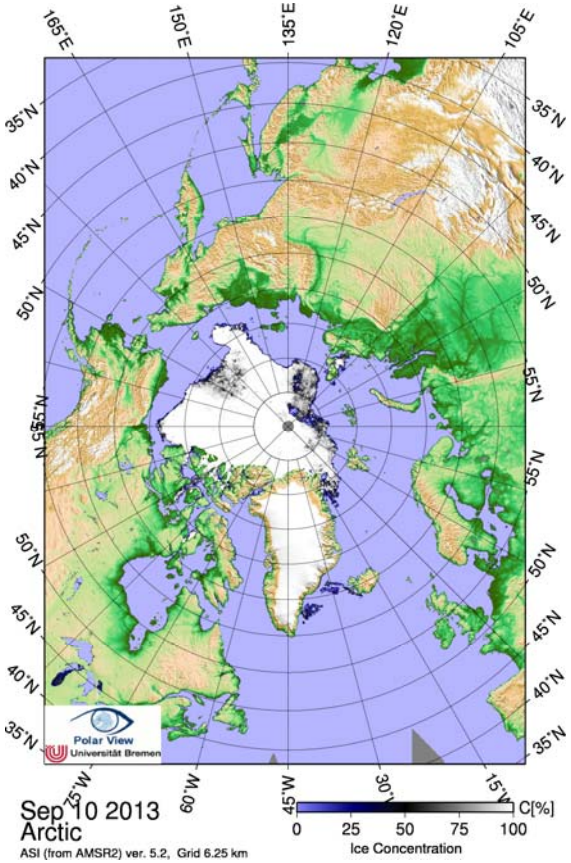


# What is changing in the Arctic Sea Ice System?

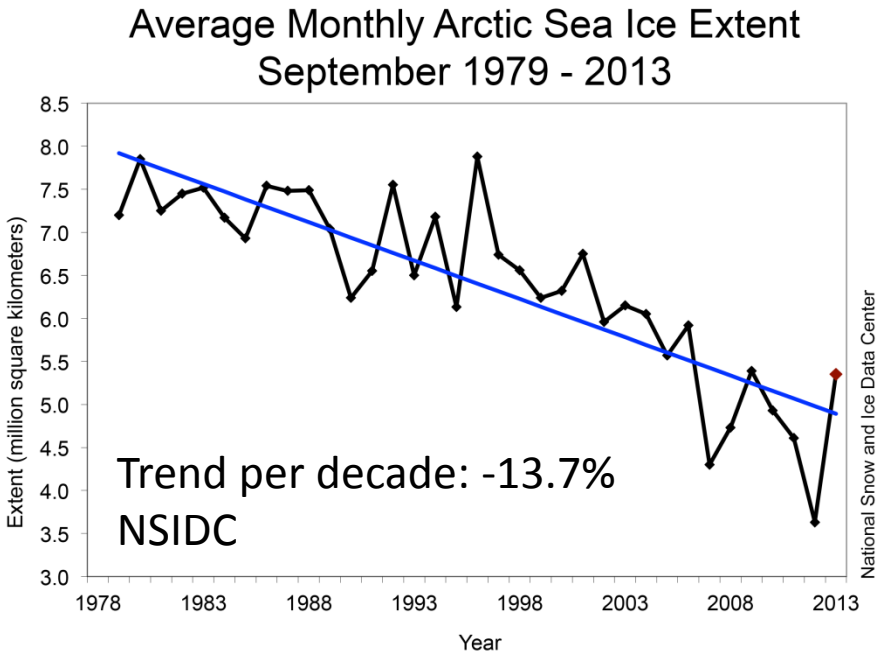
- Ice extent
- Ice dynamics and distribution
- Sea ice thickness




Arctic report card 2012/NSIDC




Univ. Bremen




See also Arctic Report Card 2013, NOAA

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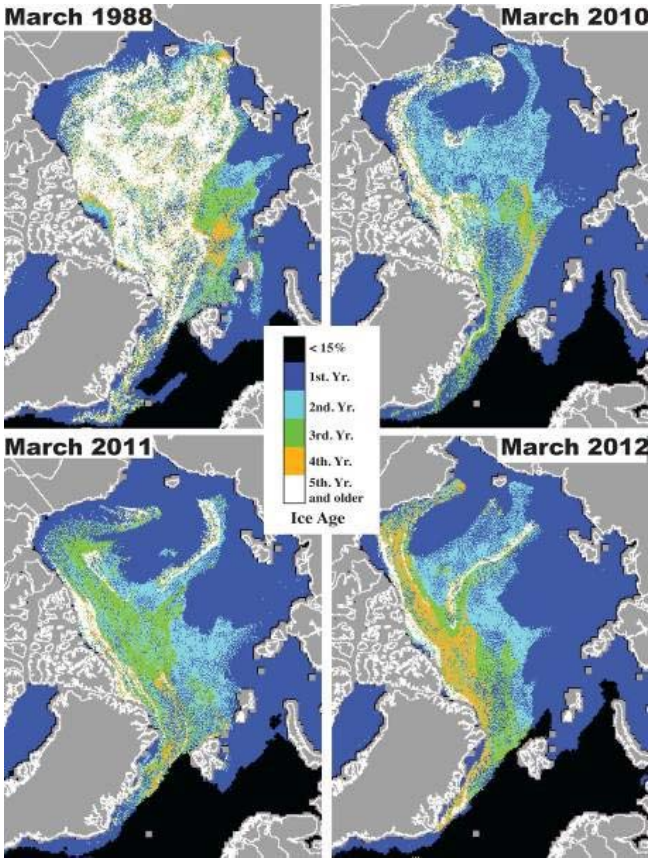
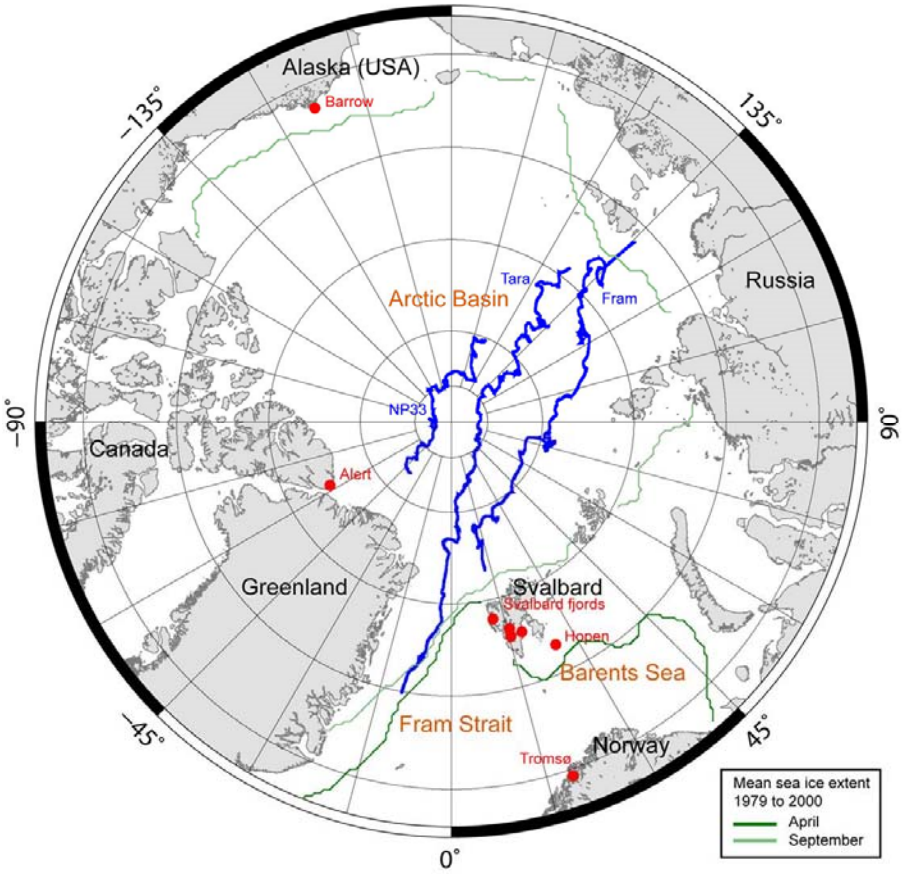



Maslanik & Tschudi, Arctic report card 2012



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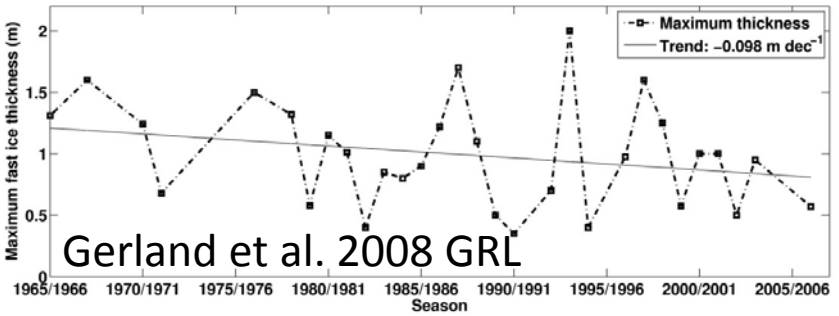
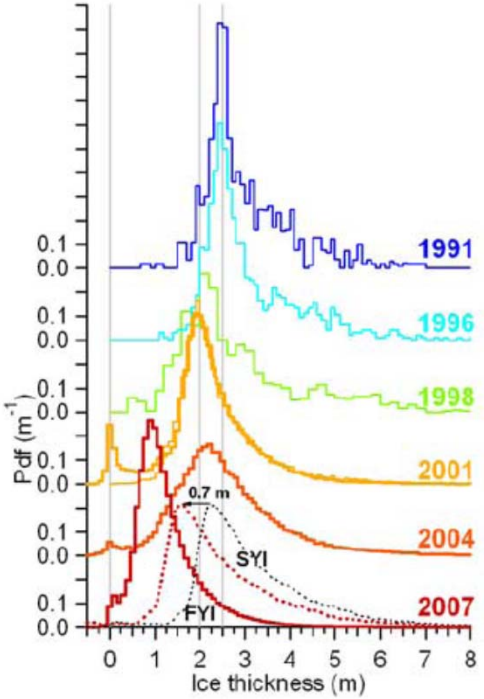
**Hopen max. seas. ice thickness ( drillings)**



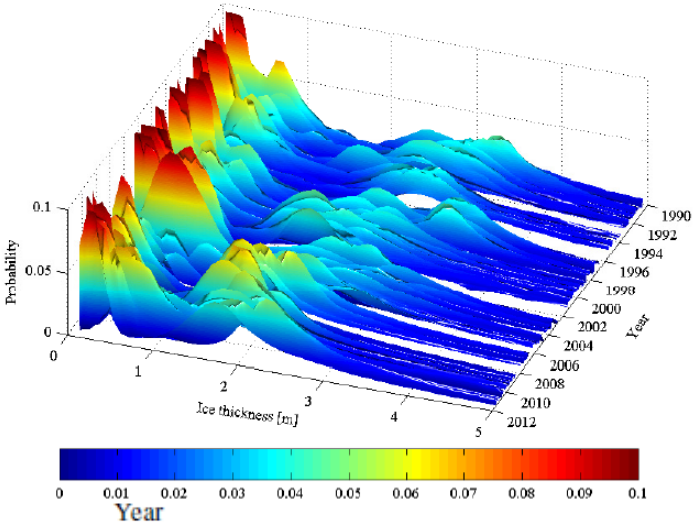

Gerland et al. 2008 GRL

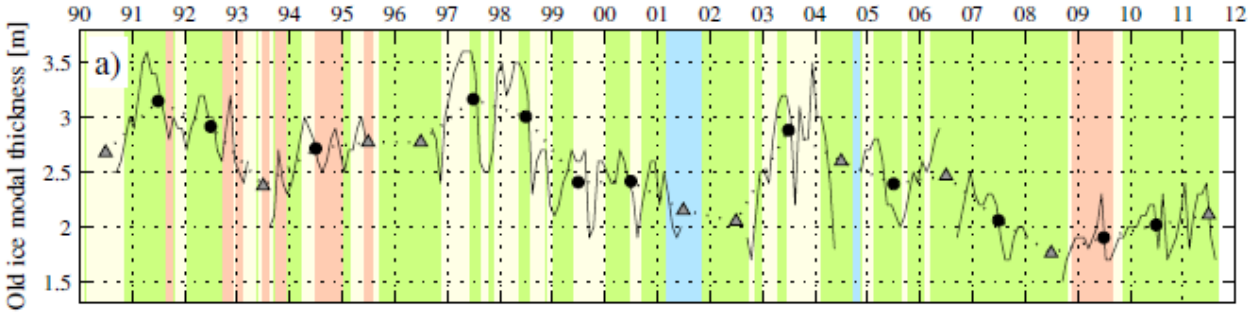
**Ice thickness transpolar drift (EM)**



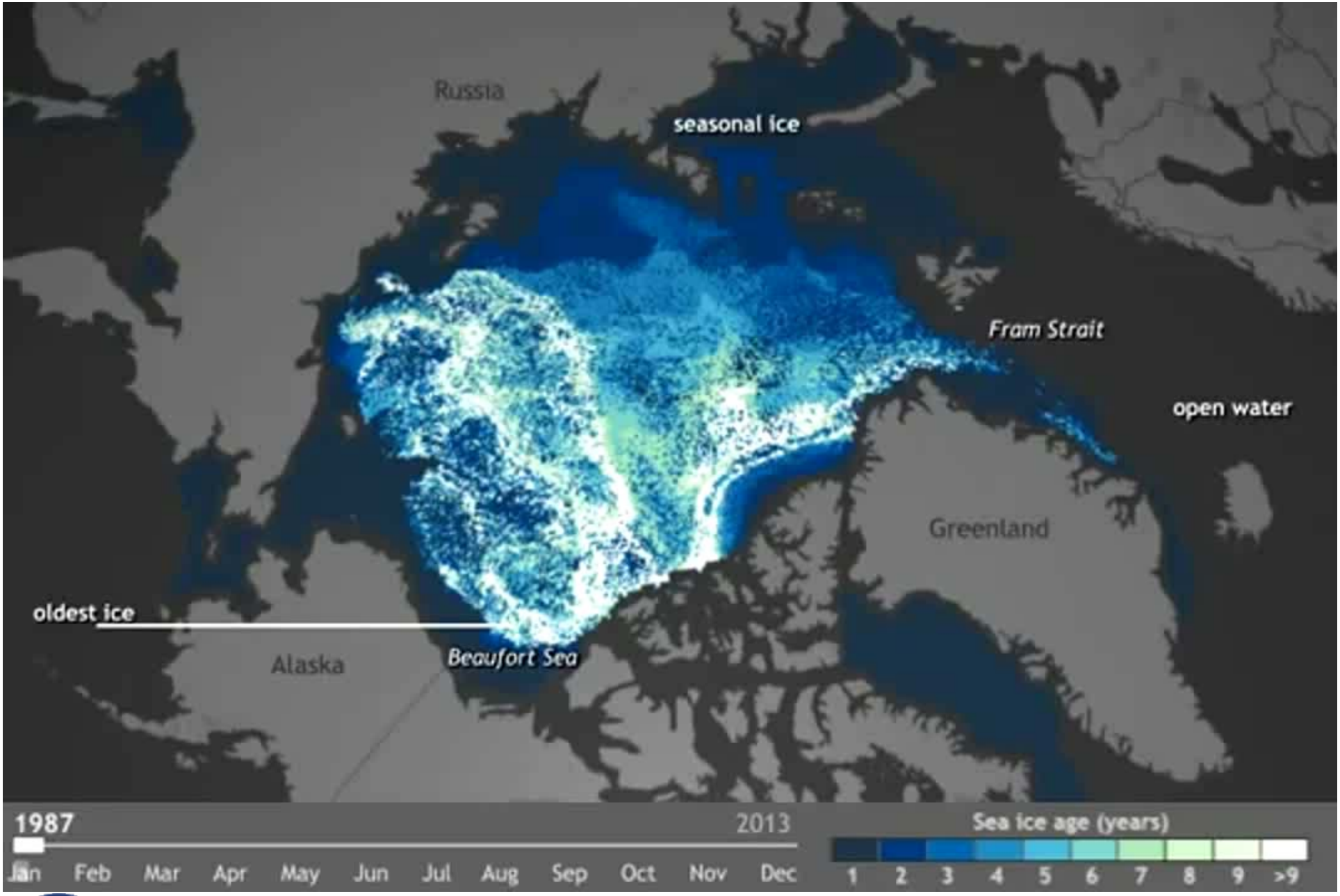

Haas et al. 2008 GRL

**Fram Strait ice thickness (ULS)**




Hansen et al. 2013 JGR




Climate.gov
science & information for a climate-smart nation

http://www.climate.gov/news-features/videos/very-little-old-sea-ice-remains-arctic

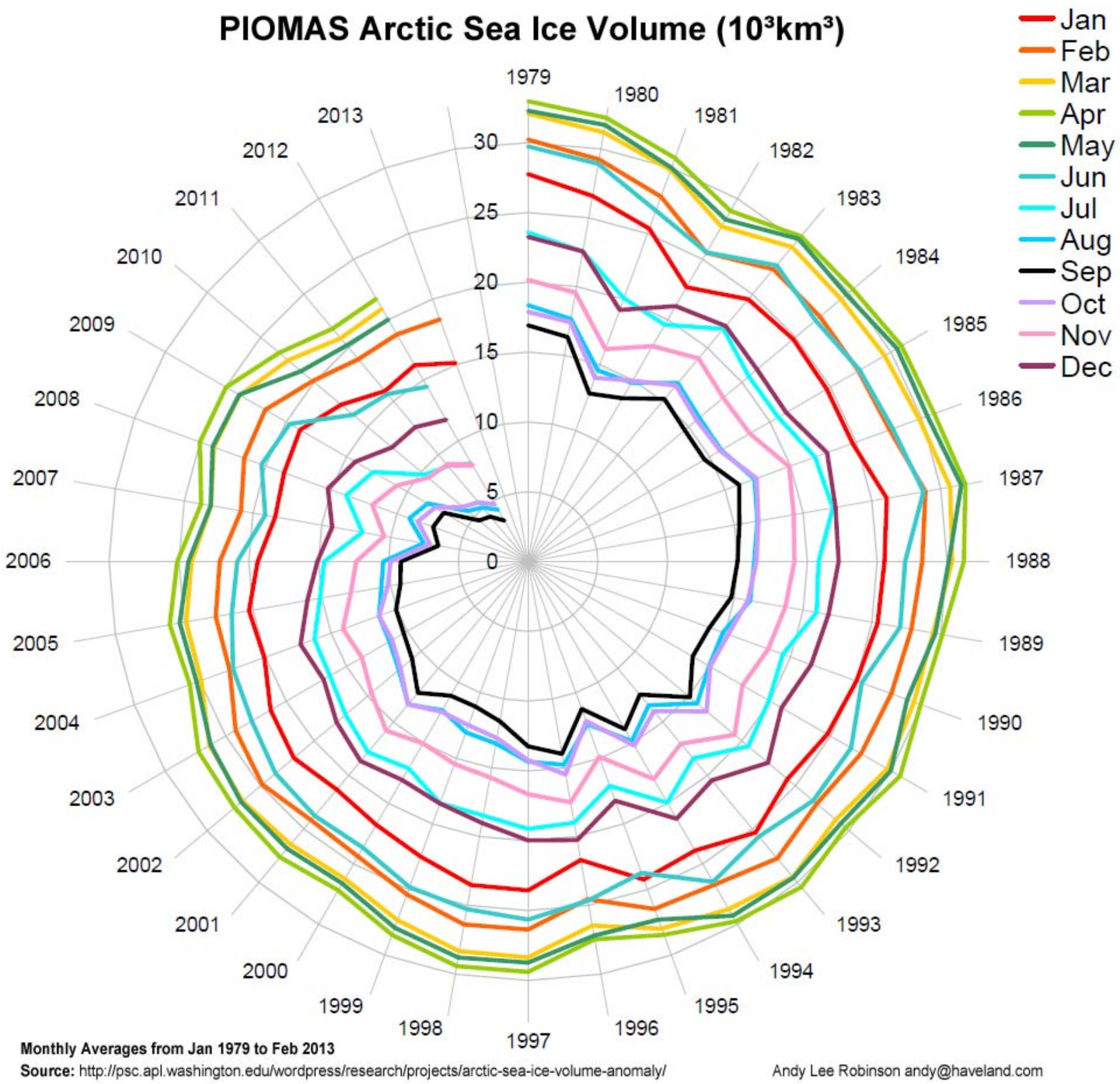

PIOMAS Arctic Sea Ice Volume (10³km³)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
30
25
20
15
10
5
0
Monthly Averages from Jan 1979 to Feb 2013
Source: http://psc.apl.washington.edu/wordpress/research/projects/arctic-sea-ice-volume-anomaly/
Andy Lee Robinson andy@haveland.com


Photo: Ann-Christine Engvall

# WALRUS

Thanks for your attention !

Photo: Kit Kovacs and Christian Lydersen

Thanks for your attention !

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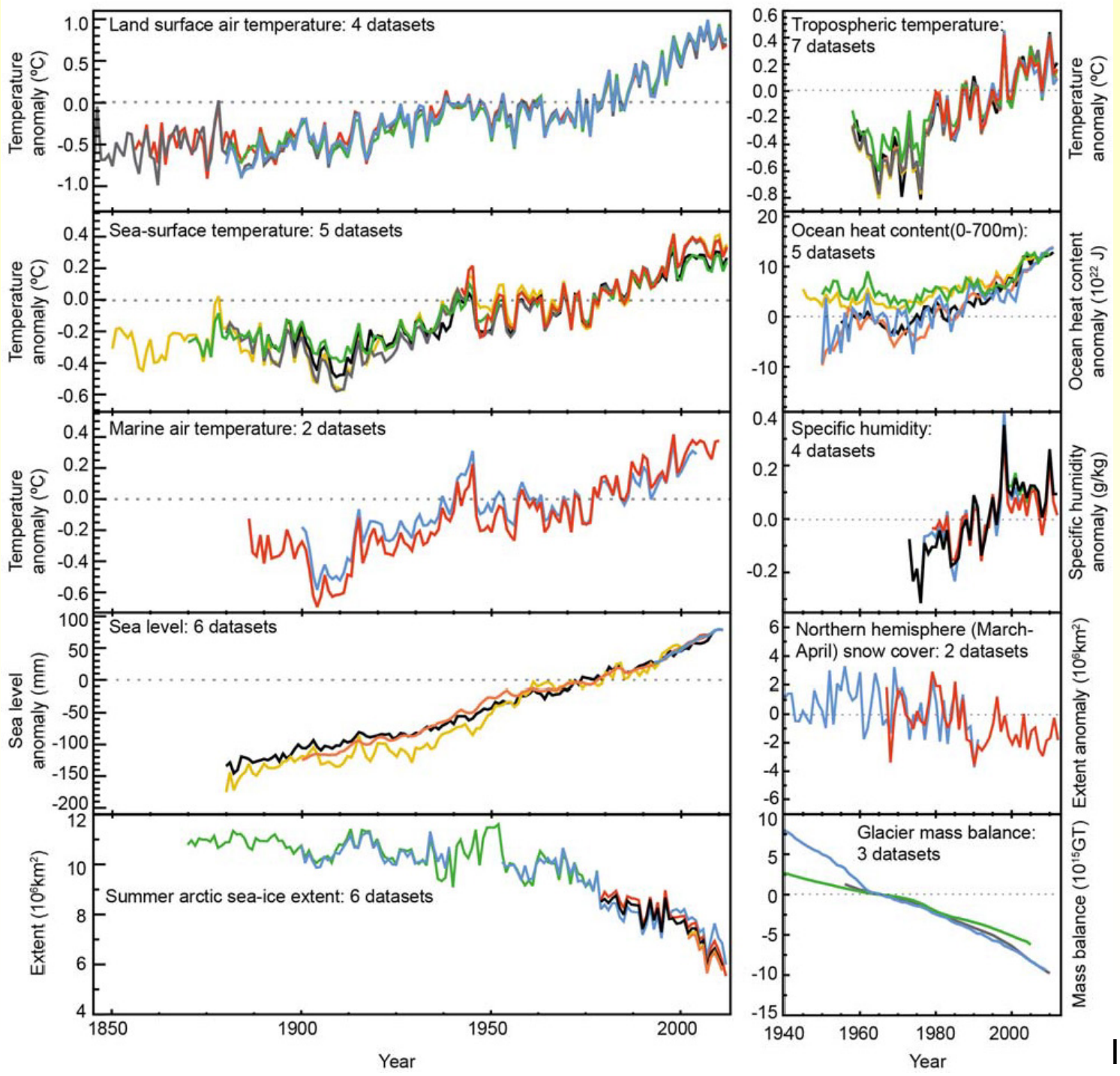
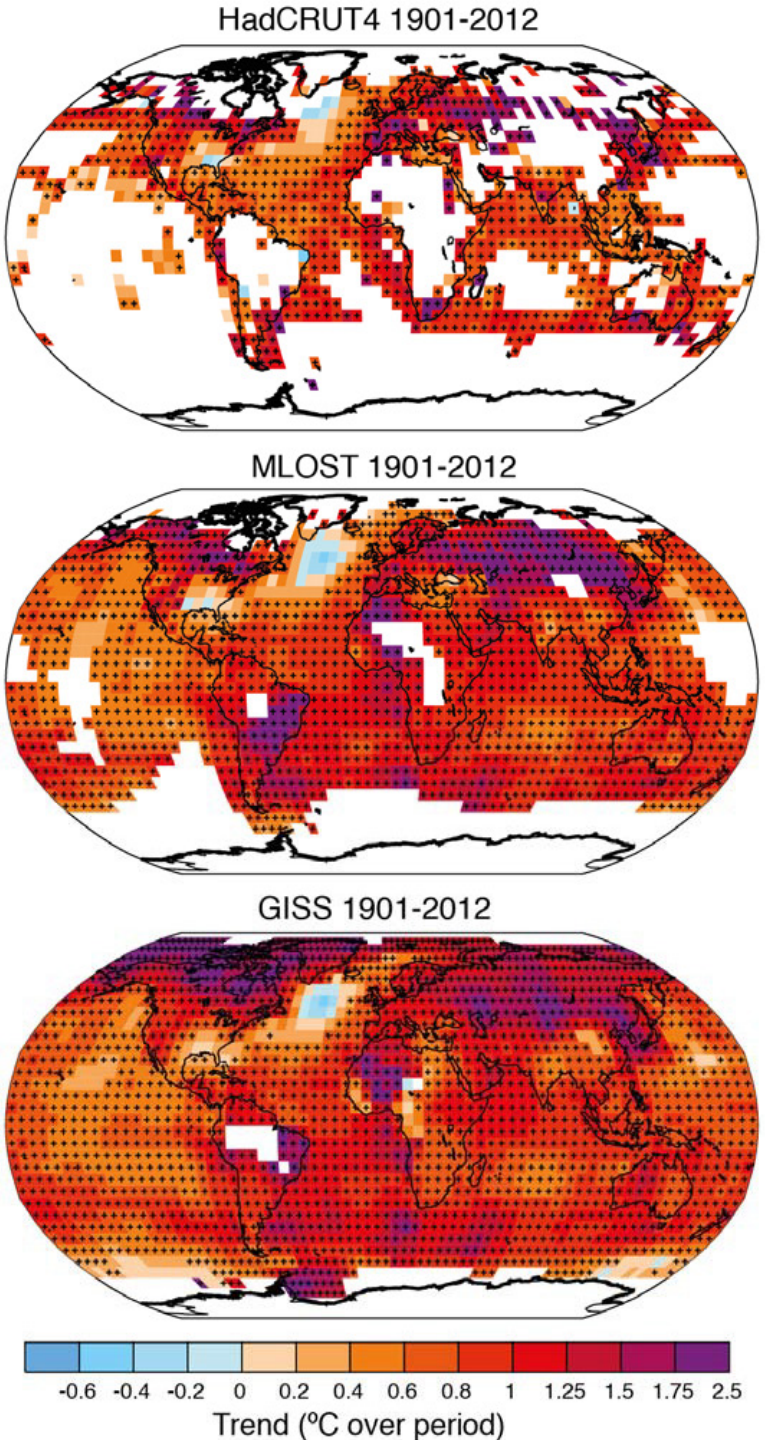

Land surface air temperature: 4 datasets
Temperature anomaly (°C)
Sea-surface temperature: 5 datasets
Temperature anomaly (°C)
Marine air temperature: 2 datasets
Temperature anomaly (°C)
Sea level: 6 datasets
Sea level anomaly (mm)
Summer arctic sea-ice extent: 6 datasets
Extent (10⁶km²)
1850
1900
1950
2000
Year
Tropospheric temperature: 7 datasets
Temperature anomaly (°C)
Ocean heat content(0-700m): 5 datasets
Ocean heat content anomaly (10²² J)
Specific humidity: 4 datasets
Specific humidity anomaly (g/kg)
Northern hemisphere (March-April) snow cover: 2 datasets
Extent anomaly (10⁶km²)
Glacier mass balance: 3 datasets
Mass balance (10¹⁵GT)
1940
1960
1980
2000
Year

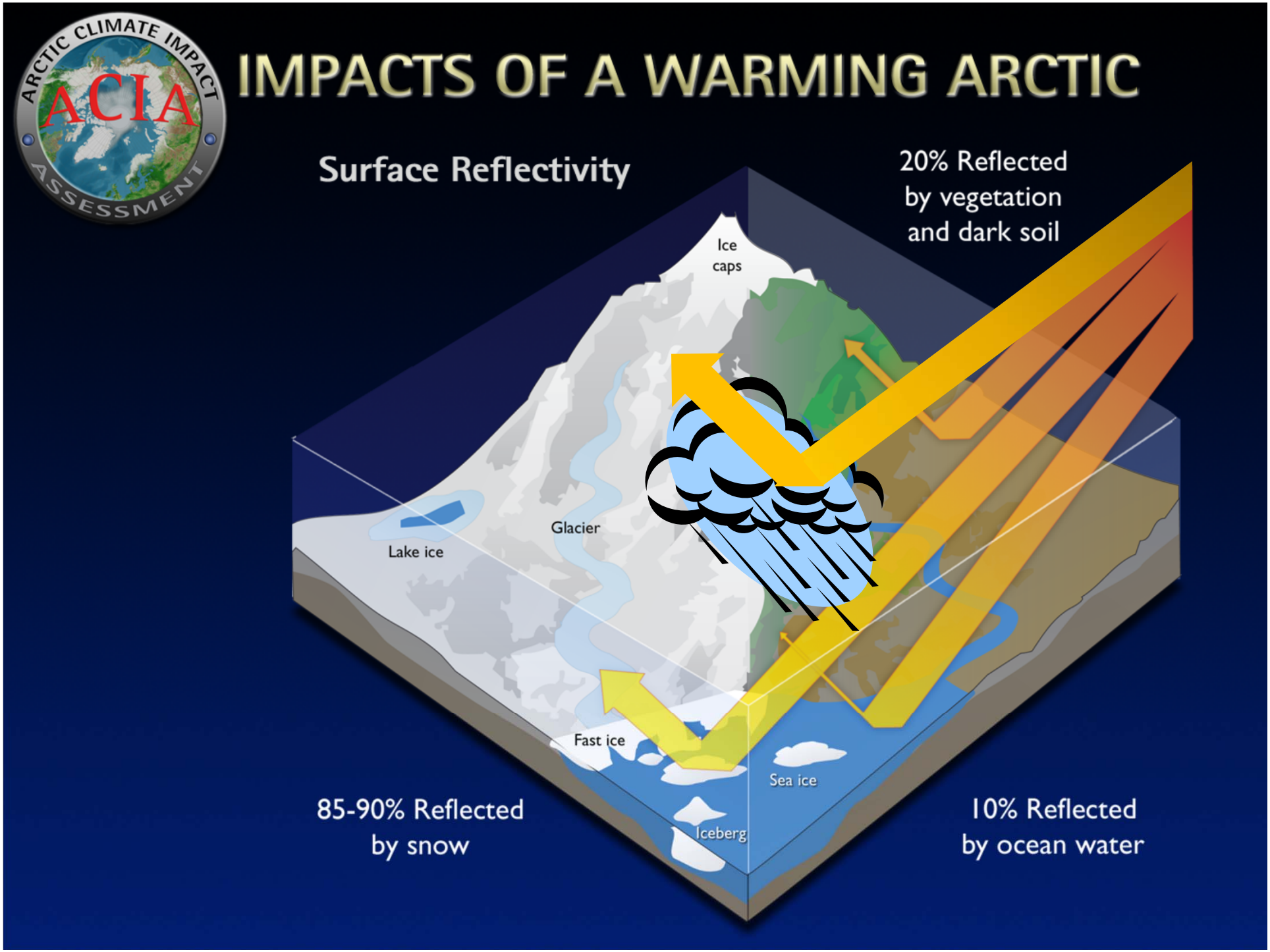
IPCC, 2013

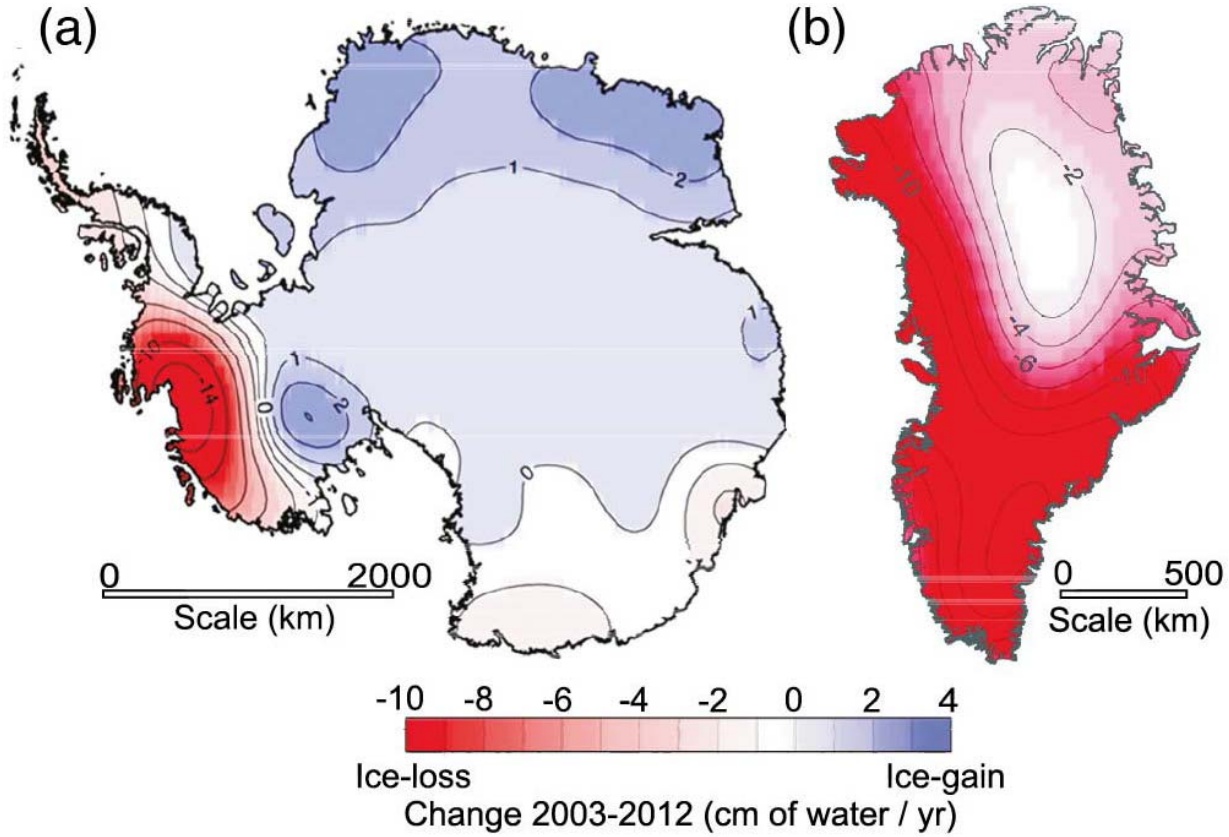


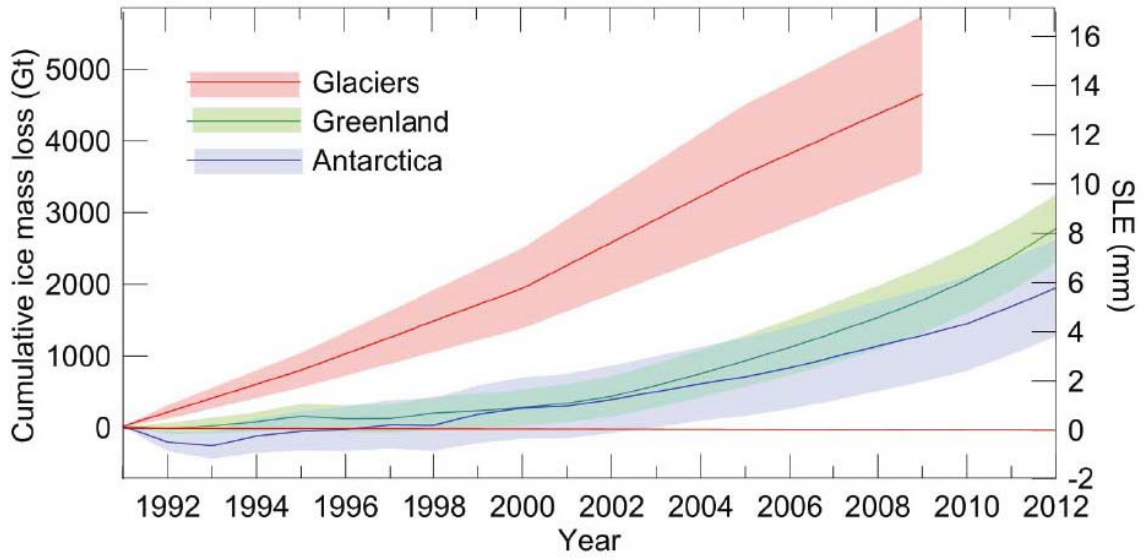

IPCC, 2013

**Kim Holmén.**

# IMPACTS OF A WARMING ARCTIC




(a)
(b)
0
2000
Scale (km)
0
500
Scale (km)
-10 -8 -6 -4 -2 0 2 4
Ice-loss
Ice-gain
Change 2003-2012 (cm of water / yr)


Glaciers
Greenland
Antarctica
Cumulative ice mass loss (Gt)
5000
4000
3000
2000
1000
0
SLE (mm)
16
14
12
10
8
6
4
2
0
-2
1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012
Year

IPCC, 2013