Cooperative Institute for Research in Environmental Sciences

National Snow and Ice Data Center
Supporting Cryospheric Research Since 1976

University of Colorado

AMAP

Climate Change in the Cryosphere: Snow, Water, Ice and Permafrost in the Arctic (SWIPA) Assessment Summary

Arctic Monitoring and Assessment Programme

Walt Meier, National Snow and Ice Data Center

SBSTA 34 Workshop on Research

Bonn, Germany

2 June 2011

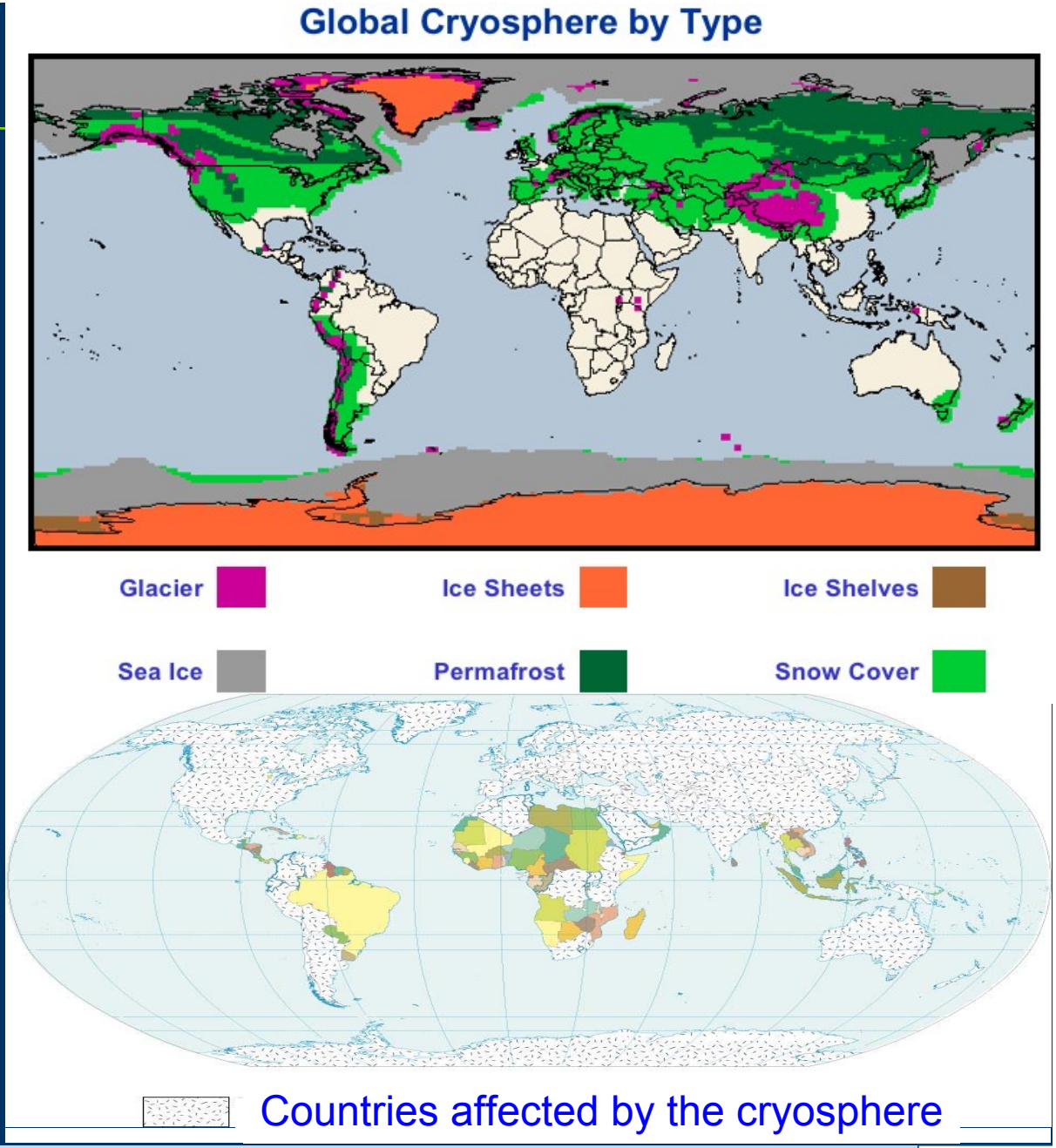
SWIPA

- Arctic Council project
- Arctic Mapping and Assessment Programme (AMAP)
- Executive Summary and provisional drafts of science report now available online:
  - http://www.amap.no
- Full report in final form expected later this summer

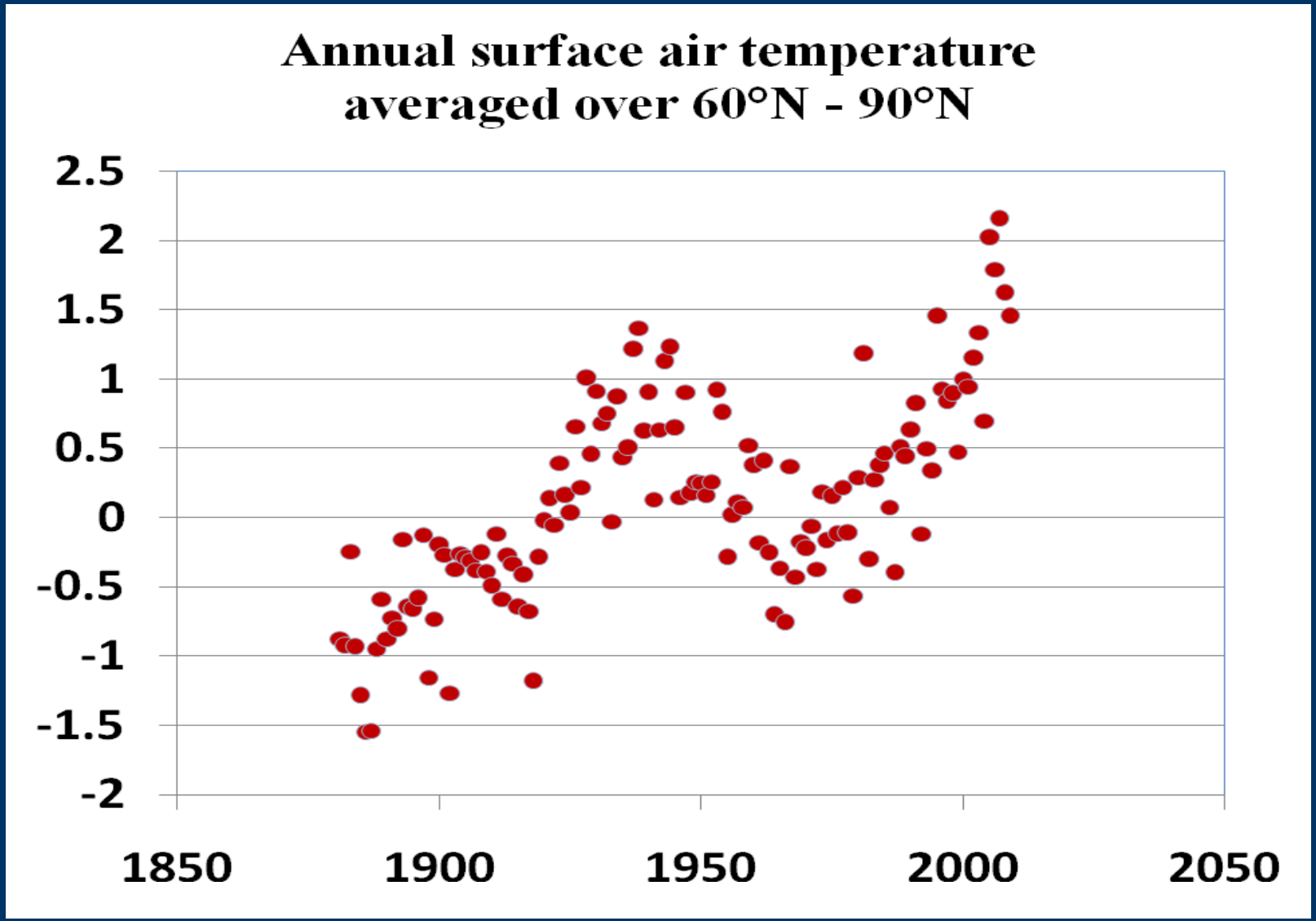
The Cryosphere

Snow and ice spans the globe, from the equator to the poles.

The cryosphere is found in over 100 countries



Temperatures rising faster in the Arctic



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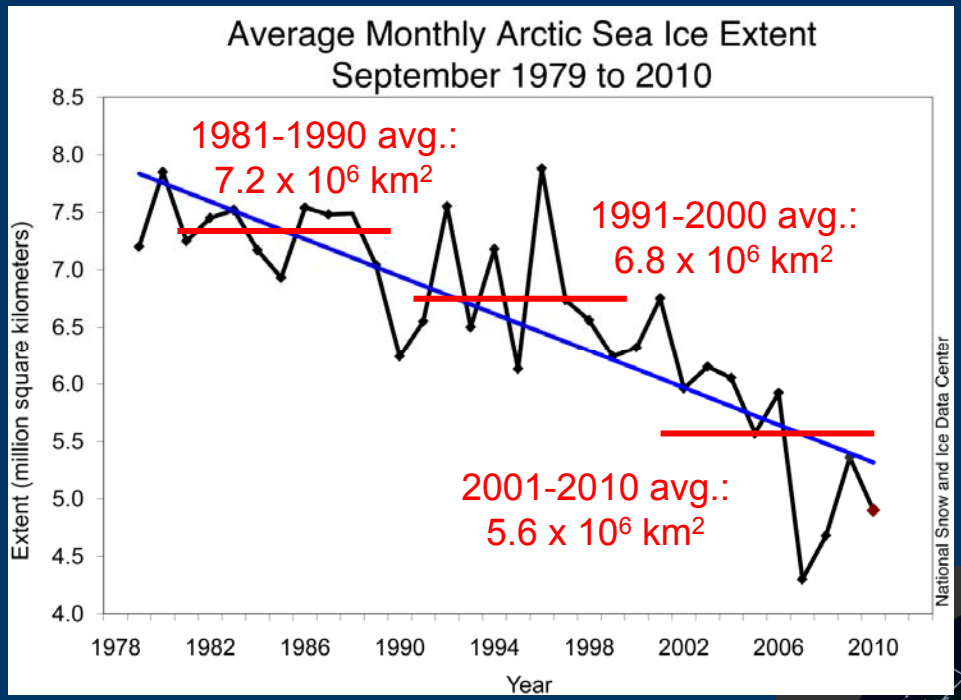
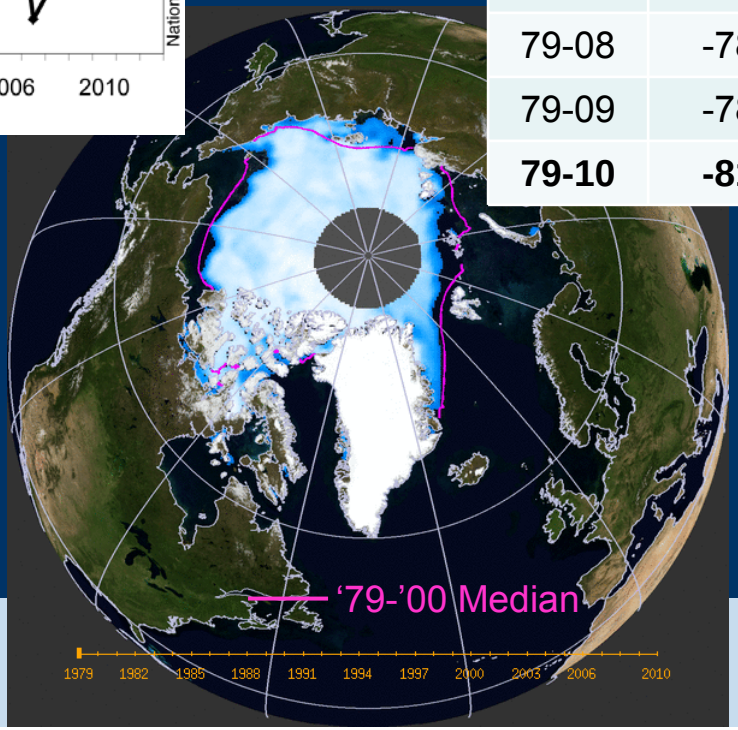
Accelerating September sea ice decline



Year Range	Trend (km^2/yr)	%/dec. rel. 79-00 avg.
79-01	-45900	-6.5
79-02	-51000	-7.3
79-03	-52800	-7.5
79-04	-54600	-7.8
79-05	-59400	-8.4
79-06	-60200	-8.6
79-07	-71600	-10.2
79-08	-78100	-11.1
79-09	-78700	-11.2
79-10	**-81400**	**-11.6**

Decline occurs throughout all seasons in almost all regions
(exception: Bering Sea in winter)



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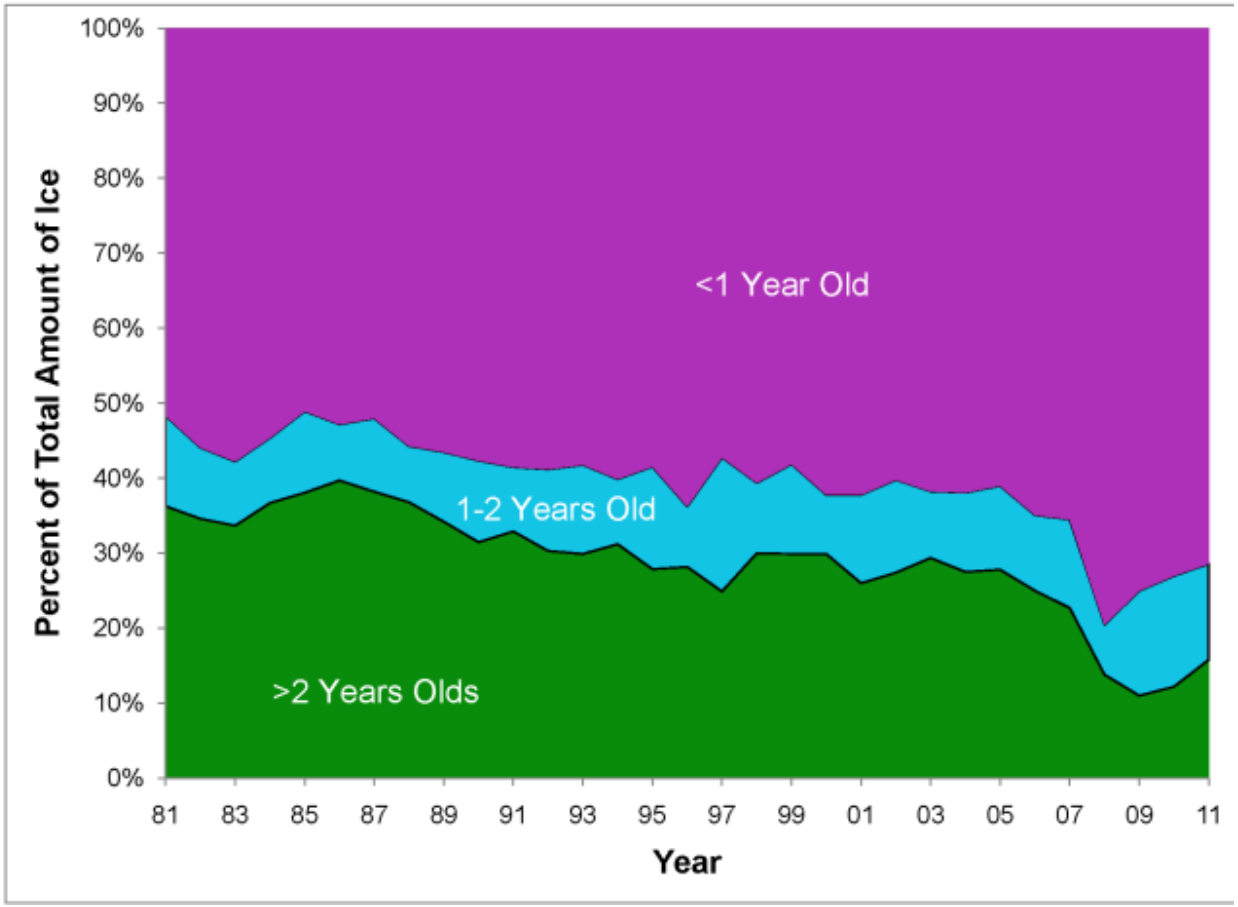
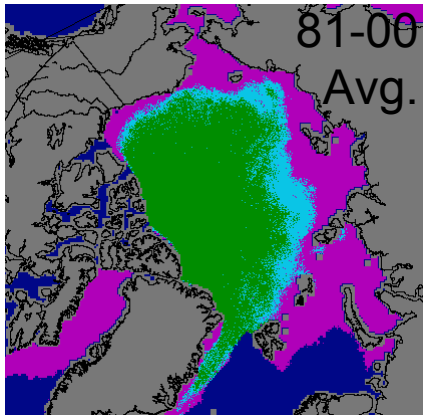
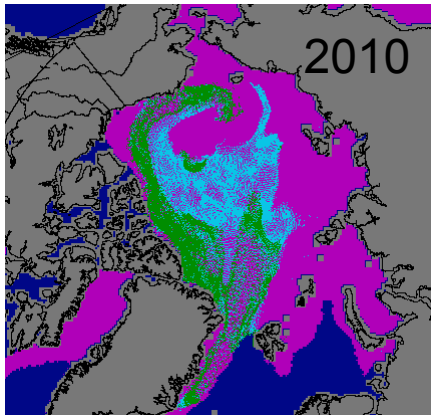
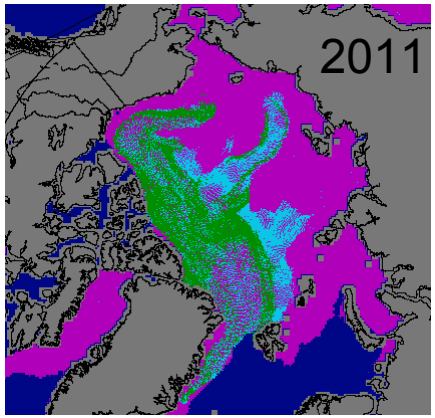
March sea ice age

Younger Ice = Thinner Ice (on average)









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Based on satellite observations; from J. Maslanik, C. Fowler, Univ. Colorado

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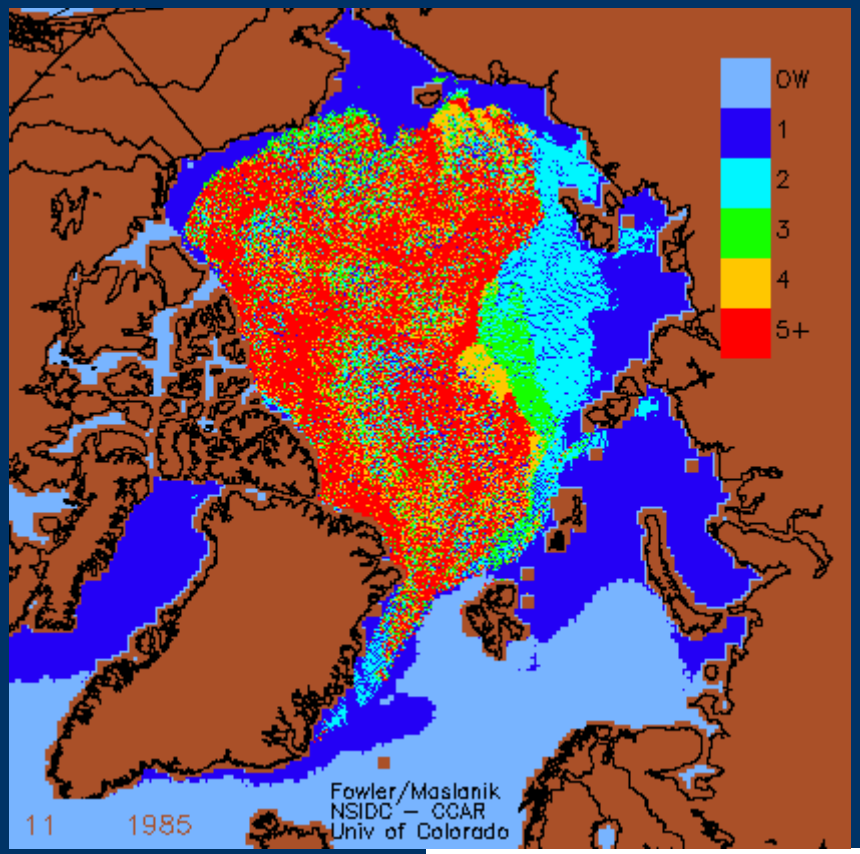
Sea ice is getting younger and thinner

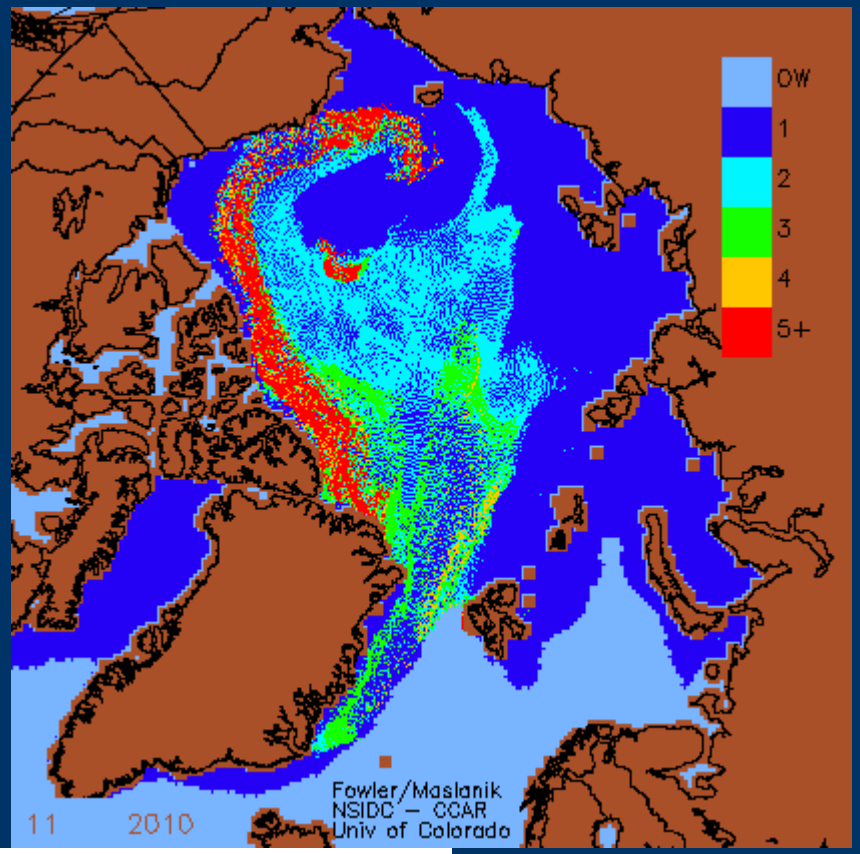
Younger Ice = Thinner Ice (on average)

Much of older, thicker ice north of Alaska now melting away during summer

Mar 1985 – Mar 1986



Mar 2010 – Mar 2011



= oldest, thickest ice (≥5 years old)

Based on satellite observations; from J. Maslanik, C. Fowler, Univ. Colorado

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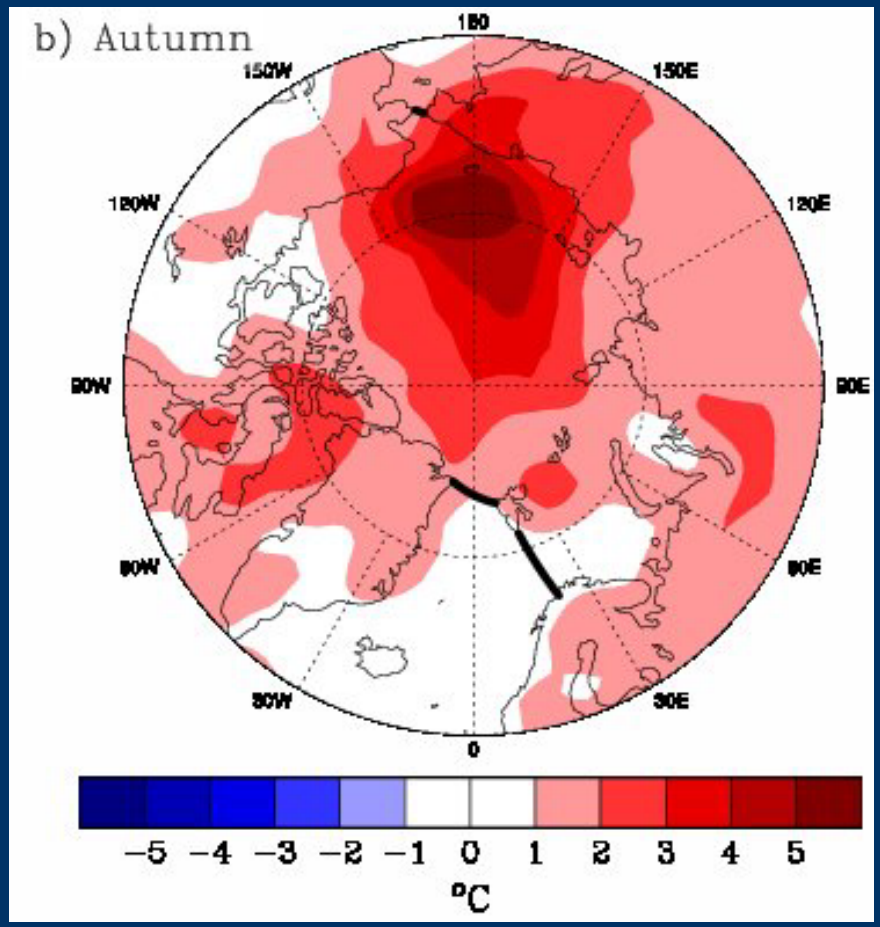
Arctic Amplification observed

- Ocean absorbs more of sun's energy during summer than sea ice
- Heat accumulated by ocean during summer must be dissipated to the atmosphere
- Enhanced atmospheric warming in autumn
- "Arctic Amplification"



Autumn air temperature anomalies, (2003-2007) minus (1979-2007)

From Serreze, et al., 2008; data from NOAA NCEP

Biological impacts

- Extinction of some Arctic endemic species highly likely if current trends in sea ice continue
  - 2/3 reduction in polar bear population by 2050
  - Walrus and seal populations threatened also
- While some species will see habitats shrink, others will find new opportunities
  - Current sub-Arctic species will migrate into the Arctic, e.g., some bird and fish species

Human impacts

- Local communities
- Shipping and navigation
- Resource extraction
- Tourism
- National sovereignty and defense issues
- Global climate impacts

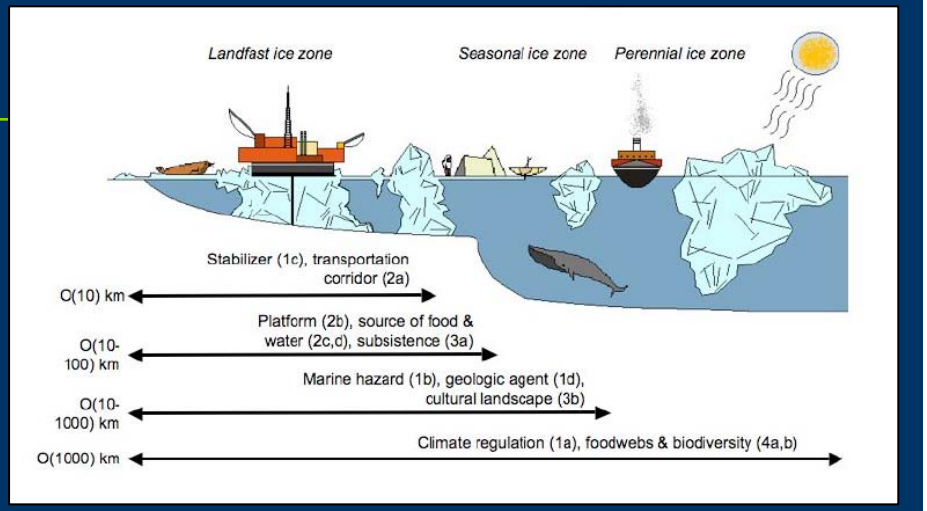
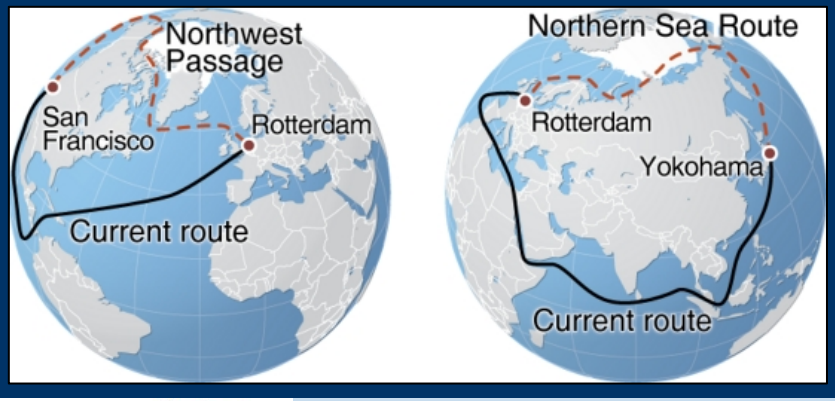



Photo by Tony Weyiouanna Sr.



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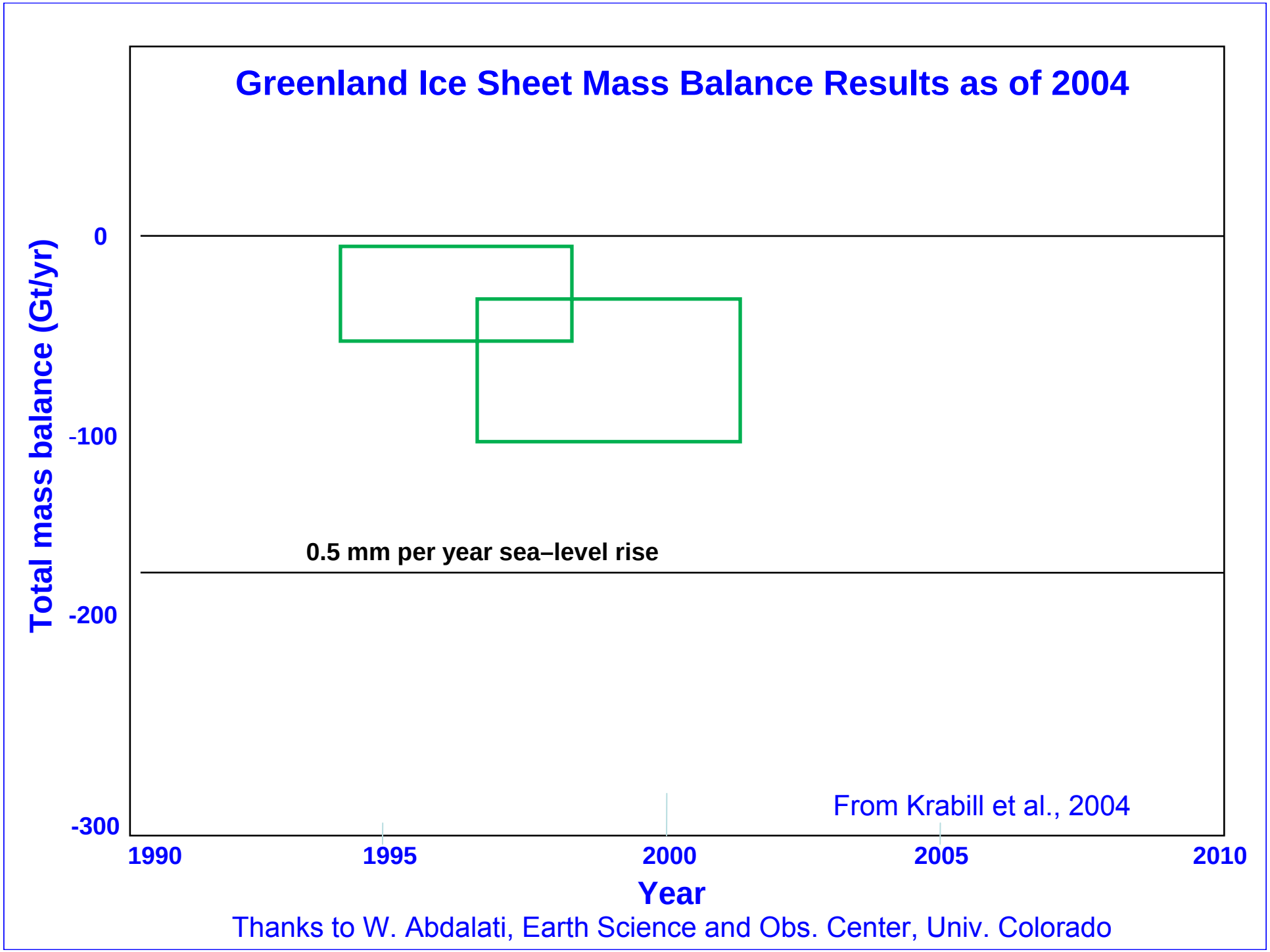
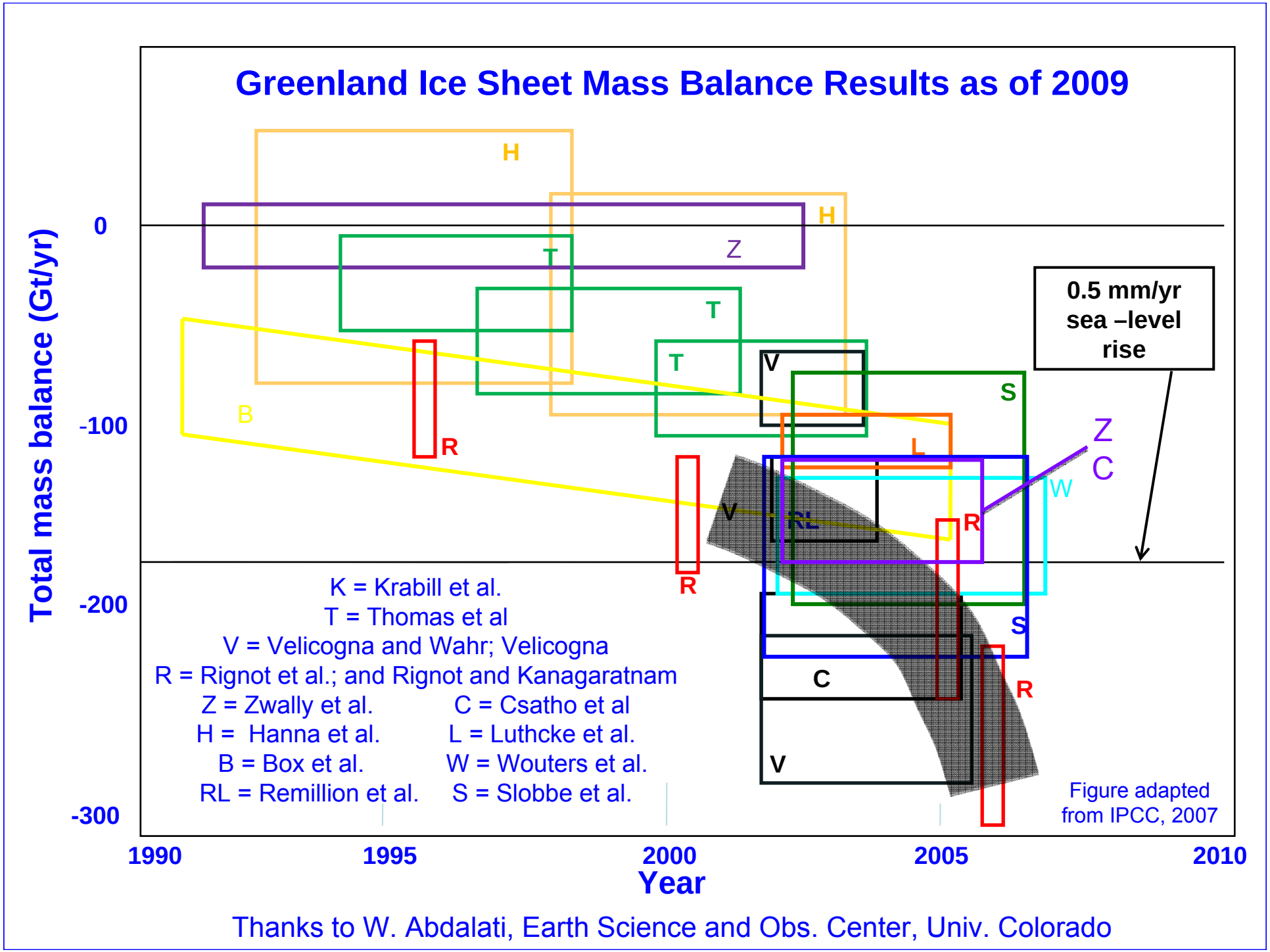


Thanks to W. Abdalati, Earth Science and Obs. Center, Univ. Colorado



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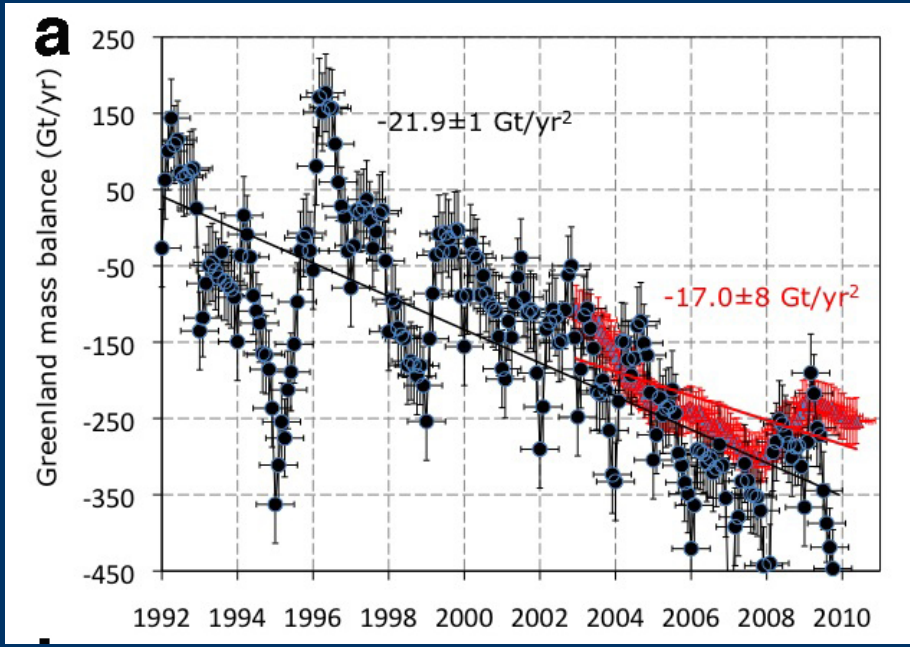
Greenland mass balance

Acceleration of mass loss



Mass Balance (Gt/year)	1990s	2005-2006
Snowfall	550	570
Melt/Runoff	250	350
Discharge	300	400
Net Balance	**-30**	**-205**

SLR (mm/year)	Earlier	Newest
Greenland	0.1	0.6
Global	1.7	3.3

1990s
Before 1900
2005-2006
1992-2010

E. Rignot et al., Geophys. Res. Letters, 2011, NASA JPL

Potential Sea Level Change Contributions

	2100 AD ***IPCC 2007***	**2100 AD** ***SWIPA 2011***	**Potential 3000 AD**
Greenland ice sheet	0.05 m →	0.14 m	1 – 3 m (?)
Total	0.35 m →	0.9 – 1.6 m	5 – 8 m (?)

Total = Greenland + Antarctic + Glaciers + Thermal Expansion

Muir Glacier, Alaska

1941 William O. Field

Bruce Molnia, USGS 2004

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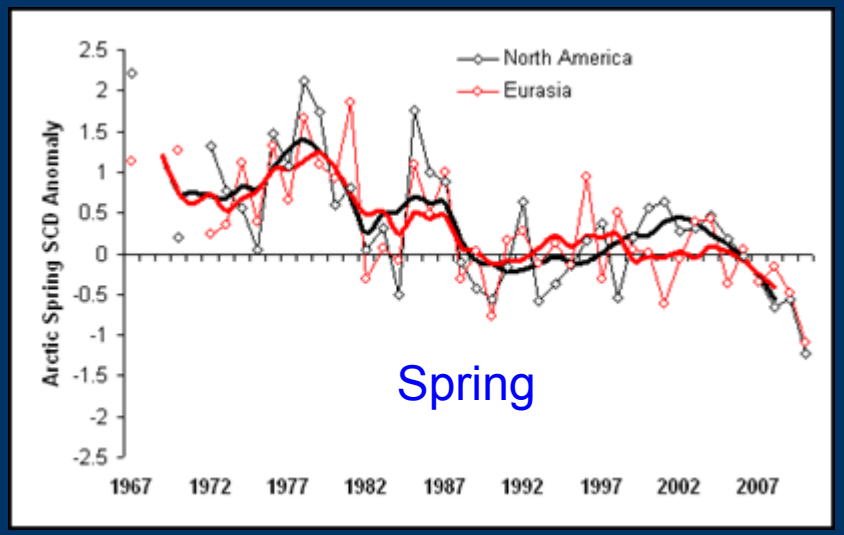
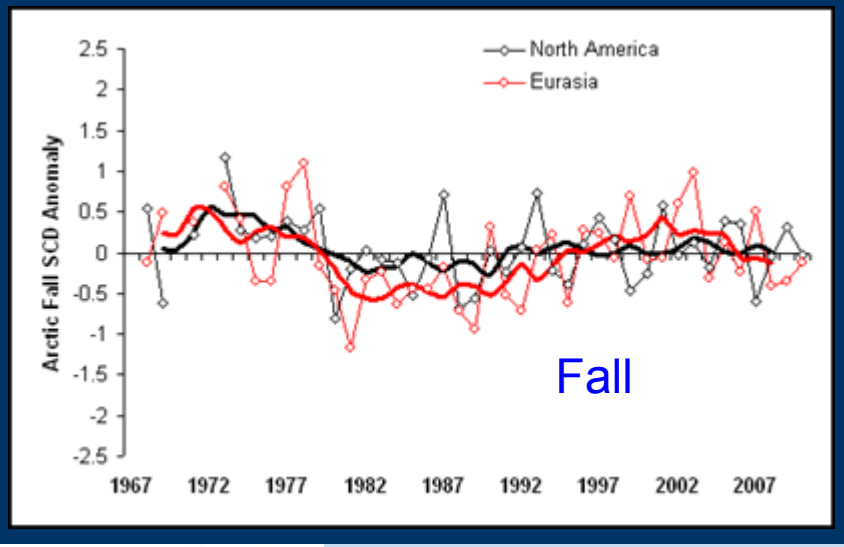
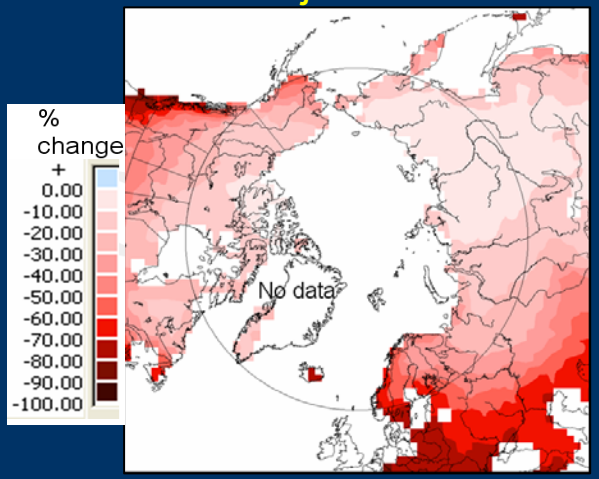
Current and projected snow cover changes

1967 – 2010 Snow Cover Duration Anomaly

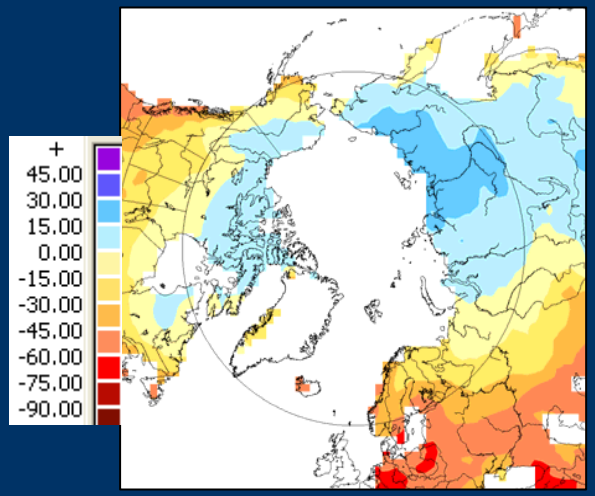




2049-2060 Projection vs. 1970-1999



Duration



Amount
(Snow Water Equiv.)

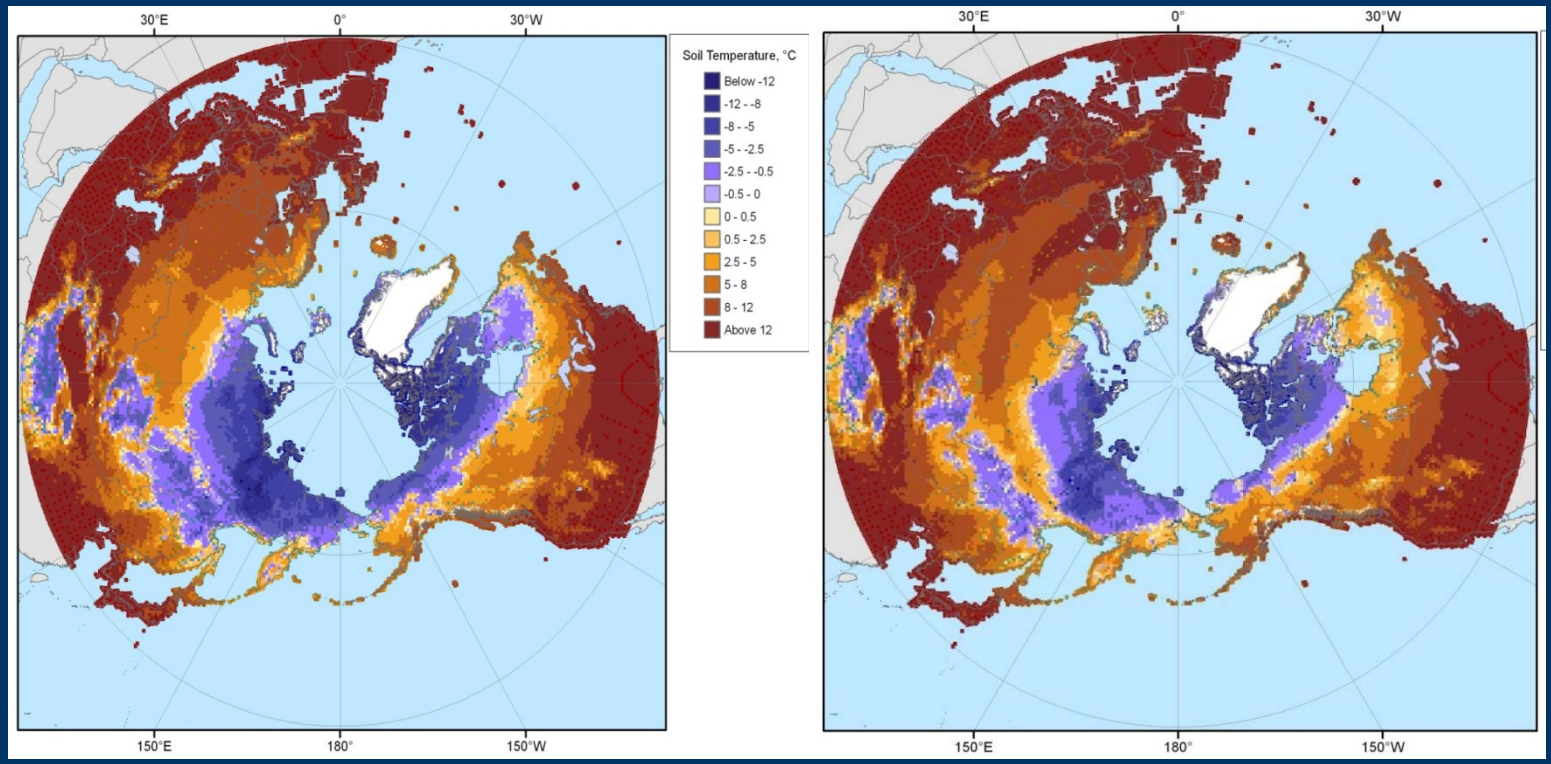
Shorter snow season, but more snow in some areas

Left: Derksen et al., 2009 and Rutgers Univ.; Right: Brown and Mote, 2009

Permafrost projections

2050 Projection

2090 Projection



Twice as much carbon is stored in the ground as is in the atmosphere today.

Potential major feedback

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Summary of Key Findings

- Summer sea ice extent decline accelerating; sea ice is thinning
- Ice sheets losing mass at a faster pace than expected; SLR estimates much higher than IPCC
- More winter snow in some places, but earlier spring melt
- Permafrost warming and thawing; potential large positive feedback from loss of carbon storage
- Most feedbacks will enhance warming
- Impacts on biology and human activities growing

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Thank you

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