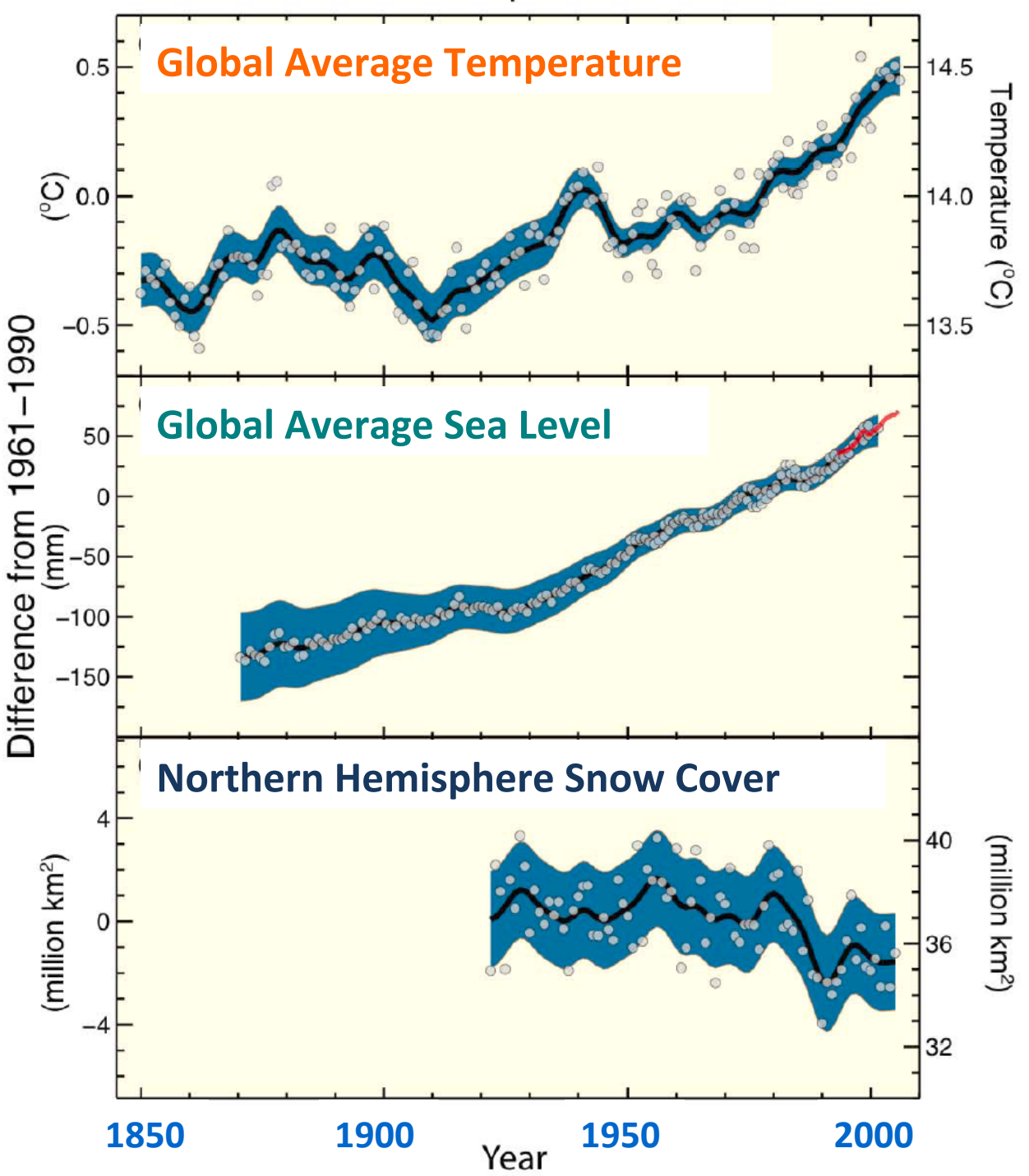
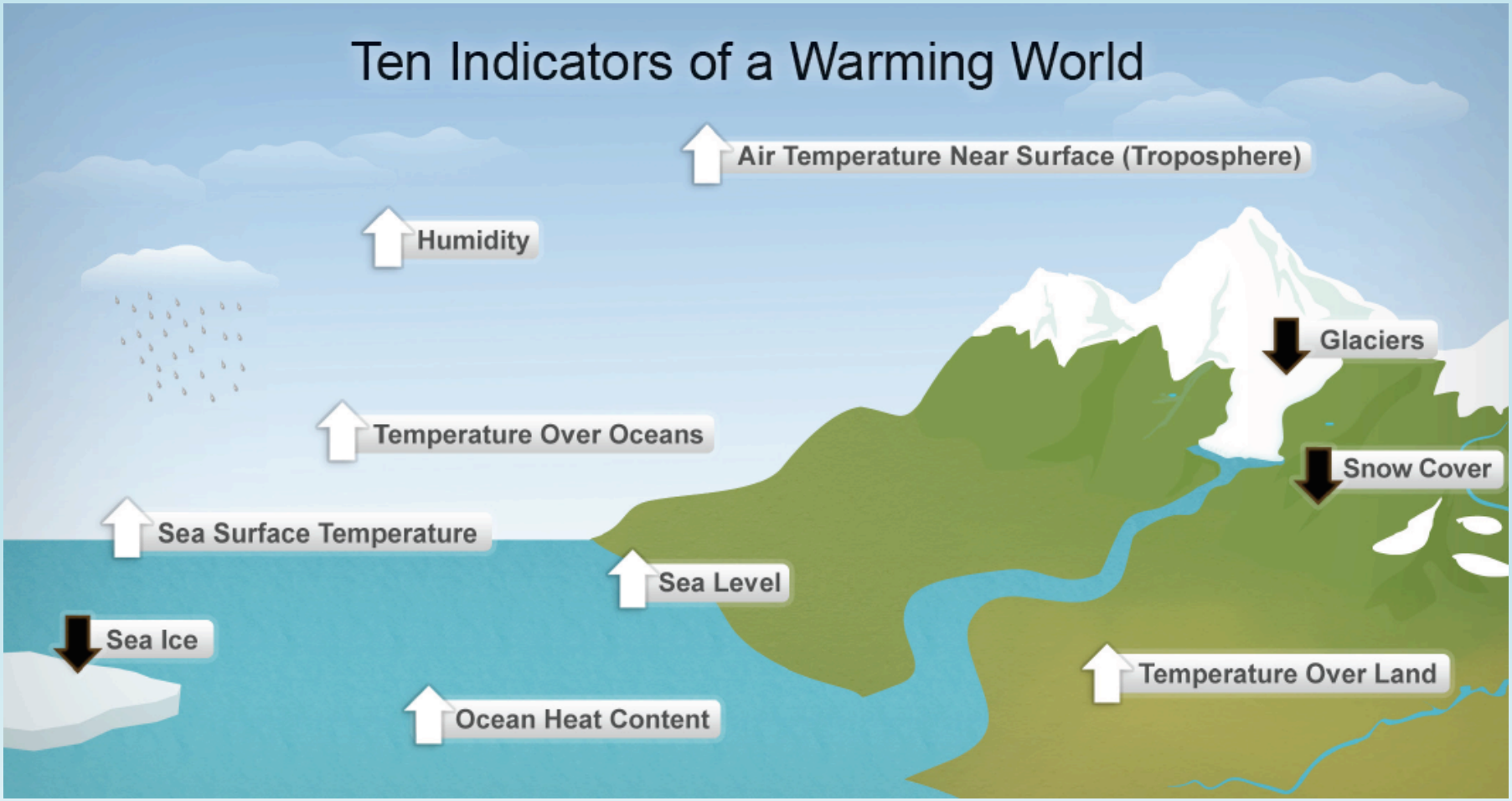
An Update on Climate Change

James J. McCarthy

Bethel , AK
21 March 2013

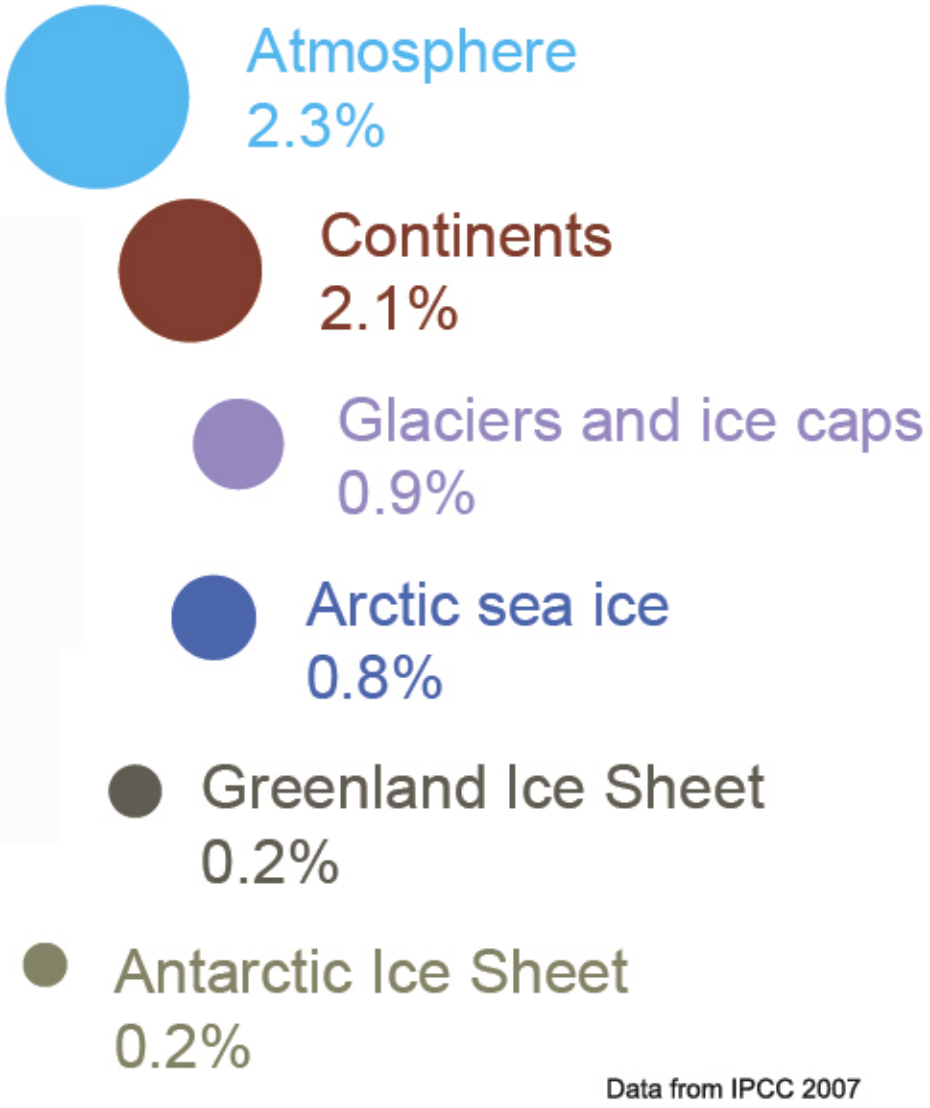

Global Average Temperature
Global Average Sea Level
Northern Hemisphere Snow Cover
Difference from 1961–1990
(°C)
Temperature (°C)
(mm)
(million km²)
(million km²)
0.5
0.0
−0.5
14.5
14.0
13.5
50
0
−50
−100
−150
4
0
−4
40
36
32
1850
1900
1950
2000
Year

IPCC 2007



NOAA BAMS SOTC 2010

Where is global warming going?



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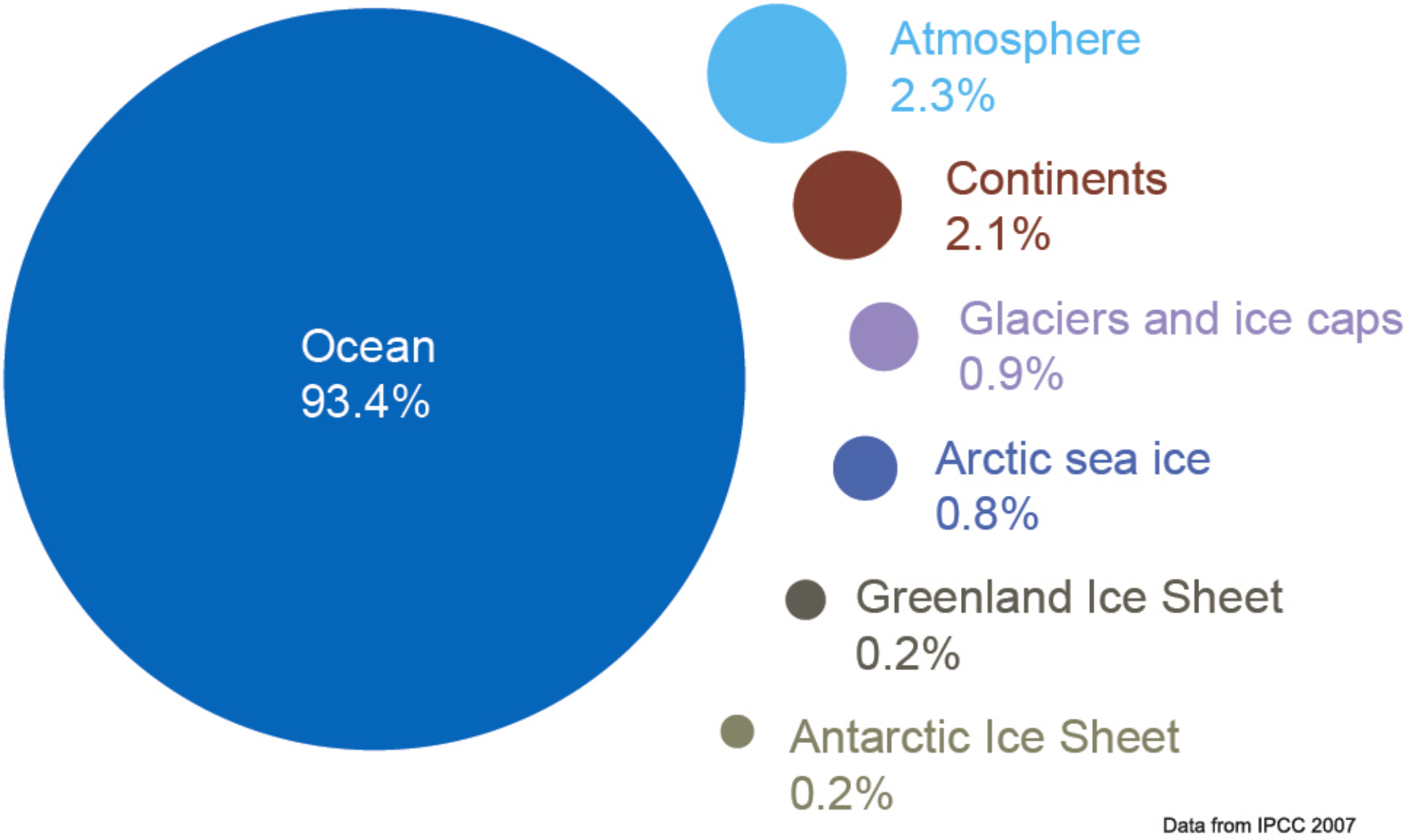
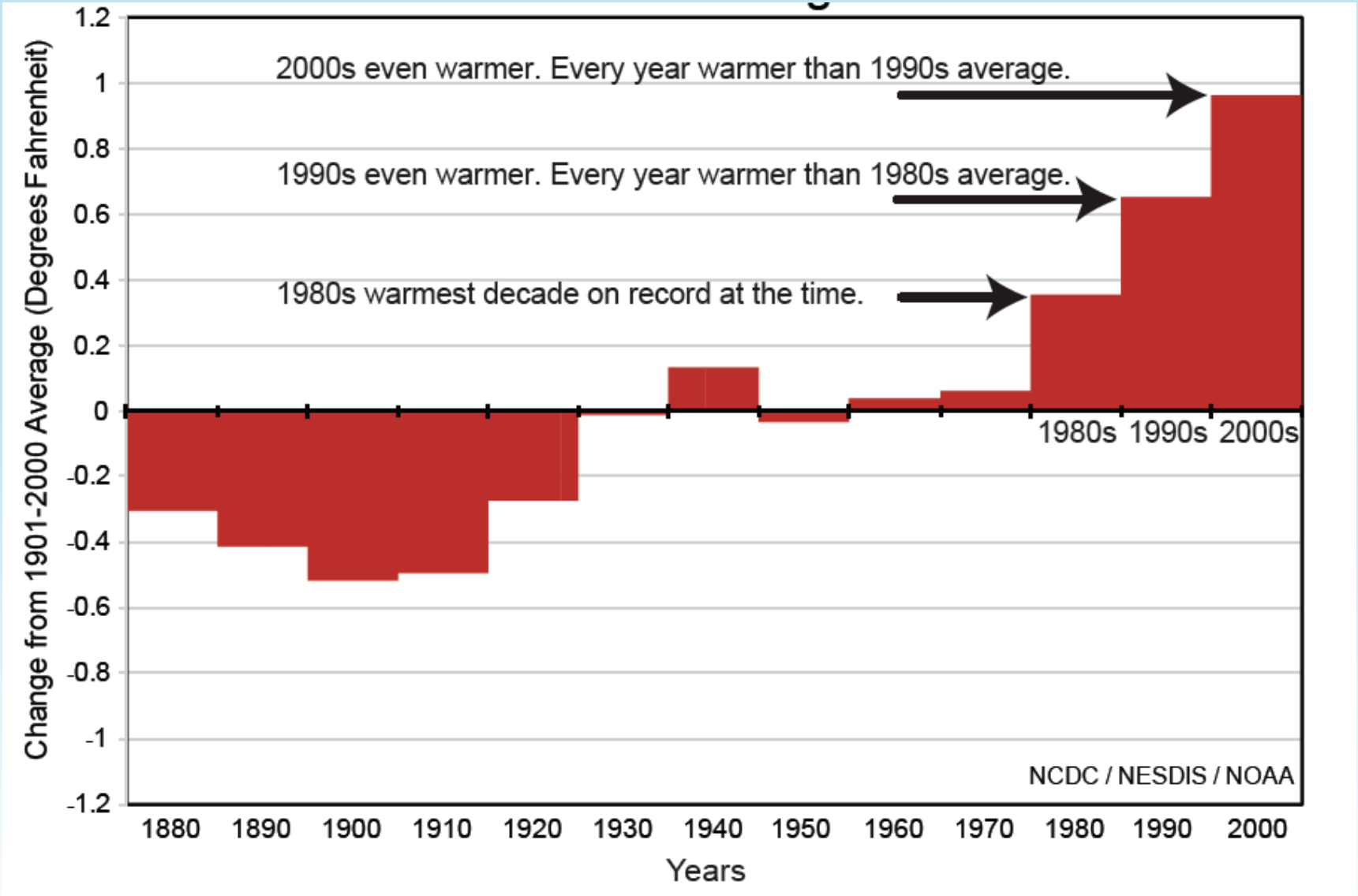
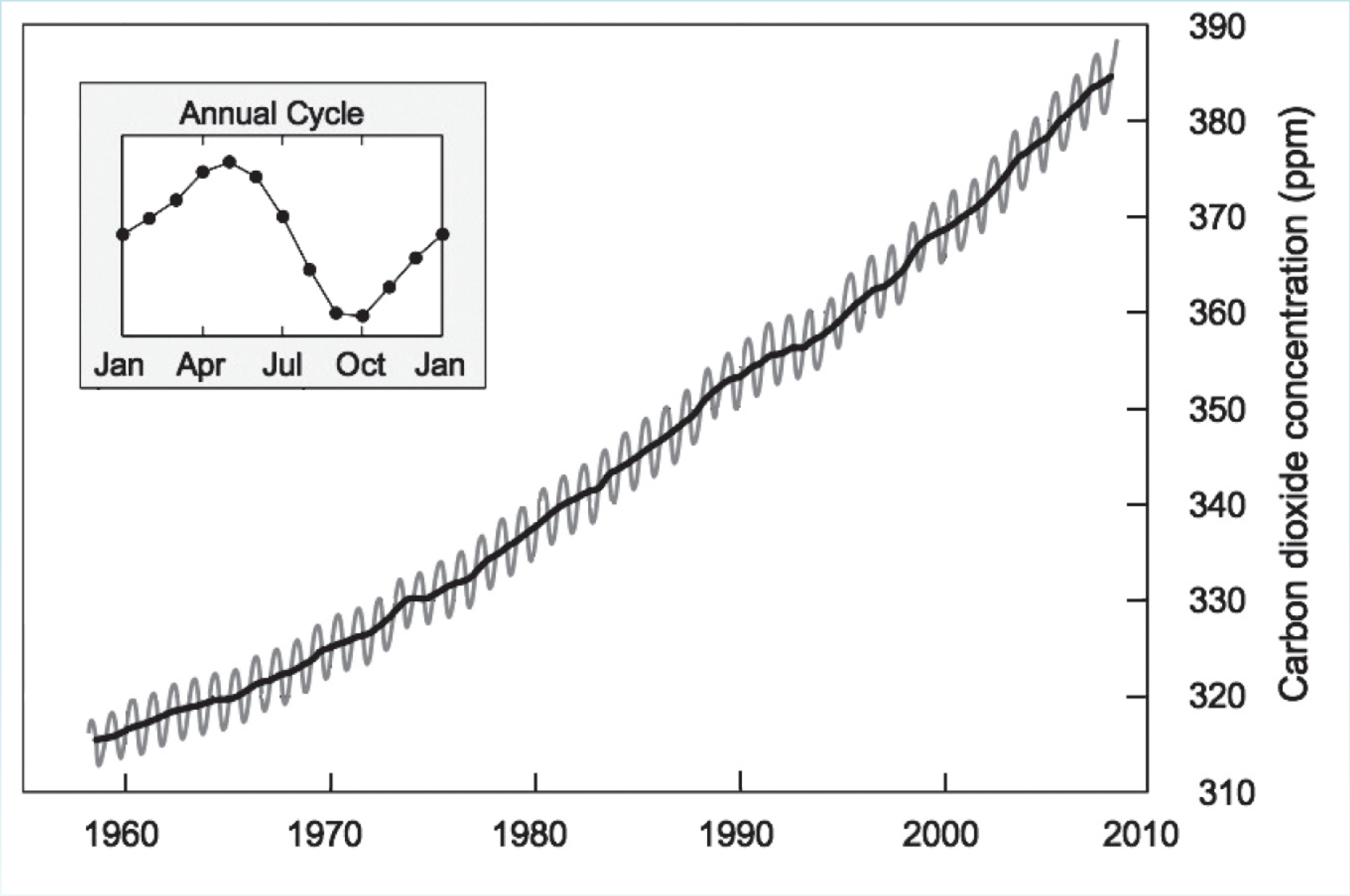


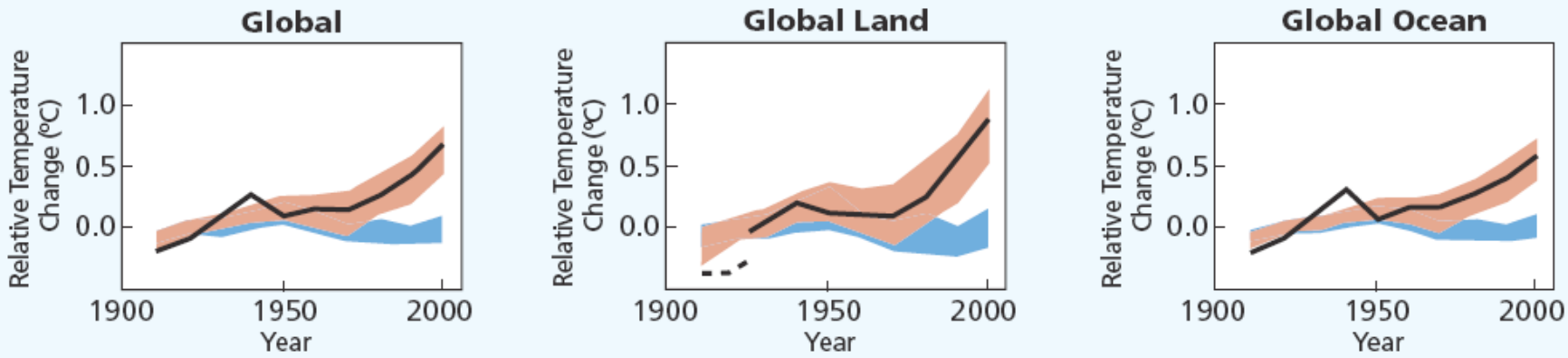
Decadal changes in average global temperature



http://www.ncdc.noaa.gov/bams-state-of-the-climate/


Annual Cycle
Jan
Apr
Jul
Oct
Jan
390
380
370
360
350
340
330
320
310
Carbon dioxide concentration (ppm)
1960
1970
1980
1990
2000
2010

How well do climate models reproduce 20th century climate with and without anthropogenic components?



Except for a failure to capture warmer ocean conditions, in the1930s the models reproduce observed climate history ***when all known climate forcings are included***.

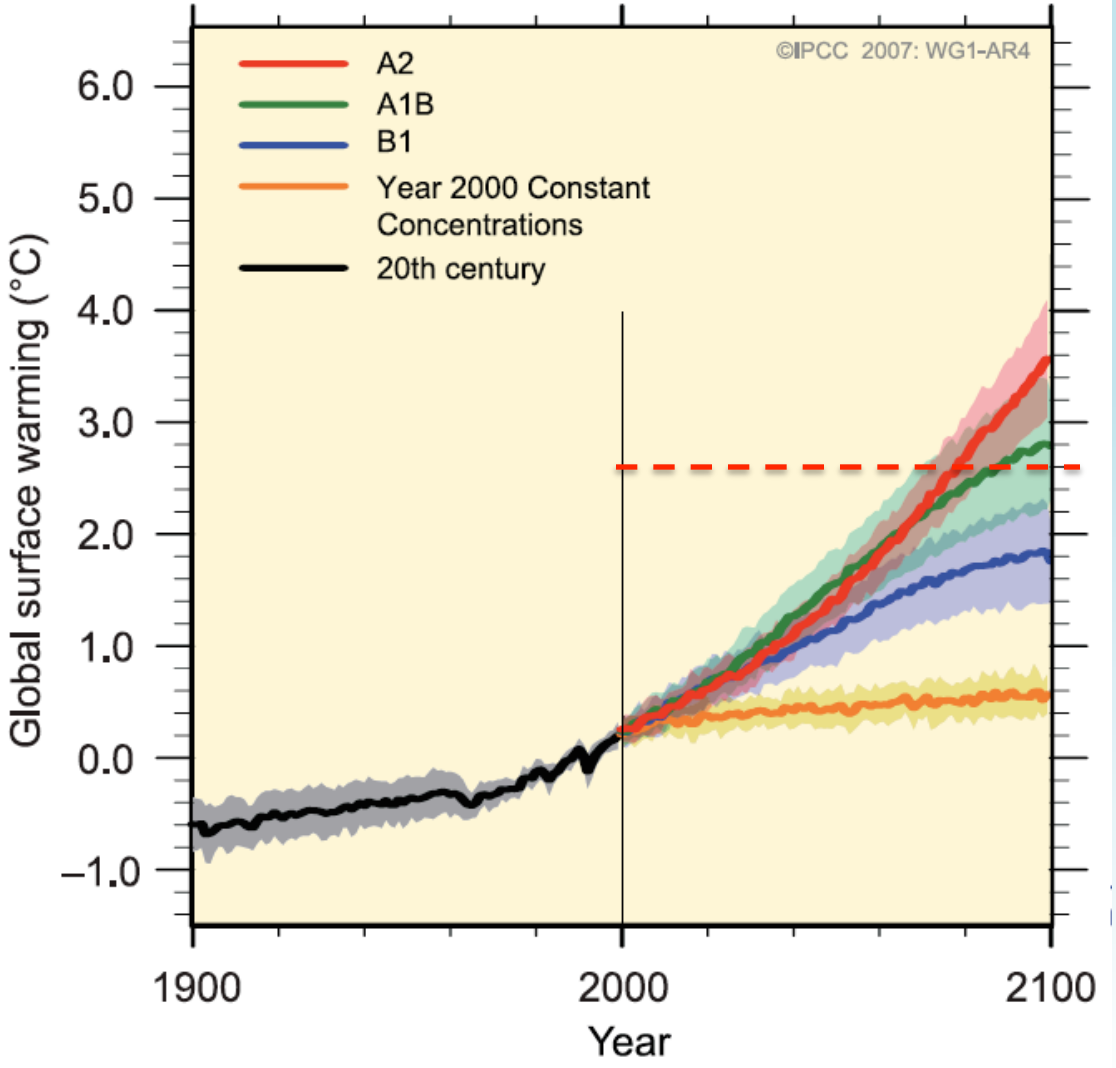
Were it not for the accumulation of greenhouse gases over the past half century, Earth's temperature today would be similar to that in 1900

IPCC 2007

In 2007 the Intergovernmental Panel on Climate Change (IPCC) stated with 90% confidence that ***emissions of heat trapping gases from human activities have caused "most of the increase in globally averaged temperature since the mid-20th century"***.

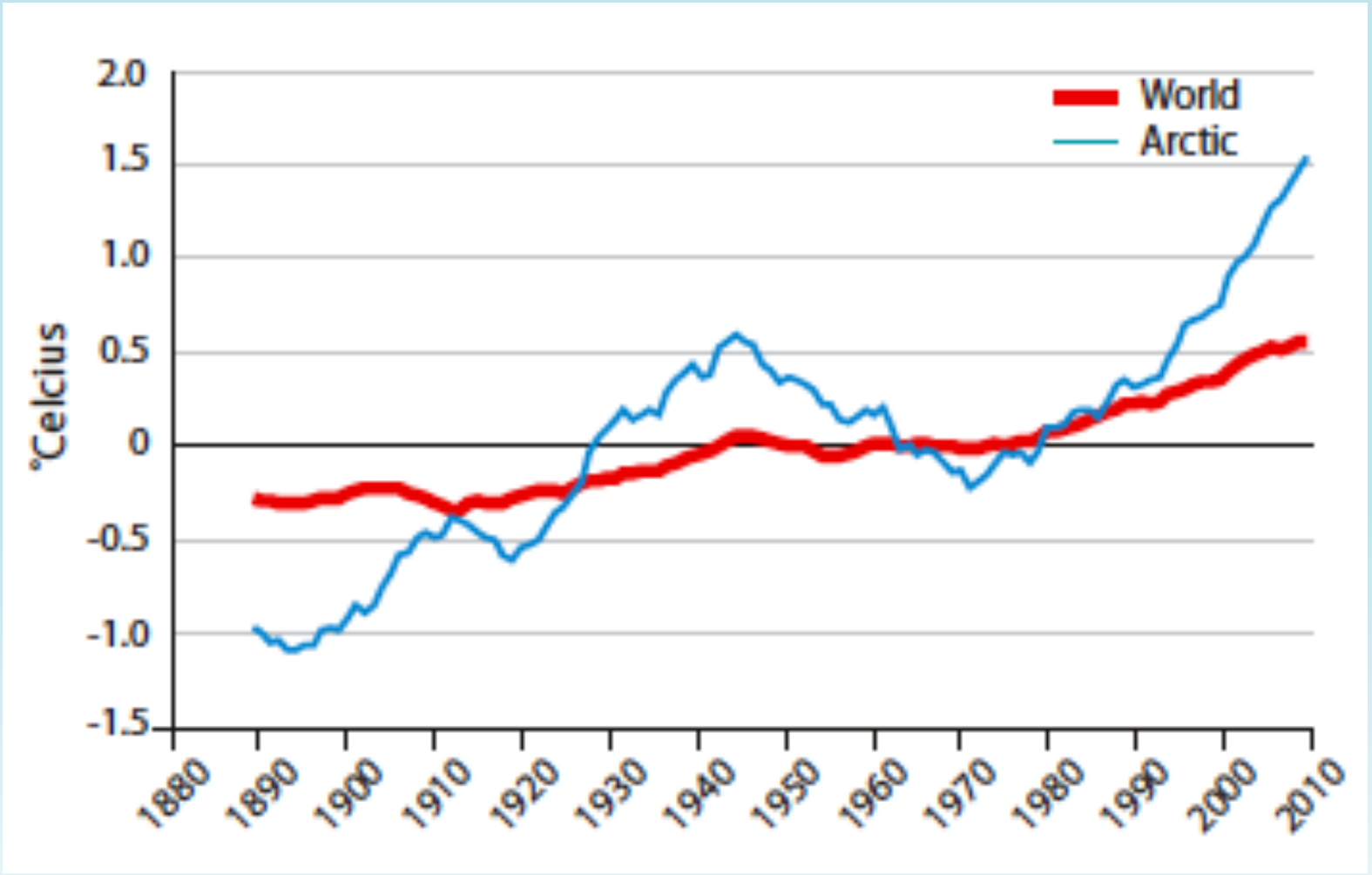
Statements of professional societies of ocean-ographers, geophysicists, and geologists (American Geophysical Union), meteorologists (American Meteorological Society), general scientific organizations (American Association for the Advancement of Science), and the National Academy of Sciences all concur with this position.

Where we're headed: The IPCC 2007 scenarios for Earth's temperatures to 2100



T reached in 2100 on the middle trajectory was last experienced on Earth in the Eocene (25-35 million years ago) when sea level was 20-30 m higher.

IPCC 2007

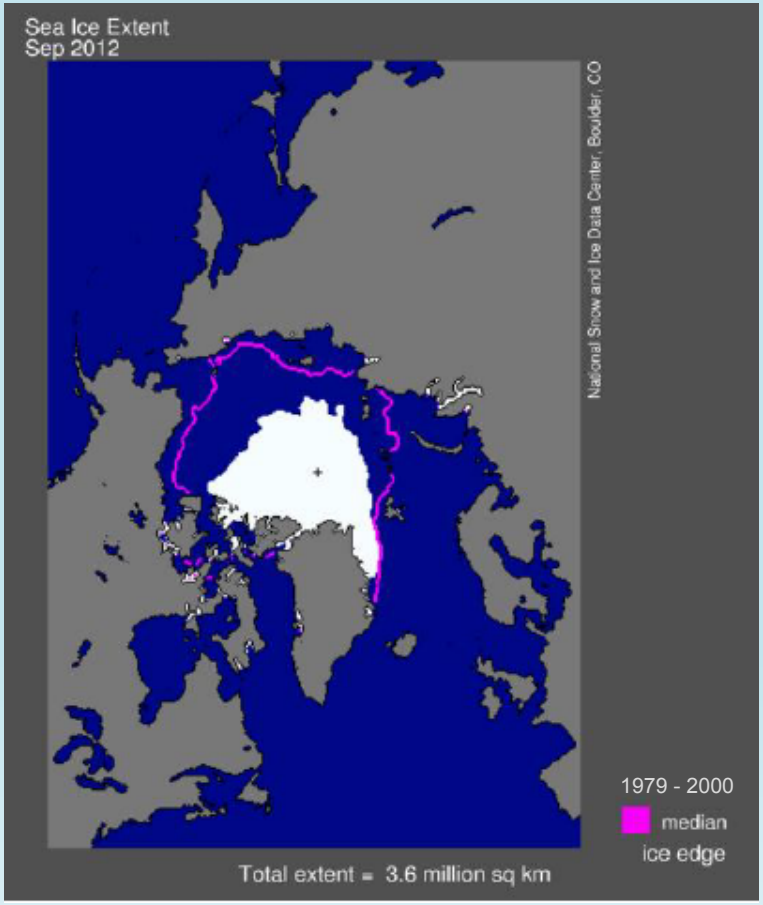

2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
°Celcius
World
Arctic
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

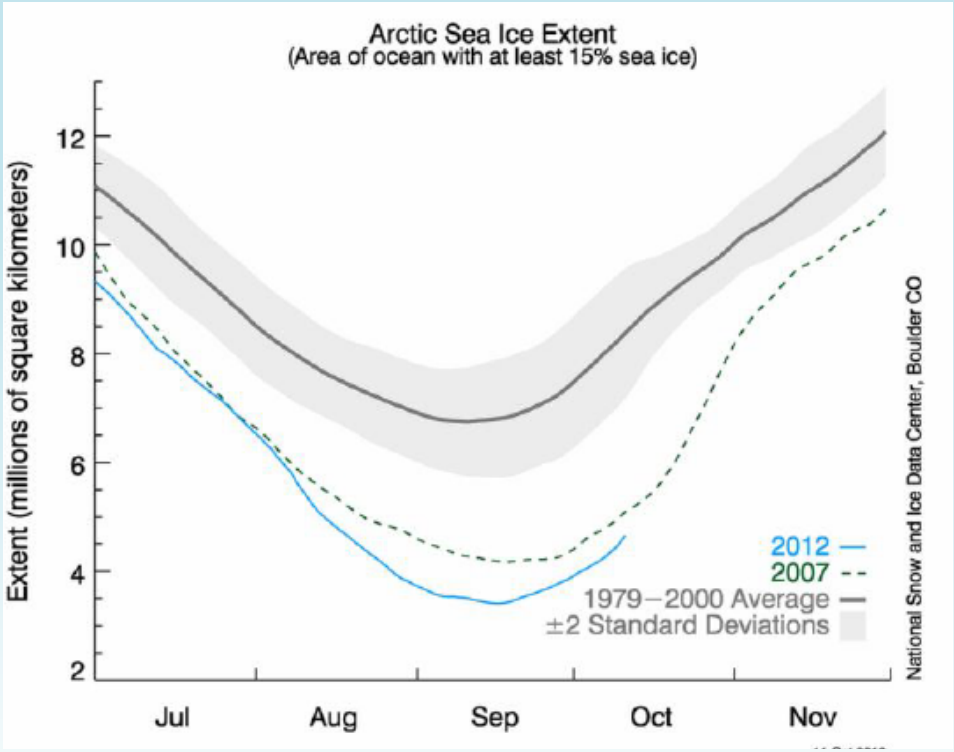
UNEP 2013

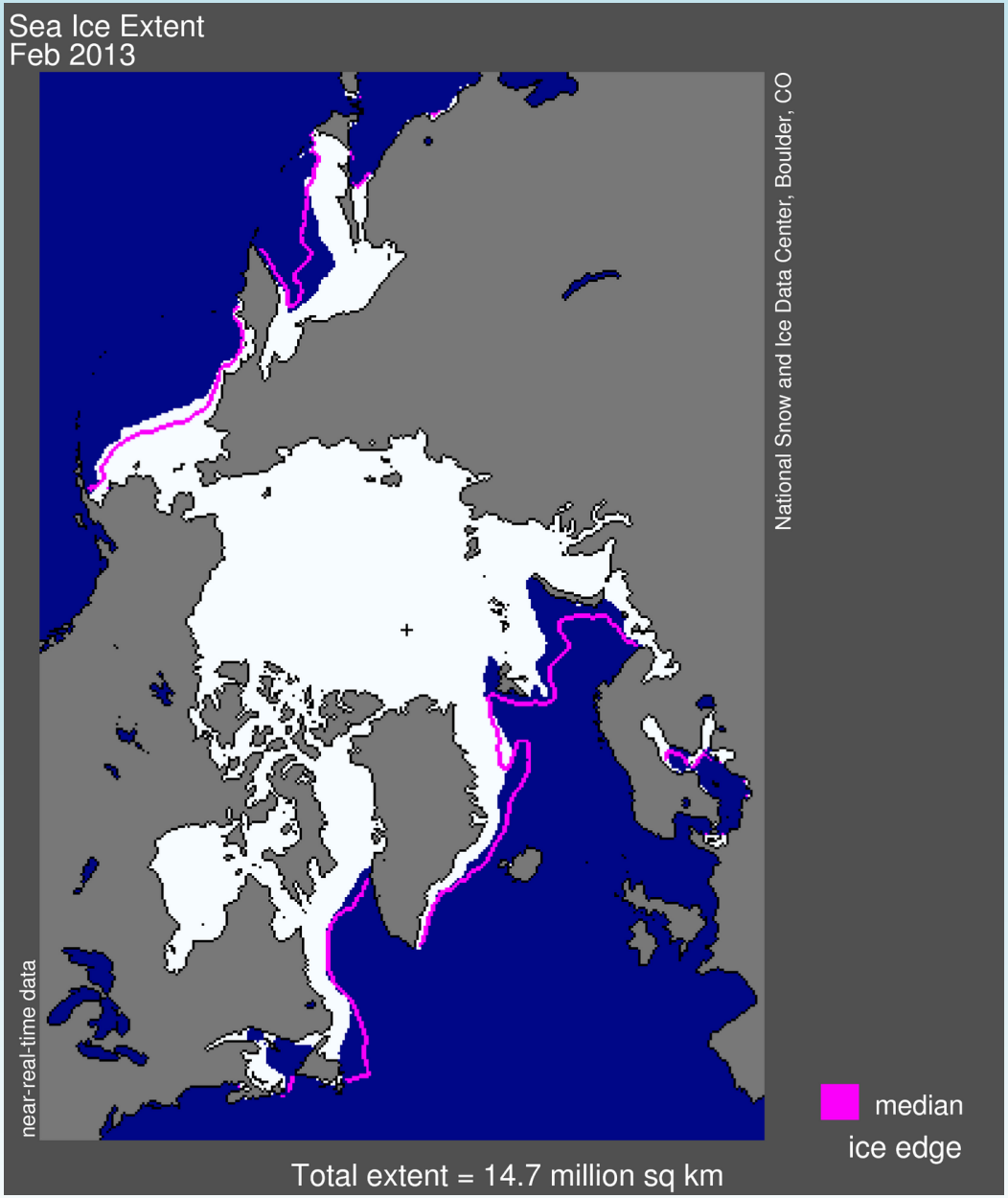
A warmer Earth will have less ice, less snow and less frozen ground

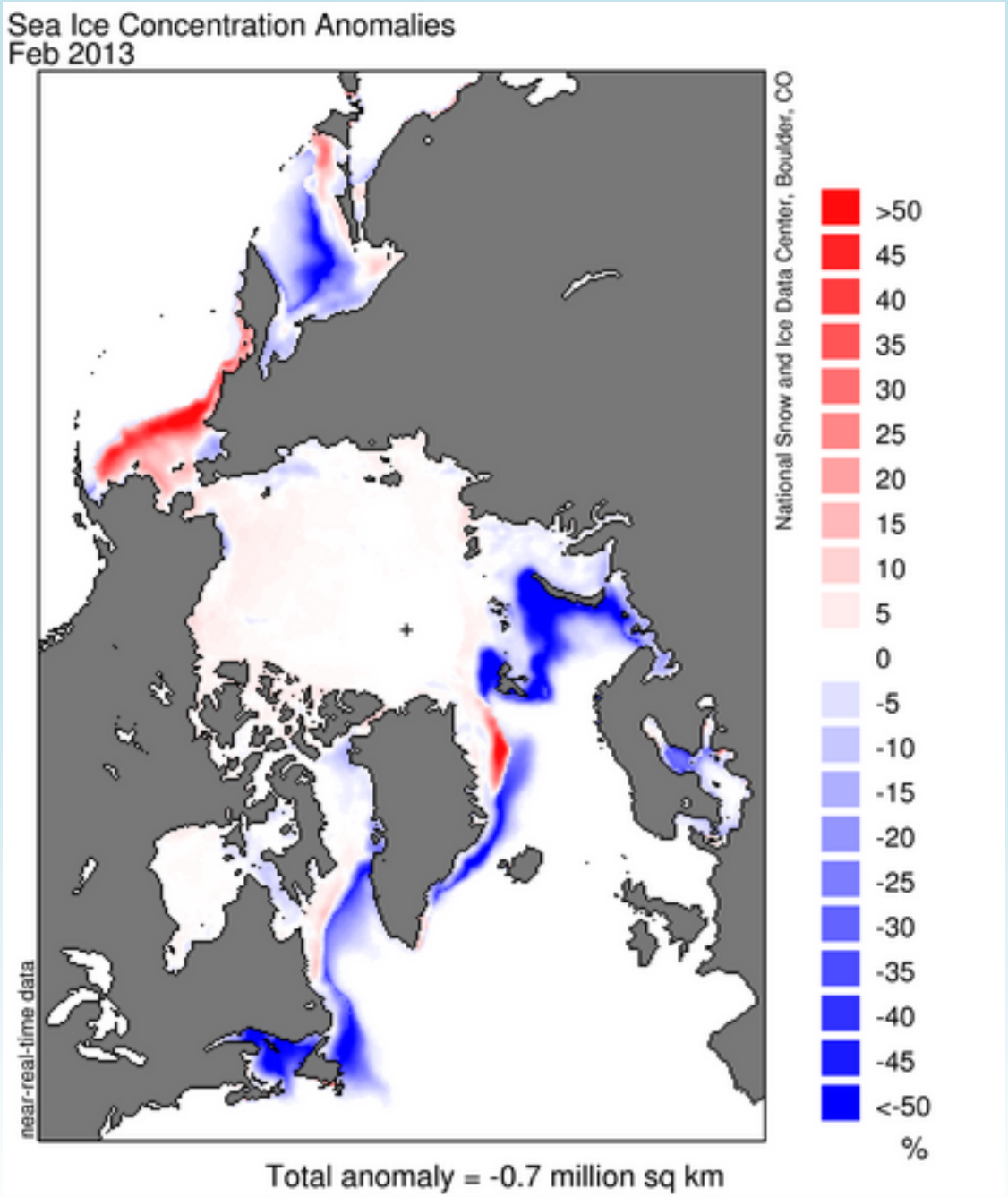
- Sea ice is projected to shrink in both the Arctic and Antarctic under all model simulations.

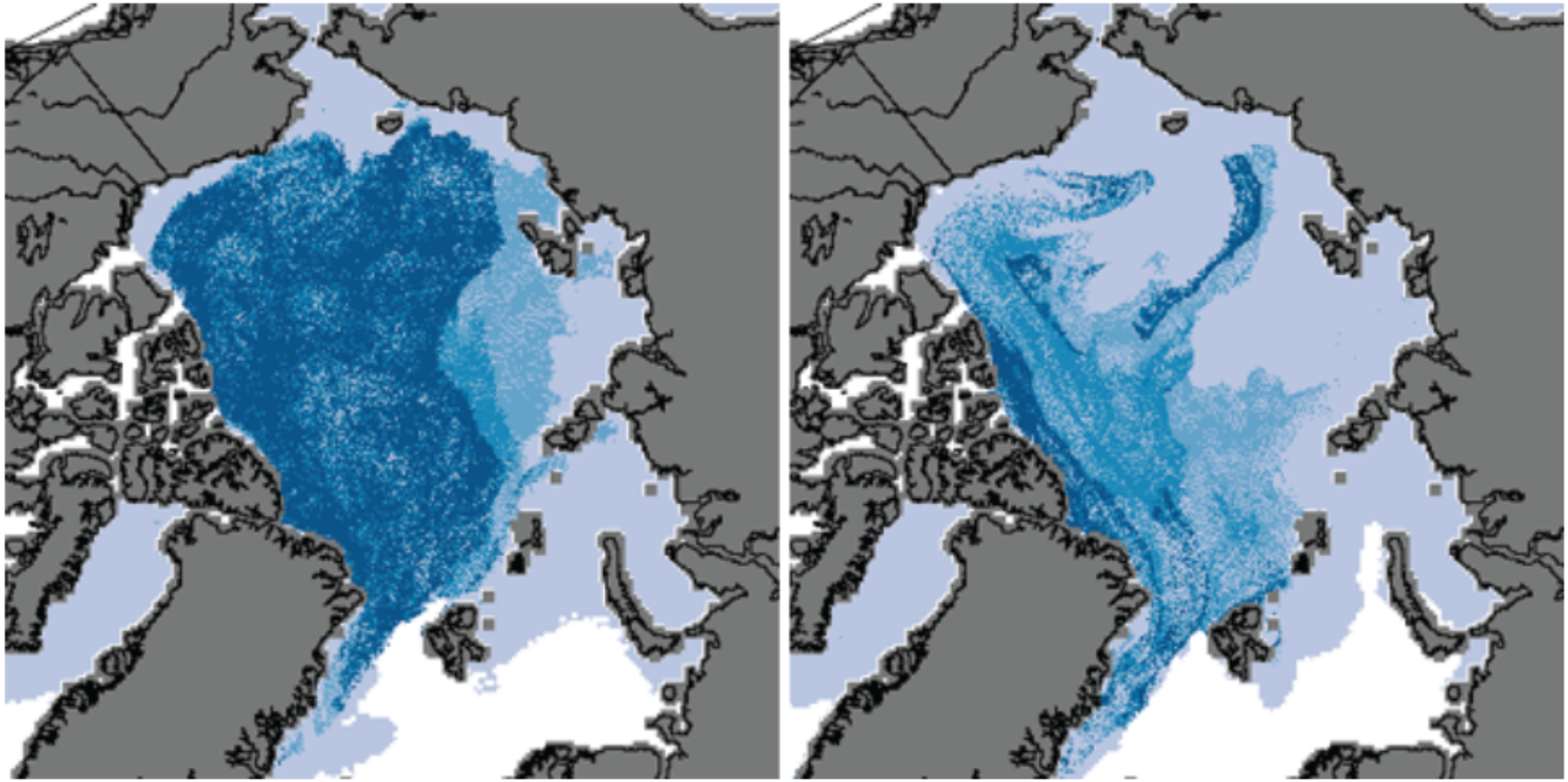
- Some projections show that by mid century, late-summer Arctic sea ice will disappear almost entirely.


Sea Ice Extent
Sep 2012
National Snow and Ice Data Center, Boulder, CO
1979 - 2000
median
ice edge
Total extent = 3.6 million sq km


Arctic Sea Ice Extent
(Area of ocean with at least 15% sea ice)
Extent (millions of square kilometers)
12
10
8
6
4
2
Jul
Aug
Sep
Oct
Nov
2012
2007
1979–2000 Average
±2 Standard Deviations
National Snow and Ice Data Center, Boulder CO

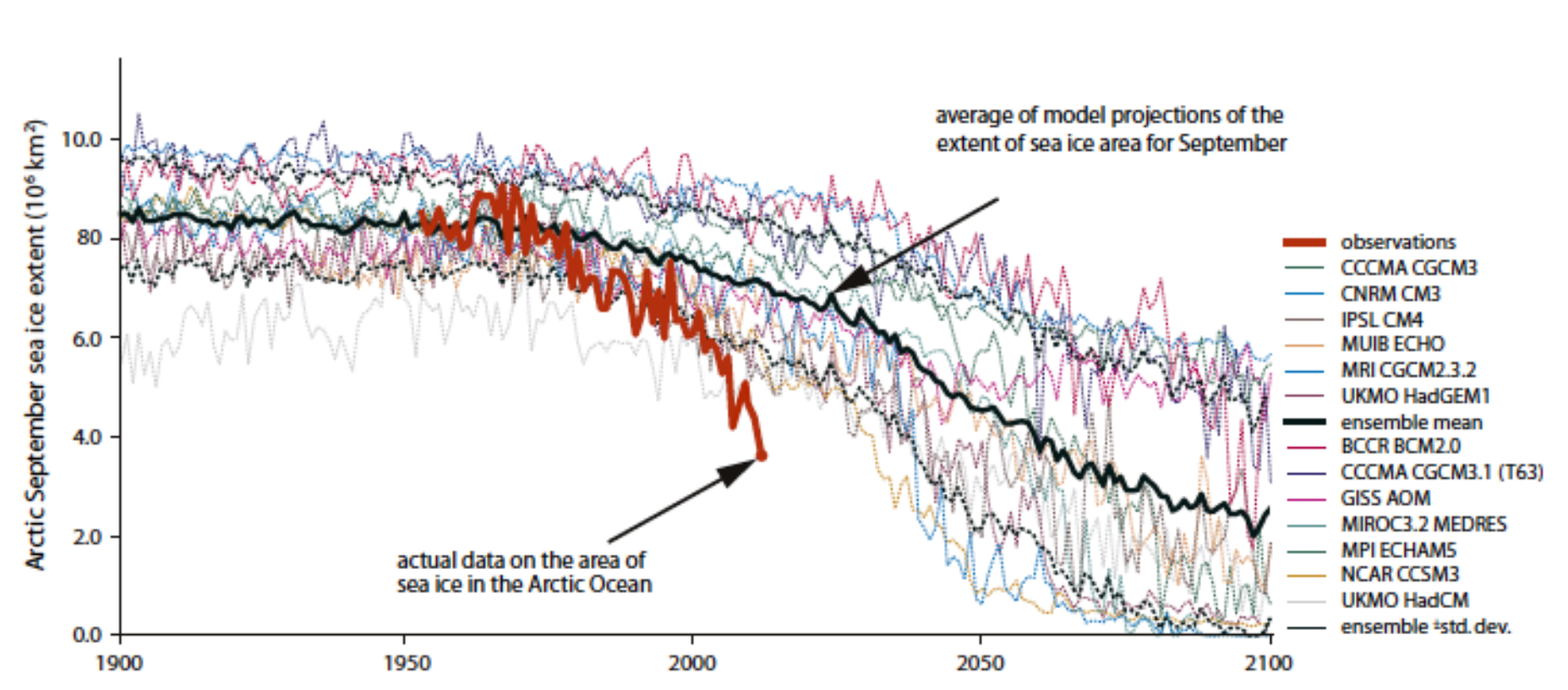

Sea Ice Extent
Feb 2013
National Snow and Ice Data Center, Boulder, CO
near-real-time data
median
ice edge
Total extent = 14.7 million sq km

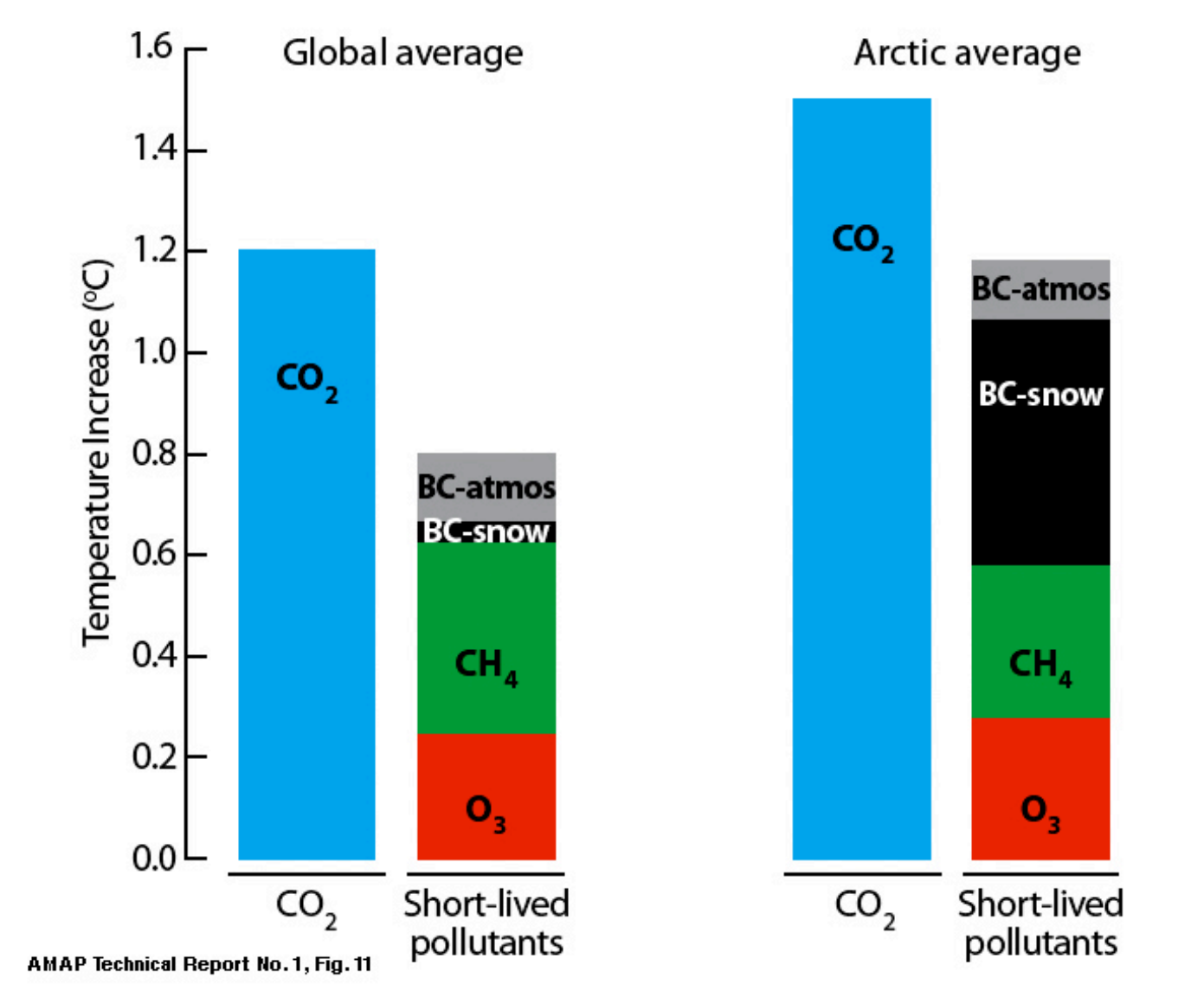

Sea Ice Concentration Anomalies
Feb 2013
National Snow and Ice Data Center, Boulder, CO
near-real-time data
>50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
<-50
%
Total anomaly = -0.7 million sq km



Old v. new ice in Arctic, March 1985 and 2011: These maps show the median age of March sea ice in 1985 (left) and 2011 (right). Overall, the proportion of young ice has increased. By March 2011, ice more than four years old accounts for less than 10 percent of the Arctic ice cover. Image by National Snow and Ice Data Center,

Summer Sea Ice is Being Lost Faster than has been Projected using Climate Models

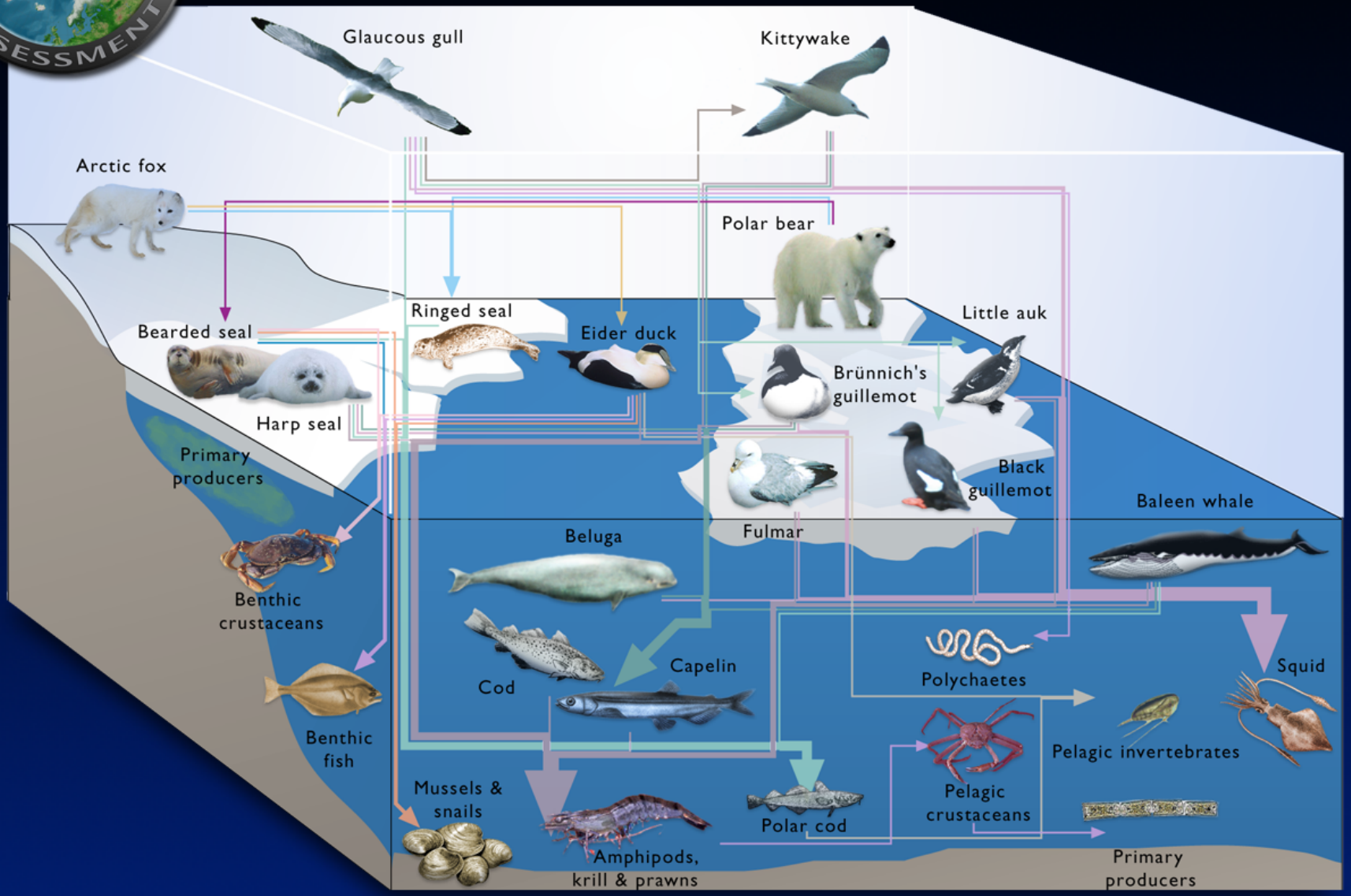




Annually averaged T increase for CO_2 and the short-lived constituents relative to pre-industrial. Global values based on IPCC (2007). Arctic values based on Quinn et al. (2008).

IMPACTS OF A WARMING ARCTIC

Arctic Marine Food Web

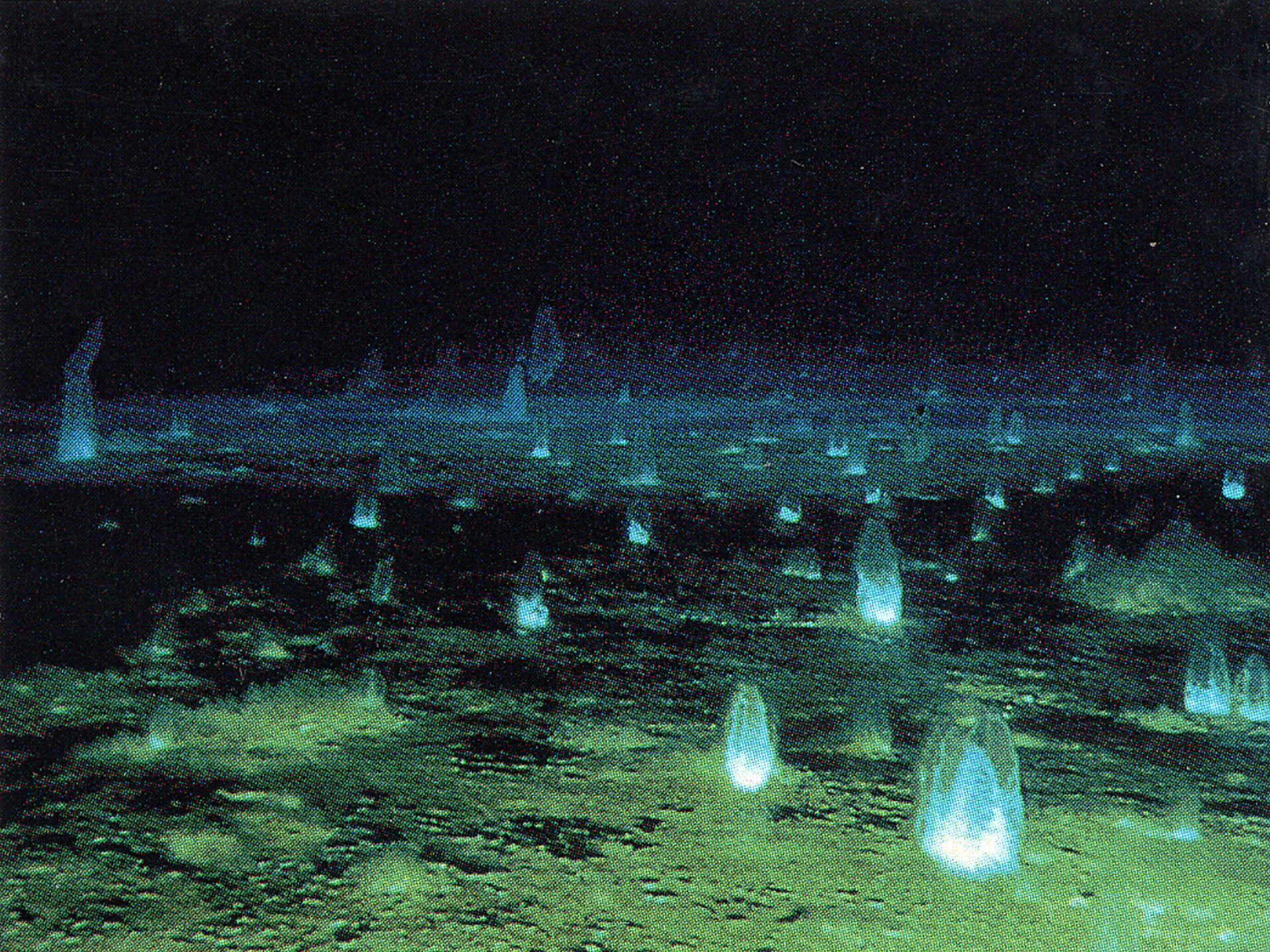


Photomicrograph of sea ice

Diverse Phytoplankton -the one cell plants of the sea

-About equal to land plants in terms of total biological production

Sir Alister Hardhy



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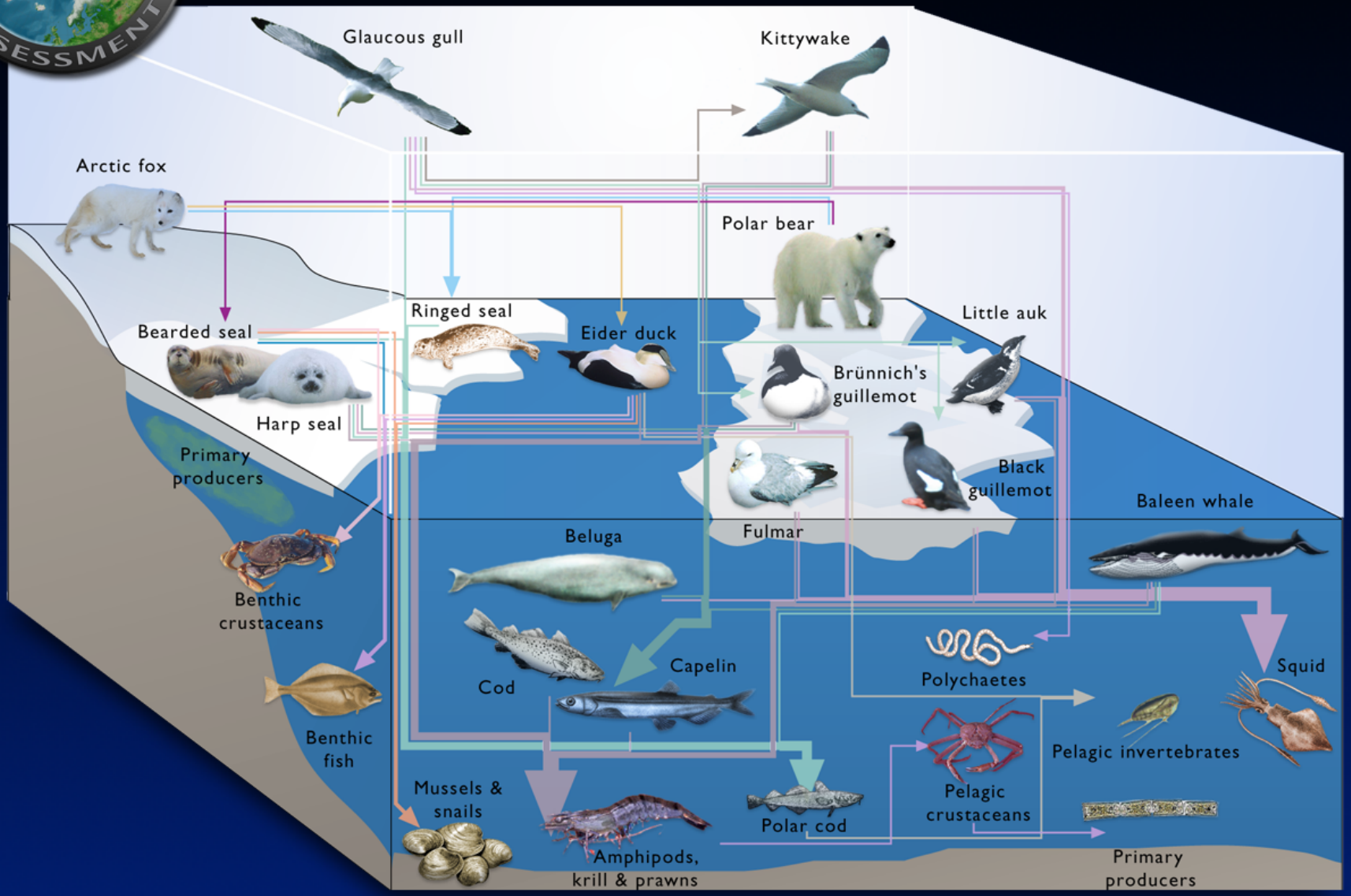

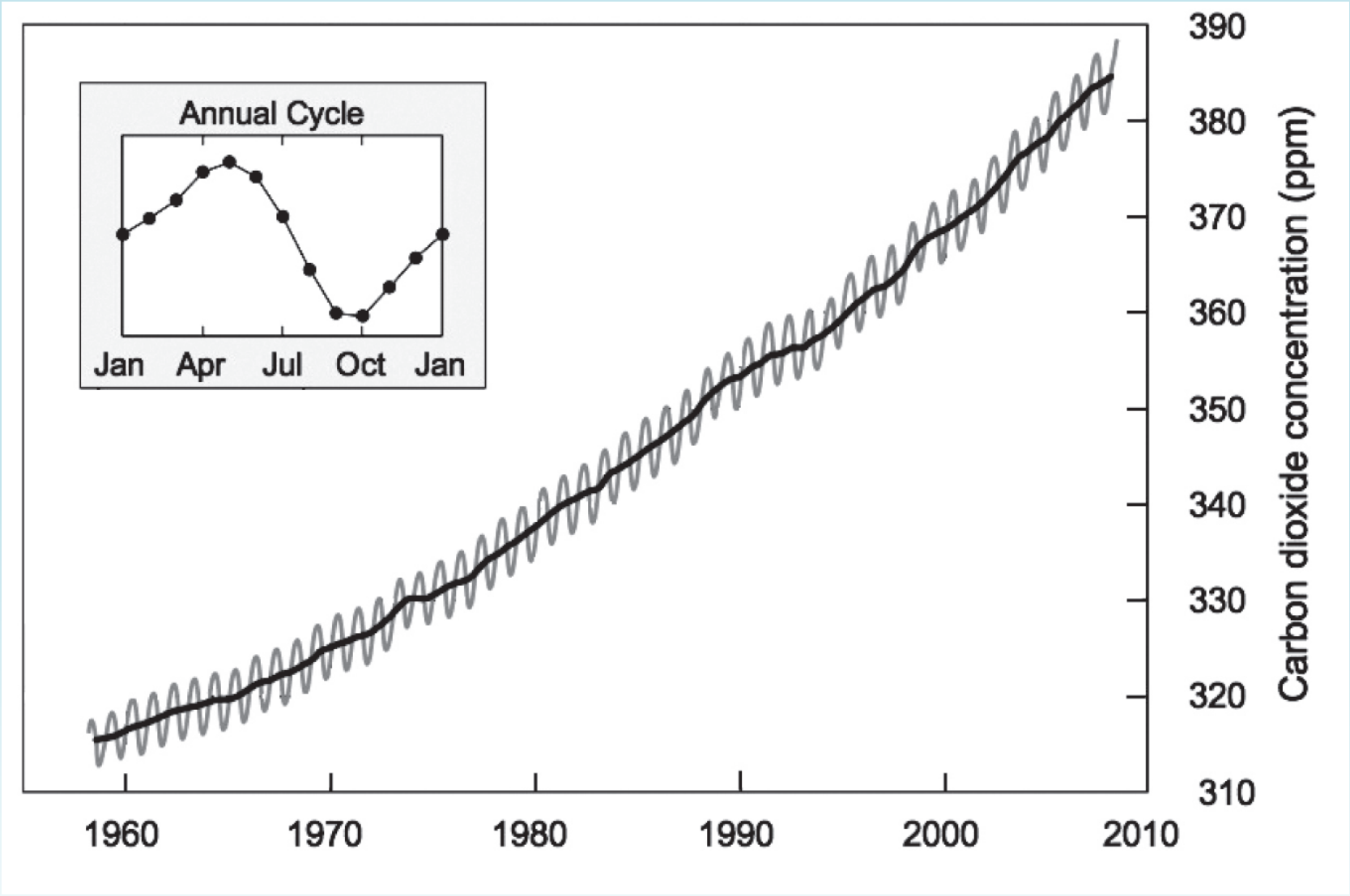
Annual Cycle
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Jan
390
380
370
360
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340
330
320
310
Carbon dioxide concentration (ppm)
1960
1970
1980
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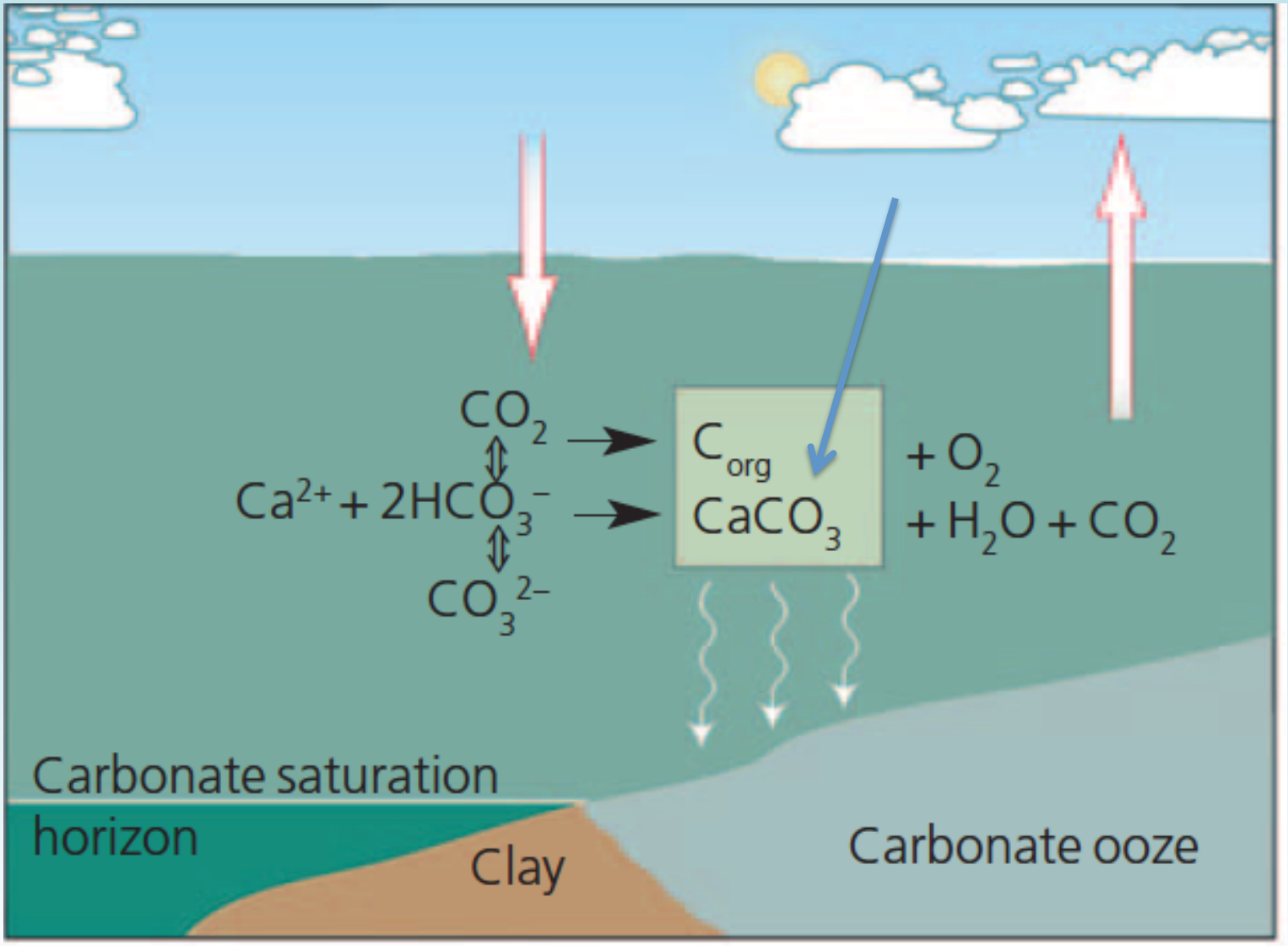
2000
2010

Shells of marine organisms are made of Calcium Carbonate ($Ca\ CO_3$)

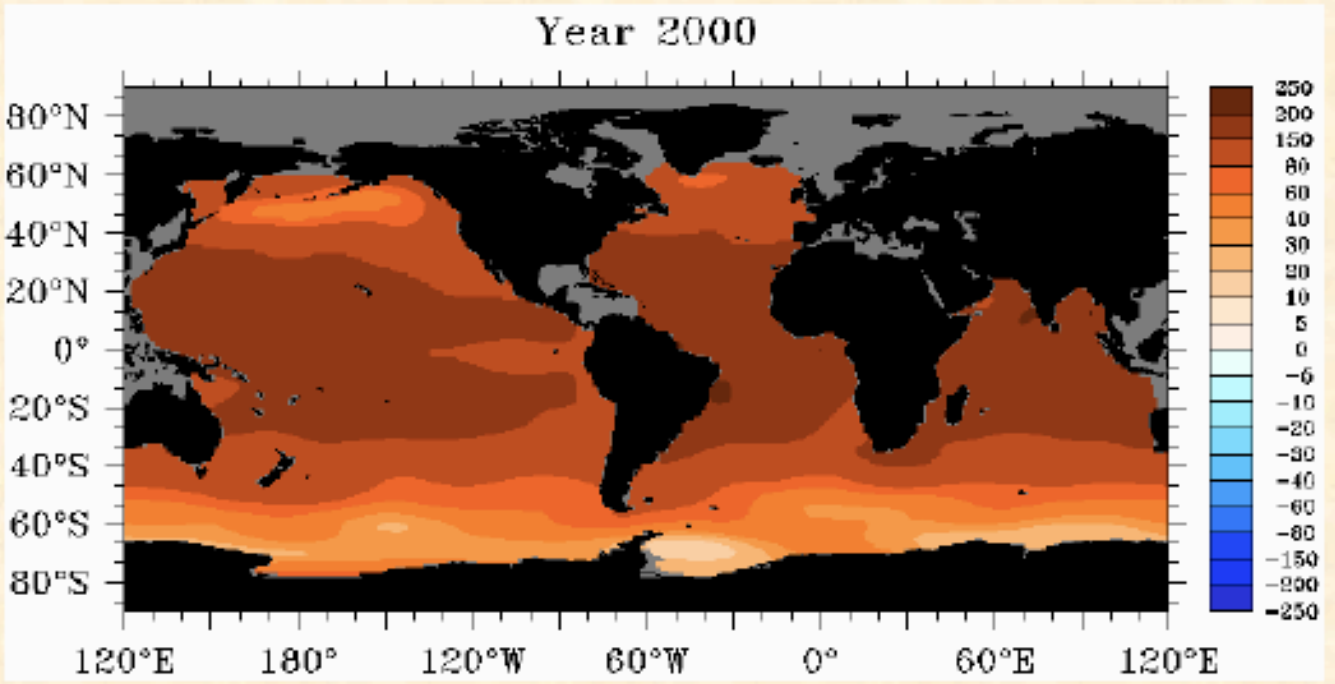


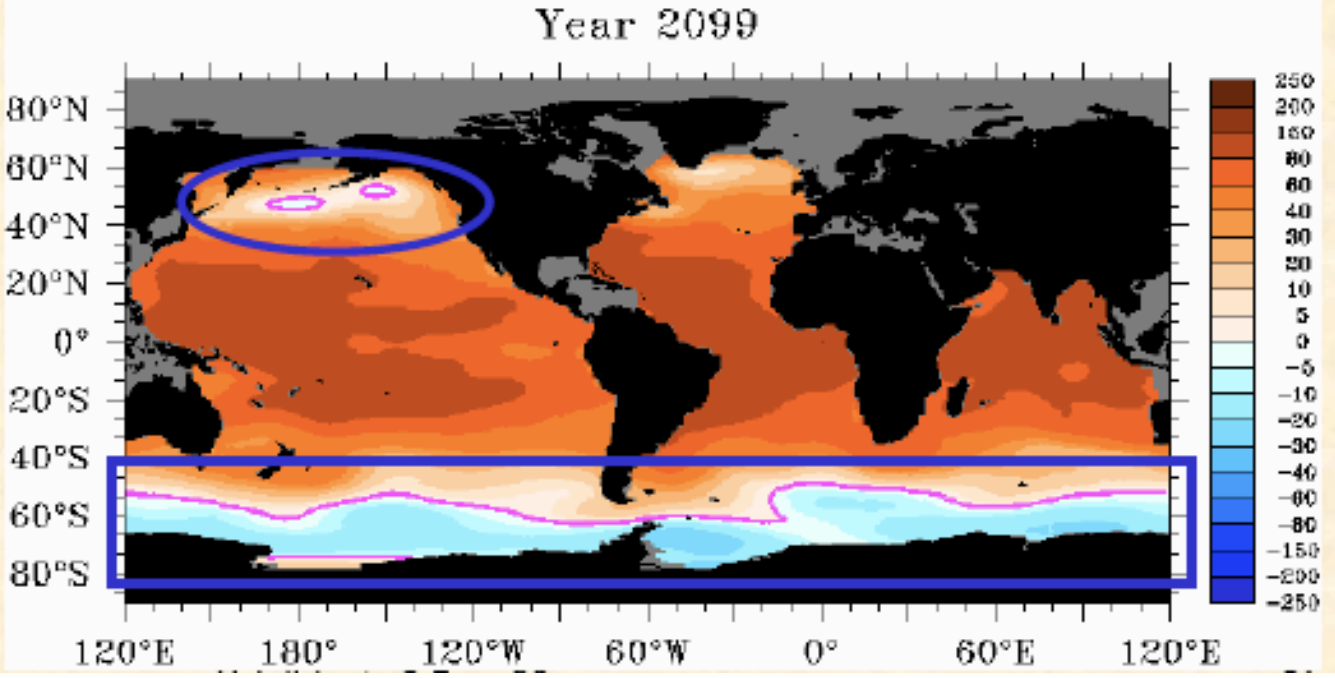
Royal Society 2011

Organisms with $CaCO_3$ skeletal structures will tend to dissolve

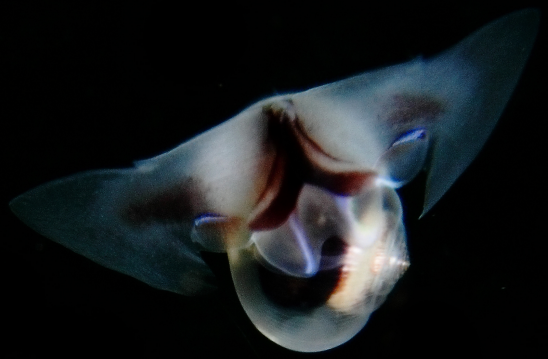
'Undersaturation' of surface ocean in N. Pacific & Southern Ocean with respect to aragonite ($CaCO_3$) in 2099

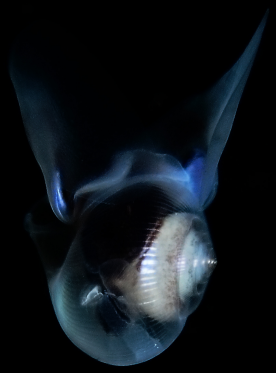
[from Orr et al., 2006 Nature, 437, 681]





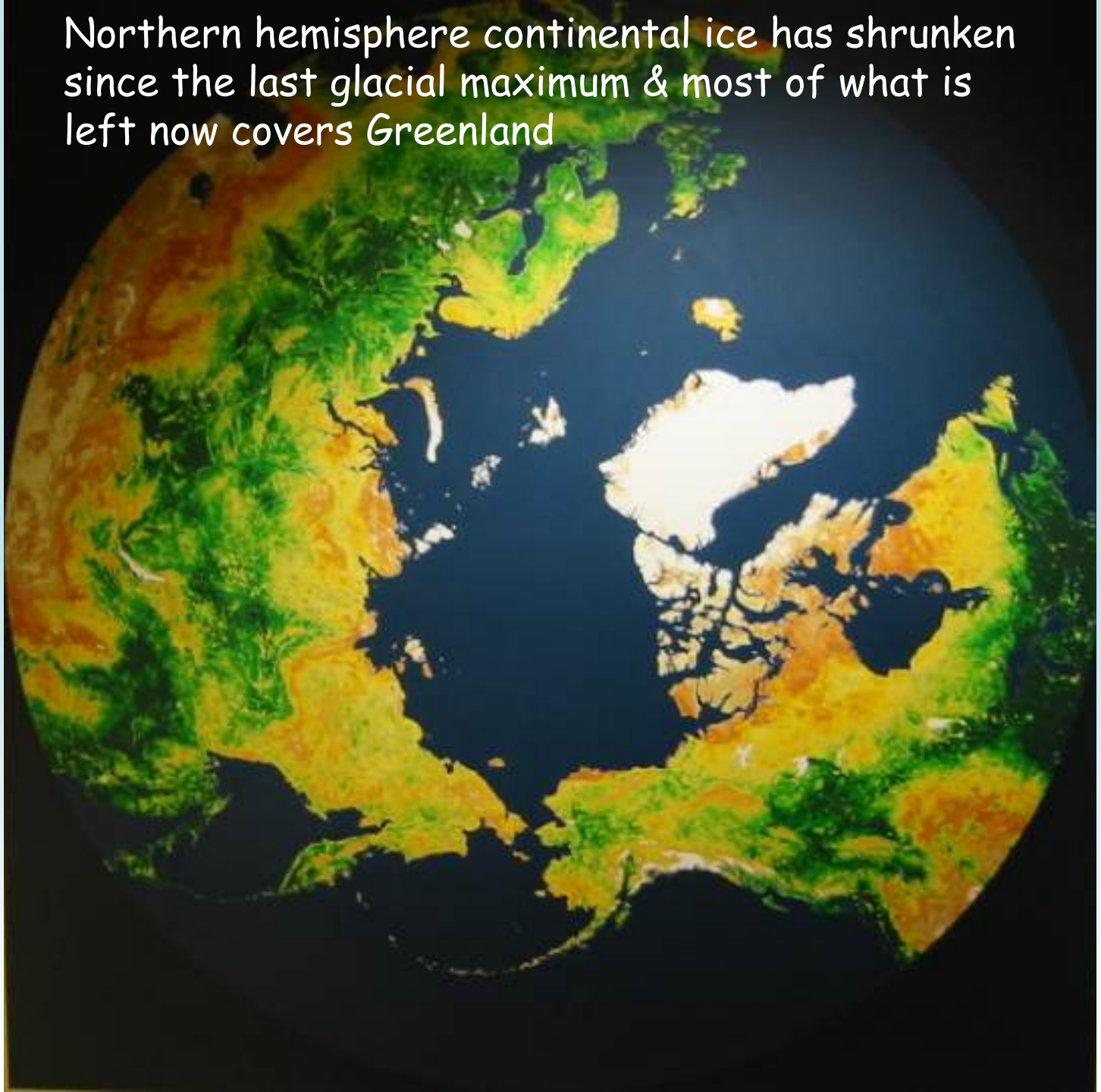
The Pteropod *Limacina sp.*
"the Sea Butterfly"





Limacina retroversa
Hopcroft/UAF/CoML

Northern hemisphere continental ice has shrunken since the last glacial maximum & most of what is left now covers Greenland

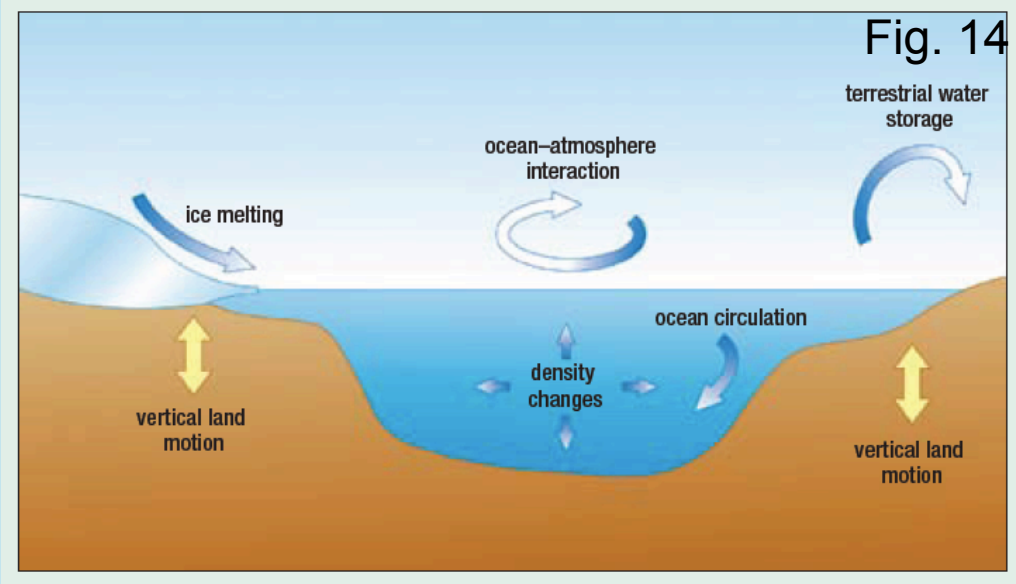


The Greenland ice cap is experiencing warmer summer conditions, and the major Greenland glaciers are receding

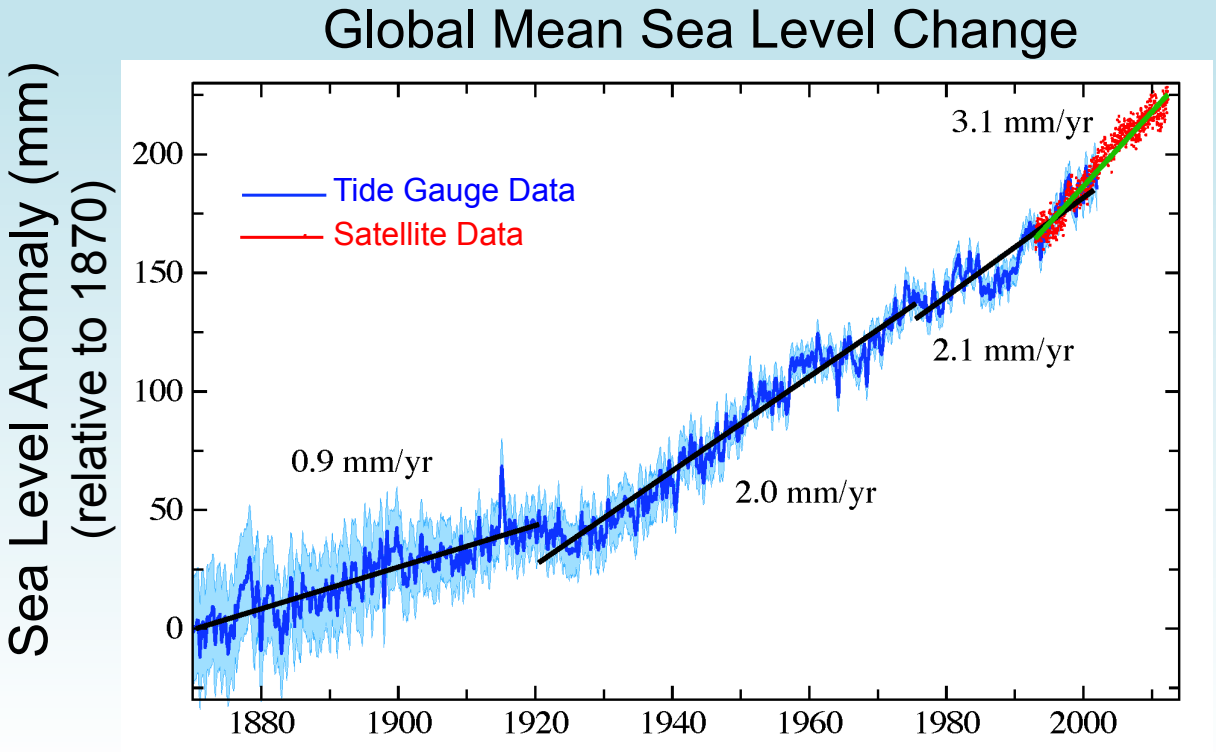
Number of summer days with temperature above freezing on the surface of the ice cap

UNEP 2013

Contributing Components to Local and Global Sea Level



Tide Gauge and Satellite Data for Sea Level 1870 - 2012

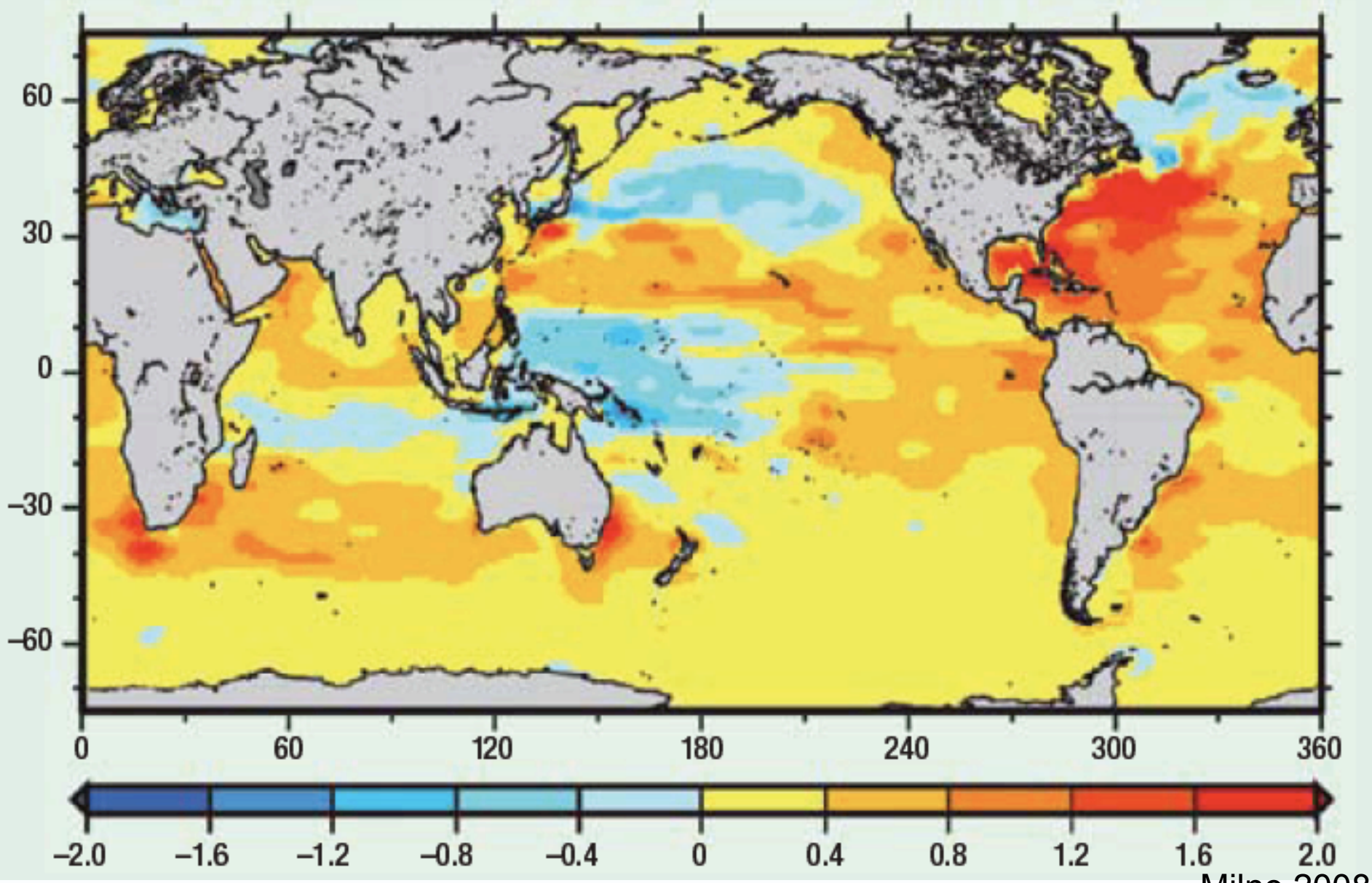


Milne 2008 & NASA

"On the basis of calculations presented here, we suggest that an improved estimate of the range of sea level rise to 2100 including increased ice dynamics lies between 0.8 and 2.0 meters [31 – 78 inches]."

Pfeffer et al. 2008

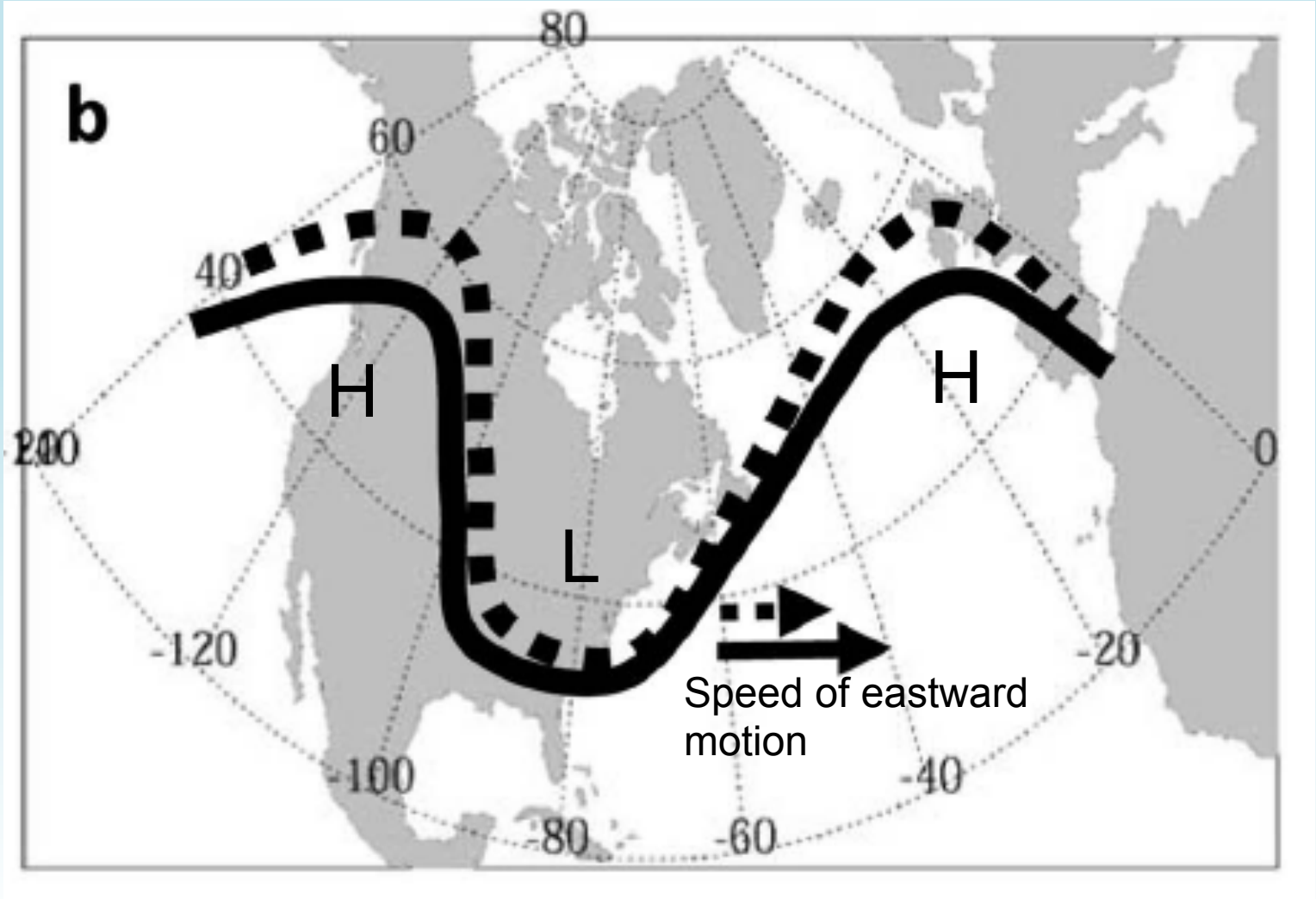
Trends in Sea- Level Change (mm/yr) due to Warming from 1955 to 2003



Milne 2008

Changes in the propagation of an atmospheric wave across temperate latitudes

Under warming Arctic conditions as dashed line



Francis & Varvus 2012

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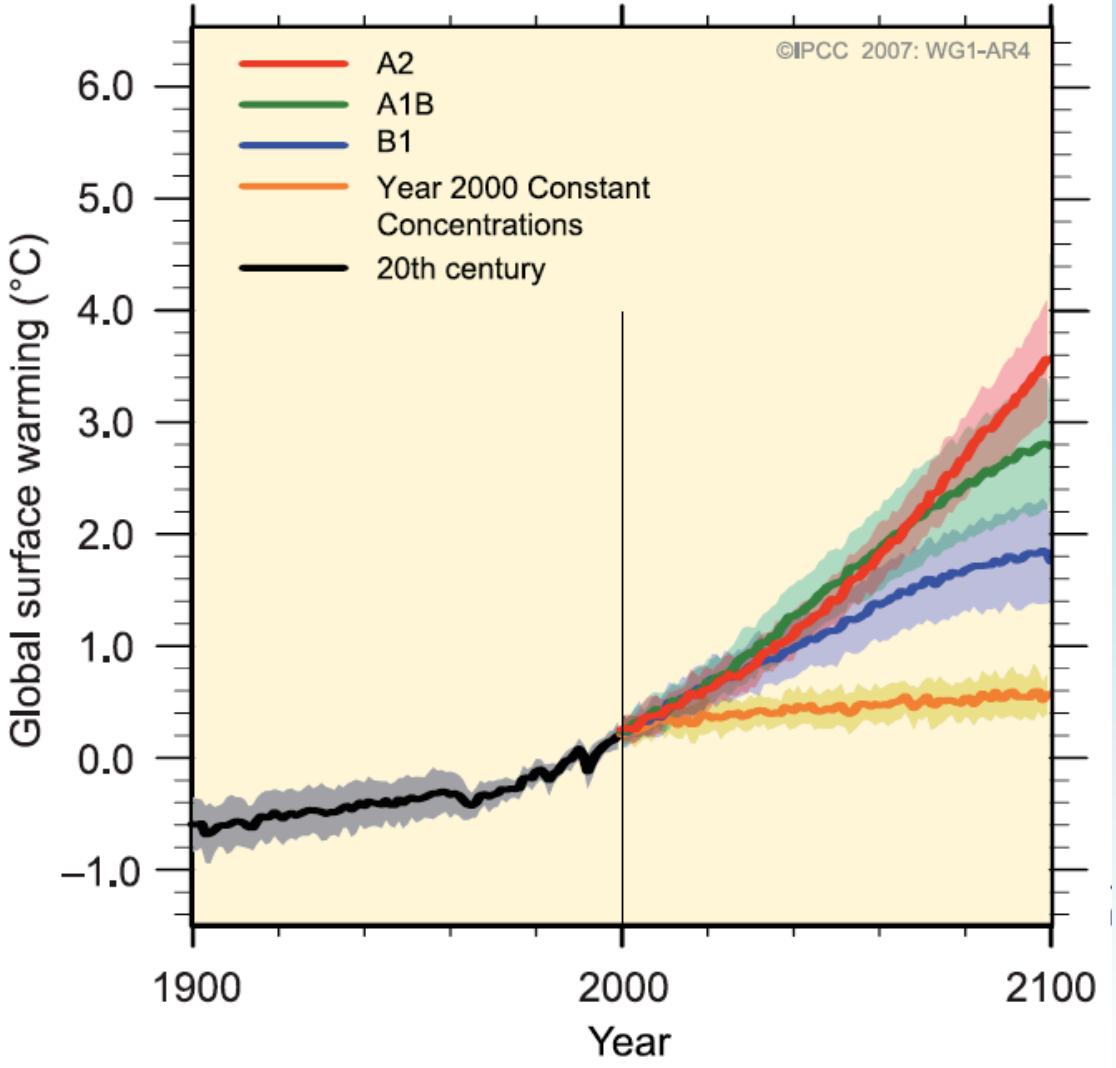

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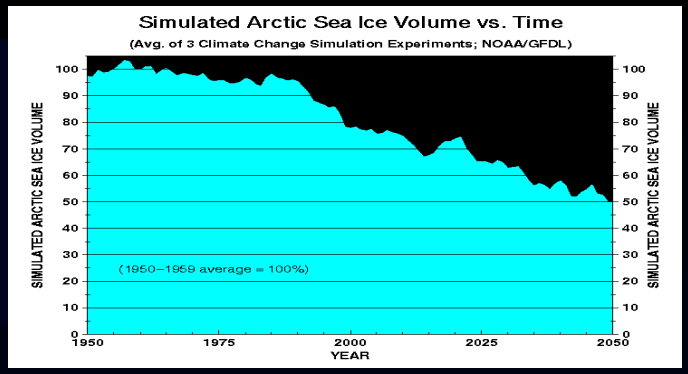
IPCC 2007

GFDL Simulation Projects 50% Reduction by 2050



(2010–2030)

(2040 – 2060)

(2070 – 2090)

Five Models Project Sea Ice Extent for Mid-September

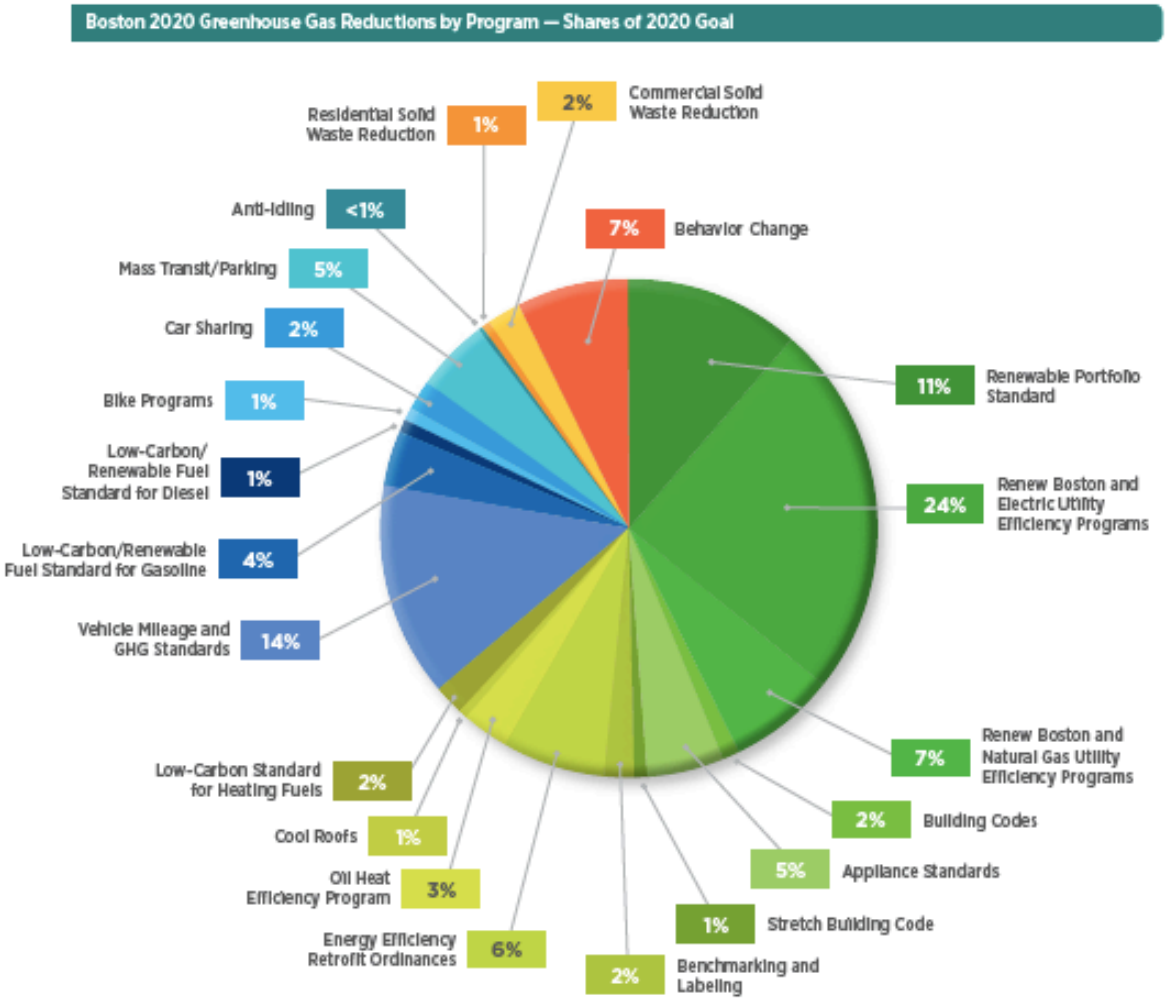
Mayor Thomas Menino's leadership in Boston

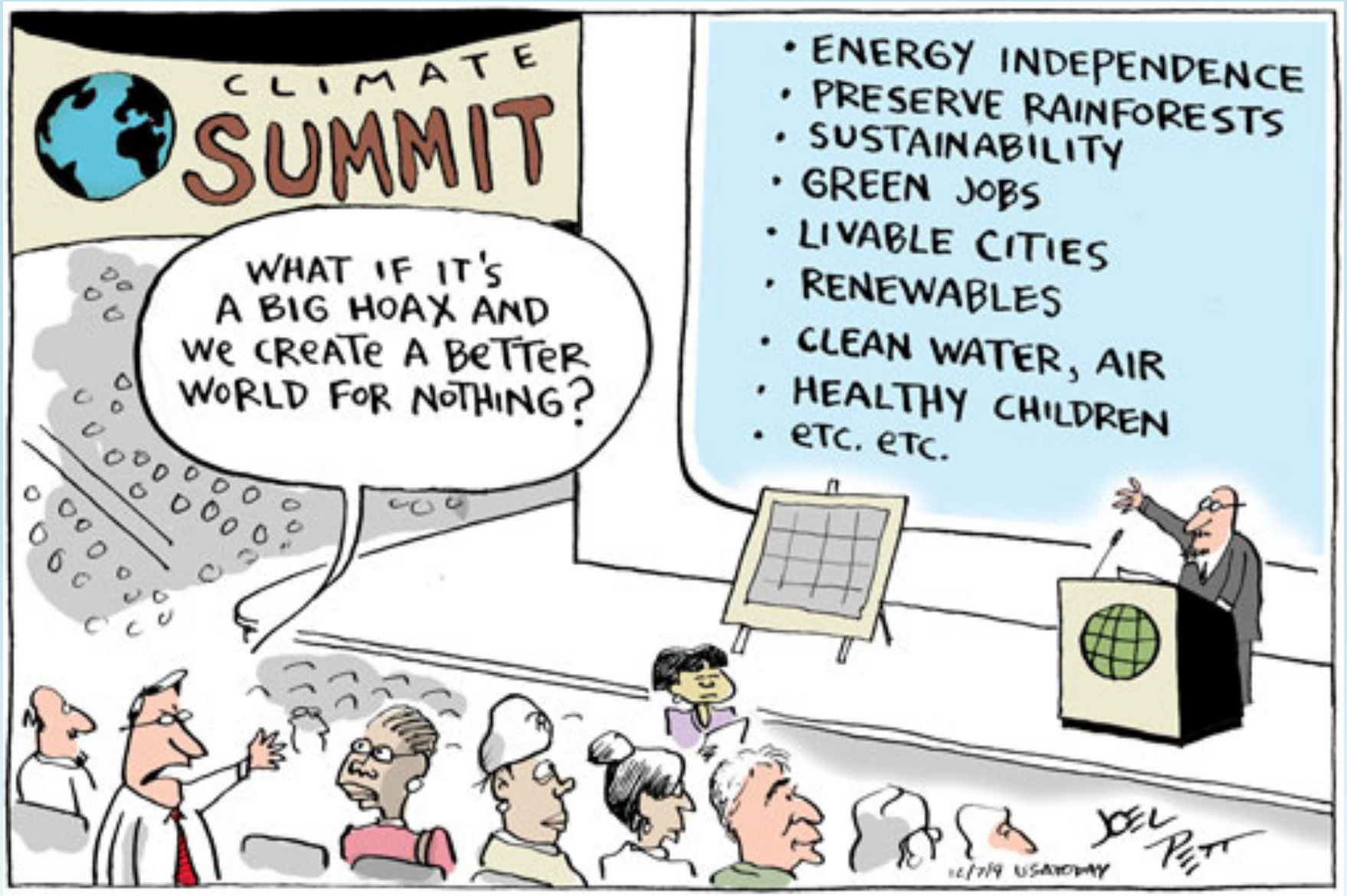
UPDATE REPORT

A Climate of Progress

City of Boston Climate Action Plan Update 2011

- Reducing community greenhouse gas emissions 25 percent by 2020 and 80 percent by 2050
- Incorporating projected climate change into all formal planning and project review processes
- Engaging all segments of the community in climate action and leadership
- Developing innovative businesses and workforce skills to take advantage of climate action opportunities




CLIMATE
SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• ETC. ETC.
JOEL PETT

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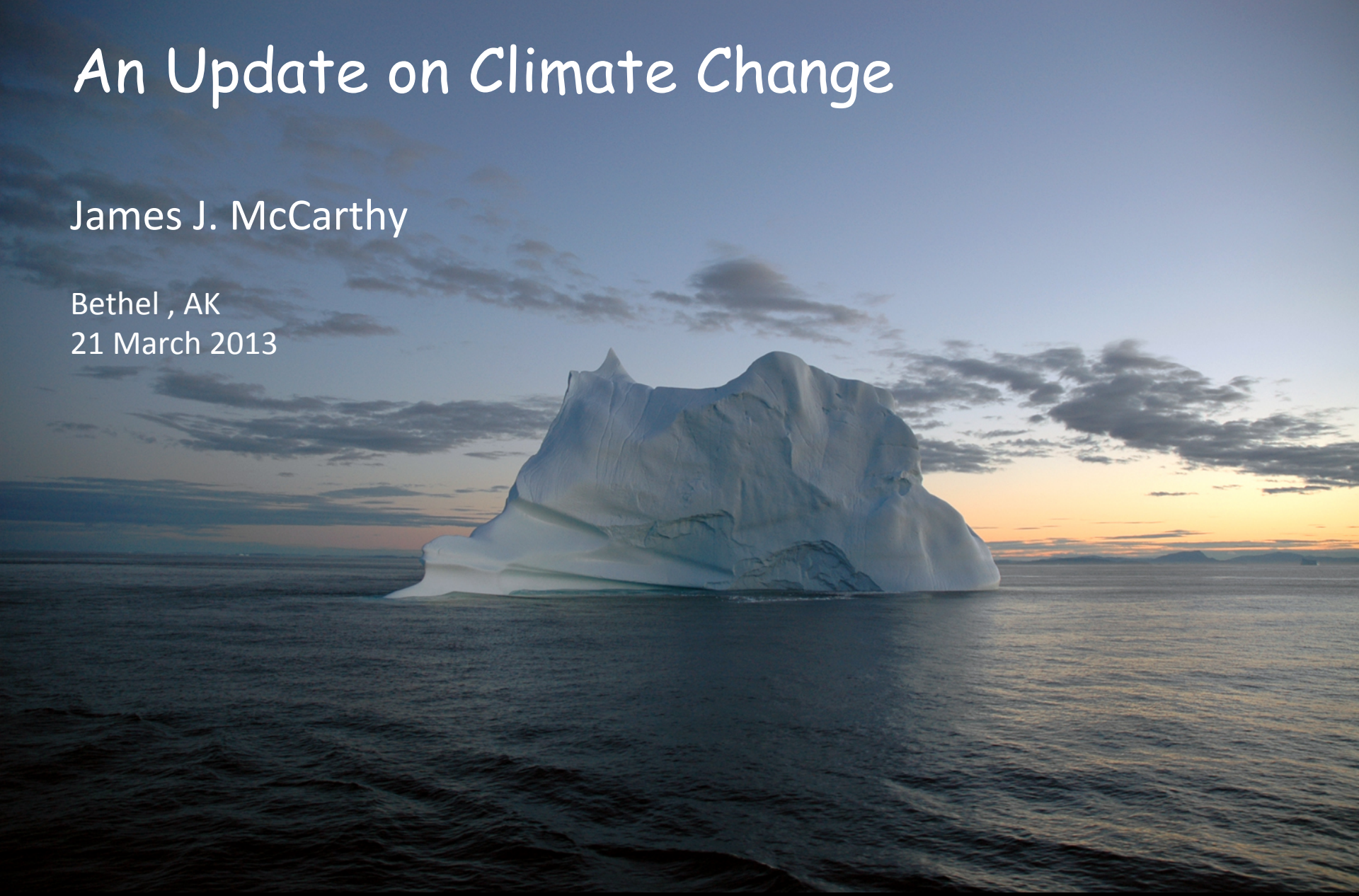
James J. McCarthy

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