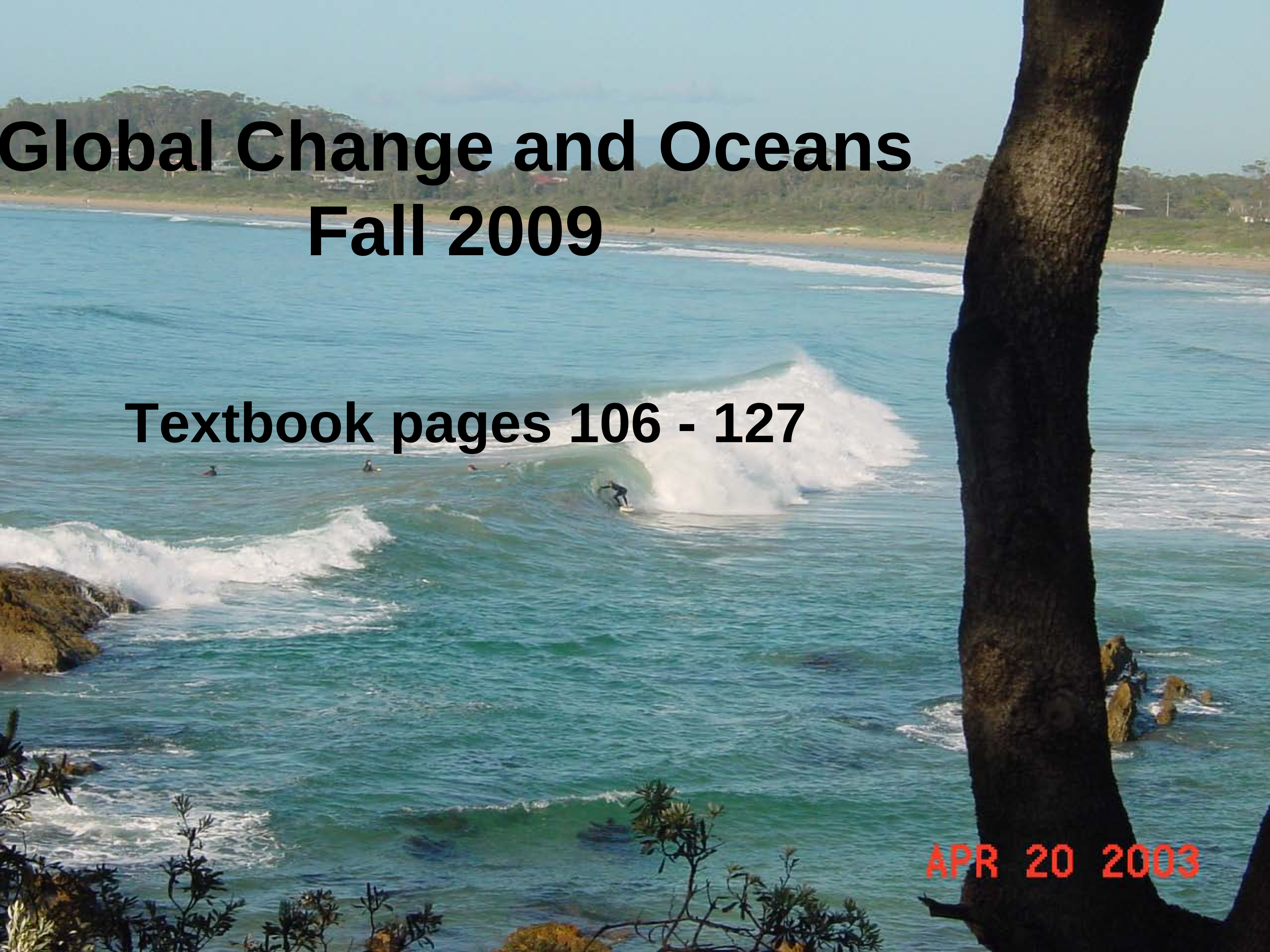
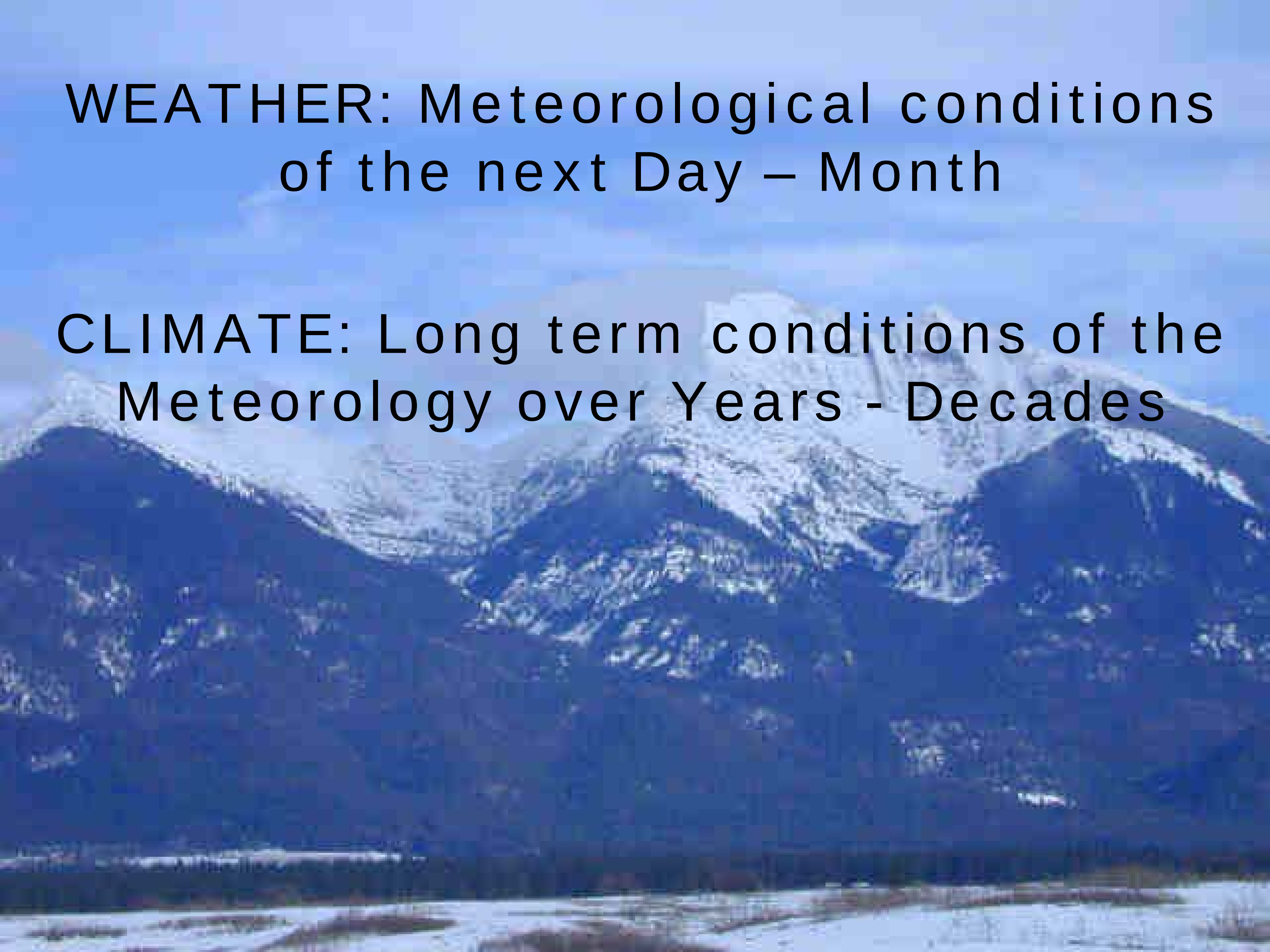
Global Change and Oceans
Fall 2009

Textbook pages 106 - 127

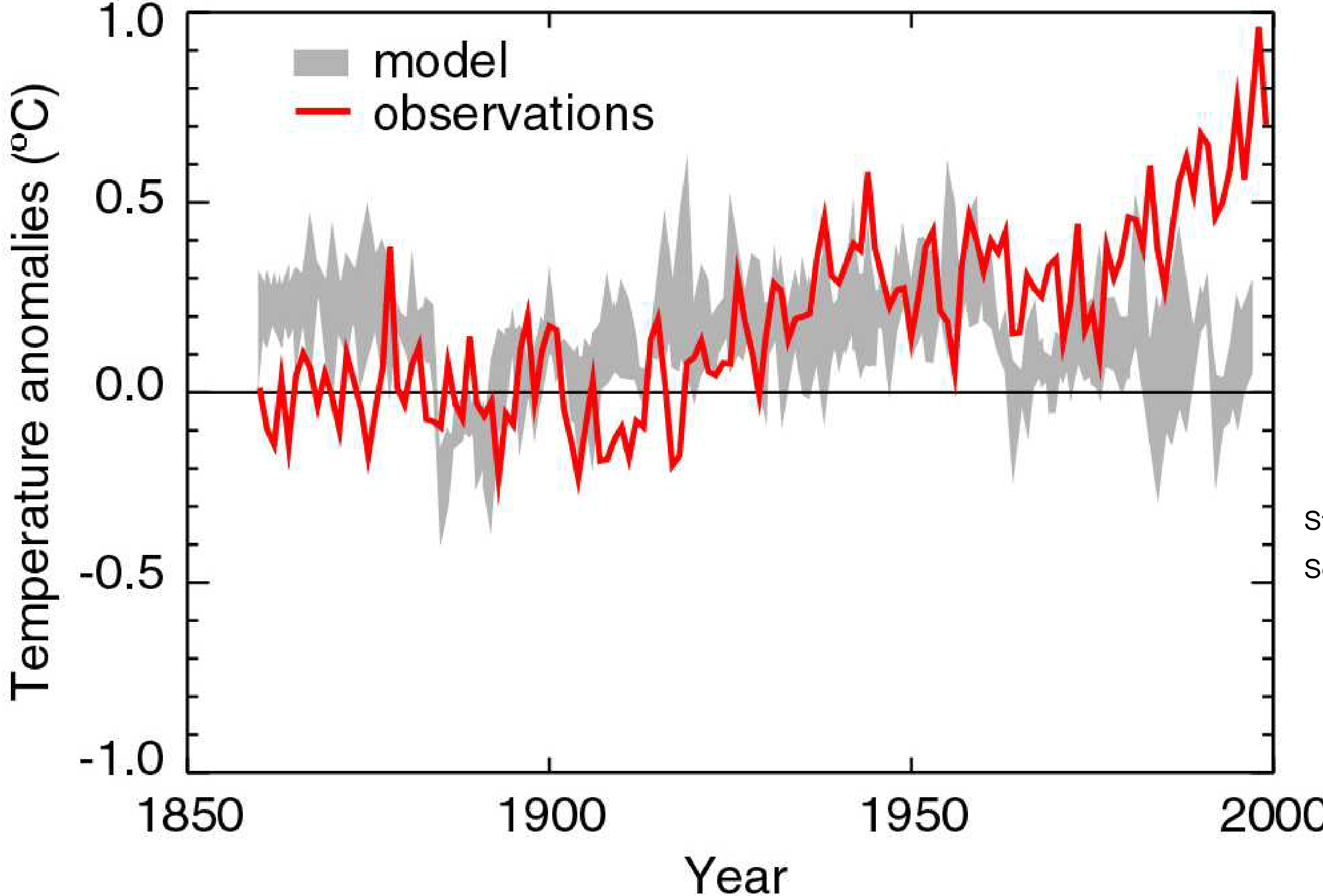




WEATHER: Meteorological conditions of the next Day – Month

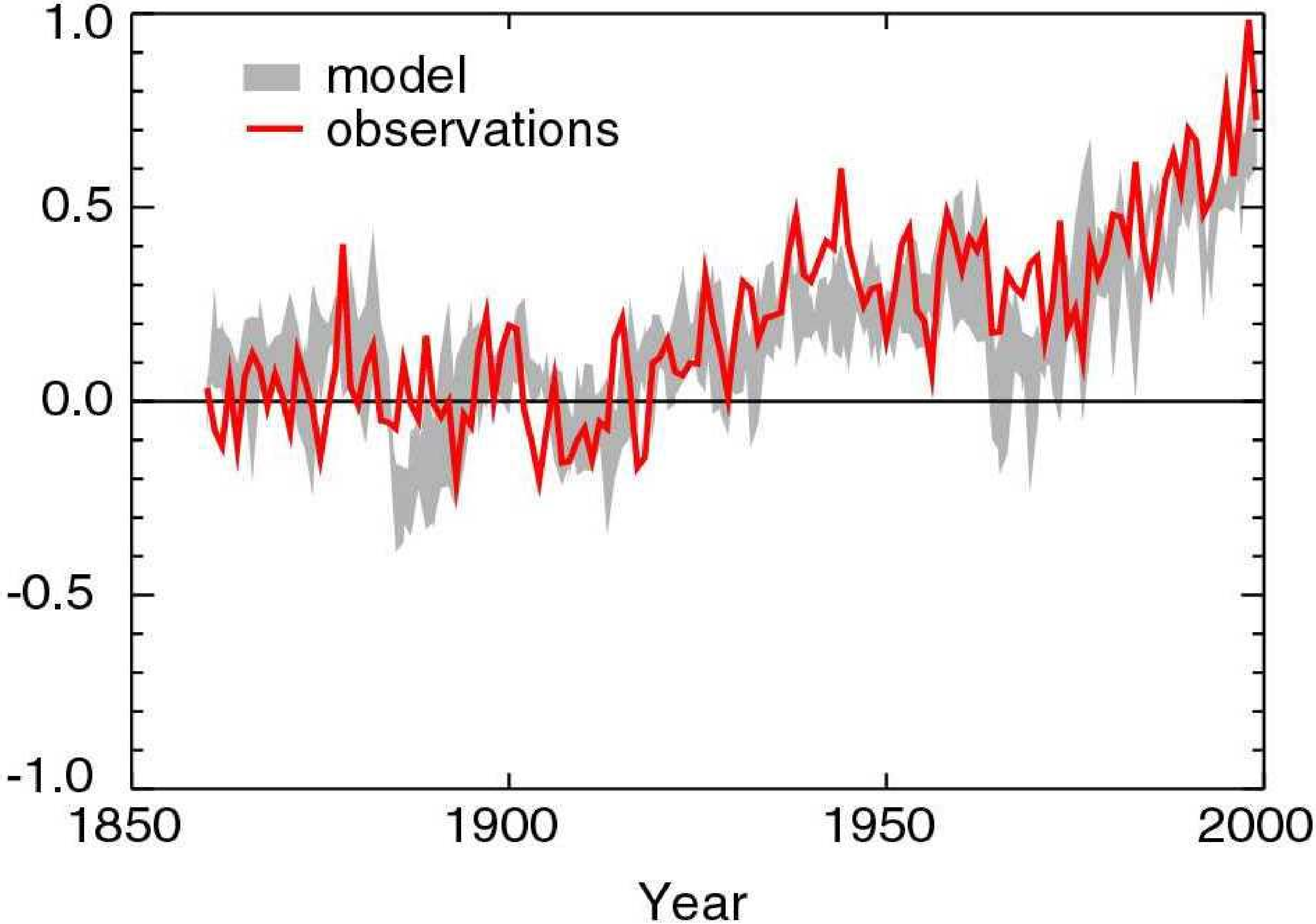
CLIMATE: Long term conditions of the Meteorology over Years - Decades

“Simulations of the response to natural forcings alone … do not explain the warming in the second half of the century” SPM

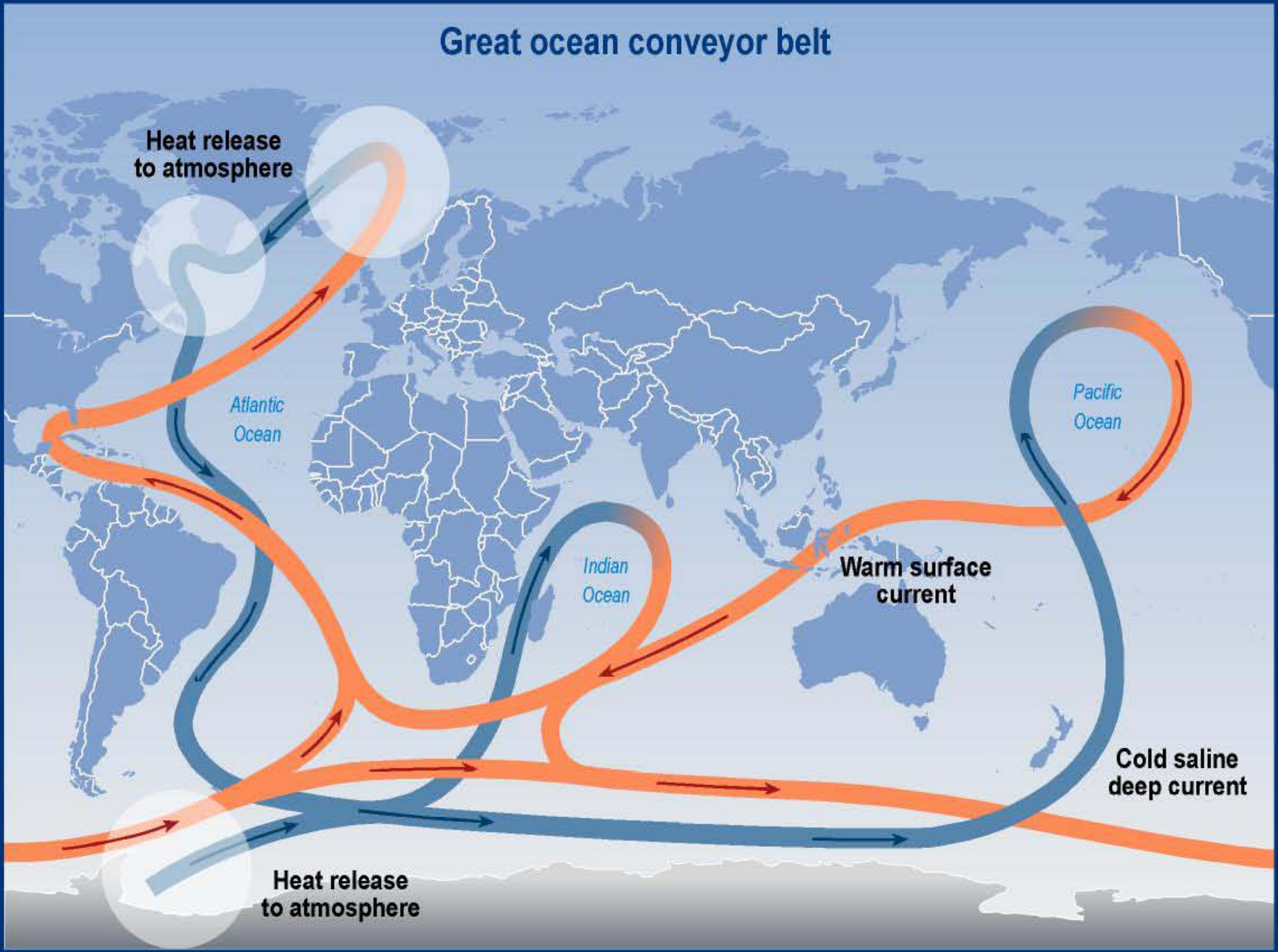


Stott et al, Science 2000

“..model estimates that take into account both greenhouse gases and sulphate aerosols are consistent with observations over this period” SPM



Stott et al,
Science 2000



SYR - FIGURE 4-2

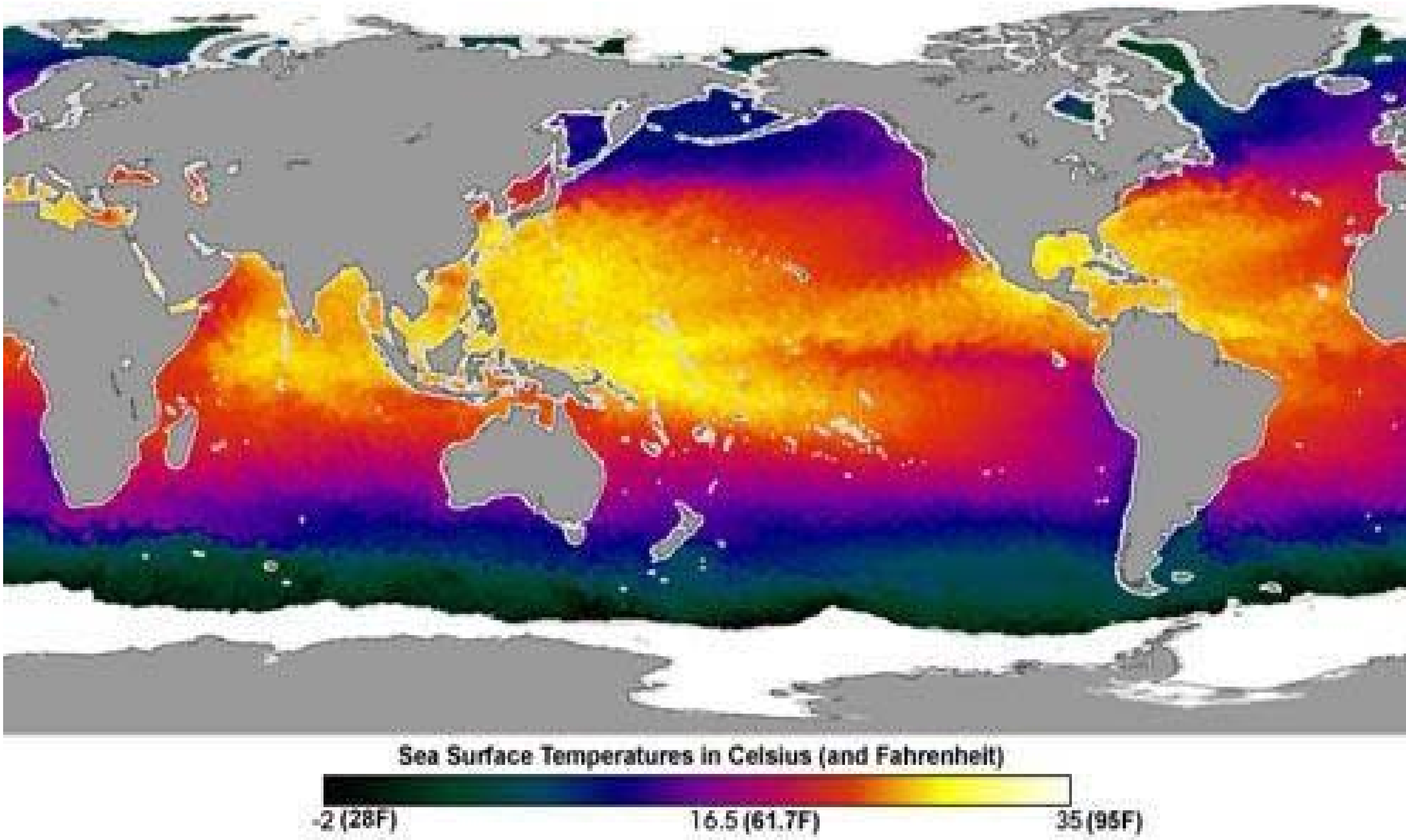
The Atmosphere is very small

Comparison of the heat balance of the climate system

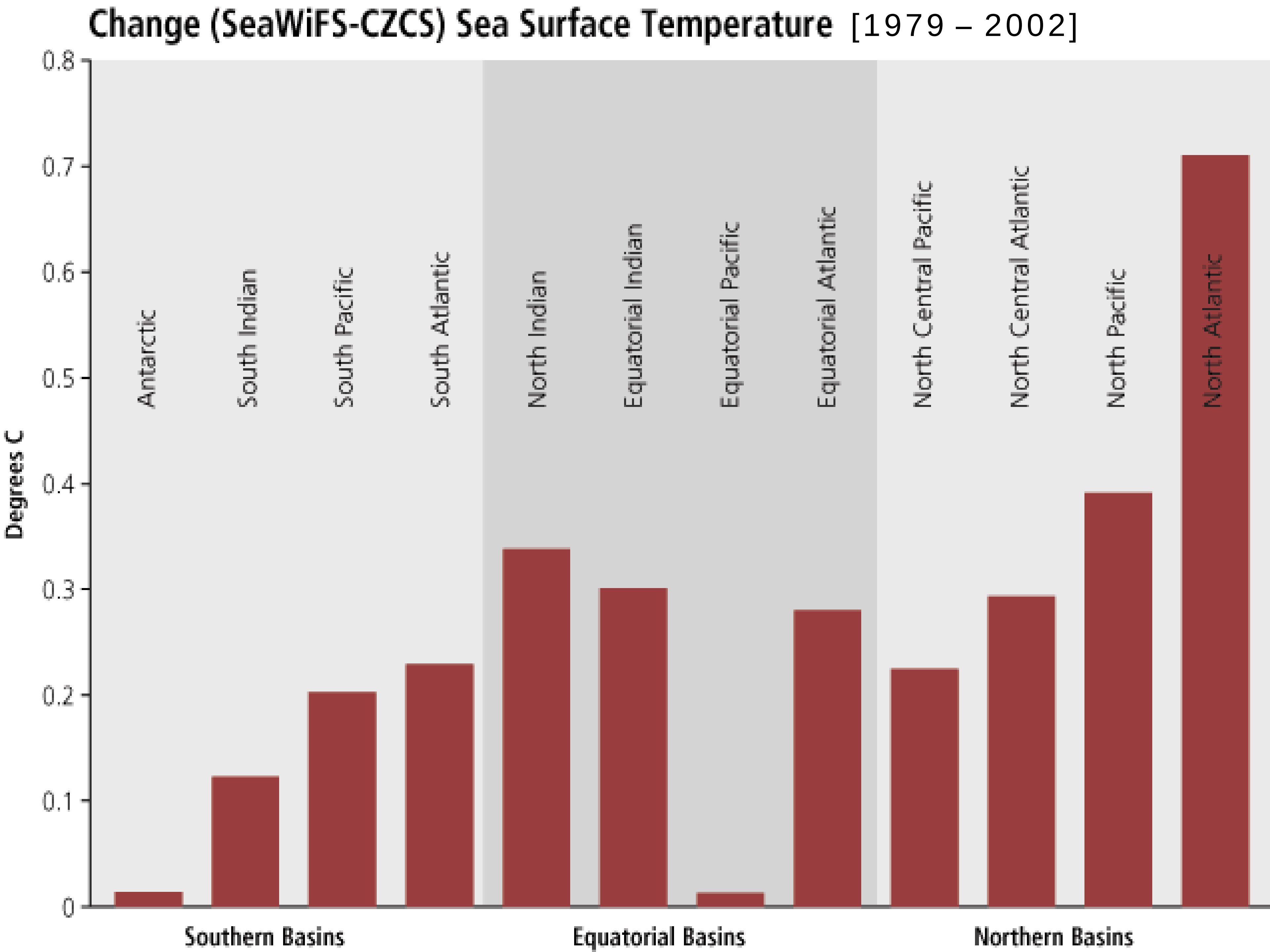
Levitus et al (2001). Science Vol. 292, pp. 268.

Component of the climate system and source of data	Time period of change	Observed or estimated change	Heat content increase or total heat of fusion	%
World ocean	1955-1996	Observed temperature increase	18.2×10^{22} J	90 90%
Global atmosphere	1955-1996	Observed temperature increase	6.6×10^{21} J	3
Decrease in the mass of continental glaciers	1955-1996	-	8.1×10^{21} J	4
Decrease in Antarctic sea ice extent	1950s-1970s	Estimated 311-km reduction in sea ice edge	3.2×10^{21} J	1
Mountain glacier decrease	1961-1997	3.7×10^{3} km decrease in mountain glacier ice volume	1.1×10^{21} J	.5
Decrease in Northern Hemisphere sea ice extent	1978-1996	Areal change based on satellite measurements	4.6×10^{19} J	.02
Decrease in Arctic perennial sea ice volume	1950s-1990s	40% decrease in sea ice thickness	2.4×10^{19} J	.01

OCEAN SURFACE TEMPERATURES

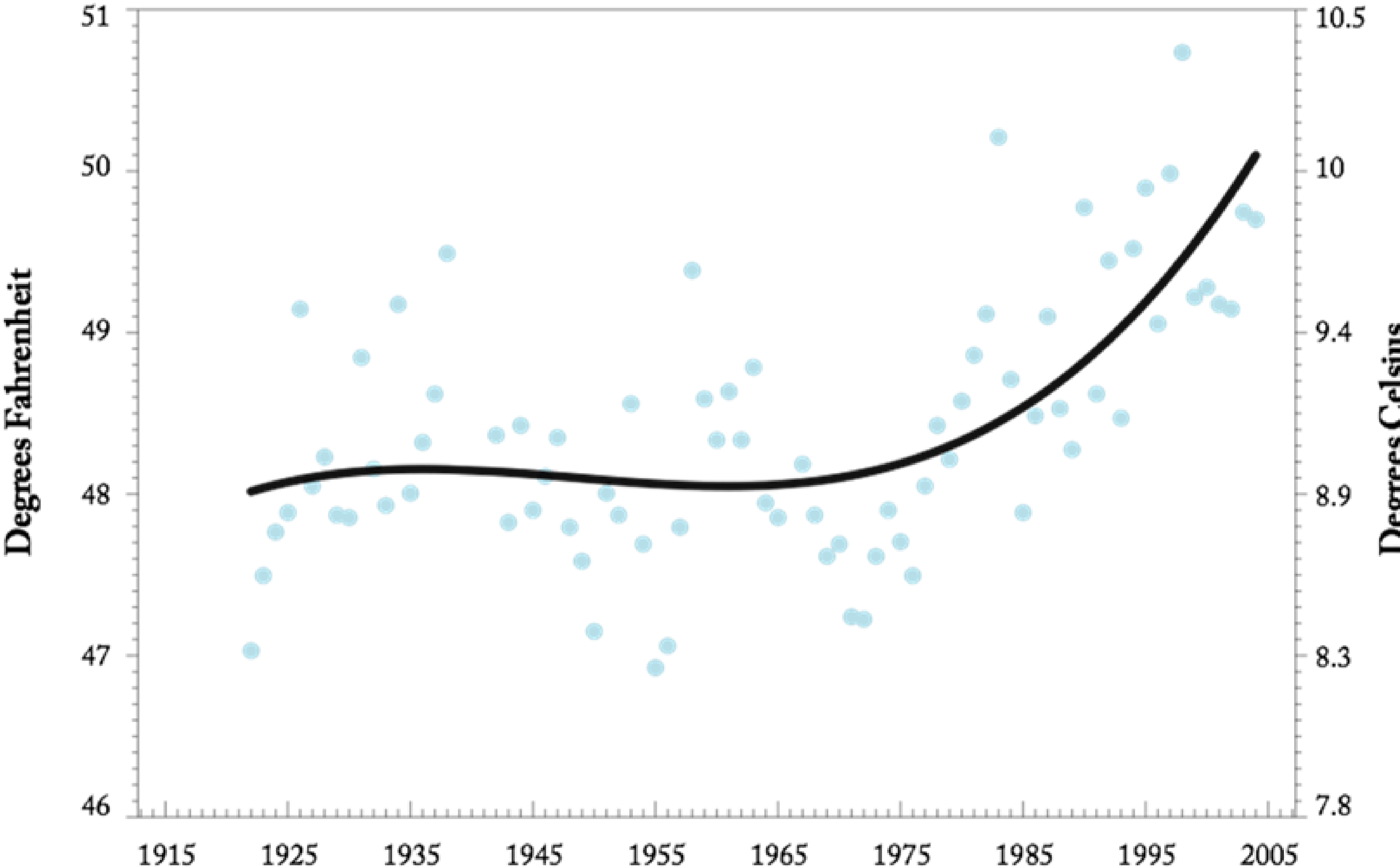


70% OF LAND IS IN NORTHERN HEMISPHERE

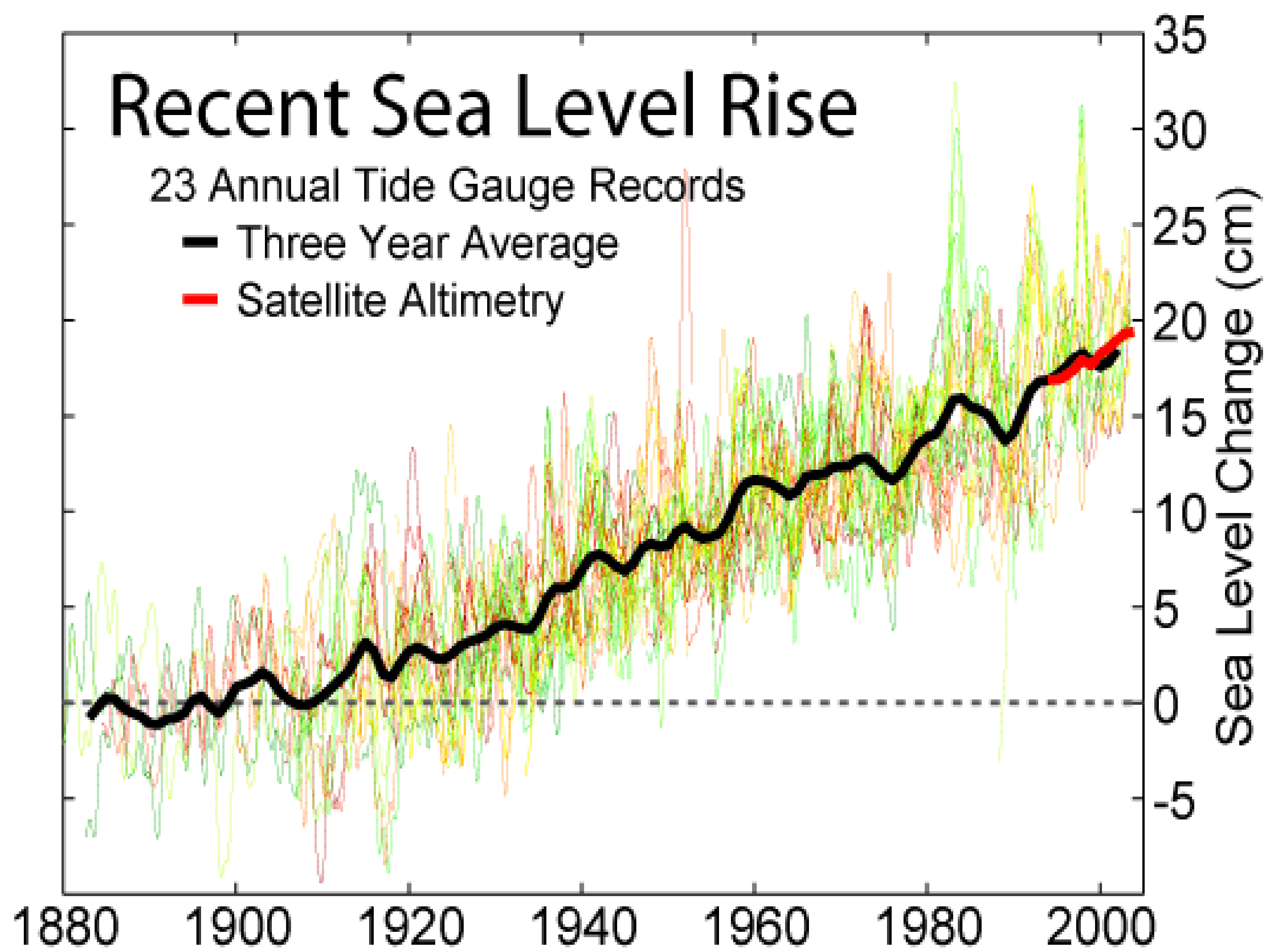


Change (SeaWiFS-CZCS) Sea Surface Temperature [1979 – 2002]
Degrees C
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Antarctic
South Indian
South Pacific
South Atlantic
North Indian
Equatorial Indian
Equatorial Pacific
Equatorial Atlantic
North Central Pacific
North Central Atlantic
North Pacific
North Atlantic
Southern Basins
Equatorial Basins
Northern Basins

Sea Surface Temperature
(Race Rocks lighthouse, Victoria)

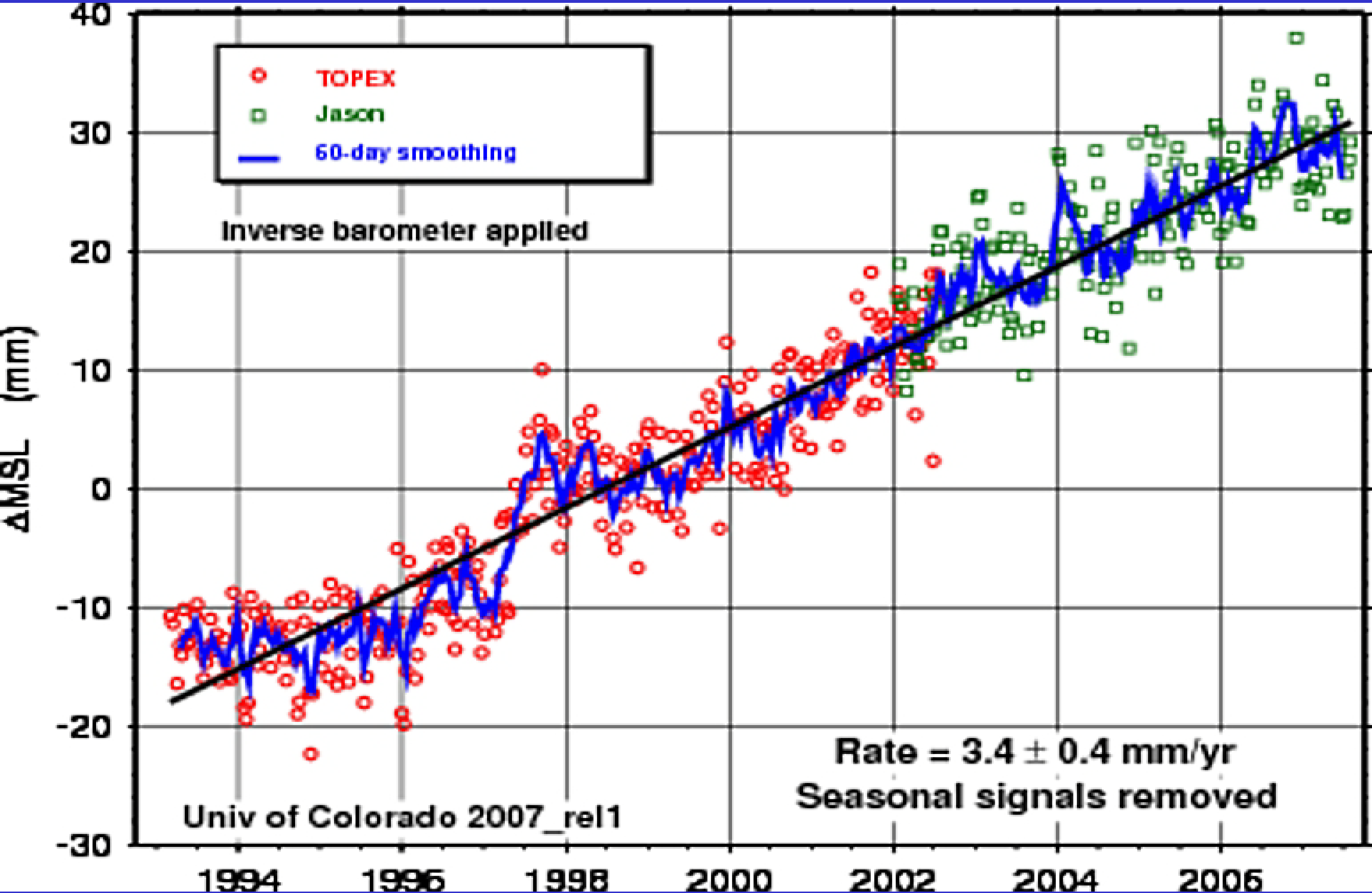


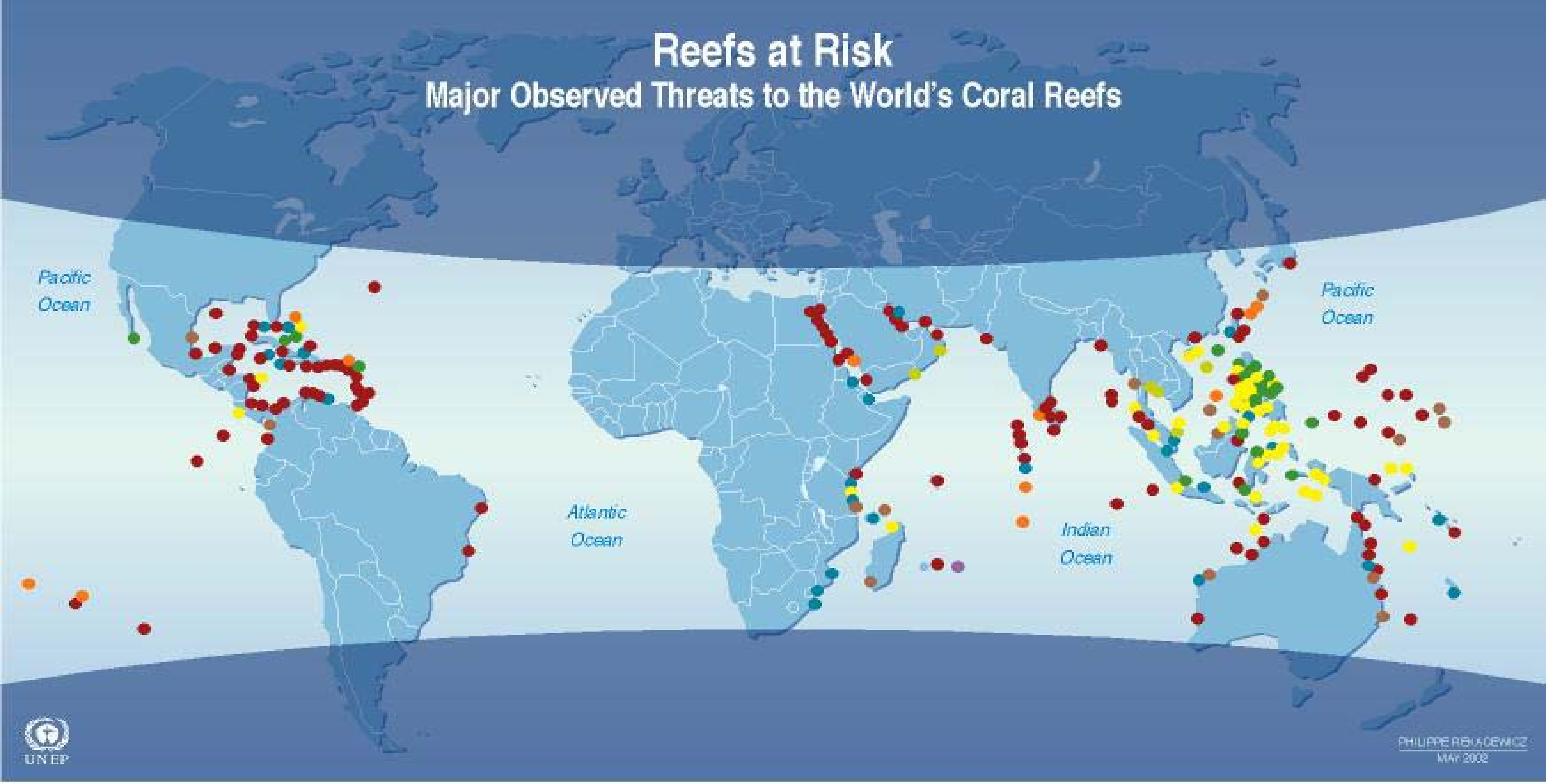
CLIMATE IMPACTS GROUP



Recent Sea Level Rise
23 Annual Tide Gauge Records
Three Year Average
Satellite Altimetry
Sea Level Change (cm)
35
30
25
20
15
10
5
0
-5
1880
1900
1920
1940
1960
1980
2000

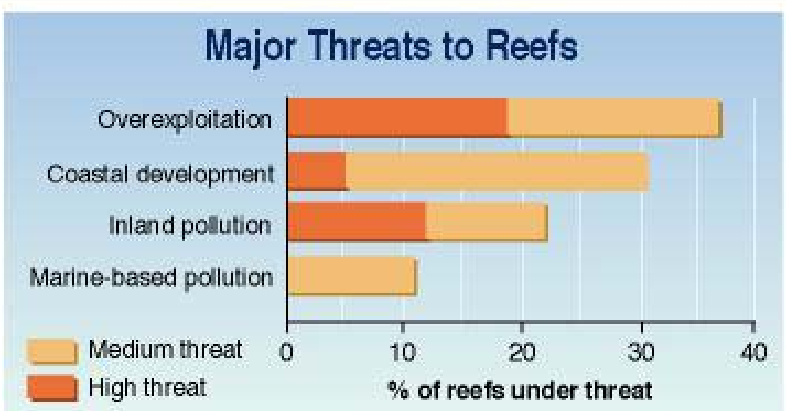
SEA LEVEL RISE

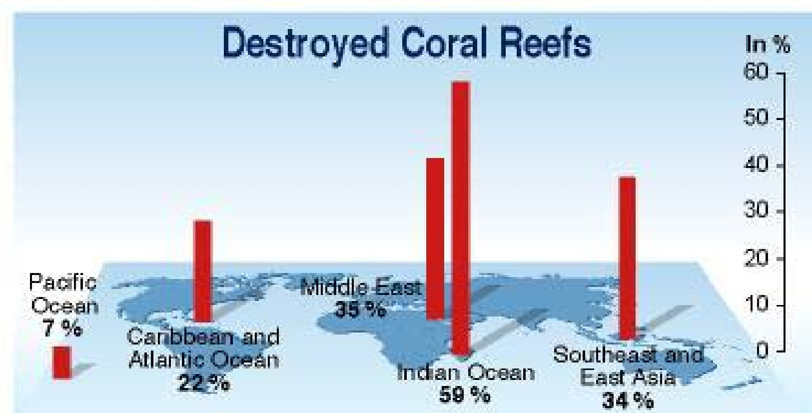




Categories

- Tourism
- Poison fishing
- Overexploitation
- Sedimentation
- Coral harvesting
- Dynamite fishing
- Pollution





Source: Bryant et al., *Reefs at Risk; a Map-Based Indicator of Threats to the World's Coral Reefs*, World Resources Institute (WRI), Washington DC, 1998.

BLEACHING OF CORAL REEFS BY OCEAN TEMPS > 85deg

Ocean acidification

- CO_2 is corrosive to the shells and skeletons of many marine organisms

Corals

Calcareous plankton

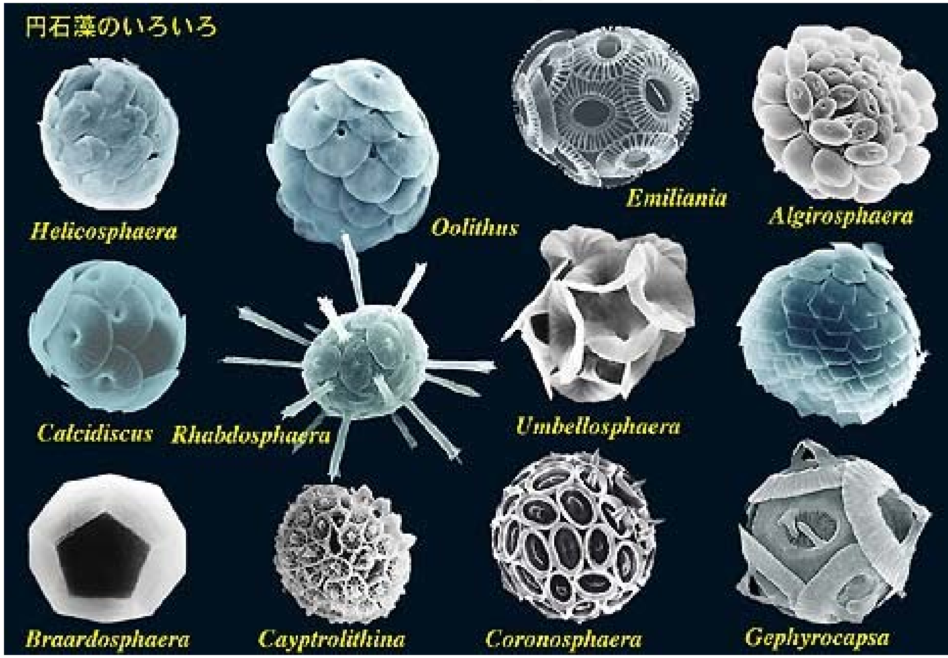


Photo: Missouri Botanical Gardens

http://www.biol.tsukuba.ac.jp/~inouye

Ocean Acidification

Over the last 200 years, about 50% of all CO_2 produced on earth has been absorbed by the ocean. (**Royal Society 6/05**)

Dissolves in sea water

Remains in the atmosphere (greenhouse gas)

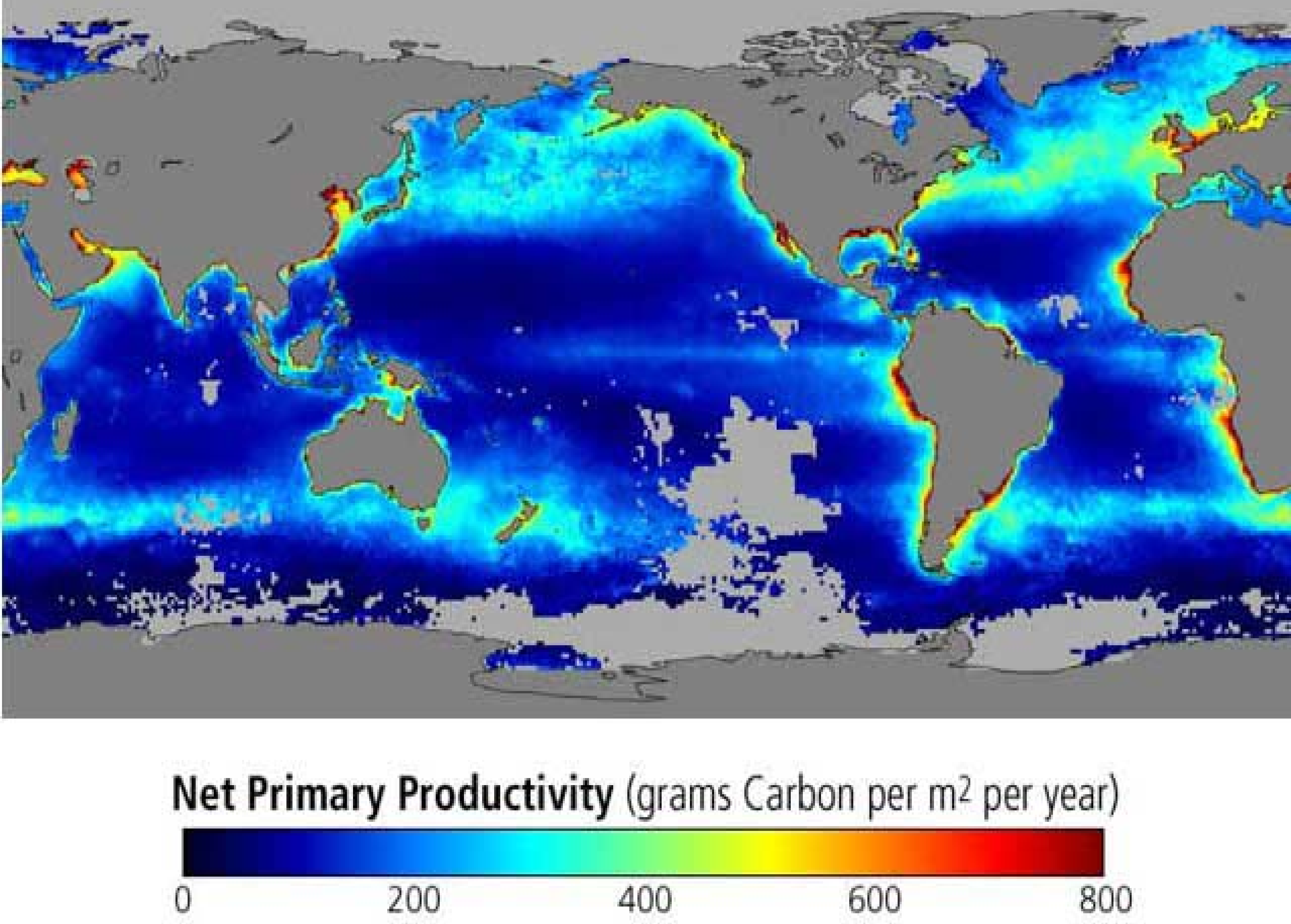
$$CO_2 + H_20 \longrightarrow HCO_3^- + H^+$$

(ACID)

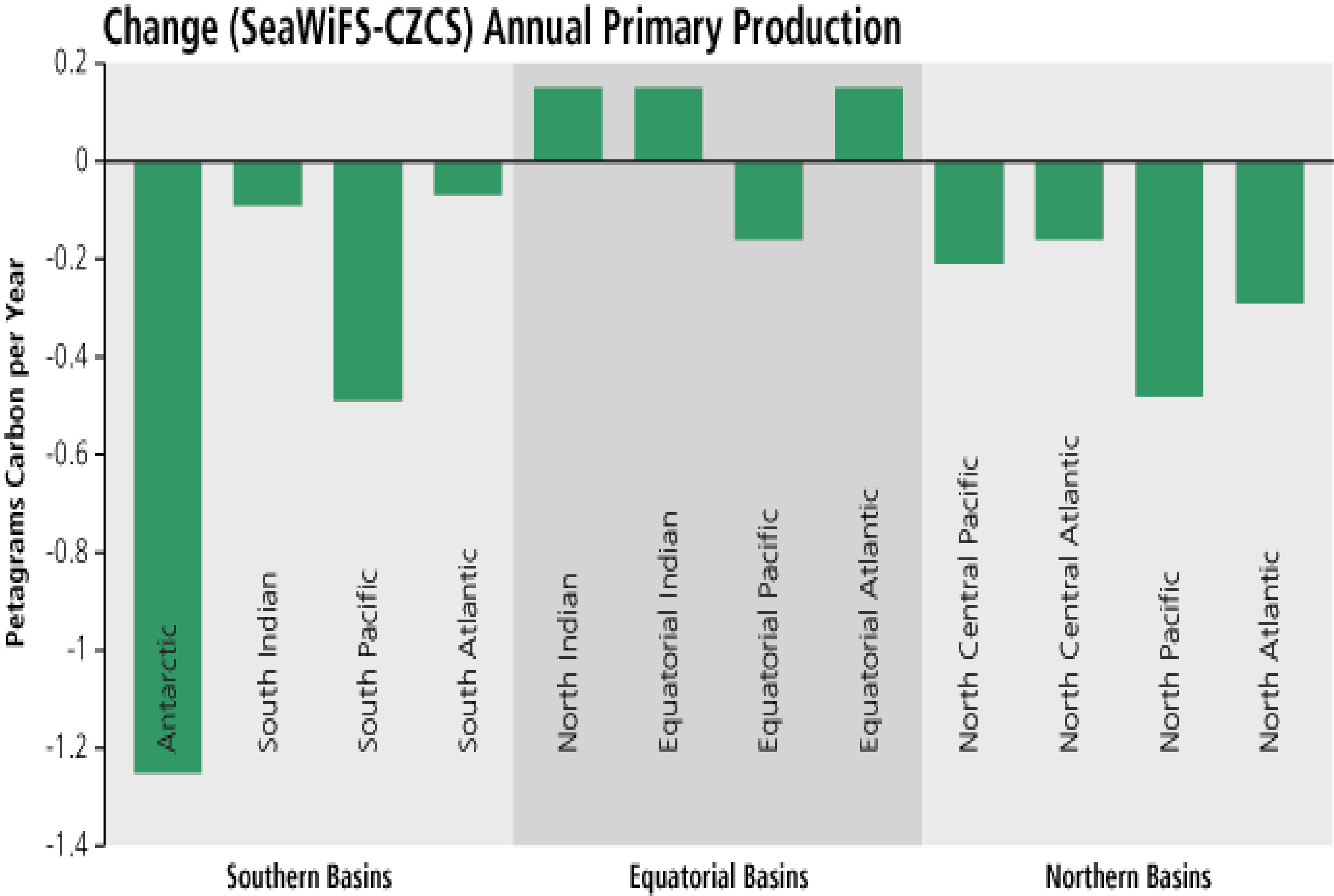
Water becomes more acidic.

CO_2

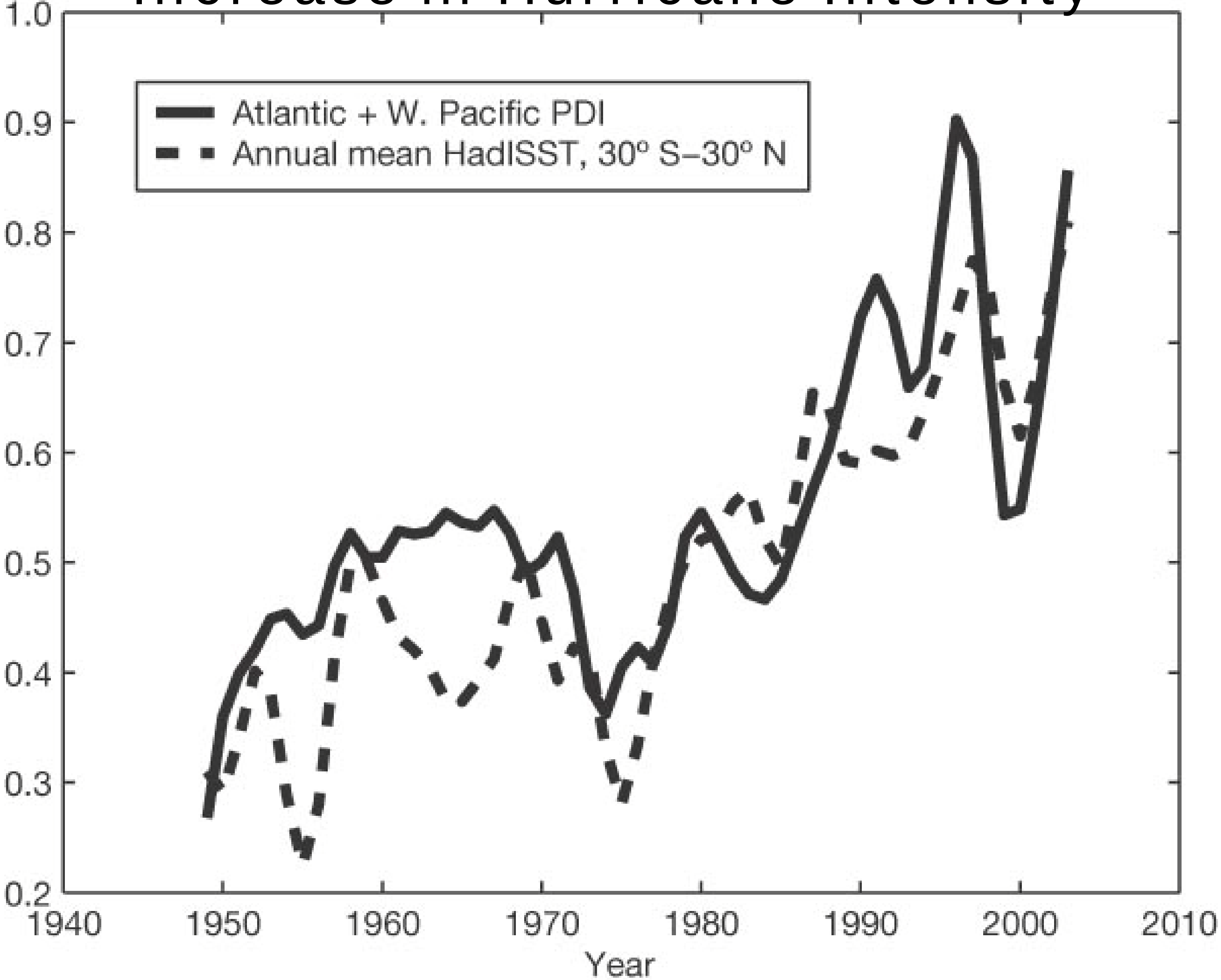
CO_2


Net Primary Productivity (grams Carbon per m2 per year)
0
200
400
600
800

CHANGE IN OCEAN NPP [1979 – 2002]



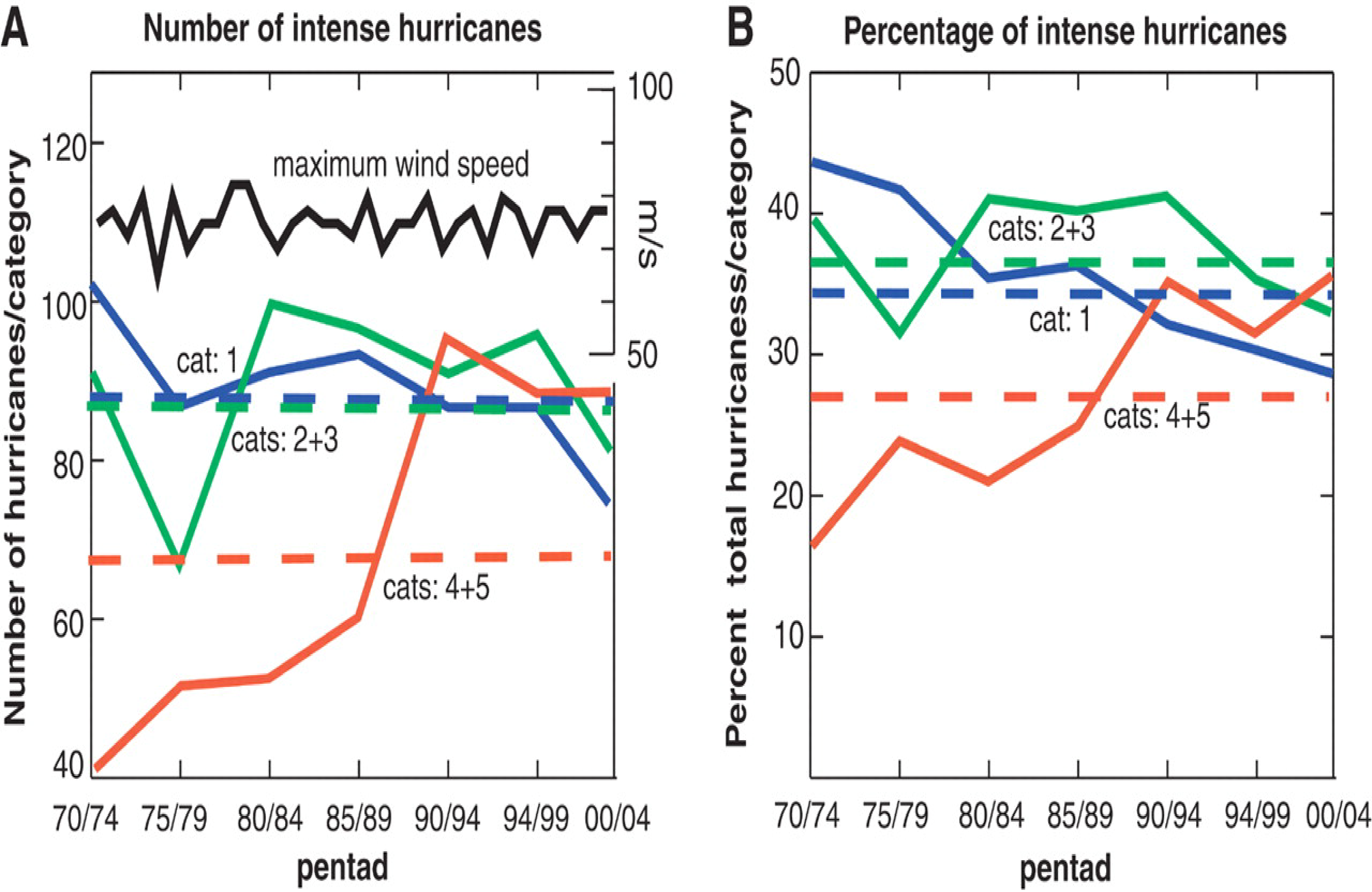
Increase in Hurricane Intensity



PDI = Potential Destructiveness Index

Emanuel, Nature 4 August 2005

Increase in Category 4-5 Hurricanes 1970 - 2004



Webster et al, Science, Sept 16 2005

Sea-level Rise Projections Include:

•ocean expansion resulting from increased water temperatures;

National Park Service

•meltwater runoff from mountain glaciers around the world; and

NASA

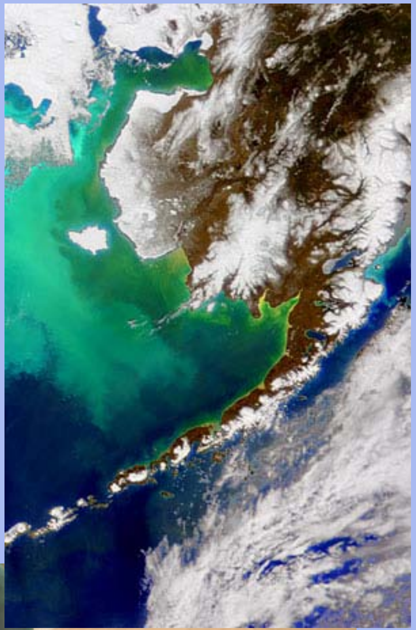
•a contribution due to increased ice flow from Greenland and Antarctica **at the rates observed for 1993-2003**.

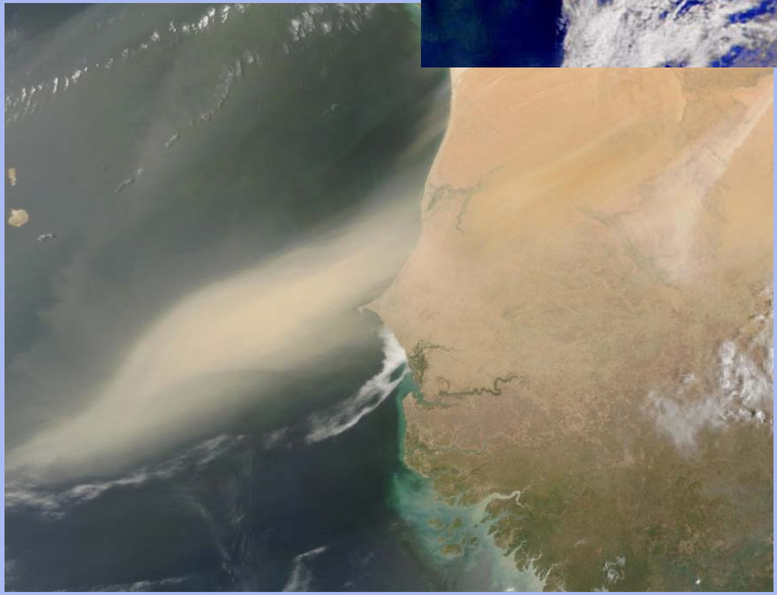
Source: IPCC *Climate Change 2007: The Physical Science Basis*—Summary for Policymakers.

Iron in the Oceans

- Sources of naturally occurring iron
  - Volcanic coastal shelves
  - Dust in blown in from land
  - Upwellings

- Role in ecosystems
  - Key nutrient that helps plants take up nitrogen





“Give me a few oil tankers full of iron,
and I’ll give you an ice age.”

– John Martin, WHOI Scientist

Cashing in on Carbon Offsets

- Climos taking over with $3.5 million in funding
- Planktos bottom up after Galapagos proposal

- Will the Carbon stay sequestered long enough to help?

- **CLIMATE CHANGE CURE?:** ***By running the flue gas from Moss Landing's mammoth smokestacks through ocean water, a new company can make cement from carbon dioxide pollution.***

- **The turbines at Moss Landing power plant on the California coast burn through natural gas to pump out more than 1,000 megawatts of electric power. The 700-degree Fahrenheit (370-degree Celsius) fumes left over contain at least 30,000 parts per million of carbon dioxide (CO2)—.**

  Today, this flue gas wafts up and out of the power plant's enormous smokestacks, but by simply bubbling it through the nearby seawater, a new California-based company called Calera says it can use more than 90 percent of that CO2 to make something useful: cement.

  It's a twist that could make a polluting substance into a way to reduce greenhouse gases. Cement, which is mostly commonly composed of calcium silicates, requires heating limestone and other ingredients to 2,640 degrees F (1,450 degrees C) by burning fossil fuels and is the third largest source of greenhouse gas pollution in the U.S., according to the U.S. Environmental Protection Agency. Making one ton of cement results in the emission of roughly one ton of CO2—and in some cases much more.

  Calera's process takes the idea a step forward by storing the CO2 in a useful product. The U.S. used more than 122 million metric tons of Portland cement in 2006, according to the Portland Cement Association (PCA), an industry group, and China used at least 800 million metric tons.

  The Calera process essentially mimics marine cement, which is produced by coral when making their shells and reefs, taking the calcium and magnesium in seawater and using it to form carbonates at normal temperatures and pressures. "We are turning CO2 into carbonic acid and then making carbonate," Constantz says. "All we need is water and pollution."