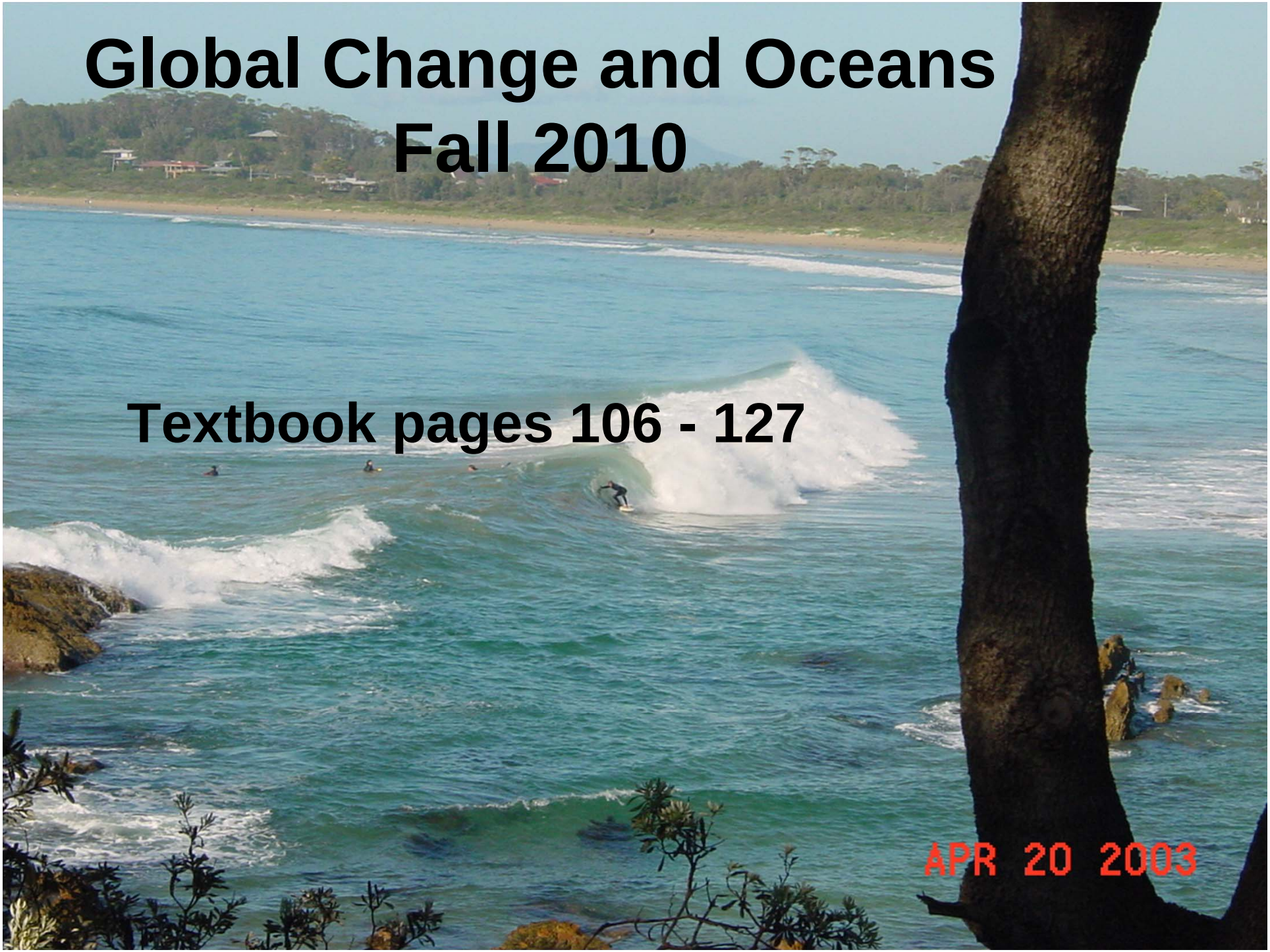
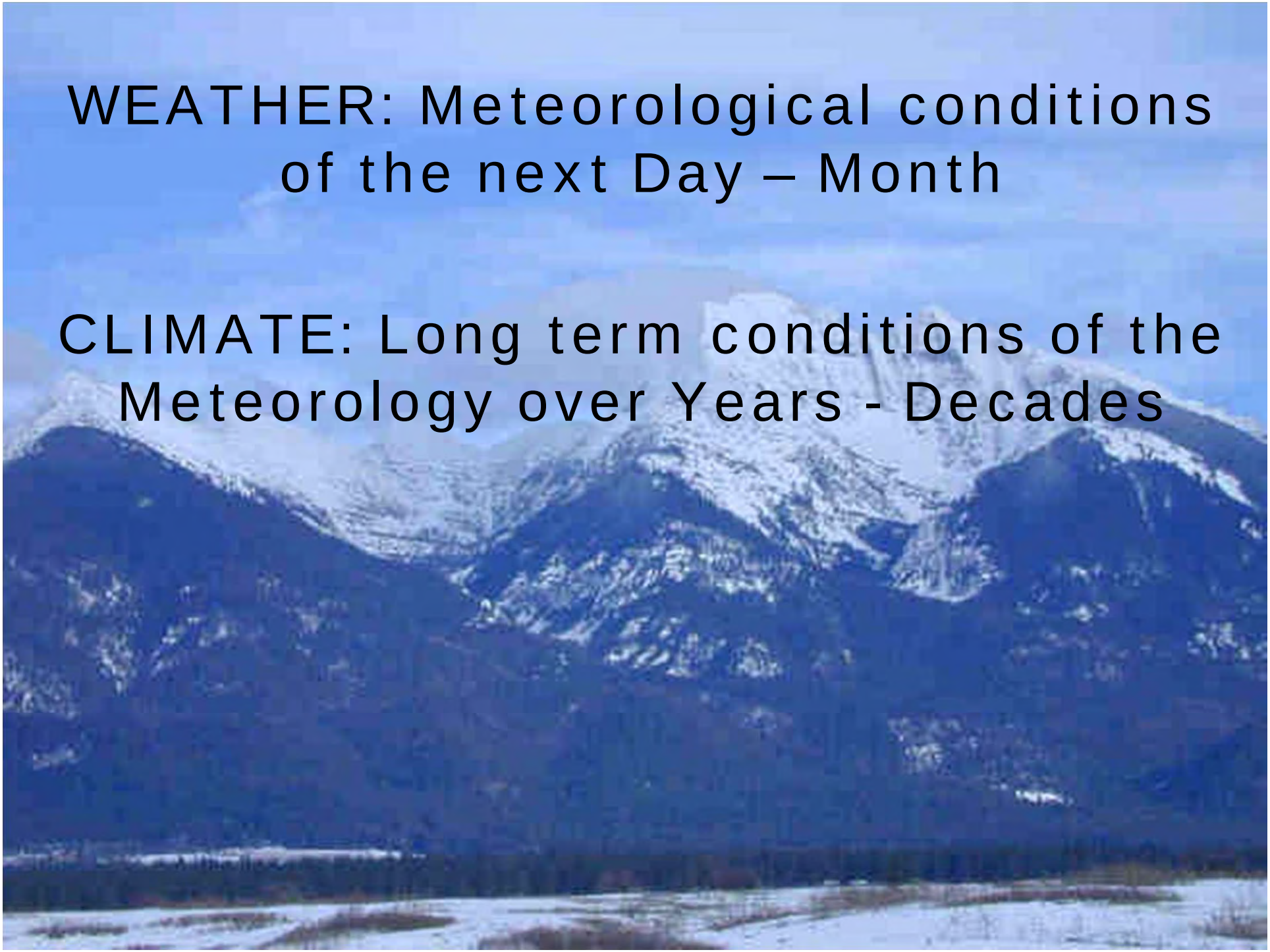
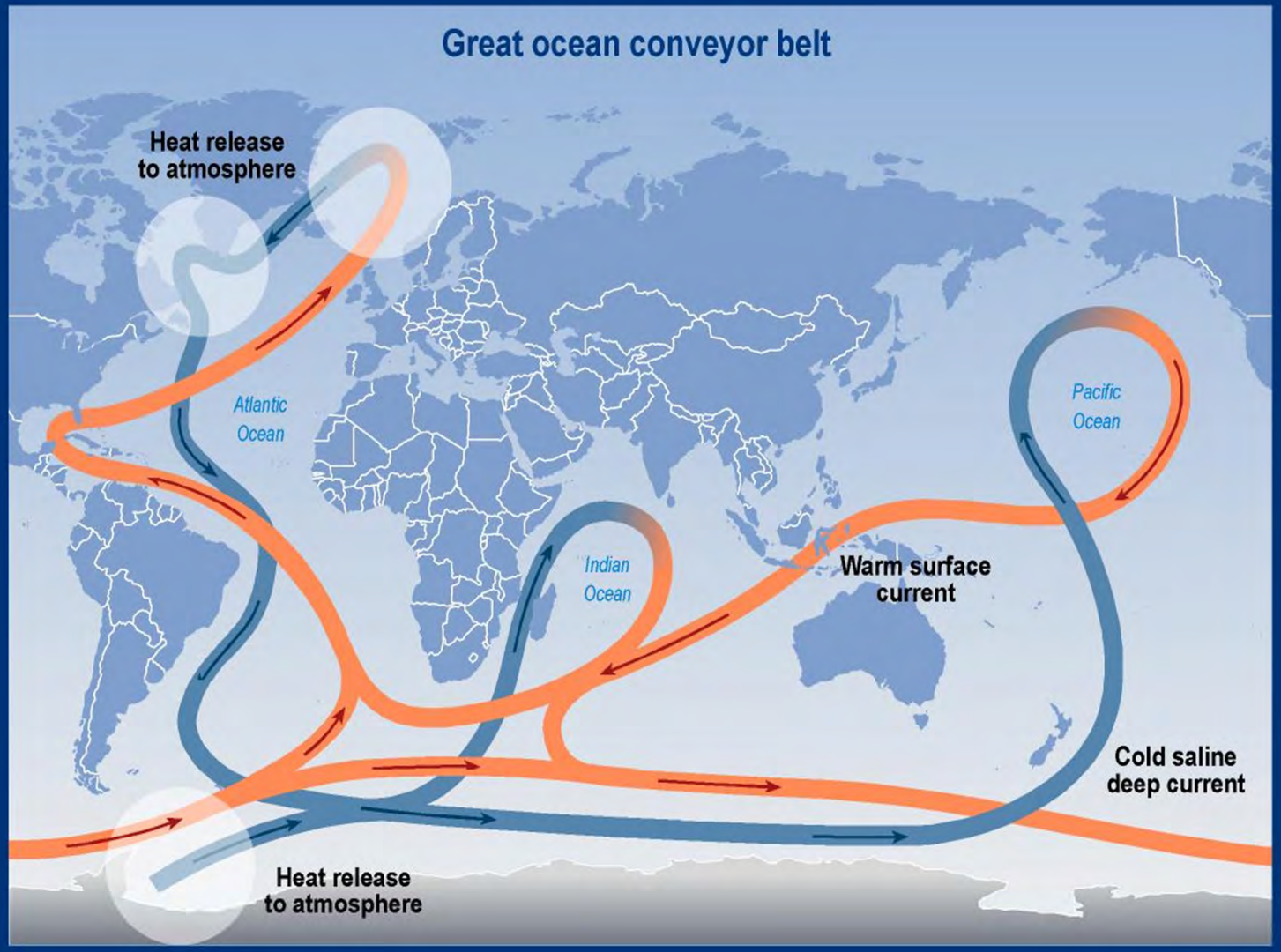
Global Change and Oceans
Fall 2010



Textbook pages 106 - 127


WEATHER: Meteorological conditions of the next Day – Month
CLIMATE: Long term conditions of the Meteorology over Years - Decades



SYR - FIGURE 4-2

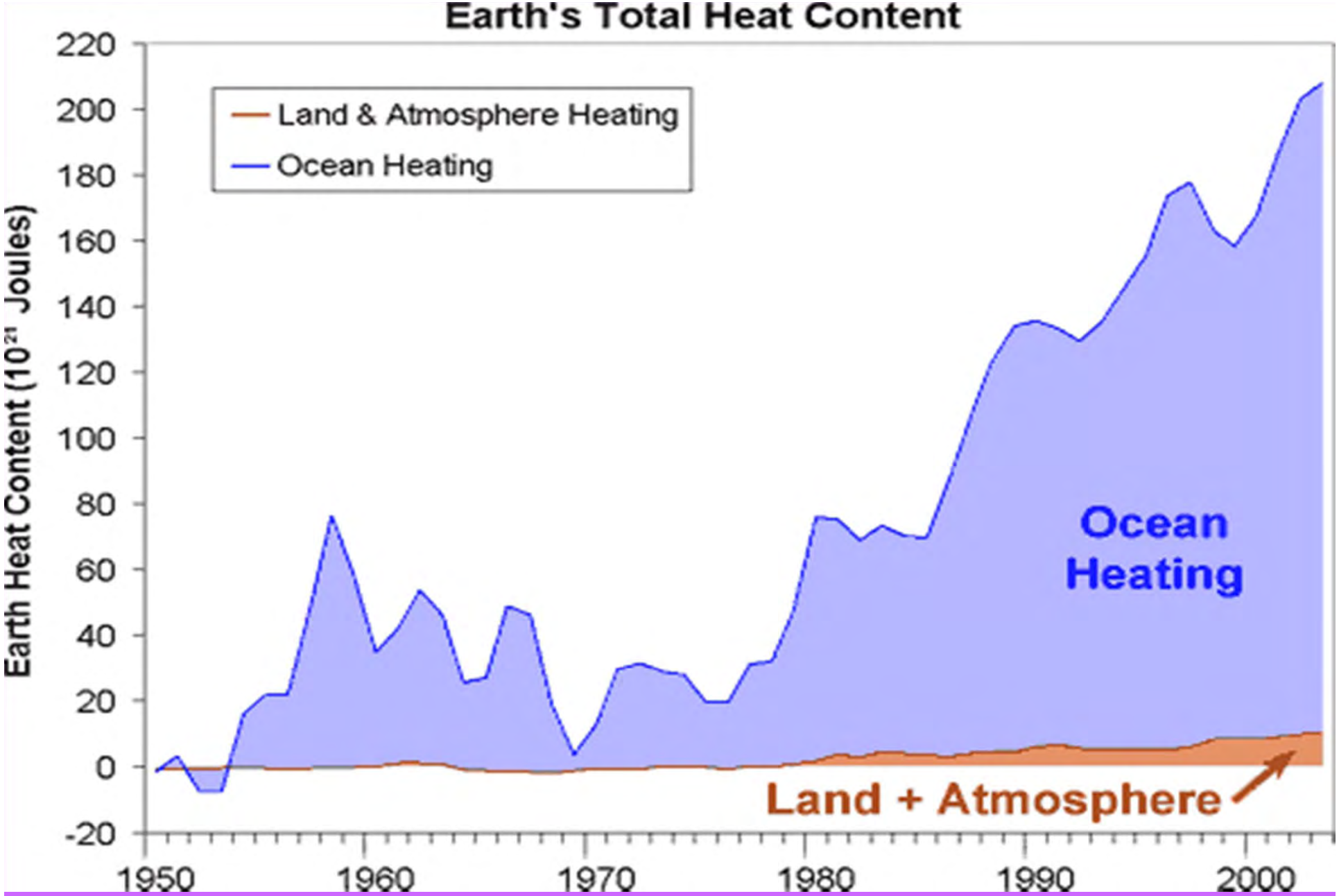

The Atmosphere is very
small

Comparison of the heat balance of the climate system

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

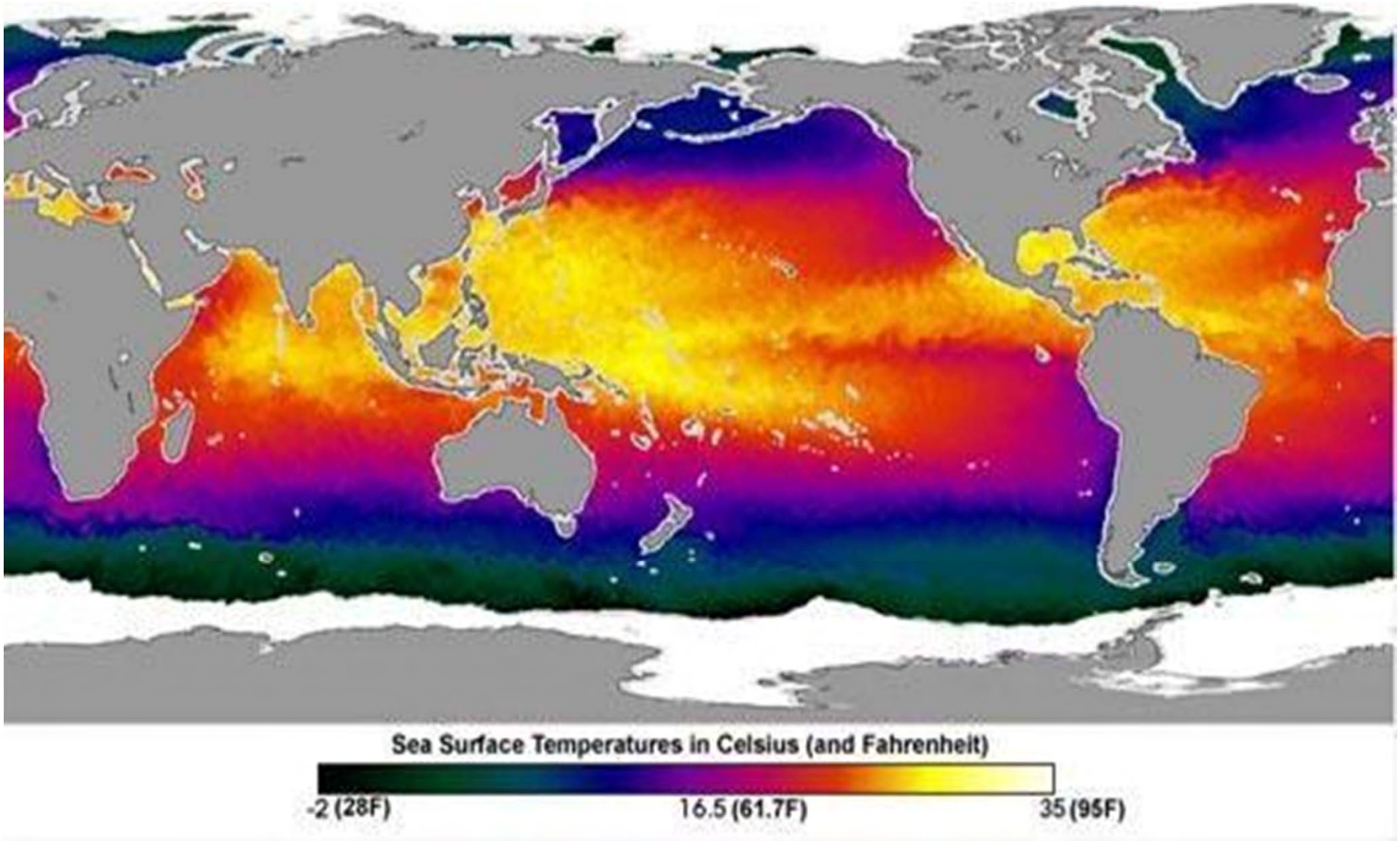
Component of the climate system and source of data	Time period of change	Observed or estimated change	Heat content increase or total heat of fusion	%
World ocean	1955-1996	Observed temperature increase	18.2×10^{22} J	90
Global atmosphere	1955-1996	Observed temperature increase	6.6×10^{21} J	3
Decrease 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

90%

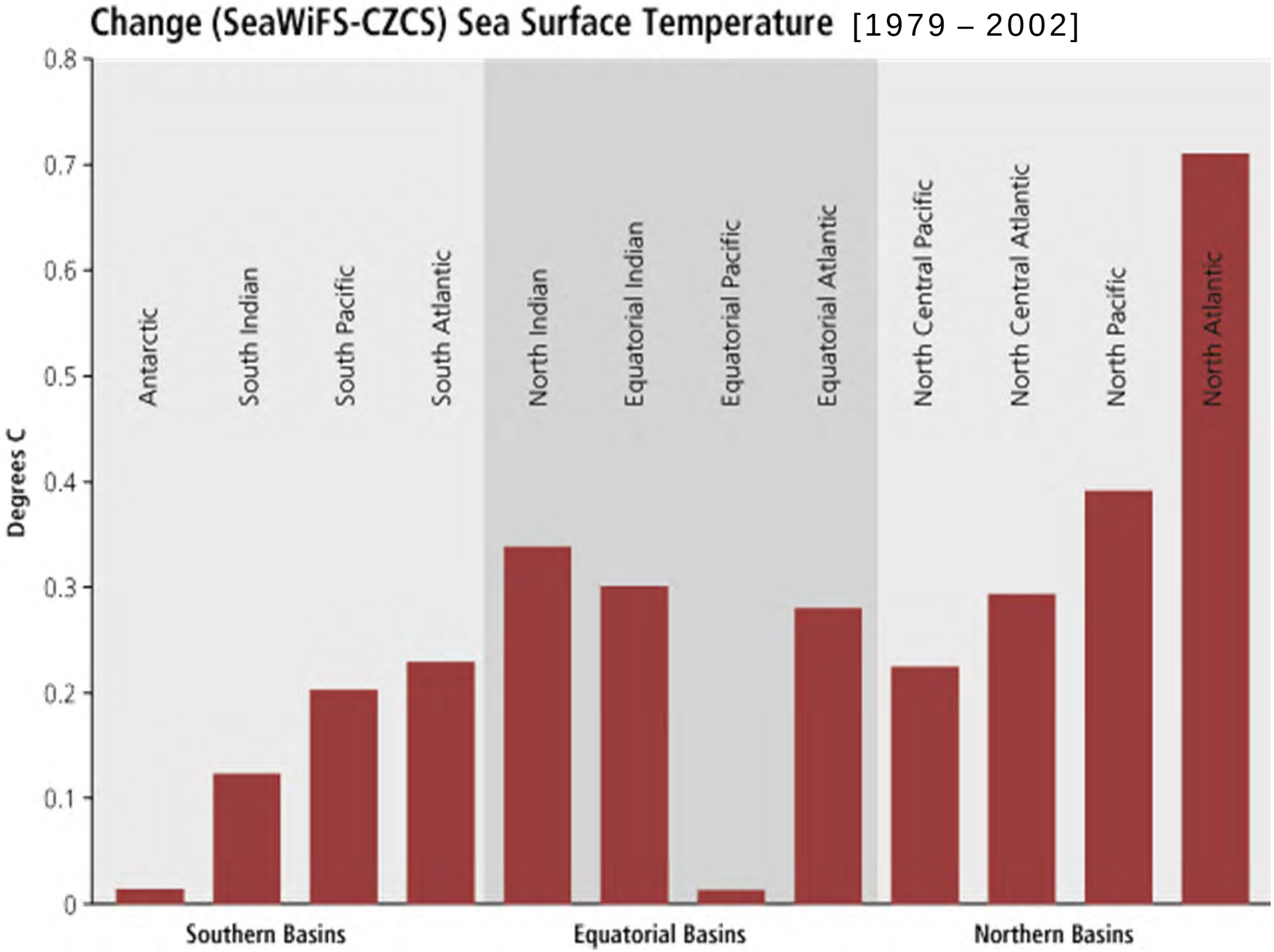


Data From Murphy et al 2009, Domingues et al 2008
Graph from http://www.skepticalscience.com/

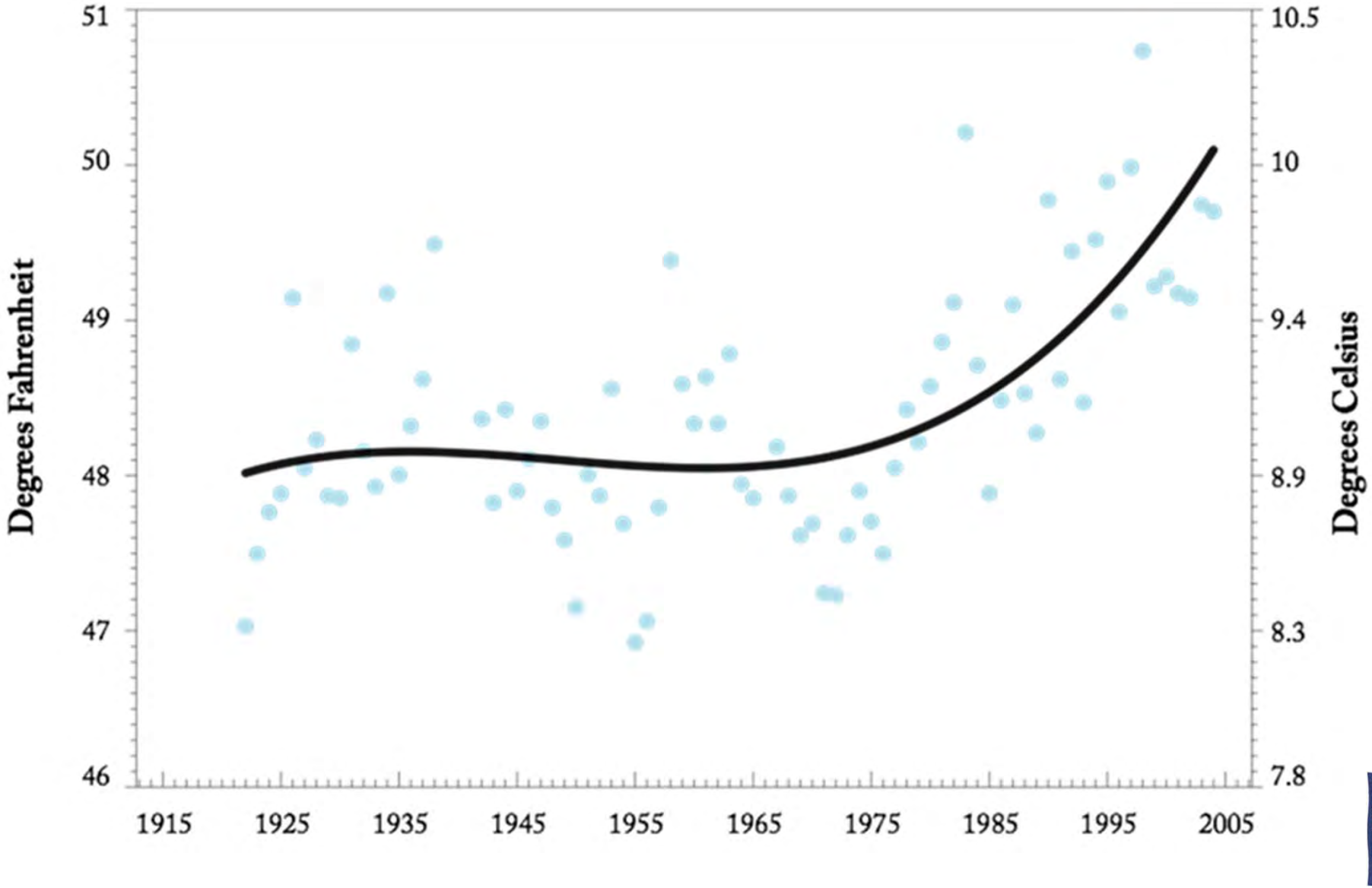
OCEAN SURFACE TEMPERATURES

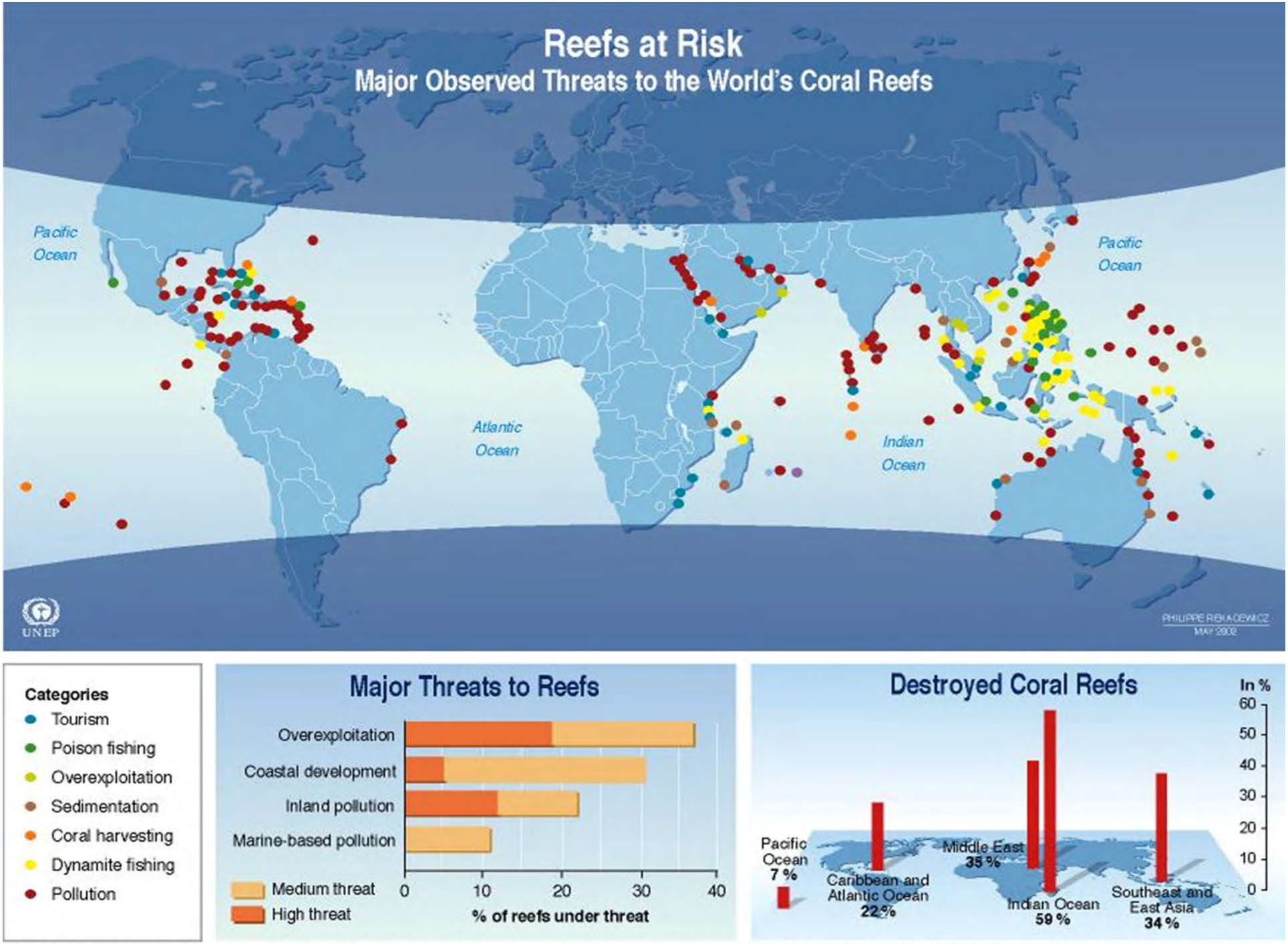


70% OF LAND IS IN NORTHERN HEMISPHERE

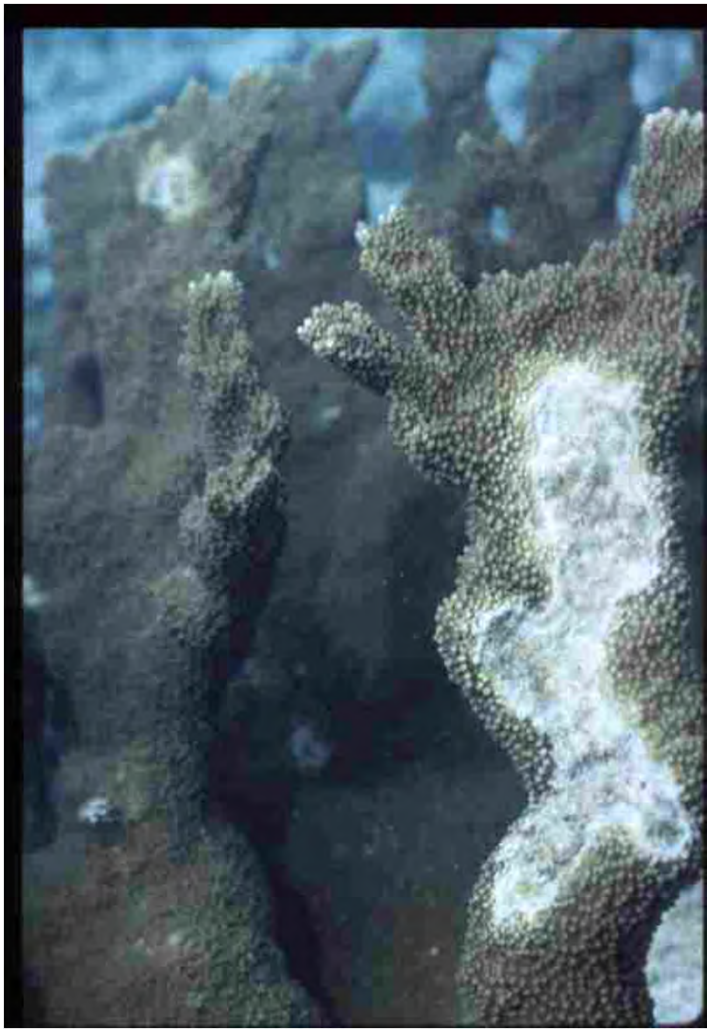

Change (SeaWiFS-CZCS) Sea Surface Temperature [1979 – 2002]
Degrees C
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Antarctic
South Indian
South Pacific
South Atlantic
North Indian
Equatorial Indian
Equatorial Pacific
Equatorial Atlantic
North Central Pacific
North Central Atlantic
North Pacific
North Atlantic
Southern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

Sea Surface Temperature
(Race Rocks lighthouse, Victoria)

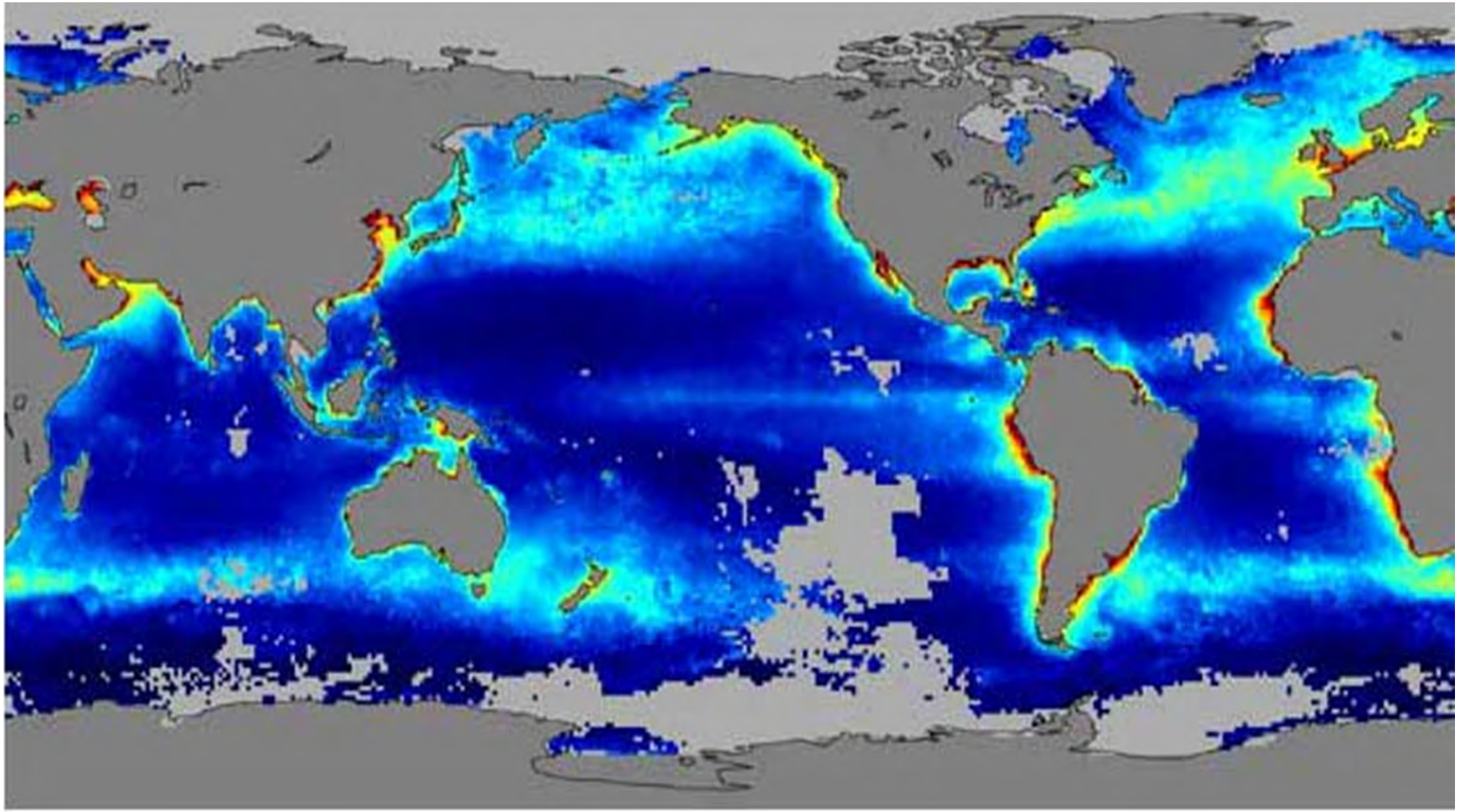




Source: Bryant et al., *Reefs at Risk; a Map-Based Indicator of Threats to the World's Coral Reefs*, World Resources Institute (WRI), Washington DC, 1998.



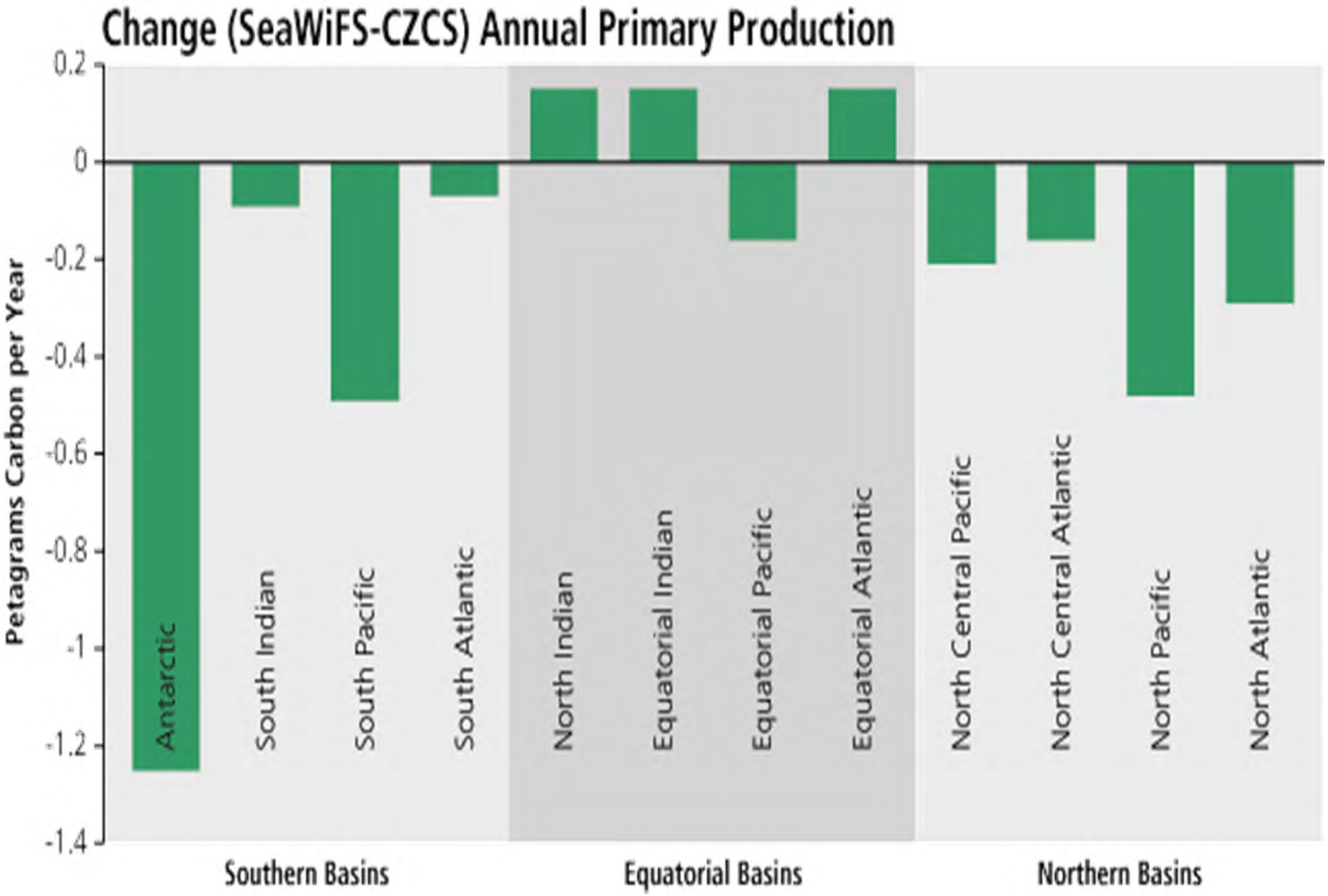
BLEACHING OF CORAL REEFS BY OCEAN TEMPS > 85deg



Net Primary Productivity (grams Carbon per m^2 per year)

0 200 400 600 800

CHANGE IN OCEAN NPP [1979 – 2002]



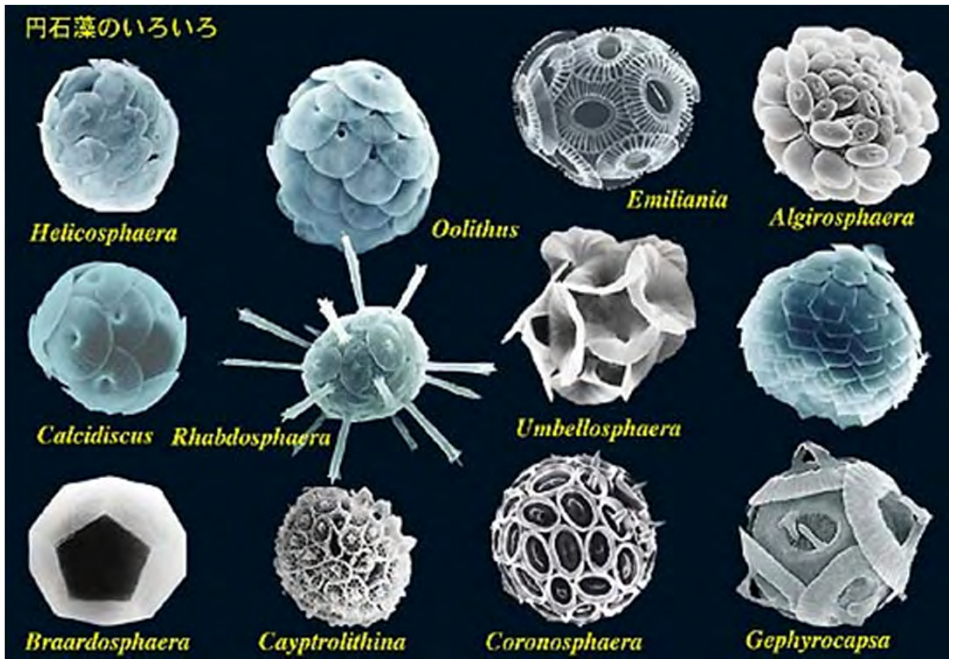
Ocean acidification

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

Corals

Photo: Missouri Botanical Gardens

Calcareous plankton



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)

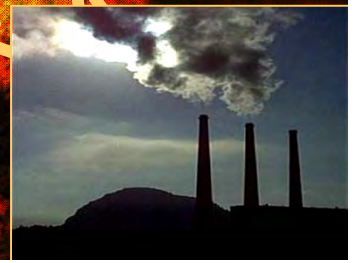
$$CO_2 + H_20 \rightarrow HCO_3^- + H^+$$

(ACID)

Water becomes more acidic.

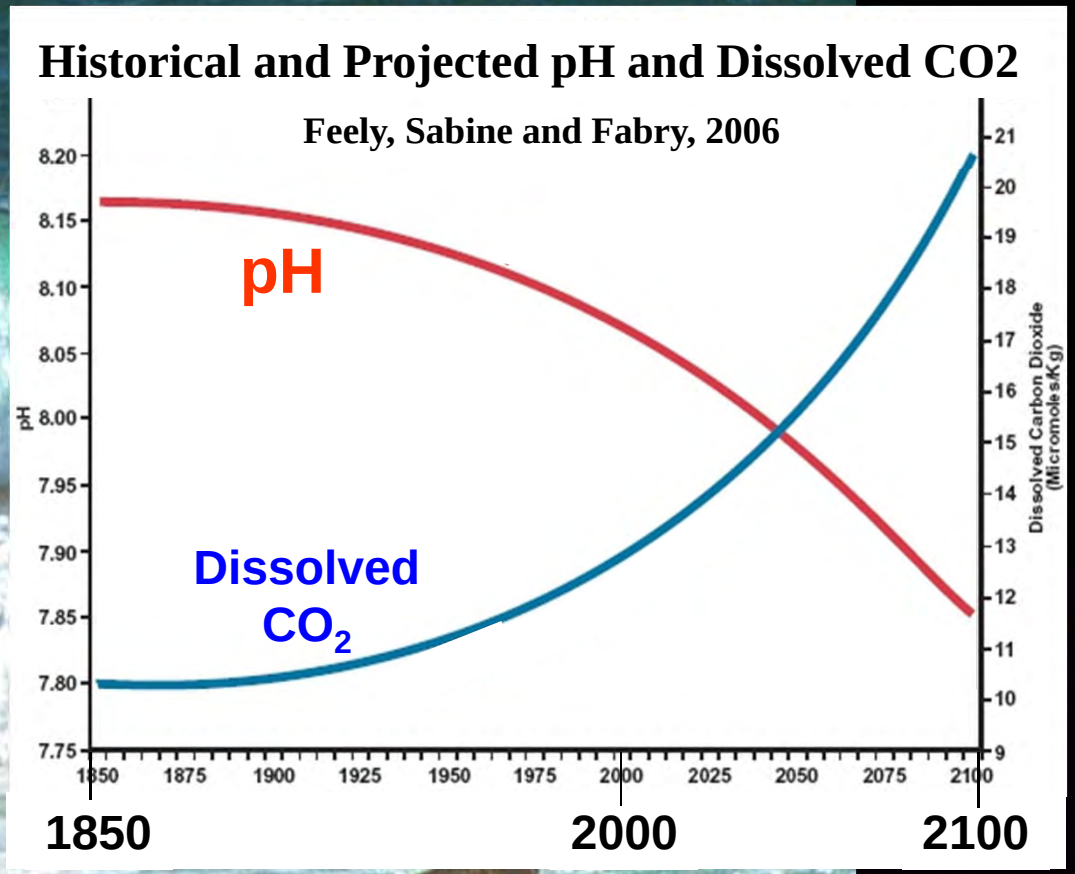
CO_2

CO_2



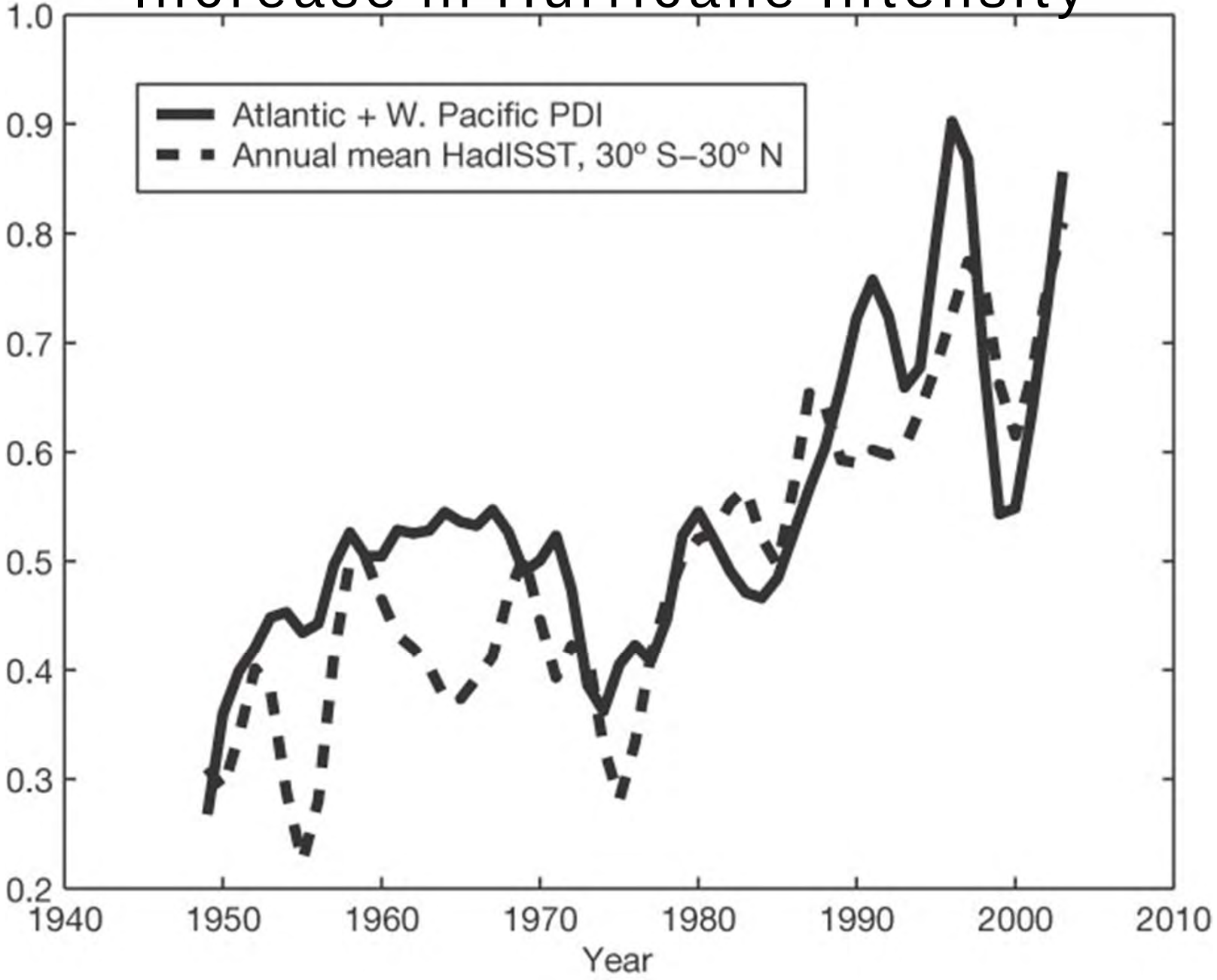
Ocean Acidification

Lower pH = MORE ACID



- Since 1850, ocean pH has decreased by about 0.1 unit (30% increase in acidity). (Royal Society 2006)
- At present rate of CO_2 emission, pH predicted to increase by 0.4 units (3-fold increase in H ions) by 2100.
- Carbonate ion concentrations decrease.

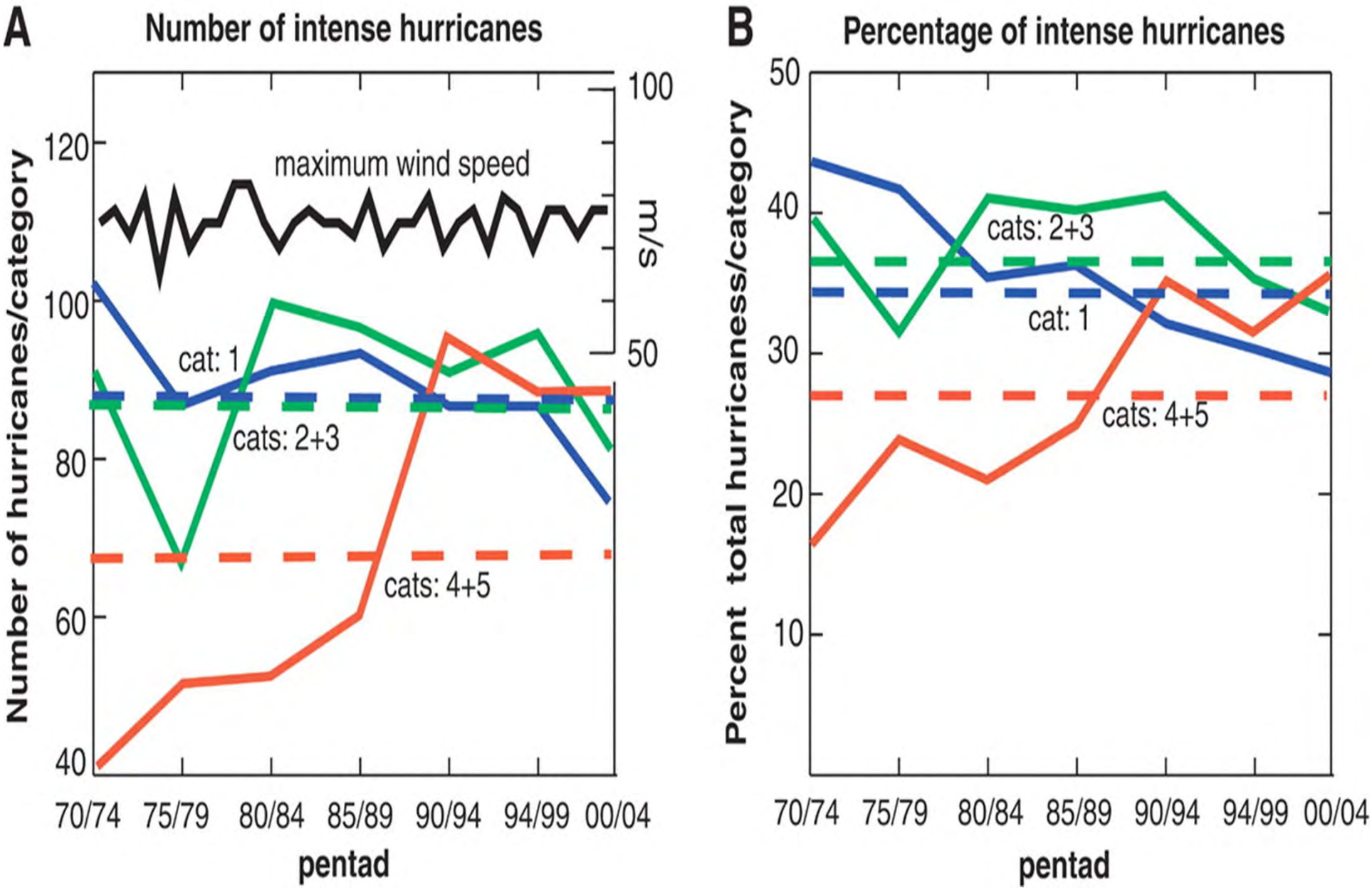
Increase in Hurricane Intensity



PDI = Potential Destructiveness Index

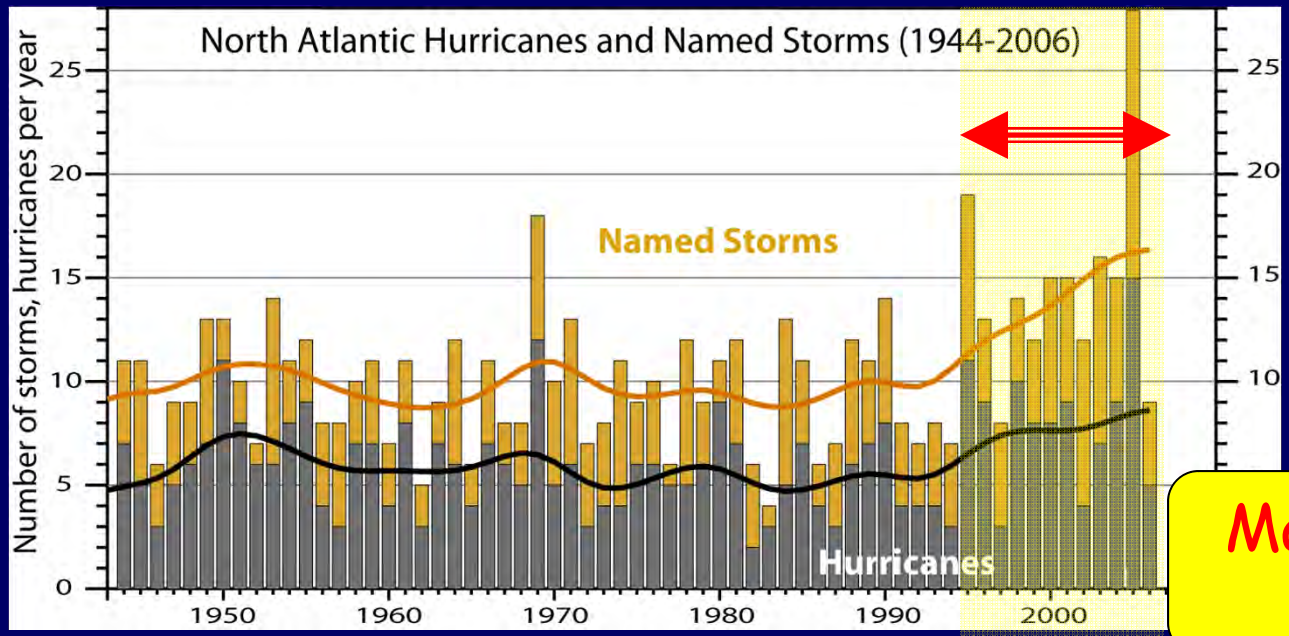
Emanuel, Nature 4 August 2005

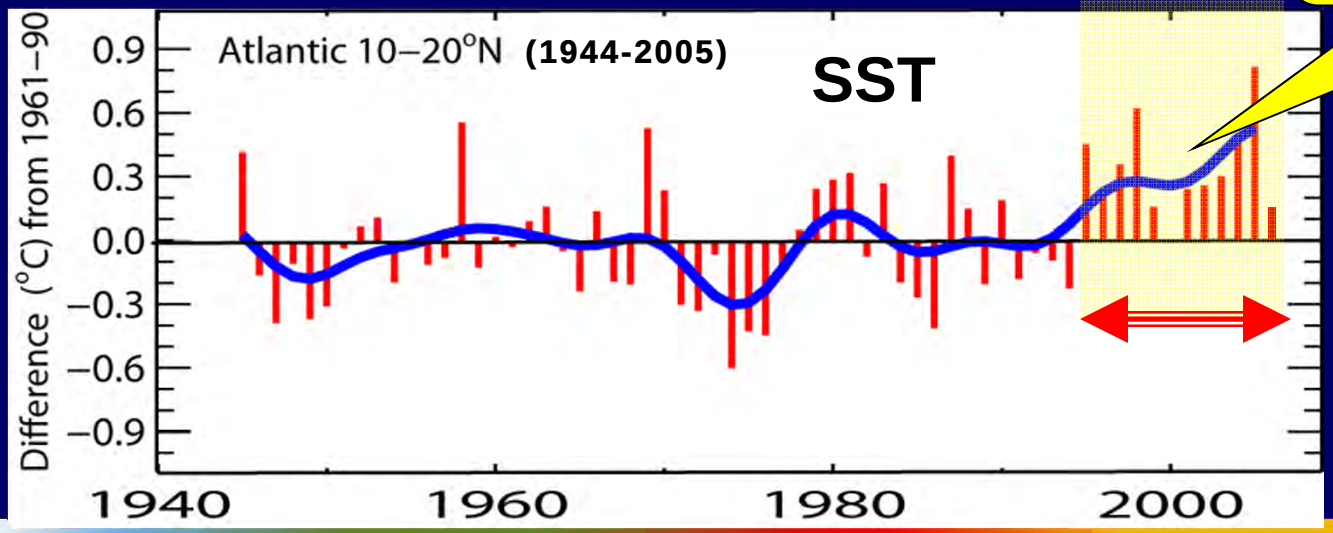
Increase in Category 4-5 Hurricanes 1970 - 2004

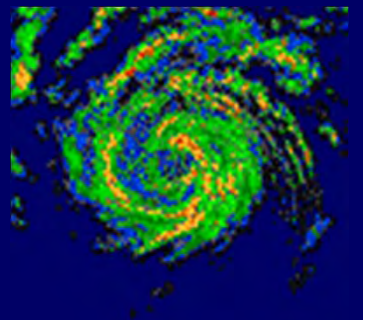


Webster et al, Science, Sept 16 2005

North Atlantic hurricanes have increased with SSTs



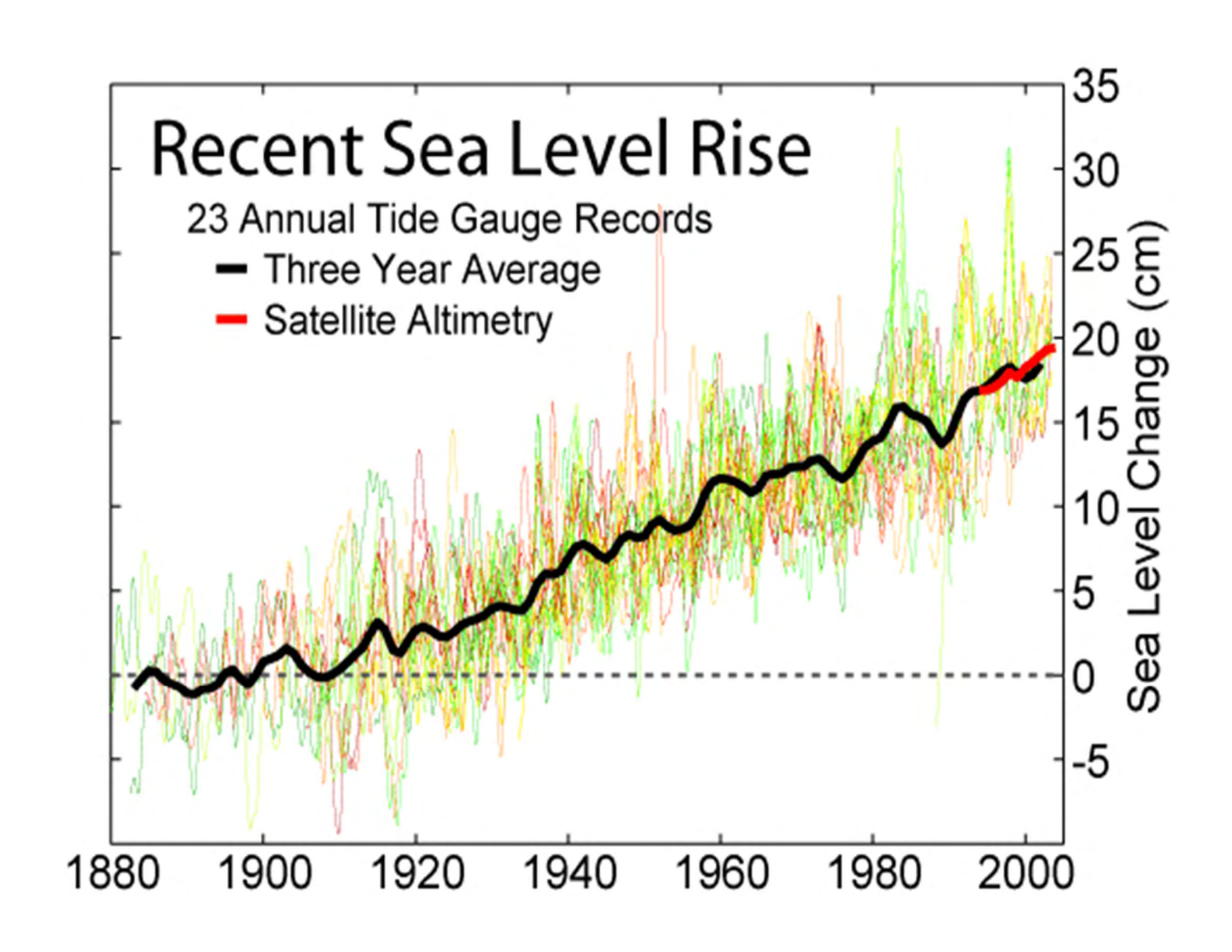




N. Atlantic hurricane record best

Marked increase after 1994

Global number and percentage of intense hurricanes is increasing


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

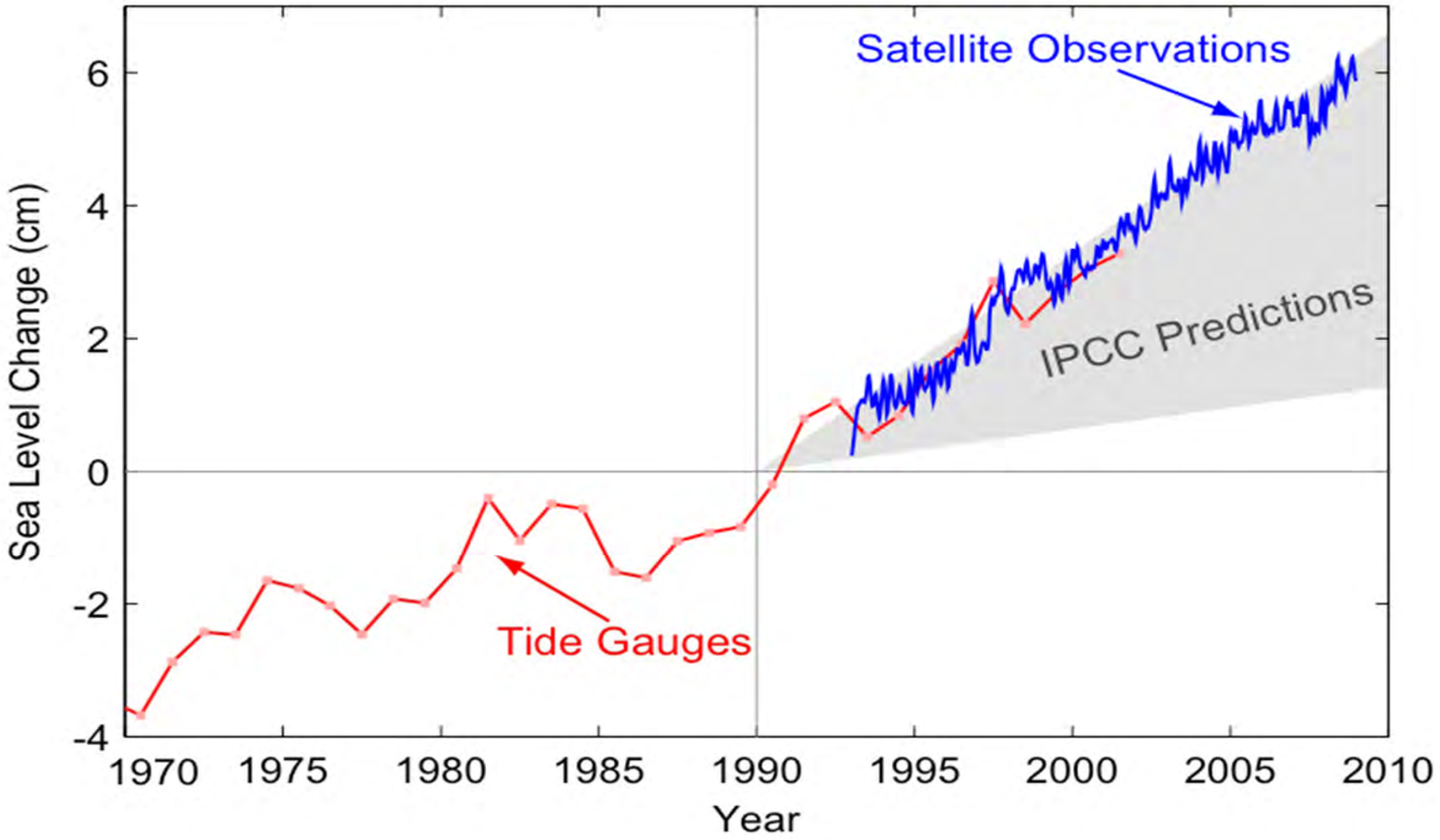


Figure 16: Sea-level change 1970-2010

The Copenhagen Diagnosis
Updating the World on the Latest Climate Science

http://www.copenhagendiagnosis.com/

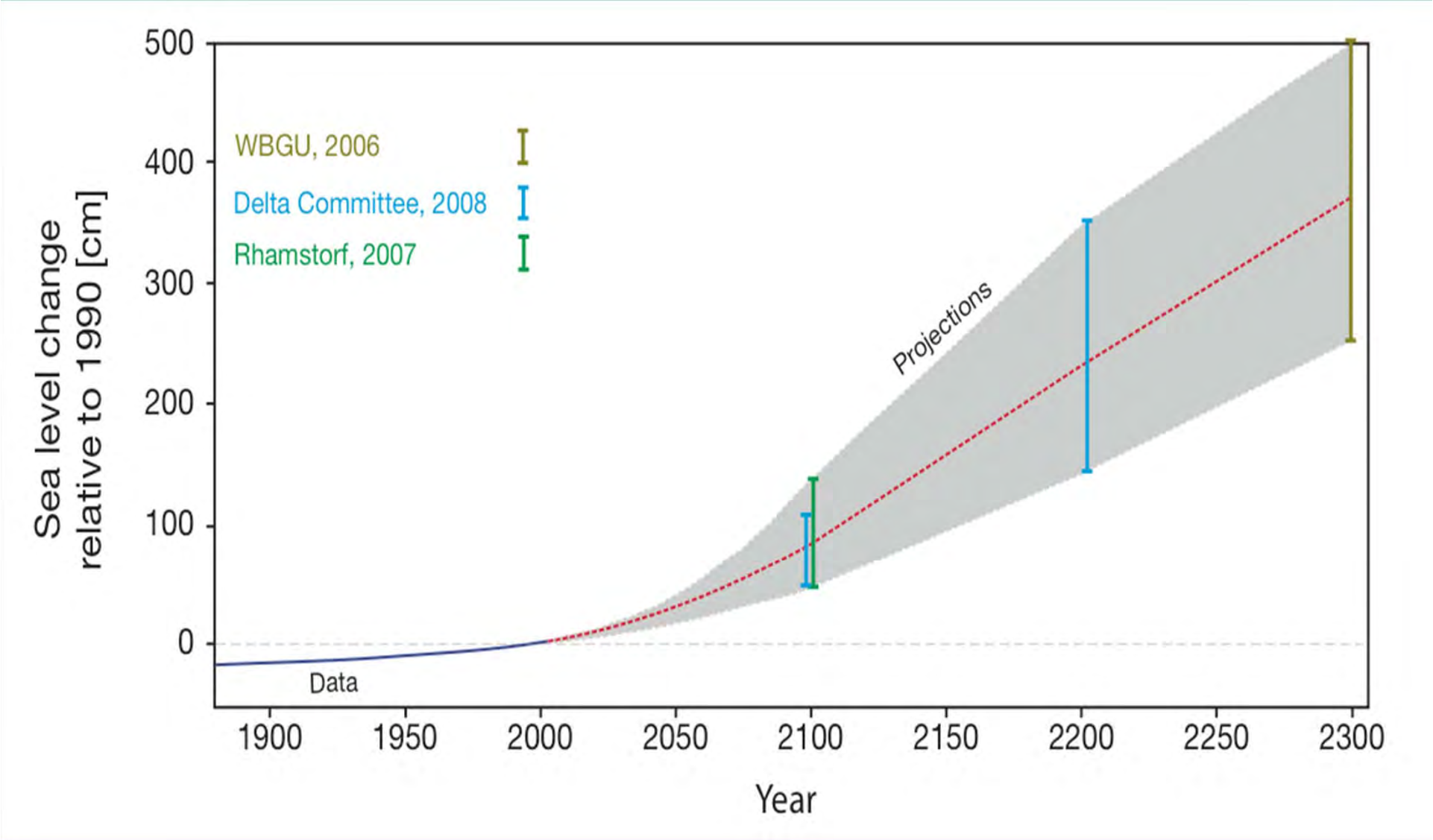
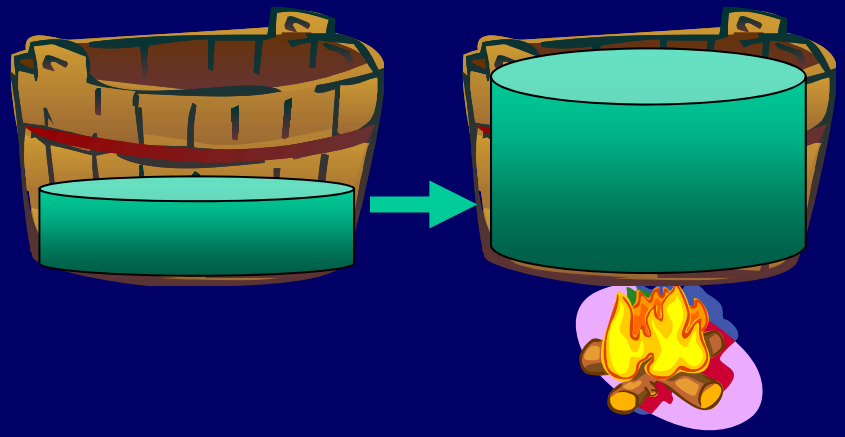


Figure 17: Past and future sea-level projections

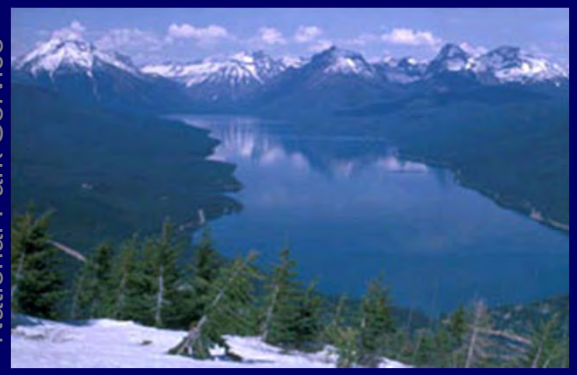
The Copenhagen Diagnosis
Updating the World on the Latest Climate Science

http://www.copenhagendiagnosis.com/

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.

Sea-level Rise Projections DO NOT Include:

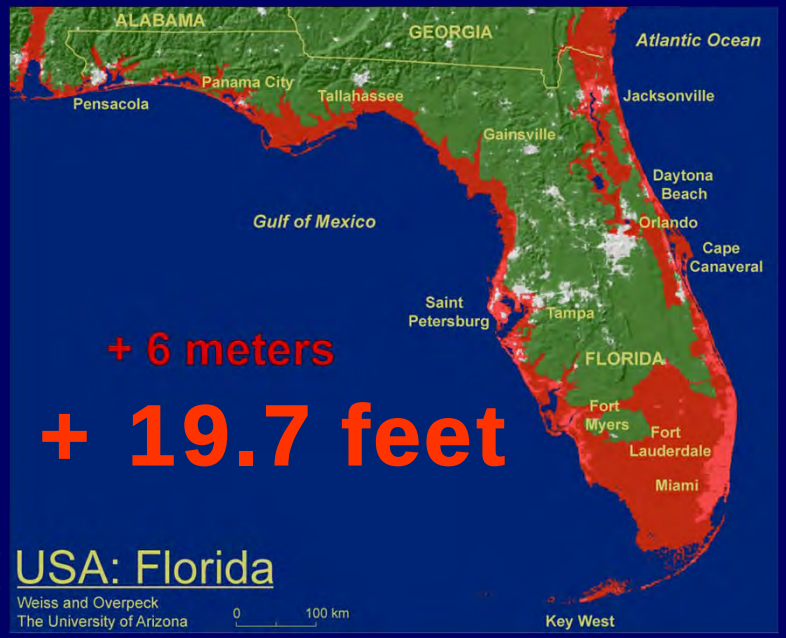
Photo Roger Braithwaite

iStockphoto.com

- Ice sheet instability
- Carbon dioxide uptake changes

IPCC: “Larger values cannot be excluded, but understanding of these effects is too limited to assess their likelihood or provide a best estimate or an upper bound for sea-level rise.”

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



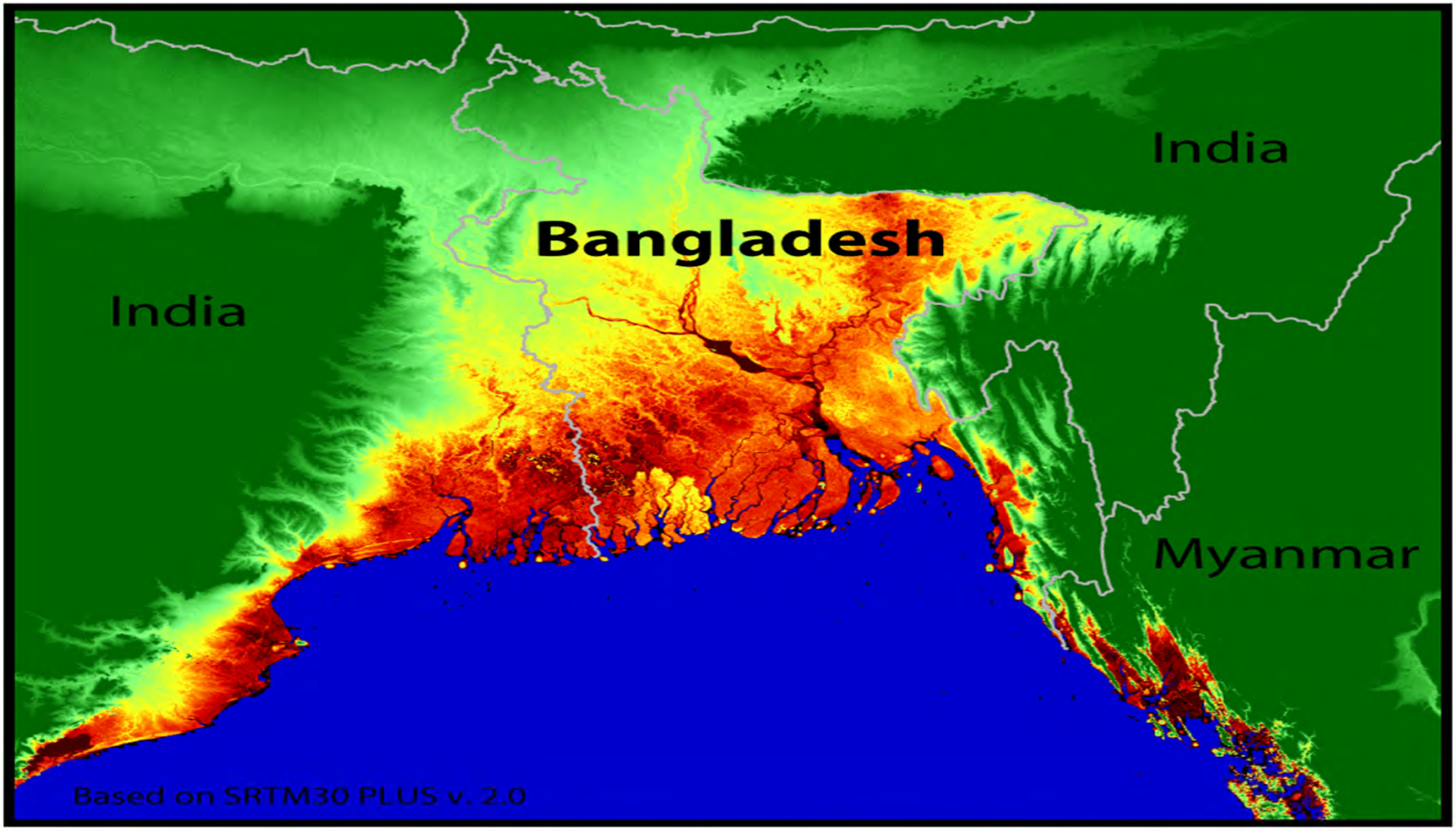
Weiss and Overpeck U. Arizona

Threshold risks:

Some models do suggest that sustained warming between 2-7°F above today's global average temperature would initiate irreversible melting of the Greenland ice sheet—which could ultimately contribute about **23 *feet*** to sea-level rise.

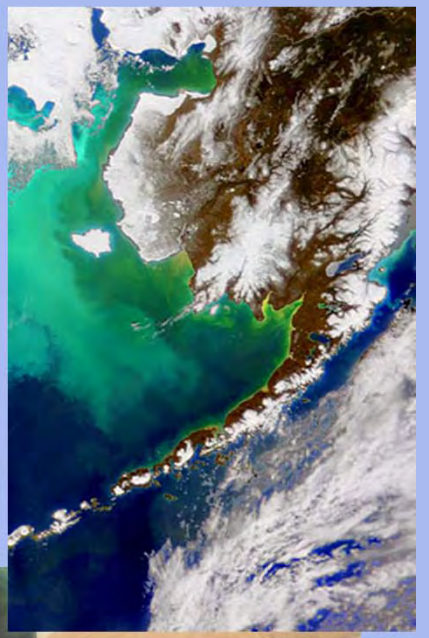
Source: IPCC *Climate Change 2007: The Physical Science Basis*—Summary for Policymakers.

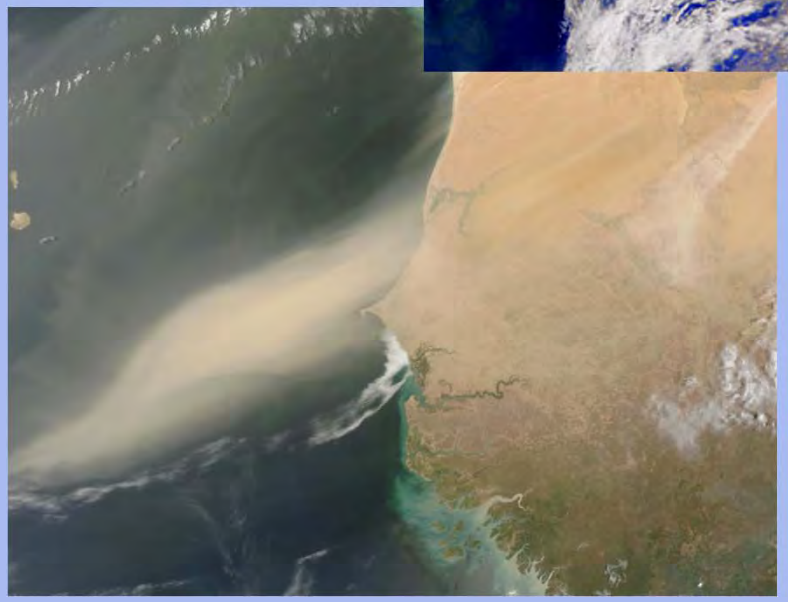
Sea Level Risks - Bangladesh



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?

NOPE!

- **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."