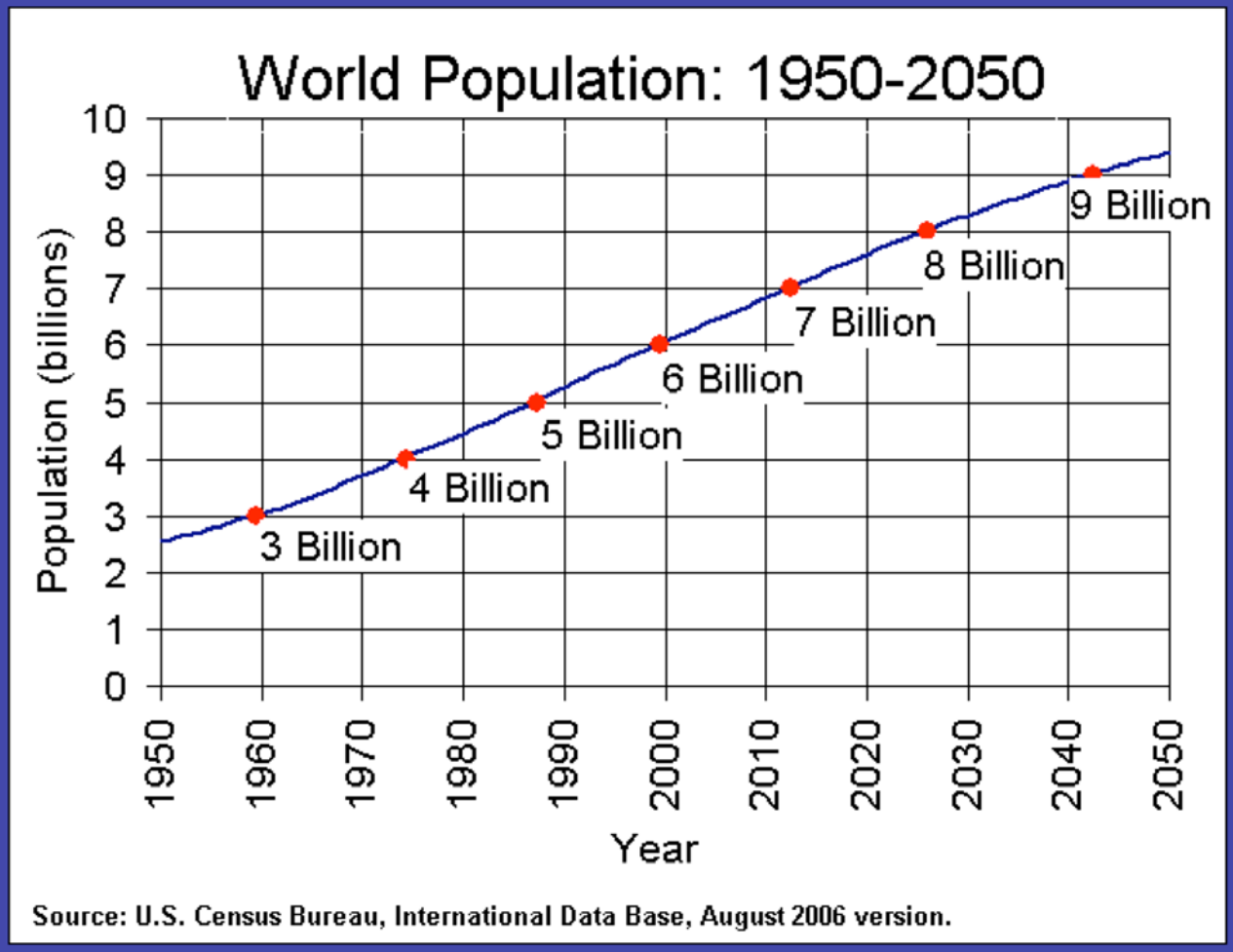
How many humans can our planet support?

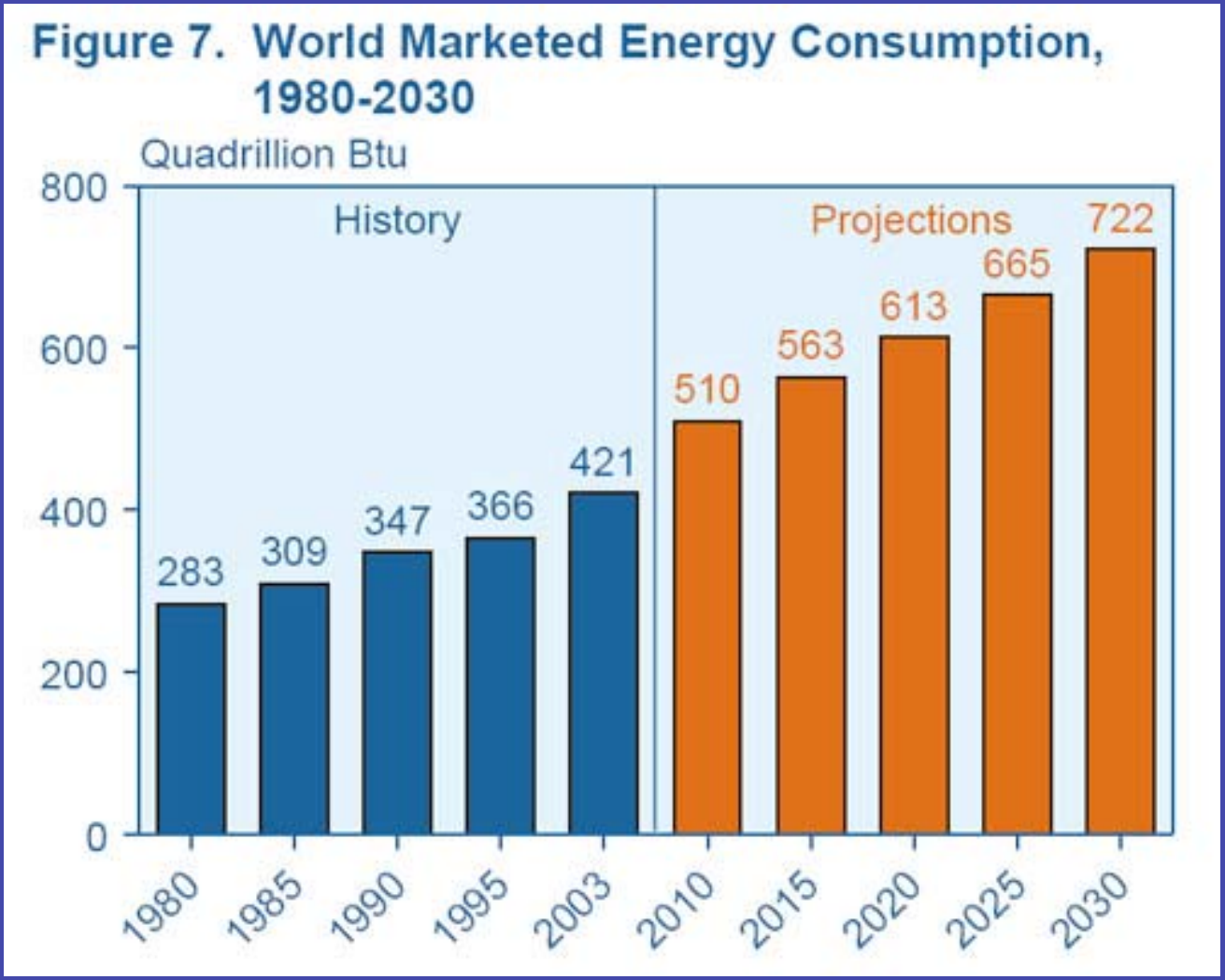


Earth's population today = 6.56 billion

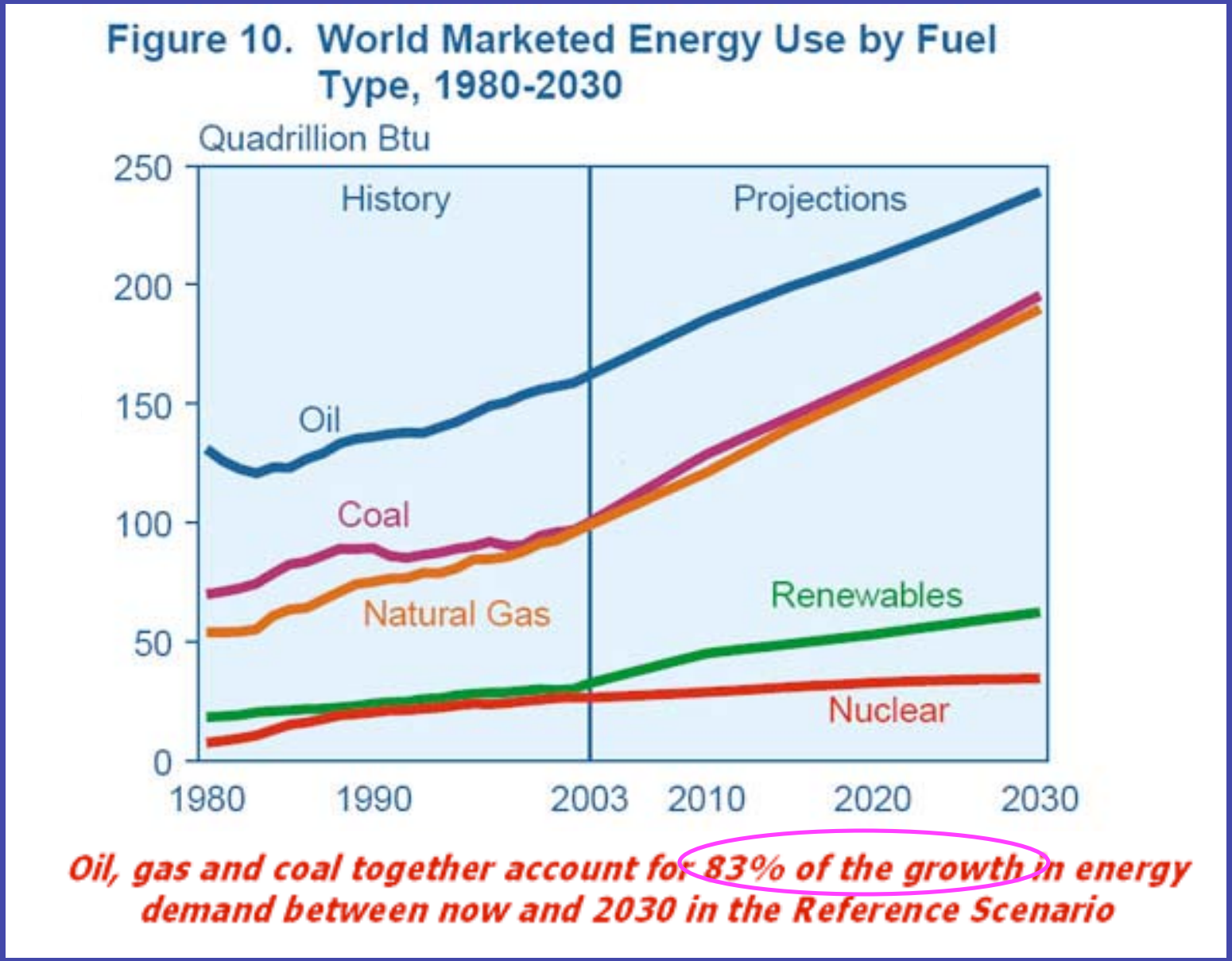


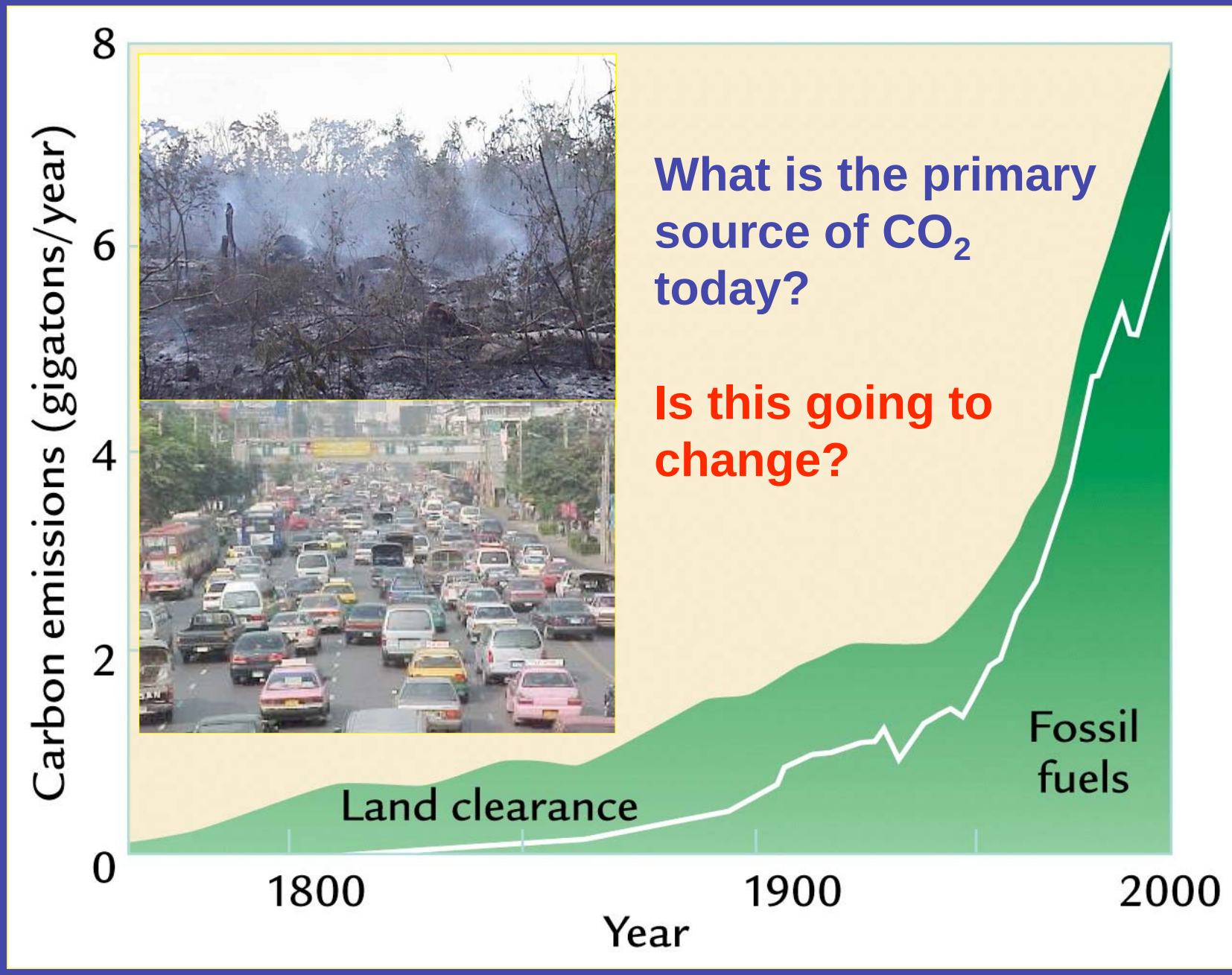
How many people will Earth hold in our lifetimes?

How does energy consumption compare to population growth?

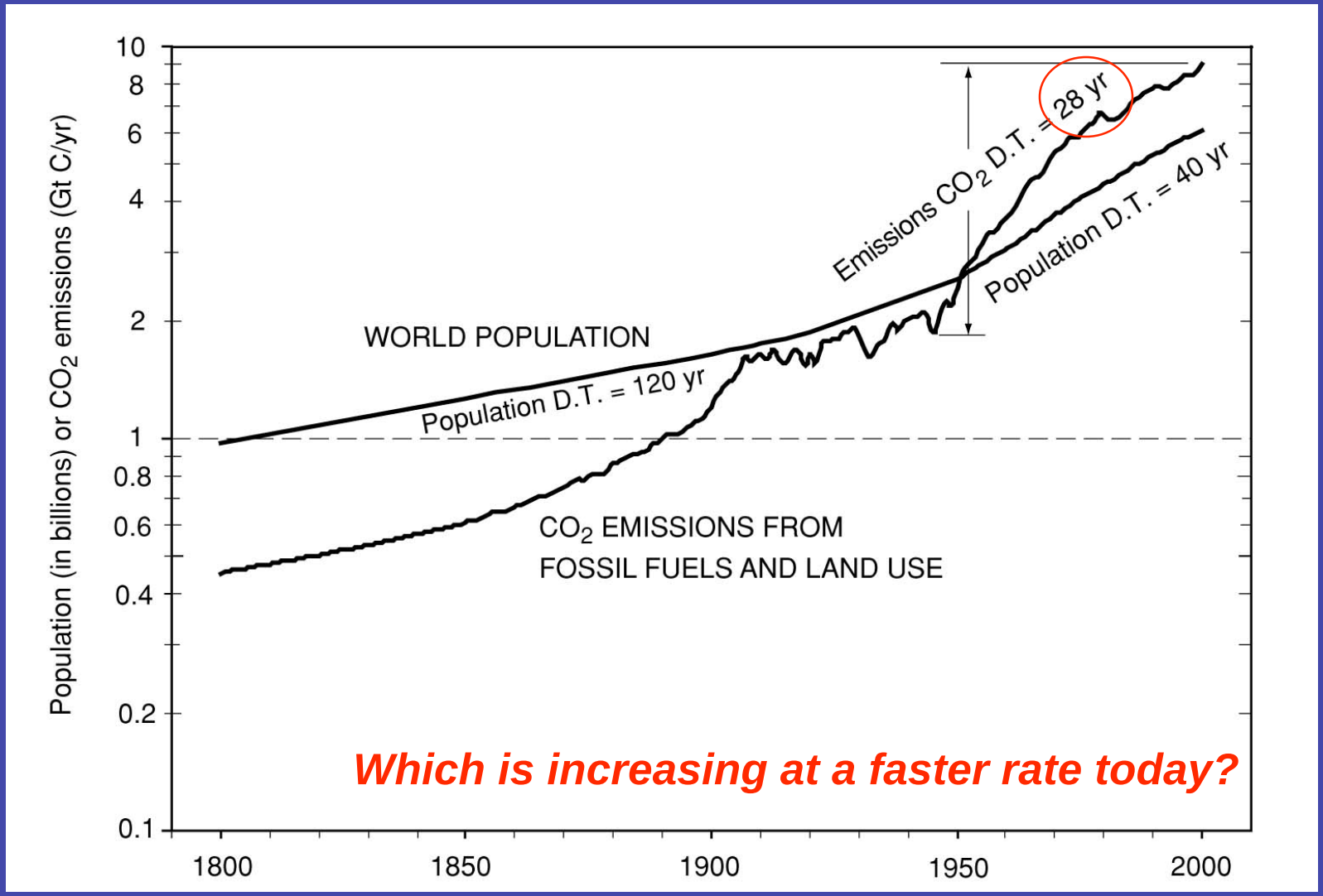


85% of world's commercial energy today from coal, oil and gas




What is the primary source of CO_2 today?
Is this going to change?
Carbon emissions (gigatons/year)
8
6
4
2
0
1800
1900
2000
Year
Land clearance
Fossil fuels

Historic world population and CO_2 emissions



Who is burning these fossil fuels?















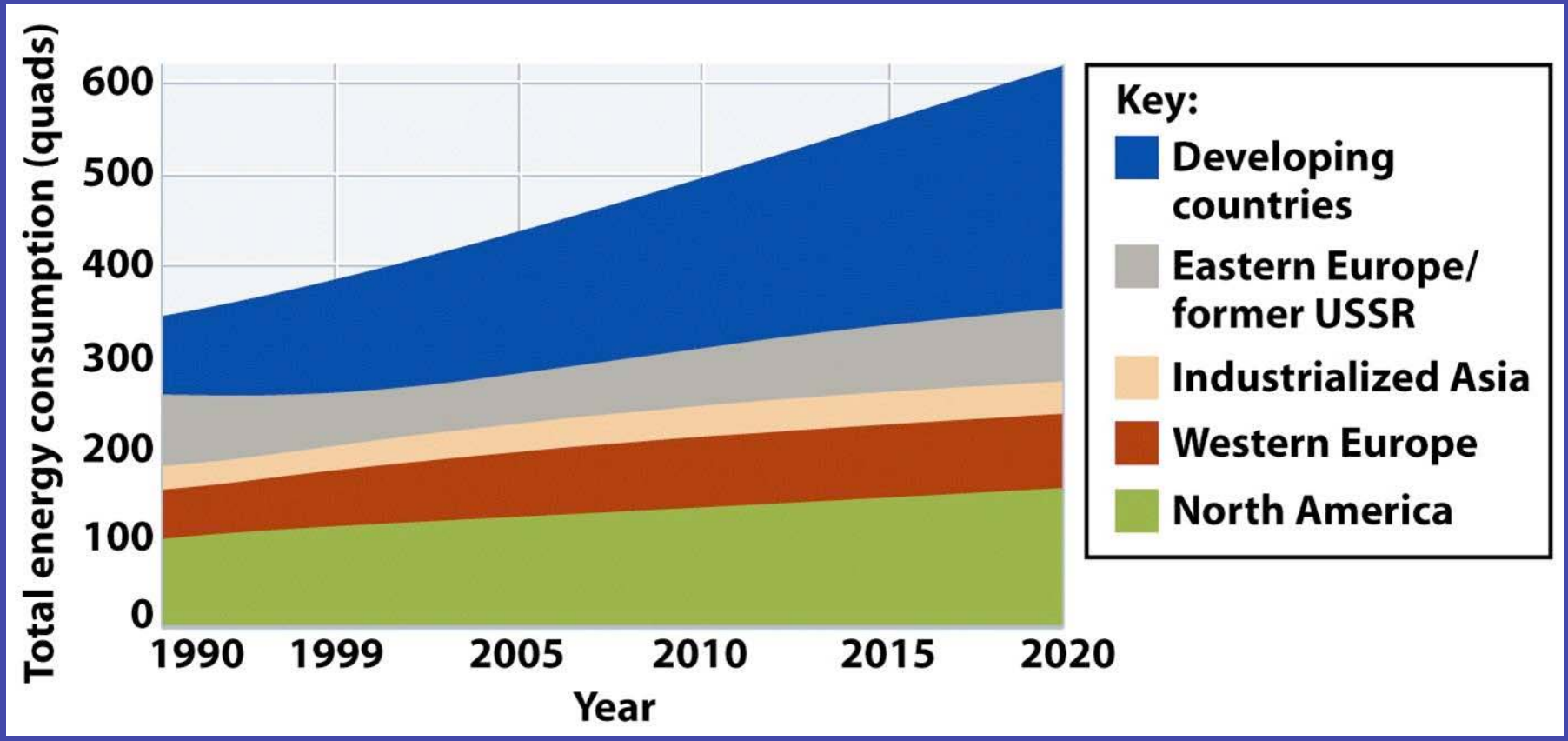
Energy Statistics > Oil consumption by country

VIEW DATA: **Totals** | Per capita | Definition | Source | Printable

Bar Graph | Pie Chart | Map | Corre

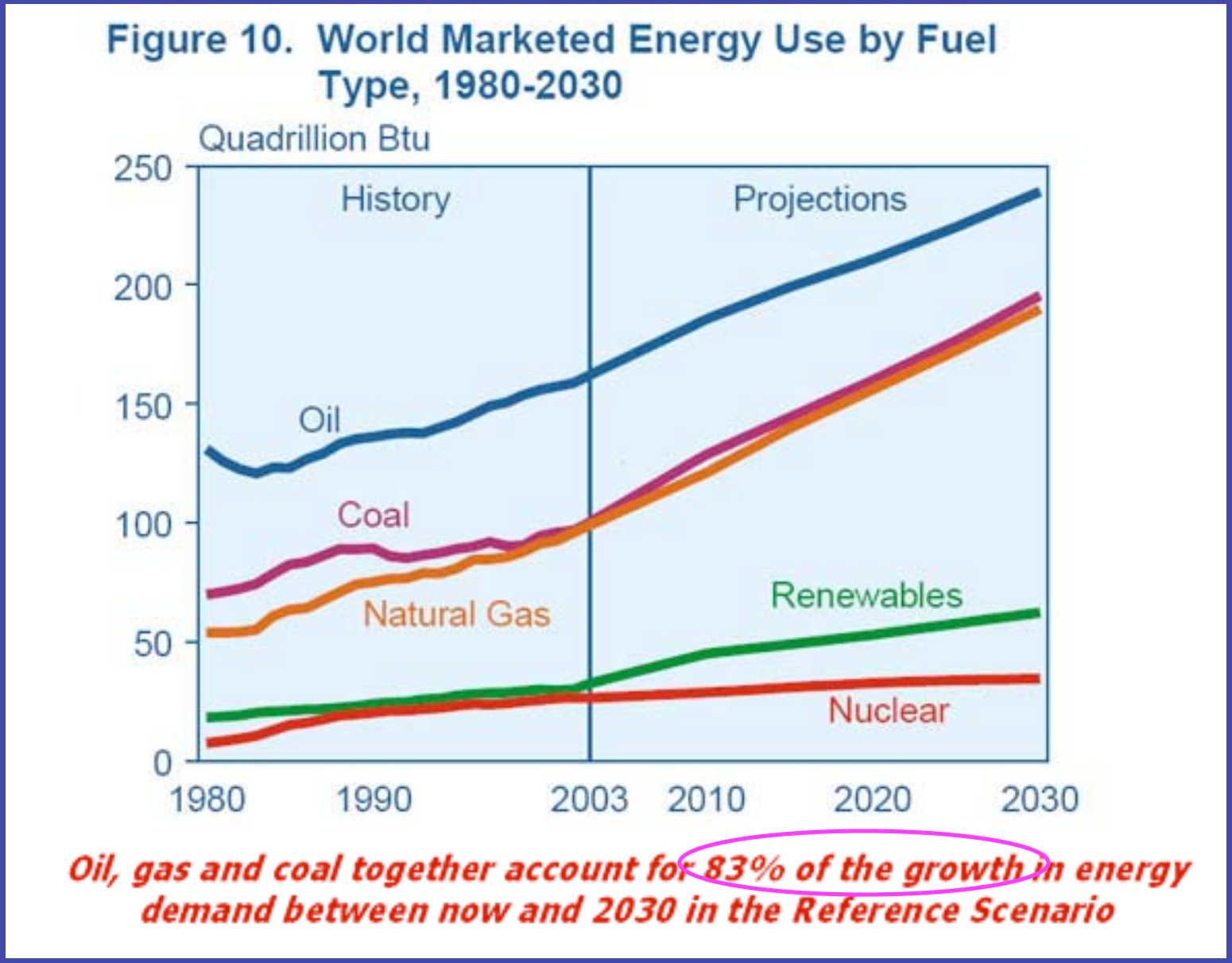
Rank	Countries	Amount (top to bottom)
#1	United States	20,030,000 barrels per day
#2	China	6,391,000 barrels per day
#3	Japan	5,578,000 barrels per day
#4	Russia	2,800,000 barrels per day
#5	Germany	2,677,000 barrels per day

3x

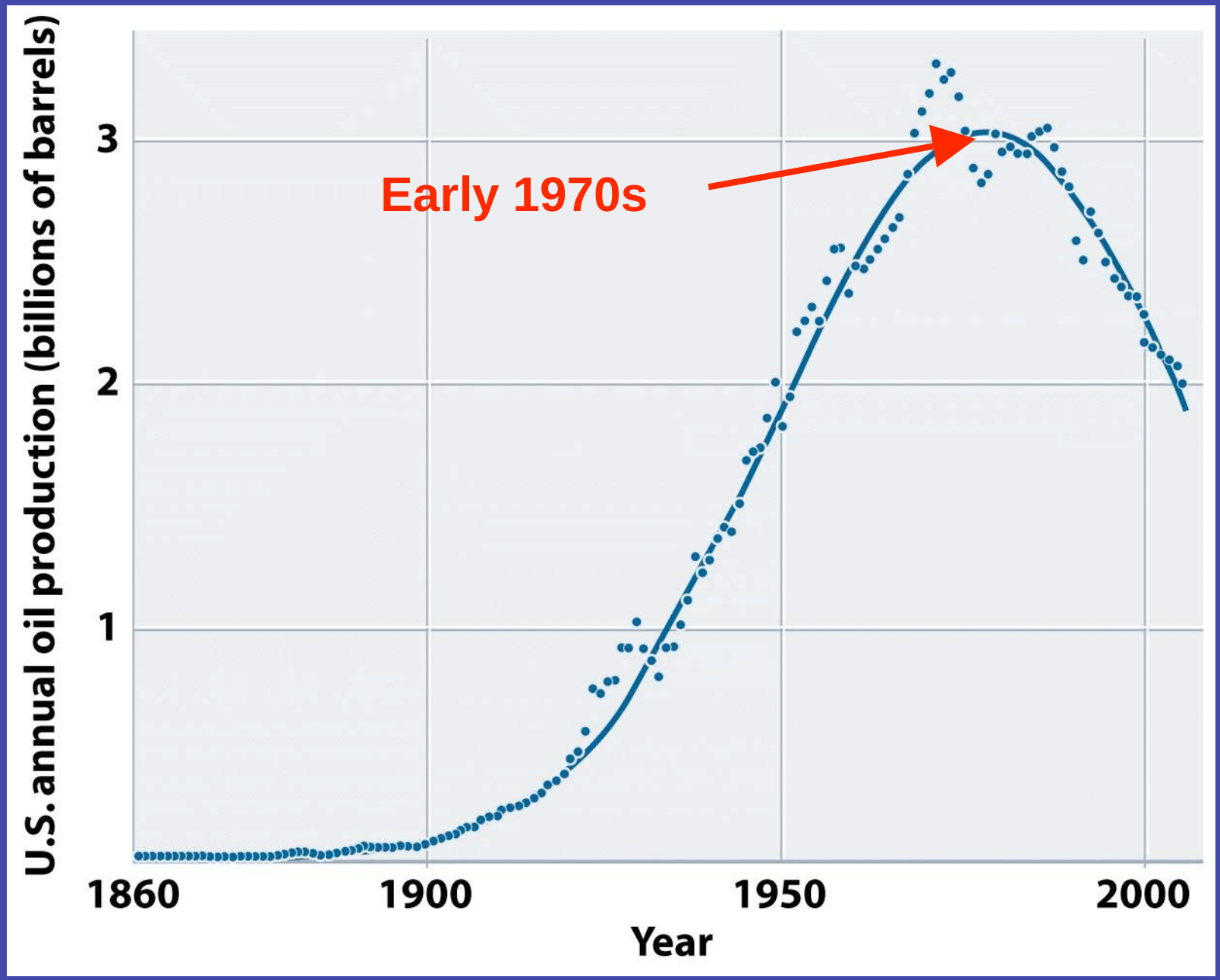

Total energy consumption (quads)
600
500
400
300
200
100
0
1990
1999
2005
2010
2015
2020
Year
Key:
Developing countries
Eastern Europe/ former USSR
Industrialized Asia
Western Europe
North America



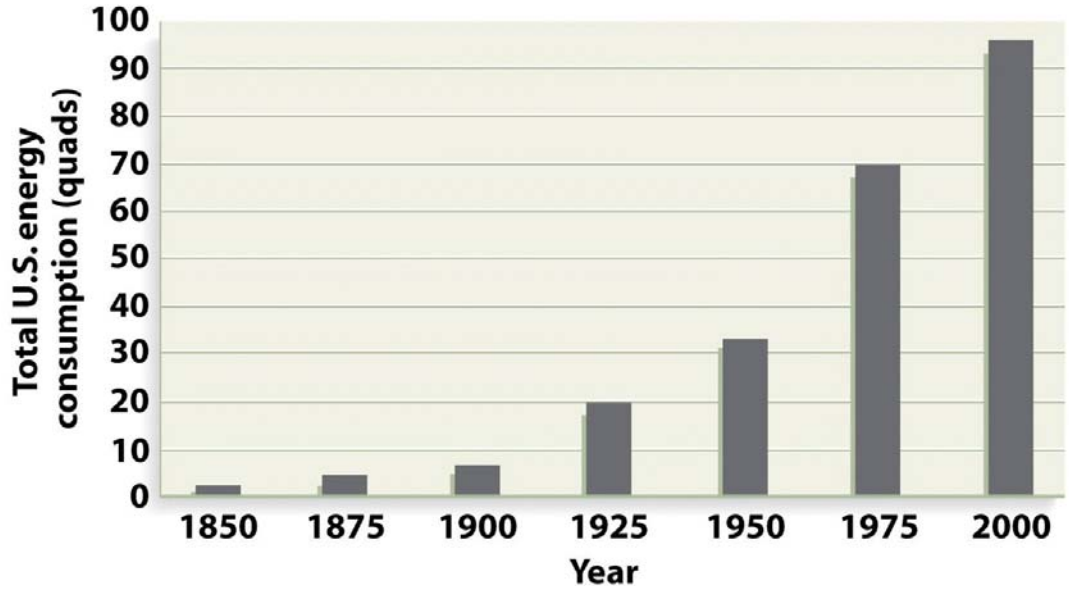
85% of world's energy today from fossil fuels, MORE in future

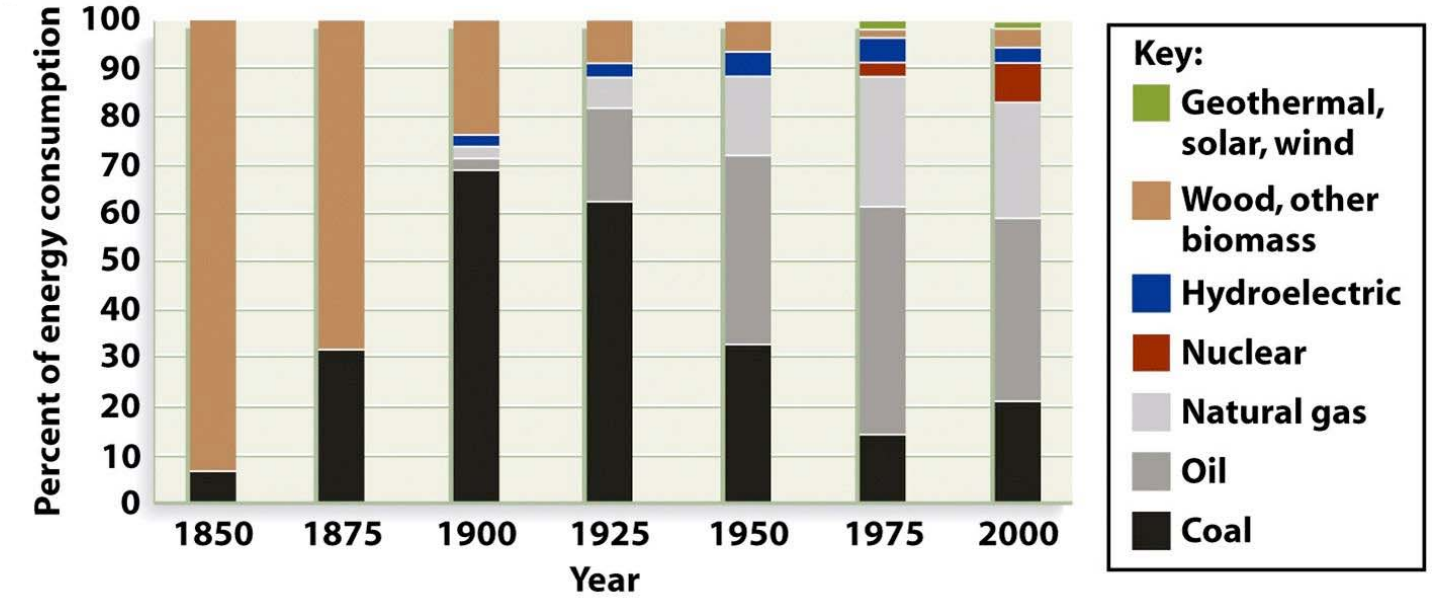


In 1956, Hubbert correctly predicted the peak in US oil production



Is U.S. fossil fuel consumption decreasing?





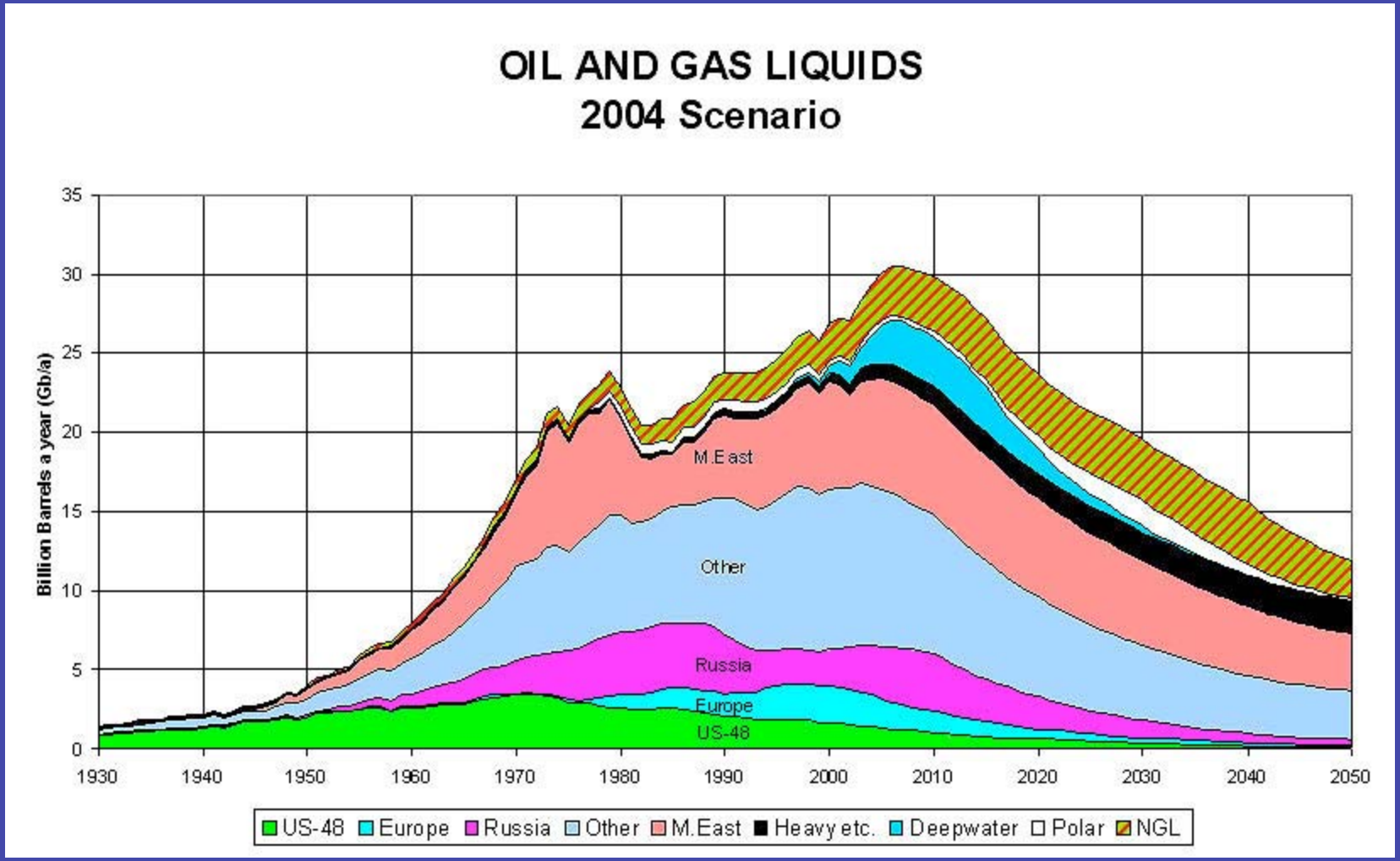
World Oil Production

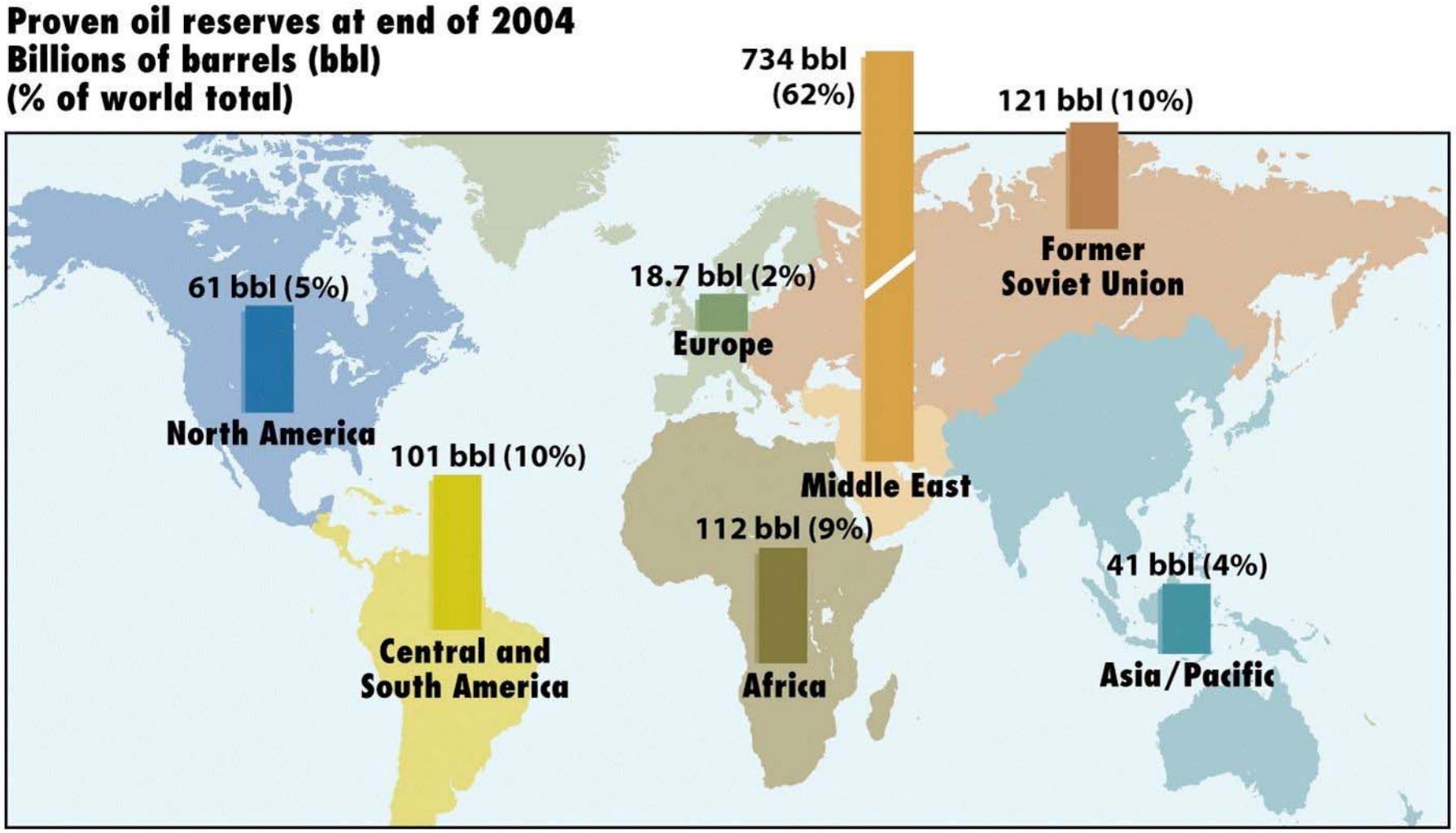






What is the effect of “Peak Oil” going to be on our planet?





Who controls the world's oil?

Greatest Oil Reserves by Country, 2006

Rank	Country	Proved reserves (billion barrels)
1.	Saudi Arabia	264.3
2.	Canada	178.8
3.	Iran	132.5
4.	Iraq	115.0
5.	Kuwait	101.5
6.	United Arab Emirates	97.8
7.	Venezuela	79.7
8.	Russia	60.0
9.	Libya	39.1
10.	Nigeria	35.9
11.	United States	21.4
12.	China	18.3
13.	Qatar	15.2
14.	Mexico	12.9
15.	Algeria	11.4
16.	Brazil	11.2
17.	Kazakhstan	9.0
18.	Norway	7.7
19.	Azerbaijan	7.0
20.	India	5.8

12x

5x

3 year supply

United States has 1:3 production/consumption gap

Energy Statistics > Oil consumption by country

VIEW DATA: Totals | Per capita | Definition | Source | Printable ve

Bar Graph | Pie Chart | Map | Correlat

Rank	Countries	Amount (top to bottom)
#1	United States	20,030,000 barrels per day
#2	China	6,391,000 barrels per day
#3	Japan	5,578,000 barrels per day
#4	Russia	2,800,000 barrels per day
#5	Germany	2,677,000 barrels per day

3x

View the rest of the list (206 more countries) »

P/C gap growing 5% per year

P/C gap cost $192 billion in 2007

($240 billion per year spent in Iraq war so far)
($100 billion to provide universal health care)
($6 billion spent on cancer research)

Why is Hawaii particularly at risk in scenarios like this?







Hawaii has one of the highest rates of per capita oil consumption in the world

2x U.S. average
4x Europe average
28x China average

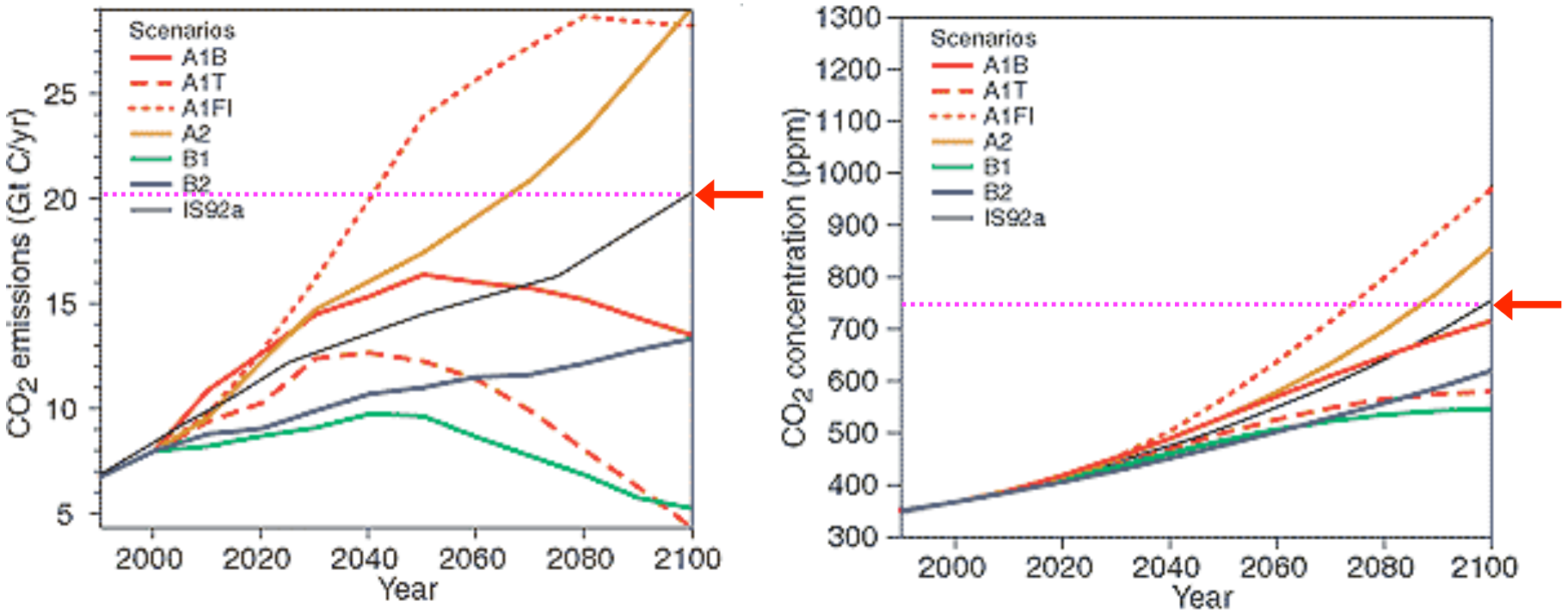
1. transportation and electricity-generating plants

2. airplanes that fuel our tourist-based economy

3. almost all of our food and consumer goods

How are human actions affecting our environment?

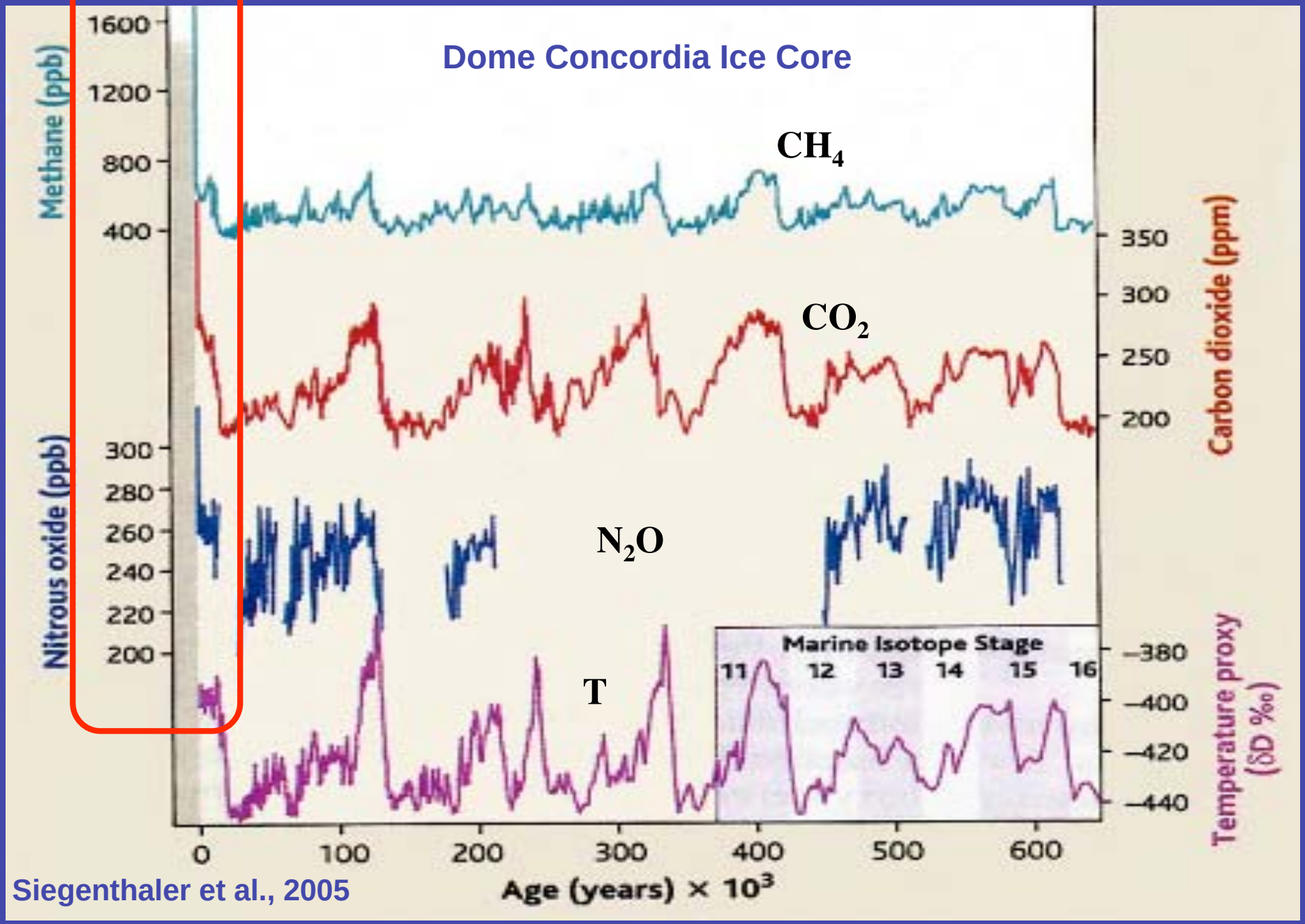
How is atmospheric CO_2 projected to change in our lifetimes?



Intergovernmental Panel on Climate Change, 2001

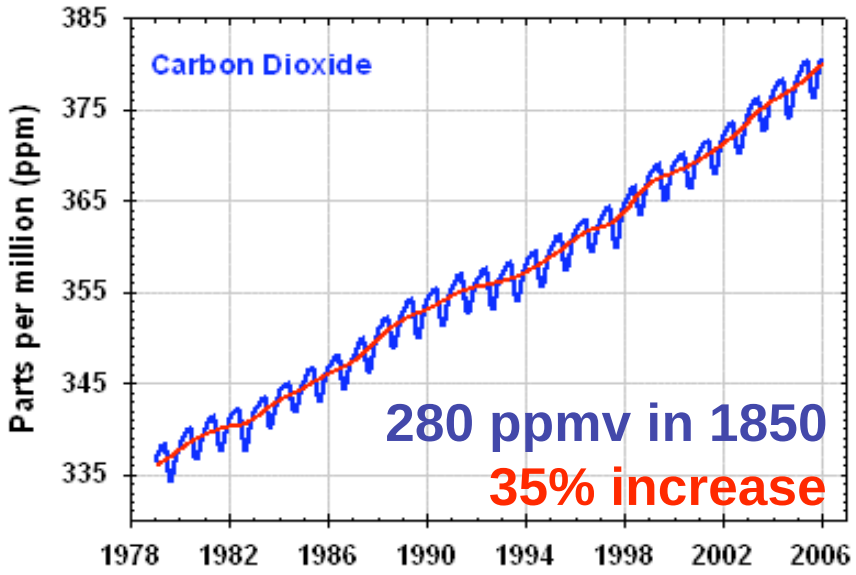
IS92a = "business as usual"

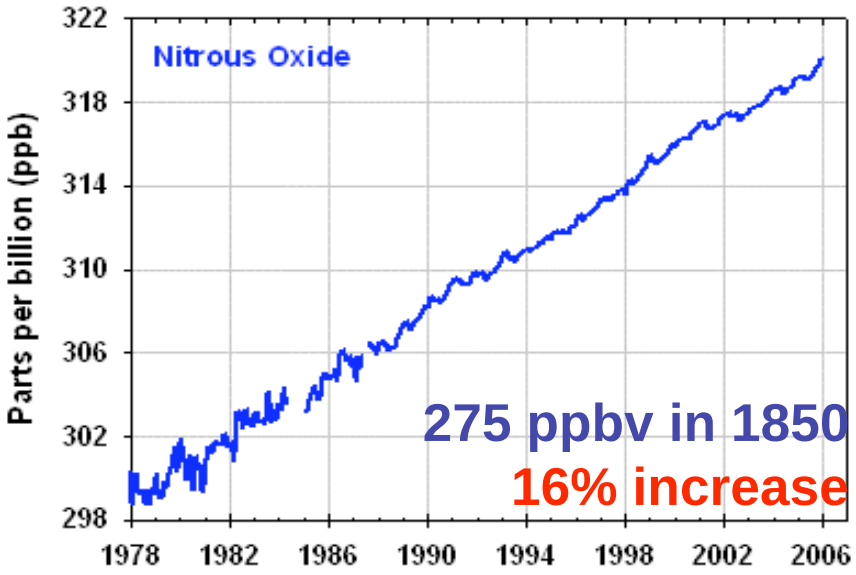
Greenhouse gas concentrations in atmosphere

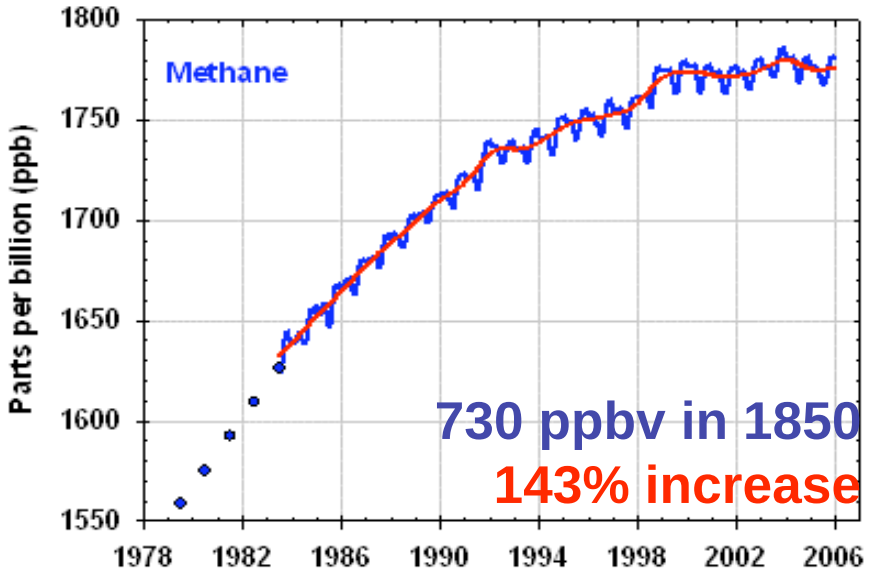


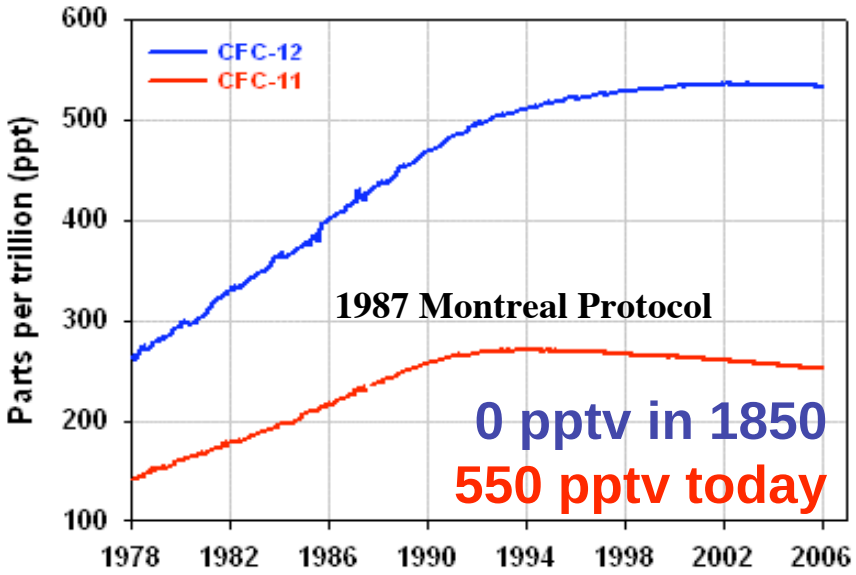
Siegenthaler et al., 2005

Without doubt human activities have changed atmospheric chemistry





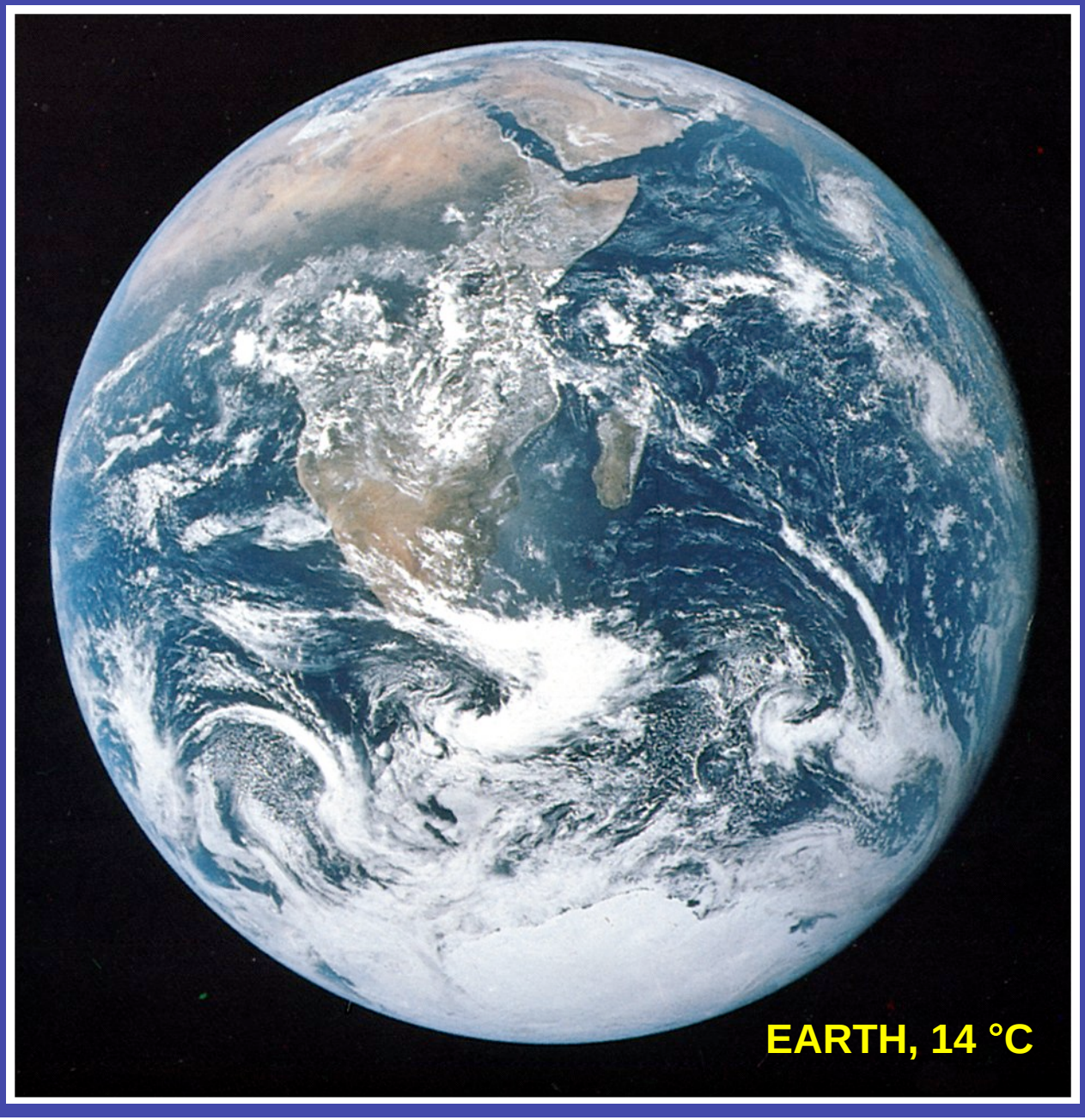


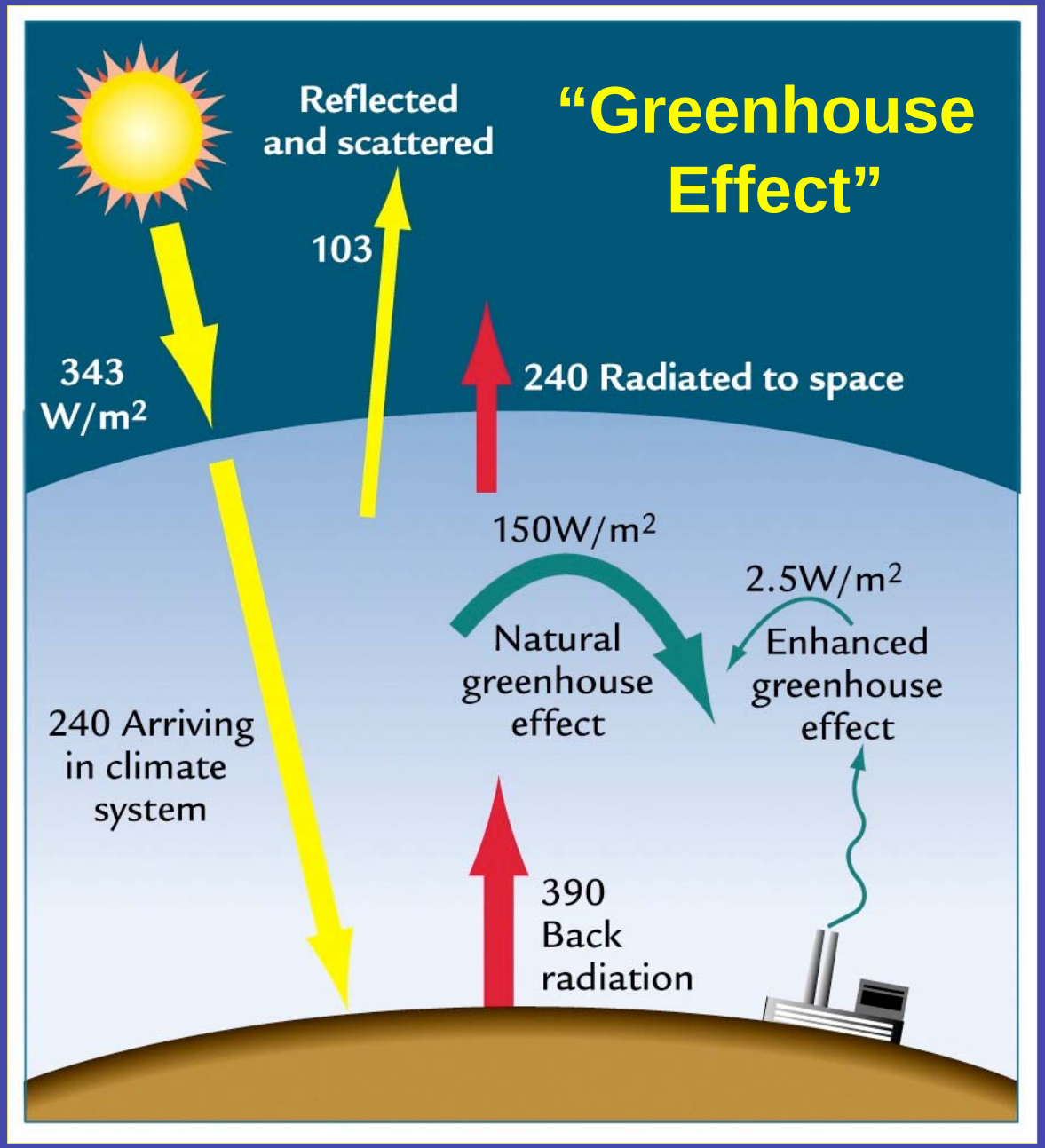


CDIAC, 2006

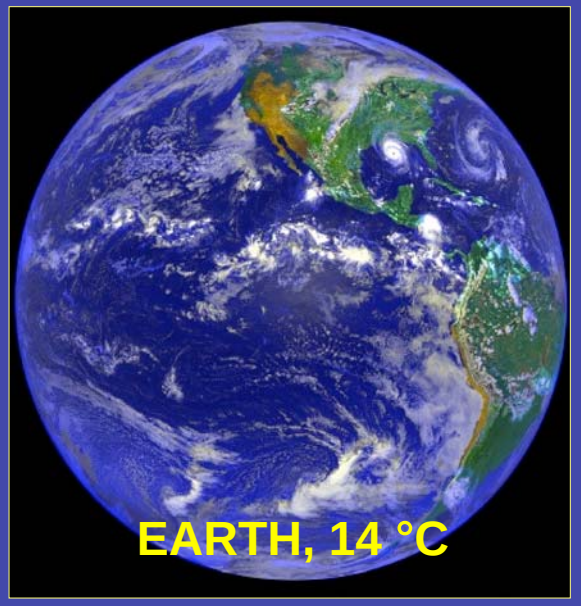
What are human-induced changes in atmospheric chemistry going to do to our environment?

What allows Earth to support life?



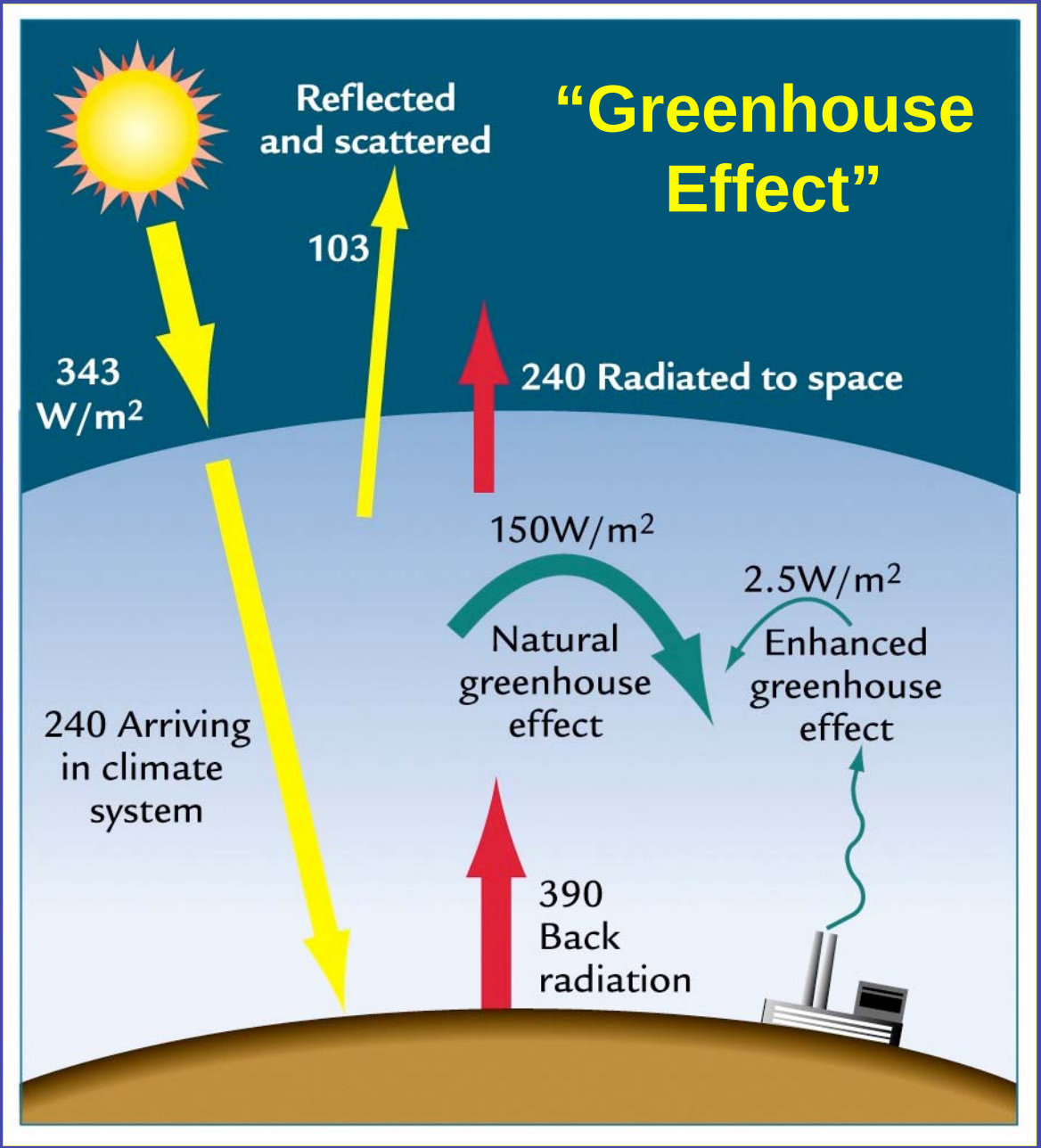


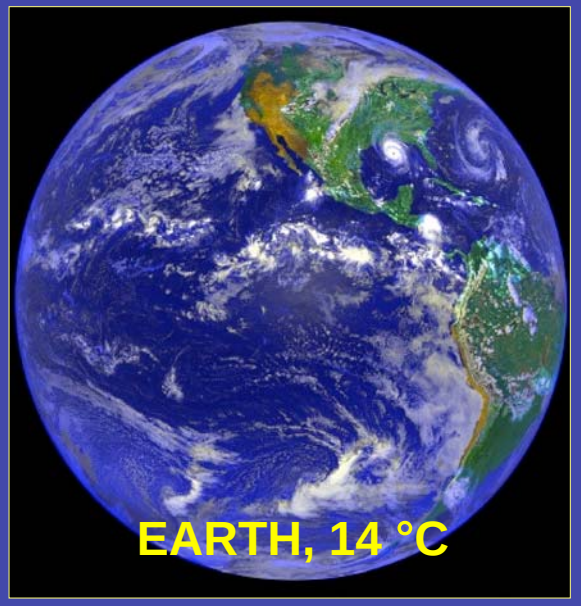
"Greenhouse Effect"



Earth's own Greenhouse Effect is

NATURAL and NECESSARY

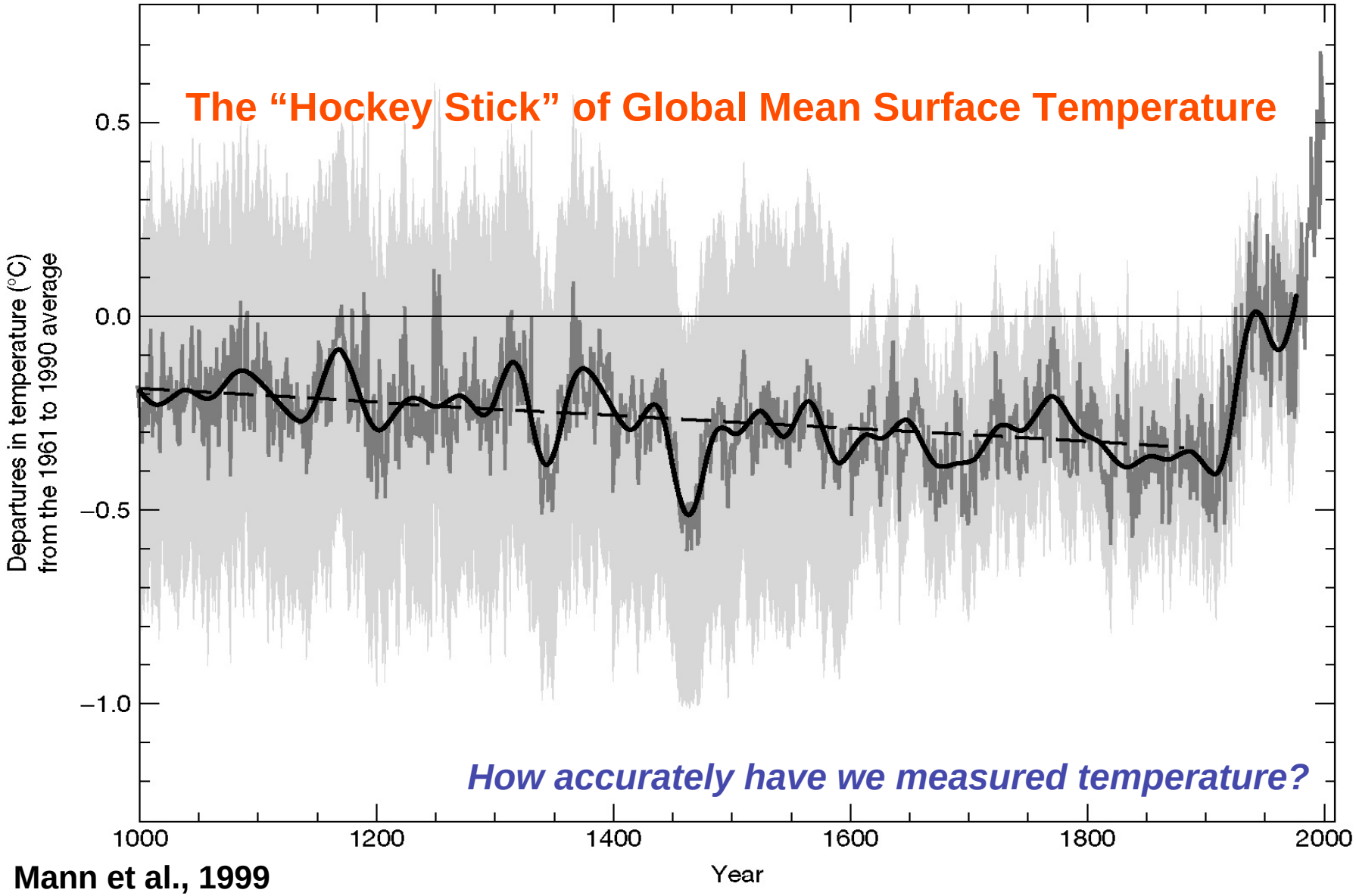




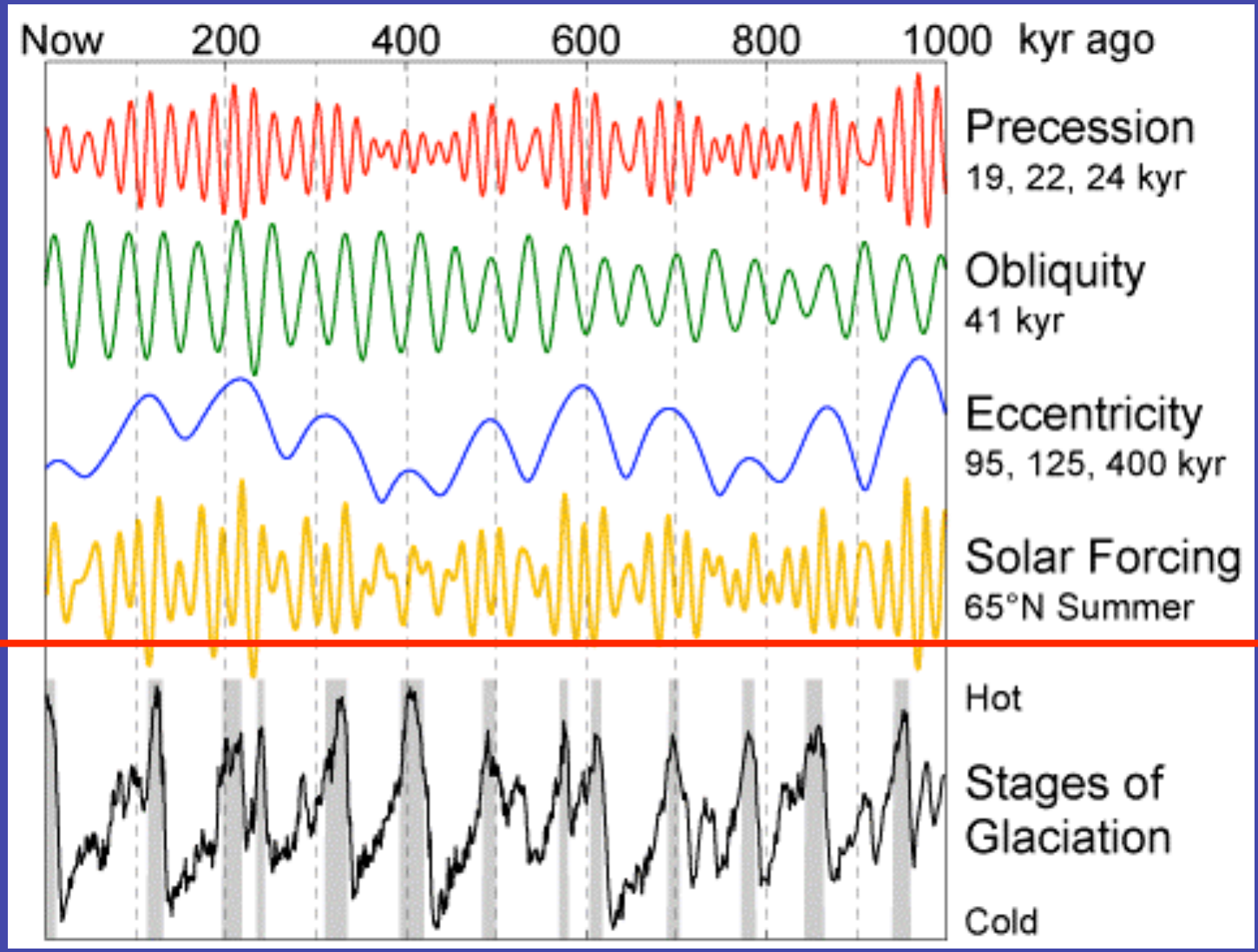
MATH PROBLEM:

Earth's Natural Greenhouse + Human Additions = Temperature Increase

Northern Hemisphere temperature record

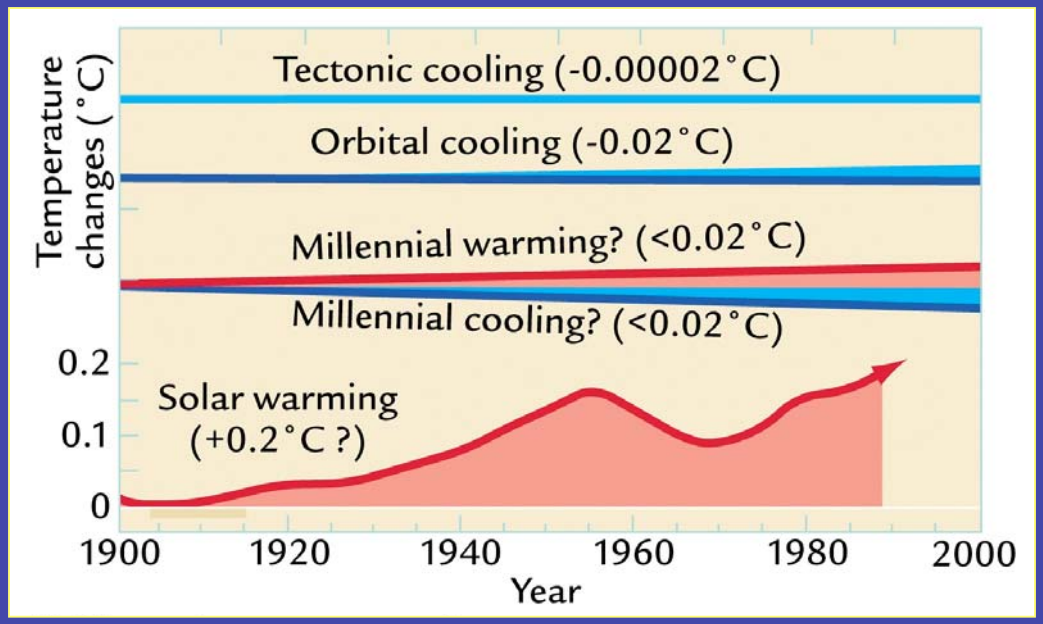


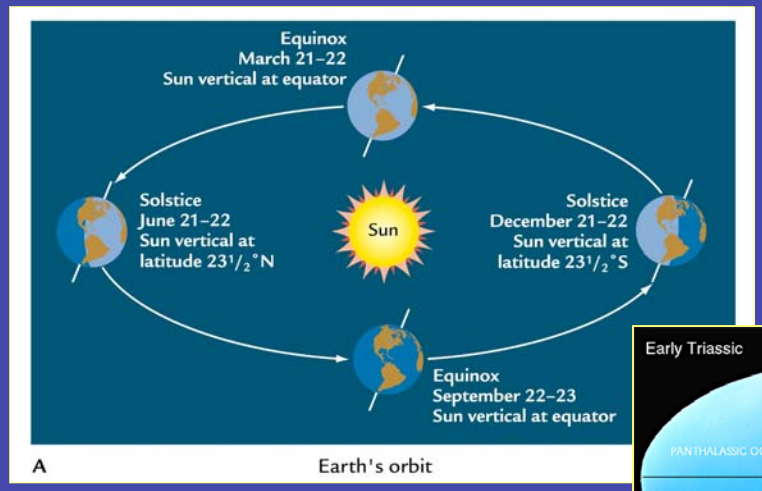
Effects of natural forcing

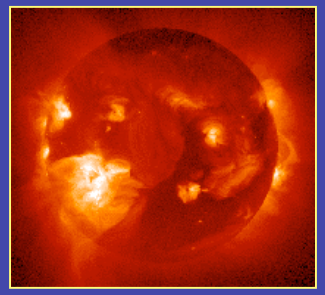


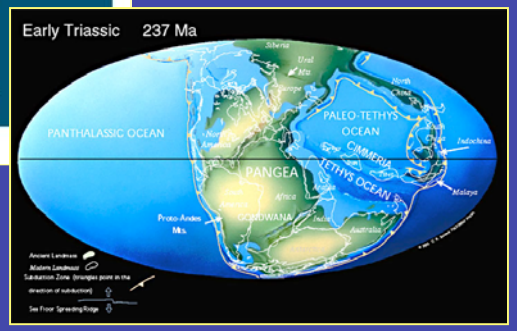
Natural Forcing **+** **Human Forcing**

Natural Forcing + Human Forcing

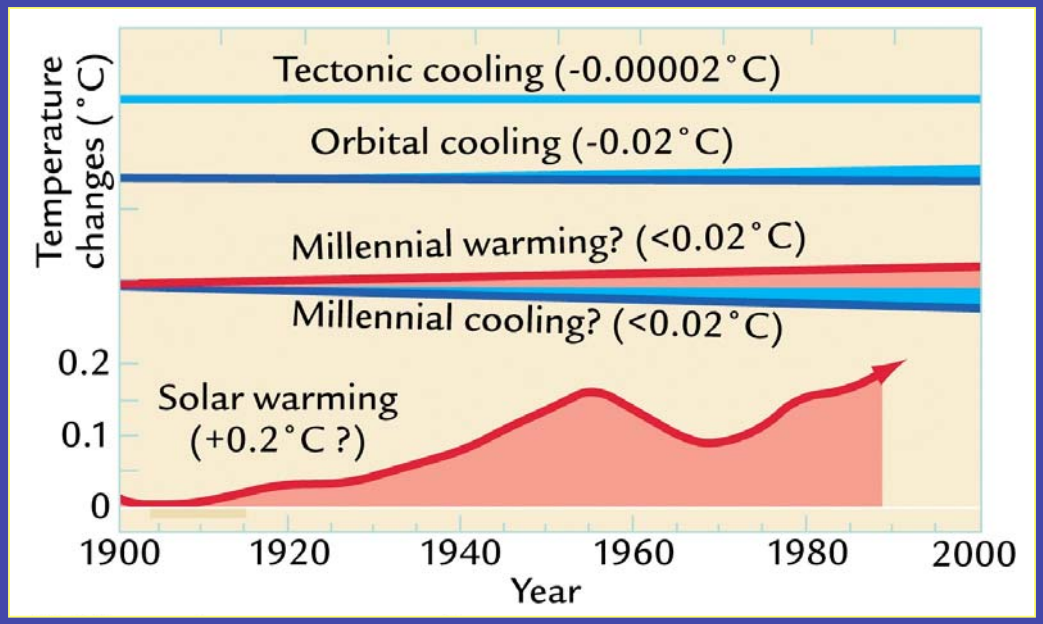


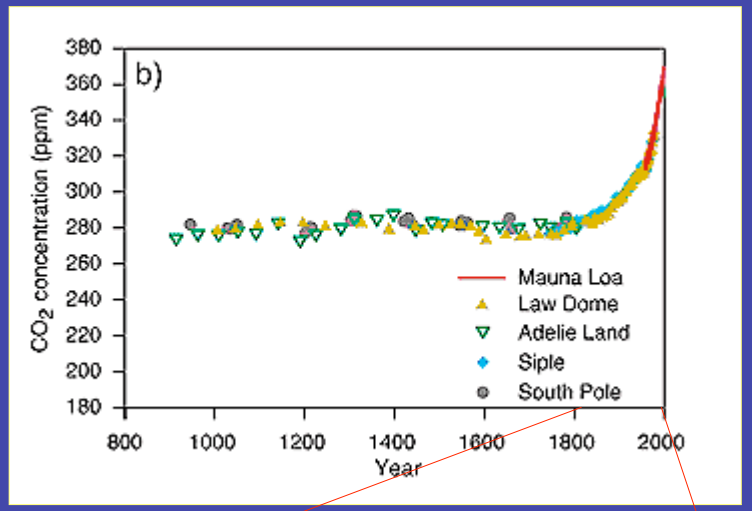


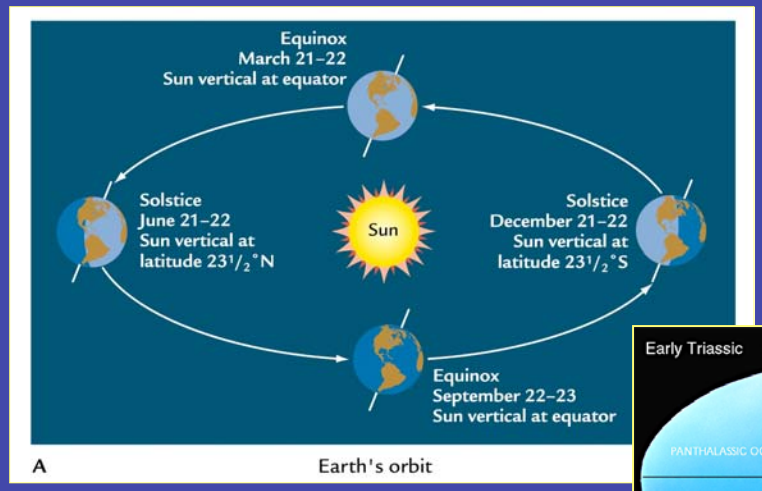


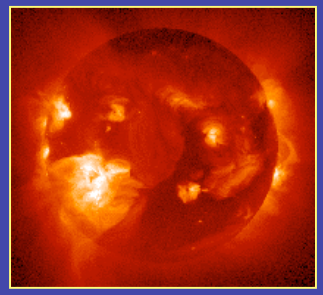


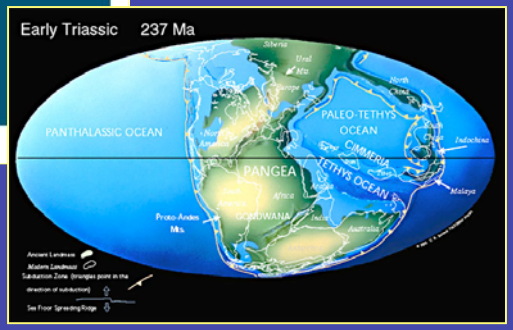
Natural Forcing + Human Forcing

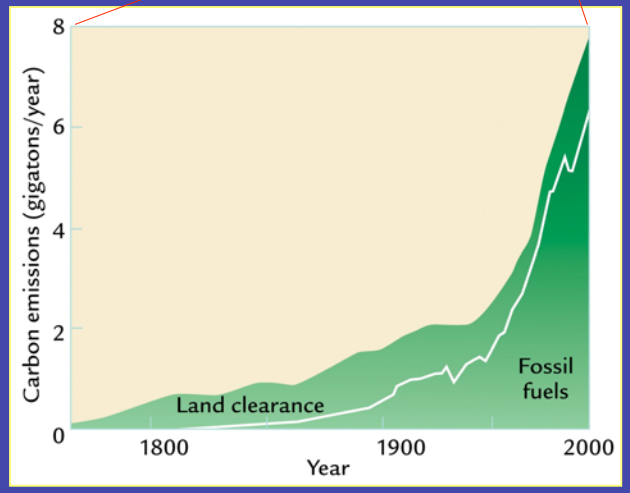






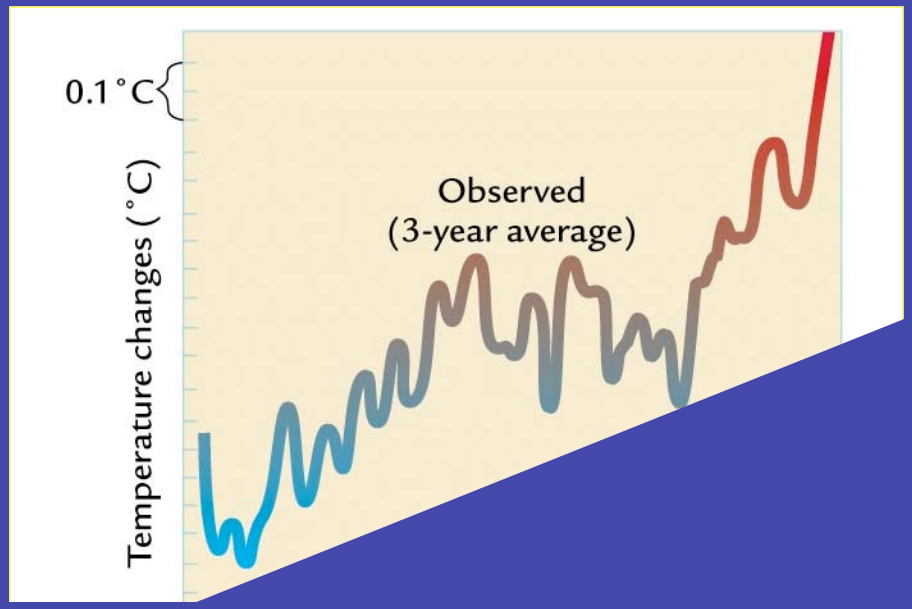






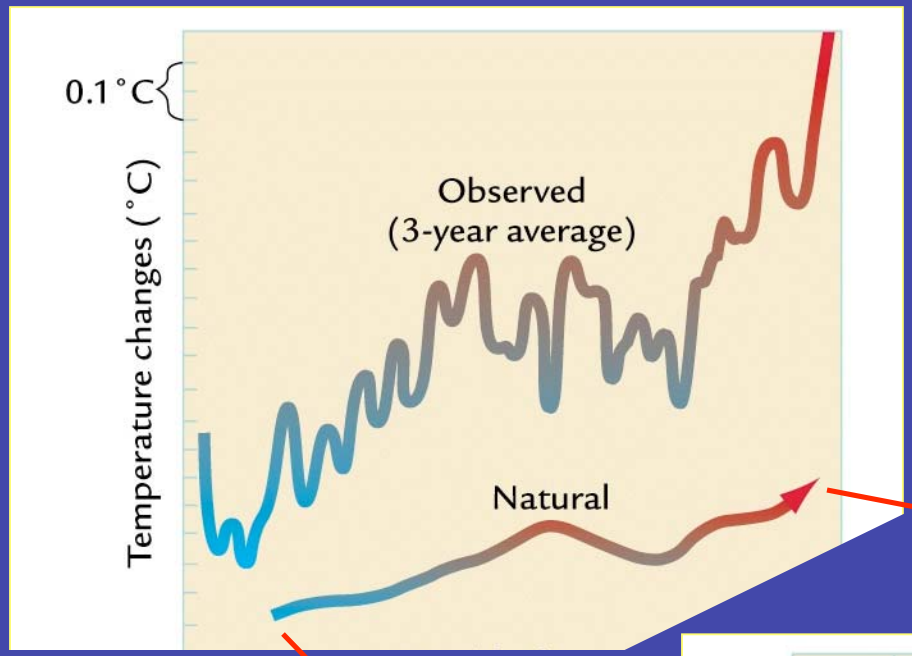


GREENHOUSE MATH PROBLEM



Observed Temperature (1900-2000)

GREENHOUSE MATH PROBLEM

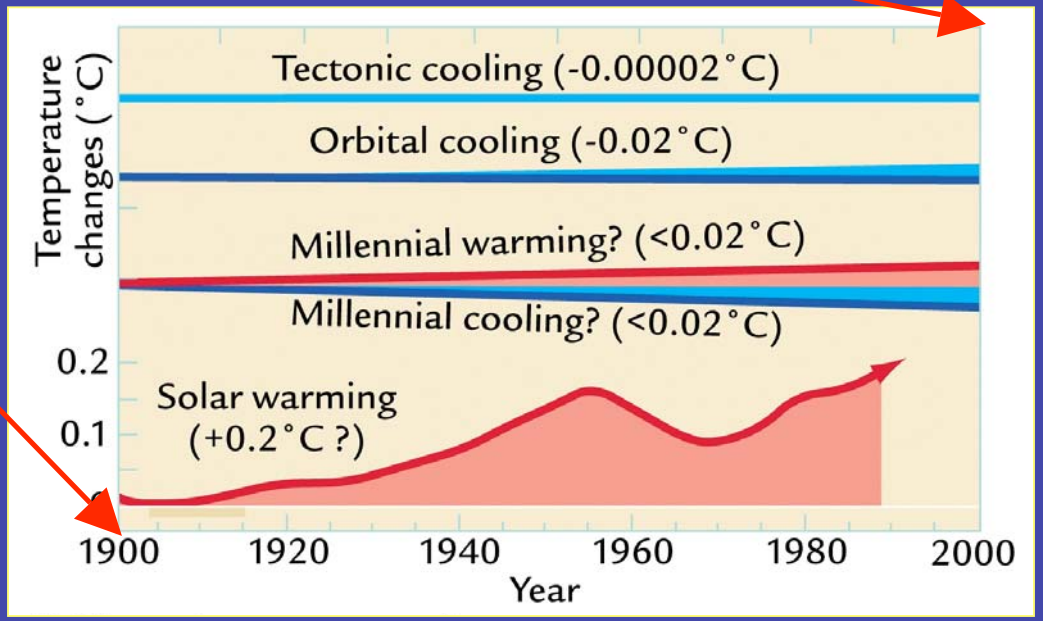


Observed Temperature

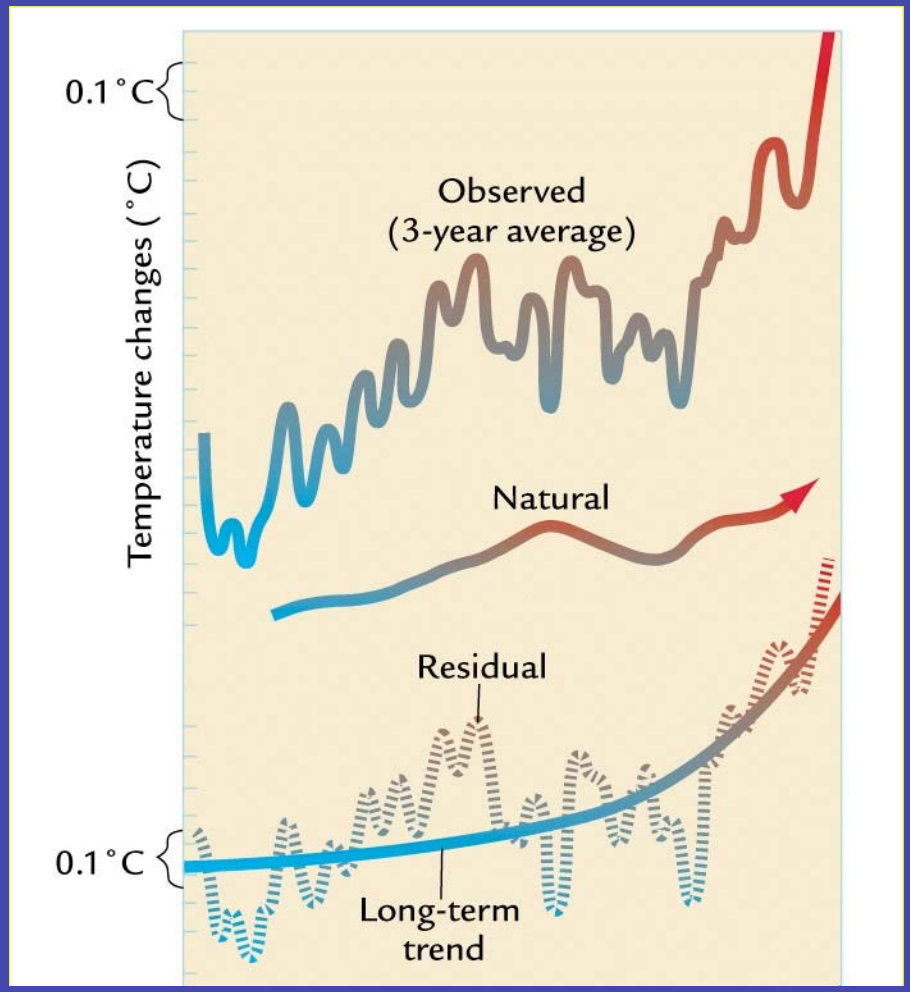
...minus...

Natural Warming

tectonic
orbital
millenial
solar



GREENHOUSE MATH PROBLEM



Observed Temperature

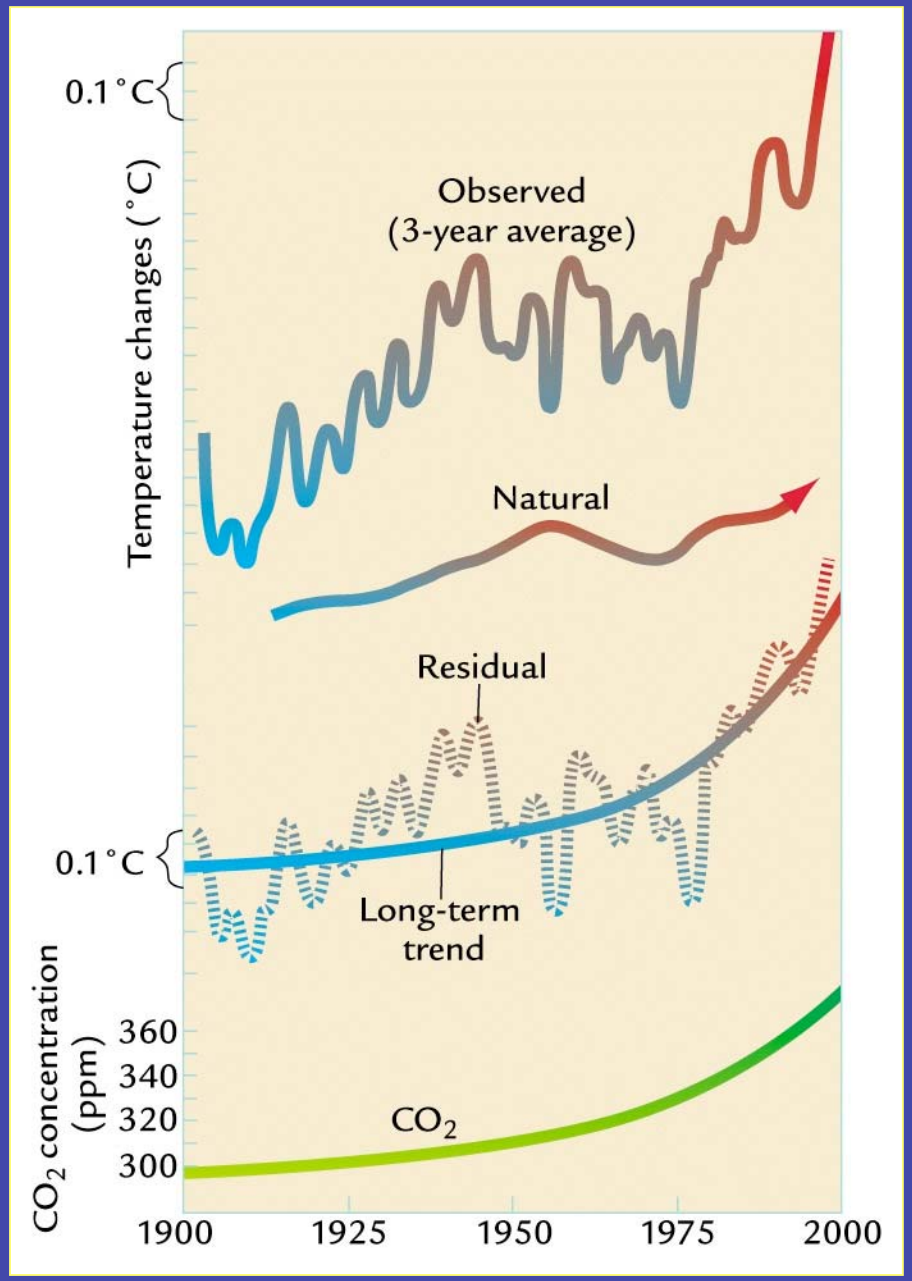
...minus...

Natural Warming

...equals...

Residual (Human Effects)

GREENHOUSE MATH PROBLEM



Observed Temperature

...minus...

Natural Warming

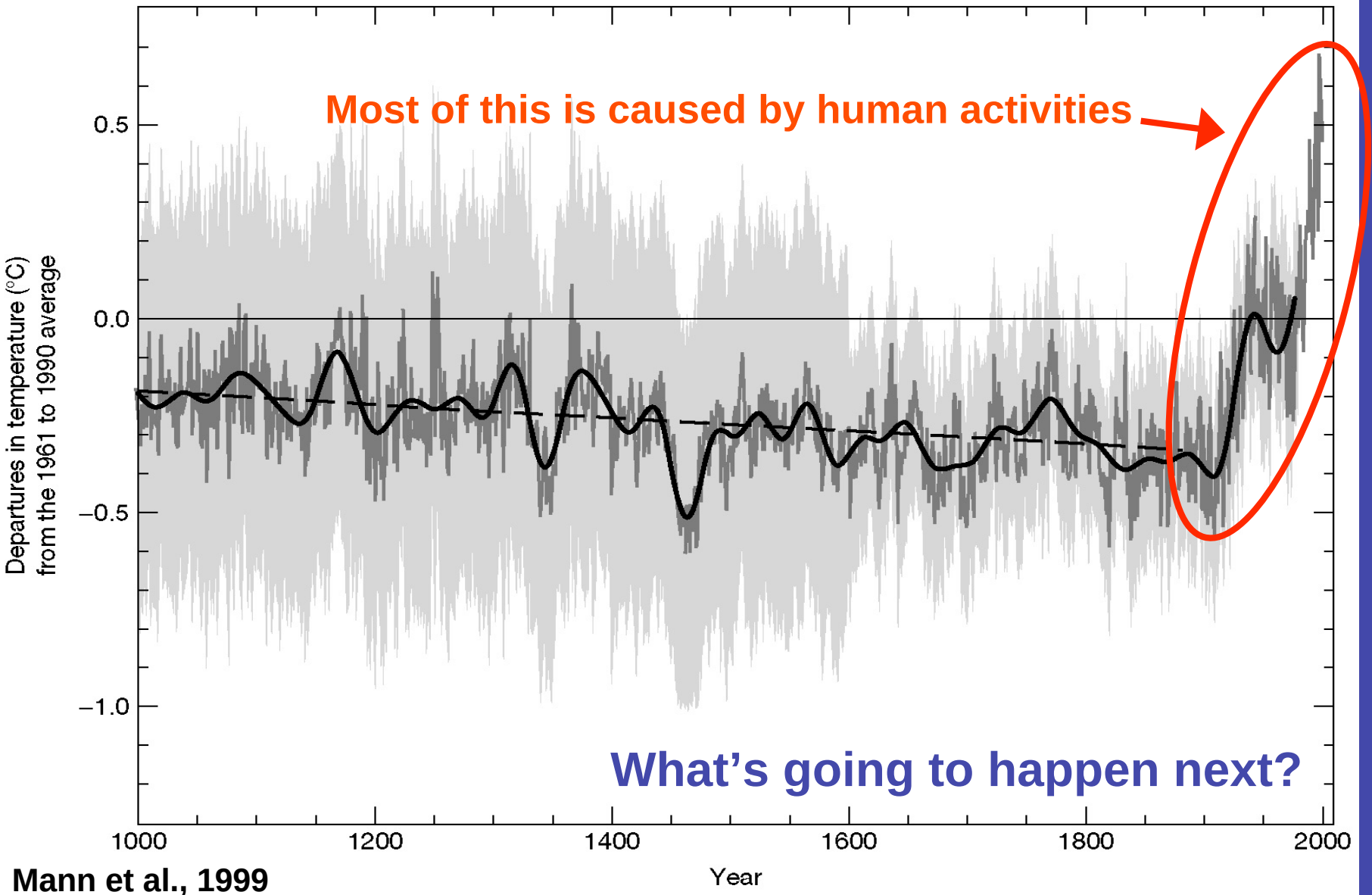
...equals...

Residual (Human Effects)

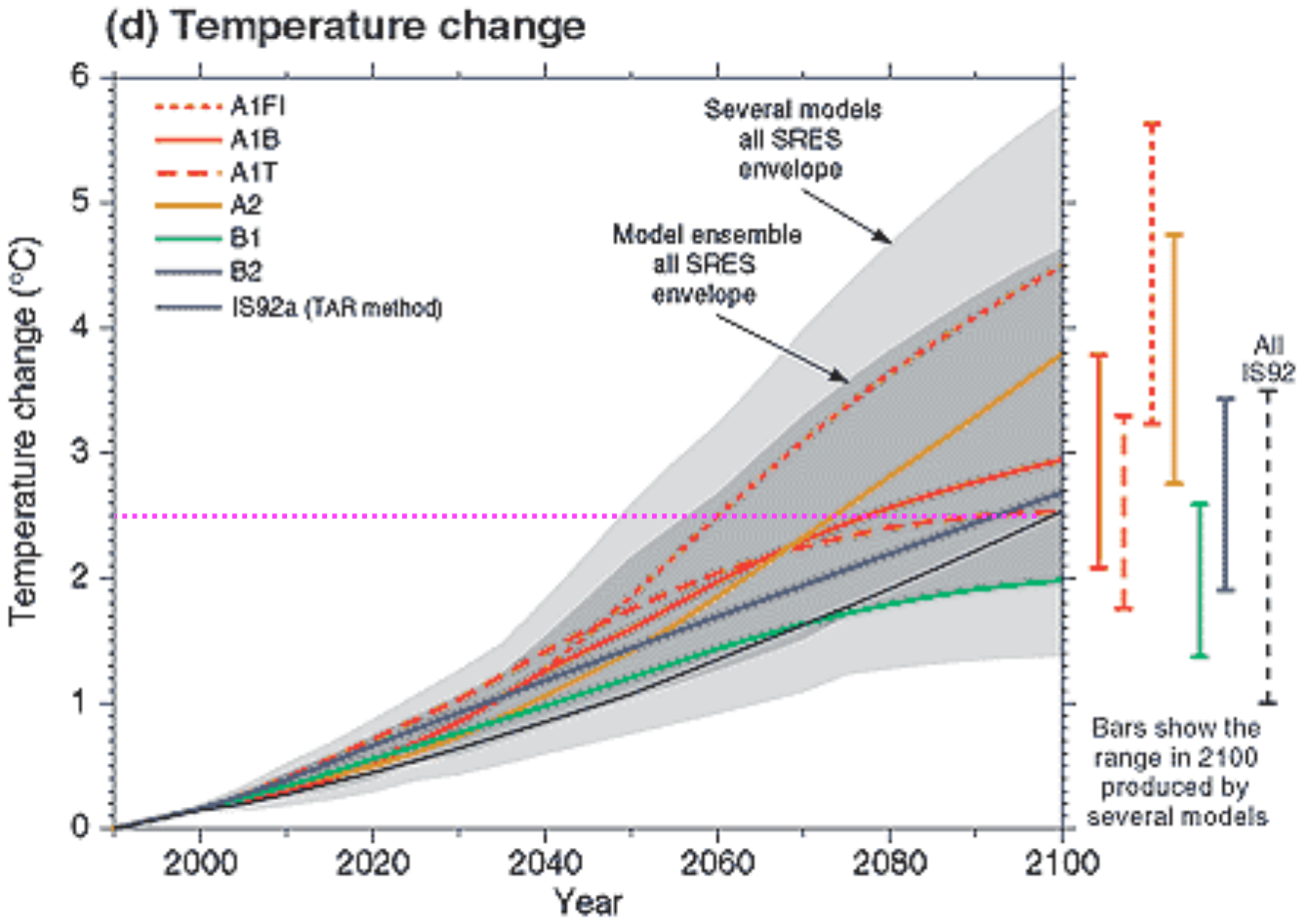
...looks a lot like...

Carbon Dioxide Increase

Northern Hemisphere temperature record



How is temperature projected to change in our lifetimes?



Intergovernmental Panel on Climate Change, 2001

IS92a = "business as usual"

What are the impacts of human-induced temperature rise?

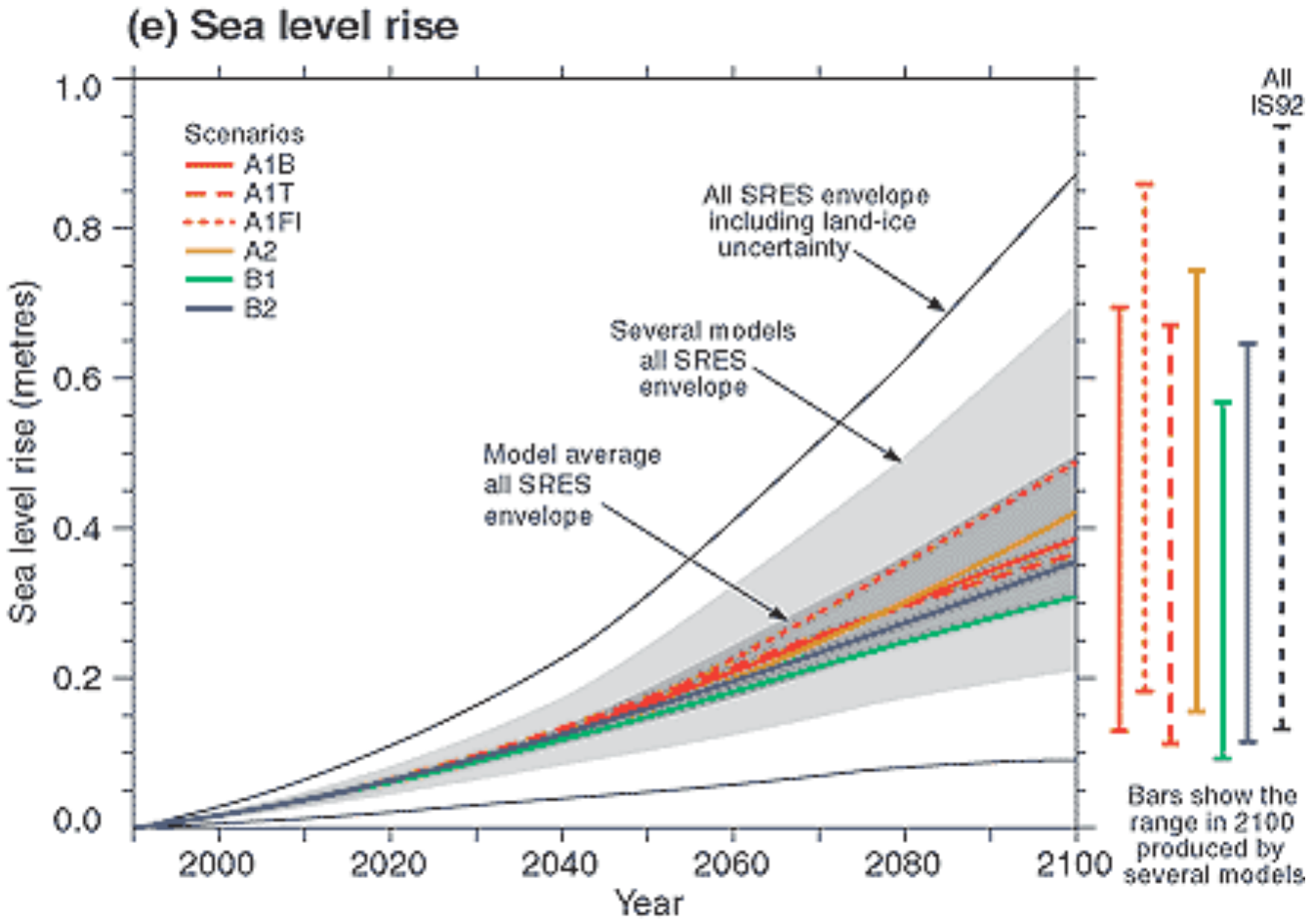








How is sea level projected to change in our lifetimes?



IPCC projection includes only thermal expansion of seawater

What's missing?



Antarctica/Greenland = 10% of Earth's surface
95% of Earth's ice

What happens when this melts?

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Greenland Melt May Swamp LA, Other Cities, Study Says

Honolulu?

Stefan Lovgren
for National Geographic News
April 8, 2004

Greenland's massive ice sheet could begin to melt this century and may disappear completely within the next thousand years if global warming continues at its present rate.

According to a new climate change study, the melting of Greenland's ice sheet would raise the oceans by seven meters (23 feet), threatening to submerge cities located at sea level, from London to Los Angeles.

Even a partial melting of the ice sheet could have catastrophic consequences for low-lying countries like Bangladesh and the Maldives.

"A one-meter [three-foot] sea level rise would submerge a substantial amount of Bangladesh," Jonathan Gregory, the study's lead author and a climate scientist at the University of Reading in England, said in a telephone interview.

Scientists have previously calculated that if the annual average temperature in Greenland increases by almost 3° Celsius (5.4° Fahrenheit), its ice sheet will begin to melt.

Many experts believe the concentration of carbon dioxide in the atmosphere will have reached levels around the year 2100 that would cause the temperature to rise that much.

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Greenland Melting? Satellite to Help Find Answer

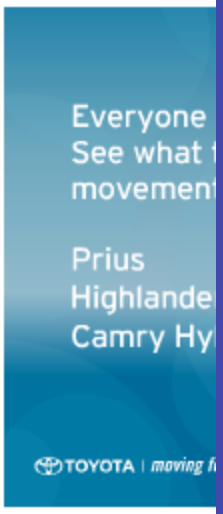
Antarctic Ice Collapse Began End of Ice Age?

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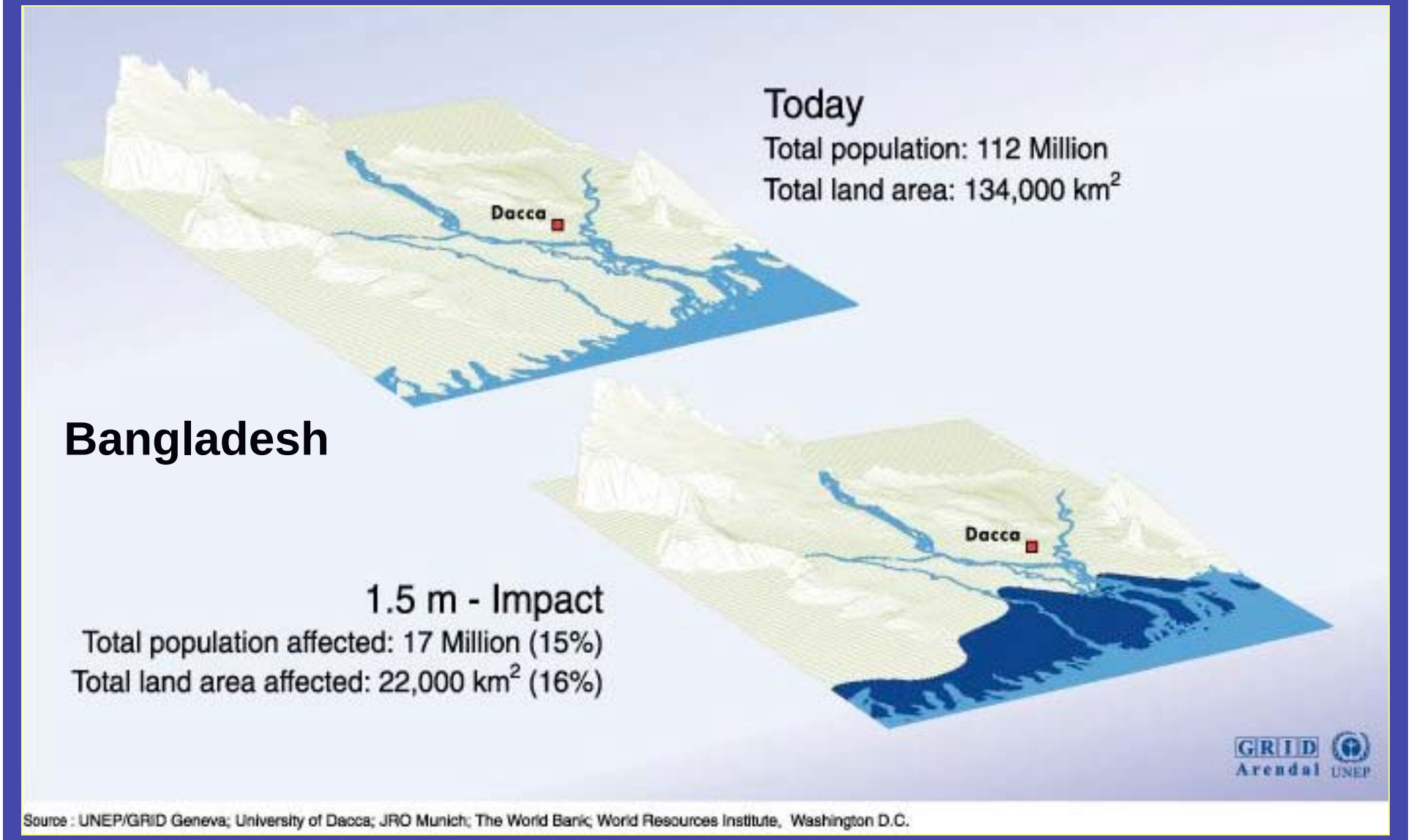


Hybri
Mount



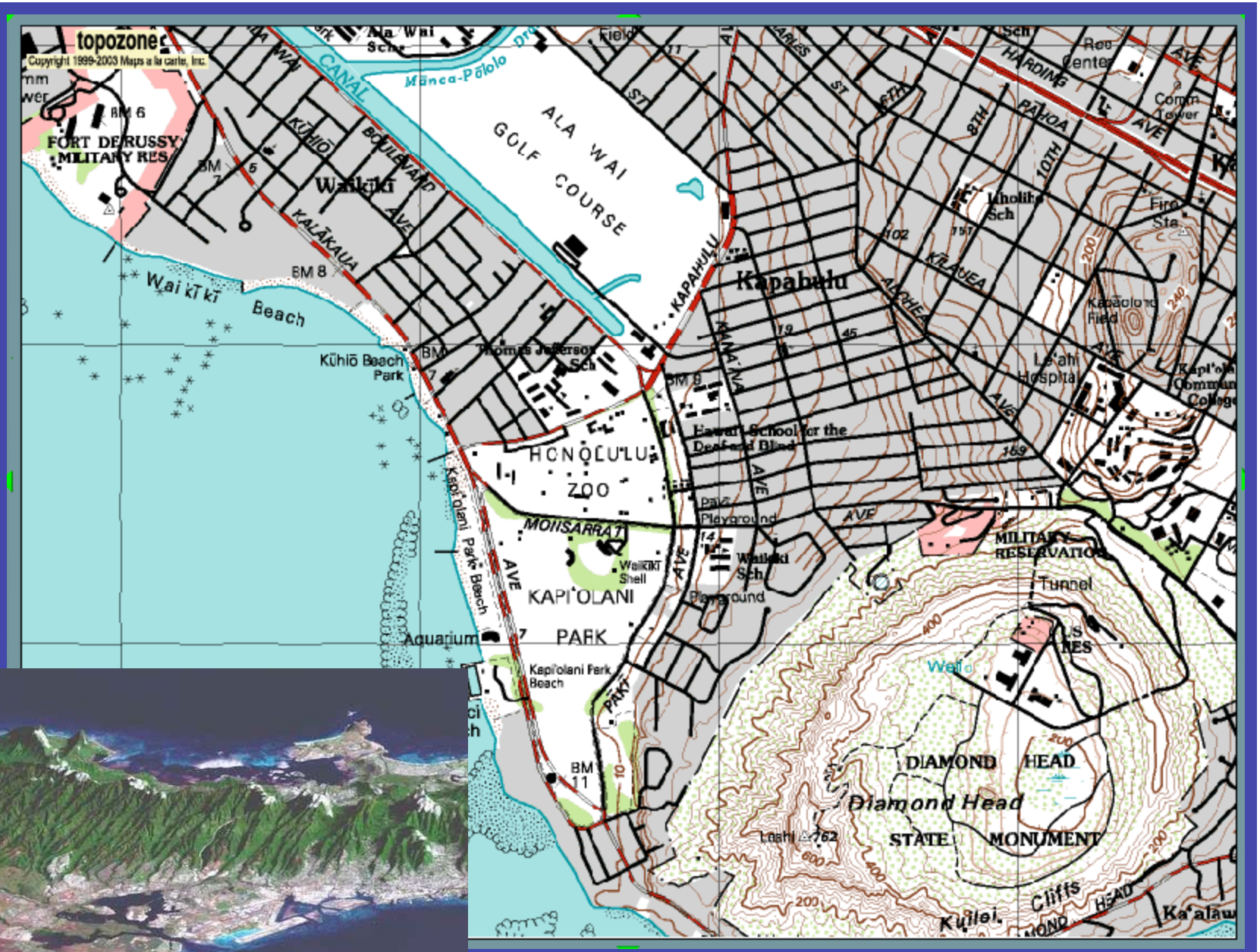
Photo
the St

Effect of sea level rise on Bangladesh

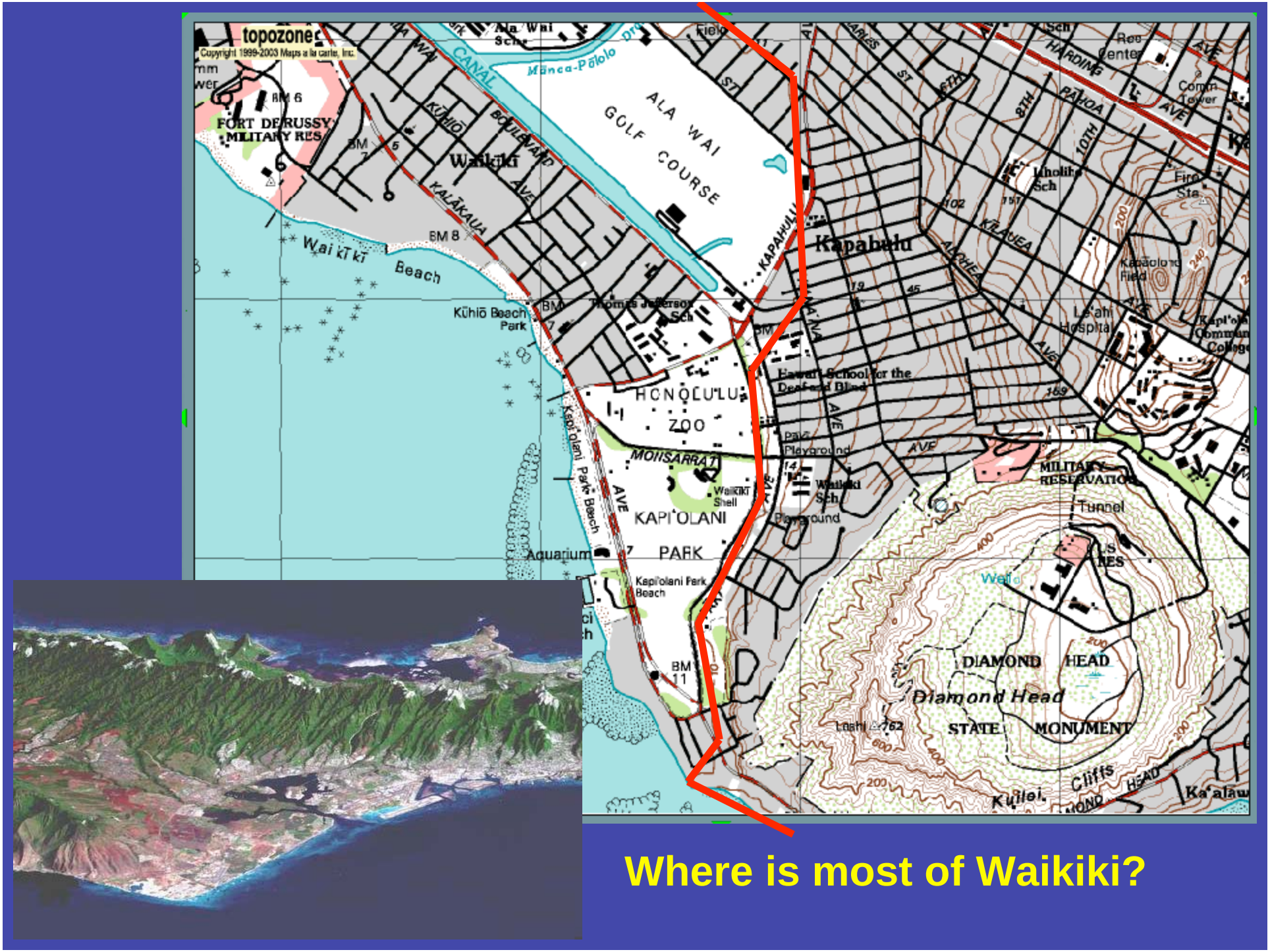


Source : UNEP/GRID Geneva; University of Dacca; JRO Munich; The World Bank; World Resources Institute, Washington D.C.

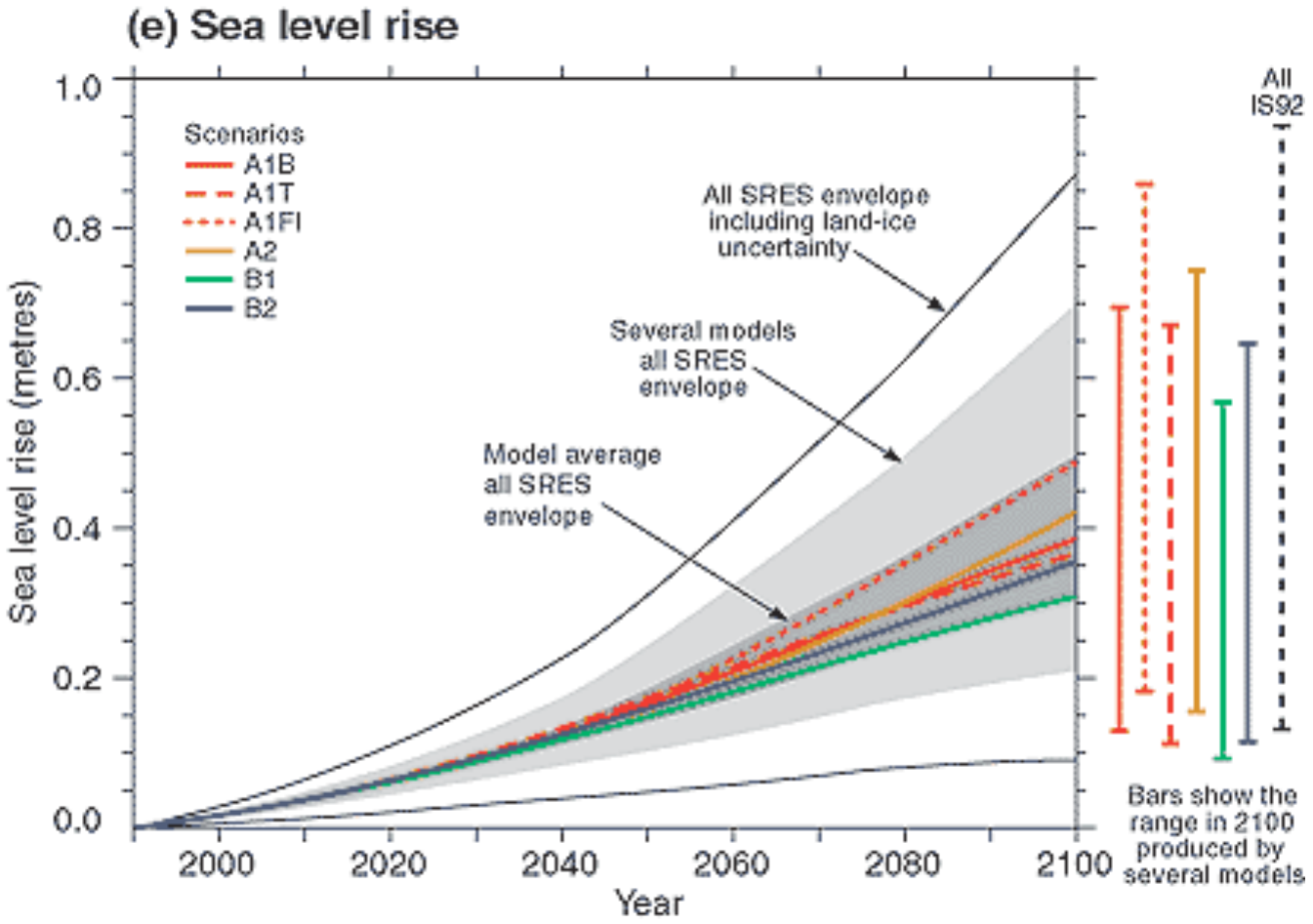




Where is 1m of sea level rise?


topozone
Copyright 1999-2003 Maps a la carte, Inc.
FORT DERUSSY MILITARY RES
Waikīkī
Wai kī kī Beach
Kūhiō Beach Park
ALA WAI GOLF COURSE
Mānoa-Pālolo Drainage Canal
Kapahulu
HONOLULU ZOO
KAPI'OLANI PARK
Kapi'olani Park Beach
Aquarium
MILITARY RESERVATION
Tunnel
DIAMOND HEAD
Diamond Head
STATE MONUMENT
Kuilei Cliffs
Ka'alawa
Where is most of Waikiki?

How is sea level projected to change in our lifetimes?

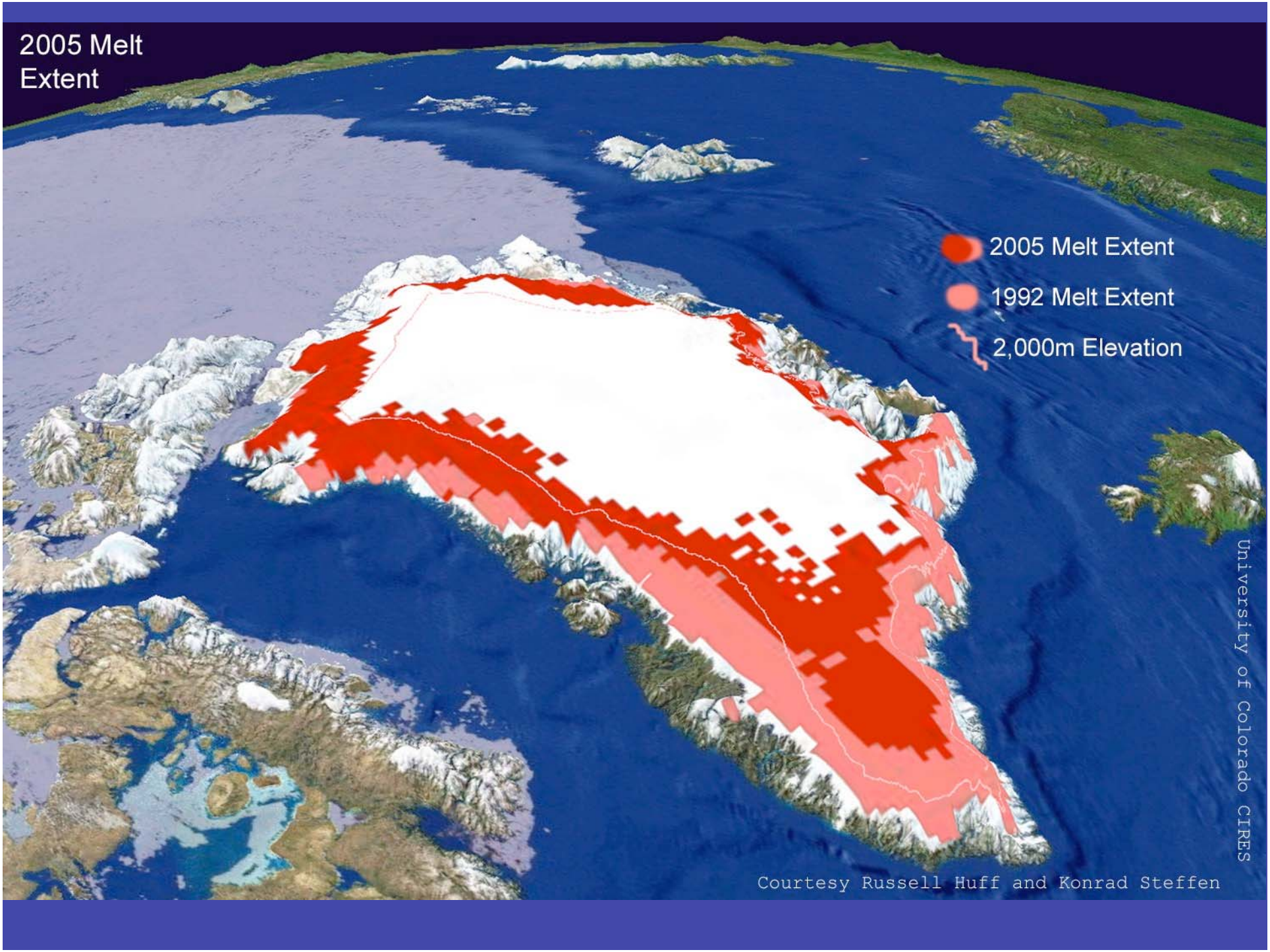


IPCC projection includes only thermal expansion of seawater

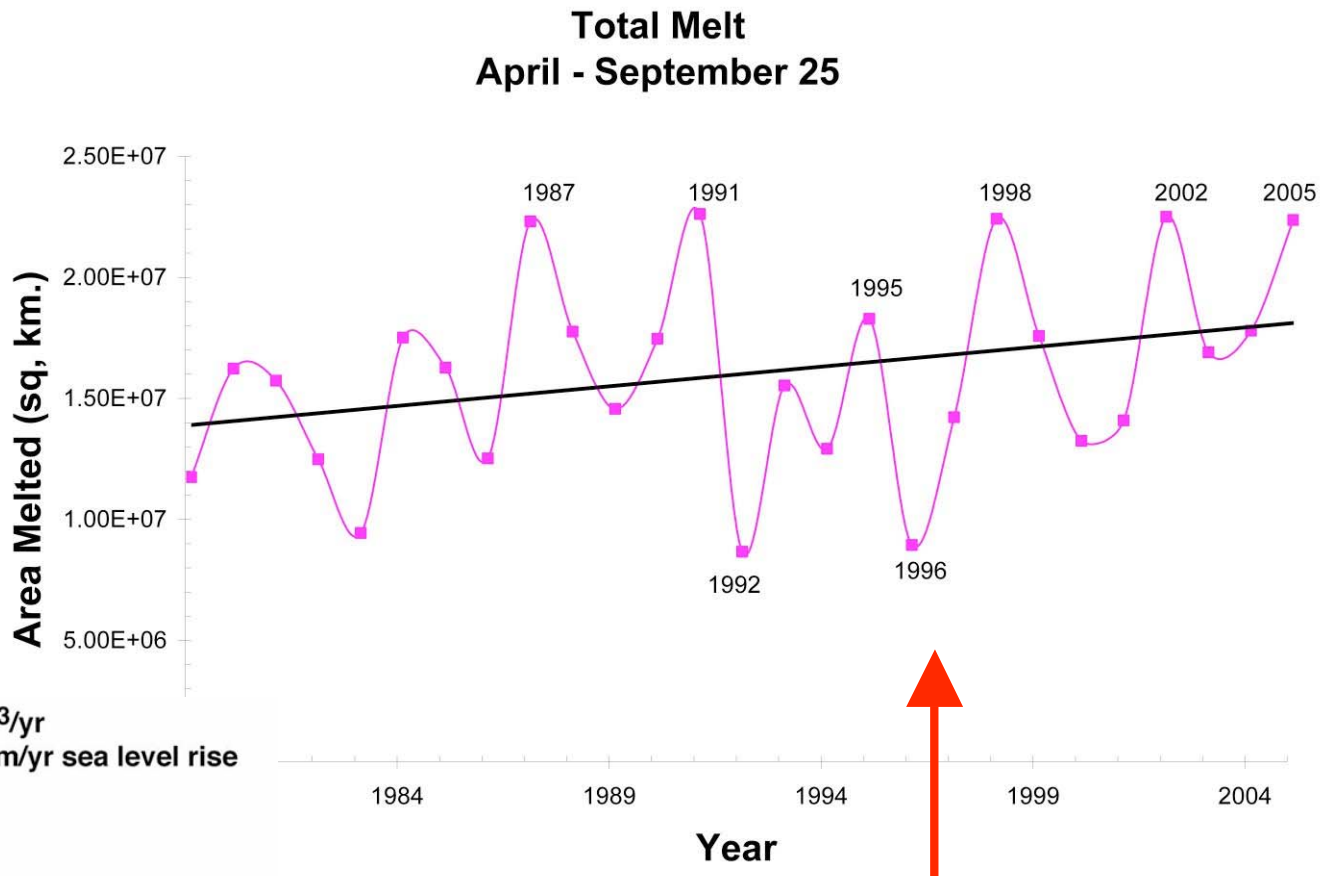
What's missing?

Thermal expansion sea level rise

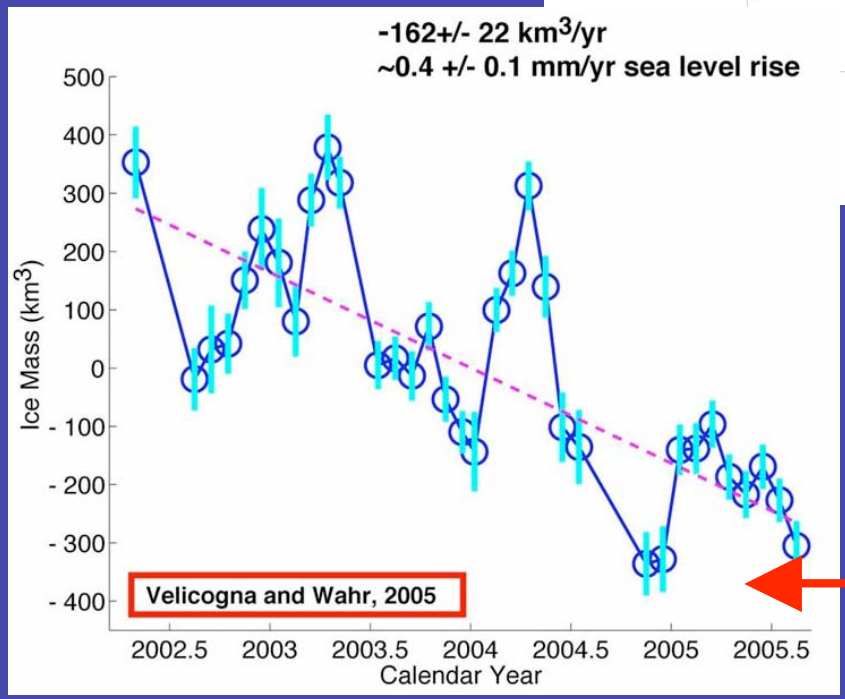



2005 Melt Extent
2005 Melt Extent
1992 Melt Extent
2,000m Elevation
Courtesy Russell Huff and Konrad Steffen
University of Colorado CIRES

Greenland ice is melting



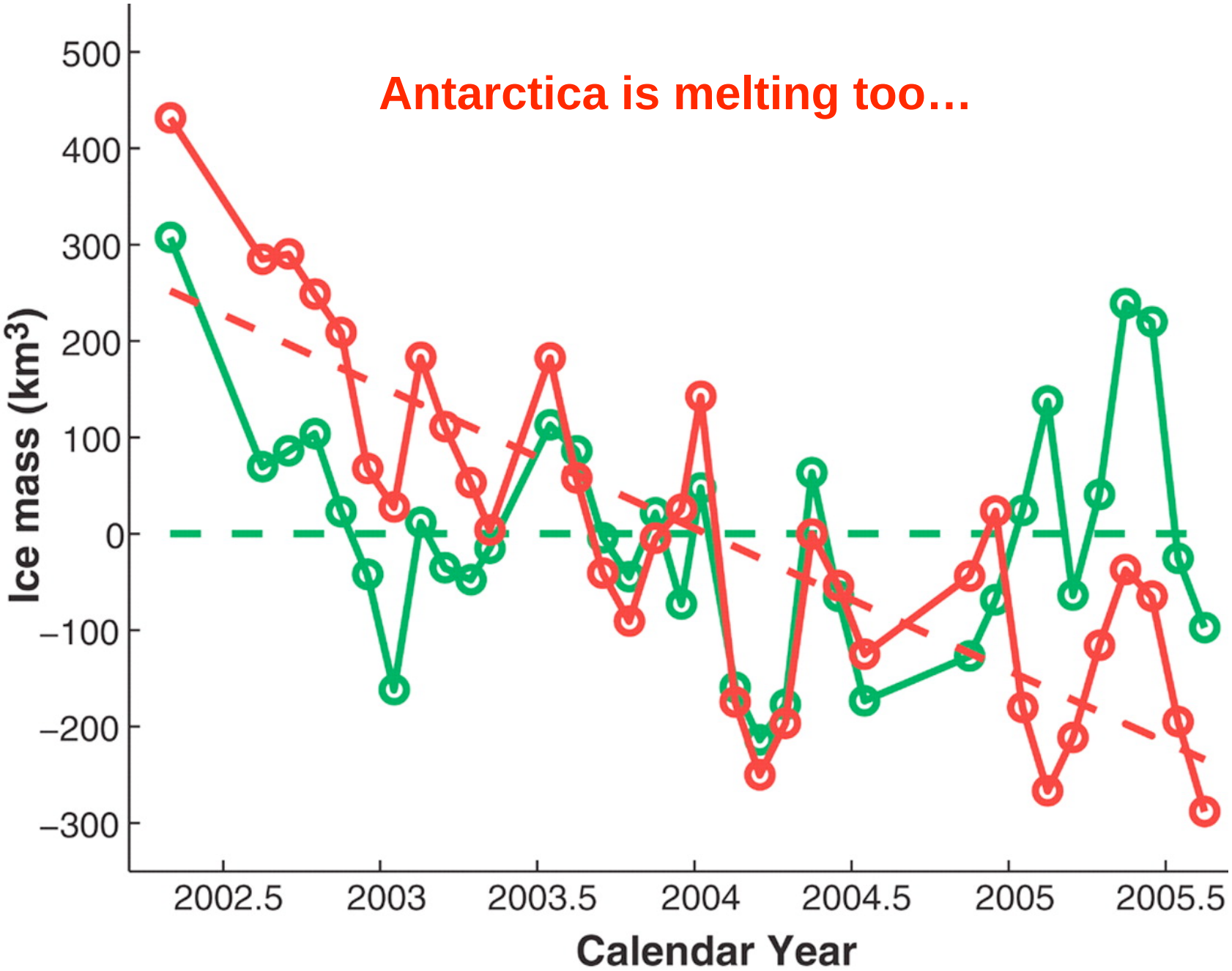
Total melt area



Ice volume

How about Antarctica?




Antarctica is melting too…
500
400
300
200
100
0
−100
−200
−300
Ice mass (km3)
2002.5
2003
2003.5
2004
2004.5
2005
2005.5
Calendar Year

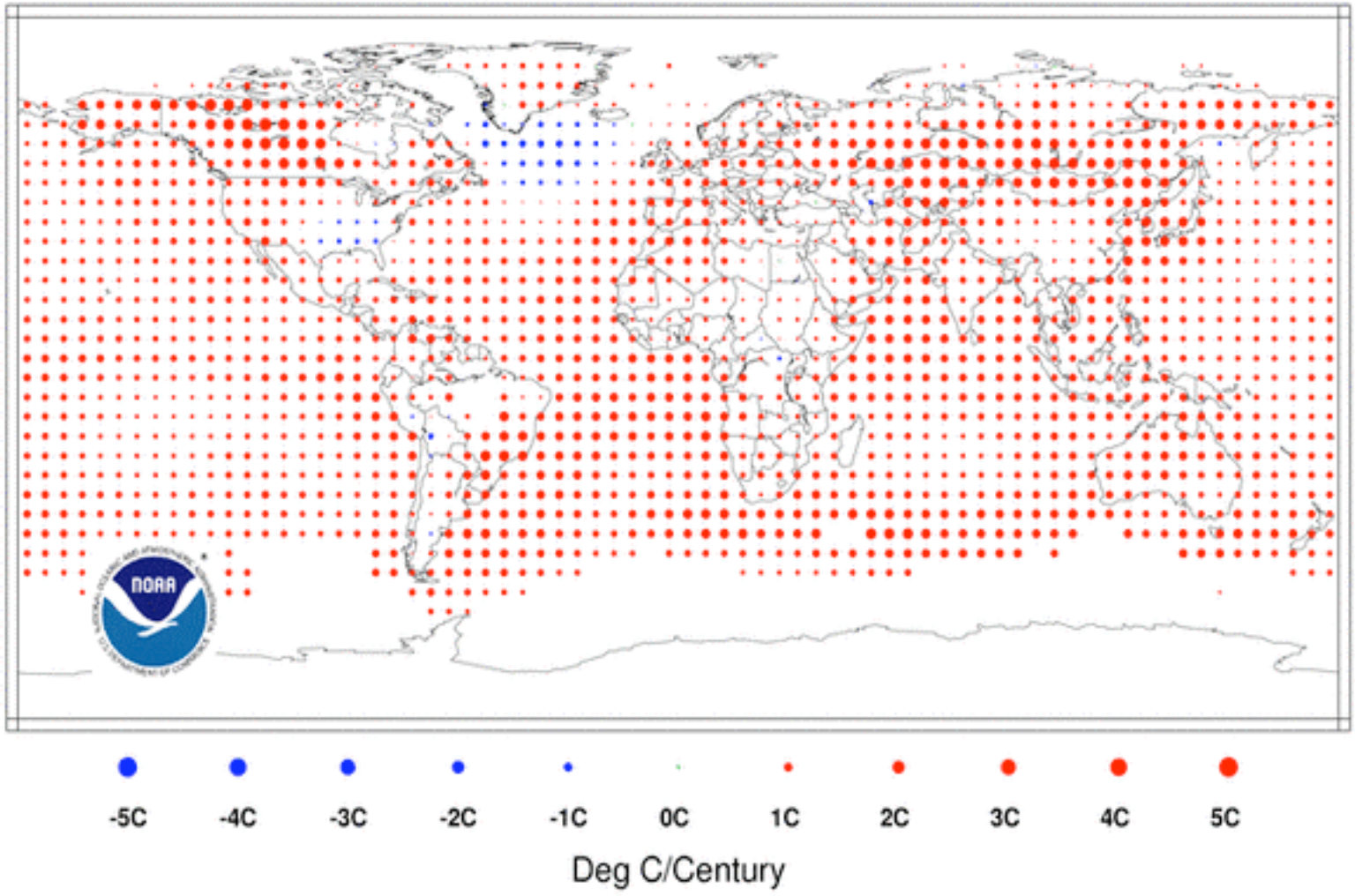
Greenland or West Antarctica - 20 feet (6 meters)



Annual Temperature Trends

1901-2003

National Climatic Data Center/NESDIS/NOAA







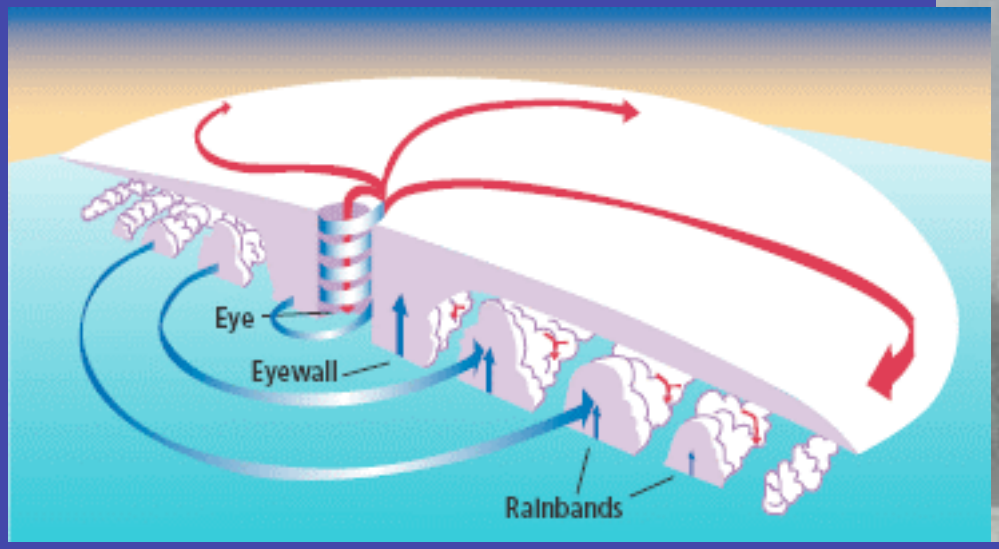
Hurricane
Cyclone
Typhoon

1) warm ocean temperatures

2) low vertical wind shear

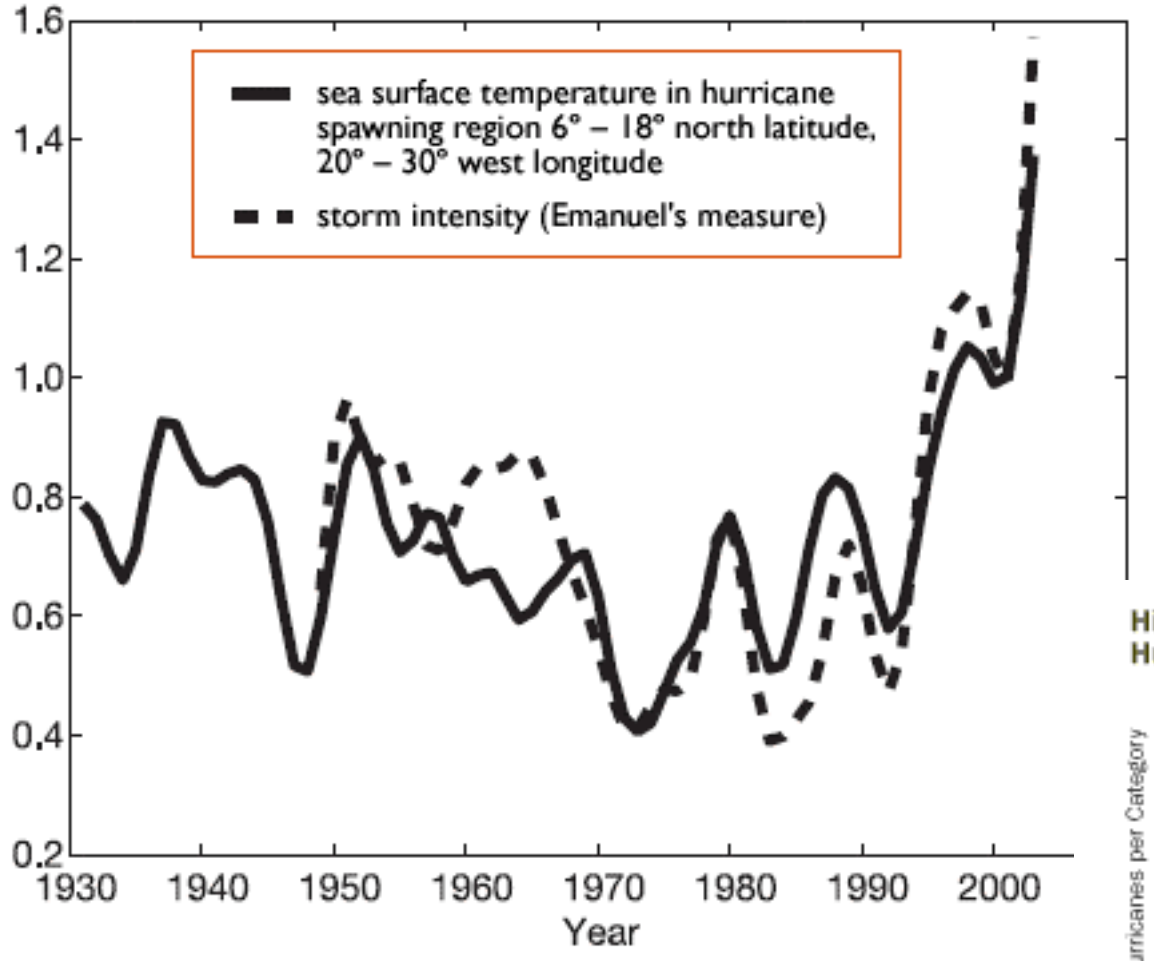
(i.e., no strong change in wind speed or direction between two different altitudes)

3) high humidity

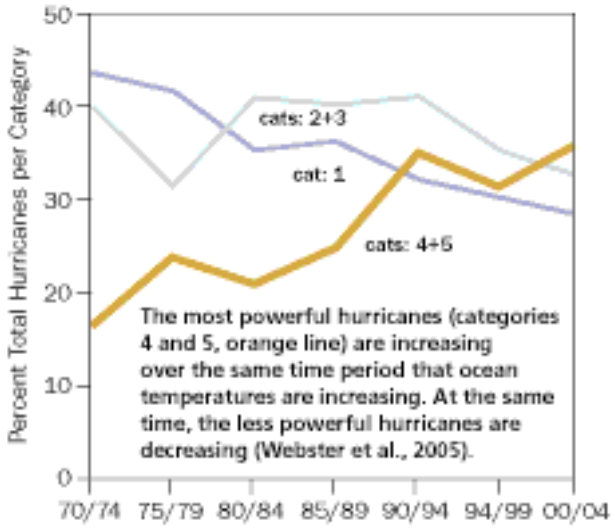




Hurricane intensity vs. ocean temperature



Higher Percent of Category 4 & 5 Hurricanes Worldwide



The most powerful hurricanes (categories 4 and 5, orange line) are increasing over the same time period that ocean temperatures are increasing. At the same time, the less powerful hurricanes are decreasing (Webster et al., 2005).

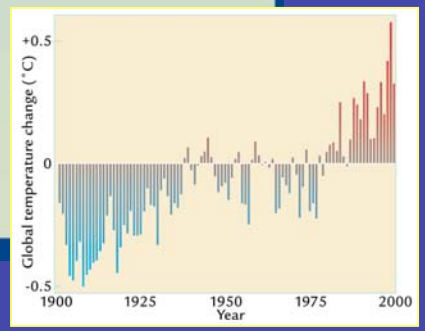
Category Five Hurricane

- Winds greater than 155 mph (135 kt or 249 km/hr).
- Storm surge generally greater than 18 ft above normal.
- Complete roof failure on many residences and industrial buildings.
- Some complete building failures with small utility buildings blown over or away.
- All shrubs, trees, and signs blown down.
- Severe and extensive window and door damage.
- Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane.
- Major damage to lower floors of all structures located less than 15 ft above sea level and within 500 yards of the shoreline.
- Massive evacuation of residential areas on low ground within 5-10 miles (8-16 km) of the shoreline may be required.

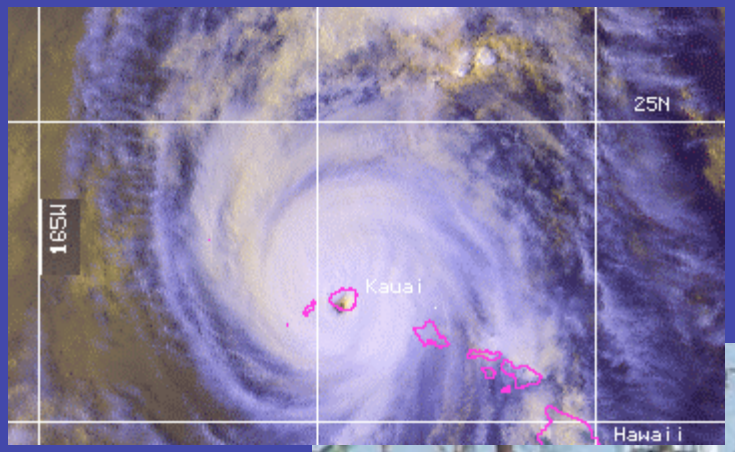
Global costs of extreme weather events (inflation-adjusted)

Annual losses, in thousand million U.S. dollars





IPCC, 2001



How many Inikis (C4) can our islands handle?

$2.6 billion



Category 4-5 projected storm surge heights 6m



Lanikai





Bellows

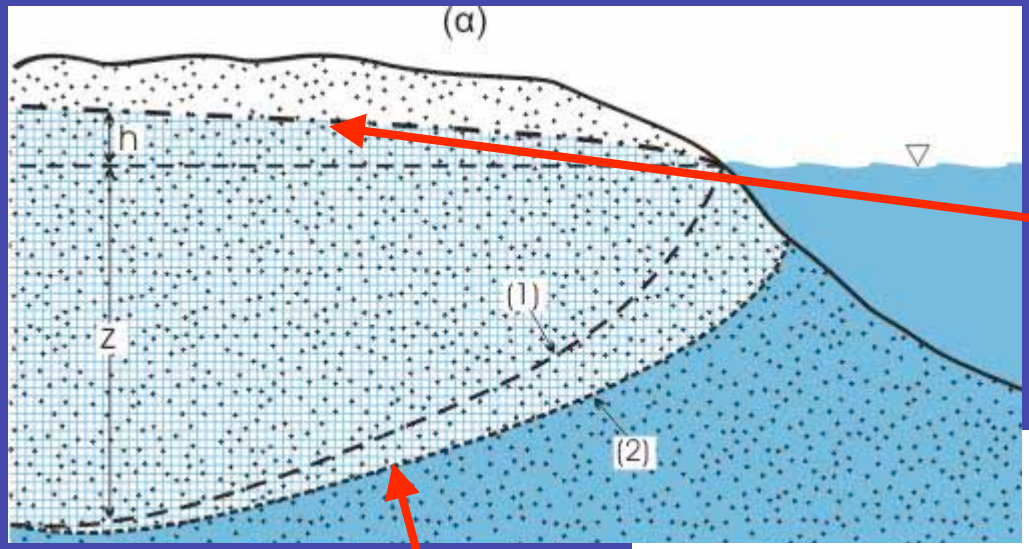
Coral bleaching





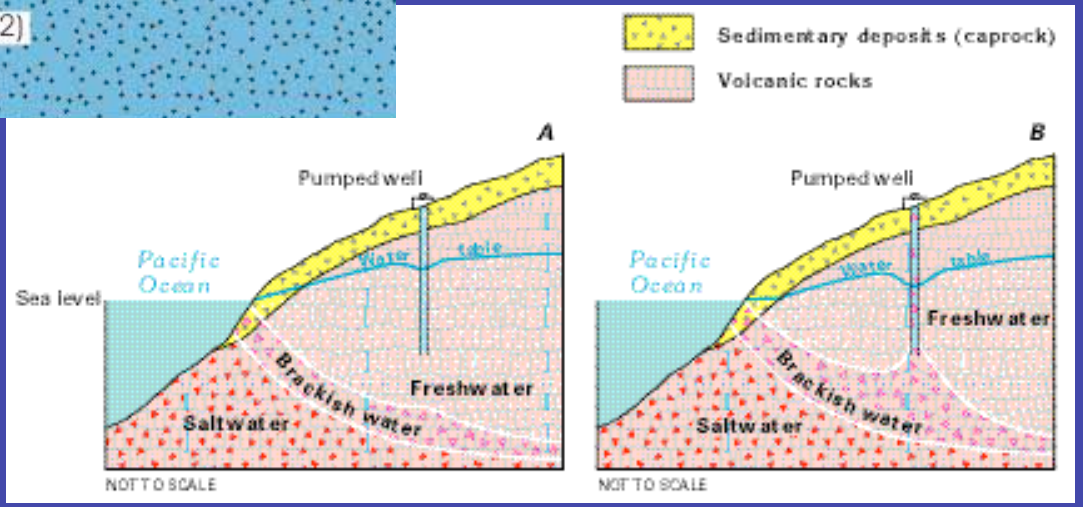


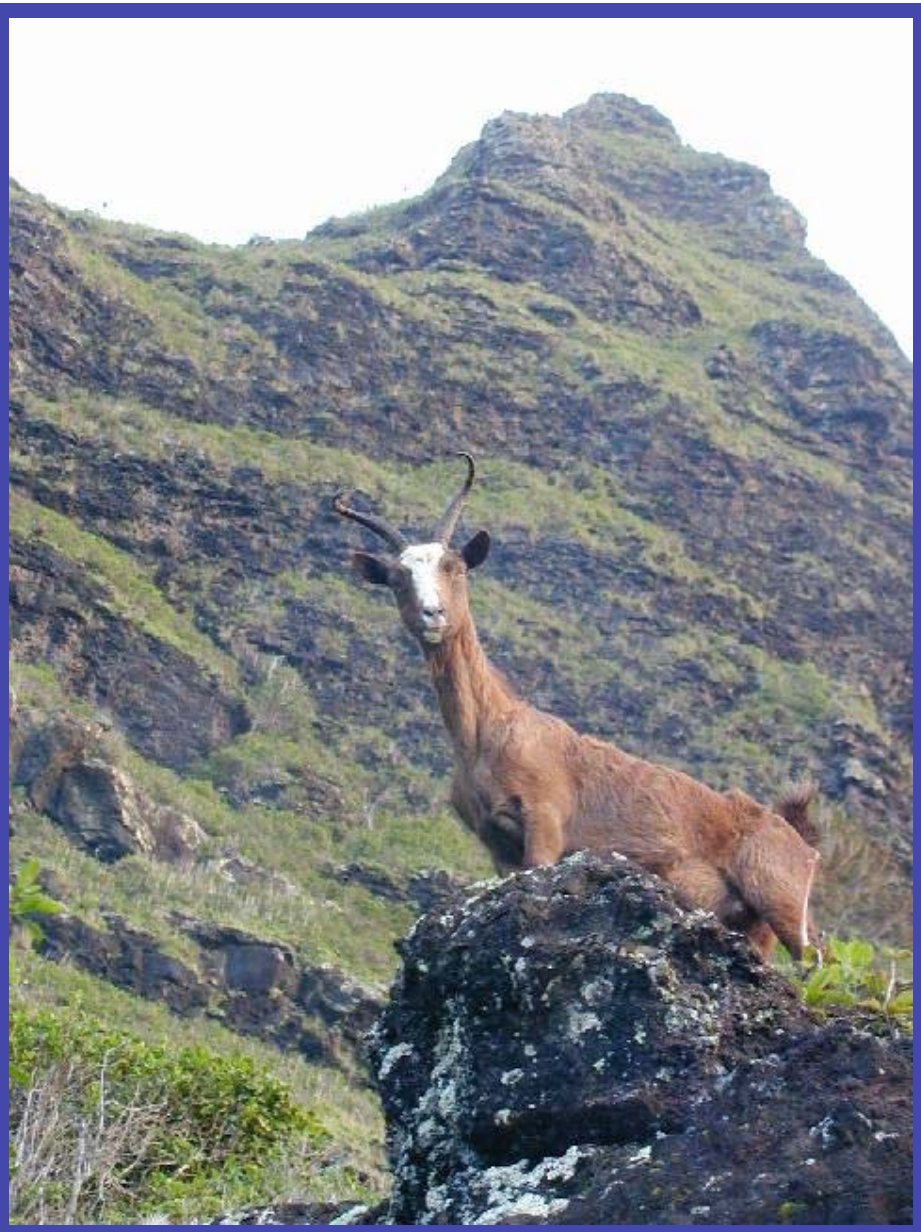
What happens when you decrease rainfall and increase sea level?



Depth to water table increasing

Depth to salt water decreasing





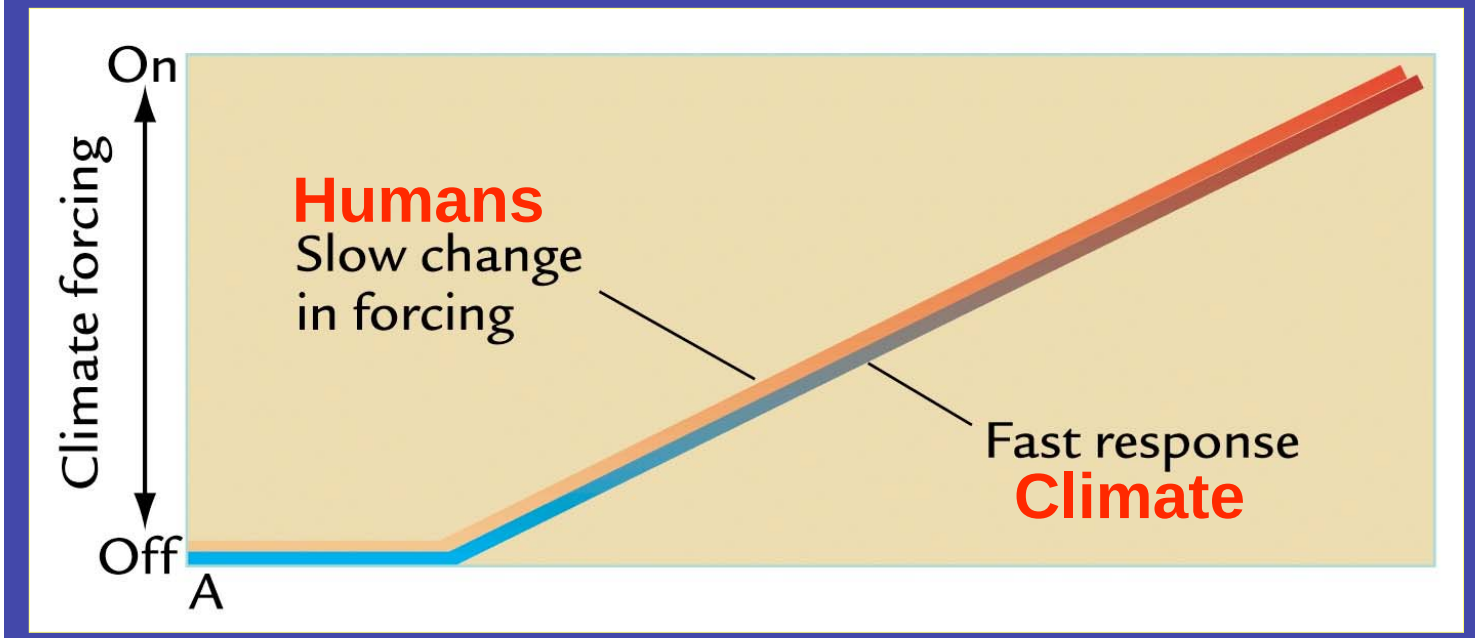
Invasive species encroachment



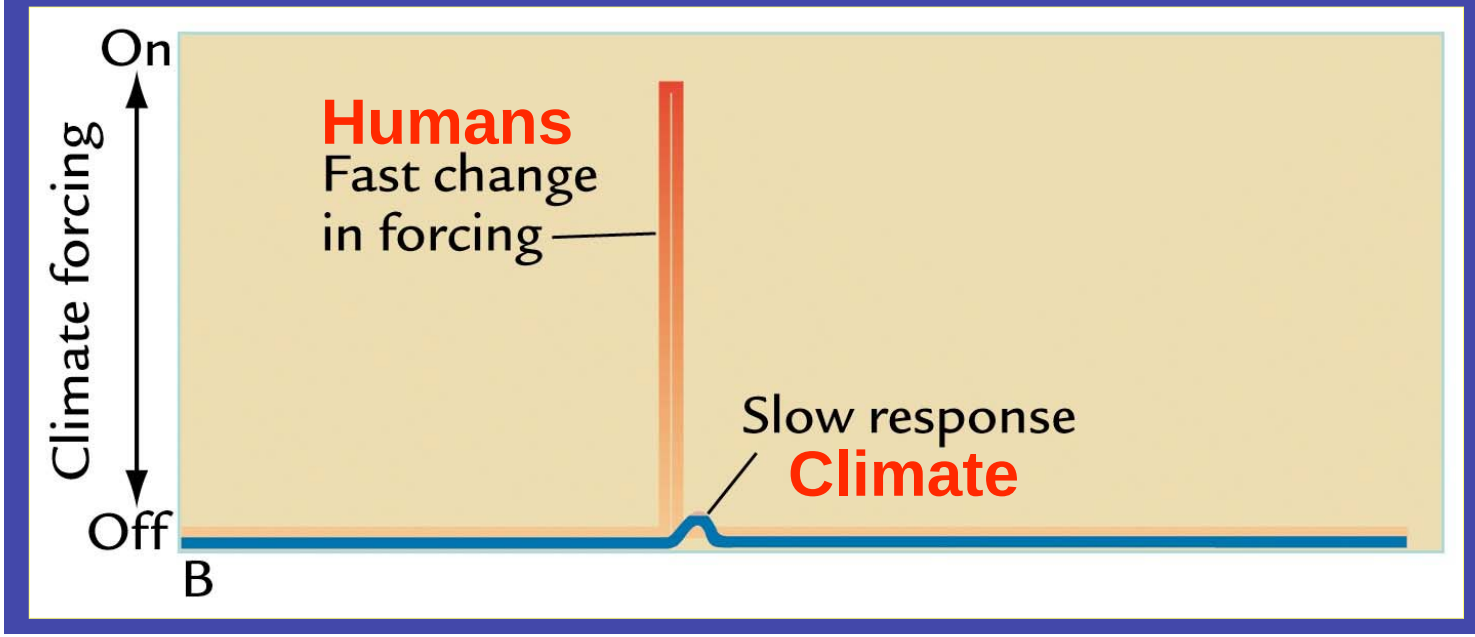




Are human effects on the environment going to last?

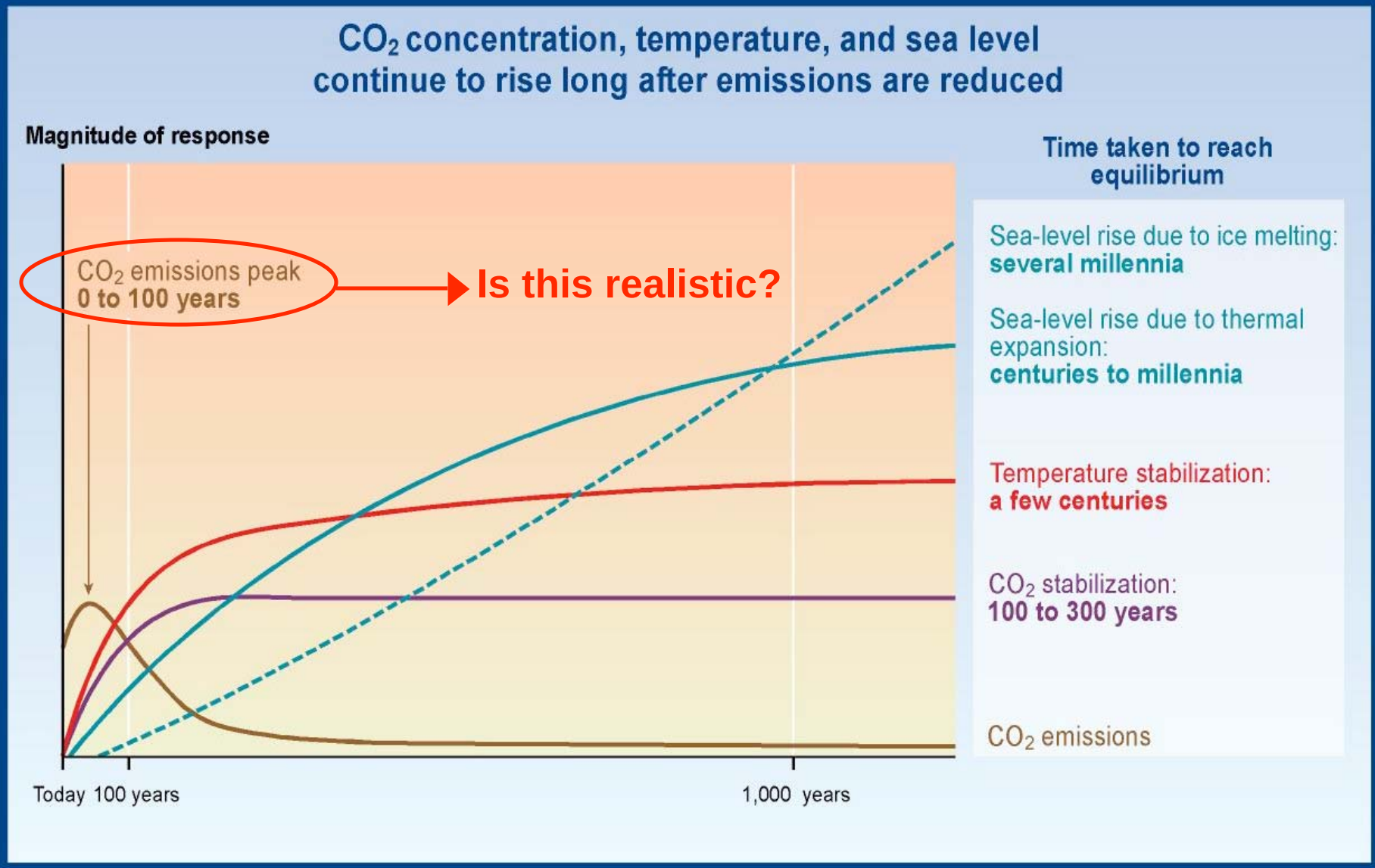


A Problem



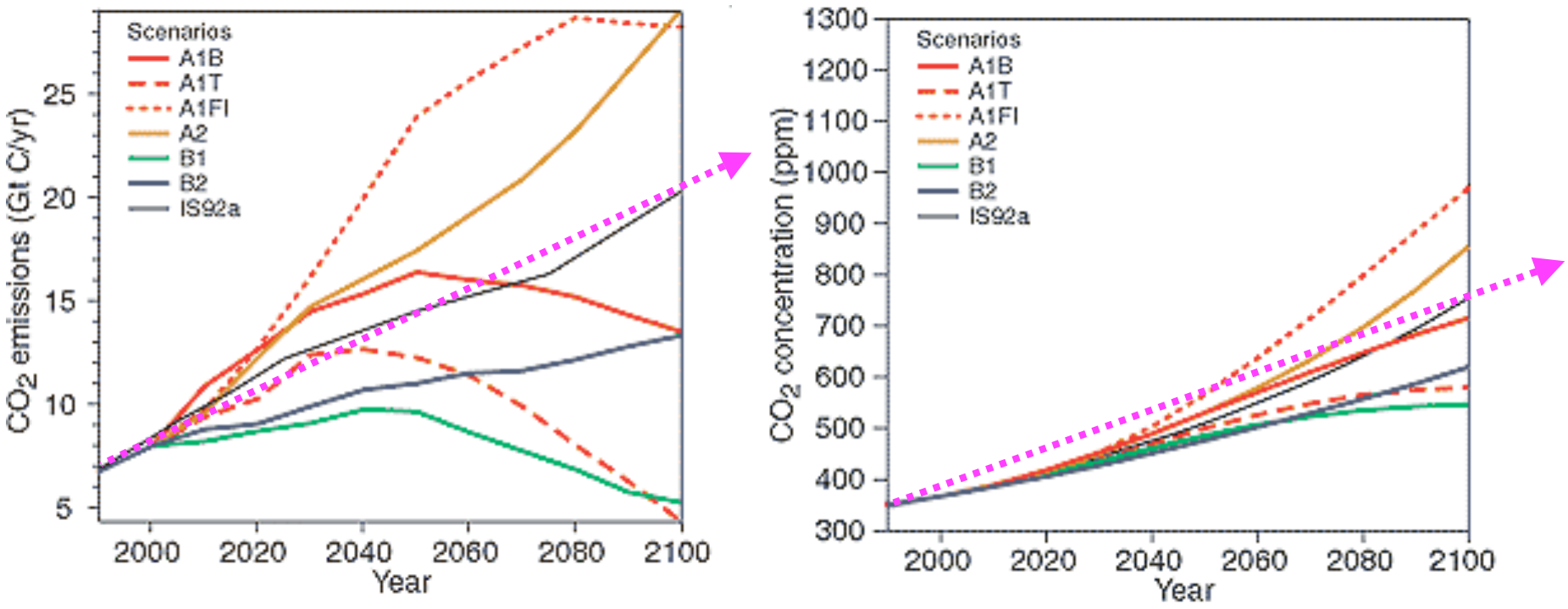
Less of a Problem

Lag time of climate components



IPCC, 2001

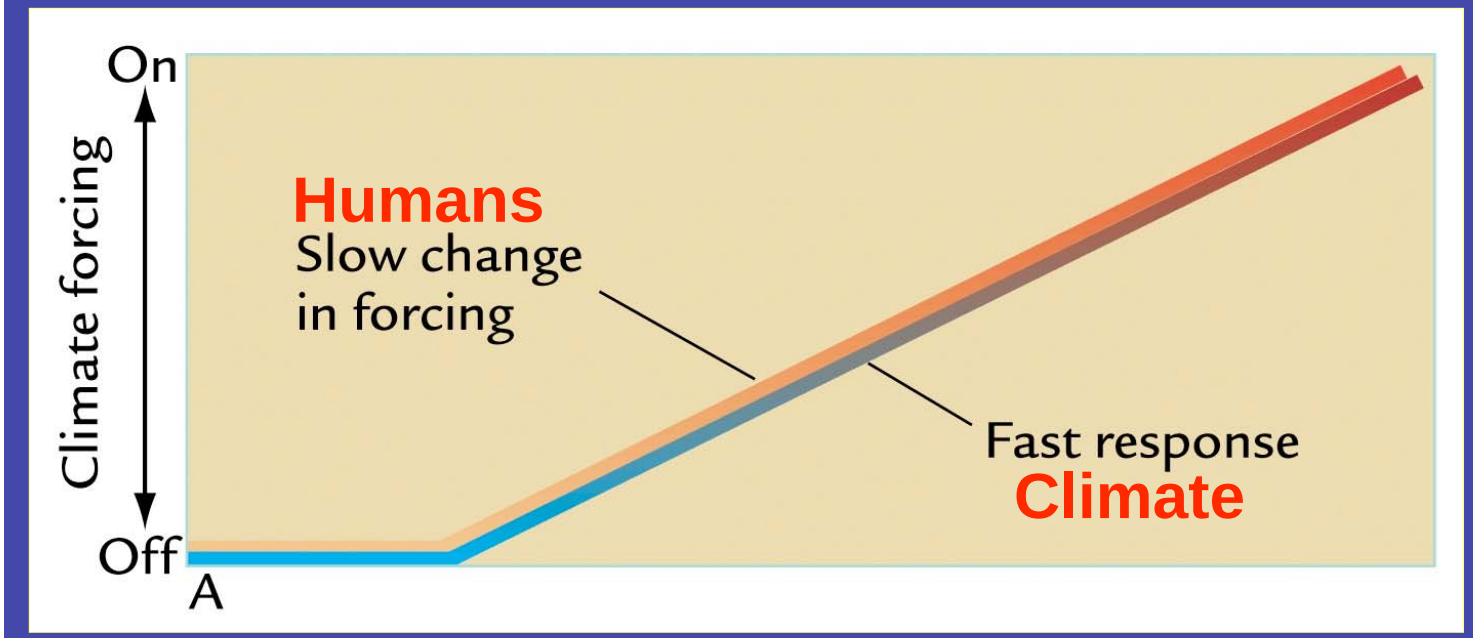
What is the trend in atmospheric CO_2?



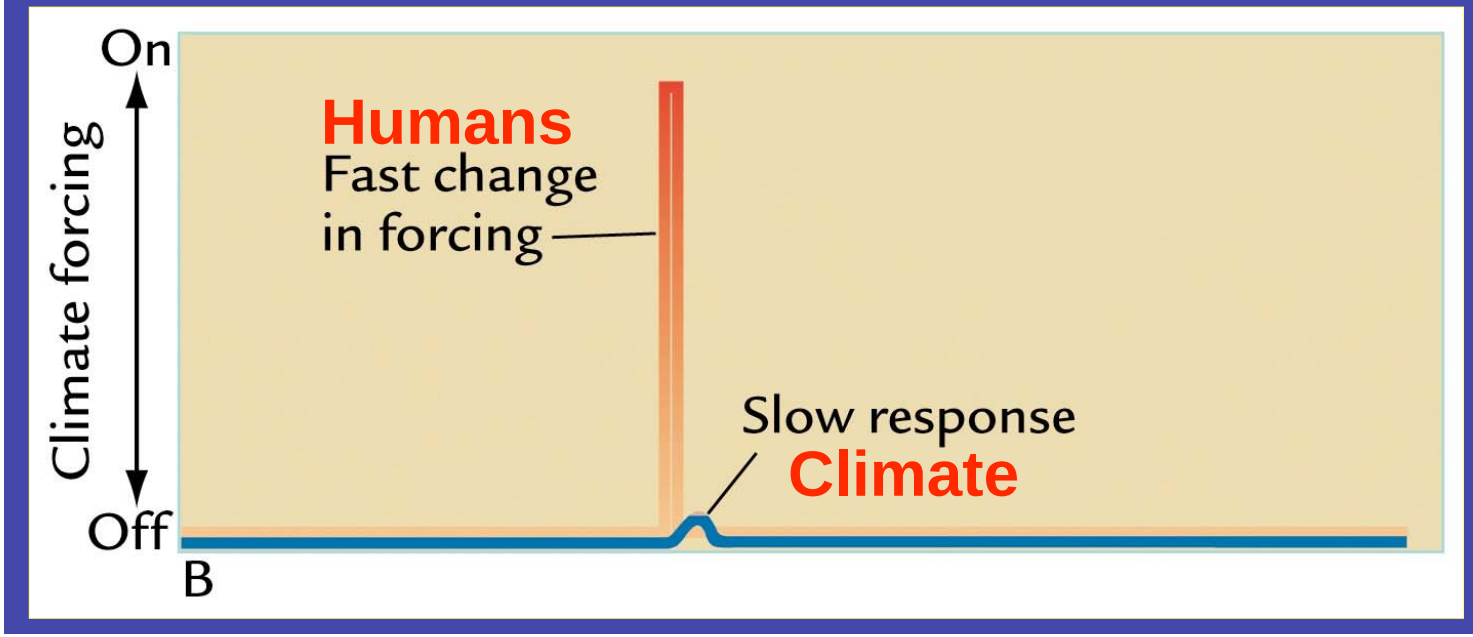
Intergovernmental Panel on Climate Change, 2001

IS92a = "business as usual"

Are human effects on the environment going to last?



Human timescale (YES)



Geologic timescale (NO)

Human/Climate Analogy

What happens when you put a frog in a pot of boiling water?





What happens when you put a frog in cold water then bring it to a boil?



Be the architects of your future, not its victims…

Buckminster Fuller

