Climate Change

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- *Is it Happening?*
- *Why is it Happening?*
- *What are the Implications?*
- *What should we do about it?*

Is Climate Change Happening?

Yes, of course.

Climate Change has always happened –

But - is this different?

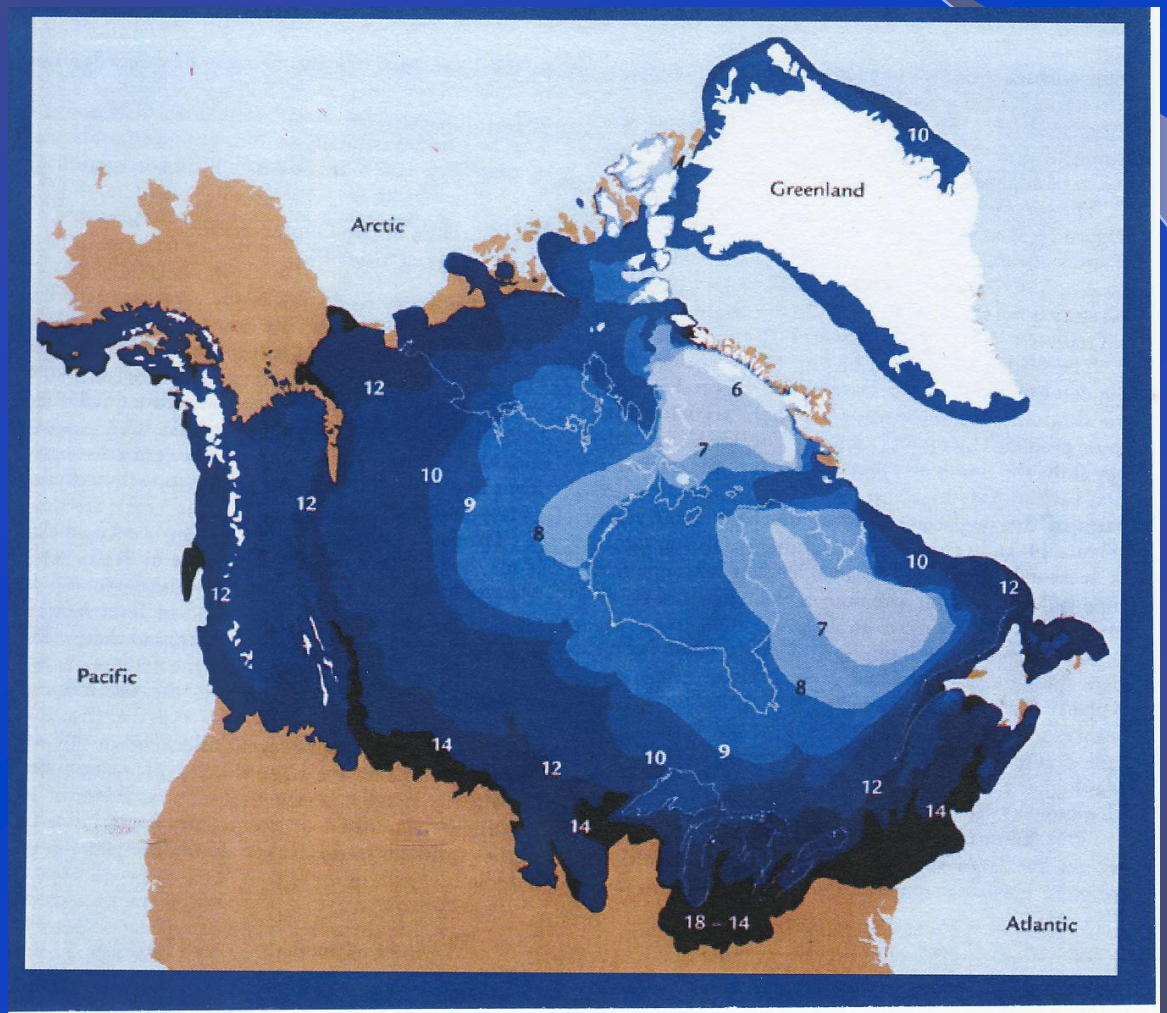
The debate is over,

whether it's different or why.

Geological Climate Change

Ice extent during the Last Glacial Maximum

Ruddiman et al (2005)



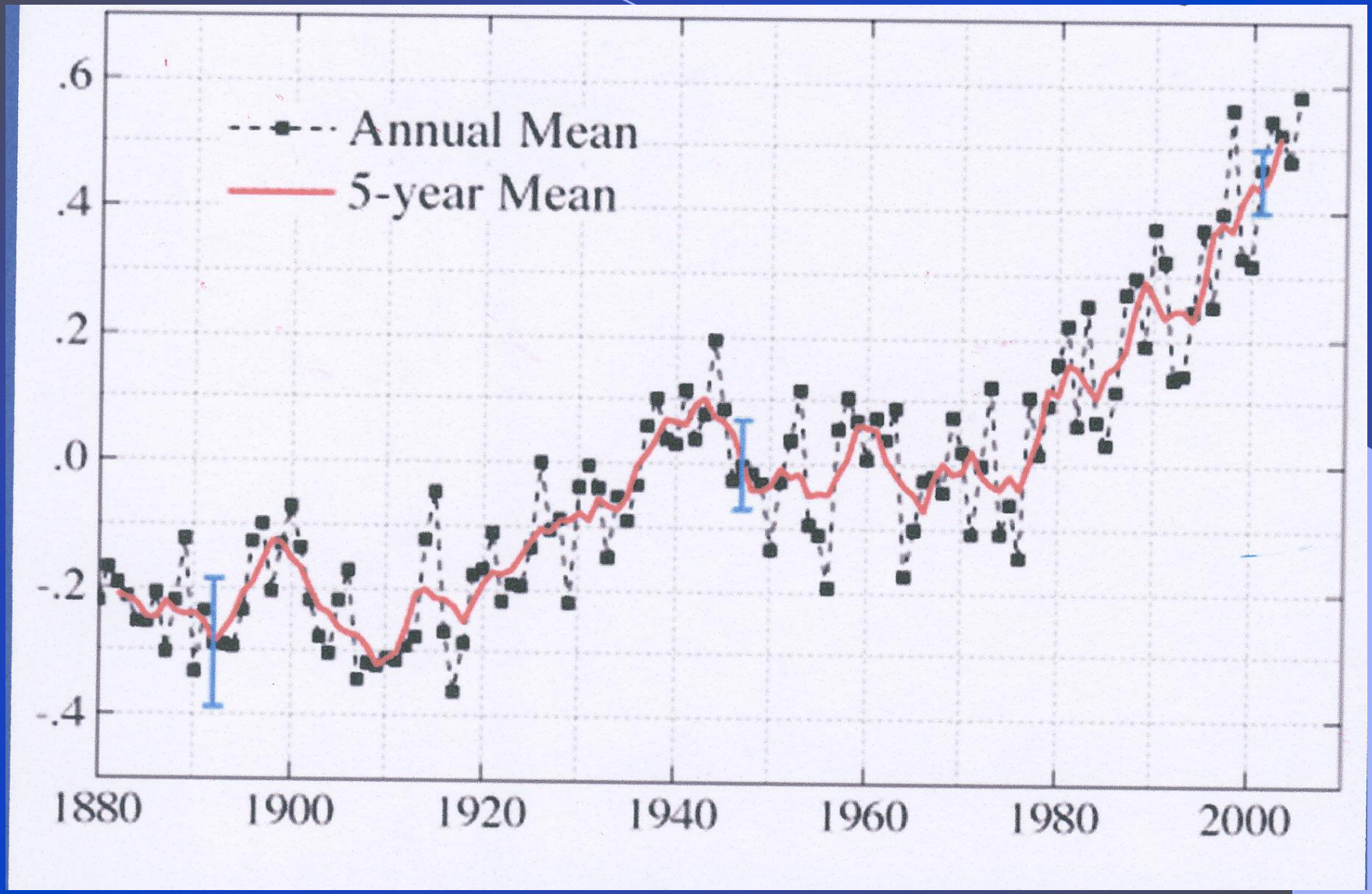
How do we know this is different?

Through:

- Scientific Data
- Historical Records
- Images of the Earth

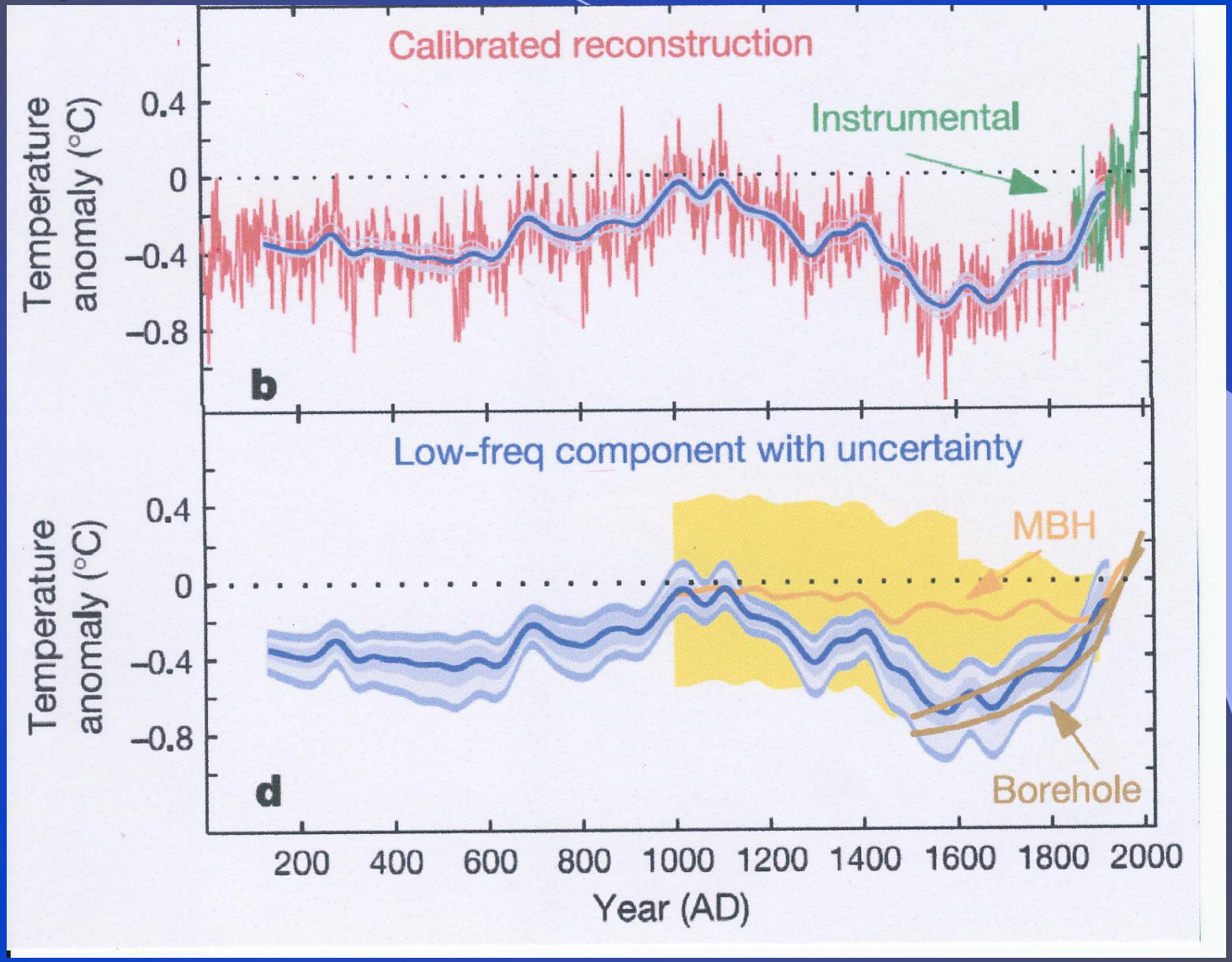
Measured Trends in Global Temperatures (°C)

0 = Average Temperature 1950 - 1980



Source: R.J. Cicerone. 2006. NCSE presentation

N. Hemisphere Long-Term Surface Temperature Reconstruction *Moberg et al (2005)*

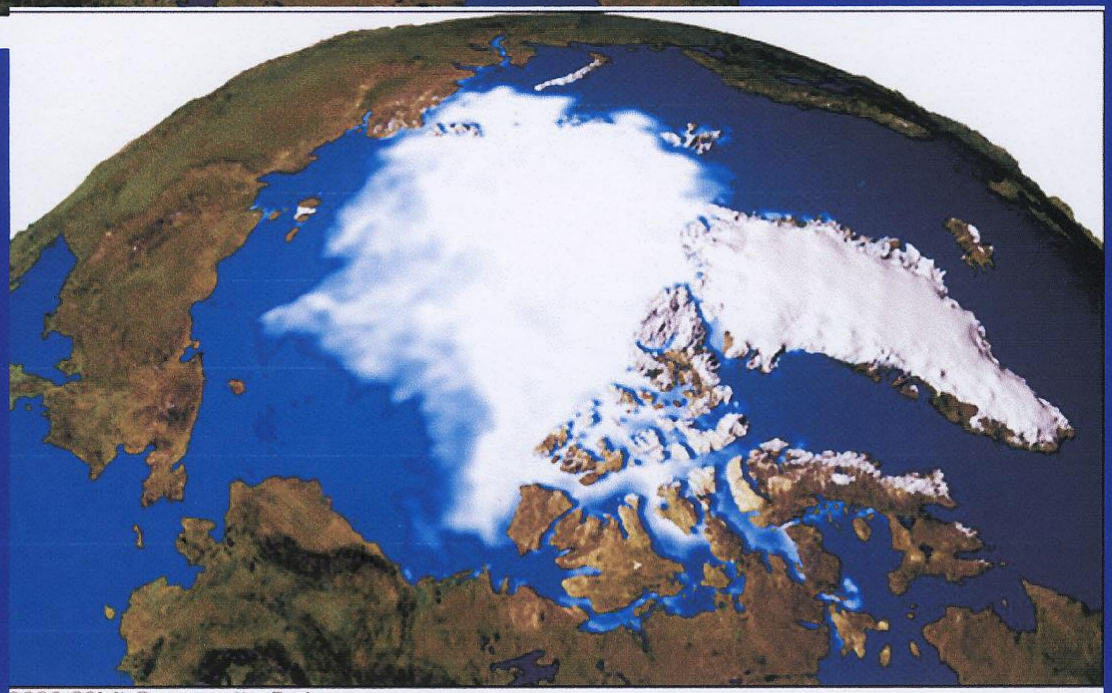


Source: R.J. Cicerone. 2006. NCSE presentation

Northern Hemisphere Sea Ice Extent (1979 versus 2003)

Image courtesy of NASA-Goddard Space Flight Center

1979 SSMI Composite Data



2003 SSMI Composite Data

Source: R.J. Cicerone. 2006. NCSE presentation

Global Climatic Change Involves More Than Temperature

Climate Change involves changes in:

- *Rainfall Patterns and Totals*
- *Vegetation and Animal Habitats and Agriculture*
- *Hurricane Intensity*

Emanuel (2005): Hurricane power dissipation index (PDI)

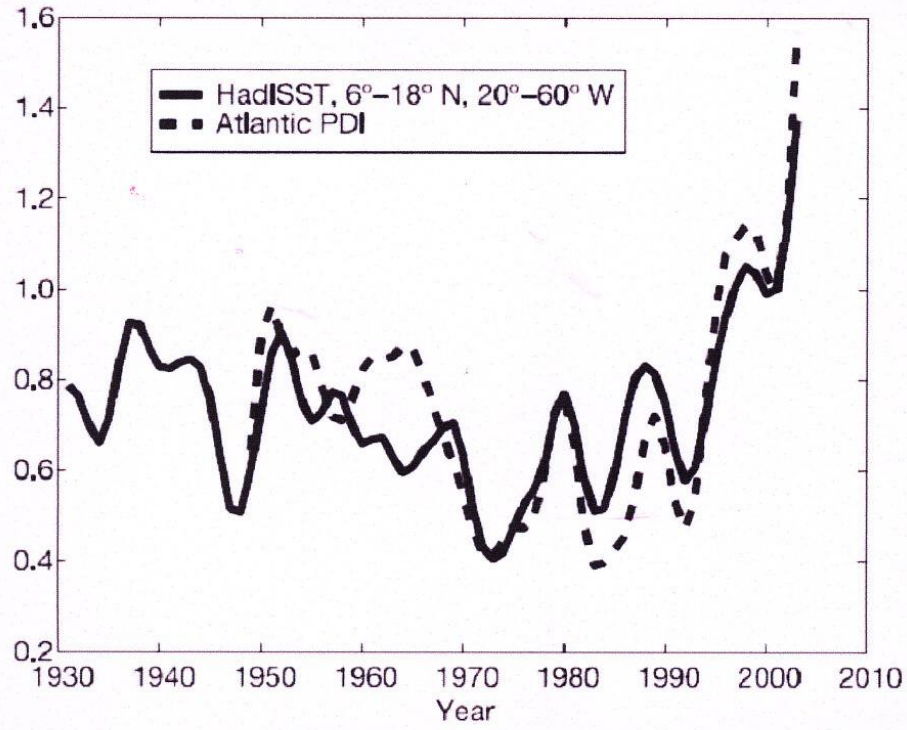


Figure 1 | A measure of the total power dissipated annually by tropical cyclones in the North Atlantic (the power dissipation index, PDI) compared to September sea surface temperature (SST). The PDI has been multiplied by 2.1×10^{-12} and the SST, obtained from the Hadley Centre Sea Ice and SST data set (HadISST)[22], is averaged over a box bounded in latitude by 6° N and 18° N, and in longitude by 20° W and 60° W. Both quantities have been smoothed twice using equation (3), and a constant offset has been added to the temperature data for ease of comparison. Note that total Atlantic hurricane power dissipation has more than doubled in the past 30 yr.

$$\mathrm{PDI} \equiv \int_0^{\tau} V_{\max}^3 \, \mathrm{d}t$$

PDI has increased dramatically in recent decades in both the Atlantic and Pacific Ocean basins

Source: R.J. Cicerone. 2006. NCSE presentation

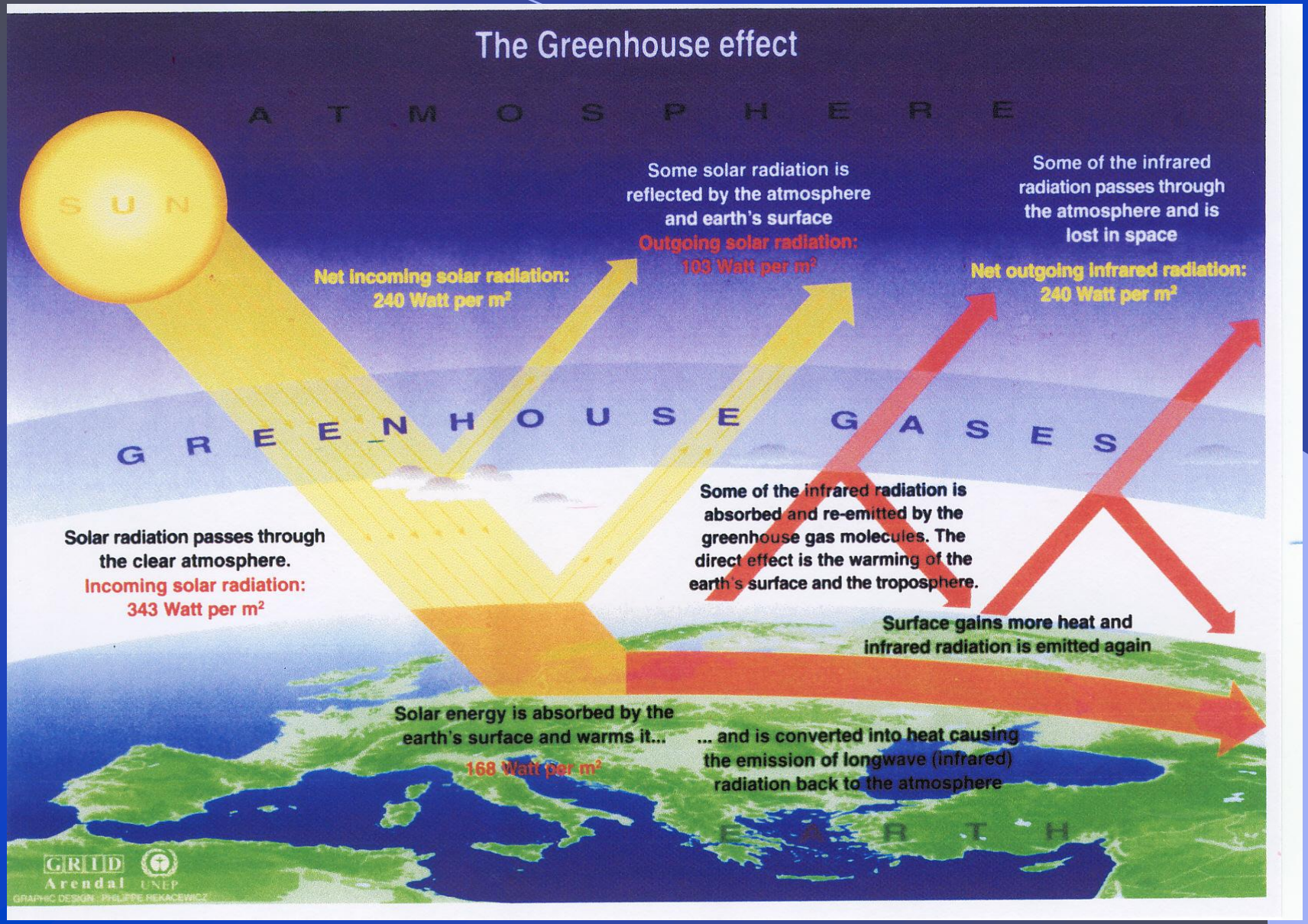
Why is it Happening?

The Greenhouse Effect

Greenhouse Gases Include:

- *Water (H_{2o})*
- *Carbon Dioxide (CO_2)*
- *Methane (CH_4)*
- *Nitrous Oxide (N_{2o})*
- *Ozone (O_3)*

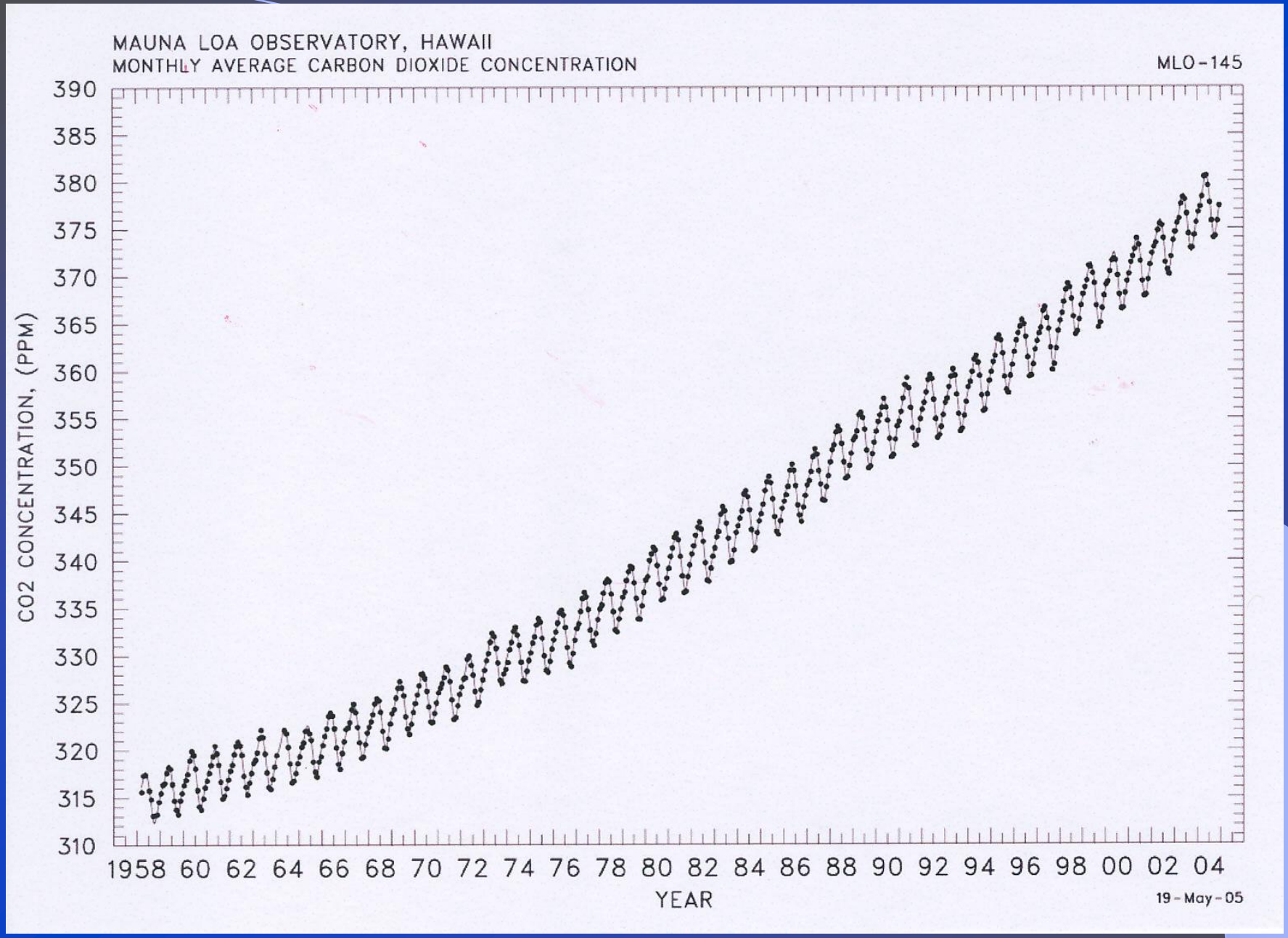
Greenhouse Effect



Source: Climate Change. The National Academies.2005

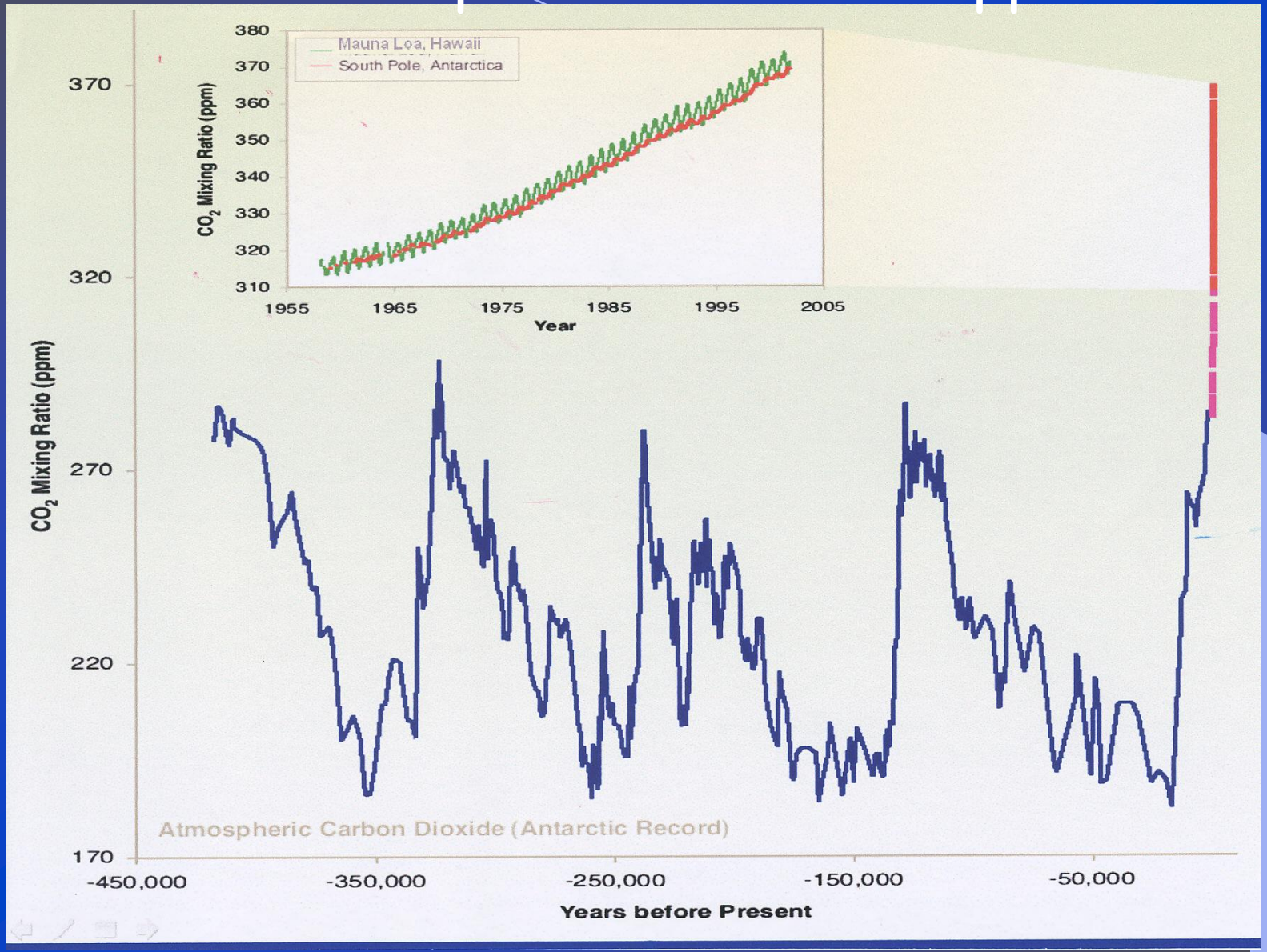
Greenhouse Gasses and Human Activities
What is the Connection?

1. Measurements of CO_2 in the atmosphere
2. Geological Measurements of CO_2 in Ice Sheets
3. What are we emitting?



Source: R.J. Cicerone. 2006. NCSE presentation

Ice Age – 180 ppm
Warmer periods 280-300 ppm



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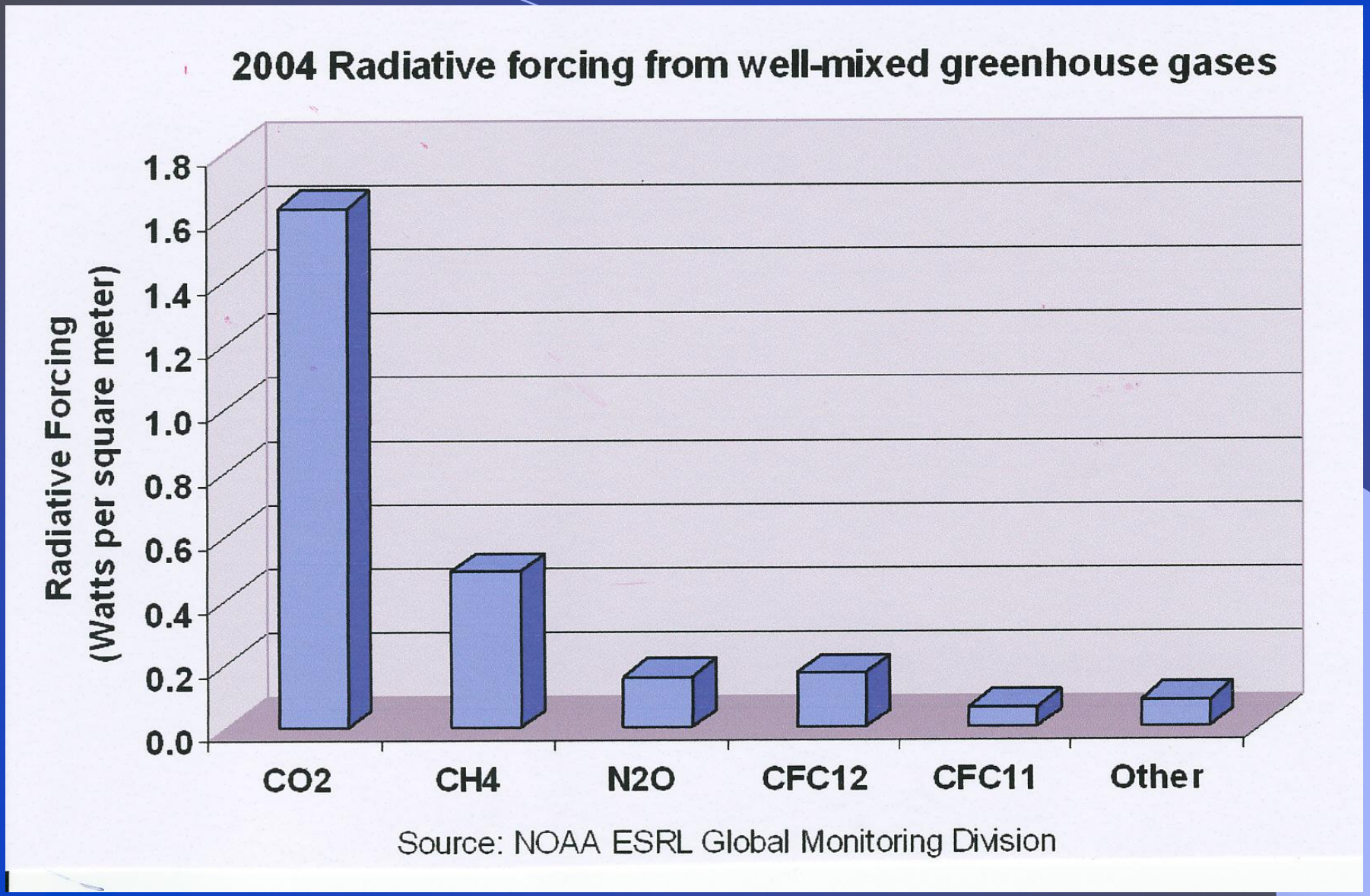
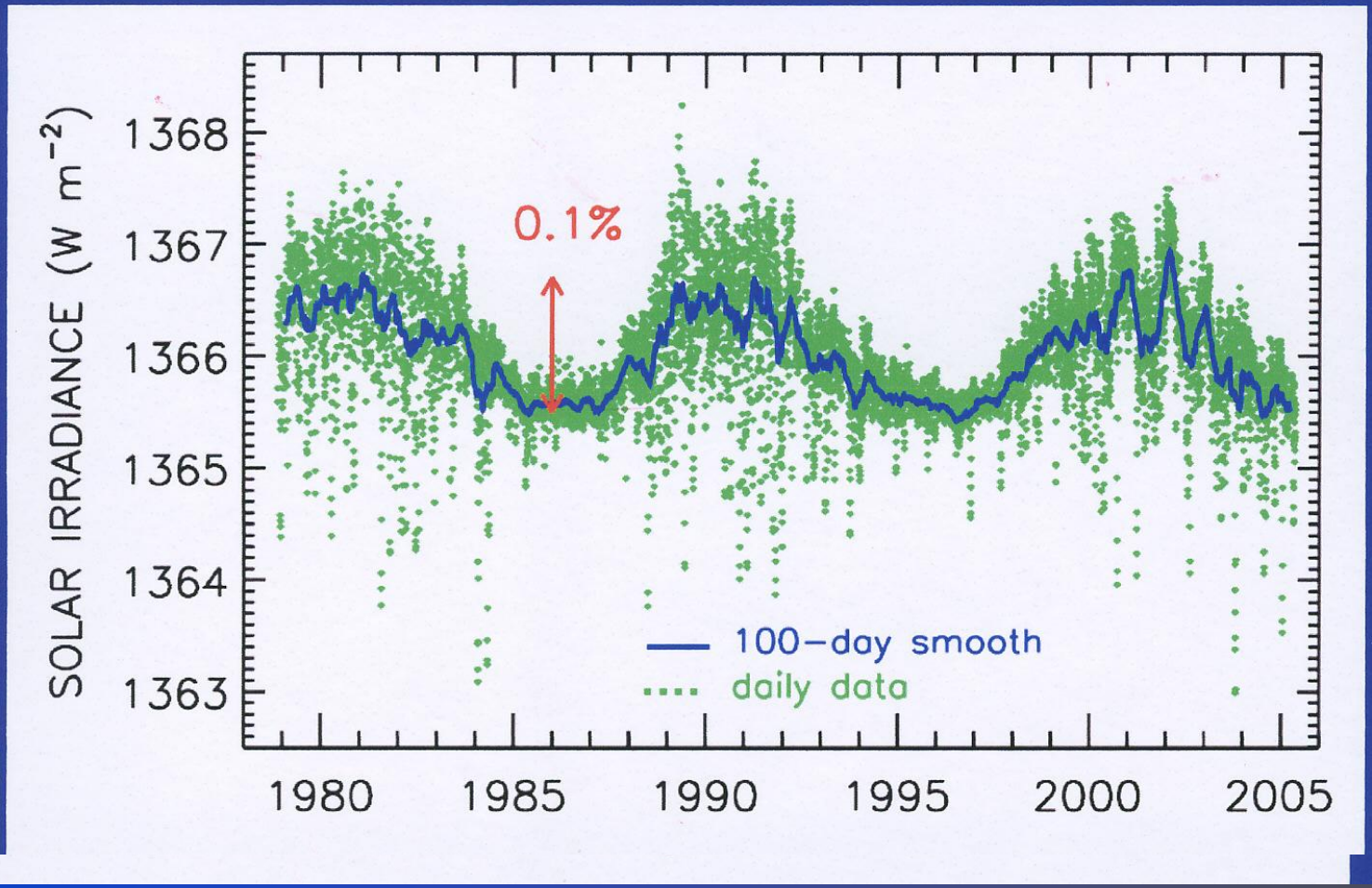
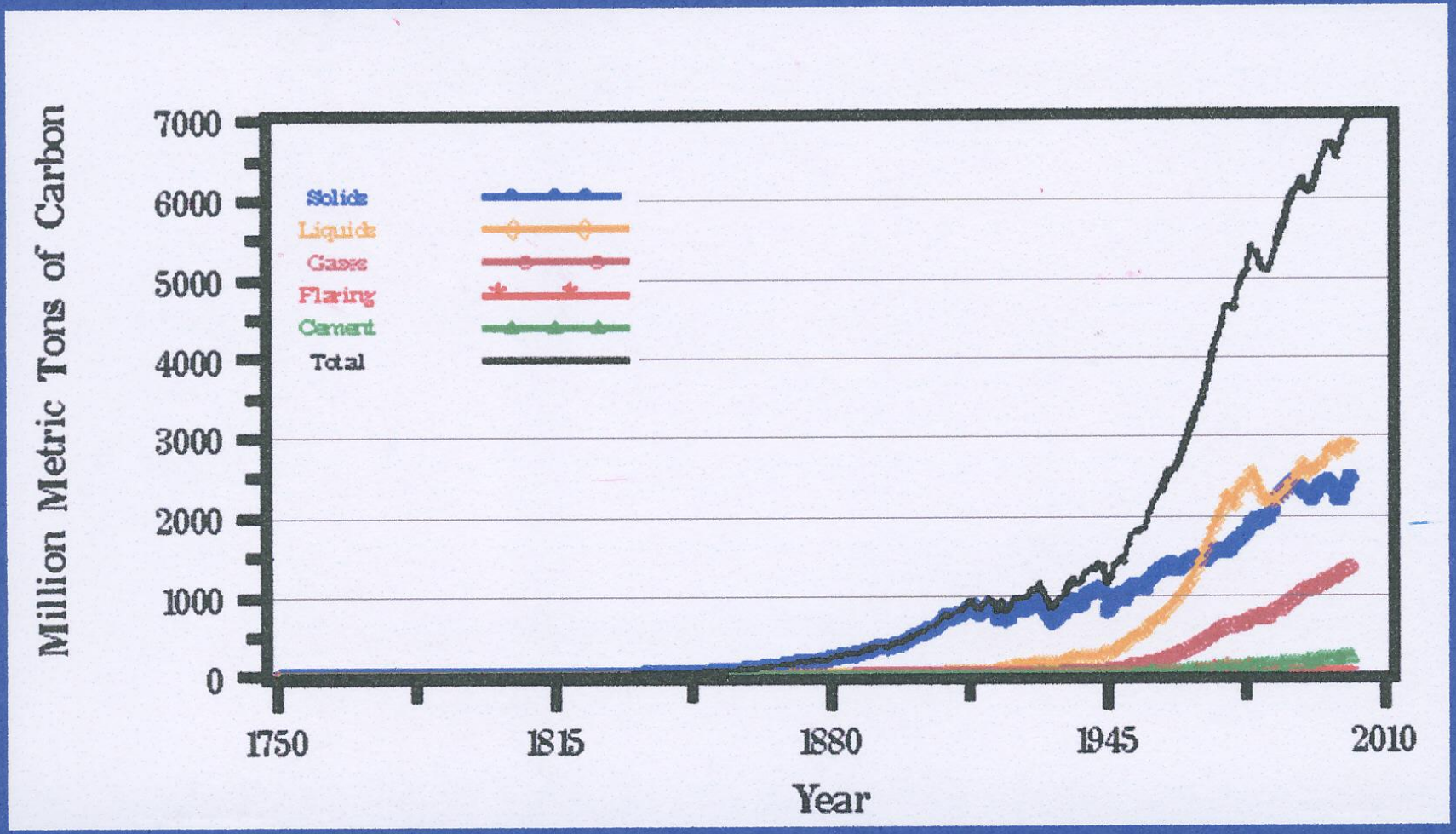

2004 Radiative forcing from well-mixed greenhouse gases
Radiative Forcing
(Watts per square meter)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
CO2
CH4
N2O
CFC12
CFC11
Other
Source: NOAA ESRL Global Monitoring Division

It's not the Sun

Frohlich and Lean (2005): Recent analyses of satellite measurements do not indicate a long-term trend in solar irradiance (the amount of energy received by the sun)

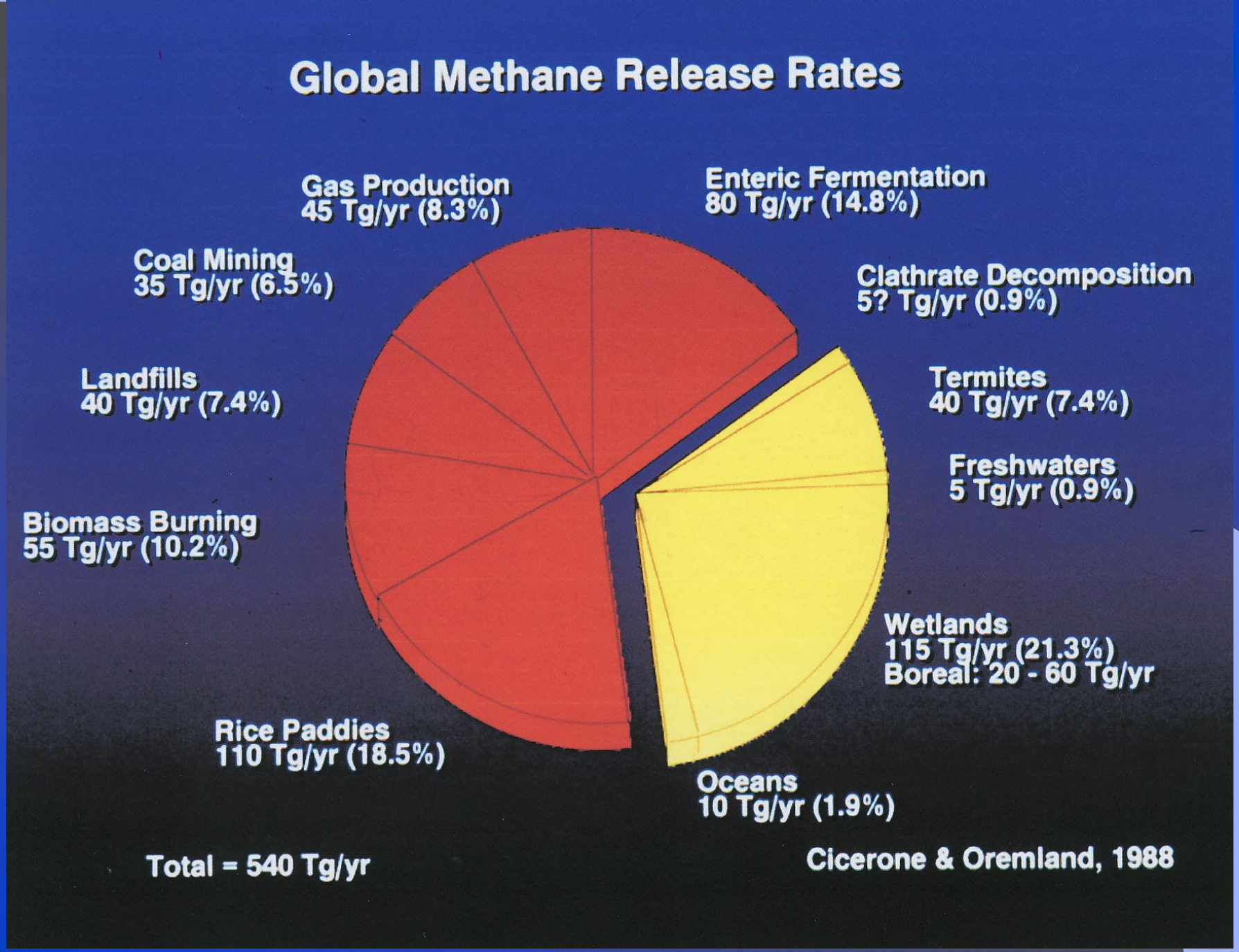


Global, Regional, and National CO_2 emissions



Global CO_2 emissions from fossil fuel burning, cement production, and gas flaring for 1751-2002

Source: R.J. Cicerone. 2006. NCSE presentation



Source: R.J. Cicerone. 2006. NCSE presentation

Climate Change Implications for Florida

Changes in:

- *Sea Level – Current & Projected*
- *Parallel Changes in Storm Surge*
- *Precipitation*
- *Increased Climate Extremes (Hurricanes, Flood, Drought)*
- *Water Supply and Water Quality*

Climate Change Implications for Florida

Changes in:

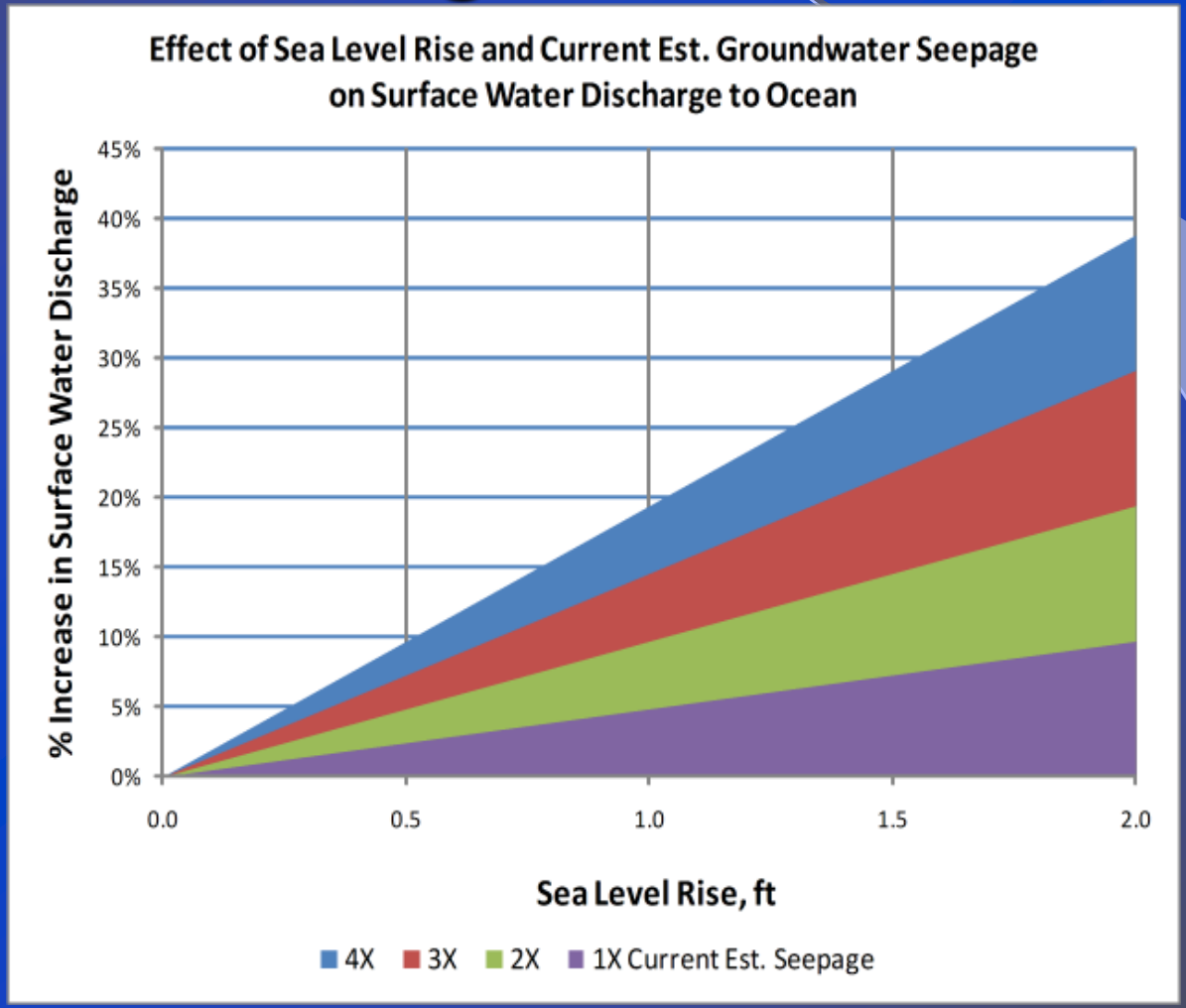
- *Temperature, particularly winter changes in central & northern Florida*
- *Impacts on agriculture*
- *Impacts on Health*
- *Impacts on coastal communities*

Each of the above potentially poses a major impact on the economy & people of Florida

Climate Change Implications More Generally

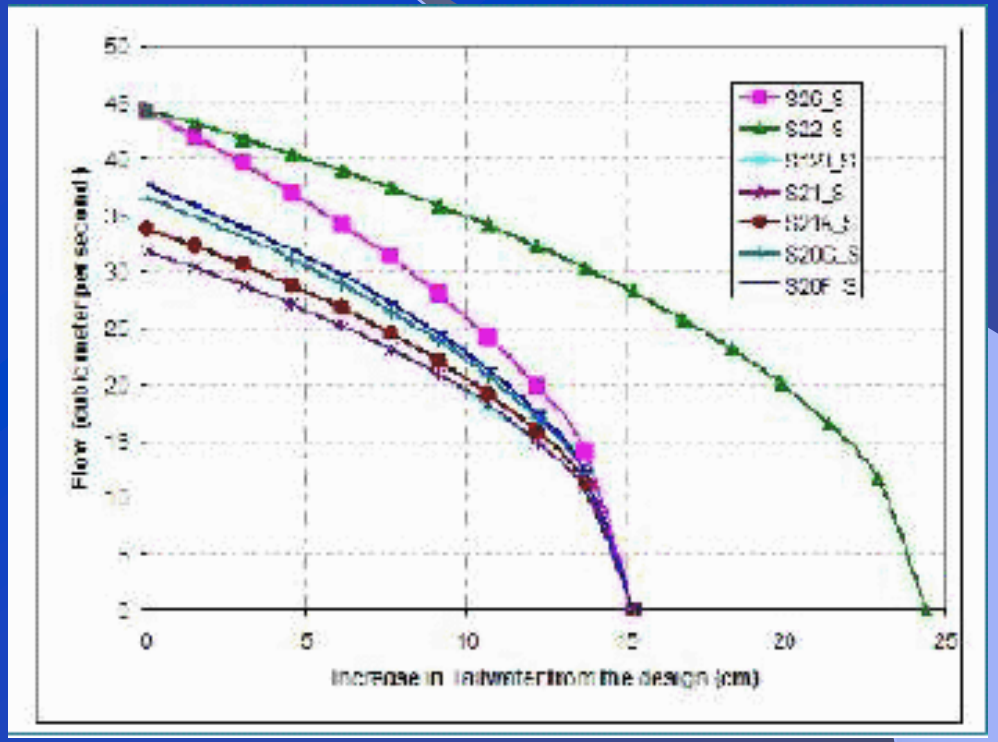
- *Rising Sea Level*
- *Rising Temperature of Oceans*
- *Rising Temperature on Land 0.2° C per Decade*
- *Changes in precipitation patterns*

Groundwater seepage rate could affect flooding as sea level rises



Coastal structures will lose capacity as sea level rises

Typical flood / salinity control structure



(Obeysekera, SFWMD, 2009)

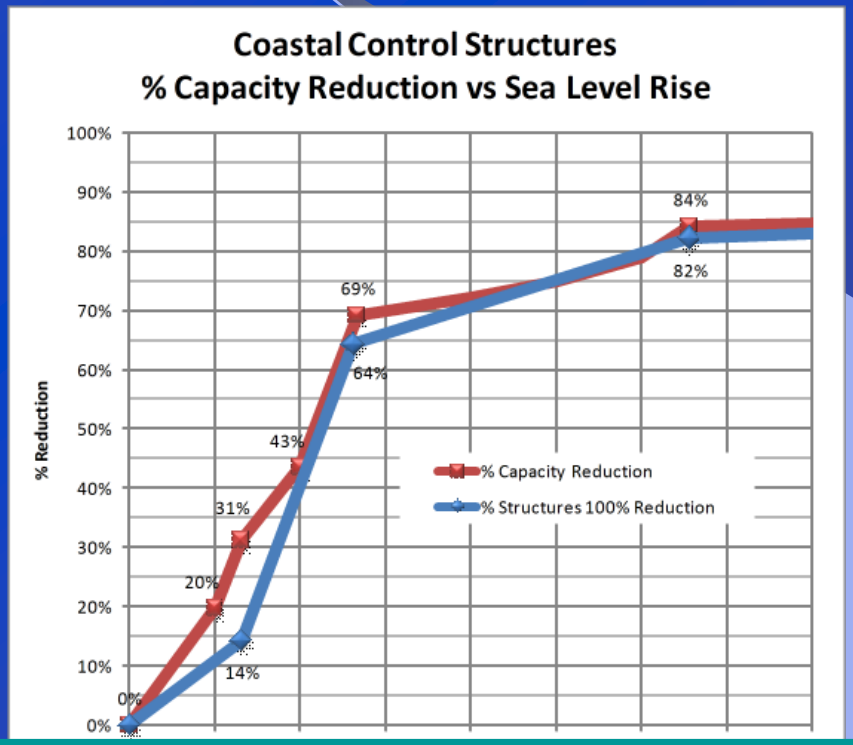
$$F = \propto \sqrt{\Delta h}$$

According to Bernoulli's Law

Coastal structures will loose capacity as sea level rises

S-13 Pumping Station

•Capacity = 540 cfs = 14.5 million gal/hr



2000 2030 2050 2060 2080

Approx. Timeline

Based on data from Obeysekera, SFWMD, 2009

Climate Change Implications
Sea Level Rise

- May be faster than IPCC 2007 Report
- May Not be a Smooth Rise
- Different effects in Different Regions
- Salt Water Intrusion

Climate Change Implications
Ocean Temperature Rise

- Acidification of Oceans – already Changes in ph – 0.1 drop in ph since 1750
- Ocean Chemistry Changing at 100 Times more rapidly than in last 650,000 years
- Summer Ocean Surface Temperatures Increased 0.3° C during 1950 – 1990's

Climate Change Implications
Rise of Land Temperature

- Rising temperature on land:
  - Beneficial in Some Areas
  - Productivity Reduction in Other Areas

Detailed Study in East Africa

Climate Change Implications Precipitation Patterns

The Future is not an indicator of Past

Impact on:

- *Hydrological Modeling*
- *Water Supply Management*
- *Agriculture and Irrigation*

What to do About Climate Change

Really another talk but:

- *Reduce emissions*
- *Plan for Adaptation*
- *Identify Local and Regional Risks*
- *Take into Account the Implications of Climate Change in all Relevant Decision Making and Planning Structures.*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Jacksonville
Florida
Tampa
Miami
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major cities
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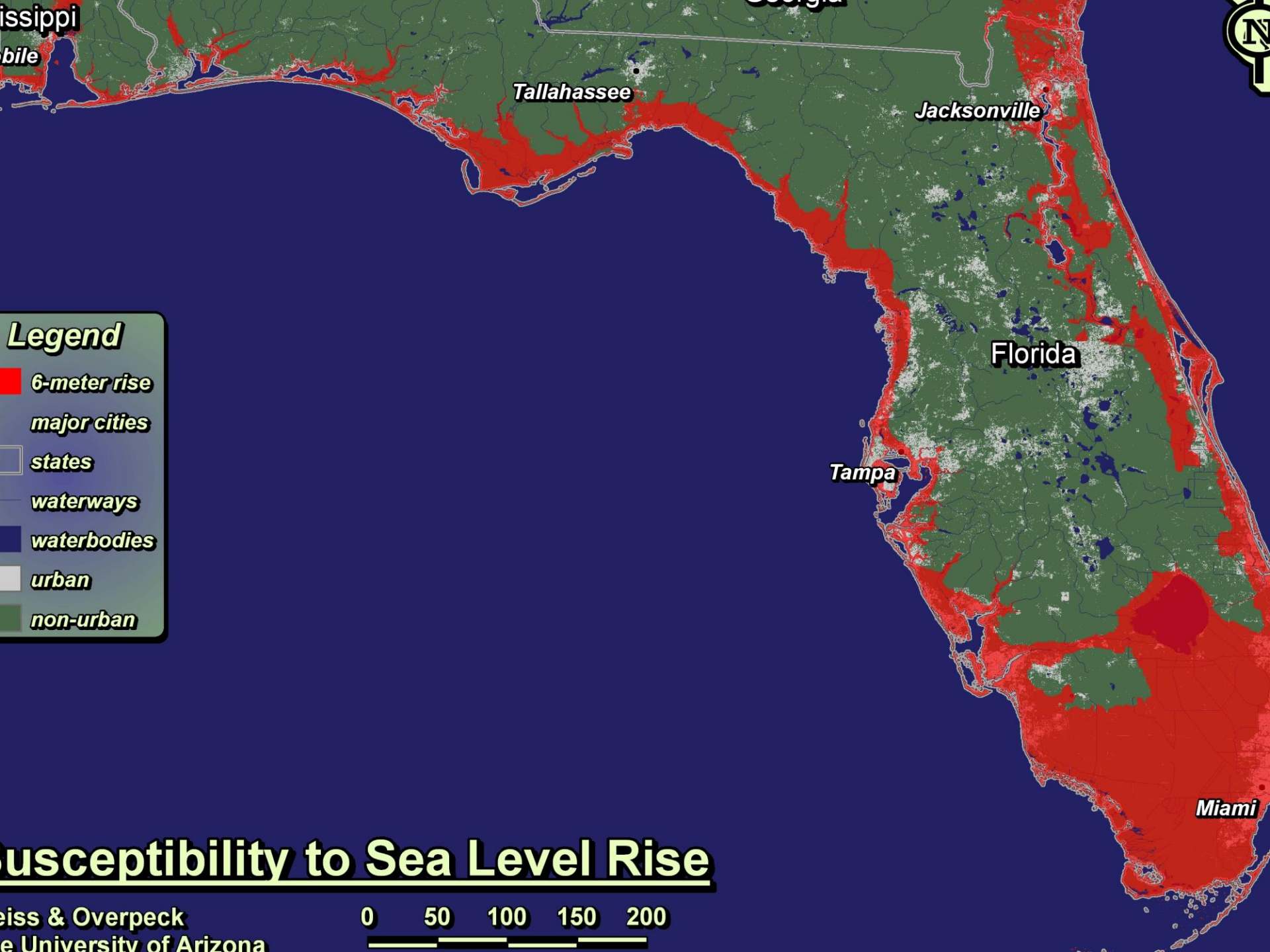

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Thank you