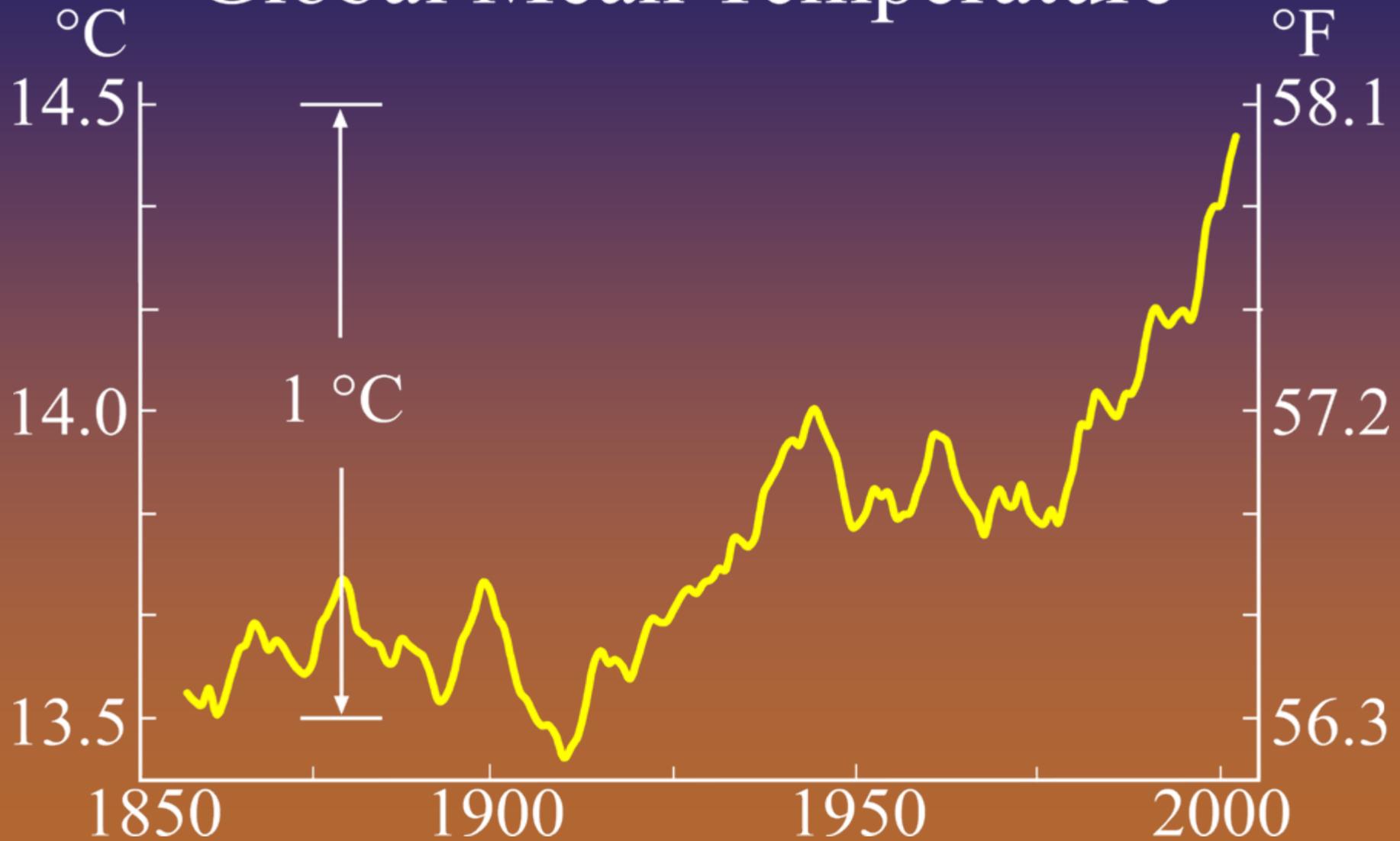


# Global Warming: More Than Hot Air



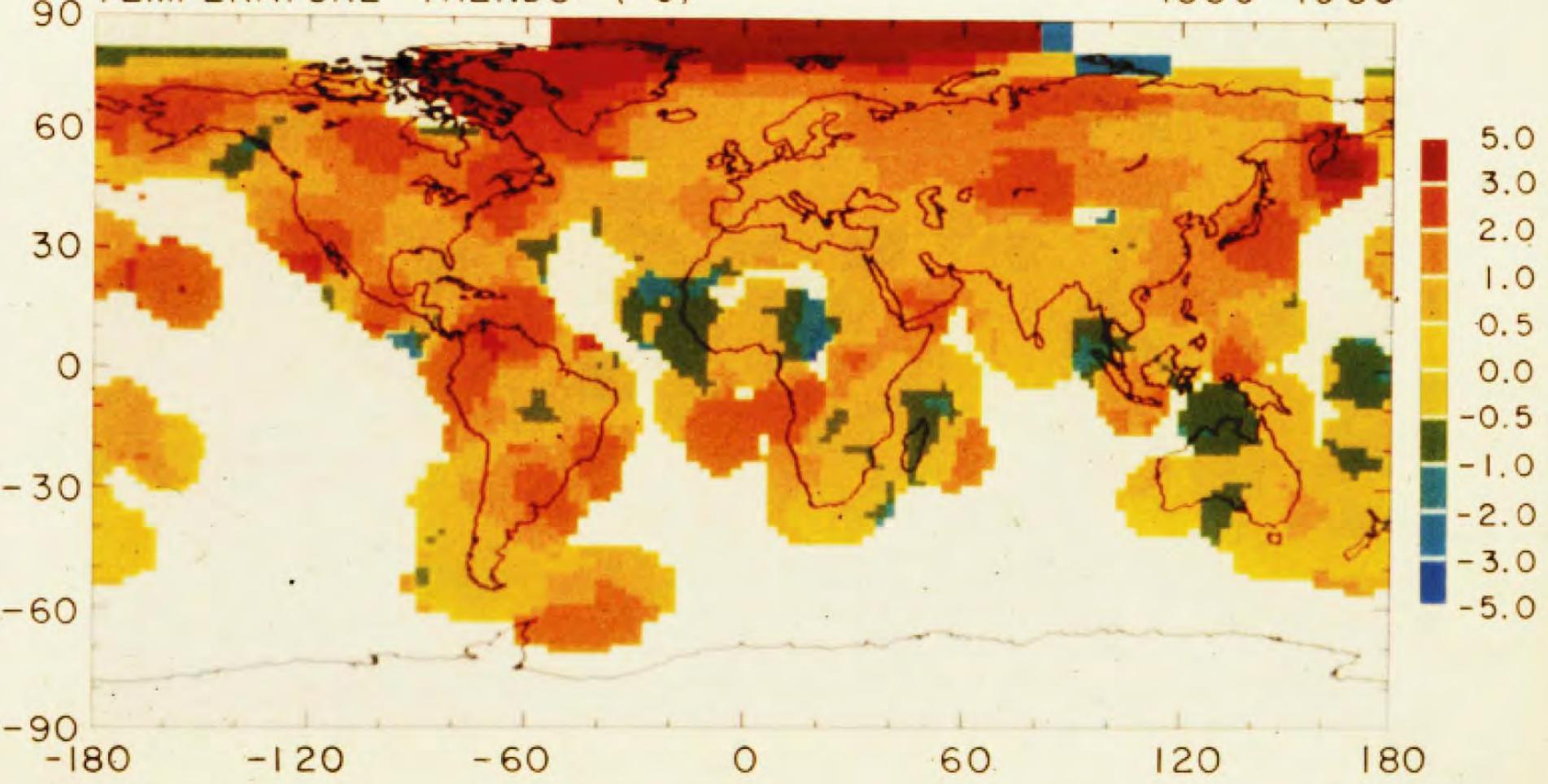
**D.S. Chapman**  
**University of Utah**

# Global Mean Temperature



TEMPERATURE TRENDS (°C)

1880-1985



(a)



1850

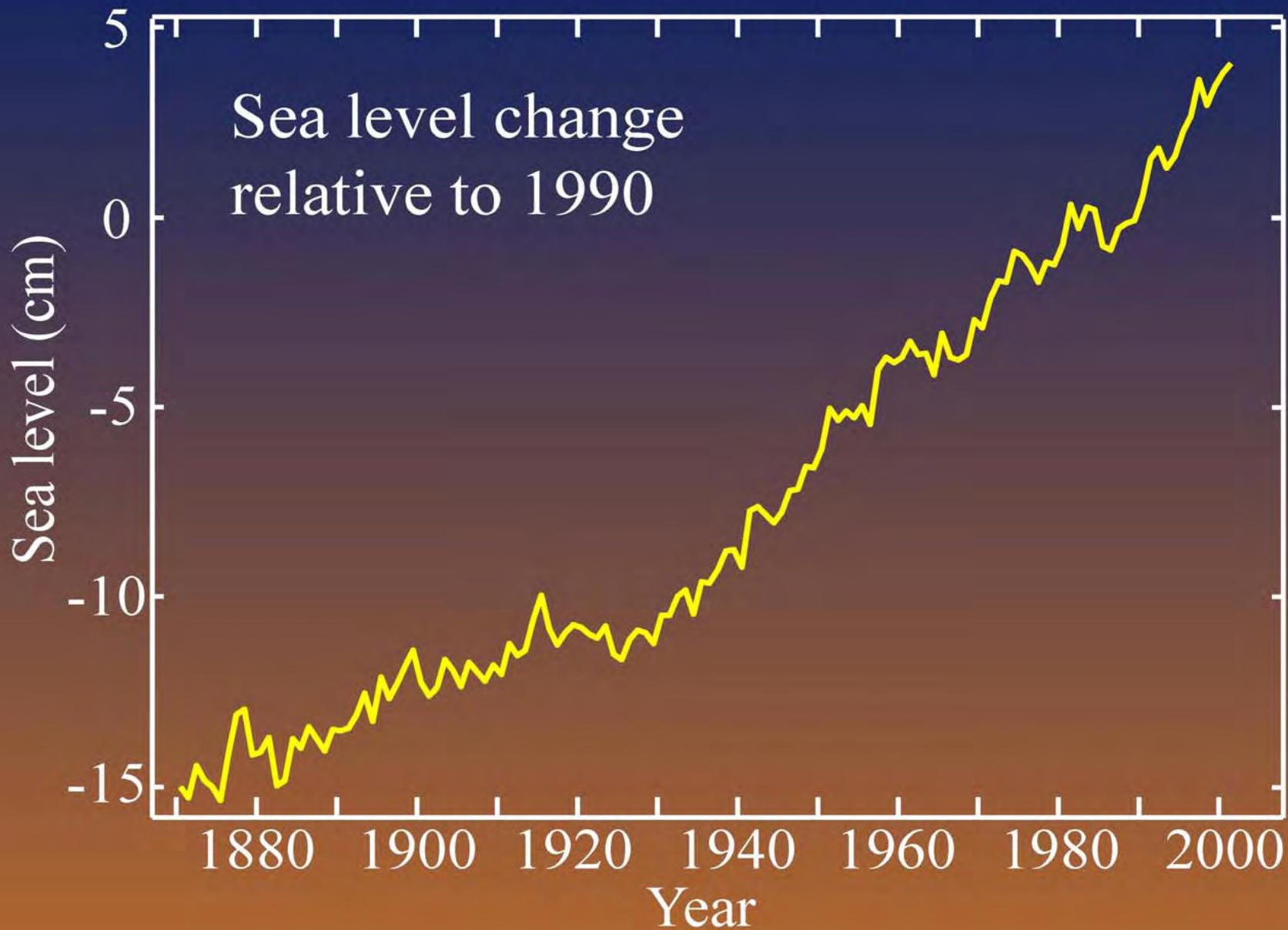
*Der Rhonegletscher im Jahre 1850*



1928

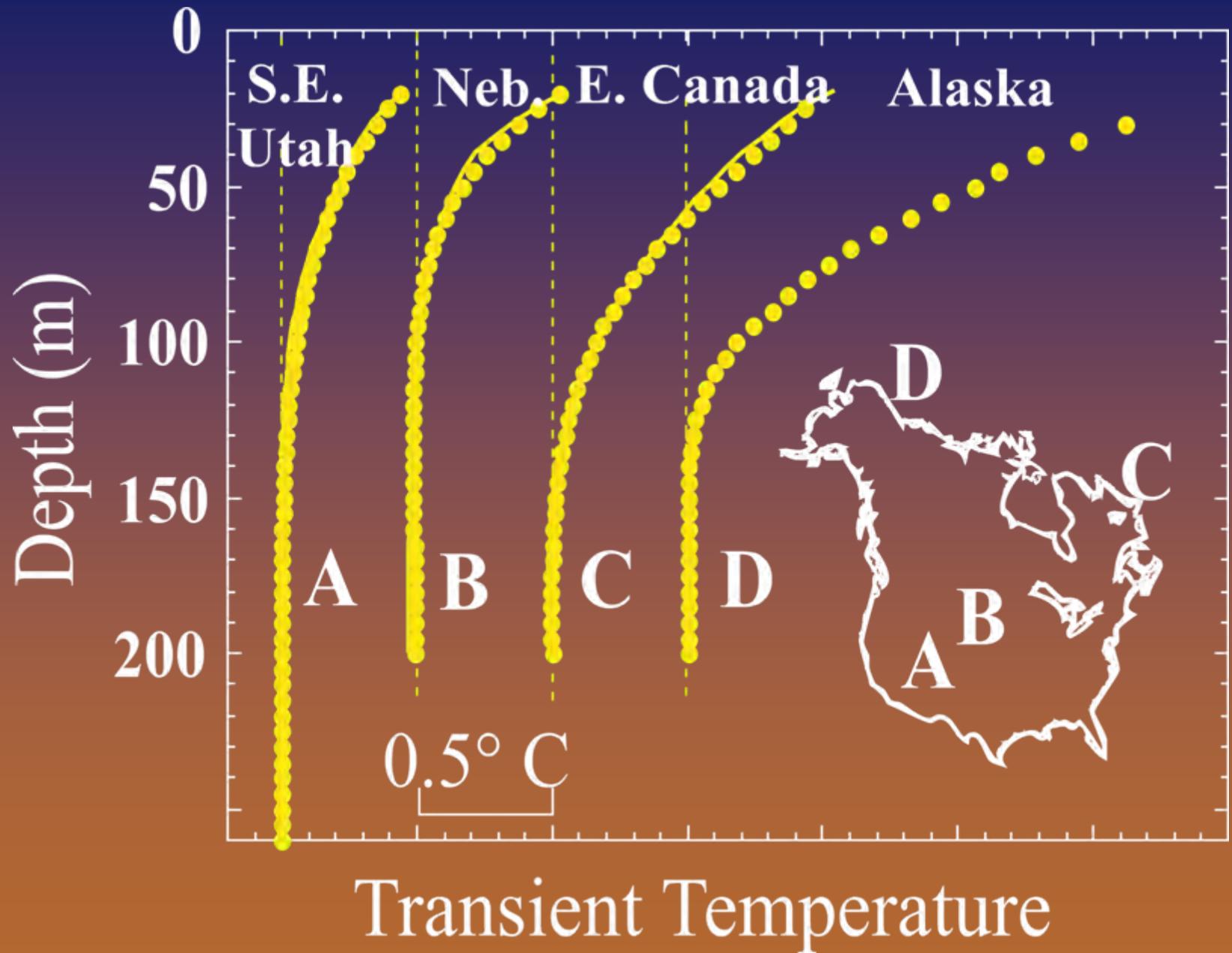


1981



# Measuring Temperature in the Earth





# Consequences of Global Warming

**Early Bird!**



**Mexican Jays are now laying eggs 10 days earlier in the year than in 1971.**  
*J. Brown, Science, 2000.*



**Growing Ecological Tensions**

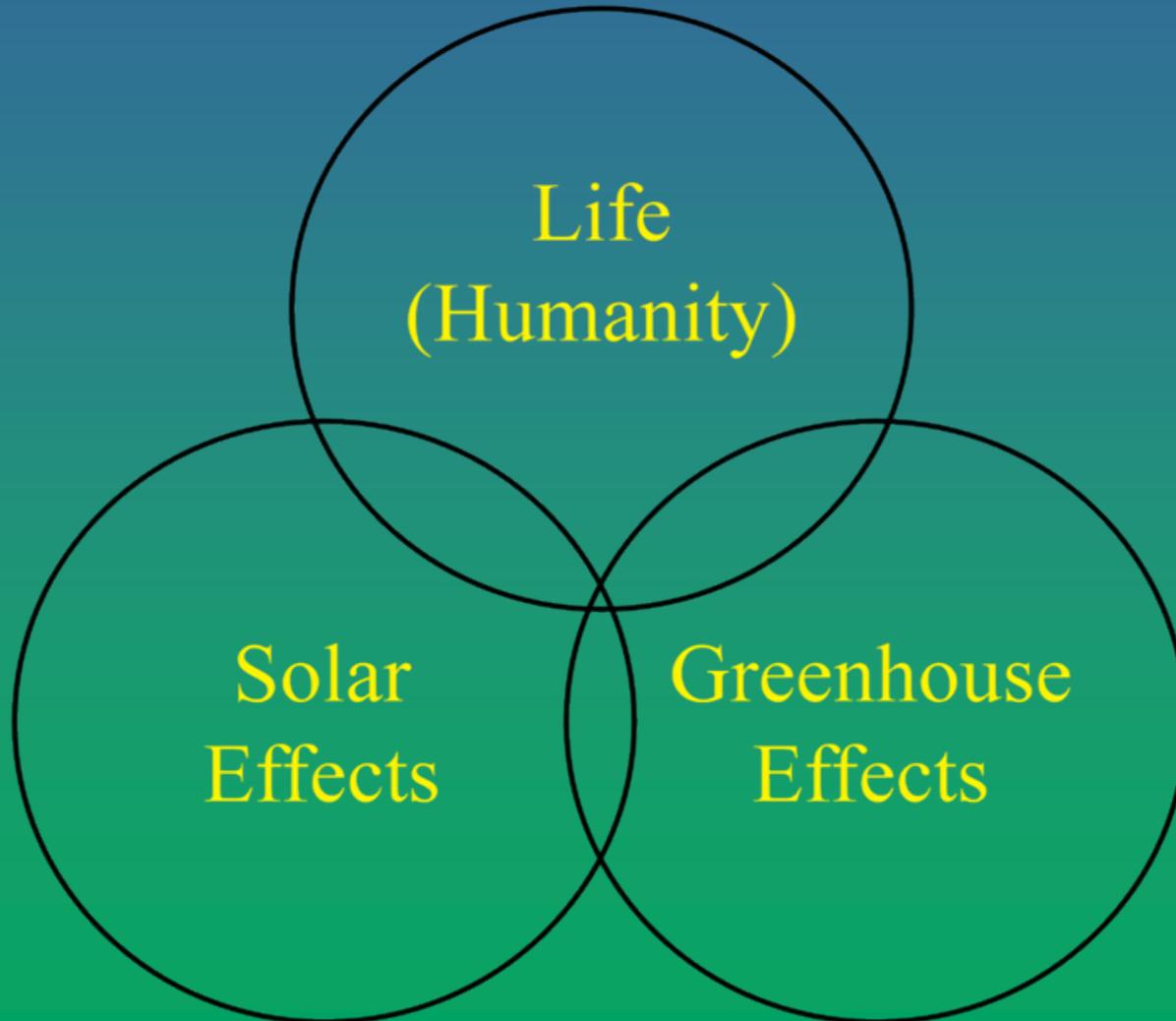
**Ward Hunt Ice Shelf, 2002**



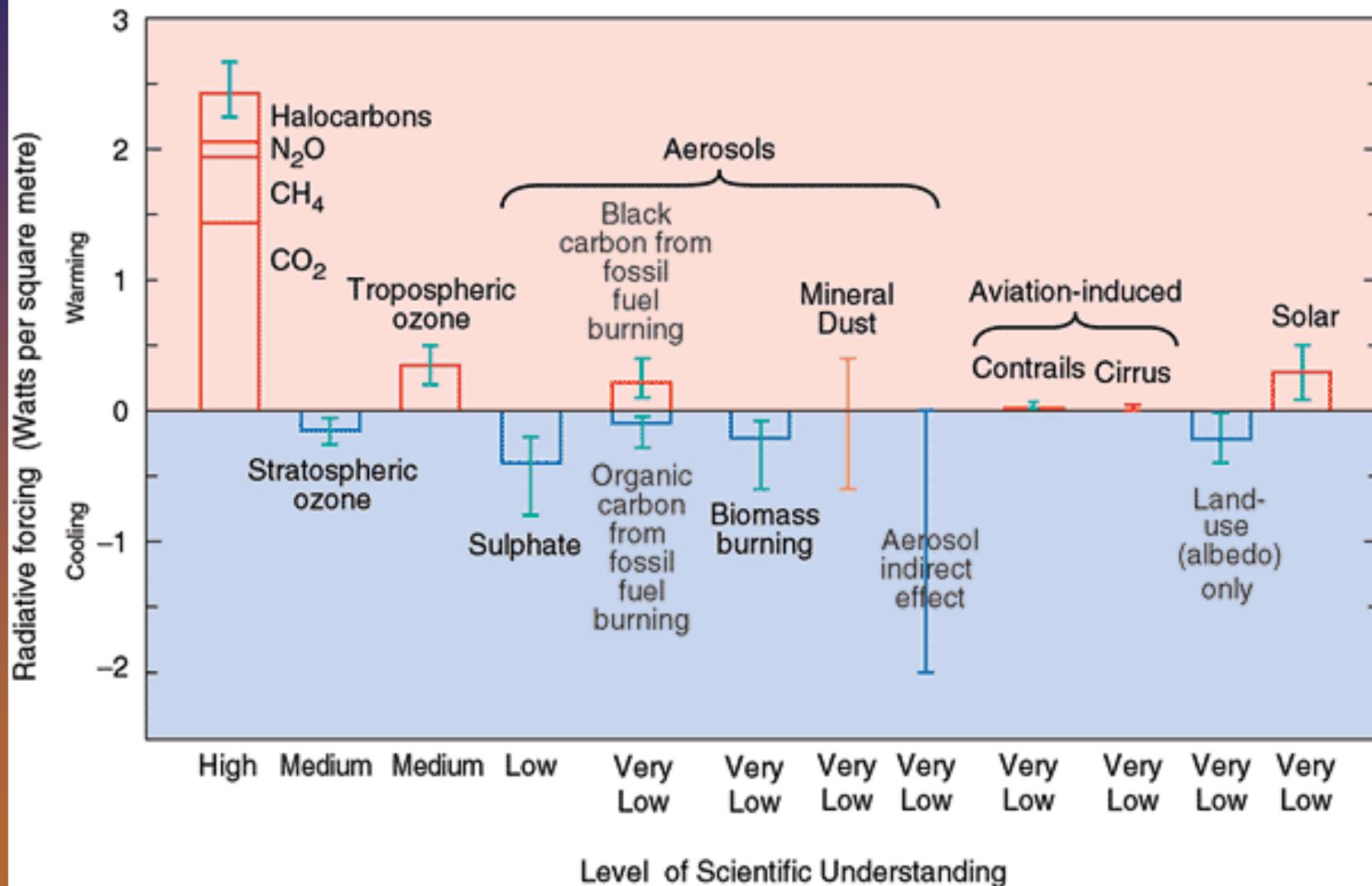
**Alaska  
Tundra  
Travel Days  
Decreased  
by Half  
Since 1970**



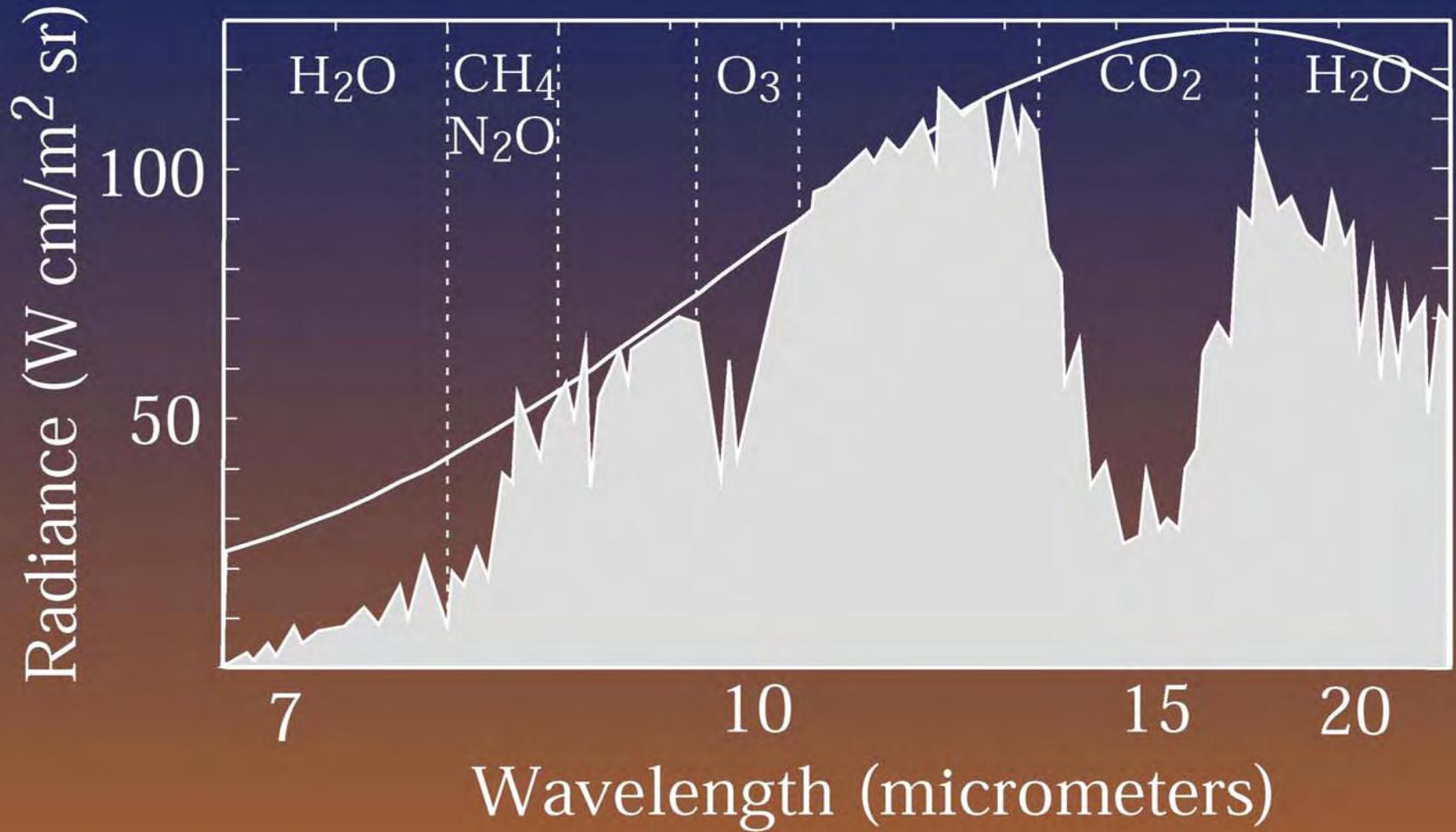
# Causes of Global Warming

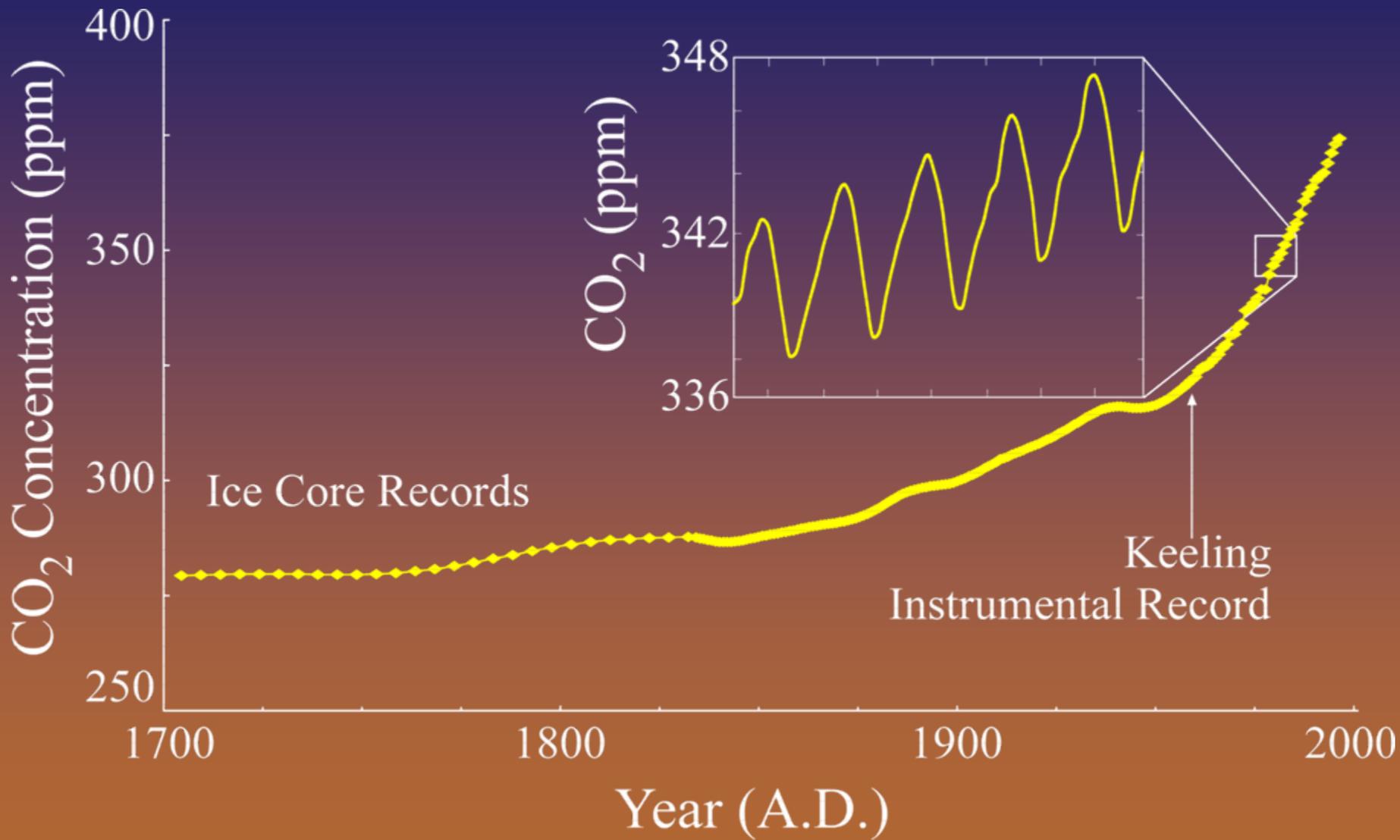


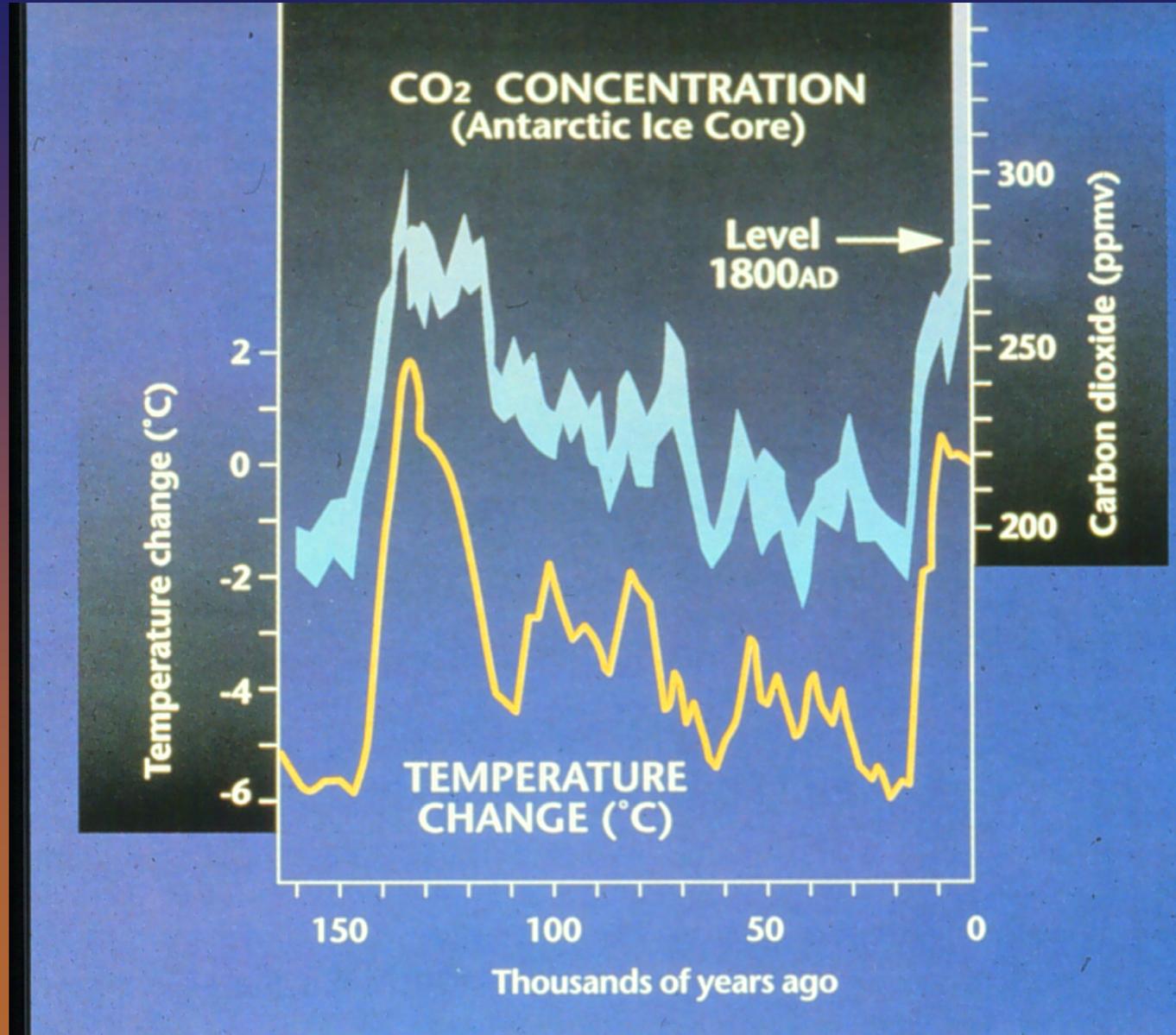
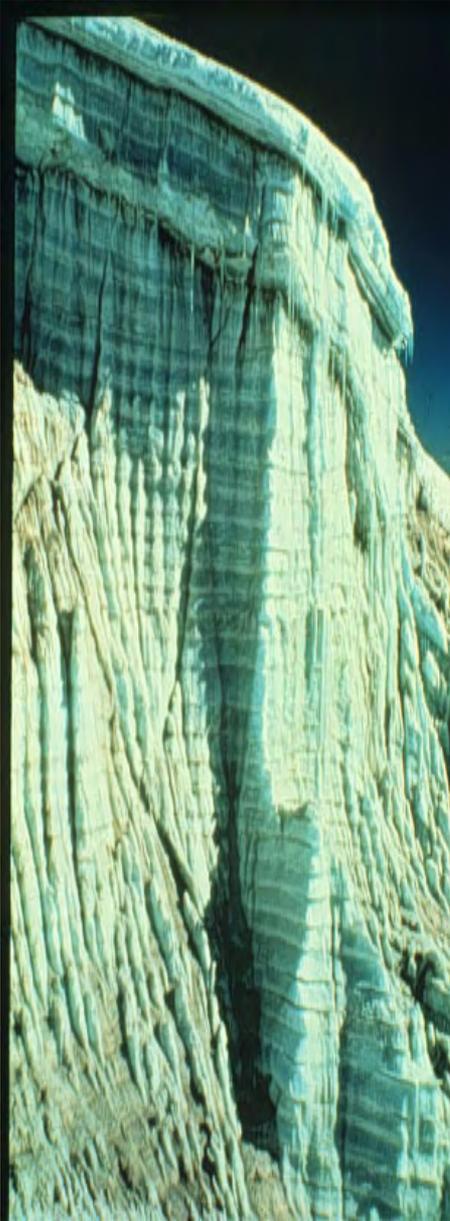
# The global mean radiative forcing of the climate system for the year 2000, relative to 1750

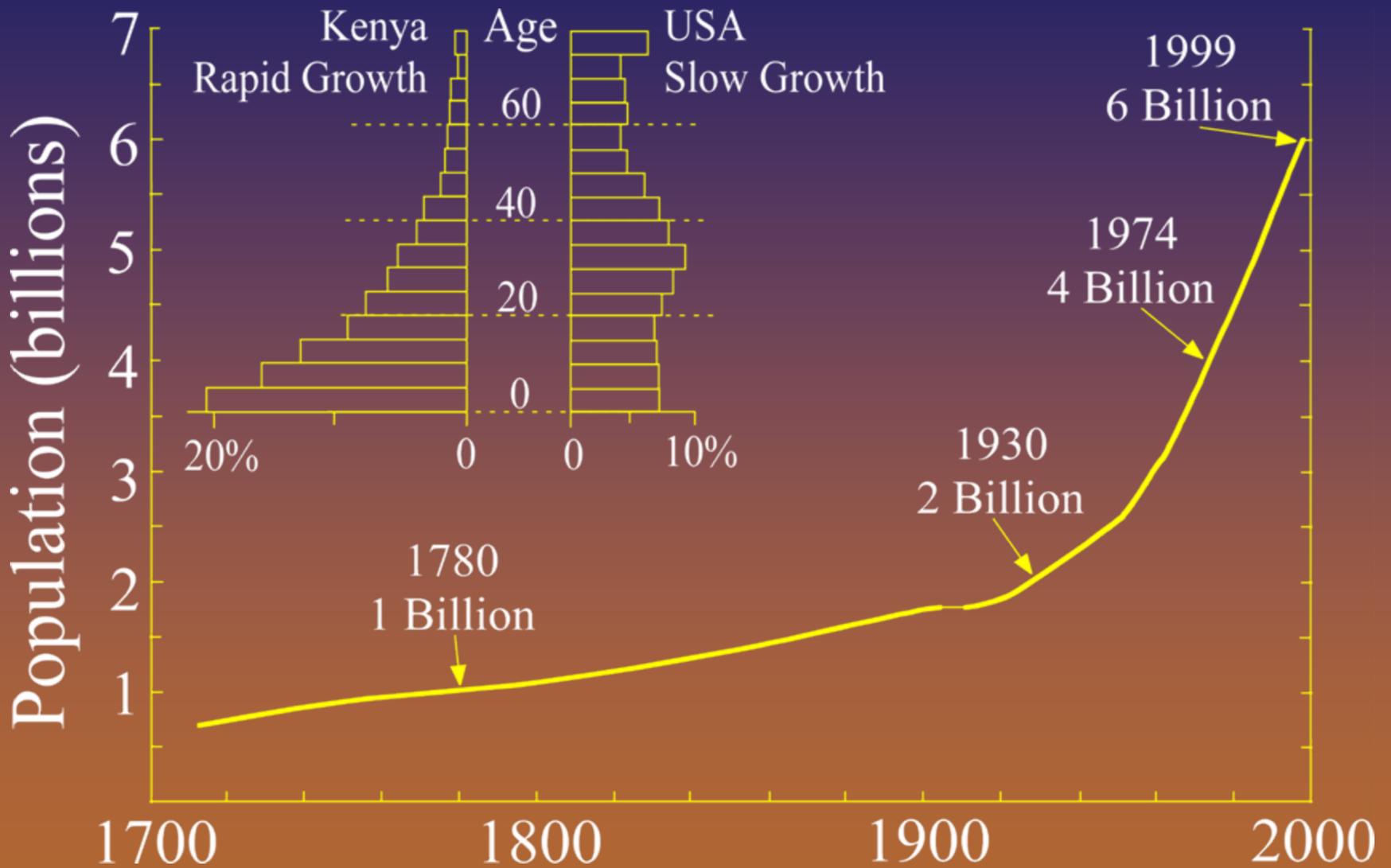


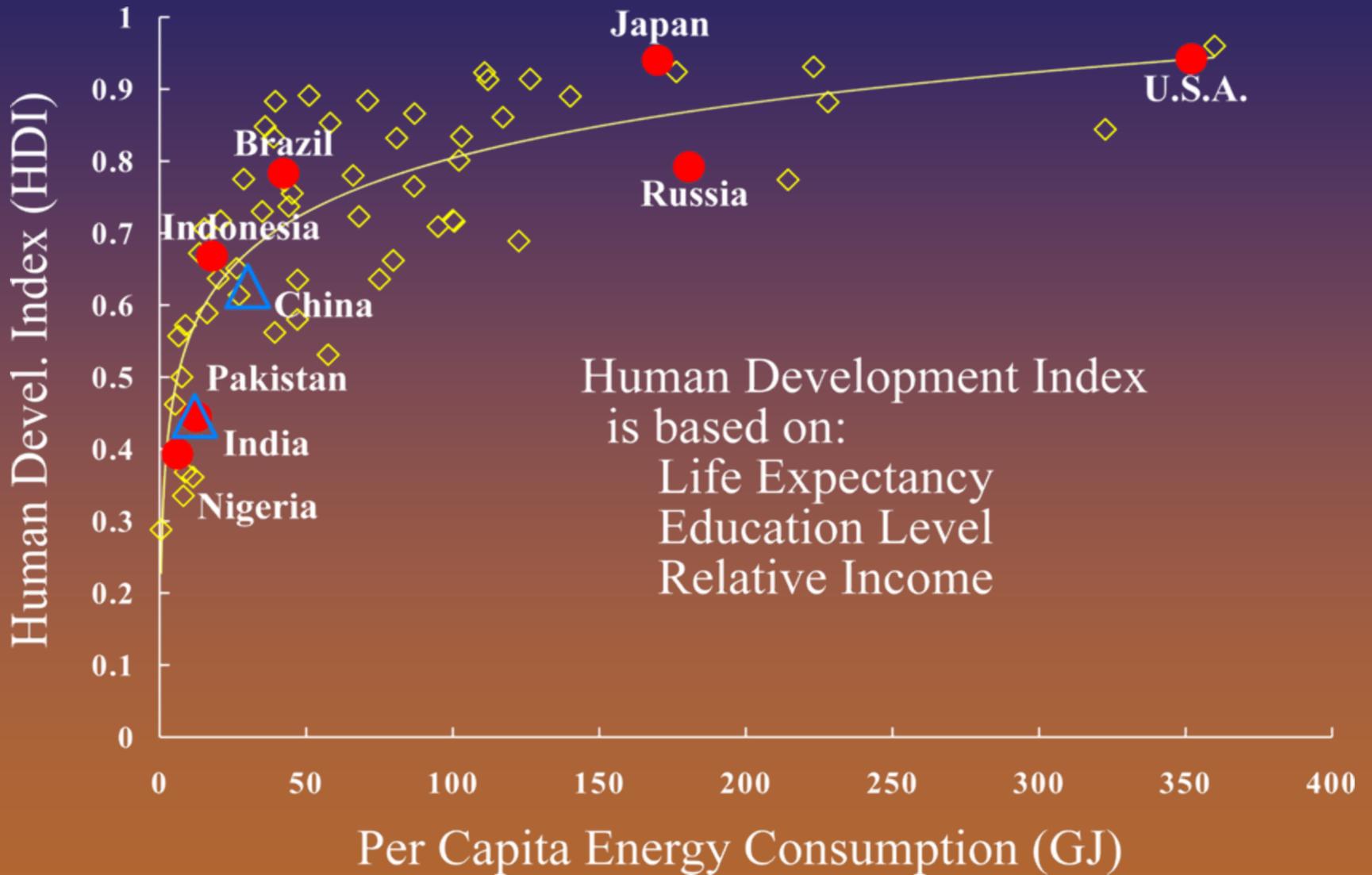
# Satellite observations of Earthlight

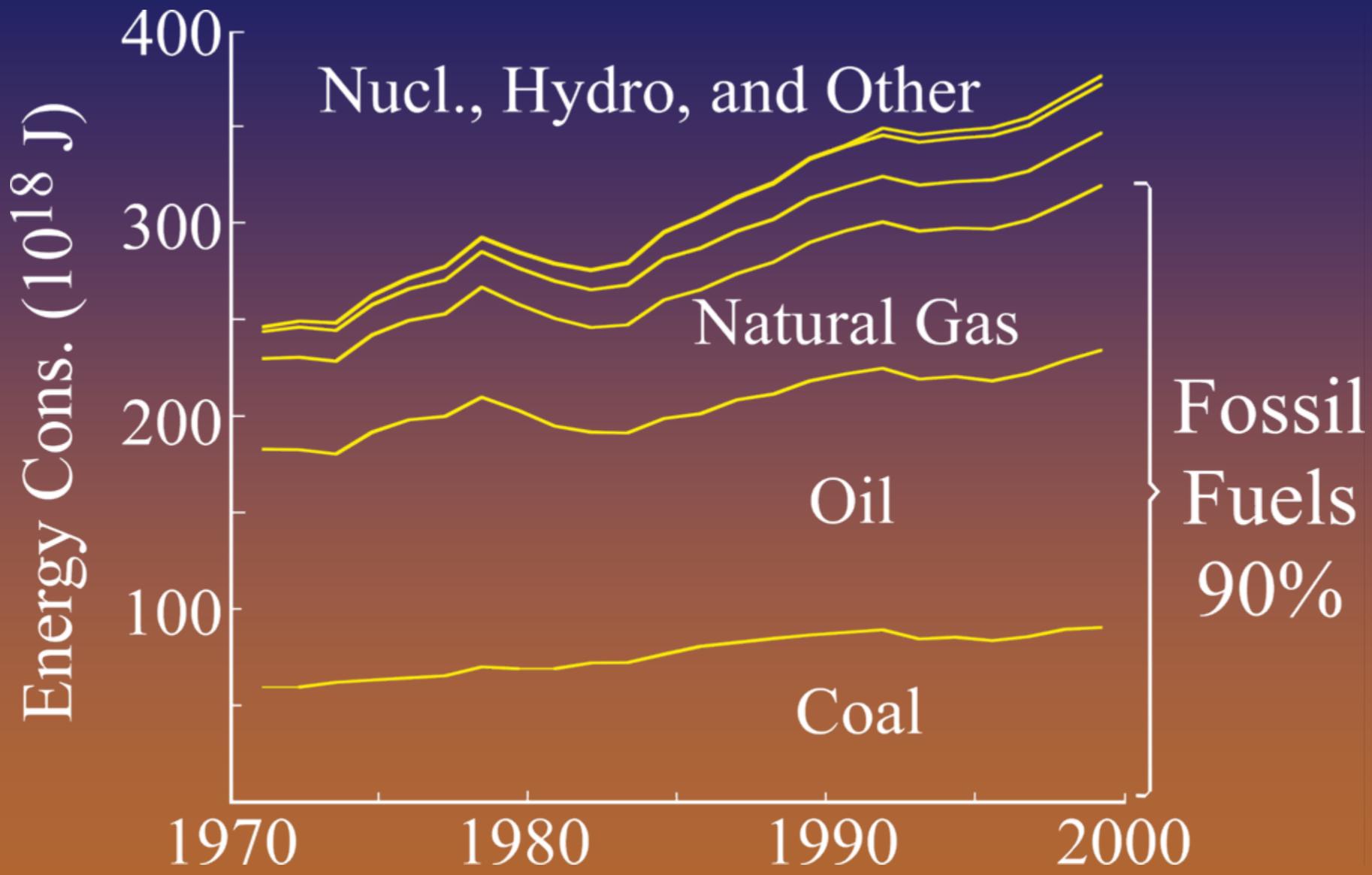




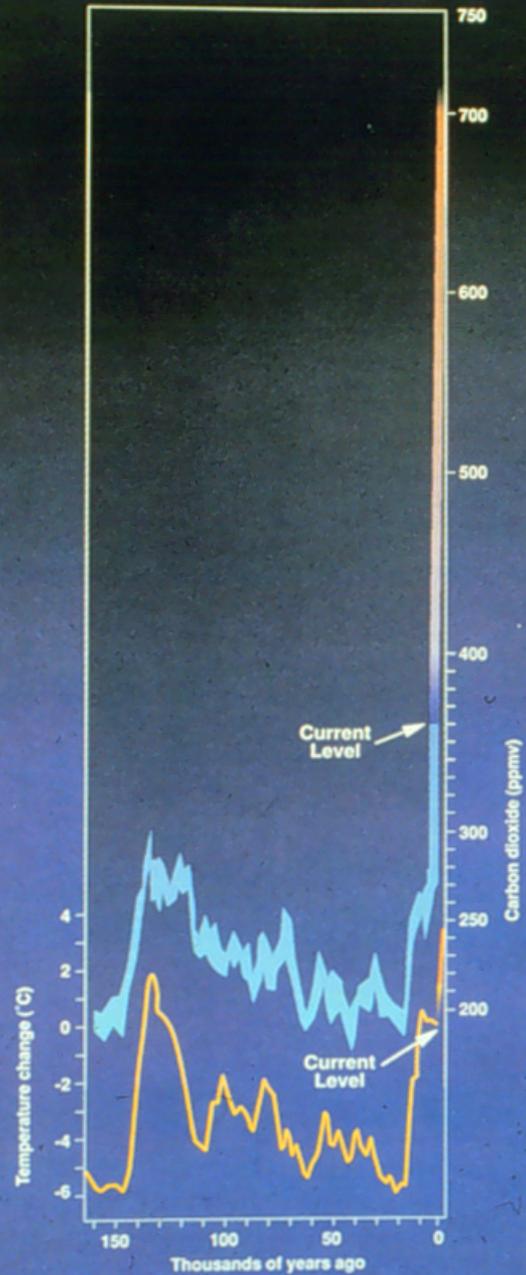








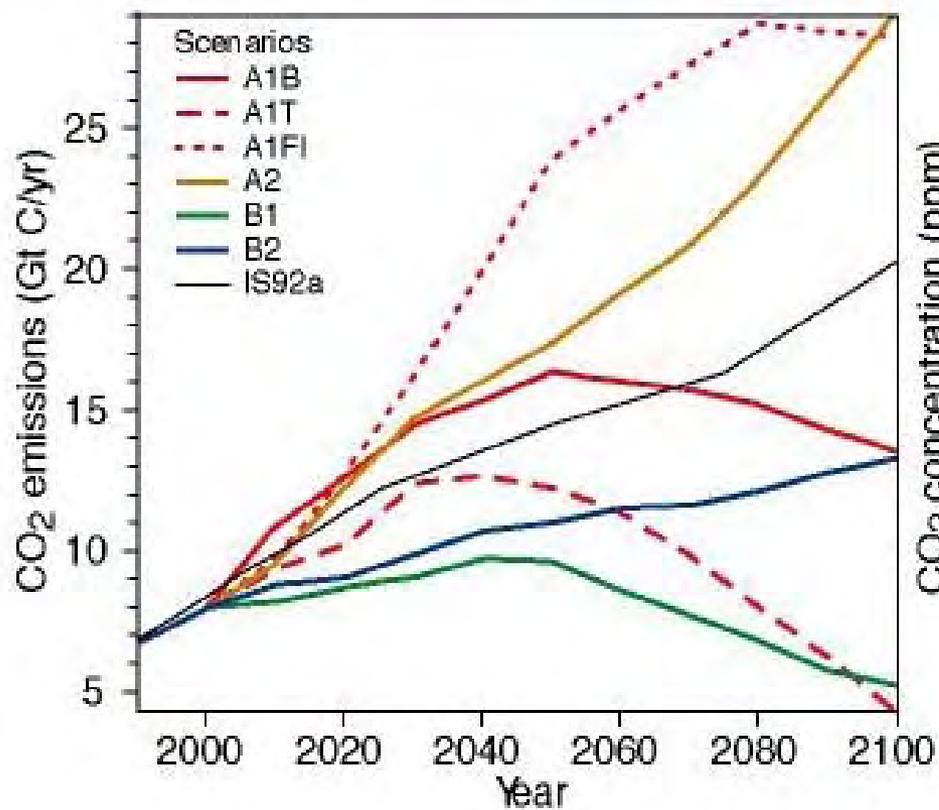
# Atmospheric Carbon Dioxide Concentration and Temperature Change



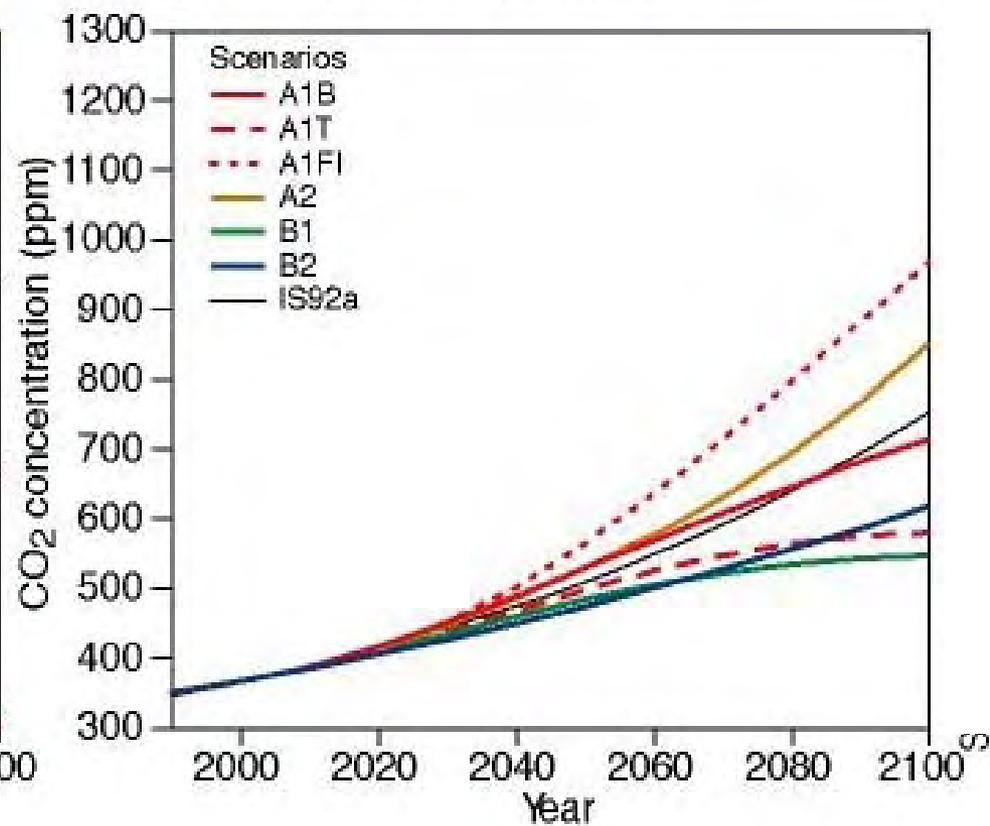
CO<sub>2</sub> concentration in the atmosphere (Antarctic Ice Core)      Temperature changes through time compared to the present temperature

# The global climate of the 21st century

(a) CO<sub>2</sub> emissions



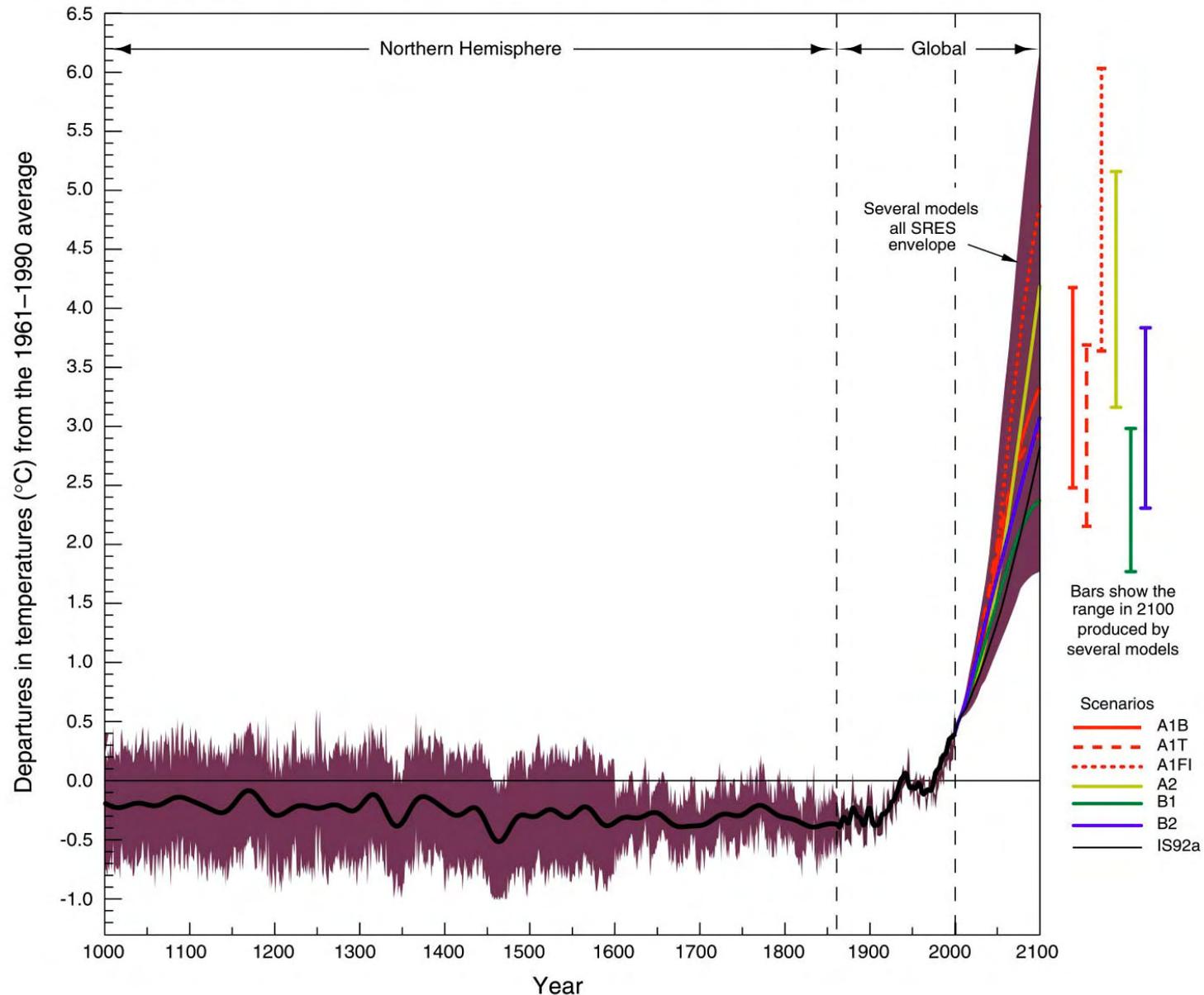
(b) CO<sub>2</sub> concentrations



WG1 - SPM FIGURE 5

# Variations of the Earth's surface temperature

1000 to 1861, N.Hemisphere, proxy data; 1861 to 2000 Global, instrumental; 2000 to 2100, SRES projections



# What don't we know?

1. We don't know everything with 100% certainty.

J.D. Mahlman, *Science*, Nov. 21, 1997

2. Climate feedback mechanisms require better understanding.

(a) Cloud-radiation feedback system  
o positive or negative?

(b) Ocean-dynamics feedback system

o heat reservoir

o carbon reservoir

atmosphere    700 Gtonnes

biosphere    2,000 Gtonnes

oceans    35,000 Gtonnes

# Global Warming – More Than Hot Air



**D.S. Chapman**  
**University of Utah**

1. Warming is real.
2. Feedback system is complex.
3. Consequences of warming are mixed; losers outnumber winners.
4. Attribution requires research.
5. Greenhouse gas emissions are growing; residence times are long.
6. Prudent path has benefits beyond reducing warming.

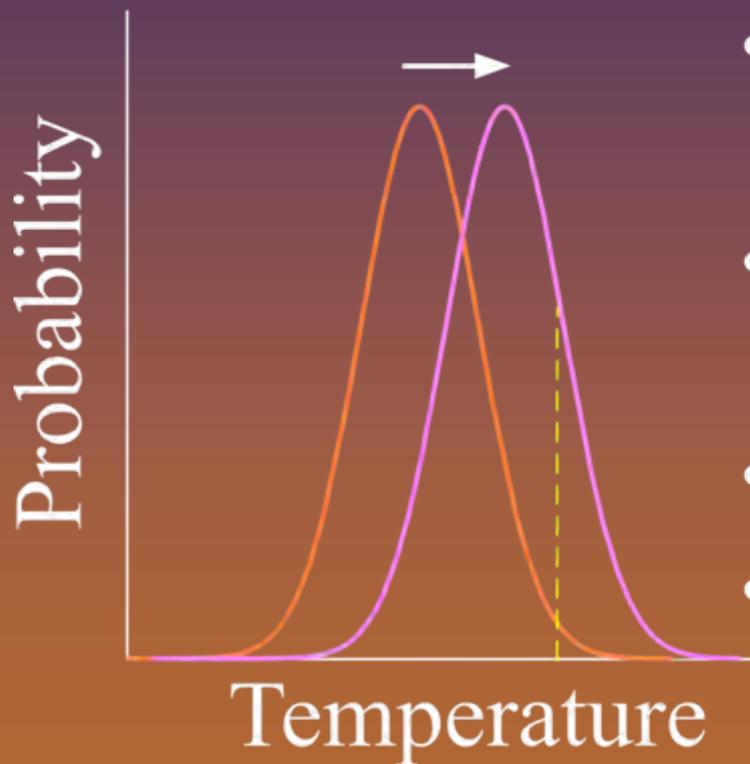
# Questions About Global Warming

Q: Why should I be concerned by just a few degrees of warming?

Q: How can global warming be caused by greenhouse gases when temperatures have sometimes decreased while greenhouse gases were increasing?

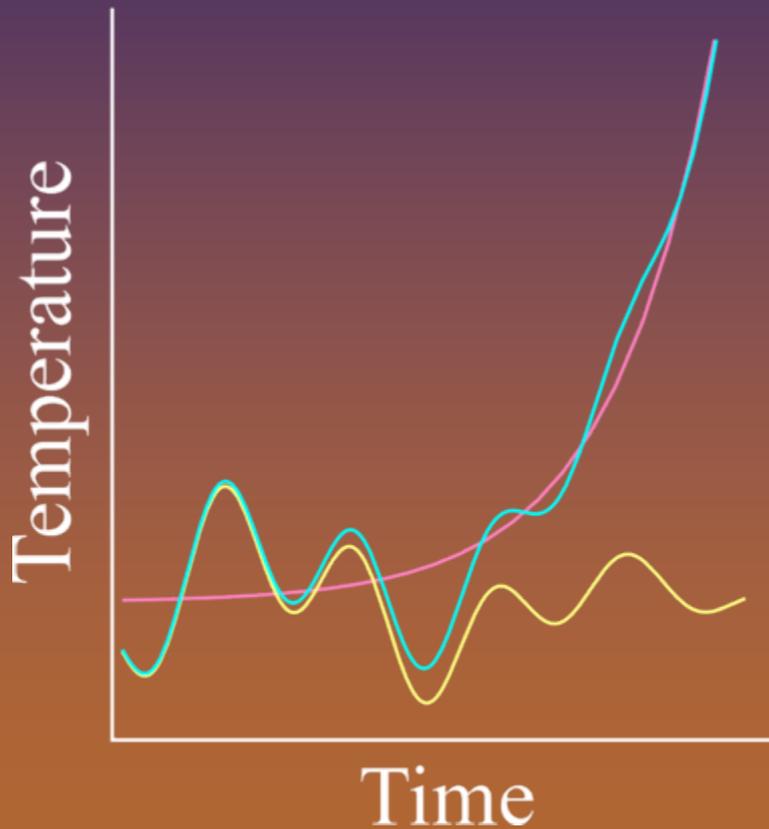
Q: Won't taking steps to reduce carbon emissions ruin our economy?

Q: Why should I be concerned by just a few degrees of warming?



- Shift in the global mean tells only part of the story.
- Regional warming may be much greater.
- Focus on critical temperature.
- Distribution may broaden (more extreme climate).

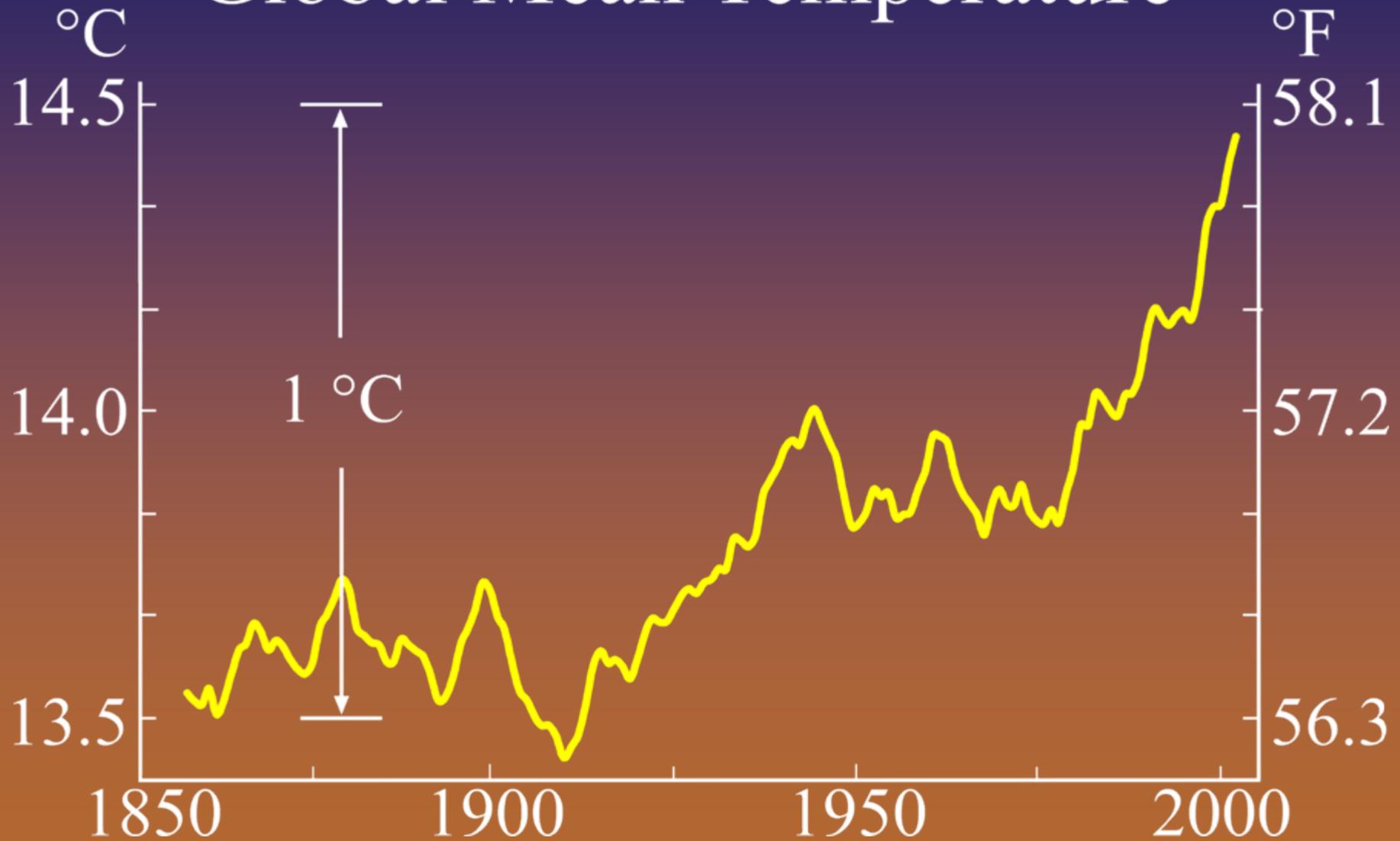
Q: How can global warming be caused by greenhouse gases when temperatures have sometimes decreased while CO<sub>2</sub> was increasing.



Climate has strong decadal and longer forcings (the chaotic part).

Think of climate ( ————— ) as being made of two parts: Chaotic ( ————— ) and Greenhouse ( ————— ).

# Global Mean Temperature



Q: Won't taking steps to reduce our CO<sub>2</sub> emissions to the atmosphere ruin our economy?

- Studies are mixed
- Consider:

$$C = \frac{C}{\text{Energy}} \times \frac{\text{Energy}}{\text{GNP}} \times \text{GNP}$$

Carbon intensity  
of fuel

1  
Efficiency

Economy

# Global Warming – More Than Hot Air



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