

Global Warming: What is the role of aerosol?



Barbara Wyslouzil, Sept. 10 2007

Outline

- Aerosols 101
- The greenhouse effect
- Global temperature records
- The global warming problem
- How do aerosols play a role
- What next

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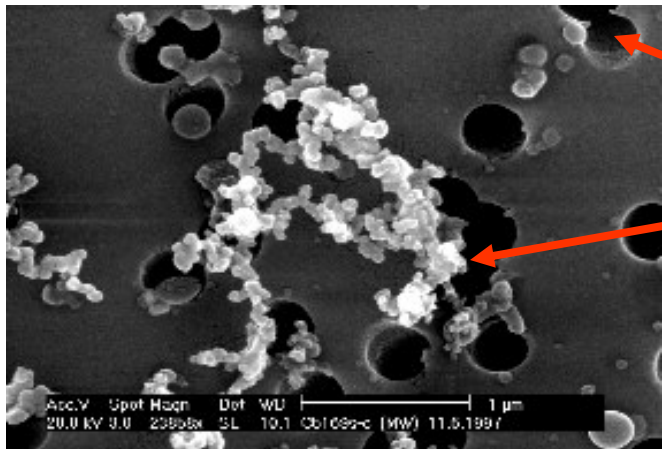
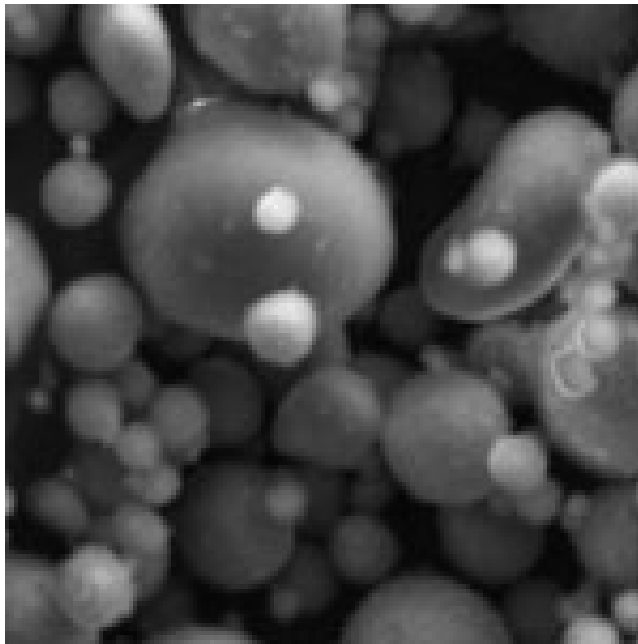
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What is an aerosol?



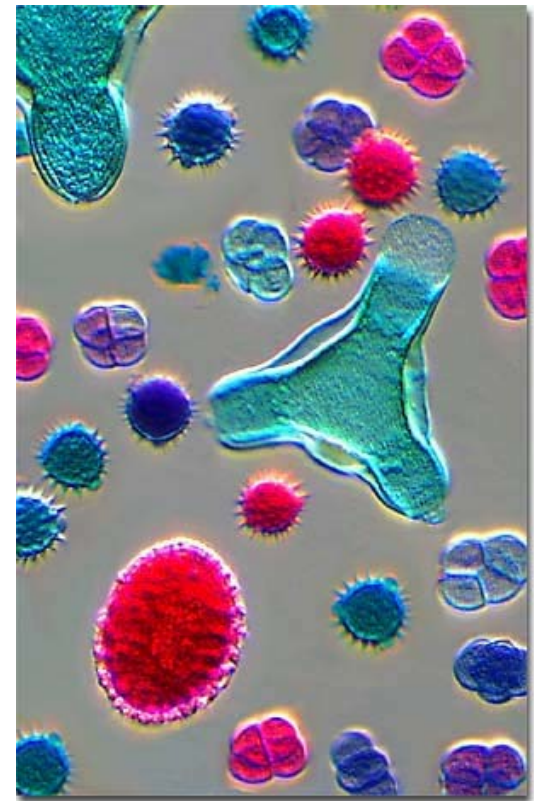
An aerosol is stuff suspended in a gas

flyash



Filter pores

soot



pollen

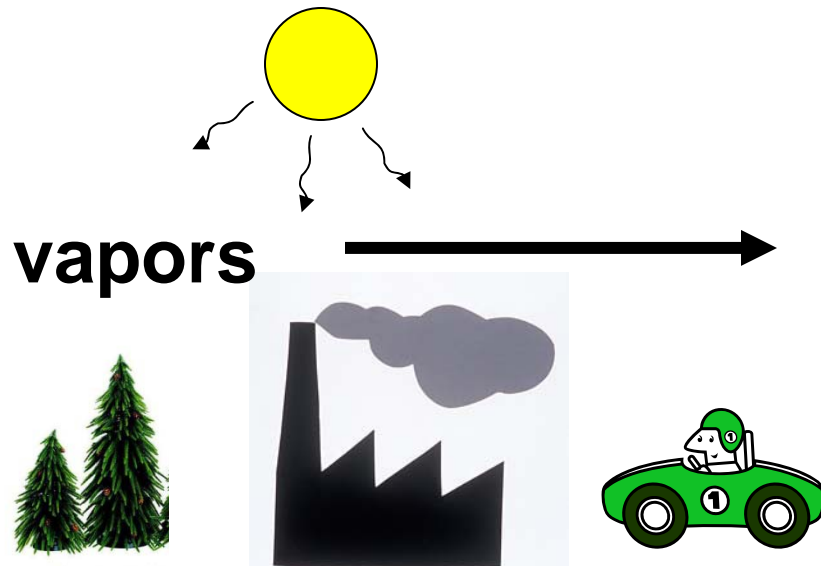
Aerosols scatter and absorb light



Aerosol sources are varied



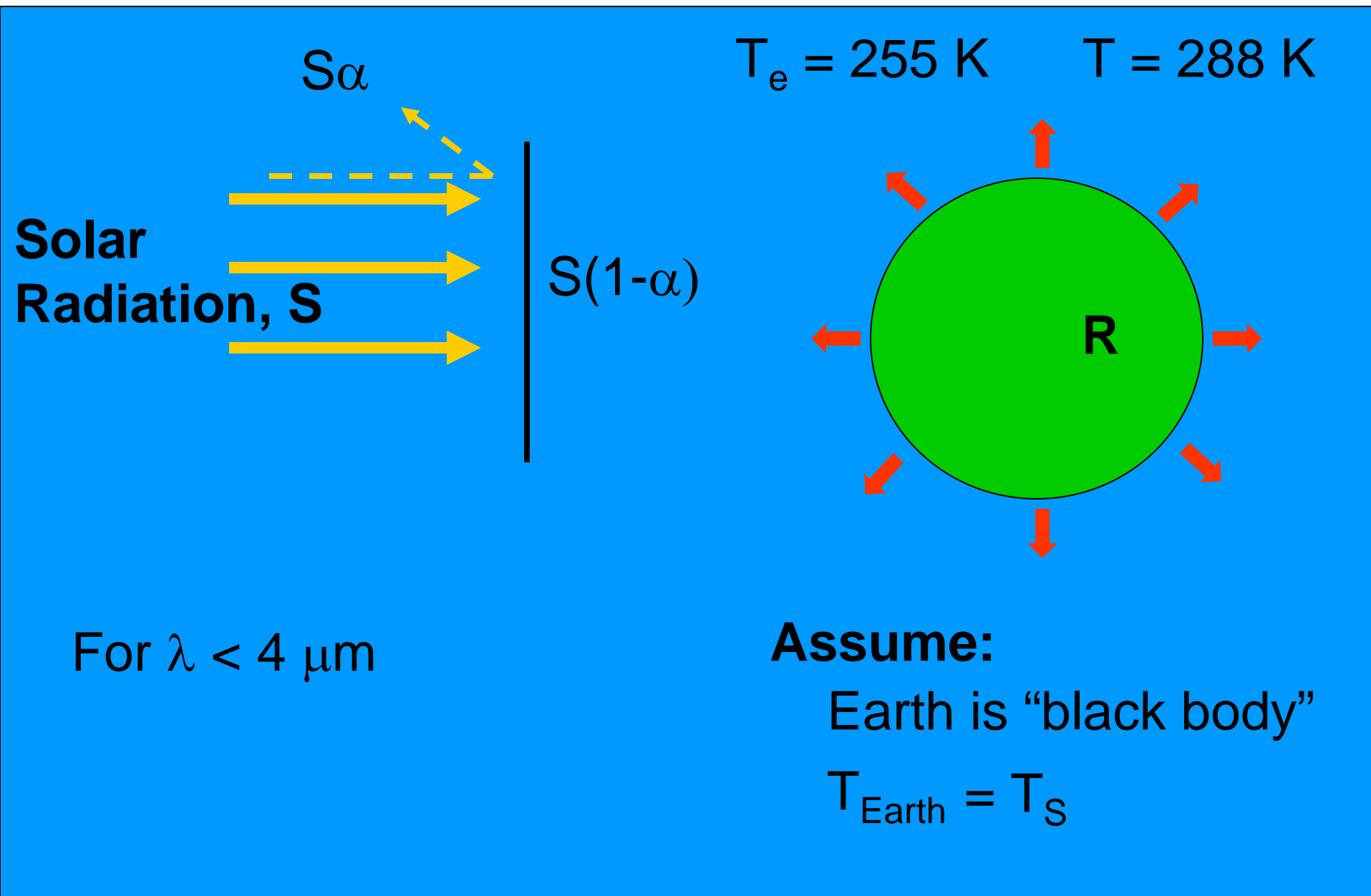
Aerosol sources are varied



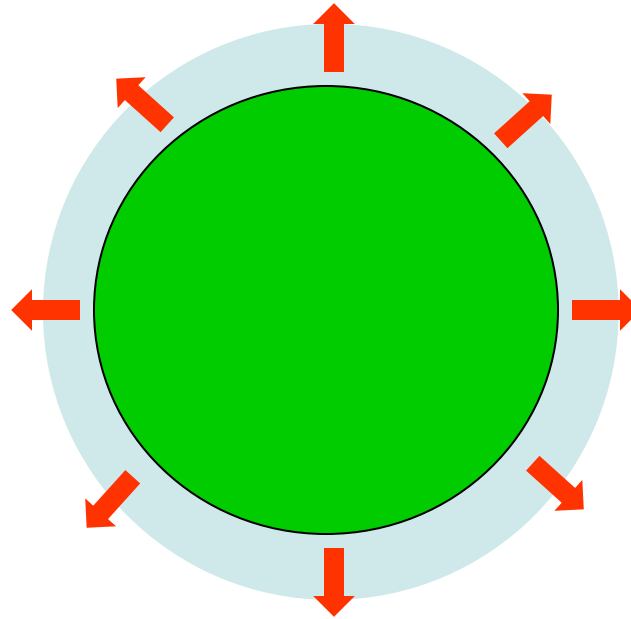
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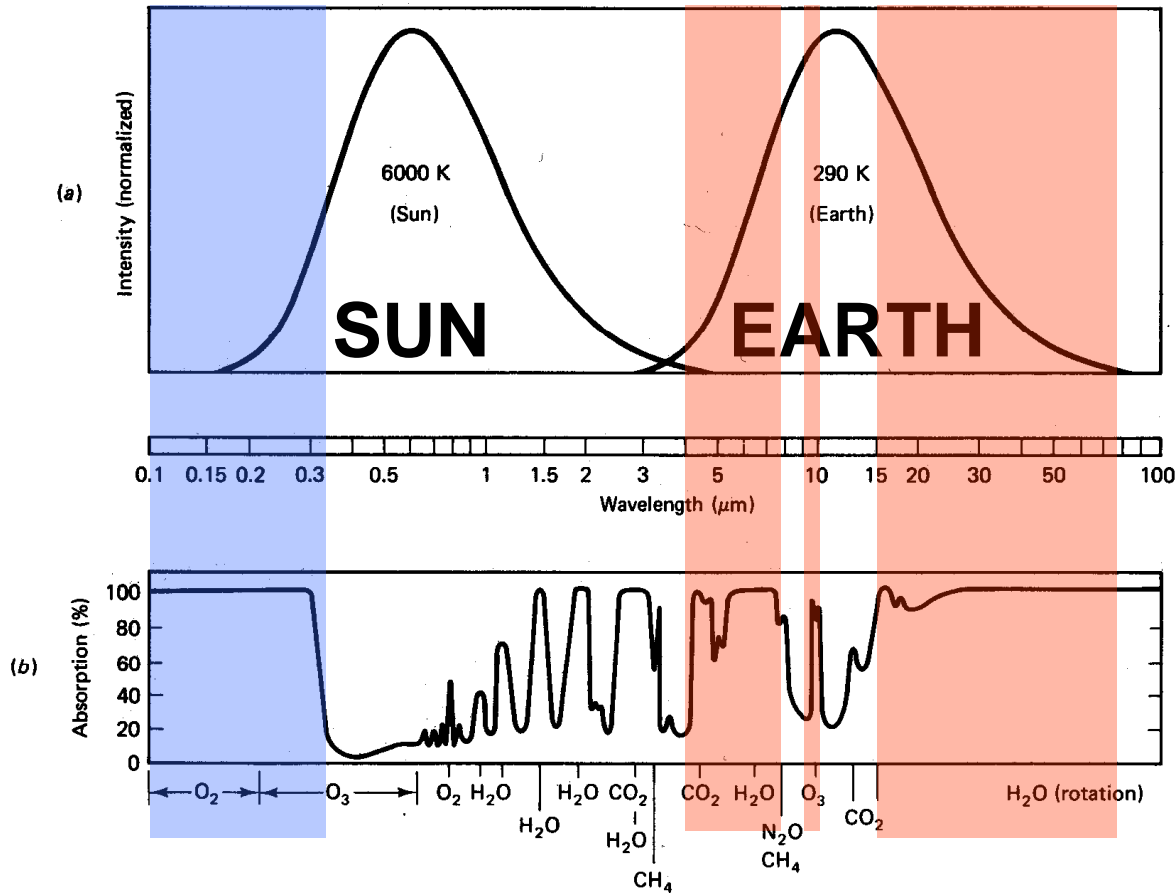
How warm should the earth be?



Why is the earth 33 K warmer than expected?



Why is the earth 33 K warmer than expected?



Gases that absorb at longer wavelengths include:

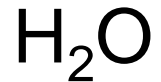
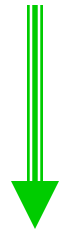
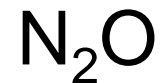
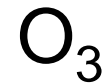
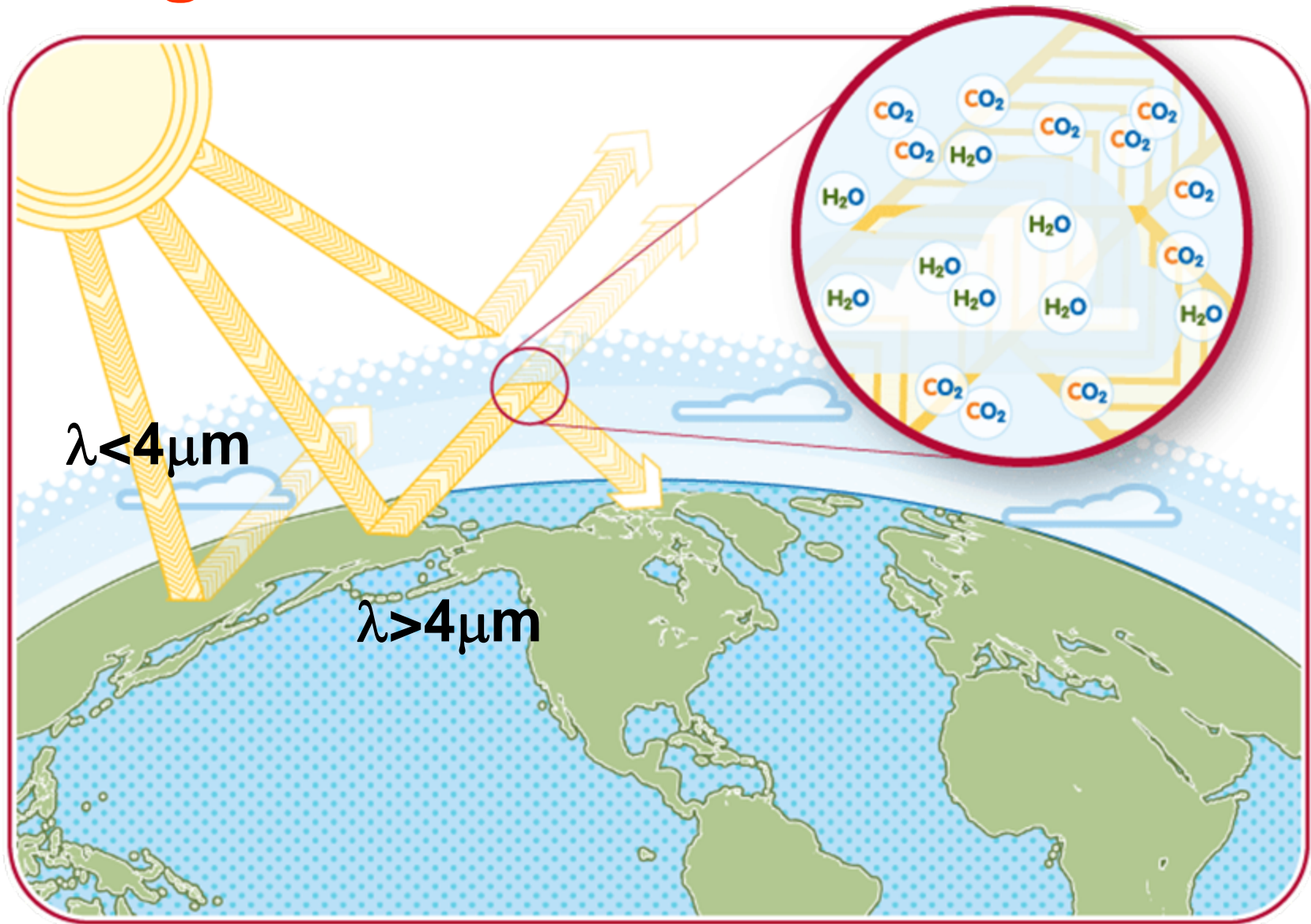


Figure 8.6 (a) Normalized blackbody radiation curves for the sun and earth. (b) Atmospheric absorption on a clear day. (Adapted from Wallace and Hobbs, 1977.)

The greenhouse effect



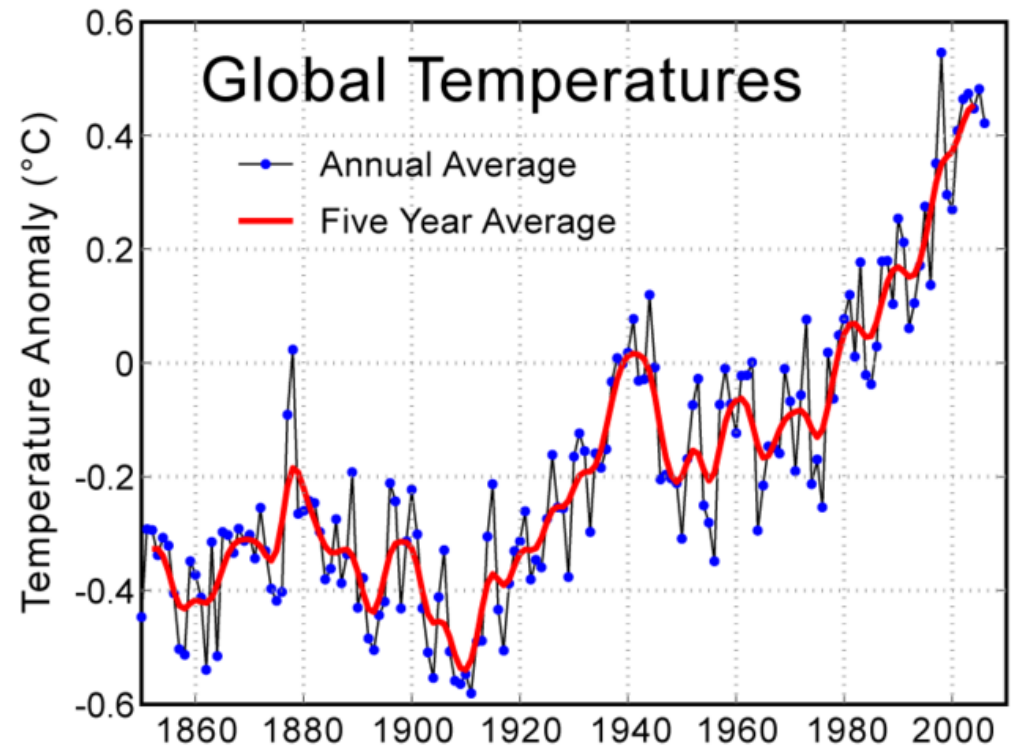
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How do we know about Global Warming / Cooling in the past?

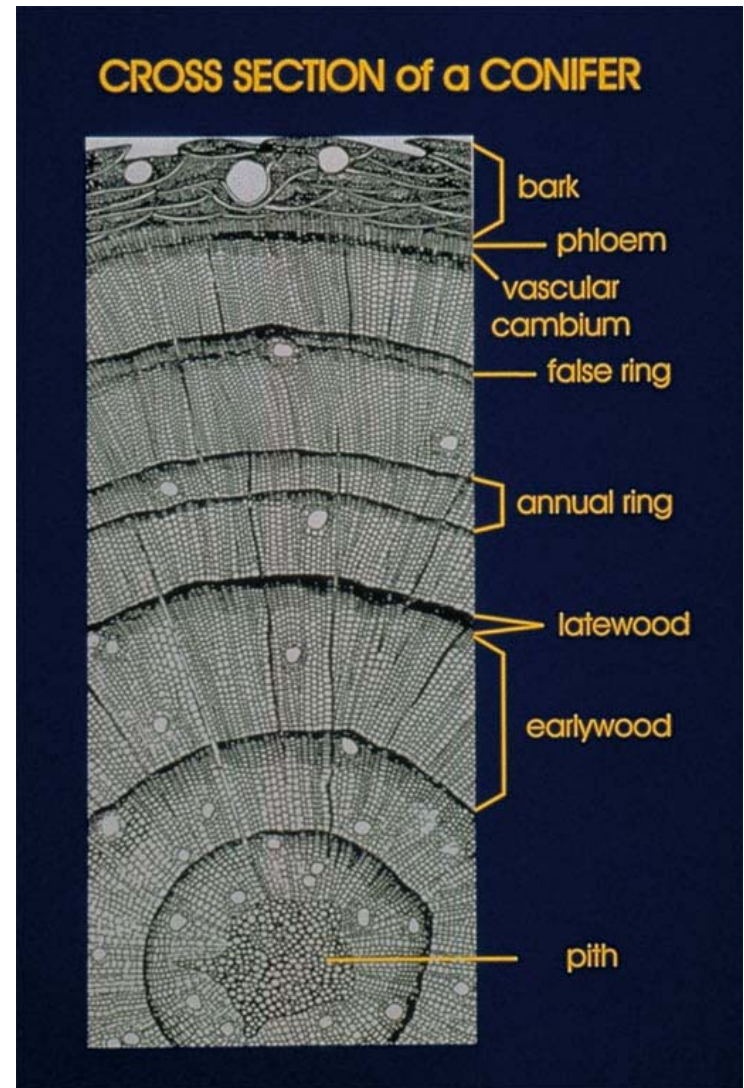
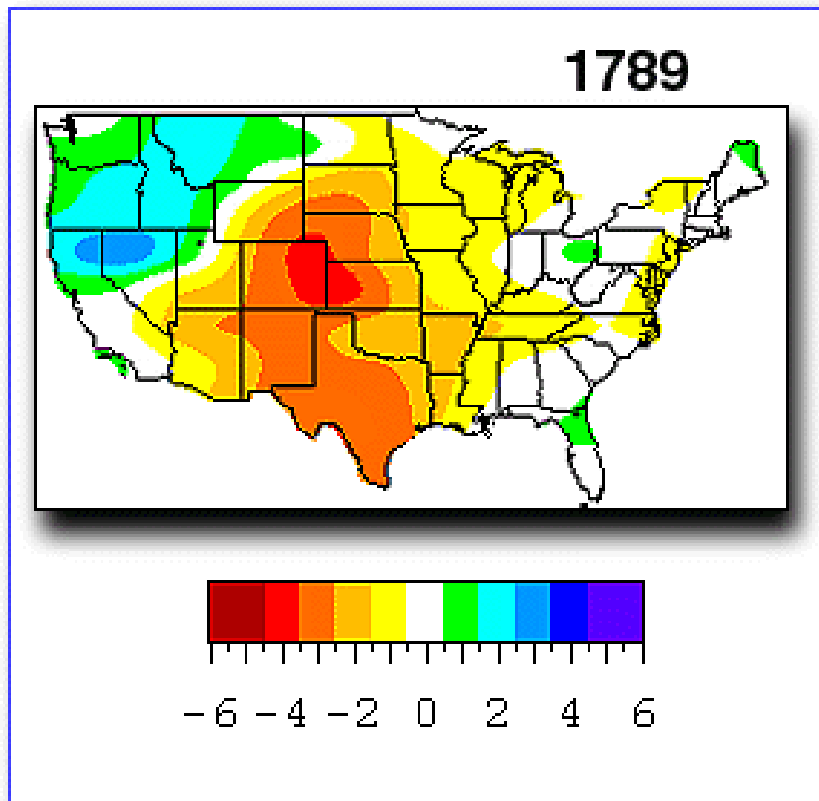


Historical records



Biological record

- tree rings
- fossil pollen analysis

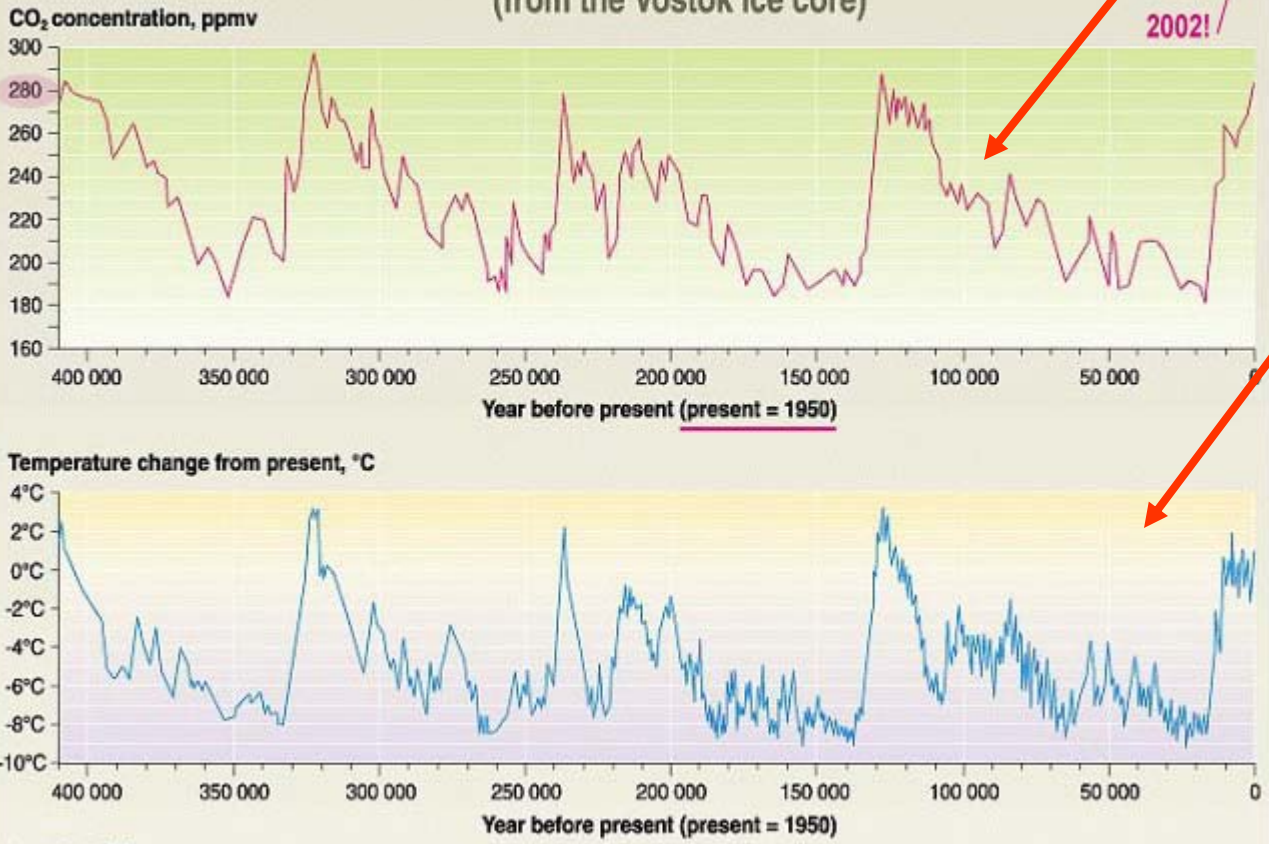


Ice cores

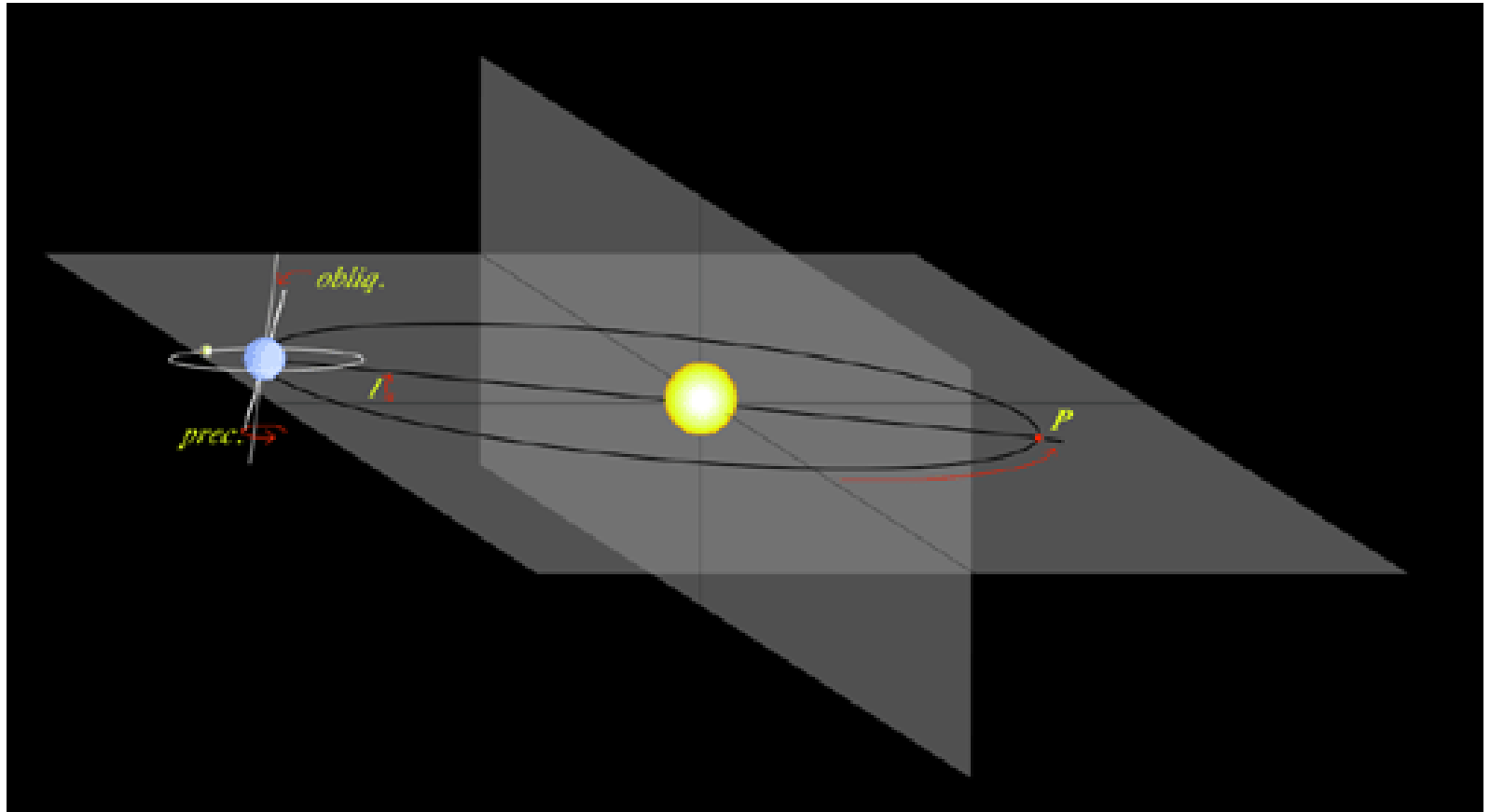
Air bubbles

$^{18}\text{O}/^{16}\text{O}$

Temperature and CO₂ concentration in the atmosphere over the past 400 000 years
(from the Vostok ice core)



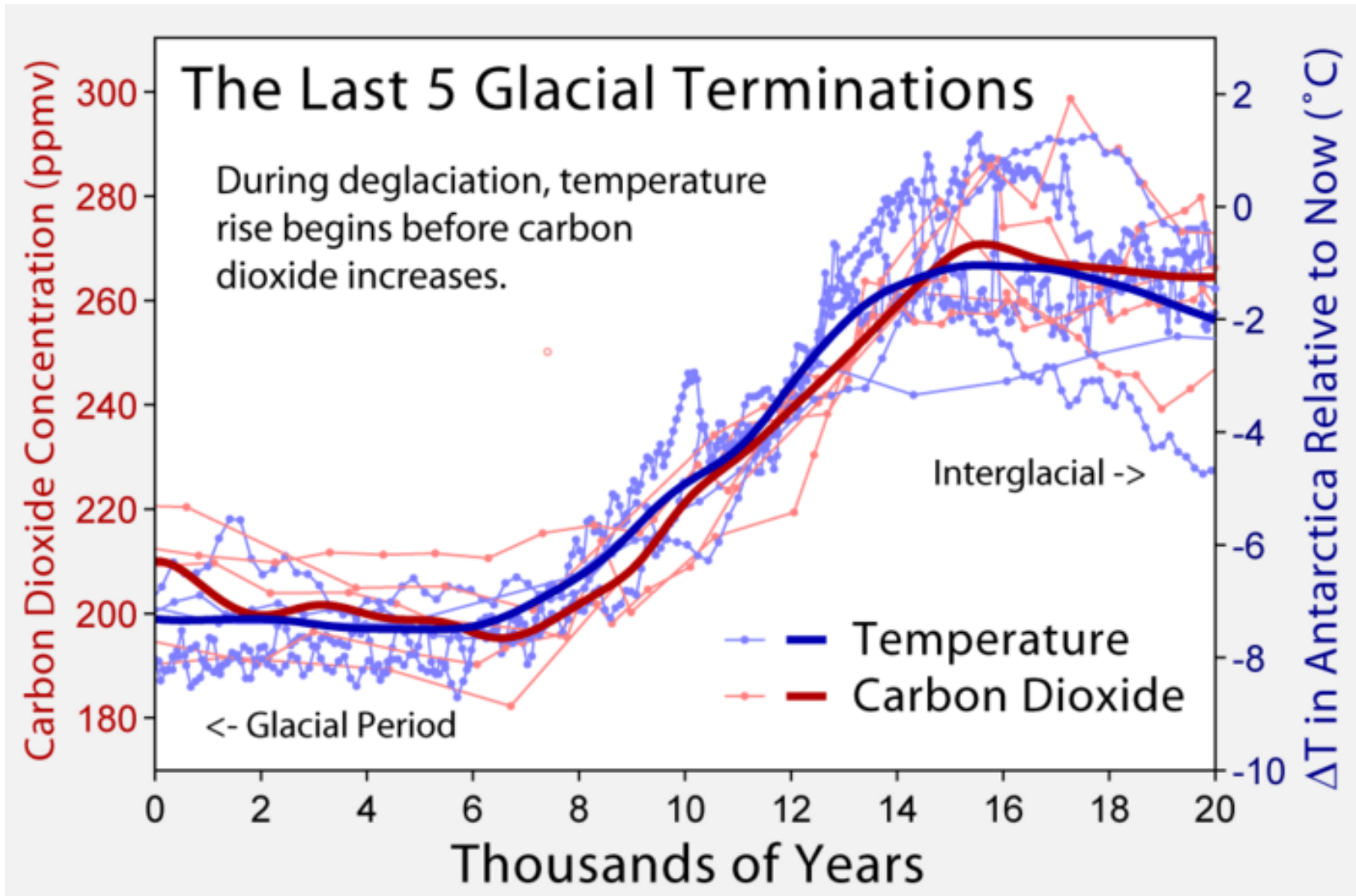
Much of the long term cycling



Due to the level of sunlight reaching the earth

→ slight changes in the earth's orbit, tilt, etc

But CO2 may amplify the effect

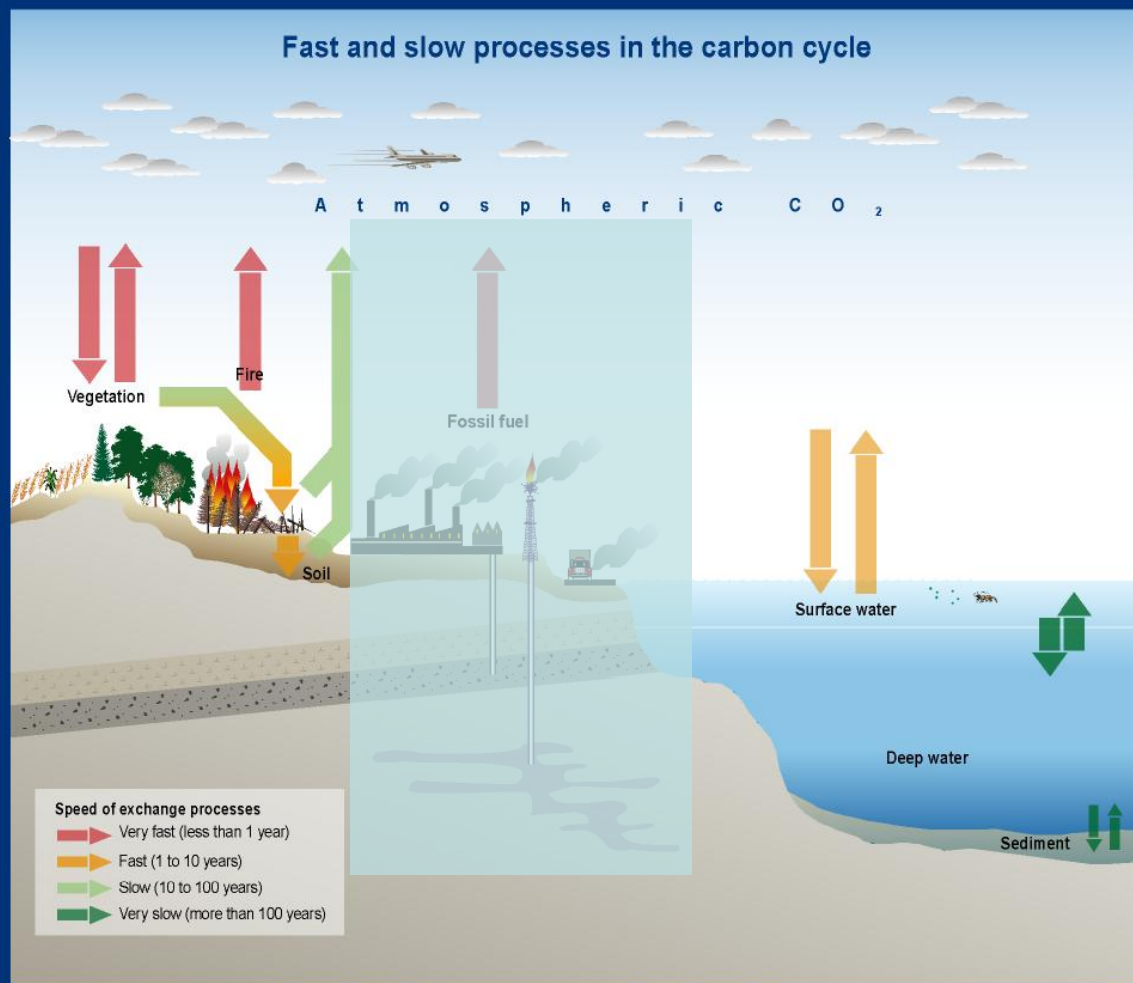


→ Positive feedback loop

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The timescales for adding and removing CO₂ are different



SYR - FIGURE 5-4

How does our activity perturb natural cycles?

What is the global warming problem?

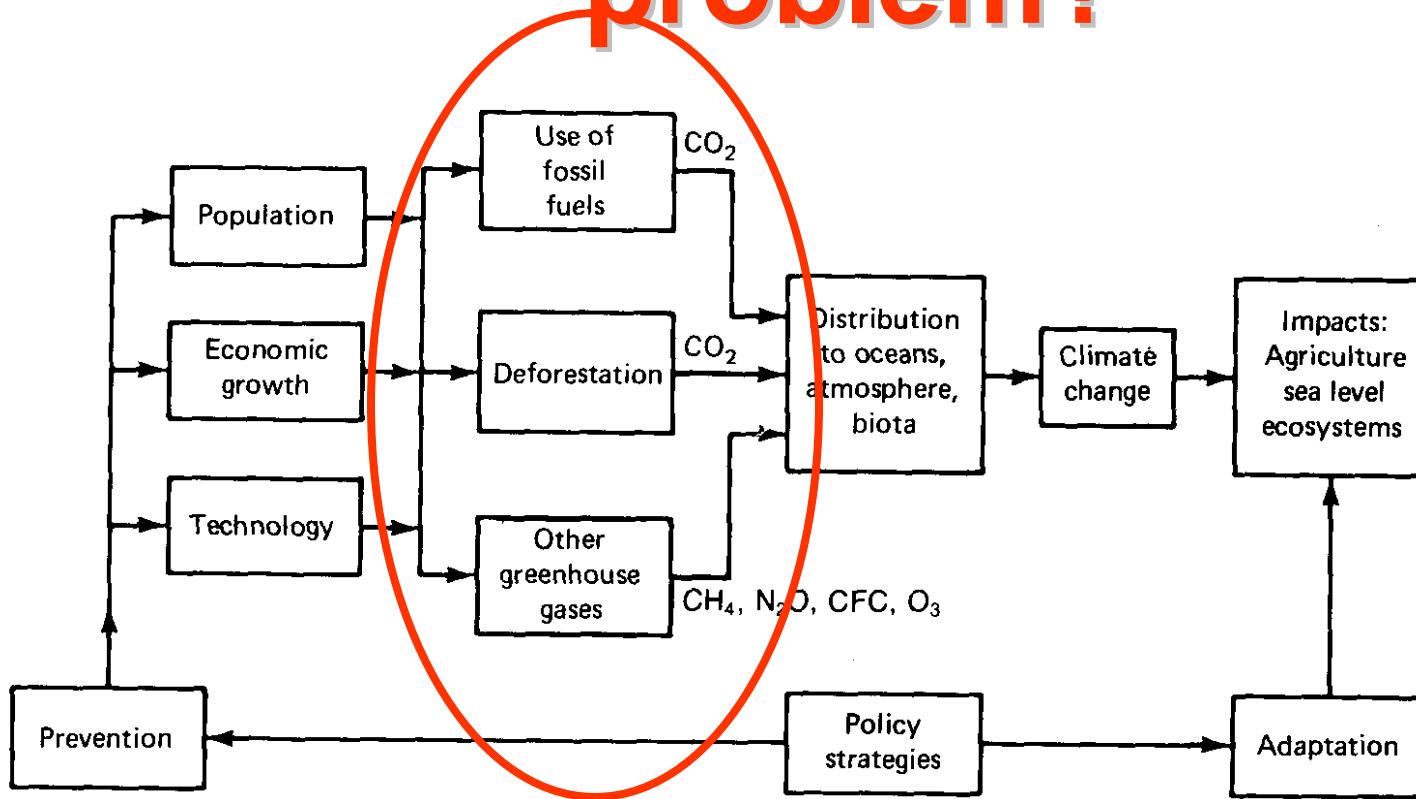
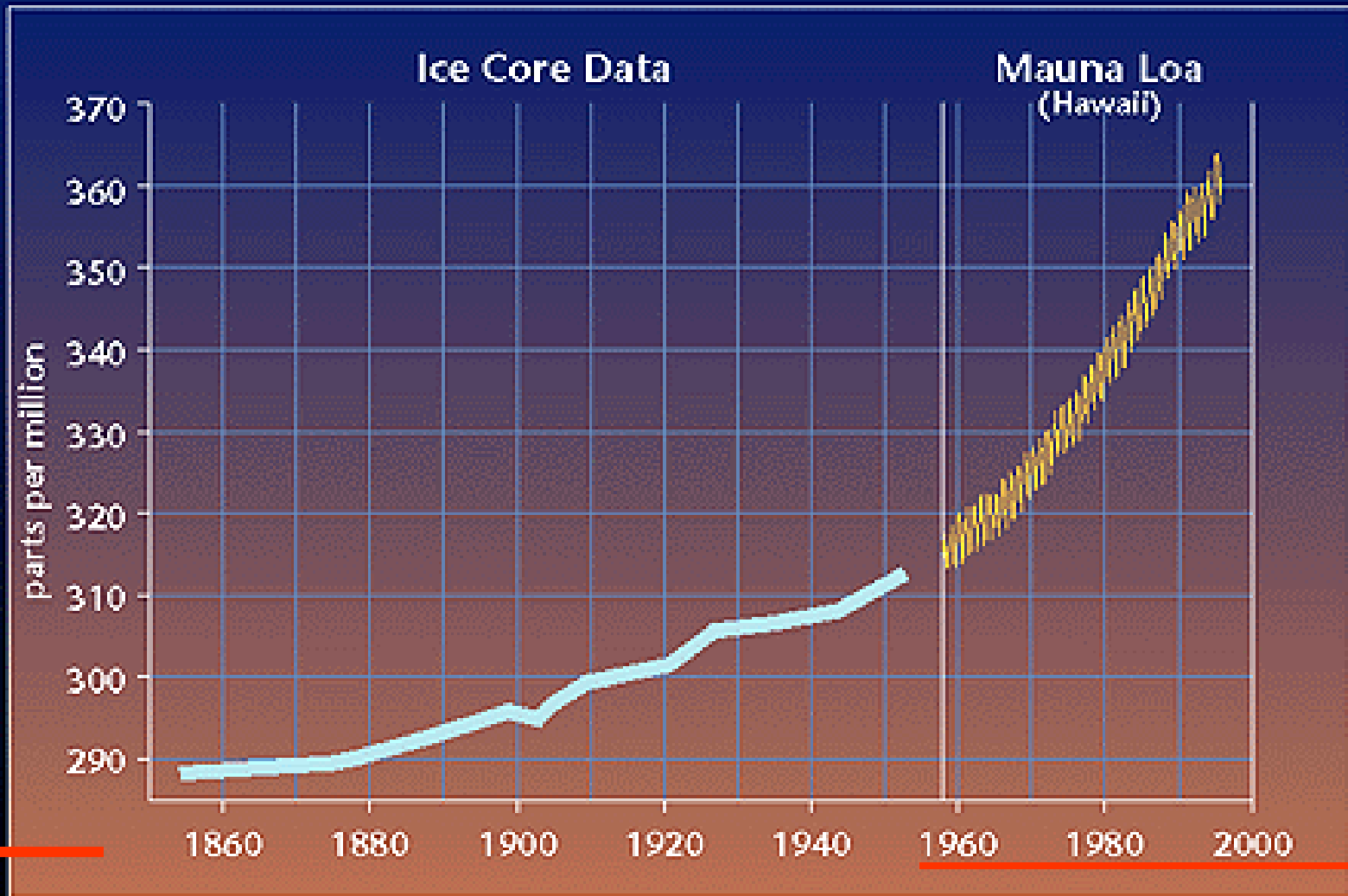


Figure 8.9 An overview of the global warming problem.

We are changing the composition of the atmosphere

Carbon Dioxide Concentrations

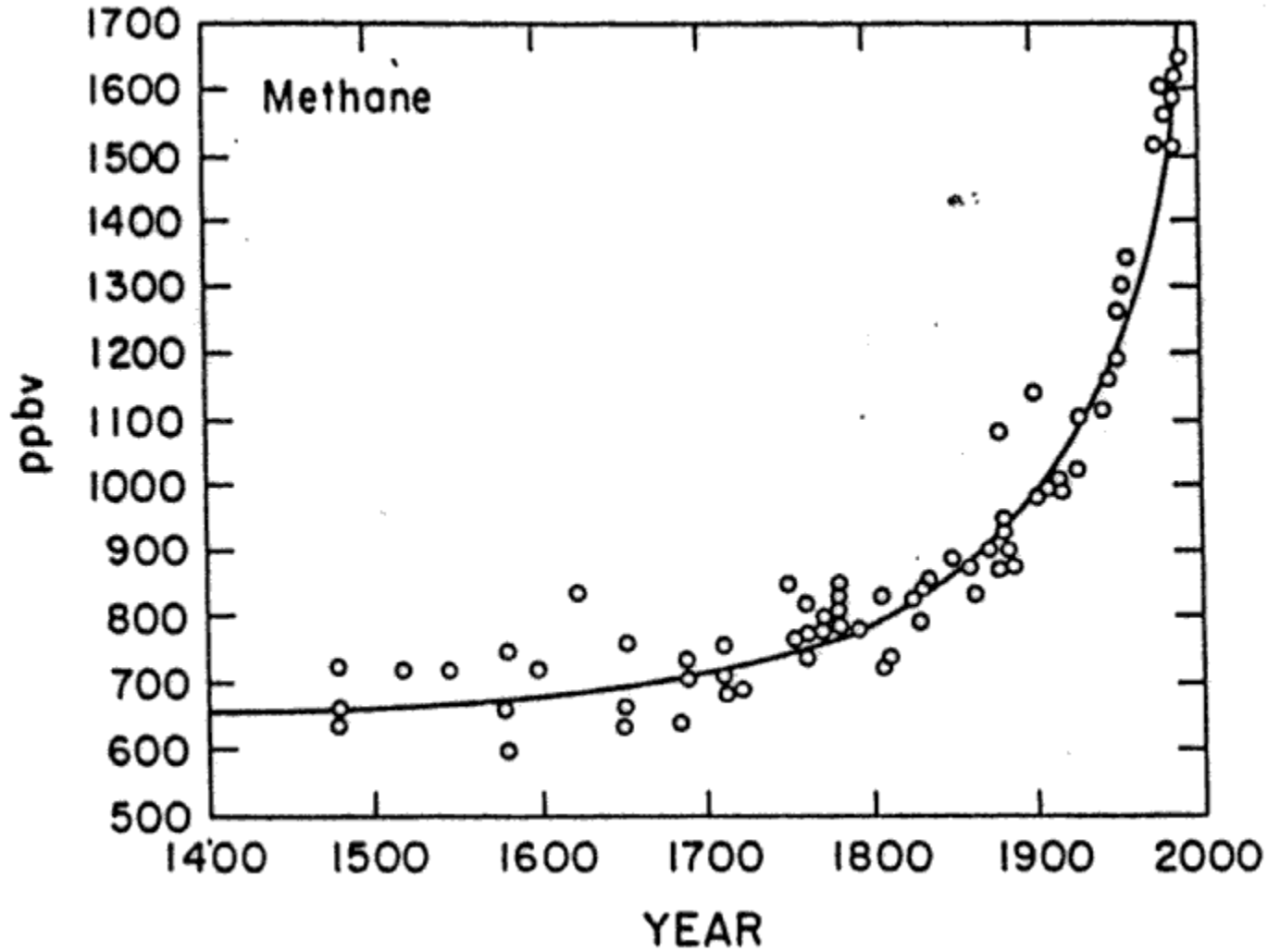


Pre industrial



Exponential increase

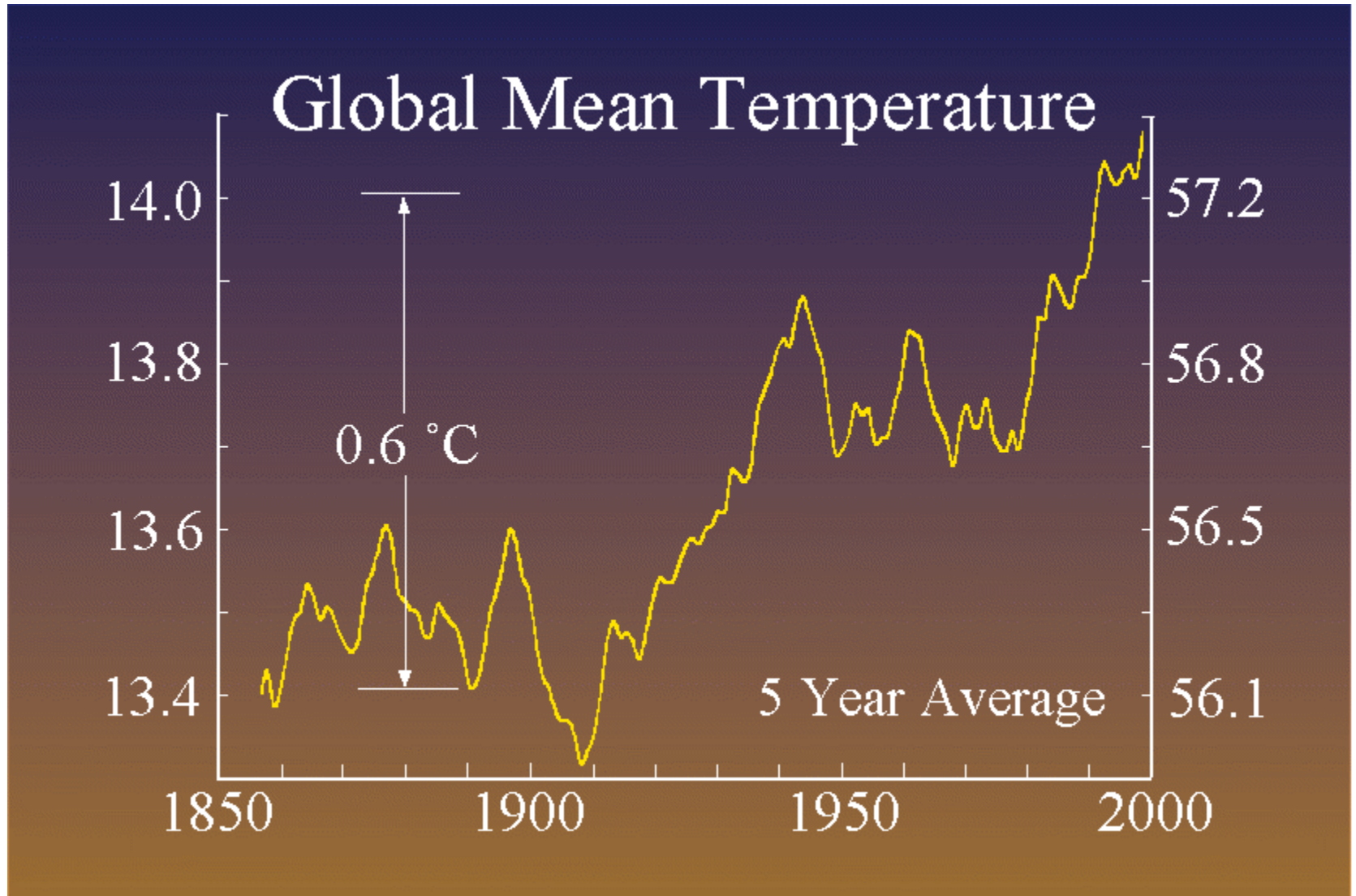
Methane is also increasing



←
Pre industrial

→
Exponential increase

Global temperatures have increased ~0.6 C



To understand what will happen next requires Global Climate Models

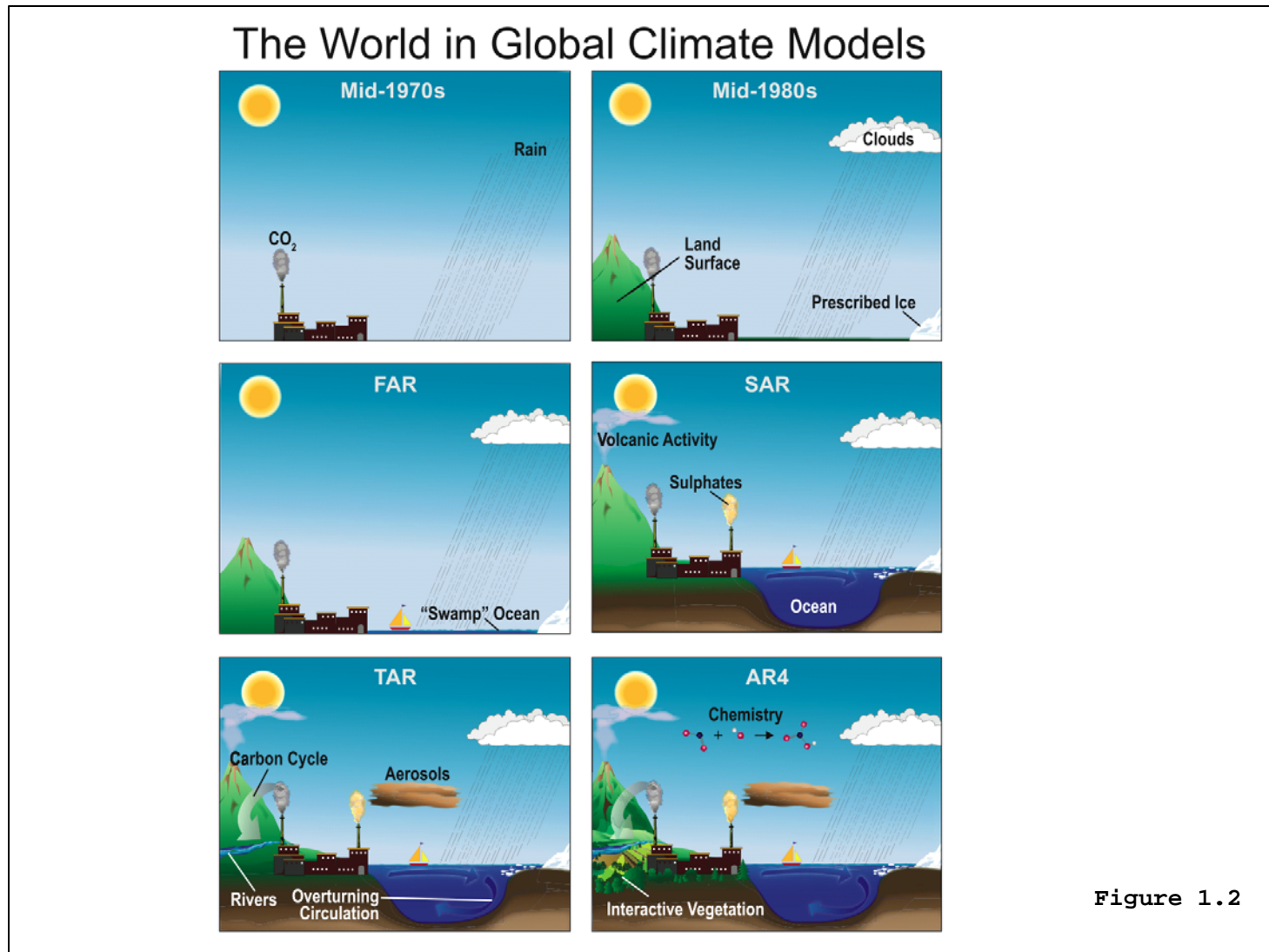
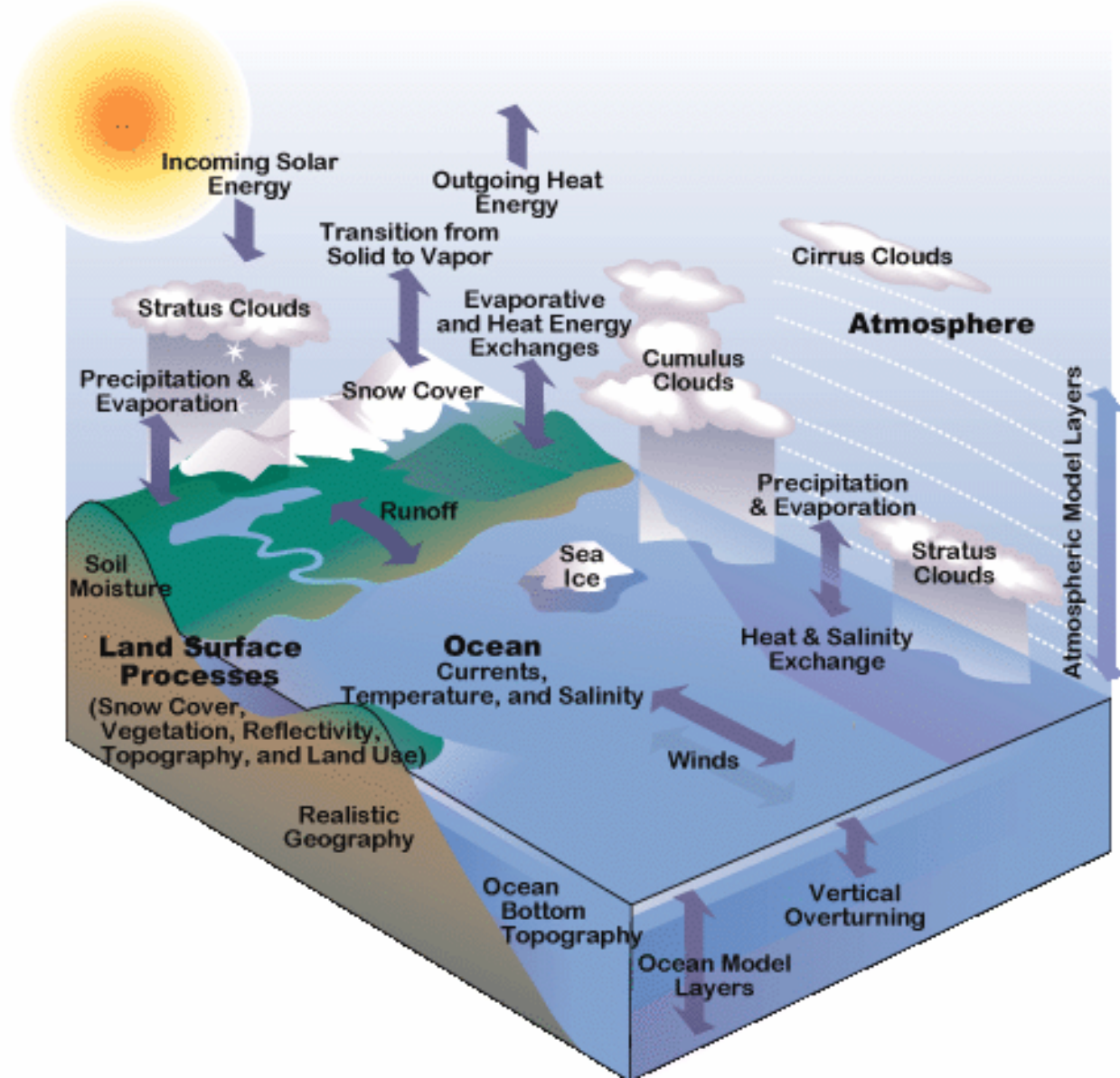
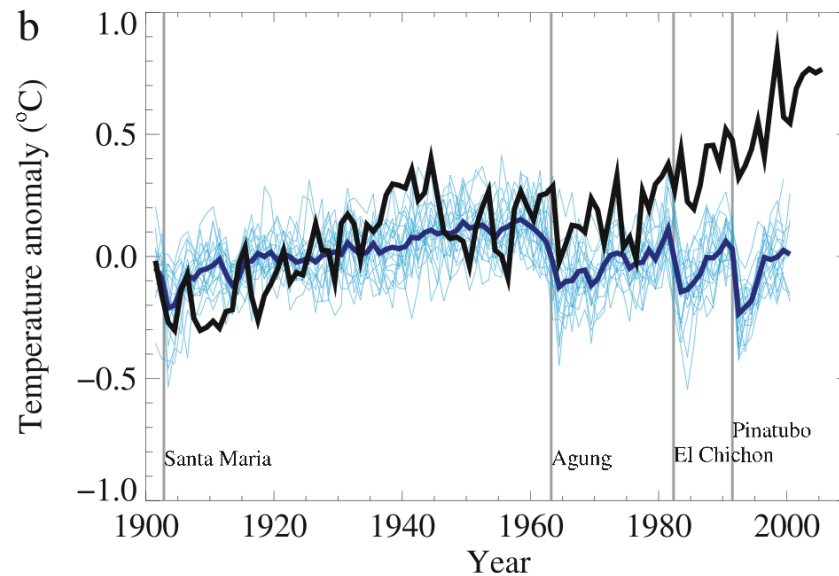
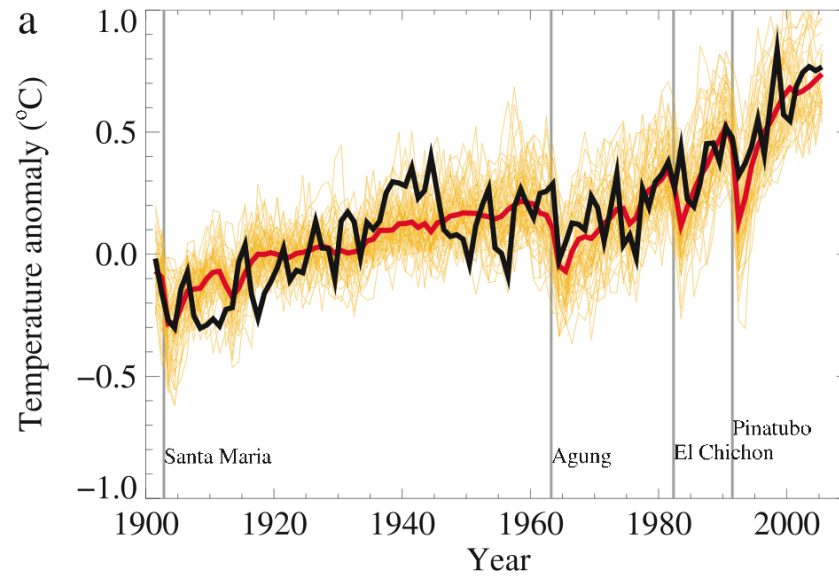


Figure 1.2

To understand what will happen next requires Global Climate Models



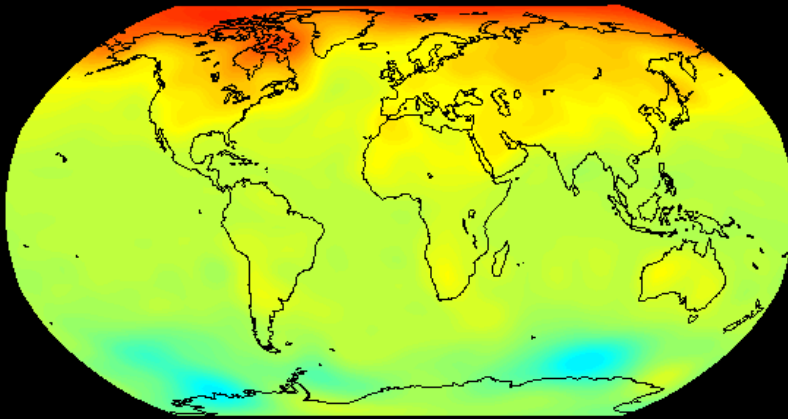
Can we match what has happened?



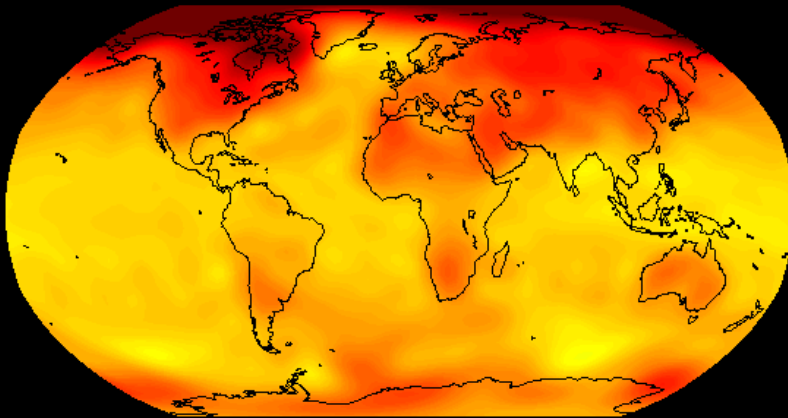
What do we predict will happen?

Surface Air Warming (°F)

2xCO₂

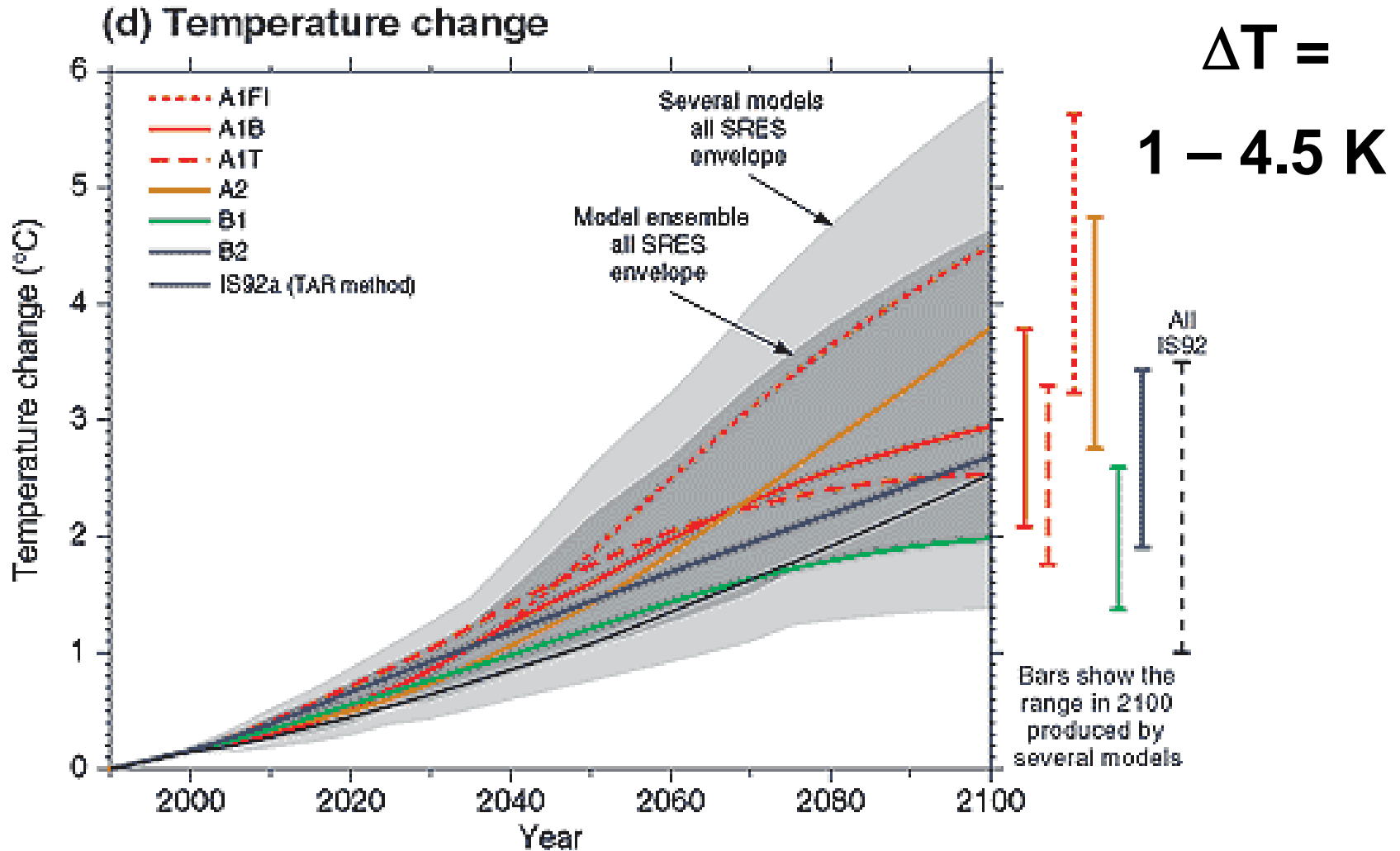


4xCO₂



Effect is not evenly distributed

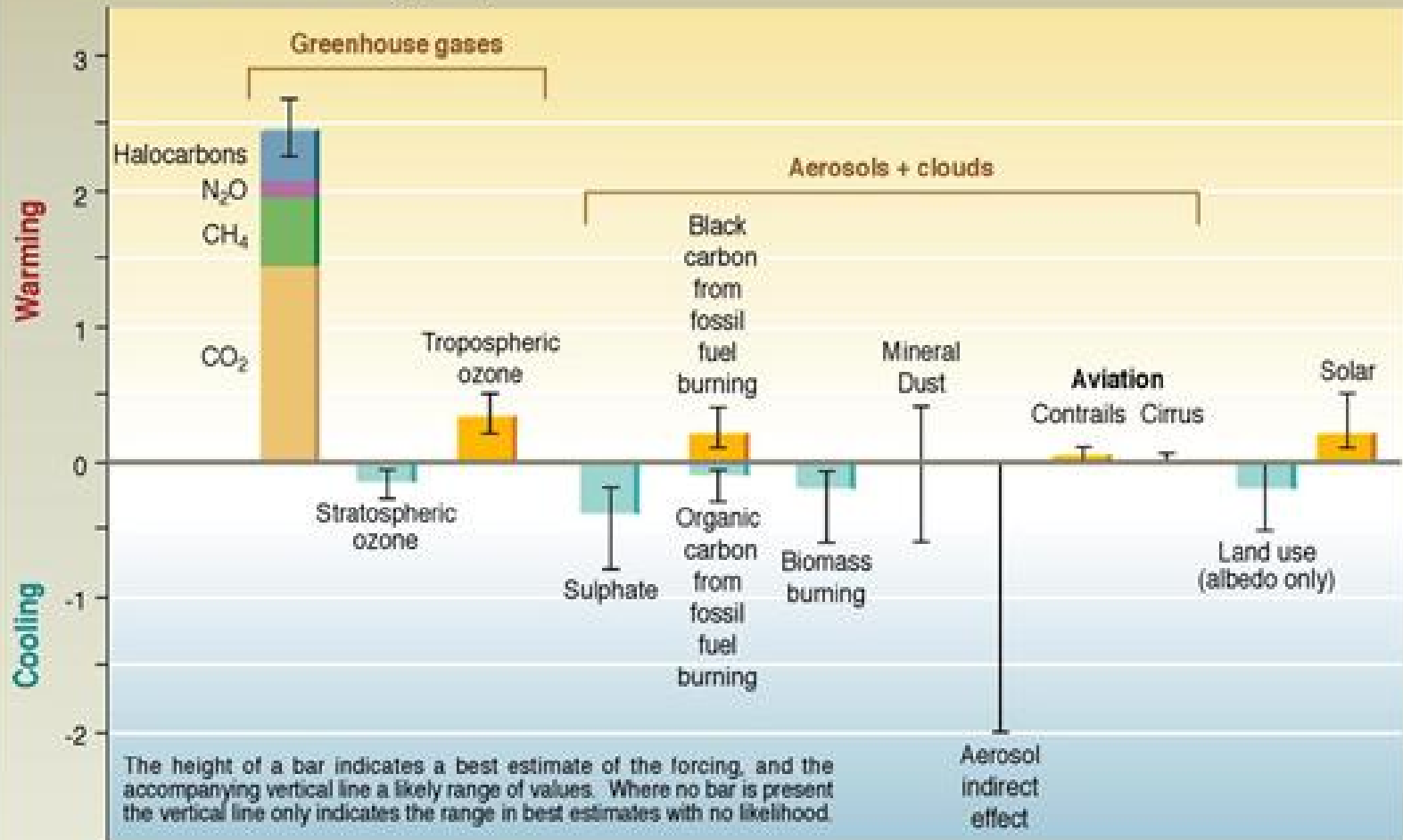
The results vary....



Why the big uncertainties?

Anthropogenic and natural forcing of the climate for the year 2000, relative to 1750

Global mean radiative forcing (Wm^{-2})



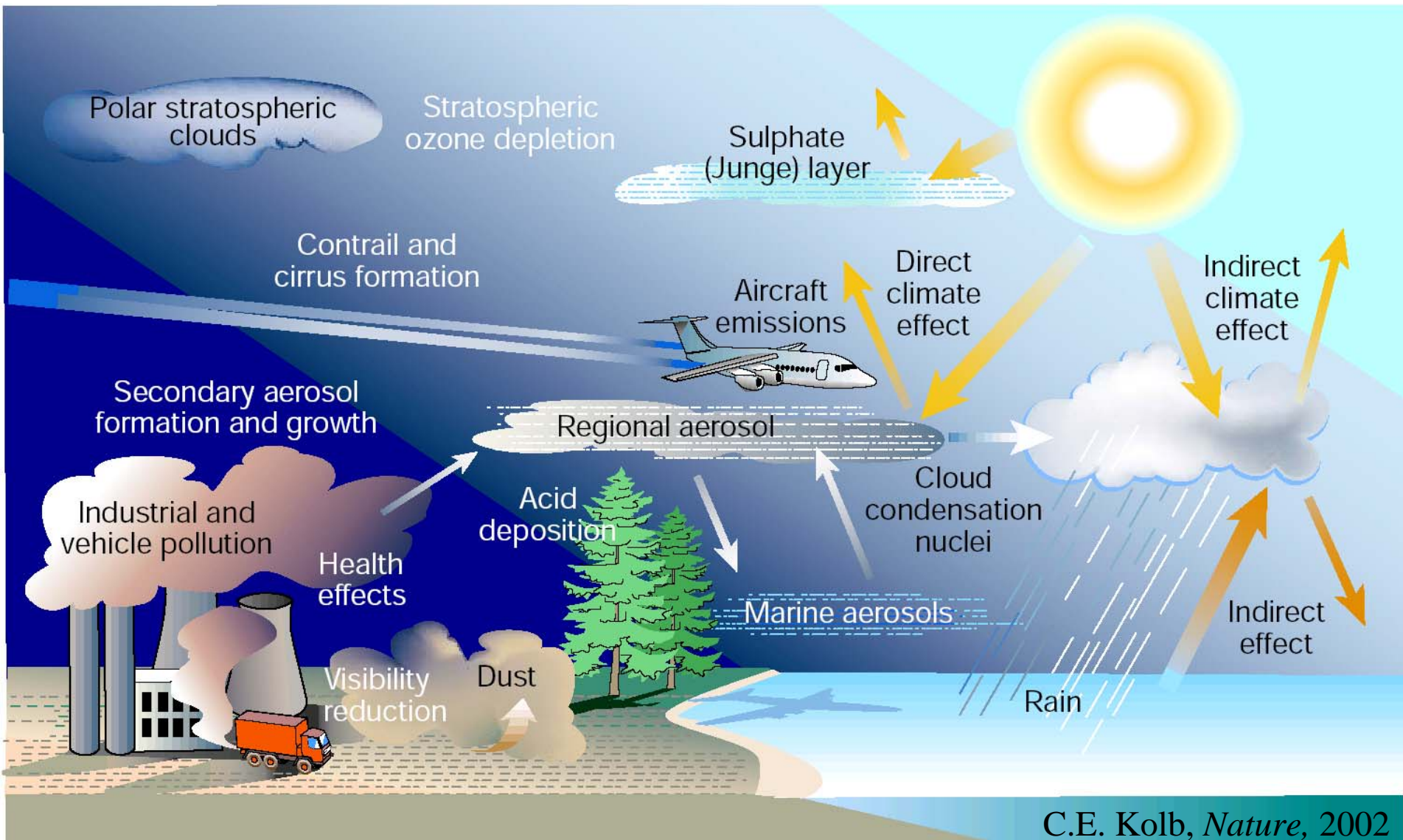
LEVEL OF SCIENTIFIC UNDERSTANDING

High Medium Medium Low Very low Very low Very low Very low Very low Very low Very low

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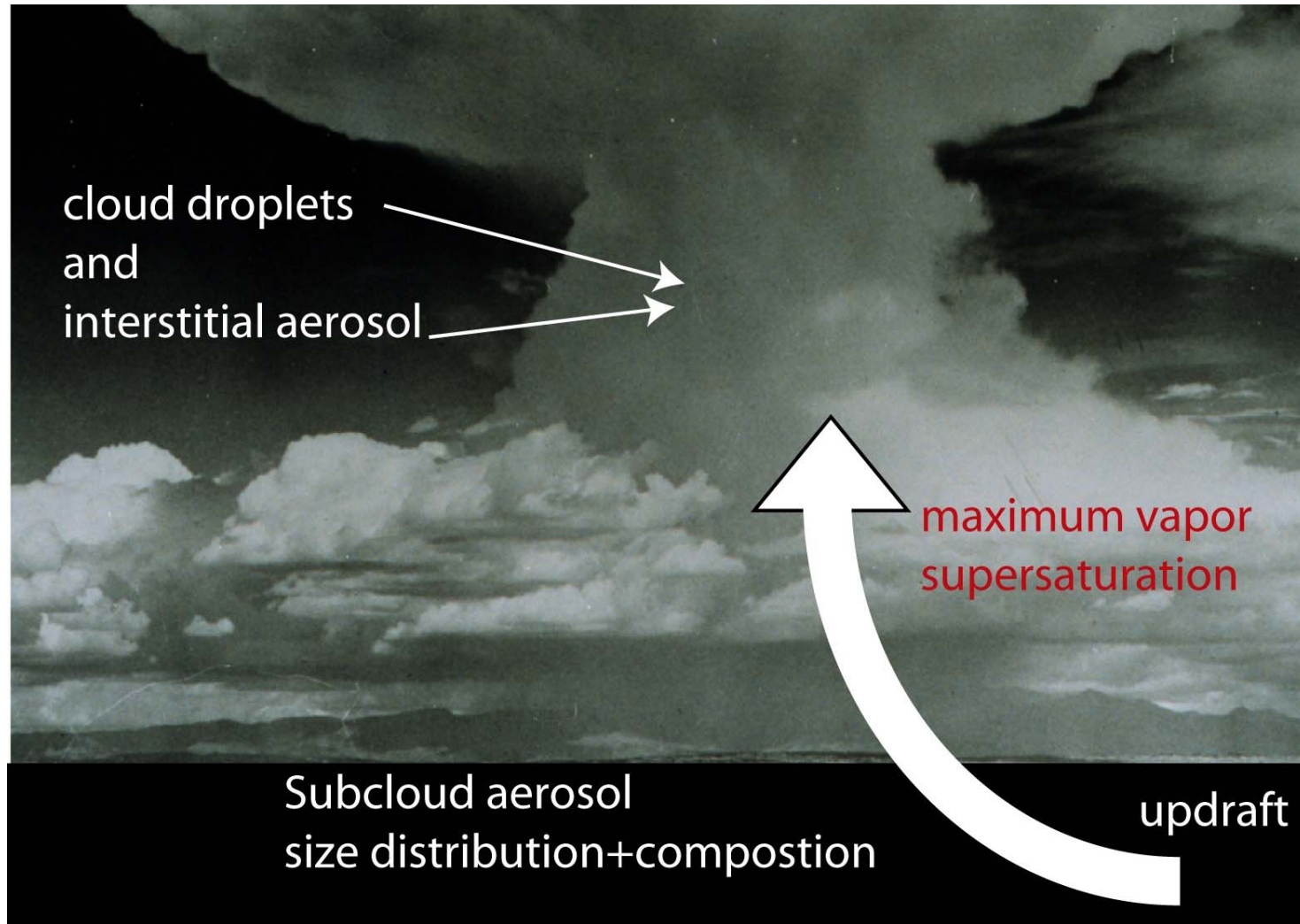
Aerosols modify the energy balance



Aerosol direct effect

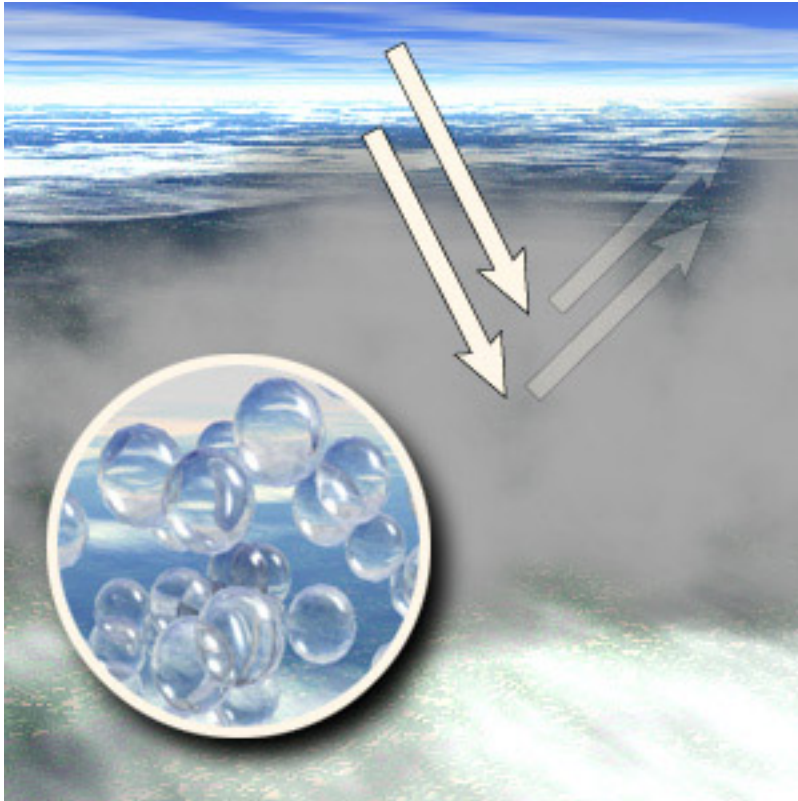


Aerosol indirect effect

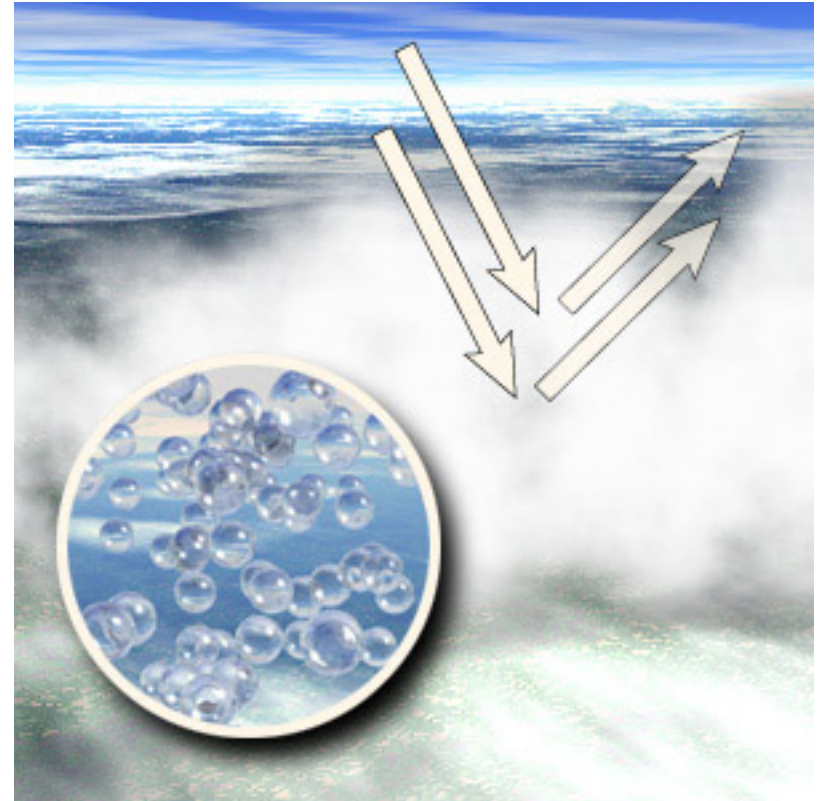


How do aerosol properties effect cloud properties?

Aerosol indirect effect

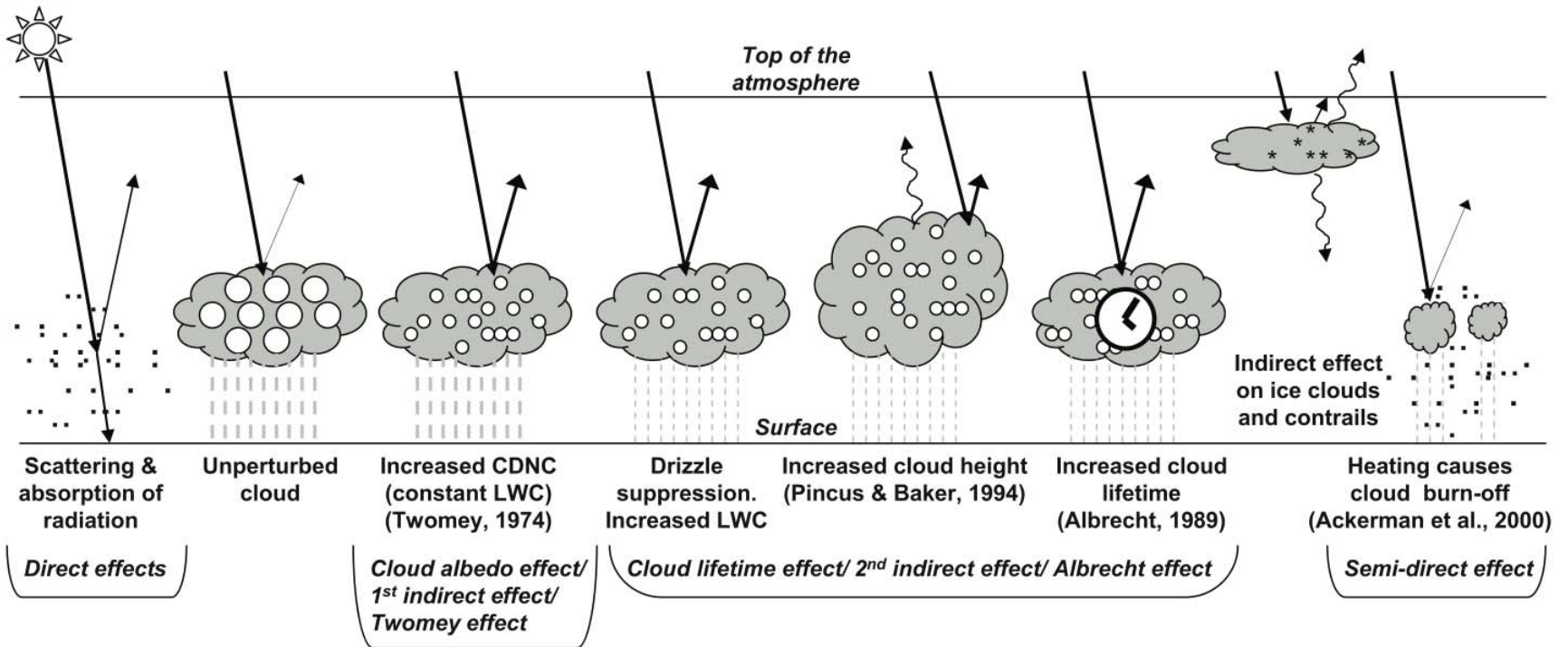


- Low particle number concentration
- Fewer, larger droplets formed
- Much of the Sun's visible radiation passes through the cloud to the Earth's surface
- Lower cloud albedo



- High particle number concentration
- More, smaller cloud droplets formed
- More visible radiation reflected back to space
- Higher cloud albedo, longer life
- Cools Earth's surface

Aerosol effects



Human activity affects clouds

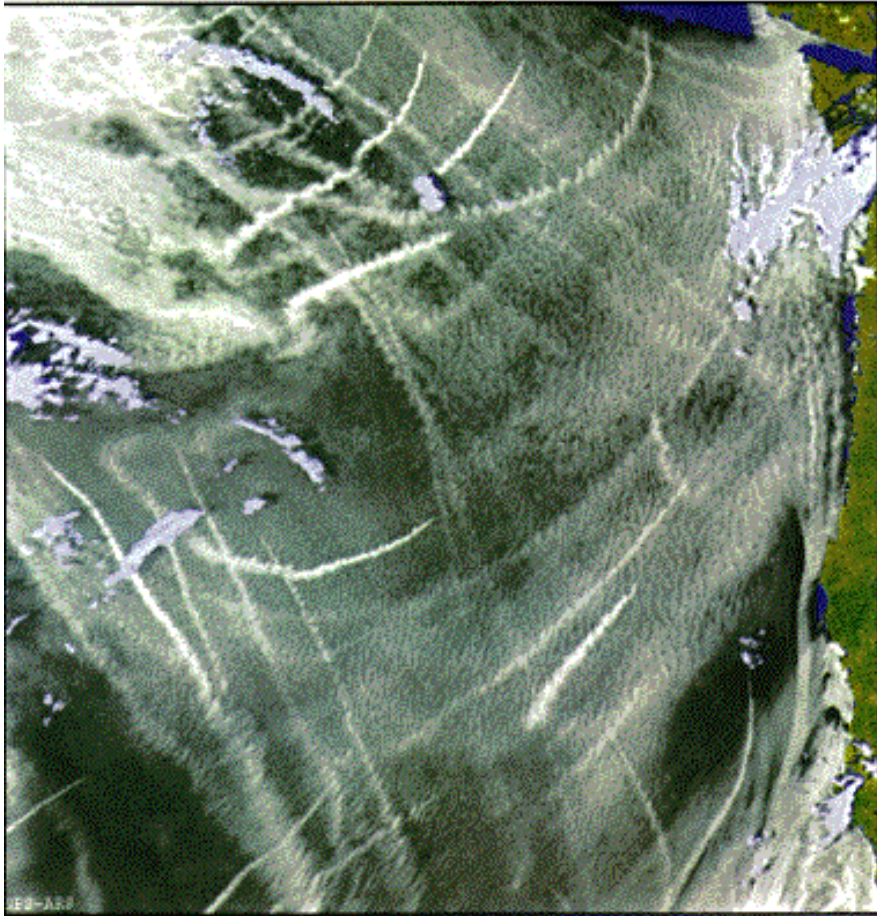
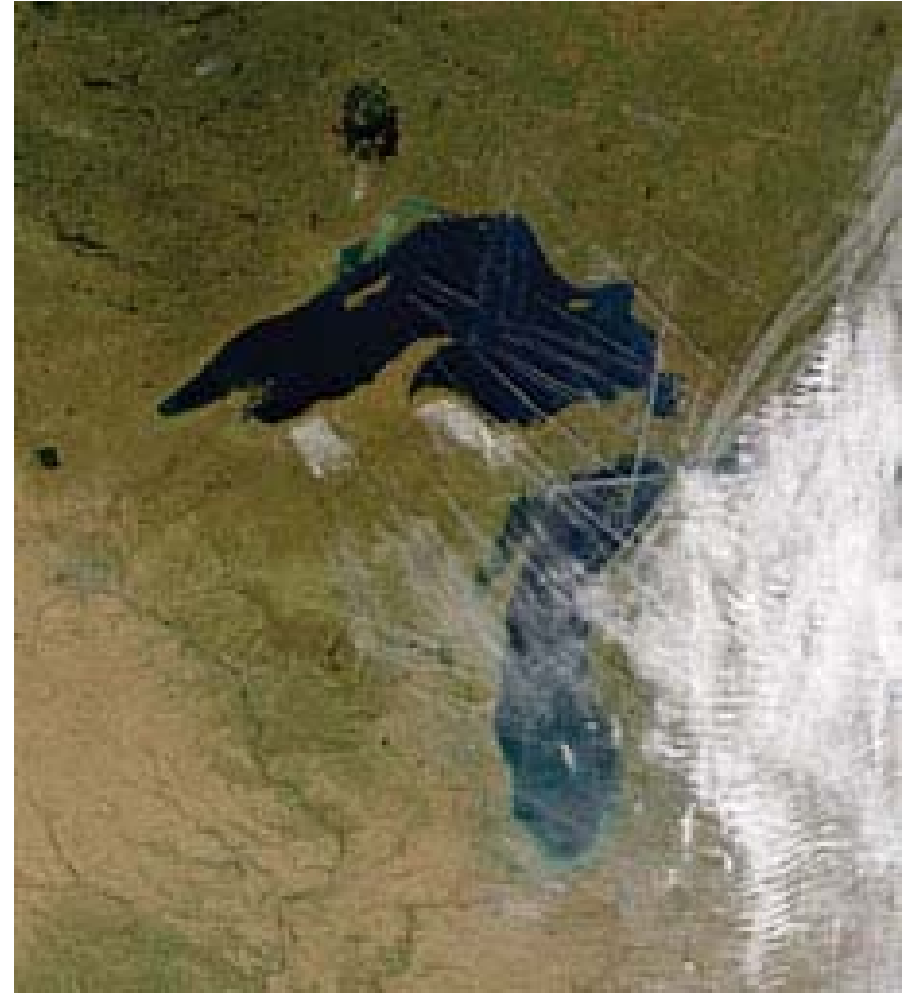
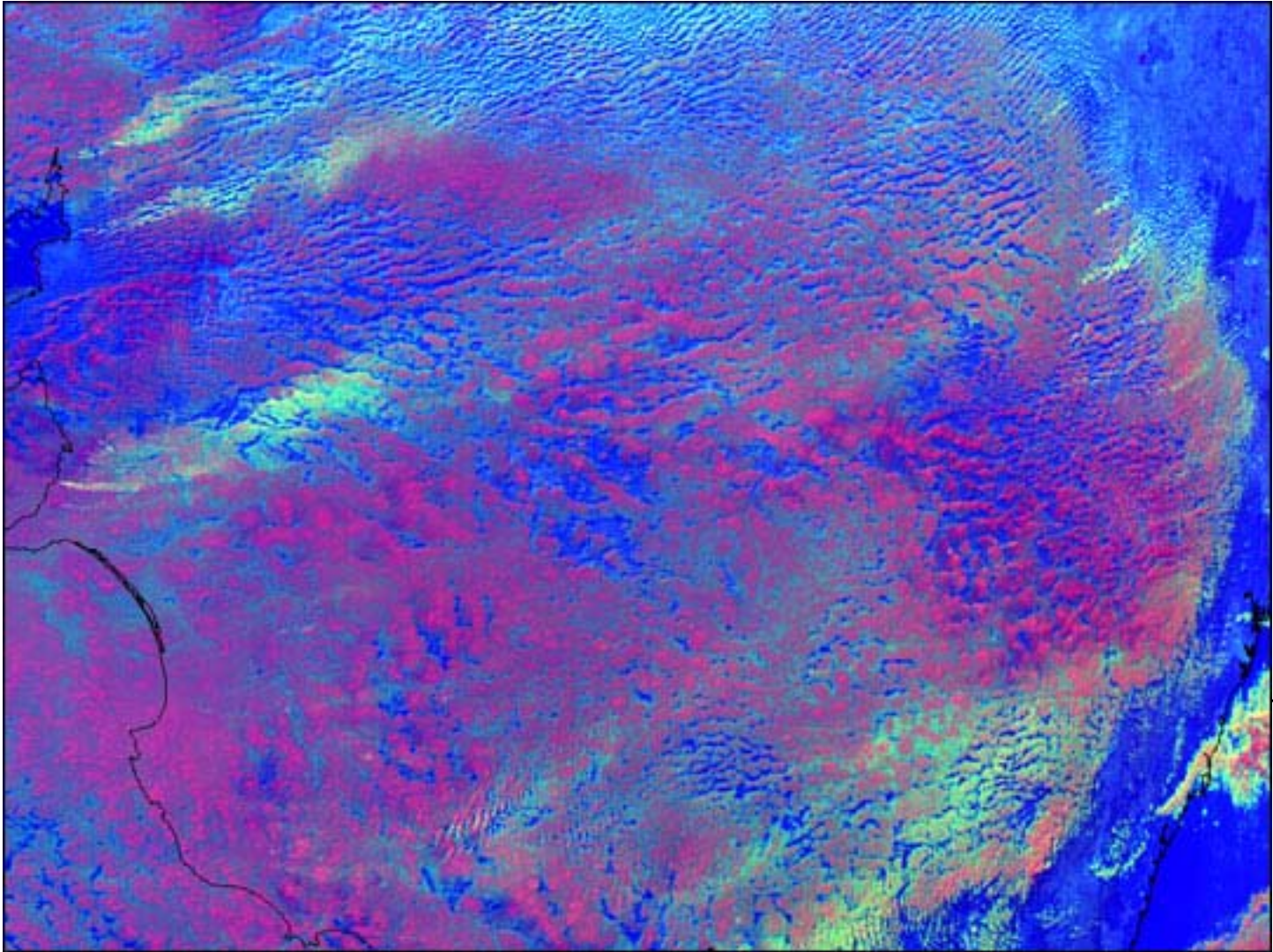


Figure 1: Ship tracks off the coast of Washington



Ship tracks and contrails

Pollution plumes



Global Dimming: surface cooling due to pollutant aerosol



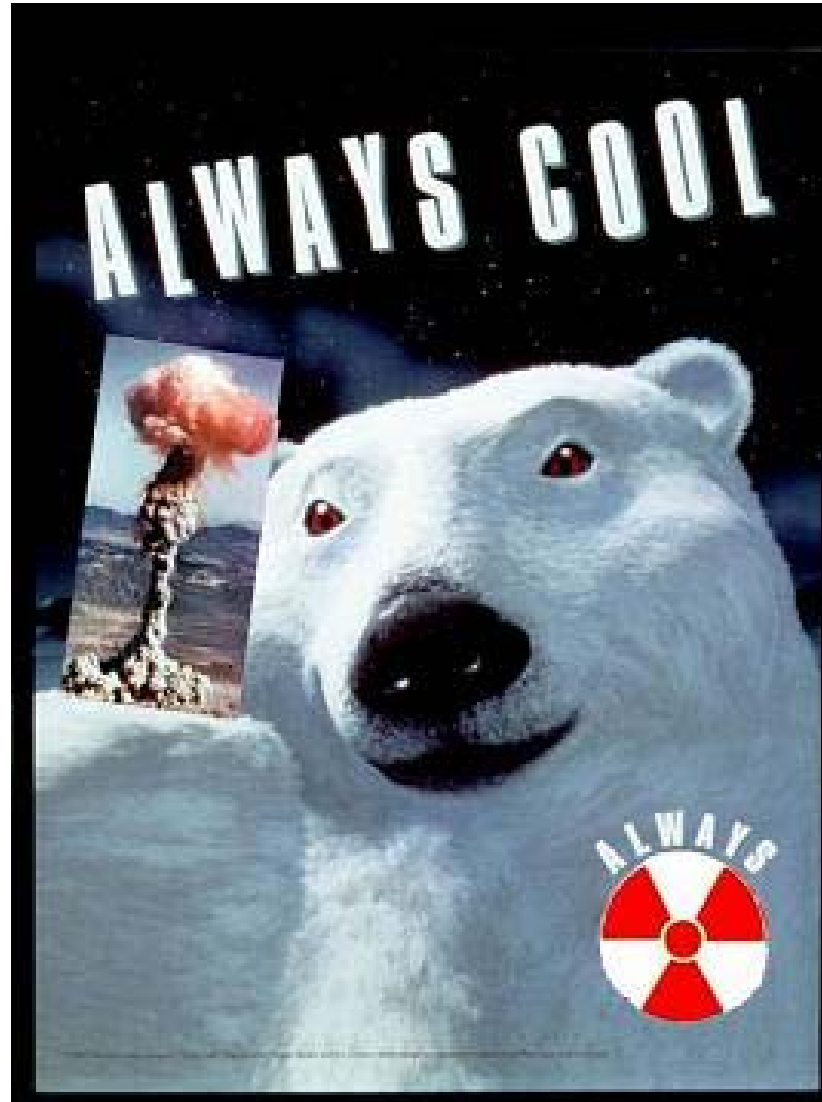
Has global dimming masked global warming?

Will pollution control of particulates enhance global warming?

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What not...



What not...

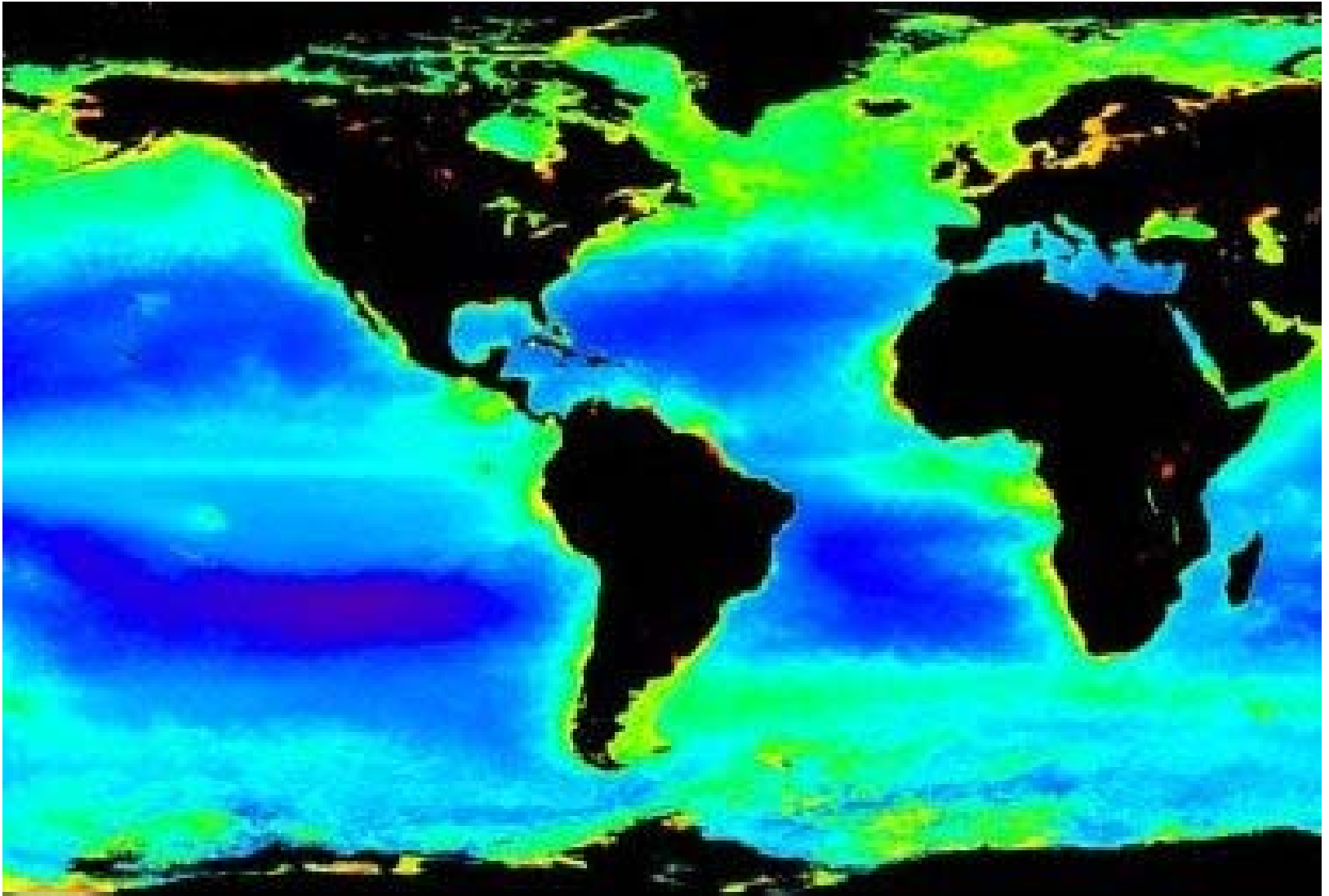
United States Patent 5,003,186, March 26, 1991, Chang , et al. [See patent](#)
Stratospheric Welsbach seeding for reduction of global warming

Abstract

A method is described for reducing atmospheric or global warming resulting from the presence of heat-trapping gases in the atmosphere, i.e., from the greenhouse effect.

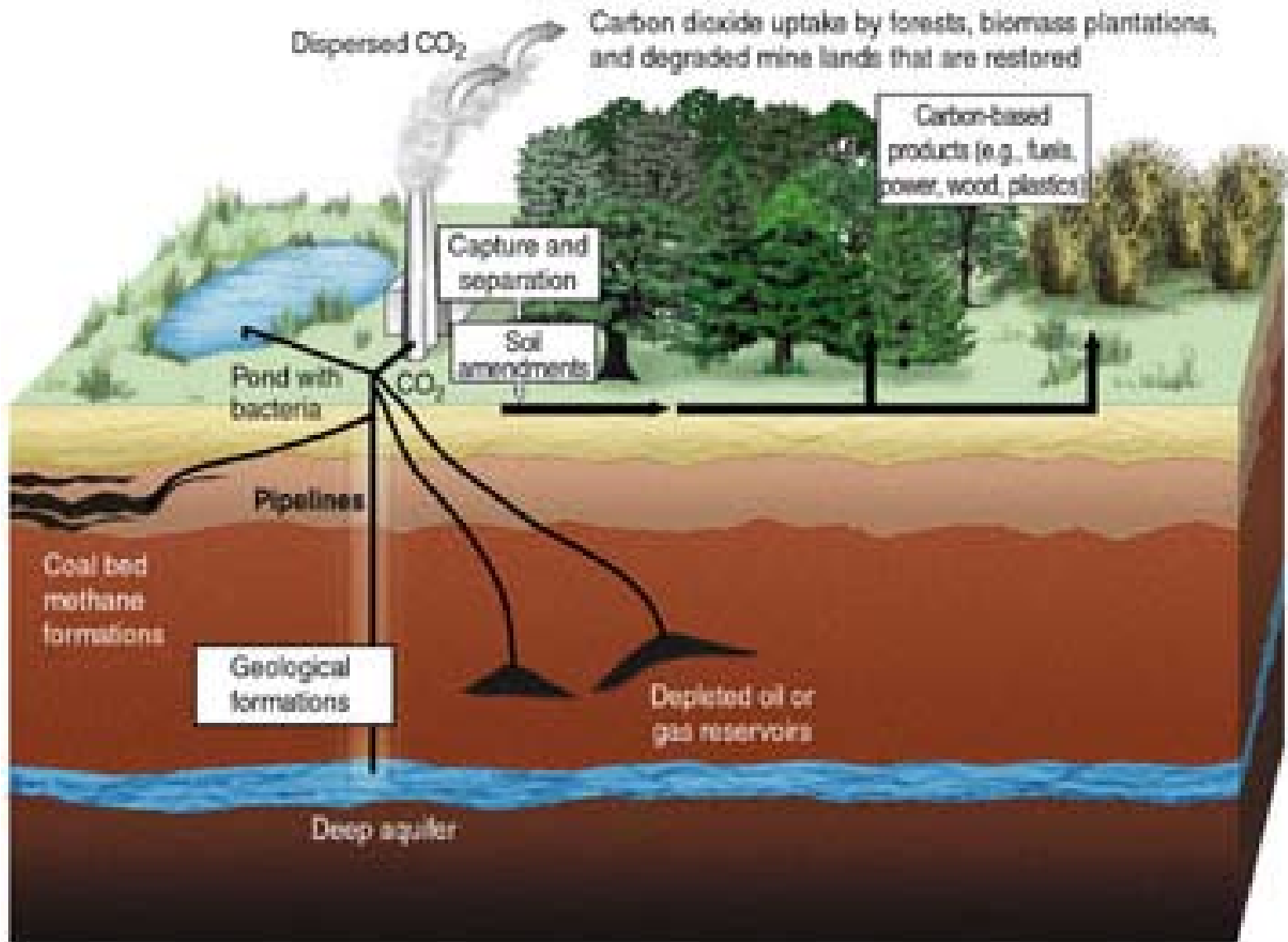
Such gases are relatively transparent to sunshine, but absorb strongly the long-wavelength infrared radiation released by the earth. The method includes the step of seeding the layer of heat-trapping gases in the atmosphere with particles of materials characterized by wavelength-dependent emissivity. Such materials include Welsbach materials and the oxides of metals which have high emissivity (and thus low reflectivities) in the visible and 8-12 micron infrared wavelength regions.

What not...



Seed the ocean with iron

Carbon sequestration...??



What may work

- Control population growth
- Help industrializing nations
- Reducing our carbon footprint

Acknowledge the problem