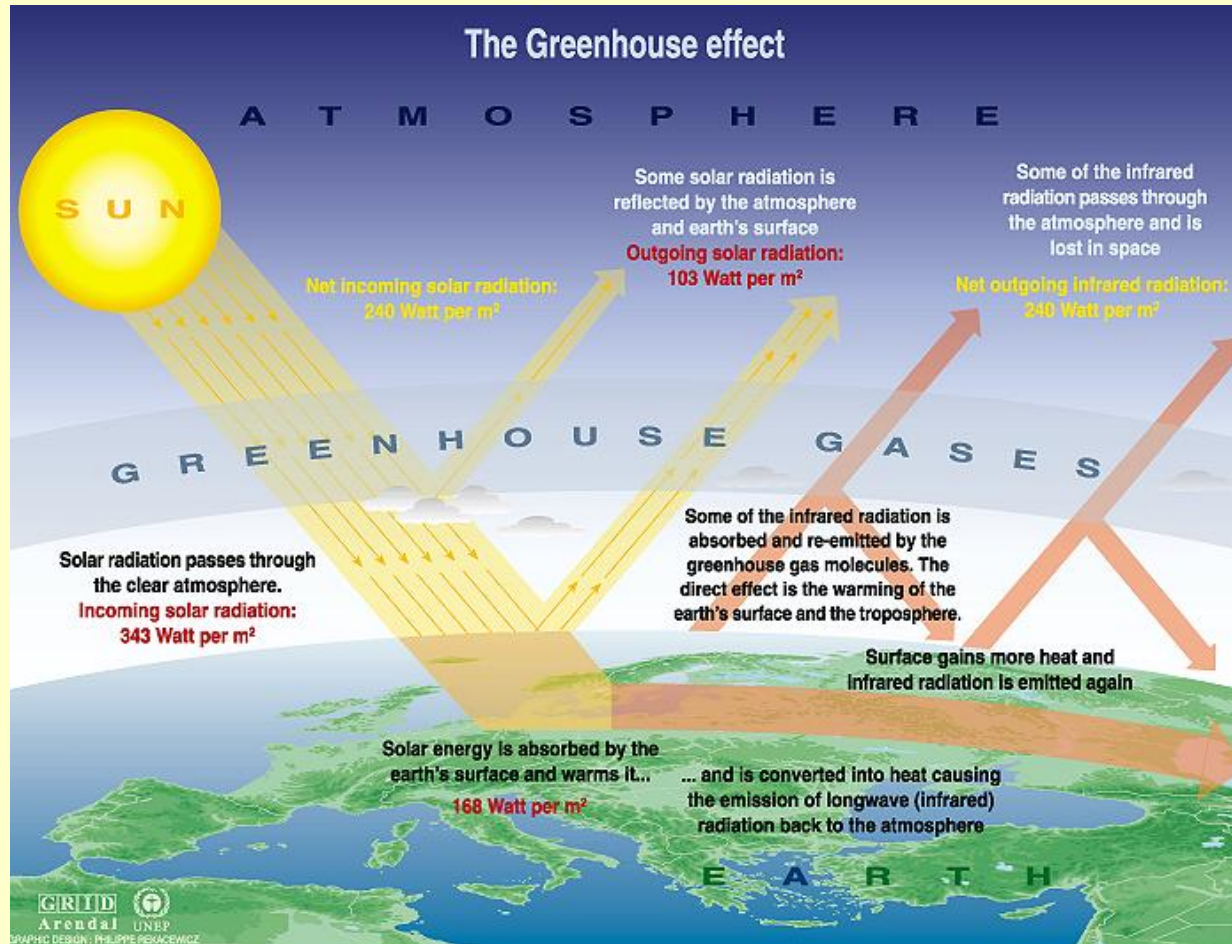
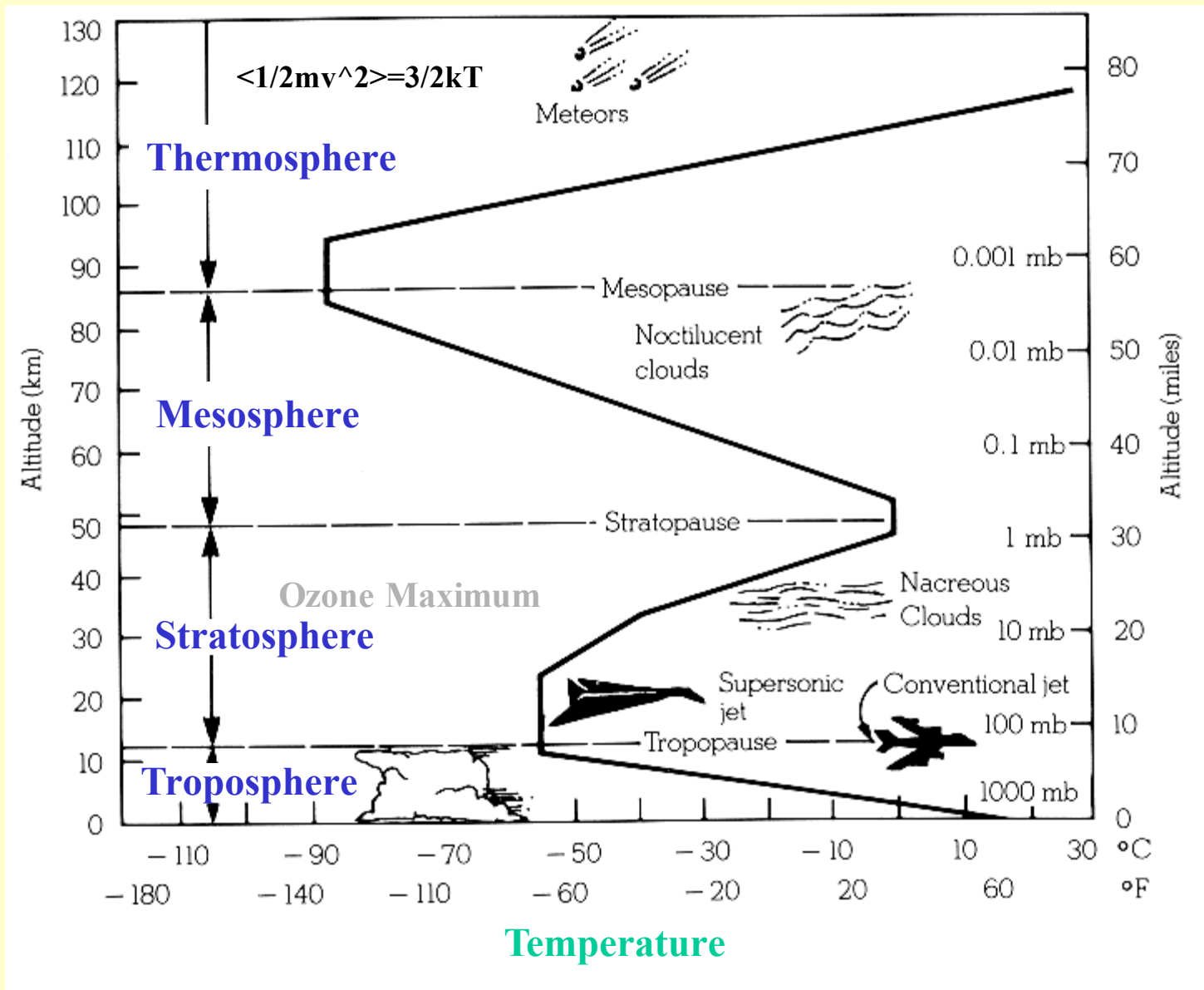


# L'effetto serra e il riscaldamento globale



Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography, United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

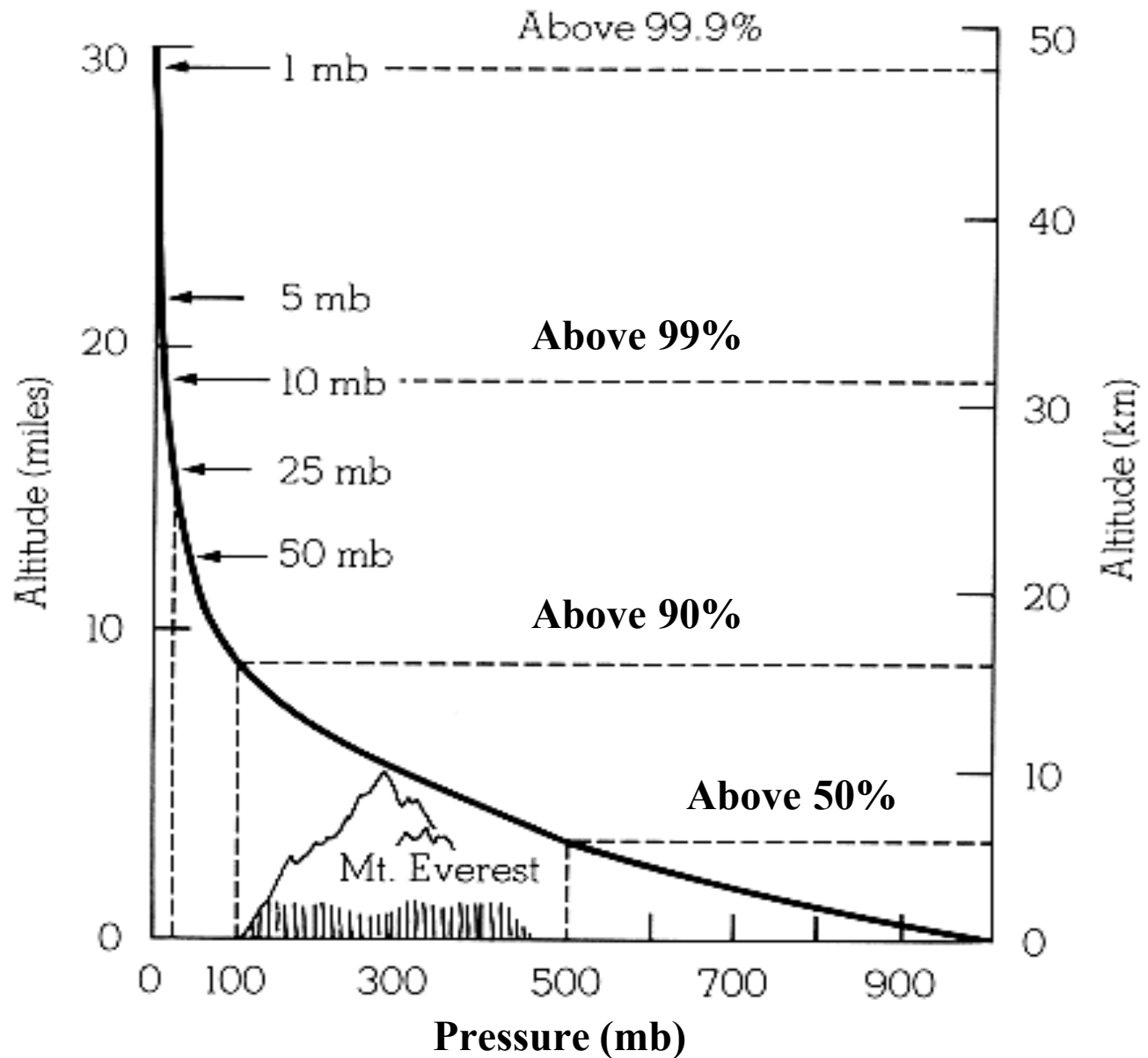
# Structure of the Atmosphere



**Atmospheric Pressure Decreases With Height**

**Most of the energy is captured close to the surface**

**That energy drives climate and weather**



**50 percent of mass of the atmosphere is within 6 km of the surface**

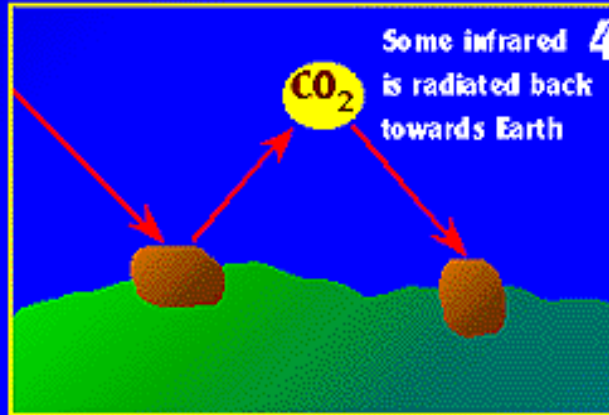
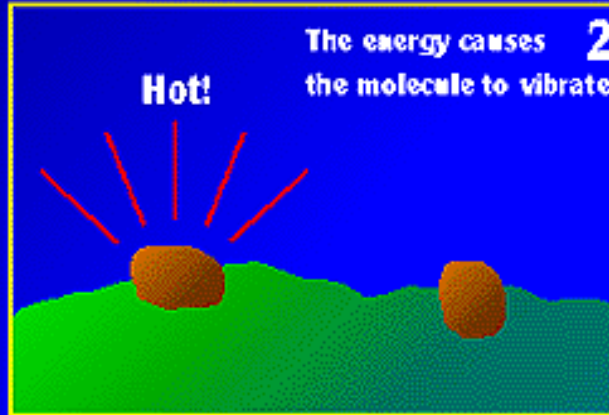
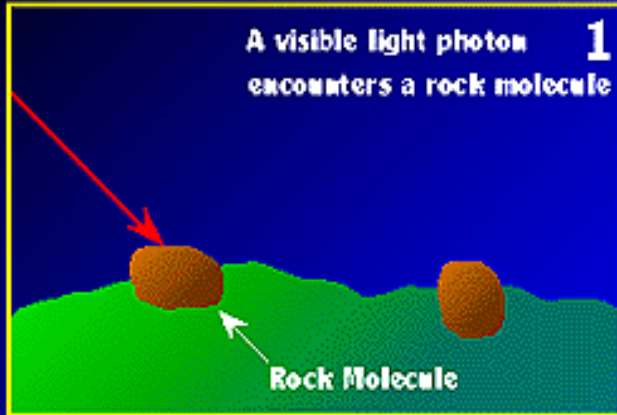
# The “Greenhouse Effect”

- \* The Earth’s surface thus receives energy from two sources: the sun & the atmosphere
  - As a result the Earth’s surface is  $\sim 33^{\circ}\text{C}$  warmer than it would be without an atmosphere

Greenhouse gases are transparent to shortwave but absorb longwave radiation

- Thus the atmosphere stores energy

# The Earth's Temperature - A Balancing Act

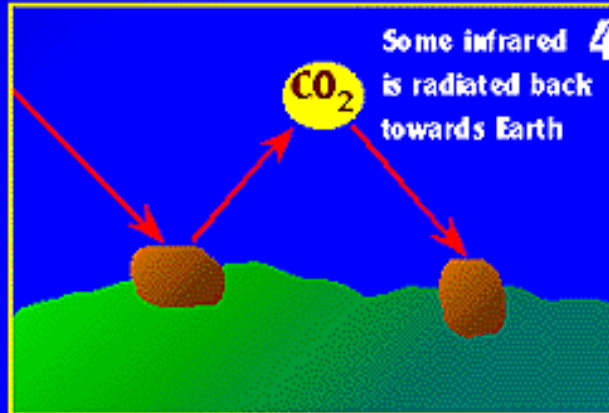
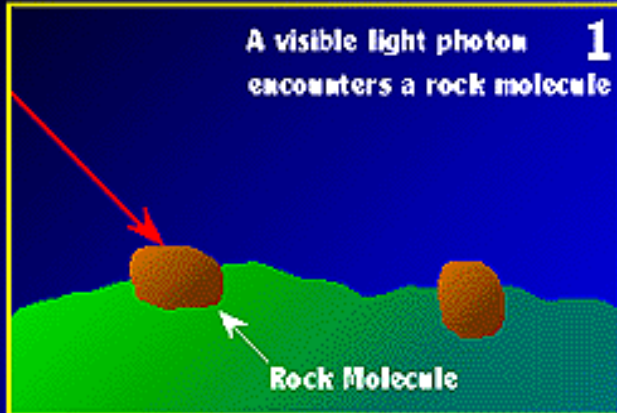


1. Shorter, high  
Energy wavelengths  
Hit the earths  
Surface

2. Incoming energy  
Is converted to heat



# The Earth's Temperature - A Balancing Act



3. Longer, infrared Wavelengths hit Greenhouse gas Molecules in the atmosphere

4. Greenhouse gas Molecules in the Atmosphere emit Infrared radiation Back towards earth



78% nitrogen

20.6% oxygen

< 1% argon

0.4% water vapor

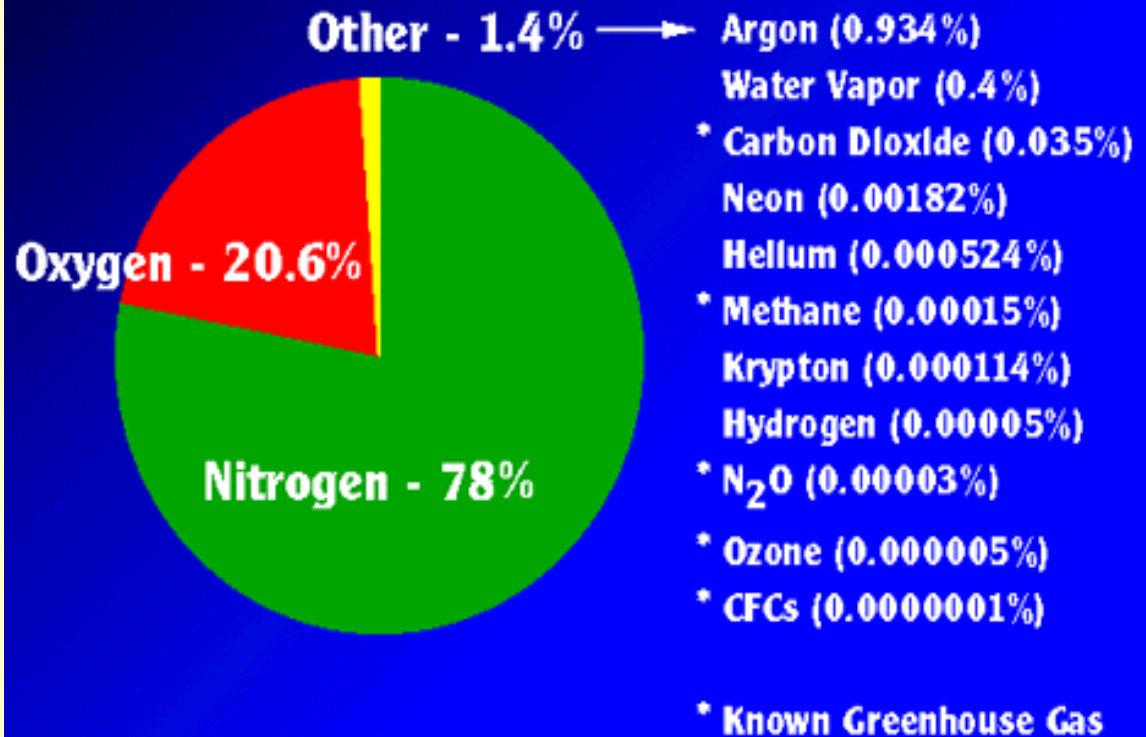
0.036% carbon dioxide

traces gases:

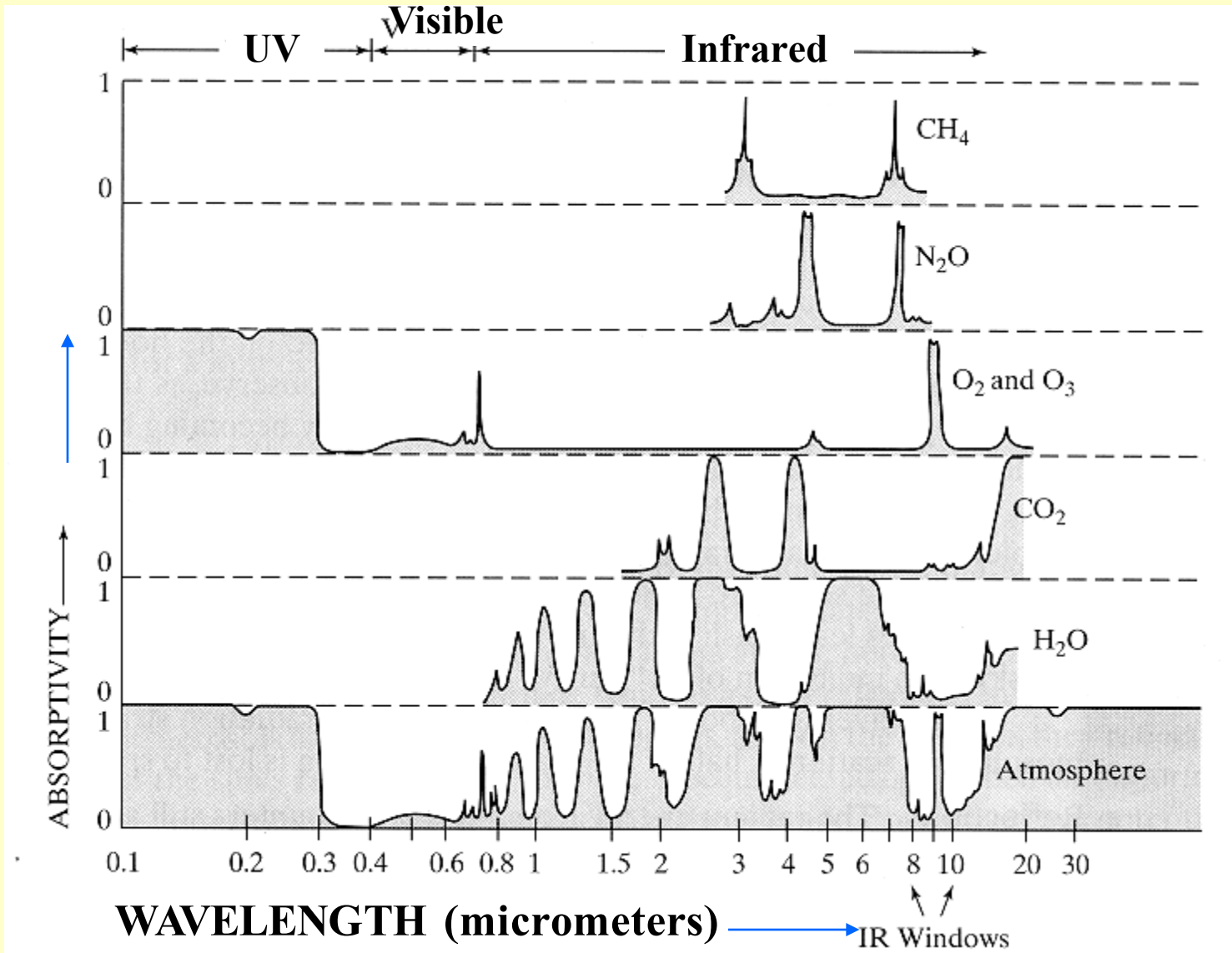
Ne, He, Kr, H, O<sub>3</sub>

Methane, Nitrous Oxide

# Composition of the Earth's Atmosphere (Gases - Percent by Volume)

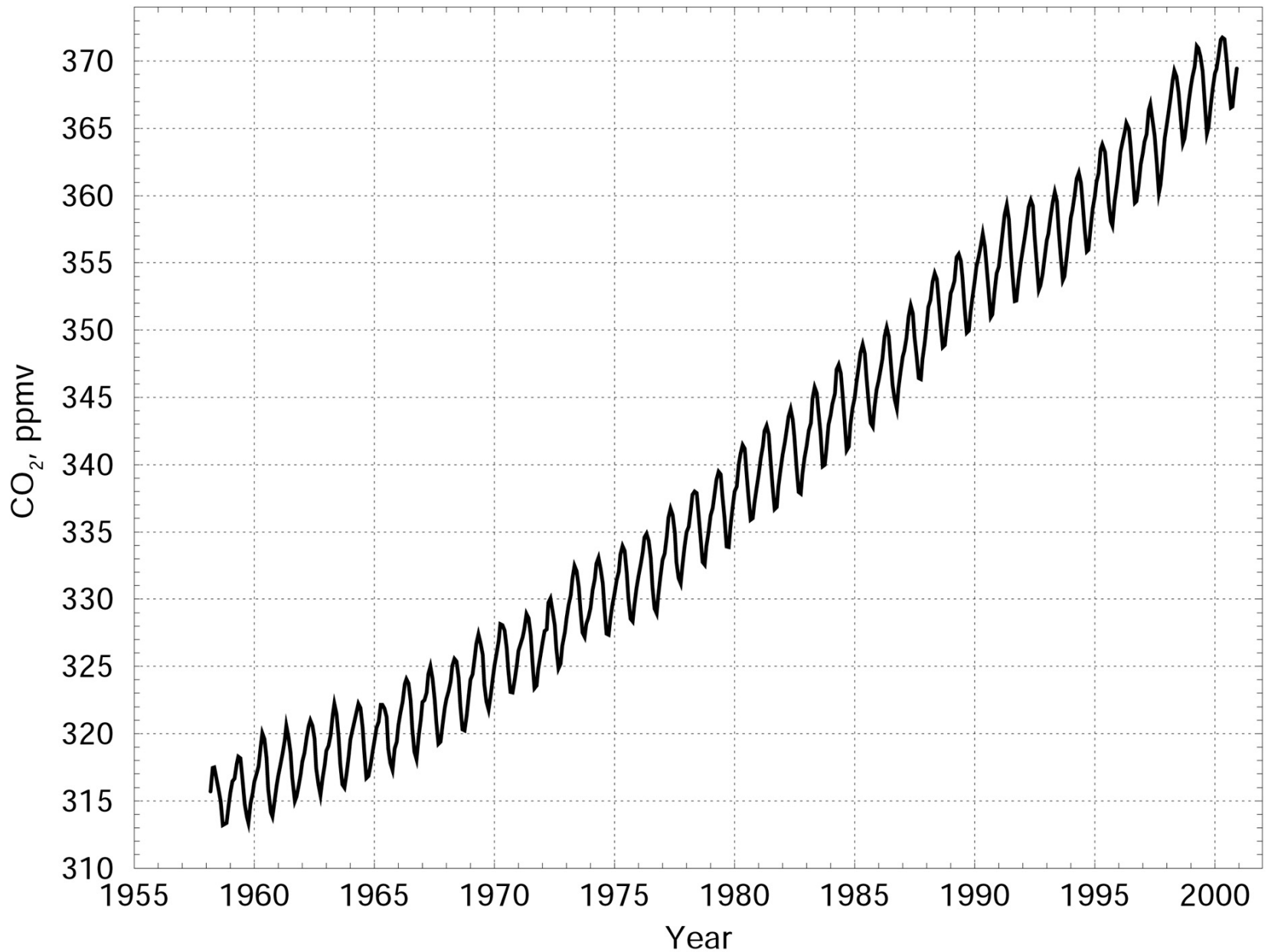


# Absorption Spectra of Atmospheric Gases





# Carbon Dioxide at Mauna Loa, Hawaii



# Selected Greenhouse Gases

- **Carbon Dioxide (CO<sub>2</sub>)**

- Source: Fossil fuel burning, deforestation

- \* Anthropogenic increase: **30%**

- \* Average atmospheric residence time: **500 years**

- \* **Methane (CH<sub>4</sub>)**

- Source: Rice cultivation, cattle & sheep ranching, decay from landfills, mining

- \* Anthropogenic increase: **145%**

- \* Average atmospheric residence time: **7-10 years**

- \* **Nitrous oxide (N<sub>2</sub>O)**

- Source: Industry and agriculture (fertilizers)

- \* Anthropogenic increase: **15%**

- \* Average atmospheric residence time: **140-190 years**

# Greenhouse Effect & Global Warming

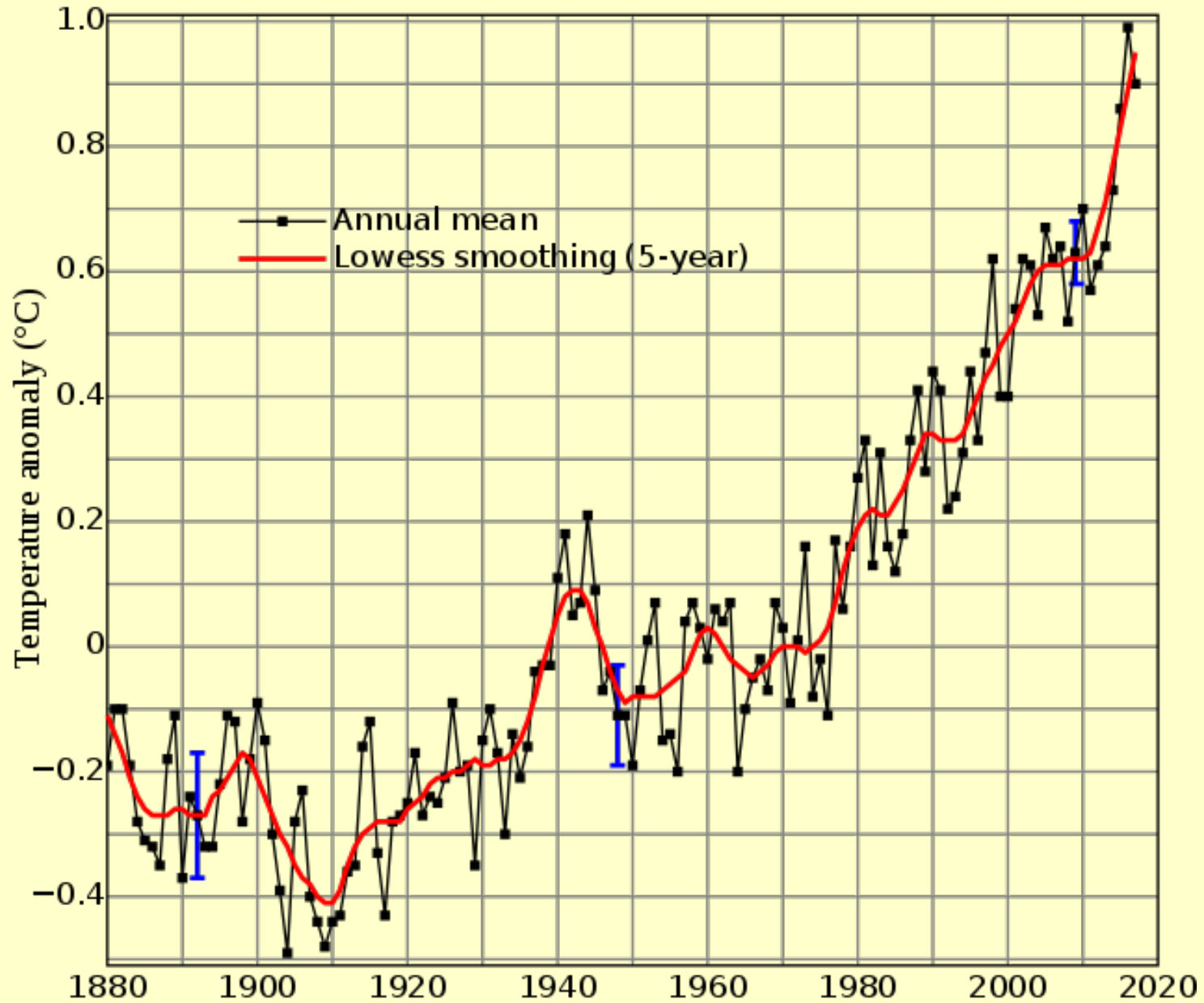
- The "***greenhouse effect***" & ***global warming*** are **not** the same thing.
  - Global warming refers to a rise in the temperature of the surface of the earth

✱

- An increase in the ***concentration of greenhouse gases*** leads to an increase in the the ***magnitude of the greenhouse effect***. (Called enhanced greenhouse effect)
  - This results in global warming

# Climate Change vs. Variability

Global land-ocean temperature index



# Climate Change vs. Variability

Climate variability is natural.

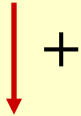
Even in a stable climate regime, there will always be some variation (wet/dry years, warm/cold years) A year with completely “average” or “normal” climate conditions is rare

The challenge for scientists is to determine whether any increase/decrease in precipitation, temperature, frequency of storms, sea level, etc. is due to climate variability or climate change.

# Atmospheric Feedbacks

## POSITIVE

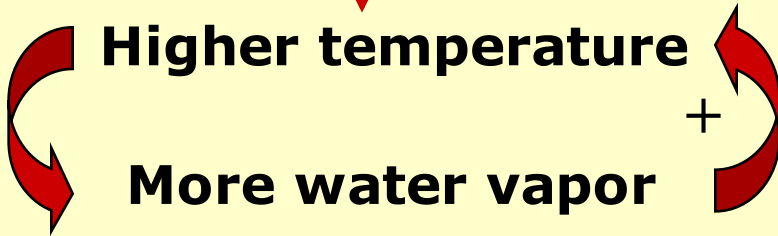
Increased CO<sub>2</sub>



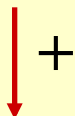
Higher temperature

+

More water vapor



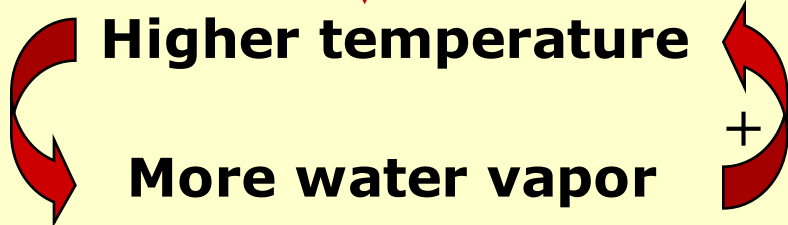
More absorbed infrared radiation



Higher temperature

+

More water vapor



## NEGATIVE

More water vapor & other changes



Increased cloud cover



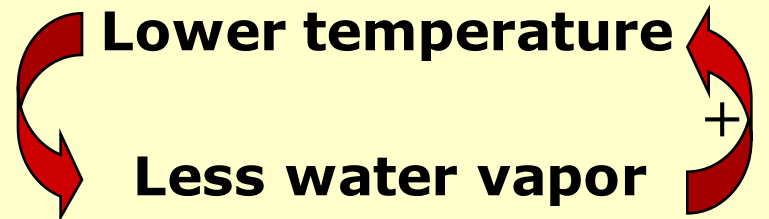
More reflected solar radiation



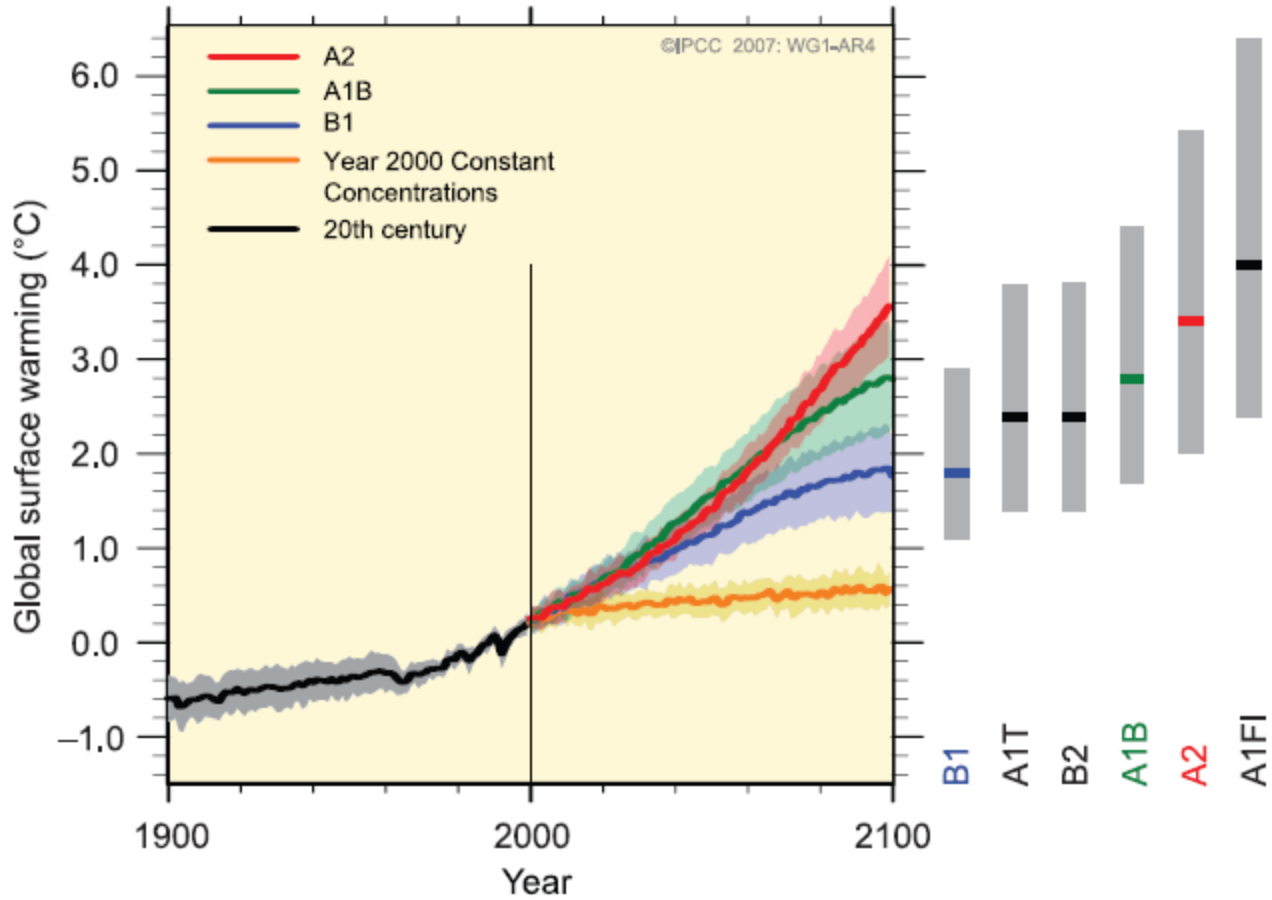
Lower temperature

+

Less water vapor

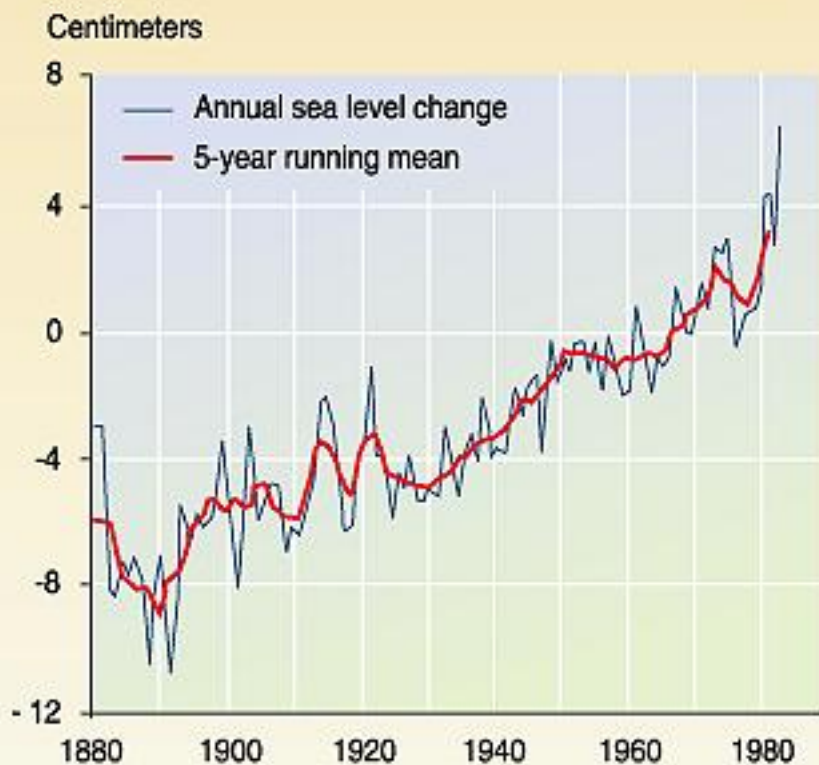


### MULTI-MODEL AVERAGES AND ASSESSED RANGES FOR SURFACE WARMING

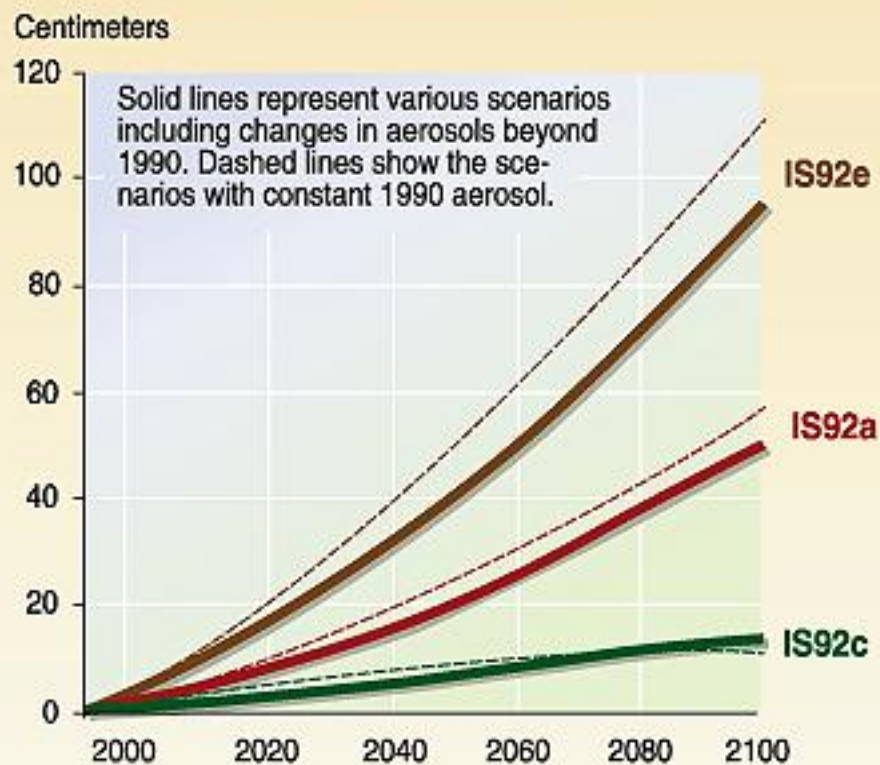


# Sea level rise due to global warming

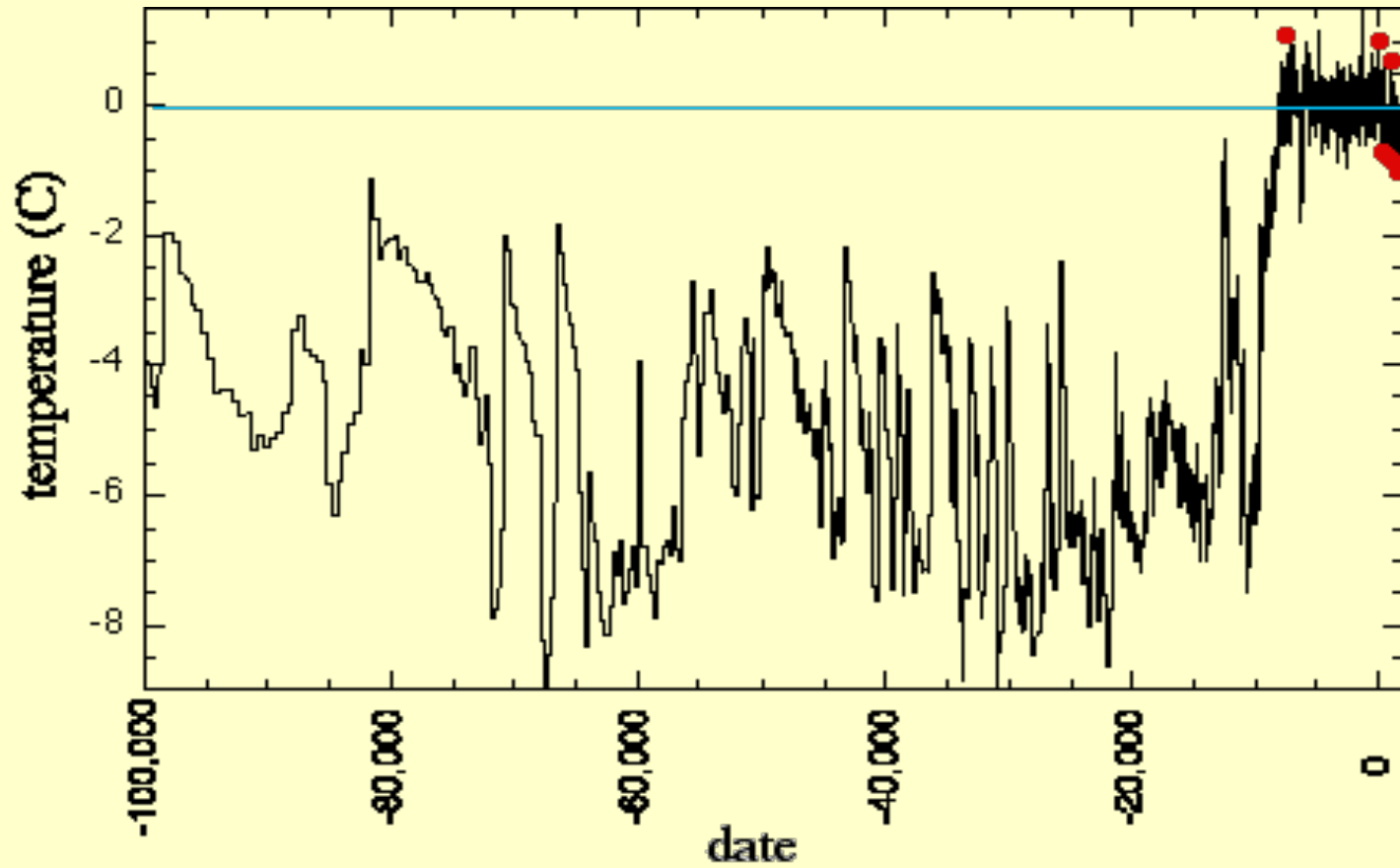
## Sea level rise over the last century



## Sea level rise scenarios for 2100







**Andamento della temperatura in Groenlandia**