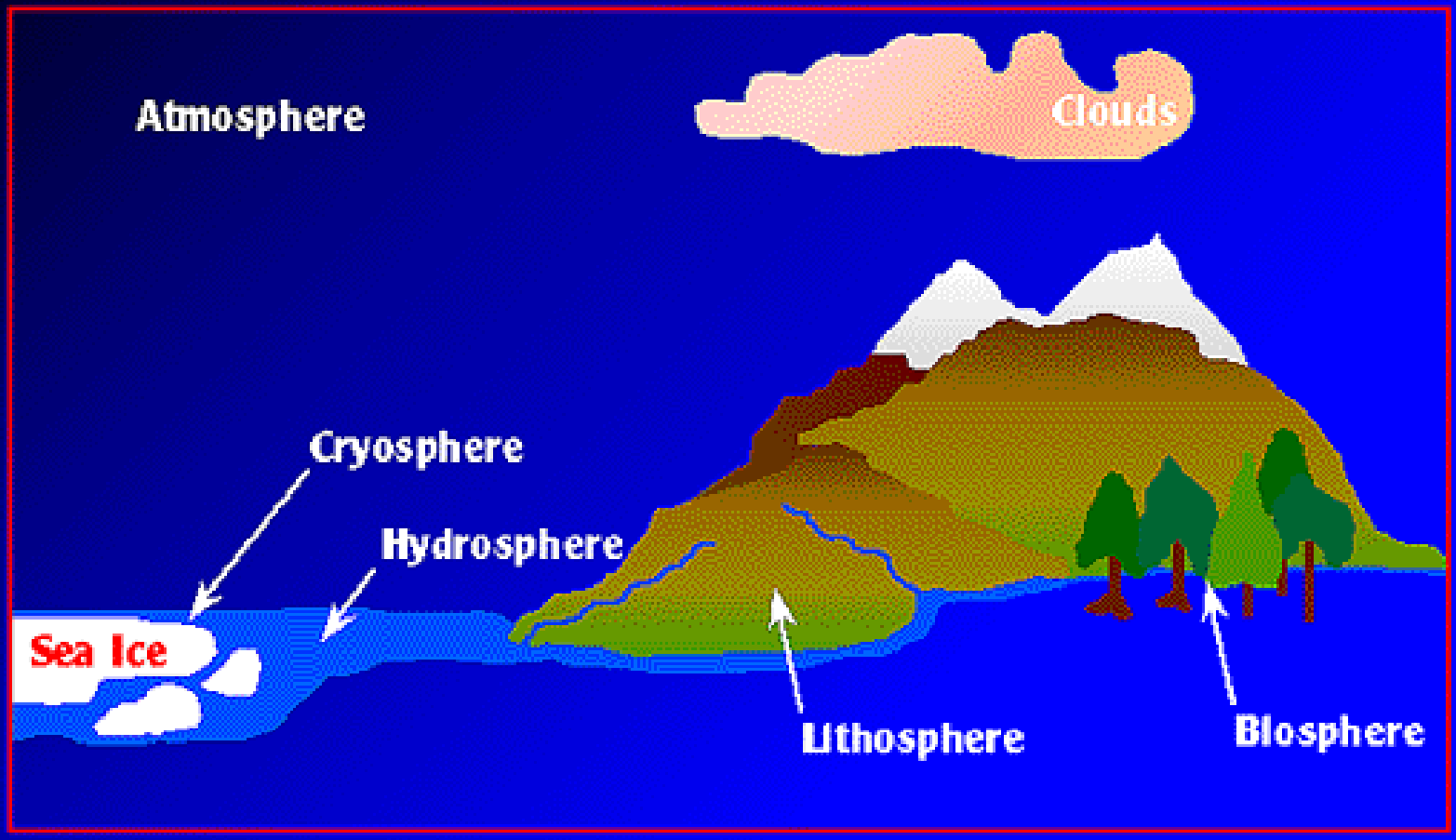
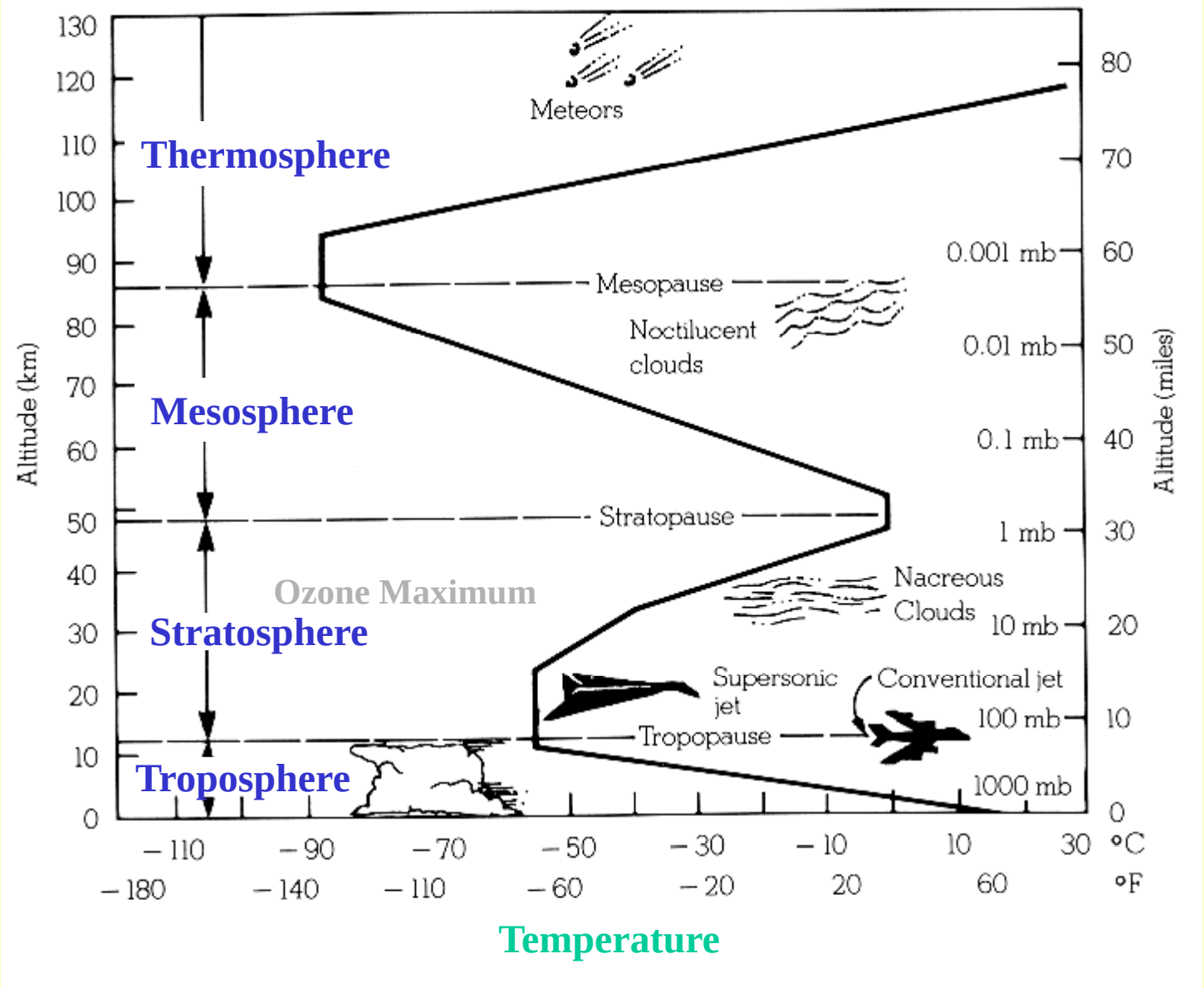
# The Major Earth Systems




CG Figure-4

# Structure of the Atmosphere



## This Class - The Green House Effect and Global Warming

**How is energy distributed to the earth's surface?**

**What are greenhouse gases and the greenhouse effect?**

**Impact of an increase in atmospheric $CO_2$ on greenhouse effect**

**Recent changes in greenhouse gas concentrations**

**Relationship between the greenhouse effect and global warming**

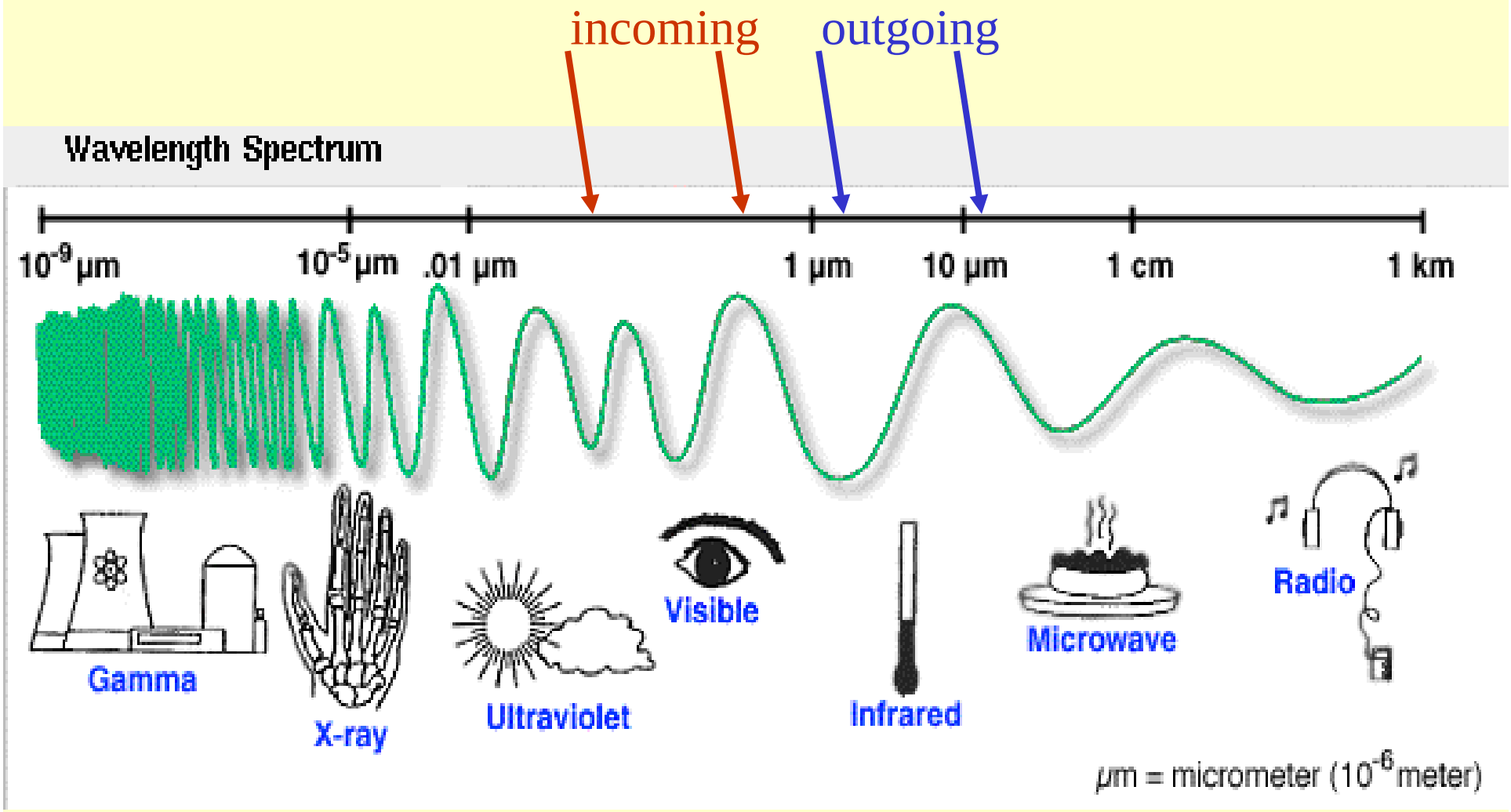
# The “Greenhouse Effect”

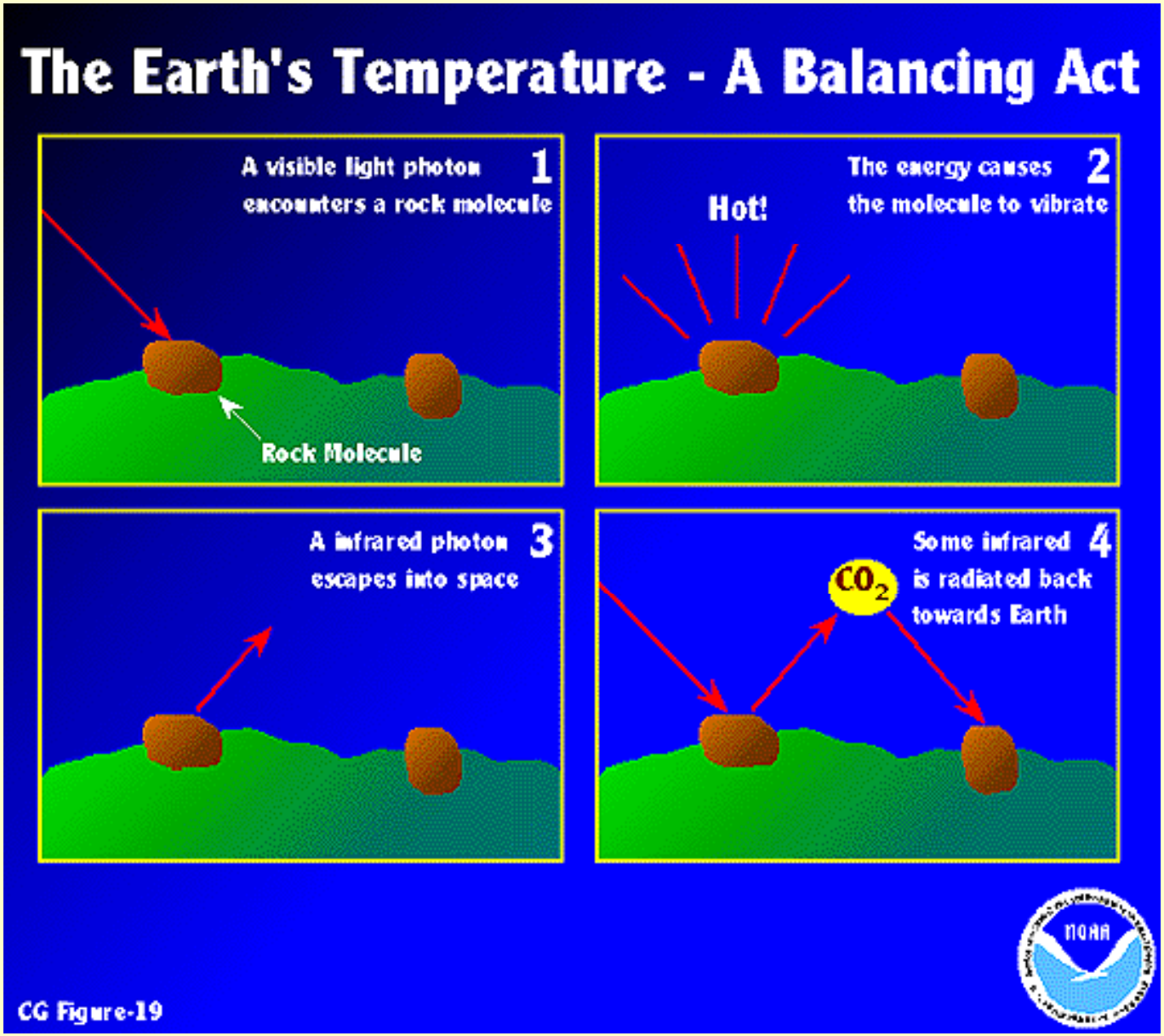
- The Earth’s surface thus receives energy from two sources: the sun & the atmosphere
  - As a result the Earth’s surface is ~33°C warmer than it would be without an atmosphere

Greenhouse gases are transparent to shortwave but absorb longwave radiation

  - Thus the atmosphere stores energy

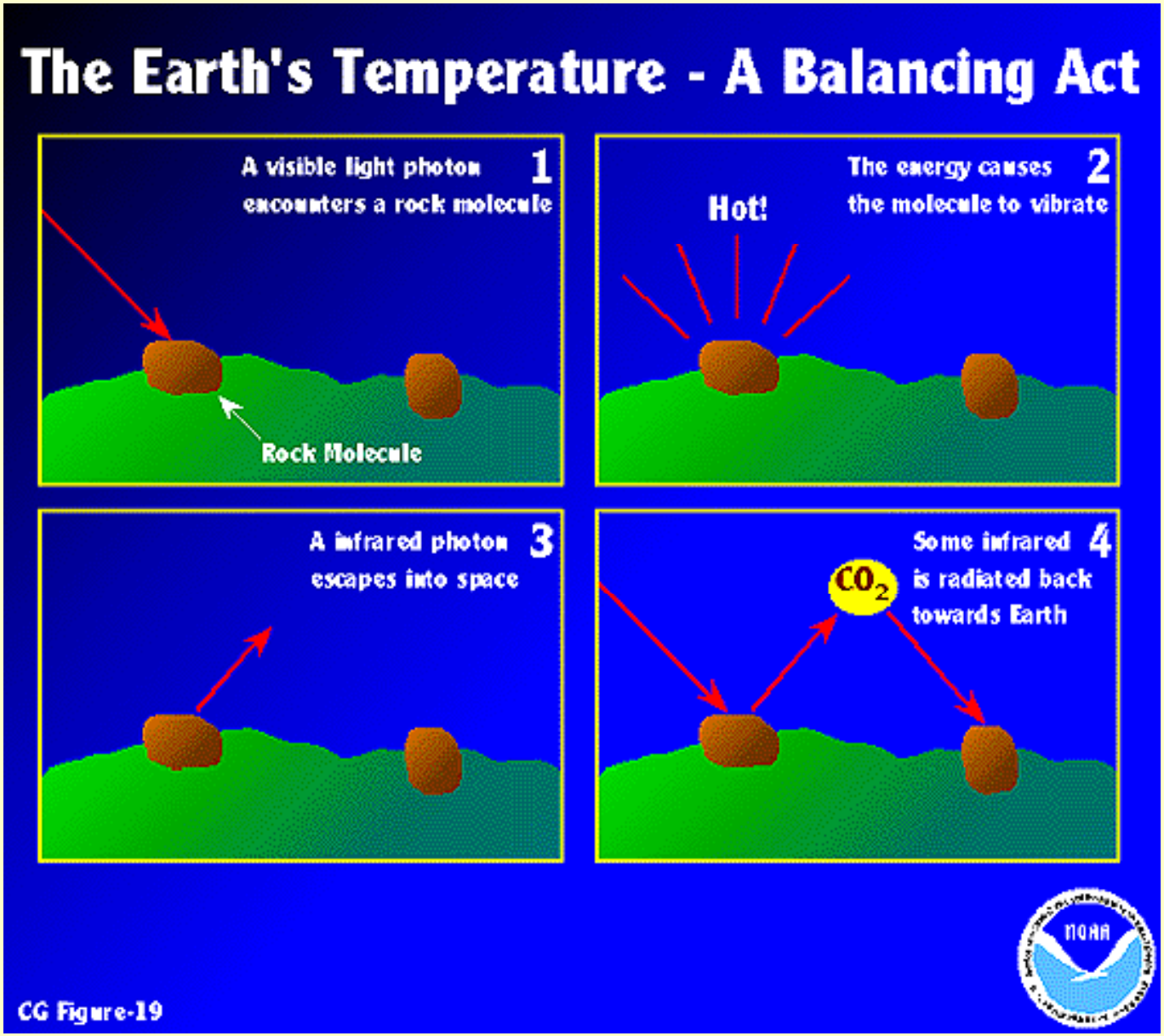
# Electromagnetic Spectrum






1. Shorter, high Energy wavelengths Hit the earths Surface

2. Incoming energy Is converted to heat




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

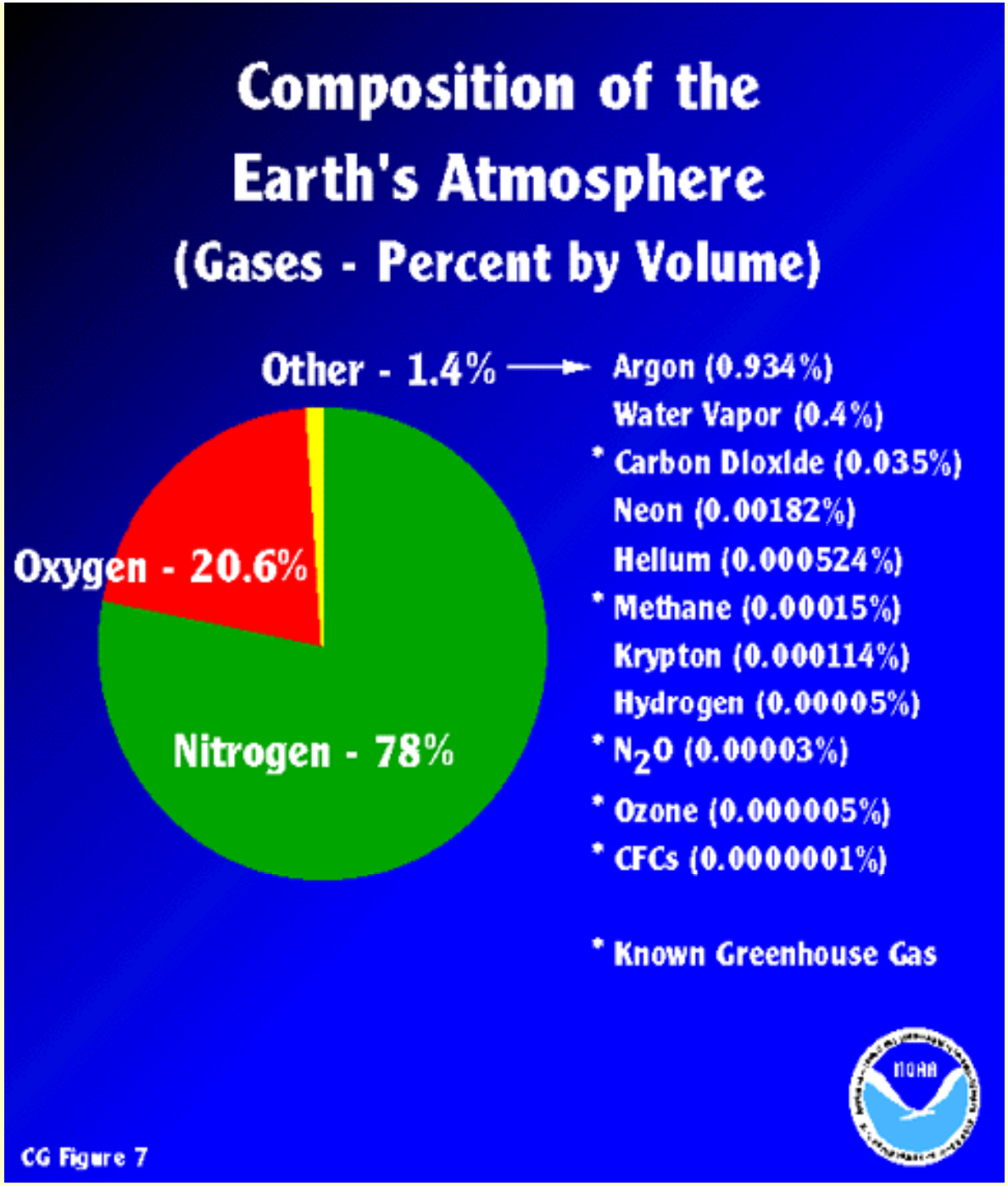
20.6% oxygen

< 1% argon

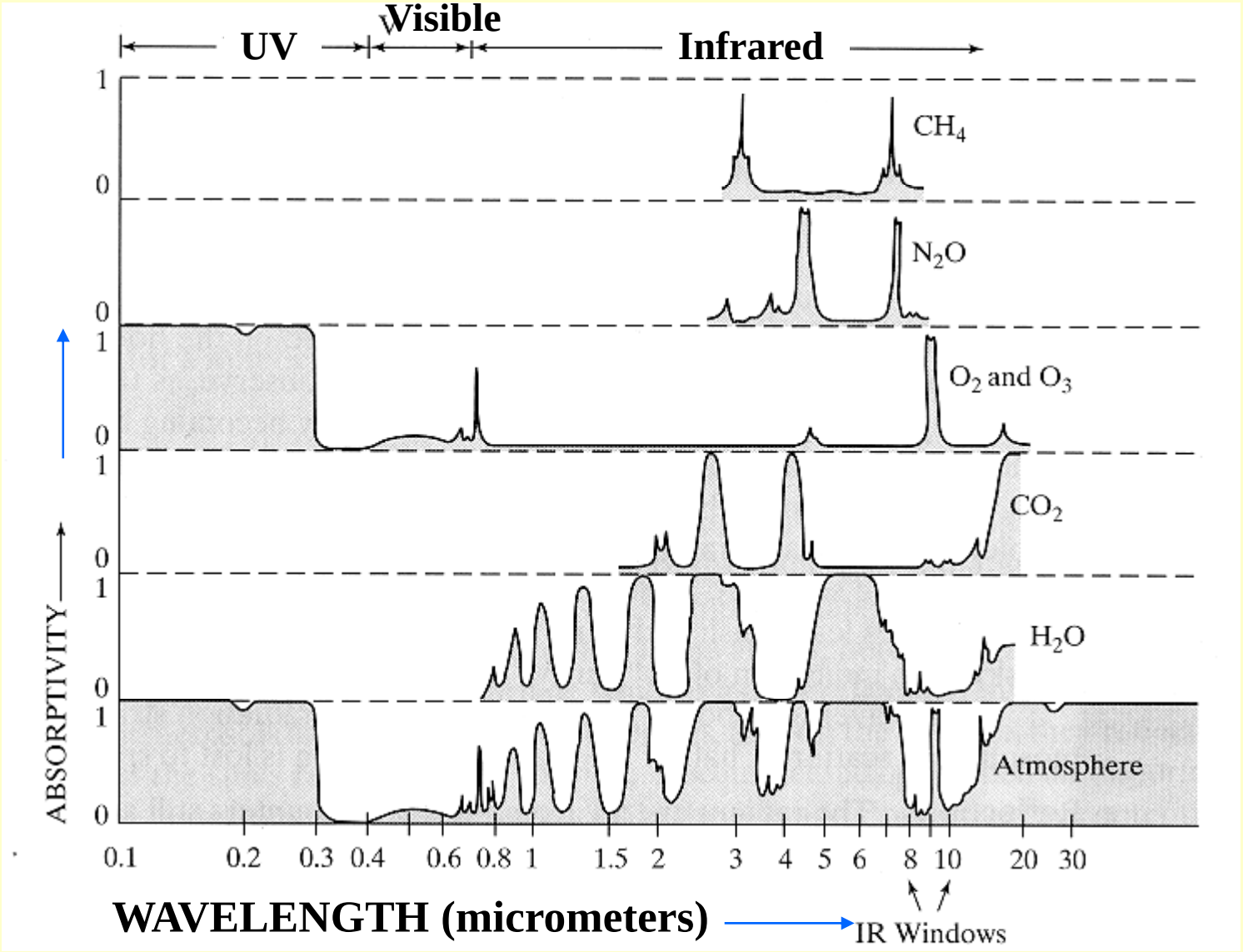
0.4% **water vapor**

0.036% **carbon dioxide**

traces gases:
Ne, He, Kr, H, $O_3$
**Methane, Nitrous Oxide**



# Absorption Spectra of Atmospheric Gases




$CH_4$

$N_2O$

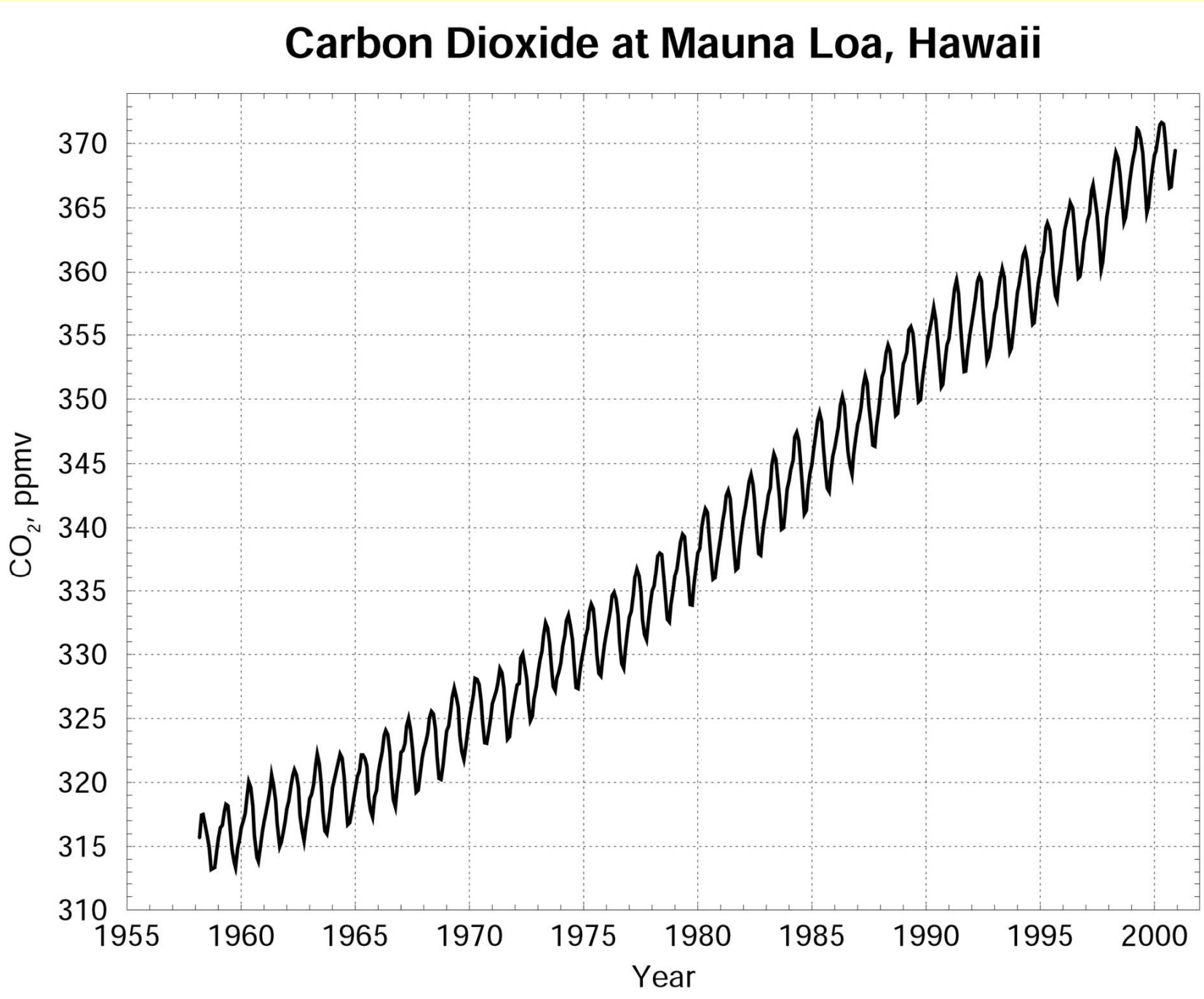
$O_2$ & $O_3$

$CO_2$

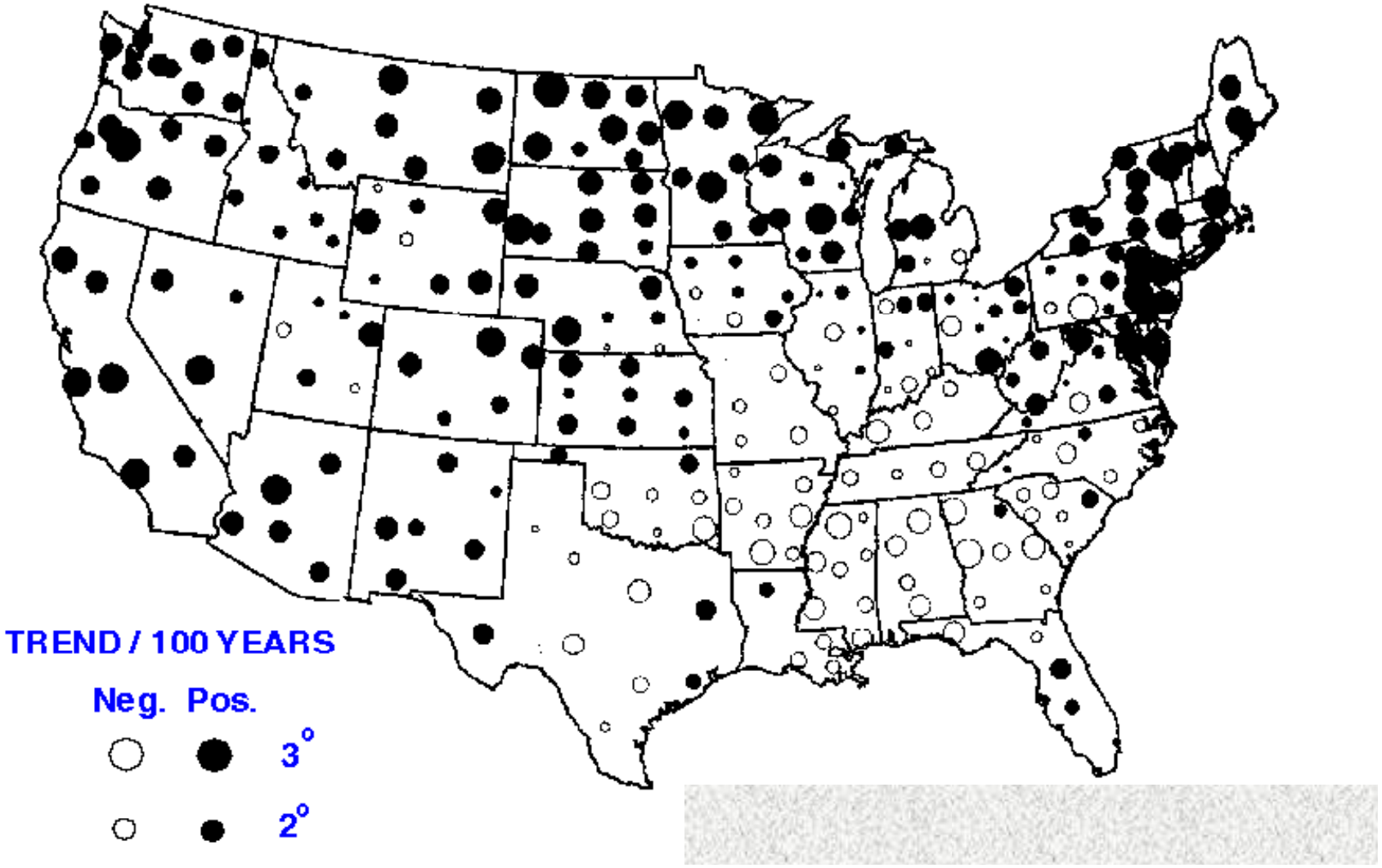
$H_2O$

atmosphere

Anthes, p. 55


Carbon Dioxide at Mauna Loa, Hawaii
370
365
360
355
350
345
340
335
330
325
320
315
310
CO2, ppmv
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year

# 1900 - 94 TEMPERATURE TRENDS



# Selected Greenhouse Gases

- **Carbon Dioxide ($CO_2$)**
  - Source: Fossil fuel burning, deforestation
  - Anthropogenic increase: **30%**
  - Average atmospheric residence time: **500 years**
- **Methane ($CH_4$)**
  - Source: Rice cultivation, cattle & sheep ranching, decay from landfills, mining
  - Anthropogenic increase: **145%**
  - Average atmospheric residence time: **7-10 years**
- **Nitrous oxide ($N_2O$)**
  - Source: Industry and agriculture (fertilizers)
  - Anthropogenic increase: **15%**
  - Average atmospheric residence time: **140-190 years**

**Summary**

Greenhouse gases absorb infrared radiation and prevent it from escaping to space.

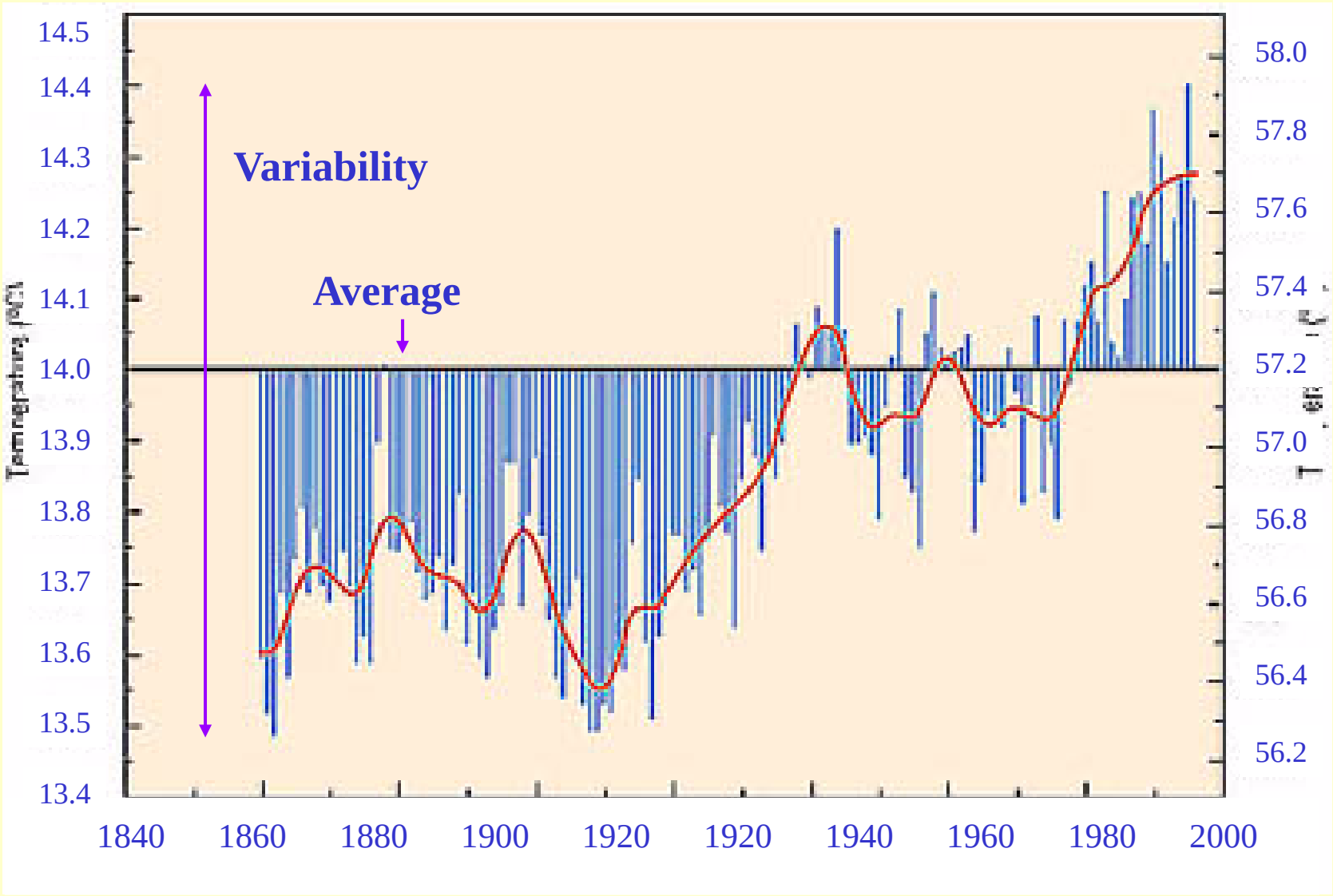
Carbon dioxide, methane, and nitrous oxide are very good at capturing energy at wavelengths that other compounds miss

# 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




www.gcrio.org/ipcc/qa/cover.html (modified)

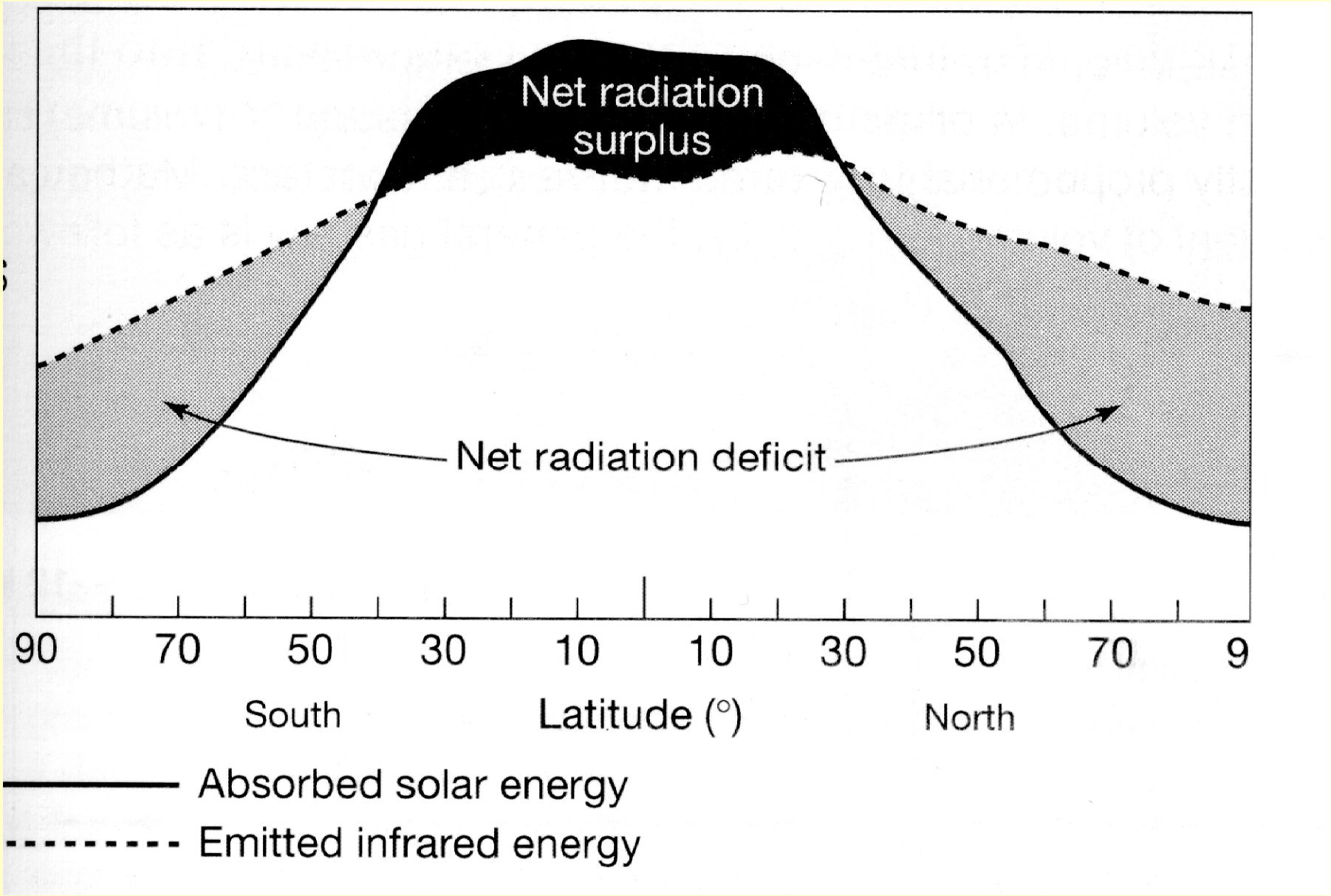
# Climate Change vs. Variability

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.

# Global Energy Redistribution



Radiation is not evenly distributed over the
Surface of the earth. The northern latitudes have an energy deficit and the low latitude/ equator has an excess. But the low latitudes don’t indefinitely get hotter and the northern latitudes don’t get colder.

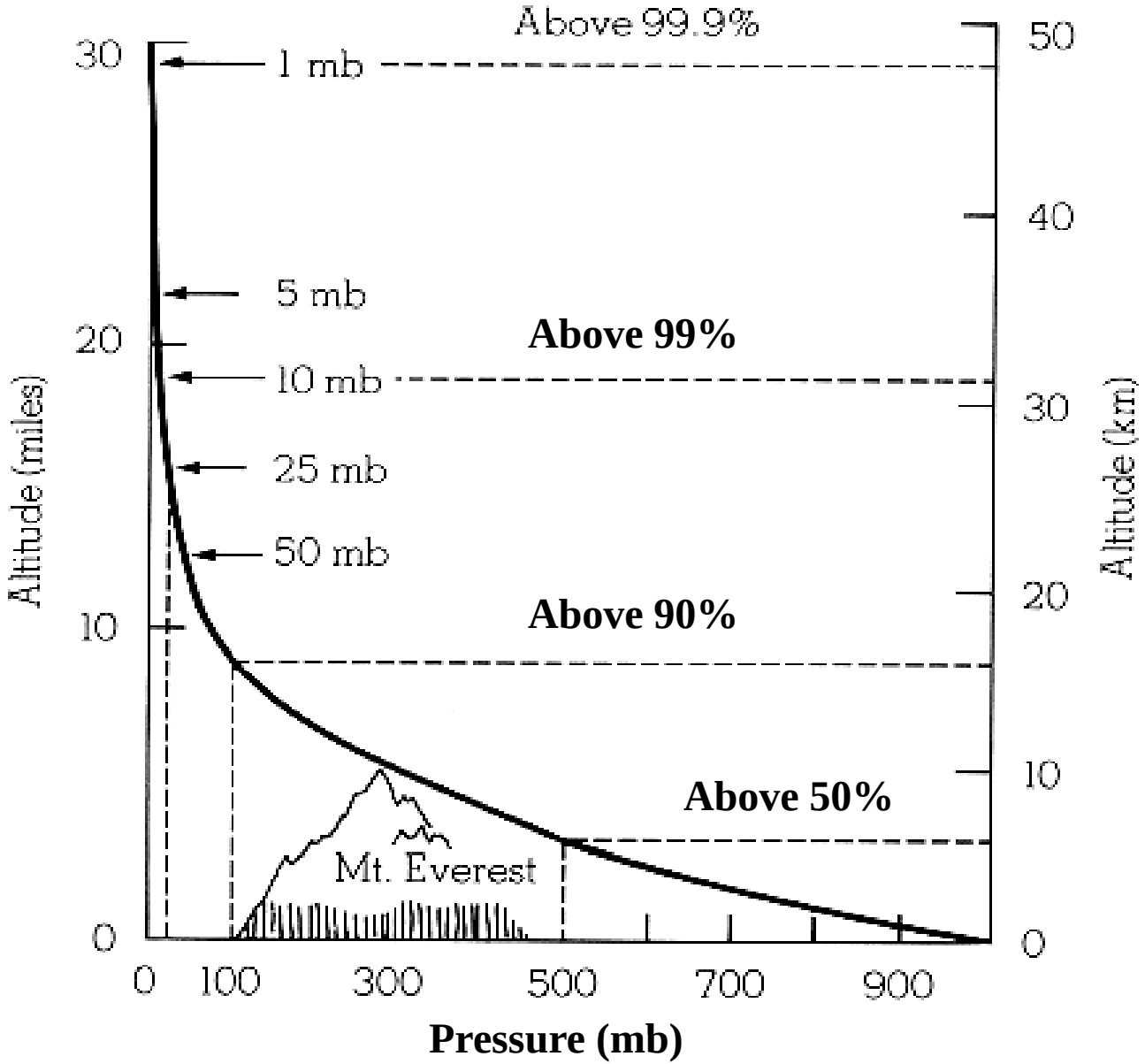
Why?

The atmosphere and ocean transfer energy from low latitudes to high

**Atmospheric Pressure Decreases With Height**

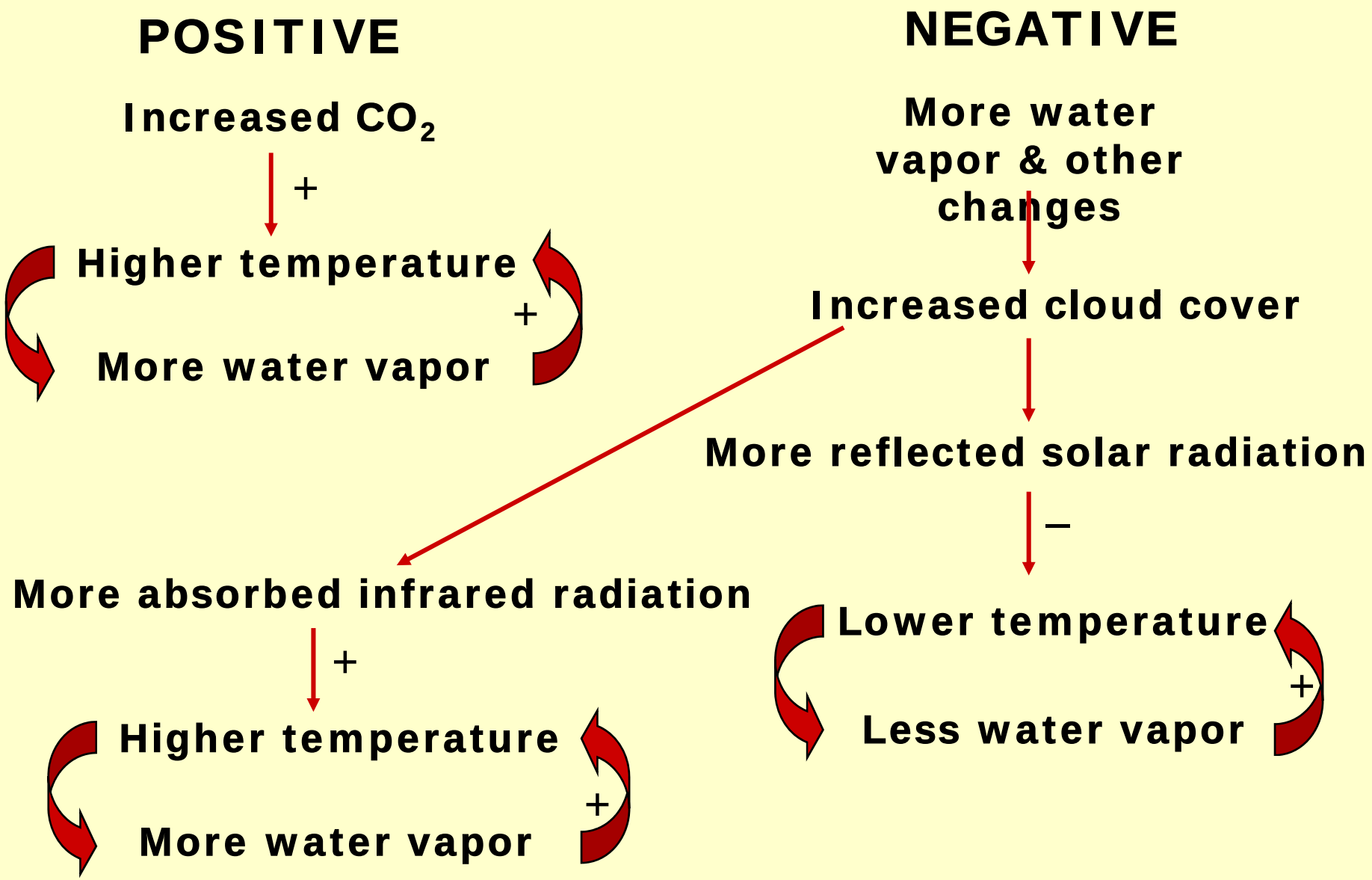
**Most of the energy is captured close to the surface**

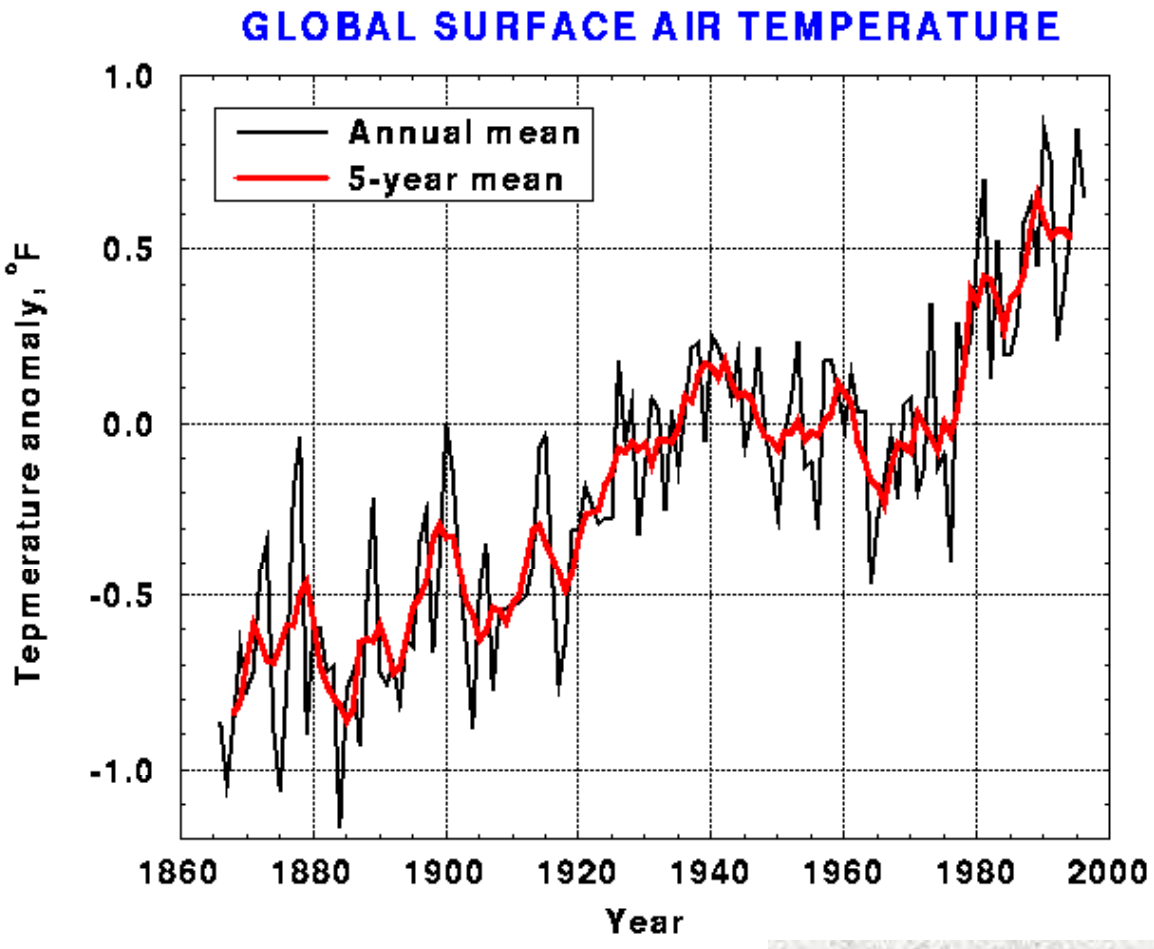
**That energy drives climate and weather**




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

# Atmospheric Feedbacks




GLOBAL SURFACE AIR TEMPERATURE
Annual mean
5-year mean
Tepmerature anomaly, °F
1.0
0.5
0.0
-0.5
-1.0
1860
1880
1900
1920
1940
1960
1980
2000
Year