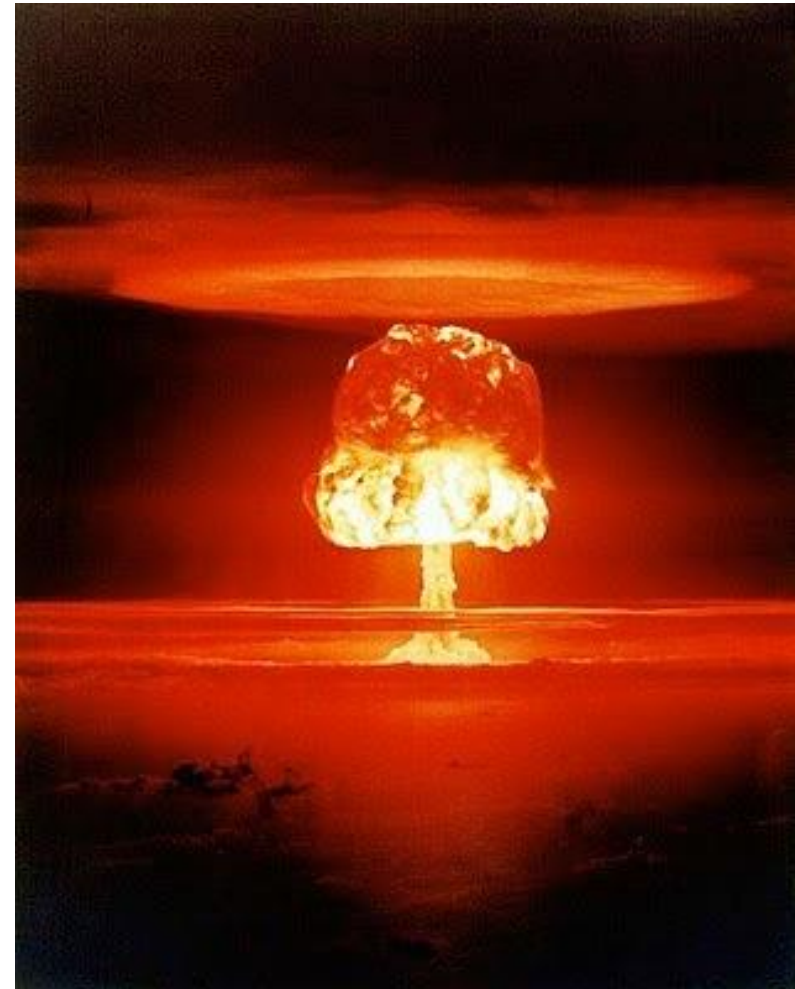


THE GLOBAL GREENHOUSE

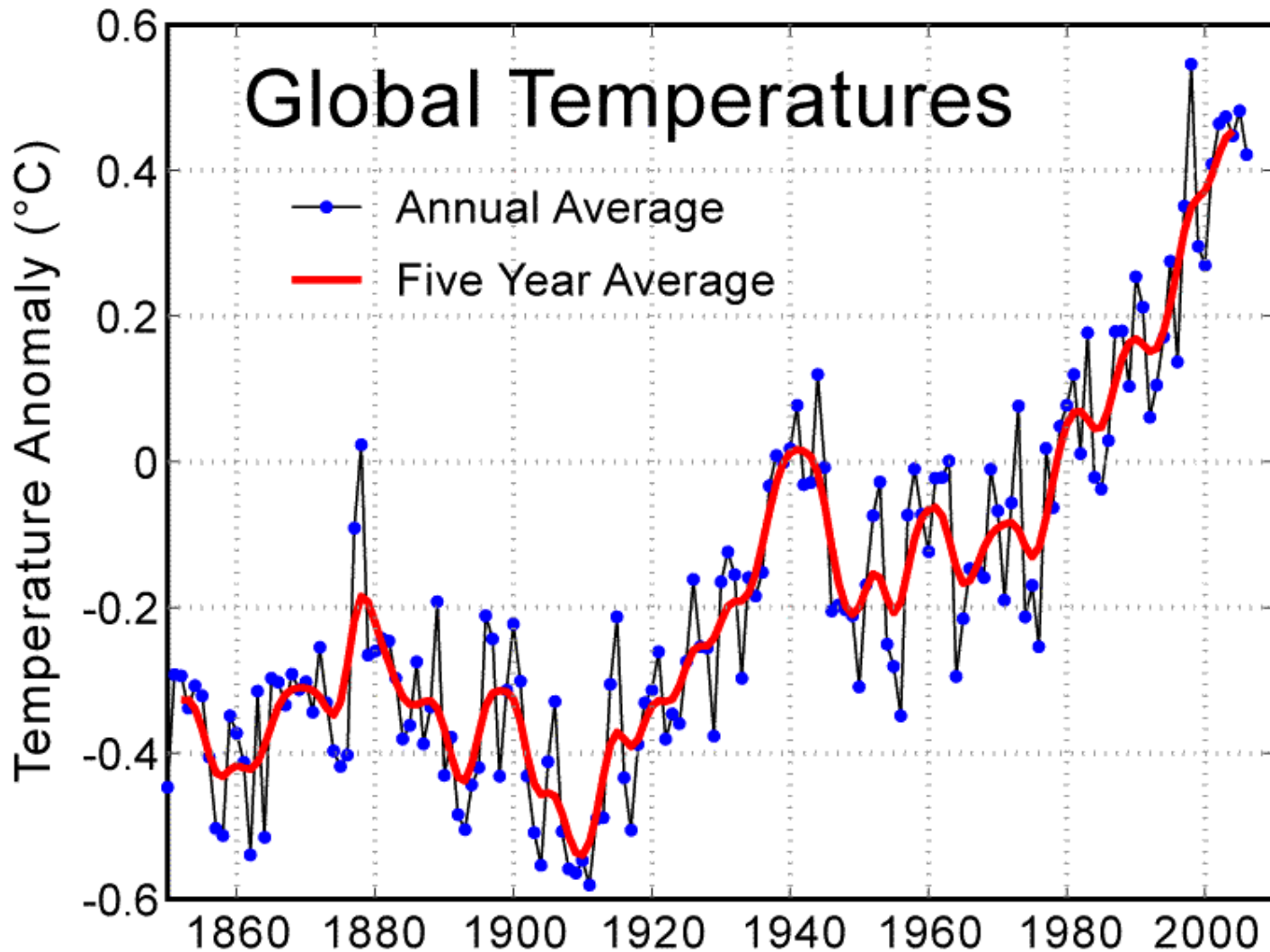
FEEM Nov 27, 2014

- recent heating and reliability of measurements
- earth heat balance and greenhouse effect
- past and future of atmospheric CO₂
- are we the cause
- the new commandment



Temperature recent history

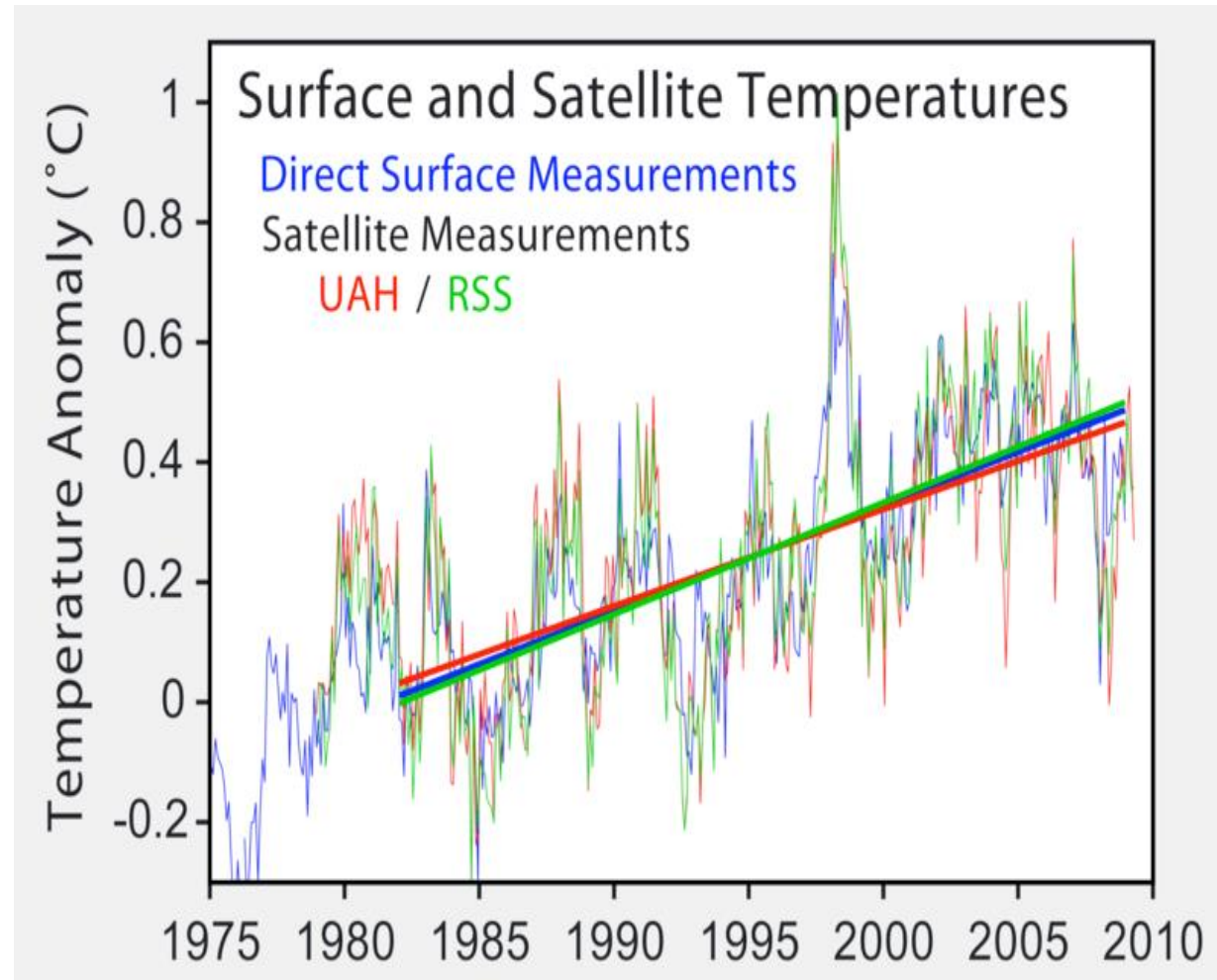
+ 0.8 °C in the last century



Should we trust the measurements?

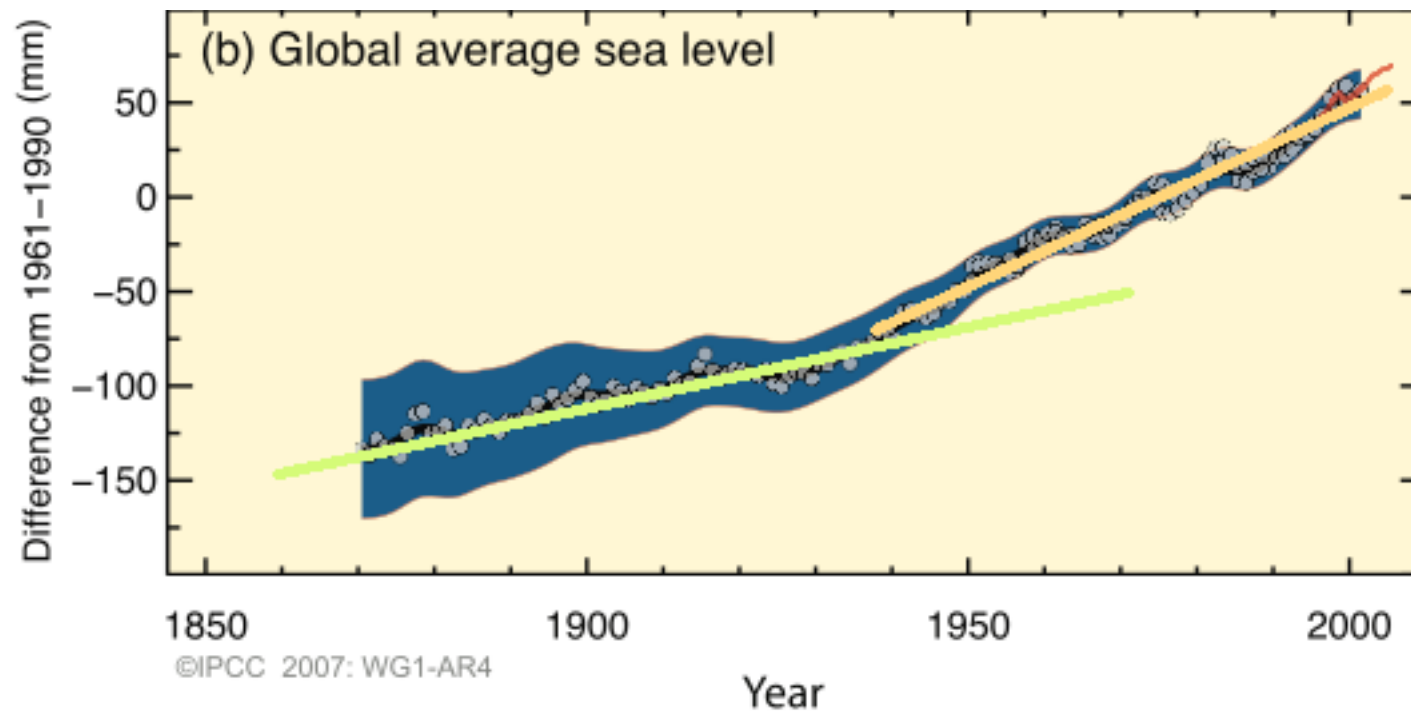
Satellite and land measurements agree

- thousands of thermometers
- sea level
- ice melting
- plant blooming
- migration dates
- UAH Univ of Alabama
- RSS Remote Sensing NASA



Sea Level

1.8 e 3 mm/year (NOAA)



IPCC AR5



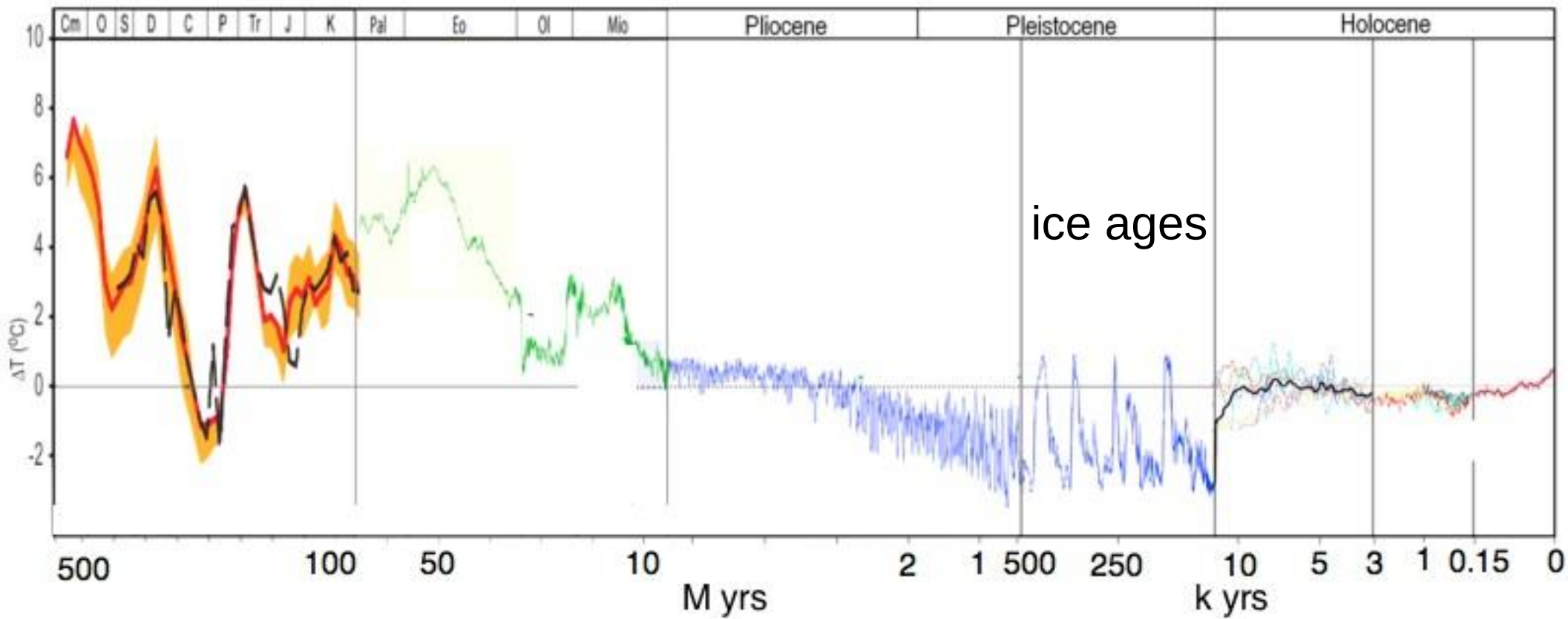
UNEQUIVOCALLY WARMING

Anthropogenic cause extremely likely (95%)

<http://www.ipcc.ch>

Long Term T

log x-scale



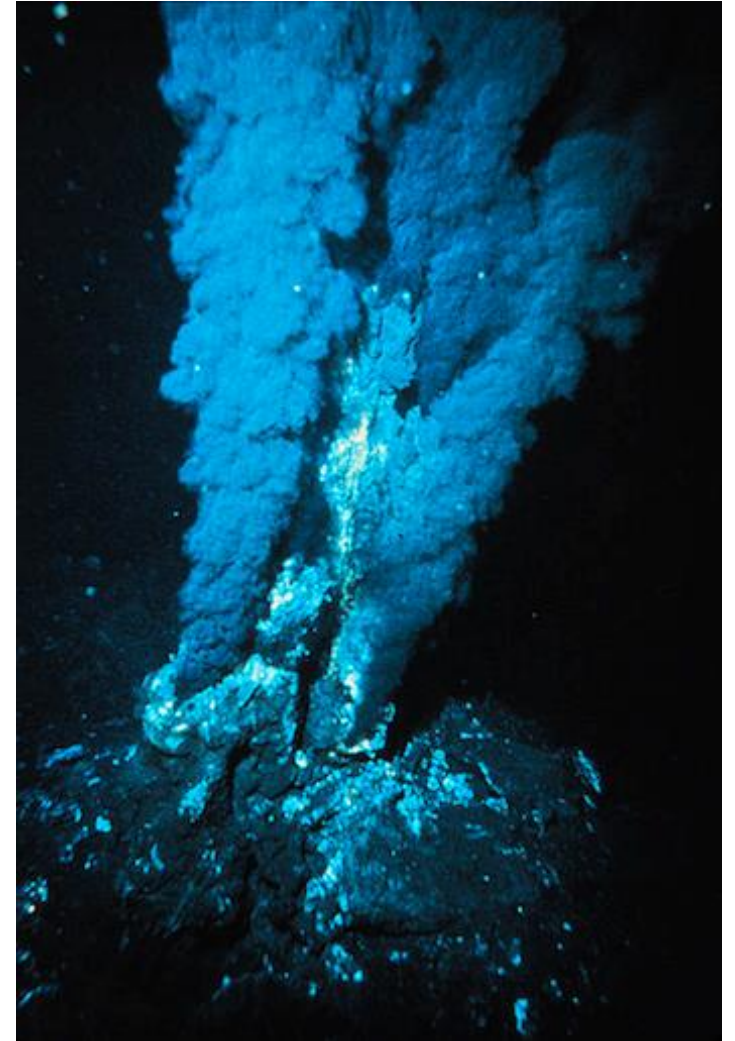
EARTH

- 5 billion years
- 8 min-light from sun
- Radius = 6,000 km
- 99% $T > 1000\text{ C}$
- crust (5 to 50 km, $< 1\%$)
- mantle (3000 km, water, 500 C to 4000 C)
- molten metal core
- oceans
- atmosphere



the crust

- mostly solid - good insulator
- tens of 10^9 years to cool
- radioactive decay 30 TW
- 44 TW or 65 mW/m^2 & 100 mW/m^2
- $P_{\text{solar}} \sim 340 \text{ W/m}^2$
- Primary Energy Usage $\sim 16 \text{ TW}$ or 2.5 kW/person
- $P_{\text{geo}} \sim .08 \text{ mW/m}^2$ or 6 W/head
- $P_{\text{metabolism}} \sim 50 \text{ W}$



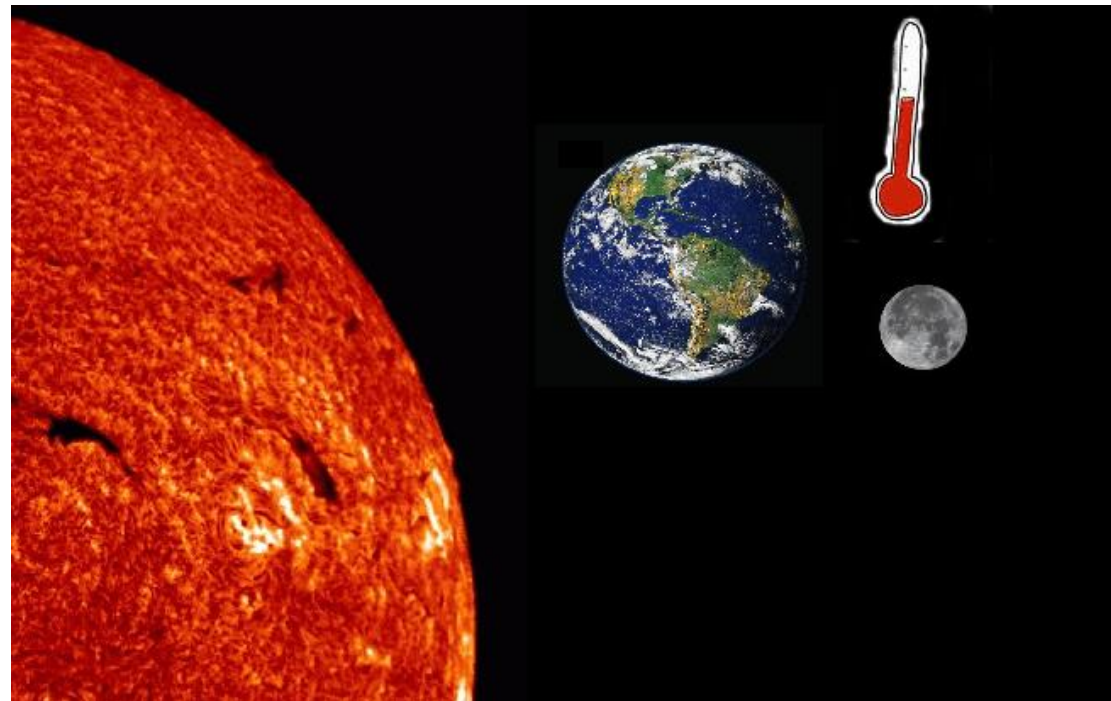
the biosphere



- soil
- seas .023% of the earth
- atmosphere (10 km) $<10^{-6}$ of earth mass
- the most crucial layer for our survival
- 20% O₂, nicer temperatures, less radiation

SOLAR RADIATION

- $T_{\text{sun}} = 5000\text{ }^{\circ}\text{C}$
- Sun diameter .5 deg
- in free space 281 K (8 $^{\circ}\text{C}$)
- average temperature on earth 287 K (14 $^{\circ}\text{C}$)
- think in deg K not $^{\circ}\text{C}$, no neg T
- liquid H_2O in a narrow orbit radius range



EQUILIBRIUM

visible light heating

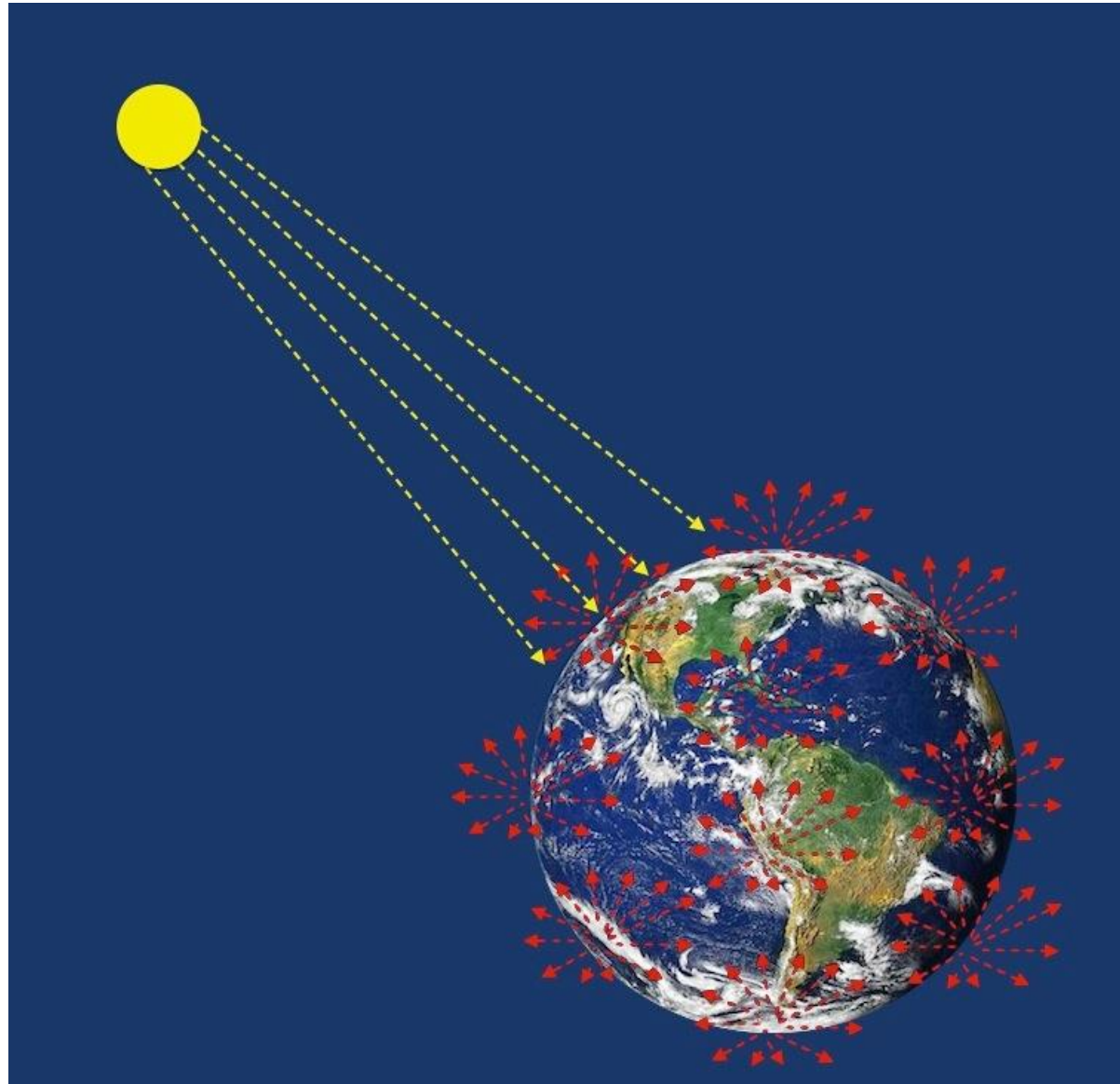
($\lambda \sim 1$ micron)

infrared cooling

($\lambda \sim 10$ micron)

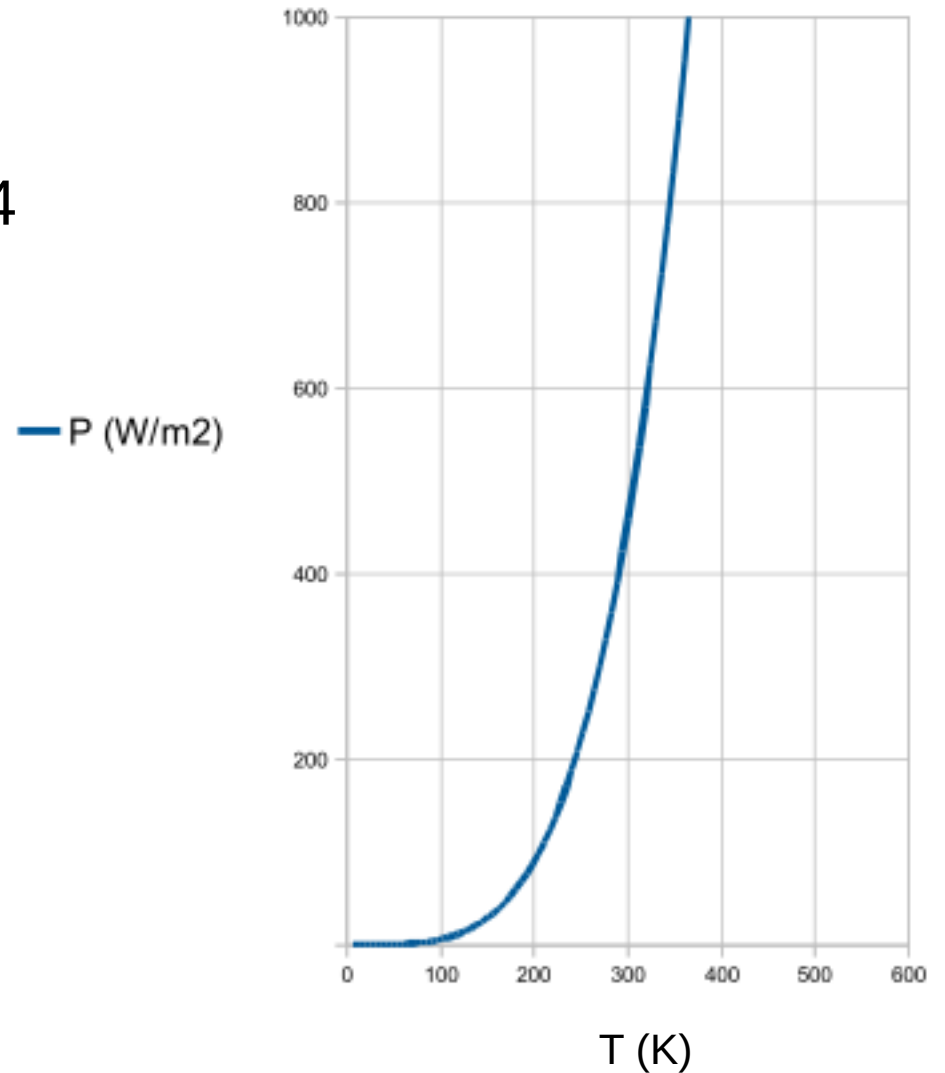
$\lambda \sim 1/T$

$P \propto T^4$ Stefan-Boltzman



THERMOSTAT

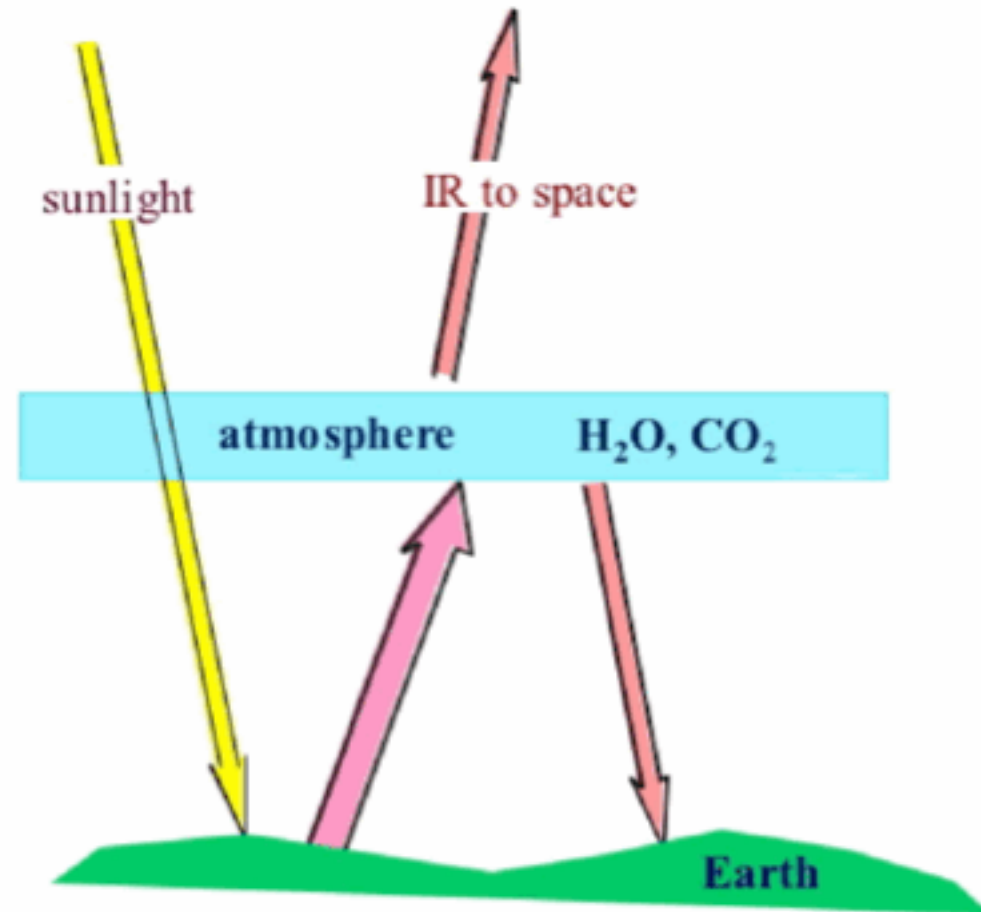
- Stefan-Boltzmann $P \propto T^4$
- Max sun power = 1300 W/m²
- Average on earth = 340 W/m²

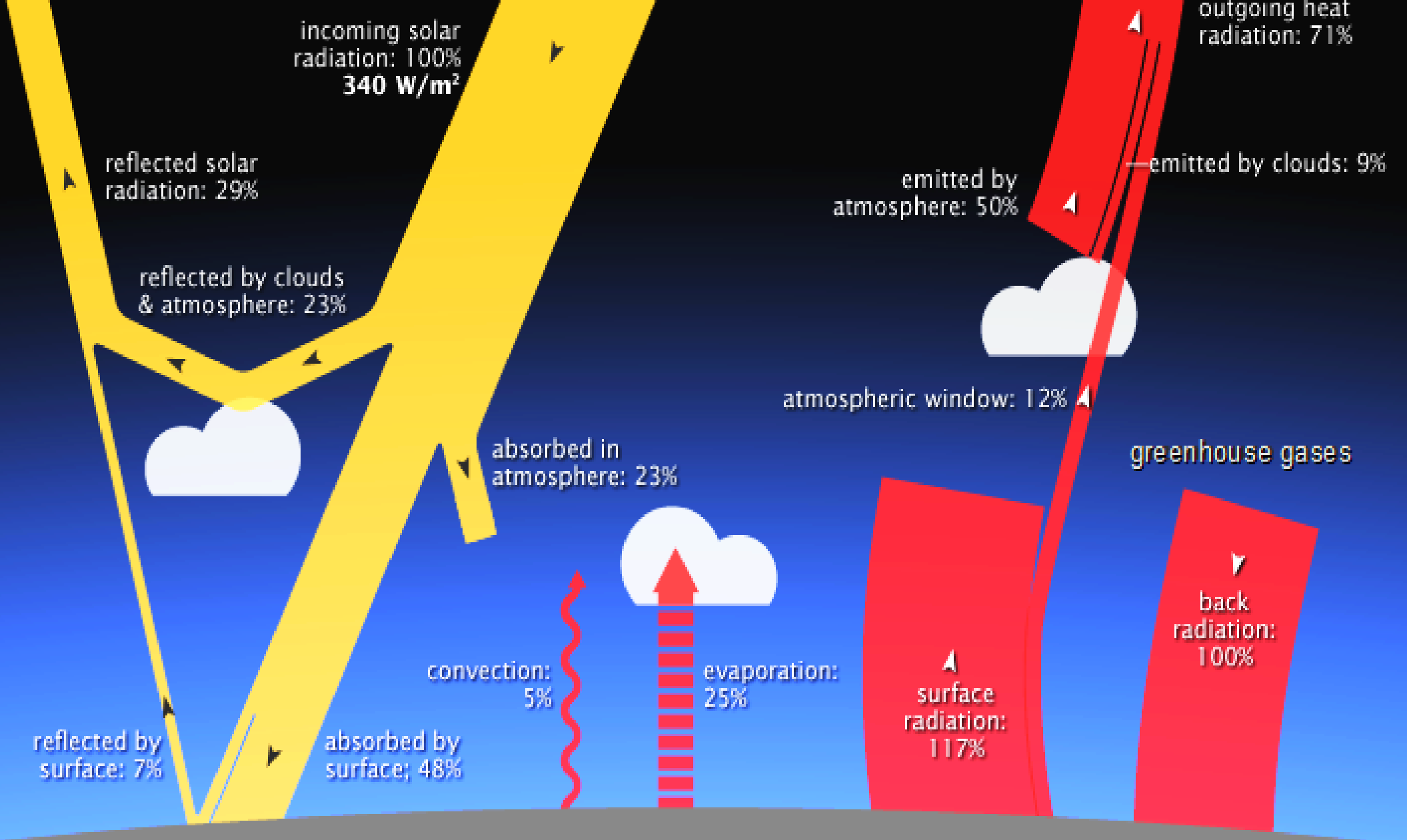


Greenhouse

visible light heating
($\lambda \sim 1$ micron)
infrared cooling
($\lambda \sim 10$ micron)

- Joseph Fourier 1824
- Svante Arrhenius 1896





a complex picture

no greenhouse $T < 30\text{ C}$ - imbalance 0.58 W/m^2

GREENHOUSE GASES

- water vapour and H_2O 36-72%
- CO_2 carbon dioxide 10-25%
- CH_4 methane 4-9%
- O_3 ozone 3-7%



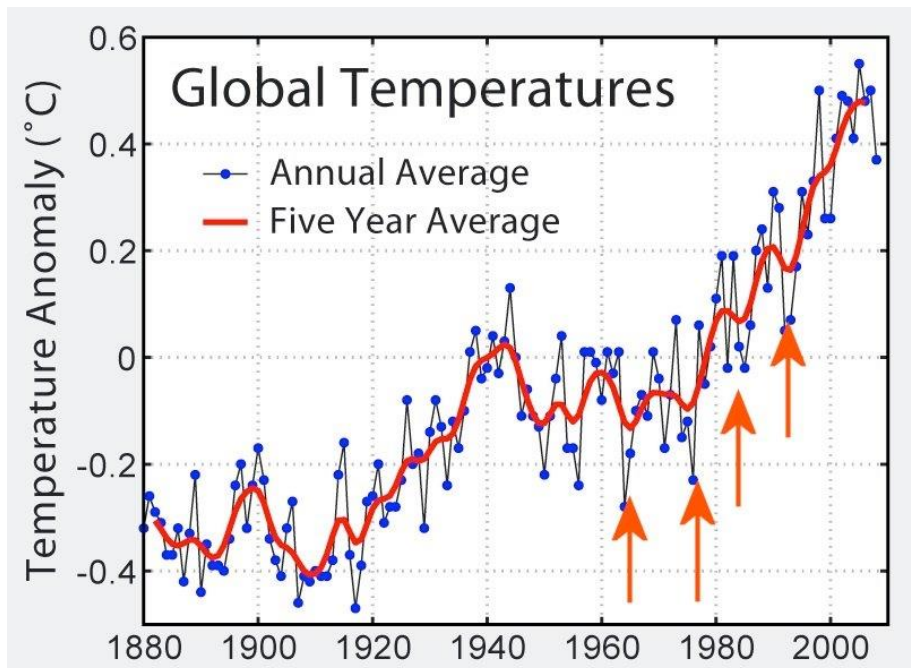
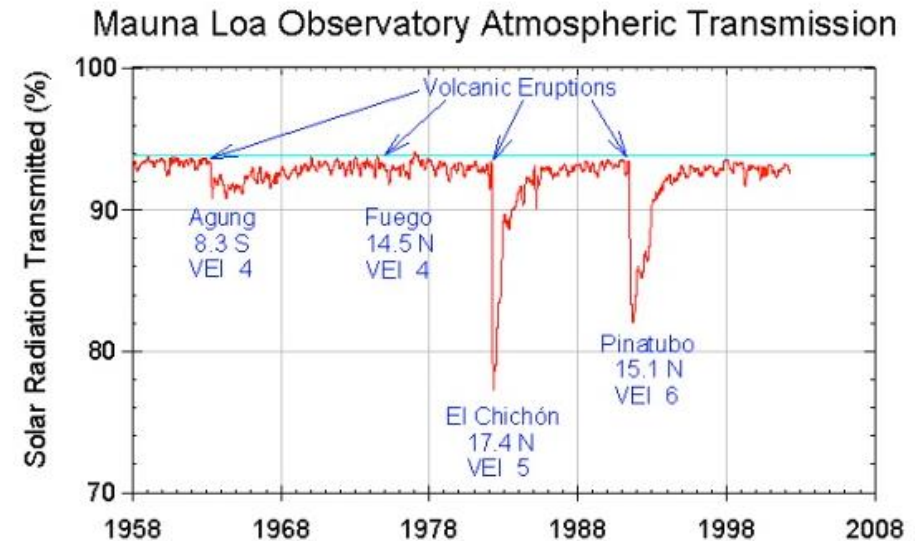
non gases:

- clouds
- aerosols
- clouds critically T dependent

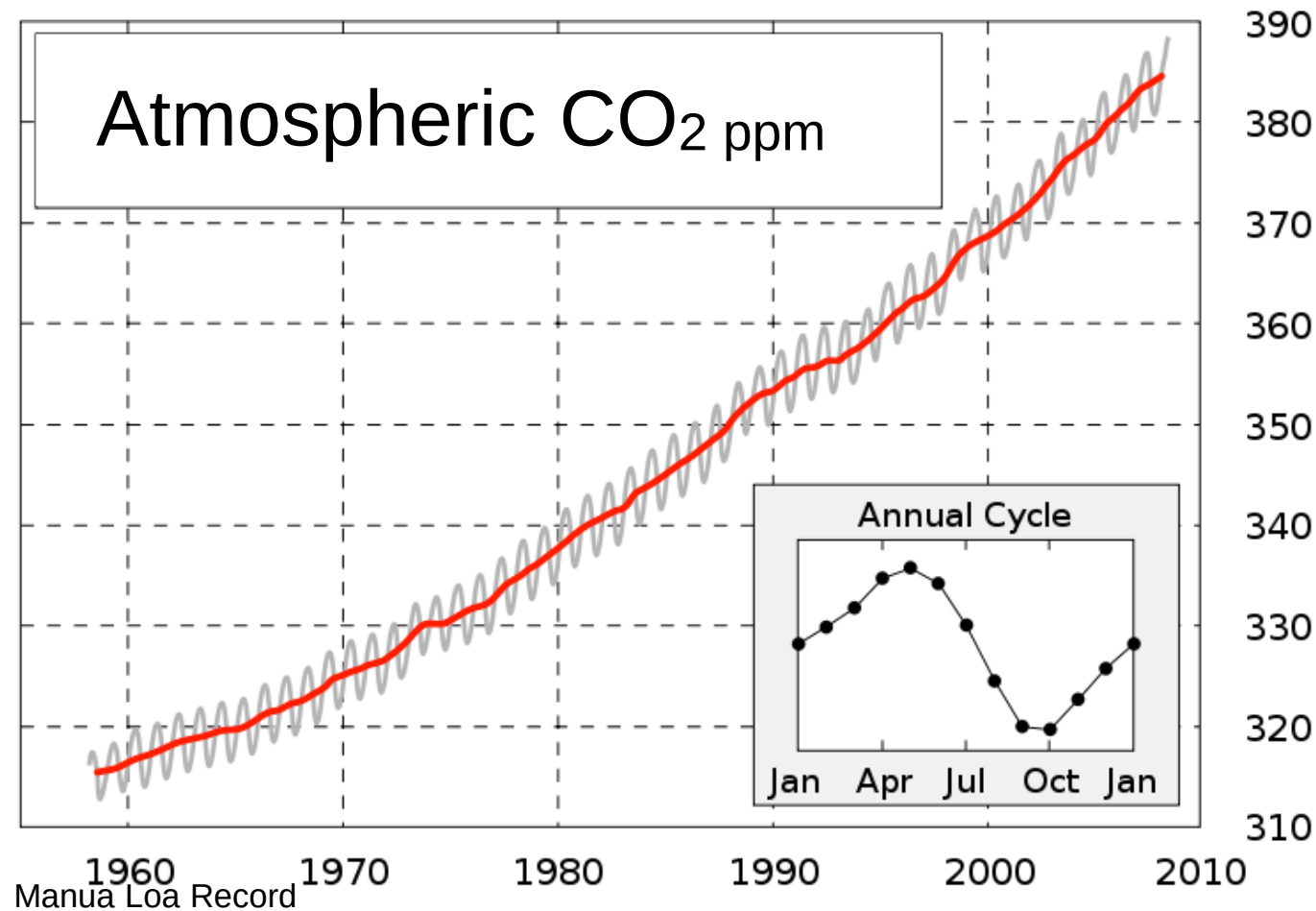
VOLCANIC ASH



Mount Pinatubo (Philippines) 1991

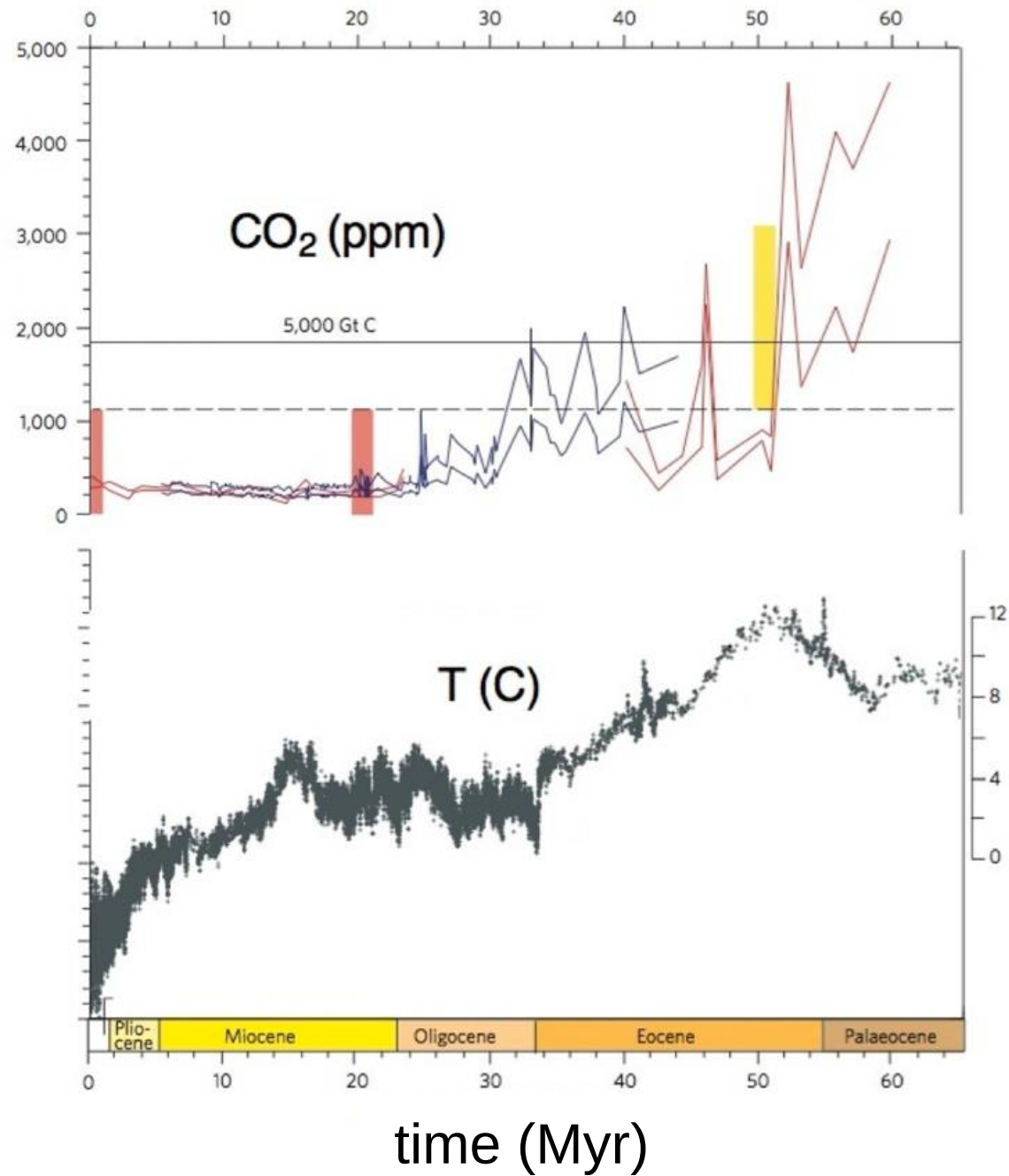


HYDROCARBONS and DEFORESTATION

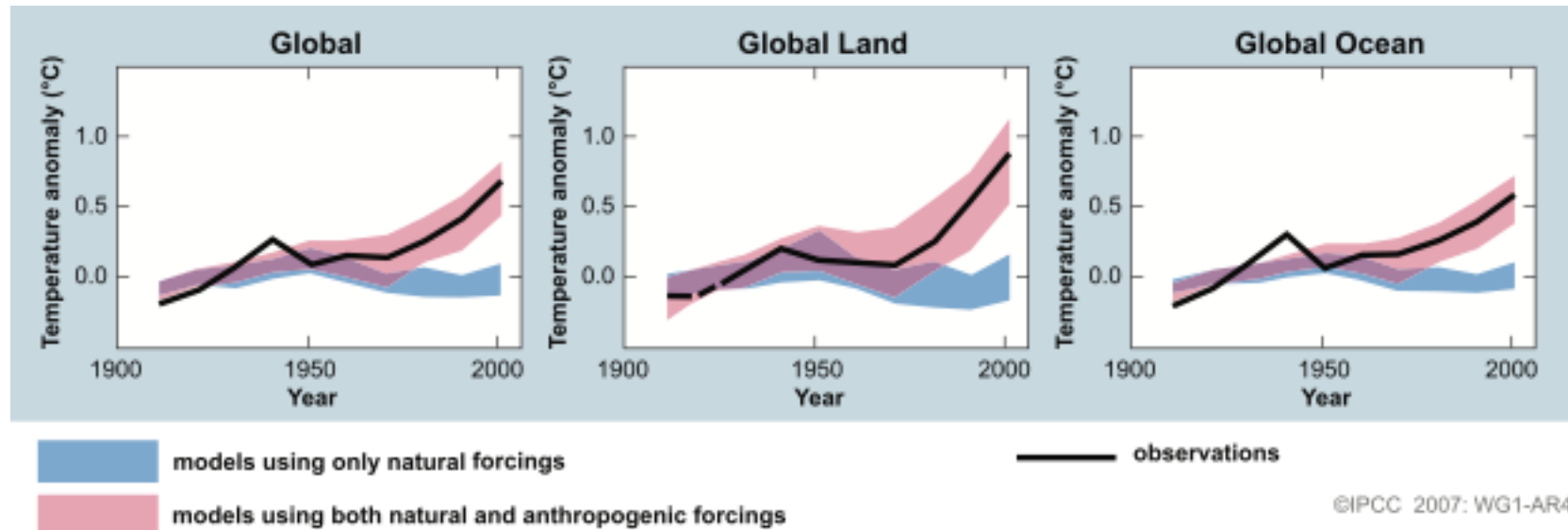


- yearly oscillation = northern hem metabolism
- average CO₂ mol lifetime = 12 years

CO₂ history



Our responsibility?



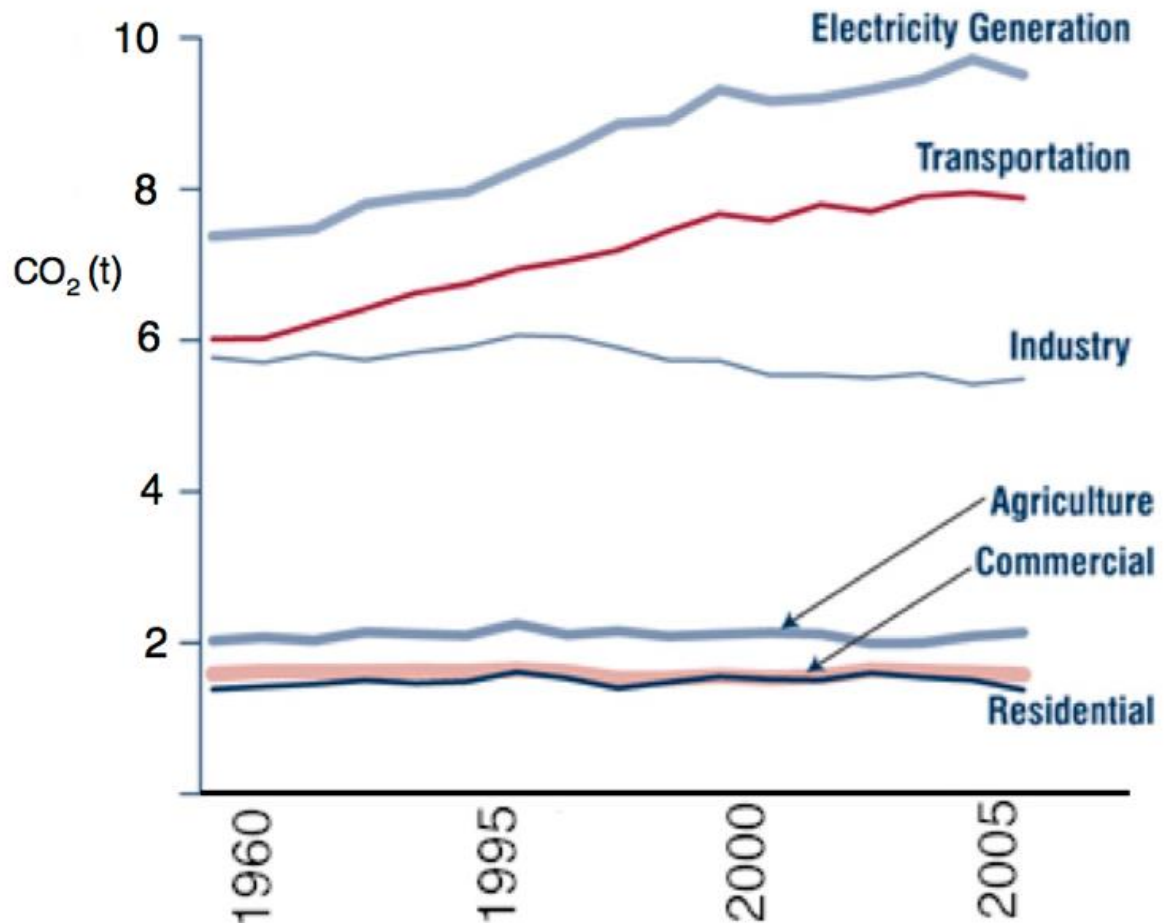
only a complex model can answer

details validate models:

- localised heating, like lower atmosphere vs high
- higher latitudes vs lower
- land vs seas
- nights relatively warmer than days

CO₂ emission

- electricity
- transports
- industry
- agriculture
- commerce
- domestic



a new entry in the 10 commandments

One Minute Calculator

Austin Footprint Calculator [Click Here](#)

For a much more comprehensive tool that will allow you to measure your carbon footprint and discover ways to reduce that footprint, try the complete Austin Carbon Footprint Calculator.



Travel

Typically, I drive ...

2400 ▲ miles per year ▼

- ☐ SUV/Truck
- ☐ Large car/minivan
- ☐ Medium car
- ☒ Small car
- ☐ Hybrid sedan
- ☐ Small hybrid

0.75

Metric tons of CO₂ / year



Flights

In an average year, I take...

- ☐ ▲ short (< 1.5 hrs) ▼
- ☐ ▲ medium (1.5-4 hrs) ▼
- 4 ▲ long (4-6 hrs) ▼
- 2 ▲ extended (6-12 hrs) ▼
- ☐ ▲ super-ext (12+ hrs) ▼

7.29

Metric tons of CO₂ / year



Diet

In a typical week I eat this many servings of...

- 0 ▲ red meat ▼
- 1 ▲ poultry ▼
- 2 ▲ dairy ▼
- 4 ▲ seafood ▼
- 10 ▲ cereals + grains ▼
- 20 ▲ fruits, nuts + vegetables ▼

1.04

Metric tons of CO₂ / year



Home

I live in a...

- ☐ Detached
- ☐ Semi-detached
- ☒ Apartment or condo

My home has...

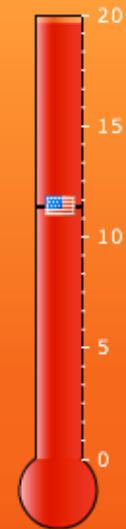
- 3 ▲ bedrooms ▼
- 1.0 ▲ people ▼
- ☒ air conditioning

10.72

Metric tons of CO₂ / year



Total



19.80

Metric tons of CO₂ / year

http://austin.zerofootprint.net/one_minute/austin

the future

The West's Carbon Emmissions Are Irrelevant

Growth in CO₂ emissions, in billions of tons per year following Copenhagen agreement

