Lec #21: Discuss Climate Change & Nuclear

F.F. 1. Supply, Extraction, Use (Chap 7)

- coal, gas, oil; what are they; how formed? where to find?
- hidden costs

F.F. 2. Combustion of FF & The Byproducts (Chap 8)

- Combustion Process and Byproducts
- Pollutants
- Atmospheric Structure and Dynamics
- Pollution Control Technology and Techniques

F.F. 3. Global Environmental Impacts of FF Burning (Chap 9)

NEXT: Nuclear Power (Chaps 13-15)

Earth's Interactions & Cycles

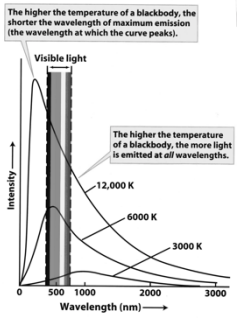
Interior	Biosphere	Atmosphere
Lithosphere		Magnetosphere
Hydrosphere		Heliosphere

- Water Cycle
- Salt Cycle
- Carbon Cycle
- Climate Cycles
- Extinction Cycle?
- Impact Cycle?
- Geological Activity Cycle?

The Greenhouse Effect

- ENERGY IN = ENERGY OUT
  - otherwise, Temperature changes
  - radiant energy only possible mechanism
- IN:
  - solar radiation (mostly visible)
- OUT:
  - reflected sunlight (visible)
  - thermal emission from surface and atmosphere (infrared, microwave)
  - Earth's interior cooling (infrared; 2700 times less)
- H_2O, CO_2, CH_4, etc. "absorb" infrared
  - block a fixed *fraction* from escaping
  - tiny changes in *composition* can change temperature

"Blackbody Radiation": Electromagnetic Radiation emitted by a dense object in thermal equilibrium



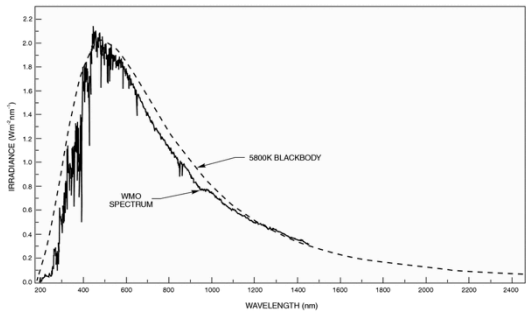
energy emitted at all wavelengths

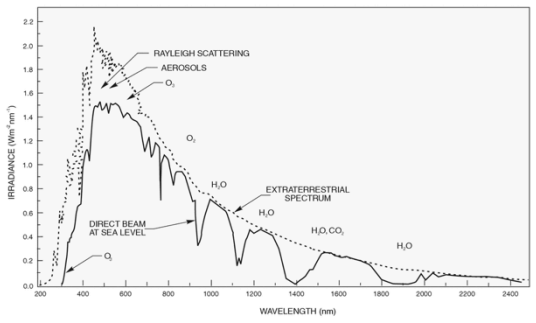
higher temperature emits more at all wavelengths

total energy emitted = (area) x σT^4

peak wavelength proportional to temperature

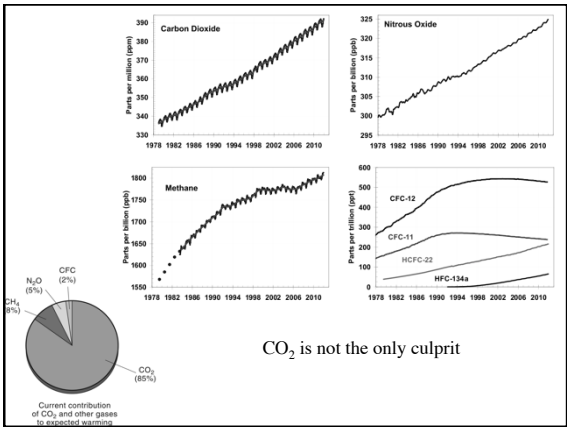
[play with Spectrum Explorer]



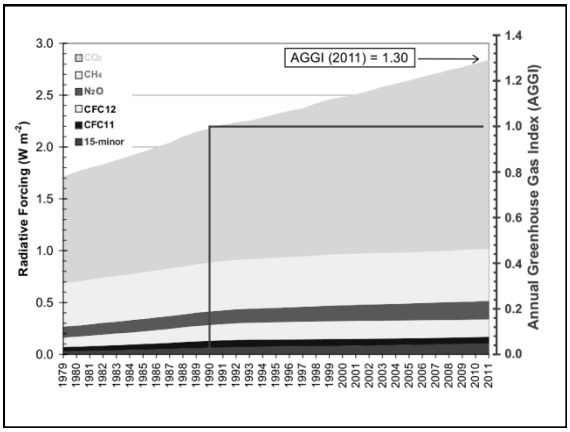


Earth's Equilibrium Temperature

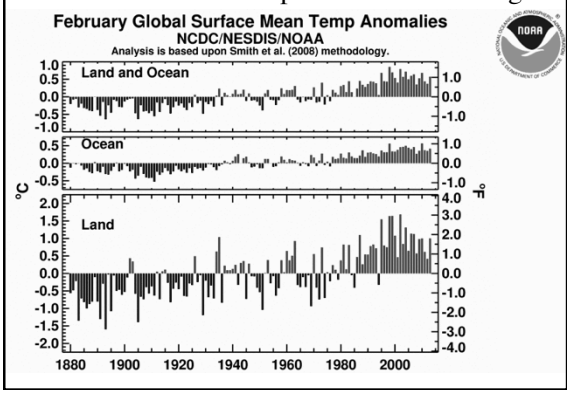
- Solar Luminosity $L_s=4\pi R_s^2\sigma T_s^4 = 10^{26}$ W
  - $T_s \sim 5800$ K
- Intensity of electromagnetic radiation decreases as square of distance
- "Flux" at Earth: $F = L_s/4\pi d^2 = 1356$ W/m^2
  - "albedo" = fraction not reflected ~ 0.5
- Radiant Energy IN = flux x albedo x πR_E^2
- Earth Luminosity $L_E=4\pi R_E^2\sigma T_E^4$
  - must equal energy IN
  - T_E will adjust to make it so
- Without atmosphere, $T_E \sim 250$ K (brrr!!)
- With atmosphere, $T_E \sim 300$ K (mostly b/c H_2O)

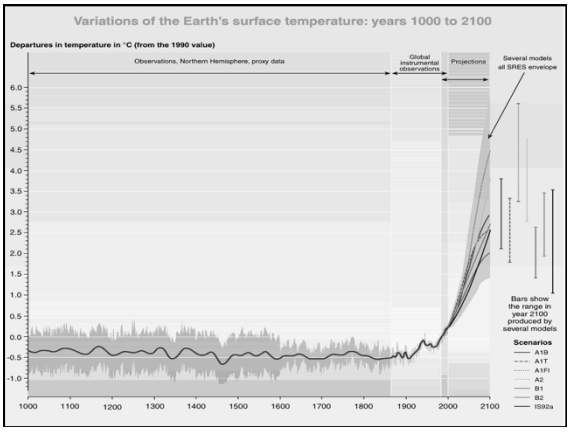


CO_2 is not the only culprit



Earth's Surface Temperature is Increasing





Summary

- fossil fuels are our primary energy source
- burning them produces CO_2 & pollutants
- we breathe the pollutants
- CO_2 --> global warming
- fossil fuel supply is finite
- Pick your favorite reason; We've got to change our ways. (and soon!)
- How?
  - Thermal Energy w/out burning (solar, geothermal, nuclear)
  - Mechanical Energy directly (wind, water, tides)
  - Radiant Energy (direct, or convert to TE or ME)

Why Is Any Of This Controversial?

- Rio, Kyoto, IPCC
  - very little dis<u></u>agreement on facts
- Scientists are their own worst enemies
  - focus on *uncertainties* and on *what we don't know*
- Non-scientists misinterpret this focus AS uncertainty and ignorance
- Hindsight does not necessarily lead to foresight. Understanding components in a complex system doesn't necessarily lead to *predictability*.
- Waiting is *not always* counterproductive (but it is in this case)

What Can, Should, Must We Do?

- Nothing? Mother Earth will find a way to protect us from our own behavior. (will it?)
- Research? Wait 'til there's no uncertainty?
- Develop alternatives to replace fossil fuels?
  - eventually, we have to do this anyway
- Drive Economic Changes? (cost accounting)
- Political Action?
- "Manage" the Earth? (introduce counter-effects)