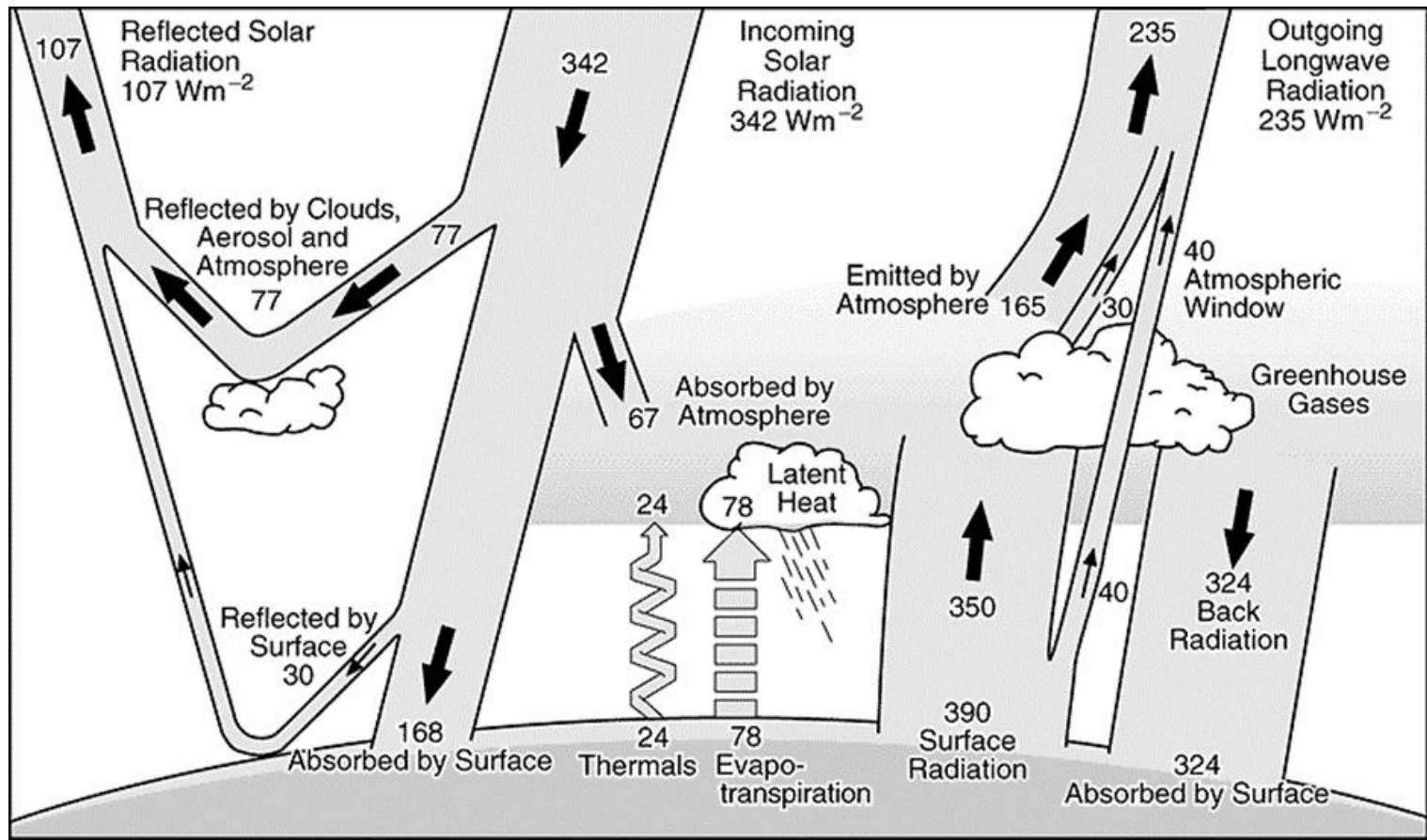


The Physics of Climate

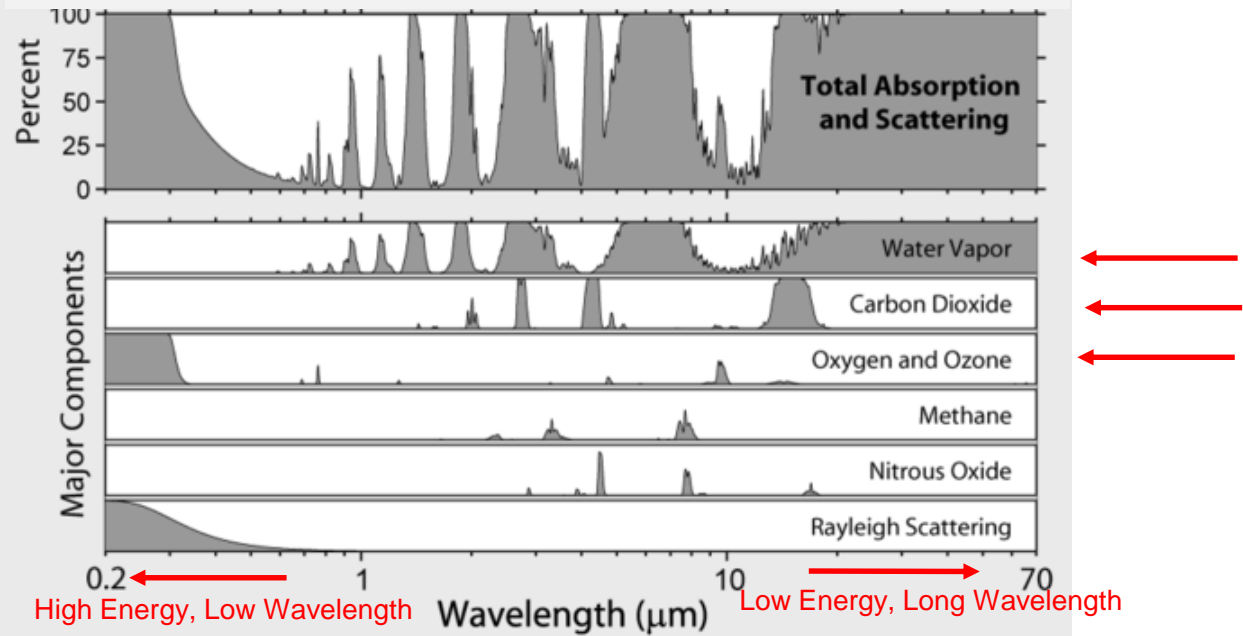
- Group quiz review
- What makes GHG
- History of these ideas
- Other planets



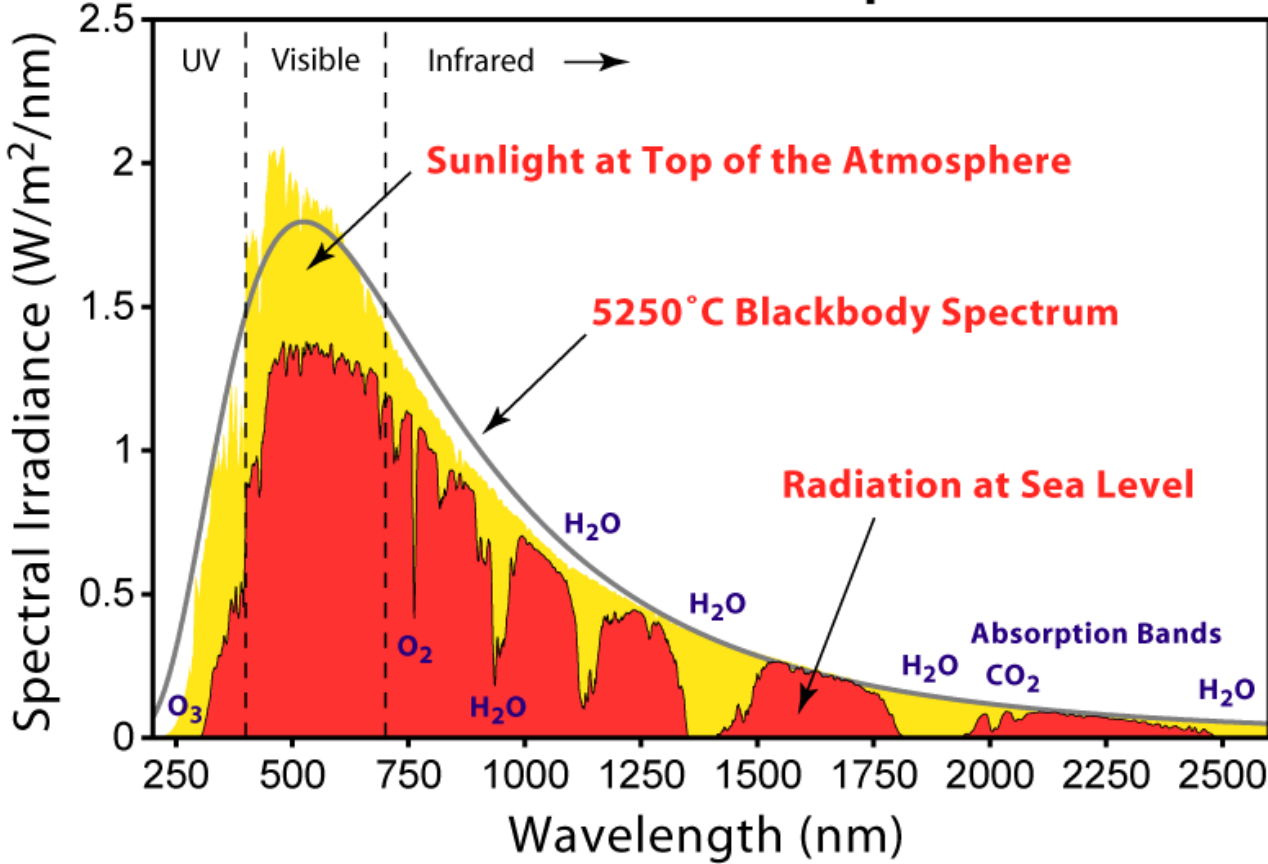
What we saw in group quiz...

- All thermal energy enters and leaves the Earth via radiation
- Without an atmosphere, energy balance equations predict a Earth much too cold
- Wavelength of incoming radiation from the sun is much smaller than outgoing radiation from the Earth. ($\lambda_{peak} = 2.9\text{mm K/ } T$)
- Simple greenhouse effect calculation gets temperature about right (a little warmer)

Radiation Transmitted by the Atmosphere

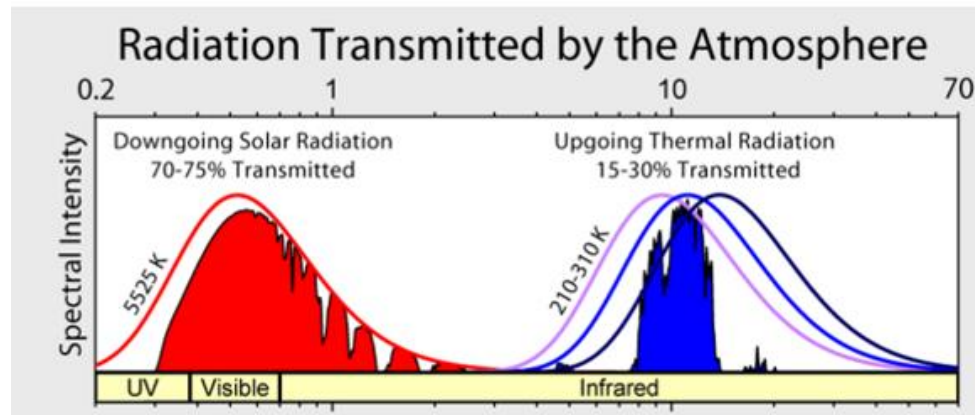


Solar Radiation Spectrum



Basic Ideas

- Amount of energy emitted via radiation depends on temperature of the object
- Energy into earth (via radiation) must equal energy out (via radiation)
- Earth's atmosphere is largely transparent to short wave radiation from the sun and opaque to long wavelength radiation back from the earth.



Not new ideas.....

1824 – Joseph Fourier calculates that the Earth would be far colder if it lacked an atmosphere.

1859 – John Tyndall discovers that some gases block infrared radiation. He suggests that changes in the concentration of the gases could bring climate change.

1896 – Svante Arrhenius publishes first calculation of global warming from human emissions of CO₂. *(He was close!)*

Not new ideas.....

1938 – Guy Stewart Callendar compiles CO₂ and temperature data. Shows that warming matches predictions.

1955 – Roger Revelle shows oceans can't absorb all CO₂.

1979 – Charles David Keeling shows CO₂ increasing.

1992 – First climate conference in Rio. President George Bush goes and signs off.

("The United States fully intends to be the world's preeminent leader in protecting the global environment.")

Venus – Runaway Greenhouse

- With no reflection (albedo = 0),
 $T_{\text{venus}} = 325\text{K}$ (127°F)
- Even with albedo = 0.7, actual temperature, **$T_{\text{venus}} = 735\text{K}$**
- Why?

Venus – Runaway Greenhouse

- Closer to the sun to started out hotter.
- Atmosphere got moist
- CO₂ not washed from atmosphere by rain.
Now 96.5% CO₂

