"The Planets"

Astro/EPS C12 (CCN 17045 or 32505)

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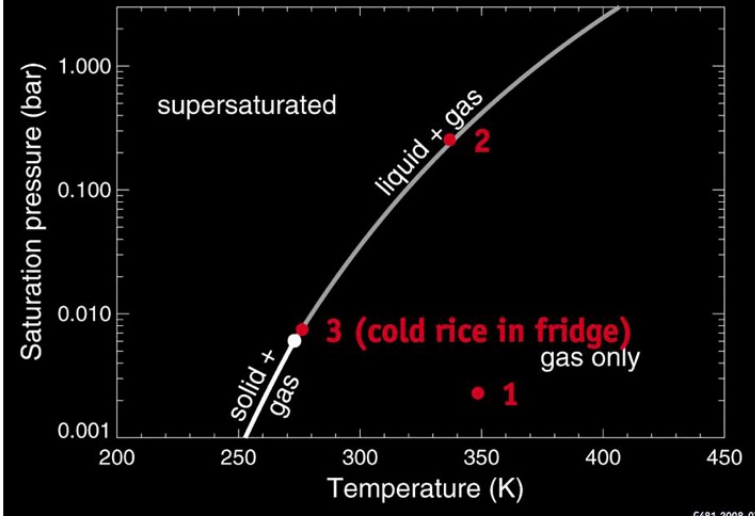
LEC: 2 LeConte TWTh, 2:40–5:00pm
Office Hours: 419 Campbell Hall,
Mon 3–4 and Tue 5–6

QUIZ 1 GRADES

QUIZ 1 grade	cutoff	N
A	7.20	15
B	6.20	12
C	4.60	14
D	2.80	12
F	0.00	11
		64

VAPOR PRESSURE CURVE



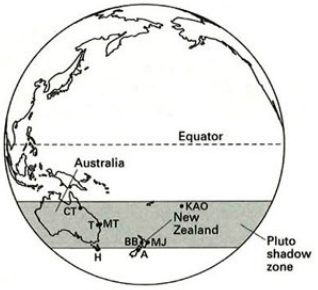
MIDTERM DETAILS

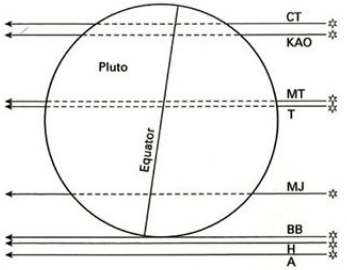
- blue-book
- one single-sided page of notes
- calculator
  - exam will be mainly conceptual (like quiz), but some math-rich extra credit may be offered
- 1-hour exam
- formulae:
  - know how to use them
  - any necessary formulae will be provided for you, so you don't need them in your notes

STUDYING FOR THE MIDTERM

- review class notes and lecture slides
  - identify major topics and themes
  - create an outline
- review book chapters
  - understand concepts behind every figure
  - identify "what, how, why" of scientific discoveries
- study independently
- study in groups
  - quiz each other
  - clarify
  - get phone numbers in class, or organize study events on the facebook site...
- let's do a sample outline of yesterday's lecture...

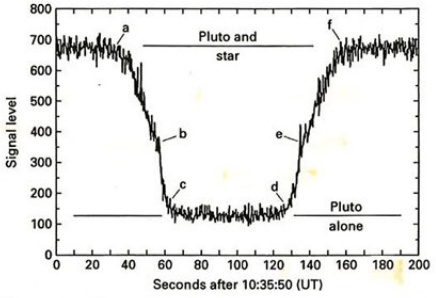
FIRST PLUTO OCCULTATION





AIRBORNE TELESCOPES

THE OCCULTATION LIGHTCURVE



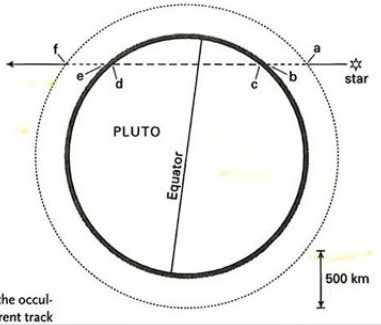


Fig. 4.7: The lightcurve obtained by the Kuiper Airborne Observatory during the occultation of a star by Pluto on June 9, 1988. The upper diagram shows the apparent track

SCALE HEIGHT, "*H*"

- describes the "thickness" of an atmosphere

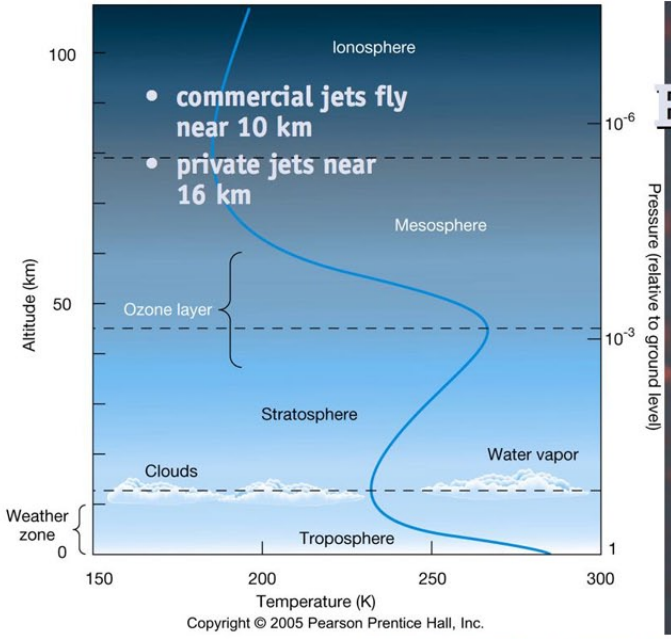
$H = (k_B T) / (m g)$, where m is the average molecular mass in kg.

or:

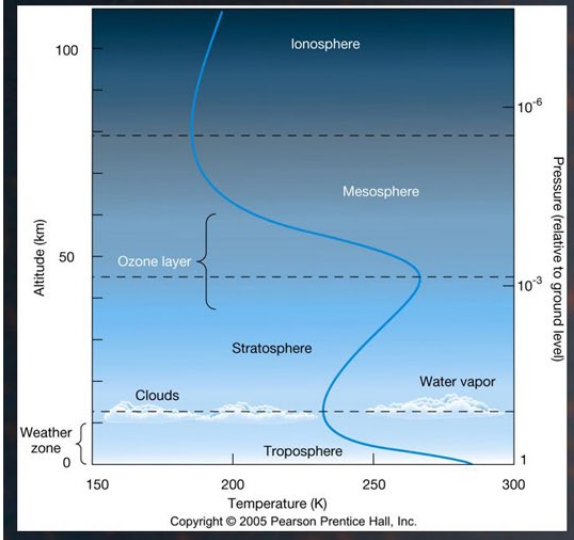
$H = (k_B T) / (\mu m_U g)$, where μ is the average molecular weight and m_U is a constant.

- scale height describes vertical pressure variation:

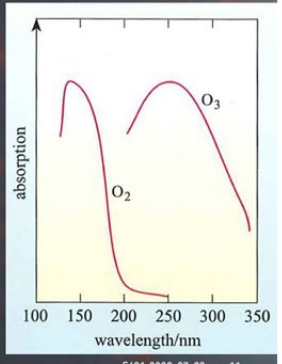
$p = p_0 \exp(-z/H)$

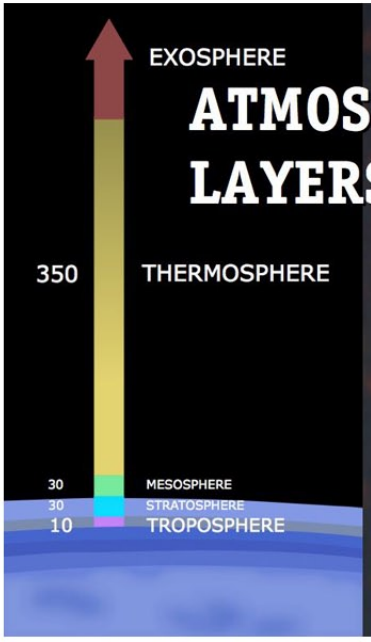


EARTH



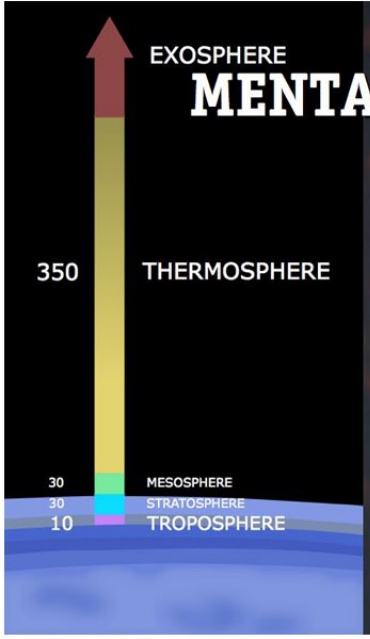
OZONE AND UV





ATMOSPHERIC LAYERS

- exosphere is the outermost layer
  - atoms/molecules rarely collide above the "exobase"
  - this is the level where atmospheric escape can occur



MENTAL EXERCISE

- where is the exobase located for a body (like the Moon) with a very thin atmosphere?

A. exobase is at the surface
B. exobase is one scale height above the surface
C. these objects have no exobases

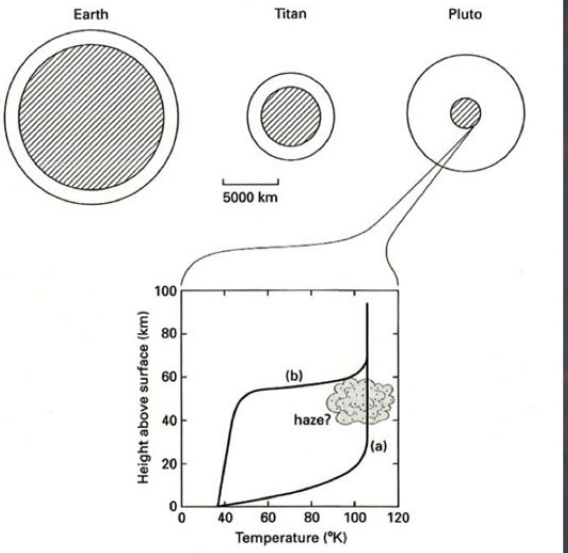
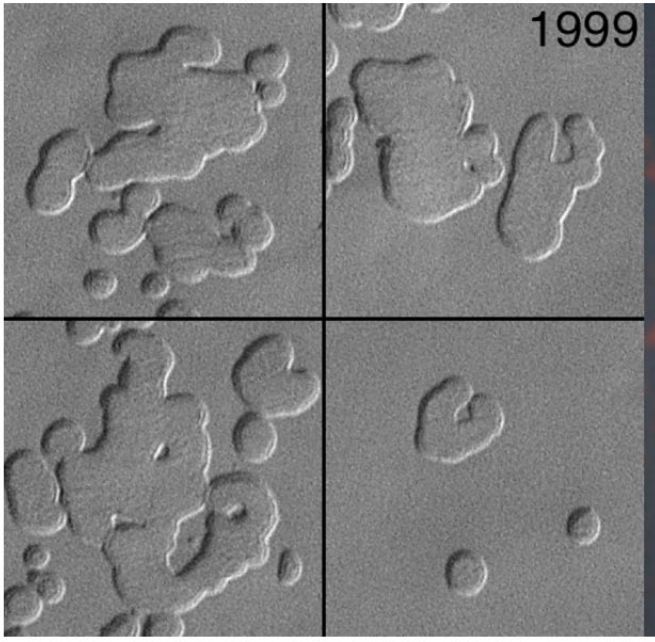


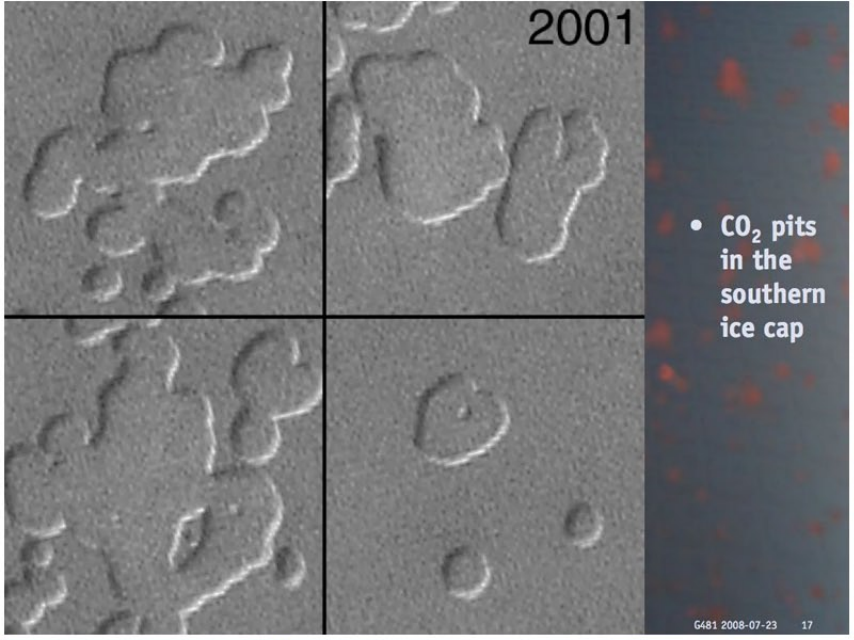
Fig. 4.9: Top: The extents of the atmospheres surrounding Earth, Titan, and Pluto are shown to scale for comparison. The limits shown represent in each case the upper stability limit, known as the *exobase*. Pluto's tenuous outer atmosphere is huge compared

MARS POLAR CAP

"vaporization erosion" has some similarities to "escape erosion" on Pluto



- CO_2 pits in the southern ice cap

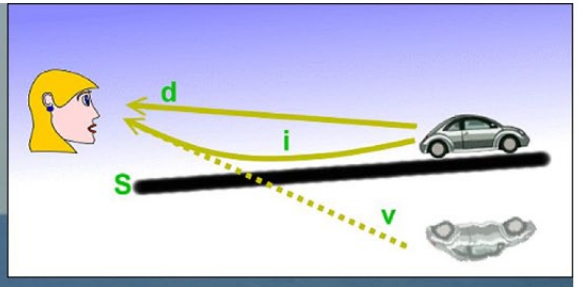


- CO_2 pits in the southern ice cap

MIRAGE

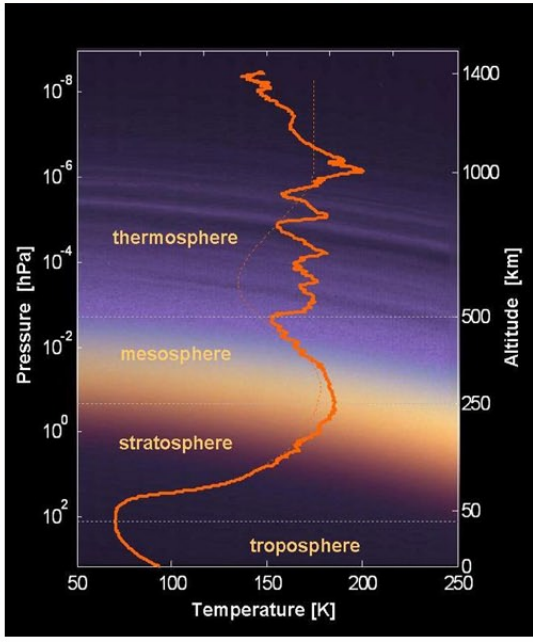
naturelover on flickr.com

MIRAGE



- sudden density change between air layers acts as a lens, bending light...

naturelover on flickr.com



TITAN

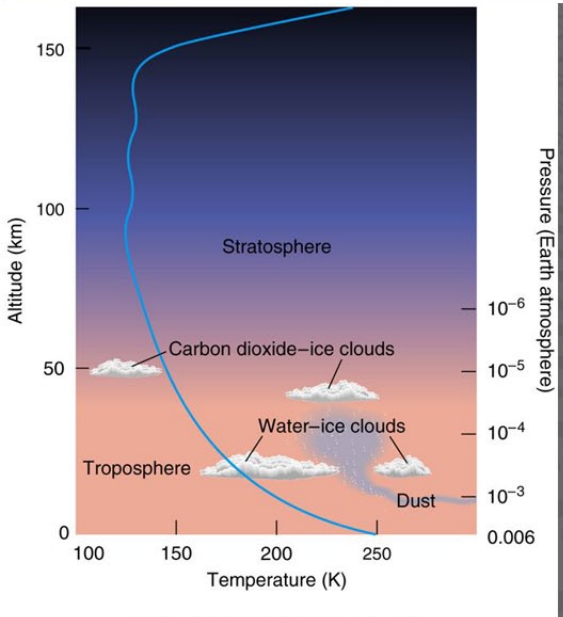
- photochemistry: solar UV breaks apart CH_4 molecules
- many chemical reactions follow, producing complex molecules

TITAN

- Cassini image in visible light
- thick hazes block view of the surface
- extended haze observed in UV light and shown here in blue

TITAN

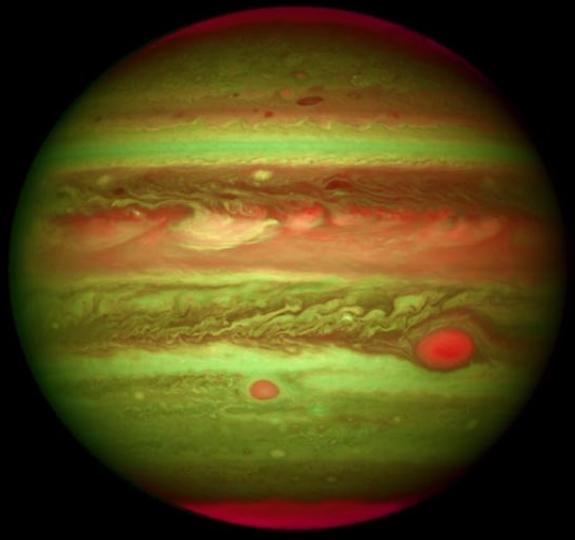
- green = ice
- yellow = hydrocarbons
- (infrared image)
- southpole clouds in white

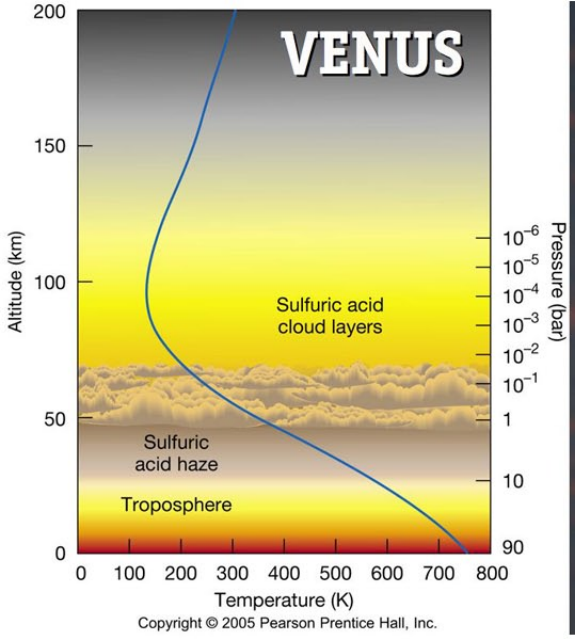


MARS

the temperature decrease with increasing altitude is because all gases obey the IDEAL GAS LAW:

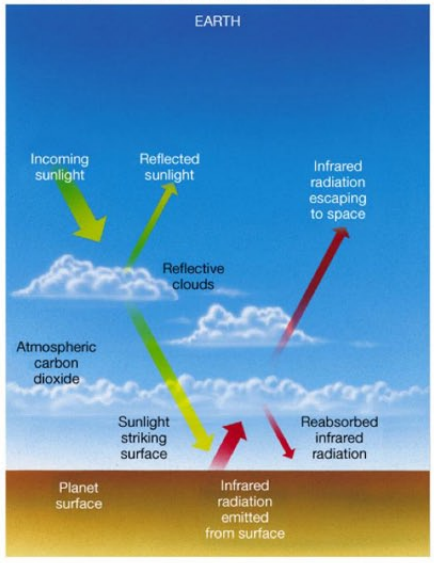
$$PV \propto T$$





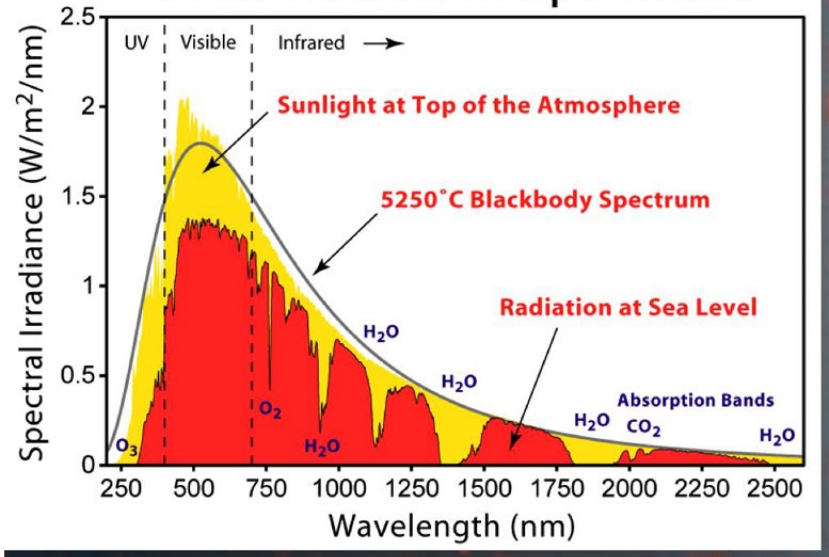
- SO_2 clouds
- 750 K surface temp
- no ozone layer like on Earth

GREENHOUSE EFFECT

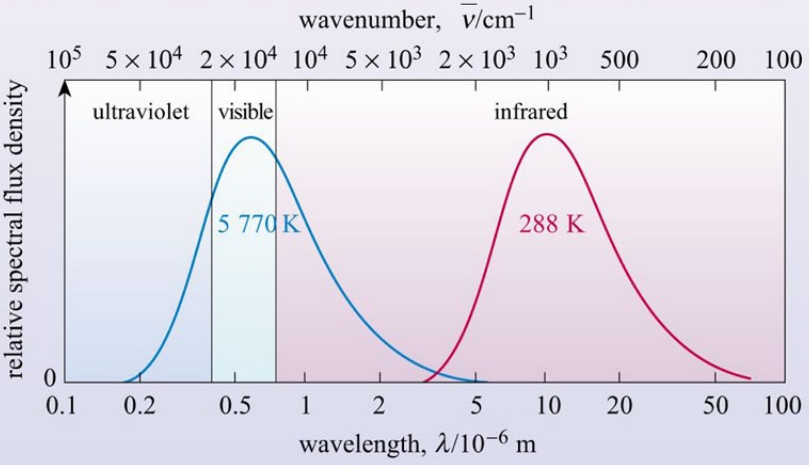


- most solar energy is in visible light
- visible light passes through the atmosphere and is absorbed by the surface
- the surface radiates in infrared
- gases in the atmosphere absorb the infrared and heat up

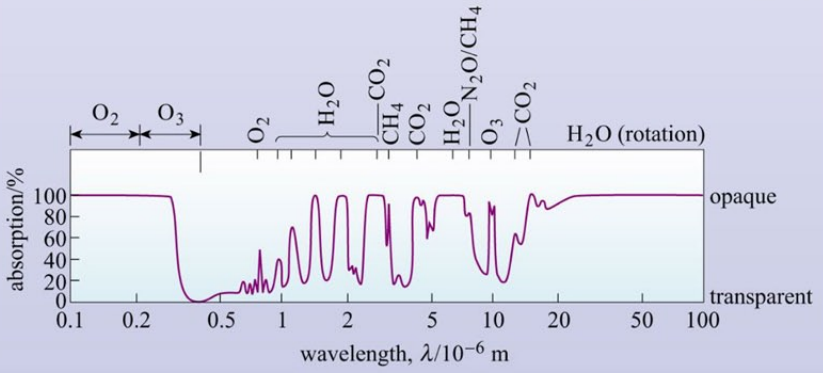
Solar Radiation Spectrum



THERMAL RADIATION



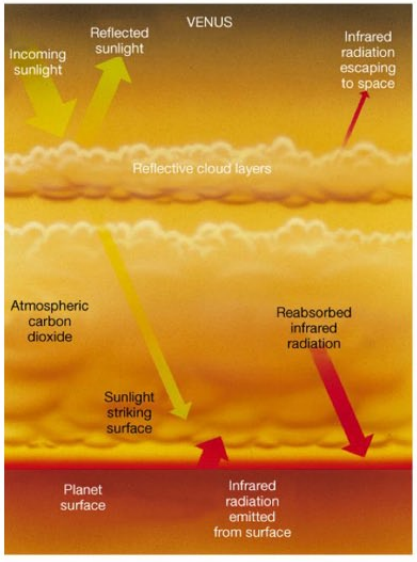
ATMOSPHERIC ABSORPTION

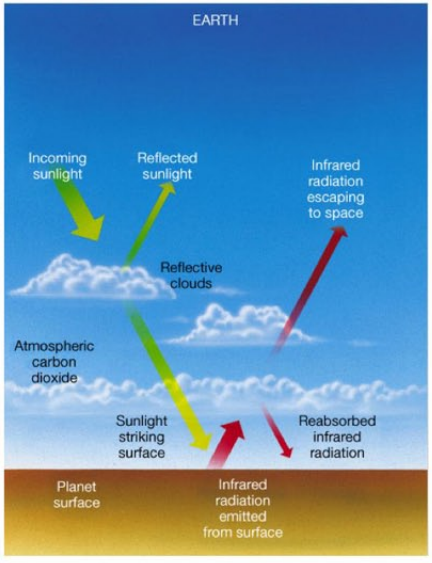


GREENHOUSE EFFECT

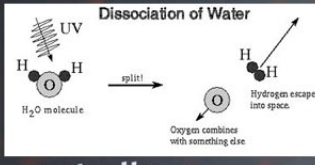
	Earth	Venus	Mars
average surface temperature	15°C (59°F)	460°C (860°F)	–55°C (–67°F)
surface temperature without greenhouse effect	–18°C (0°F)	–40° to 100°C (–40° to 215°F)	–60°C (–76°F)

VENUS vs. EARTH



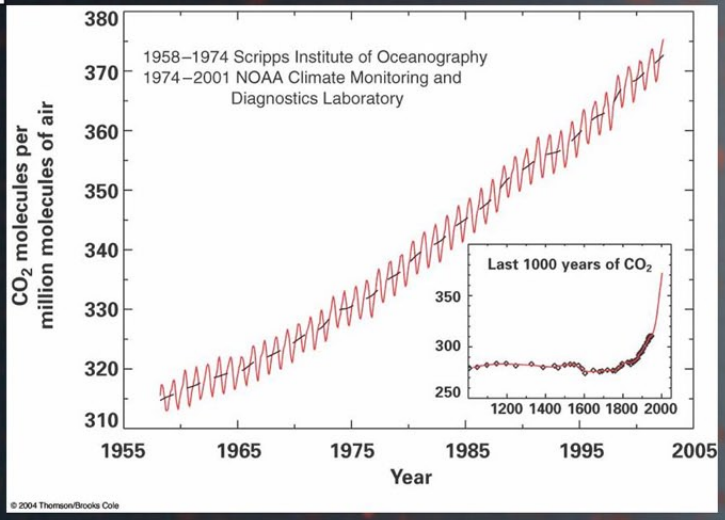


RUNAWAY GREENHOUSE

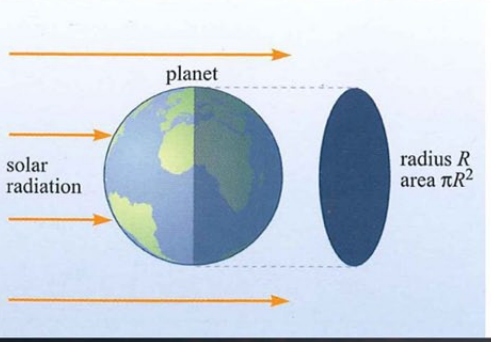


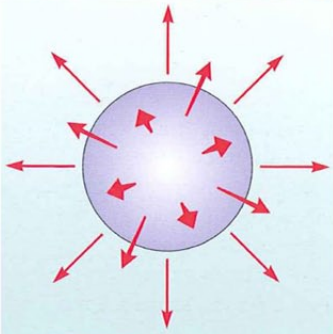
- higher temperature leads to more water in the atmosphere
- water acts as a greenhouse gas, increasing temperature on the planet
- eventually no oceans are left
- water at the top of the atmosphere is exposed to solar UV
- water is dissociated; hydrogen escapes

CO_2 INCREASE ON THE EARTH



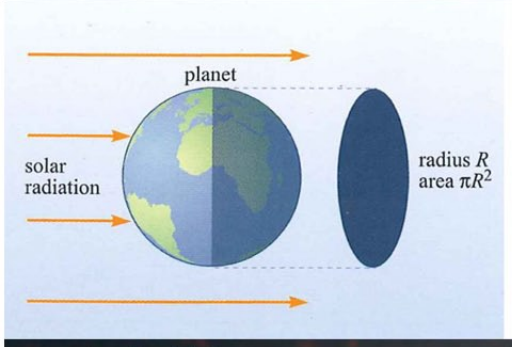
EFFECTIVE TEMPERATURE

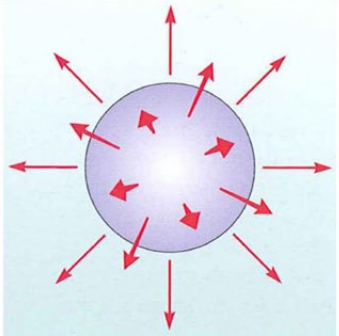




- absorbed radiation "sees" the area of a circle
- emitted radiation comes from the area of the whole sphere

EFFECTIVE TEMPERATURE





$F = F_0 (r_0/r)^2$

multiply by area to get total energy received:

$F_{received} = F \pi R^2$

$E = \sigma T^4$

total energy radiated:

$F_{radiated} = E\, 4\pi R^2$

$F_{radiated} = F_{received}$

PHASE TRANSITIONS

These transitions consume heat:

- VAPORIZE, BOIL -- go from liquid to gas
- SUBLIMATE -- go from solid to gas
- MELT -- go from solid to liquid

These transitions release heat:

- FREEZE -- go from liquid to solid
- CONDENSE -- go from gas to liquid
- DEPOSIT -- go from gas to solid

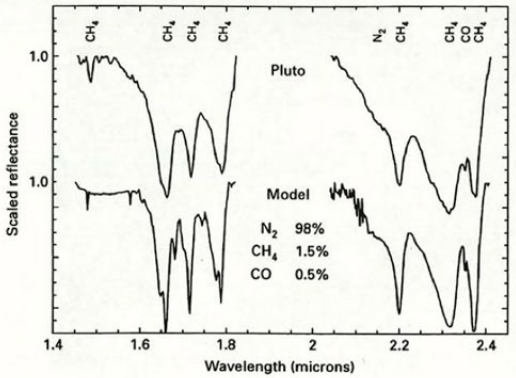


Fig. 4.14: Part of Pluto's infrared spectrum (top trace) compared with a theoretical spectrum calculated on the basis of a 98% nitrogen (N_2), 1.5% methane (CH_4), and 0.5% carbon monoxide (CO) ice. Note how well the theoretical model matches the observation. Some individual features in the spectrum due to the presence of the three frosts are labeled. (Adapted from T. Owen, D. Cruikshank 1997, in *Pluto and Charon*, University of Arizona Press)

face contained only about one carbon monoxide molecule for every 200 nitrogen molecules, and about one methane molecule for every 1000 nitrogen molecules (Figure 4.14). All the while since 1976,

HEAT TRANSPORT MECHANISMS

- radiation
- conduction
- advection
- convection

CONVECTION