Introduction to the Atmosphere

by MC DocW

Heat Transfer

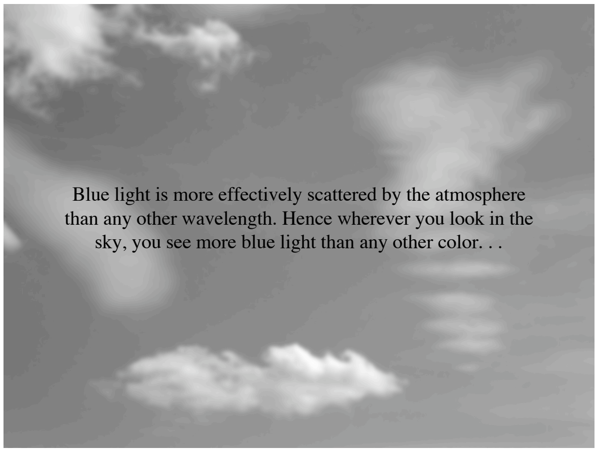
- Conduction
  - Transfer of heat through matter by molecular activity
- Convection
  - Transfer of heat through matter by mass movement or circulation
- Radiation
  - Transfer of heat through matter by electromagnetic waves (including light, infrared, UV, X-rays, gamma rays, radio waves)

Radiation

- Everything that isn't at *absolute zero* temperature gives off electromagnetic radiant energy.
  - The hotter an object is, the more energy it gives off.
  - The hotter an object is, the shorter the wavelength of energy that it gives off
  - Objects that absorb radiant energy also emit it
- Conduction and convection require matter—only radiation can travel through a vacuum
  - Thus radiation is the way by which the Earth receives virtually all its energy from the Sun

Radiation

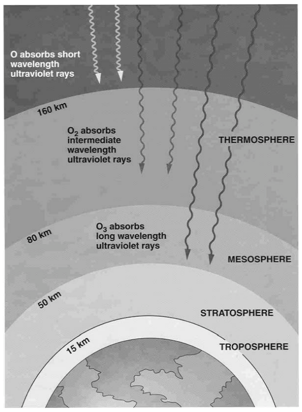
- Radiation may be absorbed, transmitted, or redirected
  - Redirection of energy may be either
    - Reflection: radiation bounces from an object with the same intensity as before
    - Scattering: radiation bounces back in the form of many weaker rays in all directions
- Incoming solar energy:
  - 30% is reflected back into space
  - 20% is absorbed by clouds and atmosphere
  - 50% is absorbed at Earth's surface



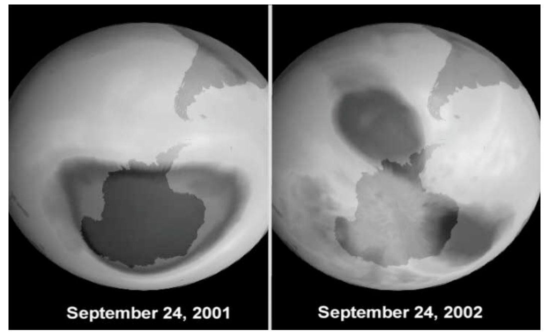
The fraction of radiation that is reflected from a surface is its *albedo*. Albedo is high for clouds (avg. 50-55%) and for icecaps (avg. 80-90%), much less for water (8%) and forest (5-10%)

Much of the sun's radiant energy passes through the atmosphere, and doesn't heat it (it would have to be absorbed in order to heat it)

So most of the atmosphere is heated by the Earth's surface, which absorbs and then reradiates the Sun's energy.



A major exception to this is oxygen gas, which absorbs ultraviolet radiation very efficiently. In particular, *ozone* (O3) in the stratosphere absorbs long-wavelength UV efficiently, which explains why the stratosphere is hotter than you'd expect.

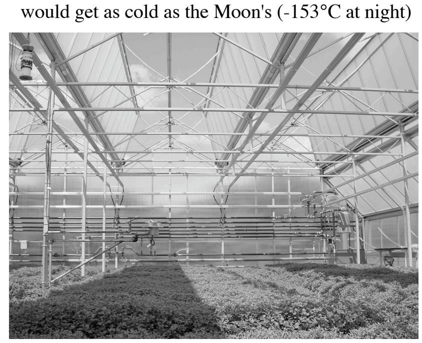


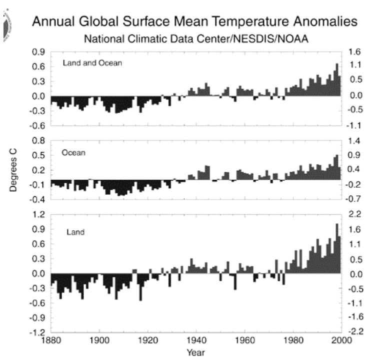
And this explains why the ozone layer is a matter of some concern. . . especially the famous "hole in the ozone layer" over Antarctica (which, as you see, comes and goes. . .)

Greenhouse Effect

- Most of the energy absorbed by Earth's surface is *reradiated* back into the atmosphere.
- The atmosphere is good at absorbing the longer-wavelength radiation emitted by the Earth.
  - Especially the gases *water vapor* and CO_2
- So the atmosphere is warmed by the Earth. . . and eventually radiates this warmth back to the Earth. The Earth is warmed by both the Sun and by reradiation from the atmosphere.
- And that's the *greenhouse effect*.

Folks think of the greenhouse effect as being a bad thing, but in fact it's necessary for life—without it, the Earth's surface would get as cold as the Moon's (-153°C at night)



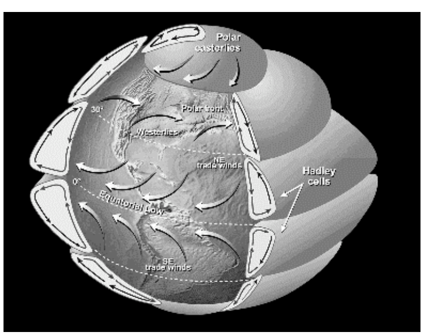


There *is* concern that human release of "greenhouse gases", especially CO_2, is driving *global warming*— that's a story for a bit later. But the greenhouse effect itself is quite beneficial.

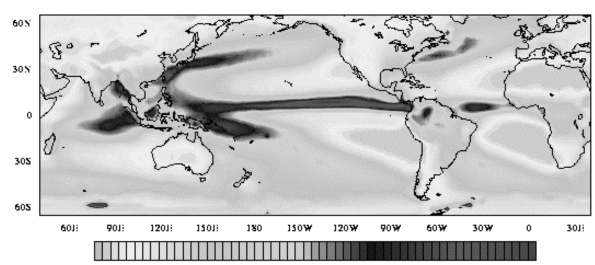
Heating of Land and Water

- Land heats and cools more rapidly and to a greater degree than water
  - Water has a very high *specific heat* (amount of energy needed to raise 1 gram of it 1°C), much greater than typical rocks
  - Water can absorb radiation at some depth; land absorbs only on its surface
  - Warm water can mix with cool water; land cannot do this
  - Water gives up heat when it evaporates
- Since water and land both heat the atmosphere by reradiation, this has a big effect on climates!

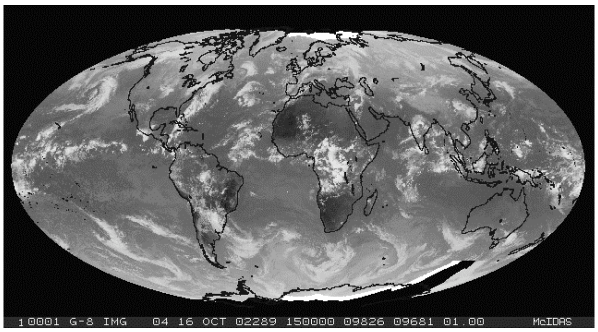
Atmospheric heating drives convection, which we've seen before in the lecture on oceans. . .



Global map of average yearly rainfall. The “thirty-degree deserts” and the equatorial rain belt are obvious.



Global composite satellite image (October 2002)



Why rain?

- *Mixing ratio* = mass of water vapor (g) / mass of dry air (kg)
  - Density of air is about 1.24 mg/cm3. 1 kg of air = about 800 liters
  - *Saturation mixing ratio* = mixing ratio when the air has as much water vapor as it can hold
  - Varies with temperature: at 0°C, saturation is 3.5 g/kg, at 25°C, it's 20 g/kg, and at 40°C, it's 47°C
- Actual mixing ratio, divided by the saturation mixing ratio for that temperature, is the *relative humidity*

After this point, I ran out of time to write more informative slides. The slides that follow are images that we looked at in class, but you'll need to refer to your notes to figure out what they mean.

—The Mgmt.

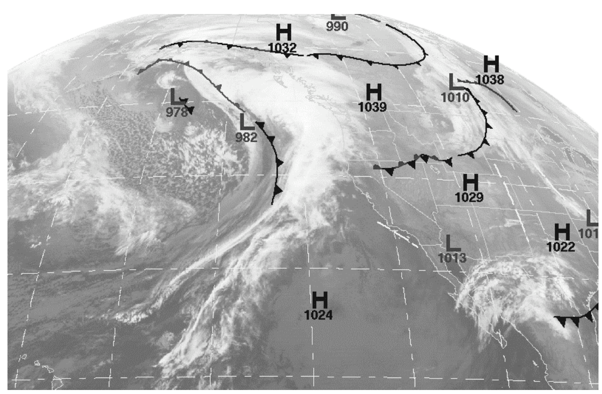
Cumulus

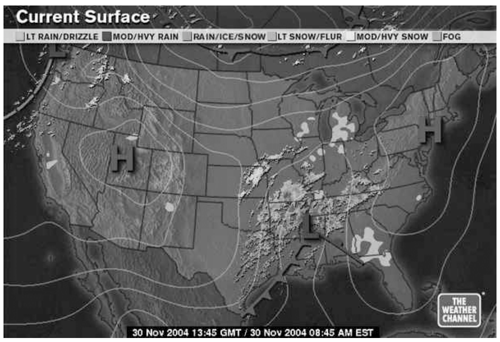
Stratus

Cirrus

Cumulonimbus

Winter satellite image, western US




Current Surface
LT RAIN/DRIZZLE
MOD/HVY RAIN
RAIN/ICE/SNOW
LT SNOW/FLUR
MOD/HVY SNOW
FOG
H
H
L
L
THE WEATHER CHANNEL
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