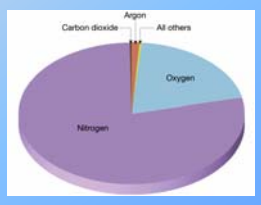
The Atmosphere

Meteorology

- Meteorology is the study of the atmosphere
- Like geology, study is concentrated on its composition and its processes
  - Temperature
  - Pressure
  - Clouds
  - Precipitation
  - Humidity

Composition of the Atmosphere

- Nitrogen (~78%)
- Oxygen (~21%)
- Argon (~0.9%)
- Carbon Dioxide (~0.0035%)
- Others (~0.0965%)



Composition of the Atmosphere

- Oxygen
  - Needed for respiration
- Carbon dioxide
  - Carbon dioxide is regarded as a greenhouse gas
  - Absorbs terrestrial radiation
  - Too much CO_2 in the atmosphere means greater absorptive capacity
  - GLOBAL WARMING
  - Issue of Global Warming

Composition of the Atmosphere

- Other constituents of the atmosphere include
  - Water vapor
    - Needed for cloud development and precipitation
  - Dust
    - Provides a surface for condensation to occur
  - Ozone
    - Protects the earth from harmful ultraviolet radiation

Atmospheric Pressure

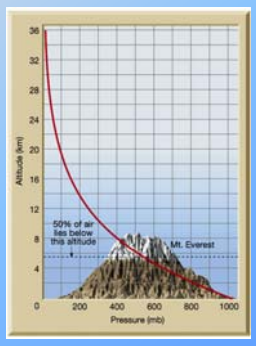
- The atmospheric pressure is the weight of the overlying air at any given location
- Air pressure is the greatest at sea level (~14.7 lbs/in^2) because there is more overlying air as opposed to mountainous regions
- As one rises in altitude, the air pressure decreases simply due to the reduction of air molecules present in the air
- Conversely, pressure increases as you travel from higher elevations to lower elevations

Atmospheric Pressure

- The same relationship holds true for water pressure in any body of water
- The pressure of water against an object increases with depth. Why?
  - More water molecules at deeper depths

Atmospheric Pressure

- Atmospheric pressure **always** decreases with altitude
- Note that 50% of all air molecules lie below an elevation of about 5.5 km



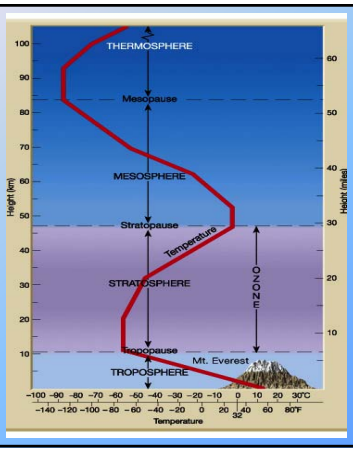
Layers of the Atmosphere

- Troposphere (0-12 km)
  - Layer closest to the earth
  - All weather takes place
  - Steady decrease in temperature (due to environmental lapse rate: -3.5° for every 1000 feet)
- Stratosphere (12km-50km)
  - The temp remains steady throughout much of the stratosphere but begins to increase at about 50 km
  - Temperature increase due to presence of the ozone layer which absorbs ultraviolet radiation from the sun

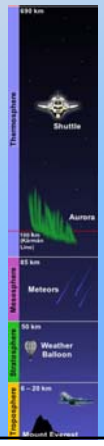
Layers of the Atmosphere

- Mesosphere (50km-80km)
  - Steady temperature decrease
  - Temperatures can reach ~ -130 degrees F
- Thermosphere (80km and above)
  - The uppermost layer
  - No defined upper boundary
  - Steady increase in temperature because, being the outermost layer, it receives the brunt of the radiation from the sun

Layers of the Atmosphere



Layers of the Atmosphere



Seasons

- Almost all of the energy that drives weather phenomena is derived from the sun
- Due to the earth's rotation and variation of the earth's surface, the solar radiation received by the sun is not distributed uniformly over the earth
- One of the most obvious weather phenomena is the variation of the seasons
- The changing seasons provide the basic framework for changing weather patterns on the earth

Seasons

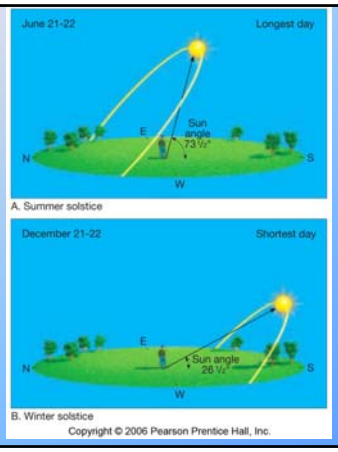
- The earth is constantly in motion
- It completes one rotation every 24 hours
- It completes one revolution around the sun every 365 days
- It is also tilted at an angle of 23.5° from vertical

http://www.zetatalk.com/index/earthdip.htm

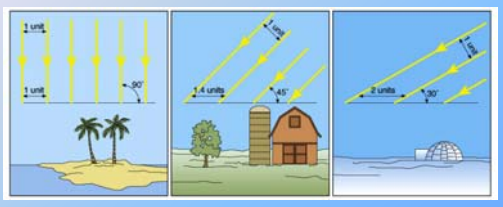
Seasons

- Amount of daylight varies during the course of a single year
- During the summer, the sun appears high in the noon sky but in the winter, the sun appears closer to the horizon
- The variation in the altitude of the sun in the sky affects the amount of radiation received by the earth in two ways:
  - When the sun is high in the sky, the energy from the sun's rays are concentrated in a smaller area
  - The angle of the sun determines the amount of atmosphere solar radiation must penetrate

Seasons

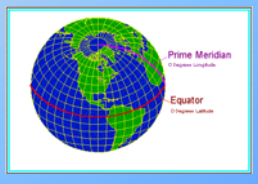


Seasons



Latitude and Longitude

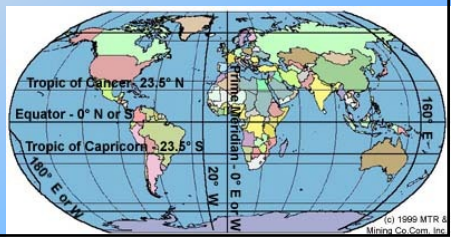
- The earth is viewed with imaginary lines that run east-west and north-south
  - East-west lines are latitude
  - North-south lines are longitude
- There is a line that runs east-west around the middle of the earth known as the equator (0° latitude)



URL: http://www.colorado.edu/geography/gcraft/notes/datum/datum_f.html

Review

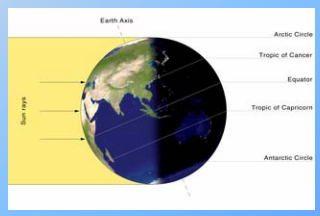
- Two special lines of latitude are also found at 23.5 ° north latitude and 23.5° south latitude
- These are known as the Tropic of Cancer (23.5° north) and the Tropic of Capricorn (23.5° south)



http://z.about.com/d/geography/1/0/V/A/equator.jpg

Solstices and Equinoxes

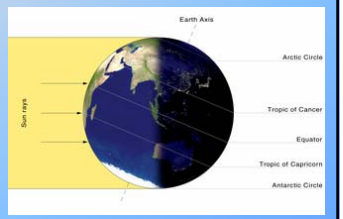
- Summer solstice (June 21 or 22)
  - The suns is directly overhead of the Tropic of Cancer
  - Northern hemisphere receives most solar radiation
  - Northern hemisphere has longer daylight hours



http://encyclopedia.calendarhome.com/upload.wikimedia.org/wikipedia/commons/thumb/c/c8/Earth-lighting-summer-solstice_EN.png/320px-Earth-lighting-summer-solstice_EN.png

Solstices and Equinoxes

- Winter solstice (December 21 or 22)
  - The suns is directly overhead the Tropic of Capricorn
  - Southern hemisphere receives most solar radiation
  - Southern hemisphere has longer daylight hours



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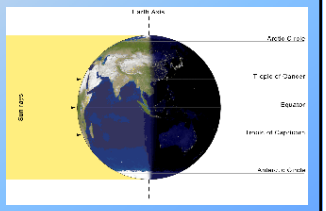
Solstices and Equinoxes

- Autumnal equinox (Sept. 22-23)
- Vernal equinox (March 21-22)
  - Sun directly over the Equator
  - Northern and Southern hemispheres receive same amount of solar radiation
  - Same number of daylight hours over entire Earth (12 hours)



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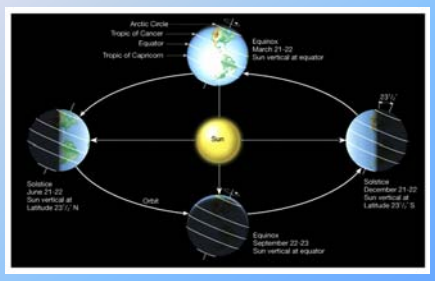
Seasons



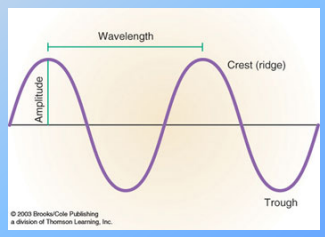
Seasons

Background Information

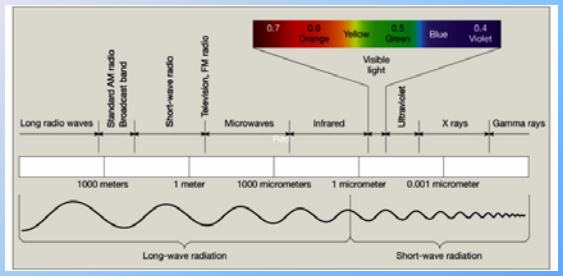
- To understand what causes the weather, information on the interaction between the earth and the sun's energy must be reviewed
- This includes
  - Mechanisms for heat transfer
  - Paths of incoming solar radiation
- Although this information seems unrelated, it all ties in to the creation of our weather

Mechanisms of Heat Transfer

- Radiation
  - Energy emitted from a central source
  - Sun emits light, heat, and other forms of energy as found in the electromagnetic spectrum
  - The most important difference between various forms of radiation is the wavelength (λ)



Electromagnetic Spectrum



Laws Governing Radiation

- All objects emit radiant energy: the sun, the earth, people, animals, everything
- Hotter objects emit more energy than cooler objects
- The hotter the radiating body, the shorter the wavelength
- Objects that are good absorbers of radiation are also good emitters

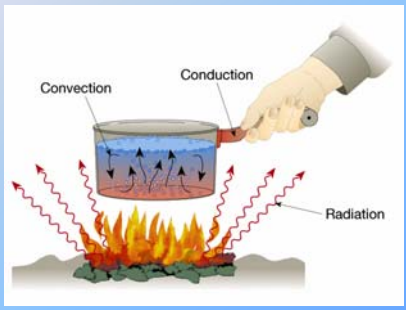
Mechanisms of Heat Transfer

- Conduction
  - The transfer of heat through matter by molecular activity
  - The energy of molecules is transferred through collisions between one molecule and another
  - A metal spoon sitting in a hot pan will increase in temperature due to conduction
  - Objects have varying abilities to conduct heat (metals are good conductors)

Mechanisms of Heat Transfer

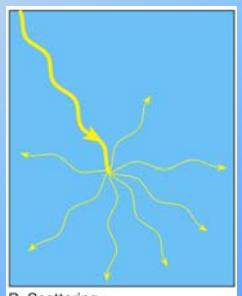
- Convection
  - Most of the heat transported through the atmosphere is done by convection
  - Air close to the earth is heated by conduction and will begin to rise (becomes less dense)
  - As air rises, it will cool and get pushed to either side by warmer air rising behind it
  - The air will then descend toward the earth where it will again heat up

Mechanisms of Heat Transfer



Paths of Incoming Solar Radiation

- Scattering
  - Dust and gases can redirect energy entering the atmosphere through scattering
  - Of the solar energy that enters the atmosphere, the radiation that corresponds with the blue portion of the visible light spectrum (~4.5 nanometers) is most easily scattered
  - This explains why our sky is blue


B. Scattering

Paths of Incoming Solar Radiation

- Reflection
  - Some of the energy that reaches the earth is redirected back out into space
  - Because of the wide variety of surfaces on the earth, there are various measures of how much energy is reflected


A. Reflection

Paths of Incoming Solar Radiation

- Reflection
  - The degree to which a surface can reflect energy is termed albedo
  - Earth has an overall albedo of ~30% but it can vary from place to place
  - Amount of albedo also depends on cloud cover, and the angle of the suns rays striking the surface

Albedo

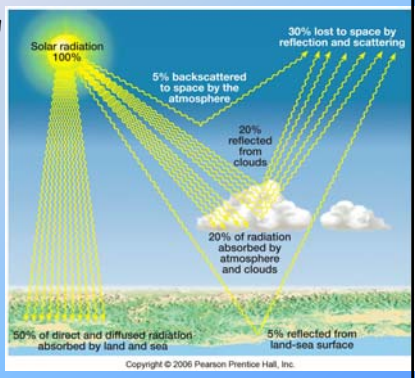
TABLE 16.2 Albedo (reflectivity) of various surfaces.

Surface	Percent Reflected
Fresh snow	80–90
Old snow	50–60
Sand (beach, desert)	20–40
Grass	5–25
Dry soil (plowed field)	15–25
Wet earth (plowed field)	10
Forest	5–10
Water (Sun near horizon)	50–80
Water (Sun near zenith)	5–10
Thick cloud	70–85
Thin cloud	25–30
Earth and atmosphere (overall total)	30

Paths of Incoming Solar Radiation

- Absorption
  - During absorption, an object (say, a gas molecule) absorbs the solar radiation and that energy is transferred into internal molecular motion (resulting in a rise in temperature)
  - The earth absorbs roughly 50% of all the energy that strikes it
  - The atmosphere as a whole generally consists of poor energy absorbers, therefore, it is heated mainly by energy that is first absorbed into the earth and conducted to the sky

Paths of Incoming Solar Radiation



Heating of the Atmosphere

- The sun emits mostly short wavelength radiation because it's a hot body
- The earth absorbs around 50% of the radiation that it intercepts
- Because the earth is a good absorber of radiation its also a good emitter (radiation law #4)
- The earth however emits long wavelength radiation because it's a relatively cool body

Heating of the Atmosphere

- The long wavelength radiation that the earth emits is absorbed by CO2 and other greenhouse gases in the atmosphere
- As the air heats, it rises (hot material has a lower density than cool material)
- In the upper atmosphere, the air is pushed to either side and that sets up the convection cells within the atmosphere

Other Controls of Temperature

- Land and Water
  - Land heats more rapidly and to higher temperatures than water and cools more rapidly and to cooler temperatures than water
- Altitude
  - Locations at higher altitudes will generally experience cooler temperatures
- Geographic position
  - Cities located closer to water bodies will experience relatively cooler temperatures due to prevailing winds from the seas
- Cloud Cover and Albedo
  - Areas with higher amounts of cloud cover will experience greater variation in daytime maximum and nighttime minimum temperatures