Earth-Sun Distance

- Change in distance has only a minimal effect on seasonal temperature.
- Note that during the N. hemisphere winter, we are CLOSER to the sun!
Eccentricity

- Changes the distance from the Earth to the sun
- Aphelion: Farthest from sun
- Perihelion: Closest to sun
- Today’s difference between aphelion and perihelion ~ 3%
  - Results in about a 7% increase in received solar radiation in January than in July
  - Max eccentricity would result in 20-30% more solar energy received at aphelion

Eccentricity Varies on 100,000 year timescales
The Earth’s orbit goes from being elliptical to nearly circular
Period: ~365.242199 days
Earth’s Axis

- Tilt: 23.5°
- Rotation is counterclockwise (when viewed from the North Pole)
- This is why the sun rises in east and sets in west
- This is why we have seasons
Obliquity

- ~41,000 year cycle
- Greater the tilt, greater the difference in season
Precession of the Axis

- ~23,000 year cycle
- Axis points to a different star
- This is not a change in Tilt!
Radiation and Orbital Parameters

- Combined tilt, precession, and obliquity effects change high-latitude insolation in summer by as much as 30%!
- Some Evidence that cycles affect the climate
- Specifically these cycles seem to be related to ice ages
Solstice and Equinox

- During the equinox, there is exactly 12 hours of day and 12 hours of night everywhere on Earth.
- During a solstice, there is either 24 hours of light or darkness, North or South of 66.5° (Arctic and Antarctic Circles)
Solstice and the Midnight Sun

- 24 hours of sunlight exposure during the summer solstice in the Arctic circle
Seasons

- Notice the change in the angle of incidence with season
The Solstice

- When the Sun reaches its farthest north or south point and begins to move back the other way, it can be thought that the earth “stands still” as far as the north or south axial movement is concerned
  - Latin: sol = sun; stice = standing

- When the sun reaches its northernmost point at the Tropic of Cancer (23.5°N), this is known in the NH as the summer solstice
  - ~21st of June

- Southernmost, Tropic of Capricorn (23.5°S) = winter solstice
  - ~22nd of December
The Equinox

- On 2 specific days of the year, the sun crosses the equator, and on that day, day and night are of equal length
- Latin: equi = equal; nox = night
- Equinox = equal night
- When moving north, we call it the vernal (spring) equinox
  - ~20$^{th}$ of March
- On its way south, the fall or autumnal equinox
  - ~23$^{rd}$ of September
Solar Intensity

- When sunlight is spread over a larger area it is a less intense heat source (Intensity = Power/Area)
- “Insolation” is a term we use for solar intensity
Insolation
Daily Total Sunshine

- 75° N in June gets more sun than the equator
- North-South temperature gradient is stronger in the winter
- Very little change in the tropics
- Why are the values larger in the SH summer than in the NH summer?
Daytime Warming

- Daylight heats the atmosphere from below by conduction and convection
- Convection leads to vertical mixing to even out vertical temperature gradients
Nighttime Cooling

- Radiational cooling creates a temperature inversion at the surface
- Cold dense air sinks
The Diurnal Cycle

- Each day is like a mini seasonal cycle
- We call this the ‘diurnal cycle’
- Sun’s rays are most intense around noon
- Maximum temperatures lag the peak in insolation because until around 3-4 pm, there is more incoming solar radiation than there is radiative cooling
What Controls Daily Temperatures?

• Temperature strongly depends on:
  - Cloud cover
  - Surface type
    • Albedo (desert or forest?)
    • Moisture
    • Difference between north and south facing slopes
  - Wind
    • Horizontal temperature advection
Annual Temperature Cycles

• Different environments effect the temperature cycle

• Some Major factors:
  – Latitude
  – Proximity to a body of water
  – Proximity to a mountain range
  – Elevation
Global Temperatures

January  
More variation in NH winter. Why?
“Sea Breezes” form during the day when there is solar heating.

- The land is heated which causes air to rise.
- Air aloft flows outward from land to ocean.
- Surface air responds with flow towards land at the low levels.
Land/Sea Breezes

- At night the land cools down so that it is relatively cooler than the ocean which forms a “Land Breeze”
- Radiative cooling of the land surface leads to sinking air and offshore flow
LAND BREEZE

SEA BREEZE

Source: NOAA
Mountain/Valley Winds

- Sunlight heats mountain slopes during the day and they cool by radiation at night.
- Air in contact with surface is heated/cooled in response.
- A difference in air density is produced between air next to the mountainside and air at the same altitude away from the mountain.
- Density difference produces upslope (day) or downslope (night) flow.
- Daily upslope/downslope wind cycle is strongest in clear summer weather when prevailing winds are light.