

# Monday AM, Explain: Seasons & Days

## MONDAY AM

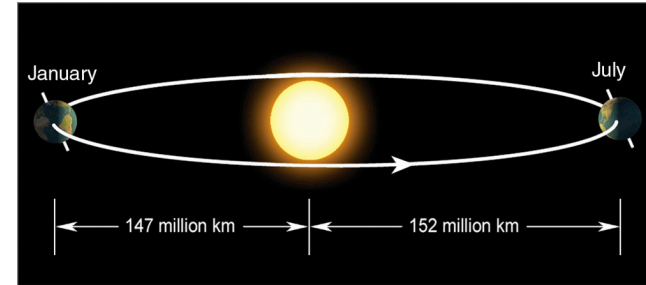
Radiation, Atmospheric Greenhouse Effect

### Seasons & Days

- Why do we have seasons?
- Why aren't seasonal temperatures highest at the summer solstice (June 21)?
- Why aren't daily temperatures highest at Noon?

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## Earth's orbit around the Sun is slightly elliptical (not circular)



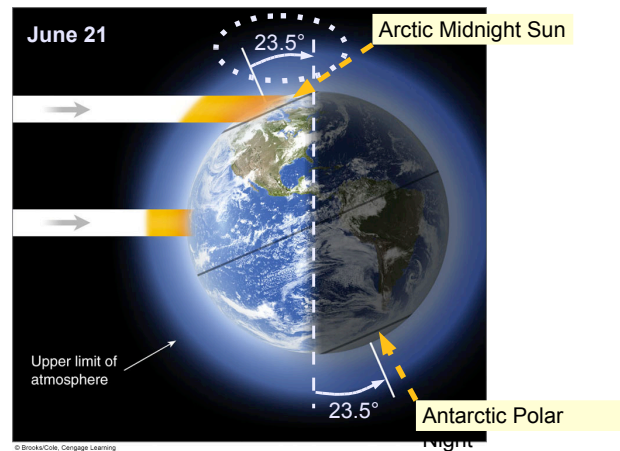
Earth is somewhat closer to Sun in January than in July ...



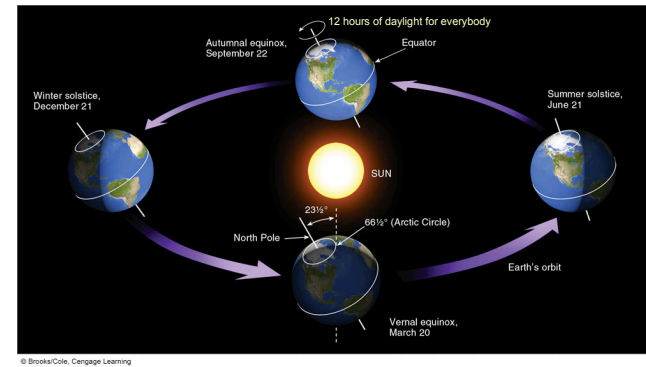
**Is this why we have seasons?**

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## Earth is tilted (oblique) on its Axis!



Seasonally varying distance to Sun has only minor effect on seasonal temperatures; instead it is the tilt of earth's axis combined with earth's orbit around the sun that leads to seasons!

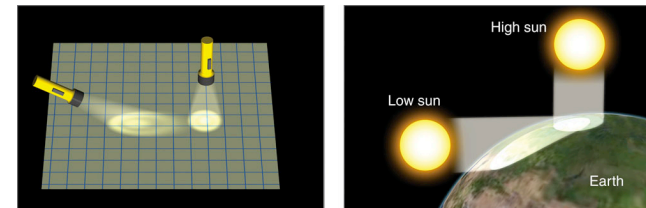


## Seasons

- Seasons are regulated by the amount of solar energy received at Earth's surface
- The solar energy received at the *top of the atmosphere* depends on:
  - angle at which sunlight locally strikes Earth's surface
  - hours of daylight
- Seasons are NOT due to elliptical nature of earth's orbit around the sun!

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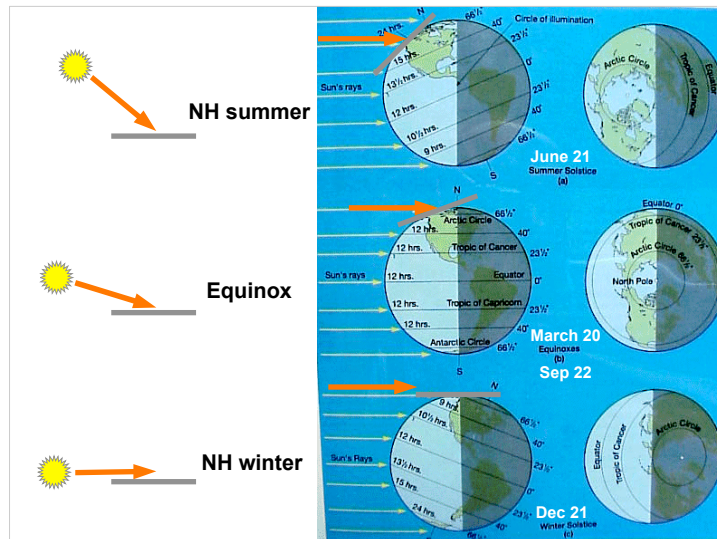
**Sun's rays that strike a surface at an angle are less intense per unit area than those from directly above**



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- Smaller angle of incoming solar radiation means the same amount of energy is spread over a larger area
- High Sun (summer) = more heating
- Low Sun (winter) = less heating

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## Midnight Sun



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The region north of the arctic circle experiences 24 hours of sunlight in summer (Earth's surface does not rotate out of solar exposure).

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## Controls of Temperature

- Air temperature as you move around the globe varies regionally as a function of:
  - Latitude
  - Land and Water Distribution
  - Ocean Currents (e.g. gulf stream)
  - Elevation
  - Mountain Ranges (e.g. Rockies)

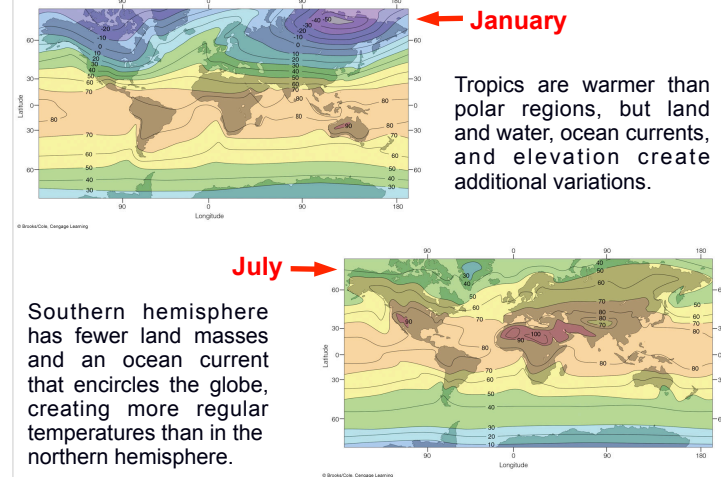
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## Land versus Water / Ocean

- **Water has a very large heat capacity (4 times as large as land):** to heat one kilogram of water by one degree Kelvin/Celcius an energy of 1000 calories is required (4186 Joules)
- Therefore, oceans (and large lakes) are able to store a large amount of heat, changing their temperature is much more difficult than land
- Some heating of oceans goes into evaporation
- Water is a fluid, so heat in the oceans is mixed efficiently; Land primarily moves heat by conduction
- Sunlight can penetrate into the ocean

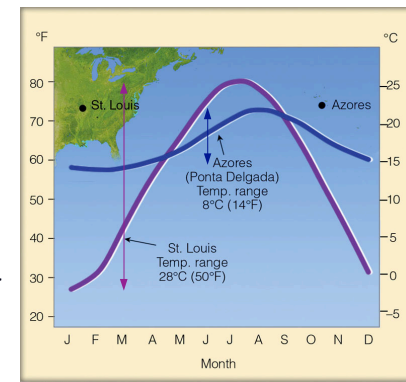
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## Sea-Level Temperatures



## Land versus Water / Ocean: Seasonal Cycles

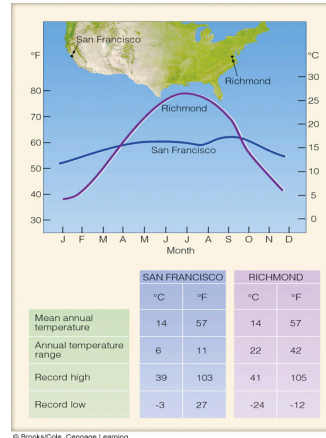
- Large heat capacity of oceans make them much more resistant to changes in heat input than land
- Hence, annual temperature range is much smaller over oceans than land



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## Regional Seasonal Cycles

- Regional differences in the seasonal cycle of temperature are influenced by geography, such as latitude, altitude, and nearby water and ocean currents, as well as heat generated in urban areas
- San Francisco, CA is downwind of the Pacific Ocean
- Richmond, VA is downwind of North America!

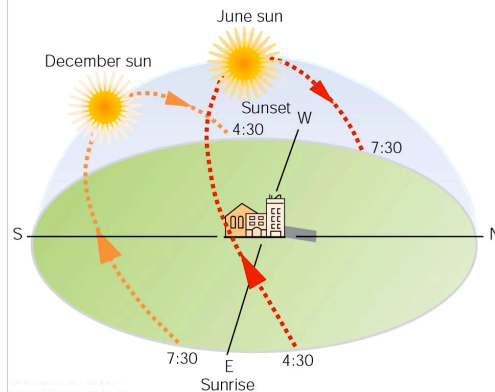


## Daily (Diurnal) Temperature Variations

- Each day is like a mini seasonal cycle:
  - Sun rays are most intense around noon
  - As is the case with seasons, the maximum temperatures lag the peak incoming solar radiation
- Heat transfer mechanisms (heating & cooling) in the atmosphere are at the heart of understanding the diurnal cycle:
  - Radiation
  - Convection
  - Conduction

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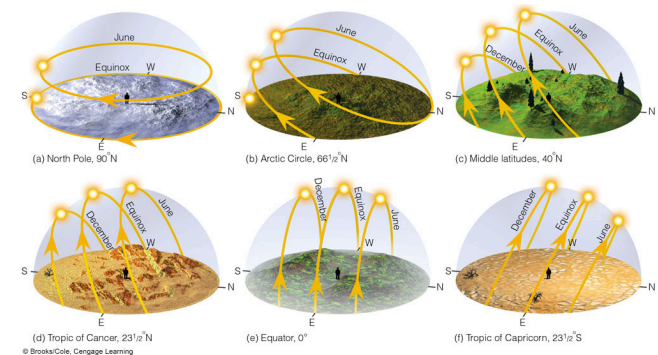
## Local Solar Changes



- Northern hemisphere sunrises are in the southeast during winter, but in the northeast during summer
- Summer noon time sun is also higher above the horizon than the winter sun

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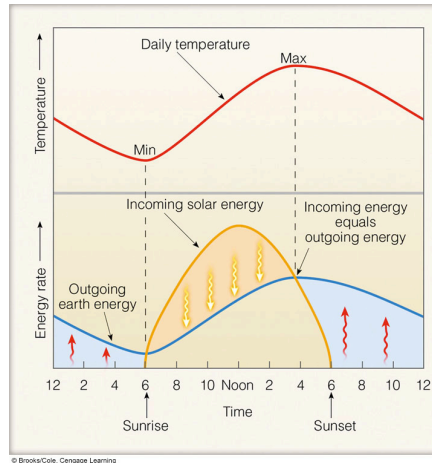
## Local Solar Changes by Latitude



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## Temperature Lags Radiation

- The Earth's surface temperature is a balance between **incoming solar radiation** and **outgoing terrestrial (longwave) radiation**
- Peak temperature lags after peak insolation because surface continues to warm until infrared radiation exceeds insolation

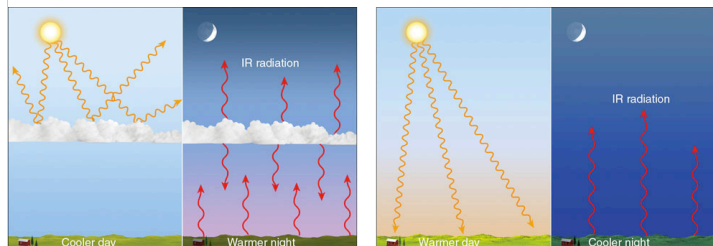


## What Controls Daily High Temperatures?

- Daily  $T_{\max}$  depends on:
  - Radiation (e.g. Cloud Cover)
  - Surface Type
    - Absorption Characteristics (strong absorbers enhance instantaneous surface heating)
    - Vegetation / Moisture (available energy partially used to evaporate water)
  - Wind
    - Strong wind generates mixing of heated air near the ground to higher altitudes

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Clouds reflect solar (shortwave) radiation but absorb and re-emit terrestrial (longwave/infrared) radiation



(a) Small daily temperature range

(b) Large daily temperature range

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