Insolation & Temperature

Part II

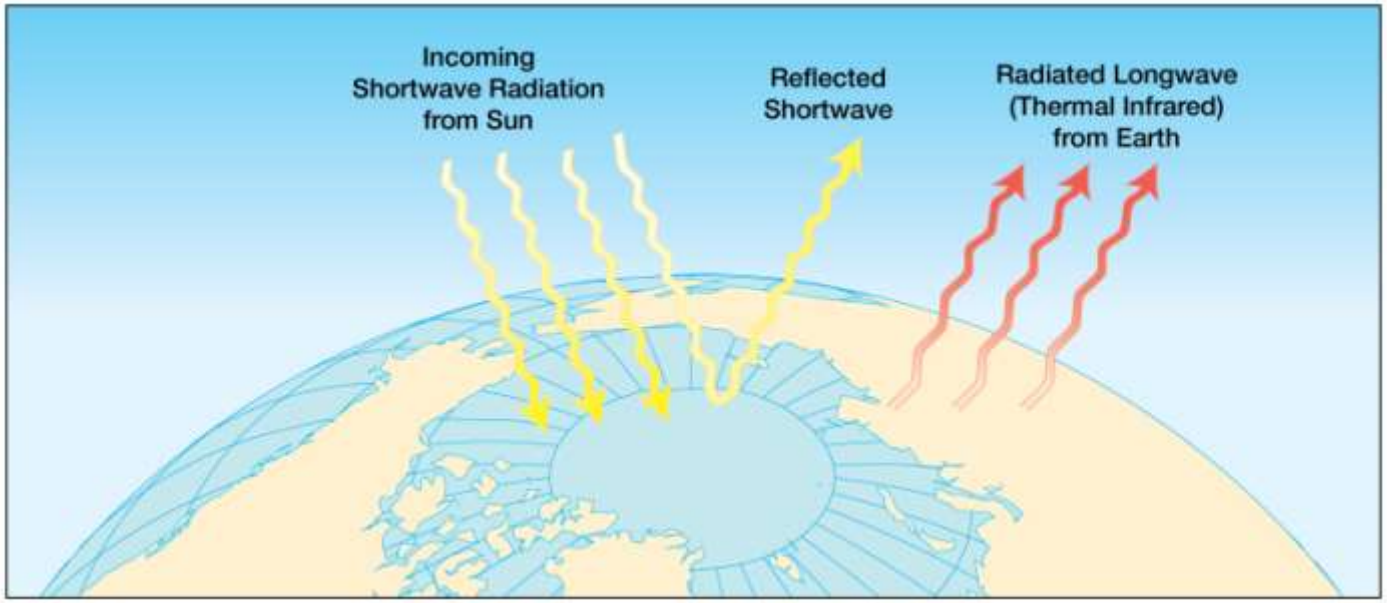
Heat, ma am! It was so dreadful here that I found there was nothing left for it but to take off my flesh and sit in my bones.

— Sydney Smith

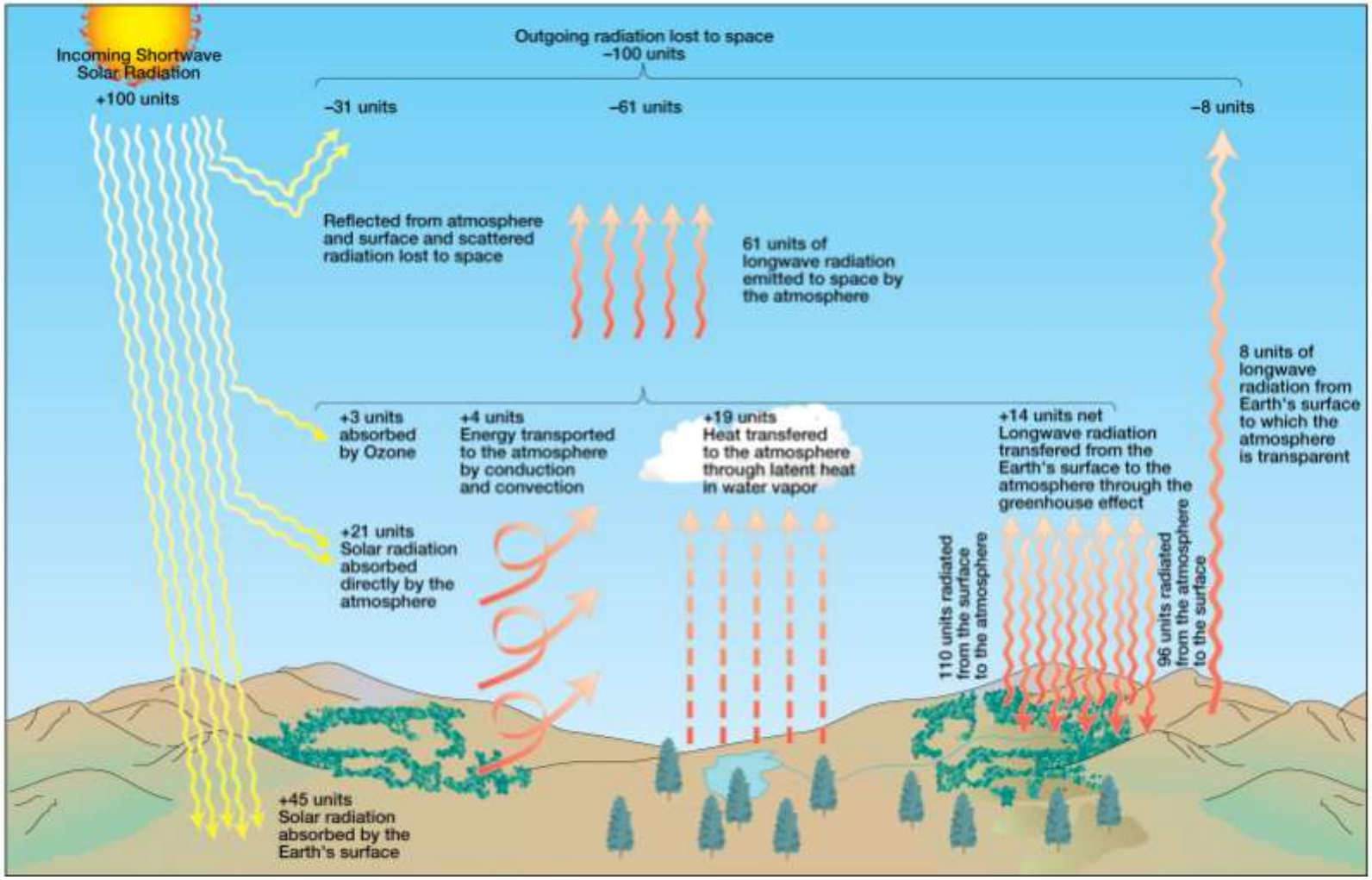
The Heating of the Atmosphere

- Atmospheric Energy Balance

Animation (Solar System Formation)

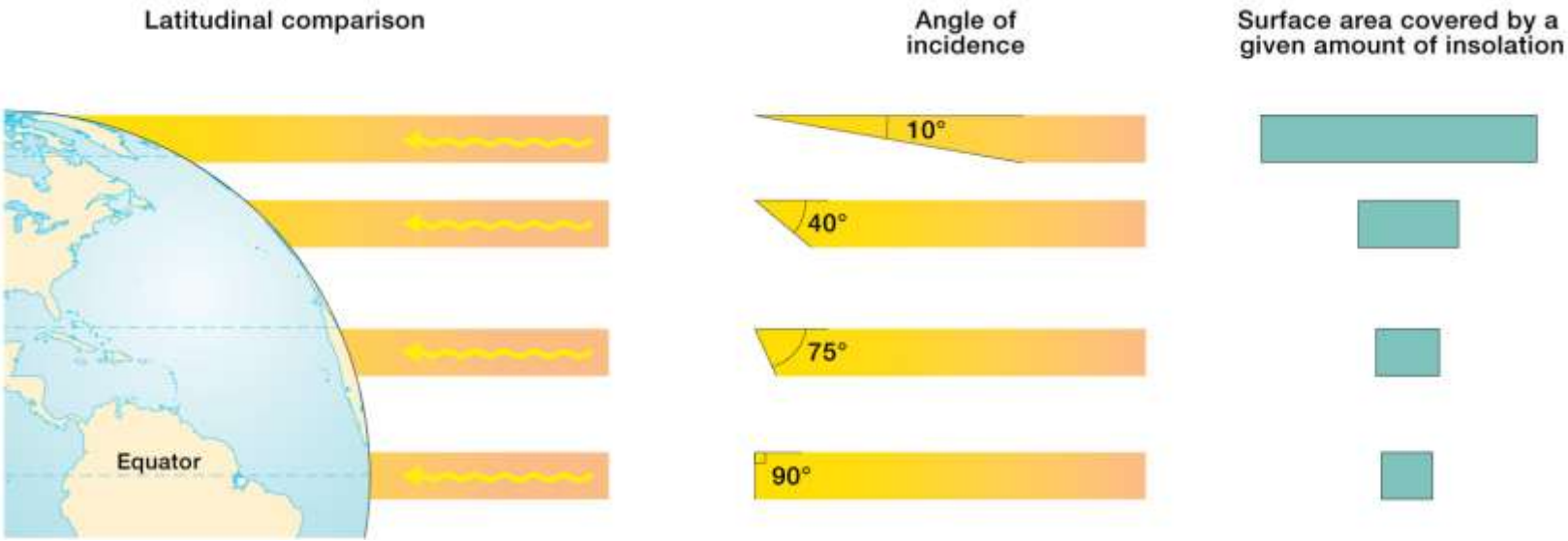


Energy budget of Earth and its atmosphere



Variations in Heating by Latitude and Season

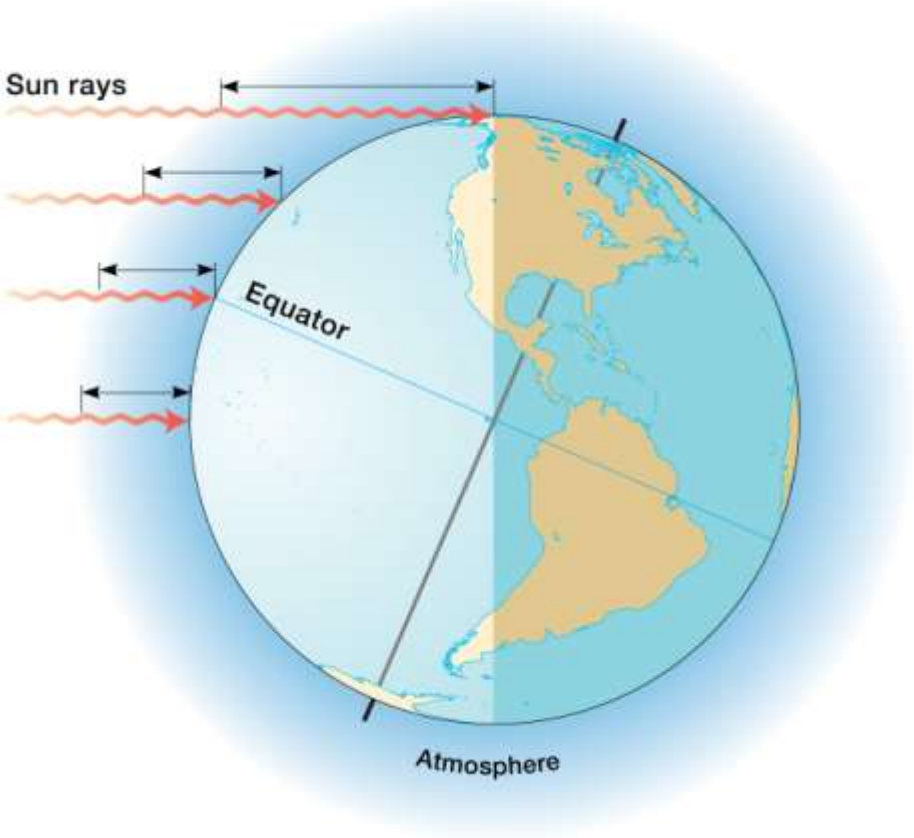
- Latitudinal Differences
  - Angle of incidence



- Day Length

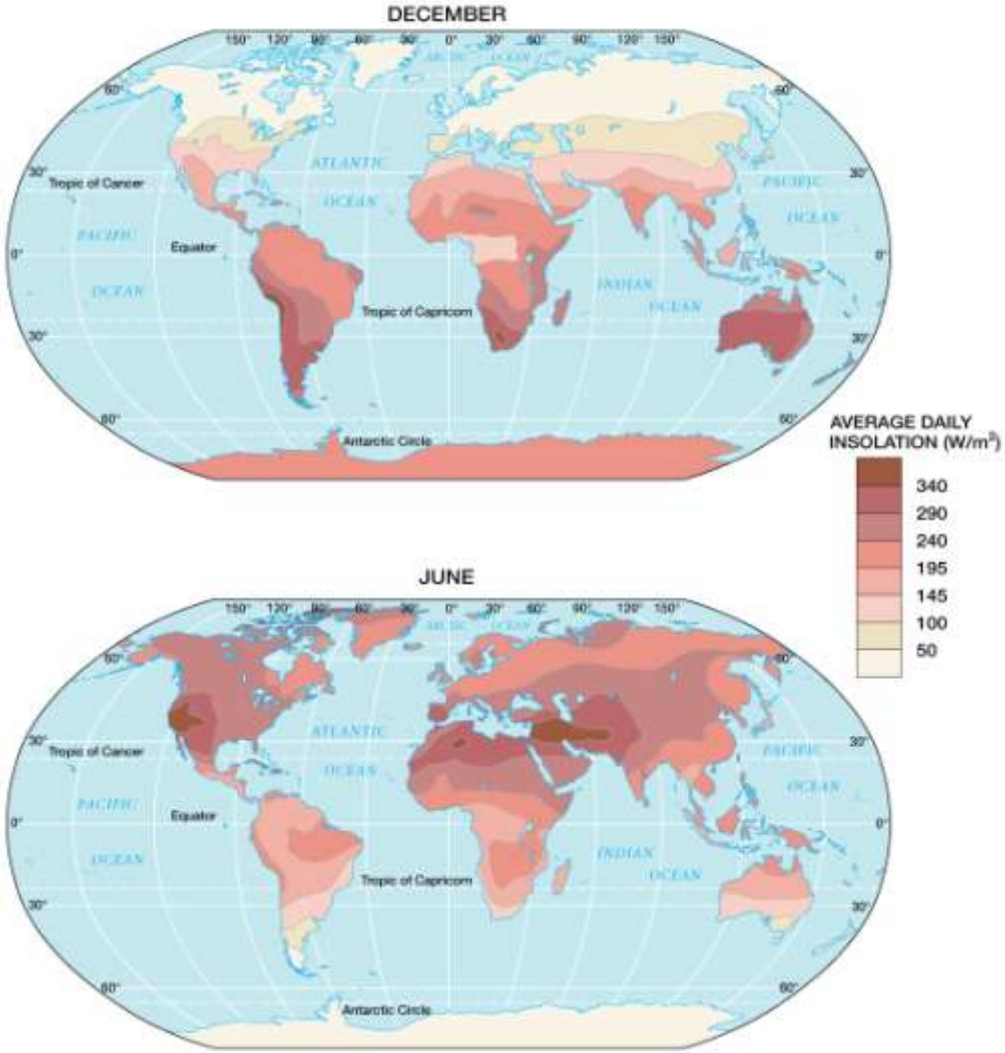
  Noontime sun

- Path Length

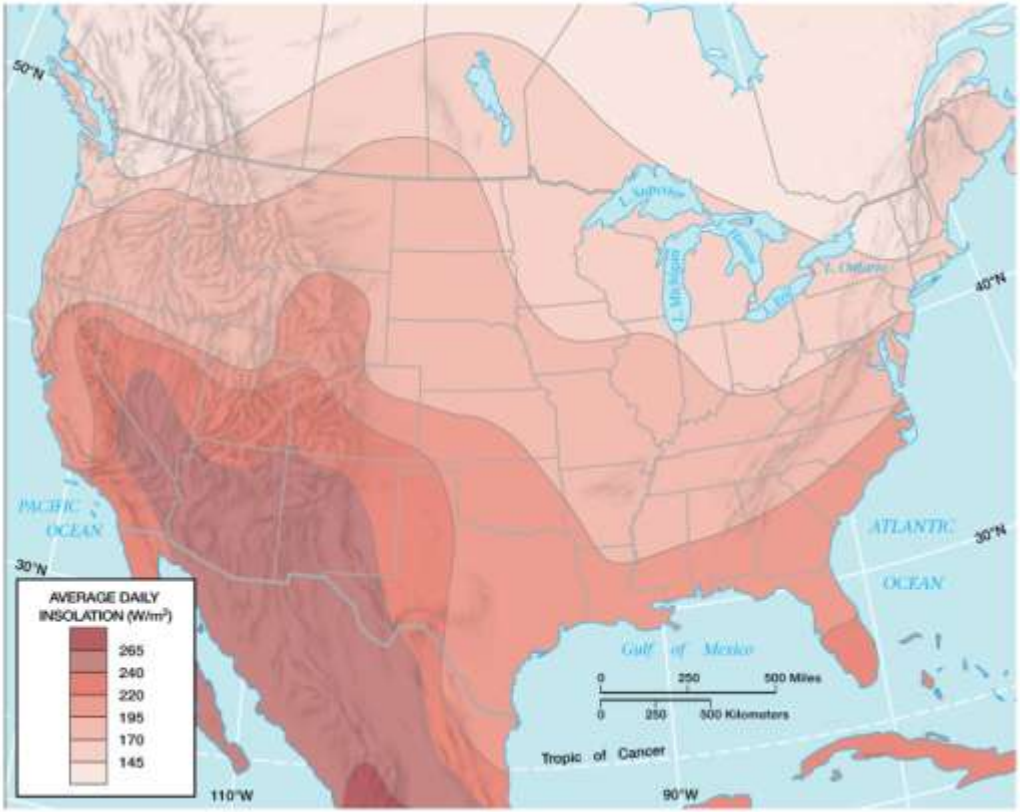


- Atmospheric Obstruction
  Clouds and haze deplete insolation

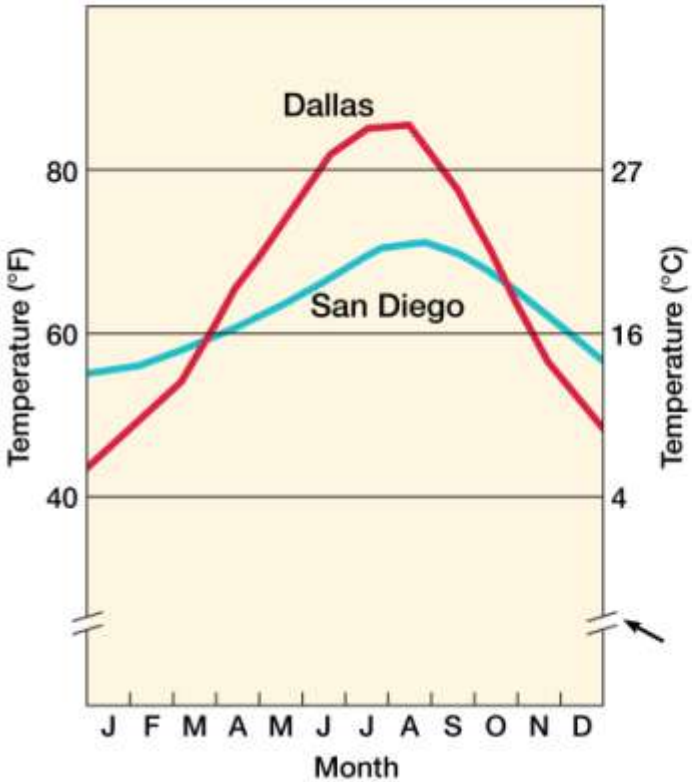
– Latitudinal Radiation Balance



- Land and Water Contrasts
  - Heating and Cooling



– Implications



Dallas
Latitude: 32° 51' N
Annual average temperature: 18°C (65°F)

San Diego
Latitude: 32° 44' N
Annual average temperature: 17°C (63°F)

– Implications (continued)

- Average annual temperature range by latitude, in degrees Celsius

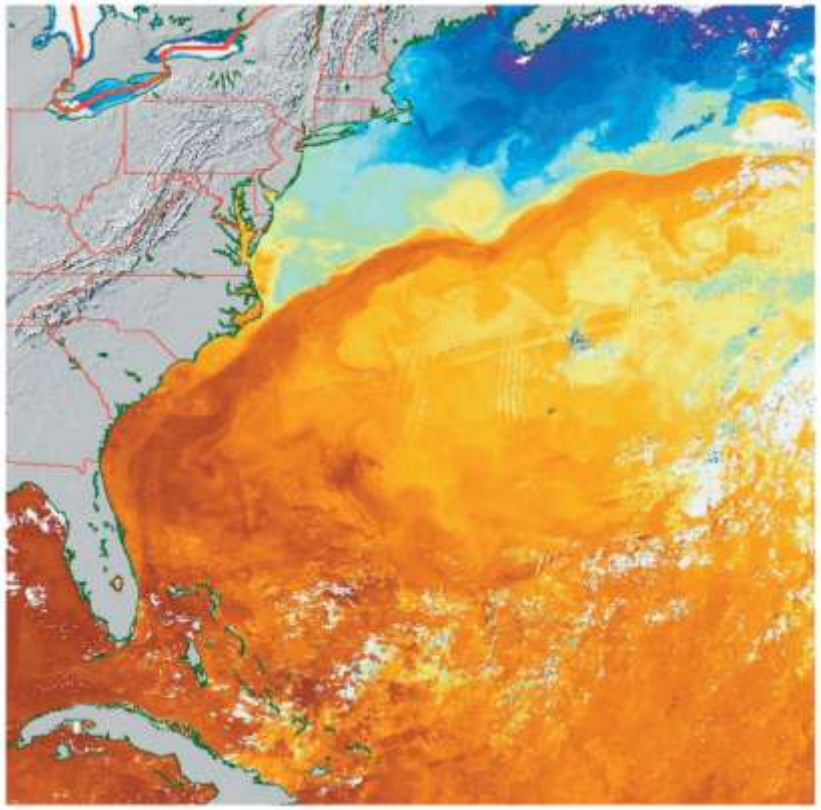
Latitude	Northern Hemisphere	Southern Hemisphere
0	0	0
15	3	4
30	13	7
45	23	6
60	30	11
75	32	26
90	40	31

Source: From Frederick K. Lutgens and Edward J. Tarbuck, *The Atmosphere: An Introduction to Meteorology*, 9th ed. (Upper Saddle River, NJ: Pearson-Prentice Hall, 2004), p. 71. Used by permission of Prentice Hall.

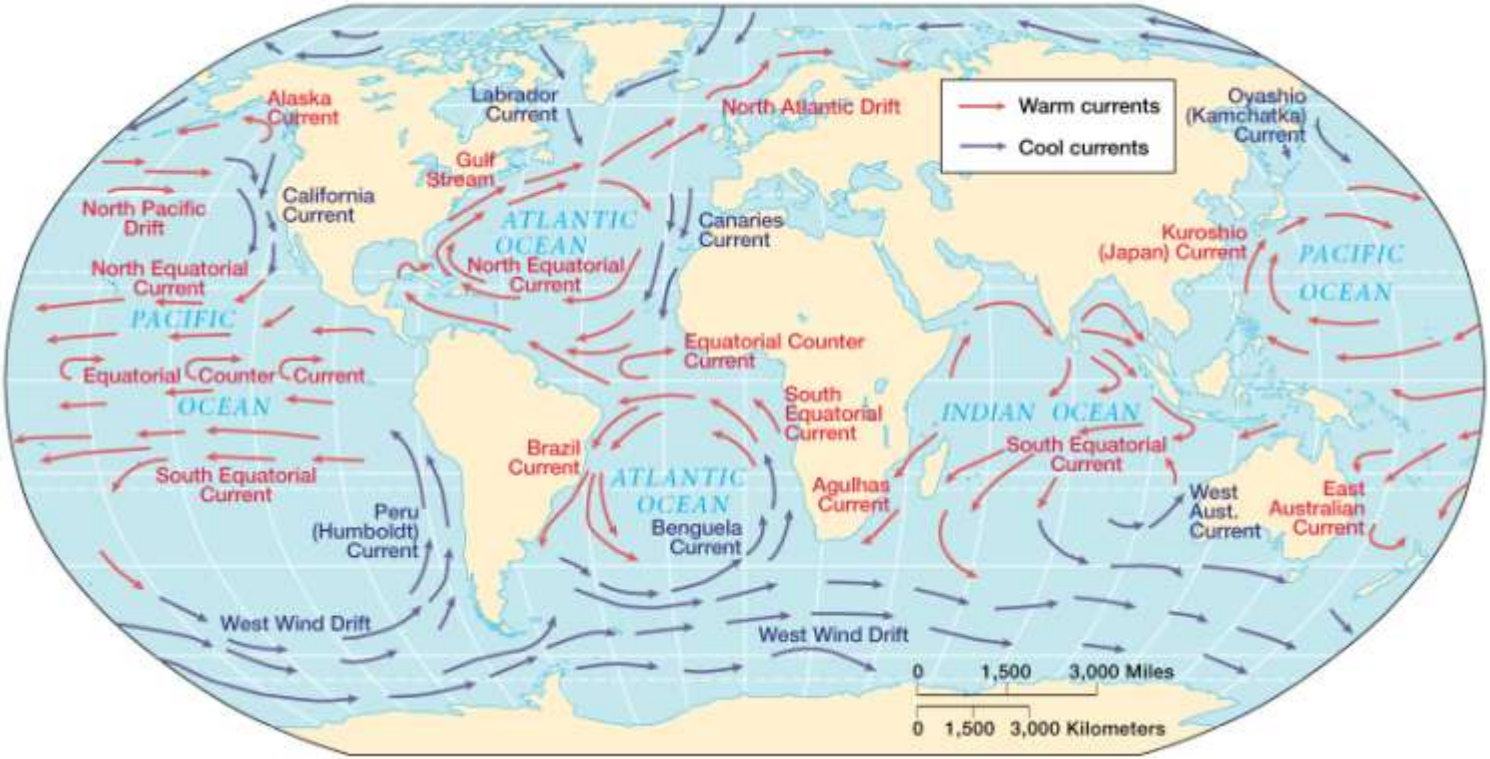
- Mechanisms of Heat Transfer

  Animation (Oceanic Circulation)

  – Gulf Stream



- Basic Pattern
  - Major Currents

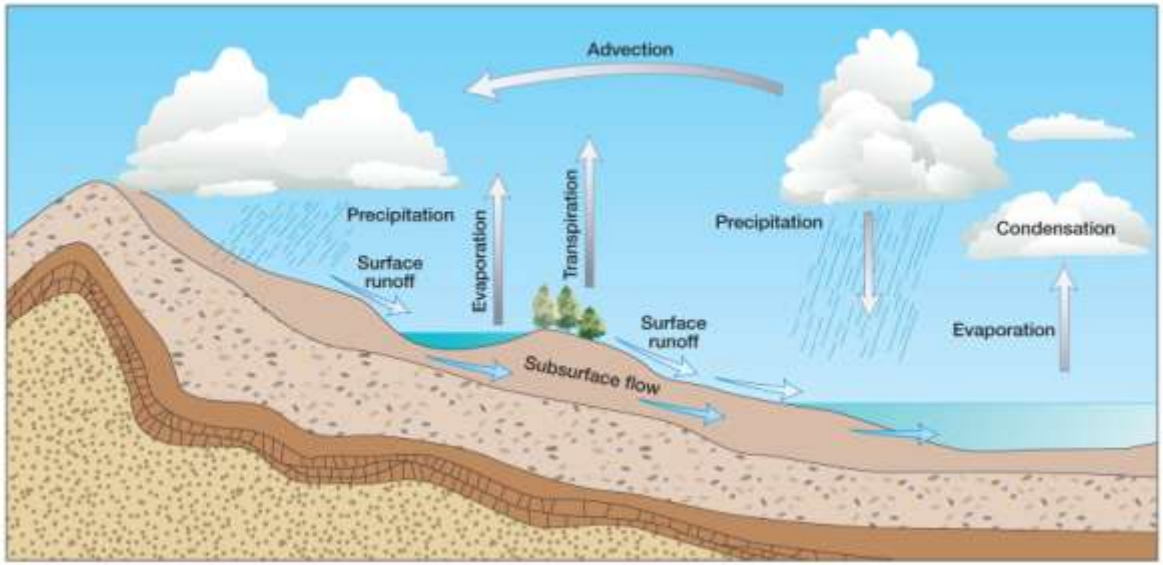


- Northern and Southern Variations
  - North Pacific versus North Atlantic
  - Antarctic Circumpolar Current (West Wind Drift)
- Temperatures of Currents
  - Low-latitude currents (warm)
  - Poleward-moving currents (warm)
  - Northern components of Northern Hemisphere
  - Southern components of Southern Hemisphere
  - Equatorial-moving currents (cool)

- Western Intensification
  - Western sides of oceans, middle latitudes, warm currents
    - Flow faster and are wider and deeper than counterpart cold currents on opposite side of oceans
  - Coriolis effect
    - Contributes to this phenomenon
  - Rounding out the Pattern
    - High Latitudes in the Northern Hemisphere
      - Cold water inflow from Arctic Sea
    - Coastal upwelling in middle latitudes on eastern sides of oceans
      - Nutrient-rich waters

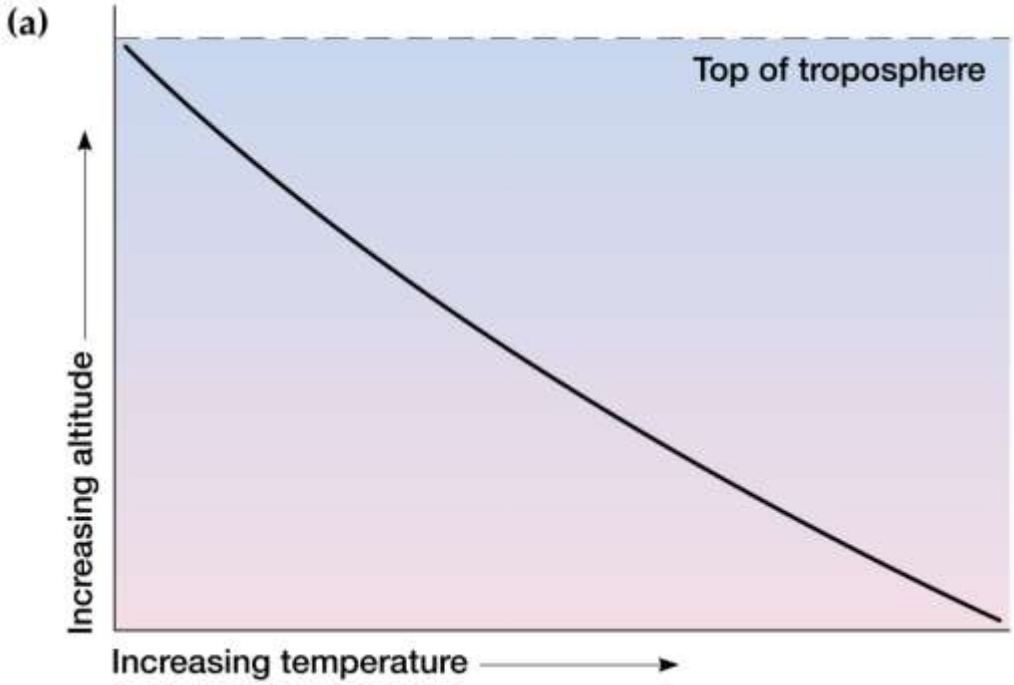
Global conveyor belt

- Deep-water ocean circulation pattern
- Tied to short-term climate change



Vertical Temperature Patterns

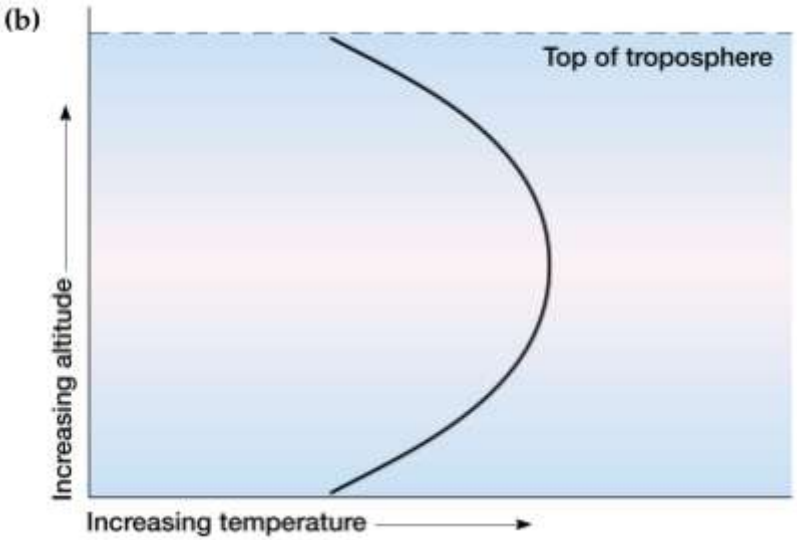
- Environmental Lapse Rate
- Average Lapse Rate

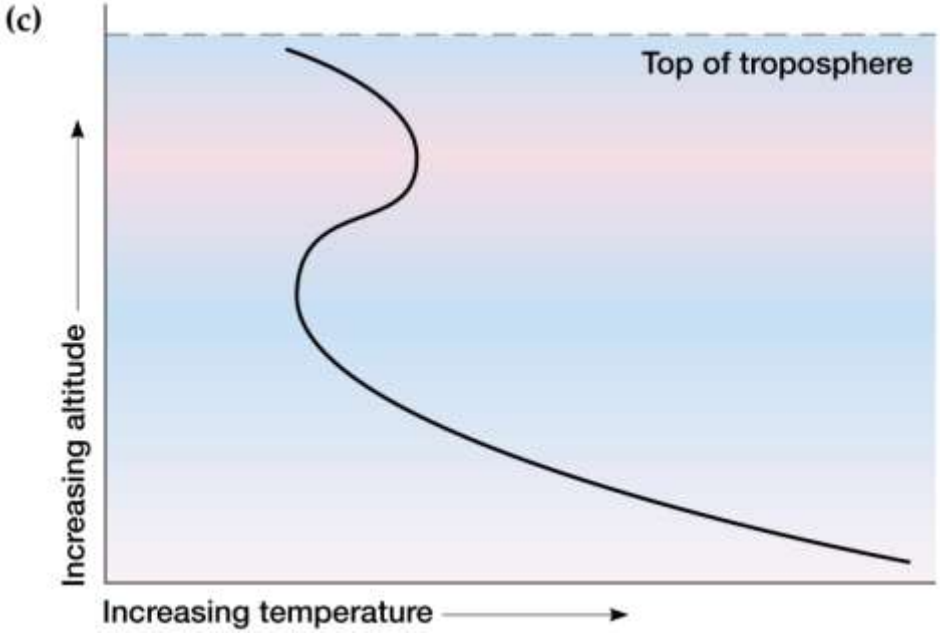


Temperature Inversions

- Surface Inversion

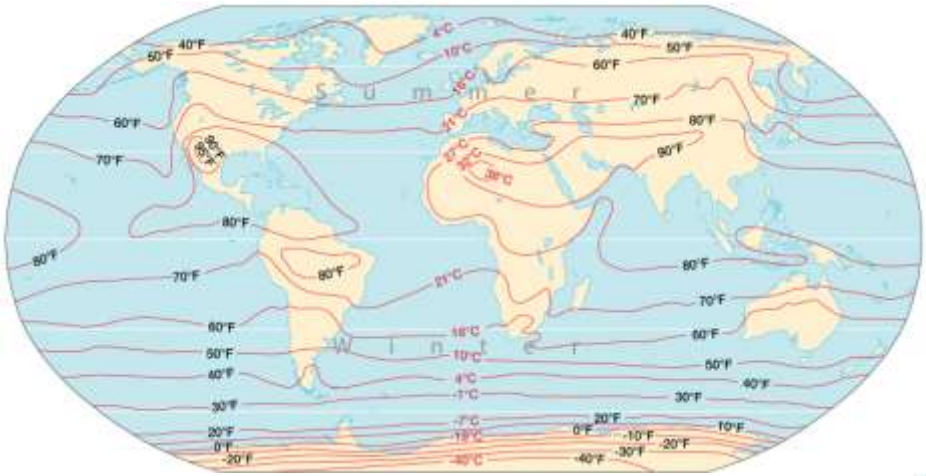
- Upper Air Inversion

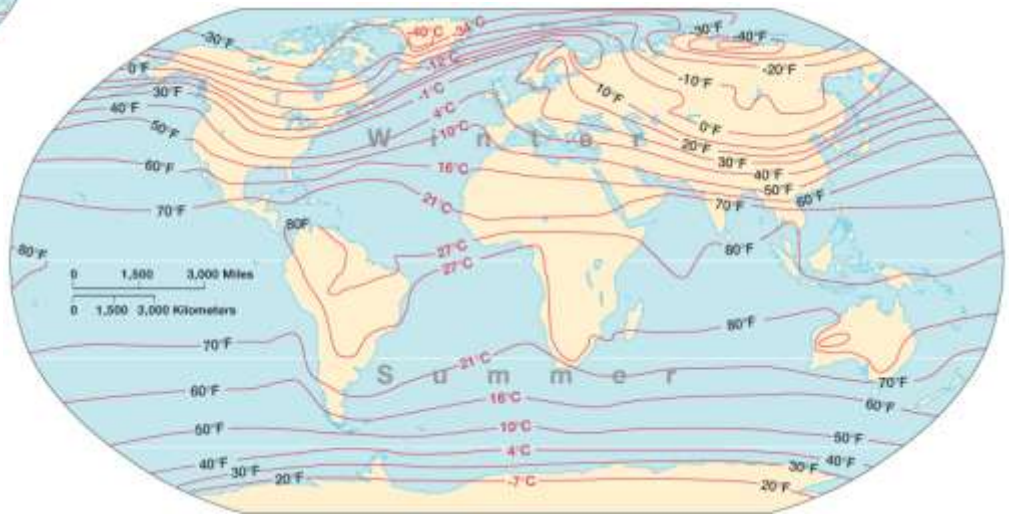




Global Temperature Patterns

- Prominent Controls of Temperature
  - Altitude
  - Latitude
  - Land-Water Contrasts
  - Ocean Currents



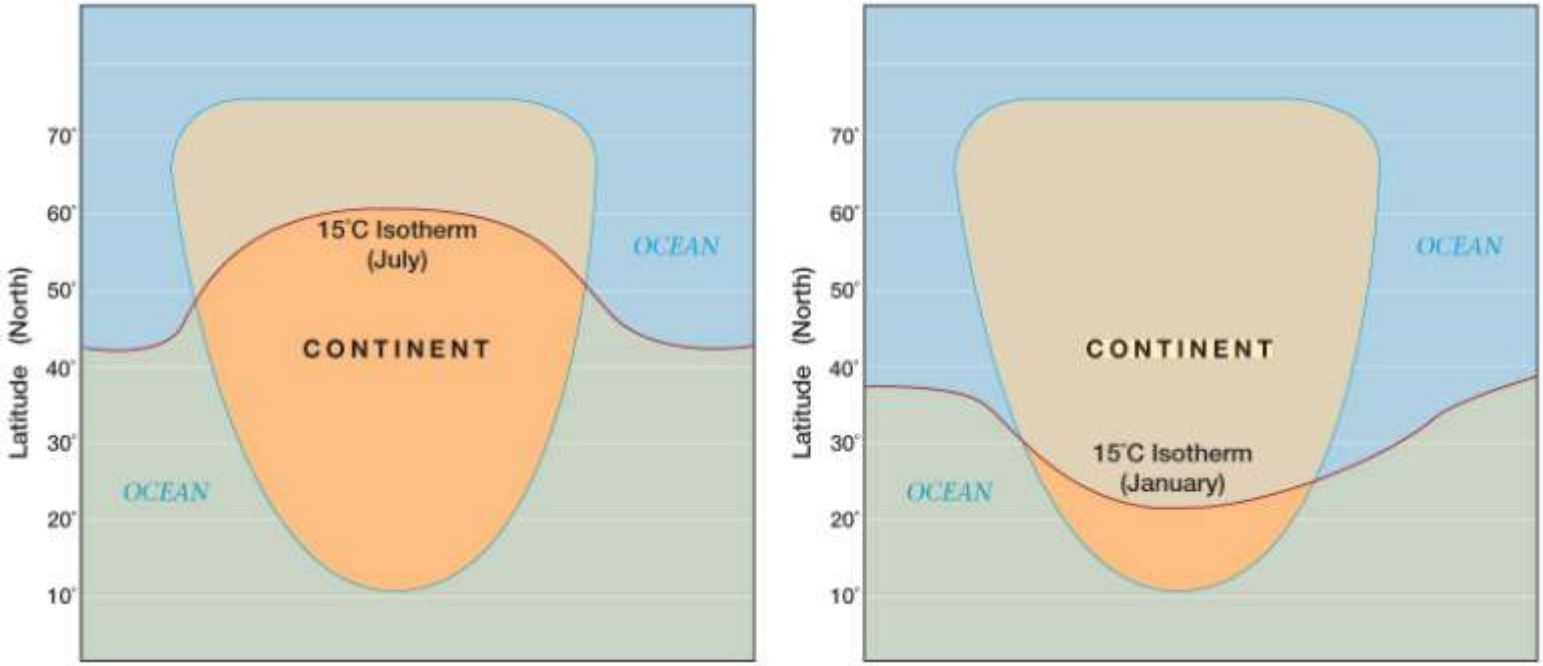


World Temperatures, July

January

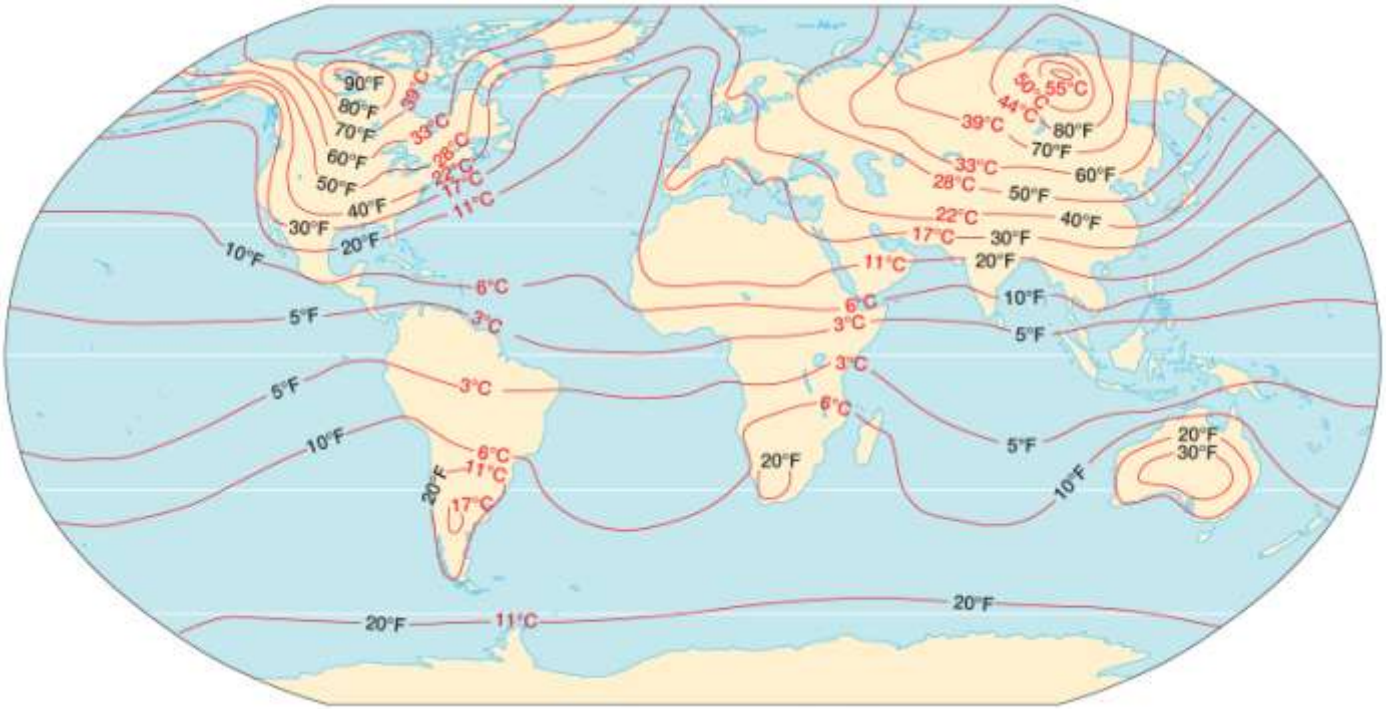
Seasonal Patterns

- Shift of isotherms



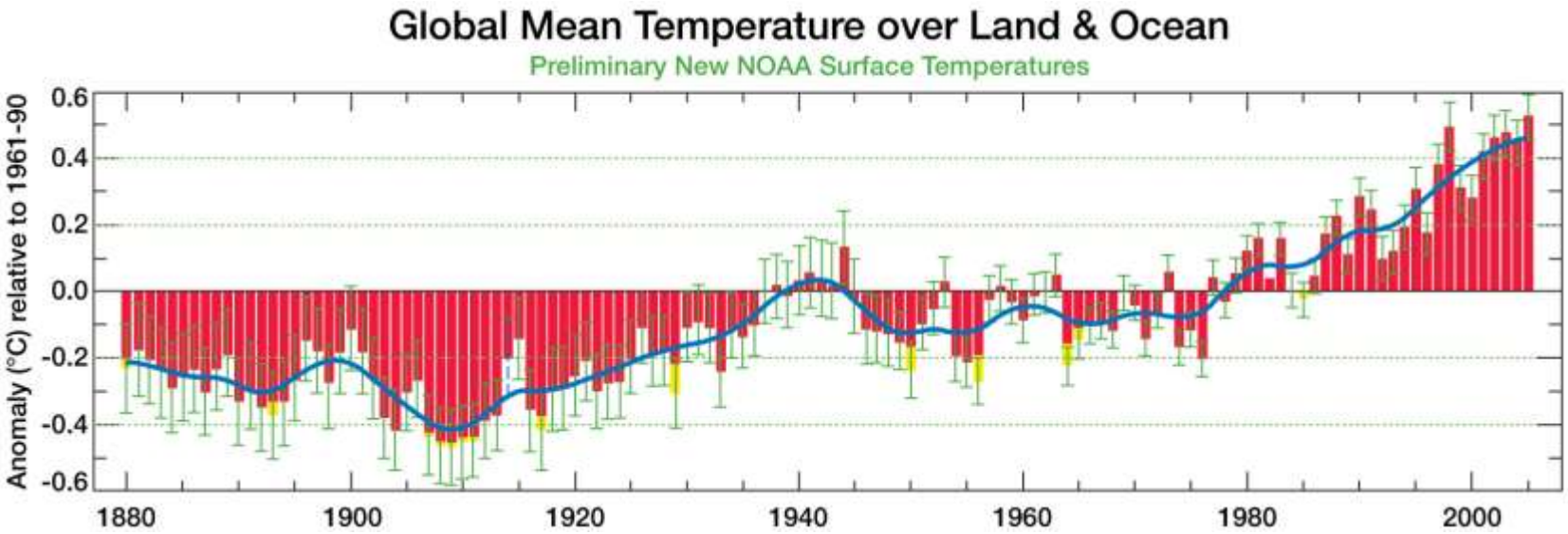
Annual Temperature Range

- Average Annual Temperature Range



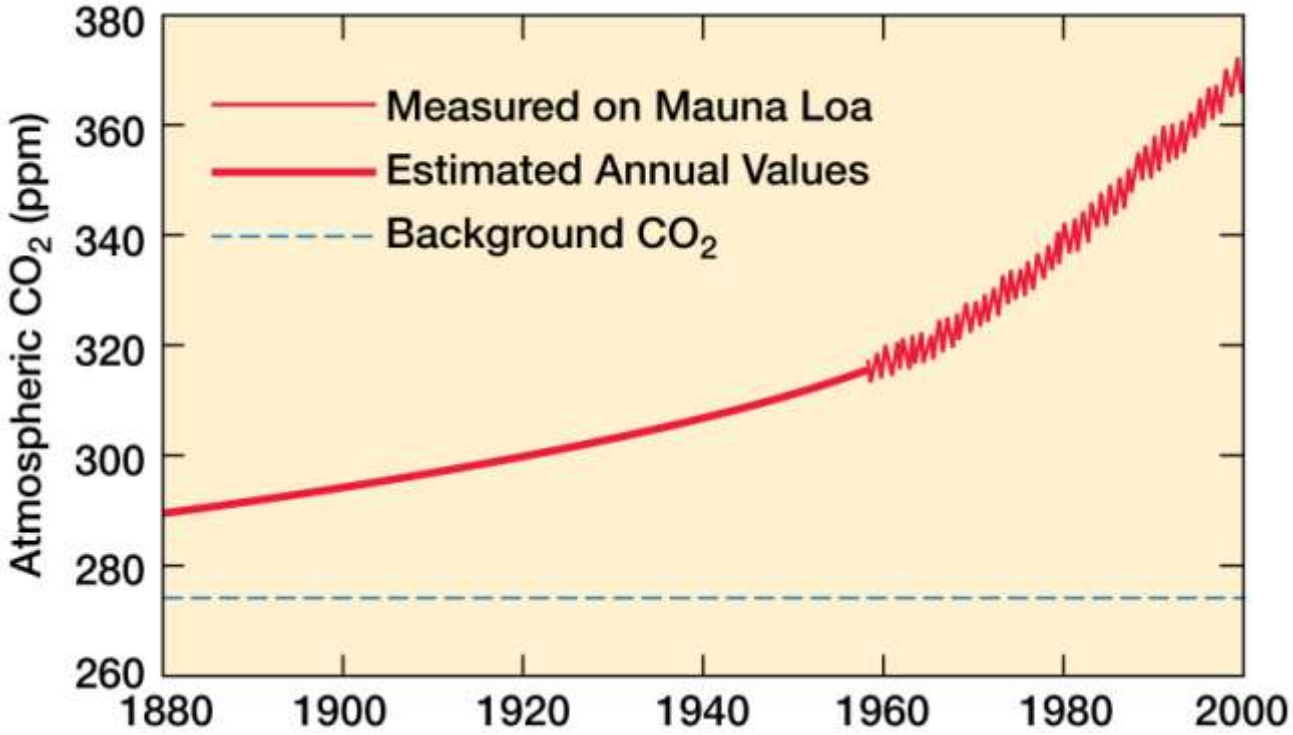
Global Warming and the Greenhouse Effect

- Warming facts:
  - 20th Century – 0.6ºC (1.0ºF) increase
  - Last quarter of 20th century – 0.2º to 0.3ºC (0.4ºF) increase

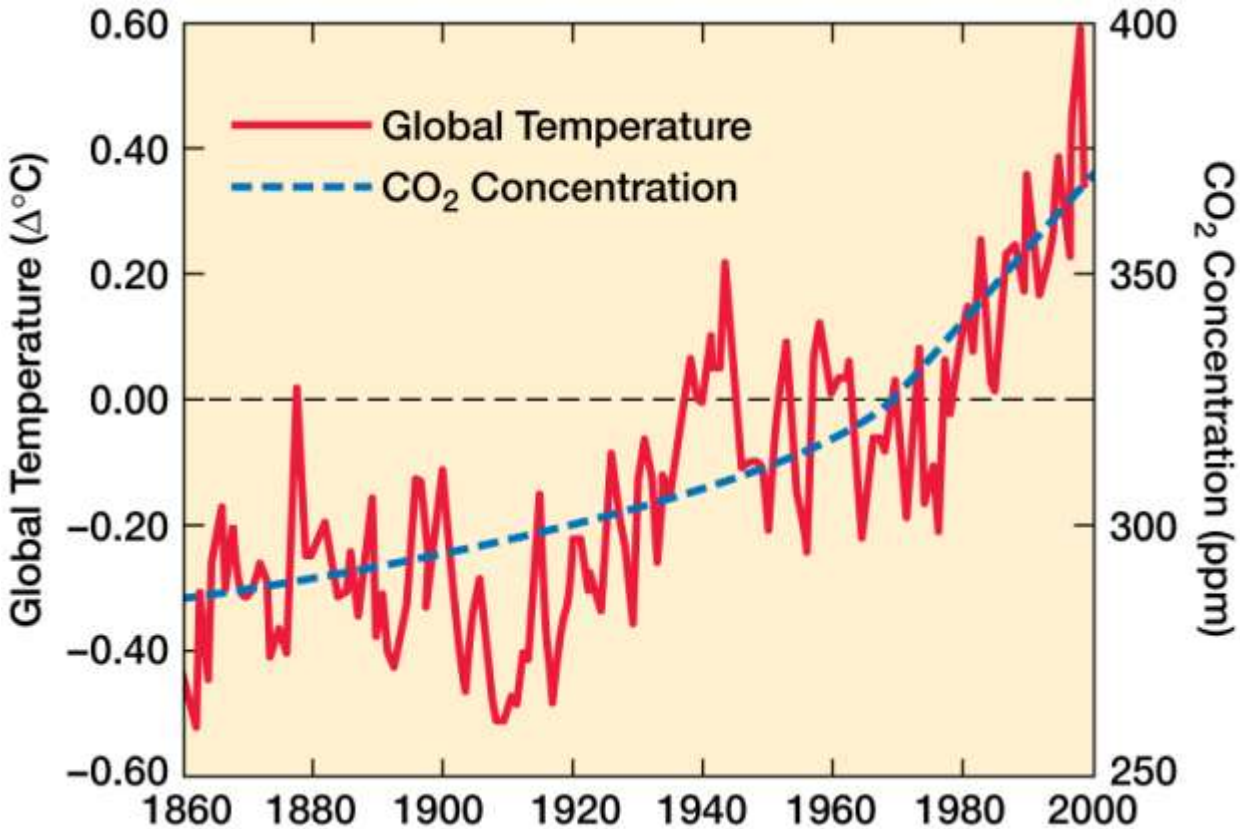


Carbon Dioxide (CO_2) is the main culprit

- Human activity increasing the amount in air



Change in atmospheric CO_2 concentration from 1880-2000



The relationship between atmospheric CO_2 concentration and mean global temperature

Other Greenhouse Gases

- Methane
- Nitrous Oxide
- Chlorofluorocarbons (CFCs)

– Animation (Global Warming)

Summary

- The Sun is the only important source of energy for Earth's atmosphere.
- Radiant energy flows as electromagnetic energy from the Sun and is mostly shortwave energy.
- Terrestrial energy is mostly long wave energy.
- That atmosphere is heated by many processes set in motion by the arrival of insolation.
- Any vertical movement of air produces adiabatic cooling or warming.

- About one half the insolation makes its way to Earth's surface.
- The insolation that reaches Earth's surface is absorbed and returned to the atmosphere as sensible heat (by means of conduction and convection) or as latent heat (by means of evaporation).
- Air over landmasses heats and cools faster and to a greater degree than over ocean areas, which means continents experience greater seasonal temperature variations than maritime climates do.

- Molecular collision produces heat.
- Temperature is an expression of the degree of hotness or coldness.
- There is a significant surplus of energy in the tropics, as the Sun is high in the sky in low latitudes. There is a corresponding deficit in polar regions.
- The general circulation of the atmosphere and the oceans functions to lessen the global imbalance between the tropics, and the poles transfer heat from the former to the latter.

- Generally, the temperature in the troposphere decreases with altitude. The most notable exception to this tendency involves temperature inversions.
- The worldwide temperature pattern is broadly controlled by several factors.
- The coldest places on Earth are over landmasses in high latitudes, whereas the warmest places are over subtropical continents.
- Global warming is occurring and it is likely to continue due to human activity. Scientists generally agree that the main culprit is human-generated carbon dioxide.