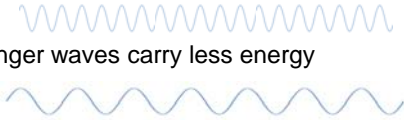


Radiation

- Energy that travels in the form of waves
- Waves release energy when absorbed by an object
 - Example: Sunlight warms your face without necessarily heating the air
- Shorter waves carry more energy
- Longer waves carry less energy

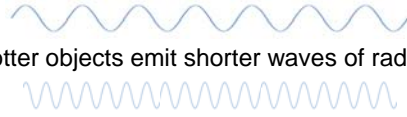


All objects emit radiation!

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All objects emit radiation

- Colder objects emit longer waves of radiation
- Hotter objects emit shorter waves of radiation
- The Sun is hot, so it emits shorter waves that happen to be visible light
 - “shortwave radiation”
 - Think about how a hot poker glows red
- The Earth is cooler, so it emits longer waves that are called infrared radiation
 - “longwave radiation”



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Earth's energy budget

R1

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Earth's energy budget

- Without an atmosphere, Earth's equilibrium temperature would be _____.
- But the average temperature of Earth is _____!

R2

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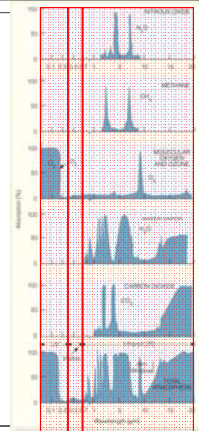
Greenhouse effect

- Earth's surface is warmed by incoming shortwave radiation
 - Earth emits longwave radiation upward toward the atmosphere
 - The atmosphere absorbs the longwave radiation and warms
- Gases such as water vapor (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) selectively absorb longwave radiation

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Absorption of Radiation by Gases in the Atmosphere

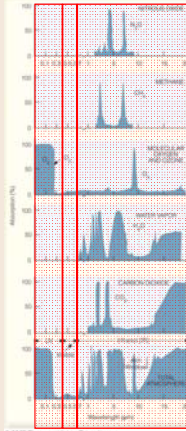
- Ultraviolet Radiation
- Visible Light
- Infrared Radiation



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Absorption of Radiation by Gases in the Atmosphere

- Ultraviolet Radiation
- Visible Light
- Infrared Radiation



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Greenhouse effect

- Gases selectively re-emit radiation; some radiation goes back to Earth's surface, warming it

R3

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Changing the energy budget

- The energy budget can be changed by adding clouds, H₂O vapor, CO₂, and other “greenhouse gases”
- **Positive feedback:**
 - An initial change in a process will **reinforce** the process
- **Negative feedback:**
 - An initial change in a process will **counteract** the process

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What will happen if we warm the Earth by adding greenhouse gases?

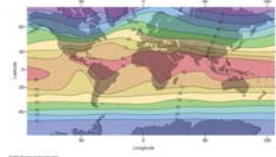
R4

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Global Temperatures

- Controls on climate:
 - intensity of sunshine and its variation with latitude
 - distribution of land and water
 - ocean currents
 - prevailing winds
 - location of high and low pressure areas
 - mountain barriers
 - elevation



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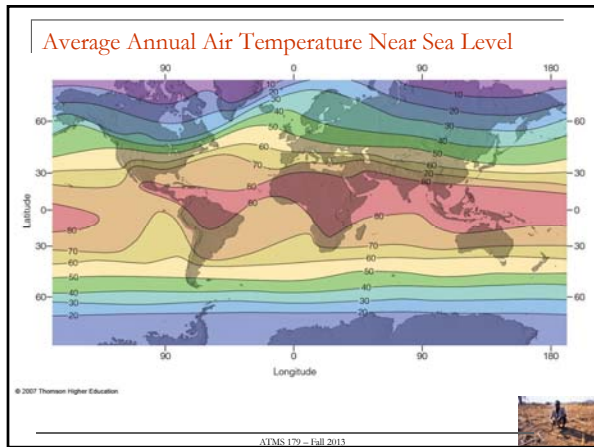
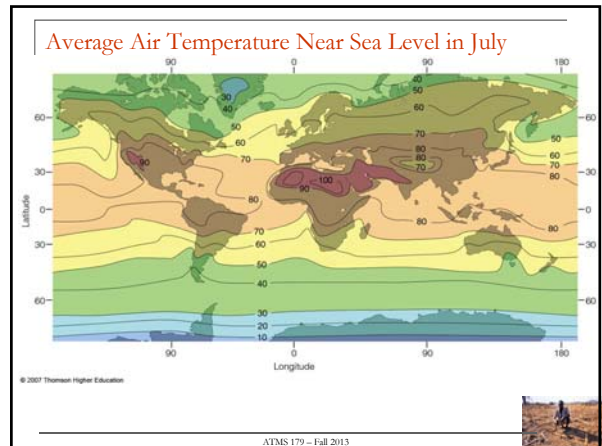
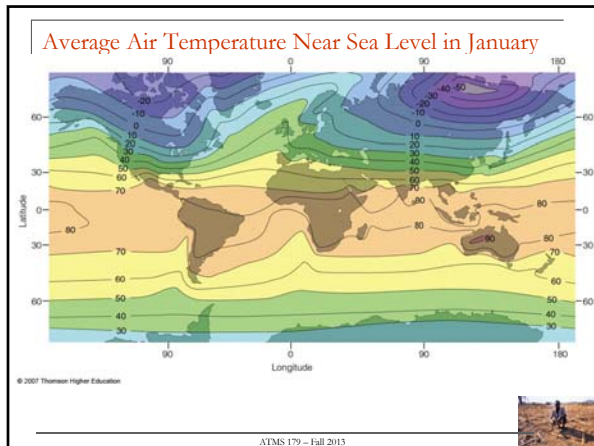


Elements that control the temperature

- 1) Latitude
 - It takes over 4 times as much energy to heat/cool water compared with land
- 2) Land and water distribution
- 3) Ocean currents
- 4) Elevation

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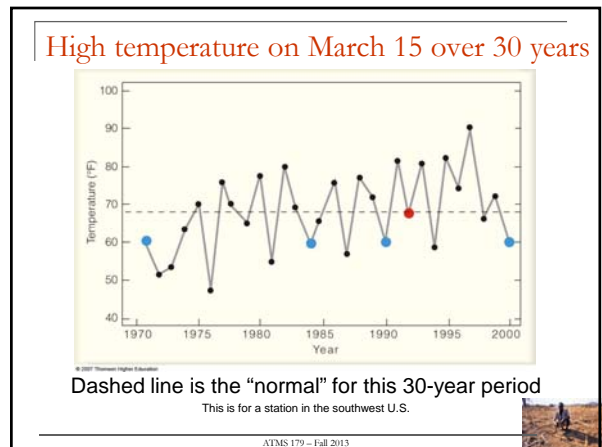
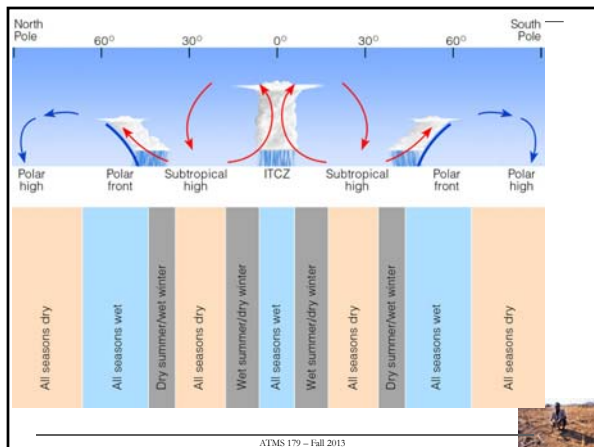
Global Precipitation

- Related to areas of rising and sinking air
- Influenced by location of Intertropical Convergence Zone (ITCZ)
- Influenced by topography (mountains)

***Precipitation is most abundant where air rises, and least abundant where it sinks.**

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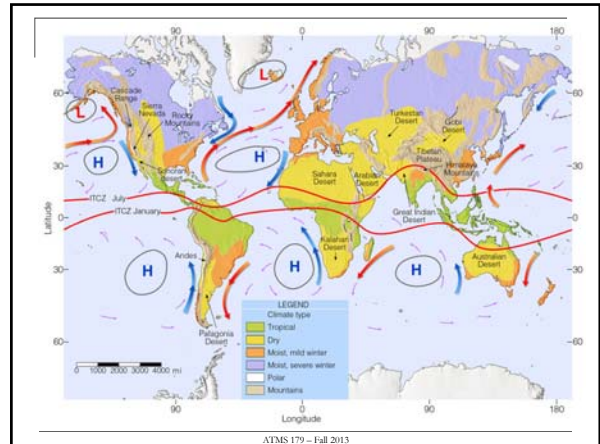


Climatic Classification – the Köppen System

- Regions are categorized by 5 major climatic types:
 - Tropical moist climates
 - Dry climates
 - Moist midlatitude climates with mild winters
 - Moist midlatitude climates with severe winters
 - Polar climates

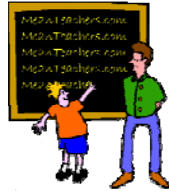
The Köppen climate classification system was first published in 1918.

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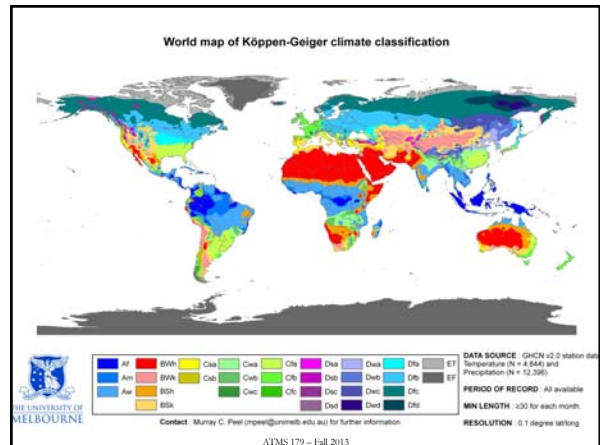
The Global Pattern of Climate

- You do not have to memorize the following climate classifications!
 - That would be mean...



- Instead, recognize that different areas have different climates
 - No two places experience exactly the same climate

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Tropical Moist Climates (Group A)

- Tropical Wet (Af)
 - Tropical rain forests
 - Few seasonal variations



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Tropical Moist Climates (Group A)

- Tropical monsoon (Am)
 - Similar to a tropical wet climate, but with a short dry season

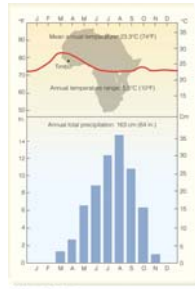


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Tropical Moist Climates (Group A)

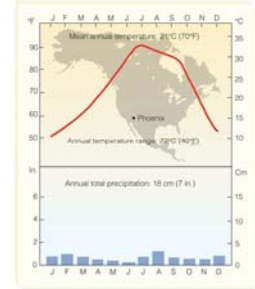
- Tropical wet-and-dry (Aw)
 - Distinct dry season



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Dry Climates (Group B)

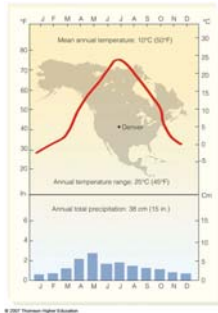
- Arid (BW)
 - Deserts – Very dry



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Dry Climates (Group B)

- Semi-arid (BS)
 - Steppes



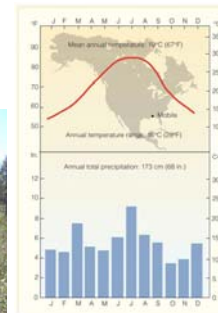
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Moist Subtropical Mid-Latitude Climates (Group C)

- Humid subtropical (Cfa)
 - Hot, muggy summers
 - Mild winters



Alabama



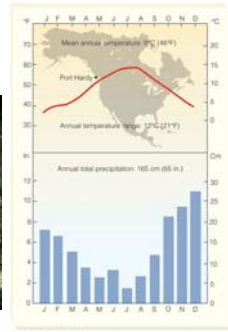
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Moist Subtropical Mid-Latitude Climates (Group C)

- Marine (Cfb)
 - Low clouds, fog, and drizzle



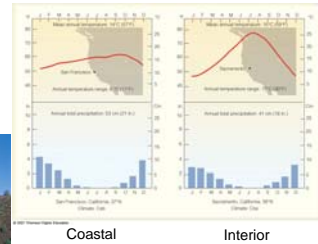
Coastal Washington (<http://www.nwhi.org/index/haabdescriptions>)



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Moist Subtropical Mid-Latitude Climates (Group C)

- Mediterranean (Cs)
 - Dry summers
 - Coastal
 - Low clouds
 - Fog
 - Interior: hot



Coastal

Interior

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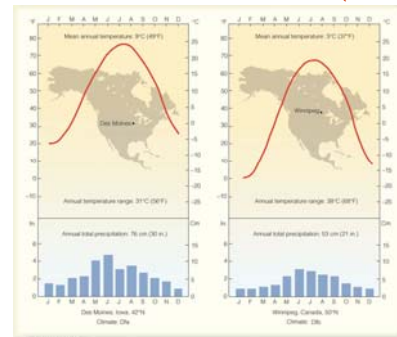
Moist Continental Climates (Group D)

- Humid continental with hot summers (Dfa)
- Humid continental with cool summers (Dfb)
- Cold winters (snowstorms)
- Climate controlled by location in interior of continent



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Moist Continental Climates (Group D)



Humid Continental Hot Summer Humid Continental Cool Summer

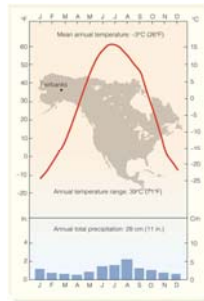
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Moist Continental Climates (Group D)

- Subpolar (Dfc)
 - Severe winters
 - Short and cool summers



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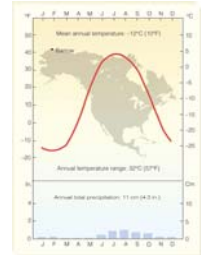


Polar Climates (Group E)

- Polar tundra (ET)
 - Year-round cold
 - Permafrost



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This climate is not necessarily found in polar regions; it is sometimes found at high elevations. There, however, it is called a highland climate (Group H).

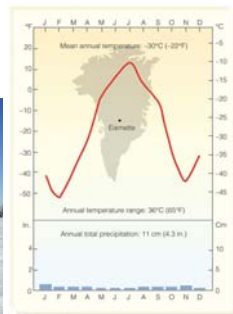
Polar Climates (Group E)

- Polar ice caps (EF)
 - Perpetual snow and ice
 - Plant growth is impossible



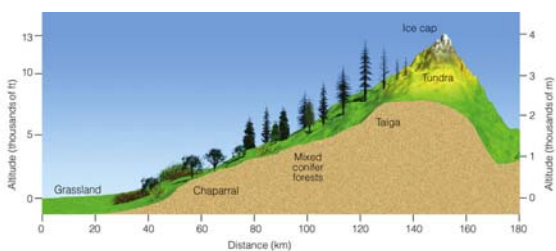
© Stephen Hudson (<http://students.washington.edu/sh13>)

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Highland Climates (Group H)

Elevation effects are similar to latitude effects



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