Today

1

- Weather and Climate
- Global Warming

Homework: Due by 5PM on 5/16/07

- Chapter 12 On-Line
  - •Multiple Choice, Identification and Critical Thinking
- Chapter 13 On-Line
  - •Multiple Choice, Identification and Critical Thinking

Backing Up… Stratosphere

- T constant to about 20 km
- T increases above that
- Ozone accumulates
  - Absorbs heat

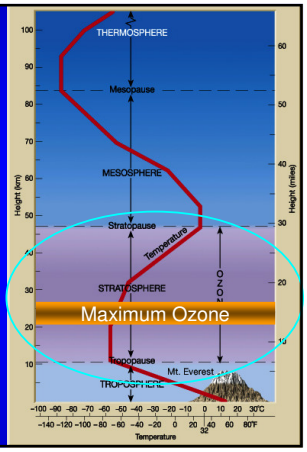
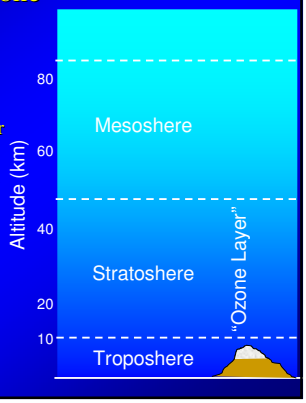


Figure 11.6

Ozone

3

- O_3
- Bad in lower atmosphere
  - Pollutant
  - < 1 part per million in lower atmosphere
- Good in upper atmosphere (6 to 30 miles high)
  - Absorbs Ultraviolet Radiation (UV)
  - Prevents Earth from getting too hot
  - Prevents us from getting skin cancer



Hole in the Ozone Layer

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- Chlorofluorocarbons (CFCs)
  - Stable in lower atmosphere
  - Break apart in upper atmosphere
  - React with O_3
  - Deplete O_3 in upper atmosphere

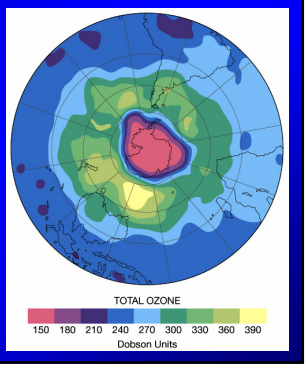

Figure 11.3

Ozone Depletion at South Pole

5

- CFCs introduced at northern mid-latitudes
- Mixed in air & carried to stratosphere
- Winds move the air toward poles
  - Nearly constant concentration in stratosphere
  - Small increase near cold poles
- At South Pole "polar stratospheric clouds" form (Low T)
- These clouds create chemical conditions that promote ozone destruction.
- No similar clouds at North Pole (oceans moderate T).

Seasons

6

- Sun Rays Striking Earth
- Axis tilted 23.5 degrees

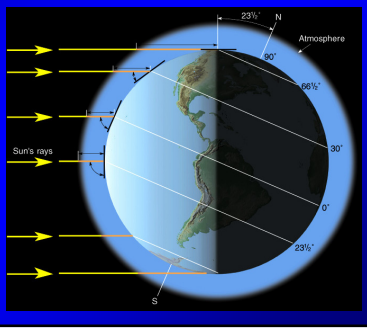

Figure 11.10

Higher angle gives more intense solar radiation

7

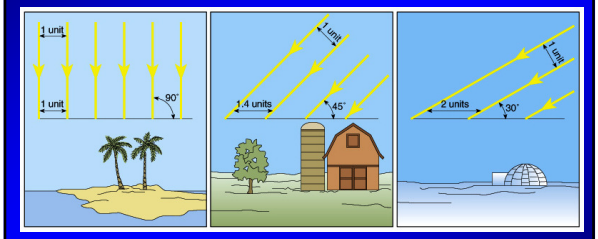

Figure 11.9

Earth-sun Orientation

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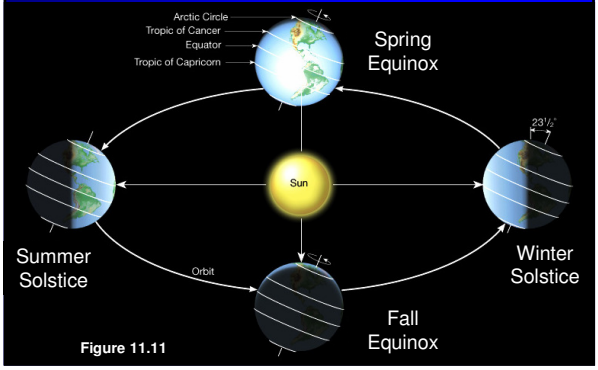

Figure 11.11

Solstices and Equinoxes

9

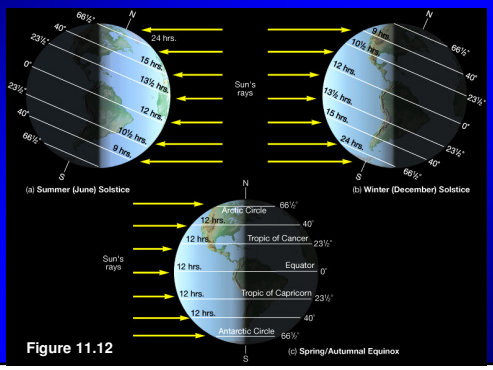

Figure 11.12

10

Why do you think the Equator is called the Equator?

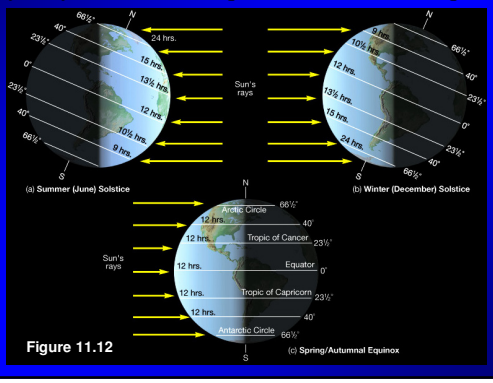

Figure 11.12

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Global Temperature - January

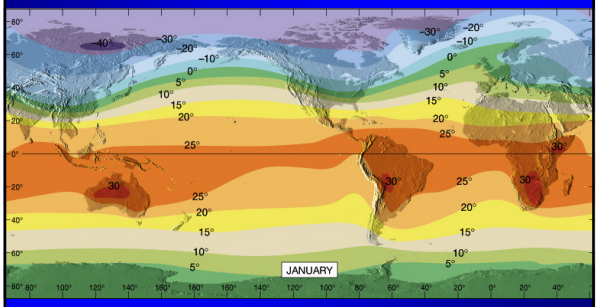

Figure 11.22

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Global Temperature - July

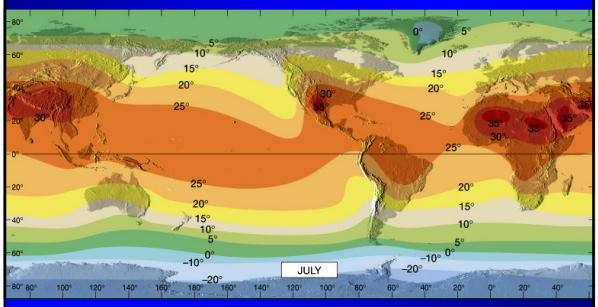

Figure 11.23

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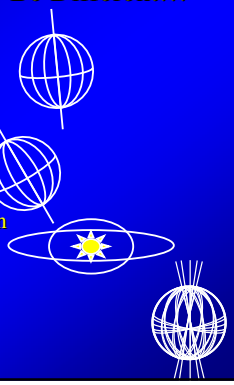
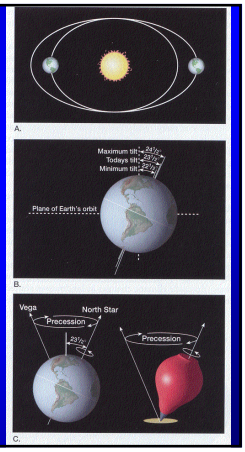
How Would Climate Be Different…

- If the tilt of Earth's axis was smaller?
- If the tilt of Earth's axis was larger?
- If Earth's orbit around the sun was more elongated?
- If Earth's axis wobbled (precessed) with time?



Causes of the Ice Ages

- Variations in eccentricity of Earth's orbit (~100,000 yr cycle)
- Changes in the tilt of Earth's axis (~41,000 yr cycle)
- Precession of Earth's axis (~26,000 yr cycle)
- Interaction = **Milankovitch Cycles**



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Milankovitch Cycles

- Can explain less than a few °C temperature variations.
  - Not Ice ages in last 14,000 years (Pleistocene)
  - Not warmer climate during age Mesozoic

CO2 and Temperature From Ice Cores

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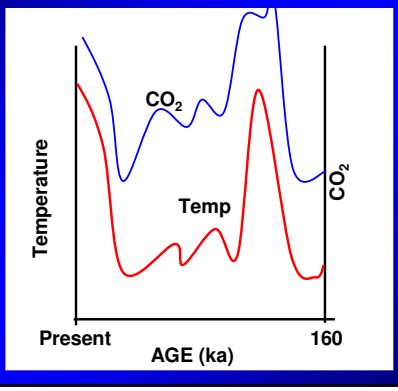

Incoming Solar Radiation

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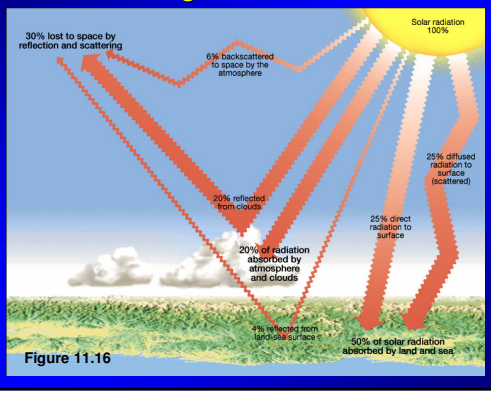

Figure 11.16

Greenhouse Effect

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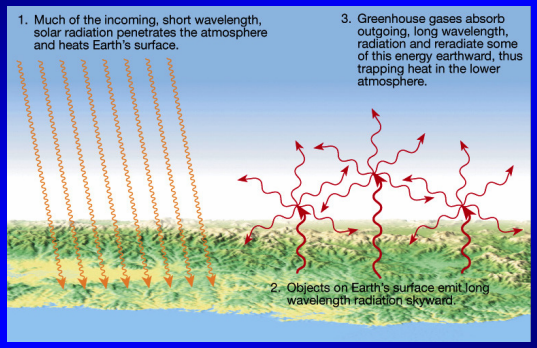

Figure 11.17

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Greenhouse Effect

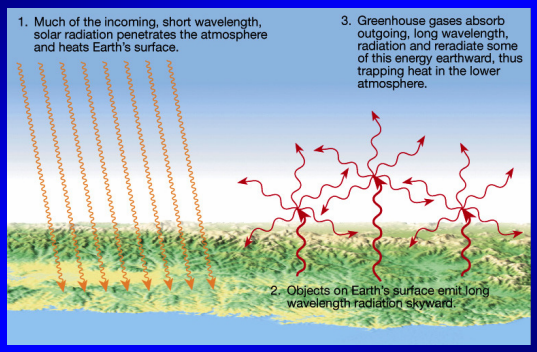

Figure 11.17

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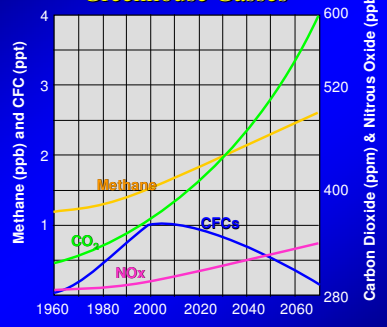
Past and Projected Abundances in Greenhouse Gasses



http://www.giss.nasa.gov/research/intro/shindell_02/

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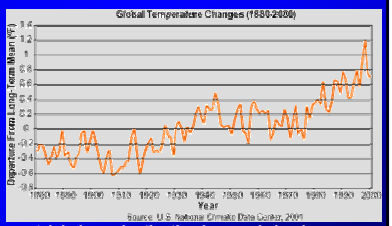
Global Warming 1880-2000

- > 1°F warmer now than in the 19th century
- Expected increase of 1 to 4.5 °F in next 50 years
  - Exceeds most rapid warming in Earth's history
- 20th century's 10 warmest years occurred between 1985 & 2000



http://www.epa.gov/globalwarming/faq/fundamentals.html

Current Global Warming Research

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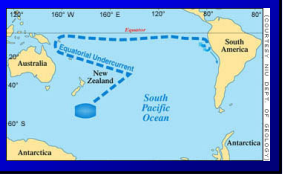
International Global Warming Conference At The Hague

- Soils
  - Will soils tend to absorb CO2 or release CO2 during warming?
    - Looks like release!
- Oceans
  - Will plankton growth increase and take up more CO2?
    - Maybe
    - But changing ocean currents may not take decaying material to ocean floor.
- Do human activities contribute to global warming?
  - Yes!
  - More important that natural factors



Projected Ozone Loss

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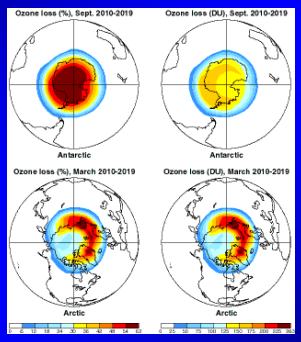

http://www.giss.nasa.gov/research/intro/shindell_02/

Consequences of Global Warming?

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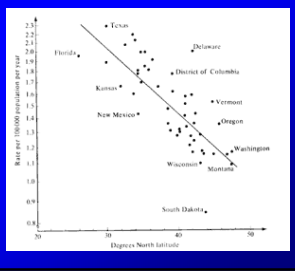
- Rising sea level
  - Sea level has risen 4 to 8 inches in the past century
  - Presently about 15 cm / 100 years

Consequences of Global Warming?

25

- Increased incidence of skin cancer



Consequences of Global Warming?

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- Destruction of tropical plant diversity
- Desertification of productive crop land
- Increased drought in some areas
- Increased flooding in some areas

Global Temperature

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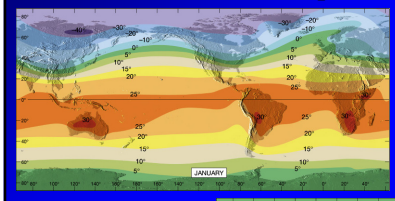

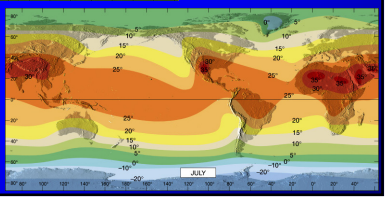

Figure 11.22 & 11.23

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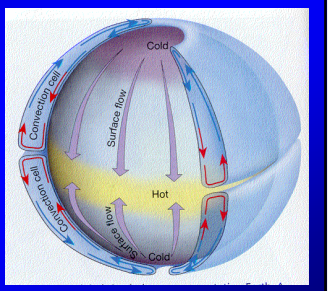
Convection in the Atmosphere

If Earth Didn't Spin

- Warm air at the equator rises
- Moves toward the poles
- Replaced by cool air sinking from the poles



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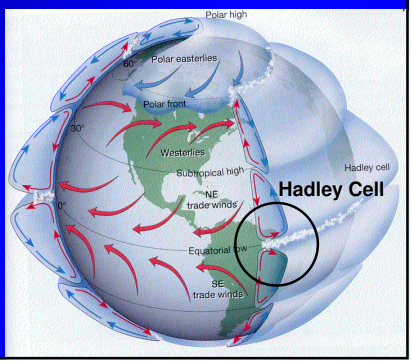
Global Circulation of the Atmosphere

- Convection combined with
  - Coriolis
  - Other dynamics



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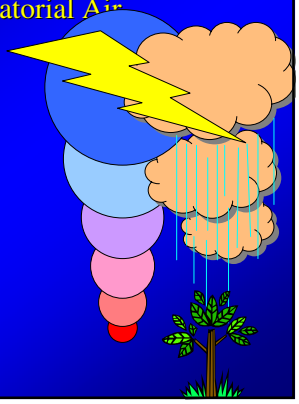
Rising Equatorial Air

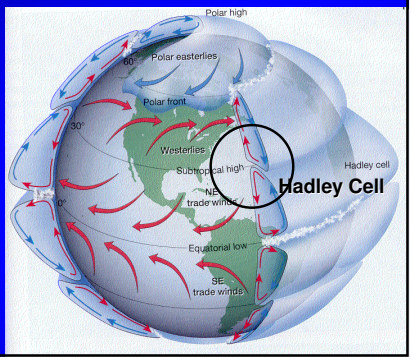
- Water Heats Air
- Hot air rises
- Expands as it rises
- Cools as it expands
  - Adiabatic cooling
- Cold air can't hold as much water
  - Rain



Global Circulation of the Atmosphere

31

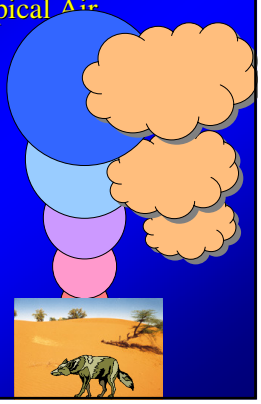
- Convection combined with
  - Coriolis
  - Other dynamics



Sinking Subtropical Air

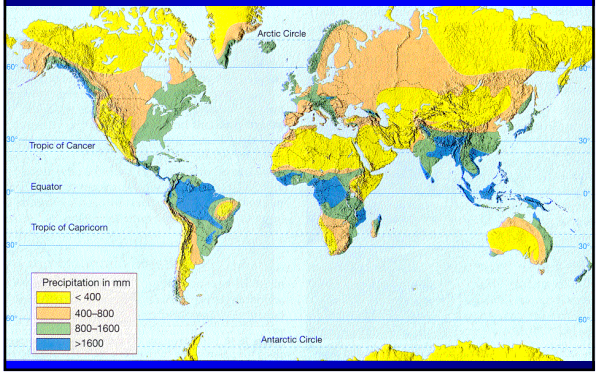
32

- Cool Air Sinks
- Compresses as it sinks
- Heats as it compresses
- Hot air can hold as more water
  - Less Rain



Average Precipitation Worldwide

33



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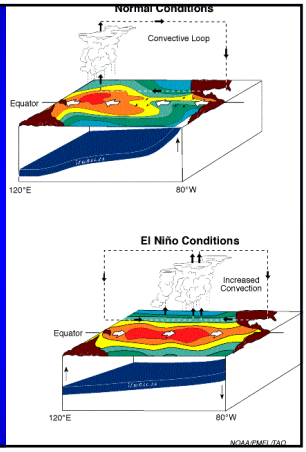
El Niño

- Warming of surface water in the equatorial Pacific
- Historically observed in December, near Christmas
  - By Peruvian Fisherman
  - El Niño
  - Associated with poor fishing years
- La Niña is cooling of sea surface temperature in equatorial Pacific

Circulation During El Niño



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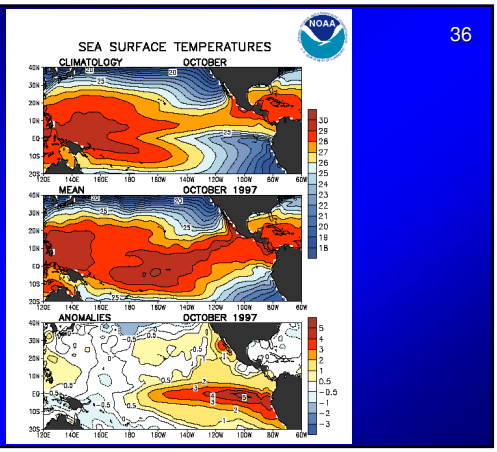

El Niño Impacts - Summer

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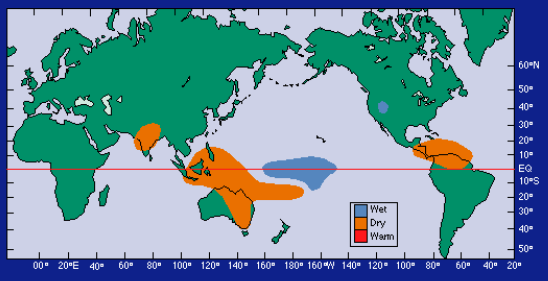
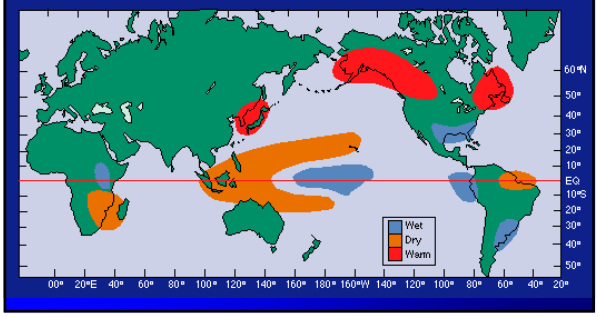
Northern Hemisphere Summer



El Niño Impacts - Winter

38

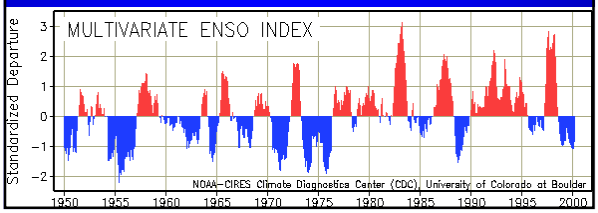
Northern Hemisphere Winter



El Niño Southern Oscillation (ENSO)

39

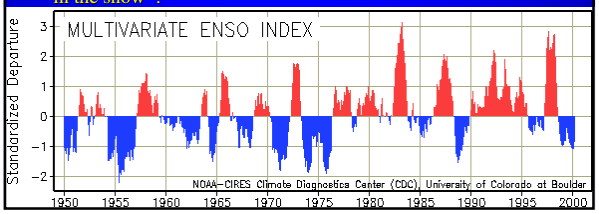
- Sea Surface Temperature (SST) varies periodically
- "ENSO Index" = statistic that captures average ENSO state
  - SST, Variations in Sea Level, Atmos Pressure,…



Trends in ENSO

40

- Describe trends in ENSO during last 50 years.
- During your life time have you seen mostly El Niño Year or La Niña Years?
- Which tend to last longer, El Niño or La Niña?
  - How long do they typically last?
- What are we in currently?
- Is it possible that your father really did "walk 5 miles to school in the snow"?



El Niño Winter Precipitation

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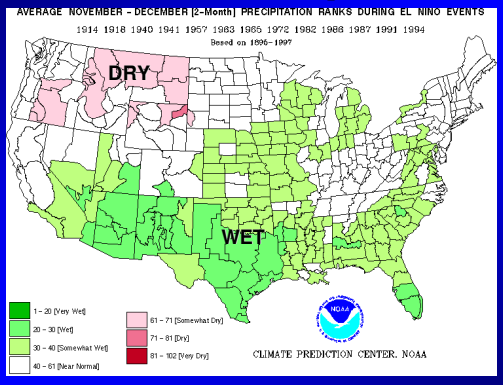
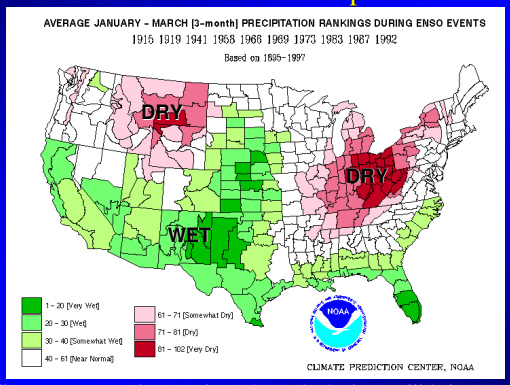


http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/dist/ca_bar.html

El Niño Jan-March Precipitation

42



http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/dist/ca_bar.html

Current Conditions

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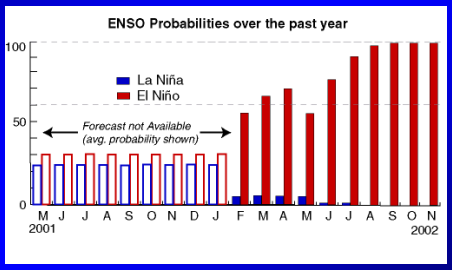
- Entering an El Niño winter



Plan for an El Niño Winter

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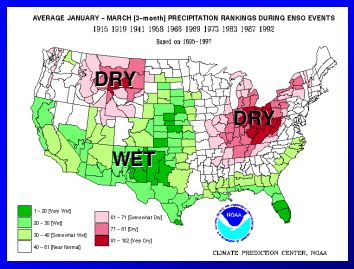
- What could (or should) you do knowing that we are entering an El Niño winter?



Water in the Atmosphere

45

- 0 to 4% of atmosphere
- Critically important
  - Absorbs heat
  - Releases heat
  - Holds heat
  - Distributes heat
- Regulates Earth's temperature

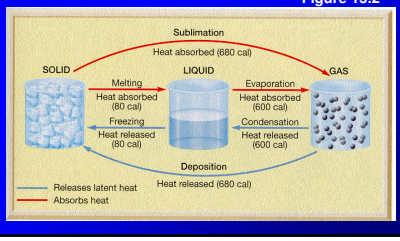
Absorption and Release of Heat From Water

46

(or, Why it is important to sweat)

- Evaporation absorbs heat
  - Cools the surrounding environment
- Condensation releases heat
  - Warming the surrounding environment
- Melting absorbs heat
- Freezing releases heat

Figure 15.2



Heat and Temperature

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- What is Heat?
  - Energy
  - Total kinetic energy of atoms and molecules
- What is Temperature?
  - A measure of average energy of individual molecules
  - Depends on substance
    - Some allow molecules to move more easily

Demo

Heat Transfer

48

- Conduction
  - Direct transfer of energy from one molecule to the next
    - By bouncing
- Convection
  - Heated molecules carried by moving fluid
- Radiation
  - Transfer of energy through "energy waves"
    - Moving molecules put some of there energy into wave energy
    - Travels through space (no direct transfer required)
    - Hits new molecules to heat them up

3 Demos

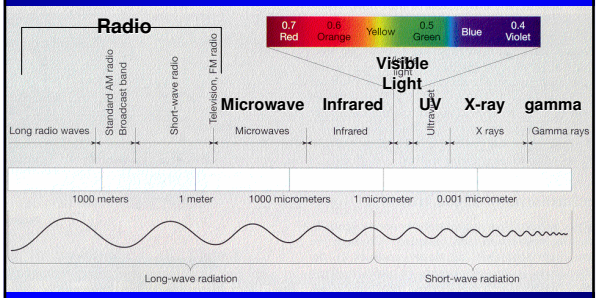
What type of heat transfer is taking place in each of the following?

49

- You accidentally touch the rack in your hot oven.
- You burn your self when you put your hand under hot running water.
- You get hot when you sun bathe.
- You feel the heat of a stove burner when you place your hand 5 inches above it.

Types of Radiation

50



Ocean Water Deep Circulation Pattern

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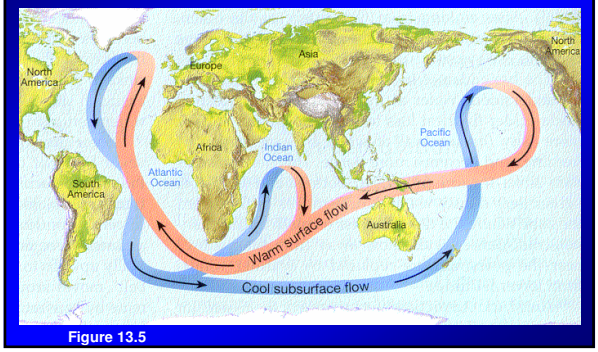

Figure 13.5

Ocean Circulation

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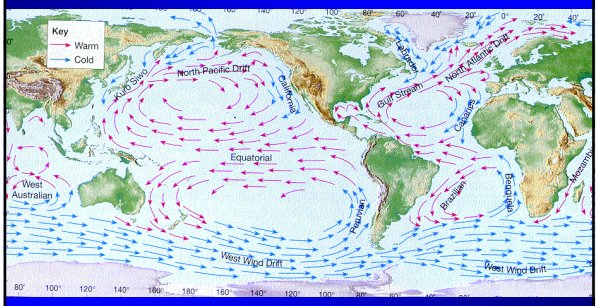
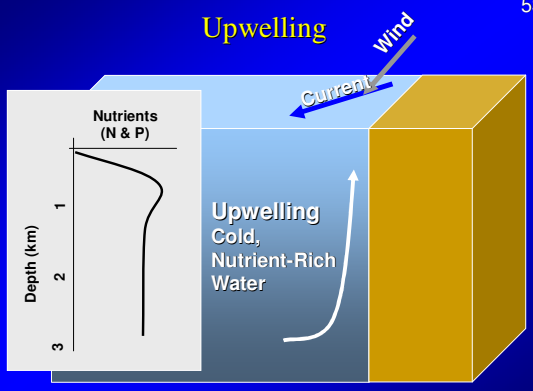


Figure 13.2

Upwelling

53



El Ni™o

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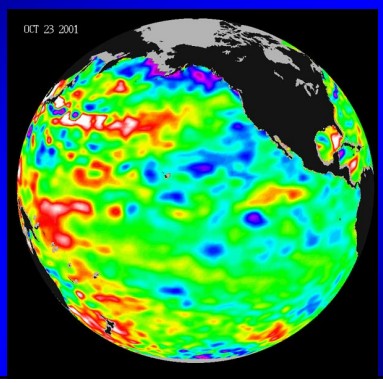
- Historically observed in December, near Christmas
  - By Peruvian Fisherman
  - El Ni™o
  - Associated with poor fishing years
- La Ni™a is cooling of sea surface temperature in equatorial Pacific

55

Current El Ni™o Conditions



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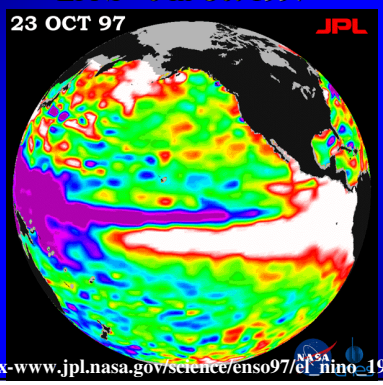
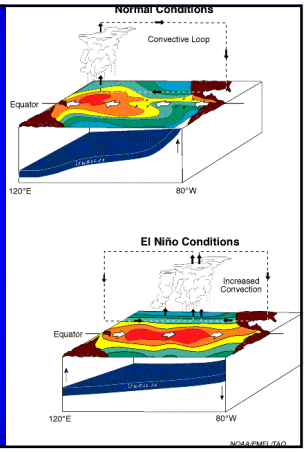
El Ni™o in Oct 1997



http://topex-www.jpl.nasa.gov/science/enso97/el_nino_1997.html

Circulation During El Ni™o



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Clouds moderate daily temperature changes

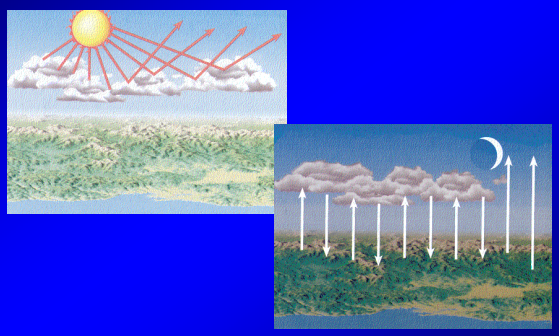

Figure 14.22