SURFACE CIRCULATION  (cont’d)

El Niño/LaNiña cycles
= ENSO

Review:  H and L pressure zones and winds
Prevailing winds (Trades, Westerlies, Polar Easterlies) drive surface currents
Rising/sinking air masses and H and L pressure zones alter the basic pattern of these winds
  Example:  Continents in summer are warm, create semi-permanent LOW pressure, so the winds tend to be from the ocean to the continent
  -- Convection cells

**El Niño / Southern Oscillation (ENSO): Intro**

*• Major change in both ocean and air currents(EQUATORIAL PACIFIC)*
*• Happens every 3(?) to 7 years*
*• The system oscillates back and forth*
  *o El Niño conditions occur in some years*
  *o La Niña conditions in some other years*
  *o Normal conditions in the rest*

**Normal Conditions:**
1. Seasonal High Pressure over Tropical E. Pacific “Easter Island High”
2. Seasonal Low Pressure over Equatorial W. Pacific “Indonesian Low”
3. Winds blow from high to low pressure
4. In this case, this enhances the Trade Winds
5. These winds push warm water toward Indonesia
6. This warm water enhances the “Indonesian Low”
We also observe:
  *• Cool surface waters and upwelling on American side*
    *o Huge fish harvest- Peru*
  *• Tilting of sea surface -- higher on Asian side*
  *• Tilting of thermocline (= temperature dropoff) higher on American side*
  See figures in textbook.

**El Niño conditions:**
Something triggers a breakdown of the normal conditions.  One way of viewing this is:
1. Warm water mounded up in W. Pacific begins to “slosh” eastward
2. This moves the Indonesian low eastward and weakens Easter Island High
3. This weakens the trade winds
4. This weakens westward ocean currents
5. Back to Step 1 above (a viscous circle)

**IMPORTANT: Feedback: Interaction and complexity in natural processes**

*• Two process affect each other, changes in one “feed back” and affect the other*
*• The feedback may amplify changes (positive feedback)*
*• Thus, a small change may be amplified into a large one.....a “Viscious Circle”*
This is a **positive feedback** situation; change in the ocean causes a change in the atmosphere which in turn increases the changes in the ocean, which in turn increases the changes in the atmosphere, and so on...

- Leads to oscillations; conditions fluctuate back and forth
- Small changes can be amplified into much larger ones
- Interrelationships like these make it very hard to predict many natural phenomena on our earth
  - El Niño
  - Other aspects of weather
  - Fish and wolf population
  - Ice age cycles
- Complex behavior: Oscillations, “chaos”
- Yet, we CAN understand these phenomena if we learn more about the system, and how the feedback occurs
- e.g., recent El Niño predictions are better (still not perfect)

**Local Effects of El Niño events (W. Coast of S. America)**

- Upwelling ceases
  - No westward water movement to cause it
  - Big effect on marine life -- Reductions in...
    - Nutrient supply
    - Phytoplankton productivity
    - Population of fish (anchovies) and fish-eating birds.
- Rainy conditions, sometimes flooding

**Global weather changes** observed during an El Niño year include:

- Droughts (summer) -- monsoon conditions are blocked:
  SE Asia, India, Australia, Africa
- Heavy rainfall and storms:
  Gulf Coast and California (winter)
- Warm winters:
  Alaska, Western Canada, Northern USA

**Example: 1997-98 El Niño**

- Increase in surface water temperatures off S.Am.: 5 deg C
- Possibly the most powerful El Niño system in 150 years. (equal to 1982-1983?)
- Winter weather as predicted: wet and stormy in the southwest USA, Texas, and most of the Gulf Coast

Extra Notes on Feedback and oscillations:

Feedback and Oscillations. The El Niño phenomenon oscillates, that is, it occurs, dies out, and eventually builds up again every few years. Why? Because it is really two processes, one oceanic, the other atmospheric, that depend on each other. An El Niño develops as follows:

1. Warm surface water develops off the coasts of Peru and Ecuador
2. This causes atmospheric pressure decreases in Eastern Pacific
3. This causes the trade winds to weaken, especially in the East Pacific
4. This causes less effective westward transport by Trade Winds
5. This causes greater migration of warm waters eastward (feedback loop connecting to 1. above)

This is a positive feedback situation; change in the ocean causes a change in the atmosphere which in turn increases the changes in the ocean, which in turn increases the changes in the atmosphere, and so on... Each change is amplified by the response or "feedback" from the other process. Eventually, the El Niño stops increasing and dissipates because of other processes (note that once it starts to die out, feedback is again important- decreases lead to more decreases) This leads to oscillations: conditions fluctuate back and forth. The El Niño is triggered somehow, grows because of the feedback/amplification, then dies out.

Many natural phenomena on the earth are like this; complex interrelationships make it possible for small changes to grow into much larger ones. These interrelationships make it difficult to predict or understand many natural phenomena on our earth, such as El Niño, other aspects of our weather, global warming (i.e., the greenhouse effect), and ice ages.