3/26/08

**GEOL 117 Notes 26**
**El Niño as an example of a complex system: Feedback and Oscillations**

**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 ElNiño 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

3/26/08

**Other Ocean/Atmosphere Oscillations**

It appears there are other, less dramatic oscillations in the ocean/atmosphere system.

Not surprising: Any system that has two or more parts connected in a positive feedback loop is likely to oscillate.

Meteorologists and Oceanographers team up to study these hypothesized oscillations:

Pacific Decadal Oscillation: 20 to 30 year cycle, affects temp. in the US

Similar to ENSO, but weaker. Affects water off west coast of USA

North Atlantic Oscillation: shorter cycle, not very consistent/predictable

Affects H and L pressure zones in North Atlantic

Influences European weather somewhat

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.