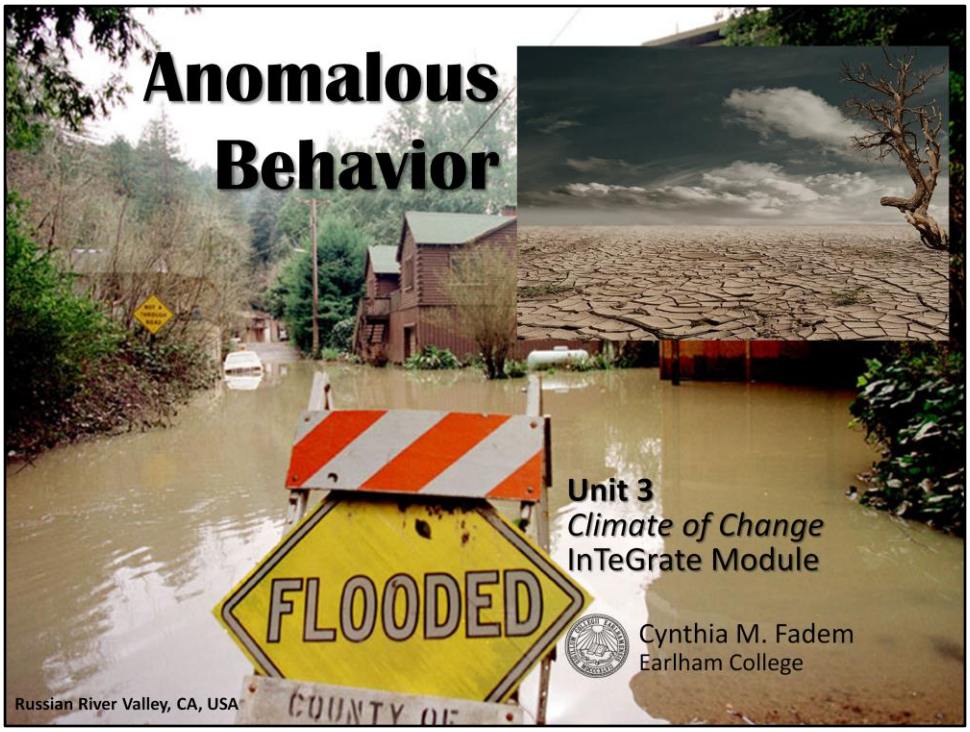
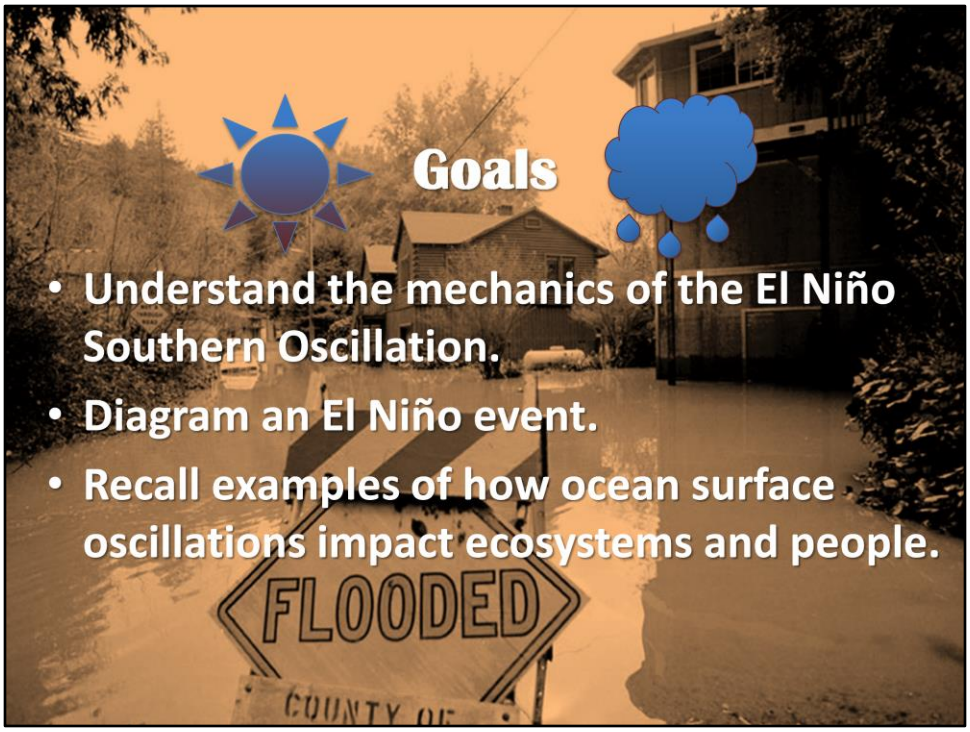
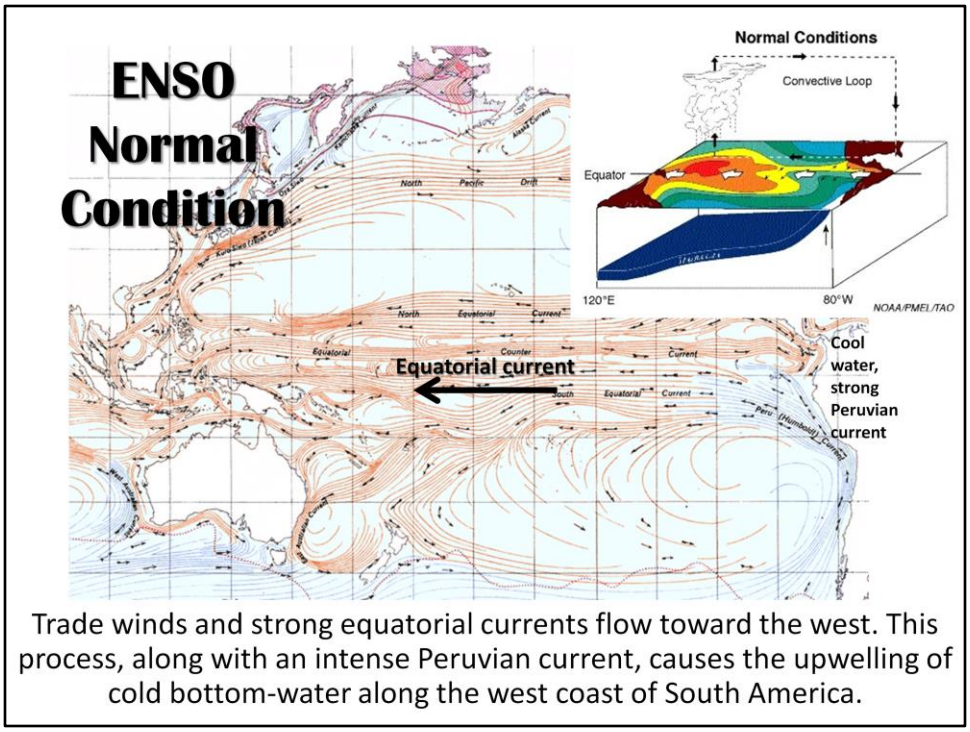


I use the stories represented by the background images to introduce the lecture affectively. These in particular demonstrate dramatically the diversity of surface ocean oscillation impacts and the necessity of understanding these phenomena. You can find these stories using the links below.

Image to left: El Nino Rains Overflow River - El Nino storms flood the Russian River in California in March, 1998.
Credit: Dave Gatley/FEMA
Source: http://www.nasa.gov/vision/earth/environment/elnino_rainchange.html, last accessed 15 July 12.

Image right: Drought conditions.
Source: http://pixabay.com/static/uploads/photo/2014/03/05/21/12/desert-279862_640.jpg You can freely use any Pixabay image without attribution in digital and printed form, even for commercial applications.

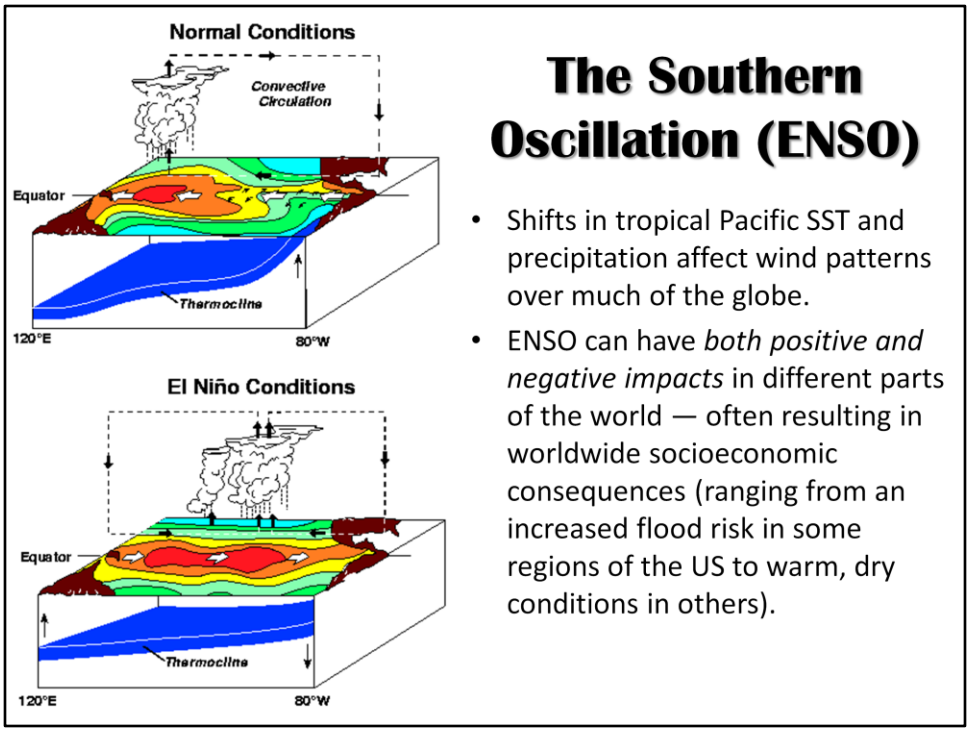

Goals
• Understand the mechanics of the El Niño Southern Oscillation.
• Diagram an El Niño event.
• Recall examples of how ocean surface oscillations impact ecosystems and people.
FLOODED
COUNTY OF



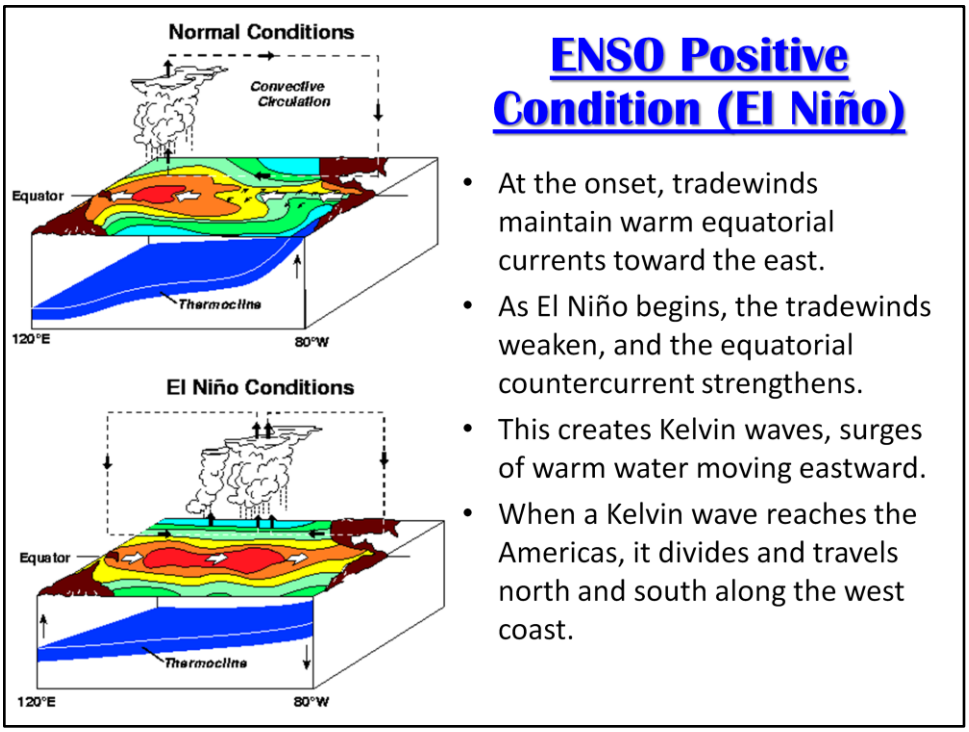
Trade winds and strong equatorial currents flow toward the west. This process, along with an intense Peruvian current, causes the upwelling of cold bottom-water along the west coast of South America.

Credit: NOAA/PMEL/TAO

Credit: Wikipedia Commons, http://commons.wikimedia.org/wiki/File:Ocean_currents_1943_for_colorblind_Pacific.png



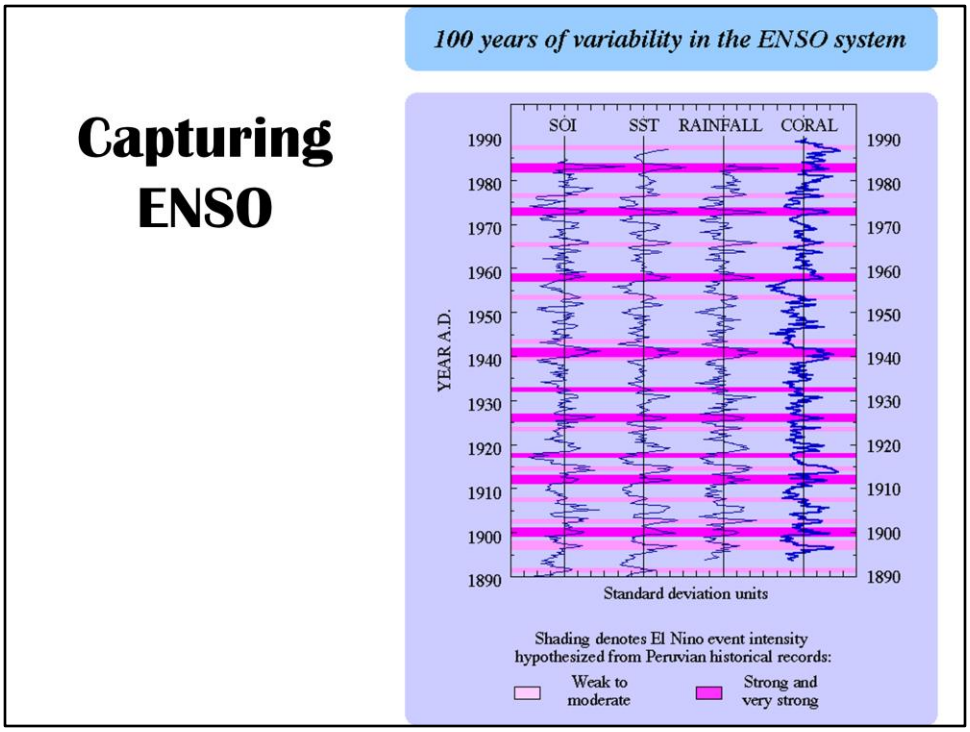
Credit: NOAA/PMEL/TAO
Source: NOAA (2006). NOAA'S role in El Niño research, monitoring and prediction. *NOAA Magazine*, 16 Nov 2006. http://www.magazine.noaa.gov/stories/mag214.htm, last accessed 1 Aug 2012.



*This slide provides a summary for students of what happens during a positive ENSO 'event' and for teachers to review the process of El Niño onset.

Title hyperlinks to an INTELECOM (2011) video on the El Niño process and its impacts to help students bridge the gap between diagrams and reality.*

Credit: NOAA/PMEL/TAO
Source: NOAA (2006). NOAA'S role in El Niño research, monitoring and prediction. *NOAA Magazine*, 16 Nov 2006. http://www.magazine.noaa.gov/stories/mag214.htm, last accessed 1 Aug 2012.

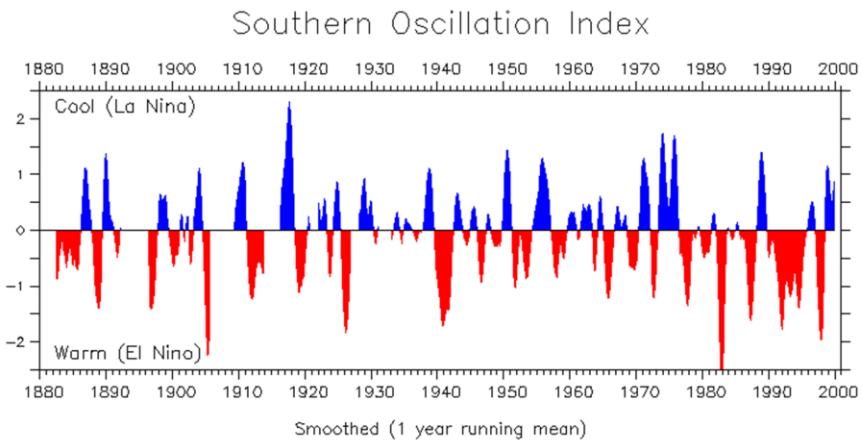


This slide and the next provide an opportunity to connect ENSO to climate records and the way we read them. This information connects most directly to Case Study 3.2.

Geologic and human records compile individual ENSO events into a series of data we can analyze to better understand the phenomenon.

Short- and long-term delta ^{18}O records obtained from Tarawa corals. The long-term record is plotted against a history of ENSO events with their intensities.
Credit: Julie Cole, University of Colorado via Heather Benway, NOAA (http://www.ncdc.noaa.gov/paleo/outreach/coral/coraldata.html, last accessed 15 December 2013)

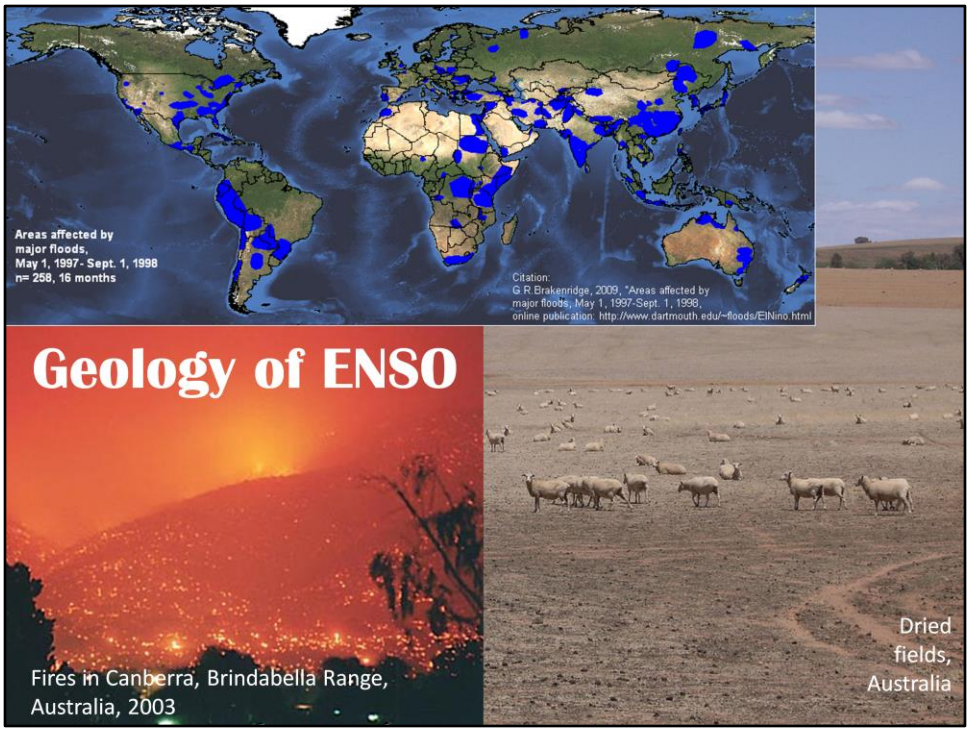
Capturing ENSO



This slide and the previous provide an opportunity to connect ENSO to climate records and the way we read them. This information connects most directly to Case Study 3.2.

The recurrence interval and intensity of ENSO are irregular.

ENSO time series of occurrence 1882-2002.
Credit: Billy Kessler, NOAA (http://faculty.washington.edu/kessler/occasionally-asked-questions.html#q24, last accessed 15 December 2015)

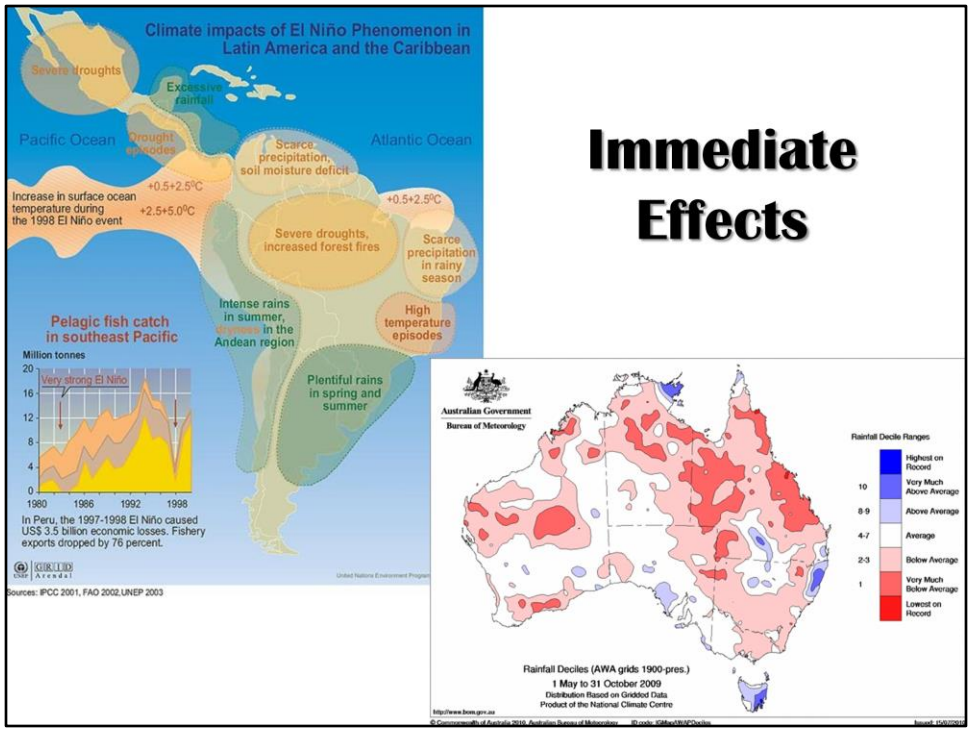


These images provide further opportunity to engage students affectively and make the connection between human experience the creation of the geologic record. These in particular demonstrate the diversity deposit types (and possibly unconformities) that could be created by these events. You can find these stories using the links below.

The Canberra fires of 2003: Brindebella Range.
http://upload.wikimedia.org/wikipedia/commons/3/37/Canberra_hills-18-01-2003.jpg, last accessed 15 July 12.
Credit: Wikimedia Commons

Sheep in grassless pasture affected by drought, Australia.
Source:
http://en.wikipedia.org/wiki/Drought_in_Australia#mediaviewer/File:Riverina_Sheep_%28during_drought%29.jpg

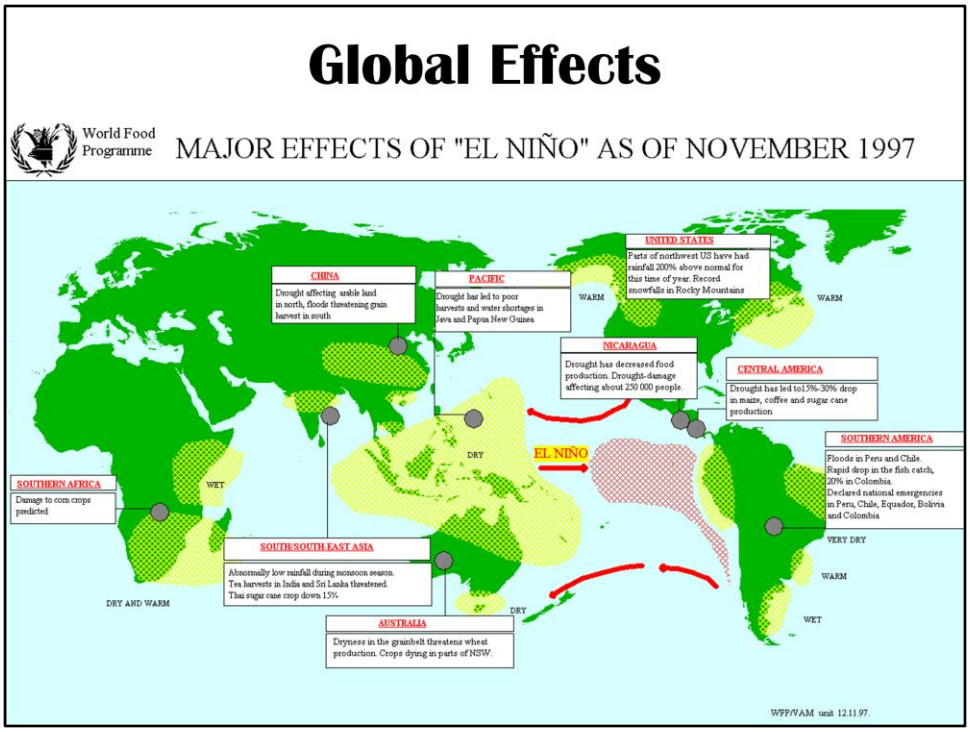
Effects of El Niño on Global Flooding.
http://www.dartmouth.edu/~floods/ElNino.html, last accessed 15 July 12.
Credit: Dartmouth Flood Observatory



These diagrams provide examples for students of direct impacts of ENSO on humans.

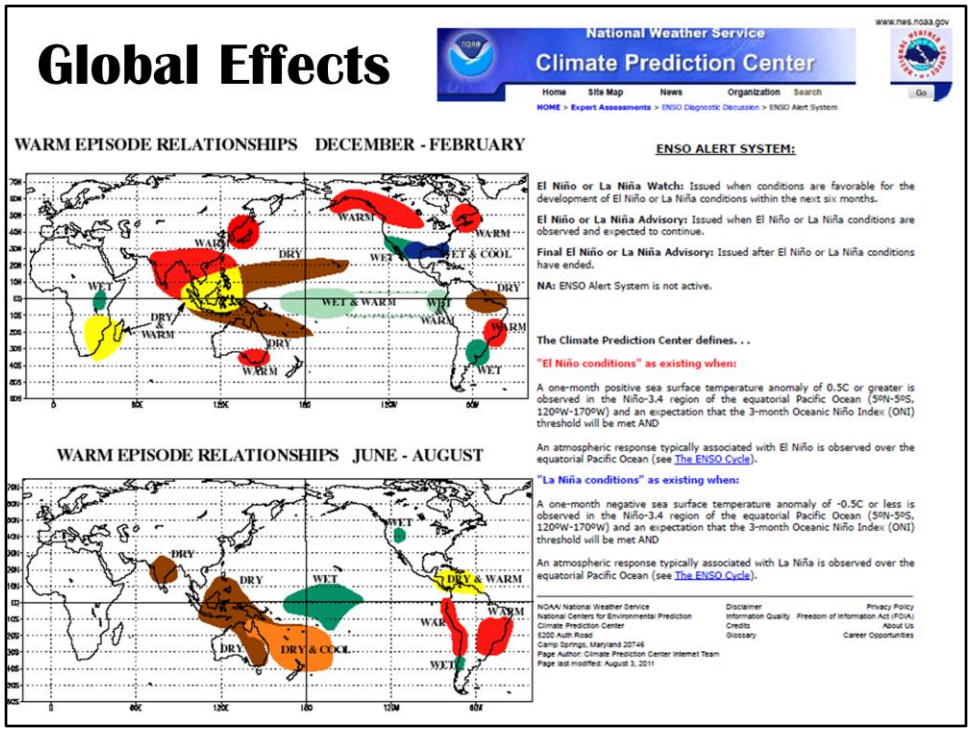
Climate impacts of El Niño Phenomenon in Latin America and the Caribbean (2005) Vital Climate Graphics – Latin America and the Caribbean.
El Niño Southern Oscillation (ENSO) is a natural phenomenon that has occurred for centuries. Ocean and atmospheric conditions in the Pacific tend to fluctuate between El Niño (warming) and a drop in temperature in the tropical Pacific known as La Niña. The fluctuations are rather irregular, but tend to appear every three to six years. A more intensive phase of each event may last for about a year. A warming climate may contribute to an increase in frequency and intensity of the El Niño phenomenon. The impacts may be significant at regional levels. In Central America, El Niño leads to excessive rainfall along the Caribbean coasts, while the Pacific coasts will remain dry. Rainfall increases on the coasts of Ecuador, the northern part of Peru, and southern zones of Chile. In Ecuador, Peru and Bolivia there will be drought in the mountainous and Andean zones, implying retreat of glaciers with subsequent changes in the availability of water and in local biodiversity. In Colombia, Venezuela and Guyana precipitation will tend to be reduced, leading to drought in the Brazilian northeast. In Argentina, Paraguay and Uruguay rainfall will increase and there will be a rise in temperatures in the southern part of Brazil.
http://www.grida.no/graphicslib/detail/climate-impacts-of-el-nio-phenomenon-in-latin-america-and-the-caribbean_921c, last accessed 15 July 12.
Credit: UNEP/GRID-Arendal

El Niño - Detailed Australian Analysis 2009-2010.
http://www.bom.gov.au/climate/enso/enlist/, last accessed 15 July 12.
Credit: Australian Government – Bureau of Meteorology



This slide provides an opportunity to ask the students if they live in any at-risk areas and how well they feel their communities are prepared for such effects.

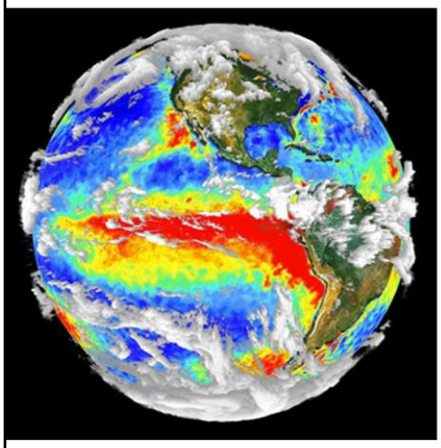
Source: http://reliefweb.int/map/world/major-effects-el-nino, last accessed 15 July 12.
Credit: UN World Food Programme http://www.wfp.org/



This slide is a good time to discuss warning systems and their utility. Can we be alerted soon enough for something like ENSO? How does ENSO compare to a disaster like a tsunami or hurricane?

http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/impacts/warm.gif, last accessed 15 July 12.
and
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/enso-alert-readme.shtml, last accessed 15 July 12.
Credit: NOAA CPC

Still Discovering El Niño...



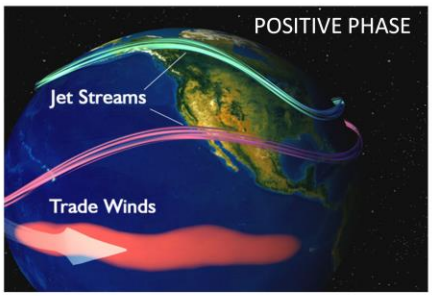
"For years, scientists have tracked the intensity of the El Niño Southern Oscillation by measuring the strength of the sea surface temperature anomaly. El Niños occur when warmer ocean water wells up toward the eastern equatorial Pacific. But the strength of the temperature anomaly may not be the only important factor in predicting El Niño-related weather events. Our researchers found that the location of sea-surface warming appears to be just as critical. For instance, El Niños that develop near the central equatorial Pacific appear to cause drought during the Indian Monsoon, whereas warm waters near the eastern equatorial Pacific may have no impact on monsoon rains."

– **Cooperative Institute for Research in Environmental Sciences (CIRES), 2012**

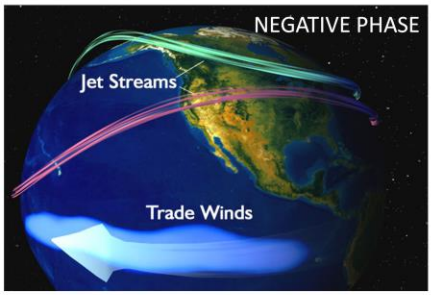
You can use this slide to start a discussion on the nature of science and the utility of policy decisions based on revisable findings.

CIRES Weather and Climate Dynamics Division: El Niño Research.
http://cires.colorado.edu/science/divisions/wcd/foci/elNino.html, last accessed 16 July 12.
Credit: CIRES

ENSO



When the trade winds shift and push warm water from the western pacific to the eastern Pacific, the jet streams change, changing the weather patterns and climate.



La Niña is characterized by unusually cold ocean temperatures in the central equatorial Pacific. The colder than normal water is depicted in this image in blue. During a La Niña stronger than normal trade winds bring cold water up to the surface of the ocean.

These images are a jumping-off point for discussing connections between different ocean surface oscillation systems. This connection may be too complicated for some class settings. (If you are continuing with the rest of the module, you can also bring glacial terrains into the discussion and ask how they might be particularly effected by these phenomena.) You can also discuss the difference between the way climate phenomena are discussed/represented by scientists vs. popular media (and in this case 'the weather').

When the trade winds shift and push warm water from the western pacific to the eastern Pacific, the jet streams change, changing the weather patterns and climate.
http://www.globalwarmingclassroom.info/basic_info.htm
Credit: NASA

La Niña is characterized by unusually cold ocean temperatures in the central equatorial Pacific. The colder than normal water is depicted in this image in blue. During a La Niña stronger than normal trade winds bring cold water up to the surface of the ocean.
http://www.nasa.gov/centers/goddard/news/topstory/2006/lanina_effect.html, last accessed 15 July 12.
Credit: NASA

Credit: from Sorenson, E. (2009). Channel 13 WREX Weather Authority Blog: NAO

411. http://addins.wrex.com/blogs/weather/2009/12/nao-411, last accessed 15 July 12.