Anomalous Behavior

Unit 3
Climate of Change
InTeGrate Module

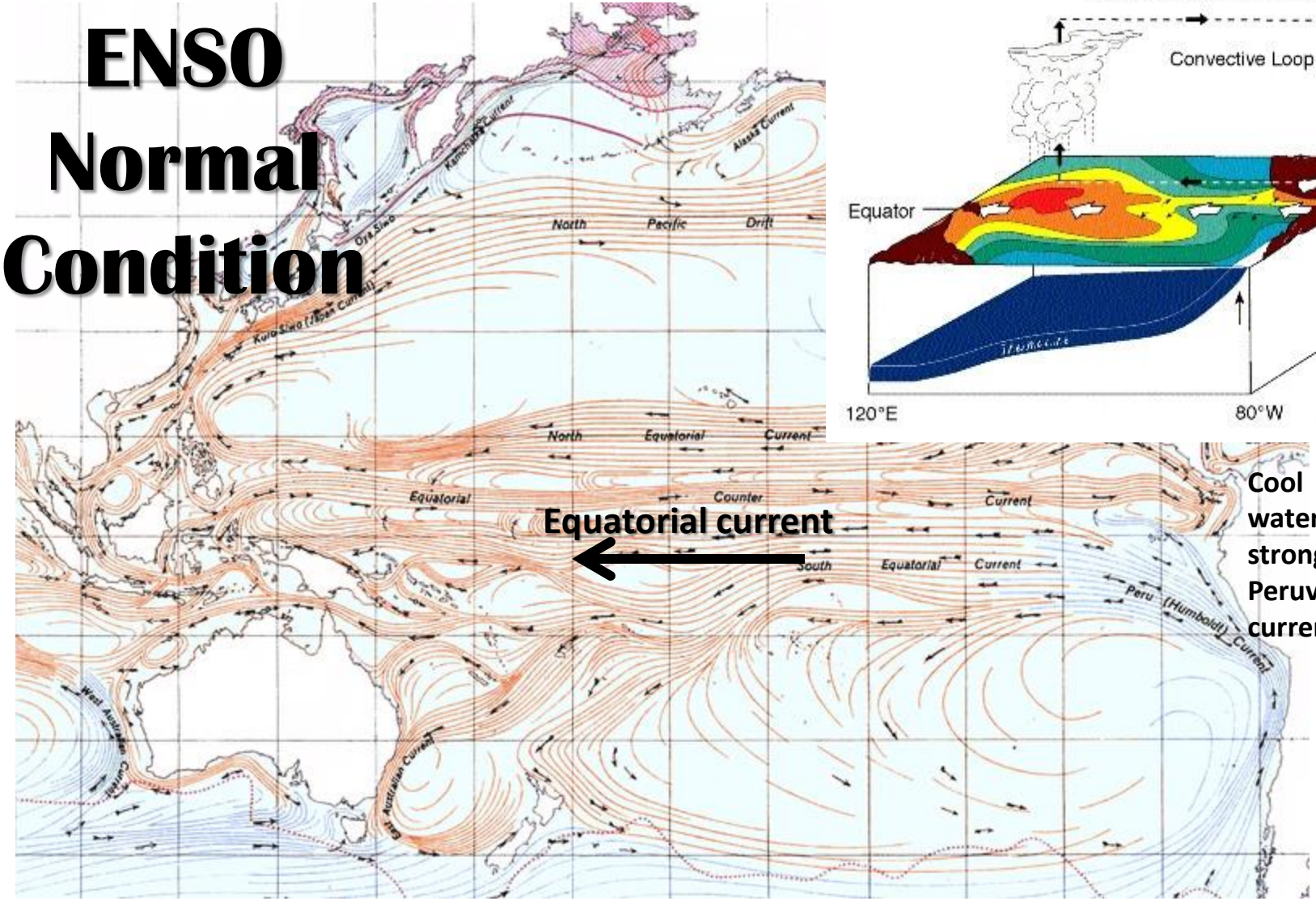
Cynthia M. Fadem
Earlham College

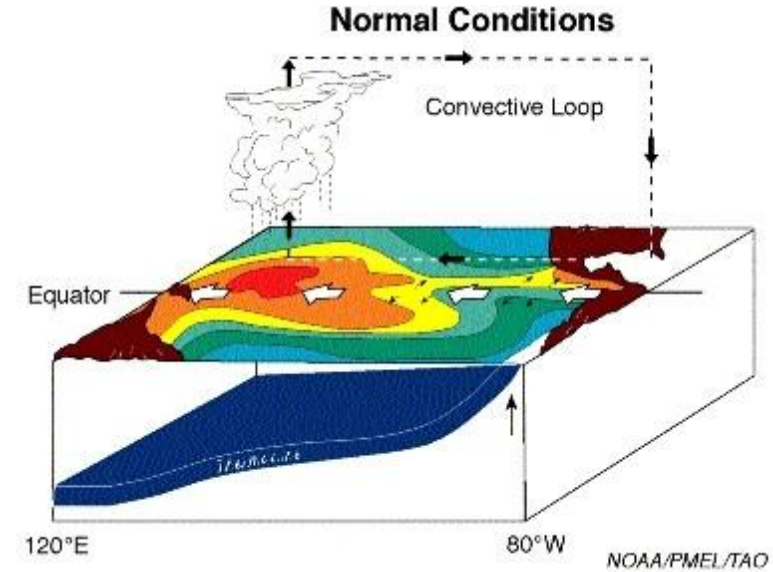
Russian River Valley, CA, USA

Goals

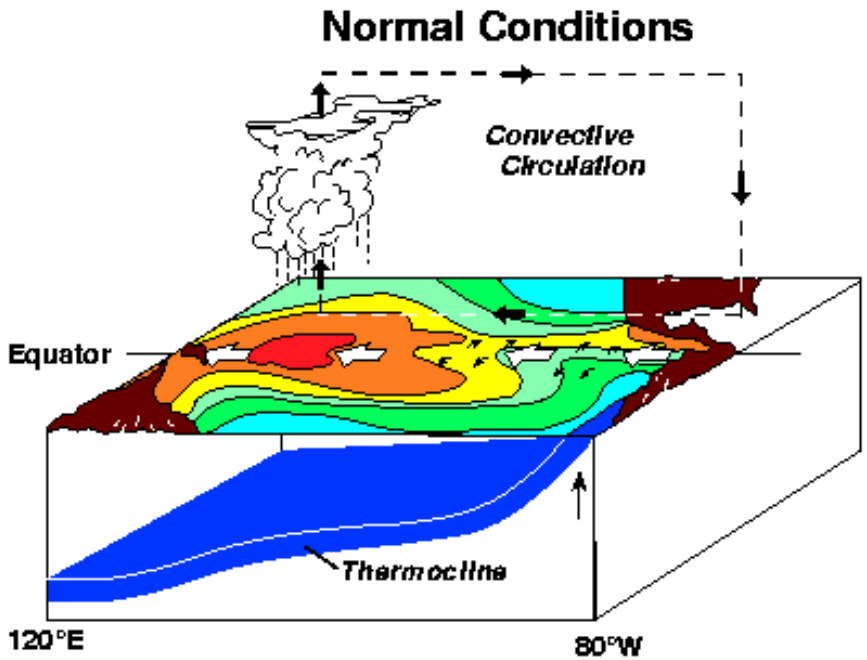
- Understand the mechanics of the El Niño Southern Oscillation.
- Diagram an El Niño event.
- Recall examples of how ocean surface oscillations impact ecosystems and people.

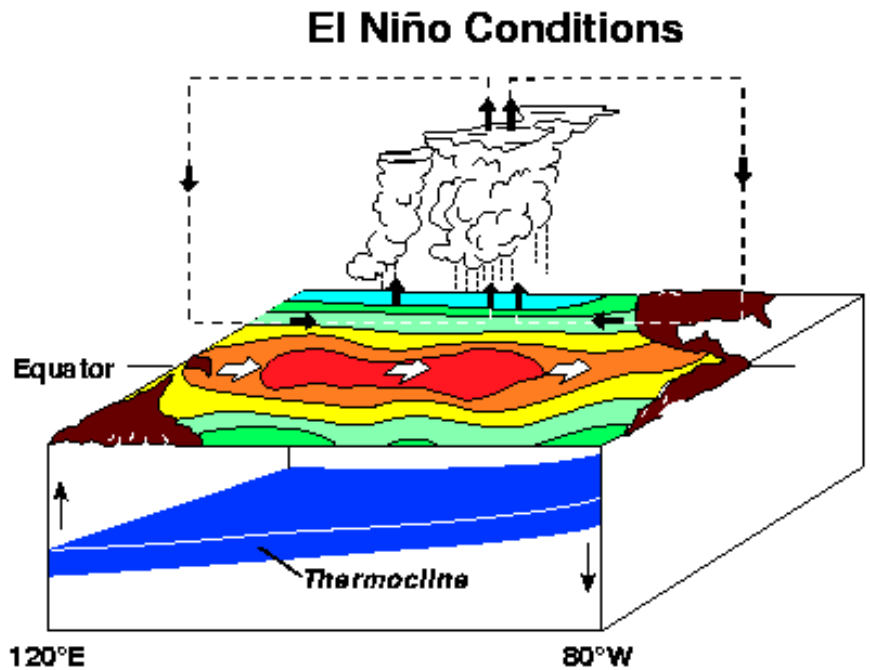
ENSO Normal Condition





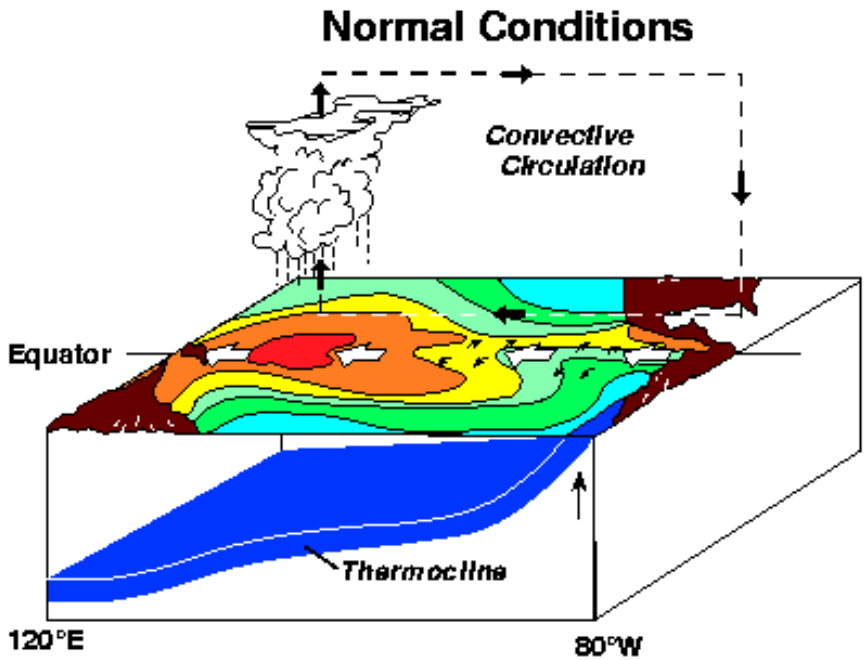
Trade winds and strong equatorial currents flow toward the west. This process, along with an intense Peruvian current, causes the upwelling of cold bottom-water along the west coast of South America.

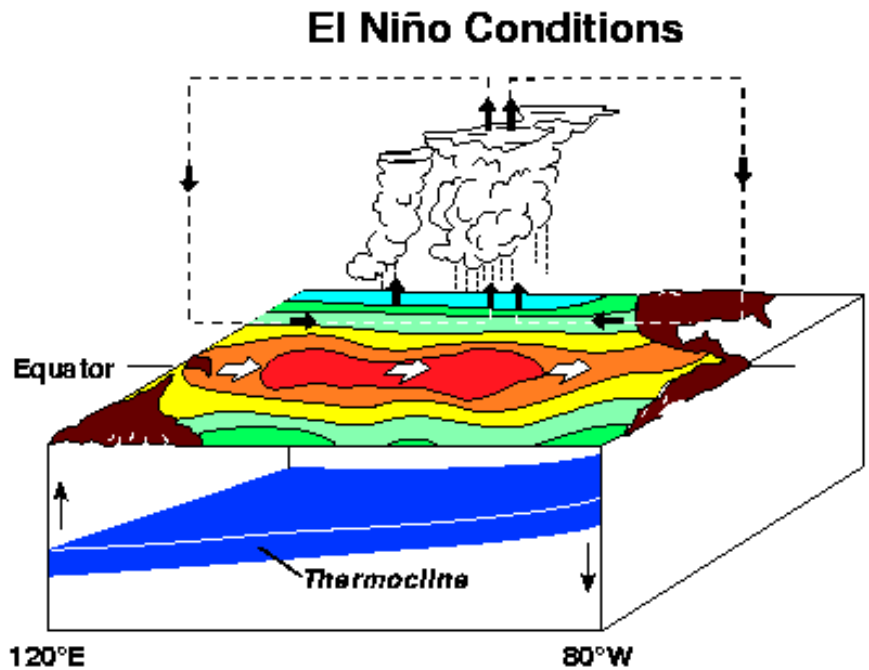




The Southern Oscillation (ENSO)

- Shifts in tropical Pacific SST and precipitation affect wind patterns over much of the globe.
- ENSO can have *both positive and negative impacts* in different parts of the world — often resulting in worldwide socioeconomic consequences (ranging from an increased flood risk in some regions of the US to warm, dry conditions in others).

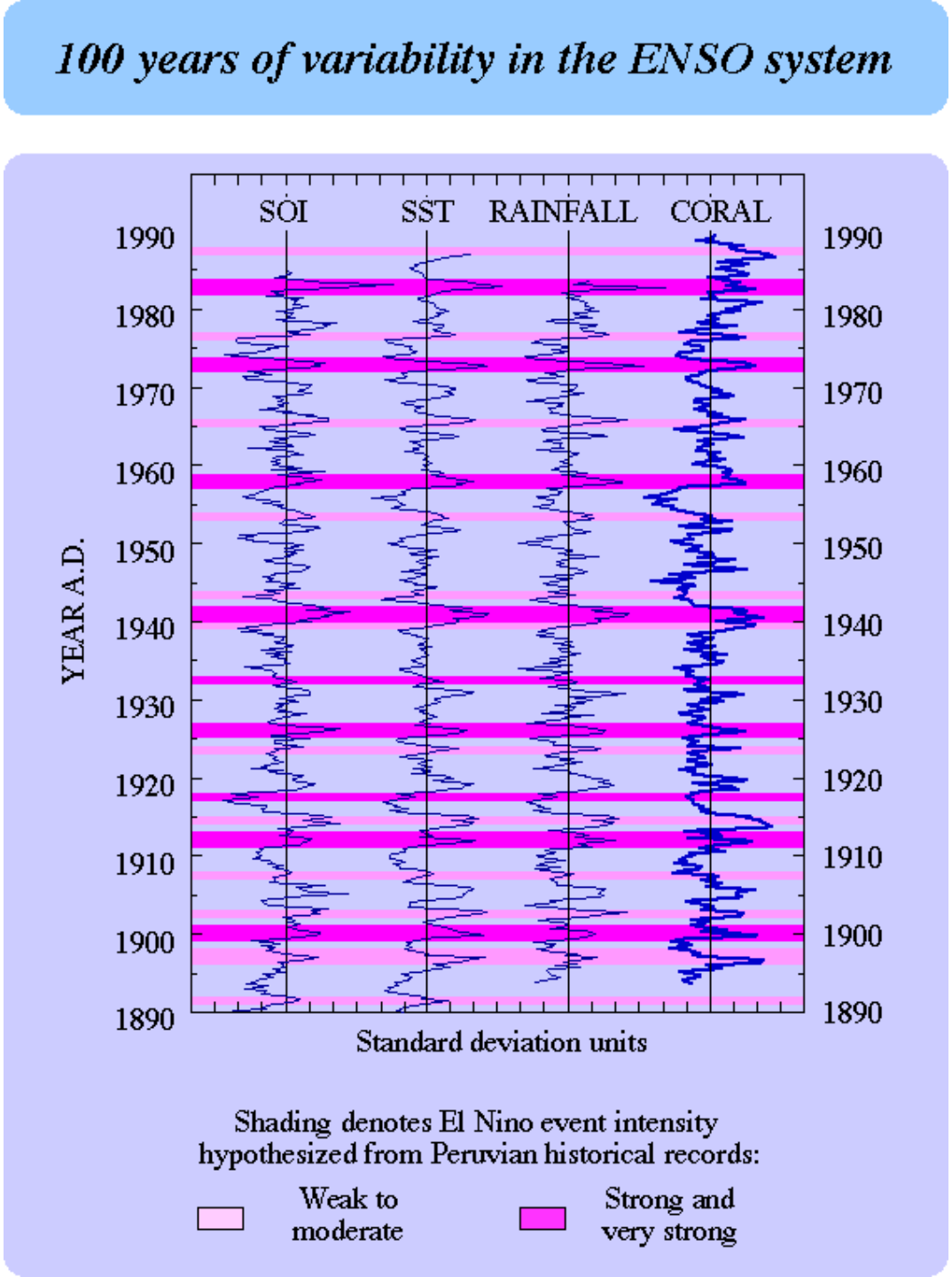




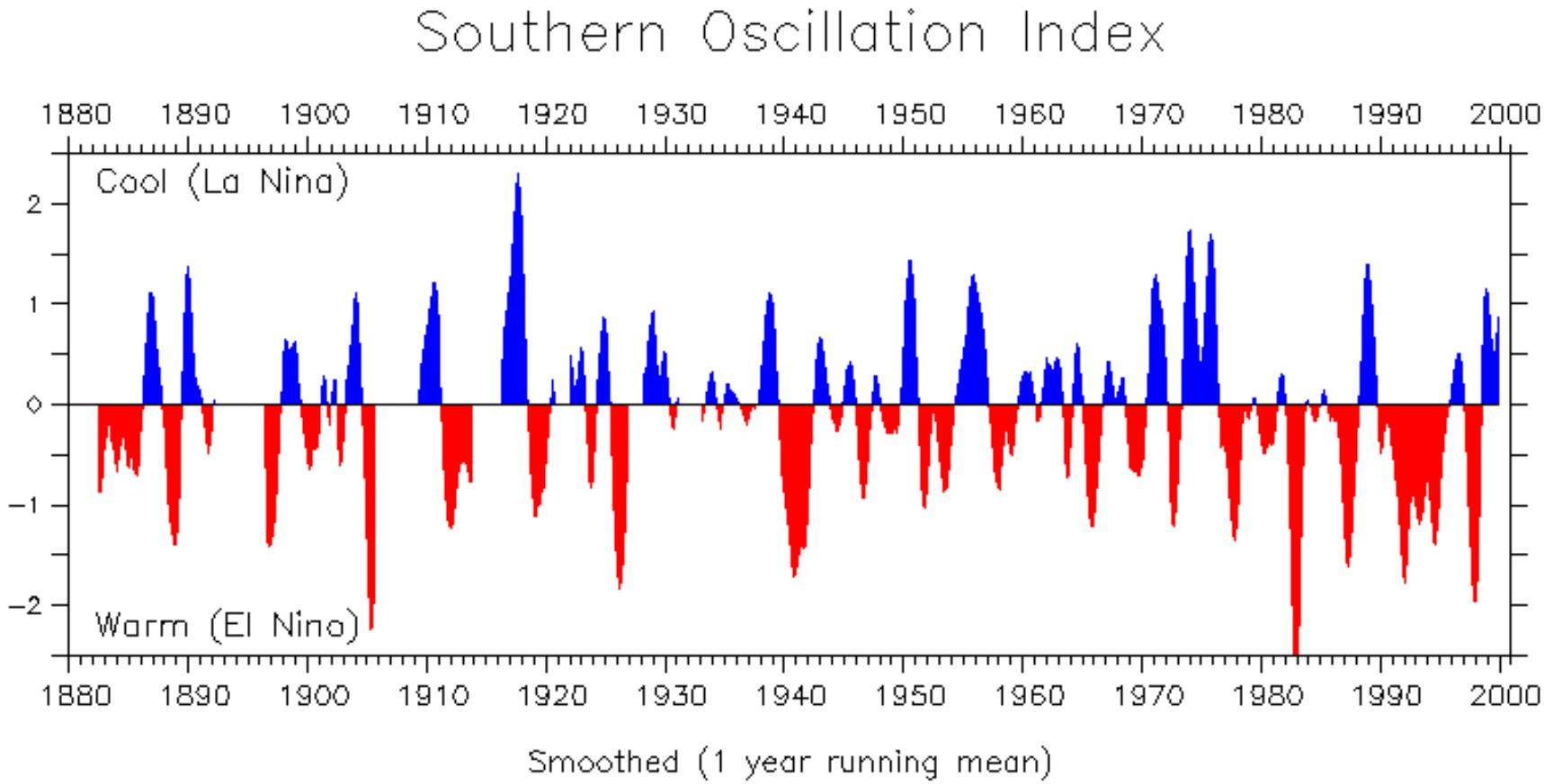
ENSO Positive Condition (El Niño)

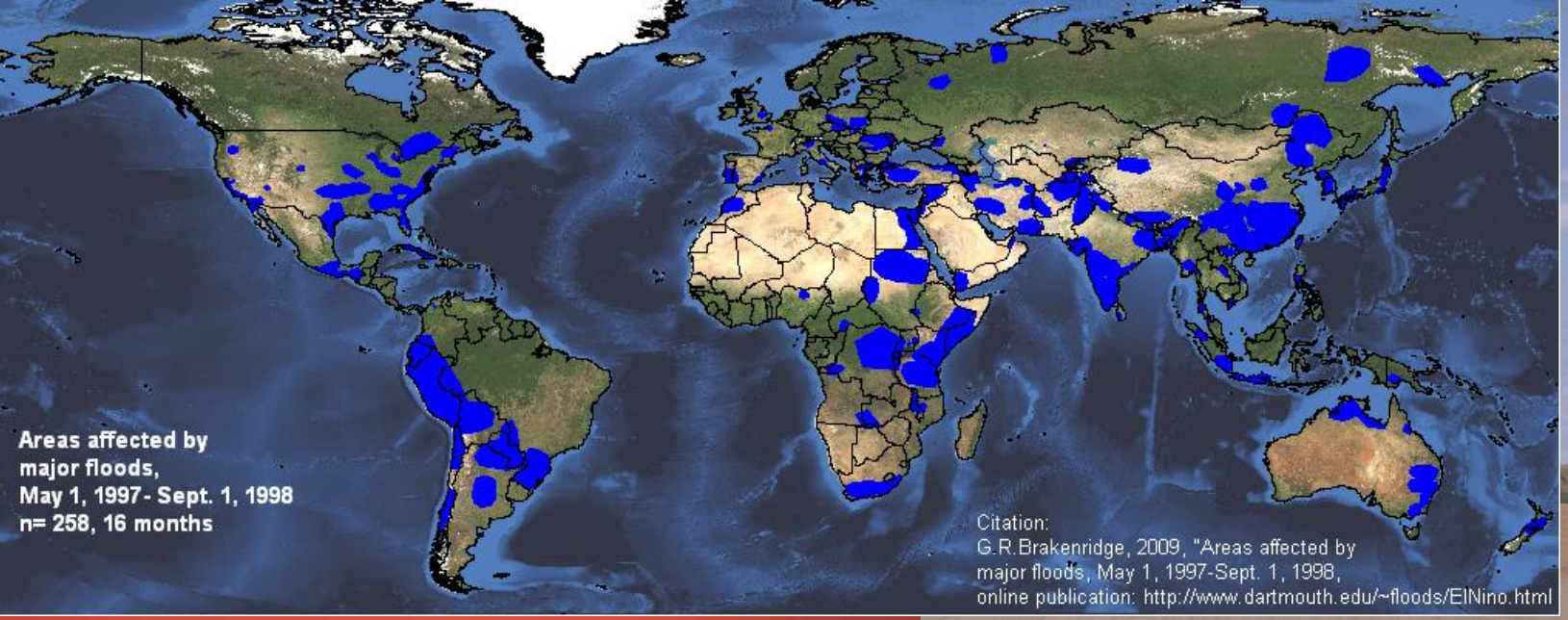
- At the onset, tradewinds maintain warm equatorial currents toward the east.
- As El Niño begins, the tradewinds weaken, and the equatorial countercurrent strengthens.
- This creates Kelvin waves, surges of warm water moving eastward.
- When a Kelvin wave reaches the Americas, it divides and travels north and south along the west coast.

Capturing ENSO

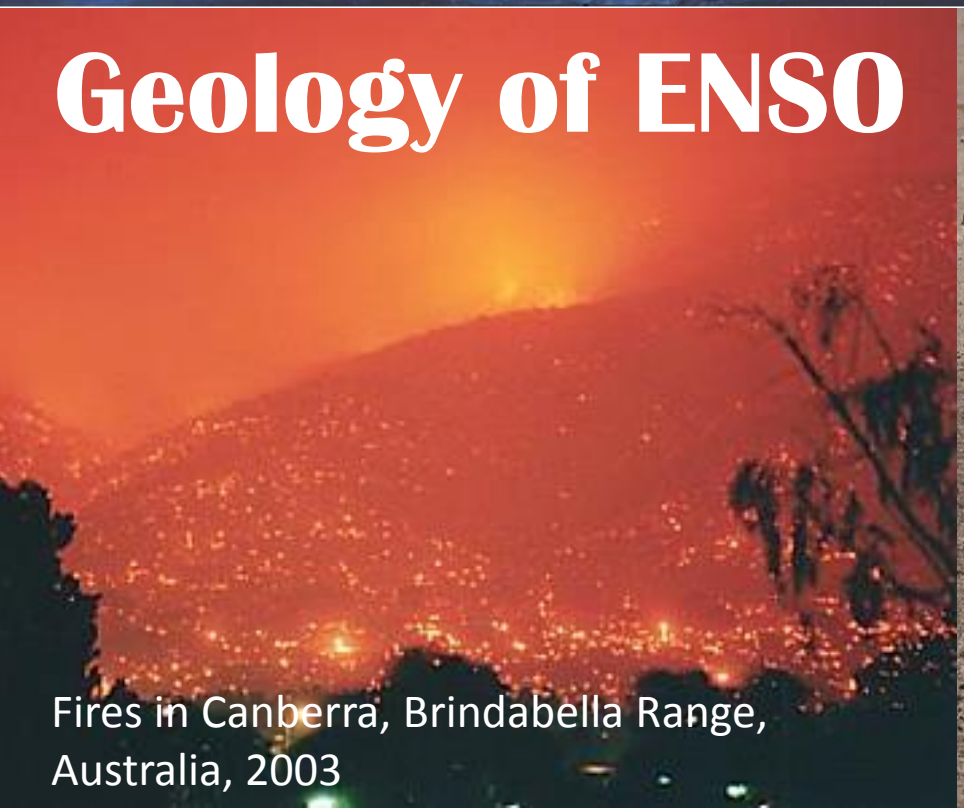


Capturing ENSO





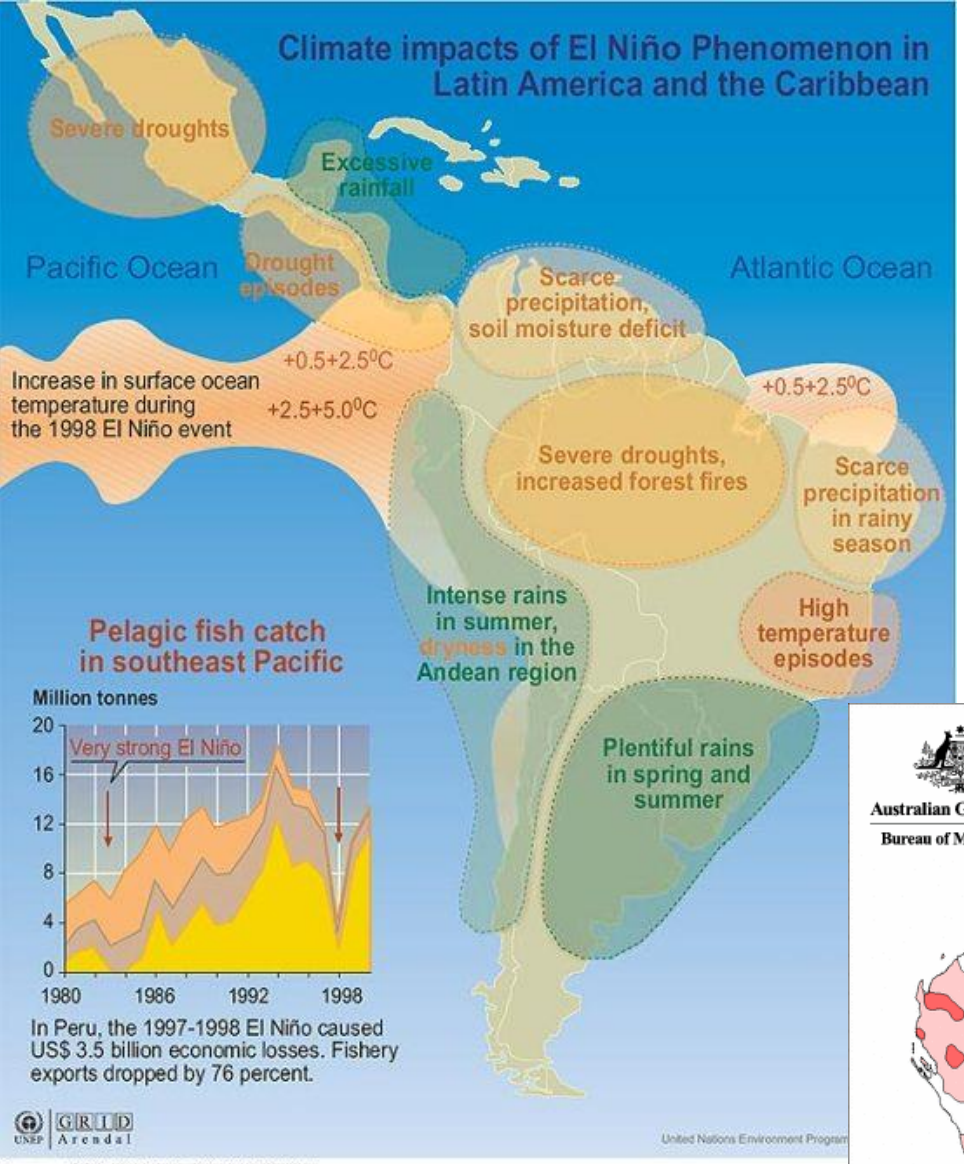
Geology of ENSO



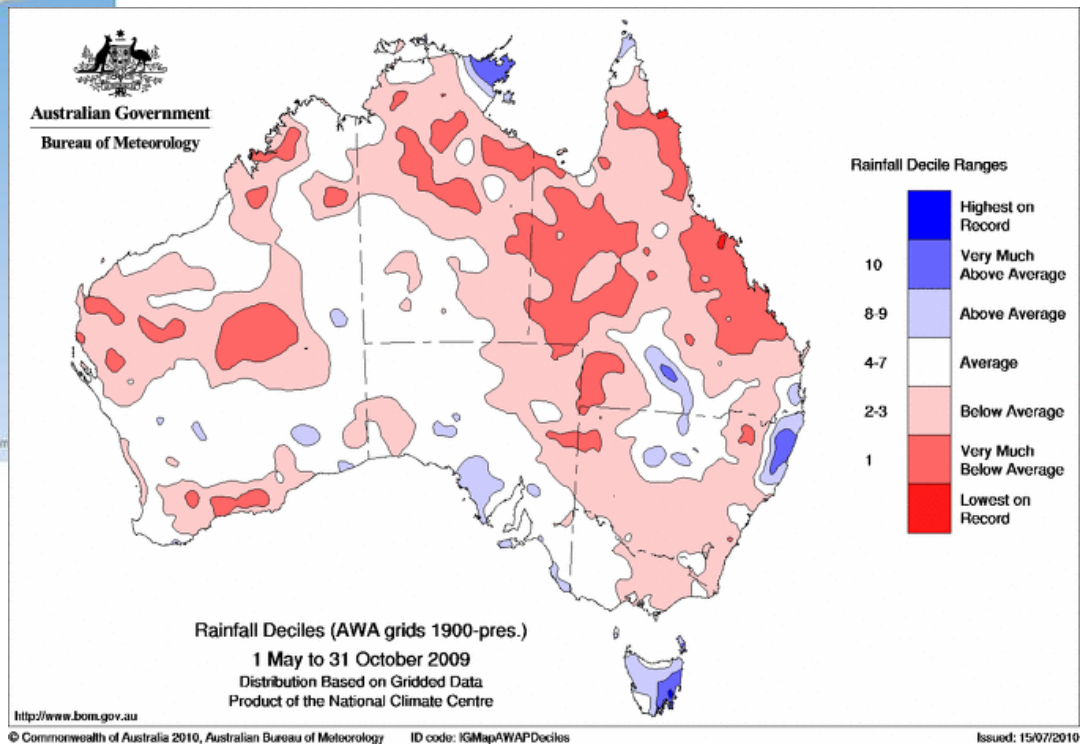
Fires in Canberra, Brindabella Range, Australia, 2003

Dried fields, Australia

Immediate Effects



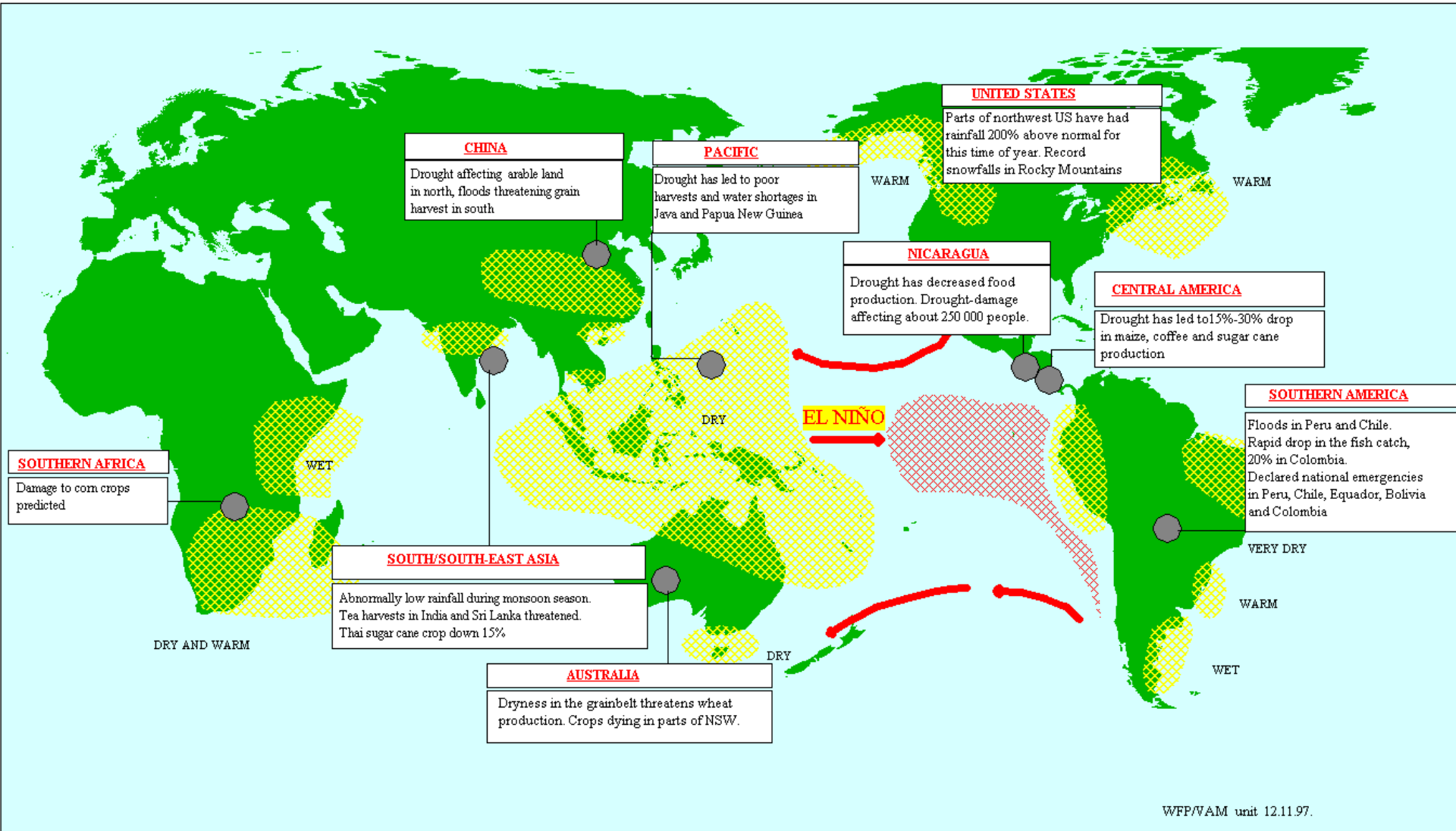
Sources: IPCC 2001, FAO 2002, UNEP 2003



Global Effects

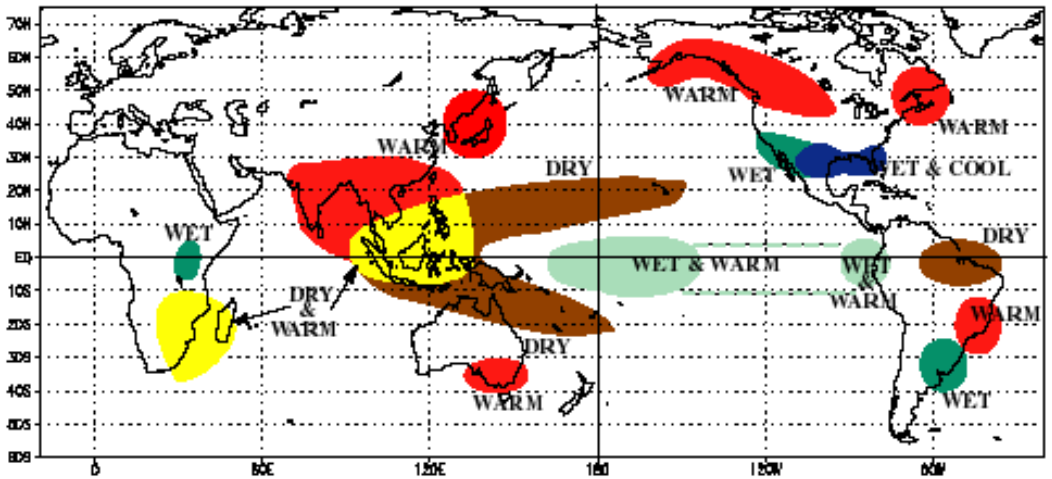
World Food Programme

MAJOR EFFECTS OF "EL NIÑO" AS OF NOVEMBER 1997

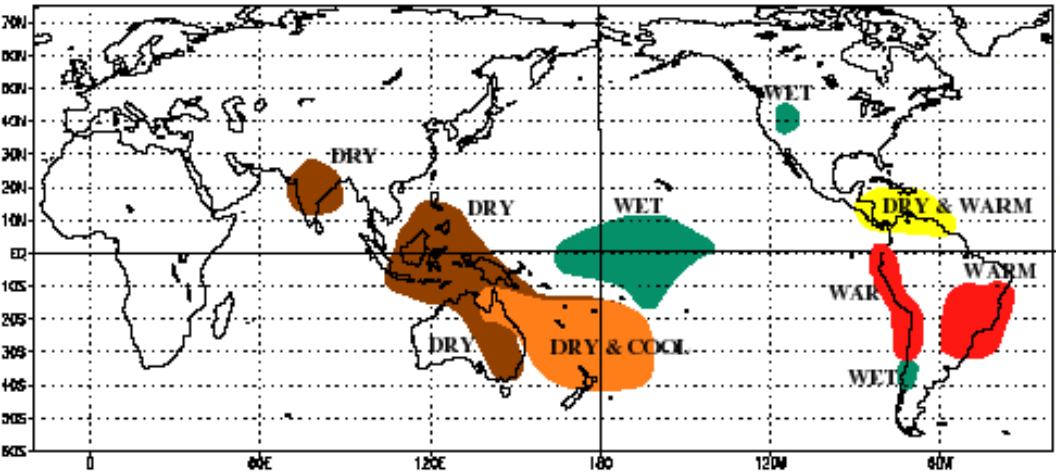


Global Effects

WARM EPISODE RELATIONSHIPS DECEMBER - FEBRUARY



WARM EPISODE RELATIONSHIPS JUNE - AUGUST



ENSO ALERT SYSTEM:

El Niño or La Niña Watch: Issued when conditions are favorable for the development of El Niño or La Niña conditions within the next six months.

El Niño or La Niña Advisory: Issued when El Niño or La Niña conditions are observed and expected to continue.

Final El Niño or La Niña Advisory: Issued after El Niño or La Niña conditions have ended.

NA: ENSO Alert System is not active.

The Climate Prediction Center defines. . .

"El Niño conditions" as existing when:

A one-month positive sea surface temperature anomaly of 0.5C or greater is observed in the Niño-3.4 region of the equatorial Pacific Ocean (5ºN-5ºS, 120ºW-170ºW) and an expectation that the 3-month Oceanic Niño Index (ONI) threshold will be met AND

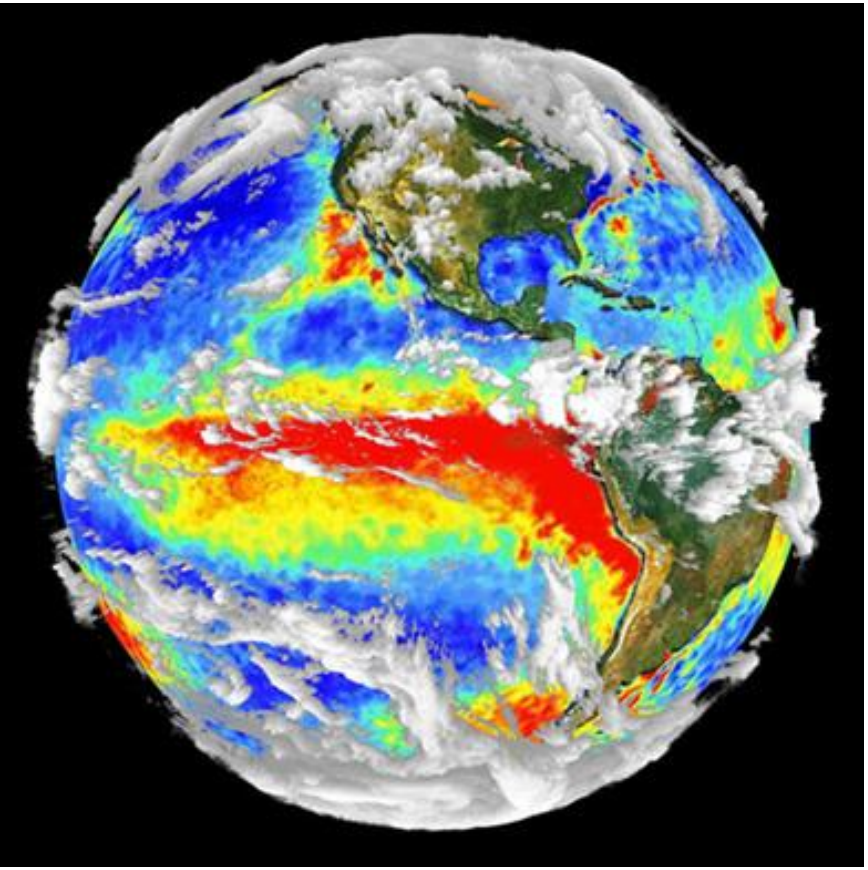
An atmospheric response typically associated with El Niño is observed over the equatorial Pacific Ocean (see The ENSO Cycle).

"La Niña conditions" as existing when:

A one-month negative sea surface temperature anomaly of -0.5C or less is observed in the Niño-3.4 region of the equatorial Pacific Ocean (5ºN-5ºS, 120ºW-170ºW) and an expectation that the 3-month Oceanic Niño Index (ONI) threshold will be met AND

An atmospheric response typically associated with La Niña is observed over the equatorial Pacific Ocean (see The ENSO Cycle).

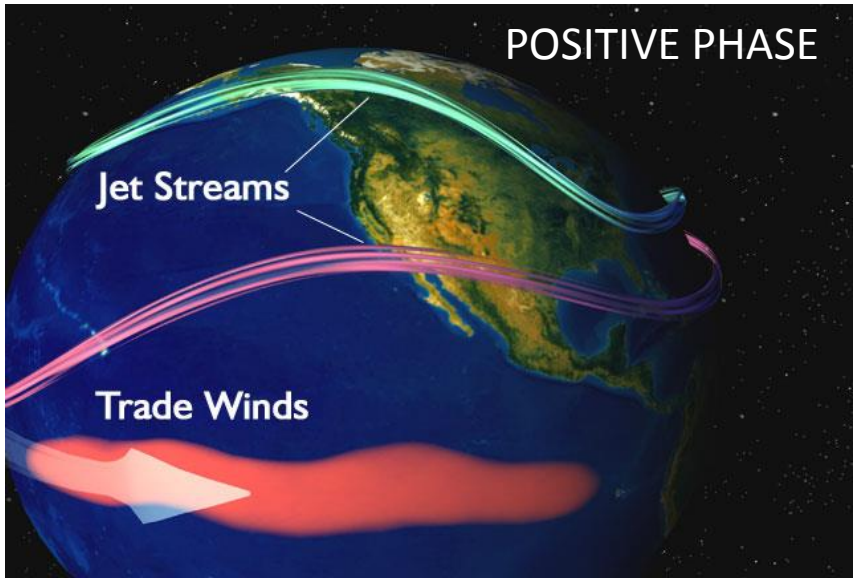
Still Discovering El Niño…



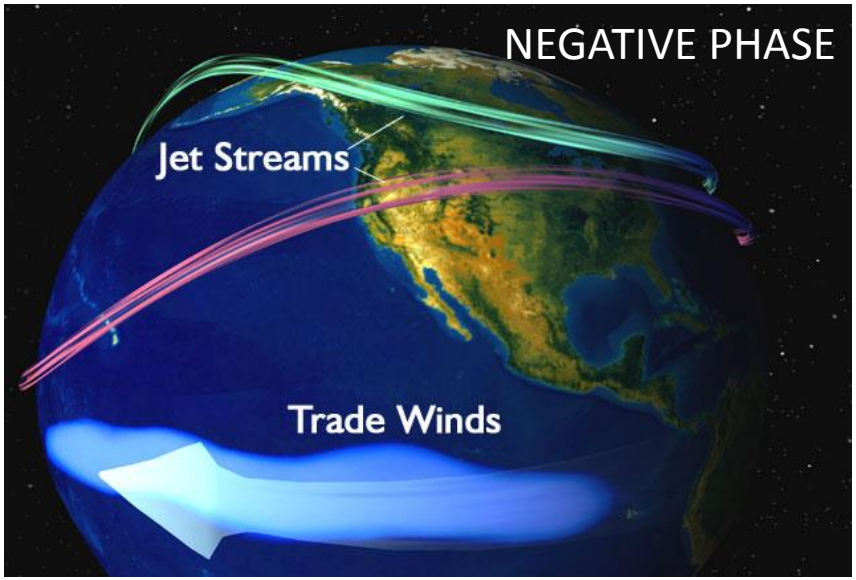
"For years, scientists have tracked the intensity of the El Niño Southern Oscillation by measuring the strength of the sea surface temperature anomaly. El Niños occur when warmer ocean water wells up toward the eastern equatorial Pacific. But the strength of the temperature anomaly may not be the only 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**

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.

Slide Image Sources:

1. El Nino rains flood Russian River, California. Image credit: Dave Gatley/FEMA http://www.nasa.gov/vision/earth/environment/elnino_rainchange.html
2. Drought conditions. Image source: http://pixabay.com/static/uploads/photo/2014/03/05/21/12/desert-279862_640.jpg
3. Ocean current map – Image credit: Wikipedia Commons, http://commons.wikimedia.org/wiki/File:Ocean_currents_1943_for_colorblind_Pacific.png
4. ENSO – Image credit: NOAA/PMEL/TAO http://www.magazine.noaa.gov/stories/mag214.htm
5. Capturing ENSO I– Image credit: Julie Cole, University of Colorado via Heather Benway, NOAA. http://www.ncdc.noaa.gov/paleo/outreach/coral/coraldata.html
6. Capturing ENSO II – Image credit: Billy Kessler, NOAA http://faculty.washington.edu/kessler/occasionally-asked-questions.html#q24
7. Geology of ENSO - The Canberra fires. Image credit: Wikimedia commons. http://upload.wikimedia.org/wikipedia/commons/3/37/Canberra_hills-18-01-2003.jpg; Sheep in grassless pasture, Australia. http://en.wikipedia.org/wiki/Drought_in_Australia#mediaviewer/File:Riverina_Sheep_%28during_drought%29.jpg; El Niño and Global Flooding, image credit: Credit: Dartmouth Flood Observatory, http://www.dartmouth.edu/~floods/ElNino.html
8. Immediate effects – Map of South America, Image credit: UNEP/GRID-Arendal http://www.grida.no/graphicslib/detail/climate-impacts-of-el-nio-phenomenon-in-latin-america-and-the-caribbean_921c; El Niño, Australian Analysis, image credit: Australian Government – Bureau of Meteorology, http://www.bom.gov.au/climate/enso/enlist/

Slide Image Sources:

10. Global Effects I - Image credit: UN World Food Programme http://www.wfp.org/ Source: http://reliefweb.int/map/world/major-effects-el-nino
11. Global Effects II – Image credit: NOAA CPC http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/impacts/warm.gif, and http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/enso-alert-readme.shtml
12. Still discovering El Nino – Image credit: CIRES http://cires.colorado.edu/science/divisions/wcd/foci/elNino.html
13. ENSO – Image credit: NASA, http://www.globalwarmingclassroom.info/basic_info.htm and http://www.nasa.gov/centers/goddard/news/topstory/2006/lanina_effect.html