ARM

CLIMATE RESEARCH FACILITY

Education and Outreach Lesson Plan

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Grade levels 6–8

Make Your Own El Niño

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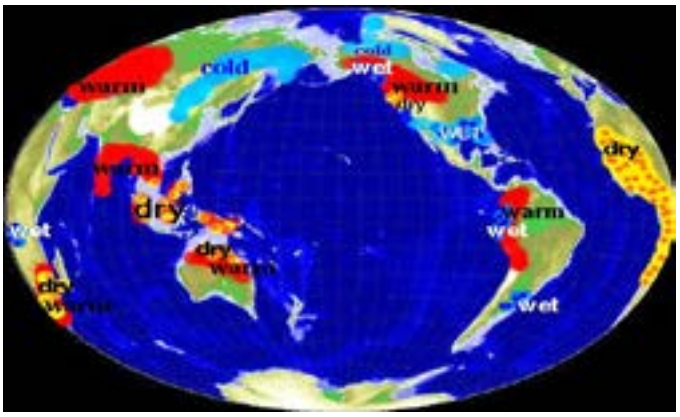


Approximate Time

One hour or more

May be made into a two - three day project:

- Day 1 demonstration; Day 2 student responses or
- Day 1 pre-teach background information; Day 2 demonstration; Day 3 student responses

Objective

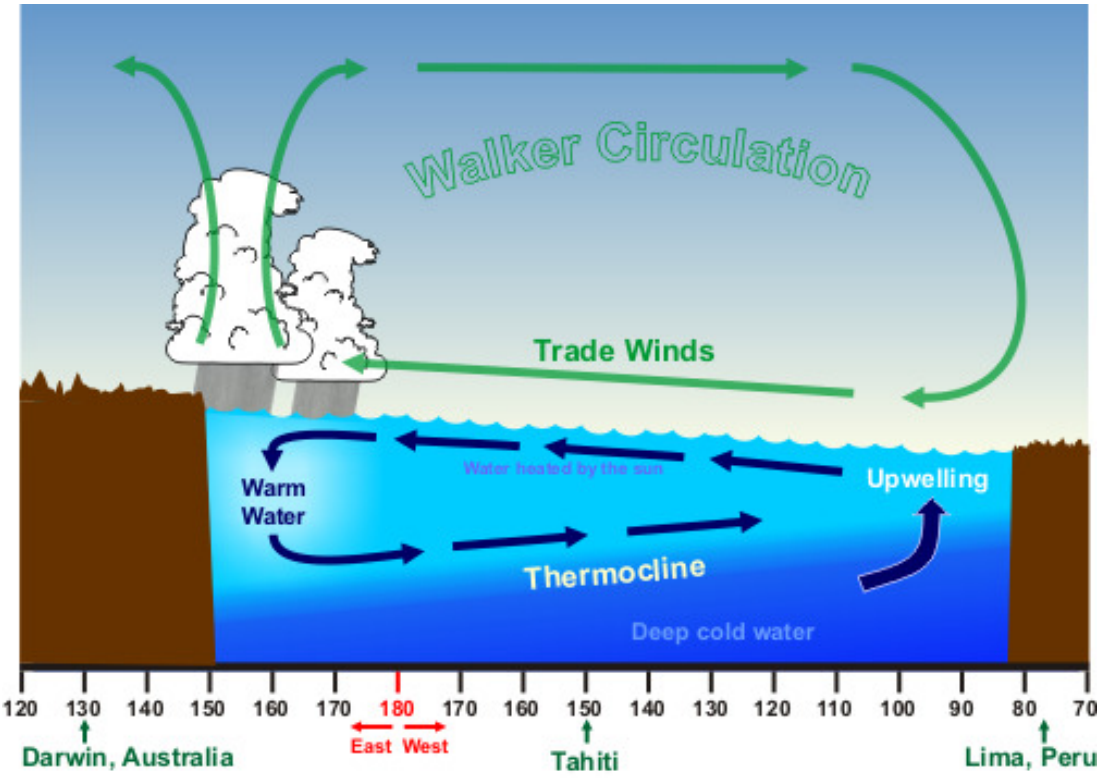
The objective of this lesson is to investigate and learn about the El Niño effect, trade winds, and upwelling, by participating in a hands-on demonstration.

Background Information

Note to Teacher-this material and accompanying vocabulary would be excellent as pre-teaching for the activity that follows.

El Niño means literally, "the Christ child", a name given to an extensive ocean warming in the **equatorial** eastern Pacific along the coast of Peru and Ecuador that often begins around Christmas (hence, the name). The warming brings nutrient-poor tropical water southward along the west coast of South America in major events that recur at intervals of 3 to 7 years. El Niño is associated with atmospheric circulations that produce wide ranging effects on global weather and climate.

Normal Conditions:



Normally, sea surface **temperature** is about 14°F higher in the western Pacific than the waters off South America.

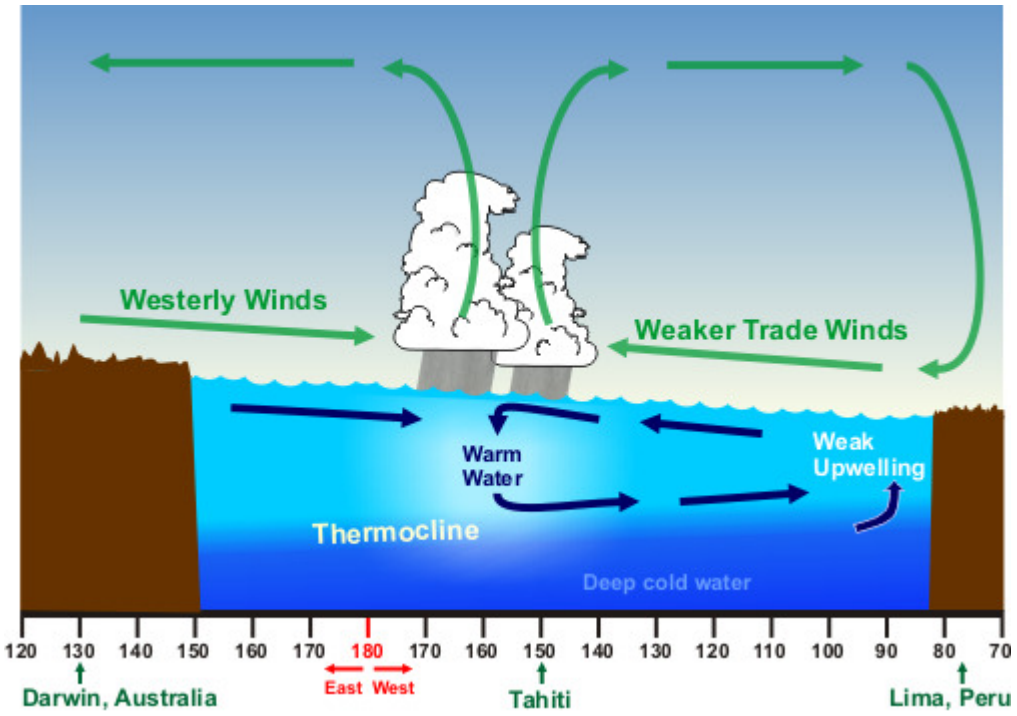
This is due to the **trade winds** blowing from east to west along the equator allowing the **upwelling** of cold, nutrient-rich water from deeper levels off the northwest coast of South America.

Also, these same trade winds push water west which piles higher in the western Pacific. The average sea-level height is about 1½ feet higher at Indonesia than at Peru.

The trade winds, in piling up water in the western Pacific, make a deep 450 foot (150 meter) warm layer in the west that pushes the **thermocline** down there, while causing the thermocline to rise in the east.

The shallow 90 foot (30 meter) eastern thermocline allows the trade winds to pull up water from below; water that is generally much richer in **nutrients** than the surface layer.

El Niño Conditions:



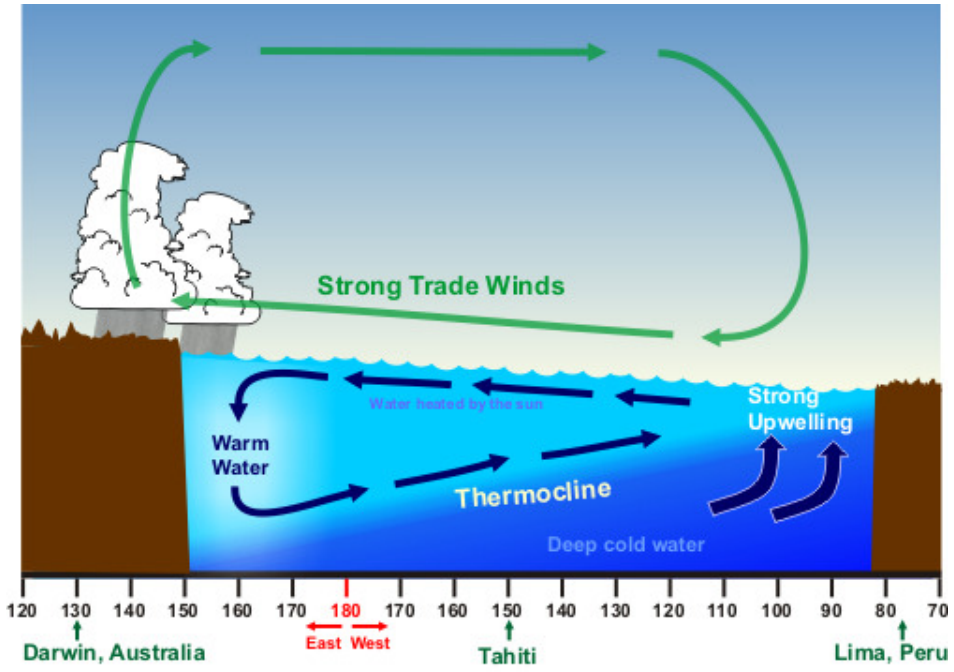
However, when the air pressure patterns in the South Pacific reverse direction (the air pressure at Darwin, Australia is higher than at Tahiti), the trade winds decrease in strength (and can reverse direction).

The result is that the normal flow of water away from South America decreases and ocean water piles up off South America. This pushes the thermocline deeper and creates a decrease in the upwelling effect.

With a deeper thermocline and decreased westward transport of water, the sea surface temperature increases *to greater than normal* in the eastern Pacific. This is the warm phase of **ENSO**, called El Niño.

The net result is a shift of the prevailing rain pattern from the normal western Pacific to the Central Pacific. The effect to the rainfall is more common in the Central Pacific while the western Pacific becomes relatively dry.

La Niña Conditions:



There are occasions when the trade winds that blow west across the tropical Pacific are stronger than normal, leading to increased upwelling off South America and hence the *lower than normal* sea surface temperatures.

The prevailing rain pattern also shifts farther west than normal. These winds pile up warm surface water in the West Pacific. This is the cool phase of ENSO called **La Niña**. What is surprising is these changes in sea surface temperatures are not large, plus or minus 6°F (3°C) and generally much less.

Source: http://www.srh.noaa.gov/jetstream/tropics/enso_patterns.htm

Primary effects of El Niño: these are directly caused by El Niño

- Alteration of weather patterns which include temperature changes, **precipitation** changes, storm track changes and intensity, alteration of currents, and ocean temperature.

Secondary effects: these are some consequences of El Niño

- Ecological impacts are fires, flooding, **drought,** crop failure**,** and insect population explosion leading to disease and **plagues**.
- Economic changes such as the price of heating, food, etc.
  - Political and social unrest
  - Crash of fisheries
  - **Famine**
  - Plagues (hanta virus)

Some benefits of El Niño:

- Fewer **hurricanes** and other **tropical cyclones** in the north Atlantic
- Milder winters in southern Canada and the northern continental United States
- Replenishment of water supplies in the southwestern United States
- Less disease in some areas due to drier weather (like malaria in southeastern Africa)

Key Vocabulary

- **Drought:** A period of dry weather, especially a long one that is injurious to crops; an extended shortage of water.
- **El Niño:** An extensive ocean warming in the equatorial eastern Pacific along the coast of Peru and Ecuador.
- **ENSO:** El Niño/Southern Oscillation
- **Equatorial:** Relating to, or located at the equator. The imaginary great circle around the earth's surface, equidistant from the poles and perpendicular to the earth's axis of rotation.
- **Famine:** A severe shortage of food.
- **Hurricane:** A severe tropical cyclone having winds in excess of 64 knots (74 miles per hour).
- **La Niña:** A cold counterpart of the El Niño Southern Oscillation
- **Malaria:** An infectious disease characterized by cycles of chills, fever, and sweating, caused by a protozoan of the genus Plasmodium in red blood cells, which is transmitted to humans by the bite of an infected female anopheles mosquito.
- **Nutrients:** A food or other substance that provides energy or building material for the survival and growth of a living organism.
- **Plagues:** Any widespread and usually highly contagious disease with a high fatality rate; an infectious disease of rodents, especially rats, transmitted to man by the bite of the rat flea.
- **Plankton:** The collection of small or microscopic organisms, including algae and protozoans, that float or drift in great numbers in fresh or salt water, especially at or near the surface, and serve as food for fish and other larger organisms.
- **Precipitation:** Any form of water particles, liquid or solid that falls from the atmosphere and reaches the ground.
- **Temperature:** The degree of hotness or coldness of a substance as measured by a thermometer. It is also a measure of the average speed or kinetic energy of the atoms and molecules in a substance.
- **Thermocline:** A layer in a large body of water, such as a lake or ocean that sharply separates regions differing in temperature, so that the temperature gradient across the layer is abrupt. As one descends from the surface of the ocean the temperature remains nearly the same as it was at the surface. Soon, however, one encounters a zone in which temperature starts decreasing rapidly with depth. This zone is called the thermocline. The thermocline is important because it can support large-scale waves which play a major role in ENSO. In studying the tropical Pacific Ocean, the depth of 20C water ("the 20C isotherm") is often used as a proxy for the depth of the thermocline. Along the equator, the 20C

isotherm is typically located at about 50m depth in the eastern Pacific, sloping downwards to about 150m in the Western Pacific.

- **Trade winds:** Winds that blow steadily from east to west and toward the equator over most of the Torrid Zone. The trade winds are caused by hot air rising at the equator, with cool air moving in to take its place from the north and from the south. The winds are deflected westward because of the Earth's west-to-east rotation.
- **Tropical cyclone**: A large-scale circulation of winds around a central region of low atmospheric pressure, counterclockwise in the northern hemisphere, clockwise in the southern hemisphere.
- **Upwelling:** In ocean dynamics, the upward motion of sub-surface water toward the surface of the ocean. This is often a source of cold, nutrient-rich water. Strong upwelling occurs along the equator where easterly winds are present. Upwelling also can occur along coastlines, and is important to fisheries in California and Peru. The rising of cold, usually nutrient-rich waters from the ocean depths to the warmer, sunlit zone at the surface. Upwelling usually occurs in the subtropics along the western continental coasts, where prevailing trade winds drive the surface water away from shore, drawing deeper water upward to take its place. Because of the abundance of krill and other nutrients in the colder waters, these regions are rich feeding grounds for a variety of marine and avian species. Upwelling can also occur in the middle of oceans where cyclonic circulation is relatively permanent or where southern trade winds cross the equator.

Materials

- Clear plastic oblong container (approx.18"x4"x4")
- Water
- Mineral oil
- Blue food coloring
- Hair dryer
- Red Oil-based Paint (optional)
- Paper sheet map showing the Pacific Ocean (see below for NOAA sample maps)

Preparation

- Fill the tray with water to within 1" of the top. Add blue food coloring to the water until it is a nice “ocean blue”. Some food coloring will settle to the bottom, which is fine because this will show ocean **upwelling.**
- Pour some mineral oil in a bowl and mix in some red oil-based paint until the oil is evenly colored. If you do not have oil-based paint, it does not affect the outcome. Gently pour the oil over the surface of the water.
- It is okay if it mixes a bit because it will separate out again. Put the container on the paper map of Pacific Ocean and mark East, Indonesia, and West, South America at either end. Plug in hair dryer, being careful to keep it away from any water spills. If possible use a ground fault (GFI) outlet.

Explanation

The liquids in the plastic container represent a slice across the Pacific Ocean in the vicinity of the equator. The oil (possibly colored red) represents the warm layer of surface water that has been heated by the sun. The blue water represents the colder water below the surface warm layer. Where the two layers meet is the thermocline. The hairdryer is about to represent the trade winds.

Procedure

1. The teacher turns on the hairdryer (no heat needed) and directs the wind across the surface of the oil-topped water from the East to the West. Ask the class to describe what effect this has on the "warm" and "cold" water.

Notes to Teacher: Notice that the warm water piles up in the West as it is blown by the trade winds, which is the normal condition for the equatorial Pacific Ocean. Discuss the location of the warm water on the globe. Discuss what will happen to the air above the warm water in terms of how much moisture the air can hold. You may notice that the sediment of the blue food dye moves upwards toward the surface at the east end. This movement is ocean upwelling that brings nutrient-rich bottom waters to the surface. **Plankton** feed on the nutrients, and in turn fish feed on the plankton, so these areas tend to be rich in fish and other sea life.

2. Now the teacher turns off the “trade winds” and asks the class to describe what happened when the trade winds stop.

Notes to Teacher: You may need to do this several times to observe the motion. The warm water pulses across the ocean from West to East; this pulse of water is the ocean’s warm water part of the El Niño condition. In the real ocean, the water also deflects up and down the coastline of South and North America. Note that in your model the "upwelling" previously seen while the trade winds were blowing is no longer present, so no nutrient-rich water surfaces to feed marine life. Now a thick layer of warm water (oil) covers the surface in the East, this will cut off the nutrient-rich cold water from upwelling to the surface.

Closure and Evaluation Questions

Pair students up and have them explain in a shared paragraph what the El Niño effect is using examples from the demonstration. Be sure to use the vocabulary words *thermocline* and *upwelling* in your paragraph. Each student needs to have equal input into the paragraph.

Suggested Follow-Up Activities

1. Illustrate the El Niño effect using blue and red colored pencils.
2. Go to the NOAA site and do further research about El Niño and La Niña. Be prepared give an oral report about the positive and negative effects of each condition. (http://www.srh.noaa.gov/jetstream/tropics/enso_patterns.htm)
3. Make a Pros and Cons chart or “T” chart showing the positive and negative effects of El Niño.
4. Using the above chart, have students in pairs of three discuss whether in their opinion El Niño is good or bad for the environment and for humankind. Could there be trade-offs? Is an environmental disruption like El Niño always a negative force or positive force?

5. Research the negative effects of El Niño in a specific geographical area, such as your coastline or an area of interest like Australia, etc.

Sources

http://www.srh.noaa.gov/jetstream/tropics/enso_patterns.htm

http://www.oc.nps.edu/webmodules/ENSO/effects.html

http://www.arm.gov/about/glossary

http://www.esrl.noaa.gov/psd/enso/enso.glossary.html

Creative contributions and adaptations by Steve Linn, 4th grade teacher at Cottonwood Elementary, Kennewick, Washington

Samples of Pacific Ocean Maps