15.11

El Niño and La Niña

What do the following reports have in common?

- Toward the end of 1997, countries in the western Pacific Ocean, such as the Philippines, that normally get heavy rains experienced a severe drought. In Indonesia, the worst drought in 50 years set the stage for huge forest fires (Figure 1).
- At the same time in countries along the west coast of South America, such as Peru, the normally dry regions sprang to life with wildflowers after heavy rainfall.
- Also at the same time, torrential rains fell in the normally dry regions of Somalia and Kenya in east Africa.
- The winter of 1997/1998 on the west coast of North America was much wetter than average. Record snowfalls fell in the Rocky Mountains, and snow fell in Guadalajara, Mexico, for the first time since 1881.
- The winter of 1997/1998 for eastern North America was much milder than average. The most devastating ice storm in North American history (the storm of 1998) struck a region that would normally be too cold for that type of weather.
- The 1997 Atlantic hurricane season was much less active than average.

Figure 1

With much lower-than-average rainfall in 1997, forest fires became a major problem in regions of the western Pacific Ocean. The fires in Indonesia destroyed vast areas of forest and created severe pollution.

The answer is that the extreme weather events around the world were a result of El Niño. El Niño is a shift in the ocean currents, temperatures (water becomes warmer), and atmospheric conditions in the tropical Pacific Ocean. Only in recent years have scientists realized how much
El Niño affects weather patterns in most areas of the world.

What Causes El Niño?

It may be difficult to visualize something as huge as the Pacific Ocean as water sloshing back and forth in a pan, but in some ways this image works. The atmospheric and surface water temperatures appear to go through cycles from low to normal to high, then back to low again. Therefore, the ocean currents, surface winds, and atmospheric pressures also go through cycles. Scientists use observations of temperatures, elevation of sea levels, and other factors to follow the cycles.

El Niño occurs during the part of the cycle when the surface temperatures of the tropical Pacific Ocean off the coast of South America are higher than average. The model in Figure 2 shows the extreme changes in ocean temperatures during the 1997–98 El Niño event.

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Figure 3 shows the currents and winds related to the cycles. During the normal period, the north and south equatorial currents flow westward, and the Pacific northeast and southeast trade winds also blow westward as they come together near the equator. This westward flow of water and air carries the warm surface waters westward. As a result, the water level on the west side of the Pacific Ocean is normally about 50 cm higher than on the east side. The warm water causes stronger convection currents of air, which carry moisture into the atmosphere, producing thunderstorms and heavy rainfall in Indonesia, the Philippines, and northern Australia. In the eastern Pacific, the westward moving warm water is replaced by cold water moving in a convection current. Because this water is cool, less upward convection of air occurs, so rainfall on the west coast of South America is minimal.

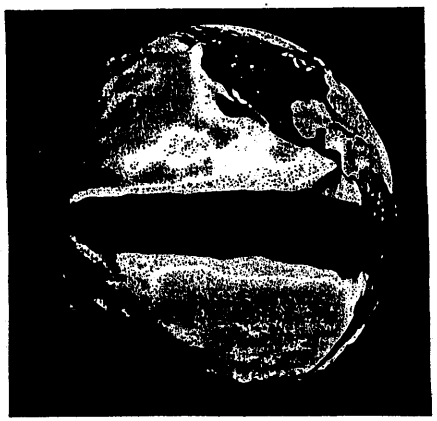


Figure 2

This model, generated from NASA satellite data, shows both unusual sea surface elevations and surface water temperatures during the El Niño event of 1997–98. Red indicates higher-than-normal temperatures, blue lower-than-normal.

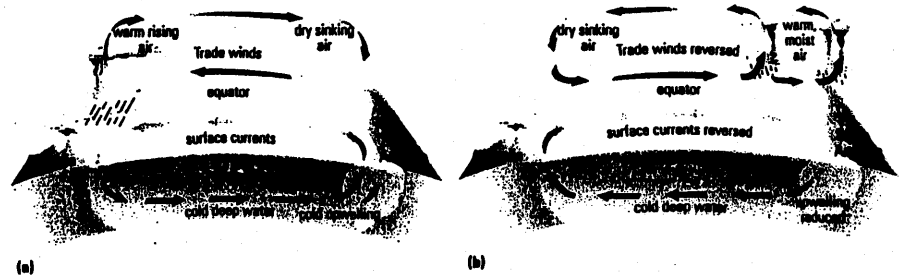
When the surface water temperature and the water level in the western Pacific become much higher than normal, El Niño begins. The extra water begins to push eastward, reversing the equatorial current flow and weakening the trade winds. This is much like carrying water in a flat pan: it sloshes back and forth. The warm waters and air cause the thunderstorms and rainfall to move eastward across the Pacific Ocean, eventually reaching the coast of South America.

One country that often receives the full extent of El Niño is Peru. Peruvians noticed that the reversal of the temperatures and other factors often seemed to happen at the end of December, so they named the event "El Niño," which means little boy or infant, after Jesus, whose birth is celebrated on December 25.

El Niño events vary in how often they occur and in how long they last. They may last for only a few months or, more often, continue for one or two years. They usually occur once every three to five years, but they may also wait for 10 years to return. Extreme El Niño events may occur once every 20 to 50 years.

Figure 3

Comparing a normal year with an El Niño year.
(a) During a normal year
(b) During an El Niño year



(a) (b)

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Other Effects of El Niño

Many of the effects of El Niño occur in and around the Pacific Ocean. For example, off the west coast of South America, normally the rising cold waters that flow in a convection current bring rich nutrients to the surface. These nutrients provide food for some of the largest fish populations in the world. But when the warm El Niño waters arrive, they prevent the cold water from rising. Thus, the fish have no food, and both the fish and animals that depend on the fish, such as birds and sea mammals, must move or die. The fishing industry also collapses.

But because the Pacific Ocean is so large, El Niño also affects ocean currents and prevailing winds around the world. For example, El Niño's influence on jet streams can be seen in North America. In the winter, El Niño pushes the polar jet stream farther north, preventing much cold Arctic air from reaching parts of the eastern United States, causing milder than average winters. El Niño also pushes the subtropical jet stream farther south than normal, resulting in higher than average precipitation in the southern parts of North America. This eastward flowing jet stream also pushes against the westward moving tropical storms in the Atlantic Ocean, reducing the chances that these storms can develop into hurricanes.

These observations lead to an important concept: evidence suggests that most (if not all) of the extreme events presented in this chapter become even more extreme during various parts of the El Niño cycle. More research will help us understand why.

Researching El Niño

Not many years ago, the public knew little or nothing about El Niño. (A 1980 university text on atmospheric science devoted only one short paragraph to the phenomenon.) Scientists now believe that El Niño is so important that it has become the subject of major concern and research. Satellites keep track of sea levels and changing water temperatures. Ocean-going ships carry instruments that record data, which are transmitted to research stations. Numerous platforms and buoys have been set up at regular intervals in the Pacific Ocean to check water temperatures both at and beneath the surface. Researchers have gathered samples of ice, soil, and coral from locations around the Pacific Ocean to look for cycles that may have occurred over the past hundreds and thousands of years. This research will lead to better understanding and forecasts.

La Niña

At the opposite end of the cycle to El Niño is La Niña, which is a shift to colder than average ocean temperatures in the eastern Pacific. (La Niña means "little girl.") During this shift, the surface water temperature off the coast of Peru can drop to as low as 24°C. The effects are opposite to those of El Niño. Indonesia and northern Australia receive higher than normal precipitation. The jet streams are also affected. For instance, the summer jet stream above North America shifts northward, so its effect on the build-up of Atlantic hurricanes north of the equator is reduced.

Hurricanes develop more easily. Thus, you can see that measuring the surface water temperature off the coast of Peru helps meteorologists predict the number of Atlantic hurricanes. This is just one example of why meteorologists want to share their exciting research and discoveries with the public in general and students in particular.

Understanding Concepts

1. A student once asked, "Could we say that the Pacific Ocean has a healthy body temperature of 28°C?" Why is that a good question?
2. (a) Under normal conditions, in what general direction do the Pacific equatorial currents flow?
   (b) Describe what happens to those currents during El Niño.
   (c) What happens to the Pacific Ocean trade winds during El Niño?
3. The Galápagos Islands archipelago, located on the equator 1000 km west of Ecuador, supports two types of iguanas: land iguanas (Figure 4) and sea iguanas.
   (a) Which type of iguana would survive better during El Niño? Explain why.
   (b) Which type would survive better during normal conditions? Why?

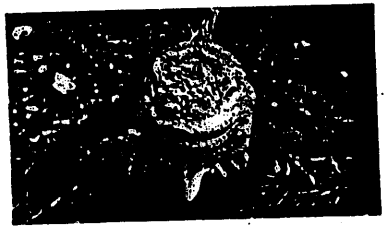

Figure 4

4. Describe how North American weather is influenced by El Niño and La Niña.

Making Connections

5. During an extreme El Niño, the fishing industry in Peru does poorly, but fishers off the west coast of North America report catching fish never before seen there. Explain why there is such a change.
6. Arrange the following statements in an order that demonstrates how a severe El Niño can affect the price of soybeans:
   (a) With an increased demand and lower supply, soybean prices rise.
   (b) The anchovies feed on the ocean plants, so with no plants, there are no anchovies.
   (c) The warm El Niño current moves southward along the coast of Peru.
   (d) With no anchovies on the world market, there is no fish meal for animal feed.
   (e) The plants in the ocean do not get enough nutrients from the water to flourish.
   (f) Farmers need animal feed, so they buy soybeans, a substitute for fish meal.
   (g) With no anchovies, there is no food for the birds and larger fish, which puts a major dent in Peru's fishing economy.
   (h) The warmer water prevents the cool, nutrient-rich bottom water from rising.
7. The term "El Niño/Southern Oscillation," or ENSO, can be used in place of simply El Niño. Explain why this term is appropriate.

Answer Questions #1-7 on a separate piece of paper!