Impacts of ENSO
(El Niño-Southern Oscillation)

GLOBE		*Related SDGs:*	*Type of activity*
Spheres	**Protocols**		
Atmosphere	Air Temperature, Surface Temperature, Precipitation	6 (Clean water and Sanitation) 13 (Climate Action) 14 (Life Below Water) 15 (Life on Land)	Exploratory
Pedosphere	Soil Moisture, Soil Temperature		
Hydrosphere	Water Temperature		
Bundle	ENSO Bundle		

Overview

Satellite images and maps are analyzed to determine the impacts of the ENSO phenomenon at a local, regional and global scale with examples of the 2015 El Niño and the 2010 La Niña events. Students analyze the local and regional impacts and develop an outreach campaign to help the population learn about the ENSO phenomenon and prepare for future impacts.

Time

4 classes

Prerequisites

Basic knowledge of meteorology, ecosystems and ICT. Ability to interpret satellite images and maps. Ability to locate points using latitude and longitude.

School Level

Upper Primary School, High School and University students

Purpose

To understand the interrelationship of energy exchange between the spheres of the Earth System during the ENSO phenomenon and its impact on human activities.

Student outcomes

- To interpret satellite images and maps to draw conclusions about the impact of the ENSO phenomenon in different regions.
- To give examples of how ENSO events affect different human activities in different regions of Latin America and the Caribbean.
- To use geographic information to develop a public awareness campaign to help the population prepare for ENSO events.

Introduction

In Latin America and the Caribbean, the ENSO phenomenon produces negative effects on the sustainability of ecosystems (coral bleaching, changes in phytoplankton that affect the food web), on agricultural production systems (coffee, sugarcane, cocoa, bananas, tubers, soybeans and other cereals, etc., reduced pastures for livestock) and on fishery resources (fish deaths) that affect prices, the economy, social security, food security and health. For example, the 2015-16 El Niño had very significant social and economic impacts, such as worsening droughts in The Caribbean and northern South America, with some extreme precipitation events and floods in Central and Southern South America. The humid zone of Argentina, Uruguay and Southern Brazil tends to record above-normal rainfall during El Niño phase, mainly in spring and summer, while during La Niña phase, this zone tends to record below-normal rainfall, particularly during the winter. Studying the ENSO phenomenon and predicting it in time helps society to develop adaptation actions to face these effects.

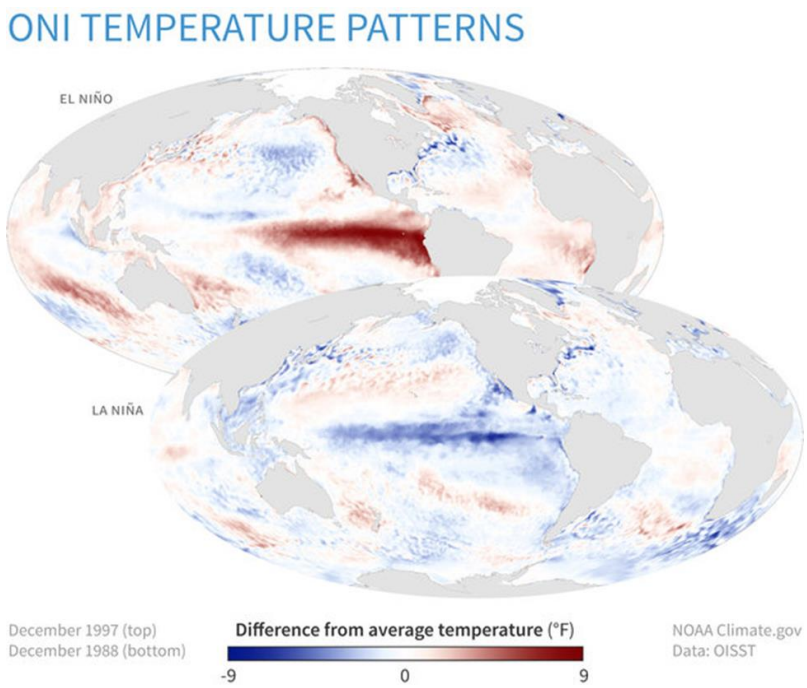

Fig. 1. Temperature anomalies during the 1997 El Niño and 1998 La Niña events

Temperature anomalies (above-normal increase or decrease) in the surface waters of the Pacific Ocean produce the El Niño-Southern Oscillation (ENSO) phenomenon. This event directly affects the distribution of rainfall and temperatures in tropical areas and can have a strong influence on the climate in other parts of the world, causing extreme weather events such as heat waves, droughts, floods and other associated problems such as diseases, fires, etc. These interactions around the world are called teleconnections.

El Niño and La Niña are the extreme phases of the ENSO cycle; between these two phases there is a third phase called Neutral. See animations. For several years now, satellites have provided a global view of ocean surface temperatures.

El Niño: occurs when the trade winds are weaker than they usually are. The warm water accumulates along the equatorial zones and moves toward the coasts of Central and South America. As the surface of the water is warmer than normal, the atmosphere also warms, causing moist air to rise, forming clouds and storms.

La Niña: is an inverse phase because the trade winds become stronger, cold water accumulates on the coasts of Central and South America. As a consequence, the atmosphere is cooled by the contact with the cold surface waters of the ocean, for this reason very little water evaporates and the air does not rise. This causes an anomalous decrease in precipitation and storms in that region.

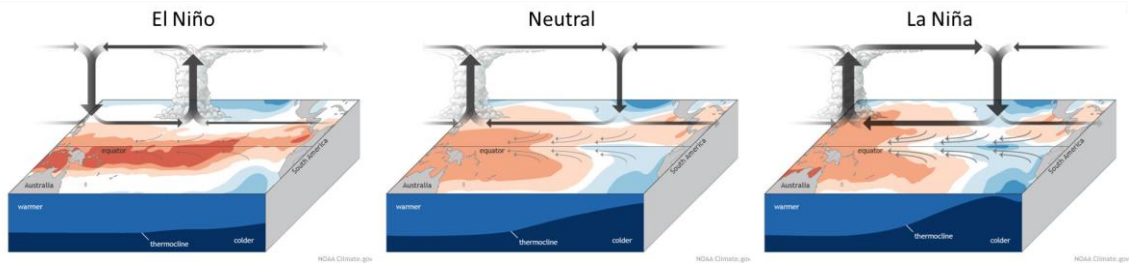

Fig. 2 Atmosphere-ocean feedback during the ENSO phenomenon. El Niño, Neutral and La Niña phases.

Oceanic Niño Index: known by its acronym in English as ONI (Oceanic Niño Index) represents the deviation of the quarterly average surface temperature of the Pacific Ocean. It is the main measure for predicting the phenomenon and is composed of 3 phases: 1) El Niño with positive values equal to or greater than +0.5ºC for three consecutive months; 2) La Niña with negative values less than or equal to -0.5ºC for three consecutive months; and 3) the Neutral phase with ONI values between -0.5 and +0.5. These events vary in intensity. See animation of the index and the map. (Interactive ONI chart in degrees Celsius and Fahrenheit)

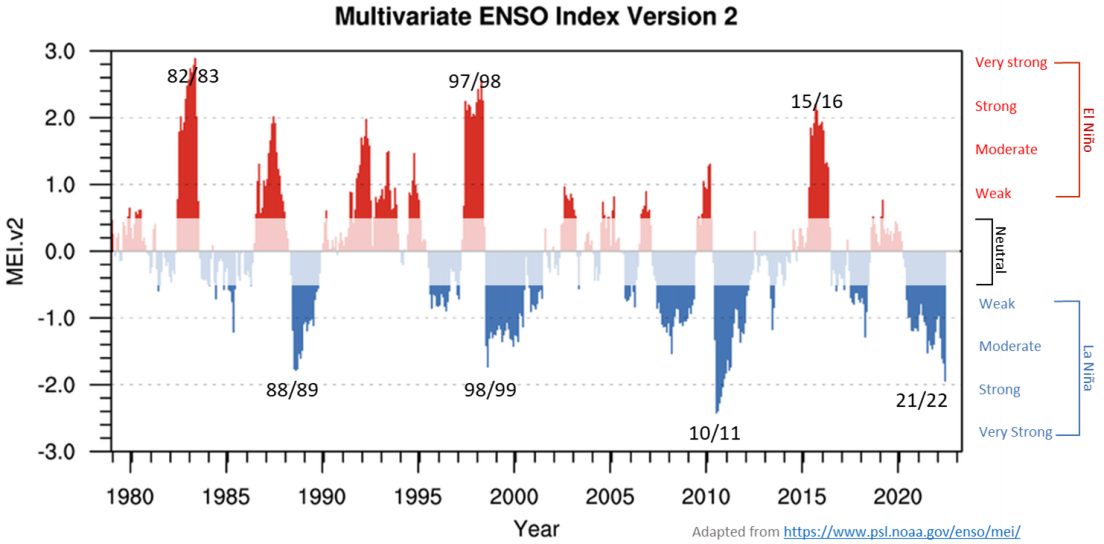

Fig. 3. El Niño Oceanic Index. The red area indicates El Niño events and the blue area indicates La Niña events. Years with very strong events are shown.

Each ENSO event is different and occurs in conjunction with other weather events. Not all impacts occur in all events, and may not be limited to the regions indicated. The maps show areas where impacts are likely to occur, based on historical evidence.

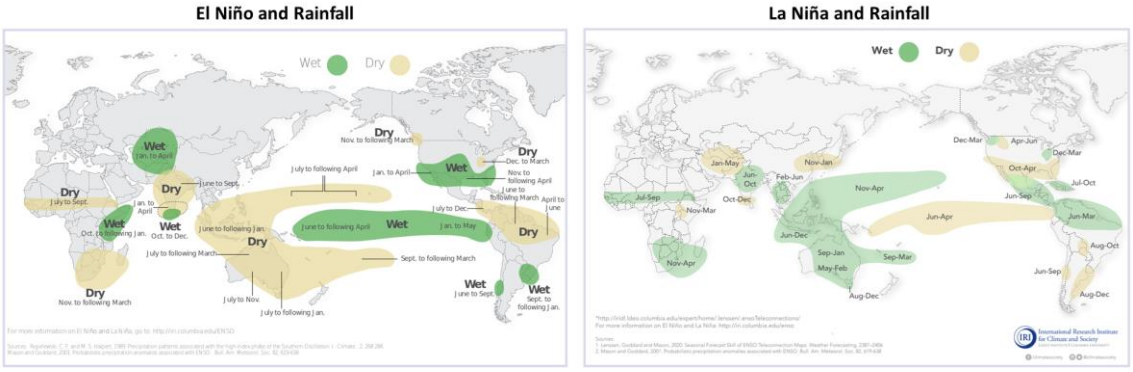

Fig. 4. Changes in precipitation patterns during El Niño and La Niña events.

El Niño and La Niña conditions in the tropical Pacific change precipitation and temperature patterns in many parts of the world. These changes vary in intensity from one event to the next, but are maintained with some consistency in the regions and months shown on the maps.

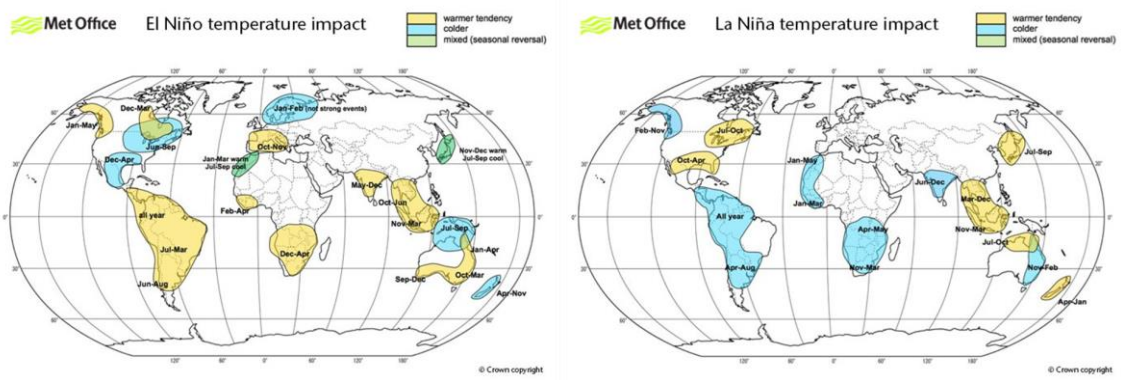

Fig. 5. Changes in temperature patterns during El Niño and La Niña events.

Guiding research questions

- What are the main differences between a normal phase (neutral) and El Niño and La Niña phases?
- How does the impact of El Niño and La Niña vary in different parts of the world?
- What changes occur in temperature and precipitation patterns during the ENSO phenomenon in your country and locality?
- How did these changes affect ecosystems, human activities, and health in your country?

Scientific concepts

- Weather and climate
- Atmospheric circulation
- Ocean currents
- Environmental hazards and vulnerability

Materials and tools

Satellite images of:

1. Sea surface temperature anomalies (El Niño: 1 Nov 2015, Neutral 1 Mar 2014 and La Niña: 14 Dec 2010)
2. Total precipitation (monthly average) (Mar 2014, Nov 2015 and 14 Dec 2010)
3. Daytime soil surface temperature (monthly average) (Mar 2014, Nov 2015 & 14 Dec 2010)
4. Impacts: Floods from El Niño (Jan 2016), fires (Feb 2022) and droughts (Oct 2020 groundwater and soil moisture) from La Niña.

What and how to do it

- ***Beginning***

  Ask your students to look for news about the impact of the ENSO phenomenon in their country. (Consider the ONI index with significant events). Generate a discussion with your students and gather the information in the following table.

Month/Day/Year	News	El Niño	La Niña

- ***Development***

1. Ask students to read the introduction to this activity and make a concept map with the information. Add to the concept map the examples of impacts in their country that they found in the news.
2. Divide the class into groups and assign a Worldview satellite image to each group (Sea Surface Temperature Anomalies and Total Precipitation). Students should answer the following questions: What does each color represent in the different images? In which regions are the colors more intense?
3. Gather all the groups and ask them to explain the images analyzed, consult the information on the concept map and determine to which ENSO phase each image corresponds.
4. Project the surface temperature images to compare with the previous ones. What happened in your region during the 2015 El Niño and the 2010 La Niña phase?
5. Consult the images of some El Niño and La Niña impacts and compare them with the impacts in your region.

- ***Ending***

Due to the relevance of the ENSO phenomenon in society, it is important to develop outreach materials for your area. Ask your students to elaborate a story with maps (Story Map), a video, or flyers to post on social media.

Frequently asked questions

Where can I find satellite images? – Worldview

Why is NASA studying the ENSO phenomenon? – This phenomenon can be investigated from space to complement measurements on the ground. Oceanography from space provides relevant information for research. The ENSO phenomenon produces changes in temperature, sea level height, winds, ocean currents, salinity, phytoplankton, sea ice. Combining satellite data with on site measurements makes it possible to analyze the events and their impacts in order to implement adaptation actions.

Suggested resources for further information

As an extension of this activity, students can consult satellite images from different dates during the ENSO events mentioned to investigate the phenomenon from beginning to end, or investigate other ENSO events that have occurred in the past. Worldview has about 20 years of satellite images stored.

Another suggestion is to make measurements in your environment (whether you are in a Neutral phase or in a La Niña or El Niño phase). This allows comparison with satellite image information to understand the impact at a local, regional and global scale. The relevant protocols for measurements are: 1) Atmosphere: Air and Surface Temperature, Precipitation. 2) Pedosphere: Soil Moisture and Temperature. 3) Hydrosphere: Water Temperature.

Other resources:

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Tutorials: Worldview, Story Map

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