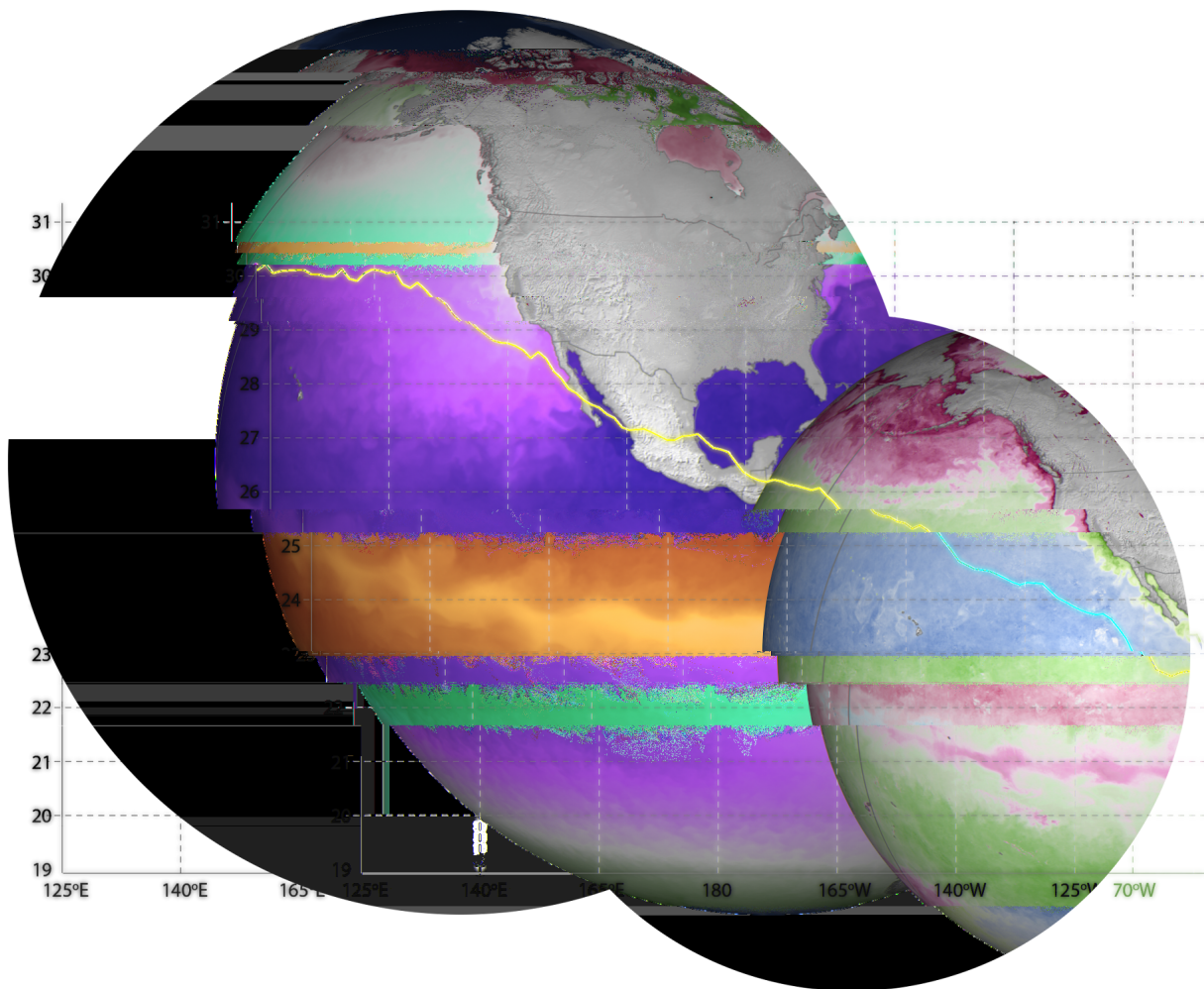


DATA IN THE CLASSROOM

INVESTIGATING EL NIÑO USING REAL DATA



2nd Edition (2017)

This curriculum module was originally developed for the NOAA Ocean Data Education (NODE) Project by Caroline Joyce and Todd Viola under a contract with the National Marine Sanctuary Foundation. The 2nd edition (2017) was completed under contract by Amy Dean. Data in the Classroom is a collaboration of many NOAA programs and offices including: National Environmental Satellite, Data, and Information Service (NESDIS), National Estuarine Research Reserve System, National Oceanographic Data Center and the Office of National Marine Sanctuaries.

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INTRODUCTION

El Niño is an interesting and complicated phenomenon. Understanding how it works requires looking at the interplay of a number of Earth's systems. This curriculum module is designed to help students use real data to explore these systems and enhance their understanding of the El Niño phenomenon. The curriculum is not designed to be a comprehensive unit on El Niño, which is treated well in textbooks and other sources. Rather, the focus is on data literacy as much as science, and the lessons are intended to help achieve important cross-curricular connections between science and mathematics.

The U.S. Ocean and Coastal Observing System maintains numerous data sets that can be used to study El Niño. This curriculum will deal primarily with two types of data that are measured using satellite instruments: sea surface temperature and the concentration of chlorophyll-a. The activities in this unit are organized as a pathway with five levels of increasing sophistication. Students first need to understand how to access and interpret sea surface temperature data, then how to identify and measure changes in temperature over time. Along the way, they will learn how these changes relate to other physical systems, specifically ocean circulation and the phenomenon of upwelling. Ultimately, students will examine these relationships with respect to biological systems, using data on chlorophyll as a measure of productivity. The goal is for students to become experienced with these kinds of data and the tools for accessing them, so that, by the end of the module, they can continue to explore data sets driven by their own inquiry.

El Nino Basics

El Niño is a set of phenomena caused by periodic changes in the ocean-atmosphere system in the tropical Pacific Ocean. During El Niño, the trade winds, which usually blow warm surface waters to the west, die down or even reverse. When the wind stops blowing the warm water to the west, the warm water pools in the east, triggering a number of effects in the atmosphere and ocean. The eastward movement of warm moist air, which follows the warm water, can bring above-average rainfall to places like Peru, as well as changes in atmospheric circulation. The warm water causes the air immediately above it to become

warmer than the surrounding air masses. This warmer air is less dense and rises. As the air rises, it adiabatically cools. The cooling air reaches its saturation temperature, and the moisture condenses, resulting in rain. In the ocean, meanwhile, the pooling of warm water pushes warmer temperatures even deeper into the water column. This disrupts the normal upwelling circulation that brings cold, nutrient-rich waters to the surface. Shutting off the supply of nutrients results in a decline in primary productivity, which then impacts organisms farther up the food chain.

Curriculum Overview

This curriculum module offers activities at five different levels of student interaction, sometimes referred to as Entry, Adoption, Adaptation, Interactivity and Invention. Levels 1 and 2 are very directed and teacher driven. Levels 3-5 of Adaptation through Invention are more student directed and open up opportunities to design lessons featuring student inquiry. This chart illustrates the five levels of this module, *Investigating El Niño Using Real Data*.

The levels also provide a natural opportunity for you to adapt and customize the curriculum module as needed. For example, if students already have experience with the topic, you may find that you can skip the entry level activities.

			5	INVENTION: Designing Your Own Investigation – Students will design their own plan to answer a research question. They will describe how they will use data and consider the limitations of the data.
			4	INTERACTIVITY: Relating SST to Productivity – Students will investigate the relationship between two different data sets by writing a hypothesis and examining it using real data.
			3	ADAPTATION: Detecting El Niño – Students will apply data skills to a real problem – detecting an El Niño event. This activity uses guided inquiry and investigation design.
		2		ADOPTION: Looking at SST Another Way – Students will examine another way of displaying temperature data in order to understand the benefits of different displays. This teacher-directed activity applies pre-existing models and provides practice reading data.
	1			ENTRY: Reading Sea Surface Temperature – Students will learn how to read and interpret sea surface temperature (SST) maps. This is a teacher-led discussion and activity.

Next Generation Science Standards (NGSS)

All Data in the Classroom modules follow guiding principles found in the Next Generation Science Standards (NGSS)¹. The standards are based on the notion of learning as a developmental progression. The activities in each module can be incorporated into an existing curriculum or unit of study to help address NGSS principles, core ideas, and concepts for grades 6-8. You can learn more about how this module relates to specific NGSS components by visiting the [Data in the Classroom website](#).

Ocean Literacy Principles

This curriculum module also supports the following Essential Principles of Ocean Sciences.²

1. The Earth has one big ocean with many features.
 - c. Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of the Earth's rotation (Coriolis effect), the Sun, and the water density differences. The shape of the ocean basins and adjacent land masses influence the path of circulation.
 - f. The ocean is an integral part of the water cycle and is connected to all of the earth's water reservoirs via evaporation and precipitation processes.
2. The ocean is a major influence on weather and climate.
 - c. The El Niño Southern Oscillation causes important changes in global weather patterns because it changes the way heat is released to the atmosphere in the Pacific.

¹ NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington D.C.: The National Academies Press. Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

² Ocean Literacy Network (2005). Ocean Literacy - The Essential Principles of Ocean Sciences K-12. Washington, D.C.

LEVEL 1: ENTRY

READING SEA SURFACE TEMPERATURE

Understanding El Niño Using Data in the Classroom

NOAA Data in the Classroom

Introduction Level 1 Level 2 Level 3 Level 4 Level 5 Get Data Teachers Guide

Reading Sea Surface Temperature

Introduction

Objective
Students will learn how to read and interpret sea surface temperature maps.

Background
One of the ways to detect an El Niño event is to look at sea surface temperature (SST). SST can be recorded using instruments on satellites that measure heat from the surface of the ocean. This data can be represented on maps in different ways. One way scientists do this is to

Color Legend

SUMMARY

- Grade Level: 6-8
- Teaching time: 45 minutes
- Activities: a) identify locations on a map using latitude and longitude and b) use a false-color map to read sea surface temperature at specific locations.
- Vocabulary:
 - *El Niño*: a set of phenomena caused by periodic changes in the ocean-atmosphere system in the tropical Pacific Ocean.
 - *Sea surface temperature* (SST): the average temperatures at the uppermost layer of the ocean – only a few millimeters deep.
 - *False color map*: an image that uses colors to represent differences in measured values, rather than true appearance.

LESSON PLAN – LEVEL 1

Objectives

Students will learn how to read and interpret sea surface temperature maps.

Background

One of the ways to detect an El Niño event is to look at sea surface temperature (SST). SST can be recorded using instruments on satellites that measure heat from the surface of the ocean. This data can be represented on maps in different ways. One way scientists do this is to plot different temperature values with different colors, producing what is called a false-color map.

Materials

- Projector
- Computers and internet access

Teacher Prep

There are a variety of ways to implement this activity. Decide which works best for your classroom, and prepare as appropriate.

- Go to the the Data in the Classroom website and familiarize yourself with the [Level 1 activities](#). *Note: there is no student worksheet associated with this lesson.*
- Use a projector to guide students through this lesson or have students work through the lesson individually (on their own devices).

Procedure

Part 1: Understanding False Color Maps

Before students can start using data to understand and detect El Niño events, they need to learn how to read sea surface temperature (SST) maps.

1. Working at a computer, students should navigate to Level 1 of the *Understanding El Niño* module.
2. Project Level 1 onto a screen to help guide students through the activity.
3. Scroll down to the section titled 'Understanding False Color Maps.' Here, you'll find a map displaying sea surface temperature measurements (SST) from space. This type of map, called a false color map, uses a variety of colors to represent different temperature measurements across the Pacific Ocean.
4. Using the projected image, discuss the key features of the map:
 - The map displays information about sea surface temperature taken from instruments aboard satellites orbiting the earth (during December 2015).
 - The geographic area of the map is defined using lines of latitude and longitude.
 - X axis = longitude, degrees east and west.
 - Y axis = latitude, degrees north and south of the Equator.
 - The land areas on the map are colored gray.
 - The Pacific Ocean is colored various shades of red and blue. The colors represent temperature at the ocean's surface.
 - Locate the color legend on the map, and click the information icon to display. This legend indicates the surface water temperature in degrees Celsius.
 - Ask students what color indicates the warmest water (dark red) and the coldest water (dark blue) on the map.

-
5. Give students time to answer the questions at the end of this section.

Answer - Question 1: Degrees north and south of the equator

Answer - Question 2: 26 °C

Part 2: Comparing Change Over Time

Now that students can read a sea surface temperature (SST) map, they can compare temperature data from one year to the next.

1. Scroll down to the next section titled 'Comparing Change Over Time.' Here, you'll find two SST maps. On the left is a map from December 1990, and on the right is a map from December 1991.
2. Ask: How are the maps alike and how are they different? *Hint:* Look at the size of the areas of high temperature.
3. Discuss these questions: How can using satellite data help researchers to study water conditions over time? Why is it important for researchers to look at data for more than one year to determine sea surface temperature change?
4. Give students time to answer the question at the end of this section.

Answer - Question 3: D. Answer A and C

Part 3: Explore More Data

Once students are comfortable reading maps, they can explore changes in SST over short and long periods of time by running a time series animation.

1. Scroll down to the final section in Level 1 titled 'Explore More Data.'
2. Ask students: After analyzing the December 1991 map above, what do you think a map from June 1992 should look like? Students can adjust the sliders and playback speed as desired and play the animation.
3. Ask students to share their observations: for example, students may have observed that the warmer band of water shifts northward in the summer months and southward in winter months.

LEVEL 2: ADOPTION

LOOKING AT SST ANOTHER WAY

Understanding El Niño Using Data in the Classroom

NOAA Data in the Classroom

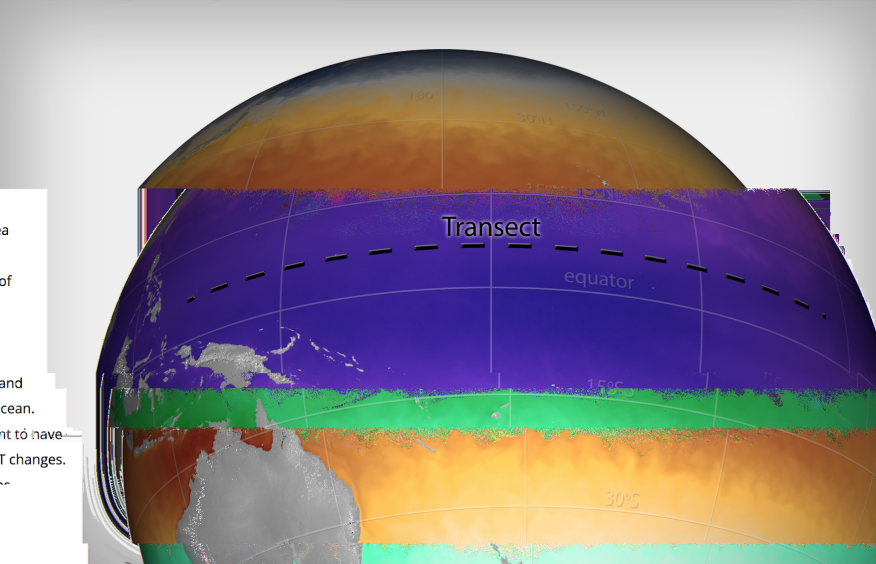
Introduction Level 1 Level 2 Level 3 Level 4 Level 5 Get Data Teachers Guide

Looking at SST Another Way

Introduction

Objective
Students will explore two different ways sea surface temperature (SST) data can be represented and describe the advantages of both displays.

Background
Researchers use satellites to collect data and provide "snapshots" of sections of the ocean.
During an El Niño event, it is important to have different tools to understand how SST changes. In the last activity, students used maps



SUMMARY

- Grade Level: 6-8
- Teaching time: 45 minutes
- Activities: a) Interpret a graph of sea surface temperature data along a single line of latitude and b) examine the relationship between data displayed on a map and on a latitude line graph.
- Vocabulary:
 - *Latitude line graph*: a plot of data along one line of latitude from west to east.

LESSON PLAN – LEVEL 2

Objectives

Students will explore two different ways sea surface temperature (SST) data can be represented and describe the advantages of both displays.

Background

Researchers use satellites to collect data and provide “snapshots” of sections of the ocean. During an El Niño event, it is important to have different tools to understand how SST changes. In the last activity, students used maps displaying SST over a large surface area in the Pacific Ocean. Now students are asked to look at that same data, but this time using a graph along a single line of latitude from west to east. This kind of graph displays finer details and can make it easier to see and measure relative differences in SST. Students should know how to use both the map and the graph, because both are useful for interpreting data and understanding an El Niño event.

Materials

- Projector
- Computers and internet access
- Photocopies of student worksheet (optional)
- Ruler (if using the student worksheets)

Teacher Prep

There are a variety of ways to implement this activity. Decide which works best for your classroom, and prepare as appropriate.

- Go to the Data in the Classroom website and familiarize yourself with the Level 2 activities (as well as the student worksheet from the Teacher Resources page).
- Use a projector to guide students through this lesson or have students work through the lesson individually (on their own devices).

Procedure

Part 1: Graphing Sea Surface Temperature Measurements

1. Working at a computer, students should navigate to [Level 2](#) of the *Understanding El Niño* module.
2. Project [Level 2](#) onto a screen to help guide students through the activity.
3. Scroll down to the section titled 'Graphing SST Measurements.' Here, you'll find a line graph of sea surface temperature data during December 2015. This type of graph, called a *latitude line graph*, displays temperature along one line of latitude, in this case along the equator.
4. Ask students: What are the units along the X and Y axes? Make sure they understand the difference between degrees of temperature and degrees of latitude/longitude.
Answer: X axis = longitude, degrees east and west, Y axis = monthly average sea surface temperature in degrees Celsius.
5. With students, practice reading data values from the graph. Example: What was the monthly average sea surface temperatures along 0° latitude at 165°E?
Answer: 29 °C
6. Give students time to answer Question 1, completing either the online chart (or the identical table on the student worksheet). Students should use decimals to represent fractional values where appropriate.
Answers to Question 1: 28.6 °C, 30.0 °C, 27.6 °C, 23.6 °C

Part 2: Understanding Maps and Graphs

1. Scroll down to the next section titled 'Understanding Maps and Graphs.' Here, you'll find a map and graph both displaying sea surface temperature. The upper image shows the SST map for December 2010. Notice the 'transect' line across the equator. The graph below shows SST data for December 2010 along the equator (indicated by the transect line on the above map).
2. Give students time to answer Question 2 and complete the online chart (or the identical table on the student worksheet).

Answers to Question 2 - SST map: answers will vary

Answers to Question 2 - SST graph: 30.0 °C, 27.0 °C, 24.4 °C, 21.0 °C

3. Ask students to compare the results they obtained using the map and line graph. Discuss any differences. Ask: Is one of the data sources wrong? What are some advantages and disadvantages of using maps versus graphs to display the same temperature data?

Answer: Maps can display data patterns over large areas, but often with less detail or resolution than graphs. Graphs represent a “slice” of data along a line, but can show smaller variations.

4. Give students time to answer Question 3 at the end of this section.

Answer to Question 3: A map can help to explain data patterns over large areas.

Using the Get Data tool

If your students have access to computers and the internet, you may challenge them to make their own sea surface temperature graphs using the ‘Get Data’ tool. Brief instructions are below. More detailed instructions can be found on the Get Data page of the *Understanding El Niño* online activity.

- a. **Which timespan?** Select ‘monthly’
- b. **Specify a date:** Select the desired month and year
- c. **Bounding Box:** Move and resize the red box on the map by clicking and dragging the edges. For example, students may resize the box to include southern Alaska, Australia and the west coast of South America.
- d. **Select an output format:** Leave the default selection, “download image.”
- e. Click ‘Download’

LEVEL 3: ADAPTATION

DETECTING EL NIÑO

Understanding El Niño Using Data in the Classroom

NOAA Data in the Classroom

Introduction Level 1 Level 2 Level 3 Level 4 Level 5 Get Data Teachers Guide

Detecting El Niño

Introduction

Objective
Students will apply map and graph skills learned in earlier levels to a real problem — identifying an El Niño event.

Background
During a typical year, the trade winds that blow across the Pacific Ocean push warm surface water to the west. On a typical SST map, the surface water in the western Pacific is warmer than in the eastern Pacific. But periodically, this pattern changes. The trade winds die down or

Upwelling and El Niño
Nino Conditions

TRADE WINDS

UPWELLING

SUMMARY

- Grade Level: 6-8
- Teaching time: Two 45-minute periods
- Activities: a) generate maps and graphs of sea surface temperature data and b) use data to distinguish between an El Niño and 'normal' SST conditions.
- Vocabulary:
 - *Trade winds*: wind systems occupying most of the tropics, which blow from approximately 30 degrees North and South of the equator. The winds blow from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere.
 - *Thermocline*: water layer with a large change in temperature with depth.
 - *Upwelling*: movement of nutrient-rich water to the surface.

LESSON PLAN – LEVEL 3

Objectives

Students will apply map and graph skills learned in earlier levels to a real problem — identifying an El Niño event.

Background

During a typical year, the trade winds that blow across the Pacific Ocean push warm surface water to the west. On a typical sea surface temperature graph (Figure 1), the surface water in the western Pacific is warmer than in the eastern Pacific. But periodically, this pattern changes. The trade winds die down or even reverse, and water temperatures in the east become warmer than usual. This change in wind patterns is the beginning of an El Niño.

This change can be seen by looking at a plot of sea surface temperature from west to east. During a ‘normal’ year, the temperature difference between warm water in the west and cooler water in the east is evident in the slope of the line (Figure 1).

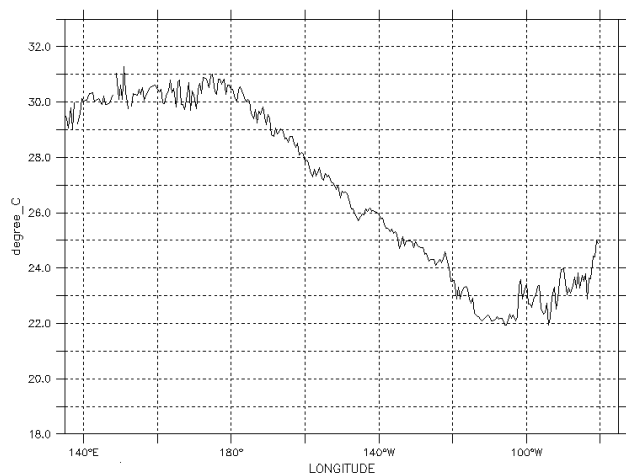


Figure 1: Sea surface temperature during a ‘normal’ year, Dec 1990.

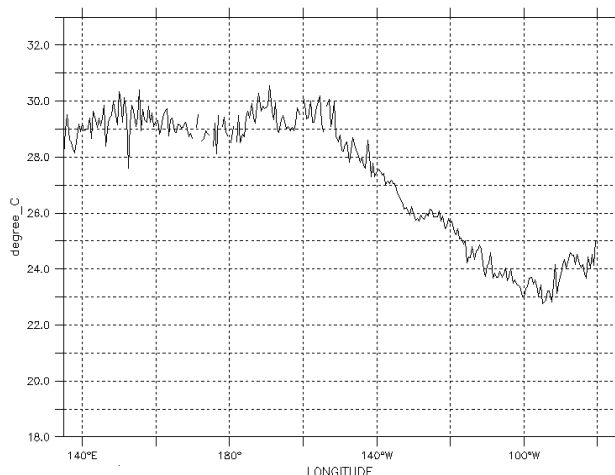


Figure 2: Sea surface temperature during an El Niño year, Dec 1991.

During an El Niño year, the area of high temperature can be seen extending farther to the east than in a typical year (Figure 2). The temperature difference from west to east may also be smaller.

The shift in temperature has an important effect on ocean circulation. Usually, cold water from the bottom of the ocean rises to the top in the eastern Pacific to replace the surface water that the trade winds have blown to the west. This rising of cold water to the surface is called upwelling, and is important because it brings nutrients from deeper water up to the surface. Cold deep water is separated from warm surface water by a layer called the thermocline. During El Niño, this thermocline shifts, disrupting the normal transport of cold, nutrient-rich water.

Materials

- Projector
- Computers and internet access
- Photocopies of student worksheet

Teacher Prep

- Go to the Data in the Classroom website and familiarize yourself with the Level 3 activities (as well as the student worksheet from the Teacher Resources webpage).
- Use a projector to guide students through this lesson or have students work through the lesson individually (on their own devices).

Procedure

Introduction to El Niño

1. Navigate to [Level 3](#) of the *Understanding El Niño* online activity. Using a projector, play the El Niño animation and discuss what is going on.
 - In a typical year, trade winds cause warm surface water to accumulate in the western Pacific Ocean.
 - The movement of warm water to the west allows cooler, nutrient-rich water to rise to the surface in the east. This is called upwelling.

-
- During El Niño, the trade winds relax or even reverse. Notice the change in the arrows that represent the trade winds. Since the warm surface waters are not transported to the west, the eastern Pacific Ocean becomes warmer than usual.
 - This change, in turn, pushes the Eastern Pacific thermocline between warm surface water and cooler deep water farther down in the water column. This disrupts the usual upwelling of cold, nutrient-rich water to the surface.
2. You can find additional resources to help introduce El Niño to your students in the [Teacher Resources](#) page of the Data in the Classroom website.

Part 1: Graphing El Niño

1. Working at a computer, students should navigate to Level 3 of the *Understanding El Niño* online activity.
2. Project Level 3 onto a screen to help guide students through the activity.
3. Scroll down to the section titled 'Graphing El Niño.' Here, you'll find two line graphs displaying temperature at the equator across the Pacific Ocean. Students should examine the temperature graphs during a 'normal' year and an El Niño year.
4. Ask students: What are the different characteristics of a normal year? Of an El Niño year?

Answer: During a 'normal' year, the temperature is about 8 °C warmer in the western Pacific (off the coast of Asia) than in the eastern Pacific. The temperature difference between the west and the east is evident in the slope of the line. During an El Niño year, the water in the eastern Pacific is warmer than normal, the temperature difference from west to east may be smaller, and the area of high temperature can be seen extending farther to the east than in a typical year.

3. Give students time to scroll down the page and answer the *Check Your Understanding* questions. Remind students to click each 'Question' to display a new image.

Answer - Question 1: A

Answer - Question 2: B

Answer - Question 3: B

Part 2: Answering a Question with Data

1. Pair up students into teams and give each team a copy of the student worksheet, *Answering a Question with Data*.
2. Review the mission and hypothesis on the worksheet. Tell student teams they must design a plan to use real data to answer the question.
3. Next, explain what types of data are available to them: sea surface temperature maps and graphs from any year after 1981. *You may want to review the advantages and disadvantages of using maps versus graphs, from Level 2.*
4. Demonstrate how to access a map: using a projector, scroll down to the next section titled 'Answering a Question with Data.' Here you'll find a data tool that will enable students to create a sea surface temperature map.
 - a. **Which timespan?** Select 'monthly'
 - b. **Specify a date:** Select the desired month and year
 - c. **Bounding Box:** Move and resize the red box on the map by clicking and dragging the edges. For example, students may resize the box to include southern Alaska, Australia and the west coast of South America.
 - d. **Select an output format:** Leave the default selection, "download image.'
 - e. Click 'Download'
5. Other than maps, students should strongly consider using line graphs to answer the question. Students can access line graphs in two ways. The simplest option is to use the graphs at the end of this lesson. Alternatively, students can make their own graphs using the data tool and a spreadsheet program such as Microsoft Excel. If desired, demonstrate how to use the tool to create a line graph or [watch this video](#).
 - a. **Which timespan?** Select 'monthly'
 - b. **Specify a date:** Select the desired month and year

-
- c. **Bounding Box:** To access SST data along the equator, input the exact latitude and longitude below.
Upper-Left Latitude: 0
Upper-Left Longitude: 125
Lower-Right Latitude: 0
Lower-Right Longitude: -80
 - d. **Select an output format:** Select “download file”
 - e. Click ‘Download’
 - f. Open the file in an application such as Microsoft Excel and generate a line graph.
6. Once students understand what data is available to them, they will need to decide exactly what data is needed to answer the question. *Will they need sea surface data from multiple years (e.g. December 2014, 2015 and 2016)? Will they need maps, or graphs or both?*
 7. After accessing and reviewing their data, students should write a detailed interpretation of what their data shows and complete the conclusion statement at the end of the worksheet.
 8. Students can check to see if their conclusion was correct by answering the *Check Your Understanding* question at the end of Level 3. **Answer - Question 4: Yes**
 9. Successful data interpretations and conclusions may include the following:
 - a. A working definition of El Niño.
 - b. A comparison of data from more than one year.
 - c. A description of characteristics of an El Niño year and a non-El Niño year.
 - d. A discussion of how the temperature data found relates to the schematic diagram of El Niño.
 - e. An explanation of how data can be graphed to illustrate information visually.

LEVEL 4: INTERACTIVITY

RELATING SST TO PRODUCTIVITY

Understanding El Niño Using Data in the Classroom

NOAA Data in the Classroom

Introduction Level 1 Level 2 Level 3 Level 4 Level 5 Get Data Teachers Guide

Relating SST to Productivity

Introduction

Objective
Students will examine the relationship between SST and chlorophyll a to understand how El Niño affects productivity in the ocean.

Background
Phytoplankton are microscopic plants that live near the surface of the ocean and provide food for larger organisms. They form the base of the food chain. During an El Niño event, warmer water from the deeper water up to sunlit surface water...

SUMMARY

- Grade Level: 6-8
- Teaching time: Two 45-minute periods
- Activities: a) Examine the relationship between sea surface temperature and chlorophyll data and b) use real data to understand a problem: how El Niño affects the food chain in the oceans.
- Vocabulary:
 - *Chlorophyll*: green pigment in the cells of many plants that enables them to use sunlight to convert carbon dioxide and water into carbohydrates in the process called photosynthesis.
 - *Phytoplankton*: microscopic floating plants that perform photosynthesis and provide many of the nutrients for life in the ocean.
 - *Productivity*: the rate per unit area or per unit volume at which producer organisms produce food for other organisms.

LESSON PLAN – LEVEL 4

Objectives

Students will examine the relationship between SST and chlorophyll a to understand how El Niño affects productivity in the ocean.

Background

Phytoplankton are microscopic plants that live near the surface of the ocean and provide food for larger organisms. They form the base of the food chain. Nutrients carried by upwelling from deeper water up to sunlit surface water encourage phytoplankton growth. This process can be compared to the addition of fertilizers to soil to encourage land plants to grow faster and larger.

Phytoplankton also contain chlorophyll, which enables them to use photosynthesis. Scientists estimate the amount of phytoplankton in the ocean by using data from satellites that can detect chlorophyll by color.

During an El Niño, when upwelling is disrupted, scientists measure a decrease in chlorophyll in areas of the eastern Pacific. This signals a decline in phytoplankton productivity.

Materials

- Projector
- Computers and internet access
- Photocopies of student worksheet

Teacher Prep

- Go to the Data in the Classroom website and familiarize yourself with the [Level 4 activities](#) (as well as the student worksheet from the Teacher Resources webpage).
- Use a projector to guide students through this lesson or have students work through the lesson individually (on their own devices).

Procedure

This activity challenges students to think like scientists by designing a scientific investigation in which data collection and analyses are important parts of the process. Students are challenged to engage in a number of scientific practices, including using real data to answer a question.

Introduction to Phytoplankton

1. Project Level 4 onto a screen to help guide students through the activity.
2. Introduce the activity to students by explaining that they will be looking at an important problem – how El Niño affects the food chain in the oceans.
3. Define and discuss phytoplankton, using the image in the introductory section of Level 4. Students should know what phytoplankton are, why they are important, and how scientists estimate the amount of phytoplankton in the ocean (using satellites). Point out the green colored chlorophyll in the cells. Explain that, although tiny, phytoplankton can bloom in such large numbers that they can change the color of the ocean. Satellites can measure these large-scale color changes from space.

Part 1: Measuring Phytoplankton from Space

1. Working at a computer, students should navigate to Level 4 of the *Understanding El Niño* online activity.
2. Scroll down to the section titled ‘Measuring Phytoplankton from Space.’ Here, you’ll find a satellite map showing chlorophyll concentrations across the ocean. Measuring chlorophyll from space allows us to identify areas of the ocean that are rich in nutrients and phytoplankton. Encourage students to examine unknown data, and use skills and techniques they learned in prior levels to read and interpret that data.
4. Give students time to answer the *Check Your Understanding* question at the end of this section.
Answer - Question 1: High levels of nutrients and plankton
5. Ask students: “Why does the California coastline have much higher chlorophyll concentrations than other parts of the ocean?”

Answer: Upwelling brings up cold, nutrient-rich waters to the surface, which support blooms of phytoplankton.

Part 2: Disrupting Ocean Productivity

1. Scroll down to the next section titled 'Disrupting Ocean Productivity.' Here, students will be challenged to use data to draw connections between sea surface temperature, upwelling and chlorophyll concentrations.
2. Students should examine the two maps, side by side, and examine the differences in sea surface temperature. They may recall, from Level 3, that during El Niño the normal upwelling of cold, nutrient-rich water is disrupted and the water along the eastern Pacific becomes warmer.
3. Give students time to answer the *Check Your Understanding* questions at the end of this section. Remind students to click each 'Question' to display a new image.

Answer - Question 2: Right map

Answer - Question 3: Left map

Part 3: Research Project - Exploring El Niño and Chlorophyll Data

1. Scroll down to the next section titled 'Research Project.' Here you'll find instructions and a defined question for students to answer using real data.
2. Explain to students that they will be investigating the effect of an El Niño on the ocean food chain along the coast of California.
3. Assign students to work in teams of two and give each team a copy of the Student Worksheet, *Research Project: Exploring El Niño and Chlorophyll Data*.
4. Review the question and ask student teams to complete the hypothesis.
5. Working at a computer, students should scroll down to the next section, *Testing a Hypothesis with Data*, and use the data maps and graphs to complete the questions and table on their worksheet.
6. Students can check to see if their conclusions were correct by answering the *Check Your Understanding* questions at the end of the section.

Answer - Question 4: 2009

Answer - Question 5: SST increases and chlorophyll decreases along the equator during El Niño years.

LEVEL 5: INVENTION

DESIGN YOUR OWN INVESTIGATION

Understanding El Niño Using Data in the Classroom

NOAA Data in the Classroom


Introduction Level 1 Level 2 Level 3 Level 4 Level 5 Get Data Teachers Guide

Designing Your Own Investigation

Introduction

Objective
Students will design an investigation using real data on El Niño to try to answer a research question of their choosing.

Background
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A large research ship with a white superstructure and a dark hull is on the left side of the image. To its right is a buoy with a white top and a red bottom, equipped with various sensors and a mast. The scene is set on a blue ocean under a clear blue sky with some light clouds.

SUMMARY

- Grade Level: 6-8
- Teaching time: Three 45-minute periods
- Activity: Design an investigation and use real data to answer a question.

LESSON PLAN – LEVEL 5

Objectives

Students will design an investigation using real data on El Niño to try to answer a research question of their choosing.

Background

Students have used real data to begin to understand the phenomenon of El Niño, but they can learn a lot more from exploring this data. In this level, students will design an investigation using real data on El Niño to try to answer a research question of their choosing. In reporting the outcome of their research, they must state what they have learned from the investigation, and use sufficient evidence to evaluate and answer their question.

For decades, satellite instruments have reliably monitored atmospheric and ocean conditions that help scientists better understand El Niño. The research questions that students select will help them consider this data over time, and perhaps lead them to offer their own predictions about future El Niño events. In this activity, students should be encouraged to develop their own research questions and hypotheses.

Materials

- Projector
- Computers and internet access
- Photocopies of student worksheet

Teacher Prep

- Go to the Data in the Classroom website and familiarize yourself with the [Level 5 activities](#), sample questions, graphs and data tools (as well as the student worksheet from the Teacher Resources webpage).

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- Practice generating SST and chlorophyll maps using the data tool in Level 5. Be prepared to demonstrate the tool for students.

Procedure

This activity challenges students to think like scientists by designing a scientific investigation in which data collection and analyses are important parts of the process. Students are challenged to engage in a number of scientific practices, including asking questions, analyzing data and constructing explanations using data.

1. Assign students to work in teams of two and give each team a copy of the Student Worksheet, *Design Your Own Investigation*.
2. Project Level 5 onto a screen and scroll down to the section titled 'Plan Your Investigation.' Locate the list of data tools.
3. Prior to developing a question, students will need to understand what types of data are available to them. The three types of data tools and graphs that are available in Level 5 are described below. With students, discuss these data and demonstrate how to use the data tools, if needed.
 - a. Graph of the El Niño Historical Index (1950 - 2016): This graph can be used to compare strength and frequency of El Niño events over time. The El Niño Index is the standard index that NOAA uses to identify El Niño and La Niña events in the tropical Pacific. El Niño events are characterized by index values of 0.5 or greater.
 - b. SST and Chlorophyll Data Tool (1981 - present): This data tool will enable students to create sea surface temperature and chlorophyll maps. Students may also make their own graphs using the data tool and a spreadsheet program such as Microsoft Excel. Instructions to use the tool can be found by clicking the 'Get Data' tab in the upper navigation bar.
 - c. NOAA View Global Data Explorer: This tool allows students to explore a variety of NOAA datasets. For instructions, click the text that reads "NOAA

View Global Data Explorer. Then click 'Watch a Video Tour' located at the bottom right side of the page.

4. Guide student selection of a research question (or have them make up their own) that is appropriate to their academic experience. Two sample questions are highlighted in the online Level 5 activities:
Sample question 1: Are El Niño events becoming stronger over time?
Sample question 2: Are El Niño events becoming more frequent?
5. Next, in their small groups, students should determine what data are needed to answer their question, making a list on their worksheet.
6. Using the data tool on the website, students can then access, save and/or print the graphical displays of data. If necessary, help students determine if they have enough data to answer their question and identify areas where they may need to seek out additional sources of information.
7. After accessing and reviewing their data, students should work together to write a detailed interpretation of what their data shows and complete the conclusion section at the end of the worksheet.
8. After students complete their research, provide time for them to present their findings to the class.
9. Use student presentations as an opportunity to relate their investigations to current news and information about El Niño and global climate change. Ask: From your own experience looking at real data, how do you view the question of global climate change?