Investigating El Niño Using Real Data

Summary

Five lessons at increasing levels of sophistication incorporate real data from NOAA to help students understand the phenomenon of El Niño.

Grade Level: 6 – 8

Aligned to National Standards in Mathematics, Science, and Geography. See page 7.

This curriculum module was developed for the NOAA Ocean Data Education (NODE) Project by Caroline Joyce and Todd Viola under a contract with the National Marine Sanctuary Foundation and in collaboration with these offices of the National Oceanic and Atmospheric Administration: National Marine Sanctuary Program, National Estuarine Research Reserve System and National Oceanographic Data Center.

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NOAA
National Marine Sanctuaries
National Estuarine Research Reserve System
IOOS Integrated Ocean Observing System

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[1] 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.

The five activities and levels of sophistication are described in more detail in the Lesson Overview on pages 4 and 5.

1 For more information about the U.S. Ocean and Coastal Observing System, visit http://www.ocean.us/.

Web Links

For links to helpful Web sites about El Niño, visit www.dataintheclassroom.org.

El Niño 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.

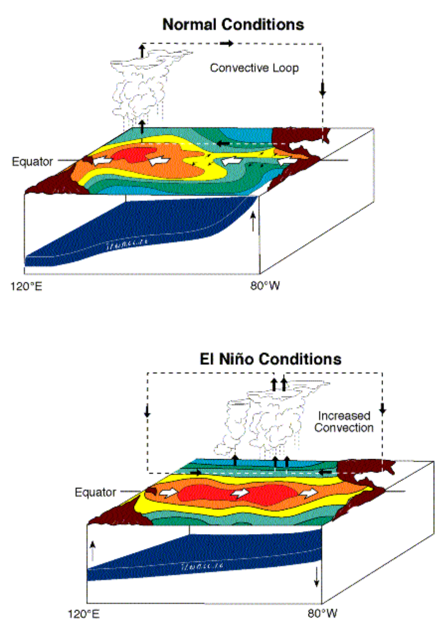

Image courtesy NOAA Pacific Marine Environmental Laboratory (PMEL).
http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html

Scaled Levels

5 **Invention**
4 **Interactivity**
3 **Adaptation**
2 **Adoption**
1 **Entry**

Lesson Overview

This curriculum incorporates a scaled approach to learning. Each module offers activities at five different levels of student interaction, sometimes referred to as Entry, Adoption, Adaptation, Interactivity, and Invention. The early levels are very directed and teacher driven. They are important first steps, however, when learning something new. The levels of Adaptation through Invention are more student directed and open up opportunities to design lessons featuring student inquiry.

The levels serve a dual purpose. They are designed to engage students in increasingly sophisticated modes of understanding and manipulation of data. They are also intended to help you, as a teacher, familiarize yourself with online tools for accessing data and to provide you with models for integrating the use of real data into your classroom practice.[2]

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2 For more information about the research behind this approach, consult these papers:

Dwyer, D. C., Rwgstaff, C., & Shanholtz, J. H. (1990). Teacher beliefs and practices, Part I: Pattern of change. ACOT Report # 8. Cupertino, CA: Apple Classroom of Tomorrow Advanced Technology Group, Apple Computer, Inc.

Bransford, J.D., Goin, L., Hasselbring, T.S., Kinzer, C.K., Sherwood, R.D., & Williams, S.M. (1999). Learning with technology: Theoretical and empirical perspectives. Peabody Journal of Education. 5-26.

The chart below illustrates the five levels of this module, Investigating El Niño Using Real Data.

5 **Invention: Design 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 access and interpret data maps to display sea surface temperature (SST).This is a teacher-led discussion and activity.

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.

Using the Technology

Teaching using technology presents some challenges. Because this curriculum demonstrates strategies for using real scientific data available on the Internet, it assumes that you and your students will have access to the Internet at some point during the investigation. Because the level and availability of Internet access varies widely from setting to setting, however, you may need to adapt the activities to suit your particular situation. To help you, the activities are designed with flexibility in mind.

For example:

- When access to real data is needed, the Preparation section describes steps that can be performed outside of class. Data and results can be saved for use in class.

- Data can be accessed through the dataintheclassroom.org Web site using special forms that have been designed for this project. While it is recommended that you familiarize yourself with how to access data using these tools, the early lessons also contain blackline masters of important maps, graphs, and other data products, which can be used in settings where live Internet access is not available.

- An important outcome of these activities, especially at the higher levels, is for students to learn how to access and manipulate data themselves. In the ideal case, students will access the Internet individually or in groups in order to generate maps and graphs using real data. In settings where this is not possible, the curriculum provides student masters, which can be reproduced and used in class. To fully explore the questions posed in the highest level activities, however, students in these settings will need to access the Internet in a library or computer center outside of class.

National Education Standards

This curriculum module is aligned with the national education standards in science, math, and geography for grades 5-8. The table below presents a list of core standards covered at the different activity levels. These standards-based activities are designed to be easily integrated into pre-existing school science and math curricula, not as “add ons” but as ways to enhance existing standards-driven curricula by using real-time data. The standards that support this curriculum facilitate learning by having students practice using real-time data within the context of a variety of standards- and inquiry-based activities.

	Mathematics[3]	**Geography**[4]	**Science**[5]
Level 1 **Reading Sea Surface Temperature**	■ Use tables, maps, and graphs to describe situations.	■ Use the characteristics, functions, and applications of satellite-produced images and models.	■ Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to such factors as distance and location.
Level 2 **Looking at SST Another Way**	■ Use observations about the differences between two characteristics on the basis of maps, histograms, box plots, and scatter plots.		■ Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to such factors as distance and location.
Level 3 **Detecting El Niño**	■ Use representations to model and interpret physical, social, and mathematical phenomena. ■ Apply and adapt a variety of appropriate strategies to solve problems.	■ Use mental models to identify the locations of certain physical features on maps to mark major ocean currents, wind patterns, landforms, and climate regions on a map.	■ Identify questions that can be answered through scientific investigations.

3 National Council of Teachers of Mathematics. (2001). *Principles and Standards for School Mathematics*. Washington, D.C.
4 Geography Education Standards Project. (1994). *Geography for Life: The National Geography Standards*. Washington, D.C.: National Geographic Society Committee on Research and Exploration.
5 National Academy of Sciences. (1996). *National Science Education Standards*. Washington. D.C.:National Academy Press.

	Mathematics	Geography	Science
Level 4 **Relating SST to Productivity**	■ Create and use representations to organize, record, and communicate mathematical ideas.	■ Explain how the physical processes help to shape features and patterns on the Earth's surface, as exemplified by being able to compare and interpret maps and charts to explain how physical processes affect features of the Earth's surface.	■ All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.
Level 5 **Design Your Own Investigation**	■ Utilize questions that lead to data collection and analysis. ■ Compare several sets of data to generate, test, and have the data dictate, confirm, or deny hypotheses. ■ Work with data in the context of real-world data situations.	■ Demonstrate an understanding of the structure and systems of Earth and other bodies in the universe, and of their interactions.	■ Design and conduct investigations that provide reliable quantitative or qualitative data, as appropriate, to answer questions.

Ocean Literacy Essential Principles

This curriculum module also supports the following Essential Principles of Ocean Sciences.[6]

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.
3. 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.

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

Reading Sea Surface Temperature

Summary

Grade Level: 6 - 8

Teaching Time: 45 minutes

Activities:

- **Identify locations on a map using latitude and longitude.**
- **Use a false-color map to read sea surface temperature at specific locations.**
- **Color code a map to represent isotherms.**

Vocabulary

El Niño – a set of phenomena caused by periodic changes in the ocean-atmosphere system in the tropical Pacific Ocean.

Sea surface temperature – the average temperatures at the uppermost layer of the ocean – only a few millimeters deep.

Isotherm – a line connecting areas of equal temperature.

False-color map – an image that uses colors to represent differences in measured values, rather than true appearance.

Objective

Students will learn how to access and interpret data maps to display sea surface temperature.

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 orbiting satellites which measure infrared radiation from the surface of the oceans. This data can be represented on maps in different ways. Researchers map temperature zones by examining lines on the maps, called isotherms, which connect areas of the same temperature. They can also use colors to represent areas of temperature, producing what is called a false-color map.

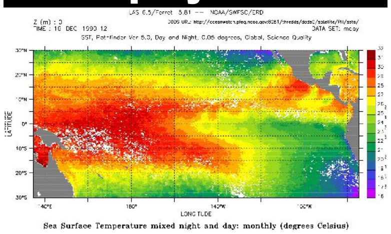
Preparation

If you have access to a computer and projector, you can display a color version of the Monthly Average Sea Surface Temperature Map for December 1990 (shown at left). Use the following steps.

1. Visit www.dataintheclassroom.org, and find the El Niño module.
2. Follow the link to “Get Data.”
3. Select “Sea surface temperature” under “Which data?”
4. Select Map on the menu labeled “Which view?”
5. Using the form, specify the date 16-Dec-1990.
6. Click the “Get Data” button.
7. Save the map image to your local computer. On a PC, right-click with the mouse and select “Save as....” On a Mac, hold down the Ctrl key and click with the mouse.
8. Repeat the procedure using the date 16-Dec-1991.

Alternatively, you can make a transparency of the blackline version of this map on page 13 for display using an overhead projector.

To Display



Generate this image at www.dataintheclassroom.org

Procedure

1. Display the map showing Monthly Average Sea Surface Temperature, December 1990, on an overhead or computer screen. Explain the key features of the map:
   - The map shows a section of the Pacific Ocean.
   - X axis = longitude, degrees east and west.
   - Y axis = latitude, degrees north and south of the Equator.

Materials

- **Computer or overhead projector**
- **Map image saved to your computer or transparency of Teacher Master**
- **Colored pencils**
- **Copies of Student Master**

- Isotherms are connected lines of equal temperature.
- The temperatures indicated by each isotherm are measured in degrees Celsius.
- On the color map, the color key at the right also indicates temperatures in degrees Celsius.

2. Give each student a copy of the Student Master, Monthly Average Sea Surface Temperature, December 1991. Ask students to use colored pencils to color code each isotherm on the map. The isotherms are already labeled in degrees Celsius. Students should use their completed maps to answer the four questions on the Master.

   Answers: 1. b. degrees north and south of the Equator
   2. 29°C
   3. 27°C
   4. 3°C

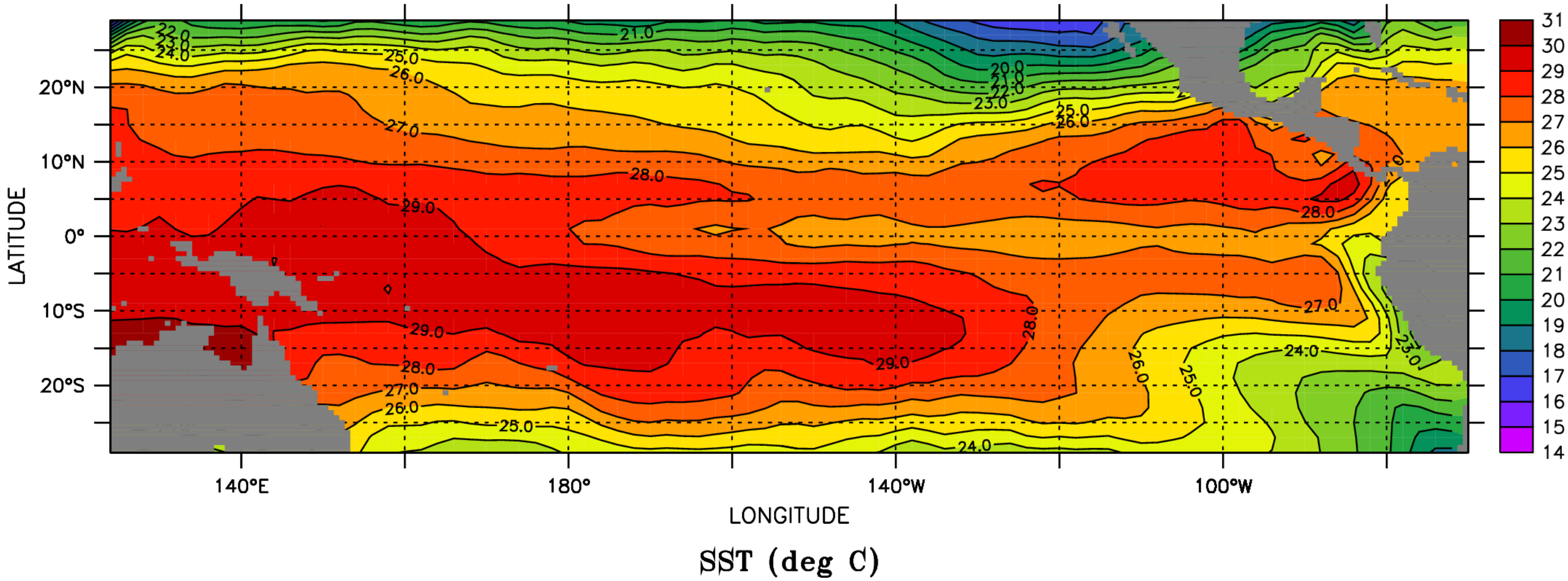
3. Discuss and compare the December 1991 map that students colored with the December 1990 you displayed. Ask: *How are the maps alike and how are they different?* **Hint:** Look at the size of the areas of high temperature.

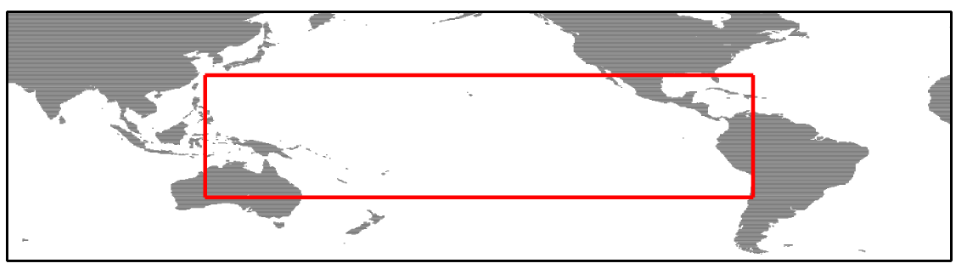
4. Discuss these questions: *How can using satellite data help researchers to study water conditions over time? Why is it important for researchers to look at data for more than one year to determine sea surface temperature change?*

5. Once students are comfortable reading maps, you can use the online tool to examine more data. If you have live Internet access in class, go to www.dataintheclassroom.org and repeat the preparation procedure with different dates to generate and discuss new maps. For example, consider changes that occur in sea surface temperature over a given year. Ask: *What do you think a map from the summer should look like?* Generate one and find out.

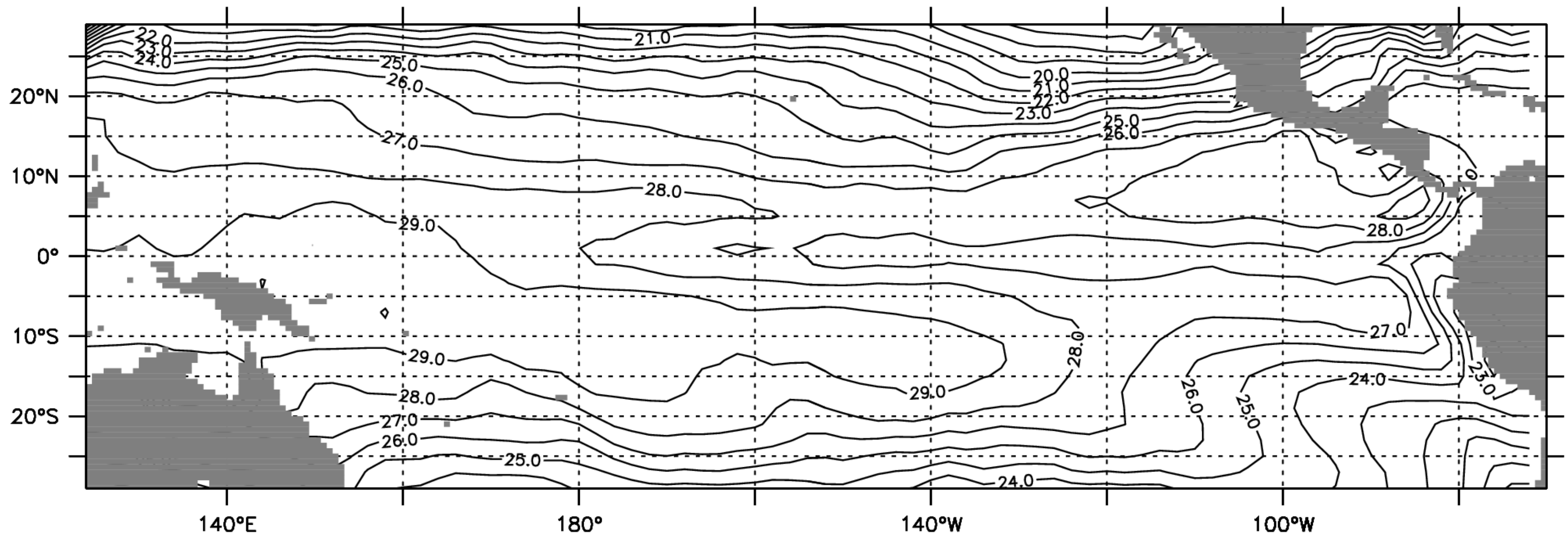
Teacher Master (Color version for reference)

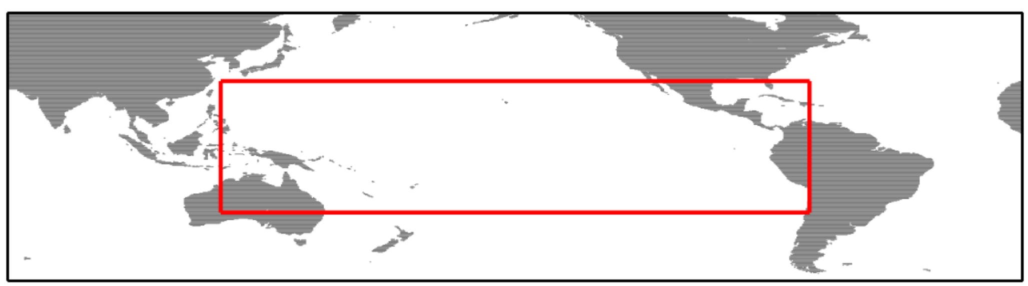
Monthly Average Sea Surface Temperature Map, December 1990





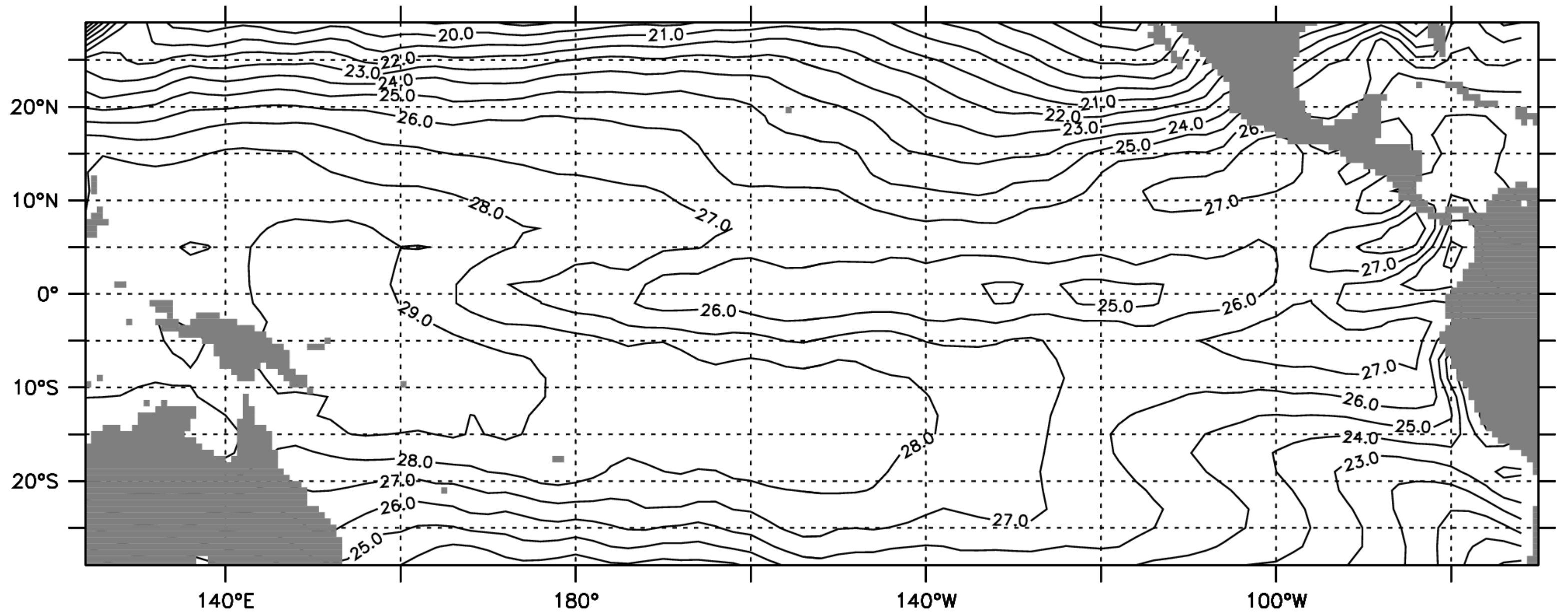
Monthly Average Sea Surface Temperature Map, December 1990





Monthly Average Sea Surface Temperature Map, December 1991

Color the map using the following color key: 29=dark red; 28=red; 27=orange; 26=light orange; 25=yellow; 24=light green; and 23=green



Questions

1. Lines of latitude indicate:

   a. degrees of temperature

   b. degrees north and south of the Equator

   c. areas of equal temperature

   d. representations of colors to indicate temperature

2. What was the monthly average temperature at 160° East and 10° South?

3. What was the monthly average temperature at 130° West and 10° South?

4. What is the difference in monthly average temperature along the line 10° South, between 160° East and 120° West?

Looking at SST Another Way

Summary

Grade Level: 6 - 8

Teaching Time: 45 minutes

Activities:

- **Generate a graph of sea surface temperature data along a single line of latitude.**
- **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.

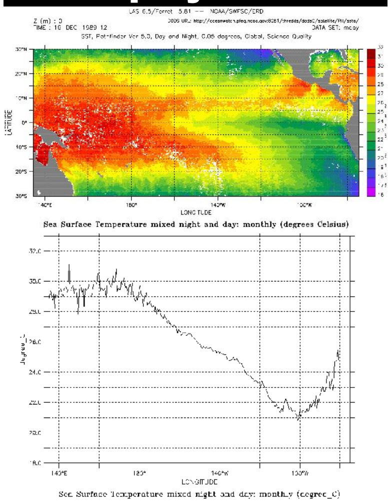
Objective

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

Background

Researchers use orbiting 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.

To Display



Generate these images at www.dataintheclassroom.org

Materials

- **Computer or overhead projector**
- **Maps and graphs saved to your computer or a transparency of the Teacher Master**
- **Rulers**
- **Copies of Student Master**

Preparation

If you have access to a computer and projector, you can use it to display examples of surface temperature maps and latitude line graphs..

1. Visit www.dataintheclassroom.org, and find the El Niño module.

2. Follow the link to “Get Data.”

9. Select “Sea surface temperature” under “Which data?”

3. Select Map on the menu labeled “Which view?”

4. Using the form, specify the date 16-Dec-1989.

5. Click the “Get Data” button.

6. Save the image to your local computer. On a PC, right-click with the mouse and select “Save as....” On a Mac, hold down the Ctrl key and click with the mouse.

7. Repeat the procedure, this time selecting the Graph view.

Alternatively, you can make a transparency of the blackline version of the graph on page 18 for display using an overhead projector.

Procedure

1. Display the latitude line graph from December 1989 on an overhead or computer screen. Explain key features of the graph:

    - X axis = longitude, degrees east and west.
    - Y axis = monthly average sea surface temperature in degrees Celsius.
    - Below the graph is a reference map showing an area of the Pacific Ocean. The red line running west to east is the area

represented by the data on the graph. Using a ruler, point out that the line lies at 0° latitude (the Equator). Explain that moving that line north or south would change the data displayed in the graph above.

2. With students, practice reading data values from the plot. Ask: *What were the monthly average sea surface temperatures along 0° latitude at these locations?*

	Answers:
140°E?	29.0°C
180°?	28.5°C
140°W?	25.6°C
100°W?	21.6°C

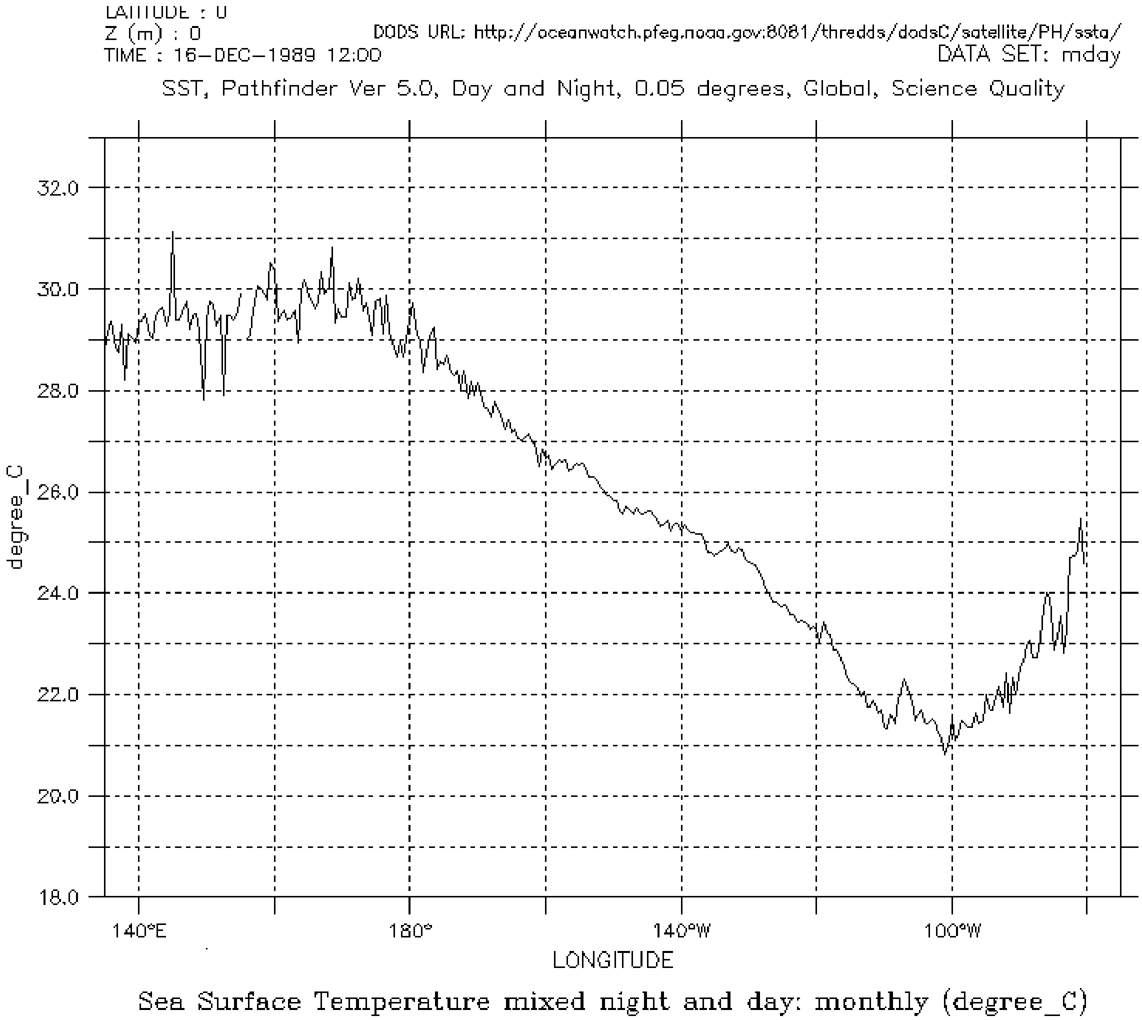
3. Give each student a copy of the Student Master which shows two figures: a Monthly Average Sea Surface Temperature Map from December 1993, and a Latitude Line Graph of the same data taken at 0° latitude.

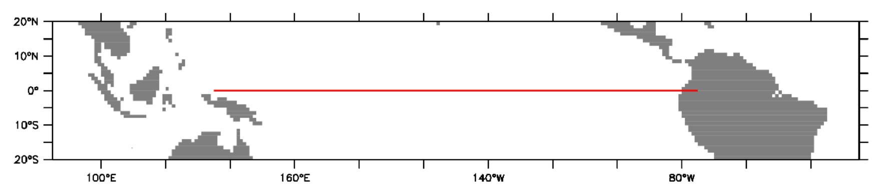
4. Using their rulers, ask students to draw a horizontal line on the Monthly Average SST map that corresponds to the latitude line represented in the graph. Ask students to fill in the table and identify the temperatures using *both* the map and the line graph. Students can use a ruler to help read temperatures from the graph at each specified longitude. Students should use decimals to represent fractional values where appropriate.

5. 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 the advantages and weaknesses of the two different displays of the same temperature data?*

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

Monthly Average Sea Surface Temperature Latitude Line Graph, December 1989



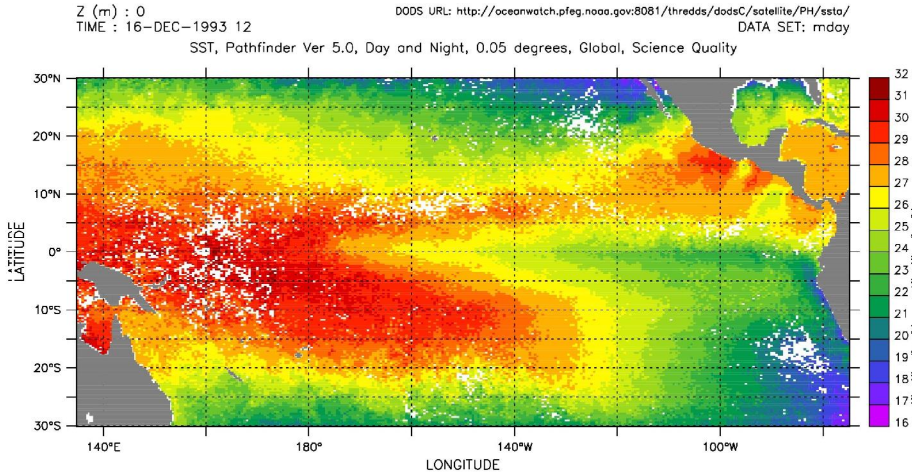


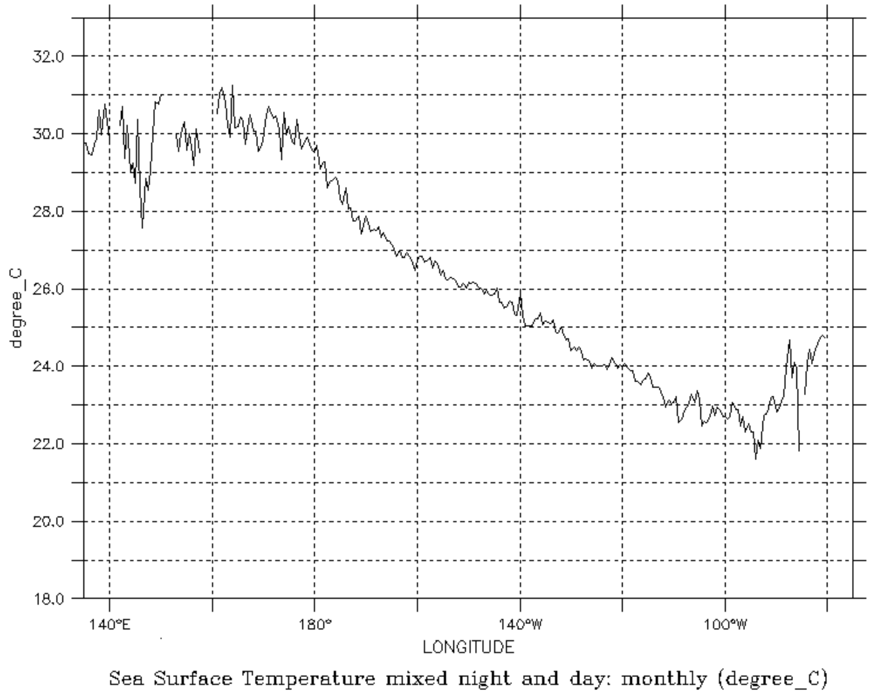
Read the chart above to complete the following table:

Monthly Average SST along 0° latitude

Longitude	140° E	180°	140° W	100° W
SST				

Monthly Average Sea Surface Temperature Map and Latitude Line Graph, December 1993





Use the map and plot above to complete this table:

Monthly Average SST along 0° latitude

Longitude	140° E	180°	140° W	100° W
SST from map				
SST from graph				

Detecting El Niño

Summary

Grade Level: 6 - 8

Teaching Time:

Two 45-minute periods

Activities:

- **Generate maps and graphs of sea surface temperature data**
- **Use real data to examine and describe an El Niño event.**

Vocabulary

Trade winds – wind systems occupying most of the tropics, which blow from approximately 30 degrees N and S 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.

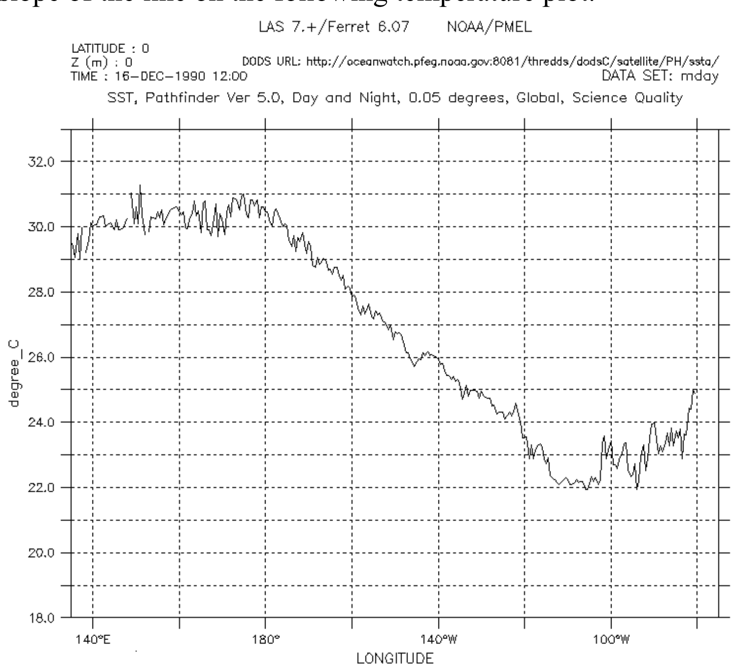
Objective

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

Background

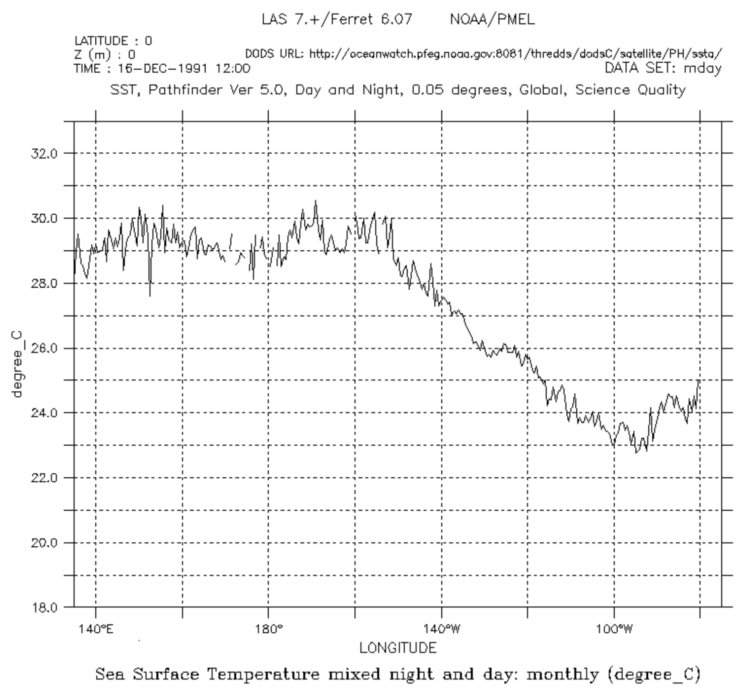
During a typical year, the trade winds that blow across the Pacific Ocean push warm surface water to the west. On a typical SST map, the surface water in the western Pacific is warmer than in the eastern Pacific. But periodically, this pattern changes. The trade winds die down or even reverse, and water temperatures in the east become warmer than usual. This change 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 typical year, the temperature difference between warm water in the west and cooler water in the east is evident in the slope of the line on the following temperature plot.



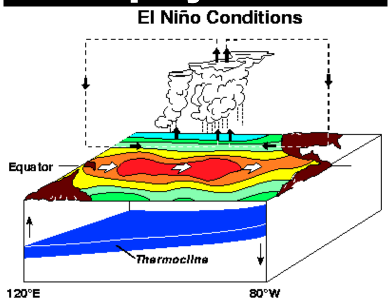
Sea Surface Temperature mixed night and day: monthly (degree_C)

During an El Niño year, the area of high temperature can be seen extending farther to the east than in a typical year. 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.

To Display



Download this image at .www.dataintheclassroom.org

Materials

- **Computer or overhead projector**
- **Saved image or transparency of Teacher Master, How El Niño Works**
- **Copies of Student Master, Supporting a Hypothesis with Data**
- **Student access to computers with Internet connections**

Preparation

Download a copy of the image shown at the left. Alternatively, you can make a transparency of the Teacher Master, How El Niño Works, on page 25.

If you have not done so already, be prepared to demonstrate for students how to access the dataintheclassroom.org Web site to generate maps and graphs. Using a computer and projector, walk students through the preparation procedure described in step 4 on page 23.

Procedure

This activity uses guided inquiry to accomplish two objectives: 1) to use real data to examine how El Niño works; and 2) to use real data in the form of graphs and maps to support or disprove a hypothesis.

1. Show students the schematic diagram of El Niño shown on the Teacher Master, How El Niño Works. Describe what is going on in the diagram:

    - 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. 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. Pair up students into teams of two and give each team a copy of the Student Master, Supporting a Hypothesis with Data.

3. Review the mission and hypothesis on the Master. Tell student teams they must design a plan to use real data to support or disprove the hypothesis.

4. If you have not done so in earlier activities, use a computer and projector to demonstrate how to use the dataintheclassroom.org Web site to generate maps and graphs of SST.

    a) Visit www.dataintheclassroom.org, and find the El Niño module.

    b) Follow the link to "Get Data."

    c) Select "Sea surface temperature" under "Which data?"

    d) Select Map on the menu labeled "Which view?"

    e) Using the form, specify the date to display.

    f) Click the "Get Data" button.

    g) Save the image to your local computer. On a PC, right-click with the mouse and select "Save as...." On a Mac, hold down the Ctrl key and click with the mouse.

    h) Repeat the procedure, this time selecting the Graph view.

5. Students will need to access the Internet to generate and save data maps and graphs. Depending on the setting, this can be done in a computer lab or assigned as homework, assuming students have access to the Internet at a library or computer center.

6. Have students carry out their plans, then present their findings as teams.

Assessment Reference

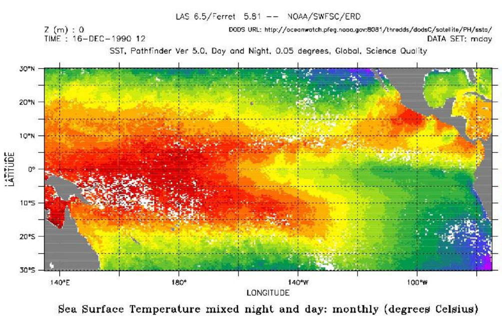
1990 was not considered an El Niño year. An El Niño did occur in 1991-92.

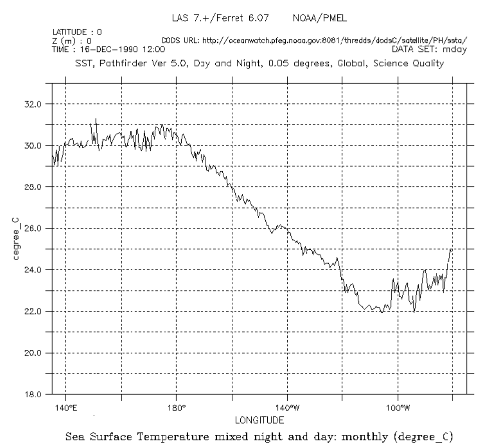
In assessing student performance, consider each team's use and explanation of data. Successful student reports may include such information as:

- A working definition of El Niño.
- A comparison of data from more than one year.
- A description of characteristics of an El Niño year and a non-El Niño year.
- A discussion of how the temperature data found relates to the schematic diagram of El Niño.
- An explanation of how data can be graphed to illustrate information visually.

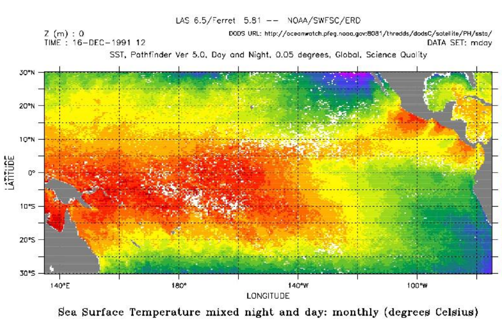
Below are some examples of data that students might generate to investigate their hypothesis.

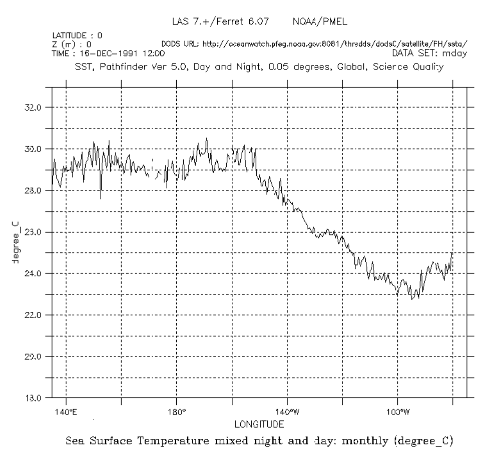
December 1990



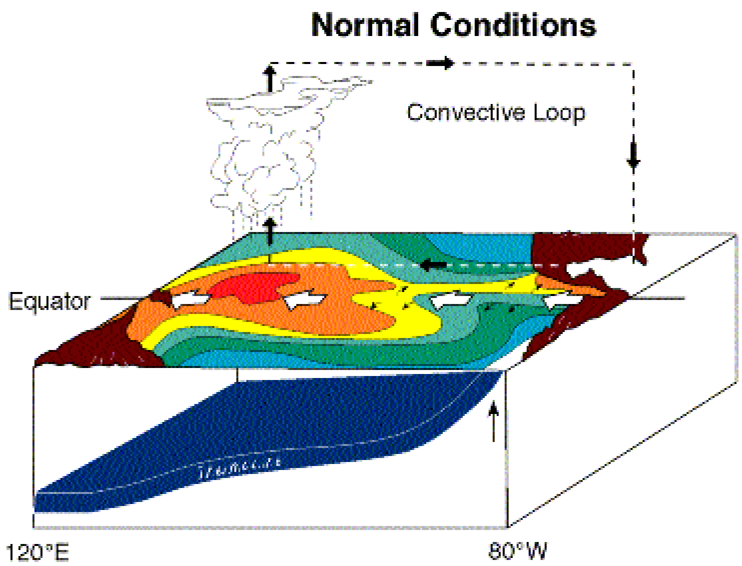


December 1991





How El Niño Works



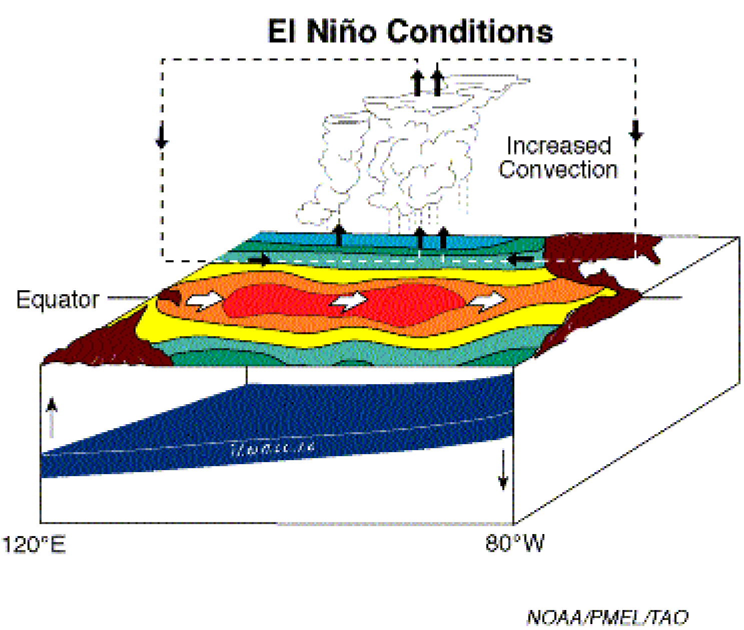


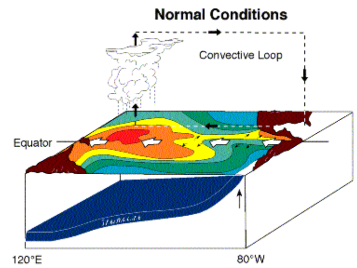
Image courtesy NOAA Pacific Marine Environmental Laboratory (PMEL).
http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html

Student Master

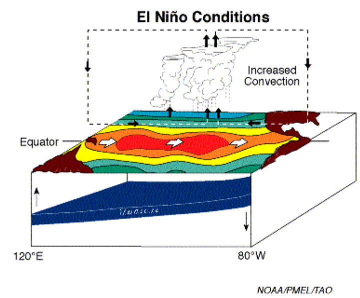
Supporting a Hypothesis with Data

Your mission is to find evidence that supports or disproves this hypothesis:
An El Niño event occurred in 1990.

During non-El Niño conditions, the trade winds blow towards the west across the tropical Pacific. These winds pile up warm surface water in the western Pacific.



During El Niño, the trade winds relax. Water temperatures in the eastern Pacific become higher than usual.



Make your plan to support or disprove the hypothesis cited above. Design an experiment using maps and graphs, and the model showing how El Niño works, to demonstrate whether or not an El Niño event occurred in 1990. Remember you must support your findings using real data.

1. Visit www.dataintheclassroom.org, and find the El Niño module.
2. Follow the link to "Get Data."
3. Select "Sea surface temperature" under "Which data?"
4. On the menu labeled "Which view," select the format you wish to view, either Map or Graph.
5. Using the form, specify the date you wish to look at.
6. Click the "Get Data" button.
7. You can save images you wish to keep to your local computer. On a PC, right-click with the mouse and select "Save as...." On a Mac, hold down the Ctrl key and click with the mouse.
8. Repeat as necessary to generate maps and graphs to support or disprove the hypothesis. Organize your findings in a brief report.

Hints: Can you support or disprove the hypothesis by looking at data from only one year?
Be careful to look at the scale on each map and graph. Make sure you are comparing the numerical values and not just the appearance of the graphs.

Relating SST to Productivity

Summary

Grade Level: 6 - 8

Teaching Time:

Two 45-minute periods

Activities:

- **Examine the relationship between sea surface temperature and chlorophyll data.**
- **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.

Objective

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

This activity serves as the model for Level 5, in which students will be asked to design their own investigation using real data.

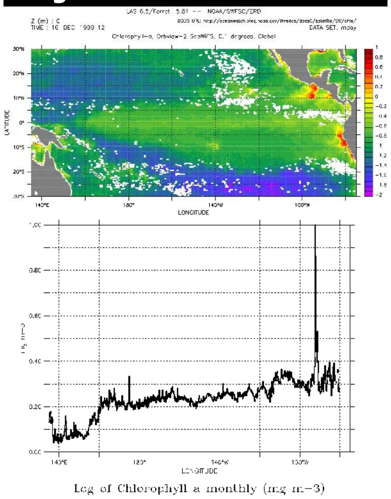
Background

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.

Try it



Generate these images at www.dataintheclassroom.org

Preparation

It is recommended that you do not show students examples of chlorophyll maps and graphs before they begin this activity. A goal of this investigation is to encourage students to examine unknown data, and use skills and techniques they learned earlier to read and interpret that data.

You should still familiarize yourself with representations of the new data set, however, by following the instructions below.

1. Visit www.dataintheclassroom.org, and find the El Niño module.
2. Follow the link to “Get Data.”
3. Select “Chlorophyll a” under “Which data?”
4. Select Map on the menu labeled “Which view?”
5. Using the form, specify the date 31-Dec-1999.
6. Click the “Get Data” button.
7. Repeat the procedure to look at different dates or to generate Latitude Line Graphs.

In this activity, students will be asked to create data tables and simple graphs using sea surface temperature and chlorophyll data they find on the Internet. It is recommended that students use spreadsheet software, such as Microsoft Excel, to help them with these tasks. This is optional, however.

Materials

- **Copies of Student Master, Research Project: Exploring El Niño and Chlorophyll Data**
- **Copies of Student Master, Data Log Sheet**
- **Student access to computers with Internet connections**
- **Microsoft Excel (optional)**
- **Graph Paper if Excel is not used**
- **Rulers**

Procedure

This activity challenges students to think like scientists by designing a scientific investigation in which data collection and analysis are important parts of the process. Students are asked to use the scientific method, using real data to solve a problem.

1. 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. Explain that they will examine a data set they have not seen before. Their job will be to interpret what the data show.

2. If necessary, explain what phytoplankton are, and how scientists estimate the amount of phytoplankton in the ocean by using satellite observations of the ocean's color.

3. Assign students to work in teams of two and give each team a copy of the Student Master, Research Project: Exploring El Niño and Chlorophyll Data.

4. Offer students a hint that a strong El Niño occurred in 1997-98. One way to investigate the effect of El Niño on productivity would be to examine data from that year and compare it to other, non-El Niño years.

5. Students will need to access the Internet to generate and save data maps and graphs. Depending on the setting, this can be done in a computer lab or assigned as homework, assuming students have access to the Internet at a library or computer center.

See an Example

A sample spreadsheet showing rows and columns of SST and chlorophyll data is available at www.dataintheclassroom.org.

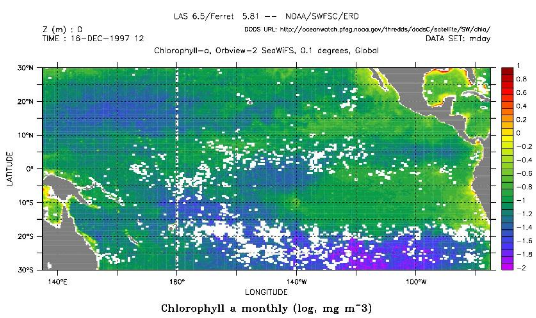
6. If students are using spreadsheet software, they may need guidance on setting up their spreadsheet and graphs.

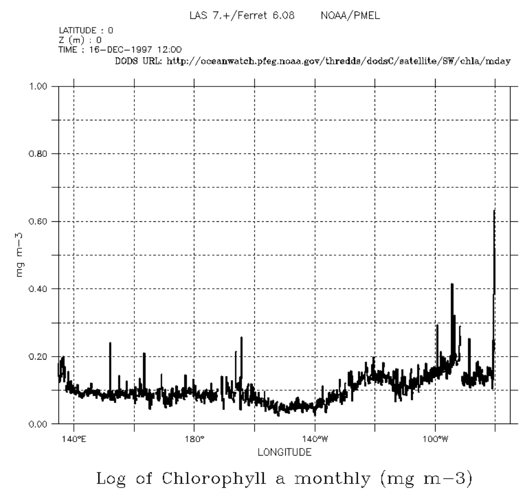
7. Have students use the scientific method to carry out their investigations on the effects of El Niño on ocean food chains. When they have finished, have teams present their findings to the class.

Assessment Reference

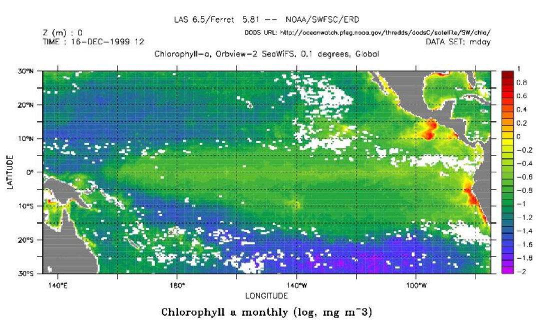
Below are some examples of data that students might generate to investigate their hypotheses.

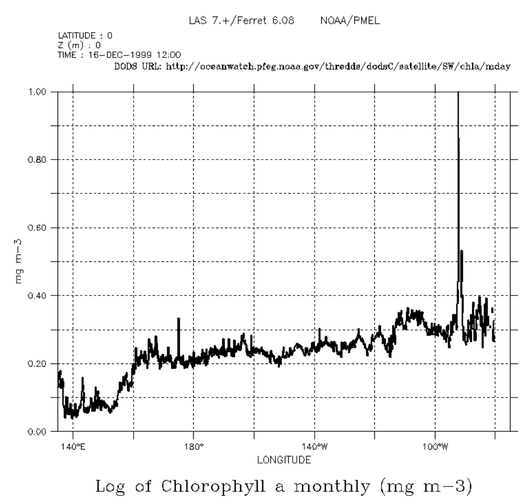
December 1997 (El Niño)





December 1999





Student Master

Research Project: Exploring El Niño and Chlorophyll Data

You have joined a team of scientists who are studying the effects of El Niño on biological systems in the ocean. Specifically, you are interested in the relationship between sea surface temperature (SST) and productivity, as measured by the amount of chlorophyll-a. Your task is to determine if there is a relationship between sea surface temperature and the distribution of phytoplankton, and, if so, how this relationship is impacted during El Niño. First, you will prepare a research plan that describes where you will conduct your study and why, what investigation methods you will use, and how you will collect data. Once your plan is accepted, you will carry out your data collection, analyze your data, and report your findings to the team.

The team has decided that you will compare two time periods: December 1997 and December 1999.

Planning your project:

1. **Form a hypothesis to answer the research question below.**

   Research Question: Is there a relationship between sea surface temperature and the distribution of phytoplankton? If so, how is this distribution impacted during El Niño?

   Hypothesis: During an El Niño event, when sea surface temperatures in the eastern Pacific ocean increase, the amount of phytoplankton, as measured using chlorophyll-a, ______(fill in)______.

2. **Design a plan to test your hypothesis and answer the research question.**

   What do you need?

   a) More information: Do you need more information about upwelling, phytoplankton, El Niño, and chlorophyll distribution?

   b) Specific data: When you go online to collect data, which of the following maps and graphs will you generate?

   c) Chlorophyll-a maps　　Sea surface temperature maps
   Chlorophyll-a graphs　　Sea surface temperature graphs

3. **Go online and get the data.**

   a) Visit www.dataintheclassroom.org, and find the El Niño module.

   b) Follow the link to "Get Data."

   c) Using the form, select the data and parameters you wish to look at.

   d) Click the "Get Data" button.

4. **Use the Data Log Sheet to keep a record of the data you select so you can refer to it later.**

5. **Analyze the data by answering the following questions.**

   a) Which is the El Niño year? Which is the non-El Niño year?

   b) Can you see any patterns between SST and chlorophyll distribution?

   c) Describe the pattern of SST and chlorophyll distribution during an El Niño year.

   d) Describe the pattern of SST and chlorophyll distribution during a non-El Niño year.

   It might help your analysis to graph two variables on the same plot. Sample the data and complete the table below. You can graph the data by hand using graph paper or use a spreadsheet.

		Date:		Date:	
Latitude	Longitude	SST	Chlorophyll-a	SST	Chlorophyll-a
	140° E				
	180°				
	140° W				
	100 °W				

6. **Draw conclusions.**

   Write down what you learned from your investigation. Use your data to help you decide whether your hypothesis is supported. If your hypothesis is not supported, think about other data you might need to collect.

Student Master

Data Log Sheet

As you use the online data access form to select data about El Niño, keep a record of the parameters you select on this data log sheet. Your data log will help you remember and keep track of the data you have looked at. Consider whether each new piece of data helps support or disprove your hypothesis.

	Data Set	Map/ Graph	Region	Date	Notes
1.	Chlorophyll	map	20°N 135°E 75°W 20°S	15-Feb-1998	Saved to disk as "Map01.gif"

Design Your Own Investigation

Summary

Grade Level: 6 - 8

Teaching Time:

Three 45-minute periods

Activity:

- **Design an investigation using real data to examine a hypothesis.**

Objective

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 their findings to evaluate, explain, and defend the validity of their hypothesis.

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. El Niño events last an average of 12 to 18 months and occur about once every two to seven years. Ten events happened in the last 42 years, with one of the most extreme occurring in 1997-98.

Satellite instruments help scientists reliably measure conditions in the atmosphere and oceans. The data that students are using, however, has only been collected over the last 20 years. 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. Here are some examples:

Research questions:

- Are El Niño events becoming stronger over time?
- Are El Niño events becoming more frequent?

Hypothesis:

- The El Niño in 1991-92 was a strong El Niño event. Support or disprove this hypothesis.

Materials

- **Copies of Student Master, Design Your Own Investigation**
- **Copies of Student Master, Data Log Sheet**
- **Student access to computers with Internet connections**
- **Microsoft Excel (optional)**
- **Graph Paper if Excel is not used**
- **Rulers**

Procedure

1. Distribute the Student Master, Design Your Own Investigation.

2. Guide student selection of a research question (or have them make up their own) that is appropriate to their academic experience. Review student hypotheses to make sure they are appropriate, and that students will be able to support or disprove them using the data available to them.

3. Have students develop a plan for designing a research project that will answer their questions.

4. Check each research project plan before students begin, to make sure the project aligns with the question and the resources available.

5. Assign students to use the tools at www.dataintheclassroom.org to access the data they need.

6. After students complete their research, provide time for them to present their findings to the class.

7. Use student presentations as an opportunity to relate their investigations to the current news and debate about global climate change. Ask: *From your own experience looking at real data, how do you view the question of global climate change?*

Research Project: Design Your Own Investigation

Planning your project:

1. **Develop a research question. Then form a hypothesis to investigate.**

   Be sure to review your hypothesis with your teacher before you begin.

   Research question:

   Hypothesis:

2. **Design a plan to test your hypothesis and answer the research question.**

   What do you need?

   a) More information:

   b) Specific data:

3. **Go online and get the data.**

   a) Visit www.dataintheclassroom.org, and find the El Niño module.

   b) Follow the link to "Get Data."

   c) Using the form, select the data and parameters you wish to look at.

   d) Click the "Get Data" button.

4. **Use the Data Log Sheet to keep a record of the data you select, so you can refer to it later.**

5. **Analyze the data.**

6. **Draw conclusions.**

   Write down what you learned from your investigation. Use your data to help you decide whether your hypothesis is supported. If your hypothesis is not supported, think about other data you might need to collect.

Student Master

Data Log Sheet

As you use the online data access form to select data about El Niño, keep a record of the parameters you select on this data log sheet. Your data log will help you remember and keep track of the data you have looked at. Consider whether each new piece of data helps support or disprove your hypothesis.

	Data Set	Map/ Graph	Region	Date	Notes