Name: Date:

Ocean Inter-annual Variability: El Niño and La Niña

Guiding Question:

- How does *El Niño* influence the oceans and climate patterns?

Introduction

What is El Niño/La Niña?

The *El Niño/La Niña* cycle is a natural climate oscillation of the ocean-atmosphere system that occurs in the Pacific Ocean. *El Niño* was first observed by scientists as an unusual ocean warming along the coasts of Peru and Ecuador in South America. The timing of this warming often coincided with the Christmas season, so it was called *El Niño* for the coming of the Christ Child. Although it occurs in the Pacific Ocean, the impacts of *El Niño/La Niña* are felt around the world and illustrate how our Earth system is inter-connected. The *El Niño/La Niña* cycle occurs every 3-7 years usually starting in December, but its impacts can last for months.

What controls El Niño?

The cycle is the result of the trade winds that blow over the central Pacific Ocean. Under 'normal' conditions, the trade winds blow from the east to the west and warm water 'piles up' on the western side of the Pacific near Australia. As the water moves away from the equatorial and eastern side of the Pacific, the surface water is replaced by cold, nutrient rich water, a process called **upwelling**. Because it is nutrient rich, upwelled water sustains high levels of phytoplankton and fish productivity. These upwelling systems are most pronounced along the equator and off the coast of Peru.

During an *El Niño* event, the trade winds lessen in strength in the central and western Pacific, allowing the warmer water near Australia to flow back towards the East (Figure 1). This warmer water has lower amounts of nutrients than the colder upwelling waters. The arriving nutrient-poor, warm water limits phytoplankton production in the equatorial upwelling system, as phytoplankton growth depends on nutrients. During a strong *El Niño*, the warm water can also reach Peru and can limit the phytoplankton and fishery production there as well, sometimes causing fisheries to collapse in this region.

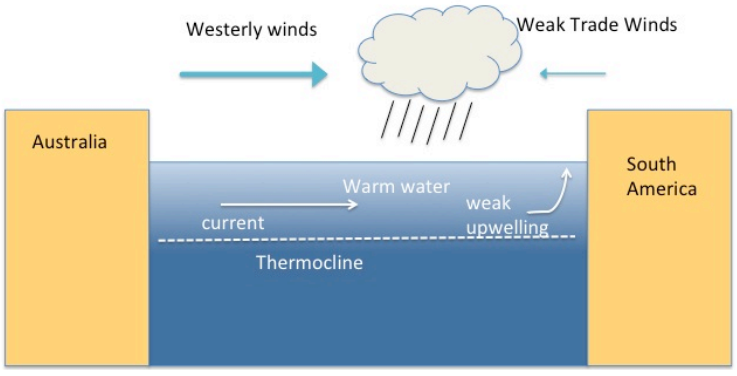


Figure 1. *El Niño* conditions in the Pacific

What is *La Niña*?

La Niña is the below normal cooling of sea surface temperatures in the eastern tropical Pacific Ocean, and has the opposite effects of *El Niño*. *La Niña* means 'The Little Girl'. *La Niña* usually follows an *El Niño* event, but not always. *La Niña* events, like *El Niño* events, will vary year to year.

In *La Niña* conditions (Figure 2), the trade winds blow towards the west across the tropical Pacific. These winds pile up warm surface water in the west Pacific, so that the sea surface is about ½ meter higher at Indonesia than at Ecuador. This brings the return of colder, nutrient-rich deep water surfaced by the Peruvian Upwelling, and higher phytoplankton and fish productivity.

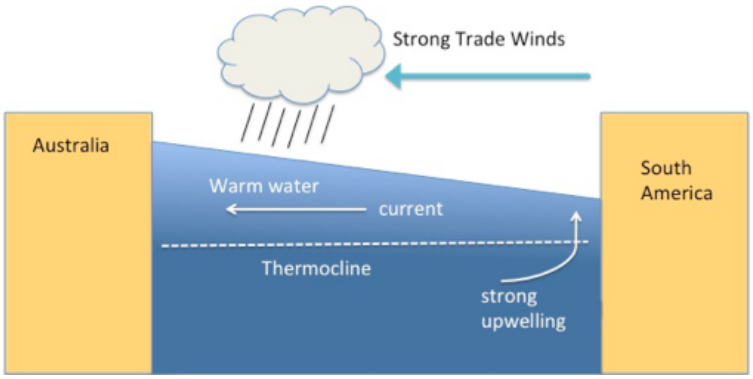


Figure 2. *La Niña* conditions in the Pacific

Global weather effects

Both El Niño and La Niña events have important consequences for weather around the Earth. Some of the impacts related to *El Niño* are increased rainfall in southern parts of the US and in Peru, and drought in the West Pacific, sometimes associated with devastating brush fires in Australia. The east coast of southern Africa often experiences drought during *El Niño*. La Niña generally causes the opposite effects of El Niño events- droughts in South America and flooding in Australia. Typical *El Niño* effects on the United States include:

- A drier than normal fall and winter in the Pacific Northwest.
- A wetter than normal winter in the Gulf Coast states from Louisiana to Florida.
- A warmer than normal late fall and winter in the northern Great Plains and the upper Midwest.
- Fewer Atlantic Ocean hurricanes.
- An increase in the number of East Coast winter storms.

Detecting *El Niño*/*La Niña*

To determine if an *El Niño* or *La Niña* event is occurring, scientists use observations of conditions in the tropical Pacific including satellite measurements of sea surface temperature and winds. This module will help you understand the effects of *El Niño* on the ocean and climate, and how to observe it with NASA tools.

Part 1. Questions

Using the Introduction, or other sources, answer the following questions:

1. In your own words, describe what *El Niño* is.

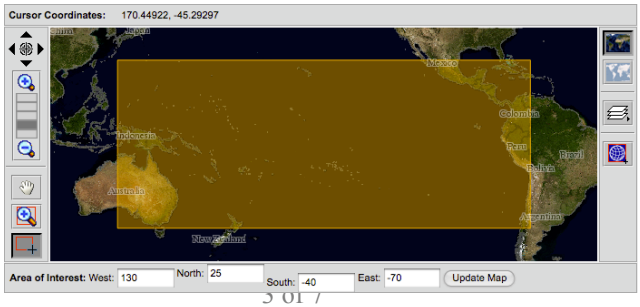
2. How are *El Niño* sea temperatures and weather conditions different from *La Niña* conditions?

3. What effects does *El Niño* have on the United States?

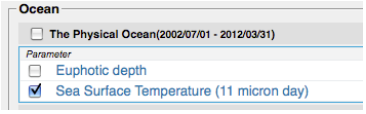
4. What effects does *El Niño* have on sea life and productivity?

Part 2. How does an El Niño event affect sea surface temperature?

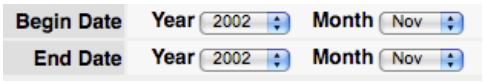
1. From the Student Climate Data website (http://studentclimatedata.unh.edu), click on the 'Ocean Data' tab at the top of the page.
2. Under 'Tools and Data' in the left panel, click 'DICCE Portal' to bring you out to the NASA DICCE data portal.
3. Click on the map, and drag your mouse across the screen to create a box that encompasses the equatorial Pacific.



4. Under the '**Physical Ocean**' parameter section, click the box next to 'Sea Surface Temperature.'



5. In the '**Temporal**' section, set both the Begin and End Date years to '2002' and months to 'Nov.'



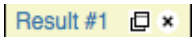
6. Using the '**Select Visualization**' drop-down menu, select 'Lat-Lon map, Time-averaged.'
7. Click 

8. Once the map loads, take a few minutes to observe the patterns in sea surface temperature.
9. Observe and **describe** the pattern of sea surface temperature from Australia (left side of the image) to South America (right side of the image) in November 2002.

10. Return to the data portal page by clicking the 

tab on the top-left of the page.
11. Keep all parameters the same, except in the **Temporal** section, change both of the years to '2008' (leaving the month as 'Nov').
12. Click 

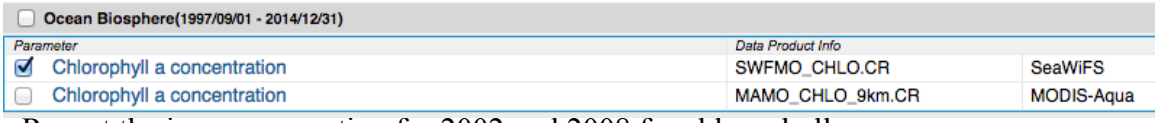
13. How does sea surface temperature change from South America (right side of the image) to Australia (left side of the image) in November 2008 compared with November 2002?

14. Based on your knowledge from the Introduction, which year do you think was an *El Niño* year? How can you tell? *Hint: you can view the previous map by clicking the* 

tab at the top of the screen.

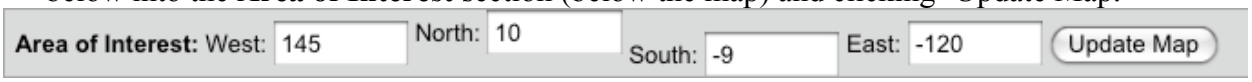
Part 3. How does an El Niño event affect chlorophyll?

1. Return to the data portal page by clicking the Home tab on the top-left of the page.
2. Click *off* the Sea Surface Temperature box, and click *on* the box next to 'Chlorophyll a concentration.'



3. Repeat the image generation for 2002 and 2008 for chlorophyll.
4. How does the pattern of chlorophyll concentration change from Australia to South America for each year? Based on your knowledge of the effects of *El Niño*, why are you seeing these patterns?

5. Return to the data portal page by clicking Home.
6. Now, change the map to isolate the equatorial upwelling system by typing the coordinates shown below into the **Area of Interest** section (below the map) and clicking 'Update Map.'



7. Set the Begin year to '1997' and End year to '2007.' Using the '**Select Visualization**' drop-down menu, select 'Time Series.'
8. Click Generate Visualization. It may take a few minutes for DICCE to create the graph.
9. What is the dependent variable on this graph (x-axis)? What is the independent variable (y-axis)?

10. What is the range of chlorophyll concentration in the equatorial upwelling zone?

11. What happens to chlorophyll concentration during the winter of an *El Niño* event? What is the difference in chlorophyll between a strong *El Niño* and a strong *La Niña* winter? Refer to Table 1 to help identify *La Niña* and *El Niño* years.

El Niño	La Niña
1997-1998	***1998-1999***
2002-2003	***1999-2000***
2004-2005	2000-2001
2006-2007	2005-2006
2009-2010	***2007-2008***

Table 1. El Niño and La Niña years. *Bold years are strong El Niño or La Niña events*.

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Part 4. Final Investigation (work with a partner)
Task: Using your knowledge from the Introduction and your data investigations, use the DICCE Data Portal to determine the year of the most recent *El Niño* event.

Record Investigation Plan. (What variables will you investigate? What visualization tools will you use? How will you tell if it is an *El Niño* year?)

Conduct Investigation. Record observations and data below in text, tables, and/or graphs.

Conclusions.

1. According to your investigation, what was the year of the most recent *El Niño* event?

2. What climate clues might you use to predict when the next *El Niño* will come?

3. If we want to predict how the oceans might respond to climate change in the future, why is it important to understand inter-annual variability in ocean processes, such as *El Niño* events?