



Ocean, Atmosphere, and Climate:

Cold Years in New Zealand

**Investigation Notebook
with Article Compilation**



© 2018 by The Regents of the University of California. All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage or retrieval system, without permission in writing from the publisher.

Teachers purchasing this Investigation Notebook as part of a kit may reproduce the book herein in sufficient quantities for classroom use only and not for resale.



These materials are based upon work partially supported by the National Science Foundation under grant numbers DRL-1119584, DRL-1417939, ESI-0242733, ESI-0628272, ESI-0822119. The Federal Government has certain rights in this material. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

These materials are based upon work partially supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A130610 to The Regents of the University of California. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.



Developed by the Learning Design Group at the University of California, Berkeley's Lawrence Hall of Science.

Amplify.

Amplify.
55 Washington Street, Suite 800
Brooklyn, NY 11201
1-800-823-1969
www.amplify.com

Ocean, Atmosphere, and Climate: Cold Years in New Zealand
ISBN: 978-1-64089-871-4
AMP.NA18

Ocean, Atmosphere, and Climate:

Cold Years in New Zealand

Investigation Notebook

Table of Contents

Safety Guidelines for Science Investigations	1
<i>Ocean, Atmosphere, and Climate: Cold Years in New Zealand</i> Unit Overview	3

Chapter 1: Air Temperature

Chapter Overview	4
Lesson 1.2: What Determines the Air Temperature of a Location?	5
Warm-Up	6
Christchurch During El Niño	7
Exploring Temperature and Energy in the Sim	8
Homework: Reading <i>Effects of El Niño Around the World</i>	9
Lesson 1.3: Energy Transferred to Air	10
Warm-Up	11
Setting Up the Heating Experiment	12–13
Gathering Evidence with the Sim	14–15
Revisiting the Claims with New Evidence	16–17
Homework: Considering How Air Gets Energy	18
Lesson 1.4: Air Temperatures Around the World	19
Warm-Up	20
Investigating Air Temperatures at Different Locations	21–22
Modeling What Determines a Location's Air Temperature	23
Homework: Determining Air Temperature at Three Locations	24
Lesson 1.5: Air Temperature in Christchurch	25
Warm-Up	26
Write and Share Routine: Student 1	27
Write and Share Routine: Student 2	28
Write and Share Routine: Student 3	29
Evaluating Evidence	30–32
Homework: Check Your Understanding	33–34

Chapter 2: Ocean Currents

Chapter Overview	35
Lesson 2.1: “The Ocean in Motion”	36
Warm-Up	37–38
Reading “The Ocean in Motion”	39
Homework: Tracking Currents in the Sim	40

Table of Contents (continued)

Lesson 2.2: Ocean Temperatures at Different Locations	41
Warm-Up	42
Investigating Ocean Surface Temperature	43–45
Homework: Energy and Temperature of Currents in Gyres	46
Lesson 2.3: Currents and Air Temperature	47
Warm-Up	48–49
Water and Air Temperature Experiment	50
Investigating Ocean Currents and Air Temperature	51–52
Air Temperature in Buenos Aires and Cape Town	53
Homework: Energy Transfer and Air Temperature	54
Lesson 2.4: Modeling Ocean Currents and Air Temperature	55
Warm-Up	56–57
Playing the Ocean Currents Game	58–59
Modeling How Currents Affect Air Temperature	60
Considering the El Niño Year	61
Homework: Writing a Report to the New Zealand Farm Council	62–63
Homework: Reading “How the Ocean Keeps Climates Stable”	64
Lesson 2.6: The Climates of Peru	65
Green Group: Warm-Up	66
Green Group: Investigating Peru’s Diverse Climates	67–69
Purple Group: Warm-Up	70
Purple Group: Investigating Peru’s Diverse Climates	71–73
Blue Group: Warm-Up	74
Blue Group: Investigating Peru’s Diverse Climates	75–77
Homework: Check Your Understanding	78–79
Chapter 3: Ocean Currents and Prevailing Winds	
Chapter Overview	80
Lesson 3.1: “The Gulf Stream”	81
Warm-Up	82
Reading “The Gulf Stream: A Current That Helped Win a War”	83
Homework: Sim Mission	84
Lesson 3.2: What Determines the Direction of Ocean Currents?	85
Warm-Up	86
Rereading “The Gulf Stream: A Current That Helped Win a War”	87
Investigating with the Currents Tank	88–91

Table of Contents (continued)

Homework: Using the Modeling Tool to Show How Currents Move	92
Homework: Reading About Prevailing Winds	93
Lesson 3.3: Christchurch: Air Temperature in Normal Years	94
Warm-Up	95
Modeling Ocean Currents Near Christchurch	96
Investigating the Effect of Changing Winds	97–99
Homework: Reading “Deep Ocean Currents: Driven by Density”	100
Lesson 3.4: Explaining the Change in Air Temperature in Christchurch	101
Warm-Up	102
Write and Share Routine: Student 1	103
Write and Share Routine: Student 2	104
Write and Share Routine: Student 3	105
Write and Share Routine: Student 4	106
The Reasoning Tool	107
Homework: Writing a Scientific Argument	108–109
Homework: Check Your Understanding	110–111
 Chapter 4: Science Seminar	
Chapter Overview	112
Lesson 4.1: Comparing Air Temperature: Past and Present	113
Warm-Up	114–115
Introducing the Science Seminar	116
Annotating and Discussing Evidence	117
Sorting the Evidence Cards	118
Lesson 4.2: Science Seminar	119
Warm-Up	120
Preparing for the Science Seminar	121
Science Seminar Observations	122
Homework: Reflecting on the Science Seminar	123
Lesson 4.3: Writing a Scientific Argument	124
Warm-Up	125
Using the Reasoning Tool	126
Organizing Your Reasoning Tool	127
Writing Scientific Arguments	128–130
Homework: Revising an Argument	131–132
Homework: Check Your Understanding	133
<i>Ocean, Atmosphere, and Climate Glossary</i>	134–135

Safety Guidelines for Science Investigations

1. **Follow instructions.** Listen carefully to your teacher's instructions. Ask questions if you don't know what to do.
2. **Don't taste things.** No tasting anything or putting it near your mouth unless your teacher says it is safe to do so.
3. **Smell substances like a chemist.** When you smell a substance, don't put your nose near it. Instead, gently move the air from above the substance to your nose. This is how chemists smell substances.
4. **Protect your eyes.** Wear safety goggles if something wet could splash into your eyes, if powder or dust might get in your eyes, or if something sharp could fly into your eyes.
5. **Protect your hands.** Wear gloves if you are working with materials or chemicals that could irritate your skin.
6. **Keep your hands away from your face.** Do not touch your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals.
7. **Tell your teacher if you have allergies.** This will keep you safe and comfortable during science class.
8. **Be calm and careful.** Move carefully and slowly around the classroom. Save your outdoor behavior for recess.
9. **Report all spills, accidents, and injuries to your teacher.** Tell your teacher if something spills, if there is an accident, or if someone gets injured.
10. **Avoid anything that could cause a burn.** Allow your teacher to work with hot water or hot equipment.
11. **Wash your hands after class.** Make sure to wash your hands thoroughly with soap and water after handling plants, animals, or science materials.

Name: _____ Date: _____

Ocean, Atmosphere, and Climate: Cold Years in New Zealand

Unit Overview

Welcome! As a climate science student, you will begin working right away on a research project. The New Zealand Farm Council has hired you as a consultant to help them investigate why the air temperature in Christchurch, New Zealand, is cooler during El Niño years. When the temperature changes, agriculture around Christchurch is affected, and the farmers want to understand and be better prepared for these changes. You'll first need to learn what determines the air temperature of various places on Earth before investigating what could be causing the air temperature to change during El Niño years. Wishing you an interesting and productive investigation . . .

Name: _____ Date: _____

Chapter 1: Air Temperature

Chapter Overview

In Chapter 1, you'll investigate the relationship between air temperature and energy at different locations on Earth. Using simulations and hands-on experiments, you and your fellow climate scientists will collect evidence to explain why different locations have different air temperatures.



Name: _____ Date: _____

Lesson 1.2: What Determines the Air Temperature of a Location?

Welcome to the *Ocean, Atmosphere, and Climate* unit! In this unit, you will be working as student climate scientists, also known as climatologists. Farmers in Christchurch, New Zealand, have noticed that the air temperature is cooler during El Niño years, and these temperature changes affect their crops. As a student climate scientist for the New Zealand Farm Council, you will investigate what is causing these temperature changes. Today you will learn more about El Niño events and air temperature, and use the Sim to begin your research.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 1 Question

- What determines the air temperature of Christchurch, New Zealand?

Vocabulary

- climate
- energy
- temperature

Digital Tools

- *Ocean, Atmosphere, and Climate* Simulation

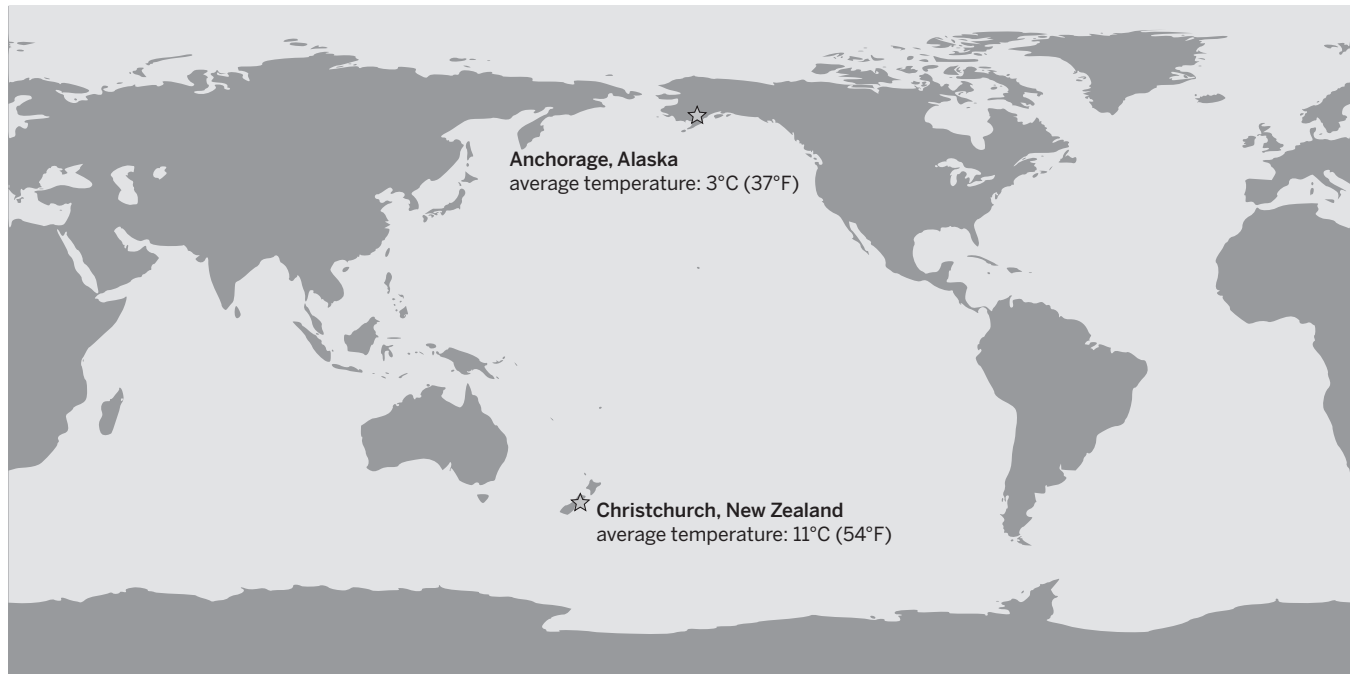
Name: _____

Date: _____

Warm-Up

Comparing Average Temperatures

Compare the average annual temperature for each of the two cities shown on the map. Then, answer the question.



What ideas do you have about what makes Anchorage, Alaska, cooler than Christchurch, New Zealand?

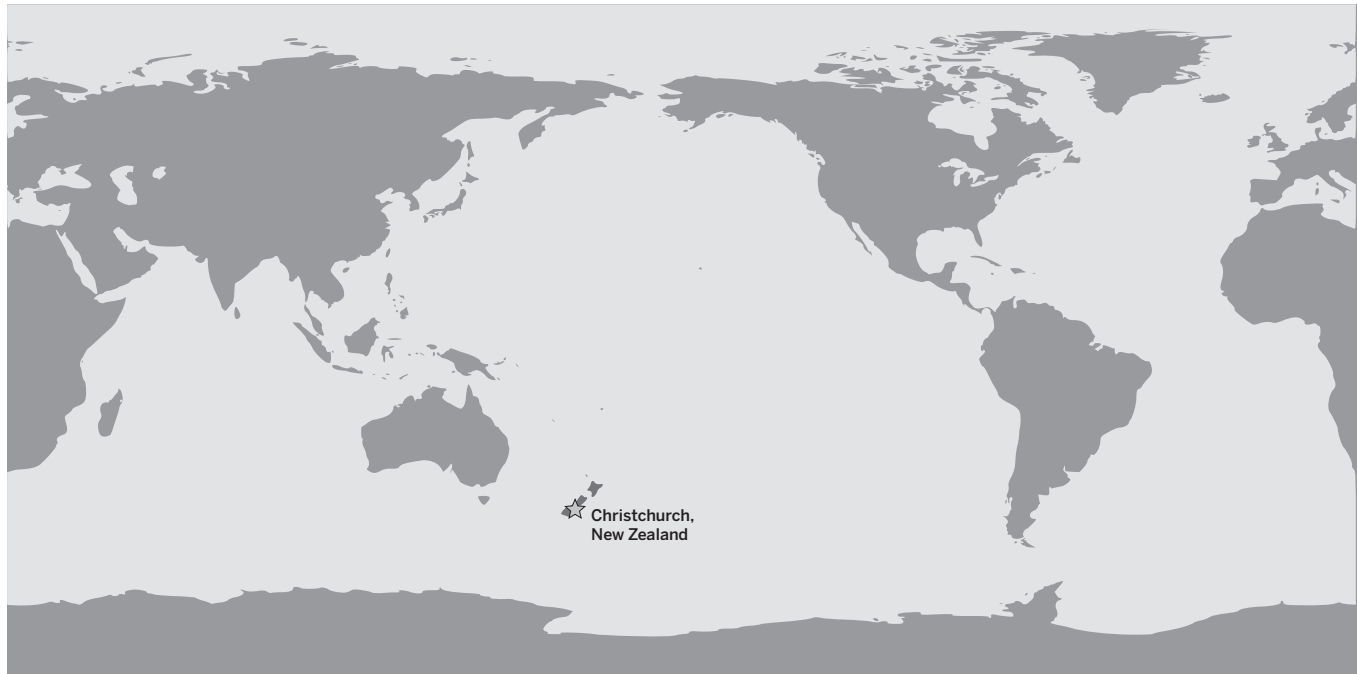
Name: _____ Date: _____

Christchurch During El Niño

Partner Discussion: Christchurch During El Niño

Share your ideas about the research question with your partner.

During El Niño years, why is Christchurch, New Zealand's air temperature cooler than usual?



Choose the claim that is most similar to your ideas. Your response does not need to be the same as your partner.

This is why Christchurch, New Zealand's air temperature is cooler than usual during El Niño years: (check one)

- ☐ **Claim 1:** The amount of incoming energy from the sun changes.
- ☐ **Claim 2:** Something about Earth's surface (land or water) changes.
- ☐ **Claim 3:** Something about the air changes.

Name: _____ Date: _____

Exploring Temperature and Energy in the Sim

Part 1: Exploring the *Ocean, Atmosphere, and Climate* Simulation

1. Launch the *Ocean, Atmosphere, and Climate* Sim.
2. Work with your partner to become familiar with the features of the Simulation.
3. When you make a discovery about the Simulation, be sure to share it with your partner!

Part 2: Sim Mission: Change the Air Temperature

1. With your partner, find ways to make the air temperature change in the Sim. Go to Energy Test mode.
 - **Partner 1:** Find a way to make the air temperature **increase**.
 - **Partner 2:** Find a way to make the air temperature **decrease**.
2. Talk to your partner about how you were able to make the temperature change.

How did you make the temperature **increase?** (circle one)

I (**added** / **removed**) energy to make the temperature increase.

How did you make the temperature **decrease?** (circle one)

I (**added** / **removed**) energy to make the temperature decrease.

Name: _____ Date: _____

Homework: Reading *Effects of El Niño Around the World*

Read the introduction about El Niño and then choose one of the three articles to learn about the effects of El Niño in a specific location. Annotate the article using the Active Reading strategies that work best for you and then answer the questions.

Optional challenge: When you are finished, choose another article to learn about the effects of El Niño in a different location.

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Which article did you read? (circle one)

“Drought in Pakistan”

“Landslide in Los Angeles”

“Malaria in Colombia”

Why do you think it is important for climate scientists to study El Niño?

Name: _____ Date: _____

Lesson 1.3: Energy Transferred to Air

In your first day of research as a student climate scientist, you explored the *Ocean, Atmosphere, and Climate* Sim and observed that more energy in the air makes the temperature warmer, while less energy in the air makes the temperature cooler. You now know that air temperature is determined by the amount of energy in the air, but how does air get energy? Today, you will use evidence from a heating experiment and from the Sim to answer this question.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 1 Question

- What determines the air temperature of Christchurch, New Zealand?

Vocabulary

- climate
- energy
- temperature
- transfer

Digital Tools

- *Ocean, Atmosphere, and Climate* Simulation

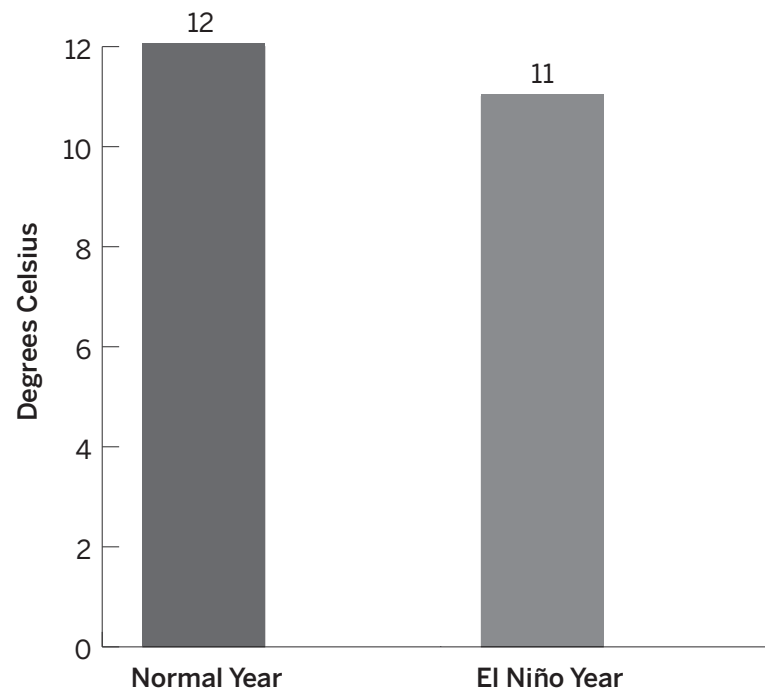
Name: _____

Date: _____

Warm-Up

Look at the graph carefully and read all the information to review how the temperature of Christchurch, New Zealand, changes during an El Niño year. Then, answer the question.

Average Air Temperature: Christchurch, New Zealand



El Niño events occur every two to seven years. There is a shift in the climate across the tropical Pacific, which causes some areas to become cooler than usual and some areas to become warmer than usual.

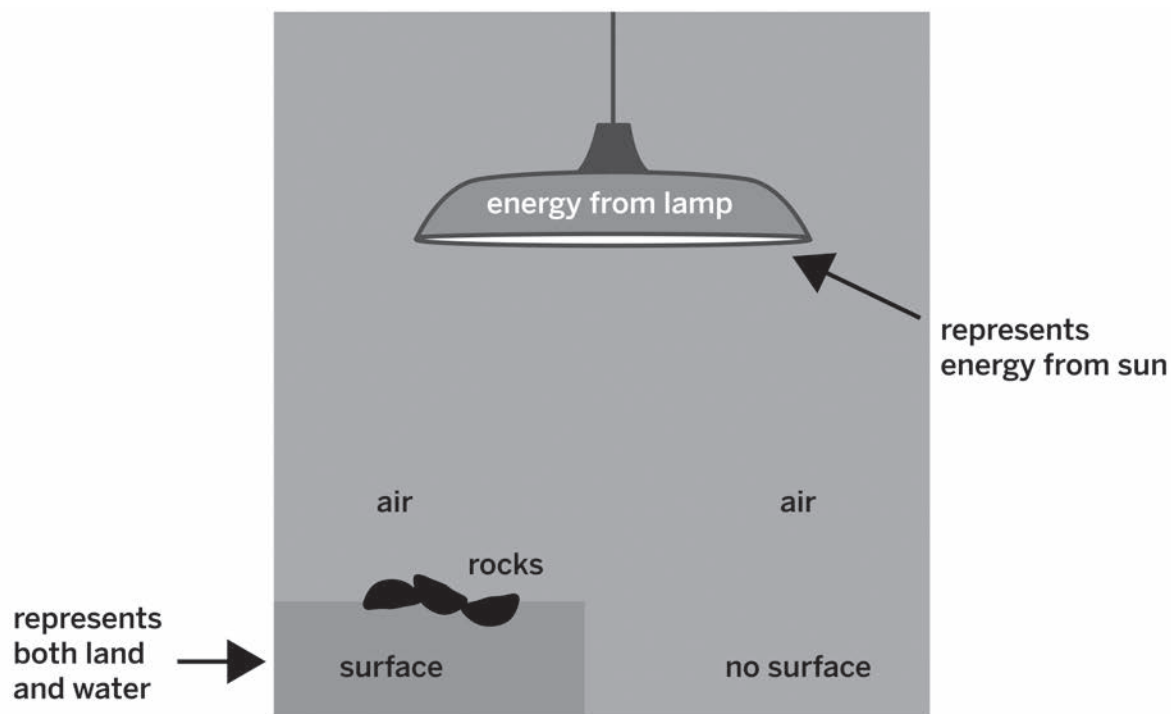
Christchurch, New Zealand's air temperature is cooler than usual during El Niño years. This means the air has _____ energy during an El Niño event. (circle one)

- a. more
- b. less

Name: _____ Date: _____

Setting Up the Heating Experiment

Your class is about to conduct an experiment to determine how air gets energy. Talk to your partner about the results you would expect to see if either of these claims were accurate.



Claim 1: Energy is transferred from the sun to the air.

- If Claim 1 were true, would you expect the air temperature with no surface underneath to be higher, lower, or the same as the air above the rocks?

Claim 2: Energy is transferred from the sun to the surface, and then to the air.

- If Claim 2 were true, would you expect the air temperature with no surface underneath to be higher, lower, or the same as the air above the rocks?

Name: _____ Date: _____

Setting Up the Heating Experiment (continued)

Heating Experiment Data Table

Observe as the air temperature of Cup 1 and Cup 2 is measured. Record the temperature data in the table.

	Starting air temperature (°C) (before lamp is turned on)	Final air temperature (°C) (20 minutes after lamp is turned on)	Change in air temperature (°C) (final temperature minus starting temperature)
Cup 1 (air above surface)			
Cup 2 (air, no surface underneath)			

Name: _____ Date: _____

Gathering Evidence with the Sim

Gather more evidence about how air gets energy by completing two tests in the Sim. Review the claims, and then follow the numbered steps.

Investigation Question: *How does air get energy?*

Claim 1: Energy is transferred from the sun to the air.

Claim 2: Energy is transferred from the sun to the surface, and then to the air.

1. Predict what will happen to the air temperature when you turn on energy from the sun, for (a) SURFACE and (b) NO SURFACE.

a. surface

I predict that the air temperature will _____ after 1 minute. (check one)

- ☐ increase
- ☐ decrease
- ☐ stay the same

b. no surface

I predict that the air temperature will _____ after 1 minute. (check one)

- ☐ increase
- ☐ decrease
- ☐ stay the same

Name: _____ Date: _____

Gathering Evidence with the Sim (continued)

2. Open the *Ocean, Atmosphere, and Climate* Sim. Go to Surface Test Mode.

a. surface

Observe what happens to the air temperature for about 1 minute. Record the results.

The air temperature _____ after 1 minute. (check one)

- ☐ increased
☐ decreased
☐ stayed the same

b. no surface

Repeat the test, being sure that Energy from the Sun is set to the same level as the first test.

Record the results. The air temperature _____ after 1 minute. (check one)

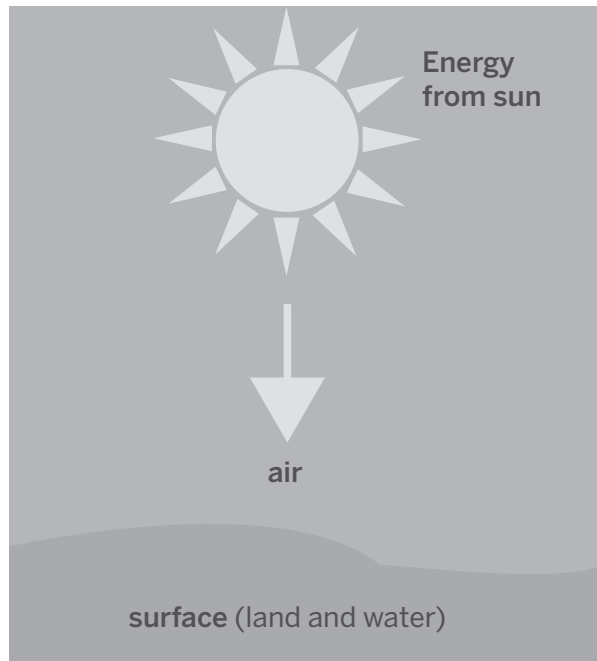
- ☐ increased
☐ decreased
☐ stayed the same

Name: _____

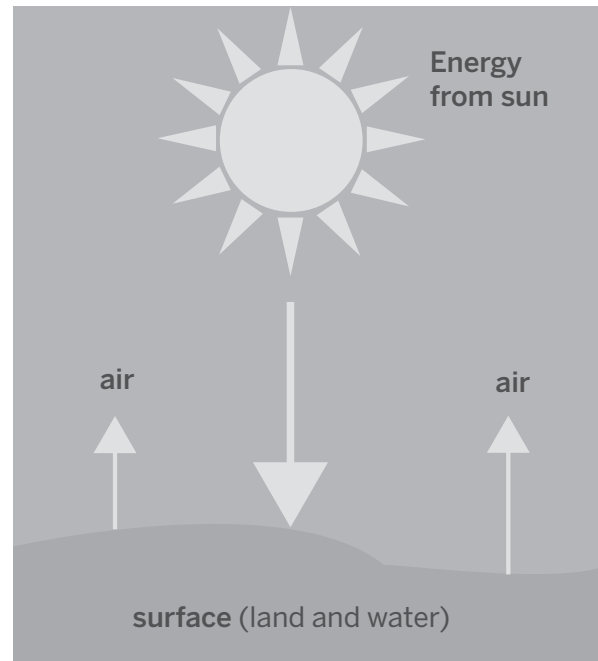
Date: _____

Revisiting the Claims with New Evidence

Investigation Question: *How does air get energy?*



Claim 1: Energy is transferred from the sun to the air.



Claim 2: Energy is transferred from the sun to the surface, and then to the air.

Discussing the Heating Experiment Results

Discuss these questions with your partner:

- What happened in the experiment?
- Do the results support Claim 1 or Claim 2?
- What did you learn from the experiment that might help you answer the Investigation Question: *How does air get energy?*

Name: _____ Date: _____

Revisiting the Claims with New Evidence (continued)

Circle the claim you think is best supported by evidence from the Sim and the heating experiment.

Claim 1: Energy is transferred from the sun to the air.

Claim 2: Energy is transferred from the sun to the surface, and then to the air.

What evidence supports the claim you chose?

Name: _____ Date: _____

Homework: Considering How Air Gets Energy

Read the statement and determine if you agree or disagree. Use evidence to support your answer.

The sun warms the air directly.

Do you agree or disagree with this statement? What evidence supports your ideas?

Name: _____ Date: _____

Lesson 1.4: Air Temperatures Around the World

One of the important jobs of climate scientists is to read and interpret different types of maps that present data about Earth's systems. Today, you will look at two maps that will help you investigate air temperature and why it's different in different places. At the end of class, you will create a model that shows your understanding of why different locations on Earth have different temperatures.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 1 Question

- What determines the air temperature of Christchurch, New Zealand?

Key Concepts

- Energy from the sun is transferred to Earth's surface. Some of that energy is then transferred to the air above the surface.

Vocabulary

- climate
- energy
- temperature
- transfer

Digital Tools

- *Ocean, Atmosphere, and Climate* Simulation

Name: _____ Date: _____

Warm-Up

Predicting the Air Temperature of Different Locations

Open the *Ocean, Atmosphere, and Climate* Sorting Tool activity: 1.4 Warm-Up.

Goal: Make predictions about cold, warm, and hot places on Earth.

Do:

- Move a green thermometer to one location you think is cold.
- Move a yellow thermometer to one location you think is warm.
- Move red thermometers to two locations you think are hot.
- Move an energy label next to each thermometer so it shows what must be true about energy in that location.

Tips:

- Think about how temperature and energy are related.

Explain how your map shows your predictions about cold, warm, and hot places on Earth.

Name: _____

Date: _____

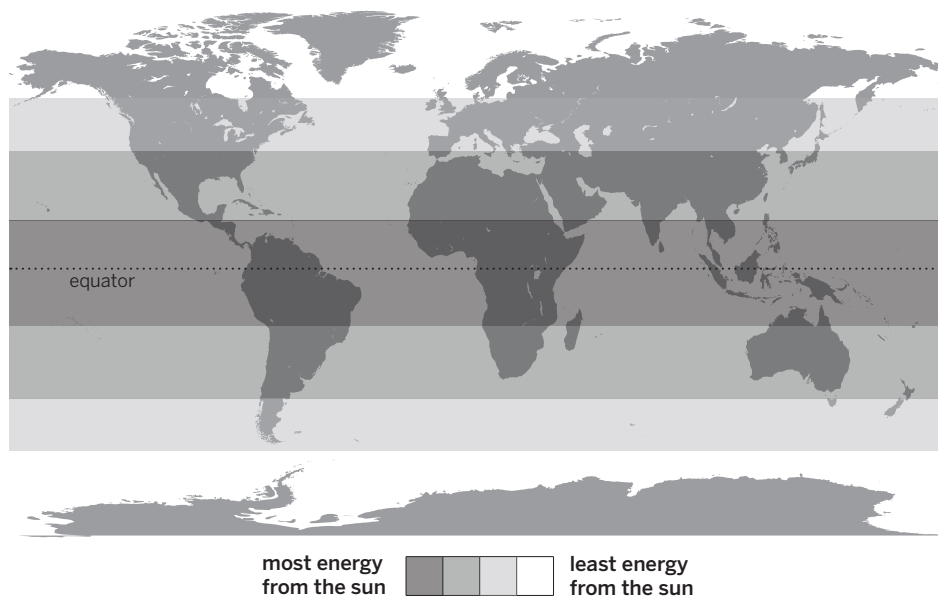
Investigating Air Temperatures at Different Locations

Discussing Energy and Temperature Maps

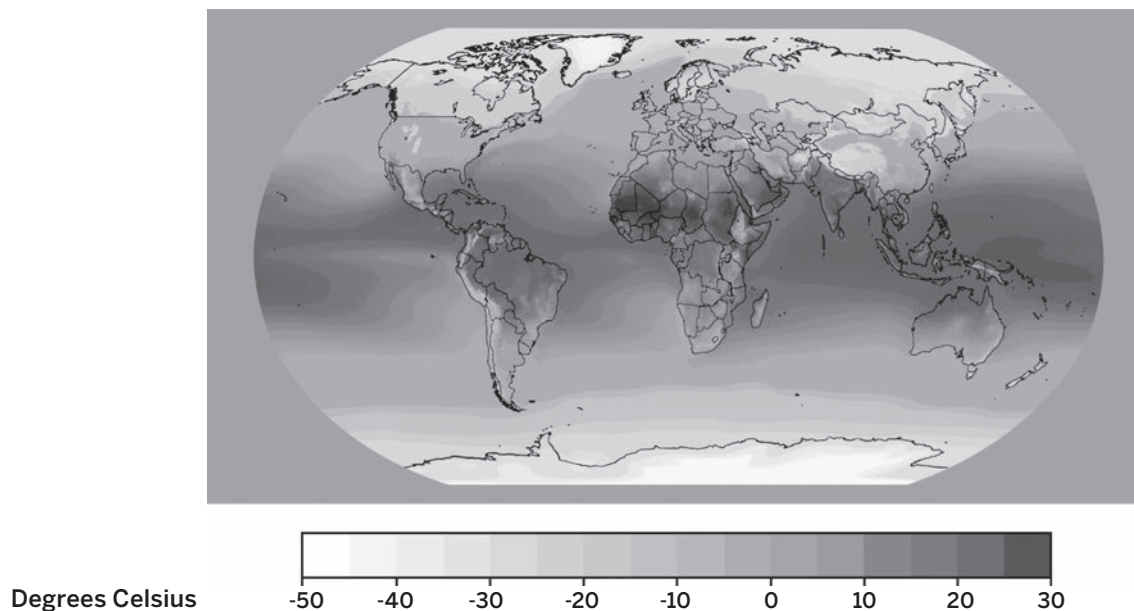
Decide on one map for each partner to focus on. Think about the questions, and then talk to your partner about what you notice. **Note:** Your teacher will project a color version of these maps.

1. What information does your map show?
2. How do the maps go together to provide evidence about the Investigation Question:
Why do different locations have different air temperatures?

Incoming Energy from the Sun



Global Air Temperature



Name: _____ Date: _____

Investigating Air Temperatures at Different Locations (continued)

3. Use evidence from the maps on the previous page to answer the Investigation Question:
Why do different locations have different air temperatures?

- Try to use the following words in your response: *energy*, *temperature*, and *latitude*.

Revisiting the Sorting Tool

Return to the *Ocean, Atmosphere, and Climate* Sorting Tool activity: 1.4 Warm-Up. Revise your map, and once you are satisfied, explain the changes you made to your map below.

Name: _____ Date: _____

Modeling What Determines a Location's Air Temperature

Open the *Ocean, Atmosphere, and Climate* Modeling Tool activity: 1.4 Different Temperatures, and create a model. Press HAND IN when your model is complete.

Goal: Model why two locations (Equator and South Pole) have different air temperatures.

Do:

- Use Energy Transfer arrows to show how energy from the sun is transferred to the air.
- Select a size for each arrow so it shows the amount of energy being transferred.
- Use thermometers to show the resulting air temperature.

Tips:

- Model the air temperature of both locations.
- Press the blue pencil to add information to your model.
- When items are properly connected, choices for size or temperature level will appear.

Explain how your model shows why two locations (Equator and South Pole) have different air temperatures.

Name: _____ Date: _____

Homework: Determining Air Temperature at Three Locations

Use the Sim to investigate energy from the sun and temperature at three locations.

Open the *Ocean, Atmosphere, and Climate* Sim. Go to Current Map mode, then select AIR for Temperature View.

1. Place Location Sensors at 1 and 2.
2. Record the level of energy transferred from the sun and the air temperature at both locations.
3. Reset the activity. Place a Location Sensor at 3.
4. Record the level of energy transferred from the sun and the air temperature at the third location.

Location number	Level of energy from the sun (low, middle, high)	Air temperature (°C)
1		
2		
3		

How is the temperature of a location determined by energy from the sun and the location's distance from the equator?

Name: _____ Date: _____

Lesson 1.5: Air Temperature in Christchurch

You have been gathering evidence to explain what determines a location's air temperature. Today, you will begin to use what you have learned to explain why Christchurch's air temperature is cooler during El Niño years. First, you will participate in a Write and Share routine that helps you review the science concepts you have learned so far. Next, you will use what you have learned to analyze real climate data that the New Zealand Farm Council sent to help with your investigation.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 1 Question

- What determines the air temperature of Christchurch, New Zealand?

Key Concepts

- Energy from the sun is transferred to Earth's surface. Some of that energy is then transferred to the air above the surface.
- The closer a location is to the equator, the more energy it receives from the sun. Therefore, a location's air temperature is affected by its distance from the equator.

Vocabulary

- climate
- energy
- latitude
- temperature
- transfer

Name: _____ Date: _____

Warm-Up

Why is Christchurch, New Zealand's air temperature cooler than usual during El Niño years?

Review the question and three claims, and then choose the one claim you think is LEAST convincing.

Christchurch's air temperature is cooler than usual during El Niño years because . . . (check one)

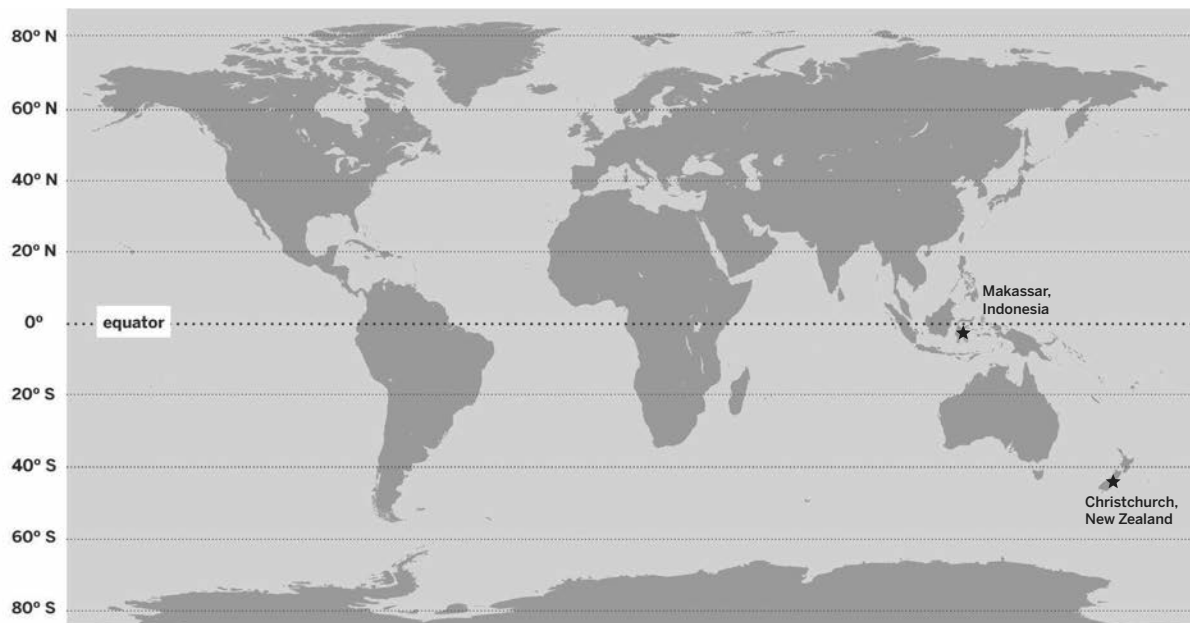
- ☐ **Claim 1:** The amount of incoming energy from the sun changes.
- ☐ **Claim 2:** Something about Earth's surface (land or water) changes.
- ☐ **Claim 3:** Something about the air changes.

Explain why you think the claim you selected is the LEAST convincing claim.

Name: _____ Date: _____

Write and Share Routine: Student 1

Location	Average air temperature
Christchurch, New Zealand	11°C (51.8°F)
Makassar, Indonesia	27.5°C (81°F)



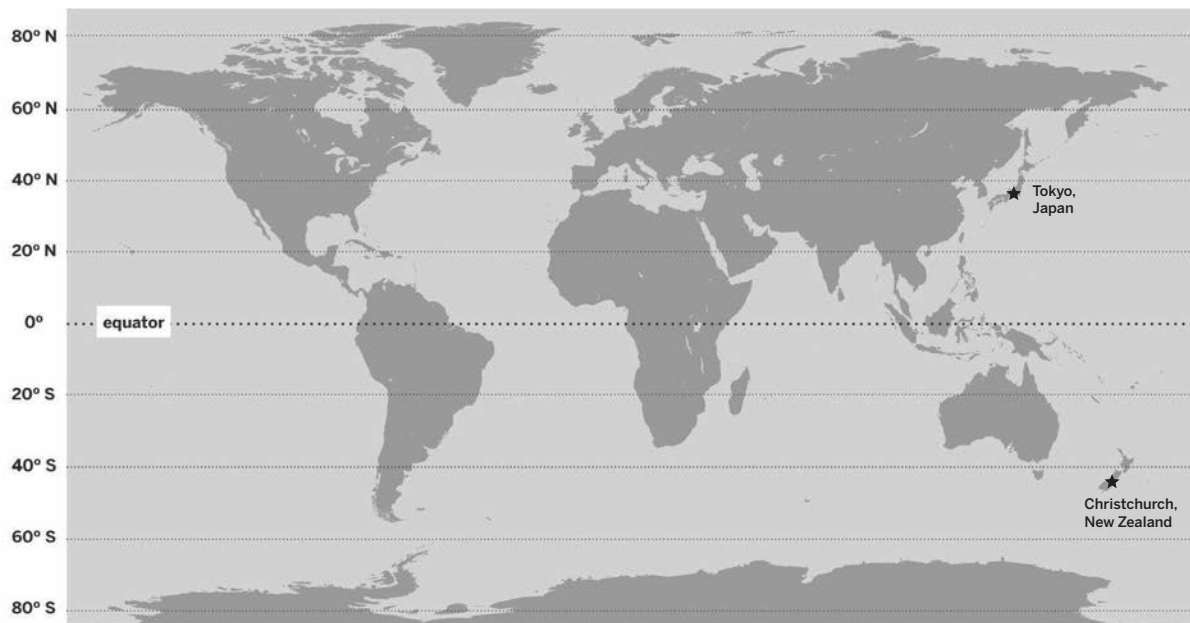
Prompt: Why is the average air temperature of Makassar warmer than the average air temperature of Christchurch?

Add annotations to the map that will help you respond to the prompt. Write an explanation, using the evidence from the map and all these words: *energy, temperature, latitude, transfer*.

Name: _____ Date: _____

Write and Share Routine: Student 2

Location	Average air temperature
Christchurch, New Zealand	11°C (51.8°F)
Tokyo, Japan	15.5°C (60°F)



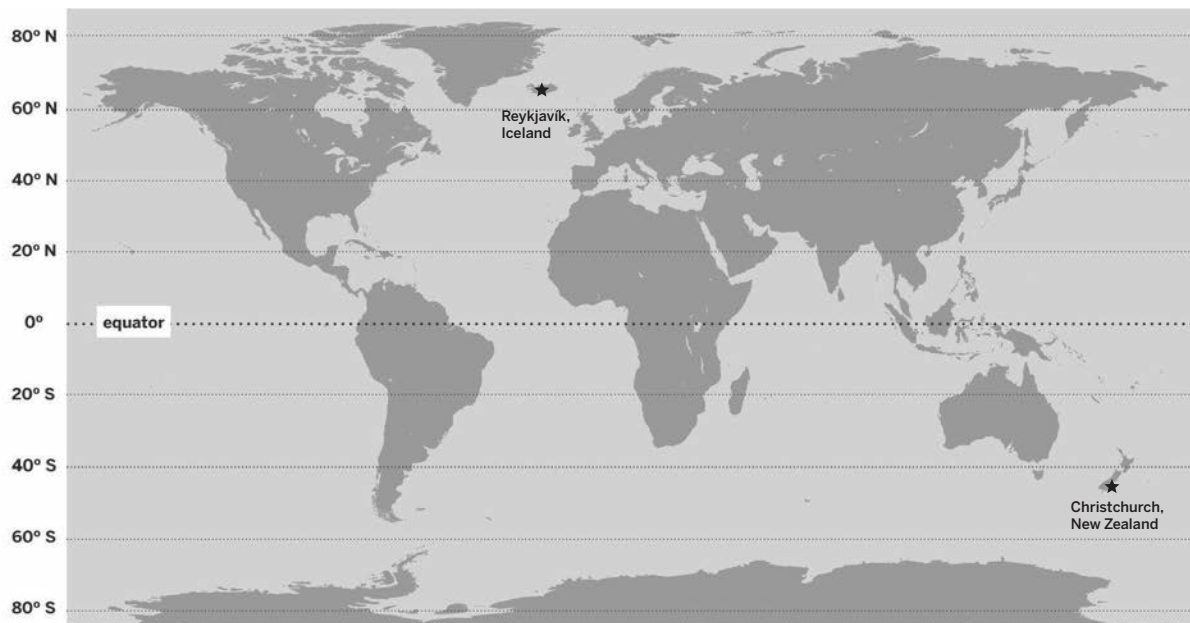
Prompt: Why is the average air temperature of Tokyo warmer than the average air temperature of Christchurch?

Add annotations to the map that will help you respond to the prompt. Write an explanation, using the evidence from the map and all these words: *energy, temperature, latitude, transfer*.

Name: _____ Date: _____

Write and Share Routine: Student 3

Location	Average air temperature
Christchurch, New Zealand	11°C (51.8°F)
Reykjavik, Iceland	5.5°C (42°F)



Prompt: Why is the average air temperature of Reykjavik cooler than the average air temperature of Christchurch?

Add annotations to the map that will help you respond to the prompt. Write an explanation, using the evidence from the map and all these words: *energy, temperature, latitude, transfer*.

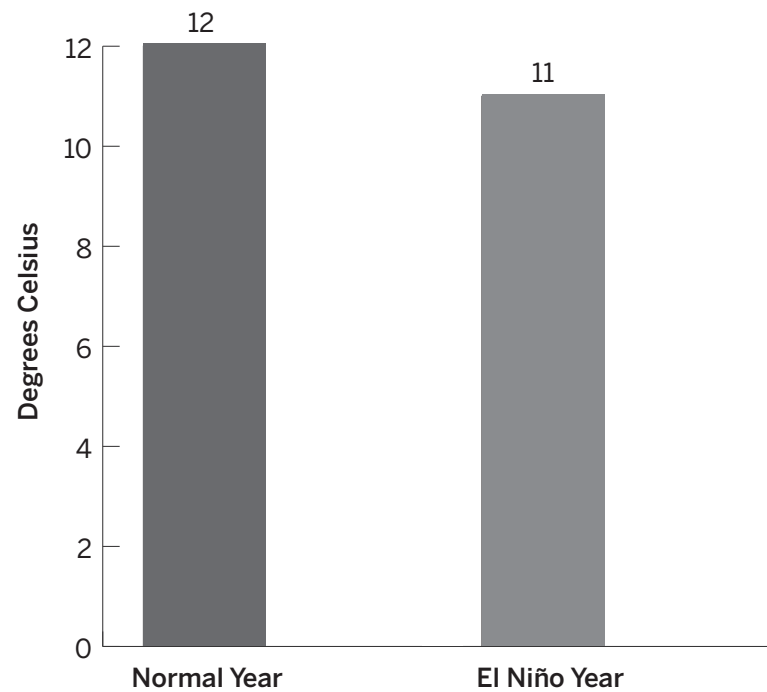
Name: _____ Date: _____

Evaluating Evidence

Part 1: Interpreting Climate Data

Participate in the class discussion about this graph.

Average Air Temperature: Christchurch, New Zealand



Name: _____

Date: _____

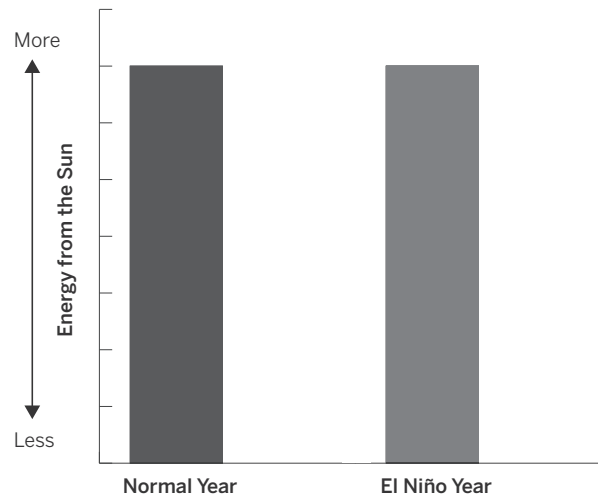
Evaluating Evidence (continued)

Part 2: Annotating and Discussing Evidence

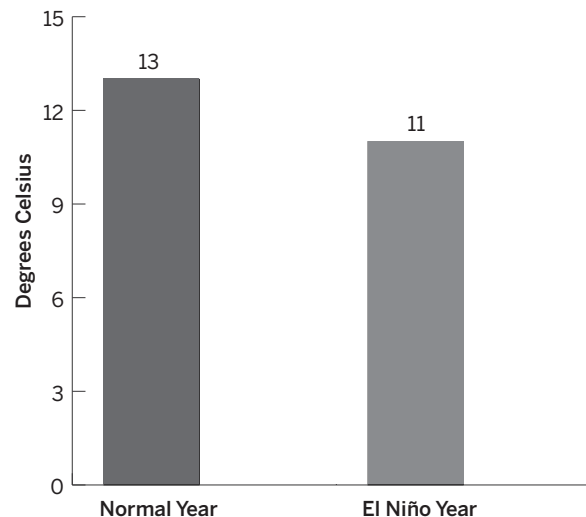
Use the first three questions to guide you as you read and annotate both graphs. When you are finished, discuss your annotations and question 4 with your partner.

1. What does each graph show?
2. What questions do you have about the information in the graphs?
3. How is the evidence connected to what you have been learning about climate, temperature, and energy?

Energy from the Sun at Christchurch, New Zealand



Average Ocean Surface Temperature Near Christchurch, New Zealand



Name: _____ Date: _____

Evaluating Evidence (continued)

4. Do the graphs support or go against the following claims about Christchurch during El Niño years?

Christchurch's air temperature is cooler than usual during El Niño years because . . .

Claim 1: The amount of incoming energy from the sun changes.

Claim 2: Something about Earth's surface (land or water) changes.

Claim 3: Something about the air changes.

Name: _____ Date: _____

Homework: Check Your Understanding

Scientists investigate in order to figure things out. Are you getting closer to figuring out why the air temperature in Christchurch is cooler in El Niño years?

1. I understand how energy is transferred to the air of Christchurch, New Zealand. (check one)

☐ yes

☐ not yet

Explain your answer choice.

2. I understand what happens to the amount of energy in the air of Christchurch in El Niño years. (check one)

☐ yes

☐ not yet

Explain your answer choice.

3. I understand how Christchurch's distance from the equator affects its air temperature. (check one)

☐ yes

☐ not yet

Explain your answer choice.

Name: _____ Date: _____

Homework: Check Your Understanding (continued)

4. I understand why the ocean near Christchurch is a different temperature than we'd expect for its latitude (distance from the equator). (check one)

☐ yes

☐ not yet

Explain your answer choice.

5. I understand why the ocean temperature near Christchurch changes in El Niño years and how it affects the air temperature there. (check one)

☐ yes

☐ not yet

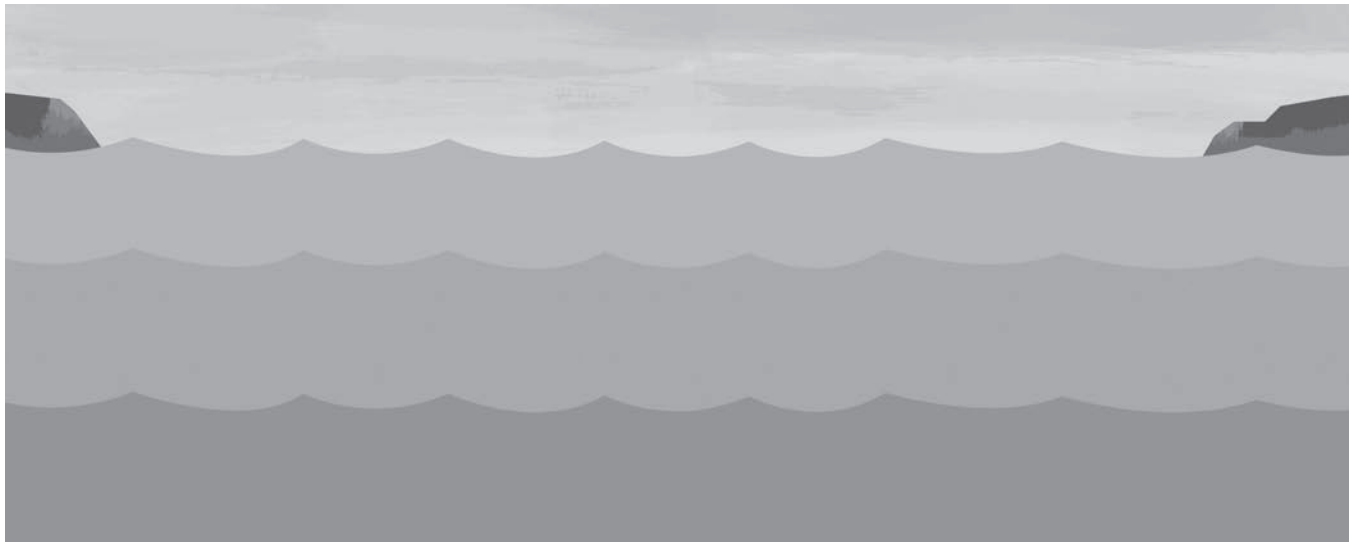
6. What do you still wonder about El Niño and air temperature?

Name: _____ Date: _____

Chapter 2: Ocean Currents

Chapter Overview

In Chapter 2, you will discover why the ocean surface varies in temperature at different locations and how this affects the air temperature of places near the ocean. You will use the knowledge you gain in this chapter (which includes an exciting article, a fun board game, and an interesting video) to demonstrate your understanding of all you've learned, using the *Ocean, Atmosphere, and Climate Modeling Tool*.



Name: _____ Date: _____

Lesson 2.1: “The Ocean in Motion”

As a student climatologist, you determined that a location’s latitude affects its air temperature. But Christchurch’s air temperature and ocean surface temperature both become cooler during El Niño years. A city’s latitude does not change, so, other than latitude, what else might affect a location’s air temperature? Dr. Parata, the New Zealand Farm Council director, has sent an article that will help you begin to answer this question.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 2 Question

- Other than latitude, what else affects the air temperature of Christchurch?

Vocabulary

- climate
- energy
- latitude
- ocean current
- temperature

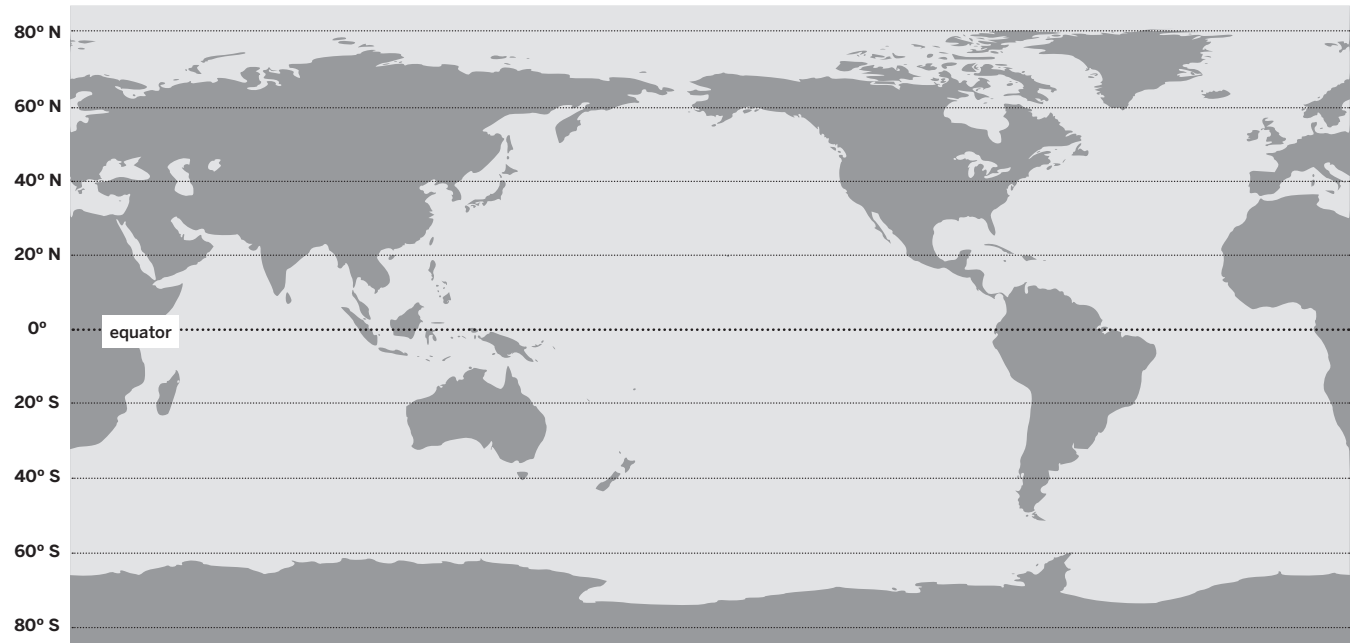
Digital Tools

- *Ocean, Atmosphere, and Climate* Simulation

Name: _____ Date: _____

Warm-Up

Find the place where you live on the world map. Estimate the latitude, and then answer the questions.



Based on the latitude you estimated, predict how much energy is transferred from the sun to the surface, and then to the air in your city.

Name: _____ Date: _____

Warm-Up (continued)

Other than latitude, what else do you think might affect the air temperature where you live?

Name: _____ Date: _____

Reading “The Ocean in Motion”

1. Read and annotate the article “The Ocean in Motion.”
2. Choose and mark annotations to discuss with your partner. Once you have discussed these annotations, mark them as discussed.
3. Now, choose and mark a question or connection, either one you already discussed or a different one you still want to discuss with the class.
4. Answer the reflection question below.

Rate how successful you were at using Active Reading skills by responding to the following statement:

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- ☐ Never
- ☐ Almost never
- ☐ Sometimes
- ☐ Frequently/often
- ☐ All the time

Active Reading Guidelines

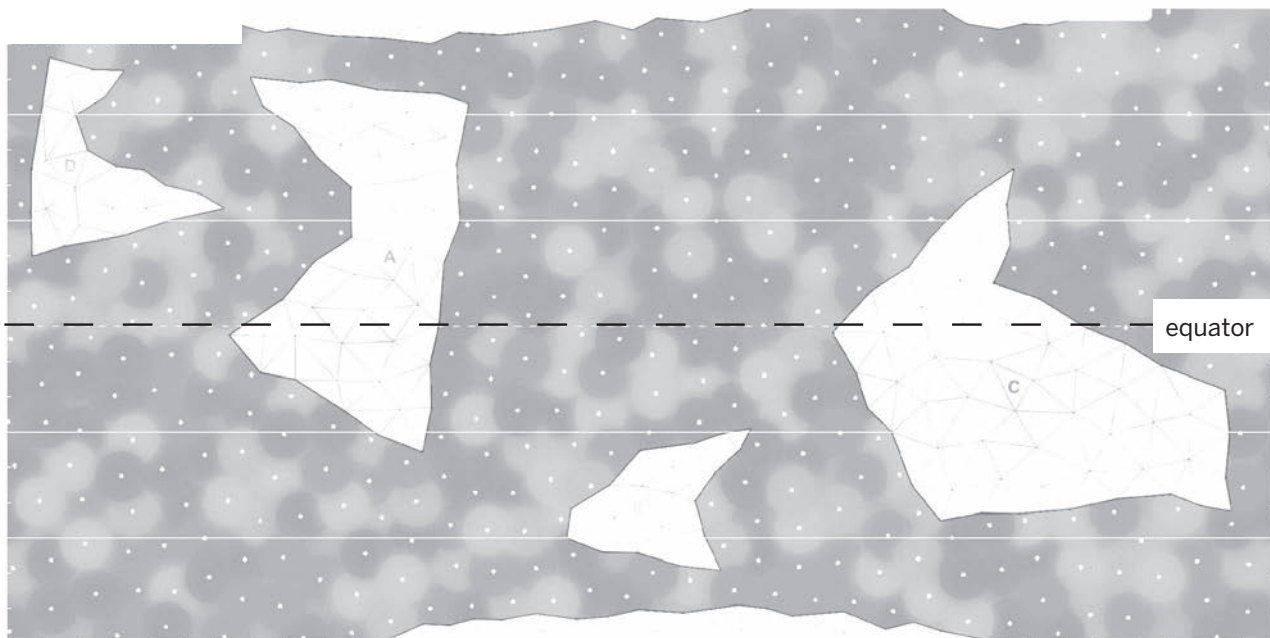
1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Homework: Tracking Currents in the Sim

Tracking a Current

- Open the *Ocean, Atmosphere, and Climate* Simulation. Select Current Map mode. Be sure NONE is selected in Temperature View.
- Find a current that could be a part of a gyre. Tap anywhere on the current to activate the tracking system and observe the path of the current.
- Draw the path of the current that you tracked onto the image.
- Then, based on your observations, answer the questions below.



- Describe the shape of the path of the current you tracked.

- Draw a star on the image to indicate the place where you think the current had the most energy. Why did the current have the most energy in this location?

- Thinking back to the shoe spill in “The Ocean in Motion,” how might those shoes have traveled from the middle of the Pacific Ocean to Oregon, Hawaii, and Japan?

Name: _____ Date: _____

Lesson 2.2: Ocean Temperatures at Different Locations

Buenos Aires and Cape Town are two coastal locations at the same latitude. Do you think the ocean surface temperature near each of these locations is the same? Do they have different temperatures? Today, you will return to “The Ocean in Motion” and use a map to get evidence that helps you answer this question.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 2 Question

- Other than latitude, what else affects the air temperature of Christchurch?

Key Concepts

- An effect may have more than one cause; these may be linked into a chain of causes and effects.

Vocabulary

- climate
- energy
- temperature
- transfer

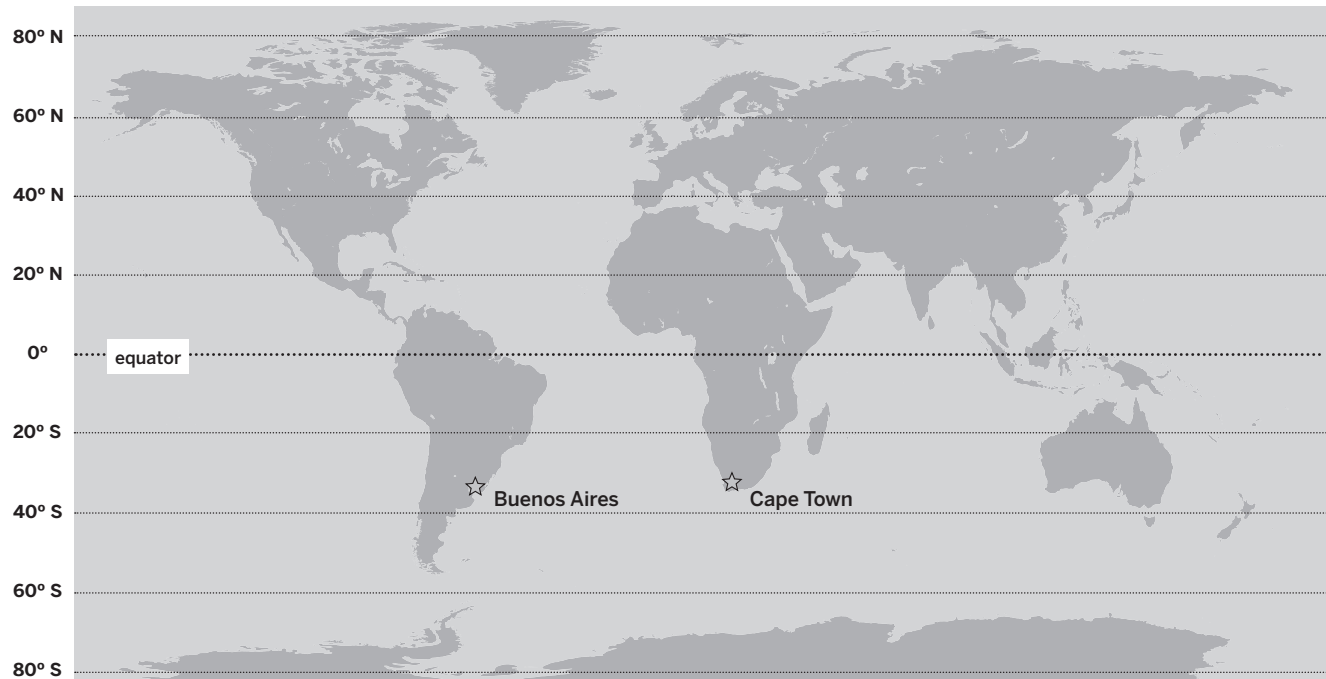
Digital Tools

- *Ocean, Atmosphere, and Climate* Sorting Tool activity: 2.2 Homework

Name: _____ Date: _____

Warm-Up

Do you think the ocean surface temperature near Buenos Aires is the same or different from the ocean surface temperature near Cape Town?



Look at the map, and then select and circle Prediction A or Prediction B.

Prediction A: Buenos Aires and Cape Town have the **same** ocean surface temperature.

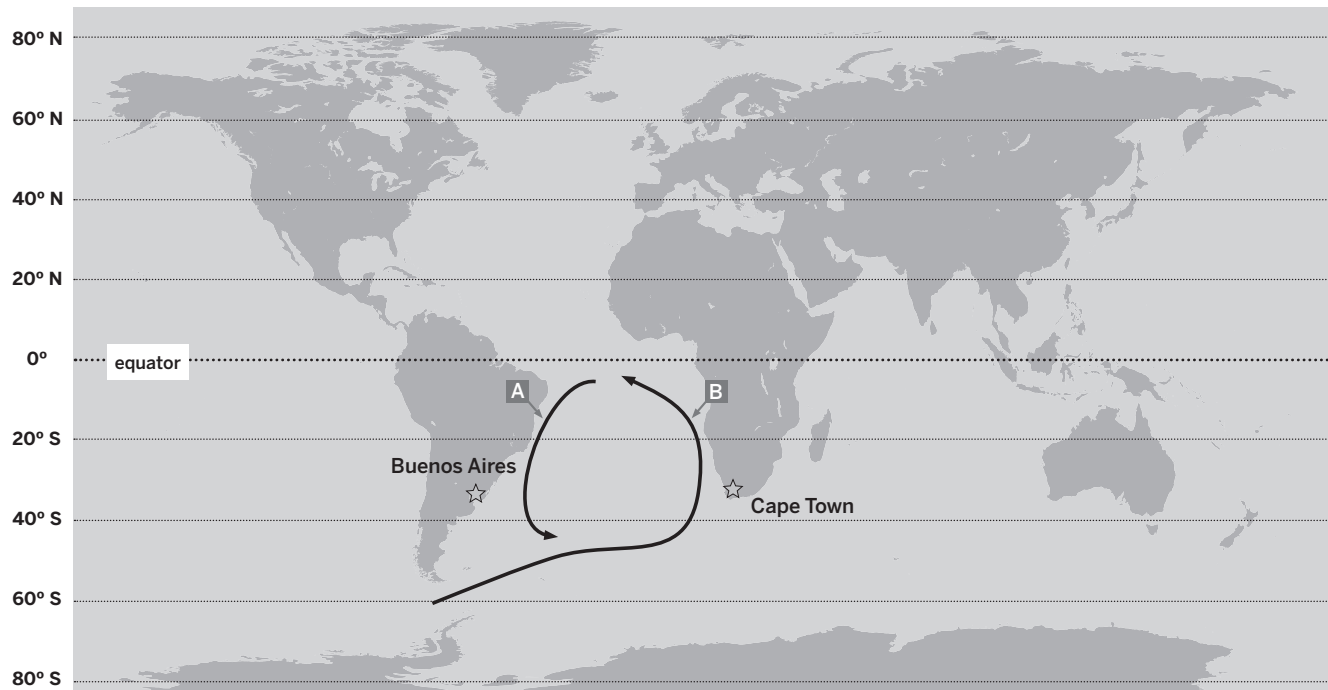
Prediction B: Buenos Aires and Cape Town have **different** ocean surface temperatures.

Explain your choice.

Name: _____ Date: _____

Investigating Ocean Surface Temperature

Currents Near Buenos Aires and Cape Town



Compare the two ocean currents (A and B) shown on the map. Match the current with the phrase that best describes it.

Current A (near Buenos Aires) _____. (circle one)

carries no energy **carries more energy** **carries the same energy** **carries less energy**

Current B (near Cape Town) _____. (circle one)

carries no energy **carries more energy** **carries the same energy** **carries less energy**

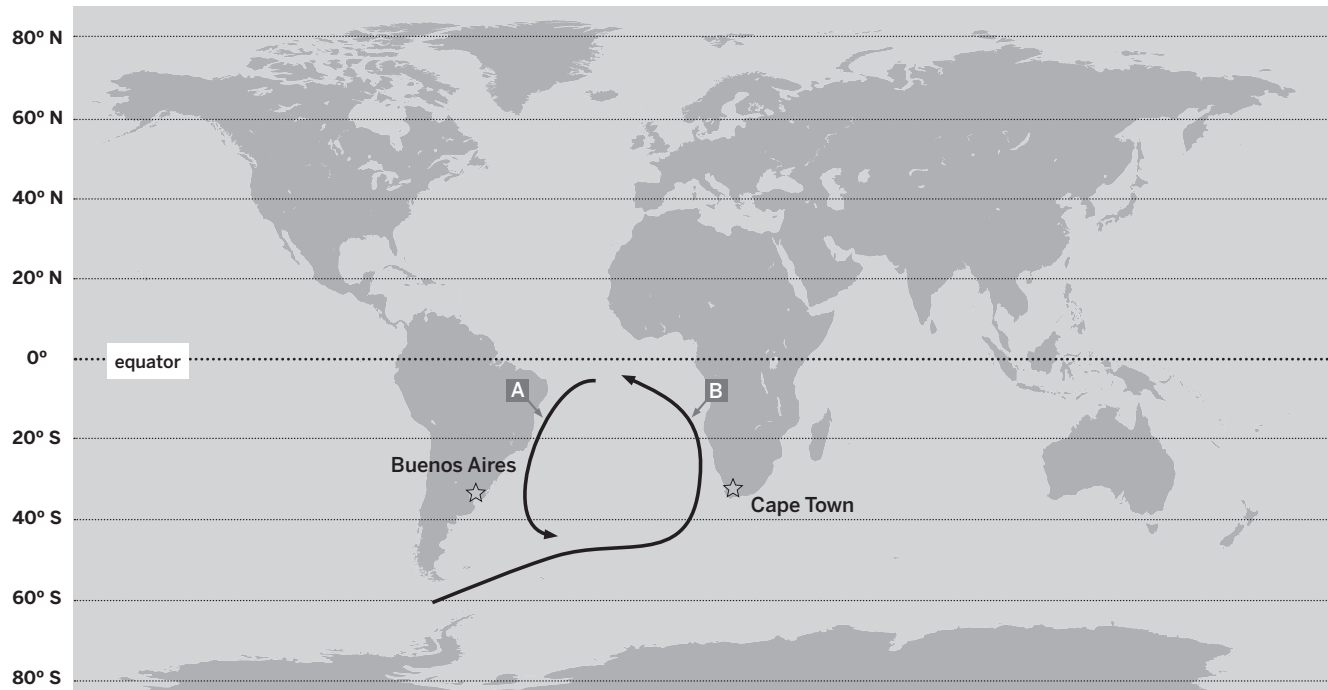
Discuss the following questions with your partner:

- What does the map show?
- Does the map provide evidence that the currents near Buenos Aires and Cape Town cause the ocean surface temperature at each location to be the same or different?

Name: _____ Date: _____

Investigating Ocean Surface Temperature (continued)

Explaining Ocean Surface Temperature



1. Which claim is better supported? (circle one)

Claim 1: Buenos Aires and Cape Town have the **same** ocean surface temperature.

Claim 2: Buenos Aires and Cape Town have **different** ocean surface temperatures.

Name: _____ Date: _____

Investigating Ocean Surface Temperature (continued)

2. How does the map support the claim you selected? Try to use all these words when you respond.

Word Bank

equator	energy	current
---------	--------	---------

Name: _____ Date: _____

Homework: Energy and Temperature of Currents in Gyres

Open the *Ocean, Atmosphere, and Climate* Sorting Tool activity: 2.2 Homework and complete the model. Answer the question below.

Goal: Show how the starting location of a current affects the amount of energy it carries.

Do:

- Use energy labels to show how much energy each current carries. Complete the six remaining ocean currents (three gyres).
- Use thermometers to show how the amount of energy that a current carries affects its temperature.

Tips:

- Some currents have already been completed.
- A star indicates the starting location of a current.
- Think about how the latitude of a current's starting location determines how much energy it carries.

How does your model show how the starting location of a current affects the amount of energy it carries?

Name: _____ Date: _____

Lesson 2.3: Currents and Air Temperature

You have determined that the surface temperature of the ocean near Cape Town is cooler than the ocean surface temperature near Buenos Aires, but how does this affect the *air* temperature of the two locations? Today, you will conduct an experiment and use the *Ocean, Atmosphere, and Climate* Simulation to gather evidence about how ocean currents affect the air temperature of the two cities. By learning more about how the ocean can affect air temperature, you will be one step closer to figuring out why Christchurch's air temperature is cooler than normal during El Niño years.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 2 Question

- Other than latitude, what else affects the air temperature of Christchurch?

Key Concepts

- An effect may have more than one cause; these may be linked into a chain of causes and effects.
- When an ocean current comes from the equator, it brings warmer-than-expected water to the places it passes. When an ocean current comes from a pole, it brings colder-than-expected water to the places it passes.

Vocabulary

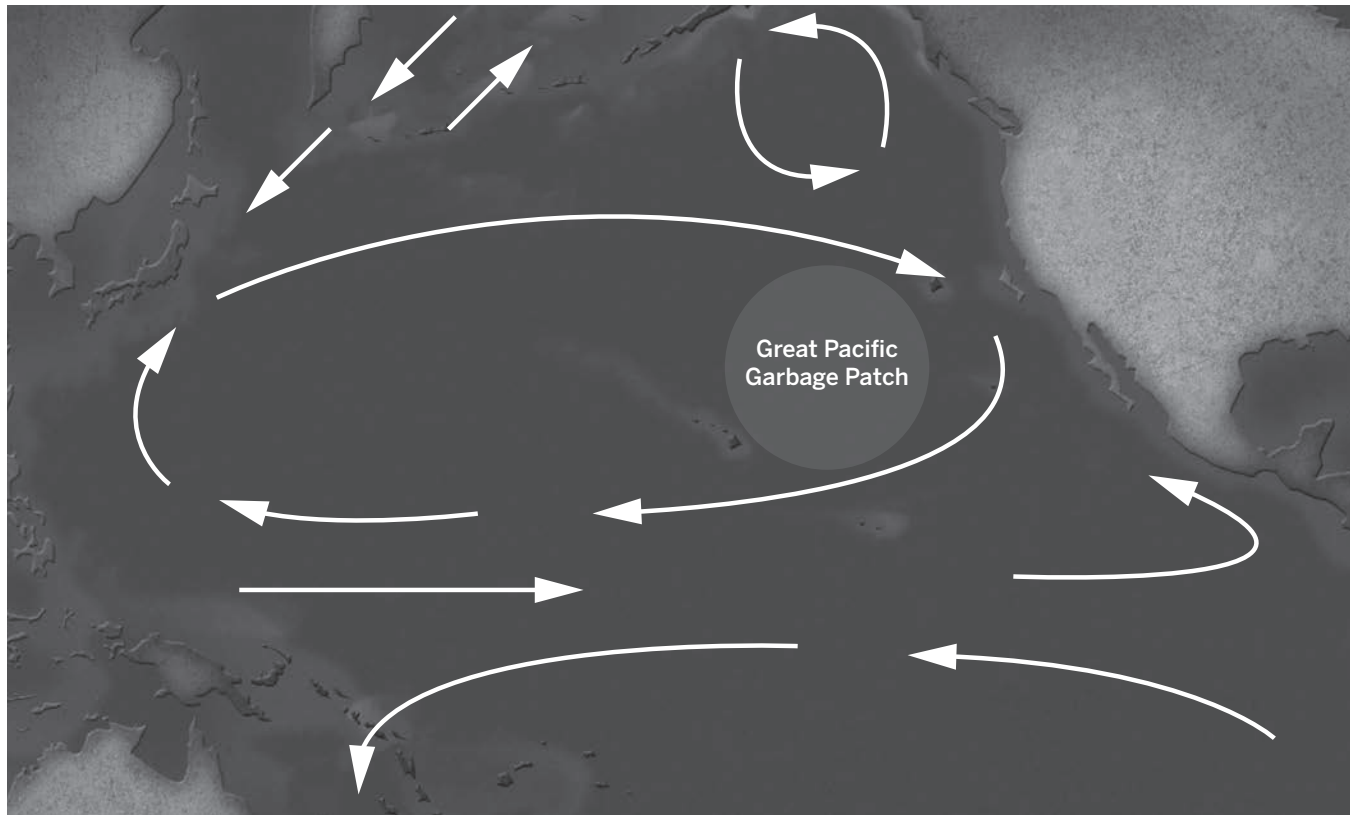
- | | | |
|-----------|-----------------|---------------|
| • claim | • evidence | • temperature |
| • climate | • latitude | • transfer |
| • energy | • ocean current | |

Digital Tools

- *Ocean, Atmosphere, and Climate* Simulation

Name: _____ Date: _____

Warm-Up



Trash from all around the world, especially plastics, pollutes the ocean. There are areas in the ocean that have much more trash than other areas. For example, the Great Pacific Garbage Patch is a huge mass of tiny pieces of garbage circulating in the Pacific.

1. Based on what you have learned about currents, how do you think this mass of trash ends up in the Great Pacific Garbage Patch?

Name: _____ Date: _____

Warm-Up (continued)

2. Looking at the map, what ideas do you have about why the trash is “trapped” in this location?

Name: _____ Date: _____

Water and Air Temperature Experiment

Safety Note: Hot Water

Handle hot water with care. If spilled, it could burn your skin.

Conduct an experiment to gather evidence about how water temperature affects air temperature. Follow these instructions:

1. Insert one thermometer through the slot of each lid and measure the initial air temperature of Cup 1 and Cup 2. Record your data in the table.
2. Pour hot water into Cup 1 and cold water into Cup 2. The cups should be about half full.
3. Replace the lids and thermometers, making sure the thermometers do NOT touch the water in either cup.
4. Wait 2 minutes and measure the final temperature of the air in Cup 1 and Cup 2. Record this data in the table.

	Initial air temperature (°C)	Final air temperature (°C)
Cup 1 (hot water)		
Cup 2 (cold water)		

Explain why the air temperature in each cup changed. What must have happened to the energy in the air of each cup?

Name: _____ Date: _____

Investigating Ocean Currents and Air Temperature

Gathering Evidence in the Sim

Open the *Ocean, Atmosphere, and Climate* Sim. Follow the instructions to gather evidence about how ocean currents affect the air temperature of the locations they pass. After you complete the activity, answer the three questions.

1. Select Current Map mode.
2. For Temperature View, select Surface.
3. Place Location Sensors at 4 and 5.
4. Record the air temperature of these two locations.
5. Press play. Observe the motion of the currents and in Side View, observe how energy is being transferred between water and air.
6. After temperatures stabilize (about 2 minutes), record your data.
 - Record the air temperature of both locations.
 - Indicate if the location was near a cold current or a warm current.
7. Then, answer the questions on the next page.

	Starting air temperature (°C)	Final air temperature (°C)	Current: cold or warm?
Sensor 4			
Sensor 5			

Name: _____ Date: _____

Investigating Ocean Currents and Air Temperature (continued)

1. At which location does energy transfer from water to air? (circle one)

Sensor 4

Sensor 5

2. At which location does energy transfer from air to water? (circle one)

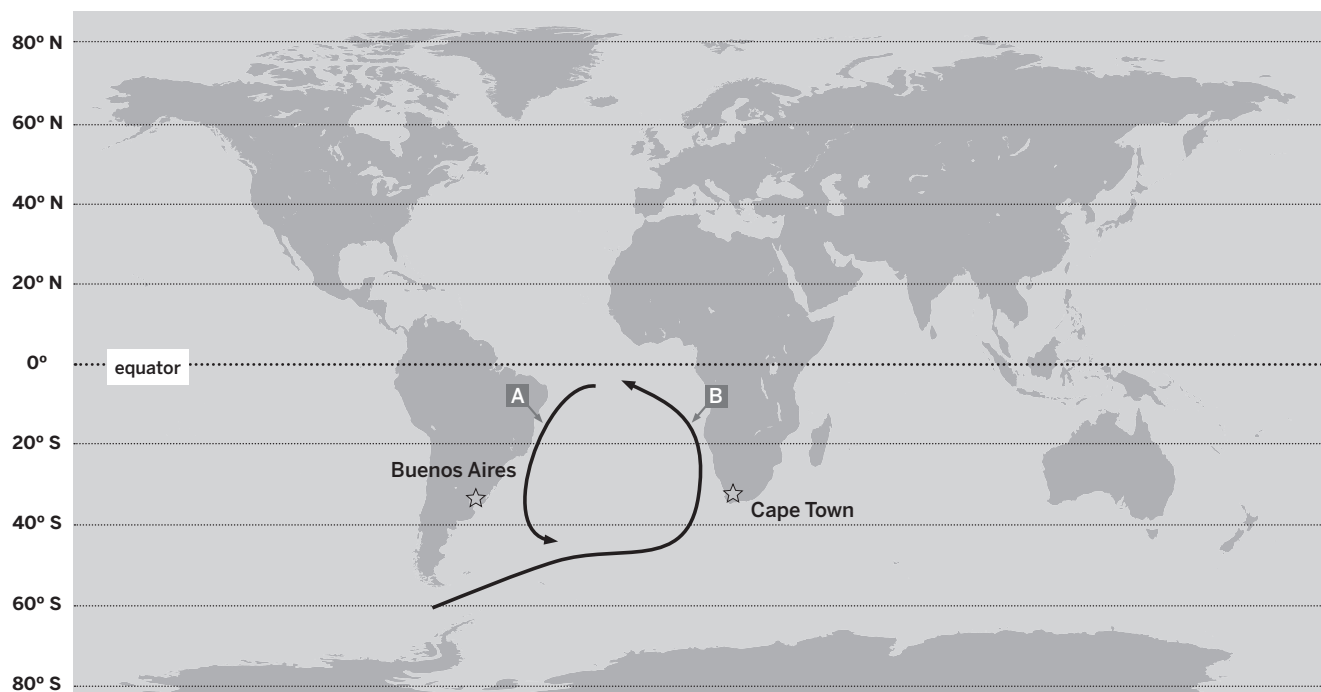
Sensor 4

Sensor 5

3. Why is the temperature shown on Sensor 4 different from Sensor 5, even though they are at the same latitude?

Name: _____ Date: _____

Air Temperature in Buenos Aires and Cape Town



1. Using what you learned in this lesson, circle the words that will complete the following sentences.
In Buenos Aires, the (**ocean** / **air**) transfers energy to the (**ocean** / **air**).
In Cape Town, the (**ocean** / **air**) transfers energy to the (**ocean** / **air**).
2. Use evidence from the Sim and the Water and Air Temperature Experiment to make a claim that compares the air temperature of Buenos Aires and the air temperature of Cape Town. Circle the words that will complete your claim. Talk to your partner about the evidence that supports your claim.

Question: How do ocean currents affect the air temperature of Buenos Aires and Cape Town?

Claim: The ocean currents near these cities cause the air temperature of Buenos Aires to be (the same as, different from) the air temperature in Cape Town.

Name: _____ Date: _____

Homework: Energy Transfer and Air Temperature

Launch the *Ocean, Atmosphere, and Climate* Sim. Select Energy Test mode so you can experiment with adding energy to the air and land. If you have extra time, you can perform the same tests, but select water as the surface.

1. Add energy to the air so the **air becomes warmer than the land**. Observe the energy transfer.
2. Add energy to the land so the **land becomes warmer than the air**. Observe the energy transfer.

When does energy transfer from the **air to the land**?

When does energy transfer from the **land to the air**?

Name: _____ Date: _____

Lesson 2.4: Modeling Ocean Currents and Air Temperature

Today you will reflect on what you have learned about how currents affect the air temperature of the locations they pass. First, you will play a board game to deepen your understanding of how energy is transferred from air to water and water to air. Next, you will model your understanding of how the ocean current moving from the equator affects Christchurch's air temperature during normal years. Finally, you will consider what changes might be causing cooler temperatures in Christchurch during El Niño years.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 2 Question

- Other than latitude, what else affects the air temperature of Christchurch?

Key Concepts

- An effect may have more than one cause; these may be linked into a chain of causes and effects.
- Energy transfers from warmer substances to colder substances. Warmer currents transfer energy to cooler air, and warmer air transfers energy to cooler currents.
- When an ocean current comes from the equator, it brings warmer-than-expected water to the places it passes, and that water is warmer than the nearby air. When an ocean current comes from a pole, it brings colder-than-expected water to the places it passes, and that water is colder than the nearby air.

Vocabulary

- | | | |
|----------|-----------------|------------|
| • cause | • latitude | • transfer |
| • effect | • ocean current | |
| • energy | • temperature | |

Digital Tools

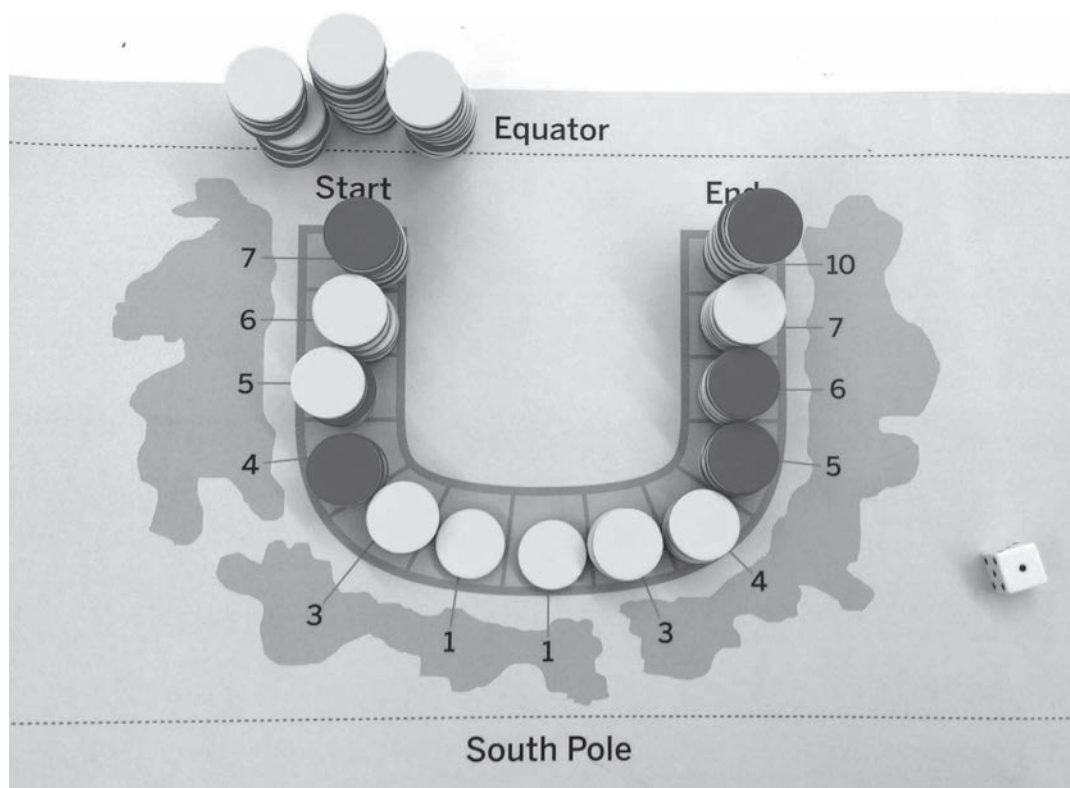
- *Ocean, Atmosphere, and Climate* Modeling Tool activity: 2.4 Currents and Temperature

Name: _____

Date: _____

Warm-Up

Today you will play Ocean Currents, which is a board game. Get prepared by reading the game overview, then answer the three questions on the next page.



Ocean Currents Game Overview

Goal: Equalize energy in the water and energy in the air by transferring energy as you move along the path of an ocean current.

- A player's stack of tokens represents the energy in water as that water moves around the ocean.
- The tokens on the board that are not part of a player's stack represent the energy in the air at those locations.
- Travel with the current by rolling the probability cube and moving your stack of tokens.
- Whenever you stop along the current's path, transfer energy tokens so the amount of energy in the water and energy in the air is the same.
- The player with the most energy tokens at the END wins that round.

Name: _____ Date: _____

Warm-Up (continued)

1. In general, what do tokens represent?

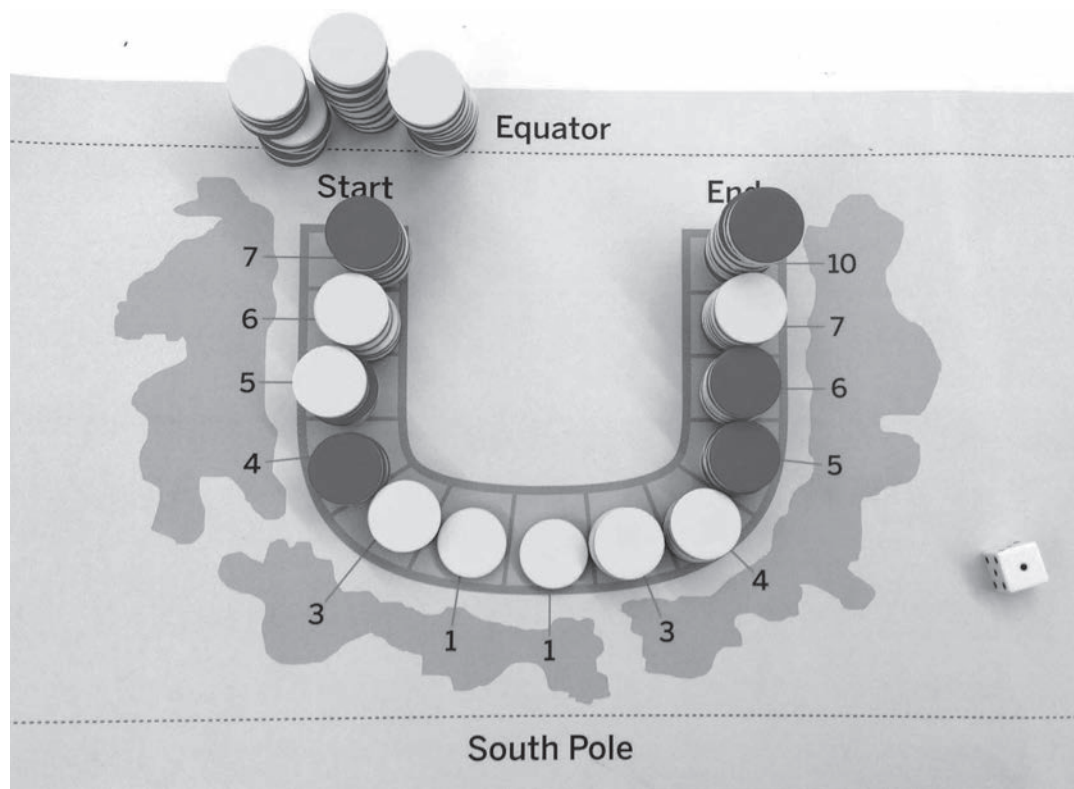
2. What does a player's stack of tokens represent?

3. What do the tokens on the board (not in a player's stack) represent?

Name: _____ Date: _____

Playing the Ocean Currents Game

1. With your group, read the Ocean Currents Game Instructions carefully.
2. Set up the board.
3. Play the game.
4. After the game, respond to the questions on the next page.



Name: _____ Date: _____

Playing the Ocean Currents Game (continued)

Describe how and when energy was transferred, either to the air or the water.

Where was the current coming from when energy was transferred from the water to the air?
(circle one)

from the equator

from the pole

Where was the current coming from when energy was transferred from the air to the water?
(circle one)

from the equator

from the pole

Name: _____ Date: _____

Modeling How Currents Affect Air Temperature

1. Open the *Ocean, Atmosphere, and Climate* Modeling Tool activity: 2.4 Currents and Temperature.
2. When your model is complete, answer the first question below.
3. Finally, complete the two sentences that explain your model in terms of cause and effect.

Goal: Show how ocean currents affect the air temperature of Christchurch, New Zealand.

Do:

- Show where current(s) that affect Christchurch begin and the locations they pass.
- Complete the information in your model with Energy Transfer arrows.
- Add thermometers that show land, water, and air temperature.

Tips:

- Drag a current from the bottom of the map. Place it, then adjust its path. The star is the beginning of the current.
- Think about what you learned about energy transfer from the Ocean Currents game.

How does your model show how ocean currents affect the air temperature of Christchurch, New Zealand?

Complete the two sentences that explain your model in terms of cause and effect.

A cause that is shown in my model is . . .

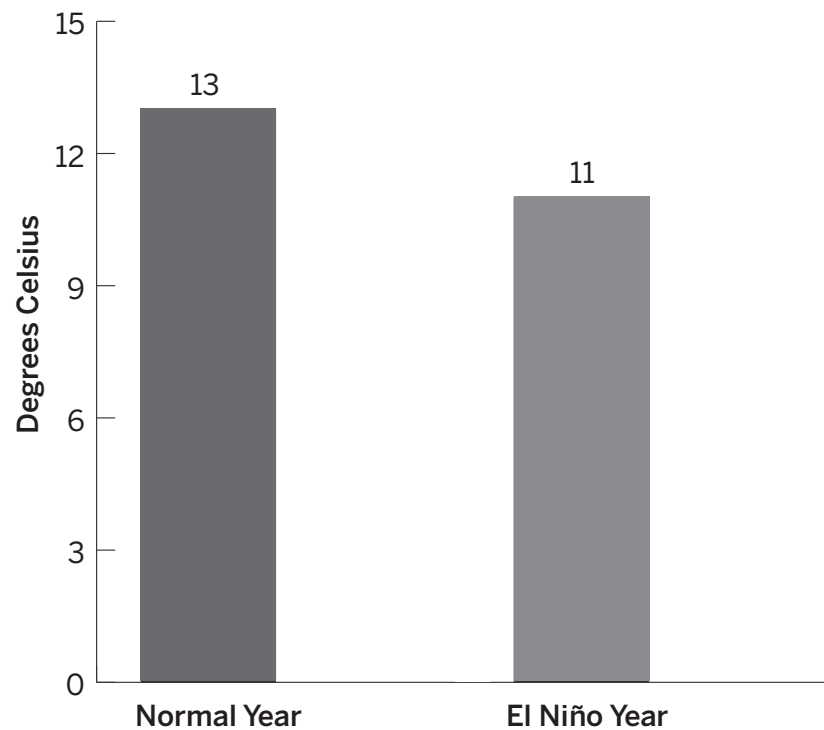
The effect of that cause is . . .

Name: _____ Date: _____

Considering the El Niño Year

Based on what you have learned, why do you think the ocean surface temperature near Christchurch is cooler during El Niño years?

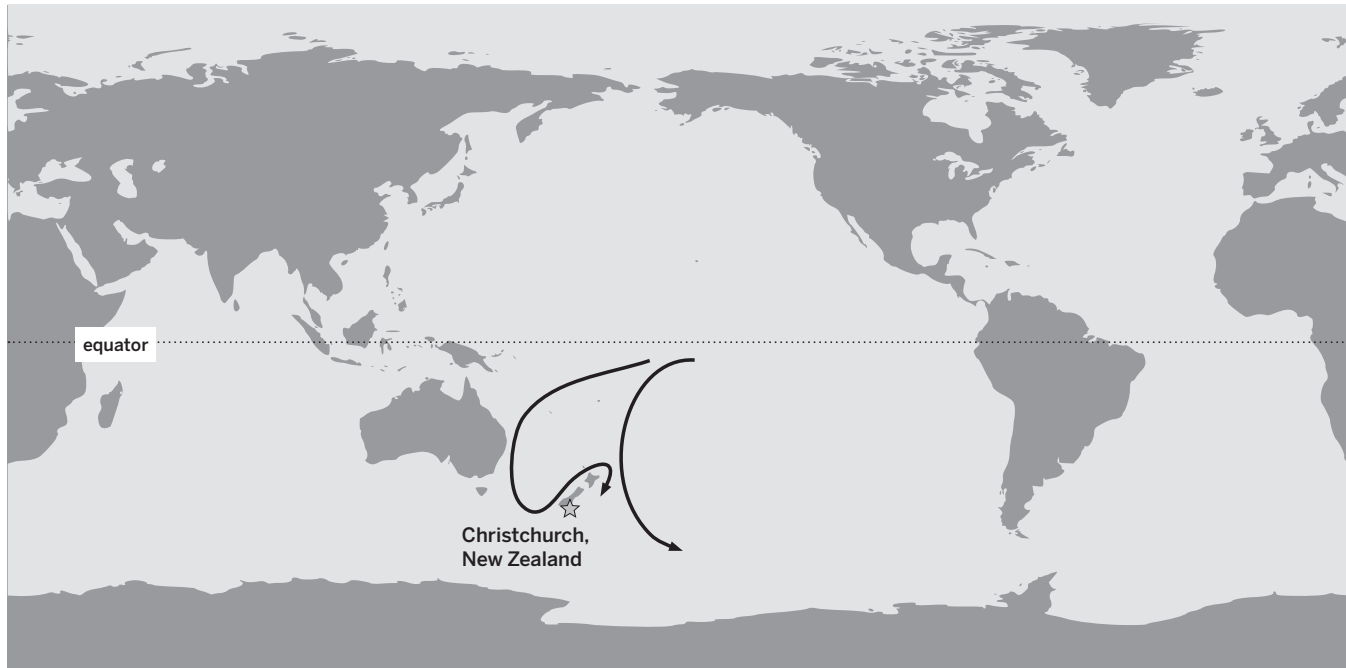
Average Ocean Surface Temperatures Near Christchurch, New Zealand



Name: _____ Date: _____

Homework: Writing a Report to the New Zealand Farm Council

Now that you understand what affects a location's air temperature, you will use the evidence you collected to **(1)** explain what affects Christchurch's air temperature in normal years, and then **(2)** share your ideas about why Christchurch's air temperature might be cooler during El Niño years. Use the words from the Word Bank as you write your responses on the next page.



Word Bank

air	energy	latitude	ocean current
surface	temperature	transfer	

Name: _____ Date: _____

Homework: Writing a Report to the New Zealand Farm Council (continued)

Explain what determines Christchurch's air temperature during normal years.

What ideas do you have about why Christchurch's air temperature is cooler during El Niño years?

Name: _____ Date: _____

Homework: Reading “How the Ocean Keeps Climates Stable”

You have learned a lot about what determines the temperature of a location. Read and annotate the “How the Ocean Keeps Climates Stable” article, then answer the question below.

Why is the temperature in Seattle more stable than Minneapolis, even though they are at similar latitudes?

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Lesson 2.6: The Climates of Peru

As a student climate scientist, you will use what you have learned so far and apply it to investigating the climate in a region of Peru. You'll read and annotate an article to learn something about your region's climate, and then you'll discuss the annotations with your partner. The Sim will help you investigate your region's climate further. Finally, you'll apply your ideas as you talk to your partner about how your region's air temperature compares to the air temperature of a different region. During these activities, you'll review the concepts you've learned so far and work toward a stronger understanding of what determines a location's air temperature.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 2 Question

- Other than latitude, what else affects the air temperature of Christchurch?

Key Concepts

- Energy from the sun is transferred to Earth's surface. Some of that energy is then transferred to the air above the surface.
- The closer a location is to the equator, the more energy it receives from the sun. Therefore, a location's air temperature is affected by its distance from the equator.
- An effect may have more than one cause; these may be linked into a chain of causes and effects.
- When an ocean current comes from the equator, it brings warmer-than-expected water to the places it passes, and that water is warmer than the nearby air. When an ocean current comes from a pole, it brings colder-than-expected water to the places it passes, and that water is colder than the nearby air.
- Energy transfers from warmer substances to colder substances. Warmer currents transfer energy to cooler air, and warmer air transfers energy to cooler currents.

Vocabulary

- | | | |
|----------|-----------------|------------|
| • cause | • latitude | • transfer |
| • effect | • ocean current | |
| • energy | • temperature | |

Digital Tools

- *Ocean, Atmosphere, and Climate* Simulation

Name: _____ Date: _____

Green Group: Warm-Up

Read and annotate the introduction AND “Peru’s Warm Rain Forests” from the article set *The Climates of Peru*. You will investigate this region of Peru today. When you are finished, answer the question below.

Rate how successful you were at using Active Reading skills by responding to the following statement:

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- ☐ Never
- ☐ Almost never
- ☐ Sometimes
- ☐ Frequently/often
- ☐ All the time

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Green Group: Investigating Peru's Diverse Climates

Part 1: Investigating Peru's Rain Forest with Current Map Mode

Launch the *Ocean, Atmosphere, and Climate* Sim, follow the steps, and then answer the questions.

1. Select Current Map mode.
2. For Temperature View, select AIR.
3. Drag a sensor to 7, which represents Peru's rain forest.
4. Observe the Side View for that location.

Using what you learned from your reading in the Warm-Up and what you observed in the Sim, why is the air temperature in the rain forest of Peru so warm?

With your partner, choose another location in the Sim where you think the air temperature will be the same as or warmer than Sensor 7. Drag a sensor to that new location and test your idea.

Why did you select that particular location?

Name: _____ Date: _____

Green Group: Investigating Peru's Diverse Climates (continued)

Part 2: Modeling Peru's Rain Forests with Surface Test Mode

5. In the Sim, select Surface Test mode from the menu in the upper left-hand corner.
6. Set Solar Output to the level that you think matches the amount of energy from the sun that is transferred to the surface of Peru's rain forest.

Describe how energy gets into the air and what happens to the air temperature.

What will happen if you decrease Solar Output? The air temperature will _____. (circle one)

decrease

increase

stay the same

If there is no surface, how will air temperature change when you change Solar Output? The air temperature will _____. (circle one)

decrease

increase

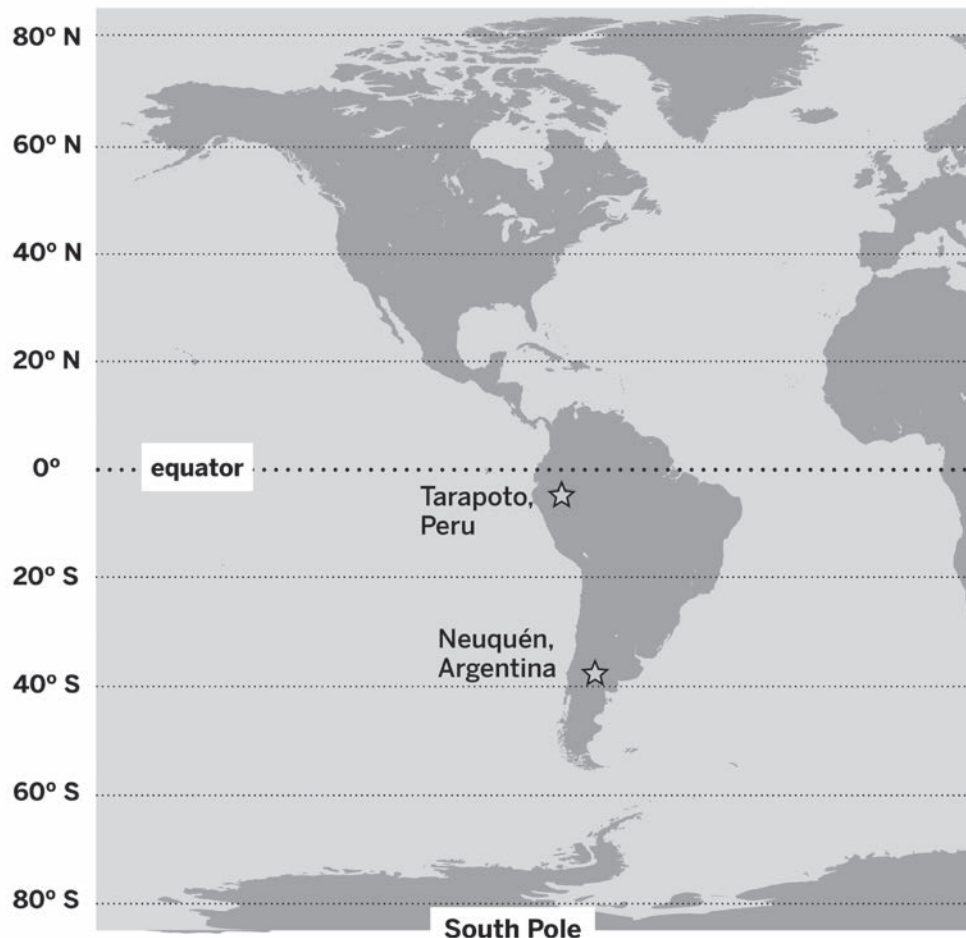
stay the same

Name: _____ Date: _____

Green Group: Investigating Peru's Diverse Climates (continued)

Part 3: Comparing Air Temperatures in Different Regions

Look at the map and, using the words in the Word Bank below, talk to your partner about this question: *Which location has the warmer air temperature, Tarapoto or Neuquén?*



Word Bank

energy

transfer

equator

Name: _____ Date: _____

Purple Group: Warm-Up

Read and annotate the introduction AND “Peru’s Cool Coastal Deserts” from the article set *The Climates of Peru*. You will investigate this region of Peru today. When you are finished, answer the question below.

Rate how successful you were at using Active Reading skills by responding to the following statement:

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- ☐ Never
- ☐ Almost never
- ☐ Sometimes
- ☐ Frequently/often
- ☐ All the time

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Purple Group: Investigating Peru's Diverse Climates

Part 1: Investigating Peru's Coastal Desert and Rain Forest with Current Map Mode

Launch the *Ocean, Atmosphere, and Climate* Sim, follow the steps, and answer the questions.

1. Select Current Map mode.
2. For Temperature View, select AIR.
3. Drag a sensor to 7, which represents Peru's rain forest.
4. Drag another sensor to 6, which represents Peru's coastal desert.
5. Use Side View to observe energy transfer at both locations.

Using what you learned from your reading in the Warm-Up and what you observed in the Sim, why is the air temperature in Peru's coastal desert cooler than in its rain forest?

Predict what would happen to the air temperature at each sensor if the currents stopped.

The air temperature of the coastal desert (Sensor 6) would _____. (circle one)

get warmer

get cooler

stay the same

The air temperature of the rain forest (Sensor 7) would _____. (circle one)

get warmer

get cooler

stay the same

Name: _____ Date: _____

Purple Group: Investigating Peru's Diverse Climates (continued)

Test your predictions by decreasing the speed of the current to 0. Observe the air temperature in both locations.

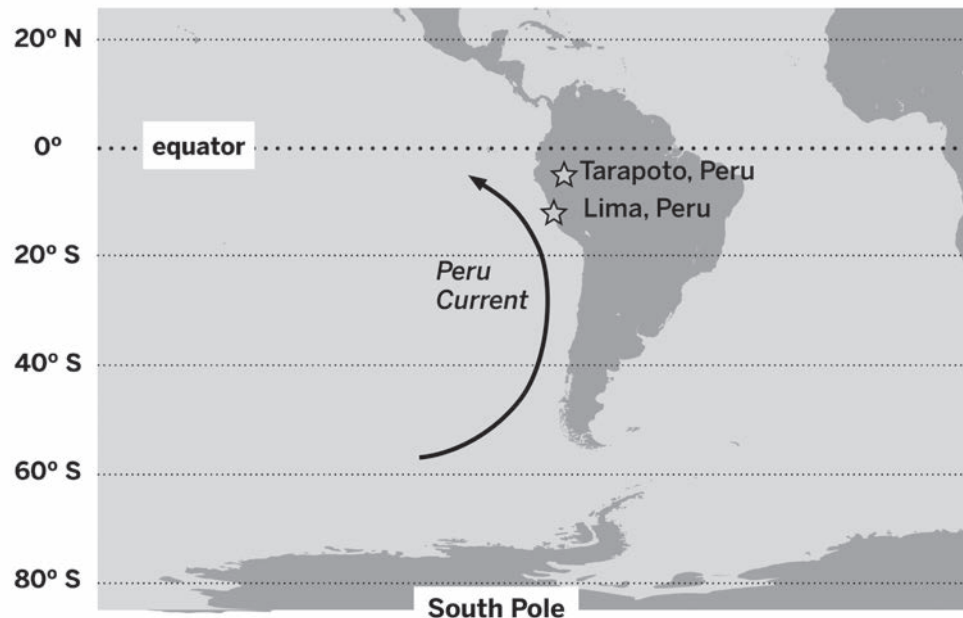
Explain what happened to the air temperature in these locations. Why?

Name: _____ Date: _____

Purple Group: Investigating Peru's Diverse Climates (continued)

Part 2: Comparing Air Temperatures in Different Regions

Look at the map and, using the words in the Word Bank below, talk to your partner about this question: *Which location has the warmer air temperature, Tarapoto or Lima?*



Word Bank

energy	equator	ocean current	transfer
--------	---------	---------------	----------

Name: _____ Date: _____

Blue Group: Warm-Up

Read and annotate the introduction AND “Peru’s Bountiful Ocean” from the article set *The Climates of Peru*. You will investigate this region of Peru today. When you are finished, answer the question below.

Rate how successful you were at using Active Reading skills by responding to the following statement:

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- ☐ Never
- ☐ Almost never
- ☐ Sometimes
- ☐ Frequently/often
- ☐ All the time

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Blue Group: Investigating Peru's Diverse Climates

Part 1: Investigating Upwelling Near Peru with Current Map Mode

Launch the *Ocean, Atmosphere, and Climate* Sim and follow the steps to complete this activity.

1. Select Current Map mode.
2. For Temperature View, select SURFACE.
3. Using what you learned from your reading in the Warm-Up, find two places that have upwelling.
4. Drag sensors to those two locations.
5. Use Side View to observe what is happening with temperature and energy transfer at these locations.

What evidence in the Sim's map let you know that you were selecting areas of upwelling?

What evidence in Side View lets you know that upwelling is happening in these locations?

Name: _____ Date: _____

Blue Group: Investigating Peru's Diverse Climates (continued)

Using evidence from your reading during the Warm-Up and the Sim activity, explain how upwelling affects the air temperature of nearby locations.

What would happen to the air temperature of a nearby region if upwelling stopped?

The air temperature would _____. (circle one)

get warmer

get cooler

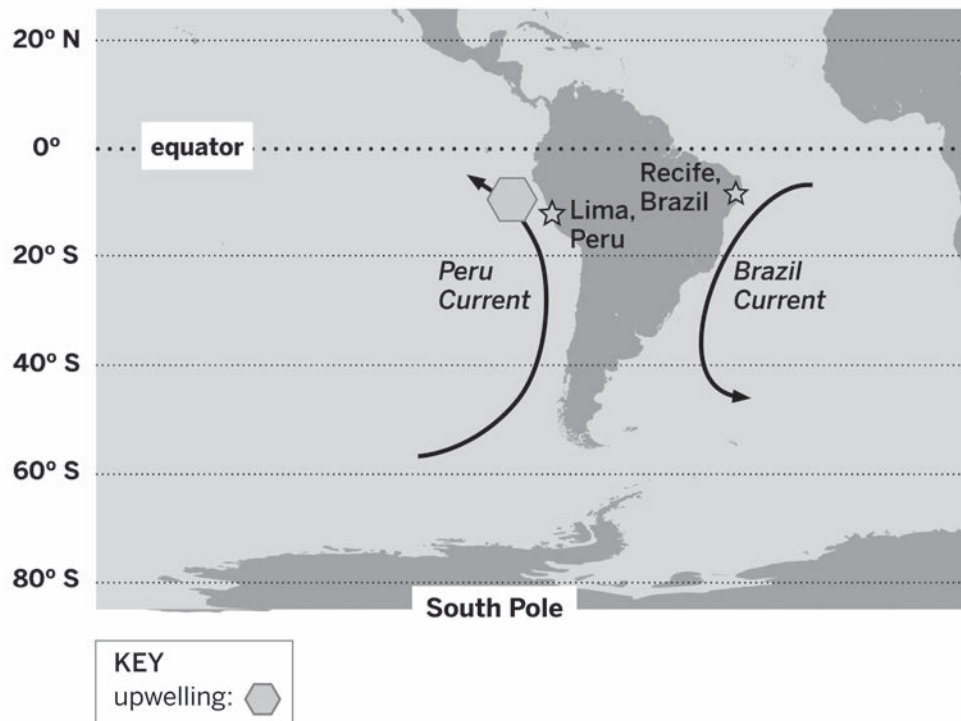
stay the same

Name: _____ Date: _____

Blue Group: Investigating Peru's Diverse Climates (continued)

Part 2: Comparing Air Temperatures in Different Regions

Look at the map and, using the words in the Word Bank below, talk to your partner about this question: *Which location has the warmer air temperature, Recife or Lima?*



Word Bank

energy	equator	ocean current	transfer	upwelling
--------	---------	---------------	----------	-----------

Name: _____ Date: _____

Homework: Check Your Understanding

Scientists investigate in order to figure things out. Are you getting closer to figuring out why the air temperature in Christchurch is cooler in El Niño years?

1. I understand how energy is transferred to the air of Christchurch, New Zealand. (check one)

☐ yes

☐ not yet

Explain your answer choice.

2. I understand what happens to the amount of energy in the air of Christchurch in El Niño years. (check one)

☐ yes

☐ not yet

Explain your answer choice.

3. I understand how Christchurch's distance from the equator affects its air temperature. (check one)

☐ yes

☐ not yet

Explain your answer choice.

Name: _____ Date: _____

Homework: Check Your Understanding (continued)

4. I understand why the ocean near Christchurch is a different temperature than we'd expect for its latitude (distance from the equator). (check one)

☐ yes

☐ not yet

Explain your answer choice.

5. I understand why the ocean temperature near Christchurch changes in El Niño years and how it affects the air temperature there. (check one)

☐ yes

☐ not yet

6. What do you still wonder about El Niño and air temperature?

Name: _____ Date: _____

Chapter 3: Ocean Currents and Prevailing Winds

Chapter Overview

In Chapter 3, you will learn what determines how ocean currents move. By reading about the Gulf Stream and simulating a current in a hands-on tank activity, you and your team of climate scientists will gather information to prepare a report for the New Zealand Farm Council.



Name: _____ Date: _____

Lesson 3.1: “The Gulf Stream”

So far you have learned about two things that affect Christchurch, New Zealand’s air temperature: its latitude and the ocean current that passes its shore. You also know that this ocean current comes from the equator, the location that receives the most energy from the sun. But what determines how ocean currents move? You will begin to investigate this question today. Kiri Parata, the director of the New Zealand Farm Council, has sent an article to help you learn more.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 3 Question

- What determines how the ocean currents near Christchurch move?

Vocabulary

- cause
- effect
- energy
- latitude
- ocean current
- prevailing wind
- transfer
- temperature

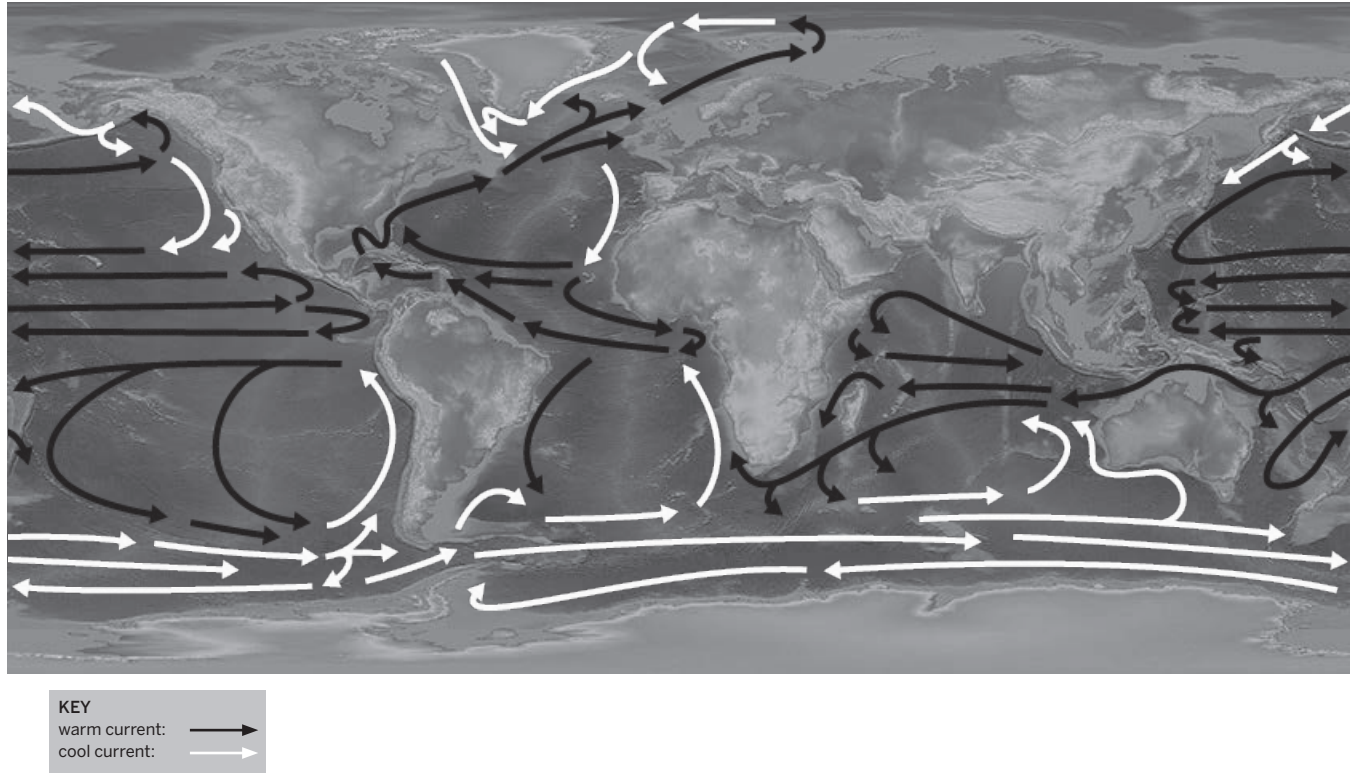
Digital Tools

- *Ocean, Atmosphere, and Climate* Simulation

Name: _____ Date: _____

Warm-Up

Major Ocean Currents



The map shows the movement pattern for major ocean currents. What ideas do you have about what might make ocean currents move?

Name: _____ Date: _____

Reading “The Gulf Stream: A Current That Helped Win a War”

1. Read and annotate the article “The Gulf Stream: A Current That Helped Win a War.”
2. Choose and mark annotations to discuss with your partner. Once you have discussed these annotations, mark them as discussed.
3. Now, choose and mark a question or connection, either one you already discussed or a different one you still want to discuss with the class.
4. Answer the reflection question below.

Rate how successful you were at using Active Reading skills by responding to the following statement:

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- ☐ Never
- ☐ Almost never
- ☐ Sometimes
- ☐ Frequently/often
- ☐ All the time

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Homework: Sim Mission

Sim Mission: Winds and Warm Currents

You read about a warm current called the Gulf Stream. Investigate a warm current in the Sim, and then answer the questions.

Launch the *Ocean, Atmosphere, and Climate* Sim, select Wind Map mode, and find a warm current (coming from the equator).

1. Focus on the current you selected. Observe the direction of the wind and the direction of the warm current.

- How do prevailing winds affect the direction of ocean currents?

2. Set the speed of the wind to HIGH, then MEDIUM, and finally LOW. Observe what happens to the current.

- How does the speed of prevailing winds affect ocean currents?

Name: _____ Date: _____

Lesson 3.2: What Determines the Direction of Ocean Currents?

In the previous lesson, you learned that prevailing winds are strong enough to push ocean currents. Based on what you know so far, do you think prevailing winds push ocean currents in the same direction all over the ocean? Or is it possible for prevailing winds and ocean currents to move in different directions? Today you will return to the Gulf Stream and conduct a hands-on investigation to learn more about what determines how ocean currents move.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 3 Question

- What determines how the ocean currents near Christchurch move?

Vocabulary

- cause
- effect
- energy
- latitude
- ocean current
- prevailing wind

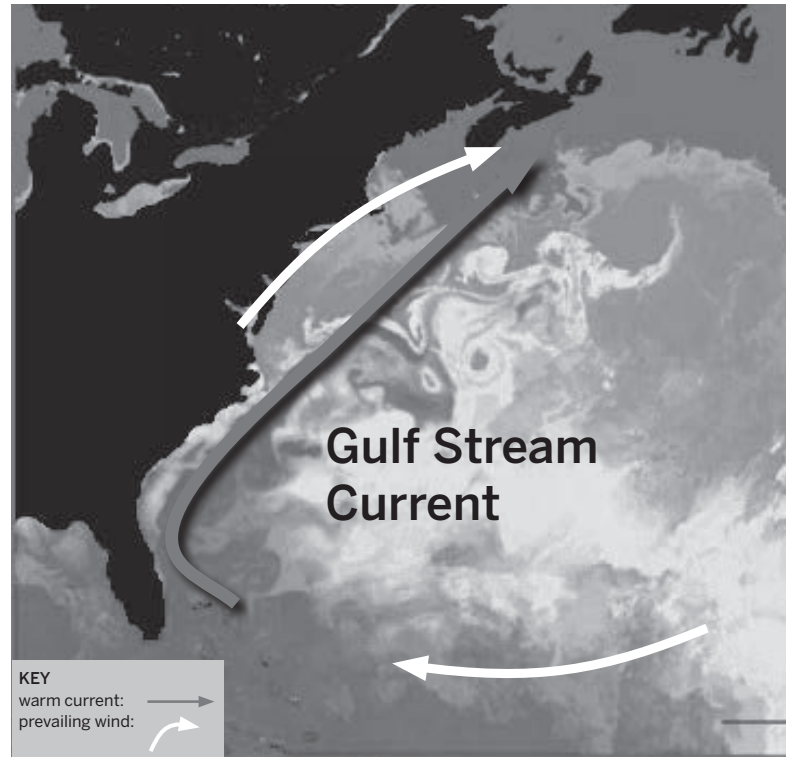
Digital Tools

- *Ocean, Atmosphere, and Climate Modeling Tool* activity: 3.2 Homework

Name: _____ Date: _____

Warm-Up

You are about to watch a video animation of this current, the Gulf Stream.



What ideas do you have about what determines how currents like this move?

Name: _____ Date: _____

Rereading “The Gulf Stream: A Current That Helped Win a War”

Reread paragraphs 4 and 5 from the article (beginning with “The Gulf Stream flows from south to north”) and highlight evidence that helps you answer the Investigation Question: *What determines how ocean currents move?*

Name: _____ Date: _____

Investigating with the Currents Tank

Safety Note: Blowing Through Straws

When blowing through straws, be careful to avoid hyperventilation. If any students feel dizzy or light-headed, they should stop blowing and sit down.

To prepare, listen to your teacher's description and complete the sentences below. When you receive your materials, follow the instructions on the next page and conduct the investigation with your group.

What determines how ocean currents move?

Describe what each component of the Currents Tank Investigation represents. Use the Word Bank below, if needed.

In the Currents Tank Investigation, . . .

the water represents _____

the sides of the tank represent _____

blowing through the straw represents _____

the moving pepper helps illustrate the movement of _____

Word Bank

continents	currents	prevailing winds	the ocean
------------	----------	------------------	-----------

Name: _____ Date: _____

Investigating with the Currents Tank (continued)

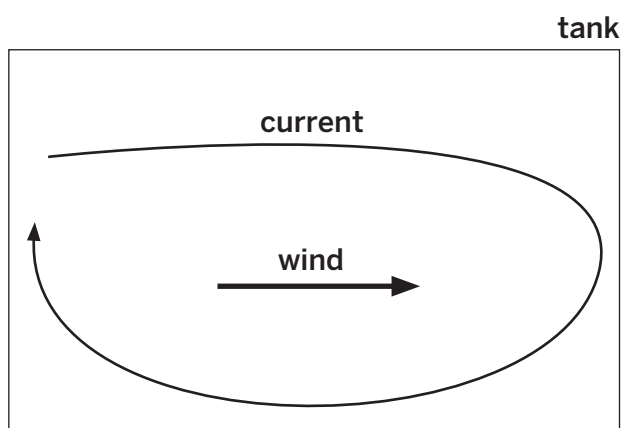
Currents Tank Investigation

1. Discuss and record your predictions.
 - Read each mission description carefully.
 - Talk to your group about the direction you plan to direct the wind in order to complete the mission.
 - Make a prediction drawing for each mission: draw one arrow to show how you will direct the wind and another arrow to show how you think the current will move (see example in Mission 1).
2. Collect materials. (one group member)
 - 1 tank with about 1 inch of water
 - 4 straws, one for each person
Do not share the straws!
3. Complete the missions, one at a time.
 - Blow wind through your straw at an angle to the surface of the water. Blow in only one direction. Do not blow air directly into the water.
 - Have only one person blowing at a time. Take turns, so no one gets dizzy.
4. Record your results after each mission by describing what you observed.



Mission 1: Find a way to make the current move in one direction, like a gyre.

Predictions:



Results: Were you able to complete this mission?

☐ yes ☐ no

If yes, describe how. If no, why not?

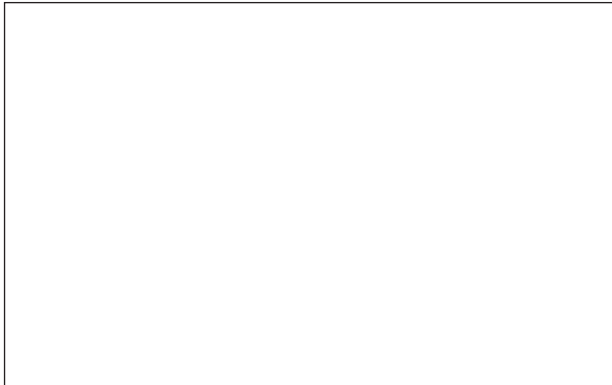
Name: _____ Date: _____

Investigating with the Currents Tank (continued)

Mission 2: Find a way to make the current move in a direction that is different from Mission 1.

Predictions:

tank



Results: Were you able to complete this mission?

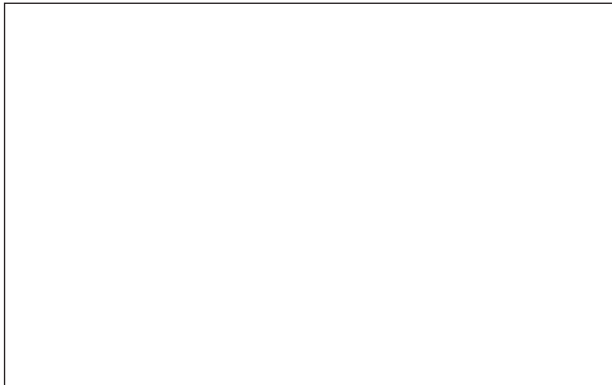
☐ yes ☐ no

If yes, describe how. If no, why not?

Mission 3: Find a way to make the current move faster than it moved in previous missions.

Predictions:

tank



Results: Were you able to complete this mission?

☐ yes ☐ no

If yes, describe how. If no, why not?

Name: _____ Date: _____

Investigating with the Currents Tank (continued)

1. Discuss the evidence you gathered from the Gulf Stream article and the Currents Tank Investigation about what determines how ocean currents move.
2. Choose the claim that best answers this question: *How do prevailing winds affect ocean currents?*

Prevailing winds cause ocean currents to move in the same direction as the winds . . . (circle one)

Claim 1: in all places in the ocean.

Claim 2: in some places in the ocean.

Claim 3: nowhere in the ocean.

Describe evidence from the Gulf Stream article and the Currents Tank Investigation that supports the claim you chose.

Name: _____ Date: _____

Homework: Using the Modeling Tool to Show How Currents Move

Launch the *Ocean, Atmosphere, and Climate* Modeling Tool activity: 3.2 Homework.
Answer the question below when your model is complete.

Goal: Show what determines the direction of ocean currents.

Do:

- Note the direction of prevailing winds.
- Model some currents that would be affected by the winds and the continents. Show where the currents begin.
- Complete the information about your currents with Energy Transfer arrows.
- Add thermometers that show water and air temperature.

Tips:

- Drag currents from the bottom of the map. Place them, then adjust the path. The star is the current beginning.
- Model as many currents as you like.

Explain how your model shows what determines the direction of ocean currents.

Name: _____ Date: _____

Homework: Reading About Prevailing Winds

Read the description of the two articles below. Then, choose one article to read and annotate. Answer the questions below.

“What Causes Prevailing Winds?”

There’s always wind blowing somewhere, whether it’s a powerful prevailing wind or a light local breeze. All winds are caused by changes in temperature—warm air rising and cooler air rushing in below to fill in empty space.

“The Coriolis Effect”

For thousands of years, sailors have used prevailing winds blowing in predictable patterns to help them cross the ocean. The path of the prevailing winds is consistent because it’s caused in part by something that doesn’t change: the spinning of Earth. The resulting Coriolis Effect causes the “bending” of the straight path of air flowing near the equator due to Earth’s rotation. The Coriolis Effect shapes the winds that cross Earth’s oceans, helps the currents form gyres, and determines the direction that ocean storms rotate.

What are prevailing winds?

In the article you read, what affects the patterns of prevailing winds, and how does it do so?

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Lesson 3.3: Christchurch: Air Temperature in Normal Years

You are close to completing your investigation into why Christchurch's air temperature is cooler than usual during El Niño years. Today, you will use the Modeling Tool to show what determines Christchurch's temperature during a normal year. Next, you will use the Sim to investigate how changes to prevailing winds can affect the air temperature of a location. This will help you to solve the mystery of the changes in Christchurch's air temperature during El Niño years.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 3 Question

- What determines how the ocean currents near Christchurch move?

Key Concepts

- Prevailing winds and the position of continents determine the direction of ocean currents.

Vocabulary

- energy
- latitude
- ocean current
- prevailing wind
- temperature
- transfer

Digital Tools

- *Ocean, Atmosphere, and Climate* Modeling Tool activity: 3.3 Christchurch Model
- *Ocean, Atmosphere, and Climate* Simulation

Name: _____ Date: _____

Warm-Up

What affects ocean currents? You may circle more than one answer. **Note:** If you have a device, you can look back at your model in the *Ocean, Atmosphere, and Climate* Modeling Tool activity: 3.2 Homework.

prevailing winds

rivers

continents

the Moon

Explain your choice.

Name: _____ Date: _____

Modeling Ocean Currents Near Christchurch

Modeling the Air Temperature in Christchurch

Launch the *Ocean, Atmosphere, and Climate* Modeling Tool activity: 3.3 Christchurch Model.
When your model is complete, answer the question below.

Goal: Create a model to explain Christchurch's air temperature during a normal year.

Do:

- Model how prevailing winds affect the direction of the current.
- Complete the information about Christchurch with Energy Transfer arrows.
- Add thermometers to show surface and air temperatures.

Tips:

- Place as many wind lines as you need in your model.

How does your model explain what determines Christchurch's air temperature during a normal year?

Name: _____ Date: _____

Investigating the Effect of Changing Winds

What Happens When Prevailing Winds Change?

Use the Sim to learn more about how changes to the prevailing winds can affect the amount of energy in the air.

Launch the *Ocean, Atmosphere, and Climate* Sim, go to Wind Map mode, and select SURFACE for Temperature View. Press PLAY to observe the currents, and then read about the two missions:

Mission 1: Find a location that has a **warm ocean current** passing by. Make a change to the wind so the air temperature of the location becomes **cooler**.

Mission 2: Find a location that has a **cold ocean current** passing by. Make a change to the wind so the air temperature of the location becomes **warmer**.

Mission Planning

Each partner will make a plan to complete one of the missions. Tell your partner about the Sim mission you plan to complete:

- Where will you place your sensor?
- What changes will you make to the wind?

I will complete **(Mission 1 / Mission 2)**. (circle one)

Name: _____ Date: _____

Investigating the Effect of Changing Winds (continued)

Once you have a plan, complete the mission you agreed on. Follow these steps, record your data, and finally, answer the questions on the next page about your results.

1. Place your sensor on the location you selected. Press PLAY if you paused the Sim.
2. Wait for the air temperature to stabilize.
3. Record the Initial Air Temperature.
4. Make a change to the wind.
5. Wait for the air temperature to stabilize again.
6. Record the Changed Air Temperature.
7. Share your results with your partner.
8. If your mission was not successful, make a new plan and try again.
9. Answer the questions on the next page.

Location (latitude/longitude)	Initial air temperature (°C) (after it's stable)	Changed air temperature (°C)	What changes did you make in order to complete this mission?

Name: _____ Date: _____

Investigating the Effect of Changing Winds (continued)

What change did you finally make that changed the air temperature of your location?

State which mission you completed, and then answer this question:

Why did changing the wind affect the air temperature?

Name: _____ Date: _____

Homework: Reading “Deep Ocean Currents: Driven by Density”

You have learned a lot about how wind and energy affect ocean currents. To learn more about ocean currents, read and annotate the article “Deep Ocean Currents: Driven by Density.” Then, answer the questions below.

What causes the movement of deep ocean currents?

How does water sink to the bottom of the ocean and then rise to the surface again?

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: _____ Date: _____

Lesson 3.4: Explaining the Change in Air Temperature in Christchurch

Congratulations, student climate scientists! You figured out what determines Christchurch's air temperature during a normal year. Now you are ready to help the New Zealand Farm Council understand why Christchurch's air temperature is cooler than normal during El Niño years. First, you will participate in the Write and Share Routine to think about how changes to prevailing winds can affect the air temperature of a location. Then, you will review evidence about Christchurch and use the Reasoning Tool to prepare a written argument. For homework, you will write to the New Zealand Farm Council and explain why Christchurch's air temperature is cooler than normal during El Niño years.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 3 Question

- What determines how the ocean currents near Christchurch move?

Key Concepts

- Prevailing winds and the position of continents determine the direction of ocean currents.
- Changes to prevailing winds affect ocean currents. Changes to ocean currents affect how much energy is brought to (or taken away from) a location.

Vocabulary

- climate
- energy
- temperature
- transfer

Name: _____ Date: _____

Warm-Up

You are trying to determine why Christchurch's air temperature is cooler than usual during El Niño years. Review the evidence card, and then answer the question.

Evidence Card C: Wind Changes During El Niño Years

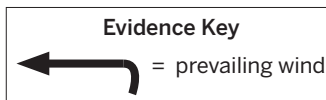
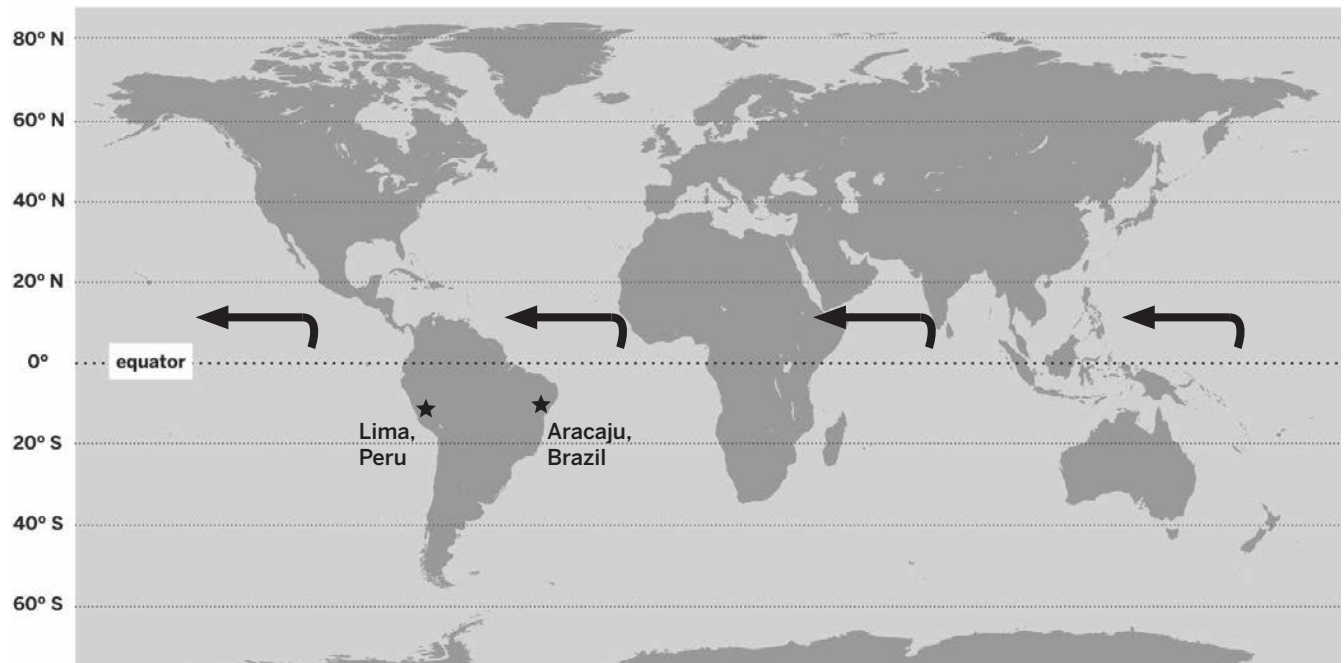
During El Niño years, the normal prevailing winds are disrupted. It is possible for them to slow down or reverse.



What ideas do you have about how changes to prevailing winds could result in Christchurch's cooler air temperature?

Name: _____ Date: _____

Write and Share Routine: Student 1

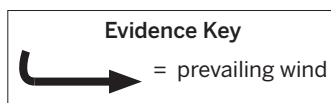
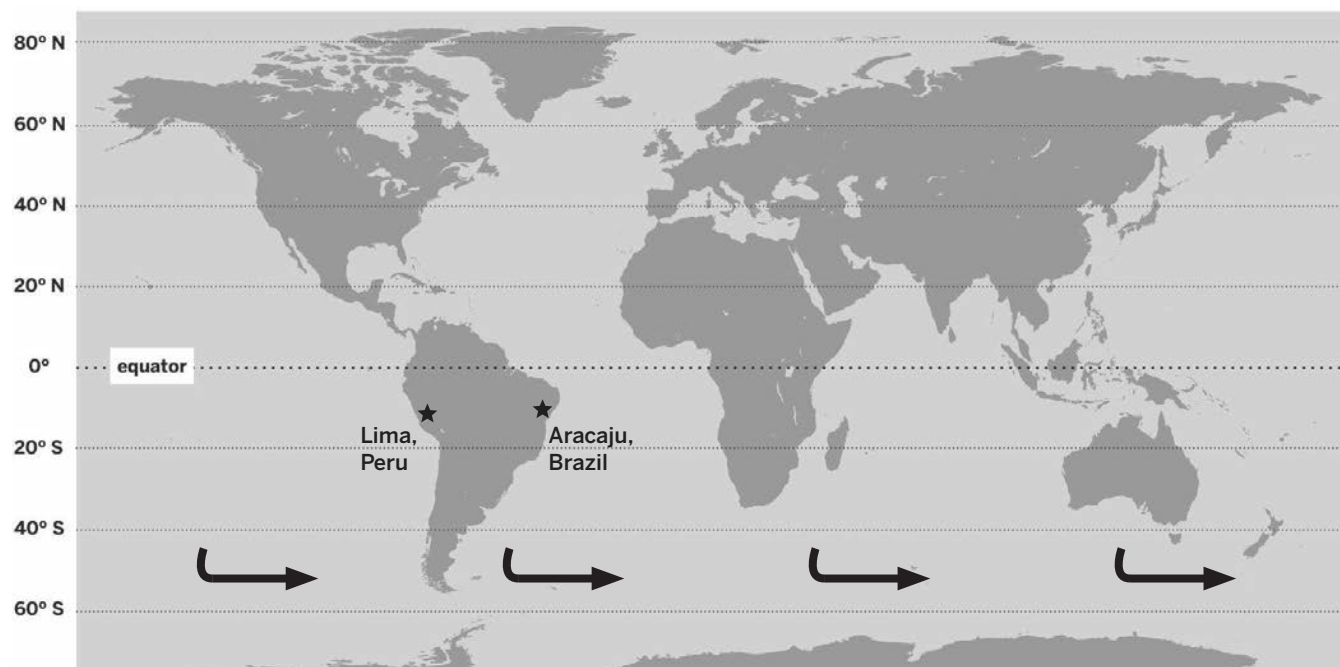


Prompt: The average air temperature in Aracaju, Brazil, is warmer than Lima, Peru.
How do the map and the evidence help explain the temperature difference?

1. Draw the direction of the ocean currents near Lima and Aracaju.
2. Add any annotation to the map that might help you respond to the prompt.
3. Explain how the evidence shows why Aracaju is warmer than Lima. Use all these words in your written explanation: *ocean current, temperature, prevailing winds, energy.*

Name: _____ Date: _____

Write and Share Routine: Student 2



Prompt: The average air temperature in Aracaju, Brazil, is warmer than Lima, Peru.
How do the map and the evidence help explain the temperature difference?

1. Draw the direction of the ocean currents near Lima and Aracaju.
2. Add any annotation to the map that might help you respond to the prompt.
3. Explain how the evidence shows why Aracaju is warmer than Lima. Use all these words in your written explanation: *ocean current, temperature, prevailing winds, energy.*

Name: _____ Date: _____

Write and Share Routine: Student 3



Evidence: Without prevailing winds, both locations would have the same average air temperature.

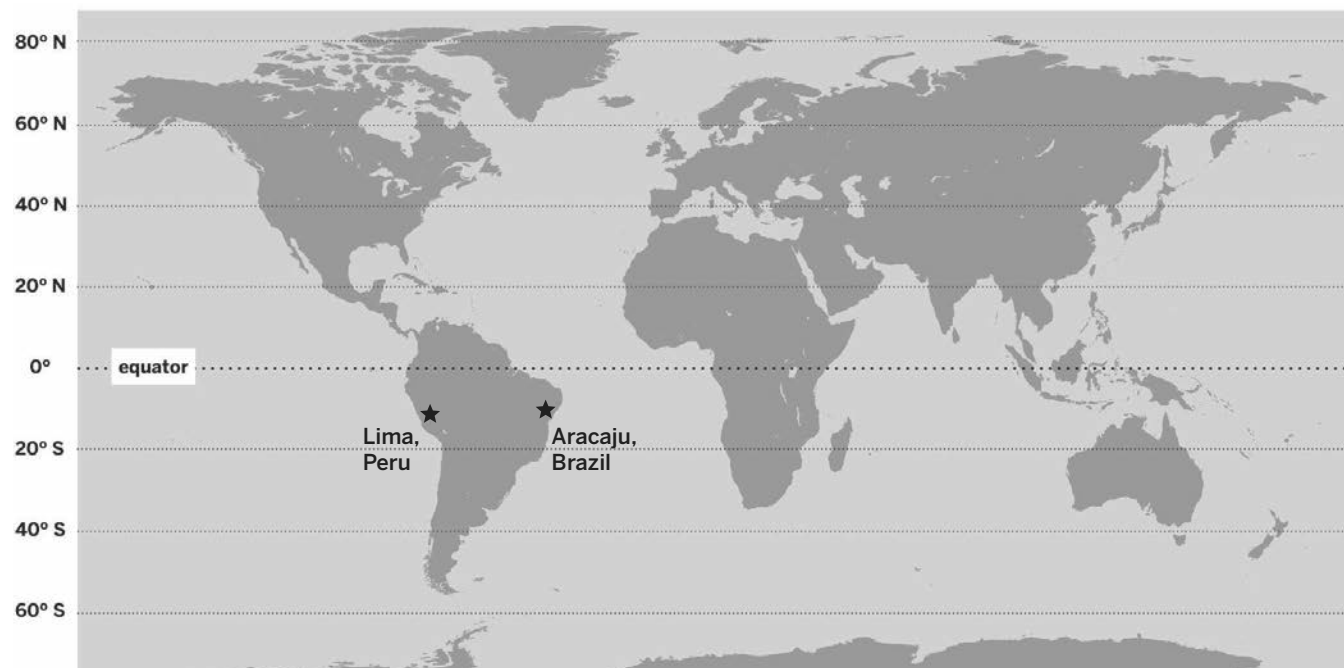
Prompt: The average air temperature in Aracaju, Brazil, is warmer than Lima, Peru.

How do the map and the evidence help explain the temperature difference?

1. Draw the direction of the ocean currents near Lima and Aracaju.
2. Add any annotation to the map that might help you respond to the prompt.
3. Explain how the evidence shows why Aracaju is warmer than Lima. Use all these words in your written explanation: *ocean current, temperature, prevailing winds, energy*.

Name: _____ Date: _____

Write and Share Routine: Student 4



Evidence: If the prevailing winds reversed direction, Lima would be warmer than Aracaju.

Prompt: The average air temperature in Aracaju, Brazil, is warmer than Lima, Peru.

How do the map and the evidence help explain the temperature difference?

1. Draw the direction of the ocean currents near Lima and Aracaju.
2. Add any annotation to the map that might help you respond to the prompt.
3. Explain how the evidence shows why Aracaju is warmer than Lima. Use all these words in your written explanation: *ocean current, temperature, prevailing winds, energy.*

Name: _____ Date: _____

The Reasoning Tool

Question: *During El Niño years, why is Christchurch, New Zealand's air temperature cooler than usual?*

1. In the right-hand column, write the claim that is best supported by the evidence. You may write the same claim in each cell of that column.
2. In the middle column, explain why your evidence matters or how it supports the claim.

Evidence	This matters because . . . (How does this evidence support the claim?)	Therefore, . . . (claim)
Evidence Card A: ocean surface temperature is cooler during El Niño years		
Evidence Card B: prevailing winds and positions of islands cause warm ocean currents to pass Christchurch in normal years		
Evidence Card C: normal prevailing winds slow down or reverse in El Niño years		
Evidence from the Sim: when prevailing winds reverse or slow, ocean currents also change		

Date: _____

Homework: Writing a Scientific Argument

During El Niño years, why is Christchurch, New Zealand's air temperature cooler than usual?

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Date: _____

Homework: Writing a Scientific Argument (continued)

[illegible]

Name: _____ Date: _____

Homework: Check Your Understanding

Scientists investigate in order to figure things out. Are you getting closer to figuring out why the air temperature in Christchurch is cooler in El Niño years?

1. I understand how energy is transferred to the air of Christchurch, New Zealand. (check one)

☐ yes

☐ not yet

Explain your answer choice.

2. I understand what happens to the amount of energy in the air of Christchurch in El Niño years. (check one)

☐ yes

☐ not yet

Explain your answer choice.

3. I understand how Christchurch's distance from the equator affects its air temperature. (check one)

☐ yes

☐ not yet

Explain your answer choice.

Name: _____ Date: _____

Homework: Check Your Understanding (continued)

4. I understand why the ocean near Christchurch is a different temperature than we'd expect for its latitude (distance from the equator). (check one)

☐ yes

☐ not yet

Explain your answer choice.

5. I understand why the ocean temperature near Christchurch changes in El Niño years and how it affects the air temperature there. (check one)

☐ yes

☐ not yet

6. What do you still wonder about El Niño and air temperature?

Name: _____ Date: _____

Chapter 4: Science Seminar

Chapter Overview

Are you ready to go back in time? We're not just talking way back, but way, way, way back! In the last chapter of this unit, you will use what you've learned about ocean currents and air temperature to engage in scientific argumentation about an ongoing debate in the field of climatology. This seminar will focus on a time period known as the late Carboniferous, which happened about 300 million years ago!



Name: _____ Date: _____

Lesson 4.1: Comparing Air Temperature: Past and Present

Congratulations on working out why Christchurch's air temperature is cooler during El Niño years! You have helped Dr. Parata and the farmers understand El Niño so they can prepare for future El Niño events. Because of your great work with the New Zealand Farm Council, a paleontologist named Dr. Xi Yang has reached out to you for help with a new question about South China during the late Carboniferous period—about 300 million years ago! By analyzing evidence, you will make an argument to support a claim about the climate of South China during that time.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 4 Question

- In South China during the late Carboniferous period, was the air temperature warmer or cooler than the air temperature in that location today?

Key Concepts

- Energy from the sun is transferred to Earth's surface. Some of that energy is then transferred to the air above the surface.
- The closer a location is to the equator, the more energy it receives from the sun. Therefore, a location's air temperature is affected by its distance from the equator.
- An effect may have more than one cause; these may be linked into a chain of causes and effects.
- When an ocean current comes from the equator, it brings warmer-than-expected water to the places it passes, and that water is warmer than the nearby air. When an ocean current comes from a pole, it brings colder-than-expected water to the places it passes, and that water is colder than the nearby air.
- Energy transfers from warmer substances to colder substances. Warmer currents transfer energy to cooler air, and warmer air transfers energy to cooler currents.
- Prevailing winds and the position of continents determine the direction of ocean currents.
- Changes to prevailing winds affect ocean currents. Changes to ocean currents affect how much energy is brought to (or taken away from) a location.

Vocabulary

- | | | |
|----------|-----------------|-------------------|
| • cause | • energy | • prevailing wind |
| • claim | • evidence | • temperature |
| • effect | • ocean current | • transfer |

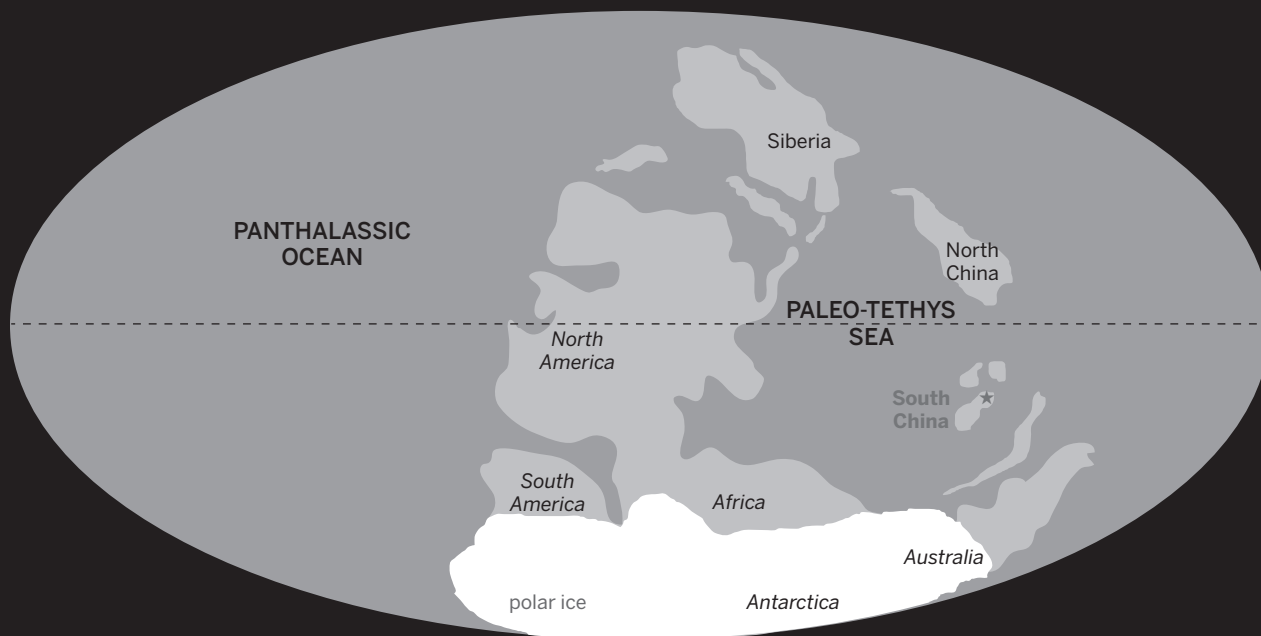
Name: _____

Date: _____

Warm-Up

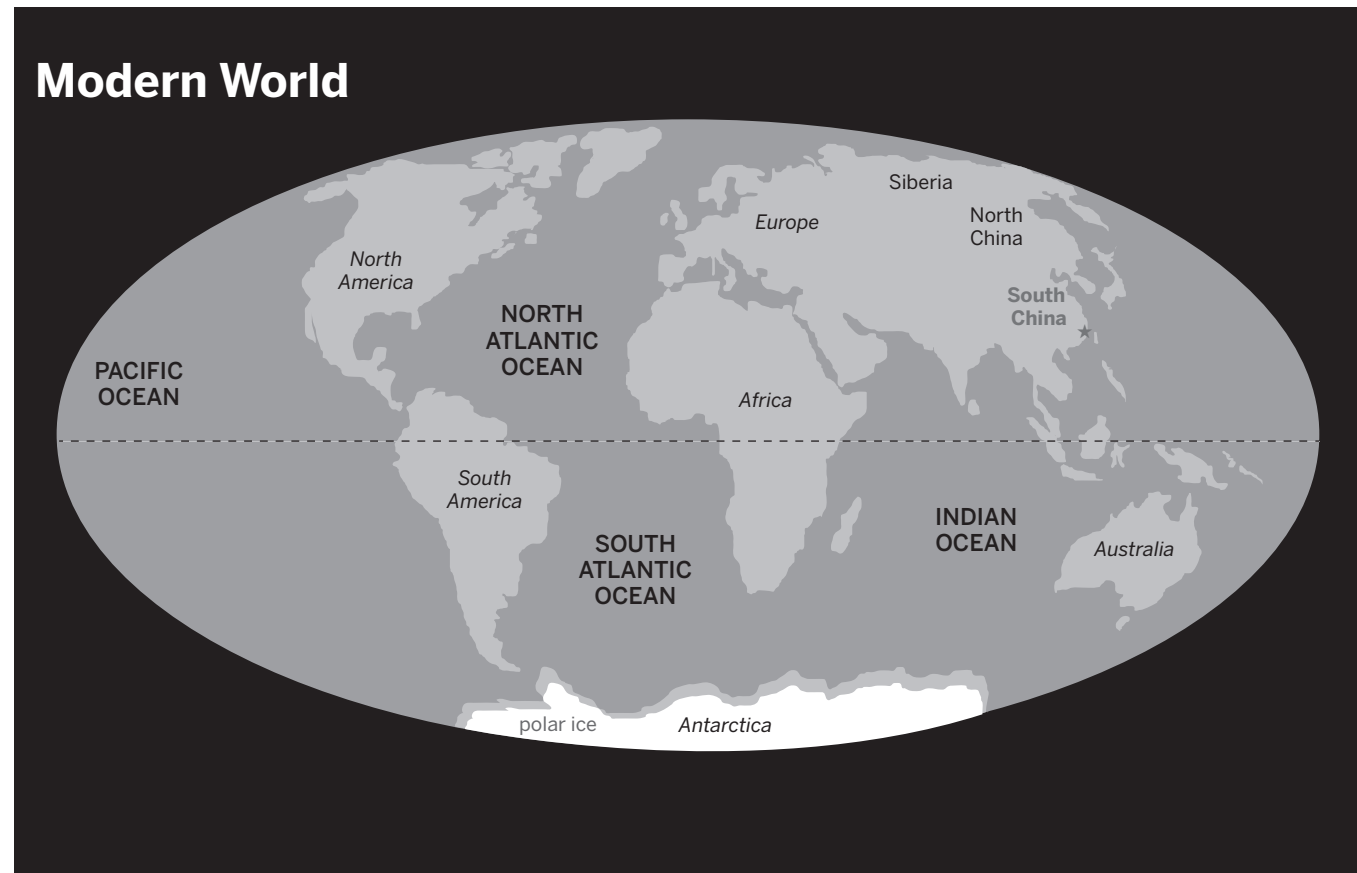
Over time, the continents on Earth are moving and changing their positions VERY slowly. This means that millions of years ago the continents were in different locations than they are today. Look closely at the two maps: observe where the region called South China was located 306 million years ago, and compare that to where it is located today. After you've made your observations, answer the question.

Late Carboniferous 306 Million Years Ago



Name: _____ Date: _____

Warm-Up (continued)



Do you think the changing position of South China has affected its air temperature? Why or why not?

Name: _____ Date: _____

Introducing the Science Seminar

Xi Yang

To: Student Climatologists

Re: Temperature—Late Carboniferous vs. Present Day

廣西



I am a paleontologist at the South China Institute of Paleontology in Guangxi, China (廣西). I study the late Carboniferous period, which occurred about 300 million years ago. During that time, Earth's continents were in different positions.

We would like your help with analyzing some evidence. We're trying to determine if South China's air temperature during the late Carboniferous period was the same or different (warmer or cooler) than the air temperature in South China today.

I look forward to hearing from you.

**Dr. Xi Yang, Paleoclimatology Department
South China Institute of Paleontology**

Name: _____ Date: _____

Annotating and Discussing Evidence

Science Seminar Question: *In South China during the late Carboniferous period, was the air temperature warmer or cooler than the air temperature in that location today?*

Individual Work

1. Read each evidence card carefully.
2. Annotate the cards, using these questions as you think about the information on each:
 - What questions do you have about the evidence?
 - How is the evidence connected to what you have been learning about the factors that affect air temperature?
 - How could the evidence help you make an explanation that answers the Science Seminar Question?

Partner Discussion

1. Talk about your questions about the evidence on the cards; see if you can help each other answer them.
2. Looking at the cards, are there any two pieces of evidence that could work together? How are those two cards connected?

Name: _____ Date: _____

Sorting the Evidence Cards

Sorting Evidence Cards by Claim

1. With a partner, discuss whether each piece of evidence supports or goes against a claim. Use the sentence starters to help you talk with your partner.
2. Make annotations on each card:
 - If the evidence supports a claim, write SUPPORTS CLAIM ____ on that card.
 - If the evidence goes against a claim, write GOES AGAINST CLAIM ____ on that card.
 - If the evidence connects with another evidence card, write CONNECTS WITH EVIDENCE CARD ____ on that card.
3. Sort the evidence by placing the cards underneath the claim they support.

Sentence Starters

I think this piece of information supports this claim because . . .

I don't think this piece of information supports this claim because . . .

I agree because . . .

I disagree because . . .

Why do you think that?

Name: _____ Date: _____

Lesson 4.2: Science Seminar

In the previous lesson, you analyzed evidence to help you investigate the Chapter 4 Question: *In South China during the late Carboniferous period, was the air temperature warmer or cooler than the air temperature in that location today?* In today's Science Seminar, you and your classmates will discuss the evidence and work together to arrive at the best answer to this question. By the end of the lesson, you will be ready to write a convincing scientific argument about whether South China's air temperature was warmer, cooler, or the same as it is now.

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 4 Question

- In South China during the late Carboniferous period, was the air temperature warmer or cooler than the air temperature in that location today?

Key Concepts

- Energy from the sun is transferred to Earth's surface. Some of that energy is then transferred to the air above the surface.
- The closer a location is to the equator, the more energy it receives from the sun. Therefore, a location's air temperature is affected by its distance from the equator.
- An effect may have more than one cause; these may be linked into a chain of causes and effects.
- When an ocean current comes from the equator, it brings warmer-than-expected water to the places it passes, and that water is warmer than the nearby air. When an ocean current comes from a pole, it brings colder-than-expected water to the places it passes, and that water is colder than the nearby air.
- Energy transfers from warmer substances to colder substances. Warmer currents transfer energy to cooler air, and warmer air transfers energy to cooler currents.
- Prevailing winds and the position of continents determine the direction of ocean currents.
- Changes to prevailing winds affect ocean currents. Changes to ocean currents affect how much energy is brought to (or taken away from) a location.

Vocabulary

- | | | |
|----------|-----------------|-------------------|
| • cause | • evidence | • prevailing wind |
| • claim | • latitude | • temperature |
| • effect | • ocean current | • transfer |

Name: _____ Date: _____

Warm-Up

Look back at the evidence cards in your envelope and review the annotations. Use the evidence cards to answer the questions.

In South China during the late Carboniferous period, was the air temperature warmer or cooler than the air temperature in that location today?

Which claim do you think is most convincing? (check one)

- ☐ **Claim 1:** It was warmer than it is today.
- ☐ **Claim 2:** It was cooler than it is today.
- ☐ **Claim 3:** No difference—the air temperature was the same as it is today.

1. Draw a star on the evidence card that best supports the claim you selected.
2. Why did you choose this piece of evidence?

Name: _____ Date: _____

Preparing for the Science Seminar

Preparing Your Science Seminar Argument

1. Take turns with your partner: Share which claim you think is most convincing.
2. Use your Warm-Up responses and the Argumentation Sentence Starters to help you share ideas.
3. Refer to the annotated claims and evidence cards in your envelope, as needed.

In South China during the late Carboniferous period, was the air temperature warmer or cooler than the air temperature in that location today?

Claim 1: It was warmer than it is today.

Claim 2: It was cooler than it is today.

Claim 3: No difference—the air temperature was the same as it is today.

Name: _____ Date: _____

Science Seminar Observations

Write a check mark in the right-hand column every time you hear one of your peers say or do something listed in the left-hand column. If you hear an interesting idea, write it in the last row of the table.

Observations during the seminar	Check marks
I heard a student use evidence to support a claim.	
I heard a student respectfully disagree with someone else's thinking.	
I heard a student explain how her evidence is connected to her claim.	
I heard a student evaluate the quality of evidence.	
I heard an idea that makes me better understand one of the claims. That idea is:	

Name: _____ Date: _____

Homework: Reflecting on the Science Seminar

Now that the Science Seminar is over, think back to the claim you supported at the beginning. After participating in the discussion, you may have changed your mind about which claim you favor. Show your current thinking by answering the questions.

In South China during the late Carboniferous period, was the air temperature warmer or cooler than the air temperature in that location today?

Claim 1: It was warmer than it is today.

Claim 2: It was cooler than it is today.

Claim 3: No difference—the air temperature was the same as it is today.

Did the Science Seminar cause your thinking about the claims to change? Explain your answer.

Name: _____ Date: _____

Lesson 4.3: Writing a Scientific Argument

What was the climate of South China like during the late Carboniferous period? Student climatologists, it's time for you to write your scientific argument. Today, you'll review the evidence and use the Reasoning Tool to organize your thinking. Then, you'll get to make your case to the paleontologist, Dr. Xi Yang, about whether South China was warmer or cooler during the late Carboniferous. How convincing can you make your argument?

Unit Question

- What determines the air temperature of a location on Earth?

Chapter 4 Question

- In South China during the late Carboniferous period, was the air temperature warmer or cooler than the air temperature in that location today?

Key Concepts

- Energy from the sun is transferred to Earth's surface. Some of that energy is then transferred to the air above the surface.
- The closer a location is to the equator, the more energy it receives from the sun. Therefore, a location's air temperature is affected by its distance from the equator.
- An effect may have more than one cause; these may be linked into a chain of causes and effects.
- When an ocean current comes from the equator, it brings warmer-than-expected water to the places it passes, and that water is warmer than the nearby air. When an ocean current comes from a pole, it brings colder-than-expected water to the places it passes, and that water is colder than the nearby air.
- Energy transfers from warmer substances to colder substances. Warmer currents transfer energy to cooler air, and warmer air transfers energy to cooler currents.
- Prevailing winds and the position of continents determine the direction of ocean currents.
- Changes to prevailing winds affect ocean currents. Changes to ocean currents affect how much energy is brought to (or taken away from) a location.

Vocabulary

- | | | |
|----------|-------------------|---------------|
| • cause | • latitude | • temperature |
| • effect | • ocean current | • transfer |
| • energy | • prevailing wind | |

Name: _____

Date: _____

Warm-Up

Making a Convincing Argument

Guadalupe and Anthony are students studying about ocean, atmosphere, and climate at another school. Below are their arguments about the air temperature in Christchurch during El Niño years. Read and compare the two arguments, and then answer the questions.

Guadalupe's Argument

Christchurch's air temperature is cooler than usual during El Niño years because the prevailing winds are disrupted and the currents change. Therefore, the change in air temperature is caused by changing winds and currents.

Anthony's Argument

Christchurch's air temperature is cooler than usual during El Niño years because the prevailing winds are disrupted. This evidence matters because prevailing winds push the warm currents that pass Christchurch. These currents carry energy, and that energy is transferred to the air, which makes the air warmer. When prevailing winds are disrupted, they do not push the currents toward Christchurch, so the energy transfer does not happen. This makes the air temperature cooler. Therefore, the change in air temperature is caused by changing winds and changing currents.

Whose argument is more convincing? (circle one)

Guadalupe's

Anthony's

What makes one argument more convincing than the other?

Name: _____ Date: _____

Using the Reasoning Tool

Reviewing the Evidence and Choosing a Claim

1. Review your Science Seminar cards.
2. With your partner, discuss the claim you plan to support. Remember, it's still okay to change your thinking.

In South China during the late Carboniferous period, was the air temperature warmer or cooler than the air temperature in that location today?

Claim 1: It was warmer than it is today.

Claim 2: It was cooler than it is today.

Claim 3: No difference—the air temperature was the same as it is today.

Using the Reasoning Tool to Support Your Claim

1. In the right column, record the claim that you think is best supported by the evidence. You may record your own claim if you prefer.
2. In the left column, tape the evidence cards that support your claim. You do not need to use all of the evidence cards, but you should use more than one to support your claim.
3. In the middle column, record how the evidence card in the left column connects to the claim in the right column.

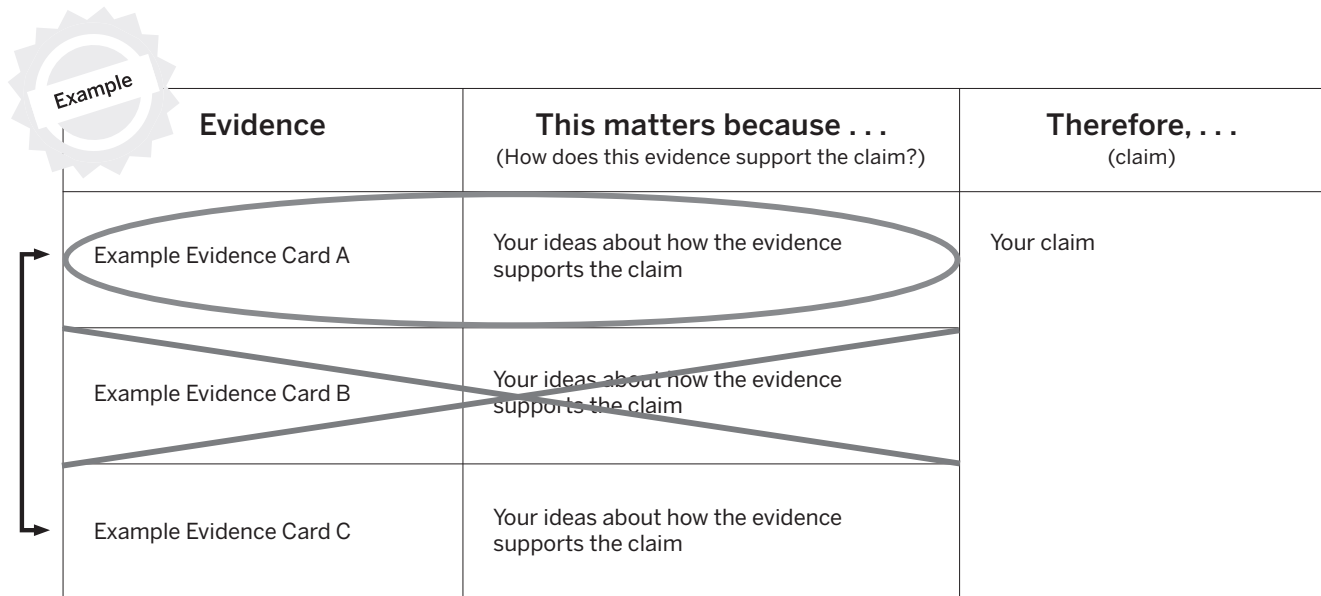
Evidence	This matters because. . . (How does this evidence support the claim?)	Therefore, . . . (claim)

Name: _____ Date: _____

Organizing Your Reasoning Tool

Before you write your argument, follow the steps below to organize your Reasoning Tool.

- Draw a circle around your strongest piece of evidence.
- Draw an X over a piece of evidence if you do not plan to use it in your argument.
- Draw an arrow to connect two pieces of evidence if you think that they go together.



Example

Evidence	This matters because . . . (How does this evidence support the claim?)	Therefore, . . . (claim)
Example Evidence Card A	Your ideas about how the evidence supports the claim	Your claim
Example Evidence Card B	Your ideas about how the evidence supports the claim	
Example Evidence Card C	Your ideas about how the evidence supports the claim	

Name: _____ Date: _____

Writing Scientific Arguments

Writing a Scientific Argument About the Air Temperature of South China

1. Review your Reasoning Tool. Include your strongest piece of evidence and connect pieces of evidence that go together.
2. Use the Scientific Argument Sentence Starters to help you explain your thinking in your argument on the next page.

In South China during the late Carboniferous period, was the air temperature warmer or cooler than the air temperature in that location today?

Claim 1: It was warmer than it is today.

Claim 2: It was cooler than it is today.

Claim 3: No difference—the air temperature was the same as it is today.

Scientific Argument Sentence Starters

Describing evidence:	Explaining how the evidence supports the claim:
The evidence that supports my claim is . . .	If ____, then . . .
My first piece of evidence is . . .	This change caused . . .
Another piece of evidence is . . .	This is important because . . .
This evidence shows that . . .	Since . . .
	Based on the evidence, I conclude that . . .
	This claim is stronger because . . .

Date: _____

Writing Scientific Arguments (continued)

Write a scientific argument that addresses the question: *In South China during the late Carboniferous period, was the air temperature warmer or cooler than the air temperature in that location today?*

1. State your claim and explain your choice.
2. Use your evidence and explain how each piece supports your claim.

This image shows a single sheet of white paper with horizontal blue ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Date: _____

Writing Scientific Arguments (continued)

[illegible]

Name: _____

Date: _____

Homework: Revising an Argument

1. Reread your scientific argument.
2. If you need to, finish writing your argument.
3. Look for ways to make your argument clearer or more convincing.
4. Consider reading your argument aloud or having another person read it.
5. Consider these questions as you review your argument:
 - Does your argument clearly explain why you decided that South China's air temperature in the late Carboniferous period was either warmer, cooler, or the same as it is today?
 - Do you describe your supporting evidence?
 - Do you thoroughly explain how the evidence supports your claim?
6. Rewrite entire sections that could be clearer or more convincing.

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Date: _____

Homework: Revising an Argument (continued)

[illegible]

Name: _____ Date: _____

Homework: Check Your Understanding

This is a chance for you to reflect on your learning so far. This is not a test. Be open and truthful when you respond to the questions below.

1. I understand that scientists revise claims as new evidence becomes available. (check one)

☐ yes

☐ not yet

Explain your answer choice.

2. What are the most important things you have learned in this unit about what determines the air temperature of a location on Earth?

3. What questions do you still have?

Ocean, Atmosphere, and Climate Glossary

cause: an event or process that leads to a result or change

causa: un evento o proceso que provoca un resultado o cambio

climate: general weather patterns over a long period of time

clima: patrones atmosféricos generales que ocurren durante un periodo largo de tiempo

climatology: the study of weather patterns over a long period of time

climatología: el estudio de patrones del clima durante un periodo largo de tiempo

continent: any of Earth's main continuous areas of land, such as Africa, Asia, and North America

continente: cualquiera de las principales áreas continuas de terreno de la Tierra, como África, Asia y Norteamérica

effect: a result or change that happens because of an event or process

efecto: un resultado o cambio que ocurre debido a un evento o proceso

El Niño: a climate pattern where water near the equator gets hotter than usual and affects the weather around the world; El Niño happens in the Pacific Ocean

El Niño: un patrón climático en el cual las aguas cercanas al ecuador se calientan más de lo normal y afectan el clima de todo el mundo; El Niño ocurre en el Océano Pacífico

energy: the ability to make things move or change

energía: la capacidad de hacer que las cosas se muevan o cambien

equator: the imaginary line that divides Earth into northern and southern hemispheres (halves)

ecuador: la línea imaginaria que divide a la Tierra en dos hemisferios (mitades): norte y sur

gyre: a giant pattern of moving water that spans whole oceans and moves water from place to place in a circle

giro: un patrón gigantesco de agua en movimiento que abarca océanos enteros y mueve el agua de un lugar a otro en forma circular

latitude: the distance of a place north or south of Earth's equator

latitud: la distancia desde el ecuador de la Tierra hasta un lugar al norte o sur

longitude: the distance of a place east or west of Earth's prime meridian

longitud: la distancia desde el primer meridiano de la Tierra hasta un lugar al este u oeste

Ocean, Atmosphere, and Climate Glossary (continued)

model: an object, diagram, or computer program that helps us understand something by making it simpler or easier to see

modelo: un objeto, diagrama o programa de computadora que nos ayuda a entender algo haciéndolo más simple o fácil de ver

observe: to use any of the five senses to gather information about something

observar: usar cualquiera de los cinco sentidos para recolectar información acerca de algo

ocean current: ocean water flowing in a continuous path

corriente oceánica: agua del océano que fluye en una ruta continua

prediction: an idea about what might happen that is based on what you already know

predicción: una idea acerca de lo que podría suceder que está basada en lo que tú ya conoces

prevailing winds: winds that move in one direction and are strong enough to push ocean currents

vientos dominantes: vientos que se mueven en una dirección y son lo suficientemente fuertes para empujar corrientes oceánicas

scientific community: scientists around the world who share information and ideas

comunidad científica: científicos/as alrededor del mundo que comparten información e ideas

solar: related to the sun

solar: relacionado con el sol

surface: the outside or top layer of something

superficie: la parte exterior o la capa más externa de algo

temperature: a measure of how hot or cold something is

temperatura: una medida de qué tan caliente o frío está algo

transfer: to move from one object to another or one place to another

transferir: mover de un objeto a otro o de un lugar a otro

upwelling: a process in which deep, cold water rises toward the surface of the ocean

afloramiento: un proceso en el cual las aguas profundas y frías se elevan hacia la superficie del océano

Lawrence Hall of Science:**Program Directors:** Jacqueline Barber and P. David Pearson**Curriculum Director, Grades K–1:** Alison K. Billman**Curriculum Director, Grades 2–5:** Jennifer Tilson**Curriculum Director, Grades 6–8:** Suzanna Loper**Assessment and Analytics Director:** Eric Greenwald**Learning Progressions and Coherence Lead:** Lauren Mayumi Brodsky**Operations and Project Director:** Cameron Kate Yahr**Student Apps Director:** Ari Krakowski**Student Content Director:** Ashley Chase**Leadership Team:** Jonathan Curley, Ania Driscoll-Lind, Andrew Falk, Megan Goss, Ryan Montgomery, Padraig Nash, Kathryn Chong Quigley, Carissa Romano, Elizabeth Shafer, Traci K. Shields, Jane Strohm***Ocean, Atmosphere, and Climate: Cold Years in New Zealand Unit Team:***

Stacy Au-yang	Candice Bradley	Jacqueline Felipe	Patrice Scinta
Elizabeth Ball	Benton Cheung	Abigail Hines	Claire Spafford
Carla Barger	Barbara Clinton	Deirdre MacMillan	Sara Walkup
Whitney Barlow	Kristina M. Duncan	Christina Morales	Desiré D. Whitmore

Amplify:

Irene Chan	Charvi Magdaong	Matt Reed
Samuel Crane	Thomas Maher	Eve Silberman
Shira Kronzon	Rick Martin	Steven Zavari

Credits:

Illustrations: Cover: Tory Novikova; Page 21 (b): Open Government License v2.0; Page 48: NOAA; Page 86: Science Source; Page 116: Walter Myers/Science Source
Photograph: Page 102: Shutterstock

Ocean, Atmosphere, and Climate:

Cold Years in New Zealand

Article Compilation

Table of Contents: Articles

Effects of El Niño Around the World	A1–A4
The Ocean in Motion	B1–B3
How the Ocean Keeps Climates Stable	C1–C2
The Climates of Peru	D1–D4
The Gulf Stream: A Current That Helped Win a War	E1–E3
What Causes Prevailing Winds?	F1–F2
The Coriolis Effect	G1–G2
Deep Ocean Currents: Driven by Density	H1–H2

Effects of El Niño Around the World

Chapter 1: Different Places, Different Effects

Different places on Earth have their own weather patterns that depend on things like local geography and distance from the equator. These weather patterns are known as regional climates, and they don't change very much from year to year . . . ordinarily. However, an El Niño year is anything but ordinary! The climate pattern called El Niño happens every 2 to 7 years, bringing important changes in temperature, precipitation, and more. El Niño affects the whole planet, but it has different effects on different locations. Choose one of the chapters that follow to learn more about the effects of El Niño on the regional climate in a particular place on the globe.



The climate pattern called El Niño causes wet weather in some places and extreme drought in others.

Chapter 2: Drought in Pakistan

Late summer and early fall are usually wet times in the country of Pakistan. Normally, the monsoon season in August and September brings heavy rainstorms. Monsoon season supplies about half of Pakistan's rain for a typical year—about 25 centimeters (16 inches) in just two months. These storms keep temperatures from getting too hot. However, the climate pattern called El Niño weakens the monsoon season in Pakistan, causing dry, hot weather instead of cool rain. This unusual weather causes a variety of health problems for people there and keeps crops from being watered. Without water to grow food, many people's health problems get worse because they don't get the nutrition they need to get well.



In Pakistan, the El Niño climate pattern causes hot, dry weather instead of monsoon storms.

Chapter 3: Landslides in Los Angeles

Normally, Southern California is a pretty dry place: the city of Los Angeles only gets about 38 centimeters (15 inches) of rain each year. During El Niño years, however, Los Angeles can get much more rain than usual. For such a dry place, the extra rain brought by El Niño may sound like a good thing—but it can be dangerous. Large amounts of rain falling on dry, hilly ground without many plants to keep the dirt in place can lead to landslides. In Los Angeles, some people build homes at the tops of hills. These hilltop homes can be destroyed when the dirt underneath them gets too wet and slides downhill. Landslides can also block or destroy roads, injuring people in their paths and causing millions of dollars in damage.



Extra rain in Los Angeles might sound like a good thing, but it can cause landslides that destroy homes and block roads.

Chapter 4: Malaria in Colombia

In the South American country of Colombia, El Niño causes serious droughts. These droughts can affect farmers in the area, but they have an even bigger effect on public health there. During El Niño years, Colombia has a 17% increase in cases of a serious disease called malaria. When rivers and streams begin to dry up in a drought, the remaining water forms many shallow pools that are good places for mosquitoes to live and breed. Mosquitoes carry malaria, transmitting it to people by biting them. More places for mosquitoes to breed means there are more mosquitoes around to transmit malaria to nearby humans. Mosquitoes typically breed faster in warm weather, so rising temperatures may also work to increase the rates of malaria in Colombia during El Niño years.



When rivers and streams begin to dry up, they form pools where mosquitoes live and breed. These mosquitoes can carry malaria and transmit it to people living nearby.



Thousands of shoes fell off the ship that was carrying them across the ocean. Eventually, some of those shoes washed up on this beach. People collected them and tried to find matched pairs.

The Ocean in Motion

Surprising things sometimes wash up on shore, and this can happen all over the world. During a powerful storm in 1990, containers packed with 61,000 shoes fell off a cargo ship travelling across the Pacific Ocean and eventually washed up on beaches in Oregon, Hawaii, and Japan. These locations are hundreds or thousands of miles away from the place where the shoes were spilled. How did the shoes make their way to these locations?

If you look at a photograph of Earth, most of what you see is the big, blue ocean—after all, the ocean covers 71% of our planet. In a photograph or on a map, it may not look like the ocean moves very much, but the opposite is actually true. The water in the ocean is always



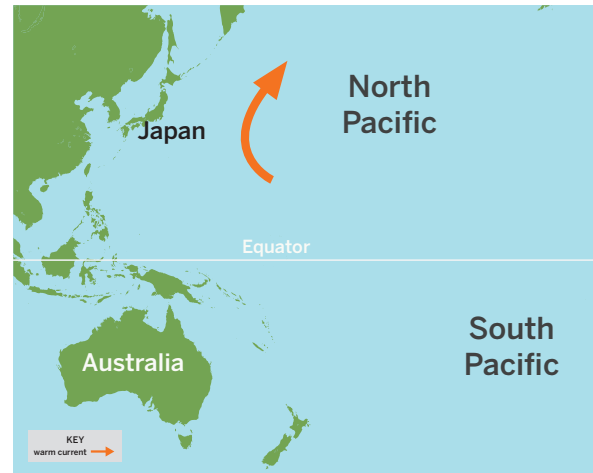
The ocean covers 71% of Earth and is in constant motion. The movement of the ocean carries energy and objects wherever it goes.

moving from place to place, carrying objects and organisms wherever it goes. Ocean water doesn't move randomly; it flows in consistent patterns. Scientists call ocean water flowing in a continuous path an ocean current. Currents carry all kinds of objects and organisms all over the world. The shoes made their way across the ocean with the help of ocean currents.

In addition to objects and organisms, ocean currents carry energy from the sun all around Earth. In fact, the motion of water around Earth's ocean is one of the main ways energy moves around the planet. Energy from the sun is transferred to the ocean surface. As the currents move across Earth's surface, the energy moves with them.

The current shown on the map at the top of this page is moving away from the equator. At the equator, a large amount of energy is transferred from the sun to the ocean's surface. As the current moves north, it carries this energy with it. If you place your finger on the map anywhere where this current moves, the water there would be warmer than you would expect for a location at this latitude because of the current that moves through this area.

The current shown on the map at the bottom of this page is moving away from the South Pole. The farther away from the equator you are, the less energy is transferred from the sun to the ocean surface, with the least amount of energy transferred at the poles. This means the current traveling from the South Pole carries less energy with it than currents coming from the equator. If the ocean water weren't moving, then ocean surface temperatures in different locations would only depend on their latitudes. However, in locations where a cold current moves past, the ocean surface temperature is lower than you would expect.

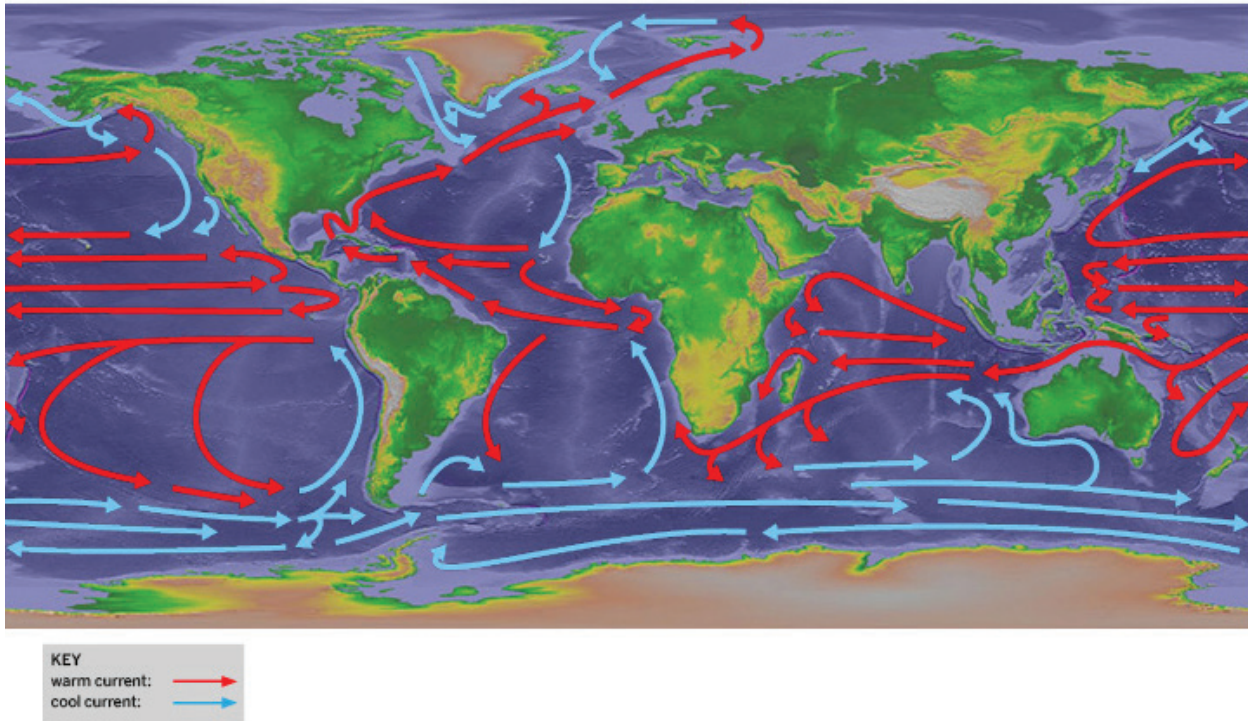


A warm current moving north from the equator keeps Japan warmer than other places at the same latitude.



A cold current traveling north from Antarctica keeps the western coast of Australia cooler than other locations at the same latitude.

Major Ocean Currents



Ocean currents form five main gyres, or circles: the Indian Ocean Gyre, the North Pacific Gyre, the South Pacific Gyre, the North Atlantic Gyre, and the South Atlantic Gyre.

The maps on this page make it look like ocean currents are constant. However, ocean currents can sometimes change direction. Since ocean currents carry energy around Earth, a change in the direction a current moves can change ocean surface temperatures at any locations the current passes on its journey.

In many parts of the ocean, surface currents come together to form gyres, huge areas of water moving in big circles. All together, these gyres move water in a predictable pattern all over the globe, carrying energy, organisms, and other objects with them. That's how shoes that were spilled in the middle of the ocean can end up in Oregon, Hawaii, and Japan!



Minneapolis is known for its cold winters and hot summers, while the climate in Seattle is relatively stable over the course of the year.

How the Ocean Keeps Climates Stable

Have you ever spent a winter in the city of Minneapolis, Minnesota? Minneapolis is located in the far north of the United States and is known for its cold winters and hot, humid summers. The city of Seattle, Washington, is also very far north. The two cities are located at similar latitudes—that is, they're about the same distance north of the equator and they get about the same amount of energy from the sun at any given time of year. However, the weather in Seattle is very different from the weather in Minneapolis. Seattle is cool and wet, and the temperature there doesn't change all that much over the course of the year.

In Seattle, the average temperature in January is 8.4°C (degrees Celsius), which equals 47°F (degrees Fahrenheit). In July, Seattle's average temperature is 24.3°C (76°F). That's a range of only 15.9°C (29°F) during the year. On the other hand, Minneapolis has an average temperature of -4.6°C (24°F) in January and 28°C (83°F) in July, a range of 32.6°C (59°F) during the year. That's a much wider range of temperatures! What makes these cities experience such different weather, even though they're at about the same latitude?

If you look at the map on the next page, you'll see that Minneapolis is right in the middle of North America, with many kilometers of land in all directions. It isn't anywhere near the ocean. Seattle, on the other hand, is near the coast, not far from the ocean at all. Being located near the ocean makes all the difference: it keeps Seattle's climate from getting too extreme. Without the ocean nearby, Minneapolis's climate is more likely to be very cold or very warm.



The cities of Minneapolis, Minnesota and Seattle, Washington are located at about the same latitude—that is, they’re about the same distance north of the equator. However, the two cities have very different climates.

Why is this? It has to do with how well water and land each store energy. Water stores energy very well: the ocean can absorb a lot of energy before it changes temperature. Another way to look at it is that it takes more energy to raise the temperature of the ocean by one degree than it does to raise the temperature of land by one degree. Because of this difference in energy storage, land heats up quickly and loses heat quickly, while water takes a long time to heat up and a long time to lose heat.

Of course, Seattle isn’t located in the ocean, and the climate in Minneapolis can’t all come from the temperature of the ground it sits on. So how does the temperature of the ocean or the land around a city affect the city’s climate? The ocean or land transfers some of its energy to the air. Since the land around Minneapolis

gains and loses energy quickly, its temperature varies a lot, and so does the temperature of the air in Minneapolis. Since the ocean near Seattle gains and loses energy slowly, its temperature stays pretty stable. This difference doesn’t just affect Seattle and Minneapolis; all coastal areas tend to have more stable temperatures over time than areas far from the ocean. Where would you rather live—somewhere with moderate temperatures throughout the year or somewhere with bigger differences between the seasons?

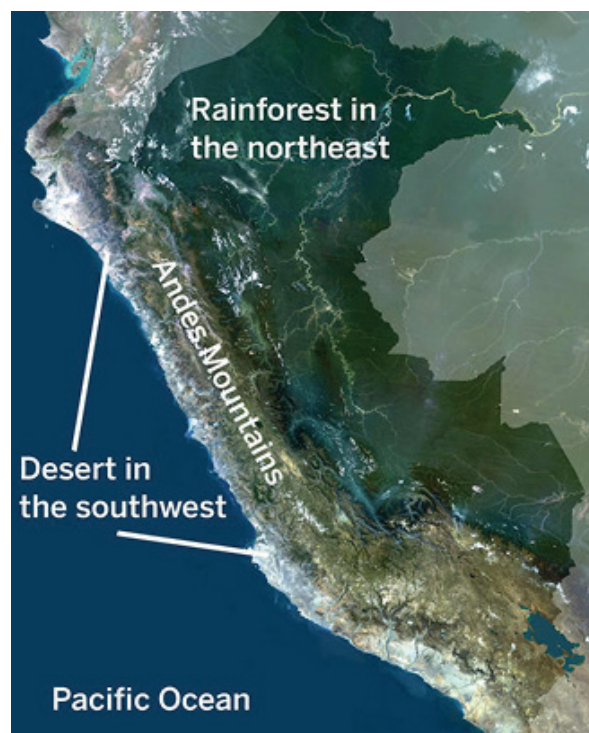


Peru is on the west coast of South America on the Pacific Ocean.

The Climates of Peru

Chapter 1: One Country, Many Climates

The country of Peru has many different climates, but two regions in particular are surprisingly different from each other. The northeast is a warm rain forest, while the southwest coastal area is a cool desert. These two regions are separated by the Andes mountains, and the mountains have a major effect on each region's climate. There are also other important factors influencing these two regional climates: Peru's location near the equator, and ocean currents traveling from the Antarctic past the west coast of Peru. To learn more about Peru, read one of the sections that follow.



This is a satellite image of Peru. The light areas near the Pacific Ocean are cool, dry deserts and the green areas are warm, wet rain forests. These two regions are separated by the Andes Mountains.

Chapter 2: Peru's Warm Rain Forests

The northeast part of Peru is covered with a warm, wet rain forest called the Peruvian Amazon. This area of Peru has more species of living things than almost any other place on Earth.

Rain forests are found where the climate is warm and wet. Because Peru is near the equator, a lot of energy is transferred from the sun to the surface there. That energy is then transferred to the air, making air temperatures very warm—an average of 30 to 38 degrees Celsius (86.0 to 100.4 degrees Fahrenheit).



About 8,000 different species of ferns and flowering plants live in the Peruvian Amazon.



The warm, wet rain forests of the Peruvian Amazon are home to many jaguars. The jaguar is the largest cat species in the Americas.

Chapter 3: Peru's Cool Coastal Deserts

The west coast of Peru is drier and cooler than the lush, green rain forest found farther from the coast. These coastal deserts get the same amount of energy from the sun as the rain forest, but the ocean current that travels past the coast affects the temperature of the air, making it cooler. This current, called the Peru Current, starts near the South Pole, where the sun transfers less energy to the surface. Since less energy is transferred to the water near the South Pole, the water is colder than water at the equator. Because Peru is near the equator, the air temperature is warm—and it is warmer than the ocean current that flows past. As the cool current passes Peru, energy from the air is transferred to the current, decreasing the temperature of the air.



The coastal deserts of Peru are cool and dry.



The Sechuran fox lives in the coastal desert of Peru, but also makes its home farther east—as far as the foothills of the Andes mountains.



The Peru Current starts near the South Pole and passes by the west coast of South America. Since the air near the equator is warmer than the current, energy will move from the air to the current, decreasing the energy of the air and decreasing the temperature.

Chapter 4: Peru's Bountiful Ocean

A cold ocean current travels up from the South Pole past Peru, making the climate at the coast of Peru cooler than the area farther away from the coast. Another process that contributes to the cold water off the coast of Peru is called upwelling. Because the sun cannot warm the water deep in the ocean, the water near the bottom of the ocean is very cold. The deep ocean water is also full of nutrients from broken-down dead matter that sinks to the bottom. In certain places on Earth, that deep, cold water rises to the top of the ocean, bringing all those nutrients with it. This rising of cold water is called upwelling. The rising cold water affects the climate of nearby land. It also provides nutrients that support the growth of a wide variety of organisms. Because of the nutrient-rich waters, these areas support large populations of organisms such as algae, marine mammals, and fish.



Humboldt penguins nest on rocky coasts of South America and feed in the nutrient-rich water that comes up from the bottom of the ocean during upwelling.

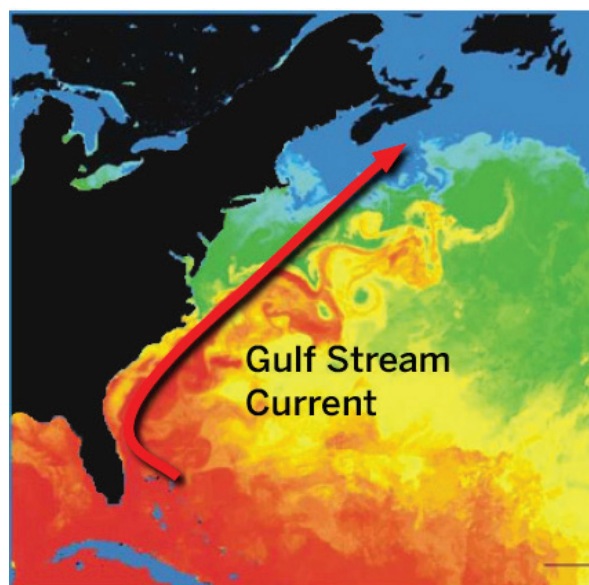
The Climates of Peru © 2018 The Regents of the University of California. All rights reserved. Permission granted to purchaser to photocopy for classroom use.
Image Credit: Mike Theiss/National Geographic Magazine

The Gulf Stream: A Current That Helped Win a War

Can you believe that an ocean current may have helped the United States become the United States? Before the Revolutionary War, Benjamin Franklin—you may know him as one of the founders of our country—and his cousin mapped a strong current called the Gulf Stream, which flows north along the East Coast of the United States. Understanding where the Gulf Stream flows was helpful for sailors coming and going from East Coast ports because ships that sailed in the same direction as the Gulf Stream, or cut straight across it, could go faster than ships that tried to sail against it. Some people have even claimed that this knowledge of the Gulf Stream might have helped America win the Revolutionary War, because American ships were able to travel around the area more quickly than British ships.

The Gulf Stream still flows today, and it still affects how goods are shipped around the world. The Gulf Stream forms near the tip of Florida and flows north, carrying warm water from the Caribbean up the east coast of North America and across the North Atlantic. This large, strong current carries more than 100 million cubic meters of water per second, more than all the world's rivers combined.

What causes the Gulf Stream current to flow, and what determines its route? The strength and direction of the Gulf Stream are driven partly by prevailing winds—winds that always blow in the same direction and are strong enough to push ocean water around. Prevailing winds near the equator blow from east to west across the ocean. Prevailing winds farther north and south blow in the opposite direction: they go from west to east. Another factor that affects the direction of the Gulf Stream and other ocean currents is the location of the continents.



This image of the Atlantic Ocean uses color to show water temperature: the warmest water looks red and the coolest water looks blue. You can see the warmer water of the Gulf Stream traveling north along the coast of North America.

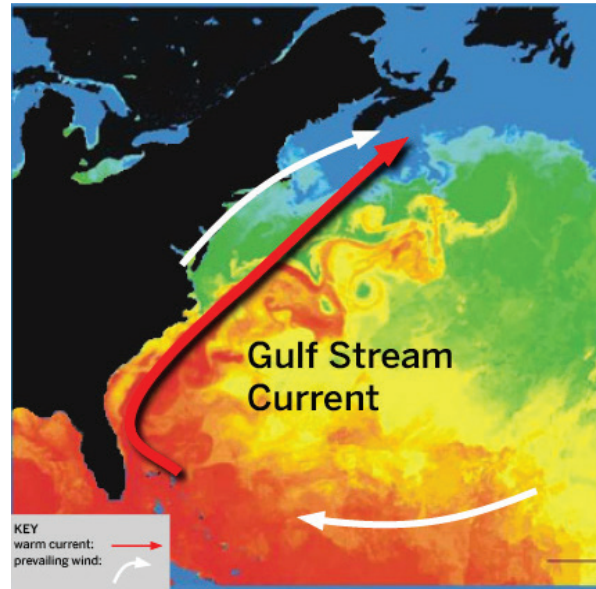


Benjamin Franklin and his cousin made the first maps of the Gulf Stream.

When a current hits a continent, it is redirected to follow the coastline.

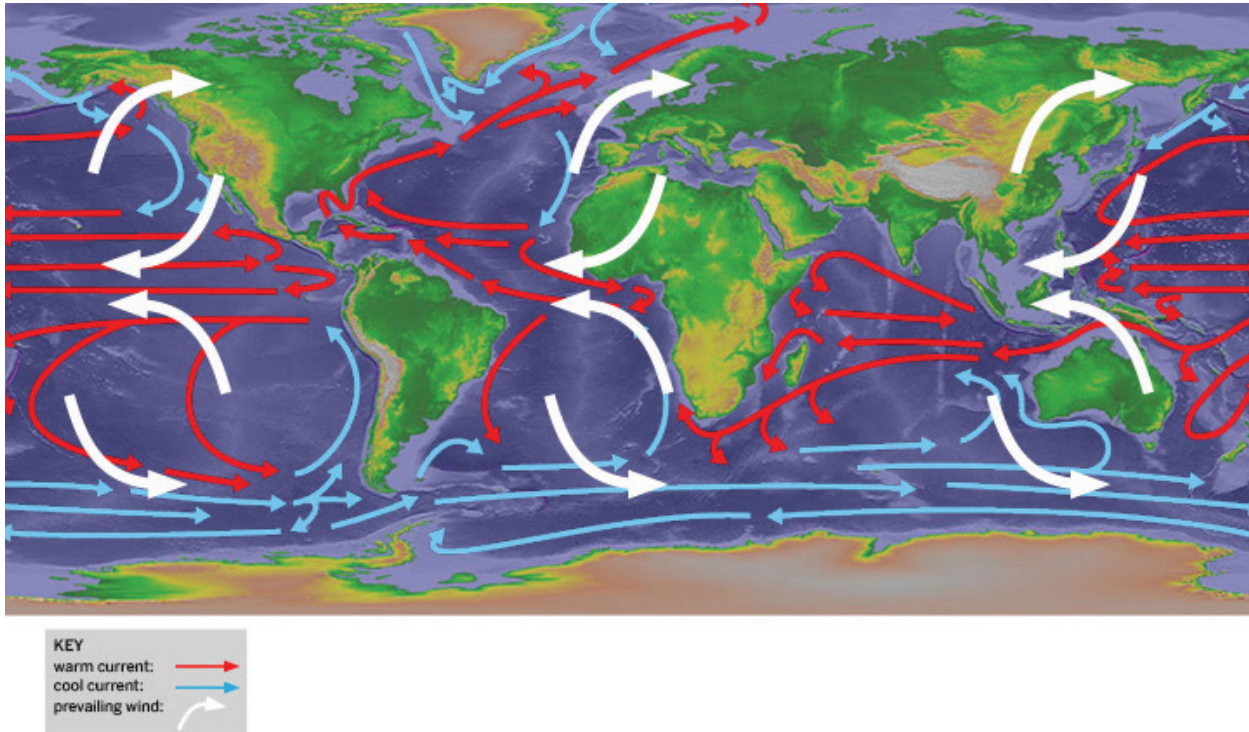
The Gulf Stream flows from south to north. How do winds blowing from the east or west make a current that flows to the north? The Gulf Stream starts off the coast of Florida, where the prevailing winds blow the water west toward Florida, in the same direction as the wind. When the water reaches Florida, it can't go any farther west, so it's forced to turn. The water flows north along the edge of North America. When the Gulf Stream reaches New England, the prevailing winds moving from west to east blow the Gulf Stream away from the coast of North America and across the northern Atlantic. The Gulf Stream warms up the air wherever it goes. The warm water carried from the equator contains a lot of energy, which transfers to the cooler air above it, bringing warm air temperatures to the East Coast of North America and making Western Europe warmer than other places at similar latitudes.

The Gulf Stream is one of the most important surface ocean currents in the world—it's very strong, covers a long distance, and has significant effects on the way humans live. Without its influence on trade routes and maybe even on the Revolutionary War, the United States might never have become the United States!



The Gulf Stream begins when warm water near the equator is pushed west across the Atlantic Ocean by the prevailing winds. When the water runs into North America, it is forced to go north along the coastline. In this map, the warmest water is represented by the color red and the coldest water is represented by the color blue. Water at a temperature between the warmest and the coldest is represented by yellow, orange, or green.

Major Ocean Currents and Prevailing Winds



Near the equator, the prevailing winds blow from east to west and drive ocean currents from east to west. Closer to Earth's poles, the prevailing winds blow in the opposite direction, from west to east. On this map, you can see how the direction of the prevailing winds in different places on Earth affects the patterns of the ocean currents.



These trees are bent over because they are in the path of the prevailing winds, which always blow in the same direction. Over time, wind has caused the trees to grow in a bent shape.

What Causes Prevailing Winds?

From a light breeze rustling the leaves on the trees in your neighborhood to the powerful winds that drive ocean currents, there's always wind blowing somewhere. Wind can blow at different strengths and in different directions—but how does wind start blowing in the first place?

Wind is caused by differences in temperature between air in one place and air in another. As warm air in one place rises, cooler air rushes in to take its place—and other air takes the place of that air, and so on. All that moving air is wind.

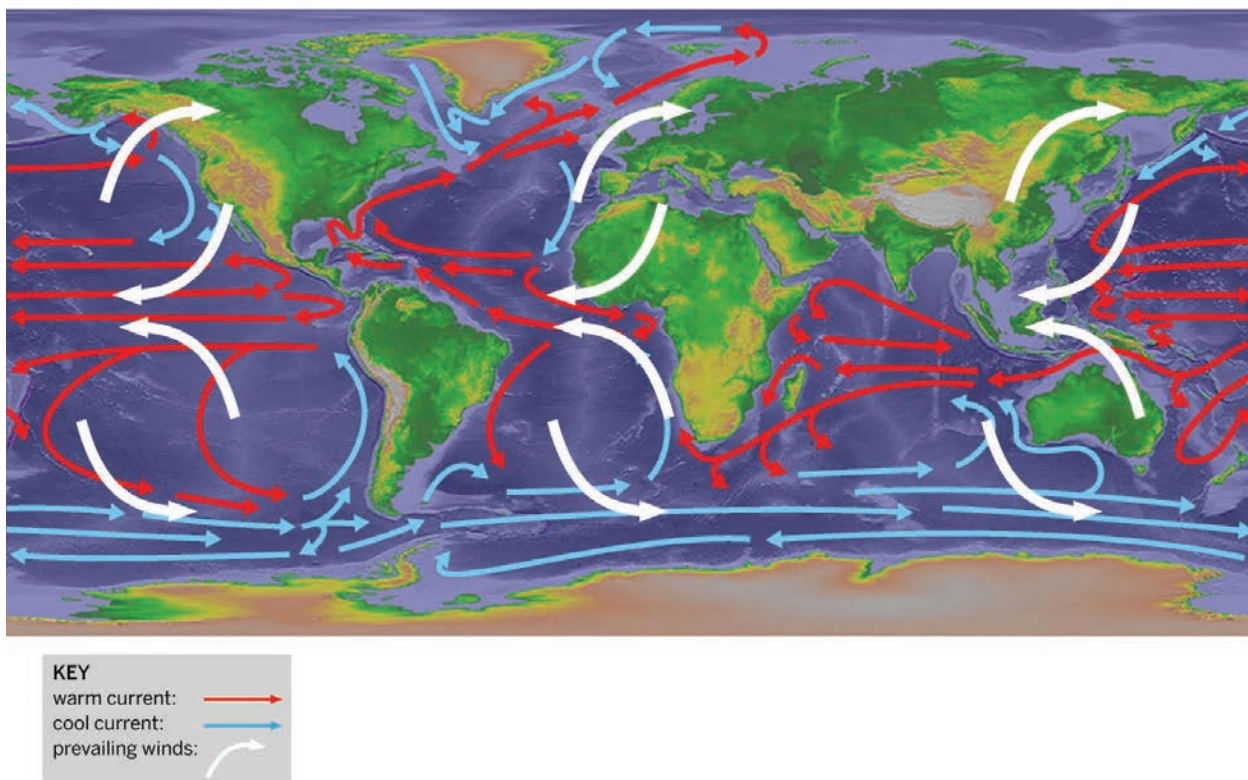
In some places on Earth, wind patterns are consistent; we call wind patterns like these prevailing winds. Prevailing winds push ocean currents all over the planet. These winds are consistent because the temperature differences that cause them are consistent. That's because the temperature differences result from the way light from the sun hits Earth at different latitudes. Latitude is the distance of a location from the equator, either to the south or to the north.

Areas near the equator get more direct sunlight than areas closer to the poles, so air tends to be warmer in areas near the equator. Areas closer to the poles get less direct sunlight, so air tends to be cooler in those places. These differences in air temperature cause wind. Warm air rises, so the warm air near the equator rises and cooler air from near the poles moves in along Earth's surface to take the place of the rising air. Because the temperature difference between

the equator and the poles doesn't change very much, the winds it causes blow consistently.

Not all winds are prevailing winds, caused by temperature differences between the equator and Earth's poles. Many of the winds you experience are local winds, which usually aren't as powerful and don't travel as far. Local winds can also blow in less consistent patterns than prevailing winds. However, even local winds are caused by the rising of warm air and the motion of cooler air to fill in those spaces. Every breeze you feel is caused by a difference in temperature somewhere.

Major Ocean Currents and Prevailing Winds



The prevailing winds consistently blow in the same patterns. The winds near the equator blow to the west, while the winds farther from the equator blow to the east.



Humans have used the wind to cross the ocean since ancient times.

The Coriolis Effect

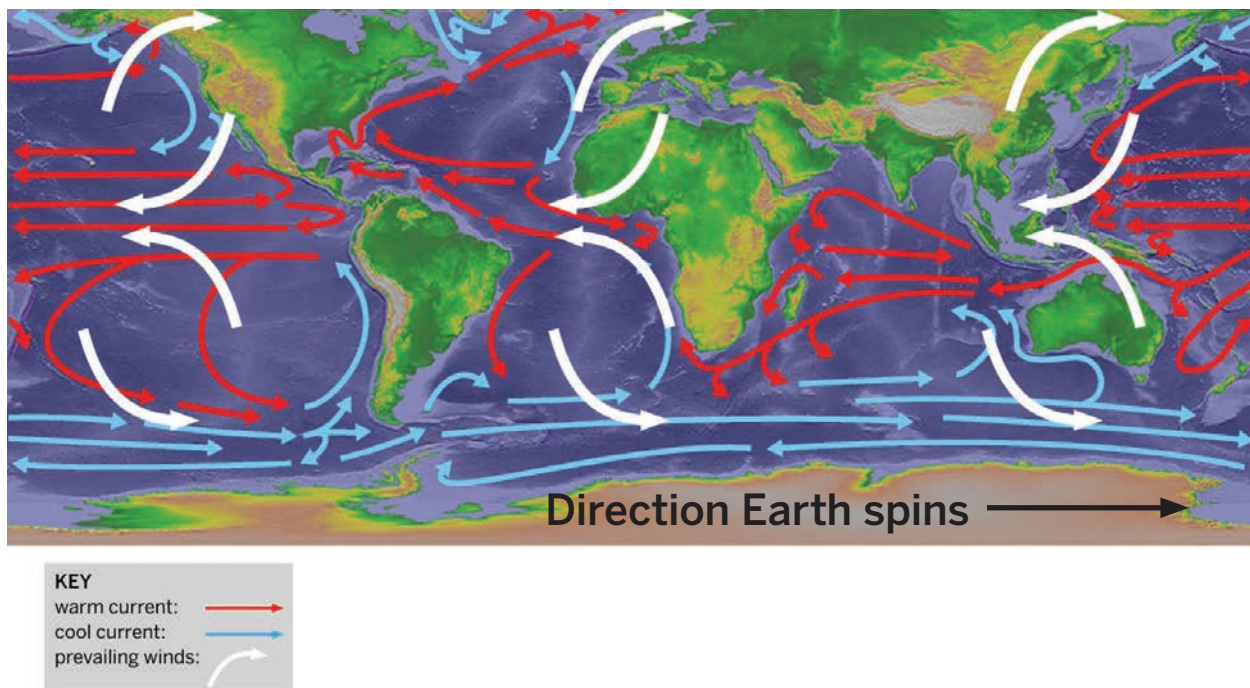
For thousands of years, the only way for humans to travel across Earth's ocean was to sail across it—and the only way to sail across the ocean was to rely on the wind. Since it's much easier to sail in the direction that the wind is blowing than to go in the opposite direction, sailors became very familiar with the patterns of wind they could depend on to take them across the ocean. Eventually, the prevailing winds closest to the equator became known as the “trade winds” because they made it possible for people from different places to travel in order to trade with one another. The prevailing winds are consistent wind patterns—but what causes them to blow consistently in the same direction? Believe it or not, the pattern they follow is partly caused by the spinning of Earth.

If Earth didn't spin, there would still be wind. The air in our atmosphere would rise at the equator and move directly north toward the poles, while air from the poles would move in to take its place. That's because wind is caused by differences in temperature between air in one place and air in another, and air at the equator is much warmer than air at the poles. However, Earth does spin—and its spinning has an important effect on patterns of prevailing winds. The curved pattern that results when something (such as wind) moves across a spinning object (such as Earth) is known as the Coriolis effect. Because of the Coriolis effect, the prevailing winds at the equator blow toward the west.

The Coriolis effect can be seen in prevailing winds all over Earth, including the trade winds that blow across the ocean. Over long distances, this curving of the flow of air causes the winds to blow in big circular patterns. As they move, the winds also push the ocean currents along with them. This is part of the reason the ocean currents form circular gyres.

By blowing in the same pattern for thousands of years, the trade winds have been a consistent influence on where humans traveled, where we decided to live, and how we traded with each other. Just think—without the Coriolis effect, life on Earth might be very different!

Major Ocean Currents and Prevailing Winds



The spinning of our planet causes winds to blow in big circular patterns. This is called the Coriolis effect, and it can be seen in the patterns of prevailing winds all over Earth.



Currents on the ocean's surface are driven by wind. However, currents in the deep ocean are caused by differences in the temperature and density of the water.

Deep Ocean Currents: Driven by Density

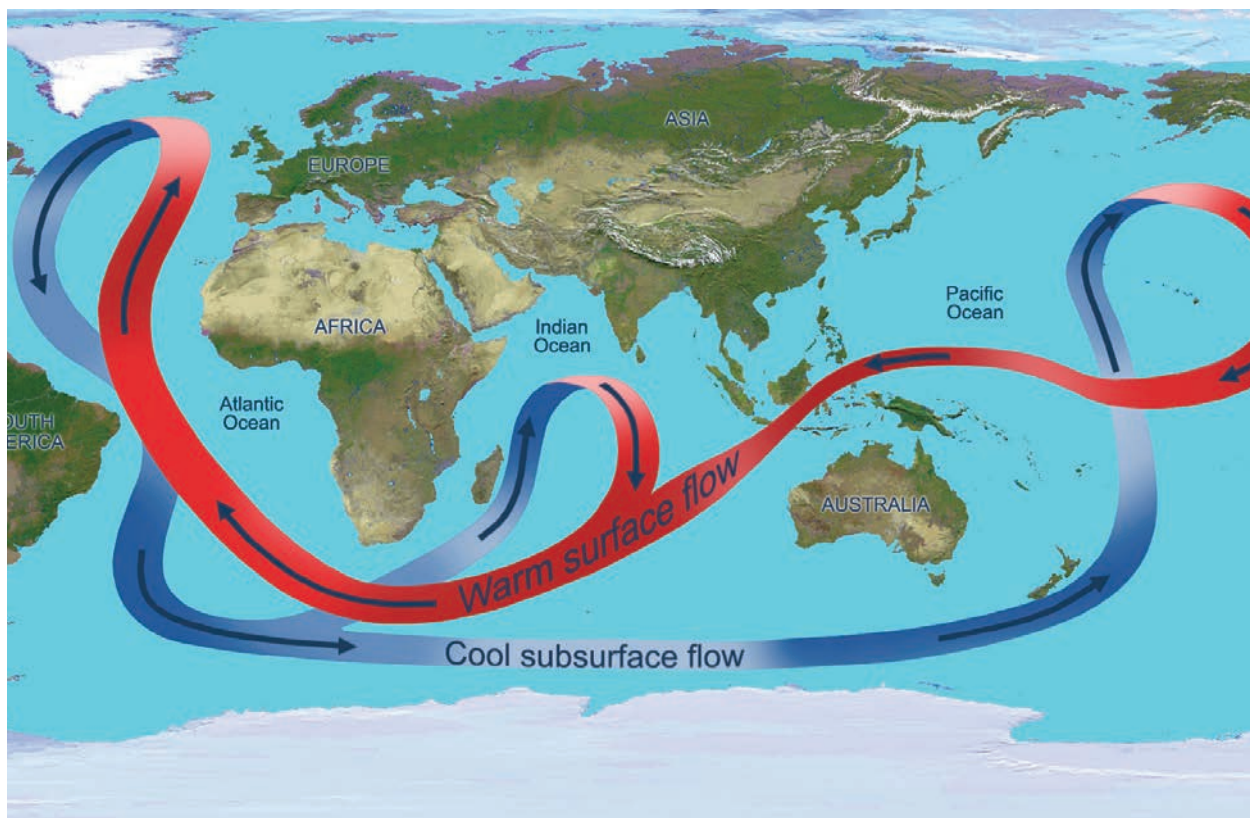
On the surface of the ocean, prevailing winds move water all over the planet, forming ocean currents that can carry everything from ships to sea turtles all over the world. However, the part of the ocean that's moved around by the wind is really only the top 300 meters (984 feet) or so—and since the ocean is an average of 3.7 kilometers (2.3 miles) deep, the layer where currents are driven by the wind is actually very thin! Water in the deep ocean travels a different path.

The motion of currents in the deep ocean is caused by differences in the water's temperature and density in different places. Density is the amount of matter in a certain space. Water that is very dense has a lot of water molecules and bits of salt packed closely together. Water that is less dense has fewer water molecules and fewer bits of salt in the same amount of space. Dense water is heavier than water that is less dense, so it sinks. That sinking water pushes other water out of the way, which pushes more water out of the way, and so on. Once the water gets moving, it's hard to stop. This process moves water all over the planet, but it takes a very long time—a complete trip around the world takes about 1,000 years!

The pattern of surface and deep-ocean currents is called the Global Conveyor Belt. The Global Conveyor Belt begins with surface ocean currents carrying warm water from the equator, where it has absorbed a lot of energy from the sun, to the chilly waters of the North Atlantic,

which don't get as much energy from the sun. Water from the equator is salty because heat from the sun causes some of the water there to evaporate, leaving salt behind. However, that salty water doesn't sink yet. Because it's warm, it isn't very dense. When that warm, salty water gets to the poles, it cools down and gets much denser. It also becomes even saltier than it was before—when sea water near the poles freezes into ice, it leaves salt behind, which gets mixed into the surrounding water. The combination of added salt and cold temperatures makes the water very dense, and it sinks to the bottom of the ocean.

Once the water reaches the bottom of the Atlantic, it takes a long, slow trip around the world—back down to Antarctica, into the Indian Ocean or around Australia and into the Pacific, where it approaches the equator and starts to rise to the surface once it begins to warm up. Eventually, it makes its way back through the Indian Ocean to the Atlantic, where it begins the whole process again. Over time, all of the water in the ocean makes this trip and cycles between the dark depths and the sunny, windy surface.



The Global Conveyor Belt carries cool water south from Greenland to Antarctica and into the Indian and Pacific Oceans. In those places, the water warms and rises to the surface, where it begins its journey back to the beginning of the cycle.

Ocean, Atmosphere, and Climate: Cold Years in New Zealand



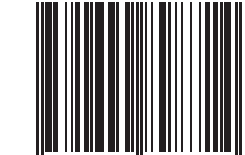
THE LAWRENCE
HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Amplify.

Published and Distributed by Amplify.
www.amplify.com

AMP.NA18

ISBN 978-1-64089-871-4



9 781640 898714 >