

Natural Causes of Climate Change

Textbook pages 464–481

Before You Read

What is the difference between climate and weather? Write your ideas in the lines below.

What is climate?

Climate describes the average conditions of the atmosphere in a large region over 30 years or more. Climate includes such characteristics as clouds and precipitation, average temperature, humidity, atmospheric pressure, solar radiation, and wind. Climate can refer to conditions in a region as small as an island or to conditions across an entire planet. Because of its varied geography, British Columbia has a range of climates. A **biogeoclimatic zone** is a region with a certain type of plant life, soil, geography, and climate. British Columbia has 14 biogeoclimatic zones.

How do scientists determine past and current climatic change?

Geologic evidence shows that, throughout its history, Earth has undergone many climatic changes, including ice ages and periods of warming. **Paleoclimatologists** study fossils and sediments or gather information about glaciers to help them understand climatic change. They examine **ice cores** to determine what types and amounts of gases existed in the atmosphere when the ice was formed. Ice core data have been used to estimate the concentration of carbon dioxide gas that was in the atmosphere over the past 650 000 years, allowing scientists to estimate past climatic conditions. Scientists draw conclusions about current climatic changes by observing current climate and by comparing their observations with evidence of past climates.



Mark the Text

Identify Concepts

Highlight each question head in this section. Then use a different colour to highlight the answers to these questions.



**Reading Check**

How do greenhouse gases increase Earth's temperature?

Which factors affect climate?

The processes that contribute to climate change are complex and include factors that affect Earth's radiation budget and heat transfer around the globe. Several factors affect climate:

1. The composition of Earth's atmosphere: **Greenhouse gases** in the atmosphere absorb and emit radiation as thermal energy, increasing Earth's temperature. The more greenhouse gases, the higher the temperature of our atmosphere. ✓
2. Earth's tilt, axis of rotation, and orbit around the Sun: Earth experiences seasons due to the combination of its tilt and orbit. Seasonal changes are most extreme when Earth's tilt is greatest (the angle of Earth's tilt varies between 22.1° and 24.5° in cycles of about 41 000 years). Changes in Earth's axis of rotation also affect the angle of incidence of the Sun's rays. Variation in the shape of Earth's orbit changes its distance from the Sun and the amount of solar radiation that reaches Earth's surface. In addition, Earth's rotation also has a wobble, which will affect the angle of incidence of the Sun's radiation over a period of thousands of years.
3. The water cycle: The **water cycle** describes the circulation of water on, above, and below Earth's surface. High temperatures increase the evaporation of water (the most abundant greenhouse gas) and the capacity of air to hold water vapour. As surface temperatures rise, so does the amount of water vapour in the atmosphere. As the atmosphere holds more water vapour, it traps more thermal energy, resulting in a further increase in temperature. As temperatures continue to rise, glaciers and ice shelves melt, causing sea levels to rise around the world.
4. Ocean currents: The sinking and rising of deep ocean waters produces convection currents that act as a global conveyor belt that transports water—and thermal energy—around Earth. Surface currents, caused in part by the Coriolis effect, exchange heat with the atmosphere, so these currents also influence both weather and climate.

continued

Periodically, surface waters off the coast of Ecuador and Peru get unusually warm, a phenomenon known as an **El Niño** event. Unusually weak westerly trade winds allow warm water in the western Pacific to move eastward. This prevents cold water from upwelling, and triggers changes in weather across much of North America. In contrast, in a **La Niña** event, stronger than normal westerly winds allow cooler-than-normal waters to come to the surface in the eastern Pacific Ocean. This brings cooler temperatures to northwestern North America. Both El Niño and La Niña affect climate in North America. The variation in the winds, including El Niño and La Niña events, is known as El Niño-Southern Oscillation.

5. **The carbon cycle:** The carbon cycle maintains the balance of carbon dioxide in the atmosphere. Carbon dioxide is an important greenhouse gas. **Carbon sinks**, such as the deep ocean, shelled organisms, and forests, remove carbon dioxide from the atmosphere. Carbon in ocean waters is converted to carbonates, an important ingredient in the shells of many marine organisms. **Carbon sources**, such as weathering and decaying vegetation, add carbon dioxide to the atmosphere. ✓
6. **Catastrophic events:** Large-scale disasters, such as volcanic eruptions and meteor impacts, add dust, debris, and gases high into the atmosphere. They reflect and absorb solar radiation, causing the atmosphere below to cool.



Reading Check

Give an example of a carbon sink.

Use with textbook pages 464–475.

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Vocabulary

carbon sink	natural greenhouse effect
catastrophic events	paleoclimatologists
climate	shape
convection currents	tilt
Coriolis effect	water vapour
El Niño-Southern Oscillation	weathering
	wobble

Use the terms in the vocabulary box to fill in the blanks. Use each term only once.

- _____ describes the average conditions of the atmosphere in a large region over 30 years or more.
- _____ gather information about glaciers using ice cores to determine what types and amounts of gases existed in the atmosphere when the ice was formed.
- Life on Earth is adapted to the conditions provided by the _____, which balances incoming solar radiation and outgoing heat.
- The combined effects of _____, _____, and the _____ of Earth's orbit can be linked to the cooling of the global climate in the past and the cause of the ice ages.
- _____ is the most abundant greenhouse gas in the atmosphere.
- _____ in the oceans transport large amounts of heat around the globe.
- Currents of air or water are deflected to the right in the northern hemisphere and to the left in the southern hemisphere due to the _____.
- The variation in the winds, including El Niño and La Niña events, are described as _____.
- The deep ocean is considered a _____ because it removes carbon dioxide from the atmosphere.
- _____ is the gradual physical or chemical process that breaks rock into smaller pieces.
- Earth has experienced many _____ or large-scale disasters such as large volcanic eruptions or being struck by meteorites.

Use with textbook pages 467–475.

Factors that affect climate

1. What would be the temperature on Earth if the amount of greenhouse gases decreased?

2. What would be the effect on the climate in the northern hemisphere if the tilt of Earth increased from 23.5° to 24.5° ?

3. Over time, the wobble in Earth's rotation will change. What effect will this have?

4. What is the relationship between the shape of the Earth's orbit and solar radiation?

5. What effect does an increase in yearly temperatures have on climate?

6. What is the main problem caused by melting glaciers?

7. What would happen to Earth's temperature if the levels of carbon dioxide released into the atmosphere continues to increase?

8. What are some of the effects of a volcanic eruption that could affect climate?

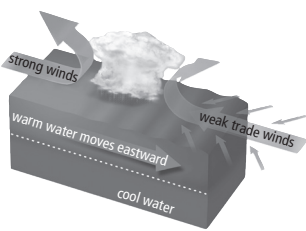
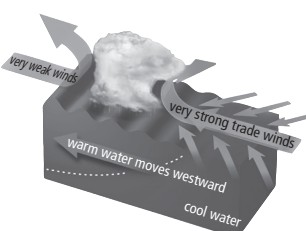
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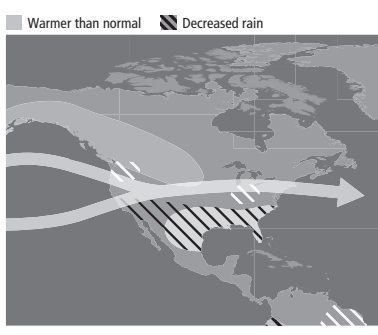
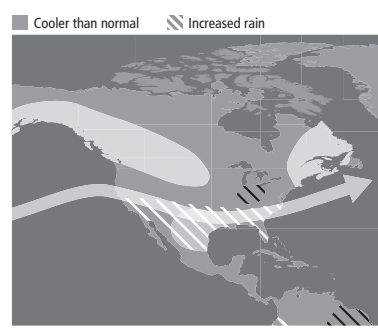
Use with textbook pages 476–479.

El Niño and La Niña

1. Answer the questions using the figures below.

	
<p>(a) What weather phenomenon is illustrated by the figure above? _____</p> <p>(b) Describe the weather patterns caused by this phenomenon.</p> <p>_____</p> <p>_____</p>	<p>(c) What weather phenomenon is illustrated by the figure above? _____</p> <p>(d) Describe the weather pattern caused by this phenomenon.</p> <p>_____</p> <p>_____</p>

2. Using the weather maps of North America below, answer the following questions.

	
<p>(a) What weather phenomenon is illustrated by the map above? _____</p> <p>(b) Describe the weather patterns in North America caused by this phenomenon.</p> <p>_____</p> <p>_____</p>	<p>(c) What weather phenomenon is illustrated by the map above? _____</p> <p>(d) Describe the weather patterns in North America caused by this phenomenon.</p> <p>_____</p> <p>_____</p>

Use with textbook pages 464–479.

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Match each Term on the left with the best Descriptor on the right. Each Descriptor may be used only once.

Term	Descriptor
1. _____ carbon sink	A. a body or process that releases carbon dioxide into the atmosphere
2. _____ carbon source	B. a system of ocean and atmospheric changes in the tropical Pacific Region
3. _____ El Niño	C. cooler-than-normal water coming to the surface in the eastern Pacific Ocean due to upwelling
4. _____ El Niño-Southern Oscillation	D. a body or process that removes carbon dioxide from the atmosphere and stores it
5. _____ greenhouse gases	E. an unusually warm ocean current that develops periodically off the coast of Ecuador and Peru
6. _____ La Niña	F. people who study climates of the past
7. _____ natural greenhouse effect	G. the closed system, provided by the atmosphere, that keeps Earth's temperatures within a range
8. _____ paleoclimatologists	H. gases in Earth's atmosphere that absorb and trap radiation as thermal energy

Circle the letter of the best answer.

9. Ice core data have been used to measure the amounts of which type of gas?
- A.** oxygen **C.** carbon monoxide
B. nitrogen **D.** carbon dioxide
10. An increase in greenhouse gases in the atmosphere will
- A.** decrease temperatures on Earth
B. increase temperatures on Earth
C. make temperatures fluctuate
D. have no effect on Earth's temperature
11. Which of the following are factors that affect the path of surface water currents?
- I.** wind
II. Earth's rotation
III. shape of continents
- A.** I only **C.** I and III only
B. I and II only **D.** I, II, and III
12. An El Niño event results in
- A.** cool temperatures in British Columbia
B. cool temperatures in California
C. warm temperatures in British Columbia
D. warm temperatures in California
13. The remains of ancient marine organisms are composed of
- A.** carbon dioxide **C.** calcium carbonate
B. sulphur dioxide **D.** sodium carbonate
14. Catastrophic events, such as large volcanic eruptions, can affect climate by
- A.** increasing the temperature of the troposphere
B. decreasing the temperature of the troposphere
C. decreasing carbon dioxide emissions
D. increasing carbon dioxide emissions