

Unit 12

Earth's Changing Climate

Background

Introduction

Earth has been undergoing one of the most extensive experiments in the history of civilization. Today the planet is warmer than it has been for thousands of years. Climate changes can be caused both by natural forces and by human activities. Ancient records of climate, held in glacial ice formations, offer some clues about a warming world. Global climate change could result in rising sea levels, changes to patterns of precipitation, increased variability in the weather, and a variety of other consequences. These changes threaten our health, agriculture, water resources, forests, wildlife, and coastal areas.

Essential Questions

- What do we know about global climate changes over the course of Earth's history?
- What are the effects of global climate change on today's world?
- What does the future hold in terms of global climate change?

Content

Unit 12 focuses on how present warming trends over the entire planet are caused by human activities, how past changes have been investigated, and what future warming scenarios might hold for natural and human ecology. The Unit 12 text introduces basic science concepts and focuses on Earth as a complex system that constantly changes. The global climate system is explained in terms of geological, hydrological, biological, and sociological interactions, which all affect global climate. Unit 12's content builds from Unit 2, Atmosphere, and leads to interesting projections of near-term impacts and the major laws and treaties that will affect future generations.

In the Unit 12 video you will be introduced to the idea that future changes might be predicted by knowledge of the past. In Part One, Dr. Lonnie Thompson and his work using ice cores from tropical glaciers to investigate past climate change provide an interesting insight into ecological field sciences and past environmental conditions. Dr. Thompson's studies indicate clearly that recent climate change is a result of human activities. However we are not sure what the future holds for ecosystems. In Part Two we meet Dr. Chris Field, whose Jasper Ridge Global Change Experiment uses various climate change scenarios to attempt to predict 50 to 75 years in the future. The results of these studies will help us to better understand, predict, and cope with global climate change.

Background

Learning Goals

During this session you will have an opportunity to build understandings of the following:

- a. Knowledge
 - i. Atmospheric changes take place over time.
 - ii. World-wide data has been collected on climate change.
 - iii. The rate of change has increased in recent history.
 - iv. Atmospheric change results in plant growth changes.
 - v. Climate change has direct ecological consequences.
 - vi. Ecological consequences cannot necessarily be predicted.
- b. Skills
 - i. Science is a descriptive process.
 - ii. Science is an experimental process.
 - iii. Science helps explain past, present, and future events.
- c. Dispositions
 - i. Global climate change has a direct impact on social, economic, political, and economic systems.
 - ii. Science helps inform us about ecological effects of changing systems.

Key Concepts

Earth's atmosphere	Recent history
Greenhouse effect	Industrial age
Greenhouse gases	Impacts
Aerosols	Human society
Climate change	Natural ecosystems
Global warming	Laws and treaties
Carbon cycle	Feedback systems

FACILITATOR: These concepts correspond roughly to the sections of the unit. There are a number of other concepts that could be included. It is best to start with the author's major ideas and then ask for input from the study group for other concepts they would include.

Background

Misconceptions and Climate Change

With the increasing public awareness and media focus on ecological conditions, it is clear that educators must address the common misconceptions people hold about climate change. The causes of misunderstandings related to climate changes come from applying ideas drawn from other ecological problems such as pollution and ozone depletion, confusing concepts of climate and weather, and intuitive observations of the existing environment.

A common misconception is that the greenhouse gases responsible for climate change are forms of air pollution. We know that pollution is made up of artificial chemicals or substances that are toxic to life. Automobiles and industry are the principal sources of these toxic chemicals. Confusing air pollution with climate change leads to misconceptions about the health effects attributed to bad chemicals and thus climate change. The pollution model of climate change ignores the influences of farming, deforestation, and efficient energy use in global climate change.

If climate change results in deforestation, it is possible that animals will use more oxygen than plants produce and will not be able to breathe. Most people know that plants (trees) take in carbon dioxide and give off oxygen. We also know that deforestation is contributing to raising the level of atmospheric carbon dioxide. Therefore, in some peoples' minds, because there are fewer trees, animals may eventually use up all the oxygen in the atmosphere and be unable to breathe.

Misconceptions about weather and climate are very common. People consider human activity to be a major factor in weather change. In addition, people believe that they have already witnessed the effects of global climate change on local weather conditions. The popularization of global climate change has provided a conceptual framework for people to interpret their personal observations. The correct interpretation is that global climate change includes changes in weather patterns, more violent tropical storms, rising sea levels, and shifts in ocean currents that could cause regional climate changes shifts in ecological zones and alterations in patterns of plant growth and development.

Getting Ready (45 minutes)

Activity One: Assessing Prior Knowledge, Questions, and Related Experiences

FACILITATOR: Distribute index cards to the study group. On the first card, participants should indicate something they know about climate change. On the second, they should write one question they have about climate change. And on the third card, they should describe a direct experience that they have had that relates to climate change. For example an individual might write:

Climate change is occurring faster than ever.

What causes climate change?

It seems the winters are warmer with less snow.

Getting Ready

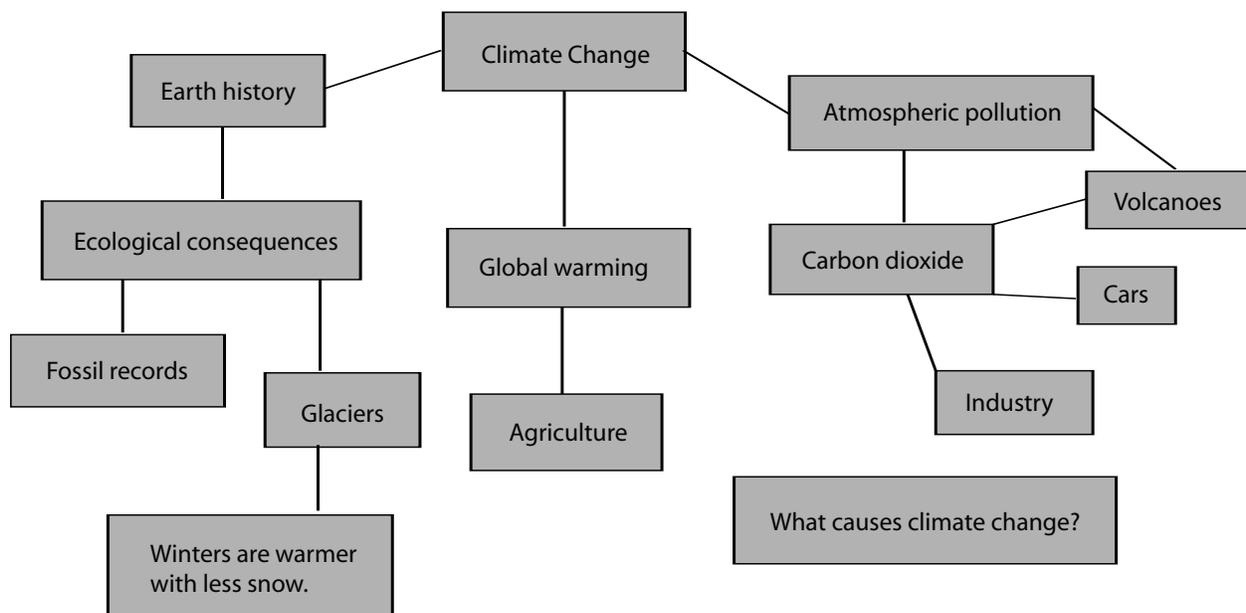


Figure 12.1 An example of a study groups' idea collection, with major subjects identified and the addition of the major focus ideas of the video. This activity links individual pre-existing knowledge with that of other members of the group and the unit content.

Activity Two: Current Events & Editorial Cartoons

Participants will share an article that they have found that relates to the week's topic. All members of the group will share their headlines for the articles. The leader should ask a few people to summarize their articles and ask for comments from others with related articles. As the group discusses the articles, a participant should record key concepts and make a list. (Participants may choose to bring in a cartoon or an editorial related to the week's topic instead of an article.)

Activity Three: Greenhouse Demonstration

The demonstration can be used during the first half of this study session to illustrate or investigate global climate change. The materials and apparatus should be set up before the workshop begins.

Materials

2 identical containers	Vinegar
2 covers	Baking soda
clock	2 shallow dishes
light source	2 thermometers
Matches	Setup

The containers should be placed side-by-side with 5–10 cm between them. Place a thin layer of black sand on the bottom of both containers. Put one thermometer inside each tank. The thermometers should be located and

Getting Ready

oriented so that they can be easily read when the experiment is underway. Place one dish, face-up, in the center of each tank. The dishes should be broad and shallow. Mount the light above the containers. The light should have at least a 150 watt bulb. Measure 5 ml of vinegar for 1 ml (~1 g) of baking soda for one container.

Procedure

The demonstration should begin with the containers at room temperature and with the light source off. Add the vinegar slowly to one container so that the dish does not overflow. At the start of the demonstration, note the temperatures in the two containers. Repeat these measurements at regular intervals every 30 seconds, until the temperatures in both tanks begin to plateau.

NOTE: It is important to begin this experiment with the containers near room temperature and to allow a minute or so between turning the light source on and taking the first temperature measurement. One complicating factor in this demonstration is that the vinegar-baking soda-CO₂ producing reaction is endothermic. During the reaction itself, the temperature in the experimental tank may go down. Give the containers time to adjust to the temperature changes.

Discussion

1. Which container heats faster and to a higher temperature?
2. Why is there a difference between the containers?
3. How is this demonstration similar to the greenhouse effect?
4. What conclusions can you draw about climate change?

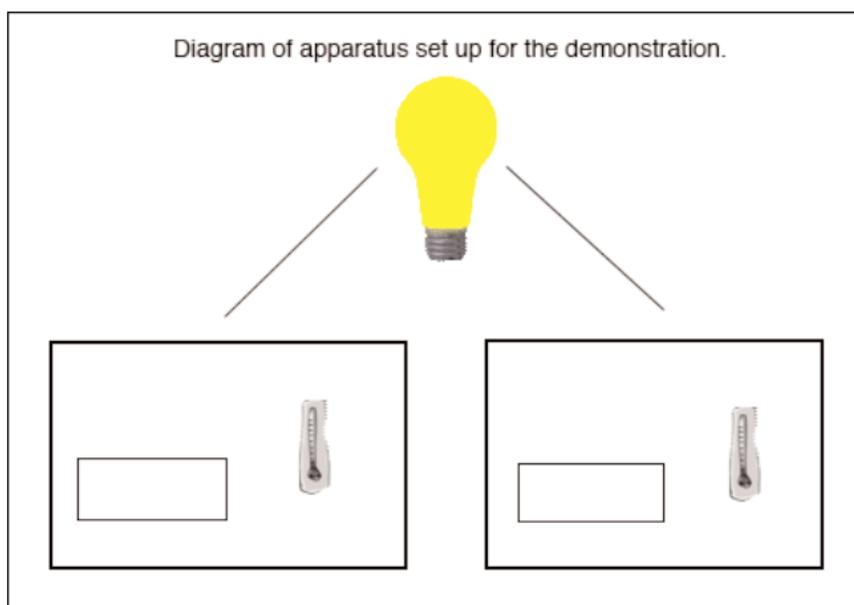


Figure 12.2 Activity 3 Set-up

Video (45 minutes)

Activity Four: Watch the Video

As you watch the video, think about the following focus questions.

1. What can we learn about recent climate change from studying ice cores?
2. Is climate change a naturally occurring event/process?
3. How and why is studying the tropics important to climate science?
4. What is preserved in ice cores that reveals climate history?
5. What is the current status of glaciers and their distribution on Earth and how rapidly are they changing?
6. How can plant communities be used to build predictive models of climate change?
7. Does carbon dioxide play a role in the negative feedback system of climate change? How?
8. What are the research findings for the Jasper Ridge Experiment?

Activity Five: Discuss the Video (15 minutes)

Discuss the following questions about the video.

1. What is the combined effect of different factors (CO₂ levels, water levels, nutrients, temperature, species diversity) on an ecosystem?
2. What evidence do we have for global warming or climate change?
3. How do scientists study global climate change in the past and how can we predict the future?
4. How does the past inform the future?

FACILITATOR: Refer back to the misconception section and Activity One: Assessing Prior Knowledge. Has the video contributed to the participants' new understanding of concepts? Are there any changes the participants would make about the arrangement of their cards from Activity One?

Going Further (60 minutes)

Activity Six: Historical Climate Statistics

This group activity focuses on the analysis and discussion of the historical temperature records from central England from 900 AD to 1900 AD. The objective is to demonstrate the concept of climate change at a specific place over time. We know from the video that scientists have evidence that global climate has changed in the past and is subject to natural changes over time. From the historical and geologic records we know that global temperature change has been both dramatic and gradual. We also know that natural events such as volcanic eruptions can have an effect on local and global temperature.

Materials

Graph paper

Going Further

The information in the following table shows the average winter temperature in central England from 900–1900 AD.

Year	900	950	1000	1050	1100	1150	1200	1250	1300	1350	
Temp (° C)	3.45	3.55	3.62	3.69	3.58	3.69	4.12	4.09	4.05	3.81	
Year	1400	1450	1500	1550	1600	1650	1700	1750	1800	1850	1900
Temp (° C)	3.63	3.46	3.65	3.5	3.21	3.18	3.38	3.55	3.47	3.66	3.97

Plot on graph paper, time on the x axis and temperature on the y axis.

Discussion Part 1

1. What conclusions can you make, in general, from the whole plot?
2. When are temperatures the highest and the lowest?

Look at the period from 1550 to 1700. This is often referred to as the Little Ice Age, a period of particularly harsh climate conditions across most parts of the world. A combination of decreased solar activity and numerous large volcanic eruptions cooled Earth's climate. Cooling caused glaciers to advance and stunted tree growth. Livestock died, harvests failed, and humans suffered from increased famine and disease. Other examples of climate change due to natural forces exist, including the "year without a summer," which followed the 1815 eruption of Tambora, in Indonesia. At an earlier time, Europe experienced a warm period that may have helped the Vikings to settle Greenland. In order to understand the current climate change debate, one must understand that natural events and cycles play an important role in determining climate on Earth.

Discussion Part 2

In the graph below you can see the percent of volcanic particles suspended in the atmosphere and the dates at which specific events occurred. Discuss the following questions.

1. How do you think volcanic particles get into the atmosphere?
2. What effect would these particles have on the amount of sunlight reaching Earth?
3. What is the correlation of the temperature graph to the volcanic particles graph?
4. What other historical events might be associated with change in annual temperature?

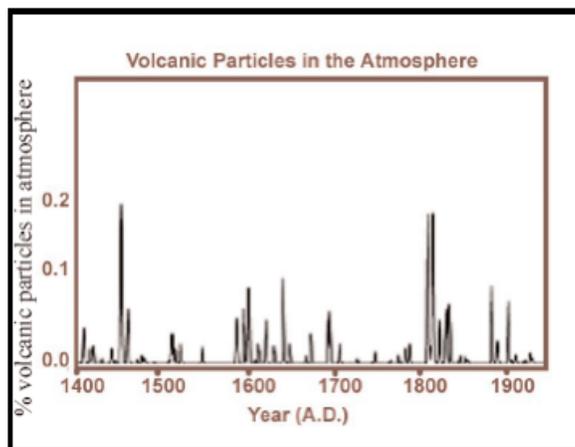


Figure 12.3 Graph of Volcanic Particles in Atmosphere from 1400 to 2000

Going Further

Activity Seven: Return to Essential Questions

The facilitator should draw the attention of the participants back to the essential questions posed in the Background Section of this unit guide. Discuss how the participants' ideas may have changed in regard to the questions. Discuss the most logical and complete answers to the questions.

Activity Eight: Discuss Classroom Supplementary Activities

Following the Between Sessions section of each unit are Classroom Supplementary Activities. These activities are related to the unit topic and are suitable for middle and secondary science classrooms. If the participants in this study group are teachers, the facilitator should take the time to review these lessons. If participants are familiar with the lessons, they should describe how they have used them. Discuss how the classroom activities might be used in relation to a specific science topic and how the activities can help relate the unit topic to classroom lessons.

Between Sessions

Bring to Next Session

Keep a record for one entire day of all of the food you eat and where each product comes from. (You can usually find where a product was made on the label.) Please bring this record to the next session where you will do an activity that examines the amount of energy used to bring food to your table.

Next Week's Topic Overview

Read Unit 13 before the next session. In Unit 13, the emphasis is on the environment's response to humans. Sub-topics will each examine a different area of concern, and examples are given. All of the sub-topics are linked to projections of the future, and the uncertainties with predicting the future will be a key part of the discussion.

Read for Next Session

Read the Unit 13 Professional Development Guide background section. Consider the essential questions as you read the text. The misconceptions section will give you some insight into what misunderstandings people may have about possible solutions to environmental challenges. Consider discussing the topic with your friends or students and discussing common misconceptions.

Current Events

Bring in a current event article, cartoon, or editorial related to solutions to today's environmental challenges.

Supplementary Classroom Activity 1

Plant Growth and Nutrient Availability

This activity demonstrates why most soils are deficient in essential plant nutrients.

Setup

Collect various types of soils, enough of each for testing with test kits (clay, sand, artificial soils such as growing media and vermiculite). All samples should be air dried before initial testing. Enough of each type of soil should be set aside so that initial tests for nutrient content may be established (N, P, K, and pH). Data should be recorded on data sheets as well as in a central location. This will be your beginning fertility data.

Procedure

Mix a commercial fertilizer with soil in a 1:1 ratio. Soil tests should be performed again after fertilization. (Air-dry soils completely if a liquid fertilizer is used.) Flower pots with drainage holes should be filled with each type of soil/fertilizer mix, one type of soil per pot.

Thoroughly water each pot (approximately 200 mL of water per pot). After watering, pots should be allowed to drain and dry for 3 days. Place the pots in a sunny location to facilitate drying.

Repeat the watering of pots two more times. Allow to dry thoroughly, then remove each soil sample from its pot to ensure complete drying before re-testing. Collect a composite from each type for testing. Complete the tests for pH N, P, and K.

Analysis

Compile all data and compare to initial soil tests. Conclusions should be drawn as to each soil type's nutrient holding capacity. This activity demonstrates why most soils are deficient in nutrients. Point out that nutrient withdrawal by plants is not the main factor that determines the soil's inherent nutrient holding capacity. Draw conclusions about other factors that affect nutrient holding capacity (soil type, organic matter content, organic vs. inorganic origin, water holding capacity, etc.).

Supplementary Classroom Activity 2

Investigating Ice Cores

Materials

Plastic graduated cylinders

Food coloring

Particles (ash or pollen)

pH test kit

Dissolved oxygen kit

Nitrogen and/or phosphate kit

Supplementary Classroom Activity 2

Preparation

Before class, the teacher should prepare one ice core per pair or triad of students. The plastic graduated cylinders should be able to stand up inside of your freezer. Over a period of a week, add different layers of water to the cylinder, allowing the water to freeze before adding the next layer. Make the various layers of ice different from each other by varying the color, suspended particles, pH, oxygen, nitrogen, or other physical factors. Be sure to correlate one chemical factor (pH) with one physical factor (ash particles).

Bring the core samples to class (packing them in ice and dishtowels in a cooler assists greatly in the preservation of the ice cores). The class will investigate the physical and chemical characteristics of each layer. They can remove the cores from the cylinder by slowly pouring warm water over the cylinder until it melts enough for the core to slip out. Students should measure, draw, and label the thickness of the different layers of ice and graph the data over imaginary time. Students then take samples from sections of the core and test for particulates, pH, or oxygen. Finally, students will draw and graph the results.

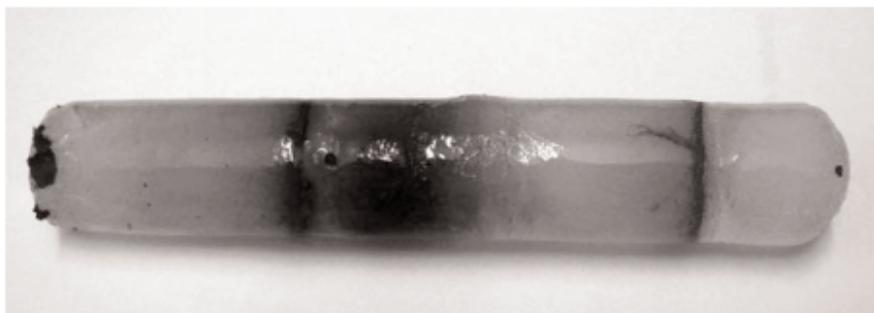


Figure 12.5 Ice Core Sample

Introduction

Conduct a general class discussion about what students know about air pollution and how they would go about finding evidence of air pollution, perhaps from a volcano. Some general open-ended questions that would be appropriate to elicit relevant student knowledge would be:

Has anyone ever seen air pollution? Where? When?

What did it look like? How does that compare to another student's description of air pollution?

How was the air pollution formed? When?

How did the air pollution get in the snow?

Procedure

Give each small group one ice core.

Ask students to do the following.

- Predict if there is evidence of air pollution in their ice core.
- Identify layers of ice and measure and diagram the layers.
- Separate the layers by cutting or breaking the ice.
- Measure the mass of the sample. Record results.
- Measure the volume of the sample using a graduated cylinder and melting the water.

Supplementary Classroom Activity 2

Discuss this aspect of the measurements with students. Density can be calculated at this time, as well.

Ask students to continue.

- Melt each of the layers and measure the pH.
- Predict the presence of air pollution in their samples based on the observation of sedimentation in each of their melted layers, and by taking a measurement of the pH level.
- Carefully extract the ash or boil away the melted ice water and mass the ash.

On the board, a large piece of paper, or an overhead, have all the groups report their results. Construct a class data table and have the students:

- Compare their predictions to their results
- Look for trends in the data, high and low pH vs. presence of air pollution
- Compare their group data to the overall class data
- Try to determine if pH does help them predict the presence or absence of air pollution in an ice core

Layer	Mass (g)	Volume (ml)	pH	Prediction	Mass of particles (g)
A	20	20	7	None	0
B	26	25	5	Some	1.0
C	19.5	18	4	Many	1.5
D	19.5	19	6	Few	.5

Discuss methods that scientists use in predicting the presence of air pollution.

Since there is bound to be some anomalous data, discuss with the class the sources of error and how the process of science includes aspects of non-confirming data.

Notes
