NATIONAL GEOGRAPHIC

**RESOURCE LIBRARY**
ACTIVITY : 45 MINS

# Earth's Changing Climates

Students are introduced to the unanswered question about the future of Earth's climate. They explore data showing temperature changes over the past 120 years and data illustrating climate trends over different time scales. Students evaluate the information the data provide and consider the limitations of conclusions based on the data.

**GRADES**

7 - 12+

**SUBJECTS**

*Earth Science*

**CONTENTS**

3 Links

## OVERVIEW

Students are introduced to the unanswered question about the future of Earth's climate. They explore data showing temperature changes over the past 120 years and data illustrating climate trends over different time scales. Students evaluate the information the data provide and consider the limitations of conclusions based on the data.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/earths-changing-climates/

## Content Created by

The Concord Consortium

# DIRECTIONS

**1. Activate students' prior knowledge about Earth's climates.**

Tell students that climate is the average weather of a region over a long period of time and that there are many different climates on Earth today. Ask:

- *What are some examples of climates?* (Some commonly known climates are desert, rain forest, tropical monsoon, tropical savanna, humid subtropical, humid continental, oceanic, subarctic, and tundra.)

- *What factors determine a region's climate?* (Climate determining factors are location—next to an ocean or near the equator, for example—precipitation, and temperature.)

Tell students that climate scientists use the average temperature of the Earth as a measure of climate change. Ask: *Has Earth always had the same climates as it has today?* (No. Earth has gone through many climatic shifts in its history, including ice ages and warm periods.) Tell students that they will be looking at global temperature data to investigate how different Earth's climates might be in the future.

**2. Discuss the role of uncertainty in the scientific process.**

Tell students that science is a process of learning how the world works and that scientists do not know the "right" answers when they start to investigate a question. Tell students they can see examples of scientists' uncertainty in climate forecasting.

Show the **Global Temperature Change Graph** from the 1995 IPCC (Intergovernmental Panel on Climate Change) report. Tell students that this graph shows several different models of forecast temperature changes. Ask: *Why is there more variation (a wider spread) between the models at later dates than at closer dates?* (There is more variation between the models at later dates than at closer dates because there is more variability in predicting the far future than in predicting the near future.)

Tell students that the ability to better predict near-term events occurs in hurricane and tropical storm forecasting as well. Project **The Definition of the National Hurricane Center Track Forecast Cone** and show students the "cone of uncertainty" around the track of the storm. Tell students that the cone shows the scientists' uncertainty in the track of the storm, just as the climate models show the scientists' uncertainty in how much Earth's temperature will change in the future. Ask: *When are scientists most confident in their predictions?* (Scientists are most confident in their predictions when they have a lot of data. This is why the forecast for near-term events is better than forecasts of longer-term events, both in storm forecasting and in climate forecasting.)

Tell students they will be asked questions about the certainty of their predictions and that they should think about what scientific and model-based data are available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

**3. Have students launch the Earth's Changing Climates interactive.**

Provide students with the link to the Earth's Changing Climates interactive. Divide students into groups of two or three, with two being the ideal grouping to allow students to share computer work stations. Tell students they will be working through a series of pages of data with questions related to the data. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

**NOTE:** Teachers can access the Answer Key for students' questions—and save students' data for online grading—through a free registration on the High-Adventure Science portal page.

Tell students that this is Activity 2 in the **What Is the Future of Earth's Climate?** lesson.

**4. Have students discuss what they learned in the activity.**

After students have completed the activity, bring the groups back together and lead a discussion focusing on the questions below. Show the graphs on page 7 of the activity. Point out the different time scales represented on the two graphs. Ask:

- *Why don't you see the temperature trend from the first graph (1880-2010) represented on the second graph (Vostok ice core)?* (The first graph shows a shorter time period (130 years) than the Vostok ice core graph [400,000 years]. The longer-term graph smooths out the short-term fluctuations while showing the longer-term temperature trend.)
- *How are ice ages represented on the Vostok ice core graph?* (Ice ages [glacial periods] are shown when the temperature is low.)
- *What is the average temperature difference between glacial and interglacial periods?* (The average temperature difference is 10 degrees Celsius [50 degress Fahrenheit].)
- *How long (in thousands of years) did it take to go from glacial periods to interglacial periods?* (The warming happens very quickly, within about five thousand years.)
- *How do these changes compare to the time scale for the most recent (current) warming trend?* (The current warming appears to be happening much faster.)
- *Why do you think scientists think the warming of the 20th century cannot be explained by the natural variability seen over geologic time?* (The warming is happening quickly, and it is occurring in synchrony with increased levels of carbon dioxide.)

# TipTeacher Tip

This activity is part of a sequence of activities in the What Is the Future of Earth's Climate? lesson. The activities work best if used **in sequence**.

# TipTeacher Tip

To save your students' data for grading online, register your class for free at the High-Adventure Science portal page.

# Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

# Informal Assessment

1. Check students' comprehension by asking them the following questions:

- How has Earth's average temperature changed over the past 400,000 years?
- How do scientists determine what the temperature was 400,000 years ago?
- What makes scientists more confident in their predictions of future climates?

2. Use the answer key to check students' answers on embedded assessments.

OBJECTIVES

# Subjects & Disciplines

**Earth Science**

# Learning Objectives

Students will:

- explore and critically analyze real-world data
- make claims about data and determine their own level of certainty with regard to their claims

# Teaching Approach

- Learning-for-use

# Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning

- Visual instruction
- Writing

# Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- 21st Century Themes
  - Global Awareness
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

# National Standards, Principles, and Practices

## NATIONAL SCIENCE EDUCATION STANDARDS

- **(5-8) Standard A-1:**

Abilities necessary to do scientific inquiry

- **(5-8) Standard A-2:**

Understandings about scientific inquiry

- **(9-12) Standard A-1:**

Abilities necessary to do scientific inquiry

- **(9-12) Standard A-2:**

Understandings about scientific inquiry

- **(9-12) Standard D-1:**

Energy in the earth system

## COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**

Craft and Structure, RST.11-12.4

- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**

Key Ideas and Details, RST.9-10.1

- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**

Craft and Structure, RST.9-10.4

- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**

Key Ideas and Details, RST.6-8.1

- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**

Key Ideas and Details, RST.11-12.1

- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**

Key Ideas and Details, RST.11-12.3

- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**

Craft and Structure, RST.6-8.4

- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**

Key Ideas and Details, RST.9-10.3

- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**

Key Ideas and Details, RST.6-8.3

## ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

- **Standard 3:**

Research and Information Fluency

- **Standard 4:**

Critical Thinking, Problem Solving, and Decision Making

## NEXT GENERATION SCIENCE STANDARDS

- **Crosscutting Concept 1:**

Patterns

- **Crosscutting Concept 2:**

Cause and effect: Mechanism and prediction

- **Crosscutting Concept 3:**

Scale, proportion, and quantity

- **Crosscutting Concept 7:**

Stability and change

- **HS. Earth and Human Activity:**

HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

- **HS. Earth and Human Activity:**

HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

- **HS. Earth's Systems:**

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

- **HS. Earth's Systems:**

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

- **HS. Earth's Systems:**

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

- **MS. Earth and Human Activity:**

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

- **Science and Engineering Practice 1:**

Asking questions and defining problems

- **Science and Engineering Practice 2:**

Developing and using models

- **Science and Engineering Practice 4:**

Analyzing and interpreting data

- **Science and Engineering Practice 6:**

Constructing explanations and designing solutions

- **Science and Engineering Practice 7:**

Engaging in argument from evidence

- **Science and Engineering Practice 8:**

Obtaining, evaluating, and communicating information.

## Preparation

## What You'll Need

### REQUIRED TECHNOLOGY

- Internet Access: Required

- Tech Setup: 1 computer per learner, 1 computer per small group, Interactive whiteboard, Projector

### PHYSICAL SPACE

- Classroom
- Computer lab
- Media Center/Library

### GROUPING

- Heterogeneous grouping
- Homogeneous grouping
- Large-group instruction
- Small-group instruction

## BACKGROUND & VOCABULARY

# Background Information

Earth's climate is continually changing. Earth has been covered in ice (snowball Earth) at some points during its existence, while at others, Earth has been ice-free. Earth is now in a warming period, due in part to enhanced human emissions of greenhouse gases. (Greenhouse gases, such as carbon dioxide, methane, and water vapor, trap heat in the atmosphere by absorbing heat energy emitted from the surface.)

Scientists use past and current temperature data to develop climate models to predict how warm the planet might get. Scientists use ancient sediments and ice cores to measure past temperatures. They put these data into sophisticated computational models to make predictions about the future.

# Prior Knowledge

[]

# Recommended Prior Activities

- None

# Vocabulary

| Term | Part of Speech | Definition |
| --- | --- | --- |
| **annual** | *adjective* | yearly. |
| **atmosphere** | *noun* | layers of gases surrounding a planet or other celestial body. |
| **carbon dioxide** | *noun* | greenhouse gas produced by animals during respiration and used by plants during photosynthesis. Carbon dioxide is also the byproduct of burning fossil fuels. |
| **climate** | *noun* | all weather conditions for a given location over a period of time. |
| **error bar** | *noun* | visual representation used in graphs to indicate the uncertainty in a measurement. |
| **glacier** | *noun* | mass of ice that moves slowly over land. |
| **greenhouse gas** | *noun* | gas in the atmosphere, such as carbon dioxide, methane, water vapor, and ozone, that absorbs solar heat reflected by the surface of the Earth, warming the atmosphere. |
| **ice age** | *noun* | long period of cold climate where glaciers cover large parts of the Earth. The last ice age peaked about 20,000 years ago. Also called glacial age. |
| **ice core** | *noun* | sample of ice taken to demonstrate changes in climate over many years. |
| **model, computational** | *noun* | a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation. |
| **running mean** | *noun* | calculation that analyzes data by creating a series of averages of different groups of a whole data set. Also called a moving mean, rolling mean, or moving average. |
| **system** | *noun* | collection of items or organisms that are linked and related, functioning as a whole. |
| **temperature** | *noun* | degree of hotness or coldness measured by a thermometer with a numerical scale. |
| **variable** | *noun* | piece of data that can change. |

## For Further Exploration

### Articles & Profiles

- National Geographic: All About Climate
- National Geographic Education: Encyclopedia—Climate Change
- National Geographic Education: Encyclopedia—Global Warming

### Instructional Content

- National Geographic Education: Activity—Constructing/Interpreting Climate Graphs

### Maps

- NG MapMaker Interactive: Climate Zones

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## PARTNER

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