CLUE into CLIMATE

KQED education network

Science ready to EXPLORE

Lesson 1e: Climate Models: Predicting the Future

SUBJECTS

Earth Science

Life Science

Investigation & Experimentation

GRADE LEVELS

4–8

CA SCIENCE STANDARDS

Grade 7: Investigation and Experimentation. 7. Scientific progress is made by asking meaningful questions and conducting careful investigations. (c)

Grade 8: Periodic Table. 7. The organization of the periodic table is based on the properties of the elements and reflects the structure of atoms. (b)

EARTH SCIENCE LITERACY PRINCIPLES

#1: Earth scientists use repeatable observations and testable ideas to understand and explain our planet. (1.4, 1.5, 1.6)

#9: Humans significantly alter the Earth. (9.1, 9.3, 9.7)

OVERVIEW

Climate models are tools that scientists have developed to help predict the future climate of our planet based on different scenarios of human impacts to the atmosphere. The last ice age occurred because of a drop of only a few degrees in global temperatures, so even small temperature increases are a concern. In this lesson, students will learn about climate models, experiment with their own climate model, and investigate how climate models are used to predict how species distributions may change as the planet warms. Prior to engaging in this lesson plan, students will need to have a general knowledge of greenhouse gases, the greenhouse effect, and global warming.

ESSENTIAL QUESTIONS

1. What is a climate model and what is its purpose? *(A climate model is a mathematical model based on data from global cycles that drive Earth's climate system; it helps scientists predict changes in our planet's climate over time.)*
2. What can climate models tell us? *(about our future climate)*
3. How can climate models help us plan for climate change? *(They can provide information about how the climate in a specific area may change, allowing for informed planning and conservation.)*

MEDIA RESOURCES

- **Diagram: Forecasting Suitable Habitat for Wolverines for the Next 100 Years**
- **Video slideshow: "Forecasting Suitable Habitat for Coast Redwoods over the Next 100 Years"**
  Slideshow length: 3 minutes, 2 seconds

Link: http://www.kqed.org/education/educators/clue-into-climate/greenhouse-gases.jsp
Through viewing these media resources, students will learn:

- How scientists use data from global climate models to predict how changes in climate may affect the distribution of animals and plants

***QUEST/Climate Watch:* "California at the Tipping Point: Climate Models"**
Video length: 3 minutes, 2 seconds
Link: http://www.kqed.org/education/educators/clue-into-climate/greenhouse-gases.jsp
Through watching this video, students will learn:

- About climate models and how they help predict the future climate

VOCABULARY

climate change
a change in long-term average weather patterns; can be natural or the result of human activities

climate envelope
the area containing temperature and precipitation levels that a species can live within; used interchangeably with "suitable habitat"

climate model
a mathematical model based on data from global cycles that drive Earth's climate system; helps scientists predict changes in our planet's climate over time

core sample
a sample that scientists take in the field (rock, snow, soil, or ice) by driving a hollow tube into the sample and withdrawing a cross-section for analysis

ACTIVITY 1: CLIMATE MODELING

Time: 30 to 45 minutes
Materials:

- Computer with Internet access
- Projector and speakers
- Handout: Student Worksheet

Procedure:

1. Make copies of and hand out the Student Worksheet. Play "Climate Modeling" twice. While watching the second time, students should answer the following questions on their Student Worksheet:
    - To prepare for global climate change, what is needed? *(a better understanding of what is coming)*
    - Bill Collins says, "We're fortunate to have an excellent record of how the climate has changed in the past." Where does this record live? *(buried in the ice cores)*
    - How many years of data have the ice cores yielded? *(100,000 years)*
    - According to ice core samples, Earth heats up and cools down all the time, but what is different about this warming trend? *(It is off rhythm—it is occurring very rapidly.)*
    - Scientists use past climate data to project what? *(climate models into the future)*
    - Based on climate models, how much warmer do scientists believe California will be by the end of the century? *(3 to 6 degrees)*
    - Why should you trust a climate model? *(They are tested to see if they accurately predict observations.)*
2. At the end of the video, have students work in pairs to compare and complete the questions.
3. Discuss the questions as a class.
4. Either in class or as a homework assignment, students write a paragraph about the following: Think about this quote from "California at the Tipping Point": "[Climate change] is going to be one of the most profound changes that we have experienced as a species." What are some ways that you see your life changing due to climate change?

ACTIVITY 2: CREATING A MINI CLIMATE MODEL

Time: 40 to 50 minutes (plus experiment waiting time)
Materials:

- Computer with Internet access
- Projector and speakers
- Whiteboard/chalkboard
- Small cooler or bucket with a drain
- Thermometer
- A large measuring cup
- Ice
- Pens/pencils
- Paper

Procedure:

1. Review the "Climate Models" video.
2. Discuss with the class. Explain how climate models work. *(Scientists use gathered data and specific equations to predict what will happen to the world's climate in the future.)* Explain how many climate models have been created recently to show what will happen to the polar ice caps if Earth's temperature continues to increase.

VOCABULARY

greenhouse gas
gases such as carbon dioxide that trap heat in the atmosphere; greenhouse gases can be emitted to the atmosphere through natural processes or human activities

isotope
any of two or more forms of an element having the same number of protons in the nucleus, or the same atomic number, but having a different number of neutrons in the nucleus, or a different atomic weight

suitable habitat
see *climate envelope*

ACTIVITY 2 CONTINUED

(possible resource: http://celebrating200years.noaa.gov/breakthroughs/climate_model/welcome.html)

3. Tell students that you will be working with them to create a demonstration of a mini climate model.
4. Draw a class data table on the board (see also attached Student Worksheet):

Description of "climate"	Air temperature	Time	Amount of water drained	Notes
Ice in the classroom		1 hour		
Ice in the shade (outside)		1 hour		
Ice in indirect or partial sun (outside)		1 hour		
Ice in full sun (outside)		1 hour		

5. Fill cooler/bucket with ice. After recording the air temperature, leave the cooler/bucket sitting in the classroom for one hour while students are working on other activities.
6. Drain into a measuring cup any water that has melted. Have the students use the measuring cup to measure the amount of drained water, then record the amount in the class data table.
7. Refill cooler/bucket with ice. After recording the air temperature, leave the cooler/bucket sitting in the shade outside for one hour while students are working on other activities. Be sure to fill the cooler/bucket with the exact same amount of ice.
8. Drain into a measuring cup any water that has melted. Have the students use the measuring cup to measure the amount of drained water, then record the amount in the class data table.
9. Refill the cooler/bucket with ice. After recording the air temperature, leave the cooler/bucket in the indirect or partial sun outside for one hour while students are working on another activity. Be sure to fill the cooler/bucket with the exact same amount of ice.
10. Drain into a measuring cup any water that has melted. Have the students use the measuring cup to measure the amount of drained water, then record the amount in the class data table.
11. Ask students to find the change in amount of water drained from the classroom to shade to partial sun.
12. Record the air temperature in full sun.
13. Based on the pattern in amount of water drained from the three data points and the air temperature in full sun, ask students to create a model of what would happen if the cooler/bucket were placed in full sun outside for one hour. Students can present this information by drawing an actual model of the cooler/bucket of ice, writing a paragraph, or showing mathematical equations.
14. If time permits, repeat the steps with the cooler/bucket in full sun. Have students compare the actual data with their model.

Please note: Experimental design may need to be altered depending on materials and location (Is it winter? Try this inside.)

WHAT CAN WE DO?

In your everyday life, think about how what you do can impact our environment and try to adjust your habits. For example, if every day you take a water bottle to school and then throw it out, consider buying a reusable water bottle that you refill instead.

ACTIVITY 3: USING CLIMATE MODELS TO PLAN FOR CLIMATE CHANGE

Time: 60+ minutes
Materials:

- Computer with Internet access
- Projector
- Paper and pencils

Procedure:

1. Ask students to write down what they know about wolverines and redwood trees (consider: habitat, food source, adaptations, appearance, life span). You can find detailed information about the wolverine at http://www.fs.fed.us/r6/sfpnw/issssp/documents/planning-docs/sfs-vert-ma-Gulo-gulo-luteus-2007-09-27.doc and about redwoods at http://www.savetheredwoods.org/education/coastredwood.shtml. Make a list of facts on the board.
2. Read aloud the description of the California Academy of Science's project (below). Answer student questions as necessary. Be sure to highlight the difference between an organism's suitable habitat, or climate envelope, and its actual distribution.
3. In partners (or as a class), students view the diagram Forecasting Suitable Habitat for Wolverines for the Next 100 Years and the video slideshow "Forecasting Suitable Habitat for Coast Redwoods over the Next 100 Years." Students should identify which states and which part of the continent *(California/Oregon and western North America)* are shown in the maps based on topographical features and state abbreviations/boundaries. Assist students as necessary with this. Please note that redwoods and wolverines are included in this lesson because they both represent important species whose suitable habitats may be affected by climate change, not because their habitats are necessarily connected.
4. Have students make note of any regions that will remain suitable for wolverines or redwoods in *both* the optimistic and the pessimistic scenarios. Discuss the climate of these suitable regions. Conduct research as necessary.
5. Student pairs will act as conservation managers that need to plan for climate change. Half of the class will research and prepare plans for protecting redwoods, and the other half will work for protecting wolverines. Student plans should include the following information:
    - Which locations should be protected and why
    - Which parks already exist in those locations, and if none do, where they should be created
    - What sort of habitat the wolverines/redwoods need in order to survive
    - What other plants and animals might benefit from protecting these regions for wolverines/redwoods
    - What other plants and animals might *not* benefit from protecting these regions for wolverines/redwoods
6. Wolverine and redwood partnerships should take turns sharing their conservation plans.

ASSESSMENT IDEAS

- Students graph data points from Activity 2 and write a paragraph about what the graph shows about their mini climate model.
- Students share their paragraphs from Activity 1.

ACTIVITY 3 CONTINUED

California Academy of Sciences Project Description
Researchers around the world use physics and math to predict the future climate of Earth (the different global climate models). The California Academy of Sciences (the Academy) project looks at our planet's future climate in response to different levels of greenhouse gas emissions (the different greenhouse gas emissions scenarios). Due to the greenhouse effect, increased greenhouse gases warm Earth and cause the climate to change.

If we continue to emit a lot of greenhouse gases, the models predict the planet will be really warm by the end of the century (2100). This is the pessimistic scenario. If we reduce our greenhouse gas emissions by around 2050, the models predict less warming. This is called the optimistic scenario. Why is the warmer scenario pessimistic (meaning gloomy or hopeless)? And why is the scenario that involves less warming optimistic (meaning hopeful or having a favorable view)? Warmer temperatures mean things will be really different on our planet. Glaciers may melt, sea levels may rise, and there may be more drought and other severe weather.

And a changing climate means the conditions where certain animals and plants can live might also change. All plants and animals have a specific "climate envelope," which is an area with the right temperature and right amount of moisture for them to survive. This is their suitable habitat. It is important to note the difference between their suitable habitat and where species of animals and plants actually live. For example, wolverines could live in the Sierra Nevada in California, but they are actually rarely seen in California. However, as our climate changes, the conditions where animals could live may become more important. You'll understand why in a moment.

Back to the Academy's project: Researchers have selected key (important) species that play an important role in their ecosystem, such as the wolverine and the redwood tree, to study. It would be impossible to model the future habitat of every species! Researchers take the records of where wolverines are actually seen and use them in their models to determine where they may be able to survive in the future.

As the planet warms, the areas where wolverines will be able to survive are predicted to shrink. This is because a warming world will cause the snowpack—which wolverines rely on—to shrink. However, animals and plants can adapt to changes in their environment, and this is why knowing their predicted suitable habitat is important.

If conservation managers know that a certain area (for example a national park) will remain a good place for wolverines to live (called a "climate refuge"), they can work now to protect that area and plan for climate change. Think about it this way: If a place where wolverines actually live today will no longer be habitable for them in 2100, wolverines could move to the protected area—if it is protected now and there is a way for them to get there! But if no areas are protected for wolverines and their suitable habitat shrinks as much as the pessimistic scenario predicts, wolverines, along with many other animals and plants, may become extinct. That's why this research is important!

ABOUT THE AUTHORS

Karen Bioski is a former science teacher who taught integrated science, biology, and chemistry using a hands-on, project-based approach to curriculum design. She has done curriculum development for KQED and also through the Stanford Research Network to help improve science education. She now works as a vice principal at a San Francisco high school and still works closely with the science team at her school.

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KQED Education Network engages with community and educational organizations to broaden and deepen the impact of KQED media to effect positive change.

www.kqed.org/education

ADDITIONAL RESOURCES

Educational Global Climate Modeling
http://edgcm.columbia.edu/
Created by the National Aeronautics and Space Administration, this downloadable software and the accompanying lesson plans allow students to explore climate change the same way that scientists do—by creating computer models to make predictions about the future of our climate.

Global Warming Kids Page, Pew Center on Global Climate Change
http://www.pewclimate.org/global-warming-basics/kidspage.cfm
This website provides simple things you can do at home to help slow global warming!

NOAA Climate Services, National Oceanic and Atmospheric Administration (NOAA)
http://www.climate.gov/#climateWatch
Find news about climate change and in-depth articles, interviews, and animations explaining many climate change–related phenomena.

Weather, NOAA
http://www.education.noaa.gov/sweather.html
This website is specifically designed for children in grades K–12 and provides fun activities for students to explore the planet they live on.

SUPPORT

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STUDENT WORKSHEET

"Climate Models" Viewing Questions

1. To prepare for global climate change, what is needed?

2. Bill Collins says, "We're fortunate to have an excellent record of how the climate has changed in the past." Where does this record live?

3. How many years of data have the ice cores yielded?

4. According to ice core samples, Earth heats up and cools down all the time, but what is different about this warming trend?

5. Scientists use past climate data to project what?

6. Based on climate models, how much warmer do scientists believe California will be by the end of the century?

7. Why should you trust a climate model?

Creating a Mini Climate Model

Description of "climate"	Air temperature	Time	Amount of water drained	Notes
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