Case Teaching Notes for "Global Climate Change: Impact and Remediation"

by
Maureen Knabb, Department of Biology, West Chester University
Timothy M. Lutz, Department of Geology, West Chester University

Introduction / Background

This case is a "clicker case." It combines the use of student personal response systems (clickers) with case teaching methods and formats.

The case is a continuation of "Global Climate Change: Evidence and Causes," in which students assumed the role of an intern working for a U.S. senator and were presented with the scientific evidence for human impact on climate change. Although there is no doubt that climate will continue to change throughout the 21st century and beyond, there are still important questions regarding how large and how fast these changes will be, and what effects they will have in different regions. In some parts of the world, global climate change could bring positive effects, such as longer growing seasons and milder winters. Unfortunately, it is likely to bring harmful effects to a much higher percentage of the world's people. For example, people in coastal communities will likely experience increased flooding due to rising sea levels.

The scientific understanding of climate change is now sufficiently clear to begin taking steps to prepare for climate change and to slow it down. Human actions over the next few decades will have a major influence on the magnitude and rate of future warming. Large, disruptive changes are much more likely if greenhouse gases are allowed to continue building up in the atmosphere at the present rate. However, reducing greenhouse gas emissions will require strong national and international commitments, technological innovation, and human willpower. This case emphasizes the short- and long-term effects of global climate change and strategies to slow its deleterious effects.

The case begins by reviewing the impact and effects of global climate change on glaciers, sea ice, ecosystems, agriculture, and health. Different strategies are presented to lessen and potentially reverse the effects of climate change. Students are asked to take the role of an intern working for a U.S. senator who needs to prepare for a town meeting with constituent groups. In order to advise the senator on future policy decisions, students need to appreciate the effects of global climate change as well as the variety of technologies and practices available to remediate the impact of climate effects.

The case was designed for use in a one-semester introductory biology course that is taken primarily by freshmen and sophomores to fulfill a general education requirement, but could be used in any introductory biology course or in an ecology or environmental science course.

Objectives

After completing the case, students should have an increased understanding of:

- The short- and long-term effects of global climate change.
- How to read graphs and interpret data.
- How positive feedback effects impact climate change.
- How the U.S. contributes to greenhouse gas emissions.
- Different strategies to lessen or reverse the impact of global climate change.

Misconceptions

- Climate change is not a serious environmental problem.
- It is a natural event and nature will take care of any problems associated with climate change independent of whether they are due to human activities.
- Even if we accept that climate change is due to anthrpogenic effects, a few degrees change in global temperature will have no major environmental effect.
- Any threats that result from global climate change are occurring far away from the U.S. and we will not be affected.
- The U.S. has no responsibility in generating or alleviating the effects of global climate change (see: YouTube - The American Denial of Global Warming, http://www.youtube.com/watch?v=2T4UF_Rmlio).

Prerequisite Concepts

Students should have an introductory understanding of ecology and ecosystems.

Classroom Management / Blocks of Analysis

The case consists of a Power Point presentation that is interspersed with questions the students answer in class.

Teaching the Case

Slide 1: Title slide.

Slide 2, Slide 3, Slide 4, and Slide 5 assess students' perceptions of the consequences of climate change (clicker question #1 on Slide 2) and set up the scenario for the case.

The next 19 slides (Slides 6–24) identify some of the major consequences associated with climate change. Slide 6 lists five major possible consequences: (1) melting of glaciers and sea ice leading to decreased water supply; (2) sea level rise and coastal erosion; (3) damage to ecosystems and reduction of threatened species; (4) changes in agricultural conditions and diminishing food supply; and (5) increased threats to human health. Each of these five possible consequences is discussed in turn on the slides that follow.

Melting glaciers and diminishing water supply are discussed in Slide 7, Slide 8, Slide 9, and Slide 10. Glaciers are very sensitive indicators of climate change, advancing when climate cools and retreating when climate warms. Glacier mass balance has been found to be decreasing for the last 17 years based on data from the World Glacier Monitoring Service (see http://www.geo.unizh.ch/wgms/). The largest implication of loss of glaciers is not the change in scenery, but the fact that the seasonal meltwater from glaciers, especially in Asia and South America, is the life support for billions of people.

Slide 11 (clicker question #2) assesses students' understanding of the material just presented, particularly the photographic evidence of the loss of glaciers from areas such as the Muir glacier in Alaska.

Slide 12 (clicker question #3) presents a graph showing sea level measurements from 23 long tide gauge records in geologically stable environments. The measurements show a rise of around 20 centimeters (8 inches) per century.

Rising sea level and melting sea ice (Slide 13, Slide 14, Slide 15, Slide 16, Slide 17, Slide 18, and Slide 19): Current sea level rise is due partly to human-induced global warming through the addition of water to the oceans from the melting glaciers and thermal expansion of water. Values for predicted sea level rise over the course of the next century typically range from 90 to 880 mm, with a central value of 480 mm. The rise in sea level is expected to have a number of impacts, particularly on coastal systems. These impacts may include increased coastal erosion, increased flood risk and potential loss of life (Slide 15 shows the potential for widespread flooding that sea level rise of only one meter would cause in the Miami, Florida, area), inhibition of primary production processes, changes in surface water quality and groundwater characteristics, and increased loss of property and coastal habitats.

Antarctica stores a large volume of ice estimated at around 70% of the world's fresh water (Slide 16—right). This ice sheet is constantly gaining ice from snowfall and losing ice through outflow to the sea. It is estimated that Antarctica, if fully melted, would contribute more than 60 meters of sea level rise. However, this catastophe is unlikely since data suggests that West Antarctica is currently experiencing a net outflow of glacial ice while East Antarctica is in balance, which will increase global sea level over time (around 0.14 mm/yr of sea level rise).

Another serious threat associated with rising atmospheric temperatures is the disappearance of permafrost and its replacement with marshland or open water (see Slide 19). The initial thawing of peatland permafrost will allow previously frozen organic material to begin decomposing, and enormous quantities of methane—23 times more powerful as a greenhouse gas than carbon dioxide—will be released into the atmosphere. There is concern that the methane emissions will result in a positive feedback, creating even more atmospheric warming.

Slide 20 (clicker question #5) reviews the impact and extent of the melting of polar ice caps as well as the effect of positive feedback on global climate change.

Ecosystems and agriculture (Slide 21, Slide 22, and Slide 23): Based on the IPCC Working Group II Summary Report, there is very high confidence that recent warming is affecting both terrestrial and aquatic species survival, reproduction, and distribution. Both terrestrial and aquatic plants and animals are moving their territories to higher latitudes and reproductive cycles are occurring earlier in the season. Species are being lost at an alarming rate, particularly in sensitive areas such as coral reefs. Approximately 20–30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5–2.5°C (IPCC, Working Group 2 Report).

Slide 21 is a good place to take a break for class discussion concerning the short- and long- term effects of these environmental changes. Ask students: *What will happen to polar bears and coral reefs with global climate change? Can you think of other examples of how animals or ecosystems could be affected by GCC?*

Changes in temperature and precipitation associated with global climate change are expected to have significant impacts on agriculture. Some areas, especially mid- to high- latitudes, will see increased productivity while others areas, particularly those susceptible to drought and/or floods, will be hardest hit. Higher average temperatures are also correlated with higher incidences of insect reproduction and disease. The poorest countries would be most at risk, with reductions in crop yields in most tropical and sub-tropical regions due to decreased water availability, and new or changed insect pest incidence.

Slide 22 and Slide 23 are appropriate break points for class discussion. The instructor could divide the class

into several groups to discuss, for example, what geographical locations might see agricultural benefits versus losses or what adaptations in plants would be necessary to survive the environmental change. Will the wealthier nations be able to feed the world?

Slide 24 (clicker question #6) asks the student to consider whether global climate change has positive and/or negative effects on natural and/or human managed environments.

Effects on health (Slide 25 and Slide 26): Health depends on safe drinking water, sufficient food, secure shelter, and good social conditions. A changing climate is likely to affect the health status of millions of people, particularly the poor, the very young, and the very old. Health problems associated with global climate change include: increasing illness and death associated with violent weather patterns, heat waves, and air pollution; increased risk of water- and vector-borne diseases due to lack of fresh water and alterations of life cycles and geographic location of disease-causing organisms; malnutrition, developmental, and growth defects in areas with insufficient food supply; and regional displacement of infected populations due to coastal flooding and civil conflict.

There have been recent examples that these effects can be significant. Abnormally high temperatures in Europe in the summer of 2003 were associated with over 35,000 more deaths than the equivalent period in previous years. In October 1999, a cyclone in Orissa, India, caused 10,000 deaths. The total number of people affected was estimated at 10–15 million. Diarrhea, malaria, and protein-energy malnutrition alone caused more than 3.3 million deaths globally in 2002, with 29% of these deaths occurring in Africa.

Slide 26 provides a good opportunity for small group and/or class discussion. Which parts of the world have not been affected much by climate change so far? How and why might this change? What types of migration might you expect from the health effects of global climate change in 2000? What predictions can you make about this image in the future?

Slide 27 (clicker question #7) assesses students' understanding of the human health impacts associated with climate change. Slide 28 and Slide 29 bring the case back to the starting scenario (refer to Slide 4) which will allow students to reflect on the constituent groups generated at the beginning of class. The answers generated for clicker question #8 will depend on the group identified by each class.

Slide 30, Slide 31, Slide 32, Slide 33, Slide 34, Slide 35, and Slide 36 address how the U.S. contributes to global climate change and the strategies that we can use to mitigate and adapt to these changes. It is clear from a recent U.S. Environmental Protection Agency (EPA) report that Americans are contributing substantially to greenhouse gas emissions through their energy use (Slide 30). There are a variety of strategies to mitigate and/or adapt to greenhouse gas emissions. Some of the strategies summarized by the IPCC Working Group 3 include:

- *Improved Energy Supply and Distribution Efficiency:* Investing in cleaner and more efficient energy infrastructure can create long-term opportunities for achieving greenhouse gas emissions reductions. Measures of this nature could involve replacing coal with natural gas, expanding the use of nuclear power, and using renewable energy sources such as hydropower, solar, wind, geothermal, and bio-energy. Increasing end-use energy efficiency in order to reduce total demand is also a highly cost-effective approach.

- *Smarter Transportation Policy:* The transport sector is a major emissions generator. Transport-related pollution will only increase, as more developing country residents are able to afford automobiles. Increasing fuel efficiency, promoting public transportation, and using land-use planning to reduce the need for travel can offset emissions increases from this sector.

- *Increased Energy Efficiency of New and Existing Buildings:* Most current buildings are highly energy inefficient. By combining power-saving lighting and electrical appliances with better insulation and building design, significant carbon emission reductions in this area are possible.

- *Changes in Agricultural Practices:* While not always associated with climate change, agriculture is an important source of GHGs. By modifying land management techniques, the soil's natural carbon sequestration ability can be maintained and strengthened.

- *Better Forest Management:* Forest-related mitigation activities can considerably reduce emissions. In fact, about 65% of the total mitigation potential is located in the tropics and about 50% of the total could be achieved by reducing emissions from deforestation.

Of course, change starts with the individual. There are a variety of changes that individual consumers can make to reduce their contribution to greenhouse gas emissions.

Answer Key

Answers to the questions posed in the case study are provided in a separate answer key to the case. Those answers are password-protected. To access the answers for this case, go to the key. You will be prompted for a username and password. If you have not yet registered with us, you can see whether you are eligible for an account by reviewing our password policy and then apply online or write to answerkey@sciencecases.org.

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  - *Author:* Bruce F. Molnia
  - *Source:* National Snow and Ice Data Center/World Data Center for Glaciology, Boulder. Glacier id: muir2005081108.
  - *Link:* http://nsidc.org/cgi-bin/gpd_deliver_jpg.pl?muir2005081108
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  - *Description:* Muir Glacier, Alaska in 1880.
  - *Author:* G.D. Hazard
  - *Source:* National Snow and Ice Data Center/World Data Center for Glaciology, Boulder. Glacier id: muir1880000001.
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    - *Description:* Muir Glacier, Alaska in 2005.
    - *Author:* Bruce F. Molnia
    - *Source:* National Snow and Ice Data Center/World Data Center for Glaciology, Boulder. Glacier id: muir2005081111.
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    - *Description:* Muir Glacier, Alaska in 1941.
    - *Author:* William O. Field
    - *Source:* National Snow and Ice Data Center/World Data Center for Glaciology, Boulder. Glacier id: muir1941081301.
    - *Link:* http://nsidc.org/cgi-bin/gpd_deliver_jpg.pl?muir1941081301
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    - *Author:* Bruce F. Molnia
    - *Source:* National Snow and Ice Data Center/World Data Center for Glaciology, Boulder. Glacier id: muir2004083101.
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    - *Author:* This figure was prepared from publicly available data by Robert A. Rohde and is incorporated into the Global Warming Art project.
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    - *Description:* Photos of Miama Beach today and with 1 m change in sea level.
    - *Source: Nation Under Siege: Sea Level Rise at Our Doorstep*, 2007, Edward Mazria and Kristina Kershner, The 2030 Research Center; link. Miami Beach, Florida—1.0-meter sea level rise ©2009 2030, Inc. / Architecture 2030, Data Source: LIDAR IHRCS.
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  - *Source:* http://en.wikipedia.org/wiki/File:Blue_Linckia_Starfish.JPG
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  - *Description:* Effects of global warming on agriculture.
  - *Source:* FactFile, Food and Agriculture Organization of The United Nations, http://www.fao.org/english/newsroom/factfile/FF9721-E.HTM
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- Slide 23
  - *Description:* Map of projected changes in agriculture in 2080 due to climate change.
  - *Author:* Hugo Ahlenius, Nordpil
  - *Source:* Data from Cline, W. R. 2007. *Global Warming and Agriculture: Impact Estimates by Country*. Washington D.C., USA: Peterson Institute. Map by UNEP/GRID-Arendal; exact source.
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  - *Description:* Effects of climate change on human health.
  - *Source:* Information adapted by the Tennessee Department of Health from Agency for Toxic Substances and Disease Registry.
  - *Link:* The Tennessee Department of Health, http://health.state.tn.us/Environmental/climatechange.htm
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  - *Description:* Health effects of climate change.
  - *Source:* Center for Sustainability and the Global Environment (SAGE) at the University of Wisconsin-Madison, http://www.sage.wisc.edu/index.html; exact source. Data drawn from

Ezzati M, Lopez AD, Rodgers A, Murray CJL (Eds) (2004) *Comparative Quantification of Health Risks: The Global and Regional Burden of Disease Attributable to Selected Major Risk Factors* (Volumes 1 and 2). Geneva: World Health Organization. Map created by a team of climate and health scientists led by Jonathan Patz, associate professor of environmental studies and population health sciences at the University of Wisconsin-Madison.
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- Slide 30
    - *Description:* U.S. Emissions of GHG.
    - *Author:* Graph prepared by case author, Timothy Lutz.
    - *Source:* Data from "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2007," US EPA, 2009 (EPA 430-R-09-004), Table ES-4 see pg 33
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    - *Description:* Photo of smokestack (top) and forest (bottom).
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    - *Description:* Graphs from IPCC report.
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