Current Climate Studies 12:

RESPONDING TO CLIMATE CHANGE: ADAPTATION AND MITIGATION

1. Print this file. Also answer the "Concept of the Week" questions in the *Weekly Climate News* File. (Check for additional *News* updates during the week.)

2. Complete the Investigation by responding to the *Chapter Progress Questions* (*Study Guide*) and the Investigations 12A and 12B from the *Climate Studies Investigations Manual*, and this *Current Climate Study*.

Note: *You have already or should soon receive information from your course LIT leader on filling out a course survey and evaluation.* ***This is a requirement for receiving credit for the course.*** *If you have not received this information by the end of the week, please contact your LIT leader.*

Note this for future reference

DataStreme Earth's Climate System participants: Your successful completion of the DataStreme ECS course with the Week 12 Investigations and Current Climate Study, your final course meeting, submitting the Lesson Plan portion of your Plan of Action, and taking the course evaluation, includes 3 graduate semester hours of credit from the State University of New York's The College at Brockport (*if eligible*). The course is officially designated:

ESC 677 Real-Time Climate Studies
A distance-learning course covering selected topics in the study of climate and societal interactions utilizing current environmental data. Administered by the American Meteorological Society.

"ESC" indicates this is a course from the Department of the Earth Sciences and "***6***77" indicates it is a course at the graduate level.

You will not receive notification from Brockport of your credit. However, you may verify your course grade subsequent to ***29 December 2015*** by accessing the SUNY Brockport computer system directly:

- go to http://www.brockport.edu/
- select the menu option "Online Services"
- then "Campus Information System"
- login with your *User ID* which is your Social Security Number
- then with *PIN* (personal identification number) - initially being your birthdate in 6 digits, e.g. Jan. 24, 1956 as 012456 *(unless you have accessed the system previously)*

You must then immediately select a new PIN. Instructions for this are provided.

To request a certified transcript copy (current cost $10), go to:
http://www.brockport.edu/registrar/official%20trans%20order%20info.html.

Introduction

The International Panel on Climate Change (IPCC), in its Fifth Assessment Report's *Climate Change 2013: The Physical Science Basis*, (IPCC WG1 AR5) states "Warming of the climate is unequivocal," "Human influence on the climate system is clear", "It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century", and, "Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system." The IPCC has essentially settled the issue: **climate change is real, it is here to stay, and its projected impacts pose serious risks to humans and the environment.** Its findings confirm what has already been accepted overwhelmingly by the climate science community. As an example, the U.S National Academies National Research Council (NRC) published a report in 2012, *Climate Change: Evidence, Impacts, and Choices*, "that (1) summarizes the current state of knowledge about climate change; (2) explains some impacts expected in this century and beyond; and (3) examines how science can help inform choices about managing and reducing the risks posed by climate change."

The NRC report makes recommendations for action. First, to minimize the risks of climate change and its adverse impacts, the nation should reduce greenhouse gas emissions substantially over the coming decades. Second, mobilizing now for coping with the impacts of climate change is essential, and planning and implementation for adaptation should be initiated at all levels of society. The report follows its list of recommendations for action by stating that "Responding to the risks of climate change is one of the most important challenges facing the United States and the world today and for decades to come."

The USGCRP's 2014 Third *National Climate Assessment* (*NCA3*), in its *Highlights* report, addresses issues related to the challenges of climate change. On page 62, Finding 12 Responses starkly states, "Planning for adaptation (to address and prepare for impacts) and mitigation (to reduce future climate change, for example by cutting emissions) is becoming more widespread, but current implementation efforts are insufficient to avoid increasingly negative social, environmental, and economic consequences."

Climate Change Adaptation and Mitigation

The USGCRP 2009 *Global Climate Change Impacts in the United States* (*NCA2*) report, on page 8, points out that society can actively respond to the challenges of climate change through ***adaptation*** and ***mitigation***. Simplistically, adaptation and mitigation can be considered as analogous to the treatment of a disease. Climate change adaptation is to treating symptoms of a disease as mitigation is to treating the cause(s) of the disease. Whether dealing with climate change or disease, the treatment of both the symptoms and the causes are necessary. However, mitigation (i.e., treatment of the cause) is ultimately the path to a final cure.

Adaptation involves measures to improve our ability to cope with harmful impacts of climate change while taking advantage of beneficial impacts that arise, now and in the future. ***Mitigation***, as defined by the IPCC, "is an anthropogenic (human-induced) intervention to reduce the anthropogenic forcing of the climate system." It includes strategies to reduce emissions of heat-trapping greenhouse gases or facilitate removal of these greenhouse gases from the atmosphere.

1. Increasing the gas mileage (fuel efficiency or miles traveled per gallon) of cars and trucks, thereby burning less fuel and reducing heat-trapping gas emissions to the atmosphere, is an example of a climate change **[(*adaptation*)(*mitigation*)]** strategy.

2. Preventing damage from climate change by shore protection (e.g., building dikes, beach nourishment), which can prevent sea level rise from flooding low-lying coastal property or eroding beaches is an example of a(n) **[(*adaptation*)(*mitigation*)]** strategy.

Adaptation: Adaptation is unavoidable. Limits on emissions will not be enough, or happen soon enough, to avoid impacts of climate change. Inevitably, Earth will be subjected to additional warming no matter what happens to reduce emissions because of the past and current emissions of heat-trapping gases (e.g., CO_2). As a result, there are impacts already built into the climate system. Adaptation efforts are necessary to reduce the severity of climate change impacts for decades to come.

Access *NCA3 Highlights* by going to your bookmarked *Highlights* address, to the course website and click on "National Climate Assessment Highlights", or directly to http://www.globalchange.gov/sites/globalchange/files/NCA3_Highlights_LowRes-small-FINAL_posting.pdf. Go to page 62 to the Finding 12 Responses section.

3. According to text on page 62, adaptation actions can be implemented **[(*reactively*)(*proactively*)(*both of these*)]** to prepare for a changing climate.

On the same page, adaptation Key Messages are presented. They point out the complexities of climate change and numerous barriers to implementing adaptation. Also, it is stated that there is no "one-size fits all" adaptation. Climate change adaptation strategies must be wide-ranging because of local and regional variability in climate change and differences in vulnerability to climate change exacerbated by other stresses in the environment such as pollution. All climate sensitive systems of society and the natural environment, including agriculture, forestry, water resources, human health, island and coastal communities, and natural ecosystems, will need to adapt to a changing climate. The consequences for not adapting will likely result in diminished productivity and functioning along with adverse effects on health and well-being.

Adaptation is not, by itself, an adequate response to climate change. With adaptation alone, the magnitude of climate change is expected to be reached that makes adaptation impossible for some natural systems. For most human systems, it will carry very high social and economic costs.

Earth system scientists are becoming increasingly concerned about dangerous anthropogenic interference and irreversibility (cannot return to its original state). The term ***committed*** is employed to describe the responses of Earth's climate system to the already observed increase of atmospheric greenhouse gas concentrations and the increase in radiative forcing that produces higher global temperatures. While the effects may be delayed, once initiated they are very likely to be irreversible.

4. As indicated on page 63, most adaptation efforts to date have occurred at **[(*global*) (*local and regional*)(*national*)]** levels.

For the *NCA3* detailed treatment of adaptation, go to the Third National Climate Assessment Downloads & Materials website at http://www.globalchange.gov/nca3-downloads-materials. Scroll down to Introduction to Response Strategies section, click on "28. Adaptation" and on "open". As stated on page 672, "This chapter highlights efforts at the federal, regional, state, tribal, and local levels, as well as initiatives in the corporate and non-governmental sectors to build *adaptive capacity* and resilience in response to climate change." [As described in the *IPCC Fourth Assessment Report: Climate Change 2007*, adaptive capacity is a necessary condition for the design and implementation of effective adaptation strategies so as to reduce the likelihood and the magnitude of harmful outcomes resulting from climate change (Brooks and Adger, 2005).]

5. The term *adaptive capacity*, defined on page 672, is the potential of a system to adjust to climate change (including climate variability and extremes) to **[(*moderate potential damages*)(*take advantage of opportunities*)(*cope with the consequences*)(*all of these*)].**

6. Figure 28.4 on page 684 of the *NCA3* adaptation chapter highlights locations of Adaptation Activity by state, local, and private actors. It is not a comprehensive list, but is intended to show a variety of efforts. The descriptions of these efforts are on the pages following the figure. For example, Chicago (Number 12 on the map), was among the first cities to officially incorporate climate adaptation into a citywide climate adaption plan. A number of strategies, including green design, **[(*have been*)(*will be*)]** implemented by the city.

Visiting the *Climate Resilience Toolkit*: The *Toolkit* is an especially useful resource for adaptation efforts related to extreme weather, climate variability, and climate change. This is because the *Toolkit* generally focuses on minimizing the impacts of local and regional vulnerabilities which people are personally aware of because of their own direct experiences.

Most of the "Taking Action" case studies appearing in the *Toolkit* are adaptation stories, including those referred to in *Current Climate Studies 9* and *11*. For another example, go to https://toolkit.climate.gov/topics/human-health/extreme-heat. Read about extreme heat, which is a sub-topic of the major topic Human Health.

7. According to the Extreme Heat discussion, extreme heat events are one of the leading causes of weather-related deaths in the U.S. From 1999 through 2009, extreme heat exposure caused more than **[(*78*)(*780*)(*7800*)]** deaths.

8. Several federal agencies have developed tools to assist in adapting to extreme heat events. The Featured Tool that is specifically designed for persons engaged in outdoor work environments was produced by **[(*EPA*)(*OSHA*)(*CDC*)]**. The Tool emphasizes three simple words: Water, Rest, Shade.

Mitigation: Effective mitigation includes reduction of greenhouse gas emissions and the enhancement of those processes, activities, or mechanisms that result in the removal of heat-trapping gases from the atmosphere.

9. Generating electricity by replacing coal, natural gas or petroleum power plants with nuclear power plants is an example of mitigation that involves **[(*reduction of greenhouse gas emissions*)(*a process that removes greenhouse gases from the atmosphere*)]**.

10. A novel innovative mitigation approach that has been investigated is the production of *biochar* that is sequestered (stored) by mixing with soil. Biochar is biologically derived charcoal. Atmospheric carbon dioxide converted by photosynthesis into organic material (forests, crops, etc.) is cooked in the absence of oxygen to produce primarily solid carbon. The resulting biochar is then incorporated into the soil, or buried, where it can remain for centuries. Such sequestering of carbon is an example of mitigation that involves **[(*reduction of human-caused greenhouse gas emissions*)(*the removal of a greenhouse gas from the atmosphere*)]**.

The global nature of climate change requires a global response effort. As stated by Paul Higgins, Director, American Meteorological Society's Policy Program, "There is a genuine need for a global effort because atmospheric greenhouse gases are well mixed: Emissions from anywhere contribute to the problem everywhere." [*Physics Today*, October 2014, p. 37] Mitigation has global benefits, so efficient mitigation needs to involve major sustained greenhouse gas emission reductions worldwide.

It would take several decades for the mitigation carried out today to begin showing evidence of benefits. Unfortunately, the most stringent of mitigation efforts cannot avoid further impacts of ongoing climate change in the decades ahead. Even if anthropogenic greenhouse gas emissions were to cease immediately, the warming of Earth and associated changes would continue beyond this century. However, it is known that mitigation efforts begun earlier would have a greater effect in reducing climate change than comparable efforts begun later [USGCRP *NCA2*, 2009, p. 9].

For the *NCA3* more detailed treatment of mitigation, go to the Third National Climate Assessment Downloads & Materials website at http://www.globalchange.gov/nca3-downloads-materials. Scroll down to Introduction to Response Strategies section, click on "27. Mitigation" and on "open". This takes you to page 648 of the full *NCA3* report.

11. The first of the Key Messages on page 649 points out that currently only about half of CO_2 entering the atmosphere due to human activities is being removed from the atmosphere by natural processes. Consequently, mitigation efforts that bring the global emission rate to a steady value **[(*would*)(*would not*)]** reduce atmospheric concentrations of CO_2. The steady emission rate would only limit the concentration's rate of increase.

12. It therefore follows that to actually stabilize the atmospheric concentration of CO_2 to a steady value it is necessary to reduce the global emission rate of CO_2 below its current value. On the top of page 651, it is mentioned that stabilizing or reducing atmospheric CO_2 concentrations requires **[(*modest*)(*very deep*)]** reductions in future emissions in order to compensate for past emissions that are still circulating in the Earth system.

Consider spending a few moments looking at the remainder of this *NCA3* chapter on mitigation. After presenting an overview of greenhouse gas emissions and their climate influence, it surveys the activities contributing to the U.S. emissions of greenhouse gases. It then summarizes current efforts to manage these emissions, and ends by assessing the adequacy of these efforts and discussing preparation for potential future action.

13. Based on the information so far discussed in this *Current Climate Studies*, immediate development and implementation of mitigation strategies to reduce greenhouse gas emissions could result in observable reductions in climate-change impacts **[(*immediately*)(*within a decade or two*)(*only after decades or more*)]**.

14. In contrast to climate change mitigation strategies, climate change adaptation strategies tend to be more **[(*local*)(*global*)]** in scope.

15. Adequate reduction in anthropogenically-caused climate change impacts can be accomplished through **[(*mitigation*)(*adaptation*)(*by either mitigation or adaptation*)(*only through a combination of mitigation and adaptation*)]**.

Political Implications

Climate experts David Archer and Stefan Rahmstorf, in their book *The Climate Crisis, An Introductory Guide to Climate Change* (Cambridge University Press, 2010), point out political implications concerning climate change. First, there is wide consensus among climate scientists that adaptation and mitigation are not alternatives. Both are essential. Climate is already changing due to human activity and will continue to change for decades. It is very likely that the ability of humans and ecosystems to adapt will be transcended if actions are not taken to limit climate change via mitigation efforts.

Archer and Rahmstorf point out that there is a fundamental political difference between mitigation and adaptation. Emissions of heat-trapping gases into the atmosphere are circulated and mixed globally, thereby affecting everyone on Earth. Mitigation efforts require worldwide participation at a level of global cooperation never achieved before in human history. Mitigation is a long-term challenge exacerbated by the fact that decades will pass before the results are evident. On the other hand, adaptation is more local in character

and something people can do for their own direct benefit (i.e., the Dutch building dikes). Adaptation often reaps immediate results. However, the benefits of adaptation are short term unless adequate mitigation is simultaneously undertaken.

Both mitigation and adaptation must be addressed, with mitigation being the harder problem as it entails much greater political negotiation. Adding to the complexities of such negotiations are problems including developed countries assisting poor countries to implement adequate adaptation. Basic to the demands of emerging countries is that developed countries, which released prodigious quantities of heat-trapping gas emissions in the past, take on the burdens of fixing the problems they have caused.

16. According to Archer and Rahmstorf, the wide consensus among climate scientists is that current and future climate change can be addressed adequately only through **[(*mitigation*)(*adaptation*)(*both mitigation and adaptation*)]**.

17. They report that **[(*mitigation*)(*adaptation*)]** efforts are more likely to produce immediate observable benefits.

18. Archer and Rahmstorf point out that adequate **[(*mitigation*)(*adaptation*)]** requires greater political participation on a global scale.

19. The same authors point out that **[(*mitigation*)(*adaptation*)]** is the more difficult problem to address and entails much greater political negotiation. Part of the challenge is determining whether those countries which added the preponderance of the additional heat-trapping gases into the atmosphere should bear the financial burdens associated with stabilizing or reducing their concentrations.

Summary

The overwhelming consensus in the climate science community is that climate change resulting from anthropogenic forcing is taking place. It is also agreed that addressing these climate change impacts requires both mitigation and adaptation. Even the most strenuous mitigation efforts will take decades to begin showing evidence of impact, although it is known that earlier mitigation efforts will have a greater effect on reducing climate change than comparable efforts made later. Adaptation is unavoidable and, without concurrent mitigation, insufficient to meet the challenges of climate change.

Climate scientists are increasingly concerned about dangerous anthropogenic interference and irreversibility. Human activity has already generated enough heat-trapping gases to commit the Earth's climate system to producing some manifestations resulting from global warming that are irreversible.

Ignoring or underestimating the possible impacts of climate change carries with it immense potential for huge environmental and societal costs. Political action at local, national, and global levels is required to adequately address these impacts.

Instructions for Communications with Mentor:

Transmit this week's work to your LIT mentor by Monday, 7 December 2015, or as coordinated with your mentor. Include:

- **Chapter Progress Response Form** from the *Study Guide* or the *RealTime Climate Portal* course website.
- **Investigations Answer Form** for 12A and 12B from the *Study Guide* or *RealTime Climate Portal* website.
- **Current Climate Studies Answer Form** from *RealTime Climate Portal* website.