Princeton University
Department of Civil and Environmental Engineering &
Woodrow Wilson School of Public and International Affairs
Fall 2013

CEE/ENV/ENE334 / WWS452
Global Environmental Issues
Frist 309
Mondays and Wednesdays 1:30-2:50PM

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Overarching goal:
Learn how science can inform environmental policy development and advance solutions to global environmental problems.

Overview:
As the world’s population grows and becomes more affluent, human impact on the global environment also increases. This course examines a set of global environmental issues including population growth, ozone layer depletion, climate change, air pollution, the environmental consequences of energy supply and demand decisions and sustainable development. It provides an overview of the scientific basis for these problems and examines past, present and possible future policy responses.

Course Format:
Course topics will usually be covered in modules with the first part of the module covering the key scientific concepts surrounding the environmental issue and the second analyzing the present and possible future policy responses. Class meetings will be divided, very roughly, into 50% lecture and 50% discussion that involve in-class activities based on pre-class reading. All students are expected to do the required weekly reading which will form the basis for classroom discussion and activities. Most of the reading is on the course Blackboard site (placed in order of importance) with some available over the internet and one book for purchase. Web addresses are noted below in the syllabus.
By midnight Sunday each student should deposit on the BlackBoard discussion board one question about the readings for that week. As time permits, the questions will be used to catalyze in-class discussions.

Most of the topics covered in class are frequently in the news. To bring the world into the classroom students are asked to find and share academic and news articles related to course topics via blogs set up on BlackBoard.

Class participation will count in your grade. In class discussions/activities, submission of discussion questions, and submission of blog posts and will all count for class participation.

**Grading:**

Grades will be based on class participation, problem sets, presentations, a mid-term and final paper according to the following percentages:

- Class participation: 30%
- Homework: 30%
- In-class quiz: 10%
- Final paper: 25% and presentation 5%

**SCHEDULE OF CLASSES**

**Week 1: September 11, 2013. Course Overview and Introduction.**

**Goal:** Describe and discuss main drivers of global change and the implications of humans becoming a geological force. Important drivers include: Population growth, increased consumption leading to increased pollutant emissions and natural resource use. Discuss differences in these drivers between developed and developing countries.

**Reading:**


The NASA satellite images in this article show the planetary scale of environmental changes associated with human activities.


This has some interesting graphs. Feel free to skim.


**Week 2. September 16 & 18, 2013. Stratospheric Ozone Depletion – Science**

**Homework #1 Distributed - Stratospheric ozone depletion science**

**Goal:** Understand the extraordinary series of discoveries (laboratory, aircraft field campaigns, satellite data) that linked the use of ozone depleting substances (ODS) to stratospheric ozone depletion and facilitated the international response to phase out the ODS.

Ozone in the stratosphere protects life on earth from excess ultra-violet (UV) radiation. It has been depleted at all latitudes except the tropics by the emission of anthropogenic (human produced) chlorofluorocarbons (CFCs) and related substances. Increases in UV radiation at the earth’s surface result in an increase in the incidence of skin cancer, eye cataracts, decrease in productivity of some ecosystems, and a decrease in air quality. A global phase-out of the production of CFCs brought about by the Montreal Protocol -- an international environmental treaty -- is expected to lead to a full recovery of the ozone layer in the second half of this century.

**Required Reading:**
EPA information on stratospheric ozone depletion:
This is a basic introduction to stratospheric ozone:

Twenty Questions and Answers about the Ozone Layer. 2011.
This is a superb summary of the key concepts of how ozone depleting substances (ODS) destroy stratospheric ozone and how the phase-out of ODS is projected to result in a full recovery of the ozone layer. Although written by scientists and technically rigorous it is highly accessible.
Supplementary Reading:


For those who are interested in more details about how stratospheric chemistry works, this is a good reference. It comes from the "Introduction to Atmospheric Chemistry" textbook written by Harvard Professor Daniel Jacob and intended for undergraduate students as their first course in atmospheric chemistry.


Homework #1 Due.

Goal: Understand how and why the Montreal Protocol was successfully ratified by virtually all countries in the world and remains the single most effective international environmental treaty.

Explain key drivers (science, industry, diplomacy, economics, technology, impacts) that made this happen.

Identify and discuss key lessons that the MP provides to address climate change and other global environmental problems. One key lesson – formalized method for feedback between scientific evaluation and policy response is effective for adapting environmental policy to evolving scientific situation.

The Montreal Protocol, an international treaty to protect stratospheric ozone, has resulted in a near global phase-out of CFCs and related substances. This treaty is considered one of the world’s global environmental success stories. We'll explore what made it possible and the lessons that can be taken from it to address other global environmental problems. We will also consider whether it should be expanded to include certain greenhouse gases (GHG).

Homework #2 distributed -- Should HFC and N2O controls be included in the Montreal Protocol? Role play in class and position memo to turn in. Please post draft position paper on BlackBoard by Tuesday midnight.

The Montreal Protocol may be expanded to include HFCs (chemicals which were developed to replace the ozone depleting CFCs and HCFCs). HFCs do not destroy stratospheric ozone but are strong GHG. In addition, there is now discussion of including nitrous oxide (N2O) an ozone depleting GHG which has its primary source from agriculture and which is currently listed under the Kyoto Protocol. In class you will be assigned various stake-holder positions (eg. scientists, diplomats, chemical manufacturers, farmers, environmental groups) and asked to write a 1-2 page memo on
their position and then debate in class how to proceed on the inclusion of these additional compounds in the Montreal Protocol.

**Reading:**


This is a long document. Just read the executive summary.

**Reading useful for homework #2:**


Kanter D. et al (2013) “A post-Kyoto partner: Considering the stratospheric ozone regime as a tool to manage nitrous oxide”, *PNAS*

**Supplementary Reading:**

Anderson S. O. and Sarma K. M., Protecting the Ozone Layer, Chapter 6 – Implementing the Montreal Protocol

Anderson S.O. et al., Technology Transfer for the Ozone Layer – ch. 2, 13, 14.
The chapters of this book, Technology Transfer for the Ozone Layer, describe how technology transfer for environmental protection has been successful. It takes lessons learned from ozone protection and examines how they can be applied to climate change.

**Week 4. September 30, 2013. Climate Change – Science**

Homework #2 (position memo) Due Monday in class.
HW #3 distributed – climate science.

Goal: Understand the level of historical climate change, future projections of climate change and the implications of these changes for human society and biodiversity. Be able to describe the implications of emissions of greenhouse gases (GHG) on future GHG concentrations, and climate response (temperature – regionally and globally, precipitation, etc.).

Connect population growth, future per capita increases in energy and food consumption with our ability to stabilize and decrease GHG concentrations. Estimate allowable future GHG emissions given the policy goal of limiting global average temperature increase to 2 C.

Human activities, primarily the burning of fossil fuels such as coal, oil and natural gas, deforestation and agriculture are increasing the concentrations of gases in our atmosphere which trap heat. The Intergovernmental Panel on Climate Change (IPCC), set up in 1988 by the United Nations Environment Program (UNEP) and the World Meteorological Organization, and composed of scientists from around the world, reviews the state of scientific knowledge on climate change and issues comprehensive reports approximately every 5-years. We will examine the current understanding and evidence for climate change as well as its potential future impacts.

Reading:


This is the primary reference we will use for climate change. This book is written by Sir John Houghton, a former director of the science assessment of the Intergovernmental Panel on Climate Change (IPCC). It is written in an accessible style and provides a definitive summary of the fourth assessment report of the IPCC. The IPCC 4th assessment report was released in 2007 and this summary was published in 2009. The fifth assessment is due out in 2014. The book is available for purchase from the U-Store (and on-line book sellers).

Please read:

Chapter 1: Global Warming and Climate Change.
This provides background and overview to the issue. Figure 1.5 is worth a careful look.
This chapter explains what causes the greenhouse effect. Figure 2.7 is worth careful attention.

This chapter discusses where the greenhouse gases (GHG) come from, how their concentrations have changed over time, and what their effect is on radiative forcing. Figure 3.11 is worth careful attention.

Chapter 4. Climates of the Past (optional).
Figures 4.1a and 4.6a are worth looking at.

Chapter 6. Climate change in the 21st century and beyond.
This chapter describes the emission scenarios used to model future climate and the resulting projections of future global and regional temperature and precipitation changes. Understand figures 6.1, 6.4, 6.6, 6.7 and 6.8.


This is the government approved summary of the IPCC reports (Science, Impacts and Mitigation) written for policy makers. Skim it and be prepared to discuss how effective you feel it is as a tool for policy makers.

IPCC. Science Assessment – Technical Summary.
This is the technical summary written by scientists that summarizes the findings of the IPCC science assessment. Skim it and be prepared to discuss how it differs from the summary for policy makers. Is this a more or less effective tool for sharing scientific findings with a larger audience?

Supplementary Material


US Global Change Research Program publications and reports may be more accessible than some of the IPCC reports. http://globalchange.gov/publications


Goal: Describe past efforts at international agreements on climate change (key treaties and mechanisms within the treaties). Evaluate potential for successful future international climate agreements. Discuss similarities and differences with MP approach.

Do technologies exist that will permit us to reduce the emission of greenhouse gases sufficiently to stabilize climate? We will examine current perspectives on this topic. The Framework Convention on Climate Change (FCCC) was signed at the 1992 Earth Summit in Rio and put the issue of climate change on the international stage. The Kyoto Protocol, negotiated in December 1997, introduced the first commitments to reduce emissions of greenhouse gases by developed countries and went into effect, without participation from the United States, February 16, 2005. In December 2009 in Copenhagen international negotiations failed to come to agreement on how climate change mitigation should be addressed internationally. We will examine similarities and differences between the policy approach to climate change and stratospheric ozone depletion and consider what needs to occur in order to reduce the rate of climate change and what may be politically possible.

Homework #3 Due.

In-class activity – climate skeptic vs. scientist and GHG mitigation research, development and deployment vs. geoengineering research and development debates.

Choose a country to report on for mid-term paper.

Reading:

Background on Framework Convention on Climate Change, Kyoto Protocol and Copenhagen Accord:

Oppenheimer, M., 2009, Memo on Global Warming. For NYU Environmental Law Seminar (available on blackboard).

Overview of the Kyoto Protocol including updates with recent developments: http://unfccc.int/kyoto_protocol/items/2830.php


Copenhagen Accord.
This is a list of several links to short articles examining the outcome of the climate meeting in Copenhagen in December 2009. Just peruse.


Economics:


**Week 6. October 14 & 16, 2013. Climate change – public perception, politics, mitigation vs. geoengineering.**

Guest Speaker: Dr. James Hansen, climate scientist and activist.

Goal: Examine public perception of climate change and how it has been influenced by climate skeptics, industry interests, etc. Examine challenges and benefits of GHG mitigation and geoengineering.

What’s the best way forward to protect the world from “dangerous anthropogenic interference with the climate system”?

Reading:


Please read the two short commentaries: "The Latest on Geoengineering" and "Scientists Grapple With ‘Completely Out of Hand’ Attacks on Climate Science". These articles appear in the "news and views" front section of Science, one of the most prestigious science journals in the world.


General analysis leaning in favor of geoengineering. Read the summary and go further if interested.

**Supplementary Reading – Samples of Dr. Hansen’s work:**

Hansen, J.. 2006. The Threat to the Planet.
This book review is written by Jim Hansen who was the director of the NASA Goddard Institute of Space Studies (a top climate modeling lab) until last year. He has published prolifically in the scientific peer reviewed literature. For a scientist he has been unusually outspoken about the threat of climate change and was heavily pressured by the President H.W. Bush administration to not speak with the press. He will be giving a STEP talk on October 14, 2013.


Goal: Describe energy technology options, the relative quantity of GHG they emit, cost, availability, penetration. Be able to do simple calculations comparing them and estimating effect their penetration at a given level will have on global CO2 emissions.

October 23: In class country presentations and debate on approaches to address climate change. Homework #4 -- Country memo due.

Reading:
Chp 10: A strategy for action to slow and stabilize climate change
Chp 11: Energy and Transport for the Future


Fall Break


Goal: Describe sources of air pollution and how it is formed/transformed and transported in the atmosphere. Understand impacts of air pollution on climate, health, agriculture and ecosystems. Analyze the benefits of controlling different emissions/industry sectors.

Distribute HW#5. Air pollution science and policy

Emissions of precursors to acid rain, ozone and particulate pollution all come from fossil fuel combustion and biomass burning and have been controlled largely due to their impacts on health. These pollutants can be transported long distances and effect
regions outside the countries where they were emitted. They also affect climate – some warm and some cool. We will examine differences between pollution levels in developed and developing countries and the effect of improving air quality on climate.

**Reading:**


Avnery, S, DL Mauzerall, J Liu, LW Horowitz. 2011. Global Crop Yield Reductions due to Surface Ozone Exposure: 1. Year 2000 Crop Production Losses and Economic Damage. *Atmospheric Environment*, 45, 2284-2296, 2011. This is a research paper in which a doctoral student and I, with collaborators at the Geophysical Fluid Dynamics Lab, calculated crop yield reductions resulting from ozone exposures globally. No need to spend a lot of time on the details, but I wanted to include something that showed you real research on the large impacts of air pollution.

**Supplementary Reading :**


**Goal:** Be able to discuss different methods of controlling air pollution and their advantages/disadvantages.

**Readings:**


Description of the Climate and Clean Air Coalition. [www.unep.org/ccac/](http://www.unep.org/ccac/)

Description of the Long Range Transboundary Air Pollution Treaty (LRTAP) [http://www.unece.org/env/lrtap/lrtap_h1.htm](http://www.unece.org/env/lrtap/lrtap_h1.htm)

Supplementary Reading:


Week 10. November 18, 2013. Air Pollution Mitigation -- GAINS model

**HW #5 due. Distribute HW #6 – GAINS model analysis**

**Reading:**
General information for GAINS: [http://www.iiasa.ac.at/web/home/research/researchPrograms/GAINS_en.html](http://www.iiasa.ac.at/web/home/research/researchPrograms/GAINS_en.html)
This is a tool used to analyze the effect of air pollutant and GHG emissions simultaneously. GAINS-Europe is used to develop policy in Europe. In particular, look at links to the version of GAINS used for China. We will do some simple analyses using GAINS-China for homework.

GAINS Tutorial: [http://www.iiasa.ac.at/web/home/research/researchPrograms/GAINS-tutorial.pdf](http://www.iiasa.ac.at/web/home/research/researchPrograms/GAINS-tutorial.pdf)

HW #6 due.

Readings:


Week 12. December 2 & 4, 2013. Sustainable Development

Goal: Be able to discuss how the drivers discussed in week 1 adversely impact sustainable development. Think about how we can go from our current situation to a more sustainable one in both developed and developing countries.

Reading:


Daly, Herman. 2009. Anathemas of Economic Growth, Conservation Biology.


This article puts the recent Rio+20 meeting on sustainable development (held this June 2012) into a valuable larger context.

United Nations Commission on Sustainable Development:
The link above provides information on the UN Commission on Sustainable Development (CSD). CSD is a global effort to develop methods to achieve sustainable development. Please just peruse the website.

**Week 13. December 9 & 11, 2013.** In-class quiz. Final wrap-up.

**Final presentations – First week of reading period, Date/time TBD.**

**Final term papers due:** Tuesday January 14, 2012 (Dean’s date).