Syllabus
EES 3310/5310: Global Climate Change

Jonathan Gilligan
Vanderbilt University

Fall 2018

1 Nuts and Bolts

1.1 Class Meetings

MWF 9:10–10:00 Stevenson 1120
Laboratory: Mondays, 2:10–5:00 PM Stevenson 2200

1.2 Professor

Jonathan Gilligan
Associate Professor of Earth & Environmental Sciences
Associate Professor of Civil & Environmental Engineering
Office: Stevenson 5735 (Stevenson #5, 7th floor),
Phone: 322-2420
`jonathan.gilligan@vanderbilt.edu`
`www.jonathangilligan.org`
Office Hours: Mon. 10:15–11:00, Thu. 10:00–11:00, or by appointment.

1.3 Teaching Assistant

Kelsea Best
Office: Stevenson 5703A
`kelsea.b.best@vanderbilt.edu`
Office Hours: Wed. 3:00–4:00 pm, Fri. 10:10–11:00 am, or by appointment.

Ms. Best will be grading labs and homework, so address questions about your homework and lab grades to her.

1.4 Email

If you want to communicate with Professor Gilligan or Ms. Best be sure to begin the subject line of your email with "EES 3310" or "EES 5310". This helps assure that we will see your message quickly and respond to it.

I have set my email reader to flag all messages like this as important, so I will read them first. This also assures that I do not mistake your email for spam. I typically receive over 100 emails per day, so if you do not follow these instructions I may not notice your email.

2 Course Description

2.1 Catalog Description

Scientific principles and policy applications. Earth's past; evidence of human impact; future climate change; and economic, social, and ecological consequences. Economic, technological, and public policy responses. Repeat credit for 2110. Students who have earned credit for 2110 will earn only one credit hour for this course. Prerequisite: one of 1030, 1080, 1510, BSCI 1510, CHEM 1601, ECON 1010, ES 1401 or PHYS 1501, 1601, 1901. [4] (MNS)

2.2 Narrative Description

This course will study earth's climate and the way it has changed throughout our planet's history. We will study:

- Determinants of climate: What factors affect climate, how do we know this, and how certain are we?
- Scientific evidence about past climates: What do we know, how do we know it, and how certain are we?
- Natural climate change in earth's history.
- Effects of human activity on global climate in the last 200 years.
- What do we know about future climate change and how will it affect the quality of people's lives?
- How do economists and political scientists assess the costs of climate change and the value of policies to limit it?
- What can we do to mitigate future global climate change or adapt to life in a different climate?
- What is happening politically, both in the U.S. and internationally, to respond to climate change?

3 Goals for the Course

My goals for this course are that at the end of the semester:

- You will have a solid quantitative understanding of the basic physical and chemical principles that control the system and be able to apply that knowledge to reasoning about the climate system and its response to disturbances.
- You will have working familiarity with a variety of computer models that simulate various aspects of the climate system and be able to use those models to explore the implications of scientific principles that are too complex to calculate with pencil and paper.
- You will have a solid scientific understanding of what scientists know, what they don't know, and how they know what they know about how climate works, how and why it has changed in the past, and how it may change in the future.

- You will be able to evaluate the evidence for and against the idea that human activity is warming the planet and assess for yourself whether the evidence is persuasive.
- You will be familiar with the ways economists and policy analysts approach the problem of climate change and public policies that respond to it.
- You will understand the history of scientific and political concern and activity around global warming, the principal policy measures being considered to address climate change, and their major strengths and weaknesses.
- You will have the tools and knowledge to make informed decisions about what climate policies you support or oppose.
- In the laboratory, you will learn to:
  - Use simple climate models to explore the dynamics of the climate system.
  - Use open-source statistical tools to download and analyze real climate data.
  - Follow established reproducible research practices.

When you leave this course, you will not be qualified to work as a climate scientist, but you will be able to follow and critically evaluate news reporting about climate change and climate policy, debate intelligently and knowledgeably, and be an informed voter.

I do not care whether you agree with me politically. I respect people who think for themselves. **What counts is whether you can present your own position clearly and support it with solid evidence and reasoned argument.**

4 Important Dates:

Many of you have athletic and other commitments during the term and may travel for personal reasons. As you plan for your semester, particularly if you are purchasing nonrefundable airplane tickets, consult the syllabus.

If you have away games that require you to miss a scheduled test or group laboratory activity, let me know well in advance.

- The mid-term test is on **Wednesday, October 3**.
- On **Monday November 5**, we will be doing a participatory role-playing exercise in lab, where you will play out different kinds of policies for reducing greenhouse gas emissions. It is especially important for you to be present for this lab.
- The take-home final exam is due at **2:00 pm Wednesday, December 13**. You submit the final exam electronically, so you do not need to be on campus for this.

5 Structure of the Course:

I divide the semester into two parts:

1. **Scientific Principles of Climate**: For the first half of the semester, we will focus on the scientific principles of climate and natural climate change in earth's past. This will be very mathematical, using basic algebra. We do not use calculus or other advanced math

in this class, but you should be comfortable with simple algebraic equations. We will then look at climate change in the last two centuries and what might happen over the next several centuries. We will emphasize examining the scientific evidence to understand what it can and cannot tell us.

2. **Human Dimensions of Climate Change: Politics, Economics, etc.:** For the second half of the semester, we will focus on the political, economic, and social aspects of climate change and possible public policy and technological responses.

5.1 Laboratory

The laboratory section of this course is very important. In the first half of the semester, you will use interactive computer models of the climate system to explore the implications of principles that we cover in class and in the reading, practice downloading and analyzing real climate data, and learning about best practices for reproducible research in order to make your work reliable, reproducible, and trustworthy. In the second half, you will use computational tools to explore the challenges of replacing fossil fuels with clean energy (renewable or nuclear), conduct quantitative economic analyses of different kinds of climate policies, and engage in role-playing exercises to simulate the way different climate policies work in practice.

To make the laboratory sessions effective, it is essential that you show up on time and prepared for the labs.

5.2 Reading Material

There are three required textbooks. Supplementary reading on the Internet or in handouts will also be assigned during the term and posted on Brightspace.

REQUIRED READING MATERIALS

- David Archer, *Global Warming: Understanding the Forecast,* 2nd ed. (Wiley, 2011; ISBN 978-0-470-94341-0). Be sure you get the second edition because it is significantly different from the first.
- William Nordhaus, *The Climate Casino: Risk, Uncertainty, and Economics for a Warming World* (Yale, 2013; ISBN 978-0-300-21264-8)
- Roger A. Pielke, Jr., *The Climate Fix* (Basic Books, 2010; ISBN 978-0-465-02519-0)

There is a companion web site to *Global Warming: Understanding the Forecast* at `climatemodels.uchicago.edu`, which includes interactive on-line computer models that we will use for some exercises in the book.

OVERVIEW OF READING MATERIALS

I will give out detailed reading that give specific pages to read for each class and notes on important things you should understand. **I expect you to complete the reading before you come to class on the day for which the reading is assigned**, so you can participate in discussions of the assigned material and ask questions if there are things you don't understand.

While science aims to give correct answers to scientific questions, there are not right or wrong answers to questions of what is the best economic model with which to assess the costs of climate change or the best policy with which to respond to climate change, so I have chosen books and other reading material that present different points of view on the political and economic aspects.

5.3 Graded Work

BASIS FOR GRADING

Class participation	5%
Mid-term exam	30%
Laboratory & Homework	33%
Final exam	32%

TESTS AND EXAMINATIONS

There will be one in-class midterm exam, on **Wednesday, October 3**. This test will be closed book. I will hold a review session before the test. **You will need to bring a calculator, number two pencils, and erasers to the in-class test.**

FINAL EXAMINATION:

There will be an open-book take-home final exam, for which you may use your books and notes. You will submit your take-home final electronically. It will be due at the end of the scheduled alternate final examination, 2:00 pm Wednesday December 13.

The final exam will be cumulative over all the material covered during the term.

6 Honor Code:

This course, like all courses at Vanderbilt, is conducted under the Honor Code.

I encourage you to to seek help from me, from Ms. Best, or from other classmates or friends in your studying. I also encourage working together on lab and homework assignments: you may talk with your friends and classmates about those assignments, compare notes on how you are working a problem, and you may look at your classmates' work. But you must work through the problems yourself in the work you turn in: **Even if you have discussed the solution with others you must work through the steps yourself and express the answers in your own words. You may not simply copy someone else's answer.**

Tests are different from homework and labs: **all work on tests and exams must be entirely your own**. **You may not work together with anyone or receive any help from anyone but me on exams and tests (this includes take-home exams and tests)**.

If you ever have questions about how the Honor Code applies to your work in this course, please ask me. **Uncertainty about the Honor Code does not excuse a violation.**

7 Final Note:

I have made every effort to plan a busy, exciting, and instructive semester. I may find during the term that I need to revise the syllabus to give more time to some subjects or to pass

more quickly over others rather than covering them in depth. Many topics we will cover are frequently in the news. Breaking news may warrant a detour from the schedule presented on the following pages. Thus, while I will attempt to follow this syllabus as closely as I can, you should realize that it is subject to change during the semester.

8 Meet Your Professor

Jonathan Gilligan has worked in many areas of science and public policy. His past research includes work on laser physics, quantum optics, laser surgery, electrical properties of the heart, using modified spy planes to study the ozone layer in the stratosphere, and connections between religion and care for the environment.

Professor Gilligan is a member of the Vanderbilt Institute for Energy and Environment, a founding member of the Vanderbilt Initiative for Smart-City Operations Research (VISOR), a founding member of the Erdős institute for Collaboration, Innovation, and Entrepreneurship, and the Associate Director for Research at the Vanderbilt Climate Change Research Network.

His current research investigates the role of individual and household behavior in greenhouse gas emissions in the United States; how "smart cities" can use technology to reduce environmental footprints and promote health and citizen empowerment; water conservation policies in American cities; vulnerability and resilience to environmental stress in Bangladesh; adaptation to water scarcity in Sri Lanka; and developing new directions for climate policy in the US.

In 2017, Professor Gilligan and Professor Michael Vandenbergh shared the Morrison Prize for the highest-impact paper on sustainability law and policy published in the previous year. Professors Gilligan and Vandenbergh have developed this work into a book, *Beyond Politics: The Private Governance Approach to Climate Change* (Cambridge University Press, 2017).

Apart from his academic work, Professor Gilligan dabbles in writing for the theater. His stage adaptation of Nathaniel Hawthorne's *The Scarlet Letter*, co-written with his mother Carol Gilligan, has been staged at The Culture Project in New York City, starring Marisa Tomei, Ron Cephas Jones, and Bobby Cannavale, and was later performed at Prime Stage Theatre, Pittsburgh and in a touring production by The National Players. Prof. Gilligan and Carol Gilligan also wrote the libretto for an opera, *Pearl*, in collaboration composer Amy Scurria, and producer/conductor Sara Jobin, which was performed at Shakespeare & Company in Lenox MA, starring Maureen O'Flynn, John Bellemer, Marnie Breckenridge, John Cheek, and Michael Corvino, and in Shanghai China, starring Li Xin, Wang Yang, John Bellemer, and Lin Shu.

Schedule of Classes (Subject to Change)

IMPORTANT NOTE: This schedule gives a rough indication of the reading for each day. See the assignment sheets posted on Brightspace for the detailed daily assignments.

Date	Topic	Reading
Wed., Aug. 22	Introduction	
Fri., Aug. 24	What is Climate Change?	*Forecast* Ch. 1; *Casino*, Ch. 1–2
Mon., Aug. 27	Energy Balance and Climate	*Forecast*, Ch. 2–3
Wed., Aug. 29	Greenhouse Effect	*Forecast*, Ch. 3
Fri., Aug. 31	Greenhouse Gases	*Forecast*, Ch. 4
Mon., Sep. 3	Vertical Structure of the Atmosphere	*Forecast*, Ch. 5
Wed., Sep. 5	Review of Greenhouse Effect	
Fri., Sep. 7	Feedbacks	*Forecast*, Ch. 7
Mon., Sep. 10	Ocean and Biosphere Feedbacks	*Forecast*, Ch. 7; Handout on feedbacks
Wed., Sep. 12	The Carbon Cycle: Ocean and Biosphere	*Forecast*, Ch. 8
Fri., Sep. 14	The Carbon Cycle: Mineral Weathering	*Forecast*, Ch. 8
Mon., Sep. 17	Perturbing the Carbon Cycle	*Forecast*, Ch. 10
Wed., Sep. 19	Climates of the Past	*Forecast*, Ch. 11; Handout on isotopes
Fri., Sep. 21	The Pleistocene Ice Ages	*Forecast*, Ch. 7–8, 11; Handout on isotopes
Mon., Sep. 24	Review	
Wed., Sep. 26	Climate Models	*Casino*, Ch. 3–4
Fri., Sep. 28	Future Climate Change	*Forecast*, Ch. 12; *Climate Casino*, Ch. 5
Mon., Oct. 1	Catching up and Review	
Wed., Oct. 3	**MIDTERM EXAM**	
Fri., Oct. 5	Uncertainty about Future Climates	*Forecast*, Ch. 12; *Casino*, Ch. 24; *Climate Fix*, Ch. 1
Mon., Oct. 8	How Will Climate Change Affect Our Lives? (Part 1)	*Casino*, Ch. 6–9
Wed., Oct. 10	How Will Climate Change Affect Our Lives? (Part 2)	*Casino*, Ch. 10–12
Fri., Oct. 12	Policy Myths	*Climate Fix*, Ch. 2; *Casino*, Ch. 25
Mon., Oct. 15	The Kaya Identity: Energy Use, Efficiency, and Conservation	*Climate Fix*, Ch. 3; *Casino*, Ch. 14

Date	Topic	Reading
Wed., Oct. 17	Reducing Carbon Emissions: Bottom-Up Approaches	*Climate Fix*, Ch. 4
Fri., Oct. 19	**FALL BREAK**	
Mon., Oct. 22	Reducing Carbon Emissions: Top-Down Approaches	*Climate Fix*, Ch. 4
Wed., Oct. 24	The Cost of Reducing Emissions	*Casino*, Ch. 14–15
Fri., Oct. 26	Goals of Climate Policy	*Casino*, Ch. 17; *Climate Fix*, Ch. 6
Mon., Oct. 29	Costs and Benefits	*Casino*, Ch. 18
Wed., Oct. 31	Pricing Carbon	*Casino*, Ch. 19
Fri., Nov. 2	Carbon Pricing Instruments	Handouts on market-based regulation
Mon., Nov. 5	Discounting and the Value of Time	*Casino*, Ch. 16; Handouts on intergenerational ethics
Wed., Nov. 7	The Limits of Economic Approaches	Handouts on Economics of Climate Change
Fri., Nov. 9	The Case for Renewable Energy	Handouts on Wind, Water, and Sun
Mon., Nov. 12	The Case for Nuclear Energy	Handouts on Nuclear Energy
Wed., Nov. 14	Geoengineering: Solar Radiation Management	*Climate Fix*, Ch. 5; *Casino*, Ch. 13; Handout on geoengineering
Fri., Nov. 16	Geoengineering: Carbon Dioxide Management	*Climate Fix*, Ch. 5; *Casino*, Ch. 14; Handout on carbon capture
Mon., Nov. 19 Wed., Nov. 21 Fri., Nov. 23	**THANKSGIVING BREAK**	
Mon., Nov. 26	Pragmatism and Climate Policy	*Casino*, Ch. 23; *Climate Fix*, Ch. 9
Wed., Nov. 28	Global Warming Gridlock	Handout
Fri., Nov. 30	Beyond Gridlock: Second-Best Policies	Handout on Private Environmental Governance
Mon., Dec. 3	Obstacles and Perspectives	*Casino*, Ch. 26; Handout
Wed., Dec. 5	Review	
Thu., Dec. 13	**TAKE-HOME FINAL EXAM DUE**	