Syllabus
Physics of the Global Climate Change
(Physics 2450)
Fall Semester 2019

Instructor: Prof. Jens Oberheide, 103 Kinard Lab, Dept. of Physics and Astronomy, Clemson University, Tel. 864-656-5163, Email: joberhe@clemson.edu

Class Hours: Tu & Th 9:30 – 10:45, 201 Kinard; you may leave class if Prof. Oberheide has not arrived after 15 minutes

Office Hours: Prof. Oberheide's office hours are Mo 12:00 – 1:00, Th 11:00 – 12:00; students can make appointments outside the regular office hours by email request

Prerequisites: None. However, this is an algebra-based physics course, similar to PHYS 2000, which requires MATH 1020. Successful participation will require some algebra, manipulating numbers in scientific notation, reading and preparing graphs, and understanding text problems. Students who feel very uncertain in these areas should consider taking a different course.

Attendance Policy: Attendance is ***required***, since additional material will be presented in class not contained in the textbook. Also in-class exercises and participation in discussions are an important part of this course. Attendance will be checked through participation in the in-class quizzes. ***A student who misses more than four classes without a valid excuse may be dropped from the course.*** See also Announcements – General Policies.

Any exam that was scheduled at the time of a class cancellation due to inclement weather will be given at the next class meeting unless contacted by the instructor. Any assignments due at the time of a class cancellation due to inclement weather will be due at the next class meeting unless contacted by the instructor. Any extension or postponement of assignments or exams must be granted by the instructor via email or Canvas within 24 hours of the weather related cancellation.

Required Materials: Smartphone with Canvas App or laptop to do the in-class quizzes (***must bring to each class***). Laptop with LockDown Browser software installed (***must bring for exams***).

Required Textbook: Dessler, Andrew: Introduction to Modern Climate Change, 2nd ed., Cambridge University Press, 2016, ISBN 978-1-107-48067-4 (paperback), ~$47. You may use the ebook edition (~$37) but note the following: ***Exams will be open book but require the LockDown Browser – which will prevent you from using the ebook during an exam.***

Recommended Textbook: Archer, David: Global Warming: Understanding the forecast, 2nd ed., Wiley, 2011, ISBN 978-0-470-94341, paperback, ~$40.

Web Sites: The main course web site is on Canvas, accessible at http://clemson.edu/canvas/. Chapter notes, announcements, and assignments will be posted here. All exams will be administered through Canvas using the LockDown Browser. Additional useful web sites are:

http://www.andrewdessler.com Andrew Dessler's book website
http://www.ipcc.ch Intergovernmental Panel on Climate Change (IPCC)
http://climatemodels.uchicago.edu Online climate models interface

Course Outline: The course is ~15 weeks with 2 classroom lectures per week. Each week requires about 2-3 additional hours for reading, working a short assignment, and preparing for quizzes and tests. In each week, we will cover approximately one chapter in the textbook by Dessler.

1 An introduction to the climate change problem
2 Is the climate changing?
3 Radiation and energy balance
4 A simple climate model
5 The carbon cycle
6 Forcing, feedbacks and climate sensitivity
7 Why is the climate changing?
8 Predictions of future climate change
9 Impacts of climate change
10 Exponential growth
11 Fundamentals of climate change policy
12 Mitigation policies
13 A brief history of climate science and politics
14 Putting it together: A long-term policy to address climate change

Method of Teaching: This is a lecture course based upon a very popular textbook. Students will prepare by reading the chapters and answer included study questions. The main points (including mathematical examples) will be reviewed and discussed in class, along with additional material presented by the instructor. We will also engage in a number of exercises exploring various web-based models and applying the knowledge. Laptop (or smartphone with a big enough screen) with web access and calculator is required for each class. Assignments, exams, in-class quizzes are administered through Canvas.

Grading: Assignments in this course are divided into these general categories, which carry the following weight in your final grade calculations:

Category	Weight
In-class quizzes	15%
Homework assignments	40%
Midterm exams	30%
Final exam	15%

There will be two midterm exams (tentative dates: Sep 26, Oct 24) and one final exam (Dec 11). Each exam carries a weight of 15%. There will be weekly homework (40% weight). The two lowest homework scores will be dropped for the final grade calculation. ***Late homework will not be accepted if you don't give me a very good reason.*** In-class quizzes (15% weight) will be given in each class (also proof of attendance). The four lowest daily average quiz scores (including missed classes) will be dropped for the final grade calculation. All exams, assignments and quizzes must be submitted through Canvas.

Letter grade: A: 90-100%; B: 80-89%; C: 70-79%; D: 60-69%; F:<60%

E-Learning Day: In case the university declares an "E-Learning Day" for days the class meets (Tue & Thu), the usual classroom instruction will be substituted by an online-only instruction, usually a reading assignment with graded questions (counted towards the homework grade with the same weight as a standard homework). The instructor will provide students with detailed instructions for these activities through a Canvas announcement. ***The university already declared Thursday, August 29 an E-Learning Day.***

Course Rationale: Climate change will be, if not already, the environmental issue of the 21st century. This course aims to address the whole complexity of climate change with the focus upon the physics of climate change and impacts on the earth system. This course fulfills the General Education competencies "Natural Science (NS)" and "Science and Technology in Society (STS)".

Some important questions addressed in this course are:

- What is the scientific basis for our understanding of climate change?
- What are the sources of emissions of greenhouse gases?
- What changes in climate might we expect over the coming century and what might be the impacts for human wellbeing?
- What technologies exist or might be developed that could mitigate climate change?
- How do private, national and world economies respond to the challenge?
- How are public opinions formed and how do they vary in time?
- What is the role of scientists in the formulation of strategic goals and policy? What is a scientific consensus?

Objectives/Learning Outcomes: Students will be expected to show mastery of a variety of concepts drawn from the Earth sciences and physics. They would able to explain the relevance of these concepts for our present understanding of human-caused climate change and for the viability of different proposed solutions for adaptation and mitigation. By the end of this course, students will be able to:

Natural Sciences: Demonstrate scientific literacy by explaining the process of scientific reasoning and applying scientific principles inside and outside the classroom.

- Understand and apply physical terms and quantities like energy, power, temperature, heat, radiation and convert between different units

- Describe how the Earth's climate system works and summarize general atmosphere circulation patterns, ocean circulation patterns and climate oscillations such as the thermohaline circulation, North Atlantic Oscillation, and the El-Niño-Southern Oscillation.
- Diagram components of the Earth's carbon cycle, quantitatively describe how addition of carbon dioxide to the atmosphere through burning of fossil fuels will influence the climate, and understand the various feedback mechanisms that enter into the modeling of global climate change.
- Explain and evaluate the evidence for human-caused climate change, in the context of historical climate change, as well as the relevant scientific uncertainties and possible evidence to the contrary.
- Explain the natural and human causes of climate change, including the sources of greenhouse gas emissions. Because energy consumption is central to greenhouse gas emissions, students will understand the global energy infrastructure in a historical context. The possible technological options for reducing greenhouse gas emissions would be studied and evaluated.
- Explain and quantify the impacts of climate change on the natural world, and evaluate means by which these impacts can be reduced by adaptation, mitigation, and geoengineering.

Science and Technology in Society: Demonstrate and understanding of issues created by the complex interactions among science, technology and society

- Summarize and analyze the range of policy issues related to global warming.
- Discuss how scientific knowledge is transmitted to society
- Evaluate the successes and failures of past efforts to address climate change, and evaluate prospects for future mitigation of climate change
- Analyze the impact of ethical decision making and controversies among different interest groups

Disclaimer: "Students may vary in their competency levels on these abilities. They can expect to acquire these abilities only if they honor all course policies, attend class regularly, complete all assigned work in good faith and on time, and meet all other course expectations of them as a student."

Academic Integrity: The Clemson University statement on academic integrity reads: "As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a "high seminary of learning." Fundamental to this vision is a mutual commitment to truthfulness, honor and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating or stealing in any form."

Student Accessibility Services: Students requesting accommodations must present a Faculty Notification Letter from Student Accessibility Services (https://www.clemson.edu/academics/studentaccess/) to the instructor. Accommodations are not retroactive and new Faculty Notification Letters must be presented each semester.

Clemson University Title IX (Sexual Harassment) Statement: Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity (e.g., opposition to prohibited discrimination or participation in any complaint process, etc.) in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. This policy is located at http://www.clemson.edu/campus-life/campus-services/access/title-ix/. Ms. Alesia Smith is the Clemson University Title IX Coordinator. She is also the Executive Director of Equity Compliance. Her office is located at 223 Holtzendorff Hall, 864.656.3181 (voice) or 864.565.0899 (TDD).