

Paleoclimatology and Paleoceanography -- EE 351 -- Spring 2025

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Class Hours: M,W,F 11:15-12:05 STO 453

Office Hours: M-W-F 1:30-2:30; other times by appointment

Course Description

It is becoming increasingly clear that Earth's climate is changing. Understanding how and why Earth's climate has varied in the past is critical to predicting and perhaps preventing future climate change. In this class we will examine Earth's climate history at a range of time scales covering all of Earth's 4.6 billion year history. We will focus on the "big picture", major climate events and changes that occurred on a global scale. We'll be taking an "Earth Systems" approach to climate science. This means we will not simply be cataloging Earth's history of climate change, but trying to understand the climate system's *response* to external and internal *forcings*. We'll also spend some time learning about how we know what we (think we) know about Earth's climate history. The course will start with elements of the climate system, paleoclimate data, and models. We then discuss climate change on tectonic, orbital, millennial, and human time scales.

Hub Learning Outcomes

This course is designed to satisfy the following BU Hub learning objectives: Historical Consciousness, Quantitative Reasoning 2, and Research and Information Literacy

Historical Consciousness: EE 351 students will evaluate the evidence for past changes in climate, ranging from written records of cherry blossoms in Japan to chemical tracers in ancient rocks. We will spend several lectures examining climate archives and will learn to calibrate proxies to extract records climate change. In addition to tracing the history of Earth's climate, a consistent thread throughout the course will be the history of *our understanding* of climate change, and the scientists that contributed to this development. You may be surprised for example to learn that the first predictions of the consequences of increasing atmospheric CO₂ were made in the 1890's, and these calculations hold up quantitatively today. You can expect exam questions on both the science we've covered and the evolution of these ideas.

Quantitative Reasoning 2: In this course you will learn to manipulate and interpret data from climate change simulations using a general circulation model. Homework sets in this course are designed to develop a quantitative understanding of climate change, applicable to both understanding past climates and future climate change. For your final project, you will work in small groups of 2 or 3 to investigate a climate change problem by proposing a hypothesis, and then run a simulation to test that hypothesis. On the last day of class we will hold a poster session where students will present the results of their final projects.

Research and Information Literacy: An important part of your research for the final project will be reading and citing the published scientific literature on your research question. We will have a lecture mid-semester devoted to research methods. You will learn about the processes that produce peer-reviewed journal articles (the primary literature) as well articles written for general interest audiences (i.e. Scientific American, Earth Magazine), and the science news journalism such as appears the New York Times and on mainstream web sites. We will explore the use of online databases (Google Scholar, Web of Science) to identify key references from the primary scientific literature. You will learn how to use backward and forward reference searches to understand how ideas evolve through the primary literature. You will gain experience critically reading the primary scientific literature, testing a hypothesis regarding a problem in climate change, and communicating your research to the class in the poster presentation.

Other Outcomes (e.g., School, Department, and/or Program Outcomes)

EE351 is a core elective in the Earth and Climate track of the Earth and Environmental Science major. While several courses in the program offer perspectives on climate change, EE351 is one of few courses in the curriculum that covers Earth Science across a range of timescales.

Instructional Format, Course Pedagogy, and Approach to Learning

This course will be taught in-person and regular attendance is expected. Please email me in advance if you must miss a lecture due to illness, COVID isolation, etc. I will post Powerpoint slides for each lecture, but these are not intended as a substitute for regular class attendance. This is an upper-level course, and everyone will be expected to participate in class. I'll encourage participation by asking questions. Furthermore, it's a huge help to me if you stop me and ask questions when something isn't clear. If you're confused it's likely that many of your classmates are not following as well! The lectures are not a recitation of material from the book but doing the reading ahead of time will help you feel more prepared for class. Good note taking is essential in this course. Educational research has shown that taking notes on paper tends to be more effective than using a laptop or tablet for note taking. Do yourself and your classmates a favor, put the devices away and minimize distractions.

Pre-requisites: EE 105 or 107 or 142 or 144; EE 101 recommended

Books and Other Course Materials

Required Textbook: Ruddiman, W. F., 2014, *Earth's Climate: Past and Future*, 3rd Edition, W. H. Freeman & Co., ISBN: 978-1429255257. Copies available at Barnes and Noble. Bill Ruddiman is a paleoceanographer who has contributed to many of the important ideas on how Earth's climate changes over long time scales. The course outline generally follows this textbook. It will be supplemented with additional readings from the two books below plus current and classic papers from the primary literature.

Supplemental Textbooks:

Bender, M., 2013, *Paleoclimate*, Princeton University Press, 306 pp. From the Princeton Primers in Climate series. Michael Bender is one of the senior leaders in the field of paleoclimatology and has done a lot of the important work on greenhouse gasses in ice cores. This is a very readable paperback, available from Amazon.com for \$30.

Weart, S., The Discovery of Global Warming, <https://history.aip.org/climate/index.htm>. Spencer Weart is a historian of science who maintains and updates this html version of his 2008 book. We will use readings from this online book to learn about the scientists and discoveries that have led to our current understanding of Earth's climate history.

Website and Email

I will post lecture powerpoints, homework assignments, and exam review sheets on Blackboard Learn (learn.bu.edu). Please get in the habit of checking your BU email daily. It is the easiest way for me to communicate with the class as a whole, and your best way to reach me outside of class.

Final Project: Much of the research on past climates, and virtually all of the forecasts of future climate change are based on model simulations using a "GCM" (which can stand for either *General Circulation Model* or *Global Climate Model*). One of the early GCM's (GISS Model II) was developed at NASA in the 1980's and used for some of the first model-based projections of climate change which hold up surprisingly well today. Columbia University developed a user-friendly web-based version of this model called EzGCM (www.ezgcm.org) that we'll use for our class projects. Working in groups, you will do background research on your selected topic, read papers from the primary scientific literature, manipulate data produced by a GISS Model II simulation, and use data visualization tools to investigate the model output. Projects will be presented in a class poster session on the last day of class (April 30th). Your

group will submit a **one paragraph proposal on your project idea** along with a list of references from the primary literature references that frame the problem you are investigating, due March 24th. I'll provide each group to with feedback on the proposal. Further details will be to come mid-semester.

Grading Criteria. Your final grade is based 50% on exams and 50% on the work that you do outside of class:

2 In-class exams	15% each
Final Exam (comprehensive):	20%
Homework	35%
<u>Final Project</u>	<u>15%.</u>
Total	100%

Resources/Support/How to Succeed in This Course:

1. My formal office hours are Monday, Wednesday, and Friday 1:30-2:30. I'll usually be around MWF until early evening, and you are welcome to stop by. I am also happy to meet with you remotely at other times via Zoom. Send me an email and we'll set up a time to talk.
2. Accommodations for Students with Documented Disabilities: If you are a student with a disability or believe you might have a disability that requires accommodations, please contact the Office for Disability Services (ODS) at (617) 353-3658 to coordinate any reasonable accommodation requests. ODS is located at 19 Deerfield Street on the second floor.

Community of Learning: Class and University Policies

1. **Please ask questions during lectures.** If you don't understand something, chances are the person next to you does not either.
2. **Attendance & Absences. Attendance & Absences.** If you know you are going to miss a lecture, please let me know in advance. BU's policy on religious observance may be found here: <http://www.bu.edu/chapel/religion/>; and a calendar of religious holidays here: <http://www.interfaithcalendar.org/>.
3. **Assignment Completion & Late Work.** Homework assignments are due on the date indicated but I would very much prefer that you turn in an assignment late rather than not doing it at all. 10% per day will be deducted for late homeworks, with a maximum deduction of 50%.
4. **Diversity and Inclusion:** Diversity enriches all research and education, and is realized only with all voices, views, and perspectives operating within a supportive and respectful community. For this reason, the Department of Earth & Environment, including myself and the students in this course, are committed to fostering diverse, inclusive, and equitable living, learning, and working environments that are supportive and free from violence, harassment, disruption, and intimidation. Further, the Department of Earth & Environment recognizes that creating a safe environment and a culture of respect is the shared responsibility of all members of our community. To ensure an equitable environment that values and respects the unique experiences and perspectives of our community, the Department, including myself and the students in this course, are dedicated to promoting diversity, inclusion, and equity among all members of our departmental community and encouraging open, honest, and compassionate communication. <http://www.bu.edu/earth/about/diversityinclusion/>
5. **Academic Conduct Statement,** You are responsible for reading and knowing the CAS Academic Conduct Code: <http://www.bu.edu/cas/students/undergrad-resources/code/>. It is ok to work with a

classmate on homework assignments but you must make sure that you fully understand the work that you've done, failing to do so will come back to bite you when homework concepts appear on an exam. _Stealing another's ideas or words is unacceptable and will result in an immediate zero on the assignment. Additional cases of plagiarism will be referred to the Dean's office. If you are uncertain about something you have written, come talk to me.