Climate 466
Carbon - Climate Interactions
Fall 2019

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Class Time and Location: Monday, Wednesday 9-10:30 in CSRB 2236

Office Hours: Wednesday 4-5 pm

Course Description

The global carbon cycle represents a complex set of interactions between humans, the atmosphere, oceans, and terrestrial ecosystems. At present, about 50% of the carbon that humans contribute to the atmosphere as CO_2 is removed by terrestrial ecosystems and the ocean. Predicting future climate requires predicting whether these processes will accelerate, persist, or shut off under global change scenarios. We therefore need to develop a mechanistic understanding of the processes that add and remove carbon from the atmosphere, as well as the processes and properties of the Earth system that are responsible for long-term storage of carbon. In this course, we will applying basic physics, chemistry, and biology toward developing the insights we need to track carbon as it flows through the climate system. Emphasis is placed on the observations and modeling needed to quantify carbon sources and sinks.

Because humans are key drivers of the long term accumulation of CO_2 in the atmosphere, we will also focus on policies and technologies that could mitigate CO_2 emissions or atmospheric concentrations. We will discuss progress toward and goals of international climate treaties, especially in the context of the UNFCCC Conference of the Parties in Dubai occurring this autumn. Finally, we will participate in the campus-wide "Arts and Resistance" theme semester, by discussing how art and protest intersect with the urgent challenge of climate change.

Learning Objectives

By the end of the semester, students will be able to:

- Understand the critical role that greenhouse gases play in the climate system
- Understand how carbon flows through reservoirs in the Earth system
- Analyze observational and model data that reflect carbon cycle processes
- Apply tools to predict how climate change will affect flows and storage of carbon, and understand the limitations of said tools
- Feel comfortable with interdisciplinary thinking
- Understand the roles that different countries play in the global burden of atmospheric CO2 and critically evaluate the responsibility that diverse actors from individual to nation states have toward meeting climate objectives
- Communicate local to global scale consequences of carbon-climate feedbacks
- Evaluate opportunities for climate change mitigation through managing carbon
- Identify a role or roles that you would like to play in the evolving intersection between climate science, sustainability engineering, policy making, and activism

Course Structure

Classes will be in-person, with lectures live-recorded and posted online. During our class time, I will lecture from slides and answer questions, and we will also have opportunities to interact in small groups.

Assignments and Grading

There will be a diverse set of assessments – both in-class and out-of-class – in the course over the semester, including python-based problem solving, writing assignments, and opportunities to engage critically with peer-reviewed literature. Given the importance of collaboration in science, we will also have in-class exercises that will be group-based.

Python exercises will be centered around hands-on data analysis, modeling, and interpretation. These exercises will be structured such that students develop a quantitative understanding of the global carbon cycle while improving their ability to conduct research and communicate scientific results. We will use simple python models to explore various facets of atmosphere-land or atmosphere-ocean carbon cycling. For these exercises, I will provide you with a jupyter notebook that contains the code, but minor modifications may be required to complete the assignment. These outside assignments will typically be worth 50-100 points and will be due Fridays via Canvas.

One of the most important skills students can develop is the ability to communicate about science. One way to cultivate this skill is to read and critique peer-reviewed journal articles. As such, for each peer-reviewed article assigned (approximately one per class period), each student will be responsible for writing down a list of three questions about the journal article that will be submitted online prior to lecture. These will be used to stimulate discussion in the class, and will also be handed in for points (10 points each set of readings). Throughout the semester, I expect that the level at which you engage with the readings will become more sophisticated and the questions you ask will be more insightful.

We will have a few in-class writing exercises during the semester; two in which you will be tasked with writing an abstract to an existing article, employing the scientific reading and writing strategies we will practice throughout the semester, and a longer exercise at the end that will involve writing up a plan for future carbon management.

In-class group exercises may involve outlining feedback loops between climate and carbon cycling, analyzing maps to describe why different features look a certain way, or plotting carbon cycle data to answer specified questions.

Finally, there will be an end-of-semester project, in lieu of a final exam. This could be based on one of the box models, data analysis, policy analysis, or a literature review. More information will be provided mid-semester.

Grades will be assigned based on a point system, with letter grades reflecting the point threshold shown below. Using this system, it may not be required for a student to complete every assignment to achieve the grade they desire.

A	1,000 points
B	900 points
C	800 points
D	700 points
F	600 points

Readings

Peer-reviewed journal articles and relevant textbook chapters will be distributed via Canvas. A few other texts that might be helpful include:

- Schlesinger, William and Emily Bernhardt, *Biogeochemistry*, Academic Press, 2013.

- Chapin, F. Stuart, Pamela A. Matson, and Peter Vitousek, *Principles of Terrestrial Ecosystem Ecology*, Springer, 2012.
- Archer, David. *Global Carbon Cycle*,Princeton University Press, 2009.

Course Policies

Inclusivity

I believe within climate science, we are missing the perspectives of those who have been excluded. I find this quote from Stephen Jay Gould to be quite relevant: "*I am, somehow, less interested in the weight and convolutions of Einstein's brain than in the near certainty that people of equal talent have lived and died in cotton fields and sweatshops.*"

Some of the implications of this quote for our class:

- Our field needs more people like you – and unlike you! I encourage each of you to participate fully and respectfully to class discussions, while making sure to save space for others to participate.
- I strive to create a learning environment that supports a diversity of thoughts, perspectives and experiences, and honors your identities (including race, gender, class, sexuality, religion, ability, etc.). I will treat every other member of the class with respect, and expect the same from all of you.
- While I try to identify readings from diverse scientists working in the climate science/carbon cycle fields, I acknowledge that I will fall short.
- I will work with each and all of you to ensure your success in this class. Please get in touch with me if you have concerns about your progress in the course – I am here to teach and here to help.
- If you feel like your performance in the class is being impacted by your experiences outside of class, please feel free to get in touch with me. I may be able to point you toward resources that can help.
- I am still in the process of learning about diverse perspectives and identities. If something was said in class by myself or another student that made you feel uncomfortable, please feel free to get in touch with me.
- I have created an anonymous google form where you can share feedback if you are uncomfortable emailing or discussing in office hours. You can access the form here: https://forms.gle/imWWR2Q1Ei6i13uz8

Absences

Please do not come to class if you are sick. Lectures are live-recorded, and you can participate in any small group activities on your own and submit for points if you are sick. Whether or not your symptoms resemble those of Covid-19, no one wants the added stress of worrying about passing along or getting sick. If an emergency situation comes up that you cannot plan for in advance (e.g., illness or family situations), please let me know as soon as possible.

With respect to planned absences, I understand that as students at the University of Michigan, you have the opportunity to participate in research and extracurricular projects that may require you to miss class. I expect that you will discuss with me **at least one week in advance** any upcoming absences and any plans to make-up missed material or assignments. am happy to work with students to devise alternative arrangements, but it is your responsibility to keep me informed and to reach out to me.

Accommodations

If you think you need an accommodation for a disability, please let me know at your earliest convenience. Some aspects of this course, the assignments, the in-class activities, and the way the course is usually taught may be modified to facilitate your participation and progress. As soon as you make me aware of your needs, we can work with the Services for Students with Disabilities (SSD) office to help us determine appropriate

academic accommodations. SSD (734-763-3000; http://ssd.umich.edu) typically recommends accommodations through a Verified Individualized Services and Accommodations (VISA) form. Any information you provide is private and confidential and will be treated as such.

If you are a pregnant or parenting student in need of any accommodations, please let me know at your earliest convenience. Certain aspects of this course may be modified to ensure your participation and progress needs are being met. Together we can determine any reasonable, necessary, and appropriate accommodations that will be adhered to during the duration of the course. Any information given regarding this matter will be kept strictly confidential.

Course Topics

Table 1: Tentative schedule subject to revision

Week	Date	Topic	Exercises (tentative)
1	28 Aug M 30 Aug W	Course logistics Introduction to carbon budget	
2	6 Sep W	Terrestrial water and carbon	
3	11 Sep M 13 Sep W	Photosynthesis	python: plotting atmospheric CO2
4	18 Sep M 20 Sep W	Terrestrial observations	python: photosynthesis by plant types
5	25 Sep M 27 Sep W	Respiration and carbon turnover	python:photosynthesis under different climates
6	2 Oct M 4 Oct W	Oceans: Carbonate Chemistry	python: estimating respiration by difference
7	9 Oct M 11 Oct W	Art and resistance Ocean circulations	python: carbonate species
8	16 Oct W 18 Oct W	Fall Break no lecture, some activity	
9	23 Oct M 25 Oct W	Ocean feedbacks	python: deep ocean carbon uptake
10	30 Oct M 1 Nov W	Atmospheric CO_2	
11	6 Nov M 8 Nov W	Inverse modeling	python: geographic differences in CO2
11	13 Nov M 15 Nov W	Atmospheric observations	python: box model
12	20 Nov M	Methane	
13	27 Nov M 29 Nov W	Human Dimensions + policy	
14	4 Dec M 6 Dec W	Modeling future feedbacks	recommendation for future carbon management