<div align="center">

Climate 466
Carbon - Climate Interactions
Fall 2021

</div>

Instructor: Dr. Gretchen Keppel-Aleks (gkeppela@umich.edu)
Associate Professor, Department of Climate and Space Sciences and Engineering

Class Time and Location: Monday, Wednesday 9-10:30 in EWRE 104
https://umich.zoom.us/j/97247542695, Passcode 658594

Office Hours: Tuesday 11-12:00, Wednesday 1-2; via Zoom

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.

Course Structure

To accommodate diverse comfort levels about and abilities to participate in in-person instruction, the class will follow a hybrid format. For the most part, lectures will be pre-recorded and posted online. During our class time, we will have opportunities to interact in small groups to work on assignments and group activities. To prepare for our M/W class times, please expect to:

Preceding Wednesday	Find out what the readings for next week will be Find out what the in-class activities for the next week will be Be assigned to a group for the following week's activities
By Preceding Friday	Communicate with group members to determine plan for next week (e.g., everyone remote, everyone in-class, hybrid) Communicate plans for in-person versus remote with instructor
Over the weekend	Watch recorded lecture Do readings and send questions to instructor via Canvas
Monday	Participate (remote or in-person) in assignment/activity during the 9-10:20 class
Tuesday	Watch recorded lecture
Wednesday	Participate (remote or in-person) in assignment/activity during the 9-10:20 class
Friday	Make sure all assignment/activities have been turned in to instructor Answer questionnaire about this week's activities

In general, if you have a laptop, please bring it to class. Many of the exercises in-class will require the use of a computer. Because these will be team exercises, so not everyone in the group will require a laptop.

<div align="center">

1

</div>

If you do not have a laptop, you could also choose to work remotely these days and Zoom in to class for access to instructor and classmates for questions.

Please expect to fill out a logistics questionnaire each Friday that looks something like this:

1. Have you uploaded your assignments/group activities to Canvas?

2. How do you plan to work with your group next week? (in EWRE 104) (remotely)

3. Did you encounter challenges related to in person learning this week? If yes, please describe briefly.

4. Did you encounter challenges related to remote learning this week? If yes, please describe briefly.

5. Did you have any concerns with your small-group dynamics this week?

6. Do you have any suggestions to make learning go more smoothly in future weeks?

Assignments and Grading

There will be a diverse set of assessments in the course over the semester, with most of the assignments being done in class. These assignments/activities including hand-written exercises, python-based problem solving, and opportunities to engage critically with peer-reviewed literature. Given the importance of collaboration in science and the relative isolation of COVID-era education, many of the in-class exercises will be ground-based. Expect that the activity for each class period will be worth about 40-50 points.

Although assignments and activities should not require additional time outside class, you have until Friday to submit them on Canvas. This extra grace period should make it easier for groups who are using different modalities to meet to circumvent any challenges. Work in the class is generally meant to be collaborative, but the written assignments that you turn in must reflect your own work and understanding.

Modeling 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.

In-class exercises may also 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.

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 class period). 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.

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.

Readings

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

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

- 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

Given that we are in the middle of a global pandemic, please do not come to class if you are sick. Lectures are pre-recorded, and you can participate in small group activities or assignments remotely via the persistent Zoom link. 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.

Covid-related policies

I understand that people in our class have different comfort levels with in-person interactions and also have different risk levels. It is not mandatory to be in the classroom. We have a persistent zoom link that will be activated for each class period. This will allow students to talk with me, or to work in a breakout room with their small group.

If you do come to the physical classroom, **masks are required in the classroom**. The mask must fully cover a person's nose and mouth. If anyone comes to class without a mask, they will be asked to put one on. If that person refuses, any member of the class who feels uncomfortable may leave. I will not remain in the classroom with an unmasked individual and will instead return to my office and use the Zoom link. While taking brief sips of a beverage is OK, please honor the spirit of the masking requirement to ensure that all class participants continue to feel comfortable in the classroom.

As the public health situation evolves, policies may change on short notice.

Course Topics

Table 1: Tentative schedule subject to revision

Week	Date	Topic	Exercises (tentative)
1	30 Aug M 1 Sep W	Course logistics Introduction to carbon budget	
2	8 Sep W	Terrestrial water and carbon	python: plotting atmospheric CO2
3	13 Sep M 15 Sep W	Photosynthesis	water-carbon feedback diagramming python: photosynthesis by plant types
4	20 Sep M 22 Sep W	Terrestrial observations	python:photosynthesis under different climates Abstract writing
5	27 Sep M 29 Sep W	Respiration and carbon turnover	python: estimating respiration by difference net carbon flux feedback diagramming
6	4 Oct M 6 Oct W	Oceans: Carbonate Chemistry	python: carbonate species python: perturbations to alkalinity
7	11 Oct M 13 Oct W	Ocean circulations	python: deep ocean carbon uptake
8	20 Oct W	Ocean biological pump	
9	25 Oct M 27 Oct W	Ocean feedbacks	ocean feedback diagramming
10	1 Nov M 3 Nov W	Atmospheric CO_2	python: geographic differences in CO2
11	8 Nov M 10 Nov W	Inverse modeling	python: box model
12	22 Nov M	Atmospheric observations	
13	29 Nov M 1 Dec W	Human Dimensions	plotting historic emissions feedback diagramming human-carbon-climate
14	6 Dec M 8 Dec W	Modeling future feedbacks	recommendation for future carbon management