ESE/EPS 129: Climate and Atmospheric Physics Laboratory

Wednesdays 3:00 â€“ 5:45 PM Science Center 312 and Geomuseum 103C.

The first meeting will be in Science Center 312 on Wednesday 8/31 and will last 90 minutes.

Because 8/31 is supposed to be a Monday schedule, there will be no need to make up this first meeting, but a video will be made available to watch after class. This meeting is to give you a flavor of the course before the easy add/drop period is over.

The second meeting will be in Geomuseum 103C on Wednesday 9/7.

Prof. Marianna Linz mlinz@seas.harvard.edu

Office Hours: 3-4 PM Tuesday in MCZ 433G, 8-9 PM Thursday on Zoom: https://harvard.zoom.us/j/95313161581?pwd=S2NMQW93UzYzUGV4cm56NUVXcVNSZz09, or by appointment

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Office Hours:

- Friday 11am-12pm MCZ 424D
- Tuesday 3-4pm on Zoom by appointment Zoom link: https://harvard.zoom.us/j/91548253482?pwd=aDFWQ1FLeU1rQWoySVBJSmkvTVJiZz09

Prerequisites: Physics 12a/15a or equivalent, Math 21a and 21b or equivalent, or permission of the instructor. Some experience with programming is recommended.

Overview:

This course will take a hands-on approach to learning climate and atmospheric physics. Topics covered will include the Greenhouse effect, global scale atmospheric dynamics, synoptic meteorology and weather forecasting, and climate modeling. Each week will have one 165-minute session to perform laboratory experiments, run models, analyze data, and create data visualizations. In this flipped-classroom environment, knowledge transfer will occur primarily outside of class through readings and pre-class assignments in preparation for each session. The course will have two field trips. One will be scheduled during regular class time and the other will be scheduled in accordance with student availability.

Course Learning Outcomes:

Knowledge:

- Predict approximate long and short-term global mean temperature response to greenhouse gas perturbations
- Explain Blackbody radiation and how it is related to the Earthâ€™s energy balance
- Read a weather map and use it to make predictions about local weather
- Explain the large-scale circulation of the atmosphere
- Explain the interaction between the large-scale circulation and extreme events

Skills:

- Conduct laboratory experiments to represent geophysical fluid dynamics
- Create effective data visualizations
- Run simple models of climate and atmospheric physics.
- Analyze data using a scientific programming language
- Synthesize a variety of perspectives to approach a complex topic

Course Schedule:

(note that we are still finalizing plans for the two field trips and these will be updated here as soon as possible)

*8/31: Introduction Week 0

Unit 1: CO_2, the Greenhouse Effect, and Climate Change

9/7: Global Warming Week 1

**9/14: Blackbody Radiation Week 2

9/21: The Greenhouse Effect and Climate Sensitivity Week 3

9/28: CO_2 Trends and Variability Week 4

9/30: Unit 1 Assignment due

Unit 2: Weather and Extremes

*10/5: GFD equations: Geostrophy and Thermal Wind Week 5

10/12: Weather Maps and Probability Distribution Functions Week 6

***10/19: Stability and Precipitation Week 7

*10/26: Hurricanes and Radial Inflow Week 8

10/28: Unit 2 Assignment due

Unit 3: Circulation and Waves

11/2: Models of the Atmospheric Circulation Week 9

11/8 First ideas for final project due

*11/9: Hadley Circulation and the Jet Stream Week 10

11/15 Final project ideas finalized

*11/16: Waves Week 11

11/18: Unit 3 Assignment Due

Course Synthesis

12/1: Review of course material + final project discussion Week 12

12/10 Final projects due

* wet lab

** NOCA glassblowing studio

*** weather balloon launch

Class Structure:

Each class will begin with a brief review of the previous weekâ€™s material followed by a quiz about the pre-class work or the readings. Then we will debrief about the quiz before getting into the weekâ€™s lab(s) and activities. At the end of each class, there will be a discussion before a final written wrap up quiz (5-10 minutes).

Attire:

*For wet labs, please wear closed-toed shoes that are comfortable. Although the dyes we will be using are machine washable, darker clothing will be less likely to stain.

****For glassblowing, (9/14) wear closed-toed shoes and cotton or wool clothing**. Synthetic fibers melt instead of burning and are therefore much more dangerous. A long-sleeved shirt that is light-colored

will be the most comfortable, but is not essential. Also, bring a water bottle.

To protect any high-risk peers and your instructor, we request that you wear a high-quality mask during class.

Assignments:

Weekly: Each week will have pre-class work and associated reading which will be the subject of the introductory quiz. *Only one of the pre-class work, the quiz, or the wrap up will be graded and will count towards the final course grade*. You will not know in advance which of these will be graded. Pre-class work will be graded on effort and process, not on correct results. Please indicate your collaborators at the top of your assignment. Each write-up must be done individually. **You will be allowed to use your pre-class work and any reading notes during the introductory quiz.** As this is an active learning course, your preparation for class will be essential for participation and if you are not prepared for class, it will be detrimental to both you and all your classmates. **Therefore, if you do not complete the pre-class assignment, even if it is not the graded component for the week, you class grade for the week will be zero.**

The primary texts are â€˜Atmospheric Science: An Introductory Surveyâ€™ by John Wallace and Peter Hobbs, â€˜Atmosphere, Ocean and Climate Dynamicsâ€™ by John Marshall and R. Alan Plumb, and course notes. Reading a few scientific papers will also be required. The readings for each week will be available through the course website, so you do not need to purchase these texts.

Unit: Each unit will have a Synthesis and Lab Report Assignment due on the Friday after the last week of the unit. You are expected to

- Synthesis:
  1. Explain in your own words the topics for each of the weeks (specific prompts will not be included). (2-4 sentences each)
  2. For one of the weeks, include a data visualization or photograph from class and describe in detail what it shows and how it relates to the topic.
  3. Thoughtfully and thoroughly address specific prompts about the unit.
  4. Propose an extension of one of the activities or propose a related project
- Lab Report: (This should be brief.)
  - For one of the weeks in the unit, (you will have a choice of two) write up the motivation, experimental/model/data set up, and results. Include a brief discussion of how the experiment did or did not address the motivating question. Include at least two data visualizations that show your results and/or support your discussion. Make sure the visualizations are properly labeled, have captions, and are relevant to your conclusions.

Final Project: Take one of the ideas you came up with in your assignments or another idea and push it farther. Run a new model set up, perform a different experiment, or revisit some of the data we have used in class. If you take this opportunity to do something risky or open-ended, your evaluation will not suffer. Groups of up to three are allowed (but not required). Each write-up must be done individually. Your project should be related to a topic that we have covered in class, and you will be expected to demonstrate mastery of at least three of the skills-based course learning outcomes. First ideas for topics will be due on 11/8, and you will schedule a meeting with Prof. Linz and TF Castillo in the following week before submitting a completed project proposal by 11/15. Details of requirements for the proposal and format for the final project will be provided by 10/12.

Grades will be based on weekly class grades, three assignments and one final project. Quizzes/Pre-class work: 20%

Greenhouse synthesis: 20%

Weather synthesis: 20%

Large-scale circulation synthesis: 20%

Final report: 20%

Late policy:

If you realize that you are going to have difficulty getting an assignment in on time because of unanticipated circumstances, let the instructor know as soon as possible and schedule a time to discuss, if possible. Many situations will warrant an extension, and we will work together to develop a plan that accounts for your particular situation. In addition to exceptions for excused lateness based on discussion with the instructor, each student will have five late days for the semester which can be used on the synthesis assignments or the final project. Up to three late days may be used for the same assignment. Inform the TF by email when you are taking a late day.

Attendance policy:

As this is a laboratory course, attendance is mandatory. If for any reason you will not be able to attend for a week, please speak with the instructor as soon as you can to determine how to proceed. Failure to attend without prearranging a way to make up the work will result in at minimum failing the weekâ€™s pre-class/quizzes and up to withdrawal from the course. If you are late to class, you will not be allowed to make up the introductory quiz. Repeated tardiness will result in additional penalties, including failing the pre-class/quiz component and up to withdrawal from the course. Classes that are not physical labs or field trips can be completed through Zoom, and this option will be made available if you are ill. Please provide warning, because otherwise, no Zoom option will be available. If you have to miss a physical lab, the kits can be checked out to run the experiments outside of class.

Equipment check out policy:

The rotating table setups we will be using are portable. If you wish to borrow one of the setups so that you can repeat the experiments outside of class, please email the TF to get access. Students are encouraged to collaborate on rerunning the experiments.

Computer lab/resources policy:

The Geomuseum computer lab, 103c, will be available to you whenever it is not in use for a class. As part of this course you will be provided with an account for the Harvard computing cluster, Cannon. Do not abuse this resource. Intentional misuse will result in a penalty of up to withdrawal from the course.

Course credit:

ESE 129 is also offered as EPS 129. Students may not take both for credit. For SB students this course can only count as a science elective in the concentration requirements, and SB students must enroll in EPS 129. AB students may enroll in either EPS 129 or ESE 129 to meet their concentration requirements.

Accommodations:

I am eager to make this class accessible to all, and I do not want the structure to prevent anyone from taking the course. Because the quizzes are so short, it will not be possible to grant extended time on these in-class assessments. If you have an accommodation of extended time for assessments, you will be graded on your pre-class work only each week but will be expected to complete the quizzes with the rest of the class. The class period is long, and you should expect at least one 10-minute break, and often two shorter breaks. If you need additional breaks, please discuss with me so that we can arrange activities accordingly. I will not require official documentation for your accommodations, so if you are in the process of obtaining them, feel free to reach out anyway.