



## **CLIM/EARTH 411: Cloud and Precipitation Processes**

**Monday, Wednesday, Friday 9:30 to 10:20am**

**Location – In Person: COOL 2918**

**Instructor: Dr. Claire Pettersen**

**Email: [pettersc@umich.edu](mailto:pettersc@umich.edu)**

**Office: CSRB 2543A**

**Class Website on Canvas: <https://umich.instructure.com/courses/580814>**

### **Instructor office hours:**

**Synchronous:** In Office (2236)  
**Thursdays 4:30pm to 5:30pm**  
**Fridays 10:30am to 11:30am**

**Asynchronous:** Piazza, Monday - Friday

## **Course Information**

**Catalog description:** Atmospheric thermodynamics related to cloud formation; the special nature of water substance; nucleation of phase changes in the free atmosphere; the structure and content of clouds; the development of physical characteristics of precipitation; and the dynamics of precipitating systems; applications of observing clouds and precipitation.

**Credits: 3**

**Advisory prerequisite(s):** CLIMATE/SPACE 350, MATH 216

*Please consult with the Instructor if these prerequisites are not met*

## **COURSE LEARNING OUTCOMES**

Upon successful completion of this course, students will be able to:

- Demonstrate an understanding of key physical processes essential in the formation of clouds and precipitation
- Assess different cloud types based on specific macro- and micro-physical characteristics such as location (vertical and spatial), size, hydrometeor phase, and texture
- Describe the role of aerosols in the formation of liquid droplets and ice particles within clouds as well as the impact of aerosols on cloud lifetime, climate, and precipitation
- Outline key differences between warm, cold, and mixed-phase cloud and precipitation processes
- Summarize and analyze different means of observing clouds and precipitation from a range of platforms (e.g., ground-based, airborne, satellite)

## Course Details

**Instructional Modality:** In person, synchronous

**Canvas Course URL:** <https://umich.instructure.com/courses/706081>

**Piazza URL:** <https://piazza.com/umich/fall2024/climate411001fa2024/home>

**Meeting time:** MWF 9:30am – 10:20am Eastern Time Zone

**Location:** COOL 2918

### **Required Textbooks/Chapters** (see Canvas under **Library Tools**):

Authors: Rogers and Yau

Title: A Short Course in Cloud Physics, 3<sup>rd</sup> Edition

ISBN: 0-08-057094-1

Authors: Wallace and Hobbs

Title: Atmospheric Science an Introductory Survey, 2<sup>nd</sup> Edition

ISBN: 0127329501

Authors: Lamb and Verlinde

Title: Physics and Chemistry of Clouds

ISBN: 1-107-08664-7

### **Recommended Textbooks/Chapters**(see Canvas under **Library Tools**):

Author: Houze

Title: Cloud Dynamics, 2<sup>nd</sup> Edition

ISBN: 0123568803

Author: Wang

Title: Clouds and Precipitation

ISBN: 1-107-23425-5

Authors: Cotton, Bryan, and van den Heever, 2<sup>nd</sup> Edition

Title: Storm and Cloud Dynamics

ISBN: 9780120885428

**Class Discussion:** This term we will be additionally be using Piazza for online class discussion (please see Participation Expectations below). The system is highly catered to getting you help fast and efficiently from classmates and myself. Rather than emailing questions to the teaching staff, you should post your homework or topic questions on Piazza. I will be active on Piazza Monday through Friday, but only student feedback should be expected on weekends. If you have any problems or feedback for the developers, email [team@piazza.com](mailto:team@piazza.com). If you are not yet signed up, please sign up here:

<https://piazza.com/umich/fall2024/climate411001fa2024/home>

## Tentative Schedule

This schedule is approximate and will possibly change during the semester. Updates will be reflected on Canvas.

Week	Dates	Topics	Theme	Reading	Assignments
1	Aug 26, 28, 30	Introduction Cloud and Precipitation Types Dry Thermodynamics	<i>Applications Atmospheric Thermodynamics</i>	PKW Ch 1 Houze Ch 1 R&Y Ch 1	
2	Sep 4, 6	Dry and Moist Thermodynamics	<i>Atmospheric Thermodynamics</i>	PKW Ch 2 R&Y Ch 1, 2 W&H Ch 3	HW #1 (Due Sunday)
3	Sep 9, 11*, 13*	Moist Thermodynamics	<i>Atmospheric Thermodynamics</i>	R&Y Ch 1, 2 W&H Ch 3	HW #2 (Due Sunday)
4	Sep 16*, 18, 20	Moist Thermodynamics Saturation	<i>Atmospheric Thermodynamics</i>	R&Y Ch 2, 3 W&H Ch 3	HW #3 (Due Sunday)
5	Sep 23, 25, 27	Stability Convection	<i>Atmospheric Thermodynamics</i>	R&Y Ch 3, 4 W&H Ch 3	HW #4 (Due Sunday) <i>Final Project Consultation</i>
6	Sep 30, Oct 2, 4	<b>Exam 1</b> Mixing Aerosols	<i>Cloud Microphysics</i>	R&Y Ch 4, 5 W&H Ch 5 Pettersen Notes	<b>Exam #1</b>
7	Oct 7, 9*, 11*	Aerosols Cloud Droplet Formation	<i>Cloud Microphysics</i>	R&Y Ch 6, 7 W&H Ch 6	HW #5 (Due Sunday)
8	Oct 16, 18	Cloud Droplet Formation Droplet Growth	<i>Cloud Microphysics</i>	R&Y Ch 6, 7 W&H Ch 6	HW #6 (Due Sunday)
9	Oct 21, 23, 25	Droplet Growth Warm Clouds	<i>Cloud Microphysics</i>	R&Y Ch 7, 8 W&H Ch 6	HW #7 (Due Sunday) <i>Final Project Proposal</i>
10	Oct 28, 30, Nov 1*	Warm Clouds Ice Nucleation Cold Clouds	<i>Cloud Microphysics</i>	R&Y Ch 9 W&H Ch 6	HW #8 (Due Sunday)

11	Nov 4, 6, 8	Cold Clouds Ice Crystal Growth	<i>Cloud Microphysics</i>	R&Y Ch 9 W&H Ch 6	<i>Final Project Check-in</i>
12	Nov 11, 13, 15	Ice Crystal Growth <b>Exam 2</b> Precipitation	<i>Applications</i>	R&Y Ch 10, 12 W&H Ch 6	<b>Exam #2</b> <i>Final Project Check-in</i>
13	Nov 18, 20, <b>22</b>	Graupel / Hail <b>SQ:</b> DSD Broadening	<i>Applications</i>	R&Y Ch 12, 13 W&H Ch 6	<i>Paper Discussion #1</i>
14	Nov 25	Graupel / Hail Lighting	<i>Applications</i>	R&Y Ch 12 Pettersen Notes	
15	Dec 2, 4, 6	<b>SQ:</b> Cold Cloud SIP <i>Final Presentations</i>			<i>Paper Discussion #2</i> <i>Final Project Presentations</i>
16	<del>Dec 9</del>	<del>No Class - AGU</del>			
<b>Finals Week</b>	Dec 16	Final Project			<i>Final Project Due</i>

Dates with an asterix (\*) mean there will be a guest lecturer

### GRADING

Exams 1 and 2 (15% each)	30%
Homeworks	35%
Final Project	20%
Paper Discussions	5%
Class Participation	10%

### The following grading scale will be used:

A :	[93.3 – 100]
A- :	[90.0 - 93.3)
B+ :	[86.7 - 90.0)
B :	[83.3 - 86.7)
B- :	[80.0 - 83.3)
C+ :	[76.7 - 80.0)
C :	[73.3 - 76.7)
C- :	[70.0 - 73.3)
D :	[60.0 - 70.0)
F :	<60

## Weekly Time Management

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
CLIM/EARTH 411 Weekly Overview	Lecture		Lecture		Lecture		
				Office Hours	Office Hours		
	Required Readings, Homework, Write ups						
	Discussion Post Due 9am		Discussion Posted 9am (Week –1)		Homework Posted 12N (Week –1)		Homework Due 10pm
	Piazza Discussions - instructor and students					Piazza Discussions - students	

## Exams (30%)

- All exams will be done in class. No working together.
- Mid-term exams will not be cumulative – they will only encompass the topics reviewed between exams.

## Homework (35%)

- Homework is assigned to Canvas on Fridays by 12N and due Sunday at 10pm (+1 week).
- Questions on the homework may be on concepts presented during the same week it is due or from prior classes.
- Graded homework will be returned the following Friday before class.
- Homework should be submitted via Canvas (see notes on Canvas on how to submit and scan)
- **Late Homework Policy:** Homework received after the due date and time will incur a 25% reduction and homework turned in more than 72 hours after the due date will not be accepted.
- Please contact me if you require additional time due to unforeseen circumstances.

## Final Project (20%)

The final project will consist of a literature review and some data analysis on an aerosol, cloud, and/or precipitation topic relevant to the course and of particular interest to you. You will be expected to choose and define your project topic in late September/early October, and will submit a project proposal mid-semester. You will report the results of your work in a written and oral presentation at the end of the semester. The total project grade will be a combination of your individual grades on the proposal, written report, and oral presentation. Additionally, you will have two required meetings with me to discuss potential topics and update me on your progress. You will be responsible for scheduling time with me to meet about the project. I will provide sample topics and grading rubrics for the presentation and paper during the semester. The final project will contribute 25% toward your final course grade. The final project grading breakdown is as follows:

- Final project written report      7%
- Oral Presentation                      5%
- Project Proposal                        4%
- Initial Consultation                    2%
- Progress Check-in                      2%

## Paper Discussions (5%)

In the last third of the semester, we will dedicate time in class towards discussing papers that address open Science Questions (SQ) in cloud and precipitation physics. You will be expected to read 1 – 3 peer-reviewed papers (these will be assigned / recommended by me) and prepare notes and key discussion points. We will spend Friday lecture periods discussing and analyzing these papers. Each week a group will be assigned to lead the discussion, but all are expected to participate and prepare talking points.

## Participation (10%)

**Lecture:** You are expected to attend lecture in person and be alert and engaged. However, if you miss class due to circumstances beyond your control, lecture recordings and the presentations will be posted on the Canvas page. Please let me know if you are expecting a long absence from live lectures. ***There will be periodic in person assigned participation exercises. These are designed to reinforce key topics from the lectures and readings.***

You are also encouraged to ask questions during lecture. If you have a question after lecture, please use Piazza and post your question there. I encourage you to ask any and all relevant questions – it is cliché, but there really are no bad questions when it comes to cloud physics and radiation.

**Piazza Forum:** The purpose of the course Piazza is for students to help each other get through difficult homework problems and understand course concepts. ***You are expected to participate in the assigned class discussions on Piazza.*** Each week there will be a posted participation or discussion question or topic to be answered/addressed on Piazza. These exercises are meant to help you become familiar with topics in class through the application of online tools and resources. Additionally, these Piazza posts can and will lead to further discussion on topics of particular interest in class.

## University of Michigan Policies

### DIVERSITY & INCLUSION STATEMENT

Diversity is a source of strength, creativity, and innovation. Our dedication to engineering for the public good is inseparable from our commitment to diversity, equity and inclusion (DEI). We lead with an equity-centered engineering mindset in how we teach, do research and support each other.

The Michigan Engineering community includes people from different races and ethnicities, gender identities, sexual orientations, ages and socio-economic backgrounds. We speak different languages, come from different cultures and countries and practice different religions. We have different abilities and disabilities, different political perspectives and life experiences. We all belong here. (Source: <https://www.engin.umich.edu/culture/diversity-equity-inclusion/>)

### QUARANTINE OR ISOLATION DUE TO COVID-19

As they have throughout the past year and a half, policies around academic and public health are subject to change as this pandemic evolves. This course will follow all policies issued by the University, which are documented on the Campus Blueprint's FAQ (<https://campusblueprint.umich.edu/faqs/>). These policies may change over the course of the term, so please review the Campus Blueprint's FAQ for the most up to date information.

## ACADEMIC CALENDAR & RELIGIOUS OBSERVANCES

- See: [https://ro.umich.edu/sites/default/files/calendar/pdfs/Cal\\_2022-2023.pdf](https://ro.umich.edu/sites/default/files/calendar/pdfs/Cal_2022-2023.pdf)

## HONOR CODE

The Honor Code outlines certain standards of ethical conduct for persons associated with the College of Engineering at the University of Michigan. The policies of the Honor Code apply to graduate and undergraduate students, faculty members, and administrators. The Honor Code is based on these tenets:

- Engineers must possess personal integrity both as students and as professionals. They must be honorable people to ensure safety, health, fairness, and the proper use of available resources in their undertakings.
- Students in the College of Engineering community are honorable and trustworthy persons.
- The students, faculty members, and administrators of the College of Engineering trust each other to uphold the principles of the Honor Code. They are jointly responsible for precautions against violations of its policies.
- It is dishonorable for students to receive credit for work that is not the result of their own efforts.

Source: <https://ecas.engin.umich.edu/honor-council/honor-code/>

## SEXUAL AND GENDER-BASED HARASSMENT POLICY

As an instructor, one of my responsibilities is to help create a safe learning environment on our campus. As such, I am dedicated to providing a harassment-free experience for everyone, regardless of gender, gender identity and expression, age, sexual orientation, disability, physical appearance, body size, race, ethnicity, religion (or lack thereof), or technology choices. *Sexual and/or gender-based harassment will not be tolerated in any form, including in class discussions, group work (homework and/or projects), or on social media or other online media.*

## INDIVIDUAL WITH REPORTING OBLIGATIONS

It is my goal that you feel able to share information related to your life experiences in classroom discussions, in your written work, and in our one-on-one meetings. I will seek to keep information that you share with me private to the greatest extent possible. However, due to my role within the University, I am considered a "Individual with Reporting Obligations (IRO)". This means that I am required to share information regarding sexual misconduct or information about a crime that may have occurred on U-M's campus with the University. The University will use this information to inform you of your rights and access to services.

Students may speak to someone confidentially by contacting the Sexual Assault and Prevention Awareness Center's (SAPAC) Crisis Line at (734) 936-3333, or using any of the other confidential resources provided on the following website: <https://sexualmisconduct.umich.edu/student-resources/>

## ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

It is the policy of the University of Michigan to maintain an academic and work environment free of discrimination and harassment for all students, faculty, and staff. The University's commitment to diversity and inclusiveness extends to students with disabilities. The University is committed to the academic success, personal development and general well-being of all students.

Source: <https://registrar.engin.umich.edu/university-policy-for-students-faculty-and-staff-with-disabilities/>

## **COURSE EVALUATIONS**

Students will be provided with an opportunity to anonymously evaluate this course and your learning experience. Student participation is an integral component of this course, and your feedback is important to me. I strongly encourage you to participate in the course evaluation.

## **RECORDING OF CLASS LECTURES**

Course lectures may be recorded and made available to other students in this course. As part of your participation in this course, you may be recorded. ***If you do not wish to be recorded, please contact me during the first week of class to discuss alternative arrangements.***

## **USE OF AI TOOLS (e.g., ChatGPT; U-M GPT, etc.)**

In principle you may submit material that contains AI-generated content, or is based on or derived from it, as long as this use is properly documented and disclosed. This includes for example drafting an outline, preparing individual sections, combining elements and removing redundant parts, and compiling and annotating references. Your documentation should make the process transparent – the submission itself should meet our standards of attribution and validation. You will be required to complete a statement on your use of AI as part of your submission, if applicable. AI should not be used for literature review as it can be unreliable and lead to articles that are not relevant or, in some cases, do not exist.

In principle you may submit or use AI-generated code for homework questions, or code that is based on or derived from AI-generated code, as long as this use is properly documented in the comments or within your homework solution: you need to include the prompt and the significant parts of the response. AI tools may help you avoid syntax errors, but there is no guarantee that the generated code is correct.

Regardless of the application of AI tools, *it is your responsibility to identify errors in the generated text and / or program logic* through comprehensive, documented editing and / or testing. Moreover, generated code, even if syntactically correct, may have significant scope for improvement, in particular regarding separation of concerns and avoiding repetitions.