

Syllabus
CLIMATE/SPACE 423:
Data Analysis and Visualization for Geoscientists
Winter 2025 (4 Credits)

An Introduction to Data Analytics, Data-Model Metrics, and Plot Visualization for Climate and Space Scientists and Engineers

Course Description:

This is an upper-level undergraduate course focusing on fundamental data science, data and error analysis, data-model comparison tests and metrics, and visualization techniques. The instructor will teach using examples from Earth, atmosphere, space, and planetary sciences using Python for analysis. While no prior experience with Python is required, basic familiarity with programming is highly recommended. By the completion of this course, students will be able to: read and write data sets using Python, perform large data set analysis, hypothesis testing and model goodness-of-fit quantification, and produce publication-ready scientific data visualization.

Course Prerequisites:

Programming experience (like ENGR 101 or CLIMATE/SPACE 323, but many other courses serve this purpose). Calc-1 is also needed, as we will do derivatives.

Instructor:

Dr. Mike Liemohn, Professor, Department of Climate and Space Sciences and Engineering
Room 1420, Climate and Space Research Building (on North Campus, 2455 Hayward St.)
Email: liemohn@umich.edu

Instructional Aide:

Player to be named later (PTBNL)

They will hold office hours and lead the Python help sessions for the course, and grade the homework assignments and exams. They might occasionally sub for me when I am on travel.

Class Sessions:

Monday and Wednesday, 2:30 – 4:20 pm, FXB Building room 1024. Yeah, two hours long; we will take a few-minute break in the middle.

Lecture Capture is set up and I will post the videos after each class session. There is no synchronous remote option.

Attendance Policy:

Attendance is required and contributes a portion of your overall course grade. However, I understand that it's sometimes impossible to come to class.

Every class will feature an interactive component, such as a poll, quiz, or free-form response. Attendance data will be pulled from participants in these activities immediately after class and uploaded to Canvas.

You can miss up to FOUR (4) classes (for whatever reason, no questions asked) without it impacting your grade. We believe this is flexible and fair. Please do not email us concerning attendance unless:

- A. Your situation is such that you will likely miss more than four classes; or
- B. We have incorrectly marked your attendance; or
- C. Your absences are covered in the exemptions below.

The "excused" exceptions are as follows:

1. **If you are sick:** Please do not come to class sick.
2. **Religious or school-function-related absences:** Please let us know if you expect to miss class due to religious observance or are traveling with a U-M sports team or organization.
3. **Job interviews:** We know that many of you are at or near the end of your schooling and might have job interviews during class time.

For any of these specific reasons, an excused absence may be requested that does not count against the 4 "no excuse" absences above. It is the obligation of students to provide the instructor with reasonable notice of the dates on which they will be absent (*before* they occur; if sick then before or very soon after). If it is an emergency medical situation, then please seek help, of course, and email later. I will determine a mutually agreeable alternative timeline within the boundaries of the class for any course deadlines during such absences (usually a shifted deadline).

iClicker:

This course will utilize iClicker for part of the interactive component. You should come to class with a wireless device such as a phone or laptop. If you do not have access to these, please contact the instructors at the beginning of class. To participate in iClicker polls, you can either use an iOS or Android app, or a web browser. Sign in to the class via <https://join.iclicker.com/NGAH> using your university email.

Somewhat Flipped Class Structure:

You will have readings each week (usually a chapter out of the book, some weeks two chapters). On days when a homework set is due, I make time on to answer any remaining questions. I will also make time to go over the new homework and introduce Python code and commands of particular usefulness to get through that week's coding tasks.

I will have travel during the term. When this occurs, either the IA will cover the course content or I will cancel class. Content from these days will be on the midterm and final exams, so I would like you to be there for them.

Office Hours:

Mike's Office Hours: Mondays, 10 AM - Noon, CSRB 1420 (Mike's Office)

Liemohn's office hours: Mondays 4:30 – 5:30 pm (right after class, right before HW is due)

Exceptions: shifted for January 20 (to January 21) and canceled for February 3

Additions: extra session for HW #1, Wednesday January 15, right after class

I am also available by appointment. Send me an email or find me before or after class.

The IA will also hold office hours, probably either Friday or Monday.

Textbook:

I have written a [textbook](#) for this course. Please get a copy of it.

Data Analysis for the Geosciences: Essentials of Uncertainty, Comparison, and Visualization
E-book version: ISBN: 978-1-119-74789-5
Paperback version: ISBN: 978-1-119-74787-1

Other Useful Books:

For the first half of the course, the content is somewhat like the Taylor book, and the second half of the course is somewhat like content in the Wilks book. Another good one, for the programming aspects of the course, is the Python data science book by Iguar and Segui.

Taylor, John R., *An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements*. Second Edition (1998). University Science Books.

Wilks, Daniel S., *Statistical Methods in the Atmospheric Sciences*, Academic Press.
International Geophysics Series, Volume 100.

Iguar, Laura, and Segui, Santi, *An Introduction to Data Science A Python Approach to Concepts, Techniques and Applications*, available [online](#) through the U-M library.

Additional Useful Online Resources:

- Michigan Institute for Data Science (MIDAS) - holds talks, classes, workshops etc.
<http://midas.umich.edu/>
- Consulting for Statistics, Computing and Analytics Research (CSCAR)
<http://cscar.research.umich.edu/>

Learning Assessment Grading Apportionment:

Participation:	20%	(recorded via iclicker cloud)
Midterm Exam:	10%	(in-class exam just before break)
Final Exam:	15%	(in-person exam, as per Registrar's schedule)
Homework:	40%	(mostly weekly, due usually on Mondays by 11:59 pm)
Project:	15%	(a long, free-form homework at the end of the class)

See the detailed day-by-day course outline below for the specific due dates of these assignments and exams. We expect to have 9 homework assignments. One will be by-hand problems, on uncertainty propagation, but the others are programming assignments, submitting Jupyter notebooks with explanatory text and Python code. You might have some extra work to do in the “text” sections of the notebook. The projects are essentially long homeworks, but this time with slide-set report (in addition to the Notebook) and flexibility on the topic and data set. Both the midterm exam and the final exam will be in-person, 2-hour tests.

Student Collaboration:

When doing homework assignments and the project, I encourage collaboration and peer tutoring. Please help each other learn the material and get through the work. You can even help each other edit and hone your Python code. When it comes to actually typing up the submission, though, I expect each of you to do your own work. You learn very little by copying another’s answers.

For homeworks and projects, you are allowed to use generative large language model services (such as UMGPT or ChatGPT) to produce work product. Please provide, as an appendix to any assignment (separate doc or PDF from the code file, please), a log of all inputs and relevant outputs to the text/code generation engine.

For the midterm and final exams, I am holding you to the Engineering Honor Code and expect that each of you will do your own independent work and submission without any input or aid

from others. For these two grading elements, you should do it all yourself. Any questions should be directed to Prof. Liemohn or the proctor.

Grading Breakdown:

This class will not be curved. The grades will be assigned as follows:

A+	97%	B	83%	C-	70%
A	93%	B-	80%	D+	67%
A-	90%	C+	77%	D	63%
B+	87%	C	73%	D-	60%

Rounding will be applied at the two-decimal-place digit, so a 96.50 is an A+ and a 96.49 is an A.

Accessibility Requests

If you think you may need an accommodation for this class, then please contact the Services for Students with Disabilities (SSD) office (<https://ssd.umich.edu/>) to be issued a Verified Individual Services Accommodation (VISA) form, which should be sent to me (electronically). I will fully accommodate all such requests.

Late Policy:

Homework assignments and the project are expected to be **submitted by 11:59 pm** on the listed due date. You get one grace day; assignments submitted after 11:59 pm the next evening will be considered **late and reduced by 10% (off the full possible value)**. After 6 more days (so, one week late), the grade is **reduced another 10%**. After two weeks, the assignment will not be graded. I will be generous with no-reduction extensions but, except for very rare cases, excused late submissions **must** be requested *before* the due date and time (except for emergencies).

Any needed alternate arrangements for the two exams will be done on a case-by-case basis. Please submit requests *well before* the start time of the exam.

Extra Credit:

There will be two opportunity for optional extra credit near the end of the course.

One is turning in the receipt acknowledging that you filled out the course evaluation. If you upload a screen shot/pic/PDF of the page showing that you submitted it, then you will receive **2% extra towards your overall course grade**. This will not be reflected in Canvas but will be added afterwards. I highly value your feedback about the course and look forward to reading your comments on what went well and what could be done differently. I strive to improve my teaching skills every term.

The second is presenting your project slide set to the class. As of the plan right now, we will do this on the second-to-last day of class. The content itself is not graded or assessed, but feedback might be provided, by either me or students. This is also worth up to **2% extra towards your overall course grade**, depending on how it satisfies the required elements as defined in the project description.

Student Mental Health and Wellbeing

An excellent place to go for help is the College of Engineering CARE Center, <https://care.engin.umich.edu/>. They are located in the basement of the Chrysler Center (which is found via the hallways off of the hallway connecting the Pierpont Commons to the Duderstadt

Center, stairs down located to the right of the lobby area). They specialize in talking with engineering students, and if they cannot address your need, they will know how to get you the help you need. For even higher-level professional help, please contact Counseling and Psychological Services (CAPS), on the fourth floor of the Michigan Union (on central campus), or call them at 734-764-8312 or online at <https://caps.umich.edu>. For a listing of University Health Services (UHS) stress and mental health resources, visit <https://uhs.umich.edu/stressresources>. We are *still* dealing with the repercussions of Covid-19, and will be for a long time, so please take care of yourself. One more resource to list is the Spectrum Center, for support of LGBTQIA+ students, located in the third floor of the Michigan Union.

Student Sexual Misconduct Policy

Title IX prohibits discrimination on the basis of sex, which includes sexual misconduct – including harassment, domestic and dating violence, sexual assault, and stalking. Sexual violence can undermine students' academic success and I encourage anyone dealing with sexual misconduct to talk to someone about their experience, so that they can get the support they need. Confidential support and academic advocacy can be found with the Sexual Assault Prevention and Awareness Center (SAPAC), located on the fourth floor of the Michigan Union, or through their 24-hour crisis line 734-936-3333 and at <https://sapac.umich.edu>. Alleged violations can be reported to the Office for Institutional Equity (OIE) at insitutional.equity@umich.edu

CLIMATE/SPACE 423 Course Outline (Winter 2025)

#	Date	Topic	Due: HW @ 11:59 pm
1	W Jan 8	Introduction to class, Ch 1: statistics fails and examples	
2	M Jan 13	Ch 1 & 2: types of uncertainty, the normal distribution	
3	W Jan 15	Ch 2: histograms, data examples, intro to Python	HW #1
	M Jan 20	No class , attend an MLK Day symposium instead	
4	W Jan 22	Ch 2: more on visualizing data and more on Python	
5	M Jan 27	Ch 3: propagating uncertainty	HW #2
6	W Jan 29	Work session with IA on calculus or coding	
	Feb 3 & 5	No class , Liemohn at MAAX Site Visit	
7	M Feb 10	Ch 4: analyzing a single data set, centroid and spread	HW #3
8	W Feb 12	Ch 4: examples and special cases for a single data set	
9	M Feb 17	Ch 5: assessing normality of a data set distribution	HW #4
10	W Feb 19	Ch 6: correlating two data sets	
11	M Feb 24	Catch-up day and recap/prep for the midterm exam	HW #5
	W Feb 26	<i>Midterm Exam</i> (during normal class time)	Midterm Exam
	Mar 3 & 5	No class , Winter Term Break	
12	M Mar 10	Ch 7: curve fitting between two data sets	
13	W Mar 12	Ch 7: curve fitting examples	
14	M Mar 17	Ch 8: metrics groupings and categories	HW #6
15	W Mar 19	Ch 8: using metrics for decisions and model assessment	
16	M Mar 24	Ch 9: fit performance metrics	HW #7
17	W Mar 25	Ch 9: more on fit performance metrics	
18	M Mar 31	Ch 10: event detection metrics	HW #8
19	W Apr 2	Ch 10: more on event detection metrics; intro to the project	
20	M Apr 7	Ch 11: sliding threshold metrics analysis	HW #9
21	W Apr 9	Ch 12: metrics uncertainties and best practices	Proj. Check-In
22	M Apr 14	Ch 12: metrics best practices, additional topics	
23	W Apr 16	Project oral reports (optional extra credit)	Project slides (opt ex cr)
24	M Apr 21	Everything else that we should talk about; final exam review	Project code and slides
	W Apr 30	<i>Final Exam</i> , 1:30 - 3:30 pm (per Registrar)	Final Exam

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Course Conduct Statement

Prof. Mike Liemohn liemohn@umich.edu

The College of Engineering has an honor code. This is taken seriously.
See the website: <http://www.engin.umich.edu/students/honorcode/code/>

Policy on Homework and Projects

You are encouraged to form study groups to work on homework problems and to study in other ways. You are allowed to consult with other students during the conceptualization of a problem. However, all written work, whether in scrap or final form, is to be generated by you alone. You are not allowed to possess, look at, use, or in any way derive advantage from the existence of solutions prepared in prior years, whether these solutions were former students' work product or copies of solutions that had been made available by others.

Policy on Exams

You are to complete all examinations on your own, with only benefit of the allowed aids (for this class...one sheet, front and back), and without looking at or talking about the examination work of others. If you see a violation of the Honor Code, then you are obligated to report it.

For those needing special accommodations, please provide me with the proper form at least two weeks before the first exam so that arrangements can be made.

Both of the exams are in-person, requiring your attendance on those days at the specified times. If you know that you have a major conflict with one (due to athletic travel, religious observances, etc.), then please let me know at least two weeks in advance so that we can make arrangements. If you miss one due to a medical emergency, then you need a doctor's note explaining the situation.

On each exam, the Honor Pledge will be printed and you should sign your name under it. The Honor Pledge is as follows:

"I have neither given nor received unauthorized aid on this examination, nor have I concealed any violations of the Honor Code."

The Honor Council policy is that I am not required to grade tests in which the signed Honor Pledge does not appear. The Honor Code remains enforced whether or not the student signs the Pledge.

During an exam, see the professor with any clarifying questions you may have. If the answer is relevant to all students, then it will be written on the board.

Violations

Violation of this policy is grounds for the initiation of a report filed with the Dean's office and the case would come before the Honor Council of the College of Engineering. If you have any questions about this policy, please do not hesitate to contact me.