

Syllabus
CLIMATE/SPACE 423:
Data Analysis and Visualization for Geoscientists
Winter 2024 (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:

Manish Venumuddula: they will hold office hours and lead the Python help sessions for the course, and grade the homework assignments. They could occasionally sub for me when I am on travel. I will probably have other guest lecturers when I am out of town, too.

Class Sessions:

Monday and Wednesday, 2:30 – 4:20 pm, FXB Building room 1024. We'll take a break in the middle.

Lecture Capture is set up and I will post the videos after each class session. There is no in-class graded component; you do not have to be physically in room 1024 to participate in this class, but please note that there is no synchronous remote option.

Somewhat Flipped Class Structure:

You will have readings each week (usually a chapter out of the book, some weeks two chapters). In the Monday class session (most weeks it will be Monday), I will go over the content and we will have Q&A time about the topic. The homework sets will be due the following Monday (except the first one). I will usually make time on Mondays to answer any remaining questions about the homework due in a few hours. I will also usually make time on Wednesdays to go over

the new homework and introduce Python code and commands of particular usefulness to get through that week's coding tasks.

I most likely will have other travel during the term. When this occurs, either the IA will cover the course content or another faculty from CLaSP will guest lecture in the 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:

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

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

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

Exceptions: next Monday is MLK Day and there are no classes, plus no HW due, so no office hours. After that, they will be as scheduled except for the week of class April 8-12, when I will be on travel. I might have other travel...I'll let you know.

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/>

Grading Apportionment:

Midterm Exam:	10%	(asynchronous limited-time exam)
Final Exam:	20%	(asynchronous limited-time exam)
Homework:	50%	(mostly weekly, due usually on Mondays by 11:59 pm)
Project:	20%	(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 take-home tests, allowing 24 hours (a full day from its posting) to get through it.

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 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. For the midterm and final, I will create a Q&A “discussion” through Canvas so that all students see my answer to all questions.

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. A typical request is extra time: students with this accommodation will get a full week grace period on all homeworks and the project, and a full extra day on the exams.

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.

For the exams, the due date and time will be clearly stated on the exam, usually 24 hours from its release. The grace period past this deadline is 10 minutes, after which it is considered late **with a 10% reduction per hour**. 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 one opportunity for optional extra credit near the end of the course: 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.

Religious or School-Function-Related Absence

If students expect to miss classes as a consequence of their religious observance or are traveling with a U-M sports team or organization, then alternate arrangements will be made to accommodate missed academic work. 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). We will determine a mutually agreeable alternative timeline within the boundaries of the class (usually a shifted deadline).

Student Mental Health and Wellbeing

If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, then services are available. The first option is talking to a trusted friend or relative. This includes me; I am our department's Rackham Diversity Ally and I am ready and willing to listen to your story. For professional help, please contact Counseling and Psychological Services (CAPS) at 734-764-8312 or online at <https://caps.umich.edu>. You may also consult University Health Service (UHS) at 734-764-8320 and at <https://www.uhs.umich.edu/mentalhealthsvcs>, or for alcohol or drug concerns, see www.uhs.umich.edu/aodresources. For a listing of other mental health resources available on and off campus, visit <http://umich.edu/~mhealth/>. We are *still* in a pandemic and will be dealing with its repercussions for a long time; please take care of yourself.

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) on 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 2024)

Date	Topic	Due: HWs @ 11:59 pm
W Jan 10	Introduction to class and to uncertainties	
M Jan 15	No class , attend an MLK Day symposium instead	
W Jan 17	Ch 1: intro to uncertainties and the normal distribution	
M Jan 22	Ch 2: data examples, intro to Python	HW #1
W Jan 24	Ch 2: visualizing data, more Python	
M Jan 29	Ch 3: propagating uncertainty	HW #2
W Jan 31	Ch 3: examples and special cases of uncertainty propagation	
M Feb 5	Ch 4: analyzing a single data set, centroid and spread	HW #3
W Feb 7	Ch 4: examples and special cases for a single data set	
M Feb 12	Ch 5: assessing normality of a data set distribution	HW #4
W Feb 14	Ch 6: correlating two data sets	
M Feb 19	Catch-up day and recap/prep for the midterm exam	HW #5
W Feb 21	No class , Midterm Exam (take home exam, 24 hours to do it)	Midterm Exam
Feb 26 & 28	No class , Winter Term Break	
M Mar 4	Ch 7: curve fitting between two data sets	
W Mar 6	Ch 7: curve fitting examples	
M Mar 11	Ch 8: metrics groupings and categories	HW #6
W Mar 13	Ch 8: using metrics for decisions and model assessment	
M Mar 18	Ch 9: fit performance metrics	HW #7
W Mar 20	Ch 9: more on fit performance metrics	
M Mar 25	Ch 10: event detection metrics	HW #8
W Mar 27	Ch 10: more on event detection metrics	
M Apr 1	Ch 11: sliding threshold metrics analysis; intro to the project	HW #9
W Apr 3	Ch 11: more on sliding the threshold	
M Apr 8	No class , go see the eclipse!	Eclipse viewing
W Apr 10	Either guest lecture, work session with IA, or no class	Proj. Check-In
M Apr 15	Ch 12: metrics best practices	
W Apr 17	Ch 12: metrics uncertainties; work session on the project	
M Apr 22	Everything else that we should talk about for this class	Projects
M-Tu 4/29-30	Final Exam (24-h window) due @ 6 pm Tues (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...nothing), 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.

All of the exams are take-home tests and should not require an excused absence. 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, email or see the professor with any clarifying questions you may have. Anonymized questions and my answer will be posted on a Discussion in Canvas, so all students can see every question and every answer.

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.