Earth/Space/Climate 323: Earth System Analysis

Winter Semester 2025
Lecture: CSRB 2424, MW 10:30AM-12:30PM, In-Person
Lab: CSRB 2230, F 10:30AM-12:30PM, In-Person
Prof. Daniel Welling (he/him, dwelling@umich.edu, CSRB 1424D)

Course Description & Learning Outcomes

EARTH / CLIMATE / SPACE 323 is an introduction to the analysis of Earth and Space science systems. The mathematical topics that will be covered include:

- Linear Algebra
- Discrete mathematics
- Harmonic analysis
- Sampling theory

The course is designed to emphasize a conceptual understanding of the underlying mathematical concepts in lecture and their applications to the analysis of scientific measurements in a programming environment. Current topics in the atmospheric and space sciences are addressed in each of the labs as a means of demonstrating the relevance of the mathematical tools to problems in Earth Systems. The labs are also intended to expose students to the Python programming environment at a level beyond that covered in a typical freshman introductory course. Each lab requires students to write or to modify a considerable amount of Python source code. In addition to coding that is directly related to the topics covered in the lectures, a number of other Python procedures that are often useful for analysis of measurements and model outputs are introduced. These include:

- Reading archival data records
- Statistical analysis of data & data products
- Automated manipulation and filtering of records
- Effective data visualization

These additional programming tools are often useful for the analysis of measurements and model outputs. One objective of the course is for a student, upon completion, to be able to download environmental, space, or other data records from the web, import them into Python, perform various spectral analysis and linear filter operations on them, and display the results both graphically and with summary statistics.

Course Goals: By the end of the semester, all students should have an understanding of the mathematical concepts underlying standard data analysis techniques on time series data. Students will be able to load data stored in a variety of formats into Python and be able to extract information from the data. Students will learn best practices for exploratory data analysis and effective communication through meaningful figures and scientific writing.

Assignments & Grading

Students will be graded via *quizzes*, *lab reports*, and *final projects*. The final project grade is broken up into four parts: the project description, report, presentation, and participation in group. There will be no exams or homework assignments.

Quizzes: Quizzes are short, Canvas-based, multiple-choice tests of core-concept knowledge from the weekly Monday/Wednesday lectures. So long as you actively attend lectures, they will be *quick and easy*. They will be assigned weekly on Wednesdays at 12:30pm and close Friday at 10:30 am. Twelve quizzes will be assigned, but only ten will be used to assess your quiz grade component (see table below). This means that your lowest two quiz grades will be dropped (even if the score is zero).

Assignment Type	Due Date	Weight
Lab Reports (8 total)	1 week after assignment	50%
Quizzes (Best 10 of 12)	Fridays *before* 10:30am	15%
Project Description	March 10, 10:30am	5%
Project Group Participation	Throughout project	10%
Project Presentation	April 10/12 (in class)	10%
Project Report	By April 21, 5pm	10%

Labs: Labs will be assigned weekly on Fridays (exceptions noted in schedule below). Lab reports will take the format of Jupyter notebooks (`*.ipynb`) and include both analysis and write-up. Lab reports must be submitted electronically through Canvas. Reports are due *before* 10:30am the following Friday, giving you 1 week to complete the work and report. See the course schedule for details. Grading criteria and rubrics for labs can be found on Canvas.

You are encouraged to discuss the labs with your group and other students. This includes the collaboration and development of algorithms and debugging scripts. However, you are individually responsible for producing your own technical report for each lab that is not a verbatim copy of any other student's work (this includes figures, code, etc.). In particular, students should individually compose the discussions, comments, and responses to questions in the lab reports.

Final Project: A project will take the place of a final exam. This will be a group assignment; however, individual contributions will be reported by all group members. The general idea is that each group will be developing new labs that make use of one or more tools from the course. Students will submit a description of their ideas (1000 words max) By March 10th, 10:30am for a completion grade. The results of the projects will be summarized in a Jupyter notebook and presented in an in-class oral presentation. Additional details, sample topics, and a grading rubric will be posted to the course website by early March.

Late Policy: Quizzes will not be accepted late due to the "drop two" policy above. Labs are due at the beginning of class on the specified due dates. Labs and project submissions will be marked down 10% for each day late. If you are unable to complete an assignment, please contact me as soon as possible to develop a timeline for submission.

If you have a personal concern about completing coursework due to illness or other issues, please email me (dwelling@umich.edu) as soon as you can and we will work towards a solution.

Course Policies

CoE Honor Code: All class activities fall under the UM CoE Honor Code. Review these policies thoroughly.

Communication: Information about the course will be shared through Canvas announcements. Students are expected to monitor the Canvas page regularly. Questions about course material should be primarily asked through the Piazza discussion board. Unless your question involves a personal issue, please ask your question on the forum so that everyone can benefit from the response. For personal questions or requests, please email me and I will make every effort to respond to emails within a day. **When emailing, please always include the course number in the subject.**

Lecture Recordings: Lectures will not be recorded for the Winter 2025 semester.

Artificial Intelligence Tools are Prohibited: AI-based tools have a place in work and school, but it is not

this course. Using AI-based tools to answer questions, generate code, or generate text is strictly prohibited. Any violation will be treated as an honor code violation.

Attendance: Earth/Climate/Space is given as an *in person* course. While attendance is not mandatory, student success is critically correlated with *regular*, *active* attendance.

Technology Requirements & Required Materials: All required software is provided to students via CAEN lab computers. Students are expected to use Canvas receive assignments, grades, and other communications. Each of the homework assignments can be creatively solved using a multitude of external software packages obtainable from the web. However, one of the goals of these assignments is to teach you to code, not to teach you how to use other's code. **Assignments should be completed using only the software libraries we utilize during the lecture**. In other words, if it doesn't run on a standard CAEN computer, it will not get graded.

Required Materials: All software reviewed in this course is open source and freely available.

Recommended Texts: No texts are required. A comprehensive list of suggested books and other references will be shared in the course's Canvas website.

Mental Health and Well-Being: Students may experience stressors that can impact both their academic experience and their personal well-being. These may include academic pressures and challenges associated with relationships, mental health, alcohol or other drugs, identities, finances, etc. If you are experiencing concerns, seeking help is a courageous thing to do for yourself and those who care about you. If the source of your stressors is academic, please contact me so that we can find solutions together. For personal concerns, U-M offers a variety of resources, many which are listed on the Resources for Student Well-being webpage https://wellbeing.studentlife.umich.edu/resources-list.

Disability Statement: The University of Michigan is committed to providing equal opportunity for participation in all classes, programs, services and activities. Requests for accommodations by persons with disabilities may be made by contacting the Services for Students with Disabilities (SSD) Office located at G664 Haven Hall. The SSD phone number is 734-763-3000. Once your eligibility for an accommodation has been determined you will be issued a verified individual services accommodation (VISA) form. Please present this form to me at the beginning of the term, or at least two weeks prior to the need for the accommodation (quizzes, labs or project).

Sexual Misconduct: Title IX prohibits discrimination on the basis of sex, which includes sexual misconduct - including harassment, domestic and dating violence, sexual assault, and stalking. We understand that sexual violence can undermine students' academic success and we encourage anyone dealing with sexual misconduct to talk to someone about their experience, so 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 sapac.umich.edu. Alleged violations can be non-confidentially reported to the ECRT.

Covid-19 Statement: For the safety of all students, faculty, and staff on campus, it is important for each of us to be mindful of safety measures that have been put in place for our protection. By returning to campus, you have acknowledged your responsibility for protecting the collective health of our community. Your participation in this course on an in-person basis is conditional upon your adherence to all safety measures mandated by the State of Michigan and the University, including maintaining physical distancing of six feet from others, and properly wearing a face covering in class. Other applicable safety measures may be described in the Wolverine Culture of Care and the University's Face Covering Policy for COVID-19.

Lecture Schedule (Subject to Change)

Week	Date	Topic	Assignments Due
1	8 Jan	Course Introduction/Basic Python	
	10 Jan	Intro to Python Lab (no report)	Course survey
2	13 Jan	Basic statistics	Quiz 1
	15 Jan	Basic statistics & Exploratory data analysis	
	17 Jan	Lab 1	
3	20 Jan	**MLK DAY NO CLASS**	
	22 Jan	Exploratory data analysis, cont'd.	Quiz 2
	24 Jan	Lab 2	Lab 1 Report
4	27 Jan	Intro to time series analysis	
	29 Jan	Time series analysis, cont'd.	Quiz 3
	31 Jan	Lab 3	Lab 2 Report
5	3 Feb	Time series analysis, cont'd.	
	5 Feb	Time series analysis, cont'd.	Quiz 4
	7 Feb	Lab 4	Lab 3 Report
6	10 Feb	Statistical analysis re-cap	
	12 Feb	Catch-up day	Quiz 5
	14 Feb	Lab 5	Lab 4 Report
7	17 Feb	Intro to Fourier analysis	
	29 Feb	Fourier analysis, cont'd.	Quiz 6
	21 Feb	Open lab session for projects	Lab 5 Report
8	24 Feb	Fourier analysis, cont'd.	
	26 Feb	SFFTs & filtering	
	28 Feb	Open lab session for projects	
1 March – 8 March		Winter Break – No Class	
9	10 Mar	Fourier transforms	
	12 Mar	Fourier transforms, cont'd.	Quiz 7
	14 Mar	Lab 6	Project descriptions due
10	17 Mar	Fourier transforms, cont'd.	
	19 Mar	Fourier transforms, cont'd.	Quiz 8
	21 Mar	Lab 7	Lab 6 Report
11	24 Mar	Fourier analysis, cont'd.	
	26 Mar	Fourier analysis, cont'd.	Quiz 9
	28 Mar	Lab 8	Lab 7 Report
12	31 Mar	Sampling & aliasing	
	2 Apr	Sampling & aliasing, cont'd.	Quiz 10
	4 Apr	Open lab session for projects	Lab 8 Report
13	7 Apr	Applications	
	9 Apr	Applications, cont'd.	Quiz 11
	11 Apr	Open lab session for projects	
14	14 Apr	Catch-up day	
	16 Apr	Project Presentations	Quiz 12
	18 Apr	Project Presentations	
15	21 Apr	Review & wrap-up	