EEPS 440/640 – Geospatial Data Science

Dr. Noemi Vergopolan
Spring 2024

Course Information

Course time: Tu-Th 4–5:15pm
Course classroom: KWG 128

Contact Information

Instructor: Dr. Noemi Vergopolan
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Office hours: by reservation (calendly.com/noemi-vergopolan) Fridays 10am-12pm

Course Objectives and Learning Outcomes

This course provides a comprehensive foundation in computational tools and machine learning techniques for exploring geospatial data-driven insights across disciplines. Students will develop key skills in Python programming, data analysis, and machine learning, applying these techniques to large and complex datasets in areas like climate, hydrology, and remote sensing. Through hands-on assignments and projects, students will learn to handle multi-dimensional data, visualize patterns, and perform statistical, spatial, and machine learning analyses to address real-world environmental challenges.

By the end of the course, students from diverse fields will be able to analyze large datasets, build predictive models using algorithms such as decision trees, random forests, and neural networks, and effectively visualize geospatial data. This interdisciplinary approach aims to equip students with valuable skills applicable across scientific, engineering, and technical domains.

Prerequisites

Calculus (differentiation, chain rule), linear algebra (vectors, matrices, eigenvalues/vectors, singular value decomposition), probability and statistics (random variables, multivariate Gaussian distribution, conditional probabilities/expectations).

Texts and Materials

Readings will be assigned from various sources, and they will be provided.

Course Evaluation

This course will not have a traditional exam but will include participation requirements, 5 homework assignments, a 1-page project proposal, a final project paper, and a final project presentation. A major component of the grade will come from the independent project, which students should begin thinking about and meet with the instructor to discuss early in the semester. The topic will be of the student's choosing based on the student's interest or curiosity. It may be related to research by the student, but it should constitute a self-contained project leveraging the

tools introduced in the class. Students will submit a proposal, presentations will be given in the last week of class, and an ~8-10 page term paper will summarize the project.

For graduate students, the final project should be motivated by strong scientific research questions and provide rigorous data analysis using advanced methods introduced in the class. The final project report will be evaluated in terms of its novelty and quality, which should be comparable to a peer-reviewed scientific article. As such, the final project paper will carry a large weight on graduate students' grading.

Grade Policies

The final grade for **undergraduates** will comprise:
10% Class Participation
40% Homeworks
50% Final Project: Proposal (10%), Presentation (10%), and Paper (30%)

The final grade for **graduate** students will comprise:
10% Class Participation
30% Homeworks
60% Final Project: Proposal (10%), Presentation (10%), and Paper (40%)

Late Work

The maximum exercise grade drops by 10% every 24 hours after the deadline. (e.g., 0-24 hours after the deadline, the exercise is worth a maximum of 90%, 24-48 hours after the deadline, it will be worth a maximum of 80%, etc.).

The project is split into a proposal, a presentation, and a final paper. All three are hard deadlines because they require peer review, in-class presentation, or are assigned based on the finals time given by Rice.

Absence exceptions must be requested in advance via email to the professor and TA and will require make-up work.

I understand that extenuating circumstances may unfortunately arise during the semester; if necessary, you may email the instructor and/or TA to request an extension for a specific assignment. Such requests will be given *much* more consideration if they are made promptly based on the circumstance and preferably well before the deadline.

Tentative Course Schedule

Timeline	Topic	Software	Assignments
01/14	Introduction	Jupyter/GitHub/Bash	
01/16	Python overview	Python	
01/21	Multi-dimensional arrays I	NumPy	
01/23	Probability/Statistics	Scipy	HW 0
01/28	Visualizing data	Matplotlib	
01/30	Data storage	NetCDF/GeoTiff/NetCDF/HDF5/Zarr	
02/04	Probability/Statistics		HW 1
02/06	Bayesian Statistics		

Timeline	Topic	Software	Assignments
02/11	Map Projections I	Cartopy	
02/18	Map Projections II	GDAL	
02/20	Multi-dimensional arrays II	CDO/Xarray	
02/25	Vector Data	OGR/Shapely/GeoPandas	
02/27	Cluster Analysis I	Scikit-Learn	HW 2
03/04	Cluster Analysis II		
03/06	Dimensionality Reduction		
03/11	Decision Trees		
03/13	Random Forests & Boosting		
Spring Break			
03/25	Artificial Neural Networks		
03/27	Convolutional Neural Networks		HW 3
04/01	Kriging and Semi-variogram		Project Proposal
04/03	Regression Kriging		
04/08	Terrain Analysis		
04/10	Interactive Visualization	Folium/leaflet	
04/15	Parallel computing	Numba/Mpi4py/Dask	HW 4
04/17	BONUS		
04/21	Oral Presentations		
04/23	Oral Presentations		Project Paper

Collaboration

This class has individuals from a variety of academic backgrounds. Do take advantage of one another's expertise. I encourage you to work together on homework exercises to share your knowledge and discuss ideas; however, each person must write up their assignment independently. As with any scientific abstract or paper, the final paper and presentation must balance your own analysis with appropriate referencing of the scientific literature and the findings of previous researchers.

The Rice Honor Council has helpful definitions here: https://cpb-us-e1.wpmucdn.com/blogs.rice.edu/dist/c/490/files/2022/08/Honor-Council-Standard-Definitions-and-Policies.pdf

If you have any questions about the Honor Code for this class or are wondering if a certain course of action is acceptable, please email me before you assume something. Ignorance of the Honor Code is not an excuse, and the Honor Council will not consider it.

Generative AI Policy

AI/ML tools, such as ChatGPT, can be valuable aids in learning, especially for understanding programming basics and structuring code. However, while these tools might work well for simple examples or small-scale problems, they are unlikely to be effective for real-world data analysis or

the complexity required in your final project. Relying on AI-generated solutions without understanding the material will limit your ability to successfully complete the more complex assignments and the final project.

You can use AI tools for brainstorming, research, or as a text editor, but **you must clearly disclose how and where AI was used** when submitting your assignments. Submitting AI-generated content as your own without proper understanding or attribution will be treated as academic misconduct. You should never submit code or analysis you do not fully understand, as you will be responsible for explaining it during assessments. Additionally, completing assignments improperly by over-relying on AI will hinder your ability to tackle the final project, where in-depth comprehension of course material is essential.

Remember, AI tools can be useful for generating ideas, drafting outlines, or summarizing information, but they are not always reliable or accurate, particularly for specialized geospatial and environmental data. You should critically evaluate any output from AI, ensuring it aligns with course objectives and accurately reflects your work. Violations of this policy will be treated as academic misconduct. If you're unsure about acceptable AI usage, please ask for clarification.

Absence Policies

Most of this course's grades derive from activities requiring active class participation, so in-person, active attendance is strongly preferred for this course. The participation grade will include attendance and active class participation. If you must miss a class, please inform the instructor in advance. If you must attend on Zoom, I still expect active participation.

Rice Honor Code

In this course, all students will be held to the standards of the Rice Honor Code, a code that you pledged to honor when you matriculated at this institution. If you are unfamiliar with the details of this code and how it is administered, you should consult the Honor System Handbook at http://honor.rice.edu/honor-system-handbook/. This handbook outlines the University's expectations for the integrity of your academic work, the procedures for resolving alleged violations of those expectations, and the rights and responsibilities of students and faculty members throughout the process.

Academic Accommodations

If you have a documented disability or other condition that may affect academic performance, you should: 1) make sure this documentation is on file with the Disability Resource Center (Allen Center, Room 111 / adarice@rice.edu / x5841) to determine the accommodations you need; and 2) talk with me to discuss your accommodation needs.

Title IX Responsible Employee Notification

Rice University is committed to providing a safe learning environment for all students that is free of all forms of discrimination and sexual harassment, including sexual assault, domestic violence, dating violence, and stalking. If you (or someone you know) has experienced or experienced any of these incidents, know that you are not alone. Rice University has staff members trained to support you in navigating campus life, accessing health and counseling services, providing academic and housing accommodations, helping with legal protective orders and more.

Please be aware all Rice faculty members and TAs are “responsible employees,” which means that if you tell any of us about a situation involving sexual harassment, sexual assault, dating violence, domestic violence, or stalking, we must share that information with the Title IX Coordinator.

Although we have to notify you, you will control how your case will be handled, including whether or not you wish to pursue a formal complaint. Our goal is to make sure you are aware of the range of options available to you and have access to the resources you need. For more information, please visit https://safe.rice.edu or email titleixsupport@rice.edu.

Syllabus Change Policy

This syllabus is only a guide for the course and is subject to change with advanced notice.