16:375:501 Environmental Science Analysis

1. Course Description:

This course will introduce data analysis techniques for applications in environmental sciences. The course will teach students scientific programming in Python, statistical analysis, visualization, spatial analysis techniques that are commonly used to process and interpret environmental datasets. The course is designed to be accessible for graduate and upper-level undergraduate students in environmental sciences or other related disciplines.

2. Instructor:

Xiaomeng Jin, Assistant Professor
Email: xiaomeng.jin@rutgers.edu
Department of Environmental Sciences
Office: ENR 230

3. Class Format:

This is an online asynchronous course, meaning that we do not 'meet', not even via the web. Therefore, you decide when to do the work. To prevent you from procrastinating too much, you will have an assignment due each week for the first 12 weeks. Your assignment each week is to follow the instructions to complete a Jupyter notebook. By the end of the semester, you should have a notebook collection that you can use as coding recipe for your final project and your future research/work.

4. Office Hours:

I will have both virtual (via Zoom) and in-person (ENR 230) office hours. Times to be announced. If my hours don't work for you, just let me know and we can make an appointment at another time. I recognize that many of you are working at real jobs. There should never be a need for you to come to campus for this course.

5. Textbook and Computers:

There is no required textbook. All materials will come from free online resources and the course website itself. Students need to have access to a computer. Students will have the option to use their laptop, Amarel (the university's high performance computing cluster), or Google's Colaboratory (https://colab.research.google.com) to work on their assignments and final project.

6. Grading:

A. Weekly Assignments (50%):

- Total: 100
- Examples: 40
- Short exercise questions and long assignments: 60

B. Weekly Quiz (20%):

- Multiple choice or short-answer questions.

- Mostly embedded in course videos.

C. Final Project (30%):

The goal of the final project is to assess your ability to combine and apply the skills you have learned in class in the context of a real-world research problem. Our class has mostly focused on tools for environmental data analysis, so this must be the focus of your final project. Specifically, we seek to assess your ability to do the following tasks:

- Discover and download real datasets in standard formats (e.g. CSV, netCDF)
- Load the data into pandas or xarray, performing any necessary data cleanup (dealing with missing values, proper time encoding, etc.) along the way.
- Perform realistic scientific calculation involving, for example tasks such as data grouping, aggregating, correlation analysis, trend analysis.
- Visualize your results in well-formatted plots.
- Clearly document your analysis to make it reproducible.

Grading rubrics:

- Total: 100
- Data: 30
- Statistical analysis: 30
- Visualization: 20
- Clean, efficient, reproducible code: 20

7. Schedule:

Week	Topic	Learning Goals
1	**Introduction**	• Know the course format. • Set learning objectives. • Explain the main challenges in computational research in Environmental sciences.
2	**Introduction to environmental datasets**	• Explain common environmental dataset formats. • Explain data quality. • Explain metadata. • Set up Python computing environment.
3	**Introduction to Python**	• Familiarize with Jupyter Lab. • Understand basic Python language, including variables, loops, list.
4	**Working with tabular data in Python**	• Import tabular data with Pandas. • Fill missing data. • Perform data filtering, organization and aggregation.
5	**Correlation and regressions**	• Explain the method of least squares for fitting a regression line.

		• Explain the concept of correlation coefficient and its properties. • Apply correlation and regression analysis to environmental datasets. • Understand the assumptions and limitations of correlation and regression analysis.
6	**Time series analysis**	• Visualize time series data with Python. • Apply temporal resampling with Python. • Conduct linear trend analysis with Python.
7	**Environmental data visualization**	• Identify types of visualizations most appropriate for the data and audience. • Understand the key elements of a scientific figure. • Display tabular environmental datasets with Matplotlib and seaborn.
8	**Spatial data analysis**	• Distinguish raster and vector data. • Visualize vector data with GeoPandas. • Conduct vector analysis with GeoPandas.
9	**Working with multi-dimensional data**	• Import and create multi-dimensional NetCDF data with Xarray. • Explain and apply data broadcasting. • Conduct dimension reduction and data aggregation with Xarray.
10	**Making maps**	• Understand map projection. • Understand the key elements of maps. • Display environmental datasets on a map.
11	**Environmental science packages in Python**	• Know where to find documentation for Python packages. • Develop a Jupyter notebook tutorial on an environmental science package not covered in class.
12 & 13	**Final project**	• See Section 6B.

8. Academic Integrity

Students should adhere to the principles outlined by the university's academic integrity policies, accessible at http://academicintegrity.rutgers.edu. Students should:

- Properly acknowledge and cite all use of the ideas, code, or words of others.
- Properly acknowledge all contributors to a given piece of work.
- Ensure that all work submitted as their own in a course or other academic activity is produced without the aid of unsanctioned materials or unsanctioned collaboration.
- Treat all other students in an ethical manner, respecting their integrity and right to pursue their educational goals without interference.

Violations of academic integrity will be treated in accordance with university policy, and sanctions for violations may range from no credit for the assignment, to a failing course grade to dismissal from the university (http://academicintegrity.rutgers.edu/academic-integrity-at-rutgers/).