Course Syllabus

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Time Series Analysis for Energy and Environment Applications

ENERGY/ENVIRON 797 — Spring 2026

Table of Contents

Class Hours

T–Th 11:45 to 1:00 (LSRC A158)
Join class on Zoom
Passcode: **TSA26**

Instructor

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Office hours: Thursdays 13:15–14:15 (Grainger Hall 3115 or Luana's Zoom), or by appointment.

Teaching Assistant

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Course Communication

We will use **Slack as our primary platform for class communication**. Slack helps ensure that I see your message/inquiry in a timely manner, while also fostering collaboration and a stronger sense of community among us. You can access Slack on your computer or mobile device. Our workspace has four channels.

- **#announcements** – Instructor & TA only: important updates.
- **#general** – General discussion and logistics.
- **#help** – Questions about assignments or material.
- **#social** – Community chat.

The Slack links on Canvas will only work after you join the course workspace: Join Course Slack Workspace

Course Description

In today's data-driven world, understanding patterns and trends over time is essential for informed decision-making and strategic planning. Time series analysis provides a powerful framework for interpreting temporal data, forecasting future outcomes, and addressing challenges in energy and environmental systems.

This course, *Time Series Analysis for Energy and Environment Applications*, equips students with the theoretical knowledge and practical skills needed to analyze, model, and forecast time series data. Through real-world case studies, hands-on programming in R, and advanced modeling techniques, students will gain insights into critical applications, from renewable energy forecasting to environmental monitoring.

Key Features

- Real-world datasets (EIA, NOAA, NREL): We will cover practical applications using datasets from the US Energy Information Administration (EIA), National Oceanic and Atmospheric Administration (NOAA), and the National Renewable Energy Laboratory (NREL).
- R Programming Emphasis: We will perform time series analysis and forecasting using R. Lectures include hands-on demonstrations using the R Studio interface. Note that R and R Studio work on Windows, Linux, and Mac operating systems.
- Comprehensive Curriculum: The curriculum includes structured modules covering foundational concepts, advanced techniques, and cutting-edge forecasting models.

Course Topics

The topics covered in this course are divided in eleven modules. There will be readings and/or recording associated with each module.

1. Introduction to TSA, R, RStudio
2. Autocovariance and Autocorrelation
3. Trend and Seasonality
4. Missing Data and Outliers
5. ARIMA Models
6. Seasonal ARIMA Models
7. Forecasting
8. Model Performance Evaluation
9. Advanced Forecasting Models
10. State Space Models
11. Model-Based Scenario Generation

Course Outcomes

Upon completion of the course, you will have the ability to conduct time series analyses, model scenarios, and extract valuable insights, positioning yourself at the forefront of impactful decision-making in energy and environmental sustainability.

Course Schedule

See the full schedule here: Course Schedule

Prerequisites

A basic understanding of statistics and programming is recommended, though not mandatory. The course provides introductory material for R programming. But since most students have taken ENVIRON 872, the introductory material will not be covered in the lectures.

Course Format & Grading

The course consists of lectures at which we will discuss theory and applications. We will learn the time series concepts through data analysis projects. During the classes we will also dedicate some time to learn the statistical packages in R related to the topic as well as small group problem solving. Aside from the in class problems, there will be a set of assignments, a forecasting competition and a final project. Grades will be based on:

Component	Percentage
Participation	10%
Assignments (A1–A7)	60%
A8 — Forecasting Competition	15%
A9 — Final Project	15%

Your participation grade will reflect your engagement with course activities, including in-class discussions, small-group work, polls, and other learning activities. Participation is assessed based on **effort and engagement**, not on having "correct" answers. Participation will also be impacted by **attendance** and **Canvas analytics reports**.

The assignments involve applying concepts and tools learned in class to a specific data set or problem. Students might work together and help each other. However, the assignments are to be submitted individually. The Assignments schedule shows due dates for the assignments.

The final project could take several forms. If you have an interesting dataset, you may choose to work with it using existing methods and software tools to run your time series analysis. Another idea is to take some previously published data and analysis and use it as a starting point. You could simply take the data and do your own analysis. Or you may reproduce part of the published analysis, but in this case you will need to go further and try different models and analysis with the data. Make sure you clearly state the difference between what you have done and what was done previously. Students are encouraged to work in teams of two or three for a project.

There will be two short presentations of your final project. For the first you will present the data set you will use, what you plan to do with it and the project motivation. For the second presentation you will show the class the main results obtained throughout the analysis. Aside from the presentations, you are required to submit a final report that will be the knitted Rmd file you used for teh project. Make sure you add some text to balance the flow from one analysis/graph to the other. Describe the data sets, tools used and results. If the data set has been used before show what else you have done with it and compare with previous published results.More information on the report requirements will be given later in the semester.

The final project grading will be weighted as follows:

Final Project

Teams of 2–3 encouraged. Two presentations + final knitted Rmd report.

Component	Percentage
Proposal Presentation	20%
Final Presentation	40%
Report	40%

Course Policies

Nicholas School Honor Code

All activities of Nicholas School students, including those in this course, are governed by the Duke Community Standard, which states:

"Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and nonacademic endeavors, and to protect and promote a culture of integrity. To uphold the Duke Community Standard:

- I will not lie, cheat, or steal in my academic endeavors;
- I will conduct myself honorably in all my endeavors; and
- I will act if the Standard is compromised."

Please add the following affirmation to the end of all assignments, and sign your name beside it: "I have adhered to the Duke Community Standard in completing this assignment."

Attendance

Each class session will also be opened on Zoom for recording purposes. **Students are expected to attend in person**, except when illness or other circumstances prevent it. If you need to join remotely, please notify the instructor or TA in advance by sending a brief message through Slack explaining the reason.

Late Submissions

Assignments are due by the deadline specified on Canvas. To encourage timely submission and fairness across the class, late work will be penalized as follows:

- 0–24 hrs: –10%
- 25–48 hrs: –20%
- 49–72 hrs: –30%
- >72 hrs: not accepted

Exceptions may be granted in cases of illness, family emergencies, or other circumstances, provided that the instructor or TA is notified as soon as possible.

AI Use

AI tools may be used in this course to support idea generation, coding, or drafting text, but their use must be responsible, transparent, and consistent with the Duke Community Standard. Any AI-generated content must be critically reviewed, refined, and thoughtfully integrated—submitting unedited output is not acceptable. You are required to clearly disclose how AI was used, including the tool, prompts, and its role in shaping your final submission. Failure to acknowledge AI use will be considered a violation of academic integrity. This course will also adopt the AI Assessment Scale. **The instructor will specify the appropriate level of AI engagement.**

Academic Accommodations

If you are a student with a disability and need accommodations for this class, it is your responsibility to register with the Student Disability Access Office (SDAO) and provide them with documentation of your disability. The SDAO will work with you to determine what accommodations are appropriate for your situation. Please note that accommodations cannot be provided until the instructor receives a Faculty Accommodation Letter from the SDAO.

Wellness & Mental Health Resources

Your mental and physical wellbeing is integral to your ability to be academically successful. Below, we have compiled a list of resources around campus that are available to support you. If there is something going on in your personal life that is preventing you from participating fully in this or other courses, please feel free to speak with any of us. You are welcome to share as much or as little as you are comfortable sharing, and we are more than happy to arrange to get you the support you need.

Counseling and Psychological Services: CAPS helps Duke Students enhance strengths and develop abilities to successfully live, grow and learn in their personal and academic lives. We offer many services to Duke undergraduate, graduate, and professional students, including brief individual and group counseling, couples counseling and more. CAPS staff also provide outreach to student groups, particularly programs supportive of at-risk populations, on a wide range of issues impacting them in various aspects of campus life.

Duke Reach: DukeReach directs students, faculty, staff, parents, and others to the resources available to help a student in need. DukeReach is located in the Dean of Students Office and works with departments and groups across campus and in the community, including Housing, CAPS, Student Health, community health providers, the Academic Resource Center, and more.

DuWell: DuWell helps students focus on their individual wellness by looking at the integration of many areas of their life through areas of wellness promotion and risk mitigation.We engage students through a variety of wellness experiences across campus in an effort to reduce stress and anxiety while emphasizing self-care.

We are always available if a student needs someone to listen or to connect them with resources. As employees of Duke, we are mandatory reporters, meaning that if we receive a report of sexual assault, we are required to confidentially report this to the Office of Student Conduct (OSC). The OSC will follow up with the student to provide further information, but the student is not required to respond and the conversation will not be shared beyond ourselves and the OSC. The following resources around campus are not mandatory reporters: The Women's Center, medical providers, campus clergy, and CAPS counselors.

Land Acknowledgment

"What is now Durham was originally the territory of several Native nations, including Tutelo (TOO-tee-lo) and Saponi (suh-POE-nee) - speaking peoples. Many of their communities were displaced or killed through war, disease, and colonial expansion. Today, the Triangle is surrounded by contemporary Native nations, the descendants of Tutelo, Saponi, and other Indigenous peoples who survived early colonization. These nations include the Haliwa-Saponi (HALL-i-wa suh-POE-nee), Sappony (suh-POE-nee), and Occaneechi (oh-kuh-NEE-chee) Band of Saponi. North Carolina's Research Triangle is also home to a thriving urban Native American community who represent Native nations from across the United States. Together, these Indigenous nations and communities contribute to North Carolina's ranking as the state with the largest Native American population east of Oklahoma."