ESM 244: Advanced Environmental Data Analysis

Bren School of Environmental Science & Management

Lectures: Tuesdays and Thursdays, 2:00pm - 3:15pm, BH 1414
Labs: Thursdays, 3:30pm - 4:45pm, BH 1414

Course forum: Slack (sign up here)
Assignments, resources, grading: GauchoSpace

Instructor: Casey O'Hara (cohara@ucsb.edu)
Office Hours: Tuesdays 3:30pm - 4:30 pm, BH 2001

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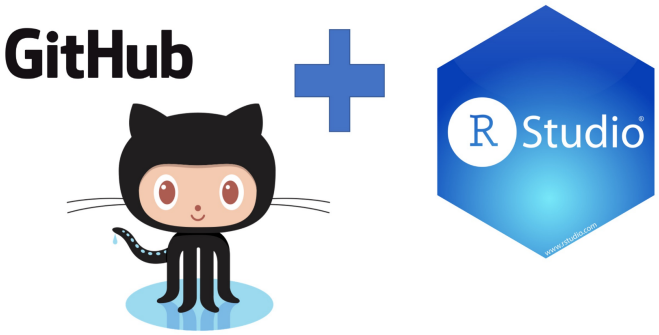
Office Hours: Wednesdays 2:00 pm - 4:00 pm, BH 3007

Overview: ESM 244 is a survey course in advanced topics in environmental data analysis, including: basics of machine learning, logistic regression, bootstrapping, intro to wrangling and analyzing time series data, spatial data visualization and analysis, principal components analysis, hierarchical cluster analysis, and basic text mining. Focus is on building conceptual understanding and applied skills using real-world environmental datasets. Students will also learn modern methods for publication in data science, including by building a website and Shiny app in R. Throughout, we will reinforce skills for data management and organization, reproducible workflows and collaboration in R, RStudio and GitHub.



ESM 244 LEARNING OBJECTIVES: Students will be able to...

- Work with novel data formats including spatial data, time series data, and text data
- Apply advanced methods for analyzing environmental data including logistic regression, clustering techniques, and nonlinear least squares
- Implement functional programming in R, including loops, functions, and iteration, to more proficiently wrangle, reshape, and visualize data
- Apply principles and best practices for data organization, conventions and code habits, project management, and reproducible workflows
- Leverage R Studio + Github to communicate analyses using Shiny (and optionally distill, gh-pages)
- Confidently debug and troubleshoot code errors

- Independently find and implement new data science skills to complete assignments and term projects

SCHEDULE (TENTATIVE):

Week	Lecture topics	Lab skills	Assignments & Projects
1	ESM 206 review Intro to time series: decomposition, autocorrelation	Git/GitHub intro and setup with R Studio Intro to R Markdown (video) Refresh your workflow, wrangling, and ggplot basics	
2	Time series forecasting basics & concerns Intro to apps with Shiny	Wrangling time series Forecasting time series Build your first Shiny app	
3	Introduction to spatial data (types, projections, CRS, applications) Spatial data interpolation (kriging)	Working with vector spatial data, visualizing spatial data, variograms and kriging (optional: self-guided raster lab) More Shiny basics (video) Git branches and pull requests	
4	Spatial point pattern analysis (quadrat, nearest neighbor, test for CSR) Introduction to text mining and analysis workflows, sentiment analysis	Spatial point pattern analysis Working with text data, parsing documents to get tokens; stop words and sentiment analysis Shiny continued (video)	Assignment 1 due Shiny app: group and topic
5	Intro to supervised vs. unsupervised machine learning Model selection, test and training data, cross validation	Cross validation to compare competing models Functions, loops, and purrr	
6	Binary logistic regression	Generalized linear models, binary logistic regression Cross validation (using tidymodels)	Assignment 2 due Shiny app: basic structure/theme
7	Nonlinear models, bootstrapping	Nonlinear least squares, bootstrapping confidence intervals; purrr in overdrive	
8	Multivariate data, unsupervised machine learning Principal component analysis (PCA)	Multivariate exploration, PCA, biplots	Assignment 3 due Shiny app: mostly functional
9	Partition-based (k-means) and hierarchical cluster analysis	K-means clustering, hierarchical clustering, dendrograms	
10	Automating data from the internet using APIs and web-scraping	Text mining and accessing data through APIs	Assignment 4 due (finals week) Present Shiny Apps to class

LAB REQUIREMENTS:

All labs will be in person, in BH 1414, unless unforeseen circumstances strike (e.g., pandemic, fire, alien invasion). You will need to bring your laptop to BH1414 to follow along each week. You will need:

- Recent versions of R (v. 4.2.0 or higher) and RStudio (at least v2023.x, from last year). *If you do **not** have a laptop that will happily run this software, I encourage you to contact the Bren Compute Team (compute@bren.ucsb.edu) to get set up with an RStudio Server account.*
    - Click here for instructions on installing R and RStudio.
- A GitHub account, with Git configured for working between RStudio & GitHub, including a valid Personal Access Token (PAT). **Note:** if you are using a different Git client, that's fine, but we might not be able to help you if you get stuck.
    - Click here for instructions on setting up Git and GitHub.
    - Click here for instructions on configuring your Git and setting up a Personal Access Token (PAT). We will walk you through this at the start of the first lab session.

All lab materials (data, keys, links, etc.) will be linked from Canvas.

COURSE RESOURCES:

There is **no textbook** for ESM 244. The resources we'll use in class are free, open-source books and online tutorials. Several essentials for this class are:

- R for Data Science by Garrett Grolemund and Hadley Wickham
- Geocomputation with R by Robin Lovelace
- Forecasting: principles and practice by Rob Hyndman and George Athanasopoulos
- Tidy text mining in R by Julia Silge and David Robinson
- Happy git with R by Jenny Bryan and UBC's stat545 TAs
- Shiny tutorials from RStudio

GRADING BREAKDOWN:

- Assignments (4): 60%
- Participation: 10%
- Term project (functional Shiny app): 30%

ASSIGNMENTS:

Assignments will be completed in R Markdown, and you will submit the .Rmd and knitted HTML files for grading through GauchoSpace. Some assignments may ask you to respond to a reading or resource on the Slack #discussions channel.

TERM PROJECT:

See guidelines for term projects HERE.

For your ESM 244 term project, you will design a Shiny app, created in groups of 2 - 3 people, that you'll present to the class during Week 10. Over the course of the quarter, each assignment will have a task related to the term project to help you stay on track.

CODE OF CONDUCT:

All students are expected to read and comply with the UCSB and ESM 244 course code of conduct.

From our ESM 244 code of conduct: All enrolled students, auditors, and course visitors are expected to comply with the following code of conduct. We expect cooperation from all members to help ensure a safe and welcoming environment for everybody.

We are determined to make our courses welcoming, inclusive and harassment-free for everyone regardless of gender, gender identity and expression, race, age, sexual orientation, disability, physical appearance, body size, or religion (or lack thereof). We do not tolerate harassment of class participants, teaching assistants, or instructors in any form. Derogatory, abusive, demeaning or sexual language and imagery is not appropriate or acceptable.

DISABLED STUDENTS:

Students with disabilities and alternative learning needs are encouraged to work with the Disabled Students Program at UCSB to ensure we can best accommodate you.

COURSE POLICIES:

- Assignments submitted late will only be accepted within one week of the due date, and will be worth 50% of the original score. **Homework submitted more than one week after the original due date will not be accepted.** We always welcome individual students to reach out to us for extra support and to discuss options as challenges arise.
- Assignments are due at the beginning of lecture on due dates.
- Cheating/plagiarism (including in R code) will result in 0 points awarded for the assignment or midterm/quiz/exam and disciplinary action according to UCSB policy. We **do** expect that you will pull from examples and tutorials by the R community but do not simply copy-and-paste - think through the examples and tutorials and adapt the code to your current context.
- If you are worried about your overall grade and/or passing the class, please reach out to us to discuss your concerns.