USC Dornsife

Modeling and Numerical Techniques for Marine Scientists

Units: 4.0

Spring Tuesdays and Thursdays 9:30-10:50 am

Location: AHF 259

Instructor: Prof. Naomi Levine
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Office Hours: contact Prof to schedule
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Course Description

Numerical models provide an invaluable tool for interpreting observations, making predictions, and generating hypotheses. Biological oceanographers face the difficult challenge of interpreting their findings in the context of a dynamic physical and chemical environment. Especially in light of recent dramatic increases in both the size and complexity of marine data sets, oceanographic research increasingly requires the use of sophisticated numerical approaches for data interpretation and analyses. This course will provide students with a basic set of quantitative and computational skills that will facilitate their research. Specifically, the course will cover the statistical analyses of data sets, the development of modeling frameworks, numerical models of varying complexity, and techniques for analyzing model results.

Learning Objectives

This course will provide students with proficiency in MATLAB, a powerful computational tool for data analysis and model construction. In addition, students will build a toolbox of statistical techniques including probability distributions, error propagation, least squares and regression techniques, principle component and factor analysis. Finally, they will construct and use 0D, 1D, and 2D ocean models and learn how to interpret the output from complex 3D global ocean models.

Prerequisite(s): none

Recommended Preparation: suggested reading MATLAB Primer (Timothy Davis, 8th edition)

Technological Proficiency and Hardware/Software Required

This course will use MATLAB as a platform to provide examples for topics discussed during the lectures and for problem sets.

Required Readings and Supplementary Materials

Required:

Modeling Methods for Marine Science, David M. Glover, William J. Jenkins and Scott C. Doney, Cambridge University Press

Supplementary Materials:

Statistics and Data Analysis in Geology, John Davis, John Wiley & Sons

Data Reduction and Error Analysis for the Physical Sciences, Philip R. Bevington and D. Keith Robinson, McGraw Hill

Description and Assessment of Assignments

Assignments will be in the form of weekly problem sets which will require the students to create and run MATLAB scripts related to the topics discussed during the week's lecture.

All students will complete a final project for the class worth 20% of their grade. The goal of this project it to apply statistical tools and/or modeling techniques covered in the course (weeks 1-10) to actual data-sets and research questions. Students are encouraged to choose a topic pertaining to their dissertation research. Each student will meet with the instructor to discuss potential project ideas in week 10 and will turn in a brief project description including a motivating 'science question' and research approach in week 13. The project will be graded based on the project description, the matlab code generated for the project, a 2 page description of the research and results, and a 15 mintute presentation to the class.

Grading Breakdown

Assignment	Points	% of Grade
Problem sets	10 x 100pts	70%
Final Project	300 pts	15%
Final Presentation	100 pts	5%
Participation	15	10%

Assignment Submission Policy

Problem sets must be submitted by Monday at noon (11:59 am PST). Maximum credit will be reduced by 10% for every day the assignment is late unless the student has obtained prior approval from the instructor.

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	Readings	Assignment due
Week 1 T Jan 9	Basic linear algebra	Ch. 1	
Th Jan 11	Introduction to MATLAB	Hints & Tips	
Week 2 T Jan 17	Probability distributions	Ch. 2	Problem Set #1: 1.1 and 1.2
Th Jan 19	Probability distributions	Ch. 2	
Week 3 T Jan 24	Statistical tests and error propagation	Ch. 2	
Th Jan 26	Statistical tests and error propagation	Ch. 2	Problem Set #2: 2.1-2.5
Week 4 T Jan 31	Regression techniques (Linear)	Ch. 3	
Th Feb 2	Regression techniques (Non-linear)	Ch. 3	
Week 5 T Feb 7	Regression techniques	Ch. 3	Problem Set #3: 3.1-3.2
Th Feb 9	Regression techniques	Ch. 3	
Week 6 T Feb 14	Guest lecture – Rubao Ji @ noon in TWR		
Th Feb 16	Principal component analysis	Ch. 4	Problem Set #4: 3.3
Week 7 T Feb 21	Principal component analysis	Ch. 4	
Th Feb 23	EOF	Ch. 4	
Week 8 T Mar 28	Dissimilarity Indices	Vegan tutorial	
Th Mar 2	ODE and integration techniques	Ch. 8	Problem Set #5: 4.2-4.3
Week 9 T Mar 7	0D box models + NPZ models	Ch. 8	
Th Mar 9	Lotka-Volterra & Random Walk	Ch. 9	Problem Set #6: 8.2
Spring Break			

Week 10 T Mar 21	Optimization techniques + NPZ models	Ch. 10	
Th Mar 23	Advection, diffusion, and turbulence	Ch. 11	Problem Set #7: Handout
Week 11 T Mar 28	Finite difference techniques	Ch. 12	
Th Mar 30	1D model: advection-diffusion	Ch. 13	
Week 12 T Apr 4	1D model: sediments	Ch. 14	Problem Set #8: 10.1 + handouts Final project topic selected
Th Apr 6	1D model: seasonal cycle	Ch. 15	
Week 13 T Apr 11	2D models: set-up and boundary conditions	Ch. 16	Problem Set #9: 12.3, see handout
Th Apr 13	2D models: examples	Ch. 16	Final project preliminary results (100 pts)
Week 14 T Apr 18	3D models	Ch. 17	
Th Apr 20	Earth System Models		
Week 15 T Apr 25	Project presentations (I)		Final project due (200pts)
Th Apr 27	Project presentations (II)		

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Section 11, *Behavior Violating University Standards*https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct/.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the *Office of Equity and Diversity* http://equity.usc.edu/ or to the *Department of Public Safety* http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us. This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. *The Center for Women and Men* http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support,

and the sexual assault resource center webpage sarc@usc.edu describes reporting options and other resources.

Support Systems

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.htmlprovides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information http://emergency.usc.edu/*will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.