MARS 8510: Modeling Marine Systems

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Office Hours:	By appointment or drop by
Office:	110K Marine Sciences Building
Semester:	Every Fall Semester
Class Times:	Wed-Fri, 3:30–4:45
Classroom:	Marine Sciences 239

Course Description

Oceanography is still largely an observational science, but the use of computer and mathematical models has increased and is now commonplace, and in some cases, a required component of research projects. As a result, you will frequently find yourself in collaborations with modelers of various types (ecosystem modelers, physical oceanography modelers etc.). To make the most of such collaborations, you should at least understand the terminology that modelers use, where models can be useful in your research, the basics of how to put a model together, and what is possible and not possible with a model.

This course will be both mathematically and computationally intensive. The aim of the course is not to turn everyone into a mathematical or computer wizard. However, being comfortable with differential and integral calculus, and basic linear algebra is essential. Some experience with a programming language will be useful — although we will cover the basics of programming, we will do so quite quickly. In addition, we will use some of the associated tools that many programmers use.

The course structure is based on a *hands-on* approach, with a lot of the practical work being done in class and in homeworks. There will be readings outside of class that will prepare you for work done in-class. In addition, students will be expected to complete a project chosen from a list of topics — this will form the bulk of the assessment in the course.

Course Objectives

After completing this course, students should be able to analyze a problem, create a conceptual model for the problem, and from that develop and solve a mathematical and computer model using suitable tools and techniques. Students should also be able to assess and critique a given model.

Textbooks

There are no required textbooks for this course, all required information will be conveyed through the lectures and online readings. However, here are some books that you might find useful to supplement the class notes and readings:

- *Modeling Methods for Marine Science* by David M. Glover, William J. Jenkins, and Scott C. Doney (Cambridge University Press, ISBN 978-0-521-86783-2). This s a good all-round textbook on modeling methods used in marine science. It covers not only model development, but also data analysis techniques. It uses Matlab primarily as a programming language, and generally stops short of delving into full 3D regional and global models.

- *Numerical Models of Oceans and Oceanic Processes* by Lakshmi Kantha and Carol Anne Clayson (Academic Press, ISBN 0-12-434068-7). This is a comprehensive text on modeling ocean systems. It is not always an easy text to read, but is worth the effort.

- *Ocean Modelling for Beginners With Open Source Software* by Jochen Kämpf (Springer, ISBN 978-3-642-00819-1). This is another book aimed more at physical oceanographers, but it explains things nicely and you can access it online through the UGA library website. There is also a suite of software that accompanies the book, but it uses Fortran rather than Python.

- *Advanced Ocean Modelling Using Open Source Software* by Jochen Kämpf (Springer, ISBN 978-3-642-10609-5). Like it's companion book above, this is aimed more at the physical oceanographer, but it includes many techniques that are useful generally. Also, like its companion, it can be obtained online through the UGA library website and is accompanied by a suite of Fortran software.

- Introduction to the Modelling of Marine Ecosystems by W. Fennel and T. Neumann (Elsevier, ISBN 0-444-51704-9). I personally found this to be a rather disappointing text, but you may find it interesting. The description of the techniques is not very well done and there is little synthesis.

- A Practical Guide to Ecological Modelling Using R as a Simulation Platform by K. Soetaert and P.M.J. Herman (Springer, ISBN 978-1-4020-8623-6). This is a nice book for those with a more ecological interest. It uses packages written by the authors for R, but the techniques are well explained and so can be translated into any computer language. As with the Kämpf books, this book can be obtained online through the UGA library website.

Computers & Software

This course will make substantial use of computers in and out of class. It is therefore essential that you have access to a laptop computer that you can bring to class and that you have administrator privileges on that computer so that you can install required software. Instructions on installing and using the software will be given in class. The main packages that we will use include:

Python This is an Open Source software package that allows you to develop code for all sorts of types of problems. The numerical, scientific, data analysis, and visualization capabilities of Python are excellent. We will be using Python 3 in this course and will be using a mixture of straight forward Python and *Jupyter Notebooks*, a notebook facility that works with Python to create a very nice reproducible computing environment.

LaTeX This is a typesetting language that works with Jupyter Notebooks to allow the typesetting of mathematics within a notebook, and the production of PDF documents from your notebooks.

Homeworks, Projects, & Course Grading

There will be regular assignments throughout the course. There will be no exams in this course. Instead, students will be expected to undertake a project chosen from a provided list of topics. The project is meant to be a substantial piece of work and will comprise 45% of the final grade and will include a written report and an oral presentation; homework assignments will comprise 45%, with the remaining10% coming from class participation (asking and answering questions etc.).

A final letter grade will be posted for the course. The correspondence between percentages and letter grades is given below The interpretation of the major letter grades is:

A : 93 – 100%	B+: 87 – 90%	C+: 77 – 80%	D: 60 – 65%
A-: 90 – 93%	B : 83 – 87%	C : 70 – 77 %	F : 59% and below
	B- : 80 – 83%	C- : 65 – 70%	

Table 1: Table of the correspondence between final letter grades and total percentages.

A This grade is used to recognize work that is excellent and of the highest calibre and that stands out from that of other students. Students who achieve this grade have demonstrated a mastery of all the content of the course.

B This letter grade is used to signify competent work. A student who achieves this grade has demonstrated proficient understanding of the concepts and content of the course sufficient for effective use of these concepts and techniques in their research.

C This letter grade signifies adequate work. A student who has achieved this grade has demonstrated a general understanding of the concepts covered in the course but with significant flaws in either their understanding or execution of techniques.

D This letter grade indicates that the work is inadequate, and that the student has not demonstrated the requisite skills and understanding to use these techniques in their research.

F This letter grade signifies work that is unacceptable.

Note that you must receive a C or better for the course, and that the average over all your graduate level courses must be a B.

Special Accommodations

If you need special accommodations for exams (e.g. additional time for taking exams) or other activities because of a disability, please make an appointment to see the instructor as soon as possible or before the end of the first full week of classes.

Absences From Class

Absences from class are sometimes unavoidable, especially in a discipline where research is conducted in the field or at sea. For planned absences due to field work or research cruises, please inform me **at least two weeks prior to your absence** — prolonged absences (i.e. more than 10 days) for field work may result in you having to drop the class and take it next year. For absences due to illness or other unforeseen events, please inform me as soon as possible.

Academic Honesty

As a University of Georgia student, you have agreed to abide by the University's academic honesty policy, "A Culture of Honesty," and the Student Honor Code. All academic work must meet the standards described in "A Culture of Honesty" found at:

https://ovpi.uga.edu/academic-honesty/academic-honesty-policy

Lack of knowledge of the academic honesty policy is not a reasonable explanation for a violation. Questions related to course assignments and the academic honesty policy should be directed to the instructor.

All students are expected to hand in work that is their own — discussion of homework assignments and projects among students is permitted (and encouraged), but the work you hand in **must be your own**. Any student found cheating or plagiarizing will be disciplined according to the University's rules and policies. Examples of plagiarism include, but are not restricted to

- Copying unattributed text from any source and presenting it as your own.
- Copying someone else's calculations or solutions and presenting them as your own.
- Copying someone else's computer codes and presenting them as your own.

Topical Outline

The following contains a schedule of topics that we will cover in the course. Please note that this schedule is preliminary, and details may change throughout the semester.

Week	**Topics**
Week 1	Course introduction & Setting up Software
Week 2	Programming in Python & Jupyter Notebooks
Week 3	Building an elementary model
Week 4	Modeling with Ordinary Differential Equations
Week 5	Modeling with Ordinary Differential Equations
Week 6	A Pelagic Ecosystem Model
Week 7	Linear Algebra
Week 8	Modeling with Partial Differential Equations
Week 9	Modeling with Partial Differential Equations
Week 10	Project Work & Model Examples
Week 11	Model Examples
Week 12	Alternative Modeling Techniques
Week 13	Largely Project Work
Week 14	Largely Project Work
Week 15	Project Presentations

Table 2: An outline of the material to be covered during the course.

Important Dates

Wednesday, January 10, 2018	First day of class
Monday, March 12 – Friday March 16	Spring Break
Wednesday, April 25, 2018	Last Class

Table 3: A table of important dates for the Fall 2018 semester.

The course syllabus is a general plan for the course; deviations announced to the class by the instructor may be necessary.