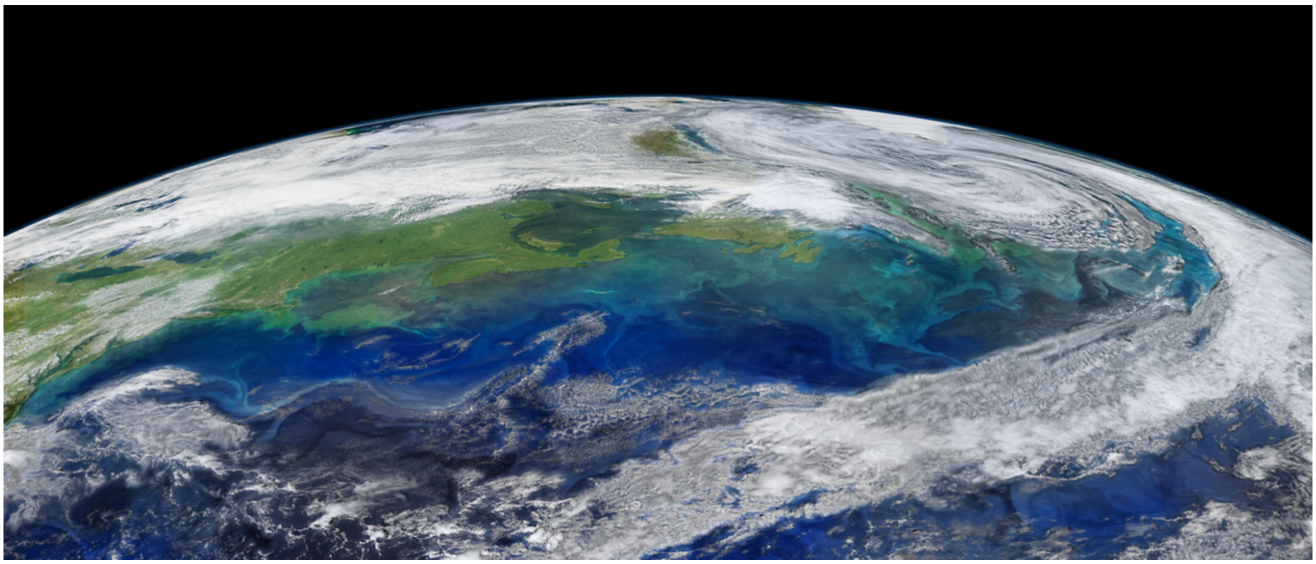
EE 422/622
Aquatic Optics and Remote Sensing

Spring 2023
MWF 09:05 - 09:55 am in CAS 327



Professor Information

Professor	Email	Office phone	Cell phone	Office Location	Office Hours
Cédric G. Fichot	cgfichot@bu.edu	617-353-2182	706-254-1629	STO 141G	M 10-11 am F 1-2 pm

Course Overview

Aquatic environments cover more than 70% of the Earth's surface, host some of our most important resources, and represent a major regulator of global biogeochemical cycles and climate. Water bodies are also subject to the ever-growing pressures of human activities and climate change, but our ability to monitor, study and predict their impacts is directly challenged by the inherent heterogeneity and dynamic nature of these environments. Optical measurements and remote sensing represent unparalleled tools for making sustained measurements of some of the vitals of aquatic environments and to capture their variability on relevant spatial and temporal scales. In this course, we will review the fundamental concepts behind the use of optical measurements and remote sensing to monitor and study aquatic environments. The course will cover topics ranging from optical properties, radiometry, radiative transfer, algorithm

development, field optical instrumentations, satellite sensors. A significant portion of the course will also focus on applications of aquatic optics and remote sensing for the biogeosciences and water quality.
The course is intended for upper-level undergraduate and graduate students interested in remote sensing and/or the aquatic sciences. It aims to provide those students with both a theoretical and practical knowledge of optics and remote sensing and of its utility in earth and environmental research and applied sciences. More specifically, students can expect to gain an understanding of:

- How light and in-water constituents interact in aquatic environments
- The main quantities and properties in aquatic optics and remote sensing
- The utility of optical measurements and remote sensing in research and applied sciences
- Challenges and uncertainties faced in this field
- How to access, process, and use field optical and ocean color remote sensing data

The course is also expected to help students improve or polish their oral and written communications skills.

Prerequisites

- **EE 107** and **EE 270**, or **permission of instructor**
- **EE 302** (recommended but not required)

Course Elements

The course will include a balanced mixture of lectures, reading of important manuscripts in the field, hands-on computer-based and lab-based activities, a research project using real data, and 2 student-led oral presentations *(a 5-min lightning-style presentation, and a 20-min conference-style presentation)*.

Lectures

Lectures will be given throughout the course by the professor in order to familiarize the students with the fundamental concepts of the course. Part of a lecture will be dedicated to providing guidance to students about effective scientific oral communication.

Homework assignments

Students will have to complete weekly homework assignments during the course. *Each assignment* will *relate to the hand-on activity done in the computer lab each week, and will directly related to concepts learned during class. Data and figures in the assignment have to be produced using MatLAB, and assignments will have to be typed using MS Word.* Assignments are due at a date given by the instructor (usually due 3 days after the hands-on activity was done in class). If extenuating circumstances arise and you need an extension, you must arrange this with the professor prior to the original lab due date.

Reading material and quizzes

On occasions students will be required to read a published manuscript (or other reading material) and will be quizzed at the beginning of the next class on the main content of the manuscript (*primarily on the main* take home messages *of the manuscript*). Papers will be discussed during class.

Hands-on activities in computer lab

These activities will aim to familiarize the students with accessing, processing, and *analyz*ing real data *using quantitative skills commonly used in aquatic optics and remote sensing*. Activities will include radiative transfer simulations, use and development of algorithms using measured and simulated optical data, and implementation of algorithms on satellite ocean color. The knowledge gained through these activities will help the students complete their research projects.

Lightning-style presentation

During the first half of the course, *each* student will be required to present a 5-min lightning-style oral presentation summarizing the main findings of a manuscript he/she chose from a list assigned by the *instructor*. The students will be provided written guidance on how to effectively present the essence of the scientific manuscript in a very condensed format that is understandable by all student peers.

Research project and conference-style presentation

The research project will require the students to define a research question (topic related to biogeoscience or water quality), *formulate a simple and testable hypothesis*, and address the question using existing ocean-color remote sensing data and field data freely available from NASA, *ESA or* the USGS. The topic of the projects will be finalized by the week after Spring Break. Students will have to *summarize their research and results in* a scientific *oral presentation* and present to the rest of the class in a 20-min presentation (+5 min for questions). There will 2 to 3 students per team for each project.

Exams

There will be two mid-term exams and one final exam *to assess students' understanding of the main concepts observed in class.*

Learning Outcomes

This course will promote the following learning outcomes:

Quantitative Reasoning 2

Students will develop quantitative reasoning skills through the completion of 6 problem-solving assignments distributed throughout the semester. The assignments will be related to concepts taught during lectures. The students will learn to use quantitative techniques and tools commonly used in aquatic optics (e.g., integration, statistical regressions, optimization techniques, radiative transfer models) during the weekly hands-on activities. The students will then have to apply these quantitative techniques using computer programming languages like Matlab and R to solve the problems posed in the assignments. The students will have to summarize their results a typeset document (MS Word, Apple Pages) where they will present results and data in figures strictly produced using computer programming (Matlab and R), typeset equations, and redacted explanations of their results. The class will also be required to read 2 manuscripts that illustrate the dangers of improperly using and interpreting remotely sensed data to make inferences about climate-driven trends. An entire class will be dedicated to discussing these manuscripts. Students will also have to complete a targeted research project during the second half of the course. They will have to identify a simple research question that can be addressed through the use of remote sensing and of the concepts and quantitative techniques they have learned throughout the course.

Oral/Signed Communication

Students will learn how to effectively craft and deliver oral scientific arguments to their student peers via the completion of two different styles of oral presentations supported by powerpoint slides. Early in the course, the students will be provided with guidance on how to effectively present scientific information and arguments to an audience of peers (written guidelines and tips for each presentation type). An entire lecture (50-min) will also be dedicated to discussing what makes an effective oral presentation, how to cater to a specific audience, and to review different styles of scientific oral presentations. During the first half of the course, the students will be required to present a 5-min lightning-style oral presentation summarizing the main findings of a manuscript he/she chose from a list assigned by the professor. Towards the end of the course, the students will also be required to do a 20-min oral presentation showcasing the results of their research project. Guidance will be provided on how to effectively present scientific research information in a conference-style presentation. These combined experiences of various lengths and styles will be expected to enhance the students' oral communication of scientific information.

Research and Information Literacy

One of the main objectives of the course is to empower students with the ability to identify an environmental research problem (using close guidance from the professor) and to address this problem on their own using their newly acquired quantitative reasoning skills and publicly available data. Specifically, the students will have to identify an environmental research question, formulate a simple testable hypothesis, and address it by applying a remote-sensing method published in a scientific literature on remote sensing data publicly available from NASA (https://oceancolor.gsfc.nasa.gov), ESA (https://www.oceancolour.org) or the USGS (https://earthexplorer.usgs.gov). Guidance from the professor will be provided to ensure that the approach is appropriate for the scope of the course. Students will finally present their results to the rest of the class and will be evaluated based on the quality and relevance of their results and the quality of their oral presentation.

Grading

Students are expected to attend all classes and arrive on time. If you must be absent from class, please contact the professor before the missed class to make arrangements. Students are also expected to come to class well prepared and to participate in class, and the grade will reflect the level of participation and preparedness of the student.

Summary

- Attendance, participation, quizzes: 5%
- Lightning-style presentation: 5%
- Assignments: 20%
- Research project + oral presentation: 25%
- Mid-term exam 1: 15%
- Mid-term exam 2: 15%
- Final exam: 15%

Percentage	Letter
93-100	*A*
90-93	*A-*
87-90	*B+*
83-87	*B*
80-83	*B-*
77-80	*C+*
73-77	*C*
70-73	*C-*
60-70	*D*
<60	*F*

Course Schedule

The first part of the course (until spring break) will focus on theoretical and field aquatic optics, whereas the second part of the course (after spring break) will focus on how these concepts are reused in remote sensing (ocean color) and on their use in research and applied sciences. Each week will generally include a lecture or two and one or two lab-based or computer-based activities in the lab. Note the detailed course schedule might vary from the general schedule presented below.

Week	*Date*	*Topic*
1	*Jan 23-27*	*Introduction* *Incident Solar Radiation*
2	*Jan 30 - Feb 3*	*Optically active in-water constituents*
3	*Feb 6-10*	*Inherent optical properties (IOP)* *of natural water constituents*
4	*Feb 13-17*	*Inherent optical properties (IOP)* *of natural water constituents*
5	*Feb 20-24*	*First mid-term exam* *Field radiometry and instrumentation*
6	*Feb 27 - Mar 3*	*Apparent Optical Properties (AOP) of natural waters*
	Mar 6-10	*Spring Break*
7	*Mar 13-17*	*Radiative transfer in water*
8	*Mar 20-24*	*Inverse modeling and algorithms*
9	*Mar 27 - Mar 31*	*Satellite ocean color Measurements, sensors, and data* *Second mid-term exam*
10	*Apr 3-7*	*Research and applications*
11	*Apr 10-14*	*Research and applications*
12	*Apr 17-21*	*Research and applications*
13	*Apr 24-28*	*Student projects presentations*
14	*May 1-3*	*Student projects presentations*

Exam Schedule

Exam	Date	Subject
Mid-term Exam 1	Week 5	Material from weeks 1 to 4
Mid-term Exam 2	Week 9	Material from weeks 5 to 9
Final Exam	Final exam period (May 9-13)	Material from weeks 10 to 14

Reading material

Reading material for the class will consists of handouts and published manuscripts, but below are some optional resources you might want to put your hands on.
Optional textbooks:

1. Light and Photosynthesis in Aquatic Ecosystems (3rd edition) by J. T. O Kirk, Cambridge University Press 2011.
2. Light in Water by Curtis Mobley (electronic version freely available)
3. IOCCG reports (all freely available at http://www.ioccg.org/reports_ioccg.html)

Software

Hands-on computer class activities will require the use of SeaDAS, SNAP, Matlab®, Hydrolight and will be carried out using classroom computers (or your personal computer if you prefer), and the SCC accessed with OnDemand. The hands-on activities are aimed to familiarize students with using these tools, and you are also strongly encouraged to get the software on your personal computers and to practice using them individually or in groups.

- SeaDAS is freely available from the NASA website https://oceancolor.gsfc.nasa.gov
- Matlab® is now freely available to all students enrolled at BU http://www.bu.edu/tech/services/support/desktop/distribution/mathsci/matlab/
- R is available at https://cran.r-project.org.
- SNAP is available at https://step.esa.int/main/download/
- Hydrolight: A limited, student version expiring at the end of the course will be made available to the students by the instructor.

Blackboard

Lecture slides, assignments, templates, reading material and other documents or scripts will all be posted on blackboard.

Academic integrity

This course will follow closely the procedures outlined in BU's Academic Conduct Code. Please consult these documents:

For undergraduate students (EE 422)

1. Academic Conduct Code

   http://www.bu.edu/academics/policies/academic-conduct-code/

2. University Policy on Religious Observance

   http://www.bu.edu/chapel/religion/

3. Multi-faith Calendar

   http://www.interfaithcalendar.org/

For graduate students (EE 622)

1. Academic Conduct Code

   http://www.bu.edu/cas/students/graduate/grs-forms-policies-procedures/academic-discipline-procedures/

2. University Policy on Religious Observance

   http://www.bu.edu/chapel/religion/

3. Multi-faith Calendar

   http://www.interfaithcalendar.org/

- For written assignments, any information presented from an outside source (books, newspapers, online sources) must be cited appropriately. Paraphrasing without citation is considered plagiarism.
- Infractions will be handled in accordance with university policy, and can result in a zero for the assignment, or reduction in course grade.

Diversity and Inclusion: Earth & Environment Statement

Diversity enriches all research and education, and is realized only with all voices, views, and perspectives operating within a supportive and respectful community. For this reason, the Department of Earth & Environment, including myself and the students in this course, are committed to fostering diverse, inclusive, and equitable living, learning, and working environments that are supportive and free from violence, harassment, disruption, and intimidation. Further, the Department of Earth & Environment recognizes that creating a safe environment and a culture of respect is the shared responsibility of all members of our community. To ensure an equitable environment that values and respects the unique experiences and perspectives of our community, the Department, including myself and the students in this course, are dedicated to promoting diversity, inclusion, and equity among all members of our departmental community and encouraging open, honest, and compassionate communication.

http://www.bu.edu/earth/about/diversityinclusion/

Student with disabilities

Accommodations for students with disabilities will be provided in accordance with the policies of Boston University.