

## Reshaping our Blue Marble Home: Climate Change and the Ocean

### CLASS BASICS:

3 Credits, Spring 2025

2:00-3:20 pm Mondays & Wednesdays

Room 203 in Marine Sciences Building - Monday & Wednesday

### INSTRUCTORS AND CONTACT INFORMATION:

Oscar Schofield	<a href="mailto:oscar@marine.rutgers.edu">oscar@marine.rutgers.edu</a>
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**Office Hours:** By appointment

Please use your Rutgers email account and include a subject line that provides the course number (11:628:402).

### COURSE DESCRIPTION:

We live on a water planet. 71% of Earth's surface is covered largely by the ocean (hydrosphere) and another ~15% is covered by ice (cryosphere). By modulating the planet's albedo (reflectivity) and atmosphere composition, this water is a key determinant of Earth's climate. Yet, human pollution (most notably carbon dioxide emissions) is forcing rapid planetary change with cascading effects for the hydrosphere and cryosphere. Given the central role of the ocean in regulating Earth's climate, this course will explore reciprocal interactions (feedbacks) within the ocean-climate system in the past, present, and future: How is our changing climate altering ocean systems and how, in turn, may ocean systems alter the trajectory of climate change? Course topics include polar oceanography, coupled nutrients cycles, future climate drivers in the ocean, and the science/ethics/possibility of geo-engineering. The course will be grounded into primary literature, IPCC reports, and on the science that underlies current debates on how to predict—and alter—today's climate trends.

### LEARNING GOALS:

The learning goals for the Marine Science major are posted on our website at <http://marine.rutgers.edu/main/academics/undergraduate>. This course addresses these learning goals by requiring students to:

- 1) Show evidence of scientific literacy, and communicate the information effectively both orally and in writing
- 2) Apply concepts in marine science to contemporary global issues
- 3) Evaluate ethical issues in marine science

We will use this course to have high level discussion about the ocean's role in structuring planetary climate, how human activity is changing, discuss how changes and proposed human interventions will impact society.

### **COURSE FORMAT:**

The course will be divided into weekly topics. Monday classes will be lecture on the topic; Wednesday classes will be split between lecture and student-led discussion of the primary literature.

Assigned readings for discussion will be listed on the Canvas site with links to the papers. The readings for each week will typically be: [1] a report, review paper, or chapter, and [2] one original research paper from the primary literature.

### **ASSIGNMENTS & GRADING:**

Student achievement of learning goals will be based on two non-cumulative exams, weekly student-led discussions on required reading and lecture material, and weekly written reactions to required reading:

- Midterm exam 20%
- Final exam 20%
- Leading a class discussion (2x) 20%
- Participation in class discussions 20%
- Written paper reactions (1/week) 20%

**Paper discussions:** Wednesday class sessions will be dedicated to a student-led discussion of papers on the topic of that week. One or two students will lead the discussion (undergrads will always co-lead in pairs, grad students will sometimes lead on their own), and each student will (co)lead two paper discussions throughout the semester. We will assign the topics/dates to students after the first class.

Students will be evaluated on their participation in these paper discussions, both as discussion leader and active participant in the other weeks. We expect all students to come to class having carefully read the papers and ready to discuss. As discussion leader, you will prepare some slides to help guide the discussion. These slides should include the key figures from the paper, and maybe a small amount of additional context/background that might be relevant to the discussion (e.g. a schematic, or a figure from another paper that this paper builds on). Importantly, these slides are meant to prompt and guide a discussion, but this should not turn into a formal presentation or lecture by the leader.

The discussion leaders should come prepared to lead the class, with questions to keep the conversation going. All students should also be prepared to share some of their questions from their paper reactions (see below).

**Weekly paper reaction:** Each week on Wednesday, before the paper discussion, students will submit a short write-up with their reaction to the readings (<1 page total). For each paper, please provide:

- a short paragraph summarizing your main takeaways and reactions to the paper
- 2-4 questions about the paper, ideally a mix of discussion and clarification questions.

Students do **not** need to submit a write-up for the weeks that they are leading the discussion.

**Mid-term and Final Exams:** The mid-term and final exams will be non-cumulative and given in-class.

## **COURSE SCHEDULE:**

### **Week 1: Overview**

Class 1 (Weds Jan 22)            Course overview and primer on Earth's biogeochemical cycles

### **Week 2: Observed trends in the past and present**

*Readings:* Letcher's 'Climate Change: Observed Impacts on Planet Earth' Ch. 3; AR6 IPCC Report (Summary for Policy Makers)

Class 2 (Mon Jan 27)            A brief (4.5 Ga) history of Earth's climate

Class 3 (Weds Jan 29)            Our present situation (*+class discussion for 30 minutes*)

#### References

Climate Change: Observed Impacts on Planet Earth (Chapter 3 Feedback mechanisms to further increase the heating of the planet) Elsevier 2021

Sixth Assessment of the Intergovernmental Panel of Climate Change (IPCC) -2023: Summary for Policy Makers

### **Week 3: The ocean and Earth's heat budget**

*Readings:* Dessler's 'Introduction to Modern Climate Change' Ch. 3; Manabe & Broccoli's 'Beyond Global Warming' Chs. 8 and 9, Palter 2015, Dong et al. 2019: Case Study Current State of the Gulf Stream and Society Impacts

Class 4 (Mon Feb 3)            Earth's heat budget: Accounting 101

Class 5 (Weds Feb 5)            How does the ocean trap and move heat? (*+class discussion for 30 minutes*)

#### References

Introduction to Modern Climate Changes. Dressler, A. E., Cambridge University Press 2011. Chapter 3 Beyond Global Warming. Manabe and Broccoli, Princeton University Press

The Role of the Gulf Stream in European Climate. Palter, J. B. Annual Review of Marine Science 2015.

#### **Week 4: Ocean, ice, and Earth's albedo—an introduction to climate feedbacks**

*Readings:* Dessler's 'Introduction to Modern Climate Change' Ch. 6; Charlson et al. 1987 *Nature* (CLAW hypothesis)

Class 6 (Mon Feb 10)      The cryosphere-albedo climate feedback and other effects of Earth's ice melt

Class 7 (Weds Feb 12)      Albedo and ocean aerosols (+class discussion for 30 minutes)

##### References

Introduction to Modern Climate Changes. Dressler, A. E., Cambridge University Press 2011. Chapter 6  
Oceanic phytoplankton, atmospheric sulphur, cloud albedo and climate. Charlson et al. *Nature* 1987  
The CLAW Hypothesis: A New Perspective on the Role of Biogenic Sulphur in the Regulation of Global Climate. Green and Hatton. *Oceanography and Marine Biology*

#### **Week 5: Carbon cycling and sequestration: The role of ocean physics**

*Readings:* Dessler's 'Introduction to Modern Climate Change' Ch. 5; Dong et al. 2019, Phrampus and Hornbach 2012

Class 8 (Mon Feb 17)      Global carbon budget and the ocean's solubility pump

Class 9 (Weds Feb 19)      How is ocean circulation changing? (+class discussion for 30 minutes)

##### References

Introduction to Modern Climate Changes. Dressler, A. E., Cambridge University Press 2011. Chapter 5  
Slow Down of the Gulf Stream during 1993-2016. Dong et al. *Scientific Reports* 2019.  
Recent changes to the Gulf Stream causing widespread gas hydrate destabilization. Phrampus and Hornbach *Nature* 2012

#### **Week 6: Carbon cycling and sequestration: The role of ocean biology and chemistry**

*Readings:* Siegel et al. 2023, Galbraith and Skinner 2020, DeVries 2022

Class 10 (Mon Feb 24)      The biological carbon pump

Class 11 (Weds Feb 26)      The alkalinity pump (+class discussion for 30 minutes)

##### References

Quantifying the Ocean's Biological Pump and Its Carbon Cycle Impacts on Global Scales. Siegel et al. *Annual Review of Marine Science*, 2023  
The Biological Pump During the Last Glacial Maximum. Galbraith and Skinner *Annual Review of Marine Science* 2020.  
The ocean carbon cycle. DeVries, *Annual Review of Environment and Resources* 2022

#### **Week 7: Ocean oxygen and nitrogen cycle feedbacks**

*Readings:* Falkowski 1997 *Nature*; Redfield 1958 *American Scientist*; Hutchins & Capone 2022 *Nature Reviews Microbiology*

Class 12 (Mon March 3) Oxygen, sea level rise, and the marine nitrogen budget

Class 13 (Weds March 5) Ocean oxygen and production of strong greenhouse gases  
(+class discussion for 30 minutes)

### References

Evolution of the nitrogen cycle and its influence on the biological sequestration of CO<sub>2</sub> in the ocean.  
Falkowski, *Nature* 1997.

The biological control of chemical factors in the environment, Redfield, *American Scientist* 1958.

The marine nitrogen cycle: new developments and global change. Hutchins and Capone, *Nature Reviews Microbiology* 2022

## **Week 8**

*No readings*

Class 14 (Mon March 10) How do we model climate change? Under the Hood of Global Climate Models (GCMs)

Class 15 (Weds March 12) EXAM 1: Earth system drivers (material from classes 1-13)

## **SPRING BREAK (Sat March 15 – Sun March 23)**

## **Week 9: A coevolving Earth system**

*Readings:* Lovelock & Margulis 1974 *Tellus*; Selden et al. 2024 *Global Change Biology*

*Additional recommended readings:* Dessler's 'Intro. to Modern Climate Change' Ch. 6

Class 16 (Mon March 24) The many faces of Gaia (revisiting the Gaia hypothesis in its varied forms)

Class 17 (Weds March 26) An introduction to tipping points (+class discussion for 30 minutes)

### References

Atmospheric homeostasis by and for the biosphere: the Gaia hypothesis. Lovelock and Margulis, *Tellus* 1974.

Is our understanding of aquatic ecosystems sufficient to quantify ecologically driven climate feedbacks.  
*Global Change Biology* 2024

Introduction to Modern Climate Changes. Dressler, A. E., Cambridge University Press 2011. Chapter 6

## **Week 10: Warming and the ocean's metabolism**

*Readings:* Brown et al. 2004 *MacArthur Award Lecture*; Schofield et al. 2024, Visser and Both 2005

Class 18 (Mon March 31) A metabolic theory of ecology and the ocean's trophic status

Class 19 (Weds April 2) Phenology and producer/grazer mismatches (+class discussion for 30 minutes)

References

Toward a metabolic theory of ecology. Brown, Ecology 2004.

Antarctic pelagic ecosystems on a warming planet Schofield et al. Trends in Ecology and Evolution 2024.

Shifts in phenology due to global climate change: a need for a yardstick. Visser and Both Proceedings of the Royal Society 2005.

**Week 11: The ocean's nutrient economy and shifts in supply/demand**

*Readings: Browning & Moore 2023 Nature; Hutchins & Tagliabue 2024 Nature Geoscience*

Class 20 (Mon April 7) How is the ocean's nutrient landscape changing? Considering the effects of stratification and changing flux patterns

Class 21 (Weds April 9) How is the stoichiometry of marine biota changing? (+class discussion)

References

Global analysis of ocean phytoplankton nutrient limitation reveals high prevalence of co-limitation. Browning and Moore Nature 2023.

Feedbacks between phytoplankton and nutrient cycles in a warming ocean. Hutchins and Tagliabue Nature Geoscience 2024

**Week 12: Biogeochemical consequences of ocean acidification and deoxygenation**

*Readings: Doney et al. 2009, Doney et al. 2020, Oschlies et al. 2018*

Class 22 (Mon April 14) Adaptation of pelagic calcifiers and calcifying ecosystem engineers to climate

Class 23 (Weds April 16) Synergistic effects warming, acidification, and deoxygenation on marine biota (+class discussion)

References

The impacts of ocean acidification on marine ecosystems and reliant human communities Doney et al. Annual Review of Environment and Resources 2020.

Ocean acidification: The other Co2 problem. Doney et al. Annual Review of Marine Science 2009

Drivers and mechanisms of ocean deoxygenation. Oschlies et al. Nature Geoscience 2018.

**Week 13: Geoengineering solutions to climate change**

*Readings: O'Lear et al. 2021, IPCC 5<sup>th</sup> Assessment Summary of Policy Makers "Mitigation of Climate Change*

Class 24 (Mon April 21) The state of geoengineering today—what ideas show promise?

Class 25 (Weds April 23) The ethics of geoengineering (+class discussion)

References

Environmental geopolitics of climate engineering proposals in the IPCC 5<sup>th</sup> Assessment. O'Lear et al. Frontiers Climate 2021.

AR5 Climate Change 2014: Mitigation of Climate Change. IPCC. 2014

## **Week 14**

*No readings*

Class 24 (Mon April 28)      What have we learned and what work must be done? (*+class discussion; no reading reaction due*)

Class 25 (Weds April 30)      EXAM 2: Consequences and feedbacks (material from classes 16-25)

## **COURSE WEBSITE, RESOURCES AND MATERIALS:**

We will use this Canvas website, which includes course materials, and zoom links for virtual classes.

**\*\*Please visit the Rutgers Student Tech Guide page for resources available to all students. If you do not have the appropriate technology for financial reasons, please email Dean of Students deanofstudents@echo.rutgers.edu for assistance. If you are facing other financial hardships, please visit the Office of Financial Aid at [https://financialaid.rutgers.edu/Links to an external site.](https://financialaid.rutgers.edu/Links%20to%20an%20external%20site)**

## **ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES**

**Disability Services (848) 445-6800 / Lucy Stone Hall, Suite A145, Livingston Campus, 54 Joyce Kilmer Avenue, Piscataway, NJ 08854 / <https://ods.rutgers.edu/>** Rutgers

University welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: **<https://ods.rutgers.edu/students/documentationguidelines>**. If the documentation supports your request for reasonable accommodations, your campus's disability services office will provide you with a Letter of Accommodations. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible. To begin this process, please complete the Registration form on the ODS web site at: **<https://ods.rutgers.edu/students/registration-form>**.

## **ABSENCE POLICY**

If you have a question, need clarification, or have a penetrating insight to offer, do it with the class as a whole rather than starting a side conversation. The ringing/beeping/chiming/singing of cell phones or other electronic devices is disruptive during class. Please make sure to disable audible alarms during class. Also, class time is not the time for you to be checking your email or surfing the web. Attendance at all class

meetings is expected because of the importance of in-class discussion. If you are not in class, you are not learning; you are wasting your time and money. We ask that you make every effort to log into to class on time, and once there, stay.

## **ACADEMIC INTEGRITY**

The university's policy on Academic Integrity is available at <http://academicintegrity.rutgers.edu/academic-integrity-policy>Links to an external site..

The principles of academic integrity require that a student:

- properly acknowledge and cite all use of the ideas, results, or words of others.
- properly acknowledge all contributors to a given piece of work.
- make sure that all work submitted as his or her own in a course or other academic activity is produced without the aid of impermissible materials or impermissible collaboration.
- obtain all data or results by ethical means and report them accurately without suppressing any results inconsistent with his or her interpretation or conclusions.
- treat all other students in an ethical manner, respecting their integrity and right to pursue their educational goals without interference. This requires that a student neither facilitate academic dishonesty by others nor obstruct their academic progress.
- uphold the canons of the ethical or professional code of the profession for which he or she is preparing.

Adherence to these principles is necessary in order to ensure that

- everyone is given proper credit for his or her ideas, words, results, and other scholarly accomplishments.
- all student work is fairly evaluated and no student has an inappropriate advantage over others.
- the academic and ethical development of all students is fostered.
- the reputation of the University for integrity in its teaching, research, and scholarship is maintained and enhanced.

Failure to uphold these principles of academic integrity threatens both the reputation of the University and the value of the degrees awarded to its students. Every member of the University community therefore bears a responsibility for ensuring that the highest standards of academic integrity are upheld.

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## **STUDENT WELLNESS SERVICES**

Just In Case Web AppLinks to an external site. <http://codu.co/cee05e>Links to an external site.

Access helpful mental health information and resources for yourself or a friend in a mental health crisis on your smartphone or tablet and easily contact CAPS or RUPD.

Counseling, ADAP & Psychiatric Services (CAPS)

(848) 932-7884 / 17 Senior Street, New Brunswick, NJ 08901 / [www.rhscaps.rutgers.edu](http://www.rhscaps.rutgers.edu)/Links to an external site.

CAPS is a University mental health support service that includes counseling, alcohol and other drug assistance, and psychiatric services staffed by a team of professional within Rutgers Health services to support students' efforts to succeed at Rutgers University. CAPS offers a variety of services that include: individual therapy, group therapy and workshops, crisis intervention, referral to specialists in the community and consultation and collaboration with campus partners.

Violence Prevention & Victim Assistance (VPVA)

(848) 932-1181 / 3 Bartlett Street, New Brunswick, NJ 08901 / [www.vpva.rutgers.edu](http://www.vpva.rutgers.edu)/Links to an external site.

The Office for Violence Prevention and Victim Assistance provides confidential crisis intervention, counseling and advocacy for victims of sexual and relationship violence and stalking to students, staff and faculty. To reach staff during office hours when the university is open or to reach an advocate after hours, call 848-932-1181.

Disability Services

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Scarlet Listeners

(732) 247-5555

[/ https://rutgers.campuslabs.com/engage/organization/scarletlisteners](https://rutgers.campuslabs.com/engage/organization/scarletlisteners)Links to an external site.

Free and confidential peer counseling and referral hotline, providing a comforting and supportive safe space.