270.626 Ocean General Circulation

Fall Term 2022.

Prof. Thomas Haine
329 Olin Hall, Tel.: 410 516 7048,

Thomas.Haine@jhu.edu
`http://sites.krieger.jhu.edu/haine/`

Tuesdays & Thursdays 9:00–10:20am, Olin 145

Synopsis

This course is on the low-frequency global ocean general circulation. The treatment is mainly phenomenological, but intuitive physical explanations are attempted almost everywhere, and there are some more detailed mathematical models too. The course is designed for graduate students with interests in oceans, atmospheres, climate dynamics, geophysics, and/or fluids. Basic familiarity with fluid mechanics is required, and a solid grounding in physics, and mathematical methods for physics, at undergraduate level is assumed. The course may be accessible to you without these requirements, but expect to do some remedial work to catch up. Prior exposure to physical oceanography (or atmospheric dynamics) is an advantage, but is not required. Again, expect to do some background reading if necessary.

Format: The course will be taught as 80min in-person classes twice a week. Some classes may be re-scheduled when I'm traveling. There will be a few lecture presentations and some traditional note-taking as I lecture. More importantly, there will often be chance to discuss ideas and work on problems together during class. We will make computations and display data, for example in MATLAB or Python (or Julia, or something else). There will also be student discussion of homework. Class materials will be posted to Canvas. I expect you to review materials (presentation pdfs, textbook reading) beforehand, so that during class we can focus on problems. I plan to use Panopto to capture lectures and post to Canvas. I don't hold regular office hours, but feel free to talk to me after class or email to setup a meeting.

I'm excited to teach Ocean General Circulation! This subject is fascinating!

Topics

We will pick a subset (probably topics 1–3 plus 2 or 3 others) of the following topics (these are chapters in *Klinger and Haine* 2019):

1. Physical Oceanography: Methods and Dynamical Framework
2. Rotating and Shallow-Water Flow

3. Two-Dimensional Horizontal Circulation
4. Surface and Mixed Layer Properties
5. Gyre-Scale Structures and Depth-Dependent Geostrophic Circulation
6. Ekman Transport, Shallow Overturning Cells, and Upwelling Regions
7. Eddies and Small Scale Mixing
8. Deep Meridional Overturning
9. The Southern Ocean Nexus
10. Arctic Circulation
11. Heat Flux, Freshwater Flux, and Climate

Each of these topics/chapters consist of sections on Observations, Concepts, and Theory.

Learning Goals

- Demonstrate proficiency in understanding and interpreting observations of physical oceanography with relevance to ocean general circulation.
- Learn, understand, and demonstrate proficiency in: observations, conceptual explanations, and theoretical models of select, key phenomena in ocean general circulation (such as: subtropical gyre, western intensification, hydrographic structure, mixed layers, deep and abyssal circulation, meridional overturning circulation, ocean's role in climate).
- Develop ability to understand both intuitive physical explanations and the corresponding mathematical arguments. Students will learn to be adept at switching between approaches.
- Increase expertise in using computers to analyze and present oceanographic data, perform numerical calculations (e.g. in MATLAB or python), and prepare clear written assignments with mathematical arguments and quantitative data (e.g. in latex).
- Increase expertise in collaborative team-work (e.g. on assignments) and informal presentations (e.g. "chalk & talk").

Textbooks

The course is based on the required textbook *Ocean Circulation in Three Dimensions* (OC3D) by *Klinger and Haine* (2019), which is at the bookstore and on reserve at the library (an electronic version is also available). The topics above are the chapters in this book. The following are also good for reference, at least on the more theoretical aspects:

- Basic principles: *Marshall and Plumb* (2008); *Cushman-Roisin* (1994). (A new edition of Cushman-Roisin's book was published in 2011, and is much updated.)
- At the level of the class: *Vallis* (2006) (although we only cover a fraction of this material).
- Advanced reading: *Pedlosky* (1996); *Salmon* (1998).

Assessment

The final grade in this class will depend on the following input data:

1. 30%: Class participation, including informal discussion, and presenting material,
2. 70% Homeworks (probably 7 in total, weighted equally).

There will be no final exam (the last assignment will probably be due on the day of the final exam). Attendance at each class is expected, and is essential for good performance. Please inform me ahead of time if you cannot attend class, or as soon as is practicable. We will adhere to the University guidelines on illness (including COVID, available at: `https://covidinfo.jhu.edu/`): don't worry about catching up with class until you're well again. You will not be academically penalized for following the advice of health professionals! Similarly, religious holidays are valid reasons to be excused from class, but please inform me in advance.

Ethics

The following guidelines are taken seriously in this class:

The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition.

In addition, the specific ethics guidelines for this course are: *Homework assignments must be completed without any collaboration with anyone else. I encourage you to discuss* *homework problems with other students, but you must write up your own answers unless told otherwise. All printed and online information source should be accurately cited. There may also be some assignments where you work together.*

Report any violations you witness to the instructor or rseitz5@jh.edu. The policy can be found here: `https://e-catalogue.jhu.edu/arts-sciences/full-time-residential-programs/graduate-policies/graduate-specific-policies/`.

Diversity and Inclusion

Johns Hopkins University values diversity and inclusion. We are committed to providing welcoming, equitable, and accessible educational experiences for all students. Students with disabilities (including those with psychological conditions, medical conditions and temporary disabilities) can request accommodations for this course by providing an Accommodation Letter issued by Student Disability Services (SDS). Please request accommodations for this course as early as possible to provide time for effective communication and arrangements. For further information or to start the process of requesting accommodations, please contact Student Disability Services at Homewood Campus, Shaffer Hall #101, call: 410-516-4720 and email: studentdisabilityservices@jhu.edu or visit `https://studentaffairs.jhu.edu/disabilities` .

Classroom Climate: I am committed to creating a classroom environment that values the diversity of experiences and perspectives that all students bring. Everyone here has the right to be treated with dignity and respect. I believe fostering an inclusive climate is important because research and my experience show that students who interact with peers who are different from themselves learn new things and experience tangible educational outcomes. Please join me in creating a welcoming and vibrant classroom climate. Note that you should expect to be challenged intellectually by me and your peers, and at times this may feel uncomfortable. Indeed, it can be helpful to be pushed sometimes in order to learn and grow. But at no time in this learning process should someone be singled out or treated unequally on the basis of any seen or unseen part of their identity. If you ever have concerns in this course about harassment, discrimination, or any unequal treatment, or if you seek accommodations or resources, I invite you to share directly with me. I promise that we will take your communication seriously and to seek mutually acceptable resolutions and accommodations. Reporting will never impact your course grade. You may also share concerns with the department chair (Sabine Stanley, sabine@jhu.edu), the Director of Graduate Studies (Sarah Horst, sarah.horst@jhu.edu), the Assistant Dean for Diversity and Inclusion (Araceli Frias, afrias3@jhu.edu), or the Office of Institutional Equity (oie@jhu.edu). In handling reports, people will protect your privacy as much as possible, but faculty and staff are required to officially report information for some cases (e.g. sexual harassment).

Anxiety and Mental Health

If you are struggling with anxiety, stress, depression or other mental health related concerns, please consider visiting the JHU Counseling Center. If you are concerned about a friend, please encourage that person to seek out their services. The Counseling Center is located at 3003 North Charles Street in Suite S-200 and can be reached at 410-516-8278 and online at `http://studentaffairs.jhu.edu/counselingcenter/`

References

Cushman-Roisin, B. (1994), *Introduction to geophysical fluid dynamics*, Prentice-Hall, Inc., Englewood Cliffs, NJ, USA.

Klinger, B. A., and T. W. N. Haine (2019), *Ocean Circulation in Three Dimensions*, 1st ed., Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Marshall, J., and R. A. Plumb (2008), *Atmosphere, Ocean, and Climate Dynamics: An Introductory Text*, 319 pp., Elsevier Inc.

Pedlosky, J. (1996), *Ocean circulation theory*, Springer-Verlag, doi:10.1007/978-3-662-03204-6.

Salmon, R. (1998), *Lectures on geophysical fluid dynamics*, Oxford University Press, doi:10.1093/oso/9780195108088.001.0001.

Vallis, G. K. (2006), *Atmospheric and Oceanic Fluid Dynamics: Fundamentals and Large-scale Circulation*, 1st ed., 745 pp., Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, doi:10.1017/cbo9780511790447.

Schedule

We will meet twice a week for two 80 minute classes in Olin 145 (and on zoom if needed, for example when I'm traveling). Our schedule is: Tuesdays and Thursdays at 09:00–10:20. These times are somewhat flexible—please let me know if you'd like to attend class, but have a conflict. The tentative schedule is as follows:

- 30 Aug, 1 Sep, Week 1: Introduction to the class. Physical Oceanography: Methods and Dynamical Framework: Observations.
- 6, 8 Sept, Week 2: Physical Oceanography: Methods and Dynamical Framework: Concepts.
- 13, 15 Sept, Week 3: Physical Oceanography: Methods and Dynamical Framework: Theory.
- 20, 22 Sept, Week 4: Rotating and Shallow-Water Flow: Concepts.
- 27, 29 Sept, Week 5: Rotating and Shallow-Water Flow: Theory.
- 4, 6 Oct, Week 6: Two-Dimensional Horizontal Circulation: Observations.
- 11, 13 Oct, Week 7 (Instructor traveling): Two-Dimensional Horizontal Circulation: Concepts.
- 18 Oct + Fall Break, Week 8: Two-Dimensional Horizontal Circulation: Theory.
- 25, 28 Oct, Week 9: TBA
- 1, 3 Nov, Week 10: TBA
- 8, 10 Nov, Week 11: TBA
- 15, 17 Nov, Week 12: TBA
- 22, 24 Nov, Week 13: TBA
- 29 Nov, 1 Dec, Week 14: Thanksgiving vacation
- 6, 8 Dec, (Instructor traveling) Week 15: TBA

Expect homework assignments every 2–3 weeks. The drop deadline is at the end of week 6.