Physics of Geophysical Fluids

Course Description

This course introduces the physics of fluids, from the basis of conservation of mass, energy, and momentum. In the context of geophysics, we examine several situational simplifications which allow analytic solutions: flow through a pipe or channel, the flow of a glacier, cyclostrophic flow, geostrophic flow, and the changes of concentration of pollutants in a controlled volume. In each case, we will derive the simplified equation and use both analytic solutions and real data to understand each physical process. Prerequisites are one semester of physics and multivariable calculus, or permission of the instructor.

Instructor

Dr. Jay Brett, email: office phone:

Office Hours:

Learning Objectives:

- Use conservation of mass to calculate rates of change of fluid properties in a control volume
- Explain the physical processes described in the Navier-Stokes equations that describe the conservation of momentum for a fluid
- For a given fluid scenario or behavior, quantify the relative size of different terms in the governing equations using reasonable values for system properties to justify simplified equations for first-order properties
- Create or extract observational data and compare to theory
- Present clear and coherent explanations of labs' methods and results
- Write clear, coherent, comprehensive lab reports that connect back to the theory

Texts:

There is no single textbook for this course. For reference, I will have a selection of texts in my office and on hold at the library. These include Geodynamics (by Turcotte and Schubert, Chapters 2 and 6), Atmospheric and Oceanic Fluid Dynamics (by Vallis, Part 1), and Geophysical Fluid Dynamics (by Pedlosky). I will also provide lecture notes that you can annotate. Come to office hours to use my textbooks, as well as if you have questions and if you have trouble accessing any material or would like additional recommendations of references to study.

Assignments:

There are 5 labs, with lab presentations and written reports for each as the primary assignments. Additional practice problems for analytical problems done as a group in class will be provided, and may be included as examples of the theory in your lab reports. Labs are done in groups for the design, data collection, data analysis, and presentation. Written reports are primarily individual efforts, but the methods and data sections are expected to be very similar within a group; attribution should be given for the work done by each group member, such as who primarily directed, ran the experiment, and recorded data. Each person must write their own introduction covering the theory and introducing the scientific question, their own analysis section that provides a rational for all decisions, and their own discussion that includes responses to questions raised by the class at the presentation and a connection back to the theory and original question. There is structured peer feedback on both presentations and draft reports. Presentations are 36% of the final grade, lab reports are 50%, and participation is 14%. Presentation grades depend on involvement in class meetings and good group work for labs.

Schedule

Week	Class 1	Lab	Class 2
1			Introductions, conservation of mass
2	Density, concentration, bucket problems, lab design	Set up and test dye systems	Control volumes in the ocean or atmosphere
3	Run-off and safe swimming Lab presentation and report structure	Data collection of dye rates, begin analysis	Conservation of energy
4	Peer feedback structure Lab presentations 1, draft exchange for peer review	Introduction to Bernoulli Introduction to digital pipe simulator, design experiments	Lab 1 reports due Bernoulli applications, possible friction effects
5	Open channel flow	Pipe flow experiments	Aqueducts
6	Lab presentations & draft exchange 2 Conservation of momentum	Data available from Ocean Atlas and weather maps	Lab 2 reports due Navier-Stokes Equations, Coriolis acceleration
7	Geostrophic balance, Rossby number	Collect data to compare winds or drifters to geostrophic current speeds	Ocean large and mesoscale circulation and thermal wind balance
8	Atmospheric structures and geostrophic balance	Geostrophic balance analysis	Cyclostrophic balance
9	Lab presentations & draft exchange 3 Tornados	Accessing Doppler weather data and locating tornados	Lab 3 reports due Waterspouts
10	Gradient wind balance	Tornado data collection	Gradient wind balance in 'geostrophic' data
11	Gradient wind balance in 'geostrophic' data	Tornado analysis	Return to friction: flow between plates
12	Lab presentations & draft exchange 4 Stress-strain relationship	Introduction to glacier data	Lab 4 reports due Glacier flow

13	Glacier flow	Glacier study design and data extraction	Glacier beds and meltwater
14	Ocean flow under winds: Ekman spiral	Glacier analysis	Ekman spiral
15	Lab presentations & draft exchange 5 Reflections discussion	none	Lab 5 reports due No meeting

Policies

Late Assignments: Late assignments without prior approval lose 10% credit per day. Please talk to me in advance if you are having trouble. Talking in person is best, but email is okay.

Missing Class: If you miss lecture/seminar class when no assignments are due, please get notes from a classmate. If assignments are due, you must let me know in advance that you are missing class. If we are having presentations, you must make up that work at a later date, and you must work with me on scheduling that immediately.

Academic Honesty: You are expected to discuss your work with your classmates. It is your responsibility to be certain you understand all aspects of the assigned work; discuss a process or an answer and write it out for yourself. In lab reports, all sentences or phrases by other authors must be put in quotation marks and correctly cited, but the methods section may be a group effort as long as you provide co-authorship of that section appropriately.