Ocean 620
Introduction to Physical Oceanography
Fall, 2017

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MSB315, MWF 10:30-11:20am
http://currents.soest.hawaii.edu/ocn620/

Overview

We will examine the physical state of the ocean, with an emphasis on the processes and forcing mechanisms that lead to observed mean patterns and variability. Our hope is that you come away with a basic understanding of what the ocean looks like - the main surface currents, the vertical structure, overturning circulations, the mixed layer, eddy variability, fronts, tides, waves, etc. Beyond a descriptive picture, we'd like you to develop a sense for why the ocean looks the way that it does, and what causes it to change on different time and space scales. This will lead us into an introduction of geophysical fluid dynamics, and an appreciation for fluid motion on a spinning Earth. We'll end by examining current interdisciplinary research areas involving PO, including climate change and ecosystem dynamics.

We hope to achieve all of this through lectures, directed readings, problem sets, computer labs, rotating tank demonstrations, and perhaps a field trip. Lectures will prove to be successful to the extent that we achieve a dialogue rather than having material delivered to you in a one-way stream. Please try to come prepared for lectures by going over reading material beforehand and coming in with questions in mind. We will introduce computing tools to allow you to explore PO datasets and to use these resources for your own pursuits.

Physics underpins all aspects of the course. We will flex our quantitative muscles a bit, but our main concern is that you understand physical concepts as opposed to detailed mathematical derivations. For example, what are the force balances behind geostrophic motion or Ekman currents? It is possible to excel in this course on a purely conceptual level; however, we expect that an exposure to basic problem solving will lead to deeper insights.

Topics

Here are some general topics that we intend to cover. They are not in any particular order and some will span several lectures. Please let us know if there are topics of interest to you that are not included and we'll try to accommodate.

1. Why does ocean physics matter, even for non-scientists? Examples: climate and weather; sea level, short term and long term; productivity and food.

2. What do ocean circulation and property distributions look like? Large-scale circulation; current measurements; property distributions; atmospheric circulation.

3. How are tracers transported? Advection, diffusion, conservation equations; Reynolds decomposition.

4. Why does the water move the way it does? Momentum balance; gravity waves; rotation; Ekman balance; geostrophy; atmospheric forcing

5. How does the ocean vary with the seasons, and over the course of a day? Mixed-layer physics; simple forced-damped systems; tides; shelf and coastal phenomena.

6. Why does the ocean circulate the way it does, on large scales? Gyres; the equatorial current system; western boundary currents; the Sverdrup balance; the Southern Ocean.

7. Why does the actual ocean velocity field at any given time bear so little resemblance to the large-scale circulation? Eddies; Rossby waves; baroclinic instability; eddy transports.

8. How do thermocline and intermediate waters get their characteristics, and how long ago did they get them? Ventilation, subduction inter-gyre transport.

9. How do deep waters get their characteristics and circulate? Deep and bottom water formation; the meridional overturning circulation; diapycnal mixing.

10. How does one region of the ocean find out about what has been happening in another region? Waves and the propagation of information. Phase and group velocity, dispersion relations. Surface gravity waves, internal gravity waves, Kelvin waves, Rossby waves.

11. What is El Niño, and why does it happen? Equatorial dynamics and ocean-atmosphere interaction.

12. Are the oceans warming? Are sea levels rising? Is the overturning circulation changing? Evidence for climate change.

Readings

Lecture notes prepared over the years primarily by Eric Firing will be available as pdf files on our web site. The lectures and notes will not be completely in sync, but you should be able to find material on most of the first half of the course, and some of the second, in the lecture notes.

We do not have an assigned textbook for the course. Instead, we suggest that you download two texts that are available online.

Introduction to Physical Oceanography by Robert H. Stewart, available online in both pdf and html form. See our web site for a link.

Regional Oceanography: an Introduction by Tomczak and Godfrey is a good source of primarily descriptive information. Unfortunately, it is no longer available from Pergamon Press, but a revised edition is available in print or as pdf. See the "Other Courses" section of our web site for a link.

You may want to consider acquiring one or two others texts depending on your particular interests. The following are notes on books that you might find helpful.

Ocean Dynamics and the Carbon Cycle by Williams and Follows was the assigned text for this course in previous years. The book gives an introduction to PO that is thorough, concise, and unusually modern. It also illustrates how PO fits into modern oceanography, and into problems of societal interest. The high-quality plots and summary information make it a particularly useful reference.

For the discussion of the large scale dynamics, rotating fluid dynamics, and climate variations, consider *Atmosphere, Ocean and Climate Dynamics* by John Marshall and Alan Plumb. The book also contains chapters on the atmosphere that we do not cover, but that you might find interesting and useful reading. One strength of the book is its use of laboratory experiments to illustrate phenomena of rotating fluids.

Atmosphere-Ocean Dynamics by Adrian Gill is a highly respected text and reference. Although as a whole it is too advanced to be used as a primary text for this course, parts may be helpful, particularly to those who continue their studies of physical oceanography or meteorology.

The book *Ocean Circulation* by the Open University course team might be helpful at the most elementary level. It has good graphics and attempts to be simple but reasonably modern.

Some students have found *Introduction to Physical Oceanography* by John Knauss to be helpful. Although it was updated a few years ago, its content is still traditional.

A completely re-written *Sixth Edition of Descriptive Physical Oceanography* by Talley et al. is packed with up-to-date PO information. It is a good supplementary reference, and can serve as a replacement for the Tomczak and Godfrey book.

Grading

The weighting for the final grade will be 30% homework, 25% for the midterm, 35% for the final, and 10% for class participation.