Syllabus for GEOL1520: Ocean Circulation and Climate (a.k.a. Notions for the Motions of the Oceans) Previously GEOL1100: Global Physical/Descriptive Oceanography

Baylor Fox-Kemper

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1 Course Description

Examines physical characteristics, processes, and dynamics of the global ocean to understand circulation patterns and how they relate to ocean biology, chemistry, and climate change. Assignments address ocean's role in the climate system; ocean observations and models; the origin, distribution, and dynamics of large-scale ocean circulation and water masses; energy and freshwater budgets; and variability of the coupled system on seasonal to centennial timescales e.g. El Nio. Intended for geological and physical sciences undergraduate and graduate students with quantitative skills and an interest in oceans, climate, paleoclimate. Pre-requisite: GEOL0350 or PHYS0720 or APMA 0340. Offered alternate years, previously offered as GEOL1100.

2 Contacts

The professor for this class is: Baylor Fox-Kemper
baylor@brown.edu
401-863-3979
Office: GeoChem room 133
`http://fox-kemper.com/teaching`, `http://fox-kemper.com/po`

Portions of the website are password-protected to ensure that fair use and copyrights are correctly obeyed as I share images from books, etc. You can access these by using:

```
username:  io
password:  ocean
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3 Getting Help!

I am usually available by email. You can make an appointment other times. Just check my calendar at `http://fox-kemper.com/contact` and suggest a time that works for you.

4 Goals

In this class you will:

- Learn about many of the physical processes that occur in the ocean.
- Learn about how these physical processes are observed, budgeted, and quantified.
- Learn about where these processes occur in the ocean.
- Learn about and access recent ocean datasets.
- Get practice writing and thinking scientifically by focused study on particular processes.
- You will also get a broader perspective and more practice by peer reviewing your colleagues' efforts.
- You will benefit from the reviews of your writing by your peers.

A list of the basic topics covered in this class is:

- Observations (1 Week)
  - What instruments are common to oceanography?
  - How are these measurements used?
  - How do the types of measurements influence the theoretical developments?
- Fluids Mechanics (2 Weeks)
  - The differential equations describing a fluid
  - The differential equations describing a Boussinesq fluid
  - How the differential equations relate to budgets & conservation of:
    - salt, freshwater, energy, entropy/potential temperature, vorticity, potential vorticity
  - Scale and Dimensional Analysis
    - How the differential equations may be reduced to a *dominant balance* for particular phenomena
    - Common non-dimensional groupings may be used to identify which *dominant balance* is likely
- Rotation (2 Weeks)
  - The equations for fluid motion in a rotating frame of reference
  - Ekman layers and balance
  - Geostrophic balance
- Stratification (2 Weeks)
  - The temperature, salinity, and density stratification of the ocean
  - Hydrostasy
  - Baroclinic and Barotropic
  - Potential temperature and potential density
  - Thermal wind balance
- Vorticity balances (1 Week)
  - Taylor-Proudman Flow
  - Sverdrup Flow
  - Thermal wind as vorticity budget
- Ocean Circulation (2.5 Weeks)
  - The Wind-Driven Ocean Circulation
  - Western Boundary Currents
  - Antarctic Circumpolar Current
  - The Meridional Overturning Circulation
  - Theories of the Thermocline
  - The pressure distribution of the ocean
- Forcing (1 Week)
  - Air-sea exchanges of sensible & latent heat, momentum, energy
  - Radiation forcing (shortwave=solar and longwave)
- Wave Basics (2 Weeks)
  - Dispersive Wave Kinematics: Phase & Group velocity

Important kinds of ocean waves: surface gravity, internal gravity, Rossby, Kelvin
Nonlinear waves, eddies, vortices, and coherent structures
El Nino

5 Meetings and Places

We will meet Tuesdays and Thursdays from 1 to 2:20PM in GeoChem 029. Office hours will be by appointment (see my schedule at `http://fox-kemper.com/contact`).

The student computer lab in GeoChem should have the software we'll be using (primarily matlab) loaded. You can download a copy of matlab for yourself from `http://software.brown.edu/dist/index.html` for free. The website has many links to datasets that are freely available. I will provide local access to some of the most convenient ones at `http://fox-kemper.com/data`.

5.1 Calendar

The main webpage for the class `http://fox-kemper.com/1520` will have the calendar with all assignment deadlines, readings, etc., set up by the first class session. The three big paper assignments will be due near the last day of February, March, and April, respectively.

6 Canvas and Websites

The primary resource for this class is the webpage: `http://fox-kemper.com/1520`. The class webpage is where all of your assignments will be announced, links to reading and textbooks will be posted, etc. The second web resource is the canvas page for the class. All homeworks, papers, and peer reviews will be turned in through canvas.

You will want to familiarize yourself with Google Scholar (`http://scholar.google.com`) and the Web of Science (`http://apps.webofknowledge.com/`). Both are free to you, and they will help you with your paper preparations.

7 Textbooks and Software

We will use three primary textbooks: *Ocean Circulation and Climate* (Siedler et al., 2013), *Ocean Circulation* (Colling, 2001), and *Atmospheric and Oceanic Fluid Dynamics* (Vallis, 2006). The first two are required, but the electronic versions can be accessed electronically through the Brown site/vpn access at `http://www.sciencedirect.com/science/bookseries/00746142/103` and `http://site.ebrary.com/lib/brown/docDetail.action?docID=10190755` (you must be on campus or hooked in with VPN or the library's EZproxy to access). You can also find links to them on Josiah. More mathematical detail will be found in Vallis (2006), which is a required textbook for this and other climate courses in the department. Two good online textbooks are (Tomczak and Godfrey, 1994; Stewart, 2008), which are linked from the course webpage.

All of the required readings will be posted on the website. Hard copies of many of these books, as well as some others you should become familiar with are in the Science Library. I recommend browsing a bit and seeing what there is (Library of Congress Call Numbers GC11, GC150, GC228, and QC809 are good places to start).

The class will require use of software capable of opening ocean datasets. I strongly recommend matlab, but you could use Java Ocean Atlas, IDL, Ocean Data View, python, or ferret (although I will be less able to offer help!). All of these are available to you free for PC, Mac, and Linux.

8 Assignments and (lack of) Exams

There will be three major assignments for this class, and all of them will be in the form of short scientific reports. You will often be working on two assignments at a time, reviewing and revising the last one (a little work), and preparing the next one (more work). There will also be short homework assignments based on lectures and reading. There will be no additional exams or midterms. The final revision of the final paper is presently scheduled to be turned in at the end of exam week, although I have tried to schedule sufficient time the preceding week so that it can be completed before exams. The weighting of the assignments will be:

- 30% Reading/Paper Prep HWs.
- 10% Plans for papers.
- 30% Original submission of papers.
- 15% Revised submission of papers.
- 15% Reviews of other students' papers.

What can help me get a good grade? Turn all of the assignments in on time. This is *more important* than turning in complete assignments. For the peer-reviewing format of the course to work, ON TIME matters, so that I can give timely feedback on paper plans, and so we can get to the reviewing.

Assignments are to be in pdf file format and created according to American Geophysical Union Geophysical Research Letters templates. If you want to use LaTeX, I can help. If you want to use something else, you can download the AGU templates, but you're on your own if things go wrong!

The scheduling of the assignments are listed on the webpage, and other than the exceptional week around fall break will be as follows.

- Paper assignment $\#n$ will be due on a Friday at 11:59 PM. They will be submitted electronically.
- By Sunday at noon, you will receive two of your colleagues' $\#n$ papers to review electronically.
- On Tuesday, we will have class and office hours. You can discuss anything with me or the class about your paper or the papers you are reviewing ($\#n$) or paper $\#n+1$ that *you have already begun thinking about*. Be careful to preserve your reviewer anonymity!
- On Wednesday by 5 PM, your reviews of your colleagues' two papers ($\#n$) are done and submitted electronically to me.
- By Thursday midnight, I will have your paper $\#n$ back to you, with my reviews and your peer reviews. Discussion during office hours is encouraged of returned paper $\#n$
- The following Wednesday at 5 PM, a revised version of your paper is due.
- That Friday, a summary of what you plan to do on paper $\#n + 1$ is due. I encourage you to have generated some results and looked for some references. I will respond by email with suggestions for the following week.
- The following Friday, paper $\#n + 1$ is due, and the process restarts.

All of this will be charted out on the calendar on the website and in CULearn.

Before you get worried about writing five papers for one class, let me explain the goals of the paper writing. These are *not* supposed to be polished, ready to submit papers detailing years of research. Instead, they are supposed to be practice in writing drafts for your real research. The idea is to get used to pounding out a working draft in only a couple of hours, so that when the time comes for you to do it for real, that part will be easy.

Since you all have different preparation, you will all be able to take advantage of what you know. However, we are working to develop elements in all of the following:

- Quantitative Skills and Equations for the Ocean (Theory/Modeling Component)

- Descriptive Skills and Geography of Ocean Currents (Descriptive Oceanography)
- Understanding of Ocean Observations and Techniques (Observations/Engineering Component)
- Physical Intuition and Dynamical Understanding (Theory/Dynamics Component)
- Implications for Climate, Society, etc. (Policy & Climate Component)

By the end of the semester, you should have addressed each element somewhat in some of your papers.

I hope you will get inspired along the way, and you can revise one of these little papers into a real paper or a prelims or honors project, but don't get upset because you have to hit the ground running. You'll have to do it sometime, and this will be in a friendly environment!

8.1 Why papers?

I think that this approach helps to balance the class. Folks with a lot of quantitative experience will be able to use that to their advantage while folks with more substantial preparation in writing, argument, and logical structure will be able to use those abilities. We will be using the most up-to-date oceanographic datasets available, and so the work you are doing is potentially cutting edge research (but that's up to you!). Also, in the future you will be expected to write much more complicated papers in a more tightly constrained time frame, you might as well get some practice now.

8.2 Peer review

In addition to writing the papers, you will each be performing anonymous reviews of each others work. This will give you an opportunity to read closely about topics other than the one you chose, and hopefully you will be able to learn about science writing more quickly. Also, there are a lot of quandaries that arise in peer-reviewing (e.g., one reviewer loves it and one hates it, or a reviewer makes incorrect statements), so you'll get some experience with those issues by practice in a friendly environment.

We will be using a rubric based on the AGU guidelines for review. They are a useful guideline to go by, and when you do reviews of your fellow students, I'll expect to get a A1 or B2 or B1 score, etc.

There are a few lessons to be learned here, that will help you write your own papers and will help you provide effective and useful reviews in your career.

- Learning to spot unfounded claims
- Learning how to properly support claims
- Learning to distinguish poor writing from poor thinking
- Learning to label equations, graphs, and numerical information understandably
- Learning about a broader swath of oceanography than those isolated topics you choose for your own papers.

8.3 What will we do with all these peer-reviewed papers?

As the semester continues, there will be some papers of yours that you like quite a bit, or that were very positively reviewed. Either you or me can designate them as 'publishable', so that the whole class can see them and subsequent classes can, too. At the end of the semester, all of you will be able to access the assembled published papers: 'Proceedings of GEOL1520: Notions for the Motions of the Oceans, Spring 2013'. You can use this proceedings for your future reference, and it will be available for future GEOL1520 inductees. It is up to you which papers you want published (if any).

You can access the previous year's proceedings through the course website with the password I've emailed to you. You will find many good ideas and interesting papers there to help you find your way in writing your own.

9 Policies

9.1 Deadlines

Because of the reviewing process, the scheduling of assignments is tight. Thus, I will have to insist that all papers be turned in on time. If they are late, they will drop a letter grade. If they are really late (so that they mess up the next step in the reviewing process) they will be counted as missed and can not be made up. If you foresee that there are big problems coming up (medical, family, etc.) let me know *before* an assignment is due and we can figure something out.

9.2 Collaboration

I encourage you to work together, and I do not mind at all if you have similar papers or share figures or matlab scripts. However, in this case, I want you to list all of your study group as co-authors or put them in the acknowledgments section of your paper. You are all required to submit a version of each assignment as first author (that is, one that you wrote yourself). You need to be careful to cite your colleagues or the textbooks or papers you might be working from. You can use as much of these resources as is convenient in your version of the paper, but you need to properly cite the sources. We will discuss this topic more as the class (and the inevitable trouble) ensues. These issues of plagiarism and proper sourcing are a big part of what is to be learned in this method of assignments.

A few other items.

- Attendance is expected. If you will miss a class, please let me know when and why so I can be sure you'll get any announcements, etc.
- Clothing and behavior (e.g., cell phone use) should be appropriate for a learning environment.
- Discrimination and harassment will not be tolerated.
- Please contact me if you have any disabilities that require accommodation.

References

Colling, A., 2001: *Ocean circulation*. 2d ed., Butterworth Heinemann, in association with the Open University, Boston, URL `http://site.ebrary.com/lib/brown/docDetail.action?docID=10190755`.

Siedler, G., S. M. Griffies, J. Gould, and J. A. Church, (Eds.) , 2013: *Ocean Circulation and Climate*, International Geophysics Series, Vol. 103. Academic Press (Elsevier Online), 185–209 pp., URL `http://www.sciencedirect.com/science/bookseries/00746142/103`.

Stewart, R. H., 2008: *Introduction to Physical Oceanography*. R. H. Stewart (online website self-publication), URL `http://oceanworld.tamu.edu/ocean410/ocng410_text_book.html`.

Tomczak, M. and J. S. Godfrey, 1994: *Regional oceanography: an introduction*. 1st ed., Pergamon, Oxford, England, URL `http://gyre.umeoce.maine.edu/physicalocean/Tomczak/regoc/pdfversion.html`.

Vallis, G. K., 2006: *Atmospheric and Oceanic Fluid Dynamics : Fundamentals and Large-Scale Circulation*. Cambridge University Press, Cambridge, URL `http://bit.ly/SDSMSK`.