“Atmosphere-Ocean dynamics and Implications for future climate change”

ENVS 312 / PHYS 314, Spring 2017

Syllabus

Tuesday: 3pm-6pm : Hayden 360
Thursday: 4:30-5:30pm: CHEM 119

Note: This class can count as either a Natural Science or Professional Elective for all Engineering students. This class counts for the Physics minor.

Instructor: Prof. Irina Marinov (research in oceanography, climate modeling, carbon cycle). Hayden 254B. Email: imarinov@sas.upenn.edu  Webpage: https://climate.sas.upenn.edu/

This course covers the fundamentals of atmosphere and ocean dynamics, and aims to put these in the context of climate change in the 21st century. The lectures will focus on the physical mechanisms responsible for the global energy balance and large-scale atmospheric and oceanic circulation. We will introduce fundamental concepts of fluid dynamics and we will apply these to the vertical and horizontal dynamics in the atmosphere and ocean. Concepts covered include: hydrostatic law, buoyancy and convection, basic equations of fluid motions, Hadley and Ferrel cells in the atmosphere, thermohaline circulation, modes of climate variability (El-Nino, Southern Annular Mode), wind driven ocean circulation. The course will incorporate readings of the 2013 Intergovernmental Panel on Climate Change (IPCC) report and relevant recent literature on climate change.

Aimed at undergraduate and graduate students who have no prior knowledge of meteorology or oceanography or training in fluid mechanics. Previous background in calculus and introductory physics is helpful. This is a general course, which spans many sub-disciplines (fluid mechanics, atmospheric science, oceanography, hydrology). The course will include sessions in which students will learn how to write and run simple Matlab programs to study the climate, as well as a few hands-on rotating tank experiments. (to simulate ocean/atmosphere flow in the lab). Computer related assignments will enhance the learning of the class material. No prior experience with Matlab is needed.

General Goals:

• For you to learn basic atmosphere and ocean dynamics, in order to be able to understand fundamental climatic processes and future changes.
• To deepen your insights into methods of scientific inquiry. To improve your math and scientific skills, teach you basic modeling in MATLAB, a very useful computing language with a great visual interface and a solid online help manual.
• To give you a sense of the incompleteness of our understanding of the climate system and acquaint you with major areas of inquiry, which you might want to pursue later.
• To get you excited about the field of climate science. More researchers are needed in this field. Great graduate school and job opportunities out there waiting for you!

Class meeting days/time:
Tuesday: 3pm-6pm and Thursday: 4:30-5:30pm.

Instructor and Office Hours: Dr. Irina Marinov, Office: Hayden Hall 254B.
imarinov@sas.upenn.edu
I am always available to chat after class on Thursdays at 5:30pm (in CHEM 119). Additional office hours will be arranged roughly every two weeks, before homeworks and labs are due. Email me to setup up a different time to meet.

Readings:
Main textbook (on reserve and 10 copies at the Penn Bookstore/Barnes&Noble at 36th and Walnut)
--- This book is also on reserve in Rosengarten Reserve.

Additional books (Rosengarten Reserve, Van Pelt library):
• “Global Physical Climatology” by Dennis Hartmann, Academic Press, 1994. I particularly like chapters 1-5.
• “Physics, Principles with applications” by D. Giancoli. Prentice Hall, 2005, general introductory physics text, particularly useful if you haven’t had physics in a while or to brush up on basic concepts as needed.

Free Online access books:
• “Introduction to Physical Oceanography” by Bob Stewart, online only, free at http://oceanworld.tamu.edu/home/course_book.htm

Grading:
Modeling and labs: 35%
Homeworks: 30%
Final exam (cumulative): 35%

Note 1: Homeworks and MATLAB Lab exercises have a lot of weight, so pay close attention to them. You may discuss the assignments and labs with each other (in fact, you are encouraged to do so!), but you need to do the writeups individually.

Note 2: Late homeworks and labs will result in a lowering of the grade by 20% for each day late.

Extra Math sessions:
If needed (and upon request), we can schedule math/physics review sessions, to cover the basic calculus and mechanics concepts needed in the class.

Academic dishonesty and plagiarism
See the student handbook or go to http://www.vpul.upenn.edu/osl/acadint.html. In addition, you will be required to sign your exams and your signature will be verified for authenticity.

Policy on Religious Holidays: The University recognizes/observes holidays as listed on http://www.vpul.upenn.edu/osl/holidays.html. If you observe any other holidays, please make special arrangements in person with me within the first two weeks of class.
Tentative breakdown of the course: (to be updated first week of classes)

This course is divided roughly in 2 parts:

1. Atmospheric Dynamics and Equations of Motion
2. Ocean dynamics and Climate

Part 1. Atmospheric Dynamics and the Equations of Fluid Motion:
Introduction to the class
Topic 2: Water and the global energy cycle
Topic 3: The vertical structure of the atmosphere and ocean.
Topic 4: Convection in the atmosphere and ocean
Topic 5: Horizontal Motion in the Atmosphere.
Topic 8: Scaling the Equations of motion: dimensional analysis
MATLAB Labs 1,2. Intro to Matlab Your first simple climate models (energy balance box models)

Part 2. Ocean Dynamics and Climate
Topic 9: Intro to the Oceans: T, S, density and thermohaline circulation
Topic 10a: Tracers of ocean circulation: CFCs, radiocarbon, Helium, Tritium (Part 1).
Topic 10b: Tracers of ocean circulation (Part 2)
MATLAB Lab 3: How diffusion drives the temperature, salinity and radiocarbon vertical distributions in the ocean (1D advection-diffusion models with time dependence).
MATLAB Lab 4: The second Diffusion lab.
Topic 12: Wind driven ocean circulation: response of the ocean interior. Why are there gyres in the ocean? Sverdrup, Stommel and Western Boundary Currents: Why is there a Gulf Stream?
MATLAB Lab 5: The Stommel model: simulating ocean gyres (2D advection-diffusion).
Topic 13: Vorticity
MATLAB Lab 6 - MATLAB Lab 7: Topics TBD
Topic 15: Eddies and turbulence in the ocean
Topic 16: Modes of Climate Variability, ocean-atmosphere interaction, annular modes (El Nino, North Atlantic Oscillation, Southern Annular Mode)
Topic 17: Summary of the class and Where do we go from here?