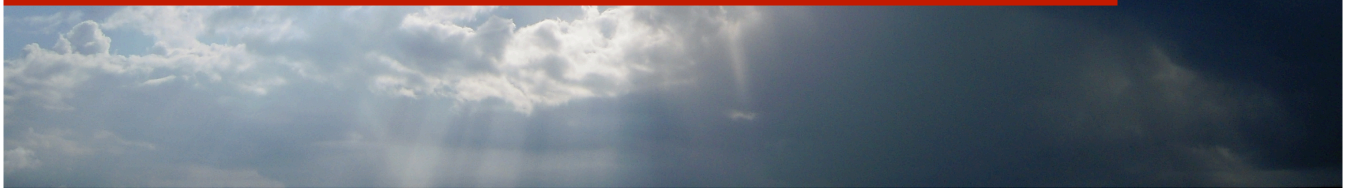
Spring 2013

Dynamics of the Earth's Atmosphere and Climate



Instructor

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Teaching Assistant

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Course Meeting Times and Locations

Lectures: Monday and Wednesday, 9:30-10:45, Warren Weaver Hall 312
Laboratory: Friday, 9:30-10:45, Warren Weaver Hall 312

Course Description

Our goal is to understand the processes that govern the Earth's climate, with particular focus on the mean state (climatology) and variability of the atmosphere and oceans. Topics will include the global energy balance, atmospheric convection and radiation, the "greenhouse effect," the impact of planetary rotation, the structure of the atmospheric and oceanic circulations, and how these elements combine to produce our climate. Along the way we'll come understand exactly what we mean by "climate," and how this differs from "weather," why Earth is a habitable planet in the first place, and how anthropogenic (human induced) activity could change things in the future.

Course Expectations

Throughout the course I will try to strike a balance between a qualitative and quantitative description of the climate. By qualitative, I mean an intuitive understanding of the underlying physical processes and how they interact together; for this reason, it is strongly encouraged that students have some background in college level physics before taking this course. By quantitative, I mean the ability to abstract and express these physical laws as mathematical relationships; for this reason a grade of a B- or better in Calculus I (or its equivalent) is a prerequisite for the course.

This said, I'm not expecting you to be a card carrying physical scientist or mathematician -- we will start from the ground up in building our physical and mathematical understanding of the Earth system. Rather, the most important requisite for this course is a genuine interest in learning more about the Earth's atmosphere and oceans. While I appreciate that grades are a strong, perhaps even necessary motivating force to learn, I don't feel they are sufficient. I expect you to be intellectually curious, and to go behind the textbook readings and lectures. The final project of the course will require you to analyze a scientific paper or conduct some research of your own, write it up in a report, and present it in front of the class.

Grades

Class and Lab participation: 20% I expect you to attend every lecture and lab unless you have a very good reason to miss it. Lectures and labs will include in-class exercises, data analysis, computer labs, and observations of tank experiments. If you miss anything, you will be expected to make it up.

Homework and quizzes: 20% I will assign bi-weekly assignments, on which you may collaborate with 1 other student, provided you both note each other's names. You will also be expected to attend and report back (1 page summary) on two scientific talks throughout the semester. More details will be provided in class.

Class Project: 20% This project will take you outside of the material discussed in lectures and labs. You'll put together a report (c. 10 pages) based on your reading of a scientific paper and/or your own research on the topic. The grade will also be based on an oral presentation of your report to the class at the end of the semester. You should discuss the topic with me and Yuan by the end of February. Complete drafts of the your final report are due **Monday April 22**, three weeks before the end of the semester, and the final version at the end of the semester, **Monday May 13**.

Midterm and Final Exam: 40% There will be two exams, the first around spring break and the second at the end of the term.

Textbook

Marshall, J and Plumb, R. A., 2008: *Atmosphere, Ocean, and Climate Dynamics,* Academic Press, 319 pp.

Course Plan

This schedule is a rough draft, and may change depending on the rate at which we can progress. Key topics are noted in bold and sections from the textbook, denoted by (§xx), should be read *before* class that week.

1/28: Intro to atmosphere and ocean sciences, fluid dynamics and climate (§0); Atmospheric composition and ideal gas law (§1).

2/4: **Black Body radiation and the greenhouse effect.** Black body radiation, planetary albedo, emission temperature, absorption of radiation (§2.1-2).

2/11: **Greenhouse effect, Vertical structure of the atmosphere** The greenhouse effect (§2.3); Climate change and climate sensitivity (§2.4); Vertical distribution of temperature and gases (§3.1)

2/18: **Hydrostatic Balance** Hydrostatic balance, vertical structure of pressure and density (§3.2-3); Buoyancy and convection(§4.1-2)

2/25: **Convection; potential temperature** Stable atmospheres; dry convection; potential temperature (§4.3-4.4)

3/4: **Moist Convection** Saturation and relative humidity; moist adiabatic; cloud types; radiative forcing of the atmosphere (§4.5)

3/11: Review and midterm exam (§1-4)

3/18: Spring Break

3/25: **Meridional structure of the atmosphere** Zonal wind and temperature; humidity; global circulation (§5.1-2)

4/1: **Newtonian mechanics** Conservation of momentum, mass and heat in a fluid; Force balance; Rotating frame of reference, Coriolis acceleration (§6 and instructors notes - we will cover this chapter very lightly)

4/8: **Geostrophic Balance** Relationship between pressure, wind and temperature on a rotating planet (aka geostrophic and thermal wind balance) - weather patterns (§7)

4/15: **General circulation of atmosphere** Thermal wind, angular Momentum; Tropical Hadley circulation; (§8.1-2)

4/22: **General circulation of atmosphere**: Potential energy and baroclinic instability; Storms and storm tracks (§8.3) Energy and momentum transport in the atmosphere; the Jetstream; Climate variations with latitude. (§8.3-6).

4/29: **Climate Variability** El Nino; Paleoclimate; the Ice Ages; anthropogenic climate change. (§12.1-2)

5/6: Student Presentations

5/13: Student Presentations

Final Exam: t.b.a.