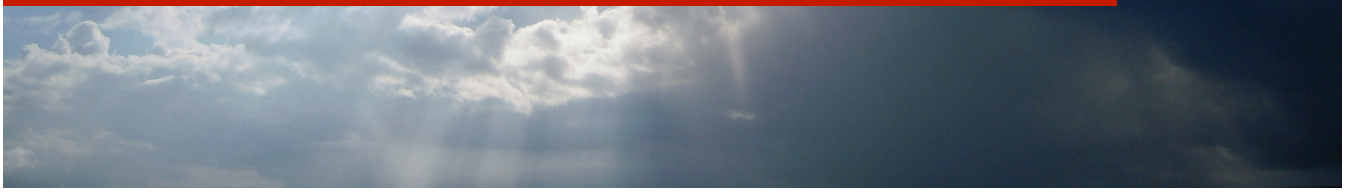
Spring 2019

Dynamics of the Earth's Atmosphere and Climate



Instructor

Prof. Edwin Gerber
gerber@cims.nyu.edu (e-mail is the best way to reach me)
212.998.3269
911 Warren Weaver Hall
Office Hours: Monday and Wednesday 11 am-12 noon, or by appointment

Teaching Assistant

Jordan Hisel
jmh903@nyu.edu
Meyer 105 at 4 Washington Sq Pl.
Office Hour: Thursday 4-5 pm

Course Meeting Times and Locations

Lectures: Monday and Wednesday, 9:30-10:45 am, Warren Weaver Hall 312
Laboratory: Friday, 9:30-10:45 am, Warren Weaver Hall 517

Course Description

Our goal is to understand the processes that govern the Earth's climate, with particular focus on the mean state and variability of the atmosphere. 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 both differs and depends on "weather"), why Earth is a habitable planet, and how our dependence on fossil fuels could change that in the future.

Course Expectations

Throughout the course I will try to strike a balance between a qualitative, physics focussed perspective on climate processes, vs. a more quantitative, mathematical description of the atmosphere. 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 (also known as equations!); 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 (quite literally) start from the ground up in building our physical

and mathematical understanding of Earth's atmosphere. Hence, the most important requisite for this course is a genuine interest in learning more about our climate!

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. (In these cases, you must write me to note the absences, preferably in advance if possible.) 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. You must also attend and report back (1 page summary) on two scientific talks throughout the semester. More details will be provided in class.

Homework and quizzes: 20% I will assign bi-weekly assignments, on which you may collaborate with other students, provided you all note each others' names.

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 by the end of March. Complete drafts of the your report are due **April 29** (this allows me time to give you feedback on your draft), and the final, graded report on the last day of class, **Monday May 13**.

Midterm and Final Exam: 40% There will be two exams, the first on March 13th, just before spring break and the second during the exam period.

Textbook

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

Course Plan

The following 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.

1/28,30: **Intro to atmosphere and ocean sciences, fluid dynamics and climate** (§0); Atmospheric composition and ideal gas law (§1).

2/4,6: **Black Body radiation and the greenhouse effect.** Black body radiation, planetary albedo, emission temperature, absorption of radiation (§2.1-2).

2/11,13: **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)

2/20 (no class on Presidents' Day 2/18): **Hydrostatic Balance** Hydrostatic balance, vertical structure of pressure and density (§3.2-3);

2/25,7 **Convection; potential temperature** Buoyancy and convection(§4.1-2), Stable atmospheres; dry convection; potential temperature (§4.3-4.4)

3/4,6,: **Potential Temperature and Moist Convection** Saturation and relative humidity; moist adiabatic; cloud types; radiative forcing of the atmosphere (§4.4,4.5)

3/11,13: **Review and midterm exam** (§1-4)

3/18,20: No class: Spring Break!

3/25,27: **Meridional structure of the atmosphere** Zonal wind and temperature; humidity; global circulation (§5.1-2)

4/1,3: **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)

4/8,10: **Geostrophic Balance** Relationship between pressure, wind and temperature on a rotating planet (geostrophic and thermal wind balance) - weather patterns (§7)

4/15,17: **General circulation of atmosphere** Thermal wind, angular Momentum; Tropical Hadley circulation; (§8.1-2)

4/22,14: **General circulation of atmosphere**: Potential energy and baroclinic instability; Storms and storm tracks (§8.3) Energy and momentum transport in the atmosphere; the Jet stream; Climate variations with latitude. (§8.3-6).

4/29*,5/1: **Climate Variability** El Nino; Paleoclimate; the Ice Ages; anthropogenic climate change. (§12.1-2) **Rough draft of papers due!*

5/6,8: **Student Presentations**

5/13: **Review for Final Exam**

Final Exam: t.b.a.