



**Thursday 9 am to 10:50 am, Warren Weaver Hall 905**

### **Instructor**

Edwin Gerber

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WWH 911, Office hours Tuesdays and Thursdays, 4-5 pm, and by appointment

### **Course Description**

How do we project changes in the Earth's climate system over the next century? Alas, pencil and paper won't cut it — though theoretical work is still of tremendous value to climate research, and if anything under appreciated. *Quantitative* prediction of the climate response to anthropogenic and natural forcing such as carbon dioxide or a volcanic eruption, however, requires comprehensive numerical climate models which seek to either directly simulate or parameterize (i.e. approximate) all the relevant physical processes: fluid dynamics, radiation, boundary layers, cloud microphysics, etc.. In this course we will work with a hierarchy of atmospheric models to illustrate these processes and get under the hood of a comprehensive climate model.

### **Class Expectations**

It is useful if you have some experience in atmospheric dynamics, but it is not required. Our goal is to understand climate physics — everything except the dynamics — and how to work with numerical models!

In terms of the course itself, I look forward to seeing you in all the lectures. If you can't make it, please e-mail me in advance if at all possible. We'll be reading a lot of papers and I'll expect each of you to present parts of the work in turn throughout the course.

Your grade will be based on a final project. You'll be expected to present them in a short, conference style talk. While solid results are certainly the most important requisite for a successful research career, as with most things in life, the packaging matters, so it's important to learn good communication and presentation skills!

### **Resources**

There is no required textbook. We'll be mostly reading papers and working with publicly available codes. You will need a NYU HPC account, and ideally, bring a laptop to class.

## Course Plans

We have three main goals. The first is to understand, at least roughly, the different physics packages that go into an atmospheric model. Processes include:

- 1) radiation (interaction with incoming solar radiation and outgoing long wave)
- 2) boundary layers (turbulent fluxes from the surface, heat, moisture, and momentum)
- 3) gravity waves (transfer momentum between surface and upper troposphere and stratosphere)
- 4) convection, clouds, microphysics (of course we can't cover all of this in full detail, but we should at least appreciate what is required)

Second, we will work with a hierarchy of four models based on GFDL's modeling framework. The goal is to find the right model for the process(es) of interest!

- 1) the "Held and Suarez" dynamical core: a dry (moisture free) General Circulation Model (GCM) with highly simplified climate "physics"
- 2) GRaM (a Gray Radiation Moist GCM): same dynamics as the H-S model, but with the addition of moist processes and a highly simplified radiation scheme
- 3) MiMA (a Model of idealized Moist Atmosphere): the same as GrAM, but now with full radiative transfer
- 4) AM2 (GFDL's Atmospheric Model 2): a comprehensive climate model used as part of the Coupled Model Intercomparison Project Phase 3 (i.e. state-of-the-art 10 years ago).

Lastly, we will explore types of climate forcings relevant to climate prediction. What are the key changes in atmosphere composition (greenhouse gases, ozone, aerosols) and how do they interact with the various processes and parameterizations?

## Final Project

The goal is to design and conduct an experiment with an Atmospheric General Circulation Model to further explore material we've covered in the course, or illustrate another topic of the atmospheric circulation. In lieu of a written report, I'd like you to help develop a website that outlines your work with the model(s). This way we can build up a record of nice experiments with the models for future students! At the end, each student will also present their results in class in a short conference presentation.