ATOC5060: Atmospheric Dynamics Project 2
Modeling the atmospheric general circulation
Due: 4pm Thursday May 1

Models of the atmospheric (and oceanic) general circulation are used to test hypotheses about atmospheric and climate dynamics, variability and change. Here we will use an atmospheric circulation model to examine changes in the zonal mean circulation due to some kind of forcing. Such forcing may include increased CO_2, reduced solar input, removal of all water, changes in ocean surface temperature, changes in topography, removal of continents, different rotation, etc.

For the project we will use a full fledged atmospheric general circulation model, that differs from a stat-of-the-art climate model (such as those in the IPCC reports) only in that it is lower resolution, such that we don't need to use a supercomputer. The model is one that is used actively for research at CU and around the world. Instructions for obtaining and running the model can be found in the class web site and in the tutorial assignments. Simulations can be run on atoc – but note simulations take time (order of an hour), and atoc will be used by all in the class. Make sure you get your runs done early!

Part 1: Design an experiment
Put forward a testable hypothesis and plan an experiment to test it. This acts as a definition of the aim for your projects. Your selection of a hypothesis can draw from topical questions of atmospheric dynamics or climate change, and you are encouraged to browse the scientific literature for motivation. You may, and are encouraged to, choose a topic that is of interest in your thesis research. Remember also that any hypothesis must be testable with the model, so you should aim to construct a hypothesis that motivates relatively simple modifications to the model or the model inputs. An appropriate hypothesis might be: There are no baroclinic waves in a planet that rotates half that of earth. An appropriate test would be: Run the model with a rotation rate that is half the normal value, and compare the results of the experiment simulation to a control simulation to examine the impact on the zonal mean circulation. Other examples may include analyzing changes due to ozone loss, role of mountains, increased CO_2 concentration, changes in large scale circulation due to variations in ocean conditions (El Nino, etc.), changes in solar input, circulation of a "snowball earth", glacial climate, "ocean world", "land world", "Mars world". Notice some experiments will be easier to set up than others, so before posing the experiment, think about what you need to do (in the model code) to set it up. Prepare you 2 sentence plan and hypothesis to hand in and for discussion in class for ***Tuesday 15 April***.

Part 2: Run the experiment
In the in-class tutorials, you configured and ran the model in its default configuration, which we refer to as the "control simulation". Make the needed changes to the code, compile, run and then analyze basic quantities of the climate model, and analyze any needed derived quantities. Your analysis should remain focused on what is needed to answer your hypothesis. It is likely you will need to examine the zonal mean zonal wind, temperature, mass flux streamfunction, meridional eddy heat and momentum transport, and possibly EP flux/flux divergence and residual streamfunction and other (stationary and transient) eddy/wave statistics. Ultimately you should compare the zonal mean circulation of your experiment to that of the control, and aim to explain the differences based on the theory we have worked on in class.

Part 3: Prepare a written report
Given your experimental results prepare a paper, in the form of a Geophysical Research Letters paper, that describes your study and the outcomes. You should aim to provide analysis of the dynamics in the contest of the theory developed in class, and doing so will score highest marks. Analysis might include comment on temperature and wind structure, overturning circulation, role of waves (stationary and transient), including discussion on their amplitude, size and phase. More detailed analysis might include examination of energy distribution and changes to the terms in the energy and momentum cycles. Your paper needs to explain the hypothesis and why it is of scientific interest, explain what you experiment was and how it was implemented, what results and analysis you performed and a conclusions which finally resolves your hypothesis (true or false) with a discussion of where the strengths and weaknesses of your study are. Are you likely to be right? Why, why not?

Writing the report in the style of GRL paper limits you to no more than 2500 words (and possibly less) and restricts you to no more than 4 pages including figures. This will encourage you to focus on presenting a clear description of your resolution of the hypothesis, and best be achieved by planning your paper ahead of starting to write. (Due ***4pm 1 May***)

Part 4: Present you findings orally
In the ***last week of semester*** we will have presentations of finding in short (7 minute!) presentations. The time limit will be strict and you will be graded on clearly presenting your work within this time constraint. The presentation should explain you hypothesis and tests, and give the results with conclusions. Using about 3 powerpoint slides would be a useful target.