AOS 801: TOPICS IN THEORETICAL METEOROLOGY
Fall 2015 – RADIATION AND ENERGY IN THE CLIMATE SYSTEM

To provide a deeper understanding of course material, students will complete two projects over the course of the semester. The first is an individual research project in which some of the foundational climate modeling experiments will be explored using simple models and the second is a team project where we will tackle a broad problem centered on analyzing modern climate model output as a group. Rough guidelines for each project are summarized below but we will refine the details over the course of the semester.

INDIVIDUAL TERM PROJECTS

The primary purpose of this project is to reproduce some early climate modeling experiments described in the course literature. Since these models are relatively simple (compared to today's climate models), these projects will involve either programming a model from scratch or making significant modifications to existing code. These tools will then be used to explore some fundamental aspects of energetics in the climate system. Topics will be chosen prior to October so that students can lead the reviews of the most appropriate papers to their subject. Each student should compose a short 1-paragraph proposal and corresponding PPT slide describing the basis for their project for in-class discussion in early October. Another brief 1 slide progress update will be due in early November. Final results will be presented in class on Dec. 15 and 17 (see guidelines below). In addition, key results will be summarized in a "Geophysical Research Letters-style" peer-reviewed write-up (~4 pages single spaced) with 2-3 key figures covering the most significant findings from the project. Two copies of an initial draft of this write-up will be distributed to peers in class on December 3. Everyone will review the two papers they receive and return their comments to the lead author on December 10. Final drafts along with reviews and appropriate responses to each reviewer will be due on Dec. 17.

Possible Topics (independent ideas are welcome):

- ☐ Create a time-dependent EBCM in the mold of Budyko or Sellers and use the model to elucidate the sensitivity of the meridional climate to various characteristics of Earth. Possibilities may include:
  - Using satellite observations of clouds and/or surface albedo to refine relevant tunable parameters in the model
  - Constrast transient and equilibrium responses in the model
  - Design and conduct new experiments to explore the role of clouds, ice-albedo feedback, changes in E-P temperature gradient, changes in orbital parameters, etc. on the mean meridional climate
- ☐ Exploring radiative-convective equilibrium using K. Emanuel's RCE model. Examples may include:
  - Modifying soundings, cloud parameterizations, the representation of convection, turbulent heat fluxes, etc.
  - Adding new functionality to the model may even be an option
- ☐ Create your own Daisyworld and use it to explore components of biological feedbacks in the climate system. A few possibilities might include:
  - Add additional species of daisy with different behaviors
  - Modify initial conditions
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Guidelines for Final Presentations:

Final presentations should follow the style of an Atmospheric Meteorological Society or American Geophysical Union talk. Everyone will be allotted 15 minutes with an additional 3-5 minutes for questions. Presentations should consist of approximately 10 slides conveying the following:

- motivate subject
- cover relevant papers
- inspiration for experiment
- setup
- results
- conclusions

TEAM PROJECT

The primary purpose of this project is to gain experience with modern techniques for analyzing climate model output and relevant observational constraints. In addition, you will hopefully gain some experience collaborating as a team including brainstorming ideas, assigning team leads and tasks, and compiling a multi-author manuscript that synthesizes the results of the effort. In practice this is often not as easy as it sounds but the results of bringing together diverse expertise to bear on a problem can be very rewarding.

Tentative Schedule (subject to change):

- Discuss topic in class on September 17: identify project lead(s) and divide responsibilities.
- Provide individual updates week of October 15
- Nov. 3: Meet as a group to initial combine findings and assign deeper analysis tasks and writing jobs
- Nov. 13: Generate first draft and circulate.
- Week of Nov. 16-20: Group review/edit, finalize write-up in the form of a standard AMS journal (e.g. *J. Climate*: https://www2.ametsoc.org/ams/index.cfm/publications/journals/journal-of-climate/).
- Final Paper Due: Nov. 24 (may be shifted into Dec. if needed)

Possible Science Questions:

1. How well do climate models represent the influence of clouds on meridional heat transport?
2. Is there a relationship between the accuracy with which climate models simulate meridional heat transport and their predicted climate sensitivities?
3. What are the similarities and differences between the hemispheres?

Divide problem into tasks to be addressed by each student early. Components will be pieced together toward the end of November. E.g.

- ☐ Estimate heat transports using ERBE or CloudSat data
  - Area-weighted clear-sky fluxes
  - Area-weighted all-sky fluxes
  - Perhaps separate ocean and atmospheric transports (sub-questions):
    - Does the cloud impact on atmospheric heating, defined as the difference between TOA cloud forcing and SFC cloud forcing, vanish when integrated over the globe?
    - Do models produce the same result?
- ☐ Repeat this exercise using CESM large-ensemble output
  - Compare biases to intra-model variability
- ☐ Repeat with CMIP5 model output (each person takes a different model)
  - Establish multi-model mean and inter-model variability
- ☐ Repeat with ERA-interim reanalyses or MERRA (some tools are already available for reading these datasets)
- ☐ Compute equilibrium climate sensitivity (ECS) from climate models
- ☐ Formulate ideas for simple combined analyses of the output (e.g. group model-derived ECS by how well they reproduce today's observations)