ATMOSSC 5901
Climate System Modeling: Basics and Applications
Autumn 2019

Days & times: Monday and Wednesdays 9:35 to 10:55 PM
Room: Derby Hall 140
Instructor: Alvaro Montenegro
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Office hours: Mondays 2:00 to 4:00 PM, or by appointment

Objectives

This is a general overview of Climate System Models (CSM), tools used to understand past and present climate and to make predictions of future climate states. The course will discuss the different types of models, their usual applications, weaknesses and strengths. It will also present in detail the distinct subcomponents (atmosphere, ocean, land surface, biosphere, land and sea-ice) that make up CSMs. The required parameterizations will be considered.

The course has a significant hands-on component with about half of lecture time spent on the computer lab where students will design experiments and evaluate output from the University of Victoria Earth System Climate Model (UVic ESCM). Model output will be analyzed using MATLAB and an introduction to this programing environment will be provided.

Expected learning outcomes include:

a) Basic understanding of the main energy and mass fluxes that determine the state of the global climate system.
b) Familiarity with the main CSM categories (Energy Balance, Radiative-Convective, Intermediate Complexity and Fully Coupled Global Climate Models) their strengths and weaknesses.
c) Knowledge of what type of questions different CSMs can help answer.
d) The ability to design experiments and interpret results from simple CSM simulations.
e) Basic programming skills in the MATLAB environment focused on analysis geophysical data.

Course Materials

Suggested reference textbook:
A Climate Modelling Primer – 4th edition, Kendal McGuffie e Ann Henderson-Sellers, John Wiley & Sons (ISBN 0-470-85750-1)
Earlier editions: While some of the discussed themes are only found in the 4th, earlier editions contain a large amount of the material presented in class.

Other useful references:
Class notes from Prof. Andreas Schmittner – to be provided to class by instructor.

Introduction to climate dynamics and climate modeling, Goosse H., P.Y. Barriat, W. Lefebvre, M.F. Loutre and V. Zunz.
Freely available online at: http://www.climate.be/textbook.

Climate Change and Climate Modeling, J. David Neelin, Cambridge University Press (ISBN 978-0-521-60243-3)

Climate System Modelling, K. E. Trenberth, Cambridge University Press (ISBN 9780521128377)

A brief introduction to MATLAB, class notes by Margot Gerritsen, will be made available to students.

An introduction to MATLAB, class notes by David Griffiths, will be made available to students.

A series of tutorials and other learning materials can be freely accessed at the MathWorks site: http://www.mathworks.com/support/learn-with-matlab-tutorials.html
Access to some content might require a (cost free) registration to the site.

Carmen web page:
You will be alerted in class about updates on our Carmen class web page. The schedule of activities (lectures, discussions, due dates for different activities) will be posted on the Carmen class web page and will be updated as the class progresses. Lecture slides will be posted as pdf files.

Evaluation

MATLAB problem sets	25%
IPCC Class Presentation Plan	5%
IPCC Class Presentation	15%
UVic ESCM experiment report (group)	15%
Final Exam	15% (Dec 9, 10:00 AM)
Take home exam on climate dynamics	15%
Presence during student IPCC Class Presentations	5%
Miscellaneous assignments	5%

IPCC Class Presentation and Presentation Plan: This is an individual effort. Students will deliver a ~35-minute presentation to the class on a chapter (or a combination of chapters) of the IPCC AR5 Group 1 Report (https://www.ipcc.ch/report/ar5/wg1/). Chapters will be selected by students under the guidance of the instructor. The presentation should be in lecture format and should discuss at least one of the papers cited in the selected chapter(s) in some detail. In-class activities would be a plus.
Presentations will take place over three lectures (Nov 20, Nov 25 and Dec 2). The goal is for two presentations to take place per lecture, but we have the last day of classes (Dec 4) as a safety net. Order of presentations will be randomly determined by the instructor.

Students are expected to submit a written presentation plan. This is an outline of what will be presented, including the paper(s) selected for the more in-depth discussion. The outline should be a list of topics in the sequence they will be presented with a short (1-2 sentences should suffice) description/justification for each. While not required, it might be useful to also have estimates of how long the student plans to spend in each topic. Presentations should end with a summary of most important points. These should be listed in the outline.
Written Class Presentation Plans are due on October 23.

Matlab problem sets: Unless otherwise stipulated by the instructor, problem sets are due a week after the lab in which they were first presented. Matlab is available on the machines found in our computer labs and student licenses can be obtained here: https://ocio.osu.edu/software

UVic ESCM report - Groups will select, under the instructor's guidance, an experiment to be performed by an (at least) 100-year simulation(s) of the UVic ESCM. A brief (1000-1500 words) report of what constituted the experiment and its main results should be handed in. In case we have time, results will be informally discussed in class. Only the written report will be graded. **The UVic ESCM report is due on Nov 25.**

Final exam – Short essay questions. Will cover all the lecture material given after the climate dynamics review. A study guide will be provided by the instructor.
The final exam will take place on our regular lecture room (DB 140) at 10:00 AM on Dec 9.

Take home exam – Will cover the material from the climate dynamics review. Students will have five days to write the exam. When writing your exam remember that the instructor will grade the take home exams more strictly than they would similar closed book counterparts.
Take home exams will be handed out on Sep 16 and are due at 5:00 PM on Sep 20.

Class participation – Determined exclusively by attendance during class presentations.

Miscellaneous assignments –Three short assignments (Daisy World, Spreadsheet EBM and Impact of Resolution on Experiment Length). These will be introduced in class and students will have a minimum of one week to work on each.

Late work policy

Unless otherwise stated, all assignments should be handed at the end of the lecture on the due date *and are expected to be stapled*. A 15% penalty will be applied to any individual or group work handed in up to one week after the due date. *Work that is eight or more days late will not be accepted.*

Course policies:

You are expected to adhere to the policies described in the OSU Student Code of Conduct: http://studentaffairs.osu.edu/resource_csc.asp

Students who anticipate missing an exam must make arrangements with the instructor at least *one week prior.* You are allowed one un-excused absence. An excused absence requires written documentation (doctor's excuse) or prior permission to be absent. I will consider your requests on a case-by-case basis.

An Important Note about Plagiarism and Academic Misconduct:

Plagiarism and other forms of cheating will not be tolerated. University rules provide severe penalties for academic misconduct, ranging from course failure to dismissal from the university. University rules are found in the handbook used in all survey courses: "University Survey - A Guidebook and Readings for New Students." Any questions about this policy, or your grade, should be brought directly to the instructor.

Disability Services

The University strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can privately discuss options. You are also welcome to register with Student Life Disability Services to establish reasonable accommodations. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. **SLDS contact information:** slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

Lecture sequence

Brief introduction to the climate system (class notes)
- Forcings
- Energy Balance
- Feedbacks

Historic overview of climate modeling - Chaps. 1 and 2**
- Model types
- The concept of sensitivity
- Parameterizations

Energy Balance Models (EMB) - Chap. 3
- Adimensional and one-dimension EMBs
- Box Models
- EMBs and glacial cycles - Snow Ball Earth and Pleistocene glaciations

Earth System Models of Intermediate Complexity (EMICs) - Chap. 4
- Radiation and energy flux
- Sensitivity experiments
- Radiative-Convective Models
- Types of EMICs
- Intro to the UVic Model

Fully coupled models - Chap. 5
- Modeling the atmosphere, ocean and cryosphere
- Modeling the land surface
- Modeling atmospheric chemistry
- Modeling ocean biology and chemistry
- Intercomparison projects

**Readings relate to chapters numbers from the text's 4th edition.

Lab sequence

Labs	Theme
Lab 1	basic data manipulation
Lab 2	descriptive statistics
Lab 3	netcdf format, n-dimensional arrays
Lab 4	n-dimensional arrays
Lab 5	correlations
Lab 6*[1]	intro to Ohio Supercomputer Center
Lab 7[1]	Intro to UVic ESCM

* Subject to change, due to dependency on availability of OSC personnel
[1] No work will be turned in by students for these labs.

Activity calendar:

September:
Monday, September 16 – Take home exam available to class
Friday, September 20, Take home exam due at 5:00 PM

October
Wednesday, October 23, Presentation Plans due.

November:
Wednesday, November 20 – Class presentations
Monday, November 25 – Class presentations and UVic Report Due

December:
Monday, December 2 – Class presentations
Monday, December 9 – Final exam, 10:00 AM at DB 140, regular lecture room.