ATMOSSC 5901
Climate System Modeling: Basics and Applications
Autumn 2018

Days & times: Monday and Wednesdays 9:35 to 10:50 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%
Term Paper	20%
UVic ESCM experiment report (group)	15%
Final Exam	15%
Take home exam on climate dynamics	15%
Participation	5%
Miscellaneous assignments	5%

Term paper: Each student will choose a theme related to climate modeling and prepare a three-thousand-word report and an associated 10-minute presentation on it. While textbooks and manuals could be used, the main references for the report should come from the scientific literature. At least three peer-reviewed papers need to be covered and properly cited by the report. The use of figures - your own or from the literature - is encouraged.

Themes are flexible and (hopefully) related to individual student interests.
Some examples: "How climate models simulate sea-ice dynamics"; "The effects of large scale deforestation from climate models", "Simulations of the Paleocene-Eocene Thermal Maximum", "Modeling the Martian Climate", "The response of Ocean pH to CO_2 emissions as seen by climate models", "Performance of cloud parameterization in CMIP models over the last two IPCC reports".

Students should contact the instructor to make sure the selected theme is viable or for help in choosing a theme and finding the pertinent literature.
Presentations will take place during the Nov 29 and/or Dec 3 lectures and the written report is due on Monday, December 3.

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 a 100-year simulation(s) of the UVic ESCM. A brief (1500-2000 words) report of what constituted the experiment and its main results should be handed in and presented by the group to the class in a ~10-minute presentation. Groups are freely formed by students with a maximum size of 3 individuals. **Presentations will take place during the November 26 and/or 28 classes and written report is due on November 26.**

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

Take home exam – Will cover the material from the climate dynamics review. Students will have two days to write the exam.

Class participation – Determined exclusively by attendance, with higher weight for presence during the term paper and UVic model 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 17 – Take home exam distributed to class
Wednesday, September 19, Take home exam due at the start of class

November:
Monday, November 26 – UVic group report presentations start. Written report due.
Wednesday, November 28 – UVic group and/or Term Paper individual presentations

December:
Monday, December 3 – Term Paper individual presentations, written reports due. Exam review.
Wednesday, December 5 – Final exam, during regular lecture period.