CLIMATE MODELING, DATA ANALYSIS, AND APPLICATIONS
ATMO 449/CEE 449
Fall 2018
University of Hawaii at Manoa – Department of Atmospheric Sciences

Instructor:
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Office hours: TTh after class or by appointment (@ HIG 335).

Class Meetings:
TR 15:00-16:15, Aug 21 to Dec 6, 2018, Holmes #242

Required Materials:
- lecture notes and readings distributed by the instructor.
- Laptop with R, NCL, EdGCM, and datasets distributed by the instructor

Information on obtaining required software
R: R is freely available online at
https://www.rstudio.com/products/rstudio/download/

EdGCM Model: http://edgcm.columbia.edu/download-edgcm/

NCL: Free software that makes plotting model output easy (and fun!). https://www.ncl.ucar.edu/

Laulima website: https://laulima.hawaii.edu/portal

Optional book resources:
The following books have been placed on course reserves. You may find them useful if you are looking for additional information on the material covered in the lectures.
- *Numerical Weather and Climate Prediction* (by Warner, Cambridge University Press). The call number is QC996 .W37 2011
- *The Climate Modelling Primer* (by McGuffie & Henderson-Sellers, Wiley BlackWell). The call number is QC981 .M482 2005
- *Climate System Dynamics and Modelling* (by Goosse , Cambridge University Press) The call number is QC874.5 .G66 2015

All physical copies of course reserves at UH Manoa are held on the 3rd floor of Sinclair Library in the Wong Audiovisual Center. All e-books can be accessed online using your UH username and password.

Course Description
This course will cover basic principles of regional and global climate modeling, and climate data analysis methods for engineers and environmental scientists, with a focus on applications.

Pre: senior standing or higher (graduate). Some background in partial differential equations, computer programming languages (e.g. R), fluid mechanics/dynamics and basic statistical analysis is desirable, but not required.

Course Outline
The class is organized in three parts:

- **Part I:** Basics of the climate system
- **Part II:** Basics of climate modeling
- **Part III:** Analysis of climate model output and use in applications.

The first part of the class focuses on basic principles of the climate system, the components of the climate system, and basic mechanisms of climate variability and change at the spatial and temporal timescales of interest for engineering applications and decision-making. The second part discusses the basic notions in climate dynamics that are used in climate modeling of increasing complexity (from 1D to 3D and state-of-the-art Global Climate Models), and includes in-class and homework exercises using simple climate models. The third part of the class focuses on methods of statistical analysis and processing of climate model output, which are frequently used in the climate science and engineering fields (regressions, EOF analysis, signal processing techniques). Additional focus will be given on preparing model output for use in engineering applications, decision-making models, and on estimating and communicating uncertainty of climate model projections.

Grades:
30%: In-class participation & attendance
30%: Final exam (take home)
20%: Final project poster
20%: Final project presentation

Note: Grading will not necessarily be on a curve. Everyone has the chance to get an A if they work for it and deserve it!

Classroom Conduct:
You are expected to show up on time and participate in class. This is an 'active' learning course, and will require your full engagement to be successful. Be respectful of other students and your instructors.

Attendance policy:
Attendance is mandatory and is taken in each class. 30% of your grade will be based on attendance and in-class activities, so any unapproved absence will hurt your grade.

Course/Student Learning objectives:
Upon successful completion of this course, students will be able to:

- Describe basic principles of the climate system, its components, and important climate phenomena affecting regional and global climate at seasonal, interannual, decadal, and centennial time scales.

- Understand the basic principles of building and running climate models of increasing complexity (from one-dimensional to state-of-the-art climate models) to simulate Earth's past, present and future climates.
- Understand the features, advantages, and limitations of global climate models.
- Access climate model data of interest, compare with observational data, and perform basic climate data processing online and offline.
- Perform intermodel comparison studies and process climate model output for use in applications.
- Assess and effectively communicate uncertainty in climate model simulations and projections of future climate.
- Prepare and present a climate model study as they would in a scientific conference.

Term project:
A final, capstone project will be worth 40% of your grade. This will include both a group-written scientific poster (made in Google Slides) and a final presentation.

You will choose an environmental engineering problem of your interest from a list of topics, such as regional precipitation, temperature variability and extremes, seawater intrusion into coastal aquifers, wind strength and/or direction, sea level variations etc. You will be identify and download climate data, analyze the data and use them as input for the problem of your choice. You may also choose to run climate model experiments, if suitable for your project. The overarching goal is a term project that illustrates the use of climate modeling and output to answer a specific regional-scale problem, and identify and assess the uncertainty in the project findings and proposed solutions. **Deliverables include a final poster, and a final in-class presentation.** We will discuss this project during the 8th week of classes and you will work both in and out of class on your analysis, and the creation of the poster and presentation.

Plagiarism Policy:
According to the UHM Student Conduct Code (1992;p.6): "Plagiarism includes but is not limited to submitting, in fulfillment of an academic requirement, any work that has been copied in whole or in part from another individual's work without attributing that borrowed portion to the individual; neglecting to identify as a quotation another's idea and particular phrasing that was not assimilated into the student's language and style or paraphrasing a passage so that the reader is misled as to the source; submitting the same written or oral or artistic material in more than one course without obtaining authorization from the instructors involved; or "drylabbing," which includes obtaining and using experimental data and laboratory write-ups from other sections of a course or from previous terms." **Academic dishonesty will not be tolerated.** If you are caught plagiarizing, you will fail the assignment, and possibly the course. In egregious cases, the instructor may file an official complaint with the Dean of Students office, which may end up on your permanent student record or lead to suspension from the program.

Final Exam
The final exam (30% final grade) will be *take home* and will test your ability to use climate model data for intermodel comparison, model-data comparison and application of the statistical techniques covered in the course.

Disability Access:

If you have a disability or related access need, the Instructor will make every effort to assist and support you. For confidential services students are encouraged to contact the Office for Students with Disabilities (known as "KOKUA") located on the ground floor (Room 013) of the Queen Lili'uokalani Center for Student Services:
KOKUA Program • 2600 Campus Road • Honolulu, Hawaii 96822 • Voice: 956-7511 • Email: kokua@hawaii.edu www.hawaii.edu/kokua

Title IX:
The University of Hawai'i is committed to providing a learning, working and living environment that promotes personal integrity, civility, and mutual respect and is free of all forms of sex discrimination and gender-based violence, including sexual assault, sexual harassment, gender-based harassment, domestic violence, dating violence, and stalking. If you or someone you know is experiencing any of these, the University has staff and resources on your campus to support and assist you. Staff can also direct you to resources that are in the community. Here are some of your options:

As a member of the University faculty, your instructor is required to immediately report any incident of potential sex discrimination or gender-based violence to the campus Title IX Coordinator. Although the Title IX Coordinator and your instructor cannot guarantee confidentiality, you will still have options about how your case will be handled. Our goal is to make sure you are aware of the range of options available to you and have access to the resources and support you need.

If you wish to remain ANONYMOUS, speak with someone CONFIDENTIALLY, or would like to receive information and support in a CONFIDENTIAL setting, use the confidential resources available here:
http://www.manoa.hawaii.edu/titleix/resources.html#confidential

If you wish to directly REPORT an incident of sex discrimination or gender-based violence including sexual assault, sexual harassment, gender-based harassment, domestic violence, dating violence or stalking as well as receive information and support, contact: Dee Uwono Title IX Coordinator (808) 956-2299 t9uhm@hawaii.edu.

Syllabus:
Lectures will follow the ***tentative*** course outline below. This syllabus is subject to change; any changes will be disclosed in class beforehand. 💻 indicates that laptop is required.

Week	Date	Topic	Comments/ Readings
1	8/21	**L1:** Course Syllabus & Introduction	
	8/23	**No class- Hurricane Warning**	
2	8/28	**L2:** Earth's energy balance (EBMs)	💻
	8/30	**L3:** EBM lab	💻
3	9/4	**L4:** Climate change: Radiative forcing factors Pt 1	💻
	9/6	**L5:** Climate change: Radiative forcing factors Pt 2	💻; Stocker, Science
4	9/11	**L6:** 20th Climate change, climate sensitivity, climate Targets	💻
	9/13	**L7:** Climate Feedbacks	
5	9/18	**L8:** Climate Variability-Interannual. Mechanisms, Impacts, Modeling	
	9/20	**L9:** Climate Variability-continued -Term project discussion	
6	9/25	**L10:** Climate Variability-Decadal. Mechanisms, Impacts, Modeling **Term project proposals due**	
	9/27	**L11:** Intro to Climate Databases and raw Model output (CMIP).	💻
7	10/2	**L12:** Climate model development: Governing equations & Numerical Frameworks	
	10/4	**L13**: Climate model development: Parameterizations	
8	10/9	**L14**: Climate model development: Model tuning	💻Schmidt et al. 2017
	10/11	**L15:** Model genealogy & uncertainty	Knutti et al. 2013
9	10/16	**L16:** KNMI climate explorer. Online processing: Observations	💻Guest instructor
	10/18	**L17:** KNMI climate explorer. Online processing: Model output	💻Guest instructor
10	10/23	**L18:** Basic components of an Earth System Model.	
	10/25	**L19:** Introduction to Educational GCM.	💻
11	10/30	**L20:** EdGCM continued. Running experiments & assessing change	💻
	11/1	**L21:** EdGCM continued- Intermodel comparison	💻
12	11/6	**No class- Election Day**	
	11/8	**L22:** Climate data visualization and analysis: NCL primer Pt 1	💻
13	11/13	**L23**: NCL primer Pt 2	💻
	11/15	**L24:** NCL primer Pt 3	💻
14	11/20	**L25:** NCL primer Pt 4	💻 Eyring et al. 2016

	11/22	**No class- Thanksgiving Day**
15	11/27	**L26:** In-class discussion on term project
	11/29	**L27:** Class Summary, Dynamical & Statistical Downscaling
16	12/4	**L29**: Term project presentations- Take Home Exam passed out
	12/6	**L30:** Last Day of Instruction- Term project presentations
17	**12/11**	**Final Exam DUE**
	12/13	**Project Poster DUE**

Reading List:

Date	**Class**	**Reading**
9/4	L5	Stocker 2013, *Science*
9/25	L11	Knutti et al. 2013, *GRL*
10/4	L14	Schmidt et al. 2017, *Geosci. Model Dev.*
10/23	L12	Taylor et al. 2012, *BAMS;* Eyring et al. 2016 , *Geosci. Model Dev.*