# Climate Modeling, Data Analysis & Applications

## ATMO/CEE/SUST 449

ONLINE
TR 10:00-
11:15

Instructor: Prof. Christina Karamperidou
(808) 956-2565 | ckaramp@hawaii.edu | HIG 335
Office hours: Tue online or by appointment

# What we'll cover

PART I

## BASICS OF THE CLIMATE SYSTEM

basic mechanisms of climate variability and change at the seasonal, interannual, decadal timescales of interest for engineering applications and decision-making

PART II

## BASICS OF CLIMATE MODELING

governing principles & components of climate models, including parameterizations, resolution, model tuning & model uncertainty

PART III

## CLIMATE DATA ANALYSIS & APPLICATIONS

processing & analysis of climate model output, visualization of results, bias correction, interpretation and data use in climate science & engineering, engineering applications



A detailed day-to-day schedule of classes can be found at the end of this syllabus, and is posted on laulima under the syllabus tab

# Student Learning Objectives

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.

Explain 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.

List 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.

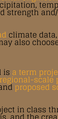
Prepare and present a climate model study as they would in a scientific conference.


## REQUIREMENTS

senior standing or higher (graduate)

Laptop with required software installed

lecture notes, term project resources & readings distributed by the instructor on laulima



some background in differential equations, computer programming languages, fluid mechanics/dynamics & basic statistical analysis is desirable, but not required

**Where to obtain required software:**

All instructions to obtain required software are on laulima under the module "Required Software"

## CLASS RESOURCES

- No required textbook
- Lecture notes will be posted on laulima after each class
- Class readings & term project resources also on laulima

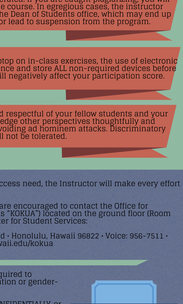
Helpful books on reserve (Sinclair Library, 3rd floor, Wong AV Center):

QC698.W37 2011: Numerical Weather and Climate Prediction (by Warner, Cambridge University Press).

QC981.M482 2005: The Climate Modelling Primer (by McGuffie & Henderson-Sellers, Wiley BlackWell).

QC874.5 .G66 2015: Climate System Dynamics and Modelling (by Goosse, Cambridge University Press)

## TERM PROJECT



A final, capstone project will be worth 30% of your grade.

Deliverables:

a project design sheet in a provided template

a group-written scientific poster (made in Google Slides)

a final oral presentation (in class).

START WORKING ON YOUR PROJECTS EARLY!

- Choose an environmental engineering/science 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.
- Identify and process 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 address the chosen regional-scale problem, and identifies and assesses the uncertainty in the project findings and proposed solutions.

We will discuss this project in class throughout the semester and you will work both in and out of class on your analysis, and the creation of the poster and presentation.

## FINAL EXAM

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



HONOR CODE: COLLABORATION IS NOT PERMITTED. YOU ARE NOT ALLOWED TO MAKE COPIES OF THE EXAM, DISCUSS OR SHARE THE EXAM WITH OTHERS IN THIS CLASS OR OUTSIDE THIS CLASS. IF YOU ARE CAUGHT IN DISHONEST BEHAVIOR, YOU WILL FAIL THE EXAM. NO EXCEPTIONS.

# Course Policies

**PARTICIPATION**



30% of your grade will be based on completing the online modules and assignments each week and participating in the in-person portion of the course. This is an "active" learning course, and will require your full engagement to be successful. Next week's modules can only be released to you after you have completed the previous week's assignments.

**PLAGIARISM**



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.

**TECHNOLOGY**



Unless you are working on your laptop on in-class exercises, the use of electronic devices is not allowed. Turn off/silence and store ALL non-required devices before the start class. Failure to comply will negatively affect your participation score.

**DECORUM**



You are expected to be courteous and respectful of your fellow students and your instructors. Listen carefully, acknowledge other perspectives thoughtfully and focus on the quality of arguments, avoiding ad hominem attacks. Discriminatory language and disruptive behavior will not be tolerated.

**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**

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.

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.

# Schedule

Lectures will follow the tentative course outline below. This syllabus is subject to change; any changes will be disclosed in class beforehand.

| Week | Topic | Comments/ Readings |
|---|---|---|
| 1 | **1.1:** Course Syllabus & Introduction<br>**1.2:** HPC set-up<br>**Zoom:** Intro and HPC set-up | web/python |
| 2 | **2.1:** Earth's energy balance (EBMs)<br>**Zoom:** EBM lab and modules | python |
| 3 | **3.1:** Climate change: Shortwave Radiation<br>**3.2:** Climate change: Longwave Radiation<br>**Zoom:** Build Your Own Earth | web |
| 4 | **4.1:** Anthropogenic Climate change<br>**4.2:** A historical perspective<br>**Zoom:** The Charney Report discussion & term project examples | |
| 5 | **5.1:** Climate Sensitivity and Feedbacks (theory).<br>**5.2:** Important Climate Feedbacks<br>**Zoom:** Climate feedback exercise & term project examples/brainstorming | python |
| 6 | **6.1:** Climate Variability-Interannual. Mechanisms, Impacts, Modeling<br>**6.2:** Intro to Climate Datasets and Climate Variability Calculations<br>**Zoom:** Connecting Climate Variability & Change to Applications | python |
| 7 | **7.1:** Climate model development: Dynamical Core<br>**7.2:** Climate model development: Parameterizations<br>**Zoom:** Term project resources & discussion, team selection | |
| 8 | **8.1:** Climate model development: Model tuning.<br>**8.2:** Model genealogy & uncertainty<br>**Zoom:** Knutti et al. discussion. Submit Term project proposals | Knutti et al. 2013 |
| 9 | **9.1:** Basic components of an Earth System Model.<br>**9.2:** Intro to Climate Databases and raw Model output (CMIP). Example analysis: Temperature & wind changes in HI (model intercomparison)<br>**Zoom:** Example discussion (python), Term project feedback in breakout rooms. Project milestone: complete lit review and data search | python |
| 10 | **10.1:** Control experiments and model skill | panoply |
| | **10.2:** Equilibrium, transient & single-forcing experiments<br>**Zoom:** Single-forcing exercise discussion. Project milestone: model-obs comparison (as needed) | python |
| 11 | **11.1:** Climate data analysis & visualization in Python<br>**11.2:** Examining ENSO simulations in a CMIP6 model | python |

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| | | |
|---|---|---|
| | **Zoom: ENSO simulation exercise discussion.** Project milestone: model output analysis (future projections) | |
| 12 | **Election Day** | |
| | **11.2:** KNMI climate explorer. Online processing: Observations | web |
| | **Zoom:** KNMI climate explorer exercises (feedback) Project milestone: connection with applications) | web |
| 13 | **12.1:** Term Project components and Feedback: Write a scientific abstract | |
| | **Zoom:** Breakout rooms and project guidance | |
| 14 | **13.1:** Project completion, feedback | |
| | **Thanksgiving** | |
| 15 | **14.1:** Class overview & outlook. Knowledge Survey | |
| | **Zoom:** Class overview & outlook. Presentation tips & logistics | |
| 16 | **Deadline to submit presentation videos. NO EXCEPTIONS.** Assignment: Watch and critique presentations. | |
| | **Zoom:** Lightning presentations. Take Home Exam passed out and discussed | |
| | Submit presentations and code (if applicable). Last day of instruction | |
| **17** | **exam period** | |
| | **Final Exam & Project Poster DUE @ 4:15 pm** | |