The Hebrew University of Jerusalem

Syllabus

Computational Models of Climate and Climate Change - 82891

Last update 21-09-2023

HU Credits: 2

Degree/Cycle: 1st degree (Bachelor)

Responsible Department: Atmospheric Sciences

Academic year: 0

Semester: 1st Semester

Teaching Languages: English

Campus: E. Safra

Course/Module Coordinator: Dr. Chaim Garfinkel

Coordinator Email: chaim.garfinkel@mail.huji.ac.il

Coordinator Office Hours:

Teaching Staff:
Prof Chaim Garfinkel

Course/Module description:
Detailed projections of future climate change are created using sophisticated computational models that simulate the physical dynamics of the oceans and atmosphere and their interaction with biological and chemical processes around the globe. These models have evolved over the last 60 years as scientists' understanding of the climate system has improved. This course provides an introduction to the science behind climate change, to the computational techniques used in constructing global climate models, and to the successes and failures of modern climate models. The course will also provide a historical perspective on climate modelling, from the early ENIAC weather simulations created by von Neumann and Charney, through to today's Earth System Models, and the role that these models play in the scientific assessments of the UN's Intergovernmental Panel on Climate Change (IPCC). The course will also address lingering uncertainties in projected future climate, and specifically the aspects of these models that are still undergoing improvement.

Course/Module aims:

Learning outcomes - On successful completion of this module, students should be able to:
Students will be able to
Explain fundamental principles and theoretical concepts of simulating Earth’s climate system, its components, and energy and material fluxes among them.

Simulate climate using a range of computer programs.

Analyze large datasets of complex climate model simulations.

Compare climate model output to observations

Evaluate the accuracy of a given numerical scheme for computing a spatial derivative or integrating forward in time.

Understand problems, challenges and uncertainties in climate modeling.

Attendance requirements(%):

100

Teaching arrangement and method of instruction: Lectures+6 assignments +project+final

Course/Module Content:

Draft set of weekly topics:

(1) History of climate and weather numerical modelling. Early climate science and weather forecasting before the advent of the computer. ENIAC runs. Co-development of climate models and super-computers. Quick overview of range of current models.

(2) Crash course on the thermodynamics of the atmosphere and ocean. What equations need to be solved? (HW #1)

(3) What governs Earth's surface temperature? energy balance model with no atmosphere and with a single atmospheric level. Adding latitudinal dependence. The need for computational solutions (HW #2)

(4+5+6+7+8+9) Numerical solutions of partial differential equations. von Neuman Stability Analysis. CFL condition. The diversity of methods to compute spatial derivatives. (HW #3-5)

(10) Intermediate climate models. Adding a layered atmosphere to a basic energy balance model. Multiple equilibria. Coupling in other earth systems (e.g. glaciers and sea ice). 3-D models. The importance of the PDE solver. (HW #6)

(11) Comprehensive earth system climate models - Using models to study interactions in the earth system. Overview of key systems (carbon cycle, hydrology, ice dynamics, biogeochemistry). Comparing models against observations. Model intercomparison projects.

(12-14) The future. Projecting future climates. Role of modelling in the IPCC assessments. Uncertainties in model projections

Required Reading:

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

Additional Reading Material:

Grading Scheme:

Written / Oral / Practical Exam 60 %

Essay / Project / Final Assignment / Home Exam / Referat 20 %

Submission assignments during the semester: Exercises / Essays / Audits / Reports / Forum / Simulation / others 20 %

Additional information: