UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Earth System Models in Climate Change Science

2627-1-F7402Q019

Aims

The aim of the course is to enable students to gain a basic knowledge of the climate system and its representation in numerical Earth System Models (ESMs), as a fundamental tool in the framework of climate change studies.

For all students, this course will provide basic knowledge on climate change, and it will allow them to communicate with experts in climate modeling, and make sense of climate model data that may constitute the inputs / starting point of their future work, for instance on the impacts of climate changes.

For those who are interested in pursuing modelling climate or other aspects of the physical world, this course could be good starting point, and should be complementary to more focused courses.

LEARNING OUTCOMES AND EXPECTED COMPREHENSIVE SKILLS

1. Knowledge and understanding
   Describe the fundamental components and processes of physical climatology, including the Earth's energy budget, the general circulation of the atmosphere and oceans, and climate system feedbacks.
   Explain the physical bases of climate change and the IPCC methodological framework concerning impacts, adaptation, and vulnerability.
   Identify the theoretical foundations of numerical climate prediction, with a specific focus on numerical integration, dynamical aspects, and physical parameterizations within Earth System Models (ESMs).
   Understand the architecture and functioning of virtual computing environments, Unix shell, and Fortran programming applied to climate modeling.

2. Applying knowledge and understanding
   Edit and run simple Fortran programs to test, validate, and exemplify theoretical concepts of physical climatology.
   Apply specialized data handling and visualization tools (such as nco and ncview) to explore and analyze climate model datasets.
   Interpret and extract outputs generated by climate models to effectively use them as inputs/starting points

for future multidisciplinary applications (e.g., climate change impact studies).

3. Making judgments, Communication skills, Learning skills
   Critically evaluate the reliability, limitations, and appropriate scope of different climate model outputs (ESMs), demonstrating the ability to independently select and interpret data for climate change and impact analysis.
   Communicate effectively with climate modeling experts and specialized peers, using appropriate technical terminology and bridging the gap between complex numerical climate data and downstream impact applications.
   Develop the methodological skills required to independently advance in scientific programming (Fortran/Unix) and autonomously integrate this knowledge with more advanced or specialized courses in climate and physical modeling.

Contents

· The climate system and climate change

· Theoretical bases of numerical climate prediction

· Applications with programming tools to explore in simplified fashion a selection of basic elements of numerical climate modelling

Detailed program

During the delivered didactics sessions there will be a review of the main aspects of physical climatology (such as the energy budget of the Earth, the general circulation of the atmosphere and the oceans, the concept of feedbacks in the climate system, etc.), and a presentation of some background information on the physical bases of climate change, as well as impacts, adaptation and vulnerability in the context of the IPCC workflow.

In addition, a specific block of delivered didactics sessions will be devoted to the acquisition of the theoretical bases of numerical climate prediction, focusing on numerical integration and on the representation of the dynamical aspects and physical parameterizations of ESMs.

The practical sessions of the lab will build up from scratch, guiding the students toward the acquisition of software tools that are typically used to set up and perform climate simulations. General tools will be first introduced: Unix shell, Fortran, very simple data handling and visualization tools (nco, ncview, etc.). Simple Fortran programs will be used / edited to test some of the basic concepts described in the theory.

All practical sessions will be hosted on virtual machines accessible through individual authentication with personal UNIMIB credentials (also from students’ private computers), for a limited number of hours.

Prerequisites

Physical Geography.

Teaching form

12 two-hour laboratory sessions (delivered didactics, in person)
8 three-hours laboratory sessions (interactive teaching, in person)

Textbook and teaching resource

Teacher slides and links to scientific papers and webpages, distributed via elearning.

Books available through the university library:

· Numerical Weather and Climate Prediction, T.T. Warner, Cambridge University Press, 2011 (also in eBook format).

· An introduction to three-dimensional climate modelling, W.M. Washington and C.L. Parkinson, University Science Book, 2005.

· A climate modelling primer, K. McGuffie and A. Henderson-Sellers, Wiley Blackwell, 2014.

Semester

1st semester.

Assessment method

Oral exam on the theory and practical topics discussed during the course.

Office hours

By appointment.

Sustainable Development Goals

CLIMATE ACTION