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| **Course title:** Advance Climate Modelling | | | |
| **Course code:** NRC172 | **No. of credits:** 3 | **L-T-P:** 24-12-12 | **Learning hours:** 42 |
| **Pre-requisite course code and title (if any):** Introduction to Climate Modelling (Sem 2) | | | |
| **Department:** Department of Energy and Environment | | | |
| **Course coordinator:** | **Course instructor:** Mr. Saurabh Bhardwaj | | |
| **Contact details:** saurabh.bhardwaj@teri.res.in | | | |
| **Course type:** Elective | **Course offered in:** Semester 3 | | |

**Course Description**

On completion of this course, students should be able to understand fundamental principles of climate modelling architecture, their physics and dynamics, their bias methodology and their practical usability. The course explains how climate models work and operate under various uncertainty and constraints. The course would also have hands on activity on using the models and generating and analyzing climate data for further usage

**Course objectives**

- Introduce students to the practical usability of climate models
- Understand the structure and usage of various data products in climate sciences
- Become mindful of the necessary technical know-how of running, testing and evaluation a climate model dataset.

**Course Contents**

| Module | Topic | L | T | P |
|---|---|---|---|---|
| 1. | Basics of Global Climate and climate variability<br>Climate sciences (Radiative forcing, energy budget, ENSO, IOD etc.)-<br>a) Atmospheric flows and forces<br>b) Modelling architecture<br>c) Modelling basics, equations, types and usability | 4 | | |
| 2. | Atmospheric Dynamics concepts -<br>a) Flow balances, thermal wind, circulation and vorticity<br>b) Circulation theorem<br>c) Kinematics of pressure systems | 4 | 4 | |
| 3. | Building blocks of a climate system model –<br>a) Model Components<br>b) Resolved processes (dynamical and kinematics)<br>c) Numerical representation of atmospheric and oceanic equations (boundary, initial conditions, parameterizations)<br>d) Atmospheric model, Land model, Ice model | 6 | 4 | |
| 4. | Testing of Models –<br>a) Model Bias<br>b) SST, Sea Ice, precipitation, model and natural variability<br>c) Uncertainty and sensitivity<br>d) Model skill | 6 | | 2 |
| 5. | Hands On -<br>a) Model porting and running on Linux machines (WRF, PRECIS etc)<br>b) Different grid systems and data formats<br>c) Open source climate datasets and their types<br>d) Climate data generation via modelling tools<br>e) Concept of validation<br>f) Climate data analysis via CDO<br>g) Trend plotting, bias, error estimation | 4 | 4 | 10 |

| | Total | 24 | 12 | 12 |
|---|---|---|---|---|

**Evaluation procedure:**
Test 1: 20%
Test 2: 20%
Assignments (including tutorials): 20%; this will be given after Test 2 to assess the tool-based understanding
Test 3: 40%

**Learning outcomes:**
- Ability to distinguish between different climate data operators (test 1)
- Ability to port and run a simple model (test 2 and tutorials)
- Developed understanding of dynamical processes in a model (assignment and tutorials)
- Application of modelling outputs towards extreme climate analysis (test 3)

**Pedagogical approach**
Class room teaching with hands-on exercises on climate data analysis

**Materials**

**List of practicals:**
1. Model porting techniques
2. To understand different grid systems and data formats
3. Working knowledge of open source climate datasets and their types
4. Generation of Climate data via modelling tools
5. Concept of validation
6. Climate data analysis using CDO
7. Trend plotting, bias, error estimation in climate datasets

**Required text**
- Gettelman A. and Rood R.B., Demystefying Climate Models.
- Goosse H., Barriat P.Y., Lefebvre W., Loutre M.F. and Zunz V., Introduction to Climate Dynamics and Climate Modeling.
- James R.H. An Introduction to Dynamic Meteorology, International Geophysics Series
- Steven A. Ackerman and John A. Knox, Meteorology Understanding the Atmosphere
- Thomas T Warner, Numerical Weather and Climate Prediction

**Suggested readings**
- Jacobson M.Z. Fundamentals of Atmospheric Modeling.
- McGuffie K. (Henderson-Sellers A., A Climate Modelling Primer, John Wiley & Sons.
- Washington W.M. and Parkinson C.L, Introduction to Three-dimensional Climate Modeling

**Websites**
- www.m2lab.org

**Journals**
- Geophysical Research
- Global Environmental Change
- Climate Dynamics
- Current Science

**Additional information (if any)**
Regular tutorial and assignments will be given

**Student responsibilities**
Attendance, timely feedback, discipline: as per university rules, adopt peer learning and knowledge sharing within the class.

## Course Reviewers:

The course is reviewed by the following experts.

1. Dr. Akhilesh Mishra, Associate Faculty (Courtesy Appointment) COAPS, The Florida State University, Tallahassee, FL, USA and Associate Professor and Coordinator, Interdiscplinary Center for Climate Research and Policy, Amity University, Jaipur, Rajasthan.
2. Dr. Madhusoodanan M.S., Associate Professor, Amrita Vishwa Vidyapeetham, Amritanagar, Coimbatore - 641 112, Tamil Nadu.