Course title: Climate Modeling			
Course code: NRC 137	**No. of credits:** 4	**L-T-P:** 50-04-04	**Learning hours:** 56
Pre-requisite course code and title (if any): Understanding of mathematics up to 12th standard and basic knowledge of computation applications. Also, Basics of climate science course offered in first semester.			
Department: Department of Natural Resources			
Course coordinator: Dr Kamna Sachdeva	**Course instructor:** Mr Saurabh Bhardwaj		
Contact details:			
Course type: Elective	**Course offered in:** Semester 3		

Course Description

The goal of this course is to introduce postgraduate students in Climate Modelling to all aspects of climate studies. The course consists of a combination of lectures and term papers designed to familiarize the student with a background of the theory of climate models, Hierarchy of Climate Models, their type and applications, the workings of the climate system, and current challenges in climate modeling. At the end of this course, students should be able to understand fundamental principles of the science contained in the models, climate integration in climate model on supercomputers, assess the quality of the model results and climate projections for scientific analysis and for policy maker.

Course objectives

Course content

SNo	Topic	L	T	P
1.	**Fundamental Forces** Pressure Gradient Force, Centrifugal Force, Gravity Force, Coriolis Force	2		
2.	**Numerical Weather Prediction (NWP)** Fundamental equations of fluid motion in rotating and non-rotating fluid in different co-ordinate system, Principle of Weather Forecasting, General Circulation of atmosphere and Ocean	6		
3.	**Climate Model** What is climate model and why climate modelling, Type of climate models, Grid and Spectral models, Details of spectral model	4		
4.	**A hierarchy of models**Energy balance models, Intermediate complexity models, General Circulation Models	2		
5.	**Testing the validity of models**Verification, validation, testing, Evaluating model performance	4	2	2
6.	**Atmospheric physics relevant to climate** Radiation Balance, Radiation in clear sky, Radiation in the presence of cloud & aerosol, Radiative forcing	3		
7.	**Advances in Modelling** Atmospheric, Ocean, Cryospheric Processes, Aerosol Modelling and Atmospheric Chemistry, Coupling, Flux Adjustments and Initialization	5	2	
8.	**Evaluation of Contemporary Climate as Simulated by Coupled Global Models** Atmosphere (temperature and precipitation), Ocean (mean temperature), Sea Ice (magnitude and distribution), Land Surface (snow cover, land surface hydrology)	2		

9.	**Climate System, Sensitivity and Feedbacks** Climate System, Components of Climate System (Atmosphere, Ocean, Sea ice, Land surface), Interaction among components of climate system, Sensitivity Physical Processes Involved in Climate Sensitivity, Feedback Processes.	6		
10.	**Climate Projections and Uncertainty** Scenarios, Global and Regional Climate Projections, Uncertainty	4		
11.	**Evaluation of Large-Scale Climate Variability as Simulated by Coupled Global Models** Indian Ocean Dipole, El Niño-Southern Oscillation, Madden-Julian Oscillation, Monsoon Variability	4		
12.	**Model Simulations of Extremes** Extreme of Temperature and Precipitation, Tropical Cyclones	4		
13.	**Data Processing** Understanding of the programming structure of FORTRAN in a UNIX/LINUX environment, Development of computer programming skills for modeling and data analysis	4		4
	Total	**50**	**4**	**4**

Evaluation criteria

- 2 Minor tests: 15% each
- Term paper: 20%
- Field visit : 10%
- 1 major test (at the end of semester): 40%

Learning outcomes

Pedagogical approach

Materials

Required text

1. Goosse H., Barriat P.Y., Lefebvre W., Loutre M.F. and Zunz V., *Introduction to Climate Dynamics and Climate Modeling*.
2. James R.H. ( ) *An Introduction to Dynamic Meteorology,* International Geophysics Series

Suggested readings

1. Geoffrey K.V. ( ) *Atmospheric and Oceanic Fluid Dynamics: Fundamentals and Large-scale Circulation*.
2. Jacobson M.Z. ( ) *Fundamentals of Atmospheric Modeling*.
3. McGuffie K. ( ) Henderson-Sellers A., *A Climate Modelling Primer*, John Wiley & Sons.
4. Taylor F.W. ( ) *Elementary Climate Physics*.
5. Washington W.M. and Parkinson C.L.( )*Introduction to Three-dimensional Climate Modeling*.

Reports

1. IPCC (2001 & 2007) Working Group I Report "The Physical Science Basis"

Case studies

Websites

Journals

1. Geophysical Research

2. Global Environmental Change
Additional information (if any)
Student responsibilities Attendance, feedback, discipline, guest faculty etc