26SC801 Climate Science, Change & Modelling 4 0 0 4

Course Description:

This PhD-level course provides an in-depth understanding of the physical processes governing the Earth's climate system, anthropogenic climate change, and modern climate modelling approaches. Students will learn fundamental climate physics, explore past and present climate variability, understand forcing mechanisms and feedbacks, and learn about conceptual and numerical models, including simplified Earth System Models.

Learning Objectives :

1. Understand the basic physical principles governing atmospheric radiation, energy balance, and the greenhouse effect.
2. Identify the major components of the climate system and describe their interactions.
3. Recognize key climate feedbacks (e.g., water vapour, ice-albedo, cloud feedbacks).
4. Distinguish between natural and anthropogenic sources of climate variability.
5. Interpret observational evidence of climate change
6. Gain familiarity with global and regional climate models and their assumptions.
7. Understand climate projections, emission scenarios (RCP/SSP), and basic downscaling concepts.

Pedagogy:

Lectures, assignments, term project/research paper discussions

Syllabus:

Fundamentals of Climate Physics - composition, structure, thermodynamics, radiative properties; solar radiation, blackbody radiation, spectral distribution, global energy budget, albedo, emissivity/absorptivity, absorption and emission, Kirchhoff's law, greenhouse effect, Surface and atmospheric radiative processes; radiative forcing basics,

Climate System and Interaction among components of climate system, Feedback mechanisms (water vapour, lapse rate, ice-albedo, clouds, carbon cycle feedbacks) and climate sensitivity.

Climate variability and Observations : Overview of climate variability: natural vs anthropogenic, internal variability (e.g. ENSO, monsoons, decadal oscillations), external forcings, Climate Data Sources and Observational Tools (satellites, ground stations, remote sensing), Evidences of climate change, Drivers of climate change, GHG emissions and drivers, climate change impacts

Climate modelling : global and regional climate models, parameterizations, Climate Projections & Data Methods - RCP/SSP scenarios, regional projections, downscaling, bias corrections.

References:

1. Oort, A. H., & Peixoto, J. P. (1992). *Physics of climate* (p. 520). New York: American Institute of Physics.
2. Hartmann, D. L. (2015). *Global physical climatology* (Vol. 103). Newnes.
3. Wallace, J. M., & Hobbs, P. V. (2006). *Atmospheric science: an introductory survey* (Vol. 92). Elsevier.
4. McGuffie, K., & Henderson-Sellers, A. (2014). *The climate modelling primer*. John Wiley & Sons.
5. IPCC, 2005: IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change
6. IPCC, 2022: The Sixth Assessment Report
7. Relevant research publications.

Course Outcomes:

CO1: Analyse physical processes and their dynamics in climate system
CO2: Describe the interaction between various components of climate system, and the feedback mechanisms
CO3 : Evaluate factors and methods of observing climate change, identify emissions trends and their drivers
CO4 : Interpret the structure and outputs of global and regional climate models and projections

Evaluation Pattern:

Midterm Exam: 30%
Continuous evaluation: 20%
End Semester Exam/Project* presentation: 50%
*The project may be given as either a modelling or a climate data analysis project. It can also be a literature review on a relevant topic.

Employability

- Prepares students for research careers in climate science, atmospheric sciences, and Earth system science.