Atmospheric and Oceanic Sciences

Preface

AS 202 (JAN) 3 : 0

Geophysical Fluid Dynamics

Large-scale, slowly evolving flows on a rotating earth. Vorticity, potential vorticity (pv), consequences of pv conservation. Poincare, Kelvin and Rossby waves. Rotating shallow water equations, effects of stratification and the rotating-stratified Boussinesq equations. Quasi- geostrophic flow and pv,Rossby waves on the mid-latitude beta plane. Basic concepts of tropicaldynamics.Waves, jets and undercurrents on the equatorial beta plane. Waves and large-scale flow in the atmosphere and ocean from observations.

Jai Suhas Sukhatme

Pre-requistes : None

References : Pedlosky, J., Geophysical Fluid Dynamics, Springer Verlag, 1977,Gill, A.,Atmosphere and Ocean Dynamics, Academic Press Inc., 1982.,Holton,J.R., An Introduction to Dynamic Meteorology, Academic Press, 1992. Relevant Journal Articles

AS 203 (AUG) 3 : 0

Atmospheric Thermodynamics

Vertical structure and composition of the atmosphere, kinetic theory of gases,first and second principles of thermodynamics, thermodynamics of dry air,concept of saturation vapour pressure, water vapour in the atmosphere,properties of moist air, isobaric and isothermal processes, atmospheric stability, parcel and area methods, nucleation, effect of aerosols, clouds and precipitation, forms of atmospheric convection.

Pre-requistes : None

References : Iribarne, I.V., and Godson, W.I., Atmospheric Thermodynamics, 2nd Edn, D Reidel Publishing Company, 1971,Rogers, R.R., A Short Course in Cloud Physics,2nd Edition, Pergamon Press, 1979,Bohren, C.F., and Albhecht, B.A.,Atmospheric Thermodynamics, Oxford University Press, 1998,Tsonis, A.A., An Introduction to Atmospheric Thermodynamics, Cambridge University Press, 2002,Wallace,

AS 205 (JAN) 2 : 1

Ocean Dynamics

Introduction to physical oceanography, properties of sea water and their distribution, mixed layer, barrier layer, thermocline, stratification and stability, heat budget and air-sea interaction, ocean general circulation, thermohaline circulation, basic concepts and equations of motion, scale analysis, geostrophic currents, wind-driven ocean circulation, Ekman layer in the ocean, Sverdrup flow, vorticity in the ocean, waves in the ocean, surface gravity waves, Rossby and Kelvin waves.

Vinayachandran P N

Pre-requistes : None

References : Talley et al., Descriptive Physical Oceanography,6th Edition, 2011,B. Cushman- Roising, Introduction to GFD,Introduction to Physical Oceanography,http: /eanworld.tamu.edu (online book)

AS 207 (AUG) 3 : 0

Introduction to Atmospheric Dynamics

Pre-requistes : None

References : None

AS 209 (JAN) 3 : 0

Mathematical Methods in Climate Science

Review of probability and statistics: probability distributions, sample statistics. Confidence intervals. Hypothesis testing; goodness of fit tests,time-series analysis: Fourier transforms, principal component analysis (PCA).

Venugopal Vuruputur

Pre-requistes : None

References : Papoulis, A., & U. Pillai, Probability, Random Variables andStochastic Processes, 4th edition, McGraw Hill, 2002.,Wilks, D., Statistical Methods in the Atmospheric Sciences, 2nd edition, Academic Press, 2006.,O. Brigham, Fast Fourier Transforms, Prentice Hall, First Edition, 1974.,Press, W. H., S. A.Teukolsky, W. T. Vetterling, and B. P. Flannery, Numerical Recipes in C/Fortran: The Art of Scientific

AS 210 (JAN) 3 : 0

Numerical methods in atmospheric modeling

Equations used in atmosphere and climate modelling and their scale analysis; numerical discretization (horizontal, vertical, time-discretization) of governing equations (e.g., mass, momentum, energy conservation); solution of discretized equations; finite difference and finite volume schemes; overview of Semi-Lagrangian techniques; various spectral techniques and Galerkin projection; numerical solutions of example problems; modelling of sub-grid scale processes (e.g., cumulus parameterization); special topics (e.g., emerging techniques/architectures, analysis of data driven/hybrid approaches).

Ashwin K Seshadri

Pre-requistes : AS-207: Introduction to Atmospheric Dynamics

References : P H Lauritzen et al., Numerical Techniques for Global Atmospheric Models, Springer, 2011

A Chandrasekar, Numerical Methods for Atmospheric and Oceanic Sciences, Cambridge University Press, 2022

AS 211 (JAN) 2 : 1

Observational Techniques

Principles of measurement and error analysis, fundamentals of field measurements, in situ measurement of atmospheric temperature, humidity, pressure, wind, radiation, precipitation and aerosols. Tower based techniques and automatic measurement systems. Upper air observations, radiosonde techniques. Measurements in the ocean, CTD, ADCP and ARGO. Modern measurement techniques.

Bhat G S

Pre-requistes : None

References : Guide to Meteorological Measurements and Methods of Observation,,World Meteorological Organization Publication No. 8,,7th Edition, WMO, Geneva. radiative transfer, the role of radiation in climate.~Harrison R. G. Meteorological Measurements and Instrumentation Wiley, (2014)~DeFelice, T. P.,An Introduction to Meteorological Instrumentation and Measurement. Prentice Hall, 1998.

AS 216 (AUG) 3 : 0

Introduction to climate system

Equations of motion for the atmosphere and oceans, observed mean state of theatmosphere and oceans, exchange of momentum, energy and water between the atmosphere and surface, angular momentum cycle, global water cycle, radiation,energetics, entropy in climate system, climate variability, The global carbon cycle, Climate System Feedbacks

Pre-requistes : None

References : J. Peixoto and A.H. Oort,Physics of Climate,,American Institute of Physics

AS 299 (JAN) 0 : 28

Project

Venugopal Vuruputur

Pre-requistes : None

References : None

AS 313 (JAN) 3 : 0

Non-Linear Model in Climate Sciences

An introduction to nonlinear dynamics: linearization, bifurcation, chaos; Galerkin projection and model reduction; Derivation and analysis of low order models for the atmosphere, ocean, climate dynamics, and geophysics (e.g., Rayleigh-Bénard convection, vorticity, general circulation, ocean thermohaline circulation, planetary dynamos, energy balance and global warming, ice sheets, ENSO, carbon cycle, examples from paleoclimate); Special topics (data driven methods; dynamics on networks)

Ashwin K Seshadri

Pre-requistes : None

References : Primary references:

A Provenzale and N Balmforth, Chaos and Structures in Geophysics and Astrophysics

AS 215 (AUG) 3 : 0

Environmental Fluid Dynamics

An overview of the field of fluid mechanics and description of the physics governing fluid flow. Principles of buoyancy-driven flow: Free-surface flows, gravity currents, stratified flows, gravity waves. Heat transfer and fluid instability: Convection, turbulence, and mixing. The course has four major components: (i) Waves in fluids: interfacial waves and internal gravity waves. (ii) Vertical flows: turbulent plumes, filling box, double-diffusive convection. (iii) Horizontal flows: shallow water approximation, single-layer hydraulics, gravity currents, two-layer flows, and (iv) Turbulent mixing: mixing across very stable interfaces and turbulent convection. The course consists of Lectures, tutorials, and simple laboratory experiments.

Pre-requistes : None

References : Fluid Mechanics 3rd Edition: Authors: Ira Cohen and Pijush Kundu: Academic Press, Published Date: 2004~Buoyancy Driven Flow: Authors: J. S. Turner: Cambridge University Press, Published Date: 1979~Waves in the Ocean and Atmosphere: Introduction to Wave Dynamics: Authours: J. Pedlosky, Spriger Verlag, Published Date: 2003

AS 217 (JAN) 2 : 1

Modelling and Forecasting

Syllabus

Overview of Numerical Methods, Hierarchy of Models - global, regional, coupled models, Skill Score Metrics, Downscaling.
Forecasting the weather, Ensemble Forecasting Technique, Dynamical Seasonal Prediction, Decadal Prediction and Climate Projections, Air Quality Modelling, Prediction of South Asian Monsoon. Architecture of Ocean Forecasting System Components, Numerical Ocean Models, Data Preparation, Forcing and IC, Data Assimilation, Forecast Evaluation. Introduction to PDE-constrained optimization, Linearization and Gradient Computation, Lagrange Multipliers; Adjoint-state Method, Seismic Wave Equation and Finite-difference Modeling, Full Waveform Inversion.

Arindam Chakraborty

Pre-requistes :

Atmosphere Dynamics/Ocean Dynamics/GFD
References : 1. 'Implementing Operational Ocean Monitoring and Forecasting Systems' https://www.mercator-ocean.eu/wp-content/uploads/2022/10/22-09-26-ETOOFS-BOOK-DOI-UPDATED-AB.pdf

AS 298 (JAN) 0 : 18

MTech Project

This is a project course for the Joint MTech programme in Earth and Climate Sciences

Venugopal Vuruputur

Pre-requistes : None

References : Research Papers