



KERALA UNIVERSITY OF FISHERIES AND OCEAN STUDIES

SYLLABUS

M.Sc. CLIMATE SCIENCE

SCHOOL OF FISHERIES ENVIRONMENT

Fisheries Station Puthuvype Campus, Kochi-682508, Kerala

Semester-wise distribution of Courses

SEMESTER- I

Course	Title of the Course		Credits	Core C/Elective (E)/Practical(P)
1	CS 2101	INTRODUCTION TO THE ATMOSPHERE	4	C
2	CS 2102	FUNDAMENTALS OF OCEANOGRAPHY	4	C
3	CS 2103	FUNDAMENTALS OF BIOSPHERE	3	C
4	CS 2104	MATHEMATICS AND STATISTICS	3	C
5	CS 2105	COMPUTER PROGRAMMING	3	C
6	CS 2106	REMOTE SENSING AND GIS	3	E
7	CS 2107	OBSERVATIONAL TECHNIQUES	2	P
		TOTAL	22	

SEMESTER - II

Course No.	Title of the Course		Credits	Core (C)/Elective (E)/Practical (P)
1	CS 2201	CLIMATOLOGY	4	C
2	CS 2202I	WEATHER AND CLIMATE DISASTERS	4	C
3	CS 2203	OCEAN-ATMOSPHERE INTERACTION	4	C
4	CS2204	WEATHER AND CLIMATE FORECASTING	4	C
5	CS 2205	CLIMATE DYNAMICS	4	E
6	CS2206	MATLAB	2	P
		TOTAL	22	

SEMESTER- III

	Course No.	Title of the Course	Credits	Core (C)/Elective (E)/Practical (P)
I	CS 2301	CLIMATE CHANGE ADAPTATION AND MITIGATION	4	C
2	CS 2302	CLIMATE SERVICES	4	C
3	CS 2303	CLIMATE PROJECTION AND CLIMATE INFORMATICS	4	C
4	CS2304	CLIMATE SYSTEM MODELLING	4	C
5	CS 2305	RESEARCH METHODOLOGY AND ETHICS	2	E
6	CS 2306	INTERPRETATION AND USE OF CLIMATE MODEL OUTPUTS	3	P
		TOTAL	21	

SEMESTER- IV

	Course	Title of the Course	Credits	Core (C) Elective (E)/Practical (P)
1	CS 2401	PROJECT WORK	25	C
		TOTAL	25	

Total Credits

Semester No.	Credits
I	22
II	22
III	21
IV	25
Total	90

SEMESTER: I

CS 2101 INTRODUCTION TO THE ATMOSPHERE

C

4

Unit I

Sun, Earth and the Atmosphere-Sun-Earth relationship, solstices and equinoxes, motion of earth - vertical thermal structure of the atmosphere, composition of the atmosphere - dry air, water vapour and aerosols.

Unit 2

Radiation- laws of black body radiation, radiation transfer. Solar radiation - latitudinal and seasonal:- variations- passage through the atmosphere-absorption - scattering and reflection - Mean disposition of solar radiation. Terrestrial Radiation- absorption in the atmosphere -atmospheric window. -radiative heat exchange- Mean heat balance of the earth- atmosphere system, atmospheric greenhouse effect - poleward transport of energy- fundamental link to general circulation

Unit 3

Gas laws and their application to the atmosphere-Equation of state for dry and moist air humidity parameters-virtual temperature. First and second laws of thermodynamics-virtual temperature. Internal energy-adiabatic processes-potential temperature-entropy-reversible and irreversible processes-Carnot's cycle. Thermodynamics of water vapour-latent heat-the Clausius-Clapeyron equation. Thermodynamics of the atmosphere-dry adiabatic lapse rate, unsaturated moist air- saturated adiabatic lapse rate, pseudo-adiabatic cases-equivalent temperature-thermodynamics of the wet-bulb thermometer-wet-bulb potential temperature - saturation potential temperature.

Unit 4

Hydrostatics of the atmosphere-Geopotential, equipotential surface-Hydrostatic equation hydrostatic equilibrium, standard atmosphere - altimetry. Atmospheric instability and convection-Stability Criteria- CAPE and CINE - parcel method - Brunt-Vaisala oscillations, lifting, mixing and convective condensation levels-potential instability and latent instability, stability indices-slice method of stability analysis- growth of cumulus clouds-entrainment.

Unit 5

Cloud formation :Cloud classification; Condensation nuclei; Ice nuclei; Growth of cloud drops; Growth of ice crystals; effects of curvature and solution; Rain drop spectra; Precipitation mechanisms; Bowen's theory ; Bergeron and Findeisen process; Collision and coalescence processes; Precipitation of warm and cold clouds; Atmospheric Optics - Visibility - attenuation of light-turbidity, Optical phenomena - rainbows, haloes, corona, glory, mirage etc. scattering - blue of the sky- colours at sun rise and sunset-atmospheric refraction.

Prescribed Book:

1. Atmospheric Science - an Introductory Survey - by John Wallace and Peter Hobbs, second edition (2006), Elsevier, 504 pages
2. Essentials of Oceanography; Allen P. Trujillo and Harold V. Truman, PHI, New Delhi (10th Edition)

Additional books:

1. Introduction to Theoretical Meteorology, Seymour L. Hess, Krieger, New York, 2006.
2. Physical Meteorology, John C Johnson, MIT Press, Cambridge, 1996.
3. Introduction to Physical Meteorology, H. Neuberger, The Pennsylvania State University Press, 1966.
4. Atmospheric Thermodynamics (Second Edition), J V Iribarne & W L Godson, Springer, 1981.
5. Physics of Atmospheres (Third Edition), J Houghton, Cambridge University Press, 2002.
6. Clouds, Rain and Rain Making (second Edition), B J Mason, Cambridge University Press, 2010.

CS 2102 FUNDAMENTALS OF OCEANOGRAPHY**C****4****Unit 1**

Introduction - history of oceanography - great voyages

Properties of sea water and their distribution: temperature, salinity, density, light penetration. sound propagation.

Heat budget - components of energy budget of the oceans - sensible and latent heat fluxes - mixed layer, thermocline - concept of water mass and water types

Unit 3

Global Ocean Circulation - Major ocean currents - Indian Ocean Circulation thermohaline circulation- Ekman spiral and Ekman transport - coastal and open ocean Upwelling.

Unit 4

Waves: Wave generation and wave characteristics - wave refraction - tides - El Nino, La Nina, the Southern Oscillation

Unit 5

Chemical composition of sea water - major and minor constituents of sea water - constancy of composition - factors affecting constancy.

Prescribed Book:

John A. Knauss: Introduction to Physical Oceanography (second edition) Riley J. P. and Chester R: Introduction to Marine Chemistry

Additional book:

1. Stewart H (Open book) - Introduction to Physical Oceanography
2. Essentials of Oceanography; Allen P. Trujillo and Harold V. Truman, PHI, New Delhi (10th Edition)

CS 2103 FUNDAMENTALS OF BIOSPHERE**C****3****Unit 1**

The biosphere - land and the oceans- Marine and coastal environment, zonation, oceanic, coastal and inter-tidal ecosystem - sea as a biological environment -marine and terrestrial environment.

Trophic system in the ocean - Plankton in the surface oceans and photosynthesis - influences of biosphere in the amount of aerosols in the atmosphere

Unit 2

Integrated approach in addressing biodiversity and climate change challenges - The Man and the Biosphere (MAB) Programme - UNESCO Strategy for Action on Climate Change: enhanced education and public awareness.

Unit 3

Role of Biosphere Reserves as areas for demonstrating adaptation measures for natural and human systems - Assisting the development of resilience strategies and practices - Buffer zones and transition areas of biosphere reserves - use of Buffer zones - testing a variety of mitigation tactics and strategies - carbon sequestration in biosphere reserves - its valuable ecosystem service.

Unit 4

Effects of global warming - Danger for Earth's biomes by Global warming spells - The dramatic effects at high latitudes - multiple processes contribute to decreased surface reflectivity- assessment of ecosystem feedbacks to the climate system -carbon sequestration - projected climatic and ecological changes as informed basis for community and regional planning.

Prescribed book:

Biosphere: by Frederic P. Miller Agnes F. Vandome John McBrewster
2010, International Book Marketing Service Ltd

Additional books:

1. Life on the Planet Earth: by Harold J. Morowitz
1980, W. W. Norton & Company
2. Geography of the Biosphere : An introduction to the Nature, Distribution and Evolution of the World's Life Zones: By Peter A. Furlley ;1983, ButterworthHeinemann
3. Biosphere: By Harshvardhan Bhaskar;2012, Publisher: Neha Publishers & distributors
4. Biosphere Origin And Evolution 1st Edition; Nikolay Dobretsov; Springer-verlag;
5. The Earth's Biosphere: Evolution, Dynamics, and Change: By Vaclav Smil; 2008 MIT Press
6. Harvesting the Biosphere : What we have taken from Nature: By Vaclav Smil 2012, MIT Press

CS 2104 MATHEMATICS AND STATISTICS

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Mathematics:

Unit 1

Calculus: Introduction -functions, area, summation, the integral, slopes, the derivative, the concept of a limit, the fundamental theorem of calculus, The logarithmic and exponential functions and series expansions and its applications.

Unit 2

Integration and differentiation: ordinary differential equations, partial differential equations, Numerical Analysis and Time Series Analysis. Taylor series expansion, Vector calculus. Gauss and Strokes theorem.

Unit 3

Matrices and its application

Statistics:**Unit 4**

Measures of central tendency- Mean, Median Mode- standard deviation-coefficient of variation- Correlation and Regression - simple and multiple Regression

Unit 5

Sampling Techniques- Sampling Designs-Simple Random Sampling, systematic sampling, cluster sampling, Multistage Sampling

Unit 6

Statistical Inference- Estimation and Testing of Hypothesis, Tests based on Z, Students T, F and chi-square, Analysis of Variance-one way and two way.

Prescribed books:

Vector Analysis- A text book for the use of students of Mathematics and Physics; Edwin Bidwell Wilson, Yale University 9th Edition(2007)

1. Elementary Linear Algebra; Anton, Howard(1987); Wiley; ISBN 0-471-84819-0
2. Statistical Methods; Snedecor and Cochran; Mohan Pramlani for Oxford & IBFI Pulp. Company, New Delhi

Additional books:

1. Schaum's Outline of Theory and Problems of Matrix Operations: Bronson, Richard (1998) Me. Graw Hill, ISBN 978-0-07-007978-6
2. Matrices and Vector Spaces; Brown, William C (1991); Marcel Dekker, New York, N.Y.
3. Principles of Multivariate Analysis; Kizanowski, Wojtek J (1988); The Clarendon Press, Oxford University Press; ISBN : 978-0-19-852211-9- MR 969370

CS 2105 COMPUTER PROGRAMMING**C****3****Unit 1**

Introduction to digital computer-functional units of a computer - storage - primary storage - secondary storage.. Generation of computers, Introduction to programming languages - types of programming languages - high level languages - assembly language - machine language. Language Processors- Compiler, Interpreter and assembler.

Classification of software-system software, application software. Number systems - Decimal, Binary, Octal and Hexadecimal - conversion from one system to another – Addition, subtraction, multiplication and division of binary numbers (no algorithms). Representation of integers Sign & Magnitude Notation, One's Complement- Two's complement.

Unit 2

The Fortran 90 Basics: Program Structure; Logical variables and operations Data Types and Numerical Operators (CHARACTER and LOGICAL operators), Valid variable names; Programming Style; Decision Making; The 'DO' Construct (Repetition with the DO construct), The CYCLE and EXIT STATEMENTS; Data type casting; Intrinsic functions: Data Type Limitations: Complex arithmetic, The true meaning of '=' in Fortran 90, Blank spaces and continuation lines, Simple Input and Output; Characters and Strings: Concatenation and substrings, Character intrinsic functions; The 'PRINT' Statement in Detail: Descriptor Symbols.

Input/ Output Formats; Edit Descriptors; Units; Open; Unformatted Files; Records; Direct access files; Non-advancing I/O; Close; Rewind, Backspace and Endfile; Inquire; Internal I/O and conversion of characters to/from numeric data types

Unit 3

Datatypes: Arrays :Declaring arrays; Indexing; Array sections; Array storage; Array operations; Masks; The Where construct; Implied Do loops; Array constructors; Vectorsubscripts; Array I/O; Dynamic storage via Allocatable arrays. Parameterized Data types and Kind; Derived Types; Pointers; Pointers and dynamic storage; Derived data types and Pointers; Dynamic sized derived type component

Unit 4

Subprogram types; Internal (Contained) Subprograms; Actual And dummy arguments; Argument association; TKR matching; Intent; Host association; Scope; Local Variables; Initialization; The Save attribute; Character and Array arguments; Inquiry Functions; Allocatable arrays and scope; optional arguments; Keyword arguments; Return; Pure ant; Elemental sub programs.

Unit 5

Modules; Modules, Scope and Use association; Multiple file compilation; Control of use association by Private and Public; Namespace Pollution; Only; Rename lists; External subprograms; Interfaces and Interface blocks; Functions as arguments; Overloading; TKR matching revisited; User defined operations and assignment.

Prescribed book:

Computer Programming In Fortran 90 And 95. V Rajaraman.

Additional books:

1. Fundamentals of Computers: V Rajaraman.
2. Fortran 90: Complete ISO/ANSI reference by Jeanne C Adams

CS 2106 REMOTE SENSING AND GIS**3****E**

Unit I: Introduction and history of Remote Sensing (R.S.) - basic principles of remote sensing- Elements of photogrammetry - Electromagnetic spectrum - Energy interaction with surface features

Principles of Geographical Information System tools, their types and capabilities, advantages of GIS over conventional methods. Importance of ground truth establishment, GIS and remote sensing for weather data, hydrographical data and land data collection - analysis and interpretation

Unit II: Sources and propagation of radiations in atmosphere; interactions with matter. Sensor systems - camera, microwave radiometers and scanners; fundamentals of aerial photographs and image processing and interpretations.

Unit III: digital image processing. Fundamentals of GIS, raster data representation, vector data representation, GIS data management, data input, editing, analysis and modeling.

Unit IV: Basic principles of remote Sensing, satellite and imagery sensor systems, spec signatures, interpretation of satellite imagery, Application of remote sensing techniques, land use, soil surveys, flood and drought management, wasteland identification and management. Application of remote sensing techniques in climate studies.

Unit V: Integration of RS and GIS. Applications of RS and GIS in different areas of meteorology, oceanography, agriculture, fisheries, animal husbandry etc. Familiarization of remote sensing and GIS hardware, software and remote sensing equipments. Methodology for establishing ground truth, Comparison between ground truth and remotely sensed data

References:

Brady NC & Well RR. 2002: The Nature and Properties of Soils. 13th Ed. Pearson Edu. 8. De Mess M.N. 2004: Fundamental of Geographic Information System. John Wiley & Sons

Elangovan K. 2006: GIS Fundamentals, Applications and Implementations. New India Publishing Agency.

Lille Sand T & Kaiffer R. 1987: Remote Sensing and Image Interpretation. John Wiley & Sons.

Lille Sand T. M & Kiefer RW. 1994: Remote Sensing and Image Interpretation. Wiley.

Nielsen D.R & Wendroth O. 2003: Spatial and Temporal Statistics. Catena Verlag GmbH
Sabbins F. 1987: Remote Sensing Principle and Interpretation. Freeman Star J & Esles J. 1990: Geographic Information System: An Introduction. Prentice Hall.

CS 2107 OBSERVATIONAL TECHNIQUES PRACTICAL**2****P****Unit 1**

Introduction-conventional measurements of Pressure, Temperature, Humidity, Wind, Precipitation, Visibility, Clouds, Soil Temperature and Moisture,

Unit 2

Radiosondes, Weather RADARS.

Unit 3

Oceanographic measurements, Measurement of SST, Protected and Unprotected thermometers, Reversing Water Bottles, MBT, XBT, CTD, XCTD, Current Meters, Position fixing at sea, GPS,

Unit 4

Analysis and interpretation of surface meteorological data

Unit 5

Analysis and interpretation of satellite cloud cover, winds, OLR, SST and Sea Surface Height anomalies

Prescribed book:

Marine Observers' Handbook: Met. 0.887, MHSO, London

Additional Books:

1. Practical Agricultural Meteorology: Srivastava A.K. and P. K. Thyagi; New India Publishing Agency, New Delhi
2. The Practice of Weather Forecasting: Wickham P.G; HMSO, London
3. Weather and Climate: Woodcock R. G., Macdonald and Evans.

Semester: II

CS 2201 CLIMATOLOGY

C

4

Unit 1: Climate classification

Global, regional and local climates- Classification of climates-genetic and empirical classifications, Koeppen and Thronthwaite's schemes - other classifications - climatic types and climatic zones. Climate change impacts on climate types.

Unit 2: Radiation climatology

Radiation and Energy balance of the earth's atmosphere. Spatial and temporal distribution incoming solar radiation, outgoing longwave radiation, net radiation. Terrestrial heat balance and other components of radiation balance. Radiation climatology of India. Impact of ClimateChange on radiation balance.

Unit 3: Monsoon and Rainfall Climatology

Southwest Monsoon- Normal dates of onset and withdrawal of monsoon - Rainfall distribution and coefficient of variation of monsoon rain- Impact of climate change on Indian Monsoon- - Concepts in Monsoon management- Precipitation zones - Rainfall climatology of India - temporal and. spatial distribution- Rainfall and monsoon climatology of Kerala - Climatology of monsoon depressions - Impact off climate change on monsoon depressions North east monsoon- - Rainfall distribution during northeast monsoon.

Unit 4: Climatology of surface air temperature, Pressure and wind

Temperature distribution over the globe and Indian region - pressure and wind distribution over the globe and India- wind roses - Climatology of evaporation and humidity over India.

Unit 5: Climatology of weather systems

Frequency and tracks of cyclones and depressions over India- Definition of cyclones - climate change and tropical cyclones- Climatology of sea surface temperature and relationship with cyclones Life cycle of cyclone-Rainfall distribution and cloud patterns in the cyclone. Structure of a cyclone -Vertical distribution of temperature and wind in the cyclone-Role of satellites and Radar in tracking the cyclone movements- Impact of climate change on cyclones - Cyclone management and mitigation of cyclone effects.

Prescribed Book:

Pant, G.B. and Kumar, K.R. 1997. Climates of South Asia. John Wiley & Sons, Chichester. 320p

Additional Books:

1. Trewartha, G.T. and Horn :An Introduction to Climate. McGraw-Hill, New 395p
2. Bridgeman H and J Oliver 2006. The Global Climate-System-Patterns, Processes and Teleconnections. Cambridge University Press
3. Asnani .G.C. Tropical Meteorology (second edition) Vol I, II, & III

CS 2202 WEATHER AND CLIMATE DISASTERS

4

C

Unit 1: Weather related disasters

Tropical cyclones: storm surges, strong winds, heavy rain - Cyclone hazard zonation of Indian Coast line- Cyclone warning system in India-Southwest monsoon: inter annual and decadal variability - droughts and floods- Monsoon onset date variability - Long break monsoon spells - early / late withdrawal of monsoon- Thunderstorms and lightning duststorms - associated Squall, Hail stones and Tornadoes - Short period heavy rain spells -cloud burst - Flash Floods - Non cyclone Strong Winds - Heat and Cold waves -Sunburns, heat burst- Fog - air Pollution hazards

Unit 2: Flood, drought and landslides

Flood Risk Zones in India - Flood forecasting and warning system in India, Drought Prone areas of India- drought management: Forecasting of droughts - Drought management short and long term measures - landslides and avalanches-vulnerability and risk in India-risk mitigation-issues and challenges-monitoring, warning and preparedness

Unit 3: Climate and Climate change

Natural and anthropogenic climate change - increase of green house gases and their global impact on climate-

melting of glaciers and polar ice - sea level rise and its impact - ozone depletion - IPCC (4th and 5th) reports and future projections of climate-

Unit 4: Forecast and warning of disasters

Cyclone warning system in India - Satellites and Radar network for cyclone warning forecast of cyclone track and intensity - storm surge prediction - short and medium range forecast of monsoon rainfall- seasonal (long range) forecast of monsoon rainfall - prediction of climate change- IPCC projections

Unit 5: Disaster, hazard and vulnerability

Disaster, hazard, exposure and vulnerability, disaster risk reduction and management. risk transfer, adaptation, resilience

Climate extremes and impacts-human impacts' and disaster losses.

Framework at national and global levels - strategies for disaster reduction - national disaster management plans - role of NGOs, community based organizations and media - Role of central, state, district and local administrations, Role of armed forces, police and other organizations

Prescribed book:

'Global warming - the Complete Briefing (second edition): John Houghton, Cambridge University Press (2009)

Additional books:

1. Tropical Cyclones, their Evolution, Structure and Effects - by Richard A. Anthes (1982), American Meteorological Society, 208 pages
2. Severe Convective Storms - edited by Charles A. Doswell (2001), American Meteorological Society, 561 pages
3. Mesoscale Meteorological Modelling, third edition by Pielke RA Sr.,(2013), Academic Press
4. Monsoon Vol I and 2 (2013), Editor Dr.AjitTyagi et al, India Meteorological department
5. Earth and Atmospheric Disasters Management - Pandarinath N and Rajan C.K. (2009), BS Publications Hyderabad India

CS 2203 OCEAN- ATMOSPHERE INTERACTION

4

C

Unit 1: Air -sea interaction

Fluxes of mass, momentum and heat- scales of air-sea interaction-boundary layer Atmospheric boundary layer . Atmospheric stability and wind profile- Ocean atmosphere heat, momentum and water.

Unit 2: Heat budget of the ocean

Sea surface Temperature- short wave and long wave heat fluxes-sensible and latent heat mixed layer- Bowen's ratio-annual cycle of heat fluxes-spatial and time variation of heat.

Unit 3: Measurement of fluxes

Bulk aerodynamic methods and remote sensing- exchange of momentum and heat- coastal ocean upwelling-wind driven currents-wind waves- generation growth and decay of waves

Unit 4: Dynamics of ocean atmosphere coupling

Meridional heat and water transfers- Atmospheric circulation- Hadley and Walker circulation and high latitude intrusion of westerlies- Tropical and subtropical jet streams and its influence on climate- Ocean conveyor belt- Thermohaline circulation.

Unit 5: Role of Oceans in climate

Large scale air-sea interaction processes- ElNino-Southern Oscillation, El Nino-Modoki and Pacific Multidecadal Oscillation and their relation with Indian summer monsoon-Indian Dipole (IOD)- ocean warming, climate change and sea level rise.

Prescribed book:

Atmosphere-Ocean Interaction; Kraus E.B.

Additional books:

1. The Sea (Vol.1); Hill M.H.
2. Introduction to Boundary Layer Meteorology; Stull R. B.
3. Air-Sea Exchange: Physics, Chemistry and Dynamics; Geernaert G.L.
4. Ocean -atmosphere interactions; Toba Y.

CS 2204 WEATHER AND CLIMATE FORECASTING**4****C****Unit 1**

Introduction, Historical Overview of NW, Model Fundamentals, Equation Systems

Unit 2

Model Structure and Dynamics, Numerical Methods I - Finite Differences, Numerical Methods II - Grid Systems, Numerical Methods III - Stability Analysis

Unit 3

Parameterization of Clouds and Precipitation, Influence of Model Physics

Unit 4

Objective Analysis/Model Initialization, Data Assimilation

Unit 5

Intelligent Use of Model Derived Products

Prescribed Book:

Fundamentals of Numerical Weather Prediction, 2011 . Jean Coiffier, Cambridge University Press.

Additional books:

1. Numerical Weather and Climate Prediction, 2011 Thomas Tomkins Warner Cambridge University Press
2. E. Kalnay, 2002: Atmospheric Modeling, Data Assimilation and Predictability, Cambridge University Press, 364pp.
3. Parameterization Schemes: Keys to understanding Numerical Weather Prediction Models David J Stensrud
4. G. J. Haltiner and R. T. Williams, 1980: Numerical Prediction and Dynamic Meteorology, 2 nd Ed., Wiley, 477pp.
5. T. N. Krishnamurti, 1996: An Introduction to Numerical Weather Prediction Techniques, CRC, 304pp.
6. R. A. Pielke, 2002: Mesoscale Meteorological Modeling, 2 nd Ed., Academic, 676pp.

CS 2205 CLIMATE DYNAMICS

E

4

Unit I

Characteristics of the atmosphere, Equation of state for the dry and moist a radiation budget. Greenhouse effect. Vertical structure of the atmosphere.

Unit 2

Convection in water, Dry convection in air, Potential temperature, moist con air, Meridional structure of the atmosphere.

Unit 3

Partial differential equations, Radial inflow experiment, Equations of motion rotating fluids Equations of motion for non-rotating fluids, Equations of n rotating fluids, Inertial motions, Equations of motion on a sphere, Geostrophic balance, Taylor- Proudman theorem, Thermal wind, Ekman layers, The general circulation of the atmosphere

Unit 4

Physical characteristics of the ocean, the observed ocean circulation, Ekman layers in the laboratory, Taylor- Proudman on the sphere. Wind driven ocean circulation, the abyssal ocean circulation, Turbulent mixing, abyssal ocean circulation

Unit 5

The atmospheric and oceanic energy budget, The Earth's heat budget

Prescribed book:

Marshall, John, and R. Alan Plumb. Atmosphere, Ocean, and Climate Dynamics Introductory Text. Boston, MA: Elsevier Academic Press, 2007.

Additional books:

1. Hartmann, Dennis L. Global Physical Climatology. International Geophysics Series. Vol. 56. San Diego, CA: Academic Press, 1994. ISBN: 97801232853
2. Iloughton, John Theodore. The Physics of Atmospheres. Cambridge, UK: Cambridge University Press, 1977. ISBN: 9780521214438.
3. Wallace, John M., and Peter Victor Hobbs. Atmospheric Science. An Introductory Survey. New York, NY: Academic Press, 1977. ISBN: 9780127329505.
4. Pickard, George L., and William J. Emery. Descriptive Physical Oceanography an Introduction. Oxford, UK: Pergamon Press, 1982. ISBN: 9780080262802.

CS 2206 MATLAB PRACTICAL**2****P****Unit I**

Introduction to MATLAB- Matrices and Arrays, Array Creation, Matrix and Array Operations. Built-in-functions- Scalar functions, Vector functions, Matrix functions. Line plots, 2D and 3D plots. M-files: Scripts and functions. - Basic Matlab data structures, file i/o, string handling, code efficiency and analysis, Matlab debugger

Unit 2

Conditional Statements. Colon Operator. Characters and text, Structures, Linear Algebra, Operations on Nonlinear functions, Multivariate data, data analysis. Vector products and transpose: Multiplying Matrices, Identity matrices, System of Linear Equations, The mldivide algorithm, Permutations of Triangular matrices, Square matrices, Rectangular matrices. Nonsingular coefficient matrix. Iterative method for solving linear system of equations Inverses and determinants. Eigen values, eigen decomposition, Multiple Eigen values, Schur decomposition, Operations on non-linear functions.

Unit 3

Introduction to Numerical Methods - Linear algebra, numerical integration and differentiation, solving systems of ODE's and interpolation of data.

Data Visualization and Statistics - Basic statistical tools in Matlab and more advanced data visualization tools (2D and 3D data visualization). Graphics- Basic plotting functions, Creating Mesh and surface plots, Plotting Image Data, basic plotting functions. Creation mesh and surface plots.

Unit 4

Practical applications on climate variability- Generic scripts -Means, STD-Anomalies Correlations-Hofmoeller (ACW)-Time series (SSTA.):detrending filtering-Interpolation regular & irregular grids- EOFs REOFs CEOFs - Spectral analysis -Wavelets -Probability, Density Functions.

Simple Climate Models- Energy balance box- model, ice-albedo feedback with multiple steady states.

Prescribed book:

A guide to matlab: Brian R. Hunt, Ronald L. Lipsman, Jonathan M. Rosenberg. Kevin R. Coombes, John E. Osborn, Garrett J. Stuck”.

Additional book:

An Introduction to Numerical Methods: A MATLAB Approach, Second Edition AbdelwahabKharab (Author), Ronald B. Guenther (Author)

SEMESTER: III

CS 2301 CLIMATE CHANGE, ADAPTATION AND MITIGATION

C

4

,Unit 1: Climate change and variability

Climate change and climate, variability- Global warming and climate change - 4' and Via' Assessment Reports of IPCC- Climate change over India- Impact of Climate change on society (health, water, agriculture, forestry and biodiversity)- Paeleoclimatology (fossil studies, dendroclimatology,pollen grains, and corals) -Theories of Climatic changes - Human impact on climate and potential consequences - Climate predictability-future climate scenarios-global warming and sea level rise- International efforts to minimize climatic change and their impacts.

Unit 2: Weather and climate modification

I Historical reviews of weather and climate modification- present status of weather and climate modification- Types of droughts and impacts - Impact of drought on Indian food grains production - remote sensing and GIS in monitoring droughts- Present status of weather and climate modification- Cloud seeding and artificial rain/hall control- Cyclone modificationModification of microclimates like fog. Meteorological conditions in artificial and controlled climates (Agriculture/Animal Husbandry) - green, plastic, glass and animal houses. Heatevasion and trapping-wind breaks and shelter belts

Unit 3: Adaptation and mitigation to Climate Change

Climate mitigation and adaptation-Green technologies-Reduction in methane emissions-Role of forests and deforestation - conservation agriculture - sustainable agricultural practicesintegrated farming-

rainwater harvesting-Renewable Energy Sources - Energy from Biomass, Types of biogas plants-Agricultural wastes- Liquid Bio fuels- Bio diesel and Ethanol from agricultural produce-Renewable energy sources (Solar energy and Wind energy - Wind farms- Tidal energy and Nuclear energy).

Unit 4: Climate policy and planning

Climate change policy-national and international- Policy making and planning- Indian climate change policy and planning- International treaties/Protocols-Role of UN organizations

Prescribed book:

Understanding and Responding to Climate Change. National Academy of Sciences, USA (2008 edition)

Additional books:

1. Britannica 2010. Earth's Changing Environment.
2. John Houghton 2009 (4th edition) Global Warming - A complete briefing. Cambridge University Press.
3. Gribbin, J. 1979. Climate Change. Cambridge University Press. New York, 280p
4. Prasada Rao, G.S.L.H.V., Rao, G.G.S.N. and Rao, V.U.M. 2010. Climate Change and Agriculture in India. PHI Learning Private Limited. New Delhi, India. 320p
5. Shukla, P.R. Sharma, S.K. and Ramana, P.V. 2002. Climate Change and Issues, Concerns and Opportunities. Tata McGraw-Hill Publishers, New Delhi.

CS 2302 Climate Services

C

4

Unit 1

Introduction to Climate Services - Importance and use of climate information for planning and decision making in socio-economic development and management - Climate services in agriculture, water ,resources, power, transport, construction fisheries. Description of climate and climate projection data resources - Remote sensing and GIS resources - Organization of climate services in India and the world - National weather services and the World Meteorological Organization.

Unit 2

Preparation and organization of climate data - Methodology of forming climate Stability of statistical measures and length of series Homogeneity of Climate Series - data - Meta data - data formats for organized data - statistical methods for analyzing.... series

Unit3

Delineation of territories according to climate - Methodology of climate resource..... and construction of climate resource maps; use of GIS - Various kinds of climate re..... and their suitability for locating different kinds of activities and socio-economic object

Unit 4

Familiarization with the following applications: climate in regional and town pl..... density, orientation, heights, area and distance between residential buildings; consu..... of micro and local climate - Climate information for construction industry; Radiation of the locality; methods of determining radiation received by buildings, duration and of radiation on walls; wind regime, slanting rain and rain fall characteristics, protection of buildings, artificial heating, ventilation and air-conditioning; wind load..... building, return frequency of extreme rainfall, temperature and wind speed in 20, 50,200 years - Climate information for location and operation of hydroelectricity, thermal, nuclear, solar and wind energy plants; methods of measurements and generation of necessary climate information for the sites in the absence of historical data - Climate information for road, rail, inland and coastal water transport and for locating airports - Information on Bio-climatology for health, climate pathology, climate therapy, medical climatology, acclimatisation of humans and animals, pests and weeds; tourism, sports; Climate information for agriculture (including aspects of storage and transport).

Unit 5

Familiarization with basic ideas and techniques on the following as applied to various sectors: Cost of climate information, value of climate information, economic impact of climate information - role of climate information in environmental auditing and green accounting - assessment and measures of accuracy, reliability and usability of climate , advisories.

Prescribed book:

1. Von Storch H, Zwiers FW (1999) Statistical analysis in climate research. Cambridge University Press, Cambridge
2. Wilks S Daniel (2005) Statistical methods in the atmospheric sciences, 2nd edn. International Geophysics series, Academic Press, Oxford
3. Coles, S. (2001) an introduction to statistical modeling of Extreme values. Springer, London. 208 pp.

Additional books:

1. WMO. 2007. Socio-economic Benefits of Meteorological and Hydrological Services ail-id Information: Madrid Action Plan. World Meteorological Organisation: Geneva, Switzerland. [pages/themes/socec/madrid action en.html](http://www.wmo.int/pages/themes/socec/madrid%20action%20plan.en.html).
2. Richard W. Katz and Allan H. Murphy (2005) Economic Value of Weather and Climate Forecasts. Cambridge University Press.
3. Internet resources where textbooks are not modelling.

CS 2303 CLIMATE PROJECTION AND CLIMATE INFORMATICS**C****4**

(Knowledge of the following tools and languages is helpful but not required. Python, Django, R, ArcGIS, MATLAB, Statistical Analysis System and or Java)

Unit I

Global climate model simulations, including dynamical downscaling methods using regions climate models forced by the global climate model simulations

Unit 2

Statistical forecast methods that combined projections of forcing and known modes of natural and internal variability: Statistical/dynamical methods that use elements of both of the previous method

Unit 3

Seamless forecast up to climate scales - Review of approach and modeling systems Simulation models, Historical data

Unit 4

Downscaling.

Unit 5

Climate Models and Climate Data from ICT perspective; Open Climate GIS - GIS for.... climate data; Climate Translator; NetCDF - the most commonly used format for climate.... simulation data; CIM (Common Information Model) - the most commonly used metadata standard for climate models and simulation data, Climate Data sources and analysis tools.

Prescribed book:

Edwards, Paul N. "How Climate Models Work", excerpt from A Vast Machine:

Additional book:

Computer Models, Climate Data, and the Politics of Global Warming (MIT Press, 2010)

CS 2304 CLIMATE SYSTEM MODELLING**C****4****Unit 1**

Climate system: Climate forcings - External cause of climate change - Anthropogenic causes. Greenhouse gases, Troposphere aerosols and clouds - Natural forcings - Volcanic eruptions Ocean circulation changes. Climate feedbacks and climate sensitivity - Ice-albedo feedback mechanism - water vapour Greenhouse effect - Carbon feedback - combining feedback effects

Unit 2

introduction to climate modeling Types of Climate Models - Energy balance climate models, one-dimensional radiative convective models, Dimensionally constrained models, General circulation models. Stable isotopes and interactive biogeochemistry. Sensitivity of climate models: Equilibrium climatic states-stability of model results - Equilibrium conditions and transmissivity of climate systems-Measures of climate model sensitivity.

Unit-3

Parameterisation of climatic processes, Interaction of Statistical forecast methods that combined projections of forcings and known modes of natural internal variability' statistical/dynamical methods that use elements of both of the previous method. Energy balance models (EBM): Planetary radiation budget - Structure of EBM - Zero & One dimensional EBM. Parameters of the climate system for EBM - Albedo-Outgoing wave radiation - Heat transport. EBM and Glacial cycle

Unit 4

models - Zonal box models - Simple Box model of the ocean-atmosphere Coupled system, land and ocean energy balance box model. Deceptively simple EBMs. One-dimensional radiative Convective (1-D RC) models Radiation factors - Convective experiments. Sensitivity experiments with RC models - humidity - clouds - lapse rate. Development of RC Models - Cloud prediction - Model sensitivity. single Column models.