M Tech Earth System Science

Curriculum

Semester I:

Code	Course Title	L	T	P	C
ESE 611	Dynamics of Atmosphere	3	0	0	3
ESE 612	Physical and Dynamical Oceanography	3	0	0	3
ESE 613	Earth Resources and Tectonic Systems	3	0	0	3
ESE 614	Radiation Processes in Atmosphere	3	0	0	3
ESE 615	Atmospheric Thermodynamics and Cloud Physics	3	0	0	3
ESE 631	Observational Technique (Lab)	0	0	3	1
ESE 632	Geology (Lab)	0	0	3	1

Semester II:

Code	Course Title	L	T	P	C
ESE 6XX	Elective I	3	0	0	3
ESE 6XX	Elective II	3	0	0	3
ESE 6XX	Elective III	3	0	0	3
ESE 6XX	Elective IV	3	0	0	3
ESE 6XX	Elective V	3	0	0	3
ESE 641	Lab I	0	0	3	1
ESE 642	Lab II	0	0	3	1
ESE 651	Seminar	0	0	0	2
ESE 652	Comprehensive Viva-Voce	0	0	0	2

Semester III:

Code	Course Title	L	T	P	C
ESE 654	Project (Midterm + Phase I)	0	0	0	14

Semester IV:

Code	Course Title	L	T	P	C
ESE 655	Project (Midterm + Phase II + Thesis)	0	0	0	18

Electives:

Code	Course Title	L	T	P	C
ESE 661	Planetary Atmospheres	3	0	0	3
ESE 662	Numerical Weather Prediction	3	0	0	3
ESE 663	Planetary Geosciences	3	0	0	3
ESE 664	Aerosol-Cloud-Climate Interaction	3	0	0	3
ESE 665	Air-Sea Interaction	3	0	0	3
ESE 666	Satellite Meteorology and Oceanography	3	0	0	3
ESE 667	Boundary Layer Meteorology	3	0	0	3
ESE 668	Polar Science	3	0	0	3
ESE 669	Ionosphere and Space Physics	3	0	0	3
ESE 670	General Circulation and Monsoon	3	0	0	3
ESE 671	Land – Atmosphere Interaction Dynamics	3	0	0	3
ESE 672	Atmospheric and Oceanic Instrumentation and Measurement Techniques	3	0	0	3

Course	Postgraduate
Semester	I
Subject Code	ESE 611
Subject Title	Dynamics of Atmosphere

Syllabus:

Concept of fluid, Continum model, Lagrange and Eulerian description of fluid flow, continuity, momentum and energy equations, boundary layer theory, turbulent flow, Inertial

and Non Inertial frames; Fundamental Forces - Pressure Gradient Forces, Gravitational Force, Friction or Viscous Force, Apparent forces -Centrifugal Force, Coriolis force, Rossby number, Effective Gravity; Hydrostatic balance, Momentum Equations-Cartesian Coordinate System, Spherical – Polar coordinate system. Scale analysis of momentum equations. Balanced motion - Geotropic Wind, Gradient Wind, Inertial flow, Cyclostropic flow, Thermal wind, Continuity equation – Horizontal divergence, Vertical motion. Isobaric coordinate System -Transformation of momentum & continuity equations. Circulation & Vorticity – Kelvins circulation theorem, Bjerknes circulation theorem. Application to Land & Sea breeze.

Vorticity equation. Potential vorticity - Application to Lee of the mountain trough, divergence equation, linear and non-linear balance equations, scale analysis of vorticity and divergence equations for planetary and synoptic scale motions;

Atmospheric waves –sound wave, gravity wave, Rossby wave, Quasi-geostrophic analysis- quasi-geostrophic omega equation,the general circulation- available potential energy,-barotropic instability, baroclinic instability, tropical dynamics

Course	Postgraduate
Semester	I
Subject Code	ESE 612
Subject Title	Physical and Dynamical Oceanography

Syllabus:

Unit I:

Physical properties of Sea water, density of sea water, density parameters, specific volume anomaly, Temperature, Salinity, Cholorinity and their determination, distribution of temperature, salinity and density in space and time, The oceanic Mixed Layer and Thermocline, Sea level variation, acoustical and optical properties of sea water, Formation and classification of water masses, T-S diagram and Water masses of the world ocean.

Waves and Tides: General aspects of ocean waves, Waves and Tides; wave characteristics, wave generation and propagation, Sea and Swell, Deep and Shallow water waves, storm surges and tsunamis; Tides and tide generating forces; their causes, variation, and types, Tidal currents.

Unit II:

Equations of Motion: Dominant Forces for Ocean Dynamics, Coordinate Systems, Types of Flow in the Ocean, Conservation of Mass and Salt, The Total Derivative, Momentum Equation, Conservation of Mass: Continuity Equation, Solutions to the Equations of Motion. Stability in the Ocean, Mixing in the Ocean.

Geostrophic Currents: Hydrostatic Equation, Geostrophic Approximation, Geostrophic Currents, Barotropic and Baroclinic Flow. Response of the Upper Ocean to Winds: Ocean Circulation; Inertial Motion, Ekman Layer and Ekman currents, Ekman Spiral, Vertical circulation, Ekman Transports, Application of Ekman Theory; upwelling and sinking, Thermohaline circulation, Currents in the Ocean, Westward intensification of currents, warm and cold currents of the major world ocean. Seasonal currents in the North Indian Ocean, Deep circulation in the ocean: Importance of the deep circulation, role of the oceans in climate and abrupt climate change, Stommel-Arons' theory of the deep circulation, Antartic Circumpolar Current. Equatorial Processes: Surface and subsurface currents, El Niño/La Niña: The variability of the equatorial currents, El Niño influence global weather.

Course	Postgraduate
Semester	I
Subject Code	ESE 613
Subject Title	Earth Resources and Tectonic Systems

Syllabus:

Internal Structure of Earth:

Introduction to Earth and formation theories. Seismicity and earth's interior. Compositional and Rheological divisions of Earth; crust, mantle and core; discontinuities. Mineralogy and Earth Resources. Minerals, ores, petroleum, coal and natural gas- their origin, structure and composition, accumulation/migration, source/reservoir rocks, distribution in space and time. General physical, chemical and optical properties of common rock forming minerals.

Igneous, Metamorphic and Sedimentary Petrology:

Rock cycles and processes involved; Formation, classification and distribution of volcanoes; partial melting and formation of primary magmas; evolution of magmas; igneous processes.

Sedimentary rocks and environment of formation, sedimentary basins Metamorphic processes, factors and types of metamorphism, grades and facies of metamorphism. Properties and formation mechanisms of common igneous, metamorphic and sedimentary processes. Geologic work of natural agents- atmosphere, wind, water and glaciers

Tectonic Systems:

Concept of continental drift, sea-floor spreading and plate tectonics; tectonics. Nature of plate boundaries: convergent, divergent and transform type. Precambrian and Phanerozoic plate tectonics. Evolution of the Himalayas, Indian Ocean and Andaman's.

Course	Postgraduate
Semester	I
Subject Code	ESE 614
Subject Title	Radiation Processes in Atmosphere

Syllabus:

The spectrum of electromagnetic radiation; Solid angle, Fundamental of radiometric quantities, Concepts of scattering, absorption and polarization of radiation, Quantitative description of radiation; Blackbody Radiation: The Plank Function, Wiens displacement Law, The Stefan-Boltzmann Law; Kirchoff's Law, Radiative equilibrium.

Absorption line profiles: Line formation and line shape, Absorption and emission by gas molecules, Physics of scattering and absorption by particles, Rayleigh Scattering, Raman Scattering, Lorentz-Mie theory of light scattering, Geometric Optics.

Radiative transfer in planetary atmosphere, Equation of radiative transfer, Radiative transfer in a plane parallel atmosphere, Beer-Bouguer Law, Reflection and absorption by a layer of the atmosphere, Absorption and emission of infrared radiation in cloud-free atmosphere, Vertical profiles of radiative heating rate; Earth's radiation budget, the Role of radiation in climate.

Application of radiative transfer to remote sensing of atmospheric properties: Retrieval of meteorological variables, gases, particulate information and surface properties.

Course	Postgraduate
Semester	I
Subject Code	ESE 615
Subject Title	Atmospheric Thermodynamics and Cloud Physics

Syllabus:

Basic concepts, composition of the atmosphere, equation of state, hydrostatic equilibrium, first law of thermodynamics, application of first law, entropy, second law, heat capacity, dry adiabatic processes, transfer processes, moist thermodynamic processes in atmosphere, static stability, cloud characteristics and processes, Global energy and entropy balances, thermodynamic feedback in the climate system, thermodynamic diagrams.

Cloud Physics: Types of clouds, Cloud microphysical processes, growth of cloud droplets, condensation, collision and coalescence, Bergeron-Findeisen theory, rain formation, cold and warm clouds, artificial rainmaking. Effects of Aerosols on Clouds: Cloud Condensation Nuclei, Cloud Droplet Spectra, and Precipitation (Heterogeneous Nucleation of water vapour condensation, Cloud Condensation Nuclei, Development of Cloud Droplet Spectra, Effects of Clouds on Aerosols: Nucleation of Aerosol in and near Clouds.

Course	Postgraduate
Semester	II
Subject Code	ESE 661
Subject Title	Planetary Atmospheres

Syllabus:

Introduction to Planets and Planetary Systems- Orbital motion – Gravitational field that shape the Earth – Internal structure of planet and its satellite, Equation of state, Density profiles, Mass-Radius relationship, The origin and evolution solar system, planetary atmospheres, Elemental abundance, outgassing processes, capture processes, Erosion and escape processes, surface processes – condensation, Adsorption, dissolution, chemical weathering, Atmospheric feedbacks – Observed atmospheric changes in Earth and other planets.

Spectroscopy and composition of planetary atmospheres, Processes causing compositional variations, Vertical temperature structure of Venus, Mars Titan, Jupiter, Uranus and Neptune. Water on Mars, Venus and Jupiter, Thermal tides, Lapse rate, Radiative transfer in planetary atmospheres, Clouds in Planetary atmospheres, Structure of clouds in Venus and Mars, Cloud Microphysics, Dust Dynamics and Storms, The general circulation regimes, Dynamics of Earth, Venus, Mars and other Jovian planets hydrodynamic instabilities, modelling of planetary atmosphere, Climate of Venus, Mars, Mechanism of climate change in Planetary atmospheres, Atmospheres of Exoplanets.

Course	Postgraduate
Semester	II
Subject Code	ESE 662
Subject Title	Numerical Weather Prediction

Syllabus:

Introduction: Numerical Weather Prediction as an Initial Value Problem, Filtering Problem, Finite Difference techniques for various partial differential equations (parabolic, hyperbolic and elliptic), Time integration schemes, Explicit, Implicit, and semi-implicit Schemes.

Consistency and stability [CFL condition], Von Newmann stability analysis for various finite difference schemes, Staggered grid, Nonlinear instability,Arakawa Jacobians, Semi lagrangian methods, Spectral Technique, Galerkin methods, Introduction to Hierarchy of numerical models: Barotropic models, Equivalent barotropic model, Two level baroclinic model, Shallow water model, Primitive equation models, Brief overview of sub-grid scale processes (convection, boundary layer, radiation, land surface), Objective analysis, Initialization schemes, Data assimilation, Variational schemes, Kalman Filter schemes , High resolution regional modelling- Nested grids, Boundary conditions , Ensemble forecasting

Course	Postgraduate
Semester	II
Subject Code	ESE 663
Subject Title	Planetary Geosciences

Syllabus:

Remote Sensing techniques applicable to planetary geology; applications derived from interaction of electromagnetic radiation (X-ray, gamma-ray, visible, near-IR, mid-IR, radar) with geologic materials. Remote sensing applications formineralogy, petrology and geochemical analyses for terrestrial and extraterrestrial environments.

SolarSystem: major concepts, planets, satellites, asteroids, meteorites and comets; formation and internal differentiation of the planets; general features of Terrestrial and Jovian planets.

Planetary atmospheres; exo- and endogenic processes associated with origin and internal evolution of planets – planetary volcanism, craters, impact cratering processes, elemental composition; mineralogy and petrology; thermal, seismic and magnetic properties, and chronological techniques.

Earth as a reference material; geology and geophysics of terrestrial planets: mars, venus and mercury; comparative planetology of Jupiter, Uranus and Saturn and their satellites; physical properties, composition, mineralogy and petrology of the air less rocky bodies: the Moon and its Terrestrial Analogues, Io, Phobos and Deimos, minor bodies such as asteroids, comets, meteor, meteoroid and meteorites.

Past, present and future planetary exploration missions.

Analyses and Interpretation of data gathered through various missions: identification of surface and morphological features, mineralogy and petrology.

Course	Postgraduate
Semester	II
Subject Code	ESE 664
Subject Title	Aerosol-Cloud-Climate Interaction

Syllabus:

Tropospheric Aerosols: Aerosols, Historical understanding of tropospheric aerosols, Contemporary understanding of tropospheric aerosols; Particle Sources and Strengths - widespread surface sources (Biogenic sources, Volcanoes, Ocean and fresh water, Crustal and Cryospheric Aerosols, Biomass burning); Spatial Sources - Gas to particle conversion (Sulfur & Nitrogern - Containing compounds, Organic and Carbonaceous Particles), Cloud as a Source of Aerosols, External Sources; Particle Size Distribution and Chemical Compositions (Polar aerosols, Background aerosols, Maritime aerosols, Remote continental aerosols, Desert dust storm aerosols, Rural aerosols, Urban aerosols); Transport, Geographical Distribution, Residence Time and influence of Clouds, Aerosol Optical Depth; Cloud Optical depth and Effective Particle Radius.

Cloud Physics: Types of clouds, Cloud microphysical processes, growth of cloud droplets, condensation, collision and coalescence, Bergeron-Findeisen theory, rain formation, cold and warm clouds, artificial rainmaking.

Aerosol-Cloud Interaction: Effects of Aerosols on Clouds: Cloud Condensation Nuclei, Cloud Droplet Spectra, and Precipitation (Heterogeneous Nucleation of water vapour condensation, Cloud Condensation Nuclei, Development of Cloud Droplet Spectra, Effect of Aerosol on Development of Precipitation, Stability of CCN population); Aerosol Effects on Cloud Radiative Properties (Effect of Aerosol on Cloud Optical Thickness and Albedo, Effects of Fossil Fuel and Biomass Burning, Ship tracks in Clouds, DMS-Cloud-Climate Hypothesis, Aerosol Effects on Ice in Clouds- Ice Nuclei). Effects of Clouds on Aerosols: Scavenging of Aerosol by Clouds (In-cloud Nucleation Scavenging, Below-Cloud Removal of Aerosol by Precipitation); Chemical Reaction in Clouds and their effects on Aerosol; Acidification of Cloud water and Precipitation; Nucleation of Aerosol in and near Clouds.

Aerosol-Cloud-Climate interaction: direct and indirect radiative forcing; Radiative effects of Clouds on Earth's Climate: Cloud radiative forcing, Radiation budget and Cloud Climatologies, Effects of Clouds on Surface and Atmospheric Energy Budgets.

Course	Postgraduate
Semester	II
Subject Code	ESE 665
Subject Title	Air-Sea Interaction

Syllabus:

The significance of Air-Sea Interaction; Atmospheric and Oceanic Interaction at various scales; Concept of Boundary Layer; Atmospheric Heat Budget; Variations of wind, temperature and moisture over the sea surface. Air sea temperature differences; Wind stress and resultant drag coefficient with variation to wind speed; Upper ocean boundary layer. Oceanic heat budget.

Physical interaction between the Ocean and Atmosphere, Radiation - Solar radiation, Longwave radiation; Heat exchange through latent and sensible heat; The Oceanic heat balance; Oceanic forcing by air-sea exchange of moisture and heat - Moisture exchange, Air-Sea Momentum transfer and drag - Charnock's Law, Sea Surface Roughness, Wind-driven circulation of the Ocean – Ocean Gyres, Ekman flow, Coastal upwelling, upwelling and sinking with special reference to the Indian Ocean, The tropical surface circulation, The Indian Ocean monsoonal circulation, Thermohaline circulation.

Large-scale Air-Sea interaction: Ocean-Atmosphere interaction in the tropics, Genesis and characteristics of ENSO; ENSO and air - sea coupling, Global impact of ENSO, ENSO and the Indian Monsoon.

Course	Postgraduate
Semester	II
Subject Code	ESE 666
Subject Title	Satellite Meteorology and Oceanography

Syllabus:

History of satellite and radar meteorology; Orbits and navigation, Orbit perturbations, Meteorological satellite orbits, Satellite positioning, tracking, and navigation, Space-time sampling, Launch vehicles and profiles; Elements of radiative transfer - Basic quantities, Blackbody radiation, Radiative transfer equation, Gaseous absorption, Scattering, Solar radiation and surface reflection; Meteorological satellite instrumentation - Operational polar orbiting satellites, Operational geostationary satellites, Other satellite instruments, Satellite data archives; Radar - Radar basics, Conventional weather radar, Radar measurements of rainfall, Comparison with satellite rainfall products, NEXRAD system, Applications to hydrology; Image interpretation; Satellite -Visible infrared and water vapor imagery, Spectral properties, Image enhancement techniques, Geo-location and calibration; Doppler radar Doppler wind measurements, reflectivity, Analysis of Doppler measurements, Atmospheric temperature and water vapor profiles, Winds, Clouds and aerosols, Precipitation; Integrated application topics - Hurricanes, Severe Storms, Agriculture Applications. Introduction to satellite remote sensing of the ocean; Propagation and sensing of EM waves and their interaction and scattering with the ocean's surface; Atmospheric absorption and scattering of microwave; visible and infrared radiation; Celestial mechanics for understanding orbital dynamics and geometric distortions; Brief review of electromagnetic wave theory, antenna patterns and ocean surface processes; Detailed survey of major instruments for measuring oceanographic variables from space; Applications of visible, infrared, and microwave observations using objective, multi-spectral, and characteristic vector analysis; Emphasis on new methodologies, error assessments, sampling considerations and data interpretation.

Course	Postgraduate
Semester	II
Subject Code	ESE 667
Subject Title	Boundary Layer Meteorology

Syllabus:

Introduction: definitions and background, variables, wind and flow, turbulent transports; Taylor's hypothesis and observing techniques, boundary layer depth and structure Mathematical and conceptual tools: Turbulence and its spectrum; spectral gap; mean and turbulent parts; basic statistical methods; rules of averaging; turbulent kinetic energy; kinematic flux, eddy flux; stresses. Governing equations for turbulent flow: methodology, basic equations, simplifications and approximations, equations for mean variables in a turbulent flow. Mixed layer theory: mixing and entropy; governing equations, model behavior, surface fluxes and entrainment. Cloud-topped boundary layers: moisture variables; radiative processes, observed structure; governing equations, entrainment. Trade wind boundary layer: mean structure and fluxes; moist convective processes; sub-cloud layer interactions; strato-cumulus to trade cumulus transitions. Deep convection and Marine boundary layer: controls on deep convection; MABL modification by downdrafts; boundary layer recovery; boundary layer modeling and parameterizations.

Course	Postgraduate
Semester	II
Subject Code	ESE 668
Subject Title	Polar Science

Syllabus:

Overview of Polar Geography and Climate; History of Indian Antarctic programme; Physical characteristics; weather and climate, ice coring in Antarctica for Paleo-environment studies, logistics of Antarctic Science, opportunities, Antarctic governance and protection of Antarctic environment, International linkages.

Ice characteristics and physical oceanography of polar seas; Sea ice: types, physical and mechanical properties, heat flux, temporal and spatial distribution, melting and freezing processes, forecasting models, and remote sensing of ice/snow covered surfaces. Physical oceanography of currents and water masses, deep and bottom water formation, fronts and eddies, polynya processes, and underwater acoustics.

Operational aspects of Arctic and Antarctic meteorology, including polar lows, boundary layer and marginal ice zone influences.

Polar oceanography: Sea ice amount, seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions. Physical oceanography of currents and water masses, deep and bottom water formation, fronts and eddies

Course	Postgraduate
Semester	II
Subject Code	ESE 669
Subject Title	Ionosphere and Space Physics

Syllabus:

Unit 1: **Structure and variability of Earth's ionosphere**

Introduction to neutral upper atmosphere and its interaction with solar radiation: Thermal structure of the atmosphere, Heat balance and temperature profile of thermosphere, Dissociation and diffusive separation and thermospheric composition, Exosphere, Solar radiation at the top of the atmosphere, Attenuation of solar radiation in the atmosphere, thermal effect of radiation, photochemical effects of radiation, Airglow

Formation of ionosphere and its processes: Structure of ionosphere, Production of ionospheric layers, Chapman's theory of photoionization, Loss mechanisms and chemistry of ionospheric regions, Transport processes in the ionosphere, Electrical conductivity, plasma diffusion.

Equatorial electrodynamics: E region dynamo theory and Sq current system, Daytime equatorial electrojet, Equatorial ionization anomaly, sporadic E, F region dynamo, spread F, Prereversal enhancement, E region plasma instabilities

Unit 11: **Space Weather**

Geomagnetism: Earth as a magnet: magnetic field of the Earth, Van-Allen radiation belts, Plasmasphere, Magnetosphere, Interaction of Solar wind with the Earth's magnetosphere

Geomagnetic storms: Geomagnetic storms, Geomagnetic indices, Effects of geomagnetic storms on the Earth's upper atmosphere and ionosphere: Electric field and neutral wind disturbances

Implications of Space weather effects: Effect on satellite electronics, satellite charging, satellite drag, heating of the neutral atmosphere, Effect on radiowave propagation, effect on communications and navigational outages

Satellite Based Augmentation Systems (SBAS): Importance SBAS, WAAS, GAGAN

Course	Postgraduate
Semester	II
Subject Code	ESE 670
Subject Title	General Circulation and Monsoon

Syllabus:

Unit I:

Global Circulation: Differential Heating - Latitude variation of radiation balance - Meridional Temperature Gradient; Meridional Heat transport through atmosphere and ocean; Thermal Wind; Jet Stream - Baroclinicity, Angular momentum; Vorticity - Relative Vorticity, Absolute Vorticity, Potential Vorticity, Isentropic Potential Vorticity; Instability - Barotropic Instability & Rossby Waves, Baroclinic Instability & Planetary Waves; Global Winds -General Circulation of the Atmosphere, Single-cell Model, Three-Cell Model, ITCZ; Westerly Winds and the Jet Streams, Brewer Dobson circulation, Quasi-Biennial Oscillations.

Air masses and fronts: Air mass production – Classification – Sources of air masses in winter and summer and their modification. Fronts and frontal surfaces – Principal frontal zones –frontogenesis and frontolysis. Extra-tropical cyclones- formation – Life cycle – Structure and movement. Anticyclones and blocking. Heat and cold waves.

Unit II:

Monsoons (Indian, Australian, African, American): Global perspective of monsoon, CTCZ, ITCZ over Indian ocean – structure and movement, 5-7 day, 30-50 day oscillations (MJO),10-20 day oscillations.

Monsoon rain bearing systems: Monsoon trough/ CTCZ, Depressions, onset vortex,Mechanism of formation, structure and dynamics, monsoon Mesoscale process, seasonal prediction and predictability of monsoon, coupled monsoon system, the role ocean in the life cycle of Indian monsoon system

Monsoon variability: Interannual variability and decadal variability, Teleconnections of India summer monsoon with southern oscillation, El-Nino, La Nina, Indian Ocean dipole mode, NAO, Reversal of monsoon system, winter monsoon.

Tropical Cyclones (Genesis, Intensification, Evolution, Dissipation, Structure, Motion, and forecasts), Thunder storms (CAPE and CINE, Favorable conditions for severe thunderstorms, influence of vertical wind shear, stability indices, Life cycle and structure of Thunderstorm).

Course	Postgraduate
Semester	II
Subject Code	ESE 671
Subject Title	Land – Atmosphere Interaction Dynamics

Syllabus:

Introduction to hydrometeorology, hydrologic and bio geochemical cycles, Water vapour in atmosphere, Vertical gradients in atmosphere, Atmospheric Boundary Layer, Surface Energy balances, Sensible heat flux, Latent heat flux, heat budgets, Plant canopy interactions with the atmosphere. Evaporation, evapotranspiration and their measurements, empirical equations, potential evapotranspiration, Global carbon cycling, Leaf energy fluxes, vegetation dynamics, Canopy processes and Canopy resistance. LAI measurements using satellite remote sensing, Carbon cycle feedback to climate system, Soil vegetation Atmosphere transfer schemes. Introduction to climate system, Land – Climate interactions. Land use Land cover change, Urbanization, Effects on climate system. Application of Satellite remote sensing in LULC changes. Numerical Modelling of Land Atmosphere interaction, Subgrid scale variability of land surface features

Course	Postgraduate
Semester	II
Subject Code	ESE 672
Subject Title	Atmospheric and Oceanic Instrumentation and Measurement Techniques

Syllabus:

Instruments and Measurement Systems: Instrument Response, Measurement Quality, Signal to Noise ratio, Measurement Artifacts, Instrument Response Time, Instrumental Time Resolution, Detection Limit and Sensivity, Sources of Uncertainties, Calibration procedures. Basic statistics, concept of error and uncertainty analysis, Error analysis, probability distribution functions, regression analysis, least square fit, goodness of fit, uncertainties in the fit, propagation of error for a simple linear system. Measurement of meteorological variables: wind, pressure, temperature, humidity, dew point temperature and rain fall, Snow and Rain Sampling Techniques. Radar Principles, Radar equation, Various types of Radar, Estimation of rainfall from weather radar measurements

Lidars: Basic lidar principles, Various types of Lidar, Lidar probing of aerosols and clouds, Principles of Microwave Radiometers for atmospheric probing of temperature and water vapour.

Principles of Visible, IR and Microwave Remote Sensing techniques, satellite orbits and their characteristics, Spectral bands used in satellite remote sensing for aerosols, clouds and water vapour, Satellite observation geometries, determination of solar and satellite zenith angles and relative azimuth, Spectral variation of surface reflectance for different surface types and vegetation, Basic concepts of satellite remote sensing: Instantaneous field of view, pixel resolution, swath, panoramic corrections, ground track, revisit period, orbital precession, Basics of satellite data structure and formats, Levels of data processing, Basic principles for retrieval of geophysical parameters from satellite observations in different spectral bands: estimation of surface reflectance, brightness temperature, detection of clouds, estimation of aerosol optical depth, estimation of cloud top temperature, Principle of GPS technique for measurement of water vapour.

Aerosols: Measurement of aerosol optical properties: aerosol optical depth, scattering coefficient, absorption coefficient, angular scattering measurements, Measurement of aerosol physical and chemical properties: aerosol sampling, Sampling Inlet types and Sampling Efficiency, Sampling and Measurement using Inertial, Gravitational, Centrifugal, and Thermal Techniques, Thermal and Optical Transmittance (TOT) Techniques, Incandescence Methods, Methods for Chemical Analysis of Atmospheric Aerosols, Principles of Ion Chromatography, Mass Spectrometry, Optical and Electrical Mobility Methods for Particle Characterization, Principles of Airborne sampling of Aerosols.

Trace Gases: Chemiluminescence, Photochemical reaction, Chemical Conversion Techniques, Spectroscopic techniques, Satellite Instrumentation for Monitoring Trace Gases.

Clouds: Optical Techniques for the Measurement of Cloud Water Content, Cloud Probes and Imager, Cloud Particle Sampling, Cloud Particle Spectrometer with Depolarization,

Radiation: Measurement of solar radiation, radiance and irradiance, spectral radiance, measurement of shortwave and longwave fluxes, Meaurement of global and diffuse radiative fluxes, principle for converion of satellite measured radiances to fluxes using ADMs.

Oceanic Research Vessels, Expendable Bathythermograph (XBT), Optical and Infrared Imaging and altimeter system, Interferometry Techniques, CTD sonde, Acoustic Doppler Current Profiler (ADCP), Moored and Drifting **Buoys** and Satellite Instrumentation.