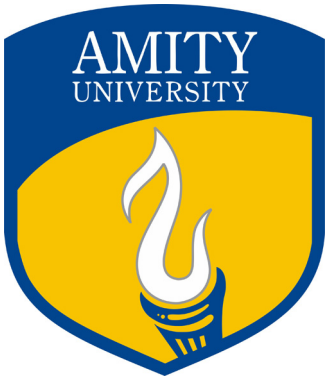
Two Year M.Sc. Program

in

Atmospheric and Environmental Sciences



Amity Centre for Ocean-Atmospheric Science and Technology
Amity University Rajasthan, NH11C, Kant Kalwar,
Jaipur, Rajasthan

AMITY CENTRE FOR OCEAN-ATMOSPHERIC SCIENCE AND TECHNOLOGY

(AMITY COAST)

Two Year M. Sc Program: Atmospheric and Environmental Sciences

Eligibility Criteria: B.Sc. with Physics, Mathematics and Chemistry/Statistics/Computer Science/Geography/Geology/Environmental Science with 50 % of marks in aggregate.

Credit Requirements:

Total	**:**	**112 Credits**
Core Courses (CC)	:	54 Credits
Domain Electives	:	09 Credits
Summer Internship	:	03 Credits
Dissertation	:	25 Credits
Open Electives (OE)	:	06 Credits
Value Added Courses (VA)	:	12 Credits

First Semester

Course Code	Course Title	Category	Hours per week			Total Credits
			L	T	P	
Core Courses (CC)						
MOA101	Atmospheric Physics	CC	3	0	0	3
MOA102	Introduction to Oceanography	CC	3	0	0	3
MOA103	Synoptic Meteorology	CC	3	0	0	3
MOA104	Air pollution Meteorology	CC	3	0	0	3
MOA105	Lab1: Fortran Programming	CC	0	1	4	3
MOA106	Lab2: Synoptic Analysis	CC	0	1	4	3
MOA107	Hydrology	DE	3	0	0	3
Value Added Courses (VA)						
BCS111	Communication Skills-I	VA	1	0	0	1
BSS111	Behavioural Science-I	VA	1	0	0	1
 FLF111 FLG111 FLS111 FLC111	Foreign Languages-I French-I German-I Spanish-I Chinese-I	VA	2	0	0	2
Open Elective (OE)						
		OE	3			3
						28

Second Semester

Course Code	Course Title	Category	Hours per week			Total Credits
			L	T	P	
Core Courses (CC)						
MOA201	Atmospheric Dynamics	CC	3	-	-	3
MOA202	Science of Climate and Climate Change	CC	3	-	-	3
MOA203	Atmospheric Chemistry and Pollution	CC	3	-	-	3
MOA204	Tropical Meteorology	CC	3	-	-	3
MOA205	Lab1: Visualization and Analysis: Climate Data	CC	0	1	4	3
MOA206	Lab2: Programming with MATLAB	CC	0	1	4	3
MOA207	Environmental Risk Assessment	DE	3	0	0	3
Value Added Courses (VA)						
BCS211	Communication Skills-II	VA	1	-	-	1
BSS211	Behavioural Science-II	VA	1	-	-	1
 FLF211 FLG211 FLS211 FLC211	Foreign Languages -II French-II German-II Spanish-II Chinese –II	VA	2	-	-	2
Open Elective (OE)						
		OE	3	-	-	3
						28

Third Semester

Course Code	Course Title	Category	Hrs per week			Total Credits
			L	T	P	
Core Courses (CC)						
MOA301	Earth System Modeling	CC	3	0	-	3
MOA302	Land-Ocean-Atmospheric Interaction	CC	3	0	-	3
MOA303	Urban Environment	CC	3	0	-	3
MOA304	Statistical Methods in Atmospheric Science	CC	3	0	-	3
MOA305	Lab1: Environmental Simulations	CC	0	1	4	3
MOA306	Lab2: Statistical Analysis	CC	0	1	4	3
MOA307	Agricultural Meteorology	DE	3	0	0	3
MOA308	Summer Internship		-	-	-	3
Value Added Courses						
BCS311	Communication Skills-III	VA	1	-	-	1
BSS311	Behavioural Science-III	VA	1	-	-	1
FLF311 FLG311 FLS311 FLC311	Foreign Languages -III French-III German-III Spanish-III Chinese -III	VA	2	-	-	2
Open Elective (OE)						
		OE	3	-	-	3
Total Credits						31

Fourth Semester

Course Code	Course Title	Category	Hrs per week			Total Credits
			L	T	P	
Core Course						
MOA401	Dissertation		-	-	-	25

Students will go to leading Scientific Research organizations, Universities/Institutes for three to five months to pursue their project-based research work during 4th semester. During this period, student will complete major part of experiments/simulation of the dissertation and return to AUR for completion of analysis and writing of the dissertation.

At the end of 4th semester student can be evaluated based on dissertation followed by presentation of their dissertation work.

MOA101: Atmospheric Physics (3-0-0)

Overview of the Earth's Atmosphere: Composition of the Atmosphere, Vertical structure of the atmosphere, weather elements

Thermodynamics of dry and moist air, atmospheric stability and dry adiabatic lapse rate, moist processes in the atmosphere, saturated and unsaturated ascent, moist adiabatic and saturated adiabatic processes in the atmosphere, saturated adiabatic lapse rate, pseudo adiabatic processes and equivalent potential temperature, conditional instability second kind, moist convection, condensation processes, formation of cloud droplets, precipitation.

Radiative transfer in atmosphere and ocean: Sun and climate, Planck function, black-body radiation, local thermodynamic equilibrium, absorption and emission, Schwarzchild's equation, radiative equilibrium in a grey atmosphere, balance between incoming solar and outgoing thermal radiation, role of aerosols, absorption by atmospheric gases, heating rates, net radiative heating, Radiative transfer in atmosphere-ocean system.

Reference Books:

1. Atmospheric Science: An Introductory Survey: J.M Wallace and P.V. Hobbs, 2nd edition, Academic Press, 2006
2. An Introduction to Atmospheric radiation: K.N. Liou 2dn edition Academic Press, 2002

MOA102: Introduction to Oceanography (3-0-0)

Defining Boundaries: Bathymetry and Plate tectonics. Physical properties of seawater: Temperature, Salinity and Conductivity, Density, Sound in the sea, Light in the sea, colour of seawater. Temperature, Salinity and density distributions. Transparency of seawater. T-S Diagram: The Structure of the Ocean, oceanic mixed layer. Heat budget of the oceans: Heat budget terms, Short and Long wave radiation, Evaporation, Heat conduction.

Equation of state of sea water; oceanic mixed layer processes; governing equations for oceanic motions; inertial and geostrophic currents; wind- driven circulation; thermohaline circulation; Barotropic and baroclinic transports; western boundary intensification; gyres and meso-scale eddies; gyre systems

Fundamentals of waves and tides: wave characteristics, wave generation, sea and swell, deep and shallow water waves. Tide producing forces, equilibrium theory and tidal currents. Major currents in world oceans; Indian ocean circulation; seasonal currents in Indian Oceans, Monsoon and Ocean Currents; coastal ocean processes; upwelling and downwelling in coastal and equatorial oceans; Rossby and Kelvin waves, biological productivity of oceans. Climate Variability: An Ocean view.

Reference Books:

1. Pond, S., G.L. Pickard, Introductory Dynamic Oceanography, Butterworth-Heinemann, 1983
2. Olbers, D.J., J. Willebrand, C. Eden, Ocean Dynamics, First edition, Springer, 2012.
3. The Ocean: Ivan Swedrup

MOA103: Synoptic Meteorology (3-0-0)

Synoptic data and collection: Surface and upper air weather data transmission- Code for inland, coastal and ship stations. Upper air data – PILOT and TEMP codes. Station models, Weather charts and analysis.

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.

Kinematics of the pressure field: Characteristic curves – General expressions for their velocity and acceleration – Movement of troughs, ridges and pressure centers, Intensification and Weakening, deepening and Filling of surface pressure systems. Kinematics of the wind field: Relation between streamlines and trajectories. Trajectories in moving cyclones and anticyclones. Differential properties of the wind field. Application of geostrophic, gradient, thermal winds, divergence and vertical velocity computations.

Reference Books:

1. Weather analysis and forecasting – Vol.1 & 2 by B. Patterson
2. Tropical meteorology by H. Riehl.
3. Climate and circulation of the tropics by S. Hasternath.

MOA104: Air Pollution Meteorology (3-0-0)

Air Pollution Meteorology: sources of air pollutants, effects of meteorological parameters on transport and diffusion, classification and air quality standards, stability conditions, meteorological roses, mixing depth, characteristics of stack plumes.

Principles of turbulence and diffusion, Dispersion of pollutants in the atmosphere: A Gaussian dispersion model, dispersion parameters and effective stack height.

Atmospheric Aerosols: sources and characteristics, air pollution weather forecasting, radiative effects and perturbation to climate; Atmospheric air pollutants: sources and impacts. Natural removal processes in the atmosphere

Reference Books:

1. Rao M. N. and Rao H. V. N., Air Pollution, Tata McGraw- Hill Publishing Company Limited, 1989
2. Seinfeld, J.H., and S.N. Pandis, Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, John Wiley and Sons, 1998.
3. Wark K., C. F. Warner and W. T. Davis, Air Pollution, Its Origin and Control, Prentice Hall, 1997

MOA105: Lab1-Fortran Programming (0-1-4)

FORTRAN programming: Characters used in FORTRAN; Fortran constants and variables; Fortran Constants; Fortran Variable names; Type declaration for integers; Arithmetic expressions; Input Output Statements.

Control Statements; Do Statement; Subscripted variables; Format specifications; Subprograms: Functions and Subroutines; Processing files in Fortran; Character manipulation in Fortran; Double precision, Complex quantities; DATA Statement; Implicit Declaration.

1. Calculation of horizontal divergence and vorticity from wind data.
2. Calculation of geostrophic wind, Equivalent potential temperature, Lifting condensation level,
3. Computation of salinity from Chlorinity and density using temperature and salinity.

Reference Books:

1. Introduction to Fortran 90/95 Stephen J. Chapman, Tata McGraw-Hill Publishing Company Limited, New Delhi.
2. Numerical Recipes in Fortran 77: William H. Press, Brian P. Flannery, The Art of Scientific Computing 2nd Edition, Cambridge University Press, New York, USA

MOA106: Lab2-Synoptic analysis (0-1-4)

1. Decoding weather messages of surface and upper air.
2. Plotting of surface and upper air data, preparation of weather chart and analysis.
3. Case studies of cyclones, Monsoon disturbance, western disturbance, break monsoon situation.

Reference Books

1. Weather analysis and forecasting – Vol.1 & 2 by B. Patterson

MOA107 Hydrology (3-0-0)

Introduction to hydrosphere and hydrology, Global climate and the hydrologic cycle, water balance, Precipitation I: meteorology and measurement, Precipitation II: spatial & temporal variability, Effects of climate change on water resources, surface runoff and the water cycle. Precipitation runoff modeling.

Snow I: formation and metamorphism, avalanches, Snow II: snowmelt and energy balance, Water in soils: infiltration and redistribution, Evapotranspiration: physical processes and estimation.

Stream networks and catchment response, Floods and drought, Climate Change and Himalayan Glaciers, Hydrological aspects of Himalayan Glacier. Meteorological Floods and Droughts, Effects of Urban Development on Floods.

Reference Books:

1. S. Lawrence, Dingman, 2002 (re-issued 2008), Physical Hydrology 2nd Ed., Waveland Press, 646 pp.
2. Ward and Trimble, 2004, Environmental Hydrology, 2nd ed. Lewis Publishers, CRC Press. ISBN: 1-56670-616-5

MOA201: Atmospheric Dynamics (3-0-0)

Inertial and Non-Inertial frames- Fundamental Forces-Pressure Gradient Forces, Gravitational Force. Friction or Viscous Force. Apparent forces- Centrifugal Force, Coriolis force, Affective Gravity. Momentum Equations- Cartesian Coordinate System, Spherical – Polar coordinate system. Scale analysis of momentum equations. Hydrostatic approximation. Balanced motion - Geostrophic Wind, Gradient Wind, Thermal wind.

Continuity equation – Horizontal divergence, Vertical motion. Isobaric coordinate System - Transformation of momentum & continuity equations. Circulation &Vorticity – Bjerknes circulation theorem. Application to Land & Sea breeze. Vorticity equation. Potential vorticity - Application to Lee of the mountain trough, CAV Trajectories, Scale analysis of vorticity equation.

Reference Books:

1. An Introduction to Dynamic Meteorology, J. R. Holton.
2. Dynamical and Physical Meteorology, G. J. Haltiner and Martin.

MOA202: Science of Climate and Climate Change (3-0-0)

Scientific foundation of natural and anthropogenic climate change; Introduction to climate models. physical processes that shape climate (e.g. solar variability, orbital mechanics, volcanic and soil aerosols) Impacts of climate change, including sea level change, variations in precipitation, vegetation, storminess, and the incidence of disease, mitigation and adaptation.

Description of the climate system (General circulation, hydrological cycle, carbon cycle). Natural greenhouse effect and the effect of trace gases and aerosols. Forcing's (natural & anthropogenic), Fast and Slow Feedbacks, Equilibrium Climate Sensitivity, Transient Climate Response. Climates of the past (ice ages, proxy records, abrupt climate change, instrumental record of climate) and future climate projections.

Reference Books

1. Climate Modeling Primer by Henderson Sellers and McGuffie
2. Three-Dimensional Climate Modeling by Washington and Parkinson.

MOA203: Atmospheric Chemistry and Pollution (3-0-0)

Historical view of air pollution problems, Atmospheric structure and composition, pressure, Ideal Gas Law, units of atmospheric composition, Atmospheric trace constituents: sulphur-containing, nitrogen-containing, and halogen-containing compounds, ozone.

Atmospheric trace constituents: carbon-containing compounds, water vapor, Simple models, atmospheric lifetime, global meteorology, Chemical kinetics, atmospheric radiation and photochemistry,

Stratospheric ozone chemistry and the Ozone Hole, Urban ozone sensitivity and isopleths. Global ozone.

Reference Books

1. John H. Seinfeld and Spyros N. Pandis, Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, 2nd Edition, 2006, Wiley.
2. Barbara J. Finlayson-Pitts and James N. Pitts, Jr., Chemistry of the Upper and Lower Atmosphere, 1999, Academic Press.
3. Mark Z. Jacobson, Atmospheric Pollution: History, Science, and Regulation, 2002, Cambridge Univ. Press

MOA204: Tropical Meteorology (3-0-0)

Special features of tropics, Pressure and Wind systems of tropics: Low level general circulation, Seasonal variation of surface circulation, world distribution of surface winds and pressures, equatorial trough, lows, highs, depressions, Trade wind inversion and warm pool over Indian Ocean.

Indian Monsoons: Land and sea breezes – Definition of monsoon – Synoptic features of southwest monsoon and north east monsoon, Regional Circulation systems: Easterly waves, Rossby waves, Kelvin waves and Kelvin–Helmholtz waves. Sudden stratospheric warmings.

Global perspective of monsoons, ITCZ over Indian Ocean - Structure and movement, Intra-seasonal oscillation, Interannual and decadal time scales, Atmospheric -Ocean surface patterns of Southern Oscillation, El-Nino, La Nina, ENSO, Indian Ocean dipole mode, Walker circulation, Hadley circulation, Tropical Biennial Oscillation. Tropical cyclones: Formation, movement, life cycle, surface and upper air structures, forecasting, storm surges.

Reference Books

1. Weather analysis and forecasting - Vol.1 and 2 by B. Petterson
2. Tropical Meteorology by H. Riehl
3. Climate and circulation of the tropics by S. Hastenrath
4. Tropical Meteorology Vol 1 and 2 by G.C. Asnani

MOA205: Lab1: Visualization and analysis: Climate Data (0-0-6)

Introduction to Grid Analysis and Display System (GrADS): Preparation of data file format, Data display: line bar graphs, scatter plots, smoothed contours, shaded contours, streamlines, wind vectors, grid boxes, shaded grid boxes, and station model plots. Grads Scripting Language: variables, operators, expressions, functions, intrinsic function

1. Plotting meteogram of various parameters using model output data
2. Visualization of two dimensional meteorological and ocean data.
3. Interpretation and analysis.

Reference Books:

1. GrADS Manual, George Mason University

MOA206: Lab2: Programing with MATLAB (0-1-4)

Introduction to MATLAB, Mathworks resources; MATLAB I/O with NetCDF, HDF and GRIB2; plotting 1, 2 and 3 dimensional weather/climate data with MATLAB; Mean/median/mode, variance/standard deviation, correlation, errors, regression; probability and distributions, how to frame and test a hypothesis, principles of statistical significance, using MATLAB functions working with spatial weather/climate data, regridding meteorological station data, interpolation, map overlays; working with time-series, interpolation, estimating trend in weather/climate variables.

Reference Books:

1. Rudra Pratap, Getting started with MATLAB, 1st Edition, Oxford, 2010.
2. Trauth, M., MATLAB Recipes for Earth Sciences, 3rd Edition, Springer 2010
3. Trauth, M. and E. Sillman, MATLAB and Design Recipes for Earth Sciences, 1st Edition, Springer, 2012

MOA207: Environment Risk Assessment (3-0-0)

Climate Change; Agriculture; Agro-ecosystem; Sustainability Global Agriculture; Environmental Pressures on Agriculture; Response of Agriculture to Rising CO^2 and Climate Change.

Sensitivity of Tropical Agriculture to Climate change; Social Vulnerability and Food Security; Economic Policy Physiological Ecology and Niche Based Responses; Effect of global change in Agricultural Pests; Possible Impacts and Dynamics at Population, Species.

Interactions and Community Level Food Webs. Crop production in Dry-land Region; Soil Organic Matters; Sequestering Soil Carbon; Food Security in Dry-land Areas; Climate Change and Crop production modeling.

Reference Books:

1. Environmental Risk Assessment by Ted Simon
2. Climate Smart Agriculture Editors**:** Lipper**, L.,** McCarthy**, N.,** Zilberman, D., Asfaw, S., Branca, G. (Eds.)

MOA301: Earth System Modeling (3-0-0)

Definition of Climate Models, Simple climate model- 0 – D & 1 – D climate models, Energy balance models and sensitivity studies, Radiative Convective model. Two-dimensional climate model.

General Circulation Climate Models- Dynamics and Physics of General Circulation Climate Model. Coupled ocean-atmosphere system, Regional Climate models, Simple Ocean-Atmosphere coupled models, Model uncertainties.

Reference Books:

1. Numerical models for Ocean circulation – Pond S. and Bryan.
2. Dynamics and modeling of ocean waves – Komen G.J and Cavaleri L.

MOA302: Land-Ocean-Atmospheric Interaction (3-0-0)

Land- Ocean and Atmospheric Interaction at various scales; Concept of Boundary Layer, Ocean – Atmosphere interaction in tropics, Land –Sea breeze,

Physical interaction between the ocean and atmosphere: Radiation, Heat exchange through latent and sensible heat, Oceanic forcing by air-sea exchange of moisture and heat, Momentum transfer and drag.

Oceanic impact on the marine atmospheric circulation. Characteristics of ENSO and the Indian Monsoon warm pool in Indian and Pacific Oceans.

Reference Books:

1. Atmosphere – Ocean Dynamics, Adrian E. Gill, 1992.
2. Air-Sea Interaction Law and Mechanisms by G.T. Csanady.

MOA303: Urban Environment (3-0-0)

Effect of settlement on radiation balance, energy flow, temperature, humidity and wind conditions in surface layers, Urban Meteorological Information and their Needs, Urban Forecasting and Monitoring Capabilities.

Urban environment: A Synopsis of the Science, Advances in Urban Forecasting and Monitoring Techniques, Emerging Technologies in Environmental Forecasting and Monitoring.

Needs and Future Challenges, human energy balance's in relation to the outdoor environment, different thermal indices and thermal comfort, connection between man and climate and behavior application of climate knowledge in urban planning and design. Urban heat island.

Reference Books:

1. The Urban Environment by Ian Douglas
2. Urban Meteorology: Forecasting, Monitoring, and Meeting Users' Needs Edited by The National Academics. (ISBN 978-0-309-38579-4 | DOI 10.17226/13328)

MOA304: Statistical Methods in Atmospheric Science (3-0-0)

Fundamental concepts of statistical methods, Linear correlation, Rank correlation, Partial and multiple correlation. Normal, binomial, gamma, students-t, $\chi 2$ distributions. Multiple linear regression, Principal component analysis, canonical correlation analysis. Error Analysis, Sampling and Test of Hypothesis, Analysis of variance.

Principal component analysis, Empirical orthogonal functions, Fourier transforms, wavelet transforms, fundamentals of signal theory, 1-D and n-D, discrete signals, Probability theory, least-square optimization, regression, non-linear; optimization. Highlighting information in the data: Interpolation; concept of frequency / wave number;

Fourier transform and FFT 1-D and 2-D; spectra and power; spectral density (PSD); Filtering, 1-D and 2-D; applications of filtering, empirical orthogonal functions, Advanced techniques; random transforms, wavelets. Comparing different datasets: Auto and cross-correlation; relationship between correlation and PSD; cross spectra; applications; canonical correlation analysis.

Reference Books:

1. Time Series Analysis and Forecasting" O.D. Anderson (Butterworths Publication)
2. Statistical Methods in the Atmospheric Sciences by D.S. Wilks

MOA305: Lab1: Environmental Simulations (0-0-6)

1. Computation of vorticity using geopotential height: Solution of Laplacian
2. Computation of advection: Solution of Jacobian
3. Relaxation for solution of barotropic vorticity equation
4. Computation of surface fluxes
5. Numerical computation of LCL, moist adiabatic
6. Barotropic Instability and Baroclinic Instability
7. Cyclone track forecasting using Mesoscale models and storm surge models

MOA306: Lab2- Statistical Analysis (0-1-4)

1. Calculation of mean/median/mode, variance/standard deviation
2. Estimation of Correlation, errors, probability density function and distributions
3. Estimation of Model Bias, Threat Score, Test Score
4. Estimation of Multiple regression Equation for Prediction of Ocean and Atmospheric variable
5. Calculation of Principle Component Analysis (PCA)
6. Calculation of Empirical Orthogonal Functions (EOF)

MOA307: Agricultural Meteorology (3-0-0)

Meaning and scope of agricultural meteorology; components of agricultural meteorology; role and responsibilities of agricultural meteorologists. Importance of meteorological parameters in agriculture; weather forecasts for agriculture at short, medium and long-range levels.

Agrometeorological advisories, preparation, dissemination and economic impact analysis; introduction to GIS, GPS and remote sensing; Concept, definition, types of drought and their causes; prediction of drought; crop water stress index and crop stress detection.

Air pollution and its influence on vegetation. Concepts of mechanistic and deterministic models; weather data and phenology-based approaches to crop modeling; validation and testing of models. Global warming and their impact on agriculture; climate classification, agro-climatic zones and agro-ecological regions of India

Reference Books:

1. Agricultural Meteorology by M C Varshney and P Balakrishna Pillai, Indian Council of Agricultural Research, 2004, 221 p, ISBN: 9798171640194
2. Agrometeorology: principles and applications of climate studies in agriculture. Mavi, H.S. and Tupper, G.T. The Haworth Press, Inc., New York, 364 pp.
3. Agriculture Meteorology by G.S.L.H.V. Prasad Rao Publisher: Prentice Hall India Learning Private Limited (2008) ISBN-10: 8120333381ISBN-13: 978-8120333383 Package Dimensions: 23.9

MOA308: Summer Internship (0-0-6)

4th Semester

MOA401: Dissertation

Students will go to leading Scientific Research organizations, Universities/Institutes for three to five months to pursue their project-based research work during 4th semester. During this period, student will complete major part of experiments/simulation of the dissertation and return to AUR for completion of analysis and writing of the dissertation.
At the end of 4th semester student can be evaluated based on dissertation followed by presentation of their dissertation work.