

Agricultural Meteorology

Course Structure – at a Glance

ORGANIZATION OF COURSE CONTENTS & CREDIT REQUIREMENTS

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600-series to Doctoral level. A PhD student must take a minimum of two 600 series courses, but may also take 500-series courses if not studied during Master's programme.
- Credit seminar for Master's level is designated by Code No. 591, and the two seminars for Doctoral level are coded as 691 and 692, respectively.
- Similarly, 599 and 699 codes have been given for Master's research and Doctoral research, respectively.

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not unequivocally exclude other such reference material that may be recommended according to the advancements and local requirements.
- A list of journals pertaining to the discipline is provided at the end which may be useful as study material for 600-series courses as well as research topics.
- E-Resources - for quick update on specific topics/events pertaining to the subject.
- Broad research topics provided at the end would facilitate the advisors for appropriate research directions to the PG students.

Minimum Credit Requirements

Subject	Master's Programme	Doctoral Programme
Major	20	15
Minor	09	08
Supporting	05	05
Seminar	01	02
Research	20	45
Total Credits	55	75
Compulsory Non Credit Courses	PGS-501 to 505	

Major subject: The subject (department) in which the students takes admission.

Minor subject: The subject closely related to students major subject (e.g., if the major subject is Entomology, the appropriate minor subjects should be Plant Pathology & Nematology).

Supporting subject: The subject not related to the major subject. It could be any subject considered relevant for student's research work.

Non-Credit Compulsory Courses: Please see the relevant section for details. Five courses (PGS 501-PGS 505) are of general nature and are compulsory for Master's programme. PhD students may be exempted from these courses if already studied during Master's degree.

**AGM 501 FUNDAMENTALS OF METEOROLOGY AND 2+1 SEM-I
CLIMATOLOGY**

Objective

To impart theoretical and practical knowledge of physical processes occurring in atmosphere and techniques used in meteorology.

Theory

UNIT I

Solar radiation and laws of radiation; greenhouse effect, albedo, and heat balance of the earth and atmosphere; variation of pressure and temperature with height, potential temperature, pressure gradient, cyclonic and anticyclonic motions; geostrophic and gradient winds; equations of motion; general circulation, turbulence, vorticity, atmospheric waves.

UNIT II

Gas laws, laws of thermodynamics and their application to atmosphere; water vapour in the atmosphere, various humidity parameters and their interrelationships; vapour pressure, psychrometric equation, hydrostatic equation, saturation deficit, stability and instability conditions in the atmosphere.

UNIT III

Lapse rates-ascent of dry and moist air, condensation; clouds and their classification; evaporation and rainfall; the hydrological cycle; precipitation processes, artificial rainmaking, thunderstorms and dust storm; haze, mist, fog, and dew; air masses and fronts; tropical and extra-tropical cyclones.

UNIT IV

Effect of earth's rotation on zonal distribution of radiation, rainfall, temperature, and wind; the trade winds, equatorial trough and its movement; the SE Asia monsoon, El Nino, La Nina and ENSO.

UNIT V

Measures of central tendency and dispersion, correlation, regression, moving average probability and their distribution function; synoptic, numerical, graphical, spatial analysis of weather systems and charts technique, thermal and comfort indices.

Practical

- Agromet observatory- different classes of observatories (A, B, C)
- Measurements and calculations of weather parameters.
- Weather chart preparation and identification of pressure systems
- Statistical technique for computation of normals, moving average, Markov chain model etc.

Suggested Readings

- Barry RG & Richard JC. 2003. *Atmosphere, Weather and Climate*. Tailor & Fransics Group.
- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Ghadekar SR. 2001. *Meteorology*. Agromet Publ.
- Mcllveen R. 1992. *Fundamentals of Weather and Climate*. Chapman & Hall.
- Petterson S. 1958. *Introduction to Meteorology*. McGraw Hill.
- Trewartha Glenn T. 1954. *An Introduction to Climate*. McGraw Hill.

**AGM 502 FUNDAMENTALS OF AGRICULTURAL
METEOROLOGY**

2+1 SEM-I

Objective

To impart the theoretical and practical knowledge of physical processes occurring in relation to plant and atmosphere with advanced techniques.

Theory

UNIT I

Meaning and scope of agricultural meteorology; components of agricultural meteorology; role and responsibilities of agricultural meteorologists.

UNIT II

Importance of meteorological parameters in agriculture; efficiency of solar energy conversion into dry matter production; meteorological factors in photosynthesis, respiration and net assimilation; basic principles of water balance in ecosystems; soil-water balance models and water production functions.

UNIT III

Crop weather calendars; weather forecasts for agriculture at short, medium and long range levels; agromet advisories, preparation, dissemination and economic impact analysis; introduction to GIS, GPS and remote sensing; use of satellite imageries and synoptic charts in weather forecasting; meteorological aspects of forest fires and their control

UNIT IV

Concept, definition, types of drought and their causes; prediction of drought; crop water stress index, crop stress detection; air pollution and its influence on vegetation.

UNIT V

Concepts of mechanistic and deterministic models; general features of dynamical and statistical modeling techniques; weather data and phenology-based approaches to crop modeling; validation and testing of models.

UNIT VI

Climatic change, green house effect, CO₂ increase, global warming and their impact on agriculture; climate classification, agro-climatic zones and agro-ecological regions of India and Haryana.

Practical

- Preparation of crop weather calendars
- Development of simple regression models for weather, pest and disease relation in different crops.
- Working with dynamic and simulation models.
- Preparation of weather based agro-advisories.

Suggested Readings

- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
Critchfield HJ. 1995. *General Climatology*, Prentice Hall of India.
Kakde JR. 1985. *Agricultural Climatology*. Metropolitan Book Co.
Mavi HS and Tupper GJ. 2004. *Agrometeorology: Principle and Application of climate Studies in Agriculture*. Haworth Press.
Variraju R and Krishnamurthy. 1995. *Practical Manual on Agricultural Meteorology*. Kalyani Publishers, Ludhiana.
Varshneya MC & Pillai PB. 2003. *Text Book of Agricultural Meteorology*. ICAR.

AGM 503

MICROMETEOROLOGY

2+1

SEM-II

Objective

To impart the theoretical and practical knowledge of physical processes occurring in lower atmosphere.

Theory

UNIT I

Properties of atmosphere near the earth's surface; exchange of mass momentum and energy between surface and overlaying atmosphere, exchange coefficients, similarity hypothesis, shearing stress, forced and free convection.

UNIT II

Molecular and eddy transport of heat, water vapour and momentum, frictional effects, eddy diffusion, mixing length; temperature instability; microclimate near the bare ground, unstable and inversion layers, soil moisture and temperature variation with depth; Richardson number, Reynold's analogy

UNIT III

Micrometeorology of plant canopies; distribution of temperature, humidity, vapour pressure, wind and carbon dioxide; modification of microclimate due to cultural practices, intercropping; radiation distribution and utilization by plant communities, leaf temperature and its biological effects; concepts of evapotranspiration and its estimation approaches

UNIT IV

Influence of topography on microclimate; shelter belts and wind breaks, microclimate in crop fields, forests, glass and plastic houses

Practical

- Micrometeorological measurements in crop canopies
- Determination of ET by different methods

Suggested Readings

- Arya S Pal. 1988. *Introduction to Micrometeorology*. Academic Press.
- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Gates DM. 1968. *Energy Exchange in the Biosphere*. UNESCO.
- Goudriaan J. 1983. *Crop Micrometeorology: A Simulation Study*. Scientific Publ.
- Grace J. 1983. *Plant Atmospheric Relationships: Outline Studies in Ecology*. Chapman & Hall.
- Gupta PL & Rao VUM. 2000. *Practical Manual on Micrometeorology*. Dept. of Agril. Meteorology, CCS HAU Hisar, India.
- Jones HG. 1992. *Plants and Microclimate*. Cambridge Univ. Press.
- Munn RE. 1970. *Biometeorological Methods*. Academic Press.
- Rosenberg NJ. 1974. *Microclimate – The biological Environment*. John Wiley & Sons.
- Sellers W. 1967. *Physical Climatology*. The University of Chicago Press.

**AGM 504 AGRO-MET INSTRUMENTATION
AND MEASUREMENTS**

1+2 SEM-II

Objective

To impart the theoretical and practical knowledge of instruments/equipments used for measurement of agro-meteorological variables.

Theory

UNIT I

Fundamentals of measurement techniques; exposure and operation of meteorological instruments/ equipments in agromet observatories; theory and working principles of barometers, thermometers, psychrometers, hygrometer, thermo-hygrograph.

UNIT II

Radiation and temperature instruments: working principles of albedometer, photometer, spectro-radiometer, sunshine recorder, quantum radiation sensors, thermographs, and infra-red thermometer.

UNIT III

Precipitation, dew and wind instruments: working principles of rain gauge, self recording rain gauge, Duvdevani dew gauges, anemometer, wind vane, anemograph.

UNIT IV

Evapotranspiration and photosynthesis instruments: working principles of lysimeters, open pan evaporimeters, porometer, photosynthesis system, leaf area meter, pressure bomb apparatus.

UNIT V

Soil thermometers, soil heat flux plates, instruments for measuring soil moisture.

UNIT VI

Automatic weather station – data logger and sensors, nano-sensors for measurement of weather variables; computation and interpretation of data.

Practical

- Working with the above instruments
- Computation and interpretation of the data

Suggested Readings

Anonymous. 1987. *Instructions to Observers at Surface Observatories*. Part I, IMD, New Delhi.

Byers HR. 1959. *General Meteorology*. McGraw Hill.

Ghadekar SR. 2002. *Practical Meteorology: Data Acquisition Techniques, Instruments and Methods*. Agromet Publ.

Middleton WE & Spilhaws AF. 1962. *Meteorological Department*. University of Toronto Press.

Tanner CB. 1973. *Basic Instrumentation and Measurements for Plant Environment and Micrometeorology*. University of Wisconsin, Madison.

AGM 505 SOIL WATER BALANCE CLIMATOLOGY 2+1 SEM-II
Objective

To impart the theoretical and practical knowledge of soil water balance and its components

Theory

UNIT I

Basic Laws of radiation; radiation interaction with plant environment; energy balance in atmosphere, crop canopy.

UNIT II

Atmosphere near the ground; laminar and turbulent flows; wind profile near the ground.

UNIT III

Theories of evapotranspiration and their comparison; aerodynamic, eddy correlation, energy balance, water balance and other methods, their application under different agroclimatic conditions; concepts of potential, reference and actual evapotranspiration; modified techniques.

UNIT IV

Influence of microclimate, plant, soil and cultural factors on ET; techniques of lysimetry in measuring actual evapotranspiration.

UNIT V

Crop coefficients; irrigation scheduling based on evapotranspiration; water use efficiency and its management, dry matter, yield-ET functions; estimation of evapotranspiration through satellite imageries – MODIS, TERRA, AQUA, AVHRR, NOVA etc.

Practical

- Measurement and evaluation of radiation components
- Measurement of wind and temperature profiles near the ground
- Computation and comparison of evapotranspiration by different methods - energy balance method, aerodynamic method, Penman method, remote sensing and other methods

Suggested Readings

- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Burman R & Pochop LO. 1994. *Evaporation, Evapotranspiration and Climatic Data*. Elsevier.
- Grace J.1983. *Plant Atmospheric Relationships: Outline Studies in Ecology*. Chapman & Hall.
- Mavi HS & Graeme J Tupper 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.
- Murthy VRK. 2002. *Basic Principles of Agricultural Meteorology*. BS Publ.
- Ram Niwas, Diwan Singh & Rao VUM. 2000. *Practical Manual on Evapotranspiration*. Dept. of Agril. Meteorology, CCS HAU Hisar.
- Rosenberg NJ, Blad BL & Verma SB. 1983. *Microclimate – The Biological Environment*. John Wiley & Sons.

**AGM 506/
AGRON 603**

**CROP PRODUCTION AND
SYSTEM MODELING**

1+2

SEM-II

Objective

To impart the theoretical and practical knowledge of various models for estimation of crop responses.

Theory

UNIT I

Principles of crop production; evaluation of crop responses to weather elements; impact of natural and induced variability of climate on crop production.

UNIT II

Systems classification; flow charts, modeling techniques and methods of integration - state, rates and driving variables, feedbacks and relational.

UNIT III

Potential production: leaf and canopy CO₂ assimilation, respiration, dry matter accumulation, crop phenology and dry matter distribution and development in different crops.

UNIT IV

Empirical and statistical crop weather models, their application with examples; regression models- incorporating weather, soil, plant and other environmental related parameters and remote sensing inputs; growth and yield prediction models; crop simulation models, e. g. CERES, WOFOST, SPAW, RESCAP, WTGROW etc.; verification, calibration and validation of models; models for forecasting of pests and diseases.

Practical

- Simulation of elementary models for crop growth
- Simulation of potential production
- Simulation with limitations of water and nutrient management options
- Sensitivity analysis using different climatic years and crop management Practices
- Working with statistical and simulation models, DSSAT models, BRASSICA, RESCAP etc.

Suggested Readings

DeWit CT, Brouwer R & de Vries FWTP. 1970. The Simulation of Photosynthetic Systems. pp. 7-70. In: *Prediction and Measurement of Photosynthetic Activity*. Proc. Int. Biological Programme Plant Physiology Tech. Meeting Trebon PUDOC. Wageningen.

Duncan WG. 1973. SIMAI- A Model Simulating Growth and Yield in Corn. In: *The Application of Systems Methods to Crop Production* (D.N. Baker, Ed.). Mississippi State Univ. Mississippi.

Gordan G. 1992. *System Simulation*. 2nd Ed. Prentice Hall.

Keulen H Van & Seligman NG. 1986. *Simulation of Water Use, Nitrogen Nutrition and Growth of a Spring Wheat Crop*. Simulation Monographs. PUDOC, Wageningen.

Ritchie JT & Hanks J. 1991. *Modelling Plant and Soil Systems*. American Society of Agronomy, Madison.

Zeigler BP. 1976. *Theory of Modeling and Simulation*. John Wiley & Sons.

AGM 507/ **WEATHER MODIFICATION AND RISK** **2+0** **SEM-I**
FSC 513 **MANAGEMENT STRATEGIES**

Objective

To impart the theoretical and practical knowledge of weather modification techniques with risk management strategies.

Theory

UNIT I

Historical reviews and theories of weather modification, present status of weather modification for agriculture; horticulture; atmospheric composition and green house effect.

UNIT II

Scientific advances in clouds and electrical behavior of clouds; hails suppression, dissipation of fog, modification of frost intensity and severe storms; shelter belts and wind breaks, mulches and anti-transpirants; protection of plants against climatic hazards; air and water pollution; meteorological conditions in artificial and controlled climates - green, plastic, glass and animal houses etc.

UNIT III

Risk characterization - definitions and classification of risks; characterization of weather and climate related risks in agriculture and horticulture in the region concerned; water related risks; radiation/heat related risks; air and its movement related risks; biomass related risks; social and economic risk factors related to weather and climate.

UNIT IV

Approaches, tools and strategies to deal with risks; Methods for weather and climate related risk assessments; mitigating practices before occurrence; preparedness for the inevitable; contingency planning and responses; disaster risk mainstreaming.

UNIT V

Perspectives for farm applications - farm applications not yet dealt with, such as making risk information products more client friendly and transfer of risk information products to primary and secondary users of such information; challenges for developing coping strategies including transferring risks through insurance schemes; application of methods that permit the incorporation of seasonal and long-term forecasts into the risk assessment models.

Suggested Readings

Anonymous 2003. *Critical Issues in Weather Modification Research Board of Atmospheric Science and Climate*. National Research Council, USA.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Chritchfield HJ. 1994. *General Climatology*. Prentice Hall.

Lenka D. 1998. *Climate, Weather and Crops in India*. Kalyani.

Mavi HS & Graeme J Tupper 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.

Rosenberg NJ, Blad BL & Verma SB. 1983. *Microclimate – The Biological Environment*. John Wiley & Sons.

Samra JS, Pratap Narain, Rattan RK & Singh SK. 2006. *Drought Management in India*. Bull. Indian Society of Soil Science 24, ISSS, New Delhi.

AGM 508 PRINCIPLES OF REMOTE SENSING AND 2+1 SEM-II
ITS APPLICATIONS IN AGRICULTURE

Objective

To impart the theoretical and practical knowledge of remote sensing principles and their use to estimate of agro-meteorological variables.

Theory

UNIT I

Basic components of remote sensing- signals, sensors and sensing systems; active and passive remote sensing.

UNIT II

Characteristics of electromagnetic radiation and its interaction with matter; spectral features of earth's surface; remote sensors in visible, infrared and microwave regions.

UNIT III

Imaging and non-imaging systems; framing and scanning systems; resolution of sensors; sensor platforms, their launching and maintenance.

UNIT IV

Data acquisition system, data processing, storage and dissemination; digital image processing and information extraction.

UNIT V

Microwave remote sensing; visual and digital image interpretation; introduction to GIS and GPS.

UNIT VI

Digital techniques for crop discrimination and identification; crop stress detection - soil moisture assessment, inventory of ground water and satellite monitoring of crop disease and pest infestation.

UNIT VII

Soil resource inventory; land use/land cover mapping and planning; integrated watershed development; crop yield modeling and crop production forecasting.

Practical

- Acquisition of maps, • Field data collection, • Map and imagery scales
- Software and hardware requirements and specifications for remote sensing
- Data products, their specifications, media types, data inputs, transformation, display types, image enhancement, • Image classification methods
- Evaluation of classification errors, • Crop discrimination and acreage estimations
- Differentiation of different degraded soils, • Time domain reflectometry
- Use of spectrometer and computation of vegetation indices
- Demonstration of case studies

Suggested Readings

- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Colwell RN. (Ed.). *Manual of Remote Sensing*. Vols. 1, II. Am. Soc. Photogrammetry, Virginia.
- Curan PJ. *Principles of Remote Sensing*. ELBS/Longman.
- Georg Joseph 2005. *Fundamentals of Remote Sensing*. University Press (India).
- Narayan LRA. 1999. *Remote Sensing and its Applications*. Oscar Publ.
- Patel AN & Surender Singh 2004. *Remote Sensing: Principles and Applications*. Scientific Publ.

AGM 509 APPLIED AGRICULTURAL CLIMATOLOGY 1+2 SEM-I

Objective

To impart the theoretical and practical knowledge of computation of different bioclimatic parameters and their applications in the agriculture.

Theory

UNIT I

Climatic statistics: measures of central tendency and variability, skewness, kurtosis, homogeneity, correlation, regression and moving averages; probability analysis using normal, binomial, Markov-chain and incomplete gamma distribution; parametric and non parametric tests; assessment of frequency of disastrous events.

UNIT II

Hydrological cycle: precipitation intensity, evaporation, infiltration, runoff, soil storage and hydrological balance.

UNIT III

Climatic water budget: potential and actual evapotranspiration and their computation; measurement of precipitation, calculation of water surplus and deficit; computation of daily and monthly water budget and their applications; assessment of dry and wet spells, available soil moisture, moisture adequacy index and their applications.

UNIT IV

Thermal indices and phenology: cardinal temperatures; heat unit and growing degree day concepts for crop phenology, crop growth and development; insect-pest development; crop weather calendars; agroclimatic requirement of crops.

UNIT V

Bioclimatic concepts: evaluation of human comfort, comfort indices (temperature, humidity index and wind chill) and clothing insulation; climate, housing and site orientation; climatic normals for animal production.

Practical

- Use of statistical approaches in data analysis
- Preparation of climatic water budget
- Estimation of agroclimatic indices using historical records
- Degree day concept and phenology forecasting and preparation of crop calendar
- Evaluation of radiation, wind and shading effects in site selection and orientation
- Study of weather-pest and disease interactions, calculation of continentality factors; calculation of comfort indices and preparation of climograph.

Suggested Readings

Anonymous 1980. *ICRISAT Climatic Classification – A Consultation Meeting*. ICRISAT.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Lal DS. 1989. *Climatology*. Chaitanya Publ. House.

Mather JR. 1977. *Work Book in Applied Climatology*. Univ. of Delaware, New Jersey.

Mavi HS & Tupper Graeme J. 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.

Raj Singh, Diwan Singh & Rao VUM. 2006. *Manual on Applied Agricultural Climatology*. Dept of Agril Meteorology, CCS HAU Hisar, India.

Thompson R. 1997. *Applied Climatology: Principles and Practice*. Routledge.

Walter J Saucier 2003. *Principles of Meteorological Analysis*. Dover Phoenix Eds.

**AGM 601 CLIMATE CHANGE AND
SUSTAINABLE DEVELOPMENT**

2+1 SEM-I

Objective

To impart the theoretical and practical knowledge of climate change and their sources.

Theory

UNIT I

Climate change and global warming: definitions of terms; causes of climate change and global warming; greenhouse gases, ozone depletion; past records, present trends, extreme weather events and future projections; astronomical predictions: lunar cycle, sunspot cycle, solar-lunar tides, Chandlers compensation, blocking highs.

UNIT II

Impacts of climate change on various systems: impacts resulting from projected changes on agriculture and food security; hydrology and water resources; terrestrial and freshwater ecosystems; coastal zones and marine ecosystems; human health; human settlements, energy, and industry; insurance and other financial services; climate change and crop diversification, loss of biodiversity, microbes and pest dynamics; climate change and storage, climate change and weed management.

UNIT III

Sensitivity, adaptation and vulnerability: system's sensitivity, adaptive capacity and vulnerability to climate change and extreme weather events; regional scenarios of climate change and variability.

UNIT IV

Mitigation strategies for sustainable development: international policies, protocols, treaties for reduction in greenhouse gases and carbon emissions; carbon sequestration; carbon credit; clean development mechanism (CDM) and land use, land use change and forestry mechanism, alternate energy sources etc.

UNIT V

Agricultural food security: reduction in carbon and GHG emission; fuel conservation and reduction in energy use, conservation tillage, biofuels for fossil fuels, reduction in machinery use etc; increasing carbon sinks; resource conservation technologies, mixed rotations of cover and green manure crops, minimization of summer fallow and no ground cover periods etc.

Practical

- Case studies on various climatic projections and consequences thereof in relation to agriculture
- Advance methodology of assessing the impact of climate change on crops

Suggested Readings

Anonymous. *Clean Development Mechanism: Building International Public-Private Partnership under Kyoto Protocol*. UNEP, UNDP Publ.

Anonymous. *IPCC Assessment Reports on Climate Change (2001, 2007)*. WMO, UNEP Publ.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Jepma CJ & Munasinghe M. 1998. *Climate Change Policy: Facts, Issues and Analysis*. Cambridge Univ. Press.

Mintzer IM. 1992. *Confronting Climate Change: Risks, Implications and Responses*. Cambridge Univ. Press.

AGM 602

WEATHER FORECASTING

2+1

SEM-II

Objective

To impart theoretical and practical knowledge of forecasting techniques used for weather prediction and preparation of agro-advisories.

Theory

UNIT I

Weather forecasting system: definition, scope and importance; types of forecasting: short, medium and long-range; study of synoptic charts with special reference to location of highs and lows, jet streams, synoptic features and weather anomalies and zones of thermal advection and interpretation of satellite pictures of clouds in visible and infra-red range; weather forecasting network.

UNIT II

Approaches for weather forecasts: methods of weather forecasts - synoptic, numerical prediction, statistical, analogue, persistence and climatological approach, nano-technological approach, Indigenous Technical Knowledge (ITK) base- signals from flora, fauna, insects, birds, animals behavior; various methods of verification of location-specific weather forecast.

UNIT III

Weather based advisories: interpretation of weather forecasts for soil moisture, farm operations, pest and disease development and epidemics, crops and livestock production; preparation of weather-based advisories and dissemination.

UNIT IV

Special forecasts: special forecasts for natural calamities such as drought, floods, high winds, cold (frost) and heat waves, hail storms, cyclones and protection measures against such hazards.

UNIT V

Modification of weather hazards: weather modification for agriculture; scientific advances in artificial rain making, hail suppression, dissipation of fog and stratus clouds, modification of severe storms and electric behavior of clouds.

Practical

- Exercise on weather forecasting for various applications
- Preparation of weather-based agro-advisories based on weather forecast using various approaches and synoptic charts.

Suggested Readings

Alan Watts 2005. *Instant Weather Forecasting*. Water Craft Books.

Ram Sastry AA. 1984. *Weather and Weather Forecasting*. Publication Division, GOI, New Delhi.

Singh SV, Rathore LS & Trivedi HKN. 1999. *A Guide for Agrometeorological Advisory Services*. Department of Science & Technology, NCMRWF, New Delhi.

Wegman & Depriest 1980. *Statistical Analysis of Weather Modification Experiments*. Amazon Book Co.

AGM 603 AIR POLLUTION METEOROLOGY 2+1 SEM-I
Objective

To impart the theoretical and practical knowledge of air pollution.

Theory

UNIT I

Introduction to air pollution- history, definition: clean air definition; natural versus polluted atmosphere; atmosphere before the industrial revolution.

UNIT II

Sources of air pollution; classification and properties of air pollutants; emission sources, importance of anthropogenic sources; behaviour and fate of air pollutants; photochemical smog; pollutants and trace gases.

UNIT III

Meteorological factors in the dispersion of air pollutants; topographical, geographical and large scale meteorological factors attached air pollution; meteorological conditions and typical plume forms; air pollution forecasting – Gaussian diffusion models, Numerical dispersion models.

UNIT IV

Air quality standards; effect of air pollution on biological organisms; ozone layer depletion; air pollution control technologies; management of air pollution; principles of diffusion of particulate matter in the atmosphere; air pollution laws and standards.

UNIT V

Air pollution sampling and measurement: types of pollutant sampling and measurement, ambient air sampling, collection of gaseous air pollutants, collection of particulate pollutants, stock sampling; analysis of air pollutants - sulfur dioxide, nitrogen dioxide, carbon monoxide, oxidants and ozone, hydrocarbons, particulate matter.

UNIT VI

Scales of air pollution: local, urban, regional, continental and global.

Practical

- Measurement of different air pollutants
- Measurement of visibility
- Measurement of ozone and Aerosol Optical Thickness (AOT)
- Study of temperature profile at different heights for determination of stability of the atmosphere
- To determine height of partial flume through chimani
- To study the effect of temperature on vegetables, orchards and agricultural crops

Suggested Readings

- Arya SP. 1998. *Air Pollution Meteorology and Dispersion*. Oxford Univ. Press.
Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
Chhatwa GR. 1989. *Environmental Air Pollution and its Control*. Anmol Publ.
Mishra PC. 1990. *Fundamentals of Air and Water Pollution*. Ashish Publ.
Mudd J Brian & Kozlowski TT. (Ed.). 1975. *Responses of Plants to Air Pollution*. Academic Press.
Weber E. 1982. *Air Pollution Assessment Methodology and Modeling*. Plenum Press.
Yunus M & Iqbal M. (Eds.). 1996. *Plant Response to Air Pollution*. John Wiley & Sons.

AGM 604 WEATHER, CLIMATE AND LIVESTOCK 2+1 SEM-II

Objective

To impart the theoretical and practical knowledge of weather, climate for livestock management.

Theory

UNIT I

Thermal balance in animals; energy exchange processes at the skin of the animals and the need for the maintenance of thermal balance in the animals.

UNIT II

Effects of weather on animal production, loss of water from the body, growth rate and body weight, reproduction, grazing habit, food intake, milk production, sun burns and photosensitive disorders.

UNIT III

Meteorological conditions prevailing in animal shed, poultry house and grain storage barns; heating, cooling and ventilation of these structures as governed by meteorological factors.

UNIT IV

Weather and animal diseases and parasites; diseases of poultry and its relation with weather and thermal comfort.

UNIT V

Management of livestock to reduce greenhouse gas emission.

Practical

- Measurement of temperature, humidity, net radiation
- Calculation of animal comfort zone index
- Radiation of animal farm house and body
- Estimation of energy fluxes on body
- Measurements of CO₂ and methane in animal farm house

Suggested Readings

Kaiser HM & Drennen TE. (Eds). 1993. *Agricultural Dimensions of Global Climate Change*. St. Lucie Press, Florida.

Monteith L & Unsworth M. 2007. *Principles of Environmental Physics*. 2nd Ed. Academic Press.

Takahashi J, Young BA, Soliva CR & Kreuzer M. 2002. *Greenhouse Gases and Animal Agriculture*. Proc. 1st International Conference on Greenhouse Gases and Animal Agriculture.

Tromp SW. 1980. *Biometeorology. The Impact of the Weather and Climate on Humans & their Environment. (Animals & Plants)*. Heyden & Son Ltd.

AGM 605 ANALYTICAL TOOLS AND METHODS FOR 2+1 SEM-I
AGRO-METEOROLOGY

Objective

To impart the theoretical and practical knowledge of new tools for analysis of agro-climatic features.

Theory

UNIT I

Review of agro-climatic approaches; characterization of agroclimatic elements; sampling of atmosphere; temporal and spatial considerations; micro-meso-macro climates.

UNIT II

Network spacing; spatial and temporal methods; GIS fundamentals and applications; numerical characterization of climatic features; crop response to climate, time lags, time and distance constants, hysteresis effects.

UNIT III

Influence of climate on stress-response relations; thermal time approach in agroclimatology - heat and radiation use efficiency in crop plants; applications to insect-pest development and prediction; comfort indices for human and animals; impact of natural and induced variability and change of climate on crop production.

UNIT IV

Instrumentation and sampling problems; design of agro-meteorological experiments.

UNIT V

Basic knowledge of application of computers in agriculture; theories of computer language BASIC, FORTRAN, C, C++ and Visual basic.

UNIT VI

Empirical and statistical crop weather models and their application with examples; incorporating weather, soil, plants and other environment related parameters as subroutine and remote sensing inputs in models; growth and yield prediction models; crop simulation models; forecasting models for insects and diseases.

Practical

- Calculation of continentality factors, • Climatic indices and climogram.
- Agrometeorological indices: Degree-days, photothermal units, heliothermal units, phenothermal index, • Crop growth rates.
- Analysis of thermogram, hygrogram, hyetogram, sunshine cards etc. stream lines and wind roses and statistical analysis of climatic data.
- Working with statistical models: crop yield forecasting, crop weather relationship and insect & disease forecasting models.
- Working with crop simulation models
- Small programme writing in computer languages like BASIC, FORTRAN, C, C++ and Visual basic, • Geographical Information System.

Suggested Readings

- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
Cooper M. 2006. *The Spirit of C. An Introduction to Modern Programming*. Jaico Publ.
Malczewski J. 1999. *GIS & Multicriteria Decision Analysis*. John Wiley & Sons.

AGM 606 STRATEGIC USE OF CLIMATIC INFORMATION 2+1 SEM-II

Objective

To impart theoretical & practical knowledge of climatic hazards and their mitigations.

Theory

UNIT I: Increasing awareness on potential climate hazards and mitigations: history of climate-related disasters (hazards and vulnerabilities) suffered in the concerned continent/region / country/sub-region and their documented or remembered impacts; hazards and their relation to agricultural production risks (intra- and inter-annual); efforts made in protection mitigating impacts of (future) disasters (prevention); trends discernable in occurrence and character of disasters, if any.

UNIT II: Selection of appropriate land use and cropping patterns: present land use and cropping patterns in the continent/region/country/sub-region concerned as related to environmental issues; outlook for present land use and cropping patterns and possible alternatives from an environmental point of view.

UNIT III: Preparedness strategies in agricultural production; preparedness for meteorological disasters in development planning; permanent adaptation strategies that reduce the vulnerabilities to hazards; preparedness as a coping strategy.

UNIT IV: Making more efficient use of agricultural inputs: agro-meteorological aspects of agricultural inputs and determination of input efficiencies; other factors determining inputs and input efficiency of the region.

UNIT V: Selection of livestock management: livestock management patterns in the continent/region/country/sub-region concerned as related to environmental issues; outlook for present livestock management strategies and possible alternatives from an environmental point of view; recent trends in livestock management strategies.

UNIT VI: Adoption of microclimate modification techniques: microclimate modification techniques practiced in the continent/country/sub-region concerned; possible improvements in adoption of microclimate modification techniques, in view of climate variability and climate change; local trends in adoption of such techniques.

Practical

- Outlook for present land use and cropping patterns and possible alternatives from environmental point of view, • Recent trends in land use and cropping patterns
- Agro-meteorological services to increase farmers design abilities of land use and cropping patterns, • Systematic and standardized data collection on protection measures against extreme climate

Suggested Readings

Anonymous. *Clean Development Mechanism: Building International Public-Private Partnership under Kyoto Protocol*. UNEP, UNDP Publ.

Anonymous. *IPCC Assessment Reports on Climate Change Policy: Facts, Issues and Analysis*. Cambridge Univ. Press.

Pretty J & Ball A. 2001. *Agricultural Influence on Carbon Emission and Sequestration: A Review of Evidence and the Emerging Trading Options*. Univ. of Essex.

Pretty JN. 1995. *Regenerating Agriculture: Policies and Practices for Sustainable and Self Reliance*. Earthscan.

Sinha SK. 1998. *Dictionary of Global Climate Change*. Commonwealth Publ.

**AGM 607/
STAT 511**

**STATISTICAL METHODS FOR
APPLIED SCIENCES**

3+1

SEM-I & II

Objective

This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Theory

UNIT I: Classification, tabulation and graphical representation of data. Box-plot, Descriptive statistics. Exploratory data analysis; Theory of probability, Random variable and mathematical expectation.

UNIT II: Discrete and continuous probability distributions: Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications, concept of sampling distribution: chi-square, t and F distributions,. Tests of significance based on Normal, chi-square, t and F distributions. Large sample theory.

UNIT III: Introduction to theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients. Coefficient of determination. Polynomial regression models and their fitting.

UNIT IV: Non-parametric tests- sign, Wilcoxon, Mann-Whitney U-test. Kruskal-Wallis test, run test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance,

UNIT V: Introduction to multivariate statistical analysis.

Practicals: Exploratory data analysis, Box-Cox plots; Fitting of distributions – Binomial, Poisson, Negative Binomial, Normal; Large sample tests, testing of hypothesis based on exact sampling distributions-chi-square, t and F; Confidence interval estimation and point estimation of parameters of binomial, Poisson and Normal distribution; Correlation and regression analysis. Non-parametric tests.

Suggested Readings

Anderson TW. 1958. An Introduction to Multivariate Statistical Analysis. John Wiley.

Dillon WR & Goldstein M. 1984. Multivariate Analysis - Methods and Applications. John Wiley. Goon AM, Gupta MK & Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.

Goon AM, Gupta MK & Dasgupta B. 1983. Fundamentals of Stat. Vol. I. World Press.

Hoel PG. 1971. Introduction to Mathematical Statistics. John Wiley.

Hogg RV & Craig TT. 1978. Introduction to Mathematical Statistics. Macmillan.

Morrison DF. 1976. Multivariate Statistical Methods. McGraw Hill.

Siegel S, Johan N & Casellan Jr. 1956. Non-Parametric Tests for Behavior Sciences. John Wiley.

PGS 505 **DISASTER MANAGEMENT** **1+0** **SEM - I, II**
(e-Course) (Nodal Teaching Department – Agricultural Meteorology)

Objectives

To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability; and capacity building.

Theory

UNIT I: Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion.

UNIT II: Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT III: Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.

Suggested Readings

- Gupta HK. 2003. *Disaster Management*. Indian National Science Academy. Orient Blackswan.
- Hodgkinson PE & Stewart M. 1991. *Coping with Catastrophe: A Handbook of Disaster Management*. Routledge.
- Sharma VK. 2001. *Disaster Management*. National Centre for Disaster Management, India.

List of Journals for Agril Meteorology

- Agricultural and Forest Meteorology
- Agricultural Systems
- Agricultural Systems and Information Technology Newsletter
- Agronomy Journal
- Atmospheric Research
- Canadian Water Resource Journal
- Climate Dynamics
- Climate Research
- Climatic Change
- Computers and Electronics in Agriculture
- Crop Science
- Ecological Modelling
- Environmental Monitoring and Assessment
- GIS India
- Hydrology Journal
- Indian Journal of Environmental Protection
- International Journal of Climatology
- International Journal of Remote Sensing
- Italian Journal of Agrometeorology
- Journal of Agricultural Meteorology
- Journal of Agrometeorology
- Journal of Applied Meteorology
- Journal of Applied Hydrology
- Journal of Applied Meteorology and Climatology
- Journal of Earth Systems Science
- Journal of Hydrologic Engineering
- Journal of Hydrometeorology
- Journal of Weather Modification Association
- Mausam
- Monthly Climatological Data for the World
- Photonirwachak
- Pollution Research
- Remote Sensing of Environment
- Vatavaran
- Vayu Mandal
- Water Resource Research
- Weather
- Weather and Forecasting
- WMO Bulletin

Suggested Broad Topics for Master's and Doctoral Research

- Microclimatic studies in crops and control climate
- Crop-weather interaction studies in field, vegetable and horticultural crops
- Crop-weather-pest interaction studies
- GIS approach in agro-ecological zoning and crop environment characterization
- Testing and validation of various existing crop simulation models to determine the production potentials in different regions of the state for major crops
- Climate change and sustainability –regional scenarios
- Weather modification studies
- Development of weather based model for major crops of the state
- The crop acreage and yield estimates for state using remote sensing approach
- Studies involving the ground-based spectral signatures for stress detection and yield modeling of important crops in the state
- Weather-based agro advisories, impact assessment and related issues
- Impact assessment studies in livestock and other agricultural production systems
- Evapo-transpiration studies using different approaches
- Extreme weather events, their impact on agriculture and their alleviation
- Agro-climatic resource characterization with reference to crops
- Crop-weather relationship for major crops
- Crop-growth simulation modeling
- Development of weather-based forewarning models for pest and disease
- Impact of climate change on agriculture
- Application model based agro-advisories to farmers
- Application of remote sensing in large scale crop condition assessment and yield prediction