CONTENTS

Preamble

Agricultural Meteorology is a branch of Meteorology that deals with the effects and impacts of weather and climate on agriculture and allied sectors. Climate is a major influencing factor of crop production. Any change in climatic elements is bound to have either positive or negative impacts on agricultural production. The Agro-meteorologist requires not only a sound knowledge of Meteorology, but also of Agronomy, Plant Physiology and Plant and Animal Pathology, in addition to common agricultural practices. Agricultural Meteorology is of particular relevance to India because of the high dependence of our agriculture on monsoon rainfall which has its own vagaries. Further, it is very well recognized that climate is not static and issues such as climate change and global warming are receiving increasing attention. The objective of this discipline is to educate students on the understanding of climate and weather elements, principles and processes, and their impact on agricultural activities.

The reliable weather information is very much important for the decision making of farmers before and during the crop season for arranging the inputs and their optimum utilization. Timely Agromet advisory can save inputs (fertilizers, seeds, plant protection chemicals, etc.), labour as well as the crop (especially at the harvest time after the crop reaches physiological maturity). Establishment of District-level Agromet Unit at different KVK is a great initiative by the Central Government and newly designed syllabus will empower the students to work in such types of project most efficiently.

Recent advances in space-borne, air-borne, and ground remote sensing have improved the spatial and temporal capacity of the discipline for crop health monitoring, crop loss assessment, crop acreage estimation, etc. Advancement in computing power is enabling us to collect big data in agriculture, analyse it and arrive at conclusions, which helps to make farming a profitable business. The new syllabus will expose the students to micrometeorological measurements, crop weather models, the principles and practices of exploring remote sensing data, spatial analysis using Geographic information system (GIS), data analysis using computer programming with open source software like ‘R’ or/and ‘Python’. The overall objective of this discipline is to educate students on the understanding of climate and weather elements, principles and processes, and their impact on agricultural activities and restructured course will help the students to achieve their goal.

Committee on Agricultural Meteorology

ICAR-BSMA Broad Subject	ICAR-BSMA Approved Disciplines	Degree Programmes		Broad Subject Coordinator (Chairman of all Disciplines' Subcommittees	Discipline Coordinator (Secretary of respective Discipline Sub-Committee)
Physical Sciences	Agricultural Meteorology	M.Sc. (Agriculture)	Ph.D.	Dr.Syed Ismail, ADP, CoA, VNMKV, Parbhani	Dr. M.G. Jadhav Professor (Agril. Meteorology), CoA, Parbhani (VNMKV, Parbhani)

Sub-Committee constituted for the finalization of common PG syllabi in Agricultural Meteorology Discipline

Sr. No	Name	
1	**Dr. Syed Ismail** Associate Dean and Principal College of Agriculture, VNMKV, Parbhani	**Chairman**
2	**Dr.V.A.Sthool** Head Dept. of Agril. Meteorology College of Agriculture, Pune, MPKV, Rahuri	Member
3	**Dr.P.R. Jaybhaye** Associate Professor Agril.Meteorology VNMKV, Parbhani	Member
4	**Dr.A.R. Tupe** Agrometeorologist AICRP on Agrometeorology, Dr.PDKV, Akola	Member
5	**Dr. S.V. Bagade** Asstt. Professor, Dept. of Agril. Meteorology College of Agriculture, Pune, MPKV, Rahuri	Member
6	**Dr.K.K. Dakhore** Agrometeorologist AICRP on Agrometeorology, VNMKV, Parbhani	Member
7	**Prof. G.N.Gote** Asstt. Professor, Dept. of Agril. Meteorology College of Agriculture, VNMKV, Parbhani	Member
8	**Dr.M.G Jadhav** Professor Agril.Meteorology, VNMKV, Parbhani	**Member Secretary**

Implementation of New Curriculum

The universities offering PG programmes in Agricultural Meteorology need to be supported for establishing specialized laboratories equipped with state-of-the art equipment's /computers for conducting practical classes especially, Measurement of different air pollutants, ozone and aerosol optical thickness (AOT), Measurements of radiation, CO_2 and methane in animal farm house, Micrometerological measurements in crop, Crop simulation models etc.

One time catch up grant should be awarded to each SAU, offering PG programmes in Agricultural Meteorology for meeting expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. For imparting total quality management, a minimum of two faculty in each department under an SAU should be given on job training in reputed national and international institutes. To execute the new PG and Ph.D. programmes in different discipline of Agricultural Meteorology in effective manner, special funds from ICAR would be required for outsourcing of faculty from Indian/Foreign Universities for some initial years.

The already existing M.Sc. and Ph.D. Programmes in Agricultural Meteorology will be considered at par with the recommended M.Sc. & Ph.D. programme by Vth Deans Committee for admission and employment.

Expected Outcome

- Revamping of post graduate programme in whole of Agricultural Meteorology throughout the country.
- Imparting quality education in Agricultural Meteorology.
- Development of technical manpower to cater the need of governments, corporate sector and research organization in India and abroad.
- Exposure to the faculty in the latest technical knowhow.

Organization of Course Contents & Credit Requirements

Minimum Residential Requirement:

M.Sc.: 4 Semesters
Ph.D.: 6 Semesters

Name of the Departments / Divisions

- Agricultural Meteorology

Nomenclature of Degree Programme

(a) M.Sc. Programmes

i) M.Sc. (Agriculture) Agricultural Meteorology

(b) Ph. D. Programmes

i) Ph.D. (Agriculture) Agricultural Meteorology

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
- 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
- Deficiency courses will be of 400 series.
- Master's research: 599 and Doctoral research: 699

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 obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 600/700 series courses as well as research topics.\
- Lecture schedule has also be given at the end of each course to facilitate the teacher to complete the course in an effective manner.

Eligibility for Admission

- **Master's Degree Programme**

B.Sc.(Agri.) / **B. Sc. (Hons.) Agriculture** under 10+2+4 system with minimum of 5.50/10 or equivalent percentage of marks or equivalent degree with four years duration of agriculture related Universities and having the Common Entrance Test in Agriculture conducted by competent authority.

(Note:- In case B.Sc. Agriculture / B.Sc. (Hons.) Agriculture candidates are not available, B. Sc. (Hort.) / B.Sc. (Hons.) Horticulture / B. Sc. (Forestry) / B.Sc. (Hons.) Forestry may be considered subjected to completion of deficiency package)

- **Doctoral Degree Programme**

Master's degree in concerned discipline (Agricultural Meteorology) with minimum of 6.50/10 or equivalent percentage of marks and based on CET score CET conducted by MAUEB or AIEEA – ICAR, Agricultural Universities (AUs) which have expressed their willingness to utilize NTA scores for their PG admissions. If required the scores will be provided by NTA.

Sr. No	Name of Department	Specialization in Ph. D	Eligibility criteria
1.	Agricultural Meteorology	Agricultural Meteorology	M.Sc. in Agricultural Meteorology

Credit Requirements

Course Details	Masters Degree	Doctoral Degree
Major Courses	20	15
Minor Courses	08	06
Supporting / Optional	06	05
Common PGS Courses	05	-
Seminar	01	02
Research	30	75
Total	**70**	**100**

Course Structure

M.Sc. Agricultural Meteorology

LIST OF CORE COURSES/ DEPARTMENT WISE SPECIALIZATION/ COMPULSORY/SUPPORTING COURSES

1. M.Sc. (Agriculture) Agricultural Meteorology

Course Code	Course Title	Credit Hrs.
AGM 501*	Fundamentals of Meteorology	2+1
AGM 502*	Fundamentals of Agricultural Meteorology	2+1
AGM 503	Crop-weather Relationships	2+0
AGM 504*	Agro-meteorological Measurements and Instrumentation	1+2
AGM 505	Crop Micrometeorology	2+1
AGM 506	Evapotranspiration and Soil Water Balance	2+1
AGM 507	Crop weather models	1+2
AGM 508	Applied Agricultural Climatology	1+2
AGM 509	Weather forecasting	2+1
AGM 510	RS and GIS Applications in Agricultural Meteorology	2+1
AGM 511	Strategic use of climatic information	2+1
AGM 512	Weather and climate risk management	2+0
AGM 513	Aerobiometeorology	2+1
AGM 591	Master's Seminar	1+0
	Total	**23+15=38**
AGM 591	Master's Research	0+30

***Compulsory Courses**

Semester wise courses offered based on credit requirement

Course Code	Semester	Course Title	Credit Hrs.
AGM 501*	I	Fundamentals of Meteorology	2+1
AGM 502*	I	Fundamentals of Agricultural Meteorology	2+1
AGM 503	I	Crop-weather Relationships	2+0
AGM 504*	II	Agro-meteorological Measurements and Instrumentation	1+2
AGM 505	II	Crop Micrometeorology	2+1
AGM 507	III	Crop weather models	1+2
AGM 508	II	Applied Agricultural Climatology	1+2
AGM 591	III	Seminar	1+0
Total			**12+9=21**
AGM 591	II-IV	Master's Research	0+30

Common Courses: (Non Credit)

Course code	Semester	Course Title	Credits
PGS 501	I	Library and Information Services	1+0
PGS 502	I	Technical Writing and Communications Skills	1+0
PGS 503	II	Intellectual Property and its management in Agriculture	1+0
PGS 504	II	Basic Concepts in Laboratory Techniques	1+0
PGS 505	III	Agricultural Research, Research Ethics and Rural Development Programmes	1+0
PGS 506	III	Disaster Management	1+0

Minor Courses/Disciplines:

Minor courses 500 series (08 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Agronomy
2. Soil Science
3. Agricultural Physics
4. Organic Farming
5. Plant Physiology
6. Agril.Entomology
7. Plant Pathology
8. Livestock Management
9. Horticulture
10. Any other related discipline

Suggestive minor or supporting courses:

Course Code	Course Title	Credit Hrs.
AGRON 501*	Modern Concepts in Crop Production	3+0
AGRON 505	Conservation Agriculture	1+1
AGRON 512	Dryland Farming and Watershed Management	2+1
SOIL 501*	Soil Physics	2+1
SOIL 508	Soil water and air pollution	2+1
AP 503	Fundamentals of Soil Physics	2+1
AP 504*	Mathematics in Agriculture	3+0
AP 511	Simulation of Soil, Plant and Atmospheric Processes	2+1
AGM 506	Evapotranspiration and Soil Water Balance	2+1
AGM 509	Weather forecasting	2+1
AGM 510	RS and GIS Applications in Agricultural Meteorology	2+1
AGM 511	Strategic use of climatic information	2+1
AGM 512	Weather and climate risk management	2+0
AGM 513	Aerobiometeorology	2+1

PP 501*	Principles of Plant Physiology I	2+1
PP 508	Physiology of Field Crops	2+0
PP 507	Photosynthetic Processes, Crop Growth and Productivity and Concepts of Crop Modelling	2+1

Optional/Supporting Courses/Disciplines:

Supporting/optional courses of 500 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Agricultural Statistics
2. Computer Science

Course Code	Course Title	Credit Hrs.
STAT 501	Mathematics for Applied Sciences	2+0
STAT 502,	Statistical Methods for Applied Sciences	3+1
STAT 511	Experimental Designs	2+1
STAT 521	Applied Regression Analysis	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1
STAT 552	Data Analysis Using Statistical Packages	2+1
MCA 501	Computers Fundamentals and Programming	2+1
MCA 512	Information Technology in Agriculture	2+0
MCA 514	Statistical Computing	1+1

Compulsory Non Credit Deficiency Courses (those who are non-Agriculture Graduates)

Students other than Agriculture stream will be required to complete Non credit deficiency courses of 400 series (6 to 10 credits) of B.Sc. Agriculture / B.Sc. (Hons.) Agriculture degree courses as decided by the Student Advisory committee.

Course Contents

M.Sc. (Agriculture) Agricultural Meteorology

AGM 501 Fundamentals of Meteorology 2+1

Theory

Unit I

Solar radiation and laws of radiation; greenhouse effect, albedo, and heat balance of the earth and atmosphere; variation in pressure and temperature with height, potential temperature, pressure gradient, cyclonic and anticyclonic motions; geostropic 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, saturation deficit, Lapse rates-ascent of dry and moist air, stability and instability conditions in the atmosphere.

Unit III

Agromet observatory and analysis of weather data; 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; pressure belts and wind pattern on Earth globe, different forces acting on wind, the trade winds, equatorial trough and its movement, polar jet stream and tropical jet stream.

Unit V

Monsoon and its origin; Indian monsoon and its seasonal aspects: Onset, advancement and retreat of monsoon in different parts of India, Walker and Hadley cell, El Nino, La Nina, Western disturbances, Indian Ocean Dipole, Southern Oscillation Index and their impact on monsoon.

VI. Practical

- Agromet observatory- different classes of observatories (A, B, C)
- Site selection and installation procedures for meteorological instruments
- Measurement of weather parameters
- Reading and recording, calculation of daily, weekly, monthly means.
- Totals of weather data.
- Weather chart preparation and identification of low pressure systems and ridges.
- Statistical technique for computation of climatic normals, moving average, etc.

VII. Teaching methods/activities

Classroom teaching and practical-classes, visit to Agromet Observatory

VIII. Learning outcome

Basic knowledge on meteorology and climatology, physical laws governing atmosphere and monsoon

IX. Suggested Reading

- Ahrens. 2008. *Meteorology today*, 9th Edition. Wadsworth Publishing Co Inc.
- Barry RG and 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 Publishers (Nagpur).

• Ghadekar SR. 2002. *Practical Meteorology*. Agromet Publishers (Nagpur).
• 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.
• Varshneya MC and Pillai PB. 2003. *Text Book of Agricultural Meteorology*. ICAR.

Journals

• *Mausam*
• *Journal of Agrometeorology*
• *Italian Journal of Agrometeorology*
• *Theoretical and Applied Climatology*

Websites

• http://www.imd.gov.in/pages/main.php
• https://public.wmo.int/en

Lecture Schedule (AGM 501)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Solar radiation and laws of radiation; greenhouse effect, albedo, and heat balance of the earth and atmosphere;	2
2	Variation in pressure and temperature with height, potential temperature, pressure gradient,	2
3	Cyclonic and anticyclonic motions; geostropic and gradient winds; equations of motion; general circulation, turbulence, vorticity, atmospheric waves.	3
4	Gas laws, laws of thermodynamics and their application to atmosphere;	2
5	Water vapour in the atmosphere, various humidity parameters and their interrelationships; vapour pressure, psychrometric equation, saturation deficit,	3
6	Lapse rates-ascent of dry and moist air, stability and instability conditions in the atmosphere.	2
7	Agromet observatory and analysis of weather data;	2
8	Condensation; clouds and their classification; evaporation and rainfall; the hydrological cycle; precipitation processes,.	2
9	Artificial rainmaking, thunderstorms and dust storm; haze, mist, fog, and dew; air masses and fronts; tropical and extra-tropical cyclones.	2
10	Effect of Earth's rotation on zonal distribution of radiation, rainfall, temperature, and wind;	2
11	Pressure belts and wind pattern on Earth globe, different forces acting on wind, the trade winds,	2
12	Equatorial trough and its movement, polar jet stream and tropical jet stream.	2

13	Monsoon and its origin; Indian monsoon and its seasonal aspects:	2
14	Onset, advancement and retreat of monsoon in different parts of India,	2
15	Walker and Hadley cell, El Nino, La Nina, Western disturbances, Indian Ocean Dipole, Southern Oscillation Index and their impact on monsoon.	2
	Total	32

AGM 502 Fundamentals of Agricultural Meteorology 2+1

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 nowcast and extended weather forecast; agromet advisories, preparation, dissemination and economic impact analysis Feedback system of agromet advisory system; use of satellite imageries in weather forecasting; synoptic charts and synoptic approach to weather forecasting.

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, meteorological aspects of forest fires and their control.

Unit V

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

VI. Practical

- Preparation of crop weather calendars
- Development of simple regression models for weather, pest and disease relation in different crops.
- Preparation of weather based agro-advisories
- Use of automated weather station (AWS)

VII. Teaching methods/activities

Classroom teaching and practical-classes, visit to Agromet Observatory

VIII. Learning outcome

Overall and basic knowledge on Agrometeorology

IX. Suggested Reading

- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Kakde JR. 1985. *Agricultural Climatology.* Metropolitan Book Co.
- Mahi and Kingra. 2014. *Fundamentals of agrometeorology*. Kalyani publishers.

• Mavi HS and Tupper. 2004. *Principles and applications of climate studies in agriculture*. CRC Press
• Varshneya MC and Pillai PB. 2003. *Text Book of Agricultural Meteorology*. ICAR.

Journals

• *Journal of Agrometeorology*
• *Italian Journal of Agrometeorology*
• *Agricultural and Forest Meteorology*
• *Current Science*

Websites

• http://www.imd.gov.in/pages/main.php
• http://www.fao.org/home/en/
• www.wmo.org
• www.ipcc.org

Lecture Schedule (AGM 502)

Sr. No	Topics to be Covered	No. of Lecture (s)
1	Meaning and scope of agricultural meteorology; components of agricultural meteorology;	2
2	Role and responsibilities of agricultural meteorologists.	1
3	Importance of meteorological parameters in agriculture;	1
4	Efficiency of solar energy conversion into dry matter production; meteorological factors in photosynthesis, respiration and net assimilation;	3
5	Basic principles of water balance in ecosystems; soil-water balance models and water production functions.	2
6	Crop weather calendars;	1
7	Weather forecasts for agriculture at short, medium and long range levels nowcast and extended weather forecast;	2
8	Agromet advisories, preparation, dissemination and economic impact analysis Feedback system of agromet advisory system;	2
9	Use of satellite imageries in weather forecasting; synoptic charts and synoptic approach to weather forecasting.	3
10	Concept, definition, types of drought and their causes; prediction of drought;	2
11	Crop water stress index, crop stress detection; air pollution and its influence on vegetation,	2
12	Meteorological aspects of forest fires and their control.	1
13	Climatic change, adaptation, and mitigation.	3

14	Greenhouse effect, CO2 increase, global warming and their impact on agriculture;	3
15	Climate classification,	2
16	Agro-climatic zones and agro-ecological regions of India.	2
	Total	32

AGM 503 Crop-weather Relationships 2+0

Theory

Unit I

Understanding the influence of weather elements on crop growth, impact of climatic Physical Sciences: Agricultural Meteorology variability and extremes on crop production, climatic normals for crop production.

Unit II

Climatic requirements of major crops, temperature effect on crop growth, radiation impact and radiation utlilization efficiency, humidity effect on crop performance, Heat units, effect of soil temperature on seed germination and root growth, wind variation and crop growth.

Unit III

Meteorological indices to predict crop production, Interpretation of weather forecasts for various agricultural operations towards improved productivity, crop-weather relationship in dryland areas. Crop weather relationship of major vegetable and horticultural crops of the region and agroforestry system.

Unit IV

Rhizosphere and microorganisms in relation to weather, fertilizer and water use efficiency in relation to weather.

VI. Teaching methods/activities

Classroom teaching

VII. Learning outcome

To enhance the knowledge on intricate relationship between crop and weather.

VIII. Suggested Reading

• Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
• Jerry L. Hatfield, Mannava VK, Sivakumar and John H. Prueger. 2017. *Agroclimatology: Linking Agriculture to climate*. Agronomy Monographs 60.
• Mavi HS. 1994. *Introduction to Agrometeorology*. Oxford & IBH.
• Prasada Rao GSLHV. 2008. *Agricultural Meteorology*. PHI Learning Publishers.

Journals

• *Journal of Agrometeorology*
• *Agricultural and Forest Meteorology*

Websites

• http://www.imd.gov.in/pages/main.php
• http://www.fao.org/home/en/

Lecture Schedule (AGM 503)

Sr. No	Topics to be Covered	No. of Lecture (s)
1	Understanding the influence of weather elements on crop growth,	1
2	Impact of climatic Physical Sciences: Agricultural Meteorology variability and extremes on crop production,	2
3	Climatic normals for crop production	1
4	Climatic requirements of major crops,	2
5	Temperature effect on crop growth,	1
6	Radiation impact and radiation utlilization efficiency,	2
7	Humidity effect on crop performance,	1
8	Heat units,	2
9	Effect of soil temperature on seed germination and root growth, wind variation and crop growth.	3
10	Meteorological indices to predict crop production,	2
11	Interpretation of weather forecasts for various agricultural operations towards improved productivity,	3
12	Crop-weather relationship in dryland areas.	2
13	Crop weather relationship of major vegetable crops of the region	3
14	Crop weather relationship of major horticultural crops of the region and agroforestry system	3
15	Rhizosphere and microorganisms in relation to weather,.	2
16	Fertilizer and water use efficiency in relation to weather	2
	Total	32

AGM 504 Agro-meteorological Measurements and Instrumentation 1+2

Theory

Unit I

Fundamentals of measurement techniques; theory and working principles of barometer, thermometer, psychrometer, hair hygrometer, thermohygrograph; exposure and operation of meteorological instruments/ equipments in agromet observatories.

Unit II

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

Unit III

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

Unit IV

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

Unit V

Boundary layer fluxes, Flux tower, soil heat flux plates, instruments to measure soil moisture and soil temperature.

Unit VI

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

VI. Practical

• Working with the above instruments in the meteorological observatory, fields and laboratory, Recording observations of relevant parameters.
• Computation and interpretation of the data.
• Analysis of AWS data.
- Data logging, data retrieval and data quality assessment

VII. Teaching methods/activities

Mostly practical classes with demonstration and hands-on use of met-instruments

VIII. Learning outcome

Practical classes and theory

IX. Suggested Reading

• 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 and Spilhaws AF. 1962. *Meteorological Department*. University of Toronto Press.
• Tanner CB. 1973. *Basic Instrumentation and Measurements for Plant Environment and Micrometeology*. University of Wisconsin, Madison.
• WMO. 2008. *Guide to Meteorological Instruments and Methods of Observation*. WMO-No.8
• Jaybhaye PR.2013 Handbook of Agricultural Meteorology

Journals

• *International Journal of Biometeorology*
• *Agricultural and Forest Meteorology*
• *Journal of Agrometeorology*

Website

https://public.wmo.int/en

Lecture Schedule (AGM 504)

Sr. No	Topics to be Covered	No. of Lecture (s)
1	Fundamentals of measurement techniques;	1
2	Theory and working principles of barometer, thermometer, psychrometer,	1

3	Theory and working principles hair hygrometer, thermohygrograph;	1
4	Exposure and operation of meteorological instruments/ equipment's in agromet observatories	1
5	Radiation and temperature measuring instruments:	1
6	Working principles of albedometer, photometer, spectro-radiometer, sunshine recorder, dew recorder,	1
7	Working principles Quantum radiation sensors, pressure bomb apparatus, thermographs, and infra-red thermometer.	2
8	Precipitation and dew instruments: working principles of rain gauge, self-recording rain gauge, Duvdevani dew gauges.	2
9	Wind instruments: working principles of anemometer, wind vane, anemograph.	1
10	Evapotranspiration and photosynthesis instruments:	1
11	Working principles of lysimeters, open pan evaporimeters, porometer, photosynthesis system, leaf area	1
12	Boundary layer fluxes, Flux tower, soil heat flux plates,	1
13	Instruments to measure soil moisture and soil temperature.	1
14	Automatic weather station – data logger and sensors, nano-sensors for measurement of weather variables; computation and interpretation of data.	1
	Total	16

AGM 505 Crop Micrometeorology 2+1

Theory

Unit I

Properties of atmosphere near the Earth's surface; micrometeorological divisions, structure of atmospheric boundary layer, exchange of mass momentum and energy between surface and overlaying atmosphere, exchange coefficient, similarity hypothesis, shearing stress, forced and free convection.

Unit II

Wind speed profile over the surface, laminar and turbulent flow, Molecular and eddy transport of heat, water vapour and momentum, frictional effects, eddy diffusion, mixing; zero plane displacement, temperature instability, eddy covariance technique, microclimate near the bare ground, unstable and inversion layers, variation in microclimate under irrigated and rainfed conditions, soil moisture and temperature variation with depth; Richardson number, Raynolds analogy, Exchange coefficients.

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; influence of topography on microclimate; shelter belts and wind breaks, microclimate

in low plant area of meadows and grain fields, microclimate within forests, glass house and plastic house climates; instruments and measuring techniques in micrometeorology.

Unit IV

Effects of ambient weather conditions on growth, development and yield of crops; measurement of global and diffuse radiation; measurement of albedo over natural surfaces and cropped surfaces; net radiation measurement at different levels; PAR distribution in plant canopies and interception; wind, temperature and humidity profiles in (a) short crops and (b) tall crops; energy balance over crops and LAI and biomass estimation; remote sensing and its application in relation to micrometeorology.

VI. Practical

• Micrometerological measurements in crop canopies
• Quantification of crop microclimate
• Determination of ET and its computation by different methods.

VII. Teaching methods/activities

Theory and practical classes

VIII. Learning outcome

Knowledge of microclimatic conditions governing crop growth

IX. Suggested Reading

• Pal AS. 1988. *Introduction to Micrometeorology*. Academic Press.
• Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
• Chang, Jen-Hu. 1968. *Climate and Agriculture: An Ecological Survey*. Aldine Publishing Company.
• 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 and 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.
• Monteith and Unsworth. 2013. *Principles of Environmental Physics*. Elsevier.
• Rosenberg NJ. 1974. *Microclimate – The biological Environmet*. John Wiley & Sons.
• Sellers W. 1967. *Physical Climatology*. The University of Chicago Press.

Journals

• *International Journal of Biometeorology*
• *Agricultural and Forest Meteorology*
• *Journal of Agrometeorology*

Website

• https://public.wmo.int/en

Lecture Schedule (AGM 505)

Sr. No	Topics to be Covered	No. of Lecture (s)
1	Properties of atmosphere near the Earth's surface; micrometeorological divisions,	1
2	Structure of atmospheric boundary layer, exchange of mass momentum and energy between surface and overlaying atmosphere,	2

3	Exchange coefficient, similarity hypothesis, shearing stress, forced and free convection	1
4	Wind speed profile over the surface, laminar and turbulent flow, Molecular and eddy transport of heat	2
5	Water vapour and momentum, frictional effects, eddy diffusion, mixing; zero plane displacement	2
6	Temperature instability, eddy covariance technique, microclimate near the bare ground, unstable and inversion layers,	1
7	Variation in microclimate under irrigated and rainfed conditions	1
8	Soil moisture and temperature variation with depth; Richardson number, Raynolds analogy, Exchange coefficients.	2
9	Micrometeorology of plant canopies; distribution of temperature, humidity, vapour pressure, wind and carbon dioxide;	2
10	Modification of microclimate due to cultural practices, intercropping;	2
11	Radiation distribution and utilization by plant communities, leaf temperature and its biological effects.	2
12	Influence of topography on microclimate; shelter belts and wind breaks, microclimate in low plant area of meadows and grain fields,	2
13	Microclimate within forests, glass house and plastic house climates;	2
14	Instruments and measuring techniques in micrometeorology.	2
15	Effects of ambient weather conditions on growth, development and yield of crops;	2
16	Measurement of global and diffuse radiation; measurement of albedo over natural surfaces and cropped surfaces.	1
17	Net radiation measurement at different levels; PAR distribution in plant canopies and interception;	1
18	Wind, temperature and humidity profiles in (a) short crops and (b) tall crops; energy balance over crops and LAI and biomass estimation;	2
19	Remote sensing and its application in relation to micrometeorology	2
	Total	32

AGM 506 Evapotranspiration and Soil Water Balance 2+1

Theory
Unit I

Energy concept of soil water, hydraulic conductivity and soil water flux; theory on hydraulic conductivity in saturated and unsaturated soils; physical factors concerning water movement in soil; concepts on evaporation, evapotranspiration, potential and actual evapotranspiration.

Unit II

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 III

Influence of microclimatic and cultural factors on soil water balance; techniques of lysimetry in measuring actual evapotranspiration. water use efficiency and scheduling of irrigation based on evapotranspiration; water use efficiency and antitranspirants, computation of Kc values and their use; irrigation scheduling based on climatological approaches

Unit IV

Yield functions; water use efficiency and scheduling of irrigation based on evapotranspiration; dry matter yield ET functions; radiation instruments; advanced techniques for measurement of radiation and energy balance; estimation of evapotranspiration through remote sensing.

VI. Practical

- Measurement of various components of soil water balance
- Evaluation of hydraulic conductivity vs. soil moisture relationship by water balance approach
- Computation and comparison of evapotranspiration by different methods – energy balance method, aerodynamic method, Penman method, remote sensing and other methods
- Soil moisture retention characteristics by pressure plate method.
- Calculation of WRSI (Water requirement satisfaction index)

VII. Teaching methods/activities

Theory and practical classes

VIII. Learning outcome

To know the estimation procedures and inter linkages among different components of field water balance

IX. Suggested Reading

- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Burman R and Pochop LO. 1994. *Evaporation, Evapotranspiration and Climatic Data*. Elsevier.
- Grace J.1983. *Plant Atmospheric Relationships: Outline Studies in Ecology*. Chapman & Hall.
- Mavi HS and Tupper GJ. 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.
- Murthy VRK. 2002. *Basic Principles of Agricultural Meteorology*. BS Publ.
- Niwas R, Singh D and Rao VUM. 2000. *Pratical Manual on Evapotranspiration.* Dept. of Agril. Meteorology, CCS HAU Hisar.
- Rosenberg NJ, Blad BL and Verma SB. 1983. *Microclimate –The Biological Environment*. John Wiley & Sons.
- Subramaniam VP. 1982. *Water balance and its application*. Andhra University Press, Waltair, India.

Journals

- *Journal of Agrometeorology*
- *Archives of Agronomy and Soil Science*
- *Agricultural Water Management*
- *Journal of Hydrology*
- *Journal of Plant Ecology*

Websites

- https://www.icrisat.org/
- http://www.iwmi.cgiar.org/
- http://www.iiwm.res.in/

Lecture Schedule (AGM 506)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1.	Energy concept of soil water, hydraulic conductivity and soil water flux;	2
2.	Theory on hydraulic conductivity in saturated and unsaturated soils;	2
3.	Physical factors concerning water movement in soil;	2
4.	Concepts on evaporation, evapotranspiration, potential and actual evapotranspiration.	2
5.	Theories of evapotranspiration and their comparison;	2
6.	Aerodynamic, eddy correlation, energy balance, water balance and other methods, their application under different agroclimatic conditions;	3
7.	Concepts of potential, reference and actual evapotranspiration - modified techniques.	2
8.	Influence of microclimatic and cultural factors on soil water balance;	1
9.	Techniques of lysimetry in measuring actual evapotranspiration.	2
10.	Water use efficiency and scheduling of irrigation based on evapotranspiration;	2
11.	Water use efficiency and antitranspirants, computation of Kc values and their use;	2
12.	Irrigation scheduling based on climatological approaches	2
13	Yield functions;	1
14	Water use efficiency and scheduling of irrigation based on evapotranspiration;	2
15	Dry matter yield ET functions; radiation instruments;	2
16	Advanced techniques for measurement of radiation and energy balance;	2
17	Estimation of evapotranspiration through remote sensing.	2
	Total	**32**

AGM 507 Crop Weather Models 1+2

Theory

Unit I

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

Unit II

Introduction and application to crop modeling, types of models, Empirical and statistical crop weather models their application with examples; concept of crop growth model in relation to weather, soil, plant and other environmental related parameters and remote sensing inputs; growth and yield prediction models;

Unit III

Dynamic crop simulation models, e.g. DSSAT, InfoCrop, APSIM, CropSyst, etc.; optimization, calibration and validation of models. Weather data and physiology based approaches to modeling of crop growth and yield; forecasting of pests and diseases; stochastic models; advantages and limitation of modeling.

VI. Practical

Working with statistical and simulation models, DSSAT models, InfoCrop, Oryza, etc.

VII. Teaching methods/activities

Theory and practical classes. Demonstration and hands-on practical's using crop models

VIII. Learning outcome

To utilize the crop weather model for observing weather influence on crop growth

IX. Suggested Reading

• Wallach D *et al*. *Working with dynamic crop models*.

• DeWit CT, Brouwer R and de Vries FWTP. 1970. *The Simulation of Photosynthetic Systems*. pp. 7-70. In. Prediction and Measurement of Photosynhetic 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. Mississipi.

• Frere M and Popav G. 1979. *Agrometeorological Crop Monitoring and Forecasting.* FAO.

• Hanks RJ. 1974. *Model for Predicting Plant Yield as Influenced by Water Use*. Agron. J. 66: 660-665.

• Hay RKM and Porter JR. 2006. *The physiology of crop yield* (2nd Edition).

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

• Singh P. *Modelling of crop production systems: Principles and applications*.

• Weixing Cao *et al*. *Crop modeling and decision support.*

Journals

• *Journal of Agrometeorology*

• *Global Environmental Change*

• *Global Change Biology*

• *Mitigation and Adaptation Strategies for Global Change*

Websites

• https://www.apsim.info/

• https://dssat.net/

Lecture Schedule (AGM 507)

Sr. No	Topics to be Covered	No. of Lecture (s)
1	Principles of crop production	1

2	Effect of weather elements on crop responses;	1
3	Impact of natural and induced variability of climate on crop production.	1
4	Introduction and application to crop modeling,	1
5	Types of models,	1
6	Empirical and statistical crop weather models their application with examples;	1
7	Concept of crop growth model in relation to weather, soil, plant and other environmental related parameters	2
8	Remote sensing inputs; growth and yield prediction models;	2
9	Dynamic crop simulation models, e.g. DSSAT, InfoCrop, APSIM, CropSyst, etc.;	2
10	Optimization, calibration and validation of models.	1
11	Weather data and physiology based approaches to modeling of crop growth and yield;	1
12	Forecasting of pests and diseases;	1
13	Stochastic models; advantages and limitation of modeling.	1
	Total	16

AGM 508 Applied Agricultural Climatology 1+2

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

Precipitation indices; Drought indices 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 III

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 IV

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.

VI. Practical

• Use of statistical approaches in data analysis
• Calculation of Drought Indices
• Preparation of climatic water budget
• Estimation of agro-meteorological variables 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.

VII. Teaching methods/activities

Theory and practical classes

VIII. Learning outcome

Knowledge on how to use the meteorological observations and derived indices are applied in agricultural field

IX. Suggested Reading

• 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 Delware, New Jersey.
• Mavi HS and Tupper Graeme J. 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture.* The Haworth Press.
• Stigter K (Ed.). 2010. *Applied Agrometeorology*. Springer
• Subramaniam VP. 1977. *Incidence and Spread of Continental Drought*. WMO/IMD Report No. 2, WMO, Geneva, Switzerland.
• Thompson R. 1997. *Applied Climatology: Principles and Practice*. Routledge.
• Walter J Saucier. 2003. *Principles of Meteorological Analysis*. Dover Phoenix Eds.

Journals

• *Theoretical and Applied Climatology*
• *Atmospheric Research Journal*
• *Journal of Agrometeorology*
• *Agricultural Climatology and Meteorology*
• *Journal of Applied Meteorology and Climatology*

Websites

• http://www.imd.gov.in/pages/main.php
• https://public.wmo.int/en

Lecture Schedule (AGM 508)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1.	Climatic statistics: measures of central tendency and variability,	1
2.	Skewness, kurtosis, homogeneity, correlation, regression and moving averages;	1
3.	Probability analysis using normal, binomial, Markov-chain and incomplete gamma distribution; parametric and non parametric tests; assessment of frequency of disastrous events.	2
4.	Precipitation indices; Drought indices Climatic water budget: potential and actual evapotranspiration and their computation;	1
5.	Measurement of precipitation, calculation of water surplus and deficit;	1
6.	Computation of daily and monthly water budget and their applications;	1
7.	Assessment of dry and wet spells, available soil moisture, moisture adequacy index and their applications	1
8.	Thermal indices and phenology: cardinal temperatures;	1
9	Heat unit and growing degree day concepts for crop phenology, crop growth and development;	1
10	Insect-pest development; crop weather calendars;	1
11	Agroclimatic requirement of crops.	1
12	Bioclimatic concepts: evaluation of human comfort, comfort indices (temperature, humidity index and wind chill) and clothing insulation;	2
13	Climate, housing and site orientation; climatic normals for animal production	2
	Total	**16**

AGM 509 Weather Forecasting 2+1

Theory

Unit I

Weather forecasting system: definition, scope and importance; types of forecasting: now cast, short, medium, long-range and extended weather forecast; 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, nanotechnological 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

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 IV

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 behaviour of clouds.

Unit V

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.

VI. Practical

• Exercise on weather forecasting for various applications

• Interpretation of synoptic chart and satellite imagery

• Preparation of weather-based agro-advisories based on weather forecast using various approaches and synoptic charts.

VII. Teaching methods/ activities

Theory and practical classes

VIII. Learning outcome

Enhancing knowledge on weather forecast and its use

IX. Suggested Reading

• Watts A. 2005. *Instant Weather Forecasting*. Water Craft Books.

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

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

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

Journals

• *Journal of Climatology and Weather Forecasting*

• *Theoretical and Applied Climatology*

• *Atmospheric Research Journal*

• *Journal of Agrometeorology*

• *Agroclimatology*

Websites

• https://www.ipcc.ch/

• https://www.imd.gov.in/pages/main.php

Lecture Schedule (AGM 509)

Sr. No.	Topics to be Covered	No. of Lecture (s)

1.	Weather forecasting system: definition, scope and importance; types of forecasting: now cast, short, medium, long-range and extended weather forecast;	2
2.	Study of synoptic charts with special reference to location of highs and lows, jet streams, synoptic features and	2
3.	Weather anomalies and zones of thermal advection and interpretation of satellite pictures of clouds in visible and infra-red range; weather forecasting network.	2
4.	Approaches for weather forecasts: methods of weather forecasts - synoptic, numerical prediction, statistical, analogue, persistence and climatological approach, nano-technological approach.	3
5.	Indigenous Technical Knowledge (ITK) base- signals from flora, fauna, insects, birds, animals behavior;	3
6.	Various methods of verification of location-specific weather forecast	2
7.	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.	2
8.	Modification of weather hazards: weather modification for agriculture;	3
9.	Scientific advances in artificial rain making, hail suppression, dissipation of fog and stratus clouds,	3
10.	Modification of severe storms and electric behaviour of clouds.	3
11.	Weather based advisories	2
12.	Interpretation of weather forecasts for soil moisture, farm operations, pest and disease development and epidemics, crops and livestock production;	3
13	Preparation of weather-based advisories and dissemination	2
	Total	**32**

AGM 510 RS and GIS Applications in Agricultural Meteorology 2+1

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 features; 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. Drone technology.

Unit IV

Data acquisition system, data preprocessing, 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 measurement of surface soil moisture and temperature; drought monitoring, monitoring of crop disease and pest infestation. Use of satellite data in weather forecasting.

Unit VII

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

VI. Practical

- Acquisition of maps
- Field data collection
- Map and imagery scales
- S/W and H/W 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 spectroradiometer and computation of vegetation indices
- Demonstration of case studies
- Hands on training

VII. Teaching methods/activities

Hands on practicals and theory

VIII. Learning outcome

Knowledge on RS-GIS technique for application in Agricultural Meteorology

IX. Suggested Reading

- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Campbell JB. 1996. *Introduction to Remote Sensing*, 2nd ed., The Guilford Press, New York.
- 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).
- Jain AK. 1989. *Fundamentals of Digital Image Processing*, Prentice Hall of India.
- Lilisand TM, Kiefer RW and Chipman JW. 2003. *Remote Sensing and Image Interpretation*, 5th ed., John Wiley & Sons, Inc., New York.
- Narayan LRA. 1999. *Remote Sensing and its Applications*. Oscar Publ.
- Panda BC. 2008. *Principles and Applications of Remote Sensing*, Viva Publications.
- Patel AN and Surender Singh. 2004. *Remote Sensing: Principles and Applications*. Scientific Publ.

Journals

• *Journal of Global Environmental Change*
• *Journal of Remote Sensing and GIS*
• *Journal of Agrometeorology*

Websites

• https://www.nrsc.gov.in/
• http://www.imd.gov.in/pages/main.php
• https://public.wmo.int/en

Lecture Schedule (AGM 510)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1.	Basic components of remote sensing- signals, sensors and sensing systems; active and passive remote sensing.	2
2.	Characteristics of electromagnetic radiation and its interaction with matter;	2
3.	Spectral features of earth's surface features; remote sensors in visible, infrared and microwave regions	2
4.	Imaging and non-imaging systems;	2
5.	Framing and scanning systems; resolution of sensors; sensor platforms, their launching and maintenance.	2
6.	Drone technology.	2
7.	Data acquisition system, data preprocessing, storage and dissemination;	3
8.	Digital image processing and information extraction	2
9.	Microwave remote sensing; visual and digital image interpretation;	2
10.	Introduction to GIS and GPS.	2
11.	Digital techniques for crop discrimination and identification;	2
12.	Crop stress detection - soil moisture assessment, inventory of ground water and satellite measurement of surface soil moisture and temperature;	2
13	Drought monitoring, monitoring of crop disease and pest infestation.	2
14	Use of satellite data in weather forecasting.	1
15	Soil resource inventory; land use/land cover mapping and planning; integrated watershed development;	2
16	Crop yield modeling and crop production forecasting.	2

	Total	**32**

AGM 511 Strategic Use of Climatic Information 2+1

Theory

Unit I

Increasing awareness on potential climate hazards and mitigations: history of climate-related disasters in the concerned continent/ region/ country/ sub-region and their documented or remembered impacts; Climatic hazards and extreme weather events (Cyclone, Hailstorm, drought, flood, etc.), Impact of climatic hazard on agricultural production; efforts made in mitigating impacts of (future) disasters (prevention); trends discernible in occurrence and character of disasters, if any.

Unit II

Selection of appropriate land use and cropping patterns: types and drivers of agricultural land use and cropping patterns based on climatic situation; history of present land use and cropping patterns in the sub-region concerned as related to environmental issues; successes and difficulties experienced by farmers with present land use and cropping patterns; outlook for present land use and cropping patterns and possible alternatives from an environmental point of view.

Unit III

Adoption of preparedness strategies: priority settings for 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 production inputs and their history; determination of input efficiencies based on weather conditions; other factors determining inputs and input efficiency; actual use of inputs in main land use and cropping patterns of the region.

Unit V

Adoption of microclimate modification techniques: review of microclimate management and manipulation methods; history of microclimate modification techniques practiced in the continent/ country/ sub-region concerned; possible improvements in adoption of microclimate modification techniques, given increasing climate variability and climate change; local trends in adoption of such techniques.

Unit VI

Protection measures against extreme climate: history of protection measures against extreme climate in the continent/ region/ country/ sub region concerned; successes and difficulties experienced by farmers with present protection measures; outlook for present protection measures and possible alternatives; trends in protection methods against extreme climate.

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.

VI. Teaching methods/activities

Theory and practical classes

VII. Learning outcome

Application of climatic information for agriculture and natural resource management

VIII. Suggested Reading

• Anonymous. *Clean Development Mechanism: Building International Public-Private Partnership under Kyoto Protocol.* UNEP, UNDP Publ.
• Anonymous. *IPCC Assesment Reports on Climate Change Policy: Facts, Issues and Anlysis*.Cambridge Univ. Press.
• Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
• Pretty J and 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.

Journals

• *Climate Risk Management*, *Journal* of *Climate* (JCLI),
• *International Journal of Climatology*
• *Journal of Agrometeorology*

Website

https://www.ncdc.noaa.gov/climate-information

Lecture Schedule (AGM 511)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1.	Increasing awareness on potential climate hazards and mitigations: history of climate-related disasters in the concerned continent/ region/ country/ sub-region and their documented or remembered impacts;	2
2.	Climatic hazards and extreme weather events (Cyclone, Hailstorm, drought, flood, etc.), Impact of climatic hazard on agricultural production; efforts made in mitigating impacts of (future) disasters (prevention); trends discernible in occurrence and character of disasters, if any	2
3.	Selection of appropriate land use and cropping patterns: types and drivers of agricultural land use and cropping patterns based on climatic situation; history of present land use and cropping patterns in the sub-region concerned as related to environmental issues;	3
4.	Successes and difficulties experienced by farmers with present land use and cropping patterns; outlook for present land use and cropping patterns and possible alternatives from an environmental point of view.	2
5.	Adoption of preparedness strategies: priority settings for 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.	2

6.	Making more efficient use of agricultural inputs: agro-meteorological aspects of agricultural production inputs and their history;	2
7.	Determination of input efficiencies based on weather conditions; other factors determining inputs and input efficiency;	2
8.	Actual use of inputs in main land use and cropping patterns of the region.	1
9.	Adoption of microclimate modification techniques: review of microclimate management and manipulation methods	2
10.	History of microclimate modification techniques practiced in the continent/ country/ sub-region concerned.	2
11.	Possible improvements in adoption of microclimate modification techniques,	2
12.	Given increasing climate variability and climate change; local trends in adoption of such techniques.	1
13	Protection measures against extreme climate: history of protection measures against extreme climate in the continent/ region/ country/ sub region concerned	2
14	Successes and difficulties experienced by farmers with present protection measures;	2
15	Outlook for present protection measures and possible alternatives; trends in protection methods against extreme climate.	3
	Total	**32**

AGM 512 Weather and Climate Risk Management 2+0

Theory

Unit I

Risk characterization – definitions and classification of risks; characterization of weather and climate related risks in agriculture; 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 II

Risks in agricultural production, history of weather and climate as accepted risk factors in agriculture in the continent/ region/ country/ sub-region concerned and the related documented risk concepts; preparedness for weather and climate risks.

Unit III

Risks of droughts; monitoring, prediction and prevention of drought; drought proofing and management; modern tools including remote sensing and GIS in monitoring and combating droughts.

Unit IV

Theories of weather modification; 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 V

Approaches and tools to deal with risks - history of methods for weather and climate related risk assessments in the continent/ region/ country/ sub region concerned and their documented evidence of application to agricultural/farming systems; strategies of dealing with risks-mitigating practices before occurrence; preparedness for the inevitable; contingency planning and responses; disaster risk mainstreaming.

Unit VI

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; heterogeneity of rural people in education, income, occupation and information demands and consequences for risk information products and their transfer; livelihood-focused support, participation and community perspectives; challenges for developing coping strategies including transferring risks through insurance schemes.

Unit VII

Challenges to coping strategies-combining challenges to disaster risk mainstreaming, mitigation practices, contingency planning and responses, basic preparedness; preparedness approaches reducing emergency relief necessities; the role that insurances can play in risk spreading and transfer; application of methods that permit the incorporation of seasonal and long-term forecasts into the risk assessment models.

VI. Teaching methods/ activities

Theory classes

VII. Learning outcome

Knowledge on different weather extremes and how to modify weather to reduce risk

VIII. Suggested Reading

• Anonymous 2003. *Critical Issues in Weather Modification Research Board of Atmoshperic 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 and Graeme J Tupper. 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.
• Mavi HS. 1994. *Introduction to Agrometeorology*. Oxford & IBH.
• Menon PA. 1989. *Our Weather*. National Book Trust.
• Pearce RP. 2002. *Meteorology at the Millennium*. Academic Press.
• Rosenberg NJ, Blad BL and Verma SB. 1983. *Microclimate – The Biological Environment*. John Wiley & Sons.
• Samra JS, Narain P, Rattan RK and Singh SK. 2006. *Drought Management in India*. Bull. Indian Society of Soil Science 24, ISSS, New Delhi.

Journals

• *International Journal of Biometeorology*
• *Agricultural and Forest Meteorology*
• *Journal of Agrometeorology*

Website

• https://www.icrisat.org/

Lecture Schedule (AGM 512)

Sr. No.	Topic	No. of Lecture (s)
1.	Risk characterization – definitions and classification of risks; characterization of weather and climate related risks in agriculture.	2
2.	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.	2
3.	Risks in agricultural production,	1
4.	History of weather and climate as accepted risk factors in agriculture in the continent/ region/ country/ sub-region concerned and the related documented risk concepts; preparedness for weather and climate risks.	3
5.	Risks of droughts; monitoring, prediction and prevention of drought; drought proofing and management; Modern tools including remote sensing and GIS in monitoring and combating droughts.	2
6.	Theories of weather modification; 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.	2
7.	Protection of plants against climatic hazards; air and water pollution; meteorological conditions in artificial and controlled climates - green, plastic, glass and animal houses, etc.	3
8.	Approaches and tools to deal with risks - history of methods for weather and climate related risk assessments in the continent/ region/ country/ sub region concerned and their documented evidence of application to agricultural/farming systems;	2
9.	Strategies of dealing with risks- mitigating practices before occurrence; preparedness for the inevitable; contingency planning and responses; disaster risk mainstreaming.	2
10.	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;	3
11	Heterogeneity of rural people in education, income, occupation and information demands and consequences for risk information products and their transfer; livelihood-focused support, participation and community perspectives;	2
12	Challenges for developing coping strategies including transferring risks through insurance schemes.	1

13	Challenges to coping strategies-combining challenges to disaster risk mainstreaming, mitigation practices, contingency planning and responses,	2
14	Basic preparedness; preparedness approaches reducing emergency relief necessities; the role that insurances can play in risk spreading and transfer;	3
15	Application of methods that permit the incorporation of seasonal and long-term forecasts into the risk assessment models.	2
	Total	**32**

AGM 513 Aerobiometeorology 2+1

Theory

Unit I

Definition and structure of Aerobiometeorology, role of Agrometeorology and Biogeography in forecasting pests and disease outbreak, insect movement in the atmosphere, intensification, Effect of weather and climate parameters on reproduction, growth, development, movements, food, habitat and dispersal of pests and diseases. Influence of weather and climate on Migratory pests (Desert locust, BPH etc.).

Unit II

Benevolent and malevolent weather conditions for salient pests & diseases of the concerned agro-climatic zones. Effects of sudden weather changes and extreme weather conditions on population built-up of the pest, heat stress and heat related mortality, climate change impact on pest and diseases.

Unit III

Biometeorology in integrated pest and disease management program, modification of plant canopy and its impact of plant diseases, management of segments of disease triangle: environment manipulation and host manipulation, weather based forewarning system for pest and diseases.

Unit IV

Soil borne pathogens, their biology, management and challenges, soil borne diseases and their control, abiotic factor in soil borne disease management, Managing of pests & diseases in controlled environment, Environmental management for pest and disease

VI. Practical

- Identification of different pests
- Pest population, observations and their index calculation
- Identification of various diseases
- Disease initiation and their intensity, percent disease index
- Relation between weather parameters and pests and disease

VII. Teaching methods/activities

Classroom teaching and practical, visit to fields

VIII. Learning outcome

Knowledge on interactions between atmospheric processes and living organisms, mainly pest and diseases

IX. Suggested Reading

- Yazdani, SS and Agarwal ML. 2002. *Elements of insect ecology*. Narosa Publishing House.
- Odum EP. *Fundamentals of insect ecology.*

• Dhaliwal GS and Arora R. *Integrated pest management*.
• Jerry L. Hatfield and Ivan J. Thomason. 1982. *Biometeorology in integrated pest management*,
Academic press.

Journals

• *Aerobiologica*
• *Journal of Agrometeorology*
• *International Journal* of *Biometeorology*

Website

• http://www.imd.gov.in

Lecture Schedule (AGM 513)

Sr. No.	Topic	No. of Lecture (s)
1.	Definition and structure of Aerobiometeorology, role of Agrometeorology and Biogeography in forecasting pests and disease outbreak.	3
2.	Insect movement in the atmosphere, intensification, Effect of weather and climate parameters on reproduction, growth, development, movements, food, habitat and dispersal of pests and diseases.	3
3.	Influence of weather and climate on Migratory pests (Desert locust, BPH etc.).	2
4.	Benevolent and malevolent weather conditions for salient pests & diseases of the concerned agro-climatic zones.	3
5.	Effects of sudden weather changes and extreme weather conditions on population built-up of the pest,	2
6	Heat stress and heat related mortality, climate change impact on pest and diseases.	2
7	Biometeorology in integrated pest and disease management program, modification of plant canopy and its impact of plant diseases,	3
8	Management of segments of disease triangle:	1
9.	Environment manipulation and host manipulation, weather based forewarning system for pest and diseases.	3
10.	Soil borne pathogens, their biology, management and challenges, soil borne diseases and their control,	3
11.	Abiotic factor in soil borne disease management.	2
12	Managing of pests & diseases in controlled environment,	3
13	Environmental management for pest and disease.	2

	Total	**32**

Ph.D. Agricultural Meteorology
Course Structure

Ph. D. (Agriculture) Agricultural Meteorology

Course Code	Course Title	Credit Hrs.
AGM 601*	Climate change and sustainable development	2+1
AGM 602	Meteorology of air pollution	2+2
AGM 603	Livestock and fisheries meteorology	2+2
AGM 604	Hydrometeorology	2+1
AGM 605	Analytical tools and methods for Agro-meteorology	1+1
AGM 606	Research and publication ethics	2+0
AGM 607	Environmental Physics for Agricultural Meteorology	3+0
AGM 608*	Computer Programs and Software for Agrometeorological data Management	1+1
AGM 691	Doctoral seminar	1+0
AGM 692	Doctoral seminar	1+0
	Total	**17+8 =25**
AGM 699	Doctoral Research	0+75

***Compulsory Courses**

Semester wise Core Courses offered based on credit requirement

Course Code	Semester	Course Title	Credit Hrs.
AGM 601*	I	Climate change and sustainable development	2+1
AGM 604	II	Hydrometeorology	2+1
AGM 605	III	Analytical tools and methods for Agro-meteorology	1+1
AGM 606	III	Research and publication ethics	2+0
AGM 607	II	Environmental Physics for Agricultural Meteorology	3+0
AGM 608*	I	Computer Programs and Software for Agrometeorological data Management	1+1
AGM 691	III	Doctoral seminar	1+0
AGM 692	IV	Doctoral seminar	1+0
		Total	**13+4 =17**
AGM 699		Doctoral Research	0+75

Minor Courses/Disciplines:

Minor courses of 600 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Agronomy
2. Soil Science
3. Agricultural Physics
4. Organic Farming
5. Plant Physiology
6. Agril.Entomology

7. Plant Pathology
8. Livestock Management
9. Horticulture
10. Any other related discipline

Suggestive minor or supporting courses:

Course Code	Course Title	Credit Hrs.
AGRON 602	Recent trends in crop growth and productivity	2+1
AGRON 607	Stress Crop Production	2+1
AGM 602	Meteorology of air pollution	2+2
AGM 603	Livestock and fisheries meteorology	2+2
SOIL 601	Recent trends in soil physics	2+0
SOIL 607	Modelling of Soil Plant System	2+0
AP 601*	Principles of Soil Physics	2+1
AP 603	Crop Micrometeorology and Evapotranspiration	2+1
AP 607	Weather Hazards and its Management	2+0
PP 606	Global Climate Change and Crop Response	2+0

Optional/Supporting Courses/Disciplines:

Supporting/optional courses of 600 series (05 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Agricultural Statistics
2. Computer Science

Course Code	Course Title	Credit Hrs.
STAT 604*	Advanced Statistical Methods	2+1
STAT 605	Modeling Techniques for Forecasting	2+1
STAT 612	Advanced Design of Experiments	2+1
MCA 603	Simulation and Modeling	1+1

Ph.D. (Agriculture) Agricultural Meteorology

AGM 601 Climate change and Sustainable development 2+1

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; Case studies on various climatic projections and consequences thereof in relation to agriculture.

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. Advance methodology of assessing the impact of climate change on crops.

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, Crop management options for low emission, 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.

VI. Practicals

• Case studies on various climatic projections and consequences thereof in relation to agriculture

• Advance methodology of assessing the impact of climate change on crops

VII. Teaching methods/ activities

Classroom teaching, showing climatic models (GCMs and RCMs) though PPT, Hands on practical

VIII. Learning outcome

Will be aware on causes, impacts, mitigation and adaptations to climate change in the field of agriculture

IX. Suggested Reading

• 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 and 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.
• Pretty J and 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.
• Salinger J, Sivkumar MVK and Motha RP. 2005. *Increasing Climate Variability of Agriculture and Forestry*. Springer.
• Sinha SK. 1998. *Dictionary of Global Climate Change*. Commonwealth Publ.

Journal

• *Mitigation and Adaptation strategies for Global Change*
• *Climate Change*
• *Climate Risk Management*
• *Journal of Agrometeorology*

Website

• https://www.ipcc.ch/
• www.environment.gov.au/climate-change/climate-science-data/climate-science/ipcc

Lecture Schedule (AGM 601)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1.	Climate change and global warming: definitions of terms; causes of climate change and global warming; greenhouse gases, Ozone depletion; past records, present trends	2
2.	Extreme weather events and future projections	2
3.	Case studies on various climatic projections and consequences thereof in relation to agriculture.	2
4	Impacts of climate change on various systems: impacts resulting from projected changes on agriculture and food security	2
5	Impacts of climate change on hydrology and water resources; terrestrial and freshwater ecosystems; coastal zones and marine ecosystems	3
6.	Impacts of climate change on human health; human settlements, energy, and industry; insurance and other financial services	2
7.	Climate change and crop diversification, loss of biodiversity, microbes and pest dynamics	2
8	Climate change and storage, climate change and weed management.	1
9	Advance methodology of assessing the impact of climate change on crops.	1

10	Sensitivity, adaptation and vulnerability: system's sensitivity, adaptive capacity and vulnerability to climate change and extreme weather events	3
11	Regional scenarios of climate change and variability.	1
12	Mitigation strategies for sustainable development	1
13	International policies, protocols, treaties for reduction in greenhouse gases and carbon emissions	2
14	Carbon sequestration; carbon credit; Clean Development Mechanism (CDM) and land use,	2
15	Crop management options for low emission, land use change and forestry mechanism, alternate energy sources, etc.	2
16	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;	2
17	Increasing carbon sinks; resource conservation technologies, mixed rotations of cover and green manure crops, minimization of summer fallow and no ground cover periods, etc.	2
	Total	32

AGM 602 Meteorology of Air Pollution 2+2

Theory

Unit I

Introduction to air pollution- history, definition: clean air definition; natural versus polluted atmosphere; atmosphere before the industrial revolution, Real time air quality index and National air quality index.

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. Acid rain and development of Gas Washing

Unit III

Meteorological factors in the dispersion of air pollutants; topographical, geographical and large scale meteorological factors attached air pollution; Planetary Boundary Layer (PBL) and mixing layer; 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 and crops; 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. Scales of air pollution: local, urban, regional, continental and global.

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.

VI. Practicals

• Measurement of different air pollutants
• Measurement of different air pollution gases
• Measurement of visibility
• Measurement of ozone and aerosol optical thickness (AOT)
• To study the temperature profile at different heights
• To study the stability of the atmosphere
• To determine height of partial flume through chimani
• To study the effect of temperature on vegetables, orchards and agricultural crops

VII. Teaching methods/activities

Classroom teaching and practical

VIII. Learning outcome

Knowledge of sources and dispersal of pollutants, indexing, the influence of meteorological activities and analysis of pollutants

IX. Suggested Reading

• Arya SP. 1998. *Air Pollution Meteorology and Dispersion*. Oxford Univ. Press.
• Oke TR. 1988. Boundary Layer Climates. Routledge.
• 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 and Kozlowski TT. (Ed.). 1975. *Responses of Plants to Air Pollution*. Academic Press.
• Pickett EE. 1987. Atmopheric Pollution. Hemisphere Publ. Corp.
• Sharma SH and Khan TI. 2004. *Ozone Depletion and Environmental Impacts*. Pointer Publ.
• Weber E. 1982. *Air Pollution Assessment Methodology and Modeling*. Plenum Press.
• Yunus M and Iqbal M. (Eds.). 1996. *Plant Response to Air Pollution*. John Wiley & Sons.

Journals

• *Atmospheric Pollution* Research,
• *Environmental Pollution,*
• *Journal of Agrometeorology*

Website

• https://www.nationalgeographic.com/environment/global-warming/pollution/

Lecture Schedule (AGM 602)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Introduction to air pollution- history, definition	1
2	Clean air definition; natural versus polluted atmosphere; atmosphere before the industrial revolution	2
3	Real time air quality index and National air quality index.	1
4	Sources of air pollution; classification and properties of air pollutants;	2
5	Emission sources, importance of anthropogenic sources	1

6	Behaviour and fate of air pollutants; photochemical smog; pollutants and trace gases.	2
7	Acid rain and development of Gas Washing	1
8	Meteorological factors in the dispersion of air pollutants; topographical, geographical and large scale meteorological factors attached air pollution	2
9	Planetary Boundary Layer (PBL) and mixing layer; meteorological conditions and typical plume forms;	2
10	Air pollution forecasting – Gaussian diffusion models, Numerical dispersion models.	2
11	Air quality standards; effect of air pollution on biological organisms, Ozone layer depletion	2
12	Air pollution control technologies; management of air pollution;	2
13	Principles of diffusion of particulate matter in the atmosphere	2
14	Air pollution laws and standards. Scales of air pollution: local, urban, regional, continental and global	2
15	Air pollution sampling and measurement	2
16	Types of pollutant sampling and measurement, ambient air sampling,	2
17	collection of gaseous air pollutants, collection of particulate pollutants, stock sampling;	2
18	Analysis of air pollutants - sulfur dioxide, nitrogen dioxide, carbon monoxide, oxidants and ozone, hydrocarbons, particulate matter.	2
	Total	32

AGM 603 Livestock and Fisheries Meteorology 2+2

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. Animal traits and physiological responses.

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, sunburns and photosensitive disorders.

Unit III

Meteorological conditions prevailing in glass-house, green house, animal shed, poultry house and grain storage barns; heating, cooling and ventilation of these structures as governed by meteorological factors. Environmental modification within the shelters of livestock.

Applications of biometeorological information for rational planning, design and management. Weather and animal diseases and parasites; diseases of poultry and its relation with weather and thermal comfort.

Unit IV

Livestock production and climate change, Management of livestock to reduce greenhouse gas emission.

Unit V

Weather effect on fish behaviour. Water temperature affecting fish activity. Marine weather and fishing. Climate change and fisheries production.

VI. Practical

- Measurement of meteorological parameters within the shelters of livestock
- Calculation of animal comfort zone index
- Radiation of animal farm house and body
- Estimation of enegy fluxes on body
- Measurements of CO2 and methane in animal farm house.

VII. Teaching methods/activities

Class room teaching for theory part, visit to farm house for practical

VIII. Learning outcome

Enhanced knowledge on weather influence on livestock and farm environment

IX. Suggested Reading

- GSLHV Prasada Rao, GG Varma and Beena (Eds). 2017. *Livestock meteorology.* New India Publishing Agency- Nipa. 542 pages
- Kaiser HM and Drennen TE. (Eds). 1993. *Agricultural Dimensions of Global Climate Change*. St. Lucie Press, Florida.
- Monteith L and Unsworth M. 2007. *Principles of Environmental Physics*. 2nd Ed. AcademicPress. Takahashi J, Young BA, Soliva CR and 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 and Plants). Heyden & Son Ltd.

Journals

- *Agricultural and Forest Meteorology,*
- *Journal* of *Animal Behaviour and Biometeorology,*
- *Journal of Agrometeorology*

Website

- www.wmo.org

Lecture Schedule (AGM 603)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	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.	2
2	Animal traits and physiological responses.	1

3	Effects of weather on animal production, loss of water from the body, growth rate and body weight, reproduction, grazing habit, food intake, milk production, sunburns and photosensitive disorders	3
4	Meteorological conditions prevailing in glass-house, green house	2
5	Meteorological conditions prevailing animal shed, poultry house and grain storage barns;	2
6	Heating, cooling and ventilation of animal shed, poultry house and grain storage barns as governed by meteorological factors.	2
7	Environmental modification within the shelters of livestock.	2
8	Applications of biometeorological information for rational planning, design and management.	2
9	Weather and animal diseases and parasites;	2
10	Diseases of poultry and its relation with weather and thermal comfort.	2
11	Livestock production and climate change,	2
12	Management of livestock to reduce greenhouse gas emission.	2
13	Weather effect on fish behaviour.	2
14	Water temperature affecting fish activity.	2
15	Marine weather and fishing.	2
16	Climate change and fisheries production.	2
	Total	32

AGM 604 Hydrometeorology 2+1

Theory

Unit I

Hydrologic cycle and its modification; rainfall and its interception by plants and crops. Interpolation and measurement of missing rainfall data; adequacy of rain gauges; average rainfall on an area depth basis; presentation and processing of precipitation data.

Unit II

Measurement of runoff, infiltration, moisture retention of soil, percolation, evaporation, evapotranspiration and its importance to agriculturists, irrigation engineers and flood forecasting personnel; water holding capacity of soils, plant available water, cultural practices on soil moisture in relation to different phases
of crop growth; evaporation from snow, lakes, reservoirs and crop fields.

Unit III

Classifying rainfall data into class interval; ranking of rainfall data; relationship between intensity and duration; methods of predicting runoff rate; factors affecting runoff; rainfall-runoff relation; estimation of evapotranspiration from water balance methods; response of crops to water stresses under different agroclimatic situation on India.

Unit IV

Moisture availability indices and their application for Indian condition; wet and dry spell by Markov-chain model; drought and its classification, hydrological drought, drought indices and their applications under Indian conditions.

VI. Practical

• Analysis of rainfall data
• Determination of effective rainfall
• To estimate missing rainfall data for a given station.
• To find out the optimum number of rain gauges for a given catchment.
• To find out the mean rainfall for a given drainage basin by Thiessen polygon method and isohyetal method.
• To estimate the volume of runoff by SCS method.
• Estimation of evopotranspiration from field based water balance method.

VII. Teaching methods/activities

Theory and practical classes

VIII. Learning outcome

Knowledge on rainfall analysis, runoff estimation, calculation of evaporation and the relationship among different hydrological parameters

IX. Suggested Reading

• Chow, Ven Te (Ed.). 1964. *Handbook of Applied Hydrology.* McGraw-Hill.
• Hillel D. 1971. *Soil and Water.* Academic Press.
• Hillel D. 1980. *Application of Soil Physics*. Academic Press.
• Hillel D. 1998. *Environmental Soil Physics*. Academic Press.

Journal

• *Journal* of *Hydrology, Journal* of *Hydrology and Meteorology,*
• *Agricultural Water Management,*
• *Journal of Agrometeorology*

Website

• https://has.arizona.edu/meteorology-hydrology-and-hydrometeorology
• www.abb.com/cawp/seitp161/4f39ac092c0598c9c1256fb8004f7726.aspx

Lecture Schedule (AGM 604)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Hydrologic cycle and its modification;	2
2	Rainfall and its interception by plants and crops.	1
3	Interpolation and measurement of missing rainfall data;	2
4	Adequacy of raingauges; average rainfall on an area depth basis;	3
5	Presentation and processing of precipitation data.	1
6	Measurement of runoff,	2
7	Infiltration, moisture retention of soil, percolation, evaporation, evapotranspiration and its importance to agriculturists, irrigation engineers and flood forecasting personnel;	3

8	Water holding capacity of soils, plant available water,	1
9	Cultural practices on soil moisture in relation to different phases of crop growth;	1
10	Evaporation from snow, lakes, reservoirs and crop fields.	1
11	Classifying rainfall data into class interval; ranking of rainfall data; relationship between intensity and duration;	2
12	Methods of predicting runoff rate (Rational formula, curve number method, Use of remote sensing and GIS, soil conservation service method)	2
13	Factors affecting runoff;	1
14	Rainfall-runoff relation;	1
15	Estimation of evapotranspiration from water balance methods;	2
16	Response of crops to water stresses under different agroclimatic situation on India.	2
17	Moisture availability indices and their application for Indian condition;	2
18	Wet and dry spell by Markov-chain model;	1
19	Drought and its classification, hydrological drought, drought indices and their applications under Indian conditions.	2
	Total	32

AGM 605 Analytical Tools and Methods for Agro-meteorology 1+1

Theory

Unit I

Review of agro-climatic methods; 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++ Visual basic and Python.

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.

VI. Practical

• Calculation of continentality factors.
• Climatic indices and climogram.
• Agrometeorological indices: Degree-days, photothermal units, heliothermal units, phenothermal index.
• Heat and radiation use efficiency and other indices of crops.
• 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.

VII. Teaching methods/activities

Theory and practical classes, learning of computer language

VIII. Learning outcome

Knowledge on collection of agromet data, sampling design for agrometeorology, calculation of different indices and analysis of data

IX. Suggested Reading

• Cooper M. 2006. *The Spirit of C. An Introduction to Modern Programming*. Jaico Publ.
• Malczewski J. 1999. *GIS & Multicriteria Decision Analysis*. John Wiley & Sons.
• WMO. 2010. *Guide to agricultural meteorological practices*. Chapter 3: agricultural meteorological data, their presentation and statistical analysis

Journals

• *The International Journal* of *Database Management* Systems
• Journal of Agrometeorology

Website

• https://www.tropmet.res.in/~icrp/icrpv12/adach.html
• www.wmo.int/pages/prog/wcp/agm/gamp/documents/WMO_No134_en.pdf

Lecture Schedule (AGM 605)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Review of agro-climatic methods;	1
2	Characterization of agroclimatic elements; sampling of atmosphere; temporal and spatial considerations; micro-meso-macro climates.	1
3	Network spacing; spatial and temporal methods;	1
4	GIS fundamentals and applications;	1

5	Numerical characterization of climatic features;	1
6	Crop response to climate, time lags, time and distance constants, hysteresis effects.	1
7	Influence of climate on stress-response relations;	1
8	Thermal time approach in agroclimatology- heat and radiation use efficiency in crop plants; applications to insect-pest development and prediction	1
9	Comfort indices for human and animals; impact of natural and induced variability and change of climate on crop production.	2
10	Instrumentation and sampling problems; design of agro-meteorological experiments.	2
11	Basic knowledge of application of computers in agriculture; theories of computer language BASIC, FORTRAN, C, C++ and Visual basic.	1
12	Empirical and statistical crop weather models and their application with examples;	1
13	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.	2
	Total	16

AGM 606 Research and Publication Ethics 2+0

Theory

Unit I

Introduction to philosophy: definition, nature and scope, concept, branches

Unit II

Ethics: definition, moral philosophy, nature of moral judgments and reactions

Unit III

Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data

Unit IV

Publication ethics: Definition, introduction and importance. Best practices/ standard setting initiatives and guidelines: COPE, WAME etc., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship,Identification of publication misconduct, complaints and appeals, predatory publishers and journals

Unit V

Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self archiving policies; software tool to identify

predatory publications developed by SPPU, Journal finder/journal suggestions tools, viz., JANE, Elsevier Journal Finder, Springer Journal Suggester etc.

Unit VI

Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools.

Unit VII

Database and Research metrics: Indexing data base, citation database, web of science, scopus, etc. Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, Gindex, i 10 index altmetrics

V. Teaching methods/activities

Classroom teaching and field and laboratory activities

VI. Learning outcome

To familiarize the students about field and laboratory activities to be performed during the study period.

Lecture Schedule (AGM 606)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Introduction to philosophy: definition, nature and scope, concept, branches	2
2	Ethics: definition, moral philosophy, nature of moral judgements and reactions	2
3	Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity	2
4	Scientific misconducts- falsifications, fabrications and plagiarism (FFP)	2
5	Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data	3
6	Publication ethics: Defination, introduction and importance. Best practices/ standard setting initiatives and guidelines: COPE, WAME etc., conflicts of interest.	3
7	Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship,	3
8	Identification of publication misconduct, complaints and appeals, predatory publishers and journals	1
9	Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self archiving policies;	2

10	Software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools, viz., JANE, Elsevier Journal Finder, Springer Journal Suggester etc.	3
11	Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad.	3
12	Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools.	2
13	Database and Research metrics: Indexing data base, citation database, web of science, scopus, etc.	2
14	Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, Gindex, i 10 index altmetrics	2
	Total	32

AGM 607 Environmental Physics for Agricultural Meteorology 3+0

Theory

Unit I

Thermodynamics of the atmosphere. Physics of radiation: origin and nature of radiation, radiation geometry in Cartesian, spherical cylindrical coordinate systems, conservation principles for radiant energy; fluid motion: laminar and turbulent transfer, fluctuation theory for turbulent transfer of momentum, heat and water vapour.

Unit II

Physics of evaporation: aerodynamic approach, energy balance approach and combination approach for evaporation estimates.

Unit III

Physics of soil water system: the concept of potential as applied to soil water system, total potential and components, movements of water on soil, fundamental equation, hydraulic conductivity, infiltration, field drainage and water vapour movement in soil.

Unit IV

Physics of water use: a physical introduction to plant-water system and relationships, water transport through soil-plant-atmosphere systems, measurement of crop water use in terms of water conservation equation.

VI. Teaching methods/activities

Classroom teaching

VII. Learning outcome

Knowledge and application of physical laws governing the agrometeorological parameters.

VIII. Suggested Reading

• Hillel D. 1971. *Soil and Water.* Academic Press.
• Hillel D. 1980. *Application of Soil Physics*. Academic Press.
• Hillel D. 1998. *Environmental Soil Physics*. Academic Press.
• Monteith JL .1973. *Principles of Environmental Physics.* Edward Arnold.
• Rose CW. 1966. *Agricultural Physics.* Pergamon Press.
• Sellers WD. 1965. *Physical Climatology.* University of Chicago Press.
• Van Wizk WR. 1963. *Physics of Plant Environment.* North-Holland Publishing.

• Waggoner PE. (Ed.). 1965. *Agricultural Meteorology.* American Meteorological Society.

Journals

• *Journal of Meteorological Research,*
• *Agricultural and Forest Meteorology*

Website

•https://fmph.uniba.sk/.../enviromentalna-fyzika-obnovitelne-zdroje-energie-meteorolo...

Lecture Schedule (AGM 607)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Thermodynamics of the atmosphere.	2
2	Physics of radiation: origin and nature of radiation,	3
3	Radiation geometry in Cartesian, spherical cylindrical coordinate systems	4
4	Conservation principles for radiant energy;	3
5	Fluid motion: laminar and turbulent transfer, fluctuation	3
6	Theory for turbulent transfer of momentum, heat and water vapour.	4
7	Physics of evaporation: aerodynamic approach,	3
8	Energy balance approach and combination approach for evaporation estimates.	4
9	Physics of soil water system: the concept of potential as applied to soil water system,	4
10	Total potential and components, movements of water on soil,	3
11	Fundamental equation, hydraulic conductivity, infiltration, field drainage and water vapour movement in soil.	4
12	Physics of water use: a physical introduction to plant-water system and relationships,	4
13	Water transport through soil-plant-atmosphere systems,	3
14	Measurement of crop water use in terms of water conservation equation.	4
	Total	48

AGM 608 Computer Programs and Software for Agrometeorological Data Management 1+1

Theory

Unit I

Data and information; types of data; climate, soil and crop data; Importance of database management, Softwares related to database management; data requirements; data collection and recording (Automatic and manual).

Unit II

Data structure/format; quality control of data through computer software; techniques of climatic data generation; missing data; introduction to different software for database management.

Unit III

Processing and analysis of data and data products; value addition of data and data products; data users, public, commercial, academic or research. Availability, accessibility and security of data; evaluating the cost of data; e-management of data. Meta analysis: Advantages and problems, Steps, Approaches and methods, Applications.

Unit IV

Computer Programming: History, Quality requirements, Readability of source code, Algorithmic complexity, Debugging, Programming languages.

VI. Practical

- Types of instruments and data recording
- AWS data retrieval, storage and transfer
- Exposure to different software for Agromet data analysis; exposure to Statistical software
- Temporal and spatial analysis of data; exposure to GIS
- Value addition to data
- Introduction to internet protocols
- Uploading and downloading data, password and security of data
- E-management of data
- Introduction to computer programming

VII. Teaching methods/activities

Hands on practical and theory

VIII. Learning outcome

Learning computer programming to manage and analyze agromet data

IX. Suggested Reading

- Ghadekar R. 2002. *Practical Meteorology – Data Acquisition Techniques, Instruments and Methods*. 4th Ed. Agromet Publ.
- IMD/ WHO. 1988. *Users Requirements for Agrometeorological Services.* IMD.
- Miles MB and Huberman AM. 1994. *Qualitative Data Analysis*. Sage Publ.
- Panse VG and Sukhatme PV. 1983. *Statistical Methods for Agricultural Workers*, ICAR.
- Potter GB. 1994. *Data Processing: An Introduction*. Business Publ.
- Ramakrishnan R and Gehrke J. 2003. *Database Management System*. McGraw-Hill.
- Sinha PK and Sinha P. 2004. *Computer Fundamentals*. BPB Publications. (6th Edn).

Journals

- *The Journal* of *Database Management*
- *International Journal* of Data Mining
- *Modelling and Management*

Websites

- https://www.cics.umass.edu/research/area/data-management
- https://www.referenceforbusiness.com/management/.../Data-Processing-and-Data-Man.

Lecture Schedule (AGM 608)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Data and information; types of data; climate, soil and crop data; Importance of database management	1
2	Softwares related to database management; data requirements; data collection and recording (Automatic and manual).	2
3	Data structure/format; quality control of data through computer software;	1
4	Techniques of climatic data generation; missing data;	2
5	Introduction to different software for database management.	1
6	Processing and analysis of data and data products;	1
7	Value addition of data and data products; data users, public, commercial, academic or research.	1
8	Availability, accessibility and security of data; evaluating the cost of data; e-management of data.	1
9	Meta analysis: Advantages and problems, Steps, Approaches and methods, Applications.	1
10	Computer Programming: History, Quality requirements	2
11	Readability of source code, Algorithmic complexity, Debugging,	1
12	Programming languages: C. C++, Java, Python	2
	Total	16

A list of international and national reputed Journals

Sr. No	Name of international and national reputed journals	NAAS Score
1	Mausam	6.64
2	Global Change Biology	16.86
3	Journal of Applied Meteorology and Climatology	8.92
4	Journal of Hydrology	11.72
5	Mitigation and Adaptation Strategies for Global Change	9.58
6	Agricultural and Forest Meteorology	11.73
7	Agricultural Water Management	10.52
8	Archives of Agronomy and Soil Science	9.09
9	Atmospheric Pollution Research	10.35
10	Current Science	7.10
11	Environmental Pollution	14.07
12	Global Environmental Change	15.52
13	International Journal of Biometeorology	9.79

14	Journal of Agrometeorology	6.55
15	Journal of Climate (JCLI)	11.15
16	Journal of Plant Ecology	7.77