

Direct Recruited Scientists Training Course (DRSTC)

Course Out line

Subject	Periods
Meteorological Observation System (Surface & UA)	20
Dynamic Meteorology	58
NWP	40
Physical Meteorology and Thermodynamics	60
Synoptic Meteorology	60
Climatology	60
Applied Meteorology	20
Aviation Meteorology	40
Satellite and Radar Meteorology	20
Hands on practical exercise session	38
General Administration	12
Written examination of 5 papers & Viva Voce	26
On the job training	26
Total	480 periods (approximately 19 working weeks#)

In every week we have 26 classes. (4 x 5+6)

Detail course Content

Observational System

- **Surface Observational system**

- Measurement at surface observatories and Automatic Weather Stations, Agromet observatories
- Marine Observations: Ship Observations, ocean drifting buoys, moored buoys, ARGO, Airborn instrumentation
- Measurements at Aeronautical Meteorological Observatories
- Measurement at Radiation and BAPMoN stations
- **Maximum sustained surface wind, gustiness, squall, gale, wind averaging (1-2-,3-, 5-,10 min), wind conversion factor, impact of wind associated with tornado, thunderstorm, depression and cyclones (Beaufort scale, Saffir Simpson wind scale, Dvork scale etc.), classification of wind.**
- **Measurement at Agromet Observatories.**

Upper air Observational system

- Measurement of upper air pressure, temperature, wind and humidity: Methods of upper wind observations, Radiosonde, Optical theodolite, Radiotheodolite, Radars, Pilot balloon, methods of calculations; with tail method; with constant rate of ascent, theodolite, balloon and accessories; computation of upper winds; principles of measurement of upper air temperature, pressure and humidity by meteorograph, radiosonde; principles of measuring winds by radar and radio theodolites, GPS radiosonde, GPS receiver, Radars, LIDARS, wind profilers. GPS Radio-Occultation techniques

Remote Sensing Observational System

- Observations through remote sensing based on satellites: atmospheric temperature and sea surface temperature measurements, measurement of water vapor and humidity, precipitation through satellite and radar, clouds including type, base and height through satellite-based sensors.
- Radar Measurements, multiparameter radars (especially polarimetric) and profiler radars and their capabilities in meteorology (besides wind measurement), use of

the sun and radio stars in the case of radars and profilers.

Radiation, Ozone and Lightning observational systems

- Radiation- Definitions, units and scales, measurement methods, Surface Solar and IR radiation, solar, terrestrial and net radiation, Radiometer sondes, Direct and Indirect, Sunshine recording system.
- Trace gases, ozone and Aerosol: Description of spatial and temporal distribution of trace gases, ozone and aerosols., Measurement Techniques: Column Ozone, Vertical distribution of Ozone, Surface Ozone, IMD's network for Ozone observation, Dobson spectrophotometer Measuring instruments for trace gases, pollutants and aerosols, ozone sondes, Aerosol measurement technique, IMD's network for aerosol observation.
- Lightning detector, atmospheric electricity measurements, potential gradient and conductivity measurements, lightning flash meters, networks for radio location of lightning, Environmental parameters- instrumentation and techniques.

Climatology & Climate Science

- **Physical climatology:** Earth Sun relationship, Ecliptic and equatorial plane, Rotation and revolution of the earth Equinoxes, Solstices, Perihelion and Aphelion, Causes of seasons, Seasonal and latitudinal variation of insolation, Definition of climate, radiative forcing. Climatic control and Climatic classification.
- **Indian Climatology:** Four seasons - (Pressure and wind distribution for mid-season months)
Southwest monsoon season – Onset and advance of southwest monsoon. Semi-permanent systems of monsoon, Factors affecting distribution of monsoon rainfall, Active-break cycle, Monsoon breaks,. Synoptic systems in monsoon (monsoon lows and depression, MTCs, and monsoon trough). Interannual and intra seasonal variability of monsoon, links to El Nino/Southern Oscillation, mid-latitude interaction, Indian Ocean Dipole and Madden Julian Oscillation Index.

Winter - Western disturbances, fog, thunderstorms, hail, cold waves, sub-tropical jet stream; Northeast monsoon - Interaction of low and high latitude disturbances, easterly waves

Pre-monsoon: Cyclonic storms, tracks, Frequency, the cyclone genesis, intensity, landfall and associated weather – gale wind, heavy rainfall and storm surge, western disturbances, fog, dust storms, thunderstorms, Nor 'westers, heat waves, pre-monsoon thunderstorms, dust-raising winds, equatorial trough

Post monsoon season - Withdrawal of southwest monsoon, Northeast monsoon (mean rainfall distribution, synoptic systems, inter-annual variability), Cyclonic storms in the Indian seas, trends in cyclonic disturbances, Western disturbances, Easterly waves.

Mean State of the global Atmosphere, Oceans, Cryosphere and Biosphere.

Mean temperature structure (global distribution and vertical structure), Mean Geopotential Height structure, Mean Atmospheric Circulation (global distribution, vertical structure, variability of the circulation), Precipitation, evaporation, runoff and cloudiness.

Mean State of the Oceans

Mean and vertical temperature, density and salinity structure, Mean Ocean circulation, SST anomalies and Asian summer monsoon (interannual variability of date of monsoon onset and quantum of Indian summer monsoon rainfall) - Tropical Biennial Oscillation – Role of ocean in the Active – Break cycle of monsoon - Relation between tropical deep Convection and SST, El Nino, Ocean state and cyclones

Mean state of the cryosphere & Biosphere

Role of the cryosphere in the climate, General features of the cryosphere, effect of biota on climate (deforestation)

Variability in the climate system:

Monsoon (southwest and northeast) Variability, diurnal, intraseasonal, Interannual, inter-decadal, long term trends from observations, Teleconnection patterns, Walker circulation, tropical –extratropical interaction.

El Nino/ Southern Oscillation, Climatology, Dynamics and prediction, links with global climate, Madden Julian Oscillations, Coupling of Ocean and Atmosphere in ENSO – Indian Ocean Dipole– Relation between ENSO.IOD and Indian monsoon, Indian Ocean Dipole, statistics, dynamics and links with global climate., Feedback process between different forcing.

North Atlantic Oscillation, Arctic Oscillation, North Pacific Oscillations, PDO, NH Teleconnection Patterns.

Climate modelling and prediction: Climate models – a brief review, Constructing a Climate Model, An atmospheric model, an ocean model and ocean - atmosphere coupling, Climate simulations and climate drift, Evaluations of climate model simulations for Indian monsoon, , Extended and long range prediction-: Scope and different methods, statistical and dynamical approaches for long range forecasting, types of forecasts and verifications, standard verification methods, Communication of uncertainty in the forecasts, Operational long range forecasting system in India– history and status.

Science of Climate Change: Basics of global climate and Climate Change, Climate Feedbacks -water vapor, cloud, oceans, snow and ice, Greenhouse gases, aerosols and other climate forcings, Observed climate change over India and globe - Ice, sea level, extreme events, Future climate projections, IPCC report results.

Paleo-climatology

Synoptic Meteorology

- Scales of weather systems (Meso, Synoptic and Planetary scales) - Map projections - representation and analysis of fields of meteorological elements on synoptic charts - Vertical time/cross sections and their analysis. Wind and pressure analysis - Isobars on level surface and contours on constant pressure surface - Isotherms, thickness field - Slope of pressure systems - Streamline and isotach analysis. Preparation, analysis, interpretation, application and limitations constant PV charts
- Winter season synoptic systems - Western Disturbance and Its structure and associated weather- Fog – cold wave – checklist for forecasting of western

- disturbances , Fog and cold wave. – satellite and RADAR features of western disturbances , Fog.
- Pre-monsoon season synoptic scale weather – maximum temperature & heat wave -Ordinary thunderstorm - Severe thunderstorm (Squall-line, Multi-cell, Supercell) – Role of CAPE, CINE and Vertical Wind Shear – synoptic conditions for thunderstorm activity over different parts of Indian continent- Norwesters, Dust-storm (ANDHI), Hail storm, Tornado, Squall, sea breeze induced Thunderstorm- Meso-high, Gust front , Down-burst and Micro-burst - checklist for forecasting of thunderstorm and hailstorms.- satellite and RADAR features of western disturbances , Fog.
 - Asian summer monsoon - Monsoon onset over Kerala – semi-permanent systems – Active and Break monsoon phases – Monsoon depression – Mid Tropospheric Cyclonic circulations - Influence of northern hemisphere mid-latitude westerly troughs – Monsoon teleconnection, NW pacific typhoons – Monsoon and orography - Intra-seasonal variability of Monsoon (15 and 40 day modes) - Withdrawal of monsoon – Monsoon and the Indian ocean .
 - North east monsoon in India. - Easterly wave and its structure and associated weather - satellite and RADAR features of easterly waves.
 - Tropical cyclone - Life cycle – horizontal structure – vertical structure- Cyclone Genesis - Intensification of cyclones – T-number – Movement of tropical cyclones - dynamical and statistical methods -Persistence, climatology and steering methods - Analogue techniques - Interaction with nearby cyclones. - NWP models for Tropical cyclones genesis, intensification and movement. Monitoring and prediction of heavy rain, gale wind, storm surge, Cyclone related warnings generation and dissemination.
 - Mid latitude Synoptic Meteorology: Zonal index & Index cycle. Air masses and fronts – Fronto-genesis - Slope of frontal surface - Extra tropical cyclone and its structure and life cycle - Fronts and associated weather - Development of cyclones and anticyclones - Jet Stream and Tropopause; long waves; cut-off lows and highs, blocking.

- Diurnal and local effects - Sea and land breezes - Slope and valley winds - Mountain wave - Clear Air Turbulence.
- Basics of Nowcasting - Meso-network - Use of radar and satellite in meso-scale analysis and forecasting.
- Tools and Techniques for Synoptic Analysis.
 - a. Digitised Forecaster's workstation (Synergy system in IMD),
 - b. Special Module available in synergy system for specific purpose, viz., Module for preparation of significant weather chart, Tropical Cyclone Module
 - c. check list for daily watch on severe weather events (e.g. Monsoon Watch, Daily Tropical Weather Watch for Cyclogenesis, Thunderstorm activities etc).
 - d. Preparation of report on severe weather.
- Impact based weather services:

Some basic concepts in impact-based forecast and warning services: Basic concepts of Hazards, forecast uncertainty, exposure, Vulnerability, risk and Risk matrix. Basic concepts of the different Paradigms in operational Weather services: Weather forecast & Warning, Impact based forecast & warning and Impact forecast & warning.

Evolving towards impact forecasting: What is an Impact-based Forecast and Warning service? Steps for Implementing Impact-based Forecast and Warning Services- Development of the Risk Matrix, Identification of weather events and hazards, Assessment of Vulnerability of identified hazards, development of impact table, Development of Advisory table. Key elements of an impact-based forecast and warning service. Benefits of impact-based forecast & warning services.

- **Atmospheric Thermodynamics:**

Equation of state for moist air, Concepts of virtual temperature. Different moisture parameters, Different thermodynamic processes in atmosphere-isobaric, Isohygric, isothermal, adiabatic (dry, saturated and pseudo). Concepts of dry bulb, wet bulb and dew point temperature, LCL, LFC, LNB, EL, PWC, Geopotential height, and

T_c. Laws of thermodynamics. Concepts of potential temperature, equivalent potential temperature, entropy, reversible and irreversible process. Introduction to T- Φ diagram and its analysis. Different stability parameters.

- **Atmospheric Radiation:**
 - Electromagnetic spectrum: quantitative description of radiation; Kirchhoff's Law, Planck's Law, Stefan-Boltzmann's Law, Wien's displacement law, and Beer's Law; atmospheric radiative transfer: Concept on radiative equilibrium and discussion on radiative flux divergence. Scattering, Rayleigh, Mie and non-dimensional scattering, absorption, and emission of radiation; Schwarzschild's equation, Refractive index variations discontinuities, refractivity turbulence, optical depth
 - Solar radiation, direct and diffuse, and global radiation and their measurements; Solar constant and its measurements; Albedo of Earth, Details of aerosol scattering and their impact on direct and diffuse radiation, Atmospheric Aerosols turbidity and its impact on solar radiation. Climatology of solar insolation, Seasonal and latitudinal variation of insolation.
 - Terrestrial radiation: Absorption of terrestrial radiation by atmosphere; Greenhouse effect, Radiative cooling of the atmosphere; Heat balance of the earth and atmosphere, Anthropogenic greenhouse gases, greenhouse effect, its role and examples from atmosphere of Venus, "Runaway greenhouse effect" Sources of greenhouse gases, linked with anthropogenic activities.
 - Refraction, scattering and diffraction of solar, IR . Impact of dust and turbidity.
- **Theory of Atmospheric visibility:** Concept of atmospheric optics and optical phenomena. visibility meters; Measurement of visibility during day and night. Slant Visibility, Koschmeidar Equation, Runway Visual Range, Impact of hydrometeors and Lithometeors on visibility, impact of air pollution and photochemical processes in the Atmospheric boundary layer on visibility.

- Upper Atmosphere and Ozone: Different techniques of exploration of upper atmosphere; thermal structure of troposphere, stratosphere, mesosphere and thermosphere and their physical explanation, QBO and stratospheric warming; Tropospheric Ozone : Chemical Properties of Ozone, Units of Measurements, Formation of Tropospheric Ozone, Health Effects . Stratospheric Ozone: Formation of Ozone in Stratosphere, Stratospheric Ozone Depletion, Antarctic Ozone Hole, Impacts of UV Radiation, Stratospheric Ozone Depletion over the Arctic, Control Strategies and International Treaties, ozone temporal and spatial variations of Ozone; measurements of total ozone; Umkher effect. Ozone hole, CFC and related concepts.
- Cloud Physics: Homogeneous Nucleation, Atmospheric aerosols and condensation nuclei, Heterogeneous Nucleation (curvature and solute effects), Kohler Curves, growth of cloud droplets by diffusion and by collision and coalescence; growth and initiation of precipitation in non-freezing clouds.; ice nucleation, Formation mechanisms of graupel, hail and snow, Bergeron-Findeisen mechanism of growth of precipitation.
- Atmospheric Electricity: Ions in the atmosphere (sources and sinks), Conductivity and its measurements, Basic concepts regarding fair weather electric field and its measurements. Air-earth current

(Conduction currents and Maxwell Currents) and its measurements, Space Charge in the atmosphere, Global Electric Circuit and its maintenance. Electrical Structure of thunderstorms. Lightning (CG and Cloud discharges) mechanisms, Upward discharges (Sprites, Blue Jets, Blue Starters, Elves). Thunderstorm electrification mechanisms. Global Electric Circuit. The concepts of lightning arrestors and lightning detectors

Dynamic Meteorology

Equation of Motion.

- **Forces: Pressure gradient force; Coriolis force, gravitational force, and friction, Local change of a field, advection of a field variable, local (Eulerian) derivative & total (Lagrangian) derivative of a field variable.**
- **Equations of motion in Cartesian coordinates. Equations of motion in spherical polar coordinates. Curvature terms.**

Scale Analysis

- **Concept of order of magnitude. Non-Dimensional analysis of different field variables**
- **Definition of scale of a weather system. Scale analysis of momentum equation for mid-latitude/tropical synoptic scale / mesoscale system.**

Geostrophic approximation:

- **Definition and properties of geostrophic wind. Vectoral expression for geostrophic wind. Schematic diagram to show how geostrophic balance is achieved.**
- **Rossby number. Use of Rossby number as a tool to test the validity of geostrophic approximation. Regions of atmosphere where Geostrophic is not a valid assumption.**
- **Ageostrophic wind, its definition and property. Vectoral expression for ageostrophic wind. Its relationship with acceleration.**

Hydrostatic Approximation .

- **Simplification of vertical momentum equation for mid latitude synoptic scale system following scale analysis leading to hydrostatic approximation. Discussion on the validity and limitations of this approximation.**
- **Using above approximation, definition of atmospheric pressure at any point.**
- **Definition of geopotential and geopotential height of a point and corresponding units.**
- **Hypsometric equation and its use in computing thickness of a layer of atmosphere.**

Natural Coordinate and balanced flow.

- **Introduction to natural co-ordinate. Horizontal equation of motion in natural co-ordinate. Gradient balance and gradient wind. Physically possible different gradient flow. Examples. Sub & super – geostrophic flow. Special cases of gradient balance: -geostrophic balance, inertial balance, and cyclostrophic balance. Examples. Is gradient flow a balanced (no acceleration) flow?**
- **Different vertical co-ordinates, pressure (p), potential temperature (θ) etc. Pressure gradient force in p & θ co-ordinates. Horizontal equation of motion with p as in any vertical co-ordinate.**

Vertical Variation of Wind.

- **Thermal wind: Definition, Thermal wind equation and properties of thermal wind.**
- **Concept of vertical wind shear. Schematic explanation for horizontal temperature gradient leading to vertical shear of geostrophic wind.**
- **Application of the concept of thermal wind in explaining Sub tropical westerly jet, Tropical easterly jet, intensification of cold (warm) core low (high) with height, tilt of axis of low (high) towards cold (warm), cold and warm advection associated with veering/backing of geostrophic wind. Analysis of the shear hodograph and stability conditions. Barotropic and baroclinic atmosphere.**

Continuity Equation and Convergence.

- **Equation of continuity with different vertical co-ordinates: Importance of ‘p’ as a vertical co-ordinate. Application of continuity equation: Dines compensation principle. Concept & importance of level of non-divergence**

(LND). Kinematical method of computing ω . Scale analysis of continuity equation. Concepts of incompressible fluid, homogeneous fluid and isotropic fluid. Moisture continuity equation.

- Divergence of an arbitrary vector field. Physical concept. 2-D (or 3-D) divergence as a fractional rate of change of area (or volume). Horizontal divergence in natural co-ordinate system & in other (Spherical polar or cylindrical) co-ordinate systems.

Kinematics of Wind Field.

- Stream lines and trajectory, their definition and differential equation, stream function, Batou's equation.
- Resolution of horizontal wind into pure translation, divergence, rotation, deformation. Invariance of divergence and vorticity under co-ordinate transformation. Equations and patterns of streamline for pure translation, divergence, rotation, deformation
- Velocity potential and stream function

Kinematics of Pressure Field.

- Mathematical definition of centre of low, high & COL. Mathematical equation of trough & ridge. Expression for the velocity of an isobaric pattern. Mathematical equation for the slope of axis of low/high.

Circulation and Vorticity.

- Definition and mathematical expression of circulation. Circulation theorems, their detailed derivation, detail discussions on their application aspects. Detailed discussions about solenoidal vector.
- Concept of vorticity of an arbitrary vector field. Definition of atmospheric vorticity along with its mathematical expression. Physical meaning of Curl of any vector. Components of vorticity vector. Relation between circulation and vorticity.
- Vorticity for solid body rotation. Concept of planetary vorticity. Relative vorticity in natural co-ordinate. Explanation of curvature and shear vorticity with specific examples. Concept of potential vorticity.
- Vorticity equation in different co-ordinates. Physical interpretations for individual terms. Scale analysis of vorticity equation. Application of vorticity equation. Conservation laws for potential vorticity and its application. Vorticity advection and its role in weather development.

Pressure Tendency and Mechanism of Pressure Change.

- Its derivation and physical interpretation, in detail, of each term, representing different mechanisms of pressure change. Importance of net divergence in an atmospheric column. Different isobaric patterns and their movement.

PBL:

- Definition and importance of PBL. Concepts of Different sub layers in PBL. Concepts of eddy flux, eddy flux divergence and their importance, role of convection and wind shear in turbulence, concept and application of flux Richardson number, Concept of Ekman layer pumping, secondary circulation, spin down, wind driven mass transport in oceanic Ekman layer and surface wind stress. **Derivations of governing equations for mean motion in PBL.**
- **K-Theory/ Flux-gradient theory/ Similarity theory. Its limitation. Mixing length theory.**
- **Derivation of logarithmic vertical profile of horizontal wind in viscous sub layer using similarity theory. Concept of roughness length and Von-Karman constant.**
- **Ekman layer: Derivation of vertical profile of mean horizontal wind in atmospheric/ oceanic Ekman layer. Derivation of depth of Ekman layer. Concept of Ekman layer pumping. Secondary circulation. Spin down. Derivation of the Relation between mass transport in oceanic Ekman layer and surface wind stress. A dynamical explanation for El-Nino and La-Nino. Convective boundary layer (CBL) or well mixed boundary layer. The turbulent kinetic energy equation. Physical interpretation, in detail, of the Buoyancy production or loss (BPL) term and mechanical production (MP) term in association with convective and mechanical turbulence, concept of Flux Richardson number. Monin-Obukov theory and Kolmogorov theory.**
- **Quasi-geostrophic theory: Quasi-geostrophic approximations, Beta-plane approximation. Governing equations in isobaric co-ordinates using quasi-geostrophic approximation. Quasi-geostrophic vorticity equation: Thermodynamic energy equation, Geopotential tendency (χ) equation: Conservation of quasi-geostrophic potential vorticity. Diagnostic ω (omega) equation (With and without diabatic heating term)**

Atmospheric waves and instabilities.

- **Perturbation theory-Why perturbation method has been proposed? Hypothesis in Perturbation method. To show that perturbation method can remove non- linearity from governing equation.**

- **Atmospheric waves - Basic concepts: Wave number, Frequency, Phase speed and group velocity. Sound wave, Rossby wave, Gravity wave (external, internal and inertia), simple inertia wave, Kelvin wave, Mixed Rossby Gravity wave- dispersion relation and physical interpretation. Eliassen-Palm flux and its conservation law.**
- **Dynamics of stratified fluids: Concepts of stratification, Static stability, The importance of stratification: The Froude number, Boussinesq approximation.**
- **Hydrodynamic instability : General definition of Hydrodynamic instability. Classification of Hydrodynamic instabilities. Static instability: Derivation of the criterion for Brunt-Vaisalla instability. Dynamic instabilities: Inertial instability, barotropic instability and baroclinic instability. Derivation of the criteria for above instabilities. Energetics and mechanism of above instabilities.**

Atmospheric energetics

- **Fundamentals of atmospheric energetics : Definition of Atmospheric energetics. Different form of atmospheric energies, viz., internal energy, potential energy and kinetic energy. Derivation of global internal energy, global potential energy and global kinetic energy equation. Detailed physical interpretations of generation of potential energy, internal energy and its conversion into kinetic energy. Detailed physical interpretation for generation mechanism of global kinetic energy, its conversion into potential and internal energy and the dissipation of kinetic energy. Belt of sub-tropical anticyclone, the source region for global kinetic energy. Global energy equation. Dynamical explanation for the Sun to be source of atmospheric energy. Equivalence of internal and potential energy in a stably stratified hydrostatic atmosphere. Physical explanation for the proportionality of I.E and P.E in hydrostatic and stably stratified atmosphere. Introduction to total potential energy (TPE), derivation of its expression. Concept of available potential energy (APE) and the derivation of the expression for it. Qualitative comparison of APE in a region based on day-to-day charts. Concept of zonal APE, KE, PE and eddy APE, KE, PE.**
- **Angular momentum budget of atmosphere: Global angular momentum balance equation. Interpretation of mountain torque, frictional torque and meridional transport of zonal angular momentum. Different mechanisms for meridional transport of zonal angular momentum. Concept of Hadley and Walker circulations.**

Numerical weather prediction:

- **Numerical Methods**
 - Basic concepts about different methods for solving model equations: Finite difference method. Implicit & semi implicit scheme. Numerical stability criterion (CFL). Spectral method.
- **Data Assimilation**
 - Basic Concepts of objective analysis and initialization, their types. Concepts of variational data assimilation technique, 3D & 4D variational data assimilation techniques, Processing of Satellite and Doppler Radar Data for quality control and mesoscale data assimilation.
- **Parameterization of physical processes**

Definition and importance of sub grid scale physical process, Parameterization of sub grid scale physical processes, Important sub grid scale physical processes in the atmosphere and their parameterization techniques in brief: Planetary boundary layer, Land surface processes, Convection, Radiation (short wave & long wave parameterization), orographic effect.
- **Operational Numerical Models and NWP products & their interpretation/application.**

Operational NWP modelling system: Global Forecast System, Regional and mesoscale forecast system (WRF, ARPS), Nowcast model, Climate Forecast System, Ensemble prediction system, multi-model ensemble technique, Direct and Derived, Post processing of model output: Model output verification: Forecast skills, Forecast errors, Systematic errors. Down scale of NWP model like location specific forecast, NWP products for aviation services, hydrological services, NWP products for localized severe weather, NWP products in Web.

Remote Sensing Meteorology

Satellite Meteorology

Satellite Meteorology

Basics Remote Sensing:

Principles of remote sensing, Application in meteorology, Introduction to satellite meteorology, Orbital mechanics. Meteorological Satellites: Polar, geostationary and low-inclination orbits, Current and future meteorological satellites of the world. Payloads on meteorological satellites, NOAA, INSAT, Kalpana, Metop, MeghaTropiques, Scatterometers. Basic Principles of Sounding: Processing of data from infrared and microwave sounders. Retrieval of products from sounders.

Hard ware basics:

INSAT Meteorological Data Processing System (IMDPS). Systems and Techniques: Automatic Weather Station (AWS), DTH-based Digital Cyclone Warning Dissemination System (DCWDS), Digital Meteorological Data Dissemination (DMDD), GPS technique for Integrated Precipitable Water Vapour (IPWV) measurement.

Interpretation & application:

Interpretation of Satellite Images: Characteristics of various channels, Identification of typical clouds and weather systems from cloud imageries, Satellite bulletin and its interpretation. Tropical cyclones, their identification and grading using Dvorak's technique. Interpretation of microwave channel images. Assimilation of satellite data in NWP models. Use of satellite in very short range forecast to now casting.

Radar meteorology

- **Basics and terminologies of radar Meteorology:**

Radar equation and its interpretation. RADAR depiction of various phenomenon; RADAR reports; Interpretation of RADAR echoes; Anomalous propagation, radar estimation of precipitation, identification of convective and stratiform precipitation, melting band. Introduction to Weather radars. Different frequency bands used in the weather radars and their applications. Principles of pulsed radar, Polarimetric radars. Definitions of Beam width, Pulse width, PRF, Antenna gain, back scattering cross section, Reflectivity factor (η) and radar reflectivity factor (Z). Anomalous propagation of EM waves.

- **Doppler Weather Radar and its application:**

Principle of Doppler Weather radar. Block diagram of Doppler Weather radar and explanation of its major components. DWR Base and derived products – their interpretation and use in Nowcasting. Warning products Analysis of severe weather events recorded by DWR.

AVIATION METEOROLOGY

TOPICS 1

1. An overview of Aviation Organisations and their functioning.
1. Definitions
2. WMO, ICAO, CAeM
3. Functioning of IMD's Aeronautical Meteorological Organisation
4. The rights and responsibilities of aviation met offices, the terms and conditions of MoU/LoA with AAI and other users
5. Meteorological publications of ICAO, DGCA, AAI, and IMD

6. Registers and formats used in Aviation met services
7. Regulatory materials (Annex-3/ CAR/ Codes/ Manual)

TOPICS 2

2. Effect of Weather on aviation

1. Effect of various atmospheric parameters on different phases of flight operation
2. Altimeter setting procedures, concept of QNH, QFE and ICAO Standard Atmosphere
3. Airport minima, low visibility procedures, categories of runways
4. Special weather phenomenon affecting aircraft operations

Mountain waves

CAT

Icing

Atmospheric Obscurity

Contrails

Microburst

Low Level Wind Shear

Thunderstorm. Dust storm and Hailstorm

5. Climatology of weather hazards

TOPICS 3-8

3. Observation and reporting of weather for Aviation services

1. METAR code and template
2. Local SPECIAL Criteria
3. Reporting of meteorological elements in METAR/ SPECI
4. Concepts of TREND forecast
5. Prepare a METAR/ SPECIAL message with TREND forecast using the given observations
6. MET Report/ SPECIAL Report Template

1. Description of the TAF code form and Template

2. Forecast of various elements in TAF

7. Examples

4. Terminal Aerodrome Forecast (TAF)

3. TAF verification procedures

5. Area/ Local forecast

1. Description of Area/ Local forecast template

2. Verification procedures

6. Take-off forecast

Description of take-off forecast

7. Route Forecast

1. Instructions on preparation of MET- T3
2. Preparation of a route forecast in MET- T3 form
3. Preparation of a route forecast wind/temperature in chart form from NWP model
8. Warnings

Aerodrome weather summary of an aerodrome (Climatological data base), Aerodrome warning, wind shear warning, SIGMET warning

TOPICS 9-12

9. Tools for forecasting & Forecast verification

1. Tools and products available for aviation weather forecasting and their use.
2. Forecast verification procedure

10. Competency assessment

11. Astronomical information

Concepts of sun rise, sunset, moon rise and set, phases of the moon

Elevation and azimuth angle and their effect on aircraft operations

12. Analysis of weather-related aircraft accidents/ incidents

TOPICS 13

13. Aeronautical Telecommunication Network (ATN)

1. Basics about aeronautical telecommunication network
2. AMSS and SADIS
3. Filing time, transit time and priority of various aviation meteorological messages
4. Basic concept of OPMET and ROBEX scheme
5. Monitoring of data transmission and rectification of errors of the messages in error queue in AMSS.
6. Basics of VOLMET broadcast and other meteorological broadcasts

TOPICS 14

14. Accident Investigation

1. Introduction
2. Responsibilities of AMS/ AMO in accident investigation
3. Responsibilities of RMC
4. Preparation of Reports

TOPICS 15

15. VIP/VVIP movement

1. Basic procedure to be followed during VIP/ VVIP Flights

TOPICS 16

16. Airport Meteorological Instruments

1. Basic functions, siting and use of airport meteorological system
2. Reporting of manual RVR
3. NOTAM Procedure

TOPICS 17

17. Competency standards and safety audit

1. Competency requirements
2. Competency standards
3. Safety oversight audit

Operational ceilings of various aircraft and their performance limitations (wherever applicable)

Applied Meteorology

Environmental Meteorology

Air Pollution- Type of pollutants, gaseous and particulate pollutants, tropospheric Ozone, its sources and sinks, ozone precursors (NO_x, CO, CH₄-NMHCs), Particulate Matters (PM₁₀ and PM_{2.5}), Black Carbon and Organic Carbon. Air quality standards and Air Quality Index. Air quality modelling, Environment Impact Assessment. Mixing length, Ventilation coefficient, Pattern of dispersal of smoke from stationary source under different wind and temperature conditions.

Day-2: Aerosol Sources: Natural Sources, Anthropogenic Sources, Gas to particle conversion, Aerosol removal processes, Chemical composition of Aerosols, physical and chemical properties. CCN nuclei, Aerosol transport, distribution and residence time, Aerosol Size Distribution, Aerosol Radiation Characteristics, Aerosol Radiative Forcing, Aerosol Optical Depth, Single Scattering Albedo, the Climatic Effects of Anthropogenic Aerosols, Indirect Effect of Anthropogenic Aerosols (Twomey Effect)

Basics of Hydrology

HYDROLOGICAL CYCLE and Observation & analysis of rainfall: Understanding the importance of Water and as the subject of observation, Hydrological information systems and its components. Uses of water resources information and types of water resources. Rainfall observations and units. Different types of Rain gauges, RAINFALL ANALYSIS: Point rainfall, Concept of basin and catchment, major river basins in India. Estimation of point rainfall at ungauged point.

HYDROMETEOROLOGICAL DISASTERS:

Definition of flood, Types of floods. Causes of flood. Droughts, types of drought. Various indices for monitoring drought. Drought monitoring and prediction practices at India Meteorological Department., GLOF, cloudburst, landslides etc. Hydro-meteorological services provided by India Meteorological Department. Rainfall monitoring and Operational Rainfall Statistics at IMD.

Basics of Agricultural Meteorology

Energy and water budget of crops, and crop yield relationship with weather elements, crop weather calendar. Agro climatic classification in India: Objectives and their applications. Agro met advisory services (AAS) : its importance to farmers, Preparation of special weather charts and bulletins for AAS, Components of AAS bulletins, Dissemination, Feedback collection.

Hands on Practical exercise sessions

- **Practical on Grads**
- **Thermodynamics practical**
- **Practical on computation of different dynamical parameters using grads.**

- **Practical on weather analysis & forecasting**
- **Practical on generation of Climate products using WMO CLIMDEX software.**

Training on General administration, Management, CCS and GFR rules.

On the Job training:

Attachment with NWFC/RWFC or Weather Section.

General lecture on overall activities of the division/section/unit. Analysis of charts, preparation of inference and forecast bulletin by the trainees.

Attachment with Satellite & Radar Units.

General lecture on overall activities of the division/section/unit. Selected imagery of Satellite and Radar shall be given, and trainees will be asked to interpret and apply.

Attachment with NWP units.

General lecture on overall activities of the division/section/unit. Trainees will be asked for job submission in the system in batch. Different selected products shall be given to the trainees and shall be asked to interpret and apply.

Weather discussion by the trainees.

Viva-Voce chaired by office Head.