Syllabus

M.Phil. and Ph.D. in Meteorology

Department of Meteorology
Faculty of Earth and Environmental Sciences
University of Dhaka

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1. BASIC INFORMATION

The M. Phil. and Ph. D. programs are developed for providing short and long term graduate studies in Meteorology in the University of Dhaka. A theory course syllabus has been designed which consists of 12 credits.

1.1 ELIGIBILITY FOR ADMISSION

Applicants must be a M. Sc. in Meteorology of any recognized university of Bangladesh or with an equivalent degree in science and engineering. The candidate must have secured a CGPA of at least 3.0 for applying for admission to the program in the undergraduate and M.Sc. level.

1.2 TOTAL CREDIT OF THE PROGRAM

The graduate student **(major) will have to complete two (02) theory courses of total 8 credits along with viva-voce of 4 credits** and **non-major students** will have to complete **three (03) theory courses of total 12 credits along with viva-voce of 4 credits** before beginning his/her research work (see section 2.2 for details). S/He will have to conduct research works for 2 years for M. Phil and 3 years for Ph.D. and will have to submit and defend a dissertation for qualifying for the respective degree. Common rules and practices of the Faculty of the Earth and Environmental Sciences, University of Dhaka would be applicable for Ph.D. and M.Phil.

2. DETAIL OF THEORY COURSES OF M. PHIL AND PH. D. PROGRAM

2.1 MARK DISTRIBUTION AGAINST GRADES

Each 4 credit course has a weight of 100 marks. The distribution grades will be in accordance to the Table below.

Table-1: Grade point distribution including letter grade with Numerical Grade

Numerical Grade	Letter Grade	Grade Point
80% and above	A +	4.00
75% to less than 80%	A	3.75
70% to less than 75%	A-	3.50
65% to less than 70%	B+	3.25
60% to less than 65%	B	3.00
55% to less than 60%	B-	2.75
50% to less than 55%	C+	2.50
45% to less than 50%	C	2.25
40% to less than 45%	D	2.00
Less than 40%	F	0.00

2.2 YEAR WISE DISTRIBUTION OF COURSES

Table-2 depicts 11 offered courses in which each course has 4 credits and MetTh 601 (Research Methodology) is compulsory for all.

Major students will have to take MetTh 601: Research Methodology as a compulsory course and will have to take another course from MetTh 603 to MetTh 611 (2 courses x 4 credit =8 credits) and Viva-voce of 1 unit of 100 marks (4 credit) in the 1st Year.

Non-Major students will have to take MetTh 601: Research Methodology and MetTh 602: Physical Meteorology as a compulsory courses and another course from MetTh 603 to MetTh 611 (2 compulsory course 8 credit + 1 optional courses x 4 credit=12 credits) and Viva-voce of 1 unit of 100 marks (4 credit) all in the 1st year.

On successful completion of 1st year, student will be allowed to complete a supervised thesis work during 2nd year equivalent to 3 units (300 marks). The student must perform the thesis work and must defend his/her thesis in the 2nd year. In all other circumstances, common rules and practices of the University of Dhaka must be applicable for M. Phil. student.

Table-2: Courses offered

Course Code	Course Name	Elective/Required course	Year	Marks	Credit
MetTh 601	Research Methodology	Compulsory	1st	100	4
MetTh 602	Physical Meteorology	required for non-major	1st	100	4
MetTh 603	Advanced Synoptic and Mesoscale Meteorology	elective for both major and non-major	1st	100	4
MetTh 604	Advanced Tropical and Monsoon Meteorology	elective for both major and non-major	1st	100	4
MetTh 605	Advanced Radar and Satellite Meteorology	elective for both major and non-major	1st	100	4
MetTh 606	Global Climate Change	elective for both major and non-major	1st	100	4
MetTh 607	Urban Meteorology	elective for both major and non-major	1st	100	4
MetTh 608	Hydro Meteorology: Forecasting and Application	elective for both major and non-major	1st	100	4
MetTh 609	Agro Meteorology: Forecasting and Application	elective for both major and non-major	1st	100	4
MetTh 610	Aviation Meteorology: Forecasting and Application	elective for both major and non-major	1st	100	4

MetTh 611	NWP& Data Assimilation	elective for both major and non-major	1st	100	4
MetV 612	Viva-voce	Compulsory	1st	100	4
MetD 701	M. Phil. Research Work and Dissertation	N/A	2nd year	200	*
MetV 702	Viva-voce	N/A		100	
MetTh 801	Ph.D. Research work, Seminar and Dissertation	N/A	2nd , 3rd & 4th year	*	*
MetV 802	Viva-voce	N/A			

*As per University and Faculty Rules

Total 2 Years minimum for M. Phil after qualifying theory examinations

Total 4Years minimum for Ph. D. after qualifying theory examinations

3. DETAIL SYLLABUS OF THEORY COURSES

MetTh 601: Research Methodology (4 Credit; 60 hour)

Research and methods: meaning of research, concepts of methods and methodologies, selection of topic, research process, categories of research: descriptive, exploratory and explanatory; conceptualization, operationalization, formulation of research proposal, review of literature, objectives of the study, concepts of reliability and validity, data analysis and interpretation.
Research Design: types of design -- case studies, trend and panel studies, experimental design, nonexperimental design, cross-sectional and quasi-experimental design, etc., Sampling design and sample size determination
Data collection methods and techniques: primary and secondary sources of data, different methods to collect data: mail-questionnaire, personal interview, telephone interview, principles of interviewing.
Qualitative data collection: observations, key informants interview (KII), in-depth interview, focus group discussion (FGD), Participatory Rural Appraisal (PRA), rapid appraisal technique (RAT), Delphi technique.
PRA methods: Facilitation, group dynamics and triangulation. Observation, semi-structured interview, Transect Walk, Group walk, Listening stories, Mobility Mapping, Seasonal Calender, Preference ranking and Scoring, Causal and impact diagram, Participatory Planning.
FGD methods: The characteristics of FGD, Steps of conducting FGD, Types and size of FGD group, Discussion guide, Role of 'Facilitation team', Dos and Don'ts in FGD, FGD in Training Needs Assessment (TNA), FGD in Training Evaluation.
Measurement of reliability and validity of data: classical theory of reliability, reliability coefficient, extension of classical theory, test-retest method, parallel forms technique, split-half method. content validity, empirical validity, construct validity, validity threats.

Research Proposal Writing : Research proposal for academic degree, teaching/research assistantship, research proposal for professional purpose, format of Technical and Financial proposal, concept of ToR, EOI, RFP, PDS, DPP, EIA and SIA.
Research Report Writing: Acknowledgements, Abstract, Table of Contents, Introduction, Literature Review, Materials and Methods, Results and Discussions, Conclusions and Recommendations, References, Appendices.
Research Communication: General format for a term paper, Innovating a scientific paper: guide for contributors, Conference paper presentation, preparing manuscript for book publication, Plagiarism etc.
Bibliography and Quotation: The Chicago Manual of Style, Modern Language association (MLA) style, American Psychological Association (APA) Style, The Council of Biology Editors (CBE) Style.
Monitoring and Evaluation: Objectives of Monitoring and Evaluation, Monitoring and Evaluation Process, Designing a Monitoring and Evaluation system, Program Performance Indicators, writing an Evaluation Report.
Logical Framework in Research Project: Key elements of a logical framework, project design using logical framework, design matrix, GOAL oriented project planning, project planning matrix, Critical path method: work breakdown structure and development of the network.
Ethics in Research: Ethics and Privacy Application Form, Participant Information and Consent Form, Conflict of Interest and Other Ethical Issues, Declaration of Researchers.

Text

Akanda, M. A. S. (2018), Research Methodology A Complete Direction For Learners, 2nd Edition, Akanda & Sons Publication, Dhaka.

References

1. Neuman, W.L., (2000), Social Research Methods: Qualitative and Quantitative Approaches, 4th Edi, Allyn and Bacon, Boston.
2. Frankfort, J., (2014), Research Methodology. 8th edition, Worth Publishers;
3. Kothari, C.R., (1995), Research Methodology, 2nd edition, New Age International Publishers.
4. Bailey., (1992), Social Research Methods. 4th edition, Broock/Cole.
5. Krisaaswami and Raaganatham., (2005), Methodology of research in social sciences, 2nd edition, Himalaya Publishing House
6. Das, A. Social survey and research.
7. Sufian, A.J.M., (1998), Methods and techniques of social research, The university press.
8. Rao, C.R., (1952), Applied Statistical Methods in Biometric Research.
9. Palmor, J.O., (1987), Statistical Methods in Research, Cambridge.
10. Kish, L., (1995), Survey Methods in Social Investigation. John & Wiley sons 11. Islam, M.N., (2011), An introduction to Research Methods, 3rd ed. Book World.

MetTh 602: Physical Meteorology (4 Credit; 60 hour)

Introduction to Meteorology- concept, weather and climate: factors and elements
Radiative Processes– short and longwave, albedo of different surfaces, radiation balance.
Equation of state- for dry and moist air, relation between atmospheric pressure and temperature.
Atmospheric moisture - relative humidity, absolute & specific humidity, mixing ratio, relation of vapor pressure with moisture content.
Temperature – drybulb, wetbulb, dewpoint, equivalent and potential
Airmass and classification
Heat transfer – convection, conduction, evaporation and condensation.
Atmospheric stability – adiabatic lapse rates and convective cloud formation, thermos-dynamic charts (Skew T diagram etc.), thermodynamic laws
Cloud types and precipitation- Cumulus, Stratus, Cirrus clouds and genesis of clouds and precipitation formation.
Energy Budget

Fundamental and apparent Forces-Pressure gradient, gravitational, frictional and Coriolis force
Geostrophic and gradient winds, Thermal wind, straight & curved flows.
Hydrodynamic Equations- Momentum, hydrostatic, continuity and heat and energy equations in different vertical coordinatesystems.
Vorticity- Relative and absolute Vorticity and divergence, vertical motion, vorticity equation, stream function and velocity potential.

Reference

Aguado, E, and Burt, J. E 2010. Understanding Weather and Climate, 5/E, Prentice Hall, New Jersey, USA
Andrews, D. G, 2010 An Introduction to Atmospheric Physics, 2/E, CambridgeUniversity Press
Aida Awad, Charles Dodd, Peter Selkin, Introduction to Earth Systems Science
David Randall. An Introduction to the Global Circulation of the Atmosphere, Princeton University Press.
Eric E. Small, The Earth System: An Introduction to Earth Systems Science
Global Atmospheric Circulations, by R. Grotjahn, Oxford Univ. Press.
Holton. Introduction to dynamical meteorology, Academic Press.
Meteorology Today: An Introduction to Weather, Climate, and the Environment, 11 th Edition- C. Donald Ahrens
OchananKushnir (2000). The Climate System: General Circulation and Climate Zones.
Satoh, Masaki. Atmospheric Circulation Dynamics and General Circulation Models, Springer.

MetTh 603: Advanced Synoptic and Mesoscale Meteorology (4 Credit; 60 hour)

Synoptic scale weather systems: gradient, advection, equations; Hydrostatic approximation; Cross sections, potential temperature, Thickness and applications

Features of the Mesoscale Meteorology, Tropical variability; Energy and moisture budgets; Synoptic and Mesoscale Setup for Severe Weather

Cloud-scale processes, the dynamic and thermodynamic aspects of clouds; cloud-physics and mesoscale meteorology.

Thermal wind balance, Mass continuity, diffluence/confluence; Surface pressure tendency equation; Potential Vorticity and its applications to a variety of tropospheric settings; The geostrophic momentum approximation, semi-geostrophic equations, and Sawyer–Eliassen equation

Quasi-geostrophic (QG) theory, including the role of diabatic heating and static stability; Alternative formulations of the QG omega and height-tendency equations (Trenberth formulation, Q vectors, P vectors, C vectors)

Ageostrophic wind, gradient wind, jet streams, Vorticity and vorticity advection Rossby-wave propagation; barotropic and baroclinic instability; generation of IPV; tropopause polar vortices (TPV).

Air Mass Boundaries- Surface and middle-upper tropospheric fronts; Characteristics of fronts, occlusions and jet streams;Frontogenesis, including the vector form of the frontogenesis function, Drylines

Tropical and extratropical cyclones and their associated fronts, Midlatitude cyclones, conveyor belts

Reference

Aguado, E, and Burt, J. E 2010. Understanding Weather and Climate, 5/E, Prentice Hall, New Jersey, USA
Markowski, P and Richardson, Y Mesosclae, 2010, Meteorology in Midlatitudes , John Wiley & Sons, Ltd, UK

Mesoscale Meteorology and Forecasting, P. Ray, editor
Cotton, W.R, et al, 2010, Storm and Cloud dynamics, Academic Press

MetTh 604: Advanced Tropical and Monsoon Meteorology (4 Credit; 60 hour)

General Circulation of Atmosphere
Mean features of the tropical atmosphere – subtropical anticyclones, trade winds, equatorial trough/ ITCZ, subtropical jet, Tropical easterly jet and African easterly jet.
The South Asian Monsoon – Tibetan High and associated winds, intra-seasonal to seasonal& inter-annual variability, role of Heat Low, Monsoon Trough, Mascarene High, Somali Jet and the Himalayas, onset and withdrawal of monsoon, strong and break monsoons, monsoon low and depressions. West African monsoon and African Easterly waves.
Tropical disturbances –Tropical cyclones (hurricanes, and typhoons), geographical and seasonal incidence, North Indian Ocean cyclone double maximum.
Equatorial waves– Atmospheric Teleconnection, Southern Oscillation; ENSO
Madden-Julian Oscillation: Observations and Mechanisms; Indian Ocean Dipole, Rossby waves,
Modelling of Tropical Cyclones and Storm Surges

Reference
Aguado, E, and Burt, J. E 2010. Understanding Weather and Climate, 5/E, Prentice Hall, New Jersey, USA
Markowski, P and Richardson, Y Mesosclae, 2010, Meteorology in Midlatitudes, John Wiley & Sons, Ltd, UK
Mesoscale Meteorology and Forecasting, P. Ray, editor
Cotton, W.R, et al, 2010, Storm and Cloud dynamics, Academic Press
T.N. Krishnamurti, Lydia Stefanova,Vasubandhu Misra. Tropical Meteorology: An Introduction (Springer Atmospheric Sciences), 2013 Edition.

MetTh 605: Advanced Radar and Satellite Meteorology (4 Credit; 60 hour)

Satellite Meteorology

Observing Weather from Space: Clouds from Bottom to Top, Visible Satellite Imagery, Infrared Satellite Imagery and Water Vapor Imagery;

Principles of Radiation and Remote Sensing:In-Situ and Remote Sensing Measurementsof the Atmosphere; electromagnetic spectrum, Stefan-Boltzman Law and Wien's Law, radiation processes, albedo

Satellites and Orbits – Past to Current Satellites; orbital dynamis, types of orbits - Polar, geostationary, tropical and equatorial satellite, coverage, advantages, application; Sensor technology: Passive and active sensor

Operational meteorological satellite (imagers and sounders, instrumentation and application; Vertical sounding of Atmosphere; Instruments onboard Polar and Geostationary Satellites: Solar Channels, IR Channels, WV Channels and CO2 and O3 Absorption Channels

Application of satellite data in weather analysis, now-casting of severe weather, monsoonal systems and tropical disturbances, land surface study, vegetation monitoring and study of oceanic featuresfrom Satellite observation; Data Assimilation for Numerical Models using satellite data

RADAR Meteorology

Radar/Lidar, multi-spectral and hyperspectral Soundings: Doppler and Dual Polarization;weather radar instruments (antennas, transmitters, and receivers etc.)

Theory of polarimetric electromagnetic wave propagation, scattering, and attenuation from distributed targets (precipitation, Bragg, insects)

Radar equation derivation and analysis for point targets; Radar equation continued for distributed targets; Radar moment calculations (dBZ, Velocity, SW); Polarimetric variables (ZDR, RhoHV, KDP, LDR); Precipitation estimation (QPE) and particle identification

Mobile radars (vehicular, airborne, and space-borne radars); Single-Doppler wind retrieval techniques (VAD, VTD, GBVTD); Multi-Doppler wind retrieval techniques

Radar Application- Severe weather applications (tornados, squall lines, and hurricanes) Clear-air applications (wind profilers, Bragg scattering, turbulence); Advanced and future radar technologies (phased array, solid state)

Reference

Robert M. Rauber and Stephen W. Nesbitt: Radar Meteorology: A First Course, 2018 John Wiley & Sons Ltd
Richard J. Doviak, Dusan S. Zrnic (Author). Doppler Radar and Weather Observations: Second Edition (Dover Books on Engineering) Paperbac, 2006.
Meischner, Peter (Ed.). Weather Radar: Principles and Advanced Applications.

MetTh 606: Global Climate Change (4 Credit; 60 hour)

Climate change science: early discoveries, energy balance model

Greenhouse gases, radiative forcing, aerosol radiative forcing, the observational record of modern climate change

The global carbon cycle-biogeochemistry

Paleoclimate

Global atmospheric circulation: Climate modeling and climate change feedbacks: linking atmosphere, oceans, biosphere and cryosphere

Global Climate Models: Types of Climate Model; Constructing Climate Models; Uses of Climate Models and Evaluating Climate Models,Earth System Models (ESMs), Pseudo-global warming

Understanding Global Climate Models: Representative Concentration Pathways (RCPs), SSP, Statistical and ynamical downscaling of GCM results. Testing model results, bias correction and future scenario development; applications for assessing/projecting future climate change

Detection and attribution of climate change

Scientific consequences and uncertainty, IPCC assessment and projection

Climate change: Impacts, adaptations and international agreements

Reference

John Hougton, Global Warming: The Complete Briefing, 5th edition, 2015, Cambridge Univ. Press
D. Jacob, Introduction to Atmospheric Chemistry,
T.N. Krishnamurti, Lydia Stefanova, VasubandhuMisra, Tropical Meteorology:An Introduction (Springer Atmospheric Sciences), 2013 Edition.
Helmis, C., Nastos, P. T. Ed (2013) Advances in Meteorology, Climatology and Atmospheric Physics.

MetTh 607: Urban Meteorology: Forecasting and Application (4 Credit; 60 hour)

Understanding of urban meteorology

Energy balance of the atmosphere- Interaction of the atmosphere with urban structures and terrain; Radiative transfer; Short and longwave radiation in urban canopy

Global and Local Controllers of Temperature - Urban energy balance Anthropogenic heat release; Heat Island

Urban boundary layer and the water cycle- Convection and rainfall pattern; Surface runoff from urban areas- urban drainage and floods

Urban air pollution - megacities air quality and larger scale effects, acid rain modeling, wet deposition, visibility and urban SMOG

Urban Climate Change and planning - Urbanization Impact on Weather and Climate, Weather in Built Environment; Large scale alteration in built environment

Weather and climate monitoring in cities - Remote sensing application in urban meteorology

Monitoring and forecast of local scale hazards

Reference

Oke, T., Mills, G., Christen, A., & Voogt, J. (2017). Urban Climates. Cambridge: Cambridge University Press. doi:10.1017/9781139016476.
Meteorology Today: An Introduction to Weather, Climate, and the Environment, 11th Edition- C. Donald Ahrens

MetTh 608: Hydro Meteorology: Forecasting and Application (4 Credit 60 hour)

Overview of Hydrometeorology; Relationship between hydrology, meteorology, and climatology, Water Balance- Movement of water in all three phases throughout the Earth system; Processes comprising the hydrological cycle and Global influences on it

Influence of different weather systems on stream and ground water flows, relationship to flooding conditions; Geomorphological modeling and floodplain estimation; measurement of stream flow and water levels; ; Flow measurement: basic hydrometry and Measuring stream discharge

Precipitation around the world; Precipitation systems; Extreme precipitation processes; Mesoscale precipitation systems; Cloud burst,Storms producing floods,Analysis of Precipitation over basin characteristics- Measurement, resolution, precision and accuracy; Point measurements of precipitation; Areal measurements of precipitation ; Approaches to estimating flood frequency

Radar measurements of rainfall; Soil moisture; Evaporation and evapo-transpiration

Hydrometeorological models and their applications: geomorphological modeling and floodplain estimation, hydrological models and modeling, drought/soil moisture modeling, stream flow modeling, flood modeling, storm surge modeling, severe storm and precipitation modeling, atmospheric and hydrological models useful for Bangladesh condition (e.g. MPAS, WRF-Hydro, WRF-Chem, WRF-ELEC etc.)

Reference

Sene, Kevin Hydrometeorology: Forecasting and Applications
J. P. Bruce R. H. Clark Introduction to Hydrometeorology, 1st Edition
W. James Shuttleworth Terrestrial Hydrometeorology 1st Edition

MetTh 609: Agrometeorology: Forecast and Application (4 Credit; 60 hour)

Perspective and application of agrometeorology; Effect of weather and climate on crops; radiation balance, solar constant, albedo, sensible heat, heat energy, wind, humidity, light, atmospheric pressure and potential evapotranspiration; seasonal variation

Future changes in greenhouse gases: Plants sense and respond to changes in CO_2concentration; and incidence of pest and disease

Measurement of short-term effects and mechanisms of underlying responses in $C_3$and C_4cropspecies; change in secondary metabolites and pest disease reaction in plants; the mechanisms of Ozone and UV damage and tolerance in plants.

Climatic distribution of crops; Thermal effects on thermoperiodism, phenology, vernalization; Cardinal temperatures and heat unit concept – Definition of Growing Degree Day (GDD), limitation and importance of GDD, interaction of temperature with other biotic and abiotic stresses in plants

Light spectrum and plant growth; photoperiodism; Modification of crop growth, metabolism, yield and quality of crops by spectral intensity and quality

Crop growth simulation models; calibration, validation, verification and sensitivity analysis. Use of crop simulation model for preparation of agro-advisory and its effective dissemination

Weather forecasting, preparation of agro-advisory bulletin based on weather forecast; crop - weather calendars; weather-based cropinsurance

Remote sensing: Application in agrometeorology; crop monitoring, irrigation, chlorophyll concentration, NDVI

References:
J. Fuhrer, Climate Change Impact and Adaptation in Agricultural Systems, 2014, University of Reading, UK.
Heidelberg *et al.* 2010. Applied Agro-meteorology", Kees Stigter (Ed.) (Springer, 2010).
Agro-meteorology and Plant Diseases Edited by Ariel Dinar and Jose Albiac, *et al*.

MetTh 610: Aviation Meteorology: Forecasting and Application (4 Credit; 60 hour)

An overview: The Atmosphere; General Circulation of Atmosphere
Effect of Weather on aviation

Airmasses and boundaries; Boundary Layer; Convective Systems

Flight Hazards- Clouds, Fog and Precipitation; Icing; Turbulence; Eddies; CAT; Windshear; Thunderstorms; down bursts, Microburst;Low and high level inversions; Influence of Mountains on airflow, clouds and precipitation; Visibility reducing phenomena-mist, smoke, smog, dust, sand and precipitation; Condensation Trail; aerosol pollution impact

Meteorological Information for Aviation- Airport Meteorological Instruments; weather observation; aircraft observations and reporting (PIREPS), data link systems; Weather Charts; Aeronautical codes: METAR, TAF, SPECI, SIGMET, WAFS, Sat Images, RADAR Images, SNOWTAM, runway report - Meteorological broadcasts for aviation: VOLMET, ATIS, ACARS

Aviation Forecasts: Meteorological warnings for Aviation; Terminal Aerodrome Forecast (TAF); SIGMET; WAFS; Aviation Area Forecast (FA); Winds and Temperatures Aloft Forecast; Sources of Aviation Weather Information –IBL

Reference
Aviation Meteorology (2012) Navale Pandharinath
Weather Flying, Fifth Edition (2013)-Robert Buck
Meteorology Today: An Introduction to Weather, Climate, and the Environment, 11 th Edition- C. Donald Ahrens

MetTh 611: NWP and Data Assimilation (4 Credit; 60 hour)

NWP- systems of equations for atmosphere and oceans, Map projections, model grids, generalized vertical coordinates, boundary conditions

wave motions, shallow-water model, linearization, phase and group velocity, hydrostatic vs. non-hydrostatic wave modes, geostrophic adjustment

Finite differences, the advection equation, truncation error, computational modes, false (numerical) diffusion, linear numerical stability analysis, grids, staggered grids, time integration (explicit and implicit)

Time integration techniques- explicit and implicit time integration schemes

Model initialization, objective analysis, spinup and insertion noise, nudging and digital filters

Ensemble methods, coupled model applications, verification methods, model analysis techniques

Linear & amp; Non-Linear balanced models, Fine mesh modeling, baroclinic spectral models.

Ocean Dynamics Modeling, non-divergent barotropic model

Parameterization: Parameterization of the sub-grid scale processes including Convection Parameterization, PBL Parameterization and Radiation Parameterization

Data Assimilation (DA): Introduction to Data Assimilation, Bayes Theorem, Linear DA Kalman filter, Ensemble Kalman Filters – Variational Data Assimilation – derivation from Bayes Theorem, exploring its features, adjoint coding, 3D-Var and 4D-Var, Nonlinear Data Assimilation– random numbers and sampling, Markov-Chain Monte-Carlo Methods (e.g. Gibbs Sampler and Metropolis-Hastings), Assessment of model sensitivity and error estimation.

Reference

Steyn. Introduction to atmospheric modeling. Cambridge University Press.
Thomas Tomkins Warner, Numerical Weather and Climate Prediction 1st Edition
Peter Inness and Steve Dorling. Operational Weather Forecasting
David J. Stens. Parameterization Schemes Keys to Understanding Numerical Weather Prediction Models Reissue Edition
Holton. Introduction to dynamical meteorology, Academic Press.
Law, Kody, Stuart, Andrew, Zygalakis, Konstantinos, Data Assimilation: A Mathematical Introduction