B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-2 : ATMOSPHERIC PHYSICS AND CLIMATE CHANGE

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Atmospheric Physics and Climate Change DSE 8-2	4	3	0	1	

COURSE OBJECTIVES

This course familiarizes the students with the atmospheric processes, and vertical thermal and dynamical features in the lower and middle atmosphere. It enables to learn remote sensing techniques to explore atmospheric processes and helps to understand long term oscillations and fluid system dynamics which control climate change. Also, it delineates characteristics of pollutants and aerosols variability in the lower and middle atmosphere. Another important aspect would be how the different atmospheric and meteorological parameters are changing over a period of time from Climate change perspective.

LEARNING OUTCOMES

By successfully completing this course students will be able to,

- Have an overview of thermal structure of the Earth's atmosphere as well as various dynamical processes occurring in different layers of the atmosphere.
- Develop an understanding of remote sensing techniques such as radar, satellite, and lidar systems.
- Understand the origin of different atmospheric oscillations, which are prominent at different altitudes. In addition, understating will be improved on several features of low- and high-pressure systems and wind circulation.
- Atmospheric and Ocean interaction can be learnt how they influence each other on long term time scales connected with such as El Niño Southern Oscillations (ENSO)
- Climate Change can be understood by using long term atmospheric data (both observations and model) and further exploring and utilization of different numerical techniques for the fine and long-term temporal and regional to global scales.
- Develop the problem-solving skills using observations and conducting simulations. This would clarify the fundamental processes and modifications under different conditions.

SYLLABUS OF DSE 8-2
THEORY COMPONENT
(Hours: 45)

Unit I **(10 Hours)**

General features of Earth's atmosphere
Thermal structure of the Earth's Atmosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations including RS/RW, meteorological processes and convective systems, fronts, Cyclones and anticyclones, thunderstorms. Dynamics of Particulate Matter (PM), pollutants and meteorological parameters diurnal, seasonal and annual variability. PM and their effect on human health.

Unit II **(13 Hours)**

Atmospheric Dynamics
Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale and general circulations.
Atmospheric Waves
Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration.

Unit III **(7 Hours)**

Remote Sensing Techniques (Atmospheric Radar)
Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Applications of radars to study atmospheric phenomena, Classification and properties of aerosols, Aerosol studies using Lidars.

Unit IV **(15 Hours)**

Climate Change
Historical trends of CO_2 and temperature, understanding on sea level rise. Thermodynamics in climatology, long term energy balance and cycles, and rudimentary introduction to climate change models. Physical processes of greenhouse gases warming the planet, Impact of climate change in extreme weather, regional case studies focus on India subcontinent, Climate policies and international agreement - UNFCCC, Kyoto Protocol, Paris Agreement, Role of COP meetings, Concept of Net-Zero Emission, and Climate Change and public health.

PRACTICAL COMPONENT: ATMOPHERIC PHYSICS AND CLIMATE CHANGE

(Hours: 30)

Atmospheric Physics

Scilab/Python/Matlab based simulations experiments based on Atmospheric Physics problems listed below.

At least 03 Experiments from the following should be conducted.

1. Numerical Simulation for atmospheric waves using dispersion relations for
   a. Atmospheric gravity waves (AGW)
   b. Kelvin waves
   c. Rossby waves, and
   d. mountain waves.
2. Processing of radar data a. VHF radar, b. X-band radar, and c. UHF radar,
3. Offline and online processing of LIDAR data.
4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe. Suggested parameters calculations are (i) Brunt Vaisala frequency, (ii) potential temperature, (iii) pressure-height conversion, and (iv) thermal wind equation.
5. Handling of satellite data and plotting of atmospheric parameters using radio occultation technique

Climate Change

i. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change.
ii. PM 2.5 measurement using compact instruments and experience with data from CPCB and DPCC to investigate the Climate Change.

Field visits to National centre for medium range weather forecasting, India meteorological departments, and ARIES Nainital to visualise onsite radiosonde balloon launch, simulation on computers and radar operations on real time basis.

REFERENCES

Essential Readings for the Theory Component

1. Fundamental of Atmospheric Physics, M.L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3 rd edn. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

Additional Readings for the Theory Component

1. Stratosphere Troposphere Interactions - K Mohanakumar, Springer Netherlands, 2008.

2. Climate change in the Himalayas, Springer publication, by GB Pant, P Pradeep Kumar, J V Revadekar, Narendra Singh, 2018.
3. PM2.5 diminution and haze events over Delhi during the COVID-19 lockdown period: an interplay between the baseline pollution and meteorology, Nature- Scientific Reports, 10(13442). https://doi.org/10.1038/s41598- 020-70179-8., S. K. Dhaka, Chetna, V. Kumar, V. Panwar, A. P. Dimri, N. Singh, P. K. Patra, Y. Matsumi, M. Takigawa, and T. Nakayama (2020)
4. Gravity wave generation in the lower stratosphere due to passage of the typhoon 9426 (Orchid) observed by the MU radar at Shigaraki (34.85 N, 136.10 E), SK Dhaka, M Takahashi, Y. Shibagaki, MD Yamanaka, S Fukao, Journal of Geophysical Research: Atmosphere 108 (D19), 2003.
5. Indian MST radar observations of gravity wave activities associated with tropical convection, SK Dhaka, PK Devrajan, Y Shibagaki, RK Choudhary, S Fukao, Journal of Atmospheric and Solar-Terrestrial Physics 63 (15), 1631-1642.
6. Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques (https://www.narl.gov.in)

References for the Practical Component

Data sources for radar, lidar, satellite and radiosondes

1. https://www.narl.gov.in
2. http://www.imd.gov.in
3. https://www.ncmrwf.gov.in/
4. https://www.aries.res.in/
5. http://www.rish.kyoto-u.ac.jp/ear/index-e.html