Course title: Fate, Transport, and Transformation of Atmospheric Pollutants			
Course code: NRE 179	**No. of credits:** 2	**L-T-P:** 28-00-00	**Learning hours:** 42
Pre-requisite course code and title (if any):			
Department: Department of Natural Resources			
Course coordinator: Prof. Suresh Jain	**Course instructor:**		
Contact details:			
Course type: Elective	**Course offered in:** Semester 3		

Course Description

This course provides state-of the-art knowledge to the field of chemical, physical, and dynamic meteorology (Fate, Transport, and Transformation of Atmospheric Pollutants). This course deals with: the atmosphere's chemical composition; atmospheric chemical reaction (including photochemistry) processes in gas phase, liquid phase, and on particle surfaces; atmospheric transformation of the important gases as well as particle-borne natural and anthropogenic pollutant substances; interaction of electromagnetic radiation (UV, visible and IR) and species in the air (gas and particles); transport and dispersion on local, regional and global scales; effects on changing atmospheric composition on the global climate, as well as underlying causes.

Course objectives

Course content

SNo	Topic	L	T	P
1.	Overview of the Global Atmosphere: Density, Pressure, Temperature, Chemical Constituents, Mixing Ratio, Number Density, and Partial Pressure; and Barometric Law	4		
2.	Origin of the Earth's Atmosphere: Formation and Evolution of the Earth System	1		
3.	Sun-Earth Relationships: Rotation of Earth and time zones, Revolution around the Sun, Seasons, Cycle of Sun's declination, and Solar Constant	1		
4.	Atmospheric Models: Box model, Column Model, Processes governing the chemical state of the atmosphere, Spatial and temporal scales of air pollution	2		
5.	Atmospheric Transport: Geostrophic flow; The General Circulation; Vertical Transport; and Turbulence; Coriolis Force, Horizontal Pressure Gradient Force, and Friction Force concepts; Buoyancy in the atmosphere; and Environmental Lapse Rate.	3		
6.	Case Study I: Emissions, transport, and back-trajectory analysis	2		
7.	Radiation Budget of the Atmosphere Solar Zenith angle; Wavelength and frequency; Blackbody radiation; Stefan-Boltzmann law; Wien's displacement Law; Scattering,	3		

	absorption and extinction			
8.	Air Quality Modeling and Chemical Kinetics: Rate law; fundamentals of reaction kinetics; rate constant	3		
9.	Atmospheric Chemistry: Sources, and Sinks of Trace Gases, Hydroxyl Radical, Reactive Nitrogen, Carbon, and Sulfur Compounds; radical (hydroxyl, peroxy, and nitrate) chemistry	2		
10.	Tropospheric Ozone: Formation, chemistry and distribution	3		
11.	Case Study II: Measurements and analysis of reactive nitrogen compounds in the troposphere; their ratioing to examine tropospheric ozone in air masses	2		
12.	Stratospheric Ozone and the Ozone Hole: Anthropogenic perturbations to stratospheric ozone; vertical transport of long lived chemical compounds (e.g. CFCs), and their subsequent interactions in the Stratosphere; along with the mathematical development associated with the Chapman Cycle	2		
	Total	**28**		

Evaluation criteria

- **Minor test :** 30%
- **Quiz:** 10%
- **Assignment:** 10%
- **Major test :** 50%

Learning outcomes

After taking this course the student should to be able to explain chemical and physical processes that are fundamental for the emissions, transport, transformation and fate of atmospheric pollutants. The importance of electromagnetic radiation laws (Planck's, Wien's, Stefan-Boltzmann, Kirchhoff's) will be examined in relation to earth's radiative balance, photo-chemistry, and climate. Sources and sinks of gases and particles of importance for environment and climate will be examined. The interplay of atmospheric gases and particles will be explored from a chemical and meteorological perspective. Basic chemical and physical laws to the transformation of gases and particles as well as to their transport and fate in the atmosphere will be examined.

Pedagogical approach

Materials

Required text

1. Introduction to Atmospheric Chemistry by Daniel J. Jacob, 1999.
2. Atmospheric Science: An Introductory Survey by Wallace, J.M., and P. V. Hobbs (2nd edition)
3. Meteorology Today by Ahrens, C. Donald (9th edition)
4. Handouts and lecture notes

5. Case Study Discussions
Additional information (if any)
Student responsibilities Attendance, feedback, discipline, guest faculty etc.