CEVE 411 / 511
ATMOSPHERIC PROCESSES
FALL 2013

Meeting Times and Location:
M/W/F 9:00-9:50 a.m., Mech Lab 251

Instructor:
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Office Hours:
Thursdays 2-4 pm. Office visits are also welcomed at other times by appointment.

Course Description:
This course will explore the chemical and physical processes that govern the formation, transformation, and transport of gases and particles in the atmosphere. The primary phenomena of focus will be atmospheric transport; global climate change; stratospheric ozone depletion; tropospheric ozone formation and related oxidant and reactive nitrogen chemistry; acid deposition; particulate matter; and mercury and other air toxics. While our primary focus will be the atmospheric chemistry and physics processes that influence these phenomena, we will also consider the broader context of environmental policy, control technologies, and impacts on human health and the environment.

Course Objectives and Expected Learning Outcomes:
Students completing this course will be able to:

1. Solve equations and simplified models representing physical and chemical processes in the atmosphere
2. Describe the photochemical processes that destroy stratospheric ozone and form tropospheric ozone under a range of conditions
3. Diagram the processes influencing Earth's radiative balance
4. Compare and contrast the challenges posed by air pollution, ozone depletion and climate change, and key policies that have been enacted to address them
5. Critically review published literature regarding the current state of scientific understanding for climate change and air pollution

The course addresses the following ABET student outcomes for the BSCE degree:

(a) an ability to apply knowledge of mathematics, science, and engineering;
(e) an ability to identify, formulate, and solve engineering problems;
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
(j) a knowledge of contemporary issues

Prerequisites:

Students are expected to have a background in the fundamentals of chemistry, physics, and calculus, equivalent to CHEM 121/122; MATH 101/102; and PHYS 101. Please contact the instructor if you have questions regarding your preparation.

Textbook and Readings:

Daniel Jacob. *Introduction to Atmospheric Chemistry*. Princeton University Press, 1999. (available as pdf at http://acmg.seas.harvard.edu/publications/jacobbook/index.html)

John Seinfeld and Spyros Pandis. *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change: Second Edition.* John Wiley & Sons, 2006.

Additional readings will be made available on the OwlSpace website for the course.

Honor Code Policy:

All students are expected to adhere to the Rice Honor Code. The following specific expectations apply to this class:

- Exams will be given under the honor system and must be entirely a student's own work, using only resources that are explicitly authorized for that exam.
- Problem sets may be discussed with other students but must be written individually by each student in their own words.
- Plagiarism is unacceptable. Specifically, for all written work (including the paper as well as paragraph or short essay questions on the problem sets) students must both cite references used and express all ideas in their own words. Any direct quotation must be explicitly noted in quotation marks.

Disability Statement:

If you have a documented disability that will impact your work in this class, please contact me to discuss your needs. Additionally, you will need to contact the Disability Support Services Office in the Allen Center.

Grading:

Students will be evaluated by their performance on the following:

Problem Sets (~8)	25%
Midterm Exam I	15%
Midterm Exam II	15%
Critical Review Paper	15%
Final Exam	30%

All assignments are due in class on the due date unless otherwise specified. Late assignments will incur a penalty of 25 points and will not be accepted after solutions are distributed. Final grades may be adjusted by up to ±2 points based on attendance and participation.

Graduate students (CEVE 511) will have a more extensive critical review paper assignment (~6-8 pages + references) than undergraduates (~5 pages + references), and will also be assigned an additional problem on some problem sets.

SCHEDULE (*subject to change*)

DATE	THEME	TOPIC	READING
8/26	**Introduction to the Atmosphere**	Importance of the Atmosphere	
8/28		Structure of the Atmosphere (measures of composition; layers; pressure; barometric law)	Jacob Ch. 1, Ch. 2
8/30		Simple models of the Atmosphere	Jacob Ch. 3
9/2		**LABOR DAY (no class)**	
9/4	**Atmospheric Transport**	Horizontal transport (Earth-Sun geometry; Coriolis force)	Jacob Ch. 4.1
9/6		Horizontal transport (friction; Hadley and general circulation)	Jacob Ch. 4.1-4.2
9/9		Vertical Transport (buoyancy; stability; inversions; cloud formation)	Jacob Ch. 4.3
9/11		Vertical Transport (cont.)	
9/13		Turbulence and Diffusion	Jacob Ch. 4.4
9/16		Tropical cyclones	Reading on Owlspace
9/18	**Climate Change**	Intro to Climate Change and its impacts	IPCC reading
9/20		Biogeochemical cycles of oxygen and carbon	Jacob Ch. 6; S&P Ch. 22.2
9/23		Radiative Balance of the Atmosphere	Jacob Ch. 7.1-7.2
9/25		Greenhouse Effect	Jacob Ch. 7.3
9/27		Radiative forcing and climate response	Jacob Ch. 7.4-7.5; S&P Ch. 23.3-23.5
9/30		Natural climate variability; Aerosols and climate	S&P Ch. 23.1-23.2, Ch. 24
10/2		Mitigation, adaptation, and geo-engineering	Readings on Owlspace
10/4	**MIDTERM 1**		
10/7	**Stratospheric Ozone**	Chemical kinetics and photolysis	Jacob Ch. 9
10/9		Intro to Stratospheric Ozone; Chapman Mechanism ozone formation	S&P Ch. 2.6; 4.7; 4.9; 5.1-5.2; Jacob Ch. 10.1; UNEP
10/11		Catalytic cycles of ozone destruction (NO_x and HO_x)	S&P Ch. 5.3-5.4
10/14		**MIDTERM RECESS (no class)**	
10/16		Halogen cycles of ozone destruction; interaction between cycles	S&P Ch. 5.5-5.6

DATE	THEME	TOPIC	READING
10/18		Ozone depletion at poles and beyond; Heterogeneous stratospheric chemistry	S&P Ch. 5.7-5.9
10/21	**Tropospheric Chemistry (Ozone)**	Policies for stratospheric ozone; Intro to Tropospheric Ozone; Hydroxyl radical	S&P Ch. 5.11, 6.1
10/23		Basic NO_x cycle; Carbon monoxide and O_3 formation	S&P Ch. 6.2-6.3
10/25		**TBD**	
10/28		Methane: Sources, sinks, and oxidation	S&P Ch. 2.4.2; 6.4
10/30		VOC oxidation; NO_x- and VOC-limited ozone formation	S&P Ch. 2.4.3-4; 6.8-10
11/1		Daytime & nighttime NO_x and NO_y chemistry (including PAN & HONO); ozone production efficiency	S&P Ch. 6.5-6.8
11/4		Policies and technologies to control ground-level ozone; Houston ozone	TBD
11/6	**MIDTERM 2**		
11/8	**Acid Deposition**	Acid deposition and its impacts; Natural acidity of rain	S&P Ch. 7.1-7.3.2
11/11		Sulfur Chemistry	S&P Ch. 2.2; 7.3.3; 7.5; 22.1
11/13		Other gases influencing acid rain; Control policies and technologies	S&P Ch. 7.3.4-7.3.6
11/13?		**Site visit to Plant Parish (TBD)**	
11/15	**Particulate Matter**	Importance of particulate matter; Properties of particles	S&P Ch. 8
11/18		Visibility	S&P Ch. 15
11/20		Sulfate, Nitrate, and Ammonium Particles	S&P Ch. 10.4
11/22		Carbonaceous Particles	S&P Ch. 14.1-14.5
11/25		Policies and technologies to control particulate matter	TBD
11/27		**TBD**	
11/29		**THANKSGIVING RECESS**	
12/2		Prof. Rob Griffin: Guest lecture & mobile lab tour	
12/4	**Air Toxics**	Mercury, Benzene, and Other air toxics	S&P App. 2.2
12/6	**Synthesis and Review**	Comparing the ozone depletion, air pollution, and climate change challenges; Exam review	TBD
TBD	**FINAL EXAM**	**(take-home)**	