Air Pollution II: Aerosols

ATMO/CHEE 469B/569B, Spring 2022
McClelland Park, Room 103
Tues/Thurs 08:00–09:15

Instructor Information

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Office Hours: Mondays 11 am-1 pm, Harshbarger 112

General Information

Description

Globally, air pollution is associated with more deaths per year than car crashes, smoking or HIV, and the majority of these deaths are associated with small particulate matter (PM2.5). In this course, we will understand what constitutes this small particulate matter, or aerosol, both from primary sources like combustion and dust storms and from secondary sources via gas-phase reaction. We will study how aerosol move, for example gravitationally or within electrical fields, and grow, for example via coagulation or condensation. The variety of instruments to study these aerosol properties and processes will be discussed, and we will examine the human impact of aerosol, both on climate through cloud formation and optical properties and on health through virus transmission and cancer.

Learning Objectives

Upon successful completion of this course, the student will be able to

1. ***Characterize*** aerosol particles, using different kinds of size distributions and basic aerosol chemistry
2. ***Predict*** how an aerosol particle moves through a fluid with and without external forces
3. ***Calculate*** how aerosol particles will form and grow via processes like nucleation and coagulation
4. ***Explain*** the relevance of aerosol to both climate and public health
5. ***Describe*** the key mechanisms at play in different aerosol instruments

Course Requirements & Grading

Homework 1 – 8, Review Activities	30%	Homework will consist of conceptual and quantitative questions each week, and prior to the midterm and final, there will be review activities to submit. All assignments are posted / distributed Tuesday, 8 am and due the following Tuesday, 8 am.
Engagement and Coffee Break	5%	Participation in in-class activities and question-asking Schedule one post-class coffee or fill out the feedback form online before the end of the semester
Research Report	20%	Read and write a report on a recent research article about aerosol
Midterm Exam	20%	Exams will be in-class with all resources other than Internet at your disposal.
Final Exam	25%	

Requests for incompletes and withdrawal must be made in accordance with university policies: https://catalog.arizona.edu/policy/grades-and-grading-system

Assignment submission

You are expected to submit homework, review activities, and the research report at the start of the class period on which they are due. Submission is preferably in-person, but if you will not be present in class, you may also email me the assignment by the due date. Homework, review activities, and the research report may all be submitted for one week after the due date. For each day that the homework is late, the maximum possible points drop by 15%.

Regrades

Please discuss any regrades in person during office hours in the week after the assignment or exam is returned.

Presence and participation

You are strongly encouraged to come to class, and a percentage of your grade will depend on engaging in in-class activities. We will work problems, do experiments, and look at instruments during our sessions, all of which will facilitate your learning. The UA policy on attendance and administrative drops is here: https://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop. The UA policy on absences for religious beliefs or for dean-approved reasons are here:
https://policy.arizona.edu/human-resources/religious-accommodation-policy
https://deanofstudents.arizona.edu/policies/attendance-policies-and-practices

Coffee Break and Research Report

Beginning in the first week of February, and COVID permitting, I will open up a calendly link, so that you can pick a date to chat with me after class. These discussions will be from about 9:15 to 10 am, Tuesdays and Thursdays, and the idea is to promote two-way feedback. As it is my first semester teaching, I would like your help identifying what is going well and what could be improved. This is also my opportunity to learn more about your academic and career interests and to tell you how I think you're progressing in the course. Plus, you get a free coffee (or cappuccino or tea) for your time! If you are not available immediately after class or feel uncomfortable with a one-on-one discussion, please let me know by email or during office hours.

Given its role in climate change and the pandemic, aerosol is a very active area of research. To incorporate this research into our semester, you will be asked to pick a topic, read related research articles, and present your findings in both a written report and a short, in-class presentation. A more detailed assignment will be provided after the midterm.

Grading scale

Your final grade will be assigned as a letter grade according to the following scale:
A 90-100% B 80-89% C 70-79% D 60-69% F 0-59%
There is no preset number of each letter grade. Exams will be curved up based on the top score. Each exam will have one extra credit question, but otherwise there are no extra credit opportunities.

Course Materials

Aerosol Technology: Properties, Behavior, and Measurement of Airborne Particles. William C. Hinds, 2nd Edition, Wiley, New York (1999), ISBN-13: 978-0471194101.

Atmospheric Chemistry and Physics: From Air Pollution to Climate Change. John H. Seinfeld and Spyros N. Pandis, 3rd Edition, Wiley, New York (2016), ISBN-13: 978-1118947401 (denoted S&P in the schedule).

All readings, as well as assignments and solutions, will be provided in electronic format via D2L. We will cover most of Hinds but only a small fraction of the material in Seinfeld & Pandis. There are rental options for both on Amazon. If you will continue in atmospheric science or air pollution engineering, you should consider buying Seinfeld & Pandis. It is a very extensive but excellent book. Lecture slides will also be posted prior to each class with gaps that you can fill in with your notes.

Course Guidelines

Code of Academic Integrity

Students are expected to adhere to the UA Code of Academic Integrity, meaning that "cheating, fabrication, facilitating academic dishonesty, and plagiarism," as well as "submitting an item of academic work that has previously been submitted or simultaneously submitted without fair citation of the original work or authorization" will not be tolerated. The full Code of Academic Integrity can be found here: https://deanofstudents.arizona.edu/policies/code-academic-integrity

Accessibility, Non-discrimination, and Harassment

This course strives to be accessible to all. If you anticipate or experience physical or mental health barriers, please come to me so we can discuss options to facilitate your learning. Disability Resources and Counseling & Psych Services can also support us in finding solutions for you.

The U of A is also "committed to creating and maintaining an environment free of discrimination. In support of this commitment, the University prohibits discrimination, including harassment and retaliation, based on a protected classification, including race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, or genetic information." Open discussion of well-founded opinions is welcome in our learning environment, but bullying and discrimination will not be tolerated. Further details on the non-discrimination and anti-harassment policy are here: https://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Electronics Policy

Out of respect to the instructor and fellow students, you are asked to put away electronic devices when you come into the classroom. Turning off your cell phone and giving your attention to course material are considered part of attendance. You are encouraged to print the lecture slides beforehand and take notes by hand rather than on your laptop to minimize distractions.

Threatening Behavior

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, include oneself. We want to foster a safe and inclusive learning environment: http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students

Course Schedule

Week	Topics	Pre-class Materials
1 - Jan 13	Session 1: Course welcome – discuss syllabus, introductions, and assess prior knowledge	Parentheses indicate optional reading
2 – Jan 18, 20	Session 2: Aerosol size distributions and statistics -- HW 1 out	Hinds 4.1-4.3

Objective 1	Session 3: Size statistics	Hinds 4.1-4.3, S&P 8.1.5
3 – Jan 25, 27 ***Objectives 1 & 5***	Session 4: Mass and surface area distributions -- HW 1 due, HW 2 out	S&P 8.1.1-8.1.4
	Session 5: Lognormal distribution; Chemical composition of primary aerosol	Hinds 4.4 Look through S&P 8.2-8.3
4 – Feb 1, 3 ***Objective 2***	Session 6: Properties of gases -- HW 2 due, HW 3 out	Hinds 2.1-2.4
	Session 7: Uniform particle motion – Reynolds number, Stokes' Law, and drag coefficients	Hinds 2.5, 3.1-3.2 (S&P 9.2)
5 – Feb 8, 10 ***Objective 2***	Session 8: Uniform particle motion – Gravitational settling and slip correction factor -- HW 3 due, HW 4 out	Hinds 3.3-3.4, 3.7 (S&P 9.3)
	Session 9: Non-spherical particles; Gravitational settling and Brownian motion demonstrations	Hinds 3.5-3.6
6 – Feb 15, 17 ***Objective 2***	Session 10: Brownian motion and diffusion; Phoretic effects -- HW 4 due, HW 5 out	Hinds 7.1, 7.3, 8.1 (S&P 9.5)
	Session 11: Particle acceleration and curvilinear motion; Impaction	Hinds 5.1-5.4
7 – Feb 22, 24 ***Objectives 2 & 5***	Session 12: Exploiting aerosol motion in instruments – Impactors and elutriators -- HW 5 due, Review Activity 1	Hinds 5.5-5.7
	Session 13: In-class activities -- Looking at impactors and measuring indoor air quality using handheld particle counters	
8 – Mar 1, 3	Session 14: Review session -- Bring Review Activity 1	
	Midterm Exam - Objectives 1 and 2	
9 – Mar 15, 17 ***Objective 3***	Session 15: Aerosol thermodynamics – Saturation vapor pressure and the Kelvin effect -- HW 6 out	Hinds 13.1-13.2
	Session 16: Aerosol formation – Classical homogeneous nucleation theory and secondary organic aerosol	S&P 14.3.1 and 14.4.1 Watch until 3:30 of https://youtu.be/uNqf5vbjJf8
10 – Mar 22, 24 ***Objective 3***	Session 17: Aerosol formation and growth – new particle formation and condensational growth -- HW 6 due, HW 7 out	Hinds 12
	Session 18: Aerosol formation and growth in climate – liquid clouds and Köhler theory	S&P 17.2-17.3

11 – Mar 29, 31 ***Objectives 3 & 4***	Session 19: Aerosol formation and growth in climate – ice clouds and heterogeneous nucleation -- HW 7 due, HW 8 out	§1 and 2 of Kanji et al. 2017 Look through www.realicecrystals.de
	Session 20: Aerosol growth – Collision efficiency and coagulation equation	Hinds 13.1-13.4, 13.7
12 - Apr 5, 7 ***Objective 4***	Session 21: Direct climate effects of aerosol – optical and radiative properties -- HW 8 due, Prepare Research Report	Look through www.atoptics.co.uk
	Session 22: Health effects via respiratory deposition, air quality indices	Hinds 11.1-11.3, Record PM2.5 for 2 locations https://gispub.epa.gov/airnow/
13 – Apr 12, 14 ***Objective 4***	Session 23: COVID transmission by aerosols -- Prepare Research Report	§1.1-1.4 from the FAQs on Aerosol Transmission
	Session 24: Scientific denialism, the tobacco industry, and health effects of cigarettes	Watch https://youtu.be/vSeJyF6F49U
14 – Apr 19, 21 ***Objective 4***	Session 25: Research Presentations 1 -- Research Report due	
	Session 26: Research Presentations 2	
15 – Apr 26, 28 ***Objective 5***	Session 27: Aerosol instrumentation + design activity	
	Session 28: Aerosol chambers, condensation particle counters, and filtration – Review Activity 2	Hinds 9.2-9.3 and 10.1, Look through www.eurochamp.org/simulation-chambers
16 – May 3	Session 29: Review session -- Bring Review Activity 2	
17 – May 12	Final exam (8 am) – All Objectives	

A Final Caveat

I am still developing the materials for the second half of the course, so the schedule and readings are subject to shift after the midterm. Please be patient and know that I will announce any changes to the syllabus both in class and on D2L.