**CEE 441**

**Air Pollution Sources, Transport and Control**

**Fall 2024 - Course Syllabus**

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## Course description and learning objectives

**Instructor**: Dr. Sotiria Koloutsou-Vakakis

3230A Newmark, [sotiriak@illinois.edu](mailto:sotiriak@illinois.edu)

**Class web page:** <https://canvas.illinois.edu/courses/36708>

**Class Hours**: MW 1:00-2:20 pm, NCEL 2310 (Yeh student center) or asynchronously online.

**Office Hours**: MW after class. F 1-2 pm NCEL 2310. M 6-7 pm Zoom office hour for online students.

**Credit**: 4 hrs

**Why care about Air Quality?**

The most important reason is to prevent serious disease and early death because of poor air quality. Other important reasons include ecosystem protection and aesthetics. Air pollution relates to visibility reduction, acid rain, climate change, ozone depletion, material damage.

**Why should you take this course?**

In this course, first we review major air pollutants of concern and the major USA law for preserving good air quality and then we delve deeper into air pollutant transport and control.

After completing this course, you will have the basic background to work as an air quality professional and you will know what resources are available and how to use them according to the special characteristics of a new project. The air quality field is vast. In this course, you will get the essential technical background, but emphasis is given on promoting your problem solving skills regarding air quality its management and control.

Finishing this class, you will know:

1. the basics of air pollution its transport and control.
2. how to access and analyze air quality data on public databases using R package *openair*.
3. about air quality model types, their usefulness, and evaluation approaches.
4. how to prepare input data and configure the regulatory air dispersion model AERMOD to predict air pollutant transport and how to interpret and evaluate its output.
5. about air pollution prevention and the principles, performance and limitations of existing technologies for air pollution abatement.
6. about design of multi air pollutant control

You will have also developed or refined your skills on

1. compiling high quality professional reports and making presentations of your work for a given audience.
2. managing time, resolving possible conflict, and working productively in teams, toward a common goal.

**What is the teaching style of the class?**

Emphasis is given to active learning. Basic principles are introduced, first. Then you are encouraged and expected to actively contribute and enhance the learning process in class.

**Note:** It is not feasible to follow a steady weekly pattern of assignments and submissions in this class. For this reason, make sure to have your notifications activated on Canvas and make sure to check your Illinois e-mail. I post weekly summaries and reminders at the end of each week, so that you are always up to speed.

**Prerequisites**: CEE 331 or equivalent; CEE 202 or equivalent (basic understanding of probability and statistics is assumed).

## Study materials and equipment

**Class Notes**: Lectures slides will be available on Canvas, along with class lecture notes and worksheets.

**Reference Textbook:** K. B. Schnelle, Jr.,R. F. Dunn, M. E. Ternes (2016). *Air Pollution Control, Technology Handbook*, Second Edition, CRC Press. (search "Air Pollution Control Technology Handbook" in <https://www.library.illinois.edu/> to get access to an electronic copy of the book through the UoI library).

**Readings**: As listed in the weekly modules on Canvas.

**Equipment needed:** A laptop having the Windows environment is needed. The Windows environment is needed because AERMOD has been developed for Windows. For Apple users, one option is to install Windows as a second OS on your laptop. The other option is to run AERMOD on the Engineering Workstations (EWS), which is possible through Citrix.

**Recording and sharing material by students:**  Recording material from this course, sharing recorded material or posting it online including lectures, discussions or other activities **is forbidden**. Any violation of these policies will be forwarded to the Office of Student Conflict Resolution for disciplinary action.

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## How am I graded?

**Weights:**

Homeworks: 15%

Project 1: 30%

Quizzes: 15%

Project 2: 30%

Final exam: 10%

**Grades:** Grading scale: A+ ≥ 97; A 92-96; A- 87-91; B+ 81-86; B 76-80; B-71-75; C+ 66-70; C 61-65; C- 56-60; D+ 51-55; D 46-50; D- 41-45; F ≤ 40. Grading rubrics are given with every assignment.

When at the border between grades for the final grade, I make an “executive decision” to go with the higher or stay with the grade that corresponds to the cut points, based on your level of involvement with the class and your progress trend during the semester. Please, keep in mind that only high quality, honest work on your part can result in a better grade. Grades are not subject to negotiation**. Also remember:** if you face difficulty, contact me as early as possible to explore ways to help you. Once the semester is over, I cannot help - not because I stop caring but because that’s how the academic cycle works.

**Homeworks**: problem sets will be assigned during the semester.The purpose of homeworks is to practice the basic principles and methods introduced in class, by solving simple straightforward problems.

**Projects:**Two team projects:

*Project 1:* you will use the EPA recommended model AERMOD to model pollutant dispersion from a real stationary source and you will critically evaluate model output by comparison to neighboring monitor data.

*Project 2:* you will review state of the art gaseous air pollution control.

The purpose of projects is to synthesize the information learned in class, to produce engineering solutions to a realistic air pollution problem. Projects are assigned at least 3-4 weeks before the due date. As you start on a project, you are first asked to submit a timeline and work plan, clearly indicating the division of tasks among the team members and including description of quality assurance and quality control procedures. As you proceed with the work, you are asked to submit an outline of your report. The final submissions include a written report and an oral presentation. You are also required to evaluate your teamwork through self-and peer-evaluation.

For projects, there are intermediate submissions, which give me the opportunity to provide feedback and to us together the opportunity to discuss your work before you finalize it. They also give you grade points to remind you that you need to submit the intermediate parts, for a better final product.

Your reports are tools for practicing effective communication. The most basic rule to remember is that you write for an audience. Your reader understands only what you explain clearly. No reader can read your mind, so even the most perfect technical work can’t be appreciated until clearly explained (need, goals, methods, results).

**Quizzes:** Quizzes are given throughout the semester. Their purpose is to help you keep in pace with the class content. As long as, there is new material covered in one week, a quiz is given in the following week. I notify you. Quizzes occur on Canvas.

**Final Exam:** It’s a short 50 min exam. It is focused on the essential basic knowledge you are expected to have at the end of this class. Open book/note. If you have studied consistently during the semester, you will find it to be easy.

**Class attendance**: It is expected for every class. Let me know **in advance** if you are going to miss class for a serious reason and to accommodate late assignment submission.

**Participation:** Participation is different from attendance. It means you actively engage with the class and positively contribute to the learning process for yourself and others.

**Cooperation:** Communication with classmates is encouraged for homeworks, projects and presentations, as the purpose of these is learning the material. “Communication” does not mean that you are doing someone else’s homework or project but that you should feel free to discuss homework and projects and class topics in general, with fellow students. We learn better and, in more depth, what we take the time to think about and intelligently discuss with our peers.

No cooperation for quizzes/exams, of course!

If you feel confused about the concept of cooperation vs cheating, even after we discuss these in class, make sure to discuss further with me.

**Makeup classes:** Makeup classes will be scheduled if needed, at times that are agreeable to most.

**Other issues:** Do not hesitate to approach me for any concerns you might have relevant to the class. I always encourage your feedback.

## How do I submit homeworks and projects?

**When:** To make it easier to remember for this class, the rule is: homeworks and projects have to be turned in by the beginning of the class period, on the day they are due.

**Where:** Submissions are on Canvas, where you upload one .pdf file per assignment and the accompanying code files, as applicable. If you use handwriting for a homework, please make sure the scan you submit is clear, clean, legible and well organized. Use the full length and width of the page. Organization and neatness in your submitted assignments is graded!

!!! You should be naming any files you submit electronically as follows: ***Your\_LastName\_AssignmentNumber.extension*** (example JONES\_HW1.R). Make a habit of naming all files you submit electronically using this format! *Over time, you will discover that consistent file naming can save your sanity, as the number of files in your laptop keeps multiplying. Repeated failure to follow this naming format will result in no acceptance of your submission.*

Each student may turn in ONE late assignment with no penalty, no questions asked. But it is always good to let me know if you submit late. For repeat late submissions, reasons for delay have to be serious and provable to avoid penalties. If your excuse comes after a given deadline, it will not be accepted. Late submissions will NOT be accepted in the last week of classes.

**Solutions to homeworks:** As a matter of policy, I do not post homework or exam solutions. Solutions to challenging problems are discussed during class and office hours. I do post solved worksheets, after their respective class.

CEE Honor Code

The CEE Honor Code pledge is the following:

*I pledge to uphold the highest levels of professional and personal integrity in all of my actions, including 1) never assisting or receiving unfair assistance during exams, 2) never assisting or receiving assistance on class assignments beyond that specified by an instructor, and 3) always fully contributing to group activities that are part of a course activity.*

## Use of AI tools

* You may use them as long as you do not lean on them to pass the class. If you lean on them, you null their usefulness for your learning journey.
* If you use AI tools to just get a better grade fast, that’s a bet. They often hallucinate (give a wrong answer). Thus, they can contribute to a worse grade, instead, for which the responsibility is only yours
* Regarding this class, let’s be realistic, AI tools are described as large language models. They digest everything on the internet. They have not been trained as air quality experts. Not, yet.
* If you use AI for anything, use it critically, check the answers based on what you know and what you learn in class.
* Use AI **ethically**!
* **If you use AI cite it!**
* Share your experiences with AI. Success and failure stories help us understand these tools better.

## Useful tips

**Etiquette in the classroom:** Please, come to class on time. Be polite and considerate to your classmates and instructors. Texting, e-mailing, instagramming, tik toking, twitting, internet surfing and the similar…, as well as doing homework for another class or watching athletic events (yes I have seen it all, the course recording camera happens to be at your back), can be done before or after this class time.

**General ‘netiquette’**

In any social interaction, certain rules of etiquette are expected and contribute to more enjoyable and productive communication. The following are tips for interacting online via e-mail or discussion board messages, adapted from guidelines originally compiled by Chuq Von Rospach and Gene Spafford (1995):

* Remember that the person receiving your message is someone like you, deserving and appreciating courtesy and respect.
* Avoid typing whole sentences or phrases in Caps Lock.
* Be brief; succinct, thoughtful messages have the greatest effect.
* Your messages reflect on you personally; take time to make sure that you are proud of their form and content.
* Use descriptive subject headings in your e-mails.
* Think about your audience and the relevance of your messages.
* Be careful when you use humor and sarcasm; absent the voice inflections and body language that aid face-to-face communication, internet messages are easy to misinterpret.
* When making follow-up comments, summarize the parts of the message to which you are responding.
* Avoid repeating what has already been said; needless repetition is ineffective communication.

Cite appropriate references whenever using someone else's ideas, thoughts, or words.

## Useful resources

**Learn how to learn:** <https://citl.illinois.edu/citl-101/teaching-learning/resources/transitioning-online/teaching-tips-articles/teaching-tips/2020/08/17/teach-yourself-how-to-learn>, electronically accessible to UI students through the library.

**Useful resource for online students**

<https://citl.illinois.edu/citl-101/teaching-learning/resources/transitioning-online/student-resources>

**Good scientific writing:** Check documents on Canvas and the following websites:

<http://guides.library.illinois.edu/citingsources/citationmanagers>

<https://www.library.illinois.edu/help-services/>

<http://people.physics.illinois.edu/Celia/MsP/MsParticular.htm>

**Effective scientific presentations**:

This my favorite: <https://www.assertion-evidence.com/tutorial.html>.

Other site I like:

<http://www.cgd.ucar.edu/cms/agu/scientific_talk.html>

**VERY IMPORTANT!!! Plagiarism: *Plagiarism in class assignments will be penalized***.Visit the following sitesto be informed about what is plagiarism and how to avoid it (see also CEE honor code above and relevant class presentation during first week of classes): <https://guides.library.illinois.edu/citingsources/plagiarism>

## University-wide important policies and resources

**Accommodations for disabilities:**

We work closely with Division of Rehabilitation-Education Services (DRES) (1207 S. Oak St., Champaign; 333-4603; disability@uiuc.edu) to make sure we offer an optimal learning environment for all our students. Please contact me as soon as possible if our arrangements are not accommodating enough for your needs, so that I can work with you to find solutions for any issues.

**Campus safety tips:**

*Important to be aware of your surroundings and alert. Visit the campus website for useful information:* <https://police.illinois.edu/services/campus-safety-tips/>

**Your Safety:**

Emergencies can happen everywhere. We better be prepared and alert. Please, keep yourselves safe and help keep our campus community safe. Make sure you sign up to ILLINI-ALERT for emergency notifications <http://emergency.illinois.edu>, and read carefully resources on safety at <http://police.illinois.edu/safe>.

**Wellness – Counseling:**

Just because we all have days that are more difficult than others, remember there is help and support. If you experience a problem, it is always best to discuss it. The earlier the better.

**Counseling**: 217-333-3704

<https://counselingcenter.illinois.edu/outreach-consultation-prevention/outreach-consultation-teams>

-For mental health emergencies, you can call 911 or walk into the Counseling Center, no appointment needed.

**Wellness**: <https://campusrec.illinois.edu/programs/student-wellness/>

**Family Educational Rights and Privacy Act (FERPA):**

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See <https://registrar.illinois.edu/academic-records/ferpa/> for more information on FERPA.

**Sexual Misconduct Policy and Reporting:**

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University’s Title IX and Disability Office. In turn, an individual with the Title IX and Disability Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: <https://wecare.illinois.edu/resources/students/#confidential>.

**Religious Observances**

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine schedule later in this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at <https://odos.illinois.edu/community-of-care/resources/students/religious-observances/> to request appropriate accommodations. **This should be done in the first two weeks of classes**.

## Inclusivity and mutual respect in my own words

This class means to provide a welcoming and safe learning environment for everyone, regardless of individual characteristics, appearance, beliefs, preferences, culture, genetics, and any other constructs that can make us lose sight of our common nature. In all ways that really matter, we are all similar: intelligent life inhabiting the only known planet that can support life for us.

Similarly, I strive to accommodate students with different technical content backgrounds. Some students might have seen some of the material before. Some might be coding pros already, while some might have never coded before. It does not matter where you start entering the class. What matters is your drive and what you know at the end of the semester.

I have made an intentional effort to make materials accessible to students of different backgrounds and offer my time to help students who need extra help. But I need you to be active in this effort!

-If you are a pro on something, do not distance your ‘pro’ selves from the class community! You can support your teammates’ learning journey by not being a ‘I know it all, I do it all myself’! Help others see how they can do things and let them do things. Remember at the end of the day good teamwork is evident in the resulting product. You benefit too by conversing with others. It might be that they come with strengths that complement yours or it might be that becoming aware of what they have difficulty with helps you clarify and add depth to your own knowledge.

-Similarly, if you are a newbie, never feel intimidated! Do feel determined to learn! You need to be active responders to class ‘stimuli’ (questions, class work, homeworks, office hours). Seek feedback and be ready to accept and use it. Feedback is a resource. Feedback is not criticism or judging.

-My role is to support your learning journey, as long as you also keep present and open to learning, in every step! Leaving this (any) class, you should feel that you have become a more accomplished person in both social/professional skills and technical skills, compared to where you started.

## Schedule of classes

*(The topic collection is not going to change but keeping the class up to date, often means that I might choose to replace an older reading with a more recent and informative one that appears in the literature. I may also need to change some submission dates.* ***Submission deadlines are always the ones shown on each assignment and Canvas****. You also learn of updates through my weekly reminders.)*

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| --- | --- |
| ***Topics#***  ***#****Weekly readings always include class notes and worksheets posted on Canvas****.*** | ***(Tentative) Weekly Assignments and Exams***  *\*Submission dates here are indicative –* ***Submission time is always 1:00 pm*** |
| **Week 1 (Aug 26 & 28)**  **Introduction**  **Air quality management**  Air pollution sources  Clean Air Act   * Air pollutant characteristics and health effects * Risk assessment and risk management in air quality   **Readings:**   1. Browse the EPA site at: <https://www.epa.gov/environmental-topics/air-topics>. 2. Schnelle et al., 2016, Chapter 1, 2, 3 | HW1 assigned: Air quality in your area of interest using ground based data from <https://www.airnow.gov/> and satellite data from <https://worldview.earthdata.nasa.gov/> and [http://giovanni.sci.gsfc.nasa.gov/](https://www.google.com/url?q=http://giovanni.sci.gsfc.nasa.gov/&sa=D&usg=AFQjCNETq0yrhD9FTjdcZOawWeq6U7IfFw) |
| **Week 2 (Labor Day: Sep 2, Class only on Sep 4)**  **Basic calculations**  Basic calculations 1  **Readings:**   1. Jacob, 1999, Chapters 1 and 2 (work through the examples). | Quiz 1 (Introduction), Sep 4  HW1: due Sep 4  HW 2 assigned: Simple calculations |
| **Week 3 (Sep 9 & Sep 11)**  **Basic calculations and useful computational tools**  Basic calculations 2 – particle size statistics  Introduction to R/RStudio basic functions  Introduction to R package *openair* developed for the analysis and visualization of air quality data.  **Readings:**   1. Jacob, 1999, Chapters 1 and 2 (work through the examples). 2. Introduction to R: Here is a good introductory resource: <https://www.linkedin.com/learning/learning-r-2/r-for-data-science?u=43607124> (access with your Illinois credentials) 3. Carslaw, D.C. (2019). The openair manual — open-source tools for analyzing air pollution data. Manual for version 2.6-6, University of York. <https://davidcarslaw.com/files/openairmanual.pdf> | HW 3 assigned |
| **Week 4 (Sep 16 & 18)**  **Air pollution meteorology**  Overview:   * Vertical pressure and temperature profiles in the atmosphere * Air pollutant lifetime – model time and space scales * Vertical transport - atmospheric stability, vertical wind profile * Horizontal transport - Global atmospheric circulation   **Readings:**   1. Jacob, 1999, Chapter 3, 4 2. Lecture slides. | HW2 due Sep 18  Quiz 2 (simple calculations), Sep 18 |
| **Week 5 (Sep 23 & 25)**  **Simple models – The Gaussian Plume Equation (GPE) model**  Simple Eulerian and Lagrangian models   * + one and multiple box models,   + puff and column models   Simple Gaussian Plume Equation model (GPE 1)  **Readings:**   1. Lecture slides and handout | Project 1 (AERMOD) assigned Sep 23  HW 3 due Sep 23  HW 4 (simple GPE) assigned |
| **Week 6 (Sep 30 & Oct 2)**  **AERMOD (1)**  GPE 2  AERMOD tutorial  **Readings:**   1. AERMOD: Description of model formulation. <http://www.epa.gov/scram001/guidance/guide/appw_05.pdf> 2. CIMORELLI et al., 2005, AERMOD: A Dispersion Model for Industrial Source Applications. Part I: General Model Formulation and Boundary Layer Characterization, Journal of Applied Meteorology, 44, 682-692 (E) (available on Canvas 3. AERMOD User’s Guide, chapters 1,2,3 (for your project) 4. Frost K. D., 2014. AERMOD Performance Evaluation for Three Coal-Fired Electrical Generating Units in Southwest Indiana, Journal of the Air & Waste Management Association, 64:3, 280-290, DOI:10.1080/10962247.2013.858651. | Quiz 3 (simple models, GPE), Oct. 2  Students build the AERMOD input file for project 1. |
| **Week 7 (Oct 7 & 9)**  **AERMOD (2)**  AERMOD formulation  Model evaluation.  **Readings**  ASTM-D6589 › Standard Guide for Statistical   1. Evaluation of Atmospheric Dispersion Model Performance, https://www.document-center.com/standards/show/ASTM-D6589 | HW 4 due Oct 09 |
| **Week 8 (Oct 14 & 16)**  **Project 1 wrap up**  Atmospheric deposition  Building effects  **Recommended Readings:**   1. Rehbein P.J.G., M. G. Kennedy, D. J. Cotsman, M. A. Campeau, M. M. Greenfield, M. A. Annett and M. F. Lepage, 2013, Combined Analysis of Modelled and Monitored SO2 Concentrations at a Complex Smelting Facility, Journal of the Air & Waste Management Association, 64:3, 272-279, DOI: 10.1080/10962247.2013.856817. 2. Douglas R. Murray & Michael B. Newman (2014) Probability analyses of combining background concentrations with model-predicted concentrations, Journal of the Air& Waste Management Association, 64:3, 248-254, DOI: 10.1080/10962247.2013.846282. | Project 1 interim due Oct 16 |
| **Week 9 (Oct 21 & 23)**  **Air Pollution Control**  **Particulate pollutant control**  Process design and basics of cost estimation  Fundamentals of particulate control/Collection mechanisms  Hoods and Ducts  **Readings:**   1. Schnelle et al., 2016, Chapters 7, 8, 19, 20 | Quiz 4 (AERMOD, atmospheric deposition), Oct 23 |
| **Week 10 (Oct 28 & 30)**  **Particulate pollutant control (1)**  Cyclones  Electrostatic precipitators  **Readings:**   1. Schnelle et al., 2016, Chapters 21, 24 | **Project 1 due Oct 28** |
| **Week 11 (Nov 4 & Nov 6)**  **Particulate pollutant control (2)**  Filtration  **Readings:**  1. Schnelle et al., 2016, Chapter 23 | Project 2 assigned Nov 4 |
| **Week 12 (Nov 11 & 13)**  **Gaseous pollutant control (1)**  Adsorption  **Readings:**   1. Schnelle et al., 2016, Chapter 12 | HM 5 assigned |
| **Week 13 (Nov 18 & 20)**  **Gaseous pollutant control (2)**  Absorption  Wet Scrubbers  **Readings:**   1. Schnelle et al., 2016, Chapters 11, 22 | Quiz 5 (particulate control), Nov 20  Project 2 interim due Nov 18 |
| **Fall break** |  |
| **Week 14 (Dec 2 & 4)**  **Gaseous pollutant control (3**)    NOx control  SOx control  [CO2 control (critical review of paper in HW4)]  Thermal oxidation and other technologies overview  **Readings:**   1. Schnelle et al., 2016, Chapters 13, 17, 18 | HW 5 due Dec 4 |
| **Week 15 (Dec 9 & 11)**  **Wrap up and reflect on Project 2**  **Final exam**  Team project 2 - 15 min presentations and reflection/discussion. | **Project 2 due Dec 9**  Last day to submit an excused late assignment Dec 11  50 min final exam on Dec. 11, in class. |