



CIV E 729 Air Quality Modeling

Winter 2025 Syllabus

Instructor: Dr. Haoran Yu, 7-308 Donadeo Innovation Centre for Engineering, hy18@ualberta.ca

Term: Winter term 2025 (January 6, 2025 – April 9, 2025)

Class times: MON/WED 14:00 – 15:20

Class location: Natural Resources Engineering Facility (NRE) 2-080

Midterm exam: February 12, 2025

Group project I due: March 19, 2025

Group project II due: April 9, 2025

Land Acknowledgement

The University of Alberta respectfully acknowledges that we are located on Treaty 6 territory, a traditional gathering place for diverse Indigenous peoples including the Cree, Blackfoot, Métis, Nakota Sioux, Iroquois, Dene, Ojibway/ Sauteaux/Anishinaabe, Inuit, and many others whose histories, languages, and cultures continue to influence our vibrant community.

1. Introduction

This course provides a comprehensive introduction to air pollution modeling techniques, covering theoretical modeling-associated principles and practical modeling technologies. Students will learn the dynamics of air pollutants and atmospheric meteorology, assess the impacts of air pollutants on air quality, and explore various models used to predict the dispersion of pollutants. Furthermore, the course integrates machine learning to enhance traditional modeling approaches, offering insights into cutting-edge research and future directions in air pollution management. Through a blend of theoretical knowledge and hands-on exercises, participants will gain the modeling skills in order to address comprehensive environmental challenges and contribute to the development of feasible and sustainable solutions.

2. Objective

This course aims to equip participants with a comprehensive understanding of the physical, geographical, and chemical principles underlying air quality modeling, and develop their practical

skills to integrate these principles into real-world applications, such as predicting, addressing, and estimating air pollutant dynamics.

3. Learning Outcomes

Upon successful completion of this course, students will be able to:

- 1) develop a comprehensive understanding of air quality fundamentals and modeling approaches. This includes knowledge of key air pollutants, criteria for air quality assessment, and the emission, transport, reaction, and removal of atmospheric pollutants.
- 2) become proficient in identifying various air quality models for application and evaluation purposes.
- 3) apply practical skills in utilizing Python to create meteorological visualizations and develop simple atmospheric models for air quality modeling and analysis.
- 4) acquire the capability to apply certain established air quality models for addressing real-world problems.
- 5) create predictive models for atmospheric pollutants using machine learning techniques to analyze sources and components using Python.

4. Credits

This course will be a 3-credit course. Two lectures will be given each week, 80 min per lecture.

5. Reference Books

The material of this course will be prepared by Dr. Haoran Yu and uploaded on Canvas; **no textbook is required by this course**. The following books and guidelines are useful but not required for this course:

- 1) Introduction to atmospheric chemistry (1999). Daniel J. Jacob*.
- 2) Atmospheric chemistry and physics, third edition (2016). John H. Seinfeld and Spyros N. Pandis*.
- 3) Air quality modeling: theories, methodologies, computational techniques, and available databases and software. Vol. 1 (2003). Paulo Zannetti*.
- 4) Chapter 16: Predicting air quality index with machine learning models. From “Machine learning and deep learning in efficacy improvement of healthcare systems (2022)”. G. Abirami et al.*.
- 5) Models in environmental regulatory decision making (2007). National Research Council of the National Academies.
- 6) Urban air quality monitoring, modelling and human exposure assessment (2021). S. Nagendra et al.
- 7) Fundamentals in air pollution: from processes to modelling (2009). B. Sportisse.

- 8) Air quality model guideline (2021). Government of Alberta.
- 9) Air pollution topic on Environment and Climate Change Canada (ECCC) website: <https://www.canada.ca/en/environment-climate-change/services/air-pollution.html>.

* The major sources of the course materials.

Please refer to the [reading list](#) of this course on *Talis Aspire* to obtain a more detailed reading list.

6. Software

This course requires programming using the Python language, with a brief introduction to Python included. Students will also explore and utilize pre-developed modeling tools, including software-based tools such as AERMOD and web-based modeling tools like HYSPLIT. **A laptop is required for this course.**

7. Course Grading Policy

The grading policy for this course is designed to assess a comprehensive evaluation of students' understanding and practice of air quality modeling concepts. It is structured as follows:

- **Group projects:** accounts for 40% of total.
- **Midterm exam:** accounts for 25% of total (there is no final exam).
- **Assignments:** account for 35% of total (20% homework + 15% lab assignment). **Assignments are due before the second class following the class in which they are assigned** (for example, an assignment given during the 4th class will be due at the beginning of the 6th class).

8. Final Grading

The final grades will be assigned based on the Grade Point system adhering to the recommended grade distribution for a 600-level course (with an average Grading Point of 3.3). Detailed information about the grading system is available on the [University website](#).

9. Outline of the Course

There will be five in-class lab sessions with a lab assignment of each session.

Series I. **Introduction to air quality modeling** (2 lectures)

- 1) Air pollution and why we are concerned
- 2) Air quality management and air quality models

Series II. **Life cycle of air pollutants: emission, transport, reaction, and removal** (5-6 lectures)

- 1) Biogeochemical cycles
- 2) Horizontal atmospheric transport
- 3) Vertical atmospheric transport
- 4) Atmospheric reactions
- 5) Atmospheric deposition

Series III. **Atmospheric meteorology** (2-3 lectures)

- 1) Planetary boundary layer (PBL) and its parameters
- 2) Plume rise

Series IV. **Mathematical models** (6-7 lectures)

- 1) Simple models

Midterm exam: covers the materials of Series I – III and Series IV: simple models (scheduled on February 12, 2025)

- 2) Chemical transport models
- 3) Pre-built trajectory analysis model: HYSPLIT
- 4) Gaussian plume dispersion models
- 5) Project 1: build your AERMOD model to find out a solution for a chemical leakage case (due on March 19, 2025)

Series V. **Statistical models** (5-6 lectures)

- 1) Receptor models: chemical mass balance (CMB) model and factor analysis
- 2) Machine learning: supervised machine learning and unsupervised machine learning
- 3) Model evaluation
- 4) Project 2 (Teamwork): Choose one
 - a. Use supervised ML technique to predict total PM_{2.5} mass from source contributions
 - b. Use unsupervised ML technique to find out the key factors contributing to PM_{2.5} mass and estimate their source
(due on April 9, 2025)

10. Important Dates

January 6, 2025	Winter Term classes begin.
February 17, 2025	Statutory Provincial holiday (NO CLASS); University buildings closed.
February 18 - 21, 2025	Winter Term Reading Week. Classes withdrawn for a full week
April 9, 2025	Last day of Winter Term classes.

11. Academic Integrity

The University Calendar describes the academic integrity in the following statement:

“The University of Alberta is committed to the highest standards of academic integrity and honesty, as well as maintaining a learning environment that fosters the safety, security, and the inherent dignity of each member of the community, ensuring students conduct themselves accordingly. Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect. Students are particularly urged to familiarize

themselves with the provisions of the [Student Academic Integrity Policy](#) and [Code of Student Behavior](#), and avoid any behaviour that could potentially result in suspicions of academic misconduct (e.g., cheating, plagiarism, misrepresentation of facts, participation in an offence) and non-academic misconduct (e.g., discrimination, harassment, physical assault). **Academic and non-academic misconduct are taken very seriously and can result in suspension or expulsion from the University.**”

All students are expected to consult the [Academic Integrity](#) website for clarification on the various academic offences. All forms of academic dishonesty are unacceptable at the University. Unfamiliarity of the rules, procrastination or personal pressures are not acceptable excuses for committing an offence. Listen to your instructor, be a good person, ask for help when you need it, and do your own work – this will lead you toward a path to success. Any academic integrity concern in this course will be reported to the *College of Natural and Applied Sciences*. Suspected cases of non-academic misconduct will be reported to the *Dean of Students*. The *College*, the *Faculty*, and the *Dean of Students* are committed to student rights and responsibilities, and adhere to due process and administrative fairness, as outlined in the [Student Academic Integrity Policy](#) and the [Student Conduct Policy](#). Please refer to the policy websites for details on inappropriate behaviours and possible sanctions.

To help students maintain academic integrity, key guidelines are provided below:

- 1) **Collaboration on assignments and projects:** For assignments, limited collaboration is permitted during off-class hours. Students may discuss problem-solving approaches, criteria, and concepts. However, direct copying answers from other students or sources is strictly prohibited. If suspected of misconduct, students may be required to explain how they have arrived at their solutions. Failure to provide a satisfactory explanation will be treated as a suspicion of academic misconduct. For projects, active collaboration is expected within each group and encouraged between different groups, but sharing final results between groups is not allowed.
- 2) **Avoid plagiarism in project reports:** Each group will submit a project report together for each project. Students are encouraged to conduct literature research, but all quoted material must be properly cited. The [Code of Student Behavior](#) defines plagiarism as: *“Plagiarism: No student shall submit the words, ideas, images or data of another person as the Student's own in any academic writing, essay, thesis, project, assignment, presentation or poster in a course or program of study.”*
Additional resources on avoiding plagiarism can be found on the university website under [“how to avoid plagiarism”](#).
- 3) **Use of ChatGPT and/or other Artificial Intelligence (AI) tools:** The use of generative AI tools in this course is guided by ethical and transparent principles. Students must obtain prior approval from the instructor before using AI tools for assignments or projects. Using AI for polishing or generating ideas does not require citation and is not prohibited. However, any critical code, analysis, or outputs generated

by AI tools must be clearly reported and appropriately cited in assignments or project reports.

- 4) **Avoid cheating in exams:** Only those items specifically authorized by the instructor may be brought into the exam facility. Students must not bring any unauthorized electronic device into an exam room, including cell phone or other devices. While students are allowed to bring a single, two-sided A4 or letter-sized exam note, sharing notes with others during the exam is strictly prohibited. Similarly, students may not pass their calculators to other students unless explicitly permitted by the instructor or invigilators. Students who choose to submit their test papers before the scheduled end time must leave the exam room immediately after submission. Any failure to comply with these instructions will be considered a suspicion of cheating.

12. Safety during Learning Activities

In all Faculty of Engineering courses, labs, seminars or other learning activities, safety is of paramount importance. Anyone found to be unable to function safely in the class or other learning activity may be asked to leave or be removed for their and the safety of other participants and instructors in alignment with the [Student Academic Integrity Policy](#) and the [Student Conduct Policy](#). The instructor will be responsible to identify and inform the proper authorities of unsafe work and study.

13. Audio and video recording

Audio or video recording, digital or otherwise, of lectures, labs, seminars or any other teaching environment by students is allowed only with the prior written consent of the instructor or as a part of an approved accommodation plan. Student or instructor content, digital or otherwise, created and/or used within the context of the course is to be used solely for personal study and is not to be used or distributed for any other purpose without prior written consent from the content author(s).

14. Student Resources

- 1) General resources:
 - a. [Office of the Student Ombuds](#): Offers confidential interviews, advice and support to students facing academic, discipline, interpersonal and financial difficulties.
 - b. [Student Services Centre](#): For awards and other funding support.
 - c. [Resources for International Students](#): Provides general support of international students, such as campus services, life in Canada, health care, and funding and scholarships for international students.
 - d. [Campus Food Bank](#): an independent charity supporting University of Alberta students, faculty, staff, and alumni for up to five years.
- 2) Academic support:
 - a. [Academic Success Centre](#): Access to a variety of services to maximize your academic success.

- b. [Accessibility Resources](#): Connects students with disabilities to accommodations.
 - c. [Decima Robinson Support Centre](#): Academic support for 100- or 200-level introductory calculus, linear algebra and statistics courses.
 - d. [Engineering Student Success Centre](#): The Faculty of Engineering provides drop-in tutoring for first-year courses.
 - e. [Writing Services](#): Offers a variety of free sources to support students with their academic writing projects.
- 3) Health and Wellness Support:
- a. [Health + Wellness Support home page](#).
 - b. [Engineering Wellness Supports](#).
 - c. [Counselling and Clinical Services](#): Free, short-term, appointment-based counselling and psychiatric services (2-600 SUB or call 780-492-5205).
 - d. [Sexual Assault Centre](#): Free, anonymous, and confidential drop-in counselling.
 - e. [The Office of Safe Disclosure & Human Rights \(OSDHR\)](#): Advises confidentially on sensitive issues you may not feel comfortable solving your own.
 - f. [Confidential Support](#) (e-mail access): Office of Safe Disclosure and Human Rights advises confidentially on sensitive issues you may not feel comfortable solving on your own. Contact the OSDHR if you want to get help or to make a report while keeping your privacy (call 780-248-1894).
 - g. [UofA Need Help Now](#): 24/7 emergency support.
 - h. Edmonton Distress Line: 780-482-4357 (HELP)
 - i. [Interfaith Chaplains Association](#): Get guidance, care, and support, whether or not you identify with a particular faith.
 - j. [The Landing](#): Offers support to students on matters of gender and sexual diversity (0-68A SUB; M-R, 11:00am-4:00pm).