Syllabus for ASEN/ATOC 5235:
Introduction to Atmospheric Radiative Transfer and Remote Sensing
University of Colorado at Boulder, Spring 2023

Instructor: Dr. K. Sebastian Schmidt (sebastian.schmidt@lasp.colorado.edu)
Classroom: SEEC S126
Time: Monday and Wednesday 9:00-10:15 or online Zoom

Contact Information
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Office Hours:
Wednesdays, 10:15-11:15 pm SEEC N239
…or by appointment

Course Page
We will use canvas, which I will populate with course content, homework assignments, etc. as the class progresses.

Summary

This course examines fundamentals of radiative transfer and remote sensing with primary emphasis on the Earth's atmosphere; emission, absorption and scattering by molecules and particles; multiple scattering; polarization; radiometry and photometry; basics of inversion theory; extinction- and emission-based passive remote sensing; principles of active remote sensing; greenhouse effect and Earth's radiative energy budget.

ATOC: graduate core course. Department enforced prerequisites: one year of calculus-based physics, and math up through differential equations.
ASEN: recommended prerequisite: one year of calculus-based physics and math up through differential equations.

Textbook: Petty: *A First Course in Atmospheric Radiation*
Additionally: Bohren and Clothiaux: *Fundamentals of Atmospheric Radiation*
Stephens: *Remote Sensing of the Lower Atmosphere*
Rodgers: *Inverse Methods for Atmospheric Sounding*

Further reading:

Twomey: *Introduction to the Mathematics of Inversion*
Thomas and Stamnes: *Radiative Transfer in the Atmosphere and Ocean*
Wendisch and Yang: *Theory of Atmospheric Radiative Transfer: a comprehensive introduction*
Goody and Yung: *Atmospheric Radiation: Theoretical Basis*
Bohren and Huffman: *Absorption and Scattering by Small Particles*
Liou: *Radiation and Cloud Processes in the Atmosphere*
Chandrasekhar: *Radiative transfer*

Class philosophy

The lectures are not intended to be comprehensive. Rather, they should give you guidance and motivation, and thus provide a structure for your learning. I will emphasize the most important concepts and illustrate them with specific examples wherever possible. It is very important that you do the assigned reading for each week. Your reading, homework, programming exercises, and a project will add depth to the "big picture" (breadth) provided in class. In the end, the intention of the course is to give you the tools for solving a real-world problem in any of the covered topics, and present it to a scientific audience.

Topics; Schedule

We will largely follow Petty's textbook, but also use Stephen's book for remote sensing concepts. A tentative schedule of topics is provided below, but it is expected to change somewhat. This semester, we will be introducing a formal core, and your (the students') help is solicited defining/refining the topics that should be included. Homework will generally be assigned on Wednesdays, and is due on Wednesdays the following week. Solutions will be made available online. Reading material will be assigned on Mondays, drawing from the textbooks, as well as research articles provided online. The course has a "lab" component where we learn to solve and visualize radiative transfer problems through publicly available code, and by writing our own code. Eventually, we will work with real data, which leads into a final project. This "mini-project" includes the definition of a problem/science question in atmospheric radiation science, code adaptation/minor development, data analysis, and a short paper (extended abstract style), as well as a conference-style presentation. There will be one mid-term and one final exam. Topics will be reviewed before the exams. We will also have quizzes based on the assigned reading, and as refresher of various topics.

Class website: canvas

Programming:

The "official" language is python 3 (Anaconda 3), but IDL can also be used for homework and the project.

Grading:

50% exams (quizzes 10%, mid-term 20%, final 20%); 40% homework; 10% project

Classroom Behavior

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

Requirements for COVID-19

As a matter of public health and safety, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements and all public health orders in place to reduce the risk of spreading infectious disease. CU Boulder currently requires COVID-19 vaccination and boosters for all faculty, staff and students. Students, faculty and staff must upload proof of vaccination and boosters or file for an exemption based on medical, ethical or moral grounds through the MyCUHealth portal.

The CU Boulder campus is currently mask-optional. However, if public health conditions change and masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct and Conflict Resolution. For more information, see the policy on classroom behavior and the Student Code of Conduct. If you require accommodation because a disability prevents you from fulfilling these safety measures, please follow the steps in the "Accommodation for Disabilities" statement on this syllabus.

If you feel ill and think you might have COVID-19, if you have tested positive for COVID-19, or if you are unvaccinated or partially vaccinated and have been in close contact with someone who has COVID-19, you should stay home and follow the further guidance of the Public Health Office (contacttracing@colorado.edu). If you are fully vaccinated and have been in close contact with someone who has COVID-19, you do not need to stay home; rather, you should self-monitor for symptoms and follow the further guidance of the Public Health Office (contacttracing@colorado.edu). {Faculty: insert your procedure here for students to alert you about absence due to illness or quarantine. Because of FERPA student privacy laws, do not require students to state the nature of their illness when alerting you. Do not require "doctor's notes" for classes missed due to illness; campus health services no longer provide "doctor's notes" or appointment verifications.}

Accommodation for disabilities

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

Preferred student names and pronouns

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

Honor code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the Honor Code may include, but are not limited to: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution (honor@colorado.edu); 303-492-5550). Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found on the Honor Code website.

Sexual Misconduct, discrimination, harassment and/or related retaliation

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, protected-class discrimination and harassment, and related retaliation by or against members of our community on- and off-campus. These behaviors harm individuals and our community. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who believe they have been subjected to misconduct can contact OIEC at 303-492-2127 or email cureport@colorado.edu.

Information about university policies, reporting options, and support resources can be found on the OIEC website.

Please know that faculty and graduate instructors have a responsibility to inform OIEC when they are made aware of any issues related to these policies regardless of when or where they occurred to ensure that individuals impacted receive information about their rights, support resources, and resolution options. To learn more about reporting and support options for a variety of concerns, visit Don't Ignore It.

Religious holidays

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, please let me know ahead of time if you foresee a conflict of a lecture, homework assignment due date, or exam ahead of time so that I can make individual arrangements.
See the campus policy regarding religious observances for full details.

Tentative Schedule

Bold text: This material constitutes the core material of the class.

Week/Dates	Topic	Reading
1 1/19	Terms & Definitions, E&M→ Atmospheric Radiation	**Petty 1,2** python introduction
2 1/23, 1/25	Earth Radiation Budget Primer Overview of Remote Sensing	**Petty 3,4**
3 1/30, 2/1	Boltzmann & Planck; Green House Effect	**Petty 5,6** BRDF paper
4 2/6, 2/8	Extinction, Emission Beer's Law	**Petty 7,8** Stephens 1
5 2/13, 2/15	Absorption, Spectroscopy	**Petty 9** Bohren 2.4-2.8
6 2/20, 2/22	Line models, HITRAN, correlated-k	**Petty 10**, Liou 3,4
7 2/27, 3/1	Scattering and Absorption	**Petty 11,12** Bohren 2.9
8 3/6, 3/8	Radiative transfer equations Multiple Scattering	**Petty 13** Bohren 5
9 3/13, 3/15	Review week 1-8 Midterm	
10 3/19, 3/21	Multiple Scattering ctd. Remote Sensing Applications I	~~**Stephens 6 (SW)**~~
3/27-31	Spring Break	
11 4/3, 4/5	Basics of Inverse Theory Remote Sensing Applications II	**Rodgers 1-2** **Stephens 7 (LW+MW)**
12 4/10, 4/12	Optimal Estimation Remote Sensing Applications III	Rodgers 3-4 **Stephens 8 (active RS)**
13 4/17, 4/19	Satellite Data Assimilation Work on Project	**Rodgers 7-8**
14 4/24, 4/26	Project Presentations Atmospheric Optics	 Bohren 8
15 5/1, 5/3	Project (turn in papers 5/2) Project Presentations; Review 8-13	
16 5/9, 1:30pm	Final exam	