Atmospheric Radiation

ATS 622–001, Department of Atmospheric Science

11:00 – 11:50 Mondays and Wednesdays, ACRC 212B

Instructor Contact Information

Prof Christine Chiu

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Office hours: Wednesday 1-3 pm

Teaching Assistant Contact Information

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Course Description

This is an introductory graduate level course on fundamentals of electromagnetic radiation and the radiative properties/processes involving the atmosphere, aerosols, clouds, and precipitation. This course introduces crucial laws and mechanisms in radiation transfer; demonstrates how they drive and influence our climate system; and relates these fundamentals to well-defined research questions. The main teaching method is lectures, with assignments that aim to develop students' practical skills.

Course Goals

Students who complete this course successfully will be able to:

- Describe and explain theoretical principles of radiative processes, focusing on solar and terrestrial radiation.
- Quantify radiative effects, heating/cooling rates, and interpret their roles in the Earth's radiation energy budget.
- Apply knowledge of atmospheric radiation and develop radiative transfer simulations for relevant research topics.

Course materials

Lecture slides and detailed notes will be available on Canvas in due course. The instructor uses the following textbooks (copies available in the library) to supplement lectures:

- Petty, G. W., 2006: A First Course in Atmospheric Radiation, Sundog Publishing, 472 pp., available from http://www.sundogpublishing.com.
- Liou, K.-N., 2002: An Introduction to Atmospheric Radiation, Academic Press, 583 pp.
- Coakley, J. and P. Yang, 2014: Atmospheric Radiation: A Primer with illustrative solutions, Wiley, 256 pp.

Class Participation

Students' participation and engagement are strongly encouraged. All interactions and discussions in the classroom are aimed to provide a supportive and active learning environment for students.

Grading

- Assignment #1: **15 points**
- Assignment #2: **15 points**
- Assignment #3: **15 points**
- Assignment #4: **25 points**
- Exam: **30 points**

Homework will be due at the date and times indicated. No late homework assignments will be accepted without prior approval. Final exam is closed book and closed notes.

Statement on Academic Integrity

This course will adhere to the CSU Academic Integrity Policy as found in the General Catalog (http://www.catalog.colostate.edu/FrontPDF/1.6POLICIES1112f.pdf) and the Student Conduct Code (http://www.conflictresolution.colostate.edu/conduct-code). At a minimum, violations will result in a grading penalty in this course and a report to the Office of Conflict Resolution and Student Conduct Services.

Disclaimer

The instructor reserves the right to make modifications to this information throughout the semester.

Preliminary Schedule of Topics and Assignments

Week	Topics / Learning outcomes	Remark
1	***Logistics & Overview*** • Why we should care about atmospheric radiation • Its relevance to meteorology, climate, remote sensing	
2	***Properties of Radiation*** • Summarize the characteristics of electromagnetic radiation • Definition of irradiance, radiance and solid angle • Compute net flux and radiation for isotropic and general cases	*Need to reschedule 01/30 (W)*
3	***The Sun and solar radiation at the top of the atmosphere*** • Describe the structure of the Sun • Summarize key features of total solar irradiance • Compute solar insolation and describe how it varies with time and latitude	***Assignment #1 due in Week 4***
4 – 5	***Planck function*** • Explain the apply Planck function and related laws • Quantify global energy flow using window-gray approximation • Derive and compute radiative time constant ***Absorption, emission and scattering by a slab of atmosphere*** • Explain fundamental optical properties • Describe Beer's law and perform Langley analysis • Formulate radiative transfer equation in plane-parallel atmosphere	
5 –7	***Scattering and absorption by particles in the atmosphere & Practical session I*** • Define scattering regimes (Rayleigh scattering, Mie scattering, and geometric optics) • Describe main features of each scattering regime • Relate these scattering regimes to atmosphere radiation and remote sensing applications	*May need to reschedule 02/25 (M) and/or 02/27 (W)* ***Assignment #2 due in Week 7***

Week	Topics / Learning outcomes	Remark
8, 10–11	***Equation of radiative transfer and its solutions & Practical session II*** • Distinguish between direct and diffusion radiation; between single scattering and multiple scattering processes • Apply single scattering approximation • Describe the underlying principle of the two-stream approximation and derive the two-stream solution • Summarize key features of cloud albedo, transmittance and absorptance • Explain the key points of the adding/doubling methods and apply them to radiative transfer	*Spring break in Week 9 – no class* ***Assignment #3 due in Week 10***
12 – 13	***Absorption and emission by atmospheric gases*** • Explain why certain gases strongly absorb radiation at certain wavelengths • Describe properties of absorption lines and identify the broadening mechanisms responsible for the line shapes • Compare and contrast line-by-line models (LBL), the k-distribution and correlated k-distribution • Apply LBL and k-distribution to realistic atmospheric conditions for both shortwave and longwave radiative transfer • Compare and contrast various absorption band models, including the Elsasser model and the Goody model	
14	***Radiative heating and cooling rate*** • Derive radiative heating equations • Provide physical interpretations for each term in radiative heating/cooling equations • Sketch shortwave and longwave heating profiles	***Assignment #4 due***
15	***The planetary radiation budget and the role of aerosols and clouds*** • Summarize key features/patterns of global annual mean radiation • Summarize key features/patterns of cloud radiative effects for the longwave, shortwave and net radiation • Describe the underlying processes of cloud radiative effects	
16	**Exam**	