PHYS 623 Introduction to Atmospheric Radiation

Fall 2025

Dates and Location:

WeFr 1:00PM - 2:15PM	Public Policy 206

Instructor: Prof. Zhibo Zhang

Phone: 410-455-6315
Email: Zhibo.Zhang@umbc.edu

Office Hours: PHYS418: Friday 2:30PM~3:30PM or Email Appointment

Texts:
Required Textbooks:

- Fundamentals of Atmospheric Radiation by Craig Bohren and Eugene Clothiaux(Zhang et al., 2016)

Recommended Textbooks

- C.F. Bohren Clouds in a Glass of Beer
- C.F. Bohren What Light Through Yonder Window Breaks?
- R.M. Goody and Y.L. Yung Atmospheric Radiation (2nd Edition)
- K.N. Liou An Introduction to Atmospheric Radiation (2nd Edition)
- G.W. Petty A First Course in Atmospheric Radiation (2nd Edition)
- M.L. Salby Physics of the Atmosphere and Climate (2nd Edition)
- G.L. Stephens Remote Sensing of the Lower Atmosphere
- G.E. Thomas and K. Stamnes Radiative Transfer in the Atmosphere and Ocean
- J.M. Wallace and P.V. Hobbs Atmospheric Science: An Introductory Survey (2nd Edition)
- J.A. Coakley and P. Yang Atmospheric Radiation: A Primer with Illustrative Solutions
- Wendisch and P. Yang Theory of Atmospheric Radiative Transfer
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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 fundamental 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 fundamental principles of radiative processes in Earth's atmosphere, including emission, absorption and scattering
• Able to connect the radiative properties of atmosphere, such as optical depth, transmittance, and emissivity, with the physical properties, such as gas composition, aerosol loading and cloud fraction
• Understand the concept of radiative energy balance and able to interpret the roles of atmospheric gases, aerosols and clouds in the balance through their radiative processes.

Grading Scheme

- Exam 1 (20%), Exam 2 (20%), Final Exam (25%), Homework (35%)
  The final exam will be given during the official exam slot scheduled for this course. The non-final exams will be given at appropriate times during the semester at a time agreed upon by all.

Exams:
Mid-term and Final Exam—two examinations will be given during the semester: together worth 40% of the final grade. The mid-term examination covers lecture topics from the two thirds of the semester. The final examination will cover lecture topics taught during the entire semester. Both exams will be proctored and administered in class. Mid-term / Final Exam format and date may change at the discretion of the instructor. If you become ill or a family emergency arises, you are required to contact me BEFORE the exam to be eligible for a make-up exam. Make-up exams will be given only with a valid written medical-related excuse related to an illness or injury of oneself or a family emergency related to a death in the immediate family with appropriate documentation of such family emergency submitted. Scores will be posted in the online grade book in the course Blackboard.

Homework Assignments:
Homework will be aggThere are 3 graded homework assignments for ARMY 301—"Start With Why," Book Essay (10%), Branch (10%), and your Leadership Journal (5%). Specific instructions and submission suspense dates are posted on BlackBoard with the "Course Schedule." These homework assignments are worth a cumulative 25% of your final course grade.

Grading Policy:

There will be no grade curving and the grading scale is as follows: A: 92.50-100.00; A-:90.00-92.49; B+: 87.50-89.99; B: 82.50-87.49; B-:80.00-82.49; C+: 77.50-79.99: C: 70.00-77.49; D: 50.00-69.99; F: < 50.00. For the final course grade, the Instructor may throw out poor exam questions, adjust the percentages that homework and exams count, and/or adjust the grading scale above. This will be done in the same way for all students and only in such a way as to help each student's overall course grade.

Course management: I will use Blackboard to post course announcements, reading assignments and homework assignments, and post grades. In addition, I will use Google Colab (https://research.google.com/colaboratory/) and/or

Github (https://github.com/) to post the codes, scripts and data for the course

COURSE OUTLINE:

1. **Overview (1 week)**
    a. Earth Atmosphere
    b. Simple radiative energy balance model
    c. Atmospheric Absorption and Greenhouse effect
    d. Impacts of aerosol and cloud on Earth's radiative energy balance
2. **Fundamentals of Radiation (2 week)**
    a. (classic) Wave and (quantum) Particle definition of radiation
    b. Blackbody Radiation
    c. Definitions of radiative quantities: radiance, irradiance, hemispheric flux and actinic flux
    d. Absorptivity and emissivity
3. **Absorption of Radiation (2 week)**
    a. Exponential attenuation of radiation: Lamber-Beer Law
    b. Directional Emissivity of Atmosphere
    c. Flux divergence and heating/cooling rate
    d. Absorption by atmospheric molecules
    e. Absorption by aerosol and cloud particles

Midterm #1

4. **Scattering of Radiation (3 week)**
    a. Concept of E&M wave
    b. Scattering by a dipole: Rayleigh scattering
    c. Superposition and interferences
    d. Coherence
    e. Scattering by particles
5. **Scattering properties of atmospheric particles (2 weeks)**
    a. Rayleigh scattering by molecules
    b. Mie scattering by spherical particles
    c. Scattering by nonspherical particles
    d. Average over particle size distributions

Midterm #2

6. **Multiple scattering and radiative transfer (3 weeks)**
    a. From single scattering to multiple scattering
    b. From multiple scattering to radiative transfer
    c. Two stream approximation
7. **Energy balance and climate system a revisit (2 week)**
    a. Global radiative energy balance
    b. Radiative effects of aerosol and clouds
    c. Energy balance of surface

Final exam

Accessibility and Disability Accommodations, Guidance and Resources (required)

Accommodations for students with disabilities are provided for all students with a qualified disability under the Americans with Disabilities Act (ADA & ADAAA) and Section 504 of the Rehabilitation Act who request and are eligible for accommodations. The Office of Student Disability Services (SDS) is the UMBC department designated to coordinate accommodations that creates equal access for students when barriers to participation exist in University courses, programs, or activities.

If you have a documented disability and need to request academic accommodations in your courses, please refer to the SDS website at sds.umbc.edu for registration information and office procedures.

SDS email: disAbility@umbc.edu

SDS phone: (410) 455-2459

If you will be using SDS approved accommodations in this class, please contact the instructor to discuss implementation of the accommodations. During remote instruction requirements due to COVID, communication and flexibility will be essential for success.

Sexual Assault, Sexual Harassment, and Gender Based Violence and Discrimination (required)

UMBC Policy and Federal law (Title IX) prohibit discrimination and harassment on the basis of sex, sexual orientation, and gender identity in University programs and activities. Any student who is impacted by sexual harassment, sexual assault, domestic violence, dating violence, stalking, sexual exploitation, gender discrimination, pregnancy discrimination, gender-based harassment or retaliation should contact the University's Title IX Coordinator to make a report and/or access support and resources:

Mikhel A. Kushner, Title IX Coordinator (she/they)

410-455-1250 (direct line), kushner@umbc.edu

You can access support and resources even if you do not want to take any further action. You will not be forced to file a formal complaint or police report. Please be aware that the University may take action on its own if essential to protect the safety of the community.

If you are interested in or thinking about making a report, please use the Online Reporting/Referral Form. Please note that, if you report anonymously, the University's ability to respond will be limited.

Religious Observances & Accommodations

UMBC Policy provides that students should not be penalized because of observances of their religious beliefs, and that students shall be given an opportunity, whenever feasible, to make up within a reasonable time any academic assignment that is missed due to individual participation in religious observances. It is the responsibility of the student to inform the instructor of any intended absences or requested modifications for religious observances in advance, and as early as possible. For questions or guidance regarding religious observance accommodations please contact the Office of Equity and Inclusion at oei@umbc.edu.

Hate, Bias, Discrimination and Harassment

UMBC values safety, cultural and ethnic diversity, social responsibility, lifelong learning, equity, and civic engagement.(Zhang et al., 2012)

Consistent with these principles, UMBC Policy prohibits discrimination and harassment in its educational programs and activities or with respect to employment terms and conditions based on race, creed, color, religion, sex, gender, pregnancy, ancestry, age, gender identity or expression, national origin, veterans status, marital status, sexual orientation, physical or mental disability, or genetic information.

Students (and faculty and staff) who experience discrimination, harassment, hate or bias or who have such matters reported to them should use the online reporting/referral form to report discrimination, hate or bias incidents. You may report incidents that happen to you anonymously. Please note that, if you report anonymously, the University's ability to respond will be limited.

Reference:

Zhang, Z., Ackerman, A. S., Feingold, G., Platnick, S., Pincus, R., & Xue, H. (2012). Effects of cloud horizontal inhomogeneity and drizzle on remote sensing of cloud droplet effective radius: Case studies based on large-eddy simulations. *J Geophys Res*, *117*(D19), D19208. https://doi.org/10.1029/2012jd017655

Zhang, Z., Meyer, K., Yu, H., Platnick, S., Colarco, P., Liu, Z., & Oreopoulos, L. (2016). Shortwave direct radiative effects of above-cloud aerosols over global oceans derived from 8 years of CALIOP and MODIS observations. *Atmospheric Chemistry and Physics*, *16*(5), 2877–2900. https://doi.org/10.5194/acp-16-2877-2016