**Physics and Chemistry of the Atmosphere (II)**

**Tuesday & Thursday 9:30 am – 10:45 am, CSS 0201**

**Instructor:**

Juying Xie Warner (jwarner5@umd.edu; 301-405-2792)

Office Hours: No formal set is posted; students may request appointments via email

**Required Textbook:**

*Radiative Transfer in the Atmosphere and Ocean,* Cambridge University Press, 1999

Gary E. Thomas and Knut Stamnes **[TS]**

**Recommended Textbooks:**

*Atmospheric Science* (*2nd Edition*)*,* Academic Press, 2006

John M. Wallace and Peter V. Hobbs **[WH]**

*Atmospheric Chemistry and Physics* (*2nd Edition*)*,* John Wiley & Sons, 2006

John H. Seinfeld and Spyros N. Pandis **[SP]**

*Chemistry of the Upper and Lower Atmosphere,* Academic Press, 2000

Barbara J. Finlayson-Pitts and James N. Pitts **[FP]**

*Theory of Atmospheric Radiative Transfer,* Wiley-VCH, 2012

Manfred Wendisch and Ping Yang **[WY]**

**Lecture Material:**

The above listed textbooks cover most of the material in this course. My lectures will focus on the key principles of the topics listed. The lecture notes will be made available on my web page after each class: <http://www.atmos.umd.edu/~juying/aosc621/>.

**Course Description:**

This is a comprehensive course designed to help students in mastering the fundamental principles, quantitative analysis, and numerical modeling of atmospheric radiation and chemistry. Topics include solar and terrestrial radiative transfer processes, specifically the absorption, scattering and emission resulting from interactions with atmospheric constituents (gases, aerosols, clouds) and the Earth’s surface, as well as how radiation drives atmospheric chemistry and climate dynamics.

**Prerequisites:**

MATH 462 – Partial Differential Equations for Scientists and Engineers

AOSC 620 – Physics and Chemistry of the Atmosphere (I)

**Grade:**

Your final grade will be based on your performance on homework (30%), two in-class exams (20% each), and a final exam (30%). These evaluations will involve both physical process understanding and quantitative problem solving.

**Course Topics:**

Solar and terrestrial radiation spectroscopy, radiative transfer processes in the atmosphere (emission, scattering, absorption), basic radiation laws, radiative transfer equations, spectral properties of atmospheric constituents, radiative effects of gases, aerosols and clouds, solution of radiation problems, cloud formation, Earth radiation budget, radiation effects on climate, photochemistry and stratospheric ozone, human perturbations and climate changes, climate sensitivity, feedback processes, and prediction uncertainty.

**Tentative Course Schedule**

The schedule below gives a tentative overview of the topics this course will cover along with the homework assignment set and due dates. It may be subject to changes as appropriate. Please see my classwebsite for update.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Class | Date | Topic Covered | Text Reading | Homework |
| 1. | 01/26 | Atmospheric composition, radiative equilibrium, thermal structure | TS:1-19 |  |
| 2. | 01/28 | Radiation quality and quantity: wavelength, frequency, polarization, density, radiance, irradiance, emittance, brightness, actinic flux | TS:34-45 |  |
| 3. | 02/02 | Radiative transfer principles: Planck law, Kirchhoff law, Stefan-Boltzmann law, Earth’s surface emission, solar insolation | TS:93-97 130-149 | HW1 set |
| 4. | 02/04 | Radiation extinction and scattering: Extinction law, Lorentz theory, differential RTE, single / Rayleigh / Mie scattering | TS:46-53 58-68 72-78 |  |
| 5. | 02/09 | Radiation absorption by atmospheric gases, photon-molecular interactions, absorption or emission lines and bands | TS:85-93  110-114 |  |
| 6. | 02/11 | Greenhouse effect, spectroscopy absorption line strengths, molecular energy transitions | TS:114-125 | HW1 due  HW2 set |
| 7. | 02/16 | Line strength, shapes and broadening | TS:68-72 |  |
| 8. | 02/18 | Radiative transfer equation, transmission in slab geometry, solution including scattering and emission, radiative heating rate | TS:150-163 |  |
| 9. | 02/23 | **Review for First Exam** |  | HW2 due |
| 10. | 02/25 | **First Exam** |  |  |
| 11. | 03/01 | Formulation of radiative transfer problems: direct and diffuse radiation, phase function, azimuthal dependence, delta approximations | TS:170-197 | HW3 set |
| 12. | 03/03 | Prototype radiative transfer problems: boundary conditions, single scattering approximation, successive orders of scattering | TS:197-205 219-224 |  |
| 13. | 03/08 | Two-stream approximations for isotropic and anisotropic scattering, Eddington method | TS:225-269 |  |
| 14. | 03/10 | Accurate RTE numerical solutions: discrete-ordinate, doubling-adding, Monte Carlo; Transmittance and absorptance: line-by-line and band models, scaling, k-distribution and correlated k-distribution methods | TS:281-328 384-410 | HW3 due |
|  |  | **Enjoy Spring Break** (March 13 to 20) |  |  |
| 15. | 03/22 | Cloud Formation: cloud type, droplet growth, condensation, collision-coalescence, Bergeron process, cloud condensation nuclei, cloud drop terminal velocity | WH:209-232 |  |
| 16. | 03/24 | Optical properties of clouds (cover, water path, droplet size, optics) | TS:335-346 | HW4 set |
| 17. | 03/29 | Cloud radiative effects | TS:458-469 |  |
| 18. | 03/31 | Aerosol direct and indirect effects | SP:1054-1084 |  |
| 19. | 04/05 | **Questions & Answers** |  | HW4 due |
| 20. | 04/07 | **Review for Second Exam** |  |  |
| 21. | 04/12 | **Second Exam** |  |  |
| 22. | 04/14 | Atmospheric Photochemistry: photolysis rate, dose rate, species absorption spectra, J-value calculation | FP:43-83 87-126 |  |
| 23. | 04/19 | Air Pollution: relative contributions from global emissions and climate change | Ref reading provided | HW5 set |
| 24. | 04/21 | Radiative forcing, greenhouse effect, Earth’s radiation budget, climate change | IPCC AR4: 94-127 |  |
| 25. | 04/26 | Climate sensitivity, radiative-convective equilibrium | TS:20-23 438-458 |  |
| 26. | 04/28 | Climate system feedbacks, climate change model projection and uncertainty | FP:762-773 783-788 438-475 | HW5 due |
| 27. | 05/03 | Continue Lecture 26 |  |  |
| 28. | 05/05 | Radar Meteorology: basic principles, range equation, Rayleigh scattering, Doppler effect, reflectivity, dBZ, refraction | Ref reading provided |  |
| 29. | 05/10 | **Review for Final Exam** |  |  |
|  | 05/13 | **Final Exam,** 8:00am-10:00am |  |  |