

**PHYS 622 Atmospheric Physics II: Spring 2010**

3 credits: Grade Method: REG/P-F/AUD

**MW.....5:00pm- 6:15pm (room PHYS201)**

**INSTRUCTORS:**

Dr. W. Wallace McMillan (Phys 418, 410-455-6315, [mcmillan@umbc.edu](mailto:mcmillan@umbc.edu))

Dr. Tamas Varnai (Phys 432, 301-614-6408, [varnai@climate.gsfc.nasa.gov](mailto:varnai@climate.gsfc.nasa.gov))

**COURSE OBJECTIVE:**

Introduction to terrestrial atmospheric physics with emphasis on atmospheric radiative transfer, and aerosol and cloud physics.

**TEXT BOOKS:**

Salby, M.L., *Fundamentals of Atmospheric Physics*, Academic Press (AP), 1996.

Roger, R. R and Yau, M. K., *A Short Course in Cloud Physics*, Pergamon Press, 3<sup>rd</sup> edition, 1989.

Wallace, J. M, and Hobbs, P. V., *Atmospheric Science: An Introductory Survey*, 1<sup>st</sup> or 2<sup>nd</sup> edition.

Handouts and reading assignments from books (see list below) and scientific papers.

**REFERENCES:**

Twomey, S., *Atmospheric Aerosols*, Elsevier Publishing, 1977

Pruppacher, H.R., and J.D. Klett, *Microphysics of Clouds and Precipitation*

Liou, K.N. *An Introduction to Atmospheric Radiation*, AP, 1980

Houghton, H.G., *Physical Meteorology*, MIT Press, 1985

Charlson, R. J. and J. Heintzenberg, Editors, *Aerosol Forcing of Climate*, Wiley and Sons 1995

Goody, R. M. and Y. L. Young, *Atmospheric Radiation: Theoretical Basis*, Oxford Univ. Press, 1989

Stephens, G. L., *Remote Sensing of the Lower Atmosphere*, Oxford Univ. Press 1994

**COURSE OUTLINE**

**I. Atmospheric Radiative Transfer -- Basic concepts (McMillan)**

***A. Fundamental radiometric definitions and terms***

***B. Blackbody radiation***

1. Kirchoff's law
2. Planck's law
3. Application to bodies not in thermodynamic equilibrium

***C. Extinction, absorption, and scattering***

1. Definitions and notation
2. Lambert's and Beer's laws
4. Single scattering
5. Multiple scattering
6. Atmospheric optics

***D. Molecular absorption***

1. Summary of important absorbing gases in the atmosphere
2. Descriptive summary of molecular absorption principles (vibration-rotation etc)
3. Overview of spectral line shapes

**II. Basic remote sensing of the atmosphere (McMillan)**

1. The radiative transfer equation in absorbing atmospheres
2. Upwelling/downwelling radiation
3. Infrared weighting functions and atmospheric remote sensing

4. The radiative transfer equation in scattering atmospheres

### **III. Atmospheric Aerosols (McMillan)**

#### ***A. Introduction to tropospheric and stratospheric aerosols.***

1. Importance in atmospheric processes
2. Radiative transfer
3. Description of mechanical generation of salt and dust particles
4. Gas-to-particle conversion
5. Sulfate and nitrate particle chemistry
6. Carbon and other particles.
7. Interactions with clouds: climate and radiation.

#### ***B. Size distributions***

1. Measured and analytic

#### ***C. Evolution of size distributions***

1. Homogeneous nucleation (nucleation mode)
2. Growth-diffusion, coagulation, kinematic, cloud processing (accumulation mode)
3. Removal – settling, impaction, collision with cloud and precipitating particles (Coarse mode)

### **IV. Clouds (Varnai)**

#### ***A. Warm cloud processes***

1. Cloud droplet microphysics (homogenous/heterogeneous nucleation, Kelvin equation, solute effect, CCN)
2. Droplet growth by condensation
3. Initial cloud droplet size distributions (CCN spectrum measurements, effect of CCN on cloud droplet concentration)
4. Droplet coagulation and warm cloud precipitation processes

#### ***B. Ice cloud processes***

1. Homogeneous/heterogeneous nucleation, ice nuclei
2. Ice particle growth by deposition
3. Crystal habits
4. Riming, aggregation, breakup

### **V. Cloud and aerosol instrumentation (Varnai)**

#### **Grading:**

Homework	20%
Research paper and presentation	35%
<u>Exams (3 x 15% each)</u>	<u>45%</u>
Total	100%

#### **Homeworks:**

Nominally you will have 5 homework sets: two on atmospheric radiation, one on aerosols, and two on cloud physics. Additional problems or reworking of problems will be assigned as required. The goal is for you to learn the material. Your writeup for each question should clearly restate the problem, and methodically lead to the answer. You should clearly state all assumptions made, and at the end, check your answer to make sure it does not violate any of your assumptions. Neatness and conciseness will be rewarded.

**Research Paper/Presentation:**

1. Each student will write and present in class a paper on a research topic of their choice.
2. It is preferred if the subject is also related to this class.
3. The paper must be 15-20 pages in length (including references).
4. The presentation will be 15-20 minutes in length.
5. Topics must be submitted on or before **February 8<sup>th</sup>**.
6. Papers must be submitted on or before **May 5<sup>th</sup>**.
7. Presentations will occur during the last two classes, **May 10<sup>th</sup> and 12<sup>th</sup>**

**Exams:**

The three take-home exams are really extended problem sets focusing on each of the three subjects covered in this course. You should approach each exam question with the same logical thoroughness you exercise for the homework problems.

**Where to find us**

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Lab: Phys 404  
e-mail: [mcmillan@umbc.edu](mailto:mcmillan@umbc.edu)  
Phone: 410-455-6315

**When to find us**

Dr. W. Wallace McMillan  
M,W: 2-3 PM and by appointment  
Dr. Tamas Varnai  
TBD

**Expected Schedule**

Classes Begin	Jan 27
Spring Break	March 15-19
Take-home Exam 1*:	March 1-8
Take-home Exam 2*:	March 31-April 7
Last Day of Classes	May 12
Final Take-home Exam	May 12 – May 19
Final Grades Due	May 24

\*Dates of the first two take-home exams are estimates only; they could change by  $\pm$  one week.

This gives us 14.5 weeks of classes, at 2/wk  $\rightarrow$  29 classes. We will reserve the last two classes for your presentations. Thus, the 27 lectures will be broken into the 3 major topics roughly as:

Atmospheric Radiative Transfer and Remote Sensing: 10 lectures  
Atmospheric Aerosols: 8 lectures  
Clouds and Precipitation: 9 lectures

Three to four of these will be special lectures by JCET, GEST, Goddard, and/or visiting scientists whose research areas include radiative transfer, remote sensing, aerosols, clouds, and/or precipitation.