ATS 620: Thermodynamics and Cloud Physics

Fall 2013
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Class website: http://reef.atmos.colostate.edu/~sue/vdhpage/ats620/ats620.php
User: 620notes  Password: ++++

The GTA for this course is Leah Grant (ldgrant@atmos.colostate.edu),
Room 417 ATS Main Bldg. Office hours are 3-5 pm on Tuesdays.

OBJECTIVES

The intent of this course is to introduce graduate students to key concepts in cloud physics and thermodynamics as applied to the atmosphere. These concepts include energy variables and energy calculations, thermodynamic diagrams, phase changes, and cloud microphysical properties and processes. A particular emphasis is on the formation of precipitation in warm and cold clouds, and links to atmospheric particulate matter.

SYLLABUS

I. Thermodynamics

a. Review and basic concepts: System, state, equilibrium, temperature; energy, work; reversibility; equation of state, properties of mixtures; atmospheric composition.

b. The First Law: Internal energy and enthalpy; heat capacities and calculation of state functions; latent heat, Kirchhoff’s equation; adiabatic processes, potential temperature.

c. The Second and Third Laws: Cyclic processes; entropy, Carnot cycle and the Second Law; generalized statement of the Second Law; Helmholtz and Gibbs functions; thermodynamic potentials; stable and unstable equilibrium; state transitions.

d. Thermodynamics of Moist Air: Phase transitions; Clausius-Clapeyron Equation; chemical potential; heterogeneous systems; equilibrium conditions; Gibbs phase rule; surface tension; equilibrium conditions for systems with curved interfaces, Laplace’s equation for mechanical equilibrium; thermodynamic diagrams; useful thermodynamic variables.

II. Cloud Physics

a. Nucleation of Droplets: homogeneous nucleation; nucleation on flat insoluble surfaces; nucleation on curved insoluble surfaces; nucleation on water soluble particles.

b. Atmospheric Aerosols: Aerosol sources over land and ocean surfaces, total concentrations; instrumentation for aerosol measurements; size distributions; removal processes.

c. Cloud Condensation Nuclei: Measurement techniques; concentrations over land and ocean surfaces; supersaturation dependence; properties of CCN.

d. Nucleation of Ice: Structure of ice; homogeneous nucleation of ice by freezing and deposition; heterogeneous nucleation of ice on flat and curved surfaces.
e. Ice Nuclei: Mode of action of ice nuclei; measurement techniques; concentrations; sources of ice nuclei; properties of ice nuclei.

f. Droplet Growth Theory: Theory for diffusional growth; growth of a droplet population; evaporation of large drops accounting for ventilation; collision-coalescence growth; stochastic processes; fall mode of large drops; microphysical structure of warm clouds; theories of broadening of cloud droplet spectra by turbulence, inhomogeneous mixing, and ultragiant hygroscopic aerosols.

g. Ice Crystal Growth Mechanisms: Growth from the vapor phase; habit theory; capacitances for various ice crystal geometries; deposition growth rates, effects of ventilation; dimensions of natural crystals, ice crystal fall speeds; growth by aggregation, growth by riming, formation of hail and growth rate of hailstones (wet and dry regimes); melting of ice particles; ice particle multiplication mechanisms.

h. Cloud Structure and Dynamics: Environmental conditions supporting various cloud types; cloud structure; microphysical properties and processes.

h. Atmospheric Electricity: Principles of atmospheric electricity; fair weather electric field, effects of atmospheric pollution; charge generation mechanisms; cloud electrification mechanisms.

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COURSE STRUCTURE, EXPECTATIONS, AND GRADING CRITERIA:

Course material will be delivered in a lecture / discussion format, meeting for two 75-minute periods each week. Lectures (.pptx or .pdf format) are posted on the class website. At least 6 hours of effort (2 hours per each hour of class time) outside of class each week are expected to complete homework assignments and any outside reading needed to support learning.

Course grading: This class is graded on a letter basis, using the +/- options. Students are expected to notify the instructors of any planned absences from class, and should make arrangements to make up any assignments. Homework is handed out on a Thursday and due to the GTA the following Thursday (as shown in the schedule). Late homeworks will not be accepted without prior arrangements.

Your course grade will be based on performances on two midterms, a comprehensive final exam and several (~10) homework assignments. The midterms will be weighted 20% each towards the course grade. The final will receive a weight of 30%, with the remaining 30% towards the homework assignments.

Texts:

There is no required text for this class. Please consult outside references for additional reading as appropriate. The following resources may be useful:

You may access Prof. Cotton’s notes, user “cotton”, password “cloud9”

http://rams.atmos.colostate.edu/AT620old/AT620Notes.html

PLEASE -- DO NOT DISTRIBUTE OUTSIDE CSU


ACADEMIC INTEGRITY:

All students are subject to the policies regarding academic integrity found in Section 1.6 of the 2010 – 2011 General Catalog, found at http://www.catalog.colostate.edu/Content/files/2012/FrontPDF/1.6POLICIES.pdf, and the student conduct code (http://www.conflictresolution.colostate.edu/conduct-code). Other information on academic integrity can be found on the Learning@CSU website (http://learning.colostate.edu/integrity/index.cfm). Examples of academic dishonesty can be found in these sources. 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.

SPECIAL NEEDS:

Please see the instructor during the first two weeks of the semester, if you have special learning needs that should be accommodated in this class, and refer to http://rds.colostate.edu/esuinfo/accommodations.asp for more information.