#### ATS 441/541 - Atmospheric Thermodynamics and Cloud Physics

## **General Information**

# A. Course Definition:

#### UAH catalog description:

General aspects of thermodynamics and cloud physical processes occurring within the atmosphere; atmospheric statics and stability, saturation point analysis, aerosols, nucleation of cloud droplets and ice crystals, and the growth of cloud particles and hydrometeors. Prerequisites: MA 324, PH 112.

#### In other words:

This course will cover several topics in atmospheric science. Most topics will have atmospheric applications. The course material can be separated into two related general categories (with the approximate weight of each indicated in parentheses):

- 1. *atmospheric thermodynamics*, including a short review of classical thermodynamics, an in- depth look at atmospheric thermodynamics, atmospheric statics, mixing processes, and a number of special atmospheric applications (60%);
- 2. *cloud physics*, including atmospheric aerosols, nucleation of cloud droplets and ice crystals, the growth of precipitation within "warm" and "cold" clouds, and some general aspects of cloud structure (40%).

Additional notes on the prerequisites:

- a) A good knowledge of calculus and differential equations is required.
- b) Some problems will require computer programming. Please see me if you have no background in computer programming.

## **B.** General goals

- 1. Some review of classical thermodynamics will naturally be incorporated into this material.
- 2. Understanding of atmospheric thermodynamic processes:
  - definitions of atmospheric thermodynamic variables
  - response of the atmosphere to heating
  - processes in clouds (latent heating, cloud-environment mixing)
  - dry and moist static energy
  - wet-bulb processes
  - consequences of the precipitation process
- 3. Evaluate and understand static stability and related indices and parameters
  - theoretical to very practical
  - potential energy in the atmosphere
  - understand and utilize atmospheric thermodynamic diagrams
- 4. Atmospheric mixing processes and saturation point (SP) analysis
- 5. Survey of cloud structure

- 6. Cloud microphysical processes
  - basic theory of particle growth diffusion and collection processes
  - relation to thermodynamics
  - relevance to radiative transfer
  - impact on dynamics
- 7. Precipitation characteristics and growth processes
  - size distributions of water drops and ice particles why are they exponential?
  - growth, melting and evaporation --> thermodynamic implications

# C. Lecture:

Instructor:	Dr. Kevin Knupp
Phone:	961-7762
Time:	1245-1405 Tuesday and Thursday
Classroom:	NSSTC 4065
Office:	NSSTC 3052
Office hours:	open

Text and reference materials:

1. Thermodynamics: A First Course in Atmospheric Thermodynamics (Grant. W. Petty, 2008, Sundog Publishing)

An extensive set of notes will also be used (class handouts).

- 2. Cloud Physics: *A Short Course in Cloud Physics* (Rogers and Yau, 1989) will be used. This book can be ordered at relatively low cost.
- 3. Notes: Additional materials will be passed out in class. Every chapeter in Tsonis and Rogers and Yau will have my own notes which represent of composite of material from other sources.

# **D.** Grading:

Exam 1:	30%	
Quiz(es):	5%	(quiz grades can be enhanced with extra credit projects) (not guaranteed)
Final (Exam 2)	35%	
Homework:	30%	

Both exams (near mid-term and final) will be closed book and will consist of problems, derivations, or discussion of physical processes. The final will be comprehensive, but the questions will focus more on cloud physics. All students are expected to hand in homework *on time*. Homework is due <u>one week</u> after being assigned unless otherwise stated. Students signed up under ATS 441 will be assigned less demanding HW sets and exams.

My typical *guideline* for grading is the conventional system: A (>90%), B (80-90%), C (70-80%), D (60-70%), and F (<60%).

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## General Course Outline

RY == Rogers and Yau: A Short Course in Cloud Physics; P == Petty: 1<sup>st</sup> Course in Atmos. Thermo.

## PART I: THERMODYNAMICS

Introduction and background, review of basic concepts, definitions, atmospheric properties (P, Ch. 1-2, notes)

Equation of state (P, Ch. 3; notes)

First and Second Laws of thermodynamics, and related definitions and processes (P, Ch. 5-6; notes)

Water-Air systems (P, Ch. 7; notes)

Atmospheric thermodynamic processes and diagrams - some examples (P, Ch. 9; notes)

Atmospheric Statics: Parcel buoyancy and atmospheric stability (P, Ch. 4,8; notes)

Saturation point analysis (notes, Betts' papers)

Mixing and convection (notes, Betts)

## Exam 1 (Thusday, October 16)

## PART II: CLOUD PHYSICS

Thermodynamics of surfaces; nucleation of water droplets and ice crystals (notes)

Observed properties of clouds (RY, notes)

Microphysics of warm clouds (RY, notes) Formation (nucleation) of cloud droplets Droplet growth by condensation Initiation of rain in warm clouds

*Microphysics of cold clouds* (RY, notes) Formation (nucleation) and ice crystals Development and growth of precipitation in cold clouds

Rain and Snow (RY)

Precipitation Processes (RY)

Review

Final Exam (1130-1400, Tuesday, 2 December 2007)

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## **Complaint Procedure**

If you have difficulties or complaints related to this course, your first action usually should be to discuss them with me. If such a discussion would be uncomfortable for you or fails to resolve your difficulties, you should contact Professor Ron Welch, Chair of the Department of Atmospheric Science. Professor Welch's office is NSSTC, Room 4042. His telephone number is 961-7789. If you still are unsatisfied, you should discuss the matter with the Associate Dean of the College of Science (Dr. Dan Rochowiak), located in the Materials Science Building. Dean Rochowiak's office and telephone number are MSB C206 and 824-6605.

## **Students with Disabilities**

I would like to hear from anyone who has a disability (learning, physical) that may require a modification of seating, testing, or other class procedures. Please see me after class or during my office hours to discuss appropriate modifications.