# Master Syllabus Department of Geography

#### GEOG 447/547: Thermodynamic Meteorology

## **Course Description**

Application of physical gas laws such as the equation of state and hydrostatic equation to investigate adiabatic processes and parcel theory as they relate to atmospheric instability and connective development. (3 credit hours).

Prerequisite: GEOG 330; MATH 165 and 166; PHYS 120 and 122; or instructor permission

## **Course Objectives**

The primary objective of this course is to provide students with knowledge regarding the fundamentals of atmospheric thermodynamics and applications of thermodynamic principles in operational meteorology and climate research. Thermodynamics is a branch of physics that examines the fluxes of heat and changes in energy content associated, in this instance, with the initialization, evolution, and/or dissipation of atmospheric systems on a variety of spatial and temporal scales. Understanding thermodynamic processes is critical to accurately assessing the current and future states of the atmosphere, including evaluating the validity of numerical weather prediction and climate system models. We will concentrate on deriving and understanding the mathematical and physical principals behind these atmospheric processes. Specifically, students upon finishing this course will be able to:

- Understand the basic principles of thermodynamics as they apply to dry air
- Comprehend the effects of the different phases of water on thermodynamic processes
- Determine how thermodynamic processes generate the observed structure of the atmosphere
- Examine how thermodynamic processes affect the stability of portions of the atmosphere
- Utilize thermodynamic diagrams for basic forecasting guidelines

# **Course Rationale**

Atmospheric thermodynamic principles form the foundation for nearly all aspects of atmospheric science, including weather forecasting, mesoscale analysis (e.g., thunderstorms and hurricanes), microcloud physics, and atmospheric dynamics. This course enables students to utilize advanced mathematical and physical science skills to solve realistic problems in the atmospheric sciences. Geography 447 serves as a requirement for the Option IV: Meteorology and Climatology, Professional Track;

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Geography 547 partially fulfills the elective requirement. In addition, atmospheric thermodynamics is one of the required courses for those seeking qualification for the title "meteorologist" by the American Meteorological Society (AMS) and for employment by the National Weather Service under the Federal Civil Service guidelines (GS-1340).

# **Course Content and Format**

Students will be presented material in a lecture-style format that will include multimedia presentations and mathematical derivations of atmospheric thermodynamics principles. The following shows an example of a potential outline of topics for this course, with time allotment for each topic at the discretion of the instructor:

- I. Review of basic concepts and systems
  - A. Systems
  - B. State variables and functions
  - C. Atmospheric composition
- II. The first law of thermodynamics
  - A. Internal energy and work
  - B. The first law of thermodynamics
  - C. Dry adiabatic processes
- III. The second law of thermodynamics
  - A. Entropy
  - B. Statements of the second law of thermodynamics
  - C. Implications of the second law of thermodynamics
- IV. Thermodynamics of moist air
  - A. Saturation
  - B. Phase changes of water
  - C. Clausius-Clapeyron equation
  - D. Humidity variables
  - E. Saturated adiabatic processes

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- V. Thermodynamic diagrams
  - A. Properties of an ideal thermodynamic diagram
  - B. Simple thermodynamic diagrams
    - 1. Tephigram
    - 2. Skew T-Log P diagram
- VI. Atmospheric statics
  - A. Geopotential
  - B. The hydrostatic approximation
  - C. Integration of the hydrostatic equation
  - D. Reduction of pressure to sea level
- VII. Mixing in the atmosphere
  - A. Horizontal mixing
  - B. Vertical mixing
  - C. The Mixing Condensation Level
- VIII. Atmospheric stability
  - A. The parcel method
  - B. Stability criteria and indices
  - C. Entrainment
  - D. Conditional instability

#### **Textbook Suggestions**

- Petty, G. W., 2008: *Atmospheric Thermodynamics*. Madison, WI: Sundog Publishing, pp. 338
- Tsonis, A. A., 2007: *An Introduction to Atmospheric Thermodynamics.* Cambridge, UK: Cambridge University Press, 187 pp.

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#### Methods for Evaluating Student Performance

Forms of evaluation might include examinations, quizzes, and homework problem sets. Graduate students enrolled in the course as Geography 547 would be expected to accomplish an additional work load (e.g., a term paper, additional problems on homework and exams, etc.).

## **Evaluation of the Course**

Student evaluation of the course using university (and departmental) course evaluation forms.