AT620 - Thermodynamics and Cloud Physics

Colorado State University
Knowledge to Go Places

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AT620 - Thermodynamics and Cloud Physics

Fall 2014 - Dr. Steven Rutledge

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, heat, enthalpy; heat capacities and calculation of state functions; latent heat, Kirchoff's equation; adiabatic processes, potential temperature.

c. The Second Law: 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; enthalpy.

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

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; depositional growth rates, effects of ventilation; dimensions of natural crystals, ice crystal fallspeeds; 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. Atmospheric Electricity: Principles of atmospheric electricity; fair weather electric field, effects of atmospheric pollution; charge generation mechanisms; cloud electrification mechanisms.

Course grading: Your course grade will be based on performances on two midterms, a comprehensive final exam and several homework assignments. The midterms will be weighted 25% each towards the course grade. The final will receive a weight of 30%, with the remaining 20% towards the homework assignments. GTA for this course is Elizabeth Thompson (liz @ atmos.colostate.edu). Formal office hours will be arranged by Elizabeth.

On some Wednesday's, we will set aside approximately 10 minutes of the period to discuss concepts and apply what we have learned to various problems, etc.
