12.S990

Atmospheric Convection

Fall, 2014

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Thursdays 3-5, Rm 54-1623

Stellar site: https://stellar.mit.edu/S/course/12/fa14/12.S990/

Course Structure: This 6-unit course will review the fundamentals of convection and move rapidly to the forefront of research on convection. There will be a series of assigned readings, and the classes will involve both traditional lectures and group discussions of assigned readings. Grades will be based on class participation and a term project.

Outline:

1. Buoyancy of dry, moist, and cloudy air
    a. Relationship to entropy
2. Convection from maintained an instantaneous point sources of buoyancy
    a. Dimensional analysis and similarity theory
    b. Comparison to laboratory experiments
3. The Prandtl problem: Convection from rough surfaces
    a. Comparison to the classical Rayleigh-Benard convection problem
    b. Modification by the presence of a mean wind
4. Moist thermodynamics
    a. Effect of water vapor on gas constants and heat capacities
    b. Phase equilibria and phase transitions in the atmosphere
    c. Entropy of moist and cloudy air
    d. The ice phase in the atmosphere
5. Stability to motions involving phase transitions
    a. Qualitative differences from the dry problem
    b. Conditional instability and CAPE
    c. Thermodynamic and stability diagrams

6. Radiative-Convective Equilibrium (RCE)
    a. Basic elements of radiative transfer
    b. Two-layer radiative-convective model
    c. Comprehensive single-column model
7. Shallow convection
    a. Observations
    b. Concepts of entrainment and buoyancy sorting
    c. Detailed numerical simulations
    d. Single-column model using the weak temperature gradient approximation
8. Deep convection
    a. Observations
    b. Velocity scales
    c. Mesoscale organization
    d. Results from cloud system-resolving models
    e. The diurnal cycle
9. Self-aggregation of deep convection
    a. Observations
    b. Results of numerical simulations
    c. Basic physics and simple models
    d. Implications for weather and climate
10. Controversial issues in moist convection
    a. Quasi-equilibrium and convective neutrality vs. store-release convection
    b. Entrainment and mixing
    c. Plume model versus buoyancy sorting
    d. Parameterize vs crudely simulate
    e. Aggregation