

## Outline

### *Preface*

- 0. Overview: our convecting atmosphere
  - 0.1. Sun-heated surface, IR-cooled air, H<sub>2</sub>O's 2 height scales
  - 0.2. Top-down vs. bottom-up convection
  - 0.3. More asymmetry: saturated drafts in clear stratification
  - 0.4. Conditionality of moist convective instabilities
  - 0.5. Unlikelihood, fitness, and the ecology of convection
  - 0.6. Observability and cognitive biases
  - 0.7. The pull of interests: extremes vs. large scales

### **Part I: Essentials of the fundamentals**

- 1. Keeping track of stuff in space
  - 1.1. Units for space, time, and "stuff"
  - 1.2. Conservation of the most fundamental stuff: mass
    - 1.2.1. Aside on mathematical expression culture
  - 1.3. Conservation of specific (per unit mass) other stuff
    - 1.3.1. Specific momentum and its physical source terms
    - 1.3.2. Other specific stuff: humidity and 'heat content'
    - 1.3.3. Specific X, or mass mixing ratio of X?
    - 1.3.4. Advection and the material time derivative
  - 1.4. Now about density...problems
  - 1.5. Solutions to problems
- 2. Good enough equations
  - 2.1. Good-enough thermodynamics of moist air
    - 2.1.1. Density and the ideal gas law
    - 2.1.2. Virtual temperature, density temperature
    - 2.1.3. First Law: internal energy and the quest for warmth
    - 2.1.4. Latent vs. 'diabatic' heating and moist adiabaticity

- 2.1.5. Static energy vs. entropy vs. potential temperatures
- 2.2. Good-enough fluid dynamics
  - 2.2.1. Gravity becomes buoyancy, PGF is univariate
  - 2.2.2. Ubiquitous simplest motions: buoyancy waves
- 2.3. Good-enough moisture and microphysics
- 2.4. Properties of an equation set: problems and solutions
- 3. Accounting scales of motion
  - 3.1. One size cut: molecular vs. macroscopic
  - 3.2. Another cut: 'large-scale flow' vs. small 'eddies'
  - 3.3. On anomalies, deviations, perturbations, eddies, etc.
  - 3.4. Fourier decomposition and (logarithmic) 'scale'
  - 3.5. Shear, eddies, and energy transfer across scale
    - 3.5.1. Downscale energy transfer: shear instability
    - 3.5.2. Upscale energy transfer: upshear momentum flux
  - 3.6. Spectral energetics and the cascade fallacy
  - 3.7. Multiscale information, DOFs, and macro-entropy
  - 3.8. Problems and solutions

## **Part II: Entities and elements of convection**

- 4. Parcels: the buoyancy of lifted air
  - 4.1. Graphical analysis for moist thermo and probability
  - 4.2. Conserved variables in lifted air
  - 4.3. Parcel diversity, dilution, and detrainment profiles
  - 4.4. Problems and computer exercises
- 5. Kinematic flow entities for the buoyant drivers
  - 5.1. Thermals, bubbles, starting plumes
    - 5.1.1. Size and geometry effects on vertical acceleration
    - 5.1.2. The multi-bubble convective 'cell'
    - 5.1.3. Dynamic entrainment
  - 5.2. Supercellular updrafts
  - 5.3. Downdrafts and condensation-evaporation asymmetries
  - 5.4. 2D entities: slabs, jumps, squalls
  - 5.5. Problems and exercises

- 6. Mass 'trains': bulk irreversible flux and mixing
  - 6.1. Plumes and entrainment and detrainment
  - 6.2. Bulk plumes as pseudo-ensemble means
  - 6.3. Entrainment dilemmas and alternative mixing models
  - 6.4. The whole convecting layer as an entity

### **Part III: Envelopes and larger-scale interactions**

- 7. The dispatcher function and multi-cellular entities
  - 7.1. Dispatch probability, survival, and reproduction
  - 7.2. Near field effects: impacts of the convected air
  - 7.3. Shear's help: focus, 2-dimensionality, supercell lift
  - 7.4. Mid-distance interactions I: mesovortex effects
  - 7.5. Mid-distance interactions II: waves of low-level T'
  - 7.6. Problems and exercises
- 8. Non-contiguous 'systems' based on pooled far-field impacts
  - 8.1. Wave dynamics, dynamic meta-entrainment, and GMS
  - 8.2. Deep tropospheric dynamics and large-scale 'entities'
    - 8.2.1. SLP and frictional convergence
    - 8.2.2. Advection of moisture
    - 8.2.3. Taking charge of surface flux over ocean
    - 8.2.4. Synoptic momentum instabilities
  - 8.3. Problems and exercises
- 9. The great game: competition and coexistence
  - 9.1. The Lotka-Volterra predator-prey equation
  - 9.2. Ecosystems: niches, trophic levels, hierarchy
  - 9.3. Information, macro-entropy, and unlikely structures
  - 9.4. Telos and Free Energy: efficiency vs. likelihood
    - 9.4.1. Thermo too weak, bio too strong, conv just right
  - 9.5. Coexistence of competitors: the spectrum
    - 9.5.1. Succession illuminates climax

- 9.5.2. Interpreting spectral slopes
- 9.6. Interestingly wrong: lessons from and for modeling
  - 9.6.1. popcorn v. typhoon
  - 9.6.2. dilemmas and too-small frameworks
- 10. Epilogue: synthesis, and back to the detail mines
  - 10.1. Categorization for models: dyn, rad, conv, cld, trb,...
  - 10.2. Thermodynamics and microphysics
  - 10.3. Radiation
  - 10.4. Dynamics and turbulence
  - 10.5. Entities and ecologies
  - 10.6. Observations and interpretations
  - 10.7. Scale-truncated modeling
  - 10.8. Teleology and closure courage
  - 10.9. Applications and further couplings
- 11. Table of symbols, equation sets
- 12. Glossary
- 13. References and resource links