There will be no exams. Grades will be based on homework.

A class web page is here:

http://kiwi.atmos.colostate.edu/group/dave/at623/

and will be modified during the semester.

There are nominally 30 class meetings. As of the beginning of the semester, my calendar says that I will miss four of them:

Feb 1 (at MIT)
Feb 13 (at UCAR Board meeting)
Feb 22 (at workshop in Canada)
Mar 29 (at faculty retreat)

It is possible but not likely that a few more classes will be missed. All missed classes will be made up on a schedule that I will work out with your input.
Topics to be covered

Introductory overview

- Characteristics of the boundary layer
  - The general concept of boundary layers
  - Definition of the atmospheric boundary layer
  - Turbulence
  - Surface fluxes
  - “Unstable” and “stable” boundary layers
  - The surface layer
  - Mixed layers
  - The stable boundary layer
  - The boundary layer top
  - Entrainment across the boundary layer top
  - The PBL depth
  - Internal profiles of temperature, humidity, and wind
  - Internal cloudiness
  - Coupling to clouds above
  - Coupling to the land surface
  - Coupling to the upper ocean
- The bulk aerodynamic formulas
- Climatology of the surface fluxes of sensible heat, latent heat, and momentum
- The diurnal cycle over land
- Stratocumulus clouds
- Shallow cumulus clouds
- Coupling to deep convection

Introduction to turbulence in the boundary layer

- Definition of turbulence
  - Many interacting vortices
  - Chaos
  - Energy cascades
  - How turbulence differs from waviness
- Preliminary discussion of the turbulence kinetic energy (TKE) equation, postponing the derivation until later
  - Shear production
  - Buoyant production
• Dissipation
• Third moment
• Pressure terms
• Advection terms
• “Storage” term

Prototype instabilities
• Shearing instability
  • Basic mechanism
  • The effects of stratification
  • Breaking waves
• Convective instability
  • Rayleigh-Benard convection
  • Thermals and plumes
  • Cumulus instability
  • Cloud-top entrainment instability

The surface layer
• Dimensional analysis and similarity theory
• Monin-Obukhov similarity theory
• The logarithmic wind profile
• Surface roughness
• The bulk aerodynamic formulas
• The limits of similarity theory

Mixed layers
• What is mixing, and what is mixed?
• Linear flux profiles
• Diffusion versus advection
• Ekman layers
• Entrainment across the top of a mixed layer

Mass fluxes
• Introduction
• Generalization
Higher-order closure
• Notation
• The Reynolds stress equation
• The TKE equation
• Return to isotropy
• Scalar variances and covariances

Stratocumulus clouds in mixed layers
• Buoyancy in cloudy layers
• The buoyancy flux profile
  • Cloud base
  • Radiation at the cloud top
  • Cloud-top entrainment instability

Partly cloudy boundary layers
• Basic concepts
• Sommeria and Deardorff
• Connection to mass fluxes
• Double Gaussians
• Buoyancy fluxes in partly cloudy layers

Interactions of the boundary layer with deep cumulus convection
• Cloud roots
• Updrafts
• Downdrafts
• Cold pools
• Elevated nocturnal convection
• The effects of deep convection on the surface fluxes