ATS 623

Atmospheric Boundary Layer (ABL)

Spring 2015
Tues and Thurs 9 a.m. (2 contact hours per week) ATS 101

Instructor: Richard H. Johnson
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Course notes: *Atmospheric Boundary Layer Notes* (2015) by Richard H. Johnson (available online at http://johnson.atmos.colostate.edu/teaching/ and in bound form from Department Office if there is enough interest)

Useful textbook: *An Introduction to Boundary Layer Meteorology* (1991) by Roland B. Stull (available at Amazon)

Course Outline

1. Observed Structure and Properties of ABL with and without clouds (descriptive overview) [*Ch. 1*][1]

   - Definitions
   - The dry convective ABL and the diurnal cycle
   - The cloud–topped ABL (shallow and deep clouds)
   - Organized circulations in the ABL

2. Cartesian Tensor Notation, stresses in a fluid [*Ch. 2*]

3. Navier–Stokes Equations, Boussinesq system of equations [*Ch. 3*]

4. Bénard Convection (Rayleigh's solution), applications to the atmosphere [*Ch. 11*]

5. Turbulent characteristics of the ABL and impacts on resolvable-scale flow [*Chs. 3, 4, 5, 6, 7, 9*]

   - Turbulence properties, production and dissipation [*Ch. 5, Ch. 6 (Closure)*]
   - Reynolds decomposition of N–S equations [*Ch. 3*]
   - Surface layer characteristics, bulk transfer formulations [*Ch. 7, Ch. 9*]
   - Ekman layer
   - Turbulent Kinetic Energy equation [*Ch. 5*]
   - Flow Stability (Richardson No.) [*Ch. 5*]
   - Nocturnal low-level jet

[1] Relevant chapter in Stull (1991)

6. One–dimensional mixed layer models [*Ch. 11*]

7. Effects of moist convective processes on boundary-layer properties [*Ch. 13*]

    - Analysis of interaction of clouds with boundary layer (stratocumulus, tradewind cumulus, deep convection)

Other useful texts on turbulence and boundary layers:

- Arya (1988) *Introduction to Micrometeorology*
- Batchelor (1953) *The Theory of Homogeneous Turbulence*
- Blackadar (1997) *Turbulence and Diffusion in the Atmosphere*
- Chandrasekahr (1961) *Hydrodynamic and Hydromagnetic Stability*
- Garratt (1992) *The Atmospheric Boundary Layer*
- Hinze (1959) *Turbulence*
- Koschmieder (1993) *Bénard Cells and Taylor Vortices*
- Kundu and Cohen (2011) *Fluid Mechanics*
- Landahl and Mollo–Christensen (1987) *Turbulence and Random Process in Fluid Mechanics*
- Lesieur (1993) *Turbulence in Fluids*
- Lumley and Panofsky (1964) *The Structure of Atmospheric Turbulence*
- Monin and Yaglom (1971) *Statistical Fluid Mechanics*
- Munn (1966) *Descriptive Micrometeorology*
- Panofsky and Dutton (1984) *Atmospheric Turbulence*
- Pasquill (1962) *Atmospheric Diffusion*
- Priestley (1959) *Turbulent Transfer in the Lower Atmosphere*
- Reynolds (1974) *Turbulent Flows in Engineering*
- Schlichting (1960) *Boundary–Layer Theory*
- Sorbjan (1989) *Structure of the Atmospheric Boundary Layer*
- Tennekes and Lumley (1972) *A First Course in Turbulence*
- Turner (1979) *Buoyancy Effects in Fluids*

On tensors:

- Aris (1962) *Vectors and Tensors and the Basic Equations of Fluid Mechanics*
- Dutton (1976) *The Ceaseless Wind* (Chap. 5)
- Kundu and Cohen (2011) *Fluid Mechanics*

Movies

Several Fluid Mechanics Series Films will be shown

Learning outcomes

After completion of this course, students are expected to have gained an understanding of the fundamentals of atmospheric boundary layer structure, properties, and processes. They will also be introduced to the nature of 3-D turbulent flow as applied to the atmospheric boundary layer and will have mastered the use of cartesian tensor notation.

Expectations for homework and outside reading

At least two hours of effort are expected to complete homework and related readings outside of class for each hour of class time.

Honor pledge

This course will adhere to the CSU Academic Integrity Policy as found in the General Catalog (http://www.catalog.colostate.edu/FrontPDF/1.6POLICIES1112f.pdf) and the Student Conduct Code (http://www.conflictresolution.colostate.edu/conduct-code). At a minimum, violations will result in a grading penalty in this course and a report to the Office of Conflict Resolution and Student Conduct Services.

Course Grading

Homework:	30%
Mid–term:	30%
Final:	40%