CE 8521: The Atmospheric Boundary Layer
Fall 2016

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Lectures: 09:45 AM - 11:00 MW, CE Bldg room 202,
Final exam: 1:30pm-3:30pm, Tuesday, December 20 (as defined by UMN)

Textbook suggested: (1) Stull, R. B., 1988: An Introduction to Boundary Layer Meteorology. Kluwer,
(2) reference books and journals (see below).
Goal: To study turbulent processes in the lower part of the atmospheric boundary layer (ABL), and their interaction with natural landscape and the built environment

Prerequisites: Working knowledge of fluid mechanics (CE3502 or equivalent class).

The course is designed for grad students enrolled in civil, mechanical or aerospace engineering, physics , earth sciences and interested in the physical mechanisms occurring in the atmospheric boundary layer.

Course Contents:
Phenomenology
1) Turbulent boundary layer definitions, mean statistics and air properties
2) A general classification of flow regions in the ABL
3) The small scales of turbulence: a brief digression into homogeneous isotropic flows
4) Stratification and convection with a mean shear

Reynolds decomposition and governing equations
5) Kinematic fluxes, eddy fluxes.
6) prognostic equations for mean variables, variances and turbulent fluxes.
7) Turbulence kinetic energy: TKE and temperature variance budget equations
8) Turbulent production and the role of mean shear

Measuring turbulent flows in the atmospheric surface layer
9) Sonic anemometers
10) Instruments for basic micrometeorology
11) Hotwire anemometry
12) Lidar

Statistical approach and Kolmogorov
13) Turbulence, coherent flow structures and spectrum,
14) K41 theory
15) Time series analysis: velocity and temperature structure functions and estimate of the power spectrum

Similarity laws, convective motions and stratification
16) Stability concepts, the Richardson number, the Monin Obukhov length

17) Key scaling variables and the modified log law
18) Comparative analysis with the neutral turbulent boundary layers
19) Field and laboratory data

Complex terrain and stability conditions:

20) Roughness and transitional roughness : sand and snow
21) Complex hills and double averaging methods
22) Wind energy in flat and complex terrain, katabatic wind
23) Coupling turbulence and landscape evolution

Course Format: We will follow a lecture format throughout the semester. Students are expected to attend class and have active participation.

Grading: Grades will be determined on the basis of homework assignments (40%), 2 projects (40%) and final exam (20%). The projects will be based on atmospheric data analysis and on a presentation of a research topic of interest. Both projects must be completed in order to pass the class. The grade of any late homework or project will be subject to penalty proportional to the delay.

Any changes in the grading policy or in the syllabus will be communicated to the students.

Suggested Book:

- Stull, R. B., 1988: An Introduction to Boundary Layer Meteorology. Kluwer, 666pp.

Further references:

- Garratt, J. R., 1992: The Atmospheric Boundary Layer. Cambridge University Press, 316pp.
- Arya, S.P., 2001: Introduction to Micrometeorology. Academic Press, 415pp.
- Kaimal, J.C. and Finnigan, J.J., 1994: Atmospheric Boundary Layer Flows: Their Structure and Measurement. Oxford University Press, New York, 289pp.

Journals: some key articles will be discussed from the following journals
Boundary Layer Meteorology, Journal of the Atmospheric Sciences, Journal of Fluid Mechanics, Physics of Fluids, Annual Review of Fluid Mechanics, Journal of Geophysical Research, Journal of Hydrometeorology, Wind Energy.