Boundary Layer Meteorology

(METR 5103)

Spring 2016 Syllabus

General information

Fundamentals of the atmospheric boundary layer dynamics and thermodynamics, including the basic concepts of turbulence theory and its applications in atmospheric modeling, will be taught. State-of-the-art approaches toward parameterization, modeling, and simulation of boundary-layer turbulent flows under different meteorological conditions will be discussed and critically analyzed. Role of the boundary layer in atmospheric processes of different scales will be addressed. Boundary-layer/land-surface parameterization schemes employed in numerical weather prediction and climate models will be presented in detail. Applications of Monin-Obukhov similarity theory for formulation of surface boundary conditions in atmospheric models will be explained and illustrated.

The course will also focus on advanced numerical simulation approaches used in boundary-layer research: direct numerical simulation (DNS) and large eddy simulation (LES). The latter technique is becoming increasingly popular in numerical analyses of mesometeorological processes. Approaches toward turbulent flow modeling based on Reynolds-averaging methodology will be considered as well.

Atmospheric boundary layer types ranging from strongly stable to neutral and to strongly unstable/convective will be conceptually analyzed, and specific modeling techniques for particular flow types will be presented.

Numerical tools commonly used in boundary layer modeling will be reviewed, and computer flow visualizations and animations will be demonstrated.

Time and place: Mon, Wed, Fri 1:00 to 1:50 p.m., NWC 5930.

Instructor: Dr. Evgeni Fedorovich (http://weather.ou.edu/~fedorovi/fedorovich.html)
School of Meteorology, Room NWC 5419, Phone: 405 325 1197.
E-mail: fedorovich@ou.edu

Office hours: by appointment.

Prerequisites: METR 5113 or permission of instructor.

Textbook

Garratt, J. R., 1994: *The Atmospheric Boundary Layer*, Cambridge University Press, 316 pp.

Recommended additional texts

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

Sorbjan, Z., 1989: *Structure of the Atmospheric Boundary Layer*, Prentice Hall, 317 pp.

Wyngaard, J. C., 2010: *Turbulence in the Atmosphere*, Cambridge Univ. Press, New York, 393 pp.

Proposed grading

Midterm exam (March): 30%. Course project: 30%. Final exam (May): 40%.

Grade cut-offs: A (≥85%), B (≥70%), C (≥50%), D (≥30%), F (<30%).

Course outline

Place of the planetary boundary layer (PBL) in the Earth's atmosphere.

Role of density/temperature stratification in the PBL.

Observational and model data regarding the structure of convective, neutral, and stably stratified atmospheric boundary layers.

Diurnal cycle of the PBL.

Interaction between the PBL and larger-scale atmospheric processes.

Governing equations of the PBL dynamics and thermodynamics.

Mean and turbulent motion in the PBL.

Reynolds decomposition and averaging.

Problem of turbulence closure.

Interaction of PBL flows with underlying surfaces of different types.

Surface energy balance.

Turbulence regime in the atmospheric surface layer (ASL).

Monin-Obukhov similarity theory.

Flux-profile relationships in the ASL.

Hierarchy of PBL turbulent flow models.

Balance of turbulence kinetic energy (TKE) in the PBL.

The TKE dissipation rate and its parameterization.

Spectral properties of the PBL turbulence.

Parameterization of turbulent transport in atmospheric models.

Direct numerical simulation (DNS) of turbulent flows; examples of DNS applications.

Large eddy simulation (LES) of turbulent flows.

Subgrid turbulence closure schemes.

Examples of LES applications.

Note: *Any student in this course who has a disability that may prevent him or her from fully demonstrating his or her abilities should contact Dr. Evgeni Fedorovich personally to discuss accommodations necessary to ensure full participation and facilitation of educational opportunities.*