Atmospheric Sciences 5220: Boundary Layer Meteorology
Fall 2015

Instructor: Professor Steve Krueger
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Classroom: 820 WBB

Class Hours: Tu Th 2:00 to 3:20

Office Hours: W 1:45 to 2:45, or by appointment

Web page: `http://www.inscc.utah.edu/~krueger/5220/`

Prerequisites: ATMOS 5000 (may be concurrent) or instructor's consent

Background: The atmospheric boundary layer is the interface between the free atmosphere and the surface. It plays a central role in the exchange of heat, moisture, momentum, trace gases, and aerosols between land, ocean, and ice surfaces, in cloud formation, and in the general circulation of the atmosphere. We are immersed in the boundary layer. Forecasts of daily high and low temperatures are boundary layer forecasts. The winds that affect buildings, bridges, trucks, boats, ships, and aircraft during take-offs and landings are boundary layer winds. Boundary layer winds create waves on lakes and oceans, resulting in swells and surf. Wildfires are strongly affected by boundary layer winds, including their interaction with complex terrain. Air pollution is generated and chemically modified in the boundary layer. Boundary layer winds vary on the mesoscale due to interactions with surface characteristics and orography. Boundary layer clouds play an important role in climate change, and are poorly represented in global climate models. Boundary layer clouds may respond to increases in carbon dioxide and aerosol concentrations due to anthropengenic sources.

Course Description: The goals of this course are to provide you with a basic understanding of boundary layer structure and processes, including turbulence, surface fluxes, vertical structure and diurnal cycle.

Topics Addressed:

- Boundary layer characteristics.
- Introduction to turbulence. Convective and shear instabilities.
- Turbulence, Reynolds averaging, turbulent fluxes, equations for turbulent flow.
- Measurement and analysis of boundary layer turbulence.
- Boundary layer wind and thermodynamic profiles. Convective and stably stratified boundary layers.

- The surface layer. Monin-Obukhov similarity theory, surface roughness.
- Surface fluxes over ocean and land. Land surface models. Diurnal cycle.

Format: Primarily lecture and assigned problem sets. The students will use MATLAB programming skills to solve problems and to present results in graphical form.

Grading:

- Homework (80 percent): You are expected to work *independently* to solve the problems, though discussions among classmates are allowed. *Plagiarism will not be tolerated.*

  You are encouraged to correct errors in your homework if your score is below 90%. As a result, you may be able to raise your homework score to a maximum of 90%.
- Final exam (20 percent): Thursday, Oct 8

The grading scale will be A: ≥ 90, B: 80-89, C: 70-79, D: 60-69, F: < 60.

Class policies: Students must take every exam with exceptions governed by University Policy. Plagiarizing, copying, cheating, or otherwise misrepresenting one's work will not be tolerated.

Missing class will not be penalized directly, but usually results in poor problem set and exam performance. Some course material that you are responsible for will only be presented during lectures (i.e., will not be found in the text or online notes).

Homework is due at the start of class on the due date, unless otherwise noted. *Late homework will not be accepted.*

Required Textbook: Wallace, J. M., and P. V. Hobbs, 2006: *Atmospheric Science: An Introductory Survey,* Second Edition, Academic Press, 483 pp. The subject of Chapter 9 is the atmospheric boundary layer.

Some other relevant textbooks:

- Arya, S. P., 2001: *Introduction to Micrometeorology,* Second Edition, Academic Press, 420 pp. A very accessible advanced undergrad introduction to the subject. It emphasizes the surface layer.
- J. R. Garratt, 1992: *The Atmospheric Boundary Layer,* Cambridge University Press, 316 pp. Contains a list of other relevant books at the end of the first chapter, including historically important texts.
- Hartmann, D. L., 1993: *Global Physical Climatology,* Academic Press, 411 pp. Chapter 4 describes the energy balance of the surface from a global climatological perspective.

- Holton, J. R., 2004: *An Introduction to Dynamic Meteorology,* 4th Ed., Elsevier Academic Press, 535 pp. Chapter 5 contains a concise description of the boundary layer and its relevance to dynamic meteorology.
- Lenschow, D. H., 1986: *Probing the Atmospheric Boundary Layer.* American Meteorological Society, 269 pp. An introduction to techniquies for measuring the boundary layer.
- Oke, T. R., 1987: *Boundary Layer Climates.* 2d ed., Methuen, 435 pp. Describes surface-atmosphere interactions in detail.
- Sorbjan, Z., 1989: *Structure of the Atmospheric Boundary Layer,* Prentice-Hall, 317 pp.
- Stull, R. B., 1988: *An Introduction to Boundary Layer Meteorology,* Kluwer Publishers, 666 pp. Nice discussion of the methods, observational and computational tools used in boundary layer meteorology.
- Tennekes, H., and J.L. Lumley, 1972: *A First Course in Turbulence.* MIT Press, 300 pp. An excellent introduction to turbulence.
- Wyngaard, J. C., 2010: Turbulence in the Atmosphere. Cambridge Univ Press, 393 pp. An excellent up-to-date introduction to turbulence in the atmosphere and in engineering flows for advanced students. Part I introduces the concepts and equations of turbulence. Part II describes turbulence in the atmospheric boundary layer. Part III covers the foundations of the statistical representation of turbulence.

Holidays: (none)

Classes that may be rescheduled: (none)

Last day of class: Thursday, Oct 8

Final exam: Thursday, Oct 8

Drop and Withdrawal dates:

- Last day to drop (delete) classes: Fri., Aug. 28 (Students can drop classes by phone or web through this date, and the classes will not appear on their transcripts.)
- Last day to add classes: Fri., Aug. 28
- Last day to withdraw from classes: Fri., Sep. 18. (Students can withdraw from classes by phone or web, but will"W" will appear on their transcript for these courses.)