ATM S 547, Spring Quarter 2018

Boundary Layer Meteorology

Canvas page (for HW grades, announcements)

Instructor: Professor Chris Bretherton
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breth@washington.edu (office hours 10:30-11:30 Wed or by appointment)

Lectures: Tu Th 11:00-12:20 (plus Mo 9:30-10:20 makeup lectures 4/2-5/14); ATG 610

Prerequisites: 505 (fluids) or permission of instructor

Recommended Text: The Atmospheric Boundary Layer, by J. R. Garratt, 1992, Cambridge University Press, 316 pp. (available on Amazon for $78.19; this is a supplement to my on-line course notes, which cover what you need for following the lectures and doing the homework).

Course Description:

Turbulence and turbulent fluxes, averaging. Convection and shear instability. Monin-Obukhov similarity theory, surface roughness. Wind profiles. Organized large eddies. Convective and stably stratified boundary layers. Measurement technologies. Large-eddy simulation. Boundary-layer parameterization. Energy fluxes at ocean and land surfaces (including soil and vegetation interactions), diurnal cycle. Cloud-topped boundary layers.

Grading

- Homework (50%): you may collaborate on this, though I ask that you write your own Matlab or Python scripts and description of results. To minimize paper use, use Canvas to submit your assignment.
- Term project (50%) on some topic of your choice related to the class (please see me for approval of your proposed topic). Each student will do a 15-20 minute oral presentation on their topic during the last two class sessions (29-31 May) and email me a 5-10 page written report by 11:59 pm on Tu 5 June.

Lecture notes (pdf). Some lectures take more than one period to complete. I may assign a few of the lectures as out-of-class reading and use class for discussion and examples instead.

- Lecture 1 and slides: Introduction; instabilities. Flow Instabilities. Please also watch the NCFMF video Flow Instabilities.
- Lecture 2 and slides: Turbulent flow. Please also watch the NCFMF video Turbulence.
- Lecture 3: Turbulent fluxes and TKE budgets
- Lecture 4 and slides: Boundary layer turbulence and mean wind profiles; mixing-length theory; observing technologies; LES.
  - LES animations of a stratocumulus topped boundary layer (courtesy Bjorn Stevens, MPI): Vertical cross-section of w and horizontal view of cloud albedo in a 4 x 4 km domain.
  - LES animation of Cu rising into stratocumulus in a 6 x 6 km domain (courtesy Irina Sandu, ECMWF; white is cloud; grey blobs are rain).
- Lecture 5 and slides: Surface roughness and the logarithmic sublayer
- Lecture 6 and slides: Monin-Obukhov similarity theory. MOex.m: Matlab example. Makes plot MOex.png
- Lecture 7 and slides: BL wind profiles and large eddy structure in convective and neutral BLs
- Lecture 8 and slides: K-theory and HOC parameterizations of BL turbulence
- Lecture 9 and slides: Nonlocal parameterizations of BL turbulence
- Lecture 10 and slides: Surface energy balance
- Lecture 11 and slides: Surface evaporation and soil moisture
- Lecture 12 and slides: Diurnal cycle over land; mixed layer modeling of CBL growth
- Lecture 13 and slides: Stable/nocturnal boundary layers, katabatic flow, and nocturnal jets
- Lecture 14 and slides: Oceanic and cloud-topped BLs - observations.
- Lecture 15 and slides: Sc physical processes
- Lecture 16 and slides Mixed layer modeling of Sc
- Lecture 17 and slides. Shallow cumulus convection and Sc-Cu transition. Time-lapse video from CSET flight RF06 from CA to HI through Sc-Cu transition (courtesy NCAR EOL and Hans Mohrmann)

Class Schedule Notes

- No class Tu 15-Th 24 May - Three meetings in Southern CA (made up via Monday lectures).

Homeworks

- Homework 1 (Due Th 12 Apr.)
- rf18L1.txt for HW1
- psduw.m for HW1.
- highpassw.m for HW1.
- hw1.py: Jeremy McGibbon's starter Python script for HW1.
- Homework 1 solutions
- hw1.m Matlab script for solving HW1.
- Homework 2 (Due Th 19 Apr)
- Homework 2 solutions
- Homework 3 (Due Th 26 Apr)
- Homework 3 solutions
- hw3.m Matlab script for solving HW3.
- Homework 4 (Due Th 10 May)
- Template for HW4 P2 - Local K-closure model for dry convective BL with no wind shear: Klocal_CBL.m (Matlab-uses dthdt.m). Python translation Klocal_CBL.py (thanks to Emily Ramnarine and Jeremy McGibbon).
- Homework 4 solutions
- hw4.m Matlab script for solving HW4.