ESS5203.03 - Turbulence and Diffusion in the Atmospheric Boundary-Layer : Winter 2020

6 Jan 2020

Instructors Peter Taylor, Petrie 112, Phone 736-2100 # 77707, pat@yorku.ca
Mark Gordon, Petrie 431, Phone 736-2100 # 22764, mgordon@yorku.ca

Class times Monday 2:30pm-4:00pm in BC 228. + ???

Text: J.R.Garratt, The Atmospheric Boundary Layer, 1994. Cambridge (approx $40, paperback from Amazon - ignore the student review)

Also some material from other texrs such as
J.C. Kaimal and J.J. Finnigan, 1994, Atmospheric Boundary-Layer Flows - Oxford.

Garratt's is a good reference book and contains a lot of material at a good price. K&F is good for complex terrain and instrument issues.

Also note as useful references,
A.K.Blackadar, Turbulence and Diffusion in the Atmosphere, 1997, Springer.
John C. Wyngaard, 2010, Turbulence in the Atmosphere. CUP
A First Course in Turbulence - H. Tennekes and J. Lumley
An Introduction to Boundary-Layer Meteorology - Roland Stull
Structure of the Atmospheric Boundary Layer - Zbigniew Sorbjan,
Introductory Micrometeorology - S.P.S. Arya
Workshop on Micrometeorology - ed. D. Haugen
Atmospheric Turbulence - H. Panofsky and J. Dutton
Boundary-Layer Climates - Tim Oke
Descriptive Micrometeorology - Ted Munn
Atmospheric Diffusion - F. Pasquill and F.B. Smith
Boundary-Layer Meteorology 25th Anniversary Issue - J.R. Garratt and P.A. Taylor

Library shelves QC 880-883 plus other nearby #s

ASSESSMENT
Final grades will be based on,
Assignments, 40%; Exam, 40%; Project, 20%

Outline: Appropriate reference material indicated as, for example G2 referring to Garratt text, Chapter 2. KF = Kaimal and Finnigan

Topics that will be covered ate listed below, though not always in this order, and others will be added based on student interests.

1a) General Introduction. Laminar and Turbulent flow, averaging, the atmospheric boundary-layer - diurnal cycle, role of density stratification. G1

1b) Review of governing equations for incompressible flow, continuity, Navier Stokes, equation of state, thermodynamic equation. Vorticity (G2)

2) Simplification of the basic equations, Reynolds averaging. Statistical description of turbulence, integral statistics (variances etc.), scales of turbulent flow, the Turbulent Kinetic Energy (TKE) equation. Boundary-layers over horizontally homogeneous terrain - constant flux layers, surface roughness - the Surface Boundary-Layer (SBL). (G2, G4)

4) Surface Energy Budget. Dimensional Analysis and Similarity, Monin-Obukhov similarity theory. The diabatic surface boundary layer. Other stratified boundary layers (suspended material) G3, G5

5) The Planetary Boundary Layer (PBL) or Atmospheric Boundary-Layer (ABL). Ekman spirals, PBL similarity theory (Rossby number similarity), Geostrophic drag laws. G3

6) Measurements, Instruments and Experiments. KF

7) Spectral Analysis. PDFs, Time and Space spectra, Energy spectra, Kolmogorov, inertial and dissipation subranges, -5/3 law. KF

8) Modelling. Ensemble average equations, closure and models. RANS models, Non-local closure models - "transilience", Direct Numerical Simulation and Large Eddy Simulation (LES) modelling.

9) Atmospheric Diffusion. Diffusion from point sources, Fickian diffusion, Gaussian plume models, G.I. Taylor's diffusion equation, Lagrangian simulation models.

10) Flow in complex terrain, roughness changes, flow over hills. G4, KF