Environmental Fluid Dynamics

ME EN 7710 Spring 2017

Instructor	Jeremy A. Gibbs, Ph.D. Email: jeremy.gibbs@utah.edu Office: MEK 2566 (hours by appointment)
Lecture	WEB 2470, Tues and Thurs, 10:45a-12:05p
Credit	3 hours
Website	Canvas http://gibbs.science/efd
Text	*An Introduction to Boundary Layer Meteorology* R.B. Stull (Kluwer, 1988), 670pp.
Recommended Texts	*Introduction to Micrometeorology, 2nd edition* S.P. Arya (Academic Press, 2001), 420 pp. *The Atmospheric Boundary Layer* J. R. Garratt (Cambridge University Press, 1992), 316 pp. *Atmospheric Boundary Layer Flows* J.C. Kaimal and J.J. Finnigan (Oxford University Press, 1994), 289 pp. *Turbulence in the Atmosphere* J.C. Wyngaard (Cambridge University Press, 2010), 393 pp. *Boundary Layer Climates, 2nd edition* T.R. Oke (Routledge, 1987), 435 pp. *Handbook of Micrometeorology* X. Lee, W. Massman, and B. Law (Kluwer, 2004), 250 pp.
Prerequisites	ME EN 3700 Undergraduate Fluid Mechanics (or equivalent) and ME EN 6700 Intermediate Fluid Dynamics or Instructor consent
Grading	Homework 20% Midterm Exam 25% Project #1 20% Final Project 35%

Course Description

An introduction to Environmental Fluid Dynamics focusing primarily on micrometeorological processes occurring in the atmospheric boundary layer (the lower 1-3 km of the troposphere). Since this is the part of the atmosphere that humans are directly in contact with, it is of great importance to both engineers and atmospheric scientists. For example, the small-scale motions responsible for pollution dispersion are related to surface fluxes of heat and momentum. The class will mostly focus on the micrometeorological processes in the atmospheric boundary layer in both rural and urban settings. The content will include turbulent flow processes in urban areas.

Scope of the Course

The lecture material will cover much of the material in the textbook, however significant supplemental journal articles will also be used. The basic transport equations for mass, momentum and energy will be developed and will include rotation and stratification effects.

Course Outline

- *Introduction*
  - The atmospheric boundary layer – basic definitions and concepts, scales of motion, diurnal cycles, introduction to rotation and stratification
  - Equilibrium and departures from it
  - Atmospheric thermodynamics - potential temperature, virtual potential temperature, buoyancy frequency, potential energy
- *Energy Balances* – radiation characteristics, near surface exchanges (fluxes), energy budget near surface, radiation budget near surface
- *Basic Equations* - rotation, stratification, boundary layer simplifications
- *Atmospheric Surface Layer Scaling* – Monin-Obukhov similarity theory
  - Neutral, convective, and stable boundary layers
- *Atmospheric Boundary Layer Turbulence* – introduction to the turbulence in the environment, the critical effects of buoyancy on turbulence, turbulent entrainment, stability effects
  - Measuring techniques – introduction to various measuring techniques including sonic anemometry, balloon borne measurements, and remote sensing techniques
  - Analysis of turbulence datasets and application to a real world field experiment
- *Nonhomogeneous Boundary Layers* – vegetative canopies, urban fluid mechanics
  - Surface inhomogeneities (roughness effects - complex terrain, urban), terrain-induced flows
  - Atmospheric dispersion concepts and models (ranging from simple Gaussian plume to Lagrangian dispersion models)
  - Urban heat island

Homework

Periodic homework assignments will be given during class and then posted on the web site and Canvas. Homework will be collected in class and via Canvas on the due date. Late homework will generally not be accepted.

Project #1

The goal of this project is to obtain a working understanding of the Surface Energy Balance (SEB) for urban areas. You will model the urban SEB for a tower located in a suburban neighborhood in the Salt Lake Valley (Murray, UT) using the LUMPS (Local-scale Urban Meteorological Parameterization Scheme) model. At the end of the project you will have a working simulation tool.

Final Project

You will investigate various aspects of turbulence by using data from recent field experiments. The purpose of this project is to understand the physics of turbulent flow occurring at the measurement site. The project will consist of two parts: a written report and an oral presentation. You may work in groups of 2 or 3.

Computer Skills

All students are expected to have basic computing skills and knowledge of a programming language (FORTRAN, C, C++, Python, etc) or scientific computing software package (Maple, Matlab, EES, etc)

Useful Information

University of Utah Accommodations Policy (III.Q)

University of Utah Student Code of Conduct

College of Engineering Guidelines

Department Of Mechanical Engineering Graduate Advising Guide