

ATOC 5060: Atmospheric Dynamics **Spring 2008**

Time: Tuesday and Thursday, 11:00-12:15 pm

Location: Duane E126

Textbook: J. R. Holton, Introduction to Dynamic Meteorology, 4th Ed., Elsevier, 2004

Web Page: <http://atoc.colorado.edu/~dcn/ATOC5060> (or google ATOC 5060)
Lecture notes, homework, projects, reading assignments, models, data, solutions, and other useful material will be posted on the class web site.

Instructor: David Noone, Ekeley (CIRES), S234. 303-735-6073 (dcn@colorado.edu)

Office hours: Tuesday after class until 5pm. Email for an appointment.

Summary: An amount of energy from the Sun is intercepted by the Earth. While, exactly this amount of energy is ultimately radiated back to space, Earth's, spherical shape and rotation causes local imbalance between incoming and outgoing radiation. This discrepancy gives rise to motions that ensure the radiative balance. Understanding the structure and dynamics of the atmosphere is central to forecasting weather and understanding climate.

This course aims to build on knowledge of the fundamental set of physical principles by applying them to quantitatively describe the behavior of large-scale atmospheric motions. By the end of this course we will have developed quantitative analysis of atmospheric propagation and instability of flow associated with mountain barriers, shallow water waves, large-scale baroclinic Rossby waves and gravity waves. A detailed examination of the development and energetics of mid-latitude baroclinic cyclones is perused, and the implications for the global scale circulation regime explored. We apply our understanding of atmospheric dynamics to problems of climatological significance, including tropical circulation, middle atmospheric flow, and the general circulation of the atmosphere.

Grading: A final grade will be composed of homework (30%), two research projects (30%), and midterm and final exams (40%).

Homework: About three homework assignments will be set and graded. Also, each lecture will have a number of problems (mostly from the textbook) that you should review each week. While not graded, someone will "volunteer" to work through the problem on the board in the next class.

Research assignments: The two projects will comprise a combination of specific tasks and open-ended "research" tasks. A deadline for handing in assignments will be given. Late submission will be penalized at a rate of 20% per day (i.e., three days late will get a maximum of half marks). If there is some reason why you can not hand in work on time, contact David *BEFORE* the day it is due.

Exams: There will be one mid-term, and a final exam. If you score higher on the final than the mid-term(s), the final exam grade will be used.

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Approximate lecture outline

Review of basic concepts (2 weeks) Holton 1-4

Conservation laws, equations of motions.
Balanced flow, simplifying assumptions, thermal wind balance, scale analysis.
Vorticity, vorticity equation, potential vorticity.

Quasi-geostrophic analysis (3 weeks) Holton 6

Quasi-geostrophic assumptions and scaling, quasi-geostrophic vorticity equation
Geopotential tendency and prediction, omega equation.
Quasi-geostrophic potential vorticity, potential vorticity inversion

Boundary layers (2 weeks) Holton 5

Reynolds averaging, surface stress
Flux gradient approximation, mixing length hypothesis
Ekman layer, pumping, and drift, circulation spin-down

Atmospheric waves (3 weeks) Holton 7

Wave concepts. Review of linearization, Fourier analysis. Topographic buoyancy waves, gravity waves, shallow water waves, free and forced Rossby waves.
Geostrophic adjustment. Frontal development, secondary circulations.

Atmospheric instability (2 weeks) Holton 8

Hydrodynamic instability. Normal mode analysis. Barotropic instability, baroclinic instability. Energetics of growing waves. Layered and stratified models.

The general circulation (3 weeks) Holton 10

Observations of the general circulation, energy balance. Available potential energy and the Lorenz energy cycle. The Hadley cell. Zonal mean structure, wave mean interaction, Charney-Drazin filtering. Large scale variability, storm tracks, annular modes, teleconnections.