ATM405: Atmospheric Dynamics I

Spring 2020

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Mahoney/Pearson116, Tuesdays and Thursdays, 12:30PM-2:00PM.

Outline:

I. Describing Atmospheric Flow

A. Mathematical tools
B. Fluid flow kinematics
C. Forces in fluids
D. Coriolis force and centrifugal force

II. Equations of Motion

A. Temperature, pressure, and hydrostatic balance
B. Conservation of momentum in fluids
C. Equations of motion in height coordinates
D. Equations of motion in pressure coordinates
E. Conservation of mass and energy

III. Large-scale Balances and Dynamics

A. Geostrophic balance
B. Thermal wind balance
C. Curved flow and gradient balance
D. Circulation and vorticity
E. Surface friction and boundary layer flow

Assignments:

There will be problem sets (30%), 2 mid-term exams (20% each), and a final exam (30%).

Resources:

We will use this meteorology textbook:

Martin, J. E., 2006: *Mid-latitude Atmospheric Dynamics: A First Course.*

Here are some other textbooks that you may find useful:

Holton, J. R., 2004: *An Introduction to Dynamic Meteorology* (4th edition).
Holton, J. R., and G. J. Hakim, 2012: *An Introduction to Dynamic Meteorology* (5th edition).
Wallace, J. M., and P. V. Hobbs, 2006: *Atmospheric Science: An introductory survey*.

ATM405 Class Schedule, Spring 2020

January 16th to May 6th.

January 14th:

Goals of the course.

Textbooks and assignments.

Expectations and grades.

Scheduling.

Questions we can answer after taking this class.

Problem Set #0 handed out.

January 16th:

Reading: Martin Chapter 1.1-1.2.

Mathematical tools: functions, gradients, vectors, and advection.

January 21st:

Problem Set #0 due.

Reading: Martin Chapter 1.3-1.4.

Advection, flow kinematics, and rotation.

January 23rd:

Reading: Martin Chapter 2.1.

Parcels, pressure forces, and friction forces.

Problem Set #1 handed out.

January 28th:

Reading: Martin Chapter 2.2.

Planetary rotation and the Coriolis force.

January 30th:

Problem Set #1 due.

Reading: Martin Chapter 3.1.

Hydrostatic balance, buoyancy, and thickness.

Illustrations of the thickness relationship.

February 4th:

Reading: Martin Chapter 3.2.

Equations of motion in vector form.

February 6th:

Reading: Martin Chapter 3.2.

Equations of motion in spherical coordinates

Scaling, geostrophic balance, and hydrostatic balance.

Problem set #2 handed out.

February 11th:

Reading: Martin Chapter 3.2.

Consequences of geostrophic balance.

The geostrophic approximation and the geostrophic wind.

February 13th:

Problem set #2 due.

Reading: Martin Chapter 3.3.

Conservation of mass.

Conservation of energy.

February 18th:

Homework problems review.

February 20th:

Midterm #1.

February 25th:

Reading: Martin Chapter 3.3.

Potential temperature, vertical motions, and stability.

Temperature structure of the atmosphere.

February 27th:

Reading: Martin Chapter 4.1.

Vertical oscillations and the Brunt-Vaisala frequency.

Equations of motion: pressure coordinates.

Problem set #3 handed out.

March 3rd:

Reading: Martin Chapter 4.3.

Thermal wind balance.

March 5th:

Problem set #3 due.

Reading: Martin Chapter 4.4

Natural coordinates.

Geostrophic flow.

Gradient wind balance.

March 17th:

Cyclostrophic flow.

Anomalous lows and highs.

Cyclones and anticyclones around the world.

Divergence and vertical motion.

March 19th:

Ageostrophic wind.

Thermal structure of the atmosphere.

Problem set #4 handed out.

March 24th:

Reading: Martin Chapter 5.1-5.2.

Re-introduction to vorticity.

Vorticity equation for two-dimensional flow.

March 26th:

Problem set #4 due.

Reading: Martin Chapter 5.1-5.2.

Circulation in two dimensions.

Circulation in three dimensions.

March 31st:

Homework problems review.

April 2nd:

Midterm #2.

April 7th:

Reading: Martin Chapter 5.3.

Mechanics of conservation of vorticity.

Vertical vorticity equation in three dimensions.

Tilting terms.

April 9th:

Scaling the vorticity equation.

Vortex stretching.

April 14th:

Reading: Martin Chapter 5.4.

Potential vorticity in the atmosphere.

April 16th:

Reading: Holton Chapter 5 (handout).

Atmospheric boundary layer, friction, and the Ekman layer.

Problem set #5 handed out.

April 21st:

Ekman layer and spin-down of cyclones.

April 23rd:

Problem Set #5 due.

Discussion of course material.

Final exam: Wednesday, May 6th, 11:00AM-1:30PM.