AOS 311 Dynamics of the Atmosphere and Ocean II

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Meeting times: 8:50-9:40 MW in AOSS Building, F 8:50-10:45 PM Room 1411

Attendance: Your alert and engaged attendance is your "ticket" to office hours. Let me emphasize that *if you miss class due to circumstances beyond your control or if despite efforts you do not understand material covered in class, I am* ***eager*** *to provide additional help*! If you can't meet during my office hours, feel free to contact me by phone or email to set up an appointment. On the other hand, *if you choose to skip class or sleep through class, you should not expect me or the TA to provide private tutoring on the material you missed*.

Office hours: (Morgan) Mondays and Wednesdays 11:00 to 12:00 PM
(Nelson) Tuesdays and Thursdays at 9:45 to 10:45 AM

Exams and grading: A significant fraction of the final grade is determined from exam and quiz performance.

Exams (4): 13 March, 10 April, 1 May, and final[1]	35 %
Quizzes (top 5):	20 %
Problem Sets (5)[2]:	10 %
Lab:	30 %
Class participation:	5 %

Course description: Intermediate theory of fluid motion for the atmosphere and ocean. In this class, emphasis will be placed on large-scale applications and basic theory for geophysical wave types. Additionally, the thermal wind, frictional flow, vorticity concepts, Rossby, planetary, topographic and inertia-gravity waves will also be discussed. Scaling assumptions for and implications of quasi-geostrophic dynamics are introduced.

There are four principle course objectives:
1) To develop an understanding of the importance of rotation and stratification on atmospheric and oceanic phenomena.
2) To begin to develop the necessary tools and skills required to analyze atmospheric and oceanic data sets.
3) To develop and use fundamental analytical skills for understanding geophysical fluid flows.
4) To strengthen problem solving skills.

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[1] The final exam will have twice the weight of an individual in-class exam. The final is scheduled for 2:45PM 14 May 2009.

[2] Problem sets are due in class before solutions sets are distributed. If you turn your problem set in late, expect to lose credit. No credit will be given to problem sets turned in after the solutions have been distributed or posted. Please turn in all problems sets to either the TA or me, not in our mailboxes unless you have written permission.

These objectives will be achieved through a combination of 1) review of lecture materials, 2) completion of frequent problem sets and practical laboratory assignments, 3) careful reading and thoughtful evaluation of reading assignments, 4) active participation in class and laboratory activities.

Course outline:

I. Introduction and review [H: CHAPTERS 1-3 and M:1-4]
- A. Importance of rotation and stratification in rotating fluids [C-R: CHAPTERS 1 and 9]
- B. Review of eq'ns of motion, thermodynamic eq'n, eq'ns of state, continuity [C-R: CHAPTERS 1-3; H: CHAPTERS 1-3]
- C. Scale analysis of equations and definitions of non-dimensional flow descriptors: Rossby numbers (Ro_T and Ro), Ekman number (Ek), Froude number (Fr) [C.R: 40-45]
- D. Basic geophysical force balances (hydrostatic, geostrophic)
- E. Hydrostatic approximation, generalized vertical coordinates [H: p. 21-24]
- F. Thermal wind
- G. Boussinesq approximation [C-R: p.37-40]
- H. Descriptions of 2D fluid flows (kinematics)

III. Neutrally stratified, rotating flows [CR: CHAPTER 4]
- A. Taylor-Proudman Theorem ($Ro_T << 1$, $Ro << 1$, $Ek << 1$, $Fr >>1$)
- B. Shallow water dynamics ($Ro_T \sim 1$, $Ro \sim 1$, $Ek << 1$, $Fr >>1$)
- C. Shallow water potential vorticity

II. Circulation and vorticity [H: CHAPTER 4; M: CHAPTER 5]
- A. Circulation theorems and the baroclinic and barotropic vorticity equations
- B. Barotropic vorticity equation and Rossby's solution

IV. Effects of friction ($Ro_T <<1$, $Ro <<1$, $Ek \sim 1$, $Fr >>1$) [C-R: CHAPTER 5; H: CHAPTER 5]
- A. Reynolds averaging, stress
- B. Energetics of turbulence
- C. Planetary boundary layer equations
- D. Bottom Ekman layer, secondary circulations, and "spin down"
- E. Surface Ekman layer

V. Neutrally stratified, rotating flows ($Ro_T \sim 1$, $Ro << 1$, $Ek << 1$, $Fr >>1$) [C-R: CHAPTER 6; H: CHAPTER 7]
- A. Introduction to wave phenomena
- B. Linearization of equations
- C. Shallow water waves (inertia-gravity, Kelvin, topographic and planetary waves)

VI. Rotating, stratified flows ($Ro_T << 1$, $Ro << 1$, $Ek << 1$) [H: CHAPTER 6]
- A. Quasi-geostrophic theory
- B. The "ω-equation" and the height tendency equation

The laboratory section of this course will consist of exercises focused toward gaining practical experience in the analysis and interpretation of atmospheric and oceanic data, and demonstrations of physical principles as manifested in atmospheric and oceanic flows through the use of a rotating tank apparatus.

Laboratory exercises and demonstrations will include but are not limited to:

1. Subjective analysis and interpretation of surface and upper tropospheric data plotted using GEMPAK
2. Using GEMPAK for diagnostics; GEMPAK scripting
3. Inversion of vorticity using MATLAB
4. Global barotropic vorticity forecast model
5. Use of rotating tank to explore and demonstrate geostrophy, thermal wind balance, Taylor-columns, and friction effects.

Class email list: atmocn311-1-s09@lists.students.wisc.edu

Class web page: http://aurora.aos.wisc.edu/311

Required Texts:
Introduction to Geophysical Fluid Dynamics, by B. Cushman-Roisin, Prentice Hall. [CR]
An Introduction to Dynamic Meteorology, by J. Holton, Academic Press. [H]
Mid-latitude Atmospheric Dynamics: A First Course by J. Martin [M]