**ATMOSSC 5952: Dynamical Meteorology II**
Spring, 2020

Instructor Prof. Zhengyu Liu,
Class Meetings TR 09:35-10:55pm
Classroom Derby Hall, Room 1116
Credits 3
Course website
Prerequisites ASP 5951 or consult instructor

Instructor Information:
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Office Hour: Tuesday: 11:00-12:00pm

**Text Book**
Handout to be emailed

**Course Objectives**
The basic objective of this course is to provide students with the advanced knowledge of the fundamentals of atmospheric dynamics beyond ASP5951. The knowledge will facilitate students' comprehension of meteorological processes that determine the weather and climate. This increased comprehension of important physical processes will improve students' ability to analyze and to forecast the state of the atmosphere and climate.
One distinctive feature of this class, different from other ASP classes, is the heavy derivation of basic equations. This is a key part of the class and is absolutely necessary for you to truly understand many basic physical concepts. This will be reflected in exams and quizzes.
The intention of this class is enable you to combine physical concepts with basic math equations such that you can have a deep understanding of the dynamics that control the atmospheric and climate variability.
The course is designed as the last dynamic course for senior undergraduate and graduate students in Geography Department, but also applies to students in other departments interested in theories of rotating fluid dynamics.

**Course Structure**
The class will meet two days per week for 80 minutes each day. Lectures present material on dynamic processes and their applications. Important equations are derived and the implications of assumptions discussed. Examples of atmospheric and oceanic problems are discussed.

**Course Description**
This course discusses advanced dynamic theories for large-scale atmospheric motion in the framework of quasi-geostrophic dynamics. The course studies the shallow water system in the first half and the stratified flow in the second half. The major concepts to be discussed are: scaling analysis, the shallow water system, potential vorticity, the quasi-geostrophic system, Rossby waves and baroclinic instability.

**Textbook**
Zhengyu Liu, Dynamic Meteorology II (handout)

**Grading**:
38% homework+quiz,
30% mid-term exam,
30% final exam,

2% class attendance and classroom interaction impression.
For fairness between undergraduates and graduates, the grading scheme for mid-term and/or final exam will be slightly in favor of undergraduates.

**Detailed Requirements**
Examination: Each examination will contain both descriptive questions and derivation questions. The descriptive questions focus on major physical concepts. The derivation questions test your basics in understanding the dynamics quantitatively.

Homework assignments: Homework assignments will be due in class every 1-2 weeks. The homework assignments are designed to accomplish two goals. The first goal is to give students some experience solving basic dynamic problems using concepts introduced in class. A second goal is to make students think about the dynamic processes that occur in certain atmospheric phenomena. More challenging problems may require students to combine dynamic principles in order to arrive at the solution to the problem.

Quiz: Short quizzes (10-20 minutes) will be given, at least, once for each chapter, on class, not necessarily with notice in advance. These quizzes are designed to test your knowledge and skill of the derivation of basic equations discussed in the class. The grade on each quiz is the same as one set of homework.

Class interaction impression and attendance: Active participation of classroom discussion, which includes raising and replying questions on class, are strongly encouraged. Class attendance will also be counted. The impression on both together will count as 5% of the total grade.

**Other Policies**
Units: Numerical answers are incomplete unless they are accompanied by the correct simplified units. Points will be deducted on examinations and homework assignments if units are incorrect, unsimplified, or missing.
Late policy: Assignments and corrections are due on the stated date. Late homework will not be accepted unless you have the permission from the instructor in advance.
Academic Misconduct: All examination and homework answers are expected to be the work of the student whose name appears on them. Copying another student's work is plagiarism and is considered to be academic misconduct.
It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the Committee (Faculty Rule 3335-5-847). For additional information, see the Code of Student Conduct (http://studentaffairs.osu.edu/info_for_students/csc.asp).
Disability Services: The University strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion.
SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

**References:**
1: Gill, A. E., Atmosphere-Ocean Dynamics, 1981, *Academic Press*.
2: Holton, J. R., An Introduction to Dynamic Meteorology (3rd or later editions), *Academic Press*.

**Course Content**

The course chapters are listed as follows:
The sections and subsections with "*" are extra materials that will not be discussed in the class. They are left in the handout for your own interest and future reference.

***Part I: Dynamics of Shallow Water System***

Chapter 1: Basics (2 weeks)
Sec.1.0: Introduction
Sec.1.1: Basic equations,
*Sec.1.2: Conservation laws
Sec.1.3: Circulation, vorticity and Kelvin's Theorem
Sec.1.4: Potential vorticity conservation
Sec.1.5: Shallow water waves on f-plane
*Sec.1.6: Geostrophic adjustment

Chapter 2: Shallow Water Rossby Wave Dynamics (3 weeks)
Sec.2.1: Quasi-geostrophic equation
Sec.2.2: Rossby waves
Sec.2.3: Group velocity and energy propagation
*Sec.2.4: Reflection and normal modes
Sec.2.5: Forced waves
*Sec.2.6: Non-plane waves

Chapter 3: Forced Circulation (1 week)
*Sec.3.1: Atmospheric circulation
Sec.3.2: Ekman dynamics
*Sec.3.3: Sverdrup flow
*Sec.3.4: Rossby wave and ocean circulation adjustment

***Part II: Dynamics of Stratified Flow***

Chapter 4: Basics of Stratified Fluid (1 weeks)
Sec.4.1: Basic equations
*Sec.4.2: Vorticity equation
*Sec.4.3: Ertel potential vorticity

Chapter 5: Rossby Wave Dynamics (3 weeks)
Sec.5.1: Quasi-geostrophic equation for stratified flow
Sec.5.2: Rossby waves in stratified fluid
Sec.5.3: Vertical normal modes
Sec.5.4: The Elliassan-Palm theorem

Chapter 6: Instability Theory (2 weeks)
Sec.6.1: Instability problem
*Sec.6.2: Baroclinic instability in a two-layer QG model
Sec.6.3: Energetics
*Sec.6.2: Charney-Stearn theorem
Sec.6.4: The Eady problem.
*Sec.6.6: Barotropic instability