Advanced Geophysical Fluid Dynamics
EAS - 6155
Spring 2017
Tue-Thu 1.30-2.45pm MOSE Room G021

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Primary Textbooks: *Atmospheric and Oceanic Fluid Dynamics* by G. Vallis, Cambridge Univ. Press, Nov 2006.
On reserve: *Geophysical Fluid Dynamics* 2nd edition, by J. Pedlosky, Springer, 1987

Course overview
This class provides fundamental mathematical tools for graduate students interested in Geophysical Fluid Dynamics (GFD) and related disciplines. Approximately half of this course will cover mathematical methods for fluid dynamics, and the other half covers simple mathematical models of geophysical flows. Students will learn how to solve ordinary and partial differential equations, Fourier and Laplace transforms, wave equations, stability analysis and eigenvalue problem.

As pre-requisite to this course, students should have a basic knowledge of ordinary differential equations, vector calculus, multiple integrals, some knowledge of partial differential equations and Fourier series.

Course evaluation
Attendance and active participation in class: 10%
Homework and problem sets: 30%
Midterm exam: 30%
Final: 30%

Outline

Review of mathematical methods (week 1-3)
Week 1: Mathematical functions: trigonometric, log, exponential, complex numbers, Taylor expansions
Linear algebra, solution for system of equations, eigenvalue and eigenvectors
Week 2: Vector calculus: vector identities, gradient, rotation and divergence, Stokes and Gauss theorem
Classification of differential equations: ODE, PDE, order, linearity, hyperbolic, parabolic, elliptic, initial value and boundary value problems
Week 3: Solution methods for ODEs: linear 1st order, Bernoulli, linear 2nd order homogeneous solution
Integral transforms: Fourier transform, Laplace transform

Kinematics, scaling and fluid dynamics principles (week 4-7)
Week 4: Review of the equation of motion: momentum equation, mass continuity equation, equation of state, compressible and incompressible flows; the energy budget
Week 5: Lagrangian and Eulerian descriptions; Rotation and Stratification: Equations in different frames of reference
Week 6: The Boussinesq approximation; hydrostatic balance, geostrophic and thermal wind balance
Week 7: Time and space scaling of various processes; differences between atmospheric and oceanic flows
Week 8: Partial review and Midterm exam

Shallow water equation and potential vorticity principle (week 9-12)
Week 9: The shallow water approximation and the vorticity equation
Week 10: Vorticity and circulation, circulation theorem and Potential vorticity
Week 11: Spring Break
Week 12: Quasi-geostrophic equation: Quasi-geostrophic approximation to shallow water and continuously stratified system, and quasi-geostrophic potential vorticity
Wave kinematics and geophysical waves (week 13-14)
Week 13: Wave equation: Phase velocity, group velocity, and wave propagation.

Dispersion relation, Rossby waves
Week 14: Geophysical wave exercises: a few topics to be chosen from acoustic wave, Kelvin waves, gravity waves, etc.
Eigenvalue-eigenvector problem and linear stability analysis (week 15-16)
Week 15: Eigenvalue problem and instability: some trivial examples, Kelvin-Helmholtz instability. Linear stability analysis for barotropic instability
Week 16: Exercise using simple models of baroclinic instability: 2-layer model of baroclinic instability, Eady model.
Finals

Class Goals
The desired **learning outcomes** for the students are:
• Acquiring an advanced foundation in geophysical fluid dynamics with application to the oceanic and atmospheric circulation (Foundations)
•Being able to propose, evaluate, and solve problems in geophysical fluid dynamics using analytical techniques (Skills)
• Being able to bring in/suggest the use of analytical tools acquired during the course and commonly used in geophysical fluid dynamics to investigate problems related to the circulation in the ocean and atmosphere (Techniques).
• Learn though exposure to different flavors of problems/solutions (Self-Assessment)

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http://www.catalog.gatech.edu/genregulations/honorcode.php.
Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be

reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Individuals with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services (often referred to as ADAPTS) at (404)89-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.