Overall goal: This class is intended to help students to advance their understanding of the dynamics of the atmosphere and oceans. The focus is on the effects of stratification, on time-variable phenomena, and on the interaction between large-scale circulation and mesoscale eddies.

Topics

I. Introduction

1. Introductory remarks. Main principles and methods of GFD
2. Review of the main equations of motion

II. Quasi-Geostrophic Theory

1. Equations of motions on synoptic scales in the atmosphere and ocean.
   Approximations and derivation
2. Effects of stratification: Layer and continuous models
3. Boundary effects and Ekman dynamics

III. Rossby waves

1. Main properties (mechanism, dispersion relation, phase speed, group velocity, effects of a background flow)
2. Rossby waves in the two-layer system
3. Continuously stratified system. Vertical structure equation and normal modes
4. Vertically propagating and forced stationary Rossby waves
IV. Linear instability theory

1. Barotropic and baroclinic instability. Mechanism and necessary condition
2. Idealized models of baroclinic instability (Eady and Phillips’ models)
3. Energy equation and available potential energy
4. Additional factors: non-zonality of the currents and effects of topography

V. Nonlinear dynamics and wave-mean flow interactions

1. Eliassen-Palm flux. Acceleration of a zonal flow
2. Transformed Eulerian mean and residual circulation
3. Geostrophic turbulence and baroclinic eddies
4. Turbulent diffusion and eddy transport

VI. Non-geostrophic dynamics

1. Extra-tropical Poincaré and Kelvin waves
2. Equatorial waves
3. Role of waves in climate dynamics
4. Frontogenesis in the atmosphere
5. Submesoscale motions in the oceans

Assignments

1. There will be four homework assignments
2. Students will participate in group projects, and present results in the form of oral presentation and a written report

Grades will be based on homework assignments (ca. 30%), mid-term exam (ca. 30%), final project (ca. 30%) and class participation (ca. 10%).

MIDTERM EXAM: March 7th, 2012

Recommended Textbooks

• G.K. Vallis: “Atmospheric and oceanic fluid dynamics” (Cambridge University Press, 2006)
• J. Pedlosky: “Geophysical fluid dynamics” (Springer Verlag, 2nd ed., 1987)
• J. Pedlosky: “Waves in the ocean and atmosphere” (Springer Verlag, 2003)

The syllabus of the class has evolved over the years in RSMAS. It does not exactly follow any textbook.