

MPO 711

Geophysical Fluid Dynamics II

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. Potential vorticity and Quasi-Geostrophic Theory

1. Potential vorticity and motions in the absence of stratification
2. Motions on synoptic scales in the atmosphere and ocean. Approximations and derivation of the main balances
3. Effects of stratification: Layer- and continuous models

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, dissipation and 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. Frontogenesis in the atmosphere
4. Submesoscale motions in the oceans

Recommended Textbooks

- G.K. Vallis: "Atmospheric and oceanic fluid dynamics" (Cambridge University Press, 2006)
- J. Pedlosky: "Geophysical fluid dynamics" (Springer Verlag, 2nd ed., 1987)
- A. E. Gill: "Atmosphere-ocean dynamics" (Academic Press, 1982)
- J. Pedlosky: "Waves in the ocean and atmosphere" (Springer Verlag, 2003)