Ocean Dynamics
and Fundamentals of Large-Scale Circulation

EAS - 8803

Spring 2007
Mon-Wed-Friday @ 10am-11am

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**Course overview**

An advanced class for graduate students in Oceanography and Climate Science that studies the basic equations governing rotating geophysical flows with application to the ocean circulation. This course includes a theoretical component on geophysical fluid dynamics and one involving a combination of observations, theory and numerical modeling relevant to understand the large scale ocean circulation.

Pre-requisite: Introduction to Oceanography (EAS - 4300/6124) (required), and/or one of the following: Introductory Fluid Dynamics (EAS – 6502); Dynamic Meteorology (EAS – 6512), Atmospheric Dynamics (EAS - 4655), Climate and Global Change (EAS – 4410). Knowledge of partial differential equations is required.
Outline

Week 1: Review of the equation of motion: momentum equation, mass continuity equation, equation of state, compressible and incompressible flows; the energy budget. (Vallis, 1.1, 1.2, 1.3, 1.7, 1.9, 1.10.)

Week 2-3: Rotation and Stratification: Equations in different frames; the Boussinesq approximation; the hydrostatic and geostrophic balance; the Ekman layer; the shallow water approximation (Vallis 2.1-2.4, 2.7, 2.8, 2.12, 3.1-3.4, 3.6-3.8, 3.10)

Week 4: The vorticity equation in a rotating frame: Vorticity, circulation, vorticity and circulation theorems, conservation of potential vorticity, properties (Vallis 4.1-4.5, 4.7, 4.8, Pedloky, GFD chapter 2)

Week 5-6: The geostrophic equations and the quasi-geostrophic approximation: The planetary geostrophic equation, the quasi-geostrophic approximation (shallow water and continuously stratified), Rossby waves, Rossby waves in the ocean and in stratified quasi-geostrophic flows (Vallis 5.1-5.4, 5.7-5.8, Pedlosky GFD Chapter 6, Salmon 2.1-2.11)

Week 7-8: Barotropic and baroclinic instability: Kelvin-Helmholtz instability, barotropic instability: necessary conditions, baroclinic instability, available potential energy, the 2-layer model (Salmon, 2.12-2.21, Vallis, 6.1-6.8, Pedlosky GFD chapter 7).

Week 9: Partial review and Midterm Exam (tentative date March 7th)

Week 10-11: Turbulence and geostrophic turbulence Fundamentals of turbulence, Kolmogorov Theory, quasigeostrophic turbulence, stratified quasigeostrophic turbulence, two-layer turbulence, baroclinic eddies in the ocean (Vallis, 8.1-8.3, 8.5, 9.1-9.2, 9.4, Salmon, 4.5-4.10, 6.1-6.5)

Week 12: Turbulent diffusion and eddy transport: Molecular and turbulent diffusion, absolute and relative dispersion, mixing length theory, transport by eddies and eddy diffusion (Vallis, 10.1-10.7)

Week 13: The Wind-driven circulation: The Stommel model and alternative formulations, the quasigeostrophic gyre model, the nonlinear problem, the inertial western boundary current, the role of friction, the Fofonoff model, topographic effects (Vallis, 14.1-14.6, Pedlosky OCT 2.5-2.9; 3.1-3.10, Pedlosky GFD chap. 5, 5.1-5.14).
Week 14: The buoyancy driven circulation: the ‘horizontal’ convection model, 2D convection, the maintenance of circulation, simple box-models, a laboratory model, a model for the abyssal oceanic flow (Vallis, 15.1-15.6; Pedlosky OCT 7.1-7.3, 7.7)

Week 15: Wind and buoyancy driven circulation: The main thermocline, the internal thermocline and the ventilated thermocline (Vallis, 16.1-16.4; Pedlosky OCT 4.1-4.12)

Finals: Tentative date May 2nd

Course evaluation

Homework and problem sets: 30%
Midterm exam: 30%
Final: 40%