Ocean Dynamics
and Fundamentals of Large-Scale Circulation

EAS - 8803

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

Dr. Annalisa Bracco
ES&T 3244; Phone: 894-1749
annalisa@eas.gatech.edu

Primary Textbook: *Atmospheric and Oceanic Fluid Dynamics* by G. Vallis, Cambridge Univ. Press, Nov 2006.

On reserve: *Lectures on geophysical fluid dynamics* by R. Salmon, Oxford Univ. Press, 1998.
Geophysical Fluid Dynamics 2nd edition, by J. Pedlosky, Springer, 1987
Ocean Circulation Theory by J. Pedlosky, Springer, 1996

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%