MPO 673: Vortex Dynamics

Spring 2010

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Classes: Tuesday, Thursday, 10:30AM-11:45AM, MSC 329.

Summary:

This course will cover fundamental to advanced topics in vortex dynamics. Beginning with a review of fluid dynamics and vorticity in two dimensions, we will study a variety of exact and approximate solutions that describe two-dimensional vortex behavior. This process will then be repeated for three-dimensional vortex dynamics in unstratified flow, and then for three-dimensional vortex dynamics in stratified flow, with applications to vortices in the atmosphere and ocean.

Outline:

I. Two-Dimensional Flow
   A. Equations of motion
   B. Angular momentum, circulation, and vorticity
   C. Vorticity and streamfunction equations
   D. Stationary solutions
   E. Asymmetric vortex dynamics
   F. Asymmetric solutions

II. Three-Dimensional Flow
   A. Equations of motion in three dimensions
   B. Vorticity inversion and Green’s functions
   C. Vortex rings and impulse
   D. Stretching, folding, and turbulence

III. Three-dimensional, stratified flow
   A. Physical phenomena and scaling
   B. Potential Vorticity
   C. Boundary Layers
   D. Asymmetric vortex dynamics in stratified flow

IV. Term Projects

The term projects will require each student to use one or two previously developed numerical models of fluid motion and vortex dynamics that may include (but are not limited to): a vortex-method model of two-dimensional flow, a vortex-method model of three-dimensional flow, a
grid-based model of two-dimensional flow, a nonlinear model of axisymmetric flow, a linear model of asymmetric vortex dynamics in the shallow water equations, and a linear model of asymmetric vortex dynamics in stratified flow. Each student will propose a simple phenomenon and/or question to investigate, and then perform a small set of calculations or numerical simulations to address them. The work will be presented in two 15 minute-presentation and a short term paper.

Assignments:

There will be occasional homeworks (10%), a mid-term (20%), and a term project with two presentations (20% each) and a short paper (30%).

Resources:

The class will not follow a single textbook. However, we will use readings and material from a variety of textbooks and monographs, some of which will be:

Vallis, G. K., 2006: Atmospheric and Oceanic Fluid Dynamics.