12.804 — Waves on a PV Front — Numerical Model

Purpose:

Study the properties of waves on one or more fronts separating regions of constant potential vorticity.

Numerical Model:

Select the `frontal waves, num (1 and 2 fronts)` link on `http://wind.mit.edu/~glenn/12.804`.

This programs are intended to solve the inversion problem

$$\nabla^2\psi = q_0 + \sum \Delta_i \mathcal{H}(y - [Y_i + \eta_i(x,t)]) \tag{1}$$

with $\mathcal{H}$ being the step-function and calculate the movement of the fronts

$$\frac{\partial}{\partial t}\eta_i = \frac{\partial\psi}{\partial y}\frac{\partial\eta}{\partial x} + \frac{\partial\psi}{\partial x}$$

Periodicity in x is assumed, with period 2π. This is equivalent to moving the points on the front as Lagrangian particles:

$$\dot{x}_j = -\psi_y(x_j, y_j) \quad , \quad \dot{y}_j = \psi_x(x_j, y_j) \tag{2}$$

The inversion of (1) is accomplished using a Green's function integral, approximated by a sum.

To Use:

You need to set the values for:

Y Vector of average y position of the interfaces (e.g., `-0.3;0.3`)

Δ Vector of PV steps across interfaces (e.g., `-1;1`)

u_0 Zonal flow in southernmost region (e.g., `-0.3`)

q_0 PV in the southernmost region (e.g., `0`)

$\eta_1(x,0)$ Initial perturbations to the fronts (e.g., `0.1*sin(x);0.1*sin(x)`

Clicking on any of the `Click here to run` buttons will show you the background zonal flow and the evolution of the frontal positions.

To think about

· Find the dispersion relationship for waves on a single front empirically.

· How does nonlinearity affect the waves?

· What effect does q_0 have?

· Consider a wave on an atmospheric/ oceanic front from some data. Estimate the speed of travel you would expect to find and compare it to the actual evolution.

· Estimate the wavelength/width ratio required for the instability of a shear layer.

· What is the effect of additional large scale shear (q_0)?

· Unequal magnitude of PV jumps? Same sign?

· Multiple waves in initial conditions?

· Triangular jet (three fronts)?

· Modify the code to look at two vortices or a vortex and a front and try some experiments with that.