12.804 — Baroclinic Inversion/ Instability — Numerical Experiments

This is a two layer version of the doubly–periodic, quasigeostrophic code we used to study Rossby waves and vortices. It solves the equations

$$\left[\frac{\partial}{\partial t} + U_1\frac{\partial}{\partial x} + J(\psi_1, \cdot)\right] q_1 + [\beta + F_1(U_1 - U_2)]\,\frac{\partial}{\partial x}\psi_1 = filter$$
$$\left[\frac{\partial}{\partial t} + U_2\frac{\partial}{\partial x} + J(\psi_2, \cdot)\right] q_2 + [\beta + F_2(U_2 - U_1)]\,\frac{\partial}{\partial x}\psi_2 = filter$$

with the inversion formulae

$$q_1 = (\nabla^2 - F_1)\psi_1 + F_1\psi_2$$
$$q_2 = (\nabla^2 - F_2)\psi_2 + F_2\psi_1$$

The model runs via `http://puddle/~glenn/12.804` with the appropriate link on the Linux machines. For the inversion, you specify the parameters U_1, U_2, F_1, F_2, and β. Given the fields for q_1 and q_2 as functions of x and y, the program will calculate ψ and contour both the PV anomalies q_i and the full PV fields $q_i + [\beta + F_i(U_i - U_{3-i})]y$. It will also show the streamfunction anomalies ψ_i and the full streamfunction $\psi_i - U_i y$.

Once you have specified the PV and/or streamfunction fields, use QG model to see how the flow evolves. The parameters are similar to those in the BT vorticity equation solver.

Experiments to consider

· Explore the relationship between upper layer PV anomalies and the flows in both layers.

· Explore the instability criterion.

· Show that stable waves can still amplify, at least temporarily, if the initial phase relationships between upper and lower layers are correct.

· Examine the interaction of two blobs of anomalous PV, one upper layer and one lower. Figure out the conditions under which they will reinforce each other. (Hint — remember that the primary effect of the PV anomalies in linear theory is to advect the background PV gradients.) What happens in the nonlinear regime?

· A growing plane wave is an exact solution to the equations above. What happens when such a wave is perturbed? Compare unperturbed to perturbed solutions.