Homework-07 Due Tue Nov.-22, 2005

1. Show that the solutions to the (nonlinear) geostrophic adjustment problem

$$\mathbf{h(x) = H\,[1 - \exp(x\text{-}L_D)/L_D)]}$$
$$\mathbf{v(x) = -(g'H)^{1/2}\,\exp(x\text{-}L_D)/L_D)}$$

are consistent with the thermal wind equation

$$\partial_z v = -g/(\rho_0 f)\,\partial_x \rho$$

which writes in discrete form (Margules relation)

$$\Delta v/\Delta z = -g/(\rho_0 f)\,\Delta\rho/\Delta x$$

where the variable h is the thickness of the upper layer of density ρ overlaying a lower layer of density ρ_0, v is the along-front velocity, $L_D=(g'H)^{1/2}/f$ is the internal Rossby radius of deformation, and $g'=g\Delta\rho/\rho_0$ is the reduced gravity [10 pts].

2. Please find and correct ALL errors in the statement:

"…the thermal wind relation $\partial_z u=g/(\rho_0 f)\partial_x\rho$ gives the horizontal velocity shear as a function of depth. A reference velocity is not necessary to estimate this quantity, however, one must prescribe a vanishing pressure gradient at the bottom to estimate a geostrophic velocity in a contineously stratified fluid…" [5pts]

3. Below you find a graphical presentation of the density anomaly ρ-1000 kg/m^3 (contours) and temperature (colors) fields taken during a survey Sept. 22-26, 2004 near 73N latitude in the Arctic Ocean (courtesy of Dr. Pickart, WHOI, see http://www.whoi.edu/arcticedge/arctic_west04/update/ for a narrative). Use the thermal wind relation to roughly estimate the geostrophic velocity field associated with this feature assuming that the horizontal pressure gradient vanishes at 300-m depth. More specifically, estimate currents relative to no flow at 300-m at distances (5,15,25) km and depths (50,100,150,250) m and sketch the results. What is the Rossby number (relative to planetary vorticity) of this feature. [10 pts]