Atm 611 **Problem Set #2** **Fall 2014**

Note: These problems were taken from Ch. 6 of Holton (2004) with a subtle modification to the first problem.

1. Given the following expression for the geopotential field where Φ_o is a function of p alone, c is a constant phase speed, k is a zonal wave number, and p_o = 1000 hPa.

$$\Phi = \Phi_o(p_o) + cf_o\{y[\cos \pi p/p_o - 1] + k^{-1} sink(x - ct)\}$$

a) Obtain expressions for the corresponding geostrophic wind and relative vorticity fields.
b) Obtain an expression for the relative vorticity advection.
c) Use the quasi-geostrophic vorticity equation to obtain the horizontal divergence field consistent with this Φ field (assume that $\frac{\partial f}{\partial y} = 0$)
d) Assuming that ω (p_o) = 0, obtain an expression for ω (x, y, p, t) by integrating the continuity equation with respect to pressure.
e) Sketch the geopotential fields at 750 hPa and 250 hPa. Indicate regions of maximum divergence and convergence, and cyclonic and anticyclonic vorticity advection.

2. For the geopotential distribution of Problem 1 obtain an alternative expression for ω by using the adiabatic form of the thermodynamic equation (equation 6.13b in Holton 2004). Assume that σ is a constant. For what value of k does this expression agree with that obtained in Problem 1

3. As an additional check on the results of Problems 1 and 2 use the approximate omega equation (eq 6.36 in Holton 2004) to obtain an expression for ω. Note that the three expressions for ω agree only for one value of k. Thus, the geopotential field Φ (x, y, p, t) of Problem 1 is consistent with quasi-geostrophic dynamics only for one value of the zonal wave number for a given value of σ and f_o.