# ATM 500: Atmospheric Dynamics
# Homework 6
### Due Thursday November 6 2015

1. Suppose that in a hydrostatic atmosphere in the southern hemisphere, temperatures increase northward on every pressure level between the surface and the tropopause. Also suppose that the pressure gradient force is zero on the 500 hPa surface (about halfway between the surface and tropopause). Make a sketch that shows how the slope of pressure surfaces and the geostrophic winds must vary with height. Make sure to explain your reasoning. What is the direction of the geostrophic wind near the surface? What about near the tropopause? (Use the meteorological convention: "westerly" = from the west, "northerly" = from the north, etc.)

2. In class we did a linear wave analysis for small perturbations in the $x, z$ plane away from a state of rest ($\vec{v_0} = 0$) for the non-rotating simple Boussinesq system.

   a. For these waves, show that the phase speed in the *vertical* direction ($c^z = \omega/m$) is in the opposite direction of the vertical component of the group velocity, $c_g^z = \partial\omega/\partial m$. (This means that energy must travel downward wherever peaks and troughs are propagating upward and vice-versa).

   b. Consider now small perturbations away from a state with a constant background velocity in the $x$ direction, $\vec{v_0} = U\hat{i}$ (where $U$ is a constant). You may still assume that the motion is a function of $x$ and $z$ only as we did above. Show that the dispersion relation for these waves is

   $$\omega = Uk \pm \frac{Nk}{\sqrt{k^2 + m^2}}$$

   c. Does the presence of a constant background velocity $U$ change your answer in part (a)?