Gravity Waves with Wind

1. Basic State with Constant Wind Modify the analysis of gravity waves shown in class to consider a basic state with a constant horizontal wind $\vec{U} = U \hat{x}$.

a) Obtain the linearized equations and the dispersion relation.

b) The “intrinsic frequency” is defined as $\omega_i = \omega - kU$, where $\omega$ is the actual frequency and $k$ is the horizontal wavenumber. Show that the dispersion relation for the intrinsic frequency for arbitrary $U$ is identical to the dispersion relation for the actual frequency in the case where the basic state has $U = 0$.

c) What does this result tell you about gravity waves with a mean wind? Think about the phase speed of the wave and ideas about reference frames.

2. Topographically Forcated Stationary Waves Consider a sinusoidal topography with wavenumber $k_0$ in the $x$-direction. Wind blowing over such a topography can excite resonant stationary waves. Here, resonant means the waves have the same horizontal wavenumber as the topography, $k = k_0$, and stationary means they are independent of time and so have zero frequency, $\omega = 0$.

a) Using your results from problem 1, solve for the vertical wavenumber $m$ for such stationary waves in terms of $U$, $N$, and $k_0$.

b) Determine which conditions give rise to waves and which give rise to modes which exponentially grow and decay in $z$. 