ATM 317 Homework # 5  
Due Tuesday 28 April, 5:00 PM EDT

Answer the following questions on a separate sheet of paper. **SHOW ALL WORK!**

1. Starting from the Quasi-Geostrophic momentum equations, derive the Quasi-Geostrophic vorticity equation, which was shown in lecture. Hint: Follow the steps used to derive the vorticity equation on height and pressure coordinates, but starting from the QG momentum equations.

2. Let us return to a question from a previous homework related to the increase of vorticity with time due to convergence or divergence (homework 2, question 4). A cyclonic vortex is observed in the atmosphere at 43°N, with an initial relative vorticity value of \( \zeta = 1 \times 10^{-5} \, \text{s}^{-1} \). A uniform field of horizontal convergence (\( \nabla \cdot \vec{V} = -2 \times 10^{-6} \, \text{s}^{-1} \)) persists for a full day.

   a) Estimate the change in \( \zeta_g \) using the Quasi-Geostrophic vorticity equation.

   b) How does your equation and answer from (a) compare to the answer you obtained by employing the vorticity equation on pressure coordinates (homework 2, question 4, which is given below)? Specifically, what aspects of this solution(s) explain the difference?

\[
\zeta(t) = [f_o + \zeta(t = 0)]e^{-(\nabla \cdot \vec{V})\times t} - f_o
\]

3. Figure 1 shows the 300 hPa geopotential height (units: m) for a specific time.

   a) Identify the jet streaks.

   b) Draw ageostrophic wind vectors, accounting for all types of accelerations.

   c) Identify locations which would be characterized by upward vertical motion. As a reminder, upward vertical motion will be present when you have divergence of the ageostrophic wind in the upper troposphere.