ATM 317
Homework 2
Due: Mon, 4 March 2019

1. Relative vorticity is defined by $\zeta = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}$.
   a. Using the isobaric definition of the geostrophic wind, derive an expression for geostrophic relative vorticity in expressed in terms of ϕ.

   b. Use your answer from part (a) to show that for the Northern Hemisphere, local minima in geopotential height represent regions of positive geostrophic relative vorticity and local maxima in geopotential height correspond to regions of negative geostrophic relative vorticity.

   c. An equivalent barotropic environment is one in which the geopotential height contours are parallel to the isotherms/thickness contours. If such an environment is present in the troposphere and characterized by a cyclonic vorticity, will the geostrophic relative vorticity be larger at 850 hPa or at 500 hPa? Use a diagram and the necessary dynamical relationships to explain your reasoning.

2. Under what conditions can curved geostrophic flow have zero relative vorticity? Draw a schematic diagram to help you explain your answer.

3. A pair of cyclonic and anticyclonic vortices is observed in the atmosphere at 43°N. Both vortices have the same area-averaged value of relative vorticity ($|\zeta| = 1 \times 10^{-5}\ s^{-1}$). A uniform field of horizontal divergence and convergence, with equal magnitudes ($|\nabla \bullet V| = 2 \times 10^{-6}\ s^{-1}$) associated with the cyclonic and anticyclonic vortices, respectively, persists for a full day.

   a. Estimate the respective changes in ζ for both the anticyclonic and cyclonic vortices as a consequence of this environment.

   b. In the real world, it is observed that departures from the average sea level pressure are larger in extreme cyclones than in extreme anticyclones. Explain why the result from (a) provides a dynamical reason for this asymmetry.