SIO 217B Atmospheric and Climate Sciences II

Exercise #15

1. a) Write down an equation for calculating the vertical component of relative vorticity in spherical coordinates. Split $\partial/\partial\phi$ (u cosϕ) into separate terms.

   b) **Optional.** What does the tangent term physically represent?

   c) Download the files containing Z_{500}, u_{500}, and v_{500} for 1993 March 14 00Z and calculate relative vorticity ζ_{500}. For more convenient numbers, multiply vorticity by 10^5. Plot contours of relative vorticity overlaid by wind vectors in the domain 20-50°N, 270-310°E using intervals of 5 (actually 5×10^{-5} s^{-1}). Add contours of geopotential height using intervals of 6 dkm.

   d) Check your results by downloading and plotting model ζ_{500} with Z_{500}, u_{500}, and v_{500} for 1993 March 14 00Z in a different figure. There will not be exact agreement due to differing methods of calculating vorticity in the model and here.

   e) Note how anticyclonic relative vorticity occurs on the equatorward side of the trough (east of Florida). Explain why relative vorticity is anticyclonic in this region even though the large scale flow is counterclockwise around a trough.

2. **Optional.** Now calculate relative vorticity using the circulation method. For example, vorticity at point i, j can be obtained from the circulation around the path extending from i-1, j-1 to i+1, j-1 to i+1, j+1 to i+1, j-1 to i-1, j-1, where i and j are longitude and latitude indices, respectively. Assume that zonal velocity between points i-1 and i+1 is the same as at point i and that meridional velocity between points j-1 and j+1 is the same as at point j. Plot ζ_{500} from circulation with Z_{500}, u_{500}, and v_{500} in the domain 20-50°N, 270-310°E. The plot should be very similar to that for ζ_{500} calculated from finite differences.

3. a) Download the file containing Z_{500} for 1993 March 14 00Z and calculate the zonal and meridional components of geostrophic wind (as in Exercise #9). Using the finite difference method, calculate the geostrophic relative vorticity ζ_g. Plot contours of geostrophic relative vorticity overlaid by geostrophic wind vectors in the domain 20-50°N, 270-310°E using intervals of 5 (actually 5×10^{-5} s^{-1}). Add contours of geopotential height using intervals of 6 dkm.

   b) **Optional.** Write down an equation for calculating geostrophic relative vorticity directly from geopotential height in spherical coordinates. Split $\partial/\partial\phi$ (cosϕ $\partial\Phi/\partial\phi$) into separate terms.

   c) **Optional.** Calculate geostrophic relative vorticity using the above method and plot it with geostrophic wind vectors in the domain 20-50°N, 270-310°E using intervals of 5 (actually 5×10^{-5} s^{-1}). Add contours of geopotential height using intervals of 6 dkm. The plot should be very similar to that for geostrophic vorticity calculated from geostrophic wind, but exact agreement cannot be expected due to the differing methods.