SIO 217B Atmospheric and Climate Sciences II

Exercise #10

1. a) Download the file containing Z_{1000} data for 1993 March 14 00Z. Calculate geostrophic wind from the Z_{1000} data as in Exercise #9. Plot geostrophic wind vectors in the domain 20-50°N, 270-310°E. Calculate the divergence of the geostrophic wind as in Exercise #5. For more convenient numbers, multiply divergence by 10^5. Plot contours of divergence over the wind vectors using intervals of 2 (actually 2×10^{-5} s^{-1}). Your plot should look very similar to that showing divergence of geostrophic wind calculated from SLP and constant density in Exercise #5.

   b) Replot wind vectors and divergence using intervals of 0.2 (actually 0.2×10^{-5} s^{-1}). Note that the divergence of the geostrophic wind is not zero, but instead is only much smaller than the divergence of the actual wind.

   c) What is the relationship between the pattern of geostrophic wind and the pattern of divergence?

2. Recalculate geostrophic wind from Z_{1000} data using a constant value of Coriolis parameter, f_0. Let $f_0 = 2\ \Omega \sin(35°N)$, since 35°N is the midpoint latitude of the domain. Recalculate divergence for constant-f geostrophic wind, and plot the new wind vectors and divergence contours using intervals of 0.2 (actually 0.2×10^{-5} s^{-1}). Note that divergence is now zero, aside from numerical errors resulting from the discretization of derivatives. These errors would decrease if we used a more sophisticated numerical method than centered differences or if we carried out calculations on grid spacing smaller than 1°×1°.

3. a) Derive an equation for the divergence of geostrophic wind in the case that Coriolis parameter is not constant. Put divergence in terms of the meridional component of geostrophic wind (v_g), Coriolis parameter (f), and the variation of Coriolis parameter with northward distance (β). Note that $\beta = df/dy = a^{-1}\, df/d\phi$, where a is the radius of the earth and ϕ is latitude.

   b) Calculate the divergence of the geostrophic wind using the above equation and multiply by 10^5 for convenience. Plot geostrophic wind vectors and divergence contours in the domain 20-50°N, 270-310°E using intervals of 0.2 (actually 0.2×10^{-5} s^{-1}).

   c) Is the divergence pattern identical to what you previously plotted? Explain physically why the meridional component of geostrophic wind produces divergence when the Coriolis parameter is not constant.