ATM 240 – Fall 2016

Problem set #7 29 pts Due: 17 November 2016

1. Jet stream acceleration and maintenance. In this problem the zonal mean eddy momentum flux convergence is compared with the angular momentum conservation in a poleward ageostrophic flow. Consider figure 5.7a. At 30N, from 75E to 135E, the wind at 200 hPa accelerates from 45 to 70m/s.

a. (4 pts) Evaluate the acceleration in the flow over the indicated longitude range by finding the value of $u^{\#}/\{r^*\cos(\varphi)\}\ \partial u/\partial\lambda$. Use the average value of u for $u^{\#}$. Evaluate the derivative using a finite difference.

b. (2 pts) Estimate the ageostrophic wind v_a from this balance: $f\ v_a = u^{\#}/\{r^*\cos(\varphi)\}\ \partial u/\partial\lambda$.

c. (4 pts) Use following observations of [u'v'] to estimate $-\{1/r\}\ \partial\{[u'v']\cos(\varphi)\}/\partial\varphi$ at two latitudes: 30N and 40N. Apply a centered second order finite difference using [u'v'] = 28.42 m^2/s^2 at 27.5N, = 39.23 at 32.5N, = 38.94 m^2/s^2 at 37.5N, and = 31.11 at 42.5N. Compare the acceleration found in part a with the accelerations found in part c.

2. (4 pts) Starting with the RHS, derive the LHS of the identity on the bottom of page 97.

3. **Rossby wave source** The Rossby wave source, S, is defined from the divergent wind $\mathbf{V}_\chi$ and divergence D (see formula at bottom of p. 276). S is a source of absolute vorticity that is related to divergent motions. S extrema are offset from velocity potential, χ, extrema. This problem shows that offset and how it locally enhances stream function gradient, and thus the winds.

Note that divergent wind components are related to χ by:

$$u_d = \frac{\partial \chi}{\partial x} \qquad v_d = \frac{\partial \chi}{\partial y} \qquad making \quad D = \nabla^2 \chi$$

Assume the problem has been nondimensionalized so that the Coriolis parameter is simply f=sin(y) and its derivative is β=cos(y). The domain is Cartesian: $\pi/4 \geq y \geq 0$, $\pi/2 \geq x \geq -\pi/2$. Convection on the 'southern boundary' y~0 and sinking on the opposite boundary are modeled by this specification: $\chi = -\cos(b^*y) * \cos(x)$ field. Find and plot the indicated quantities.

a. (6 pts) Derive the expressions for u_d, v_d, D, and S.

b. (5 pts) Plot χ , u_d, v_d, D, and S. over the domain using at least 11 grid points in each direction. Use b=4

c. (4 pts) Assume that the S found in part b can be treated as an amount of absolute vorticity that accumulates over 1 unit of time. Further assume that the inverse laPlacian of S is simply: -S and that inverse would be a stream function $\psi_S = -S$. Assume a background westerly flow is present that can be indicated by another stream function given by: Ψ = a*y and let a= -10. Add the two stream functions together and plot the result. Compare that plot with a plot the stream function Ψ. (Your comparison should indicate where the maximum stream function is in each case and where the gradient is made stronger and weaker by including ψ_S .)

NOTE: all homework is to be done by you as an INDIVIDUAL: no 'group' efforts, please. For written answers, please use a word processor, so that penmanship is not an issue. Equations and derivations can be *neatly* hand-written. Full credit requires proper units be included. Any plot must be completely and unambiguously labeled, including title and axes. Show ALL math steps.