

12.812 END-OF-TERM EXAM

December 6, 2004

1. (15%) Compare and contrast qualitatively the seasonal changes in the vertically averaged meridional flux of sensible heat by transient and stationary eddies in the Northern Hemisphere.
2. (15%)
 - (a) Define “inertial subrange.”
 - (b) How do you expect the zonal wind spectrum to depend on wave number in an inertial subrange?
 - (c) What zonal scales dominate the observed Northern Hemisphere midlatitude spectrum of transient eddy meridional sensible heat transport at 850 hPa?
3. (15%) State the modified form of the Eliassen-Palm Theorem for a quasi-geostrophic system when forcing by the eddy moisture flux is taken into account.
4. (15%) Give Lorenz’s definition of available potential energy.
5. (15%) Describe qualitatively how the Lorenz energy cycle changed in Phillips’s (1956) numerical experiment when eddies were introduced.
6. (25%)
 - (a) Assume that the zonal mean annual mean planetary albedo and thermal emissions to space are independent of latitude, and that the zonal mean annual mean incident solar radiation is described by $[\overline{Q}] = \frac{S_0}{4}(1+S_2P_2)$, where $P_2 = \frac{1}{2}(3x^2-1)$, $x = \sin$ of the latitude and S_0 and S_2 are constants. Use the equilibrium equation which relates the total dynamical transport of heat across a latitude belt (atmosphere plus oceans), $F(x)$, to the net radiative heating at the top of the atmosphere, $[\overline{R}]$, and show that the latitude where $F(x)$ peaks is independent of S_0 and S_2 .
 - (b) How does the latitude you found for the peak in $F(x)$ in part (a) compare with the observed peak?