12.812 MID-TERM EXAM
October 18, 2005

1. (15%) Suppose that daily values of the wind at a particular latitude and height are available for a one-year period, and that the following statistics have been computed separately for each 6-month semester "season" of the year. The symbols are as defined in class.

	Summer	Winter	
$[\bar{u}]$	6	14	ms^{-1}
$[\bar{v}]$	-2	3	ms^{-1}
$[\overline{u'v'}]$	4	20	$\mathrm{m}^2\mathrm{s}^{-2}$
$[\bar{u}^*\bar{v}^*]$	-4	6	$\mathrm{m}^2\mathrm{s}^{-2}$

Now suppose that a value for $[\bar{u}^*\bar{v}^*]$ is computed for the one-year period taken as a whole, and $[\bar{u}^*\bar{v}^*] = 1$. find the value of $[\overline{u'v'}]$ for this one-year period.

2. (20%) The table below gives the analysis for the annual mean $[\bar{v}]$ and $[\bar{u}]$ at the indicated levels at 40N from Oort's (1971) NOAA compilation.

   (a) Calculate directly from the analysis the vertically averaged transport of linear zonal momentum by the mean meridional circulation. You may assume that the surface pressure is 1000 hPa.

   (b) Check the analysis to see if mass is conserved. If it is not, correct the data in a simple way so as to conserve mass and re-do the calculation of part (a). Compare the two results with each other and with Oort's (1971) "balanced" result of $-1.4\ \mathrm{m}^2/\mathrm{s}^2$

	$[\overline{v}]$	$[\overline{u}]$
100 hPa	−.5 m/s	15 m/s
300 hPa	−.9 m/s	20 m/s
500 hPa	−.7 m/s	12 m/s
700 hPa	−.3 m/s	7 m/s
900 hPa	+.2 m/s	3 m/s

3. (15%) Discuss the manner in which the atmosphere achieves a balance of *zonal* kinetic energy in the Northern Hemisphere over the long term. Include in your discussion a description of the major physical processes involved and their role.

4. (20%)

   (a) Discuss the relative advantages and disadvantage of the climatological data sets produced by modern data assimilation techniques compared to the rawinsonde-based analyses used by Starr and his students.

   (b) Andersson et al. (2005) examined precipitation in the ECMWF analyses and found a bias. What was the bias and what was the evidence for it?

5. (15%) Define

   (a) latent heat

   (b) solar declination

   (c) planetary albedo

6. (15%) The incident solar radiation flux at the top of the atmosphere is given by

$$Q = \frac{S}{1^2}(\sin\phi\sin\delta_\odot + \cos\phi\cos\delta_\odot\cos\omega)$$

where the symbols have the same meanings as in lecture. Consider Q at the North Pole and at the equator. If these two insolations are averaged over one day, how does

their ratio depend on the solar declination? At what value of the declination is this ratio equal to unity?