

## 12.812 MID-TERM EXAM

October 25, 2004

1. (20%) Compute the average change in surface pressure (in units of mb) north of  $30^\circ\text{N}$  to be expected over a period of one year if for this time period there is a (mass-weighted) net meridional velocity of  $1 \text{ cm s}^{-1}$  across the entire depth of the latitude wall at  $30^\circ\text{N}$ . (Note:  $1 \text{ mb} = 10^2 \text{ kg m}^{-1} \text{ s}^{-2}$ ;  $a = \text{radius of Earth} = 6.37 \times 10^6 \text{ m}$ ;  $g = 9.8 \text{ m s}^{-2}$ ). You may approximate that initially the surface pressure everywhere is 1000 mb.
2. (15%) Two stations are located  $180^\circ$  apart in longitude along the same latitude circle  $\phi_1$ . Once-daily observations of the wind at a given level ( $p_1$ ) have been made over a three-day period, with the results given below (units are  $\text{m s}^{-1}$ )

	Station A		Station B	
	$u$	$v$	$u$	$v$
Day 1	3	-2	0	-2
Day 2	0	-2	-3	4
Day 3	-6	1	6	7

Compute the transient eddy, stationary eddy, and mean meridional circulation fluxes across  $\phi_1$  at level  $p_1$  for this period.

3. (20%)
  - (a) Discuss briefly the relative advantages and disadvantages of the rawinsonde-based analyses used by Starr and his students and the modern data assimilation analyses techniques.

(b) Discuss the evidence concerning how well determined the field of  $[\overline{u'v'}]$  is over the northern and southern hemispheres.

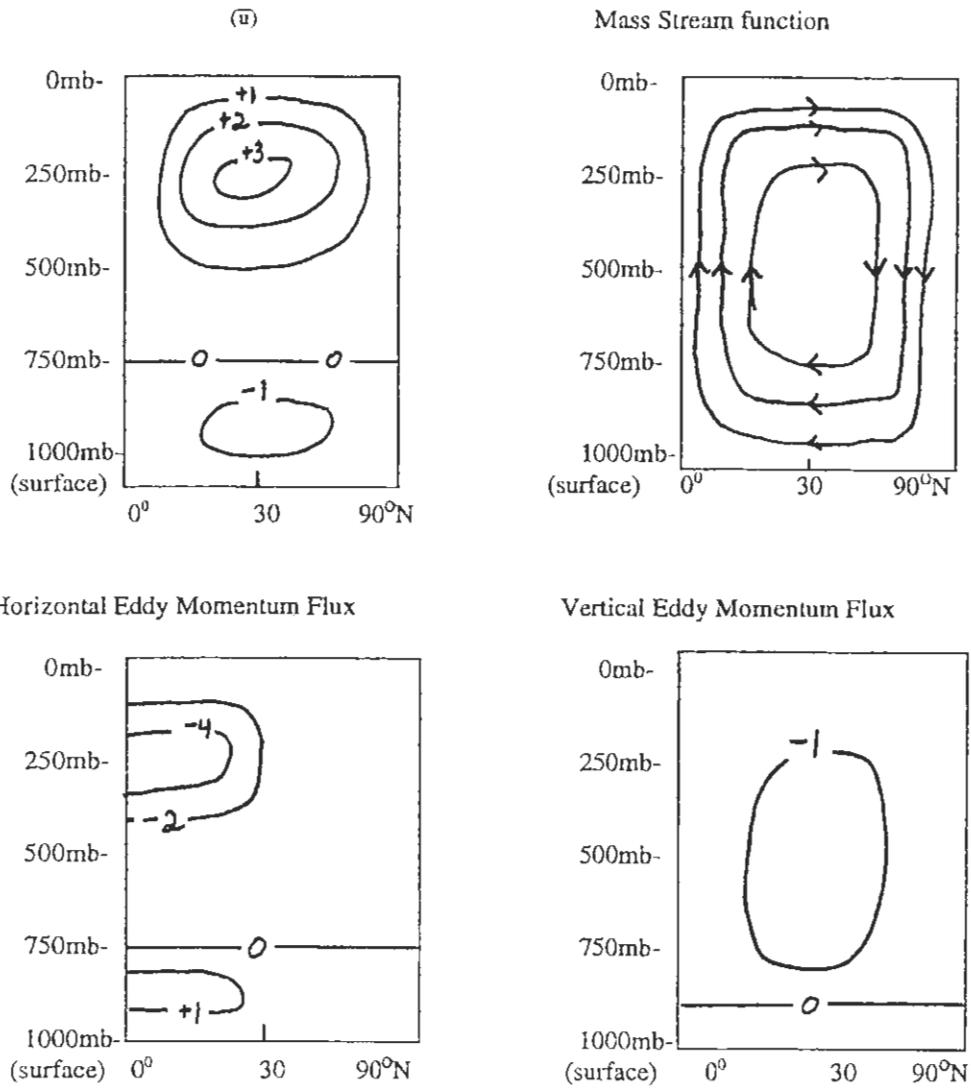


Figure 1

4. (20%) Figure 1 illustrates fields related to the flow in the mean meridional plane above the northern hemisphere of a hypothetical planet that rotates in the same sense as the Earth. The units for each quantity are arbitrary; positive winds are eastward and positive momentum flux values are northward and upward. The field of vertical eddy fluxes of momentum includes effects associated with molecular friction stresses.

(a) Do the mean circulation, horizontal eddy, and vertical eddy momentum transports tend to increase or decrease the kinetic energy in this atmosphere? *Give your reasoning.*

(b) Suppose that the mountains on this planet do not extend to pressures lower than 750 mb. Suppose, too, that pressures are higher on the east side of the average mountain range. Does the presence of these mountains tend to increase or decrease the zonal kinetic energy in this atmosphere? *Give your reasoning.*

5. (10%)

(a) On what time scale does the global atmospheric angular momentum (AAM) contain the most variance?

(b) If the atmosphere were to come to a stop relative to the solid Earth (i.e., if the global relative AAM were to equal zero), by how much would the length of day approximately change?

(1) It would increase by 2.5 milliseconds

(2) It would decrease by 2.5 milliseconds

(3) It would decrease by 0.25 milliseconds

(4) It would increase by 0.25 milliseconds

6. (15%) Describe the main elements of the atmosphere's annual mean hydrological cycle.