SAN FRANCISCO STATE UNIVERSITY METEOROLOGY 503
DEPARTMENT OF GEOSCIENCES Spring 2005

Homework No. 3
and In-class Laboratory
Due Thursday 4/14/05

Reading in Textbooks: Severe Weather Segue

Bluestein Vol. 1 pp. 124-129; **Vol II,** pp. 436-432; 436-441; 444-459
Djuric: pp. 99, Appendices, D, I
Vasquez, 49-54, Chps 5 and 9

Doswell, C.A., 1991: A review for forecasters on the application of hodographs to forecasting severe thunderstorms. *Nat. Wea. Digest*, **10**, pp. 2-10.

Lay out all steps. Number all equations sequentially. Maps/charts are to be neatly analyzed using correct color conventions.

1. Consider a situation in which equation 3.3.29 (in Vol. 1) is to be evaluated for the morning wind profile at a station in which no "dynamics" (QG-forcing is minimal or zero) are occurring.

   There are, however, horizontal pressure gradients at every level of the atmosphere. Which term drops out of the expanded equation (3.3.29) and why?

2. The expression for the **horizontal helicity** may also be written as

$$H = -\vec{V}\left[\bullet \vec{k} \times \left(\frac{\partial \vec{V}}{\partial z}\right)\right] \qquad (1)$$

   where V is the horizontal wind.

   Expand out equation (1) and show that it is equal to equation (3.3.29) WITHOUT the terms you identified in (1).

3. The air ingested into thunderstorms often occurs across a layer several 100s of meters deep. Much research has verified that the source of rotation in thunderstorms lies in the horizontal helicity (horizontal vorticity, horizontal streamwise vorticity) that is tilted into the vertical.

In order to estimate this, the helicity through the ingested (inflow) layer needs to be calculated:

$$H = -\int_0^h \vec{V}\left[\bullet \vec{k} \times \left(\frac{\partial \vec{V}}{\partial z}\right)\right] dz \qquad (2)$$

where 0 is ground level and h is the height at the top of the inflow layer.

Other research shows that the motion of the storm needs to be subtracted out to obtain an estimate of the ingest of horizontal vorticity relative to the storm:

$$H = -\int_0^h \left[\left(\vec{V} - \vec{c}\right) \bullet \vec{k} \times \left(\frac{\partial \vec{V}}{\partial z}\right)\right] dz \qquad (3)$$

where c is the storm motion vector.

Compute (3) for the hodograph in Figure 1.10 (Pg. 20) for the 0-3 km layer. (The thunderstorm motion shown on the hodograph is 212^{o}, 13.5 m s^{-1}, or c_x=7.2 m s^{-1} and c_y=11.4 m s^{-1}.

- to compute $\partial V/\partial z$ use a finite difference ($\Delta V/\Delta z$) with the value of this derivative evaluated from the ground to 1 km using a Δz of 1 km etc.
- you will have to break the wind into components at 0, 1, 2, and 3 km to compute the finite difference.
- Also, you will need to obtain the AVERAGE wind components for each layer and insert the average wind components for each layer to obtain the storm relative winds for each layer.

(Note: The best way to accomplish the computation is to expand out equation (3) and then use Excel or other spreadsheet program to compute the derivatives).