Mesoscale Meteorology: Assignment #7

Due 4 May 2017

1. This question relates to storm mode for an observed thunderstorm event in late June 2016 in the southeastern United States.
    a. (5 pts) Using the data in the spreadsheet linked with Fig. 1, please find the mean potential temperature (K) and water vapor mixing ratio (g kg^{-1}) within the lowest 1 km above ground level (p = 995 hPa or z = 180 m above sea level). While you do not need to show your work, please indicate the data point(s) used to calculate each quantity. No interpolation between levels is necessary to obtain a 1 km observation; use the observation that is closest to 1 km above the ground as the 1 km observation.
    b. (5 pts) Plot your answers to (a) at 995 hPa on Fig. 1. Identify the LCL, LFC, and EL (if each exist) for this mixed-layer parcel. Darken the process lines used to find each level. Shade and label the mixed-layer CAPE and mixed-layer CIN for this parcel. How do mixed-layer CAPE and CIN compare to their surface-based (using T, not T_v) counterparts?
    c. (3 pts) From this sounding, would you expect the predominant storm mode to be single-cell, multicell, or supercell? Why?
    d. A few hours prior to the sounding in Fig. 1, a thunderstorm passed over the Smyrna, TN METAR station less than 20 km southeast of the Nashville, TN site. As this thunderstorm passed, the 2-m temperature fell from 93°F to 75°F.
        i. (5 pts) Let $B \approx \frac{T' - T_{env}}{T_{env}} g$ (with all temperatures in K). Assuming T' to be equal to the temperature after thunderstorm passage and T_{env} to be equal to the temperature before thunderstorm passage, compute B at Smyrna, TN. Show all work, including units.
        ii. (7 pts) Assume a cold pool depth of 1 km and a linear profile for B within the cold pool, with minimum value at the surface and B = 0 at the top of the cold pool. Given this information, compute $u_{R,0}$, representing the speed of the cold pool relative to the ambient flow. Show all work, including units.
        iii. (7 pts) How does your answer to (ii) compare to the ambient flow within the lowest 1 km above ground level for the sounding in Fig. 1? Does this support your answer to (c)? Discuss.
    e. (5 pts) Request KOHX (Nashville, TN) "Level III Products (ALL)" data for 26 June 2016 between 1900-2100 UTC from NCEI. Copy the Order ID in the e-mail notification, load the NOAA Weather and Climate Toolkit, and enter the Order ID into the entry box under the NCEI/CLASS order tab and click on "List Files." Zoom to central Tennessee in the background display window. Create an animation of Base Reflectivity (0.5 elev angle) data. Describe what you see and how it evolves through time. Does this support your answers to (c) and (d)(iii)? Discuss.

2. This question relates to storm mode and structure for an observed supercell thunderstorm event in early May 2016 in the south-central United States.
   a. (5 pts) Wind observations from the Norman, OK (KOUN) 0000 UTC 9 May 2016 sounding are available at:

      http://derecho.math.uwm.edu/classes/Meso/assignments/A7/Assignment7-Sounding2.xlsx

      On a blank hodograph (available from the course website), please plot these data. Label with a number the observations closest to 0, 1, 2, 3, 4, and 6 km AGL.
   b. (8 pts) Given these data, compute the mean 0-6 km wind (m s^{-1}) as an approximate storm motion estimate. Plot the resulting value on the hodograph and label it $\boldsymbol{v_m}$.

      Note that to compute the mean wind, you should first convert the individual wind observations to *u* and *v* components, find the average for each, and then convert the results to speed and direction. To convert from wind speed and direction to *u* and *v* components, use the following equations:

$$u = \text{-Spd} * \sin(\text{Dir} * 3.141592654/180.0)$$
$$v = \text{-Spd} * \cos(\text{Dir} * 3.141592654/180.0)$$

      To convert from *u* and *v* components to wind speed and direction, use the following equations (assuming you use a spreadsheet like Excel for your calculations):

$$Spd = \sqrt{u^2 + v^2}$$
$$Dir = \text{atan2}(-v,-u) * 180.0/3.14159265$$

      Returned directions between 0-180° match the meteorological convention; i.e., 90° indicates a wind from the east. Returned directions between -180° and 0° must have 360° added to them; i.e., -175°+360° = 185°, or a wind from just west of due south, and -130°+360° = 230°, or a wind from the southwest. Include your data with your completed assignment.
   c. (8 pts) If wind speed and direction vary linearly along the hodograph between the 1524 m and 1807 m observations, plot a representative horizontal vorticity vector at *z* = 1.65 km. Decompose it into its streamwise and crosswise components. Label each appropriately. Is this hodograph supportive of splitting supercells? Discuss.
   d. (8 pts) Given a splitting supercell in this environment, would you expect the right-split, left-split, or both splits to persist? Discuss.
   e. (8 pts) Request KFDR (Altus AFB, OK) "Level III Products (ALL)" data for 8 May 2016 between 2100-2300 UTC from NCEI. Copy the Order ID in the e-mail notification, load the NOAA Weather and Climate Toolkit, and enter the Order ID into the entry box under the NCEI/CLASS order tab and click on "List Files." Zoom to southwest Oklahoma in the background display window. Create an animation of

Base Reflectivity (0.5 elev angle). Describe the nature and evolution of the storm(s) that pass closest to the radar. Does this match your answers to (c) and (d)? Discuss.

f. (8 pts) Using the Base Reflectivity data, identify the locations of the left- and right-split supercells nearest the radar at each of 2200 UTC and 2230 UTC. From these positions, compute the storm motion vectors for both storms (in m s^{-1}) and plot them (as $\boldsymbol{v}_{LM}$ and $\boldsymbol{v}_{RM}$) on the hodograph. (Note: to find the distance between two points, use a great circle calculator. Use trigonometry to determine the direction of motion from the north-south and east-west displacements.)

g. (8 pts) Determine the streamwise and crosswise vorticity at z = 1.65 km for both the left- and right-split supercells, labeling each appropriately. (Note: if you find that it is too messy to do this on the hodograph, please do so on an additional sheet.)

h. (10 pts) From your answer to (g), is the left- or right-split supercell more supportive of further splits? Why? Discuss. Also from your answer to (g), does the hodograph support the maintenance of the left-split, the right-split, both splits, or neither split? Why? Discuss.

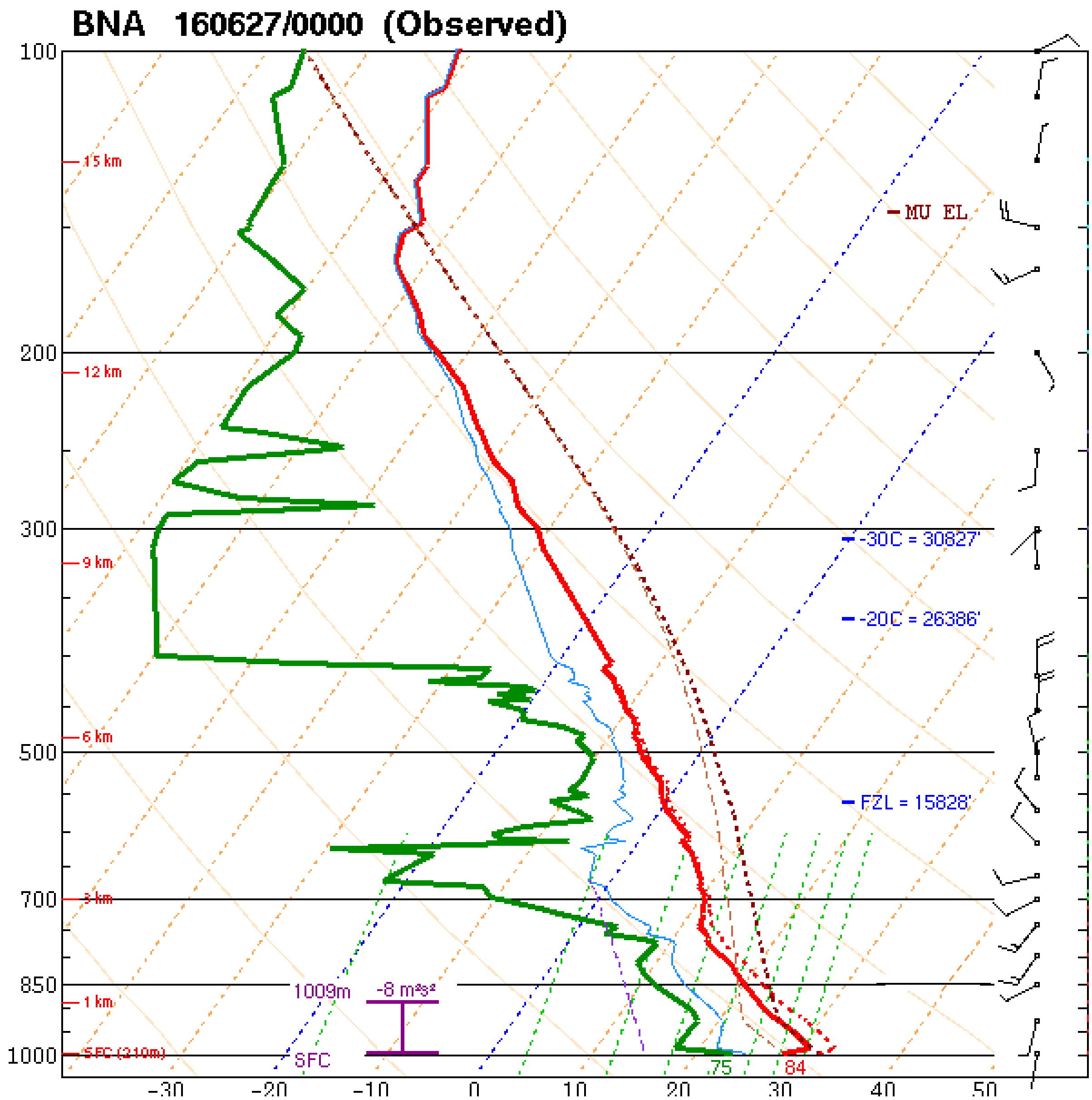

Figure 1. Nashville, TN (KBNA) skew *T*-ln *p* diagram valid 0000 UTC 27 June 2016. The solid red trace depicts temperature (°C) while the solid green trace depicts dew point temperature (°C). The light blue trace depicts wet bulb temperature (°C). The thick dashed red trace depicts virtual temperature (°C). The thick dashed brown line depicts the parcel ascent curve for a surface-based parcel (using virtual temperature). The thin peach dashed line depicts the parcel ascent curve for a surface-based parcel (using temperature). Barbs at right represent the horizontal wind (half-flag: 5 kt, full flag: 10 kt, pennant: 50 kt). Dashed light green lines represent constant water vapor mixing ratio; excluding the left-most line, the values corresponding to each line are 6, 10, 14, 18, 22, 26, and 30 g kg^{-1} from left to right.

The data (to 200 hPa) comprising this plot are available at:

http://derecho.math.uwm.edu/classes/Meso/assignments/A7/Assignment7-Sounding1.xlsx