<u>Mesoscale Meteorology – Assignment #2 – Sounding and Stability Exercise</u>

Due 16 February 2017

1. (14 pts) The image below depicts the typical life cycle of a thunderstorm, from birth (a) to maturity (b) to decay (c).

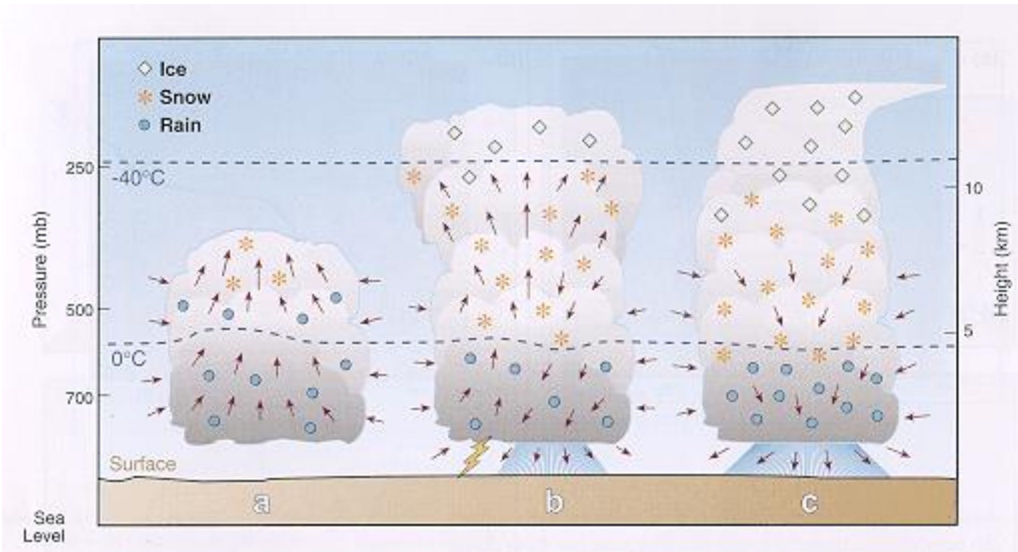

Fig. 1. The three stages of the thunderstorm life cycle: (a) birth, (b) maturity, and (c) decay. The predominant hydrometeor species is given in symbols per the legend at upper left. Vectors depict the wind direction. Figure from http://climate.ncsu.edu/climate/tstorms/lifecycle.php.

At which stage is the pseudoadiabatic (versus the reversible moist adiabatic) approximation most valid? How about least valid? Please justify your answers physically; i.e., why?

2. Data from a rawinsonde launched in a central United States severe convective environment are provided in the spreadsheet available at:

http://derecho.math.uwm.edu/classes/Meso/assignments/Assignment2-Sounding1.xlsx

This question will require you to have a blank skew T-ln p diagram, available from:

http://derecho.math.uwm.edu/classes/Meso/skewt.pdf

a. (6 pts) Plot the vertical profile of temperature and dew point from this rawinsonde launch on a blank sounding. Use a thick black line for each trace.
b. (6 pts) Using only the observed temperature and dew point data, identify the LCL, LFC, EL, and lifted parcel path for a surface-based parcel. Indicate the lifted parcel path with a thick blue line and label the LCL, LFC, and EL on the right side of the diagram.

c. (6 pts) Given your answer to (b), lightly shade the surface-based CAPE in red and surface-based CIN in purple.
d. (6 pts) Compute the vertical profile of virtual temperature. Plot this on the sounding using a thick green line. (You do *not* need to print and submit the spreadsheet column with your virtual temperature calculations.)
e. (6 pts) Using your answer to (d), identify the LCL, LFC, EL, and lifted parcel path for a surface-based parcel. Indicate the lifted parcel with a thick brown line and label the LCL, LFC, and EL on the left side of the diagram.
f. (6 pts) Given your answers to (c) and (e), shade the area of surface-based CAPE added to the profile and the surface-based CIN removed from the profile in dark red and dark purple, respectively. Briefly, describe if and how the potential for surface-based deep, moist convection changes between your answers to (c) and (e).
g. (6 pts) On a new blank sounding, repeat (a) but only for data between 850-700 hPa. Consider the approximately isothermal layer between 796-722 hPa. Lift this layer by 100 hPa. Lightly indicate the process lines used to do so, and use thick black lines to indicate the temperature and dew point traces after lifting. How does the stability of the layer differ after versus before lifting? Does this agree with the potential stability criteria? How?

3. This question uses the same rawinsonde data as the previous question. You will need to have a blank hodograph, available from:

http://derecho.math.uwm.edu/classes/Meso/hodograph.pdf

On this hodograph, note that range rings are separated by 2 m s^{-1}. Azimuthal spacing is 10° below 10 m s^{-1}, 5° between 10-20 m s^{-1}, 2.5° between 20-40 m s^{-1}, and 1.25° above 40 m s^{-1}. The numbers labeled every 10° of azimuth indicate the direction the wind is blowing *from* on top; i.e., a wind from 240° should be plotted along the radial labeled 240 [060].

a. (6 pts) Plot the vertical profile of winds between 983-500 hPa on a blank hodograph, indicating each with a light red line of appropriate length and direction. Use a thick black line to create the characteristic hodograph curve.
b. (6 pts) For the observation from 850 hPa, identify the local shear vector **S** and label it with a thick blue line. Identify the horizontal vorticity vector $\vec{\omega}_H$ at this altitude and label it with a thick green line. Ensure that each vector has appropriate length and direction.
c. (6 pts) Assume a feature motion of 180° at 20 m s^{-1}. Place a marker at this location on the hodograph and draw the feature-relative motion vector for the observation at 850 hPa; indicate this with a thick red line. Draw the corresponding vectors for the streamwise and crosswise vorticity; indicate these with labeled light green lines. How much (qualitatively speaking) of the horizontal vorticity is streamwise vs. crosswise?
d. (4 pts) Shade the storm-relative helicity for the 983-700 hPa (roughly 0-3 km) in light grey. Indicate any lines that you needed to draw to obtain this area in black.

4. Data from a rawinsonde launched in a central United States winter precipitation environment are provided in the spreadsheet available at:

http://derecho.math.uwm.edu/classes/Meso/assignments/Assignment2-Sounding2.xlsx

This question will require you to have a blank skew T-ln p diagram, available from:

http://derecho.math.uwm.edu/classes/Meso/skewt.pdf

a. (6 pts) Plot the vertical profile of temperature and dew point from this rawinsonde launch on a blank sounding. Use a thick black line for each trace.
b. (4 pts) Assume that this sounding supports precipitation that starts high in the cloud (at or above 500 hPa) as snow. Based on the temperature profile only, what is the most likely precipitation type to result from this sounding? Why?
c. (6 pts) Using your plotted sounding, determine the wet bulb temperature (T_w) at 1000 hPa, 925 hPa, and 850 hPa. Indicate the lines that you followed to do so using a coloring and/or labeling scheme of your choice. Given these data, has your inference of the most likely precipitation type changed from (b)? Why or why not, and if so, how?
d. (6 pts) Consider the layer between 900-850 hPa. Lift this layer by 100 hPa. Lightly indicate the process lines used to do so, and use thick black lines to indicate the temperature and dew point traces after lifting. How does the temperature of this lifted layer compared to that observed between 800-750 hPa? Given these data, if strong lifting occurs in the 900-850 hPa layer, has your inference of the most likely precipitation type changed from (b) and/or (c)? Why or why not, and if so, how?