**ATMO 574b: Weather Analysis and Forecasting II**
**Homework 1: Thermodynamic diagrams and diagnosis of convection**

You are provided:

- Upper-air morning (12 UTC) sounding data for three different locations in the CONUS during the period of the warm season (April – September)
- Corresponding surface METAR data for the same stations for the remainder of the day.

Data in raw format (see class handout). Data were obtained from the Plymouth State Meteorology archive.

## Part 1: Data Analysis

Manual plotting of soundings:
For each of the three soundings, plot the corresponding skew-T, log-P diagram. Your diagram should include the standard sounding information: temperature, dew point temperature, and wind. Include all standard pressure levels and any significant pressure levels, as reported in the raw observations. I suggest use different colors to differentiate the temperature and dew point temperature.

Plotting surface data: Plot the time evolution of surface temperature, dew point temperature, and wind for each of the stations. Note the time of day when the maximum values in these quantities occur.

Computation of thermodynamic variables: At each standard pressure level reported in the sounding compute the following thermodynamic variables, as discussed in class lecture. Report all values in SI units:

*Dry atmospheric variables*:
Temperature (T)
Potential Temperature (Θ)
Total dry air density ($\rho_{dry}$)

*Moist atmospheric variables:*
Dew point temperature (Td)
Density of water vapor ($\rho_{vapor}$)
Vapor pressure (e)
Water vapor mixing ratio ($r_v$)
Relative humidity (RH)
Saturation vapor pressure ($e_s$)
Virtual temperature ($T_v$)
Wet bulb temperature ($T_w$): Only where air is sub-saturated
Wet bulb potential temperature ($\Theta_w$)
Equivalent temperature ($T_e$)
Equivalent potential temperature ($\Theta_e$)

Present your results in tabular format for each station. You may use graphical methods on the skew-T, log-P diagram to compute these quantities and/or the equations presented in class and in the textbook.

Provide accompanying list of brief physical explanations for each of these thermodynamic variables, and the procedure for how you computed them (sentence or two each).

**Part 1 due February 6**

**Part 2: Computation of integrated quantities, diagnosis of atmospheric instability**

Do for each of the three soundings, follow this procedure, referring the diagrams and equations provided in class notes and textbook:

CAPE, CIN computation

1. Using the surface METAR data, determine what is the maximum temperature achieved during the day (up to 0 UTC)? For purposes here we'll call this the convective temperature.
2. Determine the height of the lifting condensation level at the time of the daily maximum temperature. This is the convective condensation level.
3. Estimate the depth of the boundary layer and water vapor mixing ratio
4. Compute the convective available potential energy and convective inhibition in the sounding. I suggest show your work in tabular format so it is clear how you perform the calculation. State your result in J $kg^{-1}$
5. Estimate the maximum vertical velocity of a storm updraft
6. Determine the equilibrium level, that would define the height of the convective cloud.

You may make additional notations on your skew-T, log-P diagrams to facilitate these steps, consistent with procedures described in class.

Convective indices

Compute the values of the convective indices presented in class: Showalter index, Lifted index, K index, and Totals-Totals index. Explain your procedure and how each of the indices physically relates to atmospheric instability.

Discussion

Based on your results, discuss how would you characterize the instability of the atmosphere and potential for severe weather for each of these soundings. Do all of these metrics yield consistent results? Why or why not?

**Due February 12**

**Part 3: Hodograph analysis**

Hodograph plotting

For each of the three soundings, hand plot the wind hodograph, consistent with procedures described in lecture and the textbook. Use wind hodograph template from Plymouth State provided as class handout. Use all wind data available from the sounding, including standard and significant pressure levels. The diagram is configured to plot wind in units of knows.

Computation of vertical shear and total horizontal vorticity

*Step 1*: At each standard pressure level, compute the vertical wind shear vector (**S**), as shown in Fig. 2.12 of the textbook. Compute the shear vector as the difference of winds within a 100-mb layer, centered at the given pressure level.

*Step 2*: Compute the total horizontal vorticity vector at each standard pressure level as **k** x **S** as in equation 2.150 in the textbook. Graphically you are just rotating the shear vector 90° to the left of the S.

Show your results in either tabular and/or graphical format with **i** and **j** components in units of $s^{-1}$.

Estimation of streamwise and cross-wise vorticity

*Step 1*: Assume that a storm motion vector (**c**) can be defined by the average wind in the 850-600-mb layer. This is approximately the NWS guidance for deep convection. Compute this storm motion vector for each of the soundings.

*Step 2*: Next compute the storm-relative wind vector (**v** – **c**) at each standard pressure level. Normalize this vector so it has unit length equal to 1.

*Step 3*: Following the schematic in Fig. 2.12 in the book, compute the streamwise ($\boldsymbol{\omega_s}$) and cross-wise vorticity ($\boldsymbol{\omega_c}$) vector at each standard pressure level.

- Streamwise vorticity: Dot product of the normalized storm-relative wind vector with horizontal vorticity vector
- Crosswise vorticity: Cross product of the normalized storm-relative wind vector with horizontal vorticity vector

Show your results in either tabular and/or graphical format with **i** and **j** components in units of $s^{-1}$.

Discussion

Compare and contrast the soundings in terms of their 1) total horizontal vorticity and 2) streamwise and crosswise vorticity components. Based on this assessment and your prior thermodynamic analyses, where are these soundings most likely to be geographically located and what time of year did they probably occur? What is the most likely resultant type of severe weather that was experienced at each location? Remember to utilize the previous surface METAR observations to help you answer these questions.

**Due Wednesday after Spring break.**