Weather Analysis and Forecasting
ATMO 574
Homework #3: Synoptic Analysis of a Significant Weather Event
Isentropic Analysis

Part 1: Cross-section analysis

Using GEMPAK tools, generate the atmospheric cross sections, considering the 12 UTC February 2, 2016 case for the first two assignments. Use the upper-air data from the Iowa State website as shown in class. Before doing this, familiarize yourself with Section 12.1 of the GEMPAK tutorial. The relevant GEMPAK function is SNCROSS.

Cross section #1: Zonal cross section
Grand Junction (GJT), Denver (DNR), Dodge City (DDC), Topeka (TOP), Springfield, IL (ILX), Wilmington, OH (ILN)

Cross Section #2: Meridional cross section:
Shreveport (SHV), Little Rock (LZK), Springfield, MO (SGF), Topeka (TOP), Omaha (OAX), Aberdeen (ABR)

Perform the following two plots for each cross-section

1) Potential temperature (θ) surfaces on a log-pressure plot at 5 degree K intervals, with vertical wind profiles (barbs with knots) at standard pressure levels
2) Equivalent potential temperature (θ_e) on a log-pressure plot at 5 degree K intervals, with vertical wind profiles (barbs with knots) and relative humidity at standard pressure levels.

Discuss any features of note on these cross-sections, consistent with class lectures and Chapters 3 and 4. These would include, for example:

- Locations of cold domes, warm bowls, and fronts
- Areas of relatively stable and unstable air
- The position of the jet stream
- Location of the tropopause
- Tropopause folding and potential vorticity anomalies

What new information does this add beyond what you determined in previous homeworks?

Part 2: Adiabatic vertical motion via cross section

Using the adiabatic method as discussed in class, calculate vertical motion at 700-mb (as both omega and w) for each of the interior stations in your cross-sections.

For this class exercise:

- You may neglect the effect of local temperature tendency.
- Consider a synoptic scale distance *ΔS* (~250 km each side of the station); 2) the horizontal wind in the plane of the respective cross sections as either the zonal wind component (u) or meridional wind component (v)

For purposes of computing vertical motion in the plane of the cross sections the equations are:

$$\varpi_{(zonal\ X-sec)} = \frac{u\cdot\frac{\partial \mathrm{T}}{\partial \mathrm{x}}}{-\frac{\partial \theta}{\partial p}} \qquad \varpi_{(meridional\ X-sec)} = \frac{v\frac{\partial T}{\partial y}}{-\frac{\partial \theta}{\partial p}}$$

I suggest use a 200-mb interval to compute the stability parameter

You should show your work, in terms of at least outlining your methodological approach, but you may do the calculations with a computer program (e.g. Excel). Show your results in graphical form along the cross section. Your answers for vertical velocity should be expressed in cm per second.

Based on your results, discuss:

- How the vertical motion computed with the adiabatic method qualitatively compares with the prior diagnostic analyses of synoptic scale vertical motion. What are the comparative strengths and weakness of each approach?
- Are any fronts that appear on your cross sections best classified as katafronts or anafronts? What do these terms mean?

Finally, considering your analysis of equivalent potential temperature and relative humidity in the first part, identify the specific areas in your cross section where diabatic processes are a factor in modifying the vertical motion. In these areas, qualitatively explain how and why you would expect the vertical velocity to change relative that computed by the adiabatic method.

<u>Part 2: Adiabatic vertical motion via isentropic surface</u>

Plot the 300 K isentropic surface valid 12 UTC 2 February 2016 and 0 UTC 2 February 2016 over the contiguous United States. Include wind barbs and some indication of atmospheric moisture (suggest mixing ratio). Your figure should be similar to Fig. 3.10 in the textbook.

Calculate vertical motion (omega) on the 300 K isentropic surface for 12 UTC 2 February 2016 using the system relative method, for all of the radiosonde stations considered in Part 2. See posted lecture notes for details. Neglect diabatic heating and stability changes with height. The relevant equation is

$$\varpi = (\vec{V} - \vec{c}) \cdot \nabla_\theta p$$

Notes: 1) The velocity c is the storm velocity, considered over the past twelve hours. You will need to estimate this from consider the previous analysis time (previous 12h) and estimate the position of the upper-level low; 2) Consider component of adjusted wind parallel to the pressure gradient at the point; 3) consider a reasonable synoptic-scale distance over which to compute the pressure gradients (~500 km each side of the station).

You can perform these calculations using a spreadsheet as in Part 2, but provide the tabular information that substantiates your calculation.

How do your results compare with the cross section analysis of vertical motion from Part 2? Where are the areas experiencing strongest upward or downward motion? Are any synoptic-scale moisture conveyor belts associated with the system? Qualitatively describe how might this modify your estimate of vertical motion?

Due prior to Thanksgiving break.