

Mesoscale Meteorology – Assignment #4 – Frontal Analysis and Frontogenesis

Due: 2 March 2017

1. (25 pts) For this question, please refer to Figure 1. On this chart, please contour mean sea-level pressure every 4 hPa from 980-1040 hPa (black contours), 2-m temperature every 5°F from 0-65°F (red contours), and 2-m dew point temperature every 5°F from 0-60°F in green contours. You can do this on one chart, two charts, or even three charts if desired. Based upon your isoplethed analyses, please indicate the locations of a cold and a warm front on these charts.
2. (20 pts) For this question, you will be using the Grid Analysis and Display System, or GrADS, software to create isopleths of mean sea-level pressure, 2-m temperature, and 2-m dew point temperature from a gridded meteorological dataset (here, the 1° resolution GFS analysis valid at 1200 UTC 1 February 2015).

For the following, you will need to be on one of the Macs in EMS W434. You may also wish to install [GrADS](#) on your own computer, but I do not recommend this (especially for Windows) and I am not able to provide support for doing so at this time. The process to plot the data for this question is described below.

Start by opening a terminal window. To do so, click on the Launchpad icon at lower left, then enter the Other folder, then choose Terminal. Next, go to the website below:

<http://derecho.math.uwm.edu/classes/Meso/assignments/A4/>

and copy the link for one of the files to the clipboard; you can do this by Control-clicking on the file and choosing “Copy link to clipboard.” Return to the terminal and type:

```
wget (pasted link)
```

without the parentheses around the pasted link. Once this command has been run, repeat the process for the other two gfs files from the website directory. Next, open GrADS by typing grads into the terminal. When it asks you for landscape vs. portrait mode, hit enter.

Next, open the control file that describes the data:

```
open gfsctl
```

Set your desired display window (20-55°N, 110-80°W):

```
set lat ### ###  
set lon ### ###
```

For this and later steps, replace the ###s with the desired numbers. Western longitudes should be prefaced with negative signs (e.g., -110 or -80); neither should include N or W.

Choose a high-resolution map dataset:

```
set mpdset hires
```

Change the display color to white, then clear the screen to set it:

```
set display color white  
clear
```

By default, GrADS displays data as contoured fields. It will choose a default set of contour levels and contour colors if you do not set them. The contour colors are rainbow colors for the first field you contour, black contours for the second field, and green contours for the third field. Do not change these; instead, change the contour levels. These can be set by specifying their minimum, maximum, and interval values:

```
set cmin ###  
set cmax ###  
set cint ###
```

The mean sea-level pressure, 2-m temperature, and 2-m dew point temperature variables are named `prmslmsl` (units: Pa), `tmp2m` (units: K), `dpt2m` (units: K), respectively.

Display mean sea-level pressure every 4 hPa from 980-1040 hPa in the default rainbow colors, 2-m temperature every 5°F from 0-65°F in black contours, and 2-m dew point temperature every 5°F from 0-60°F in green contours. For example, if I wanted to display 2-m temperature in °F, I would issue the following command:

```
display (tmp2m-273.15)*1.8+32
```

After creating a plot of the desired fields, save it to an image file:

```
gxprint _____
```

Replace _____ with your desired file name, ending with `.png`. Quit GrADS by typing `quit`. You can then import your image into a Word document or print it directly. Include the plot you created with your completed assignment.

Describe how your manual analysis compares to the GFS-derived analysis prepared for this question. Comment on areas where the two are consistent with each other. Are there areas in which the two differ substantially from each other? Where are these, and how do they differ?

3. (20 pts) Gridded numerical model analyses have their drawbacks, chief among them being that they are model-derived syntheses of observations and thus limited by biases in the model and observation assimilation system. However, they have several advantages, including their superior spatial distribution (uniform rather than irregular) and resolution (particularly for upper-air products). In this question, we wish to exploit the 1° resolution GFS analysis valid at 1200 UTC 1 February 2015 to evaluate frontogenesis.

Open GrADS as you did in the previous question. Open the control file, set your desired display window (30-50°N, 110-80°W), choose a high-resolution map data set, change the display color to white, and clear the screen, all as in the previous question. This time, you also need to set the desired vertical level, here to 700 hPa:

```
set lev ###
```

Note that you should not provide it with the units; it expects the value to be in hPa.

The temperature, u-wind, and v-wind variables are named tmpprs (units: K), ugrdprs (units: m s^{-1}), and vgrdprs (units: m s^{-1}), respectively. Display temperature every 3°C from -24°C to 3°C in the default rainbow colors. To overlay wind barbs, we must tell GrADS to display barbs rather than contours:

```
set gxout barb
```

Barbs are defined by vector components, i.e.,

```
display ivector;jvector
```

With this in mind, plot wind barbs in kt. After creating this plot, save it as an image as in the previous question. You may then quit GrADS.

Focus on the western Great Lakes. Using an image editing tool, or adding it manually to a printed version of the chart, please denote the axis of dilatation. Describe the orientation of this axis relative to the isotherms within this region. Is this a frontogenetic or frontolytic situation? Discuss. Repeat this process for the south-central United States.

4. (15 pts) Recall that the frontogenesis equation underlying the evaluation in the previous question has the form:

$$F = \frac{\|\nabla_h \theta\|}{2} (D_{tot} \cos(2b) - \delta)$$

We wish to compare our qualitative analysis to a formal frontogenesis computation using this equation. Archived charts of this computation are available from the Storm Prediction Center:

<http://www.spc.noaa.gov/exper/mesoanalysis/>

Click on “National Sector Archive” just above the map. Choose the HTML5 JavaScript Version, then load 700 hPa frontogenesis at 1200 UTC 1 February 2015 for a 6 h period. Advance to and pause the loop at 1200 UTC. How does this analysis compare to that in the previous question? Discuss areas of agreement and disagreement. For reference, note that the units of the plotted quantity are K per 100 km per 3 h.

5. (20 pts) The frontogenesis evaluation conducted thus far utilizes the full wind. However, we have also developed a frontogenesis diagnostic that utilizes the geostrophic wind: the relationship between \mathbf{Q} and the horizontal temperature gradient. This relationship holds so long as the flow is geostrophic. In the vicinity of fronts, however, the ageostrophic component of the flow cannot be neglected. For instance, as the geostrophic flow is non-divergent by definition, the relationship between \mathbf{Q} -vectors and frontogenesis cannot account for a key contributor to frontogenesis.

In this question, we wish to compare the **Q**-vector-based frontogenesis interpretation to that using the full wind. How they differ can give us insight into the contributions of ageostrophic flow (and thus divergence) to frontogenesis. For the current case, archived **Q**-vector analyses can be obtained from:

<http://www.atmos.albany.edu/student/heathera/2015.html#QVECT>

Load the 1/22-2/7 **Q**-vector loop for North America. Advance to 1200 UTC 1 February 2015. For (a) the western Great Lakes and (b) south-central United States, what is the orientation of the horizontal temperature gradient? How is it oriented with respect to the **Q**-vectors? Is there frontogenesis, frontolysis, or neither? Shade areas of frontogenesis in light grey. How does this analysis compare to that in (4)? Discuss your answers.

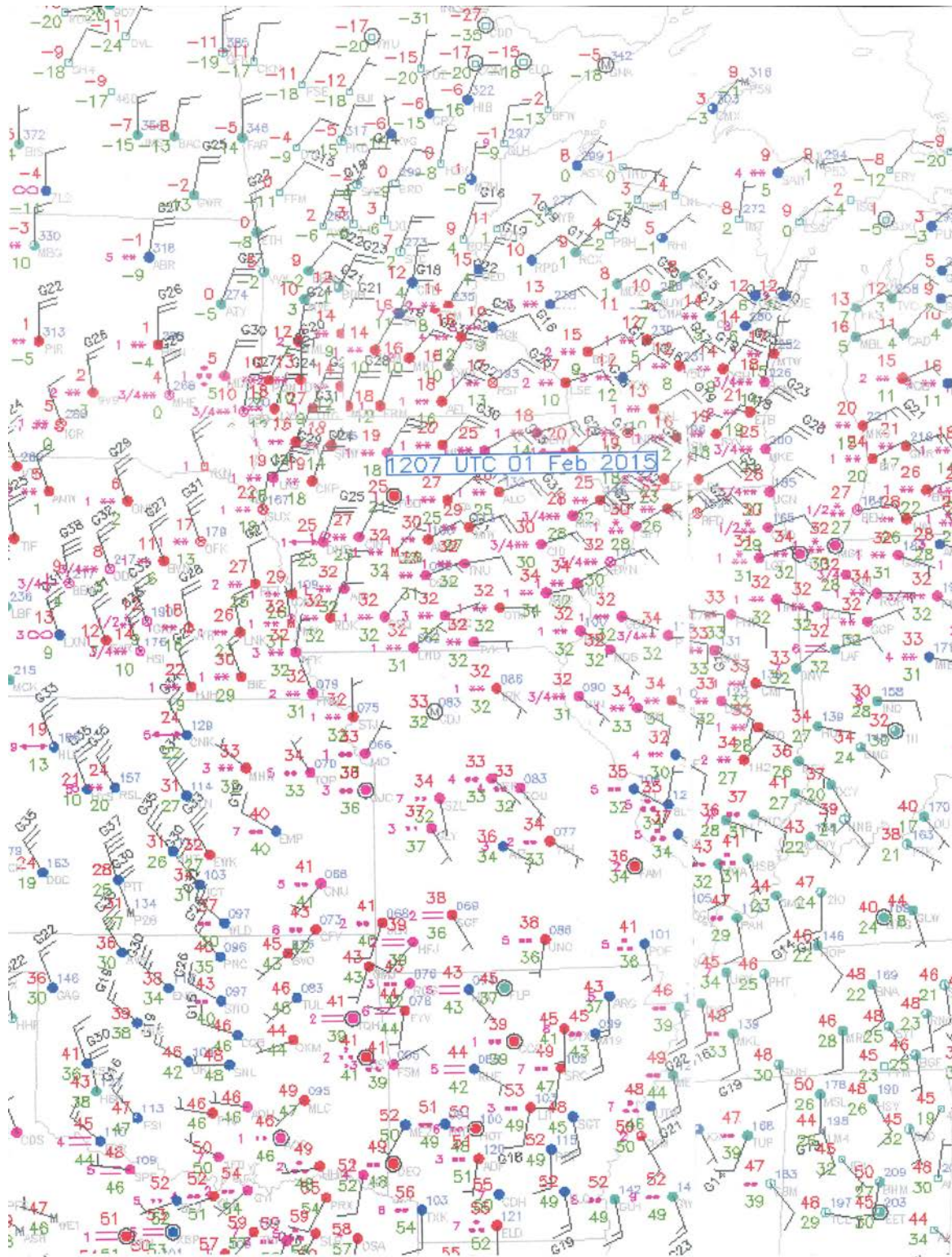


Figure 1. Surface chart across the central United States valid at 1207 UTC 1 February 2015. Red values indicate temperature in °F, green values indicate dew point temperature in °F, blue values indicate mean sea-level pressure in hPa (*10; leading 9 or 1 omitted, such that 098 = 1009.8 hPa and 982 = 998.2 hPa), and wind observations are given by the barbs (half-flag: 5 kt, flag: 10 kt, pennant = 50 kt). Images obtained from <http://www.mmm.ucar.edu/imagearchive>.