Synoptic Meteorology I: Frontal Analysis Application

Whether we are analyzing a cold front, warm front, or occluded front, we can apply what we have learned about frontal properties to meteorological data to help identify fronts on weather maps. In general, a surface front can be identified on a weather map using the following guidelines:

- Start within a warm air mass and move toward where you believe the cold air to be located. The locations at which the temperature and/or thickness begins to decrease rapidly over a short horizontal distance provide a first guess for the front's location.
- Start within a moist air mass and move toward where you believe the drier air to be located. Locations where moisture – often dew point temperature, but potentially also water vapor mixing ratio or equivalent potential temperature – begins to decrease rapidly over a short distance provide a first guess of a frontal boundary's location. The resulting frontal location estimate will typically agree well with that deduced from the isotherms.
- Utilizing a sea-level pressure analysis, look for where the maximum troughing, sharpness, or curvature in the isobar field is located. The surface front is generally located within this region at the locations where sea level pressure is minimized. Because fronts are localized minima in pressure (for surface fronts) or geopotential height (for fronts above the surface), we typically sharpen the isobars or isohypses across the frontal boundary.
- Utilizing a surface pressure tendency analysis, look for adjacent locations where sea-level pressure is rapidly rising and rapidly falling. Surface fronts are found ahead of regions of rapidly rising sea-level pressure and behind regions of rapidly falling sea-level pressure.
- Utilizing surface wind observations, look for locations where the wind curves cyclonically over a short distance. The surface front is generally located through such regions.
- Surface front motion is fairly consistent with time. Surface front placement at one time can often be approximated by extrapolating from a series of previous surface frontal analyses.
- Clouds and precipitation are generally found close to surface frontal boundaries.
- Utilizing a temperature tendency analysis, look for locations where temperature is rapidly changing. Surface fronts are found on the leading edges of regions of rapid warming (warm fronts) or rapid cooling (cold fronts).

Cold fronts will typically meet all of the above criteria, while warm fronts and occluded fronts will typically meet most of the above criteria.

Representative examples of isoplethed temperature, sea-level pressure, and dew point temperature fields in support of surface cold-front placement are provided in Figs. 1 and 2. In this example, there is not a significant change in sea-level pressure across the front, but the front is located along a corridor where sea-level pressure is minimized. However, there are relatively large gradients of temperature and dew point temperature as well as a wind shift from southerly to northerly along and immediately behind the cold front. Although temperature continues to warm ahead of the cold front, it does so less rapidly (over a given distance) than it does along and behind the cold front.

Although not depicted on these charts, the frontal zone itself is limited in horizontal extent behind the cold front to three to four isopleths behind the cold front. Although temperature and dew point temperature continue to decrease rearward of this zone, they do so at a smaller rate than along and immediately behind the cold front.

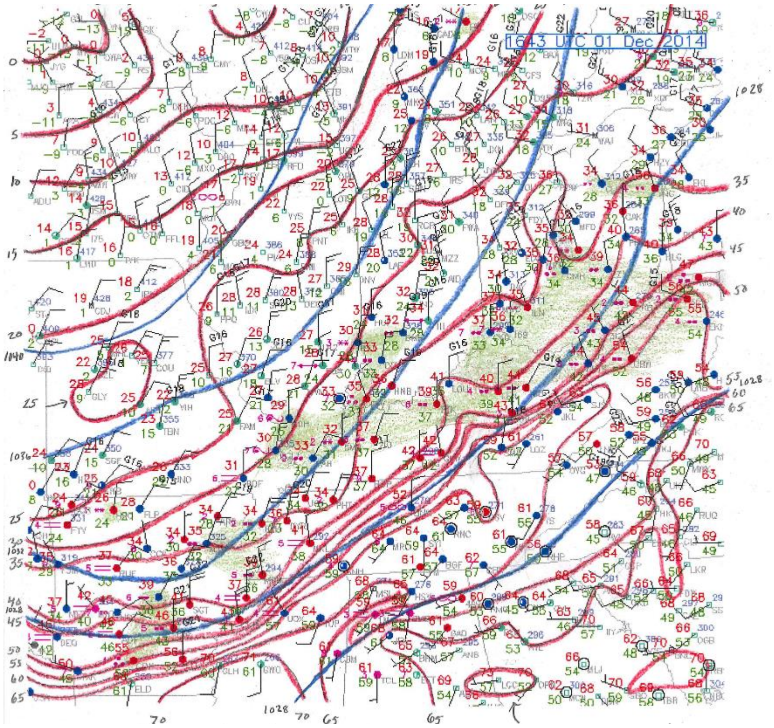

Figure 1. Isotherms (red lines every 5°F), isobars (blue lines every 4 hPa), and active precipitation (light green shading) at 1643 UTC 1 December 2014. Data: http://weather.ral.ucar.edu/surface/.

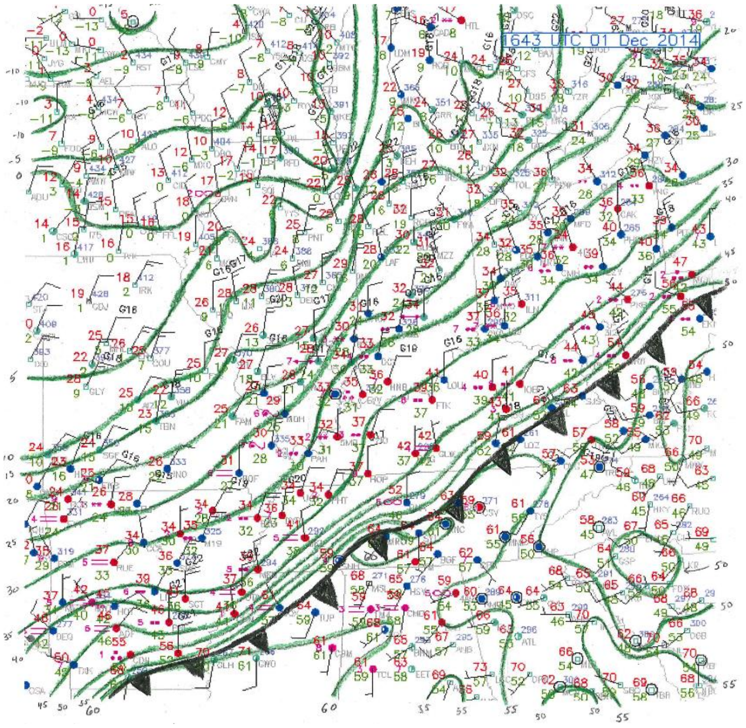

Figure 2. Isodrosotherms (green lines every 5°F) and surface cold front (black line with triangles) at 1643 UTC 1 December 2014. Data: http://weather.ral.ucar.edu/surface/.

We can also use thickness data over an appropriate lower- to midtropospheric vertical column to identify and locate a front. Thickness is largest within the warm air mass ahead of a surface cold front. Travelling rearward into the cold frontal zone, the near-surface temperature cools compared to that ahead of the cold front but does not do so above the frontal zone. Thus, we expect thickness to be lower here, but not substantially so. As we travel further rearward, however, the air's coldness – and the vertical depth over which it is found – increase. Thus, we expect thickness to continue to decrease. Similar arguments can be made for a warm front.

Suppose we have a thickness analysis for the 1000 hPa to 500, 700, or 850 hPa layer. We expect the smallest values of these isolines to be found well behind a surface cold front and/or well ahead of a surface warm front and the largest values of these isolines to be found just ahead of a surface cold front and/or just behind a surface warm front. The largest horizontal changes in thickness are along and behind the surface cold and/or warm fronts. Applying these principles, we can obtain a reasonable guess for the location(s) of the surface cold and/or warm front(s), as in the hypothetical example in Fig. 3.

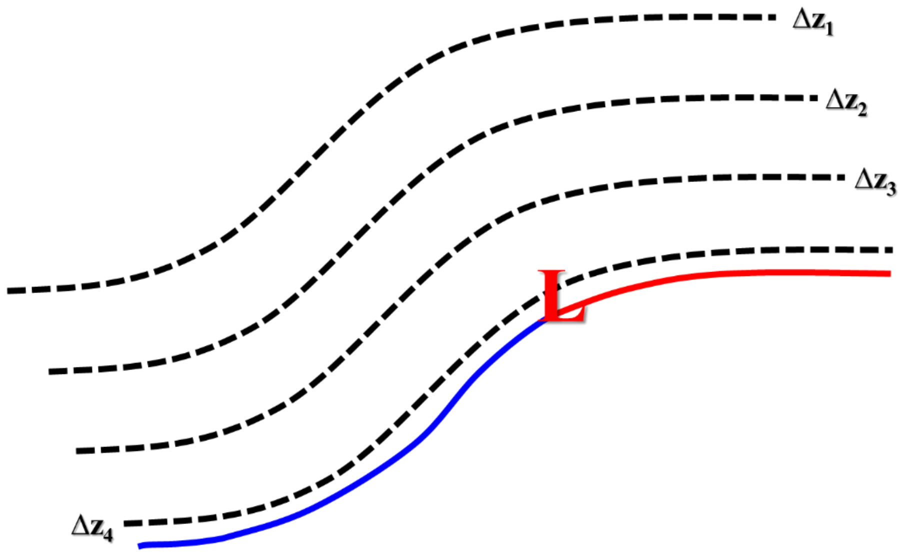

Figure 3. Idealized representation of 1000 hPa to 500 hPa layer thickness contours (dashed lines, with $\Delta z_1 < \Delta z_2 < \Delta z_3 < \Delta z_4$) and a surface cold (blue) and warm (red) front. In practice, slight deviations in frontal placement from the leading edge of the thickness contours are possible.