Synoptic Meteorology I: Kinematics Application

As in Cartesian coordinates, the total wind is not represented exclusively by divergence, vorticity, or any single part of either kinematic field. Rather, the total wind represents a combination of each of the four terms examined in the above. An example is given in Fig. 1 below.

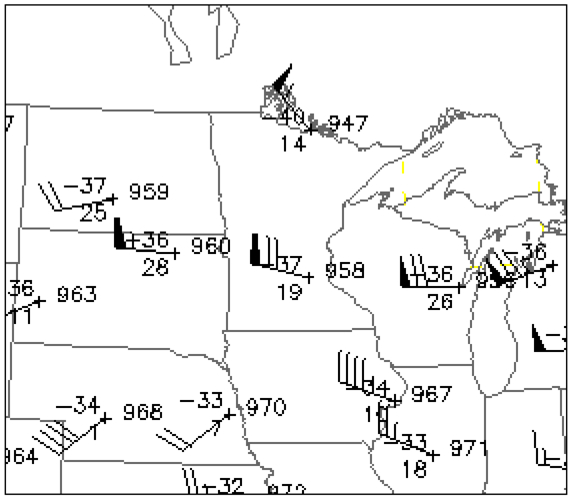

Figure 1. Observations of temperature (upper left), dewpoint temperature (lower left), geopotential height (dam), and wind speed and direction (barbs; half flag: 5 kt, full flag: 10 kt, pennant: 50 kt) on the 300 hPa isobaric surface valid at 1200 UTC 27 August 2014 across the upper Midwest of the United States. Data obtained from http://weather.ral.ucar.edu/upper/.

Let us consider Minneapolis, MN, roughly located in the center of the diagram. At Minneapolis, the wind is out of the west-northwest at 70 kt. If we draw the *s*- and *n*-axes at Minneapolis, we find that International Falls, MN is nearly located along the positive *n*-axis, Omaha, NE is nearly located along the negative *n*-axis, Green Bay, WI is nearly located along the positive *s*-axis, and Aberdeen, SD is located nearly along the negative *s*-axis, thereby aiding our analysis.

We first wish to evaluate the speed divergence term at Minneapolis. At Green Bay, the wind speed along the *s*-axis is roughly 70 kt, the same as at Minneapolis. At Aberdeen, the wind speed along the *s*-axis is roughly 50 kt, lower than at both Green Bay and Minneapolis. Thus, at Minneapolis, there exists *speed divergence* because wind speed increases in the positive *s*-direction.

We next evaluate the diffluence term at Minneapolis. At International Falls, the wind is out of the northwest (315°, or 1.75π). At Omaha, the wind is out of the southwest (225°, or 1.25π). Thus, the wind angle increases along the positive *n*-axis. Given the sign convention on this term, this indicates *confluence* at Minneapolis.

We now evaluate the curvature term at Minneapolis. However, the flow at Minneapolis itself is relatively straight, at least given the data in Fig. 1. If we look along both the positive and negative *n*-axis, we find that the flow is *cyclonically curved* along the positive *n*-axis (toward International Falls) and *anticyclonically curved* along the negative *n*-axis (toward Omaha).

Finally, we evaluate the normal shear term at Minneapolis. Using trigonometry, we could find the wind speed perpendicular to the *n*-axis at International Falls and Omaha. For our purposes, however, it is sufficient to qualitatively state that the wind speed perpendicular to the *n*-axis is less than or equal to the observed wind speed at each location. Between Minneapolis and International Falls, *V* decreases along the positive *n*-axis, which we previously identified with *cyclonic normal shear*. Conversely, between Omaha and Minneapolis, *V* increases along the positive *n*-axis, which we previously identified with *anticyclonic normal shear*.