Synoptic Meteorology I: Isoplething Example

Overview

On the following pages, isoplethed analyses of sea-level pressure (every 4 hPa; Fig. 1), 2-m temperature (every 5°F; Fig. 2), 2-m dew point temperature (every 5°F; Fig. 3), and 250 hPa geopotential height (every 60 m; Fig. 4) and isotachs (at 75 kt; Fig. 4) are provided. The chosen isopleths adhere to our rule that isopleths should be evenly divisible by the interval between them, and below we examine the isopleths in light of the guidelines we established in lecture.

General Comments

From page 16 of "Meteorological Data and an Introduction to Synoptic Analysis,"

> *Thus, isoplething involves interpolation of the values of the quantity being examined between the observations. To do so, we assume that meteorological fields are continuous; i.e., if the temperature is 10°C at one point and 20°C at the nearest adjacent point, we assume that the temperature between the two points changes smoothly and uniformly between the two points.*

Thus, if you are drawing a 1000 hPa isobar and you have 998.7 hPa and 1003.4 hPa sea-level pressure observations, the isobar should be drawn proportionately closer to the 998.7 hPa observation than to the 1003.4 hPa observation. The same is true for your isotherms, isodrosotherms, and isohypses.

An example of where this rule was not followed is provided in Fig. 3 over Oklahoma. There are 45°F and 64°F observations to support the locations of the 45°F and 65°F isodrosotherms, but no observations between them to refine the locations of the 50°F, 55°F, and 60°F isodrosotherms. In the absence of such observations and/or an applicable conceptual model to argue for an alternative isodrosotherm arrangement, the 45-65°F isodrosotherms should be evenly spaced. Instead, the 45-60°F isodrosotherms are tightly packed to the west of the 65°F isodrosotherm. This may be true: we just do not have the observations to support that analysis.

Furthermore, as noted at the end of the above-referenced text, all isopleths should be smooth. Unless the data support small-scale detail, they should be not implied by your isopleths. Isobars and isohypses tend to be very smooth, while isotherms and isodrosotherms have somewhat small small-scale detail and thus can and do "wiggle" a little bit.

From page 17 of the same set of lecture notes,

> *Isopleths should be evenly spaced unless there is a specific reason for their spacing to vary, such as tied to a conceptual model of the atmosphere.*

In addition to the example provided above, a correct example of this is given in Fig. 2 along the eastern portion of the Nebraska/South Dakota border. We do not have any observations here, but the isotherm orientation (curvature/lack thereof) and spacing (even) drawn here is well-supported by the isotherms drawn in the regions where we do have data. The same can be said to great extent on Fig. 3 in this same region.

Related to this idea is that isopleths should have higher values of the isoplethed field on one side of them and lower values on the other side. Consider the isotherm analysis over the northern Rocky Mountains and High Plains in Fig. 2. The 45°F isotherm has high values of temperature to the northwest and lower values of temperature to the south and east. Next comes a 40°F isotherm, which has lower values of temperature to the south and west and higher values of temperature to the northwest, north, and east. A second 45°F isotherm is found east of here. The area across southern Canada and far northern Montana and North Dakota is between 45°F isotherms – temperatures to the left of the leftmost 45°F isotherm and to the right of the rightmost 45°F isotherm are warmer than 45° while they are between 40-45°F between the two isotherms. A similar situation occurs over the Appalachian Mountains on Fig. 2 and the southeastern portion of the analysis domain in Fig. 3. It is thus possible, and sometimes even desired, to have multiple isopleths with the same value.

Again quoting from page 17 of the same set of lecture notes,

> *Assume that each observation is correct unless you can prove beyond a reasonable doubt that it is in error, following the guidelines under "Representativeness of Observations" above. Circle any observations that you do exclude from your analysis.*

On the surface charts, one observation was very clearly in error: that on the far eastern edge of Lake Huron. For clarity, this is highlighted in green on each image. It was also decided that, given surrounding observations, the sea-level pressure observation of 1004.2 hPa in east-central South Dakota was likely in error; however, the rest of the data from that station were deemed to be good.

On the 250 hPa chart, the southern Nevada observation was deemed to likely be erroneous in terms of geopotential height (too high), wind speed (too low), and wind direction (too westerly) relative to surrounding observations. This, too, is highlighted in green on Fig. 4.

This guideline also gives us insight regarding local variability. For instance, consider the far lower-right corner of Fig. 2. Note how the isotherms in this location are elongated from north-northeast to south-southwest. They have this orientation largely because of the presence of the Appalachian Mountains, which have similar orientation. The same can be said for the 25°F isodrosotherm in southeastern Wyoming and north-central Colorado: drawn along the immediate Front Range of the Rocky Mountains. It is thus important to keep in mind that these data are not erroneous.

Quoting again from page 17 of the same set of lecture notes,

> *Your isopleth analysis should be neat, including isopleths that are both smooth and labeled at their ends. Erase all errors or preliminary markings.*

This implies that there *will* (and should!) be preliminary markings. Even the most experienced of analysts has to revise their analysis at least once in some location. If you look closely at these analyses, you will see many faint pencil lines erased after reviewing the data several times. Do not be haphazard with your analysis – be willing to revise it once, twice, even three times to ensure its accuracy!

Isobars, Isohypses, and Frontal Placement

Quoting from page 16 of the same set of lecture notes,

> *When preparing an isoplethed analysis, there are specific guidelines that should be followed. The most important of these guidelines is that isopleths should satisfy the conceptual model of the atmosphere most applicable to the isoplethed field.*

At and above 700 hPa, isohypses are very nearly parallel to the wind, with lower geopotential height to the left of an observer with their back to the wind. The reason for this is geostrophic balance, which holds to large extent on the synoptic-scale away from the surface. Thus, consider the northern and central High Plains on the 250 hPa chart. Wind observations imply a cyclonic-rotating feature centered over southern Wyoming. Consequently, closed isohypses are drawn here to reflect the presence of this feature, with some uncertainty in the precise orientation of the 10500 m isohypse given the observation in eastern Montana.

At the surface, isobars are somewhat parallel to the wind, albeit with the wind directed across the isobars toward low pressure. The placement of the surface low and upper-level low centers should match both the isohypses/isobars and the wind direction. One should not, for instance, place the surface low north of the easterly wind observation near the Nebraska/South Dakota/Iowa border.

Both isobars and isohypses should be drawn more tightly packed where the wind speed is faster. One of the key contributors to the wind is the horizontal pressure (or, equivalently on an isobaric surface, geopotential height) gradient, such that a larger horizontal pressure/height gradient corresponds directly to a faster wind speed. Note, thus, how the isotachs on Fig. 4 are found where the horizontal geopotential height gradient is largest and not where it is relatively small.

We will discuss frontal analysis in more detail in the weeks ahead. However, with respect to frontal analysis, one should expect to see continuity between isobars, isotherms, isodrosotherms, and wind direction. Fronts separate distinct air masses – warm/moist vs. cold/dry – and are found where the contrast between such air masses begins. They are also found where the pressure is locally low and where the wind direction changes in a cyclonic fashion. If you complete your isoplethed analyses on separate sheets of paper, place them on top of each other and hold them up to a bright light. Your isotherms and isodrosotherms should have similar orientation; both should be most tightly packed behind a cold front and ahead of a warm front, and your isobars should be kinked to reflect changes in wind direction at the leading edge of the packed isotherms/isodrosotherms (e.g., at frontal locations).

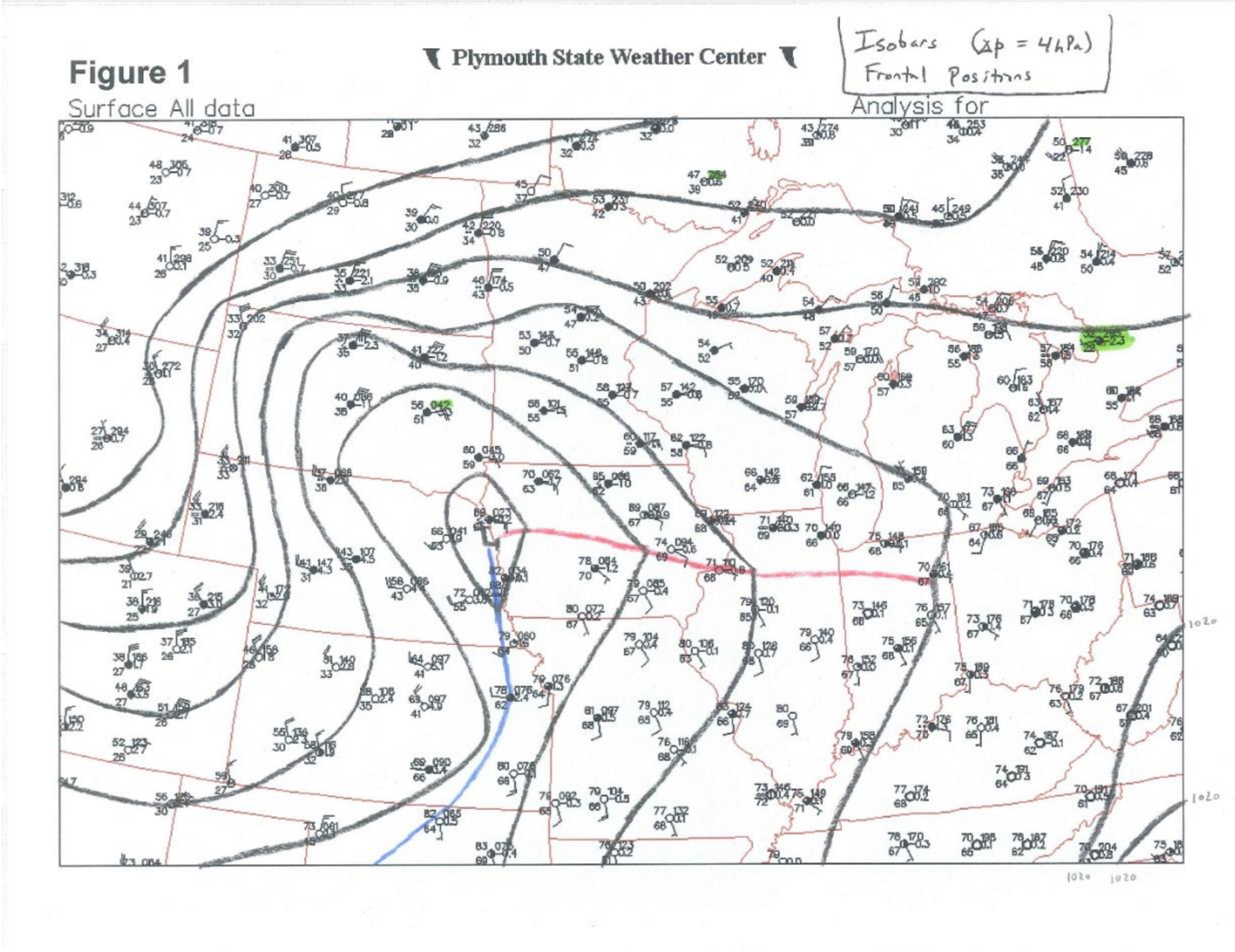

Figure 1. Isobar analysis. Original image obtained from Plymouth State University.

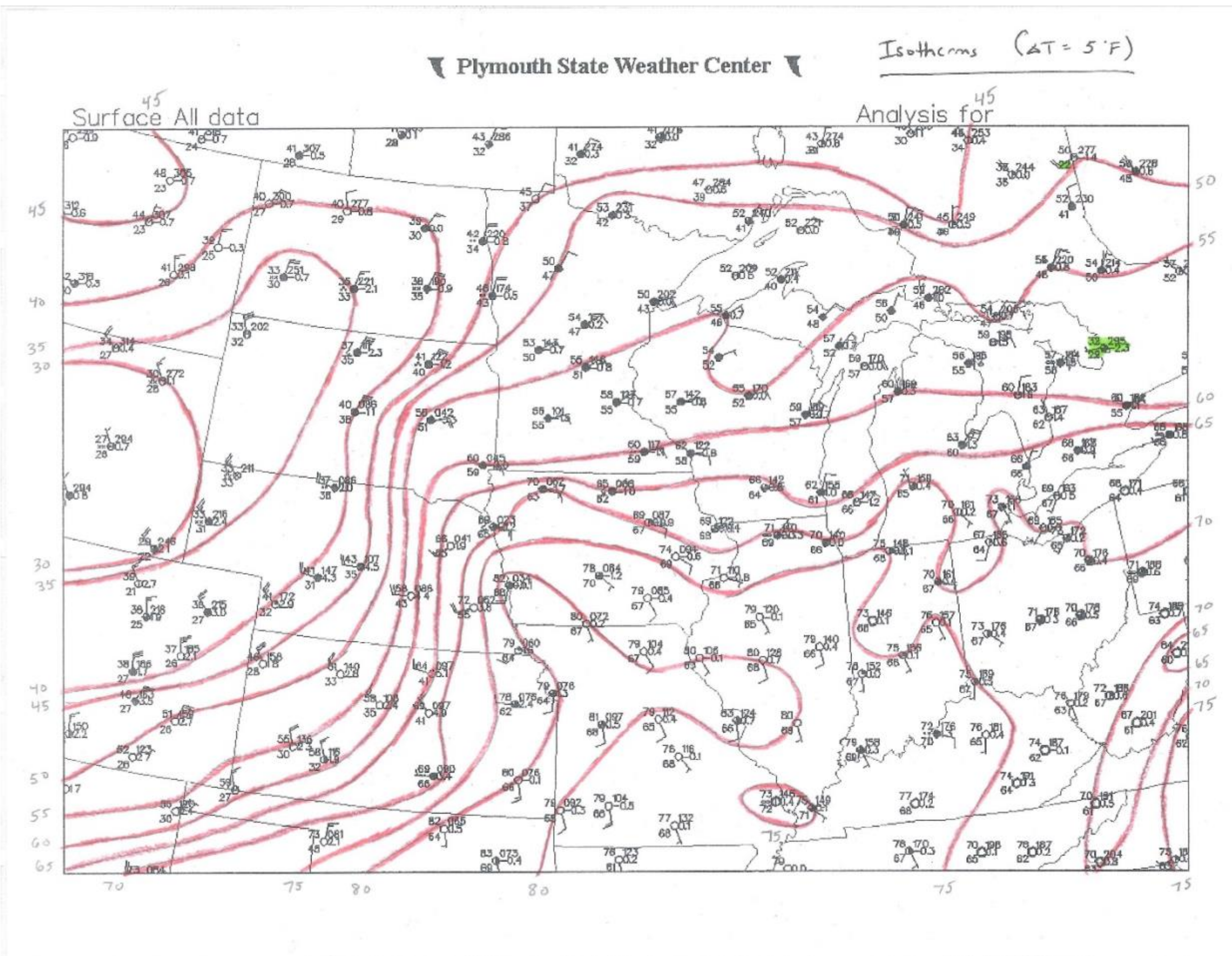

Figure 2. 2-m isotherm analysis. Original image obtained from Plymouth State University.

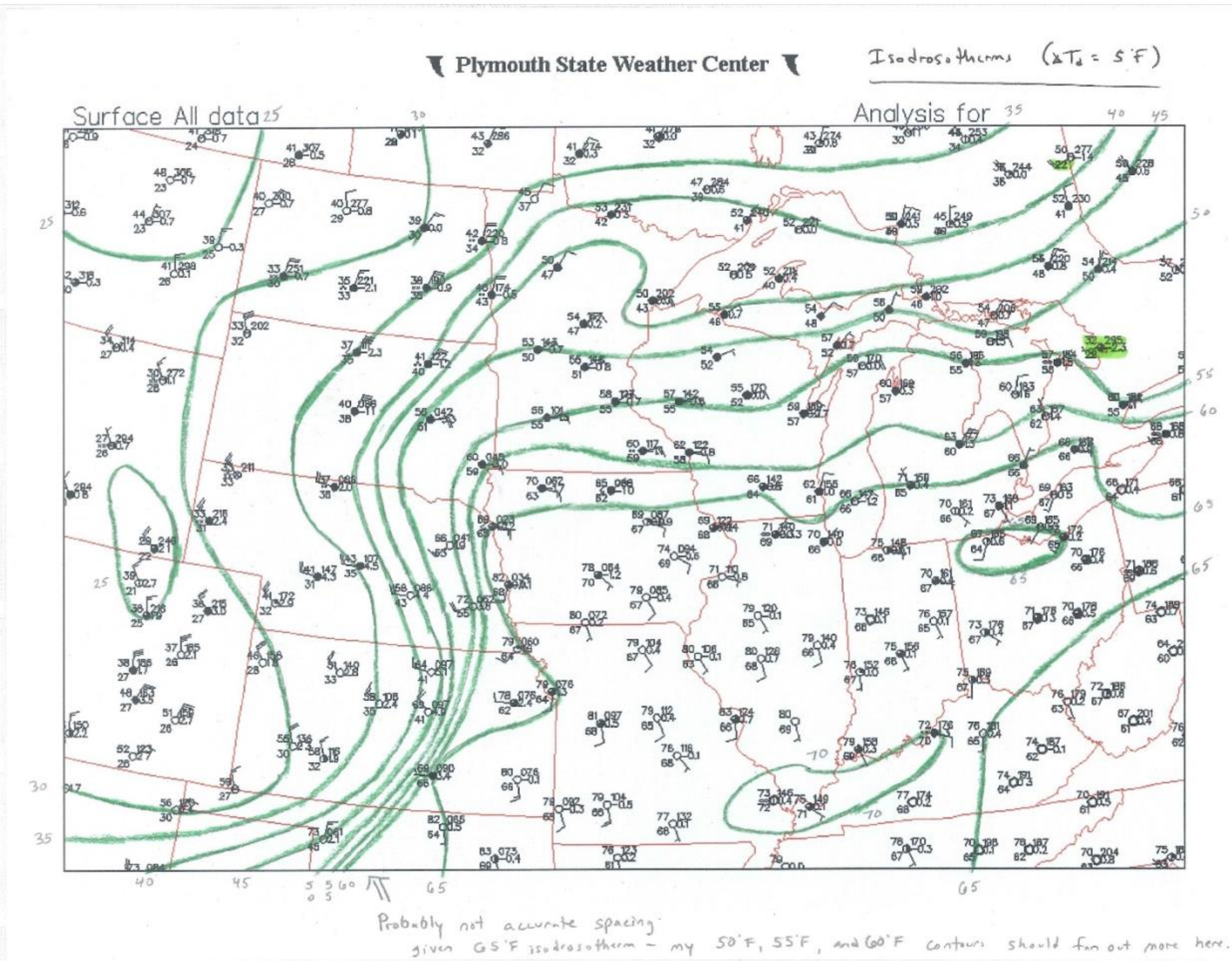

Figure 3. 2-m isodrosotherm analysis. Note comment on analysis in Oklahoma at bottom of figure. Original image obtained from Plymouth State University.

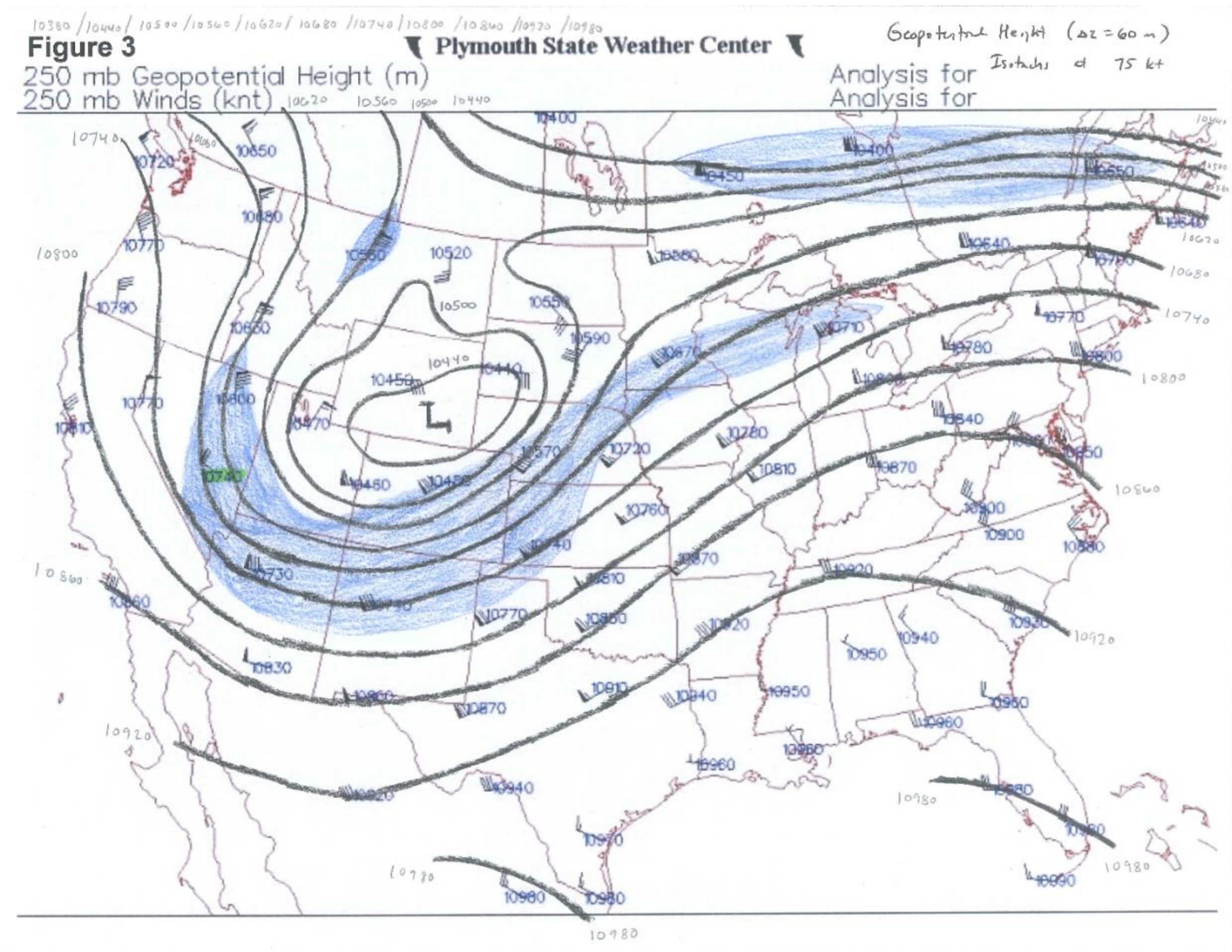

Figure 4. 250 hPa isohypse (black lines) and isotach (blue shading) analysis. Please refer to the text for a discussion of the analysis over Montana and Wyoming. Original image obtained from Plymouth State University.