Chapter 3

Drawing Isopleths

Pattern recognition is a major part of the meteorological analysis process. Patterns are represented on weather charts by a set of isopleths of various weather parameters. Construction of these isopleths can be done manually (by a human weather analyst) or by computer algorithms. This chapter focuses on manual line-drawing methods while computer algorithms are discussed in Chapter 4.

The Basic Assumptions

The objective of drawing isopleths on a weather chart is to transform a dataset into a series of lines (or isopleths) that represent a pattern for some weather parameter. The dataset may be a collection of irregularly spaced observations or it may be gridded data from a computer forecast model. For either dataset, the process of manually drawing isopleths is the same.

When drawing isopleths for a specific weather parameter, the analyst assumes that the data points are part of a continuous field of that parameter. The analyst attempts to represent that continuous field as accurately as possible within the limitations presented by the available data and analysis techniques. This assumption is true for both human line-drawing and computer algorithms. The assumption of continuity is used in meteorological analysis when derivatives are calculated.

Isopleth Properties

Isopleths are lines along which the value of some weather parameter is constant. Lines of specific parameters have specific names: isobar for atmospheric pressure; isotherms for temperature; isodrosotherm for dew point temperature; etc.

Two rules define isopleths properties:

Rule 1: The interval between isopleths is always the same. For example, on a typical surface chart covering the entire United States an interval of 4 millibars (mb) is usually used for atmospheric pressure. Using a constant interval allows easy evaluation of gradients. A gradient is the change in value of a parameter (f) over some distance (s), i.e., the horizontal

spatial derivative, $\partial f/\partial s$. For a constant interval, closely-packed isopleths represent relatively stronger gradients while widely-spaced isopleths represent relatively weaker gradient.

Rule 2: The value of an isopleth is exactly divisible by the interval used. For example, for the 4 mb interval used for surface charts, typical isobar values (in mb) would be: 988, 992, 996, 1000, 1004, 1008, 1012, etc. The only exception to this rule in routine chart construction is for wind speed. Isotachs (or lines of constant wind speed) on upper level charts are drawn at a 20 knot interval starting at 10 knots. This allows for easy recognition of the jet stream which is defined by a minimum wind speed of 50 knots.

Isopleths have the following properties:

a. At all points along an isopleth, the value of the parameter is the same.
b. No isopleths breaks abruptly or stops except at the limits of the data field, that is, isopleths either close on themselves or end at the boundaries of the data field.
c. Isopleths of different value never cross.
d. Isopleths never branch or fork.
e. Two isopleths of the same value can cross at a point.
f. Isopleths should always be labeled with the value of the quantity represented.

The Figures 3-1 and 3-2 illustrate these characteristics. Can you list the reasons why Figure 3-2 is an example of the improper construction of isopleths?

Interpolation

Interpolation is a mathematical process that estimates the value of a parameter at some intermediate location from known, explicitly located, values of that parameter. From a practical perspective, when drawing isopleths on a chart, this involves two steps:

a. Determination of the value(s) of the one or more isopleths that will occur between two data points.
b. Placement of these isopleths at the appropriate points between data points.

As a first approximation we assume that the value of a parameter varies linearly between two adjacent data points. This
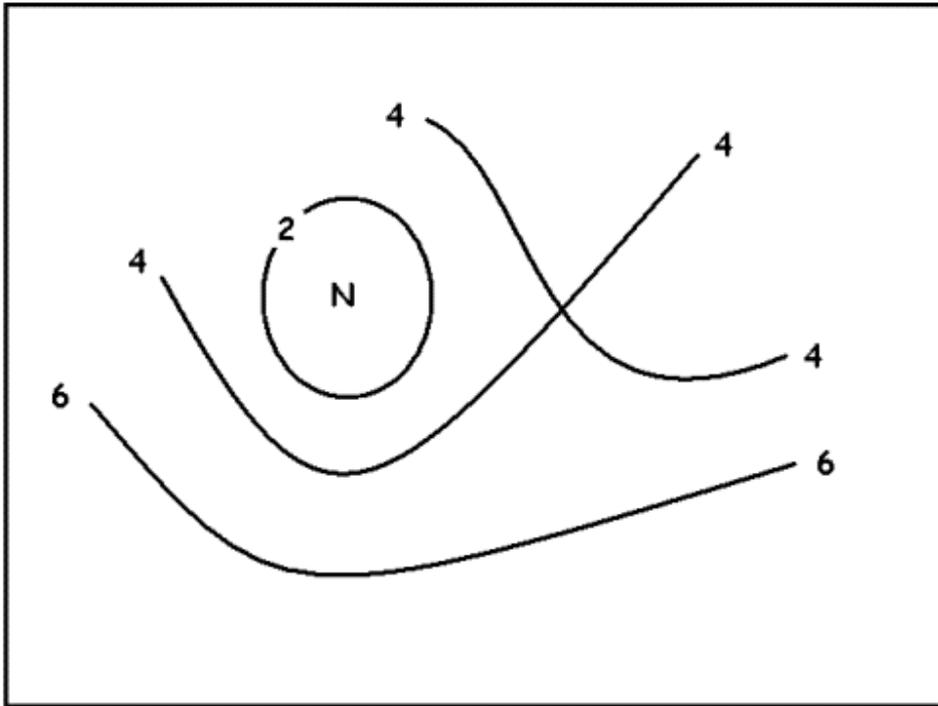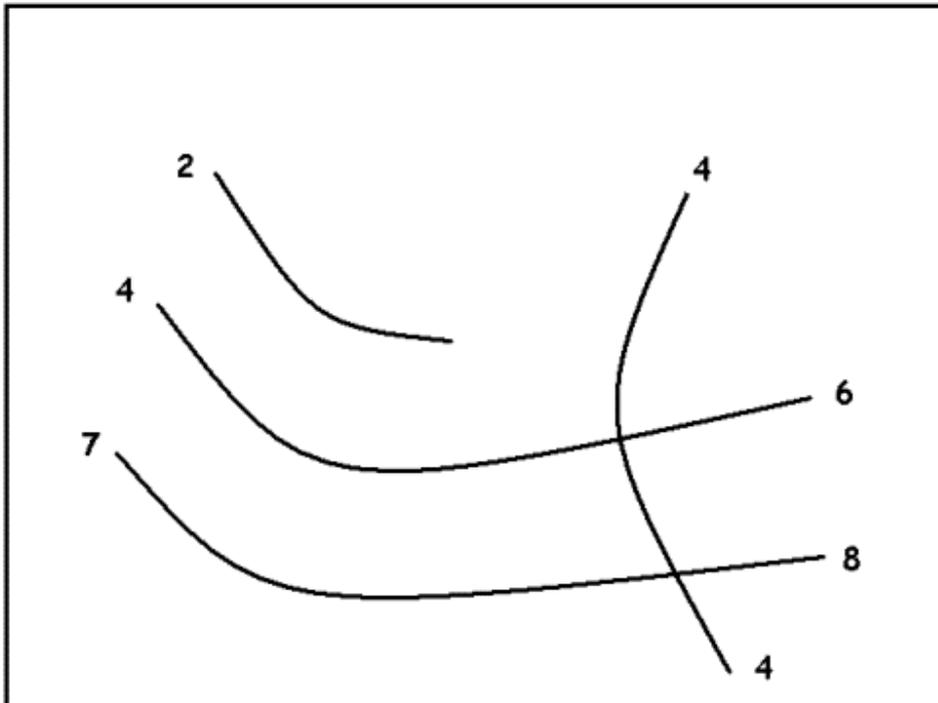
Figure 3-1: Example of Proper Isopleths

Figure 3-2: Example of Improper Isopleths

assumption governs the placement of isopleths between these data points.

Isopleths values are determined by looking at the maximum and minimum values within the dataset and following the rules described above. For example, in Figure 3-3a the minimum value is 41 while the maximum value is 53. If you want to draw isotherms at a 5 degree interval, you will need isotherms with values of 45 and 50 degrees.
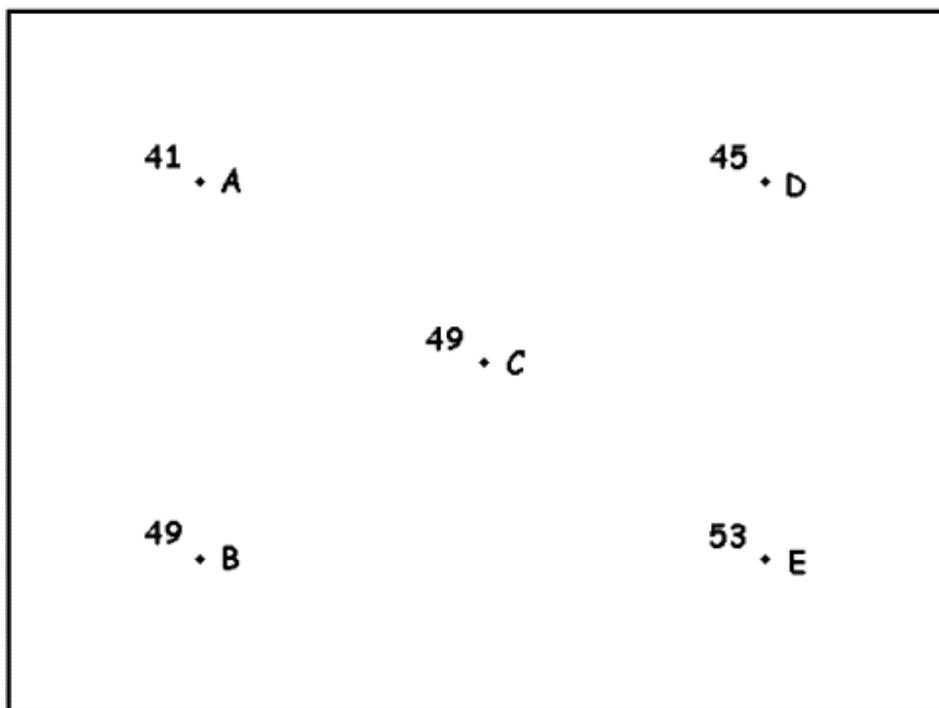

Figure 3-3a: Data Points

The actual drawing process involves good hand-eye coordination. As you draw an isopleth you need to look at adjacent data points and ask yourself two questions:

   a. Does the isopleth that I am drawing go between these two data points?
   b. If the answer to the first question is no, look at two other adjacent points and ask the first question again.
   c. If the answer to the first question is yes, then ask: Where do I place the isopleth?

For Figure 3-3a above, if you want to draw a 45 degree line, start with the data points A and B. The value 45 is between 41 and 49. In fact, it is half way between these values. You can then place the 45 degree isotherm half way between points A and B. Place a light dot or x at this location. Similarly, 45 is half way between points A and C. Place another light dot or x between these points. Point D has a value of 45. Our 45 degree isotherm will go through this point. You now have three points to connect to form the initial placement of the 45 degree isotherm (Figure 3-3b).

Once an isopleth is drawn, all data values on one side of an isopleth are lower than the isopleth value while all data values on the other side are higher than that isopleth value. In Figure 3-3b, all data values above the 45 degree line are smaller than 45 degrees while all data points below the 45 degree line are larger than 45 degrees.
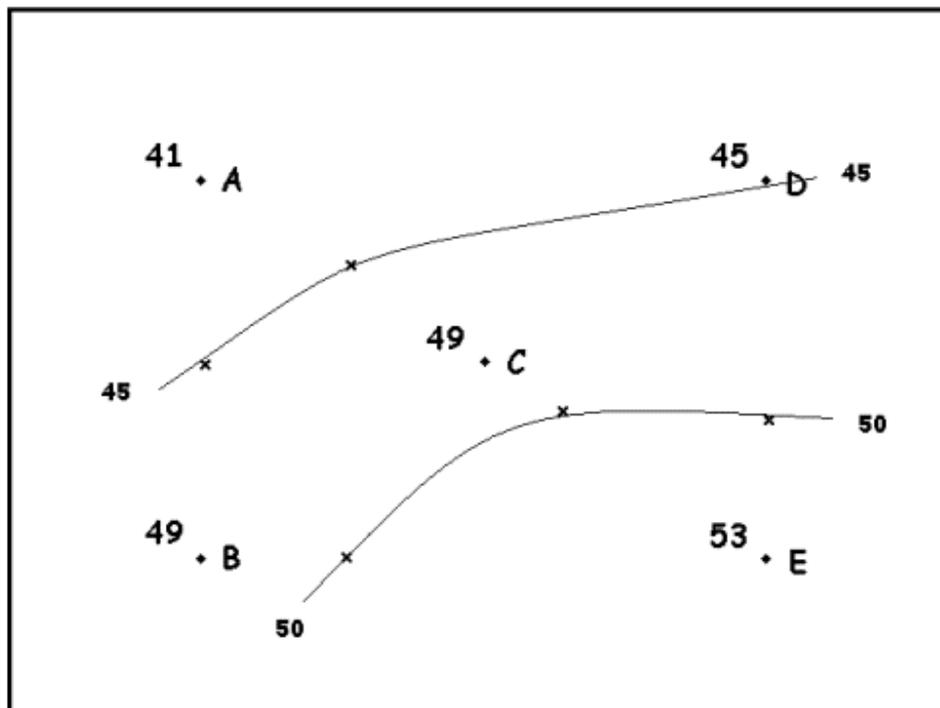

Figure 3-3b: Data Points with Isopleths

Now repeat the process for the 50 degree line. This line will not go between points A and B but will go between points B and E. The difference in values between B and E is 4 degrees. The 50 degree isotherm is 1 degree warmer than point B and 3 degrees

cooler than point E. Hence, the 50 degree line will do one-fourth of the way from B toward E. Estimate this location and place a light dot or x at that spot. Similarly, for points C and E, the 50 degree line will be about one-fourth of the way from C toward E. The 50 degree line continues to the left and goes between points D and E. The difference between these points is 8 degrees. The 50 degree line is 5 degrees warmer than point D and 3 degrees cooler than point E. Hence, the 50 degree line is placed five-eighths of the way from point D toward point E. For a larger plot, continue this process until the entire chart is drawn.

It is not critical to place isopleths with mathematical precision between appropriate points. Just make a reasonable estimate of where the line should be located.

Recommended Procedure

The following sequence is recommended for drawing a series of isopleths on a weather chart:

a. If there are previous charts of the parameter available, review these charts to get a feeling for the history of that parameter (or weather system) and recent changes in the pattern.
b. Conduct a preliminary, visual evaluation of the plotted data in order to determine the general pattern.
c. Lightly sketch the isopleths of the parameter of interest in pencil.
d. Start where the data density is highest and gradients are strongest.
e. Work inward toward maximum and minimum centers and outward toward the edge of the chart.
f. Add any symbols for meteorological analysis models such as fronts or drylines.
g. Once the entire chart is drawn, review your line placement, make adjustments to ensure a smooth pattern that is consistent with accepted meteorological analysis models.
h. Finally, label all isopleths and centers.

The art of drawing isopleths on a weather chart is an acquired skill. The more that you draw charts, the easier it gets. With the wide availability of computer-drawn weather charts, many meteorologists rarely draw isopleths. Nevertheless, this skill is useful at times. So, develop and hone this skill.

Wind Adjustments

When you draw contours on an upper level charts, you should take into consideration the wind values at data points. Figure 4 illustrates this situation. Based on pure linear interpolation, the placement of the 564 dm contour would be half way between the 560 dm value and the 568 dm values. However, the difference in wind speed at the upper point (40 knots) and lower point (20 knots) implies that the interpolation is not linear. If you assume that the wind is in geostrophic balance, the pressure gradient should be stronger around the upper point than around the lower point. This means that the place of the 564 dm contour must be shifted toward the upper point to account for this balance. Although you could calculate this location exactly, in practice, just shift the contour to represent the difference in wind speed.
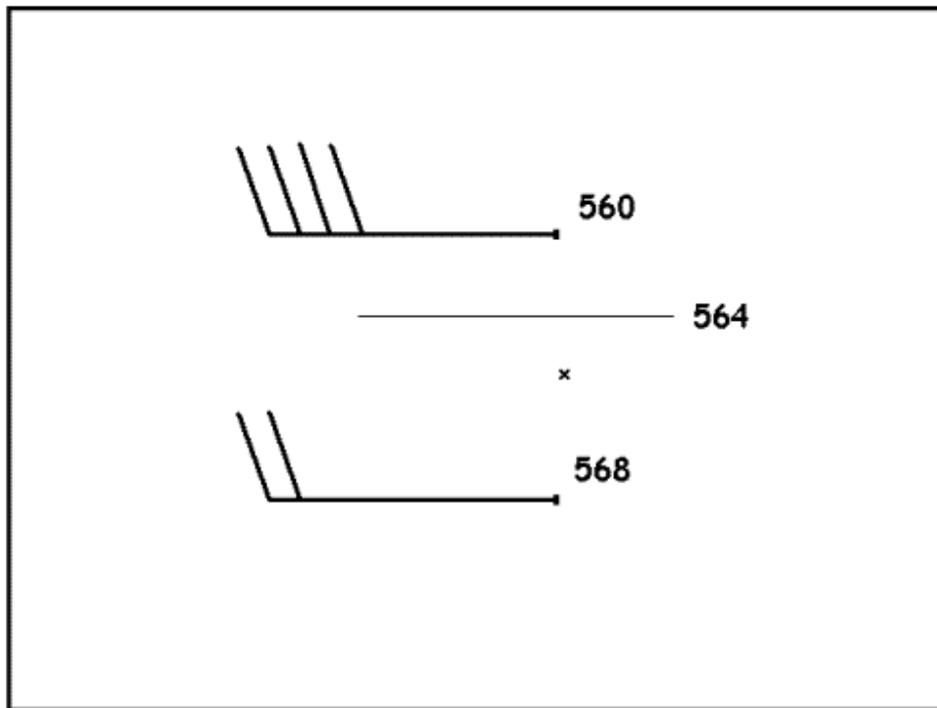

Figure 3-4: Impact of Wind on Isopleth Placement

Smoothing

Your first set of isopleths will likely be a little noisy, that is, contain random fluctuation or wiggles. Smoothing is a process whereby these fluctuations are removed. For a gridded dataset, smoothing can be done by a mathematical averaging

procedure. For hand-drawn charts, the analyst modifies the initial isopleths into an even flowing pattern. Too much smoothing can remove significant details and must be avoided. You must achieve a balance between smoothing out the wrinkles and preserving the important patterns on the chart. Experience is the best teacher for learning smoothing.

Concluding Remarks

This chapter has outlined, in fairly specific terms, the details of constructing hand-drawn weather charts. It is somewhat general in nature but can be applied to a variety of datasets. As noted above, the art of drawing charts has, for the most part, been replaced by computer-drawn charts. Nevertheless, the ability to effectively draw weather charts should be part of every meteorologist's toolbox and an essential part of any meteorological training course.

Draft: 5-01-2009
Final: 5-10-2011