SURFACE AIR PRESSURE PATTERNS

Objectives

Weather is defined as the state of the atmosphere at a particular time and place. Our atmosphere is a mixture of gases with measurable properties such as temperature, density, moisture content and movement. Many of our weather experiences involve air being in motion, whether as gentle breezes or hazardous gales. Wind is the motion of air relative to Earth’s surface. Differences in the pressure exerted by the air over a distance are what cause the air to move. These air movements carry temperature and humidity changes, produce clouds, and may lead to precipitation. Across a horizontal surface such as Earth at sea level, variations in air pressure from place to place result in winds tending to blow from where the pressure is relatively high toward locations where the pressure is relatively low. Determining these air pressure patterns and their differences result in understanding the resulting air motions and predicting what weather is likely to be. We analyze the reported values of air pressure across the country to determine the pressure pattern. This pattern shows locations of centers of relatively high and low pressure on weather maps. These large-scale pressure centers are typically associated with fair and stormy weather systems, respectively.

After completing this investigation, you should be able to:

- Show the patterns of surface air pressures across the nation at map time by drawing lines of equal pressure (isobars).
- Locate regions of relatively high and low air pressures on the same surface map.

Introduction

Air pressure at any point on Earth’s surface or within the atmosphere is determined by the weight of the atmosphere above that point pressing on a unit area. This means that air pressure decreases with increasing altitude. Hence, the higher the elevation of Earth’s surface, the lower the surface air pressure at that location. Consequently, locating centers of high and low atmospheric pressure, which helps to identify weather systems, requires analysis of air pressure values determined at numerous locations at the same elevation.

Air pressures routinely reported on surface weather maps are values “corrected” to sea level. That is, air pressure readings are adjusted to what would be expected if all the reporting stations were actually located at sea level. Adjustment of air pressure readings to the same elevation eliminates the variations of air pressure based on Earth’s topographical relief. This adjustment allows determinations of horizontal pressure differences and recognition of pressure patterns due to the weather systems. These patterns reveal existing broad-scale areas of high and low pressure that play a major role in the weather we experience.

Horizontal air pressure patterns on a weather map are revealed by drawing lines representing points where equal pressure is shown or would exist. These lines are called isobars because every point on the line has the same air pressure (barometric) value. Each isobar separates stations reporting pressures higher than that of the isobar value from those stations with pressures lower than its value.
The Figure 1 surface map segment shows air pressure in whole millibar (mb) units at various locations. [One millibar (the pressure unit traditionally used for atmospheric pressure) is equal to one hectopascal (hPa), that is, one hundred Pascals. A Pascal is one Newton per square meter; named for Blaise Pascal, a French mathematician and physicist.] (Average midlatitude, sea-level air pressure is 1013.25 mb.) On the map, consider each pressure value to have been observed at the center of the plotted number.

Figure 1. Surface weather map with pressures reported in whole millibar units. The 1004- and 1008-mb isobars have been drawn and labeled.

Print a copy of Figure 1 for analysis purposes. Please note that Figure 1 and all other Investigations Manual figures are available for printing from your electronic Investigations Manual or via
the Learning Files section of the RealTime Weather Portal. To view these images, click on the figure in the Manual or on the “eInvestigations Manual Images” link on the Portal, then go to the row containing the appropriate investigation name, and select the appropriate figure within that row. Thus to view and print Figure 1 from the Portal, go to the row labeled “1A” and select “Fig. 1.” Proceed to print the figure. This figure is also available as a PDF in the eInvestigations Manual Image Workbook, linked from the Learning Files section of the RealTime Weather Portal.

1. On the Figure 1 map, the lowest plotted pressure is 1013 mb and the highest plotted value is ______ mb.

   [ ] 1026
   [ ] 1029
   [ ] 1031

Segments of the 1016-, 1020-, and 1024-mb isobars have been drawn in various portion of the map. Complete the pressure analysis by drawing the 1016-mb, 1020-mb, 1024-mb, and 1028-mb isobars where needed. Label each completed isobar by writing the appropriate pressure value at a break in the curve if it is closed or at its ends as shown.

**Tips on Drawing Isobars**

Keep the following “rules” about drawing isobars in mind whenever you are analyzing air pressure values reported on a surface weather map.

a. Always draw an isobar so that air pressure readings greater than the isobar’s value are consistently on one side of the isobar and lower values are on the other side.

b. When positioning isobars, assume a uniform pressure change between neighboring stations. For example, a 1016-mb isobar would be drawn about half way between 1014 mb and 1018 mb plotted station values.

c. Adjacent isobars tend to be shaped alike. The isobar you are drawing will generally align with the curves of its neighbors because horizontal changes in air pressure from place to place are usually gradual.

d. Continue drawing an isobar until it reaches the boundary of the plotted data or “closes” by making its way back to its starting point.

e. Isobars never end within a data field, and they never fork, touch or cross one another.

f. Isobars cannot be skipped if their values fall within the range of air pressures reported on the map. Isobars must always appear in sequence; for example, there must always be a 1000-mb isobar between the 996-mb and 1004-mb isobars even if no values between 996 mb and 1004 mb are plotted on the map.

Always label all isobars.

2. By U.S. convention, isobars on surface weather maps are usually drawn using the same interval (the difference in air pressure between adjacent isobars) as that described for the Figure 1 map. This isobar interval is ______ mb. The isobar interval is selected so as to provide what is generally the most useful resolution of the field of data; too small an interval (for example, 1 mb) would clutter the map with too many lines and too great an interval (for example, 10 mb) would ordinarily mean too few lines to adequately define the pattern.
Also by U.S. convention, isobars drawn on surface weather maps are a series of values that, when divided by 4, produce whole numbers (e.g., $1000 \div 4 = 250$). The progression of isobaric values can be found by adding 4 sequentially to 1000 and/or subtracting 4 sequentially from 1000 until the full range of pressures reported on the map can be evaluated.

3. Which of the following numbers would not fit such a sequence of isobar values? ______

[ ] 1000  
[ ] 1004  
[ ] 1006  
[ ] 1008  
[ ] 1012  
[ ] 1016

The change of pressure over a given distance is called the *pressure gradient*. On surface weather maps, the directions of the horizontal pressure gradients (greatest pressure change over distance) are always oriented perpendicular to the isobars. And, the closer together the isobars appear on a map, the stronger are the pressure gradients.

4. From the isobar pattern you have shown to exist on the Figure 1 map, the horizontal pressure gradient is stronger across ______.

[ ] Illinois – Indiana  
[ ] Georgia – Alabama

As directed by your course instructor, complete this investigation by either:

1. **Going to the Current Weather Studies link on the RealTime Weather Portal**, or

2. **Continuing the Applications section for this investigation that immediately follows.**

**Applications**

*Figure 2* ("Pressures" map) was acquired from the *RealTime Weather Portal* and shows reports of surface air pressures (corrected to sea level) rounded to the nearest whole millibar on 21 August 2016 at 00Z. [UTC, or Z time, is four hours “ahead” of Eastern Daylight Time (EDT), so the 00Z map of August 21st depicts conditions at local times of 8 PM EDT (7 PM CDT, 6 PM MDT, 5 PM PDT, etc.) the evening before]. **Print a copy of Figure 2 for analysis purposes, see directions above.**
Figure 2. Pressures map at 00Z 21 August 2016 of surface air pressures (corrected to sea level) in whole millibars.

Most weather map products from the *RealTime Weather Portal* are created for **AMS Weather Studies** by the National Weather Service’s (NWS) National Centers for Environmental Prediction at the National Oceanic and Atmospheric Administration (NOAA).

5. The lowest plotted air pressure on the map was 998 mb at ________.

   [ ] Boise, Idaho
   [ ] Alpena, Michigan
   [ ] Little Rock, Arkansas

6. The highest reported pressure was ________ mb occurring simultaneously at three stations in Wyoming, South Dakota, and Nebraska, and twice in Maine.

   [ ] 1011
   [ ] 1014
   [ ] 1016
7. The isobars in the conventional series that will be needed to complete the pressure analysis between the lowest and highest values on this map are ________ mb.

[ ] 998, 1002, 1006, 1010, 1014
[ ] 999, 1003, 1007, 1011, 1015
[ ] 1000, 1004, 1008, 1012, 1016

Using a pencil, follow the steps below to complete the pressure analysis for the map area to determine the pressure pattern that existed at the time the observations were made. For completing the map, refer to the Tips on Drawing Isobars in the first portion of Investigation 1A from the Investigations Manual. More than one isobar of the same value may need to be drawn on the map if pressure values located in separate sections of the map area require it. Consider each pressure value to be located at the center of the reported number. Portions of isobars with values of 1008 and 1012 mb, and 1004 mb surrounding a localized value of 1003 mb, have already been drawn in the western and southwestern U.S. area. The 1008-mb isobar extending into western Texas, and the 1012-mb isobar crossing northwestern Colorado, need to be lengthened from their arrow heads. The labels for those isobars have been added at their ends where they reached the boundary of the map area having plotted data.

8. Let us start arbitrarily by drawing the 1000-mb isobar. The isobar will go generally through that pressure value, from Lake Superior around to the Ontario/Quebec border in Canada. It will separate values where the lowest value on the map remains to one side while higher values are on the other side. Label this isobar with its value, 1000, as was done in the Southwest. The pressure values of locations generally over the central Great Lakes area are therefore ________ 1000 mb.

[ ] less than
[ ] equal to
[ ] greater than

Continue drawing and labeling isobars of the series where they existed within the data pattern over the central and eastern U.S. Complete all isobars in the range of values necessary to cover the data points. After completing all the isobars, label the area with the lowest values within the nearly-closed isobar in the Great Lakes area with a bold L (about 1 cm high). The area of high pressure in the west-central U.S. area should have an H situated in the center of those highest values.

9. Figure 3 is the analyzed surface pressure map from the RealTime Weather Portal produced at the NOAA’s National Centers for Environmental Prediction for 00Z 21 AUG 2016. The Figure 3 map shows the locations of isobars, air pressure system centers, and fronts at the same time as those on the Figure 2 map you have analyzed. The overall isobar patterns on the two maps over the contiguous U.S., particularly for the north-central Low and the western High, are generally ________.

[ ] similar
[ ] very different
The Figure 3 map of isobars was constructed by a computer, based on a much more complete set of pressure values than that shown on your Figure 2. This degree of detail can be seen, for example, for the latest surface map available, at http://www.wpc.ncep.noaa.gov/html/sfc-zoom.php (). (This may account for some of the variations between your analysis and that by the computer. The computer-based analysis is the source of some additional plotted Ls denoting locally minimally lower pressure centers and Hs for higher pressure areas, respectively.)

By analyzing the pressure values reported on weather maps to find pressure patterns, one can locate the centers of locally highest and lowest pressures. We will see that these pressure centers often mark the midpoints of major weathermakers; either regions of fair weather or stormy conditions, respectively.

As we go through the term, mention of locally understood geographic regions will appear in the Daily Weather Summaries and Current Studies. Common NWS terminology for these regions of the country which may be useful to understanding is at: http://www.wpc.ncep.noaa.gov/images/us_bndrys1_print.gif () and http://www.wpc.ncep.noaa.gov/images/us_bndrys2_print.gif ().

Please note that Internet addresses appearing in this Investigations Manual can also be accessed via the Learning Files section of the RealTime Weather Portal by clicking on “eInvestigations Manual Web Addresses”. Then, go to the appropriate investigation and click on the address link. We recommend this approach for its convenience. This also enables AMS to update any addresses that are changed after this Investigations Manual was prepared. If a link does not work, click the icon () following it to go to the Web Addresses page on the RealTime Weather Portal.

Suggestions for further activities: The AMS Weather Studies RealTime Weather Portal routinely delivers unanalyzed (“Pressures”) and analyzed (“Isobars & Pressures”) surface pressure maps. Practice
drawing isobars by using the unanalyzed version. Then, compare your results with the analyzed version for the same time. Note: If you would like to practice more on drawing isopleths (lines of a constant value) in groups of numbers, from simple to more complex patterns, go to: http://profhorn.aos.wisc.edu/wxwise/AckermanKnox/chap1/Contour_page1.html.