ACTIVITY Surface Air Pressure Patterns

Upon completing this activity, you should be able to:

- Draw lines of equal pressure (isobars) to show the pattern of surface air pressures on a weather map.
- Locate regions of relatively high and low air pressure on a surface weather map.
- Locate regions on a surface weather map exhibiting relatively large air pressure changes over short horizontal distances and broad areas with gradually varying air pressure.

Materials

- Pencil

Introduction

Air pressure is determined by the weight of the overlying air, and it varies from place to place and over time. Surface air pressure is the force exerted per unit area on an object at the Earth's surface by the air above, approximately 100,000 newtons per square metre or 100 kilopascals.

Pressure variations bring about atmospheric motions that set the stage for much of the weather we experience. Knowing the patterns of pressure is basic to understanding what the weather is and what it is likely to be where you live.

Air pressures routinely reported on surface weather maps are values "corrected" to sea level. That is, air pressure readings are adjusted to what they would be if the reporting stations were actually located at sea level. Adjustment of air pressure readings to a common elevation (sea level) removes the influences of the earth's relief (topography) on air pressure readings. This adjustment allows comparisons of horizontal pressure differences that can lead to the recognition of weather patterns.

Horizontal air pressure patterns on a weather map are revealed by drawing lines joining points of equal pressure, or representing equal pressure, on the map. These lines are called *isobars* because every point on a given line has the same air pressure value. Each isobar separates stations reporting pressure values higher than that of a particular isobar's value from stations reporting pressure values lower than that isobar.

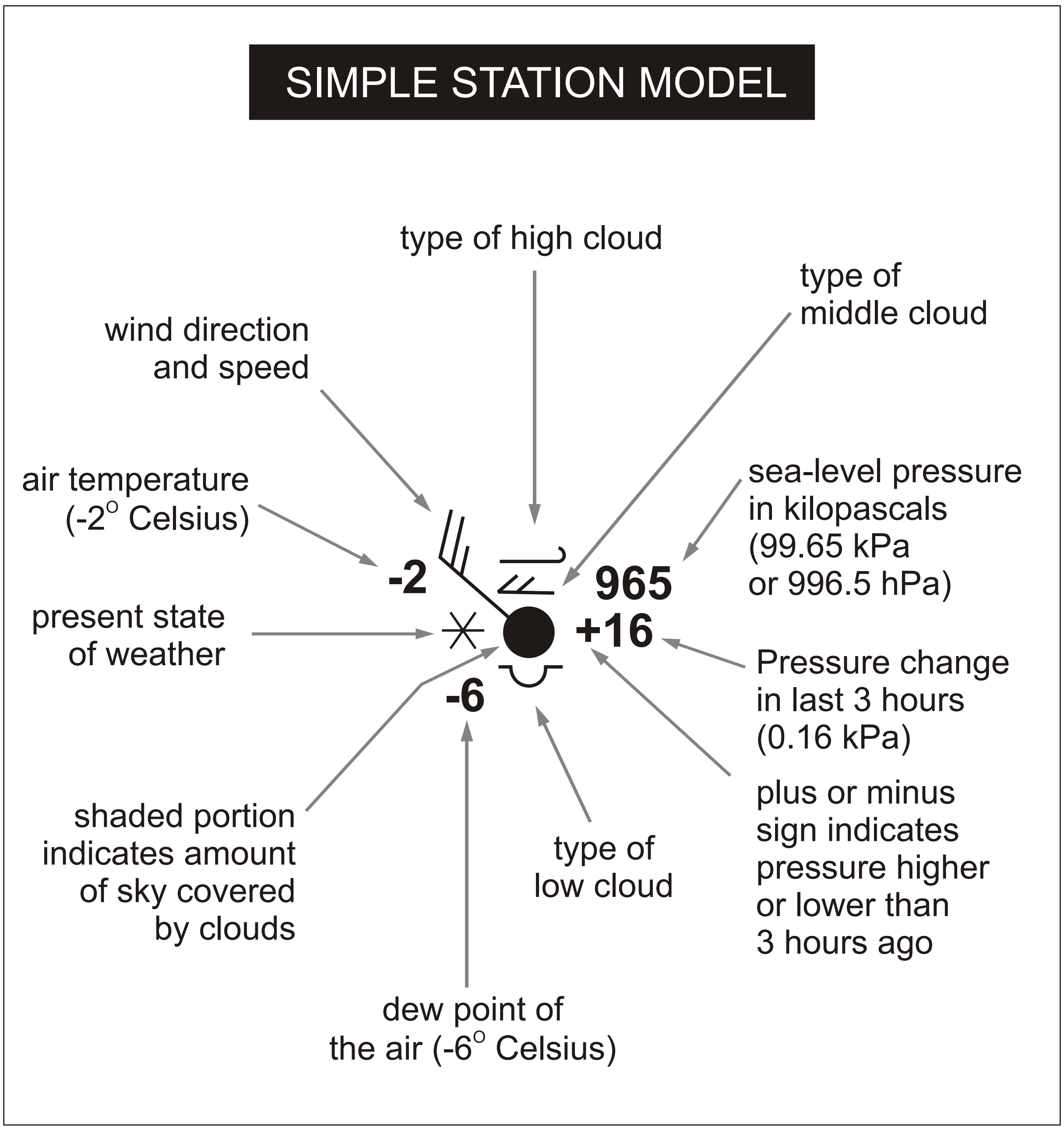
Station Pressure Plotting and Analysis on Weather Maps

The standard unit of atmospheric pressure at the surface of the earth is the kilopascal (kPa). Today's barometers read the station pressure accurately to the second decimal point; for example, 101.25 kPa.

In the plotting of weather maps, it is common practice to <u>drop the decimal points</u> from the map to facilitate legibility and to avoid confusion with station symbols. The plot on a weather map thus shows the station pressure of 101.25 kPa simply as "125" (or the last three digits of the pressure value) as depicted in the station plot model shown below.

The initial *10*, or 9 in the case if pressures below 100 kPa is also dropped for convenience on most maps. Since most sea-level pressures fall between 970 and 1050 hPa, there is little chance for confusion.

By convention, isobars on surface weather maps are usually drawn using standard intervals. Remembering that 100.0 kilopascals is the approximate force exerted per unit area on an object at the Earth's surface by the air above, a pressure value 100.0 kilopascals (kPa) or 1000 hectopascals (hPa) becomes an easily recognized reference value. Again, remembering that the use of the decimal point in map plotting is avoided whenever possible the 1000 hectopascal (hPa) value becomes a reference for isobaric analysis.



Activity 1

Figure 1 represents a surface map plot which shows air pressure in hectopascals (hPa) at various locations. (The example uses whole numbers and not the traditional station plot format for the purpose of this exercise only) Each pressure measurement is placed on the location it represents. A 1012-hPa isobar, which encircles one station on this map has been drawn. Complete the 1008-hPa isobar that has already been started. Finally draw the 1004-hPa isobar. Label each isobar by writing the appropriate pressure value at its end point.

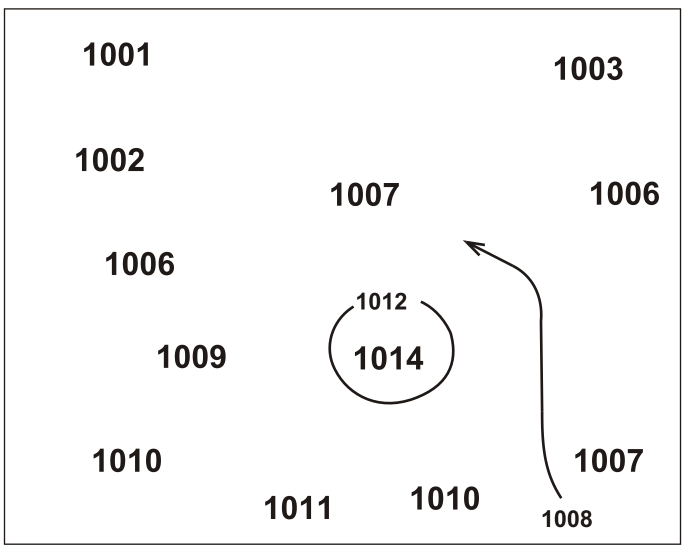


Figure 1 - Sample plot of surface pressure values in hectopascals (hPa) at various stations. (This example uses whole numbers and not the traditional station plot format for the purpose of this exercise only)

Investigations

Referring to the completed surface pressure analysis of Figure 1:

1. By convention, isobars on surface weather maps are usually drawn using the same interval (the difference between air pressure values from one isobar to the next) as that used on this map. That isobar interval is _______ hPa. The isobar interval is selected so as to provide the most useful depiction of the field of data; too small an interval will clutter the map with too many lines, and too great an interval gives too few lines to adequately define the pattern.
2. Isobars that are drawn on surface weather maps follow a sequence of values that can be found by adding or subtracting 4 from 1000, then adding or subtracting another 4 from the resulting numbers, and so on until the full range of values plotted on the map have been accounted for. Cross out the numbers in the following set which do not fit such a sequence of isobaric values: 992, 994, 996, 1000, 1002, 1004, 1008, 1009, 1010, 1012.
3. The letters "H" and "L" mark the centres of closed isobars and signify centres of maximum high and minimum low pressure, respectively, compared to pressure readings in the surrounding area. On the completed surface pressure analysis of Figure 1, the pressure inside the 1012-hPa isobar is higher than the isobar value. Place an "H" inside the closed isobar.

Tips for drawing isobars:

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 steady pressure change with distance between neighbouring stations. For example, a 1012-hPa isobar would be drawn between the observations of 1013 hPa and 1010 hPa about one-third the way from the 1013 hPa reading.

c. Adjacent isobars tend to follow a similar pattern. The isobar that you are drawing will generally parallel the curves of its neighbours 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" to form a loop by making its way back to its starting point.

e. Isobars never stop or 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 pressure reported on the map. Isobars must always appear in sequence, for example, there must always be a 1000-hPa isobar between a 996-hPa and 1004-hPa isobar.

g. Always label isobars.

Activity 2

Figure 2 represents a surface map showing air pressure in hectopascals (hPa) at various locations. As in Figure 1, this example uses whole numbers and not the traditional station plot format for the purpose of this exercise only, and each pressure measurement is placed on the location it represents. The 996-, 1000- and 1004-hPa isobars have already been drawn. Draw all other isobars in the sequence that spans the range of pressure values appearing on the map. (An isobar may appear more than once on the map if the pattern of values requires it.)

Activity 3

Go to the Environment Canada Web Site to view the latest surface weather map analyses (surface weather charts):

http://weatheroffice.ec.gc.ca

Navigate to the **Weather Maps** page. Select **Analysis Charts**

Under **Surface Analysis: MSLP** (Mean Sea Level Pressure), a variety of surface weather map analyses for 00z, 06z, 12z and 18z are available. For viewing purposes, the smaller Canadian coverage analyses may be the preferred option.

Examine the various surface map analyses available on the web site. Select one for further evaluation. The map selected should have both "closed" Highs and Lows and some variation in the degree of horizontal pressure changes depicted.

Either by printing a hard copy of the Surface Analysis or through online display, examine the surface analysis and the isobars drawn on the weather map from the perspective of:

a) Applying the tips for drawing isobars.

b) Locating regions of relatively high and low air pressure on a surface weather map.

c) Locating regions on a surface weather map exhibiting relatively large air pressure changes over short horizontal distances and broad areas with gradually varying air pressure.

Note: If internet access to a surface map analysis is not readily available, Activity 3 can be completed using the surface map analyses provided in figures 3 and 4.

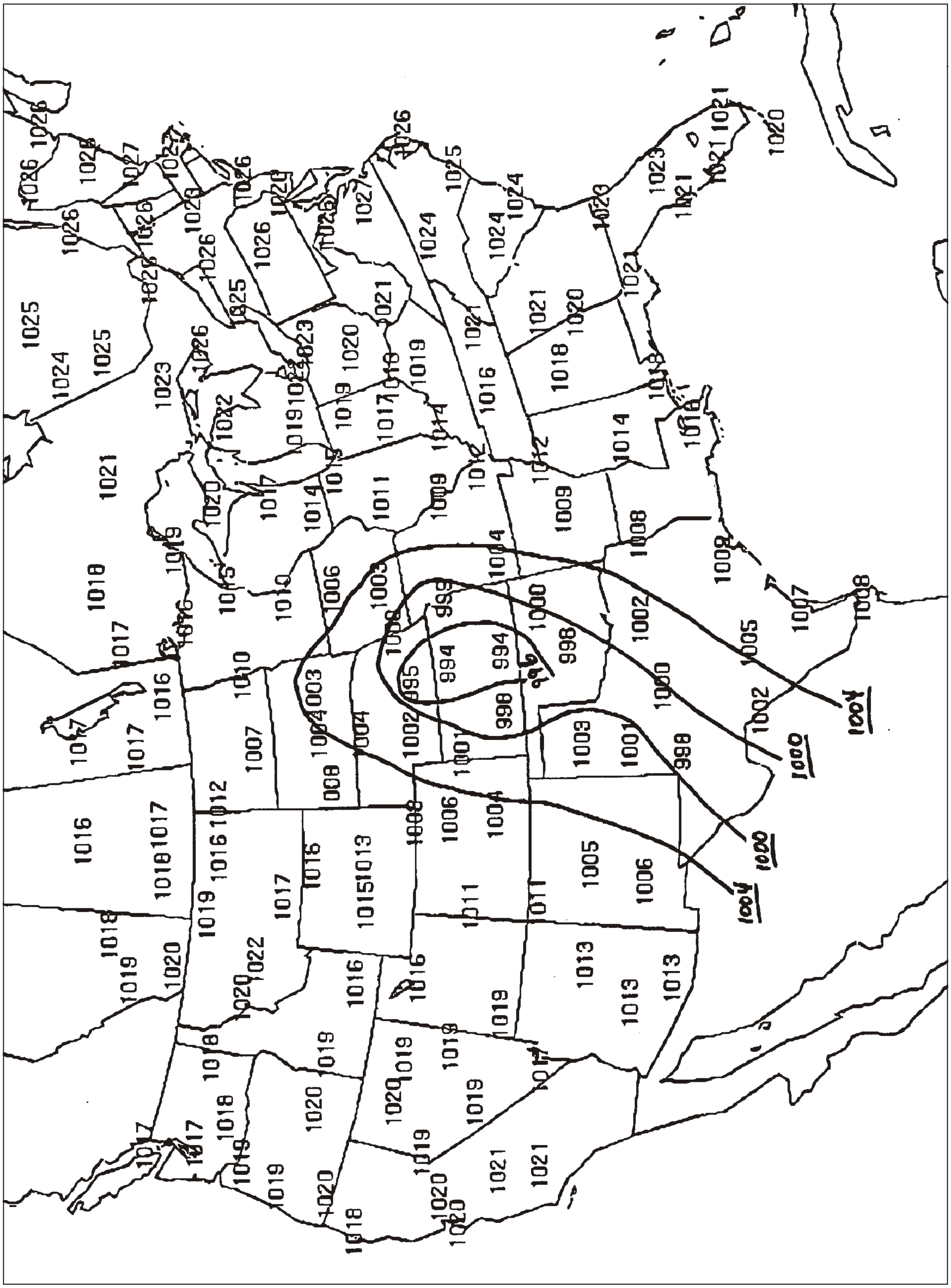


Figure 2 - surface map showing air pressure in hectopascals (hPa) at various locations across Canada and the United States. (This example uses whole numbers and not the traditional station plot format for the purpose of this exercise only)

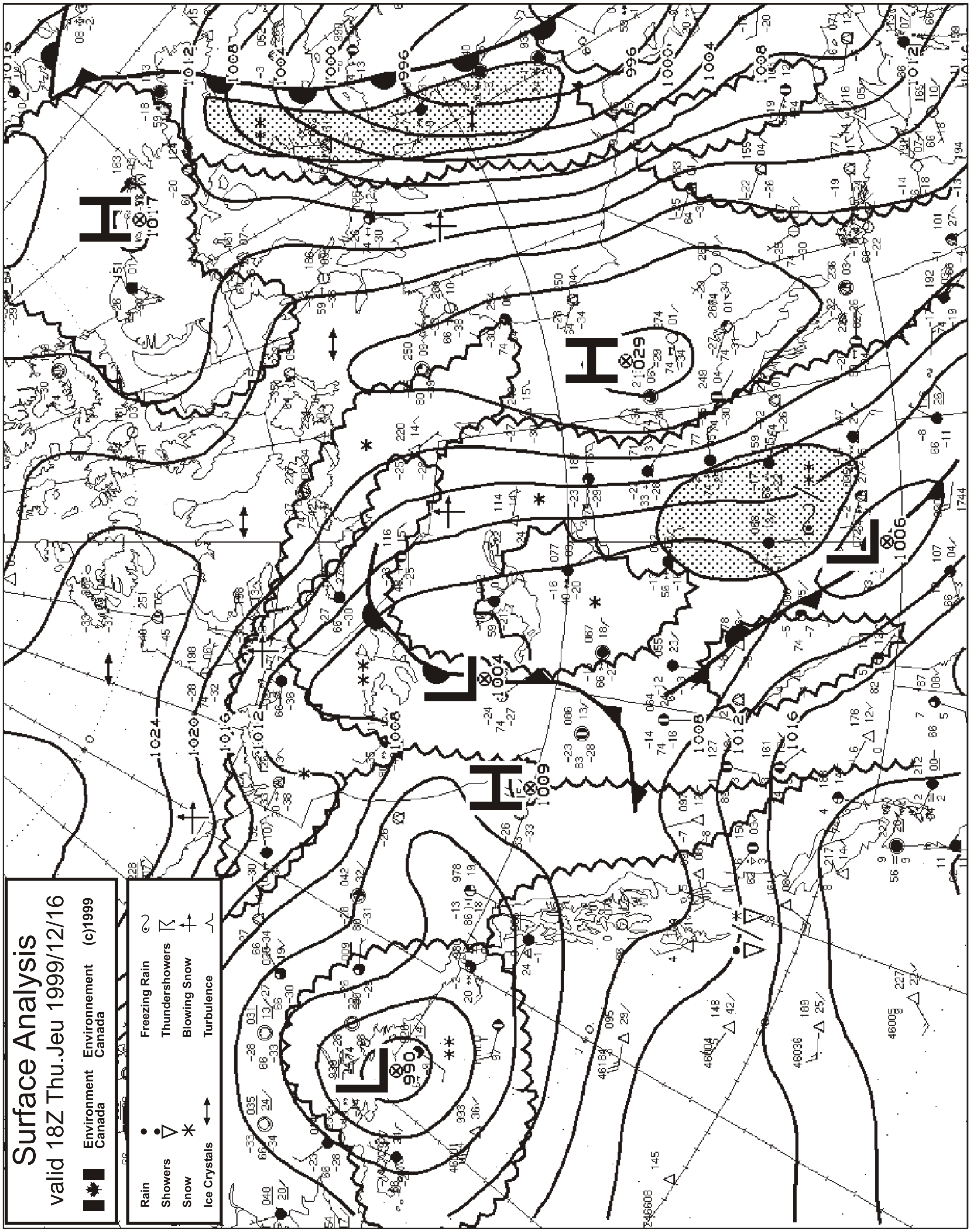


Figure 3 - An example of a regional surface map analysis showing isobars, highs, lows, fronts, clouds, and precipitation. (This chart can be used for Activity 3 on Surface Air Pressure Patterns)

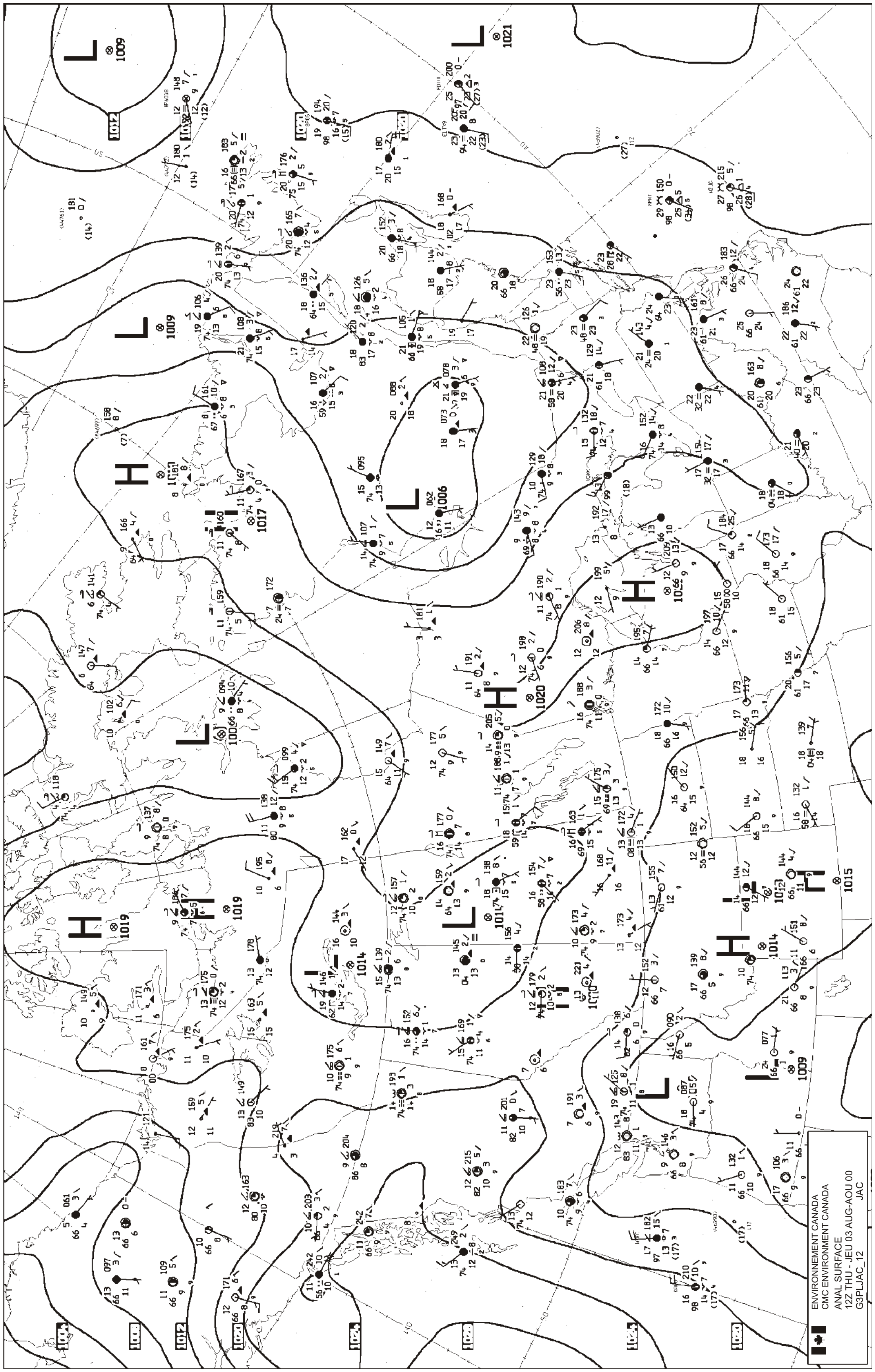


Figure 4 - An example of a computerized national surface map analysis showing isobars, highs and lows. (This chart can be used for Activity 3 on Surface Air Pressure Patterns)

ACTIVITY Air Motion — The High and Low of It

Upon completing this activity, you should be able to:

- Describe the general air motions and weather conditions associated with a high pressure system, or High.
- Describe the general air motions and weather conditions associated with a low pressure system, or Low.
- Based upon the locations of the centres of Highs and Lows, as shown on a weather map, predict general wind directions and weather conditions for different locations.

Introduction

Weather can be fair or stormy. Generally, fair weather is associated with high surface air pressure while stormy weather is associated with low surface air pressure. Broad-scale areas of high and low surface pressure dominate weather in middle latitudes and are simply called **Highs** and **Lows.**

Highs and Lows are regions where air pressures are higher or lower compared to the surrounding areas and are typically hundreds, or even thousands, of kilometres across. On a weather map, a large "High" or **H** symbolizes the location of highest pressure in a High whereas a large "Low" or **L** symbolizes the position of lowest pressure in a Low. Highs and Lows generally travel from west to east while exhibiting at least some motion toward the north or south. As they travel, they bring changes in the weather to the places along their paths.

This activity investigates (1) the horizontal and vertical air motions in Highs and Lows, and (2) the impacts of these motions on weather at locations under the influence of Highs and Lows.

Materials

- Pencil

Procedure: Construction of a Model High Pressure System

1. Using a copy of the map of North America found in Figure 5, place an **H** over Edmonton representing the centre of a broad high pressure area. Lightly draw a circle on the map about 3 cm in diameter around the "H."
2. Place the map flat on your desk. If possible, stand up. (This exercise works better standing up.) Bring the thumb and fingertips of your left hand (if you are right-handed) or your right hand (if your are left-handed) close together and place them on the circle you drew.
3. Rotate your hand slowly clockwise, as seen from above, and gradually spread out your thumb and fingertips as your hand turns. Do not rotate the map. Practice this until you achieve as full a twist as you can comfortably.
4. Place your thumb and fingertips back in your starting position on the circle. Mark and label the positions of your thumb and fingertips 1, 2, 3, 4, and 5, respectively.
5. Slowly rotate your hand clockwise while gradually spreading your thumb and fingertips. Go through about a quarter of your twisting motion. Stop, mark, and label the positions of your thumb and fingertips on the map. Follow the same

procedure in quarter steps until you complete your full twist.

6. Connect the successive dots for each finger and your thumb using a smooth curved line. Place arrowheads on the lines to show the directions your thumb and fingertips moved.
7. The spirals represent the general flow of surface air that occurs in a typical high pressure system (or High)

Procedure: Construction of a Model Low Pressure System

1. Using another copy of the map of North America found in Figure 5, place an "L" over Des Moines representing the centre of a broad low pressure area. Lightly draw on the map a circle about 3 cm in diameter around the "L".
2. Again, if possible, stand up. Place your non-writing hand flat on the map with your palm covering the circle and your fingers and thumb spread out.
3. Practice rotating your hand <u>counter-clockwise</u> as seen from above while gradually pulling in your thumb and fingertips as your hand turns until they touch the circle. Do not rotate the map. Practice until you achieve a maximum twist with ease.
4. Place your hand back in the spread position on the map. Mark and label the positions of your thumb and fingertips 1, 2, 3, 4, and 5, respectively.
5. Slowly rotate your hand <u>counter-clockwise</u> while gradually drawing in your thumb and fingertips. Stopping after quarter turns, mark and label the positions of your thumb and fingertips. Continue the twist until your thumb and fingertips are on the circle.
6. Connect the successive dots for each finger and your thumb using a smooth curved line. Place arrowheads on the lines to show the directions your thumb and fingertips moved.
7. The spirals represent the general flow of surface air that occurs in a typical low pressure system (or Low).

Investigations: Characteristics of High & Low Pressure Systems

Directions: Refer to the Activity Introduction and the Model Highs and Lows you constructed to complete the following questions.

1. Moving in the direction towards the centre of a **High,** the surface atmospheric pressure (***increases***) (***decreases***). When moving towards the centre of a **Low,** the surface atmospheric pressure (***increases***) (***decreases***).
2. Which of the following best describes the surface wind circulation around the center of a High-pressure system (as seen from above)?
   a) Counter-clockwise and spiralling outward
   b) Counter-clockwise and spiralling inward
   c) Clockwise and spiralling outward
   d) Clockwise and spiralling inward
3. Which of the following best describes the surface wind circulation around the centre of a Low-pressure system (as seen from above)?
   a) Counter-clockwise and spiralling outward
   b) Counter-clockwise and spiralling inward
   c) Clockwise and spiralling outward
   d) Clockwise and spiralling inward

4. On your desk, repeat the hand twists for the High and Low pressure system models. Note the vertical motions of the palm of your hand. For the High, the palm of your hand (***rises***) (***falls***) *during* the rotating motion, whereas for the Low, the palm of your hand (***rises***) (***falls***) during the rotating motion.

5. The motions of your palms during these rotations represent the directions of vertical air motions in Highs and Lows. Vertical motions in a High are (***upward***) (***downward***) while vertical motions in a Low are (***upward***) (***downward***). Note that horizontal surface winds in a High and Low are considerably stronger than vertical air motions.

6. In a High pressure system, air flows
   a) Downward and outward in a clockwise spiral
   b) Downward and inward in a counter-clockwise spiral
   c) Upward and outward in a clockwise spiral
   d) Upward and inward in a counter-clockwise spiral

7. In a Low pressure system, air flows
   a) Downward and outward in a clockwise spiral.
   b) Downward and inward in a counter-clockwise spiral
   c) Upward and outward in a clockwise spiral
   d) Upward and inward in a counter-clockwise spiral

8. The weather associated with a **Low** can be significantly different than that of a **High.** Different vertical motions account for some of these differences. Vertical motions lead to temperature changes in the rising or sinking air. The temperature changes occur because air warms when it is compressed and cools when it expands. (That is why a bicycle pump heats up as it compresses air and why air coming out of a tire valve cools as it expands while rushing from the higher pressures in the tire into the lower pressure of the atmosphere.) In the open atmosphere, air pressure decreases with increasing altitude. Consequently, air expands and cools when (***ascending***) (***descending***). Air is compressed and warms when (***ascending***) (***descending***).

9. In a **Low,** air generally exhibits ascending motion. The rising air experiences (***increasing***) (***decreasing***) atmospheric pressure. The ascending air (***expands***) (***is compressed***) and its temperature (***increases***) (***decreases***).

10. In a **High,** air displays descending motion. The sinking air experiences (***increasing***) (***decreasing***) atmospheric pressure. Consequently, the descending air (***expands***) (***is compressed***) and its temperature (***increases***) (***decreases***).

11. Most clouds form by the cooling of air. Air, if sufficiently cooled, will become saturated with water vapour. Continued cooling will result in condensation, cloud formation, and possible precipitation. The vertical motion in a (***High, Low***) often leads to cloud formation.

12. Warming causes clouds to evaporate. Cloudy air is saturated with water vapour. With sufficient warming, it will become unsaturated and existing cloud particles (water droplets or ice crystals) will evaporate. The vertical motions in a (***High***, ***Low***) produce warming, promote cloud dissipation, and lead to clear skies.

13. Descending air in a **High** leads to (***fair***)(***stormy***) weather and ascending air in a **Low** tends to make weather (***fair***)(***stormy***).

14. The broad horizontal expanses of Highs and Lows cover large geographical areas such that their circulations transport colder air from higher latitudes and warmer air from lower latitudes. Consequently, in a High, air to the east of the system's centre is generally (***colder***) (***warmer***) than air to the west.

15. In a **Low**, air to the east of the system's centre is generally (***colder***) (***warmer***) than air to the west.

16. Turn to your map with the **High** marked on it. Examine the model High you constructed on the map. The hand-twist model of a High indicates the sky is probably (***clear***) (***cloudy***) at Edmonton.

17. Surface winds at Prince George are probably from the general direction of (***north***) (***south***) and temperatures are (***higher***) (***lower***) than those in Saskatoon.

18. The centre of the High is forecast to be near Regina tomorrow. The weather at Edmonton tomorrow will probably be most like the weather in (**Regina**, **Prince George**, **Helena**) today.

19. Turn to your map with the **Low** marked on it. Examine the model Low that you constructed on the map. The hand-twist model of a Low indicates that the sky is probably (***clear***) (***cloudy***) at Des Moines.

20. Surface winds at Cheyenne are probably from the general direction of (***north***) (***south***), and temperatures are (***higher***) (***lower***) than those in Toronto.

21. In the table below, describe the typical characteristics of Highs and Lows. Within each box, the related question number is listed for easy reference.

	HIGH	LOW
Pressure Change Towards Center (increase, decrease)	1	1
Surface Winds Around Center (clockwise, counter-clockwise)	2	3
Surface Winds Around Center (inward, outward)	2	3
Vertical Motion (up, down)	5	5
Change in Temperature of Vertically Moving Air (increases, decreases)	10	9
State of the Sky Around Center (clear, cloudy)	12	11
General Weather (fair, stormy)	13	13

Figure 5 - Reference map of North America for Activity - Air motion - the high and low of it