Weather Maps and Forecasting
Michigan State University Cooperative Extension Service
4-H Club Bulletin
Weather Project Unit 3
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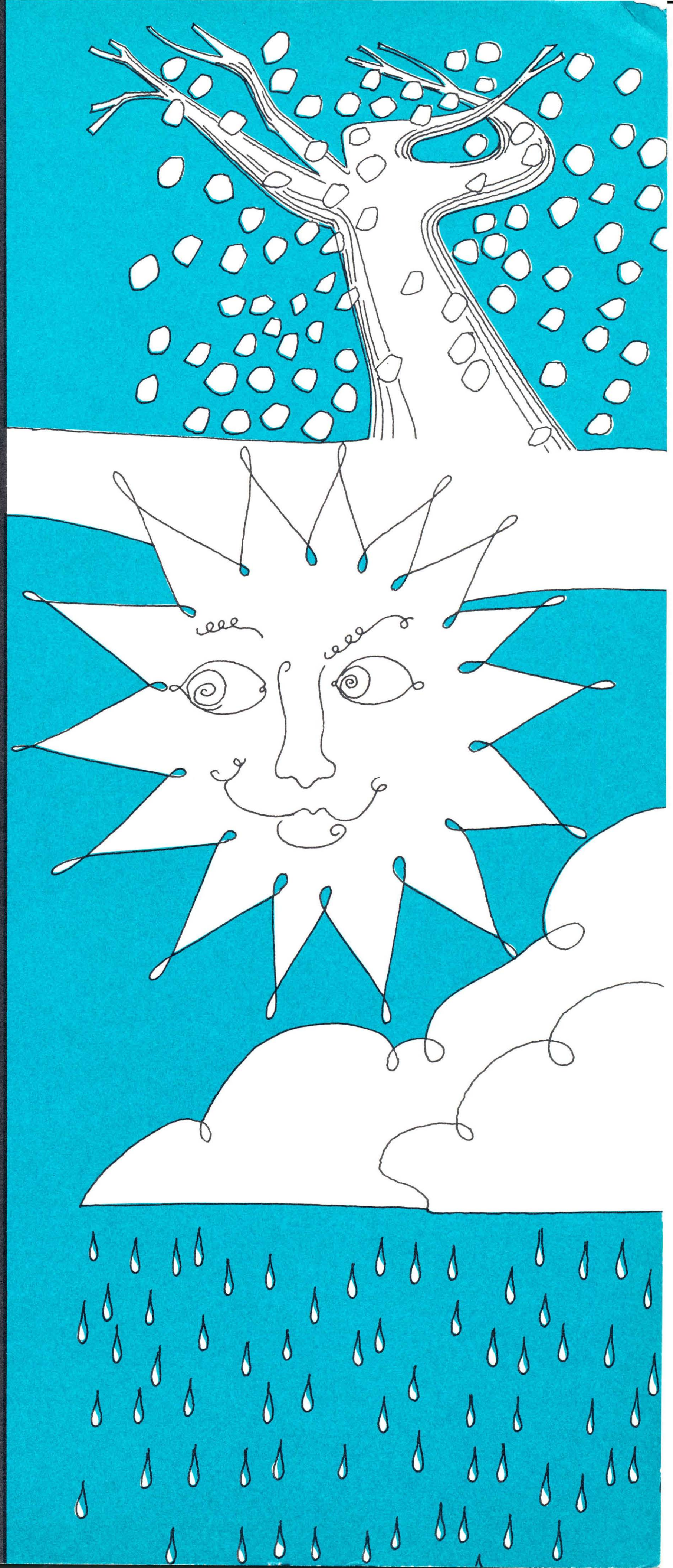
UNIT **3** 4-H WEATHER PROJECT

WEATHER MAPS AND FORECASTING



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Member's Guide
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Cooperative Extension Service
Michigan State University

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Heat Wave Continues! no relief in sight

WASHINGTON—The 63rd [redacted]

Weather forecasts are *news*. They are so important to our daily lives that newspaper editors may stretch them across the front page in bold banner headlines. Think of what happens when the headline above appears. Air conditioner sales increase. So do sales of bottled "pop", electric fans, suntan lotion, and backyard pools. Farmers irrigate their crops. We get up early to water the lawn. . . The mayor may warn us to conserve water. Thousands of families leave the city, jamming highways as they head for the lakes. Extra state police are put on duty to control the heavy traffic. Park officials and resort owners prepare for the busy days ahead.

Weather, in other words, governs much of what we do. When we consider the importance of weather forecasts to farmers, storekeepers, businessmen, city and state officials, families —to everyone, in fact—we realize that being able to predict the weather is much more than an intriguing pastime. It is a skill we can use all our lives.

Meteorologists make their forecasts by "reading" weather maps, observing the speed and direction of overall weather changes, and then relating this information to local conditions. We can do the same. The purpose of this unit is to explain the weather map and to demonstrate how it can be used, along with readings from a home weather station, to predict storms, fair skies, increasing cloudiness, steady rains, sudden temperature changes and many other conditions.

WEATHER MAPS AND FORECASTING

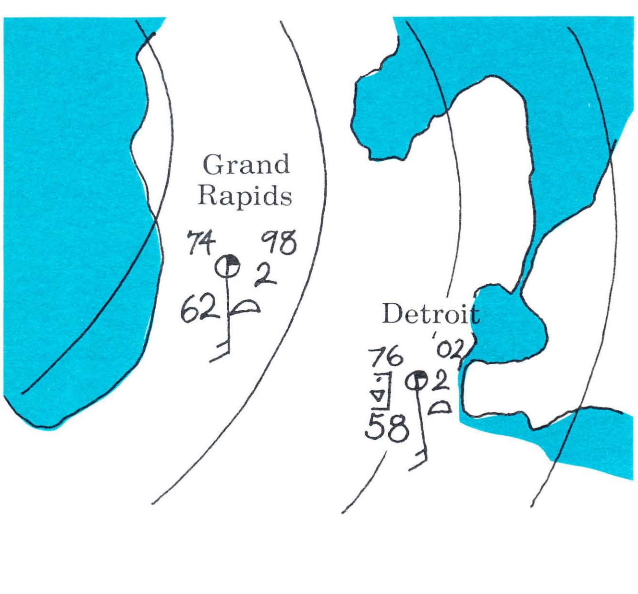
A Look at the Weather Map

Weather maps are a summary of current weather conditions over a large area. For the most accurate predictions, two maps are used, one charting the movement and characteristics of the upper air, and the other of general weather conditions at the earth's surface. On a surface map, meteorologists plot barometric pressure readings, temperatures, dewpoints, winds, clouds and precipitation reports — basically the same information you have been obtaining from your own weather station. Meteorologists take a broader view. Their data is collected every 3 to 6 hours by radio or teletype from stations all over the world. This information, fed into high-speed electronic computers, comes out as weather maps which summarize the reports and show patterns of high and low pressure areas.

Until very recently, weather maps were plotted by hand. Many still are, where conditions are too variable for the machines to handle. Even computer weather maps must be adjusted by meteorologists so that local conditions are taken into consideration. The results of this combined effort of man and machine are extremely reliable forecasts, accurate from 85% to 95% of the time.

HOW WEATHER DATA IS SUMMARIZED

So that all essential information can be included on a weather map an abbreviated form called a *station model* is used for each reporting station. On the simplified weather map below, you'll find the following markings around Detroit:



Here's what they mean. Starting in the upper right hand corner of the station model and moving clockwise:

02 Represents pressure at sea level given in millibars. Add either a 9 or 10 in front of the number given for the complete pressure reading. Examples: 02 is 1002 millibars; 92 would be 992. Normally, 48 (1048) would be the highest pressure observed and 68 (968) would be the lowest.

2⋀ Shows pressure change in the last three hours. The 2 indicates a change of 2 millibars and ⋀ indicates that the pressure rose then fell 2 millibars below the pressure of three hours earlier.

⌓ Indicates the type of clouds. This symbol represents cumulus.

58 Stands for dewpoint, or the temperature to which the air would have to be cooled before it reaches the saturation point.

Represents the present weather. This symbol means that rain showers ended. About 80 other symbols appear here.

76 Indicates present temperature.

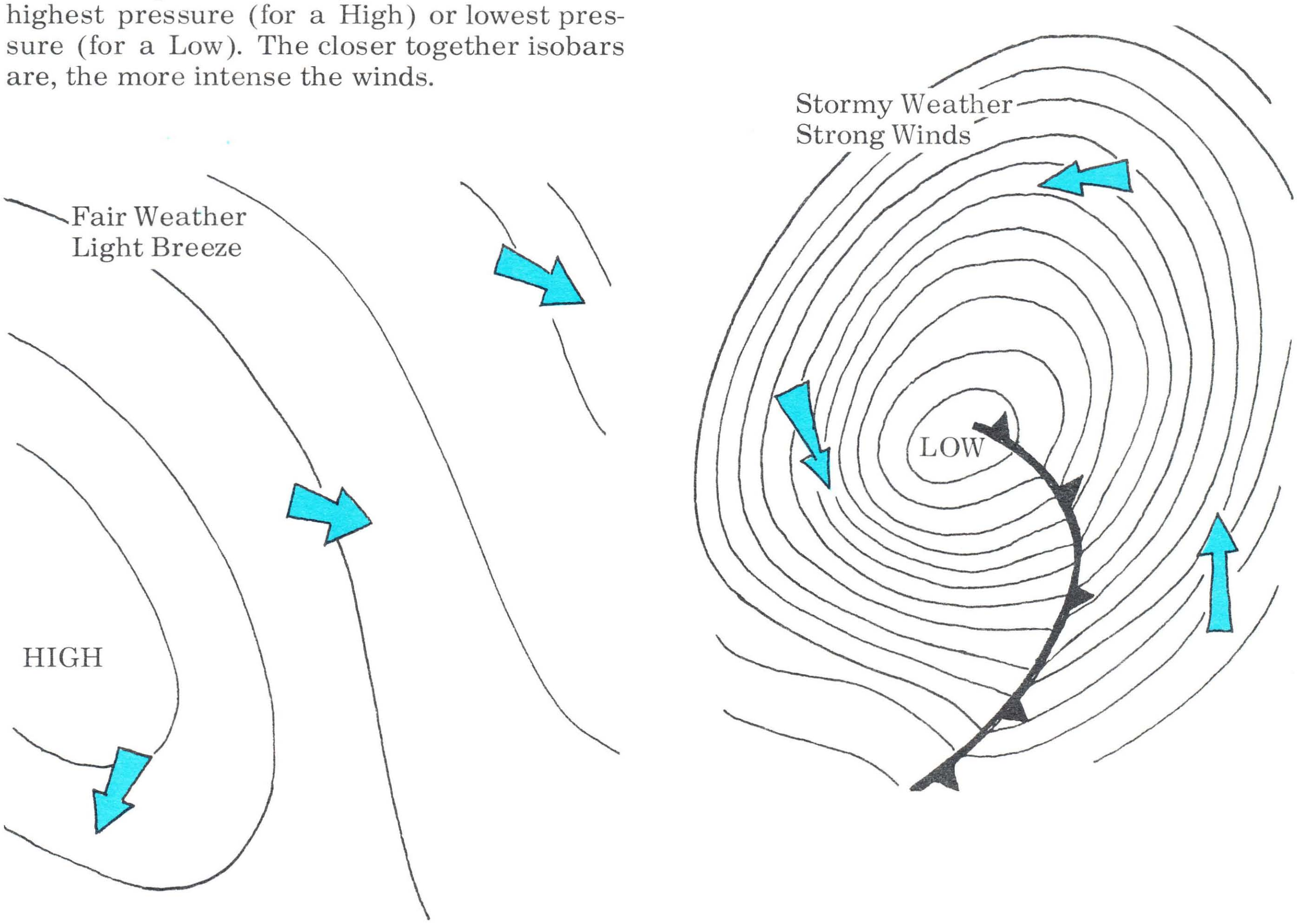
Consider this an arrow showing wind direction and velocity. The shaft always points in the direction from which the wind is blowing. One full feather represents 10 knots and a half feather is five knots. This wind is from the south travelling at a speed of 15 knots (about 17 miles per hour).

Indicates four-tenths of sky covered by clouds.

All symbols used are periodically explained on the back of official Weather Bureau maps. See the back of the official weather map in your leader's guide. In the space below, can you make a station model for your community, using current readings from your own weather station for a number of consecutive days?

MAPPING HIGHS AND LOWS

To locate high and low pressure areas on a weather map, barometric pressure readings are first recorded for cities all over the United States. Then places with the same pressure are connected by lines called *isobars*. When the map is complete, the isobars generally fall into a pattern of rings around a center of highest pressure (for a High) or lowest pressure (for a Low). The closer together isobars are, the more intense the winds.



TV AND NEWSPAPER WEATHER MAPS

Weather maps we see on television or in daily newspapers are highly simplified versions of official Weather Bureau surface maps. Nevertheless, if they include outlines of high and low pressure areas, show warm and cold fronts, and give some indication of expected movements, we have the basic information for general weather predicting.

You've probably seen at least a simplified weather map many times, but have you any idea of what the notations on them mean? Most of us don't. Nor do we realize that what we see drawn before us are the battle lines of two ancient protagonists—Polar Air to the north, Tropical Air to the south, waging war as they have since the world began. Endlessly, these air masses advance or retreat, bringing heat waves and cold waves, clear skies or cloudy, fair weather or foul.

The scene of most of this action is a very special segment of the globe—the middle latitudes, roughly between 30 and 60 degrees. The United States and other lands lying within these latitudes have the most changeable weather in the world.

Let's find out why.

Learning the Ground Rules

"You gotta have a program. . . " shouts the vendor at a football game. Essentially he's right. You have to know the rules of the game to make much sense of the action. Polar Air and Tropical Air in their war overhead follow predictable action patterns or "ground rules", too. Let's consider a few of them.

HOW WEATHER TRAVELS

Benjamin Franklin was the first American to discover that weather travels eastward. In a series of letters to his brother, he was amazed to discover that a storm one day in Philadelphia was experienced the next day by his brother in Boston, although the winds were from the northeast. The storm, in other words, traveled from west to east, instead of in the direction of the rain-bearing winds.

Weather, we now know, is affected by the earth's rotation. The west to east spin of the earth sets our general weather moving in the same direction.

Try this—Ask your club leader or County 4-H Agent how you can learn the names of 4-H members in Illinois, Iowa, Nebraska and Oklahoma. Write and ask that they send you a card once a week telling you the weather for that day. Ask for cloud type, wind speed and direction, precipitation, and barometric pressure. Keep a record. Then see if you receive the same weather they had a few days later.

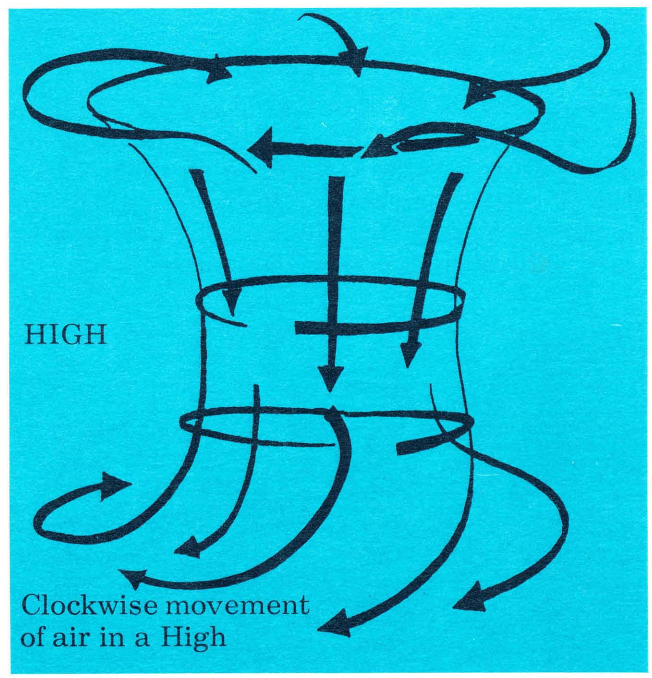
Try the same thing with northern New York, northern New England, and eastern Canada. See how the weather you are having today affects these states two or three days later.

Understanding how weather systems travel across our country is the beginning of understanding weather forecasting. But why is weather good one day and bad the next? One reason is pressure.

THE NATURE OF HIGHS AND LOWS

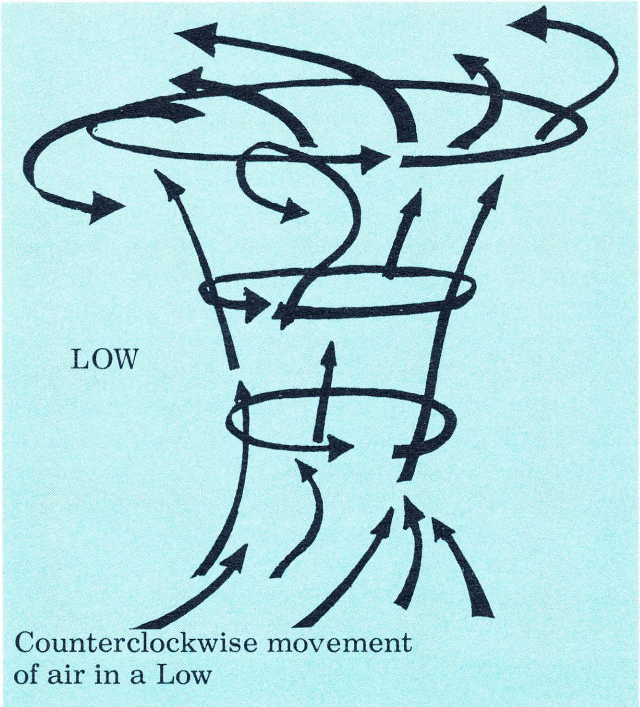
Our daily weather is determined by the movement of high and low pressure areas over us. Highs generally bring fair weather. Lows most often are accompanied by cloudiness, rain or snow. In fact, in many respects, Highs and Lows are the complete opposite of each other.

Highs. High pressure areas form wherever air sinks and piles up. As we shall see later, Polar Air and Tropical Air have favorite areas where they pause, pile up and develop into most of the highs that affect our middle latitude. weather. The most significant characteristic of any High is that air is sinking. Approaching ground level, the sinking air can only move outward. In the northern hemisphere, the earth's rotation deflects this movement to the right (see Coriolis effect, Unit II). If you have forgotten why this happens, try the experiment again. The air begins to spiral in a downward, outward, clockwise direction.



Also, while falling from the upper atmosphere, the air is warming adiabatically (about 5½ degrees for every 1000 feet). This increases its capacity to hold water. Thus, when a High passes over us, we can reasonably expect a rising barometer and days that are clear and dry.

Lows. Lows develop where warm air rises, as at the Equator, or where air masses of different temperatures come together, forcing the warmer air upward. Most of the Lows of our middle latitudes form when two Highs—usually masses of Polar and Tropical air—meet and interact. (See page 11.)



Counterclockwise movement of air in a Low

Whether the warmer air rises or is lifted, cooler, denser air from some nearby High moves in to fill the void. The Coriolis effect, still at work, deflects the in-moving air to the right. The result this time is air spiraling inward, upward and counterclockwise.

Something else happens to the rising air. Cooling adiabatically, it loses part of its water-holding capacity. The excess vapor condenses, clouds form, and if conditions are right, rain or snow soon follow.

When a Low passes over us, therefore, we can reasonably expect a falling barometer, warmer temperatures, clouds and precipitation.

WHAT'S IN A NAME

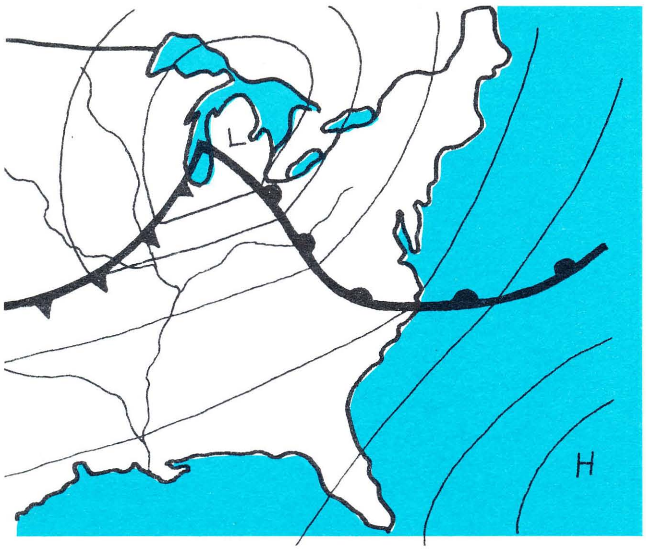
Middle latitude Lows may actually have rather high barometric pressure readings. They are "Lows" because their pressures are lower than in surrounding areas.

The scientific name for a Low is a *cyclone.* This can be confusing if you come from a part of the midwest where tornadoes are commonly, but erroneously, called "cyclones". Because of the reverse movement of the air within them, Highs are called *anticyclones.*

WIND CHANGES AND WHAT THEY MEAN

Winds are caused by air moving from a high pressure area to a low pressure area. In the northern hemisphere, winds move out from a High in a clockwise direction and then spiral counterclockwise towards the nearest Low. (See diagram below.)

How air travels from a high-pressure cell to a low.



With this in mind, can you mark the direction of the winds on the weather map above? From what direction would you expect the winds as a Low approaches? As the center of a Low passes over you? If the center of the Low passes north of you? South of you?

WINDS AND WEATHER LORE

Long before pressure systems were understood, sailors and country folk sensed the importance of wind changes. Northern hemisphere winds that change direction in a counterclockwise manner (for example, blowing first from the east, then the northeast, then the north, and finally the northwest) were called a *backing wind.* Those changing direction clockwise were called a *veering wind.* The abrupt change of winds from southeast to northwest as a center of a Low passes came to be known as a *wind shift.*

The following weather sayings developed from very early observations of the changing surface winds. How would you explain them in light of our modern knowledge?

"A veering wind means weather fair;
A backing wind, foul weather's near."

"When the wind backs and the weather glass falls,
Then be on your guard against gales and squalls."

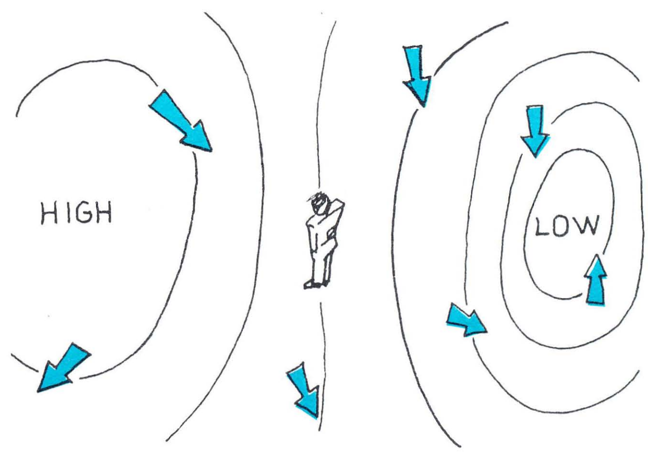
"When the wind shifts in a drought, expect rain."

Here's a scientific experiment, exciting if you get the hoped-for results. From what you now understand of wind movement, observe wind direction and then plot its probable path. Obtain a few helium-filled balloons (often available at dime or hardware stores) and release them into the winds. The object is to see where and how far the balloons go. To each balloon, attach a note explaining your project and a postcard with your return address, both wrapped in plastic.

FORECASTING WITH THE WINDS

By now, from your weather station and daily weather log, you should be able to make general forecasts of fair or poor weather by observing the trends of wind direction, wind speed, temperature and barometric pressure. See how accurate you can become.

The following rule can also help you locate Highs and Lows out-of doors: If you stand facing the wind, the lowest pressure will always be to your right and the high will be to your left.



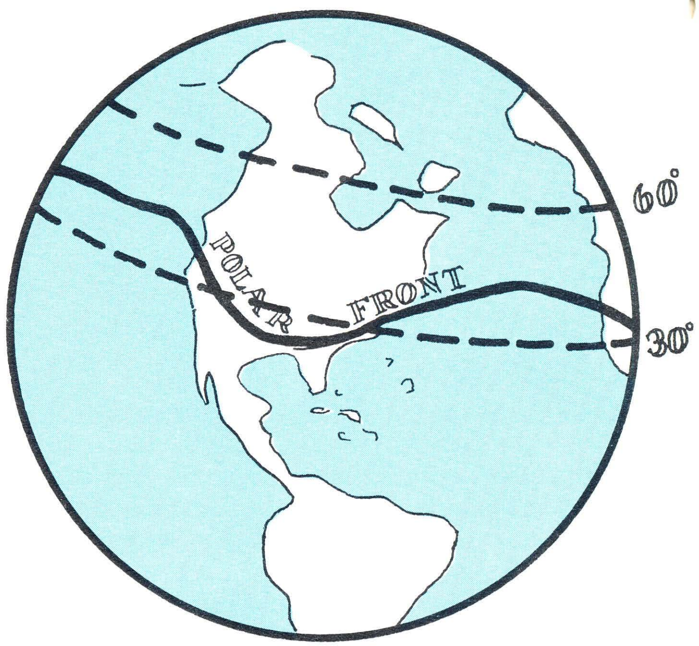
This holds true for pressure systems in the northern hemisphere. (In the southern hemisphere, where wind movements are reversed, the lowest pressure would be to your left.) The rule does not apply to local winds caused by geographic variations (land and sea breezes, or mountain winds, for example). Since weather travels eastward, a Low to the west could be a sign of approaching bad weather.

MARCH WINDS AND WHERE THEY COME FROM

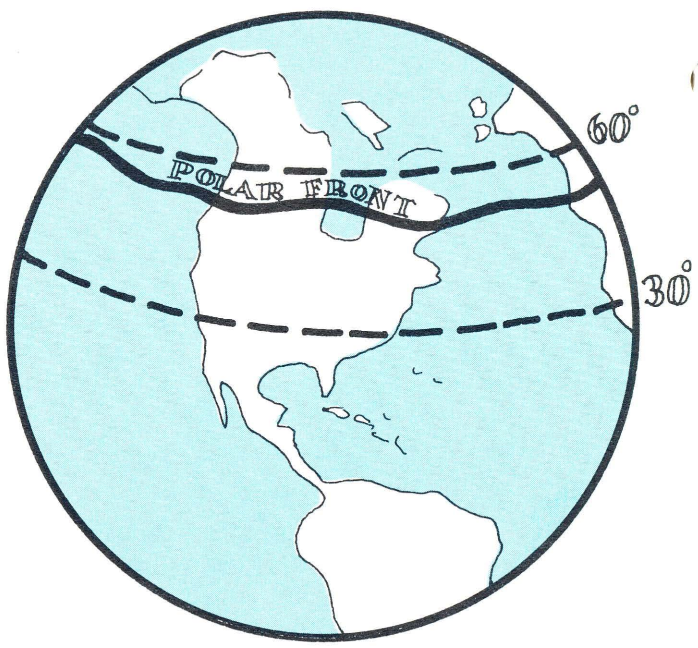
Have you ever wondered why March is so windy? In early spring, the Canadian Arctic has scarcely begun to warm up. The cold air piles up and high pressure prevails. In the southern parts of the United States, however, the earth is warming rapidly. This creates larger pressure differences which in turn bring stronger winds—just right for flying kites.

Polar Air vs Tropical Air

Around the turn of the century, scientists began to notice that Lows, and their accompanying storms, seemed to form between warm and cold air currents. A few suggested that Polar Air and Tropical Air coming together might be responsible for our changing weather. Not until World War I, however, was the idea fully explored. Then, two Norwegian meteorologists, a father and son named Bjerknes, among many others, were cut off by the war from Western weather reports. Searching for some new approach to weather understanding, they took a closer look at these theories. What they discovered forms the basis for all modern weather forecasting.



Polar Front in the Winter
Polar Air Advances



Polar Front in the Summer
Polar Air Recedes

THE POLAR FRONT

Briefly, Polar Air flowing south, and Tropical Air drifting north, do indeed meet and interact. The Norwegians, considering the Polar and Tropical masses as armies of air, called the area where they meet the "Polar Front". Generally, the Polar Front runs through the middle of Canada, somewhere between 50 to 60 degrees of latitude. In the winter, however, Polar Air gathers in strength and advances into Tropical territory. This is the cold wave that can reach far south and set Miami shivering. In the summer, as northern lands warm up, Polar Air loses much of its vigor and retreats. Tropical Air, now fortified by the summer sun, pushes the front back still further—sometimes to the Arctic wastes.

HOW HIGHS ARE FORMED

Both Polar Air in its southward travels and Tropical Air headed north settle over smooth, uniform surfaces called *source regions.*

In our hemisphere, cold, dense air, slithering down from the Arctic regions finds two vast oceanic areas where it can pause and gather strength—the North Atlantic on one side of the continent, and the North Pacific on the other. Winter provides Polar Air with a third, and to us, even more important source region—a huge ice and snow-covered basin across the face of Canada. To the west, the air is hemmed in by the Canadian Rockies. To the south and east, highlands block its flow. In the summer, when the basin thaws out and the region loses much of its uniformity, less Polar Air accumulates.

Now let's take a look at what is happening to Tropical Air. Rising up from the equator, huge currents of warm air drift toward the poles. Cooling, the air sinks and, like Polar Air, settles over vast, smooth areas. In our hemisphere, Tropical Air finds two large source regions: the Atlantic Ocean, roughly opposite the Carolinas around the Bermuda Islands, and the mid-Pacific Ocean, off the coast of California. Smaller air masses develop over the Gulf of Mexico and the Carribean Sea. In the summer, some tropical Air also tends to accumulate over the plains of Texas.

As air builds up over a source region, two important things happen:

1. The air mass takes on the characteristics of the source region.
2. The accumulated air eventually spills over its boundaries and starts to move as a high-pressure system.

HOW HIGHS DIFFER

Despite their similarities, high-pressure systems are not the same. Air masses develop and pick up very different temperature and moisture characteristics, primarily from their source regions. Maritime air masses, growing over oceans, become very moist and more moderate in temperature. Continental air masses, piling up over land, are much drier. They may also be extremely hot or cold. Four different air masses influence our weather:

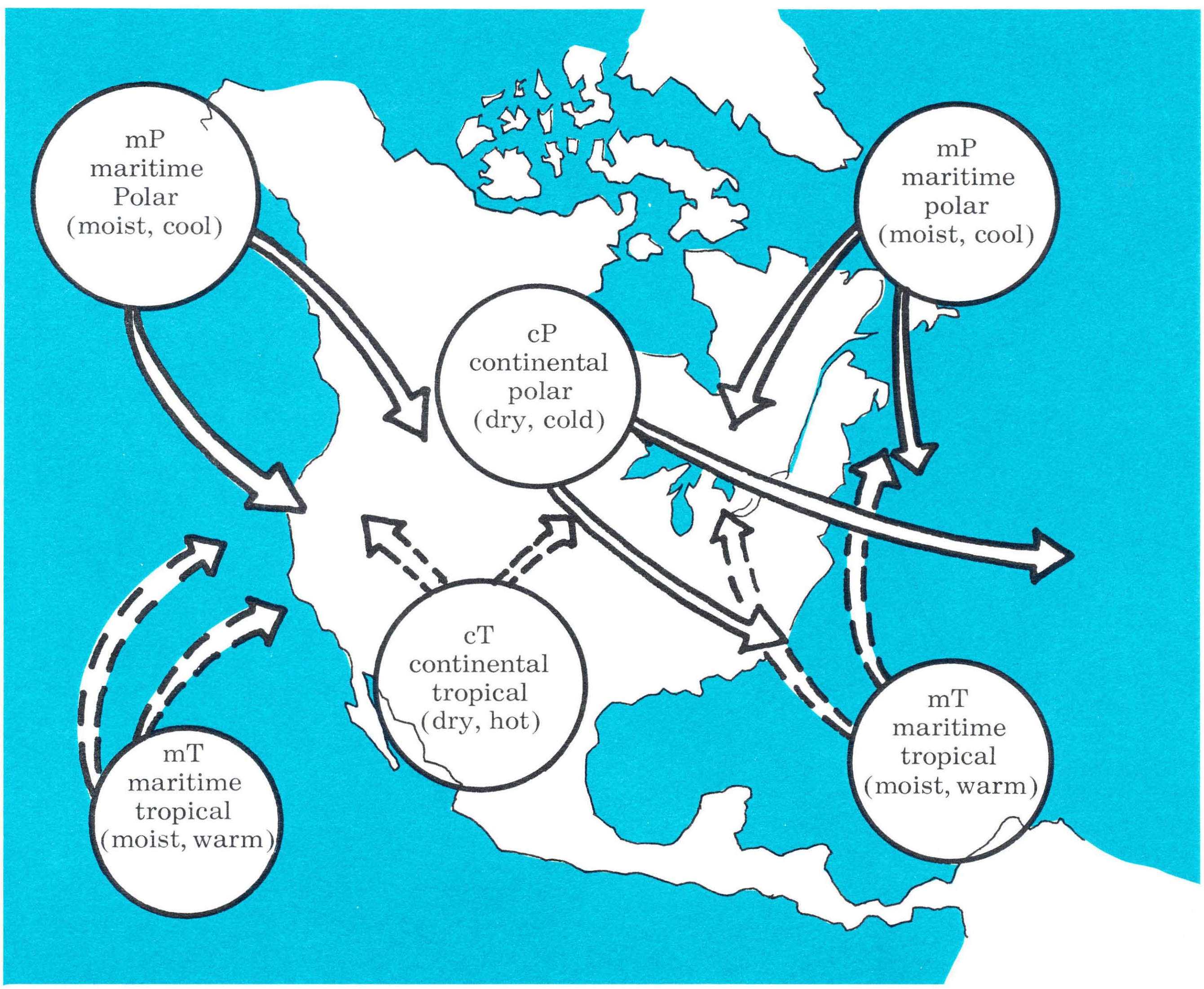
Continental Polar or cP (from Canada and the Arctic)—cold and dry

Maritime Polar or mP (from the northern oceans)—moist and cool

Continental Tropical or cT (from the southwest plains)—hot and dry

Maritime Tropical or mT (from warm seas and oceans)—warm and very moist

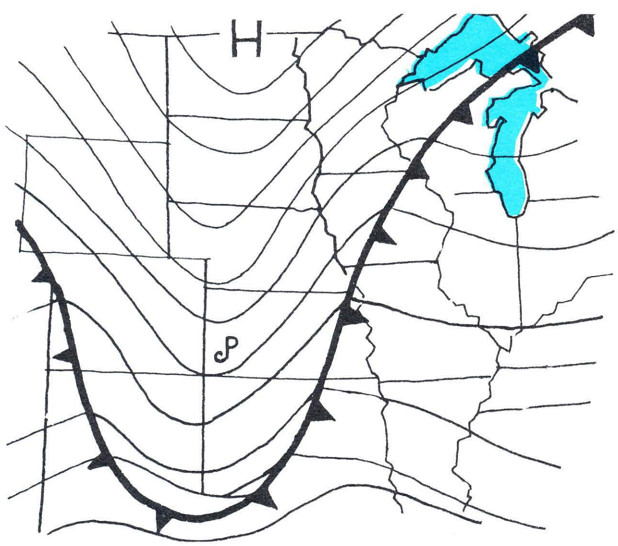
As these air masses start to move they sometimes change considerably, growing warmer or colder, picking up moisture or drying out, depending on the area over which they are traveling.



HOW HIGHS TRAVEL

Polar Highs migrate, or move away from their source regions, much more freely than do Tropical Highs. In general, Polar Highs sweep down from the north and are carried eastward by the Prevailing Westerlies. Tropical Highs tend to stay put, and for this reason are called semi-permanent. They are often called "blocking highs", but more about that later. They seldom move far from their source regions although they do build up westward, especially in the summertime. Since much of our weather is determined by the movement of these highs, let's trace their paths over the country.

Continental Polar Highs deliver much of our cold weather, especially in the winter. Originating over Canada, cP travels southeastward across Canada and the United States. Crossing the Great Lakes, cP picks up moisture, which it drops in the form of rain or snow on such states as Michigan and New York. Sometimes cP will travel down into the Central Plains where heavy cumulus clouds mark the temperature change. Less often, cP sinks westward, bringing frost or freezing weather to southern California. Continental Polar air in the summer is quite different from winter cP. As the land under it warms, so does cP, becoming cool, rather than cold, and weak instead of strong.



Maritime Polar Highs developing over the north Pacific Ocean are warmer and moister than cP air masses. Coming ashore, mP brings fog and showers to the West Coast and dumps snow on the west side of the Cascades in Oregon. Crossing these mountains and the Sierra Nevadas, mP dries out, bringing fair weather to the central states. Some of our most pleasant fall days are due to dry mP air. Maritime Polar air masses may also form in the North Atlantic off Labrador. Here they are responsible for the gales that sweep over the northeastern states.

Maritime Tropical Highs move very slowly, tending more to enlarge and spread out from their source regions. In the summer, when cP Highs have lost most of their vigor, the Bermuda High—a maritime Tropical air mass off the coast of the Carolinas, may grow so large that it covers the entire eastern half of the United States. There it settles for days and weeks at a time, like a hot, humid blanket, while we swelter in the oppressive heat. This same Tropical air mass has an important weather function even in the winter when it recedes. Sitting in the Atlantic the Bermuda High effectively blocks the southward movement of any Polar Highs, forcing them to take a more northerly route. For this reason, the Bermuda High is often called a blocking high.

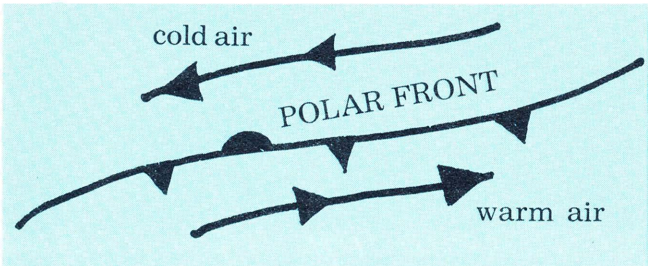
KEEPING TRACK OF AIR MASSES

Obviously, knowing that a high-pressure system is approaching or passing over us isn't quite enough for accurate weather predicting. We should also know where the air is coming from. Weathermen keep track of where air masses originate and how they change by sampling the air in the upper levels of the atmosphere. This is done with such devices as pilot balloons carrying radiosondes and rawindsondes, by radar, airplane observations, and satellites. Find out how all these devices are used and in what levels of the atmosphere. Write this new information in the chart. Perhaps you can visit weather stations that take upper-air soundings. This is done for Michigan by weather stations in Flint and Sault Ste. Marie.

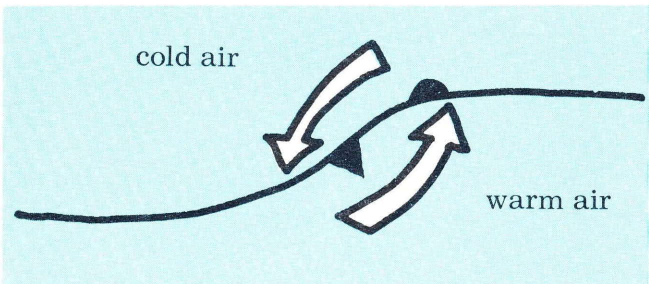
Device	Altitude of Use	Information Received
Radar		
Radiosonde		
Rawindsonde		
Pilot Balloon		
Airplane		
Others (list)		

HOW MIDDLE LATITUDE LOWS DEVELOP

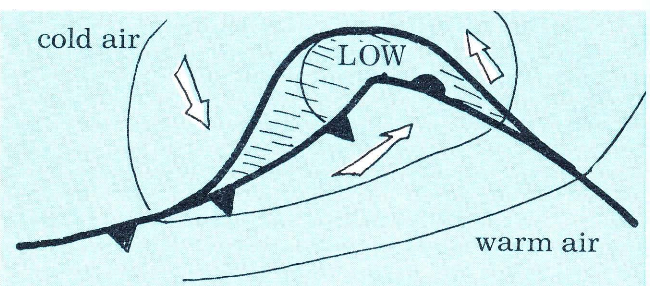
Polar Air traveling southward and Tropical Air heading north may pass each other at the front without too much interaction. Only a line or trough of lower pressure develops where they meet. More often, however, a difference in the earth's topography or heat buildup will cause a wave-like disturbance along their common boundary. The air masses begin to swirl into each other in a counterclockwise direction and a low develops. This small initial low can grow to cover hundreds or thousands of square miles, moving eastward until it finally dies out.



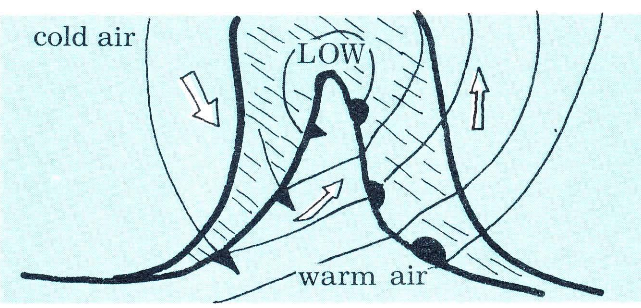
Warm and cold air masses do not freely mix. They may flow past each other without advancing or retreating or interacting in any other significant way. This is called a stationary front, marked on a weather map as a heavy line with teeth on one side (frontal edge of the cold air mass) and humps on the other side (frontal edge of the warm air mass).



If some disturbance develops along the front, the cold air begins to push in and under the warmer air. The displaced warmer air overruns the cold air to the north and east. The cold air swirling down and inward and the warm air pushing up and out starts a counterclockwise rotation of air.

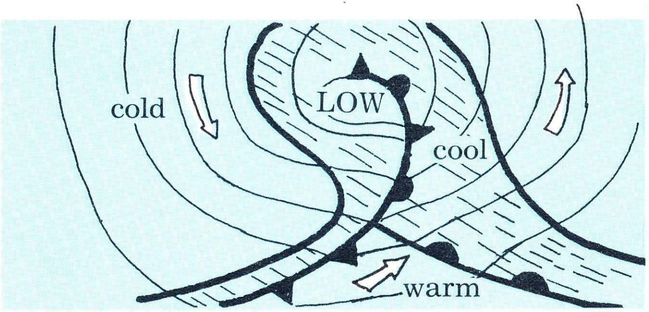


The advancing edge of the Polar mass is called a cold front (marked with teeth). The frontal edge of warm air, advancing faster than the cool air can retreat, is called a warm front (marked by a line with humps). An area of low pressure and precipitation will start to develop around the crest of the wave where warm, moist air is being lifted.



Cold fronts move forward about twice as fast as warm fronts. This deepens the wave. Along the cold front, warm air is rising over cooler air. Along both fronts precipitation is taking place.

KEY: Precipitation



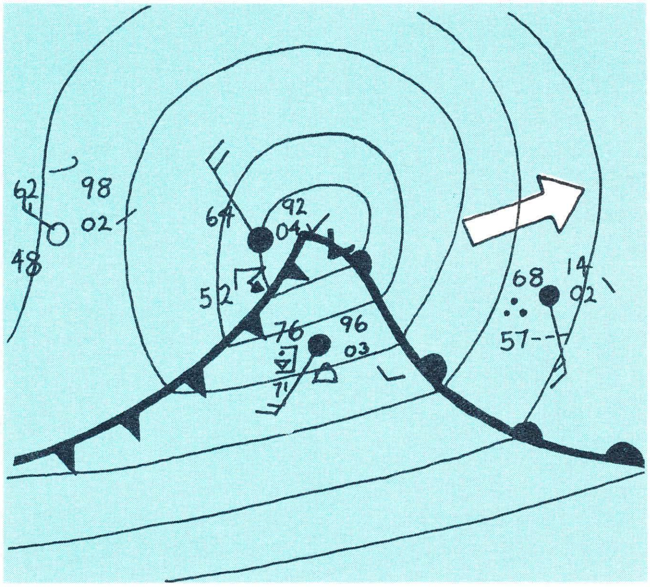
Finally, the cold front overtakes the warm front and lifts the warmer air right off the ground. Cold air from behind the cold front catches up to the air (usually cool) from in front of the warm front. This is called an *occluded front* and is the dying stage of a low. Occluded fronts are shown on maps as curves with alternate teeth and humps on the same side.

While Lows are forming, the Low as well as the high-pressure air masses from which it developed are moving eastward across the country. This gives us the following sequence of weather: a High of cooler air; a falling barometer as a Low approaches; a warm front; a steady barometer with warmer air, and finally a cold front, followed by a rising barometer and colder air. Warm fronts, followed by cold fronts move endlessly across the United States.

LOCATING LOWS

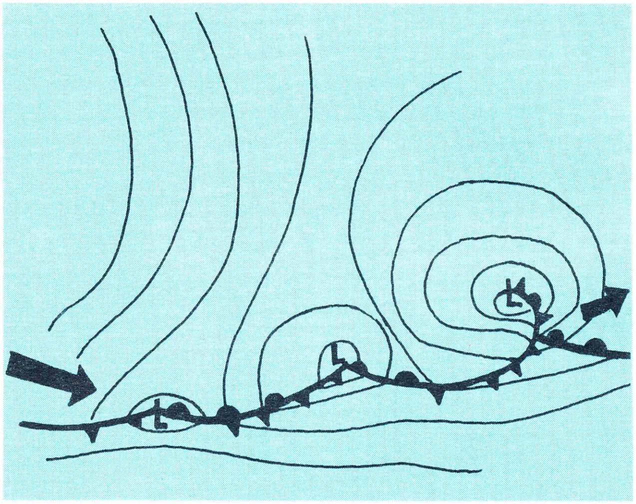
On the map below, locate the low pressure area and the warm and cold fronts around which it has formed. Keep in mind that:

1. The point of lowest pressure will be around the crest of the wave;
2. Winds spiral inward around the Low;
3. Winds change direction abruptly from one side of a front to another;
4. Temperatures will be warmest within the wave or warm sector of the Low.



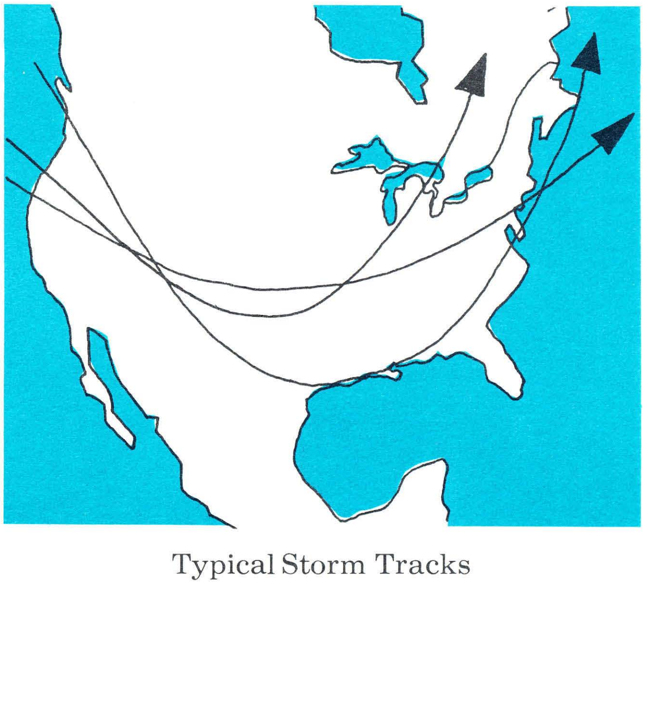
HOW LOWS TRAVEL

Lows have a life history of from one to three days or more. They frequently develop between two highs of different temperatures, increase in intensity for a while and then die out. Very often, whole families of Lows develop, and a series of them in progressive stages of development can be seen moving eastward across the country. The big arrows show the direction this Low is moving.



What is the direction of the winds?

With our knowledge of where Highs originate and how they move, it is easy to see that Lows must also move in rather well-defined paths. These paths are called *storm tracks*. Meteorologists always want to know which path the Low is taking. In the winter, for example, meteorologists are not too concerned with a Low originating around Alberta and following a northern route. The Low's moisture supply will have been cut off, and snow, if any, will be light and fluffy. A Low travelling northeastward from Colorado bears a little more watching. It may or may not have enough moisture for heavy snow. A Low developing in the southwest, then veering sharply north and east, can mean serious trouble. The Low is loaded with moisture from the Gulf of Mexico which will surely fall on northern cities as heavy, traffic-snarling snow.

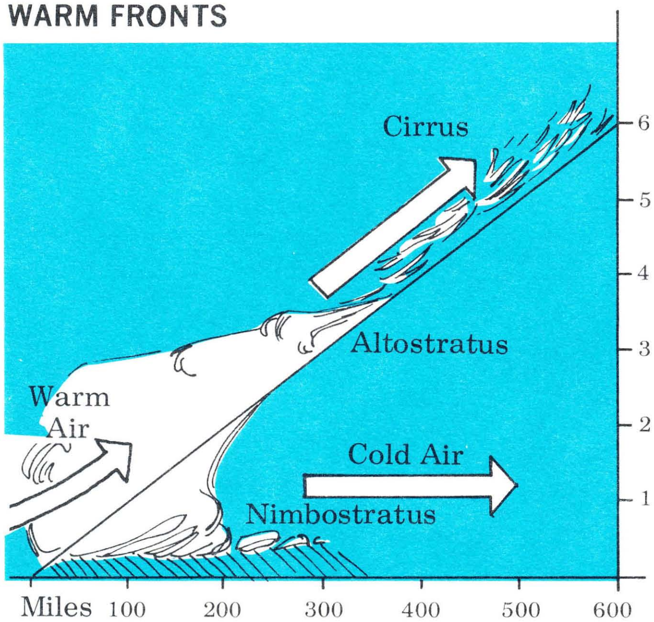


Typical Storm Tracks

Weather at the Front

Fronts generally bring bad weather. When air masses of different temperatures come together, the warmer air rises over or is lifted by the colder mass. In either event, the warm air cools, clouds form and precipitation takes place. How long the bad weather will last and how severe it will be depends on the kind of front, how fast it is moving, the temperature and humidity differences between the air masses and the warmth of the area over which the front is passing.

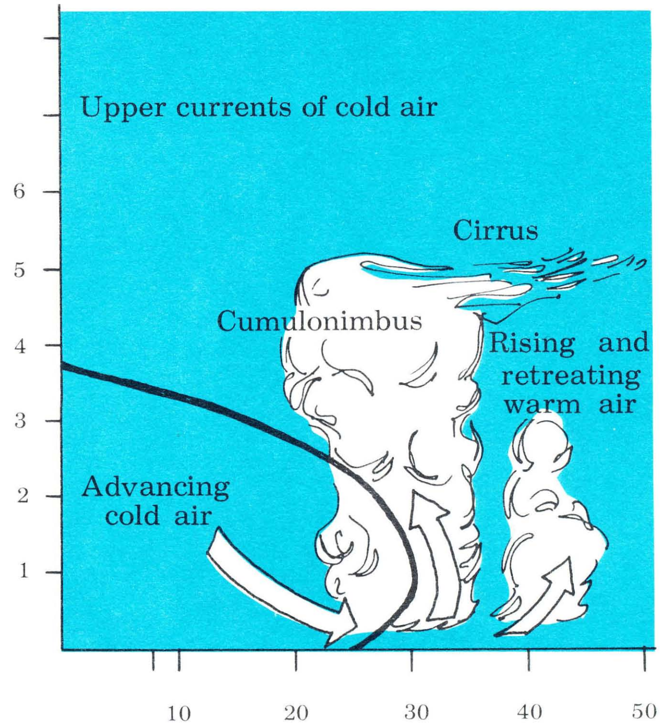
WARM FRONTS



As a warm front advances, the warmer air mass slides up over the dragging tail end of a cool air mass and moves forward in a gradual slope until the cool air completely retreats. For this reason, the very first sign of a warm front may be high, wispy, cirrus clouds, sometimes as much as 1000 miles, or 48 hours, ahead of the main body of warm air. These clouds are too high and thin for precipitation. However, as larger currents of warm air approach, lower and thicker alto-stratus clouds appear, accompanied by rain or snow. Because warm fronts move slowly and cover a large area, they are characterized by gray overcast skies and longlasting drizzles or steady rain.

As the warm front passes, the skies clear up and temperatures rise, with generally fair weather prevailing. This is the portion of Tropical air trapped between the warm and cold fronts — the warm sector of the wave shown on our weather map.

COLD FRONTS



Close behind this body of warm air is a faster moving mass of cold air. This cold air, moving faster than the warm air, wedges under the warm air and lifts it. Huge cumulus-type clouds boil up accompanied by showers, thunder-storms and other brief but more violent kinds of weather. Cold fronts blow over much quicker than warm fronts and are followed by a rising barometer and clear but colder weather.

OCCLUDED FRONTS

In the dying stages of a Low, the air in the warm sector is lifted off the ground as the air behind the cold front catches up to the air ahead of the warm front. There is usually a temperature difference between the two remaining masses of air. As a result, the warmer of these two masses of air will also be forced to rise. The weather from this occluded front may then take on characteristics of either a warm front, a cold front, or a combination of both in which thunder showers may occur in the midst of a steady rain.

STATIONARY FRONTS

Even stationary fronts may be marked by cloudy, rainy weather. When the warm air at the front rises, a trough of low pressure develops and clouds form, with possible precipitation following.

Here Comes a Front

Illustrated on these two pages are two views of a Low. The first one, plotted on a weather map, shows how a Low might look from over-head. The second view shows what is happening at the earth's surface. By studying either map we can expect the following kinds of weather:

In Buffalo: Weather here has been clear and dry for several days. However, the barometer is now starting to fall. Cirrus clouds which appeared earlier are now lower and thicker in the skies. Winds are from the SE.

In Erie: The sky may be completely overcast with a low, dreary gray cover of clouds. It's either drizzling or raining steadily with no let-up soon in sight. Temperature is probably a few degrees higher than in Buffalo. Winds are from the S.

In Toledo: The warm front has passed, and Toledo is just drying out from a long but mild rain. The sun is out and everyone is enjoying the fine, warm weather. Humidity is probably high. A few cumulus clouds may dot the skies. Winds here are from the SW.

In Fort Wayne: A fast moving cold front hit Fort Wayne about 2½ hours ago. The sky is still black with heavy cumulus clouds and the rain is really coming down, but clear skies to the west indicate that the storm will soon be over. Winds are from the N.

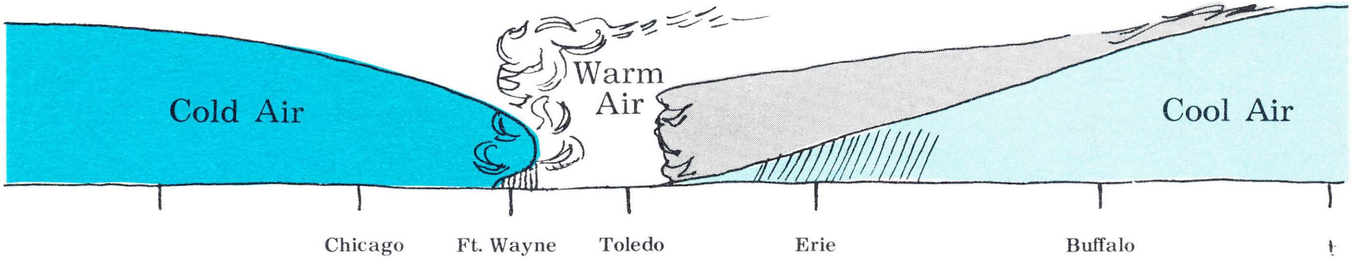
In Chicago: The sun is shining; the skies are clear; the barometer is rising, but the air is very cool. Winds are from the NW.

Let's assume that the cold front is moving at 25 miles an hour, and that the warm front is advancing at 15 miles an hour. Let's also assume that this is the weather picture for 1 p.m. today. Using the approximate distances between cities as shown on the second view, what kind of weather would you expect in Fort Wayne, Toledo, Erie and Buffalo at 4 p.m.? 8 p.m.?

This in general is the reasoning meteorologists must use in predicting weather. Their job is rarely this easy, however. Fronts can speed up, slow down, or fizzle out. Upper air currents can turn a cumulonimbus cloud into a tornado or drastically change the weather picture in some other way. Changes of topography will also alter the weather picture. In other words, the meteorologist must look at the weather in three dimensions. He must be aware of what's going on at the earth's surface through local reports and weather maps and he must keep track of air movements in the upper atmosphere by air samplings and now, most recently, by weather satellites.

Even without the upper air data a meteorologist uses, we can have a good idea of what is happening in the upper levels of the atmosphere by observing the clouds. If we relate our own observations of local pressure, temperature, humidity and wind changes to the general weather picture and then observe the clouds, we can, in time, make very accurate forecasts for a locality.

Let's see what the clouds can tell us.



Forecasting by Clouds

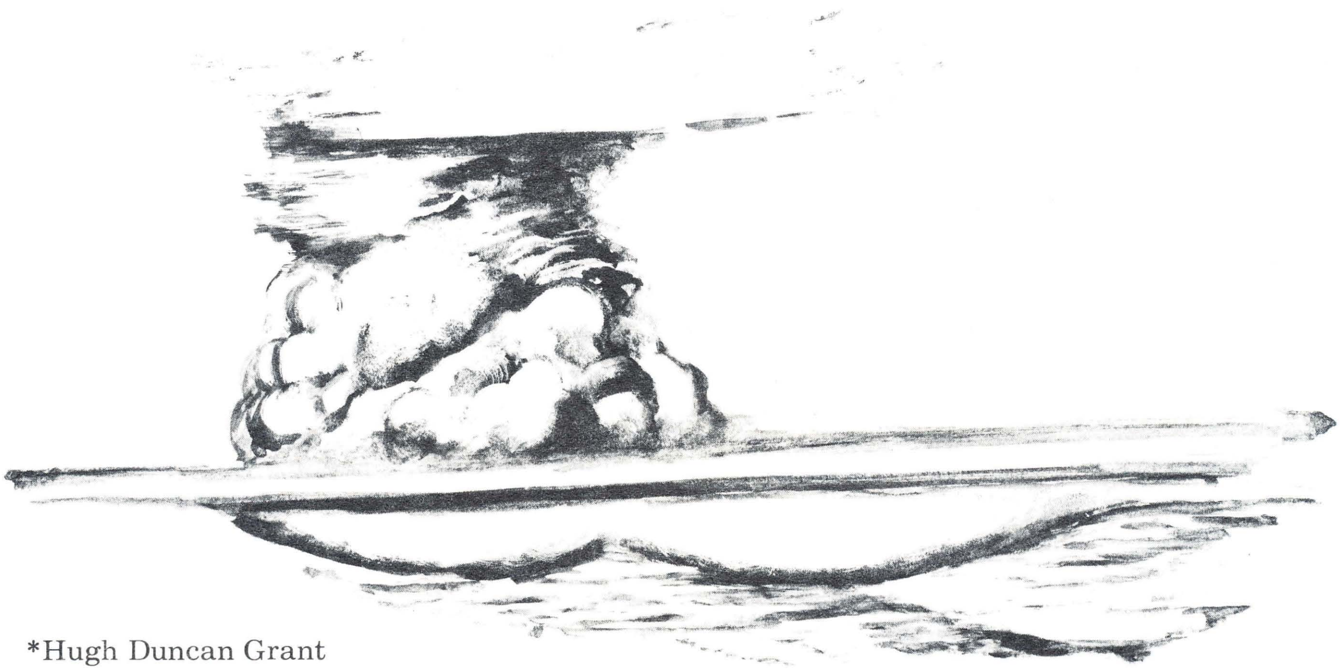
"Clouds," a British meteorologist* once wrote, "are gigantic hieroglyphics, spelling out the story of the weather on the open book of the sky." Now we can start to understand what he meant. Air masses coming together produce distinctive cloud sequences in any frontal area.

HOW CLOUDS ARE IDENTIFIED

Basically, clouds can be identified as layered or straight *(stratus),* piled up or accumulated *(cumulus),* or as high, wispy curls *(cirrus).* Another Latin term used, *nimbus,* means rain and is added to the name of a cloud type to identify it as rain-bearing. Cumulonimbus is a cumulus cloud that has grown into a dark and towering thunderhead.

Clouds can also be divided into families according to the height at which they develop. See opposite page.

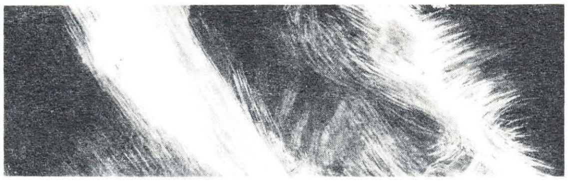
Keep a log as shown below on the types of clouds you see for the next few days. For practice, use station model symbols wherever possible.



*Hugh Duncan Grant

DATE	TIME	CLOUD TYPE	SYMBOL (SEE WEATHER MAP)	SKY COVERAGE (SYMBOL)	PRECIPITATION (DESCRIBE)	WHAT WILL HAPPEN TO THESE CLOUDS IN:		
						6 Hrs.	12 hrs.	24 hrs.

HIGH CLOUDS
(20,000 to 25,000 feet)



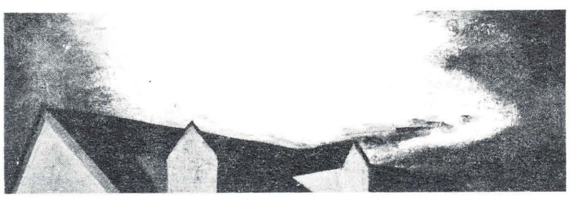
Cirrus, the highest clouds, are made up entirely of ice crystals and are too thin for precipitation.

Cirrocumulus, the sailor's "mackerel sky" are high and patchy clouds and look like ripples in the sky.

Cirrostratus clouds are thin sheets that look like a veil. The ice crystals in them can refract the light from the sun or moon and give the appearance of a halo around either. Cirrostratus are often an early sign of an approaching warm front.

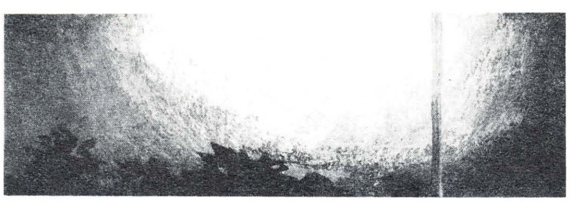
ALTO OR MIDDLE CLOUDS
(above 6,000 feet)

Altocumulus clouds are patches or layers of puffy roll-like clouds that resemble a sheep's back. The sun seen through them often looks reddish around the rim, pale blue inside. This is called a *corona effect* and is caused by the diffraction of the sunlight through the cloud's water molecules.



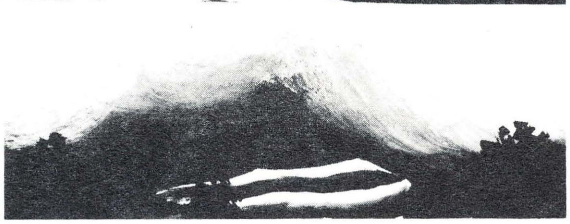
Altostratus clouds are dense veils of gray or blue. Behind them the sun looks like it's shining through frosted glass.

LOW CLOUDS
(range in height from near the earth's surface to about 6,500 feet)



Stratus clouds are low and sheet-like, covering the skies.

Nimbostratus are true rain clouds and have a dark, wet look. Rain or snow from nimbostratus will be steady and longlasting.



Stratocumulus are masses of puffy clouds spread out in layers.

WHAT CLOUDS MEAN

If you understand why and how a cloud has formed, you have the clue to what it means. Stratus-type, for example, form when layers of warm air are lifted gradually. This can happen in a warm front area as warm air rises over a retreating layer of cool air.

Cumulus clouds form when shafts of warm air rise and cool. Cumulus are most often a sign of fair weather. However, a mass of cumulus marching across the sky can often signal a coming cold front. If the rising column of air is warm enough in contrast to the colder air masses around it, the cumulus cloud which forms may develop higher and higher, becoming heavy and dark—a towering cumulonimbus. You'll probably be right if you forecast brief but heavy showers.

Both thunderstorms and tornadoes develop from cumulus formations. See if you can find out how these peaceful clouds become violent storm centers.

Considering everything you know about frontal weather and cloud formation, how would you explain the following old sayings?

"The higher the clouds the finer the weather."

"Mares tails and mackerel scales make tall ships take in their sails."

"Halo around the sun or moon, rain or snow soon."

"When clouds appear like rocks and towers, the earth's refreshed by frequent showers."

You are now a weather expert. Well, not really. But if you have studied all three units,—*Understanding Weather, Building a Weather Station* and *Weather Maps and Forecasting,* carefully and performed all the experiments shown—you probably know more about weather than 99 percent of your fellow countrymen—of any age.

You should now be able to do limited weather forecasting. Fill in the following weather log using what you have learned. Your weather station (from Unit II) will give much of the information you need. Later compare your prediction with the official Weather Bureau prediction. How often was your forecast wrong? How often was the weatherman wrong? Don't be disappointed by your mistakes. Keep in mind that the weathermen obtain information several times a day from all over the world. Even they miss occasionally.

How can you make use now of what you know? Maybe your parents are planning a weekend picnic. Should your dad paint the house tomorrow? Will it be a good day for ice skating? Should you carry your raincoat or umbrella to school? These are just a few of the ways you can use your new-found knowledge right now. This weather project you are completing can be the beginning of a whole new adventure.

DATE	TIME	PRESSURE	HUMIDITY	WIND DIRECTION	WIND SPEED	CLOUD TYPE	CLOUD AMOUNT	PRECIPITATION TYPE	PRECIP-AMOUNT	TIME PRECIP-STARTED	TIME ENDED	FORECAST 4:00 P.M.	FORECAST 8:00 P.M.	

Summing Up...

Although attempts at forecasting weather date back to primitive times, weather forecasting as a science is relatively new. Not until the telegraph was invented (around 1840) was it possible to collect weather reports fast enough or from a large enough area to make a forecast meaningful. Early meteorologists, therefore, were limited to forecasting local storms.

The development of radio telegraphy between 1900 and 1920 made it possible to collect weather data from the ocean areas as well as from land areas. The airplane added an important dimension to weather forecasting by providing information on the state of the upper atmosphere. So did the radiosonde. Developed and improved in the 1930's and 1940's, the radiosonde is released by balloon into the upper atmosphere and sends back radio signals of temperature, pressure, humidity and winds.

During World War II, the development of radar gave the meteorologist another important tool for collecting information on clouds and heavy precipitation areas. In very recent years, meteorology has taken a giant step forward with the development of two more devices: weather satellites and electronic computers. Weather satellites, sending back TV pictures of cloud formations, have made it possible to spot hurricanes and other storm centers in their earliest stages of formation. Electronic computers have speeded up the entire process of collecting information, diagnosing weather trends and solving difficult mathematical weather problems.

Still, even these advanced instruments have not been able to probe all of weather's secrets. For instance, will it ever be possible to stop a tornado, or dissolve a hurricane before it hits land, or stir up the atmosphere to clear away smog? With nuclear fallout one of the serious threats of the future, can we learn enough about air flow to locate areas that would not be contaminated? Can we someday control rainfall so that drought is a thing of the past?

These are only a few of the challenges of the future. Can they be accomplished? Considering the advances in our knowledge of weather in the last ten years, meteorologists can confidently reply: "Anything is possible."

Would you like to know more about weather and how it works? Here are several projects that could be carried out individually or as a group:

1. Visit your local weather station. Learn all you can about how weather is recorded and reported. Find out if your area needs a cooperative weather substation. These substations are manned by volunteers who keep records of rainfall, daily maximum and minimum temperature readings, and other weather notes. Cooperative observers report their findings regularly to the U.S. Weather Bureau. Instruments for a cooperative station are sometimes supplied by the Weather Bureau.

2. Subscribe to the official U.S. Weather Bureau map service and from these maps try to forecast the coming weather. These maps are sent daily and may be purchased from the Superintendent of Documents, Washington 25, D.C. at a cost of $9.60 a year or $2.50 for three months.

3. Meteorology as a science and public service becomes more important every year. Besides the many career opportunities within the U. S. Weather Bureau, businesses, industries, aviation, shipping, agriculture, and conservation all use the services of trained meteorologists. Find out all you can about the careers now available in meteorology.

4. Make a study of tornadoes, thunderstorms, hurricanes, and other violent weather conditions. Why do they occur, and what is being done to control them or curb their effects?

5. With the knowledge you now have of weather and how it works, carry out an advanced research project. A few possibilities might be:

   How to prevent frost damage in crops

   Heating a home with solar radiation

   Applying weather facts to determine fallout patterns

NEW WEATHER WORDS

ANTI-CYCLONE—The clockwise rotation of air about a high-pressure area.

BACKING WIND—Winds which change their directions of movement in a counterclockwise direction.

COLD FRONT—The movement of a cold air mass advancing behind a warm air mass. Characteristic weather includes short but violent thunderstorms, heavy rain squalls and occasionally hail and tornados. Weather behind the passage of the Cold Front will usually be cooler and dryer than before with clear skies.

CYCLONE—The counterclockwise rotation of air about a low-pressure area.

DIFFRACTION—The bending of light rays passing through microscopic droplets of water or water vapor which causes halos around the sun or moon. Also, causes the breaking up of light into bands of color which gives us rainbows following a summer shower.

FRONT—The boundary between a warm and cold mass of air.

HIEROGLYPHICS—An ancient system of writing which used pictures and symbols rather than letters and words.

HIGH—A mass of air whose barometric pressure is higher than the pressure of surrounding air. Characteristic weather within a high-pressure system is usually clear and steady.

ISOBAR—Lines on weather maps which connect points of equal barometric pressure.

LOW—An area where the barometric pressure is lower than the surrounding areas. Usually caused by the interaction of a warm and cold air mass. Characteristic weather includes general cloudiness and precipitation in many forms.

OCCLUDED FRONT—The merging or coming together of an advancing Cold Front with a retreating Warm Front. Characteristic weather may resemble either the normal warm front or cold front or a combination of both. The occlusion represents the dying stages of a low-pressure system.

RADIOSONDE—An instrument carried aloft by a balloon which transmits information by radio on atmospheric temperature, pressure and humidity from upper altitudes.

RAWINDSONDE—By tracking the signal from a Radiosonde with radar, weathermen can determine upper altitude wind direction and speed. This observation is called Rawindsonde.

SOURCE REGION—Special areas around the earth over which cold or warm masses of air originate.

STATION MODEL—Information from weather stations is recorded on weather maps in the form of abbreviations and symbols. This collection of information, or symbols, for each station is called "the station model".

STATIONARY FRONT—The front or boundary between a cold and warm air mass which remains stationary over the earth for a period of hours or days.

STORM TRACK—The path across the earth of a low-pressure system. Storm Tracks across the United States usually come from the Northwest, dip Southeastward into the plains states, then change direction and travel Northeasterly across the East Coast and New England toward the North Atlantic Ocean. Storm Tracks across Michigan are usually from the West and Southwest.

VEERING WINDS—Winds which change their direction of movement in a counterclockwise direction.

WARM FRONT—A mass of warm air advancing behind a mass of cool air. Characteristic weather may be several days of heavy, overcast and drizzels. The weather following the passage of a warm front will often be hot and humid.

WIND SHIFT—A sudden change in wind direction, either backing or veering, as a front passes.