8-15-1957

Weather in the Making

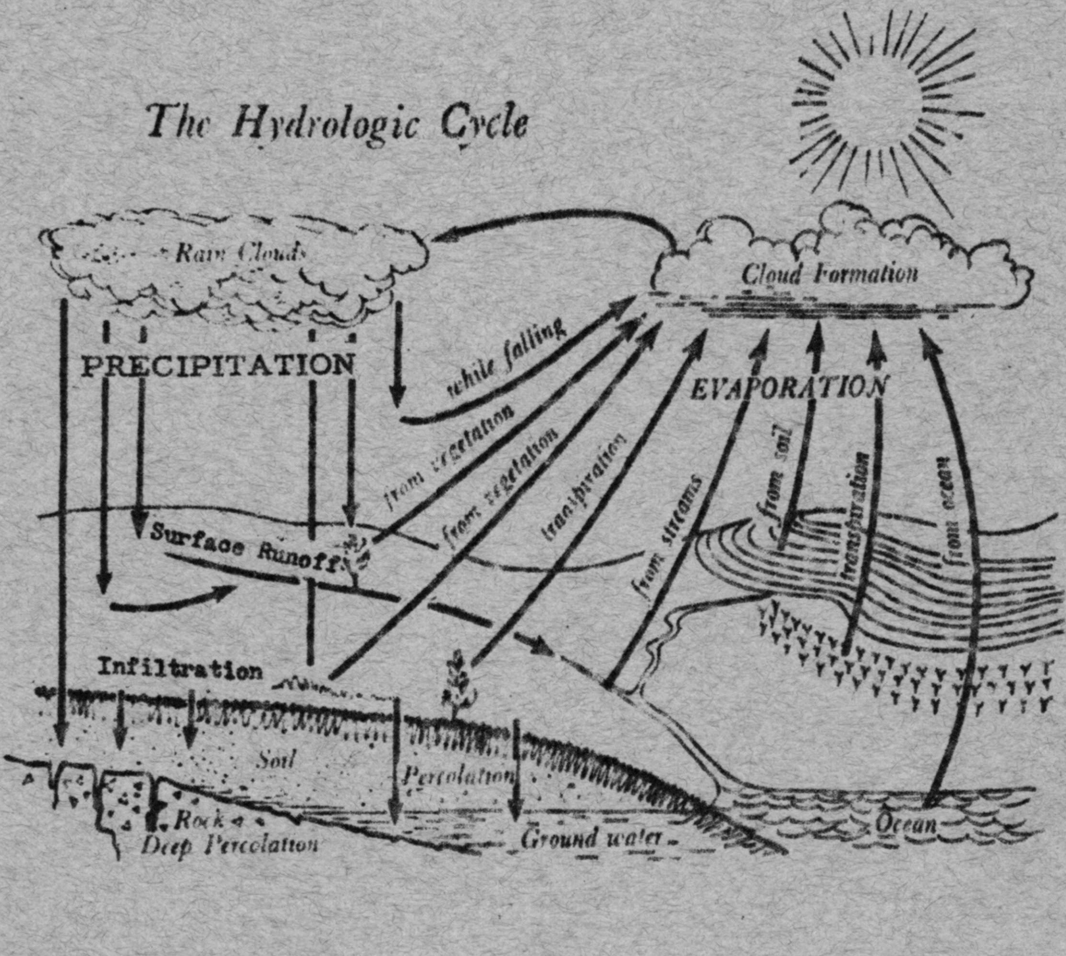
Ray F. Pengra

Agricultural Economics
Pamphlet No. 89

August 1957

WEATHER IN THE MAKING

The Hydrologic Cycle



Department of Economics
South Dakota State College
Agricultural Experiment Station
Brookings, South Dakota

WEATHER IN THE MAKING

by

Ray F. Pengra

Data and illustrations used in this pamphlet are taken from the "Pilot's Weather Handbook" and the 1955 "Yearbook of Agriculture". Acknowledgement is also due William Hodge of the U. S. Weather Bureau for reading and criticism of the manuscript.

TABLE OF CONTENTS

INTRODUCTION

The objective of this pamphlet is to present some of the basic atmospheric phenomena that are related to weather. It is hoped that this will give research workers and others interested a general idea of how weather develops in the atmosphere and make possible a more realistic application of available weather data to agricultural research.

Data and illustrations from "The Pilot's Weather Handbook" and the 1955 "Yearbook of Agriculture", as well as other government publications, are presented to provide an application of weather factors to agriculture and its problems.

NATURE OF THE ATMOSPHERE

The atmosphere consists of an ocean of air surrounding the earth. There is a tendency for the air to rotate with the earth as it revolves on its axis. This tendency diminishes as height above the earth increases. In addition to the tendency of the atmosphere to rotate with the earth, the entire body of the atmosphere is in constant motion. This is due in part to the differences in temperatures, atmospheric pressure and local content of portions of the entire air mass.

For convenience in disucssion, the atmosphere has been divided into three parts or layers. See Figure 1. The part of the atmosphere nearest the earth is called the troposphere and extends 5 to 10 miles above the earth. Within this zone the temperature normally decreases with height. There is a narrow zone directly above the troposphere where temperatures do not normally decrease with additional height but may slightly increase as height increases. This is called the tropopause. Within the portion of the atmosphere above the tropopause temperatures remain almost constant. This is called the stratosphere and includes the entire air mass above the tropopause. The atmosphere is composed of a mixture of gases but also contains a great number of dust particles and other impurities together with water vapor in amounts from 0 to 5% by volume. The water vapor and its distribution over the earth is of major significance to agriculture. Atmospheric conditions affecting weather are chiefly within the lower zone called the troposphere. It is this zone with which we are concerned here.

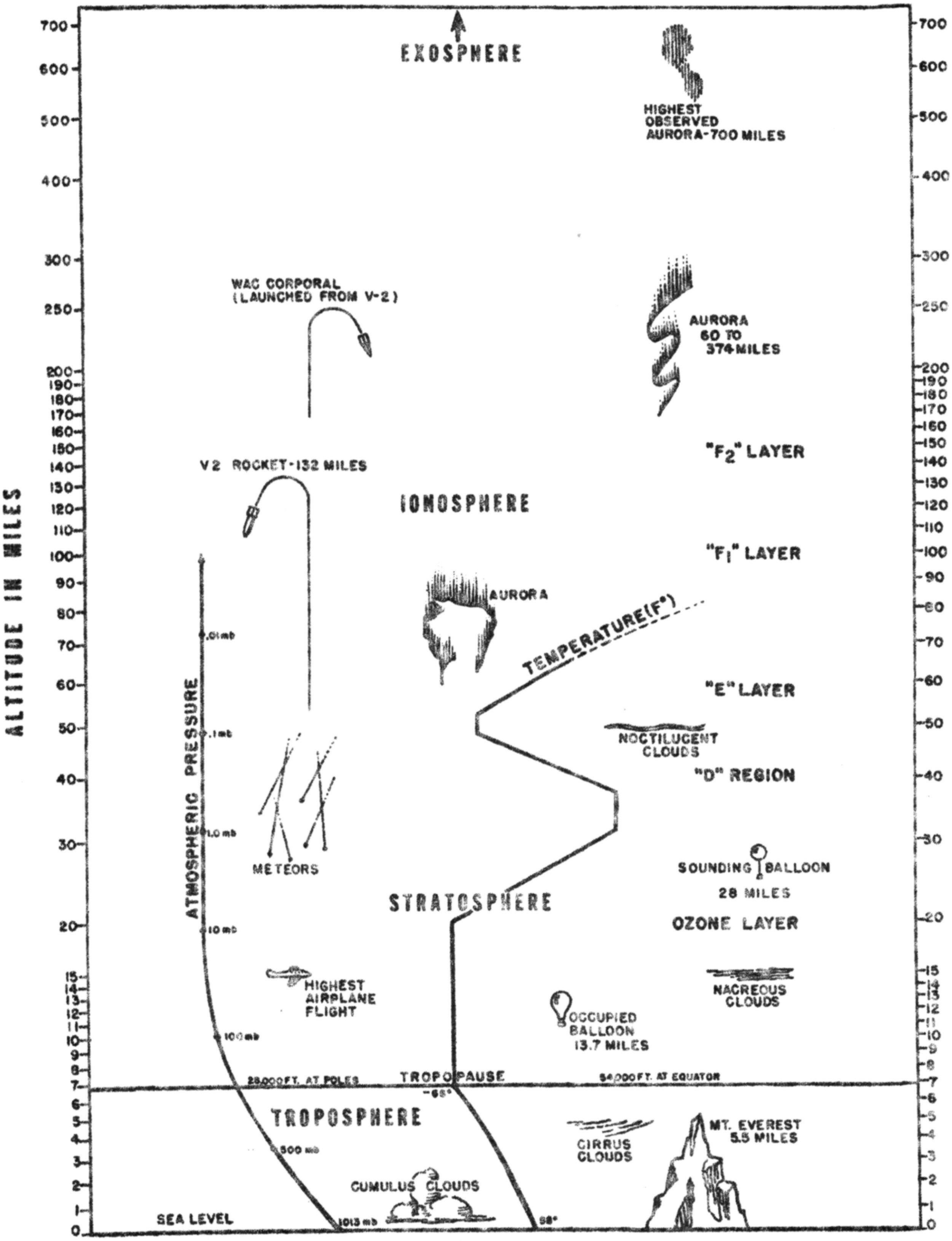


Figure 1. Schematic Cross Section of the Atmosphere

ATMOSPHERIC PRESSURE

At any point within the atmosphere the weight of all the air above that point is called the atmospheric pressure. At sea level, with little or no air movement and at 59° F. the weight of air will raise mercury 29.92 inches in a vacuum column. This amounts to approximately 15 pounds per square inch of surface. Most Weather Bureau charts and maps use the term isobar to indicate air pressure on which scale 1013.2 isobars is normal sea level pressure corresponding to 29.92 inches in the mercury column. Pressures vary at neighboring points over the surface of the earth and are indicated on weather chart as "highs" or "lows". Centers of low pressure marked on weather maps are usually areas of more air movement than highs. In the northern hemisphere, air movement or wind about a low center will flow in a counter clockwise direction and is called a cyclone by meteorologists. About a high center air movements flow in a clockwise direction and less turbulence is usually noted than around low centers. See Figure 2.

As the height above sea level increases, the atmospheric pressure decreases since there is less weight of air above at higher elevations.

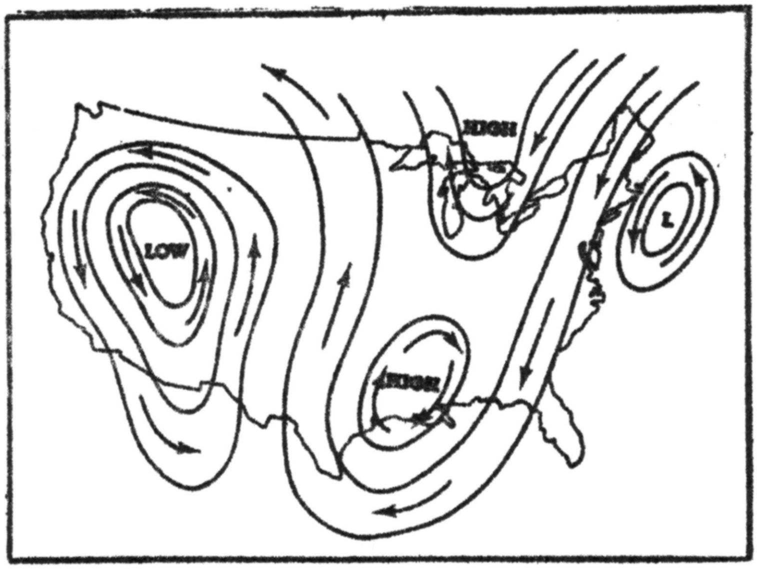


Figure 2. Wind Flow Around High and Low Pressure Areas

TEMPERATURES

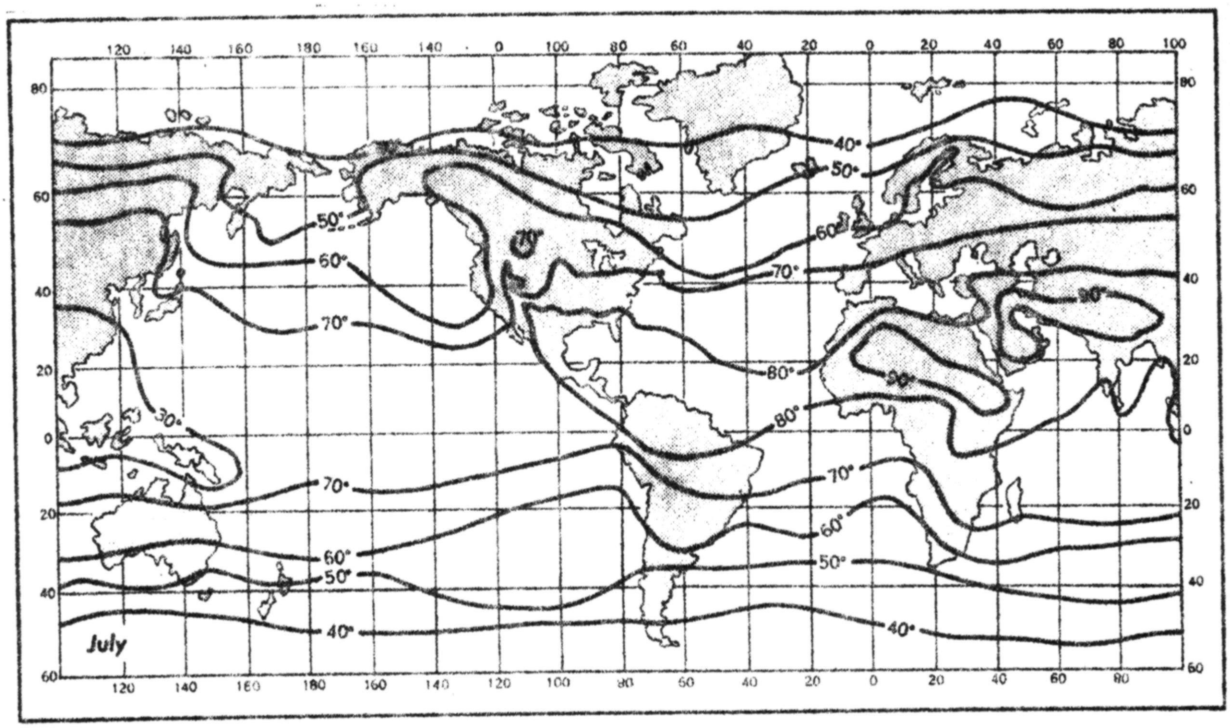
The sun is the source of atmospheric as well as of most other temperatures on the earth. The atmosphere is not heated directly by the sun. The sun heats the earth's surface and the atmosphere gets most of its heat indirectly from the surface of the earth. The air also changes temperatures due to a change in elevation within the atmosphere. All gases expand with increased temperature. As temperature of any portion of the atmosphere rises above the temperature of the adjoining air the warmer air will expand and tend to rise. As it does so, air pressure will decrease and air from surrounding areas will move in to replace the air that has risen.

When the sun's rays strike the earth as they do when the sun is directly overhead, the heat from the sun is concentrated in a relatively small area. As a result, more heat is received and stored from the sun in the tropics than from the slanting rays that strike the earth nearer the polar regions. See Figure 3. In the tropics, there is a constant accumulation of heat from the sun. At the poles sufficient heat is never received to melt the ice and snow. As a result, there is a constant source of extreme temperatures over the earth. Natural forces attempt to neutralize these temperatures through air movement.

Within limits of ordinary atmospheric temperatures, the warmer a body of air is the greater its capacity to hold moisture. Also as the temperature of an air mass is reduced, its capacity to hold moisture is reduced accordingly, as shown in Figure 4. The dew-point temperature is the temperature to which any air mass would have to be reduced for that air mass with the same moisture content to be completely saturated.

Evaporation of water from any source into the atmosphere cools the surface from which it evaporates and the more rapid the evaporation the greater the cooling effect. Also the drier the atmosphere the more rapidly evaporation takes place.

In order to get a measure of the moisture content in the atmosphere, the Weather Bureau uses two thermometers. One thermometer called a dry bulb is an ordinary thermometer exposed directly to the air. The other thermometer is called a wet bulb and has a wick that keeps the bulb wet. The difference in reading of the two thermometers represents the cooling effect of evaporation of water vapor into the atmosphere. When the atmosphere has little or no moisture and the air is hot, evaporation will be relatively greater and there will be considerable difference between the two readings. This difference in



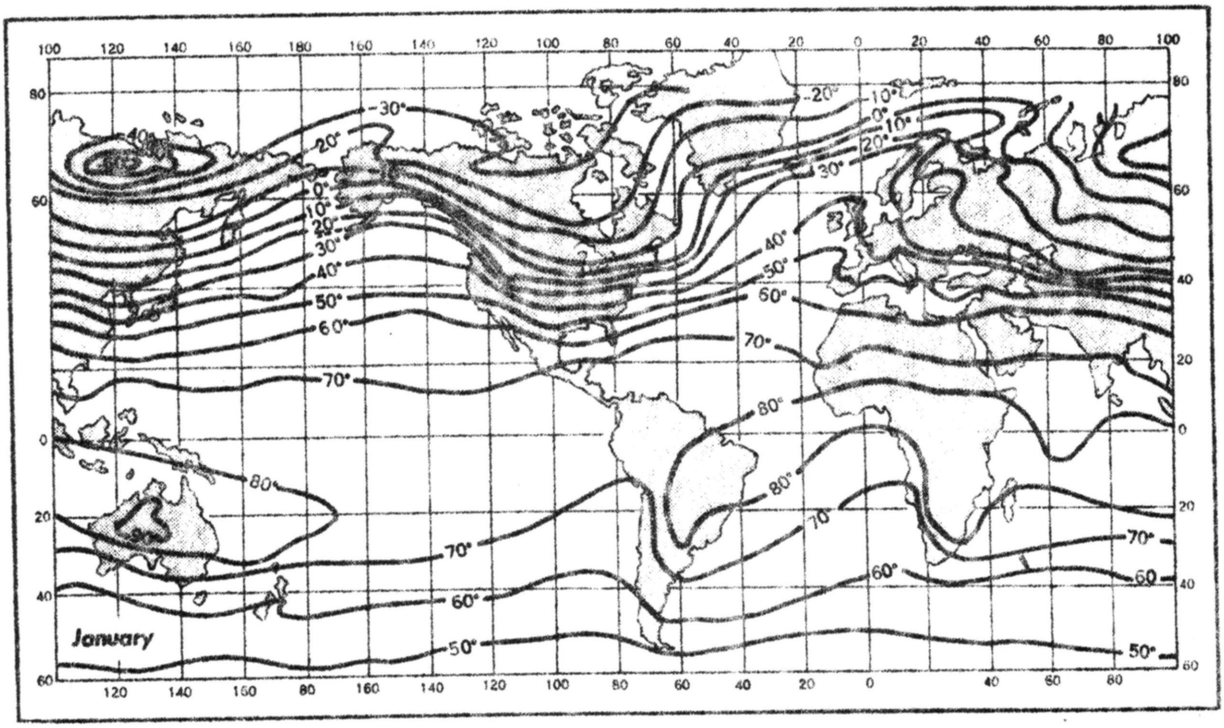


Figure 3. World Temperature Charts

the two readings can be used to determine the dew point or the temperature at which the air at that time and with its present water vapor content will be completely saturated. When the dry bulb and wet bulb readings are the same, the atmosphere will be saturated and the dew point will correspond with the readings of both thermometers.

RELATIVE HUMIDITY

Relative humidity is a measure of the percentage that the water vapor present in the air is of the amount of water vapor that would be required to bring that air to the saturation point. See Figure 5. If one cubic foot of air contained 3 grains of water vapor at 80° F., the relative humidity would be 25%. When this same volume of air is reduced to 60° F., the relative humidity would be 50%. The same volume of air reduced to 40° F. containing the 3 grains of water vapor would be completely saturated and the relative humidity would be 100% and condensation would start.

MOISTURE IN THE ATMOSPHERE

The source of moisture in the atmosphere is evaporation of water due to the heat of the sun. The annual total water evaporated on the earth has been estimated at 95,000 cubic miles, 80,000 from the oceans and 15,000 from lakes and land surfaces. The cover illustration presents a visual picture of the water cycle showing sources and method of returning to the oceans.

Moisture exists in the atmosphere in solid, liquid and gaseous forms. Solid forms are hail, snow, ice-crystal clouds and ice-crystal

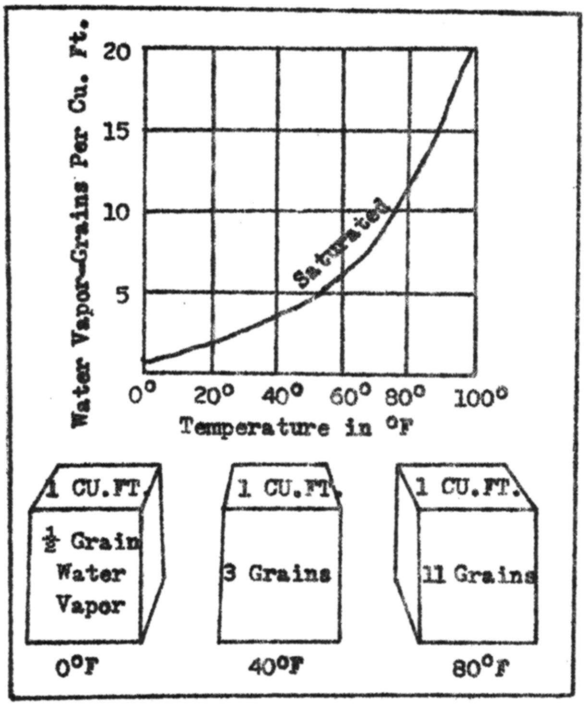


Figure 4. Air Can Hold Increased Amount of Water Vapor as Temperature Increases

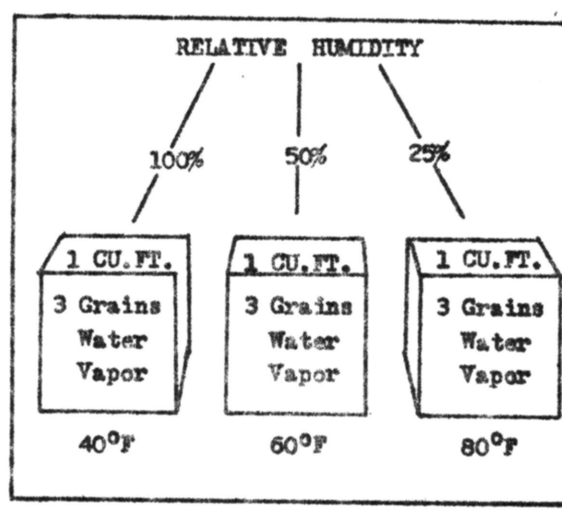


Figure 5. Relative Humidity Decreases as Temperature Increases When the Amount of Moisture in the Air Remains the Same

fogs. Liquid forms consist of clouds and fog which are composed of very small water droplets and as rain. In the gaseous state, moisture in the air exists as water vapor.

For large scale evaporation intense heat is required. Water vapor passing into the atmosphere at intensely high temperatures rises to great heights in the tropical regions. As this vast volume of moist hot air rises, cooler air from neighboring regions moves in to replace it. The cooler air in turn leaves space for still cooler air to move in to take its place. Thus is started a continual effort of nature to equalize air pressures and temperatures over the earth.

Figure 4 presents a graphic picture of the moisture content of air and its dew-point temperature. At 0° F. a cubic foot of air could hold only 1/2 grain of water vapor. When the air temperature is raised to 40° F. the same volume of air would not be saturated until it contained 3 grains of water vapor. At 80° F., 11 grains or 22 times the water vapor that that same volume of air could hold at 0° F. would be required in order for it to be completely saturated. Likewise, when air at 60° F. containing 5 grains of water vapor per cubic foot is cooled to 40° F., there will be more water vapor present than that air can hold at that temperature. Some of the water vapor will start to condense as soon as the temperature is reduced to the dew point.

WIND

Air movement, commonly called wind, is the distribution system of the atmosphere. The movement of air over the surface of the earth is the result of a number of natural factors which contribute to determine the direction and force or speed of air movements. Rotation of the earth is the most constant and uniform force affecting air movements. There is also an attempt in the physical realm for temperatures and atmospheric pressure to neutralize, or equalize, temperature and atmospheric pressure over the entire face of the earth. Figure 6 presents a theoretical picture of the air currents that would exist if the earth did not rotate and the surface of the earth were even, eliminating mountains and valleys. Figure 7 pictures the likely path of air currents within the northern hemisphere due to the rotation of the earth. The extreme variations in temperatures over the face of the earth also exert their influence on air movements. See Figure 2. These factors, along with irregularities of the surface of the earth, all contribute and play a part in the final resulting air movements as they exist.

Local weather is the final result of all the complicated factors that contribute to air movement over the entire surface of the earth. Air currents distribute life-giving moisture to sections of the earth that are located so that air currents flow from the sources of moisture and meet up with air currents whose temperature is such that moist air is reduced in temperature to the saturation point where condensation will result. Where cold air currents or a change in temperatures due to vertical movement of the air are not present to reduce temperatures to the dew point, no precipitation will result.

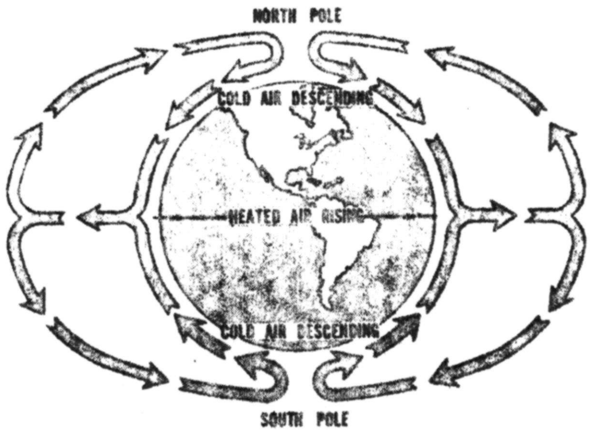


Figure 6. Paths Which Air Currents Would Follow if the Earth Did Not Rotate

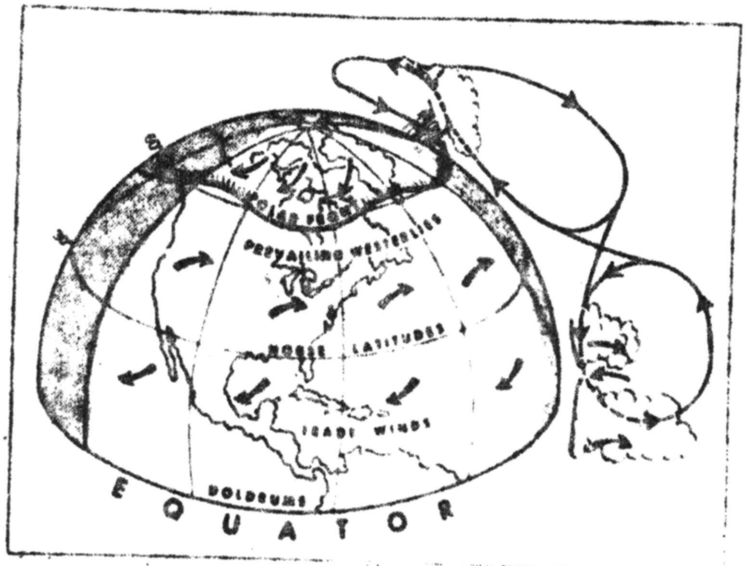


Figure 7. The Theoretical Winds on an Earth of Uniform and Even Surface Would Follow the Pattern Shown Here

AIR MASSES

An air mass is a large body of air having relatively similar characteristics horizontally as to temperature and moisture content. Usually an air mass exists or moves as a unit. Air masses as shown on meteorologists' charts take their names from the source region within which they were formed. The two general source regions are the tropics and the snow or ice-covered polar regions. In addition to the source region, their name also indicates whether they were formed or modified as a result of passing over extensive land or sea areas. For example, an mP air mass indicates a polar maritime air mass while a cP air mass designates it as a continential polar air mass. Furthermore, to describe an air mass that is colder than the surface over which it is passing, the letter K is added to its designation. Likewise, a W indicates that the air mass is warmer than the surface over which it is passing at the time. Figure 8 shows typical paths taken by air masses entering the United States. These paths vary considerably from day to day. Tropical air masses originating over the ocean usually will be warm and moist, while polar and arctic masses will be cold and dry.

What moisture the polar air masses contain originally came from the tropics and was carried at high altitude toward the poles. The moist tropical air met and mingled with cooler air sufficient to reduce it to the dew point where condensation started resulting in rain or snow in temperate and polar regions. Much of the balance of the water vapor and ice crystals within the air moving toward the poles will

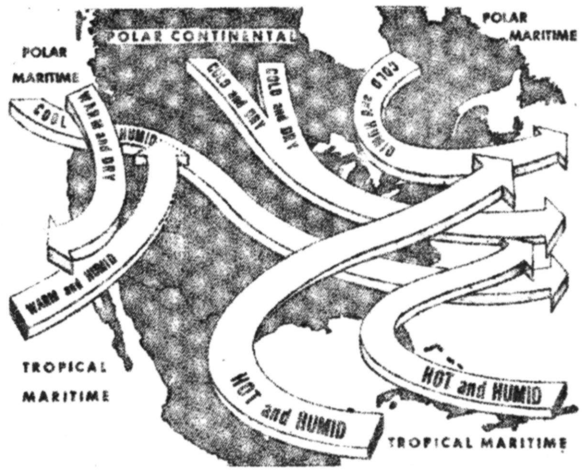


Figure 8. Typical Paths Taken by Air Masses Entering the United States

be released within the polar region resulting in the dry polar air that forms into polar and arctic masses and starts its return trip to replace warmer air as it is heated and rises within the warmer areas of the earth.

CLOUDS

Clouds are composed of ice crystals or liquid water droplets and result from saturation-producing processes which take place in the atmosphere. Clouds are formed when moisture laden air rises in the atmosphere and the temperature is reduced to the point where condensation of the water vapor occurs, but when the condensation is not great enough to form into drops that will fall as rain.

When up-drafts or vertical air currents are present, cumulus or piled-up clouds are formed. Where this up-draft is present, the warm air is cooled rapidly and as a result a relatively greater percentage of the available moisture falls as precipitation. When layers of moist air are cooled without the direct vertical up-drafts, clouds of the stratus type are formed. These clouds are composed of water droplets.

FRONTS

The leading edge of an advancing air mass is called a front. The four different types of fronts as used in weather terminology are cold, warm, stationary and occluded. If cold air is replacing warm air or moving into space formerly occupied by warm air, it is called a cold front. Where warm air is replacing cold the front is called a warm front. The direction of the wind corresponds to and is a determining factor in the frontal movement. A stationary front is one when the front is not moving in a horizontal direction enough to qualify it as either cold or warm. Wind movement is usually parallel to a stationary front. The figures show typical warm and cold front formations. The actual shape will be influenced by air movements and surface conditions and will be different in each instance. Friction of the cold air with the ground surface tends to retard the movement of the cold air. See Figure 9. When cold air is advancing, the tendency is for the cold front to be steep while in the case of the warm front the upper air will be carried along by air movement while the air near the surface of the earth will move more slowly

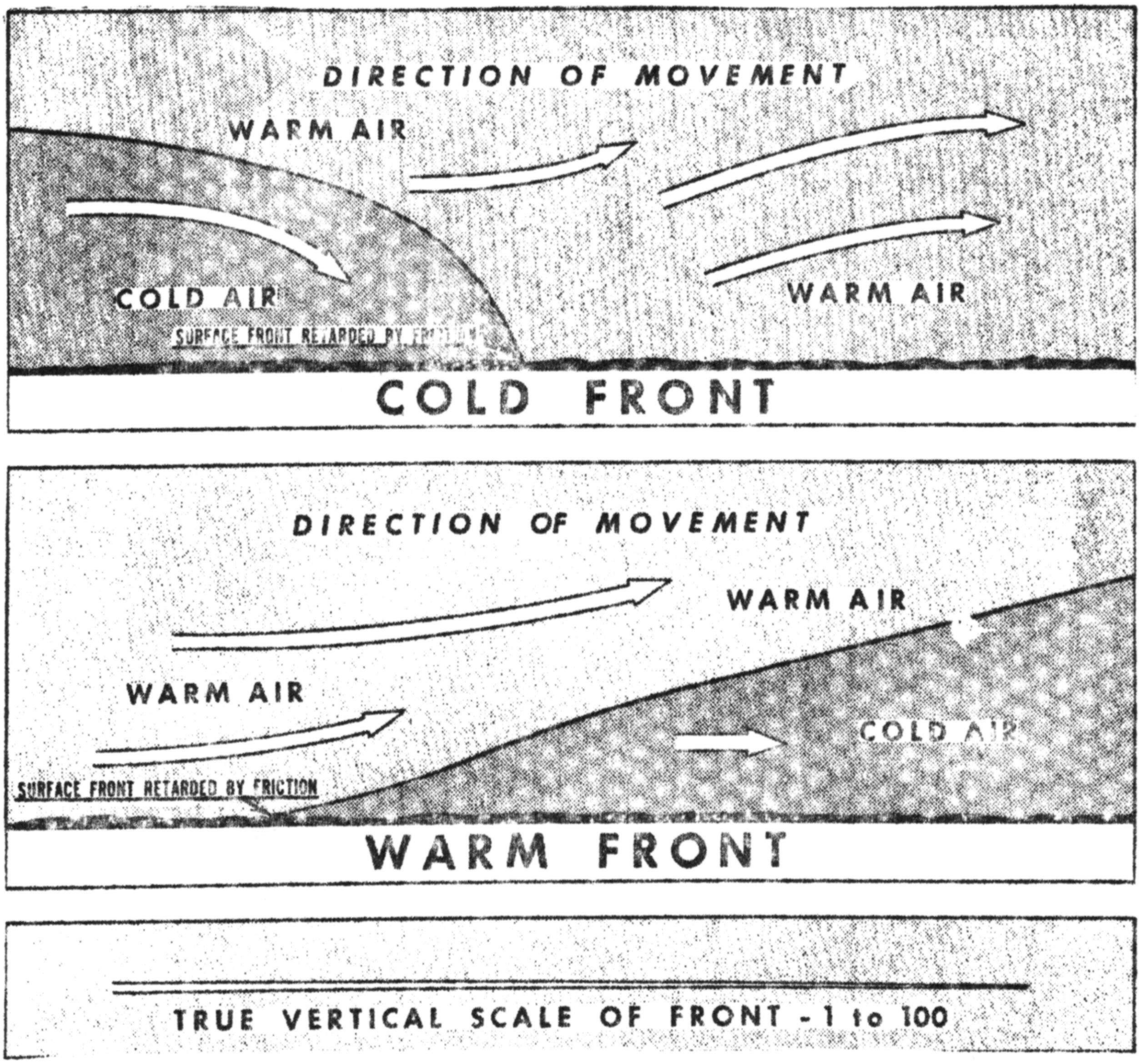


Figure 9. The Slope of a Cold Front is Steeper Than the Slope of a Warm Front. (Vertical Dimensions are Exaggerated in the Drawing.)

resulting in a flat gradual slope to the cold air mass. See Figures 10, 11, 12, and 13. The moisture content of the air masses will be a factor determining the amount of precipitation; however, the air movement within the frontal area will determine the extent to which the two air masses will mix. In order for precipitation to result, the warm moist air must be reduced to the dew point temperature in order for condensation to start. With unstable warm air, there are vertical air movements, forcing the moist air to rise. As the air rises it cools and when it reaches the dew point condensation results. The fast moving cold front with unstable moist warm air is most likely to develop into thunderstorms; usually rapid clearing and colder temperatures with gusty winds will follow a fast moving cold front. Areas over which a warm front is passing consisting of moist warm air will frequently result in precipitation ahead of the front or main body of warm air and increase in intensity as additional warm air advances feeding into colder currents of the cold air mass.

Unstable warm air in a warm air front will likely result in widespread precipitation ahead of the front. As intensive rain falls into the cold air the cold air will become saturated with water vapor. The moisture passing through will raise the humidity of the cold air to or near the saturation point resulting in low ceiling and low visibility.

THUNDERSTORMS

Thunderstorms develop when an air mass becomes unstable to the point of violent overturning. They always start with a cumulus cloud;

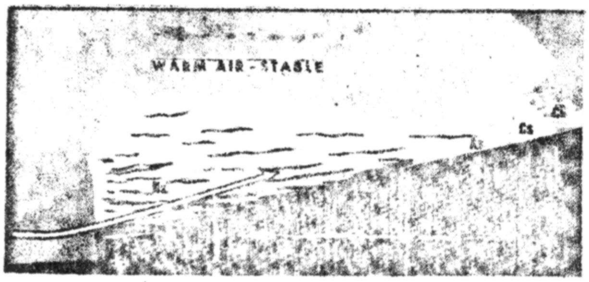


Figure 10. A Warm Front, With Stable Warm Air

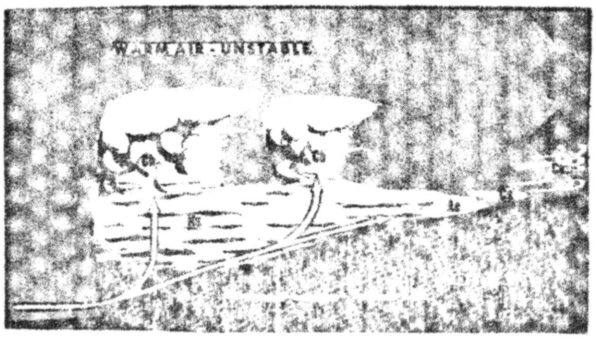


Figure 11. A Warm Front, With Unstable Warm Air

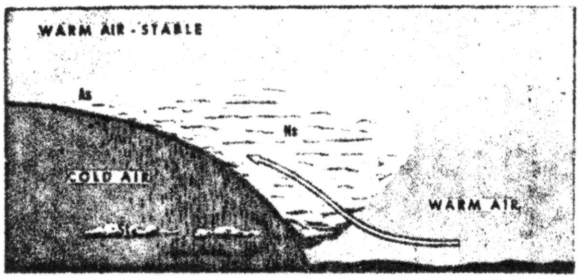


Figure 12. A Slow Moving Cold Front, With Stable Warm Air

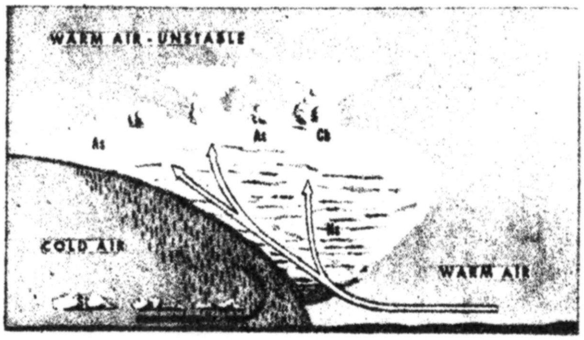


Figure 13. A Slow Moving Cold Front, With Unstable Warm Air

however, not all cumulus clouds develop into thunderstorms. When a portion of the air mass near the surface of the earth is heated rapidly to a higher temperature than the surrounding air, the heated air will start to rise and may cause strong updrafts or convection currents. In order to replace the air that has risen in the updrafts, air from the surrounding area as well as the air at higher elevation being forced out as a result of the updraft of the hot air, will start to replace the air that has risen. These updraft currents usually extend from the ground to as high as 25,000 feet and travel at speeds as great as 3,000 feet per minute. Some pilots have reported them at 60,000 feet. Air from the sides of the cell is also drawn into the updraft. The rise in elevation cools the air. The colder air into which the updraft carries the warm air also starts condensation and water droplets form. Within the updraft, water droplets may be found several thousand feet above the 32° F. isotherm due to the speed with which the updraft is carrying the moist air upward. Within the mature stage of the cell, there will be downdrafts as well as the continued updrafts. When the forces that caused the original updrafts are neutralized, turbulence is reduced and the dissipation of the cell results. In the meantime, the moist warm air within the cell has been cooled and has started to form water droplets. These water droplets caught in the strong updrafts within the cell are carried to extreme heights where they are frozen. When they have attracted enough moisture so that their weight overcomes the force of the updraft, the frozen drops start downward. As they do so they continue to increase in size

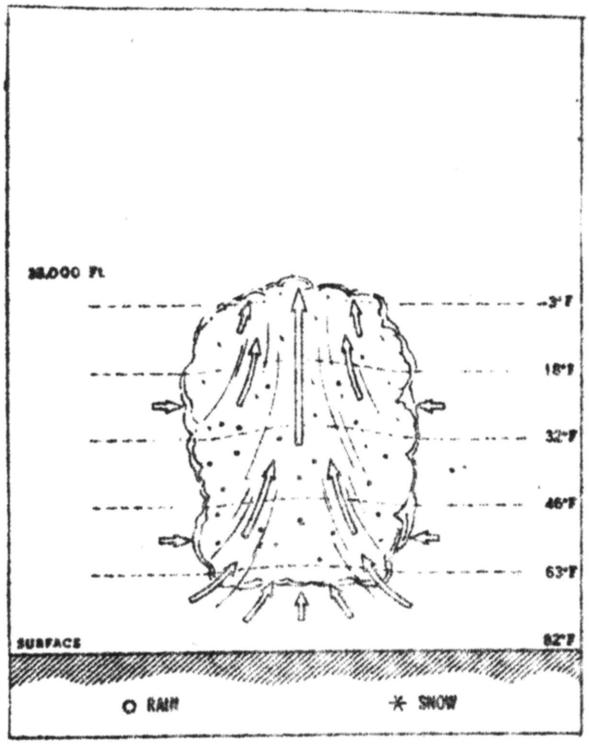


Figure 14. Idealized Cross Section of a Thunderstorm Cell in the Cumulus Stage

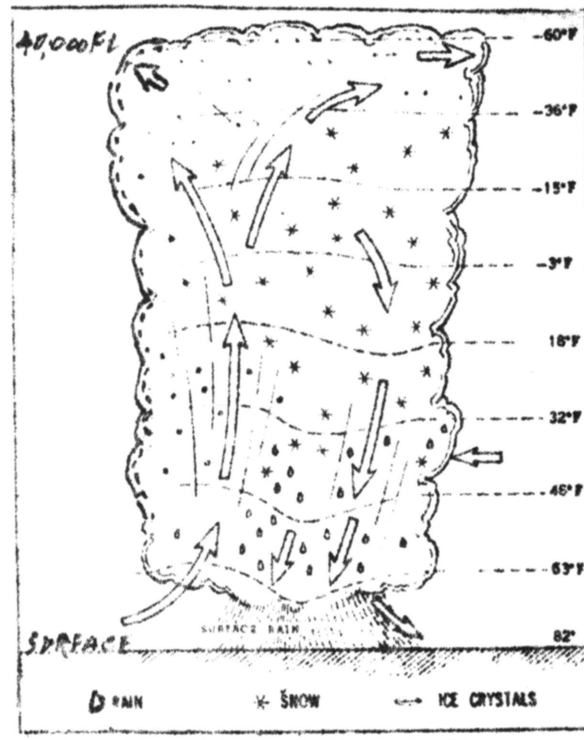


Figure 15. Idealized Cross Section of a Thunderstorm Cell in the Mature Stage

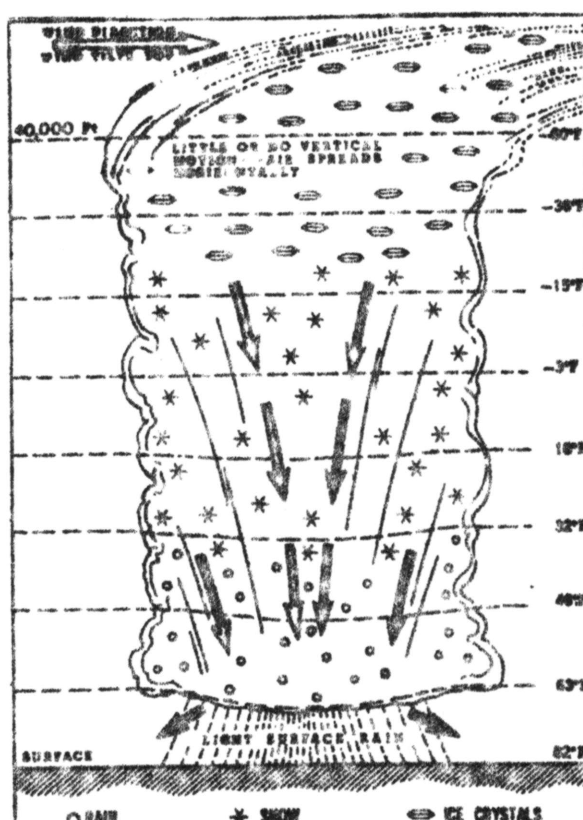


Figure 16. Idealized Cross Section of a Thunderstorm Cell in the Dissipating Stage

by collecting additional droplets. If the updraft at lower levels is great enough to stop their fall, the frozen hail may make additional trips through the cell. The final result will depend on the air currents and temperatures during the final dissipating stage of the cell. In case there is not sufficient warm air to soften the hailstones they will fall as hail. If there is warm air sufficient to partially melt the stones, they may fall as soft or mushy hail; however, if sufficient warm air currents are present to melt the hail, the moisture will fall as rain. If some method could be devised to counteract the violent updrafts during the early stage of the cell formation, it might reduce the violence of the hailstorm.

LIGHTNING

The physical conditions that contribute to the accumulation of electrical potential within the atmosphere are present within the thunderstorm cell. The exact physical factors responsible for the accumulation of the centers of opposing electrical charges in the thunderstorm cell are not positively known. See Figure 17. The earth naturally possesses a negative electrical charge. When sufficient electrical force within the thunderstorm cell is generated to bridge the gap to a center of the opposite force, there is a discharge from the positive center into the area of negative force to neutralize the two forces. The result is the lightning flash as we see it.

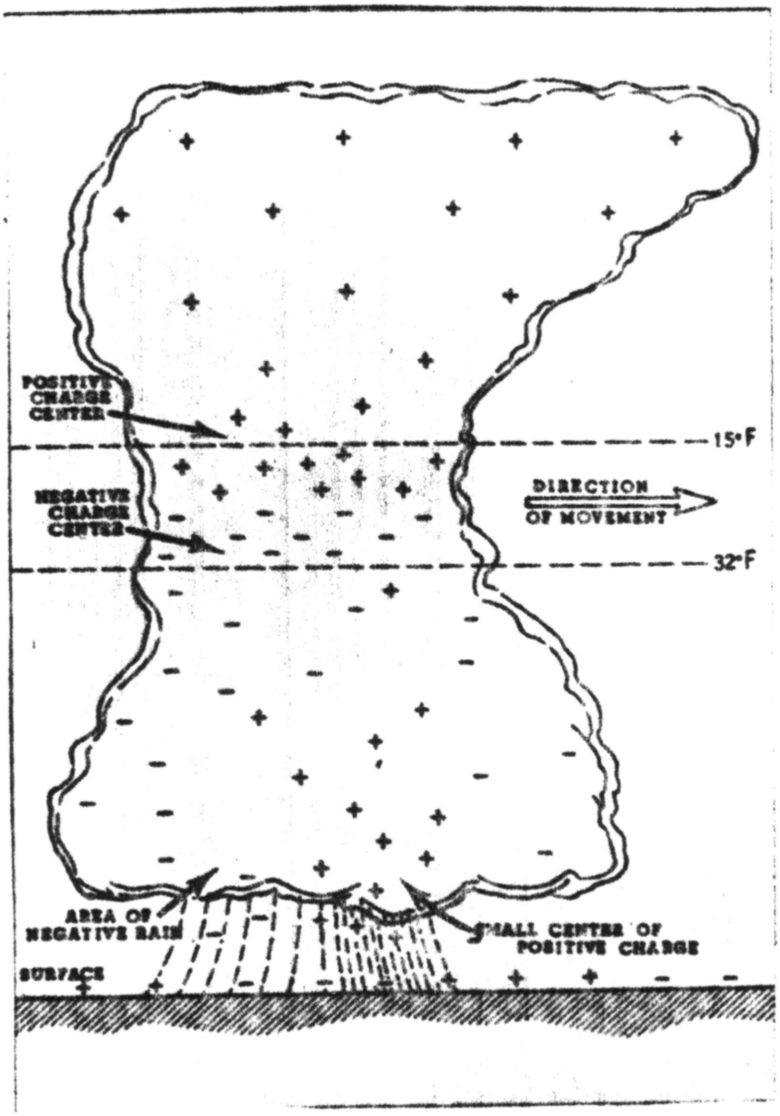


Figure 17. Location of Electric Charges Inside a Typical Thunderstorm Cell

EFFECT OF LOCAL SURFACE CONDITIONS

Local surface conditions appear to affect the amount of precipitation received. Mountainous wooded areas such as the Black Hills of South Dakota receive more precipitation than many of the surrounding areas. The more uneven terrain of these areas may develop air masses large enough to cause updrafts that help to cool moist air above the area to the dew point temperature when condensation of moisture will start. See Figure 18. Surface air currents, also as they approach a mountainous area are forced to higher levels and lighter air. As the air rises it is cooled due to the expansion at the approximate rate of 3 1/2° F. per thousand feet of increased elevation. This also lowers the temperature sufficiently to be a

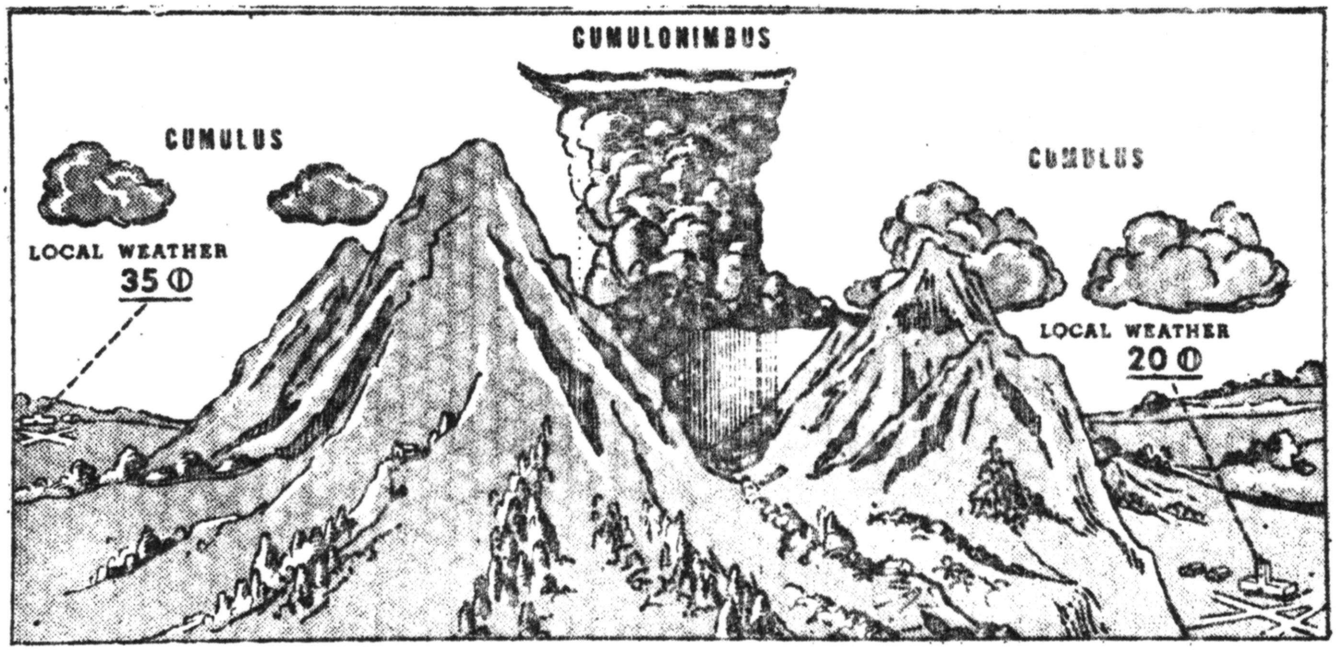


Figure 18. Weather Between Two Stations May Be Different From That Reported by Either of Them

factor in increased condensation of moisture in the atmosphere at these higher levels. As surface air currents pass over the mountains and surface elevation is reduced, the air mass will be heated again as it moves to lower elevation at the rate of 5 1/2^{o} F. per thousand feet of elevation. As this air temperature rises, the capacity of the air to hold moisture increases. This will result in stopping the condensation and so reduce the amount of precipitation received after the mountainous area is passed.

WEATHER DATA IN FORECASTING

Figure 19 presents a theoretical situation as it might appear on a weather map when the meteorologist has plotted current information from stations within his area. When the fronts are established together with information on temperatures, humidity and direction of the air movement within the area an estimate is made of the time at which the air currents will reduce the temperature of the warm moist air to the condensation point. The upper and lower cross sections of the chart show the areas of probable precipitation.

This is a simplified version of the complicated factors with which the meteorologist has to contend in making his final estimate of the most likely effects of the development of weather over the period directly ahead.

Two or three days are required for moisture laden air from the Gulf of Mexico to reach the north central regions of the United States. The usually slower movement of cold air from the poles may be longer coming from the polar regions. Estimates of wind direction, tempera-

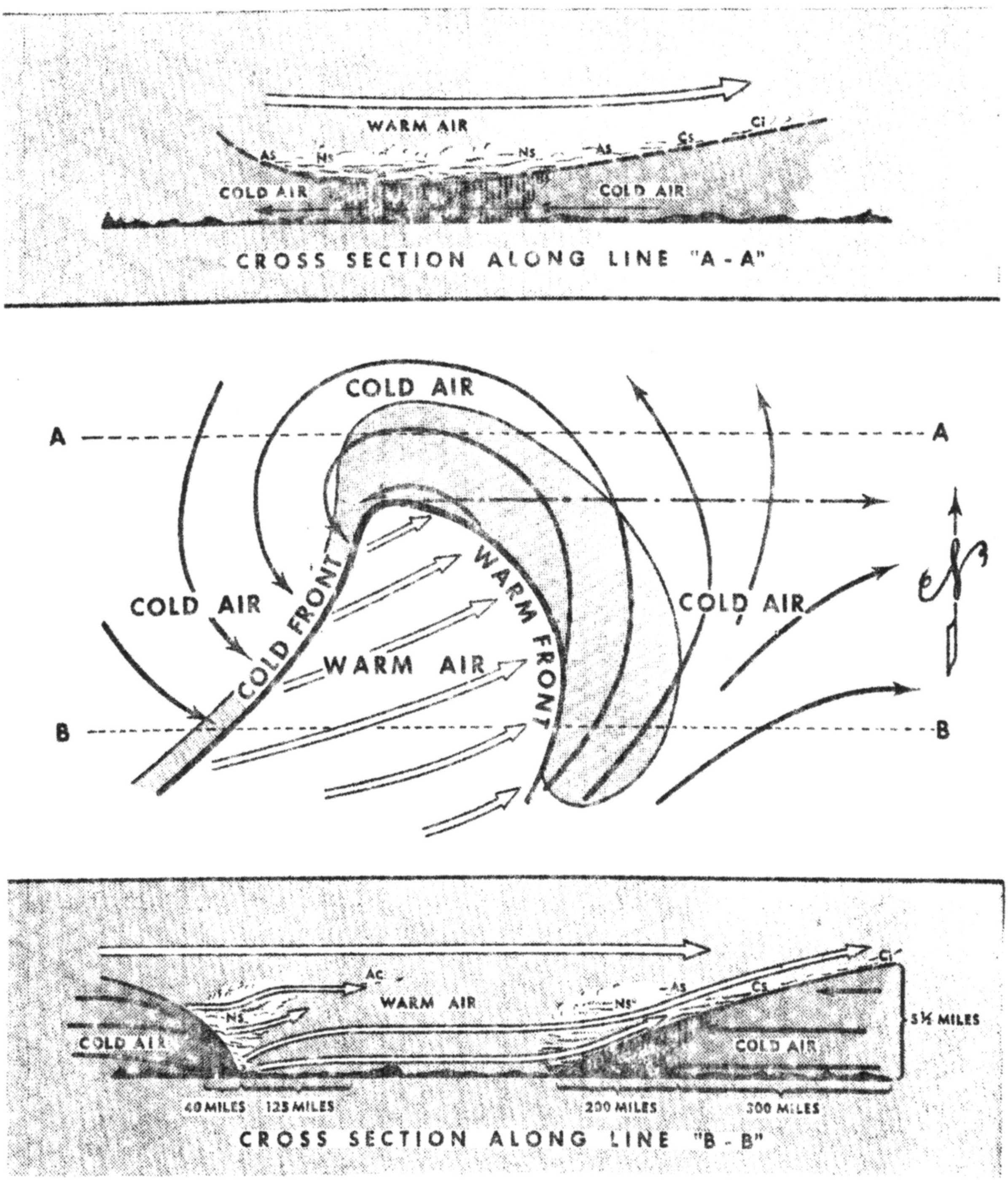


Figure 19. The Center Panel Shows a "Top View" of a Low-Pressure System, With Cross Sections at Two Points Being Shown in the Upper and Lower Panels

ture and precipitation to be expected will be influenced by the amount of water vapor present in the air that is headed for a particular region. Temperatures, air movement, atmospheric pressure as well as surface conditions over which the air will pass must also be considered. Many factors are involved, and changes frequently occur that will alter the entire picture after a forecast is made. As additional data become available regarding weather relationships, meteorologists will be in position to make more accurate forecasts. Additional information regarding past weather relationships will contribute to the improvement of weather forecasts and provide farmers and others interested with information that will make it possible for them to prepare for probable weather conditions and in many cases reduce or minimize losses resulting from unfavorable weather. More complete weather information is essential and it is thought that a bird's eye view of the complicated factors involved in weather will be of interest.

DEFINITION OF TERMS

AIR MASS: A term applied by meteorologists to an extensive body of air within which the conditions of temperature and moisture in a horizontal plane are essentially uniform.

AIR MASS PROPERTY: Any quality or quantity the nature or value of which can be used to describe the physical state or condition of an air mass.

ARCTIC FRONT: The line where a definite change occurs between very cold air flowing from the Arctic regions and polar maritime air that has moved away from its source region in an indirect path and has been warmed through contact with the ocean surface.

ATMOSPHERE: The entire mass of air surrounding the earth.

BAROMETER: An instrument for measuring the pressure of the atmosphere.

CEILING: The lowest height above the surface at which the total cloudiness (as seen by a ground observer) covers more than half of the sky.

CHINOOK, OR CHINOOK WIND: A wind blowing down the eastern slopes of the Rocky Mountains over the adjacent plains, in the United States and Canada. This warm dry wind occuring in winter often causes snow to disappear rapidly and has been named (snoweater).

COLD AIR MASS: An air mass that is cold relative to neighboring air masses. It usually is colder than the surface over which it is flowing.

COLD FRONT: The break at the forward edge of an air mass which is displacing warmer air in its path.

COLD WAVE: A rapid and marked fall in temperature during the cold season of the year.

CONTINENTAL CLIMATE: The type of climate characteristic of the interior of a continent.

CONVECTION: The upward or downward movement of a limited portion of the atmosphere. Convection is essential to the formation of many clouds, especially of the cumulus type.

CONVERGENCE: The condition that exists when the distribution of winds within a given area is such that there is a net horizontal inflow of air into the area. Areas of convergent winds are regions favorable to the occurrence of precipitation.

CYCLONE: An area of low barometric pressure with its attendant system of winds moving in counter clockwise direction.

DEW POINT: The temperature at which, under ordinary conditions, condensation begins in a cooling mass of air.

DIVERGENCE: The condition that exists when the distribution of winds within a given area is such that there is a net horizontal flow of air outward from the region. Areas of divergent winds are regions unfavprable to the occurrence of precipitation.

DOLDRUMS: The equitorial belt of calms or light variable winds, lying between the two trade-wind belts.

EQUINOX: The moment occurring twice each year when the tip of the earth is such that the sun shines directly down on the equator.

FAHRENHEIT TEMPERATURE: A temperature reading on a thermometer with a scale showing 32° as the freezing temperature of water and the boiling point at sea level of 212°.

FOG: A cloud at the earth's surface. Fog consists of numerous drops of water, which are so small they cannot be distinguished by the naked eye.

FRONT: The boundary between two different air masses.

FROST: Atmospheric moisture deposited on objects in the form of ice crystals.

GLAZE: A smooth coating of ice on objects due to the freezing of rain.

GUST: A sudden brief increase in the force of the wind.

HAIL: A form of precipitation consisting of balls or irregular lumps of ice.

HAZE: A lack of transparency in the atmosphere caused by the presence of dust or salt particles.

HIGH: An area of high barometric pressure; an anticyclone.

HOT WAVE: A period of abnormally high temperatures.

HUMIDITY: The degree to which the air is charged with water vapor. Relative humidity is the ratio of the amount of moisture in the air to the greatest amount that the air can hold at the same temperature. In other words, it is the percentage of saturation of the air.

INVERSION: The atmospheric temperature is ordinarily observed to become lower with increasing height, but occasionally the reverse is the case, and when the temperature increases with height there is said to be an "inversion."

ISOBAR: A line on a weather chart or diagram drawn through places having the same barometric pressure.

ISOTHERM: A line on a weather chart or diagram drawn through places having equal temperatures.

LAND AND SEA BREEZES: The breezes that on certain coasts and under certain conditions blow from the land by night and from the water by day.

LAPSE RATE: The rate of decrease of temperature in the atmosphere with height.

LIGHTNING: An electrical discharge in the atmosphere.

LOW: An area of low barometric pressure, with its attendant system of winds.

MILLIBAR: A unit of pressure equal to a force of 1,000 dynes per square centimeter. 1,013.2 millibars is standard atmospheric pressure at sea level equal to 29.92 inches of mercury.

MIST: A very thin fog.

NORMAL: The average value of any meteorological element over a specified period.

NUCLEUS: A particle upon which condensation of water vapor occurs in the free atmosphere to form a water drop or an ice crystal.

OCCLUDED FRONT: The front that is formed when and where a cold front overtakes the warm front of a cyclone.

POLAR CONTINENTAL AIR: The term used to describe any air mass that originates over land or frozen ocean areas in the polar regions.

POLAR FRONT: The surface of change separating an air mass of polar origin from one of tropical origin.

POLAR MARITIME AIR: Any air mass that originally came from the polar regions but has since been modified by reason of its passage over a relatively warm ocean surface.

PRECIPITATION: The collective name for deposits of atmospheric moisture in liquid or solid form. It includes rain, snow, hail, dew and hoarfrost.

PRESSURE: Used in meteorological literature for atmosphere pressure.

PREVAILING WESTERLIES: The belts of winds lying on the poleward sides of the subtropical high-pressure belts.

PSYCHROMETER: An instrument for measuring atmospheric humidity.

SATURATION: The condition that exists in the atmosphere when the air contains all the water vapor that it can hold at its present temperature.

SHOWER: A fall of precipitation of short duration.

SLEET: Frozen or partly frozen rain.

SNOW: Precipitation in the form of small ice crystals.

SOURCE REGION: An extensive area of the earth's surface where conditions are such that air masses are formed.

THUNDERSTORMS: A local disturbance marked by sudden variations in pressure, temperature and wind.

TRADE WINDS: Two belts of winds, one on either side of the equatorial doldrums in which the winds blow almost constantly from an easterly direction.

TROPICAL MARITIME AIR: The term used to describe any air mass that originated over an ocean in the tropics.

TROUGH: An elongated area of low barometric pressure.

TURBULENCE: Irregular motion of the atmosphere produced when air flows over a comparatively uneven surface, or when two currents of air flow by each other in different directions or at different velocities.

WARM AIR MASS: An air mass that is warm relative to neighboring air masses.

WARM FRONT: The forward edge of an advancing current of relatively warm air which is displacing a retreating colder air mass.

WIND: Air in motion.