Fronts, Clouds and Visibility

Need for pilots to acquire a better understanding of weather is emphasized by the large number of general aviation accidents with weather as a contributing factor

EDITOR'S NOTE: This is the second of a series of four articles based on the U. S. Weather Bureau's outline for a "Guide For Aviation Weather Seminars." The first article, published in The PILOT last month, dealt with the "Weather and Human Factors."

The pilot's voice was tense with anxiety. "I can't see the ground" he told Tampa radio.

It was 9:08 a.m. and the pilot had called Tampa radio on VHF, reported he was between layers with solid undercast, with no visibility, and was lost. He requested help in determining his position.

9:12 a.m.—In response to questions, the pilot said he had one hour of fuel remaining aboard. He reported that he had his wife and two young children with him and no one else in the plane to assist him. Clouds were gradually getting thicker and precipitation becoming heavier.

9:13 a.m.—The pilot advised Tampa radio that his omni receiver showed him on a course of 80° to the Tampa VOR ground station. The pilot was told to tune in on Cross City VOR and report the indication received.

9:14 a.m.—Pilot reported his omni indicated 85° to Tampa and 185° from Cross City. The pilot was informed by the Tampa radio that his position was over the Gulf of Mexico to the west of Tampa. He was told to fly a compass heading of 85°.

9:22 a.m.—After several tries the Tampa radio was unable to raise the pilot. Twenty-four hours later the wreckage of the plane was found and one more accident was chalked up. Cause: "Insufficient knowledge of flying weather conditions."

Had the pilot cited in this accident known and heeded the conditions that result from frontal patterns, perhaps his life and that of his wife and children would have been saved. It is this basic reason, to save lives, that the U. S. Weather Bureau in Washington, D. C., stresses the importance to pilots in its outline of a "Guide for Aviation Weather Seminars" of knowing what to look for in flying weather and how to use it. It is knowledge based on limits of weather conditions beyond which a pilot cannot safely fly.

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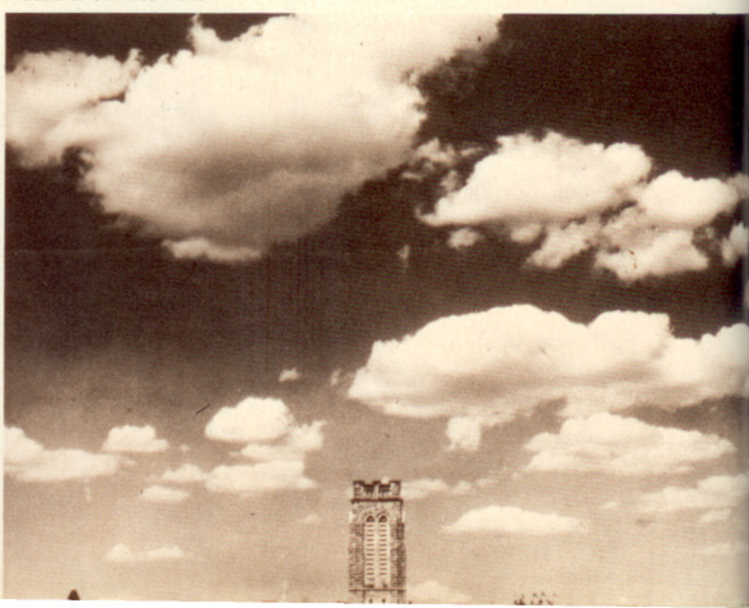
It is the purpose of this article and the purpose of the U. S. Weather Bureau's proposed "Guide For Aviation Weather Seminars" to present a condensed elementary course in weather, including fronts, and the significance of clouds and visibility to the pilot. It is hoped that new pilots will learn some basics about weather and experienced pilots will obtain a refresher course; that all pilots will be stimulated to further study of weather and thereby lessen the awesome number of fatalities.

A front is a boundary between two large air masses having noticeably different temperatures or moisture conditions. For instance, where two air masses from different regions meet, such as cold, dense polar air and warm, light tropical air, they do not simply

FIGURE 2. Stratus type cloud shown in lower portion of the picture

FIGURE 3. Cumulus cloud



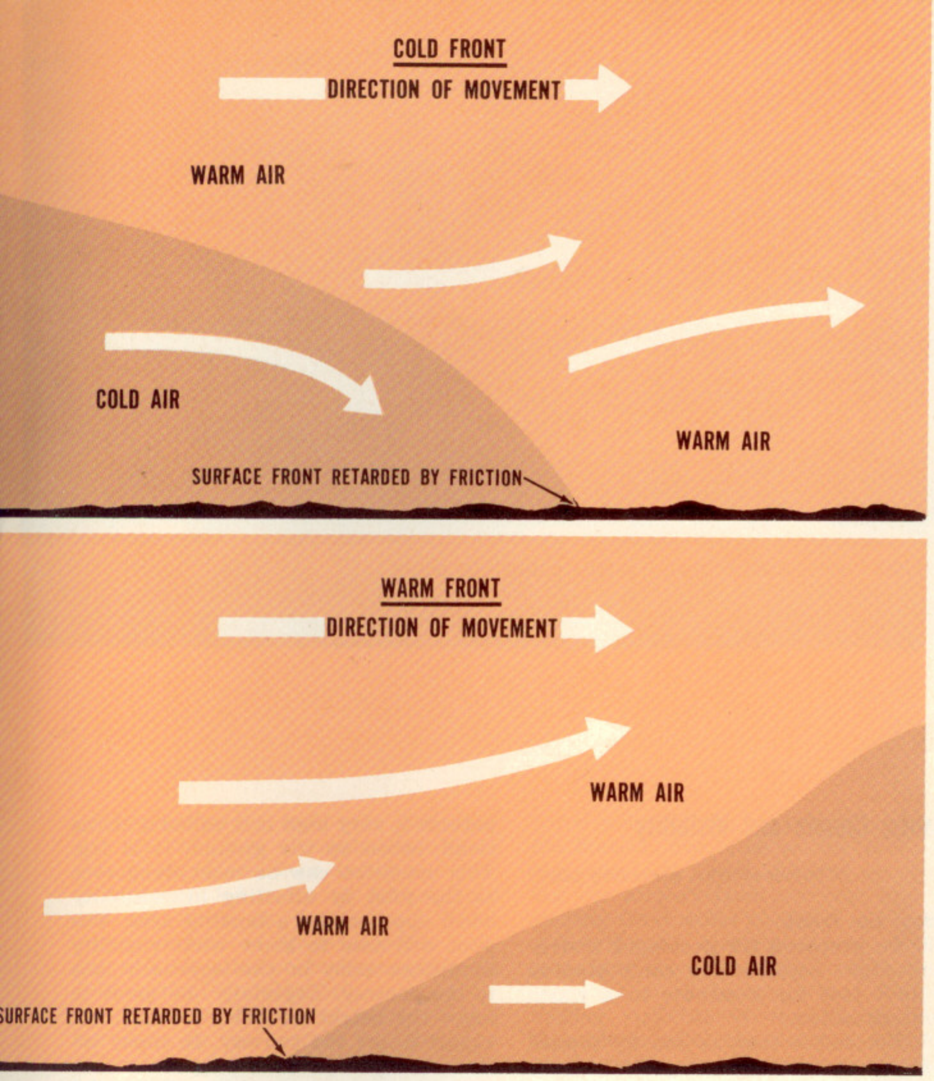


FIGURE 1. The slope of a cold front is steeper than the slope of a warm front

U.S. Weather Bureau photos and illustrations

mix but create an erratic atmospheric situation. This boundary between the warm and cold air is called a front. Clouds, precipitation, turbulence, icing and windshift conditions may occur as the result of a front—all of which are extremely important and often dangerous to pilots.

There are two main types of fronts, cold fronts and warm fronts, and their general movement is from west to east. (See Figure 1.)

A front is called a "cold front" when the cold air is overtaking and replacing warm air. The average width of the cold front is about 50 miles. The length may be hundreds of miles. Marked weather changes take place along cold fronts and some of the most hazardous flying weather is found in cold-front zones.

The sequence of events with the passage of a typical cold front is as follows:

Southerly winds will increase in the warm air lying ahead of the front. High cumuliform, or "cauliflower-like," clouds will appear on the horizon in the direction from which the front is approaching. Next, the altocumulus formed by cumuliform clouds will lower and showers will begin and increase in intensity. Thus, in flying toward a typical cold front the pilot will first see towering cumulus clouds ahead with cirrus clouds overhead. As the pilot approaches closer, the clouds overhead will become thicker. Rain and possibly thunderstorms will be encountered. In the cold winter months there may be snow rather than rain and thunderstorms.

To fly through a cold front, a pilot must stay underneath or go VFR on top. VFR on top, however, demands a lot from a light aircraft; clouds can build at rates that exceed the maximum rate of climb of most small aircraft. Sustained flight above 10,000 feet should not be attempted without oxygen, and winds at high altitudes may be half or more than the cruising speed of the aircraft.

The following safety rules for flying cold fronts are recommended to the private pilot at all times:

1. Wait it out on the ground, especially if the front is fast moving. In extreme cases cold fronts have been observed to move at speeds of 60 m.p.h., thereby causing extremely hazardous weather.

2. Fly the shortest course possible underneath the front.

3. Select flight level either where temperatures are well below or well above freezing.

4. Keep frequent watch for icing when in precipitation.

5. Stay well below or well above clouds to avoid turbulence—about ⅔ of the distance from surface to cloud base; higher is too rough, lower is too dangerous.

6. Be sure you can see all the way through when you try to go underneath the front.

7. Reduce airspeed for heavy turbulence in order to maintain better control of the aircraft.

8. Beware of downdrafts in heavy showers.

The second type of front known as the "warm front" is one in which warm air is overtaking and replacing cold air. Warm fronts move generally from southwest to northeast and average 15-20 m.p.h. As the warm air flows up over the thin wedge of heavier cold air below it, a continuous band of cirrostratus clouds will be encountered if the warm air is stable. If, on the other hand, the warm air is unstable, cirrocumulus, altocumulus clouds, and frequently thunderstorm cumulonimbus may be found ahead of the front.

When the air being lifted is stable, the precipitation that falls from the cloud system ahead of the warm front increases and often continues until the passage of the front. However, with unstable air, cumulonimbus clouds develop and the warm front precipitation becomes showery.

Widespread precipitation in a warm front may cause very low ceilings and visibilities which may close in thousands of square miles. The frontal zone itself may have zero ceilings and visibilities over a wide area. In winter months precipitation falling from the warm air into the cold air below will sometimes freeze on aircraft flying in the cold air.

From the air, the first indications of a warm front to a pilot are high cirrus clouds which become solid and lower toward the horizon. As the pilot flies toward the front, clouds gradually get thicker and lower, precipitation begins and gets heavier. The ceiling may be zero due to fog and low clouds close to the front.

Had the pilot who called Tampa radio in distress had sufficient weather knowledge, he would have recognized the first signs of a warm front and landed at the nearest available spot to wait out the frontal passage. He did not know his weather, nor that he could not fly over a warm front VFR on top. And it is too late for him to learn about it.

The following are safety rules that all private pilots should know and observe concerning warm fronts:

1. Beware of freezing precipitation during winter months or at high altitudes. Check for icing frequently.

2. Fly either high (above 18,000) or low (below 6,000) if flying IFR.

3. Expect ceilings to lower at a rate of at least 5,000 feet every 100 miles when flying through a warm front.

4. Fly the shortest path—directly

(Continued on next page)

FIGURE 4. Nimbostratus cloud shown in upper portion of the picture

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(Continued from preceding page)

across the front.

5. Be prepared for prolonged instrument flight because you can't plan to be IFR just for a minute in a warm front situation.

6. Remember that as you fly toward a front, it is also moving. Make sure of which direction it is moving.

7. Remember that ceilings and visibilities often lower abruptly with the onset of darkness in pre-warm front conditions. Plan to land early to avoid getting trapped.

Not all fronts produce bad flying weather. Fronts that don't get sufficient moisture and others that don't get sufficient lifting of the warm air to cause clouds and precipitation may hardly be noticeable to the pilot. But it is imperative that the pilot be able to recognize what is important and what is not. He can only do this where the weather is concerned by knowing something about it—in this case by knowing what is meant by a cold front and a warm front and what their typical weather patterns are, how to identify them and what they mean to the pilot in the air.

Equally as important to the pilot is the recognition of cloud types that are sometimes symptoms of fronts, and affect visibility.

Clouds are accumulations of condensed water vapor which is always present in the air but is not always visible. Vapor is condensed to liquid water by cooling and the rate of cooling of air determines the type of cloud; slow, steady cooling produces stratiform clouds and rapid, irregular cooling of air produces cumuliform clouds.

Stratus clouds, which produce a steady precipitation, may occur at any height and lie mostly in horizontal layers. (See Figure 2.) When the cloud pattern is very high it is called a cirrus cloud; when on the ground, it is fog. This condition can be most dangerous to the pilot by affecting his visibility when approaching a landing area. The pilot will need to know what visibility conditions exist in the approach lane to the runway. Especially, he needs to know the height at which he can first expect to see the runway. In many instances fog requires a partial or complete instrument landing. The pilot should be aware of this and above all should stay out of fog if unqualified to make an instrument landing.

In addition to the stratus cloud that causes flying hazards there is the cumuliform or "bumpy-like" cloud (Figure 3). It also may occur at any height and has a vertical development which indicates turbulence and instability, produces showers, thunderstorms and hail. Icing of aircraft is a common happening as a result of these conditions. This is usually in the form of a glaze or clear ice formation but also may be mixed with soft hail or snow. Snow is another condition where visibility may be seriously hampered. Due to the speed of an aircraft, the relative motion of the snow flakes is almost horizontal, causing them to hit the windshield or flow around it in such numbers that almost total loss of forward visibility can result.

In addition to the stratus and cumuliform division of cloud types, there is a subdivision made by adding the word "nimbus," meaning "raincloud," to each of the two types. Therefore, a stratus-type cloud from which rain is falling is called nimbostratus (Figure 4). A swelling cumulus cloud that has grown into a thunderstorm cloud is called a "cumulonimbus" (Figure 5). Turbulence is stronger in higher levels of cumulonimbus and its rate of vertical growth often exceeds the rate of climb of an aircraft.

FIGURE 5. Cumulonimbus cloud

Thunderstorms, hail, rain and snow are not the only elements that affect safe flying. Haze, dust and smoke particles suspended in the air scatter light and cut down on "seeability." Thick concentrations of these elements may put a VFR pilot on instruments, with only vertical visibility left.

In-flight visibility frequently is not the same as the surface visibility due to the unequal vertical distribution of haze, dust and smoke particles and because the pilot sees these conditions from a different angle than does the observer on the ground. For instance, layers of smoke and haze around industrial centers may seriously restrict the ground observer's visibility, but to the pilot flying over an airport it may appear as only a thin film through which the airport runways and buildings are still visible. At other times, smoke and haze may lift enough to result in good visibility at ground level, but the in-flight pilot may be unable to see ground objects.

It is therefore important for the pilot to realize that visibility may be different depending on whether or not it is judged from ground level or observed from a control tower. This is explained for the pilot by remarks added to the observation report compiled by the weather observers. These reports are based almost entirely on visual observation by the weather observers, rather than instruments. The observer knows the distance from the weather station to various prominent objects within visual range of the airport and therefore uses these references to determine the visibility. Standard weather observing procedures are to report the "prevailing" visibility as the maximum visibility that is common to more than half of the surrounding horizon. This half, however, need not be continuous. For example, let us say that the weather observer determines the visibility to be three miles to the north and south of the station, five miles to the east, and one mile to the west. A pilot approaching the airport from the east and expecting three miles visibility would find it considerably better, while a pilot approaching from the west would find the visibility much lower. When the prevailing visibility is variable and less than three miles the observer adds remarks to the observation report to indicate the range of variability.

The sun is another important factor in determining visibility. When the sun is within about 45° of the horizon, the pilot's effective visibility may vary considerably, depending on whether he is looking into or away from the sun. When there is considerable haze, dust or smoke, the pilot's effective visibility may be a fraction of a mile when he is looking toward the sun, while in other directions it may be several miles or more. When the visibility around an airport is not uniform, frequently it is better or worse along a particular runway and airport approach lane. Thus, the report from the weather station may or may not be representative of the contions the pilot may encounter when landing. No two weather systems are ever *exactly* alike—whether it be visibility conditions caused by the sun, smoke, haze, dust, or cloud formations or whether it be frontal conditions. Weather is always changing and even the weather forecast accuracy drops with time that has elapsed between forecasts. It is therefore up to the pilot to learn the conditions that affect his individual flight route, know what they are and judge his qualifications to meet them. There is no cheaper flight insurance.

Next month: "Icing and Turbulence," the third in a series of four articles based on the Weather Bureau's outline for a "Guide For Aviation Weather Seminars." END