THUNDERSTORMS

Introduction to Thunderstorms...

At any instant there is, on average, at least one aviator who is looking squarely at a thunderstorm on radar or out the window of the aircraft while flying. Almost once a second, on average, a lightning strike between the ground and a cloud occurs in the United States. Over 100 lightning strikes take place every second over the Earth, where over 44,000 thunderstorms are occurring right now ... significant hazards to aviation and ground operations. There is a very good chance you'll be facing a potential thunderstorm encounter within the next month or two. During that encounter, you will face the many and powerful hazards of a thunderstorm, including strong winds and windshears, heavy precipitation, lightning, hail, and tornadoes. Are you ready?

The definition of a thunderstorm is pretty basic, yet misunderstood by many. The weatherman's definition of a thunderstorm is any local storm with lightning and thunder, produced by a cumulonimbus cloud, usually producing gusty winds, heavy rain and sometimes hail. However, what the weather observer primarily uses to identify a thunderstorm is ... thunder! That's all, just hearing thunder, according to the handbook published for all observers.

Cumulonimbus clouds or "CBs" are vertical columns of cloud mass with rain descending from them which could potentially be thunderstorms. But until the first thunder is heard, there technically is not a thunderstorm at the airfield.

Weather manuals do allow observers to report thunderstorms using other criteria when the airport environment's regular noise would hamper the detection of thunder. Weather observers can also use the presence of lightning in the immediate vicinity (5 NM), or hail, to identify when a thunderstorm is impacting an airfield.

The weather observation will stop reporting thunderstorms 15 minutes after the last reporting criteria is observed.

This, however, begs one of aviation weather's biggest questions. How do the new automated weather observing systems found on airports sense thunderstorms? The answer right now is that unless a human is augmenting the system, it doesn't usually. This is changing as we speak.

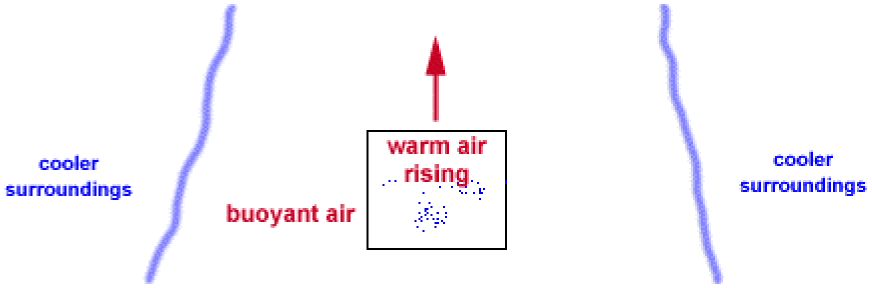
A Review of Thunderstorm Meteorology

What does it take to make a thunderstorm? While thunder is key to the storm's identification, there are a few basic ingredients needed to create the phenomenon. We can imagine the whole process as an engine sustained by fuel and activated by a trigger.

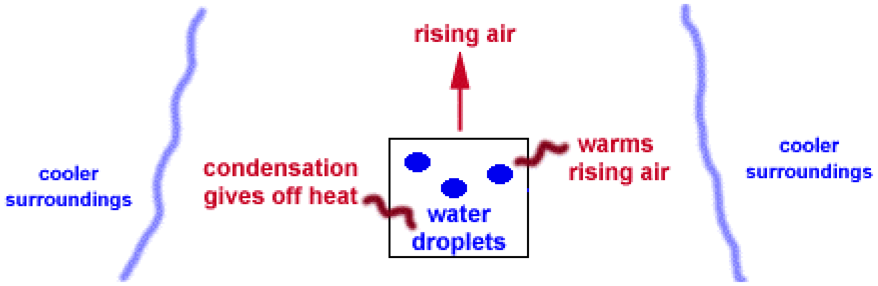
An unstable atmosphere is the first ingredient and the "engine" that keeps the process going. Instability occurs when there is air that is warmer than the atmosphere around it. Under those conditions the warmer air is lighter and will rise, expand and cool to the same temperature as its environment. As the air cools it transfers energy to the surrounding air. When the air cools to the dew point temperature a visible cloud forms. While rising air is the "engine," it needs a source of "fuel."

Updrafts/Downdrafts

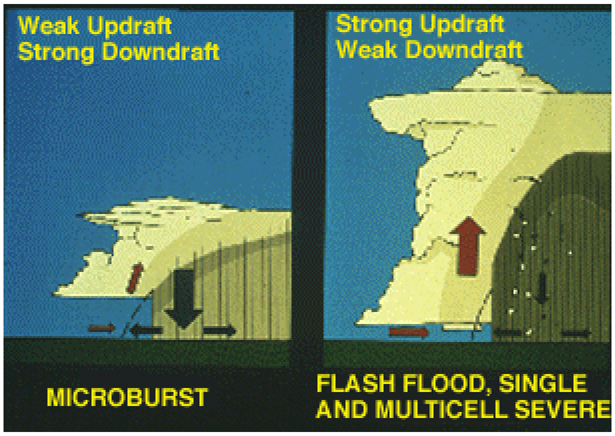
All thunderstorms require instability (potential) and lift. The lift is the mechanism that releases the instability. Lift is produced by such things as fronts and low pressure troughs, or by air rising upslope.



We say that the atmosphere is unstable when air rising in a cloud is warmer than its environment, like a hot-air balloon. It is the heat released by condensation within a cloud that permits the rising air to stay warmer than its surroundings, and thus to be buoyant through great depths.

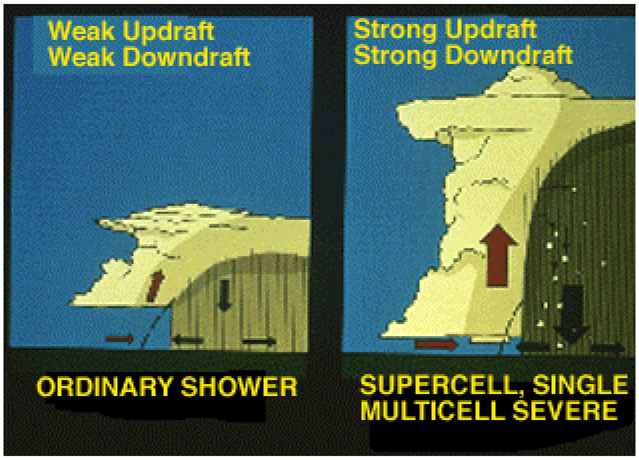


In the same way, air that is cooler than its environment tends to sink as long as it can stay cooler than its surroundings. The upward moving air in a thunderstorm is known as the updraft, while downward moving air is the downdraft. The atmosphere can be unstable for updrafts but stable for downdrafts, stable for updrafts but unstable for downdrafts, stable for both, or unstable for both. The degree of atmospheric instability is one of the two major factors in determining the strengths of thunderstorm updrafts and downdrafts. Furthermore, vertical draft strengths basically determine the degree of storm severity. If we consider a "generic" storm, there are four possible combinations of weak and strong draft strengths.



When the low-level air is unstable but relatively dry and adequate mid-level moisture is present, a storm may develop with a weak updraft but a strong downdraft with the latter the result of strong negative buoyancy and cooling through evaporation of precipitation into the dry air. This high based storm resembles high terrain, western U.S. storms which occasionally produce dry microbursts. Significant hail and rain are unlikely.

A storm which contains a strong updraft and weak downdraft; will not produce wind damage, but can foster heavy rains and/or damaging hail. Single and multicell storms comprise this category. They include storms that dump heavy rain, but little or no hail because of warm conditions aloft, and multicell storms that are capable of producing hail because of lower environmental freezing levels. Strong updraft, weak downdraft storms often form in very moist atmospheres where there is little, if any, dry air and evaporational cooling to drive downdrafts.



Relatively weak updrafts and downdrafts are found with non-severe showers and thunderstorms. The last possible combination is a storm with strong updrafts and downdrafts. These storms frequently produce destructive downbursts, hail, heavy rain, and tornadoes. As one would expect, the most severe storms, including supercells, have strong vertical drafts and occur in the most unstable atmospheres.

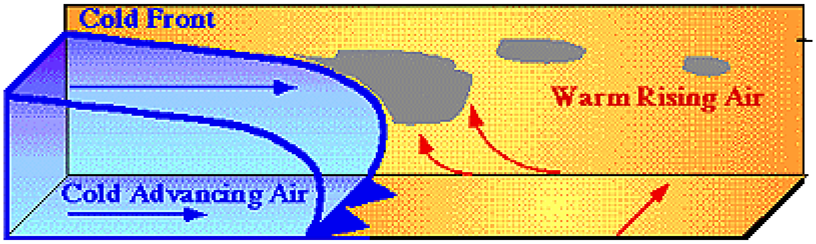
Moisture in the form of water vapor is the second ingredient in our recipe and the fuel for the process. The more moisture there is, the better the environment is for creating a thunderstorm. With more moisture, the dew point temperature is higher so clouds will form with less cooling. There will also be more energy to release to the surrounding atmosphere during the cooling process (the solar energy stored in the water when the sun evaporated it from lakes, rivers, and oceans.) Warm, moist air is the fuel that keeps the unstable atmosphere creating thunderstorms, but we still need the trigger.

The final ingredient is a mechanical device, the "trigger," that will initially lift the air up so that the atmosphere's instability will keep it rising. There are actually a number of triggering mechanisms. Mountainous terrain, fronts, or colliding airflows force air upward.

All weather fronts (cold, warm, stationary, or occluded) can be sources of uplift for the initial development of thunderstorms. At the frontal boundaries, warmer air rises over cooler air masses to create upward motion. Because cold fronts have a steeper slope, the uplifted air moves faster which can create more severe thunderstorms. Frontal storms are also hazardous because the thunderstorms can be embedded and unseen within stratiform clouds that also form.

Fronts

A front is defined as the transition zone between two air masses of different density. Fronts extend not only in the horizontal direction, but in the vertical as well. Therefore, when referring to the frontal surface (or frontal zone), we referring to both the horizontal and vertical components of the front.



The types of fronts discussed in this module include:

Fronts

Stationary Front
A front that is not moving.

Cold Front
Leading edge of colder air that is replacing warmer air.

Warm Front
Leading edge of warmer air that is replacing cooler air.

Occluded Front
When a cold front catches up to a warm front.

Dry Line
Separates a moist air mass from a dry air mass

Associated with rapidly moving cold fronts is the source of some of the strongest thunderstorms, the squall line. Here large-scale wind flows converge between 50 and 300 miles ahead of the cold front, and have nowhere to go but up. This strong and rapid movement upward creates a thin band of very unstable air that extends in a long line. The thunderstorms here are very active and potentially quite hazardous.

Another source of uplifting motion comes from the movement of moist air over rising terrain features or "**orographic**" lift. The thunderstorm will usually form on the windward side of the terrain if the air is unstable, and the storms are usually embedded within layers of clouds near the peaks.

The collision of moving air, or convergence, plays a role in thunderstorms. Since solar heating of the land occurs unevenly, some areas will be warmer while other areas are cooler. Air rises over the warmer areas, and is replaced in low levels by air converging from surrounding cooler areas. These converging airflows collide and force an uplifting motion. The squall lines mentioned above are dangerous examples; sea breeze convergence fronts along coastlines are a tamer example. Convergence also occurs when cooler air from nearby thunderstorms descends to the ground, spreads out, and pushes under the warmer air, lifting it upward to form a whole new thunderstorm. Sometimes, the descending air from different storms meet and force warmer air upward.

There are three major stages of development to the life of a thunderstorm. The whole process lasts from only 20 minutes to several hours. Watching the development of a single-cell thunderstorm through all three stages gives us a chance to understand the forces involved in creating this aviation hazard.

The first, or updraft stage, begins with a simple cumulus cloud. During this initial stage, the updraft that carries the moist air aloft can be as rapid as 3,000 feet per minute and extend from the ground to several thousand feet above the cloud. The heat energy released as the air cools, expands the bubble of unstable air. As the air moves upward, cloud droplets collide with others and grow in size. The suspended water can be in liquid form well above the altitude at which water freezes, due to the energy released in the growing cloud. Towering cumulus clouds, TCU, are now visible.

In the mature stage of the thunderstorm, the liquid droplets grow to a size where they can no longer be suspended aloft by the updrafts within the cloud. Precipitation begins and drags cooler air from the higher altitudes down with it. This creates a **downdraft** within the cloud. This colder air accelerates groundward at up to 2,500 feet per minute. As precipitation descends, drier air mixes into the cloud in a process called "entrainment," causing some of the rain to evaporate. Cooling accompanies the evaporation and accelerates the descent. When the downdraft strikes the Earth's surface, it spreads out to create a **gust front** with strong **windshears** and damaging winds. If the downburst is less than 2.2 NM wide (4 km) it is called a microburst**;** a larger downburst is called a **macroburst**. Updrafts gain intensity to the point that some storm clouds can grow at up to 8,000 to 10,000 feet per minute. With updrafts and downdrafts located close to each other, large droplets that were carried aloft to be frozen in the higher portions of the atmosphere, fall and collect more moisture only to be snatched by an updraft and carried aloft again. This cycle can eventually form hail. Throughout the mature stage, the movement and collisions of the air molecules and water droplets create electrical fields within the cloud, producing lightning (the cause of thunder) and therefore a thunderstorm. Turbulence is severe within the cloud. At its maximum intensity, a thunderstorm top reaches the tropopause and ice crystals spread out in the faster winds of the higher altitudes to create the familiar anvil formation.

Finally, in the dissipating stage, downdrafts form throughout the cloud, decreasing the uplifting taking place. The source of energy to sustain the storm is removed. The intensity then decreases until all that is left is the floating cirrus anvil.

Most individual thunderstorm cells last from 20 minutes to an hour within a system of multi-celled clusters of CBs. The gust front usually produces additional uplifting action ahead of the thunderstorm, creating a new one that will have a life of its own. Where there is a lot of moisture available, the cluster will grow to a large size called a **mesoscale convective complex** or **MCC.** It is important to understand that new thunderstorms form wherever gust fronts create lifting, but the whole system moves in a direction steered by winds in the middle altitudes.

When there is stronger wind aloft the mature thunderstorm will tilt. In this situation the process of growth and maturity can be sustained for a long time. This is the "**supercell,**" a source of some of the severest weather produced by thunderstorms.

Supercells exist because of the strong windshears created between lower level warm moist air and the dry upper-altitude winds, and the very strong rotation of air moving upward within the cell. The difference in wind speeds and directions also form a horizontal rotation much like the formation that creates roll clouds or causes waves to curl on a shoreline. When the horizontal rolling motion is tilted vertically, the portion that is rotating in the same direction as the winds within the cell (usually counterclockwise in the Northern Hemisphere) adds its motion to the storm's spin and a **tornado** forms. Sustained by large amounts of warm moist air lifted into the path of the cell by a large gust front up to 15 miles ahead of the cell, the formation can grow to over 60,000 feet in altitude and punch through the tropopause in a formation called an "**overshooting top**." These cells can live long enough to travel hundreds of miles along the surface of the Earth, dragging damaging tornadoes with them.

A tornado is not the only form of damaging winds from large thunderstorms. Besides the gust fronts and the havoc they can play on aviation, downbursts taking place in a larger scale system can create very damaging straight-line winds called "**derechos**." A derecho is a system of downbursts produced by convective weather systems that, because there are so many downbursts so close to each other in time and space, the net effect is a destructive straight-line wind that could reach over 100 knots.

Whether severe or not, all thunderstorms have the vertical motions that create electrical hazards. As the liquid and frozen water droplets collide in the violent vertical motions of a towering cumulus cloud growing to maturity, electrical fields are created in the cloud. There is a thin area of negative charge at the top of the cloud. Below it, within the anvil, is an area of positive charge. Around the freezing level is a strong area of negative charge as water exists in all three states. Finally, along the bottom, there is a thin area of positive charge. Underneath the cloud, and traveling with it, is a very strong area of positive charge.

At a point, the differences between the high concentration of negative charge at the freezing level and a nearby positively charged area is so great, that nature seeks to neutralize the differences. Most of the time, it is a positively charged area within a cloud, whether the same or different one, that is used. Some of the time, it is the positively charged ground that is used.

Whichever way it happens, the electrons from the negative area move away from the cloud in small 10 to 50 foot movements called the "**stepped leaders**." Because air is so resistant to the flow of electrons, it takes lots of electrons to flow to find the path of least resistance, making a forked pattern. Additional 15 to 25 footsteps take place from stepped leaders as the path grows towards the positively charged area. When the stepped leader gets close to the target, a path of positive charge is drawn towards the negative charge. If the target is the ground, the "**streamer**" ascends through a high point such as a flagpole, lightning rod, tree, or the occasional human. When contact is made between the negative leaders and the positive streamer, there is a mass migration of positive charge along the entire path created by the leaders. As the positive and negative charges collide, the one-eighth to six-inch thick pathway heats up to 10,000 degrees Celsius. (That's hotter than the surface of the sun.) The heat energy creates light and the rapid expansion of the air around it. We see lightning**.** We hear thunder. This whole process has taken less than a second to occur, and since the pathway through the air is now less resistant to electrical flow, it can be repeated up to three or more times in a second as "**dart leaders**" travel down the same path as the step leaders. This gives lightning a flickering appearance. We hear thunder "rolling" as the soundwaves from different parts of the flash reach us at different times. We have a thunderstorm on our hands.

If you are out on the ramp and want to know how close lightning is use the "five second rule". For every five seconds the thunder takes to reach you after the flash, the lightning is one mile away.

AC 00-24B - THUNDERSTORMS

Department of Transportation
Federal Aviation Administration

1/2/83

Initiated by: AFO-260

1. PURPOSE. This advisory circular describes the hazards of thunderstorms to aviation and offers guidance to help prevent accidents caused by thunderstorms.

2. GENERAL. We all know what a thunderstorm looks like. Much has been written about the mechanics and life cycles of thunderstorms. They have been studied for many years; and while much has been learned, the studies continue because much is not known. Knowledge and weather radar have modified our attitudes toward thunderstorms, but one rule continues to be true - any storm recognizable as a thunderstorm should be considered hazardous until measurements have shown it to be safe. That means safe for you and your aircraft. Almost any thunderstorm can spell disaster for the wrong combination of aircraft and pilot.

3. HAZARDS. A thunderstorm packs just about every weather hazard known to aviation into one vicious bundle. Although the hazards occur in numerous combinations, let us look at the most hazardous combination of thunderstorms, the squall line, then we will examine the hazards individually.

a. Squall Lines. A squall line is a narrow band of active thunderstorms. Often it develops on or ahead of a cold front in moist, unstable air, but it may develop in unstable air far from any front. The line may be too long to detour easily and too wide and severe to penetrate. It often contains steady-state thunderstorms and presents the single most intense weather hazard to aircraft. It usually forms rapidly, generally reaching maximum intensity during the late afternoon and the first few hours of darkness.

b. Tornadoes.

(1) The most violent thunderstorms draw air into their cloud bases with great vigor. If the incoming air has any initial rotating motion, it often forms an extremely concentrated vortex from the surface well into the cloud. Meteorologists have estimated that wind in such a vortex can exceed 200 knots; pressure inside the vortex is quite low. The strong winds gather dust and debris and the low pressure generates a funnel shaped cloud extending downward from the cumulonimbus base. If the cloud does not reach the surface, it is a "funnel cloud"; if it touches a land surface, it is a "tornado."

(2) Tornadoes occur with both isolated and squall line thunderstorms. Reports for forecasts of tornadoes indicate that atmospheric conditions are favorable for violent turbulence. An aircraft entering a tornado vortex is almost certain to suffer structural damage. Since the vortex extends well into the cloud, any pilot inadvertently caught on instruments in a severe thunderstorm could encounter a hidden vortex.

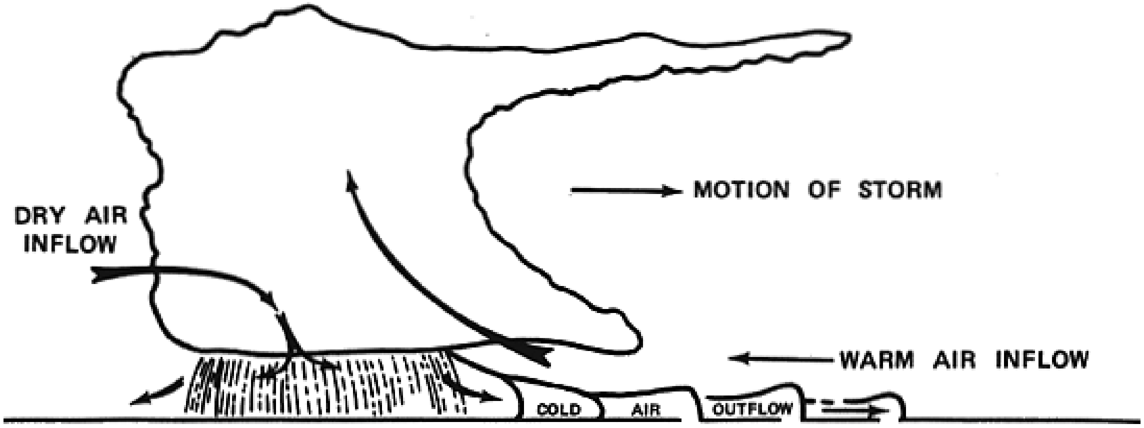
(3) Families of tornadoes have been observed as appendages of the main cloud extending several miles outward from the area of lightning and precipitation. Thus, any cloud connected to a severe thunderstorm carries a threat of violence.

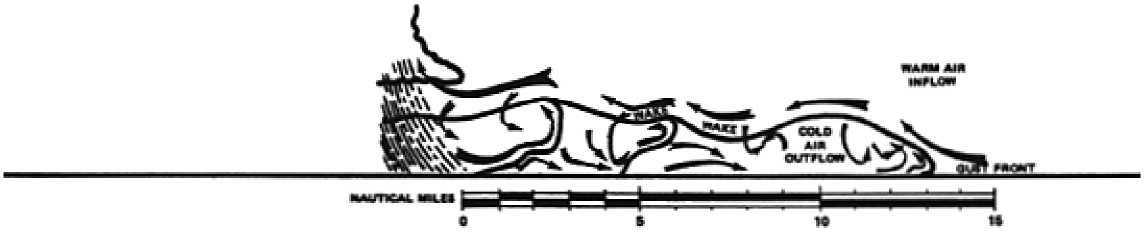
c. Turbulence.

(1) Potentially hazardous turbulence is present in all thunderstorms, and a severe thunderstorm can destroy an aircraft.

Tail of an Air Force C-141 that flew through
a thunderstorm.

Strongest turbulence within the cloud occurs with shear between updrafts and downdrafts. Outside the cloud, shear turbulence has been encountered **several thousand feet above and 20 miles laterally** from a severe storm. A low level turbulent area is the shear zone associated with the gust front. Often, a "roll cloud" on the leading edge of a storm marks the top of the eddies in this shear and it signifies an extremely turbulent zone. **Gust fronts often move far ahead (up to 15 miles) of associated precipitation.** The gust front causes a rapid and sometimes drastic change in surface wind ahead of an approaching storm. Figure 1 shows a schematic cross section of a thunderstorm with areas outside the cloud where turbulence may be encountered.





(2) It is almost impossible to hold a constant altitude in a thunderstorm, and maneuvering in an attempt to do so produces greatly increased stress on the aircraft. It is understandable that the speed of the aircraft determines the rate of turbulence encounters. Stresses are least if the aircraft is held in a constant attitude and allowed to "ride the waves." To date, we have no sure way to pick "soft spots" in a thunderstorm.

d. Icing.

(1) Updrafts in a thunderstorm support abundant liquid water with relatively large droplet sizes; and when carried above the freezing level, the water becomes supercooled. When temperature in the upward current cools to about -15 °C, much of the remaining water vapor sublimates as ice crystals; and above this level, at lower temperatures, the amount of supercooled water decreases.

(2) Supercooled water freezes on impact with an aircraft. Clear icing can occur at any altitude above the freezing level; but at high levels, icing from smaller droplets may be rime or mixed rime and clear. The abundance of large, supercooled water droplets makes clear icing very rapid between 0 °C and -15 °C and encounters can be frequent in a cluster of cells. Thunderstorm icing can be extremely hazardous.

e. Hail.

(1) Hail competes with turbulence as the greatest thunderstorm hazard to aircraft. Supercooled drops above the freezing level begin to freeze. Once a drop has frozen, other drops latch on and freeze to it, so the hailstone grows - sometimes into a huge iceball. Large hail occurs with severe thunderstorm with strong updrafts that have built to great heights. Eventually, the hailstones fall, possibly some distance from the storm core. Hail may be encountered in clear air several miles from dark thunderstorm clouds.

(2) As hailstones fall through air whose temperature is above 0 °C, they begin to melt and precipitation may reach the ground as either hail or rain. Rain at the surface does not mean the absence of hail aloft. You should anticipate possible hail with any thunderstorm, especially beneath the anvil of a large cumulonimbus. Hailstones larger than one-half inch in diameter can significantly damage an aircraft in a few seconds.

f. Low Ceiling and Visibility. Generally, visibility is near zero within a thunderstorm cloud. Ceiling and visibility also may be restricted in precipitation and dust between the cloud base and the ground. The restrictions create the same problem as all ceiling and visibility restrictions; but the hazards are increased many fold when associated with the other thunderstorm hazards of turbulence, hail, and lightning which make precision instrument flying virtually impossible.

g. Effect on Altimeters. Pressure usually falls rapidly with the approach of a thunderstorm, then rises sharply with the onset of the first gust and arrival of the cold downdraft and heavy rain showers, falling back to normal as the storm moves on. This cycle of pressure change may occur in 15 minutes. If the pilot does not receive a corrected altimeter setting, the altimeter may be more than 100 feet in error.

h. Lightning. A lightning strike can puncture the skin of an aircraft and can damage communications and electronic navigational equipment. Lightning has been suspected of igniting fuel vapors causing explosion; however, serious accidents due to lightning strikes are extremely rare. Nearby lightning can blind the pilot rendering him momentarily unable to navigate either by instrument or by visual reference. Nearby lightning can also induce permanent errors in the magnetic compass. Lightning discharges, even distant ones, can disrupt radio communications on low and medium frequencies. Though lightning intensity and frequency have no simple relationship to other storm parameters, severe storms, as a rule, have a high frequency of lightning.

i. Engine Water Ingestion.

(1) Turbine engines have a limit on the amount of water they can ingest. Updrafts are present in many thunderstorms, particularly those in the developing stages. If the updraft velocity in the thunderstorm approaches or exceeds the terminal velocity of the falling raindrops, very high concentrations of water may occur. It is possible that these concentrations can be in excess of the quantity of water turbine engines are designed to ingest. Therefore, severe thunderstorms may contain areas of high water concentration which could result in flameout and/or structural failure of one or more engines.

(2) At the present time, there is no known operational procedure that can completely eliminate the possibility of engine damage/flameout during massive water ingestion. Although the exact mechanism of these water induced engine stalls has not been determined, it is felt that thrust changes may have an adverse effect on engine stall margins in the presence of massive water ingestion.

(3) Avoidance of severe storm systems is the only measure assured to be effective in preventing exposure to this type of multiple engine damage/flameout. During an unavoidable encounter with severe storms with extreme precipitation, the best known recommendation is to follow the severe turbulence penetration procedure contained in the approved airplane flight manual with special emphasis on avoiding thrust changes unless excessive airspeed variations occur.

4. WEATHER RADAR.

a. Weather radar detects droplets of precipitation size. Strength of the radar return (echo) depends on drop size and number. The greater the number of drops, the stronger is the echo; and the larger the drops, the stronger is the echo. Drop size determines echo intensity to a much greater extent than does drop number. Hailstones usually are covered with a film of water and, therefore, act as huge water droplets giving the strongest of all echoes.

b. Numerous methods have been used in an attempt to categorize the intensity of a thunderstorm. To standardize thunderstorm language between weather radar operators and pilots, the use of Video Integrator Processor (VIP) levels is being promoted.

c. The National Weather Service (NWS) radar observer is able to objectively determine storm intensity levels with VIP equipment. These radar echo intensity levels are on a scale of one to six. If the maximum VIP Levels are 1 "weak" and 2 "moderate," then light to moderate turbulence is possible with lightning. VIP Level 3 is "strong" and severe turbulence is possible with lightning. VIP Level 4 is "very strong" and severe turbulence is likely with lightning. VIP Level 5 is "intense" with severe turbulence, lightning, hail likely, and organized surface wind gusts. VIP Level 6 is "extreme" with severe turbulence, lightning, large hail, extensive surface wind gusts, and turbulence.

d. Thunderstorms build and dissipate rapidly. Therefore, do not attempt to plan a course between echoes. The best use of ground radar information is to isolate general areas and coverage of echoes. You must avoid individual storms from inflight observations either by visual sighting or by airborne radar. It is better to avoid the whole thunderstorm area than to detour around individual storms unless they are scattered.

e. Airborne weather avoidance radar is, as its name implies, for avoiding severe weather - not for penetrating it. Whether to fly into an area of radar echoes depends on echo intensity, spacing between the echoes, and the capabilities of you and your aircraft. Remember that weather radar detects only precipitation drops; it does not detect turbulence. Therefore, the radar scope provides no assurance of avoiding turbulence. The radar scope also does not provide assurance of avoiding instrument weather from clouds and fog. Your scope may be clear between intense echoes; this clear area does not necessarily man you can fly between the storms and maintain visual sighting of them.

f. Remember that while hail always gives a radar echo, it may fall several miles from the nearest visible cloud and hazardous turbulence may extend to as much as 20 miles from the echo edge. Avoid intense or extreme level echoes by at least 20 miles; that is, such echoes should be separated by at least 40 miles before you fly between them. With weaker echoes you can reduce the distance by which you avoid them.

5. DO'S AND DON'TS OF THUNDERSTORM FLYING.

a. Above all, remember this: never regard any thunderstorm lightly, even when radar observers report the echoes are of light intensity. **Avoiding thunderstorms is the best policy**. Following are some do's and don'ts of thunderstorm avoidance:

(1**) Don't** land or take off in the face of an approaching thunderstorm. A sudden gust front of low level turbulence could cause loss of control.

(2**) Don't** attempt to fly under a thunderstorm even if you can see through to the other side. Turbulence and windshear under the storm could be disastrous.

(3**) Don't** fly without airborne radar into a cloud mass containing scattered embedded thunderstorms. Scattered thunderstorms not embedded usually can be visually circumnavigated.

(4) **Don't** trust the visual appearance to be a reliable indicator of the turbulence inside a thunderstorm.

(5**) Do** avoid by **at least 20 miles** any thunderstorm identified as severe or giving an intense radar echo. This is especially true under the anvil of a large cumulonimbus.

(6**) Do** circumnavigate the entire area if the area has 6/10 thunderstorm coverage.

(7) **Do** remember that vivid and frequent lightning indicates the probability of a severe thunderstorm.

(8) **Do** regard as extremely hazardous any thunderstorm with tops 35,000 feet or higher whether the top is visually sighted or determined by radar.

b. If you cannot avoid penetrating a thunderstorm, following are some do's **BEFORE** entering the storm:

(1) Tighten your safety belt, put on your shoulder harness if you have one, and secure all loose objects.

(2) Plan and hold your course to take you through the storm in a minimum time.

(3) To avoid the most critical icing, establish a penetration altitude below the freezing level or above the level of -15 °C.

(4) Verify that pitot heat is on and turn on carburetor heat or jet engine anti-ice. Icing can be rapid at any altitude and cause almost instantaneous power failure and/or loss of airspeed indication.

(5) Establish power settings for turbulence penetration airspeed recommended in your aircraft manual.

(6) Turn up cockpit lights to highest intensity to lessen temporary blindness from lightning.

(7) If using automatic pilot, disengage altitude hold mode and speed hold mode. The automatic altitude and speed controls will increase maneuvers of the aircraft thus increasing structural stress.

(8) If using airborne radar, tilt the antenna up and down occasionally. This will permit you to detect other thunderstorm activity at altitudes other than the one being flown.

c. Following are some do's and don'ts DURING the thunderstorm penetration:

(1) Do keep your eyes on your instruments. Looking outside the cockpit can increase danger of temporary blindness from lightning.

(2) Don't change power settings; maintain settings for the recommended turbulence penetration airspeed.

(3) Do maintain constant attitude; let the aircraft "ride the waves." Maneuvers in trying to maintain constant altitude increase stress on the aircraft.

(4) Don't turn back once you are in the thunderstorm. A straight course through the storm most likely will get you out of the hazards most quickly. In addition, turning maneuvers increase stress on the aircraft.