WEATHER THEORY AND PRODUCTS

FULFILLS PA.I.C, CA.I.C, AI.III.C, AII.III.A

Objective	
The student shall understand the theory behind weather phenomena. The student shall become familiar with how to obtain current and future weather information during flight planning and assessing the risk of weather both preflight and inflight.	
Instructor Actions	**Student Actions**
- Explain theory behind weather phenomena - Present tools for obtaining weather information - Walk through Aviation Weather and ForeFlight weather tools - Demonstrate inflight weather sources - Fill in personal minimums sheet with student	- Take notes and participate in instructor's discussion - Practice obtaining weather briefing - Participate in go/no-go decision exercise - Add weather prediction and validation to T-1 day preflight planning - Fill in personal minimums sheet
Case Studies	**Equipment**
- AOPA Air Safety Institute – Time Lapse - AOPA Air Safety Institute – Blind over Bakersfield - Delta Flight 191 Microburst	- AIM - Computer - Personal Minimums Sheet - PHAK - White Board
Completion Standards	
The student shall explain methods for determining weather conditions during preflight planning for a mock cross country. The student shall become familiar with making a go/no-go decision and developing strong aeronautical decision making regarding weather risk.	

ANDREW TRAFICANTE

ELEMENTS

RESOURCES

FAA-S-ACS-6C (Private Pilot ACS) - Area I Task C
FAA-S-ACS-7B (Commercial Pilot ACS) - Area I Task C
FAA-S-ACS-25 (CFI ACS) - Area III Task C
FAA-S-8081-9D (CFII PTS) - Area III Task A

AIM Chapter 7: Safety of Flight

FAA-H-8083-25C PHAK Chapter 12: Weather Theory
FAA-H-8083-25C PHAK Chapter 13: Aviation Weather Services
FAA-H-8083-28 Aviation Weather Handbook

AC 91-74B – Pilot Guide: Flight In Icing Conditions

1800wxbrief
Aviation Weather Center
Convective Outlook Charts - Storm Prediction Center
GOES West
How to Read Surface Weather Maps - NOAA
Icing - Weather.Gov

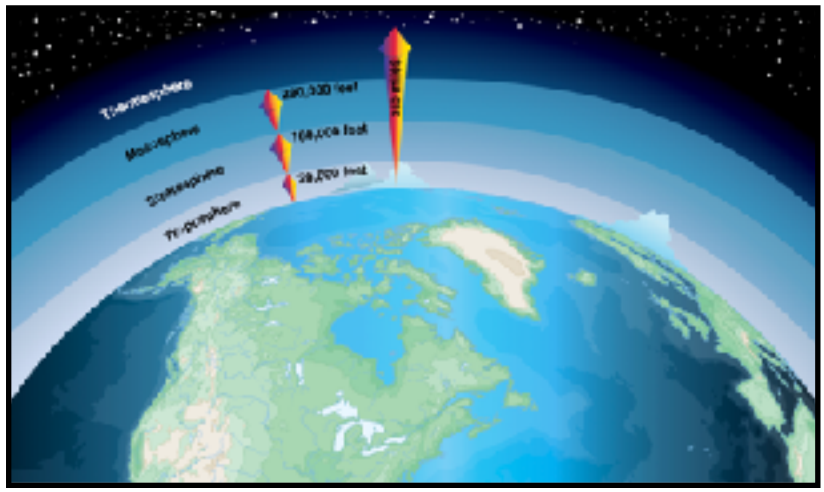
1. ATMOSPHERIC COMPOSITION AND STABILITY

1.1. Composition

The PHAK explains the atmosphere clearly:

> The atmosphere is a blanket of air made up of a mixture of gases that surrounds the Earth and reaches almost 350 miles from the surface of the Earth. This mixture is in constant motion. If the atmosphere were visible, it might look like an ocean with swirls and eddies, rising and falling air, and waves that travel for great distances.

What is air? 78% Nitrogen, 21% Oxygen, and 1% other gases. Water is suspended in the air as a vapor (gas), but often condenses into familiar features such as fog and clouds.



The air is not uniform for the entirety of the atmosphere. Instead, we classify four distinct levels of the atmosphere, dependent on temperature changes, winds, and chemical composition. Not pictured in the figure is the tropopause, a thin layer of air that holds the jetstream. This altitude can be found on this weather chart! However, most weather is contained in the troposphere.

The Earth is continuously bombarded by solar energy, heating the ground significantly. This heating is far from uniform; the equatorial areas receive far more radiation than polar regions (think how the canter of a flashlight is the brightest part, and the sun is a big flashlight), and varying surfaces on the Earth's surface absorb heat differently. This fundamental property of a material is known as its *specific heat capacity.* Water has the highest specific heat capacity, meaning it requires significant amounts of energy to increase its temperature and requires significant time to cool (5-8). Sand, however, requires little energy to increase in temperature, but cools relatively quickly. This uneven heating causes all weather.

Flashlight example

As with any fluid, hotter parcels are more buoyant than cooler ones. As the ground reflects and emits heat, air around the surfaces also heats. Hotter air is less dense than cooler air, and it begins to rise. Additionally, air with more water vapor (more humidity) is less dense than dry air. Thus, warm, moist air is the most prevalent to rising, also known as the least stable. Think about a pot of boiling water.

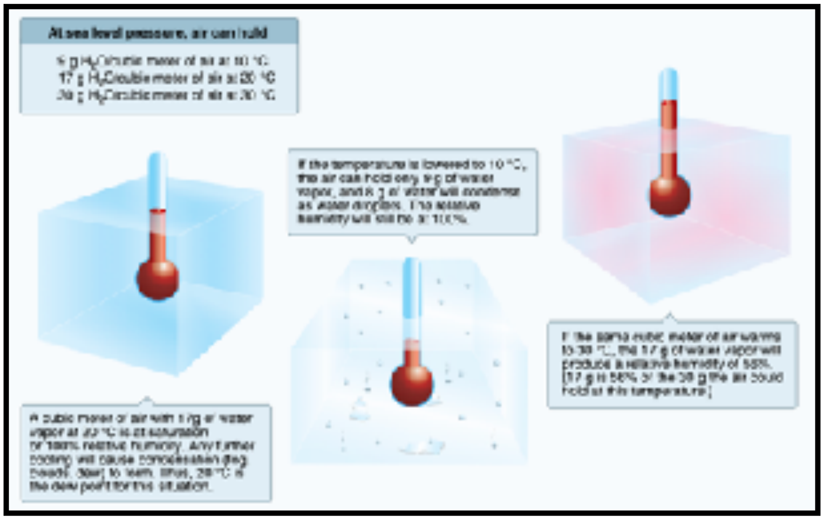
1.2. Atmospheric Stability

Atmospheric Stability is the measure of the atmosphere's resistance to vertical motion. Cool, dry air is the most stable, since it will descend relative to the ambient atmosphere. Consequently, warm, moist air tends to rise the most, attributing to its lesser stability. Air with less lifting action traps smog, smoke, and other particles, resulting in haze. Thus, stable days are correlated with poor visibility, flat clouds, and showery precipitation. Unstable days are correlated with good visibility, puffy clouds, and intermittent precipitation.

If we launched a rocket straight up from, the ambient temperature would decrease with increasing altitude. The rate at which temperature decreases is a measure of atmospheric stability. Dry air cools at 3 °C /1000ft, and moist air cools at 1.1-2.8 °C /1000ft.

1.3. Humidity

At a given temperature, a parcel of air can hold a certain amount of water vapor. More water can be held in a hot parcel of air than a cold parcel. The ratio of suspended water to maximum suspendible water is known as the **relative humidity**. For a given water content, the temperature at which that parcel would have 100% humidity is known as the dew point. The larger the spread between the temperature and dew point, the lower the relative humidity.



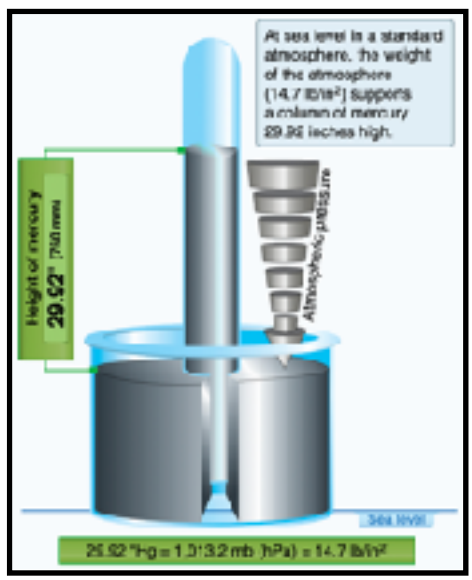
Since the dew point also decreases with altitude (due to the drop in pressure), the rate of convergence for the temperature and dew point as altitude increases is 2 °C or 4.4 °F. If an airport is reporting a temperature of 32 °C with a dew point of 26 °C, the air is expected to become saturated at 3000 feet AGL. Clouds can be expected there. Furthermore, if a station is reporting a temperature AND dew point of the same temperature, there may be fog at the surface.

1.4. Pressure

Similarly to how pressure rises in the ocean at immense depths, air pressure increases as you descend through the atmosphere. While altitude is the largest influence on air pressure, temperature and humidity also are factors.

Pressure is often reported in terms of inches of mercury. Physically, this is referring to the column of mercury that air pressure can push up into a tube. At airports of higher elevation, their station pressure is corrected for sea level to provide a more-useful indication to the pilot.

When performance figures refer to a “standard day”, they refer to a day when the sea level pressure and temperature are 29.92” Hg and 15 °C.



Barometer

1.5. Density

Draw molecular representation of air

Density refers to the weight for a given volume of air. It is of upmost interest to pilots, and density is the main factor in determining aircraft performance. Higher density air allows more molecules for combustion, lift generation, and propeller thrust.

Hotter temperatures decrease density

Heat causes air to “spread out”, as the individual molecules have more energy.

Lower pressures decrease density

Air molecules are not pressed into each other like the would be under high pressure.

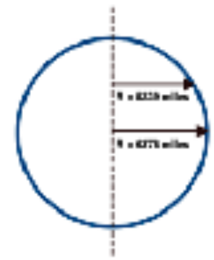
High humidity decreases density

Water vapor is physically lighter than the air molecules it displaces.

2. AIR MASSES AND FRONTS

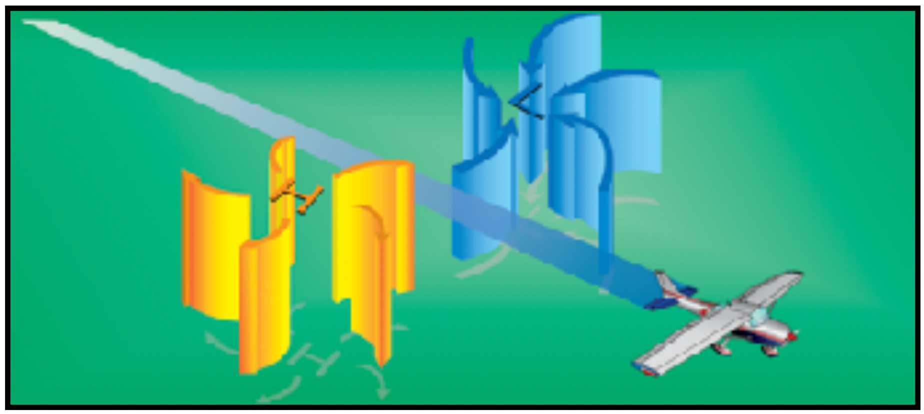
2.1. Coriolis Force

A fundamental principle of rotation objects is that as distance from the axis of rotation increases, tangential velocity increases. This is evident on propellors (varying blade pitch), car wheels (larger wheels need to rotate slower), and even the Earth. Imagine a parcel of air at the equator. If it were to move north (or south), it moves closer to the axis of rotation. However, the air parcel retains its tangential component of velocity. So, as it moves closer to the poles it begins to accelerate ahead, traveling in an arc path. The opposite happens when a parcel moves toward the equator.



2.2. High and Low Pressure Regions

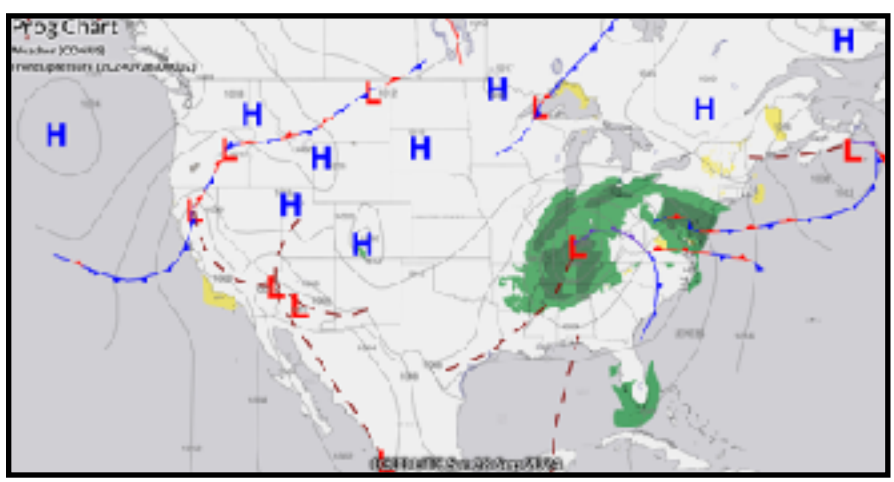
If you understand the Coriolis force, regions of high pressure and low pressure interact with the surrounding air in non-surprising ways. High pressure always travels outward into areas of relatively lower pressure, and the Coriolis force causes air to be deflected to the right relative to its direction of travel. Low pressure systems suck air inward, deflecting it to the left relative to its path. Less intuitively, high pressure systems also force air downwards (due to increased density), and low pressure systems suck air upward. Thus, **low pressure systems decrease the stability of the atmosphere.**



2.3. Air Masses

Large bodies of air often sweep the nation, transferring properties of polar and tropical climates to areas quite distant from their source. These masses are either warmer or colder then the regions they are moving into, and the boundary between the moving mass and the stationary mass is known as a warm or cold front (depending on the temperature of the moving mass). Of most importance, an approaching front guarantees a change in weather.

The location of fronts and air masses can be found on surface analysis and prognosis charts.

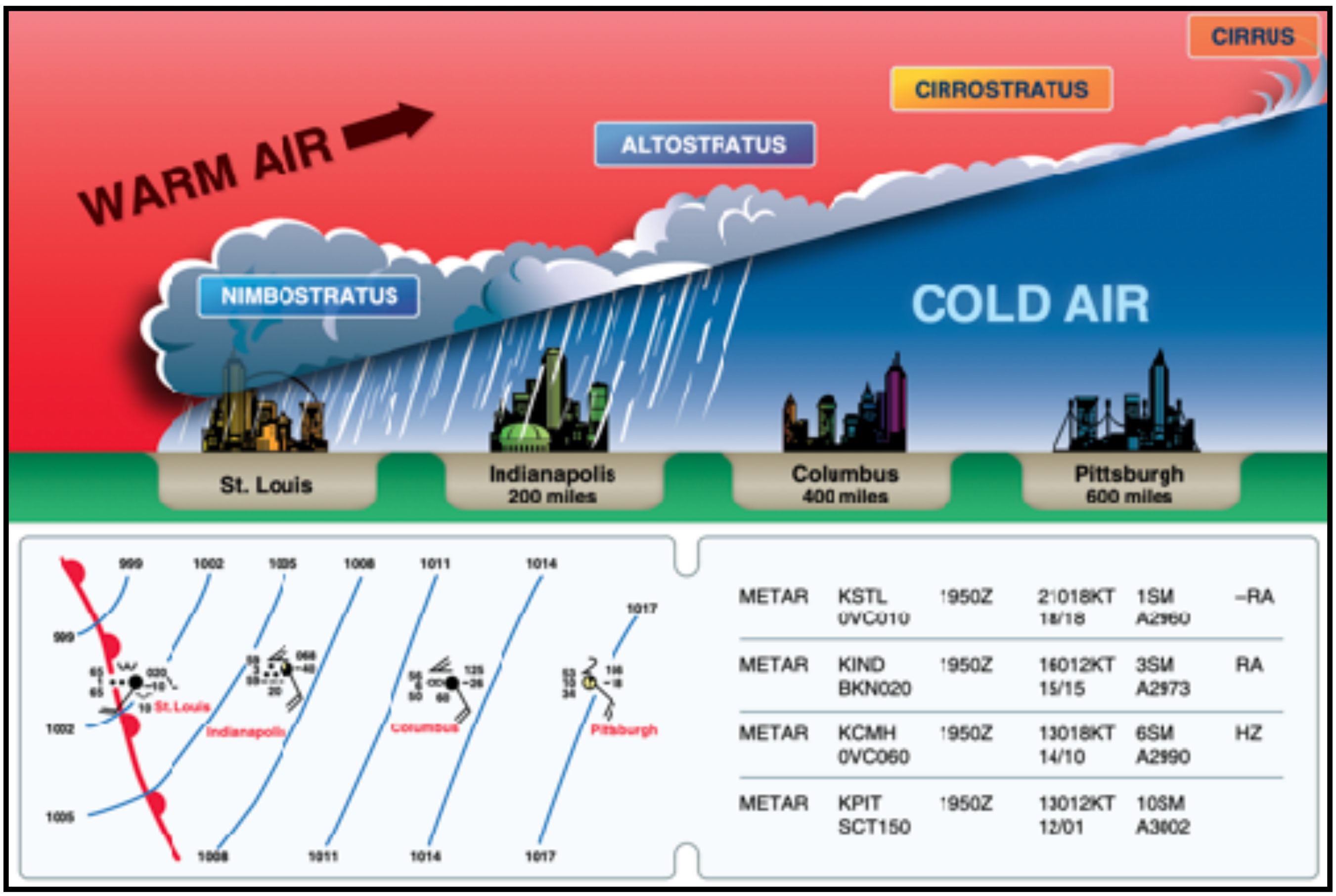


2.3.1. Warm Fronts

> Warm fronts move slowly, typically 10-25 mph. The slope of the advancing front slides over the top of the cooler air and gradually pushes it out of the area. Warm fronts contain warm air that often has very high humidity. As the warm air is lifted, the temperature drops and condensation occurs. – PHAK

Approaching warm fronts are characterized by decreasing barometric pressures and winds blowing from the south. While warm fronts bring poor weather, cold fronts bring convective weather!

Warm fronts are depicted with the following symbol:

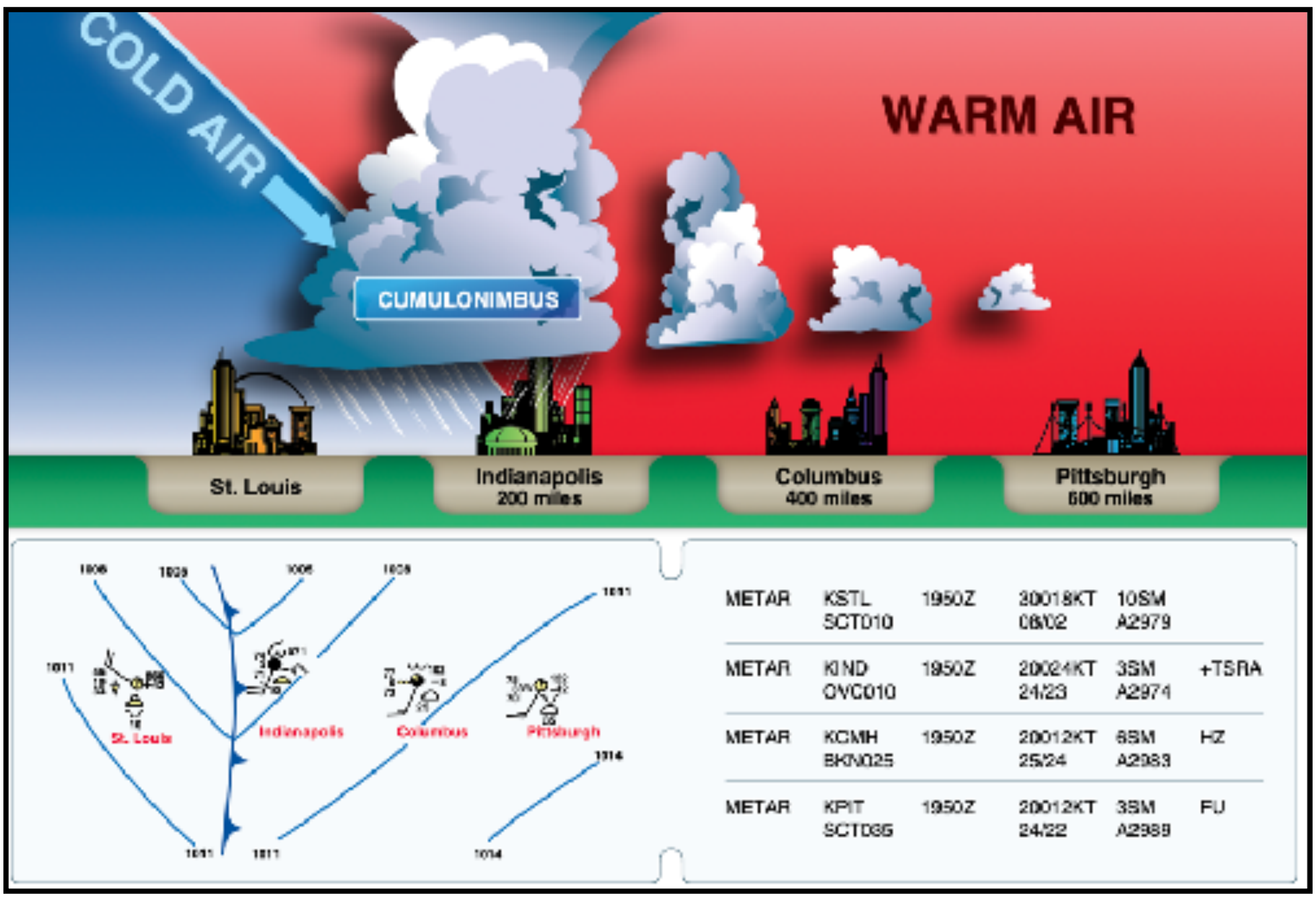


2.3.2. Cold Fronts

> Cold fronts move more rapidly than warm fronts, progressing at a rate of 25 to 30 mph. However, extreme cold fronts have been recorded moving at speeds of up to 60 mph. A typical cold front moves in a manner opposite that of a warm front. It is so dense, it stays close to the ground and acts like a snowplow, sliding under the warmer air and forcing the less dense air aloft. The rapidly ascending air causes the temperature to decrease suddenly, forcing the creation of clouds. The type of clouds that form depends on the stability of the warmer air mass. A cold front in the Northern Hemisphere is normally oriented in a northeast to southwest manner and can be several hundred miles long, encompassing a large area of land. – PHAK

Approaching cold fronts push warm and moist air upward, leading to the formation of towering cumulus clouds. If the cold front is moving quickly, ground friction will cause the slope of the cold front to be near vertical, increasing the lifting action and worsening the already convective intent of the front. Barometric pressures decrease as the front is approaching, but then increases after passage.

Cold fronts leave behind severe clear skies and gusty wind conditions, as the cold air is more dense and higher pressure. Cold fronts are depicted with the following symbol:



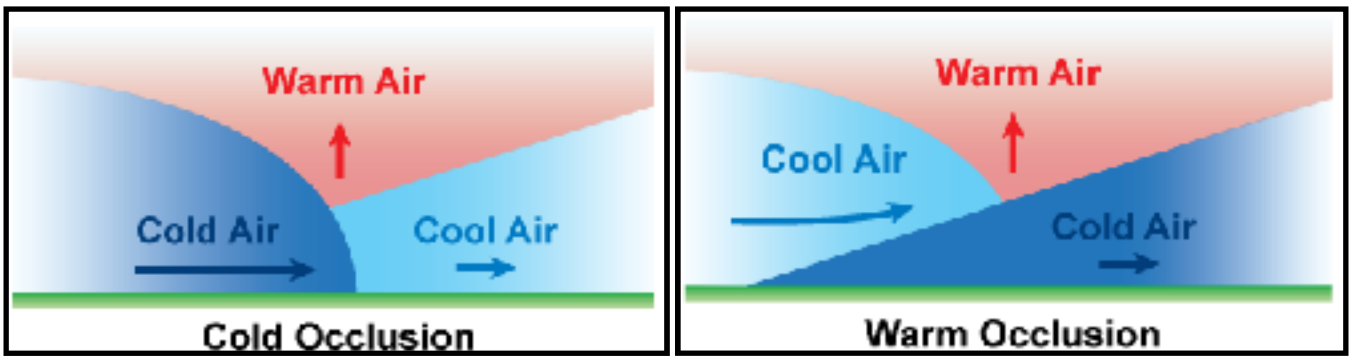
2.3.3. Stationary Fronts

> When the forces of two air masses are relatively equal, the boundary or front that separates them remains stationary and influences the local weather for days. This front is called a stationary front. The weather associated with a stationary front is typically a mixture that can be found in both warm and cold fronts. – PHAK

2.3.4. Occluded Fronts

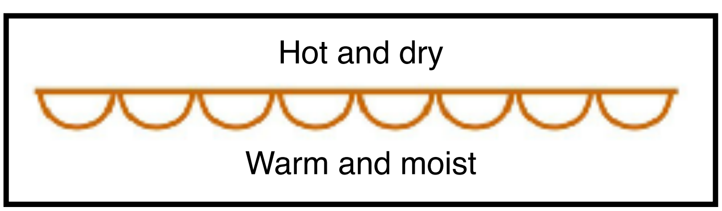
> An occluded front occurs when a fast-moving cold front catches up with a slow-moving warm front. As the occluded front approaches, warm front weather prevails but is immediately followed by cold front weather. – PHAK

The warm occlusion could produce more severe weather.



2.3.5. Dry Lines

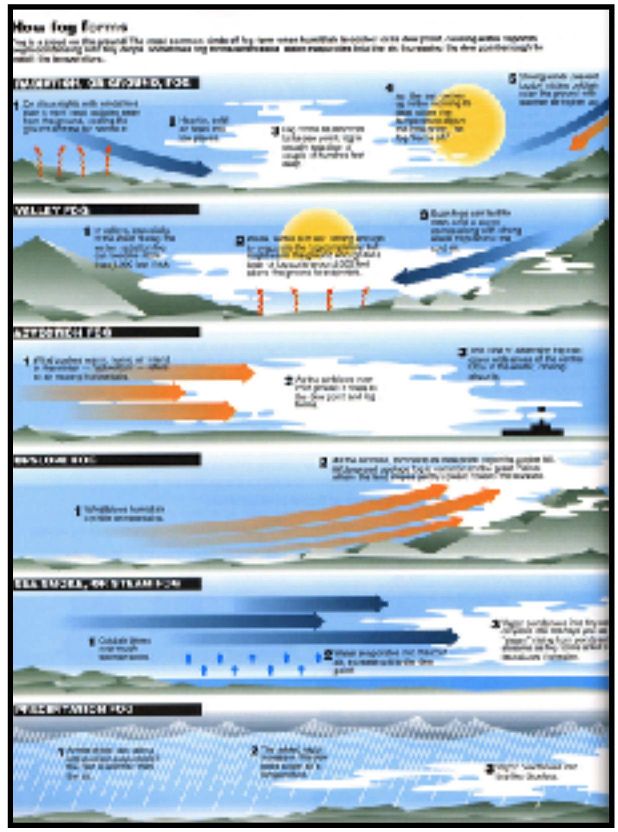
> Dry Lines are the boundary between two air masses of different moisture content and divide warm, moist air from hot, dry air. Moist air is less dense than dry air. Dry lines therefore act similarly to fronts in that the moist, less dense air is lifted up and over the drier, more dense air.
>
> The air temperature behind a dry line is often much higher due to the lack of moisture. That alone will make the air less dense, but the moist air ahead of the dry line has an even lower density, making it more buoyant. The end result is air lifted along the dry line, forming thunderstorms. This is common over the plains in the spring and early summer. – NOAA



3. CLOUDS AND THUNDERSTORMS

3.1. Low Clouds and Dew/Frost

> Fog is a cloud that is on the surface. It typically occurs when the temperature of air near the ground is cooled to the air's dew point. At this point, water vapor in the air condenses and becomes visible in the form of fog. Fog is classified according to the manner in which it forms and is dependent upon the current temperature and the amount of water vapor in the air.

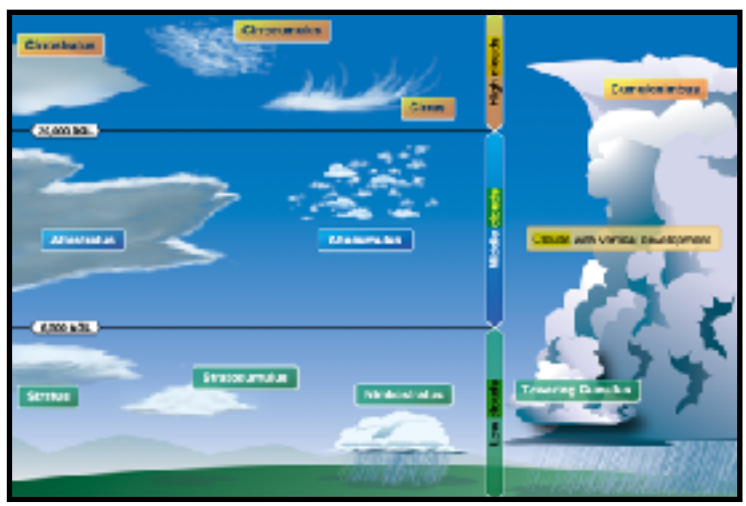


Fog does not typically pose a hazard to aircraft except for limiting visibility. The various types of fog can be found in the PHAK and this graphic.

Dew and frost, however, refer to air condensing on solid surfaces like grass or windows. If the dew point of the air is below freezing, moisture is deposited as frost. If deposited on the wings, it can be just as detrimental as airframe icing.

3.2. Regular Clouds

The clouds are a valuable visual reference for current weather conditions. Their shape, altitude, and even presence serve useful in understanding atmospheric conditions.



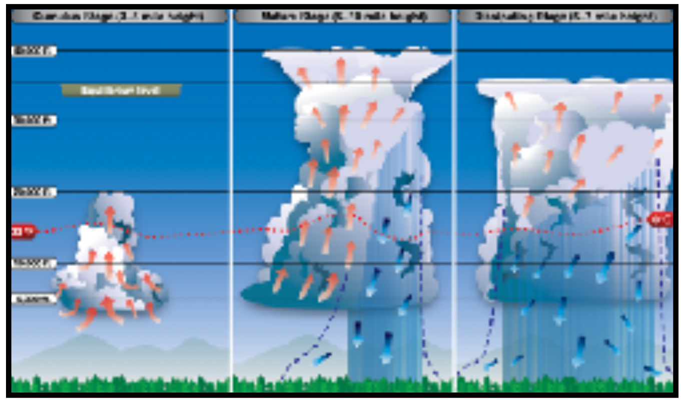
Clouds are classified on the height of their base, with low, medium, high, and clouds and clouds with extensive vertical development (i.e. tall). For clouds to form, there must be adequate moisture (temp and dew point equal) and condensation nuclei (particulates).

Cumulus clouds, the puffy ones often seen in the early afternoons before thunderstorms, indicate lifting action, instability, and moisture. Consequently, these are the three ingredients for a thunderstorm!

Thunderstorms, while simple in definition, pose a significant hazard to pilots even when operating far away. Thunderstorms are differentiated from a simple rain cloud in that they produce lightning, which indicates updrafts and downdrafts strong enough to produce electrostatic charge.

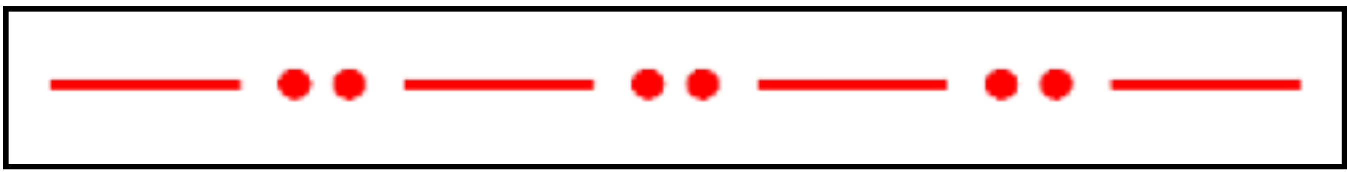
Thunderstorms progress through these stages:

Draw on board



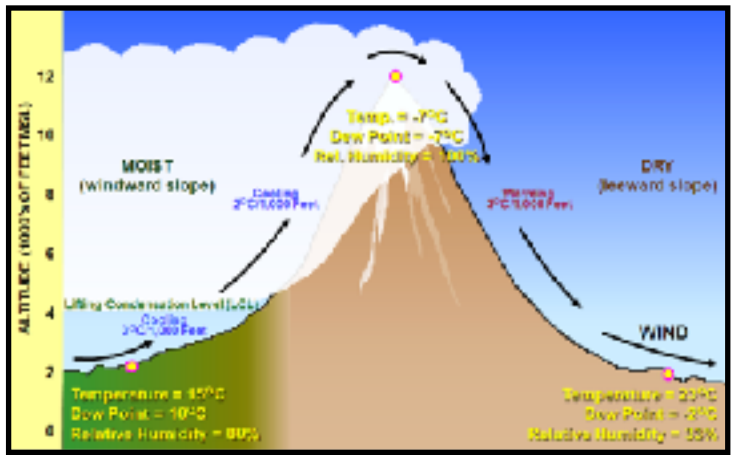
Cumulus Stage – characterized by updrafts and vertical growth (15 mins)
Mature Stage – characterized by the beginning of precipitation
Dissipating Stage – characterized by having predominantly downdrafts

Once thunderstorms reach altitudes in the tropopause, the jetstream may stretch the top of the cumulonimbus cloud and form the characteristic anvil top. Flying within 20 miles of a thunderstorm or beneath either the core or the anvil top is particularly discouraged due to significant hail and turbulence concerns. Squall line thunderstorms are often more severe, especially since they could span several hundred miles. These are depicted on prog and surface analysis charts with the following symbol:



3.3. Orographic Effects

When air moves up a mountain slope, it cools and may form clouds at the top, known as lenticular clouds. These clouds are not necessarily aligned with the peak, but always indicate airflow around the peak. As the air continues on the other side, it rarely descends smoothly. Rather, rotor winds form and can pose a significant hazard to small aircraft.



3.4. Wind Shear and Microbursts

> Wind shear is a sudden, drastic change in wind speed and/or direction over a very small area. Wind shear can subject an aircraft to violent updrafts and downdrafts, as well as abrupt changes to the indicated airspeed of an aircraft. – PHAK
>
> **Size** The microburst downdraft is typically less than 1 mile in diameter as it descends from the cloud base to about 1,000-3,000 feet above the ground. In the transition zone near the ground, the downdraft changes to a horizontal outflow that can extend to approximately 2 $^{1}/_{2}$ miles in diameter.

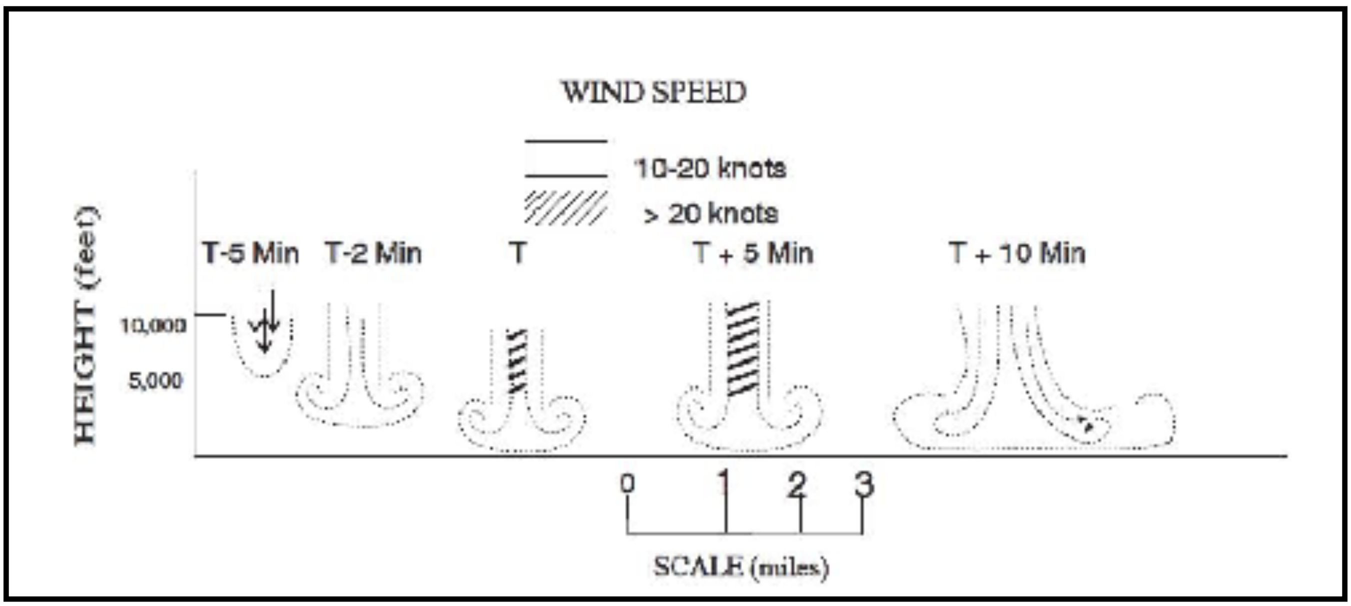
Intensity The downdrafts can be as strong as 6,000 feet per minute. Horizontal winds near the surface can be as strong as 45 knots resulting in a 90 knot shear (headwind to tailwind change for a traversing aircraft) across the microburst. These strong horizontal winds occur within a few hundred feet of the ground.

Visual Signs Microbursts can be found almost anywhere that there is convective activity. They may be embedded in heavy rain associated with a thunderstorm or in light rain in benign appearing virga. When there is little or no precipitation at the surface accompanying the microburst, a ring of blowing dust may be the only visual clue of its existence.

Duration An individual microburst will seldom last longer than 15 minutes from the time it strikes the ground until dissipation. The horizontal winds continue to increase during the first 5 minutes with the maximum intensity winds lasting approximately 2-4 minutes. Sometimes microbursts are concentrated into a line structure, and under these conditions, activity may continue for as long as an hour. Once microburst activity starts, multiple microbursts in the same general area are not uncommon and should be expected.

– From AIM 7-1-24(d)

If a microburst is encountered, pilots should turn 90° left or right and to allow a faster exit from the microbursts most severe downdrafts, providing the shortest escape route. Flying straight through a microburst results in encountering headwinds, downdrafts, and tailwinds, all dangerous in sequence. For more information, read Section 22.7.3 in the Aviation Weather Handbook.



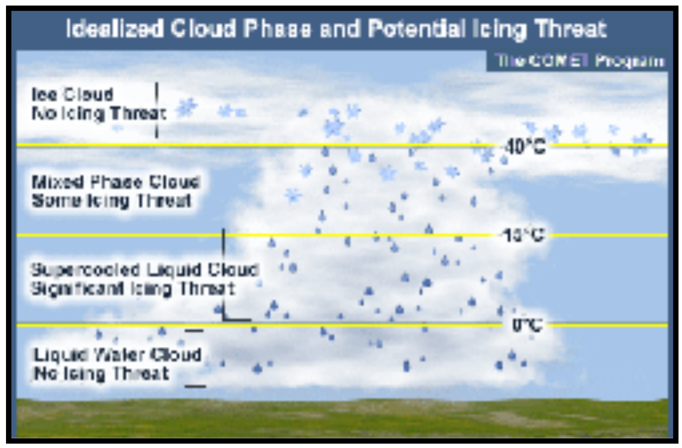
4. ICING

> Icing is a cumulative hazard. The longer an aircraft collects icing, the worse the hazard becomes.
> - Aviation Weather Handbook

Although the ambient temperature may be below freezing, water droplets suspended in clouds or fog may remain in the liquid state due to surface tension effects. These water droplets are referred to as "supercooled" since their temperature is below freezing but they remain as a liquid.

Many small airplanes are not certified into "flight into known icing." "'Known icing conditions' involve instead circumstances where a reasonable pilot would expect a substantial likelihood of ice formation on the aircraft based upon all information available to that pilot." (See Bell-AOPA Legal Interpretation)

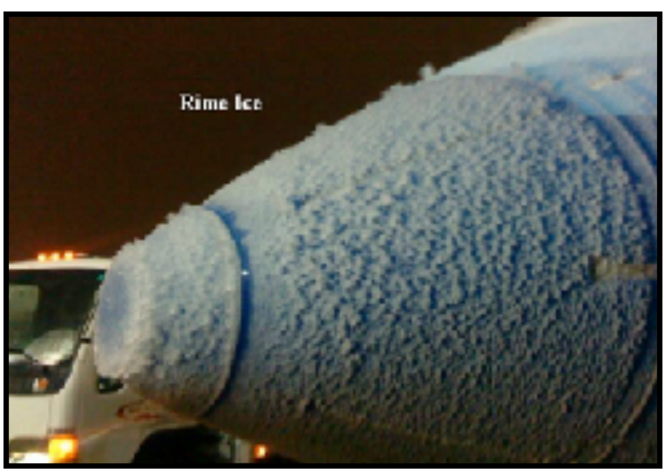
> Supercooled water content of clouds varies with temperature. Between 0 and -10 °C, clouds consist mainly of supercooled water droplets. Between -10 and -20 °C, liquid droplets coexist with ice crystals. Below -20 °C, clouds are generally composed entirely of ice crystals. However, strong vertical currents (e.g., cumulonimbus) may carry supercooled water to great heights where temperatures are as low as -40 °C. Supercooled water will readily freeze if sufficiently agitated. This explains why airplanes collect ice when they pass through a liquid cloud or precipitation composed of supercooled droplets.
>
> - Aviation Weather Handbook 20.2.

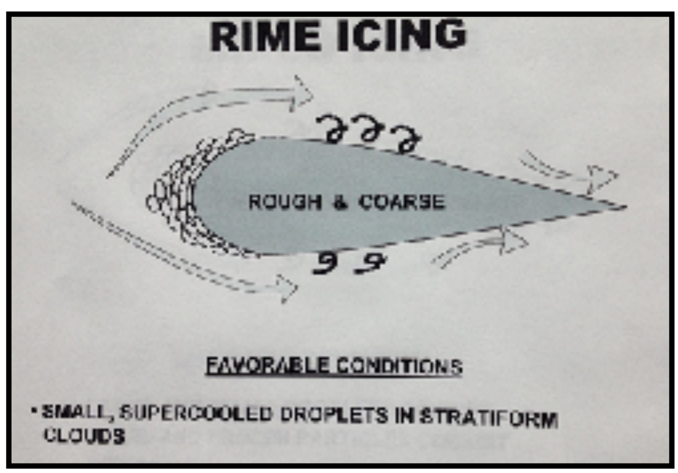


4.1. Structural Icing

4.1.1. Rime Ice (Most Common)

> Rime ice is rough, milky, and opaque ice formed by the instantaneous freezing of small, supercooled water droplets after they strike the aircraft. **It is the most frequently reported icing type.** Rime ice can pose a hazard because its jagged texture can disrupt an aircraft's aerodynamic integrity.
>
> Rime icing formation favors colder temperatures, lower liquid water content, and small droplets. It grows when droplets rapidly freeze upon striking an aircraft. The rapid freezing traps air and forms a porous, brittle, opaque, and milky-colored ice. Rime ice grows into the air stream from the forward edges of wings and other exposed parts of the airframe. - Aviation Weather Handbook 20.3.1





4.1.2. Clear Ice (Most Dangerous)

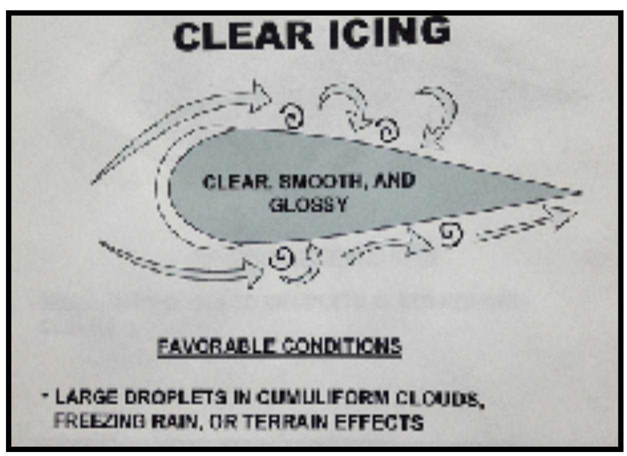
Clear ice (or glaze ice) is a glossy, clear, or translucent ice formed by the relatively slow freezing of large, supercooled water droplets. Clear icing conditions exist more often in an environment with warmer temperatures, higher liquid water contents, and larger droplets.

Clear ice forms when only a small portion of the drop freezes immediately while the remaining unfrozen portion flows or smears over the aircraft surface and gradually freezes. Few air bubbles are trapped during this gradual process. Thus, clear ice is less opaque and denser than rime ice. It can appear either as a thin smooth surface or as rivulets, streaks, or bumps on the aircraft.

Clear icing is a more hazardous ice type for many reasons. It tends to form horns near the top and bottom of the airfoils' leading edge, which greatly affects airflow. This results in an area of disrupted and turbulent airflow that is considerably larger than that caused by rime ice. Since it is clear and difficult to see, the pilot may not be able to quickly recognize that it is occurring. It can be difficult to remove since it can spread beyond the deicing or anti-icing equipment, although in most cases, it is removed nearly completely by deicing devices.

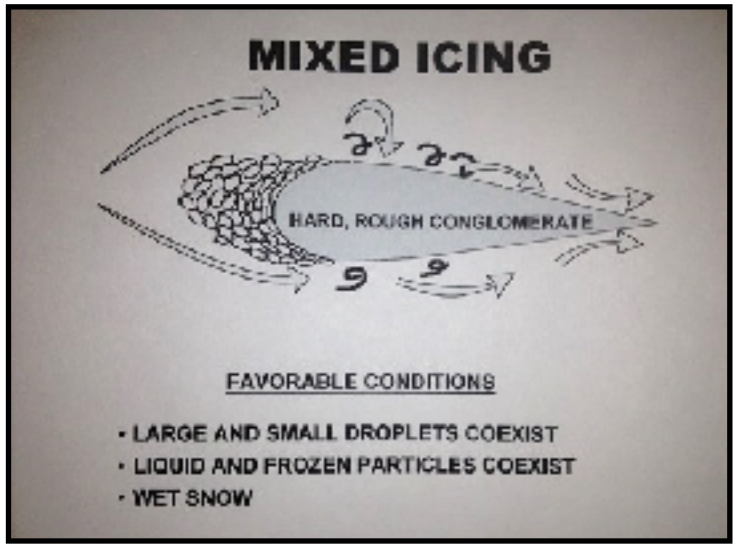
A type of clear icing that is especially dangerous to flight operations is ice formed from SLDs. These are water droplets in a subfreezing environment with diameters larger than 40 microns, such as freezing drizzle (40 to 200 microns) and freezing rain (>200 microns). These larger droplets can flow along the airfoil for some distance prior to freezing. SLDs tend to form a very lumpy, uneven, and textured ice similar to glass in a bathroom window.

SLD ice tends to form aft, beyond the reach of deicing equipment. Thus, ice remaining on the airfoil continues to disrupt the airflow and reduce the aircraft's aerodynamic integrity. Even a small amount of ice on the lower and upper surfaces of the airfoil can seriously disrupt its aerodynamic properties. The residual ice generates turbulence along a significant portion of the airfoil. This residual ice can act as a spoiler, a device actually used to slow an aircraft in flight. In extreme cases, turbulence and flow separation bubbles can travel along the airfoil and inadvertently activate the ailerons, creating dangerously unstable flying conditions. - Aviation Weather Handbook 20.3.2



4.1.3. Mixed Ice

> Mixed ice is a mixture of clear ice and rime ice. It forms as an airplane collects both rime and clear ice due to small-scale (tens of kilometers or less) variations in liquid water content, temperature, and droplet sizes. Mixed ice appears as layers of relatively clear and opaque ice when examined from the side. Mixed icing poses a similar hazard to an aircraft as clear ice. It may form horns or other shapes that disrupt airflow and cause handling and performance problems. It can spread over more of the airframe's surface and is more difficult to remove than rime ice. It can also spread over a portion of airfoil not protected by anti-icing or deicing equipment. Ice forming farther aft causes flow separation and turbulence over a large area of the airfoil, which decreases the ability of the airfoil to keep the aircraft in flight. - Aviation Weather Handbook 20.3.3



4.2. Structural Icing Factors

Icing is very temperature dependent. If the OAT is too cold (less than -20°C), suspended water droplets have frozen into ice crystals. However, the upper limit is not necessarily 0°C. Aircraft that have cold-soaked at an icing-conducive temperature that descent or fly into lower temperatures may remain accepting to icing, especially areas of the skin surrounding fuel tanks.

4.2.1. Stratiform clouds

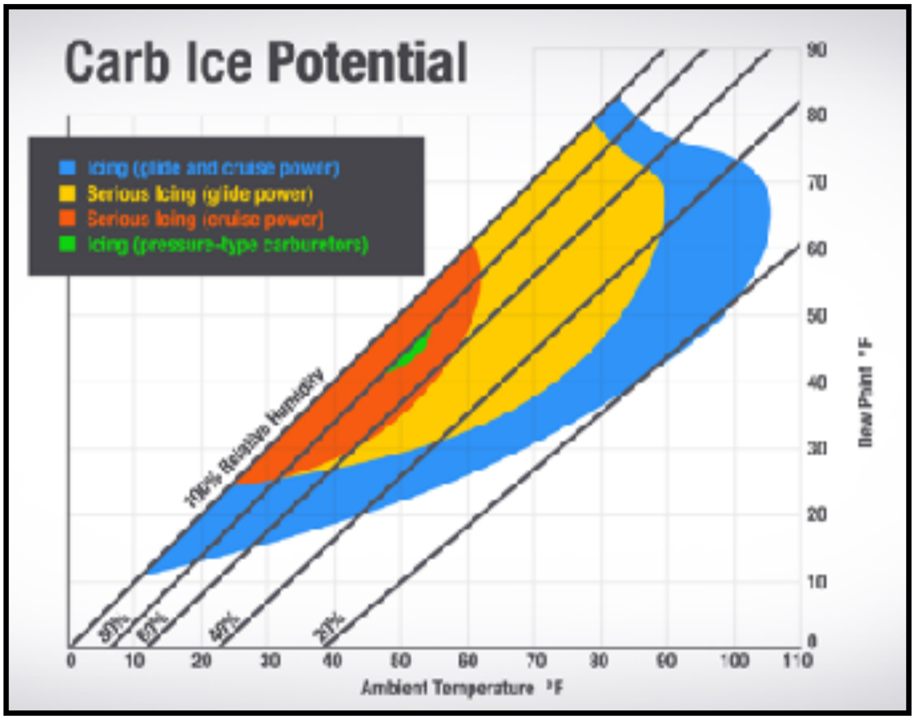
> Icing in middle and low-level stratiform clouds is confined, on the average, to a layer between 3,000 and 4,000 ft thick. Thus, a change in altitude of only a few thousand feet may take the aircraft out of icing conditions, even if it remains in clouds. The main hazard lies in the great horizontal extent of stratiform clouds layers. - Aviation Weather Handbook 20.3.5

4.2.2. Cumulus Clouds

> The icing layer in cumuliform clouds is smaller horizontally, but greater vertically than in stratiform clouds. Icing in a cumuliform cloud is usually clear or mixed with rime in the upper levels. - Aviation Weather Handbook 20.3.6

4.3. Induction Icing

The carburetor process that results in fuel vaporization may lower the air temperature in the Venturi by 100°F or 38°C. Carburetor icing may be characterized by a loss of RPM (fixed pitch props) or loss of manifold pressure (constant speed props). If carb ice is indicated, pilots should apply **full** carb heat, not an intermediate setting. The application of carb heat may liquify any water in the carburetor, causing the engine to run rougher. Do not turn off carb heat! Wait for the engine to operate smoothly.



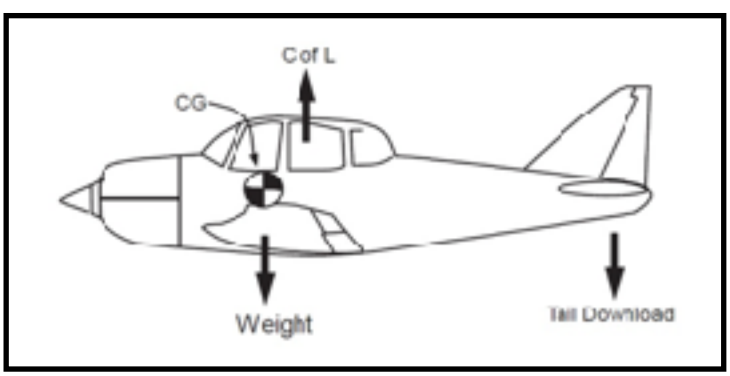
4.4. Pitot Static Icing

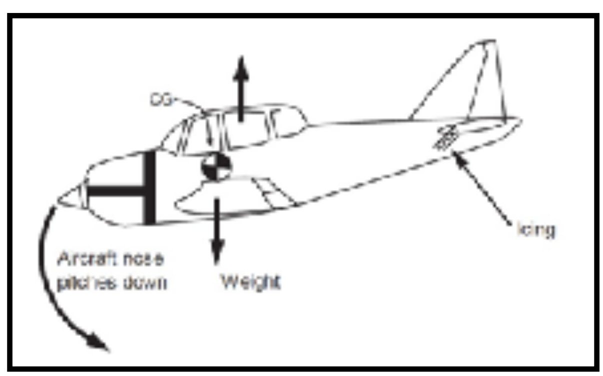
See lesson plan II.A, Aircraft Systems.

4.5. Tailplane Icing

Ice may accumulate on the horizontal stabilizer, decreasing its effectiveness in providing an aerodynamic downforce. More forward elevator may be needed. Eventually, the plot may run out of elevator travel resulting in an nose-up pitching moment. If operating on an autopilot, the pilot may not even notice until the autopilot disconnects.

Deploying flaps also increases the AOA of the tail. If operating with tailplane icing, consider not deploying the flaps. More information in AC 91-74B.





4.6. Systems to Combat Icing

i. Pitot heat
ii. Alternate static
iii. Defroster

5. OBSTRUCTIONS TO VISIBILITY

5.1. Smoke, Haze, Volcanic Ash

Air in the Antelope Valley is always moving. As a result, we can expect clear skies as all the particles are carried away. However, this is the result of high winds and unstable atmosphere.

In the LA basin, the opposite is often true. Smog, smoke, and other particles linger, creating decreased visibility. Combined with the infamous “marine layer”, a low cloud ceiling that moves in from the overnight temperature inversion, the LA basin is often MVFR or even IFR.

At first, our flights will occur during 10+ mile visibility days. However, the instructor will demonstrate what decreased visibility looks like. We should consider visibility during cross country planning, as it may be beneficial to decrease the visual waypoint spacing to avoid getting off course when lower visibility (10-20 miles) are expected.

6. WEATHER SERVICES

Observations, analyses, and forecasts

Wifi icon indicates available over FIS-B

Accessing weather information is just as important as understanding it. Hundreds of weather products exist to assist in determining past, present, and future weather conditions. We will split this discussion into current and forecast weather products. All weather products discussed are available in-air via FIS-B.

6.1. Past and Present Conditions

METARs – Weather reports issued by airports automatically (AWOS/ASOS, every 20 mins) or with human intervention (ATIS, every hour). Three types of METARs: routine, SPECI (when conditions change significantly within the hour), and COR (when a correction is needed).

METARs are valid for the area within 5 nm of the station.

VC refers to conditions between 5-10 nm from the station. DSNT refers to conditions greater than 10 nm away.

ATIS may omit ceiling and visibility if weather is better than 5000 and 5 (**per this**)

KBCT 220153Z 14012KT 10SM SCT017 29/26 A3008 RMK LTG DSNT S AND SW.

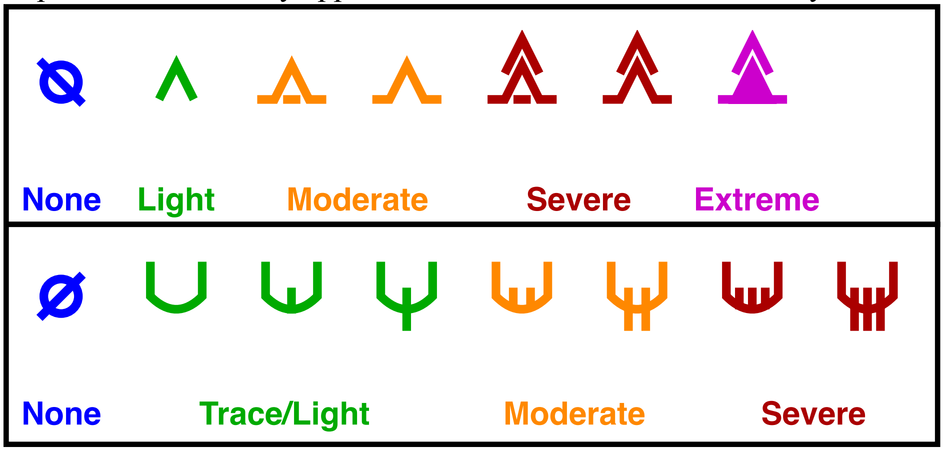
Qualifier		Weather Phenomena		
Intensity or Proximity 1	Descriptor 2	Precipitation 3	Obscuration 4	Other 5
– Light	MI Shallow	DZ Drizzle	BR Mist	PO Dust/sand whirls
Moderate (no qualifier)	BC Patches	RA Rain	FG Fog	SQ Squalls
+ Heavy	DR Low drifting	SN Snow	FU Smoke	FC Funnel cloud
VC In the vicinity	BL Blowing	SG Snow grains	DU Dust	+FC Tornado or waterspout
	SH Showers	IC Ice crystals (diamond dust)	SA Sand	SS Sandstorm
	TS Thunderstorms	PL Ice pellets	HZ Haze	DS Dust storm
	FZ Freezing	GR Hail	PY Spray	
	PR Partial	GS Small hail or snow pellets	VA Volcanic ash	
		UP Unknown precipitation		

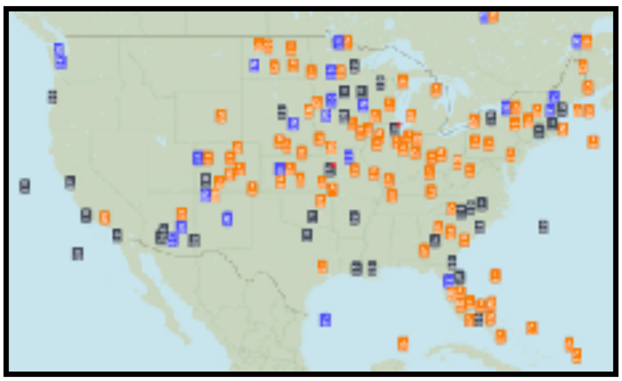
Sky Cover	Contraction
Less than ⅛ (Clear)	SKC, CLR, FEW
⅛–²⁄₈ (Few)	FEW
⅜–⁴⁄₈ (Scattered)	SCT
⅝–⅞ (Broken)	BKN
⁸⁄₈ or (Overcast)	OVC

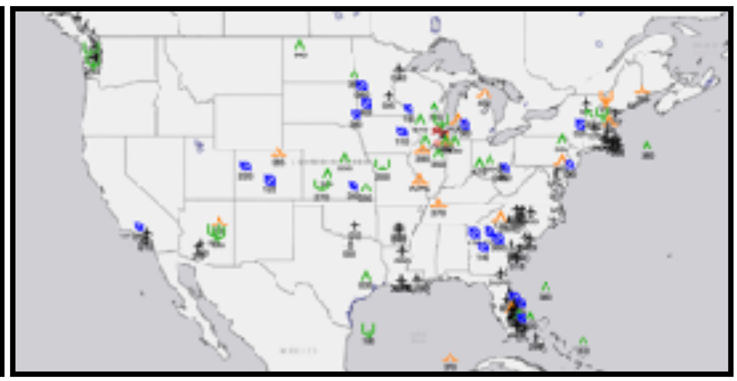
PIREPs (PIlot REPorts) – real time conditions reported by pilots including cloud heights, turbulence, icing, wind shear, and other pertinent information.

UA /OV OPF/TM 0153/FL010/TP C650/RM SMOOTH

PIREPs can be obtained from sources like ForeFlight (left) and the Aviation Weather Center (right). It is important to select any applicable PIREPs and read the advisory!







Encoding Pilot Weather Reports (PIREPS)			
1	XXX	3-letter station identifier	Nearest weather reporting location to the reported phenomenon
2	UA	Routine PIREP, UUA-Urgent PIREP.	
3	/OV	Location	Use 3-letter NAVAID idents only. a. Fix: /OV ABC, /OV ABC 090025. b. Fix: /OV ABC 045020-DEF, /OV ABC-DEF-GHI
4	/TM	Time	4 digits in UTC: /TM 0915.
5	/FL	Altitude/flight level	3 digits for hundreds of feet. If not known, use UNKN: /FL095, /FL310, /FLUNKN.
6	/TP	Type aircraft	4 digits maximum. If not known, use UNKN: /TP L329, /TP B727, /TP UNKN.
7	/SK	Sky cover/cloud layers	Describe as follows: a. Height of cloud base in hundreds of feet. If unknown, use UNKN. b. Cloud cover symbol. c. Height of cloud tops in hundreds of feet.
8	/WX	Weather	Flight visibility reported first: Use standard weather symbols: /WX FV02SM RA HZ, /WX FV01SM TSRA.
9	/TA	Air temperature in celsius (C)	If below zero, prefix with a hyphen: /TA 15, /TA M06.
10	/WV	Wind	Direction in degrees magnetic north and speed in six digits: /WV270045KT, WV 280110KT.
11	/TB	Turbulence	Use standard contractions for intensity and type (use CAT or CHOP when appropriate). Include altitude only if different from /FL, /TB EXTRM, /TB LGT-MOD BLO 090.
12	/IC	Icing	Describe using standard intensity and type contractions. Include altitude only if different than /FL: /IC LGT-MOD RIME, /IC SEV CLR 028-045.
13	/RM	Remarks	Use free form to clarify the report and type hazardous elements first: /RM LLWS -15KT SFC-030 DURC RY22 JFK.

AIRMETs (AIRmen METeorological information) – issued for phenomena of interest to all aircraft, but primarily concerned with light aircraft.

Issue Frequency: 6 hours

Types: Sierra AIRMETs, Tango AIRMETs, Zulu AIRMETs

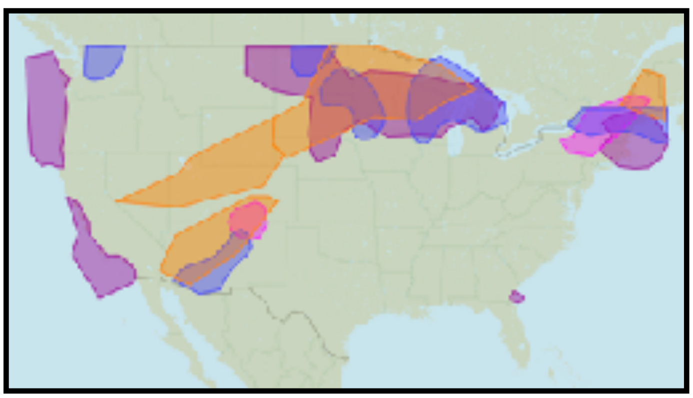
Each AIRMET type contains two pieces of information:

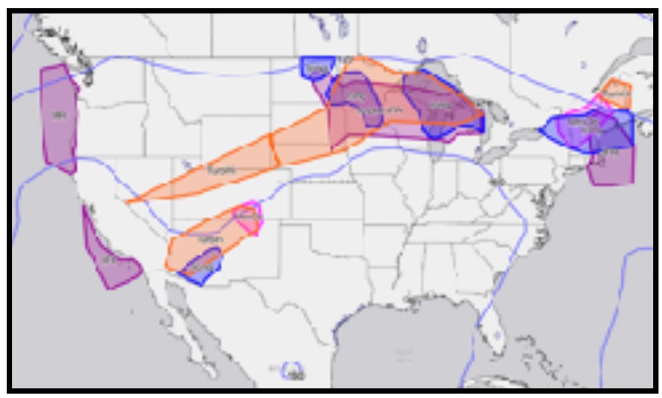
Sierra (IFR)
Ceilings less than 1000 feet and/or visibility less than 3 miles affecting over 50% of the area at one time
Extensive mountain obscuration

Tango (Turbulence)
Moderate turbulence
Sustained surface winds of 30 knots or more at the surface

Zulu (Icing)
Moderate icing
Freezing levels

AIRMETs can be obtained from sources like ForeFlight (left) and the Aviation Weather Center (right). It is important to select any applicable AIRMETs and read the advisory!





SIGMETs (SIGnificant METeorological information)[1] – issued for non-convective weather that is potentially hazardous to all aircraft.

Issue Frequency: Unscheduled; issues as needed, valid for **4 hours** (except if relating to hurricane, then 6 hours)

Issued For:

i. Severe or greater turbulence (SEV TURB).
ii. Severe icing (SEV ICE).
iii. Widespread dust storm (WDSPR DS).
iv. Widespread sandstorm (WDSPR SS).
v. Volcanic ash (VA).

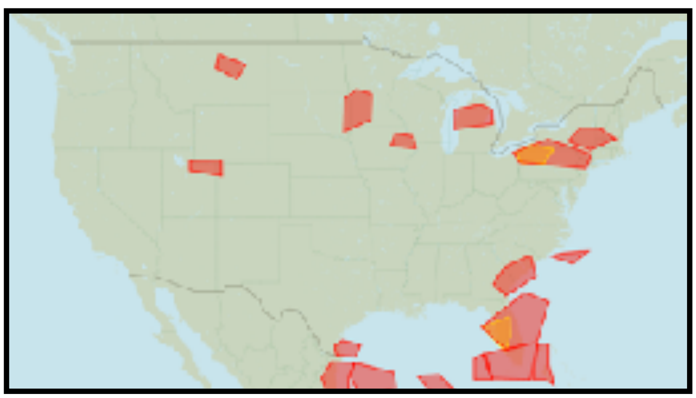
Convective SIGMETs – issued for hazardous convective weather that affects the safety of every flight.

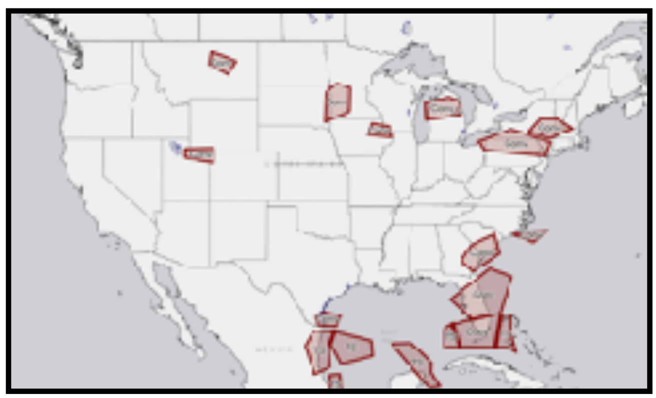
Issue Frequency: typically 55 past the hour or as needed, valid for 2 hours

Issued For:

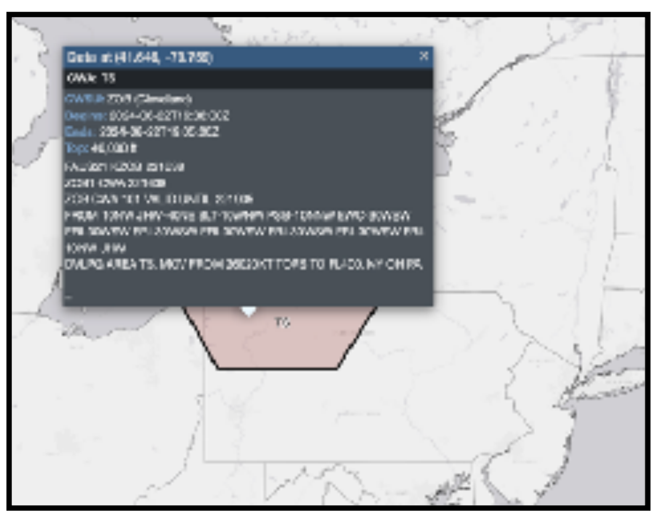
i. Severe thunderstorm due to:
   a. Surface winds greater than or equal to 50 knots.
   b. Hail at the surface greater than or equal to $^3/_4$ inches in diameter.
   c. Tornadoes.
ii. Embedded thunderstorms.
iii. A line of thunderstorms.
iv. Thunderstorms producing precipitation greater than or equal to heavy precipitation affecting 40 percent or more of an area at least 3,000 square miles.

SIGMETs and convective SIGMETs can be found from sources like ForeFlight (left) and the Aviation Weather Center (right). It is important to select any applicable SIGMETs and read the advisory!





CWAs (Center Weather Advisory) – Issued by local air traffic control centers for hazardous weather when there is no existing in-flight advisory from the AWC, regarding any pertinent weather (often overlapping with the definitions of AIRMETs, SIGMETs, etc).[2]



[1] Aviation Weather Handbook pg. 26-5

[2] Aviation Weather Handbook pg. 26-21

PA.I.C, CA.I.C, AI.III.C, AII.III.A

Winds Aloft –

Sometimes, winds aloft data is delivered in its legacy format, as seen below from the Aviation Weather Center.

```
DATA BASED ON 101800Z
VALID 110000Z   FOR USE 2000-0300Z. TEMPS NEG ABV 24000
```

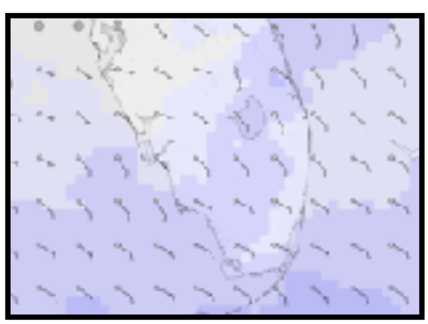
FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
BIH		9900	2010+08	2314+02	2421-13	2422-27	242144	252154	272557
BLH	9900	1205+13	1006+08	9900+02	2306-13	2415-25	245141	730046	731354
FAT	9900	1911+11	1916+06	2119+01	2323-14	2419-27	261443	261253	291757
WJF		2307+13	1907+07	1905+02	2109-14	2012-27	232243	232552	234655

The first two digits refer to the **true** direction of the winds, without a "0". The next two digits refer to the speed. So, 1318 refers to winds FROM 130° true at 18 knots. The final two digits are the temperature.

Rules, according to PHAK:

- The temperature is given in degrees Celsius
- No winds are forecast when a given level is within 1,500 feet of the station elevation
- Temperatures are not forecast for any station within 2,500 feet of the station elevation
- If the wind speed is forecast to be greater than 99 knots but less than 199 knots, the computer adds 50 to the direction and subtracts 100 from the speed. To decode this type of data group, the reverse must be accomplished. For example, when the data appears as "731960," subtract 50 from the 73 and add 100 to the 19, and the wind would be 230° at 119 knots with a temperature of –60 °C
- If the wind speed is forecast to be 200 knots or greater, the wind group is coded as 99 knots. For example, when the data appears as "7799," subtract 50 from 77 and add 100 to 99, and the wind is 270° at 199 knots or greater
- When the forecast wind speed is calm, or less than 5 knots, the data group is coded "9900," which means light and variable
- Temperatures are assumed negative above FL240.

More modern solutions exist, like graphical winds aloft and winds aloft data not restricted to select airports.



Weather Briefings – AIM 7-1-5

In addition to ForeFlights acceptable weather briefing, a pilot can request a weather briefing over the phone at 1800wxbrief or at 1800wxbrief.com. Phone briefing options include the **standard briefing**, **abbreviated briefing** (to supplement a standard briefing when departure is delayed less than 6 hours), and an **outlook briefing** for a departure more than 6 hours away. The items contained in a standard briefing are:

- Adverse conditions
- VFR flight not recommended
- Synopsis
- Current conditions
- En route forecast
- Destination forecast
- Forecast winds and temps aloft
- NOTAMs
- ATC delays
- Other information

For more information, consult the PHAK page 13-5.

Weather Radar –

While many website offer radar viewing, FIS-B broadcasts the NEXRAD radar product to pilots. It is important to be aware of the delay: that is, the radar shows where the weather was, not necessarily where it is. Several accidents have occurred due to pilots misinterpreting the radar around fast moving storms.

Case Study 1

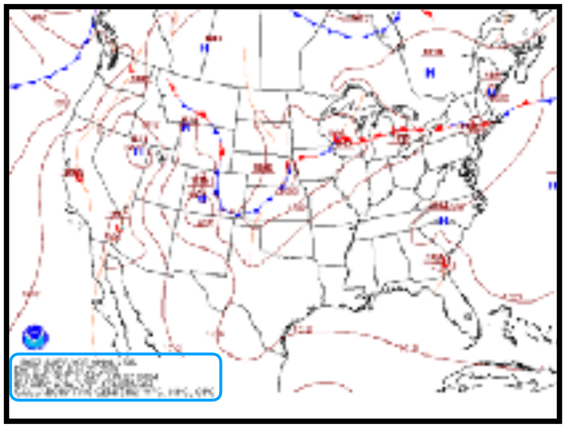
Resource 1

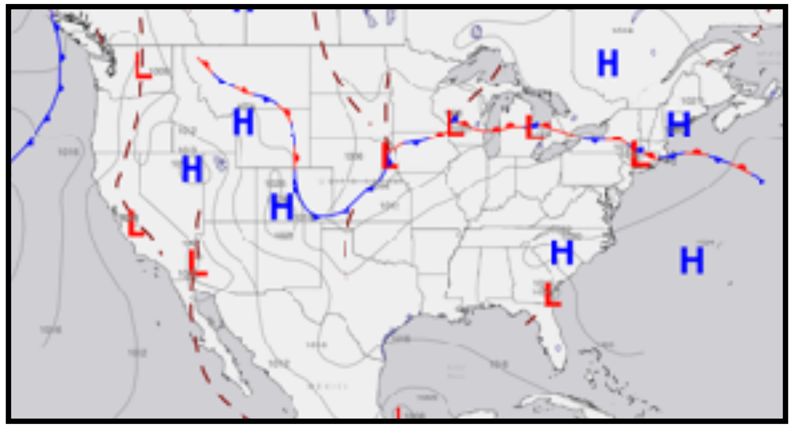
FAA Weather Cameras

Weather cameras

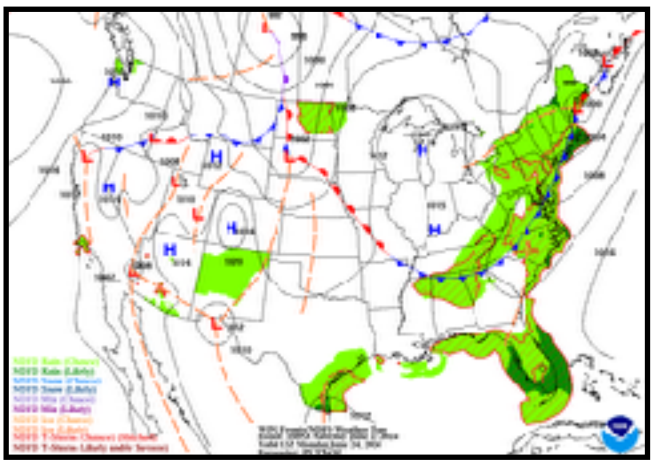
Weather Charts – Old static weather charts have been phased out in favor of the Aviation Weather Center's new dynamic observations tool. Here, fronts, AIRMETs, SIGMETs, PIREPs, METARs, and other hazardous weather can all be viewed on an interactive map.

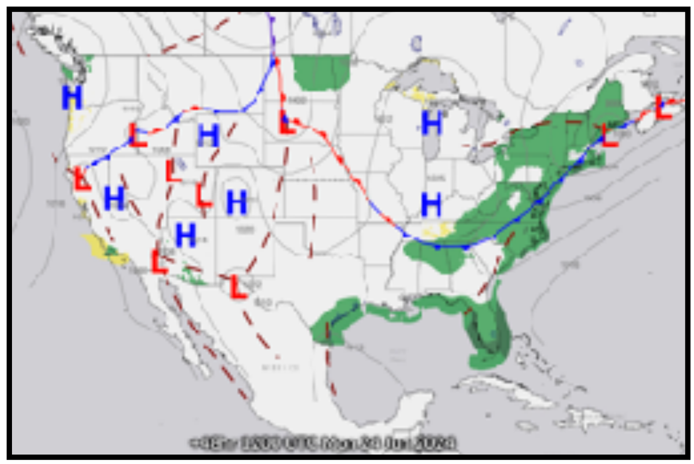
The legacy surface analysis chart can be found on Aviation Weather's decision support imagery and ForeFlight's imagery section.A surface analysis chart is a snapshot of fronts and air masses at the stated time, as seen below.



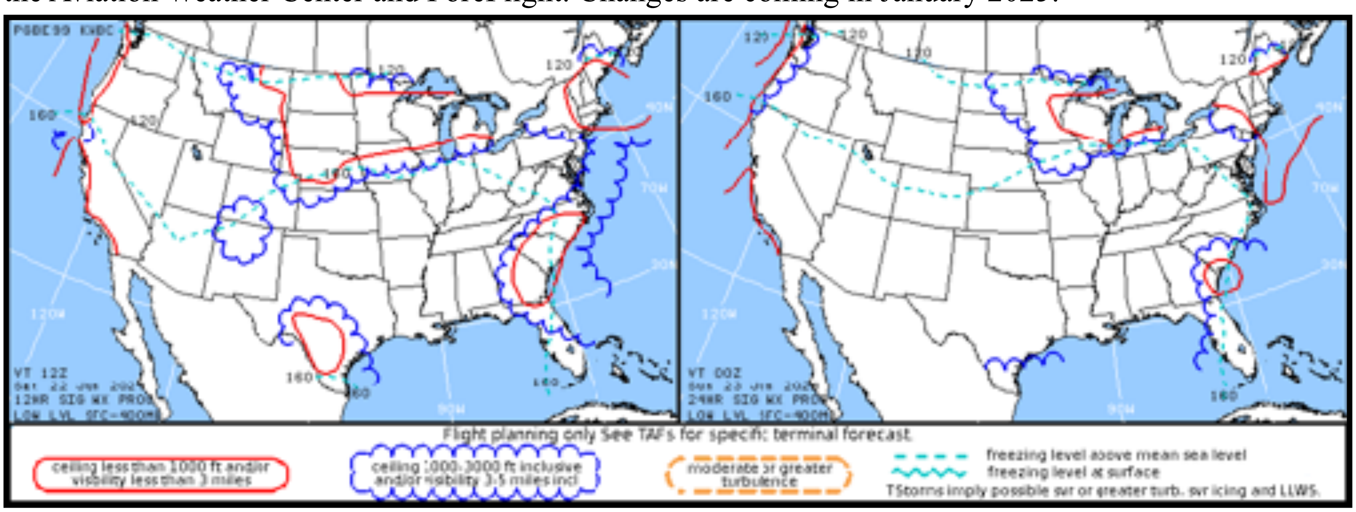


Prog charts, however, portray this information as a forecast, valid at a particular time in the future.

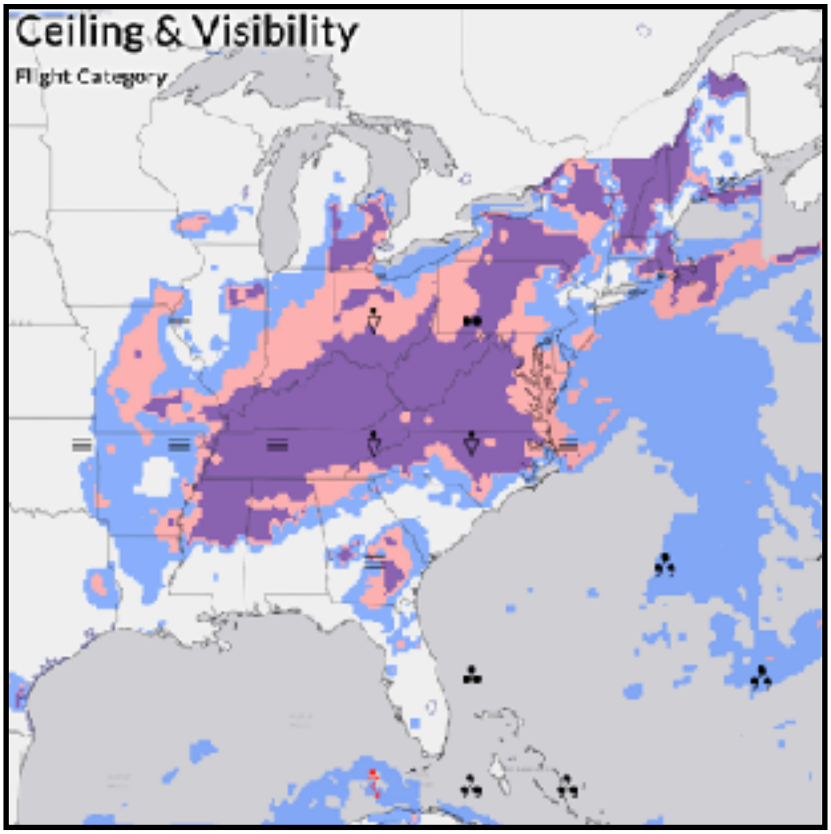




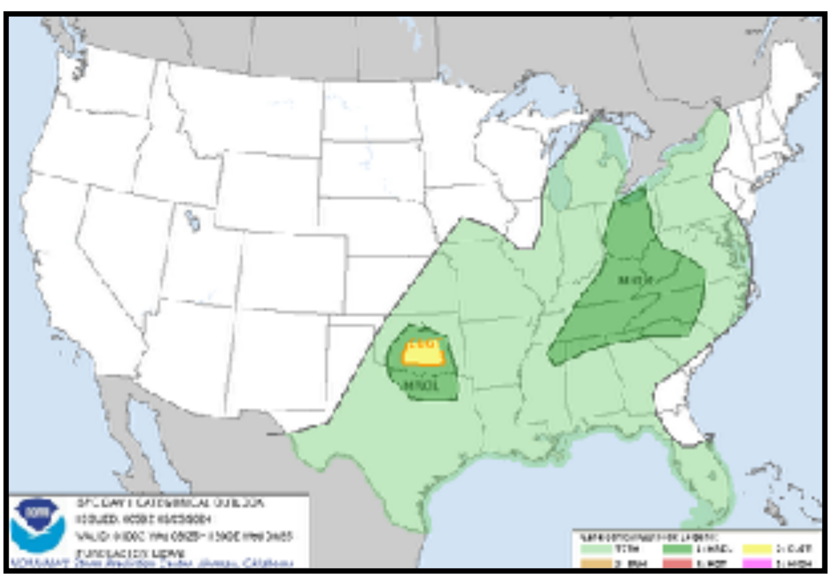
Another useful forecast chart is the low level significant weather chart, found only as a legacy product at the Aviation Weather Center and ForeFlight. Changes are coming in January 2025.



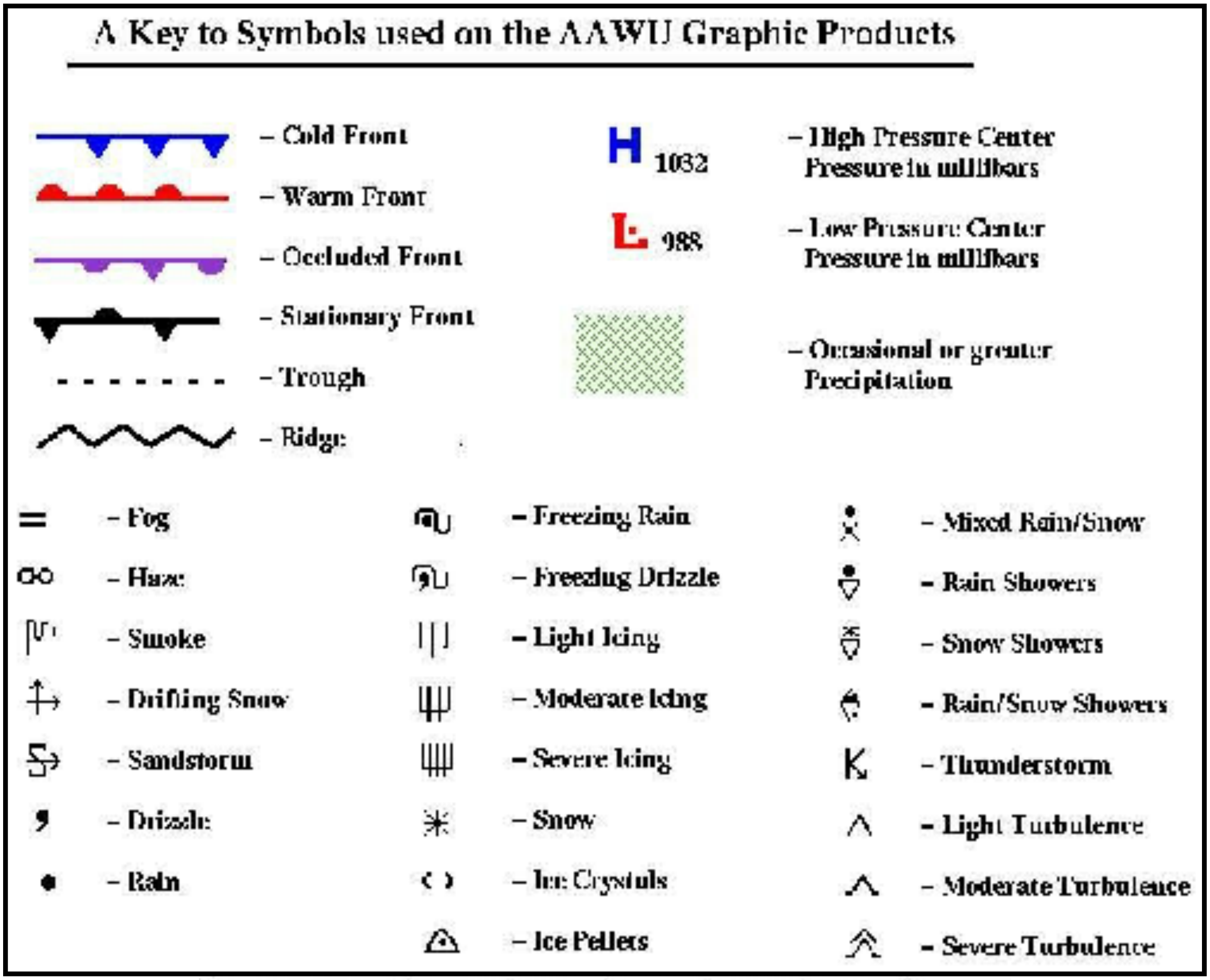
The ceiling and visibility chart can be configured to show ceiling, visibility, or flight category for a forecast time. In the example shown, flight category is set. Weather symbols are overlayed to indicate the cause of diminished ceiling or visibility. This chart satisfies the IFR alternate airport weather forecast requirement under 91.169.

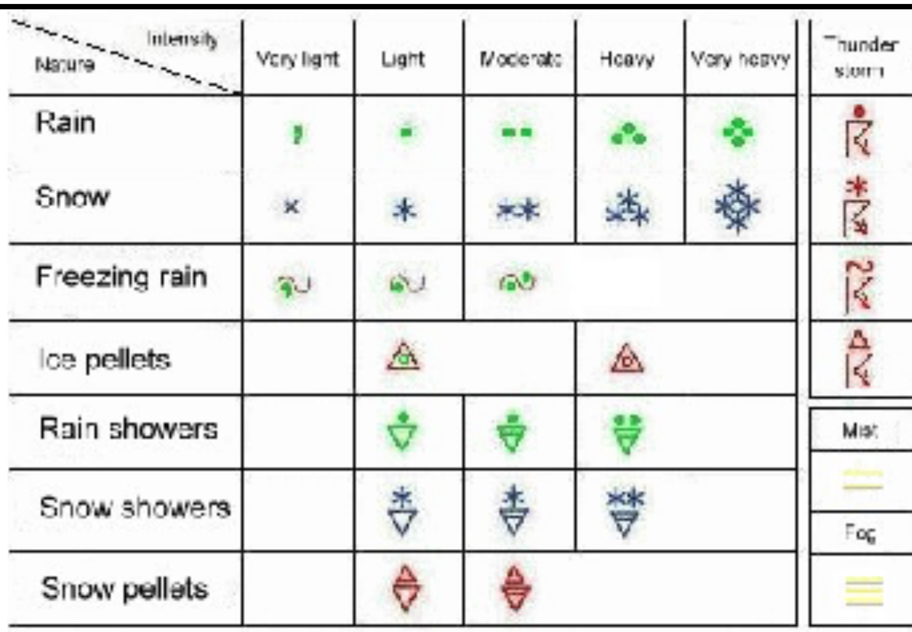


Convective Outlook charts are published by NOAA's Storm Prediction center and depict regions of convective activity or thunderstorms.



Common Symbols on Weather Charts





6.2. Future Weather

TAFs (Terminal Aerodrome Forecasts) – Forecast weather valid for a 5 statue mile radius around larger airports (specifically from the center of the airport runway complex). Issued every 6 hours (0000Z, 0600Z, 1200Z, 1800Z), and valid for 24 or 30 hours. Also includes a textual forecast discussion.

221737Z 2218/2318 12010KT P6SM VCTS SCT045CB BKN150
TEMPO 2218/2220 3SM TSRA BKN030CB
FM222100 14008KT P6SM VCSH BKN060 BKN150
FM230000 VRB04KT P6SM SCT060 BKN100
FM231500 12009KT P6SM VCSH SCT030 BKN080

(18Z TAFS) ISSUED AT 140 PM EDT SAT JUN 22 2024
VFR conditions forecast outside of convection. Ongoing shower and storm development across southern portions of ECFL will expand northwestward towards the interior terminals. TEMPOs in effect at MLB and TIX through 20Z, with TEMPOs at the interior terminals between 19 to 23Z for MVFR VIS and CIGs due to TSRA. Lingering VCSH along the coast will diminish after 00Z, with conditions across the interior improving after 03Z. Southeast winds will become light and variable overnight, picking back up out of the south between 5 to 10 knots tomorrow morning after 15Z. Another day of showers and storms is forecast for tomorrow, with VCSH at the coastal terminals after 16Z. Activity will expand towards the interior in the afternoon.

7. DELIVERY TO THE COCKPIT

Many of these weather products are derived via FIS-B on the 978 MHz frequency. FIS-B includes

AIRMET
AWW/WW
Ceiling
Convective SIGMET
D-ATIS
Echo Top
METAR/SPECI
MRMS NEXRAD (CONUS)
MRMS NEXRAD (Regional)
NOTAMs-D/FDC
NOTAMs-TFR
PIREP
SIGMET
SUA Status
TAF/AMEND
Temperature Aloft
TWIP
Winds aloft
Lightning strikes
Turbulence
Icing, Forecast Potential (FIP)
Cloud tops
1 Minute AWOS
Graphical-AIRMET
Center Weather Advisory (CWA)
Temporary Restricted Areas (TRA)
Temporary Military Operations Areas (TMOA)

8. RISK MANAGEMENT

8.1. Personal Minimums

8.2. Limitations of Inflight Weather Reports