BASICS FOR AIR TRAFFIC CONTROL – HAZARDOUS WEATHER

MODULE OVERVIEW

Purpose: This module discusses the characteristics of hazardous weather and their effects on aviation. The hazards covered in this module each have their own distinct and very real dangers for pilots. You will be able to identify these characteristics by the end of this module.

MODULE OUTLINE

Lesson: Adverse Weather

Purpose: This lesson identifies the severity and impact that weather hazards and adverse wind have on aircraft, especially during takeoff and landing.

Objectives:

- Define adverse weather conditions that can affect an aircraft
- Define adverse wind effects that affect aircraft

Topics:

- Aviation Weather Hazards
- Adverse Wind Effects
- Knowledge Check
- Adverse Winds
  - Crosswinds

Video – Crosswind Landing Examples (1:01 mins.)

  - Gusts
  - Tailwind
  - Variable Wind
  - Wind Shift
- Aircraft Size and Wind
- Knowledge Check
- Review/Summary

Question and Answer Session – *Parking Lot*

Lesson: Instrument Flight Rules (IFR) Weather

Purpose: This lesson describes the type of weather that requires operation under Instrument Flight Rules and the danger this weather poses to aircraft in this environment.

Objective:

- Describe IFR weather hazards during aircraft takeoff and landing

Topics:

- Instrument Flight Rules (IFR) Weather

- Ceiling vs. Indefinite Ceiling
    - Layer Aloft Ceiling
    - Indefinite Ceiling
- Knowledge Check
- Fog
- Precipitation
- Volcanic Ash Cloud
- Mountain Obscuration
- Knowledge Check
- Review/Summary

Lesson: Turbulence

Purpose: The purpose of this lesson is to define the environmental conditions that cause aircraft turbulence and the effects they produce. This lesson also describes the levels of turbulence intensity, from light to extreme.

Objectives:

- Identify types of turbulence that affect aircraft
- Identify causes of aircraft turbulence

Topics:

- Aircraft Turbulence
- Causes of Turbulence
    - Convective Turbulence
    - Mechanical Turbulence
    - Mountain Waves
- Knowledge Check
    - Wind Shear Turbulence
- Wind Shear Turbulence Conditions
    - Temperature Inversion
    - Frontal Zone
    - Clear Air Turbulence (CAT)
- Turbulence Intensity Classifications
- Aircraft Reaction to Turbulence
- Knowledge Check
- Review/Summary

Question and Answer Session – *Parking Lot*

Lesson: High Density Altitude

Purpose: The purpose of this lesson is to describe the effects of high density altitude on aircraft, as related to hazardous weather conditions.

Objective:

- Describe effects of high density altitude on aircraft

Topics:

- High Density Altitude
- Knowledge Check
- Review/Summary

Question and Answer Session – *Parking Lot*

Lesson: Icing

Purpose: The purpose of this lesson is to define the types of icing hazards for aircraft.

Objectives:

- Identify characteristics of icing
- Identify how icing affects an aircraft

Topics:

- Icing on Aircraft
- Supercooled Water

Video – Principle of Supercooling (0:40 mins.)

- Structural Icing
  - Rime Ice
  - Clear Ice
  - Mixed Ice
- Icing Intensity Classification
- Factors that Affect Accumulation
  - Commercial Jets
  - Small Turboprops
- Icing Effects
- Avoiding Icing
- Knowledge Check
- Review/Summary

Lesson: Thunderstorms

Purpose: The purpose of this lesson is to describe hazardous effects that occur to aircraft during a thunderstorm.

Objective:

- Identify hazardous effects of thunderstorms on an aircraft

Topics:

- Thunderstorms
- Hazardous Effects of Thunderstorms
- Ingredients for Thunderstorm Cell Formation
  - Water Vapor
  - Unstable Air
  - Lift
- Lifecycle Stages of a Thunderstorm Cell
  - Towering
  - Cumulus Stage
  - Dissipating Stage
- Downburst
- Downburst Lifecycle
  - Formation
  - Impact
  - Dissipation
- Landing in a Microburst

Video – Crash of L-1011 at Dallas-Fort Worth (6:23 mins.)

- Wind Shear Product Systems
  - LLWAS
  - TDWR
  - ASR-WSP

Video – Vectoring Around Thunderstorms (0:50 mins.)

- Knowledge Check
- Review/Summary

Question and Answer Session – *Parking Lot*

Lesson: Low-Level Wind Shear (LLWS)

Purpose: The purpose of this lesson is to demonstrate how low-level wind shear affects aircraft during takeoff and landing.

Objective:

- Identify the effects of low-level wind shear (LLWS) on aircraft

Topics:

- Low-Level Wind Shear (LLWS)
  - Wind Shear – Change from Headwind to Tailwind on Landing
  - Wind Shear – Change from Tailwind to Headwind on Landing
- Knowledge Check
- Review/Summary

Activity – Name that Hazard!

Question and Answer Session – *Parking Lot*

End-of-Module (EOM) Test

INTRODUCTION

LESSONS	▪ Adverse Weather ▪ Instrument Flight Rules (IFR) Weather ▪ Turbulence ▪ High Density Altitude ▪ Icing ▪ Thunderstorms ▪ Low-Level Wind Shear (LLWS)
TOTAL ESTIMATED RUN TIME	4 hrs. 47 mins.
MODULE CONTENT	▪ Module Overview ▪ Lesson: Adverse Weather ▪ Q&A Session – Parking Lot ▪ Lesson: Instrument Flight Rules (IFR) Weather ▪ Lesson: Turbulence ▪ Q&A Session – Parking Lot ▪ Lesson: High Density Altitude ▪ Q&A Session – Parking Lot ▪ Lesson: Icing ▪ Lesson: Thunderstorms ▪ Q&A Session – Parking Lot ▪ Lesson: Low-Level Wind Shear ▪ Activity – Name that Hazard! ▪ Q&A Session – Parking Lot ▪ End-of-Module Test

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
▪ Instruct students to select ***Hazardous Weather*** module link within Blackboard ▪ Instruct students to read the module introduction and then wait quietly for additional instructions	Blackboard **EST. RUN TIME** 2 mins.

Your job as an air traffic controller is to provide a service to the flying public. Weather is perhaps the most significant factor that affects the flow of air traffic and accounts for a significant percentage of all accidents. FAA Order JO 7110.65 states that controllers shall advise pilots of hazardous weather that may impact operations within 150 nautical miles (NM) of their sector or area of jurisdiction. Therefore, it is critical that you are able to identify the characteristics of hazardous weather and their effects on aircraft.

This module discusses the characteristics of hazardous weather and their effects on aviation. The hazards covered in this module each have their own distinct and very real dangers for pilots. You will be able to identify these characteristics by the end of this module.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Adverse Weather*** lesson in Blackboard ■ Instruct students to navigate to the ***Adverse Weather*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed	Blackboard **EST. RUN TIME** 15 mins.

ADVERSE WEATHER

Purpose: This lesson identifies the severity and impact that weather hazards and adverse wind have on aircraft, especially during takeoff and landing.

Objectives:

- Define adverse weather conditions that can affect an aircraft
- Define adverse wind effects that affect aircraft

References for this lesson are as follows:

- Aeronautical Information Manual (AIM)
- American Meteorology Society (AMS), Glossary of Meteorology
- UCAR/COMET: Writing TAFS for Winds and LLWS
- NASDAC Review of NTSB Weather Related Accidents

Aviation Weather Hazards

An aviation weather hazard is an atmospheric condition that, when encountered in flight, can potentially cause damage to the aircraft, personal injury, a crash, or death.

Pilot and aircraft capabilities are factors that must be considered.

- Some hazards impact all flights
- Some hazards only impact pilots and aircraft with limited capabilities

Factors that influence aviation weather safety:

Pilot	**Ratings and Experience** ■ Instrument rated ■ Visual Flight Rules (VFR) only
Aircraft	**Design Performanace Specifications** ■ Power ■ Speed ■ Range ■ Service ceiling
Equipment	**Onboard Equipment** ■ De-ice/anti-ice ■ Navigational aids ■ Autopilot ■ Radar ■ Lightning detector (Stormscope or Strikefinder) ■ Uplink weather

Adverse Wind Effects

Adverse wind is responsible for most weather-related accidents and often triggers air traffic management decisions that adversely impact traffic.

Adverse wind's impact on:

Aircraft	■ **General aviation (GA) pilots** flying aircraft with lower crosswind and tailwind threshold values are the most at risk ■ **Takeoff and landing** are the most critical phrases of flight and are most susceptible to adverse wind
Air Traffic Control	■ **Change of runway configuration –** Wind determines which direction planes will land ■ **Reduced arrival rates –** Capacity constraints can cause ripples throughout the National Airspace System (NAS)

Knowledge Check A

REVIEW what you have learned so far about adverse weather. ANSWER the question listed below.

1. Which factors influence aviation weather safety? *(Select all correct answers that apply.)*
   - ❑ **Pilot instrument rating**
   - ❑ Aircraft color
   - ❑ **Aircraft speed, power, range, and service ceiling**
   - ❑ **Aircraft onboard equipment**

Adverse Winds

Adverse wind phenomena include:

Crosswind – When used concerning wind conditions, the word means a wind not parallel to the runway or path of an aircraft.

Aircraft take off and land more efficiently when oriented into the wind. The aircraft's groundspeed is minimized, less runway is required, and the pilot has more time to make adjustments necessary for a smooth landing.

As the wind turns more perpendicular to the runway and becomes a crosswind, aircraft performance gradually degrades and directional control of the aircraft becomes increasingly difficult.

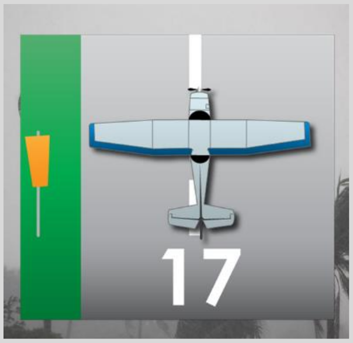
If a pilot does not correctly compensate for the crosswind:

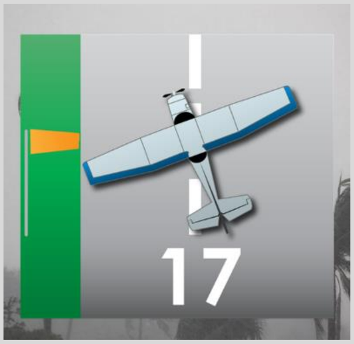
- The aircraft may drift off the side of the runway
- Side load on landing gear can occur, possibly leading to gear collapse

An unforecasted crosswind en route can cause an aircraft to drift off its expected flight path, leading to navigation errors.

Note: *All aircraft have a maximum crosswind component at which they can operate.*

Video – *Crosswind Landing Examples* (1:01 mins.)





Gust – A sudden, brief increase in the speed of the wind.

Even if the aircraft is oriented into the wind, gusts during takeoff and landing cause airspeed fluctuations which can cause problems for pilots.

- A gust increases airspeed, which may increase lift, and cause an aircraft to briefly rise
- Once the gust ends, a sudden decrease of airspeed occurs, which may decrease lift and cause the aircraft to sink
- This may cause an aircraft to bounce on the runway and possibly lead to a crash

Tailwind – Any wind more than 90 degrees to the longitudinal axis of the runway.

A tailwind can be hazardous during both takeoff and landing.

Takeoff
A longer takeoff roll is required. A higher ground speed is required to generate sufficient lift. The aircraft may roll off the end of the runway before liftoff.

A smaller initial rate of climb occurs during takeoff, which may be insufficient to clear obstacles at the end of the runway.

Landing
Aircraft experiences a higher ground speed on landing. Thus, the pilot has less time to make adjustments necessary for a smooth landing and may roll off the end of the runway.

Variable Wind – Wind that changes direction frequently.

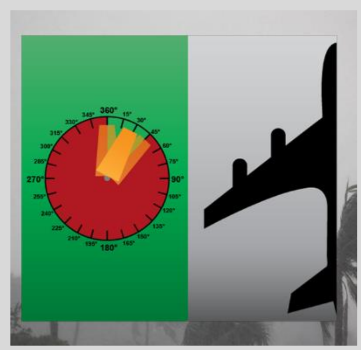
Wind direction is considered to be variable when, during the 2-minute evaluation period, it fluctuates by 60 degrees or more and the wind speed is more than 6 knots.

The wind direction may also be considered variable if, during the 2-minute evaluation period, the wind speed is 6 knots or less.

Wind Shift is a change in wind direction of 45 degrees or more which takes place in less than 15 minutes and has sustained winds of 10 knots or more throughout the wind shift.

Variable wind and sudden wind shifts, even at low speeds, can make takeoffs and landings difficult.

- A headwind can quickly become a crosswind or tailwind



Aircraft Size and Wind

Small aircraft are more affected by tailwinds and crosswinds during takeoff and landing than large aircraft. This is because small aircraft generally have slower takeoff and approach speeds than larger aircraft.

Knowledge Check B

REVIEW what you have learned so far about adverse weather. ANSWER the questions listed below.

1. When an aircraft is taking off into a headwind, what will gusts possibly cause it to do? *(Select the correct answer.)*
   - ❑ Drift off the side of the runway
   - ❑ **Bounce on the runway**
   - ❑ Roll off the end of the runway

2. How can a variable wind be dangerous to an aircraft on takeoff and landing? *(Select the correct answer.)*
   - ❑ Cause engine failure
   - ❑ **Quickly become a crosswind or tailwind**
   - ❑ Cause the pilot to experience vertigo

3. Which aircraft will perform better in adverse wind conditions due to their higher tailwind and crosswind thresholds? *(Select the correct answer.)*
   - ❑ Smaller aircraft
   - ❑ Helicopters
   - ❑ **Larger aircraft**

Adverse Weather Summary

Hazardous weather can be devastating to aircraft. Of all the weather phenomenon, adverse wind is the most dangerous when taking off and landing a plane. This lesson identified the severity and impact that weather hazards and adverse wind have on aircraft. Adverse weather and wind direction will make a difference on how air traffic is directed.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Review content presented in ***Adverse Weather*** lesson ■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content	Facilitated Discussion **EST. RUN TIME** 15 mins.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Instrument Flight Rules (IFR) Weather*** and ***Turbulence*** lessons in Blackboard ■ Instruct students to navigate to the ***Instrument Flight Rules (IFR) Weather*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of ***Instrument Flight Rules (IFR) Weather*** instruct students to navigate to the ***Turbulence*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed	Blackboard **EST. RUN TIME** 15 mins.

INSTRUMENT FLIGHT RULES (IFR) WEATHER

Purpose: This lesson describes the type of weather that requires operation under Instrument Flight Rules and the danger this weather poses to aircraft in this environment.

Objective:

- Describe IFR weather hazards during aircraft takeoff and landing

References for this lesson are as follows:

- Aeronautical Information Manual (AIM)
- AC 00-6, Aviation Weather
- AC 00-45, Aviation Weather Services
- American Meteorology Society (AMS), Glossary of Meteorology
- FMH-1, Surface Weather Observations and Reports

Instrument Flight Rules (IFR) Weather

IFR Weather – Weather conditions below the minimum for flight under Visual Flight Rules (VFR).

En route or terminal weather conditions of sufficiently low visibility to require the operation of aircraft under instrument flight rules (IFR).

IFR weather can be hazardous during takeoff and landing.

Continued visual flight into IFR weather is one of the single greatest causes of fatal hazards.

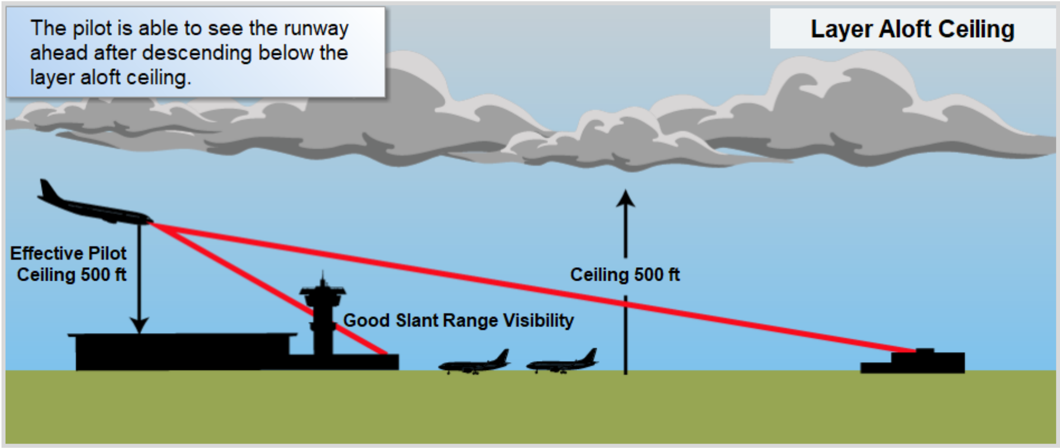
Most aircraft accidents related to IFR weather involve pilots who are not instrument qualified.

- These pilots attempt flight by visual reference into weather that is suitable only for instrument flight
- The most common cause of these accidents is vertigo (**vertigo** – the feeling that you or your environment is moving or spinning)
- Pilots also run the risk of flying into unseen obstructions or terrain

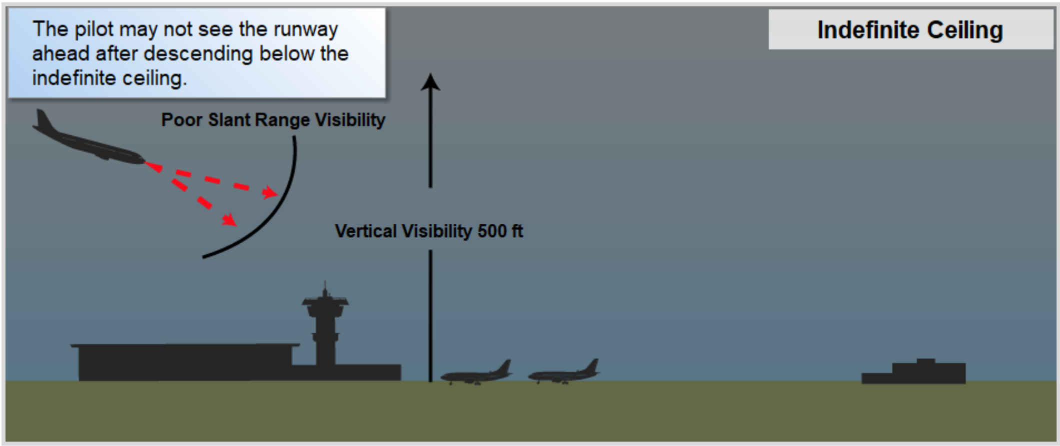
Ceiling vs. Indefinite Ceiling

Ceiling – The lowest layer aloft reported as broken or overcast, or the vertical visibility into an indefinite ceiling. There are two distinct types of ceilings, Layer aloft, and indefinite.

Layer Aloft Ceiling – Once a pilot descends below a ceiling caused by a layer aloft or layer aloft ceiling, the pilot can see both the ground below and the runway ahead. Layer aloft includes the lowest broken (BKN) or overcast (OVC) cloud layer. For example, layer aloft will read BKN005, OVC008 on a weather report. An equal ceiling occurs when a layer aloft is unbroken or completely overcast.



Indefinite Ceiling – The ceiling classification that is applied when the reported ceiling value represents the vertical visibility (VV) upward into a surface-based obscuration. An indefinite ceiling is more hazardous than an equal ceiling caused by a layer aloft; For example, VV005 is more hazardous than BKN005 as shown on a weather report. An indefinite ceiling restricts the pilot's slant-range (air-to-ground) visibility.



Knowledge Check C

REVIEW what you have learned so far about IFR weather. ANSWER the questions listed below.

1. Which type of pilot rating is the most at risk for instrument weather aircraft accidents? *(Select the correct answer.)*
   - ❑ IFR
   - ❑ **<u>VFR</u>**
   - ❑ VFR and IFR

2. What is an indefinite ceiling? *(Select the correct answer.)*
   - ❑ **<u>A surface-based obscuration</u>**
   - ❑ Layer aloft obscuration
   - ❑ Overcast cloud layer

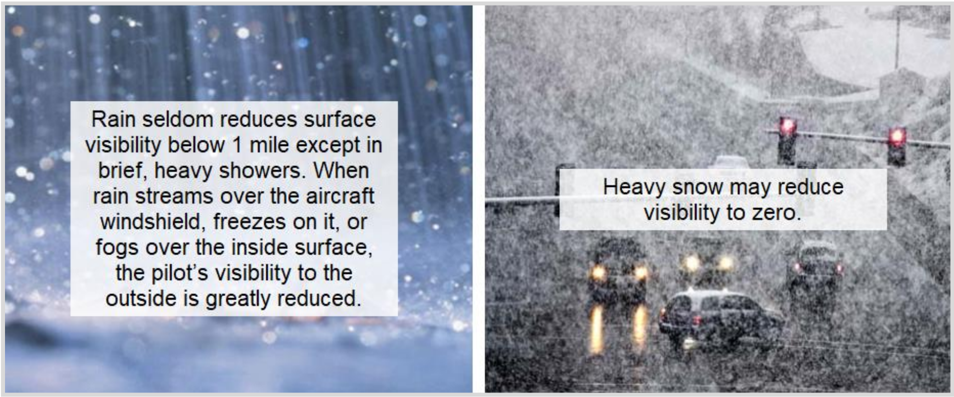
Fog

Fog – A visible aggregate of minute water droplets based at the Earth's surface and reducing horizontal visibility to less than 5/8 statute mile. Unlike drizzle, fog does not fall to the ground.

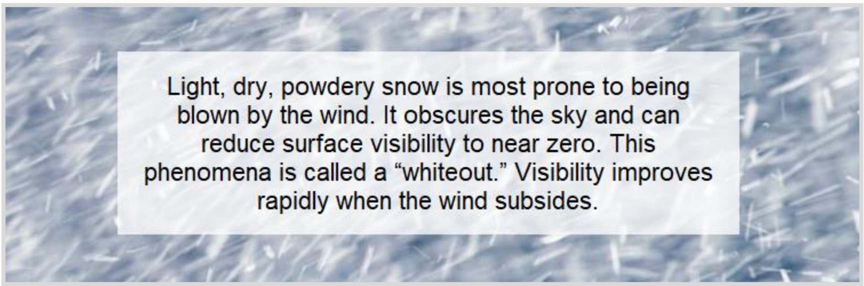
Fog vs. Clouds	Fog differs from clouds only in that its base must be at the Earth's surface while clouds are above the surface.
Fog Formation	Fog forms when the temperature and dew point of the air become identical (or nearly so).
Fog as a Hazard	The speed with which fog can form makes it especially hazardous to aircraft. Fog is one of the most common and persistent weather hazards encountered in aviation.

Precipitation

Precipitation – Any of the forms of water particles, whether liquid or solid, that fall from the atmosphere and reach the ground. Rain, drizzle, and snow are the types of precipitation which most commonly produce IFR weather.



Blowing Snow – Snow lifted from the surface of the Earth by the wind to a height of 6 feet or more above the ground and blown about in such quantities that the reported horizontal visibility is reduced to less than 7 statute miles.



Note: *Snow falling from clouds is not required to produce blowing snow. In fact, skies above the blowing snow could be clear.*

Volcanic Ash Cloud

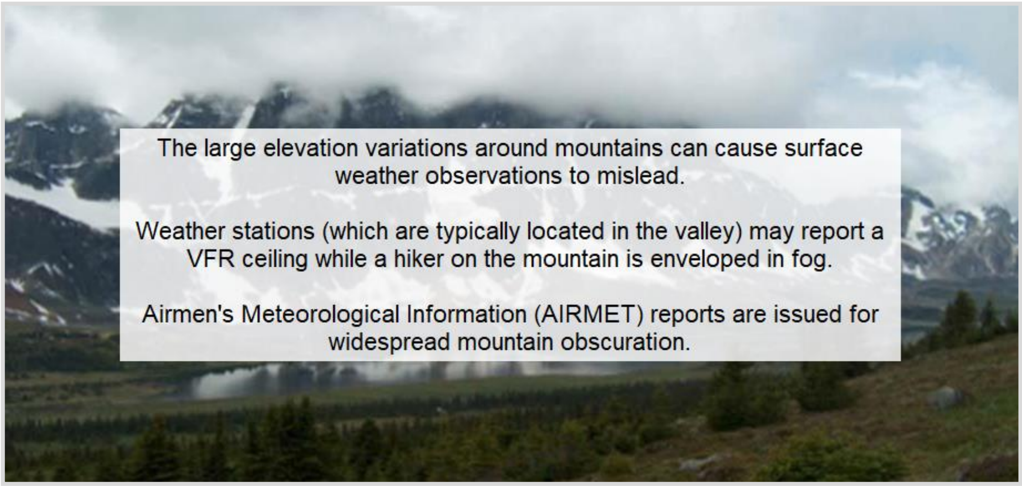
Volcanic Ash – Fine particles of rock powder that originate from a volcano and that may remain suspended in the atmosphere for long periods.

Volcanic Ash vs. Clouds	Even if visible, it is difficult to distinguish visually between an ash cloud and an ordinary cloud. A volcano ash cloud may not be detected by aircraft or Air Traffic Control (ATC) radar.
Volcanic Ash as a Hazard	Aside from producing IFR weather, flying into a volcanic ash plume can be exceedingly dangerous. Ingestion of volcanic ash into an engine can lead to partial or total power loss. Also, ash covering a runway can hide its markings and cause aircraft to lose traction during takeoffs and landings.

Note: *If volcanic ash is pulled into a jet engine, it can be heated to temperatures that are higher than the melting temperature of the ash. The ash can melt in the engine and the soft, sticky product can adhere to the inside of the engine. This restricts engine airflow and adds weight. Volcanic ash may not be visible, especially at night or in instrument conditions.*

Mountain Obscuration

Mountain Obscuration – Conditions over significant portions of mountainous geographical areas are such that pilots in-flight should not expect to maintain visual meteorological conditions or visual contact with mountains or mountain ridges near their route of flight.



Knowledge Check D

REVIEW what you have learned so far about IFR weather. ANSWER the questions listed below.

1. When does fog form? *(Select the correct answer.)*
   - ❑ Temperature is less than dew point
   - ❑ **Temperature equals dew point**
   - ❑ Temperature is greater than dew point

2. Which precipitation most commonly produce instrument weather? *(Select the correct answer.)*
   - ❑ **Rain, drizzle, and snow**
   - ❑ Hail, snow grains, and ice pellets
   - ❑ Snow, snow grains, and ice crystals

3. Which weather phenomenon involves the obscuration of mountain peaks caused by clouds, precipitation, smoke, haze, mist, or fog? *(Select the correct answer.)*
   - ❑ Blowing snow
   - ❑ Volcanic ash cloud
   - ❑ **Mountain obscuration**

IFR Weather Summary

This lesson described the type of weather that requires operation under IFR and the danger this weather poses to aircraft in this environment. Directing air traffic in instrument weather requires an in-depth knowledge of the weather environment within which pilots operate.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ ***Note: Turbulence*** lesson should already have been enabled in Blackboard, if not ensure it is enabled ■ Instruct students to navigate to the ***Turbulence*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed	Blackboard **EST. RUN TIME** 15 mins.

TURBULENCE

Purpose: The purpose of this lesson is to define the environmental conditions that cause aircraft turbulence and the effects they produce. This lesson also describes the levels of turbulence intensity, from light to extreme.

Objectives:

- Identify types of turbulence that affect aircraft
- Identify causes of aircraft turbulence

References for this lesson are as follows:

- Aeronautical Information Manual (AIM)
- AC 00-6, Aviation Weather
- American Meteorology Society (AMS), Glossary of Meteorology
- UCAR/COMET: Mountain Waves and Downslope Wind

Aircraft Turbulence

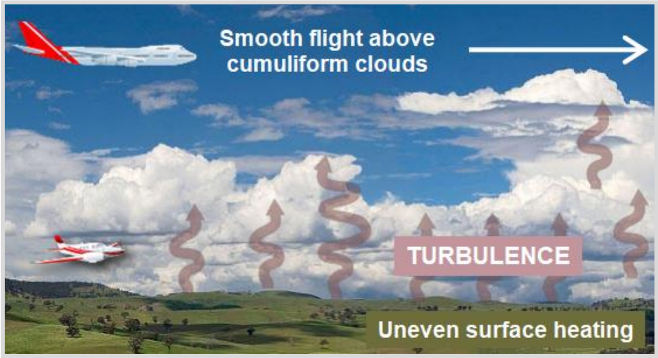
Aircraft Turbulence is irregular motion of an aircraft in flight, especially when characterized by rapid up-and-down motion, caused by a rapid variation of atmospheric wind velocities.

Turbulence ranges from annoying bumpiness to severe jolts that cause structural damage to aircraft and/or injury to its passengers.

Causes of Turbulence

Turbulence is caused by convective currents (called “convective turbulence”), obstructions to wind flow (called “mechanical turbulence”), and wind shear.

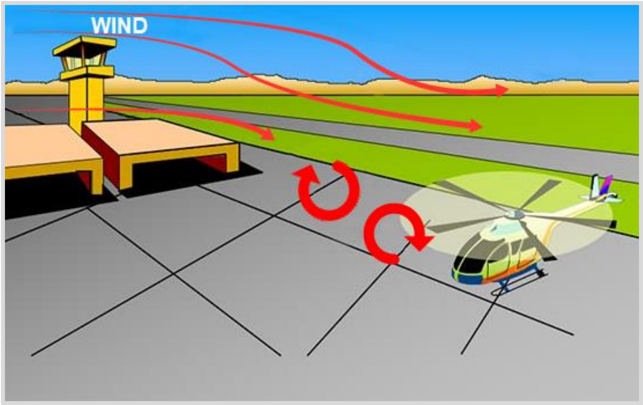
Convective Turbulence



Convective turbulence result from convective storms, particularly thunderstorms that are felt by aircraft. The turbulence is caused by strong updrafts and downdrafts.

- Convective currents are most active on warm summer afternoons when winds are light
- Turbulence strength can vary considerably within short distances due to uneven surface heating
  - Barren surfaces and plowed fields become hotter than open water or ground covered by vegetation
- Billowy cumuliform clouds indicate convective turbulence
  - The cloud top marks the upper limit of the convective current
- When the air is too dry for cumuliform clouds to form, convective currents can still be active

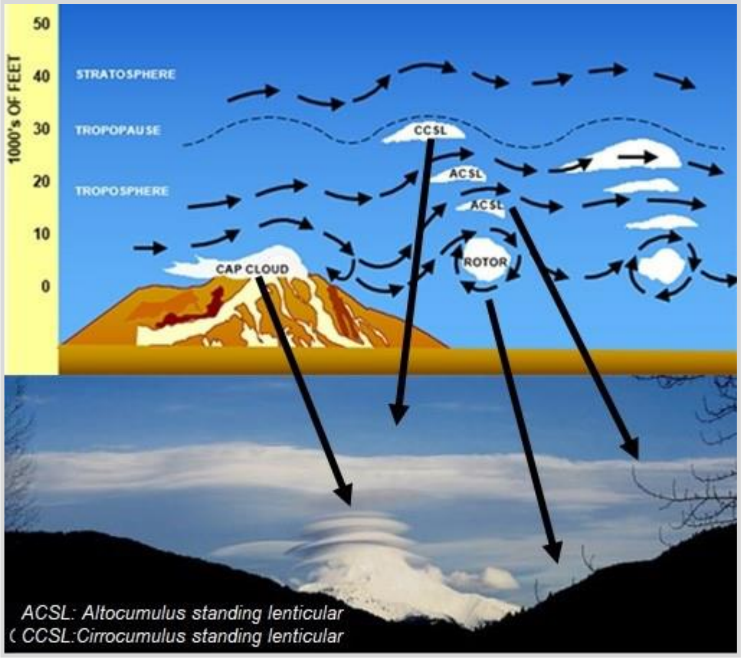
Mechanical Turbulence



Mechanical turbulence is turbulence produced by shear flow. This is caused by obstructions, such as trees, buildings, and mountains.

- Obstructions to the wind flow disrupt the smooth flow of air
- Turbulence intensity is directly related to:
  - Wind speed
  - Shape of the obstructions

Mountain Waves



A **mountain wave** is an atmospheric gravity wave formed when stable air flow passes over a mountain or mountain barrier.

- Mountain waves develop above and downwind of mountains
  - The waves remain nearly stationary while the wind blows rapidly through them
  - The waves may extend 100 miles or more downwind from the mountain range
  - Mountain waves frequently produce severe to extreme turbulence
    - Location and intensity varies with wave characteristics

Note: *Mountain waves usually extend upward into the lower stratosphere.*

Knowledge Check E

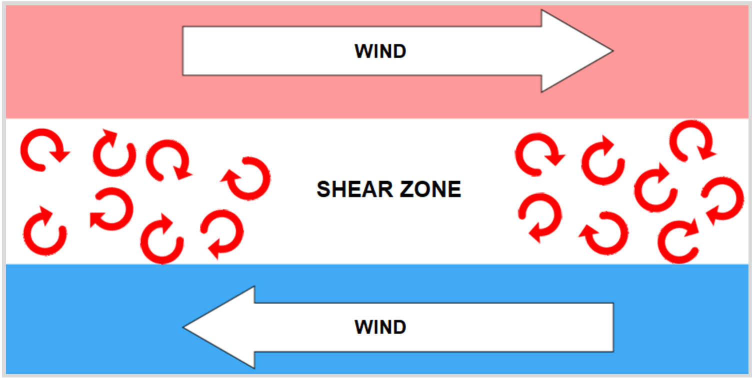
REVIEW what you have learned so far about turbulence. ANSWER the questions listed below.

1. When the air is too dry for cumuliform clouds to form, which type of currents can still cause turbulence? *(Select the correct answer.)*
   - ❑ Wind shear
   - ❑ Mechanical
   - ❑ **Convective**

2. Which type of turbulence forms when stable air flows over a mountain? *(Select the correct answer.)*
   - ❑ **Mountain wave**
   - ❑ Mountain downwind
   - ❑ Mountain turbulence

Wind Shear Turbulence

Wind Shear is a change in wind speed and/or wind direction in a short distance resulting in a tearing or shearing effect. It can exist in a horizontal or vertical direction and occasionally in both.



Wind Shear Turbulence Conditions

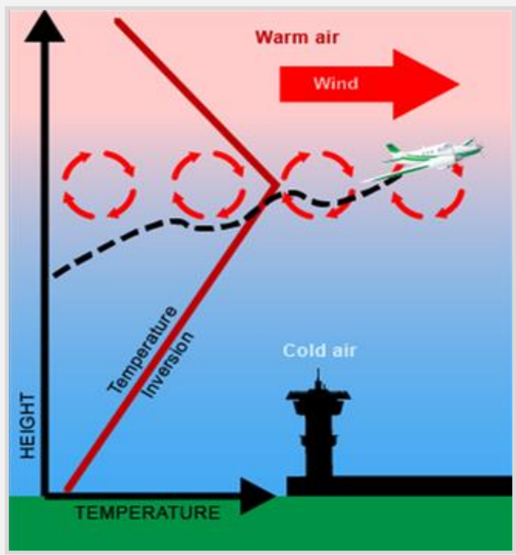
Three conditions of wind shear are of special interest: wind shear with low-level temperature inversion, wind shear with a frontal zone, and clear air turbulence (CAT) associated with the jet stream.

Temperature Inversion

Temperature inversion is a layer in which temperature increases with altitude.

Inversions occur:

- Within the lowest few thousand feet above ground due to nighttime cooling
- Along frontal zones
- When cold air is trapped in a valley

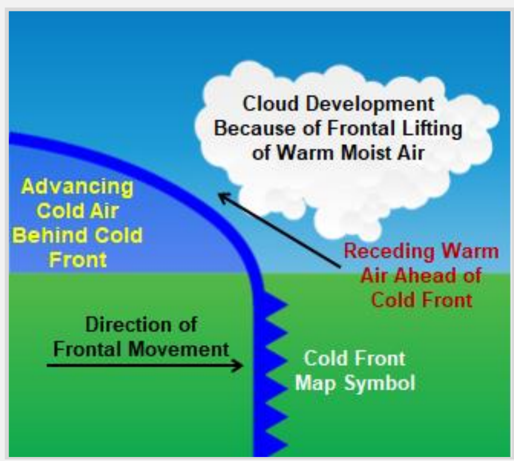


Frontal Zone

Frontal zone is the interface or transition zone between two air masses of different density.

A front can be between two dry air masses and be devoid of clouds but produce strong winds from different directions.

The degree of turbulence depends on the magnitude of the wind shear**.**

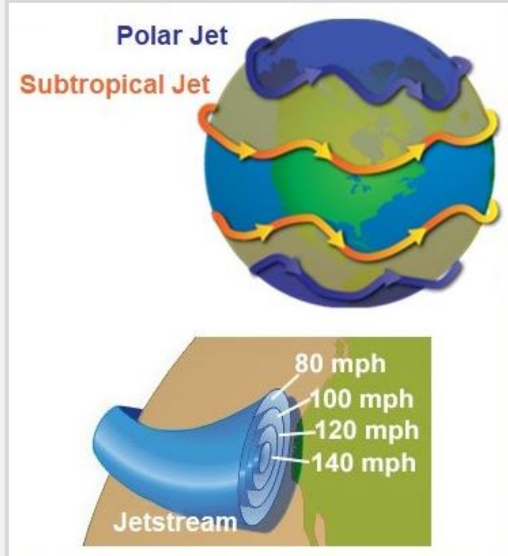


Clear Air Turbulence (CAT)

Clear Air Turbulence (CAT) is a higher altitude (~20,000 to 50,000 ft.) turbulence phenomenon occurring in cloud-free regions associated with wind shear, particularly between the core of a jet stream and the surrounding air.

CAT frequency and intensity are maximized during winter when jet streams are the strongest.

Jet stream CAT is usually best avoided by changing altitude a few thousand feet.



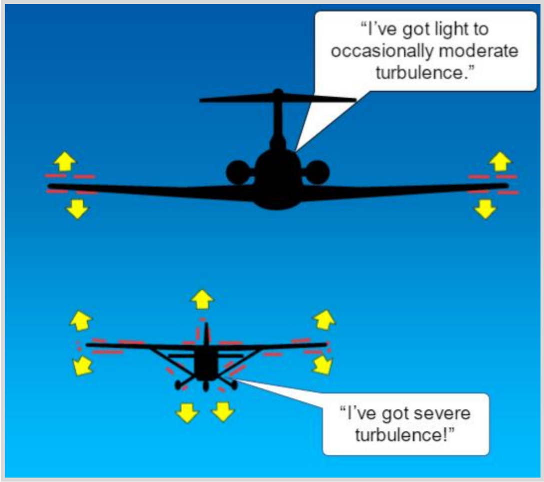
Turbulence Intensity Classifications

INTENSITY	CODED	AIRCRAFT REACTION	REACTION INSIDE AIRCRAFT
Light	**LGT**	Momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw).	Occupants may feel a slight strain against seat belts or shoulder straps. Unsecured objects may be displaced slightly. Food service may be conducted and little or no difficulty is encountered in walking.
Moderate	**MOD**	Changes in altitude and/or attitude occur, but the aircraft remains in positive control at all times. It usually causes variations in indicated airspeed.	Occupants feel definite strains against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.
Severe	**SEV**	Causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control.	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.
Extreme	**EXTRM**	Aircraft is violently tossed about and is practically impossible to control. It may cause structural damage.	
Chop is a category of turbulence that causes rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. May be reported as light chop or moderate chop.			

Aircraft Reaction to Turbulence

Aircraft reaction varies with:

- Difference in windspeed in adjacent currents
- Aircraft size
- Wing loading
- Airspeed
- Aircraft altitude



Knowledge Check F

REVIEW what you have learned so far about turbulence. ANSWER the questions listed below.

1. What type of turbulence momentarily causes slight erratic changes in altitude and/or attitude (pitch, roll, yaw)? *(Select the correct answer.)*
   - ❑ **Light**
   - ❑ Moderate
   - ❑ Severe

2. During what type of turbulence is the aircraft violently tossed about and practically impossible to control? *(Select the correct answer.)*
   - ❑ Moderate
   - ❑ Severe
   - ❑ **Extreme**

3. What generates turbulence between two wind currents of differing wind directions and/or speeds? *(Select the correct answer.)*
   - ❑ **Wind shear**
   - ❑ Obstructions to the wind flow
   - ❑ Convective currents

Turbulence Summary

This lesson identified the types and causes of turbulence that affect aircraft, as related to hazardous weather conditions.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Review content presented in ***IFR Weather*** and ***Turbulence*** lessons ■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content	Facilitated Discussion **EST. RUN TIME** 20 mins.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *High Density Altitude*** lesson in Blackboard ■ Instruct students to navigate to the ***High Density Altitude*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed	Blackboard
	EST. RUN TIME
	5 mins.

HIGH DENSITY ALTITUDE

Purpose: The purpose of this lesson is to describe the effects of high density altitude on aircraft, as related to hazardous weather conditions**.**

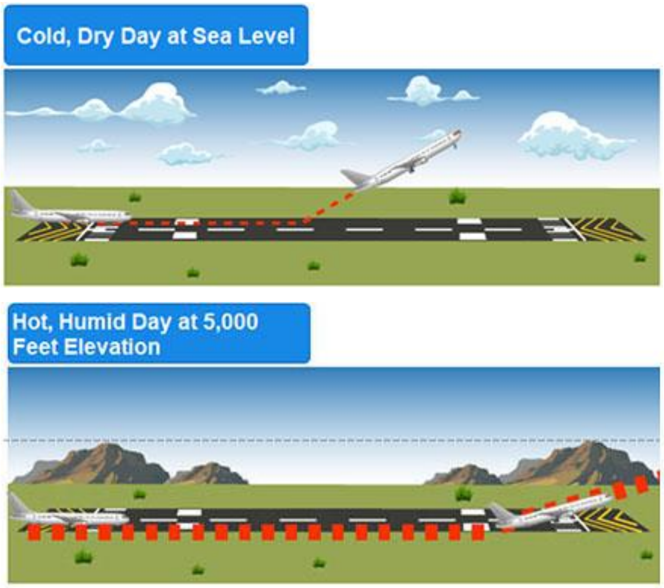
Objective:

- Describe effects of high density altitude on aircraft

Reference for this lesson are as follows:

- AC 00-6, Aviation Weather
- FAA-P-8740-2, Density Altitude

High Density Altitude



High density altitude is a term that comes from the fact that the density of the air decreases with altitude. A high density altitude means that air density is reduced, which has an adverse impact on aircraft performance.

- High density altitude can be hazardous during both takeoff and landing
  - It reduces power and thrust
  - A longer takeoff and landing roll are required

Knowledge Check G

REVIEW what you have learned so far about high density altitude. ANSWER the question listed below.

1. How does high density altitude affect power and thrust of an aircraft? *(Select the correct answer.)*
   - ❑ Increases
   - ❑ **<u>Reduces</u>**
   - ❑ Does not alter

High Density Altitude Summary

This lesson described the effects of high density altitude on aircraft, as related to hazardous weather conditions.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Review content presented in ***High Density Altitudes*** lesson ■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content	Facilitated Discussion **EST. RUN TIME** 20 mins.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Icing*** and ***Thunderstorms*** lessons in Blackboard ■ Instruct students to navigate to the ***Icing*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of ***Icing*** instruct students to navigate to the ***Thunderstorms*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed	Blackboard **EST. RUN TIME** 15 mins.

ICING

Purpose: The purpose of this lesson is to define the types of icing hazards for aircraft.

Objectives:

- Identify characteristics of icing
- Identify how icing affects an aircraft

References for this lesson are as follows:

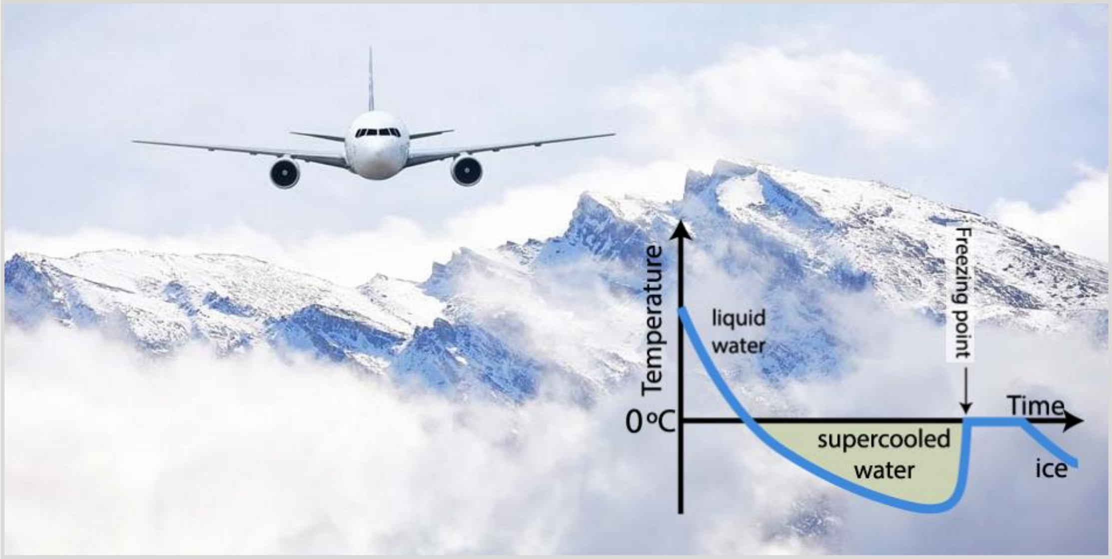
- AC 00-6, Aviation Weather
- American Meteorology Society (AMS), Glossary of Meteorology
- UCAR/COMET: Forecasting Aviation Icing: Ice Type and Severity
- AOPA Safety Advisor: Aircraft Icing

Icing on Aircraft

Icing is any deposit of ice forming on an aircraft object caused by the impingement and freezing of liquid (usually super-cooled) hydrometeors.

Supercooled Water

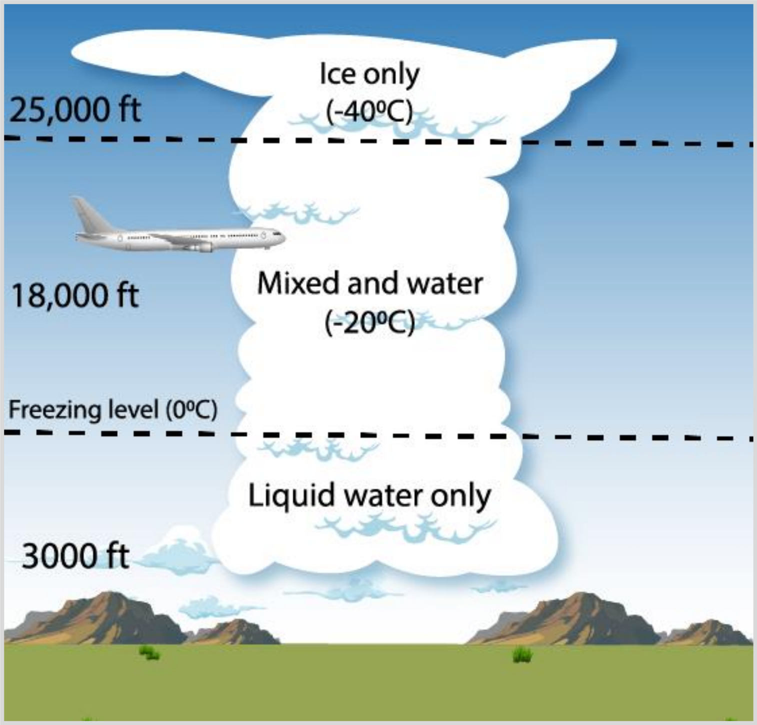
Supercooled water is liquid water at temperatures below the freezing point (0°C). Water chilled below its standard freezing point will crystallize in the presence of a solid around which a crystal structure can form.



Droplets of supercooled water often exist in:

- Stratiform clouds
- Cumulus clouds

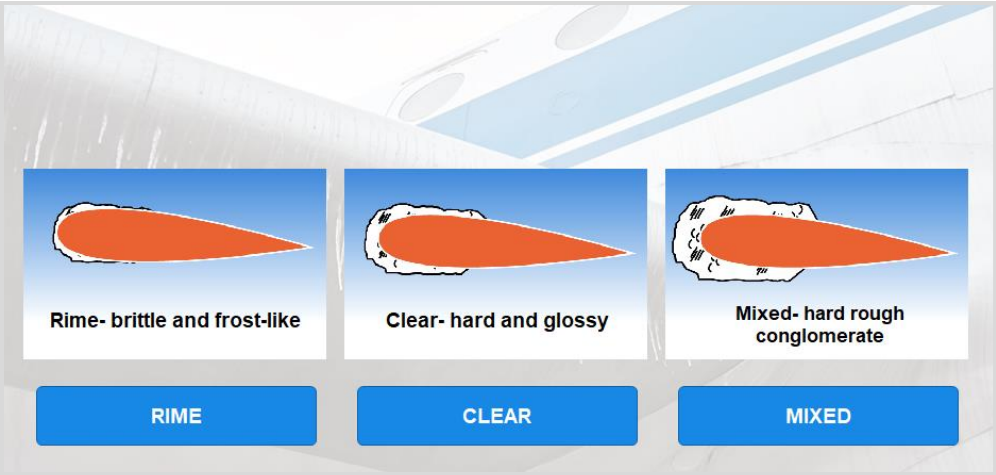
Aircraft flying through these clouds see an abrupt crystallization of these droplets, resulting in the formation of ice on the aircraft.



Video – *Principle of Supercooling* (0:40 mins.)

Structural Icing

Structural icing is ice that sticks to the outside of an aircraft. Structural icing forms when supercooled water strikes the aircraft's airframe, and can accumulate on every exposed frontal surface of the aircraft. The three types of structural ice are rime, clear (or glaze), and mixed.



Rime Ice

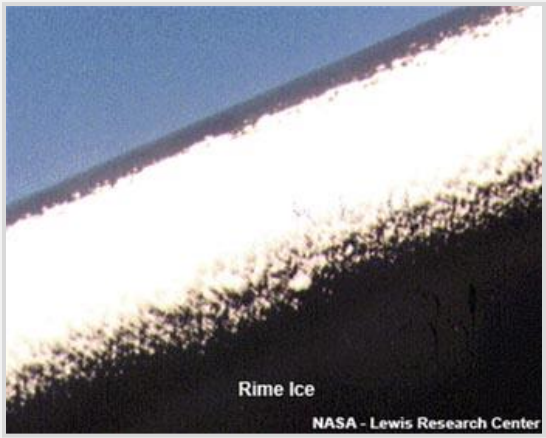
Rime ice is rough, milky, opaque ice formed by the instantaneous freezing of small supercooled water droplets after they strike the aircraft.

Favorable conditions:

- Lower liquid water contents
- Small droplets

Most common, but least serious type:

- Typically controlled by deicers or anti-icers
- Its shape and texture disturb the airflow
- Its brittleness makes it easier to remove



Clear Ice

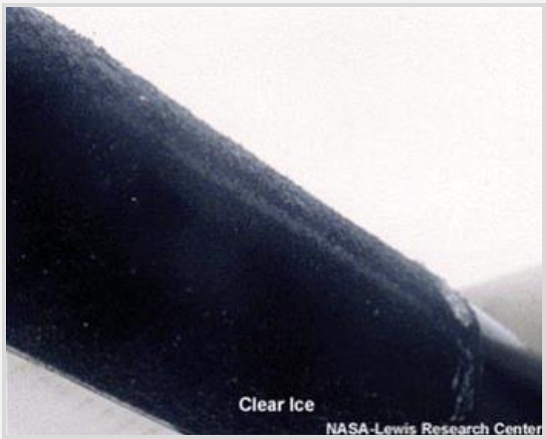
Clear ice (or glaze ice) is a glossy, clear, or translucent ice formed by the relatively slow freezing of large supercooled water droplets.

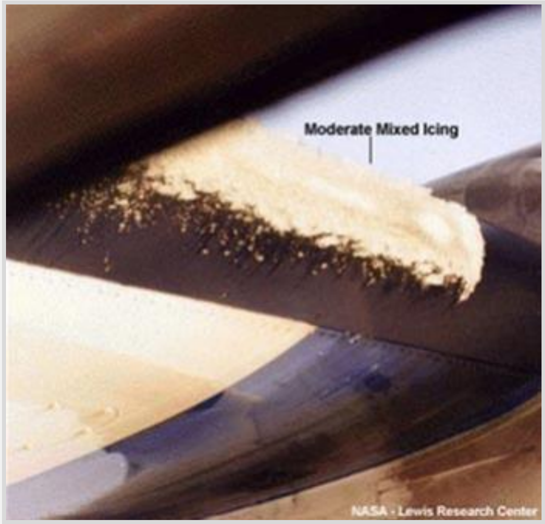
Favorable conditions:

- Higher liquid water contents
- Larger droplets

More hazardous than rime:

- Can greatly disrupt airflow
- Pilots may not see it
- Can be difficult to remove
- Can spread beyond the reach of deicing/anti-icing equipment



Mixed Ice	
Mixed ice is simultaneous appearance or a combination of rime and glaze ice characteristics. Since the clarity, color, and shape of the ice will be a mixture of rime and glaze (clear) characteristics, accurate identification of mixed ice from the cockpit may be difficult. ▪ Appears as layers of relatively clear and opaque ice when examined from the side ▪ Mixed icing combines the dangerous effects of both clear and rime icing conditions	

Icing Intensity Classification

Icing Intensity	Coded	Description
Trace	**TRACE**	Ice becomes perceptible. Rate of accumulation slightly greater than sublimation. Deicing/anti-icing equipment is not utilized unless encountered for an extended period of time (over 1 hour).
Light	**LGT**	The rate of accumulation may create a problem if flight is prolonged in the environment (over 1 hour). Occasional use of deicing/anti-icing equipment removes/prevents accumulation. It does not present a problem if the deicing/anti-icing equipment is used.
Moderate	**MOD**	The rate of accumulation is such that even short encounters become potentially hazardous and use of deicing/anti-icing equipment if flight diversion is necessary.
Severe	**SEV**	The rate of accumulation is such that deicing and icing/anti-icing equipment fails to reduce or control the hazard. Immediate flight diversion is necessary.

Factors that Affect Accumulation

- Aircraft type
- Aircraft design
- Altitude
- Airspeed
- Meteorological factors:
  - Supercooled water
  - Temperature
  - Droplet size

<table>
<tr><th>Commercial Jets</th><th>Small Turboprops</th></tr>
<tr><td></td><td></td></tr>
<tr><td>Commercial jets are less vulnerable due to:
■ Powerful anti-icing/deicing equipment
■ Tendency to cruise at higher altitudes where temperatures are typically too cold for icing
(< -40 degrees Celsius)</td><td>Small turboprops are more susceptible to icing due to:
■ Typically flying at lower altitudes where temperatures often support icing
(0 to -20 degrees Celsius)</td></tr>
</table>

Icing Effects

Structural icing is a significant hazard:

- ***Increased drag*** while ***decreasing*** the ability of the airfoil to create ***lift***
- Increases weight
  - ***Increased weight*** is insignificant compared to the airflow disruption
- Can cause antennas to vibrate so severely that they break
- Can block airflow into a pitot tube to cause false airspeed readings

In moderate to severe icing, build up can be significant enough to prohibit continued flight.

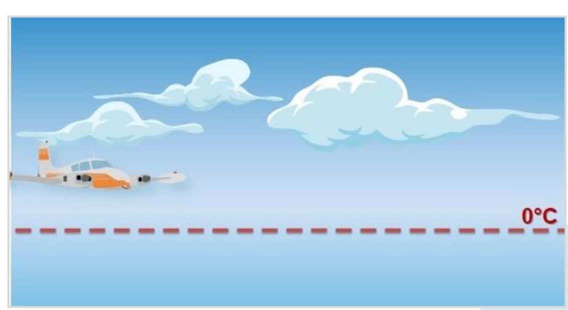
- Aircraft may stall at much higher speeds and, for certain aircraft types, lower angles of attack than normal
- Aircraft can roll or pitch uncontrollably and recovery might be impossible

Note: *Wind tunnel and flight tests have shown that frost, snow, and ice accumulations (on the leading edge or upper surface of the wing) no thicker or rougher than a piece of coarse sandpaper can reduce lift by 30 percent and increase drag up to 40 percent.*
Larger accumulations can reduce lift even more and can increase drag by 80 percent or more.

Avoiding Icing

To escape icing, a pilot can:

- Exit the area of visible moisture
- Climb or descend to positive temperatures
- Climb to altitudes where temperatures are too cold to support supercooled droplets



Knowledge Check H

REVIEW what you have learned so far about icing. ANSWER the questions listed below.

1. What type of icing is the most common and the least serious because it is easier to remove? *(Select the correct answer.)*
   - ❑ **Rime**
   - ❑ Clear
   - ❑ Mixed

2. Which level of icing intensity produces a rate of accumulation that may create a problem if the flight is prolonged over 1 hour? *(Select the correct answer.)*
   - ❑ Moderate
   - ❑ Trace
   - ❑ **Light**

3. Which of the following are factors that affect accumulation to occur on an aircraft? *(Select all correct answers that apply.)*
   - ❑ **Aircraft type and design**
   - ❑ Pilot rating
   - ❑ **Meteorological factors**

4. Which adverse effect of structural icing is least significant to an aircraft? *(Select the correct answer.)*
   - ❑ Increased drag
   - ❑ **Increased weight**
   - ❑ Decreased lift

Icing Summary

Specific meteorological factors, aircraft type and designs, altitude, and airspeed all contribute to icing in the aviation environment. This lesson Identified the characteristics of icing and how it affects an aircraft in the event you can assist others in need of avoiding or escaping a potentially dangerous icing situation.

<table>
<tr><th>FACILITATOR INSTRUCTIONS</th><th>DELIVERY METHOD</th></tr>
<tr><td rowspan="3">Note: Thunderstorms lesson should have already been enabled in Blackboard, if not ensure it is enabled
Instruct students to navigate to the Thunderstorms lesson in Blackboard
Instruct students to work individually through the lesson content
Upon completion of the lesson, students should review previously introduced content or wait quietly until other students have completed</td><td>Blackboard</td></tr>
<tr><td>EST. RUN TIME</td></tr>
<tr><td>20 mins.</td></tr>
</table>

THUNDERSTORMS

Purpose: The purpose of this lesson is to describe hazardous effects that occur to aircraft during a thunderstorm.

Objective:

- Identify hazardous effects of thunderstorms on an aircraft

References for this lesson are as follows:

- Aeronautical Information Manual (AIM)
- AC 00-6, Aviation Weather
- American Meteorology Society (AMS), Glossary of Meteorology
- NWS: Jetstream: Online School for Weather

Thunderstorms

A **thunderstorm cell** is a storm produced by a cumulonimbus cloud, and always accompanied by lightning and thunder, usually with strong gusts of wind, heavy rain, and sometimes with hail.

Hazardous Effects of Thunderstorms

A thunderstorm can produce almost every aviation weather hazard including:

- Adverse winds
- Instrument Flight Rules (IFR) weather
- Turbulence
- Icing
- Lightning
- Hail
- Downburst/microburst
- Tornado
- Rapid pressure/altimeter changes

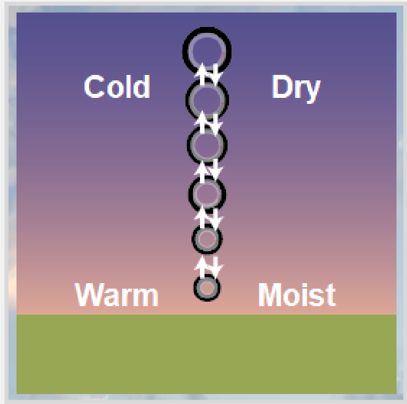
A thunderstorm is a storm produced by a cumulonimbus (CB) cloud, and is accompanied by some or all:

- Lightning
- Thunder
- Strong gusts of wind
- Heavy rain
- Hail

Controllers should anticipate pilot requests for deviation/routing around thunderstorms.

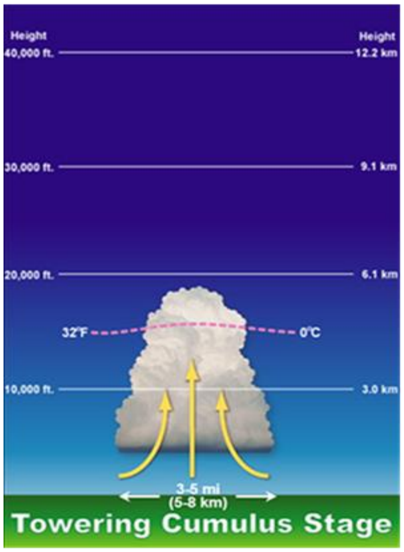
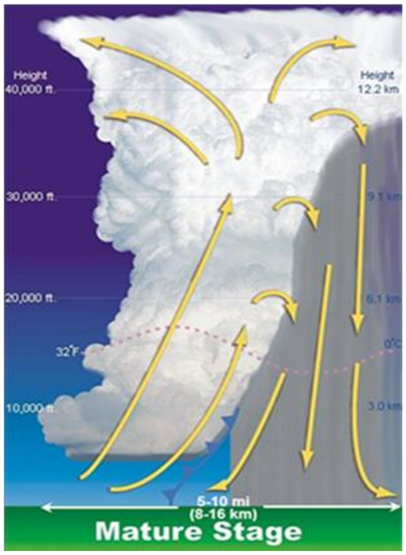
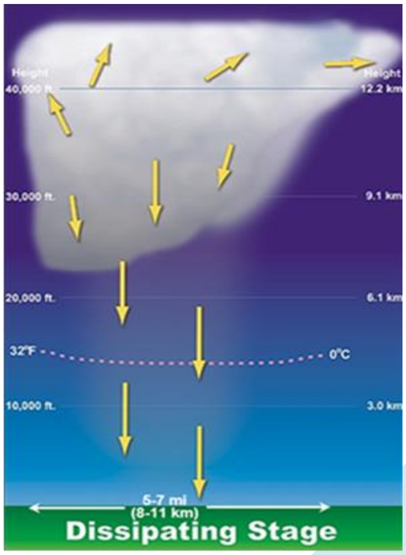
Ingredients for Thunderstorm Cell Formation

Thunderstorm cell formation requires the following three ingredients:

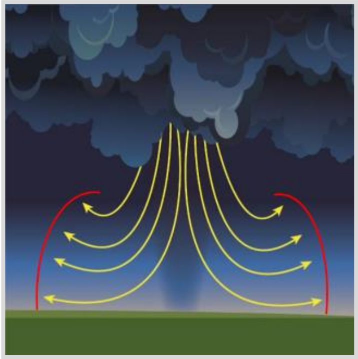
Water Vapor	Unstable Air	Lift
		
Sufficient water vapor ■ Measured using dew point	An atmospheric state warm air below cold air. Since warm air naturally rises above cold air (due to warm air being less dense than cold air), vertical movement and mixing of air layers can occur.	Lifting mechanism(s) strong enough to release the instability ■ Converging winds around surface lows ■ Fronts

Lifecycle Stages of a Thunderstorm Cell

A thunderstorm cell goes through these three distinct stages during its lifecycle, which typically lasts a total of 30 minutes.

Towering Cumulus Stage	Mature Stage	Dissipating Stage
■ Updrafts can have speeds greater than 3,000 feet per minute, which can exceed the ability of certain aircraft to out climb them	■ Precipitation downdraft reaches the surface ■ Leading edge of downdraft air is called a "gust front" ■ Weather hazards reach peak intensity	■ Precipitation tapers off and ends ■ Cloud gradually vaporizes from below, leaving only a remnant anvil cloud
		

Downburst



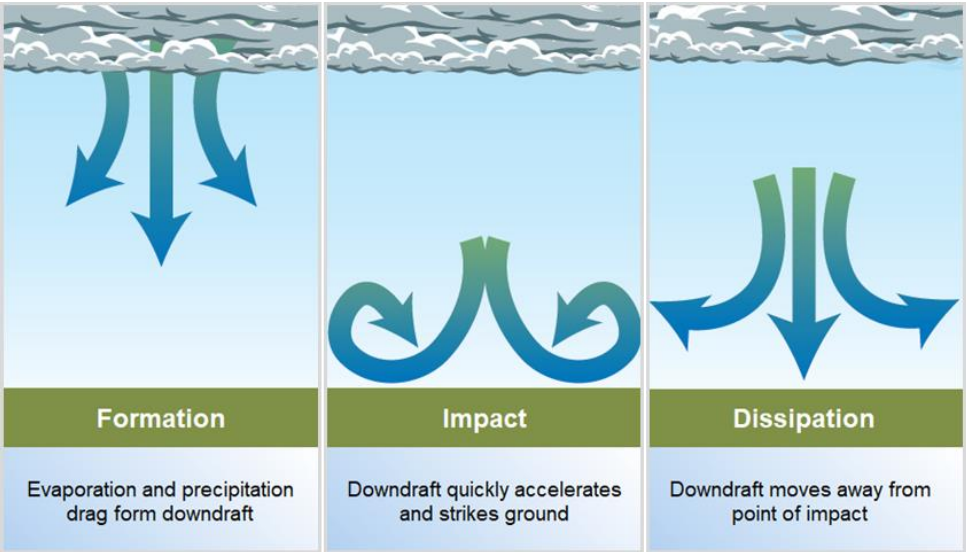
A **downburst** is a strong downdraft that induces an outburst of damaging winds on or near the ground.

- Damaging winds are highly divergent
  - Straight
  - Curved
- Sizes of downbursts vary from:
  - ½ mile or less *(to)*
  - More than 10 miles
- Intense downbursts often cause widespread damage
- Damaging winds
- Downbursts are an extreme hazard to flight, in particular to landing and departing aircraft

Microburst ≤ 2.5 miles in diameter	**Macroburst >2.5 miles in diameter**
A microburst is a small downburst with outbursts of damaging winds extending 2.5 miles or less. In spite of its small horizontal scale, an intense microburst could induce wind speeds as high as 150 knots.	A macroburst is a convective downdraft with an effected outflow area greater than 2.5 miles wide and peak winds lasting between 5 and 20 minutes. Intense macrobursts may cause tornado-force damage of up to F3 intensity.

Downburst Lifecycle

A strong wind shear associated with a downburst can cause aircraft accidents.

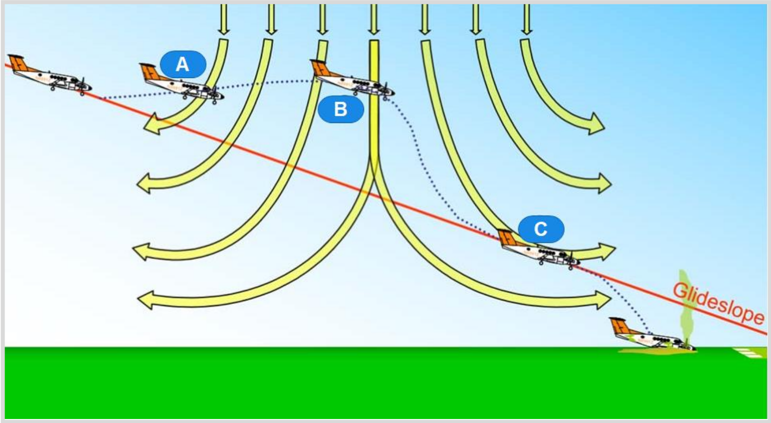


Landing in a Microburst

At point A, the aircraft enters the microburst zone, where a headwind causes it to balloon above the normal glideslope.

At the center of the microburst, ***point B***, there is a downdraft, which causes the aircraft to sink.

At point C, the aircraft enters the most lethal zone, where a sudden tailwind causes the aircraft to lose airspeed and crash.



A downburst is especially dangerous to aircraft when it is encountered during takeoff or during the approach to landing.

- During these phases, the aircraft is operating at relatively slow speeds
- A major change of wind velocity can lead to a loss of lift and a crash

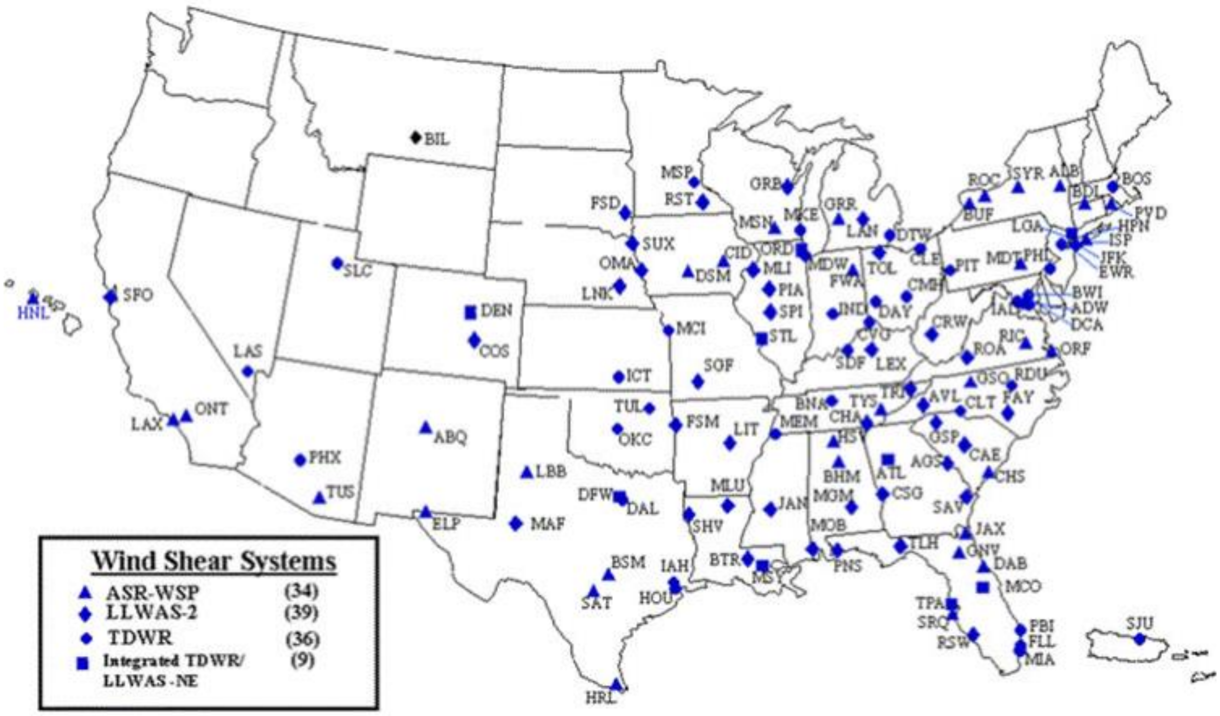
Pilots should be alert for a downburst early in the approach phase and be ready to initiate a missed approach at the first indication.

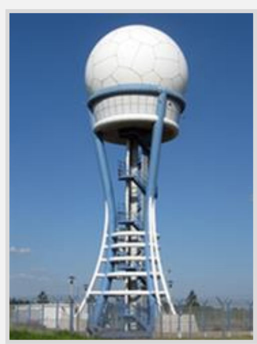
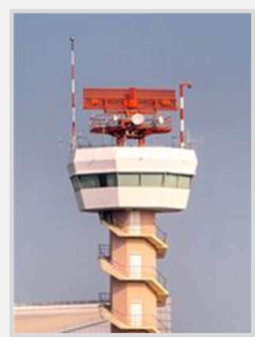
- It may be impossible to recover from a downburst encounter at low altitude

***Video** – Crash of L-1011 at Dallas-Fort Worth – On August 2, 1985, an L-1011 landing at Dallas-Fort Worth International Airport encountered a microburst that resulted in the deaths of 137 people. This video is a faithful recreation of that tragedy. It provides three views of the final 2 minutes before impact.* (6:23 mins.)

Wind Shear Product Systems

To warn terminal controllers and pilots of microbursts, wind shear, and gust fronts, the FAA has installed three wind shear product systems. Tower controllers relay specific alerts from these systems to pilots via voice radio communication.



LLWAS	TDWR	ASR-WSP
		
Low-Level Wind Shear Alert System (LLWAS) detects surface wind shear through the use of up to 32 remote wind sensors situated around an airport.	Terminal Doppler Weather Radar (TDWR) consists of specialized weather radars used to detect microbursts, gust fronts, and convective storms along arrival and departure paths.	Airport Surveillance Radar (ASR)-Weather System Processor (WSP) is an enhanced weather processor for the air traffic control radar that includes Doppler wind estimation for the detection of LLWS.

Video – *Vectoring Around Thunderstorms* (0:50 mins.)

Knowledge Check I

REVIEW what you have learned so far about thunderstorms. ANSWER the questions listed below.

1. What does a thunderstorm cell formation require besides unstable air and lift? *(Select the correct answer.)*
   - ❑ An inversion
   - ❑ Stratiform clouds
   - ❑ **Water vapor**

2. Which of the following weather conditions may be impossible to recover from when encountered by an aircraft flying at low altitude? *(Select the correct answer.)*
   - ❑ Headwind
   - ❑ **Microburst**
   - ❑ Outburst

3. Why is an aircraft in danger when encountering a downburst during takeoff or the approach to landing? *(Select the correct answer.)*
   - ❑ Aircraft is operating at fast speeds, a sudden change in wind direction can throw the aircraft off course
   - ❑ As the aircraft hits the downburst, it causes the aircraft to balloon above the glideslope
   - ❑ **Aircraft is operating at relatively slow speeds; if a major change in wind velocity occurs, it can lead to loss of lift and a crash**
   - ❑ As the aircraft encounters the downburst, it loses climbing capabilities

Thunderstorms Summary

Knowledge of thunderstorms and the associated hazards is critical to the safety of flight. If conditions are favorable, it may take little time for a thunderstorm to form and can lead to an aircraft accidents or fatalities. As a controller, you should anticipate requests and provide guidance to any aircraft during thunderstorms.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ Review content presented in ***Icing*** and ***Thunderstorms*** lessons ■ Navigate to the ***Parking Lot*** link within Blackboard and review any student questions ■ Address ***Parking Lot*** questions and facilitate a brief discussion of the lesson content	Facilitated Discussion **EST. RUN TIME** 20 mins.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Low-Level Wind Shear (LLWS)*** lesson in Blackboard and ***Name that Hazard!*** activity in ***Exercises and Activities*** folder in Blackboard ■ Instruct students to navigate to the ***Low-Level Wind Shear (LLWS)*** lesson in Blackboard ■ Instruct students to work individually through the lesson content ■ Upon completion of the lesson, instruct students to proceed to ***Name that Hazard!*** activity in the ***Exercises and Activities*** folder in Blackboard ■ The activity may be performed individually ■ Instruct students to answer each question ■ At the end of the activity, the activity will evaluate the students' performance ■ Suggest allowing opportunities to repeat the activity during periods of down time	Blackboard and Activity **EST. RUN TIME** 10 mins.

LOW-LEVEL WIND SHEAR (LLWS)

Purpose: The purpose of this lesson is to demonstrate how low-level wind shear affects aircraft during takeoff and landing.

Objective:

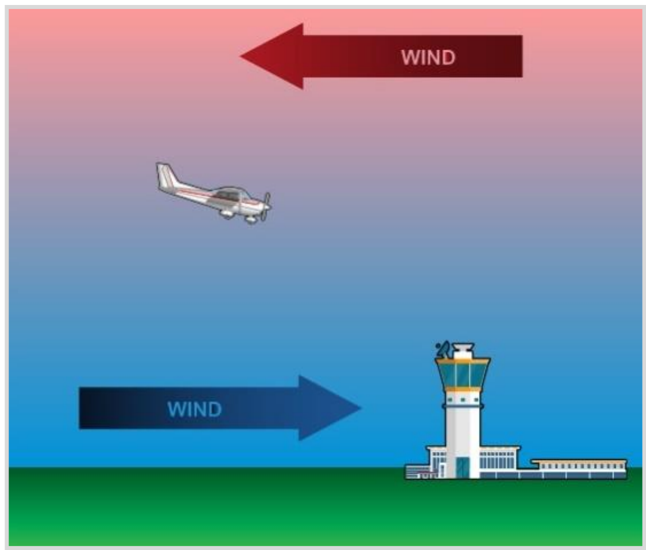
- Identify the effects of low-level wind shear (LLWS) on aircraft

References for this lesson are as follows:

- AC 00-6, Aviation Weather
- UCAR/COMET: Writing TAFS For Winds and LLWS

LLWS

Low-level wind shear is a wind shear below 2,000 feet AGL, other than convectively induced, exceeding 10 knots per 100 feet.



LLWS is especially dangerous during takeoff and landing.

- During this phase, aircraft are operating at relatively slow speeds
- A change in wind velocity will cause aircraft to move above or below its glideslope

Wind Shear – Change from Headwind to Tailwind on Landing

While an aircraft is on approach, a shear from a headwind to a tailwind causes:

- Airspeed to decrease
- Nose to pitch down
- Aircraft to drop below the glideslope

If the pilot pulls the nose up to compensate, airspeed will be reduced even further.

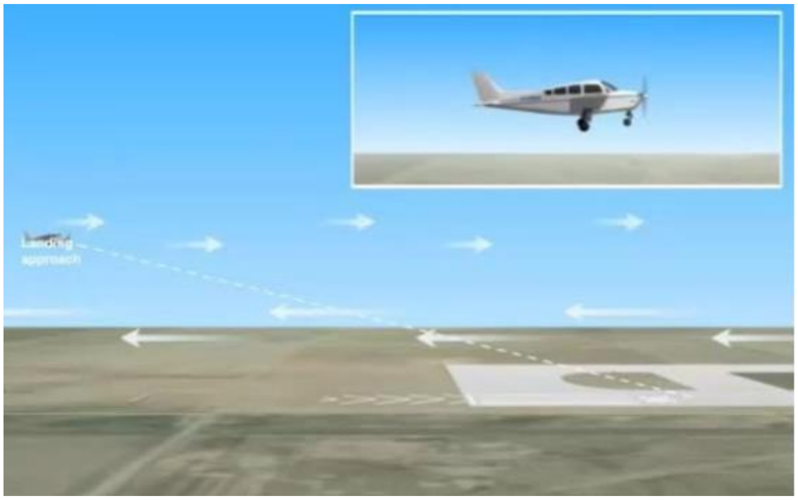
Wind Shear – Change from Tailwind to Headwind on Landing

Conversely, if the wind is calm, or there is a slight tailwind, and the flow shears into a headwind, this causes:

- Airspeed to increase
- Nose to pitch up
- Aircraft to rise upward above the glideslope
- Aircraft to land long and possibly run out of runway

Small, general aviation aircraft are much more prone to the effects of LLWS than large commercial aircraft because their approach speeds are much closer to their stall speeds.

Example: It may only take 15 knots (kt.) of airspeed loss to cause a Cessna 172 to stall, as opposed to greater than 42 kt. for a Boeing 737.



Knowledge Check J

REVIEW what you have learned so far about LLWS. ANSWER the questions listed below.

1. Which of the following effects occur while an aircraft is on approach and encounters a shear from a tailwind to a headwind? *(Select all correct answers that apply.)*
   - ❑ **Increased airspeed**
   - ❑ Decreased airspeed
   - ❑ Nose pitches down
   - ❑ **Nose pitches up**
   - ❑ **Aircraft rises upward above glideslope**
   - ❑ Aircraft drops below glideslope

2. Why are small general aviation aircraft more prone to the effects of LLWS than large commercial aircraft? *(Select the correct answer.)*
   - ❑ Aircraft will land long and run out of runway
   - ❑ Pilots compensate by increasing power
   - ❑ **Approach speeds are much closer to their stall speed**

Low-Level Wind Shear Summary

Controllers must be alert to the effects a low level wind shear could potentially cause small general aviation aircraft. Knowing how an aircraft typically responds when encountering a low level wind shear will allow you to be prepared to react if the aircraft requires assistance.

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ ***Note: Name that Hazard!*** activity should already have been enabled in Blackboard, if not ensure it is enabled ■ Instruct students to navigate to the ***Exercises and Activities*** folder in Blackboard ■ Instruct students to locate student activity ***Name that Hazard!*** ■ The activity may be performed individually ■ Instruct students to answer each question ■ At the end of the activity, the activity will evaluate the students' performance ■ Suggest allowing opportunities to repeat the activity during periods of down time	Activity **EST. RUN TIME** 15 mins.

ACTIVITY: NAME THAT HAZARD! (ANSWER KEY)

Note: *The questions in the key and their distractors may appear in a different order than displayed here due to activity question randomization.*

Question	Answer
1. **Definition:** This type of wind blows not parallel to the runway or path of an aircraft. **Risk:** The aircraft may drift off the side of the runway or side load on landing gear, which leads to gear collapse.	**Crosswind** Gust Tailwind Variable wind
2. **Definition:** This type of weather is based at the Earth's surface and forms when the temperature and dew point of the air become nearly identical. **Risk:** This hazard forms very rapidly and reduces horizontal visibility to less than 5/8 of a statute mile.	**Fog** Precipitation Blowing snow Volcanic ash cloud
3. **Definition:** This type of weather includes liquid or solid water particles that fall from the atmosphere and reach the ground. **Risk:** This phenomenon frequently produces IFR weather, which greatly reduces visibility.	**Precipitation** Fog Wind shear Volcanic ash cloud
4. **Definition:** This phenomenon consists of an irregular motion of an aircraft in flight caused by a rapid variation of atmospheric wind velocities. **Risk:** This may cause structural damage to aircraft and/or injury to its passengers.	**Turbulence** Macroburst Frontal zone Downburst

Question	Answer
5. **Definition:** This phenomenon consists of a change in wind speed and/or wind direction in a short distance, resulting in a tearing or shearing effect. **Risk:** This weather phenomenon, in combination with low-level temperature inversion, frontal zones, and clear air turbulence associated with the jet stream, can cause violent turbulence for aircraft.	**Wind shear** Macroburst Thunderstorm cell Precipitation
6. **Definition:** A condition that means the air density is reduced, which has an adverse impact on aircraft performance. **Risk:** This phenomenon can be hazardous during both takeoff and landing by reducing power and thrust and requiring a longer takeoff and landing roll.	**High density altitude** Temperature inversion Ceiling Indefinite ceiling
7. **Definition:** This phenomenon forms on and sticks to the outside of an aircraft when supercooled water strikes the aircraft's airframe. **Risk:** Can greatly disrupt airflow and may go unseen. Can be difficult to remove and can spread beyond reach of equipment.	**Structural icing** Precipitation Blowing snow Wind shear
8. **Definition:** This weather phenomenon is produced by a cumulonimbus cloud accompanied by lightning and thunder, usually with strong gusts of wind, heavy rain, and sometimes with hail. **Risk:** This hazardous weather can produce adverse winds, IFR weather, turbulence, icing, lightning, hail, downburst/ microburst, tornados, and rapid pressure/altimeter changes.	**Thunderstorm** Temperature inversion Indefinite ceiling Mechanical turbulence
9. **Definition:** A type of wind shear below 2,000 feet AGL, other than convectively induced, exceeding 10 knots per 100 feet. **Risk:** This phenomenon is most dangerous during takeoff and landing and could cause the aircraft to move above or below its glideslope, possibly leading to crash.	**Low-Level Wind Shear** Tailwind Crosswind Variable wind

SUMMARY

This purpose of this module was to identify characteristics of hazardous weather and explain how they affect aviation.

In accordance with Aeronautical Information Manual (AIM); American Meteorology Society (AMS), Glossary of Meteorology; AC 00-6, Aviation Weather; AC 00-45H, Aviation Weather Services; NASDAC Review of NTSB Weather Related Accidents; UCAR/COMET: Writing TAFS for Winds and LLWS; Mountain Waves and Downslope Wind; Forecasting Aviation Icing: Ice Type and Severity; AOPA Safety Advisor: Aircraft Icing; FMH-1, Surface Weather Observations and Reports; and NWS: Jetstream: Online School for Weather, you should now be able to:

- Define adverse weather conditions that can affect an aircraft
- Define adverse wind effects that affect aircraft
- Describe IFR weather hazards during aircraft takeoff and landing
- Identify types of turbulence that affect aircraft
- Identify causes of aircraft turbulence
- Describe effects of high density altitude on aircraft
- Identify characteristics of icing
- Identify how icing affects an aircraft
- Identify hazardous effects of thunderstorms on an aircraft
- Identify the effects of low-level wind shear (LLWS) on aircraft

<table>
<tr><th>FACILITATOR INSTRUCTIONS</th><th>DELIVERY METHOD</th></tr>
<tr><td rowspan="3">Navigate to the Parking Lot link within Blackboard and review any student questions
Address Parking Lot questions and facilitate a brief discussion of the lesson content
Instruct students to prepare for the End-of-Module test by putting away their Student Guides</td><td>Facilitated Discussion</td></tr>
<tr><td>EST. RUN TIME</td></tr>
<tr><td>30 mins.</td></tr>
</table>

FACILITATOR INSTRUCTIONS	DELIVERY METHOD
■ **ENABLE *Hazardous Weather End-of-Module Test*** link in Blackboard ■ Instruct students: ○ Clear desks ○ Do not write anything during or after the test ○ Navigate to the ***Hazardous Weather End-of-Module Test*** link in Blackboard ○ Once they are satisfied with their responses, click “Save and Submit;” do not click “OK” to review results until directed to do so ○ Choose “Cancel” if they receive a warning message that the test has unanswered questions; choosing OK will submit the test and not allow them to go back and answer the questions ○ Leave the room after submitting the test and return at the “Be Back” time ■ ***Note:*** *This test is scored but not graded* ■ During test, monitor students to ensure a secure testing environment ■ Identify the most commonly missed questions by reviewing student statistics in Blackboard ■ Instruct students to click “View Results” when ready to review commonly missed questions ■ Review commonly missed questions with students	Blackboard Assessment **EST. RUN TIME** 30 mins.

END-OF-MODULE TEST (ANSWER KEY)

Note: *Test questions in Blackboard are presented to the students in random order. Please be aware the test key question order will not match the student version.*

1. Which type of adverse weather can cause an aircraft to bounce on the runway when taking off into a headwind? *(Select the correct answer.)*
   - ❑ **<u>Gust</u>**
   - ❑ Wind shift
   - ❑ Tailwind
   - ❑ Crosswind

   Reference(s): AMS Glossary of Meteorology

2. A sudden wind shift, even at low speeds, can be hazardous on takeoff and landing because it can ________. *(Select the correct answer.)*
   - ❑ **<u>Quickly become a crosswind or tailwind</u>**
   - ❑ Cause engine failure
   - ❑ Cause wing failure
   - ❑ Cause the plane to bounce on the runway

   Reference(s): AIM, Pilot/Controller Glossary

3. Which of the following types of precipitation does **NOT** commonly produce IFR weather? *(Select the correct answer.)*
   - ❑ **Hail**
   - ❑ Rain
   - ❑ Drizzle
   - ❑ Snow

   Reference(s): FMH-1, Appendix A

4. Which type of turbulence intensity is directly related to wind speed and roughness of the obstructions? *(Select the correct answer.)*
   - ❑ **Mechanical turbulence**
   - ❑ Convective turbulence
   - ❑ Aircraft turbulence
   - ❑ Wind shear turbulence

   Reference(s): AC 00-6, Aviation Weather, Chap. 9

5. Which of the following is a characteristic of a temperature inversion? *(Select the correct answer.)*
   - ❑ **Increased temperatures with increased altitude**
   - ❑ They cannot form along frontal zones
   - ❑ Decreased temperatures with increased altitude
   - ❑ They never occur at or near the surface of the Earth

   Reference(s): AMS Glossary of Meteorology

6. Which of the following is **NOT** a characteristic of high density altitude? *(Select the correct answer.)*
   - ❑ **Altitude drops abruptly**
   - ❑ A longer takeoff and landing roll are required
   - ❑ It reduces power and thrust
   - ❑ It reduces an aircraft's performance capability

   Reference(s): AC 00-6, Aviation Weather, Chap. 3

7. What causes an abrupt crystallization and ice to form when an aircraft flies through cumulus clouds? *(Select the correct answer.)*
   - ❑ **Supercooled water**
   - ❑ Rime ice
   - ❑ Clear ice
   - ❑ Mixed ice

   Reference(s): AC 00-6, Aviation Weather, Glossary; AOPA Safety Advisor: Aircraft Icing

8. When deicing or anti-icing equipment fails to reduce or control the icing hazard, the icing is categorized as ________. *(Select the correct answer.)*
   - ❑ **Severe**
   - ❑ Extreme
   - ❑ Moderate
   - ❑ Heavy

   Reference(s): AIM, Chap. 7

9. Which stage of a thunderstorm is characterized by updrafts exceeding 3,000 feet per minute? *(Select the correct answer.)*
   - ❑ **Towering cumulus**
   - ❑ Mature
   - ❑ Virga
   - ❑ Dissipating

   Reference(s): AMS Glossary of Meteorology; NWS: Jet Stream: Online School for Weather

10. Which of the following poses more danger for a small aircraft when encountering a wind shear? *(Select the correct answer.)*
    - ❑ **Takeoff and landing**
    - ❑ While en route
    - ❑ While in a holding pattern
    - ❑ At levels above 2,000 feet

    Reference(s): AC 00-6, Aviation Weather