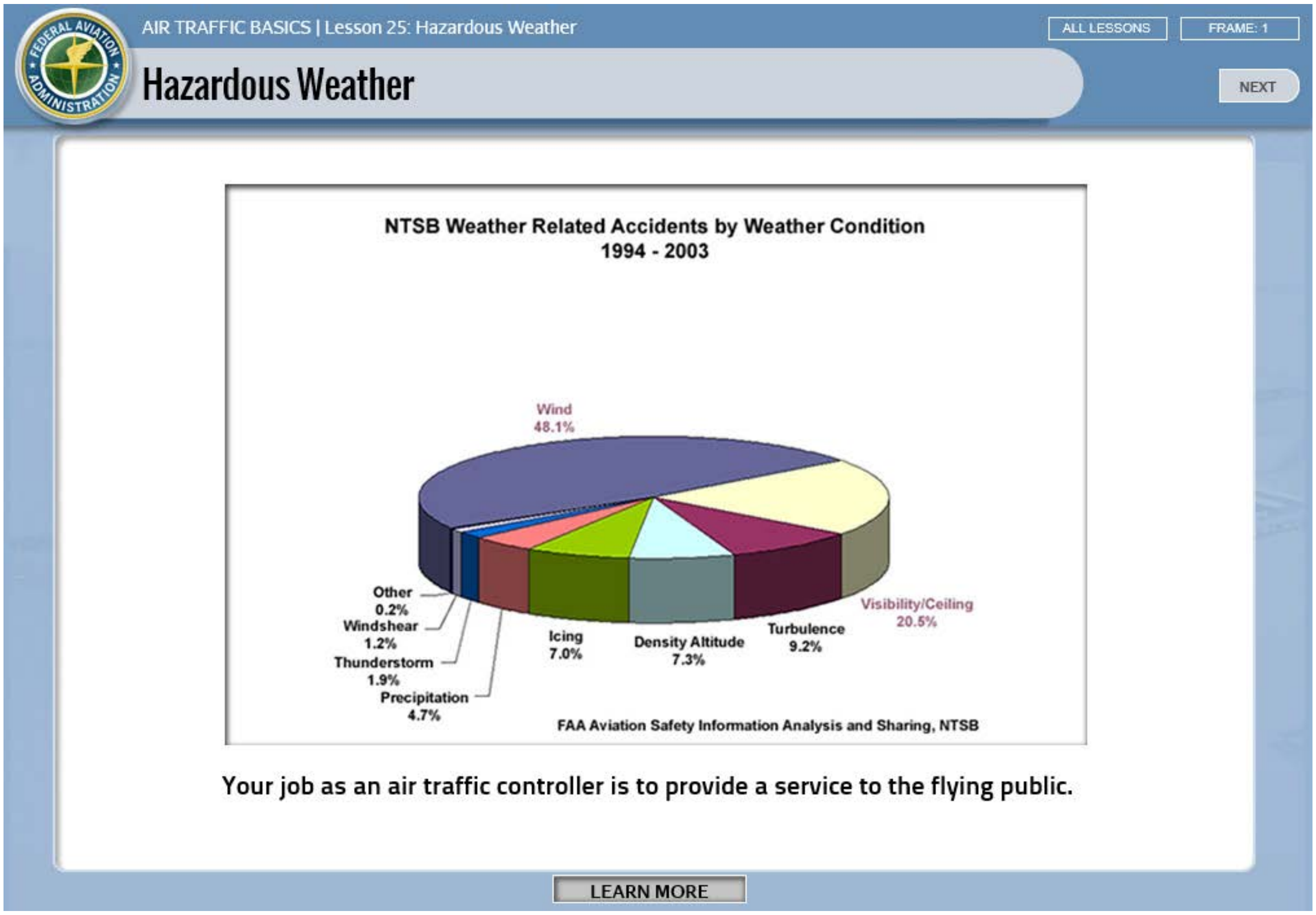
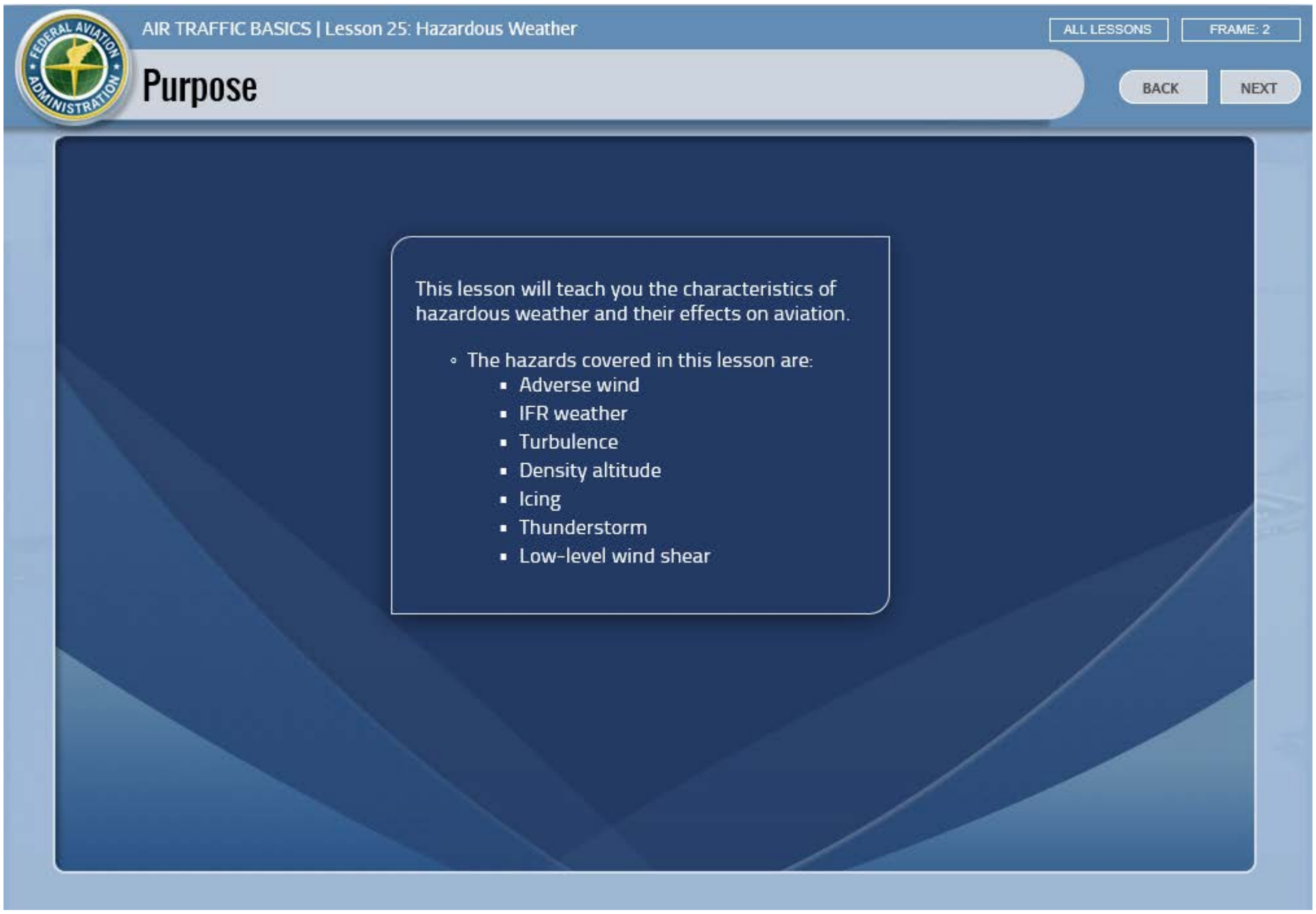


Weather is perhaps the most significant factor, which affects the flow of air traffic and accounts for a significant percentage of all accidents.

- You must be able to identify the characteristics of hazardous weather and their effects on aircraft.
- FAA Order 7110.65 states that controllers shall advise pilots of hazardous weather that may affect operations within 150 NM of their sector or area of jurisdiction.


AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather
ALL LESSONS
FRAME: 2
Purpose
BACK
NEXT
This lesson will teach you the characteristics of hazardous weather and their effects on aviation.
The hazards covered in this lesson are:
Adverse wind
IFR weather
Turbulence
Density altitude
Icing
Thunderstorm
Low-level wind shear

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 3

BACK NEXT

Objectives

In this lesson, you will identify the characteristics and effects of hazardous weather that impact aviation.

You will meet these objectives in accordance with the following references:

- AC 00-6, Aviation Weather
- FMH1, Surface Weather Observations and Reports
- Aeronautical Information Manual (AIM)

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 4

BACK NEXT

Aviation Weather Hazards

Factors

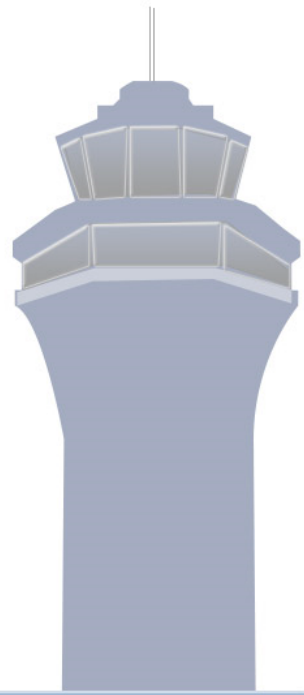
An aviation weather hazard is an atmospheric condition which, when encountered in flight, can potentially cause damage to the aircraft, personal injury, a crash, or death.

Pilot and aircraft capabilities are factors which must be considered.

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

Factors that influence aviation weather safety include:

- Pilot ratings and experience:
  - Instrument rated
  - Visual flight rules only
- Aircraft design and performance specifications:
  - Power
  - Speed
  - Range
  - Service ceiling
- Onboard equipment:
  - De-ice/anti-ice
  - Navigational aids (NAVAIDs)
  - Autopilot
  - Radar
  - Lightning detector (Stormscope or Strikefinder)
  - Uplink weather



AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 5

Adverse Winds

BACK NEXT

General

Adverse wind is responsible for most weather-related accidents.

- Particularly General Aviation (GA) pilots flying aircraft with lower crosswind and tailwind threshold values.
- Takeoff and landing are the most critical periods of any flight and are most susceptible to adverse wind.

Adverse winds often trigger air traffic management decisions that adversely impact traffic.

- Change of runway configuration
  - If there is only one runway, wind determines which direction planes will land or whether they can land at all.
- Reduced arrival rates
  - This increases fuel consumption, and therefore costs.
  - Can cause a ripple throughout the National Airspace System

Adverse wind phenomena include:

- Crosswinds
- Gusts
- Tailwind
- Variable wind
- Sudden wind shift

NASDAC Review of NTSB Weather-Related Accidents; UCAR/COMET: Writing TAFs for Winds and LLWS

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 6

BACK NEXT

Adverse Winds

Crosswind – Hazardous Effects

When used in aviation, refers to a wind that is not parallel to the runway or path of an aircraft.

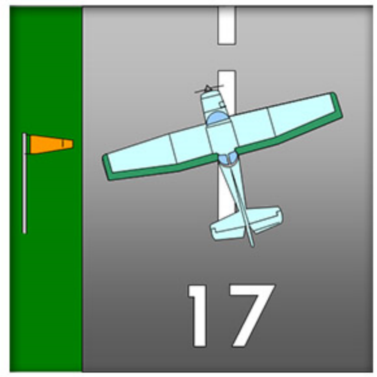
Airplanes take off and land more efficiently when oriented into the wind.

- The aircraft's groundspeed is minimized.
- Less runway is required to achieve lift-off.
- The pilot has more time to make adjustments necessary for a smooth landing.

As the wind turns more perpendicular to the runway to become a crosswind, airplane performance gradually degrades.

- 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 might occur, leading to gear collapse.

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



AMS Glossary of Meteorology; UCAR/COMET: Writing TAFs for Winds and LLWS
CROSSWIND EFFECTS

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ALL LESSONS FRAME: 7

Adverse Winds

BACK NEXT

Crosswind Landing Examples

You will now watch the video compilation of jet aircraft landing in severe crosswinds.

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ALL LESSONS FRAME: 8

Adverse Winds

BACK NEXT

Gusts

A sudden, brief increase in the speed of the wind

AMS Glossary of Meteorology; UCAR/COMET: Writing TAFs for Winds and LLWS

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 9

Adverse Winds

BACK NEXT

Gusts – Hazardous Effects

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

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

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 10

BACK NEXT

Adverse Winds

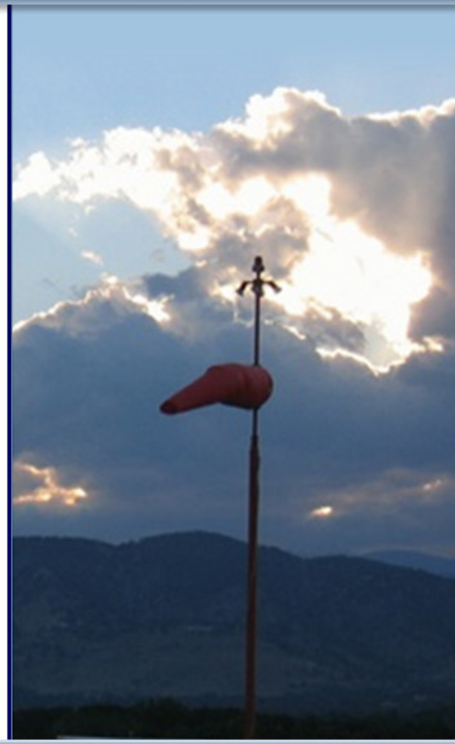
Tailwind Hazardous Effects

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

A tailwind can be hazardous during both takeoff and landing.

- **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.**
  - **May be insufficient to clear obstacles at the end of the runway.**
- **A longer landing roll is required.**
  - **Aircraft must maintain 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.**

AMS Glossary of Meteorology



Adverse Winds

Variable Wind/Sudden Wind Shift – Hazardous Effects

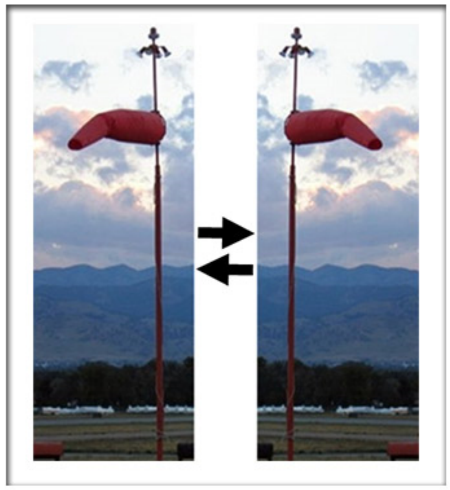
Variable wind – Wind that changes direction frequently

Sudden wind shift – A line or narrow zone along which there is an abrupt change of wind direction

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.**

AMS Glossary of Meteorology



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ALL LESSONS FRAME: 12

Adverse Winds

BACK NEXT

Airplane Size and Wind

Small airplanes are more affected by tailwinds and crosswinds during takeoff and landing than large airplanes.

- **This is because small airplanes generally have slower takeoff and approach speeds than larger aircraft.**

UCAR/COMET: Writing TAFs for Winds and LLWS

IFR Weather

BACK NEXT

General

IFR Weather – Weather conditions below the minimum for flight under visual flight rules

- **En Route or Terminal weather conditions of sufficiently low visibility to require the operation of aircraft under instrument flight rules (IFR)**

NOTE: Some IFR weather phenomena produce additional hazards which will be discussed in this lesson.

AMS Glossary of Meteorology

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 14

IFR Weather

BACK NEXT

Beech Model 18 (VFR into Fog)

Effects of IFR Weather

IFR weather is primarily a hazard during takeoff and landing.

Continued visual flight into IFR weather is the single greatest cause of fatal accidents.

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.

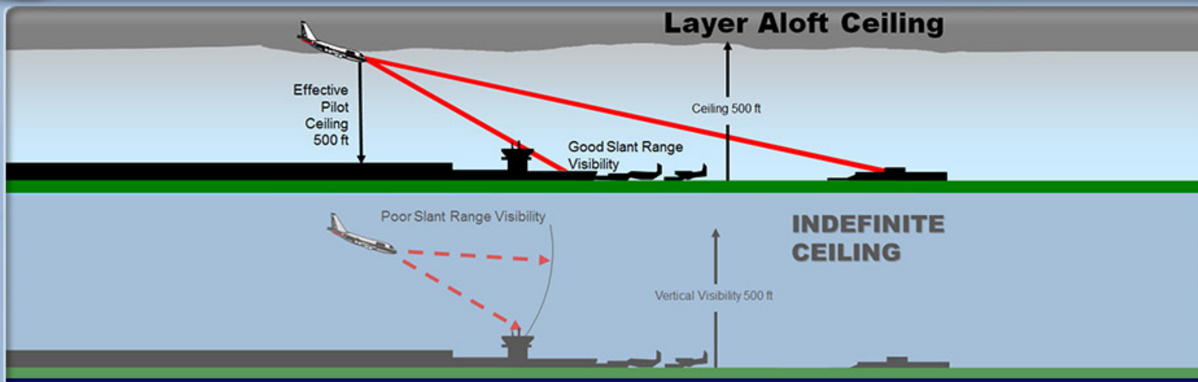
AC 00-6, Chap. 13

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 15

IFR Weather

BACK NEXT



Layer Aloft Ceiling vs. Indefinite Ceiling

Ceiling – The lowest layer aloft reported as broken or overcast; or the vertical visibility into an indefinite ceiling

Indefinite ceiling – The ceiling classification that is applied when the reported ceiling value represents the vertical visibility upward into a surface-based obscuration such as: fog, mist, haze, smoke, dust, etc.

An indefinite ceiling is more hazardous than an equal ceiling caused by a layer aloft.

- Once a pilot descends below a ceiling caused by a layer aloft, he can see both the ground below and the runway ahead.
- An indefinite ceiling restricts the pilot's slant-range (air-to-ground) visibility.
  - Thus, he may not see the runway ahead after he descends below the indefinite ceiling.

FMH1, pp. A-3, A-5; AC 00-6, Chap. 13

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 16

IFR Weather

BACK NEXT

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 differs from clouds only in that its base must be at the earth's surface while clouds are above the surface.

Fog forms when the temperature and dew point of the air become identical (or nearly so).

Fog is the most common and persistent weather hazard encountered in aviation.

- The speed with which fog can form makes it especially hazardous.

FMH1, p. A-4; AMS Glossary of Meteorology

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 17

IFR Weather

BACK NEXT

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.

- Rain seldom reduces surface visibility below 1 mile except in brief, heavy showers.
  - When rain streams over the aircraft windshield, freezes on it, or fogs over the inside surface, the pilot's visibility to the outside is greatly reduced.
- Heavy snow may reduce visibility to zero.

FMH1, p. A-7; AC 00-6, Chap. 13

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS | FRAME: 18

IFR Weather

BACK | NEXT

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 blow about in such quantities that the reported horizontal visibility is reduced to less than 7 statute miles.

Light, dry, powdery snow is most prone to being blown by the wind.

- **It obscures the sky and can reduce surface visibility to near zero.**
  - **Called a "whiteout"**
  - **Visibility improves rapidly when the wind subsides.**

NOTE: Snow falling from clouds is not required to produce blowing snow. In fact, skies above the blowing snow could be clear. Blowing snow is one of the classic requirements of a blizzard.

FMH1, p. A-2; AC 00-6, Chap. 13; AMS Glossary of Meteorology

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 19

IFR Weather

BACK NEXT

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 may not be visible, especially at night or in instrument conditions.

- **Even if visible, it is difficult to distinguish visually between an ash cloud and an ordinary cloud.**
- **May not be detected by aircraft or ATC radar**

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.**
- **Ash covering a runway can cover 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 FMH-1, p. A-11; AIM, Chap. 7

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 20

IFR Weather

BACK NEXT

Mountain Obscuration

A condition in which pilots in flight are unable to maintain visual contact with mountains or mountain ridges (due to clouds, precipitation, or obscurations)

The large elevation variations around mountains can cause surface weather observations to mislead.

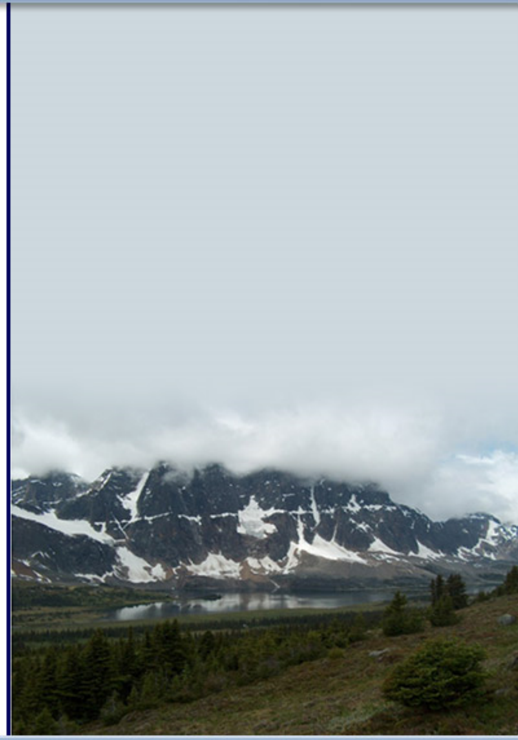
- **Weather stations (which are typically located in the valley) may report a VFR ceiling, while a hiker on the mountain is enveloped in fog.**
  - **A pilot flying up the valley beneath the clouds could run out of room and crash.**

Pilots should beware if operating VFR above clouds in mountainous terrain.

- **They could be flying closer to the mountains than they think because the tops are hidden in a cloud deck below.**

NOTE: AIRMETs are issued for widespread mountain obscuration and will be covered later.

AIM, Chap. 7

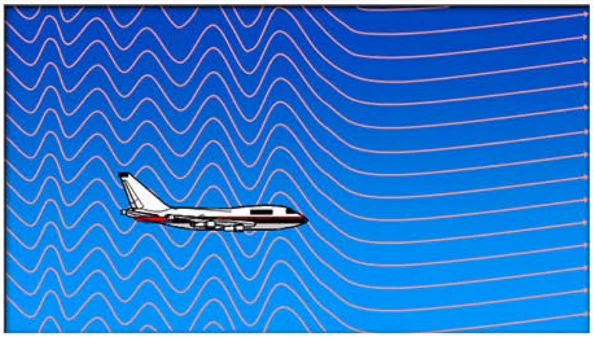


AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 21

Turbulence

BACK NEXT



General

Aircraft turbulence - 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 which cause structural damage to aircraft and/or injury to its passengers.

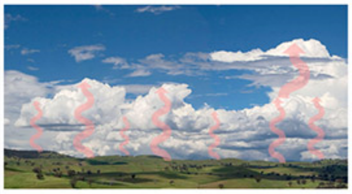
AMS Glossary of Meteorology; AC 00-6, Chap. 9

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

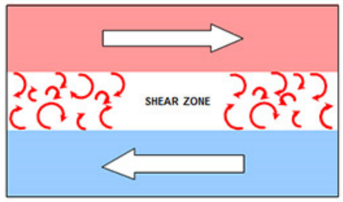
ALL LESSONS FRAME: 22

Turbulence

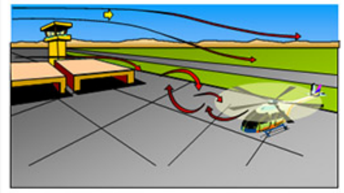
BACK NEXT



Convective currents



Wind shear



Obstructions to wind flow

Turbulence is caused by:

- Convective currents (called "convective turbulence")
- Obstructions to wind flow (called "mechanical turbulence")
- Wind shear

AC 00-6, Chap. 9

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 23

Turbulence

BACK NEXT

Convective Turbulence

Turbulent vertical motions that result from convective currents and the subsequent rising and sinking of air

Convective currents are most active on warm summer afternoons when winds are light.

The strength of convective turbulence 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.

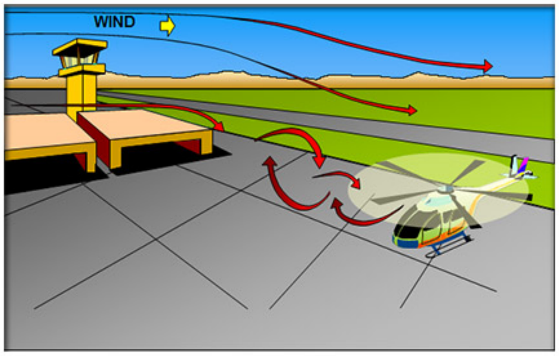
AC 00-6, Chap. 9

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS | FRAME: 24

Turbulence

BACK | NEXT



Mechanical Turbulence Caused by Obstruction

Turbulence caused by obstructions, such as trees, buildings, mountains, etc.

Obstructions to the wind flow disrupt the smooth flow of air.

- Aircraft flying through these areas experience mechanical turbulence.

Turbulence intensity is directly related to:

- Wind speed
- Roughness of the obstructions

AC 00-6, Chap. 9

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 25

Turbulence

BACK NEXT

Mechanical Turbulence – Mountain Wave

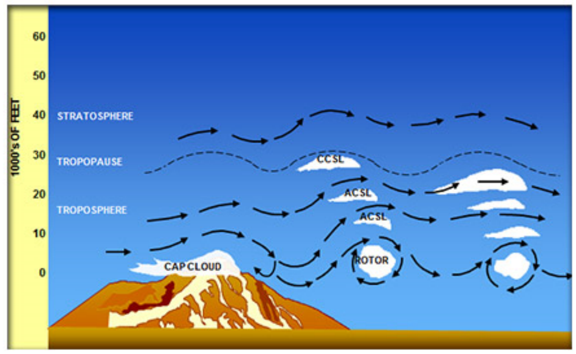
An atmospheric wave disturbance formed when stable air flow passes over a mountain or mountain ridge

Mountain waves develop above and downwind of mountains.

- **The waves remain nearly stationary while the wind blows rapidly through them.**
- **The waves may extend 600 miles or more downwind from the mountain range.**
- **Mountain waves frequently produce severe to extreme turbulence.**
  - **Location and intensity varies with wave characteristics.**

NOTE: Incredibly, "vertically-propagating" mountain waves have been documented up to 200,000 feet and higher.

AMS Glossary of Meteorology; AC 00-6, Chap. 9, glossary; UCAR/COMET: Mountain Waves and Downslope Wind



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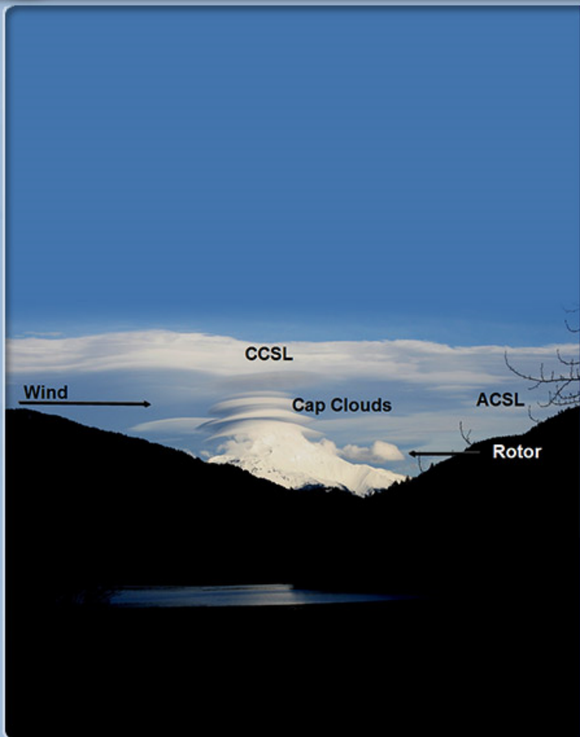
ALL LESSONS FRAME: 26

Turbulence

BACK NEXT



Mechanical Turbulence – Mountain Wave Clouds

A cloud that forms in the rising branches of mountain waves and occupies the crests of the waves. The most distinctive are the sharp-edged, lens-, or almond-shaped lenticular clouds.

When sufficient moisture is present in the upstream flow, mountain waves produce interesting cloud formations including:

- Cap clouds
- Cirrocumulus standing lenticular (CCSL)
- Altocumulus standing lenticular (ACSL)
- Rotor clouds

These clouds provide visual proof that mountain waves exist.

- However, clouds may be absent if the air is too dry.

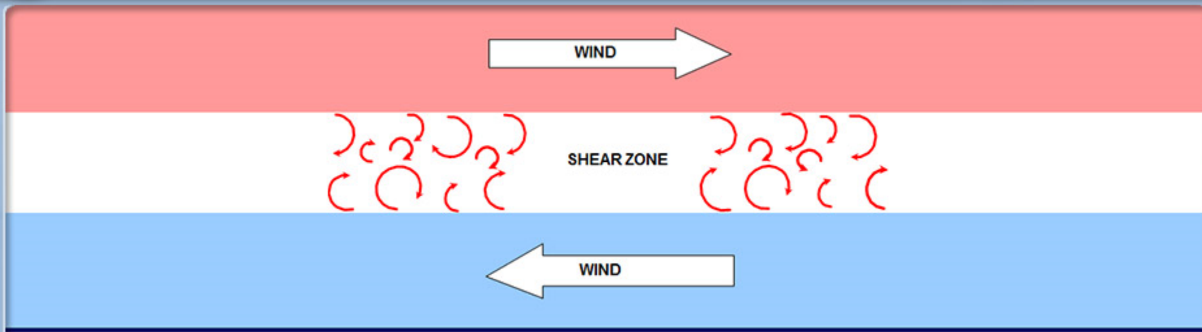
AMS Glossary of Meteorology

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 27

Turbulence

BACK NEXT



Wind Shear Turbulence

Wind shear – A change in wind speed and/or wind direction in a short distance resulting in a tearing or shearing effect.

Wind shear generates turbulence between two wind currents of different directions and/or speeds

- **Wind shear may be associated with either a wind shift or a wind speed gradient at any level in the atmosphere.**

JO 7110.65, Glossary

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 28

BACK NEXT

Turbulence

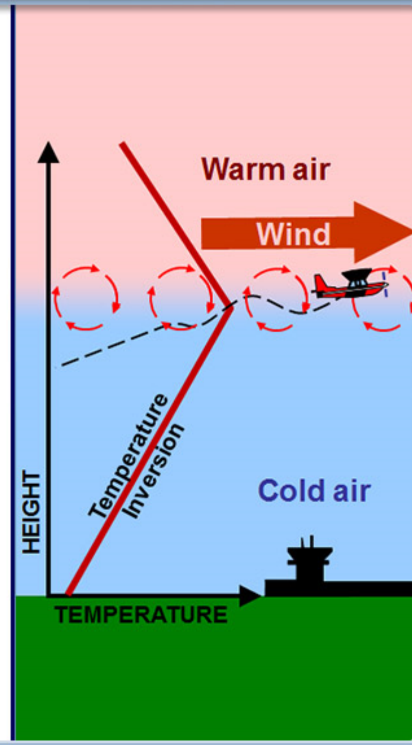
Temperature Inversion

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

AMS Glossary of Meteorology; AC 00-6, Chap. 9



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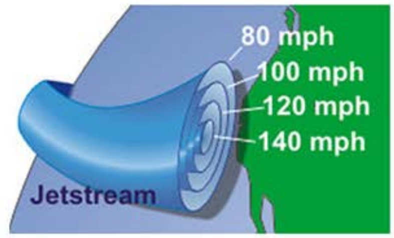
ALL LESSONS FRAME: 29

Turbulence

BACK NEXT



Clear Air Turbulence (CAT)

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. It can often affect an aircraft without warning.

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.

AMS Glossary of Meteorology; AC 00-6, Chap. 13

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 30

Turbulence

BACK NEXT

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 which causes rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. May be reported as light chop or moderate chop.

AIM, Chap. 7

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 31

Turbulence

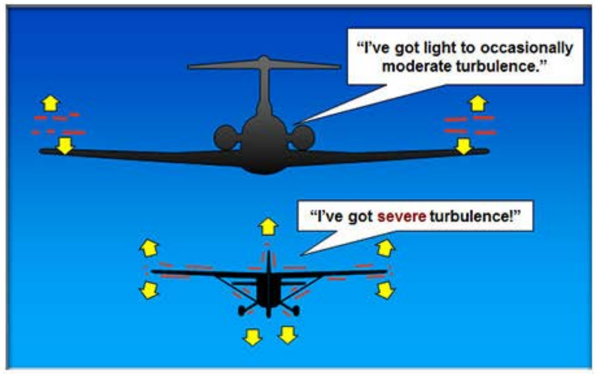
BACK NEXT

Turbulence Factors

Varies with:

- Intensity of the turbulence
- Aircraft size
- Wing loading
- Airspeed
- Aircraft attitude

AC 00-6, Chap. 9

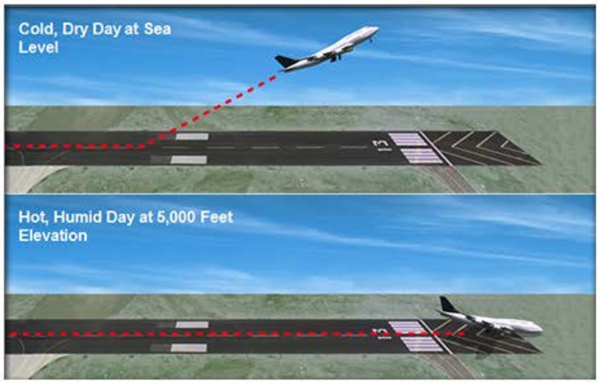


AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 32

High Density Altitude

BACK NEXT



Effects of High Density Altitude

A condition of the atmosphere that reduces an aircraft's performance capability below a level of standard performance at a specified altitude

High density altitude can be hazardous during both takeoff and landing.

- **It reduces power and thrust**
- **A longer takeoff and landing roll are required**

AC 00-6, Chap. 3.

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 33

Icing

BACK NEXT

Icing on Aircraft

In general, any deposit of ice forming on an object

AC 00-6, glossary

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 34

Icing

BACK NEXT

Structural Icing

Supercooled water – 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 and cumulus clouds.**
- **Aircraft flying through these clouds seed an abrupt crystallization of these droplets, resulting in the formation of ice on the aircraft.**

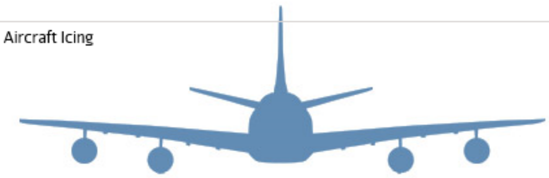
Structural icing is ice that sticks to the outside of an airplane.

- **Forms when supercooled water strikes the aircraft's airframe.**
- **Can accumulate on every exposed frontal surface of the airplane.**

Three types:

- **Rime**
- **Clear (or glaze)**
- **Mixed**

AC 00-6, glossary; AOPA Safety Advisor: Aircraft Icing



AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 35

Icing

BACK NEXT

PRINCIPLE OF SUPERCOOLING

You will now watch a video example of supercooled liquid water freezing as soon as it touches something solid.

AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 36

Icing

BACK NEXT

Structural Icing: Rime

Rime Ice - Rough, milky, opaque ice formed by the instantaneous freezing of small supercooled water droplets after they strike the aircraft

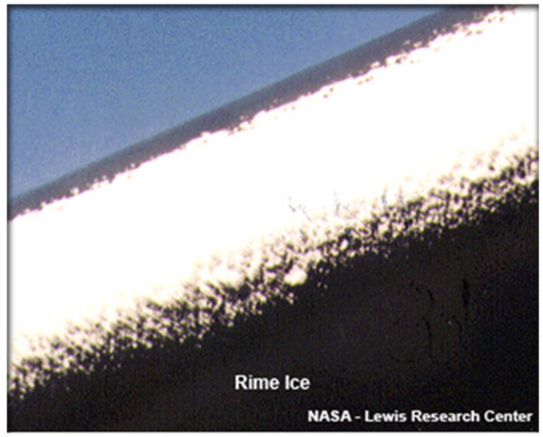
Favorable conditions:

- **Lower liquid water contents**
- **Small droplets**

Most common, but least serious type:

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

AIM, Pilot/Controller Glossary; UCAR/COMET: Forecasting Aviation Icing: Icing Type and Severity



AIR TRAFFIC BASICS | Lesson 25: Hazardous Weather

ALL LESSONS FRAME: 37

BACK NEXT

Icing

Structural Icing: Clear

Clear Ice (or glaze ice) - 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**
- **Pilot may not see it**
- **Can be difficult to remove**
- **Can spread beyond the reach of de-icing/anti-icing equipment**

AIM, Pilot/Controller Glossary; UCAR/COMET: Forecasting Aviation Icing: Icing Type and Severity

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Icing

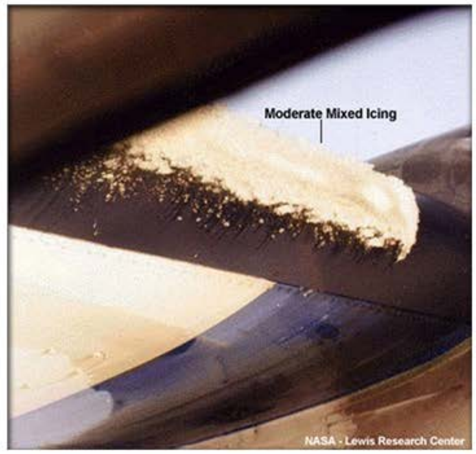
Structural Icing: Mixed

Mixed Ice - A mixture of clear ice and rime ice

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.

AIM, Pilot/Controller Glossary; UCAR/COMET: Forecasting Aviation Icing: Icing Type and Severity



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Icing

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 this 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 or flight diversion is necessary.
Severe	SEV	The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard. Immediate flight diversion is necessary.

AIM, Chap. 7

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Icing

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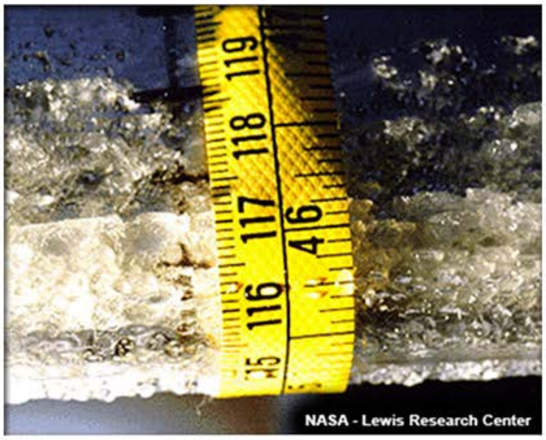

Icing Factors

Dependent upon:

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

UCAR/COMET: Forecasting Aviation Icing: Icing Type and Severity

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Icing

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Courtesy NASA


Courtesy FAA

Icing Factors

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)

Light turboprops are more susceptible to icing.

- They typically fly at lower altitudes where temperatures often support icing (0 to -20 degrees Celsius).

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Icing

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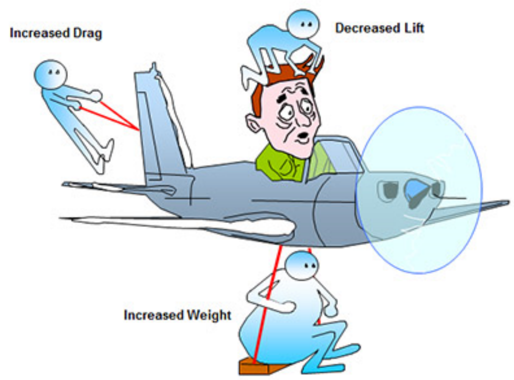
Icing Effects

Structural icing is a significant hazard.

- **It destroys the smooth flow of air, increasing drag while decreasing the ability of the airfoil to create lift.**
  - **The increased weight is insignificant compared to the airflow disruption.**
- **It can cause antennas to vibrate so severely that they break.**
- **It can block airflow into a pitot tube to cause false airspeed readings.**
- **In moderate to severe icing, a light aircraft can become so iced up that continued flight is impossible.**
  - **The airplane may stall at much higher speeds and, for certain aircraft types, lower angles of attack than normal.**
  - **It 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.

AC 00-6, Chap. 10; AOPA Safety Advisor: Aircraft Icing

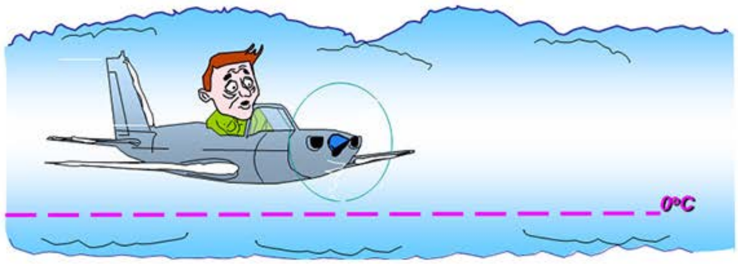


Icing

Icing Avoidance

To escape icing, a pilot must:

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



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Thunderstorms

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Hazardous Effects of Thunderstorm

Thunderstorm – A storm produced by a cumulonimbus (CB) cloud, and always accompanied by lightning and thunder, usually with strong gusts of wind, heavy rain, and sometimes with hail

A thunderstorm can produce almost every aviation weather hazard in one vicious bundle, including:

- Adverse winds
- Instrument (IFR) weather
- Turbulence
- Icing
- Other hazards, including:
  - Lightning
  - Hail
  - Downburst/Microburst
  - Tornado
  - Rapid pressure/altimeter changes

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

AMS Glossary of Meteorology

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Thunderstorms

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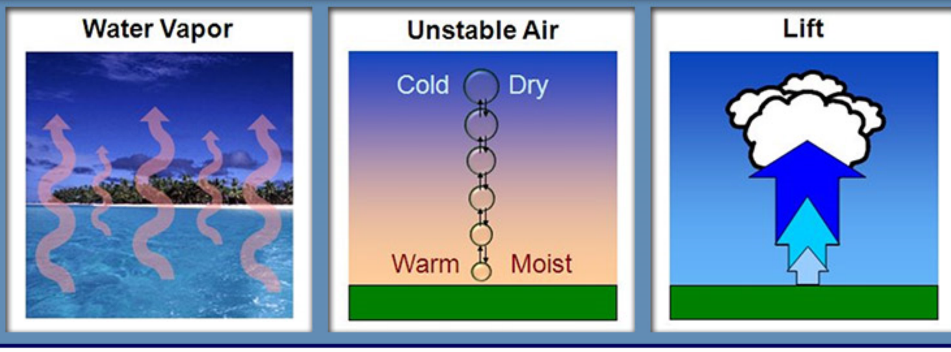
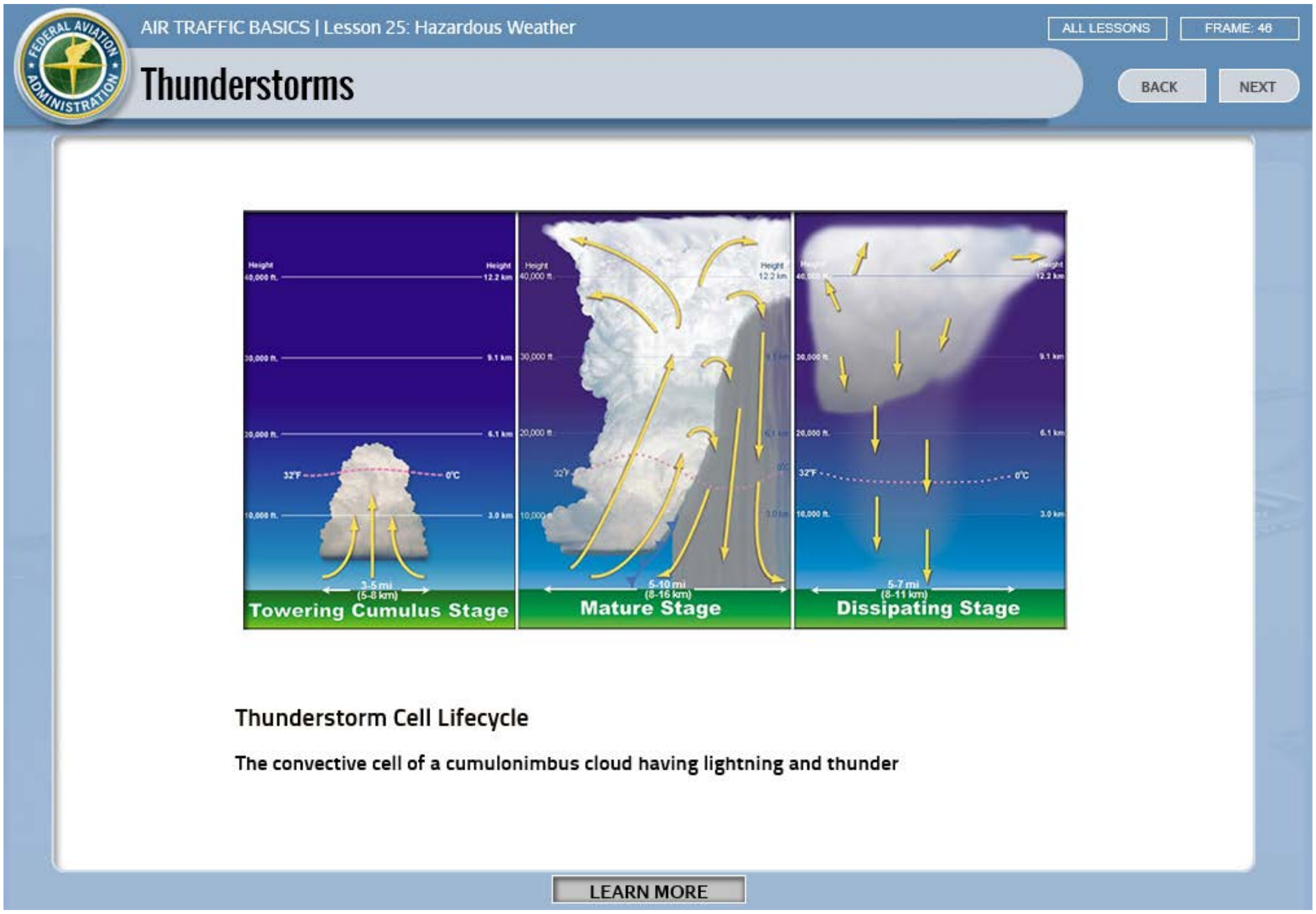


Three Ingredients for Thunderstorm Cell Formation

Thunderstorm cell formation requires the following three ingredients:

- Sufficient water vapor
  - Measured using dew point
- Unstable air
- Lifting mechanism(s) strong enough to release the instability
  - Converging winds around surface lows
  - Fronts

NWS: JetStream: Online School for Weather; AC 00-6, Chap. 11



A thunderstorm cell undergoes three distinct stages during its lifecycle:

- Towering cumulus stage
  - Updraft speeds of greater than 3,000 feet per minute exceed the climbing capability of most aircraft.
- Mature stage
  - Precipitation downdraft reaches the surface.
  - The leading edge of downdraft air is called a “gust front.”
  - Weather hazards reach peak intensity.
- Dissipating stage
  - Precipitation tapers off and ends.
  - The cloud gradually vaporizes from below leaving only a remnant anvil cloud.

NOTE: *The total lifecycle is typically about 30 minutes.*

References:

- AMS Glossary of Meteorology
- NWS: JetStream: Online School for Weather

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Thunderstorms

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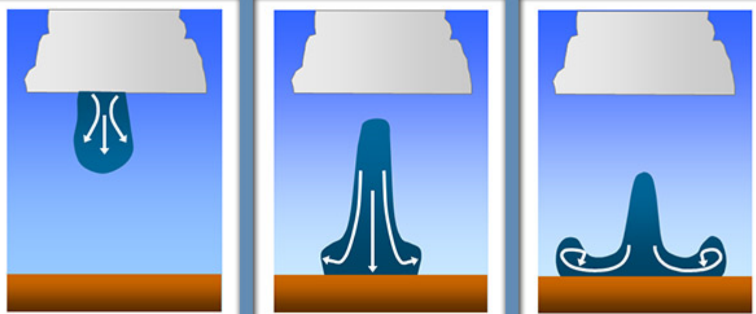

FORMATION – Evaporation and precipitation drag forms downdraft

IMPACT – Downdraft quickly accelerates and strikes ground

DISSIPATION – Downdraft moves away from point of impact

Downburst – A strong downdraft which induces an outburst of damaging winds on or near the ground. Damaging winds, either straight or curved, are highly divergent. The sizes of downbursts vary from ½ mile or less to more than 10 miles. An intense downburst often causes widespread damage. Damaging winds, lasting 5 to 30 minutes, could reach speeds as high as 120 knots.

Microburst – A downburst that covers an area up to 2.5 miles along a side with peak winds as high as 150 knots that lasts 2 to 5 minutes

The strong wind shears associated with a downburst can cause aircraft accidents

J O 7110.65, Glossary

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Thunderstorms

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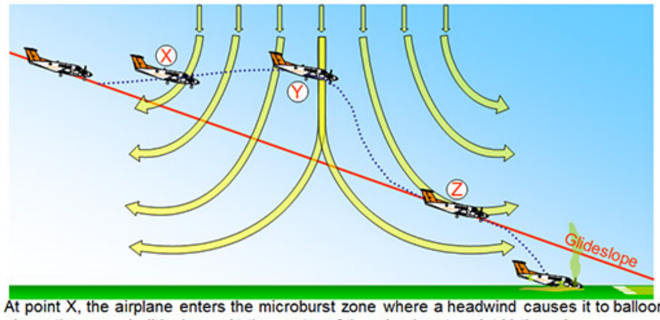

At point X, the airplane enters the microburst zone where a headwind causes it to balloon above the normal glideslope. At the center of the microburst, point Y, there is a downdraft which causes the airplane to sink. At point Z, the airplane enters the most lethal zone where a sudden tailwind causes the airplane to lose airspeed.

Landing in a Microburst

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

- **During this phase, 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.**

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Thunderstorms

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CRASH OF L-1011 AT DALLAS-FT. WORTH

You will now watch the video, "Crash of L-1011 at Dallas-Ft. Worth."

On August 2, 1985, an L-1011 landing at Dallas-Fort Worth International Airport encountered a microburst which resulted in the deaths of 137 people.

This video is a faithful recreation of that tragedy.

It provides three views of the final two minutes before impact.

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Thunderstorms

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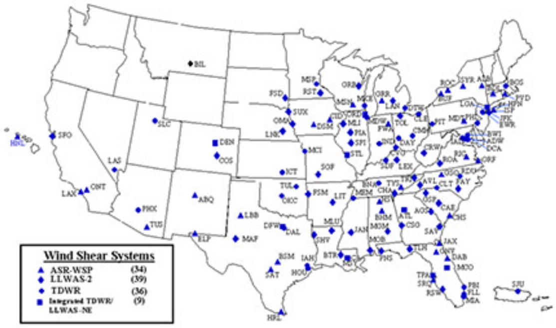
National Airspace System (NAS) Wind Shear Product Systems

To warn terminal controllers and pilots of microbursts, wind shear, and gust fronts, the FAA has installed the following systems:

- 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)
  - 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)
  - An enhanced weather processor for the ASR-9 air traffic control radar that includes Doppler wind estimation for the detection of low-level wind shear

Tower controllers relay specific alerts from these systems to pilots via voice radio communication.



AIM, Chap. 7; AMS Glossary of Meteorology

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Low-Level Wind Shear (LLWS)

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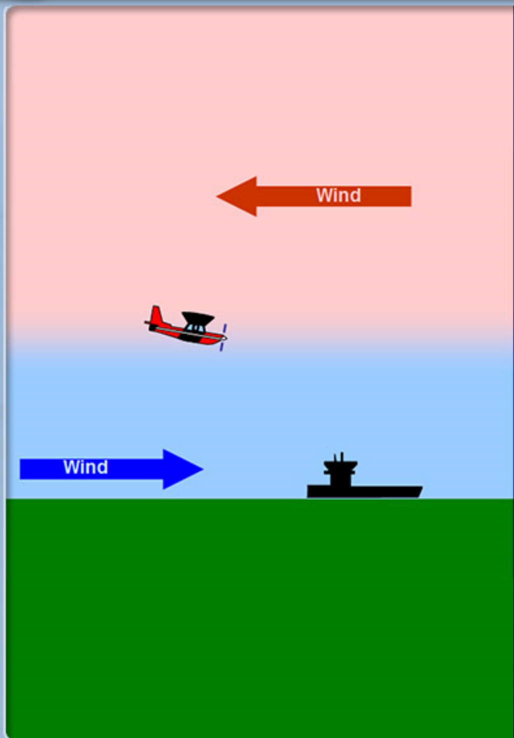

Low-Level Wind Shear (LLWS)- Hazardous Effects

Low-level wind shear (LLWS) – A wind shear of 10 knots or more per 100 feet in a layer more than 200 feet thick which occurs within 2,000 feet of the surface

LLWS is especially dangerous during takeoff and landing.

- **During this phase, the airplane is operating at relatively slow speeds.**
  - **A change in wind velocity will cause the airplane to move above or below its glideslope and could lead to a crash.**

NOTE: Convective low-level wind shear caused by downbursts and microbursts was covered in the thunderstorm section.

UCAR/COMET: Writing TAFs for Winds and LLWS

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Low-Level Wind Shear (LLWS)

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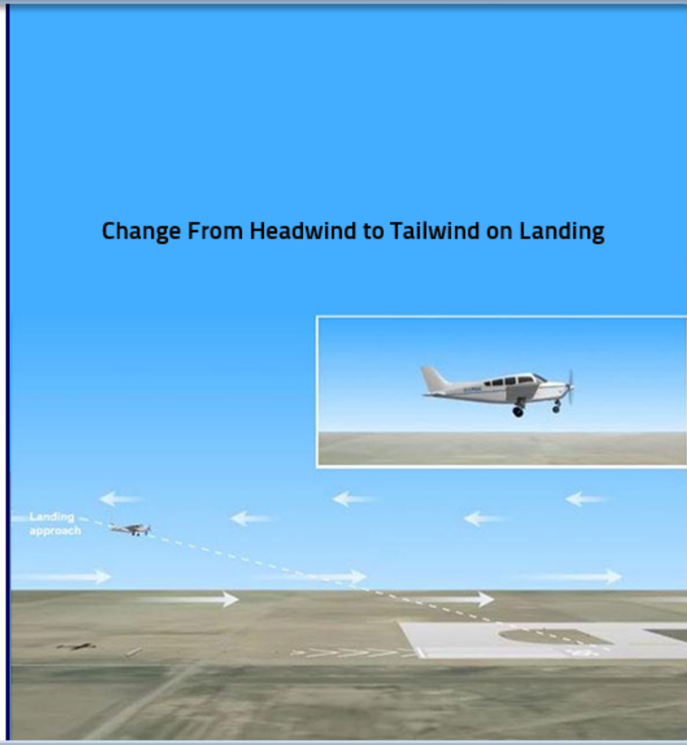
Wind Shear

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.
    - The pilot will typically compensate by increasing power, but if the engines don't spool up fast enough, the airplane may land short, slow, and hard and could lead to a crash.



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Low-Level Wind Shear (LLWS)

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Wind Shear

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
- The airplane will land long and could run out of runway.

Small, general aviation aircraft are much more prone to the effects of low-level wind shear than large commercial aircraft because their approach speeds are much closer to their stall speeds.

NOTE: For example, it may only take 15 kt of airspeed loss to cause a Cessna 172 to stall as opposed to greater than 42 kt for a Boeing 737.

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Conclusion

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Lesson Summary

This lesson covered:

- Aviation Weather Hazards
- Adverse Winds
- IFR Weather
- Turbulence
- High Density Altitude
- Icing
- Thunderstorms
- Low-Level Wind Shear (LLWS)