ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 1

EO M436.01 – EXPLAIN WINDS

Total Time:	30 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Prepare the slides or handouts located at Attachment A.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An interactive lecture was chosen for this lesson to orient the cadets to winds and generate interest in the subject.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall have explained winds.

IMPORTANCE

It is important for the cadets to explain winds as this information is used by pilots to be aware of the direction and speed of wind during all parts of the flight. Being able to explain winds provides knowledge for potential instructional duties and is part of the fundamentals that cadets pursing future aviation training will require.

Teaching Point 1	**Explain surface winds.**
Time: 15 min	Method: Interactive Lecture

SURFACE WINDS

Wind is a major factor in flight planning and flight characteristics. Pilots must constantly be aware of the direction and speed of wind during the flight, especially when close to the ground during takeoff and landing.

Surface friction plays an important role in the speed and direction of surface winds. The friction between the air and the ground slows the air down causing a lower wind speed than would be expected from the pressure gradient. The friction also changes the direction causing the wind to blow across the isobars toward the centre of a low pressure area and away from the centre of a high pressure area.

The effect of surface friction usually does not extend more than a couple of thousand feet into the air. At 3 000 feet above the ground, the wind blows parallel to the isobars with a speed proportional to the pressure gradient.

Hills and valleys substantially distort the airflow associated with the prevailing pressure system and the pressure gradient. Katabatic and anabatic winds and mountain waves are examples of wind phenomena in mountainous areas.

Katabatic and Anabatic Winds

Show slides of Figures A-1 and A-2.

At night, the sides of hills cool by radiation. The air in contact with them becomes cooler and denser, and blows down the slope into the valley. A katabatic wind is the term for down slope winds flowing from high elevations down the slopes to valleys below. If the slopes are covered with ice and snow, the katabatic wind can also carry the cold dense air into the warmer valleys during the day.

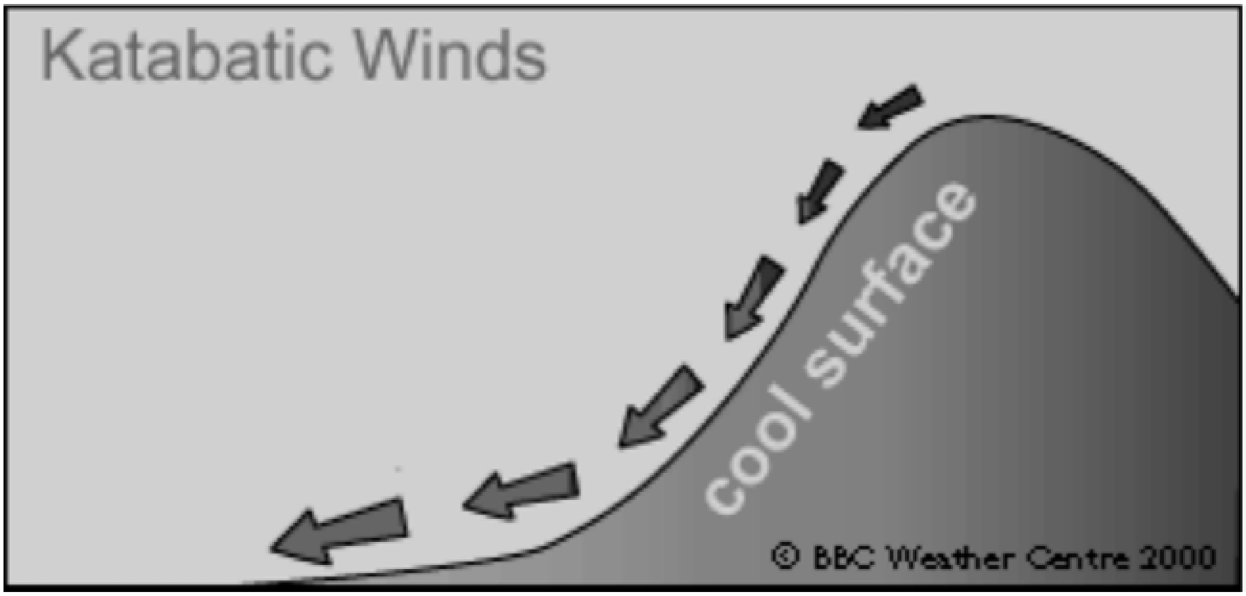


Figure 1 Katabatic Wind

Note. From "Wind", by BBC, 2008. Copyright 2000 by BBC Weather Centre. Retrieved October 14, 2008, from http://www.bbc.co.uk/weather/weatherwise/factfiles/basics/wind_localwinds.shtml

Anabatic wind occurs during the day when the slopes of hills, not covered by snow, are warmed. The air in contact with them becomes warmer and less dense, therefore flowing up the slope.

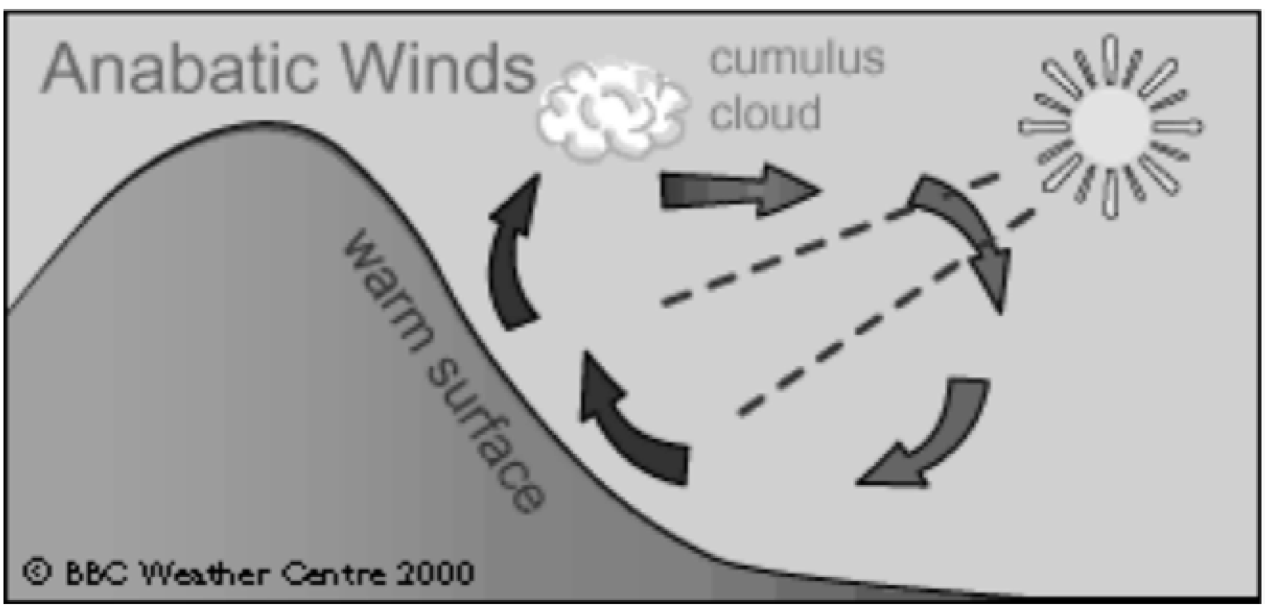


Figure 2 Anabatic Wind

Note. From "Wind", by BBC, 2008. Copyright 2000 by BBC Weather Centre. Retrieved October 14, 2008, from http://www.bbc.co.uk/weather/weatherwise/factfiles/basics/wind_localwinds.shtml

Mountain Waves

Show slide of Figure A-3.

Air flowing across a mountain range usually rises smoothly up the slope of the range. Once over the top, it pours down the other side with considerable force, bouncing up and down, creating eddies and turbulence. It also creates powerful vertical waves that may extend for great distances downwind of the mountain range. This phenomenon is known as a mountain wave. The most severe mountain wave conditions are created in strong airflows that are blowing at right angles to the mountain range in very unstable air.

If the air mass has high moisture content, clouds of a very distinctive appearance will develop, thereby serving as a warning to pilots. Orographic lift causes a cap cloud to form along the top of the ridge. Lenticular (lens-shaped) clouds form in the wave crests aloft and lie in bands that may extend well above 40 000 feet. Rotor clouds resemble a long line of stratocumulus clouds and form in the rolling eddies downstream.

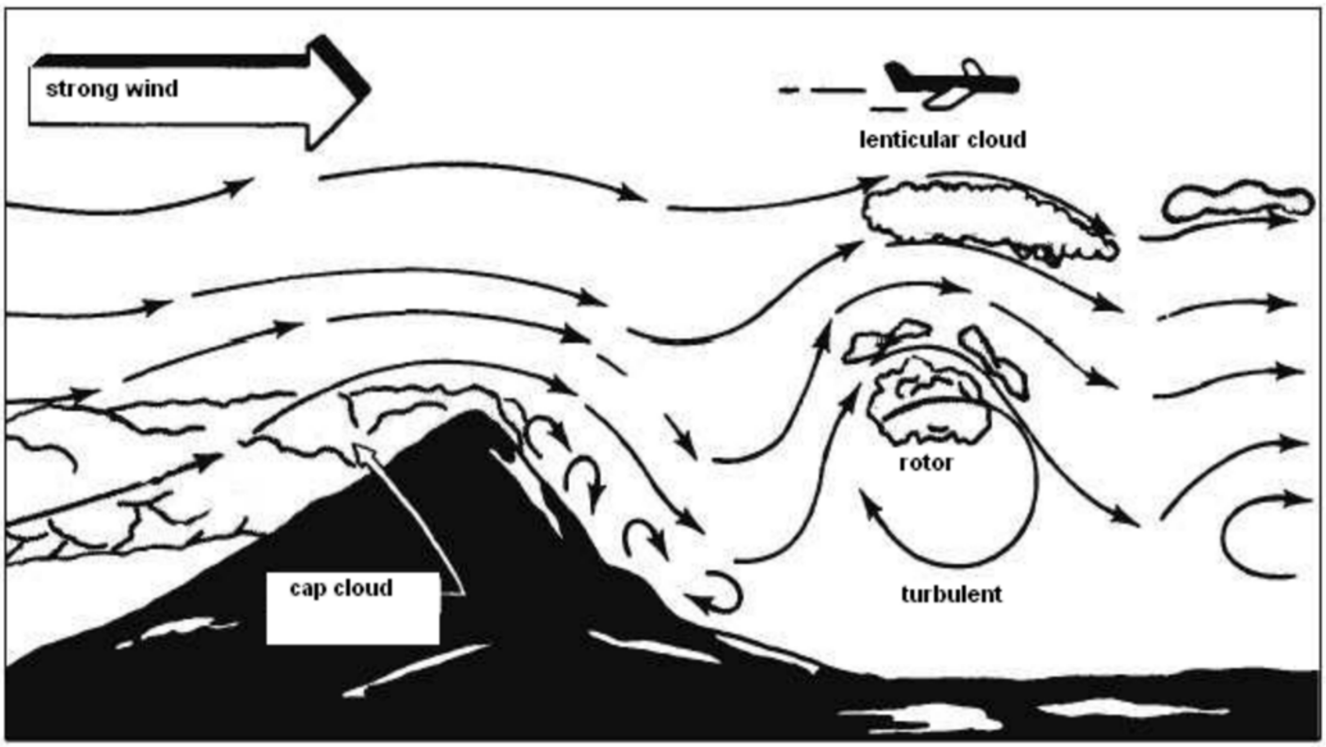


Figure 3 Mountain Wave

Note. From "Integrated Publishing", 2003. *Aerographer / Meteorology*, Copyright 2003 by Integrated Publishing. Retrieved October 14, 2008, from http://www.tpub.com/weather2/3-25.htm

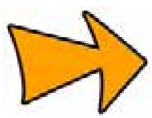
Mountain waves may cause many dangers to aircraft, such as:

- common downdrafts of 2 000 feet per minute along the downward slope;
- extremely severe turbulence in the air layer between the ground and the tops of the rotor clouds;
- severe wind shear due to wind speed variation between the crests and troughs of the waves;

- severe icing due to large supercooled droplets sustained in the strong vertical currents; and
- an altimeter error of more than 3 000 feet on the high side due to the increase in wind speed and accompanying decrease in pressure.

Gusts

A gust is a rapid and irregular change of wind speed and may be associated with a rapid change in wind direction. Gusts are caused by mechanical turbulence that results from friction between the air and the ground and by the unequal heating of the earth's surface, particularly during hot summer afternoons.



Wind gusts are a hazard to gliders due to their light weight and relatively slow stalling speed. Therefore, the Air Cadet Gliding Program has a maximum permissible gust differential of 10 knots (12 mph). Any gust differential beyond this will require an immediate shutdown of gliding operations.

Squalls

A squall is a sudden increase in the strength of the wind of longer duration than a gust and like a gust, may be accompanied by a rapid change of wind direction. Squalls may be caused by the passage of a fast moving cold front or thunderstorm.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. Explain anabatic wind.

Q2. What types of clouds are caused by mountain waves?

Q3. What causes gusts?

ANTICIPATED ANSWERS:

A1. Anabatic wind occurs during the day when the slopes of hills not covered by snow are warmed. The air in contact with them becomes warmer and less dense, therefore flowing up the slope.

A2. Cap clouds, lenticular clouds, and rotor clouds.

A3. Gusts are caused by mechanical turbulence that results from friction between the air and the ground and by the unequal heating of the earth's surface.

Teaching Point 2	**Describe jet streams.**
Time: 10 min	Method: Interactive Lecture

JET STREAMS

Show slides of Figures A-4 and A-5.

Jet streams are narrow bands of exceedingly high speed winds that exist in the higher levels of the atmosphere at altitudes ranging from 20 000 to 40 000 feet or more. They flow from west to east and are usually 300 nautical miles wide and 3 000 to 7 000 feet thick. Winds in the central core of a jet stream are generally between 100 and 150 knots, although they may reach speeds as great as 250 knots.

The northern hemisphere has two such streams: the mid-latitude (polar) jet, which is the one usually affecting weather in North America, Europe and Asia, and the subtropical jet.

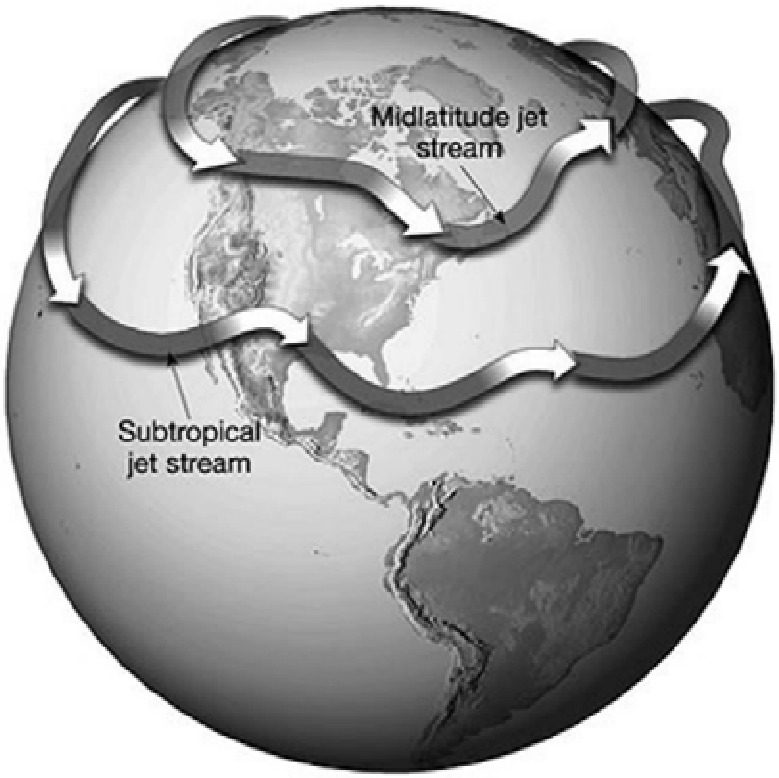


Figure 4 The Jet Stream

Note. From "Remote Sensing Tutorial", by N. Short, 2005, *Federation of American Scientists*. Retrieved February 26, 2009, from http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1c.html

When the mid-latitude jet is farther north, in Canada, the weather to its south tends to be mild or at least less cold. When the stream swings south well within the United States (U.S.), especially in winter, very cold, often harsh weather prevails at the surface on the northern side.

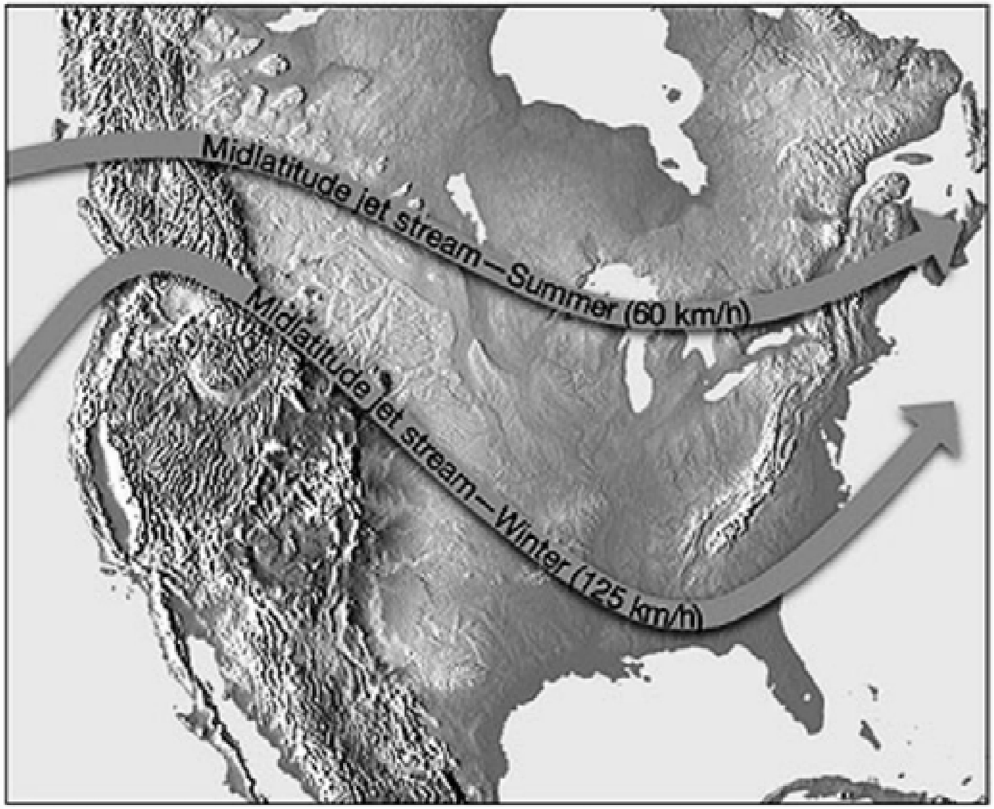


Figure 5 Seasonal Mid-Latitude Jet Stream

Note. From "Remote Sensing Tutorial", by N. Short, 2005, *Federation of American Scientists*. Retrieved February 26, 2009, from http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1c.html

Knowing the location of a jet stream is important when planning long range flights at high altitudes. For example, on an eastbound flight a pilot would want to take advantage of the excellent tail winds a jet stream would provide. On a westbound flight they would want to avoid the winds.

Clear Air Turbulence (CAT)

CAT is a bumpy, turbulent condition that occurs in a cloudless sky. It occurs at high altitudes, usually above 15 000 feet and is more severe near 30 000 feet. The most probable place to expect CAT is just above the central core of a jet stream.

CAT is almost impossible to forecast and can be severe enough to be a hazard to modern high-performance airplanes. Therefore, knowledge of areas in which CAT is most likely to occur is important for pilots to help minimize encounters with it.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS:

Q1. What are jet streams?

Q2. In what direction do jet streams flow?

Q3. Where is clear air turbulence most likely to occur?

ANTICIPATED ANSWERS:

A1. Jet streams are narrow bands of exceedingly high speed winds that exist in the higher levels of the atmosphere at altitudes ranging from 20 000 to 40 000 feet or more.

A2. Jet streams flow from west to east.

A3. Clear air turbulence is most likely to occur just above the central core of a jet stream.

END OF LESSON CONFIRMATION

QUESTIONS:

Q1. What must pilots be aware of when close to the ground during takeoff and landing?

Q2. List examples of wind phenomena in mountainous areas.

Q3. What is the range of wind speeds in the central core of the jet stream?

ANTICIPATED ANSWERS:

A1. The direction and speed of wind.

A2. Examples include:

- katabatic winds,
- anabatic winds, and
- mountain waves.

A3. 100 to 150 knots but may reach speeds as great as 250 knots.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

This EO is assessed IAW A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 3, Annex B, Aviation Subjects–Combined Assessment PC.

CLOSING STATEMENT

Wind is a major factor in flight planning and flight characteristics. Pilots must constantly be aware of the direction and speed of wind during all parts of the flight. Knowledge of winds is essential for future aviation training and for instructional duties at the squadron.

INSTRUCTOR NOTES / REMARKS

Cadets who are qualified Advanced Aviation may assist with this instruction.

REFERENCES

C3-116 ISBN 0-9680390-5-7 MacDonald, A. F., & Peppler, I. L. (2000). *From the ground up: Millennium edition*. Ottawa, ON: Aviation Publishers Co. Limited.

C3-334 Short, N. (2005). Remote Sensing Tutorial. *Federation of American Scientists*. Retrieved February 26, 2009, from http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1c.html

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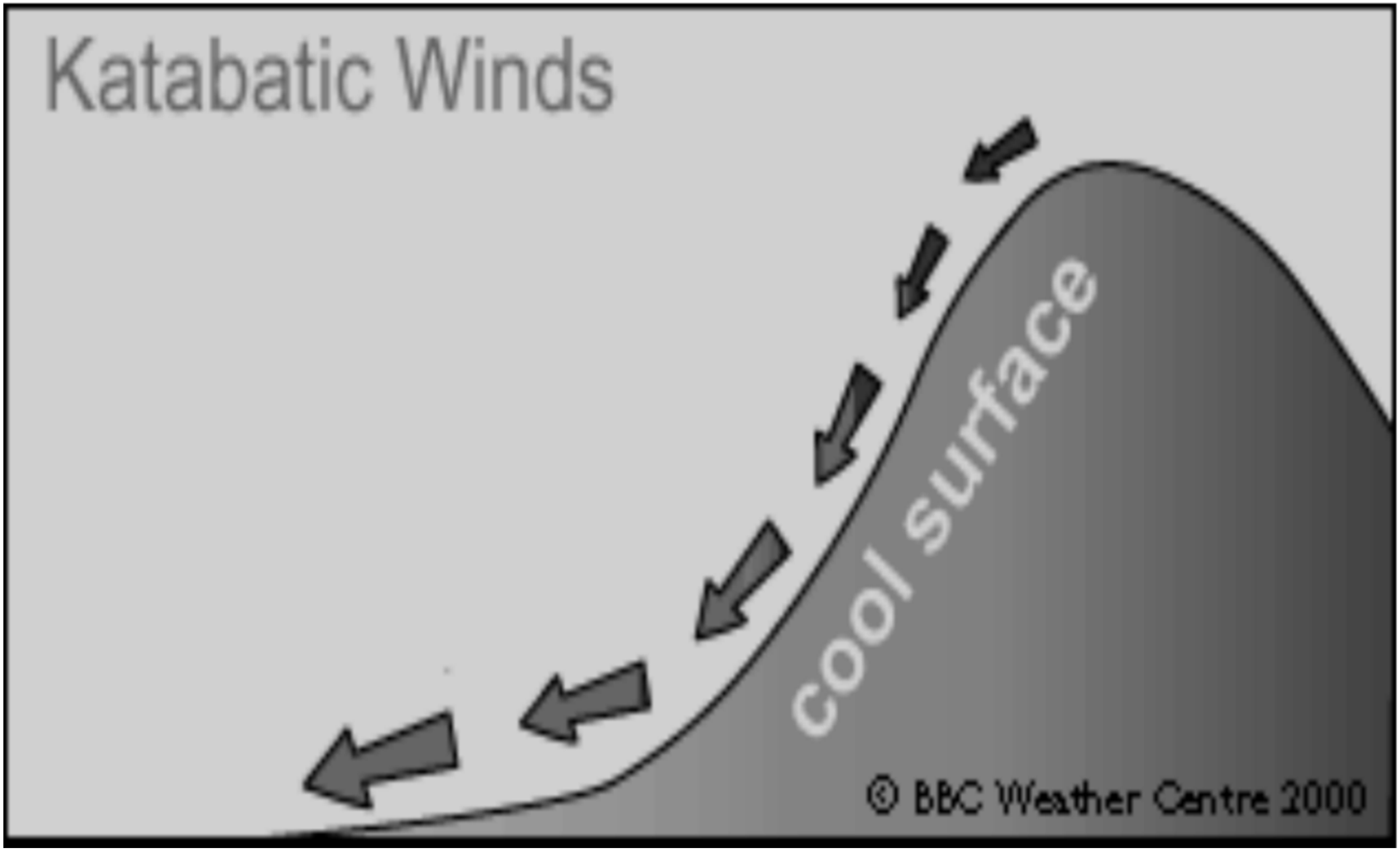

Figure A-1 Katabatic Wind

Note. From "Wind", by *BBC*, 2008. Copyright 2000 by BBC Weather Centre. Retrieved October 14, 2008, from http://www.bbc.co.uk/weather/weatherwise/factfiles/basics/wind_localwinds.shtml

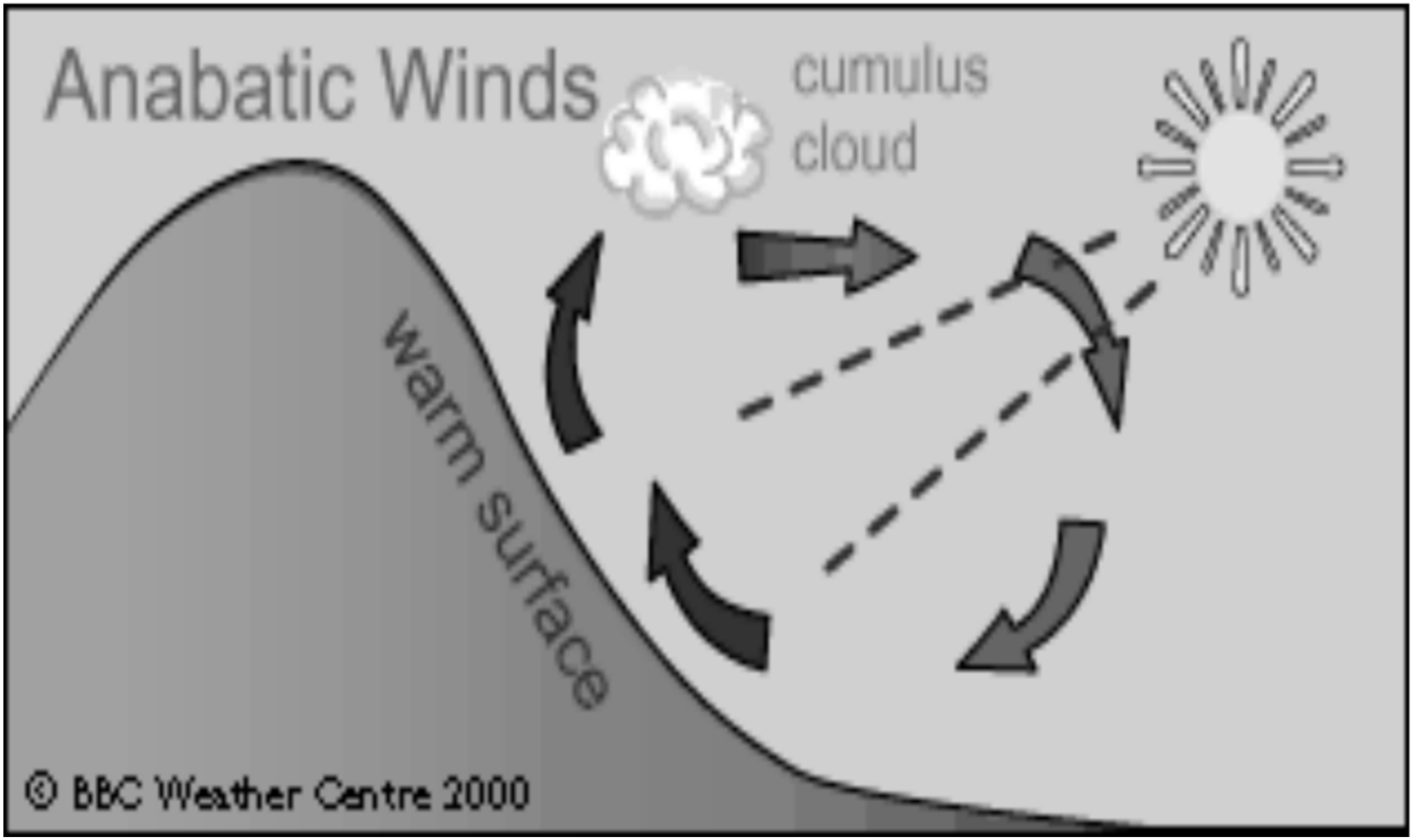

Figure A-2 Anabatic Wind

Note. From "Wind", by *BBC*, 2008. Copyright 2000 by BBC Weather Centre. Retrieved October 14, 2008, from http://www.bbc.co.uk/weather/weatherwise/factfiles/basics/wind_localwinds.shtml

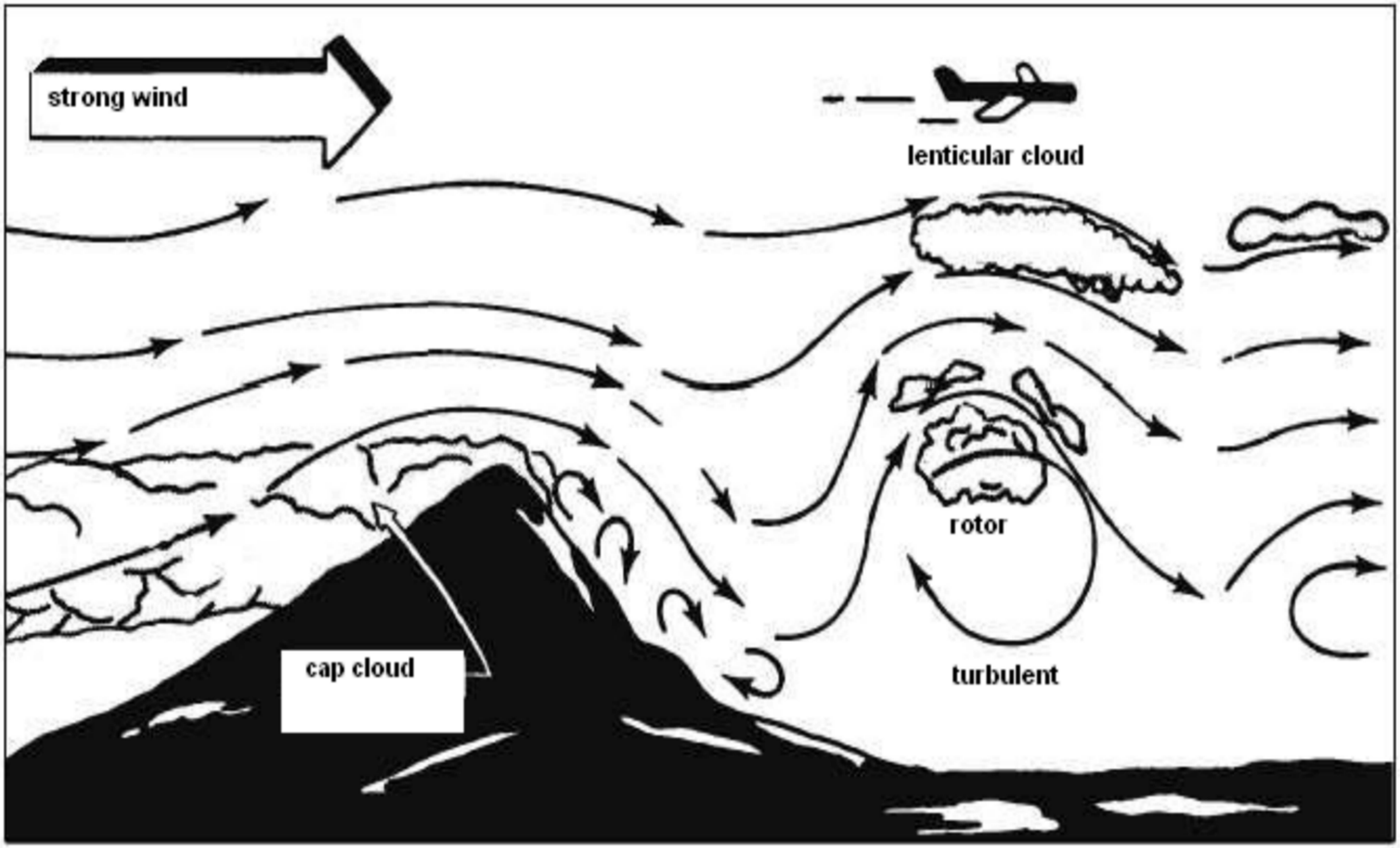

Figure A-3 Mountain Wave

Note. From "Integrated Publishing", 2003, *Aerographer / Meteorology*. Copyright 2003 by Integrated Publishing. Retrieved October 14, 2008, from http://www.tpub.com/weather2/3-25.htm

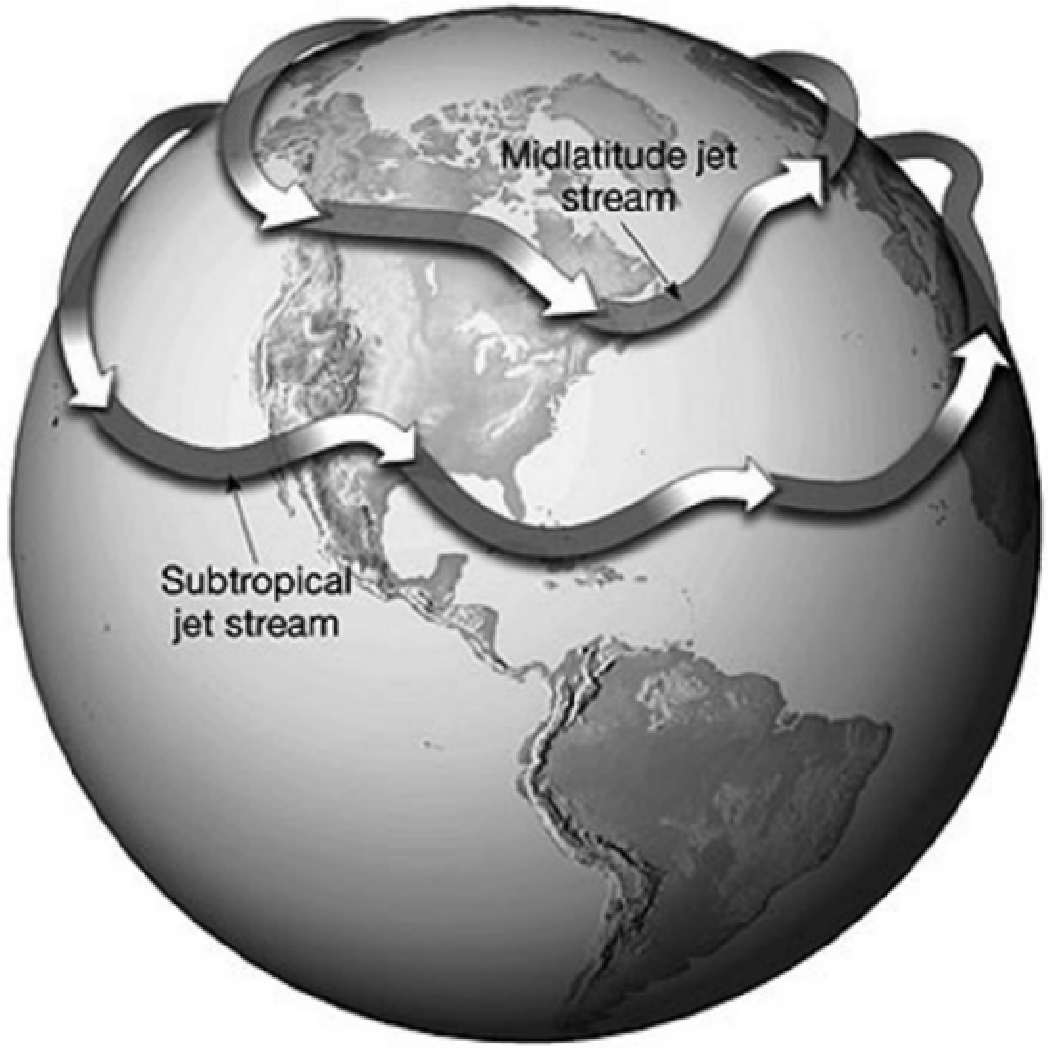

Figure A-4 The Jet Stream

Note. From "Remote Sensing Tutorial", by N. Short, 2005, *Federation of American Scientists*. Retrieved February 26, 2009, from http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1c.html

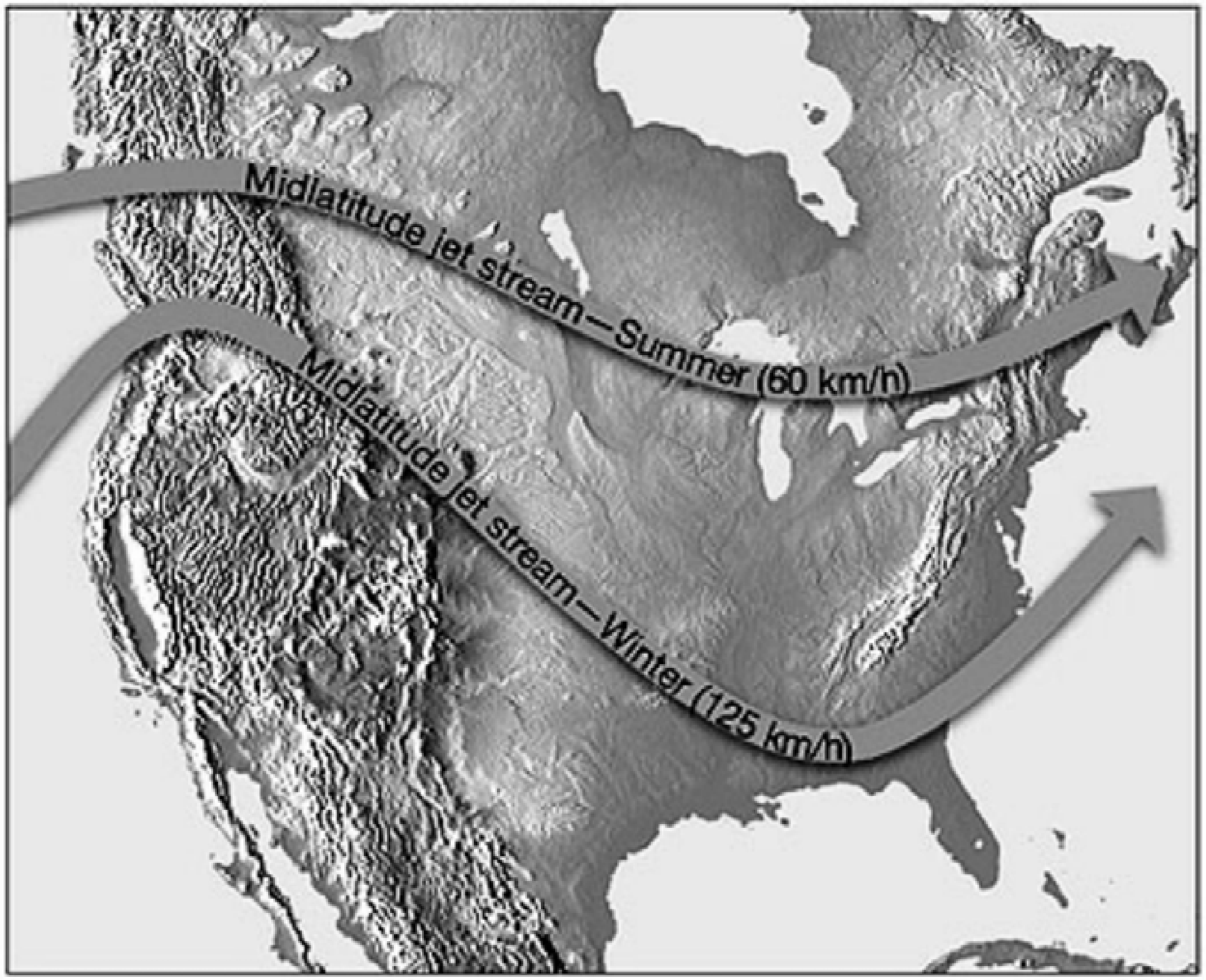

Figure A-5 Seasonal Mid-Latitude Jet Stream

Note. From "Remote Sensing Tutorial", by N. Short, 2005, *Federation of American Scientists*. Retrieved February 26, 2009, from http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1c.html

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ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 2

EO M436.02 – DESCRIBE AIR MASSES AND FRONTS

Total Time:	90 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Review and prepare the demonstration located at Attachment A.

Prepare the slides located at Attachments B and C.

Photocopy the handout located at Attachment D for each cadet.

Prepare the learning stations located at Attachments E–I.

Photocopy a set of the fronts worksheets located at Attachment J for each cadet.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An interactive lecture was chosen for TPs 1 and 2 to orient the cadets to air masses and fronts and generate interest in the subject.

An in-class activity was chosen for TP 3 as it is an interactive way to present types of fronts and associated weather.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall be expected to describe air masses and fronts.

IMPORTANCE

It is important for cadets to describe air masses and fronts as knowledge of this material helps them to understand changes in weather conditions. Being able to describe air masses and fronts provides knowledge for potential instructional duties and is part of the fundamentals that cadets pursing future aviation training will require.

Teaching Point 1	**Explain weather in an air mass.**
Time: 10 min	Method: Interactive Lecture

WEATHER IN AN AIR MASS

There are three main factors that determine the weather in an air mass:

- moisture content,
- the cooling process, and
- the stability of the air.

Moisture Content

Continental air masses are very dry and little cloud develops. The high moisture content in maritime air may cause cloud, precipitation, and fog.

The Cooling Process

Even if the air is moist, condensation and cloud formation only occur if the temperature is lowered to the dewpoint. The cooling processes that contribute to condensation and the formation of clouds are:

- contact with a surface cooling by radiation,
- advection over a colder surface, and
- expansion brought about by lifting.

Cloud formation within an air mass is not uniform. For example, clouds may form in an area where the air is undergoing orographic lift even though the rest of the air mass is clear.

The Stability of the Air

In stable air, stratus cloud and poor visibility are common, whereas in unstable air, cumulus cloud and good visibility are common.

Characteristics of Cold Air Masses and Warm Air Masses

Cold air masses (eg, arctic and polar air masses) will typically have the following characteristics:

- instability,
- turbulence,
- good visibility,
- cumuliform clouds, and
- precipitation in the form of showers, hail, and thunderstorms.

Warm air masses (eg, tropical air masses) will typically have the following characteristics:

- stability,
- smooth air,
- poor visibility,

- stratiform clouds and fog, and
- precipitation in the form of drizzle.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. What are the three main factors that determine weather in an air mass?

Q2. What are the cooling processes that contribute to condensation and the formation of clouds?

Q3. What are the characteristics of a warm air mass?

ANTICIPATED ANSWERS:

A1. Moisture content, the cooling process, and the stability of the air.

A2. Contact with a surface cooling by radiation, advection over a colder surface, and expansion brought about by lifting.

A3. Stability, smooth air, poor visibility, stratiform clouds and fog, and precipitation in the form of drizzle.

Teaching Point 2	**Define and explain types of fronts.**
Time: 15 min	Method: Interactive Lecture

FRONTS

A front is the transition zone between two air masses. The interaction of air masses along their frontal zones is responsible for weather changes.

Conduct the demonstration outlined at Attachment A to illustrate the mixing of warm and cold air masses:

1. Allow the cadets to move closer so they can observe what will happen.
2. Have the cadets predict what will happen when the divider is removed.
3. Observe the action between the red and blue colored water.

The blue-dyed water represents a cold air mass and the red-dyed water represents a warm air mass. The area where these two air masses meet and mix is a front.

Show the slides located at Attachment B as fronts are presented.

The blue water (colder and more dense) will slide underneath the warmer water which is the same that occurs to the air.

Figure 1 Cold Front

Note. From Remote Sensing Tutorial by N. Short, 2005, *Federation of American Scientists*. Retrieved February 26, 2009, from http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1c.html

The cold air mass is more dense and therefore sinks, undercutting the warm air which will ascend over the cold air.

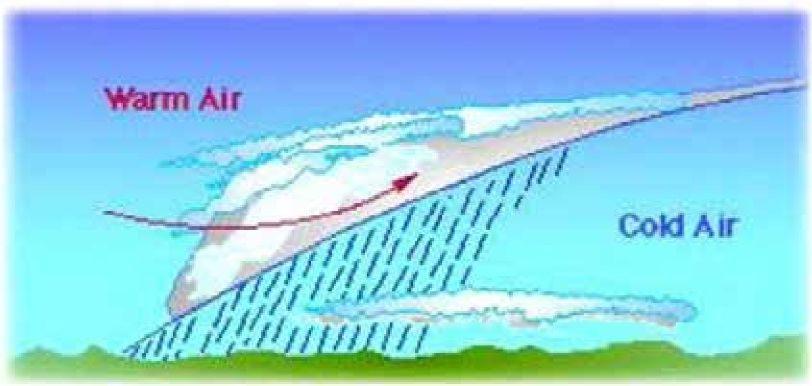

Figure 2 Warm Front

Note. From Remote Sensing Tutorial by N. Short, 2005, *Federation of American Scientists*. Retrieved February 26, 2009, from http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1c.html

Show the slides located at Attachment C as front symbols are presented.

An air mass is a large section of the troposphere with uniform properties of temperature and moisture in the horizontal. An air mass can be several thousands of kilometers across and takes on the properties from the surface over which it formed.

Formation over ice and snow of the artic will be dry and cold. Formation over the South Pacific will be warm and moist. Formation over a large body of water is moist and is referred to as maritime air. An air mass over a large land area is dry and is referred to as continental air.

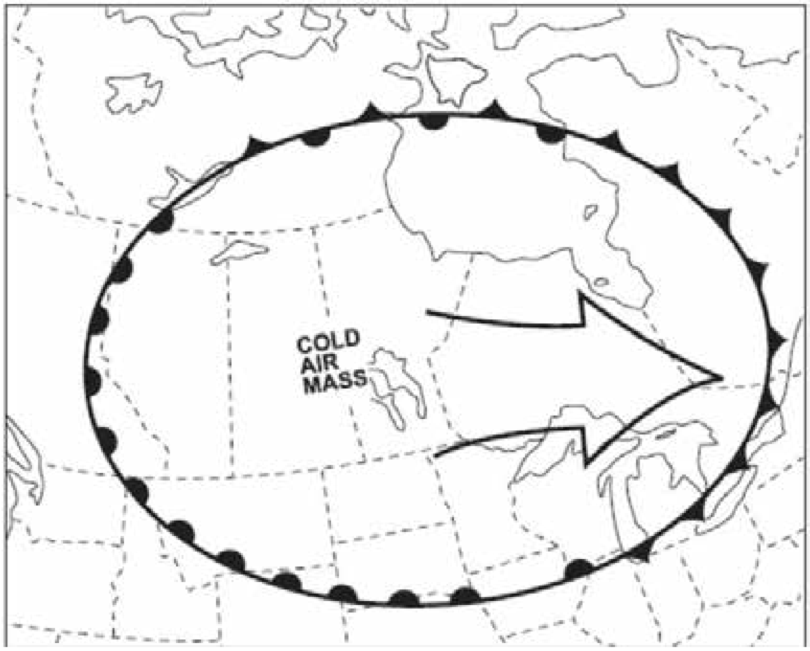

Figure 3 Air Masses and Fronts

Note. From *Air Command Weather Manual* (p. 6-8), 2004, Winnipeg, MB: Wing Publishing Office. Copyright 2004 by Her Majesty the Queen in Right of Canada.

Distribute the handout located at Attachment D to each cadet. Cadets will label each symbol as the information is presented.

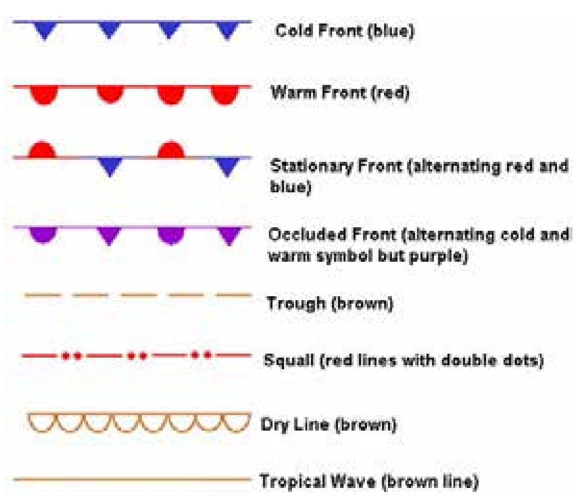

Figure 4 Front Symbols

Note. From "Weather", About.com, by R Oblanck, Copyright 2009 by The New York Times Company. Retrieved February 27, 2009 from http://weather.about.com/od/frontsandairmasses/qt/front_symbols.htm

CONFIRMATION OF TEACHING POINT 2

QUESTIONS:

Q1. Define a front.

Q2. What does the interaction of air masses along their frontal zones cause?

Q3. Explain what happens when a cold air mass and a warm air mass meet.

ANTICIPATED ANSWERS:

A1. A front is the transition zone between two air masses.

A2. Changes in the weather.

A3. The air in a cold air mass is more dense and therefore sinks, undercutting the warm air. The air in a warm air mass will ascend over the cold air.

Teaching Point 3	**Conduct an in-class activity to describe types of fronts and associated weather.**
Time: 55 min	Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets identify different types of fronts and their associated weather.

RESOURCES

- Pen / pencil,
- Coloured pencils / markers,
- Fronts information sheets located at Attachments E–I, and
- Fronts worksheets located at Attachment J.

ACTIVITY LAYOUT

Set up and clearly mark five learning stations, located at Attachments E–I.

ACTIVITY INSTRUCTIONS

1. Distribute all five fronts worksheets and a pen / pencil to each cadet.
2. Divide the cadets into groups of two or three and place each group at one of the learning stations.
3. Have the cadets fill out the appropriate fronts worksheet for that station.

At learning stations with more than one diagram the cadet can choose which one to draw.

4. After nine minutes have the groups rotate to the next station until each group has completed all five stations.

5. Review the fronts worksheets as a class and answer any questions.

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 3

The cadets' participation in the activity will serve as the confirmation of this TP.

END OF LESSON CONFIRMATION

QUESTIONS:

Q1. What are the characteristics of a cold air mass?

Q2. What clouds indicate the passing of a warm front?

Q3. What is the term for the wedge-shaped mass of warm air lying above the colder air masses in an occluded front?

ANTICIPATED ANSWERS:

A1. Instability, turbulence, good visibility, cumuliform clouds, and precipitation in the form of showers, hail, and thunderstorms.

A2. Cirrus, cirrostratus, altostratus, nimbostratus, and stratus.

A3. Trowal.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

This EO is assessed IAW A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 3, Annex B, Aviation Subjects–Combined Assessment PC.

CLOSING STATEMENT

There are two basic types of weather: air mass and frontal. Knowledge of air masses and fronts is crucial for understanding weather patterns and making accurate predictions of changing weather conditions. This knowledge is essential for future aviation training and for potential instructional duties at the squadron.

INSTRUCTOR NOTES / REMARKS

It is recommended that the three periods required for this EO be scheduled consecutively.

Cadets who are qualified Advanced Aviation may assist with this instruction.

REFERENCES

A3-044 CFACM 2-700 Air Command. (2001). *Air Command weather manual*. Ottawa, ON: Department of National Defence.

C3-116 ISBN 0-9680390-5-7 MacDonald, A. F., & Peppler, I. L. (2000). *From the ground up: Millennium edition*. Ottawa, ON: Aviation Publishers Co. Limited.

C3-334 Short, N. (2005). "Remote Sensing Tutorial". *Federation of American Scientists*. Retrieved February 26, 2009, from http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1c.html

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WARM AND COLD FRONT DEMONSTRATION OUTLINE

1. Fill a thermos / cooler / bottle with warm water and another with cold water.

Figure A-1 Air Mass Equipment

Note. Created by Director Cadets 3, 2009, Ottawa, ON: Department of National Defence

2. Add a few drops of red food colouring to the bottle with warm water.
3. Add a few drops of blue food colouring to the bottle with cold water.
4. Shake / stir each bottle to evenly mix the colouring and water.
5. Place the empty jars together to ensure an exact match.
6. Fill one jar to almost overflowing with blue-dyed water and the other jar with red-dyed water.

Figure A-2 Jars Filled

Note. Created by Director Cadets 3, 2009, Ottawa, ON: Department of National Defence

7. Place an index card or a plastic coated paper on the top of the warm (red-dyed) water jar and press down around the edges of the jar to make a seal.

Figure A-3 Card Over Red Jar

Note. Created by Director Cadets 3, 2009, Ottawa, ON: Department of National Defence

8. Place the warm water jar over the top of the cold water jar so that the edges meet.

Figure A-4 Jars Stacked with Card Inserted

Note. Created by Director Cadets 3, 2009, Ottawa, ON: Department of National Defence

9. Have an assistant gently remove the paper once the jars are stacked on each other, keeping the jars together (do this over a sink or container to catch any water that may leak out).

Figure A-5 Jars Stacked with Card Removed

Note. Created by Director Cadets 3, 2009, Ottawa, ON: Department of National Defence

10. Keeping one hand on each jar, slowly turn the jars to one side while holding the centre together.

Figure A-6 Turn Jars on Side

Note. Created by Director Cadets 3, 2009, Ottawa, ON: Department of National Defence

11. Observe the action between the red and blue colored water.

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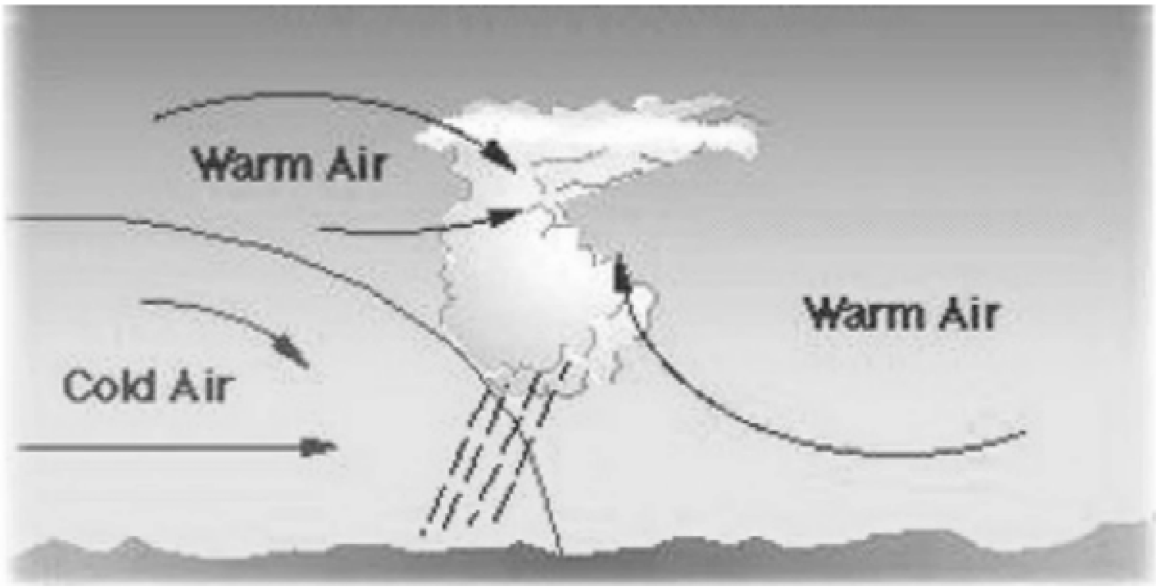

Figure B-1 Cold Front

Note. From Remote Sensing Tutorial by N. Short, 2005, *Federation of American Scientists*. Retrieved February 26, 2009, from http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1c.html

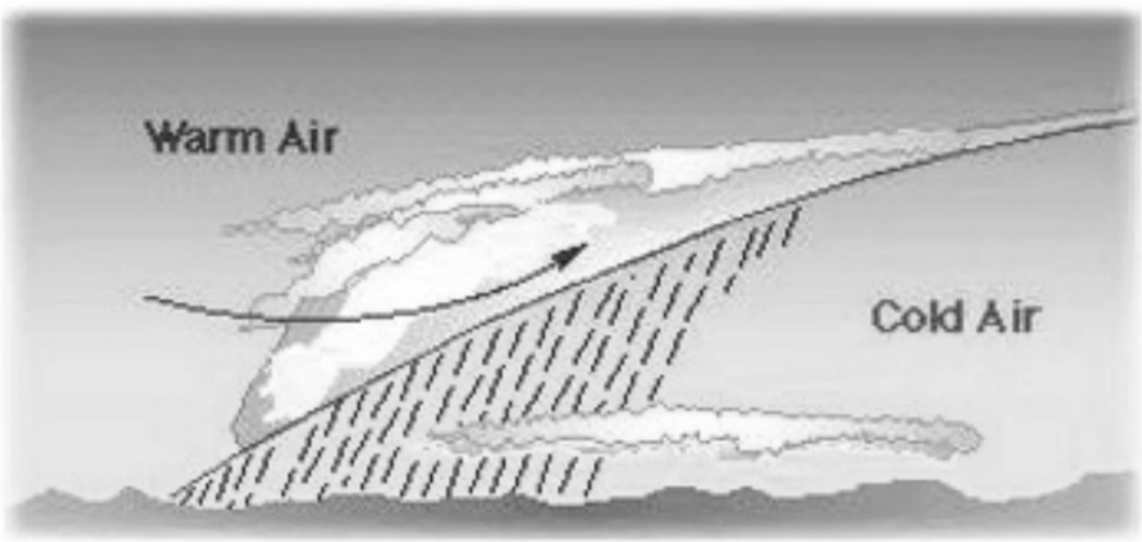

Figure B-2 Warm Front

Note. From Remote Sensing Tutorial by N. Short, 2005, *Federation of American Scientists*. Retrieved February 26, 2009, from http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1c.html

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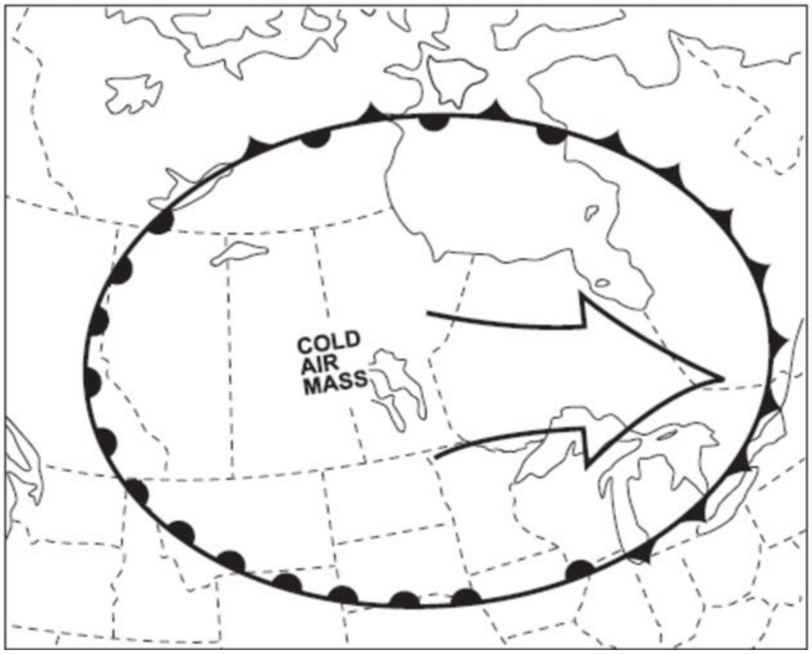

Figure C-1 Air Masses and Fronts

Note. From *Air Command Weather Manual* (p. 6-8), 2004, Winnipeg, MB: Wing Publishing Office. Copyright 2004 by Her Majesty the Queen in Right of Canada.

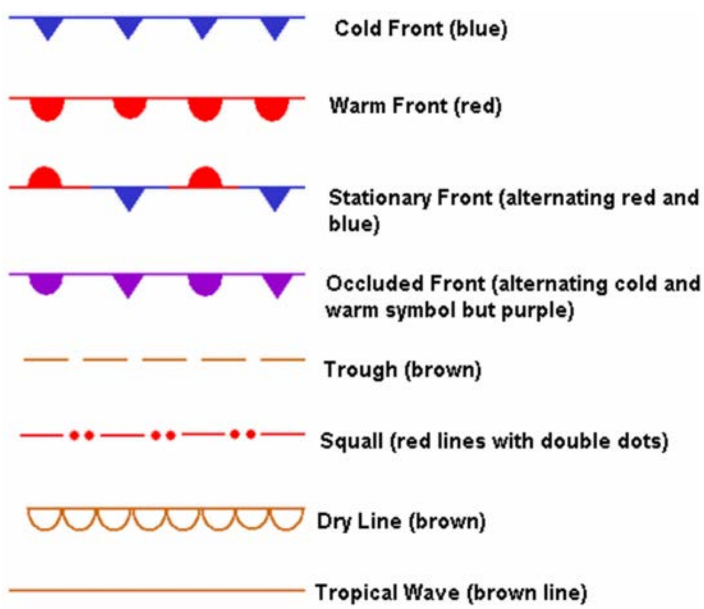

Figure C-2 Front Symbols

Note. From "Weather" About.com, by R Oblanck, Copyright 2009 by The New York Times Company. Retrieved February 27, 2009, from http://weather.about.com/od/frontsandairmasses/qt/front_symbols.htm

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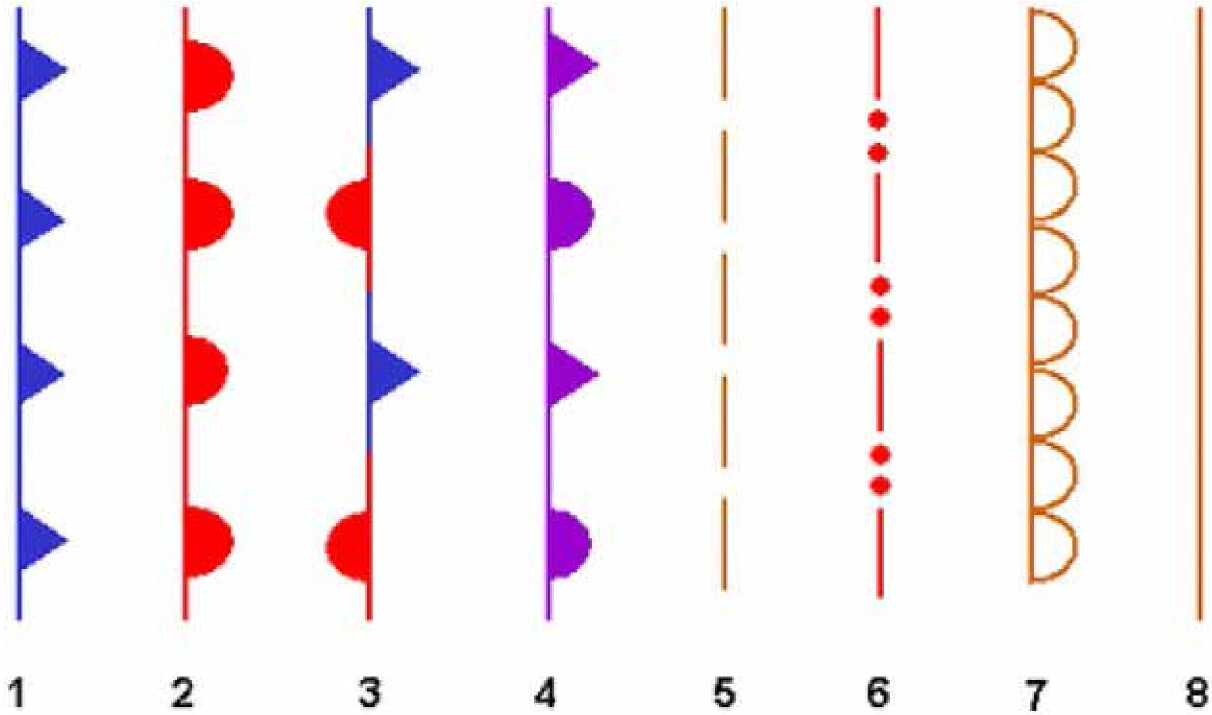
WEATHER MAP SYMBOLS



	Front	Colour
1		
2		
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COLD FRONT

A cold front is the part of a frontal system along which cold air is advancing.

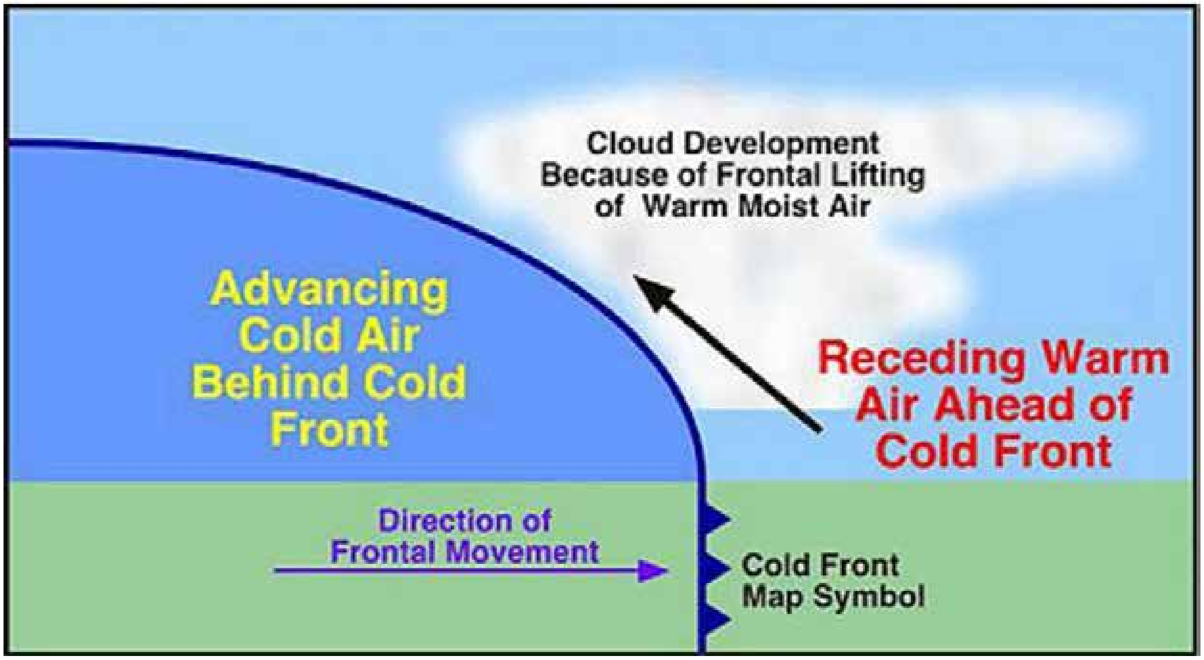

Figure E-1 Cold Front

Note. From Remote Sensing Tutorial by N. Short, 2005, *Federation of American Scientists*. Retrieved February 26, 2009, from http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1c.html

When a mass of cold air overtakes a mass of warm air, the cold air, being denser, stays on the surface and undercuts the warm air violently. The slope of the advancing cold front is quite steep as surface friction slows the air at the surface, allowing the upper air to catch up. The rapid ascent of warm air gives rise to a relatively narrow band (only about 50 nautical miles) of cumuliform cloud that frequently builds up into violent thunderstorms.

The severity of the weather depends on the moisture content and stability of the warm air mass that the cold air mass is undercutting and the speed of the advancing cold front. If the warm air is very moist and unstable, towering cumulus clouds and thunderstorms are likely to develop, bringing heavy showers in the form of rain, snow, or hail. A slower moving cold front advancing on more stable and drier air will produce stratus or altocumulus clouds with light or no precipitation.

A squall line, a continuous line of thunderstorms, sometimes develops ahead of a fast moving cold front. The weather brought about by a squall line is extremely violent, including rapid shifts in wind, heavy rain or hail, and thunder and lightning. Pilots should avoid squall lines at all costs.

A sharp fall in temperature, a rise in pressure, and rapid clearing usually occur with the passage of the cold front.

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WARM FRONT

A warm front is the part of a frontal system along which cold air is retreating.

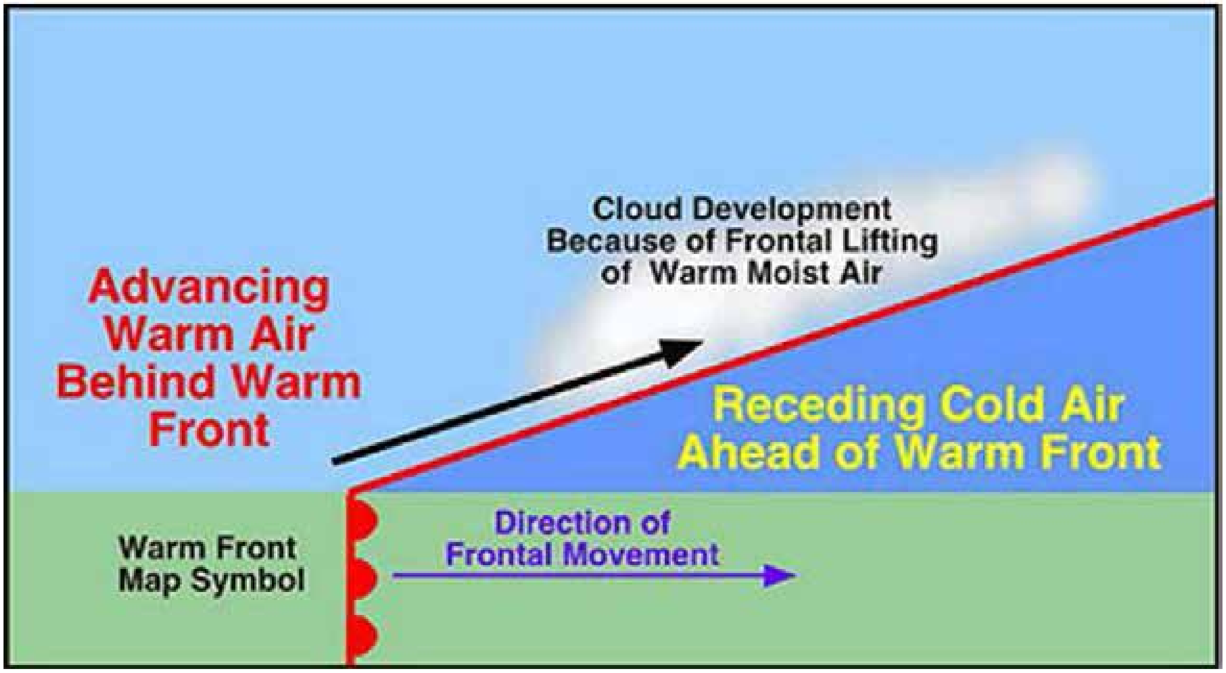

Figure F-1 Warm Front

Note. From Remote Sensing Tutorial by N. Short, 2005, *Federation of American Scientists*. Retrieved February 26, 2009, from http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1c.html

As a mass of warm air advances on a retreating mass of cold air, the warm air, being lighter, ascends over the cold air in a long gentle slope. As a result of this long gentle slope and the relatively slow speed of warm fronts, the cloud formation associated with them may extend for 500 or more nautical miles in advance. If the warm air is moist and stable, these clouds develop in a distinctive sequence:

1. cirrus,
2. cirrostratus,
3. altostratus,
4. nimbostratus, and
5. stratus.

The clouds indicating the passing of a warm front can easily be remembered using the mnemonic "C-CANS".

If the warm air is moist and unstable, cumulonimbus and thunderstorms may be embedded in the stratiform layers, bringing heavy showers.

Warm fronts bring low ceilings and restricted visibility for a considerable length of time due to their slow movement.

In winter, when temperatures in the cold air are below freezing and temperatures in the lower levels of the warm air are above freezing, snow and freezing rain can be expected. Snow (SN) falls from the part of the warm air cloud that is high and therefore below freezing. Rain (RA) falls from the lower warm air cloud but becomes supercooled as it falls through the cold air mass. This creates freezing rain (FZRA) and ice pellets (PL). Therefore, icing is a problem associated with warm fronts in winter.

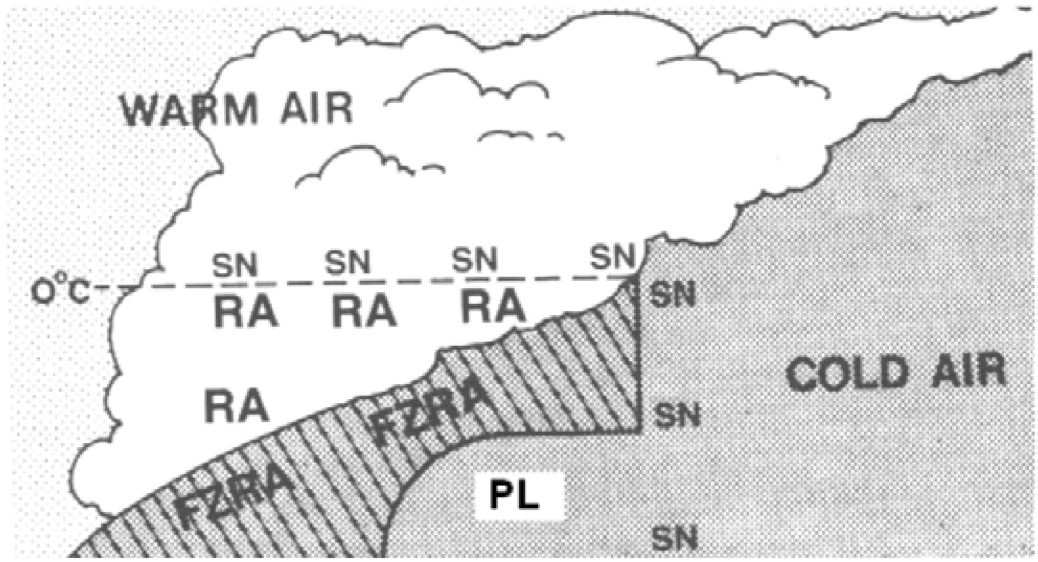

Figure F-2 Precipitation in a Warm Front in Winter

Note. From *From the Ground Up: Millennium Edition* (p. 145), by A. F. MacDonald and I. L. Peppler, 2000, Ottawa, ON: Aviation Publishers Co. Limited. Copyright 2000 by Aviation Publishers Co. Limited.

The passing of the warm front is marked by a rise of temperature due to the entry of the warm air, and the sky becoming relatively clear.

STATIONARY FRONT

A stationary front is the part of a front along which the colder air is neither advancing nor retreating.

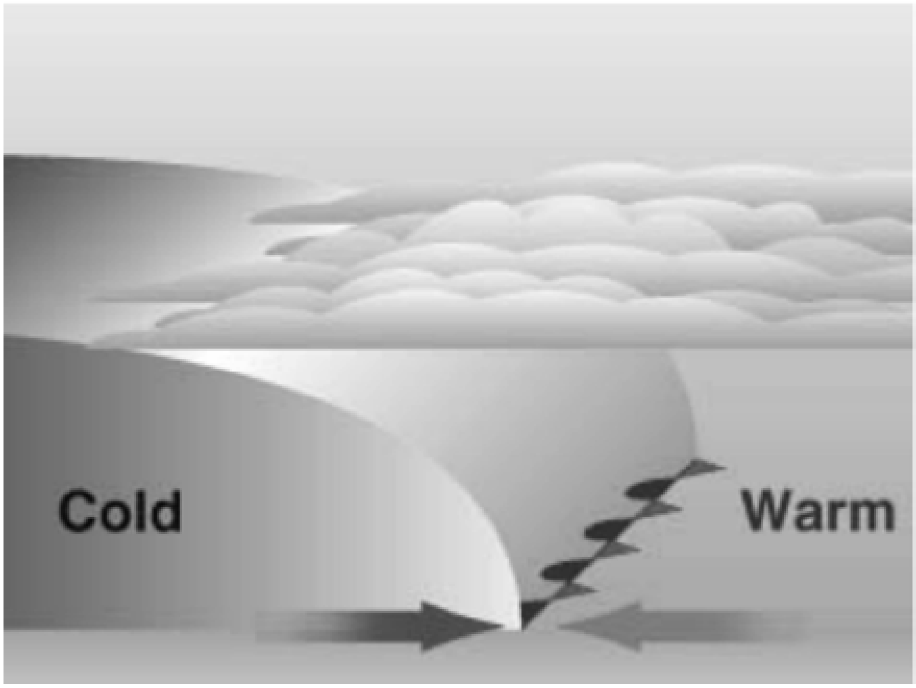

Figure G-1 Stationary Front

Note. From Geography for Kids, *KidsGeo.com*, Copyright 1998–2000. Retrieved October 17, 2008, from http://www.kidsgeo.com/geography-for-kids/0129-stationary-fronts.php

A stationary front occurs when the front does not move because the opposing air masses are of equal pressure. The weather conditions are similar to those associated with a warm front, (low cloud, and continuous rain or drizzle) although generally less intense and not so extensive. Usually a stationary front will weaken and eventually dissipate. Sometimes, however, it will begin to move after several days, becoming either a cold front or a warm front.

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OCCLUDED FRONTS

A wave-like disturbance sometimes forms on a stationary front. This can develop into a small low known as a depression. As the depression forms, one section of the front begins to move as a warm front and the other section as a cold front. Over time, under certain atmospheric conditions, the cold front gradually overtakes the warm front and lifts the warm air entirely from the ground forming a single occluded front. Basically, the cold air catches up with itself as it flows around the low pressure area.

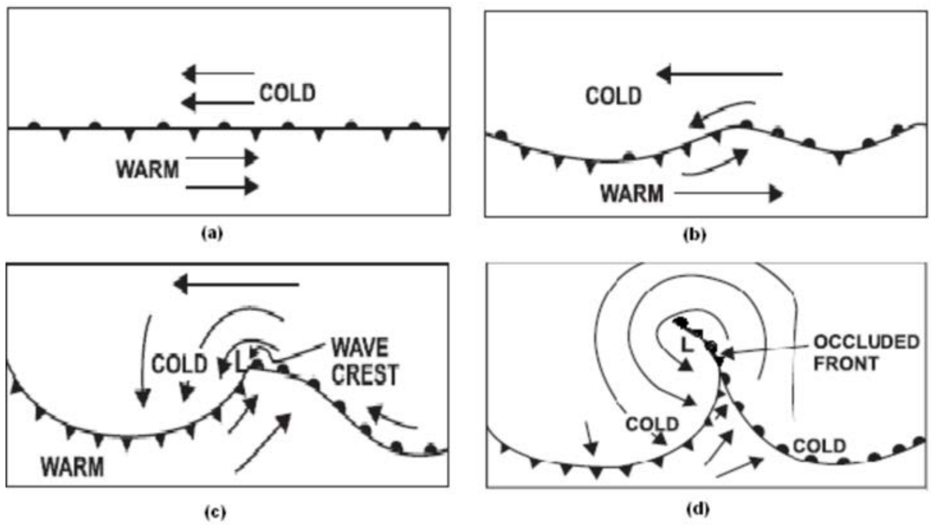

Figure H-1 Occluded Front Formation

Note. From *Air Command Weather Manual* (pp. 7-12 and 7-14), 2004, Winnipeg, MB: Wing Publishing Office. Copyright 2004 by Her Majesty the Queen in Right of Canada.

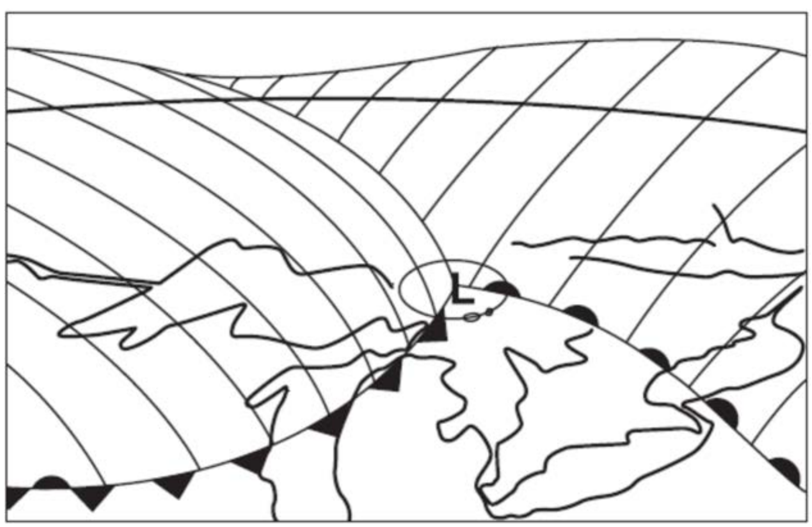

Figure H-2 Frontal Depression

Note. From *Air Command Weather Manual* (pp. 7-13), 2004, Winnipeg, MB: Wing Publishing Office. Copyright 2004 by Her Majesty the Queen in Right of Canada.

If the cold air is not as cold as the air it is overtaking (cool air advancing on cold air), the front is known as a warm occlusion.

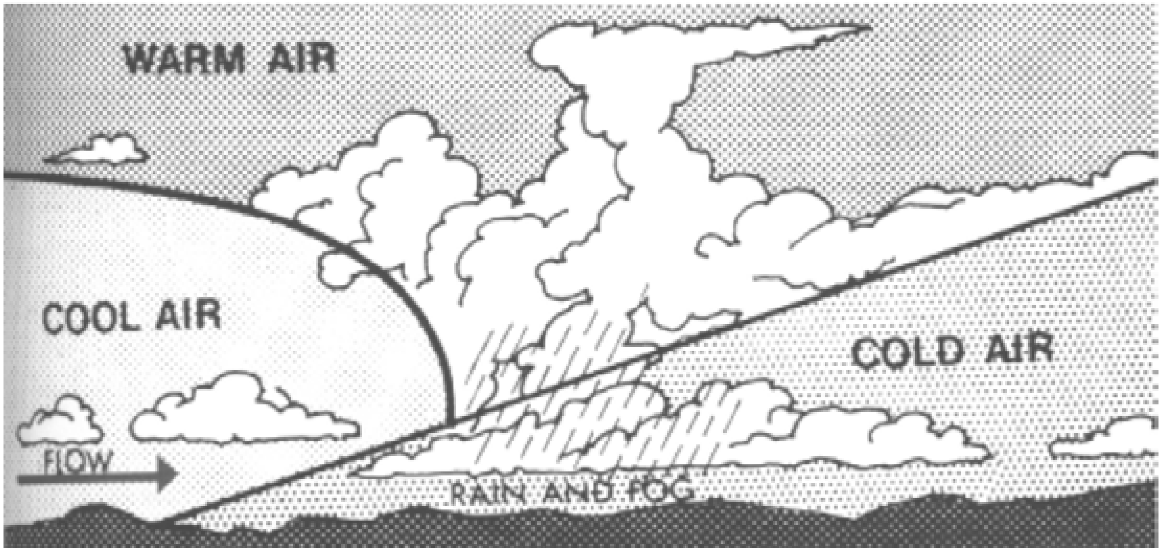

Figure H-3 Warm Occlusion

Note. From *From the Ground Up: Millennium Edition* (p. 143), by A. F. MacDonald and I. L. Peppler, 2000, Ottawa, ON: Aviation Publishers Co. Limited. Copyright 2000 by Aviation Publishers Co. Limited.

If the cold air is colder than the air it is overtaking (cold air advancing on cool air), the front is known as a cold occlusion.

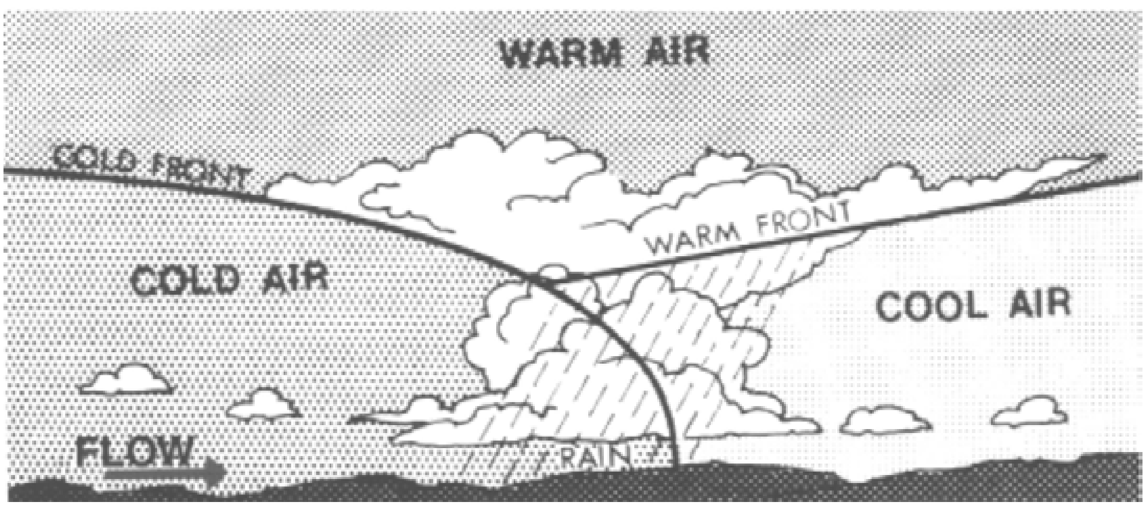

Figure H-4 Cold Occlusion

Note. From *From the Ground Up: Millennium Edition* (p. 143), by A. F. MacDonald and I. L. Peppler, 2000, Ottawa, ON: Aviation Publishers Co. Limited. Copyright 2000 by Aviation Publishers Co. Limited.

In both warm occlusions and cold occlusions, three air masses are present: a cool air mass, a cold air mass, and a warm air mass lying wedge-shaped over the colder air. The wedge-shaped mass of warm air is known as a trowal.

Both warm occlusions and cold occlusions have much the same characteristic as warm fronts, with low cloud and continuous rain. If the warm air is unstable, cumulonimbus clouds may develop; they are more likely to occur and bring about heavy turbulence, lightning, and icing in a cold occlusion.

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UPPER FRONTS

An upper cold front can form in two ways:

- A cold front advancing across the country may encounter a shallow layer of colder air resting on the surface. The cold front will then leave the ground and ride up over the colder, heavier air.

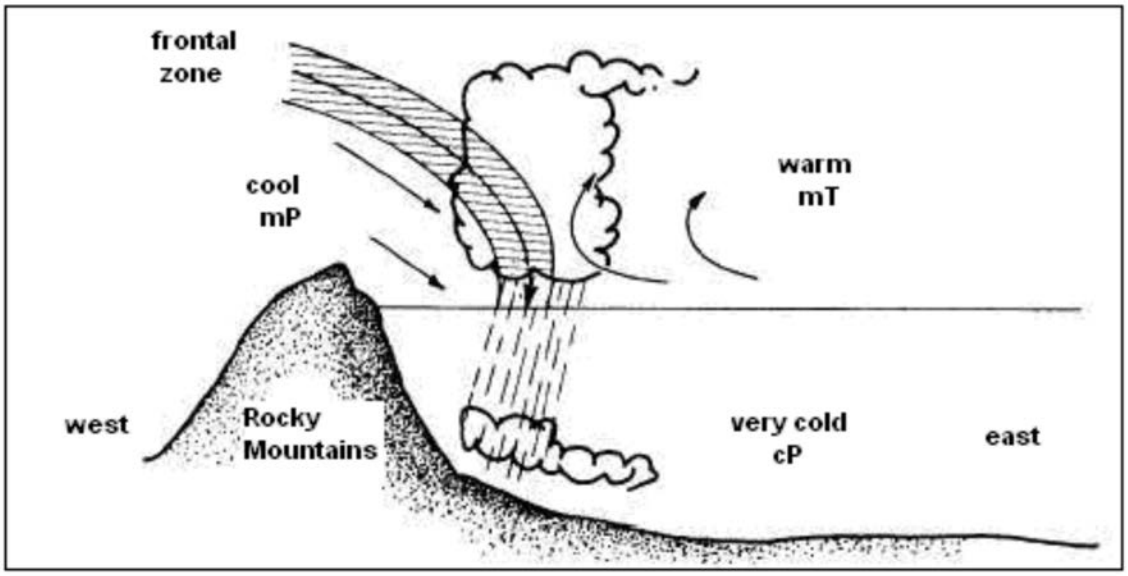

Figure I-1 Upper Cold Front

Note. From Integrated Publishing, *Aerographer / Meteorology*, Copyright 2003 by Integrated Publishing. Retrieved October 20, 2008, from http://www.tpub.com/content/aerographer/14312/css/14312_121.htm

- The structure of the advancing cold front is such that the cold air forms a shallow layer for some distance along the ground in advance of the main body of cold air. This causes the frontal surface of the main mass of cold air to be very steep. The line along which the frontal surface steepens is also known as an upper cold front.

An upper warm front can form in two ways:

- An advancing warm front rides up over a layer of cold air trapped on the ground. A change of air mass is not experienced on the ground because the front passes overhead.

- The surface of the cold air that is retreating ahead of an advancing warm front is almost flat for some distance ahead of the surface front and then steepens abruptly. The line along which the surface of the retreating cold air steepens sharply is also called an upper warm front.

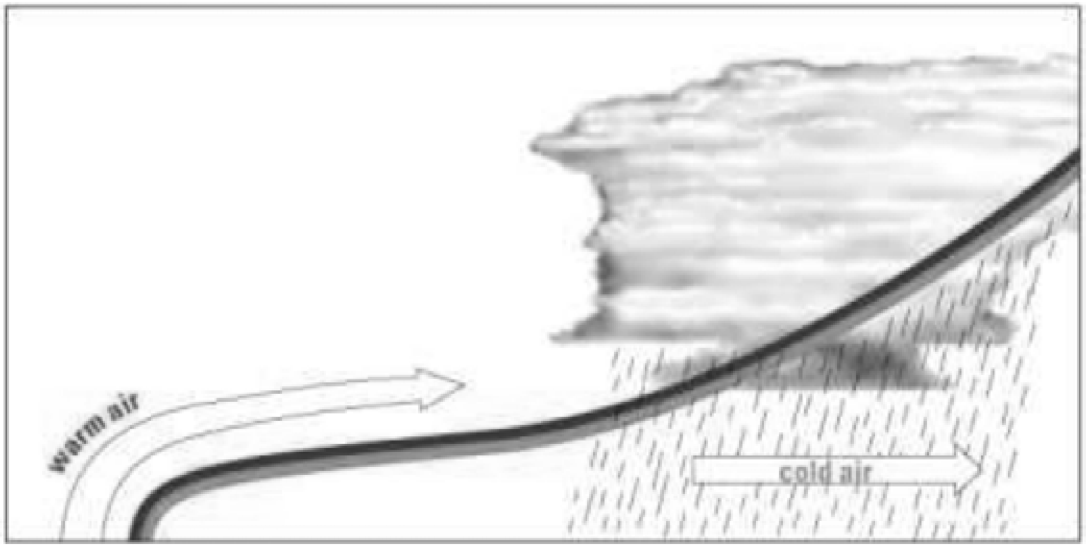

Figure I-2 Upper Warm Front

Note. From Weather and Frontal Systems, 2004, *Meteorological Services of Canada*. Copyright 2004 by Environment Canada. Retrieved October 20, 2008, from http://www.qc.ec.gc.ca/meteo/Documentation/Temps_fronts_e.html

Weather in upper fronts can be particularly hazardous in winter. Similar to warm fronts, rain from the warmer air falls through the layer of cold air on the surface causing freezing rain and icing conditions.

COLD FRONT

DEFINITION:

ASSOCIATED WEATHER:

INTERESTING FACTS:

DIAGRAM:

WARM FRONT

DEFINITION:

ASSOCIATED WEATHER:

INTERESTING FACTS:

DIAGRAM:

STATIONARY FRONT

DEFINITION:

ASSOCIATED WEATHER:

INTERESTING FACTS:

DIAGRAM:

OCCLUDED FRONTS

DEFINITION OF WARM OCCLUSION:

DEFINITION OF COLD OCCLUSION:

ASSOCIATED WEATHER:

INTERESTING FACTS:

DIAGRAM:

UPPER FRONTS

UPPER COLD FRONT FORMATION:

1.

2.

UPPER WARM FRONT FORMATION:

1.

2.

ASSOCIATED WEATHER:

DIAGRAM:

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ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 3

EO C436.01 – EXPLAIN FOG

Total Time:	30 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Acquire jars, strainers, and oven mitts (1 pair per group) for each group in TP 1.

Obtain three or four ice cubes for each group for TP 1.

Use a kettle(s) to boil water for each group for TP 1.

Prepare slides or handouts located at Attachment A.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An in-class activity was chosen for this lesson as it is an interactive way to present the formation and types of fog.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall be expected to explain fog.

IMPORTANCE

Fog is one of the most common and persistent weather hazards encountered in aviation which impedes a pilot's visibility. Being able to explain fog provides knowledge for potential instructional duties and is part of the fundamentals that cadets pursing future aviation training will require.

Teaching Point 1	Have the cadets perform an experiment to illustrate the formation of fog.
Time: 10 min	Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadet demonstrate how fog forms.

RESOURCES

- Glass jars,
- Strainers,
- Oven mitts,
- Kettle,
- Water,
- Rubbing alcohol, and
- Ice cubes.

ACTIVITY LAYOUT

Nil.

ACTIVITY INSTRUCTIONS

1. Divide the cadets into groups of two to four.
2. Use a kettle to boil water for each group.
3. Distribute resources to each group.
4. Briefly explain the steps of the experiment below and have the cadets make a hypothesis regarding the outcome.
5. Have each group perform the following experiment:
    a. Fill the jar completely with hot water and let it stand for one minute.
    b. Using oven mitts pour out all but 3 cm of water from the jar.
    c. Add three to four drops of rubbing alcohol to water.
    d. Put the strainer over the top of the jar.
    e. Place three or four ice cubes in the strainer.
    f. Observe the results.
6. Give the groups time to discuss what they have observed.
7. Ask the cadets to provide an explanation of what has happened.

The warm, moist air is cooled by the ice cubes to a temperature below its dewpoint, causing the water vapour to condense and form a cloud. A cloud in contact with the ground is called fog.

Fog can also form when the dewpoint is raised to the air temperature through the addition of water vapour.

The following are the ideal conditions for the formation of fog:

- an abundance of condensation nuclei,
- high relative humidity,
- a small temperature dewpoint spread, and
- some cooling process to initiate condensation.

Fog is usually dissipated by heating from below as sunlight filters down through the fog layer.

SAFETY

- Warn the cadets the water is hot and may cause burns.
- Ensure the cadets use oven mitts and caution when pouring the hot water.

CONFIRMATION OF TEACHING POINT 1

The cadets' participation in the activity will serve as the confirmation of this TP.

Teaching Point 2	**Conduct an in-class activity to explain types of fog.**
Time: 15 min	Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets explain types of fog.

RESOURCES

- Flip chart paper,
- Flip chart markers, and
- *From the Ground Up: Millennium Edition*.

ACTIVITY LAYOUT

Arrange the classroom for group work.

ACTIVITY INSTRUCTIONS

1. Divide the cadets into four groups.
2. Assign a leader in each group. The group leader will be responsible for assigning tasks to fellow cadets. Each group will need a recorder and at least one presenter.
3. Distribute flip chart paper and flip chart markers to each group.
4. Assign each group one of the following:
    a. radiation fog,
    b. advection fog,
    c. upslope fog and steam fog, and
    d. precipitation-induced fog and ice fog.
5. Have each group prepare a two-minute presentation on their type of fog using *From the Ground Up: Millennium Edition*, p. 147 as a reference.

> Encourage the cadets to be creative and draw diagrams of the formation of their types of fog.

6. Have each group deliver their presentation.

> Give handouts to each cadet or show slides located at Attachment A.

7. Answer any questions about the types of fog.

> The types of fog can easily be remembered using the mnemonic "RAIS UP", as in "RAIS UP da roof".

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS:

Q1. What conditions are ideal for the formation of radiation fog?

Q2. The drifting of warm, moist air over a colder land or sea surface causes which type of fog?

Q3. Explain the formation of steam fog.

ANTICIPATED ANSWERS:

A1. Light wind, clear skies, and an abundance of condensation nuclei.

A2. Advection fog.

A3. Steam fog is formed when cold air passes over a warm water surface. Evaporation of the water into the cold air occurs until the cold air becomes saturated. The excess water vapour condenses as fog.

END OF LESSON CONFIRMATION

QUESTIONS:

Q1. What is fog?

Q2. What are the two basic ways in which fog is formed?

Q3. What type of fog is associated mostly with warm fronts?

ANTICIPATED ANSWERS:

A1. Fog is a cloud in contact with the ground.

A2. Fog is formed in the following ways:

- warm, moist air is cooled to a temperature below its dewpoint, causing the water vapour to condense and form a cloud; or
- the dewpoint is raised to the air temperature through the addition of water vapour.

A3. Precipitation-induced fog.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

A good lookout is one of the most important aspects of airmanship when flying under Visual Flight Rules, making visibility from the cockpit a key factor in flight. Fog is one of the most common and persistent weather hazards encountered in aviation which impedes a pilot's visibility. An understanding of fog and the conditions under which it forms is essential for future aviation training.

INSTRUCTOR NOTES / REMARKS

Cadets who are qualified Advanced Aviation may assist with this instruction.

REFERENCES

C3-116 ISBN 0-9680390-5-7 MacDonald, A. F., & Peppler, I. L. (2000). *From the ground up: Millennium edition*. Ottawa, ON: Aviation Publishers Co. Limited.

C3-200 Weather Wiz Kids. (2008). *Make fog*. Retrieved September 26, 2008, from http://www.weatherwizkids.com/fog.htm

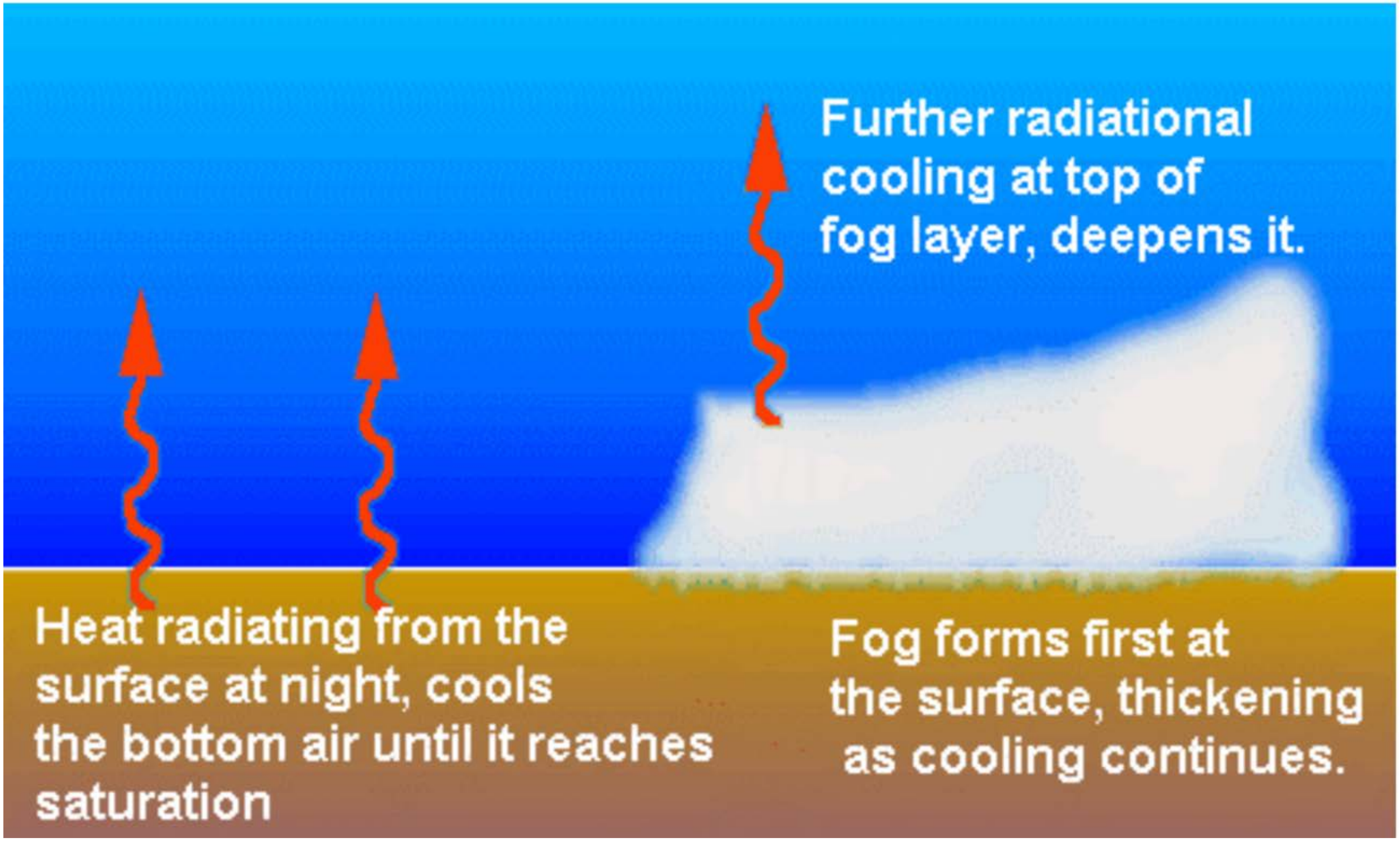


Figure A-1 Radiation Fog

Note. From The Fog Rolls In, 2002, *Weather Almanac for September*. Copyright 2002 by The Weather Doctor. Retrieved March 2, 2009, from http://www.islandnet.com/~see/weather/almanac/arc2002/alm02sep.htm

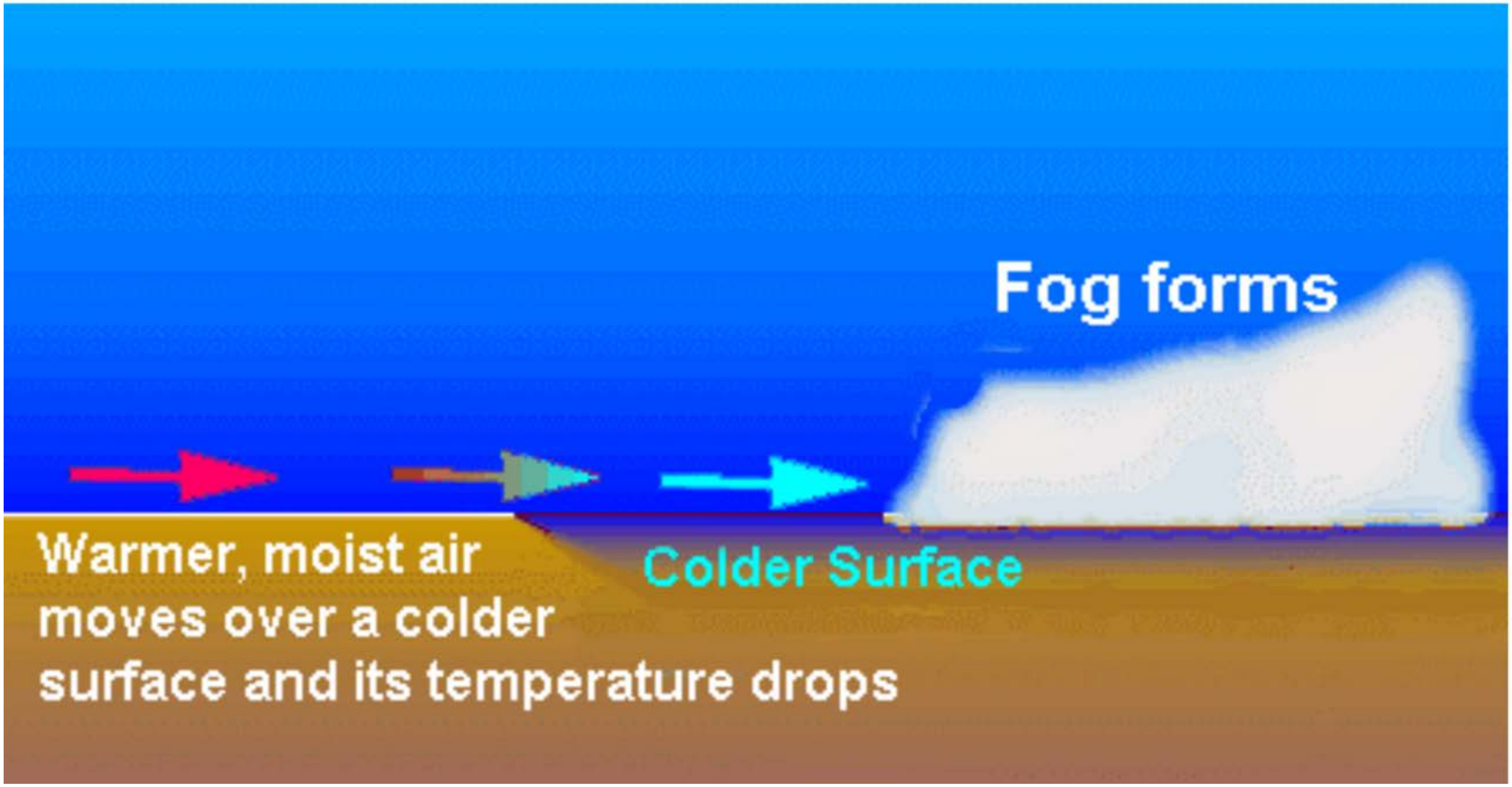


Figure A-2 Advection Fog

Note. From The Fog Rolls In, 2002, *Weather Almanac for September*. Copyright 2002 by The Weather Doctor. Retrieved March 2, 2009, from http://www.islandnet.com/~see/weather/almanac/arc2002/alm02sep.htm

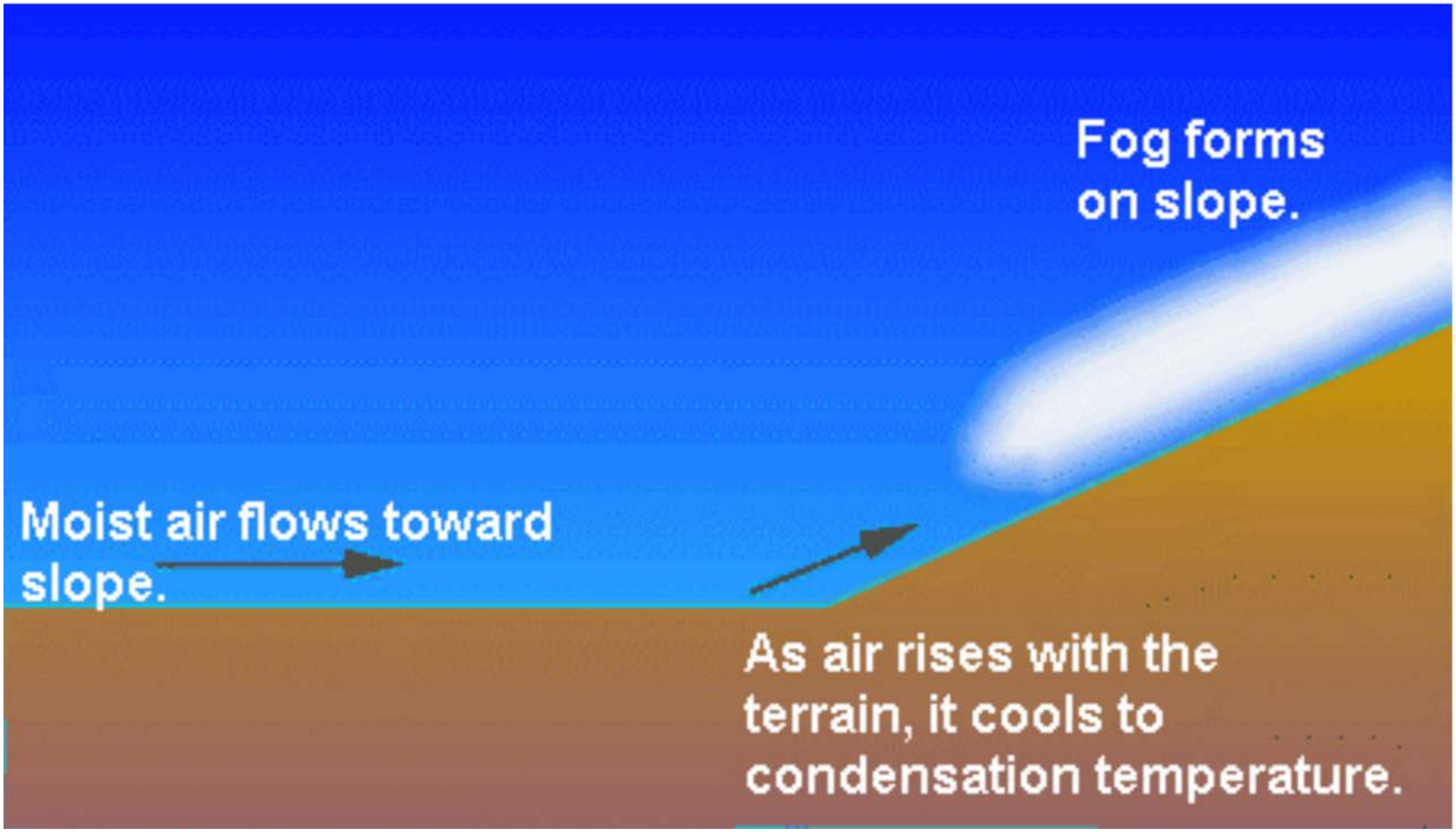


Figure A-3 Upslope Fog

Note. From The Fog Rolls In, 2002, *Weather Almanac for September*. Copyright 2002 by The Weather Doctor. Retrieved March 2, 2009, from http://www.islandnet.com/~see/weather/almanac/arc2002/alm02sep.htm

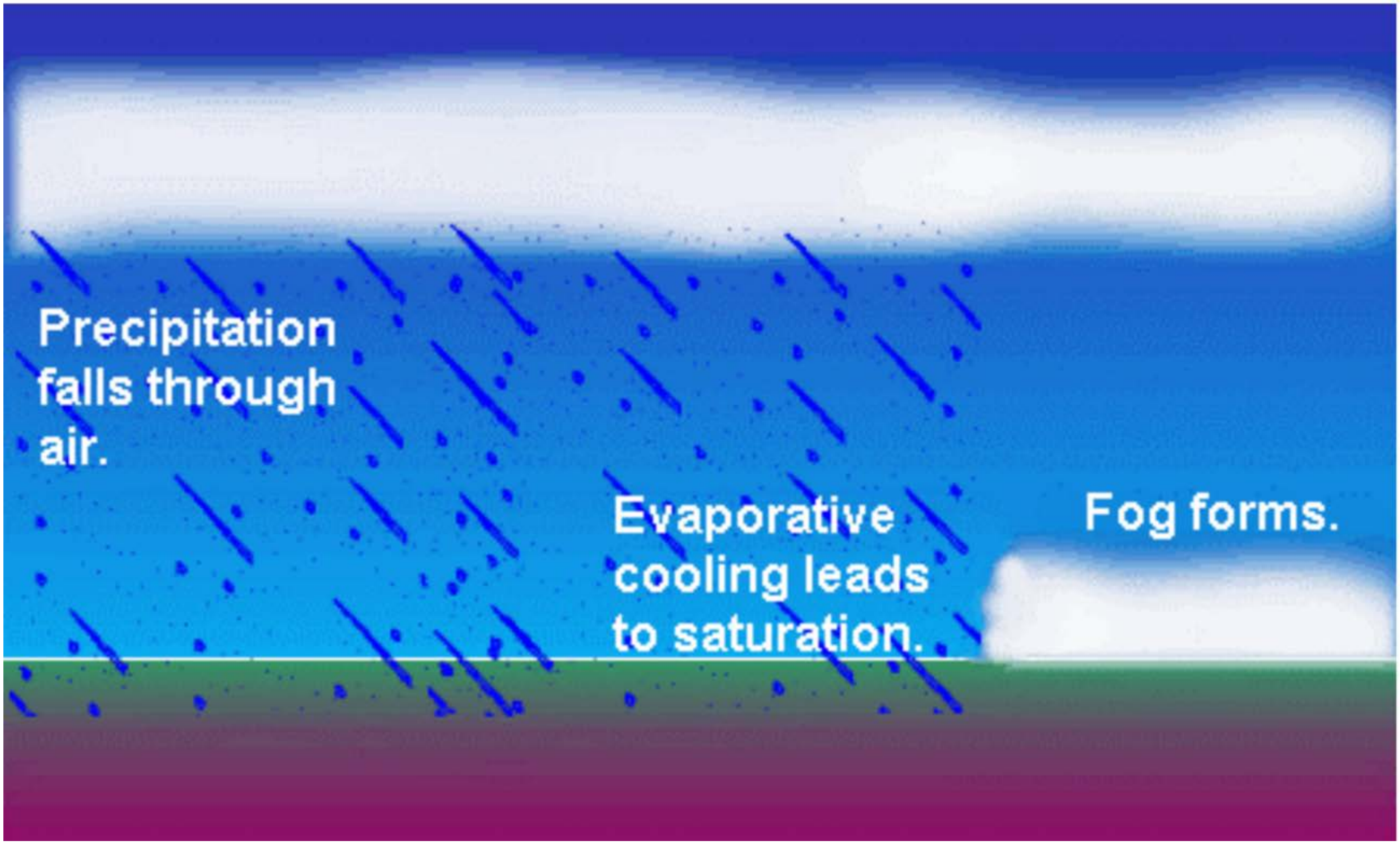


Figure A-4 Precipitation-Induced Fog

Note. From The Fog Rolls In, 2002, *Weather Almanac for September*. Copyright 2002 by The Weather Doctor. Retrieved March 2, 2009, from http://www.islandnet.com/~see/weather/almanac/arc2002/alm02sep.htm

ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 4

EO C436.02 – DESCRIBE SEVERE WEATHER CONDITONS

Total Time:	30 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-804/PG-001, *Proficiency Level Four, Qualification Standard and Plan*, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Prepare slides located at Attachment A.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An interactive lecture was chosen for this lesson to introduce the cadet to severe weather conditions and to generate interest.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall be expected to describe severe weather conditions.

IMPORTANCE

It is important for cadets to describe severe weather conditions as knowledge of this material is essential for future aviation training and potential instructional duties at the squadron.

Teaching Point 1	**Describe thunderstorms.**
Time: 10 min	Method: Interactive Lecture

THUNDERSTORMS

Formation

The requirements for the formation of a thunderstorm are the following:

- unstable air,
- high moisture content, and
- some form of lifting agent.

The intensity of these conditions is the difference between a harmless cumulus cloud and a violent thunderstorm. Such unstable atmospheric conditions may be brought about when air is heated from below (convection), forced to ascend the side of a mountain (orographic lift), or lifted over a frontal surface (frontal lift).

Show slide of Figure A-1.

There are three distinct stages of a thunderstorm:

1. cumulus,
2. mature, and
3. dissipating.

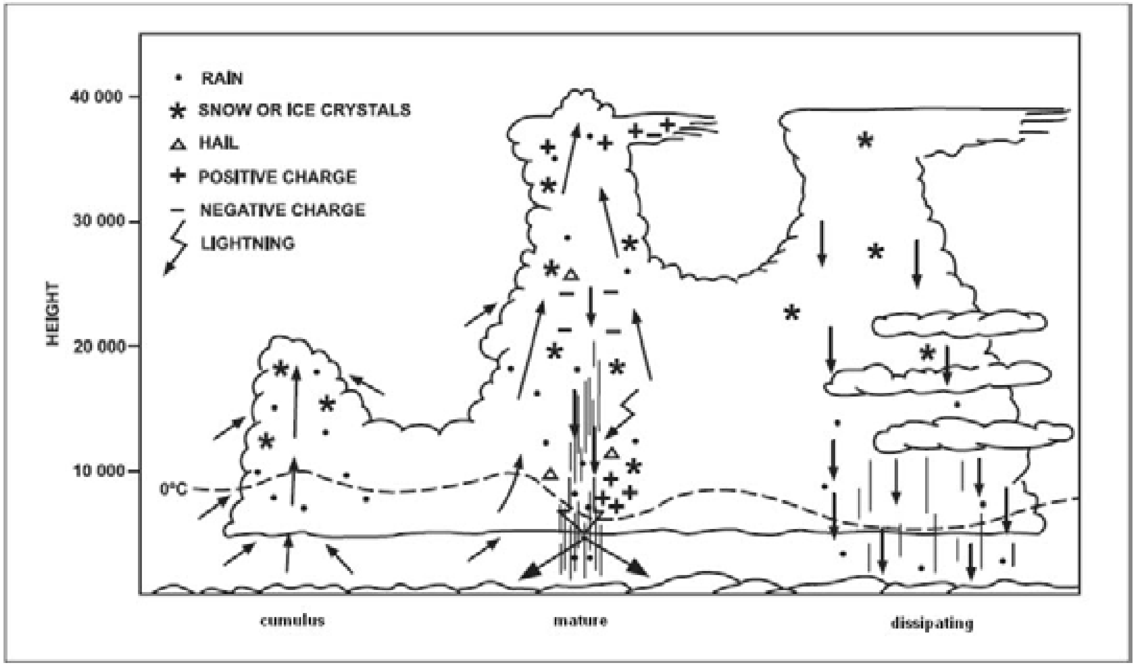


Figure 1 Stages of a Thunderstorm

Note. From *Air Command Weather Manual* (p. 15-2), 2004, Winnipeg, MB: Wing Publishing Office. Copyright 2004 by Her Majesty the Queen in Right of Canada.

Every thunderstorm begins as a cumulus cloud. Strong updrafts, due to the unstable air and lifting agent cause the cloud to build rapidly into a towering cumulus and then cumulonimbus cloud. There is usually no precipitation in this stage as the water droplets and ice crystals are kept suspended in the cloud by the strong updrafts.

In the mature stage, the cumulonimbus cloud may reach heights up to 60 000 feet, with updrafts of 6 000 feet per minute and downdrafts of 2 000 feet per minute. Precipitation, violent turbulence, and thunder and lightning are all associated with thunderstorms in their mature stage.

The precipitation tends to cool the lower region of the cloud causing the thunderstorm cell to dissipate. The downdrafts spread throughout the whole cell except for a small portion at the top where updrafts still occur. The rainfall gradually ceases and the top of the cell spreads out into an anvil shape.

Dangers

Show slide of Figure A-2.

The dangers of flying in or close to a thunderstorm are:

- severe turbulence,
- lightning,
- hail,
- icing,

- unreliable altimeter readings due to rapid changes in pressure,
- strong wind gusts, and
- heavy rain.

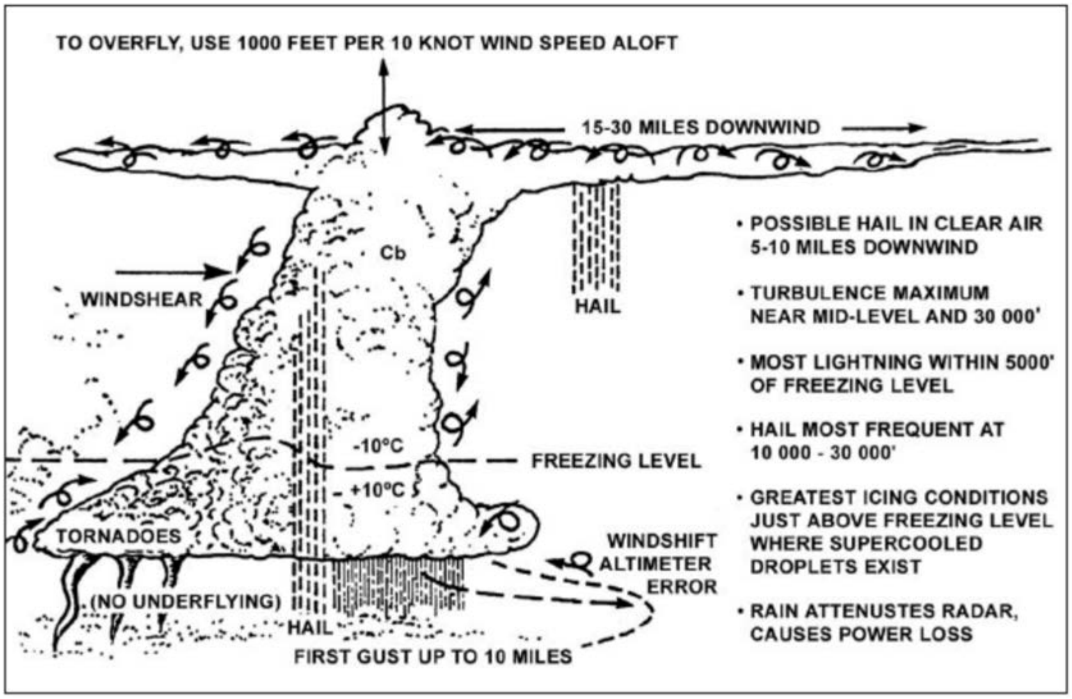


Figure 2   Thunderstorm Dangers

Note. From *Air Command Weather Manual* (p. 15-2), 2004, Winnipeg, MB: Wing Publishing Office. Copyright 2004 by Her Majesty the Queen in Right of Canada.

Avoidance

Stay at least five miles away from a thunderstorm. When flying around a thunderstorm, fly to the right side of it as the wind is circulating counter-clockwise around the low pressure area. Never fly through a thunderstorm in a light aircraft.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. What are the requirements for the formation of a thunderstorm?

Q2. In which stage of a thunderstorm will the top of the cumulonimbus cloud take on an anvil shape?

Q3. What are three of the dangers associated with thunderstorms?

ANTICIPATED ANSWERS:

A1. Unstable air, high moisture content, and some form of lifting agent.

A2. The dissipating stage.

A3. Cadets may give any three of the following answers:

- severe turbulence,
- lightning,
- hail,
- icing,
- unreliable altimeter readings due to rapid changes in pressure,
- strong wind gusts, and
- heavy rain.

Teaching Point 2	**Describe icing.**
Time: 5 min	Method: Interactive Lecture

ICING

When an airplane flies at an altitude where the outside air temperature is at or below freezing and strikes a supercooled water droplet, the droplet will freeze and adhere to the airplane. This can occur in cloud, freezing rain, or freezing drizzle. Icing can also occur in clear air through sublimation.

Types of Icing

There are three main types of icing:

- clear ice,
- rime ice, and
- frost.

Show slide of Figure A-3.

Clear ice is a heavy coating of glassy ice which forms when flying in dense cloud or freezing rain. It forms when only a small part of the supercooled water droplet freezes on impact, with the rest of the droplet spreading out and freezing slowly. Clear ice is the most dangerous form of icing because of the following:

- loss of lift due to the altered camber of the wing,
- increase in drag due to the enlarged profile area of the wings,
- increase in weight due to the large mass of ice, and
- the vibration caused by the unequal loading on the wings and propeller blades.

Rime ice is an opaque (milky white) deposit of ice. Rime ice forms when the aircraft skin is at a temperature below zero degrees Celsius, causing the water droplet to freeze completely on contact. Although rime ice is light, it is dangerous due to the aerodynamic alteration of the wing camber and the interference it causes with the carburetor and pitot static system.

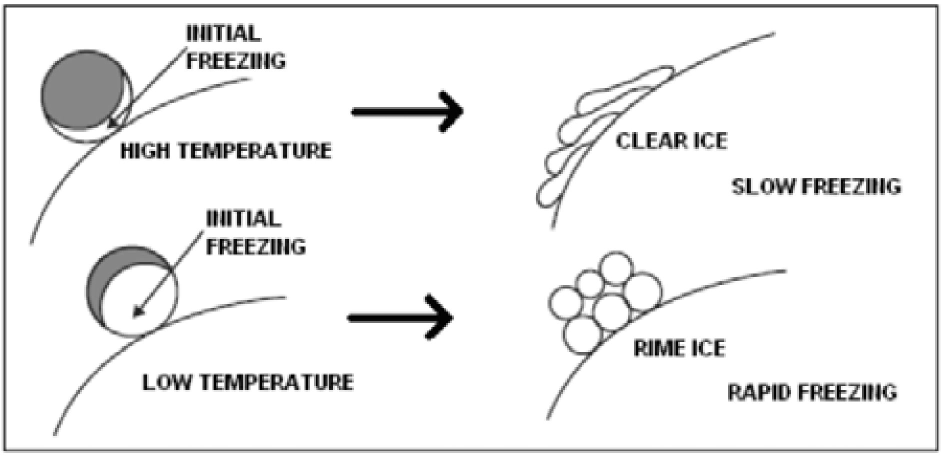


Figure 3 Clear Ice and Rime Ice

Note. From *Air Command Weather Manual* (p. 9-4), 2004, Winnipeg, MB: Wing Publishing Office. Copyright 2004 by Her Majesty the Queen in Right of Canada.

Frost is a white semi-crystalline form of icing which forms in clear air by the process of sublimation. It generally forms on two occasions:

- when a cold aircraft enters warmer and damper air during a steep descent; and
- when an aircraft parked outside on a clear cold night cools by radiation to a temperature below that of the surrounding air.

Frost should be removed before takeoff as it will reduce lift and increase the stall speed of the aircraft.

Show slide of Figure A-4.

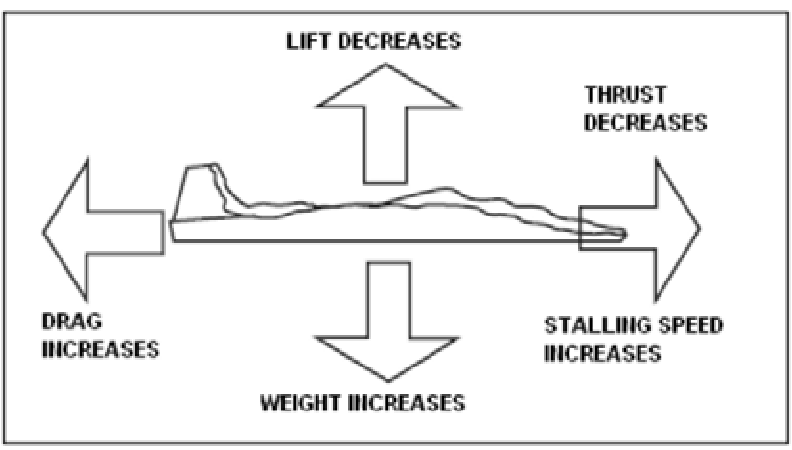


Figure 4 Effects of Icing

Note. From *Air Command Weather Manual* (p. 9-1), 2004, Winnipeg, MB: Wing Publishing Office. Copyright 2004 by Her Majesty the Queen in Right of Canada.

Protection From Icing

Many modern airplanes are fitted with various systems designed to prevent ice from forming or to remove ice after it has formed. Three of these systems are:

- fluids,
- rubber boots, and
- heating devices.

Fluids with a low freezing point are released over the blades of the propellers and the surfaces of the wings to prevent icing.

Show slide of Figure A-5.

Rubber boots are membranes of rubber attached to the leading edges that can pulsate in such a way that ice is cracked and broken off after it has formed.

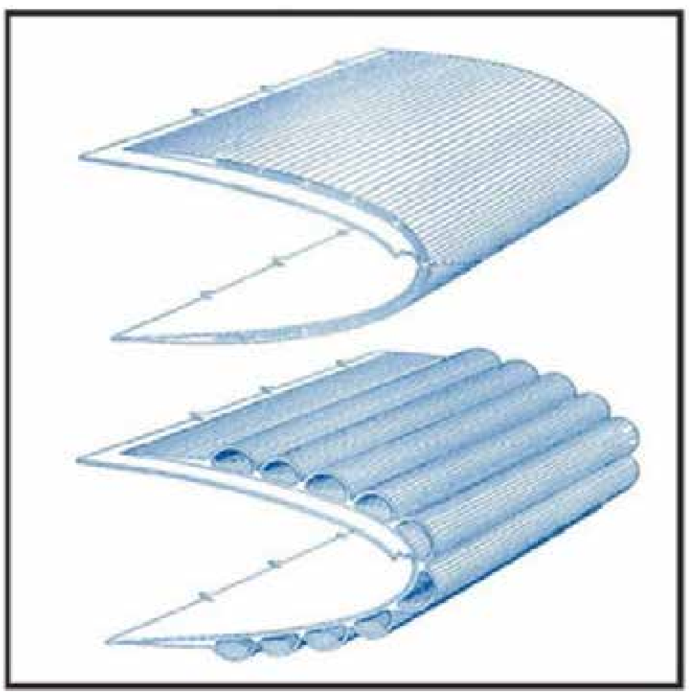


Figure 5 Rubber Boots

Note. From "Icing Conditions in Flight", *Pilot Friend*. Retrieved October 22, 2008, from http://www.pilotfriend.com/safe/safety/icing_conditions.htm

Heating vulnerable areas with hot air from the engine or special heaters prevents the buildup of ice.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS:

Q1. How can a pilot tell the difference between clear ice and rime ice?

Q2. How does frost form?

Q3. What are three methods of protection from icing?

ANTICIPATED ANSWERS:

A1. Clear ice is glassy while rime ice is opaque.

A2. Frost forms through sublimation.

A3. Fluids, rubber boots, and heating devices.

Teaching Point 3	**Describe types of turbulence.**
Time: 10 min	Method: Interactive Lecture

TYPES OF TURBULENCE

Turbulence is an irregular motion of the air resulting from eddies and vertical currents. It is one of the most unpredictable of all the weather phenomena.

There are four types of turbulence:

- mechanical turbulence,
- thermal turbulence,
- frontal turbulence, and
- wind shear.

Show slides of Figures A-6 and A-7.

Mechanical Turbulence

Mechanical turbulence is caused by friction between the air and the ground. The intensity of mechanical turbulence depends on the strength of the surface wind, the nature of the terrain, and the stability of the air. Strong winds, rough terrain, and very unstable air create greater turbulence. Mountain waves produce some of the most severe mechanical turbulence.

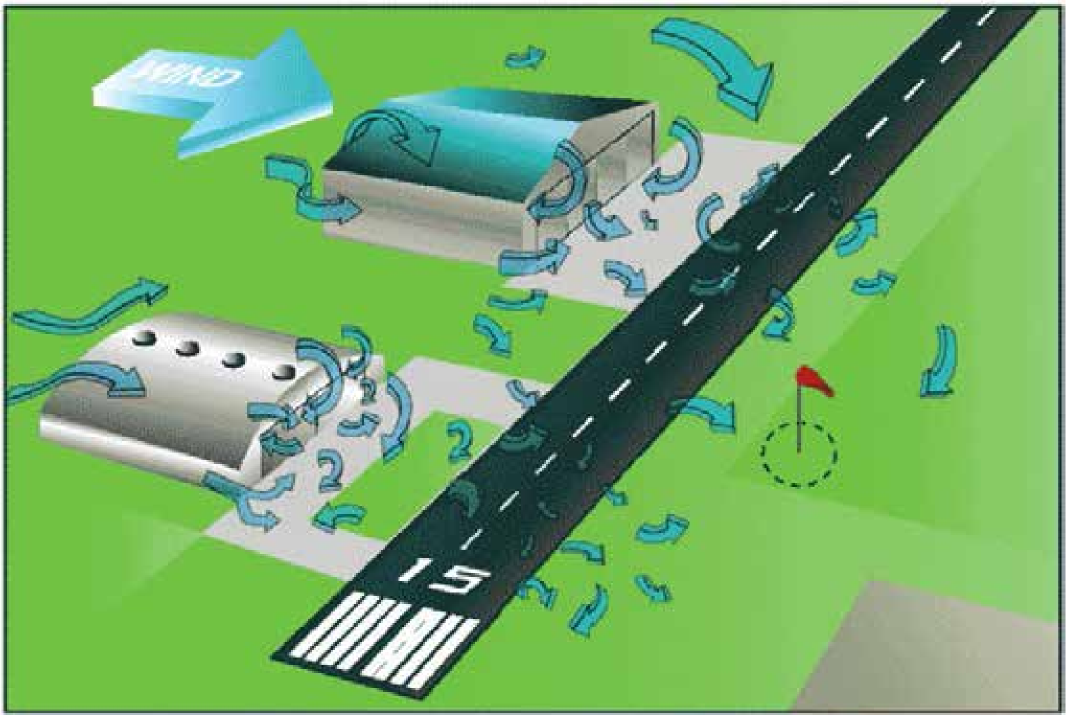
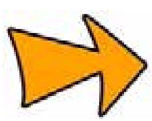


Figure 6 Mechanical Turbulence

Note. From "Aviation Weather", *Free Online Private Pilot Ground School*. Retrieved October 22, 2008, from http://www.free-online-private-pilot-ground-school.com/Aviation-Weather-Principles.html

Thermal Turbulence

Thermal turbulence is caused by the uneven heating of the ground. Certain surfaces, such as plowed fields and pavement, are heated more rapidly than others, such as grass-covered fields and water. This causes isolated convective currents that are responsible for bumpy conditions as an airplane flies in and out of them. These convective currents can have a pronounced effect of the flight path of an airplane approaching a landing area, causing it to either overshoot or undershoot.



Rising convective currents are commonly referred to as "thermals" or "lift". Glider pilots use their knowledge of the terrain to find thermals and soar for extended periods of time. They also learn to recognize and avoid sinking convective currents (commonly known as "sink").

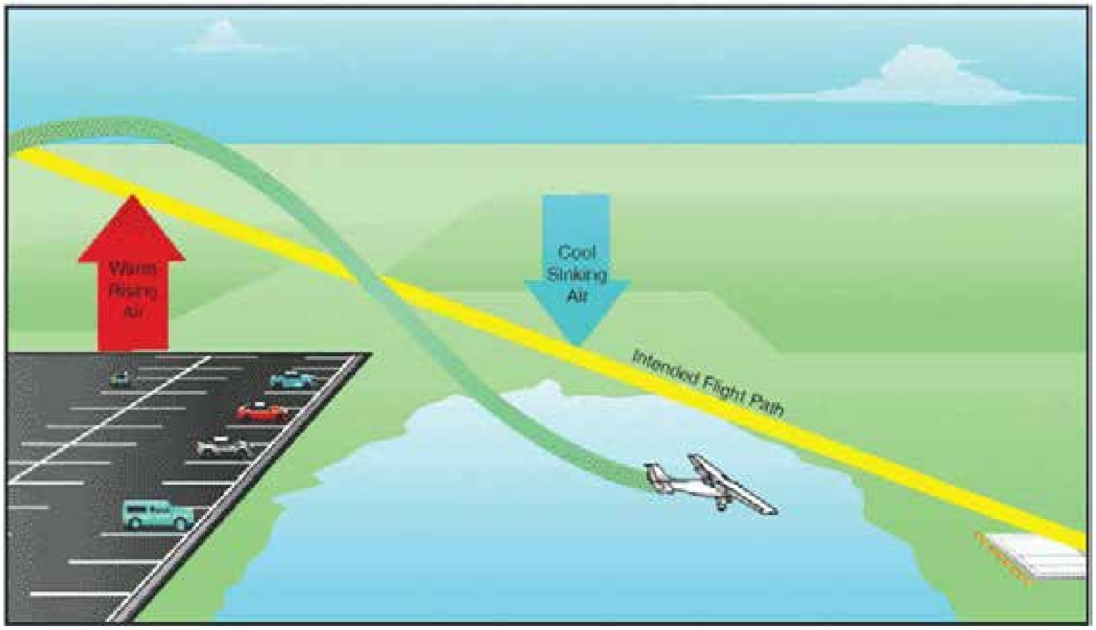


Figure 7 Thermal Turbulence

Note. From "Aviation Weather", *Free Online Private Pilot Ground School*. Retrieved October 22, 2008, from http://www.free-online-private-pilot-ground-school.com/Aviation-Weather-Principles.html

Frontal Turbulence

Frontal turbulence is caused by the lifting of warm air by the sloping frontal surface and the friction between the two opposing air masses. This turbulence is strongest in cold fronts, especially when the warm air is moist and unstable.

Wind Shear

Wind shear is caused when there are significant changes in wind speed and direction with height.

CONFIRMATION OF TEACHING POINT 3

QUESTIONS:

Q1. What causes mechanical turbulence?

Q2. Name two examples of terrain that heat more rapidly than water.

Q3. In which type of front is turbulence more pronounced?

ANTICIPATED ANSWERS:

A1. Mechanical turbulence is caused by friction between the air and the ground.

A2. A plowed field and pavement.

A3. Cold front.

END OF LESSON CONFIRMATION

QUESTIONS:

Q1. What are the three stages of a thunderstorm?

Q2. What are the three main types of icing?

Q3. What are the four types of turbulence?

ANSWERS:

A1. Cumulus, mature, and dissipating.

A2. Clear ice, rime ice, and frost.

A3. Mechanical turbulence, thermal turbulence, frontal turbulence, and wind shear.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

Severe weather conditions can adversely affect a flight and ruin a pilot's day. Knowing how to recognize and deal with these conditions is essential for future aviation training.

INSTRUCTOR NOTES / REMARKS

Cadets who are qualified Advanced Aviation may assist with this instruction.

REFERENCES

C3-116 ISBN 0-9680390-5-7 MacDonald, A. F., & Peppler, I. L. (2000). *From the ground up: Millennium edition*. Ottawa, ON: Aviation Publishers Co. Limited

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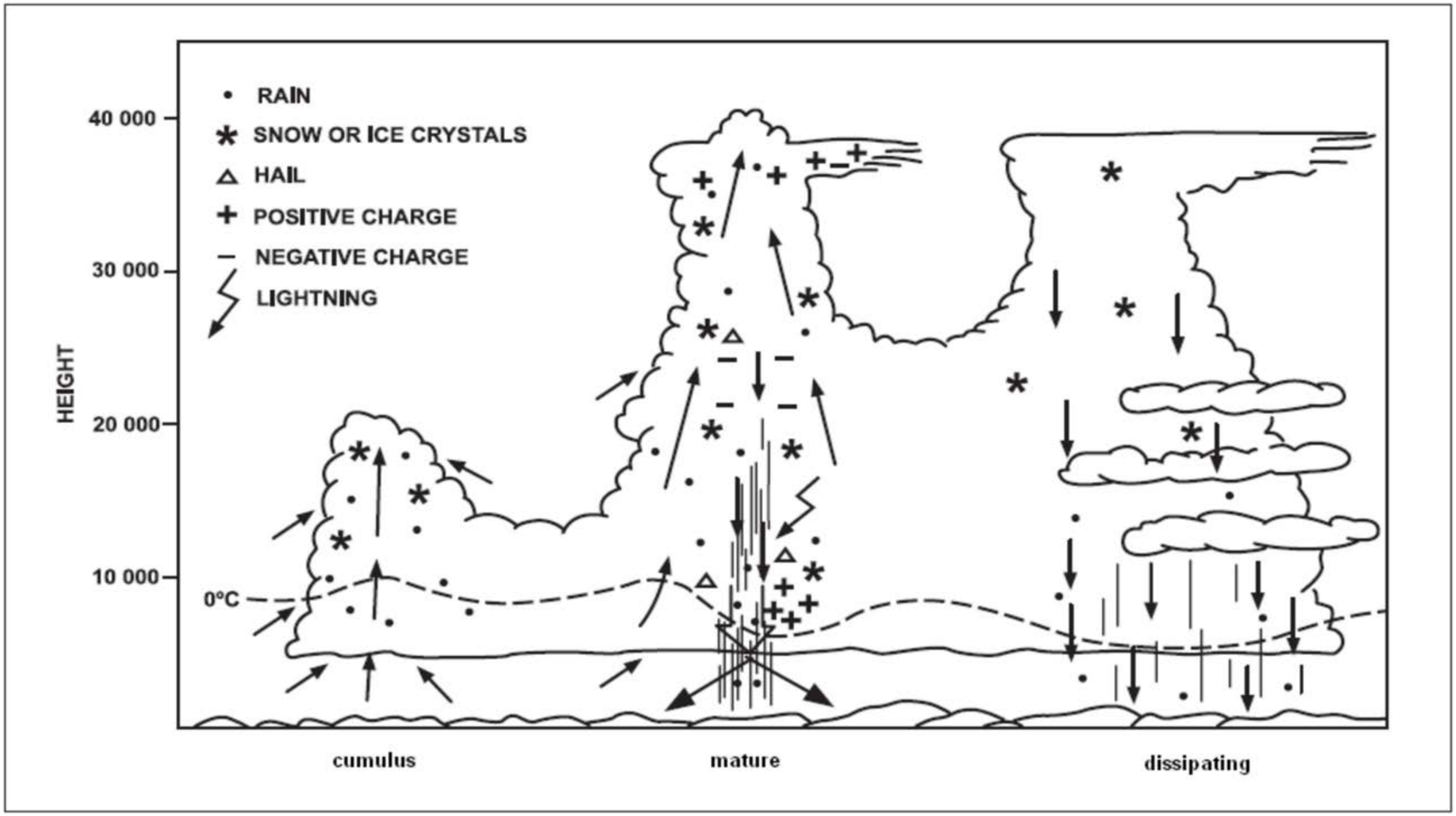

Figure A-1 Stages of a Thunderstorm

Note. From *Air Command Weather Manual* (p. 15-2), 2004, Winnipeg, MB: Wing Publishing Office. Copyright 2004 by Her Majesty the Queen in Right of Canada.

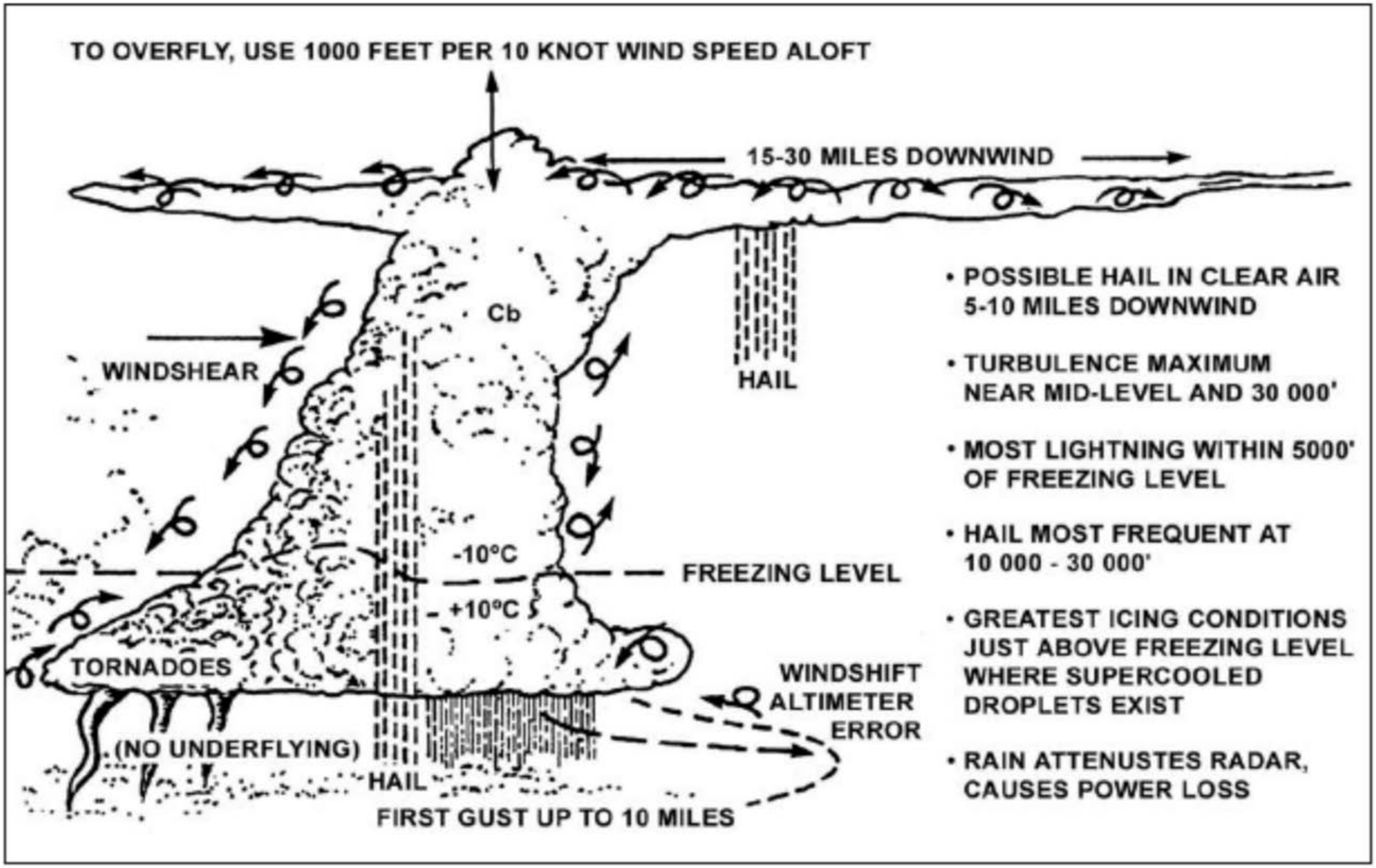

Figure A-2 Thunderstorm Dangers

Note. From *Air Command Weather Manual* (p. 15-2), 2004, Winnipeg, MB: Wing Publishing Office. Copyright 2004 by Her Majesty the Queen in Right of Canada.

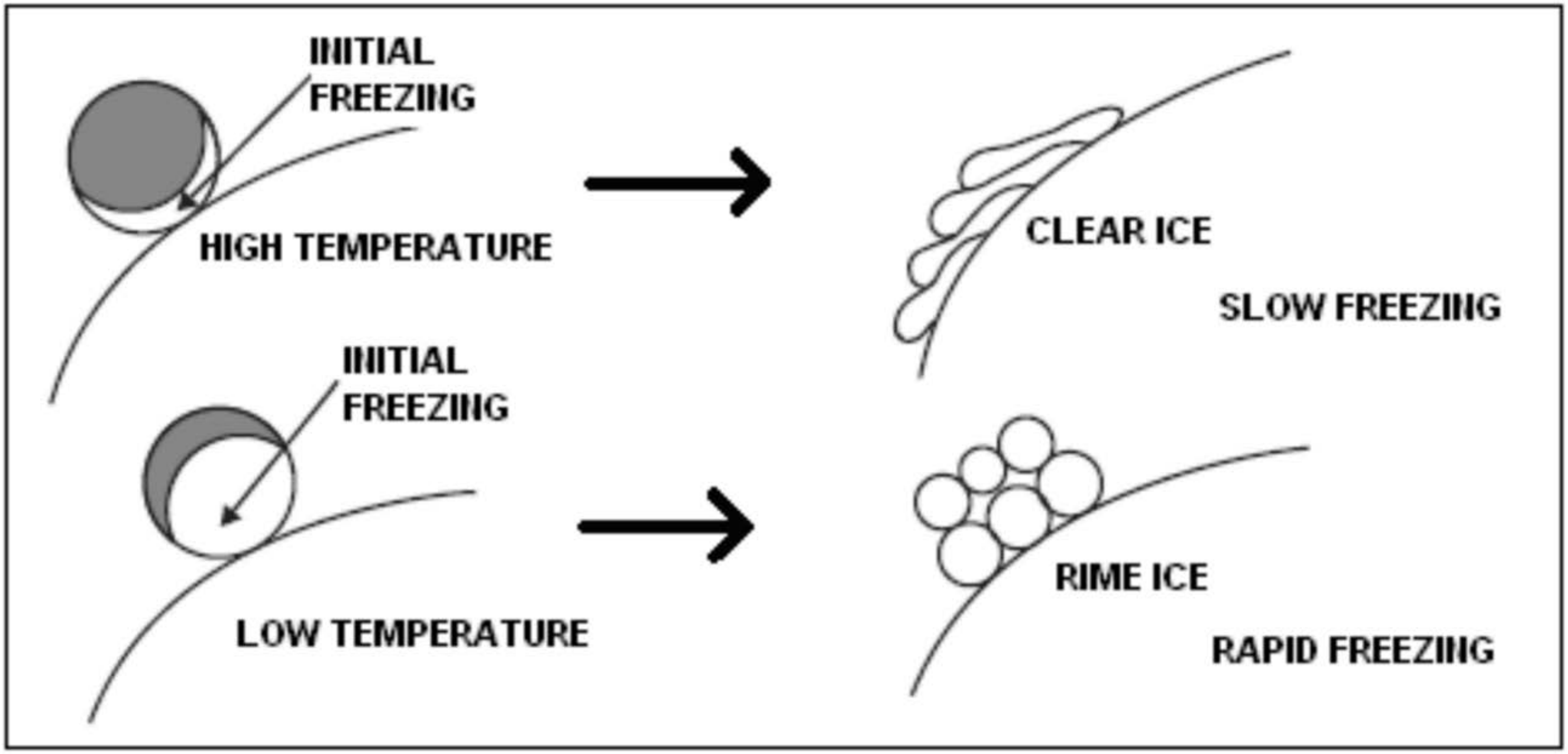

Figure A-3 Clear Ice and Rime Ice

Note. From *Air Command Weather Manual* (p. 9-4), 2004, Winnipeg, MB: Wing Publishing Office. Copyright 2004 by Her Majesty the Queen in Right of Canada.

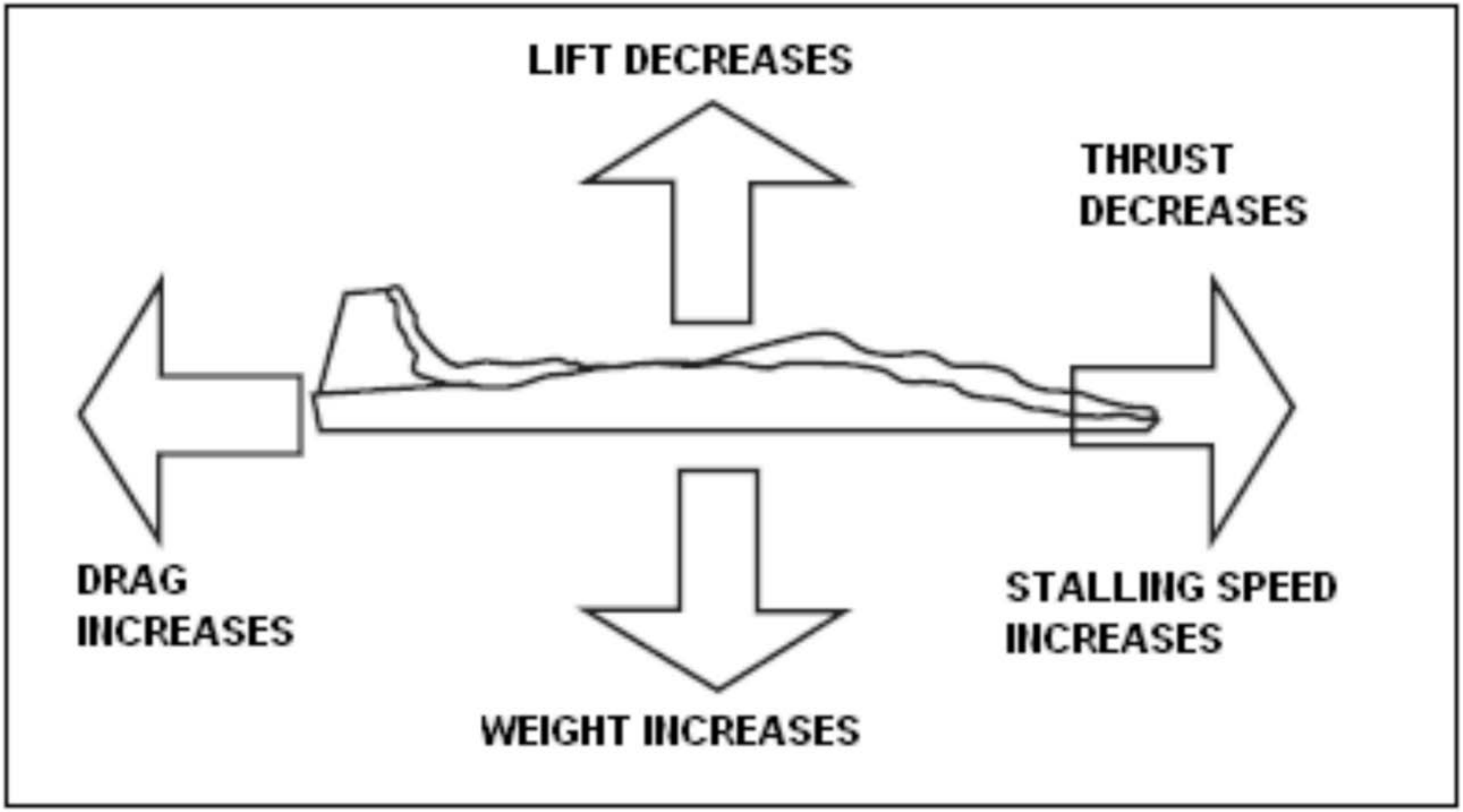

Figure A-4 Effects of Icing

Note. From *Air Command Weather Manual* (p. 9-1), 2004, Winnipeg, MB: Wing Publishing Office. Copyright 2004 by Her Majesty the Queen in Right of Canada.

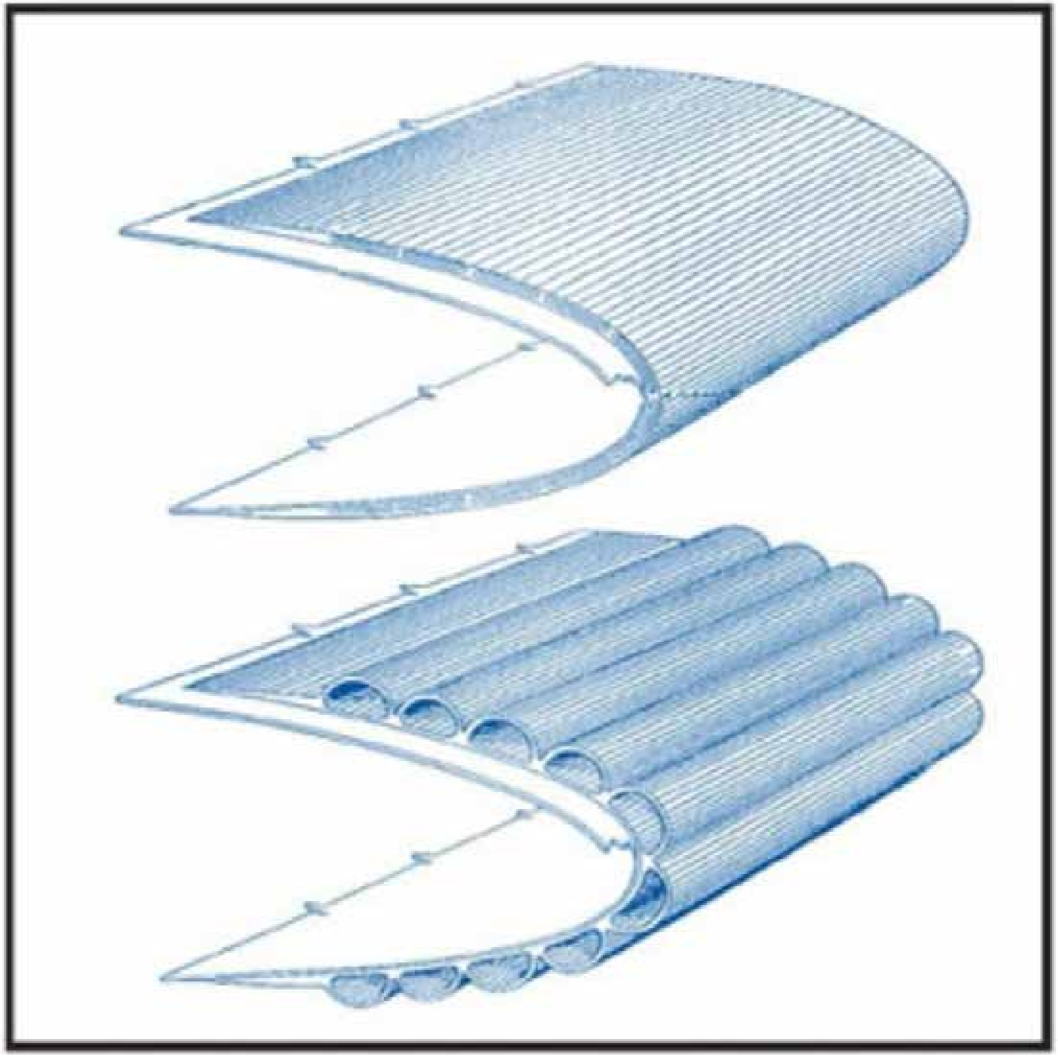

Figure A-5 Rubber Boots

Note. From "Icing Conditions in Flight", *Pilot Friend*. Retrieved October 22, 2008, from http://www.pilotfriend.com/safe/safety/icing_conditions.htm

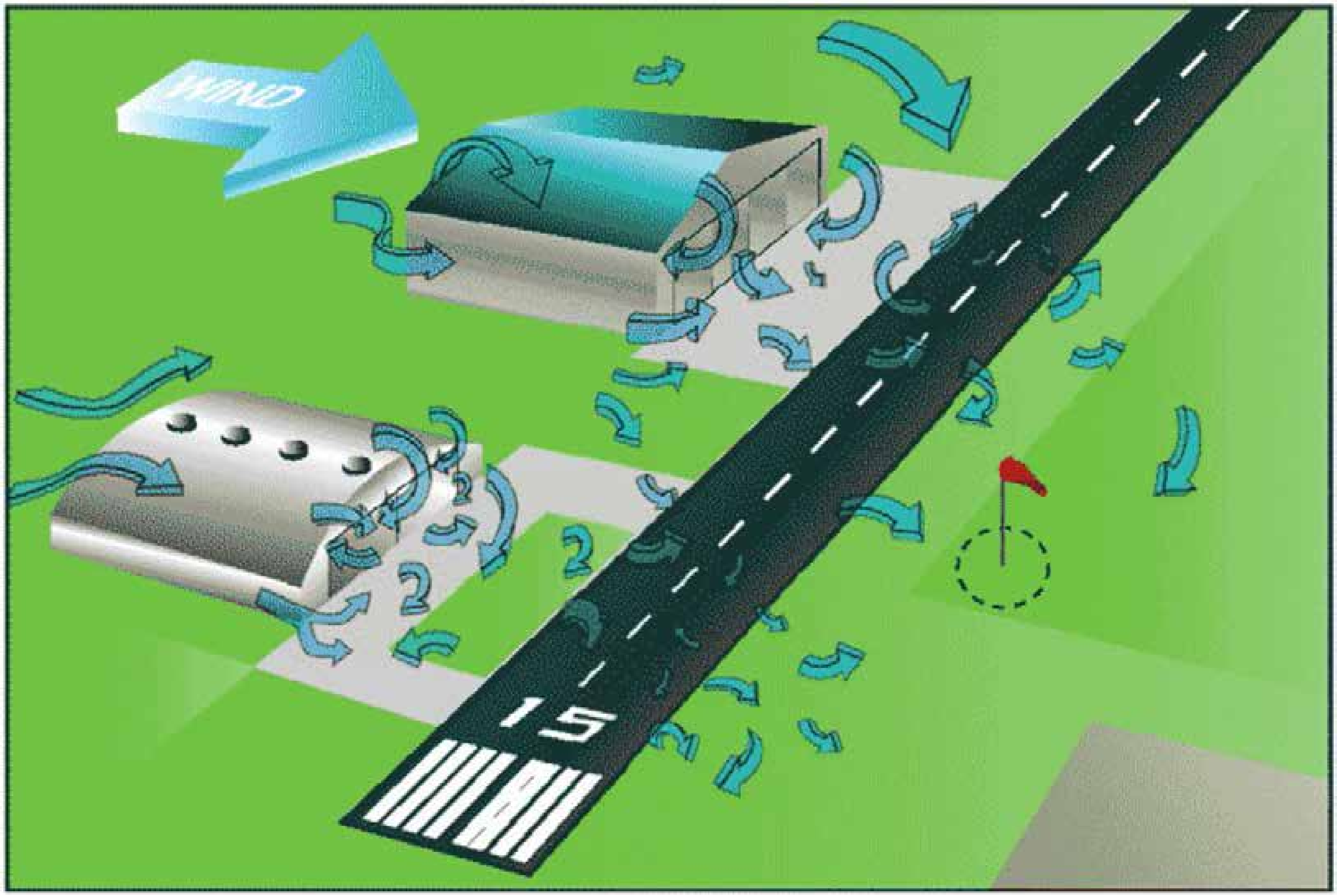

Figure A-6 Mechanical Turbulence

Note. From "Aviation Weather", *Free Online Private Pilot Ground School*. Retrieved October 22, 2008, from http://www.free-online-private-pilot-ground-school.com/Aviation-Weather-Principles.html

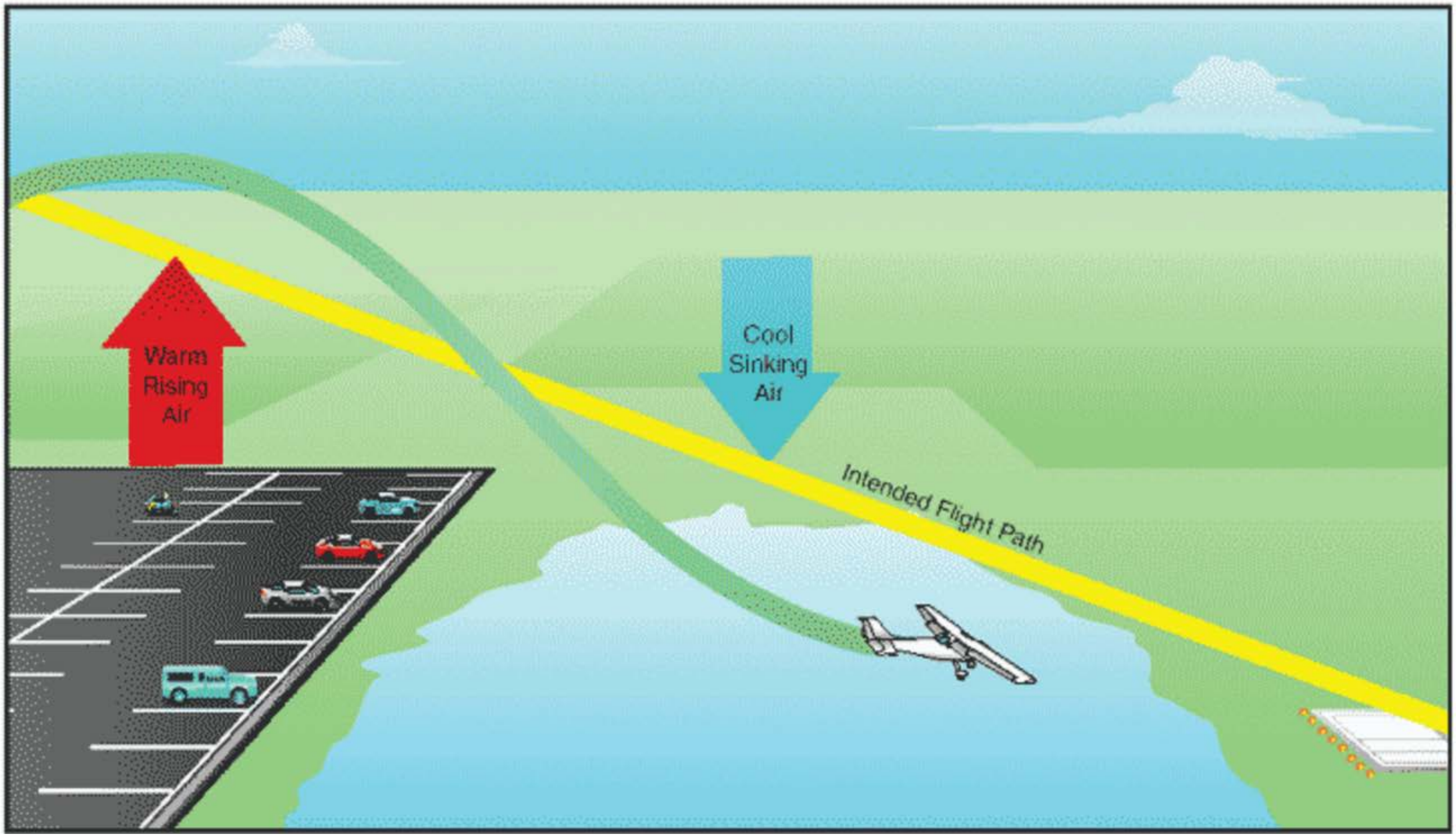

Figure A-7 Thermal Turbulence

Note. From "Aviation Weather", *Free Online Private Pilot Ground School*. Retrieved October 22, 2008, from http://www.free-online-private-pilot-ground-school.com/Aviation-Weather-Principles.html

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ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 5

EO C436.03 – ANALYZE WEATHER INFORMATION

Total Time:	90 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Prepare the slides located at Attachments A, C–G, I and J.

Photocopy the handouts located at Attachments B and H.

Make handouts of recent METARs, TAFs, FDs and GFAs in standard format from the NAV CANADA aviation weather website for each cadet.

Make a copy in plain language of the same METARs, TAFs, FDs and GFAs handouts from the NAV CANADA aviation weather website being given to each cadet.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An interactive lecture was chosen for TPs 1–7 to introduce weather reports and forecasts, to give the cadets the basic material they need to decode and analyze the information and to generate interest in the subject.

An in-class activity was chosen for TP 8 as it is an interactive way for the cadets to practice analyzing weather information under supervision.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall have analyzed weather information.

IMPORTANCE

It is important for cadets to analyze weather information as this skill is used by cadets to analyze weather when preparing for day-to-day activities and to fly. Being able to analyze weather information provides knowledge for potential instructional duties and is part of the fundamentals that cadets pursing future aviation training will require.

Teaching Point 1	**Describe a METAR.**
Time: 5 min	Method: Interactive Lecture

METARs

Show the cadets the slide of Attachment A.

Definition

METAR is the name given to the international meteorological code used in aviation routine weather reports. These reports describe the existing weather conditions at a specific time and location. In other words, the METAR is a snapshot of the current weather; it is not a forecast.

Frequency of Reports

METARS are normally issued every hour, on the hour as weather does not normally change much in this brief period of time. METARs are only valid at the time that they are issued, not for the hour between reports.

Special Weather Reports (SPECI)

There are times when the weather changes drastically in a short period of time. When this happens a SPECI is issued. SPECIs use the same code as a METAR, but start with SPECI.

Where METARs are Available

METARs can be found at several locations. The three most common locations are:

- NAV CANADA's aviation weather website,
- a Flight Services Station (FSS), and
- a Flight Information Centre (FIC) (normally accessed by phone).

CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. What does a METAR describe?

Q2. How often are METARs normally issued?

Q3. When is a SPECI issued?

ANTICIPATED ANSWERS:

A1. A METAR describes the existing weather conditions at a specific time and location.

A2. METARS are normally issued every hour, on the hour.

A3. A SPECI is used when the weather changes drastically in a short period of time.

Teaching Point 2 | **Familiarize the cadets with METAR terminology.**

Time: 15 min | Method: Interactive Lecture

TERMINOLOGY USED IN METARs

Indicate on the slide of Attachment A each of the following groupings as they are covered.

METAR is a code used in aviation weather reporting. This code is based on the World Meteorological Organization's (WMO) standards and conventions. A METAR is organized into sections with each section always in the same order.

Report Type

The report name is in the first line of the text. The name will show as either METAR or SPECI.

Location Indicator

Each weather reporting station in Canada is assigned a four-letter identifier, starting with the letter C. The second letter indicates the type of station and the last two letters identify the specific reporting station.

For example, CYOW is the reporting station at Ottawa / MacDonald-Cartier International Airport. The C means the station is Canadian, the Y means the station is co-located with an airport, and OW is the airport identifier.

Date and Time of Observation

The date and time of the observation are given as a six-digit grouping, based on Coordinated Universal Time (UTC / ZULU / Z). The first two digits signify the day of the current month, while the last four digits signify the time of the day. The official time of the observation is given for all METAR reports that do not deviate more than 10 minutes from the top of the hour. SPECIs will have the time reported to the exact minute.

For example, a METAR will show as 091000Z which means that the observation was taken on the ninth day of the month at 1000 hours UTC (or within 10 minutes of that hour).

For example, a SPECI will show as 091036Z, which means that a significant change in weather was observed on the ninth day of the month at 1036 hours UTC.

Report Modifier

This field may contain two possible codes: AUTO or CC* (where * is a letter from A–Z which represents corrections). AUTO indicates that the report is primarily based on observations from an automated weather observation station (AWOS). CC* is used to indicate corrected reports, where the first correction is CCA, the second is CCB, and so on. Both AUTO and CC* may be found in the same report.

Wind

This group reports the two-minute average wind direction and speed. Direction is always three digits, given in degrees true but rounded off to the nearest 10 degrees. Speed is normally two digits, and is given in knots (nautical miles per hour or kt). A reading of 00000KT indicates calm winds.

For example, 35016KT means winds are from 350 degrees true (rounded off) at 16 knots.

If gust conditions exist, the direction and speed will be followed by a G and the maximum gust strength. A gust must be five knots stronger than the 10-minute average wind speed.

For example, 35016G25KT means winds are from 350 degrees true at 16 knots gusting to 25 knots.

Prevailing Visibility

Prevailing visibility is the average visibility at the reporting station. The prevailing visibility is reported in statute miles (SM) or fractions of a statute mile.

For example, 3SM means the prevailing visibility is 3 statute miles.

Runway Visual Range

This is only included if the prevailing visibility is less than 1 SM, or the runway visual range is less than 6 000 feet. This group will start with an R, then the runway number (eg, 06) and position (eg, L for left, R for right, C for centre), followed by the runway visual range in hundreds of feet. This is based on a 10-minute average. The runway visual range trend is indicated if there is a distinct upward or downward trend from the first to the second five-minute part-period. If the runway visual range changes by 300 feet or more it is indicated as /U for an upward trend or /D for a downward trend. No distinct change is indicated as /N. If it is not possible to determine the trend it will be left blank.

For example, R06L/4000FT/D means the runway visual range for runway 06 left is 4 000 feet with a downward trend.

Present Weather

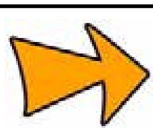
Distribute the handout of Attachment B to the cadets.

This group indicates the current weather phenomena at the reporting station. This may include precipitation, obscuration, or other phenomena.

Each phenomenon is represented by a code, which may be two to nine characters in length. Each code may include one or both of the following prefixes:

- **Intensity.** (-) indicates light, (+) indicates heavy, and no symbol indicates moderate.
- **Proximity.** Used primarily with precipitation or tornadoes. VC will precede certain phenomena, meaning that they are in the vicinity (5 SM) of the station, but not actually at the station.

For example, VCFZRABLSN+SNVA means in the vicinity of the airport there is freezing rain, blowing snow, heavy snow, and volcanic ash.



The abbreviations used for present weather are a mixture of English and French root words. FZ comes from freezing, while BR comes from brumé (mist), and FU comes from fumée (smoke).

Sky Conditions

This group reports the sky condition for layers aloft. The group will include how much of the sky is covered, measured in oktas (eighths of the sky) and the height of the clouds in hundreds of feet above ground level (AGL). The sky cover is represented by the following abbreviations:

- **SKC.** Sky clear, no cloud present.
- **FEW.** Few, greater than zero to two-eighths cloud cover.
- **SCT.** Scattered, three-eighths to four-eighths cloud cover.
- **BKN.** Broken, five-eighths to less than eight-eighths cloud cover.
- **OVC.** Overcast, eight-eighths cloud cover.
- **CLR.** Clear, clear below 10 000 feet AGL.

Cloud height is represented by a three-digit number, which when multiplied by one hundred equals the actual height AGL. There will be one entry for every layer of cloud.

For example, SCT025 means scattered cloud at 2 500 feet AGL.

Temperature and Dewpoint

This group reports the air temperature and dewpoint temperature, rounded to the nearest whole degree Celsius. A negative value will be preceded by an M. A forward slash (/) will separate the two values.

For example, M05/M08 means the temperature is minus five degrees Celsius and the dewpoint is minus eight degrees Celsius.

Altimeter Setting

This group reports the altimeter setting at the reporting station in inches of mercury. The group starts with an A followed by four digits, which directly relate to the actual value of the altimeter setting. Place a decimal after the second digit in order to read this group.

For example, A3006 means the altimeter setting is 30.06 inches of mercury.

Recent Weather

This group reports recent weather of operational significance. The group indicator RE follows without a space, by the appropriate abbreviation(s) for weather observed during the period since the last METAR or SPECI, but not observed at the time of observation.

For example, RE+PL means although not observed now, there were heavy ice pellets recently reported.

Wind Shear

This group reports low level wind shear (within 1 600 feet AGL) along the takeoff or approach path of the designated runway. The two-number runway identifier is used, to which the letters L, C, or R may be appended. If the existence of wind shear applies to all runways, WS ALL RWY is used.

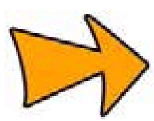
Remarks

This group will usually include cloud types in each layer as well as opacity, general weather remarks, and sea level pressure measured in hectopascals (hPa). The sea level pressure will always be the last entry in a METAR, prefaced by SLP. Sea level pressure is translated by placing the decimal point between the last two digits and either adding a 9 or a 10 in front of the value given. The goal is to make the number as close to 1 000 as possible.

For example, SLP123 means sea level pressure is 1012.3 hPa.

For example, SLP998 means sea level pressure is 999.8 hPa.

SLP actually represents the station pressure or the theoretical sea level pressure at the reporting station.



The = symbol is used to indicate the end of information.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS:

Q1. How are date and time expressed in a METAR?

Q2. What does the present weather section indicate?

Q3. What is the last entry of a METAR?

ANTICIPATED ANSWERS:

A1. The date and time of the observation are given in a six-digit grouping, based on universal coordinated time (UTC).

A2. This section indicates the current weather phenomena at the reporting station.

A3. The sea level pressure will always be the last entry in a METAR.

Teaching Point 3	**Describe a TAF.**
Time: 5 min	Method: Interactive Lecture

TAFs

Show the cadets the slide of Attachment C.

Definition

TAF is the name given to the international meteorological code for an aerodrome forecast. These forecasts describe the expected weather conditions that will affect takeoff and landing at the aerodrome.

Issue and Validity

TAFs are prepared for approximately 180 aerodromes across Canada. They are limited to aerodromes for which METAR and SPECI reports are available. TAFs are generally prepared four times daily with periods of coverage from 12–24 hours. A TAF is valid from the time of issue until it is amended or until the next scheduled TAF is issued.

Where TAFs are Available

TAFs can be found at several locations. The three most common locations are:

- NAV CANADA's aviation weather website,
- a Flight Services Station (FSS), and
- a Flight Information Centre (FIC) (normally accessed by phone).

CONFIRMATION OF TEACHING POINT 3

QUESTIONS:

Q1. What do TAFs describe?

Q2. How often are TAFs generally prepared?

Q3. Where can TAFs be found?

ANTICIPATED ANSWERS:

A1. The expected weather conditions that will affect takeoff and landing at an aerodrome.

A2. Four times daily.

A3. TAFs can be found at:

- NAV CANADA's aviation weather website,
- an FSS, or
- an FIC.

Teaching Point 4 **Familiarize the cadets with TAF terminology.**

Time: 15 min Method: Interactive Lecture

TERMINOLOGY USED IN TAFs

Indicate on the slide of Attachment C each of the following groupings as they are covered.

Much of this information will be a brief review as TAFs are similar to METARs in many ways. The abbreviations of expected weather conditions will follow the same form and order of the METAR, and will have the same meaning.

A TAF is organized into sections with each section always in the same order.

Report Type

The code name TAF is given in the first line of text. It may be followed by “AMD” for amended or corrected forecasts.

Location Indicator

A four-letter International Civil Aviation Organization (ICAO) location indicator is used, as in the METAR.

Date and Time of Origin

As with the METAR format, the day of the month and time (UTC) of origin are included in all forecasts. TAFs are issued approximately 30 minutes before the validity period. Some forecasts have update cycles as frequent as every three hours; however, the next issue time will always be indicated in the remarks group.

Period of Validity

The period of validity for the TAF is indicated by two four-digit date / time groups. The first four-digit group indicates the start date and time of the TAF, and the second four-digit group indicates the end date and time of the TAF. The maximum validity period for a TAF is 30 hours; however, some TAFs have staggered issue times and more frequent update cycles, which will affect their periods of validity.

Wind

The forecasted wind direction and speed are encoded as in a METAR.

Low-Level Wind Shear

This group is used if the forecaster has strong evidence to expect significant, non-convective wind shear that could adversely affect aircraft operation within 1 500 feet AGL over the aerodrome. The coded grouping begins with the letters WS followed by a three-digit grouping indicating the height in hundreds of feet AGL of the shear zone. A slash followed by a five-digit group indicates the wind speed and direction at that height.

For example, WS 015/20015KT means wind shear is forecast at 1 500 feet AGL over the aerodrome. The wind will be from 200 degrees true at 15 knots.

Prevailing Visibility

The prevailing visibility is encoded as in a METAR, except that visibility greater than six statute miles will be indicated by the code P6SM.

For example, 3/4SM means the visibility is forecast to be 3/4 statute mile.

Significant Weather

Refer the cadets to the handout of Attachment B.

Significant weather is encoded with the same codes as present weather in METARs. Intensity and proximity qualifiers, descriptors, precipitation, and obscuration are included as required.

For example, -RA BR means light rain and mist.

Sky Condition

Sky condition is encoded as in a METAR. Possible codes for sky cover amounts are SKC, FEW, SCT, BKN, OVC, CLR, and VV. A vertical visibility (VV) is reported in hundreds of feet when the sky is obscured. Forecast cloud type is not identified except in the case of cumulonimbus layers.

For example, BKN040CB means broken cumulonimbus cloud at 4 000 feet.

Change Groups

There are four change groups:

- FM (from),
- BECMG (becoming),
- TEMPO (temporarily), and
- PROB (probability).

FM. Indicates the weather is forecast to change permanently and rapidly. All forecast conditions given before this group are superseded by the conditions indicated after the group. In other words, a complete forecast will follow and all elements must be indicated, including those for which no change is forecast. The time group represents hours and minutes in UTC.

For example, FM280945 means from the 28th day of the month at 0945Z.

BECMG. Used when a permanent change in a few weather elements is forecast to occur gradually, with conditions evolving over a period of time (normally one to two hours, but not more than four hours). Normally only those elements for which a change is forecast to occur will follow BECMG. Any forecast weather element not indicated as part of the BECMG group remains the same as the period prior to the change.

The start and stop time of the change period is indicated by two four-digit date / time groups following BECMG. The first two digits of each group indicate the date, while the last two digits of each group indicate the time in whole UTC hours.

For example, BECMG 2808/2809 OVC030 means a change towards overcast sky conditions at 3 000 ft AGL occurring gradually between 0800Z and 0900Z on the 28th day of the month.

TEMPO. Used when a temporary fluctuation in some or all of the weather elements is forecast to occur during a specified period. When an element is not indicated after TEMPO, it is the same as the period prior to the change. The time period is indicated the same as with BECMG.

For example, TEMPO 2812/2815 1SM RA BR means temporarily between 1200Z and 1500Z on the 28th day of the month, visibility is forecast to be one statute mile with rain and mist.

> If a significant change in weather or visibility is forecast, all weather groups are indicated following BECMG or TEMPO, including those that are unchanged. When the ending of significant weather is forecast, the abbreviation NSW (no significant weather) is used.

PROB. Used to indicate a 30 or 40 percent probability of changing conditions that would constitute a hazard to aviation, such as thunderstorms, freezing precipitation, and low-level wind shear. The time period is indicated the same as with BECMG and TEMPO.

For example, PROB30 2817/2821 1/2SM +TSRAGR means there is a 30 percent probability between 1700Z and 2100Z on the 28th day of the month that visibility will be 1/2 statute mile with heavy thunderstorms, rain, and hail.

> A probability of less than 30 percent is not considered to justify the use of the PROB group. When the probability is 50 percent or more, this shall be indicated by the use of BECMG, TEMPO, or FM, as appropriate.

Remarks

Remarks will be prefaced by the abbreviation RMK. Remarks may include such information as when a TAF is based on observations taken by an Automated Weather Observation System (AWOS), and when there are significant discrepancies between the AWOS and a TAF. Remarks will indicate the issue date and time (UTC) of the next regular TAF.

CONFIRMATION OF TEACHING POINT 4

QUESTIONS:

Q1. What abbreviation will be used when the ending of significant weather is forecast?

Q2. What does the change group FM indicate?

Q3. In which section will the issue time for the next TAF be indicated?

ANTICIPATED ANSWERS:

A1. NSW.

A2. FM indicates the weather is forecast to change permanently and rapidly.

A3. The remarks section.

Teaching Point 5	**Describe an FD.**
Time: 5 min	Method: Interactive Lecture

FDs

> Show the cadets the slide of Attachment D.

Definition

An FD is an forecast of upper wind conditions and temperatures at selected levels. Wind direction is given in degrees true to the nearest ten degrees and wind speed is in knots.

Decoding

Temperatures are not forecast for 3 000 feet; in addition, this level is omitted if the terrain elevation is greater than 1 500 feet. All forecast temperatures for altitudes over 24 000 feet are negative.

When the forecast speed is less than five knots, the code group is 9900, which reads light and variable. Encoded wind speeds from 100–199 knots have 50 added to the direction code and 100 subtracted from the speed. Wind speeds that have had 50 added to the direction can be recognized when figures from 51–86 appear in the code. Since no such directions exist (eg, 510 degrees to 860 degrees), obviously they represent directions from 010 degrees to 360 degrees. Should the forecast wind speed be 200 knots or greater, the wind group is coded as 199 knots. For example, 7799 is decoded as 270 degrees at 199 knots or greater.

Show the cadets the slide of Attachment E.

Examples of decoding FD winds and temperatures are as follows (the third and fourth examples are for altitudes above 24 000 feet):

EXAMPLE	DECODED
9900+00	Wind light and variable. Temperature zero degrees Celsius.
2523	Wind 250 degrees true at 23 knots.
791159	Wind 290 degrees true (79 - 50 = 29) at 111 knots (11 + 100 = 111). Temperature minus 59 degrees Celsius.
859950	Wind 350 degrees true (85 - 50 = 35) at 199 knots or greater, temperature minus 50 degrees Celsius.

Figure 1 FD Decoding

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

Where FDs are Available

FDs can be found at several locations. The three most common locations are:

- NAV CANADA's aviation weather website,
- a Flight Services Station (FSS), and
- a Flight Information Centre (FIC) (normally accessed by phone).

CONFIRMATION OF TEACHING POINT 5

QUESTIONS:

Q1. What is an FD?

Q2. At which level are temperatures not forecast?

Q3. What does the code group 9900 mean?

ANTICIPATED ANSWERS:

A1. An FD is a forecast of upper wind conditions and temperatures at selected levels.

A2. 3 000 feet.

A3. Winds are light and variable.

Teaching Point 6	**Describe a GFA.**
Time: 10 min	Method: Interactive Lecture

GFAs

Show the cadets the slide of Attachment F.

Definition

A GFA consists of a series of weather charts, each depicting the most probable meteorological conditions expected to occur below 24 000 feet, over a given area at a specified time.

Issue and Validity

GFA charts are issued four times daily, approximately 30 minutes before the beginning of the forecast period. GFAs are issued at approximately 2330, 0530, 1130, and 1730 UTC and are valid at 0000, 0600, 1200, and 1800 UTC respectively.

Each issue of the GFA is a collection of six charts; two charts valid at the beginning of the forecast period, two charts valid six hours into the forecast period and the final two charts valid twelve hours into the forecast period. Of the two charts valid at each of the three forecast periods, one chart depicts clouds and weather while the other chart depicts icing, turbulence, and freezing level. The cadets will learn to read only the GFA Clouds and Weather Chart.

Coverage Area

Show the cadets the slide of Attachment G.

There are seven distinct GFA areas covering the entire Canadian Domestic Airspace.

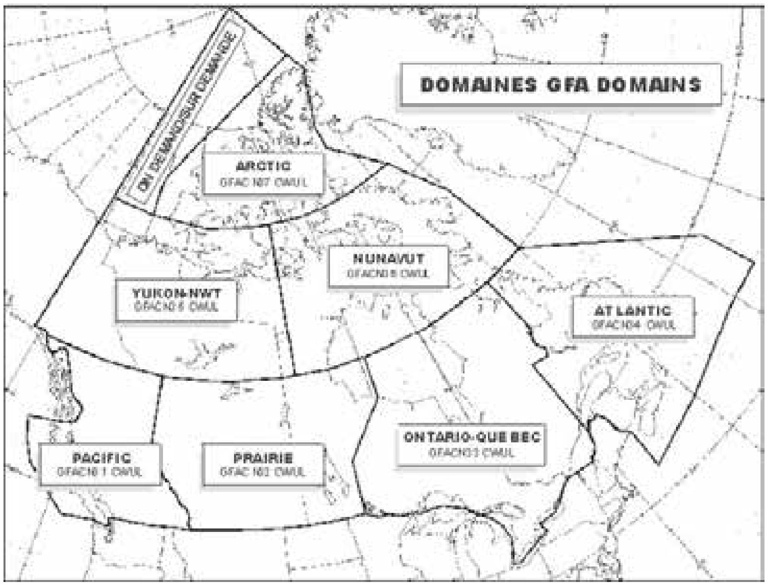


Figure 2 GFA Domains

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

Units of Measure

Speeds in a GFA are expressed in knots (kt). Horizontal visibility is measured in statute miles (SM). Times are stated in Co-ordinated Universal Time (UTC). A nautical-mile (NM) scale bar is included to assist in determining approximate distances on the chart. All heights are measured in hundreds of feet above sea level (ASL) unless otherwise noted.

Abbreviations and Symbols

Distribute the handout of Attachment H to the cadets. Show the cadets the slide of Attachment I.

Only standard meteorological abbreviations are used in a GFA. Figure 3 is a list of common weather symbols that may be found in a GFA.

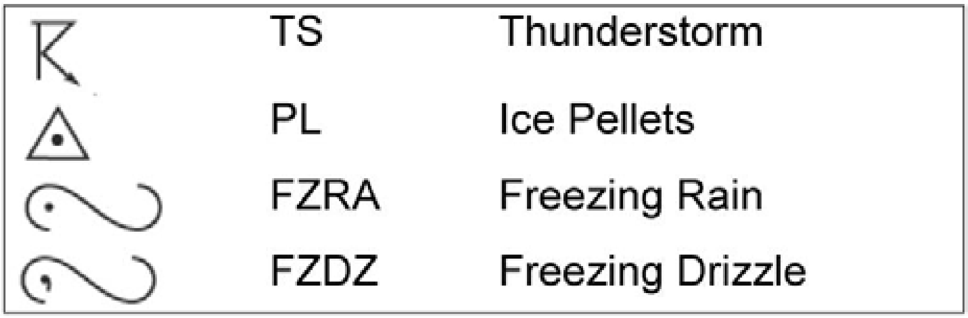


Figure 3 Weather Symbols

Note. Created by Director Cadets 3, 2008, Ottawa, ON: Department of National Defence.

Where GFAs are Available

GFAs can be found at several locations. The three most common locations are:

- NAV CANADA's aviation weather website,
- a Flight Services Station (FSS), and
- a Flight Information Centre (FIC) (normally accessed by phone).

CONFIRMATION OF TEACHING POINT 6

QUESTIONS:

Q1. How often are GFAs issued?

Q2. How are heights measured in GFAs unless otherwise noted?

Q3. How many distinct GFA coverage areas are there in Canada?

ANTICIPATED ANSWERS:

A1. Four times daily.

A2. In hundreds of feet above sea level (ASL).

A3. Seven.

Teaching Point 7 **Familiarize the cadets with GFA Clouds and Weather Chart layout.**

Time: 15 min Method: Interactive Lecture

GFA CLOUDS AND WEATHER CHART LAYOUT

Indicate on the slide of Attachment F each of the following groupings as they are covered.

Each GFA chart is divided into four parts: title box, legend box, comments box, and weather information section.

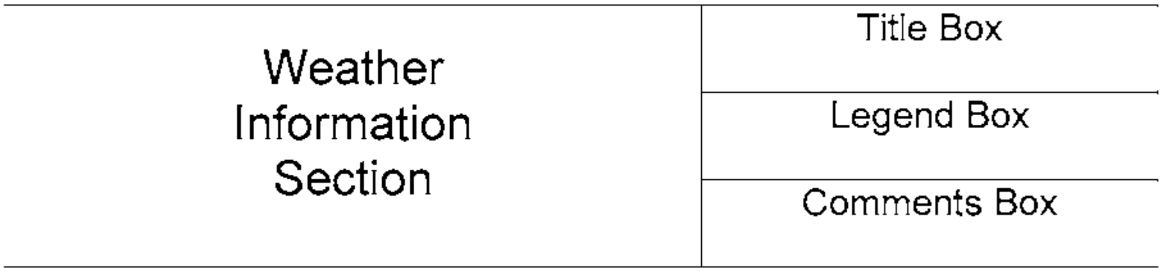


Figure 4 GFA Chart Layout

Note. Created by Director Cadets 3, 2008, Ottawa, ON: Department of National Defence.

Title Box

The title box includes the chart name, issuing office four-letter identification, name of the GFA region, chart type, the date and time of issue, and the validity period.

Legend Box

The legend box includes weather symbols that may be used in the weather information part of the GFA chart. It also includes a nautical-mile scale bar to facilitate determining distances.

Comments Box

The comments box provides information that the weather forecaster considers important (eg, formation or dissipation of fog, increasing or decreasing visibility). It is also used to describe elements that are difficult to render pictorially or, if added to the depiction, would cause the chart to become cluttered (eg, light icing). The following standard phrases are also included in the comments box:

- HGTS ASL UNLESS NOTED,
- CB TCU AND ACC IMPLY SIG TURB AND ICG, and
- CB IMPLIES LLWS.

The comments box of the 12-hour GFA Clouds and Weather Chart also includes an Instrument Flight Rules (IFR) outlook for an additional 12-hour period in the lower section of the box. The IFR outlook is always general in nature, indicating the main areas where IFR weather is expected, the cause for the IFR weather, and any associated weather hazards.

Weather Information Section

The weather information section of the chart depicts a forecast of the clouds and weather conditions.

Show the slide of figures located at Attachment J as they are covered.

Synoptic features. The motion of synoptic features, when the speed of movement is forecast to be five knots or more, will be indicated by an arrow and a speed value. For speeds less than five knots, the letters QS (quasi-stationary) are used.

For example, a low pressure centre moving eastwards at 15 knots with an associated cold front moving southeast at 10 knots would be indicated as follows:

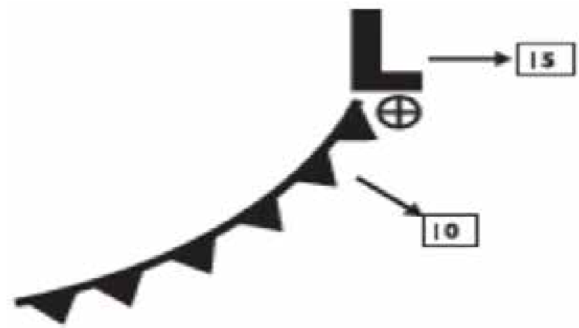


Figure 5 Synoptic Features

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

Clouds. The bases and tops of forecast clouds between the surface and 24 000 feet ASL will be indicated. The tops of convective clouds (eg, TCU, ACC, CB) are indicated, even if they extend above 24 000 feet ASL. Cirrus clouds are not depicted on the chart. The cloud type will be indicated if considered significant, however, convective clouds such as CU, TCU, ACC, and CB will always be stated when forecast to be present.

A scalloped border encloses organized areas of clouds where the sky condition is either broken (BKN) or overcast (OVC).

For example, an organized area of broken cumulus clouds based at 2 000 feet ASL with tops at 8 000 feet ASL would be indicated as follows:

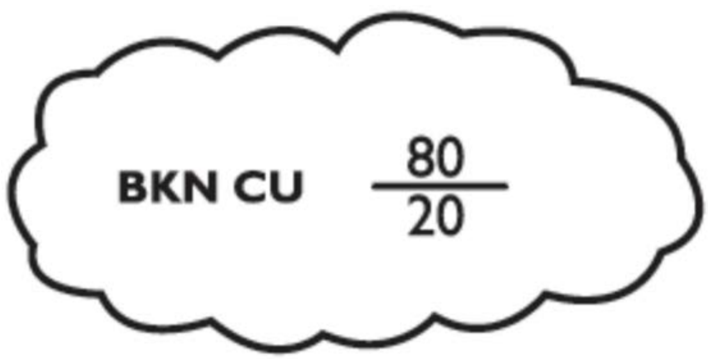


Figure 6 Broken Cumulus Clouds

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 28, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

In areas where organized clouds are not forecast and the visibility is expected to be greater than six statute miles a scalloped border is not used.

For example, unorganized scattered clouds based at 3 000 feet ASL with tops at 5 000 feet ASL would be indicated as follows:

$$\text{SCT}\ \frac{50}{30}$$

Figure 7 Scattered Clouds

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 28, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

When multiple cloud layers are forecast, the bases and tops of each layer are indicated.

For example, a scattered layer of cumulus cloud based at 3 000 feet ASL with tops at 5 000 feet ASL and a higher overcast layer of altostratus cloud based at 10 000 feet ASL with tops at 13 000 feet ASL would be indicated as follows:

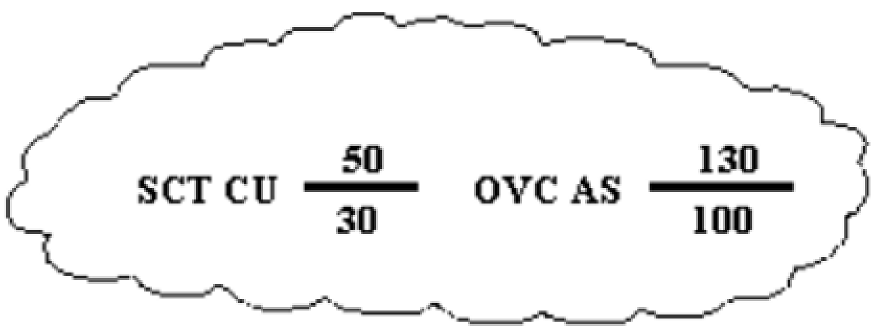


Figure 8 Multiple Cloud Layers

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 28, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

Surface-based layers. The abbreviation OBSCD (obscured) is used to describe surface-based layers. The vertical visibility in surface-based layers is measured in hundreds of feet AGL.

For example, local obscured ceilings with a vertical visibility between 300 and 500 feet AGL would be indicated as: LCL OBSCD CIG 3 - 5 AGL.

Visibility. The forecast visibility is measured in statute miles. When the visibility is expected to be greater than six statute miles, it is indicated as P6SM.

For example, a forecast visibility that is expected to vary between two and four statute miles with light rain showers would be indicated as: 2 - 4 SM - SHRA.

Weather and obstructions to vision. Forecast weather is always included immediately after the visibility. Obstructions to vision are only mentioned when the visibility is forecast to be six statute miles or less (eg, 2 - 4SM - RA BR). Areas of showery or intermittent precipitation are shown as hatched areas enclosed by a dashed green line. Areas of continuous precipitation are shown as stippled areas enclosed by a solid green line. Areas of obstruction to vision not associated with precipitation, where visibility is six statute miles or less, are enclosed by a dashed orange line. Areas of freezing precipitation are depicted in red and enclosed by a solid red line.

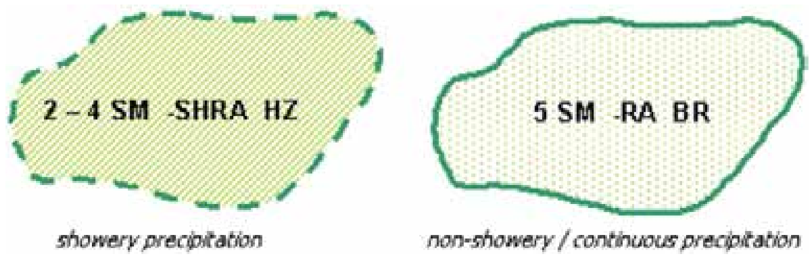


Figure 9 Weather and Obstructions to Vision

Note. From Nav Canada, 2007, *Aviation Weather Website*. Retrieved October 28, 2008, from http://www.flightplanning.navcanada.ca/cgi-bin/CreePage.pl?Page=info-gfa&NoSession=NS_Inconnu&TypeDoc=gfa&Langue=anglais#abbr_symb

Isobars. Lines joining points of equal surface pressure. They are included in the GFA Clouds and Weather Chart at four-millibar intervals.

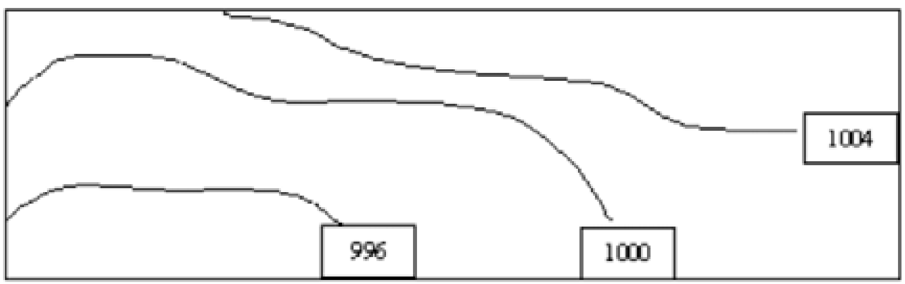


Figure 10 Isobars

Note. From Nav Canada, 2007, *Aviation Weather Website*. Retrieved October 28, 2008, from http://www.flightplanning.navcanada.ca/cgi-bin/CreePage.pl?Page=info-gfa&NoSession=NS_Inconnu&TypeDoc=gfa&Langue=anglais#abbr_symb

Surface winds. The speed and direction of forecast surface winds with a sustained speed of at least 20 knots are indicated by wind barbs and an associated wind speed value. Wind gusts are indicated by the letter G, followed by the peak gust speed in knots.

For example, surface winds forecast to be from the west (270 degrees true) with a speed of 25 knots and a peak gust speed of 35 knots would be indicated as:

Figure 11 Surface Winds

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 28, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

CONFIRMATION OF TEACHING POINT 7

QUESTIONS:

Q1. In which section of a GFA Clouds and Weather Chart would an IFR outlook be found?

Q2. How are areas of showery or intermittent precipitation shown?

Q3. How are organized areas of clouds where the sky condition is either broken or overcast shown?

ANTICIPATED ANSWERS:

A1. Comments box.

A2. As hatched areas enclosed by a dashed green line.

A3. Enclosed by a scalloped border.

Teaching Point 8 — **Conduct an activity to have the cadets read METARs, TAFs, FDs and GFA Clouds and Weather Charts.**

Time: 15 min — Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets read METARs, TAFs, FDs and GFA Clouds and Weather Charts.

RESOURCES

- Handouts of two or three copies of METARs, TAFs, FDs and GFA Clouds and Weather Charts in standard format,
- Copies of the same METARs, TAFs, FDs and GFA Clouds and Weather Charts in plain language format for review, and
- Abbreviations handout located at Attachment H.

ACTIVITY LAYOUT

Nil.

ACTIVITY INSTRUCTIONS

1. Divide the cadets into pairs.
2. Distribute the handouts of METARs, TAFs, FDs and GFA Clouds and Weather Charts in standard format among the pairs.
3. Show the cadets a sample METAR, TAF, FD and GFA Clouds and Weather Chart and demonstrate reading it.
4. Indicate a section of a METAR, TAF, FD and GFA Cloud and Weather Chart and have the cadets read it.

5. Display the copies of the same METARs, TAFs, FDs and GFA Clouds and Weather Charts in plain language format to correct the cadets' work.

6. Repeat Steps 3–5 as time permits.

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 8

The cadets' participation in the activity will serve as the confirmation of this TP.

END OF LESSON CONFIRMATION

The cadets' participation in the activity will serve as the confirmation of this lesson.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

Weather is a major factor in aviation. Pilots must constantly watch the weather around them as it will affect the operation and navigation of an aircraft. In particular, pilots must analyze weather information prior to flying to decide whether it is safe to fly.

INSTRUCTOR NOTES / REMARKS

Recent METARs, TAFs, FDs, and GFAs can be found at http://www.flightplanning.navcanada.ca. Click on the METAR / TAF, UPR WNDS (FDs), or Graphical FA icon and choose the desired region. METARs, TAFs, FDs, and GFAs can be printed in standard and plain language format.

It is recommended that the three periods required for this EO be scheduled consecutively.

Cadets who are qualified Advanced Aviation may assist with this instruction.

REFERENCES

C2-044 *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved September 29, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

C3-116 ISBN 0-9680390-5-7 MacDonald, A. F., & Peppler, I. L. (2000). *From the ground up: Millennium edition*. Ottawa, ON: Aviation Publishers Co. Limited.

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SAMPLE METARs AND SPECIs

METAR CYHZ 111700Z 28009G16KT 15SM FEW250 00/M11 A2990 RMK CS0 SLP134=

METAR CYHZ 111800Z 29015KT 15SM FEW250 01/M10 A2989 RMK CI0 SLP128=

METAR CYHZ 111900Z 30008KT 15SM FEW250 02/M12 A2987 RMK CI0 SLP123=

SPECI CYYJ 111744Z CCA 23019G24KT 20SM -SHRA BKN014 BKN030 BKN120 09/07 RMK SC5SC1AC1=

SPECI CYYJ 111744Z 23019G24KT 20SM -RA BKN014 BKN030 BKN120 09/07 RMK SC5SC1AC1=

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WORLD METEOROLOGICAL ORGANIZATION
CODE FOR PRESENT WEATHER

QUALIFIER					WEATHER PHENOMENA			
INTENSITY or PROXIMITY 1	DESCRIPTOR 2		PRECIPITATION 3		OBSCURATION 4		OTHER 5	
Note: Precipitation intensity refers to all forms combined.	**MI**	Shallow	**DZ**	Drizzle	**BR**	Mist (Vis ≥ 5/8 SM)	**PO**	Dust/ Sand Whirls (Dust Devils)
	BC	Patches	**RA**	Rain	**FG**	Fog (Vis < 5/8 SM)	**SQ**	Squalls
	PR	Partial	**SN**	Snow	**FU**	Smoke (Vis ≤ 6 SM)	**+FC**	Tornado or Waterspout
	DR	Drifting	**SG**	Snow Grains				
- Light	**BL**	Blowing	**IC**	Ice Crystals (Vis ŏ 6 SM)	**DU**	Dust (Vis ≤ 6 SM)	**FC**	Funnel Cloud
	SH	Shower(s)						
Moderate (no qualifier)	**TS**	Thunderstorm	**PL**	Ice Pellets	**SA**	Sand (Vis ≤ 6 SM)	**SS**	Sandstorm (Vis < 5/8 SM) (+SS Vis < 516 SM)
			GR	Hail				
+ Heavy	**FZ**	Freezing	**GS**	Snow Pellets	**HZ**	Haze (Vis ≤ 6 SM)	**DS**	Dust storm (Vis < 5/8 SM) (+DS Vis < 516 SM)
VC In the vicinity			**UP**	Unknown precipitation (AWOS only)	**VA**	Volcanic Ash (with any visibility)		

Figure B-1 World Meteorological Organization Code for Present Weather

Note. From *Aeronautical Information Manual* (p. 145), by Transport Canada, 2008, Ottawa, ON: Transport Canada. Copyright 2007 by Her Majesty the Queen in Right of Canada.

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SAMPLE TAFs

TAF CYHZ 201738Z 2018/2118 25008KT P6SM OVC015 TEMPO 2018/2020 OVC025
FM202000 24010KT P6SM OVC025 TEMPO 2020/2022 OVC020
FM202200 23012KT P6SM BKN030
FM210200 23010KT P6SM SCT030
RMK NXT FCST BY 202100Z=

TAF CYVR 201739Z 2018/2124 10012G22KT P6SM -RA SCT025 OVC050 TEMPO 2021/2103 5SM -RA BR BKN020
BECMG 2021/2022 14012G22KT
BECMG 2101/2102 28020G30KT
FM210300 28020G30KT P6SM FEW030 SCT060
BECMG 2103/2104 26012KT
FM210800 11005KT P6SM -SHRA BKN030
BECMG 2110/2112 14010G20KT
FM211600 12012G22KT 5SM -RA BR SCT008 BKN012
RMK NXT FCST BY 202100Z=

TAF CYYG 201738Z 2018/2106 25012KT P6SM FEW009 OVC015 TEMPO 2018/2020 6SM -SHSN BKN009
FM202300 24012KT P6SM BKN025 TEMPO 2023/2102 BKN020
FM210200 26008KT P6SM SCT025 TEMPO 2102/2106 BKN025
RMK NXT FCST BY 210000Z=

TAF CYOW 201738Z 2018/2118 34012KT P6SM BKN040
FM202200 31005KT P6SM FEW050 SCT100
FM211600 31012KT P6SM BKN030
RMK NXT FCST BY 202100Z=

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SAMPLE FDS

STN YNA - NATASHQUAN. QUEBEC	**for use**	**3000**	**6000**	**9000**	**12000**	**18000**
FDCN01 CWAO FCST BASED ON 271200 DATA **VALID 271800**	**17-21**	2130	2129+05	2131+03	2140-03	2158-11
FDCN02 CWAO FCST BASED ON 271200 DATA **VALID 280000**	**21-06**	1916	1917+06	2023+03	2130-02	2152-11
FDCN03 CWAO FCST BASED ON 271200 DATA **VALID 281200**	**06-17**	1635	1633+05	1929+03	1936+00	1838-11

STN YQI - YARMOUTH. NS	**for use**	**3000**	**6000**	**9000**	**12000**	**18000**
FDCN01 CWAO FCST BASED ON 271200 DATA **VALID 271800**	**17-21**	1616	1919+10	1936+05	1934+00	2043-10
FDCN02 CWAO FCST BASED ON 271200 DATA **VALID 280000**	**21-06**	1842	1843+11	1843+06	1842+00	1842-10
FDCN03 CWAO FCST BASED ON 271200 DATA **VALID 281200**	**06-17**	1451	1551+10	1537+04	1651+00	1865-08

STN YQI - YARMOUTH. NS	**for use**	**24000**	**30000**	**34000**	**39000**	**45000**	**53000**
FDCN01 KWBC DATA BASED ON 271200Z **VALID 271800Z**	**1700-2100Z.**	2145-24	225139	225248	206558	215363	213964
FDCN02 KWBC DATA BASED ON 271200Z **VALID 280000Z**	**2100-0600Z.**	2043-23	215140	215149	214558	215062	213864
FDCN03 KWBC DATA BASED ON 271200Z **VALID 281200Z**	**0600-1700Z.**	1855-23	195738	205047	226656	216062	204264

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Decoding FDs

EXAMPLE	DECODED
9900+00	Wind light and variable, temperature zero degrees Celsius.
2523	Wind 250 degrees true at 23 knots.
791159	Wind 290 degrees true (79 - 50 = 29) at 111 knots (11+ 100 = 111), temperature -59 degrees Celsius.
859950	Wind 350 degrees true (85 - 50 = 35) at 199 knots or greater, temperature -50 degrees Celsius.

Figure E-1 FD Decoding

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

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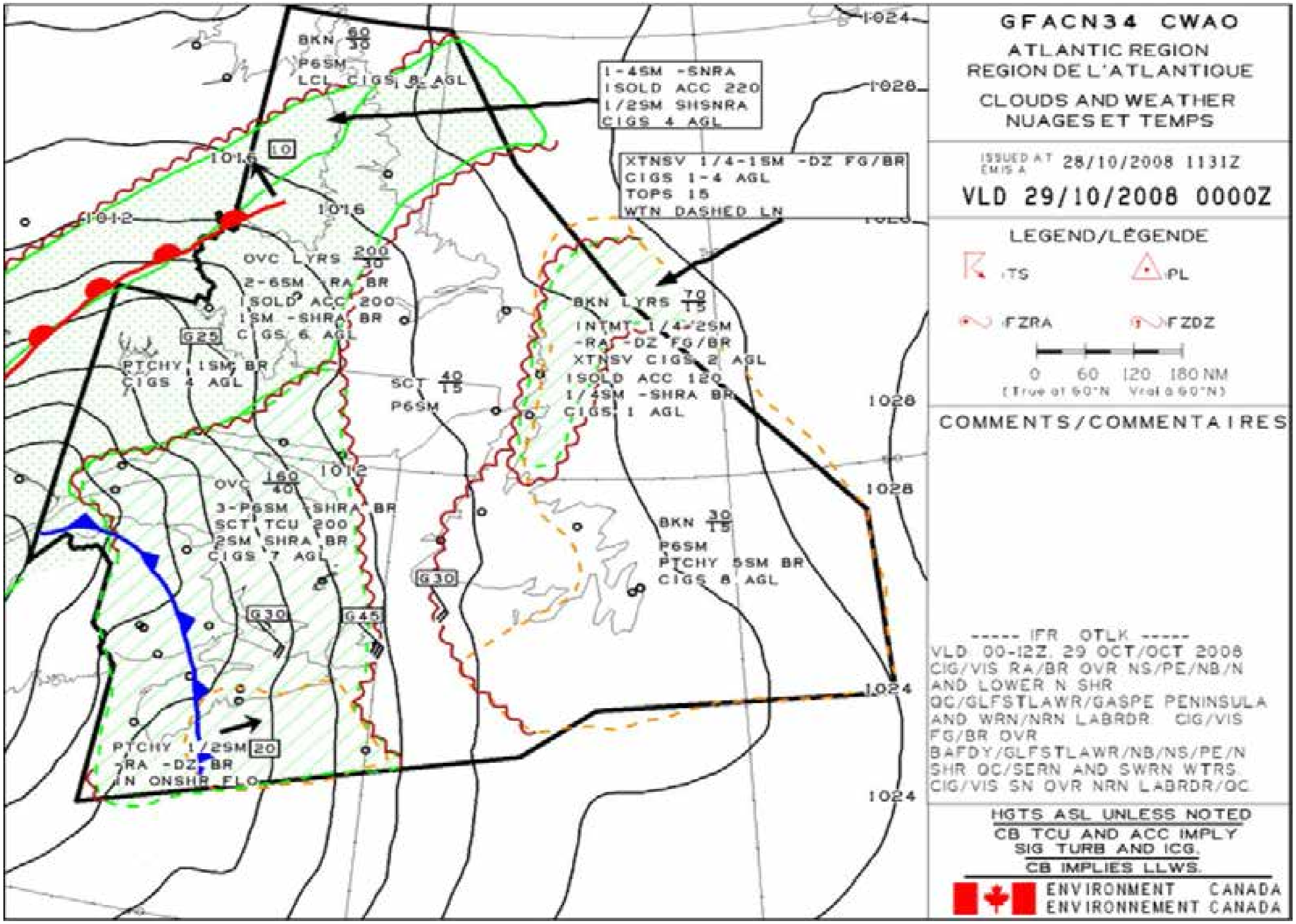

Figure F-1 GFA Clouds and Weather Chart

Note. From Nav Canada, 2007, *Aviation Weather Website*. Retrieved October 28, 2008, from http://www.flightplanning.navcanada.ca/cgi-bin/CreePage.pl?Langue=anglais&NoSession=NS_Inconnu&Page=forecast-observation&TypeDoc=html

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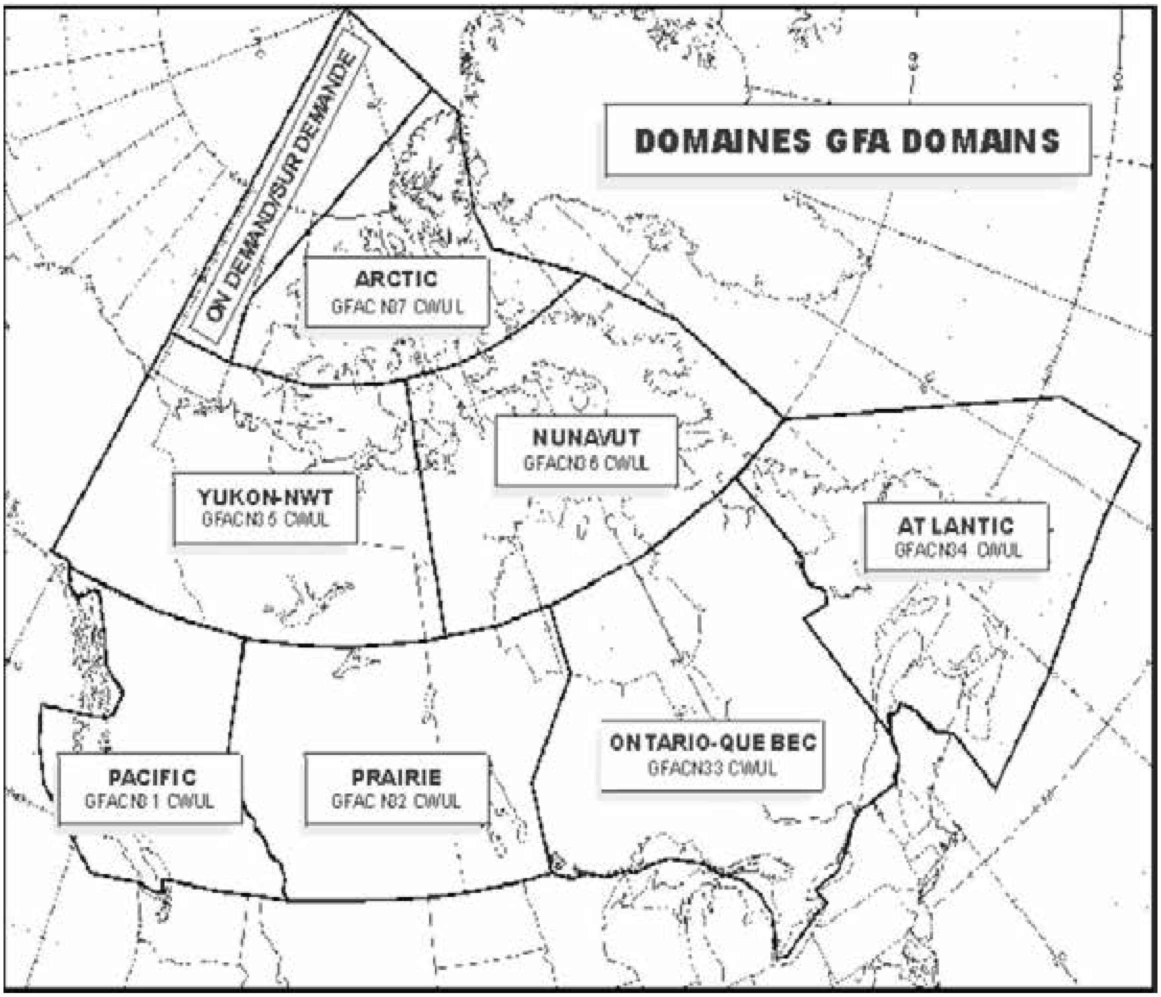

Figure G-1 GFA Domains

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

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3.6 Abbreviations – Aviation Forecasts

CONTRACTION	PLAIN LANGUAGE
ABV	above
ACCAS	altocumulus castellanus
ACRS	across
ACSL	standing lenticular altocumulus
ACT	active
AFT	after
AFL	above freezing layer
AHD	ahead
ALF	aloft
ALG	along
ALT	altitude
AIRMS	air mass
APCH	approach
APCHG	approaching
ASL	above sea level
AWOS	Automated Weather Observation System
BECMG	becoming
BFR	before
BGN	begin
BGNG	beginning
BHND	behind
BKN	broken
BL	blowing
BLDG	building
BLO	below
BLZD	blizzard
BDRY	boundary
BR	mist
BRF	brief
BRFLY	briefly
BRKS	breaks
BTN	between
CAT	clear air turbulence
CAVOK	ceiling and visibility OK
CB	cumulonimbus
CIG	ceiling
CLD	cloud
CLR	clear

CONTRACTION	PLAIN LANGUAGE
CLRG	clearing
CNTR	centre
CNTRD	centred
CONDS	conditions
COTRAILS	condensation trails
CONTUS	continuous
CONTG	continuing
CST	coast
CU	cumulus
DCRG	decreasing
DEG	degree
DFUS	diffuse
DIST	distant
DNS	dense
DNSLP	downslope
DP	deep
DPNG	deepening
DRFTG	drifting
DURG	during
DVLPG	developing
DZ	drizzle
E	east
ELSW	elsewhere
ELY	easterly
EMBD	embed
ENDG	ending
ENTR	entire
FCST	forecast
FEW	few clouds
FG	fog
FILG	filling
FLWD	followed
FLWG	following
FM	from
FNT	front
FRQ	frequent
FZLVL	freezing level
FROIN	frost on indicator
FROPA	frontal passage
FRQ	frequent

Figure H-1 Abbreviations

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

CONTRACTION	PLAIN LANGUAGE
FT	feet, foot
FU	smoke
FZ	freezing
GND	ground
GRAD	gradient
GRDLY	gradually
HGT	height
HI	high
HLTP	hilltop
HND	hundred
HR	hour
HVY	heavy
ICG	icing
ICGIC	icing in cloud
ICGIP	icing in precipitation
IMDTLY	immediately
INCRG	increasing
INDEF	indefinite
INSTBY	instability
INTMT	intermittent
INTS	intense
INTSFY	intensify
ISLD	island
ISOL	isolate(d)
KT	knot(s)
LCL	local
LFTG	lifting
LGT	light
LIFR	low IFR
LK	lake
LLJ	low level jet stream
LLWS	low level wind shear
LN	line
LO	low
LTL	little
LVL	level
LWIS	limited weather information system
LWR	lower
LWRG	lowering
LYR	layer

CONTRACTION	PLAIN LANGUAGE
MDFYD	modified
MDT	moderate
MI	shallow
MID	middle
MOVG	moving
MPH	miles per hour
MRNG	morning
MRTM	maritime
MSTR	moisture
MTS	mountains
MVFR	marginal VFR
MXD	mixed
MXG	mixing
N	north
NE	northeast
NELY	northeasterly
NGT	night
NLY	northerly
NM	nautical mile(s)
NMRS	numerous
NR	near
NRLY	nearly
NSW	no significant weather
NW	northwest
NWLY	northwesterly
OBSC	obscure(d)
OCLD	occlude
OCLDG	occluding
OCLN	occlusion
OCNL	occasional
OCNLY	occasionally
OFSHR	offshore
ONSHR	onshore
ORGPHC	orographic
OTLK	outlook
OTWZ	otherwise
OVC	overcast
OVR	over
OVRNG	overrunning
PCPN	precipitation

Figure H-2 Abbreviations

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

CONTRACTION	PLAIN LANGUAGE
PD	period
PL	ice pellets
PRECDD	preceded
PRECDS	precedes
PRES	pressure
PROG	prognostic, prognosis
PRSTG	persisting
PSG	passage, passing
PSN	position
PTCHY	patchy
PTLY	partly
RA	rain
RDG	ridge
RFRMG	reforming
RGN	region
RMNG	remaining
RPDLY	rapidly
RPRT	report
RSG	rising
RUF	rough
RVR	river
S	south
SCT	scattered
SCTR	sector
SE	southeast
SELY	southeasterly
SFC	surface
SH	shower
SHFT	shift
SHFTG	shifting
SHLW	shallow
SKC	sky clear
SLO	slow
SLOLY	slowly
SLY	southerly
SM	statute mile(s)
SML	small
SN	snow
SNRS	sunrise
SNST	sunset

CONTRACTION	PLAIN LANGUAGE
SPECI	special
SPRDG	spreading
SQ	squall
STBL	stable
STG	strong
STGTN	strengthen
STNRY	stationary
SEV	severe
SVRL	several
SW	southwest
SWLY	southwesterly
SXN	section
SYS	system
T	temperature
TCU	towering cumulus
TEMPO	temporary
THK	thick
THKNG	thickening
THN	thin
THNC	thence
THNG	thinning
THRU	through
THRUT	throughout
THSD	thousand
TILL	until
TRML	terminal
TROF	trough
TROWAL	trough of warm air aloft
TRRN	terrain
TS	thunderstorm
TURB	turbulence
TWD	toward
UNSTBL	unstable
UPR	upper
UPSLP	upslope
UTC	co-ordinated universal time
VC	vicinity
VLY	valley
VRB	variable
VIS	visibility

Figure H-3 Abbreviations

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

CONTRACTION	PLAIN LANGUAGE
VV	vertical visibility
W	west
WDLY	widely
WK	weak
WLY	westerly
WND	wind
WRM	warm
WS	wind shear
WV	wave
WX	weather
XCP	except
XT	extend
XTDG	extending
XTRM	extreme
XTSV	extensive
Z	ZULU (or UTC)

Figure H-4 Abbreviations

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.pdf

GFA Weather Symbols

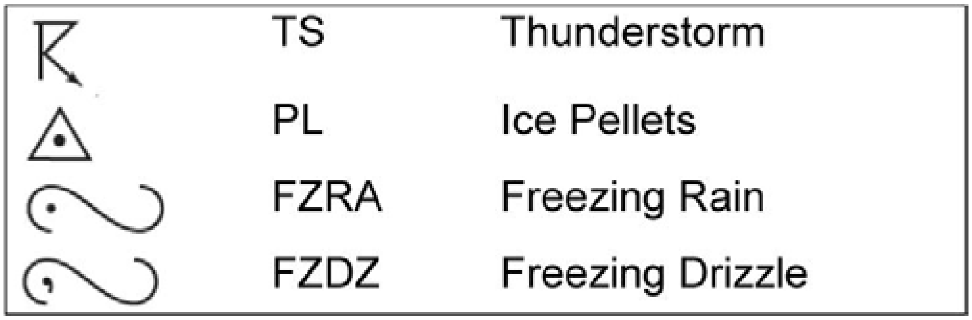

Figure I-1 Weather Symbols

Note. Created by Director Cadets 3, 2008, Ottawa, ON: Department of National Defence.

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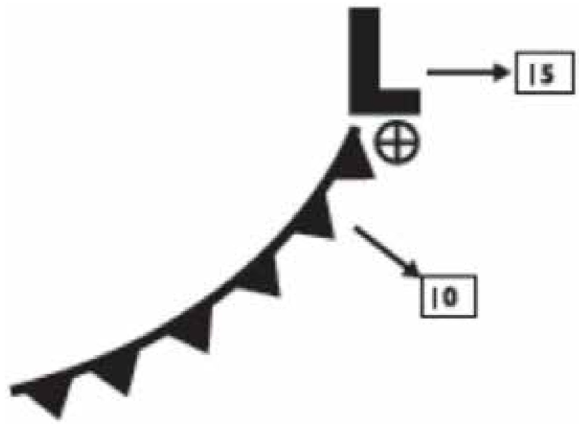

Figure J-1 Synoptic Features

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

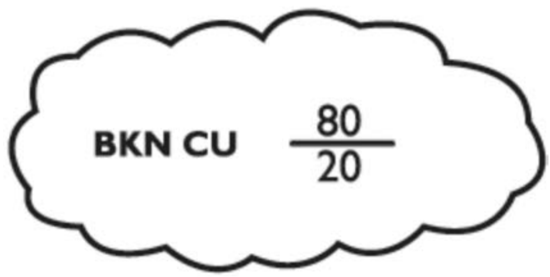

Figure J-2 Broken Cumulus Clouds

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

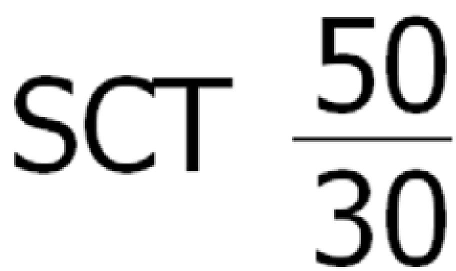

Figure J-3 Scattered Clouds

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

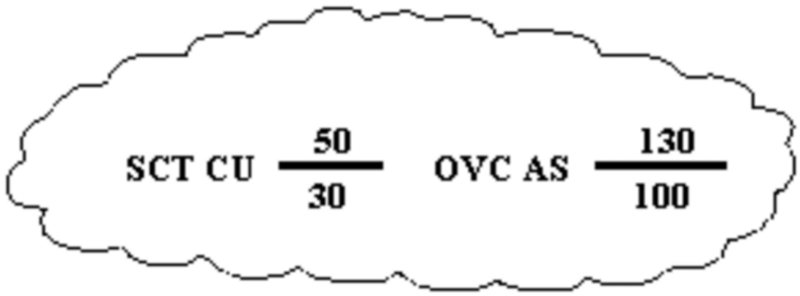

Figure J-4 Multiple Cloud Layers

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF

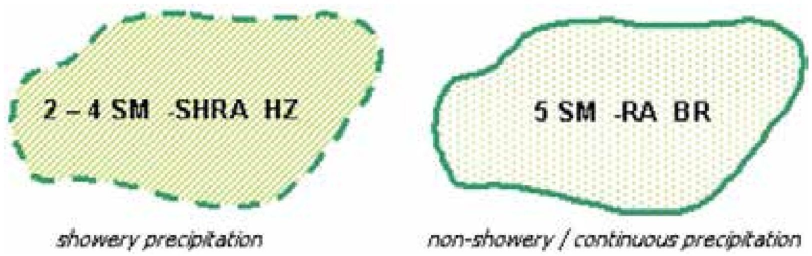

Figure J-5 Weather and Obstructions to Vision

Note. From Nav Canada, 2007, *Aviation Weather Website*. Retrieved October 28, 2008, from http://www.flightplanning.navcanada.ca/cgi-bin/CreePage.pl?Page=info-gfa&*NoSession=NS_Inconnu&TypeDoc=gfa&Langue=anglais#abbr_symb*

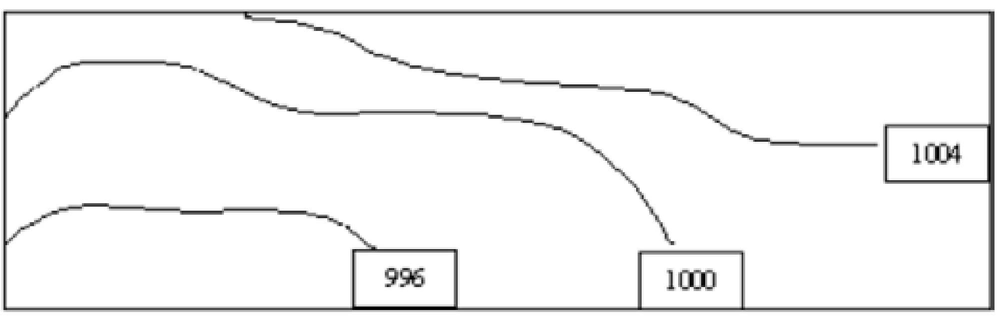

Figure J-6 Isobars

Note. From Nav Canada, 2007, *Aviation Weather Website*. Retrieved October 28, 2008, from http://www.flightplanning.navcanada.ca/cgi-bin/CreePage.pl?Page=info-gfa&*NoSession=NS_Inconnu&TypeDoc=gfa&Langue=anglais#abbr_symb*

Figure J-7 Surface Winds

Note. From *Aeronautical Information Manual*. by Transport Canada, 2008, Retrieved October 27, 2008, from http://www.tc.gc.ca/publications/EN/TP14371/PDF/HR/TP14371E.PDF