ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL THREE

INSTRUCTIONAL GUIDE

SECTION 2

EO M336.02 – EXPLAIN THE FORMATION OF CLOUDS

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-803/PG-001, 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.

Create slides of Annexes B to I.

PRE-LESSON ASSIGNMENT

N/A.

APPROACH

An interactive lecture was chosen for this lesson to introduce the concepts of cloud formation.

INTRODUCTION

REVIEW

N/A.

OBJECTIVES

By the end of this lesson the cadet shall have explained the formation of clouds.

IMPORTANCE

It is important for cadets to know how clouds form as it will enhance their knowledge of meteorology and their ability to predict weather.

Teaching point 1 **Explain Cloud Classification**

Time: 5 min Method: Interactive Lecture

CLOUD CLASSIFICATION

Clouds are classified based on type of formation and cloud height.

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Types of Formation

There are two main types of cloud formations:



Show slide of Annex B.

- **Cumulus.** Cumulus clouds are formed by air that is unstable. They are cottony or puffy, and are seen mostly during warmer seasons. Cumulus clouds may develop into storm clouds.



"Victoria Weather", by UVic, School-Based Weather Station Network. Retrieved November 1, 2007, from http://www.victoriaweather.ca/clouds

Figure 1 Cumulus Cloud

- **Stratus.** Stratus clouds are formed in air that is stable. They are flat and can be seen year round, but are associated with colder temperatures.



Show slide of Annex C.

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"Victoria Weather", by UVic, School-Based Weather Station Network. Retrieved November 1, 2007, from http://www.victoriaweather.ca/clouds

Figure 2 Stratus Cloud

Cloud Height

Clouds are also classified based on their height above ground level (AGL). There are four main categories:

- **Low Clouds.** The bases of low clouds range from the surface to a height of 6 500 feet AGL. Low clouds are composed of water droplets and sometimes ice crystals. Low clouds use the word stratus as either a prefix (eg, stratocumulus) or a suffix (eg, nimbostratus).
- **Middle Clouds.** The bases of middle clouds range from 6 500 to 23 000 feet AGL. They are composed of ice crystals or water droplets, which may be at temperatures above 0 degrees Celsius. Middle clouds use the prefix of "alto" (eg, altocumulus).
- **High Clouds.** The bases of high clouds range from 16 500 to 45 000 feet, with an average of 25 000 feet in the temperate regions of the earth. High clouds are composed of ice crystals. High clouds use the prefix of "cirrus" or "cirro" (eg, cirrocumulus).
- **Clouds of Vertical Development.** The base of these clouds may be as low as 1 500 feet AGL and may rise as high as the lower reaches of the stratosphere. They may appear as isolated clouds or may be seen embedded in layers of clouds. Clouds of vertical development are associated with thunderstorms and other phenomena which occur during the summer months.



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The following chart includes a brief description of the more common cloud types.

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Cloud Name	Cloud Family	Cloud Description
Cirrus	High	High, thin, wispy clouds blown by high winds into long streamers. Cirrus clouds usually move across the sky from west to east. They generally indicate pleasant weather.
Cirrocumulus	High	Appear as small, round white puffs. The small ripples in the cirrocumulus sometimes resemble the scales of a fish. A sky with cirrocumulus clouds is sometimes referred to as a “mackerel sky.”
Altocumulus	Middle	Appear as grey, puffy masses, sometimes in parallel waves or bands. The appearance of these clouds on a warm, humid summer morning often means thunderstorms will occur by late afternoon.
Altostratus	Middle	A grey or blue-grey layer cloud that typically covers the entire sky. In the thinner areas of the cloud, the sun may be dimly visible as a round disk. This cloud appears lighter than stratus clouds.
Stratus	Low	Uniform grey layer cloud that often covers the entire sky. They resemble fog that does not reach the ground. Usually no precipitation falls from stratus clouds, but sometimes they may drizzle.
Nimbostratus	Low	Dark grey layer clouds associated with continuously falling rain or snow. They often produce precipitation that is usually light to moderate.
Stratocumulus	Low	A series of rounded masses that form a layer cloud. This type of cloud is usually thin enough for the sky to be seen through breaks.
Cumulus	Vertical Development	Puffy clouds, which are thick, round, and lumpy. They sometimes look like pieces of floating cotton. They usually have flat bases and round tops.
Cumulonimbus	Vertical Development	Thunderstorm clouds that form if cumulus clouds continue to build. Violent vertical air currents, hail, lightning, and thunder are associated with the cumulonimbus clouds.

Director Cadets 3, 2007, Ottawa, ON: Department of National Defence

Figure 3 Common Clouds

CONFIRMATION OF TEACHING POINT 1

QUESTIONS

Q1. How are clouds classified?

Q2. What are the two types of cloud formations?

Q3. What are the four categories of cloud height?

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ANTICIPATED ANSWERS

A1. By type of formation and height.

A2. Cumulus and stratus.

A3. Low clouds, middle clouds, high clouds and clouds of vertical development.

Teaching point 2 **Explain Air Stability**

Time: 5 min Method: Interactive Lecture

AIR STABILITY

At the surface, the normal flow of air is horizontal. Disturbances may occur, which will cause vertical currents of air to develop. This is normally caused by a change in temperature. If the air that is displaced resists the change, then it is said to be stable. If it does not resist the change then it is unstable. When air rises, it expands and cools.

Stable Air. If a mass of rising air is cooler than the air that it comes in contact with, then it will sink back to its original position. Stable air may have the following affects on flight characteristics:

- poor low-level visibility (fog may occur),
- stratus type cloud,
- steady precipitation,
- steady winds, which can change greatly with height, and
- smooth flying conditions.

Unstable Air. If a mass of rising air is still warmer than the new air around it, then the air mass will continue to rise. Unstable air may have the following affects on flight characteristics:

- good visibility (except in precipitation),
- cumulus type cloud,
- showery precipitation,
- gusty winds, and
- moderate to severe turbulence.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS

Q1. What may create vertical currents?

Q2. What is stable air?

Q3. What is unstable air?

ANTICIPATED ANSWERS

A1. A change in temperature.

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A2. When a mass of rising air is cooler than the air that it comes in contact with, then it will sink back to its original position.

A3. When a mass of rising air is warmer than the new air around it, then the air mass will continue to rise.

Teaching point 3 **Explain Lifting Agents**

Time: 10 min Method: Interactive Lecture

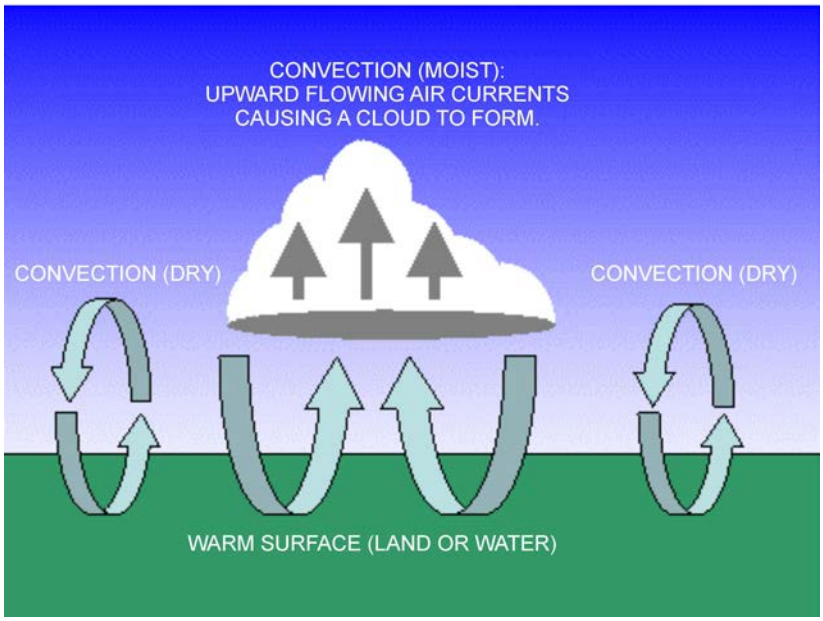
LIFTING AGENTS

Rising currents of air affect many weather conditions. There are five conditions that provide the lift required to initiate rising currents of air.



Show slides of Annexes E to I as applicable.

Convection. The air is heated through contact with the earth's surface. As the sun heats the surface of the earth, the air in contact with the surface warms up, rises, and expands. Convection may also occur when air moves over a warmer surface and is heated by advection.



WeatherQuestions.com, 2007, What is Convection. Copyright 2007 by WeatherStreet. Retrieved March 17, 2008, from http://www.weatherquestions.com/What_is_convection.htm

Figure 4 Convection

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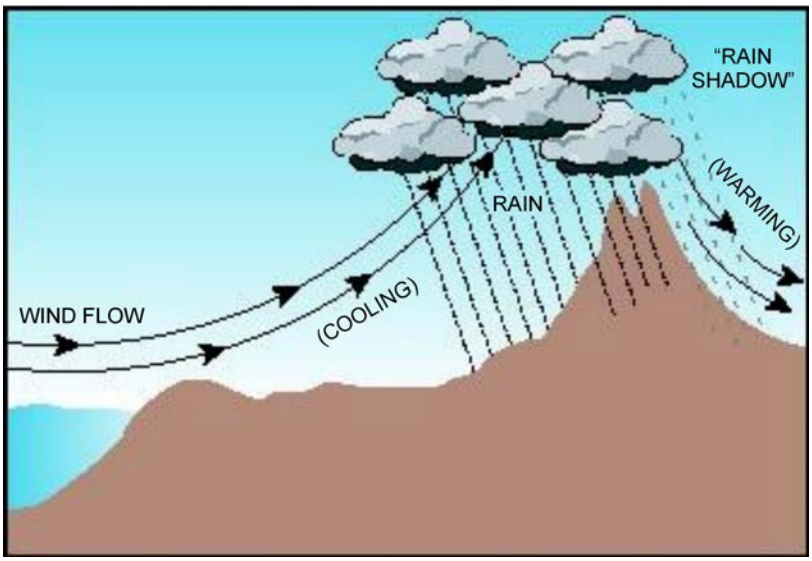
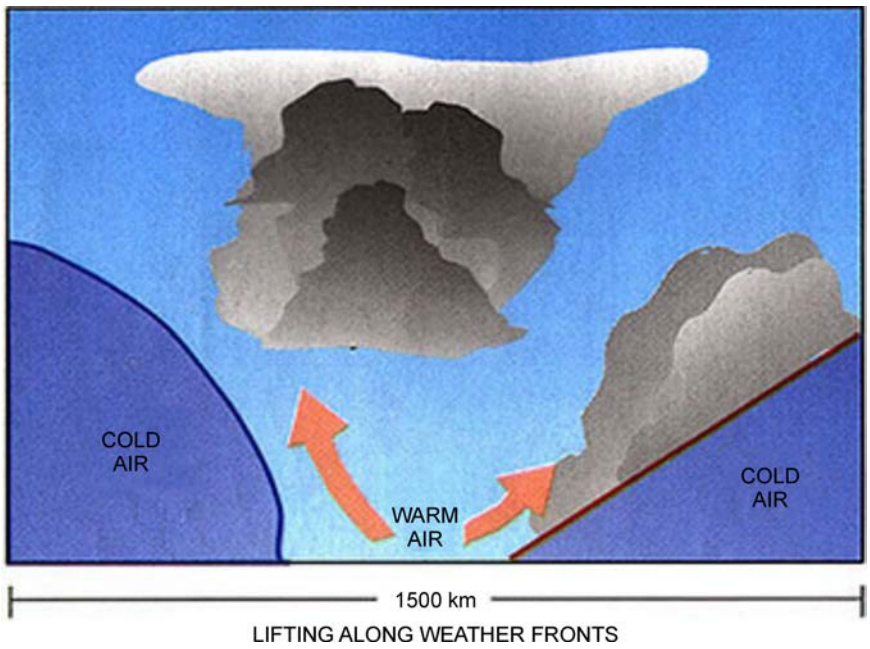
Orographic Lift. Orographic lift occurs when the sloping terrain forces the air upward. This process can be exaggerated if the air mass is already.



Water Encyclopedia, by G. H. Taylor, 2007, Water as a Climate Moderator. Copyright 2007 by Advameg. Retrieved March 17, 2008, from http://www.waterencyclopedia.com/Ce-Cr/Climate-Moderator-Water-as-a.html

Figure 5 Orographic Lift

Frontal Lift. When different air masses meet, the warmer air is forced upwards by the denser cold air. This process may be exaggerated if the warm air mass becomes unstable.



Federation of American Scientists, by N. M. Short, Sr, 2007, Atmospheric Circulation: Weather Systems. Copyright 2007by FAS. Retrieved March 17, 2008, from http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1c.html

Figure 6 Frontal Lift

Mechanical Turbulence. Air moving over the ground may be affected by terrain that is not as pronounced as mountains. Forests, buildings, large ditches and quarries also affect the air through friction. This friction

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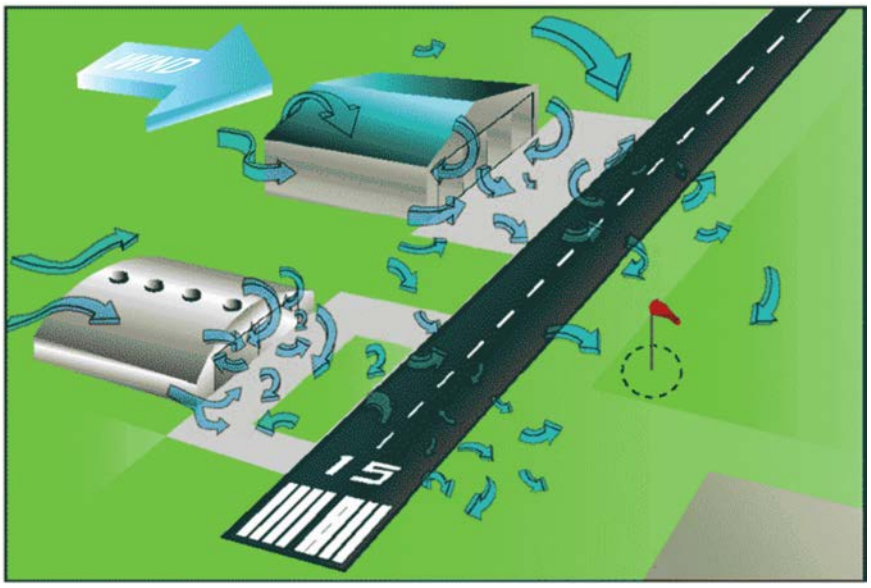
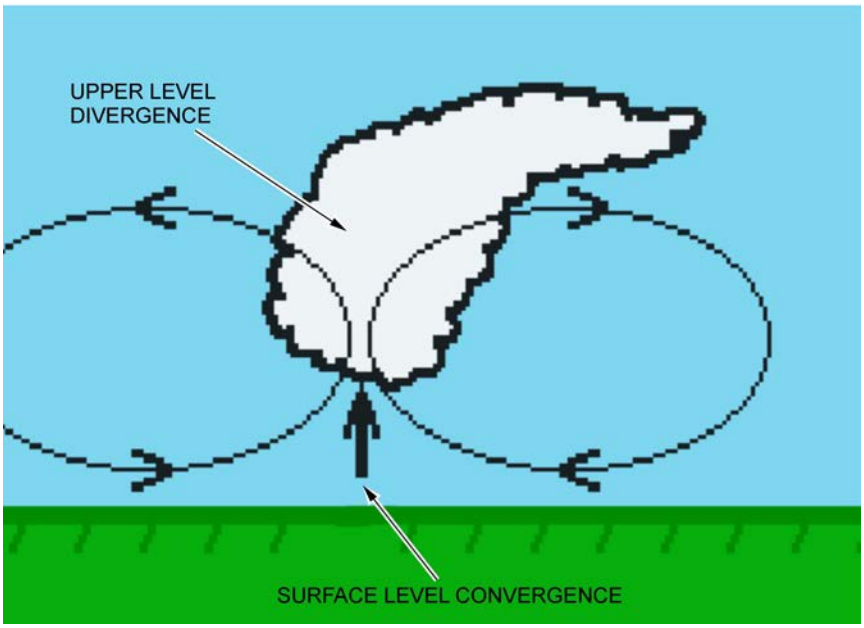
causes eddies, which are usually confined to the first few thousand feet of the troposphere. This process may be exaggerated if the air mass becomes or is already unstable.



Free Online Private Pilot Ground School, 2006, Aviation Weather–Principles. Copyright 2006. Retrieved March 17, 2008, from http://www.free-online-private-pilot-ground-school.com/Aviation-Weather-Principles.html

Figure 7 Mechanical Turbulence: Man-Made

Convergence. In a low pressure system, the wind blows toward the centre of the system. The excess air that collects here is forced upward to higher altitudes.



The Weather Doctor, by K. C. Heidron, PhD, 2002, What Goes Up: Part 3 Convergence and Divergence. Retrieved March 17, 2008, from http://www.islandnet.com/~see/weather/elements/whatgoesup3.htm

Figure 8 Convergence

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CONFIRMATION OF TEACHING POINT 3

QUESTIONS

Q1. Explain how convection (as a source of lift) occurs.

Q2. Explain orographic lift.

Q3. Explain frontal lift.

ANTICIPATED ANSWERS

A1. Convection is caused by heating of the air that is in contact with the surface of the earth.

A2. Orographic lift occurs when the sloping terrain forces the air upward.

A3. When different air masses meet, the warmer air is forced upward by the denser cold air. This process may be exaggerated if the warm air mass becomes unstable.

Teaching point 4 **Describe Cloud Formation**

Time: 5 min Method: Interactive Lecture

CLOUD FORMATION

Clouds are formed by the lifting agents and air stability.

Clouds are formed in two ways. Either the temperature drops to the saturation point of the air or the temperature is constant but the amount of water in the air increases.

Relating Lifting Agents to Air Stability

Each of the lifting agents described have an effect on, or is affected by, air stability. Convection, for example, is normally associated with unstable air since heat causes the convection, and is also a source of instability in the air.

Another example would be orographic lift, which is usually associated with stable air. After the air has been forced up by the terrain, it cools and becomes dense. The effect is similar to positive stability in an airplane.

Relating Air Stability to Types of Formation

Air stability will have a direct affect on cloud formation. Clouds created in stable air will form as stratus-type clouds. Clouds formed in unstable air will form as cumulus-type clouds.

CONFIRMATION OF TEACHING POINT 4

QUESTIONS

Q1. What are the two ways in which a cloud forms?

Q2. How does orographic lift relate to air stability?

Q3. What cloud type will form in stable air?

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ANTICIPATED ANSWERS

A1. Either the temperature drops to the saturation point of the air or the temperature is constant but the amount of water in the air increases.

A2. After the air has been forced up by the terrain, it cools and becomes dense. The effect is similar to positive stability in an airplane.

A3. Clouds created in stable air will form as stratus-type clouds.

END OF LESSON CONFIRMATION

QUESTIONS

Q1. What are the two types of cloud formation?

Q2. Define unstable air.

Q3. What cloud type will form in unstable air?

ANTICIPATED ANSWERS

A1. Cumulus and stratus.

A2. When a mass of rising air is warmer than the new air around it, then the air mass will continue to rise.

A3. Clouds created in unstable air will form as cumulus-type clouds.

CONCLUSION

HOMEWORK/READING/PRACTICE

N/A.

METHOD OF EVALUATION

This EO is assessed IAW A-CR-CCP-803/PG-001, Chapter 3, Annex B, Aviation Subjects – Combined Assessment PC.

CLOSING STATEMENT

Knowing how a cloud is formed will help predict the weather conditions that may exist. Conversely, knowing the weather conditions will assist in determining what clouds will form later in the day, and it may be possible to predict what the weather for the day will be.

INSTRUCTOR NOTES/REMARKS

N/A.

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.

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