๖๓๒๒-๒๑๙-๐๗ ภาษาอังกฤษสำหรับงานอุตุนิยมวิทยา ๓ - ๐ - ๓

(English for Meteorological Field)

จุดประสงค์รายวิชา เพื่อให้

๑. มีความรู้ความเข้าใจเกี่ยวกับคำศัพท์ วลี ภาษาอังกฤษสำหรับงานด้านอุตุนิยมวิทยา

๒. มีความรู้ความเข้าใจเกี่ยวกับความหมาย และแนวทางการใช้ภาษาอังกฤษสำหรับงานอุตุนิยมวิทยา

๓. มีความรู้ความเข้าใจเกี่ยวการรายงานข่าวอากาศ การพยากรณ์อากาศและแจ้งเตือนสภาพอากาศภาษาอังกฤษ

๔. มีเจตคติที่ดีเกี่ยวกับการเรียนรู้ ฝึกฝน และค้นคว้าเพิ่มเติมภาษาอังกฤษสำหรับงานด้านอุตุนิยมวิทยา

สมรรถนะรายวิชา

๑. อ่าน ฟัง พูดและเขียนคำศัพท์ วลี ภาษาอังกฤษสำหรับงานด้านอุตุนิยมวิทยา

๒. แสดงความรู้เกี่ยวกับความหมายและแนวทางการใช้ภาษาอังกฤษสำหรับงานอุตุนิยมวิทยา

๓. แสดงความรู้เกี่ยวกับการรายงานข่าวอากาศ การพยากรณ์อากาศและแจ้งเตือนสภาพอากาศภาษาอังกฤษ

คำนำ

เอกสารประกอบการบรรยายวิชาภาษาอังกฤษฉบับนี้จัดทำขึ้นเพื่อใช้ประกอบการเรียนรู้ในกลุ่มสมรรถนะวิชาชีพ เฉพาะ ๖๓๒๒-๒๑๙-๐๗ ภาษาอังกฤษสำหรับงานอุตุนิยมวิทยา (English for Meteorological field) ตามหลักสูตรโรงเรียนจ่าอากาศ พุทธศักราช ๒๕๖๔ เหล่าทหารอุตุ โรงเรียนจ่าอากาศ กรมยุทธศึกษาทหารอากาศ เพื่อให้นักเรียนจ่าอากาศ เหล่าทหารอุตุมีความรู้ด้านภาษาอังกฤษที่เกี่ยวข้องกับงานอุตุนิยมวิทยา

เอกสารประกอบการบรรยายได้จำแนกเนื้อหาหลักออกเป็นสองส่วน โดยส่วนแรกนำมาจากตำรา MODULE 006 WEATHER ของ Defense Language Institute English Language Center (DLIELC)ซึ่งเป็นการประยุกต์ระหว่างวิชาภาษาอังกฤษ(โครสร้างและไวยากรณ์)และเนื้อหาสาระทางอุตุนิยมวิทยา ผู้เรียนจะได้เรียนรู้และพัฒนาทักษะด้านการอ่าน พูด ฟัง เขียนและเพิ่มพูนทักษะการใช้ภาษาอังกฤษ ส่วนที่สองเกี่ยวข้องกับ English language for RTAF Weather Corps. เนื้อหาสาระมุ่งเน้นในการพูดโต้ตอบในการให้บริการเบื้องต้นหรือการแจ้งเตือนข้อมูลข่าวอากาศชนิดต่าง ๆ ให้กับผู้เกี่ยวข้องหรือเมื่อได้รับการร้องขอ ความรู้และทักษะที่ได้รับจะเป็นพื้นฐานเบื้องต้นให้กับผู้เรียนใช้ศึกษาค้นค้วาเอกสาร ตำรา บทความทางอุตุนิยมวิทยาในส่วนที่เป็นภาษาอังกฤษที่เผยแพร่ทั่วไปหรือตามสื่ออิเล็กทรอนิกส์ต่าง ๆ ได้ในระดับหนึ่ง ตลอดจนสามารถให้บริการหรือบรรยายสรุปภาคภาษาอังกฤษ ซึ่งมีการปฏิบัติจริงในการปฏิบัติงานในหน้าที่

ผู้จัดทำ (น.อ.เสนีย์ ฉัตรวิไล) หวังเป็นอย่างยิ่งว่าเอกสารประกอบการศึกษานี้จักเป็นประโยชน์ต่อผู้ทำการสอนและผู้เรียน หรือผู้สนใจใคร่รู้ตามสมควร อย่างไรก็ตามหากพบข้อบกพร่อง หรือมีข้อแนะนำเพิ่มเติมกรุณาแจ้งต่อผู้จัดทำเพื่อจะได้ดำเนินการแก้ไข ปรับปรุงอันจะทำให้เอกสารประกอบการศึกษามีความสมบูรณ์ยิ่งขึ้นต่อไป

โรงเรียนจ่าอากาศ กรมยุทธศึกษาทหารอากาศ

๒๕๖๔

กิติกรรมประกาศ

ตามที่ คณก. ปรับปรุงหลักสูตรสายวิทยาการอุตุนิยมวิทยาได้เสนอให้มีการเพิ่มเติมวิชาภาษาอังกฤษที่เกี่ยวข้องกับอุตุนิยมวิทยาในหลักสูตรโรงเรียนจ่าอากาศ พุทธศักราช ๒๕๖๔ เหล่าทหารอุตุ โรงเรียนจ่าอากาศ กรมยุทธศึกษาทหารอากาศและได้รับการอนุมัติให้มีการเรียนการสอนนั้น ผู้จัดทำได้รับมอบให้จัดทำเอกสารประกอบการเรียนการสอน และจากประสบการณ์ที่ได้รับทุน IMET FY96 ให้ไปศึกษา ณ ประเทศสหรัฐอเมริกา โดยในเบื้องต้นได้เข้ารับการศึกษาที่ Defense Language Institute English Language Center(DLIELC), Lackland Air Force Base มลรัฐ Texas ก่อนที่จะไป Follow On Training ขณะที่ผู้จัดทำได้เรียน MODULE 006 WEATHER พบว่าตำราที่ DLIELC จัดทำขึ้นเพื่อวัตถุประสงค์ในการพัฒนาทักษะด้านต่าง ๆ ตลอดจนเพิ่มพูนการใช้ภาษาอังกฤษทางด้านอุตุนิยมวิทยาซึ่งสอดคล้องอย่างมากกับวัตถุประสงค์ที่ทาง คณก.ฯ ต้องการ และจากนโยบายของ กพ.ทอ. ให้หน่วยจัดทำภาษาอังกฤษที่ใช้ในสายวิทยาการขึ้นจึงเป็นที่มาของเอกสารประกอบการเรียนการสอนฉบับนี้

ผู้จัดทำกราบขอบพระคุณครู อาจารย์ที่สั่งสอนวิชาภาษาอังกฤษทั้งในประเทศและต่างประเทศ และขอขอบคุณ คณก.ปรับปรุงหลักสูตรฯ ที่ได้มีการปรับปรุงหลักสูตรของโรงเรียนจ่าอากาศ เหล่าทหารอุตุฯ รวมทั้งได้มอบความไว้วางใจให้จัดทำเอกสารประกอบการเรียนการสอน นอกจากนี้ขอขอบคุณ ร.ท.มณเฑียร ทาสี ที่กรุณามอบตำรา MODULE 006 WEATHER ในชุด INSTRUCTOR Book ซึ่งได้รับมอบจากศูนย์ภาษา ยศ.ทอ.ทำให้เอกสารประกอบการเรียนการสอนมีความครบถ้วนสมบูรณ์ทั้งของผู้สอนและผู้เรียนอันเป็นการเพิ่มประสิทธิภาพในการเรียนการสอนได้ดียิ่งขึ้น สุดท้ายขอขอบคุณ จ.อ.วัชรพงศ์ ทิพย์ภาลัย ผู้รับมอบหน้าที่ในการจัดพิมพ์ตลอดจน จนท. ทุกท่านที่มีส่วนช่วยในการจัดทำเอกสารประกอบการเรียนการสอนจนกระทั่งสำเร็จเรียบร้อย

น.อ.เสนีย์ ฉัตรวิไล

ประจำ คปอ.และ รรก.รอง ผบ.ศขอ.กขอ.คปอ.

ก.ย.๖๔

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Introduction To Weather

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1. Movement Of The Earth - Rotation

The earth is a sphere that revolves around the sun. At the same time that the earth revolves around the sun, it also rotates around its own axis. The sun radiates light/heat that is received by the earth. When the earth rotates on its axis, some parts of the earth receive light/heat from the sun (day); while parts on the opposite side of the earth do not (night). Since the earth completes one rotation every 24 hours, each part of the earth has one "day" period and one "night" period every 24 hours. The rotation of the earth produces the sequence of nights and days. See figure 1.

2. Movement Of The Earth - Revolution

While the earth is rotating around its own axis, it is also revolving around the sun in a circular path. The earth completes one revolution around the sun every 365% days. Each revolution the earth makes around the sun takes one year. See figure 1.

3. The Angle Of The Earth's Axis

If the earth's axis were straight up and down, as in figure 2, the amount of radiation from the sun that each part receives would not change as the earth made its revolution around the sun. But, the earth's axis is not straight up and down, it is at an angle as is shown in figure 3. According to where the earth is in its revolution around the sun, one hemisphere will be closer to the sun than the other. See figure 3.

4. The Seasons

The revolution of the earth around the sun and the angle of the axis produce the general changes in temperature that are called the seasons: winter, spring, summer, and fall. When the areas above the equator in the northern hemisphere have winter because they are angled away from the sun, the areas below the equator in the southern hemisphere have summer because they are angled toward the sun. See figure 3, position 1. Six months later, when the earth has made half of a revolution around the sun, the positions will be reversed. The northern hemisphere will be having summer while the southern hemisphere will be having winter. See figure 3, position 2. As the earth continues its revolution, the northern hemisphere will start to be away from the sun

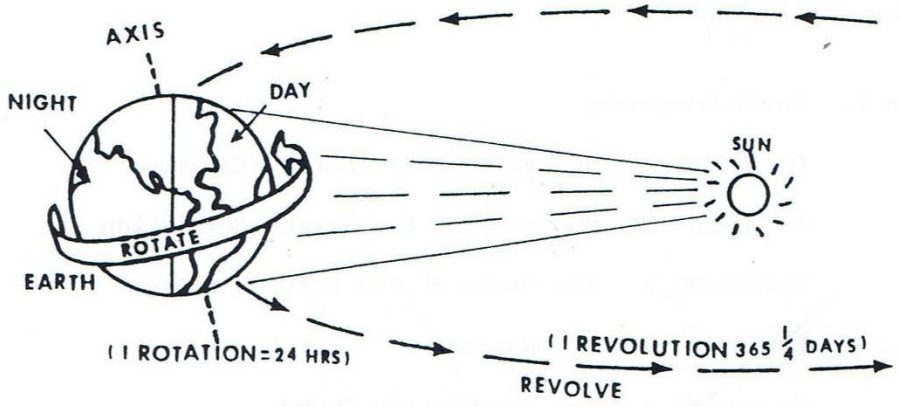


Figure 1

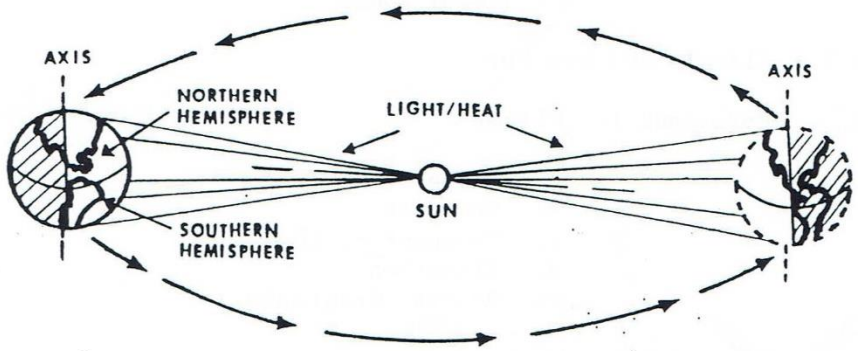


Figure 2

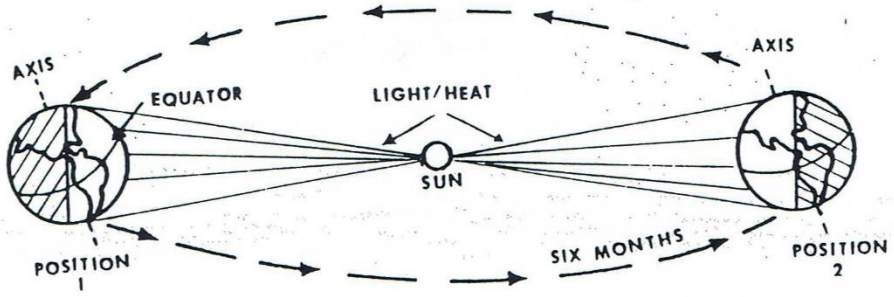


Figure 3

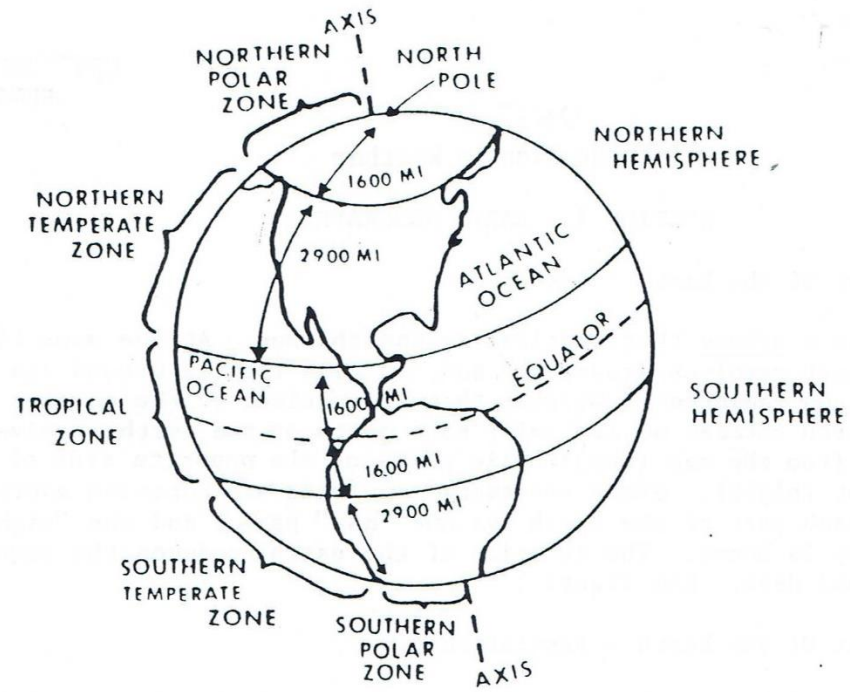


Figure 4

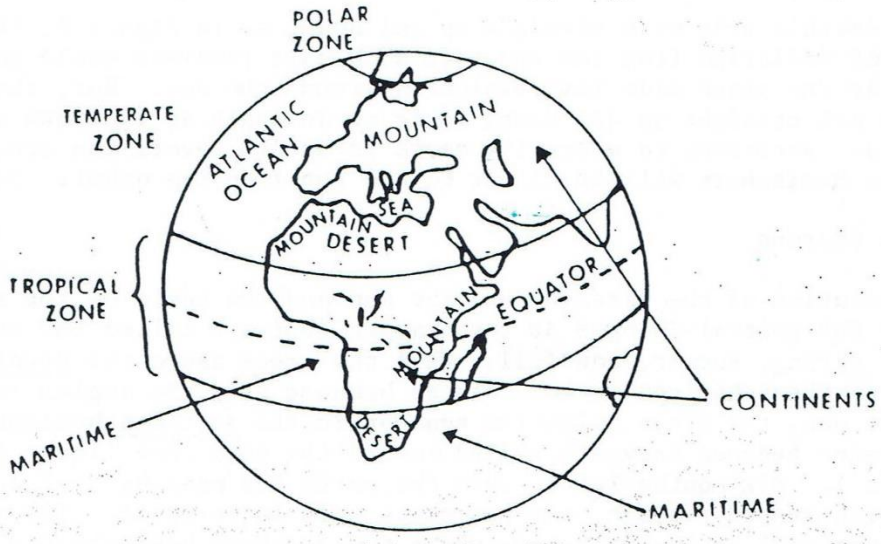


Figure 5

and have fall, while the southern hemisphere will start to be toward the sun and have spring. The revolution of the earth and the angle of the axis produce the sequence of the seasons--winter, spring, summer, and fall--each year.

5. The Temperature Zones

It is useful to divide the earth's surface into three general types of temperature zones, based on the angle of the earth's axis and the revolution of the earth around the sun. See figure 4.

a. Tropical Zone. The tropical zone extends approximately 1600 miles (2600 km) north of the equator and 1600 miles south of the equator. The areas in the tropic zone tend to be warm or hot throughout the year. See figure 4.

b. Temperate Zones. There are two temperate zones, one in the northern hemisphere and the other in the southern hemisphere. The northern temperate zone extends north from the tropical zone approximately 2900 miles (4700 km). The southern temperate zone extends south from the tropical zone the same distance. Areas in the temperate zones tend to have warm or hot summers and cool or cold winters. See figure 4.

c. Polar Zones. There are also two polar zones, one in each hemisphere. The northern polar zone extends approximately 1600 miles from the northern temperate zone to the north pole. The southern polar zone extends from the southern temperate zone to the south pole. Areas in the polar zones tend to be cold. See figure 4.

SECTION 2. CLIMATE AND WEATHER

1. Climate

Climate is the word used to describe the general year after year weather conditions in a particular region or area. When a particular area is described, the geography of the area and its climate are closely related. Some of the major factors that determine the climate of an area are as follows:

a. The Temperature Zone. The temperature zone that an area is located in is usually a major factor in its climate. See figure 5.

b. Humidity. The amount of evaporated water in the air is a major factor in the climate of an area. Clouds are formed when evaporated water condenses into very small drops of water. Larger drops become precipitation that falls as the area's rain, snow, sleet, and hail.

c. Movement of the Air. The air that makes up the earth's atmosphere does not remain in one place but moves about the earth. Cold polar air moves across the temperate zones, as does tropical air. Maritime air from overseas and oceans moves across the continents, and continental air moves over other parts of the continent, or out over the seas. The movement of air is a major climate factor.

d. Elevation. The height of an area above sea level is often an important climate factor. As a general rule temperatures decrease as height or altitude above sea level increases. Higher areas usually have cooler or colder climates than low regions in the same area. See figure 5.

e. General Geography. In addition to the general temperature zone an area is located in, other geographic factors that are important to a climate can be the availability of surface water in the form of oceans, seas, rivers, and lakes, and the location of mountain zones that control the movements of the air in a region or area. See figure 5.

2. Weather

If climate is a word used to describe the general year-to-year weather conditions in an area, then weather is the word used to describe the day-to-day atmospheric conditions. Since everybody experiences the weather conditions around him throughout his life, weather is discussed in nontechnical terms by all people. Some of the more common terms used to describe particular weather features are listed below.

a. Temperature. Days are described as hot, cold, cool, or warm; or thermometer temperatures are given in degrees Celsius or degrees Fahrenheit.

b. clouds. Days are described as being clear, cloudy, or overcast. Clouds on the surface are called fog. Certain clouds, particularly if they are black colored, are called rain clouds or thunder clouds.

c. Precipitation. hail, or sleet.

Precipitation is identified as being rain, snow,

d. Winds. Winds are described as being strong or light, and are often identified by the direction they blow from, i.e., north wind, east wind, etc.

e. Storms. Strong winds that combine with other conditions are called storms, i.e., rainstorms, snowstorms, hailstorms, sandstorms, duststorms, and thunderstorms.

f. Humidity. Days are described as being humid or dry.

GLOSSARY

AREA: noun; a particular zone, region, or part

Ex. This area of the country has a lot of mountains.

CONTINENT: noun; a large land area on the earth's surface

Ex. The North American continent is north of the equator.

CONTINENTAL: adjective form of continent (-al)

ELEVATION: noun; the height of a feature on a surface, usually the distance above sea level

Ex. That city is near the sea; the elevation is only 50 feet.

EQUATOR: noun; an imaginary line around the middle of the earth midway between the north and south poles

Ex. The area of the earth north of the equator is called the northern hemisphere.

EXTEND: verb; (1) to reach from one point to another

Ex. The United States extends from the Atlantic Ocean to the Pacific Ocean.

Ex. The blackboard extends from one wall to the other.

(2) to reach out or up

Ex. The atmosphere extends many miles up from the surface of the earth.

Ex. The wings extend out from the sides of the airplane.

MARITIME: adjective; areas near the sea or sea areas

Ex. Air from the maritime areas usually contains a lot of moisture.

NORTHERN: Adjective form of north (-ern)

POLAR: adjective form of pole (-ar)

POLAR ZONE: noun; the temperature zones near the north pole and the south pole.

SEA LEVEL: noun; the height of the surface of the oceans, usually used as the zero (Ø) point to measure elevation

Ex. The elevation of the airport is 2,000 feet above sea level.

SOUTHERN: adjective form of south (-ern)

SPHERE: noun; a ball-shaped object

Ex. An orange is a sphere-shaped fruit.

Note: hemisphere = half-sphere

TEMPERATE ZONE: the area of the earth's surface between the tropical zone and the polar zones

THERMOMETER: an instrument used to measure temperature

Ex. It's cold today, the thermometer only shows 5 degrees centigrade.
Note: thermo (heat) + meter (measuring instrument)

TROPICAL: adjective form of tropic

TROPICAL ZONE: the area of the earth's surface extending 1600 miles north and 1600 miles south of the equator

Language Exercises

I. NEW TERMINOLOGY: Oral Exercises

1. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

Equator	polar zones	tropical zone
extend	southern	
northern	temperate zone	

a. The tropical zone _____ about 1600 miles north and south of the equator.

b. The northern_____ _____ is located between the tropical zone and the northern polar zone.

c. Temperatures in the _____ _____ tend to be warm or hot through out the year.

d. The dividing line between the northern hemisphere and the southern hemisphere is the _____ .

e. Temperatures in the southern temperate zone are about the same as those in the _____ temperate zone.

f. The _____ temperate zone is located between the tropical zone and the southern polar zone.

g. We associate ice, snow, and year-round cold weather with the _____ .

h. When the northern hemisphere is having winter, the _____ hemisphere is having summer.

i. When we are above the _____ , temperatures get colder as we go northward; when we are below the_____, they get colder as we go southward.

J. We usually think of the earth's axis as the imaginary line. That _____ through the earth, from the north pole to the south pole.

k. The _____ _____ get their names from the fact that they are the zones located around the north and south poles.

l. Weather in the _____ _____ is not the same throughout the year; summers are warm/hot and winters are cool/cold.

m. The_____ _____ has a warm/hot climate throughout the year because its position in relation to the sun does not change much as the earth makes its revolution

n. The climates in the two _____ _____ and the two _____ _____ show changes by seasons because their positions are greatly changed in the revolution, according to whether they are angled toward, or away from the sun.

2.Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

area	maritime	thermometer
continent	polar	tropical
continental	sea level	
elevation	sphere	

a. We usually think of _____ climates as being cold all year.

b. Africa is a good example of a large land area that is called a _____ .

c. When we talk about a maritime area, we can almost assume that the elevation is at, or near, _____ _____ .

d. Higher _____ usually have lower temperatures than lower _____ in the same region.

e. Most people associate hot or warm year-round climates with _____ areas, but there are mountains near the equator that have snow all year.

f. It is necessary to have a _____ to accurately measure temperature.

g. Evaporation from the oceans and seas causes _____ air to be humid.

h. We would expect air from a _____ area to be cold, and air from a _____ area to be warm or hot.

i. Since air from a _____ area is assumed to be humid, air from a _____ area is usually assumed to be dry.

j. As a general rule, when _____ increases we expect temperature to decrease.

k. The word _____ is used to show that something is round like a ball, and not round like a dish, or round like a cigarette.

l. Measurement from the surface upward is called height, measurement from sea level upward is called .

m. Some books say that North and South America are two separate _____ ; others say that they are one n. Since the earth is in the shape of a _____ , one half of it is called a hemisphere.

II. SENTENCE PRACTICE: Oral Exercises

NOTE: When we talk about events that occur in the same way each time that they occur, or when we talk about things that are normally or generally true, we often use sentences with the words "when" or "if." In this kind of sentence "when" and "if" have approximately the same meaning. Compare the two example sentences that state "water freezes at 0°c."

(1) When the temperature falls below zero degrees centigrade, water freezes.

(2) If the temperature falls below zero degrees centigrade, water freezes.

1. Use the information given to make "if" sentences as shown below.

Examples:

Information: Winter/Northern Hemisphere.

Say: "If it is winter in the northern hemisphere, it is summer in the southern hemisphere."

. Information: Winter/Southern Hemisphere.

Say: "If it is winter in the southern hemisphere, it is summer in the northern hemisphere."

Information:

a. Spring/Northern Hemisphere_____

_____

b. Summer/Northern Hemisphere_____

_____

c. Fall/Northern Hemisphere _____

_____

d. Winter/Northern Hemisphere _____

_____

e.Spring/Southern Hemisphere _____

_____

f.Summer/Southern Hemisphere _____

_____

g.Fall/Southern Hemisphere _____

_____

h. Winter/Southern Hemisphere _____

_____

2. Use the information given to make "if" sentences as shown below.

   Examples:

   Information: West Say: "If the wind blows from the west, it is called a west wind."
   Information: East Say: "If the wind blows from the east, it is called an east wind."

   Information:

   a. North _____

      _____

b. Northeast _____

   _____

c. East _____

   _____

d. Southeast _____

_____

e. South

_____

f. Southwest _____

_____

g. West _____

_____

h. Northwest _____

_____

3. Use the information given to make "if" sentences as shown below.

Examples:

Information: Strong Winds/Rain.

Say: "If strong winds and rain are combined, we say it is a rainstorm."

Information: Strong Winds/Dust.

Say: "If strong winds and dust are combined, we say it is a dust storm."

Information:

a. Strong Winds/Ice _____

_____

b. Strong Winds/Hail _____

_____

c. Strong Winds/Sand _____

_____

d. Strong Winds/Snow _____

_____

e. Strong Winds/Sleet _____

_____

f. Strong Winds/Rain _____

_____

g. Strong Winds/Dust _____

_____

h. Strong Winds/Thunder _____

_____

4. Use the information given to make "if" sentences as shown below.

Examples:

Information: In the Mountains/Cool.

Say: "If a town is located in the mountains, it probably has a cool climate."

Information: Near a Sea/Humid

Say: "If a town is located near a sea, it probably has a humid climate."

Information:

a. Near a Desert/Dry _____

_____

b. Near the Equator/Hot _____

_____

c. Near a Polar Zone/Cold _____

_____

d. Near the Sea/Maritime _____

_____

e. Near a Tropical Sea/Warm-Humid _____

_____

f. Near a Tropical Desert/Hot-Dry _____

_____

g. Near a Northern Sea/Cool-Humid _____

_____

h. Near a Northern Desert/Cool-Dry ____

____

III. VOCABULARY EXPANSION: Oral Exercises

NOTE: Once you learn one form of a word, ex. verb: to heat, you should learn to recognize and understand the other forms as they usually contain the same basic meaning.

EXAMPLE: Verb: to heat, i.e., The sun heats the air.

Noun: heat, i.e., Deserts have a dry heat.

Noun: heaters, i.e., Small electric heaters are cheap.

Adjective: heating, i.e., Many houses have central heating systems.

Adjective: heated, i.e., The heated air expands and rises.

Abbreviations: Noun = n. Verb = v. Adjective = adj. Adverb = adv.

Use the correct forms of the words listed to complete the following sentences. Some of the words may be used more than once.

a. angle(s), n. angle(d), v. angled, adj.

1) When you come to the intersection, take the road that _____ to the right.

2) We learned how to measure _____ in school.

3) During one part of the year the northern hemisphere is _____toward the sun.

4) The road goes up the mountain in a series of _____ turns.

b. cool(ed), v. cooling, adj. cooled, adj.

cooler, n. coolly, adv. cool (er) (est), adj.

1) This _____ will keep soft drinks cold for about three hours.

2) In this section of the country _____ weather begins in September.

3) I'll have to wait until the coffee _____ before I can drink it.

4) A lot of cars don't use water, they have air _____ engines.

5) Our classrooms were very hot last week, the central _____ system was broken.

6) The electric motor was running _____ ,then it got hot and began to smoke.

7) Every night about nine o'clock we get a _____ wind from the north.

8) This is the _____ day we have had in a long time.

c. divide (ed), v. division(s), n. divided, adj.

dividing, adj. divider(s), n.

1) It is useful to _____ the earth's surface into five temperature zones.

2) It is much safer to drive on a _____ highway than to drive on one that has two-way traffic. The of the year into four seasons

3) The _____of the year into four seasons is more accurate in the temperate zones.

4) The _____ line between the two hemispheres is the equator.

5) You can buy notebooks that have colored _____that separate them into three or four sections.

6) He _____ the class into two groups, those who did well on the test, and those who didn't. Guess what _____ I was in.

Fig 1

PHONETIC ALPHABET

ALFA

BRAVO
(BRAH–VOH)

CHARLIE
(CHAR LEE)

DELTA
(DELL TAH)

ECHO
(ECK OH)

FOXTROT
(FOKS TROT)

GOLF

HOTEL
(HOH TELL)

INDIA
(IN DEE AH)

JULIETT
(JEW LEE ETT)

KILO
(KEY–LOH)

LIMA
(LEE–MAH)

MIKE

NOVEMBER
(NO VEM BER)

OSCAR
(OSS CAH)

PAPA
(PAH PAH)

QUEBEC
(KEH–BECK)

ROMEO
(ROW ME OH)

SIERRA
(SEE AIR RAH)

TANGO
(TANG GO)

UNIFORM
(YOU NEE FORM)

VICTOR
(VIK TAH)

WHISKEY
(WISS KEY)

XRAY
(ECKS RAY)

YANKEE
(YANG KEY)

ZULU
(ZOO LOO)

WUN

TOO

THUH–REE

FO–WER

FI–YIV

SIX

SEVEN

ATE

NINER

ZERO

THOUSAND
THOW–ZAND

UNIT 2

Weather Causes (1)

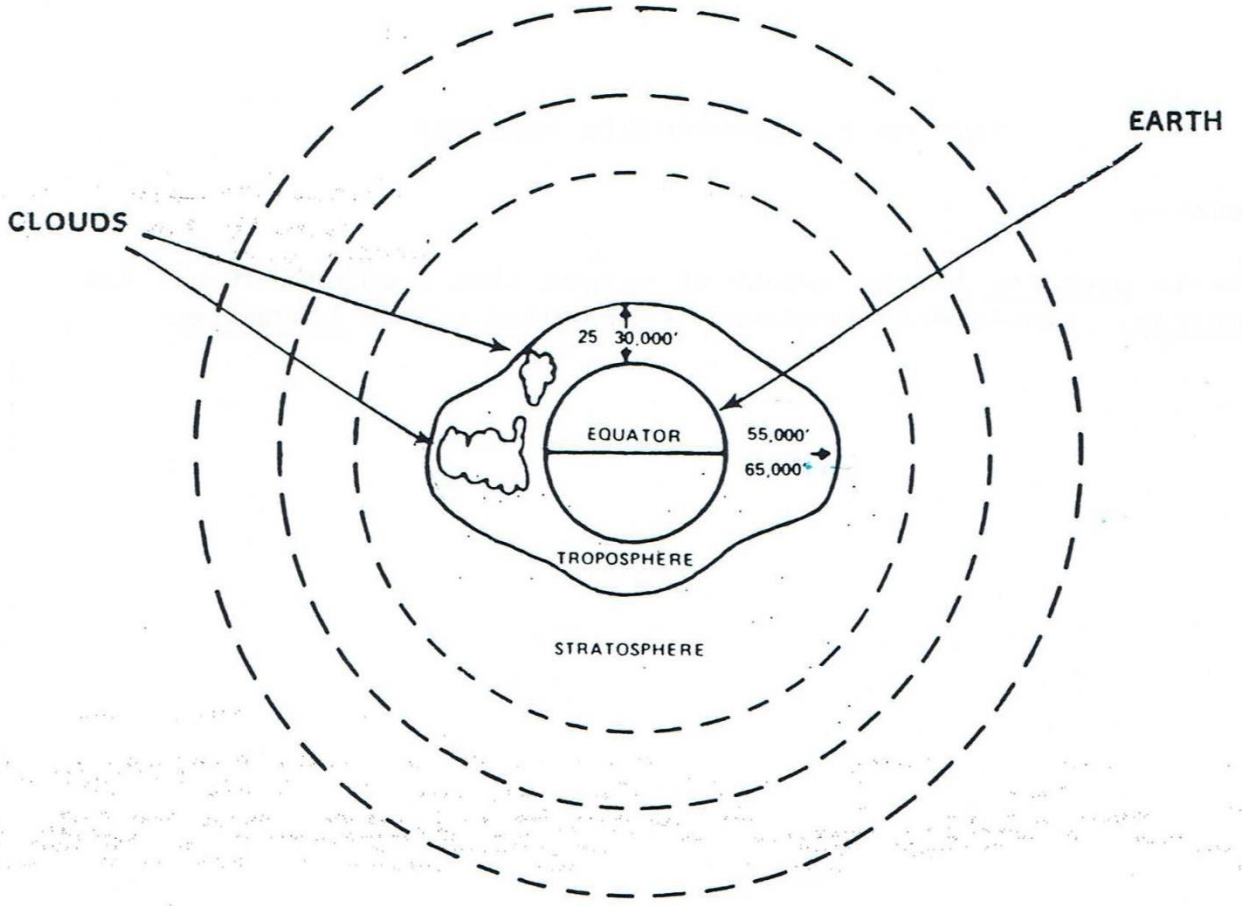
SECTION 1. ATMOSPHERE

1. General

This study of weather causes is not a complete course in meteorology. It is a review of basic meteorology, and provides you with sufficient knowledge to effectively use weather information. It covers atmospheric properties, the structure of the atmosphere, atmospheric processes, and weather-producing systems.

2. Layers

The atmosphere is divided into five layers with each layer having certain features. For our purpose we will talk about the troposphere and the stratosphere, since most aircraft flights occur in those layers.



Vertical structure of the atmosphere showing one division into layers or spheres based on temperature.

Figure 1

3. Troposphere

The troposphere is the layer of air that begins at the surface of the earth and extends upward to an average altitude of 7 miles. Its height varies from the equator to the poles, and from season to season. It is higher over the equator than over the poles, and it also has a greater height in the summer. The troposphere contains about three quarters (75%) of the earth's atmosphere by weight and almost all of the weather. The border between the troposphere and the stratosphere is called the tropopause. It is important because high-speed winds are often found near the tropopause. I

4. Stratosphere

The stratosphere is the layer just above the tropopause. The stratosphere begins (base) at an average height of seven miles and extends upward to an average height of 22 miles (top). The characteristics of the layer are a slight increase of temperature with height and almost no humidity. Occasionally, however, a strong thunderstorm in the troposphere will cross the tropopause and enter into the lower stratosphere.

SECTION 2. ATMOSPHERIC PRESSURE

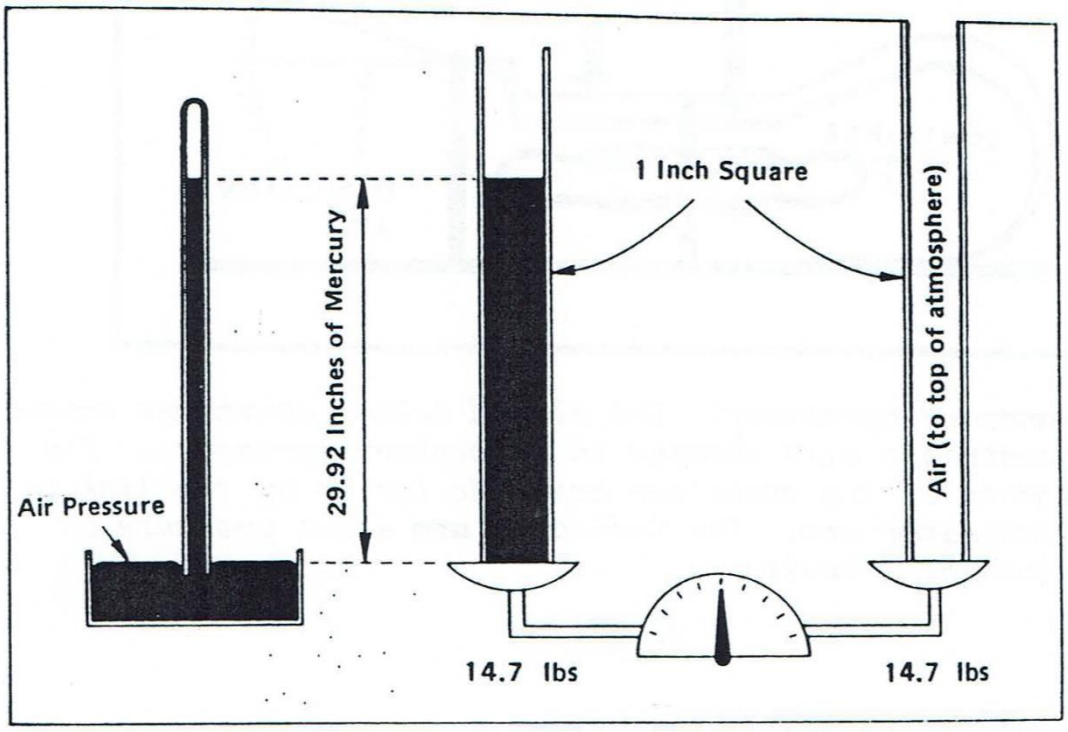
1. Pressure

Atmospheric pressure is the amount of weight that a column of air has on an object.

Atmospheric pressure is measured with a barometer.

2. Mercurial Barometer

A mercurial barometer uses a column of mercury in a glass tube to measure the weight of the atmosphere. The height of the column of mercury in the tube changes as the weight of the atmosphere changes. If the atmospheric pressure increases, the mercury will rise higher in the tube; if the atmospheric pressure decreases, the mercury will move downward in the tube. The height of the mercury in the tube is measured in inches. This height, measured in inches, is used as a measurement of atmospheric pressures.



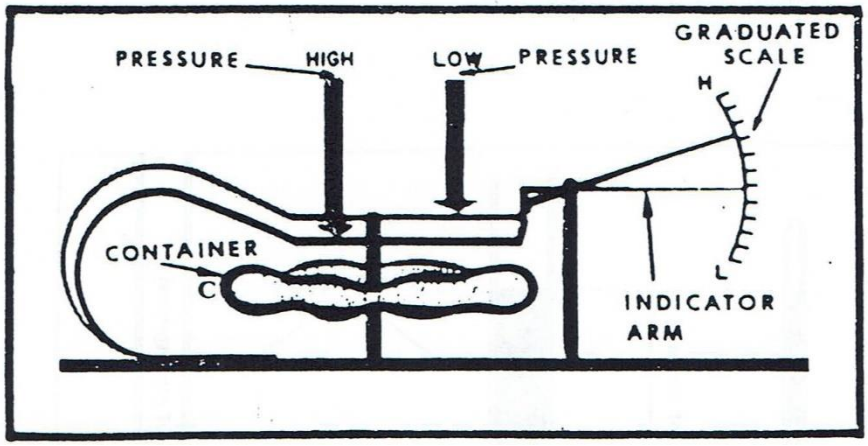
At the left: A mercurial barometer showing air pressure supporting a column of mercury 29.92 inches high in the barometer tube.

At the right: A scale showing that the weight of a 29.92 inch high column of mercury, one inch square, is the same weight as a column of air one inch square that extends to the top of the atmosphere.

Figure 2

3. Aneroid Barometer

An aneroid barometer uses a closed hollow container, partially emptied of air, to measure atmospheric pressure. The container is sensitive to differences in atmospheric pressure; when pressure increases the container is slightly compressed, when pressure decreases the container expands slightly. The hollow container is connected to an arm that indicates the pressure on a graduated scale. The aneroid barometer is smaller and easier to move around than a mercurial barometer, but generally it is less accurate and more likely to need adjustment. When it is used for official measurements it must be checked by comparing it with a mercurial barometer at least once a week.



The aneroid barometer. The closed hollow container expands and contracts with changes in atmospheric pressure. The movements of the container are made. larger by the link to the indicator arm. The indicator arm shows pressure on the graduated scale.

Figure 3

4. Conversion To Sea Level Pressure

If all weather stations were at the same elevations, barometer readings for each station's location marked on a weather map would give a correct record of the atmospheric pressures all over the map. However, pressure decreases with height at the rate of approximately one inch of mercury per thousand feet in the lower few thousand feet of the atmosphere. (The rate of decrease is greater in colder air.) Since the stations that report pressure have a wide range of elevations the barometer readings must be converted to sea level pressures so that they will only show the difference in air pressure that is not related to elevation. There conversion shows what the pressure would be if the station were at sea level. This makes the pressure on weather maps and reports more useful and more meaningful.

5. Conversion To Millibars

After the barometer pressure reading is converted to what it would be at sea level, it is changed to millibars, as millibars are the units of atmospheric pressure measurement that are used on weather maps. When the pressures at the different stations are compared, it is possible to determine many factors that indicate the trend of weather conditions.

6. Altimeter

The altimeter is a type of aneroid barometer that shows the pressure reading as feet of altitude or elevation. An altimeter reading is most accurate in showing actual true altitude when it is on or near the airport from which the altimeter setting has been obtained. An altimeter is set by adjusting it to show local differences in atmospheric pressure. When an accurate altimeter has been set to the local pressure, it will read the airport's elevation when it is on the surface of the airport.

SECTION 3. TEMPERATURE

1. Temperature Distribution

Two temperature scales are commonly used in communicating weather information--Fahrenheit (F) and Celsius/centigrade (C). The freezing point of water is 32° on the Fahrenheit scale (32°F) and zero on the Celsius scale (0°C). Water boils at 212°F, or 100°C when it is at sea level.

2. Lapse Rate

Temperature normally decreases with increasing altitude in the lower 30 to 40 thousand feet of the atmosphere. This decrease in temperature with an increase in height is defined as the lapse rate. A standard lapse rate is approximately 2°C per thousand feet.

3. Inversion/Inversion Layer

An inversion is an abnormal increase of the temperature of the atmosphere with height.
An inversion layer is a layer of air that shows inversion characteristics.

4. Isothermal Layer

An isothermal layer is a layer in which temperature does not change with height.

SECTION 4. STANDARD ATMOSPHERE

1. Characteristics

Several general characteristics of the atmosphere have already been mentioned, but in order to measure a change from normal, we have to establish a standard for a "normal" atmosphere. Conditions through the world for all areas and all seasons have been averaged to determine:

a. a surface temperature of 59°F (15°C) at sea level

b. a surface pressure of 29.92 inches of mercury (1013.2 millibars) or 14.7 pounds per square inch at sea level

c. a lapse rate (decrease of temperature with height) in the troposphere of approximately 2°C per thousand feet

d. a tropopause of approximately 36,000 feet

e. a temperature at the tropopause of -55°c

GLOSSARY

ALTIMETER: noun; an instrument used to measure altitude

Ex. The altimeter showed that the plane was at 10,000 ft.

Note: alti (high) + meter (measuring instrument)

ANEROID BAROMETER: noun; a type of barometer that does not use liquid to measure pressure

Ex. He used an aneroid barometer because it was smaller and easier to move from place to place.

AVERAGE: noun; the total of a column of figures, divided by the number of items in the column. Also the total length, cost, weight, etc., of a group of items divided by the number of items

Ex. The average of 4, 5, and 9 is 6.

Ex. The average height of the three men was 5 feet, 8 inches.

BAROMETER: noun; an instrument used to measure atmospheric pressure

Ex. The weather station has two types of barometers.

Note: baro (pressure/weight) + meter (measuring instrument)

BOIL: verb; to use heat to change water to steam

Ex. He boiled water to make tea.

Ex. Water boils at 100°c

.CHARACTERISTIC(S): noun; the feature or features that identify one thing as being different from another thing

Ex. A characteristic of an inversion is that the temperature increases with height.

CONVERT: verb; to change one thing into another thing

Ex. Inches can be converted to centimeters by multiplying the inches by 2.54.

CONVERSION: the noun form of convert

DETERMINE: verb; to find out or to identify

Ex. The pilot uses his altimeter to determine his altitude.

INVERSION LAYER: noun; a layer of the atmosphere in which temperatures increase with height

Ex. The air temperature is increasing, we must be climbing through an inversion layer.

Note: Inversion = noun form of verb "invert," to turn over.

ISOTHERMAL LAYER: noun; a layer of air in which the temperature does not change with height

Ex. We have climbed 2,000 feet without having any change in the air temperature; we must be in an isothermal layer.

Note: iso (equal) + thermal (heat)

LAPSE RATE: noun; the rate of temperature decreases as altitude increases

Ex. The normal lapse rate is a decrease of 2°C with each increase of 1,000 feet.

MERCURIAL: adjective form of mercury (chemical symbol Hg)

METEOROLOGY: noun; the science that studies the atmosphere and weather

Ex. You have to study meteorology before you can be a weatherman.

MILLIBAR: noun; a unit used to measure atmospheric pressure shown on a barometer. 34 millibars = 1 inch of mercury

Ex. Barometer pressures can be reported as inches of mercury or as millibars.

OBJECT: noun; a thing

Ex. What are those three objects on the desk?

PRESSURE: noun; the amount of weight on a surface, divided by the area of the surface. Pressure is usually measured in pounds per square inch (PSI) or kilograms per square centimeter (Kg per c?)

Ex. Check the pressure in the tire to be sure that it is not more than 32 PSI.

PROCESSES: noun; a series of changes that produce a particular result

Ex. The atmosphere must go through a number of processes before clear weather becomes cloudy, rainy weather.

PROPERTIES : noun; the particular characteristics of a material

Ex. Some of the properties of water are that between 0° and 100°c, it is a liquid; below 0°c it freezes to a solid; and above 100°C it becomes a gas.

SET: verb; to adjust an instrument to a standard

Ex. Do you have the correct time? I want to set my watch.

SETTING: noun; a particular adjustment

Ex. What setting do I use on my radio to receive the weather reports?

STRATOSPHERE: noun; the layer of atmosphere that starts at approximately 7. miles and extends to 22 miles in altitude

Ex. Many modern aircraft are capable of flying so high that they fly in the stratosphere.

Note: strato + sphere.

STRUCTURE: noun; the order of parts or the construction of a thing

Ex. Each of the five layers that make up the structure of the atmosphere has a name.

TROPOPAUSE: noun; the name of the border between the stratosphere and the troposphere

Ex. Clouds do not usually rise high enough to cross the tropopause.

Note: tropo (change) + pause (stop)

TROPOSPHERE: noun; the name of the layer of the atmosphere that begins at the surface of the earth and extends upward approximately seven miles

Ex. Almost all of the changes we call weather occur in the troposphere.

Note: tropo (change) + sphere

Language Exercises

I. NEW TERMINOLOGY: Oral Exercises

1. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

meteorology	process	average
property t	roposphere	tropopause
tructure	stratosphere	

a. Do you know much about the _____ of clouds being formed from evaporated water in the air?
b. In some desert areas the _____ rainfall is less than five inches per year
c. Most people spend their lives in the troposphere. You would normally only enter the _____ if you were in a high-flying airplane.
d. I saw a picture showing the _____ of the atmosphere; it showed five different layers of air, one above the other.
e. Almost everyone knows some of the _____ of water; it freezes at 0°C and boils at 100°c.
f. The layer of air closest to the ground is the _____
g. I wanted to know more about weather so I bought a book on _____ .
h. When you go from the troposphere to the stratosphere, you cross the _____ .
i. It is easy to understand the _____ of the atmosphere if you just think of a series of transparent balls; a large one, then a smaller one inside it, then an even smaller one inside that one, and so on.
j. The layer above the tropopause is called the _____ .
k. The _____height of the troposphere is 7 miles; actually it is higher at the equator than at the poles.
l. Most of what we call weather occurs in the troposphere; occasionally a storm will enter the
m. The _____ of ice changing to water is called "melting."
n. The atmosphere has several _____ that are related to altitude; both temperature and pressure change with height.

2. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense.

Do not try to write the words in the spaces.

characteristic	barometer	convert
pressure	mercurial	conversion
object	aneroid barometer	

a. If you know the elevation, it isn't difficult to _____ the barometer reading to sea level pressure.
b. I guess we would say this is a _____ thermometer; it has mercury in it.
c. One of the _____ of the atmosphere is that it is mainly composed of oxygen and nitrogen.
d. In some countries standard sea level _____ is called "one atmos;" it is probably an abbreviation for one atmosphere.
e. When we want to find the length of an _____ we measure it; when we want to know the _____ weight, we weigh it.
f. f. One way to remember the difference between the two types of barometers is that the _____ _____ is made from metal.
g. The _____ of pounds to kilograms is not difficult; one kilogram equals 2.2 pounds.
h. The _____ of the atmosphere decreases as we go higher.
i. A thermometer is used to measure any temperature, but a _____ is only used to measure atmospheric pressure.
j. We have to know the standard atmospheric _____ that we can compare the day-to-day changes.
k. The _____ barometer uses two fluids to measure pressure, one is the gas "air," the other is a liquid metal.
l. The liquid "water" can be _____ to the solid "ice" by freezing.
m. Since the _____ _____ measures pressure mechanically, it should be checked about once a week with the other type. n. If your mercurial barometer has two scales, one in millibars : and the other in inches, there is no need to make the _____ from one to the other; you can read it directly.

3. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

altimeter	inversion layer	set
boil	isothermal layer	setting
determine	lapse rate	

a. Do you have the correct time? I want to _____ my watch.

b. If you are at sea level, you can expect water to _____ at 100°

c. An altimeter uses a unit like an aneroid barometer to _____ height.

d. If you know that the standard _____ _____ is 2°c per thousand feet, you know why temperatures are cooler in the mountains.

e. If the temperature begins to increase as you go higher, you are probably in an _____ _____.

f. Pilots use an _____ to find out how high they are flying.

g. Since pressure changes from day to day, and from place to place, the altimeter _____ _____ has to be changed to show local pressure at each airfield.

h. I wish you would change the _____on that alarm clock; it wakes us up 10 minutes too early.

i. The temperature is staying the same, but the altimeter shows we have gone up 2,000 feet; that is a sure characteristic of an _____ _____

j. Isothermal layers and inversion layers are easy to identify because they don't follow the standard _____ _____; one reverses it, the other just doesn't change.

k. One reason a pilot is told the local pressure is so he can _____ his altimeter.

l. When water _____ at 100°c, it is changing from a liquid to a gas.

m. There is no easy way to _____ atmospheric pressure without a barometer.

n. If there is hot air above cool air, it will be called an _____ _____.

II. SENTENCE PRACTICE: Oral Exercises

NOTE: When we talk about the location of things, we tend to use the same type of sentence and only change the names of the things we are describing.

1. Use the information given to make location sentences as shown below:

Examples:

Information: Northern Hemisphere: Equator/North Pole.

Say: "The northern hemisphere extends from the equator to the north pole."

Information: Troposphere: Surface of the Earth/ Approximately 7 Miles Up.

Say: "The troposphere extends from the surface of the earth to approximately 7 miles up."

Information:

a. Northern Temperate Zone: Tropical Zone/Northern Polar Zone.

_____

_____

b. Northern Polar Zone: Northern Temperate Zone/North Pole.

_____

_____

c. Tropical Zone: 1600 Miles North of the Equator/1600 Miles South of the Equator.

_____

_____

d. Southern Temperate Zone: Tropical Zone/Southern Polar Zone.

_____

_____

e. Southern Polar Zone: Southern Temperate Zone/ South Pole.

_____

_____

f. Northern Hemisphere: Equator/North Pole.

_____

_____

g. Southern Hemisphere: Equator/South Pole.

_____

_____

h. Troposphere: Surface of the Earth/Approximately 7 Miles Up.

_____

_____

i. Stratosphere: Tropopause/Approximately 22 Miles Up.

_____

_____

j. Isothermal Layer: About 8,000 Feet/About 9300 Feet.

_____

_____

k. Inversion Layer: About 4500 Feet/About 6,000 Feet.

_____

_____

1. Atmosphere: Surface of the Earth/More than 600 Miles Up.

_____

_____

m. Maritime Zone: Ocean/About 25 Miles Inward from the Ocean.

_____

_____

n. Standard Lapse Rate Area: Sea Level/About 30 to 40 Thousand Feet.

_____

_____

o. Rainstorms: 20 Miles Northeast of Here/30 Southwest.

_____

_____

p. North African Desert: Morocco/Egypt.

_____

_____

NOTE: Most long sentences are combinations of smaller sentences. One of the most common kinds of long sentences occurs when "and" is used to combine sentences so that the speaker doesn't have to repeat phrases that occur in both sentences. Compare the sentences below.

EXAMPLES:

The troposphere's height varies from the equator to the poles. The troposphere's height varies from season to season. (combined) The troposphere's height varies from the equator to the poles and from season to season.

2. Use the information given to make combined sentences as shown below.

Information: The troposphere contains 75% of the atmosphere by weight.
The troposphere contains almost all of the weather.

Combined: The troposphere contains 75% of the atmosphere by weight and almost all the weather.

Information: The tropical zone extends 1600 miles north of the equator.
The tropical zone extends 1600 miles south of the equator.

Combined: The tropical zone extends 1600 miles north and south of the equator.

Information:

a. Each part of the earth has one "day" period every 24 hours.
Each part of the earth has one "night" period every 24 hours.

_____
_____

b. This section is a review of basic meteorology.
This section is a review of weather terminology.

_____
_____

c. The troposphere is the layer of air that begins at the surface of the earth.
The troposphere is the layer of air that extends upward about 7 miles.

_____
_____

d. The stratosphere begins above the troposphere.
The stratosphere extends upward to a height of 22 miles.

_____
_____

e. Occasionally a strong thunderstorm will cross the tropopause.
Occasionally a strong thunderstorm will enter the stratosphere.

_____

_____

f. The aneroid barometer is smaller than a mercurial barometer.
The aneroid barometer is easier to move around than a mercurial barometer.

_____

_____

g. The freezing point of water is 32° on the Fahrenheit scale.
The freezing point of water is 0° on the Celsius scale.

_____

_____

h. Inversion layers do not show the standard lapse rate.
Isothermal layers do not show the standard lapse rate.

_____

_____

I. Aneroid barometers are used to measure atmospheric pressure.
Mercurial barometers are used to measure atmospheric pressure.

_____

_____

j. Temperature decreases with height.
Pressure decreases with height.

_____

_____

k. Areas in the temperate zones tend to have warm or hot summers.
Areas in the temperate zones tend to have cool or cold winters.

_____

_____

l. The mercury rises in the tube when the atmospheric pressure increases.
The mercury falls in the tube when the atmospheric pressure decreases.
(use two "and's," one in each phrase)

_____

_____

m. The container expands when the pressure decreases.

The container contracts when the pressure increases. (use two "and's")

_____

_____

III. VOCABULARY EXPANSION: Oral Exercises

NOTE: Many words in English have a noun form and a verb form; there is usually very little difference in the basic meaning

Directions:

(1) Read the sentence out loud.
(2) Say the verb form of the underlined noun.
(3) Make and say a simple, related sentence using the verb form with the same basic meaning.

Example:

Read: The clothes dried by evaporation.

Say: "evaporate"

Say: "The water evaporated" or "The water in the clothes evaporated" ... etc.

a. You will have to make a correction in the spelling. _____

_____

b. The contraction is caused by increased pressure. _____

_____

c. The rotation of the earth produces day and night. _____

_____

d. Radiation from the sun reaches the earth. _____

_____

e. The location of a region is a factor in the climate. _____

_____

f. The tube has graduations to show the height of the mercury. _____

_____

g. There is a relation between altitude and pressure. _____

_____

h. The conversion from inches to millibars is not difficult. _____

_____

i. There is no indication that the pressure has changed. _____

_____

j. The division of the atmosphere's structure into five layers is useful. _____

_____

k. The compression of the container causes the indicator arm to move._____

_____

1. When the elevation of the barometer is changed, the pressure reading will change.

_____

m. You can make adjustments in the aneroid barometer so that it agrees with the mercurial barometer. _____

n. The altimeter will show upward and downward movements of the aircraft. _____

_____

_____

o. The measurement of atmospheric pressure is accomplished every hour. _____

_____

UNIT 3

Weather Causes (2)

SECTION 5. CIRCULATION

1. Basic Circulation

The atmosphere tends to maintain an equal pressure over the entire earth just as the ocean tends to maintain a constant level. Whenever the equilibrium is disturbed, air begins to flow from areas of higher pressure to areas of lower pressure.

2. Causes of Atmospheric Circulation

a. The factor that disturbs the normal equilibrium is the uneven At the equator,heating of the earth. the earth receives more heat than in areas to the north and south.This heat is transferred to the Thus The atmosphere, warming the air and causing it to expand and rise. expansion caused by the warming lowers the density of the air. an area of low pressure is produced at the equator. The air at the poles is cold. Cooling causes air to contract cooler, (become denser) and sink to the surface. This heavier, denser air from the north and south moves along the earth's surface toward the equator to equalize the pressure. This air also becomes warm and rises, thereby establishing a constant circulation. On a non-rotating earth this circulation would consist of two circular paths, one in each hemisphere, followed by the air rising at the equator, traveling aloft toward the poles, and returning along the earth's surface to the equator.

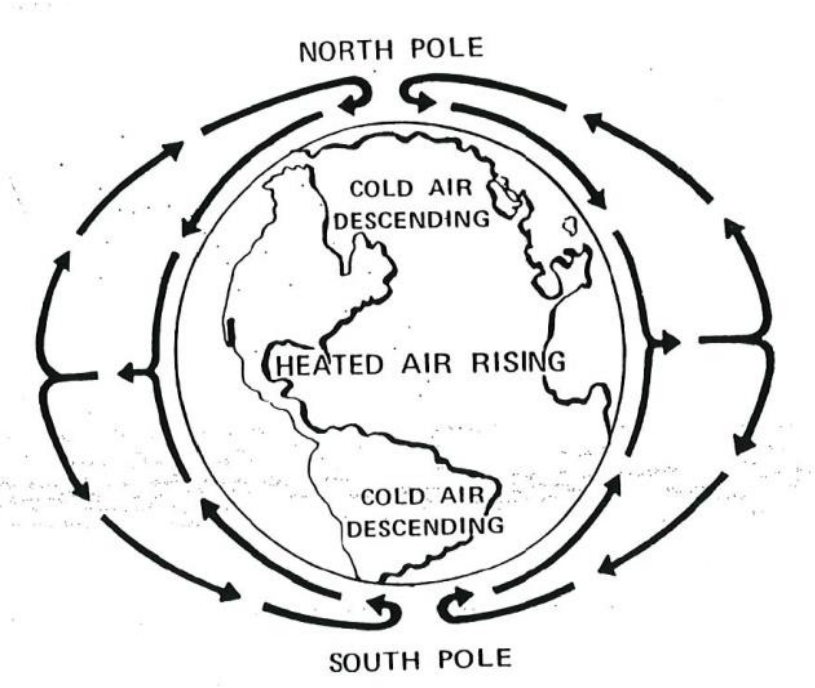
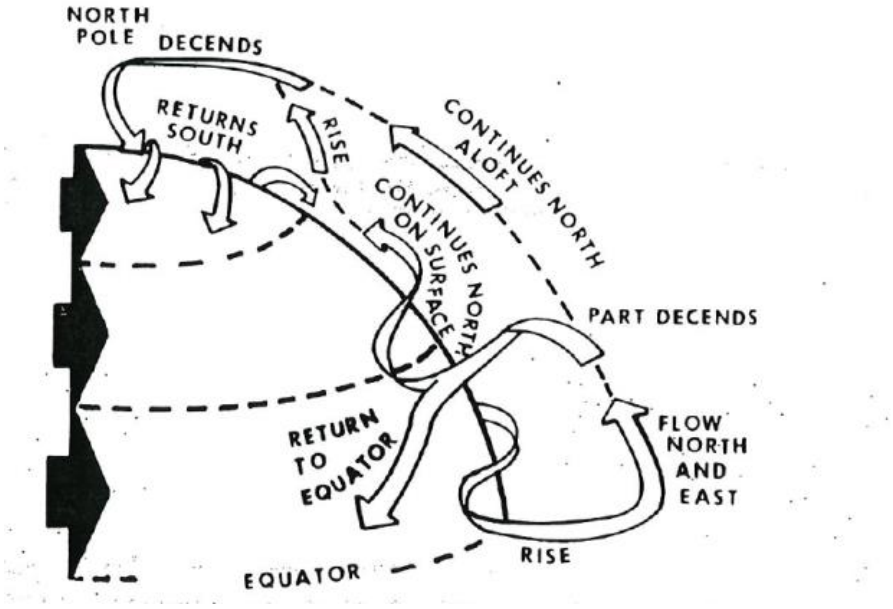


Figure 1 Circulation as it would be on a non-rotating earth. Intense heating at the equator lowers the density. Denser air at the poles flows toward the equator forcing the less dense air upward where it flows aloft toward the poles.

b. The form of circulation that would occur in theory (as shown in figure 1) is greatly modified by many forces, one being the rotation of the earth. In the northern hemisphere, this rotation causes air to In the southern hemisphere, air flow to the right of its normal path. This action caused by the earth's flows to the left of its normal path. We will only rotation is called the Coriolis force. talk about the movement of the air in the northern hemisphere.

C. As the air rises and moves northward from the equator, it is deflected toward the east, and by the time it has traveled about a third of the distance to the pole it is no longer moving northward, but eastward. This causes the air to accumulate in a belt and creates an area of high pressure. Some of this air is then forced down to the th's surface, where part flows southward, returning to th and part flows northward along the surface. The remaining portion of s air aloft continues its journey northward. As it moves it is cooled, and finally descends near the pole, where it begins a return trip to the equator. Before it moves very far southward it comes conflict with the warmer air, that had descended in the fi and flowed northward on the surface. The warmer air moves up over the air and continues northward, producing an accumulation hemisphere. the northern part of the As it becomes cooled and denser, it flows southward.



The general circulation. The Coriolis force deflects high level winds from the south to the east. Low level north Between winds from the pole are deflected to the west. these two movements is a large mixing zone. The warm air masses slide over the cold air masses as t they migrate between the equator and the poles.

Figure 2

d. Additional complications in the general circulation of the air are brought about by: the irregular distribution of oceans and continents, the difference in how different surfaces transfer heat to the atmosphere, the daily variation in temperature, the seasonal changes, and many other factors. The general flow of weather in the United States is from northwest to southeast.

3. Lows

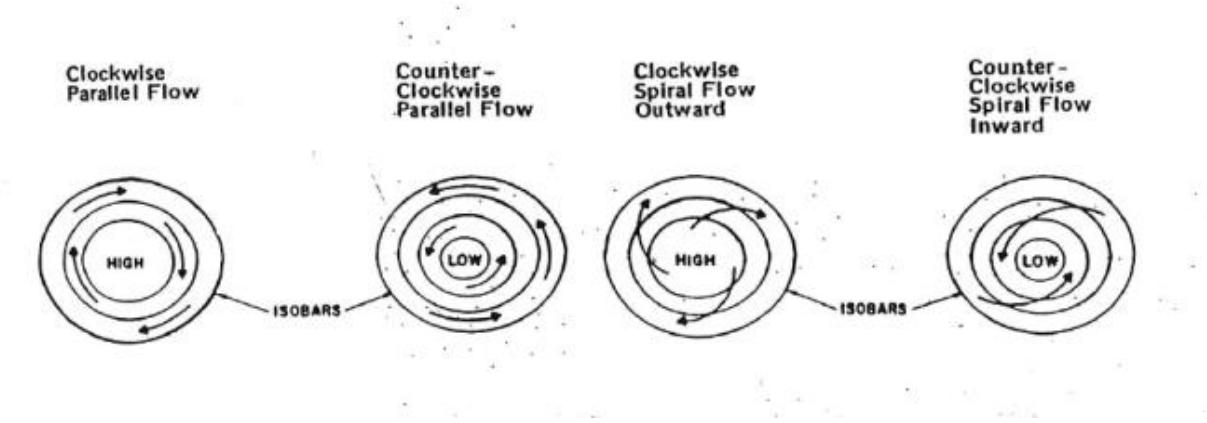
Regions of low pressures develop where air lies over land or water surfaces that are warmer than the surrounding areas. Lows form over the desert southwest of the United States during the summer months.

4. Highs

Regions of high pressure develop where the air lies over surfaces that are cooler than the surrounding areas, such as polar regions, and where air traveling from the equator to the poles is forced to descend.

5. Wind Patterns

Wind flows from high pressure to low pressure. In the northern hemisphere Air wind is deflected to the right of its path by the earth's rotation. moving outward from a "high" flows in a clockwise spiral around the "high" center; and air moving into a "low" flows in a counterclockwise spiral around the "low" center.



Flow of air around a high- and low-pressure area in the northern hemisphere above the surface.

Flow of air around a high- and low-pressure area in the northern hemisphere at the surface.

Figure 3

6. Isobars

The pressure at each statton is marked on the weather map and lines called Isobars are drawn to connect the points of equal pressure. Many of these lines make complete circles and surround areas marked H (high) or L (1ow). Isobars are similar to the lines that are drawn on regular surface maps to show elevation. However, instead of indicating the elevation of terrain and the steepness of slopes, Isobars indicate the amount of pressure and steepness of pressure gradients. If the gradient (slope) is steep, the isobars will be close together, s and the wind will be strong. If the is gradual, the lsobars will be far apart, and the win light. Isobars provide useful information about the winds aloft. Close ith, wind direction is modified by the terrain over ses, and wind speed is reduced by friction with The At tudes two or three thousand feet above the surface, however Is greater and the direction is usually parallel to the isobars.

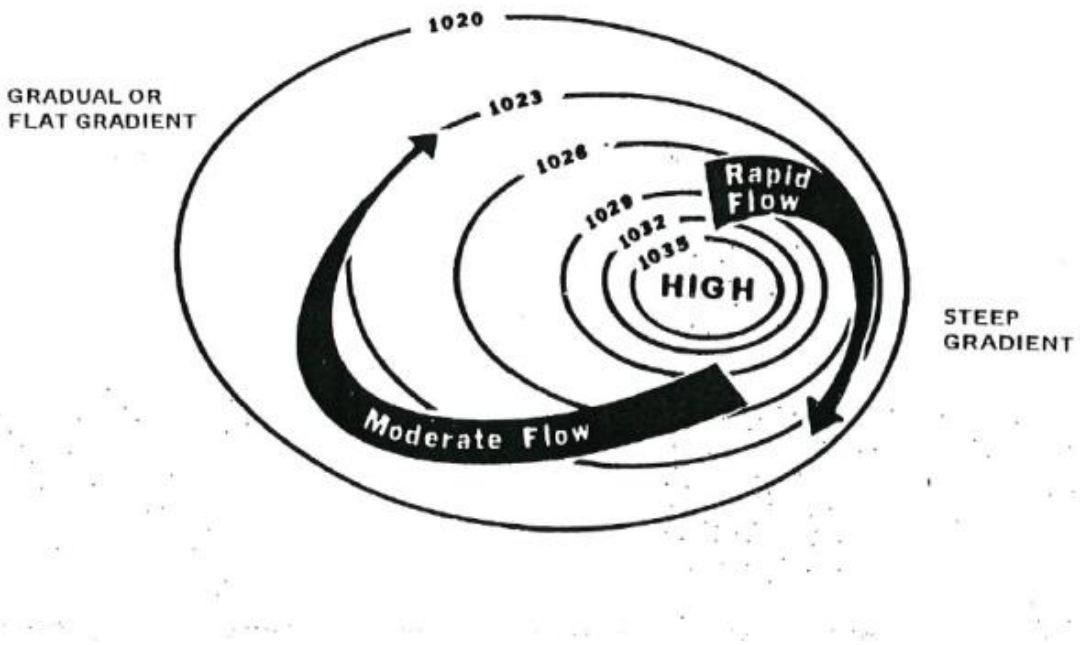
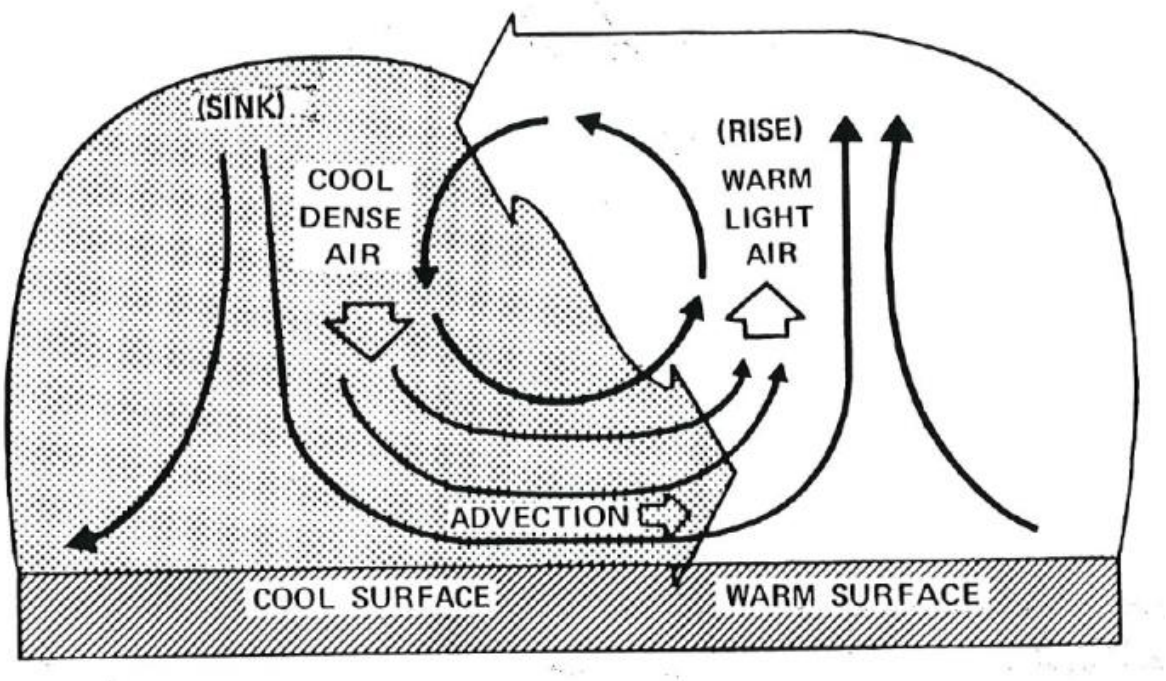


Figure 4

7. Convection Currents

a. When two bodies of air next to each other are heated unequally, the warmer air expands and becomes lighter or less dense than the surrounding cool air. The denser air is drawn to the ground by its greater weight and 1ifts or forces the warm air upward. The flow parallel to the ground between the two bodies is called advection



Convection current as a result of unequal heating of the atmosphere by different surface temperatures. Cold air sinks forcing warm air upward. The horizontal flow in a convection current is usually called advection.

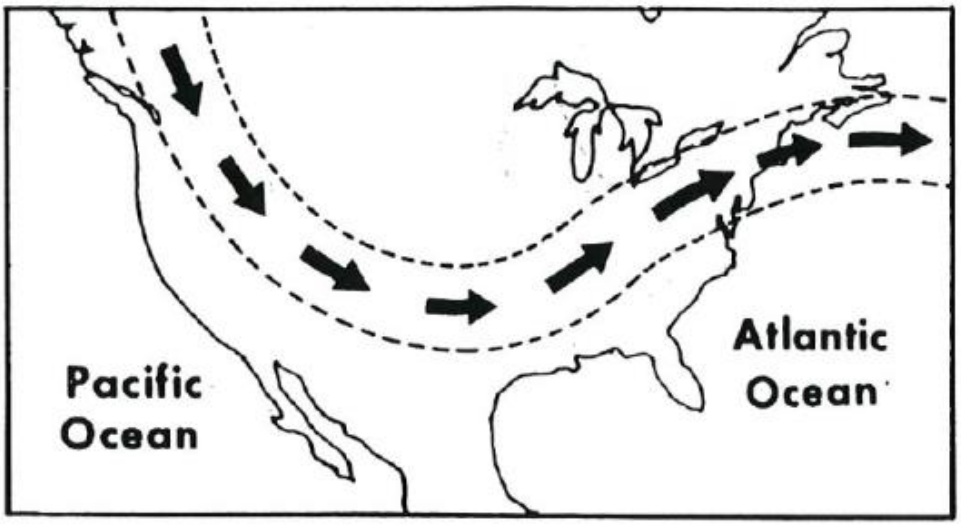
Figure 5

b. These convection currents cause small-size wind systems that occur within the larger overall system of circulation. These systems may influence local weather and be small enough to affect only one airport, or large enough to affect an area of several thousand square miles. But they do not include the large high- and low-pressure systems called migratory highs and lows that migrate from one area of the earth to another.

8. Jet Stream

The jet stream is a narrow, high-speed, river of wind that moves at a shigh altitude around the-earth. It does not flow directly in a straightpath, and it may not always be a continuous flow. It moves through the normal wind patterns aloft. Wind speeds in the jet stream range from

100 to 150 knots, and occasionally they may be as much as 200 to 250 knots. A well-developed jet stream normally varies from 1,000 to 3,000 miles in length, 100 to 400 miles in width, and from 3,000 to 7,000 feet from top to bottom.



Jet stream flow across the United States in the winter.

Figure 6

SECTION 6. AIR MASSES

1. General

a. The various air masses take on the temperature and moisture characteristics of the areas in which they are formed--the coldness of the polar regions, the heat of the tropics, the moisture of the oceans, and the dryness of continents.

b. As they move away from their source regions and pass over land and sea, air masses are constantly being modlfied through heating or cooling from below, rising or descending or gaining or losing moisture. In general, however, they keep their orlginal characteristics and can be recognized and identified as they move over the surface of the earth.

2. Movement of Air Masses

Since the general movement of the atmosphere in the United States is toward the east, the polar and arctic air masses generally move toward the south- east, and the tropical and equatorial air masses move toward the northeast. The speed varies according to the season and the type of the air mass, but Cold air masses move it generally averages from 500 to 700 miles a day. a little more rapidly than warm air masses

GLOSSARY

ADVECTION: noun; the horizontal flow of air between two bodies of air which have different temperatures

Ex. This is a local wind caused by advection.

AFFECT: verb; to produce a change

Ex. This bad weather will affect our travel plans.

AIR MASS: noun; a large body of air that has the same temperature and humidity characteristics

Ex. A continental air mass is usually dry.

ALOFT: adjective; above the ground, in the air

Ex. The winds aloft at 5,000 feet are much stronger than they are here on the surface.

ARCTIC: noun; the ice covered area at the north pole.

Ex. It is unusual for temperatures in the Arctic to be above freezing

CIRCULATION: noun; a regular movement that follows a circular path and returns to the starting place

Ex. There is a general circulation of air from the equator to the poles and back again.

CONFLICT : noun; the condition that results when one force meets and opposes another force

Ex. In this area there is a conflict between warm air masses moving northward and cold air masses moving southward.

CONSTANT: adjective; continually the same

Ex. The mercury in the barometer doesn't have a constant height because the pressure changes daily.

CONVECTION: noun; the circulation of air between two air masses that have different temperatures

Ex. This air movement is caused by convection.

CORIOLIS FORCE: noun; the force produced by the rotation of the earth

Ex. The Coriolis force causes the air to flow to the right.

COUNTERCLOCKWISE: adjective; opposite of clockwise.

Ex. Air moving into a "low" flows in a counterclockwise spiral around the "low" center.

CURRENT: noun; a movement of air (or water) through a mass of air (or water)

Ex. Don't swim in this part of the river, the current is too strong.

Ex. Convection is producing a strong current of air in this area.

DEFLECT : verb; to turn to a different direction

Ex. The warm air is deflected upward when it meets the cold air on the surface.

DENSE: ajective; close together. The property that makes some heavier than other objects that are the same size

Ex. When air is cooled it contracts and becomes dense; this causes it to sink.

DENSITY: noun form of dense. dense + (-ity)

DESCEND: verb; to go downward

Ex. A lot of accidents happen when people are descending stairs

in a hurry.

EQUALIZE: verb form of equal. equal + (-ize)

EQUATORIAL: adjective form of equator. equator + (-ial)

EQUILIBRIUM: noun; a condition of two things being equal

Ex. There is an equilibrium between the weight of the atmosphere on the mercury outside the barometer tube and the weight of the column of mercury in the tube.

GRADIENT: noun; the rate of change of a measurement that varies by distance

Ex. The isobars are very close together here; the pressure gradient is very steep.

HIGH: noun; an air mass that is characterized by high pressures

Ex. A high is located over northern Canada.

ISOBAR: noun; a line drawn on a weather map to connect areas that have the same pressure

Ex. This isobar runs right across the middle of the state.

JET STREAM: noun; a high level, high speed current of air

Ex. The plane made the trip in less time than usual because it was able to fly in the

jet stream.

KNOT : noun; a unit of measurement for windspeed or speed. of an aircraft

through the air. 1 knot = approximately 1.15 miles per hour (mph) or 1.85 kilometers per hour

Ex. There is a 15-knot wind blowing from the north.

LOW: noun; an air mass that is characterized by low pressures

Ex. A low is located over the state of Florida.

LIE: verb; to be on an object or surface

Ex. When an air mass lies over a hot area it takes up the heat from the surface.

MIGRATE: verb; to regularly move from one place to another place

Ex. Hot air from the equator migrates toward the poles.

MIGRATORY: adjective form of migrate. migrate + (-ory)

PRESSURE GRADIENT: noun; the gradient that measures pressure by distance

Ex. The pressure gradient is not very steep here; the isobars are very separated.

SPIRAL: noun; a continuously curved line that follows a decreasing (or increasing) size; a movement of That form

Ex. Ex. He walked in a spiral.

TRANSFER: verb; to move from one place (or object) to another place or object.

Ex. Heat is transferred from the surface to the air mass that lies on it.

Language Exercises

I. NEW TERMINOLOGY: Oral Exercises

1. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

constant (-ly)	equalize	dense (-ity) (-er)
equilibrium	circulation	Coriolis force
transfer equilibrium	aloft	deflect

a. The hot air at the equator rises and flows _____ toward the poles.

b. Heat from the ground is _____ to the air that lies over it.

C. The general _____ of the earth's atmosphere is from the equator to the poles then back again to the equator.

d. In a mercurial barometer there is an _____ between the weight of the mercury in the tube and the weight atmosphere.

e. When a warm air mass meets a cold air mass, the warm air is _____ upward over the cold air mass.

f. The warm air mass does not move directly northward to the pole, it is deflected to the east by the_____

g. Cold air is _____than hot air, so it sinks and moves on the surface toward the equator. When it reaches there its _____ changes because it is heated.

h. Even at sea level the atmospheric pressure is not a _____ 29.92 due to the circulation of different air masses.

i. Local pressures are converted to sea level pressures to _____ the differences in elevation.

j. A cubic meter.(1 m3) of cold air weighs more than a cubic meter- of hot air. The cold air is_____ .

k. The uneven heating of the earth's surface causes a _____ circulation of the atmosphere.

l. If two air masses have the same characteristics there will be no flow between them, but if the _____ is disturbed by heating, high pressure air will flow to the low-pressure area.

m. Since high-pressure air flows toward a low-pressure area, we say that the system tends to_____ pressure difference.

n. The theory of circulation of air on a rotating earth must consider the deflection caused by the_____

2. Select words from the list below to complete the following Some of the words may be used more than once, sentences. I may have to make the word plural or change the Do not try to write the words in the spaces.

Descend	high	pressure gradient
Conflict	spiral	gradient
Low	counterclockwise	
lie	isobar	

a. This is a steep road; the _____ is a one-foot increase in elevation for every 20 feet of distance.

b. The mercury is moving downward in the barometer; there must be a _____ moving into this area.

c. If the hands of a watch moved backward, we would say they moved in a _____ direction.

d. If you drew a line on the map connecting these stations that have the same pressure, you would call the line an _____ .

e. If you start at an altitude of 10,000 feet and _____ . the pressure and temperature will increase.

f. If a cold air mass moving south meets a warm air mass moving north, there is a _____ because they are moving in opposite directions.

g. Due to the differences in temperature, we expect to find _____ at the poles and _____ at the equator.

h. The air masses that _____ over an area tend to take the temperature and humidity characteristics of that area.

i. At the surface, wind in a low-pressure system moves in a _____toward the center of the low.

j. hen you look at a weather map, the distance between isobars indicates the steepness of the _____ .

k. There is a _____ in our readings, one barometer shows pressure going down, the other shows it going up.

l. one method of looking for lost objects is to start outside of the area and walk around in smaller and smaller circles; this is called a _____ search.

m. Air masses that _____ over oceans are called maritime air masses. over oceans are called

n. As a rule, when air is heated it rises; when it's cooled it _____ .

3. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

Affect	current	arctic
Advection	equatorial	migrate (-ory) (-1on)
air mass	jet stream	
convection	knot	

a. The air masses that move southward from the polar region are called _____ air masses; they are "cold" highs.

b. Although there is a small difference, a 10- _____wind moves at about 10 miles an hour.

c. Air masses that have their source at the equator are called _____

air masses; they are "warm" lows.

d. Polar highs _____ southward; equatorial lows _____ northward.

e. When he opened the window a _____ of air blew the papers off the desk.

f. The heating of the ground causes _____ currents to move upward.

g. Cool air currents, known as _____ currents, move the ground toward the local low-pressure area by the convection currents.

h. The main point in understanding weather is to know how heating and cooling _____ the density of air masses.

i. The _____ that move as part of the general circulation are known as migratory highs and lows.

j. The upward movement of the air at the equator is an example of _____ currents caused by heating.

k. The high currents near the tropopause, called _____ , are not considered to be "air masses.''

l. A mile is used to measure distance; a _____ is used to measure speed.

m. Arctic air masses and equatorial air masses are good examples of _____ air masses..

n. The _____ of air masses causes the pressure at a station to change.

II. SENTENCE PRACTICE: Oral Exercises

NOTE: Since long sentences are usually combinations of two or more shorter sentences, one of the methods of understanding a very long sentence that is difficult or confusing is to take it apart into shorter sentences.

Compare the sentences below.

Original: The heat is transferred to the atmosphere, warming the air and causing it to expand and rise.

Parts: (1) The heat is transferred to the atmosphere.

(2)' The heat warms the air.

(3) a.The heat causes the air to expand.

b. The expanded air rises.

Break the following long sentences into smaller sentence parts as shown in the examples.

Examples:

Original: On a non-rotating earth this circulation would consist of two paths, one in each hemisphere; followed by the air rising at the equator, traveling aloft toward the poles, and returning along the earth's surface to the equator;

Say: (1) ''On a non-rotating earth circulation would consist of two paths."

(2) "There is one path in each hemisphere."

(3) '''The path is followed by the air that rises at the equator."

(4) "The air travels aloft toward the pol

(5) ''The air returns along the surface to the equator."

Original: As the air rises and moves northward from the equator, it is deflected to the east; and by the time it Has traveled about a third of the distance to the pole, it is no longer moving northward, but eastward.

Say: (1) the air rises and moves northward from the equator

(2) ''As it moves, it is deflected to the east."

(3) ''After it has traveled a third of the distance to the pole, it's not going northward anymore."

(4) ’’After it has traveled a third of the distance the pole, its going eastward."

Original Sentences:

a. Some of the air is then forced down to the earth's where part flows southward returning to the equator, and part flows northward along the surface.

_____

_____

_____

_____

b. As it moves northward it is cooled and finally descends near the pole, where it begins a return trip to the equator.

_____

_____

_____

c. The warmer air moves up over the cold and continues northward, ng an accumulation of air in the northern part hemisphere.

_____

_____

_____

_____

d. Regions of high pressure develop where the air lies over surfaces that are cooler than surrounding areas, such as polar regions; and where air traveling from the equator to the poles is forced to descend.

_____

_____

_____

_____

e. Air moving outward from a "high" flows in a clockwise spiral around the 'high" center; air moving into a "low" flows in center.

_____

_____

_____

_____

f. These systems may influence local weather and be small enough to affect only one airport, or large enough to affect an area of several thousand miles.

_____

_____

_____

_____

g. They do not include large high-: and low-pressure systems called migratory highs and lows that migrate from one area of the earth another.

_____

_____

_____

_____

h. A well-developed jet stream normally varies from 1,000 to 3,000 miles in length, 100 to 400 miles in width, and from 3,000 to 7,000 feet from top to bottom.

_____

_____

_____

_____

i. As air masses move away from their source regions and pass land and sea, they are constantly being modified heating or cooling from below, rising or descending, or gaining or losing moisture.

_____

_____

_____

_____

_____

III. VOCABULARY EXPANSION: Oral Exercises

The ending "-ward" is added to many words to give the meaning of "in the direction." Ex. upward, downword, northward, etc. Use words ending in "-ward" to complete the following sentences as shown in the examples.

EXAMPLES:

Sentence: If you want to see the sun rise, look

Say: "If you want to see the sun rise, look eastward."

Sentence: Hot air moves _____ .

Say: . "Hot air moves upward."

SENTENCES:

a. If you travel _____ long enough, you will reach the north pole.

b. I heard a plane, but when I looked _____ it was so high I couldn't see it.

c. The air around a high spirals _____ away from the center.

d. When the air is cooled, it sinks _____ .

e. If you want to see the sun go down, look _____.

f. Your chair is too far back from the desk, move it_____ .

g. If you travel from the north pole to the equator, you are moving _____.

h. The air around a low spirals _____ to the center.

i. Airplanes only fly forward, they can't fly _____ .

j. If your right hand is to the east, and your left hand to the west, you are facing _____ .

k. Put the key in the door and turn it _____ the right.

i. 'If the hands on your watch move counterclockwise, your watch is running _____ .

m. The heated air at the equator rises and moves aloft _____ .

and _____ toward the poles.

n. In the northern hemisphere the Coriolis force causes the air moving to the pole to flow_____ .

o. If you don't want to see where you are going, you can close your eyes, or you can walk_____ .

UNIT 4

Weather Causes (3)

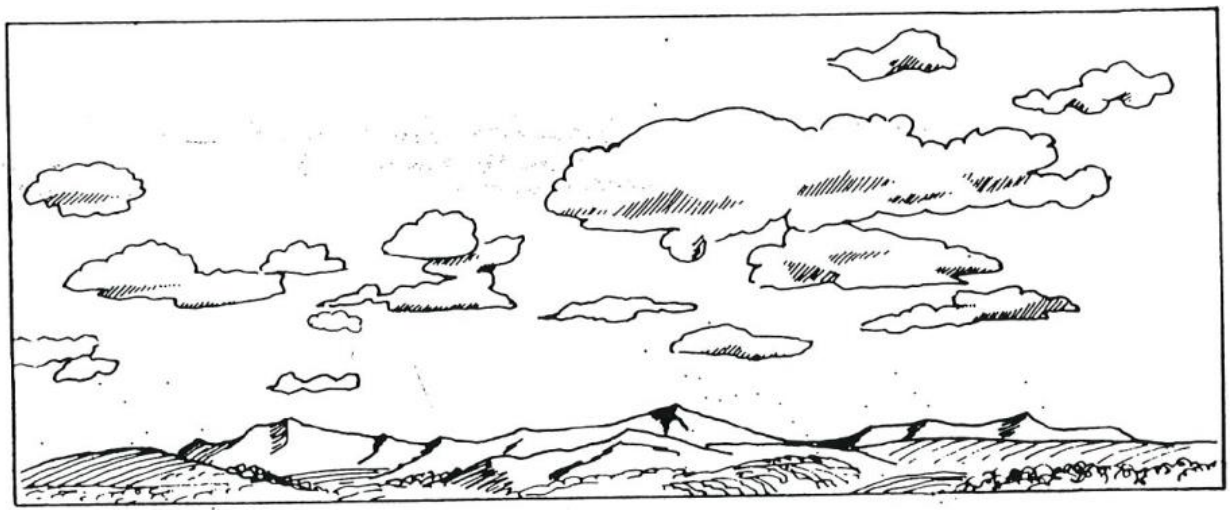
SECTION 7. CLOUDS

1. General

Cloud types are classified by their method of formation, their com-position, and the altitude at which they are found.

2. Cloud Types

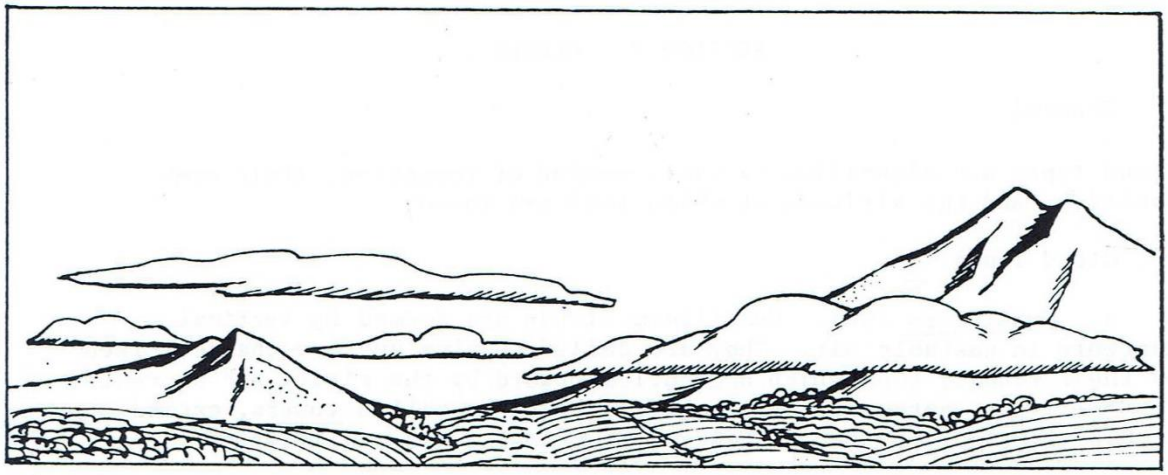
a. Cumuliform (Cu). Cumuliform clouds are formed by vertical currents in unstable air. They are called cumulus and are characterized by their rounded tops which are pulled upward by the rising air currents. In some types, extensive vertical developments, called towers, extend upward thousands of feet. The name "cumulus" means accumulation.



Fair weather cumulus (Cu). cumulus clouds form in convective currents and are characterized by relatively flat bases and rounded tops. Fair weather cumulus do not show extensive vertical development, and do not produce precipitation. A cumulus may be the first step in the development of cumulus-type storm clouds or cumulus-type rain clouds.

Figure 1

b. Stratiform (St). Stratiform clouds are formed when an entire layer of stable air is 1ifted. They are characterized by their stratified or layered appearance, and are called stratus clouds.



Stratus (St). Stratus is a low, regular, sheet-like cloud. It usually has a relatively low base.

Figure 2

c. Cirroform (Ci). Cirroform clouds are formed from moisture that has been 1ifted so high that it becomes ice particles.. They are often nearly transparent so t that large amounts of sky can be seen through and around them.

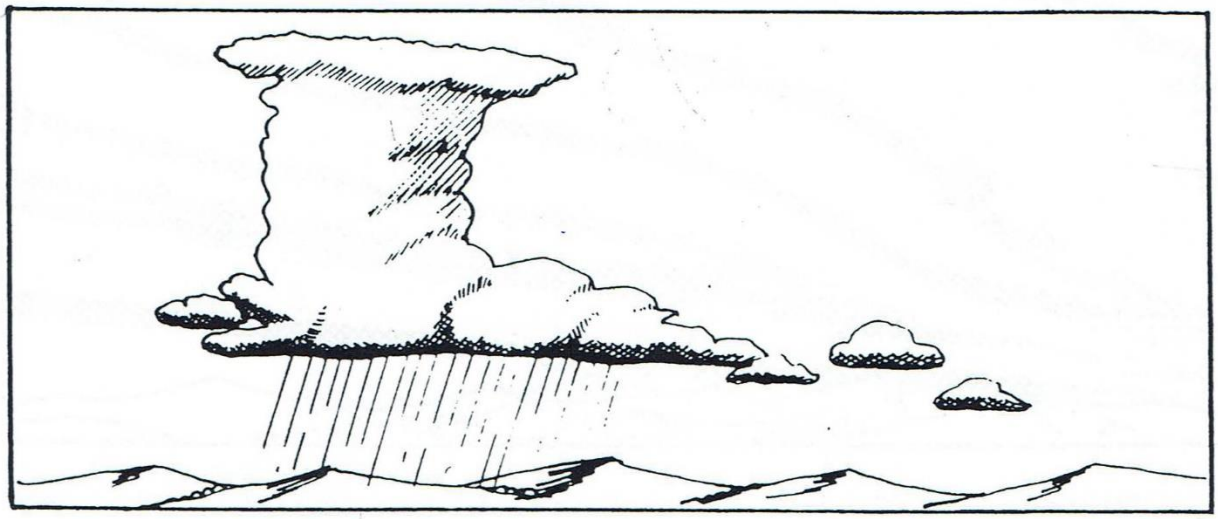
Cirroform. High clouds formed from ice particles. Usually they do not cover the sky; areas of sky can be seen through and around them.

Figure 3

3. Cloud Type Subclassifications

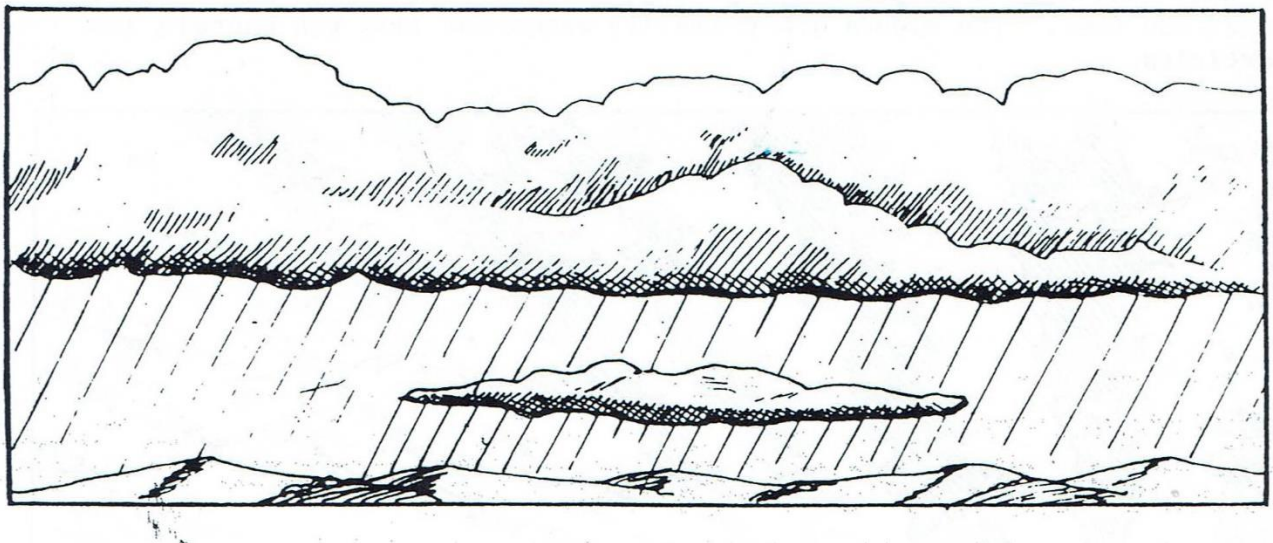
   a. Nimbo-Nimbus. The prefix "nimbo-,' " or suffix "-nimbus," means rain cloud. Stratus clouds from which rain is falling are nimbostratus (Ns), cumulus clouds from whichrain is falling are cumulonimbus (Cb).

   b. Fractus . Clouds that are broken into small pleces are often identified by the suffix "-fractus;" for example, cumulofractus.



Cumulonimbus (Cb). This "thunderstorm" cloud type contains many hazards to flying aircraft: ice, hail, rain, strong air currents, and lightning.

Figure 4



Nimbostratus (Ns). Heavy cloud layers that produce nearly ĉgntinuous rain, snow, or sleet.

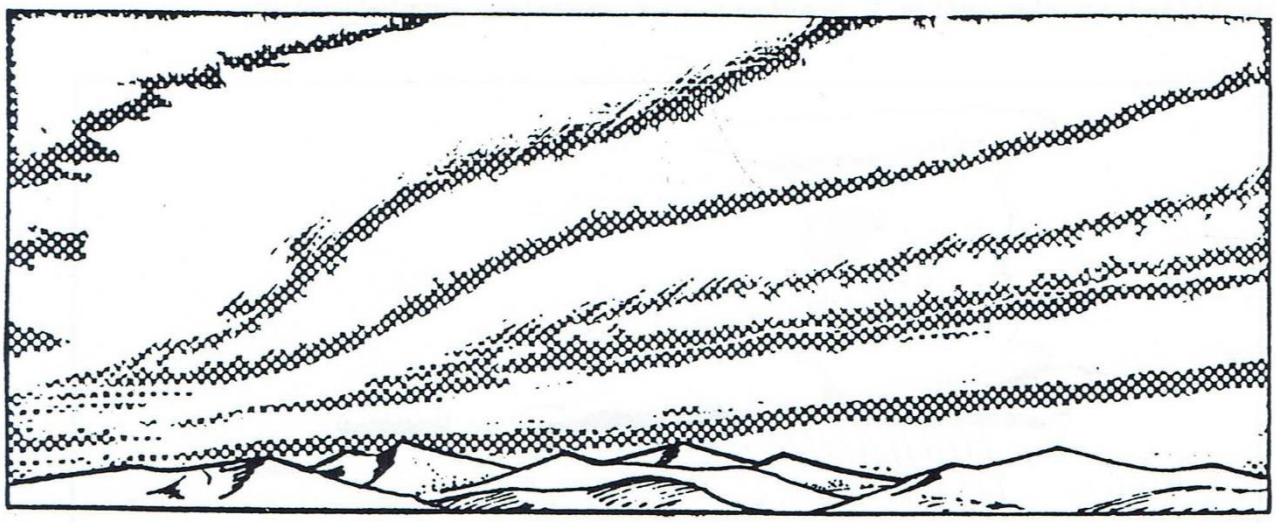
Figure 5

4. Cloud Families

a. Low Clouds. Stratus (St) and stratocumulus (Sc) clouds are in the low cloud group.

The bases of these clouds range from near the surface to about 6,500 feet. Low clouds are almost entirely water but the water may be cooled to below freezing temperatures.

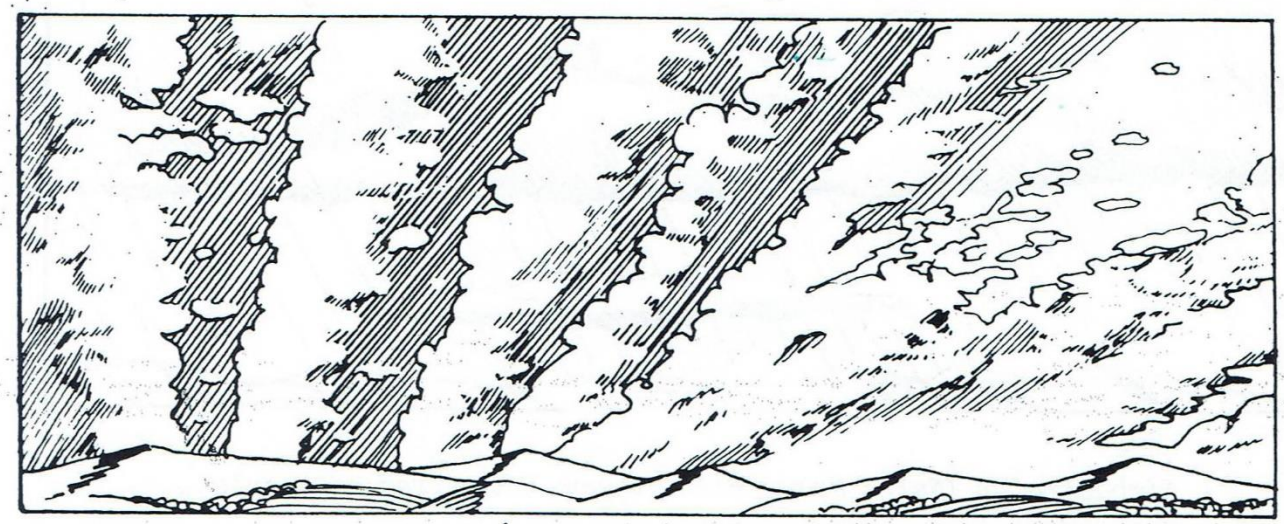
They can contain snow and ice particles.



Stratocumulus (Sc) have lines of rounded bases instead of the even base of a stratus cloud. This cloud often forms when a stratus cloud or cumulus cloud separates into smaller clouds.

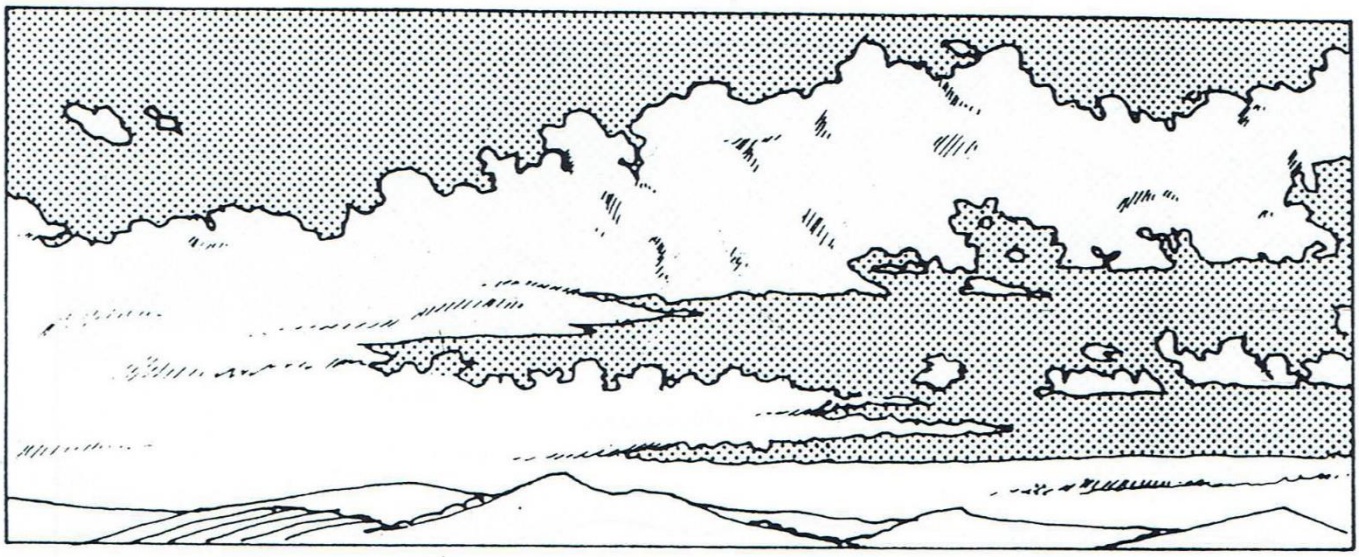
Figure 6

b. Middle Clouds. Middle clouds are the altostratus (As), altocumulus (Ac), altocumulus castellanus (Accas), and some nimbostratus (Ns) clouds. The height of the bases of these clouds ranges from about 6,500 to.23,000 feet. The clouds are primarily water but they can contain ice particles.



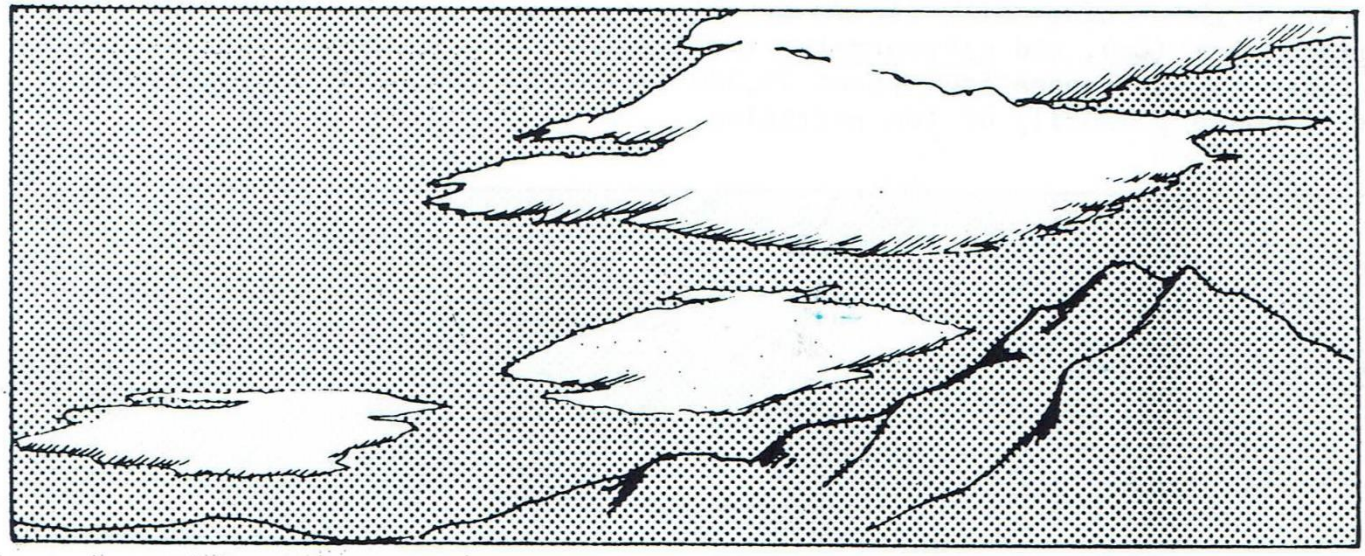
Altocumulus (Ac) form as long bands. The individual clouds are larger than similar-appearing cirroform clouds.

Figure 7



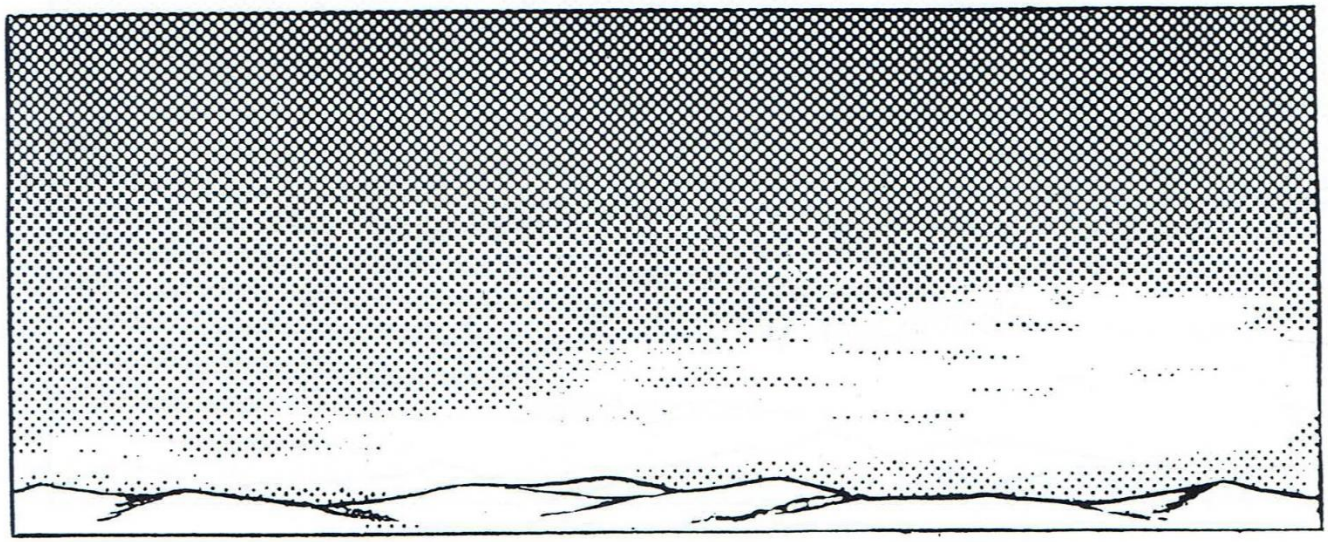
Altocumulus castellanus (Accas) are middle-height convective clouds. They are characterized by lifted tops and comparatively high bases.

Figure 8



Standing lenticular altocumulus (Acsl) are formed where the wind flows over an obstacle such as a line of hills or mountains. The clouds are called "standing" because they tend to stay in one location. Similar clouds called standing lenticular cirrocumulus (Ccsl) may also form at higher altitudes. Since the standing lenticular cirrocumulus are formed from ice particles they are usually whiter than the standing lenticular altocumulus.

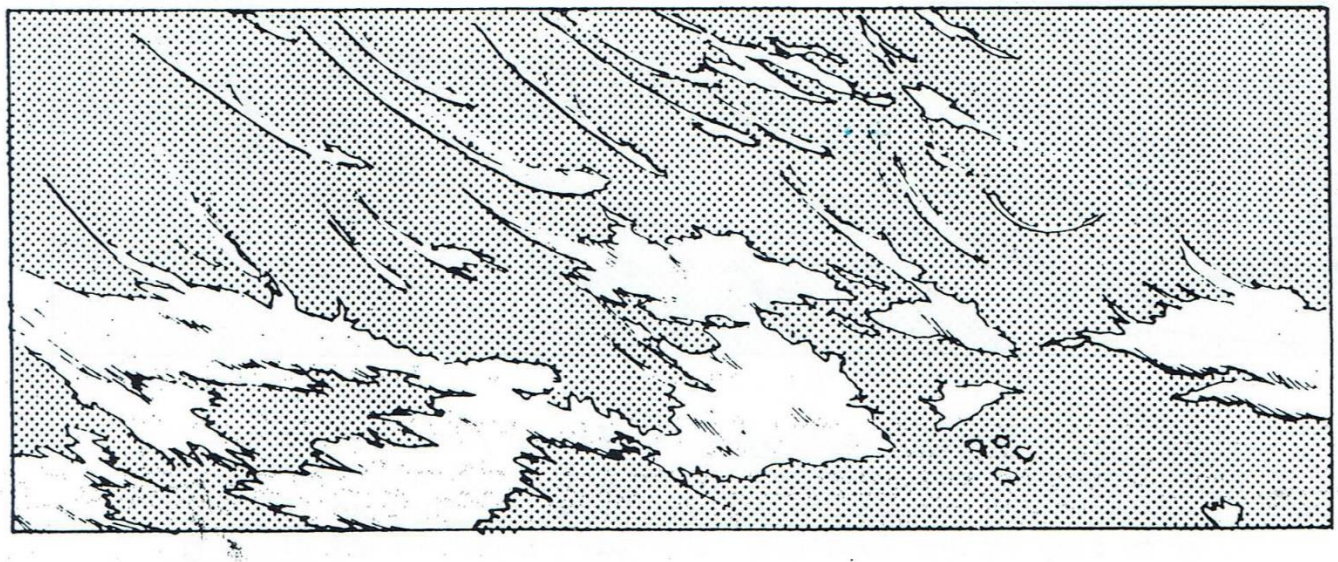
Figure 9



Altostratus (As) is a middle-layer cloud that often is nearly transparent so that the shape of the sun can be seen through it. It sometimes forms so high that it extends to the higher layer, similar-appearing, cirroform clouds.

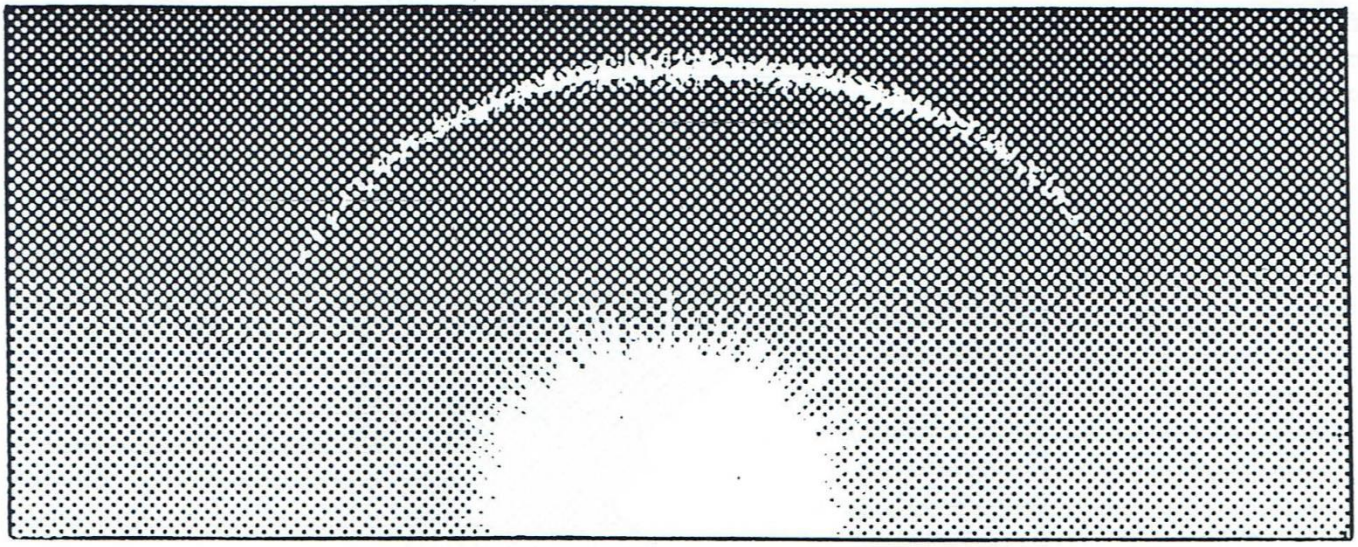
Figure 10

c. High Clouds. High clouds are cirroform and include the cirrus (Ci), cirrocumulus (Cc), and cirrostratus (Cs) clouds. The height of the bases of these clouds ranges from about 16,500 to 45,000 feet. Cirroform clouds are composed primarily of ice particles.



Cirrus (Ci) clouds are very high, light clouds composed entirely of ice. The edges often appear as if they have been pulled to long lines by wind.

Figure 11



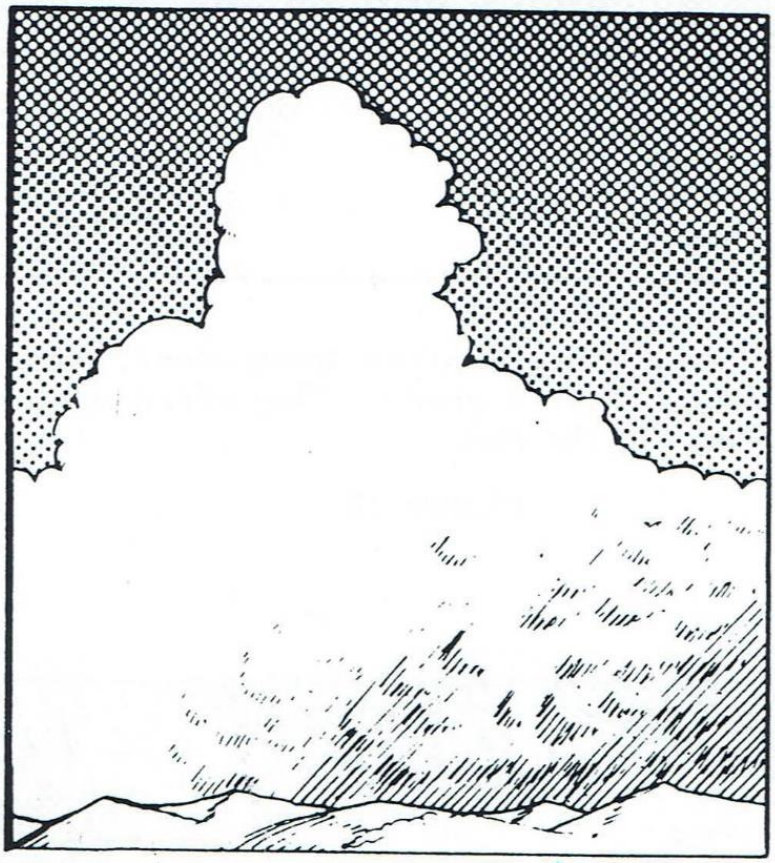
Cirrostratus (Cs) are high, often transparent, cloud layers that appear like a whitish sheet. They often appear as a circular line around the sun.

Figure 12

Cirrocumulus (Cc) are high ice-particle clouds that often appear as a layer of small individually separated clouds.

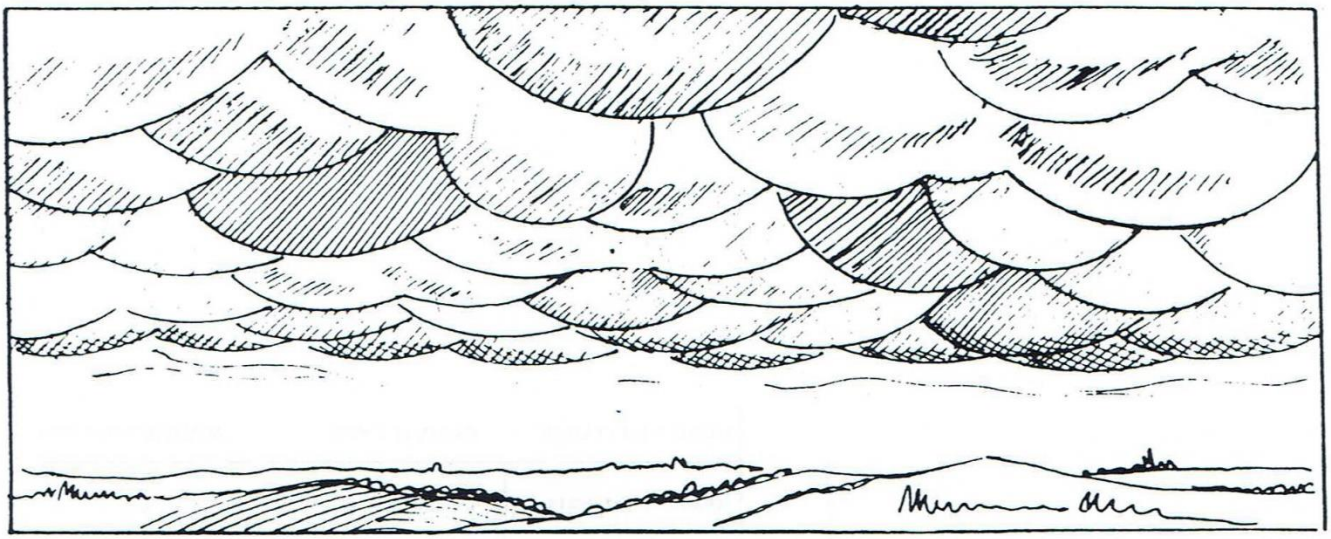
Figure 13

d. Clouds With Extensive Vertical Development. The vertically developed clouds are called cumulus and cumulonimbus. The height of their anges from as low as 1,500 feet to slightly more than 10,000 Tops in a fully developed cumulonimbus cloud may be higher than 50,000 feet. clouds with extensive vertical development are definite indications of unstable air. The towering cumulus cloud is a common example of a vertically developed cloud.



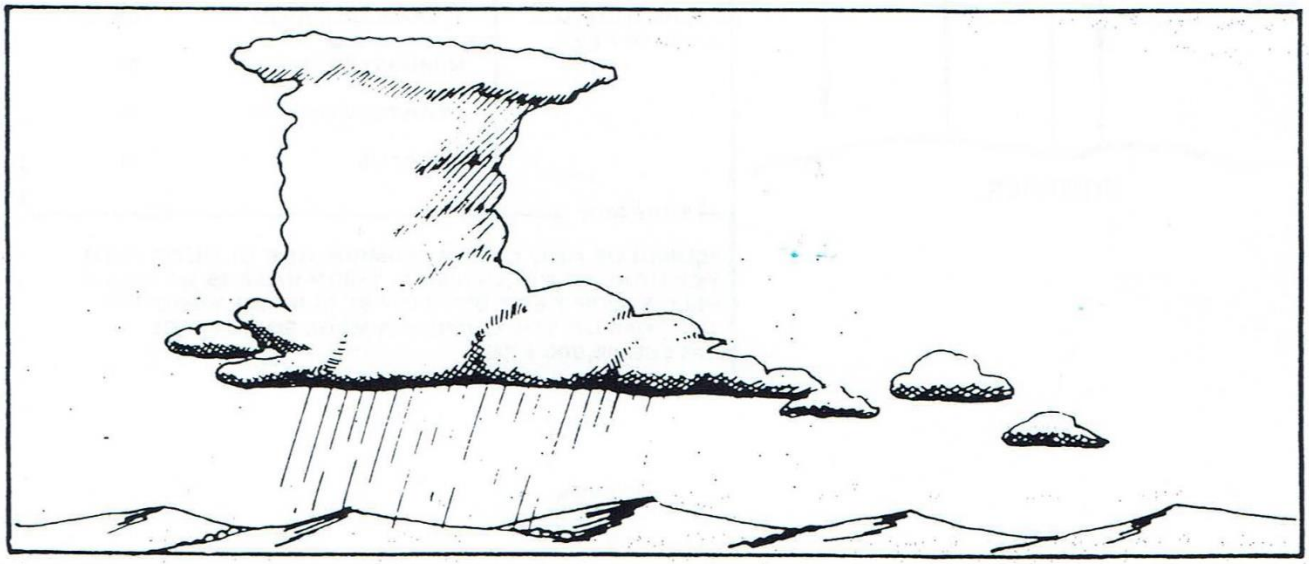
Towering cumulus (Tcu) indicate a deep layer of unstable air. Their bases are flat and usually are not as white as the base of a fair weather cumulus. Towering cumulus show extensive vertical development and have high, large rounded tops. They often produce rain showers that do not continue very long.

Figure 14



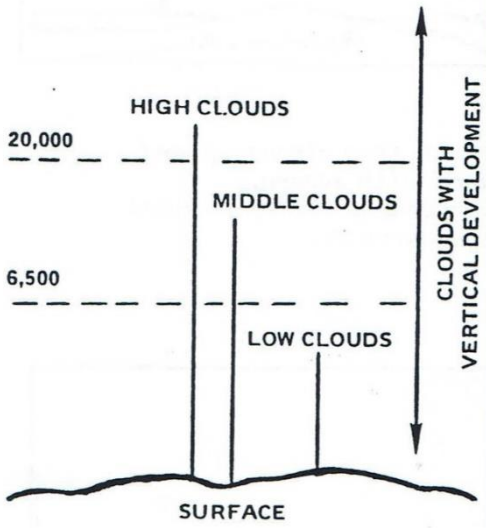
Cumulonimbus mamma (Cbmam) clouds result from strong up and down currents, and are often associated with severe, turbulent weather. They are characterized by black, rounded bases which are caused by downward air currents.

Figure 15



Cumulonimbus (Cb) "thunderstorm" cloud. The large, flat top or anvil is largely composed of ice particles. The Cb or thunderstorm contains most types of flying hazards; turbulent winds, ice, hail, etc.

Figure 16



BASE ALTITUDE	CLOUD TYPE	ABBREVIATION
BASES OF HIGH CLOUDS USUALLY ABOVE 20,000 FEET	CIRRUS	Ci
	CIRROCUMULUS	Cc
	CIRROSTRATUS	Cs
— 20,000 FEET		
BASES OF MIDDLE CLOUDS RANGE FROM 6,500 FEET TO 20,000 FEET	ALTOCUMULUS	Ac
	ALTOSTRATUS	As
— 6,500 FEET		
BASES OF LOW CLOUDS RANGE FROM SURFACE TO 6,500 FEET	*CUMULUS	Cu
	*CUMULONIMBUS	Cb
	NIMBOSTRATUS	Ns
	STRATOCUMULUS	Sc
	STRATUS	St
— SURFACE		

*CUMULUS AND CUMULONIMBUS ARE CLOUDS WITH VERTICAL DEVELOPMENT. THEIR BASE IS USUALLY BELOW 6,500 FEET BUT MAY BE SLIGHTLY HIGHER. THE TOPS OF THE CUMULONIMBUS SOMETIMES EXCEED 60,000 FEET.

Figure 17

GLOSSARY

ALTOCUMULUS (Ac): noun; a middle height, cumulus-type cloud

Note: alto + cumulus

ALTOCUMULUS CASTELLANUS (Accs): noun; a middle height, cumulus-type cloud that shows some vertical development

Note: alto + cumulus + castellanus

ALTOSTRATUS (As) ; noun; a middle height, stratus-type cloud

Note: alto + stratus

ANVIL: noun; the large flat top that develops on some cumulonimbus clouds

Ex. Pilots should avoid flying near or through the anvil of a thunderstorm cloud.

CIRROCUMULUS (Cc): noun; a high altitude, cirroform, cumulus-type cloud

Note: cirro- + cumulus

CIRROFORM: noun; high altitude clouds formed from ice particles

Ex. There are three basic cloud types; cumuliform, stratiform, and cirroform.

Note: cirro + form

CIRROSTRATUS (Cs): ・noun; a high-altitude, cirroform, stratus-type cloud

CIRRUS (Ci): noun; a high-altitude, often transparent, cloud layer or group of separated clouds

CUMULIFORM: noun; a cloud type characterized by flat bases and lifted rounded tops

Ex. There are three basic cloud types; cumuliform, stratiform, and cirroform.

CUMULOFRACTUS : noun; cumulus clouds that have developed as (or been separated into) small separate clouds

Note: cumulo + fractus

CUMULONIMBUS (Cb): noun; a cumulus-type cloud with possible precipita - tion

Note: cumulo + nimbus

CUMULONIMBUS MAMMA (Cbmam): noun; a large turbulent, cumulus-type storm cloud characterized by rounded extensions of the base

Note: cumulo + nimbus + mamma

CUMULUS (Cu): noun: a cloud characterized by a flat base and lifted, rounded top

-FRACTUS: suffix; adds the meaning of broken or separated into pieces

Ex. cumulofractus

NIMBO- (N-): prefix; adds the meaning of precipitation possibility (rain, snow, etc.)

Ex. nimbostratus (Ns)

-NIMBUS (-b): suffix; adds the meaning of precipitation possibility(rain,snow, etc.)

Ex. cumulonimbus (Cb)

NIMBOSTRATUS (Ns): noun; a stratus-type cloud with possible precipitation

Note: nimbo + stratus

STANDING LENTICULAR ALTOCUMULUS (Acs1): noun: a middle height-type cloud that forms and remains near an obstacle to the wind

Note: standing + lenticular + alto + cumulus

STANDING LENTICULAR CIRROCUMULUS (Ccs1): noun; a high altitude cumulus-type cloud that forms and remains near an obstacle to the wind

Note: Standing + lenticular t cirro t cumulus

STRATIFIED: adjective; formed in layers

Ex. Look at this piece of rock; you can see from the layers that it is stratified.

Note: strata (layer) + fied (made)

STRATIFORM: noun; a cloud type characterized by its flat, sheet-like appearance

Ex. There are three basic cloud types; cumuliform, stratiform, and cirroform.

STRATUS (St): noun; a low, flat, sheet-like cloud

STRATOCUMULUS (Sc): noun; a low cloud layer that is formed into long separated,

rounded bands

Note: strato + cumulus

TOWER: noun; the extended top of a cumulus-type cloud.

Ex. Upward currents will cause cumulus clouds to form towers.

TOWERING. CUMULUS (Tcu): noun; a cumulus cloud with extensive vertical development

Note: tower t ing+ cumulus

Language Exercises

I. NEW TERMINOLOGY: Oral Exercises

1. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

Cumuliform	stratified	nimbostratus
Cumulus	stratus	cumulonimbus
Tower	cirroform	-fractus
Stratiform	nimbo-/-nimbus	cumulofractus

a. When a stratus cloud is producing rain, the prefix_____. is added to its name; and it is called a _____ cloud.

b. Of the three basic cloud types,_____ clouds form at the highest altitude.

C. The tops of cumulus clouds can be pulled upward into _____ by rising air currents

d. Of the three cloud types,_____ clouds are produced by vertical currents in unstable air.

e. When a cumulus cloud is producing rain the suffix _____ is added to its name and it is called a _____cloud.

f. The main difference between cumulus and stratus clouds is that _____ clouds form in unstable air, and _____ clouds form in stable air that has been lifted.

g. Of the three cloud types, _____ clouds form as a flat ayer, or in flat layers.

h. Wher things are formed in layers, they are described as being _____ .

i. Clouds that are broken up and separated into small pieces are identified by the suffix_____; small separated pieces of cumuliform clouds are called_____ .

j. When it is raining we can expect to have either _____ Or _____clouds.

k. The _____ type of cloud is made up of ice particles.

i. The three basic cloud types are identified by the suffix "_form;" they are _____ , _____ , and_____ .

2. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

Stratocumulus	altocumulus castellanus
altostratus	standing lenticular altocumulus
altocumulus	standing lenticular altocumulus
cumulus	stratus
cirrocumulus	cirrostratus

a. Cumuliform and stratiform clouds can exist at al1 three alti- tude divisions. When they are low they are called just _____ and _____ .

b. When cumuliform and stratiform clouds occur at the middle altitudes, they are called _____ and _____ .

c. High-altitude cumuliform and stratiform clouds are called_____ and _____ .

d. When low stratus or cumulus clouds break up and begin to separate into lines of clouds with rounded bases, they are often identified as _____; the name is a combination of both names because they could be formed from either _____or _____ clouds.

e. Middle altitude cumulus clouds that form into lines with small towers are identified as _____ .

f. Standing clouds can form at middle altitudes and high altitudes over areas where wind flows over a line of hills or mountains. The middle altitude standing clouds are identified as _____ _____ ,and the high ones are identified as _____ _____ _____ .

g. Stratiform clouds can occur at low, middle, and high altitudes. They are called _____ ,_____ , and _____ .

h. Cumuliform clouds also occur at all three altitudes, called (low) _____(midd1e) _____ , and (high)_____ .

3. Select words from the list below to complete the following sentences. Some words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

cirrus	cirrostratus
towering cumulus	cirrocumulus
cumulonimbus mamma	cirroform
anvil	

a. High altitude clouds are classified as _____ ; the actual cloud could be _____ , _____ , or _____ .

b. High altitude clouds with cumulus characteristics are called _____ .

c . High altitude clouds with stratus characteristics are called_____ .

d. Cumulus clouds with extensive vertical development are called _____ _____.

e. Towering cumulus clouds often form flat large tops called _____ .

f. Cumulus rain clouds with dark rounded bases are called _____ _____ .

II. SENTENCE PRACTICE: Oral Exercises

NOTE: Very often when you are reading technical material you will see that certain words become associated with each other. The same words will be the second noun and verb in one sentence, the verb and first noun in another sentence, and then will appear as an adjective plus in a third sentence. Compare the following sentences .

The air currents lift the tops of the clouds

The tops of the clouds are lifted.

The lifted tops form towers.

Use the information given'to make two sentences as shown in the examples.

Complete the last part of the last sentence with your own words.

EXAMPLES:

Information: The ground heats the

Say: "The air is heated."

Say: "The heated air ….. " (i.e., rises and expands)

Information: The manufacturer partially empties the container.

"Say: "The container is partially emptied."

Say: "The partially emptied container …." (i.e., expands and contracts)

Information:

a. The uneven heating disturbs the air .

_____ .

b. The Coriolis force modifies the path followed by the air.

_____ .

c. Convection currents break the clouds into pieces._

_____ .

d. The heat at the equator expands the air.

_____ .

e. The movable arm indicates the pressure on a scale.

_____ .

f. The cold air mass deflects the hot air upward.

_____ .

g. The sun radiates heat and light to the earth.

_____ .

h. The weatherman converts the pressure to millibars.

_____ .

i. Cooling decreases the density of the air.

_____ .

j. The pilot adjusts the altimeter to show sea-level pressure.

_____ .

k.' The ground transfers heat to the air.

_____ .

i. The weatherman connects the points of equal pressure with lines.

_____ .

m. The dry air evaporates water.

_____ .

n. Evaporation increases the humidity of the air.

_____ .

III. VOCABULARY EXPANSION: Oral Exercises

NOTE : Many words in English have a noun form and a verb form; there is usually very little difference in the meaning. Often the verb is changed to the noun by the addition of "-tion."

Directions:

(1) Read the sentence to yourself.

(2) Make and say a simple sentence using the underlined verb as a noun with the same general meaning. (Add "-tion.")

a. The Coriolis force acts on the air moving poleward.

b. There is a system to abbreviate the cloud names.

c. Water evaporates much faster on a hot, dry day.

d. The indicator rotates to show the wind direction.

e. Weather stations communicate their readings to a central station.

f. A change in pressure often indicates a change in weather.

g. They correct all errors with a red pencil.

h. Air masses migrate from area to area.

i. The mountains north of here deflect a lot of the wind to the east.

j. They locate weather stations throughout an area.

k. After a few years, the station accumulates a lot of records about the weather in that area.

i. The air circulates from the equator to the poles and back again.

m. Cumulus clouds form in unstable air.

n. The moisture in the air condenses and precipitates.

UNIT 5

Weather Causes (4)

SECTION 8. FRONTS

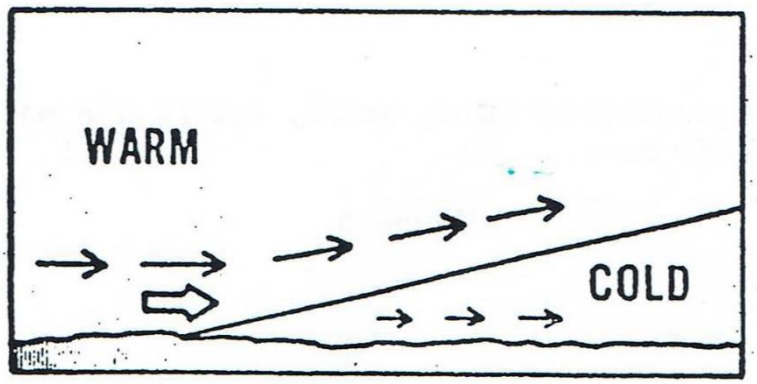
1. General

a. When two different air masses meet, they normally do not mix (unless their temperatures, pressures, and relative humidities are very similar). Instead, a boundary is created called a frontal zone, or "front." When warm air moves forward, the colder air mass projects under the warmer air mass in the form of a wedge. If the boundary is not moving, the condition is called a "'stationary front."

b.Usually, the boundary moves along the earth's surface. one air mass moves back from a given area, it is replaced by the other air mass moving forward. This action creates a moving front. If warmer air is replacing the colder air, the front is called warm, or a warm front If colder air is replacing the warmer air, the front is called cold, or cold front. Since fronts normally lie between two areas of differing pressures, wind shifts occur in both types, but the degree of difference is usually greater in a cold front.

2. Warm Fronts

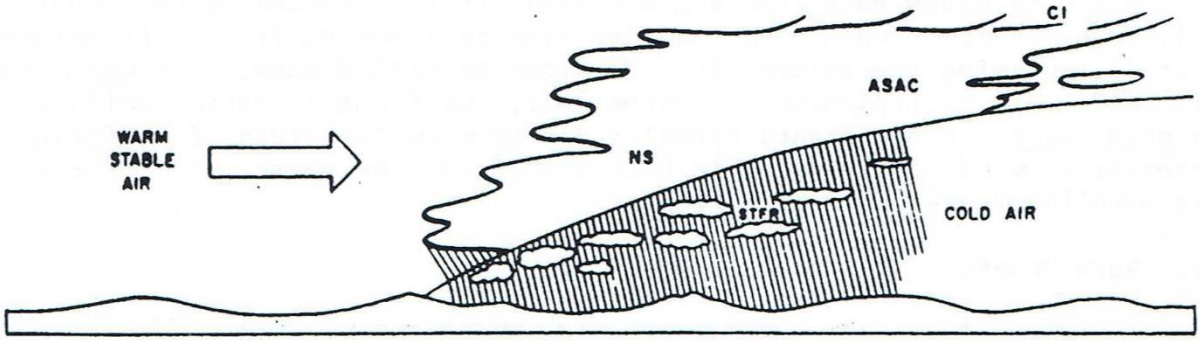
a. When a warm front moves forward, the warm air slides over the wedge of colder air ahead of it.See the cross section below.



Cross section of a warm front. The slope of a warm front generally is more gradual than the slope of the cold front. Movement of the warm front (shown by the large white arrow) is slower than the wind in the warm air (shown by the black arrows). The warm air gradually eats away the cold air as it moves across the slope of cold air.

Figure 1

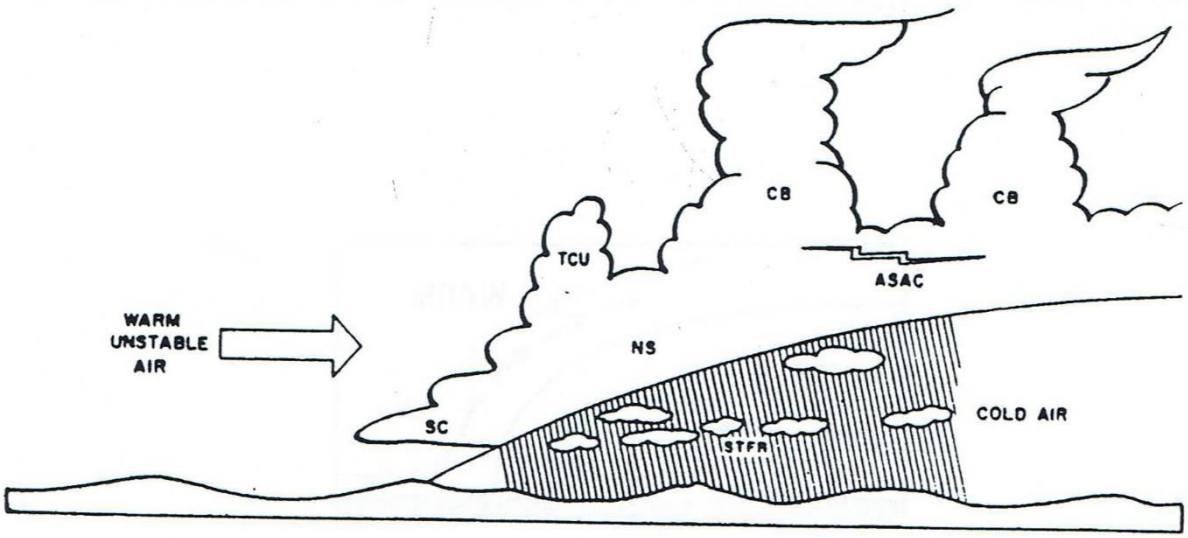
b. Warm air usually has higher humidity. As the warm air is lifted, its temperature is lowered. As the lifting process continues, the moisture in the air condenses. Low nimbostratus and stratus clouds form, and Any drizzle and rain develop. The rain falls through the colder air below, increasing its moisture content so that it also becomes saturated. Any reduction of temperature in the colder air may result in extensive fog. The temperature of the cold air may be reduced when the ground cools after the sun goes down, or it may be reduced by the colder air moving up and rising over sloping terrain such as hills or mountains. As stable warm air moves up the slope of the front and the temperature of the warm air continues to fall, clouds appear at increasingly higher levels in the form of altostratus (middle height) and cirrostratus (high altitude) clouds.



A warm front containing warm, moist, stable air moving up over a cold air mass.

Figure 2

c. If the warm front air moving over the colder air mass is unstable, cumulus clouds (Cu), cumulonimbus clouds (Cb), and altocumulus clouds (Ac) will form and frequently produce thunderstorms and showers.



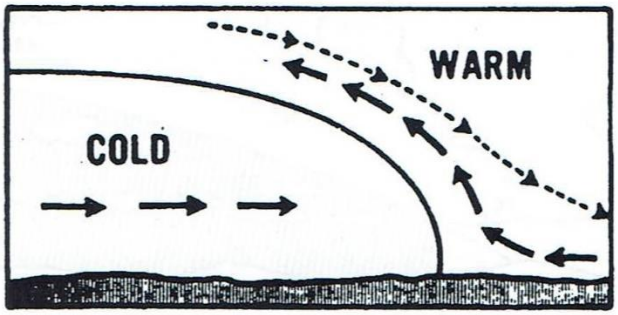
A warm front with warm, moist unstable air moving up over a cold air mass. Lifting along the slope of the cold air mass is more gradual than the type that occurs when a cold front advances, because the wedge of cold air is flatter. Showers and thunderstorms caused by the instability are spread above the frontal surface. Convective storms may occur in the layer of stratiform clouds. Stratus fractus clouds form in the precipitation area, as water is evaporated from the warm raindrops and is condensed in the cold air.

Figure 3

d. As a last step of warm front air movement, the warm air is. Forced up near the stratosphere. In the freezing temperatures at that height, the condensed moisture appears as cirrus clouds (Ci). The up-slope movement of the warm front air over the wedge of cold air is very gradual. It rises approximately 1,000 feet every 20 miles. Cirrus clouds may form at an altitude of approximately 25,000 feet and 500 miles in advance of the point on the surface that marks the position of the front.

3. Cold Fronts

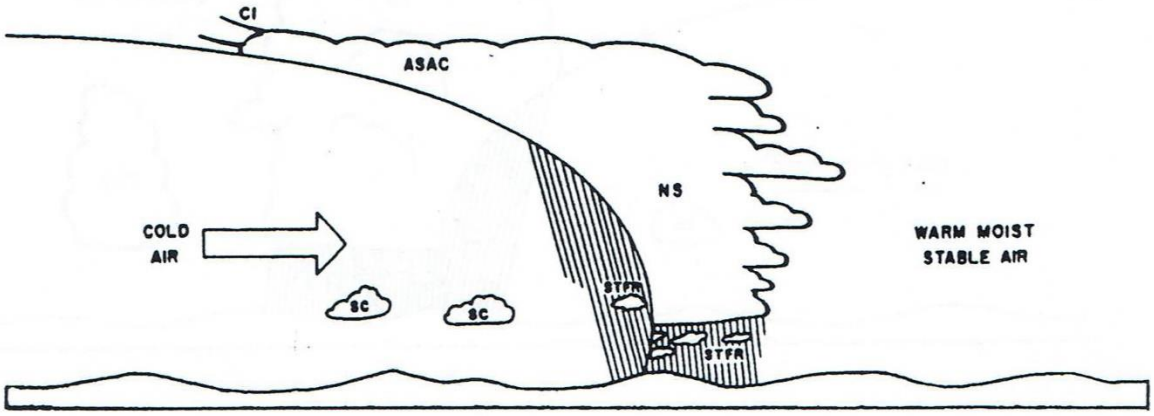
a. When a cold front moves forward, it slides under the warmer air and forces it aloft. This causes sudden cooling of the warm air and forms clouds. the type of clouds formed depends on the stability warm air.



Cross section of a cold front. The frontal slope is steep near the forward edge as cold air replaces the warm air. The large white arrow shows the movement of the front. Warm air may descend over the front as indicated by the broken-line arrows, but more commonly, the cold air forces warm air upward over the frontal surface as shown by the solid-line arrows.

Figure 4

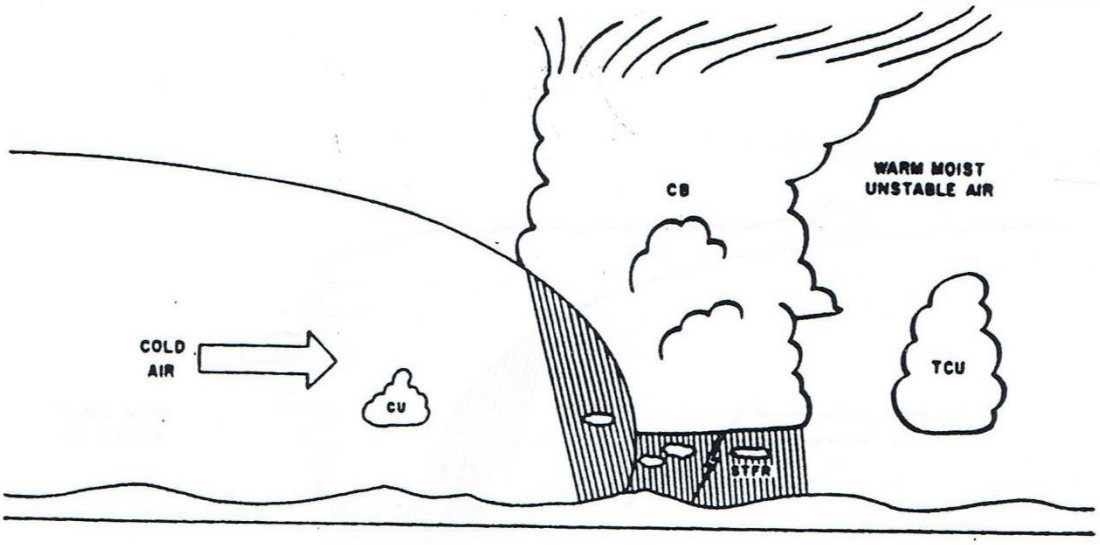
b. In fast-moving cold fronts, friction at the ground slows front so that a steeper frontal surface is created. ntal surface causes a narrow band of weather to be located forward edge of the front. If the warm air is stable, an overcast sky may occur for some distance behind the frontal passage, accompanied by general rain.



A cold front running under warm moist stable air. Stable stratified clouds form above the front much as they do above a warm front, except that the slope is steeper and the clouds do not cover as large an area. The cold air is stable except where surface heating has created a convective layer. Clouds that form in the cold air are stratocumulus. If you compare this illustration to the warm front shown in figure 3, you will see that cloudiness associated with the warm front appears before surface passage of the front; large area cloudiness with the cold front occurs after surface frontal passage.

Figure 5

c. If the warm air is unstable, scattered thunderstorms and showers may form in it. In some cases an almost continuous line of thunderstorms may form along the front or ahead of it. These lines of thunderstorms,''squall lines," contain some of the most turbulent weather that is experienced by pilots.



A cold front with slightly unstable air underrunning warm, moist, unstable air. Rapid lifting of the warm air at the surface frontal area produces a line of thunderstorms in advance of the front. Fair weather cumulus clouds develop in the slightly unstable cold air. Cumulus clouds may also develop ahead of the front in the warm air due to surface heating.

Figure 6

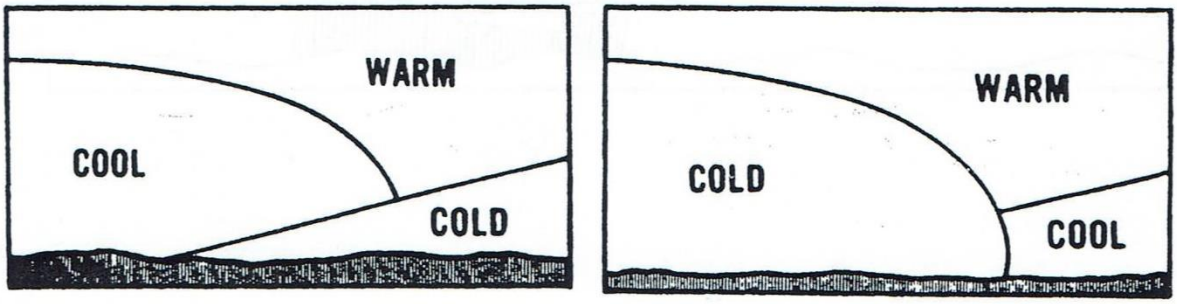
d. Behind the fast-moving cold front there is usually rapid clearing of the clouds, gusty and turbulent winds at the surface, and colder temperatures. The slope of the cold front is much steeper than that of a warm front and the progress is generally more rapid. Usually it moves at a rate of 20 to 35 miles per hour, although, occasionally, cold fronts have been known to move as fast as 60 miles an hour. Weather activity produced by a cold front usually takes place right at the front instead of in advance of the front, and the winds and storms are stronger. In late afternoons in the warm season, a squall line will frequently develop as much as 50 to 200 miles in advance of the actual cold front. Warm front dangers usually consist of low ceilings and low visilbilities ; cold-front dangers are mainly sudden storms, strong, gusty, surface winds and turbulence.

e. Cold fronts move into an area rapidly and make a complete change in the weather within the period of a few hours, and then move on to another area. The squall line that is formed is generally very narrow--50 to 100 miles in width--but it is likely to extend for hundreds of miles in length. Altostratus clouds sometimes form slightly ahead of the front, but they are seldom more than a hundred miles in advance. After the front drier air, and is passed, the weather clears rapidly, there is usually unlimited ceilings and visibility.

4. Occluded Front

a. An occluded front occurs when a cold front overtakes a slower moving warm front and forces it aloft so that the warm air is no longer in contact with the ground. This is a condition in which a warm air mass is caught between two colder air masses. It is forced aloft to higher and higher altitudes until it finally spreads out and loses its identity as a particular air mass.

b. Meteorologists subdivide occlusions into two types: cold front occlusions, depending on the relative tem-perature of the air mass that is advancing.

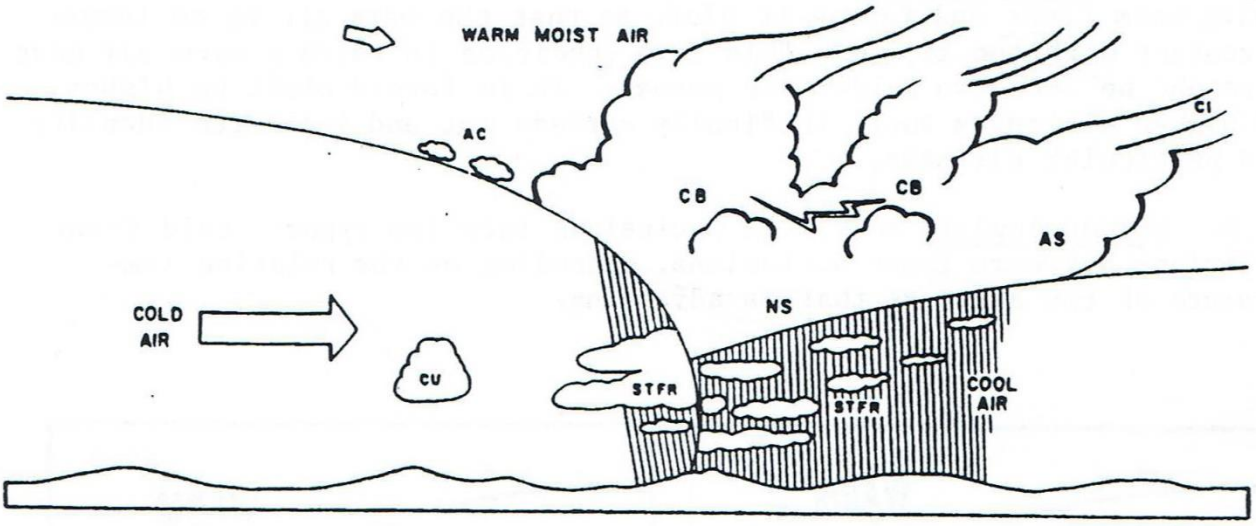


Cross section of a warm front occlusion. Air in the advancing cold front is not as cold as the air ahead of the warm front. When the cold front overtakes the warm front, the cool air slides up over the cold air. In this warm front occlusion, cool air (which is relatively warmer) advances and replaces the cold air at the surface.

Cross section of a cold front occlusion. Air in the advancing cold front is colder than the air ahead of the warm front. When it advances it forces the warm aloft. In this cold front occlusion, cold air advances and replaces the (relatively warmer) cool air at the surface.

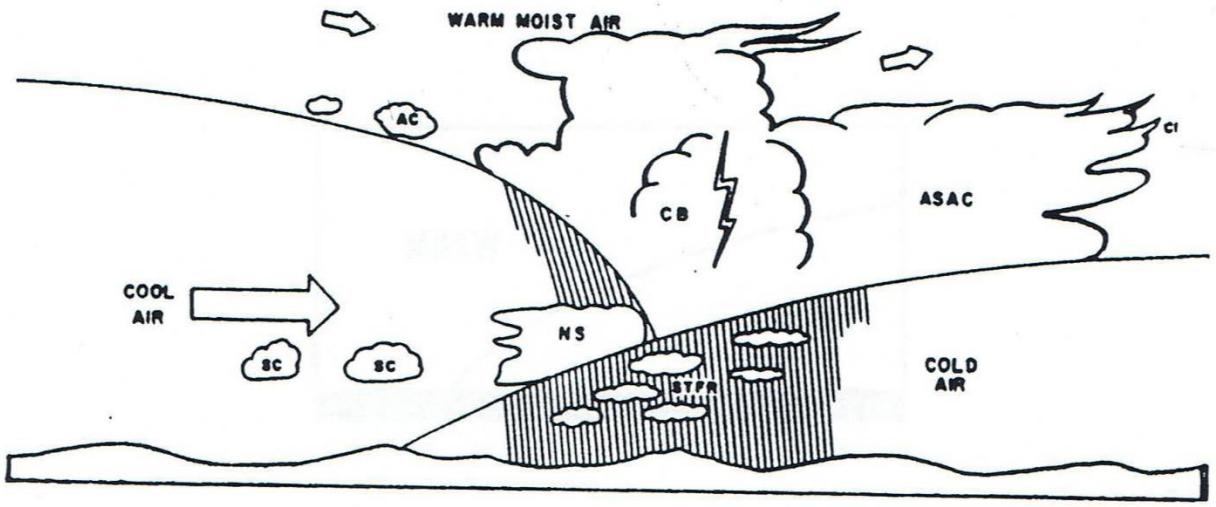
Figure 7

C. The weather in any occlusion is a combination of warm front and cold front conditions. As the occlusion approaches, the usual warm front type conditions occur: Ceilings become lower, visibility is reduced, and precipitation falls. Generally, the warm front weather is followed almost immediately by cold front type weather: rainstorms, turbulence, and thunderstorms, followed by rapidly clearing weather.



A cold front occlusion. Note that cold air replaces cool air at the surface forcing the warm air aloft. Cold air is nearly stable; cool air, stable; and warm air, unstable.

Figure 8

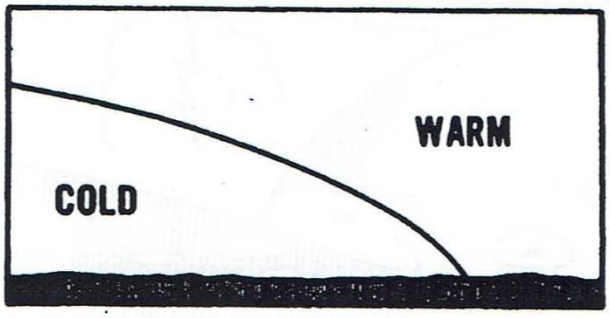


A warm front occlusion. Here cool air is running over cold air, forcing the cold front aloft. The cool air is stable, the cold air is stable, and the warm air is unstable. Clouds produced by convective currents develop along the cold front aloft. Stratified clouds with possible thunderstorms develop above the warm front. Stratocumulus clouds form in the stable cool air, and stratus fractus clouds (Stfr) form in the cold air due to the warm rain falling through the cold air.

Figure 9

5. Stationary Front

As indicated by its name, the stationary front does not move. The slope of a stationary front generally is gradual, although it may be steep if the difference in the density of the air behind the front and in advance of the front is small. It also may be steep depending on the flow of wind in the two air masses at the front.



Cross section of a stationary front. The front has little or no movement and winds are nearly parallel to the front both in warm and cold air. The steepness of the slope of the front may vary considerably depending on the density of the two air masses and the winds in the air masses.

Figure 10

GLOSSARY

BOUNDARY : noun; the dividing line or border between two objects

Ex. The boundary between those two air masses is called the front.

CEILING: noun; the height above the ground of the layer of clouds, or overcast, that covers half or more than half of the sky There is a low layer of stratus clouds today, the ceiling is only 3,000 feet.

COLD FRONT: noun; the name of the frontal zone that occurs when a cold air mass advances and replaces a warm air mass

Ex. You better wear a coat tomorrow, there is a cold front passing through here tonight.

CROSS SECTION: noun; a picture drawn to show how an object would look if it were cut in half from top to bottom

Ex. They made a cross-section drawing of the engine so you can see inside.

DRIZZLE: noun; a type of light rain that consists of very small drops

Ex. I don't think I'll need a raincoat, I don't have to go very far and it's only drizzling.

FRONT : noun; the boundary zone of an advancing air mass

Ex. You can expect the wind to change direction when the front passes;

FRONTAL: adjective form of front

GUSTY: adjective; wind that changes speed frequently and irregularly

Ex. The winds have been gusty all day.

METEOROLOGIST: noun; a person who prepares weather reports and predictions

Ex. My brother is an Air Force meteorologist.

OCCLUDED FRONT: noun; a warm front that has been lifted aloft by a more rapidly moving cold front

Ex. That warm front that passed through here yesterday is an occluded. Front now.

OVERTAKE: verb; to come up from behind and pass a slower moving object going in the same direction

Ex. Since cold fronts usually move faster than warm fronts, frequently cold front will Overtake warm front that is moving in the same direction.

PASSAGE : noun form of to pass

Ex. The weather will usually change with the passage of a cold front.

SATURATED: adjective; full of water (very high humidity)

Ex. I think the air is almost saturated; it takes the wet clothes a long time to dry, and water on the floor evaporates very slowly.

SCATTERED: adjective; separated into small pieces and distributed over a large area

Ex. There are a few fair weather cumulus clouds scattered across the sky.

SHIFT : noun; a rapid change from one, position or direction to another position or direction

Ex. You can expect a wind shift when the front passes.

SHOWER: noun; a rainfal1 that only lasts a short time

Ex. If we wait a couple of minutes, the shower will probably be over.

SQUALL LINE: noun; a line of storms that develops parallel to and in advance of a cold front

Ex. We can expect to see a squall line come through here before the front arrives.

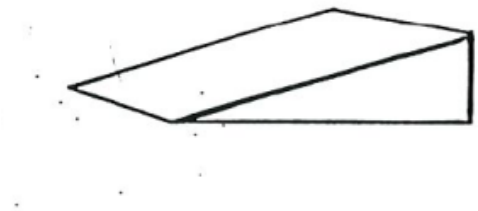
STATIONARY FRONT : noun; a non-moving frontal zone

Ex. The weather is going to stay pretty much the same as long as this is a stationary front.

WARM FRONT: noun; the name of a frontal zone that occurs when a warm air mass advances and replaces a cold air mass

Ex. We will have a couple of rainy days as the warm front passes.

WEDGE: noun; any object that has the appearance of a long narrow triangle

Ex.  (wedge shape)

Language Exercises

I. NEW TERMINOLOGY: Oral Exercises

1. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

Frontal	stationary front	shift
Boundary	warm front	cross section
Front	cold front	drizzle
wedge		

a. A _____of cold air extends under the warm. front.

b. A front is really the _____ between two air masses that have different characteristics.

c. The wind was blowing from the north but it just _____ to the east.

d. If the adjective for center is central, the adjective for_____ is_____.

e. The zone where one air mass is in contact with a different air mass is called a _____ zone.

f. A _____ occurs when warm air is replaced by cold air.

g. This precipitation isn't heavy enough to be called a rai is more like a_____.

h. It is more useful to show fronts with a_____ picture.

i. When warm air replaces cold air, we say that a_____ has come in.

j. A _____ occurs when neither air mass moves forward.

k. You can expect a wind _____ when you cross a _____ zone, or when a front moves through the area.

l. In a _____picture of a warm front, the cold air has a characteristic _____ shape.

m. Warm fronts often produce fog, rain, and _____ over large areas.

n. In general, a fast-moving front is usually a _____ .

o. The _____zone of a _____ stays in one area for a number of days.

2. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

ceiling	overtake	shower
gusty	passage	squall line
meteorologist	saturated	
occluded front	scattered	

a. bi Fog and stratus clouds often form when the air contains so much moisture that it is _____ .

b. The clouds were almost continuous this morning, but a strong wind broke them up and _____ them.

C. The two cold air masses 1ifted the warm air off the surface and caused an _____ .

d. We often have rain _____in this season, but they don't usually last more than half an hour.

e. He studied two years to become a _____ .

f. You can tell from how the trees are moving that the wind is _____today; they will be standing quiet, then they will move and bend.

g. He just left a minute ago. If you hurry, you can _____ .him before he reaches the messhall.

h. Often the _____of a cold front will produce strong winds and rain.

i. A warm front often produces a layer of low stratus clouds; this low_____ prevents pilots from seeing the ground when they are descending for a landing.

j. The group of storms called the _____ came through here this morning, but the actual cold front isn't expected until tonight.

k. The weather usually clears quickly after the _____of a cold front.

l. If this cold front _____the warm front that went through here yesterday, it will force it aloft.

m. If it rains behind a cold front, it usually occurs as _____showers because the clouds are broker up.

n. The humidity is very high today; the air must be almost _____ .

II. SENTENCE PRACTICE: Oral Exercises

NOTE : Sentences about technical information are often composed of two parts: One part makes a statement; the other part describes a condition that is necessary in order for the statement to be true.

The front is called warm, or a warm front
(statement) If warm air is replacing cold air (condition)

Sentences of this type may occur with the statement
first followed by the condition, or with the condition first
followed by the statement. Compare the following:

(1) The front is called warm, or a warm front, if warm air is replacing cold air.
(2) If warm air is replacing cold air, the front is called warm, or a warm front.

Statement-condition sentences may use "1f," "when," "as," "since," "whenever," etc.

Direct ions

(1) Look at the phrases given and identify which statement and which is the condition.
(2) Combine the phrases so that the statement is first and say the sentence.
(3) Combine the phrases so that the condition is first and say the sentence.

Example:

Whenever the equilibrium is disturbed (condition) Air begins to flow from areas of higher pressure to areas of lower pressure (statement)

Say: ''Air begins to flow from areas of higher pressure to areas of lower pressure whenever the equilibrium is disturbed."

Say: ''Whenever the equilibrium is disturbed, air begins to flow from areas of higher pressure to areas of lower pressure.''

a. (1) Each part of the earth has one day period and one night period every 24 hours

(2) Since the earth completes one rotation every 24 hours

_____
_____
_____
_____

b. (1) According to where the earth is in its revolution around the sun

(2) One hemisphere will be closer to the sun than the other

_____
_____
_____
_____

C. (1) As the weight of the atmosphere changes

(2) The height of the column of mercury in the tube changes

_____
_____
_____
_____

d. (1) The aneroid barometer must be checked by comparing it with a mercurial barometer

(2) When it is used for official measurement

_____
_____
_____
_____

e. (1) As millibars are the units of atmospheric pressure used on weather maps

(2) The sea level barometric pressure reading is converted to millibars

_____
_____
_____
_____

f. (1) The altimeter will read the airport's elevation

(2) When an aircraft's altimeter has been set to the local pressure

Note: Use "it" in the second phrase of your sentence.

_____
_____
_____
_____

g. (1) Temperature decreases with increasing altitude

(2) In the lower 30 or 40 thousand feet of the atmosphere

_____
_____
_____
_____

h. (1) In the northern hemisphere

(2) This rotation causes air to flow to the right of its normal path

_____
_____
_____
_____

i. (1) The air is deflected to the east

(2) the air rises and moves northward from the equ

Note: Use "it" in the second phrase of the sentence.

_____
_____
_____

j. (1) At altitudes two to three thousand feet above the surface

(2) The wind speed is greater and the direction is usually parallel to the isobars

_____
_____
_____
_____

k. (1) The warmer air expands and becomes lighter than the surrounding cool air

(2) When two bodies of air next to each other are heated unequally

_____
_____
_____
_____

l. (1) The polar and arctic air masses generally move toward the southeast, and tropical air masses move toward the northeast

(2) Since the general movement of the atmosphere in the United States is toward the east.

_____
_____
_____
_____

m. (1) Unless their temperatures, pressures, and relative humidities are very similar

(2) Two different air masses normally do not mix when they meet

_____
_____
_____
_____
_____

III. VOCABULARYEXPANSION: Oral Exercises

Select the word from the three given to complete the sentences.

1. condense condensation condensed

a. Sometimes moisture in the air _____ on a cool surface and forms drops of water.

b. Fog and clouds are a result of the _____of moisture in the air.

c. The _____ moisture forms 1arger and larger drops

d. Evaporation and _____ are two processes that relate to moisture in the air.

2. saturate saturation saturated

a. The air is _____ , it can't take up any more moisture.

b. Often, when precipitation falls through a lower layer of air,_____ of the lower layer occurs.

c. Come in out of the rain, your clothes must be _____ .

d. First the rain _____ the ground, then the water starts to collect on the surface.

3. extend extension extended

a. We won't be able to finish the test in one hour so I will _____ the class period by fifteen minutes.

b. The course is normally done in three weeks; but we have a one week _____ this time because of the holidays.

c. The wire is _____as far as it will go; but it is stil1 too short.

d. The warm air of a warm front _____wedge of cold air.

4. reduce reduction reduced

a. If we take a bus rather than a train, we can_____ the cost of the trip.

b. The higher you go in the troposphere, the more the temperature is_____ .

c. There is no_____ in temperature in an inversion area.

d. when a low pressure system is in the area, the _____ pressure allows the container in the aneroid barometer to expand and move the indicator arm.

5. combine combination combined

a. Normally air from two different air masses won't _____ unless the characteristics are very similar.

b. An occluded front wil1 produce a _____of warm-front and cold-front conditions.

c. Driving is very dangerous when high speed is _____with wet roads.

d. The _____ of low cellings and continuous rain is a characteristic of a warm front.

6. modify modification modified

a. All air masses are _____ slightly by the characteristics of the regions they pass over

b. Heating at the equator causes a _____in the density of the air mass.

c. Convection currents can _____the weather in a local area.

d. There haven't been any _____ in the basic mercurial barometer, but the aneroid barometer has been _____ . several times to make it more accurate.

e. The _____aneroid barometer doesn't have to be checked so often.

UNIT 6

Weather Hazards

SECTION 1. RESTRICTIONS TO VISIBILITY

1. Visibility

a. There are three types of visibility which affect aviation.

They are: horizontal surface visibility; air-to-air, or flight visibility ; and air-to-ground, or slant visibility.

(1) Horizontal surface visibility refers to the ability of an observer on the surface to see other
objects on the surface.

(2) Air-to-air visibility refers to the ability of an observer aloft to see other objects aloft.

(3) Air-to-ground and slant visibility refer to the ability of an observer aloft to see objects on the surface.

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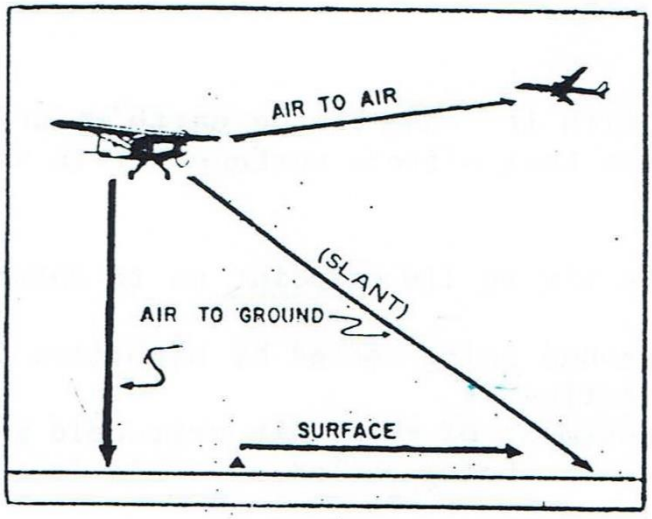


Types of visibility in aviation: air-to-air, air-to-ground, and horizontal surface. Surface visibility is observed and reported by ground stations. Air-to-air and air-to-ground visibility are reported by pilots in flight.

Figure 1

a. Except in periods of overall clear weather, the three types of visibility that affect aviation function independently of each other. Horizontal surface visibility may be good at a time when cloud condi- tions 1imit air-to-air and air-to-ground visibility. At other times, horizontal surface visibility and air-to-air visibility may be good in an area where cloud layers limit air-to-ground visibility. A particular airport may be closed so that aircraft do not arrive or depart because of bad horizontal surface visibility, while air-to-air visibility may be excellent a short distance above the surface.

b. The stability of air largely determines the type and intensity of restrictions to visibility near the ground. Stable air, which resists vertical movement, doesn't break up and spread out re to visibility. However, unstable air produces vertical currents which vertically and horizontally. d to break up and separate fog, and to spread haze and smoke Precipitation in stable air tends to without stopping, precipitation in unstable air ally cover large areas, nor does it usually continue a long t can say, stable air will have a characteristic of poor visi - bility, and unstable air, good visibility.

c. As the earth and lower layers of air become warm during , air that was stable during the early morning hours ma unstable. For this reason visibility usually improves as temperatures rise. If cloud layers aloft keep the sun's heat from reaching the ground, visibility improvement is usually slow.

2. Fog
   a. Fog is a cloud with its base at the earth's surface. f Fog forms by an atmospheric process that affects surface air in one or both of the following ways:
      (1) Cooling the air to its dewpoint or to saturation by:
         (a) the ground being cooled by nighttime loss of heat, which then cools the air contacting it
         (b) the movement of moist air over cold ground..
         (c) moving air being cooled as it is forced to rise.up sloping terrain

(2) Raising the dewpoint to that of the air temperature. Normally happens when the evaporation

of warm rain adds water vapor to the air. This air is then cooled by surrounding cold air.

b. The conditions favorable to fog formation are: light winds of 10 knots or less, and a small difference in the temperature and the dewpoint

3. Stratus Clouds

At times when conditions are favorable for fog, a very low cloud layer may form. This is especially true over flat terrain. These fog-like clouds form in stable air and often exist together with fog. When this happens, there is no exact point where it can be said that the fog layer stops and the stratus cloud layer begins. An observer on the surface then reports the vertical visibility as the distance he can see upward into the fog.

4. Haze and Smoke

Visibility is reduced when a stable layer of air contains large amounts of very small dust or salt particles. The particles produce the condition called haze. The haze may occasionally extend from the surface up to 15,000 feet. Haze layers often have definite upper 1imits or tops, above which air-to-air visibility is good. However, air-to-ground visibility from above a haze layer is poor, especially on a slant. Smoke restricts visibility in a manner similar to haze. Smoke sometimes collects in layers aloft, restricting visibility at that altitude, while visibility under it and over it may be good. Haze and smoke wil1 normally be a more severe restriction to visibility when a temperature inversion exists.

5. Blowing Snow, Dust, and Sand

ong surface winds and vertical currents in unstable air carry a erials from the surface such as dust, sand, or snow. These I reduce surface visibility to near zero over large areas. I favorable conditions dust can be carried aloft to 15,000 feet and restrict slant, flight, and surface visibility. Sand and snow are seldom carried aloft beyond a few hundred feet.

6. Precipitation

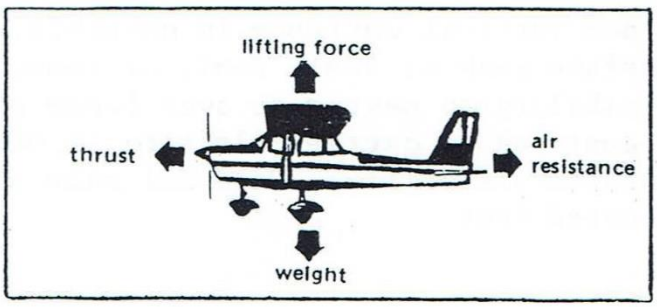
Snow, drizzle, and rain are the most common forms of precipitation that cause restrictions to visibility. Of these, snow is usually the most effective in reducing visibility. Heavy snow frequently reduces surface and slant visibility to near zero. Rain rarely reduces surface visibility to less than one mile and has a tendency to wash dust, smoke, and even fog particles out of the air. However, drizzle often occurs at the same time fog, haze, and smoke are present, resulting in visibility being less than it would be if rain had occurred. Precipitation on the windows of an aircraft greatly reduces a pilot's visibility; and if it freezes, he may have no forward visibility at all.

SECTION 2. ICING

l. General

a. Aircraft icing affects an aircraft's flight characteristics. When icing is severe, it can cause an aircraft to be unable to continue flying. Ice that forms on the outside surfaces of an aircraft increases the weight of the aircraft and changes the shape of surfaces on which it forms. Icing can also occur in the engine equipment that leads outside atmospheric air to the engine. Icing inside these parts reduces the flow of air to the engine. The amount of air entering the engine can be so reduced that the engine can no longer produce the required power or it stops completely. Icing is so dangerous to aircraft that many aircraft have equipment to prevent: the formation of ice.

b. Four forces act on flying aircraft: the downward force, weight; the downward force, lift; the resistance of the air, drag; and the force oves it forward, thrust. Icing affects all four fo It decreases the lifting force as increases the weight of the aircraft. result of the extra weight and the change of shape of the lif surfaces. on surfaces causes changes in the flow of air around aircraft and results in increased drag. The decrease in lift and the increases in drag and weight result in a decrease in the forward movement produced by thrust.



Aircraft icing affects the forces acting on an aircraft: lift is decreased, weight is increased, drag is increased, and thrust is decreased.

Figure 2

2. Structural Icing

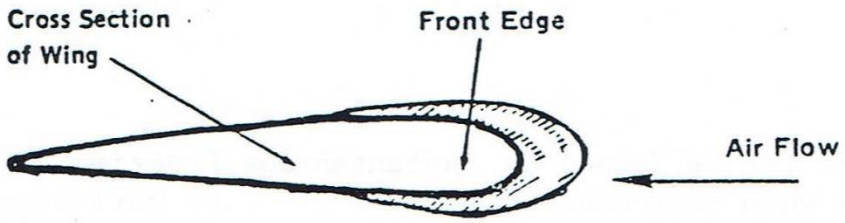
The ice that forms on the outside surfaces of the aircraft is clas- sified as structural icing. The rate of structural ice accumulation is affected by the shape, size, speed through the air, and angle to the air of the stiucture, such as the wing. Some aircraft are less affected by ice than otgers, but ice affects the flying performance of all arcraft. Although ice may form on any exposed surface of the aircraft, ice on structures such as the wings has the largest effect on flight character- istics. Two conditions are enecessary for serious ice accumulation on aircraft:

(1) The aircraft must be flying through visible water such as rain or the small drops of water that form clouds.

(2) The temperature of the water or of the plane must be O'.

3. Clear Ice

a. Clear ice is a transparent ice that has a glassy surface. It is Identical to the transparent ice that forms on trees and other objects during a freezing rain. It is formed by the relatively slow freezing of large supercooled water drops. The 1ce is smooth and transparent when it is formed from raindrops or large supercooled cloud drops with- out solid precipitation. Ice tends to take the shape of the surface on which it freezes, but it accumulates more at the part of the surface that first meets the flow of air. The icing tends to be thicker and on the front edge of a surface such as a wing, and be thinner as it extends back over the surface.



Clear Ice: Smooth and Glassy

Clear ice can appear in seconds and accumulates rapidly. Pilots have the greatest difficulty in removing clear ice.

Figure 3

b. Clear ice is the most serious of the various forms of ice be of its rapid accumulation. It adheres strongly to the surfaces it forms on and is difficult to remove.

c. The conditions most favorable for the formation of clear ice are: large amounts of water present in the air, large size rain drops or large cloud-forming drops, temperatures only slightly below freezing, high speed of the aircraft through the air, and thin aircraft structures such as wings. Clear ice is encountered most frequently in cumulus-type clouds and freezing rain or drizzle

4. Rime Ice

a. Rime ice is a white-colored, non-transparent, accumulation of ice particles that has a rough surface.

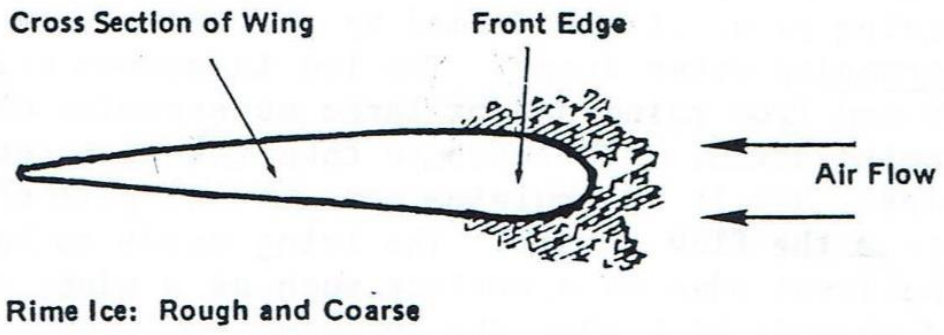


Figure 4

b. Rime ice is formed by instantaneous freezing of small supercooled er drops when they contact exposed aircraft surfaces. This us freezing causes a large amount of air to be caught in The air gives the ice its white non-transparent color, and makes it easy to break. Rime ice usually forms on the front edge of a structure and extends forward into the airflow. that takes the shape of the structure. It does not usually form in a layer The fast-freezing rime ice is kely to accumulate in temperatures between -10 C.

c. Rime ice is most frequently encountered in stratiform clouds, and is so common in cumulus type clouds at temperatures bel C. e primary danger from rime ice is the change it make flow across the aircraft's surfaces; the ice seldom ac rapidly. removal methods.

5.Mixed Ice

Rime and clear ice frequently occur together and combine the most dangerous characteristics of both types. mixed with snow, ice particles, or small hail, the mixed ice becomes If the liquid drops are rough, whitish, and irregularly shaped.

6. Frost

a. Frost is a very thin type of ice caused by the condensation of water vapor directly into ice on surface objects whose temperatures are below freezing. It is' similar in appearance to a thin layer of snow. It is the same type of ice that forms on a car's windows when the temperature falls below freezing and there is moisture in the air.

b. Thin metal structures are especially likely surfaces on which frost will form. Frost does not change the shape of a wing but its roughness destroys the smoothness of the surface and affects the flow of air across the wing's surfaces. The changing of the airflow over the surface results in decreased lift. A thick layer of hard frost on aircraft structures wil1 increase the minimum speed at which the air- craft can continue to fly by 5% to 10%.

7. Icing Intensity

The military and civilian aviation groups and the National Weather ice have agreed to use a standard classification system to report the intensity of icing. The system uses four classifications of icing: trace, light, moderate, and severe.

ICING INTENSITIES

STRUCTURAL ICING REPORTING TABLE

Intensity	Ice Accumulation	Pilot Report
Trace	Ice becomes visible. The rate of accumulation is slightly more than the melting rate. It is not hazardous even though ice-prevention/ice-removal equipment is not used, unless the condition is encountered for a long period of time--over one hour.	Aircraft identity Location Time Intensity of the type of ice (Rime/clear) Altitude of aircraft Type of Aircraft Indicated airspeed*
Light	The rate of accumulation may create a problem if the flight is continued in those conditions (over one hour). Occasional use of ice-prevention/ ice-removal equipment removes or prevents the accumulation. It does not create a problem if the equipment is used.	
Moderate	The rate of accumulation is such that even short encounters could become hazardous. The use of ice-prevention/ ice-removal equipment or change of route is necessary.	
Severe	The rate of accumulation is such that ice-prevention/ice-removal equipment does not reduce or control the hazard. Immediate change of route is necessary.	

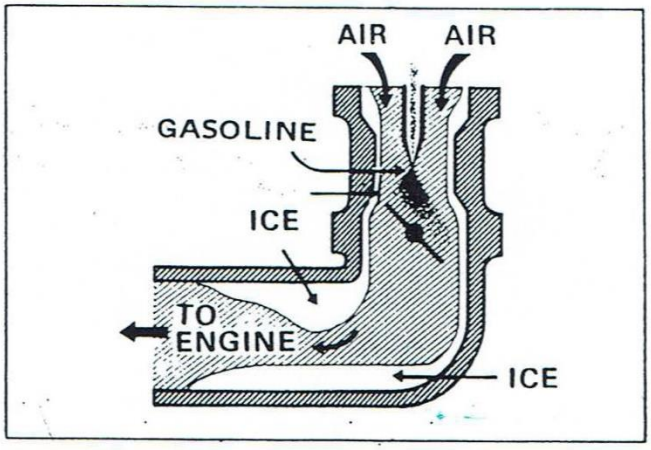
*The speed of the aircraft through the air as shown on the airspeed instrument.

8. Ground Icing

Water on the airport surface is thrown up on the aircraft as the aircraft moves on the ground; just as water is thrown up on cars driving on wet roads. If the temperatures are below freezing, this water may form ice on the exposed surfaces of the aircraft and prevent correct operation of the various mechanical parts, such as the equipment that raises and lowers the wheels, the brakes, etc.

9. Induction System Icing

Induction system icing is caused when the gasoline is changed to a vapor and mixed with the air entering the engine. The vaporization of the gasoline combined with the expansion of the air as it passes through the carburetor causes a rapid cooling of the mixture. The temperature of the air passing through the carburetor may fall as much as 60'F in a fraction of a second. The water vapor in the air is forced out of the air by this cooling, and if the temperature in the carburetor is O'C or below, the moisture wil1 form as frost or ice inside the carburetor. Even a slight accumulation of carburetor ice will reduce power and may lead to complete stopping of the engine if the accumulation is allowed to continue.



Carburetor icing is a form of induction system icing. This type of icing occurs under a wide range of atmospheric conditons. More accidents result from carburetor icing than from any other kind.

Figure 6

GLOSSARY

CARBURETOR: noun; a piece of equipment used on some gasoline engines to mix air with the gasoline so that it can be burned in the engine

Ex. Atmospheric air enters the engine through the carburetor.

CLEAR ICE: noun ; transparent glassy ice

Ex. The rain froze last night; all of the trees are covered with clear ice.

DEWPO INT : noun; the temperature at which the humidity in a particular local air mass reaches the saturation point

Ex. The air isn't saturated at this temperature; but if the temperature falls 10 F it will reach the dewpoint.

DRAG : noun; the name of the force that opposes the forward movement of an aircraft through the air

Ex. Structural icing increases the aircraft's drag.

EFFECT: noun; a result of an action a To3bob

Ex. I don't know what the effect of this change will be.

Note: affect = verb, effect = noun

FAVORABLE : adjective; good conditions for a particular thing to happen, or good conditions

Ex. The weather conditions will be favorable for snow over the next three days.

FROST: noun; a light form of ice caused by condensation of the water from the air in freezing temperatures Ex. There was frost on the grass and trees this morning when I got.' up.

HAZE: noun; the restriction to visibility caused by very small dust or salt particles in the air

Ex. Normally you can see the mountain from here if there is no haze.

HORIZONTAL: adjective; parallel to the surface of the earth, opposite of vertical

Ex. Stratiform clouds form in horizontal layers.

ICING: noun; the process of forming ice on a surface

Ex. Three aircraft have reported icing in thiat area.

INDUCTION SYSTEM: noun; the group of parts that guide air to the aircraft engine

Ex. If air can't enter through the induction system, won't run.

LIFT: noun; the name of the force that opposes weight and causes an aircraft to move upward

Ex. The airplane wouldn't be able to fly if it didn't have lift.

MODERATE: adjective; an amount that is not particularly large or small

Ex. We have only had a moderate amount of rain this year.

POOR: adjective; not good, almost bad

Ex. Visibility is poor when it is snowing.

PREVENT : verb; to stop something from happening

Ex. The doctor gave him some medicine to prevent him from sick on the airplane.

RIME ICE: noun; rough, white-colored ice

Ex. When the airplane landed it still had rime ice on the wings.

SUPERCOOL: adjective; cooler (colder) than normal

Ex. They are called supercooled drops because they are still 1iquid even though it is below o c.

Note: super - more than normal, i.e., superlight, much lighter than normal.

THICK : adjective; (1) the third measurement for solid objects

Ex. The book is 10 inches 1ong, 8 inches wide, and 1 1/2 inches thick.

Ex. This book is thicker than yours.

(2)the opposite of thin

Ex. .The material in our winter uniform is thick; the cloth in our summer uniforms is thin.

THIN: adjective; (1) the opposite of thick

Ex. Don't walk on the wing of the airplane when you,work on it; the metal is very thin.

(2)the opposite of fat

Ex. He is so thin now that his uniforms don't fit him.

THRUST: noun; the name of the force that moves an aircraft forward and opposes drag

Ex. The ice on the wings is increasing drag; our effective thrust is decreasing

TRACE : noun; a small amount, sufficient to show something exists

Ex. There was a trace of ice on the wings, but it had no real effect.

VAPOR: noun; a gas as compared to a liquid or a solid

Ex. When water evaporates into the air, the gas is called water vapor.

VAPORIZE: verb; to change to a gas

Ex. The gasoline is vaporized in the carburetor.

Language Exercises

I. NEW TERMINOLOGY: Oral Exercises

1. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

Horizontal	dewpoint	drizzle
haze	vapor	icing
poor	favorable	prevent

a. Liquid gasoline is dangerous; the _____ the evaporates from the gasoline is very dangerous.

b. I just heard the weather report. is raining now and the temperature will drop below freezing. We should watch for _____ .

c. The instructor said that I will have to take the test again because I made such a _____score the first time.

d. There are no clouds and the day is sunny; but the _____keeps you from seeing very far.

e. When small drops of water condense on grass early in the morning it's called dew. It doesn't occur unless the air reaches its . _____ .

f. High humidity and cool temperatures are _____conditions for the occurrence of dew.

g. One way to _____making mistakes is to work slowly and carefully, and to stop and rest when you are tired.

h. When we say that writing paper has lines, we usually mean that it has _____ lines, not vertical lines.

i. I don't think we will get very wet; it's not raining, it's just a _____ .

j. Most people call the evaporated water in the air, water _____ .

k. Haze, fog, drizzle, etc., are all causes of_____ visibility.

l. I put my name on the front of my book to _____somebody from taking it by mistake.

m. Normally when we ask a person 'How far can you see?" we are talking about _____ visibility.

n. After a cold front passes, the air clears and conditions are usually _____ for good visibility.

2. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

Lift	effect	thick (-er, -est)
drag	supercooled	thin (-er, -est)
thrust	clear ice	
structure	rime ice	

a. Increased weight is one of the _____ of icing on aircraft.

b. When the downward and upward forces are in an equilibrium, the aircraft keeps flying at the same altitude. If the _____force is increased, the aircraft will increase its altitude.

C. When ice is 1ike glass and you can see through it, it is called_____ .

d. Normally water freezes at O'C; but sometimes drops stay liquid at temperatures below 0'C. They are called _____drops.

e. Often when a large building is built, they will complete the _____before they put in any walls or floors.

f. The engine of the aircraft provides the _____that moves forward.

g. A person who is 2 meters tall and weighs 60 kilograms is a _____person.

h. Hail is similar to _____ because it is usually rough and white.

i. A book with 300 pages is usually_____. than a book with 100 pages.

j. Since icing affects the airflow over an aircraft's structure, force. it usually increases the _____ force.

k. It is easy to remember the forces acting on an aircraft as opposites;_____ opposes weight,_____ opposes thrust.

i. If _____ and _____occur at the same time, it is called mixed ice.

m. Haze isn't like precipitation; it has no _____ no the aircraft, it only limits visibility.

n. The _____ of the aircraft is covered with thin metal.

3. Select words from the list below to complete the following es. Some of the words may be used more thai and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

frost	vaporization	trace frost
moderate	carburetor	carburetor
induction system	structural	

a. Some regions have what is known as a _____ climate; it isn't particularly hot in the summer or cold in the winter.

b. Moisture that condenses on a surface as drops of called dew. When it condenses on a surface as thin ice, it is called_____ .

C. Liquid gasoline is changed place in the carburetor. to a gas; this _____takes place in the carburetor.

d. There was a _____of rain last night, but there wasn't enough to measure.

e. Some engines use a _____ to vaporize the gasoline and mix it with air.

f. Since the _____ is used to lead outside air to the engine, it also can be affected by icing.

g. The shape of the aircraft's surfaces. can be changed by _____ icing.

h. When icing just shows on a surface and doesn't increase, it is classified as a _____; it is no danger to the aircraft.

i. Evaporation and _____ have almost the same meaning.

j. It didn't snow last night, and there was no rain to freeze; that white stuff on the car must be_____ .

k. The weight of the aircraft is increased by _____ . Icing

l. Icing in the _____ can reduce the flow of outside air to the engine.

m. 'Icing can also form when the vaporized gasoline and air mix. This _____icing reduces or. even stops the flow of the gasoline air mixture to the engine.

II. SENTENCE PRACTICE: Oral Exercises

NOTE: Long sentences are often formed by using a connecting word or se to join, two (or more) statements. The connecting word or phrase usually identifies a relationship between the two statements. Compare the connectors used in the following sentences.

(1) The northern hemisphere has summer when the southern hemisphere has winter.

(when = at the same time)

(2) The earth is rotating around its own axis while it is revolving around the sun. (while = at the same time; frequently used with "-ing" verbs)

(3) Temperature decreases as altitude or height above sea level increases. (as = at the same time, with the idea of gradually or step by step)

(4) Weather is discussed in nontechnical terms by all people since everybody experiences the weather conditions them throughout their lives. (since = because, for this reason, etc.)

(5) Maritime air moves over the continents and continental air moves over the seas and oceans. (and = both events happen; i.e. John studies French and his sister stu English.)

(6) The drops get larger and larger and the drops fall as precipitat ion. (and = sequence; one event fo11owed by another event.)

Other frequently used connectors are:

because= for this reason

when = sequence; i.e., I'll buy a car when I get my driver's license.

since = for this reason; i.e., Since you paid for dinner last night, I'l1 pay tonight.

since = sequence; event 2 began at time specified, i.e., He has been studying English since he arrived in May.

until = sequence; event 1 continues up to time of event 2.

before= sequence; event 1 occurred before event 2.

after= sequence; event 2 occurred after event 1.

so = reason; i.e., He bought a camera so he could send pictures home.

at the same time

whenever = event 2 occurs each time event 1 occurs.

Unless = event 2 does/doesn't occur except when event/condition does/doesn't occur.

Select connectors and combine the fol1owing sentences as shown in the example. Use "it" or "they" when appropriate.

Examples: The earth revolves around the sun.

The earth rotates around its own axis.

Say: the earth revolves around the sun at the same time it around its own axis."

a. (1) The height of the column of mercury in the barometer changes.

(2) The weight of the atmosphere changes.

_____

_____

b. (1) The partially empty container expands and contracts.

(2) The container is sensitive to changes in atmospheric pressure.

_____

_____

C. (1) The earth completes one rotation every 24 hours.

(2) Each part of the earth has one day period and one night period every 24 hours.

_____

_____

d. (1) We only studied about the troposphere and the stratosphere.

(2) Most aircraft flights and weather occur in those layers.

_____

_____

e. (1) The aneroid barometer is checked weekly against a mercurial barometer.

(2) The aneroid barometer is less accurate and may need adjustment.

_____

_____

f. (1) Air begins to flow from areas of higher pressure to areas of lower pressure.

(2) The equilibrium of atmospheric pressure is disturbed.

_____

_____

g. (1) The air at the equator expands and rises.

(2) The earth receives more heat, at the equator and transfers it to the air.

_____

_____

h. (1) The air in the northern hemisphere is deflected toward the earth.

(2) The air rise's and moves northward from the equator.

_____

_____

i. (1) Air masses move away from their source regions.

(2) Air masses are constantly modified by the areas they pass over.

_____

_____

k. (1) Two air masses that meet normally do not mix.

(2) Two air masses have similar temperatures, pressures, and relative humidity.

_____

_____

l. (1) The warm air mass is replaced by a colder air mass.

(2) The warm air mass moves back from a given area.

_____

_____

m. (1) The warm air slides over the wedge of colder air ahead of it.

(2) The warm air mass moves forward.

_____

_____

n . (1) Clouds in the form of altostratus and cirrostratus appear.

(2) Stable warm air moves up the slope of the front and the temperature falls.

_____

_____

0. (1) The fast moving cold front has passed.

(2) The weather clears rapidly, there is cooler drier air, and usually unlimited ceiling and visibilities

_____

_____

III. VOCABULARY EXPANSION: Oral Exercises

Use the correct form of the words listed to complete the following sentences. Some words may be used more than once.

a. vision, n. visible, adj. visibility, n.

invisible, adj. visibly, adv.

(1) You can't see air, it's a good example of something that is _____ .

(2) It is a good idea to have your_____ checked every year.

(3) After a cold front passes, the air clears and _____ is very good.

(4) When ice is just _____on the surface ut does not accumulate, it is classified as "trace.''

(5) The shape of the wing changed _____as the ice accumulated.

(6) Convection currents are _____ but cumulus clouds are an indication that they are occurring.

b. limit, n. limit, v. limited, adj. unlimited, adj.

limitations, n. limiting, adj.

(1) Even' on a cloudless day, haze can _____ visibility to a short distance.

(2) It was such a clear day that we had _____visibility.

(3) If you want to go on the trip, tell them quickly; because the number they can take is _____ .

(4) The policeman stopped him because he was driving faster than the speed _____ .

(5) I would really like to travel and see the country but there are several _____ factors: I don't have much money; I don't have much free time; and I don't speak the language.

(6) The post office establishes _____on the type of package that can be mailed; it must be less than a certain size, weight, etc.

(7) The tropopause marks the _____ of the troposphere.

c.

observe, v.	observer, n.	observation, n.
observed, adj.	observing, adj.	unobserved

(1) An _____ person can predict what the weather will be for the next few hours just by knowing about the different types of clouds.

(2) At the weather station they make official weather _____ every hour.

(3) Many changes in cloud formations are _____ because they occur at night.

(4) His brother works as a weather _____ the government.

(5) the weather report includes information about the _____ clouds, the pressure, the humidity, the wind speed and direction, and _____ precipitation.

(6) Anyone can learn to _____ the weather around him.

(7) The station keeps records of all of the weather _____ for the last few years.

UNIT 7

Weather Hazards (2)

SECTION 3. TURBULENCE

1. General

a. The effect of turbulence on aircraft ranges all the way from a few small bumps to severe jolts which are capable of producing structural damage. Since turbulence is associated with many different weather situations, it is helpful to have a knowledge of its causes and how the irregular air movements act.

b. The atmosphere is considered turbulent when irregular eddies of air affect aircraft so that a series of intermittent jolts or bumps are felt. A large range of eddy sizes exist, but those causing turbulence are about the same size as the aircraft and usually occur in an irregular sequence. The reaction of the aircraft to the turbulence varies not only with the intensity of the eddies, but also with the aircraft characteristics such as flight speed, size of the aircraft, altitude of the aircraft, and wing lift/weight relations. Turbulence can cause quick unpredictable changes in the aircraft's altitude and attitude.

2. Intensity of Turbulence.

a. Classification of turbulence intensity is a difficult problem for pilots and weathermen. The pilot's judgment of turbulence severity may be influenced by the length of time his plane is exposed to turbulence, the amount of experience the pilot has, and the type of aircraft he is flying.

b. In order to provide a standard for reporting and describing turbulence, turbulence has been classified into four intensities; light, moderate, severe, and extreme, according to its effect on the aircraft and its occupants. Turbul ence that causes a continuing rapid series of bumps or jolts is called chop.

Figure 1

TURBULENCE REPORTING CRITERIA TABLE			
INTENSITY	AIRCRAFT REACTION	REACTION INSIDE AIRCRAFT	REPORTING TERM-DEFINITION
Light	Turbulence that causes slight unpredictable changes in altitude and/or attitude, report as LIGHT TURBULENCE; or Turbulence that causes slight rapid continuous bumpiness without large changes in altitude/attitude, report as LIGHT CHOP.	Occupants may feel slight pressure against seat belts. Objects may move slightly. Food may be served and little or no difficulty is encountered in walking.	Occasional - less than one-third of time. Intermittent - one-third to two-thirds. Continuous - more than two-thirds.
Moderate	Turbulence that is similar to Light Turbulence but of greater intensity. Changes in altitude and/or attitude occur but the aircraft remains in control at all times. It usually causes variation in the indicated airspeed, report as MODERATE TURBULENCE. or Turbulence that is similar to High Chop but of greater intensity. It causes rapid bumps or jolts without major change in altitude or attitude, report as MODERATE CHOP.	Occupants feel definite pressure against seat belts. Objects are moved and/or fall. Food service and walking are difficult.	NOTE 1. Pilots should report location(s), time, intensity, whether in or near clouds, altitude, type of aircraft and, when applicable, time length of turbulence. 2. Time length may be based on time between two locations or over a single location. All locations should be easily identifiable.
Severe	Turbulence that causes quick large changes in altitude and/or attitude. It usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control, report as SEVERE TURBULENCE.*	Occupants are forced against their seat belts. Objects are thrown around. Food service and walking are impossible.	
Extreme	Turbulence in which the aircraft is thrown about with great force and is almost impossible to control. It may cause structural damage, report as EXTREME TURBULENCE.		

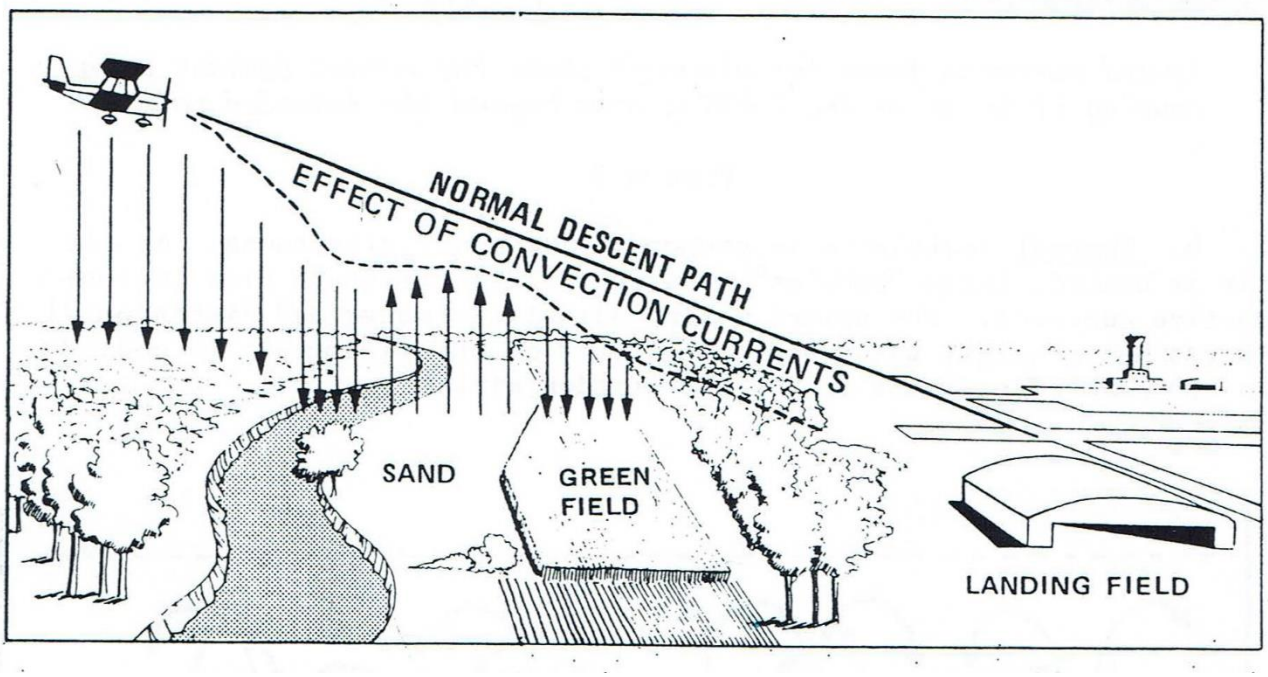
*High level turbulence (normally above 15,000 feet ASL) not associated with cumuliform cloudiness, including thunderstorms, should be reported as CAT (clear air turbulence) preceded by the appropriate intensity, or light or moderate chop.

3. Types of Turbulence

Turbulence is divided into four general types based on the meteorological and physical properties responsible for its existence. These types are convective, mechanical, wind shear, and high altitude clear air turbulence (CAT). Although the principal cause of clear air turbulence is wind shear, it is given a special classification because of its importance for jet aircraft.

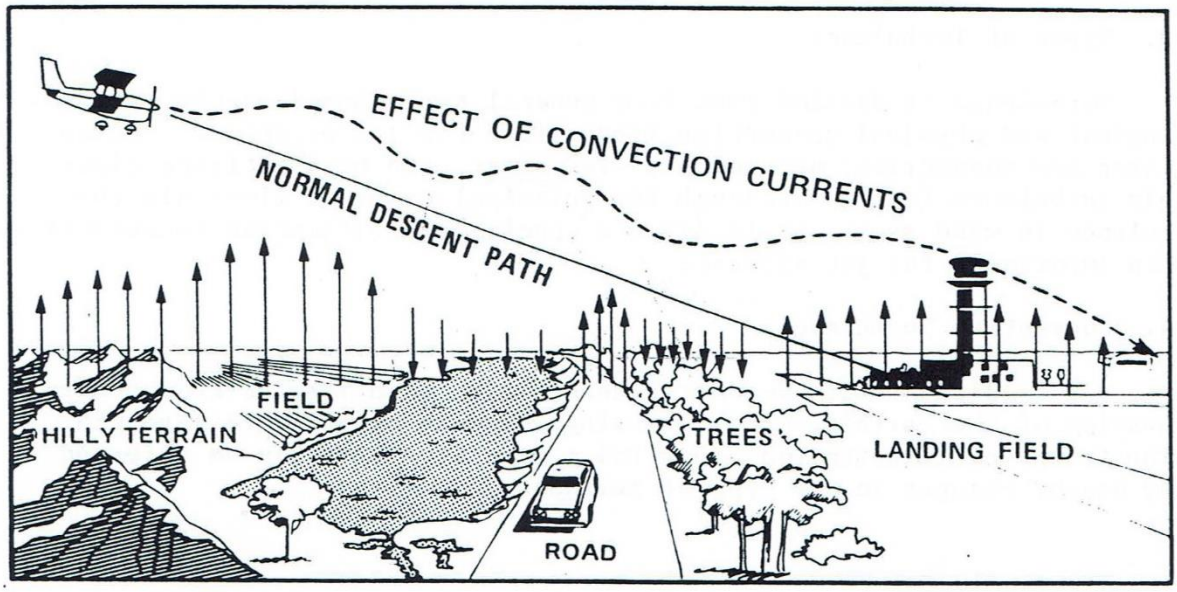
4. Convective Turbulence

a. As discussed in Weather Causes, convection results from uneven heating of the earth's surface causing currents of variable strength. The following illustrations show how a normal descent may be affected by nearby changes in the type of surface.



Downward currents allow the aircraft to fall below the normal descent path causing it to enter the landing area short of the intended point.

Figure 2



Upward currents force the aircraft above the normal descent path causing it to enter the landing area beyond the intended point.

Figure 3

b. Thermal turbulence is common during sunny afternoons. As the air is heated, large "bubbles" of warm air are forced to rise in convective currents. The upward moving air rises faster and faster until • it reaches a height where the temperature of the rising air is cooled to the same temperature of the surrounding air.

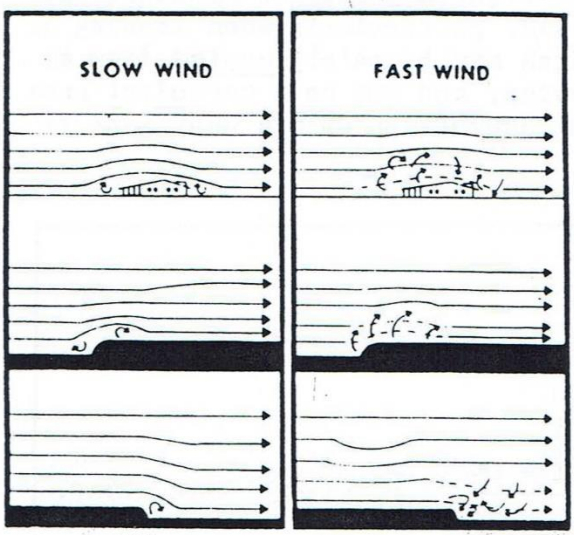
Cumulus clouds are signs of convective currents. Aircraft flying below the tops of cumulus clouds encounter turbulent air. Above the tops smooth flight is possible if convection does not extend above the cloud tops

Figure 4

c. It is important to remember that both up and down drafts develop. Turbulence is more severe when updrafts and downdrafts are close together. Even if the air is very dry with no clouds, convective turbulence may be present.

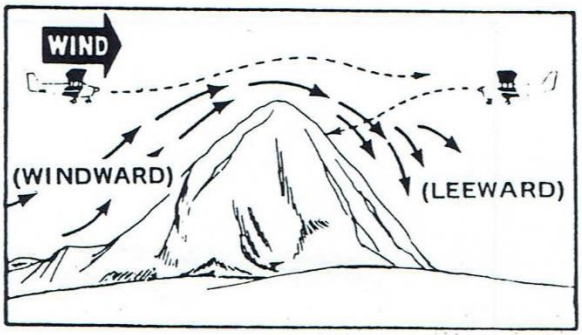
5. Mechanical Turbulence

a. An object placed in any moving air current disturbs the flow by causing the wind to change its direction of flow to go around the object. Mechanical turbulence is caused by wind flowing over or around an obstruction. The area before the obstacle is called the windward side; the area after is the leeward side



Obstructions to wind flow cause irregular eddies when the wind flows around and passes the obstacle. The degree of turbulence depends on the size and shape of the obstacle, the speed of the wind, and the stability of the air.

Figure 5



Mechanical turbulence in mountains. Air flowing through mountainous terrain is forced upward over the mountains then sinks downward on the opposite side. The degree of turbulence caused by the mountains depends on the shape and size of the mountains, the direction and speed of the wind, and the stability of the air.

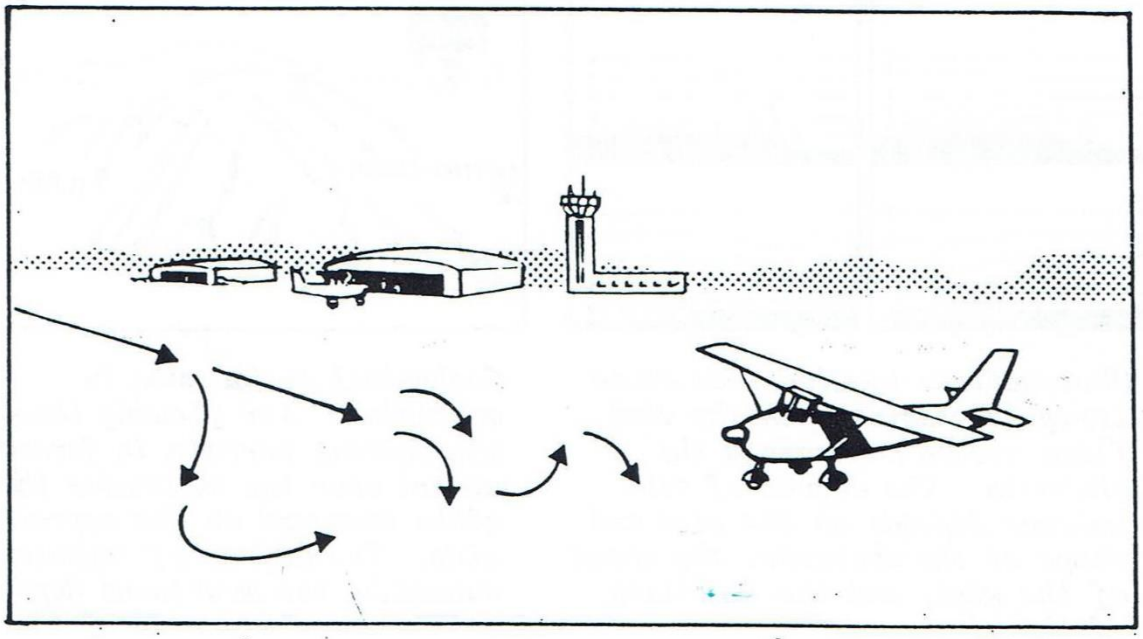
Figure 6

b. Air currents separate to flow around an obstacle and rejoin after they pass the obstacle. When they rejoin, eddy currents develop in the flow that has passed the obstacle. These eddy currents create mechangcal turbulence. If the obstacle had not been there, and no other factor influenced the flow, the wind would flow smoothly and undisturbed. Mechanical turbulence is caused by obstructions in the path of the wind, and is not caused by meteorological processes in the air mass itself. Some objects which tend to produce this type of turbulence are mountains, hills, buildings, and moving aircraft.

6. Low-Level Mechanical Turbulence

a. Low-level mechanical turbulence is turbulence near the ground that is caused by wind flowing over and around obstructions. The obstructions can be large or tall buildings and other man-made structures, hills, trees, etc. The amount and location of the turbulence is dependent on the wind speed and direction it is blowing from. The turbulence forms downwind from the obstruction, i.e., a west wind produces turbulence east of the obstruction.

b. It is important for pilots of light aircraft to consider the variability of the wind near the ground, particularly when landing or departing an airport. The landing area may be safely upwind from an obstruction when an east wind is blowing, and yet be a turbulent area because it is downwind from the same obstruction when a west wind is blowing.

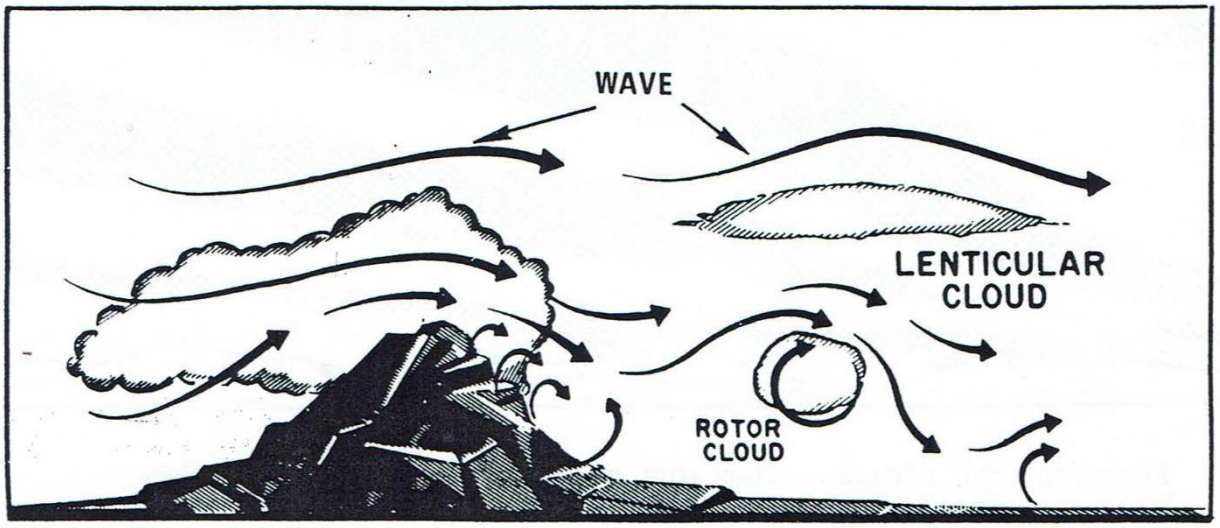


Obstructions at an airport may cause turbulence in the landing area. It is necessary to become familiar with the location and type of turbulence produced in the airport area by winds coming from different directions and at different speeds.

Figure 7

7. High-Level Mechanical Turbulence

a. The air flow becomes very disturbed when wind blows over long lines of mountains. The wind blowing up the slope is usually relatively smooth if the air is stable. On the downwind side the air falls rapidly down the slope. This produces strong downdrafts and causes the air to be very turbulent. When air passing over the line of mountains has sufficient water vapor to produce clouds, lenticular and rotor clouds form downwind from the mountains and indicate severe turbulence. If water vapor is not sufficient to form clouds, severe turbulence can exist even though the characteristic clouds are not present.



When air is forced over mountains and there is sufficient water vapor, characteristic clouds can form. The most characteristic clouds are those that surround the mountain top, and the lenticular and rotor clouds downwind. The lenticular and rotor clouds are signs of severe turbulent conditions, though the conditions may exist even when the clouds are not present.

Figure 8

b. When winds faster than about 50 knots blow directly across a line of mountains, the resulting turbulence may be extreme. Areas of continuous updrafts and downdrafts can extend many times higher than the elevation of the mountain tops. When these conditions occur the air cutrents make regular upward and downward movements called waves in the downwind areas. The waves sometimes extend upward beyond the tropopause. They are called standing waves when they tend to continue in the same location over periods of time.

c. Waves not only reach great altitudes, but they also sometimes extend as far as a hundred miles horizontally downwind from the line of mountains. These waves of air are referred to as standing waves or mountain waves. They are characterized by standing lenticular altocumulus and/or rotor clouds when sufficient moisture is available. These clouds may form as long lines which are called standing wave clouds.

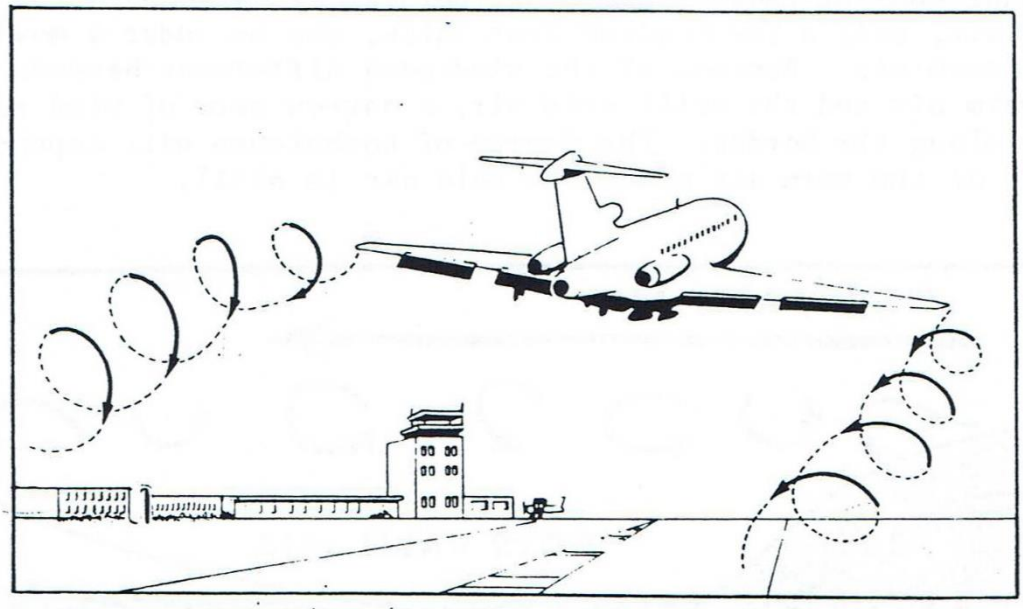
Standing wave clouds. They are called standing because they have very little movement, but the wind flowing through the clouds can be extremely strong.

Figure 9

d. Reports of turbulence in waves may range from none to extreme, but usually moderate to severe turbulence will be encountered. The most dangerous characteristic of the standing wave airflow is that the updrafts and downdrafts can be very strong and extend great distances upward or downward.

8. Wake Turbulence

Every aircraft produces a wake when in flight. This turbulence is in the form of two counter-rotating vortices of air extending backward from the tips of the wings. The strength of the vortex produced by the wing tip is determined primarily by the weight, speed, and shape of the wing of the aircraft. The wake produced by a large aircraft can be particularly dangerous to a small, light aircraft.



Turbulence in the form of air currents flowing in a spiral is produced by the wings of an aircraft. These vortices produced by the wing tips are called wake turbulence.

Figure 10

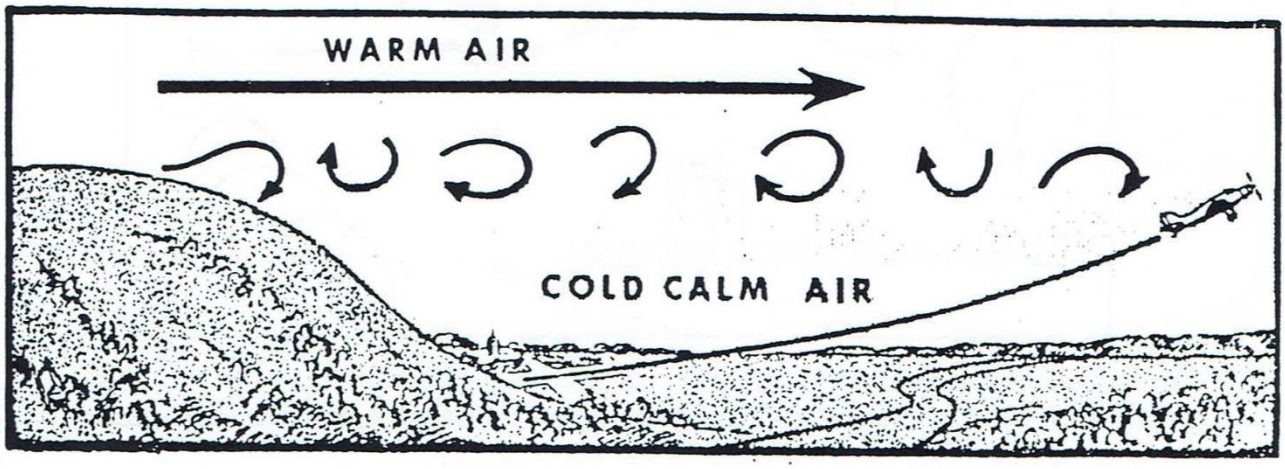
9. Wind Shear

Wind shear exists when there is contact between currents of air flowing in different directions and/or at different speeds. There is a tearing or shearing effect where the currents are in contact with each other. The eddies formed in this contact area are called wind shear turbulence. Wind shear can exist at the horizontal boundary between layers of air moving in different directions and/or at different speeds, or it can exist along a vertical boundary when upward or downward currents are in contact with currents moving in a different direction and/or at a different speed. Horizontal or vertical wind shear can exist at any altitude. The intensity of the turbulence increases as the amount of wind shear increases.

10. Shear with Temperature Inversion

a. A narrow zone of wind shear, and the turbulence it produces, is often encountered when an aircraft goes up through or descends through a temperature inversion. The wind speed and/or direction sometimes changes very quickly with altitude in this zone.

b. Wind shear that occurs with a strong temperature inversion near the ground is a particular hazard to aircraft immediately after departing or just before landing at an airport. Typically, heat from the ground radiates up and is lost during the night. This nighttime radiational cooling causes a layer of cold air to form near the ground. The cold air, only a few hundred feet thick, may be under a moving layer of warm air. Because of the windspeed difference between the moving warm air and the still cold air, a narrow zone of wind shear develops along the border. The degree of turbulence will depend on the speed of the warm air since the cold air is still.



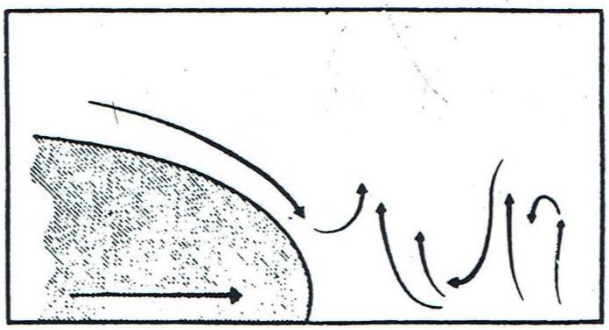
Wind shear located in a zone between the still wind within an inversion and the relatively strong wind above the top of the inversion. This condition is most common at night.

Figure 11

11. Shear Turbulence with Fronts

a. Because winds on either side of a front have different speed and direction, a shear zone exists along the border of these winds.

b. This shear can produce hazardous turbulence for aircraft landing or departing in an airport area when frontal passage takes place. The air ahead of a fast moving cold front is forced upward by strong lowlevel winds. This results in gradually increasing low-level turbulence as the front approaches the airport.



Turbulence ahead of a fast moving cold front. The rapid movement of the approaching cold air creates eddies ahead of the front. Conditions in the frontal zone are favorable for wind shear turbulence.

Figure 12

12. Clear Air Turbulence

The term "clear air turbulence" (CAT) generally refers to high-level wind shear turbulence which frequently occurs in the area of a jet stream. The intensity of CAT may be such that it causes serious problems for aircraft and passengers.

13. Characteristics of CAT

High-level clear air turbulence tends to occur in limited areas for short periods of time. The size of the turbulent area is quite variable, but it is thought to be around 2,000 feet thick, 20 miles wide, and 50 miles or more long. The areas become longer in the direction of the wind. The exact position of one of these areas is difficult, if not impossible to locate. The determination of the locations is largely dependent on pilot's reports; however, the meteorologist can predict general areas where the turbulence might occur.

14. CAT by Seasons

There are from three to four times more CAT occurrences during winter han sunmer. The most frequent altitude of jet stream CAT en counters is 30,000 feet in winter and 34,000 feet in summer.

GLOSSARY

ATTITUDE: noun; the position of an aircraft in relation to its areas, i.e., whether the front is pointed upward or downward, or to the right or left; or whether one wing is higher than the other Ex. When the aircraft leaves the airport the pilot usually puts it in a front-up attitude to gain altitude rapidly.

BUMP: noun; (1) a small projection or raised area on an even surface

Ex. Drive slowly here, there are a lot of bumps in the road.

(2) the effect on a vehicle or aircraft as if it has run over a bump.

Ex. I didn't see what we ran over but I felt the bump.

CHOP: noun; (when reporting turbulence) a turbulence that produces

the effect of a continuous series of close together bumps

Ex. We had about three minutes of light chop but otherwise there was no turbulence and the flight was smooth.

DRAFT: noun; a current of air; updraft = a current of air upward,

downdraft = a current of air downward

Ex. The aircraft went through a strong downdraft and lost altitude.

DOWNWIND: adjective or adverb; a position from an object so that the

wind blows from the object to that position

Ex. You can expect turbulence if you are downwind from the mountains.

EDDY: noun; a turning current of air behind an obstruction caused by

the motion of the air passing around or over the obstruction

Ex. There are eddies of air downwind from the building that are dangerous to small aircraft when they are landing.

EXTREME: adjective; a very large degree of effect

Ex. The heat last summer was extreme for this area.

Ex. The aircraft was damaged by extreme turbulence.

INTERMITTENT: adjective; occurring with irregular frequency

Ex. We have had intermittent rains for three days.

JOLT: noun; the effect on a vehicle or aircraft as if the structure

had received a quick strong hit

Ex. That last jolt was very strong, if we have many more like that the aircraft will be damaged.

LEEWARD: adjective or adverb; the position of objects that are downwind

from another object (See downwind.). Ex. Lenticular clouds form on the leeward side of the mountain.

LEVEL: noun; a particular altitude

Ex. There is too much turbulence at this level; let's go up a couple of thousand feet.
Ex. There are a few low-level clouds but that's all.

OCCUPANT(S): noun; the person(s) in a vehicle, aircraft, building, area, etc.

Ex. The aircraft was damaged when it landed, but none of the occupants were hurt.
NOTE: verb; occupy

REACTION: noun; an action produced as a result of another action

Ex. Turbulence that affects a small aircraft may produce no

reaction in a large, heavy aircraft.

ROTOR CLOUD: noun; a ball-shaped cloud that sometimes forms near a line of mountains
Ex. Rotor clouds and standing lenticular clouds are signs of severe turbulence.

SHEAR: noun; a tearing or breaking effect produced by force moving

in one direction against a stationary object, or an object moving in the opposite direction

Ex. You can see on the piece of metal that it is breaking as a result of shear caused by too much weight.

NOTE: verb; shear

Ex. When the truck went off the road it sheared the tree off right at the surface of

the ground.

THERMAL: adjective; caused by heat, or dealing with heat

Ex. Hot air rising is sometimes called a thermal current.

UPWIND: adjective or adverb; a position from an object so that wind

blows from that position to the object

Ex. You won't find much turbulence when you are upwind from the obstruction.

VORTEX, VORTICES: noun; a current that flows in a spiral

Ex. Water forms a vortex in a container when it drains from a hole in the bottom of the container.

Ex. The wind flowing over and around the wing tips creates vortices behind the aircraft.

WAKE: noun; the disturbance in a fluid (liquid or air) caused by an

object moving through the fluid

Ex. You can see the wake behind the boat. Ex. the aircraft leaves a wake behind it as it moves through the air.

WAVE: noun; a regular up and down movement in a fluid (liquid or air)

Ex. The strong wind caused large waves to form on the lake.

Ex. The mountains caused waves to form in the air current.

WINDWARD: adjective or adverb; the position of an object that is upwind from another object (See upwind.)

Ex. Updrafts are more common on the windward side of the mountains.

Language Exercises

I. NEW TERMINOLOGY: Oral Exercises

1. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

bump	intermittent	extreme
jolt	reaction	
eddy	attitude	

a. The front of the aircraft is the nose. When the aircraft is climbing it usually has a nose-up _____.

b. When we say an area has a moderate climate, we mean that it doesn't have _____ cold in the winter or _____ heat in the summer.

c. If a strong wind is blowing across an obstacle,_____ currents are formed downwind from the obstacle.

d. They really should repair this road; it's old and has a lot of _____.

e. This has been an unusual day; we have had _____ rain and sun all day.

f. Since you can't see wind, it is difficult to know how strong it is; but you can watch trees to see the _____ of the trees to the wind.

g. There was a strong _____ when the car hit the bus, but no one was hurt.

h. The pilot puts the plane in a nose down _____ when he is descending to land.

i. The turbulence was like a series of small _____ ; it was just strong enough to feel but it didn't cause any problems.

j. Roll clouds and lenticular clouds often form in the _____ currents downwind from a mountain.

k. A gusty wind is a wind that has _____ increases of speed that don't last very long.

l. Unless it is corrected, the _____ of an aircraft to an updraft is to increase altitude.

m. When turbulence is classified as _____ , it is very dangerous to aircraft.

2. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

occupants	draft	upwind
shear	level	chop
thermal	downwind	

a. Since convection currents are caused by heating, they are also called _____ currents.

b. Mechanical turbulence can be expected in the _____ area from an obstacle.

c. If a car has a driver and three other people in it, it has four _____ .

d. The towers of cumulus clouds are formed by up _____.

e. CAT is a special form of high _____ turbulence.

f. Since the bumping caused by the turbulence was continuous, the pilot reported it as _____.

g. If the wind is blowing from your position toward an obstacle, you are _____ _____from the obstacle.

h. If the air is still near the ground and moving at a higher altitude, there is wind _____ near the border of the two layers.

i. Mechanical turbulence is classified into two general types, high _____ mechanical turbulence and low _____mechanical turbulence, according to the altitude it occurs at.

j. When there is a local convection circulation, the hot air rises as up _____ and the cool air descends as down _____ .

k. Since upward and downward currents move at different speeds than the air around them, wind _____ occurs along the edges of the currents.

l. When an aircraft is flying through turbulence, the _____ of the aircraft should keep on their seatbelts.

m. A sunny day is more likely to produce. _____currents than a cool cloudy day.

n. If the wind is blowing from the east, the eastward side of an obstacle is the _____side, the westward side is the side.

3. Select words from the list below to complete the following sentences.

Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

leeward	vortices	windward
rotor cloud	wake	
vortex	wave	

a. When standing lenticular clouds and small round _____ occur in a downwind area they are signs of severe turbulence.

b. A spiral-shaped current is often called a _____ .

c. The town is south of the mountain, that means it is on the _____ side when a northwind blows.

d. The turbulence produced by a moving aircraft is a special kind of mechanical turbulence _____ called turbulence.

e. The wingtips of a moving aircraft produce two _____ of air that extend behind the aircraft.

f. High-speed winds blowing across a mountain can create _____ currents that extend far above the mountain.

g. There should be much less turbulence on the _____ side of an obstacle.

h. Large, fast-moving vehicles disturb the air as they move. Even though it is invisible, they leave a _____ of air behind them

i. Downwind and _____ refer to the same position, and upwind and _____ also have the same general meaning.

j. Strong upward and downward currents called _____ often form to the leeward of mountains when strong, winds are blowing:

k. Lenticular clouds and _____form on the leeward side of the mountains

II. SENTENCE PRACTICE: Oral Exercises

NOTE: A series of two or more short sentences is often combined to make a single sentence that has the same general meaning. Compare the two following short sentences and the combined one.

(1) The earth rotates.

(2) The earth revolves around the sun.

Combined: The rotating earth revolves around the sun.

Combine the two shorter sentences into a single sentence as shown in the examples.

Example 1

(1) The water vapor condenses.

(2) The water vapor forms clouds.

Say: "The condensing water vapor forms clouds."

Example 2

(1) The larger drops precipitate.

(1) The larger drops fall as rain, snow, sleet, or hail.

Say: "The precipitat ing larger drops fall as rain, snow, sleet, or hail."

a. *(1)* The air masses move.

(2) The air masses are a major factor in an area's climate.

_____

_____

_____

b. (1) The height of the column of mercury varies.

(2) The height of the column of mercury indicates changes in atmospheric pressure.

_____

_____

_____

c. (1) The hollow container expands and contracts.

(2) The hollow container moves an indicator arm up and down a scale to show pressure changes.

_____

_____

_____

d.

(1) The air at the equator expands.

(2) The air' at the equator rises and moves toward the poles.

_____

_____

_____

e. (1) The air circulates.

(2) The air follows a regular path from the equator to the poles and back.

_____

_____

_____

f. (1) The cold air contracts.

(2) The cold air descends to the surface near the poles.

_____

_____

_____

g. (1) The large high- and low-pressure systems migrate.

(2) The large high- and low-pressure systems have the temperature and humidity characteristics of their source regions.

_____

_____

_____

h. (1) The air currents rise.

(2) The air currents produce the rounded tops of cumulus clouds.

_____

_____

_____

i. (1) The warm air mass advances.

(2) The warm air mass slides over the wedge of cold air.

_____

_____

_____

j. (1) The warm front air rises and cools.

(2) The warm front air forms cirrus clouds up to 500 miles in advance of the front.

_____

_____

_____

k. (1) The wing tip vortices counter-rotate.

(2) The wing tip vortices extend to the rear of the aircraft.

_____

_____

_____

l. (1) The aircraft land and depart.

(2) The aircraft may experience temperature inversion wind shear.

_____

_____

_____

III. VOCABULARY EXPANSION: Oral Exercises

Read the sentence given, say the verb form of the underlined noun, and make a sentence using the verb form. Your sentences should say something about weather.

a. When the flow of air meets an obstruction it must either go over it or around it.

b. There is a standard classification for the intensity of turbulence.

c. The table gives a description of the effects of the different intensities of turbulence.

d. The variation in turbulence is very large, from small bumps to severe jolts.

e. The division of turbulence into four types is based on the causes of the turbulence.

f. Uneven heating of the earth near an airport may produce currents that affect an aircraft's descent.

g. Long lines of mountains can produce severe disturbances in the airflow.

h. Rotor and lenticular clouds indicate the existence of severe turbulence.

i. At night the radiation of heat from the ground may cause an inversion layer to form.

j. The determination of the location of CAT is largely dependent on pilots' reports.

k. The expansion caused by warming lowers the density of the air.

l. The northward movement of the air produces an accumulation of air in the northern part of the hemisphere.

m. There is a general circulation of the air from the equator to the poles and back again.

n. Weathermen spend many hours practicing the identification of different cloud types.

o. Towering cumulus clouds are definite indications of unstable air.

p. Any reduction of temperature in saturated cold air may produce fog.

UNIT8

Weather Hazards (3)

SECTION 4. THUNDERSTORMS

1. General

The thunderstorm is a local storm which is produced by a cumulonimbus cloud and is always accompanied by lightning and thunder. Thunderstorms are particularly dangerous for pilots because they are almost always accompanied by strong gusts of wind, severe turbulence, and icing. Heavy rainshowers normally accompany the thunderstorm, and hail is not uncommon. Since thunderstorms are so dangerous to a pilot, he is frequently provided with information as to the existence and location of thunderstorms. This section describes the structure, general types, and hazards of thunderstorms so that the importance of the information provided to pilots will be understood.

2. Formation

a. In order for a thunderstorm to form, the air must have sufficient water vapor, be unstable, and (initially) be forced upward. The first updrafts can be caused by convection currents from surface heating, sloping terrain, a front, converging winds, or any combination of the above.

b. As the upward moving air expands and cools, it causes condensation of the water vapor and the formation of a cumulus cloud. The process of condensation releases heat which slows the cooling caused by expansion. If this saturated updraft becomes warmer than the surrounding air, its lower density causes the updraft to increase the speed of its upward movement as more and more water vapor is pulled into the cloud and condenses, the cloud builds upward into a towering cumulus, and finally becomes a cumulonimbus cloud and produces a thunderstorm.

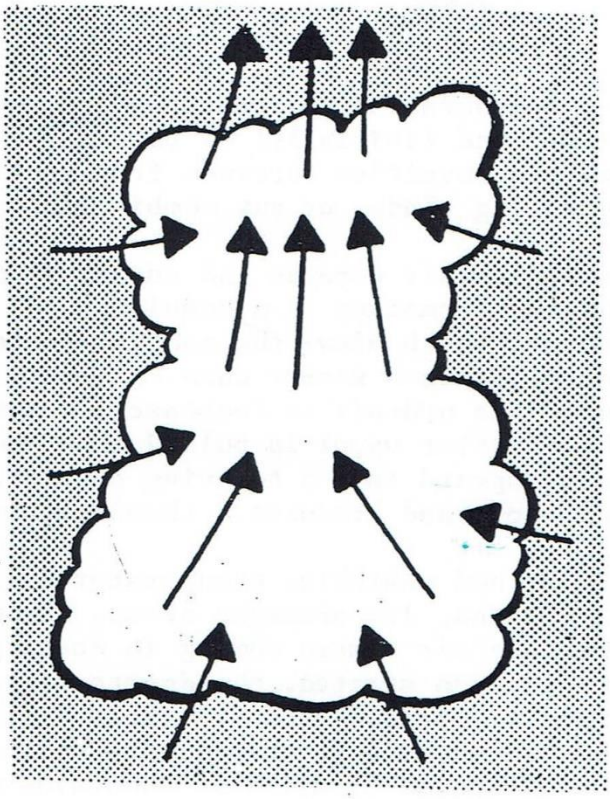
c. When air is moist and unstable, thunderstorms may be caused by daytime heating of the ground, low pressure areas, winds moving up a slope, or fronts. Even dry air masses coming in contact with moist air can cause thunderstorms. Once started, thunderstorms generally move with the winds aloft and may travel a considerable distance from their source. Thunderstorms caused by a front can move well ahead of the front as a squall line. Thunderstorms formed over mountains may move many miles out over the nearby flat lands.

3. Life-Cycle

All thunderstorm cells progress through three stages called the lifecycle. These stages are (1) the cumulus stage, (2) the mature stage, and (3) the dissipating stage. The difference between a severe and a less severe thunderstorm is related to the length of time and area covered when it is in the mature stage. Local air mass thunderstorms have a life-cycle from about 20 minutes to 15 hours, and are one type of thunderstorm. The other type covers larger areas, such as squall lines in advance of fronts, and may last as long as 24 hours.

4. Cumulus Stage

Although most cumulus clouds do not become thunderstorms, the initial stage of a thunderstorm is always a cumulus cloud. The main feature of the cumulus or "building" stage is the predominant updraft which may extend from the earth's surface to several thousand feet above the visible cloud top. During the early period of this stage the water drops in the cloud are very small but they grow into raindrops as the cloud builds upward.



Cumulus stage of a thunderstorm cell showing all upward vertical currents or updrafts.

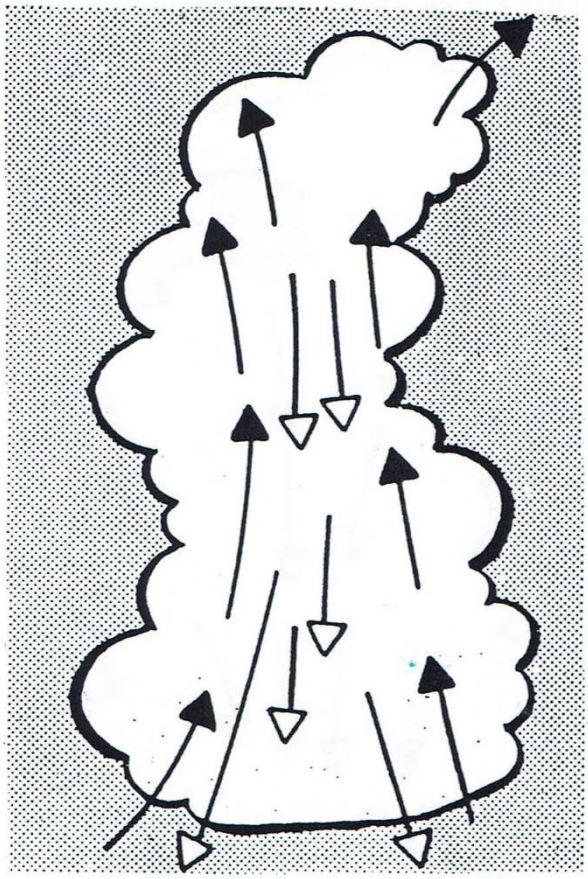
Figure 1

5. Mature Stage

a. The mature stage begins when drops are thrown out from the updrafts, or they become so large that the updraft can no longer hold them or lift them upward, and the drops begin to fall. This occurs approximately 10-15 minutes after the cloud has built upward above the freezing level.

b. As the raindrops fall they pull air with them. This is a major factor in the formation of downdrafts which characterize a thunderstorm in the mature stage.

c. The air being pulled downward by the falling rain is cooler than the surrounding air, and the pull caused by the falling raindrops speeds up its downward movement. Throughout the mature stage, downdrafts continue to develop and exist at the same time as the updrafts.

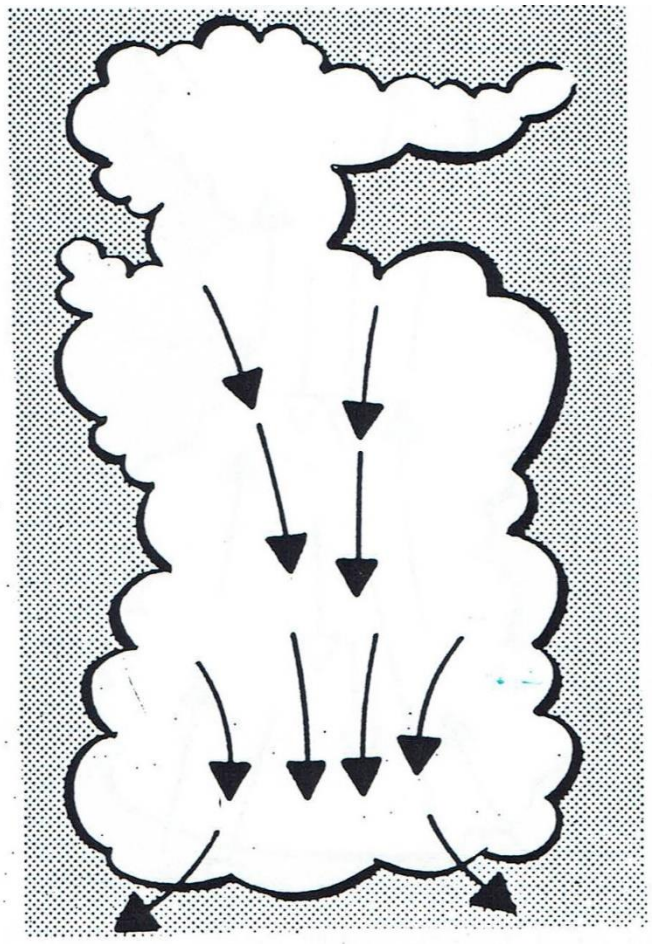


Mature stage of a thunderstorm cell. Downdrafts are passing through updrafts. The mature stage has the greatest vertical shear and is the most turbulent stage in the life-cycle of any thunderstorm.

Figure 2

6. Dissipating Stage

The dissipating stage begins when downdrafts predominate. When the updraft is too weak to hold the raindrops, precipitation falls through the upd raft. If the updraft is strong enough to prevent precipitation from falling through it, the precipitation may fall just outside the upward current. Whichever happens, the effect of the precipitation is to increase the density of the air by pulling cooler air downward with it, and to slow the updraft by the action of falling through it. The updraft will be slowed and finally reversed so that it becomes a downdraft. The downdraft and precipitation cool the lower part of the storm cloud and the surface over which it lies. The in-flow of water vapor to the cloud is stopped and the storm dissipates. When all rain and hail have fallen from the cloud, the dissipating stage is complete.



Dissipating stage of a thunderstorm cell. Vertical currents are all downdrafts. The rising effect has ended, and precipitation formation has stopped.

Figure 3

7. Thunderstorm Hazards

a. Turbulence

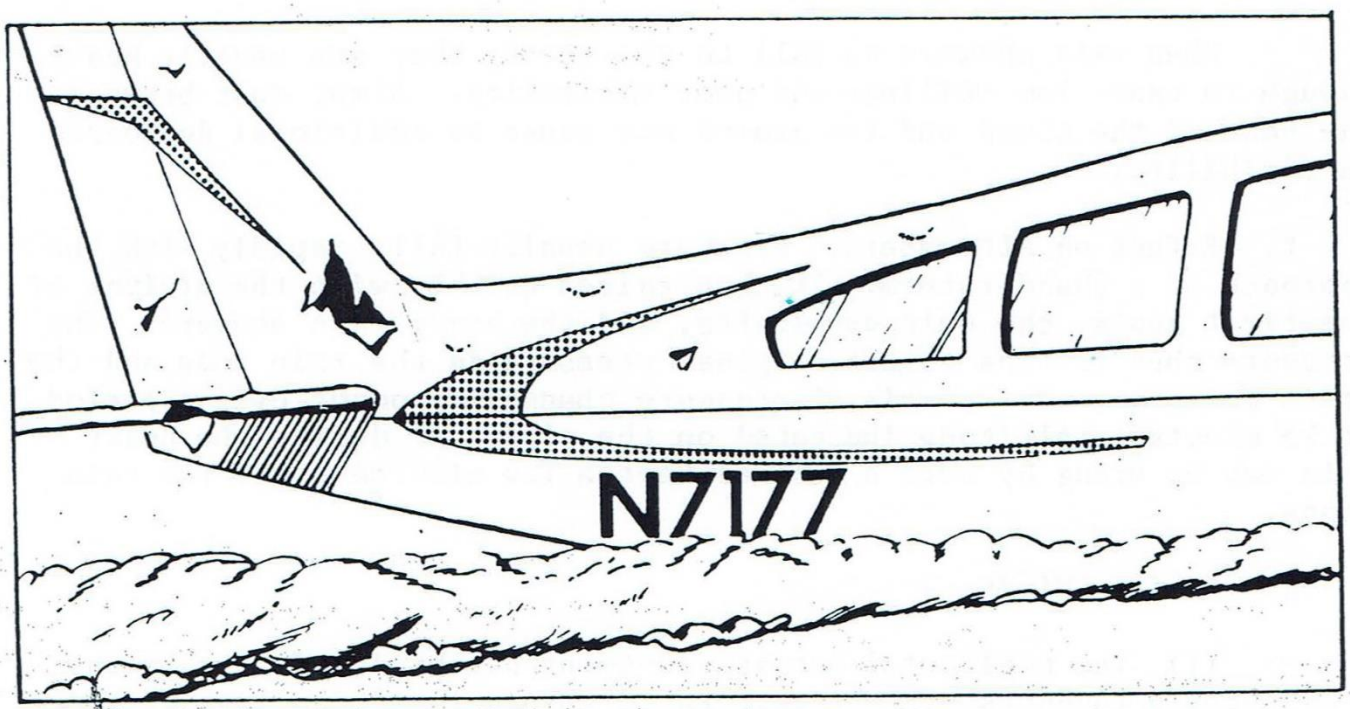
(1) All thunderstorms are turbulent, and some are potentially destructive to aircraft. Almost any thunderstorm has the potential to produce "severe" turbulence and some may produce turbulence classified as "extreme."

(2) Turbulence should also be expected outside of the area of the visible cloud and in the case of severe thunderstorms, "severe" to "extreme" turbulence can be encountered several thousand feet above and 20 miles laterally from the storm.

b. Hail

(1) Hail is a ball or irregularly shaped piece of ice ranging in size from approximately .6 centimeters to 13 centimeters in diameter. Large hailstones usually have alternating layers of clear and white ice. In general large hail and severe turbulence occur in the same storms.

(2) Hail and turbulence are nearly equal in being the greatest hazard to aircraft produced by a thunderstorm. Hail can cause severe damage to surfaces such as the front edge and tops of the wings. In extreme cases hail has broken out aircraft windows.



Hail damage to aircraft.

Figure 4

(3) Frequently hail is carried aloft by updrafts and thrown out of the top or sides of the clouds; it may be encountered in clear air several miles from the thunderstorm. Most thunderstorms have hail in the interior of the cumulonimbus cloud. In a large percentage of the cases, the hail melts before reaching the ground, but this does not make it any less of a danger to the pilot who may encounter it aloft.

c. Lightning. The electricity produced by a thunderstorm is rarely a great hazard to the structure of an aircraft, but its general hazards include:

(1) Temporary loss of vision at night due to the sudden flash of light.

(2) Damage to the electronic equipment.

(3) Holes in the aircraft exterior covering due to actual hits by lightning.

d. Icing. Clear ice accumulation in thunderstorms above the freezing level can be so rapid that an aircraft may become incapable of keeping its altitude and/or attitude.

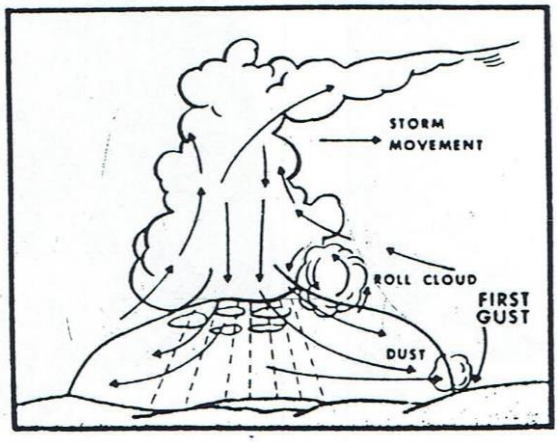
e. Precipitation/Low Ceiling and Visibility. A thunderstorm contains considerable amounts of liquid water, but this moisture is not necessarily falling to the earth as rain. Water drops are carried aloft by the updrafts or may be held in the updrafts so that visibility is reduced to near zero in the thunderstorm.

When rain showers do fall to the earth, they are usually heavy enough to cause low ceilings and poor visibility. Also, dust between the base of the cloud and the ground may cause an additional decrease in visibility.

f. Effect on Altimeters. Pressure usually falls rapidly with the approach of a thunderstorm. It then raises quickly with the arrival of the first gusts, the cold downdrafts, and the heavy rain showers. The pressure then returns to the original pressure as the rain ends and the storm moves on. This cycle of pressure change may occur over a period of 15 minutes. Altitude indicated on the altimeter during the heavy rain may be wrong by over a hundred feet a few minutes after the rain stops.

g. Surface Winds

(1) The horizontal outward movement of the downdrafts in the area unde a thunderstorm causes a rapid change in wind direction and speed (low-level wind shear) in the area around the thunderstorm. The gusty shifting winds are usually hazardous to landing aircraft.



Cross section of a thunderstorm showing location of surface wind gusts, and other turbulent areas relative to the movement of the storm. Surface gusts and rotating air motion can be extremely hazardous to aircraft flying at low altitudes, landing, or departing from airports.

Figure 5

(2) Usually the approach of a thunderstorm is preceded by the first gust and low level wind shear, then the roll cloud, and finally, the rain. Often the surface winds pick up and carry dust and small light objects as the thunderstorm moves, so that the approach of the storm can be seen. The first gust is frequently the strongest wind observed at the surface during the thunderstorm and it may reach a speed of 100 knots in extreme cases. The roll cloud is not always present, but it is found most frequently on the front edge of fast moving fronts or squall lines and indicates extremely turbulent conditions.

h. Tornadoes

(1) Tornadoes occur only with the strongest and most turbulent thunderstorms. They are strong cone-shaped spirals of air, mixed with cloud moisture and dust. They range from 100 feet (30 m.) to half a mile (.8 Km.) in diameter. Pressure is extremely low in the center of the spiral cone and wind speeds are probably up to 200 knots. Tornadoes appear as funnel-shaped clouds from the base of thunderstorms and usually move at a speed of 25 to 50knots.

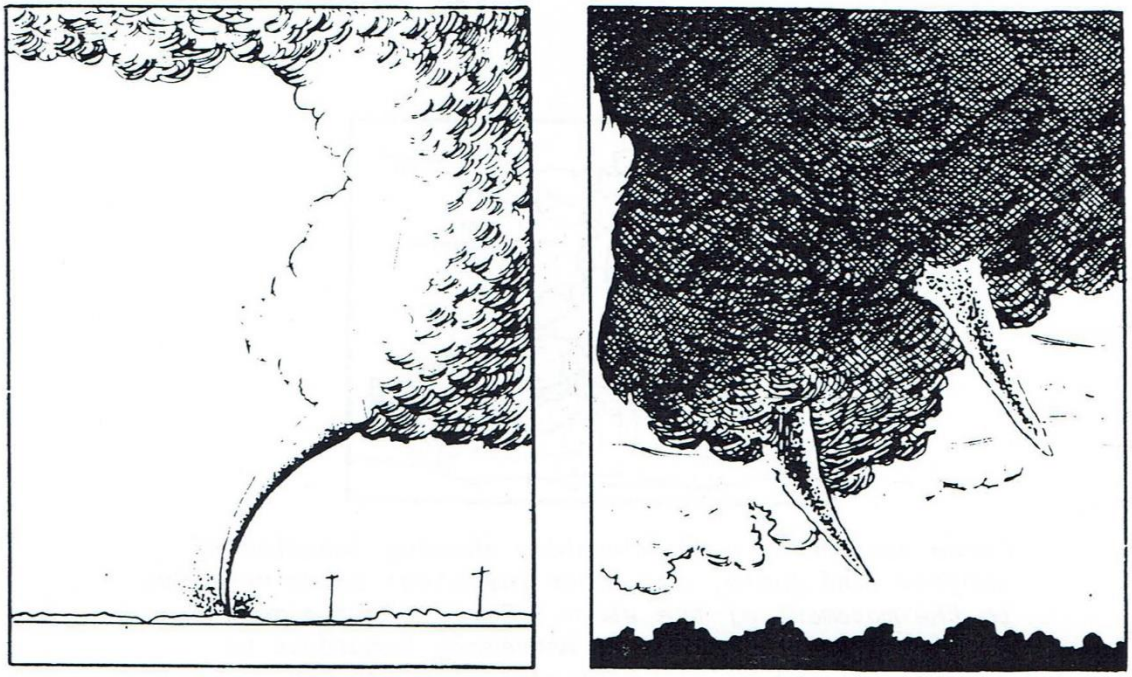


Figure 6

(2) Technically, the funnel or spiral of air must touch the ground to be called a tornado. When they occur over water, they are called waterspouts. When the characteristic spiraling clouds extend downward from the cloud base but do not reach the surface, they are called funnel clouds.

(3) Frequently, cumulonimbus mamma clouds occur in connection with strong turbulent thunderstorms and tornadoes. Tornadoes occur with individual separate thunderstorms at times but they more frequently occur with cold fronts and squall lines.

i. Squall Lines

(1) A squall line is a narrow band of active thunderstorms. They are considered non-frontal because they often develop a few hundred miles ahead of a cold front in moist unstable air. The line may be several hundred miles long and may vary in width up to 50 miles.

(2) The squall line often contains severe, long-lasting thunderstorms. It is the major hazard to heavy aircraft that are flying by use of instruments due to restricted visibility.

A squall line usually forms quickly and moves rapidly. It generally completes its life-cycle within 24 hours and reaches maximum intensity in the late afternoon or early night.

GLOSSARY

ACCOMPANY: verb; (1) to go with somebody.

Ex. John is going there too, why don't you accompany him so that he won't have to go alone.

(2) to occur at the same time

Ex. The weather report said to expect heavy showers accompanied by strong winds.

CASE: noun; an instance or occurrence of something

Ex. Normally hail is about 2.5 cm in diameter or smaller, but in this case it was as big as an egg.

CELL: noun; a portion of the atmosphere that functions as one unit

Ex. A high pressure cell has covered this area for the last 72 hours.

Ex. Sometimes when you are flying at a high altitude you can see three or four d ifferent thunderstorm cells at the same time.

CONVERGE: verb; to move toward one point or to come together

Ex. There is a big traffic problem in some of the older cities because the main highways leading to the city converge in the downtown area.

Ex. The winds converge at the center of the low-pressure area, then rise upward.

CYCLE: noun; a series of regular changes that usually lead back to the same starting point or condition.

Ex. The circulation cycle is very simple; the air at the surface is heated, it rises, then at high altitudes it is cooled and sinks back to the surface. When it is at the surface the cycle starts again.

DISSIPATE: verb; to separate into smaller and smaller parts until it no longer exists.

Ex. The fog will dissipate in about two hours

Ex. This is just a local summer storm; they form, rain, and dissipate, all in about 30 minutes.

FUNNEL: noun; a cone-shaped object, open at the top and bottom, used as a guide when pouring into a small opening

Ex. He used a funnel when he poured the water into the bottle.

GUST: noun; a sudden, short-time increase in wind speed

Ex: Wind speed is 10 knots with gusts up to 20 knots.

LATERAL: adjective; concerning the side, located at or moving to or away from the side

Ex. In this aircraft the pilot has good vision to the front, but lateral vision is limited, and he can't see to the rear at all.

LIGHTNING: noun; the flash of light produced when atmospheric electricity jumps from one cloud to another cloud, or from a cloud to the ground

Ex. The storm didn't produce much rain but there was a lot of lightning

MATURE: adjective; fully developed

Ex. That tree is still young, when it is mature it will be at least 20 meters tall.

Ex. The cumulonimbus cloud of a mature thunderstorm may extend as high as 50,000 feet.

POTENTIAL: noun; a possibility that can become an actual thing or happening

Ex. He has only had a few hours of flying lessons but I can see. that he has the potential to become a good pilot.

POTENTIAL: adjective; capable of happening

Ex. The report advised the pilots that there were potential thunderstorms in the area.

POTENTIALLY: adverb form of potential

PREDOMINANT: adjective; main, primary or strongest characteristic or feature

Ex. The predominant feature of a thunderstorm is the vertical development of the cumulus cloud.

PREDOMINATE: verb; to be the strongest feature

Ex. Although there are some downdrafts in this stage of the .storm, updrafts predominate.

PROGRESS: verb; to move forward or to continue to develop

Ex. The front is expected to progress southward at about 15 miles per hour.

Ex. The cumulus cloud progressed into a cumulonimbus, then into a thunderstorm; all in about 45 minutes.

ROLL CLOUD: noun; a ball-shaped cloud that sometimes forms at the front edge of a thunderstorm

Ex. A roll cloud indicates severe turbulent conditions.

STAGE: noun; a step in a development, progress, or change

Ex. The first stage of every thunderstorm is a cumulus cloud.

TORNADO: noun; a destructive storm characterized by very high speed winds rotating in a spiral cone-shaped pattern. The cone reaches to the ground and causes great damage.

Ex. A tornado went through part of the town and destroyed 400: houses.

WATERSPOUT: noun; a tornado that forms over water, i.e., the sea, etc.

Ex. A thunderstorm that develops in a maritime area may also produce waterspouts.

Language Exercises

I. NEW TERMINOLOGY: Oral Exercises

1. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

accompany	converge	cycle
lightning	progress	mature
gusts	stage	dissipate (-ing)

a. Occasionally in a thunderstorm, _____ will hit a tall building or a tree and start a fire.

b. He is a very _____ person, he acts much older than his age.

c. The atmosphere follows a _____ when it circulates; the hot air rises then returns to the earth where it is heated.

d. The first _____ of any thunderstorm is a cumulus cloud.

e. Local thunderstorms develop very quickly, but the rain doesn't last long and they _____ almost as quickly as they form.

f. The winds in a low-pressure system _____ at the center of the system; that is why we say they spiral inward.

g. As a migratory air mass _____ along its path, it is modified by the surfaces it passes over.

h. Usually just before a storm arrives there is a series of strong _____ of wind.

i. You can expect any thunderstorm to be _____ by rain, hail, and turbulent winds.

j. During the cumulus _____ of a thunderstorm most of the air currents are moving upward.

k. The thunderstorm is in the _____ stage when most of the air currents are moving downward.

l. All thunderstorms are similar because they all_____ through the same three stages.

m. Unless a storm is _____ by thunder and lightning, it is not considered to be a thunderstorm.

n. The wind speed is 10 knots with _____ up to 20 knots.

o. After the initial updrafts start in a thunderstorm, the air in the surrounding area begins to _____ at the base and rise also.

2. Select words from the list below to complete the following sentences. Some of the words may be used more than once, and you may have to make the word plural or change the tense. Do not try to write the words in the spaces.

case	potential (-ly)	tornado
cell	predominant	waterspout
funnel	predominate	
laterl (-ly)	roll cloud	

a. It is easier to pour water into a bottle if you have a _____ .

b. Helicopters can move in all directions, up and down, forward and backward, and _____ .

c. He is _____ the best student in the class, but he won't study or do his homework, so his grades are poor.

d. You may have a tornado, but don't expect to see a _____ in a desert country.

e. Thunderstorms usually are over in an hour and a half, but in the _____ of a squall line they may last up to 24 hours.

f. A squall line is a series of thunderstorm _____ that develop in advance of a cold front.

g. Updrafts _____ in the cumulus stage of a thunderstorm.

h. In the United States the _____ movement of cold air. is from the northwest to the southeast.

i. The rotor cloud and the _____ look like each other, and they both are signs of severe turbulence.

j. A _____ is a vertical vortex of rapidly rotating air that touches the ground.

k. Every thunderstorm _____ goes through three stages in its life-cycle.

l. Tornadoes and waterspouts begin as a _____ cloud.

m. One _____ danger of any severe thunderstorm is that tornadoes can develop.

n. Severe maritime thunderstorms have the _____ to produce _____ .

II. SENTENCE PRACTICE: Oral Exercises

NOTE: Written sentences tend to be longer and more complicated than spoken sentences. Since they are printed the reader can re-read them several times If he has difficulty in understanding them. When sentences are spoken the listener usually only has one chance to hear the sentences. Written sentences can be changed to spoken sentences by making them into a number of shorter simpler sentences.

Use the examples below as a guide to change the following written sentences to spoken sentences.

Examples:

Written: The thunderstorm is a local storm which is produced by a cumulonimbus cloud and is always accompanied by thunder and lightning.

Spoken: A thunderstorm is a local storm.

It's produced by a cumulonimbus cloud.

It's always accompanied by thunder and lightning.

Written: The pilot's judgement of turbulence severity may be influenced by the length of time his plane 18 exposed to turbulence, the amount of experience the pilot has and the type of aircraft he is flying.

Spoken: The pilot's judgement of turbulence severity may be influenced by three things.

It is influenced by the length of time his plane is exposed to turbulence

It is influenced by the amount of experience he has. It is influenced by the type of aircraft he is flying.

a. The upward moving air rises faster and faster until it reaches a height where the temperature of the rising air is cooled to the same temperature of the surrounding air.

b. An object placed in any moving air current disturbs the flow by causing the wind to change direction of flow to go over or around the object.

c. Mechanical turbulence is caused by obstructions in the path of the wind and is not caused by meteorological processes in the air ma88 itself.

d. The landing area may be safely upwind from an obstruction when an east wind is blowing and yet be a turbulent area because it is downward from the same obstacle when a west wind is blowing.

e. When air passing over a line of mountains has sufficient water vapor to form clouds, standing lenticular and rotor clouds form downwind from the mountain and indicate areas of severe turbulence.

f. Wind shear can exist at the horizontal boundary between layers of air moving in different directions and/or at different speeds, or it can exist along a vertical boundary when upward or downward currents are in contact with currents moving in a different direction and/or at a different speed.

g. As more and more water vapor is pulled into the cloud and condenses, the cloud builds upward into a towering cumulus, and finally becomes a cumulonimbus cloud and produces a thunderstorm.

h. The main characteristic of the cumulus or "building" stage is the predominant updraft which may extend from the earth's surface to several thousand feet above the visible cloud top.

i. The mature stage begins when drops are thrown out from the updraft, or they become so large that the updraft can no longer hold them or lift them upward, and the drops begin to fall.

j. Turbulence should also be expected outside of the area of visible cloud, and in the case of severe thunderstorms, "severe" to "extreme" turbulence can be encountered several thousand feet and above and up to twenty miles laterally from the storm.

k. Clear ice accumulation in thunderstorms above the freezing level can be so rapid that an aircraft may become incapable of keeping its altitude and/or attitude.

1. Usually the approach of a thunderstorm is preceded by the first gust and low level wind shear, then the roll cloud, and finally the starting of the rain.

III. VOCABULARY EXPANSION: Oral Exercises

1. Select words from the lists given below to complete the sentences.

a. intensify intense intensity

(1) The strength of the updrafts will _____ as the cumulus stage progresses.

(2) There is some difficulty in identifying the _____ of turbulence because it depends on the pilot's judgment.

(3) A pilot may encounter _____ turbulence even though he is some distance from the thunderstorm.

(4) When turbulence reaches "extreme" _____ it may be impossible to control the aircraft's altitude and attitude.

B. vary variation variable

(1) CAT is a _____ of wind shear turbulence that exists at high altitudes.

(2) Its occurrence _____ according to the season; it is more frequent during the winter.

(3) In this season the winds are _____ ; they may come from any direction.

(4) The atmospheric pressure _____ from day to day even though the temperature might not change.

c. predominate predominant predominantly

(1) The _____ feature of mechanical turbulence is that it is produced by some kind of object or obstacle.

(2) In some areas a particular group of weather conditions may _____ for a long period of time.

(3) Cold air masses move _____ from northwest to southeast in the United States.

(4) When downdrafts begin to _____ over updrafts, the mature stage of the thunderstorm is over.

d. consider consideration considerable

(1) All pilots should recognize that there is _____ danger associated with flying in and around thunderstorms.

(2) When advised that a thunderstorm is in the area, a pilot may want to _____ changing his plans to avoid the general area of the storm.

(3) When deciding where to locate an airport, _____ should be given to such things as predominant winds, high buildings and other obstructions in the area, etc.

(4) The strong winds and hail that accompanied the storm did _____ damage to the aircraft that were on the ground.

e. develop development developmental

(1) The first stage in the _____ of any thunderstorm is the cumulus stage.

(2) It is not unusual for a local thunderstorm to _____ and dissipate, all within a period of an hour to an hour and a half.

(3) In the _____ or building stage of a thunderstorm it is not unusual for rain and hail to be lifted upward and thrown out from the top of the cumulus cloud.

(4) Any severe thunderstorm may _____ funnel clouds, and any funnel cloud may _____ into an actual tornado.

Review : UNIT 1

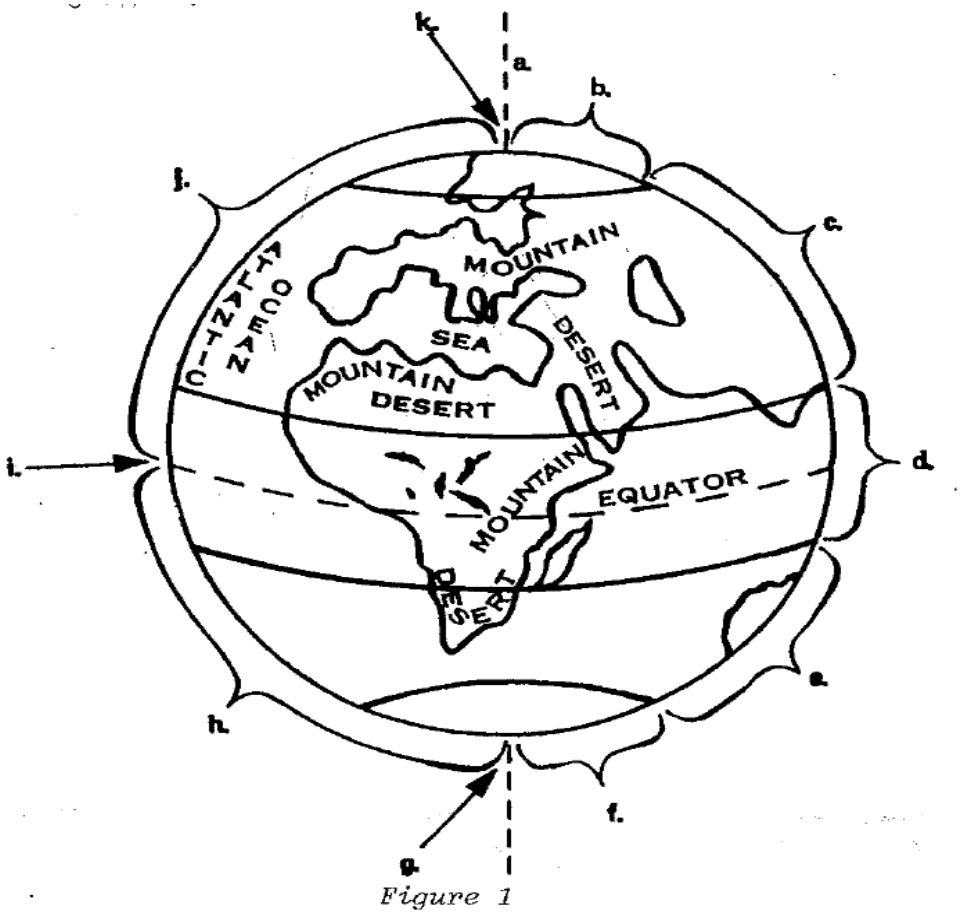


Figure 1

1. Refer to the illustration above and identify the following:

   a. The broken line identified by letter a indicates the _____ .

   b. The zone identified by letter b is the _____ .

   _____ _____ .

   c. The zone identified by letter C is the _____ .

   _____ _____ .

   d. The zone identified by letter d is the _____ .

   _____ .

   e. The zone identified by letter e is the _____ .

   _____ _____ .

f. The zone identified by letter f is the _____ .

_____ _____ .

g. The arrow identifled by letter g indicates the location of the
_____ _____ .

h. The area of the earth identified by letter h is the

_____ _____ .

i. The broken line identified by letter i is the _____ .

j. The area of the earth identified by letter i is the

_____ _____ . .

k. The arrow identified by letter k indicates the location of the
_____ _____ .

2. Use the information you studied in Unit 006-1A to answer at least 13 of the following 16 questions correctly.

a. What are the two movements of the earth?

_____

_____

b. What is the source of the light/heat radiation received by the ear th?

_____

_____

c. How long does it take the earth to complete one rotation?

_____

_____

d. How long does it take the earth to complete one revolution around the sun?

_____

_____

e. factors produce the sequence of the earth's seasons?

_____

_____

f. What is the season in the southern hemisphere when it is summer in the northern hemisphere?

_____

_____

g. What are the five temperature zones?

_____

_____

h. What are clouds formed from?

_____

_____

i. Identify or name three types of precipitation.

_____

_____

j. What is the general rule that explains why high regions usually have cooler temperatures than low regions in the same area?

_____

_____

k. What are three of the factors that determine the climate of an area?

_____

_____

i. What is the zero point that elevation is measured from?

_____

_____

m. Which direction does a north wind blow from?

_____

_____

n. What instrument is used to measure temperature?

_____

_____

0. What are the names of four of the different kinds of storms?

_____

_____

p. What is humidity?

_____

_____

REVIEW : UNIT 2

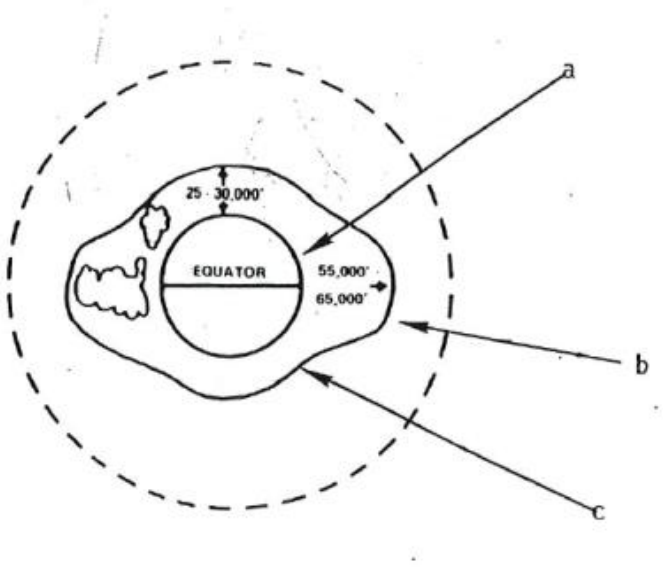


Figure 2

1. Refer to the illustration above and identify the following:

a. The layer of air indicated by arrow a is the _____ .

b. The layer of air indicated by arrow b is the_____ .

c. The border between the two layers of air, indicated by arrow is called the

_____ .

2. Write the following characteristics in the correct columns below:

uses a glass tube	fluid moves to show pressure change
uses a hollow container	indicator moves to show pressure change
uses a liquid	is similar to an altimeter
uses a gas	is easy to move around
needs frequent adjustment	is more accurate

a. Mercurial Barometer	b. Aneroid Barometer
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

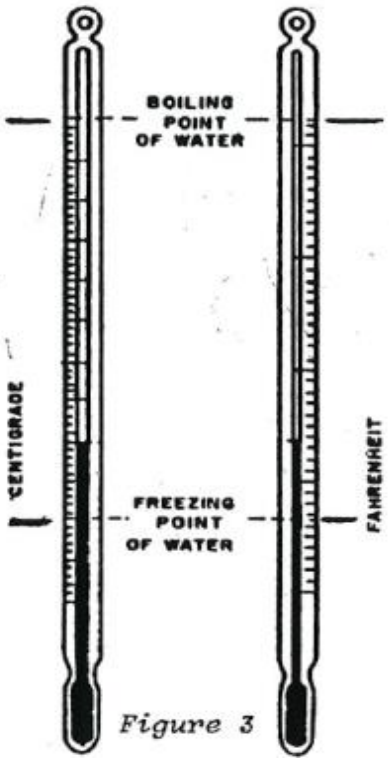


Figure 3

3. Refer to the illustration above and fill in the blanks in the follow- ing statements .

   a. Water freezes at _____˚C; it boils at _____˚C.

   b. Water freezes at _____˚F; it boils at _____ ˚ F

4. Use the information you studied in Unit 006-1B to answer at least 15 of the following 18 questions correctly.

   a. Which layer of air contains 75% of the atmosphere by weight?

   _____

   _____

   b. In which layer of the atmosphere does most of the weather take place?

   _____

   _____

c. Name two instruments that are used to measure atmospheric pressure.

_____

_____

d. What type of barometer is used to measure atmospheric pressure and is also used to measure altitude when it is part of another instrument?

_____

_____

e. Which way will the mercury in a barometer move when the atmospheric pressure decreases?

_____

_____

f. If you are told that the mercurial barometer reads 30.13, " thirty point one three,'' how high is the column of mercury in the baro- meter?

_____

_____

g. If the atmospheric pressure increases, will the hollow metal pressure sensitive container in the aneroid barometer expand or will it be compressed?

_____

_____

h. What instrument is used to check the accuracy of an aneroid barometer?

_____

_____

i. At what rate does pressure decrease with altitude in the lo of the atmosphere?

_____

_____

j. What is the standard lapse rate in the troposphere?

_____

_____

k. What are the properties of water in regard to temperature?

_____

_____

l. If the barometer of a station at 2,000 feet elevation shows a pressure of 27.95, what sea level (converted) pressure would it report?

_____

_____

m. What unit of atmospheric pressure is used to show pressure on a weather map?

_____

_____

n. If an airport at 1,000 feet elevation has a converted sea level pressure of 29.92 inches of mercury, and a plane's altimeter has been set to read 29.92, what altitude will be shown on the altimeter when the plane is on the ground at that airport?

_____

_____

o. What are the two types of air layers that do not show. a standard lapse rate?

_____

_____

p. What is the technical name of a layer of air that does not show temperature change with height?

_____

_____

q. What is the technical name of a layer of air that shows temper- ature increases with height?

_____

_____

r. What are the characteristics of standard atmosphere in regard to surface temperature, surface pressure, and lapse rate?

_____

_____

REVIEW : UNIT3

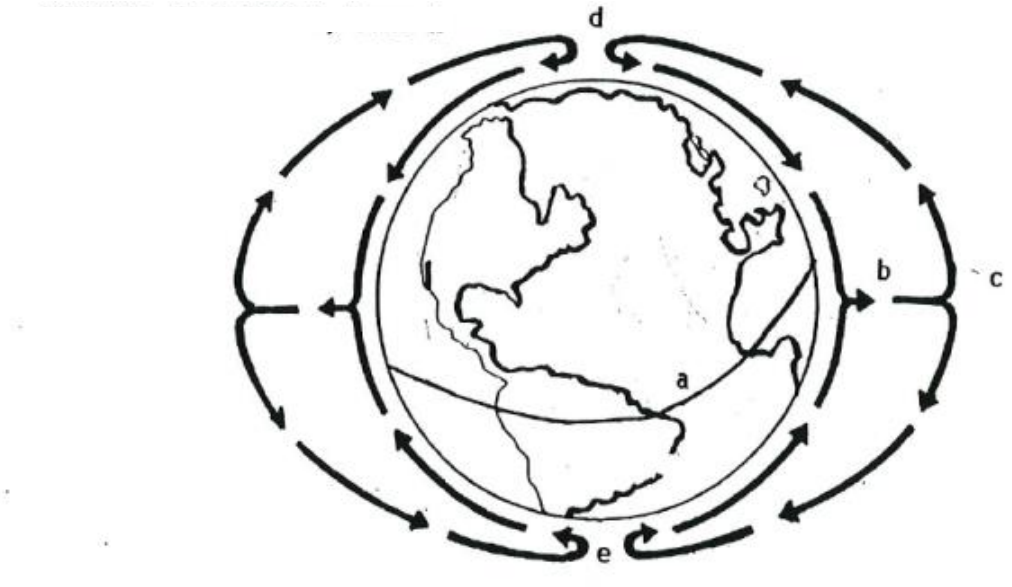


Figure 4

1. Refer to the 11lustration above and use the following terms to fill in the blanks below. Some of the terms may be used more than once.

cold	rise	south	descend	hot
air	north	pole(s)	equator	

a. The line identified by letter a is the _____ .

b. The sun causes the air at the _____(letter a) to become _____ .

c. The hot _____expands (becomes less dense) and _____ .

d. The arrow at letter b indicates that the _____ air is rising.

e. The arrows at letter c indicate that the hot _____ aloft travels _____ward and _____toward the _____ .

f. As the hot air aloft travels to the _____ _____(letter d) and the _____ _____ (letter e), it cools.

g. When air becomes _____ it contracts (becomes more dense).

h. The cold air _____ to the surface near the north and south _____ .

i. The _____ air from the poles returns along the surface to the _____ (a) where it is heated again.

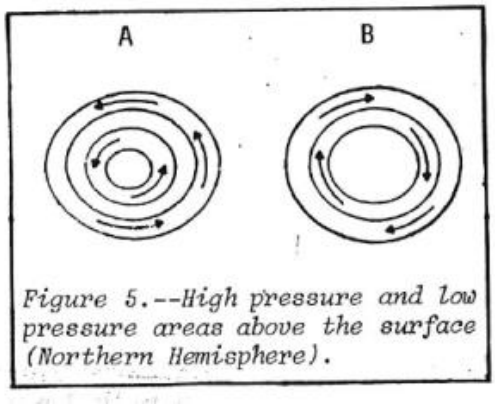


Figure 5.--High pressure and low pressure areas above the surface (Northern Hemisphere).

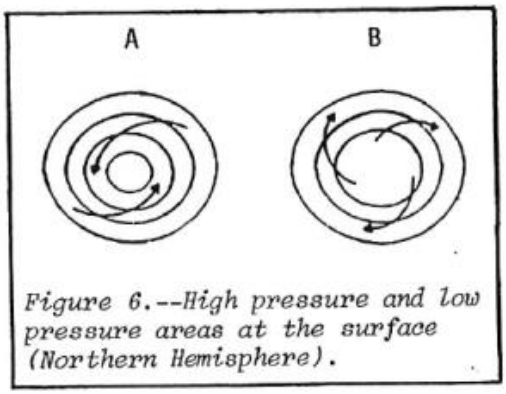


Figure 6.--High pressure and low pressure areas at the surface (Northern Hemisphere).

2. Refer to the illustrations above and use the following terms to fill in the blanks below. Some of the terms may be used more than once.

Clockwise	parallel flow	isobar
counterclockwise.	parallel flow	inward
high	flow	outward

a. Figure 5A represents a _____pressure area.

b. We know 5A represents a _____pressure area because the arrows showing wind flow indicate a _____movement.

c. When the wind flow is shown you do not need to have atmospheric lines in order to pressure readings on the _____ lines in order to identify a "high" or a "low."

d. Figure 5B represents a _____pressure area.

e. We know 5B represents a _____pressure area because the wind flow is in a _____ direction.

f. Figure 5, A and B, shows high and low pressure areas above the surface. In relation to the isobars the wind has a _____ _____ .

g. Figure 6A represents a _____ pressure area.

h. In figure 6A, the wind flow is in a _____ direction.

i. Figure 6B represents a _____ pressure area; the _____ wind flow is in a _____ direction.

j. In figure 6, A and B, the wind moves in a _____ in relation to the isobars.

k. At the surface (figure 6) the wind in a high pressure system flows pressure and _____ ; in a low pressure system it flows _____ and upward.

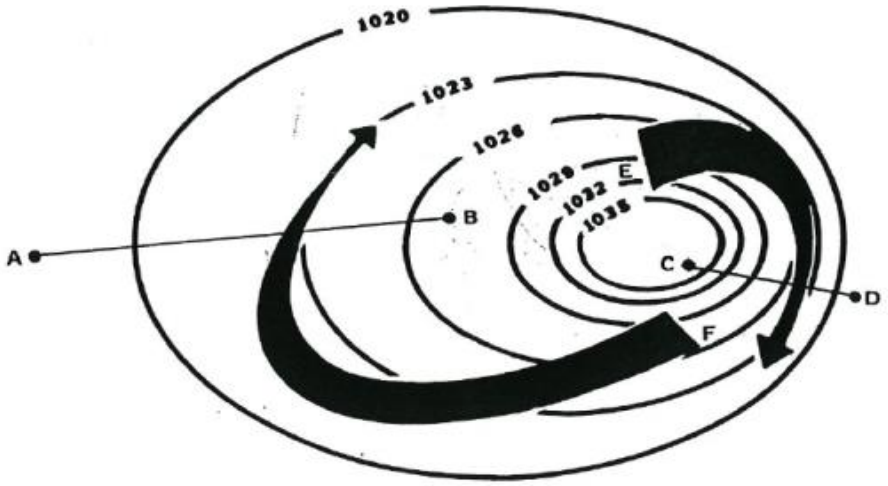


Figure 7

3. Refer to the figure above and answer the following questions. You may use short answers.

a. Does figure 7 show a "high" or a "low"? _____ .

b. What direction does the wind flow? _____ .

c. What type of pressure gradient exists between point A and point B?

_____ .

d. What type of pressure gradient exists between point C and point D?

_____ .

e. What type of wind flow (as to speed) occurs in the flow indicated by arrow E?

_____ .

f. What type of wind flow (as to speed) occurs in the flow indicated by arrow F?

_____ .

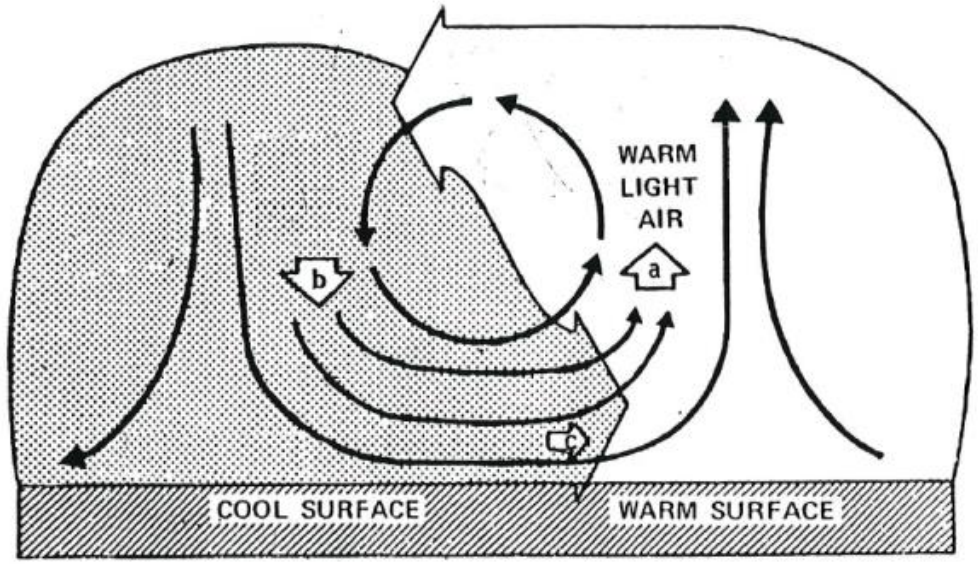


Figure 8

4. Refer to the illustration above and use the following terms to fill in the blanks below. Some of the terms may be used more than once.

air	light	sinks
warm	dense	advection
cool	rises	

a. A warm or cool surface causes the _____above it to become warm or cool.

b. Warm air becomes _____ ,cool air becomes _____ .

c. Light air _____ ; dense air _____ .

d. Arrow a indicates the upward currents that are produced when warm_____ air _____ .

e. Arrow b indicates the downward currents produced when cool_____ air _____ .

f. Arrow c indicates a current parallel to the ground, the current from the cooler area to the warmer area is called _____ .

5. Use the information you studied in Unit 006-2A to answer at least 16 of the following 19 questions correctly.

a. What is the direction of air flow between a high pressure system and a low pressure system?

_____

_____

b. What two actions normally take place when air is warmed?

_____

_____

c. What two actions normally take place when air is cooled?

_____

_____

d. What is the effect of cooling on the density of air?

_____

_____

e. What is the effect of warming on the density of air?

_____

_____

f. the general direction and height of the warm air f the equator?

_____

_____

g. What is the general direction and height of the cool air flow from the poles?

_____

_____

h. What force causes air in the northern hemisphere to flow to the right of its normal path?

_____

_____

i. What conditions produce a region of low-pressure air?

_____

_____

j. What conditions produce a region of high-pressure air?

_____

_____

k. What is the direction of windflow in a low pressure system?

_____

_____

l. What is the direction of windflow in a high pressure system?

_____

_____

m. What are the lines that connect points of equal pressure on a weather map called?

_____

_____

n. How is the pressure gradient described when the isobars are close together?

_____

_____

o. How is the pressure gradient described when the isobars are far apart?

_____

_____

p. What is the flow of air parallel; to the ground between a local warm air mass and cool air mass called?

_____

_____

q. What is the jet stream?

_____

_____

r. What are the pressure systems that regularly move from one area of the earth to another called?

_____

_____

s. What two characteristics does an air mass take from the region in which it is formed?

_____

_____

REVIEW : UNIT 4

1. Refer to the illustrations (figs. 9, 10, and 11) and identify the general cloud type shown in each.

a. Figure 9 shows a

_____ cloud.

b. Figure 10 shows a

_____ cloud.

C. Figure 11 shows a

_____ cloud

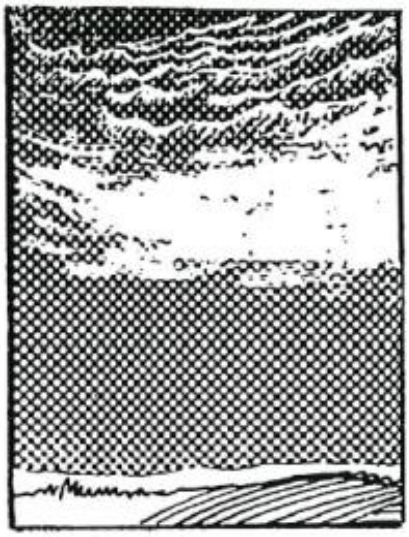


Figure 9

Figure 10

Figure 11

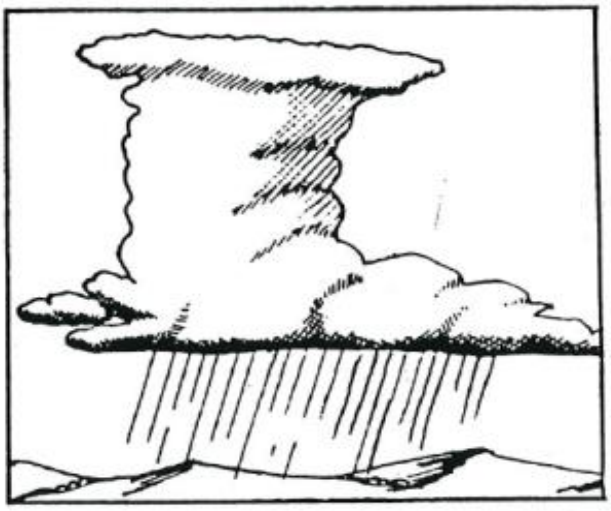


Figure 12

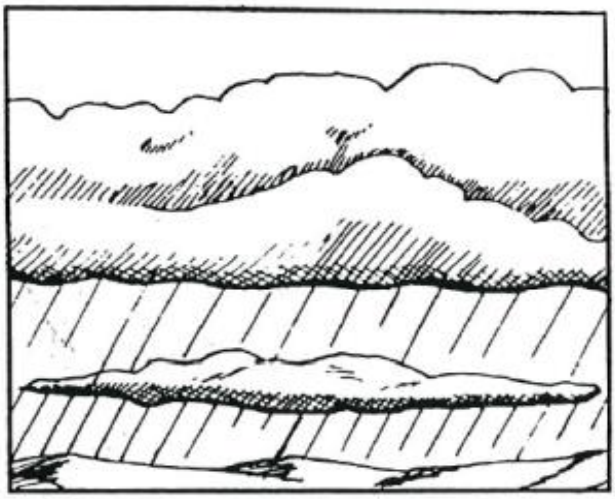


Figure 13

2. Refer to the 1llustrations above (figures 12 and 13) and identify the cloud type in each by full name.

a. Figure 12 shows a _____cloud.
b. Figure 13 shows a _____ cloud.

3 . List each of the following cloud names in the proper group below.

Cumulus	cirrocumulus	altostratus
altocumulus	stratocumulus	cirrus
stratus	cirrostratus	

Group 1	Group 2	Group 3
Low Clouds	Middle Clouds	High Clouds
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

4. Write the letter that identifies each cloud name in the blank after the abbreviation for that name.

a. cirrus	TCU	_____
b. cirrocumulus	St	_____
C. cirrostratus	Cb	_____
d. standing lenticular cirrocumulus	Ns	_____
e. standing lenticular altocumulus	Sc	_____
f. altocumulus	Cu	_____
g. altostratus	Acsl	_____
h. altocumulus castellanus	As	_____
i. cumulus	Accas	_____
j. cumulonimbus	Ac	_____
k. towering cumulus	Ccs1	_____
l. stratus	Cs	_____
m. nimbostratus	Cc	_____
n. stratocumulus	Ci	_____

5. Use the information you studied in 006-2B to answer at least 12 of the following 15 questions correctly.

a. What kind of air do cumulus clouds form in?

_____

_____

b. What kind of air do stratus clouds form in?

_____

_____

c. What are cirroform clouds composed of?

_____

_____

d. What does the prefix/suffix " nimbo (-us)" indicate when it is attached to a cloud name?

_____

_____

e. What does the suffix "fractus" indicate when it is attached to a cloud name?

_____

_____

f. Where does a standing lenticular cloud usually form?

_____

_____

g. What type of cloud has such extensive vertical development that the base can be at 6,500 feet and the top over 50,000 feet?

_____

_____

h. Where is the anvil of a cumulonimbus cloud located?

_____

_____

i. What causes towers to form in cumulus clouds?

_____

_____

j. What are the three basic types of clouds?

_____

_____

k. what are the three altitude classifications that clouds are divided into?

_____

_____

l. What kind of clouds form in convective currents?

_____

_____

m. What two cloud types are likely to produce precipitation?

_____

_____

n. What produces the irregular rounded bases of cumulonimbus mamma clouds?

_____

_____

o. What type of cloud contains most flying. hazards?

_____

_____

REVIEW : UNIT 5

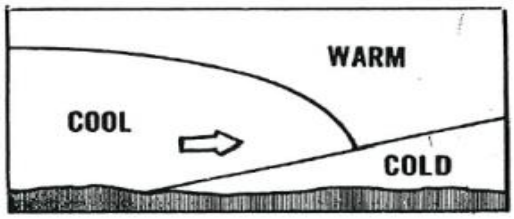


Figure 1

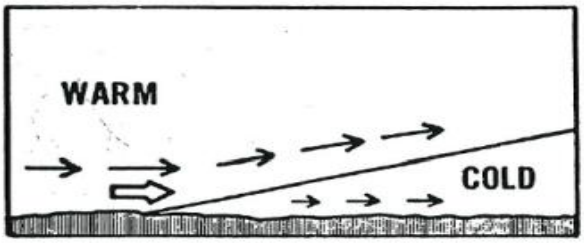


Figure 2

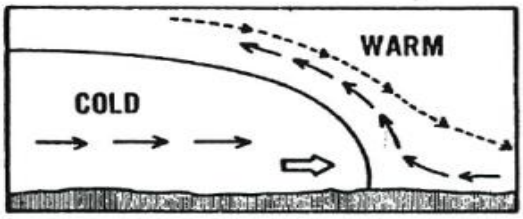


Figure 3

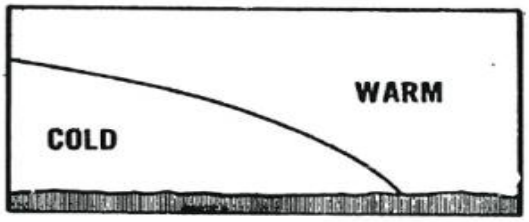


Figure 4

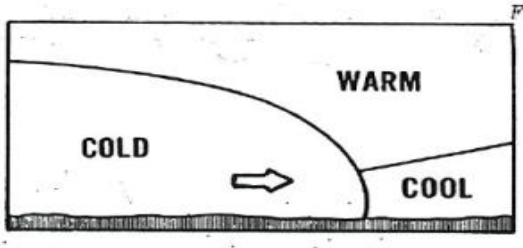


Figure 5

1. Refer to the illustrations above (figs. 1--5) and identify the fronts shown.

a. Figure 1 is a cross-section representation of a/an

_____

b. Figure 2 is a cross-section representation of a/an

_____

c. Figure 3 is a cross-section representation of a/an

_____

d. Figure 4 is a cross-section representation of a/an

_____

e. Figure 5 is a cross-section representation of a/an

_____

2. Use the information you studied in Unit 006-3A to answer at least 13 of the following 16 questions correctly.

a. What is formed in the area of contact when two different air masses meet?

_____

_____

b. Which air mass takes a characteristic wedge shape when a warm front advances?

_____

_____

c. What type of front occurs when warm air replaces cold air?

_____

_____

d. What type of front occurs when cold air replaces warm air?

_____

_____

e. What type of front occurs when a warm air mass is 1ifted above two colder air masses?

_____

_____

f. What type of front occurs when neither the cold air mass nor the warm air mass is advancing?

_____

_____

g. What are the two types of occluded fronts?

_____

_____

h. What type of front will often produce a squall line in advance of the front?

_____

_____

i. Which type of front usually moves the most rapidly across surface?

_____

_____

j. Which type of front produces cirroform clouds up to 500 miles in advance of the front?

_____

_____

k. Which type of front does not have warm air contacting the surface?

_____

_____

l. Which type of front is usually associated with low ceilings and limited visibility?

_____

_____

m. Which type of front is usually associated with sudden storms, strong gusty winds, and turbulence?

_____

_____

n. Which type of air mass (after the front has passed) is as with clear air and unlimited visibility.

_____

_____

o. When does an occluded front occur?

_____

_____

p. Which type of front usually has a steep frontal slope?

_____

_____

REVIEW : UNIT 6

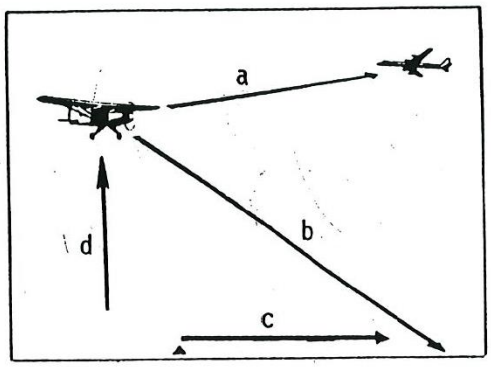


Figure 6

1. Refer to the illustration above and fill in the blanks below.

a. Arrow a indicates _____ visibility.

b. Arrow b indicates _____ visibility.

C. Arrow c indicates _____ visibility.

d. Arrow d indicates _____ visibility.

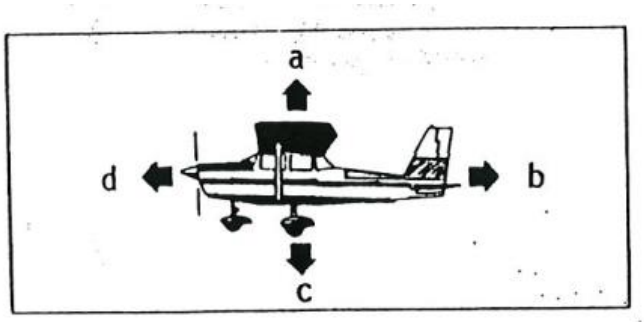


Figure 7

2. Refer to the illustration above and fill in the blank below.

a. Arrow a represents the effect of _____.

b. Arrow b represents the effect of _____ .

c. Arrow c represents the effect of _____

.

Figure 8

Figure 9

3. Refer to the illustrations above and fill in the blank below.

   a. Figure 8 represents an accumulation of _____ ice on a wing.

   b. Figure 9 represents an accumulation of _____ ice on a wing.

4. Write the letter that identifies each term in the blank after the characteristic/description for that term.

a. fog _____1. A hard smooth transparent ice.

b. dewpoint _____2. A white, nontransparent rough, coarse ice.

c. haze _____3. A cloud with its base on the earth's d. drizzle surface.

d. drizzle _____4. Water in the form of gas mixed in the air.

f. clear ice _____5. Ice formed on a surface directly from evaporated water in the air.

g. rime ice _____6. Asmall amount, only sufficient to show that something exists.

h. water vapor _____7. Particles of 1iquid having temperatures below 0.

i. frost _____8. Restriction to visibility caused by dust or salt particles in the air.

j. trace _____ 9. Precipitation in the form of very small drops that descend very slowly.

_____10. The saturation temperature of a local air mass.

5. Use the information you studied in Unit 006-3B to answer at of the following 16 questions correctly.

a. What does air-to-air visibility refer to?

_____

_____

b. What does air-to-ground visibility refer to?

_____

_____

c. What does horizontal surface visibility refer to?

_____

_____

d. What does vertical visibility refer to?

_____

_____

e. What are the general characteristics of stable air as to visibility?

_____

_____

f. What are the general characteristics of unstable air as to visibility?

_____

_____

g. What are the three types of solid particles that are often lifted from the surface and blown by winds so that they restrict visibility?

_____

_____

h. What is the term for the downward force that acts on an aircraft?

_____

_____

i. What is the term for the force that moves a flying aircraft forward ?

_____

_____

j. What is the term for the upward force that acts on a flying aircraft?

_____

_____

k. What is the term for the force that opposes the forward movement of a flying aircraft?

_____

_____

l. What type of icing occurs on the outside surfaces of a flying aircraft?

_____

_____

m. What type of icing occurs as a result of surface water being thrown up on an aircraft?

_____

_____

n. What type of icing affects the flow of air to an aircraft's engine?

_____

_____

o. What type of ice is the result of combined clear and rime ice?

_____

_____

p. What four terms, in the order from not dangerous to very dangerous, are used to describe icing intensity?

_____

_____

REVIEW : UNIT 7

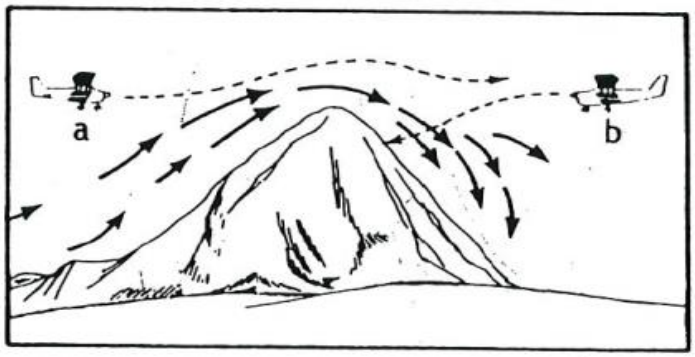


Figure 10

1. Refer to the illustration above and fill in the blanks below.

   In relation to the airflow:

   Aircraft a is on the _____ side

   Aircraft b is on the _____ side.

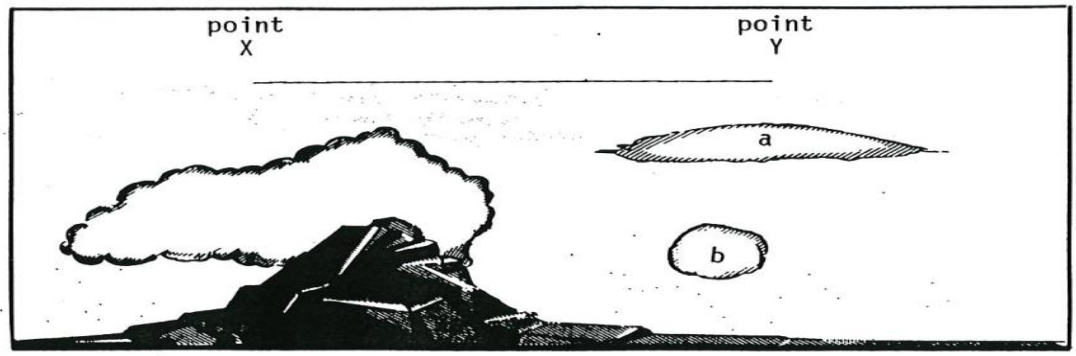


Figure 11

2. Refer to the illustration above and fill in the blanks below.

   a. Cloud a is a representation of a _____ _____ .

   b. Claud b is a representation of a _____ _____ .

   c, In relation to line X--Y, the windflow shown in the illustration is from point

   _____ to point _____ .

3. List each of the following types of turbulence in the appropriate column below:

convective turbulence
wind shear turbulence
wake turbulence
frontal wind shear turbulence
high-level mechanical turbulence
standing wave turbulence
thermal turbulence
clear air turbulence
temperature inversion shear turbulence
low-level mechanical turbulence

a. Turbulence produced by natural processes:

_____
_____
_____
_____
_____
_____

b. Turbulence produced by objects:

_____
_____
_____
_____
_____
_____

4. List the following terms used to describe the intensity of turbulence. in the order of increasing amount of turbulence.

moderate extreme light severe

a. _____ (least)

b. _____

c . _____

d. _____ (most)

5. Use the information you studied in Unit 006-4A to answer at least 15 of the following 19 questions correctly.

a. When is the atmosphere considered to be turbulent? .

_____

_____

b. What kind of turbulence is called "chop'' ?

_____

_____

c. When is turbulence considered to be occasional?

_____

_____

d. When is turbulence considered to be intermittent?

_____

_____

e. When is turbulence considered to be continuous?

_____

_____

f. What are the four terms for reporting the intensity of turbulence ?

_____

_____

g. What are the four types of turbulence?

_____

_____

h. What is the cause of convective turbulence?

_____

_____

i. What is the cause of mechanical turbulence?

_____

_____

j. When does wind shear occur?

_____

_____

k. What do the letters in the abbreviation CAT stand for?

_____

_____

l. What type of clouds are signs of convective currents?

_____

_____

m. What are standing lenticular and rotor clouds a sign of?

_____

_____

n. What causes wake turbulence?

_____

_____

o. What is the shape of the wake turbulence produced by the wing tips of a moving aircraft?

_____

_____

p. Which of the four types of turbulence would be expected in a frontal area?

_____

_____

q. Which of the four types of turbulence would be expected at high altitudes near the jet stream?

_____

_____

r. Which of the four types of turbulence would be expected above a line of mountains?

_____

_____

s. Which of the four types of turbulence would be expected near cumulus clouds?

_____

_____

REVIEW : Unit 8

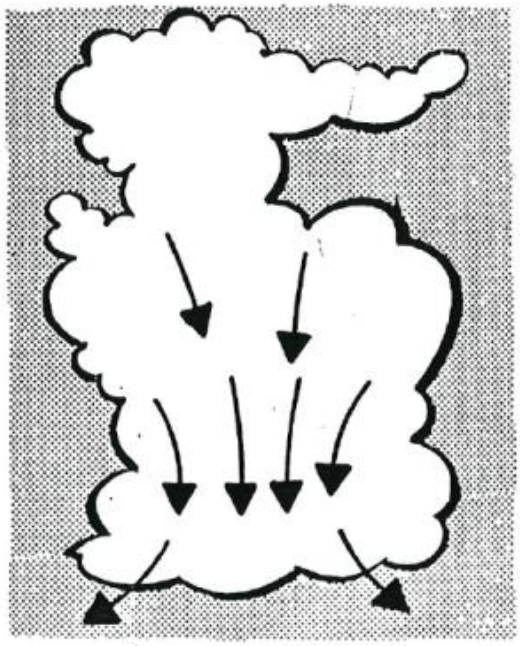


Figure 12

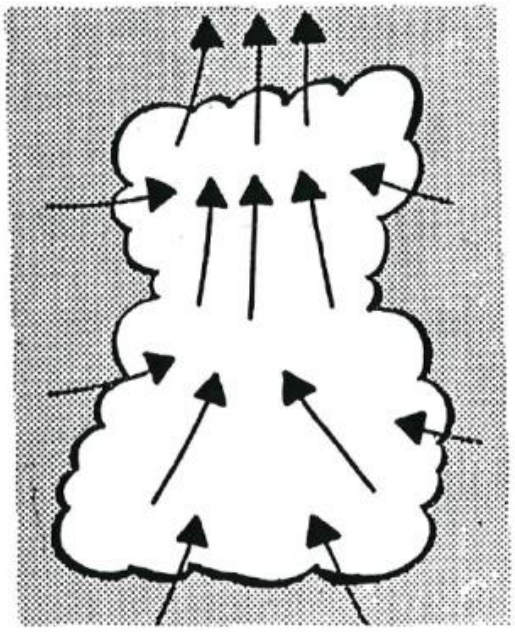


Figure 13

1. Refer to figures 12, 13, and 14, and fill in the blanks below.

   a. Figure 12 is a representation of the _____stage of a thunderstorm.

   b. Figure 13 is a representation of the _____stage of a thunderstorm.

   c. Figure 14 is a representation of the _____ of a thunderstorm.

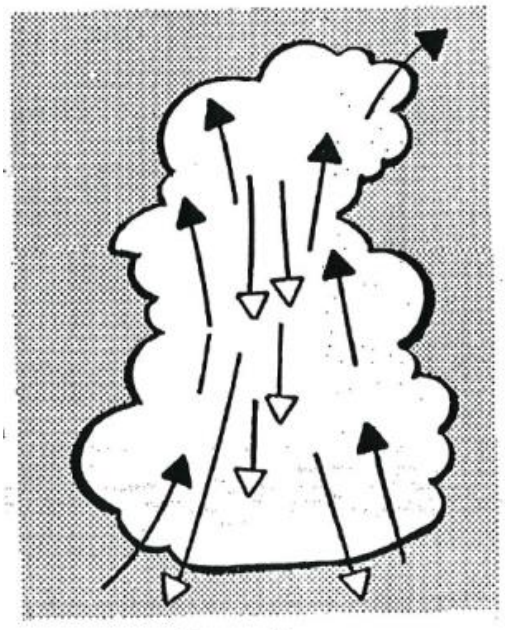


Figure 14

2. Use the information you studied in Unit 006-4B to answer at least 16 of the following 19 questions correctly.

   a. What two features always accompany and characterize a thunderstorm?

   _____

   _____

   b. What types of precipitation normally accompany a thunderstorm?

   _____

   _____

   c. What three features must be present for a thunderstorm to form?

   _____

   _____

   d. What three stages make up the life-cycle of a thunderstorm?

   _____

   _____

   e. About how long is the life-cycle of a typical local air mass thunderstorm?

   _____

   _____

   f. About how long is the maximum life-cycle of the thunderstorms that form a squall line?

   _____

   _____

   g. What kind of drafts predominate in the cumulus stage of a thunderstorm?

   _____

   _____

h. What kind of drafts predominate in the dissipating stage of a thunderstorm?

_____

_____

i. In which stage of the life-cycle of a thunderstorm do updrafts and downdrafts exist at the same time?

_____

_____

j. What material is hail composed of?

_____

_____

k. What are the two greatest hazards to aircraft produced by a thunderstorm?

_____

_____

l. Which thunderstorm hazard may cause temporary loss of vision and/or damage to electronic equipment?

_____

_____

m. What does a roll cloud indicate?

_____

_____

n. What type of pressure occurs in the spiral cone of a tornado?

_____

_____

_

o. What is a funnel cloud that touches the ground called?

_____

_____

p. What is a funnel cloud that touches the surface of water called?

_____

_____

q. What is the technical term for tornadoes that don't touch the surface?

_____

_____

r. What is the name of a line of thunderstorms that often develops ahead of a cold front?

_____

_____

s. Why are squall lines considered non-frontal storm?

_____

_____

English Language

for

RTAF Weather Corps

ภาษาอังกฤษสำหรับสายวิทยาการอุตุนิยมวิทยา

กองทัพอากาศ

Directorate of Air Operations Control

กรมควบคุมการปฏิบัติทางอากาศ

ก.ค.๖๓

PREFACE

Royal Thai Air Force maintains vision as “One of the Best Air Forces in ASEAN” by developing capability of 3 dimensions which are Air Domain, Cyber Domain and Space Domain. On the basis of balance and sustainability, thus the Air Force will be able to completely carry out security missions by preparing capabilities and use of such capabilities under the authority of the Ministry of Defence. Moreover, all departments under the Air Force must adhere to the mission and unit development. To be accordance with the Air Force Doctrine, B.E. 2560, the Air Force Plan, B.E. 2560, the 20-Year Air Force Strategy (2018 - 1980) and related development plans. Also, the objective of English development of the Air Force is to develop the ability to use English covering all 4 skills (Listening, speaking, reading, and writing) and be able to communicate and apply to work efficiently.

Weather Division, Directorate of Air Operations Control is taking this practice by using English language in Aviation Weather Service System and also joint training. English has also been used in weather briefing and in meteorology technical training to develop personnel performance and efficiency comparable with the international standards, moreover, it has been used as a reference in performing duties and in coordinating with foreign partners.

กองทัพอากาศดำรงวิสัยทัศน์ “กองทัพอากาศชั้นนำในภูมิภาค” โดยการพัฒนาขีดความสามารถทั้ง ๓ มิติ ได้แก่ มิติทางอากาศ (Air Domain) มิติไซเบอร์ (Cyber Domain) และมิติอวกาศ (Space Domain) บนพื้นฐานของความสมดุลและยั่งยืน เพื่อให้กองทัพอากาศสามารถปฏิบัติภารกิจหลักด้านความมั่นคงได้อย่างสมบูรณ์ โดยการเตรียมและใช้กำลังกองทัพอากาศตามบทบัญญัติที่กฎหมายกำหนด ซึ่งทุกหน่วยงานภายในกองทัพอากาศต้องยึดถือการปฏิบัติภารกิจและการพัฒนาหน่วย ให้เป็นไปตามหลักนิยมกองทัพอากาศ พ.ศ.๒๕๖๒ แผนการทัพอากาศ พ.ศ.๒๕๖๒ ยุทธศาสตร์กองทัพอากาศ ๒๐ ปี (พ.ศ.๒๕๖๑ - ๒๕๘๐) และแผนการพัฒนาที่เกี่ยวข้อง ทั้งนี้การพัฒนาภาษาอังกฤษของกองทัพอากาศ มีเป้าหมายเพื่อให้กำลังพลกองทัพอากาศได้รับการพัฒนาความสามารถในการใช้ภาษาอังกฤษครอบคลุมทั้ง ๔ ทักษะ (ฟัง พูด อ่าน เขียน) ให้สามารถสื่อสารและประยุกต์ใช้ในการปฏิบัติงานได้อย่างมีประสิทธิภาพ

กองข่าวอากาศ กรมควบคุมการปฏิบัติทางอากาศ ได้มีการนำภาษาอังกฤษมาใช้ในการปฏิบัติงานในด้านการบริการข่าวอากาศการบิน การฝึกร่วม/ร่วมผสม การบรรยายสรุปข่าวอากาศและการเรียนการสอนในหลักสูตรสายวิทยาการอุตุนิยมวิทยา เพื่อพัฒนาขีดความสามารถและประสิทธิภาพของกำลังพลของหน่วยเป็นไปตามมาตรฐานสากล และสามารถนำไปใช้อ้างอิงในการปฏิบัติงานและติดต่อประสานกับต่างประเทศได้

Air Chief Marshal

(NAPADEJ DHUPATEMIYA)

Commander

Directorate of Air Operations Control

TABLE OF CONTENTS

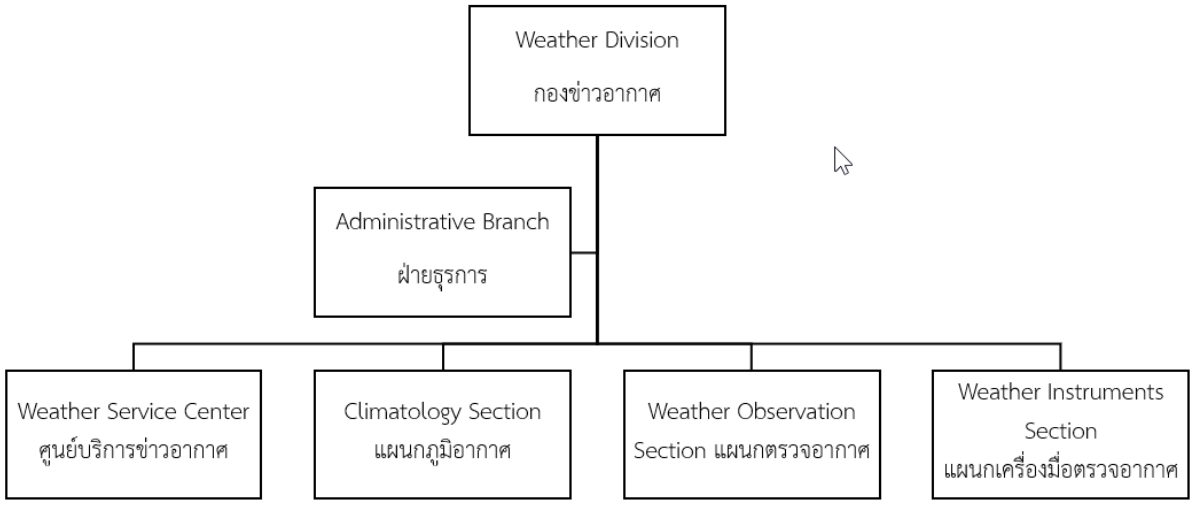
Part I

Mission of Weather Division (ภารกิจ กองข่าวอากาศ)

Weather Division is responsible for preparing, coordinating, supervising, controlling and possessing weather observation and forecasting, weather warning, weather service and weather instruments maintenance.

กองข่าวอากาศ มีหน้าที่ เตรียมการ ประสานงาน กำกับการ ควบคุมและดำเนินการเกี่ยวกับการตรวจอากาศ พยากรณ์อากาศ แจ้งเตือนสภาพอากาศ การบริการข่าวอากาศและเครื่องมือตรวจอากาศ มีผู้อำนวยการกองข่าวอากาศเป็นผู้บังคับบัญชารับผิดชอบ

Organization Chart (การจัดส่วนราชการ)



1. **Weather Division** (กองข่าวอากาศ)

1.1 Weather Service Center (ศูนย์บริการข่าวอากาศ)

1.2 Climatology Section (แผนกภูมิอากาศ)

1.3 Weather Observation Section (แผนกตรวจอากาศ)

1.4 Weather Instruments Section (แผนกเครื่องมือตรวจอากาศ)

1.5 Administrative Branch (ฝ่ายธุรการ)

Part II

1. Weather supports (สนับสนุนข้อมูลข่าวอากาศ)

Prepare operational weather supports corresponding to mission of Royal Thai Air Force and other related branch of the Department of Defense.

สนับสนุนข้อมูลข่าวอากาศสำหรับภารกิจ ทอ.และหน่วยที่เกี่ยวข้อง

1.1 Analyse Forecasts and Warnings (วิเคราะห์ พยากรณ์และแจ้งเตือน)

Continuously analyse the weather report data from meteorological station in order to plot various of weather charts for example, surface chart, wind aloft chart, Skew-T Log P diagram and pressure change chart. Forecast the weather in short, medium and long range forecast as assigned schedule and to provide to requested organization. Report weather information to related organization, including issue warning hazardous weather such as tropical cyclone, strong monsoon and weather-related disasters which bring about the damage to life and property.

วิเคราะห์ข่าวอากาศจากข้อมูลการรายงานข่าวอากาศ เพื่อนำมาเขียนลงในแผนที่อากาศในแต่ละชนิด เช่น แผนที่อากาศผิวพื้น แผนที่ลมชั้นบน แผนภูมิเทอร์โมนามิกส์ แผนที่ความกดอากาศเปลี่ยนแปลงเป็นต้น พยากรณ์สภาพอากาศทั้งในระยะสั้น ระยะกลาง และระยะยาว ตามระเบียบปฏิบัติประจำ และตามที่มีหน่วยงานร้องขอข้อมูล รายงานข้อมูลสภาพอากาศอย่างต่อเนื่องให้แก่หน่วยที่เกี่ยวข้อง รวมถึงแจ้งเตือนสภาพอากาศรุนแรง เช่น พายุหมุนเขตร้อน มรสุมกำลังแรง และภัยพิบัติที่เกิดจากสภาพอากาศอันอาจก่อให้เกิดอันตรายต่อชีวิตและทรัพย์สินของทางราชการ

<u>คำศัพท์ที่เกี่ยวข้อง</u> (Vocabulary)

คำศัพท์	ความหมาย	คำศัพท์	ความหมาย
Surface chart	แผนที่อากาศผิวพื้น	Tropical cyclone	พายุหมุนเขตร้อน
Pressure change chart	แผนที่ความกดอากาศเปลี่ยนแปลง	Weather report data	ข้อมูลรายงานข่าวอากาศ
Wind aloft chart	แผนที่ลมชั้นบน	Skew-T Log P Diagram	แผนภูมิเทอร์โมไดนามิกส์

<u>แบบฝึกหัด</u>

1. What type of weather chart that describe the difference of pressure between today and yesterday?

a. Surface chart
b. Pressure change chart
c. Skew T Log P diagram
d. Wind aloft Chart

Conversation between A – Flying Officer Yaya (USAF) and B – FS1.Nadej (RTAF)

A: Hello Nadej. What are you doing?

B: Hello Yaya. I'm analyzing the synoptic data

A: That's great. Did you check the warning?

B: I've already checked it.

A: Good Job. Keep doing.

B: Thank you sir.

บทสนทนาระหว่าง A – ร.ต.หญิง ญาญ่า (ทอ.สหรัฐอเมริกา) และ B – พ.อ.อ.ณเดช (ทอ.ไทย)

A: สวัสดีณเดช ทำอะไรอยู่

B: สวัสดีครับญาญ่า ผมกำลังวิเคราะห์ข่าวอากาศประจำชั่วโมงครับ

A: เยี่ยมมาก ได้ตรวจสอบประกาศแจ้งเตือนหรือยัง

B: ตรวจสอบเรียบร้อยแล้วครับ

A: ดีมาก ทำต่อไปนะ

B: ขอบคุณครับ

1.2 Weather monitoring and weather advices (ติดตามสภาพอากาศและให้ข้อเสนอแนะด้านอุตุนิยมวิทยา)

Constantly monitoring weather hazards and provide meteorological watch, warning and advisory for RTAF missions, threat-warning and threat-mitigation for example, to monitor and provide the weather situation in Line Application or RTAF email. Arrange the staff for weather briefing at the military terminal for aviation mission including prepare staff to brief the weather forecast at the meeting i.e. Operation Center RTAF.

ติดตามสภาพอากาศและให้ข้อเสนอแนะข้อมูลด้านอุตุนิยมวิทยา เช่น การติดตามและรายงานสภาพอากาศทางแอพพลิเคชั่นไลน์ อีเมล หรือ จัดเจ้าหน้าที่บรรยายสภาพอากาศที่ท่าอากาศยานทหารในภารกิจที่ต้องมีการเดินอากาศรวมถึงการจัดเจ้าหน้าที่บรรยายสรุปในการประชุมต่าง ๆ เช่น การประชุม ศปก.ทอ. เพื่อบรรลุเป้าหมายของภารกิจหรือหลีกเลี่ยงอันตรายจากสภาพอากาศ

คำศัพท์ที่เกี่ยวข้อง (Vocabulary)

คำศัพท์	ความหมาย	คำศัพท์	ความหมาย
weather briefing	บรรยายสรุปสภาพอากาศ	meteorological advisory	ข้อเสนอแนะด้านอุตุนิยมวิทยา
military terminal	ท่าอากาศยานทหาร	aviation mission	ภารกิจทางการบิน

แบบฝึกหัด

2. The weather officer must prepare for the ..... as the Wing 6 had requested for the weather forecast at the terminal 7.00 am tomorrow.

a. Officer course
b. Pressure change chart
c. Weather briefing
d. Tropical storm

Conversation between A – Flying Officer Yaya (USAF) and B – FS1.Nadej (RTAF)

A: Hello Nadej. What are you typing?

B: I'm typing the weather forecast for briefing tomorrow.

A: Is there any request?

B: Yes, Wing 6 had requested for the weather forecast from Don Meaung to Udon Thani for the flight of Air Chief Marshal Airbull Suttiwan.

A: Check it carefully Nadej.

B: Yes sir.

บทสนทนาระหว่าง A – ร.ต.หญิง ญาญ่า (ทอ.สหรัฐอเมริกา) และ B – พ.อ.อ.ณเดช (ทอ.ไทย)

A: สวัสดีณเดช พิมพ์อะไรอยู่

B: กำลังพิมพ์พยากรณ์อากาศไปบรรยายสรุปวันพรุ่งนี้ครับ

A: มีการร้องขอมาหรือ?

B: ใช่ครับ กองบิน 6 ขอสภาพอากาศจากดอนเมือง ไปอุดรธานี สำหรับเที่ยวบินของผบ.ทอ.ครับ

A: ตรวจสอบดี ๆ นะ ณเดช

B: รับทราบครับ

2. Technical skills development (พัฒนากำลังพลด้านอุตุนิยมวิทยา)

Develop the personnel in meteorological aspect, knowledge, technique according to the changing technology.

พัฒนากำลังพลด้านอุตุนิยมวิทยาให้ก้าวทันองค์ความรู้ เทคนิค วิธีการ และเทคโนโลยีที่เปลี่ยนแปลงอย่างต่อเนื่อง

2.1 Weather education and Training (ฝึกอบรมบุคลากรสายงานอุตุนิยมวิทยา)

Provide academic training in meteorology corps which covers the non-commissioned officer course and officer course. For example, the starter course for the graduate from Air Technical Training School (ATTS), the weather technician course for the weather forecast task and the weather officer course for the officer in meteorology corps. Contact with the Thai Meteorological Department to send the staff for joining the basic and advance meteorology course or prepare the staff for apply for the IMET scholarship to attend the weather course that provided by USAF in United State of America. Moreover, projects and workshops in related fields will be conducted as per the situation and up-to-date knowledge.

จัดอบรมบุคลากรในหลักสูตรสายวิทยาการอุตุนิยมวิทยา โดยจัดให้มีหลักสูตรทั้งในระดับนายทหารประทวนและนายทหารสัญญาบัตร เช่น หลักสูตรเจ้าหน้าที่ข่าวอากาศขั้นพื้นฐานสำหรับผู้ที่จบจากโรงเรียนจ่าอากาศ หลักสูตรเจ้าหน้าที่เทคนิคข่าวอากาศสำหรับผู้ที่จะทำหน้าที่พยากรณ์อากาศ และหลักสูตรนายทหารข่าวอากาศสำหรับนายทหารสัญญาบัตรในเหล่าอุตุนิยมวิทยา ตลอดจนจัดส่งกำลังพลในสายงานอุตุนิยมวิทยาไปศึกษาหลักสูตรอื่น ๆ นอกกองทัพอากาศ เช่น หลักสูตรอุตุนิยมวิทยาชั้นต้นและชั้นสูงของกรมอุตุนิยมวิทยา หลักสูตรตามโครงการ IMET ของสหรัฐอเมริกา เป็นต้น นอกจากนั้นยังจัดทำโครงการและสัมมนาเชิงปฏิบัติการด้านอุตุนิยมวิทยาหรือที่เกี่ยวข้องอื่นๆ

<u>คำศัพท์ที่เกี่ยวข้อง</u> (Vocabulary)

คำศัพท์	ความหมาย	คำศัพท์	ความหมาย
non-commissioned officer	นายทหารประทวน	weather officer	นายทหารข่าวอากาศ
weather forecaster	นักพยากรณ์อากาศ	eligibility	คุณสมบัติผู้สมัคร

Conversation between A – Flying Officer Yaya (USAF) and B – FS1.Nadej (RTAF)

A: Hello Nadej. Did you apply for the weather forecaster course?

B: I didn’t. What is this course about?

A: It’s the course that train about weather forecast technique. It’s important for you.

B: I will check the eligibility and apply for it.

A: Good luck.

B: Thank you sir.

บทสนทนาระหว่าง A – ร.ต.หญิง ญาญ่า (ทอ.สหรัฐอเมริกา) และ B – พ.อ.อ.ณเดช (ทอ.ไทย)

A: สวัสดีณเดช ได้สมัครหลักสูตรเจ้าหนี้ที่เทคนิคข่าวอากาศหรือยัง

B: ยังเลยครับ เป็นหลักสูตรเกี่ยวกับอะไรครับ

A: เป็นหลักสูตรที่สอนเกี่ยวกับเทคนิคการพยากรณ์อากาศ สำคัญมากเลยนะ

B: ผมจะตรวจสอบคุณสมบัติและสมัครครับ

A: โชคดีค่ะ

B: ขอบคุณครับ

2.2 Prepare Handbooks, manuals and training documents (จัดทำ ปรับปรุงเอกสารตำราอุตุนิยมวิทยา)

Prepare and document the handbooks, manuals, and instructional-media to be as standard according to the manual of World Meteorological Organization (WMO) and update the knowledge from the worldwide journal which can be adapted to Thailand meteorological aspects including collect the lesson-learned from the staff who attended the domestic and international meteorology course.

จัดทำ รวบรวม เรียบเรียงและปรับปรุงเอกสาร ตำรา คู่มือและสื่อการสอนทางอุตุนิยมวิทยาให้ทันสมัยและเป็นมาตรฐาน โดยยึดหลักตามองค์การอุตุนิยมวิทยาโลก และติดตามความรู้จากงานวิจัยจากต่างประเทศที่สามารถนำมาปรับใช้กับองค์ความรู้อุตุนิยมวิทยาของไทยได้ รวมถึงความรู้ที่ได้จากการส่งกำลังพลไปศึกษาหลักสูตรต่าง ๆ ทั้งในและต่างประเทศ

คำศัพท์ที่เกี่ยวข้อง (Vocabulary)

คำศัพท์	ความหมาย	คำศัพท์	ความหมาย
journal	งานวิจัย	instructional-media	สื่อการสอน
handbook	คู่มือ	adapt	ปรับใช้

แบบฝึกหัด

3. The ametsoc.org website provides a lot of ..... which related to meteorological contents. All the staff in meteorology corps is encouraged to visit this website to update their own knowledge.

a. Weather maps
b. Adaptation
c. Weather briefing
d. Journals

Conversation between A – Flying Officer Yaya (USAF) and B – FS1.Nadaj (RTAF)

A : Good Morning, How are you?

B : Good Morning, I'm fine. And you?

A : I'm good

B : How can I help you?

A : Can you provide me the flight route forecast from Korat airport to Payalebar airport tomorrow?

The take-off time is 10 local time, flight time is 2 hours, at flight level 30,000 feet and we have Butterworth airport as the alternate airport.

B : OK. And what time you will come to pick up the forecast?

A : Tomorrow at 7 local time

B : 0700 OK tomorrow at 7

A : Thank you so much.

B : You're welcome

บทสนทนาระหว่าง A – ร.ต.หญิง ญาญ่า (ทอ.สหรัฐอเมริกา) และ B – พ.อ.อ.ณเดช (ทอ.ไทย)

A : สวัสดีตอนเช้า คุณสบายดีหรือไม่

B : สวัสดี ผมสบายดี แล้วคุณสบายดีหรือเปล่า

A : สบายดี

B : มีอะไรให้ผมช่วยหรือเปล่า

A : ฉันต้องการข้อมูลพยากรณ์สภาพอากาศเส้นทางบินสนามบิน โคราช ไป สนามบินพายาเลบาร์ วันพรุ่งนี้ เวลาวิ่งขึ้น 1000 เวลาท้องถิ่น ใช้เวลาบิน 2 ชั่วโมง ที่ระดับบิน 30,000 ฟุต มีสนามบินบัตเตอร์เวอร์ตเป็นสนามบินสำรอง

B : จะมารับข้อมูลเวลาเท่าไร

A : พรุ่งนี้ เวลา 0700 เวลาท้องถิ่น

B : ได้ครับ พรุ่งนี้ 0700

A : ขอบคุณ

B : ด้วยความยินดี

Index

Definitions (นิยามศัพท์)

เมฆคิวมูลัส (Cu)	Cumulus
เมฆนิมโบสเตรตัส (Ns)	Nimbostratus
เมฆคิวมูโลนิมบัส (Cb)	Cumulonimbus
เวอร์ก้า (vir)	Virga
ฐานเมฆ	Cloud base
ยอดเมฆ	Cloud Top
ความสูงของเมฆ	Vertical extent of a cloud
ชั้นของเมฆ	Cloud Layer
เมฆชั้นต่ำ	Low – level cloud – Low cloud
เมฆชั้นกลาง	Medium – level cloud – Middle cloud
เมฆชั้นสูง	High – level cloud – High cloud
การเกิดเมฆและการจัดตัวของเมฆ	Cloud formation and arrangement of clouds
อุณหภูมิอากาศ	Air temperature
อุณหภูมิตุ้มแห้ง	Dry-bulb temperature
อุณหภูมิตุ้มเปียก	Wet-bulb temperature
จุดเยือกแข็ง	Freezing point
จุดเดือด	Boiling point
จุดหลอมเหลว	Melting point
อุณหภูมิสูงสุดประจำวัน	Daily maximum temperature
อุณหภูมิต่ำสุดประจำวัน	Daily minimum temperature
อุณหภูมิเฉลี่ยรายวัน	Mean daily temperature
น้ำฟ้า หรือหยาดน้ำฟ้า	Precipitation
ฝนละออง หรือฝนหยิม	Drizzle = DZ
ฝน	Rain = RA
ฝนซู่ หรือฝนไล่ช้าง	Shower
จำนวนฝน หรือปริมาณฝน	Rainfall amount
หิมะ	Snow = SN
เกล็ดหิมะ	Snow Grains = SG
ผลึกน้ำแข็ง	Ice Crystals = IC
เกล็ดน้ำแข็ง	Ice Pellets = PE
ลูกเห็บและลูกเห็บขนาดเล็ก	Hail = GR and Small Hail = GS
เกล็ดหิมะ	Snow Pellets = GS
น้ำท่วม หรือน้ำขัง	Flood

ท่วมฉับพลัน หรือน้ำป่า	Flash flood
ภัยแล้ง	Drought
น้ำป่าไหลหลาก	Flash flood
น้ำล้นตลิ่ง	Overbank Flow
พายุหมุนเขตร้อน หรือพายุไซโคลนเขตร้อน	Tropical cyclone
พายุโซนร้อน	Tropical Storm
พายุใต้ฝุ่น	Typhoon
พายุทอร์เนโด หรือลมงวง	Tornado
ลมบ้าหมู ลมหมุน	dust devil, whirl wind
พายุฟ้าคะนอง	Thunderstorm
น้ำค้าง	Dew
ฮอร์ฟรอสต์	Hoar frost
หมอก	Fog
หมอกน้ำค้าง	Mist
หมอกแดด	Haze
เครื่องมืออุตุนิยมวิทยา	Meteorological Instrument
เทอร์มอมิเตอร์ (เทอร์โมมิเตอร์) หรือเครื่องวัดอุณหภูมิ	Thermometer
เทอร์โมกราฟ หรือเครื่องวัดอุณหภูมิแบบกราฟ	Thermograph
เรือนเทอร์มอมิเตอร์ หรือตู้สกรีน	Thermometer screen – thermometer shelter
บารอมิเตอร์ (บาโรมิเตอร์) หรือเครื่อง (มาตร) วัดความกดอากาศ	Barometer
บารอมิเตอร์ปรอท	Mercury barometer
บารอมิเตอร์ตลับ หรือเครื่องวัดความกดอากาศแบบตลับ หรือ แอนเนอรอยด์บารอมิเตอร์	Aneriod barometer
แอนนิมอมิเตอร์ หรือเครื่องวัดลม หรือมาตรวัดลม	Anemometer
ถุงวัดลม	Wind sleeve – Wind sock
กล้องทีออโดไลต์ หรือกล้องวัดมุม	Theodolite
ไฮกรอมิเตอร์	Hygrometer

ไฮกรอมิเตอร์แบบเส้นผม	Hair hygrometer
โพรเจคเตอร์ฐานเมฆ	Ceiling projector
เครื่องวัดน้ำฝน	Raingauge

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