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AVIATION WEATHER STUDENT GUIDE

MULTI-ENGINE

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1. CNATRA P-559 (New 08-08) PAT, is issued for information, standardization of instruction, and guidance for all flight instructors and student aviators within the Naval Air Training Command.

2. This publication shall be used as an explanatory aid to all T-44/TC-12 MULTI-ENGINE curricula. It is a reference with applicability for all stages of training.

3. Recommendations for changes shall be submitted via CNATRA TCR form CNATRA 1550/19 in accordance with CNATRAINST 1550.6E.

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AVIATION WEATHER STUDENT GUIDE

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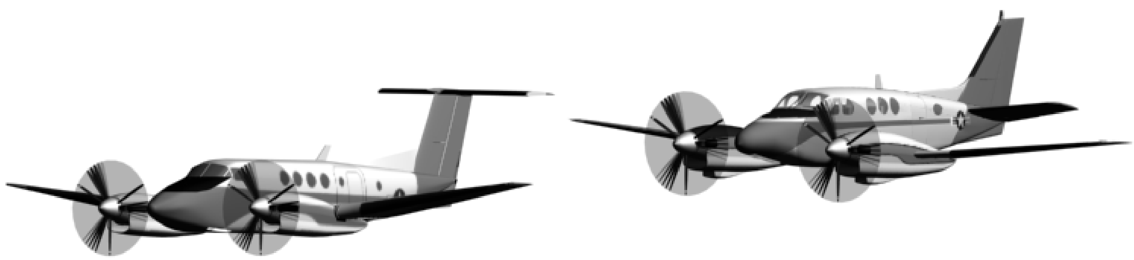

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LIST OF EFFECTIVE PAGES

Dates of issue for original and changed pages are:
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INTERIM CHANGE SUMMARY

The following changes have been previously incorporated in this manual:

CHANGE NUMBER	REMARKS/PURPOSE

The following interim Changes have been incorporated in this Change/Revision:

INTERIM CHANGE NUMBER	REMARKS/PURPOSE	ENTERED BY	DATE

SAFETY/HAZARD AWARENESS NOTICE

This course does not require any special safety precautions other than those normally found on the flight lines.

HOW TO USE THIS WORKBOOK

1. Read and become familiar with the objectives of each chapter. These objectives state the purpose of this chapter of instruction in terms of WHAT YOU WILL BE ABLE TO DO as you complete the chapter. Most importantly, your end-of-course examination is developed directly from these objectives. Therefore, it is to your benefit to know all information the objectives are asking you to comprehend.

2. ***Before the class presentation,*** read the information in each chapter using the objectives as a guide. Develop a list of questions about material that is unclear to you at this point. This practice will allow you to ask questions when the topic is covered during the classroom presentation, or at a later time with the instructor in a one-on-one setting. You may also wish to consult your *Weather for Aircrews* handbook for further information.

3. ***After the class presentation,*** re-read each chapter to ensure your comprehension of the subject material. If you desire further information, explanation, or clarification, consult the other resources available to you such as your *Weather for Aircrews* book and your instructor.

4. Answer the questions provided in the "Study Questions" sections. These questions will help you recall the information presented in each chapter, and they will also serve as a practice for the examination. Check your answers to the Study Questions with those provided in Appendix E. If your answer to a question is incorrect, review the objective and information covering that subject area prior to continuing to the next chapter. **"Good Luck."**

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WORKBOOK SCOPE

Upon completion of this unit of instruction, student aviators and flight officers will demonstrate knowledge of meteorological theory which will enable them to make intelligent decisions when confronted with various weather phenomena and hazards, as well as interpreting and using various weather products for flight planning.

TERMINAL OBJECTIVES

1.0 Describe the general characteristics of atmospheric structure, temperature, and pressure.

2.0 Describe the meteorological mechanics of winds, moisture, and stability.

3.0 Describe the general characteristics of a front and frontal weather.

4.0 Describe the various hazards associated with thunderstorms.

5.0 Describe the aviation hazards of turbulence, icing, and visibility.

6.0 Describe displayed data in Aviation Routine Weather Reports (METARs) and Terminal Aerodrome Forecasts (TAFs).

7.0 Describe displayed data shown on various weather imagery products.

8.0 Describe displayed data on Severe Weather Watches, Military Weather Advisories, and In-Flight Weather Advisories, and state the use and requirements for Pilot Weather Reports (PIREPs).

9.0 Describe indicated data on the DD 175-1, "Flight Weather Briefing Form," and state the sources of hazardous weather information used to complete the form.

INSTRUCTIONAL MATERIALS

The USAF publication, Air Force Handbook 11-203, Volume 1, *Weather for Aircrews*, **must** be issued to each student, as it is an integral part of the Aviation Weather syllabus. This student guide was written with the intention of each student having their own copy of *Weather for Aircrews* to read for further information that is not covered in this text, as well as for future reference.

Additionally, this course is designed to be taught by a winged Military Aviator instructor with the corresponding electronic classroom presentation, consisting of Macromedia Authorware files Menu.exe, Lesson1.exe, Lesson2.exe, etc., through Lesson9.exe.

INTRODUCTION

In accordance with applicable military instructions, all pilots are responsible for reviewing and being familiar with weather conditions for their planned flight. Where Weather Services are available, weather briefings shall be conducted by a qualified forecaster. They may be conducted either in person or via telephonic, autographic, weather vision, or approved Internet methods. In some cases pilots may have to complete the briefing and DD 175-1 Weather Briefing Forms on their own.

In preparing for a flight, aircrew should always make an analysis of the weather. The pilot is negligent in the performance of duties if a weather brief is accepted that is not completely understood. The object of such a pre-brief analysis is to give the aircrew a complete picture of the weather conditions and developments that will affect flight along the route. It will also enable the crew to discuss intelligently any apparent discrepancies in the forecast given during the weather brief itself. Once in the air, a pilot cannot always consult the forecaster or the charts to understand the reasons for unexpected changes and to choose the best corrective action. At these times the aircrew must rely on knowledge, experience, and the information obtained before departure.

Before going into a weather office to receive a flight weather briefing, the pilot and aircrew must know exactly what information is needed. The crew needs to know the local weather at the time of takeoff and during the climb to altitude, the weather to be expected while en route and the effect on aircraft performance, and the existing and forecast weather at destination and alternate airfield(s). The type of information needed will vary considerably depending upon whether the pilot is flying a jet aircraft, turboprop, piston-driven propeller aircraft (not covered in this text), or a helicopter.

So how can a pilot or navigator, whose specialty is flying aircraft, be able to carry on an intelligent discussion with a professional meteorologist? Better yet, how can the aircrew make intelligent decisions about dealing with the weather once airborne? The answer lies in learning a foundation of weather knowledge that continues to grow over the course of one’s career through experience *and* personal study. Thus, the purpose of this course in Aviation Weather is not to produce meteorologists, but rather aviators who understand the basics of weather phenomena and the weather information systems in use.

The first part of this course, chapters 1-5, presents the building blocks of meteorology and the major hazards that weather presents to aviation, such as found with thunderstorms, turbulence, icing, obstructions to vision, and volcanoes. The last part, chapters 6-9, deals with the weather products available to aviators–from the codes and abbreviations used to communicate weather in a precise manner, to the charts and warnings, and finally to the Flight Weather Briefing Form itself, the DD 175-1.

The authors of this book hope that you find this course informative, and that you are able to use this book and *Weather for Aircrews* as a reference throughout your career.

CHAPTER ONE
ATMOSPHERE, ATMOSPHERIC TEMPERATURE AND PRESSURE

ASSIGNMENT SHEET

General Structure of the Atmosphere, and Atmospheric Temperature and Pressure
Assignment Sheet 1.1A

INTRODUCTION

The purpose of this assignment sheet is to introduce the student to the general composition and structure of the atmosphere, and the properties of temperature and atmospheric pressure, and their effect on aircraft altimeters.

LESSON TOPIC LEARNING OBJECTIVES

Terminal Objective:
Completely supported by this lesson topic:

1.0 Describe the general characteristics of atmospheric structure, temperature, and pressure.

Enabling Objectives:
Completely supported by this lesson topic:

1.1 Define atmospheric pressure.

1.2 State the standard units of pressure measurement.

1.3 Define the standard atmosphere to include temperature and pressure.

1.4 Differentiate between sea level pressure and station pressure.

1.5 Define indicated altitude, calibrated altitude, Mean Sea Level (MSL) altitude, Above Ground Level (AGL) altitude, pressure altitude, and density altitude.

1.6 Describe the effects of pressure changes on aircraft altimeters.

1.7 State the effects of temperature deviations from the standard lapse rate on aircraft altimeters.

STUDY ASSIGNMENT

Review Information Sheet 1.1I, and answer the Study Questions.

INFORMATION SHEET

General Structure of the Atmosphere, and Atmospheric Temperature and Pressure
Information Sheet 1.1I

100. INTRODUCTION

This lesson will discuss that pressure is important to the aviation community since one of the most basic flight instruments, the barometric altimeter, operates from the action of atmospheric pressure upon its sensors. In order to gain a complete understanding of the altimeter, the effects of temperature and pressure variations on altimeter readings will also be discussed.

REFERENCES

1. *Weather for Aircrews*, AFH 11-203, Volume 1, Chapters 1, 3, and 4.
2. *Aviation Weather for Pilots and Flight Operations Personnel*, Chapters 1-3.

INFORMATION

101. ATMOSPHERIC PRESSURE

Pressure is force per unit area. **Atmospheric (barometric) pressure** is the pressure exerted on a surface by the atmosphere due to the weight of the column of air directly above that surface. For example, the average weight of air on a square inch of the Earth's surface at sea level under standard conditions is 14.7 pounds. Pressure, unlike temperature, *always* decreases with altitude. In the lower layers of the atmosphere pressure decreases much more rapidly than it does at higher altitudes because density decreases as altitude increases.

102. UNITS OF MEASUREMENT

In the U.S., two units are used to measure and report atmospheric pressure: inches of mercury (in-Hg) and millibars (mb). Inches of mercury is a measure of the height of a column of mercury that can be supported by atmospheric pressure. The millibar is a direct representation of pressure, which is defined as force per unit area. Normal sea level pressures in the atmosphere vary from as low as 28 in-Hg (about 960 mb) to as high as 31 in-Hg (about 1060 mb).

Some countries, particularly those using the metric system, use millibars for altimeter settings. However, in the United States and Canada altimeter settings are reported in inches of mercury.

103. THE STANDARD ATMOSPHERE

For a standard reference, a concept called a standard day is used. In aviation, everything is related to standard day conditions at sea level, which are 29.92 in-Hg (1013.2 mb) and 15 °C (59 °F). In the lower atmosphere, and thus for most aviation applications, a 1,000 foot increase in altitude will result in a pressure decrease of approximately 1 in-Hg (34 mb) and a temperature decrease of 2 °C (3.5 °F). These values are the standard day pressure and temperature lapse rates.

104. PRESSURE CHARTS

The pressure at the Earth's surface changes for several reasons. The most noted reason for this change is the movements of high and low pressure systems. The temperature and moisture content of air also affect surface pressures.

Meteorologists track these different weather systems by noting the pressure each time a weather observation is made and then forwarding all observations to the national weather service (NWS). The NWS then plots the weather on various charts. The resulting horizontal distribution of pressure across the Earth's surface is depicted on weather charts by **isobars**, or lines of equal barometric pressure (Figure 1-1).

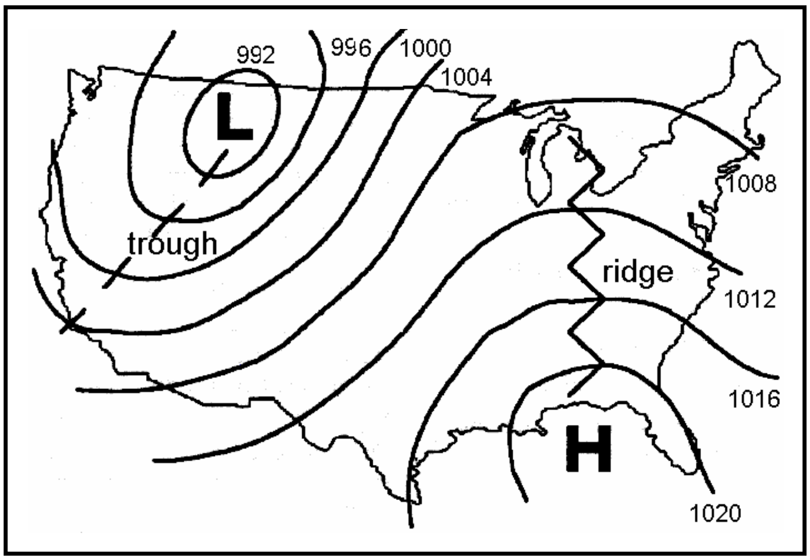

Figure 1-1 Pressure Systems

There are several standard types of pressure distribution patterns found on weather charts (Figure 1-1). A high-pressure area (or **high**)–where the pressure in the center is higher than the surrounding areas–may be thought of as a mountain on a surface pressure chart. Similarly, a **low**-pressure area–where the pressure in the center is lower than the surrounding areas–may be thought of as a basin or valley. A **ridge** is an extension of a high-pressure area, and a **trough** (or **trof**) is an extension of a low-pressure area. There are certain characteristic winds and weather systems associated with these pressure systems. For example, poor weather such as found with fronts and squall lines are generally associated with troughs and lows, while good weather is associated with highs and ridges.

105. STATION AND SEA LEVEL PRESSURE

Station pressure is the atmospheric pressure measured directly at an airfield or other weather station. **Sea level pressure** is the pressure that would be measured from the existing weather if the station were at mean sea level (MSL). This can be measured directly at sea level, or calculated if the station is not at sea level using the standard pressure lapse rate.

Surface analysis charts, such as the one in Figure 1-1, use MSL as the reference level for the depicted isobars (to provide a common reference), even though the pressure was first measured at a weather station. This is done so that daily pressure variations associated with weather systems can be tracked as they move across the country, as mentioned above. If, instead, station pressures were used, the pressure charts would depict the inverse of the land topography, reflecting the contour lines of a map. Mountain tops would always have lows over them, and valleys would have highs. In other words, high altitude stations such as Denver would always reflect lower pressure than surrounding stations at lower altitudes regardless of the day to day pressure variations that occur with passing weather systems. Thus, for pressure to be meaningful, all stations–even those far from the ocean–will report sea level pressure.

106. ALTITUDE MEASUREMENT

Altitude is defined as the height above a given reference. The instrument that displays altitude in the cockpit is called an **altimeter**. The **barometric altimeter** is an aneroid barometer that is calibrated to display altitude in feet, as opposed to pressure in inches of mercury (Figure 1-2).

Figure 1-2 Barometric Altimeter

Since an altitude includes not only the height number, but also the reference, altimeters have a Kollsman window that shows the reference pressure, known as the **altimeter setting**. The altimeter setting is the value to which the scale of the pressure altimeter is set so the altimeter indicates true altitude at field elevation. It is very nearly equal to the station pressure corrected to mean sea level pressure (not exact, but close enough for instructional purposes). An adjustment knob allows the altimeter setting to be changed. If the local altimeter setting is dialed in to the Kollsman window, the altimeter will indicate the altitude in feet above mean sea level (ft MSL). If 29.92 is set, the altimeter will indicate the altitude above the standard datum plane. These are the two altitudes most often displayed on the altimeter, MSL and pressure altitudes, and both are discussed in the next section.

107. ALTITUDES

Indicated altitude is the altitude read directly from the altimeter. Since altimeters need no power (except for lighting–they operate by measuring the outside pressure), they will always indicate some value. Figure 1-2 shows an altitude of 5,635 feet indicated. For an indicated altitude to be useful, however, the altimeter needs to have the correct reference for the situation by dialing either the local altimeter setting or 29.92 in to the Kollsman window. This way, the indicated altitude will be equal to either the MSL or the pressure altitude (still to be discussed).

To illustrate, if an aircraft is parked at Sherman Field with the local altimeter setting in the Kollsman window, the indicated altitude should be the same as the airfield elevation, and the indicated altitude will be an MSL altitude. Therefore, the altimeter should indicate approximately 30 feet MSL since Sherman Field is 30 feet above mean sea level.

Altimeters are subject to mechanical errors caused by installation, misalignment, and positioning of the static ports that measure the pressure. Collectively, these errors are referred to as **instrument error**. Instrument error is determined prior to takeoff by noting the difference between field elevation and indicated altitude. For example, an aircraft taking off from Sherman Field (elevation +30 ft MSL) with an indicated altitude of 70 ft would have an instrument error of +40 ft. If the instrument error is in excess of 75 ft, the aircraft is considered unsafe for instrument flight. **Calibrated altitude** is indicated altitude corrected for instrument error.

Mean Sea Level (MSL) or **true altitude** is the actual height above mean sea level (MSL). It is found by correcting calibrated altitude for temperature deviations from the standard atmosphere. On a standard day, MSL/true altitude is equal to calibrated altitude. If there is no instrument error, true altitude would also be equal to indicated altitude. Mean Sea Level/MSL altitude is very important since airfields, hazards, and terrain elevations are stated in feet above mean sea level.

AGL or **absolute altitude** is the aircraft's height above the terrain directly beneath the aircraft and is measured in feet above ground level (AGL). Absolute altitude is not normally displayed on an altimeter, but it can be calculated by subtracting the terrain elevation from the true altitude. Additionally, it can be displayed directly on a radar altimeter.

Pressure altitude is the height above the standard datum plane. The standard datum plane is the actual elevation above or below the earth's surface at which the barometric pressure is 29.92 in-Hg. Federal Aviation Rules (FAR) require that all aircraft operating above 18,000 feet MSL set 29.92 in to the altimeter to ensure consistent altitude separation. Since most mountains in the U.S. are well below 18,000' MSL, there is less concern with terrain avoidance than with aircraft separation above that altitude. Thus, a pilot flying a pressure altitude will have an altimeter setting of 29.92 instead of the local altimeter setting. In short, a pressure altitude is the height above the place in the atmosphere where the pressure is 29.92 in-Hg. Whether this place is above, below, or coincides with sea level is of little concern.

When aircraft fly pressure altitudes, they are assigned a flight level (FL) of three digits, representing hundreds of feet above 29.92. As an example, an aircraft assigned FL250 (pronounced *"flight level two five zero"*) would be flying a pressure altitude, and the pilot would fly the aircraft so that the altimeter reads 25,000 feet with 29.92 in the Kollsman window. These above altitude definitions are illustrated in Figure 1-3.

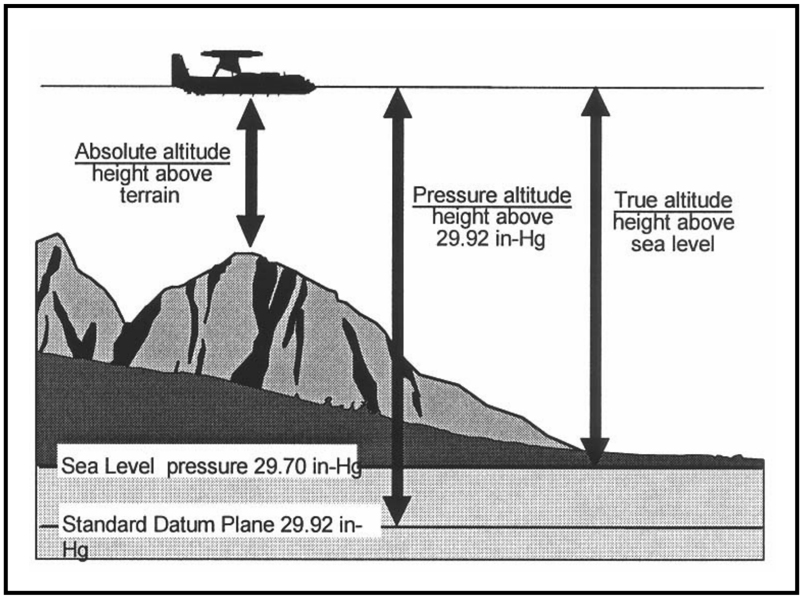

Figure 1-3 Altitudes

Density altitude (DA) is pressure altitude corrected for nonstandard temperature deviations. On a hot day, air molecules are farther apart, *decreasing* the air density and *increasing* the density altitude. In this situation, the DA of an airfield would be higher than both the published field elevation and the pressure altitude. The opposite is true on a colder day: increased air density causes a decreased density altitude and a DA lower than the published field elevation and the pressure altitude.

Density altitude is not a height reference; rather, it is an index to aircraft performance. It affects airfoil, engine, propeller, and rotor performance. Thrust is reduced because a jet engine has less mass (air) to compress. Lift is also reduced due to thinner air. Additionally, higher density altitudes result in longer takeoff and landing distances and a reduced rate of climb. Takeoff distances are longer since reduced thrust requires a longer distance to accelerate to takeoff speed. Landing distances are longer since a higher true airspeed is required to land at the same indicated airspeed. Climb rate is decreased because of reduced available thrust. At certain high density altitudes, takeoffs and/or single-engine flight (loss of one engine after becoming airborne) are not possible due to limitations of thrust, lift, and runway length. Table 1-1 summarizes the effects of temperature on aircraft performance. Moisture affects aircraft performance in the same manner as temperature, but to a much lesser degree.

HIGH TEMPERATURE OR MOISTURE	LOW TEMPERATURE OR MOISTURE
Lower Air Density	Higher Air Density
Higher Density Altitude	Lower Density Altitude
Decreased Thrust and Lift	Increased Thrust and Lift
Longer Takeoffs and Landings	Shorter Takeoffs and Landings

Table 1-1 Density Altitude Effects on Aircraft Performance

108. ALTIMETER ERRORS

Pressure

When an aircraft flies from one place to another at a constant indicated altitude (by referencing the barometric altimeter), it is flying along a surface of constant pressure. Figure 1-4 shows the path of an aircraft as it follows such a constant pressure surface–done by flying a constant indicated altitude. As the sea level pressure on the surface decreases (all other conditions remaining the same), the whole column of air aloft is lowered, causing an aircraft flying at an assigned MSL altitude to descend to a lower AGL altitude. Only by updating the reference of the altimeter setting can this potential problem be eliminated, and a more constant AGL altitude can be maintained.

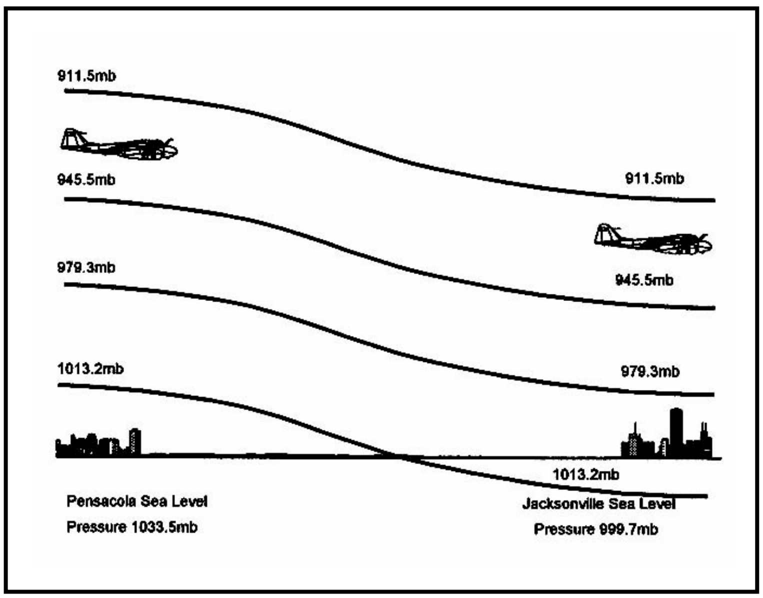

Figure 1-4 Path of Aircraft Flying a Constant Indicated Altitude with Decreasing Surface Pressure

This updating is accomplished via radio throughout the flight. Usually, when switching to a different air traffic controller–about every 50-100 miles–an updated altimeter setting will also be passed to the aircrew. This ensures that all aircraft in a given area are flying at the correct altitudes (up to FL180). A change in pressure of 0.10 in-Hg will change the altimeter reading 100 feet. Therefore, it is imperative to receive a current altimeter setting at your destination prior to landing. If the altimeter is not adjusted and your flight path takes you into an area of lower MSL pressure the aircraft will be lower than the altimeter indicates. Conversely, if your flight path takes you into an area of higher MSL pressure, the aircraft will be higher than the altimeter indicates. These events are summarized by a set of rhymes, as well as by Table 1-2.

RULE: High to Low, LOOK OUT BELOW
The aircraft is lower than indicated, thus the indicated altitude is higher than the aircraft.

RULE: Low to High, PLENTY OF SKY
The aircraft is higher than indicated, thus the indicated altitude is lower than the aircraft.

PRESSURE CHANGE	ALTIMETER	ACTUAL MSL ALTITUDE
Flying toward lower MSL pressure	Indicates higher than actual	Lower than indicated by the altimeter
Flying toward higher MSL pressure	Indicates lower than actual	Higher than indicated by the altimeter

Table 1-2 Pressure Change vs. Indicated and MSL Altitude

Temperature

Aircraft altimeters are calibrated for a standard lapse rate. An incorrect altitude indication will result if the temperature deviates from the standard. For every 11 °C that the temperature varies from the standard, the altimeter will be in error by 4%. If the air is colder than the standard atmosphere, the aircraft will be lower than the altimeter indicates. If the air is warmer than standard, the aircraft will be higher than the altimeter indicates (Table 1-3, and Figures 1-5 and 1-6). You may notice that the rules presented in the pressure section, above, also apply to temperature deviations.

TEMPERATURE CHANGE	ALTIMETER	ACTUAL MSL ALTITUDE
Flying from standard temp. toward lower temp.	Indicates higher than actual	Lower then indicated
Flying from standard temp. toward higher temp.	Indicates lower than actual	Higher than indicated

Table 1-3 Temperature Deviation vs. Indicated and MSL Altitude

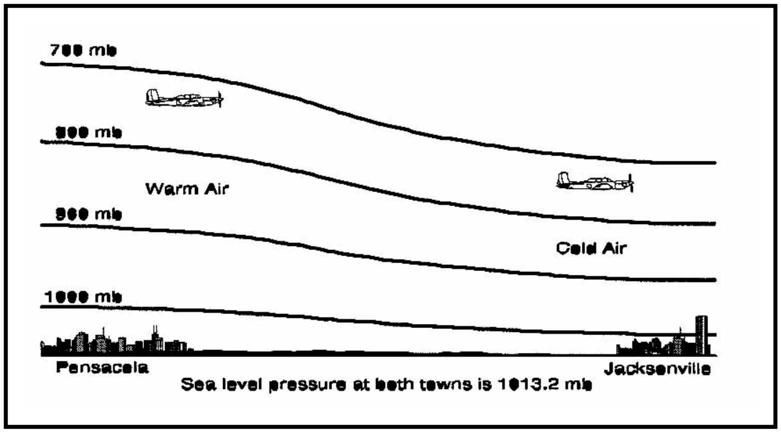

Figure 1-5 Path of Aircraft Flying a Constant Indicated Altitude with Decreasing Temperature

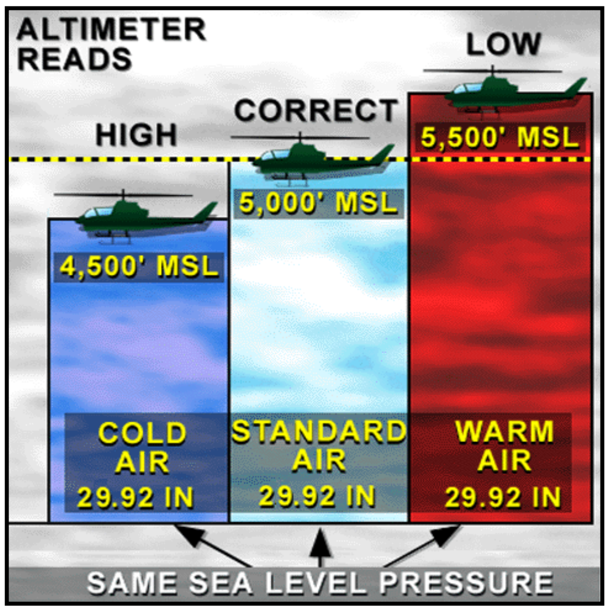

Figure 1-6 Temperature Deviation vs. Indicated and MSL Altitude

Figures 1-5 and 1-6 show that as you fly from warm to cold air, an altimeter will read too high–the aircraft is lower than the altimeter indicates. Over flat terrain, this lower true reading is no great problem; other aircraft in the vicinity are also flying indicated altitudes resulting from the same temperature and pressure conditions, and the altimeter readings are compatible because the errors result from the same conditions.

Since these deviations due to temperature are usually relatively small, these errors are often ignored in the early stages of flight training, and calibrated altitude is often treated directly as true altitude. However, toward the advanced stages, tactical accuracy becomes paramount, and temperature effects cannot be ignored. For example, when flying in cold weather over mountainous terrain, you must take this difference between indicated and true altitude into account by calculating a correction to the indicated altitude.

STUDY QUESTIONS

General Structure of the Atmosphere, and Atmospheric Temperature and Pressure

1. Which one of the following best describes the change in atmospheric pressure with increasing altitude?

   a. Increases
   b. Decreases
   c. May increase or decrease, depending on weather conditions
   d. Remains constant

2. Which one of the following correctly lists the standard day conditions of sea level pressure, temperature, pressure lapse rate, and temperature lapse rate?

   a. 30.00 in-Hg, 15 °C, 1.5 in-Hg/1000’, 3.0 °C/1000’
   b. 29.92 in-Hg, 59 °C, 34 in-Hg/100’, 5 °C/100’
   c. 29.92 in-Hg, 15 °C, 1 in-Hg/1000’, 2 °C/1000’
   d. 30.02 in-Hg, 20°C, 2 in-Hg/1000’, 1 °C/1000’

3. The horizontal distribution of pressure on the Earth’s surface is depicted on weather charts by

   a. isotherms.
   b. isotachs.
   c. isogonic lines.
   d. isobars.

4. The weight of the air mass over any point on the Earth’s surface defines

   a. density altitude.
   b. atmospheric pressure.
   c. pressure altitude.
   d. true weight.

5. The quantities 1013.2 mb and 29.92 in-Hg are two different expressions for the

   a. atmospheric density at a standard air temperature of 15 °C.
   b. atmospheric pressure at sea level at an air temperature of 0 °C.
   c. standard atmospheric pressure at mean sea level and at a standard air temperature of 15 °C.
   d. weight of the atmosphere at the surface of the Earth.

6. In the lower 5,000 feet of the atmosphere, a decrease of one inch of mercury in atmospheric pressure would cause a change in an altimeter reading of approximately ________ feet (assuming constant elevation and altimeter setting).

a. minus 100
b. plus 100
c. minus 1,000
d. plus 1,000

7. Which one of the following correctly describes the meteorological feature of a trough?

a. An elongated area of relatively low pressure
b. An elongated area of relatively high pressure that extends from the center of a High pressure area.
c. An area where the pressure in the center is higher than the surrounding areas
d. A long shallow often V-shaped receptacle for the drinking water or feed of domestic animals

8. Which one of the following items would have a value closest to that used as a Kollsman window setting for an altimeter in the U.S. (assuming an airfield above sea level)?

a. Station pressure
b. Station temperature
c. AGL pressure
d. Sea level pressure

9. The height of an aircraft above the ground is known as

a. MSL/True altitude.
b. AGL/absolute altitude.
c. indicated altitude (IA).
d. pressure altitude (PA).

10. Which one of the following types of altitudes would be assigned in the U.S. above 18,000 feet MSL?

a. MSL/True altitude
b. AGL/absolute altitude
c. Indicated altitude (IA)
d. Pressure altitude (PA)

11. Density altitude is

a. the same as an MSL/True altitude.
b. pressure altitude corrected for nonstandard field elevations.
c. an indicator of aircraft performance.
d. the height above the standard datum plane.

SITUATION FOR ITEMS 12-14: The altimeter setting at Randolph AFB is 29.85 in-Hg, and at Vance AFB, the altimeter setting is 30.15 in-Hg. A pilot sets the altimeter correctly at Randolph and flies to Vance at an indicated altitude of 5,000 feet without changing the altimeter setting.

12. Assuming a standard lapse rate, what is the MSL/true altitude when flying over Vance at the assigned indicated altitude?

a. 4,700 feet
b. 5,000 feet
c. 5,030 feet
d. 5,300 feet

13. If Vance's elevation is 1307' MSL, what is the AGL/absolute altitude over Vance?

a. 3,393 feet
b. 3,693 feet
c. 3,723 feet
d. 3,993 feet

14. If the pilot lands successfully at Vance (elevation 1307' MSL) without resetting the altimeter, what altitude will the altimeter indicate?

a. 0 feet
b. 1,007 feet
c. 1,307 feet
d. 1,607 feet

CHAPTER TWO
WINDS, CLOUDS AND MOISTURE, AND ATMOSPHERIC STABILITY

ASSIGNMENT SHEET

Atmospheric Mechanics of Winds, Clouds and Moisture, and Atmospheric Stability
Assignment Sheet 2.1A

INTRODUCTION

The purpose of this lesson topic is to introduce the student to the concepts associated with large and small scale wind systems, the relationship between atmospheric temperature, moisture content, major cloud types, and their effects on flight, as well as the various terms and requirements used to describe atmospheric stability and instability.

LESSON TOPIC LEARNING OBJECTIVES

Terminal Objective:
Partially supported by this lesson topic:

2.0 Describe the meteorological mechanics of winds, moisture, and stability.

Enabling Objectives:
Completely supported by this lesson topic:

2.1 Explain the term pressure gradient.

2.2 Explain and identify gradient winds with respect to the isobars around high and low pressure systems in the Northern Hemisphere.

2.3 Explain and identify the surface wind direction with respect to the gradient winds in a high and low-pressure system in the Northern Hemisphere.

2.4 Describe the jet stream.

2.5 Describe sea breezes and land breezes.

2.6 Describe valley and mountain winds.

2.7 Define saturation, dew point temperature, dew point depression, and relative humidity.

2.8 State the relationships between saturation, air temperature, dew point temperature, and dew point depression that are necessary for the formation of clouds, fog, and precipitation.

2.9 Describe the three characteristics of precipitation.

2.10 Describe the types of precipitation.

2.11 Identify the four principal cloud groups.

2.12 Identify the weather conditions associated with various clouds and types of precipitation.

2.13 Describe atmospheric stability, instability, and neutral stability.

2.14 Describe the four types of lifting.

2.15 Identify the flight conditions associated with a stable and unstable atmosphere including cloud type, turbulence, precipitation, visibility, winds, and icing.

STUDY ASSIGNMENT

Review Information Sheet 2.1I, and answer the Study Questions.

INFORMATION SHEET

Atmospheric Mechanics of Winds, Clouds and Moisture, and Atmospheric Stability
Information Sheet 2.1I

200. INTRODUCTION

This chapter covers a wide range of topics that are basic to the understanding of weather phenomena. After an introduction to the meteorological station model, which will be used in this chapter mainly to show wind direction in diagrams, we build upon the pressure basics presented in chapter 1 to determine why winds blow in the particular direction that they do. To keep our analysis as simple as possible, we will focus only on winds in the Northern Hemisphere. Since winds and some forces in the Southern Hemisphere are a mirror image, discussing both patterns at this stage would unnecessarily complicate things for a first-time introduction to weather.

The next topics covered are the two main types of precipitation match up with two types of clouds. Clouds are additionally classified according to the altitude of their bases, and we cover four major cloud types in this chapter. Eventually–and usually more often than desired–all aviators will fly into clouds, and thus an understanding of cloud composition and activity will be essential to this course.

Additionally, cloud types can be a visual signal of atmospheric stability or instability. These two conditions can be a further indication to meteorologists as well as to aircrew regarding the various weather and flight conditions that may be encountered. As you will read, there can be great differences in the expected weather found between stable and unstable conditions, each with their own particular hazards to flight. Consequently, knowing the relationships between atmospheric stability and flight conditions could prove invaluable to an aviator.

REFERENCES

1. *Weather for Aircrews*, AFH 11-203, Volume 1, Chapters 2, 5, 6, and 9

INFORMATION

201. WINDS

Understanding the causes of wind and wind direction is essential to the safe operation of an aircraft. Takeoffs and landings are best performed into a headwind, whereas landing with a strong crosswind can be dangerous, to say the least. In addition, the circulation of air brings about changes in weather by transporting water vapor, and, therefore, wind plays an important role in the formation of fog, clouds, and precipitation.

So how does one determine the wind direction? Wind direction is always expressed in terms of the direction *from* which it is blowing. This convention holds throughout the world–civilian or military, weather or navigation, aviation or sailing–wind always blows from a particular direction. Thus, it would be best for a student to master this particular concept as early as possible in a career where wind is an everyday concern.

There are many different ways that weather phenomenon, such as wind, are annotated on charts or in print. One of these methods is the use of a station model. Since the basics of station models will be used throughout this course, they will be discussed in the next section. In chapter 7, when other chart features are explained, it will be assumed that station models are understood.

Station Models

Some weather charts display the information gathered from individual weather stations through the use of the **station model**, shown in Figure 2-1. This model begins with a circle (or a square for automated stations) at the center to represent the location of the station that issued the weather report. Around the station symbol, data describing wind, temperatures, weather, and pressures are displayed in a pictorial shorthand (Figure 2-2) to provide the maximum amount of data in a minimum of space.

Another noticeable feature of the station model is a line coming out of the circle indicating the wind direction. Since the station models are aligned for ease of reading, north is at the top of the page. Therefore, in Figure 2-1, the winds are *from* the northwest. At the end of this stick are any numbers of barbs, which come in three shapes, to indicate the wind speed. A long barb represents 10 knots, short barbs are 5 knots, and pennants are 50 knots.

The numbers to the left of the station symbol indicate the temperature (top left) and dew point (bottom left). In between the temperature and dew point, there may be a symbol from Figure 2-2 representing the present weather at the station. Additionally, the circle (or square) may be filled in to represent the amount of sky that is covered by clouds, in eighths. An empty circle would mean clear skies, while a fully darkened circle would indicate a completely overcast sky (also from Figure 2-2).

The right-hand side of the station model describes the pressure at the station. On the top right, there will be three digits to represent the sea level pressure (SLP) in millibars and tenths. Since SLP will always be somewhere around 1000 millibars, the hundreds digit (and thousands, if present) is dropped, and the decimal point is also omitted. Thus, depicted pressures beginning with large numbers (such as a 9) really start with a hidden “9”, and pressures beginning with small numbers (such as a 1) actually have a “10” in front of them. Below the current SLP is the pressure tendency over the last 3 hours, beginning with a (+) or (-) sign to denote an overall rise or fall, and then the value of that total pressure change. After this notation is a set of two connected line segments that graphically show the pressure change over those three hours, as indicated on the right-hand side of Figure 2-2.

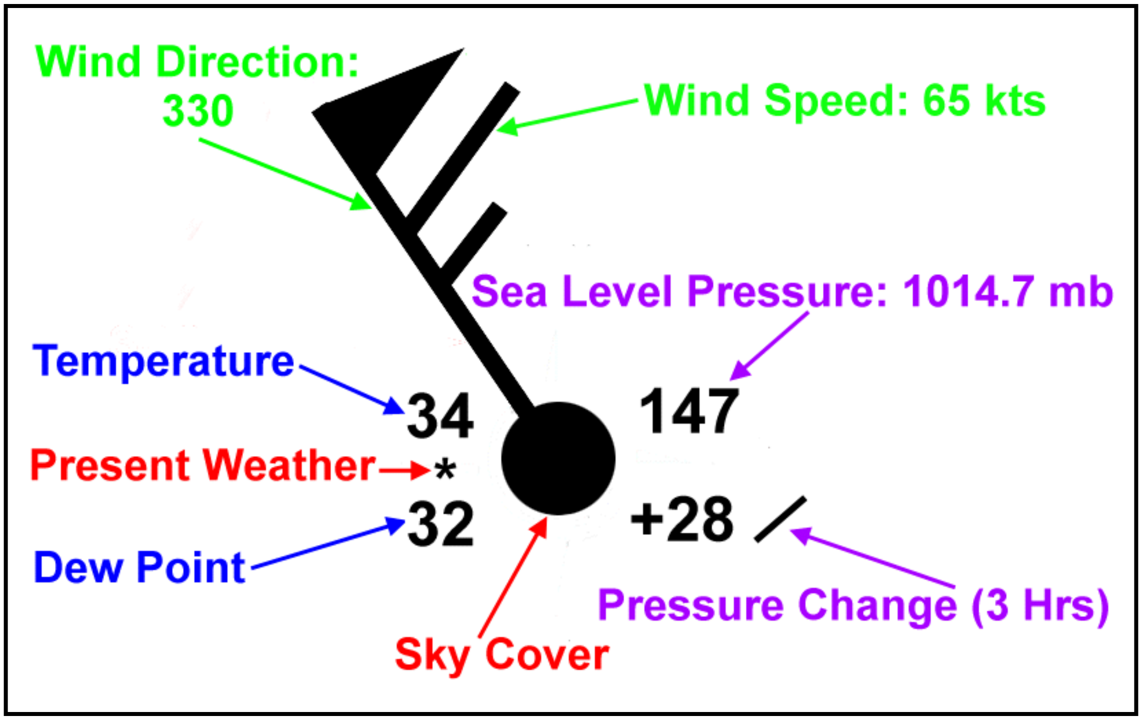

Figure 2-1 Station Model Explanation

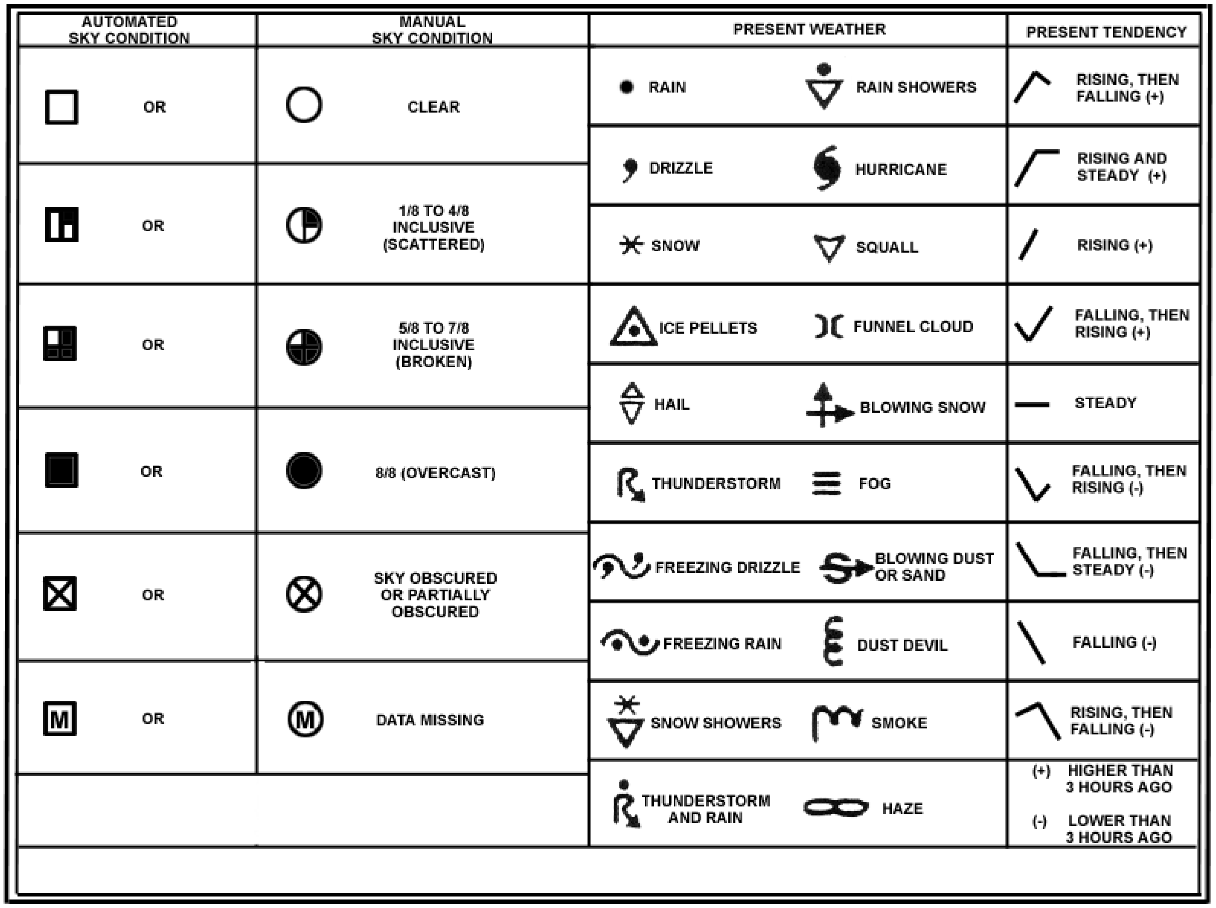

Figure 2-2 Major Station Model Symbols

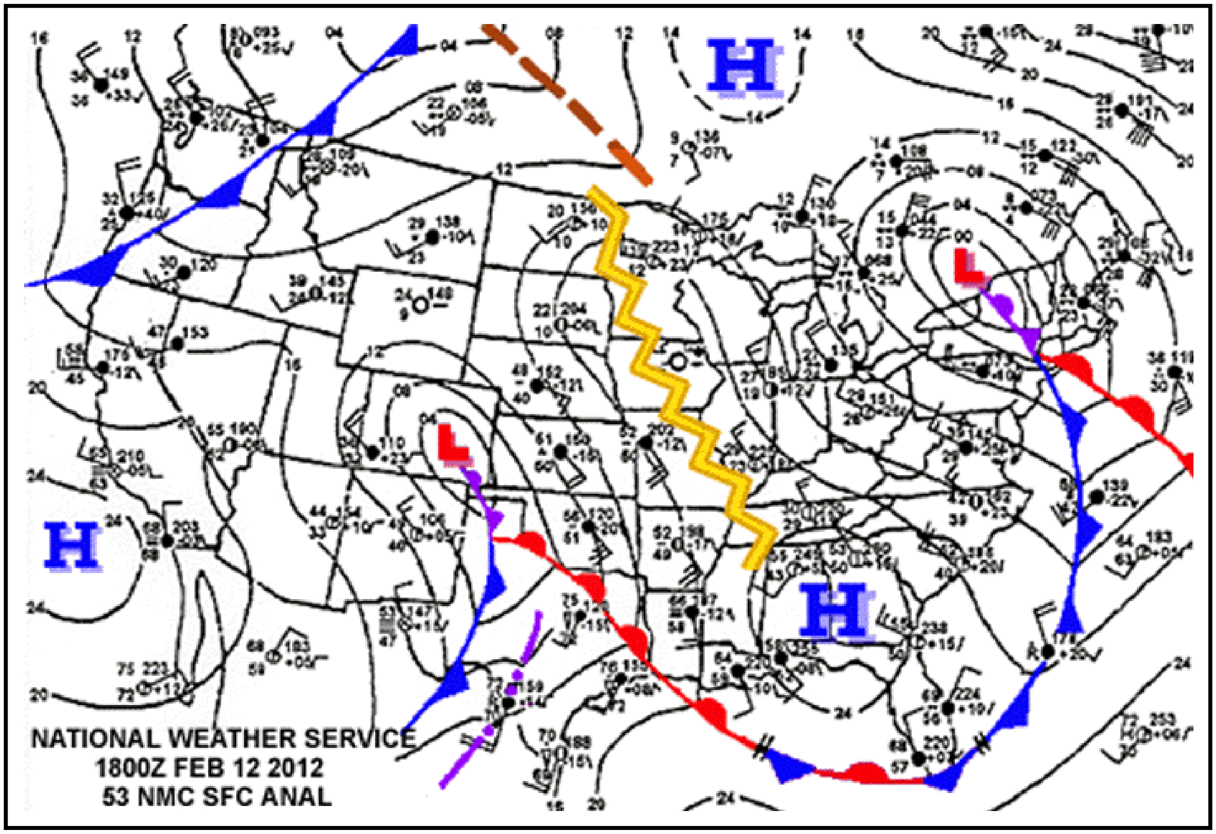

Figure 2-3 Typical surface analysis chart

The Jet Stream

Wind speeds generally increase with height through the troposphere, reaching a maximum near the tropopause, and often culminating in the jet stream. The **jet stream** is a narrow band of strong winds of 50 knots or more that meanders vertically and horizontally around the hemisphere in wave-like patterns. The jet streams (polar and subtropical) have a profound influence on weather patterns.

These winds average about 100-150 knots but may reach speeds in excess of 250 knots (Figure 2-4). Since the jet stream is stronger in some places than in others, it rarely encircles the entire hemisphere as a continuous river of wind. More frequently, it is found in segments from 1,000 to 3,000 miles in length, 100 to 400 miles in width, and 3,000 to 7,000 feet in depth.

The average height of jet stream winds is about 30,000 feet MSL, but they can be above or below this level depending on the latitude and the season. During the winter, the position of the jet stream is further south, the core rises to higher altitudes, and its speed is faster than in the summer.

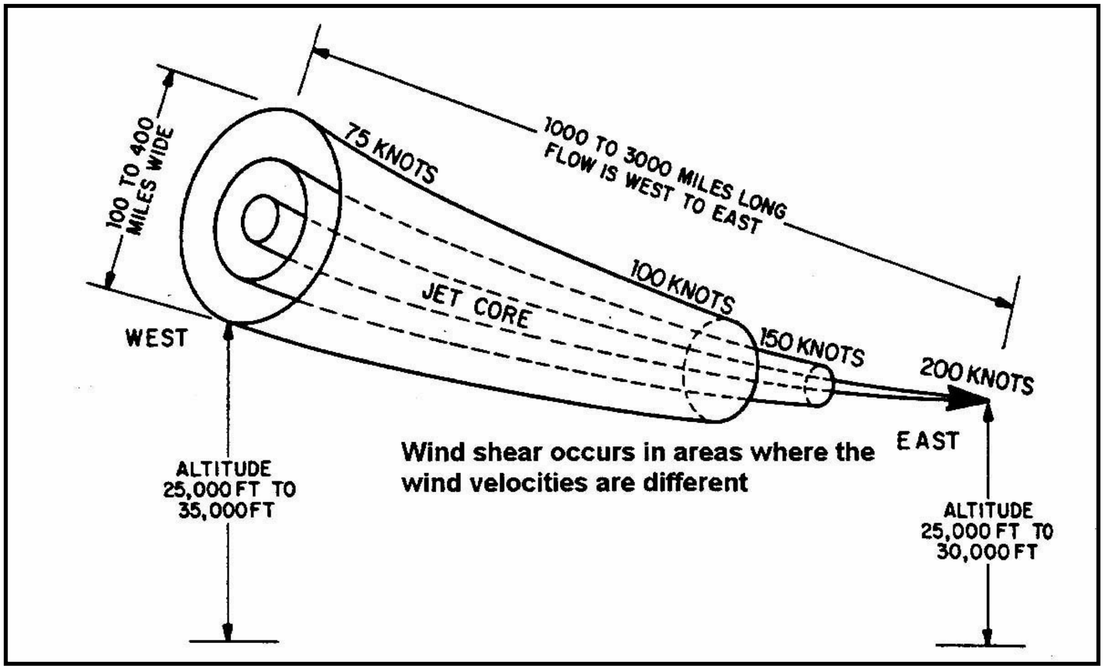

Figure 2-4 Jet Stream

The existence of jet streams at operational altitudes requires additional aircrew flight planning consideration. The greater headwind component for westbound aircraft will increase fuel consumption and may require additional alternate landing fields along the route. Wind shear associated with the jet stream may also cause turbulence, forcing the aircrew to change altitude or course.

202. LOCAL WINDS

The term "local," in the case of wind systems, applies to areas whose sizes range from tens of miles across, to long, geographically thin areas. The local wind systems created by mountains, valleys, and water masses are superimposed on the general wind systems and may cause significant changes in the weather.

Sea and Land Breezes

The differences in the specific heat of land and water cause land surfaces to warm and cool more rapidly than water surfaces through insolation and terrestrial radiation. Therefore, land is normally warmer than the ocean during the day and colder at night. This difference in temperature is more noticeable during the summer and when there is little horizontal transport of air in the lower levels of the atmosphere. In coastal areas, this difference of temperature creates a tendency for the warmer, less dense air to rise, and the cooler, denser air to sink, which produces a pressure gradient. During the day, the pressure over the warm land becomes lower than that over the colder water. The cool air over the water moves toward the lower pressure, replacing the warm air over the land that moved upward. The resulting onshore wind, blowing from the sea, is called a **sea breeze**, with speeds sometimes reaching 15 to 20 knots (Figure 2-5).

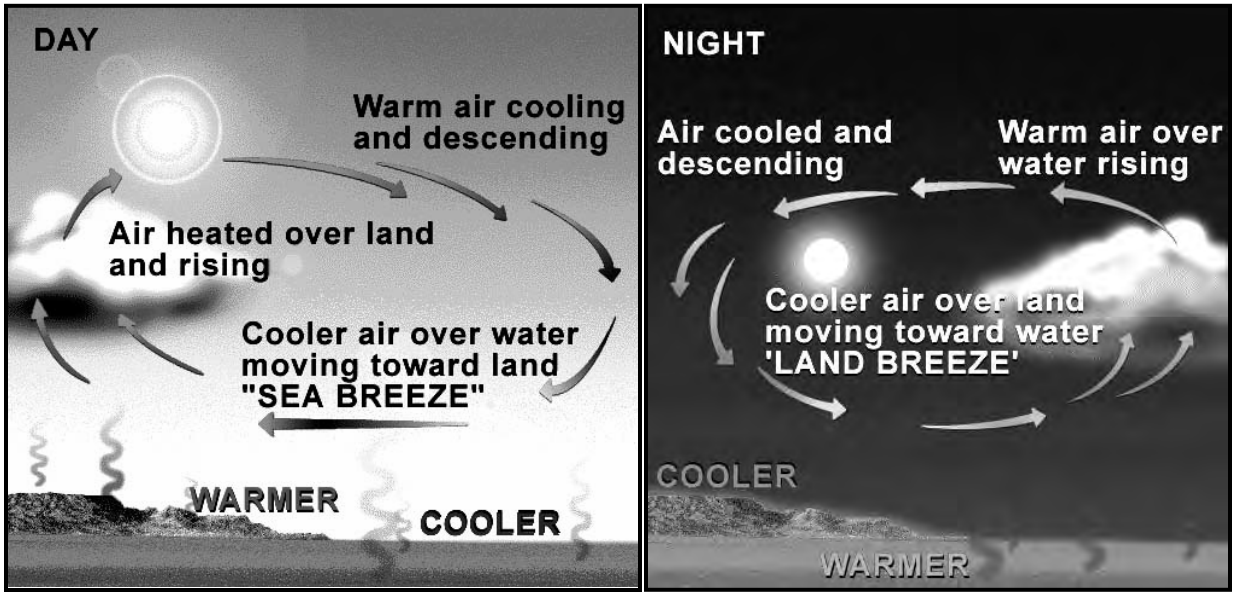

Figure 2-5 Sea Breeze and Land Breeze

At night, the circulation is reversed so that the air movement is from land to sea, producing an offshore wind called the **land breeze** (Figure 2-5). The sea breezes are usually stronger than the land breezes, but they seldom penetrate far inland. Both land and sea breezes are shallow in depth, and their existence should be considered during takeoff and landing near large lakes and oceans.

Mountain and Valley Winds

In the daytime, mountain slopes are heated by the Sun's radiation, and in turn, they heat the adjacent air through conduction. This air usually becomes warmer than air farther away from the slope at the same altitude, and, since warmer air is less dense, it begins to rise (Figure 2-6). It cools while moving away from the warm ground, increasing its density. It then settles downward, towards the valley floor, completing a pattern of circulation (not shown in Figure 2-6). This downward motion forces the warmer air near the ground up the mountain, and since it is then flowing from the valley, it is called a **valley wind**.

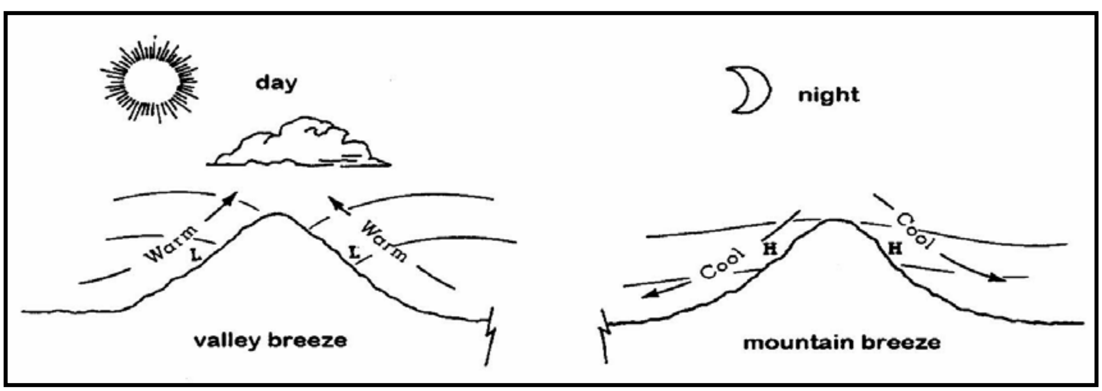

Figure 2-6 Mountain and Valley Winds

At night, the air in contact with the mountain slope is cooled by outgoing terrestrial radiation and becomes more dense than the surrounding air. As the denser air flows downhill, from the top of the mountain, it is called the **mountain wind**, and a circulation opposite to the daytime pattern forms.

These winds are of particular importance for light aircraft, helicopter, and low-level operations. In mountainous areas where the performance of some fixed-wing aircraft or helicopters is marginal, the location of mountain and valley winds can be critical.

203. CHARACTERISTICS AND TYPES OF PRECIPITATION

The characteristics and types of precipitation reveal information about various atmospheric processes. The nature of precipitation may give a clue about a cloud’s vertical and horizontal structure, or indicate the presence of another cloud deck aloft. The three characteristics of precipitation are:

1. **Showers –** Characterized by a sudden beginning and ending, and abruptly changing intensity and/or sky conditions. Showers are associated with cumuliform clouds.

2. **Continuous –** Also known as steady (not showery). Intensity changes gradually, if at all. Continuous precipitation is associated with stratiform clouds.

3. **Intermittent –** Stops and restarts at least once during the hour. Intermittent precipitation may be showery or steady, and therefore may be associated with cumuliform or stratiform clouds.

Precipitation takes many forms. Only a few of the more common types of precipitation are mentioned here.

1. **Drizzle –** Very small droplets of water that appear to float in the atmosphere.

2. **Freezing drizzle –** Drizzle that freezes on impact with objects.

3. **Rain –** Precipitation in the form of water droplets that are larger than drizzle and fall to the ground.

4. **Freezing rain –** Rain that freezes on impact with objects.

5. **Hail or graupel –** A form of precipitation composed of irregular lumps of ice that develop in severe thunderstorms, consisting of alternate opaque and clear layers of ice in most cases. Water drops, which are carried upward by vertical currents, freeze into ice pellets, start falling, accumulate a coating of water, and are carried upward again, causing the water to freeze. A repetition of this process increases the size of the hailstone. It does not lead to the formation of structural ice, but it can cause structural damage to aircraft.

6. **Ice pellets or sleet –** Small translucent and irregularly shaped particles of ice. They form when rain falls through air with temperatures below freezing. They usually bounce when hitting hard ground and make a noise on impact. Ice pellets do not produce structural icing unless mixed with super-cooled water.

7. **Snow –** White or translucent ice crystals, usually of branched hexagonal or star-like form that connect to one another forming snowflakes. When condensation takes place at temperatures below freezing, water vapor changes directly into minute ice crystals. A number of these crystals unite to form a single snowflake. Partially melted, or "wet" snow, can lead to structural icing.

8. **Snow grains –** Very small white, opaque grains of ice. When the grains hit the ground, they do not bounce or shatter. They usually fall in small quantities from stratus-type clouds, never as showers.

Precipitation, depending on the type and intensity, affects aviation in many ways:

> Visibility in light rain or drizzle is somewhat restricted. In heavy rain or drizzle, it may drop to a few hundred feet. Rain or drizzle streaming across a windscreen further restricts forward visibility. Snow can greatly reduce visibility and can lead to a total lack of forward vision.
>
> Very heavy rain falling on a runway may cause hydroplaning. During hydroplaning, the tires are completely separated from the runway surface by a thin film of water. Tire traction becomes negligible, and the wheels may stop rotating. The tires now provide no braking capability and do not contribute to directional control of the aircraft. Loss of control may result.
>
> If there is enough wet snow on the runway, it tends to pile up ahead of the tires during takeoff. This can create sufficient friction to keep the aircraft from reaching rotation speed and becoming airborne.
>
> Heavy rain ingested into the engines of a jet or turboprop aircraft in flight can cause power loss or even flameout.
>
> Hail can cause serious damage to any aircraft, but so can rain if it is penetrated at very high speed.

204. CLOUDS

Clouds may be defined as the visible manifestation of weather. With some knowledge of the weather conditions that cause clouds to develop, a pilot can get an excellent picture of the weather environment and can make a reasonable forecast of the weather conditions to follow. The most important element in the formation of clouds is water vapor.

General Theory of Clouds

Clouds are condensed water vapor, consisting of water droplets or ice crystals. They form when the air becomes saturated either by being cooled to the dew point or through the addition of moisture. Most clouds are the result of cooling from some lifting process, such as surface heating. The excess moisture condenses on minute particles in the atmosphere, thus forming droplets.

Condensation Nuclei

Water vapor requires a surface on which to condense. An abundance of microscopic solid particles, called **condensation nuclei**, are suspended in the air and provide condensation surfaces. Condensation nuclei consist of dust, salt crystals from the sea, acid salts from industrial waste, ash and soot from volcanoes and forest fires, rock particles from wind erosion, and organic matter from forests and grass lands. The most effective condensation nuclei are the various salts since they can induce condensation or sublimation even when air is almost, but not completely, saturated.

205. TYPES OF CLOUDS

Clouds provide visible evidence of the atmosphere's motions, water content, and degree of stability and are therefore weather signposts in the sky. They can be numerous or widespread, form at very low levels, or show extensive vertical development.

Knowledge of principal cloud types helps the aircrew member when being briefed to visualize expected weather conditions. Knowledge of cloud types will also help the pilot recognize potential weather hazards in flight. Clouds are classified according to their appearance, form, and altitude of their bases, and may be divided into four groups:

1. **Low clouds**, ranging from just above the surface to 6,500 feet AGL.

2. **Middle clouds** with bases between 6,500 and 20,000 feet AGL.

3. **High clouds** found above 20,000 feet AGL.

4. **Special clouds** with extensive vertical development.

The height of the cloud base, not the top, determines the classification. A cloud with a base at 5,000 feet AGL and a top at 8,000 feet AGL is classified as a low cloud. Each group is subdivided by appearance. There are two principal cloud forms:

1. **Cumuliform –** A lumpy, billowy cloud with a base showing a definite pattern or structure.

2. **Stratiform –** A cloud with a uniform base, formed in horizontal, sheet-like layers.

Low Clouds

Cloud bases in this category range from just above the surface to 6,500 feet AGL (Figure 2-7). Low clouds are mainly composed of water droplets. The low clouds have no special prefix attached to their name. However, if the word **nimbo** or **nimbus** appears, beware that these clouds are producing violent, or heavy, precipitation.

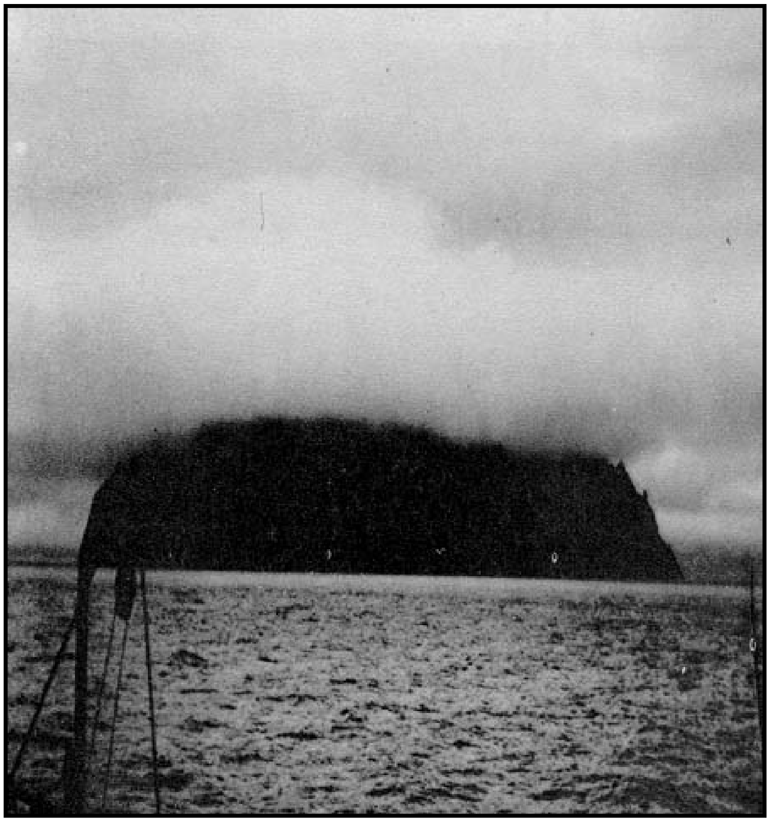

Figure 2-7 Stratus

Low clouds frequently present serious hazards to flying. The most serious hazard is the proximity of the cloud base to the surface of the Earth. Some of the low cloud types hide hills, making a collision with the terrain a very real danger, and visibility within low clouds is very poor. Low clouds may also hide thunderstorms. If the clouds are at or below freezing temperatures, icing may result. Icing accumulates faster in low clouds since they are generally denser than middle and high clouds. Turbulence varies from none at all to moderate turbulence. Expect turbulence in and below the clouds. Precipitation from low clouds is generally light rain or drizzle.

Middle Clouds

In this category, cloud bases form between 6,500 and 20,000 feet AGL. The names of the middle clouds will contain the prefix **alto-** (Figure 2-8). They are composed of ice crystals, water droplets, or a mixture of the two.

Figure 2-8 Altocumulus Clouds

A special cloud, nimbostratus, produces continuous rain, snow, or ice pellets. The cloud base will extend down to about 1,000 feet AGL, and fog is often present. Expect poor visibility and low ceilings with very slow clearing.

Visibility in middle clouds varies depending on cloud density from ½ mile to a few feet. Turbulence may be encountered in middle clouds. Frequently these clouds are dark and turbulent enough to make formation flying difficult. Icing is common due to the presence of super-cooled water droplets. Rain, rain and snow mixed, or snow can be encountered in thick middle clouds.

Virga, which is rain or snow that evaporates before reaching the ground, may be encountered below these clouds.

High Clouds

In this category, cloud bases average 20,000 to 40,000 feet AGL. The names of the high clouds will contain the prefix **cirro-** or the word **cirrus** (Figure 2-9).

High clouds have little effect on flying except for moderate turbulence and limited visibility associated with dense jet stream cirrus. Since high clouds are composed mostly of ice crystals, they have no precipitation and do not constitute an icing hazard. Severe or extreme turbulence is often found in the anvil cirrus of thunderstorms.

Figure 2-9 Cirrus Clouds

Special Clouds with Extensive Vertical Development

This category consists of towering cumulus and cumulonimbus clouds. The bases of these clouds are found at the low to middle cloud heights and their tops extend through the high cloud category. Figure 2-10 shows cumulonimbus clouds.

Figure 2-10 Cumulonimbus Clouds

Towering cumulus are clouds nearing the thunderstorm stage. They can produce heavy rain showers and moderate turbulence in and near the cloud. Icing is common above the freezing level.

Cumulonimbus clouds are thunderstorm clouds. A cumulonimbus cloud is sometimes referred to as a “CB.” Cumulonimbus is an exceedingly dangerous cloud, with numerous hazards to flight such as severe to extreme turbulence, hail, icing, lightning, and other hazards to be discussed in chapter 4. Table 2-1 summarizes the weather conditions found in the various types of clouds.

Cloud Groups				
	High Clouds	**Middle Clouds**	**Low Clouds**	**Clouds with Extensive Vertical Development**
Visibility	Good to Fair	½ mile to a few feet	A few feet	A few feet
Icing	None to Light	None to Moderate	None to Moderate	Severe
Turbulence	None to Light	None to Moderate	None to Moderate	Severe

Table 2-1 Cloud Families

STUDY QUESTIONS

Atmospheric Mechanics of Winds, Clouds and Moisture, and Atmospheric Stability

1. Which one of the following types of pressure gradients would indicate the presence of strong winds?

a. Steep	c. Weak
b. Low pressured	d. Shallow

2. The initial movement of air toward a low-pressure area is caused by the

a. pressure gradient force.	c. centrifugal force.
b. Coriolis force.	d. force of friction.

3. The forces that determine the wind direction in the atmosphere are weakened at the Earth's surface by the

a. pressure gradient force.	c. centrifugal force.
b. Coriolis force.	d. force of friction.

4. Gradient winds move parallel to the isobars above 2,000 feet AGL because they are NOT affected by the

a. pressure gradient force.	c. centrifugal force.
b. Coriolis force.	d. force of friction.

5. The surface wind, when compared with the gradient wind is of

a. lesser speed and blows parallel to the isobars.
b. lesser speed and blows across the isobars toward low pressure.
c. greater speed and blows across the isobars toward high pressure.
d. greater speed and blows across the isobars toward low pressure.

6. In the Northern Hemisphere, the wind blows

a. from low to high pressure.	c. counterclockwise around a low.
b. clockwise around a low.	d. perpendicular to the isobars.

7. Gradient winds blow parallel to the isobars because of the

a. Coriolis force.	c. centrifugal force.
b. frictional force.	d. wind force.

8. The sea breeze blows from the _______ to the _______ during the _______, and the land breeze blows from the _______ to the _______ during the _______.

a. water, land, day; water, land, night
b. land, water, day; land, water, night
c. land, water, day; water, land, night
d. water, land, day; land, water, night

9. __________ and water vapor must be present in the atmosphere for precipitation to occur.

a. Carbon dioxide
b. Condensation nuclei
c. Wind
d. Nitrogen

10. When air contains the maximum moisture possible for a given temperature, the air is __________.

11. The temperature to which air must be cooled to become saturated is called the _____________________.

12. Which one of the following conditions could produce fog, clouds, or precipitation?

a. Dew point spread of 5 °C
b. Dew point greater than air temperature
c. RH of 0%
d. RH of 100%

13. Stratiform clouds are associated with (stable/unstable) flight conditions.

14. At which altitude could an altostratus cloud be found?

a. 5,000’ MSL
b. 5,000’ AGL
c. 10,000’ AGL
d. 25,000’ AGL

15. Cumulonimbus clouds typically produce which type of precipitation?

a. Drizzle
b. Light steady
c. Heavy showers
d. Fog

16. Nimbostratus clouds will produce ______________ precipitation.

a. heavy showery
b. light showery
c. heavy steady
d. light steady

17. Which one of the following correctly lists the four methods of lifting?

    a. Convergence, frontal, orographic, and thermal
    b. Convergence, subsidence, orographic, and thermal
    c. Convergence, convection, adiabatic, and katabatic
    d. Divergence, subsidence, frontal, and convective

18. If lifted air is warmer than the surrounding air, then __________ clouds will form resulting in __________ flight conditions.

19. If stratus clouds are present, which of the following flight conditions could be expected?

    a. Rough turbulence, good visibility, showery precipitation, and clear icing
    b. Smooth flight, good visibility, steady winds, and no precipitation
    c. Poor visibility, steady winds, continuous precipitation, and rime icing
    d. Smooth flight, turbulent flight, good visibility, and showery precipitation

20. Which one of the following types of clouds could be produced by unstable conditions?

    a. Cirrus
    b. Cumulonimbus
    c. Stratus
    d. Nimbostratus

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CHAPTER THREE
MECHANICS OF FRONTAL SYSTEMS

ASSIGNMENT SHEET

Mechanics of Frontal Systems
Assignment Sheet 3.1A

INTRODUCTION

The purpose of this lesson is to introduce the student to various frontal systems, including their formation, flight conditions, and associated weather patterns.

LESSON TOPIC LEARNING OBJECTIVES

Terminal Objective:
Completely supported by this lesson topic:

3.0 Describe the general characteristics of a front and frontal weather.

Enabling Objectives:
Completely supported by this lesson topic:

3.1 Define the terms air mass and front.

3.2 Describe the structure of a front.

3.3 Describe the discontinuities used to locate and classify fronts.

3.4 Describe the factors that influence frontal weather.

3.5 Describe the conditions associated with a cold front.

3.6 Describe the characteristics of a squall line.

3.7 Describe the conditions associated with a warm front.

3.8 Describe the conditions associated with a stationary front.

3.9 Describe the conditions associated with occluded fronts.

3.10 Describe the conditions associated with an inactive front.

STUDY ASSIGNMENT

Review Information Sheet 3.1I, and answer the Study Questions.

INFORMATION SHEET

Mechanics of Frontal Systems
Information Sheet 3.1I

300. INTRODUCTION

The main purpose of this chapter is to introduce frontal systems, since most of the active weather is concentrated along fronts. The goal of this chapter is to present a broad description of each of the frontal types, along with the general flight conditions associated with each. With this knowledge, an aviator is in a much better position to carry on a conversation about flight conditions with the meteorologist during the weather brief, as opposed to having a one-way conversation. Because only the flight crew understands the details and ramifications of the mission, it would be impossible to expect a meteorologist to foresee all the possibilities and to brief the weather accordingly.

REFERENCES

1. *Weather for Aircrews*, AFH 11-203, Volume 1, Chapter 8

INFORMATION

301. AIR MASSES

The weather in the mid-latitude regions is a direct result of the continuous alternation of warm and cold air masses. Warm air masses predominate in the summer and cold air masses predominate in the winter. However, both cold and warm air may prevail almost anywhere in the temperate zone–the region between 30 and 40 degrees North latitude, which covers the continental United States–at any season.

An **air mass** is a large body of air that has essentially uniform temperature and moisture conditions in a horizontal plane, meaning that there are no abrupt temperature or dew point changes within the air mass at a given altitude. It may vary in size from several hundred to more than several thousand square miles (Figure 3-1).

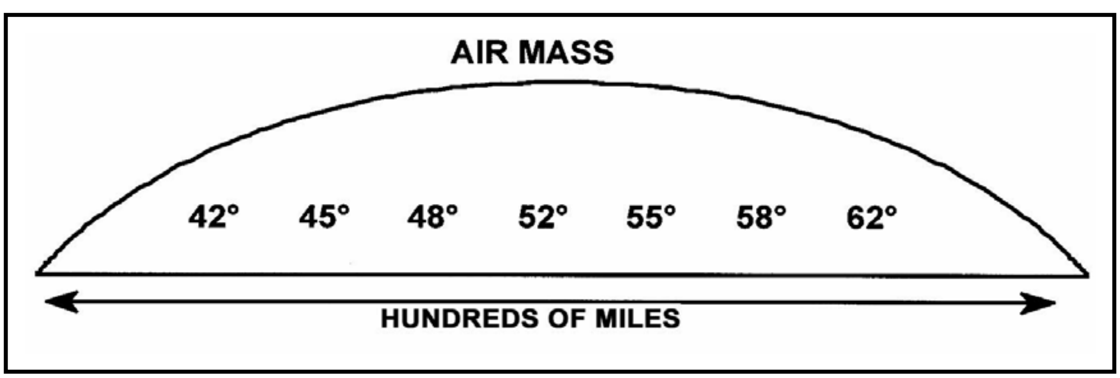


Figure 3-1 Air Mass Profile

Air masses are named according to their moisture content, location, and temperature. The location of an air mass has a large influence over the other two properties. Naturally, moist air masses will have a greater potential for producing clouds and precipitation than dry air masses. Most importantly, though, its temperature indicates the stability of the air mass. Warm air masses bring stable conditions, while cold air masses are inherently unstable.

302. FRONTAL SYSTEMS

A **front** is an area of discontinuity that forms between two contrasting air masses when they are adjacent to each other. A front can be thought of as a border, boundary, or line between the air masses. These air masses must have sufficiently different temperature and moisture properties–the defining characteristics of an air mass–otherwise there would be little reason to distinguish between them. Since air masses cover many thousands of square miles, the boundary between them can be hundreds of miles long. As air masses are three-dimensional, fronts are, as well. The point where a front comes in contact with the ground is called the surface front. The **surface front** is the line that is plotted on surface analysis charts with different colors and shapes representing each type of front, as pictured in Table 3-1.

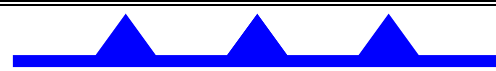
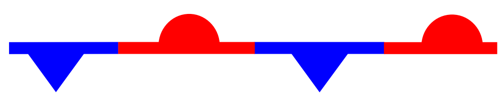
Type of Front	Color Scheme	Symbol
Cold front	Blue	
Warm front	Red	
Occluded front	Purple	
Stationary front	Blue and Red	
Trough	Brown or Black	
Ridge	Yellow or Black	
Squall line	Purple	

Table 3-1 Frontal Symbols

The **frontal zone** is that area that encompasses the weather located on either side of the front. The depth of this frontal zone depends on the properties of the two air masses. When the properties differ greatly, the resulting narrow frontal zone can include sudden and severe weather changes. It is often impossible to determine the exact outer boundaries of a frontal zone.

Most active weather is focused along and on either side of the surface front and frontal zone. Likewise, most aviation weather hazards are also found in the vicinity of fronts. In the mid-latitudes, fronts usually form between the warmer, tropical air to the south and the cooler, polar air to the north.

When a pilot passes through a front, or a front moves past a station, the atmospheric conditions change from one air mass to those of the other. Abrupt changes indicate that the frontal zone is narrow, and in some cases, the zone can be less than a mile wide. On the other hand, gradual changes indicate the frontal zone is broad and diffuse, often over 200 miles in width. Abrupt changes will bring more severe weather than gradual changes.

Aviation weather hazards are not limited to the area of frontal zones. Some fronts do not produce clouds or precipitation. Additionally, weather associated with one section of a front is frequently different from the weather in other sections of the same front. Do not conclude that all adverse weather occurs along fronts. In some cases, very large areas of low ceilings and poor visibility occur in areas that are far removed from a front.

Air Masses and Fronts

Now that we have introduced the basics of both air masses and fronts, an analysis of a real-world situation can help show how these pieces fit together. Figure 3-2 shows the weather across the U.S. at the same time from three different points of view. From the frontal systems shown on the Current Surface chart, we can see that there are three major air masses over the nation: one over the West, one over the Midwest and the East, and one over the Deep South. For simplicity, we will compare only the two eastern air masses.

Looking at the Current Temperatures chart, the Midwest air mass (centered approximately on the "H" of the high pressure) has temperatures in the 50s, give or take a few degrees. So far, this shows a relatively uniform temperature across the air mass, matching with what we would expect from the discussion above. The southern air mass, on the other hand, has much warmer temperatures, generally in the 70s and 80s. Even so, these temperatures are still relatively uniform throughout the air mass.

The dew points are also different between the two air masses. Even though the Dew Point chart only indicates dew points above 50 °F, it is clear that the southern air mass contains much more moisture than the air mass to its north. Thus, these charts indeed show two air masses over the eastern U.S., each with temperature and moisture properties different from the other. Accordingly, a front has been drawn between the two. From the "L" to just south of the "H," there is a warm front, and to the east of that position, all the way to the next "L" over New England, it is a cold front.

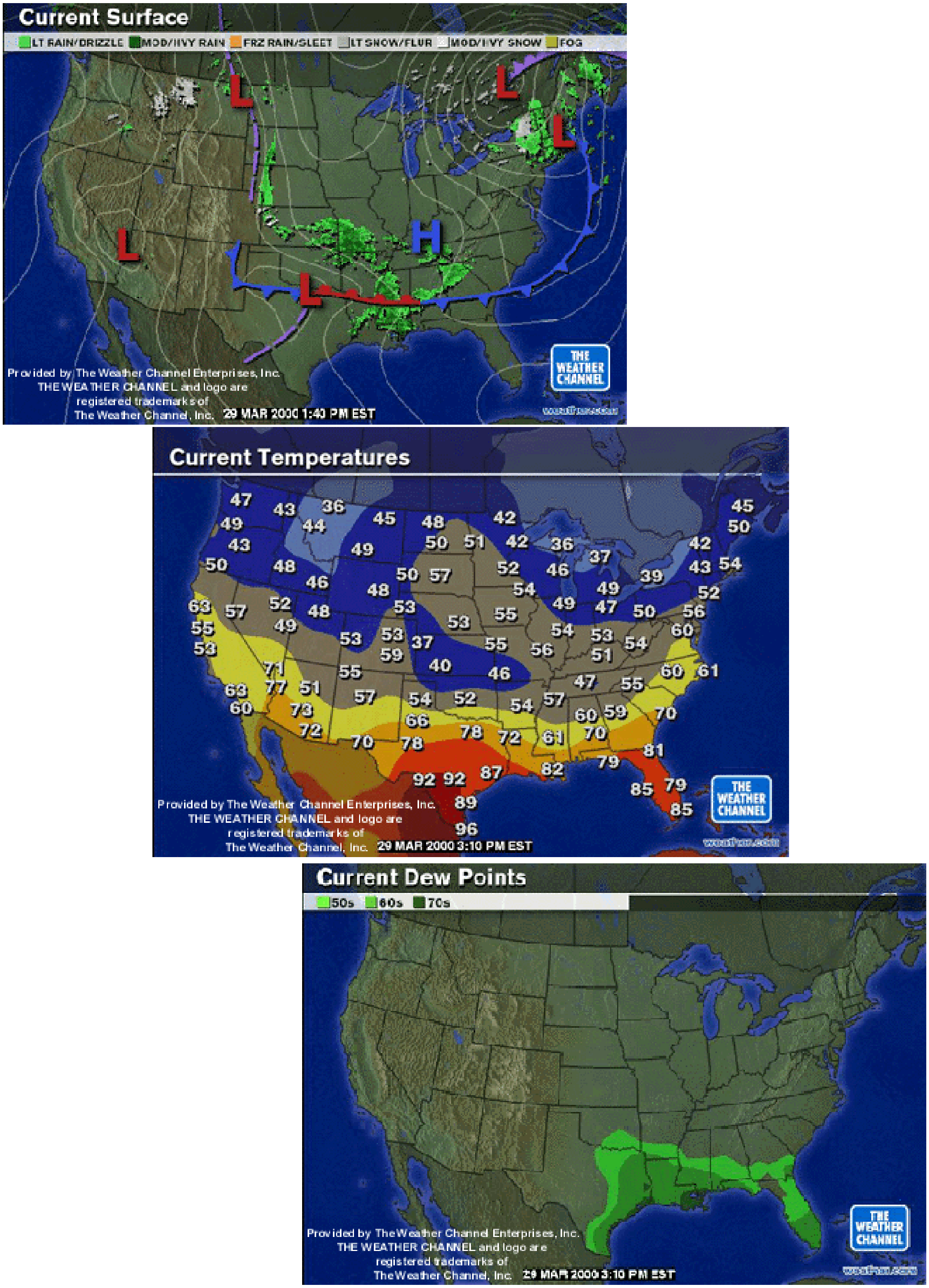


Figure 3-2 Uniform Temperature and Moisture of Air Masses

General Frontal Structure

The characteristics of each air mass on either side of the front diminish with increasing altitude. At some level above the surface, usually above 15,000 to 20,000 feet, the differences between the two air masses forming the front become negligible, and the cloud and precipitation patterns in the upper frontal zone are not easily attributable to one frontal type or another (Figure 3-3). Therefore, the most significant frontal weather occurs in the lower layers of the atmosphere. However, the temperature contrast between the air masses can sometimes extend as high as the tropopause.

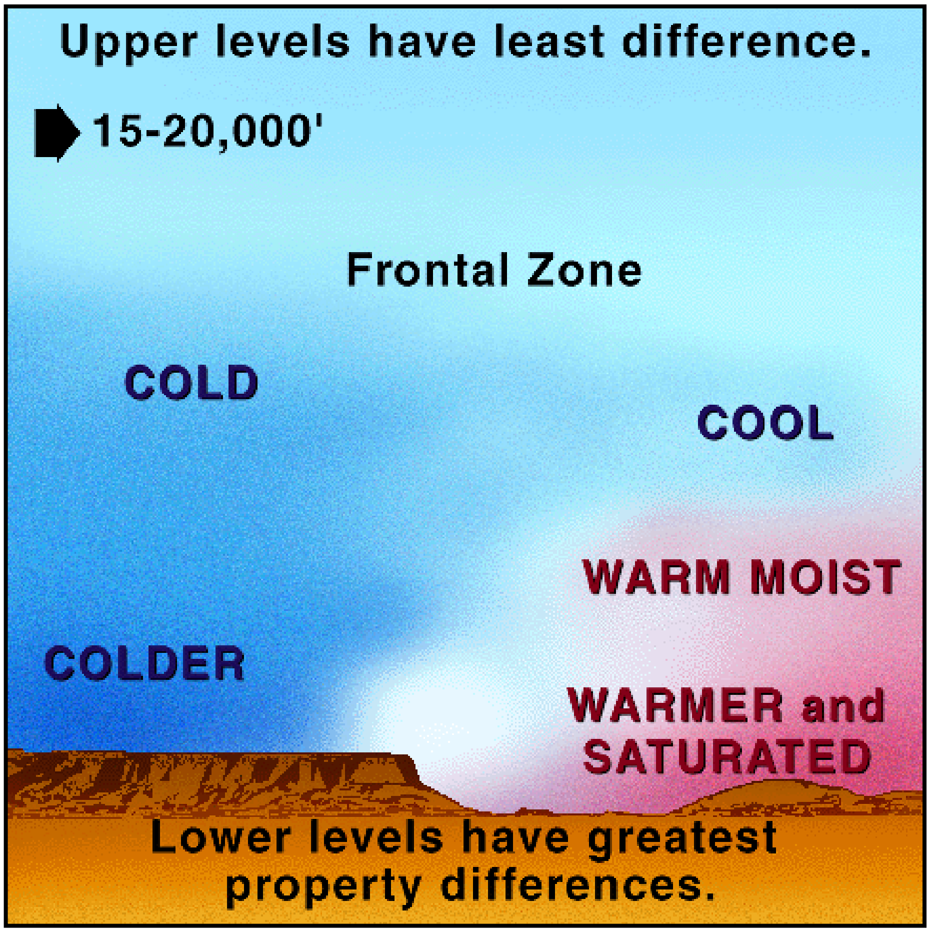


Figure 3-3 Frontal Zone Structure

Most fronts, regardless of type, have some common characteristics. First, fronts are named according to the temperature change they bring. For example, if the temperature will become warmer after the front passes, it is named a warm front. Second, fronts move across the country with their attached low-pressure system and isobars, as the corresponding air masses move. As they move, we are only concerned with any movement perpendicular to the line representing the front; thus, fronts are considered to move perpendicular to the way they are drawn. Also, cold fronts move faster than warm fronts, in general. Next, we usually see a 90° wind shift from one side of the front to the other, with two exceptions that will be explained below. Finally, every front is located in a trough of low pressure.

This course will use the general frontal model presented in Figure 3-4 to illustrate the different characteristics of the various fronts. Remembering the basics of this model can aid in the comprehension of how the various fronts usually move, as well as the characteristic changes in weather from one side of a front to the other. Once this model is understood, it can easily be modified to fit the appropriate real-world situation by rotating the system, by changing the angle between the fronts, or by considering a curvature to any of the frontal lines. As we discuss each frontal type, imagine zooming in on this model to study the particular characteristics of that front. These frontal characteristics will be discussed in depth for each type of front, and as a group in the next section, which explains how meteorologists determine where to place fronts on weather charts.

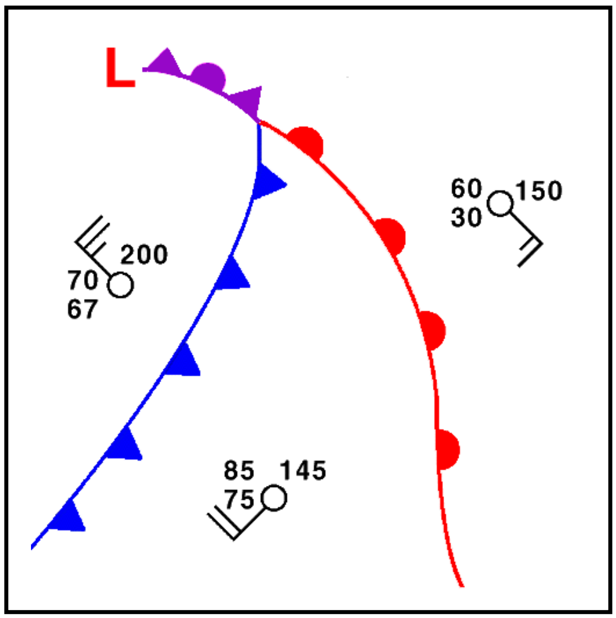


Figure 3-4 General Model of a Frontal System

303. FRONTAL DISCONTINUITIES

Differences in the various properties of adjacent air masses–in particular, their temperature, moisture (indicated by the dew point), winds, and pressure–are used to locate and classify fronts. For example, when comparing two dissimilar air masses, one will be colder than the other. Because of this, the colder one will be denser and drier (it must have a lower dew point). Cloud types are also useful indicators of the type of front and will be discussed in connection with each individual front.

Temperatures

Temperature is one of the most easily recognizable differences across a front. In the lower layers of the atmosphere a greater temperature change will be noticed with frontal passage or when flying through a front. The amount and rate of change partially indicates the front's intensity. Strong and weak fronts are accompanied by abrupt and gradual changes in temperature, respectively.

Dew Points

The dew point temperatures reported from weather observing stations are helpful in locating the position of a front. The dew point temperature and the air temperature give an indication of the relative humidity of the air. Cold air masses will usually have lower dew point temperatures than warm air masses. Higher dew points indicate a greater amount of moisture available to produce clouds, fog, or precipitation.

Pressures

All fronts are located in troughs of low pressure. The arrows in Figure 3-5 indicate the trough (where low pressure extends outward from the center of the low), as well as the direction of movement of the low-pressure system. Therefore, when a front approaches a station, or a pilot flies toward a front, the pressure decreases. Pressure then rises immediately following frontal passage. Figure 3-5 illustrates this pressure fall and rise with the time-sequence of the weather at station NSE. The earliest time is pictured in the upper right, when the pressure is 1011 mb, and the last point in time is at the lower left, with a pressure of 1007 mb. Because of this pressure change, it is extremely important to obtain a new altimeter setting when flying in the vicinity of a front.

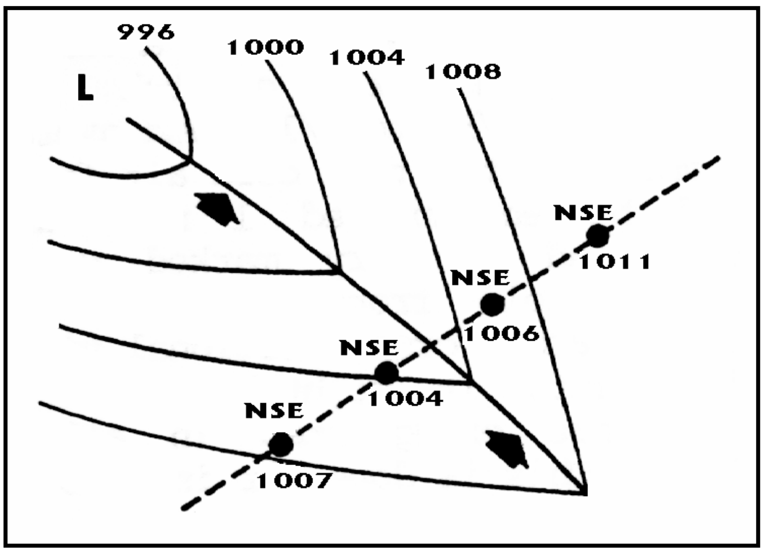


Figure 3-5 Pressure Changes across a Front

Winds

Near the Earth's surface, the wind changes direction across a front. In the Northern Hemisphere, as the front approaches and passes a station the wind changes direction in a clockwise rotation. When flying across a front, because of this wind shift you must adjust heading to the right to maintain your original ground track (Figure 3-6). This wind shift often creates a hazardous wind shear when departing or approaching an airfield. For example, winds at 220 degrees at 10 knots ahead of the front can rapidly change to 330 degrees at 20 knots gusting to 30 knots immediately after the front.

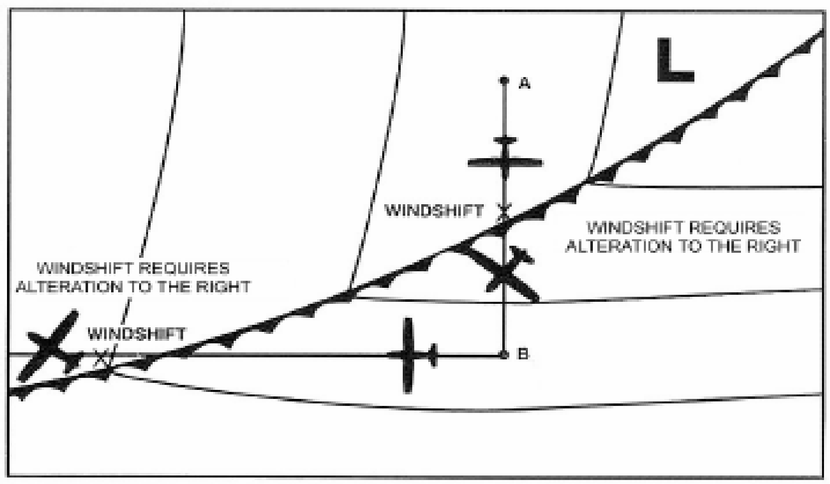


Figure 3-6 Wind Shift across a Cold Front

304. FACTORS INFLUENCING FRONTAL WEATHER

The weather along fronts is not always severe. Flying conditions can vary from insignificant weather to situations that are extremely hazardous. The hazardous situations can include thunderstorms, turbulence, icing, low ceilings, and poor visibility. The severity of the clouds and precipitation occurring along a front are dependent on the following factors:

1. The amount of moisture available (shown by the dew point)

2. The degree of stability of the lifted air

3. The slope of the front

4. The speed of the frontal movement

5. The contrast in the amounts of temperature and moisture between the two air masses.

The amount of moisture available, as indicated by the dew point, greatly determines the amount of weather associated with a front. Often little or no significant weather is associated with a front or a portion of a front because of a lack of moisture, despite the presence of all other factors.

The degree of stability of the air that is lifted determines whether cloudiness will be predominantly stratiform or cumuliform. With stratiform clouds, there is usually steady precipitation and little or no turbulence. Precipitation from cumuliform clouds is showery and the clouds indicate turbulence.

The **slope** is the ratio of the vertical rise to horizontal distance. The slope of a warm front is generally shallow, while the slope of a cold front can be quite steep (Figure 3-7). Shallow frontal slopes tend to produce extensive cloudiness with large areas of steady precipitation, while steep frontal slopes tend to move rapidly producing narrow bands of cloudiness and showery precipitation. Steep frontal slopes normally separate air masses of vastly different properties, indicating the potential for more severe weather.

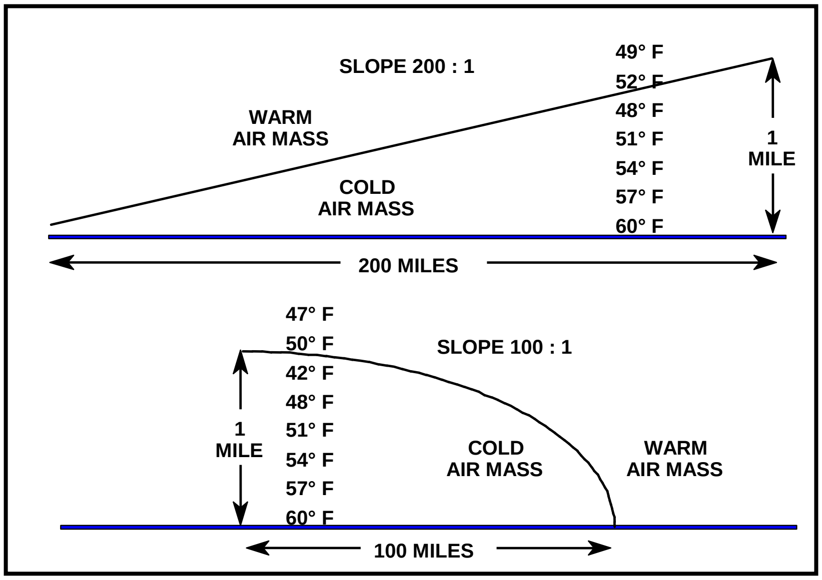


Figure 3-7 Frontal Slope

The speed of the frontal movement affects the weather associated with it. Faster moving fronts are generally accompanied by a narrow band of more severe weather. On the other hand, slower moving fronts have less severe weather, but the frontal zone is more extensive.

The greater the contrast in temperature and moisture between the colliding air masses, the greater the possibility of weather associated with a front, particularly severe weather. For example, most tornadoes occur in the spring due to very cold, dry air from Canada colliding with very warm, moist air from the Gulf of Mexico.

305. COLD FRONTS

A **cold front** is the leading edge of an advancing cold air mass. In this case, the colder (more dense) air mass is overtaking and wedging underneath a relatively warmer (less dense) air mass. As the cold air pushes the warm air upward, this motion sometimes produces very violent and unstable conditions, to include strong thunderstorms (cumulonimbus clouds) and severe turbulence. Figure 3-8 shows the manner in which a cold front is depicted on a surface weather chart. Cold fronts move toward the SE at 20kts, on average, and the wind shift is from the SW to the NW.

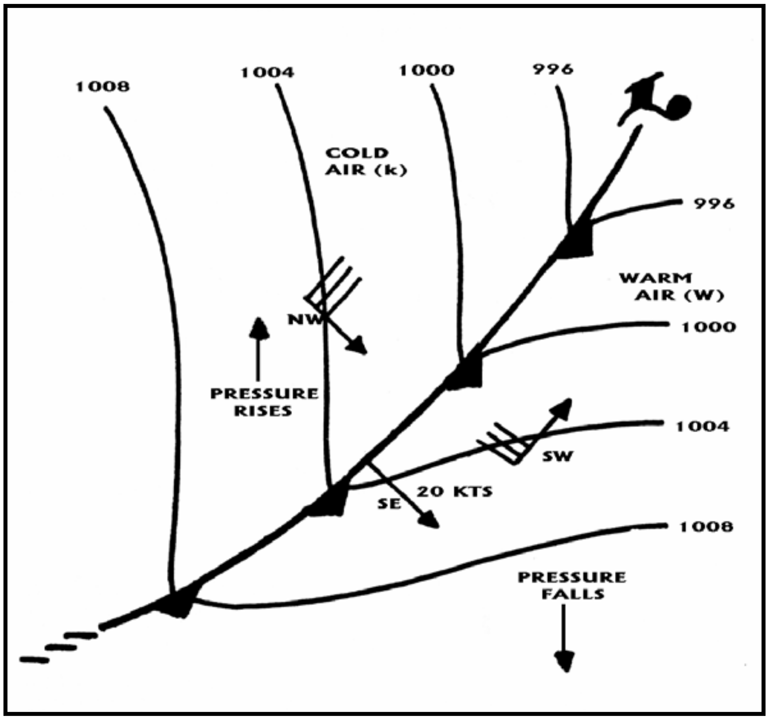


Figure 3-8 Cold Front

Cold front weather can vary greatly depending on the speed of the front and the characteristics of the air masses. Usually, though, as the cold front approaches, the southwesterly winds in the warm air mass ahead of the front begin to increase in speed. Meanwhile, the barometric pressure decreases, and altocumulus clouds appear on the horizon. Next, the cloud bases lower, and rain or snow showers begin as the cumulonimbus clouds move into the area. The precipitation increases in intensity and may persist as the front nears the station. As the front passes, the pressure rises sharply and the wind shifts approximately 90° from SW to NW. The postfrontal weather includes rapidly clearing skies, fair weather cumulus clouds, and decreasing temperature and dew point. The extent of postfrontal cloudiness depends on the degree of stability and moisture content of the cold air mass. In some cases, the sequence of events described here may be considerably different, depending on the specific atmospheric conditions (Figure 3-9).

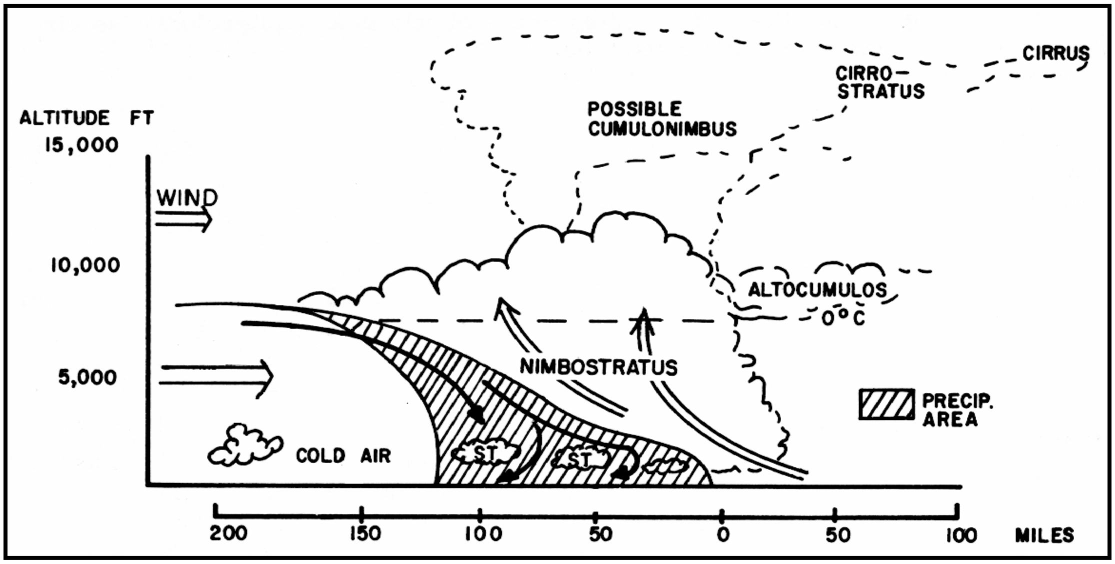


Figure 3-9 Cold Front Cloud Formation

Weather with fast-moving cold fronts occurs in a narrow band, is usually severe, and clears rapidly behind the front. Cumuliform clouds, showers, or thunderstorms may form near the front position. Lines of fast-moving thunderstorms, or squall lines, can form well ahead of the front. Weather with slow-moving cold fronts (usually from late fall through early spring) occurs over a large area, is less severe, but may persist for hours, even after the front is past.

Recognizing Cold Fronts During Flight

During a flight over flat terrain, you may see a long line of cumuliform clouds on the horizon. These clouds may indicate you are flying toward an approaching active cold front. When flying above an altocumulus layer extending ahead of the front, the lower frontal clouds are often hidden. Stratus or stratocumulus decks extending many miles ahead of a front may conceal the main clouds from a low flying aircraft.

Cold Front Flight Problems

Wind shifts — Expect an abrupt wind shift when passing through a frontal zone, especially when flying at lower altitudes. Turbulence is often associated with the wind shift. The wind generally shifts from SW to NW with greater speeds behind the front.

Ceiling and visibility — If an active cold front moves at a moderate or rapid speed (15-30 knots), its weather zone is generally less than 50 miles wide. If the front moves slower, its weather zone may be broad enough to seriously affect flight operations for many hours. Ceilings and visibilities are generally visual meteorological conditions (VMC), but isolated instrument meteorological conditions (IMC) exist in heavy precipitation and near thunderstorms. Wider areas of IMC conditions can exist in winter due to snow showers.

Turbulence — Many active cold fronts have turbulent cloud systems associated with them, but thunderstorms may not always be present. Even when there are no clouds, turbulence may still be a problem. As a rule, expect a rough flight in the vicinity of an active cold front, even when flying at a considerable altitude.

Precipitation and icing conditions — Active cold fronts usually have a relatively narrow belt of precipitation, especially if the precipitation is showery. Icing may be severe in cumuliform clouds. Slow-moving cold fronts may have a broader area of precipitation and a greater threat of remaining in icing conditions for a longer period.

Thunderstorms and squall lines — Severe weather is implied to exist in areas of reported thunderstorms. Chapter 4 will detail the hazards associated with thunderstorms.

306. SQUALL LINES

A **squall line** is a line of violent thunderstorms. They are indicated on surface charts by a dashed, double-dotted purple line. They develop 50 to 300 miles ahead of the cold front and roughly parallel to it. They form when cold air downdrafts flowing ahead of a cold front lift additional warm, unstable air. The uplifted air develops its own updrafts and downdrafts and starts the thunderstorm development cycle (Figure 3-10). Sometimes, however, squall lines can be located nowhere near a cold front, possibly from the convergence of air flows at one location. Squall lines are usually the most intense during the late afternoon and early evening hours, just after maximum daytime heating.

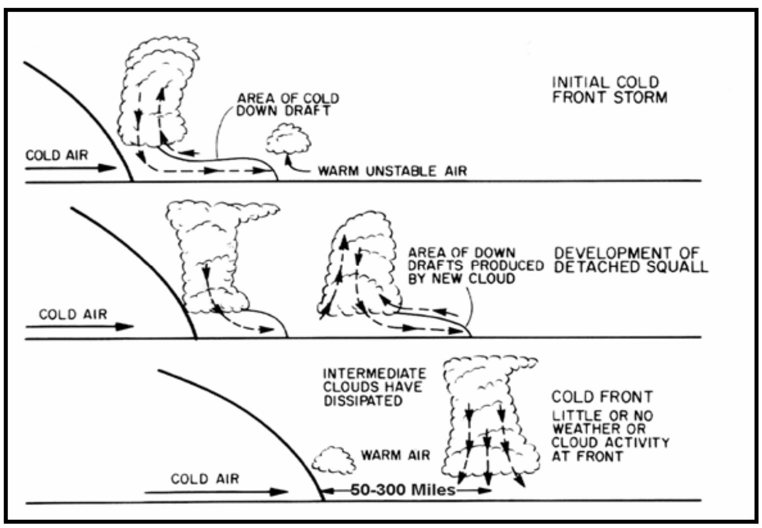


Figure 3-10 Squall Line Formation

It is often impossible to fly through squall lines, even with radar, since the storms are extremely close to one another. Similar to cold fronts, Squall lines will also have a 90° wind shift from the SW to the NW.

307. WARM FRONTS

A warm front is the boundary of the advancing warm air mass that is overtaking and replacing a colder air mass. To do so, the warmer, less dense air must ride up and over the top of the cold air mass. Figure 3-11 shows the manner in which a warm front is depicted on a surface weather chart. The warm air mass gradually moves up over the frontal surface creating a broad area of cloudiness. This cloud system extends from the front's surface position to about 500 to 700 miles in advance of it (Figure 3-12).

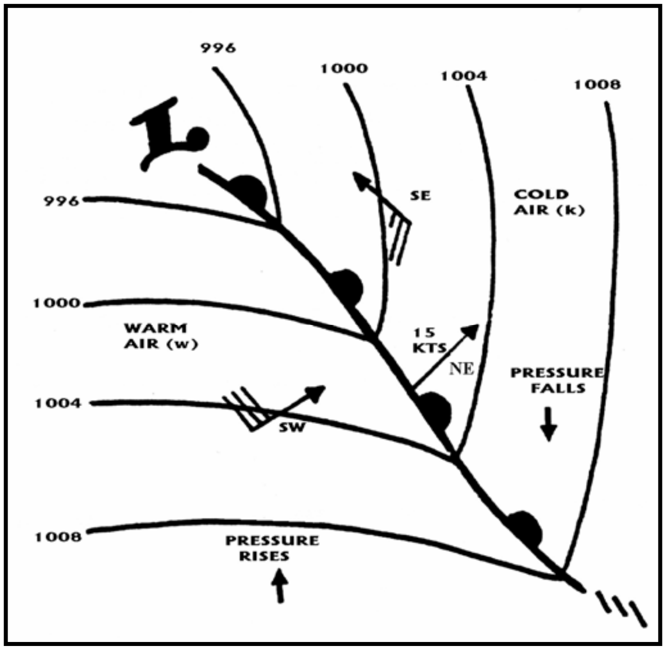


Figure 3-11 Warm Front

A warm front typically moves at a slower speed than a cold front–15 knots on average–and produces a more gradual frontal slope, as well as sloping forward, ahead of the surface front. Because of this slower speed and gradual slope, warm fronts are not as well defined as cold fronts. The winds shift across a warm front from the SE to the SW.

Recognizing Warm Fronts During Flight

The most common cloud found along a warm front is the stratiform cloud. If one were to approach the front from the east, the sequence of clouds would be cirrus, cirrostratus, altostratus, nimbostratus, and stratus, rain and fog (Figure 3-12). Steady precipitation gradually increases with the approach of this type of warm front and usually continues until the front passes.

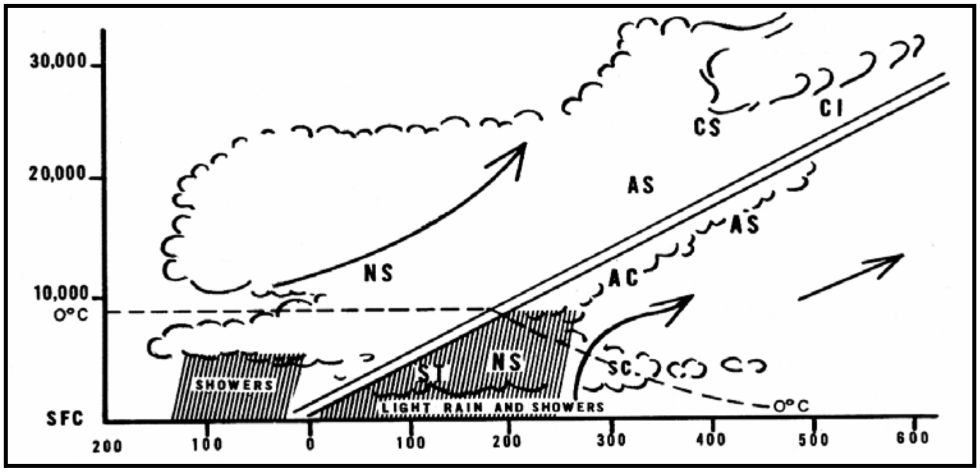


Figure 3-12 Warm Front Cloud Formation

Warm Front Flight Problems

Wind Shift — Warm front wind shifts are not as sudden as those of a cold front, and therefore, turbulence isn't likely. The wind generally shifts from SE to SW.

Ceiling and Visibility — The widespread precipitation ahead of a warm front is often accompanied by low stratus and fog. In this case, the precipitation raises the moisture content of the cold air until saturation is reached. This produces low ceilings and poor visibility covering thousands of square miles. Ceilings are often in the 300 to 900-foot range during steady, warm frontal rain situations. Just before the warm front passes the station, ceilings and visibilities can drop to zero with drizzle and fog. The worst conditions often occur in the winter when the ground is cold and the air is warm; the best scenario for dense fog and low ceilings.

Turbulence and Thunderstorms — If the advancing warm air is moist an unstable, altocumulus and cumulonimbus clouds can be embedded in the cloud masses normally accompanying the warm front. These **embedded thunderstorms** are quite dangerous, because their presence is often unknown to aircrews until encountered. Even with airborne radar, it can be difficult to distinguish between the widespread areas of precipitation normally found with a warm front and the severe showers from the embedded thunderstorms. The only turbulence along a warm front would be found in such embedded thunderstorms. Otherwise, little to no turbulence exists in warm front systems.

Precipitation and Icing — Approaching an active warm front from the cold air side (from the east), precipitation will begin where the middle cloud deck is from 8,000 to 12,000 feet AGL. Often, this precipitation will not reach the ground–a phenomenon called virga. As you near the front, precipitation gradually increases in intensity and becomes steadier. Occasional heavy showers in the cold air beneath the frontal surface indicate that thunderstorms exist in the warm air aloft. Drizzle, freezing drizzle, rain, freezing rain, ice pellets (sleet), and snow are all possible in a warm front, depending on the temperature. The shallow slope and widespread thick stratiform clouds lead to large areas of icing. It may take a long time to climb out of the icing area, and you may need to descend into warmer air to avoid the icing.

308. STATIONARY FRONTS

Sometimes the frontal border between the air masses shows little or no movement. Since neither air mass is replacing the other, the front is called a **stationary front** (Figure 3-13). Stationary fronts are indicated on surface charts by an alternating warm and cold front symbols, retaining their original red and blue colors, but pointing in opposite directions. Even though the front may not be moving, winds can still be blowing. Surface winds tend to blow parallel on both sides of the front rather than against and or away from it. Therefore, a stationary front has a 180° wind shift. The wind shift may be from any one direction to the opposite direction, as stationary fronts are less likely to be aligned in any one particular direction.

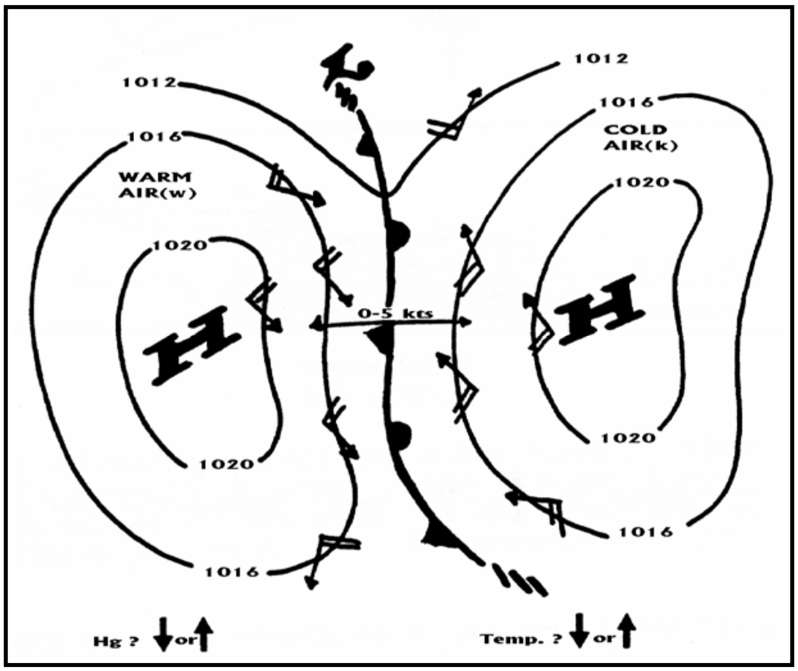


Figure 3-13 Stationary Front

The weather conditions occurring with a stationary front are similar to those found with the warm front, but are usually less intense. The weather pattern of a stationary front may persist in one area for several days, until other, stronger weather systems are able to push the stationary front weather along its way.

309. OCCLUDED FRONTS

Occluded fronts form when a faster moving cold front overtakes a slower moving warm front. There are two types of occluded fronts, cold and warm. The type of occlusion that forms depends on which front remains in contact with the ground. For example, if the cold front remains in contact with the ground, then it is named a cold front occlusion.

Occlusions are shown on surface charts with both cold and warm frontal symbols pointing in the same direction, but colored purple. Both types of occlusions tend to be aligned from NW to SE, and hence move toward the NE at the speed of the front that remains on the ground. The wind shift across either type of occlusion will be a 180° shift, as there are actually two fronts in the same location. Therefore, ahead of the occlusion, the winds will be the same as those ahead of the warm front, and behind the occlusion, the wind will be from the same direction as behind the cold front: the wind shift is SE to NW. Because the occluded front is the result of the meeting of both a cold front and a warm front, the weather associated with the occlusion will be a combination of both types of frontal weather.

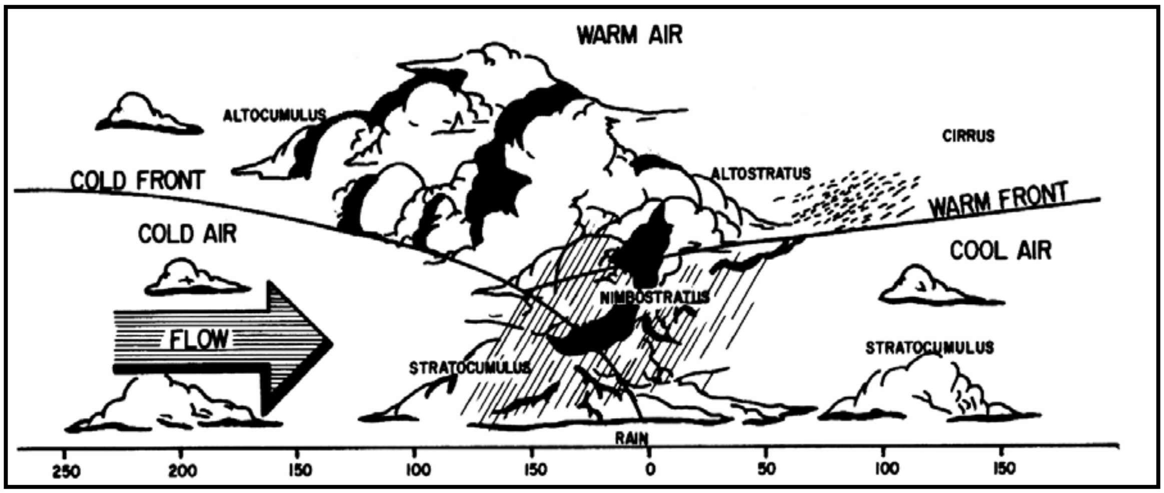


Figure 3-14 Occluded Front

Figure 3-14 depicts a profile of an occluded front. If either type of occlusion is approached from the east, you would first encounter warm front type weather which may extend for several hundred miles to the east of the surface front. On the other hand, if it were approached from the west you would first encounter cold front type weather. The location of the occluded front is significant to aircrews because the most severe weather, including ceilings and visibilities, is generally located in an area 100 NM south to 300 NM north of the frontal intersection. Figure 3-15 illustrates the stages of development of an occlusion.

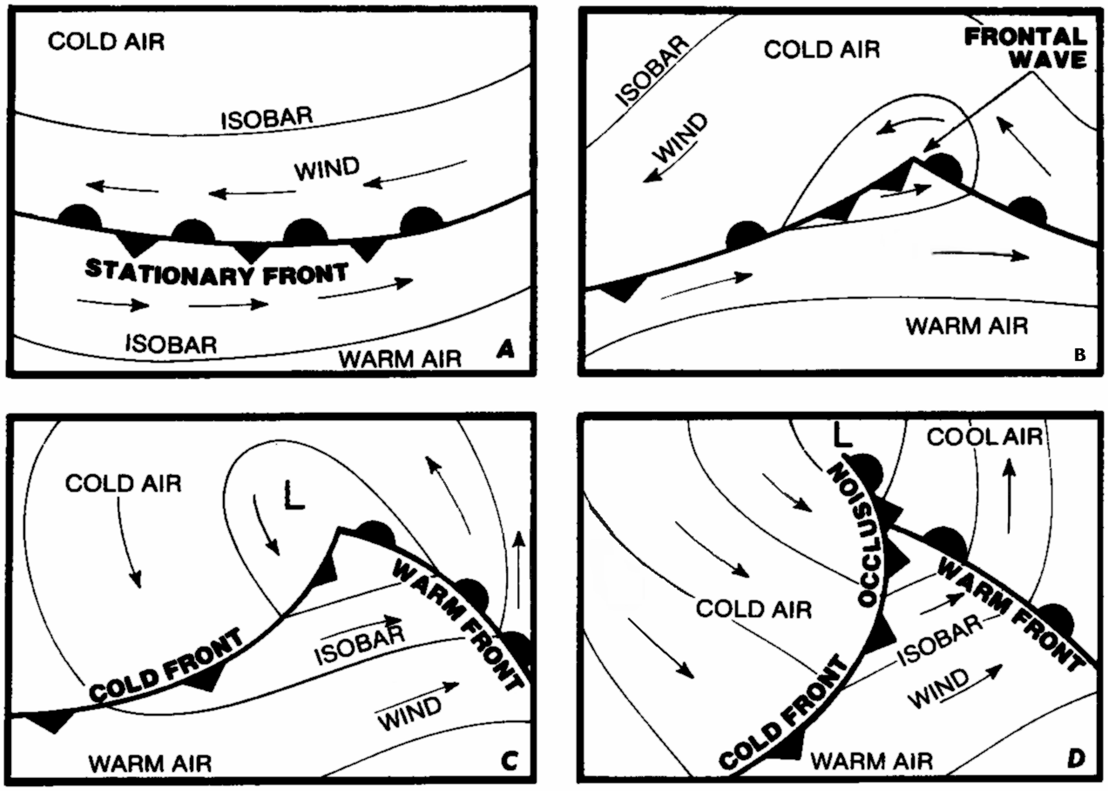


Figure 3-15 Occluded Wave Formation

310. INACTIVE FRONTS

Clouds and precipitation do not accompany inactive fronts. Sometimes the warm air mass is too dry for clouds to form even after the air is lifted and cooled. Inactive fronts may also be referred to as dry fronts.

The reason for showing an inactive front on the weather chart is to indicate the boundary of the opposing air masses. Additionally, it displays the location of potentially unfavorable flying weather. The warm air mass may gradually become more moist and lead to the formation of clouds and precipitation in the frontal zone. In many cases the inactive front only has a shift in the wind direction and a change in the temperature and pressure.

STUDY QUESTIONS

Mechanics of Frontal Systems

1. Which one of the following parameters of an air mass are generally uniform when measured across any horizontal direction?

a. Pressure and stability
b. Pressure and moisture
c. Temperature and pressure
d. Temperature and moisture

2. Which one of the following correctly indicates the four frontal properties used to locate and classify fronts?

a. Pressure, wind, stability, and slope
b. Pressure, temperature, dew point, and wind
c. Pressure, temperature, dew point and slope
d. Pressure, wind, dew point, and stability

3. Which one of the following indicates two of the five factors that influence frontal weather?

a. Slope and stability
b. Slope and pressure change
c. Stability and winds
d. Stability and pressure change

4. With frontal passage, the winds of a cold front will shift from the _____to the ____, and the winds of a warm front will shift from the _____to the _____.

a. southeast to the northwest, southeast to the northwest
b. southeast to the southwest, southwest to the northwest
c. southwest to the northwest, southeast to the southwest
d. northwest to the southwest, southwest to the southeast

5. In one respect, embedded warm-front thunderstorms present a greater flying hazard than cold-front thunderstorms because the warm-front cumulonimbus clouds

a. may be hidden in stratus type clouds.
b. generally contain a great amount of cloud-to-ground lightning.
c. have lower bases and lie closer to the earth’s surface.
d. are much more violent and turbulent.

6. Which one of the following would indicate that a cold front has passed?

a. Wind shifts
b. Pressure falls
c. Humidity increases
d. Temperature rises

7. If you are flying from east to west and you encounter cirrus, cirrostratus, alto-stratus, nimbostratus and then stratus clouds, you are most likely approaching a

a. stationary front.
b. warm front.
c. either a or b.
d. neither a nor b.

8. In each cell of the table below, circle the correct characteristics of each of the types of fronts. This is similar to a multiple-choice question, where the question is formed by matching a column heading with a row heading, and the alternatives are listed in the intersecting cell.

Type of Front	Wind Shift	Temper-ature Change	Pressure Change	Direction of Movement	Speed of Movement (kts)	Cloud Types	Turbulence Conditions	Color Code
Warm Front	SE to SW SW to NW SE to NW 180°	Warmer Colder Either	Rises then Falls Falls then Rises	SE NE NW None	0 to 5 15 20 25	Stratiform Cumuliform Combination	Smooth Rough Combination	Red Blue Purple R & B
Cold Front	SE to SW SW to NW SE to NW 180°	Warmer Colder Either	Rises then Falls Falls then rises	SE NE NW None	0 to 5 15 20 25	Stratiform Cumuliform Combination	Smooth Rough Combination	Red Blue Purple R & B
Warm Front Occlusion	SE to SW SW to NW SE to NW 180°	Warmer Colder Either	Rises then Falls Falls then rises	SE NE NW None	0 to 5 15 20 25	Stratiform Cumuliform Combination	Smooth Rough Combination	Red Blue Purple R & B
Cold Front Occlusion	SE to SW SW to NW SE to NW 180°	Warmer Colder Either	Rises then Falls Falls then rises	SE NE NW None	0 to 5 15 20 25	Stratiform Cumuliform Combination	Smooth Rough Combination	Red Blue Purple R & B
Stationary Front	SE to SW SW to NW SE to NW 180°	Warmer Colder Either	Rises then Falls Falls then rises	SE NE NW None	0 to 5 15 20 25	Stratiform Cumuliform Combination	Smooth Rough Combination	Red Blue Purple R & B

CHAPTER FOUR
THUNDERSTORMS

ASSIGNMENT SHEET

Thunderstorms
Assignment Sheet 4.1A

INTRODUCTION

The purpose of this lesson topic is to introduce the student to the fundamentals of thunderstorm hazards and the proper techniques for safe flight in their vicinity.

LESSON TOPIC LEARNING OBJECTIVES

Terminal Objective:
Partially supported by this lesson topic:

4.0 Describe the various hazards associated with thunderstorms.

Enabling Objectives:
Completely supported by this lesson topic:

4.1 Identify the hazards associated with thunderstorms.

4.2 Define a microburst.

4.3 Identify the characteristics of a microburst.

4.4 Explain how radar can aid a pilot when flying in the vicinity of thunderstorms.

4.5 Describe the recommended techniques for avoiding thunderstorm hazards.

STUDY ASSIGNMENT

Review Information Sheet 4.1I, and answer the Study Questions.

INFORMATION SHEET

Thunderstorms
Information Sheet 4.1I

400. INTRODUCTION

Thunderstorms contain many of the most severe weather hazards. They are often accompanied by strong wind gusts, severe turbulence, lightning, heavy rain showers, severe icing, and possibly hail and tornadoes. As a result, thunderstorms should be avoided if possible.

About 44,000 thunderstorms occur daily over the earth and pilots can expect to encounter one occasionally. In some tropical regions, thunderstorms occur year-round. In the mid-latitudes, they develop most frequently in spring, summer, and fall. This chapter presents hazards a pilot must consider when flying in the vicinity of, or actually entering, a thunderstorm. Being familiar with these factors will help you better understand what is going on both inside and outside the cockpit. Knowledge of thunderstorm characteristics and the application of tested procedures will help aircrews operate more safely near thunderstorms.

REFERENCES

1. *Weather for Aircrews*, AFH 11-203, Volume 1, Chapters 10 and 13

INFORMATION

401. THUNDERSTORM DEVELOPMENT

The basic requirements for thunderstorm formation are moisture, unstable air, and some type of lifting action. Lifted air does not always result in thunderstorm activity. Air may be lifted to a point where the moisture condenses and clouds form, but these clouds may not grow significantly unless the air parcel reaches a point where it will continue to rise freely (recall the LFC from chapter 2). The higher the moisture content, the easier the LFC is reached. One of the four lifting methods (from chapter 2) is necessary to force warmer air from its lower level to the LFC, which is the trigger to starting the cumulus cloud through the thunderstorm life cycle. Once moist air is lifted in an unstable environment, the rapidly rising unstable air quickly forms towering cumulus and eventual cumulonimbus clouds. The degree of vertical cloud growth often indicates the potential severity of the thunderstorm.

402. THUNDERSTORM WEATHER HAZARDS

Thunderstorms are accompanied by some or all of the following hazards: extreme turbulence, hail, microbursts, severe icing, lightning, and tornadoes.

Turbulence

Severe turbulence is present in all thunderstorms. One of the major characteristics of every thunderstorm is updrafts and downdrafts that can occur near each other creating strong, vertical shear and turbulence. This turbulence can extend over 5,000 feet above the cloud tops and down to the ground beneath the cloud base. It can damage an airframe and cause serious injury to passengers and crew.

The **first gust** or **gust front** of an approaching thunderstorm is another form of turbulence that can cause a rapid and drastic change in the surface wind (Figure 4-1). An attempt to take off or land with an approaching thunderstorm nearby could have disastrous results. Gust fronts can travel 5 to 20 miles from the thunderstorm.

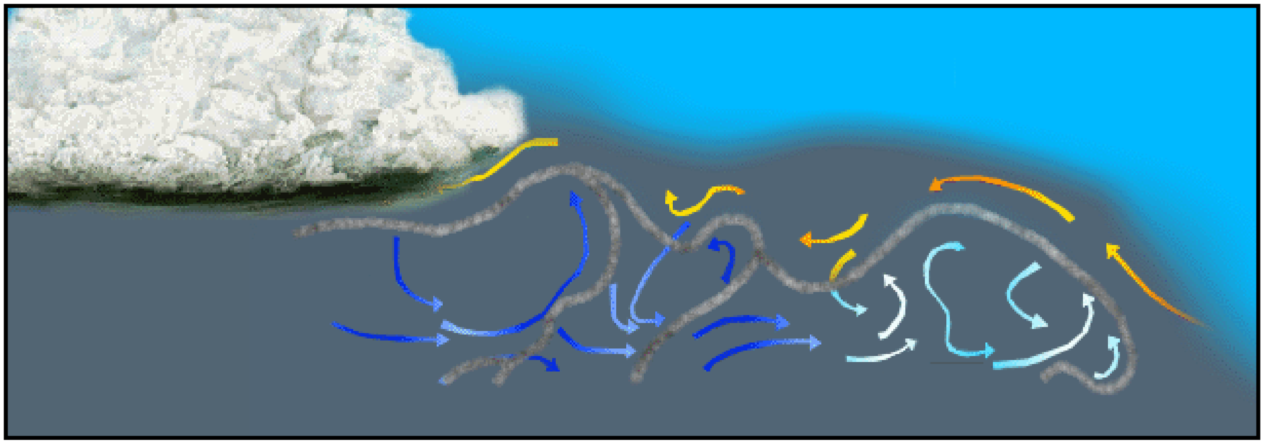


Figure 4-1 Gust Front

A roll cloud on the lower leading edge of a cumulonimbus cloud marks an area of strong eddy currents and identifies the location of wind shear and severe turbulence occurring with the onset of the gust front (Figure 4-2).

Figure 4-2 Roll Cloud

Large pressure changes can accompany thunderstorm formation due to the turbulence of updrafts and downdrafts. Therefore, if the altimeter setting is not updated, the indicated altitude might be in error by over 200 feet. The pressure variations associated with thunderstorms follow a common pattern:

1. A rapid fall in pressure as the storm approaches
2. An abrupt rise in pressure with the onset of the first gust and arrival of rain showers
3. A gradual return to normal pressure as the storm passes and the rain ceases

Hail

As a rule, the larger the storm, the more likely it is to produce hail. Hail has been encountered as high as 45,000 feet in completely clear air and may be carried 10 to 20 miles downwind from the storm core. Aircrews should anticipate possible hail with any thunderstorm, especially beneath the anvil of a large thunderstorm. Hailstones larger than ½ to ¾ of an inch (Figure 4-3) can cause significant aircraft damage in only a few seconds. Give yourself a clearance of at least 20 miles around a thunderstorm.

Figure 4-3 Hailstones

Lightning and Electrostatic Discharge

Lightning occurs at all levels in a thunderstorm. The majority of lightning bolts never strike the ground, but occur between clouds or within the same cloud. Lightning also occurs in the clear air around the tops, sides, and bottoms of storms. Aircrews flying several miles from a thunderstorm can still be struck by the proverbial "bolt out of the blue." Lightning strikes can also occur in the anvil of a well-developed or dissipated thunderstorm. Additionally, lightning strikes in the anvil have occurred up to 3 hours after the thunderstorm has dissipated.

An electrostatic discharge (ESD) is similar to a lightning strike, but it is caused by the aircraft itself. The larger and faster the aircraft, the more particles it impacts, generating a greater static electricity charge on the airframe. The electrical field of the aircraft may interact with the cloud and an electrostatic discharge may then occur. Aircraft have reported damage from electrostatic discharges occurring in cirrus clouds downwind of previous thunderstorm activity, in cumulus clouds around a thunderstorm's periphery, and even in stratiform clouds and light rain or showers. This release of static electricity is frequently called **Saint Elmo's fire**.

Aircraft Lightning or ESD Encounters

Lightning strikes and electrostatic discharges are the most reported weather related aviation incidents. All types of aircraft are susceptible to lightning strikes and electrostatic discharges. Aircraft have been struck by lightning or experienced electrostatic discharges at altitudes ranging from the surface to at least 43,000 feet.

Most lightning strikes occur when aircraft are operating in one or more of the following conditions:

1. Within 8 °C of the freezing level

2. Within approximately 5,000 feet of the freezing level

3. In precipitation, including snow

4. In clouds

5. In some turbulence

It should be noted that not all these conditions need to occur for a lightning strike or an electrostatic discharge to take place.

Lightning strikes have varied effects on aircraft and aircrews (Figure 4-4). Usually the structural damage is minor, but it has the potential to be severe. Normally, it will only interrupt electrical circuits, causing damage to aircraft electrical systems, instruments, avionics, or radar.

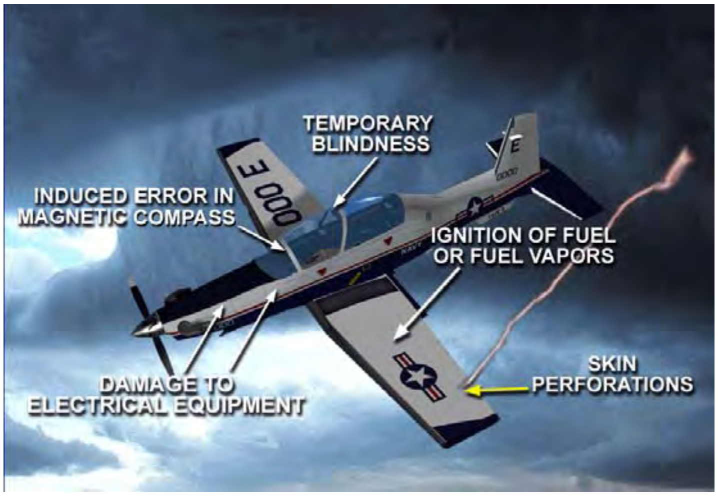


Figure 4-4 Lightning Hazards

Catastrophic fuel ignition can occur under certain conditions. In non-pressurized fuel tanks, a mixture of vaporized fuel and air fills the space above the liquid fuel. The proper ratio of fuel vapor to air can form a highly explosive mixture. For this reason, as well as for battle survivability, most military aircraft fuel tanks are pressurized.

Pilots are not immune to the effects of lightning strikes, either. Temporary night vision degradation can occur due to flash blinding, but this effect can be minimized by turning cockpit lighting to maximum intensity. Some pilots have also experienced mild electric shock and minor burns.

Tornadoes

A **tornado** is a violent, intense, rotating column of air that descends from cumulonimbus clouds in funnel-like or tube-like shapes. If the circulation does not reach the surface, it is called a funnel cloud. If it touches down over the water, it is called a waterspout. A tornado vortex is normally several hundred yards wide, but some have been measured up to 2 ½ miles wide. Within the tornado's funnel-shaped circulation, winds have been measured at speeds over 300 miles per hour, while the forward speed of tornadoes averages 30-40 knots.

Observed as appendages of the main cloud, tornadoes often form in groups or families of funnel clouds, some as far as 20 miles from the lightning and precipitation areas. Innocent looking cumulus clouds trailing a thunderstorm may mask tornadic activity, and the vortex may not be visible to warn unwary aircrews. The invisible vortices may be revealed only by swirls in the cloud base or dust whirls boiling along the ground, but may be strong enough to cause severe damage to aircraft.

Tornadoes form only with severe thunderstorms. The hazards they present have been chronicled often by news reports and television documentaries. To avoid tornadoes, avoid areas of severe thunderstorm activity.

Microbursts

A **microburst** is an intense, highly localized downward atmospheric flow with velocities of 2,000 to over 6,000 feet per minute. This downward flow diverges outward, producing a vortex ring of wind that can produce differential velocities ranging from 20 to 200 knots in an area only ¼ to 2½ miles in diameter (Figures 4-5 and 4-6). Microbursts may emanate from any convective cloud, not just cumulonimbus clouds. Another unique aspect of a microburst is its short life span–usually only 5 to 10 minutes after reaching the ground–which makes the study, and hence the prediction, of microbursts a difficult task.

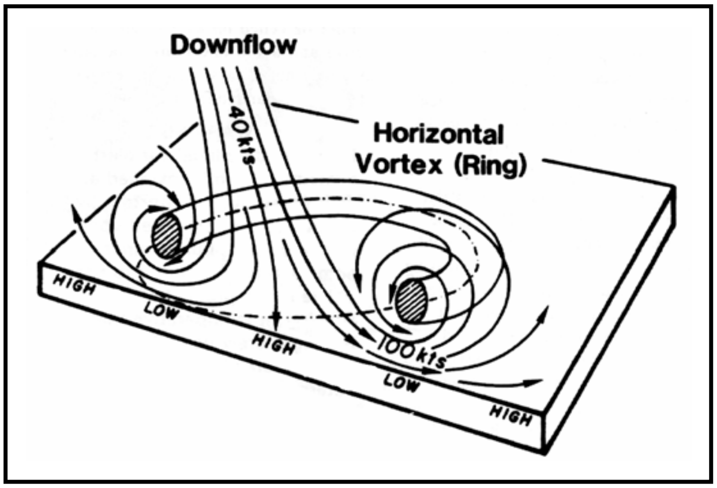


Figure 4-5 Vortex Ring of a Microburst

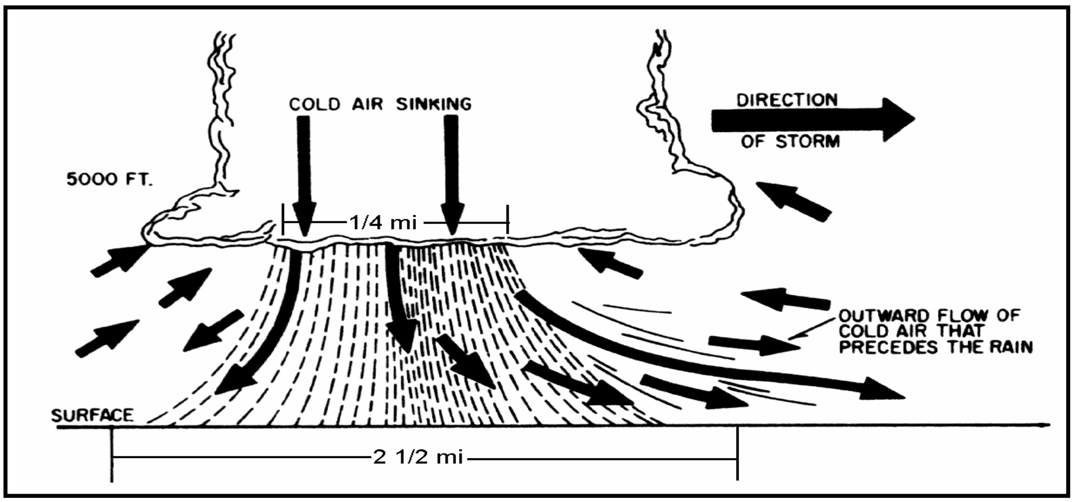


Figure 4-6 Cross Section of a Microburst

The wind shear created by microbursts is extremely dangerous to aircraft during the takeoff, approach, and go-around phases of flight. Not all microbursts are associated with thunderstorms. Microbursts are possible with any rain shower, even if the rain isn't reaching the ground (virga).

In Figure 4-7, the aircraft at position 1 has entered a microburst. At this point, the crew may notice an increased angle of attack as the aircraft enters the upward flow of the vortex ring. Once inside the microburst, the aircraft will experience a strong increase in headwind, with a resulting increase in indicated airspeed and lift, which will cause the aircraft to pitch up (position 2). A natural reaction of the pilot would be to reduce power and apply nose down stick force. This would correct the situation if the aircraft was not in a microburst, and would appear to work here until the reaching position 3. At this point, the aircraft will be in a severe downdraft, and a transition from a strong headwind to a strong tailwind will occur (position 4). The resulting loss of indicated airspeed and lift will cause the aircraft to pitch down and lose altitude. At this point (or earlier), the correct reaction would be to add maximum power and establish a climbing attitude on the vertical gyro. Chances of successful recovery depend on reaction time, aircraft performance capabilities, and the altitude of the aircraft.

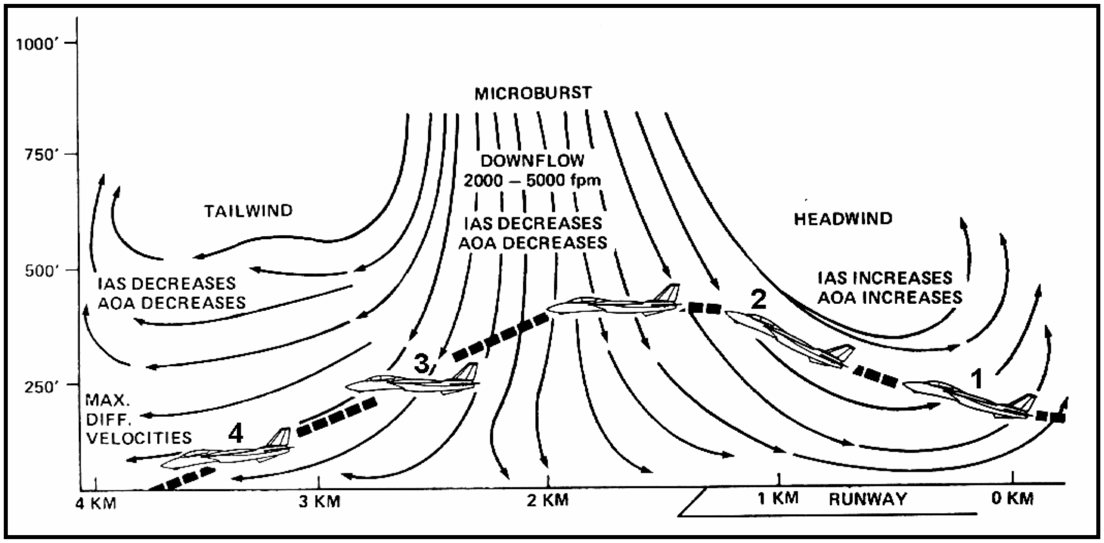


Figure 4-7 Attitude Changes with Microburst Penetration

If you encounter a microburst on final approach or on takeoff, the results could be disastrous. The best course of action is to avoid microbursts at all costs. This point cannot be over emphasized. You must always be alert for the warning signs of a microburst. Remember–avoid, avoid, avoid. You may only get one chance to make a life or death decision.

Methods of Microburst Detection

Because microbursts are such a dangerous phenomenon, early detection is vital to mishap prevention. In most microburst accidents there have been warning signs that were ignored, misinterpreted, or misunderstood. You must evaluate the warning signs and make a decision quickly and decisively. Here are some very important clues that indicate the presence of microburst.

Ground-based Doppler radar now has the capability to accurately detect hazards that can take the form of microbursts, tornadoes, and other low-level wind shear activity. Therefore, when weather observations or recordings mention low-level wind shear, or call for gusty winds, heavy rain, or severe thunderstorms, be aware that the potential for microburst activity exists.

Visual cues are also very important in detecting microbursts. In fact, in many fatal wind shear mishaps the pilot continued the approach or takeoff in visible and known thunderstorm conditions. Visual cues include virga, localized blowing dust (especially in circular or elliptical patterns), rain shafts with rain diverging away from the core of the cell, roll clouds, and, of course, experiencing vivid lightning or tornado-like activity.

If you suspect the potential for wind shear conditions prior to take off or landing, get additional information from the tower or base weather station to include the latest radar report and pilot reports (PIREPs). Some airfields even have a wind shear warning system to help you. These sources will not identify every microburst situation, so if in doubt, wait it out! If you do encounter a wind shear condition, you **must** make a PIREP to warn fellow aviators about the dangerous situation. Your PIREP should include the location where the activity was encountered, an estimate of its magnitude and, most importantly, a description of what was experienced, such as turbulence, airspeed gain or loss, glidepath problems, etc.

Icing

Expect severe icing in thunderstorms where the free-air temperature is at or below freezing. Since heavy rainfall and turbulence most frequently occur at the freezing level, this particular altitude appears to be the most hazardous. Most of the icing, however, occurs in the top 2/3 of the thunderstorm cell. Note that the actual altitude of the freezing level will fluctuate with the up and down drafts, and it will be lower in the area of downdrafts. Due to the heavy amounts of moisture and large water droplets, the icing in thunderstorms is mostly clear icing, accumulating rapidly on the airfoils and other aircraft surfaces. Other aspects of icing will be covered in more detail in chapter 5.

403. RADAR THUNDERSTORM INFORMATION

Ground-based weather radar is the most accurate means of tracking thunderstorms. In addition to the locating and tracking of cumulonimbus cells, their intensities can also be determined. The large drops of water and hail, if present, within thunderstorms yield the strongest return signals. Smaller droplets result in dimmer areas on the scope and snow produces the faintest echo.

Detection and warnings are more accurate with the modern NEXRAD Doppler radar systems (Figure 4-8). This is particularly true for microbursts and wind shear alerts.

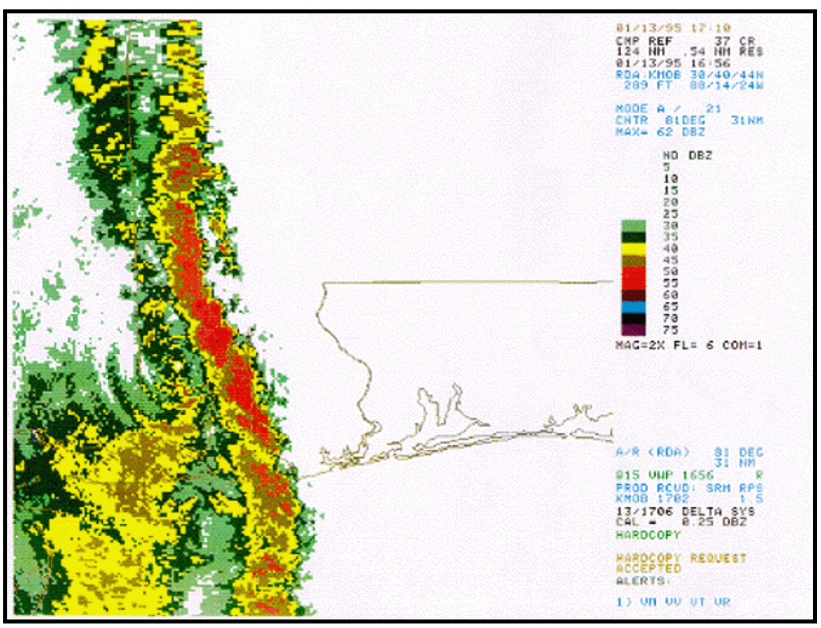


Figure 4-8 NEXRAD Doppler Radar Composite

A direct relationship exists among the strength of the radar echoes, the presence of aircraft icing, and the intensity of turbulence. Stronger radar echoes are associated with more severe thunderstorms.

The following weather radar information is of particular interest to pilots:

1. A thunderstorm with radar echo tops indicated above 35,000 feet often contains extreme turbulence and hail.

2. Hazardous weather associated with scattered echoes can usually be circumnavigated. However, if the lines or areas are reported as broken or solid and are of moderate to strong intensity, hazardous weather can be avoided only if the aircraft is radar equipped.

3. Severe clear air turbulence and hail may be experienced between thunderstorms if the separation between echoes is less than 30 miles.

Ground-based weather radar is the most valuable to a pilot when there are numerous thunderstorms that are obscured by multiple cloud layers. However, echoes can change shape, character, and intensity in a matter of minutes when updrafts reach velocities of over 6,000 feet per minute. Therefore, radar information received before takeoff may be worthless by the time thunderstorms are encountered.

A pilot with airborne weather radar should remember that radar does not eliminate the hazards of the thunderstorm. It merely helps to locate the most severe conditions. Since the radarscope indicates only precipitation areas within thunderstorms, hazards can be encountered even in soft spots. Thunderstorms having frequent, vivid lightning discharges are especially dangerous.

Airborne weather radar should be used as an avoidance rather than penetration tool. The pilot should take time to properly evaluate scope indications and watch for trends in order to avoid the most intense echo patterns. The pilot without airborne weather radar should make no attempt to find soft spots on the basis of any radar information that is not current up-to-the-minute.

404. FLIGHT TECHNIQUES IN THE VICINITY OF THUNDERSTORMS

Since thunderstorms have so many potential hazards, it is appropriate to list some recommended practices for pilots who must cope with these “uninvited guests.” As far as flying is concerned, there is no such thing as a small thunderstorm, so some common sense recommendations are provided below:

1. If at all possible, avoid thunderstorms.

2. Do not venture closer than 20 miles to any storm cloud with overhanging anvils because of the possibility of encountering hail.

3. Do not attempt to fly under thunderstorms in mountainous regions even if the area on the other side of the mountains can be seen. Winds that are strong enough to provide the lifting action to produce the thunderstorms can also create extreme turbulence between mountain peaks.

4. If at all possible, avoid flying under thunderstorms because updrafts and downdrafts can exceed the performance of the aircraft.

5. Do not take off or land if a thunderstorm is approaching. Sudden wind shifts or microbursts can cause control problems.

6. Do not fly into a cloud mass containing scattered embedded thunderstorm without airborne radar. Radar is necessary to "see" storms in the cloud mass. Scattered thunderstorms can be circumnavigated visually unless they are embedded.

7. To avoid lightning do not penetrate a thunderstorm or fly through the cirrus anvil of a well-developed or dissipated thunderstorm. Aircraft should also avoid clouds downwind of thunderstorms.

8. The brighter and more frequent the lightning, the more severe the thunderstorm.

9. Regard any thunderstorm with tops 35,000 feet or higher as severe.

Thunderstorms should be avoided if at all possible using the following recommendations, listed in order of priority of choice:

1. Fly **around** (circumnavigate) the storm.

2. Fly **over** the top of the storm.

3. Fly **under** the storm.

If it is not possible to avoid the storm(s) then,

4. Fly **through** the lower 1/3 of the storm.

When thunderstorms are isolated, they are easily circumnavigated provided the surrounding area is clear of masking clouds. If lines of thunderstorms are present or if masking clouds obscure the area around the storm, other techniques must be employed.

Circumnavigation

Circumnavigation presents no special flight problems. When the aircrew determines that circumnavigation is possible, they merely alter course to take them around the storm (Figure 4-9). Since most individual thunderstorm cells are about five to ten miles in diameter, detouring to one side or another would not appreciably add to either the time or distance of the flight. In case of a line of thunderstorms, it is sometimes possible to circumnavigate them by flying through thin spots of precipitation between the storms. Care should be exercised in this procedure because another thunderstorm may lie on the other side of a thin spot.

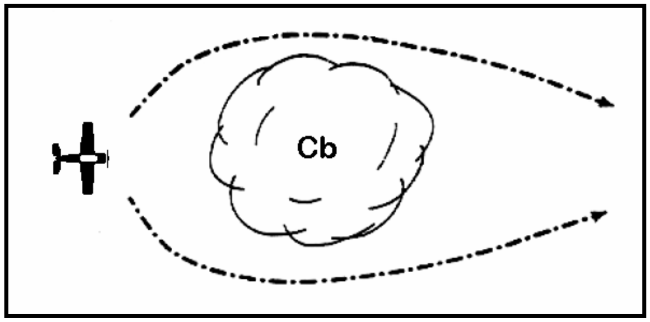


Figure 4-9 Around a Thunderstorm

Over the Top

When circumnavigation of thunderstorms is not possible, the next best course of action is to go over the top (Figure 4-10). Realize that thunderstorms build to great heights, and that this procedure is restricted to aircraft with the capability and fuel to climb to these altitudes. Some turbulence may be encountered in the clear air above the cloud. In addition, hail can be thrown out the top of the cumulonimbus cloud. Thus, allow a margin of safety by choosing an altitude separation from the top of the thunderstorm of 1,000 feet for every 10 knots of wind speed at the altitude of the tops. Oftentimes, aircraft cannot climb over the top of the cloud, but it will still be possible to fly over the saddlebacks between the build-ups.

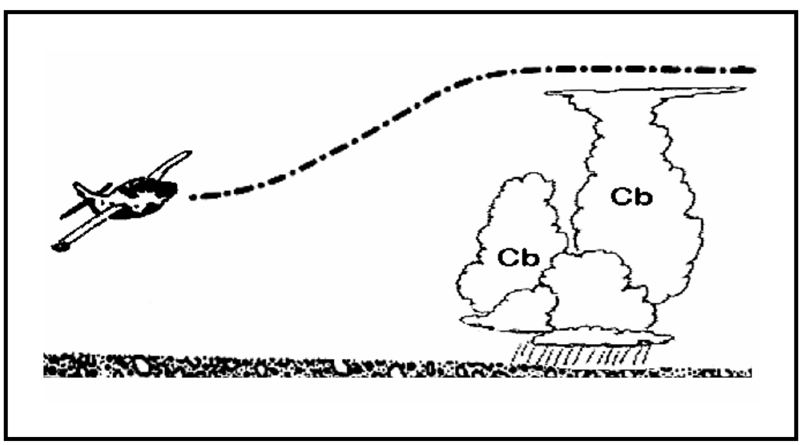


Figure 4-10 Over the Top

Underneath

If you are unable to circumnavigate the thunder-storms in your area and the ceiling capabilities of your aircraft will not permit an over-the-top flight, you should consider flying below the base of the cloud. The speed of downdrafts usually decreases closer to the surface (Unless a microburst is present!). Therefore, an altitude should be selected which will keep you as far away from the cloud base as possible and still enable you to maintain adequate terrain clearance.

Here you can use the 1/3 rule which specifies selecting an altitude 1/3 the distance from the surface to the base of the cloud (Figure 4-11). This procedure is not recommended for areas of mountainous terrain. Below the storm, expect a low ceiling, poor visibility, and moderate turbulence. Perhaps the most dangerous threat to flight below a thunderstorm is the downburst, or microburst, which can be deadly to the unsuspecting pilot.

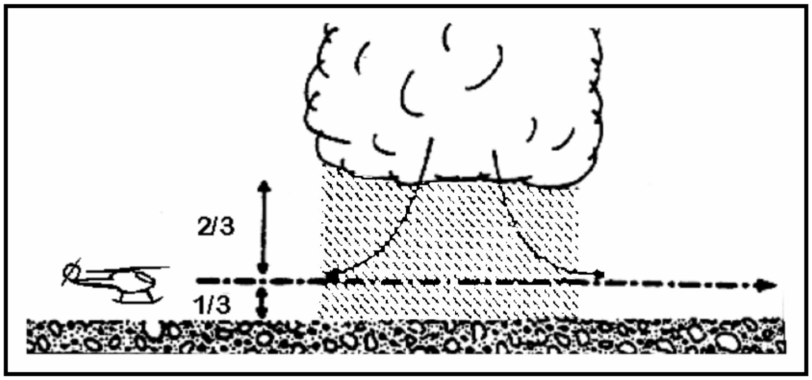


Figure 4-11 Under the Thunderstorm

Penetration

Mission urgency or fuel state dictates whether thunderstorm penetration is required when avoidance is not possible. The lower in the storm the penetration is made, the less the chance of encountering hail, structural icing, or being struck by lightning. Therefore, another version of the 1/3 rule applies: penetrate through the lower 1/3 of the storm, since most hazards are more severe in top 2/3 of the cell (Figure 4-12). However, with the strong updrafts and downdrafts, adequate terrain clearance should also be considered in the selection of a penetration level. When crossing a line of thunderstorms (a squall line for example), attempt to determine the orientation of the line and penetrate the line at right angles (Figure 4-13). During the penetration of a thunderstorm, do not attempt to turn back once you are inside the storm. Remember that single-cell thunderstorms are only about one to five miles in diameter, and turning around will only increase your time in the storm. Turning around can also result in a pilot becoming disoriented and flying in the storm for a considerably longer period of time than continuing directly through the storm in the first place. With no other information to make a decision, a penetration altitude between 4,000 and 6,000 feet AGL should be adequate.

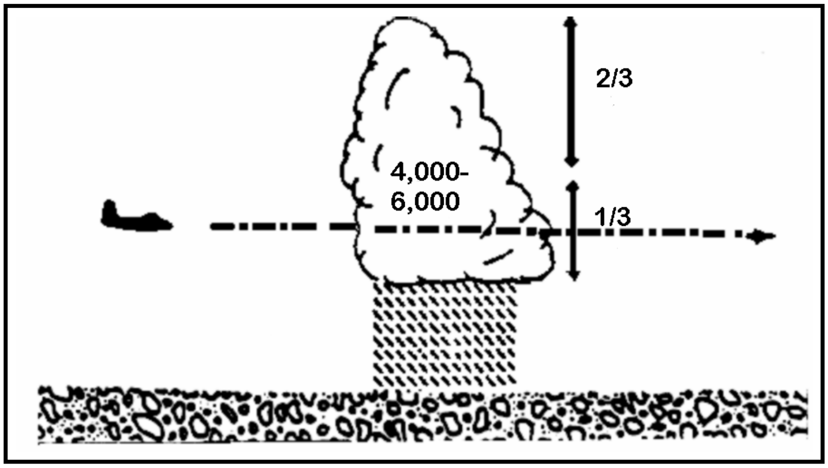


Figure 4-12 Through the Thunderstorm

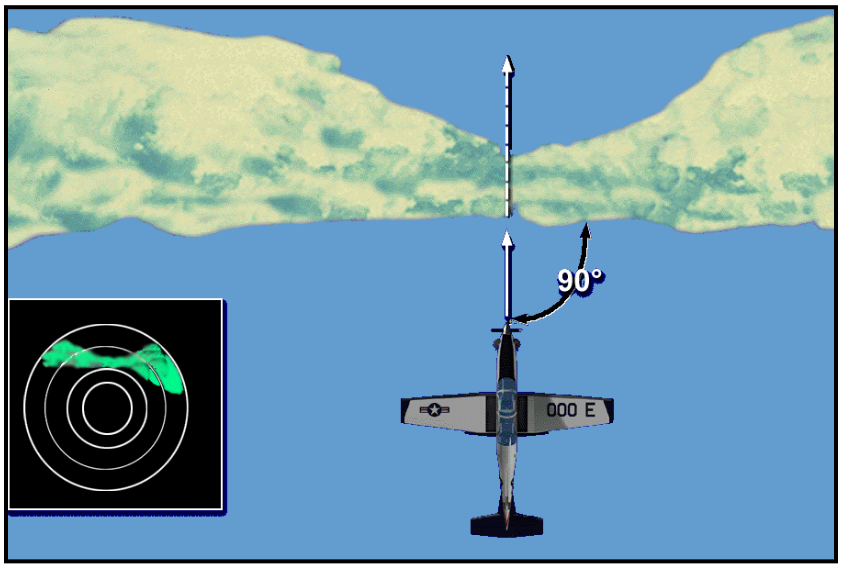


Figure 4-13 Thunderstorm Penetration

Penetration Procedures

The faster a plane is going when it strikes an updraft or downdraft, the greater the shock. Refer to your flight manual for the recommended turbulent air penetration speed.

Once inside the storm, the pilot should let the plane ride out the updrafts and downdrafts and concentrate on maintaining a level attitude. With power set to maintain the proper airspeed, maintaining the same attitude will result in only minor airspeed variations. However, the aircraft's altitude may vary by thousands of feet. The rapidly changing pressure conditions within the storm will result in unreliable indications and erratic variations in altitude, airspeed, and rate of climb instruments. Since the attitude gyro is independent of the pitot-static system, its indications should be considered reliable.

If thunderstorm penetration is unavoidable or you inadvertently fly into a thunderstorm, follow these procedures:

1. Secure all loose objects, tighten your lap belt and lock your shoulder harness. Turn cockpit lights up to highest intensity.

2. Turn on pitot heat. (Also turn on engine anti-ice, if the aircraft is so equipped. Neither the T-34 nor the T-6 has engine anti-ice.)

3. If able, plan your course to take you through the storm in minimum time, penetrating below the freezing level or above -20 °C to avoid the most critical icing areas.

4. Establish the recommended turbulent air penetration speed and disengage the autopilot to minimize control inputs that could increase structural stresses.

5. Don’t chase the airspeed and minimize power changes. Expect significant deviations in attitude and altitude. Keep your eyes on your instruments.

6. Don’t turn back once in the thunderstorm.

Experience in severe weather flying is gained by necessity more often than by design and planning. Your first flight experience near a severe thunderstorm will make the dangers listed in this chapter all too real. No pilot should knowingly fly into severe weather if the mission does not demand it. In making a “go/no-go” decision, consider that it is better to arrive at the destination late than not at all.

STUDY QUESTIONS

Thunderstorms

1. The atmospheric conditions necessary for the formation of a thunderstorm include a combination of

a. stable air or relatively low humidity and some type of lifting action.
b. stable air of relatively high humidity and some type of subsiding action.
c. unstable air of relatively low humidity and some type of subsiding action.
d. unstable air of relatively high humidity and some type of lifting action.

2. Which one of the following hazards to flight are associated with thunderstorms?

a. Hail, turbulence, and lightning
b. Hail, icing, and microbursts
c. Hail, turbulence, and icing
d. All of the above are correct

3. Which one of the following is an indication of turbulence found in thunderstorms?

a. Rotor clouds
b. The gust front
c. Orographic lifting
d. Severe icing

4. Which one of the following type clouds could indicate the possibility of microburst activity?

a. Convective only
b. Cumulonimbus only
c. Both a and b
d. Nimbostratus

5. Which one of the following telltale signs in the vicinity of thunderstorms should alert you to the possibility of microburst activity?

a. Roll clouds
b. Blowing dust
c. Gusty conditions
d. All of the above

6. Which one of the following is/are correct concerning thunderstorm recommended flight techniques?

a. Penetration of a thunderstorm should be at an altitude of 4,000 to 6,000 feet AGL.
b. When flying under a thunderstorm, select an altitude 1/3 the distance from the surface to the base of the cloud
c. Both a and b above are correct
d. Neither a or b above are correct

7. When flying through a thunderstorm a pilot should concentrate on maintaining a level attitude.

a. True
b. False

CHAPTER FIVE
TURBULENCE, ICING, CEILINGS, VISIBILITY, AND ASH CLOUDS

ASSIGNMENT SHEET

Weather Hazards of Turbulence, Icing, Ceilings, Visibility, and Ash Clouds
Assignment Sheet 5.1A

INTRODUCTION

This chapter will cover the causes of turbulence, classification of the various categories of turbulence, conditions under which turbulence exists, and will recommend flying procedures to be used when turbulence is encountered. This chapter will also cover the requirements for icing formation, types of icing, and their effects on aircraft flight and aircraft components, including techniques that should be following for safe flight. Finally, this chapter will introduce the student to ceilings and visibility, sky coverage terminology, and the requirements for fog formation and dissipation, plus a synopsis of the aviation hazards of volcanic ash clouds.

LESSON TOPIC LEARNING OBJECTIVES

Terminal Objective:
Partially supported by this lesson topic:

5.0 Describe the aviation hazards of turbulence, icing, and visibility.

Enabling Objectives:
Completely supported by this lesson topic:

5.1 List the types and intensities of turbulence used in Pilot Reports (PIREPs).

5.2 Define the terms used to report turbulence with respect to time.

5.3 Describe how thermal turbulence develops.

5.4 Describe how mechanical turbulence develops.

5.5 Describe the cloud formations associated with mountain wave turbulence.

5.6 Describe techniques for flight in the vicinity of mountain waves.

5.7 Describe how frontal lifting creates turbulence.

5.8 Describe how jet streams and temperature inversions are examples of wind shear turbulence.

5.9 Describe the recommended procedures for flying through turbulence.

5.10 Describe the types of structural icing.

5.11 State the requirements for the formation of structural icing.

5.12 State the temperature range most conducive to structural icing.

5.13 Identify icing conditions associated with fronts.

5.14 Identify the effects and hazards of aircraft icing.

5.15 Describe induction icing and compressor icing.

5.16 Describe ground icing hazards.

5.17 Identify the procedures to minimize or avoid the effects of icing.

5.18 List the types and intensities of icing used in Pilot Reports (PIREPs).

5.19 Define the following terms: visibility, flight visibility, prevailing visibility, slant range visibility, and runway visual range.

5.20 Define and identify obscuring phenomena.

5.21 List the sky coverage terms that define a ceiling.

5.22 Identify the parameters that define fog.

5.23 Identify the requirements for fog formation.

5.24 Identify the two main types of fog and how they form and dissipate.

5.25 Describe the aviation hazards of ash clouds.

STUDY ASSIGNMENT

Review Information Sheet 5.1I, and answer the Study Questions.

INFORMATION SHEET

Weather Hazards of Turbulence, Icing, Ceilings, Visibility, and Ash Clouds
Information Sheet 5.1I

500. INTRODUCTION

Turbulence is one of the most unexpected aviation hazards to fly through and is also one of the most difficult hazards to forecast. Severe and extreme turbulence has been known to cause extensive structural damage to military aircraft, with lesser intensities resulting in compressor stalls, flameouts, and injury to crewmembers and passengers. From minor bumps to severe mountain wave turbulence, turbulence comes in many forms and is usually worst during the winter months. It is estimated that turbulence causes $30 million in damage annually to aviation assets.

Aircraft icing is another aviation weather hazard. Many aircraft accidents and incidents have been attributed to aircraft icing. In fact, many icing-related mishaps have occurred when the aircraft was not deiced before attempting takeoff. Most of the time, ground deicing and anti-icing procedures will adequately handle icing formation. However, there are times when pilots may be caught unaware of dangerous ice buildup.

Historically, low ceilings and poor visibilities have contributed to many aircraft accidents. Fog, heavy snow, heavy rain, blowing sand, and blowing dust all restrict visibility and can also result in low ceilings. Adverse weather conditions causing widespread low ceilings and visibilities can restrict flying operations for days. Since ceiling and visibility is so important to operational flying, it is imperative that a pilot understands the strict meanings of the two terms. There are many different kinds of “visibility,” but pilots are usually more concerned with “prevailing visibility.”

Ash clouds from volcanic eruptions present a unique hazard to aviation. Though most prudent aviators would choose to keep well clear of any active volcano, certain situations such as evacuations may require the military to operate in close proximity to ash clouds. The corresponding causes of aircraft damage are discussed in the last portion of the chapter.

REFERENCES

1. *Weather for Aircrews*, AFH 11-203, Volume 1, Chapters 9, 10, 11, 12, and 16
2. DoD Flight Information Publication (Enroute) *Flight Information Handbook*, Section C

INFORMATION

501. TURBULENCE DEFINED AND CLASSIFIED

Turbulence is any irregular or disturbed flow in the atmosphere producing gusts and or eddies. Occurrences of turbulence are local in extent and transient in character. Although general forecasts of turbulence are quite good, forecasting precise locations is difficult.

Turbulence intensity is classified using a subjective scale. Table 5-1 contains the four intensity levels and the three time descriptors used by aircrew when giving a Pilot Report (PIREP), which details the in-flight weather. You can see how individual crewmembers of the same aircraft might not agree on the degree of turbulence that they encountered. Realize that moderate turbulence for a B-52 could be severe or extreme for a T-34 or a T-6.

Intensity	Aircraft Reaction	Reaction Inside Aircraft
Light	Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw). Report as Light Turbulence; [1] or Turbulence that causes slight, rapid, and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. Report as Light Chop.	Occupants may feel a slight strain against seat belts or shoulder straps. Unsecured objects may be displaced slightly. Food service may be conducted and little or no difficulty is encountered in walking.
Moderate	Turbulence that is similar to Light Turbulence but of greater intensity. Changes in altitude and/or attitude occur but the aircraft remains in positive control at all times. It usually causes variations in indicated airspeed. Report as Moderate Turbulence; [1] or Turbulence that is similar to Light Chop but of greater intensity. It causes rapid bumps or jolts without appreciable changes in aircraft altitude or attitude. Report as Moderate Chop.	Occupants feel definite strains against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.
Severe	Turbulence that causes large, abrupt 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; [1]	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.
Extreme	Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage. Report as Extreme Turbulence.	

[1]High level turbulence (normally above 15,000 feet MSL) 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.

NOTE: Reporting Term Definition

Reporting Term	Definition
Occasional	Less than 1/3 of the time
Intermittent	1/3 to 2/3 of the time
Continuous	More than 2/3 of the time

Table 5-1 PIREP Turbulence Reporting Table

The different types of turbulence can be divided according to their causative factors: thermal, mechanical, frontal, and large-scale wind shear.

Two or more of these causative factors often work together. Any of the four types of turbulence may occur without the visual warning associated with clouds. Turbulence in the absence of or outside of clouds is referred to as **clear-air turbulence (CAT)**.

Clear Air Turbulence

CAT normally occurs outside of clouds and usually occurs at altitudes above 15,000 feet MSL, due to strong wind shears in the jet stream. CAT is not limited to jet streams–in fact CAT can be found in each of the four categories of turbulence–but the most severe CAT is associated with jet streams. You may also notice that the Wind Shear category of turbulence is *only* CAT.

502. THERMAL TURBULENCE

Thermal (or convective) turbulence is caused by localized vertical convective currents resulting from surface heating or cold air moving over warmer ground. Strong solar heating of the Earth's surface can result in localized vertical air movements, both ascending and descending. For every rising current, there is a compensating downward current that is usually slower in speed since it covers a broader area. Such vertical air movements can also result from cooler air being heated through contact with a warm surface. The turbulence that forms as a result of heating from below is called thermal, or convective, turbulence.

The strength of convective currents depends in part on the extent to which the earth's surface has been heated, which in turn, depends upon the nature of the surface (Figure 5-1). Notice in the illustration that dry, barren surfaces such as sandy or rocky wasteland and plowed fields absorb heat more readily than surfaces covered with grass or other vegetation, which tend to contain more moisture. Thus, barren surfaces generally cause stronger convective currents. In comparison, water surfaces are heated more slowly. The difference in surface heating between land and water masses is responsible for the turbulence experienced by aircrews when crossing shorelines on hot summer days.

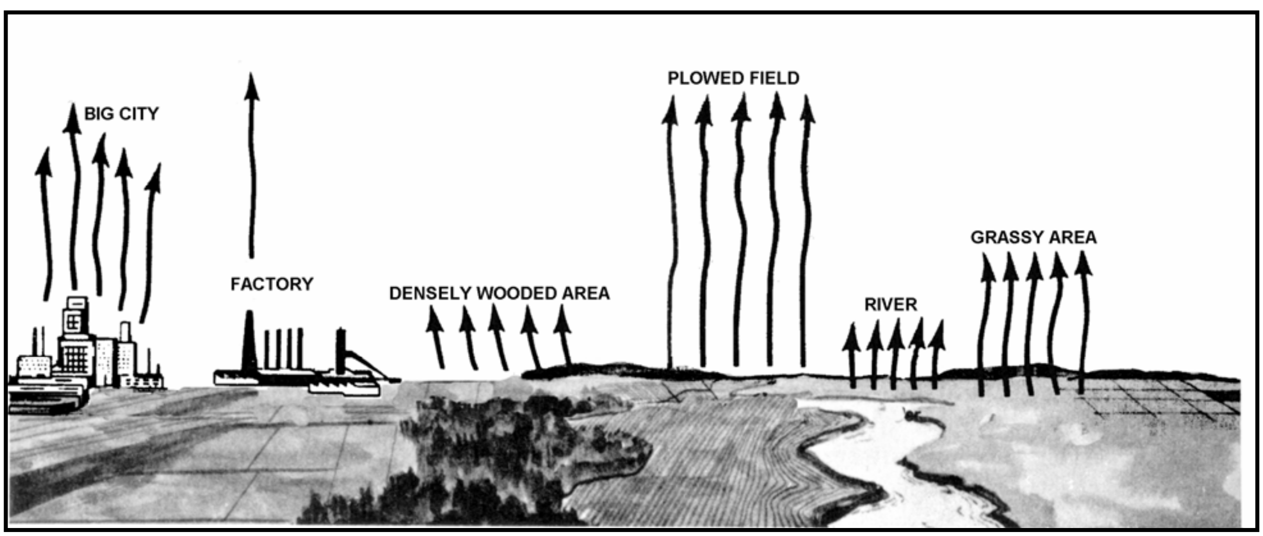


Figure 5-1 Strength of Convective Currents Vary with Composition of Surface

When air is very dry, convective currents may be present even though convective-type clouds (cumulus) are absent. The upper limits of the convective currents are often marked by haze lines or by the tops of cumulus clouds that form when the air is moist. Varying surfaces often affect the amount of turbulence experienced in the landing pattern and on final approach.

503. MECHANICAL TURBULENCE

Mechanical turbulence results from wind flowing over or around irregular terrain or other obstructions. When the air near the surface of the Earth flows over obstructions, such as bluffs, hills, mountains, or buildings, the normal horizontal wind flow is disturbed and transformed into a complicated pattern of eddies and other irregular air movements (Figure 5-2). An eddy current is a current of air (or water) moving contrary to the main current, forming swirls or whirlpools. One example of mechanical turbulence may result from the buildings or other obstructions near an airfield.

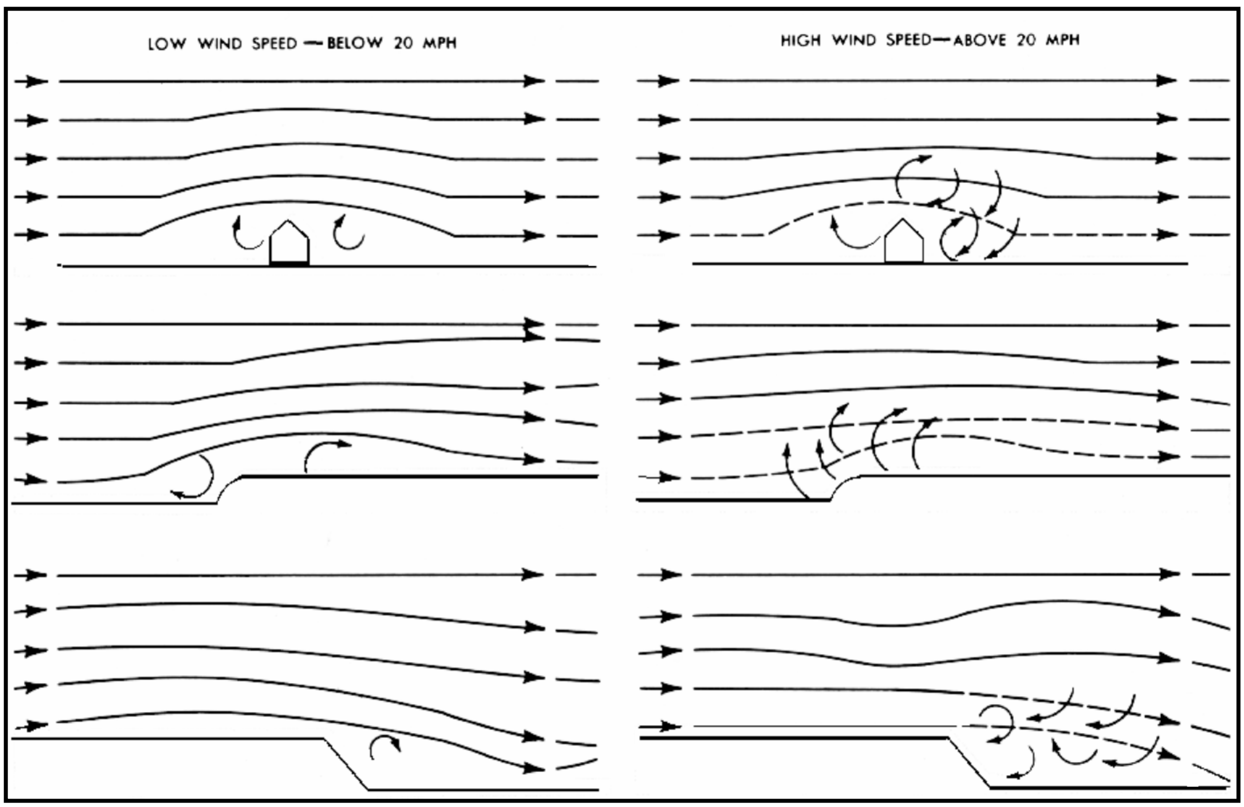


Figure 5-2 Airflow Over Irregular Terrain

The strength and magnitude of mechanical turbulence depends on the speed of the wind, the roughness of the terrain (or nature of the obstruction), and the stability of the air. Stability seems to be the most important factor in determining the strength and vertical extent of the mechanical turbulence. When a light wind blows over irregular terrain, the resulting mechanical turbulence has only minor significance. When the wind blows faster and the obstructions are larger, the turbulence intensity increases and it extends to higher levels.

Mountain Wave Turbulence

When strong winds blow approximately perpendicular to a mountain range, the resulting turbulence can be severe. Associated areas of steady updrafts and downdrafts may extend to heights from 2 to 20 times the height of the mountain peaks. When the air is stable, large waves tend to form on the lee side of the mountains and extend up to the lower stratosphere for a distance of up to 300 miles or more downwind. These are referred to as **standing waves** or **mountain waves**, and may or may not be accompanied by turbulence (Figure 5-3). Pilots, especially glider pilots, have reported that the flow in these waves is often remarkably smooth. Others have reported severe turbulence.

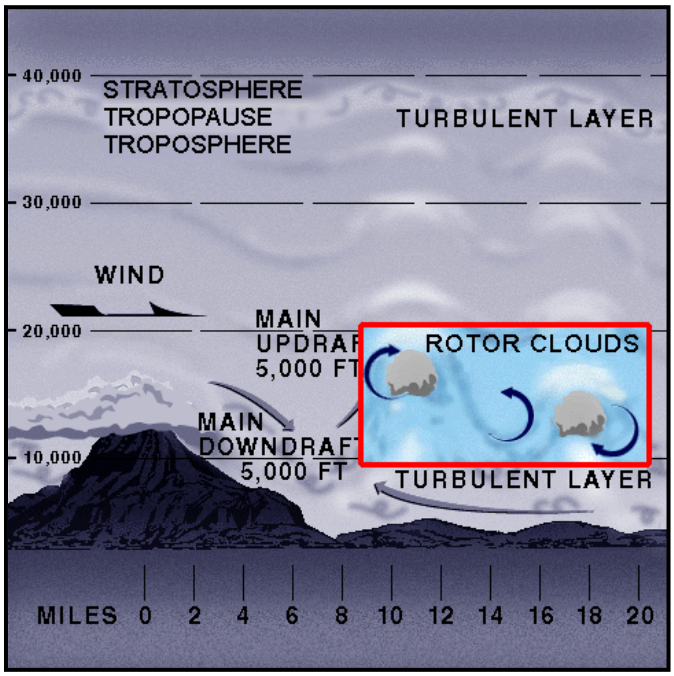


Figure 5-3 Mountain Wave Turbulence

Even though mountain wave turbulence may be present, when the airflow begins to move up the windward side of the mountain, is usually fairly smooth as the orographic lifting imparts the vertical component to the motion of the air. The wind speed gradually increases, reaching a maximum near the peak of the mountain. Past the peak, the air naturally flows down the leeward side, completing one cycle of oscillation and setting up the standing wave pattern of the mountain wave turbulence. Downwind, perhaps 5 to 10 miles from the peak, the airflow begins to ascend again, where the rotor or lenticular clouds may appear. Additional waves, generally less intense than the primary wave, may form farther downwind. Note in Figures 5-3 and 5-4 that the mountains are on the left and the wind is flowing from left to right.

Figure 5-4 Lenticular Clouds

While clouds are usually present to warn aircrews of mountain wave activity, it is possible for wave action to take place when the air is too dry to form clouds, producing CAT. Still, cloud forms particular to wave action provide the best means of identifying possible turbulence, aside from weather forecasts and PIREPs. Although the lenticular clouds in Figure 5-4 are smooth in contour, they may be quite ragged when the airflow at that level is turbulent. These clouds may occur singularly or in layers at heights usually above 20,000 feet. The **rotor cloud** forms at a lower level and is generally found at about the same height as the mountain ridge. The **cap cloud** usually obscures both sides of the mountain peak. The **lenticular clouds** (Figure 5-4), like the rotor and cap clouds, are stationary in position, even though the wind flows through them.

The pilot is concerned, for the most part, with the first wave because of its more intense activity and proximity to the high mountainous terrain. Extreme turbulence is usually found at low levels on the leeward side of the mountain in or near the rotor and cap clouds when the winds are 50 knots or greater at the mountaintop. With these wind conditions, severe turbulence can frequently be found to exist from the surface to the tropopause and 150 miles downwind. Moderate turbulence can be experienced often as far as 300 miles downwind under those same conditions. When the winds are less than 50 knots at mountain peak level, a lesser degree of turbulence may be experienced.

Mountain wave turbulence is dangerous in the vicinity of the rotor clouds and to the leeward side of the mountain peaks. The cap cloud must always be avoided in flight because of the turbulence and the concealed mountain peaks.

The following techniques should be applied when mountain wave turbulence has been forecast:

1. Avoid the turbulence if possible by flying around the areas where wave conditions exist. If this is not feasible, fly at a level that is at least 50% higher than the height of the highest mountain range along your flight path. This procedure will not keep the aircraft out of turbulence, but provides a margin of safety if a strong downdraft is encountered.

2. Avoid the rotor, lenticular, and the cap clouds since they contain intense turbulence and strong updrafts and downdrafts.

3. Approach the mountain range at a 45° angle, so that a quick turn can be made away from the ridge if a severe downdraft is encountered.

4. Avoid the leeward side of mountain ranges, where strong downdrafts may exist, until certain turbulence is not a factor.

5. Do not place too much confidence in pressure altimeter readings near mountain peaks. They may indicate altitudes more than 2,500 feet higher than the true altitude.

6. Penetrate turbulent areas at air speeds recommended for your aircraft.

504. FRONTAL TURBULENCE

Frontal turbulence is caused by lifting of warm air by a frontal surface leading to instability, or by the abrupt wind shift between the warm and cold air masses. The vertical currents in the warm air are the strongest when the warm air is moist and unstable. The most severe cases of frontal turbulence are generally associated with fast moving cold fronts. In these cases, mixing between the two air masses, as well as the differences in wind speed and or direction (wind shear), add to the intensity of the turbulence.

Ignoring the turbulence resulting from any thunderstorm along the front, Figure 5-5 illustrates the wind shift that contributes to the formation of turbulence across a typical cold front. The wind speeds are normally greater in the cold air mass.

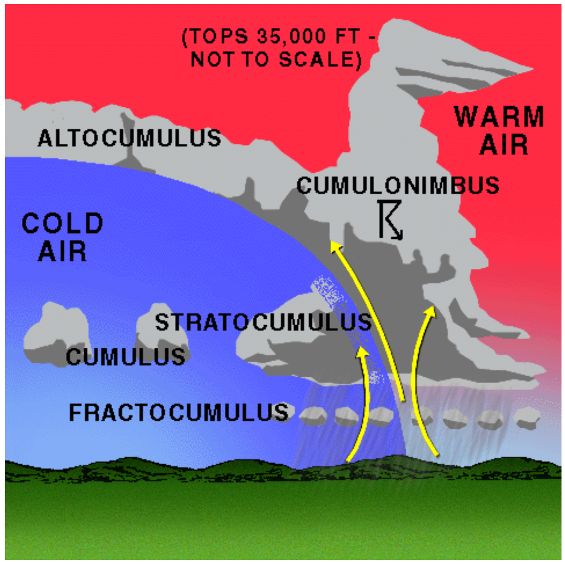


Figure 5-5 Frontal Turbulence

505. WIND SHEAR TURBULENCE

Large-scale wind shear turbulence results from a relatively steep gradient in wind velocity or direction producing eddy currents that result in turbulence. Wind shear is defined as a sudden change in wind speed or direction over a short distance in the atmosphere. The greater the change in wind speed and/or direction in a given area, the more severe the turbulence will be. These turbulent wind shear flight conditions are frequently encountered in the vicinity of the jet stream, where large shears in both the horizontal and vertical planes are found, as well as in association with land and sea breezes, fronts, inversions, and thunderstorms. Strong wind shear can abruptly distort the smooth flow of wind, creating rapid changes in aircraft performance.

Jet Stream Turbulence

As described in chapter 2, one of the major sources of wind shear turbulence is the jet stream, which can sometime reach speeds of over 250 knots (Figure 5-6). The highest wind speeds and probable associated turbulence is found about 5,000 feet below the tropical tropopause, and closer to the tropopause in the polar regions. The rapid change of wind speed within a short distance of the jet core is particularly significant. The vertical shear is generally close to the same intensity both above and below the core, and it may be many times stronger than the horizontal shear. The horizontal shear on the cold air side of the core is stronger than on the warm air side. Thus, if it is desired to exit jet stream turbulence, a turn to the south should result in smoother air. Also, a climb or descent to a different flight level should also help, as jet stream turbulence often occurs in patches averaging 2,000 feet deep, 20 miles wide, and 50 miles long. If changing altitude, watch the outside air temperature for a minute or two to determine the best way to exit the CAT quickly. If the temperature is rising, climb; if the temperature is falling, descend. This maneuver will prevent following the sloping tropopause or frontal surface and thereby staying in the turbulent area. If the temperature remains the same, either climb or descend.

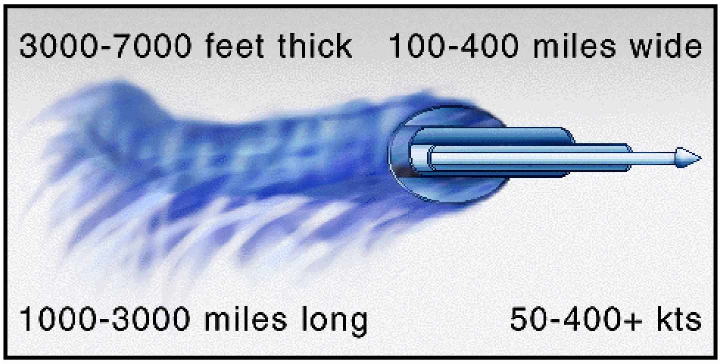


Figure 5-6 Jet Stream Diagram

Temperature Inversions

Recall from chapter 1 the lapse rate where temperature increases with altitude, the temperature inversion. Even though this produces a stable atmosphere, inversions can cause turbulence at the boundary between the inversion layer and the surrounding atmosphere. The resulting turbulence can often cause a loss of lift and airspeed near the ground, such as when a headwind becomes a tailwind, creating a decreasing-performance wind shear. It is important to know how to recognize and anticipate an inversion in flight so you can prepare and take precautions to minimize the effects. If you are caught unaware, the loss of lift can be catastrophic because of your proximity to the ground. Inversions often develop near the ground on clear, cool nights when the winds are light and the air is stable. If the winds just above the inversion grow relatively strong, wind shear turbulence can result.

Figure 5-7 shows a wind shear zone and the turbulence that developed between the calm air and stronger winds above the inversion. When taking off or landing in near-calm surface winds under clear skies within a few hours of sunrise, watch for a temperature inversion near the surface. If the wind at 2,000 to 4,000 feet AGL is 25 knots or more, expect a shear zone at the inversion. To prepare yourself, allow a margin of airspeed above normal climb or approach speed if turbulence or a sudden change in wind speed occurs in order to counteract the effects of a diminished headwind or increased tailwind at and below the inversion.

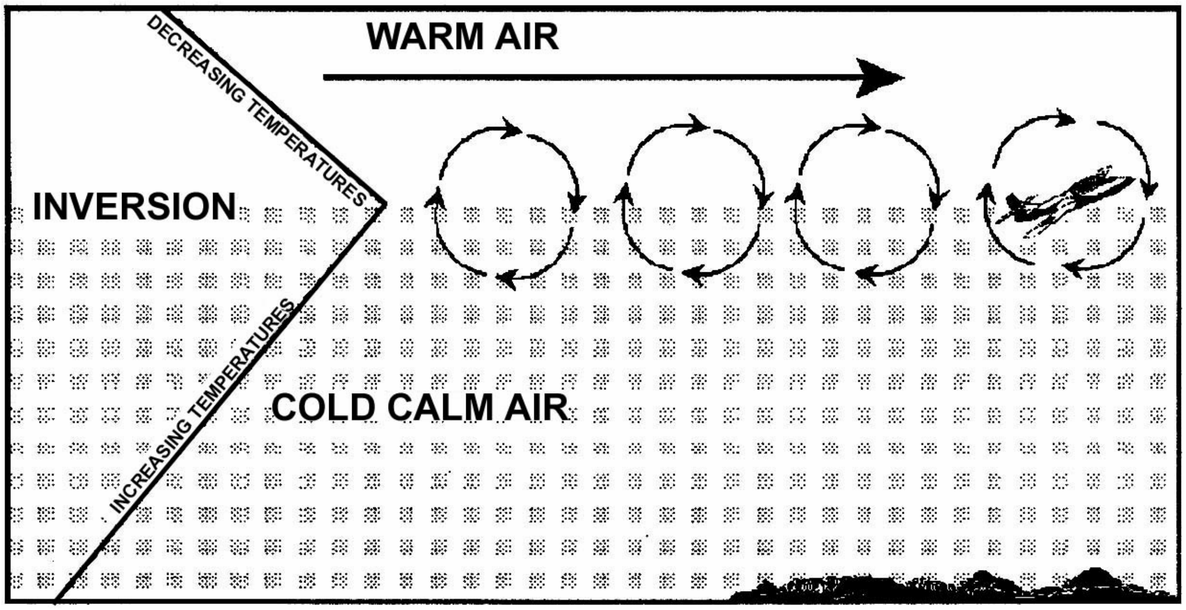


Figure 5-7 Wind Shear Associated with a Temperature Inversion

Turbulence Associated with Thunderstorms

The strongest turbulence within cumulonimbus clouds occurs with the shear between the updrafts and downdrafts. Outside the clouds, wind shear turbulence has been encountered several thousand feet above and 20 miles laterally from a severe storm. Severe turbulence can be encountered in the anvil 15 to 30 miles downwind. The storm cloud is only the visible portion of a turbulent system whose updrafts and downdrafts often extend outside the storm.

506. FLIGHT TECHNIQUES FOR TURBULENCE

The following are recommended procedures if you can't avoid flying in turbulence:

1. Establish and maintain thrust settings consistent with turbulent air penetration airspeed and aircraft attitude. Severe turbulence may cause large and rapid variations in indicated airspeed. Don't chase airspeed.

2. Trim the aircraft for level flight at the recommended turbulent air penetration airspeed. Don't change trim after the proper attitude has been established.

3. The key to flying through turbulence is proper attitude control. Both pitch and bank should be controlled by reference to the attitude gyro indicator. Extreme gusts may cause large changes in pitch or bank. To avoid overstressing the aircraft, don't make abrupt control inputs. Use moderate control inputs to reestablish the desired attitude.

4. Severe vertical gusts may cause appreciable altitude deviations. Allow altitude to vary. Sacrifice altitude to maintain desired attitude. Don't chase the altimeter.

507. AIRCRAFT ICING

Summary of Air Florida Mishap
On January 13, 1982, Air Florida Flight 90, a Boeing 727-222 (N62AF), was a scheduled flight to Fort Lauderdale, Florida, from Washington National Airport, Washington D.C. There were 74 passengers, including 3 infants, and 5 crewmembers on board. The flight's scheduled departure time was delayed about 1 hour 45 minutes because of moderate to heavy snowfall, which necessitated the temporary closing of the airport.
Following takeoff from runway 36, which was made with snow and/or ice adhering to the aircraft, the aircraft at 1:31 EST crashed into the barrier wall of the northbound span of the 14th Street Bridge, which connects the District of Columbia with Arlington County, Virginia, and plunged into the ice-covered Potomac River. It came to rest on the west side of the bridge 0.75 nm from the departure end of runway 36. Four passengers and one crewmember survived the crash.
When the aircraft hit the bridge, it struck seven occupied vehicles and then tore away a section of the bridge barrier wall and bridge railing. Four persons in the vehicles were killed; four were injured.
The National Transportation Safety Board determined that the probable cause of this accident was the flight crew's failure to use engine anti-ice during ground operation and takeoff, their decision to take off with snow/ice on the airfoil surfaces of the aircraft, and the captain's failure to reject the takeoff during the early stage when his attention was called to anomalous engine instrument readings. Contributing to the accident were the prolonged ground delay between deicing and the receipt of ATC takeoff clearance during which the airplane was exposed to continual precipitation, the known inherent pitch up characteristics of the B-727 aircraft when the leading edge is contaminated with even small amounts of snow or ice, and the limited experience of the flight crew in jet transport winter operations.

Table 5-2 Air Florida Mishap Abstract

As graphically demonstrated by Table 5-2, icing poses a serious threat to aviation. No matter which part of the world home base is located, icing can become a hazard to any phase of flight, not just the takeoff or landing phase.

Aircraft icing is classified into two main groups: structural and engine icing.

Structural icing is icing that forms on the external structure of an aircraft. Structural ice forms on the wings, fuselage, antennas, pitot tubes, rotor blades, and propellers. Significant structural icing on an aircraft can cause control problems and dangerous performance degradation. The types of structural icing are clear, rime, mixed, and frost.

Engine icing occurs when ice forms on the induction or compressor sections of an engine, reducing its performance.

Icing Requirements

There are two requirements for the formation of aircraft icing. First, the atmosphere must have super-cooled visible water droplets. Second, the free air temperature (measured by the aircraft's outside air temperature gauge) and the aircraft's surface temperature must be below freezing.

Clouds are the most common form of visible liquid water, and **Super-cooled water** is liquid water found at air temperatures below freezing. When super-cooled droplets strike an exposed object, such as a wing, the impact induces freezing and results in aircraft icing. Therefore, when penetrating a cloud at subzero temperatures, icing should be expected.

Super-cooled water forms because, unlike bulk water, water droplets in the free air do not freeze at 0 °C. Instead, their freezing temperature varies from –10 to –40 °C: the smaller the droplets, the lower the freezing point. As a general rule, serious icing is rare in clouds with temperatures below –20 °C since these clouds are almost completely composed of ice crystals. However, be aware that icing is possible in any cloud when the temperature is 0 °C or below.

Structural Icing Conditions

Clear icing normally occurs at temperatures between 0 °C and –10 °C, where water droplets are large because of unstable air, such as in cumulus clouds and in areas of freezing rain or drizzle. Instead of freezing instantly upon contact with the aircraft's surface, these large water droplets move along with the airflow, freeze gradually, and form a solid layer of ice. This layer of clear ice can cover a large portion of the wing surface and is difficult to break off. Clear icing is extremely hazardous because it builds up fast, can freeze the flight controls, and disrupts airflow over the wings.

Rime icing is milky white in appearance and is most likely to occur at temperatures of –10 to –20 °C. It is more dense and harder than frost, but lighter, softer, and less transparent than clear ice. Rime ice occurs in stable conditions–clouds where the water droplets are small and freeze instantaneously, such as stratiform clouds and the upper portions of cumulus clouds. It is brittle and fairly easy to break off. Rime ice does not normally spread over an aircraft surface, but protrudes forward into the air stream along the leading edges of airfoils.

Mixed icing is a combination of clear ice and rime ice, occurring where both large and small water droplets are present, normally at temperatures of –8 to –15 °C. Because mixed icing is a combination of large and small water droplets, it takes on the appearance of both rime and clear icing. It is lumpy, like rime ice, but also hard and dense, like clear ice. The most frequent type of icing encountered is usually a form of mixed icing.

Frost is a thin layer of crystalline ice that forms on exposed surfaces. It normally occurs on clear, calm winter nights on aircraft surfaces just as it does on automobiles. Frost also forms in flight when a cold aircraft descends from a zone of freezing temperatures into high relative humidity. The moist air is chilled suddenly to below freezing temperatures by contact with the cold surfaces of the aircraft, and deposition occurs. Frost, like other forms of icing, disrupts the smooth boundary layer flow over airfoils, and thus increases drag, causes a loss of lift, and increases stall speed. Though it is unlikely to add considerable weight to an aircraft, any amount of frost is hazardous and must be removed prior to takeoff.

Aircrews should anticipate and plan for some type of icing on every flight conducted in below freezing temperatures and should be familiar with the icing generally associated with different atmospheric conditions, as discussed in the next section.

Frontal Icing Conditions

Cold fronts and squall lines generally have a narrow band of both weather and icing. The associated clouds will be cumuliform. The icing zone will be about 10,000 feet thick, 100 miles wide, and the icing will be predominantly clear, accumulating rapidly.

Warm fronts and stationary fronts generally have a much wider band of weather and icing, reflecting the size of the warm frontal zone. The icing will be found mainly inside stratiform clouds, accumulating at a relatively low rate, due to the smaller size of the super-cooled water droplets. The vertical depth of the icing zone will generally be about 3,000 to 4,000 feet thick, possibly up to 10,000 feet. The type of icing will be predominantly rime, but may also contain mixed icing.

The most critical freezing precipitation (rain or drizzle) area is where water is falling from warm air above to a flight level temperature that is below freezing. In this case, severe clear ice would be encountered below the cloud layer and the evasive action is to climb to an altitude where the temperature is above freezing.

Occluded fronts often produce icing covering a very widespread area, containing both stratiform and cumuliform-type clouds. The depth of the icing zone will often be 20,000 feet– approximately double the depth of icing zones with other type fronts. The types of icing will be clear, mixed, and rime, with a very rapid and heavy rate of accumulation.

508. EFFECTS AND HAZARDS OF STRUCTURAL ICING

The most hazardous aspect of structural icing is its aerodynamic effects. The presence of ice on an aircraft decreases lift, thrust, and range, and increases drag, weight, fuel consumption, and stall speed. The added weight with reduced lift and thrust can be a dangerous combination (Figure 5-8). Ice can alter the shape of an airfoil, changing the angle of attack at which the aircraft stalls therefore increasing the stall speed. Ice reduces lift and increases drag on an airfoil. Ice thickness is not the only factor determining the effect of icing. Location, roughness, and shape are important, too. For example, a half-inch high ridge of ice on the upper surface of the airfoil at 4% chord reduces maximum lift by over 50%. Yet, the same ridge of ice at 50% chord decreases maximum lift by only 15%. On another airfoil, a distributed sandpaper-like roughness on the leading edge of the wing may decrease lift by 35%. Along with this decrease in lift, it is obvious that parasite drag will significantly increase. The buildup of ice on various structural parts of the aircraft can result in vibration, causing added stress to those parts. This is especially true in the case of propellers and rotors, which are delicately balanced. Even a small amount of ice, if not distributed evenly, can cause great stress on the propeller and engine mounts.

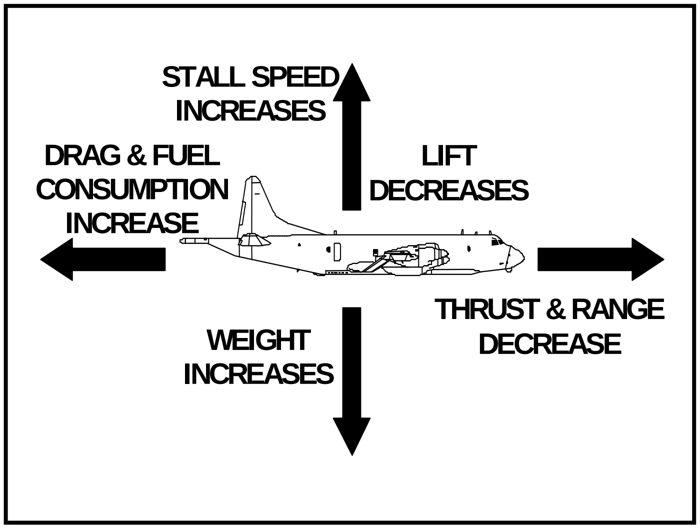


Figure 5-8 Cumulative Effects of Icing

Icing is not restricted to airfoils and other external structure. Engines, fuel, and instruments may also be affected by ice formation.

Ice associated with freezing rain or drizzle can accumulate beyond the limits of an ice protection system. If you encounter any type of freezing rain or drizzle, the best course of action is to leave the area.

Structural icing can block the pitot tube (Figure 5-9) and static ports. This can cause a pilot to either lose or receive erroneous indications from various instruments such as the airspeed indicator, VSI, and altimeter. For example, if the pitot tube becomes blocked with ice, the “total pressure” input to the system remains constant. Therefore, during a descent, as the “static pressure” input to the system increases, the airspeed indicator gives an erroneous indication of decreasing airspeed. The opposite would be true during a climb.

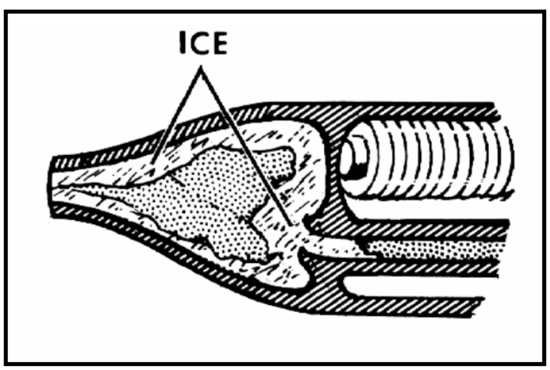


Figure 5-9 Pitot Tube Icing

During flight, it can be difficult to detect ice on areas such as the empennage that may be impossible to see. Some cues which signal the potential for icing include the following: (1) ice on windshield wiper arms or projections such as engine drain tubes, pitot tubes, engine inlet lips, or propeller spinners, (2) decreasing airspeed with constant power and altitude, and (3) ice detector annunciation.

Icing on rotary wing aircraft is related to those involving wings and propellers. Ice formation on the helicopter main rotor system or antitorque rotor system may produce serious vibration, loss of efficiency or control, and can significantly deteriorate the available RPM to a level where safe landing cannot be assured. In fact, a 3/16-inch (4.8-mm) coating of ice is sufficient to prevent some helicopters from maintaining flight in a hover.

509. OTHER TYPES OF AIRCRAFT ICING

Induction icing – In flights through clouds that contain super-cooled water droplets, air intake duct icing is similar to wing icing. However, the ducts may ice when skies are clear and temperatures are above freezing. The reduced pressure that exists at the intake lowers the temperature to the point that condensation and or deposition take place, resulting in the formation of ice. The degree of temperature decrease varies considerably with different types of engines. However, if the free air temperature is 10 °C or less (especially near the freezing point), and the relative humidity is high, the possibility of induction icing exists. Ingestion of ice shed ahead of the compressor inlet may cause severe foreign object damage (FOD) to the engine.

Compressor icing – Ice forming on compressor inlet screens and compressor inlet guide vanes will restrict the flow of inlet air, eventually causing engine flameout. The reduction in airflow is noticeable through a loss of thrust and a rapid rise in exhaust gas temperature. As the airflow decreases, the fuel-air ratio increases, which in turn raises the temperature of the gases going to the turbine. The fuel control attempts to correct any loss in engine RPM by adding more fuel, which merely aggravates the condition. Ice build-up on inlet screens sufficient to cause turbine failure can occur in less than 1 minute under severe conditions.

Ground icing hazards – We have already stressed the importance of removing all icing and frost from an aircraft prior to takeoff. De-icing itself, however, can also be a hazard. De-icing fluids (discussed in the next section) are highly corrosive to internal aircraft and engine parts. Thus, it is imperative that de-icing crews understand the particular requirements for your type of aircraft. Additionally, taxiing through mud, water or slush on ramps and runways can create a covering of ice that can hamper the movement of flaps, control surfaces, and the landing gear mechanism. Ice and snow on runways are conditions that affect braking action of aircraft. Braking action varies widely with aircraft type and weight. Therefore, pilots must be aware of the limits to their aircraft’s braking capabilities.

510. MINIMIZING OR AVOIDING ICING HAZARDS

Flight Path Options

In coping with an icing hazard in flight, a pilot usually has two alternatives. First, the pilot can climb to the colder temperatures where the precipitation will be frozen and therefore not an icing hazard. Second, the pilot can descend to an altitude where the air temperatures are well above freezing (Figure 5-10). However, if encountering clear icing in the freezing precipitation below the clouds of a warm front, the aircraft is most likely in the cold air ahead of the warm front. In this case, the best alternative may be to climb to warmer temperatures, across the frontal boundary, as the freezing precipitation may extend all the way to ground level.

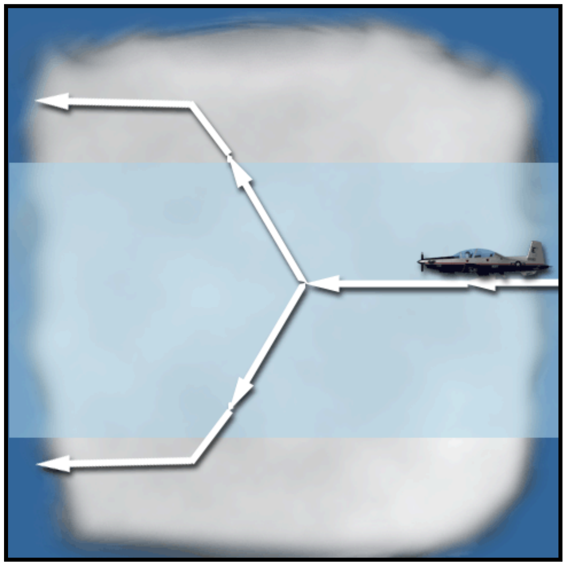


Figure 5-10 Options to Escape Icing

Anti-Icing and Deicing Equipment

Deicing equipment eliminates or removes ice that has already accumulated on the aircraft. **Anti-icing equipment** prevents the accumulation of ice on specific aircraft surfaces. Most military aircraft are equipped with anti-icing and or deicing equipment. There are three common methods for preventing and or eliminating ice buildup: mechanical, fluids, and heat.

The mechanical method uses deicing boots, which are rubber bladders installed on the leading edges of lift producing surfaces. Compressed air cycles through these rubber boots causing them to alternately inflate and deflate, thus cracking accumulated ice and allowing the air stream to peel it away.

Anti-icing fluids are freezing point depressants and are pumped through small holes in the wing's leading edge. This fluid coats the wing, preventing ice from forming on the wing's surface. Deicing fluids are also used by ground crews to remove and prevent ice buildup before takeoff.

Heat application capability to wings, props, tail surfaces, or engine intakes is installed in most aircraft. Systems of this nature can be designed for either anti-icing or deicing purposes. Critical areas can be heated electrically or by hot air that is bled from the engine's compressor section.

Recommended Precautions

Keep these precautions in mind when flying in the vicinity of icing conditions.

1. Don't fly into areas of known or forecast icing conditions.

2. Avoid flying in clouds with temperatures from 0 °C to –20 °C.

3. Don't fly through rain showers or wet snow with temperatures near freezing.

4. Avoid low clouds above mountain ridges or crests. Expect the heaviest icing in clouds around 5,000 feet above the mountaintops.

5. Do not make steep turns with ice on the airplane due to increased stall speeds.

6. Avoid high angles of attack when ice has formed on the aircraft since the aircraft is closer to stall speed in these maneuvers.

7. Under icing conditions, increased drag and additional power required increases fuel consumption.

8. Change altitude to temperatures above freezing or colder than -20 °C. An altitude change also may take you out of clouds.

9. In freezing rain, climb to temperatures above freezing, since it will always be warmer at some higher altitude. Don't delay your climb since ice can accumulate quickly. If you are going to descend, you must know the temperature and terrain below.

10. Do not fly parallel to a front while encountering icing conditions.

11. Avoid icing conditions as much as possible in the terminal phase of flight due to reduced airspeeds.

12. Expect to use more power on final approach when experiencing structural icing.

13. Always remove ice or frost from airfoils before attempting takeoff.

511. ICING INTENSITIES AND PIREPS

Weather personnel cannot generally observe icing; they must rely on PIREPs. When flying during icing conditions, pilots should report these conditions as indicated in Table 5-3. However, forecasters attempt to forecast the maximum intensity of icing that may be encountered during a flight, not necessarily the intensity of icing that will be encountered by a particular aircraft. It becomes the pilot's responsibility to make certain that a complete weather briefing is obtained, to include the information for safe completion of the flight.

Intensity	Airframe Ice Accumulation	Pilot Report
Trace	Ice becomes perceptible. Rate of accumulation slightly greater than rate of sublimation. It is not hazardous even though deicing/anti-icing equipment is not used, unless encountered for an extended period of time--over one hour.	Aircraft identification, location, time (GMT), altitude (MSL), type aircraft, sky cover, visibility & weather, temperature, wind, turbulence, icing, remarks. Example of PIREP transmission: "Pensacola METRO, Rocket 501, holding 20 miles south of Navy Pensacola, at 2100Z and one-six thousand feet, single T-39 Sabreliner, we're IFR in stratus clouds, temperature –15 °C, winds 330 at 25, no turbulence, Light Rime Icing, flying 200 knots indicated.
Light	The rate of accumulation may create a problem if flight is prolonged in this environment (over one hour). Occasional use of deicing/anti-icing equipment removes/prevents accumulation. It does not present a problem if the deicing/anti-icing equipment is used.	
Moderate	The rate of accumulation is such that even short encounters become potentially hazardous and use of deicing/anti-icing equipment or diversion is necessary.	
Severe	The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard. Immediate diversion is necessary.	

Icing may be rime, clear, or mixed:

- Rime ice – Rough milky opaque ice formed by the instantaneous freezing of small super-cooled water droplets.
- Clear ice – A glossy, clear or translucent ice formed by the relatively slow freezing of large super-cooled water droplets.
- Mixed ice – A combination of rime and clear ice.

Table 5-3 Icing Reporting Criteria

STUDY QUESTIONS

Weather Hazards of Turbulence, Icing, Ceilings, Visibility, and Ash Clouds

1. Which one of the following is NOT one of the classifications used to describe turbulence?

   a. Trace
   b. Light
   c. Moderate
   d. Extreme

2. Which one of the following may cause mechanical turbulence when air is flowing over it?

   a. Irregular terrain
   b. Buildings
   c. Mountains
   d. All of the above

3. Which one of the following is not one of the cloud formations associated with mountain wave turbulence?

   a. Lenticular cloud
   b. Roll cloud
   c. Rotor cloud
   d. Cap cloud

4. Frontal turbulence would be the most severe when associated with a

   a. fast moving warm front.
   b. fast moving cold front.
   c. slow moving warm front.
   d. slow moving cold front.

5. Which one of the following is not one of the recommended procedures for flying through turbulence?

   a. Establish and maintain thrust settings consistent with cruise airspeeds.
   b. Control attitude by referencing the attitude gyro indicator.
   c. To avoid overstressing the aircraft, don't make abrupt control inputs.
   d. Allow airspeed and altitude to vary; don't chase the altimeter.

6. What conditions are necessary for the formation of ice on aircraft?

   a. Freezing temperatures, invisible moisture, and rain
   b. Freezing temperatures, visible moisture, and aircraft skin temperature below freezing
   c. Freezing temperatures, humidity above 75 percent, and aircraft skin temperature below freezing
   d. Freezing temperatures, strong head winds, and clear skies

7. An aviation hazard associated with structural icing is that it results in

   a. a reduction of lift by changing the airfoil characteristics.
   b. a decrease in airspeed.
   c. a decrease in drag.
   d. both a and c are correct.

8. Clear icing will generally be encountered between a temperature range of

a. –2 °C and –10 °C.
b. 0 °C and –10 °C.
c. 0 °C and –20 °C.
d. +2 °C and –20 °C.

In questions 9 through 12, match the types of structural ice in column B with the correct descriptions in column A.

A	B
9. Formed from small super-cooled water droplets in stratiform clouds of stable air	a. Clear icing
10. Consists of ice crystals formed by deposition.	b. Rime icing
11. Formed by large individual water droplets freezing as they strike the aircraft surface	c. Mixed icing
12. Considered to be the most frequently encountered type of icing	d. Frost

13. What happens to stall speed when ice forms on the wings of an aircraft?

a. It will increase.
b. It will decrease.
c. It will remain the same.
d. All of the above.

14. Engine failure due to icing conditions encountered by a jet aircraft is generally the result of

a. carburetor icing.
b. a rapid drop in exhaust gas temperature.
c. a decrease in the fuel-air ratio.
d. induction icing.

15. Ice in the pitot tube or static ports could affect instruments, depending on the type of aircraft and its system hookup.

a. True
b. False

16. Which one of the following would be correct if an aircraft attempted to take off without removing frost that has formed during the night?

a. Increase in the stall speed
b. Lift and drag/ratios will be affected
c. Extensive weight increase
d. All of the above are correct
e. Only a and b are correct

17. Which one of the following types of clouds would you most likely be flying through if encountering clear icing?

a. Nimbostratus
b. Cumulus
c. Cirrocumulus
d. Both b and c are correct

18. Which one of the following states a correct evasive tactic for use when wet snow or freezing rain is encountered?

a. Climb or descend to colder air in either case.
b. Climb or descend to warmer air in either case.
c. Climb to colder air with wet snow and climb to warmer air with freezing rain.
d. Climb to warmer air with wet snow and climb to colder air with freezing rain.

19. Which one of the following is NOT one of the classifications used to describe icing?

a. Light
b. Moderate
c. Severe
d. Extreme

20. Which one of the following conditions would most likely result in frost on an aircraft?

a. Cloudy nights, 5 knots of wind, dew point 28° F
b. Clear nights, no wind, dew point of 28° F
c. Clear nights, 5 knots of wind, dew point of 32° F
d. Cloudy nights, no wind, dew point of 37° F

21. Which one of the following describes a basic type of fog classification?

a. Air mass
b. Advection
c. Adiabatic
d. All of the above are correct

22. Which one of the following will result in the saturation of an air mass?

a. Rising dew point
b. Lowering humidity
c. Lowering dew point
d. Rising temperature

23. A layer of condensed water vapor is considered to be fog if its base is at or below 20 feet above terrain elevation and greater than 50 feet in thickness.

a. True b. False

24. Radiation fog could be expected in areas characterized by

a. low wind speed, and clear skies.
b. low wind speed, and cloudy skies.
c. high wind speed, and cloudy skies.
d. high wind speed, and clear skies.

25. What phenomenon would your aircraft be flying through if experiencing a rise in oil temperatures, acrid odor (possibly from an electrical fire), airspeed fluctuations, pitted windscreens, and a bright orange glow around the engine inlets?

a. Advection fog
b. Microburst
c. Volcanic ash cloud
d. Mountain wave turbulence

CHAPTER SIX
WEATHER REPORTS AND TERMINAL AERODROME FORECASTS

ASSIGNMENT SHEET

Aviation Routine Weather Reports and Terminal Aerodrome Forecasts
Assignment Sheet 6.1A

Introduction

This chapter introduces the student to the format and use of two meteorological products available to aviators, the Aviation Routine Weather Report (METAR) and the Terminal Aerodrome Forecast (TAF). The discussion will demonstrate the interpretation of each of these products, which use numerous codes and abbreviations, as well as the differences among military METARs and TAFs and those of the civilian and international community. Finally, this chapter will demonstrate how to apply this knowledge to various flight planning situations.

LESSON TOPIC LEARNING OBJECTIVES

Terminal Objective:
Partially supported by this lesson topic:

6.0 Describe displayed data in Aviation Routine Weather Reports (METARs) and Terminal Aerodrome Forecasts (TAFs).

ENABLING OBJECTIVES:
Completely supported by this lesson topic:

6.1 State the use of METARs.

6.2 State the letter identifies used to report various types of METARs.

6.3 Identify wind data in METARs.

6.4 Identify visibility in METARs.

6.5 Identify runway visual range in METARs.

6.6 Identify present weather in METARs.

6.7 Identify sky condition in METARs.

6.8 Identify temperature/dew point in METARs.

6.9 Identify altimeter setting in METARs.

6.10 Identify various manual and automated remarks in METARs.

6.11 State the use of TAFs in flight planning.

6.12 Identify data in a TAF.

6.13 Identify differences in U.S. Civil, Military, and International TAFs.

6.14 State the definition of a ceiling and identify the ceiling in METARs and TAFs.

6.15 State the IFR/VFR rules for flight planning in reference to OPNAV 3710.7.

6.16 State the OPNAV 3710.7 requirement for an alternate on an IFR flight plan.

STUDY ASSIGNMENT

Review Information Sheet 6.1I, and answer the Study Questions.

INFORMATION SHEET

Aviation Routine Weather Reports and Terminal Aerodrome Forecasts
Information Sheet 6.1I

600. INTRODUCTION

The Aviation Routine Weather Report (METAR) and the Terminal Aerodrome Forecast (TAF) are the most widely used methods of disseminating weather observations and forecasts (respectively) to aircrew. They are also the quickest means, as well, because they contain only letters and numbers. Years ago, when Teletype was the quickest means of information dissemination, METARs and TAFs were distributed across the country and overseas by this method, as well. Today, even though electronic communication is an important part of the existing military and civilian weather networks, the same basic character set is used, and these reports are still often called “teletype” products.

The METAR and TAF formats have not changed greatly over recent years, except to conform better to international standards. Thus, these formats contain certain codes, which–while they may be cumbersome at first–provide users with precise weather information because of their clear and exact nature.

Once the interpretation of a METAR has been discussed, the TAF format should then be easier to understand, since they use similar data groups. The TAF, however, is usually longer since it is a forecast covering a greater period of time. As such, the TAF format has additional rules that must be understood before an aviator can apply the forecast information to a particular situation. Following the discussion of these topics, this chapter will point out the major differences between the military TAF and its civilian and international counterparts. Finally, this chapter will demonstrate how to apply this knowledge to various flight planning situations.

REFERENCES

1. NAVMETOCCOMINST 3141.2 Series
2. DoD Flight Information Publication (FLIP) *General Planning*, Chapter 8
3. Air Force Instruction 11-202 (Vol. 3), *General Flight Rules*
4. Chief of Naval Operations Instruction 3710.7 series, *NATOPS General Flight and Operating Instructions*

INFORMATION

601. THE AVIATION ROUTINE WEATHER REPORT (METAR)

Aviation Routine Weather Reports (METAR) provide a rapid and efficient means of transmitting the latest observed weather information for various stations throughout the world. These reports are transmitted over available computer/teletype circuits.

A METAR example is shown below in Figure 6-1.

```
SAU55 KAWN 151800
METAR KALO 151756Z 14015KT 6SM BLDU OVC015 09/07 A3024 RMK SLP240 RADAT 80052
METAR KBAL 151758Z 35012KT 1 1/2SM R10/6000FT RA BR HZ BKN005 OVC010 08/06
            A2978 RMK SLP085
METAR KRDR 151756Z 09009KT 15SM SCT050 BKN090 OVC200 M15/M18 A2997 RMK PSR09P
            SLP149
METAR KHAR 151757Z 05015G22KT 1 1/2SM RA BR BKN011 OVC015 07/05 A2986 RMK PK
            WND 05025/32 SLP112
METAR KNKX 151758Z 08012KT 8SM BKN007 OVC040 09/07 A2984 RMK BINOVC BKN TOPS
            020 SLP105
METAR KCBM 151755Z 00000KT 10SM SCT012 BKN029 OVC120 M06/M07 A2998 RMK IR18
            SLP156
METAR KPAM 151757Z 17015G22 5SM HZ SCT007 BKN040 OVC050 22/21 A2990 RMK
            SCT007VBKN SLP125
METAR KPHX 151756Z 33007KT 20SM SKC M14/M24 A3021 RMK SLP230
METAR KVPS 151758Z 18009KT 7SM OVC006 19/17 A2994 RMK CIG005V007 SLP139
METAR KOZR 151755Z 22012G16 15SM OVC017 23/17 A2987 RMK OVC TOPS 045/054
            SLP115
METAR KBNA 151759Z 27003KT 1 1/2SM DZ BR SCT000 SCT017 OVC025 19/16 A2977 RMK
            VIS 1V2 CIG 023V027 BR SCT000 TOPS OVC 066
```

Figure 6-1 Sample METAR Printout

METARs are used to communicate the latest observed weather to meteorologists and aircrew so they can determine the existing weather at the destination or alternate, and whether a field is operating under conditions of instrument flight rules (IFR) or visual flight rules (VFR). These users can also use METARs to determine weather trends by checking the last several hours of reports to see if they indicate improving or deteriorating conditions. Additionally, METARs can provide a comparison between the observed and forecast weather, to determine if conditions are actually developing as originally forecast.

602. METAR FORMAT

A METAR example is shown below in Figure 6-2 with each coded group underlined and labeled for reference during the following discussion. METARs have two sections: the body of the report and the remarks section.

Group 1: Type of Report

The first word of the report line, either “METAR“ or “SPECI,“ will indicate which of these two main types of observations was reported (Figure 6-3).

METAR — An hourly routine scheduled observation–containing wind, visibility, runway visual range, present weather, sky condition, temperature/dew point, and altimeter setting–constitutes the body of the report. Additional coded data or plain language information that elaborates on the report may be included in the "Remarks" section.

SPECI — A SPECIal, unscheduled observation containing all the data elements found in a METAR whenever critical data have changed from the previous observation (reasons are too numerous to cover in this course). All SPECI are made as soon as possible after the element criteria are observed.

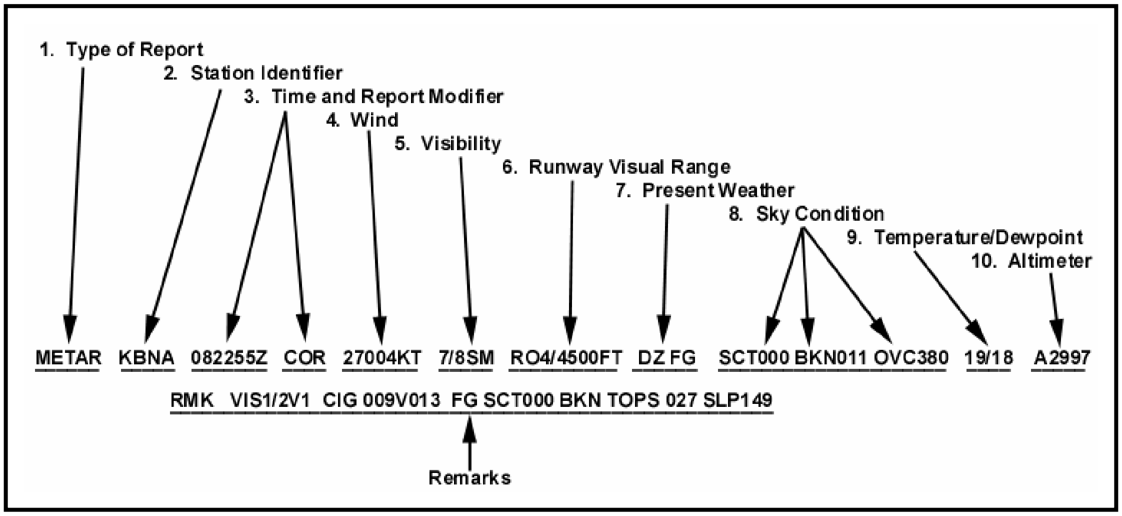


Figure 6-2 METAR Code Groups

```
METAR KNPA 082255Z 27004KT 7/8SM R04/4500FT DZ FG SCT000 BKN011 OVC380 19/18
           A2997 RMK VIS1/2V1 CIG009V013 FG SCT000 BKN TOPS 027 SLP149

SPECI KNPA 082317Z 31020G30KT 3/8SM R04/2500FT VCTS SCT000 BKN006 OVC380
           17/17 A2993 RMK VIS1/8V1 CIG004V008 FG SCT000 BKN TOPS 350 SLP136
```

Figure 6-3 Type of Report: METAR or SPECI

Group 2: Station Identifier

The METAR code format uses a 4-letter ICAO (International Civil Aviation Organization) identifier. In the continental U.S., all 3-letter identifiers are prefixed with a "K," e.g., KLAX for Los Angeles, and KBOS for Boston (Figure 6-4). Elsewhere, the first two letters of the ICAO identifier indicate what region of the world (e.g. K=USA, C=Canada, P=Pacific, E=Europe) and country the station is located. For example, PAFA is Fairbanks, Alaska, PHNA is Barber's Point, Hawaii, and CYUL is Montreal, Canada. Also, EG indicates a station in England, and LI indicates a station in Italy. For a complete worldwide listing of all the identifiers, one must refer to the ICAO Document 7910 Location Identifiers.

```
METAR KNPA 082255Z 27004KT 7/8SM R04/4500FT DZ FG SCT000 BKN011 OVC380 19/18
           A2997 RMK VIS1/2V1 CIG009V013 FG SCT000 BKN TOPS 027 SLP149
```

Figure 6-4 Station Identifier in METAR

Group 3: Date Time Group and Report Modifier

The time of observation will be included in all reports, using the standard date time group (DTG) format. Times are always given in Universal Coordinated Time (UTC) and therefore will end in "Z," indicating Zulu, or UTC, time. The first two numbers are the date, and the second four are the time of the report (Figure 6-5).

```
METAR KNPA 082255Z 27004KT 7/8SM R04/4500FT DZ FG SCT000 BKN011 OVC380 19/18
           A2997 RMK VIS1/2V1 CIG009V013 FG SCT000 BKN TOPS 027 SLP149
```

Figure 6-5 DTG in METAR

Manual METAR observations are required to be started no earlier than 15 minutes prior to the reporting time, which is a window between 55 and 59 minutes past the hour. Additionally, elements having the greatest rate of change are evaluated last. At automated stations, evaluations are based on sensor data taken within 10 minutes of the report time (although sky cover data is gathered over the preceding 30 minutes). Therefore, as an aviator, you can be assured you have the most up-to-date information available, assuming you're checking the weather at the top of the hour.

Of course, report times given for SPECI observations are the time at which the event requiring the SPECI report occurred.

Reports may also contain one of two modifiers, "COR," or "AUTO," which will appear after the DTG:

COR — Indicates a CORrected report, which is transmitted as soon as possible whenever an error is detected in a METAR or SPECI report. In this case, the DTG will be the same time used in the report being corrected.

AUTO — Indicates a routine scheduled observation was sent from a fully AUTOmated station with no human intervention. In the remarks section, either "AO1" or "AO2" will be present indicating the type of automatic precipitation measuring equipment. Sometimes, manual observations are reported using data gathered from automatic devices, in which case an "AO1" or "AO2" will be present in the remarks without an "AUTO" following the DTG.

Group 4: Wind

Winds are a 2-minute average speed and direction report in knots and degrees true from which direction the wind is blowing. The wind direction is first and will be in tens of degrees, using three digits. Directions less than 100 degrees are preceded by a zero to supply three digits. Speed is in whole knots, using two or three digits after the direction, without spaces, and speeds of less than 10 knots are preceded with a zero. The wind group will always end with the letters "KT" to indicate knots. Other countries may use different units of measurement, such as KM (kilometers), MPH (miles per hour), or MPS (meters per second) (Figure 6-6).

```
METAR KNPA 082255Z 27004KT 7/8SM R04/4500FT DZ FG SCT000 BKN011 OVC380 19/18
         A2997 RMK VIS1/2V1 CIG009V013 FG SCT000 BKN TOPS 027 SLP149
```

Figure 6-6 Wind Direction and Speed in METAR

Examples:
09008KT — Wind from 090 degrees at 08 knots.
270112KT — Wind from 270 degrees at 112 knots.

GUSTS — The letter "G" immediately following the average wind speed indicates the presence of gusts, which are rapid fluctuations in speeds of peaks and lulls of 10 knots or more. Wind speed for the most recent 10 minutes is used to determine gusts, and the maximum peak is reported using two or three digits.

Examples:
14015G28KT — Wind from 140 degrees at 15 knots with gusts to 28 knots.
33065G105KT — Wind from 330 degrees at 65 knots with gusts to 105 knots.

VARIABLE WINDS — If "VRB" is present in place of the wind direction, the direction cannot be determined (used with wind speeds of 6 knots or less). If the wind direction is variable with speeds greater than 6 knots, a special group will immediately follow the wind group using the letter "V" between two directions (listed clockwise).

Example:
22015KT 180V250 — Winds from 220 degrees at 15 knots with direction varying from 180 degrees to 250 degrees.

CALM WINDS — Calm winds are reported as 00000KT.

NOTES

(1) Peak winds and wind shifts will be reported in the RMK section of the METAR/SPECI. (See remarks section later in this chapter.)

(2) A sudden increase in wind speed of at least 16 knots and sustained at 22 knots or more for at least 1 minute requires that Squalls (SQ) be reported in the present weather section of the report.

Group 5: Visibility

METAR uses the prevailing visibility, reported in statute miles (SM) in the United States and in meters at overseas stations (Figure 6-7). Any of the values in Table 6-1 may be used. Automated stations may use "M" to indicate less than ¼ statute mile when reporting visibility (think of "Minus"). If visibility is less than 7 statute miles, then the weather/obstruction to vision will also be reported (using the abbreviations discussed later in the Present Weather section and shown in Table 6-2).

```
METAR KNPA 082255Z 27004KT 7/8SM R04/4500FT DZ FG SCT000 BKN011 OVC380 19/18
         A2997 RMK VIS1/2V1 CIG009V013 FG SCT000 BKN TOPS 027 SLP149
```

Figure 6-7 Visibility in METAR

Examples:
1 1/8 SM — Visibility one and one-eighth statute miles.
5SM — Visibility five statute miles.
M1/4 — Visibility from an automated station less than one-quarter statute mile.

NOTE

Other types of visibility are reported in the RMK portion of the METAR/SPECI (see the remarks section later in this chapter). At military stations tower visibility will be reported when either surface or tower visibility is 4 miles or less. This visibility will be a remark with the surface visibility remaining in the body of the report.

Source of Visibility Report							
Automated			Manual				
M1/4	2	9	0	5/8	1 5/8	4	12
1/4	2 1/2	10	1/16	3/4	1 3/4	5	13
1/2	3		1/8	7/8	1 7/8	6	14
3/4	4		3/16	1	2	7	15
1	5		1/4	1 1/8	2 1/4	8	20
1 1/4	6		5/16	1 1/4	2 1/2	9	25
1 1/2	7		3/8	1 3/8	2 3/4	10	30
1 3/4	8		1/2	1 1/2	3	11	35[a]
a. Further values in increments of 5 statute miles may be reported (i.e., 40, 45, 50, etc.)							

Table 6-1 Visibility Values Reportable in METAR

Group 6: Runway Visual Range (RVR)

The runway visual range (RVR), defined in Chapter 5, is a measure of the horizontal visibility as determined from instruments (transmissometers) located alongside and about 14 feet higher than runway centerline. They are calibrated with reference to the sighting of either high-intensity runway lights or the visual contrasts of other targets, whichever yields the greater visual range. Only activities with operational equipment are allowed to report RVR.

RVR is reported whenever the prevailing visibility is 1 statute mile or less and/or the RVR for the designated instrument runway is 6,000 feet or less. RVR is measured in increments of 200 feet through 3000 feet and in 500-foot increments above 3,000 feet (Figure 6-8).

```
METAR KNPA 082255Z 27004KT 7/8SM R04/4500FT DZ FG SCT000 BKN011 OVC380 19/18
          A2997 RMK VIS1/2V1 CIG009V013 FG SCT000 BKN TOPS 027 SLP149
```

Figure 6-8 RVR in METAR

RVR is encoded with an "R" indicating runway, followed by a 2-digit group denoting runway number, and may be followed by an "R," "L," or "C," denoting right, left, or center runway. Next is a forward slash followed by the constant reportable value in four digits and ending with the letters "FT" for feet.

If RVR is varying, the coding will be the same as above, except the two reportable values will be separated by a "V." If RVR is less than its lowest reportable value, the 4-digit value will be preceded with an "M" (for Minus), and if greater than the highest reportable value, it is preceded with a "P" (for Plus).

Examples:
R33/1800FT — Runway 33 visual range 1,800 feet.
R17R/3500FT — Runway 17 Right visual range 3,500 feet.
R09/1000V4000FT — Runway 09 visual range 1,000 feet variable to 4,000 feet.
R28L/P6000FT — Runway 28 Left visual range greater than 6,000 feet.
R02/M0800FT — Runway 02 visual range less than 800 feet.

NOTE

Runway visual range is not reported from USN/USMC stations. It will, however, be disseminated locally to arriving and departing aircraft.

Group 7: Present Weather

Present weather includes precipitation, well-developed dust or sand swirls, squalls, tornadic activity, sandstorms, and dust storms. It may be evaluated instrumentally, manually, or through a combination of methods. The codes used for present weather as seen below in Figure 6-9 and Table 6-2 are used throughout meteorology with one exception–the Radar Summary Chart– which has its own codes.

```
METAR KNPA 082255Z 27004KT 7/8SM R04/4500FT DZ FG SCT000 BKN011 OVC380 19/18
          A2997 RMK VIS1/2V1 CIG009V013 FG SCT000 BKN TOPS 027 SLP149
```

Figure 6-9 Present Weather in METAR

In addition to the notes of Table 6-2, the following are a few of the conventions used to report present weather conditions in METAR/SPECI observations.

1. Present weather given in the body of the report occurs at the point of observation or within 5 miles from the station. If the letters "VC" are used, the weather is in the vicinity of 5-10 miles. Any reported weather occurring beyond 10 miles of the point of observation will be included in the remarks portion of the METAR.

2. Intensity refers to the precipitation, not its descriptor (TS or SH).

3. TS may be coded by itself, or it may be coded with RA, SN, PL, GS, or GR.

QUALIFIER		WEATHER PHENOMENA[1]		
INTENSITY OR PROXIMITY 1	DESCRIPTOR 2	PRECIPITATION 3	OBSCURATION 4	OTHER 5
– Light	MI Shallow	DZ Drizzle	BR Mist	PO Well-Developed Dust/ Sand Whirls
Moderate[2]	PR Partial	RA Rain	FG Fog	SQ Squalls
+ Heavy	BC Patches	SN Snow	FU Smoke	FC Funnel Cloud(s) (Tornado or Waterspout)[3]
VC In the Vicinity	DR Low Drifting	SG Snow Grains	VA Volcanic Ash	SS Sandstorm
	BL Blowing	IC Ice Crystals[2]	DU Widespread Dust	DS Dust Storm
	SH Shower(s)	PL Ice Pellets	SA Sand	
	TS Thunder-storm	GR Hail[2]	HZ Haze	
	FZ Freezing	GS Small Hail and/or Snow Pellets	PY Spray	
		UP Unknown Precipitation		

1. Weather groups are constructed by considering columns 1 to 5 above in sequence, i.e., intensity, followed by description, followed by weather phenomena (e.g., heavy rain shower(s) is coded as +SHRA).
2. No symbol denotes moderate intensity. No intensity is assigned to Hail (GR) or Icing (IC).
3. Tornadoes and waterspouts in contact with the surface are coded +FC.

Table 6-2 Present Weather Codes Reportable in METAR

Group 8: Sky Condition

```
METAR KNPA 082255Z 27004KT 7/8SM R04/4500FT DZ FG SCT000 BKN011 OVC380 19/18
          A2997 RMK VIS1/2V1 CIG009V013 FG SCT000 BKN TOPS 027 SLP149
```

Figure 6-10 Sky Condition in METAR

The sky condition group (Figure 6-10) gives a description of the appearance of the sky including the type of clouds, cloud layers, amount of sky coverage, height of their bases, and any obscuring phenomena. Cloud layer amounts for each layer indicate eighths of the sky that is covered, according to the abbreviations in Table 6-3, which is the same as Table 5-3.

Reportable Contractions	Meaning	Amount of Sky Cover
SKC or CLR[1]	Sky Clear	0/8
FEW[2]	Few	> 0/8 - 2/8
SCT	Scattered	3/8 - 4/8
BKN	Broken	5/8 - 7/8
OVC	Overcast	8/8
VV	Obscured[3]	8/8 (surface based)

1. The abbreviation CLR is used at automated stations when no clouds at or below 12,000 feet are reported; the abbreviation SKC is used at manual stations when no clouds are reported.
2. Any amount less than 1/8 is reported as FEW.
3. The last 3 digits report the height of the vertical visibility into an indefinite ceiling.

Table 6-3 Sky Coverage

In addition to the notes of Table 6-3, the following are some of the cloud reporting rules that are used in METAR/SPECI.

1. All sky cover heights are reported in feet above the ground level (AGL).

2. Sky condition is annotated by a 6-digit group, the first 3 digits (letters) describing the amount of sky cover (from Table 6-3), and the second 3 digits (numbers) the height of that layer in hundreds of feet. Layers will be reported in ascending order up to the first overcast. If the cloud layer is below the station (for mountain stations), the height will be coded as ///.

3. When the sky is *totally* obscured by a surface-based obscuration the only group in the sky condition section will be a 5-digit group, the first 2 digits VV (Vertical Visibility) and the last 3 digits the height of the vertical visibility into the indefinite ceiling. Most always this height will be 000, as any surface-based phenomenon is (by definition of "surface-based") within 50 feet of the surface, and will be rounded down to the nearest hundred feet (i.e., zero).

4. When the sky is *partially* obscured by a surface-based obscuration, the amount of the sky cover hidden by the weather phenomena will be reported as FEW000, SCT000, or BKN000. A remark will then also be given to describe these details (see Remarks section).

5. At manual stations CB (cumulonimbus) or TCU (towering cumulus) will be appended to the layer if it can be determined.

Examples:
BKN000 — Partial obscuration of 5/8 to 7/8 (surface-based).
VV008 — Sky obscured, indefinite ceiling, vertical visibility 800 feet AGL.
SCT020CB — Scattered clouds (3/8 to 4/8 of the sky) at 2000 feet AGL composed of cumulonimbus clouds.
FEW011 BKN040 OVC120 — Few clouds (1/8 to 2/8) at 1100 feet AGL, broken clouds (5/8 to 7/8) at 4000 AGL, overcast clouds (8/8) at 12,000 feet AGL.

<u>Group 9: Temperature/Dew Point</u>

Temperature and dew point are reported as two 2-digit groups, rounded to the nearest whole degree Celsius, and separated with a (/) (Figure 6-11). Sub-zero temperatures or dew points will be prefixed with the letter “M” (for Minus). If the temperature and dew point are not available, the entire group is omitted. If only dew point is unavailable, then only temperature is coded, followed by the (/).

```
METAR KNPA 082255Z 27004KT 7/8SM R04/4500FT DZ FG SCT000 BKN011 OVC380 19/18
          A2997 RMK VIS1/2V1 CIG009V013 FG SCT000 BKN TOPS 027 SLP149
```

Figure 6-11 Temperature and Dew Point in METAR

If necessary, convert between Fahrenheit and Celsius using the following formulas:

$$F = (C * 9/5) +32 \qquad C = (F - 32) * 5/9 \qquad (9/5 = 1.8)$$

or by using the conversion scale on the CR-2 circular slide rule.

<u>Group 10: Altimeter Setting</u>

The altimeter setting will be included in all reports. The altimeter group always starts with the letter “A”, and will be followed with a 4-digit group using the tens, units, tenths, and hundredths of inches of mercury. For example, A2992 indicates an altimeter setting of 29.92 inches of Hg (Figure 6-12).

```
METAR KNPA 082255Z 27004KT 7/8SM R04/4500FT DZ FG SCT000 BKN011 OVC380 19/18
          A2997 RMK VIS1/2V1 CIG009V013 FG SCT000 BKN TOPS 027 SLP149
```

Figure 6-12 Altimeter Setting in METAR

Remarks Section

Remarks will be included in all METAR/SPECI reports if deemed appropriate. They will be separated from the body of the report by a space and the abbreviation RMK. If there are no remarks, then "RMK" is omitted (Figure 6-13). The remarks fall into three major categories, (1) Manual and Automated remarks, (2) Plain language remarks, and (3) Additive data and Maintenance remarks. Only the first two will be discussed in this chapter, as the last is of very little importance to an aviator.

```
METAR KNPA 082255Z 27004KT 7/8SM R04/4500FT DZ FG SCT000 BKN011 OVC380 19/18
          A2997 RMK VIS1/2V1 CIG009V013 FG SCT000 BKN TOPS 027 SLP149
```

Figure 6-13 Remarks Section of METAR

Remarks are made in accordance with the following conventions.

1. Where plain language is called for, authorized abbreviations and symbols are used to conserve time and space.

2. Time entries will be in minutes past the hour if occurrence is during the same hour the observation is taken. If not, then hours and minutes will be used.

3. Present weather in the body of the report using VC (vicinity) may be further described, if known. DSNT (distant) indicates weather that is beyond 10 miles of the point of observation, and it will be followed by the direction.

4. Movement of clouds and weather indicates the direction *toward* which it is moving (remember wind is *always* from).

5. Directions use the eight points of the compass.

6. Insofar as possible, remarks are entered in the order they are presented in the following examples:

TORNADO B13 6 NE	Tornado began 13 minutes past the hour, 6 statute miles northeast of the station
AO2A	Automated station with precipitation measuring equipment, augmented by observer
PK WND 28045/15	Peak wind of 45 knots from 280 degrees occurred at 15 minutes past the hour
WSHFT 30 FROPA	Wind shift 30 minutes after the hour with frontal passage
TWR VIS 1 1/2	Tower visibility one and one-half statute miles
VIS 1/2V2	Visibility varying between 1/2 and 2 statute miles
VIS 2 1/2 RY11	Visibility at second sensor located on runway 11 is two and one-half statute miles

DVR/R11L/1000V5000FT	Dispatch visual range varying between 1000 and 5000 feet on runway 11 left (automated stations only)
DVR/P6000FT	Dispatch visual range not associated with a specific runway is greater than 6000 feet (automated stations only)
OCNL LTG	Occasional lightning
FRQ LTGCGIC	Frequent lightning cloud to ground in vicinity
LTG DSNT W	Lightning distant west (beyond 10 miles but less than 30 miles)
RAB05E30SNB20E55	Rain began 5 minutes past the hour and ended 30 minutes past the hour, snow began 20 minutes past the hour and ended 55 minutes past the hour
TSB0159E30	Thunderstorm began at 0159 and ended at 0230
CIG 005V010	Ceiling varying between 500 feet and 1000 feet
CIG 002 RY11	Ceiling at second location on runway 11 is at least broken at 200 feet
PRESRR	Pressure rising rapidly
PRESFR	Pressure falling rapidly
SLP982	Sea Level Pressure is 998.2 millibars
SLPNO	Sea Level Pressure not available
VIS NE 2 1/2	Visibility northeast two and one-half statute miles
TS SE MOV NE	Thunderstorm southeast moving northeast
GR 1 1/4	Hailstones one and one-quarter inch
VIRGA SW	Precipitation southwest not reaching the ground
FG SCT000	Fog partially obscures 3/8 to 4/8 of the sky
BKN014 V OVC	Broken clouds at 1400 feet are variable to overcast
CB W MOV E	Cumulonimbus clouds west moving east
CBMAM E MOV S	Cumulonimbus mammatus clouds east moving south
TCU W	Towering cumulus clouds west
TOP OVC050	Tops of overcast are 5,000 feet MSL.
ACC NW	Altocumulus castellanus northwest (indicates turbulence)
ACSL SW-W	Altocumulus standing lenticular clouds southwest through west (indicates mountain wave turbulence)
APRNT ROTOR CLD NE	Apparent rotor cloud northeast (also indicates mountain wave turbulence)
CCL S	Cirrocumulus standing lenticularis south
FU BKN020	Smoke layer broken at 2000 feet
ACRFT MSHP	Aircraft mishap

Special Remarks That May be Appended to the Remarks Section

Runway Condition Reporting (RSC & RCR) — Runway condition, when reported, will include two parts, the RSC (runway surface condition), and the RCR (runway condition reading) as determined by the airfield manager or operations officer. The following RSCs describe the runway condition:

WR	Wet runway
SLR	Slush on the runway

LSR	Loose snow on the runway
PSR	Packed snow on the runway
IR	Ice on the runway
RCRNR	Base Operations closed

The RCR is a 2-digit number giving an average decelerometer reading from 02 to 25 (Table 6-4). Two slants (//) will be entered when the runway is wet, slush-covered, or when no decelerometer reading is available.

Runway Braking Action Reading	Equivalent Terminology	% Increase in Landing Roll
02 to 05	NIL	100% or more
06 to 12	POOR	99% to 46%
13 to 18	FAIR (MEDIUM)	45% to 16%
19 to 25	GOOD	15% to 0%

Table 6-4 RCR Values and Corresponding Braking Action

The following will be added to the report when applicable:

(1) "P" is appended to the RCR when there are patches of ice, snow, or slush on the runway.

(2) "SANDED" is appended when runways have been treated with sand or other friction enhancing materials.

(3) "P WET" or "P DRY" is appended whenever the rest of the runway is either wet or dry.

(4) ICAO braking action remarks (such as BA GOOD, BA NIL) may be reported at airfields not equipped with decelerometers when required.

Examples:

PSR15	Packed snow on runway, RCR value 15
IR//	Ice on runway, no RCR value available
LSR08P DRY	Loose snow on runway, RCR value 08 patchy, rest of runway dry
WR//	Wet runway
RCRNR	Base Operations closed
PSR12 HFS IR08	Packed snow on runway, RCR value 12 on touchdown, on rollout portion of a high friction surface with ice on runway, RCR value 08
PSR// SANDED BA MEDIUM	Packed snow on runway, no RCR available, runway treated with friction enhancer, braking action medium

Freezing Level Data (RADATS) — Information beginning with the contraction RADAT gives freezing level data. (Think of RAdiosonde DATa. A radiosonde is a weather balloon.) RADAT is followed by the relative humidity (RH) at the freezing level and the height of the freezing level in hundreds of feet MSL. When multiple crossings are reported, the order will be the lowest crossing first, followed by the intermediate crossing with the highest RH, then the highest crossing. A letter "L" or "H" after the RH value will indicate to which altitude the RH corresponds. A single slash after these altitudes indicates that more than three crossings occur, and the number of additional crossings is noted after the slash. When a "00" appears for the RH, this indicates an RH of 100%. If "20" is coded, this indicates that the RH is the lowest that can be obtained. Two slashes, "//", indicate RH data is missing.

Examples:

RADAT 63017	Freezing level at 1700 feet MSL with 63% RH
RADAT 91L028039061	Freezing levels at 2800, 3900, and 6100 feet MSL with 91%RH at 2800 feet
RADAT 84H008025085/1	Freezing levels at 800, 2500, and 8500 feet MSL with 84% RH at 8500 feet, and one additional crossing
RADAT ZERO	Freezing level at the surface
RADAT MISG	Unable to obtain, high winds, or equipment failure
RAICG 89MSL	Balloon iced up at 8900 feet MSL

603. THE TERMINAL AERODROME FORECAST (TAF)

TAF Use for Flight Planning

Any aviator planning a flight should know both the destination's existing and forecasted weather. Previously we learned the Aviation Routine Weather Report (METAR) provides existing weather. Now, we will discuss the surface forecasted weather conditions by learning how to read Terminal Aerodrome Forecasts (TAFs). This teletype information will also aid you in planning for the type of flight (IFR/VFR), type of approach you require, determining if an alternate is required, and selection of the best alternate.

Although there are many differences in TAF reporting between the military and civilian weather offices, as well as throughout the world, we will focus this discussion on the U.S. military TAF since the bulk of your training flights will commence from military bases. Once this has been accomplished, it will be much easier to point out differences existing among the TAFs of the U.S. military, civilian, and international communities.

TAF Sequence

It will become readily apparent that each line of the TAF forecast will follow the same basic sequence: message heading or change group, time, wind, visibility, weather and obstructions to vision, clouds, altimeter, and remarks. The only deviation that occurs is the addition of wind shear, temperature, icing, and turbulence groups when applicable. Figure 6-14 shows an example of a single line forecast with a breakdown of each group. Figure 6-15 shows an actual forecast for Navy Whiting Field.

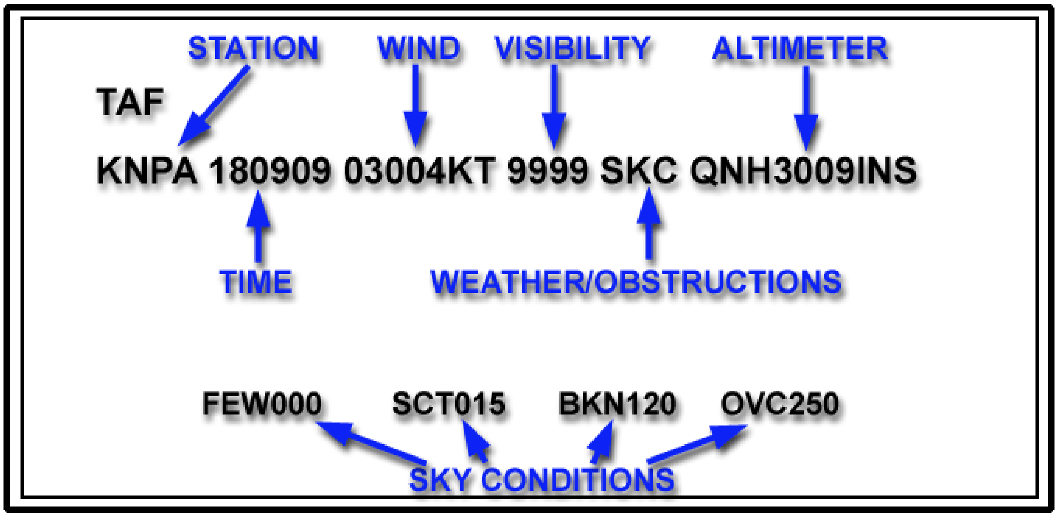


Figure 6-14 TAF Groups

```
KNSE TAF 260909 28004KT 9000 HZ SCT020 SCT200 QNH2998INS
FM1200 26007KT 9000 HZ SCT025 SCT080 BKN250 QNH2996INS VCSHRA
BECMG 1416 9999 SCT025CB SCT250
BECMG 1718 23015G25KT 530004
TEMPO 1902 8000 TSSHRA SCT010 BKN025CB
FM0200 27010KT 9999 SCT030 BKN080 BKN250 QNH3001INS 20/09Z

KMOB 262046Z 262121 00000KT 3200 BR VV004 QNH3012INS
BECMG 0607 14012 9999 SCT004 SCT025 QNH3016INS
```

Figure 6-15 TAF Example

Message Heading

The message heading begins with the 4-letter ICAO location identifier (e.g., KNSE for NAS Whiting Field) as shown in Figure 6-16. Next comes the letters “TAF” and any modifiers such as AMD, COR, or RTD, which stand for AMenDed, CORrected, or RouTine Delayed, unless the station is USN/USMC, in which case a remark will be appended to the last line of the forecast.

```
KNSE TAF 260909 28004KT 9000 HZ SCT020 SCT200 QNH2998INS
```

Figure 6-16 TAF Heading

Forecast Times

The 6-digit number following the message heading indicates the forecast period of the entire TAF, which is usually 24 hours (Figure 6-17). The first two digits represent the date of the forecast. The second two digits indicate the beginning hour of the forecast, and the final two digits indicate the ending hour of the forecast. For example, 260909 means that the forecast begins at 0900Z on the 26th day of the month and covers the 24-hour period up to but not including 0900Z the next day. U.S. civil stations include date and time of transmission prior to the forecast period (i.e., 091720Z 091818).

```
KNSE TAF 260909 28004KT 9000 HZ SCT020 SCT200 QNH2998INS
```

Figure 6-17 TAF Time Group

Whenever the forecast is an AMD, COR, or RTD, the times may not be for a 24-hour period and will be indicated accordingly. When USN/USMC stations amend, correct, or have a routine delayed forecast, a remark will be appended to the last line of the forecast with the appropriate time (e.g., AMD2218).

Winds

Wind direction is forecasted to the nearest 10 degrees true, in the direction *from* which the wind will be blowing (Figure 6-18). If wind direction is expected to vary by 60 degrees or more, the limits of variability will be noted as a remark, e.g., WND 270V350. The contraction VRB can only be used to replace direction when forecasted wind speed is 6 knots or less, or in more rare cases when it is impossible to forecast a single wind direction, such as for thunderstorms.

```
KNSE TAF 260909 28004KT 9000 HZ SCT020 SCT200 QNH2998INS
```

Figure 6-18 TAF Winds

Forecasted wind speeds and gust data are given in whole knots; if the wind speed is over 100 knots, then 3 digits are used. Calm winds are represented by “00000” for the wind group. “G” will be included to indicate gusts when the peak wind exceeds the average wind by 10 knots or more. Presently all U.S. winds are in knots and the contraction KT will end these wind groups. Some overseas stations use KPH (kilometers per hour) or MPS (meters per second).

Visibility, Weather, and Obstructions to Vision

For TAFs, forecasted prevailing visibility is reported in meters and rounded down to the nearest reportable value (Figure 6-19). U.S. civil stations, however, will report visibility in statute miles (Table 6-5). Whenever the prevailing visibility is forecasted to be 9000 meters or less (6 miles or less) the weather or obstructions to vision causing the reduced visibility will be included using the same notation as the METAR present weather group, described above in Table 6-2. A visibility code of "9999" indicates 7 miles visibility or greater is forecast, i.e. unlimited visibility. When appropriate, RVRs will follow immediately after the prevailing visibility.

```
KNSE TAF 260909 28004KT 9000 HZ SCT020 SCT200 QNH2998INS
```

Figure 6-19 TAF Visibility Group

VISIBILITY CONVERSION TABLE - STATUE MILES TO METERS					
Statute Miles	Meters	Statue Miles	Meters	Statute Miles	Meters
0	0	3/4	1200	1 7/8	3000
1/16	100	7/8	1400	2	3200
1/8	200	1	1600	2 1/4	3600
3/16	300	1 1/8	1800	2 1/2	4000
1/4	400	1 1/4	2000	3	4800
5/16	500	1 3/8	2200	4	6000[a]
3/8	600	1 1/2	2400	5	8000
1/2	800	1 5/8	2600	6	9000[b]
5/8	1000	1 3/4	2800	7	9999
Notes: [a] Rounded down from 6400m; [b] Rounded down from 9600m.					

Table 6-5 Reportable Visibility Values for TAFs

If any significant weather or an obstruction to vision is forecast (rain, snow, sleet, hail, blowing dust, etc.), it will be included after visibility, using the codes in Table 6-2. If there is no significant weather, this group will be omitted.

Sky Condition Group

This group(s) will be included as often as necessary to indicate all forecast cloud layers–up to the first overcast layer (8/8ths)–in ascending order of cloud bases, with lowest layer first (Figure 6-20).

```
KNSE TAF 260909 28004KT 9000 HZ SCT020 SCT200 QNH2998INS
```

Figure 6-20 TAF Sky Condition Group

As with METARs, TAF sky conditions will consist of five or six characters. The first two or three letters indicate the amount of sky coverage, from Table 6-3, above, and the last three digits indicate the height of the cloud bases in hundreds of feet AGL.

The types of clouds will not be forecast with the exception of cumulonimbus (CB), which will always be given as a separate layer (e.g., SCT005CB). In the event of a partial obscuration, it will be considered the first cloud layer and will be reported as FEW000, SCT000, or BKN000.

Special Wind Shear Group

An entry such as "WS020/22030KT" indicates the presence of wind shear. The three digits before the slash indicate the altitude (AGL), and the characters following the slash indicate wind direction and speed. North American stations will insert this special non-convective wind shear group immediately after the cloud group when it is forecast for altitudes 2000 feet AGL and below. However, if it cannot be forecast with accuracy, a less specific format of "WSCONDS" (wind shear conditions) may be used, and no further numeric data will be given. If no wind shear is forecast, then this group is omitted.

Icing Group

This group consists of six numbers only and begins with a "6." It is used to forecast non-thunderstorm icing (the presence of thunderstorms implies moderate or greater icing), and is repeated as often as necessary to indicate multiple icing layers. The group is omitted if no icing is forecasted. The following example illustrates the decoding of the icing group:

`641104`

The "6" indicates that icing is forecasted. The next digit, "4," is the type of forecasted icing from Table 6-6 (moderate icing). If more than one type of icing is forecast within the same stratum of air, the highest code figure–the most severe–will be used. The next three digits, "110," indicate the height of the base of the icing stratum in hundreds of feet AGL, which is 11,000' AGL in this case. If the numbers "000" are used, this would indicate icing occurring at or below 100 feet AGL. The last digit, "4," is the thickness of the icing layer in thousands of feet (4,000' here) using numbers 1 through 9. If layer is thicker than 9,000 feet, the icing group is repeated so that the base of the repeated group coincides with the top of the first encoded icing group. If multiple layers are forecasted that are not related to each other, the layers are encoded in an ascending order.

Ic	TYPE OF ICING	B	TYPE OF TURBULENCE
Code	Description	Code	Description
0	No icing	0	None
1	Light icing	1	Light turbulence
2	Light icing in cloud	2	Moderate turbulence in clear air, occasional
3	Light icing in precipitation	3	Moderate turbulence in clear air, frequent
4	Moderate icing	4	Moderate turbulence in cloud, occasional
5	Moderate icing in cloud	5	Moderate turbulence in cloud, frequent
6	Moderate icing in precipitation	6	Severe turbulence in clear air, occasional
7	Severe icing	7	Severe turbulence in clear air, frequent

8	**Severe icing in cloud**	**8**	**Severe turbulence in cloud, occasional**
9	**Severe icing in precipitation**	**9**	**Severe turbulence in cloud, frequent**
		X	**Extreme turbulence**

Table 6-6 TAF Icing and Turbulence Codes

Turbulence Group

This group is similar to the icing group because it is consists of six characters and follows the same format. The turbulence group, however, begins with a "5," and the second digit represents the turbulence intensity, also from Table 6-6 (above). The turbulence group is used to forecast non-thunderstorm turbulence (the presence of thunderstorms implies moderate or greater turbulence) and is also repeated as often as necessary to indicate multiple turbulence layers. The group is omitted if no turbulence is forecasted. The example below illustrates the decoding of the turbulence group:

```
510302
```

Following the same rules as the icing group, above, one would expect light turbulence from 3,000' AGL to 5,000' AGL.

Altimeter Group

This group forecasts the lowest expected altimeter setting in inches of Hg (Mercury) during the initial forecast period and each subsequent BECMG and FM group (to be discussed shortly) that follows. TEMPO groups (also to be discussed shortly) do not forecast the QNH group. This minimum altimeter setting becomes quite valuable when aircraft lose radio communications in IMC conditions and need a useful altimeter setting for the destination airfield (Figure 6-21).

```
KNSE TAF 260909 28004KT 9000 HZ SCT020 SCT200 QNH2998INS
```

Figure 6-21 TAF Altimeter Group

The "QNH" indicates that sea level pressure is being given. The next four digits indicate the lowest forecast altimeter setting in inches of Hg (and hundredths), without the decimal. "INS" simply indicates the unit of measurement is inches. Other standards, such as QNE and QFE, are also used in different circumstances. QNE is the standard datum plane, 29.92 in-Hg, and some countries use QFE, the actual station pressure not corrected to sea level. If QFE is set, the altimeter indicates actual elevation above the field, but does not ensure terrain clearance. Aircrews must exercise extreme caution if conducting operations at a location using QFE.

International stations report the altimeter in millibars (a.k.a. hectopascals, hPa) and use the letter "Q" for indicator. For example, "Q1013" indicates a forecast altimeter setting of 1013 millibars. U.S. civil stations generally will not forecast an altimeter setting.

Remarks

Various remarks may be appended to the end of the initial forecast period and subsequent change groups. The contractions listed in Table 6-2 are used for weather and obstructions to vision, while the FAA General Use Contractions will be used for other abbreviations.
The abbreviation "VC," also from Table 6-2, will only be used for air mass weather that is expected to occur within the forecast area. For example, "VCSHRA W" would indicate that rain showers are in the vicinity to the west. However, "VC" will not be used for weather expected to occur within a 5-mile radius of the runway complex, since that is considered to be "at the station."

Temperature Group

This is an optional group; however, its usage is highly encouraged and should be included to meet the requirements of local operations, especially for helicopter and VSTOL aircraft, which require density altitude. The forecast maximum or minimum temperature, depending on the time of the day, is given in two digits Celsius, using "M" for minus temperatures. This is followed by the 2-digit hour during which the maximum or minimum is expected to occur. It will be on the last line of the TAF, unless the forecast was amended.

604. CHANGE GROUP TERMINOLOGY

The change groups of "FM," "BECMG," and "TEMPO" will be used whenever a change in some or all of the elements forecasted are expected to occur at some intermediate time during the 24-hour TAF period. A new line of forecasted text is started for each change group. More than one change group may be used to properly identify the forecast conditions (Figure 6-22).

FM (From) and BECMG (Becoming) are indicators of expected speed of change. FM is used when the change is expected to be quick, and BECMG is used when the change is expected to occur over a longer period of time. FM indicates that a permanent, dramatic or relatively dramatic, change to a weather pattern is forecast to occur in a short period. All elements of the forecast conditions will be listed on that TAF line. BECMG indicates that some forecast elements are going to change permanently, or possibly that all of the forecast elements are to change. TEMPO (Temporary) means just that: a temporary or non-permanent change to the to the overall weather pattern.

```
KNSE TAF 260909 28004KT 9000 HZ SCT020 SCT200 QNH2998INS
FM1200 26007KT 9000 HZ SCT025 SCT080 BKN250 QNH2996INS VCSHRA
BECMG 1416 9999 SCT025CB SCT250
```

```
BECMG 1718 23015G25KT 530004
TEMPO 1902 8000 TSSHRA SCT010 BKN025CB
FM0200 27010KT 9999 SCT030 BKN080 BKN250 QNH3001INS 20/09Z
```

Figure 6-22 TAF Change Groups

FM Group

The heading "FM" followed immediately by a time (hours *and* minutes) indicates that the forecast weather is expected to change rapidly to the conditions on that line. In other words, the time indicates the beginning of a significant and permanent change in the whole weather pattern, and all previously forecast conditions are superseded by the conditions forecasted on this line. Additionally, the "FM" line includes all elements of a normal forecast as discussed above.

Using Figure 6-22 as an example, the change group "FM1200" starts the change line, and this indicates a change is forecasted to occur at 1200Z. All elements on that line will be in effect from 1200Z to the end of the original 24-hour period (0900Z in this example), unless changed later in the forecast by another change group (as is the case here).

BECMG Group

A line beginning with the heading "BECMG" indicates a change to forecast conditions is expected to occur slowly within the period designated in the time group immediately following the heading. In this time group of four digits, the first two indicate the beginning hour, and the last two represent the ending hour during which the change will take place. The duration of this change is normally about 2 hours, 4 at most.

The elements included in the BECMG line will supersede *some* of the previous TAF groups, but it is possible that all the groups may change. Any group omitted in the BECMG line will be the same during the BECMG period as indicated in the main TAF line. These new conditions are expected to exist until the end of the TAF forecast time period (unless changed later in the forecast by another change group).

```
KNSE TAF 260909 28004KT 9000 HZ SCT020 SCT200 QNH2998INS
FM1200 26007KT 9000 HZ SCT025 SCT080 BKN250 QNH2996INS VCSHRA
BECMG 1416 9999 SCT025CB SCT250
BECMG 1718 23015G25KT 530004
TEMPO 1902 8000 TSSHRA SCT010 BKN025CB
FM0200 27010KT 9999 SCT030 BKN080 BKN250 QNH3001INS 20/09Z
```

Figure 6-23 TAF BECMG Group

From Figure 6-23, some aspects of the weather will begin to change slowly sometime between 1700 and 1800Z, specifically the winds and turbulence. These forecast winds of 230° at 15 kts, gusting to 25 kts, and the frequent, moderate CAT can be expected to last until superseded by the FM group at 0200Z.

TEMPO Group

The heading "TEMPO" followed by a 4-digit time group indicates the weather conditions on this line will occur briefly, and *will* not represent a permanent change in the overall forecast weather pattern. Rather, there will be a short-lived overlay to the base forecast occurring only between the beginning and ending hours (two digits for each) specified by the time group. Furthermore, *only* the elements listed are forecast to be affected.

For example, in Figure 6-24, the temporary occurrence of thunderstorms and rain showers are forecast to exist only from 1900 up to, but not including, 0200. After this time, the conditions listed in the TEMPO line will be replaced by the forecast from other lines.

```
KNSE TAF 260909 28004KT 9000 HZ SCT020 SCT200 QNH2998INS
FM1200 26007KT 9000 HZ SCT025 SCT080 BKN250 QNH2996INS VCSHRA
BECMG 1416 9999 SCT025CB SCT250
BECMG 1718 23015G25KT 530004
TEMPO 1902 8000 TSSHRA SCT010 BKN025CB
FM0200 27010KT 9999 SCT030 BKN080 BKN250 QNH3001INS 20/09Z
```

Figure 6-24 TAF TEMPO Group

PROB Group

Civilian stations will sometimes forecast the probability of occurrence of thunderstorms or other precipitation events. Such a line begins with "PROB," followed by a 2-digit percentage and the corresponding weather, as this example illustrates:

PROB40 1/2SM +TSRA OVC005CB

This station forecasts a 40% chance of heavy rain from thunderstorms, producing an overcast ceiling of cumulonimbus clouds at 500 feet, with visibility ½ mile. This group may also be followed by a 4-digit time period group giving the beginning and ending time for the occurrence. USN/USMC stations will not use this change group.

Change Groups and Times (FROM/TO)

In order to use a TAF effectively, one must know how long a given pattern of weather will last, as well as what that pattern will be. To do this, establish the FROM and TO times of that pattern. (Note: in this text, *TO* will mean up *TO, but not including* that time.)

1. The times on the first line of code, after the location, are the *FROM* and *TO* date and times for the entire forecast, and the beginning (*FROM*) time of the first forecast line.

2. The time listed immediately after a FM can be a beginning time of a new pattern of weather as well as a TO time of a previously defined pattern, depending upon where it falls in the forecast.

3. The first two digits of the 4-digit time group following BECMG will be the beginning (*FROM*) time of the new forecast elements, and the last two digits are the ending (*TO*) time of the previous pattern.

4. The first two digits of the 4-digit time group shown after a TEMPO are the beginning (*FROM*) time, and the last two digits are the ending (*TO*) time for that TAF line.

```
KNSE 200909 00000KT 0800 FG VV001 620106 QNH3000INS
TEMPO0912 00000KT 2400 BR SCT000 SCT005 SCT080 SCT250
FM1400 20005KT 6000 HZ SCT025 SCT080 SCT250 QNH3004INS
BECMG1617 9999 QNH3002INS
BECMG2022 23010KT 9999 SCT025 SCT080 BKN250 WSCONDS 531006 QNH2996INS VCTSSH
TEMPO2303 VRB15G30KT 1600 TSSH OVC010CB
```

Figure 6-25 From/To Example

Using the example in Figure 6-25, the first forecast line (KNSE 200909) begins *FROM* 0900Z on the 20th and is good up *TO* 1400Z on the third line. (0900Z to 0900Z is also the 24 hour forecast period.) The second forecast line (TEMPO0912) begins *FROM* 0900Z and is forecast to occur up *TO* 1200Z. The third forecast line (FM1400) begins *FROM* 1400Z and is good up *TO* 1700Z, with some of these conditions changing by up TO 1700Z, the fourth line. The fourth forecast line (BECMG1617) begins *FROM* 1600Z and is good up *TO* 2200Z. The fifth forecast line (BECMG2022) begins *FROM* 2000Z and is forecast to occur up *TO* at least 0900Z, the end of the forecast period. The sixth line (TEMPO2303) begins *FROM* 2300Z and is forecast to occur up *TO* 0300Z.

605. SUMMARY OF U.S. CIVIL/MILITARY TAF DIFFERENCES

Civilian weather stations are required to adhere to slightly different formats than military stations, as has been discussed in the corresponding sections above. For reference, these differences are summarized below. An example follows in Figure 6-26.

1. U.S. civil stations will use statute miles instead of meters.

2. U.S. civil stations include date time group of transmission prior to the forecast period (e.g., 091720Z 081818).

3. When U.S. military stations amend, correct, or have a routine delayed forecast, a remark will be appended to the last line of the forecast with the appropriate time (e.g., AMD2218).

4. U.S. civil stations may include probability of precipitation occurrence.

```
KLCH TAF 032240Z 032323 01012G22KT 5SM HZ OVC006
BECMG 0002 01015G25KT 2SM -DZ BR OVC004 PROB40 0004 VRB25G35KT 2SM TSRA VV002
FM0400 01012G20KT 2SM BR OVC004
BECMG 1516 01015G25KT 4SM HZ OVC008
```

```
FM1700 01010KT 5SM HZ OVC009;

KSHV TAF 032240Z 032323 36010KT 4SM BR OVC004 WS005/27050KT
TEMPO 2316 35015KT 2SM -FZDZ PL OVC020
FM1700 04008KT P6SM BKN025;
```

Figure 6-26 Civilian TAF Examples

Additionally, there are some differences between military TAFs and International TAFs, which are summarized in Table 6-7.

TAF Differences			
U.S. Military TAF		International TAF	
Forecast Period	24 Hours	Forecast Period	Variable
Wind Speed	Knots	Wind Speed	Knots-, or Meters- or Kilometers-per-hour
CAVOK not used		CAVOK used	

Table 6-7 Differences Between Military and International TAFs

The term CAVOK is similar to the term sometimes used among aviators, CAVU, which stands for "Clear Air, Visibility Unlimited." The term CAVOK stands for "Clear Air, Visibility O.K." and is not used in U.S. Military TAF reporting.

606. DETERMINATION OF CEILING IN METARS AND TAFS

In chapter 5 we first introduced the concept of cloud layers and ceilings. As you may recall, the definition of a ceiling is the height above the ground (AGL) ascribed to the lowest broken or overcast layer; or the vertical visibility into an obscuring phenomenon (total obscuration). Remember that partial obscurations, such as FEW000, or SCT000, do not constitute a ceiling.

Ceilings may be easy to determine in METAR, but more difficult in TAFs, since they usually have more than one line. Therefore, it is important to carefully evaluate the ceiling by using the appropriate time period, as will be discussed below in "Using TAFs for Flight Planning." Once the ceiling (and other cloud layers) has been determined, then one can move onward to determining the type of flight plan (IFR or VFR) as well as whether an alternate landing airfield is required.

607. IFR/VFR RULES FOR FLIGHT PLANNING

The governing service instructions mandate that VFR flights maintain certain ceiling and visibility minimums. The Chief of Naval Operations Instruction 3710.7 series, *NATOPS General Flight and Operating Instructions*, referred to as OPNAV 3710.7, or as "the 3710", requires VFR flights to maintain ceiling and visibility minimums of at least 1,000 feet and 3 statute miles. Air Force Instruction 11-202 (Vol. 3), *General Flight Rules*, requires VFR flights to maintain ceiling and visibility minimums of at least 1,500 feet and 3 statute miles. In other words, existing and forecast weather must be such as to permit VFR operations for the entire duration of the flight and at the destination, including ±1 hour of the ETA (both services). If this cannot be maintained, as determined by reference to the applicable METAR and TAF products, then one must file and fly an IFR flight plan.

608. REQUIREMENTS FOR AN ALTERNATE ON IFR FLIGHT PLANS

Each airfield has minimum ceiling requirements for commencing an approach and landing at that field. These minimums are found on the airfield's approach plates and play an important role in the flight planning process. In particular, when filing an IFR flight plan, an alternate landing airfield may or may not be required to be included on the DD-175 Flight Plan.

Naturally, the OPNAV 3710.7 provides rules that determine when an alternate is required, as pictured in Figure 6-27.

DESTINATION WEATHER ETA plus and minus 1 hour	ALTERNATE WEATHER ETA plus and minus 1 hour		
0 - 0 up to but not including published minimums	3,000 - 3 or better		
Published minimums up to but not including 3,000 - 3 (single-piloted absolute minimums 200 - 1/2)	NON-PRECISION	PRECISION	
		ILS	PAR
	* Published minimums plus 300-1	* Published minimums plus 200-1/2	* Published minimums plus 200-1/2
3,000 - 3 or better	No alternate required		

* In the case of single-piloted or other aircraft with only one operable UHF/VHF transceiver, radar approach minimums may not be used as the basis for selection of an alternate airfield.

Figure 6-27 OPNAV 3710.7 Determination of Requirement for Alternate

When filing a Navy IFR flight plan, an alternate is required if the destination is forecasting a ceiling below 3,000 feet or if the visibility is less than 3 statute miles (referred to as 3,000-3) for the time period of ±1 hour of the planned ETA. If the forecast ceiling for the destination airfield is "below minimums," then an alternate must be selected that has VFR weather, 3,000-3, or better. However, if the destination has ceilings above the minimums but below 3,000-3, then the alternate airfield must have forecast ceiling and visibility above the minimums for the planned approach by the appropriate margin (indicated on the right of Figure 6-27), either 300-1 for a non-precision approach, or 200-1/2 for a precision approach.

AFI 11-202 (Vol. 3) provides rules that determine when an alternate is required, as pictured in Figures 6-28 and 6-29, depending on whether flying fixed wing or rotary wing aircraft.

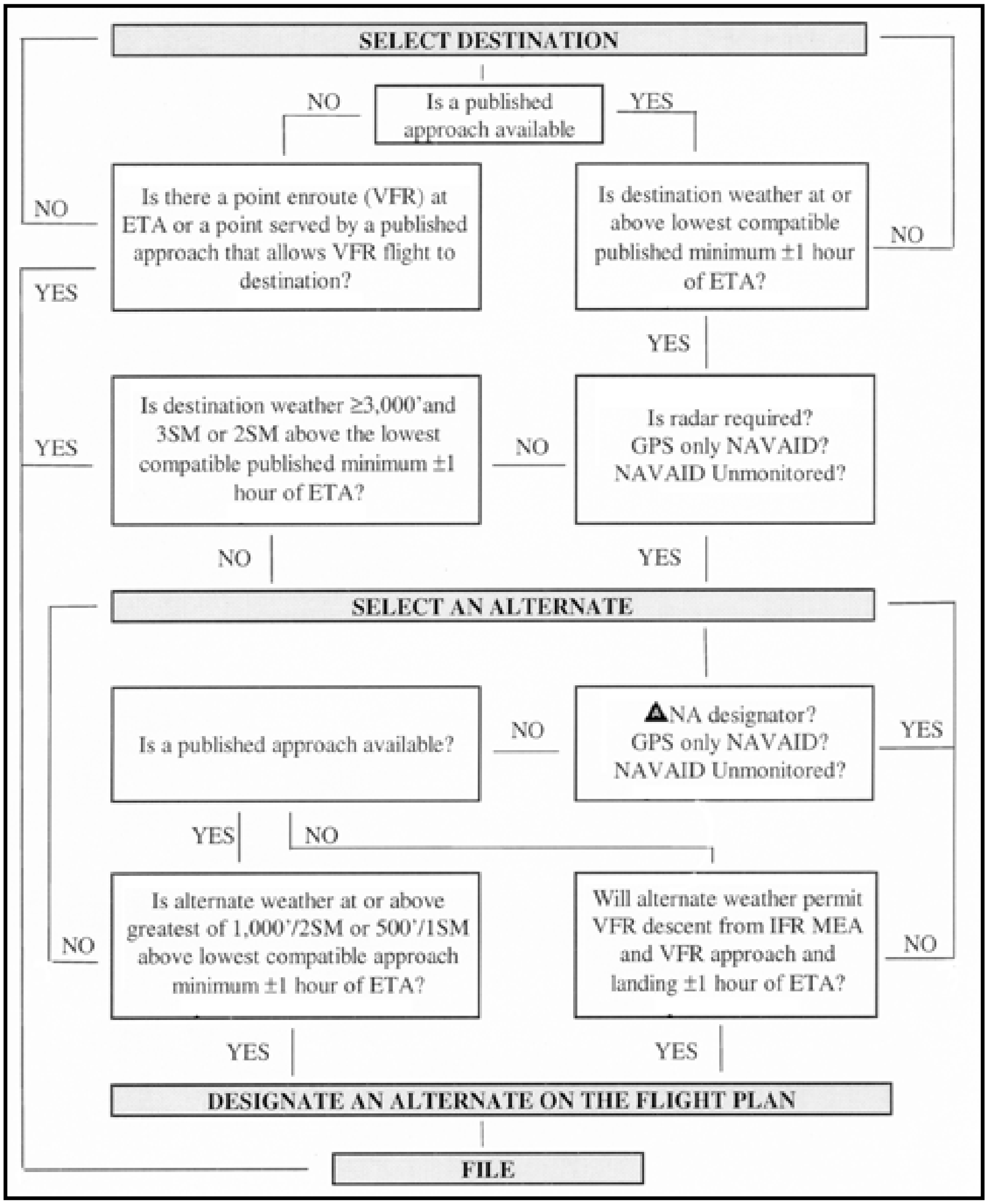


Figure 6-28 USAF Fixed Wing Determination of Requirement for Alternate

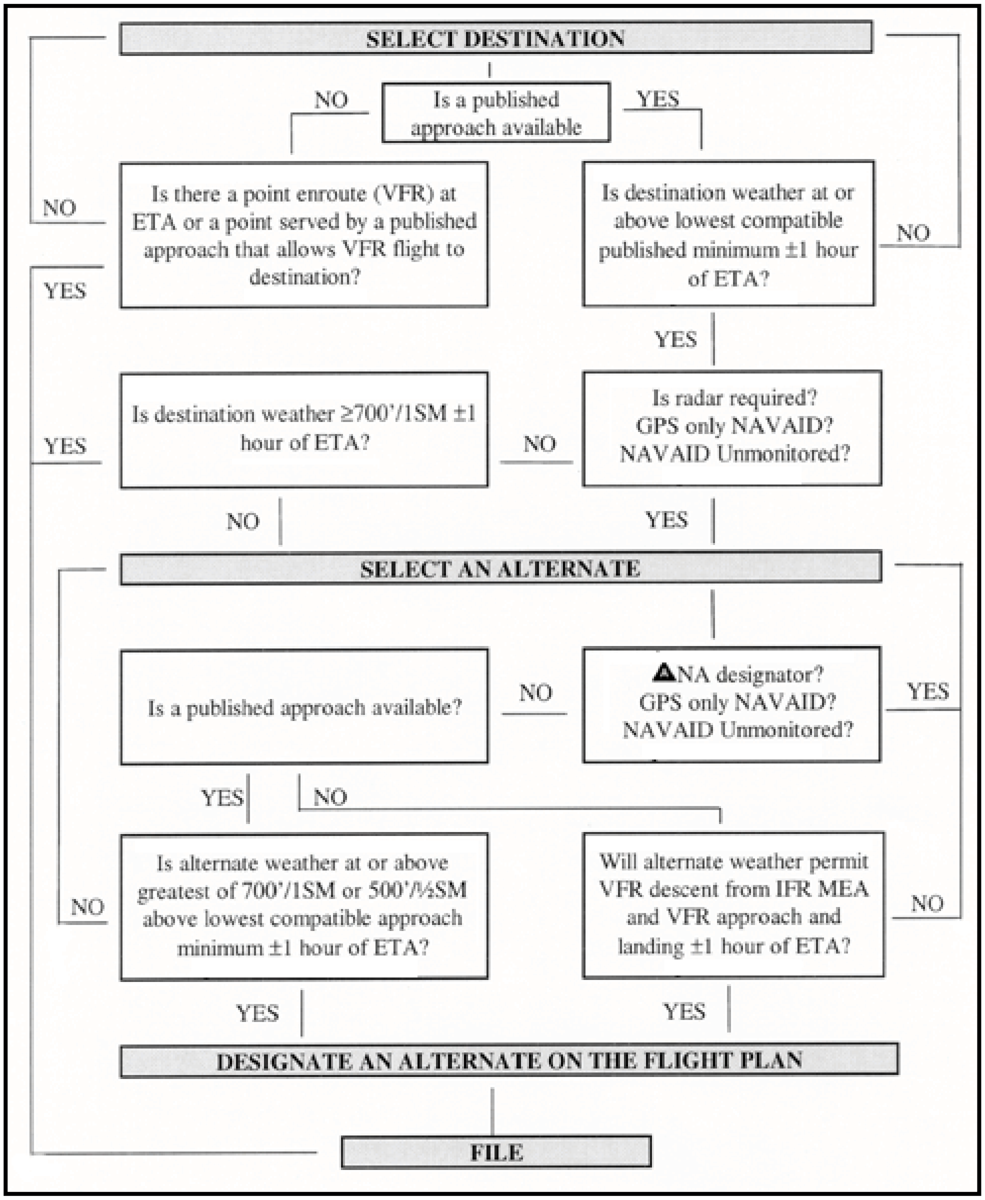


Figure 6-29 USAF Rotary Wing Determination of Requirement for Alternate

In summary, USAF pilots are required to designate an alternate if, for the ETA (±1 hour) for the first point of intended landing (or each point of intended landing on a stopover flight plan), the worst weather (TEMPO or prevailing) is forecast to be less than

For fixed wing aircraft:

- A ceiling of 3,000 feet, or
- A visibility of 3 SMs or 2 SMs more than the lowest compatible published landing minimum visibility, whichever is greater.

For rotary wing aircraft:

- A ceiling of 700 feet, or
- A visibility of 1 SM.

609. EXAMPLE OF MILITARY TAF WITH DESCRIPTION OF ELEMENTS

```
KNSE TAF 260909 28004KT 9000 HZ SCT020 SCT200 QNH2998INS
FM1200 26007KT 9000 HZ SCT025 SCT080 BKN250 QNH2996INS VCSHRA
BECMG 1416 9999 SCT025CB SCT250
BECMG 1718 23015G25KT 530004
TEMPO 1902 8000 TSSHRA SCT010 BKN025CB
FM0200 27010KT 9999 SCT030 BKN080 BKN250 QNH3001INS 20/09Z
```

Figure 6-30 Military TAF Example

1st line — Forecast for NAS Whiting field (KNSE) beginning at 0900Z (0909) and valid up to but not including 1200Z on the second line (FM1200), winds from 280 degrees and speed 4 knots (28004KT), visibility 6 miles (9,000 meters), in haze (HZ), scattered clouds at 2,000 feet AGL (SCT020), scattered clouds at 20,000 feet AGL (SCT200), altimeter setting 29.98 inches (QNH2998INS).

2nd Line — From 1200Z (FM1200), up to but not including 1600Z (BECMG 1416), winds from 260 degrees at 7 knots (26007KT), visibility 6 miles (9,000 meters), in haze (HZ), scattered clouds at 2,500 feet AGL (SCT025), scattered clouds at 8,000 feet AGL (SCT080), broken clouds at 25,000 feet AGL (BKN250), altimeter setting of 29.96 inches (QNH2996INS), and rain showers in the vicinity (VCSHRA), ceiling at 25,000 feet.

3rd Line — From 1400Z (BECMG 1416), up to but not including 1800Z (BECMG 1718), winds the same as 2nd line (26007KT), visibility greater than 6 miles (9999), scattered cumulonimbus clouds at 2500 feet AGL (SCT025CB), and scattered clouds at 25,000 feet AGL (SCT250), altimeter setting same as 2nd line (QNH2996INS); remarks same as 2nd line.

4th Line — From 1700Z (BECMG 1718) up to but not including 0200Z (FM02), winds from 230 degrees at 15 knots with gusts to 25 knots (23015G25KT), visibility same as 3rd line (9999), clouds same as 3rd line (SCT025CB, SCT250), moderate turbulence in clear air from surface up to 4,000 feet (530004), altimeter setting same as 2nd line, 29.96 inches (QNH2996INS).

5th Line — Temporarily between 1900Z and 0200Z (TEMPO 1902), winds same as 4th line (23015G25KT), visibility 5 miles (8,000 meters), with thunderstorms and rain showers (TSSHRA), scattered clouds at 1,000 feet AGL (SCT010) and broken cumulonimbus clouds at 2,500 feet AGL (BKN025CB), turbulence same as 4th line (530004), altimeter same as 2nd line (QNH2996INS), with ceiling at 2,500 feet.

6th line — From 0200Z (FM0200) up to but not including 0900Z (end of TAF), winds from 270 degrees at 10 knots (27010KT), visibility greater than 6 miles (9999), scattered clouds at 3,000 feet AGL (SCT030), broken clouds at 8,000 feet AGL (BKN080), broken clouds at 25,000 feet AGL (BKN250), altimeter setting 30.01 inches (QNH3001INS), ceiling at 8,000 feet AGL, minimum temperature forecasted for the day is 20 °C (68 °F) at 0900Z.

610. USING TAFS FOR FLIGHT PLANNING

For flight planning purposes, an aviator must consider the worst weather conditions that fall within the period of 1 hour prior to the planned estimated time of arrival (ETA) up to but not including 1 hour after ETA, for a total of a 2-hour window. As an example, assume an ETA of 1620Z at NAS Whiting, use the TAF in Figure 6-31, and follow these simple steps:

1. Determine the arrival window, which would be 1520 – 1720Z in this case.

2. Evaluate the whole TAF to determine the forecast time period to which each line applies. If any part of the 2-hour ETA window falls within the time period of that line, then the information in that line will be applicable. In this case, lines 2, 3, and 4 each cover part of the 1520 – 1720Z window.

3. Finally, mix and match the weather from each line for use in flight planning, building a set of the *worst-case scenario* for each group: strongest winds, lowest visibility, worst weather, lowest ceiling, and lowest altimeter.

Another technique is to lay out a timeline in order to dissect and categorize the applicability of the various lines of a TAF. By drawing labeled brackets around the times to which each line applies and around the 2-hour ETA window, it becomes easier to see which lines of the TAF are applicable. This technique is especially useful when planning a mission with numerous approaches or enroute delays, or when the weather will be a deciding factor for the landing time. Figure 6-31 shows a diagram of this technique for our example.

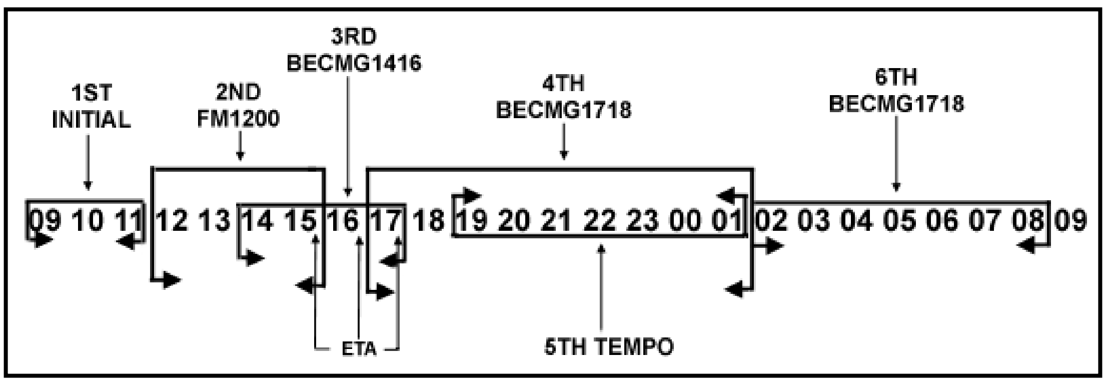


Figure 6-31 TAF Timeline Example

This technique also requires the flight crew to apply the 2nd, 3rd, and 4th lines of the forecast. Using either method, they would look for the worst weather among each of these lines and plan for:

1. Winds 230 degrees at 15 knots gusting to 25 knots (23015G25)
2. Visibility 6 miles in haze (9000 HZ)
3. Scattered cumulonimbus at 2500’ AGL, scattered clouds at 8,000’ AGL, and broken clouds at 25,000’ AGL, with ceiling at 25,000’ (SCT025CB, SCT080, BKN250)
4. Altimeter setting 29.96 inches (QNH2996INS)
5. Frequent moderate clear air turbulence from the surface up to 4,000 feet (530004)
6. Rain showers in the vicinity (VCSHRA)

STUDY QUESTIONS

Aviation Routine Weather Reports (METAR)

Use Figure 6-32 for questions 1-6, as well as any tables needed from the chapter.

```
KLEX 0359Z 19004KT 7SM BKN250 22/20 A3020 RMK SLP220
KPAH 0358Z 09008KT 15SM -RA BKN011 OVC060 22/20 A3007 RMK CB OVHD MOVG E SLP178
KAND 0357Z 09005KT 060V140 12SM SCT050 BKN250 30/22 A3015 RMK SLP204
KCAE 0356Z 00000KT 10SM FEW000 FEW050 SCT300 25/20 A3013 RMK CB N LTGIC SLP201
KAVL 0458Z 12004KT 2SM BR HZ SCT000 SCT060 BKN080 21/20 A3028 RMK FG HZ SCT000 PRESFR
      SLP226
KRDU 0456Z 13008KT 2SM HZ SCT000 24/22 A3017 RMK HZ SCT000 SLP208
```

Figure 6-32 METAR for Questions 1-6

1. The report for Anderson (AND) indicates

   a. broken clouds at 25,000 feet.
   b. that the altimeter setting is 29.05 inches of mercury.
   c. that the wind is 200° at 40 miles per hour.
   d. broken clouds at 5,000 feet.

2. The report for Lexington (LEX) indicates

   a. that the ceiling is reported at 25,000 feet.
   b. that the wind is from the south at 40 miles per hour.
   c. no ceiling.
   d. that the station pressure reduced to sea level is 922.0 mb.

3. The report for Paducah (PAH) indicates

   a. the ceiling is 6,000 feet.
   b. the overcast is measured at 1,100 feet.
   c. the altimeter setting is 30.07 inches of mercury.
   d. that it is snowing.

4. The report for Columbia (CAE) indicates

   a. over 15 statute miles visibility.
   b. that there is no ceiling.
   c. a mistake in the dew point.
   d. a pilot would prefer to approach this station from the north.

5. The report for Asheville (AVL) indicates

   a. 20 statute miles visibility.
   b. that the wind was 210° at 4 miles per hour.
   c. that the visibility was restricted because of mist and haze.
   d. that the wind was 040° at 12 knots.

6. The report for Raleigh (RDU) indicates

   a. that there was no ceiling.
   b. that the altimeter setting was 20.17 inches of mercury.
   c. a partial obscuration.
   d. that A and C are correct.

Use Figure 6-33 for questions 7-12, as well as any tables needed from the chapter.

```
KTLH 0455Z 040412KT 6SM -RA DZ BKN015 OVC018 22/21 A2995 RMK -RA OCNLY RA SLP144
KAQQ 0456Z 22010KT 3SM R04/P6000FT FG SCT000 BKN008 BKN080 OVC250 19/18 A994 RMK
        FG SCT000 CIG 006V010 SLP142
KSUU 2157Z 16009KT 10SM BKN027 BKN200 30/26 A2999 RMK SLP190
KNGP 2158Z 18012KT 12SM SKC 20/12 A2964 RMK VSBY E 1 1/2FU SLP037
KTIK 2158Z 18015G25KT 7SM BKN012 OVC090 26/14 A2966 RMK CIG LWR N SLP044
KBAD 2057Z 19007KT 15SM SCT055 BKN180 26/15 A2996 RMK VSBY SE 3 FU SLP146
```

Figure 6-33 METAR for Questions 7-12

7. The report for Tallahassee (TLH) indicates

   a. that the light rain is occasionally heavy.
   b. the ceiling is estimated to be 1,800 feet AGL.
   c. the present weather is light rain and drizzle.
   d. the sea-level pressure is 1014.2 inches.

8. The report for Appalachicola (AQQ) indicates

   a. that there are two ceilings.
   b. that on RWY 04, the visual range is greater than 6,000 feet.
   c. the ceiling varies between 6,000 and 10,000 feet MSL.
   d. fog obscures five-eighths of the sky.

9. The report for Travis AFB (SUU) indicates that

   a. the wind is 160° at 9 miles per hour.
   b. there was a ceiling .
   c. the visibility is 10 nautical miles.
   d. the altimeter setting is 29.99 mb.

10. The report for NAS Corpus Christi (NGP) indicates that

    a. there is no ceiling.
    b. the wind is 12 knots from the south.
    c. the visibility in the area is restricted.
    d. A and B are correct.

11. The report for Tinker AFB (TIK) indicates that

    a. the ceiling is 900 feet and is overcast.
    b. a pilot flying at 10,000 feet would be above all clouds.
    c. the ceiling on an approach from the north may be lower.
    d.. there are squalls.

12. The report for Barksdale AFB (BAD) indicates

    a. the magnetic wind is 190° at 07 knots.
    b. the visibility is 15 statute miles in all directions.
    c. the temperature-dew point spread is 12 °C.
    d. none of the above.

Use Figure 6-34 for questions 13-19, as well as any tables needed from the chapter.

```
KNQA SPECI 2056Z 36007KT 3/4SM FG VV004 22/21 A2976 RMK SLP078
KBWG 1357Z 13004KT 10SM TSRA PL SCT025CB SCT035 SCT100 BKN250 28/26 A2990 RMK
        TSSH ALQDS SLP125
KMEM 1356Z 04010KT 010V070 30SM BKN120 BKN250 30/17 A2995 RMK SLP142
 KPAH 1358Z 17023G30KT 12SM SKC 34/24 A2990 RMK FEW CI SLP111
KSDF SPECI 1357Z 00000KT 1SM -RA FG BKN006 19/18 A2976 RMK SLP078
KTRI 1356Z 00000KT 20SM BKN065 A3010 RMK LSR08P DRY SLP193
```

Figure 6-34 METAR for Questions 13-19

13. The report of NAS Memphis (NQA) at 2100Z indicates

    a. an overcast at 400 feet.
    b. that the visibility is 3 statute miles.
    c. that the ceiling was due to an obscuration.
    d. that the lowest cloud layer is at 300 feet.

14. The 2100Z report from NAS Memphis (NQA) indicates

    a. that this was a special weather observation.
    b. that the visibility is unrestricted.
    c. that the wind information is missing.
    d. no clouds.

15. The report for Memphis (MEM) indicates that

    a. the wind is steady from 040° magnetic at 10 knots.
    b. the ceiling is 12,000 feet.
    c. there is another ceiling at 25,000 feet.
    d. the altimeter setting is 29.95 hectopascals.

16. The report for Bristol (TRI) indicates

    a. the temperature and dew point are minus values.
    b. that the wind information is missing.
    c. that the temperature is missing.
    d. two layers of clouds.

17. The report for Bowling Green (BWG) indicates

    a. that the ceiling is 2,500 feet.
    b. that ice pellets were falling at the time of the observation.
    c. that the wind is 130° at 4 miles per hour.
    d. broken clouds at 10,000 feet.

18. The report for Paducah (PAH) indicates

    a. gusty winds.
    b. that the wind speed reached 30 miles per hour.
    c. that there are no clouds.
    d. that the barometric pressure is 911.1 mb.

19. The report for Louisville (SDF) indicates

    a. light rain and fog.
    b. that the wind is calm.
    c. the height of the ceiling was 600 feet.
    d. that all are correct.

Use Figure 6-35 for questions 20-25, as well as any tables needed from the chapter.

```
KADM SPECI 0958Z 32014KT 7SM SKC 21/18 A2970 RMK SLP057 RADAT 79100
KOKC 1008Z 108014KT 15SM SCT010 BKN025 28/23 A3006 RMK DSNT TSSH SLP219
KPWM 1055Z 30018KT 2SM R30/P6000FT -SN SCT000 OVC008 M01/M02 A2991 RMK SN SCT000
          DRFTG SN PSR20 SLP118
KLUF 1356Z 18005KT 45SM SCT025 SCT050 BKN240 04/M06 A3017 RMK SHSN OBSCG MTNS N
          SLP217
KNFB SPECI 0123Z 01023G35 1/2SM R36R/1200FT -BLSN SCT000 OVC005 RMK VIS 3/8V5/8 BLSN
          SCT000 CIG 004V006
KNXX 0058Z COR 13008G15KT 100V170 8SM SCT005 BKN008 OVC012 06/M01 A2945
RMK BKN TOPS 070 SLP985
```

Figure 6-35 METAR for Questions 20-25

20. The report for Ardmore (ADM) indicates that

    a. the freezing level was observed to be at 10,000 feet MSL.
    b. the time of the RADAT observation was 1008Z.
    c. the freezing level was forecast to be at 10,000 feet MSL.
    d. the freezing level was forecast to be at 10,000 feet AGL.

21. The report for Oklahoma City (OKC) indicates

    a. it is raining in sight of the field.
    b. the temperature-dew point spread was 9 °C.
    c. Oklahoma City was still able to transmit the report at the assigned time slot.
    d. that A and C are correct.

22. The report for Portland (PWM) indicates that

    a. the sky is partially obscured by snow.
    b. the runway visual range is greater than 6,000 feet.
    c. the ceiling was 800 feet.
    d. all above are correct.

23. Luke AFB (LUF) reported

    a. a visibility of 45 statute miles.
    b. no weather in the vicinity of the station.
    c. an unlimited ceiling.
    d. all of the above.

24. The report for NAS Grosse Isle (NFB)

    a. indicates a partial obscuration due to blowing snow.
    b. is in error, since RVR does not coincide with prevailing visibility.
    c. indicates a possible ceiling at 400 feet.
    d. indicates the conditions stated in A and C.

25. NAS Willow Grove (NXX) reported:

    a. base of the overcast at 1,200’ MSL, top of the overcast at 7,000’ MSL.
    b. conditions which would point up the wisdom of monitoring reports for further weather developments at Willow Grove while en route to that terminal.
    c. VFR conditions over the field.
    d. wind steady from 310° at 8 knots with gusts at 15 knots.

Terminal Aerodrome Forecasts (TAFs)

Use Figure 6-36 for questions 26-50, as well as any tables needed from the chapter.

```
KNPA 201212 36005KT 0800 DZ FG VV002 QNH3001INS
FM1500 02011KT 8000 HZ BKN007 BKN020 BKN140 BKN300 641403 540209 QNH2995INS
TEMPO1822 16008KT 4800 SHRA SCT008 BKN020

KNTU 201212 02008KT 1600 RA BR OVC004 QNH3000INS
TEMPO1216 VRB05KT 0800 FG VV001
FM1600 02011KT 6000 HZ BKN007 BKN020 OVC300 670708 QNH2993INS
TEMPO1822 19006KT 4800 SHRA SCT009 BKN020

KDOV 201212 36007KT 0800 DZ FG VV002 QNH3001INS
FM1500 02011KT 8000 HZ BKN007 BKN020 BKN150 OVC300 621403 540209 QNH2995INS
TEMPO1822 16008KT 4800 SHRA SCT008 BKN020

KNBE 201212 VRB05KT 0800 DZ FG VV001 QNH3004INS
FM1300 12006KT 1600 BR OVC005 QNH3007INS VCRA
FM1700 17010KT 8000 HZ SCT007 BKN020 OVC300 650106 540209 QNH2991INS VCSHRA
TEMPO1823 18015KT 4800 SHRA BKN020
BECMG0102 VRB05KT 3200 BR BKN005 OVC020 QNH 3000INS

KTIK 201212 VRB05KT 1600 DZ BR OVC004 QNH2999INS
FM1500 15010KT 0800 DZ FG OVC006 QNH3001INS
BECMG2122 17010KT 2400 DZ BKN014 OVC025 QNH3005INS
FM0000 22012KT 9999 SCT030 OVC050 QNH3002INS
BECMG0608 24012KT SKC QNH3004INS

KSPS 201212 17010KT 4800 BR BKN008 OVC015 QNH2987INS
FM1500 17015KT 9999 OVC015 QNH2989INS
FM2000 19012KT 9999 BKN030 QNH2990INS
BECMG0204 19010KT SKC QNH2993INS

KNQA 201515 18008KT 9999 SKC QNH3016INS
FM1800 17012G20KT 9999 BKN025 611109 521103 QNH3012INS
FM0400 17015G22KT 9999 BKN020 BKN100 WSCONDS QNH3008INS
TEMPO0408 20025G35KT 1600 TSSHRA OVC008CB

KNBG 201515 13008KT 9999 SCT025 SCT100 651309 521303 QNH3025INS
TEMPO1500 13012KT 9999 BKN025 BKN100
FM0900 VRB04KT 2400 BR SCT015 QNH3021INS
TEMPO0913 00000KT 0800 FG OVC015
FM1300 17010KT 9999 SCT030 QNH3020INS

KNMM 201515 14005KT 8000 BR SCT025 QNH3028INS
FM1900 16005KT 8000 HZ SCT025 BKN080 651109 561203 QNH3024INS
TEMPO1902 18010KT 6000 HZ BKN025 OVC080
FM0200 00000KT 9999 SKC 562005 QNH3020INS
BECMG0809 1600 BR SCT000 QNH3018INS
```

Figure 6-36 TAF for Questions 26-50

26. What is the forecast period for the first line of code on the Navy Pensacola (NPA) forecast?

a. 1200Z up to, but not including 1200Z
b. 1200Z up to, but not including 2200Z
c. 1200Z up to, but not including 1800Z
d. 1200Z up to, but not including 1500Z

27. An aircraft with an ETA into NPA of 1715Z would expect a ceiling of no less than

a. 2000 feet MSL.
b. 2000 feet AGL.
c. 700 feet AGL.
d. 700 feet MSL.

28. What is the highest visibility forecast throughout the forecast period at NPA?

a. 3 SM
b. 5 SM
c. 1/2 SM
d. >6 SM

29. Would a pilot flying over NPA during the hours of 1600Z to 2000Z expect icing?

a. Yes
b. No

30. Which lines of the forecast for Navy Oceana (NTU) would it be necessary to look at to formulate the worst case scenario for an ETA of 1615Z?

a. Line 3 only
b. Lines 2 and 3 only
c. All lines would be used.
d. Lines 1 thru 3

31. What minimum visibility would be expected at NTU for an ETA of 1300Z?

a. 1 SM
b. 1/2 SM
c. 4 SM
d. >6 SM

32. What type of turbulence is forecast over NTU at 2000Z?

a. Severe turbulence in clear, frequent
b. Severe turbulence in cloud, infrequent
c. Severe turbulence in clear, infrequent
d. None forecast at that time

33. What is the temporary forecast sky cover between 1200Z and 1600Z at NTU?

    a. A. 800 foot ceiling
    b. B. Nine-tenths cloud coverage
    c. C. Partial obscuration
    d. D. Total obscuration

34. What is the forecast period for the second line of code for Dover, DE (DOV)?

    a. A. 1500Z up to, but not including 1200Z
    b. B. 1200Z up to, but not including 1500Z
    c. C. 1500Z up to, but not including 2200Z
    d. D. 1500Z up to, but not including 1800Z

35. Between which altitudes would icing be expected at DOV, at any time, if at all?

    a. A. 14,000 - 17,000 feet
    b. B. 14,000 - 14,300 feet
    c. C. 2,000 - 11,000 feet
    d. D. None is forecast for DOV

36. What are the maximum forecast winds at DOV throughout the forecast period?

    a. A. 020° MAG at 11 mph
    b. B. 150° True at 16 knots
    c. C. 020° True at 11 knots
    d. D. 180° MAG at 22 knots

37. How many, if any, different types of weather are forecast throughout the forecast period at DOV?

    a. A. 3
    b. B. 5
    c. C. 4
    d. D. 2

38. What is the forecast period for the TEMPO line on the Navy Dallas, TX (NBE) forecast?

    a. A. 1800Z up to, but not including 0200Z
    b. B. 1800Z up to, but not including 1200Z
    c. C. 1800Z up to, but not including 0100Z
    d. D. 1800Z up to, but not including 2300Z

39. The minimum expected ceiling throughout the forecast period for NBE is

    a. A. 1,000 feet AGL.
    b. B. 100 meters MSL.
    c. C. 100 feet AGL.
    d D. 500 feet MSL.

40. What are the forecast winds for NBE for an ETA of 0315Z?

    a. 170/10
    b. Variable at 5 kts
    c. 180/15
    d. Calm

41. Was Navy Memphis was expecting wind shear at anytime during the forecast period? (Yes or No)

For questions 42-46, provide the minimum ceilings and visibilities for the location and ETA listed.

42. **NTU** ETA 1300Z: __/__; ETA 1900Z: __/___; ETA 0900Z: __/__
(CIG) / (VSBY)

43. **DOV** ETA 1400Z: __/__; ETA 1800Z: __/___; ETA 0100Z: __/__

44. **NBE** ETA 1415Z: __/__; ETA 1920Z: __/___; ETA 0130Z: __/__

45. **TIK** ETA 1300Z: __/__; ETA 1545Z: __/___; ETA 0300Z: __/__

46. **SPS** ETA 1310Z: __/__; ETA 1730Z: __/___; ETA 2300Z: __/__

47. Fill in the forecast elements for the following table:

	NQA/ETA 0700Z	**NBG**/ETA 1600Z	**NMM**/ETA 0730Z
2 HOUR WINDOW	_______	_______	_______
CEILING (MIN)	_______	_______	_______
VISIBILITY (MIN)/WEATHER(S)	___/___	___/___	___/___
ALTIMETER (LOWEST)	_______	_______	_______
WINDS (MAX)	_______	_______	_______
ICING (TYPE/ALTITUDES)	______/	______/	______/
	______	______	______
TURB (TYPE/ALTITUDES)	______/	______/	______/
	______	______	______

Answer questions 48-50 for NQA, NBG, and NMM in regards to ceilings and visibilities only.

48. Is NQA, NBG or NMM forecast to be IFR for the ETA's listed in question 47 (circle yes or no for each station)?

a. NQA (Yes/No)
b. NBG (Yes/No)
c. NMM (Yes/No)

49. Would NQA, NBG or NMM require an alternate at the ETA (circle yes or no for each station)?

a. NQA (Yes/No)
b. NBG (Yes/No)
c. NMM (Yes/No)

50. Why would NQA, NBG or NMM require an alternate at the ETA, if at all?

a. NQA Ceilings and/or Visibilities? (Circle one or both)
b. NBG Ceilings and/or Visibilities? (Circle one or both)
c. NMM Ceilings and/or Visibilities? (Circle one or both)
d. No alternate required for either station

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CHAPTER SEVEN
DATA ON WEATHER IMAGERY PRODUCTS

ASSIGNMENT SHEET

Data Displayed on Weather Imagery Products
Assignment Sheet 7.1A

INTRODUCTION

This assignment will aid the student in understanding and interpreting the data displayed on various weather imagery products, including Surface Analysis Charts, Low Level Significant Weather Prognostic Charts, Radar Summary Charts, NEXRAD, Satellite Images, Weather Depiction Charts, Winds-Aloft Prognostic Charts, and Winds-Aloft Forecasts.

LESSON TOPIC LEARNING OBJECTIVES

Terminal Objective:
Partially supported by this lesson topic:

7.0 Describe displayed data shown on various weather imagery products.

ENABLING OBJECTIVES:
Completely supported by this lesson topic:

7.1 State the pilot's use of a Surface Analysis Chart.

7.2 Identify displayed data on Surface Analysis Charts.

7.3 Describe displayed data on Station Model Plots.

7.4 State the pilot's use of a Low Level Significant Weather Prognostic Charts.

7.5 Identify displayed data on Low Level Significant Weather Prognostic Charts.

7.6 Identify plotted data on Radar Summary Charts.

7.7 Identify various weather data on NEXRAD imagery.

7.8 Identify potential significant weather data on two types of satellite imagery.

7.9 Identify plotted data on Weather Depiction Charts.

7.10 Identify ceilings on Weather Depiction Charts.

7.11 State the use of Winds-Aloft Prognostic Charts.

7.12 State the meaning of valid time on Winds-Aloft Prognostic Charts.

7.13 Identify plotted data on Winds-Aloft Prognostic Charts.

7.14 State the teletype identifier of Winds-Aloft Forecasts.

7.15 Identify coded data on Winds-Aloft Forecasts.

7.16 State the rules of wind parameters and omission of temperature in Winds-Aloft Forecasts.

7.17 Select a flight altitude that results in the most favorable wind component using Winds-Aloft Forecasts and Winds-Aloft Prognostic Charts.

STUDY ASSIGNMENT

Review Information Sheet 7.1I, and answer the Study Questions.

INFORMATION SHEET

Data Displayed on Weather Imagery Products
Information Sheet 7.1I

700. INTRODUCTION

This chapter will introduce a number of different weather products that are available from the local weather office or over other lines of communication. An understanding of these visual products, which are produced to show a national scale, will quickly provide an aviator a broader picture of the weather than can be gathered from METARs and TAFs.

New aviators may find these products to be the most often used weather documents for flight planning. Once a mission is assigned, whether for training or operational flying, the next stop is usually to find out the weather. Sometimes there will be a number of different possibilities for operating areas or routes of flight, and the weather may be the biggest factor in deciding which to choose. For instance, a Navy mission requiring a low-level visual navigation on a military training route requires weather to be greater than 3,000-foot ceilings and 5 miles of visibility. If there are routes available to the north, east, and west, and areas of IFR to the north and east, then a western route would be preferred. A quick glance at a Weather Depiction Chart, Low Level Significant Weather Prognostic Chart, or even a satellite image can provide the information to make such a decision. Other types of missions may require knowledge of the winds, and all aviators ought to know whether their flight will be affected by thunderstorms or other hazards. The other products discussed in this chapter can also provide such necessary information at a quick glance, because each type of chart is designed for a particular purpose. Once an aviator has a general knowledge of the purpose and use of each product, it becomes very easy to gather the required information.

REFERENCES

1. Chief of Naval Operations Instruction 3710.7 series, *NATOPS General Flight and Operating Instructions*
2. Air Force Instruction 11-202 (Vol. 3), *General Flight Rules*

INFORMATION

701. SURFACE ANALYSIS CHARTS

Weather forecasting, to a great extent, is dependent on weather charts that show the weather, its development, and movement from place to place. Regular scheduled observations (METAR) are taken throughout the world at selected times and compiled by computer at the Suitland, Maryland Weather Bureau Center. The computers analyze this information and produce a number of products, including the Surface Analysis Chart, which are transmitted to subscribers throughout the world.

At weather offices, two types of Surface Analysis Charts may be displayed. One is a computerized Surface Analysis Chart that is usually displayed on a computer monitor, or printed out and posted near the briefing desk. The other version is a less-common, locally prepared product drawn and plotted by hand.

The Surface Analysis Chart is used by pilots to obtain an overall facsimile picture of observed weather, including the location of pressure systems, winds, air masses, and fronts, in relation to their planned flight route (Figure 7-1). At this point, each of these features should be familiar: Pressure gradients and winds were covered in chapter 2; air masses and fronts were covered in chapter 3.

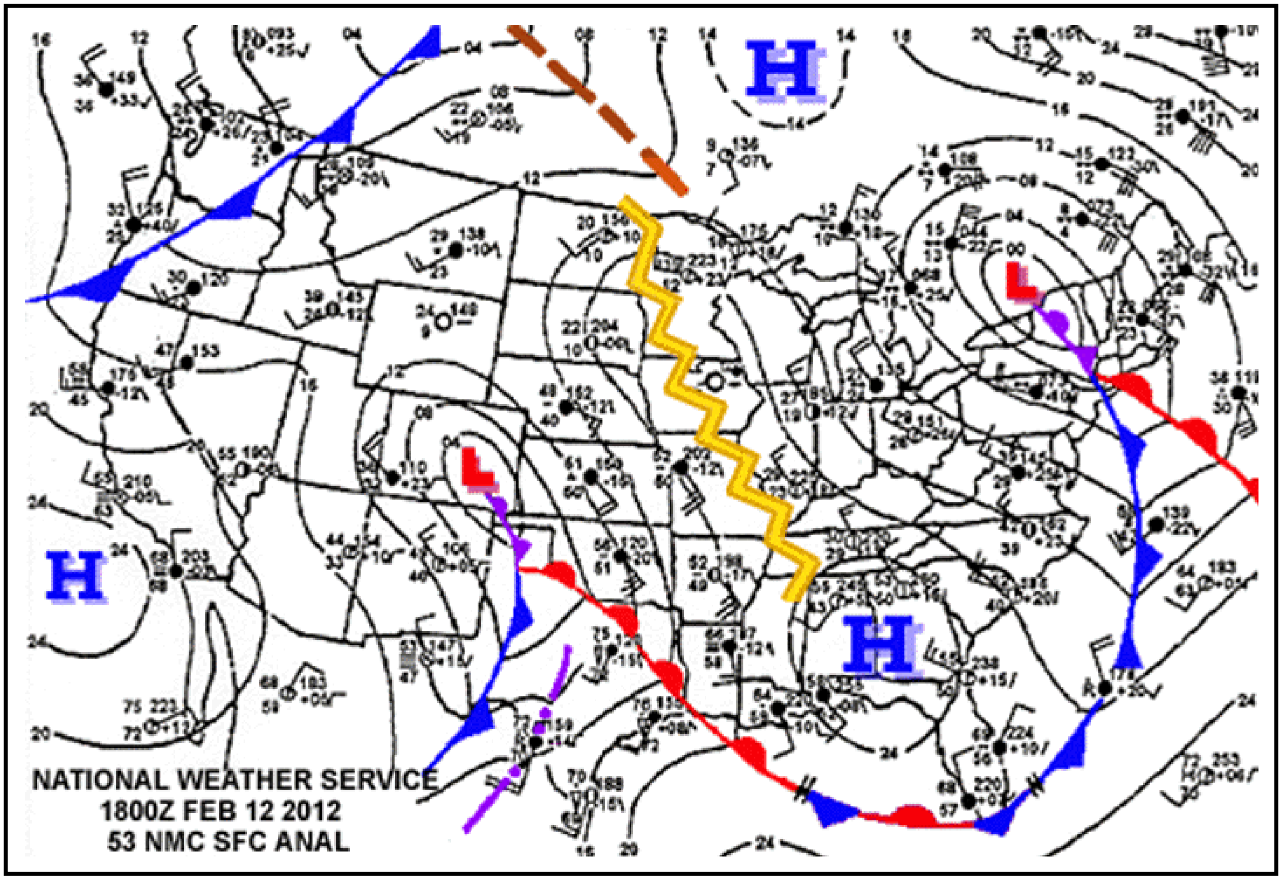


Figure 7-1 Surface Analysis Chart

The information displayed on the Surface Analysis Chart is observed weather, meaning that the chart represents past history, and is *not* a forecast. The valid time (VT) of the chart is located in the lower left-hand corner. This is given in Coordinated Universal Time (UTC), and is the observation time of the information that was gathered to compile the chart.

The pressure systems mentioned are outlined by isobars drawn at 4-millibar intervals. When the pressure gradient is very shallow, intermediate isobars (short dashed lines) are sometimes drawn on the chart at one-half the standard interval. The values of the isobars are indicated by a two-digit number (e.g., 16, which would indicate 1016.0 millibars).

Station Model Plots

To build a Surface Analysis Chart, some of the information received is displayed around circles in the form of station models. Discussed in chapter 2, the station model is a pictorial shorthand that provides the maximum data in a minimum amount of space. Figures 7-2 and 7-3 are provided as a review and a reference for other charts that use the station model plot.

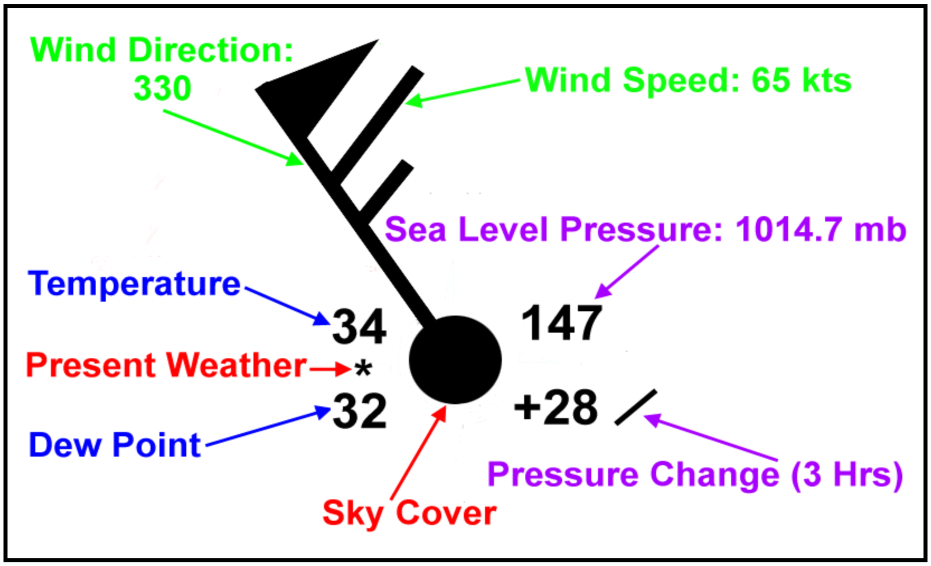


Figure 7-2 Station Model Explanation

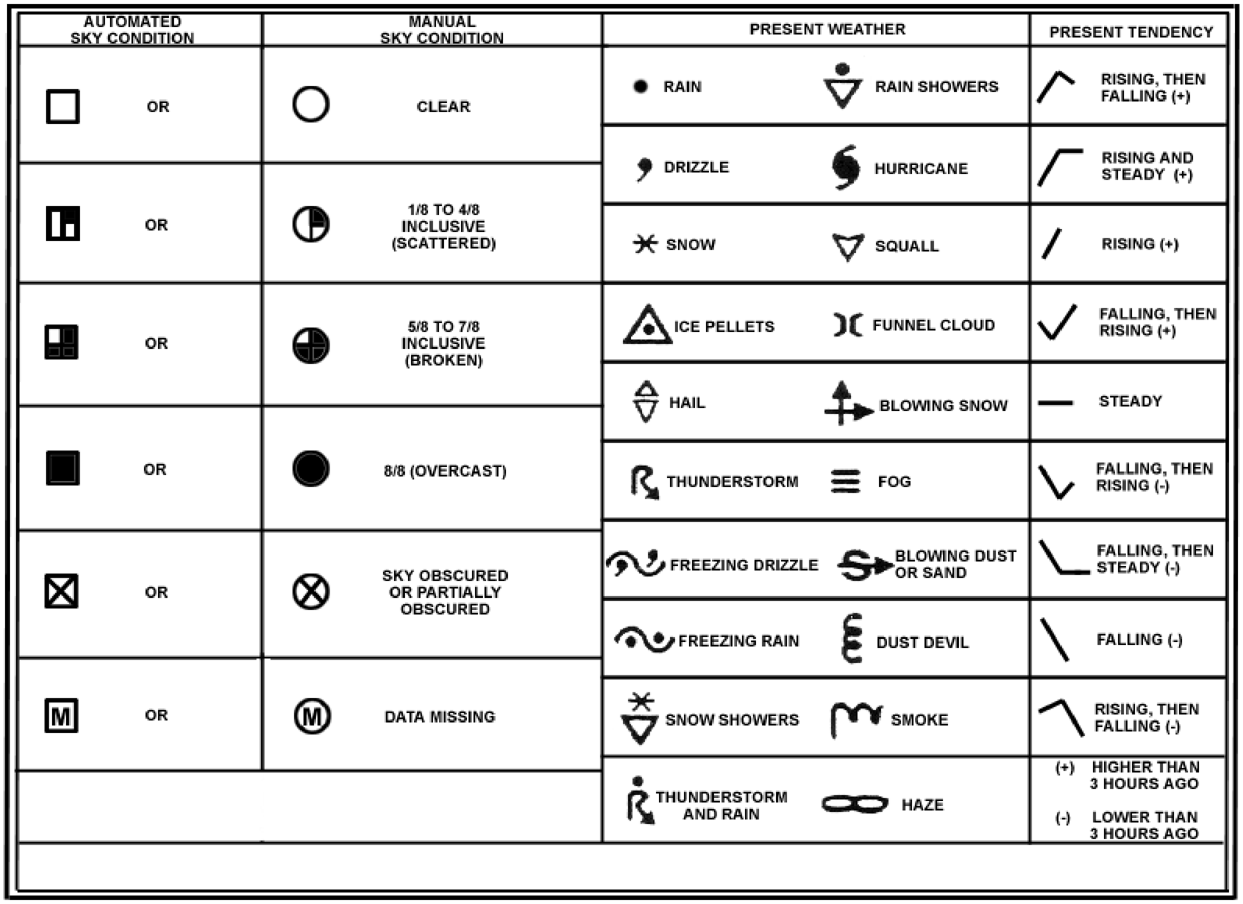


Figure 7-3 Major Station Model Symbols

702. LOW LEVEL SIGNIFICANT WEATHER PROGNOSTIC CHARTS

The Low Level Significant Weather Prognostic Chart (Figure 7-4) is composed of four panels that show a forecast of weather conditions affecting aviation from the surface to 24,000 feet MSL. Figure 7-5 is a simplified version of the chart, showing an expanded legend, as well as an explanation of each panel and their relation to each other.

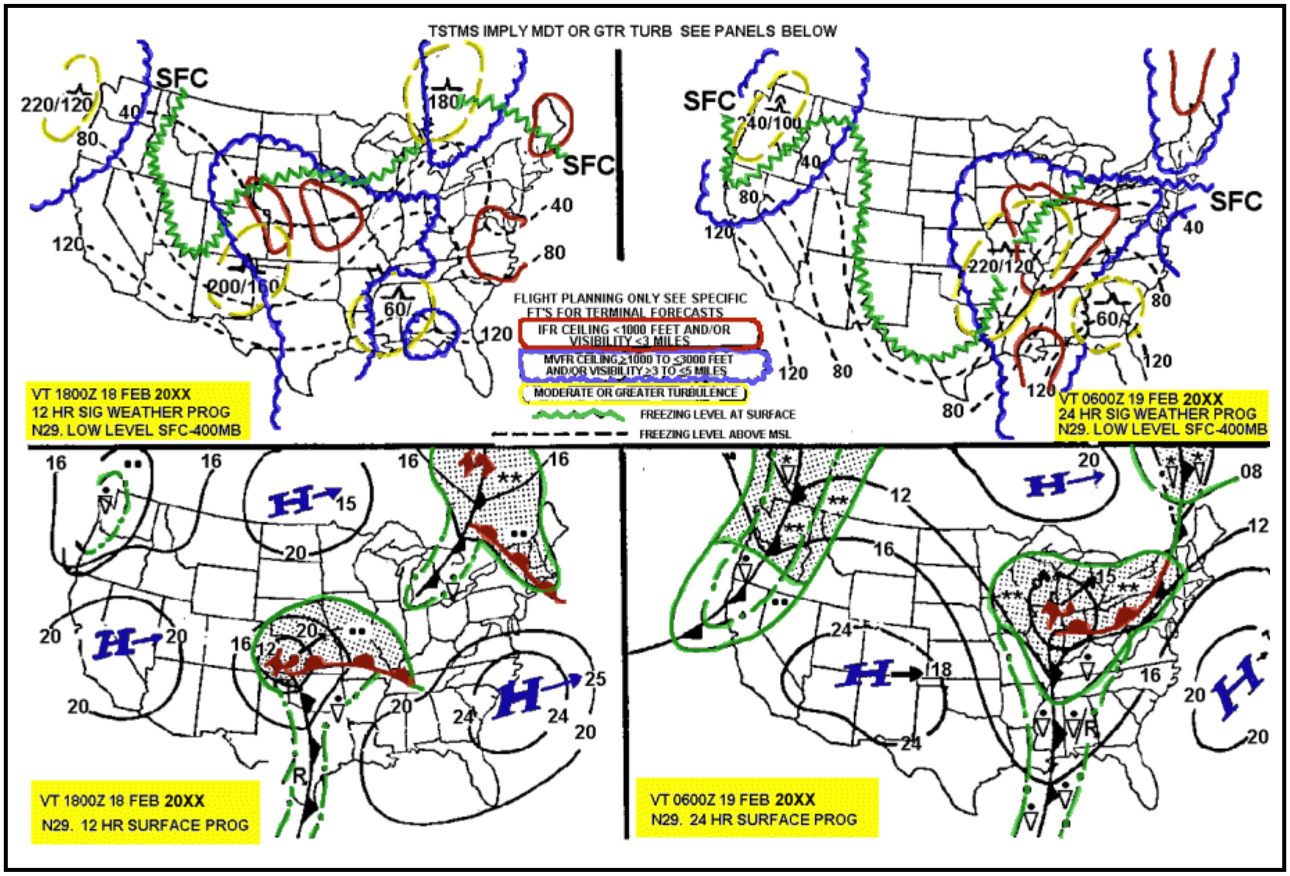


Figure 7-4 Low-Level Significant Weather Prognostic Chart

The left two panels are a 12-hour forecast, while the right two are a 24-hour forecast. The bottom two panels are a surface prognosis, as indicated in the chart label in the lower part of each panel. These indicate the conditions forecast to occur on the surface, and can be thought of as the “cause” for the top two panels, the “effect.” The top two panels show the significant weather that is a result of the forecast surface conditions, including areas of VFR, MVFR, and IFR, the locations of the freezing level, and areas of moderate or greater turbulence. Note also that the legend applies only to the top two panels, as those lines are not used in the bottom two. Each particular line will be labeled with its corresponding altitude, either “SFC” for the surface, or a 2 or 3-digit number representing the altitude in hundreds of feet MSL.

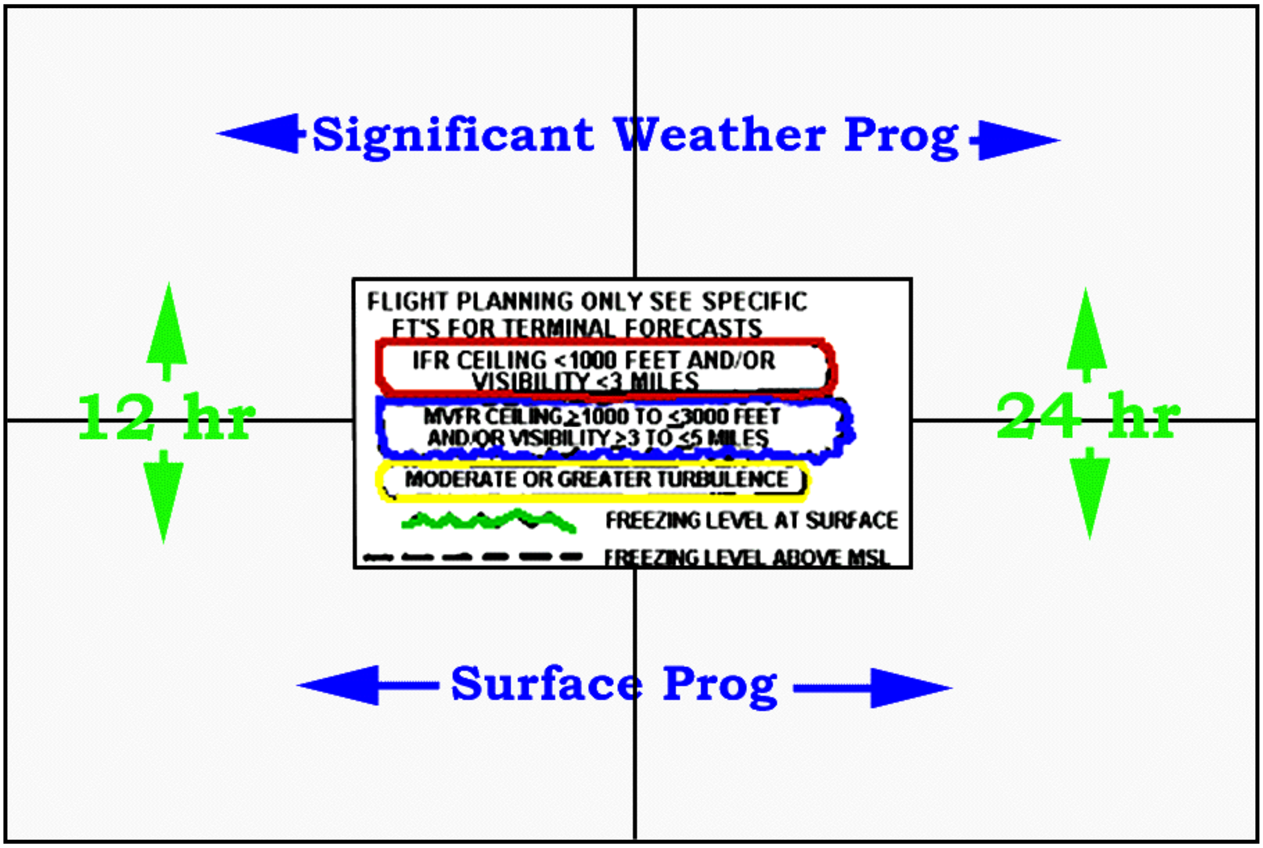


Figure 7-5 Significant Weather Prognostic Legend

The bottom two panels–the surface prognostic–use a different legend, which is shown in Figure 7-5. These lines and shadings depict the type and coverage of precipitation forecast to occur. Areas enclosed by solid lines indicate steady precipitation, while broken lines (dash-dot) indicate areas of showery precipitation. The area will be shaded if precipitation is expected to cover ½ or more of the area. If not, there will be no shading. Additionally, a symbol will be included from the present weather column of Figure 7-3 to represent the particular type of precipitation, such as rain, drizzle, or snow. A single symbol denotes intermittent precipitation, while a double symbol denotes continuous precipitation.

Turbulence

Symbols shown in an area of turbulence denote intensity (Figure 7-6). The numbers to the left of a slash (/) indicate tops of forecasted turbulence, and numbers to the right indicate the base of the forecasted turbulence in hundreds of feet MSL. No figure to the right of the slash indicates turbulence from surface upward, while absence of a figure to the left of the slash indicates turbulence above the limits of the chart (24,000 feet MSL).

Prognostic Symbols

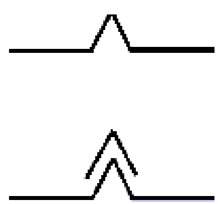
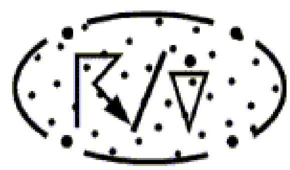
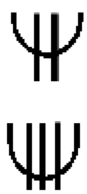
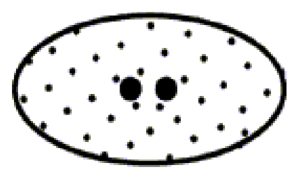
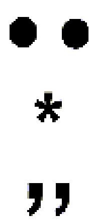
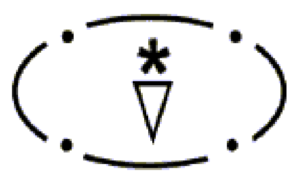
Depiction	Meaning	Depiction	Meaning
	Moderate turbulence Severe turbulence		Showery Precipitation (thunderstorms/rain showers) covering 1/2 or more of the area
	Moderate icing Severe icing		Steady Precipitation (rain) covering 1/2 or more of the area
	Continuous rain Intermettent snow Continuous drizzle		Showery Precipitation (snow showers) covering less than 1/2 of the area

Figure 7-6 Surface Prognostic Legend

Freezing Level

Freezing level height contours are drawn on the charts for every 4,000-foot interval. These contours are labeled in hundreds of feet MSL. The surface freezing level, however, is labeled SFC. If an upper level freezing contour crosses the surface freezing level line, this indicates multiple freezing levels due to an intermediate temperature inversion. Areas of structural icing are not specifically outlined on this chart, but icing can be inferred in clouds or precipitation above the freezing level.

703. RADAR SUMMARY CHARTS

The Radar Summary Chart (Figure 7-7) is a computer-produced facsimile presentation based on radar observations of echo activity (thunderstorms, rain, sleet, etc.). The Radar Summary Chart is used in flight planning to provide pilots with a pictorial display of echo activity along their planned route of flight. This chart is transmitted on a variable schedule, and the date-time group reflects the time the radar observations were taken.

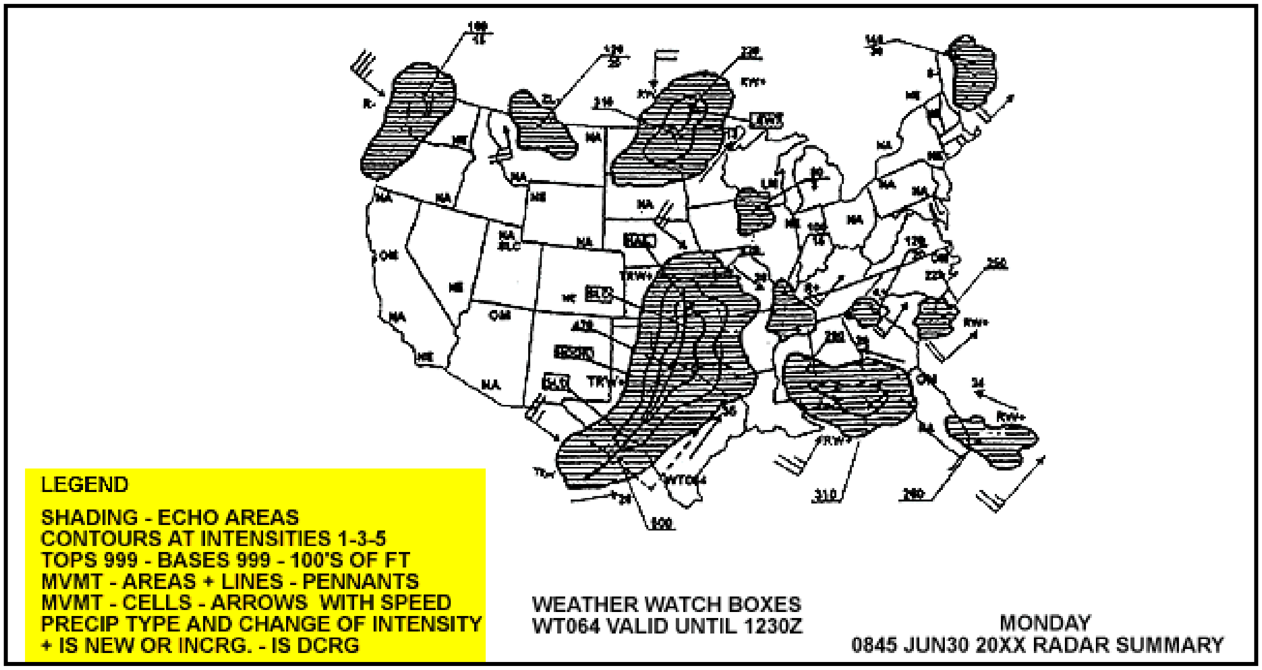


Figure 7-7 Radar Summary Chart

Graphic Display

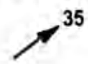
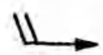
Rather than plotting each echo on the chart, the computer will outline and shade areas where echoes were observed. When echoes can be identified as forming into an apparent line, the computer will indicate this as a solid line, which could be a front or squall line. As movement of the echoes is determined, this will also be indicated on the chart in one of two ways. Individual cell movement is indicated by an arrow showing the direction and a number to indicate the knots of speed of the cell movement. Larger areas or lines of thunderstorms also may move, and their directions may be different than individual cells. Thus, different symbology is used: Area or line movement is indicated by an arrow with wind-barb notation for speed of movement. See Table 7-1 for the particular details of other data that may be displayed on the Radar Summary Chart.

VIP LEVEL	ECHO INTENSITY	PRECIPITATION INTENSITY	CONDITIONS A PILOT SHOULD EXPECT
1	WEAK	LIGHT	(SELF-EXPLANATORY)
2	MODERATE	MODERATE	MODERATE TO SEVERE TURBULENCE
3	STRONG	HEAVY	SEVERE TURBULENCE POSSIBLE AND LIGHTNING
4	VERY STRONG	VERY HEAVY	SEVERE TURBULENCE PROBABLE AND LIGHTNING
5	INTENSE	INTENSE	SEVERE TURBULENCE, LIGHTNING, HAIL LIKELY AND ORGANIZED WIND GUSTS
6	EXTREME	EXTREME	SEVERE TURBULENCE, LIGHTNING, LARGE HAIL, AND EXTENSIVE WIND GUSTS

*The numbers representing the intensity level do not appear on the chart. Beginning from the first contour line, bordering the area, the intensity level is 1-2, second contour is 3-4, and the third contour is 5-6.

SYMBOLS USED ON CHARTS

SYMBOL	MEANING
R	RAIN
RW	RAIN SHOWER
HAIL	HAIL
S	SNOW
IP	ICE PELLETS
SW	SNOW SHOWER
L	DRIZZLE
T	THUNDERSTORM
ZR, ZL	FREEZING PRECIPITATION
NE	NO ECHOES OBSERVED
NA	OBSERVATIONS UNAVAILABLE
OM	OUT FOR MAINTENANCE
STC	STC ON - *all precipitation may not be seen*
ROBEPS	RADAR OPERATING BELOW PERFORMANCE STANDARDS
RHINO	RANGE HEIGHT INDICATOR NOT OPERATING

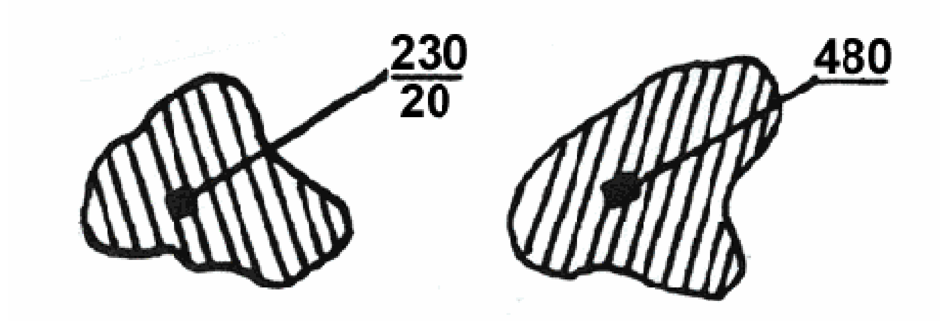
SYMBOL	MEANING
+	INTENSITY INCREASING OR NEW ECHO
-	INTENSITY DECREASING
NO SYMBOL	NO CHANGE IN INTENSITY
 35	CELL MOVEMENT TO NE AT 35 KNOTS
	LINE OR AREA MOVEMENT TO EAST AT 20 KNOTS
LM	LITTLE MOVEMENT
MA	ECHOES MOSTLY ALOFT
PA	ECHOES PARTLY ALOFT

SYMBOL	MEANING
	LINE OF ECHOES
SLD	8/10 OR GREATER COVERAGE IN A LINE
WS999	SEVERE THUNDERSTORM WATCH
WT999	TORNADO WATCH
LEWP	LINE ECHO WAVE PATTERN
HOOK	HOOK ECHO
BWER	BOUNDED WEAK ECHO REGION
PCLL	PERSISTENT CELL
FNLN	FINE LINE

Table 7-1 Key to Radar Summary Chart

Tops And Bases

The radar set can determine tops and bases of clouds. These echo tops and bases will be included on the Radar Summary Chart whenever they are available. Echo tops and bases are indicated by the format in Figure 7-8.



Indicates that average cloud echo contours are23,000 feet MSL and the average bases are 2,000' MSL.

Indicates that a cloud echo top is located here with maximum cell top at 48,000 feet MSL.

Figure 7-8 Echo Tops and Bases

Intensity Levels

As shown in Table 7-1, the levels of precipitation intensity determined by the Vertical Integrator Processor (VIP) range in value from 1 to 6 and are shown graphically by a set of up to three lines enclosing concentric shaded areas, where the middle areas have higher intensities (Figure 7-9).

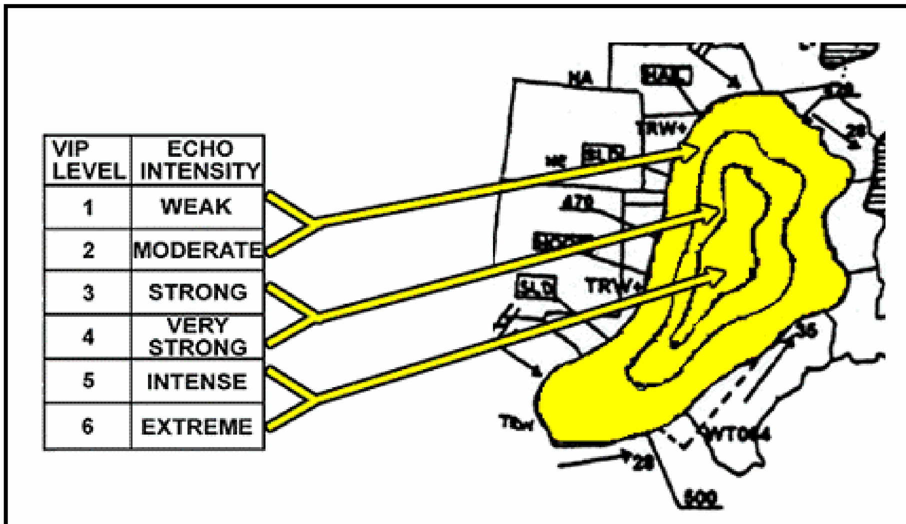


Figure 7-9 Precipitation Intensity Levels

Abbreviations

Although all abbreviations used are listed in Table 7-1, some deserve additional explanation. For example, NE is used when no echoes were observed, from available radar information. NA is used when radar information is not available, thus one cannot determine whether precipitation is present. Likewise, OM indicates that no radar information is available.

Severe Weather Boxes

When an Aviation Severe Weather Watch (WW) is in effect, the area covered will be outlined on the Radar Summary Chart by a dashed box. The valid time and number of the watch will also be shown on the chart. The letters "WT" denote a tornado watch while the letters "WS" denote a severe thunderstorm watch. This is the only forecast information displayed on the chart. This box should alert the pilot to the OPNAVINST 3710.7 or local Air Force command restrictions that apply to military aircraft in association with Severe Weather Watches (to be covered in chapter 8).

704. NEXT GENERATION RADAR (NEXRAD)

Next Generation Radar (NEXRAD) images provide an excellent source of weather information for pilots. The computer monitor image seen in a weather office is a computer-generated compilation of radar data transmitted from a radar site.

Advantages

The NEXRAD system has significant advantages over conventional weather radar systems. The resolution of the display is improved, while the displays provide meteorologists and aircrew with numerous options for presentation of a wide variety of system products. For example, Figure 7-10 is a NEXRAD display of a storm track showing the northeasterly progress of a storm in the Mobile, Alabama area.

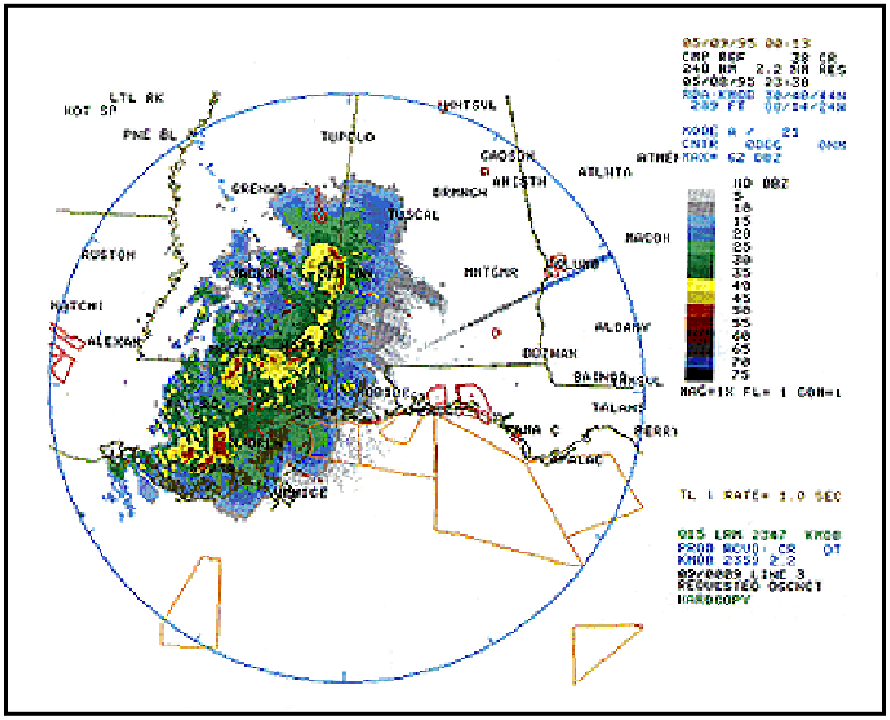


Figure 7-10 Mobile, Alabama NEXRAD Display

While older weather radar show only basic displays, the NEXRAD system can display derived products, such as composite reflectivity. This is the type of precipitation display most commonly used in flight planning. A wind profile screen can also be displayed.

Precipitation Display

NEXRAD presentations show precipitation levels in the area scanned by the radar system. The NEXRAD does not measure the rate of precipitation directly; rather, it measures the energy return from the precipitation particles. The image seen on the screen is actually a computer-generated compilation of returned energy shown in varying colors. This display is referred to as the reflectivity presentation.

The intensity of precipitation can be determined by using the graduated scale shown in the legend area of the screen (Figure 7-10). The maximum radar return strength at the time of the presentation is listed above the scale. This is measured in "dbz," or strength in decibels, of the energy received by the radar. Through use of this scale, precipitation strength can quickly be deciphered for a given area by comparing the color of the area to the color-coded legend. Higher precipitation levels are farther down the color scale. During flight planning, a pilot should carefully analyze the higher intensity areas in relation to the planned route of flight or operating area.

Other Features

Other unique features of the NEXRAD provide the capability to display areas of hail, tornadoes, wind shear, and microbursts (Figure 7-11). This type of information is particularly useful in planning a flight around known areas of potentially dangerous weather conditions.

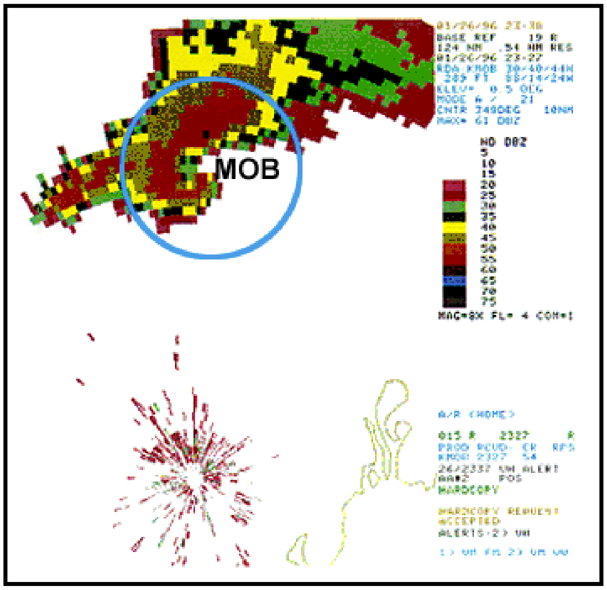


Figure 7-11 Hook Echo on NEXRAD

Hail

The structure of a storm can provide clues to the potential for hail (covered in chapter 4). Hailstorms have intense cores, generally between 2 and 5 NM in diameter, and usually begin developing at higher altitudes and descend toward the base of a storm. Very high reflectivity values (over 55 dbz) may also indicate that the precipitation is in the form of hail. Thunderstorms with strong updrafts, extensive vertical height, high liquid water content, and large cloud drop sizes are favorable conditions for the formation of hail.

Tornadoes

The NEXRAD system does not directly observe tornadic circulation; however, the system can display what is referred to as a "hook echo" that is considered indicative of a tornado (chapter 4). In Figure 7-11, a dark shaded hook echo is evident just west-southwest of MOB. This echo actually resulted in a tornado that caused severe property damage and injuries to personnel. A pilot looking at a NEXRAD display should plan around areas of red on the color-coded scale, as these are generally considered danger areas and should be avoided.

Wind Shear

A major hazard to aviation is the presence of low-level wind shear and frontline wind shear (chapter 5). Although wind shear can occur at any altitude, it is particularly hazardous when it develops over a short period of time within 2,000 feet of the ground. The primary concern for aircraft at low altitudes is a rapid change in wind direction that could affect the aircraft's handling characteristics. There are several display and data analysis options available to indicate possible wind shear.

Microbursts

Microbursts (chapter 4) are detectable by NEXRAD because of the density gradient of the descending air, the particulate matter contained therein, or both. However, because of the shallow vertical extent of the outflow from a microburst, the phenomenon will usually not be detected beyond a range of 20 NM from the radar site.

705. SATELLITE IMAGERY

For general-purpose use, there are two types of satellite imagery available. When combined they provide a great deal of information about clouds to a pilot. Through interpretation, one can determine the type and height of clouds as well as the temperature and the thickness of cloud layers. From this information, the pilot can get a good idea of possible associated weather along the planned route of flight.

Visible Imagery

One type of imagery is the visible satellite (Figure 7-12). With a visible satellite picture, we are looking at clouds and the Earth reflecting sunlight back to the satellite sensors. The greater the reflected sunlight reaching the sensors, the brighter white the object is on the picture. The amount of reflectivity reaching the sensors depends upon the height, thickness, and ability of the object to reflect sunlight. Since clouds are much more reflective than most of the earth, clouds will usually show up white on the picture, especially thick clouds. Thus, the visible picture is primarily used to determine the presence of clouds and the type of clouds from shape and texture. Due to the obvious lack of sunlight at night, there are no visible pictures available during this period.

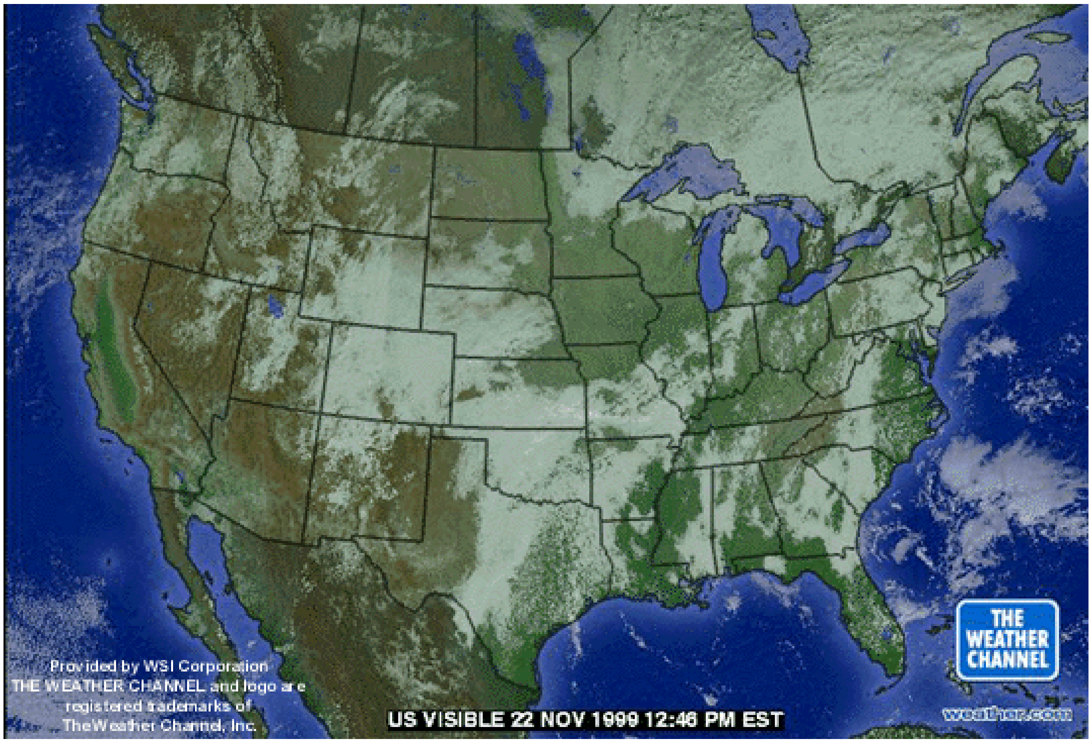


Figure 7-12 Visible Satellite Imagery

Infrared Imagery

The second type of imagery is the infrared (IR) satellite (Figure 7-13). With an IR picture, we are looking at heat radiation being emitted by the clouds and earth. The images show temperature differences between cloud tops and the ground, as well as temperature gradations of cloud tops over the surface of the Earth. Ordinarily, cold temperatures are displayed as light gray or white. High clouds appear the whitest, middle clouds appear light gray, and low clouds appear dark gray.

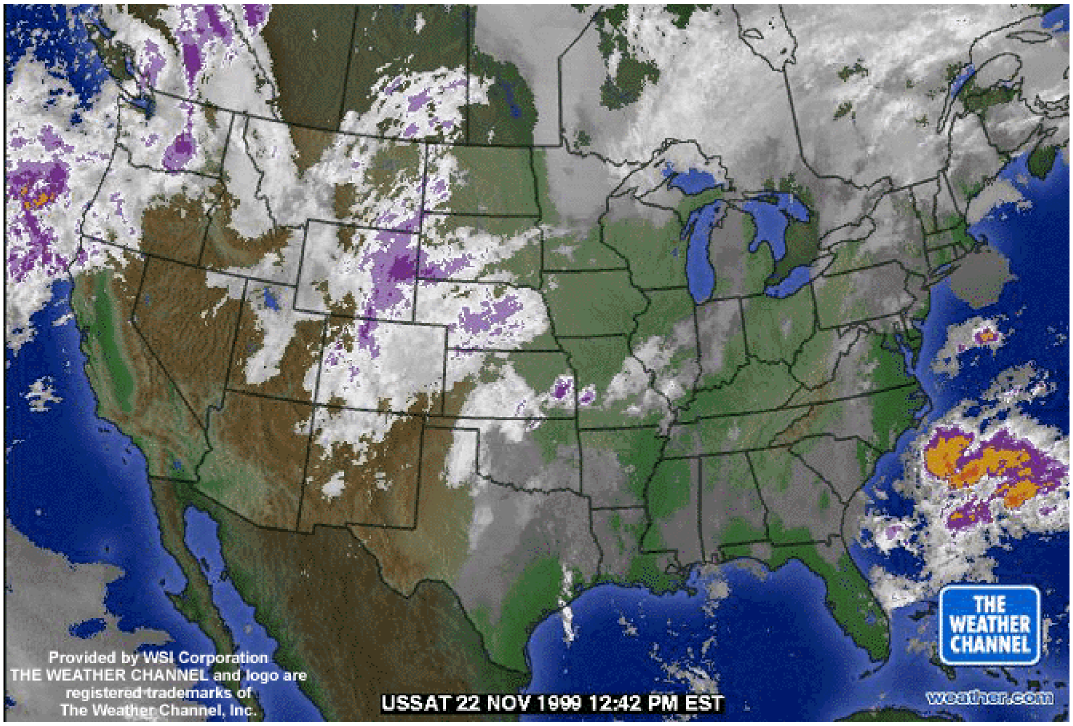


Figure 7-13 Infrared Satellite Imagery

706. WEATHER DEPICTION CHARTS

The Weather Depiction Chart is a facsimile presentation of the surface METARs, valid as of the time indicated on the chart (Figure 7-14). It is used in flight planning to determine areas of IFR/VFR and to determine the minimum ceilings en route. To help the pilot better understand the cause of low ceilings and/or poor visibilities, the chart will also include the positions of fronts from the previous hour. The station models depicted represent individual station observations, but they are different from the general station model presented in chapter 2. Because of the purpose of the chart, information presented is kept to a minimum for simplicity. Therefore, these models have no wind, temperature, or pressure, and indicate only (1) sky coverage, (2) ceilings or the height (AGL) of the lowest cloud layer (SCT or greater), (3) visibilities of 5 miles or less, and (4) weather and obstructions to visibility, each of which are described below.

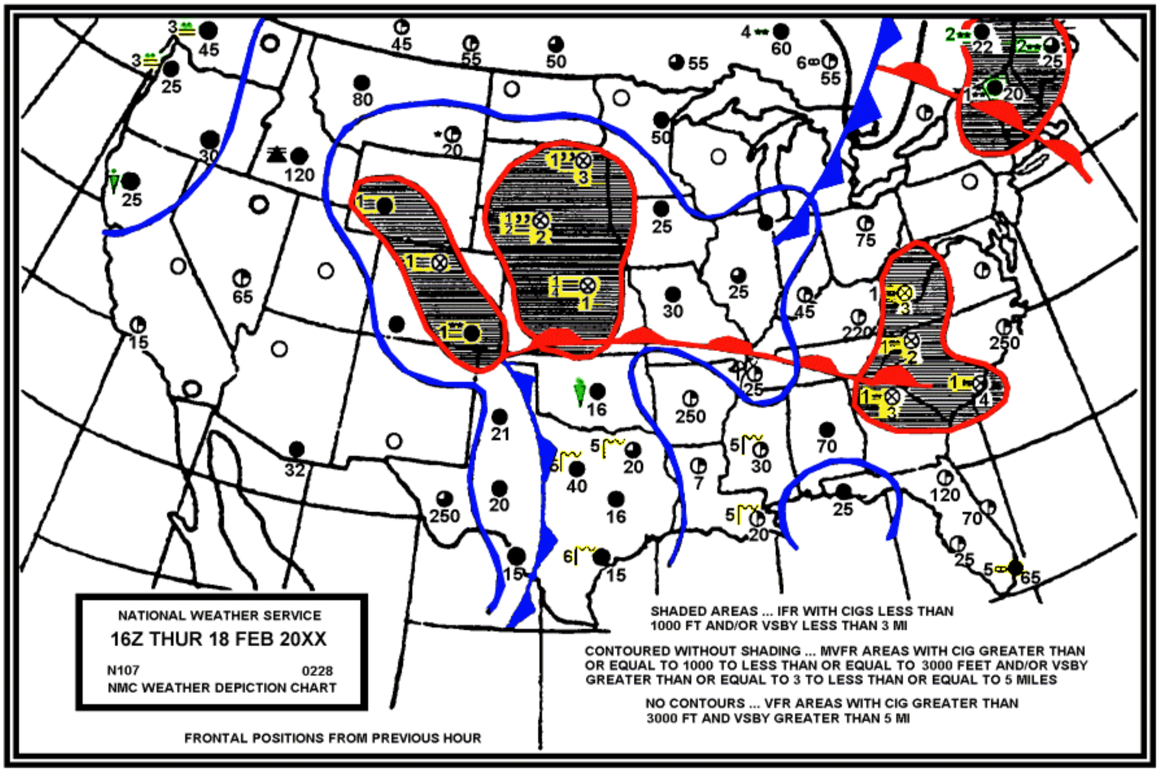


Figure 7-14 Weather Depiction Chart

Sky Cover Symbols

Total sky cover is reported in the station models of the Weather Depiction Chart using the same methods listed in Table 7-1. Additionally, a right bracket (]) to the right of the symbol indicates the METAR is from an automated station.

Ceiling Heights

The height of the sky cover is plotted in the 6 o'clock position of the station model. Heights are given in hundreds of feet AGL. Recall the definition of a ceiling from chapter 5, because it also applies to the Weather Depiction Chart. If the sky cover is broken or overcast, or if the sky cover is an obscuration, the height will represent the height of the ceiling. If the sky cover is scattered, the height represents the height of the lowest scattered layer of clouds. When a broken or greater sky cover is plotted without a height entry, the clouds are thin. If an obscuration is plotted without a height entry, it indicates a partial obscuration.

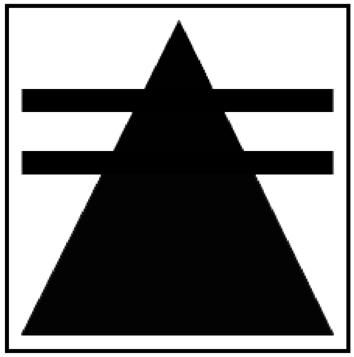


Figure 7-15 Clouds Topping Ridges Symbol

Visibilities and Obstructions to Vision

Visibilities of 5 statute miles or less will be entered at the 9 o'clock position of the station model and will be indicated in miles and fractions of miles. Visibility of greater than 5 statute miles will be omitted. Precipitation and obstructions to vision will follow the visibility, using the same weather symbols as presented in Table 7-1. When several types are occurring simultaneously, only the most significant one or two types will be entered. One symbol unique to the Weather Depiction Charts is used when clouds are topping the ridges of mountains, as shown in Figure 7-15.

Legend

In addition to the frontal symbols on the Weather Depiction Chart, three areas associated with ceilings and visibilities are also depicted by a set of lines and shadings. The legend on the lower right-hand corner of the chart describes each of these three areas, which is summarized in Figure 7-16. A solid line enclosing a shaded area indicates IFR conditions: ceilings below 1,000 feet and/or visibilities below 3 miles. A line enclosing an unshaded area indicates marginal VFR (MVFR) conditions: ceilings between 1,000 and 3,000 feet and/or visibility between 3 and 5 miles. The portion of the chart that is not enclosed by lines–shaded or unshaded–indicates VFR conditions: ceilings of greater than 3,000 feet and visibilities over 5 miles.

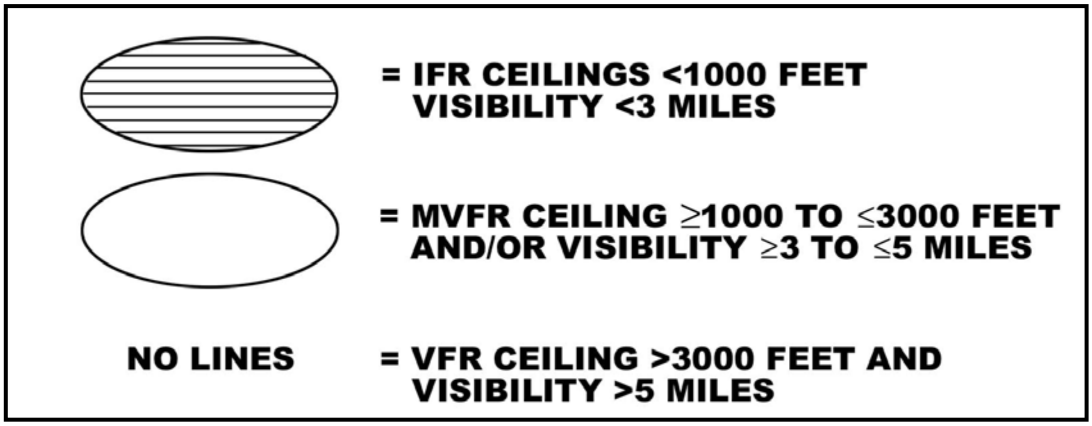


Figure 7-16 Weather Depiction Chart Legend

Color Coding

Weather Depiction Charts are sometimes color-coded by personnel in USN/USMC weather offices. IFR areas are colored RED and MVFR areas are colored BLUE. This color-coding gives the pilot a quick indication of areas of observed IFR weather and MVFR weather.

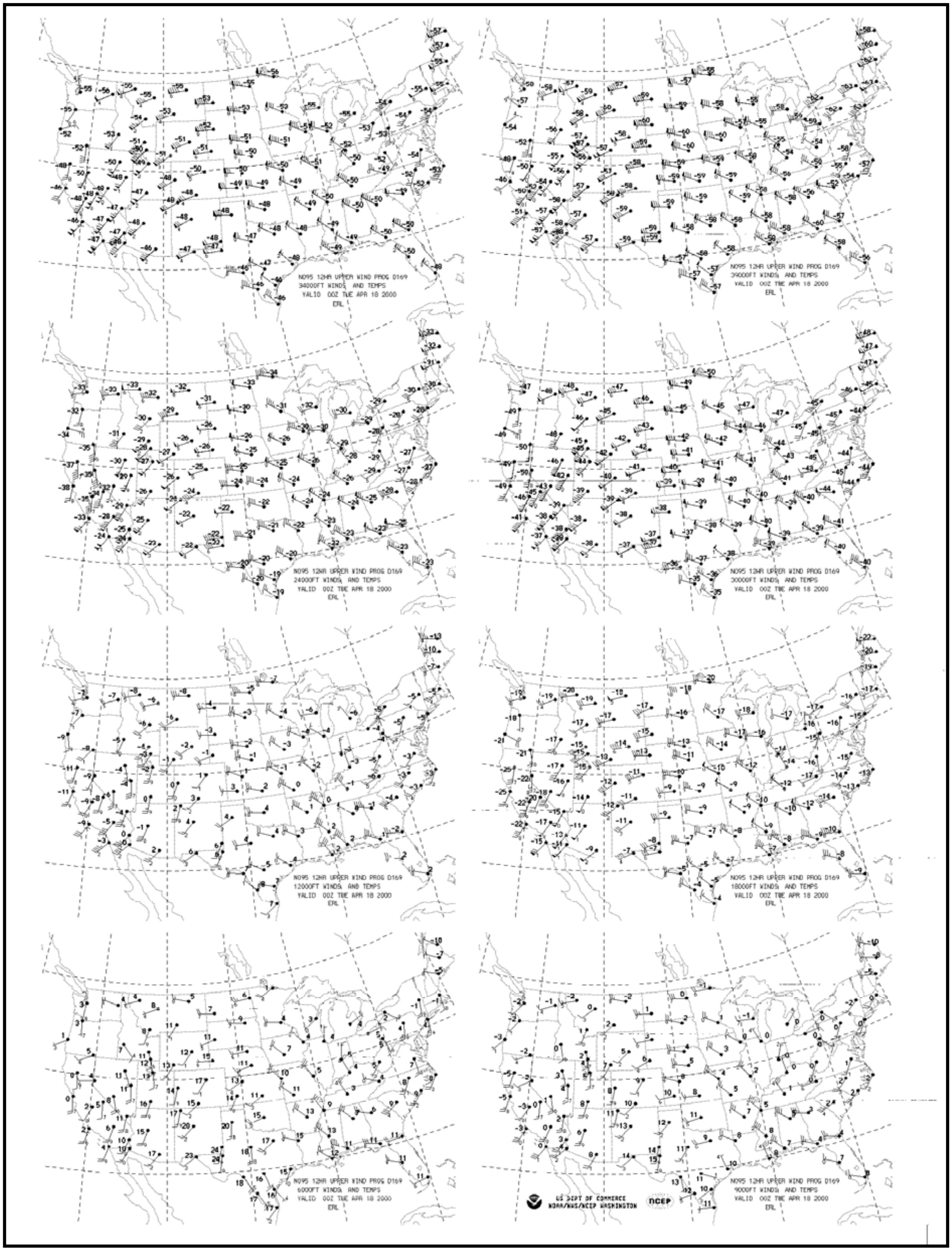


Figure 7-17 Winds-Aloft Prognostic Charts

The Winds-Aloft Prognostic Charts (Figure 7-17, preceding page) are facsimile presentations that present the average forecast flight level winds and temperatures aloft, in whole degrees Celsius. These charts are computer constructed and are transmitted by the Weather Bureau two times daily–at 1200Z and 0000Z.

These charts are constructed for a range of eight altitudes within the continental United States and are displayed in a series of eight panels, one for each altitude: 6, 9, 12, 18, 24, 30, 34, and 39 thousand feet. The first three altitudes (below 18,000' MSL) are true altitudes, but for 18,000 feet and above, the altitudes given are simply more useful approximations for the pressure altitudes at which the winds and temperatures were actually measured (18,000 = 500 mb, 24,000 = 400 mb, 30,000 = 300 mb, 34,000 = 250 mb, and 39,000 = 200 mb).

Station Models in Winds-Aloft Prognostic Charts

Winds-Aloft Prognostic Charts use station models to show forecast wind speed, direction, and temperature for a given location. Much like the station models used in Weather Depiction Charts, these models are customized from the detailed models presented in chapter 2 in order to simplify the chart, presenting only the relevant information. As depicted in Figure 7-18, wind speed and direction is plotted in the same manner as the basic station model. The station itself, however, is simply a filled-in circle, and in some versions of the chart, the station circle is left off completely (Figure 7-19, next page). Since temperature is the only other data needed, it is shown adjacent to the station circle (or at the base of the wind shaft) in whole degrees Celsius.

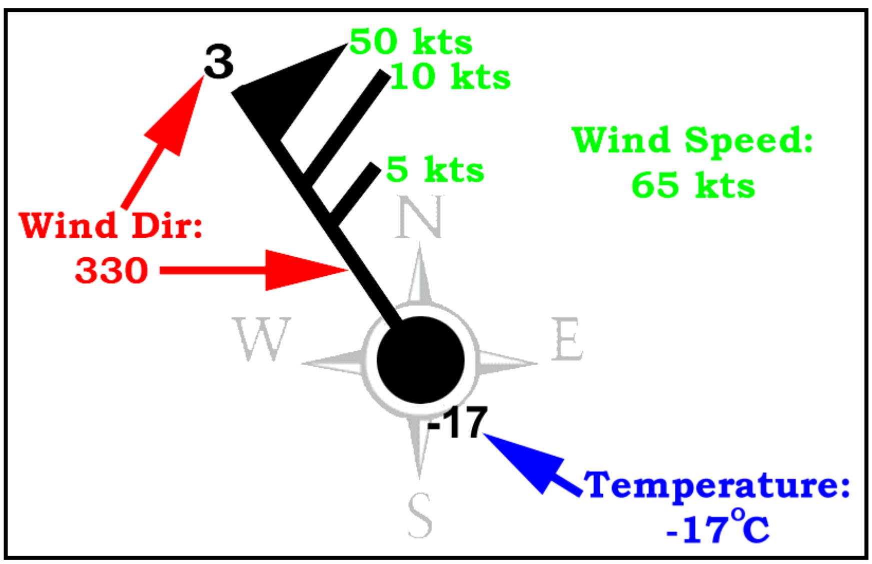


Figure 7-18 Winds-Aloft Prognostic Chart Station Model

Because wind is the main purpose of the chart, the tens digit of the actual wind direction, rounded to the nearest ten degrees, is given at the speed-end of the wind symbol. Thus, with the shaft indicating the general direction or quadrant, the specific direction can be easily determined, as shown in Figure 7-18. A "99" to the lower left of the station circle with no wind shaft would indicate calm or light and variable winds.

Valid Time

The computer constructs the Winds-Aloft Prognostic Charts based on observed winds and temperatures recorded at a particular valid time. Figure 7-19 shows four panels with enlarged legends for easier viewing. These charts represent forecast winds and temperatures for a *specific* time, rather than a period of time. Since wind speeds generally change slowly in the upper atmosphere, these winds and temperatures are considered to be representative forecast averages until the next set of charts is received. Therefore, the information shown is theoretically accurate for the valid time of the chart only.

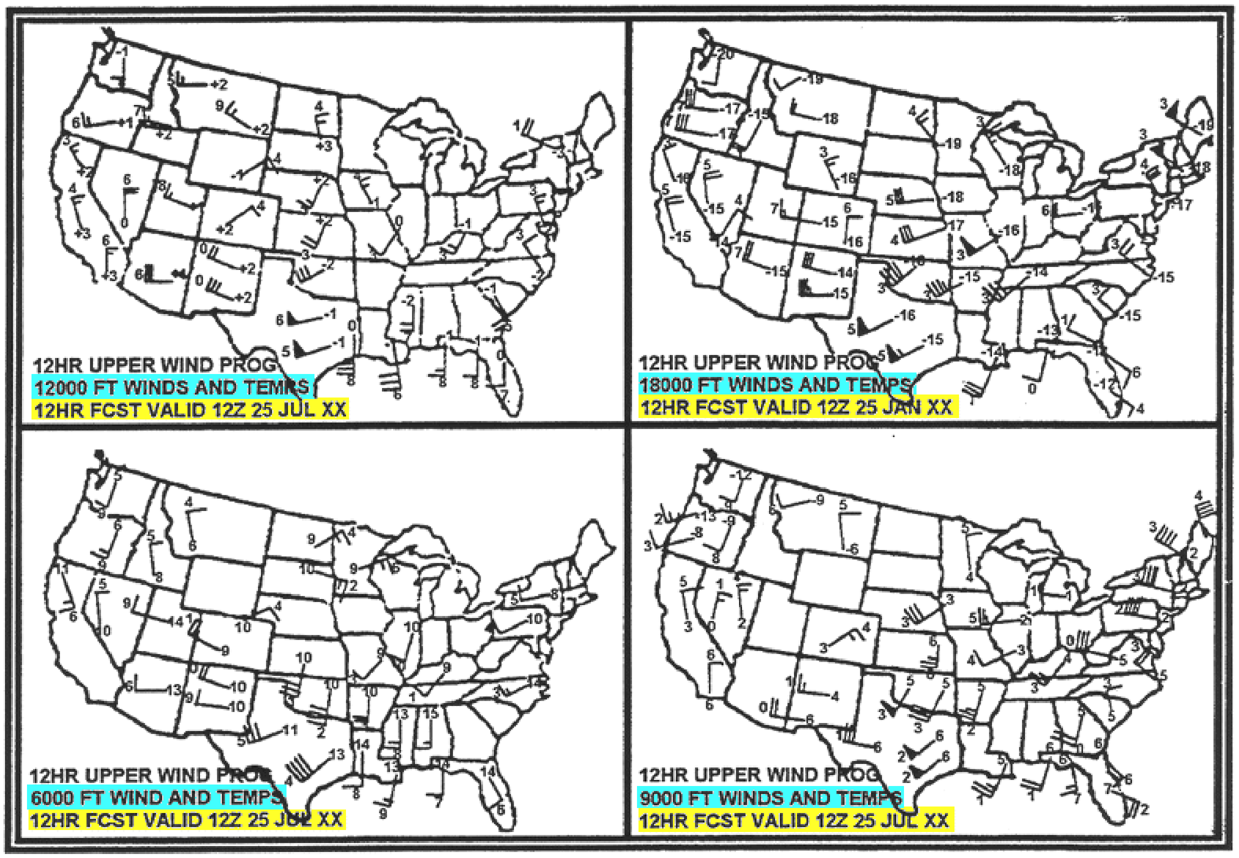


Figure 7-19 Legend of Winds-Aloft Prognostic Charts

707. WINDS-ALOFT FORECASTS

Winds-Aloft Forecasts are teletype forecasts of upper winds and temperatures for selected stations within the continental United States (Figure 7-20). They are transmitted twice a day and the teletype identifier "FD" appears in the heading. Additionally, they are broken into two segments. Each segment gives a valid time and a for-use time (the forecast period) at the beginning of each segment; the total forecast is usable for a period of 15 hours. The forecast represents conditions both as they should occur specifically at the valid time and also the average conditions as they should occur during the for-use time.

FDUS1 KWBC 180545Z
DATA BASED ON 180000Z

VALID 181200Z FOR USE 0600Z - 1500Z, TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
JAX	1008	1005+08	9900+04	9900-01	3016-15	3027-28	305042	296749	296552
TLH	1110	1207+09	9900+04	9900+00	2816-14	2832-26	295641	297049	296653
PIE	1113	1110+09	1007+05	9900+00	3118-13	3037-26	306040	296948	296252
MIA	1118	1218+10	1010+06	0505+02	3222-13	3141-25	306040	306147	304852
TRI		3010+05	2920+00	2931-05	2946-18	2953-30	297044	298852	299156
GRW	1615	1914+08	2216+03	2421-03	2632-17	2639-29	276243	289052	289557
MEM	1723	1925+09	2024+04	2124-02	2429-16	2537-28	265942	268351	269256
LIT	1829	2034+10	2033+04	2131-02	2333-16	2443-28	256242	258650	750056
SGF	1732	2038+09	2038+04	2136-03	2337-17	2446-29	246644	259851	751357
OKC	1730	1940+11	2043+05	2142-01	2245-01	2358-28	237843	730450	732055
AMA		1925	2140+05	2146-03	2156-18	2271-30	229244	721551	721553

VALID 181800Z FOR USE 1500-2100Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
JAX	1512	1611+08	1708+04	1705-01	2913-14	3029-26	315641	317249	316743
TLH	1514	1614+08	1712+04	1811-01	2716-14	2934-25	295639	306547	296354
PIE	1313	1513+09	1511+04	1408+00	3012-13	3035-24	315938	316647	306053
MIA	1017	1219+09	1113+05	0909+01	3317-12	3241-24	326339	316546	315251
TRI		2411+06	2618+01	2827-04	2841-17	2847-29	286744	299452	790256
GRW	1822	2028+12	2128+06	2226-03	2532-17	2642-28	275943	278649	770856
MEM	1828	2134+10	2133+05	2133-02	2335-16	2546-27	266342	268748	761456
LIT	1832	2142+10	2141+04	2139-02	2241-16	2453-27	257141	259348	751756
SGF	1835	2144+10	2145+04	2145-02	2248-17	2359-28	247543	259549	751556
OKC	1832	2044+11	2149+05	2149-02	2256-17	2273-28	239241	730548	731154
AMA		2026	2242+02	2247-06	2258-21	2278-30	710243	721049	229951

Figure 7-20 Winds-Aloft Forecasts

Wind Coding/Decoding Rules

While the Winds-Aloft Forecast may seem like nothing more than a bunch of numbers, it presents wind information similar to that found in Winds-Aloft Prognostic Charts in an organized series of four- or six-digit groups. The left column lists the reporting station, and the top row lists the corresponding altitudes for which wind and temperature data are given, referenced to feet MSL.

Wind information on the Winds-Aloft Forecast is given with a series of four digits. The first two represent the true wind direction to the nearest ten degrees true, and the last two digits represent the speed in knots. For example, 2435 indicates a wind from 240 °T at 35 knots.

For most altitudes, the temperature follows the wind information in a set of two digits that may or may not include a sign for positive or negative. For example, 2435+07 indicates the wind will be 240 °T at 35 knots with a temperature of +7 °Celsius. Notice that all temperatures are negative above 24,000 feet as indicated in the heading information by the phrase "TEMPS NEG ABV 24000." At these altitudes, all the digits are run together, eliminating the redundant minus sign between the wind and the temperature. For example, 274650 forecasts a wind from 270 °T at 46 knots with a temperature of –50 °Celsius.

Special Circumstances

The above procedures are used for all "normal" wind information; however, there are exceptions for unusual wind conditions. A direction of “99” indicates a variable wind direction. When forecast wind speeds are less than 5 knots, direction is difficult to determine, and the winds are called “light and variable,” and the code “9900” will be listed.

When a wind speed of 100 knots or greater is forecast, the simple four-digit wind code no longer works satisfactorily and an additional set of rules is used. For example, if the winds are forecast to be 230 at 145 knots, the normal code would require five digits, requiring a change to the format of the entire Winds-Aloft Forecast. Therefore, if you see a direction that would translate to be greater than 360 °T, it was not a mistake; it is this extra rule. The wind was encoded by adding 500° to the direction and subtracting 100 knots from the speed, thus requiring a total of only four digits again. To decode such winds, then, one must subtract 50 from “unrealistic” direction codes and add 100 to the indicated speed. For example, a code of 7345 would forecast winds of 230 °T at 145 knots. If winds are forecasted to be 200 knots or greater, the wind group is coded as 199 knots. For example, 8299 would be decoded as 320 °T at 199 knots or greater.

Additionally, it is sometimes impractical to forecast the temperature and wind. This is particularly true for conditions near the surface, where the temperature is more likely to deviate from the standard lapse rate, and where the winds are more likely to be gusty and variable due to thermal or mechanical turbulence. So, for the following conditions, wind and temperature are omitted from the Winds-Aloft Forecast.

1. Wind information is never forecast for altitudes within 1,500 feet of the surface.
2. Temperature information is never forecast within 2,500 feet of the surface.
3. Temperature information is never forecast for the 3,000-foot level.

708. FLIGHT ALTITUDE SELECTION

Pilots planning a flight can use winds-aloft information to their advantage. When the wind appears to be a tailwind component, they should generally try to take advantage of the situation by filing for an altitude with the fastest wind speed. When the wind would be a headwind component, they should generally try to minimize the disadvantage by filing for an altitude with the least wind speed. However, they must keep in mind several other factors and potential hazards that may influence the selection of an altitude such as: clouds at flight level, visibility at flight level, icing and the minimum freezing level, thunderstorms, turbulence, and precipitation.

For general planning purposes, Winds-Aloft Prognostic Charts are the most useful, as they give a pictorial representation of the winds. They can quickly narrow the search for generally favorable winds, or provide a fast solution to finding an alternate route that avoids unfavorable winds. The FDs may also be consulted as additional information in selecting the best particular altitude for which to file the flight plan, or when the Winds-aloft Prognostic Charts are not available. Often, the wind information will not be forecast for the exact altitude for which a pilot may wish to file. In this case, one must interpolate to find the desired information.

STUDY QUESTIONS

Data Displayed on Weather Imagery Products

1. Which one of the following would NOT be found on a Surface Analysis Chart?

    a. Fronts
    b. Station models
    c. Areas of moderate or greater turbulence
    d. Isobars

2. Which one of the following is a true statement about the Surface Analysis Chart?

    a. It transmits teletype information describing observed weather for use by meteorologists and aircrew.
    b. The chart is used by pilots to obtain an overall facsimile picture of forecast weather.
    c. The chart is a computer-produced facsimile presentation based on radar observations of echo activity.
    d. The information displayed on the Surface Analysis Chart is observed weather and is NOT a forecast.

3. What would a square indicate on a station model plot?

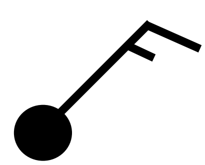
    a. An automated station has reported the depicted weather.
    b. A manned station has reported the depicted weather.
    c. The sky condition indicated constitutes a ceiling.
    d. Ice pellets have been observed on the Surface Analysis Chart.

4. Where is the temperature data located on a Surface Analysis Station Model Plot?

    a. Left side
    b. Right side
    c. Bottom
    d. Temperature cannot be indicated by Station Model Plots

5. What type of winds would be indicated by the following Station Model Plot?

    a. Northwest winds at 15 knots
    b. Northeast winds at 15 knots
    c. Southwest winds at 15 knots
    d. Southwest winds at 55 knots



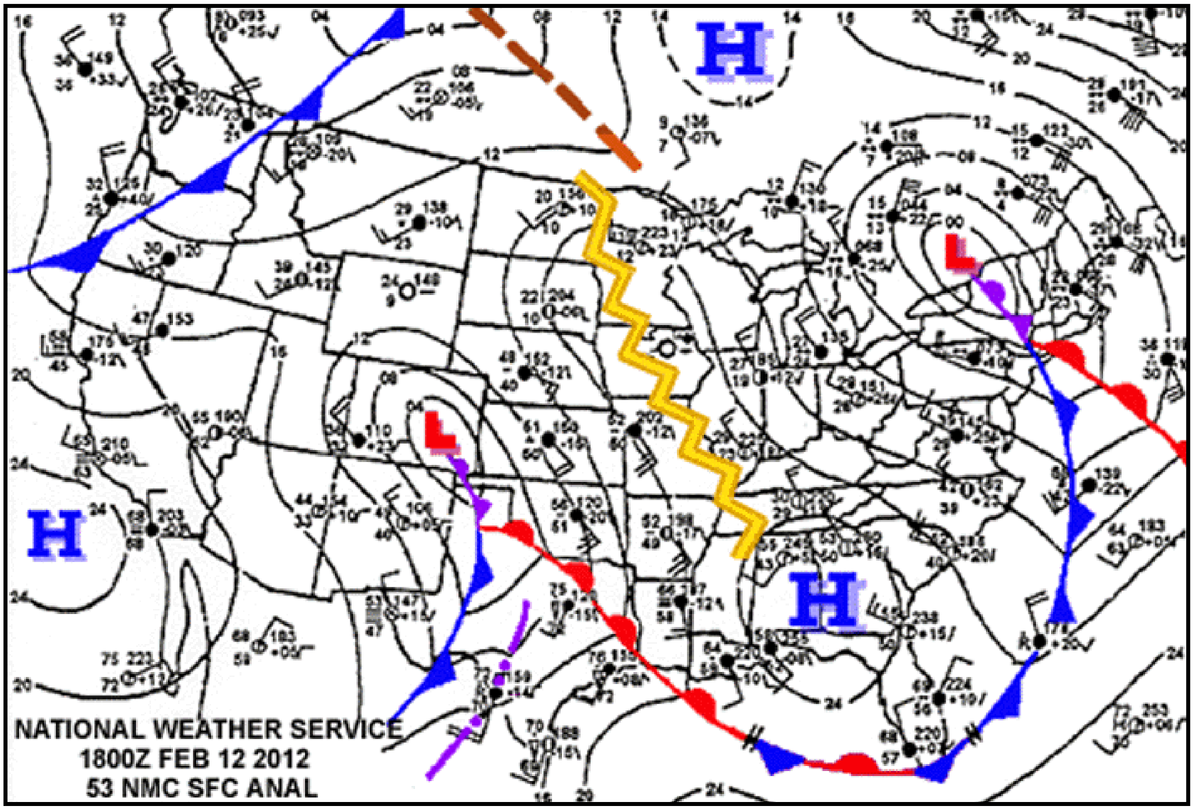


Figure 7-21 Surface Analysis Chart for Questions 6 - 9

6. The Pensacola area is under the influence of __________ pressure.

   a. Steep
   b. High
   c. Low
   d. Moderate

7. The sky cover in California is predominantly

   a. clear.
   b. scattered.
   c. broken.
   d. overcast.

8. The line symbol in southern Canada extending west-northwest to east-southeast is called a __________, and the line symbol from Minnesota south-southeast to western Tennessee is called a __________.

   a. warm front, cold front
   b. occlusion, front
   c. trough, ridge
   d. ridge, trough

9. Which one of the following weather products could be used to determine areas of forecast IFR weather?

   a. Surface Analysis Chart
   b. Low Level Significant Weather Prognostic Chart
   c. Visible Satellite Imagery
   d. Winds-Aloft Forecasts

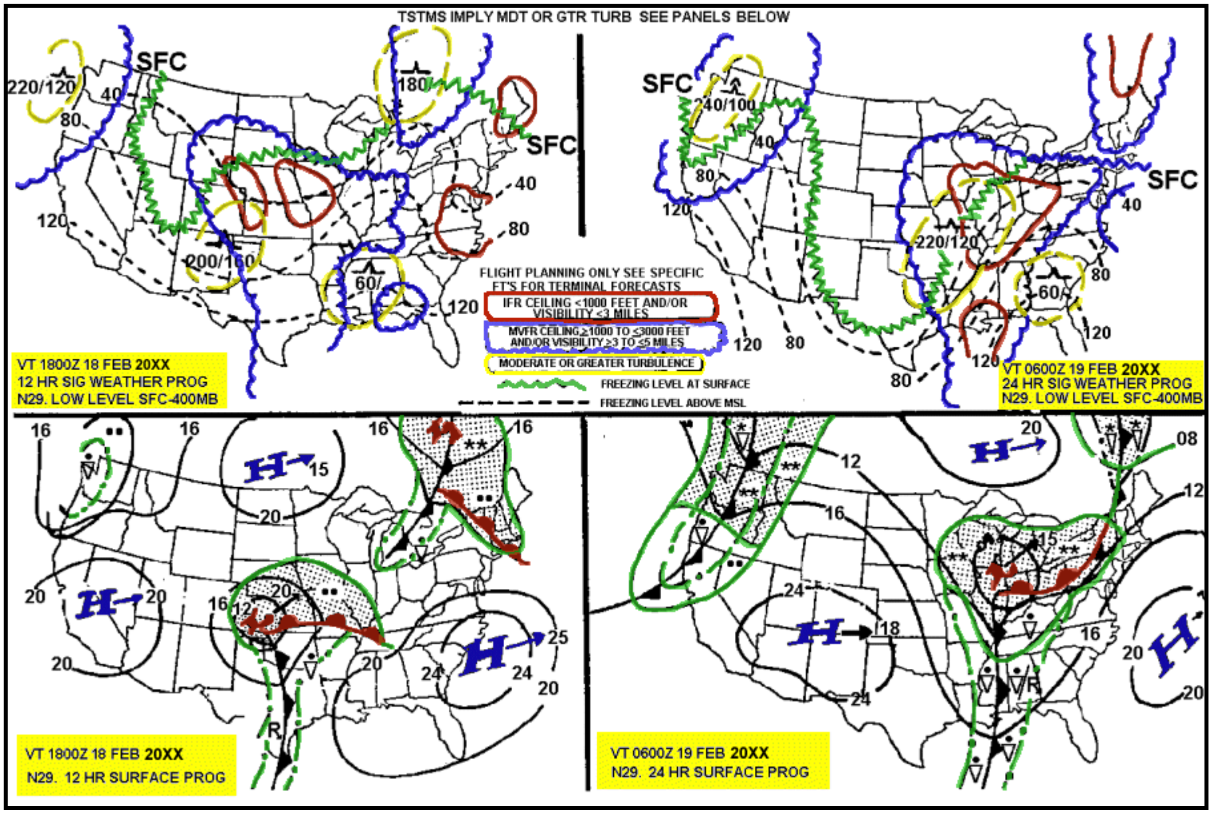


Figure 7-22 Low Level Significant Weather Prognostic Chart for Questions 10 - 13

10. Which panel of the Low Level Significant Weather Prognostic Chart shows the 24-hour significant weather forecast?

    a. Upper left
    b. Upper right
    c. Lower left
    d. Lower right

11. What type of weather is forecast to occur over the state of Michigan in 24 hours?

    a. Showery precipitation covering over half the area
    b. Showery precipitation covering less than half the area
    c. Steady precipitation covering over half the area
    d. Steady precipitation covering less than half the area

12. What does the dashed line circling Louisiana, Mississippi, and Alabama indicate for flight conditions in the next 12 hours?

    a. IFR conditions, with ceilings of 600 feet and visibilities of zero
    b. Widespread MVFR, with ceilings less than 3,000 feet and visibility less than 5 miles
    c. Moderate turbulence from the surface to 6,000 feet.
    d. Rain showers and thunderstorms

13. Which one of the following flight conditions could be expected during a flight over Illinois at 0600Z?

a. Moderate turbulence
b. IFR
c. Steady precipitation
d. All of the above

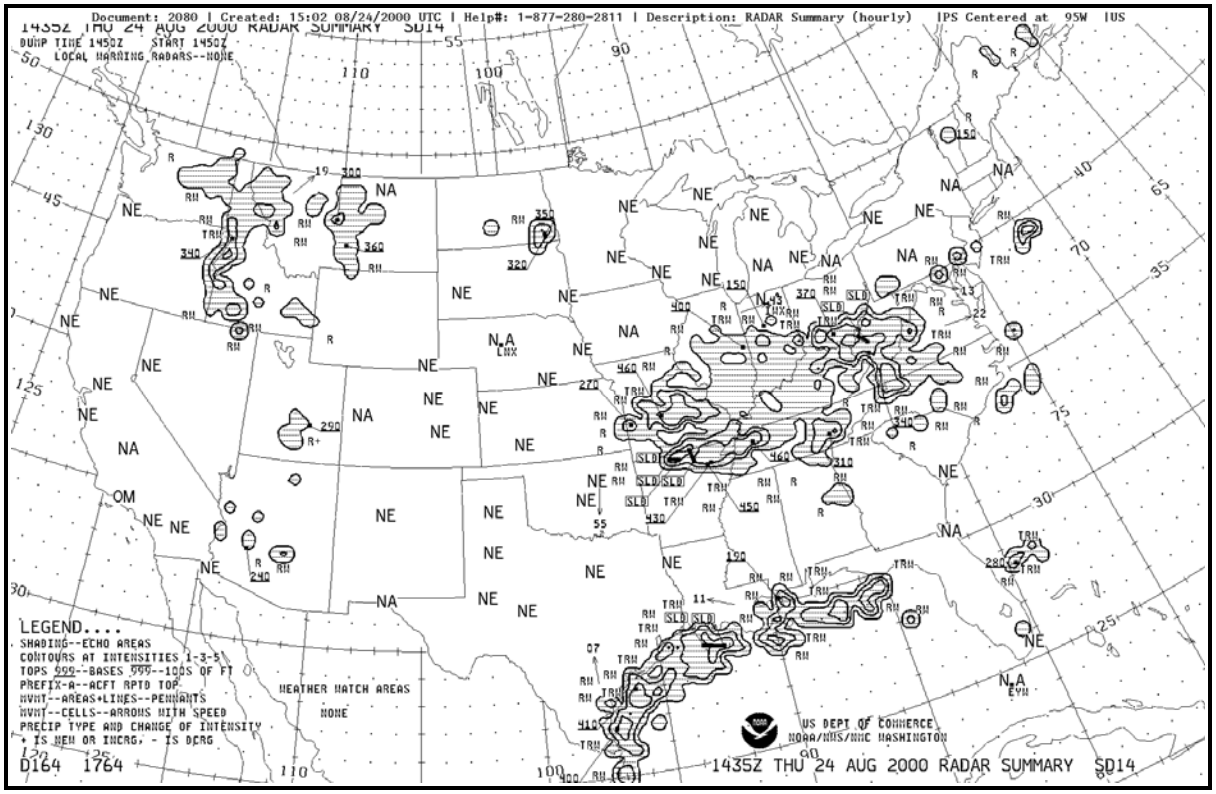


Figure 7-23 Radar Summary Chart for Questions 14 – 17

14. Which one of the following symbols would be used on a Radar Summary Chart to indicate a thunderstorm cell moving to the east at 20 knots?

a. **HOOK**

b.  **20**

c. 

d. **ROBEPS**

15. What are the maximum tops of the echoes reported over western Tennessee?

a. 31,000' MSL
b. 43,000' MSL
c. 45,000' MSL
d. 46,000' MSL

16. The area of echoes over Utah is precipitation that consists of ________ that is __________ in intensity during the last hour?

    a. rain, increased
    b. rain showers, moved 290° T
    c. rain showers, built to level 3
    d. rain, decreased

17. The area north of Los Angeles, California, could expect no echo activity. True or False, and why?

    a. False. The echoes over Arizona are moving quickly to the west.
    b. True. There are no echoes indicated on the chart.
    c. False. The radar stations are out for maintenance or observations are unavailable.
    d. True. It's Southern California; it never rains there.

18. Which one of the following weather products may be used to identify areas where an Aviation Severe Weather Watch is in effect?

    a. Low Level Significant Weather Prognostic Chart
    b. Radar Summary Chart
    d. NEXRAD
    c. Weather Depiction Chart

19. Which one of the following weather products would NOT be helpful in determining the intensity of a severe thunderstorm?

    a. Radar Summary Chart
    b. NEXRAD
    c. IR Satellite
    d. Weather Depiction Chart

20 Which one of the following weather phenomena is NOT normally determined by using NEXRAD?

    a. Formation of a tornado
    b. Intensity of precipitation
    c. Height of cloud tops
    d. Differential wind speeds

21. A/an ______________ shows sunlight reflected from clouds and the Earth.

    a. visible satellite image
    b. infrared image
    c. NEXRAD display
    d. water vapor satellite image

22. Which one of the following would give the brightest return on a satellite image?

    a. The ocean
    b. Low clouds
    c. The clouds that are higher relative to the others
    d. The clouds that are warmer relative to the others

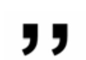
23. The Weather Depiction Chart is a

    a. teletype presentation of TAFs, valid for the period indicated in the heading in the lower left-hand corner of the chart.
    b. flight planning tool used by pilots that depicts wind data and frontal locations.
    c. forecast representation of the Surface Analysis Chart.
    d. facsimile presentation of the surface METARs, valid as of the time indicated on the chart.

24. The Weather Depiction Chart will not indicate visibility if

    a. the airfield is IFR.
    b. visibility is reduced to 5 statute miles or less.
    c. visibility is greater than 5 statute miles.
    d. obstructions to visibility are indicated.

25. Which one of the following symbols is unique to the Weather Depiction Chart?

a. 

b. 

c. 

d. 

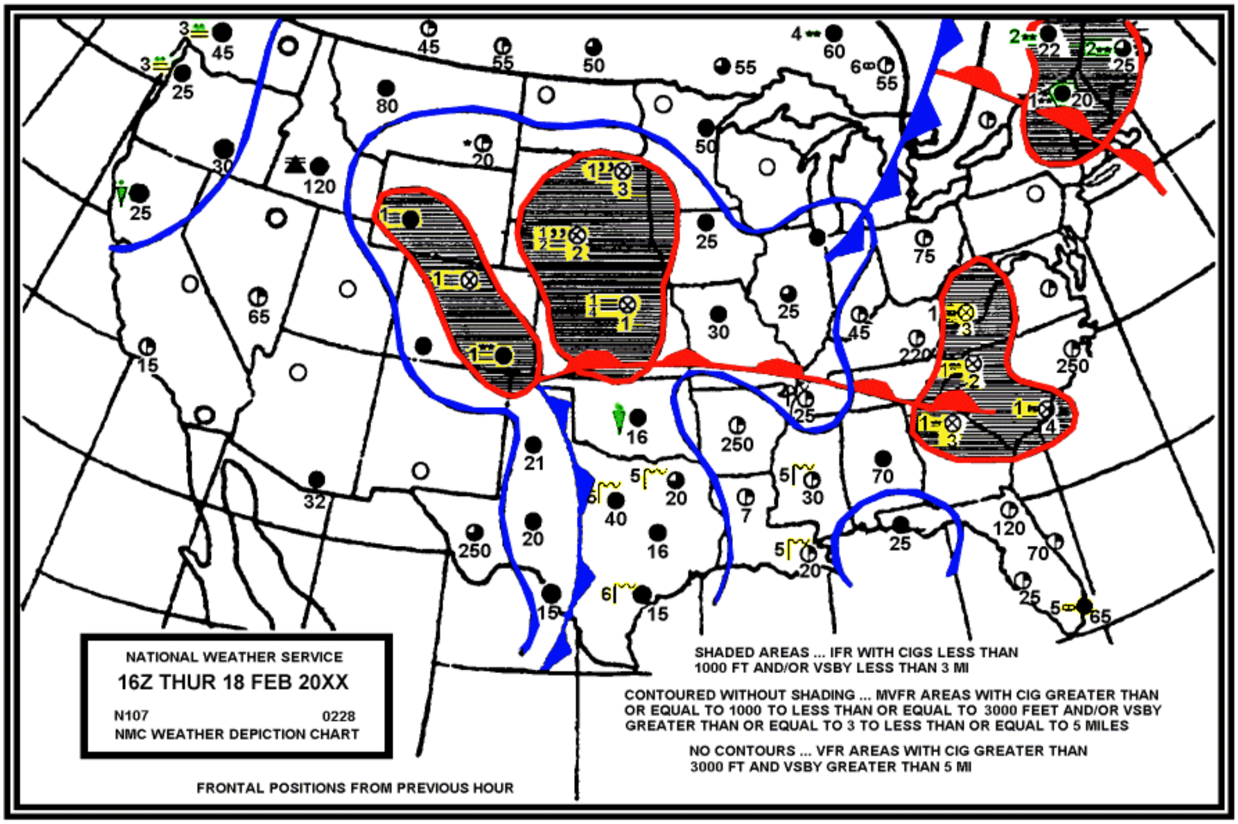


Figure 7-24 Weather Depiction Chart for Questions 26 - 29

26. The area from West Virginia to Georgia is under __________ conditions due to __________ skies and __________.

a.	IFR, obscured, fog	c.	warm front, dark, visibility zero
b.	VFR, scattered, smoke	d.	MVFR, overcast, visibility > 5 miles

27. What is the reported visibility in northwest Florida and Alabama?

a.	Zero	c.	5 miles
b.	2.5 miles	d.	Greater than 5 miles

28. What type of cloud cover is reported in southern Nevada?

a.	Scattered	c.	Overcast
b.	Broken	d.	Obscure

29. What is the height of the cloud cover reported in southern Nevada?

a.	65’ AGL	c.	6,500’ MSL
b.	650’ MSL	d.	6,500’ AGL

30. Which one of the following is a graphic representation of the winds observed at various flight levels?

    a. Weather Depiction Chart
    b. Winds-Aloft Forecast
    c. Winds-Aloft Prognostic Chart
    d. Doppler Radar Summary

31. Which one of the following correctly lists the data presented on a Winds-Aloft Prognostic Chart?

    a. Wind speed, wind direction, air temperature at altitude
    b. Wind speed, wind direction, surface temperature and dew point
    c. Wind speed and direction, sky cover, present weather
    d. Wind speed and direction, areas of turbulence, location of freezing level

32. How long is the forecast period for a Winds-Aloft Prognostic Chart?

    a. 6 hours
    b. 12 hours
    c. 24 hours
    d. The Winds-Aloft Prognostic Chart is technically not forecast for a period; it is accurate for the valid time only.

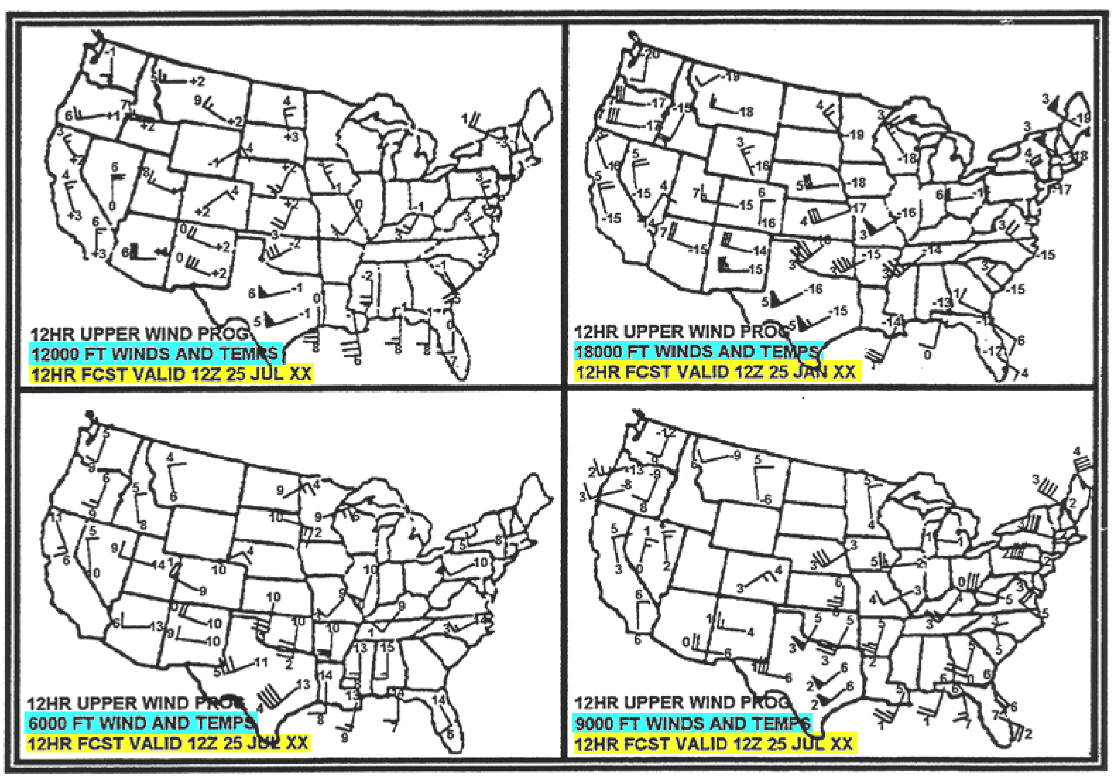


Figure 7-25 Winds-Aloft Prognostic Chart for Questions 33 - 34

33. Which one of the following altitudes would provide the most favorable winds for a flight from San Francisco to Los Angeles, California?

    a. 6,000
    b. 9,000
    c. 12,000
    d. 18,000

34. What are the winds and temperatures as plotted on the 9,000-foot chart over southeastern Texas?

    a. 060° at 50 knots, 2 °C
    b. 250° at 55 knots, –15 °C
    c. 220° at 50 knots, 6 °C
    d. 260° at 50 knots, 2 °C

35. Winds-Aloft Forecasts are

    a. facsimile presentations that present the average forecast winds and temperatures aloft, in whole degrees Celsius.
    b. constructed for a range of eight altitudes within the continental United States and are displayed in a series of eight panels, one for each altitude.
    c. transmitted twice a day and the teletype identifier "FW" appears in the heading.
    d. teletype forecasts of upper winds and temperatures for selected stations within the continental United States.

36. Which one of the following situations would cause the 6,000-foot level winds and temperatures to be omitted from a Winds-Aloft Forecast?

    a. Stations located at mean sea level
    b. A mountain station with an elevation of 4,800’ MSL
    c. A station with a temperature below –24 °C
    d. A mountain station with an elevation of 3,000’ MSL

37. Which one of the following is NOT a consideration in the selection of a flight level?

    a. Headwind/tailwind component
    b. Turbulence
    c. Potential icing conditions
    d. Microburst activity

VALID 181800Z FOR USE 1500-2100Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
JAX	1512	1611+08	1708+04	1705-01	2913-14	3029-26	315641	317249	316743
TLH	1514	1614+08	1712+04	1811-01	2716-14	2934-25	295639	306547	296354
PIE	1313	1513+09	1511+04	1408+00	3012-13	3035-24	315938	316647	306053
MIA	1017	1219+09	1113+05	0909+01	3317-12	3241-24	326339	316546	315251
TRI		2411+06	2618+01	2827-04	2841-17	2847-29	286744	299452	790256
GRW	1822	2028+12	2128+06	2226-03	2532-17	2642-28	275943	278649	770856
MEM	1828	2134+10	2133+05	2133-02	2335-16	2546-27	266342	268748	761456
LIT	1832	2142+10	2141+04	2139-02	2241-16	2453-27	257141	259348	751756
SGF	1835	2144+10	2145+04	2145-02	2248-17	2359-28	247543	259549	751556
OKC	1832	2044+11	2149+05	2149-02	2256-17	2273-28	239241	730548	731154
AMA		2026	2242+02	2247-06	2258-21	2278-30	710243	721049	229951

Figure 7-26 Winds-Aloft Forecasts for Questions 38 – 40

38. What are the strongest flight level winds forecast to exist over PIE at 1800Z?

   a. 306° at 53 knots
   b. 300° at 60 knots
   c. 310° at 66 knots
   d. 260° at 166 knots

39. Which one of the following altitudes over MIA is the freezing level predicted to be located?

   a. 12,000’ MSL
   b. 12,000’ AGL
   c. 39,000’ MSL
   d. 24 to 30,000’

40. Which one of the following altitudes would provide the most favorable winds for a flight over AMA on a heading of 215 °T?

   a. FL 240
   b. FL 300
   c. FL 340
   d. FL 390

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CHAPTER EIGHT
SEVERE WEATHER WATCHES, MILITARY ADVISORIES, AND PIREPS

ASSIGNMENT SHEET

Severe Weather Watches, Military Advisories, and PIREPs
Assignment Sheet 8.1A

INTRODUCTION

This assignment will aid the student in understanding the data presented in various weather watches and advisories, and the use and requirements for submitting a Pilot Report (PIREP) to meteorology offices while in flight.

LESSON TOPIC LEARNING OBJECTIVES

Terminal Objective:
Partially supported by this lesson topic:

8.0 Describe displayed data on Severe Weather Watches, Military Weather Advisories, and In-Flight Weather Advisories, and state the importance of Pilot Reports (PIREPs).

ENABLING OBJECTIVES:
Completely supported by this lesson topic:

8.1 State the Severe Weather Watch's two-letter teletype identifier.

8.2 State the requirements for issuing a Severe Weather Watch.

Read and identify data on a Severe Weather Watch message.

8.4 State the OPNAVINST 3710.7 requirements for flight planning regarding a Severe Weather Watch.

8.5 Describe displayed data on a Military Weather Advisory (MWA).

8.6 State the use of In-Flight Weather Advisories.

8.7 State the teletype letter identifiers of each of the In-Flight Weather Advisories.

8.8 State the criteria used for issuing each of the In-Flight Weather Advisories.

8.9 Read and identify data from In-Flight Weather Advisories.

8.10 State the requirements for and the importance and use of Pilot Weather Reports (PIREPs).

STUDY ASSIGNMENT

Review Information Sheet 8.1I, and answer the Study Questions.

INFORMATION SHEET

Severe Weather Watches, Military Advisories, and PIREPs
Information Sheet 8.1I

800. INTRODUCTION

While the weather products described in the previous two chapters presented the means of determining basic present and forecast weather conditions, this chapter introduces the systems for dissemination of weather warnings, watches, and advisories. When aviators begin their flight planning routine, checking for any severe weather should be the very first step. Changes to missions are a commonplace occurrence due to quickly changing weather conditions, and new aviators will soon appreciate the ability to plan around the weather, when able.

As might be expected, the Severe Weather Watch, Military Weather Advisory, and In-Flight Weather Advisories pass massive amounts of critical weather information to a variety of civil and military stations, and every aviator needs a solid foundation in the understanding of these messages. This can be possible only via a thorough understanding of the fundamentals of weather mechanics and related hazards to aviation. Additionally, a great deal of information regarding severe weather can only be gathered through Pilot Weather Reports, especially when operating over less-populated areas or overseas. Again, this necessitates that aviators have a solid understanding of weather phenomena and reporting systems.

All of the severe weather watches, warnings, and advisories are transmitted in text, or teletype, format. Additionally, some are available in both text and graphic, or facsimile, format. As technology advances, more and more of the text weather messages are transformed by computer and available as graphic images. Some are even available in plain-language translations over the Internet. Still, the message format presented here will be used for a number of years to come, as brevity and accuracy continue to be paramount in ensuring timeliness of distribution to the greatest number of stations.

REFERENCES

1. Air Force Manual 15-125, *Weather Station Operations*
2. Aeronautical Information Manual, Section 7
3. Aviation Weather Center, Kansas City, Missouri (http://www.awc-kc.noaa.gov)
4. Chief of Naval Air Training Instruction 3710.8 series, *Restriction of Flight Into, Through, or Within Aviation Severe Weather Areas*
5. Chief of Naval Operations Instruction 3710.7 series, *NATOPS General Flight and Operating Instructions*
6. DoD Flight Information Publication (Enroute) *Flight Information Handbook, Section C*
7. FAA Contractions Manual

INFORMATION

801. SEVERE WEATHER WATCHES

Aviation Severe Weather Watch Bulletins are teletype presentations that are identified by the letters “WW” in the heading. WWs originate from the National Storm Prediction Center, and they are sometimes referred to as Severe Weather Forecasts.

WWs are not issued on a scheduled basis, but rather as required by the progress and development of severe weather. The forecast period is also variable, again depending on the particular weather. All times are given in local time, as indicated in the warning itself. When possible, the area of coverage is limited in size to 10,000 square miles to provide increased accuracy. Aviators may also encounter a Severe Weather Forecast Alert Message (AWW), which is a preliminary message issued to alert users that a (WW) is being issued.

WW Format

The heading of the Aviation Severe Weather Watch Bulletins consists of a few lines of information including the station identifier of the message originator (KMKC), the teletype identifier (WW), the date-time group of issue (181845), the bulletin number (29), and the time of issue (1245 PM CST).

The bulletin is arranged in several paragraphs giving such information as the area of coverage, the effective time of the watch, the expected type of severe weather, the mean wind vector, and any amplifying remarks deemed necessary.

Whenever possible, wording in teletype presentations is shortened by abbreviating words or phrases according to the FAA Contractions Manual. Words or phrases are usually shortened by omitting the vowels. For further information on word or phrase contractions, refer to Appendix B of this text.

WW Issuing Requirements

Aviation Severe Weather Watch Bulletins (Figure 8-1) are issued for two types of expected severe weather conditions:

1. Funnel clouds or tornadoes.
2. Severe thunderstorms, defined by frequent lightning and one or more of the following:
    a. 50 knots of wind or greater;
    b. 3/4 inch diameter hail or larger

802. MILITARY RESTRICTIONS REGARDING SEVERE WEATHER WATCHES

Since WWs restrict the operation of military aircraft, aviators should always first check for WWs when beginning the flight planning process. Otherwise, you may plan a flight and find out during the weather brief that you are unable to fly that plan.

```
WWUS 9 KMKC 181845
MKC WW 181845

BULLETIN - IMMEDIATE BROADCAST REQUESTED
SEVERE THUNDERSTORM WATCH NUMBER 29
NATIONAL WEATHER SERVICE KANSAS CITY MO
1245 PM CST THUR FEB 18 20XX

A...THE STORM PREDICTION CENTER HAS ISSUED A SEVERE THUNDERSTORM WATCH FOR


                          SOUTH CENTRAL KANSAS
                          CENTRAL OKLAHOMA
                          NORTH CENTRAL TEXAS
                          EAST TEXAS

EFFECTIVE FROM 1 PM CST UNTIL 6 PM CST THIS THURSDAY AFTERNOON

LARGE HAIL...DANGEROUS LIGHTNING…AND DAMAGING THUNDERSTORM WINDS ARE POSSIBLE
IN THESE AREAS.

THE SEVERE THUNDERSTORM WATCH AREA IS ALONG AND 70 STATUTE MILES EITHER SIDE
OF A LINE FROM 70 MILES WEST OF AUSTIN TEXAS TO 35 MILES WEST OF WICHITA
KANSAS.

REMEMBER...A SEVERE THUNDERSTORM WATCH MEANS CONDITIONS ARE FAVORABLE FOR
SEVERE THUNDERSTORMS IN AND CLOSE TO THE WATCH AREA. PERSONS IN THESE AREAS
SHOULD BE ON THE LOOKOUT FOR THREATENING WEATHER CONDITIONS AND LISTEN FOR
LATER STATEMENTS AND POSSIBLE WARNINGS.

B...OTHER WATCH INFORMATION...THIS SEVERE THUNDERSTORM WATCH REPLACES SEVERE
THUNDERSTORM WATCH NUMBER 28. WATCH NUMBER 28 WILL NOT BE IN EFFECT AFTER 1
PM CST.

C...A FEW SVR TSTMS WITH HAIL SFC AND ALF TO 2 IN. EXTRM TURBC AND SFC WND
GUSTS TO 70 KT. SCTD CBS WITH MAX TOPS TO 500 PSBL. MEAN WIND VECTOR 22040KT.

D...WITH CLD FNT MOVG SEWD FM WRN KS N CNTRL TX AND DVLPG LOW OK PANHANDLE
MOVG EWD STG CNVRGNC SHLD DVLP ALG CLD FNT AND NR INTERSECTION WITH WRM FNT.
CONTD STG INFLOW OF UNSTABLE AMS.
```

Figure 8-1 Aviation Severe Weather Watch Bulletin

803. OPNAVINST 3710.7 RESTRICTIONS

The OPNAVINST 3710.7 Series restrictions for USN/USMC aircraft regarding WWs is listed as follows:

> Except for operational necessity, emergencies, flights involving all-weather research projects or weather reconnaissance, pilots shall not file into or through areas that the National Weather Service (NWS) has issued a WW unless one of the following exceptions applies:

a. Storm development has not progressed as forecast for the planned route. In such situations:

   (1) VFR filing is permitted if existing and forecast weather for the route permits such flights.

   (2) IFR flight may be permitted if aircraft radar is installed and operative, thus permitting detection and avoidance of isolated thunderstorms.

   (3) IFR flight is permissible in positive control areas if visual meteorological conditions (VMC) can be maintained, thus enabling aircraft to detect and avoid isolated thunderstorms.

b. Performance characteristics of the aircraft permit an enroute flight altitude above existing or developing severe storms.

NOTE

It is not the intent to restrict flights within areas encompassed by or adjacent to a WW area unless storms have actually developed as forecast.

Note that only a *qualified forecaster* can make the determination as to whether storm development has progressed as forecast.

CNATRA WW (CAWW)

The Chief of Naval Air Training (CNATRA) may also issue warnings in the form of a CNATRA Aviation Weather Warning (CAWW) for the local operating areas in the absence of WWs and/or SIGMETs and when conditions warrant such action. These warnings will be issued when one or more of the following criteria have been reported, detected by radar, or are imminently expected within 100 miles of the station and WW coverage is inadequate or nonexistent:

1. Embedded thunderstorms
2. Severe thunderstorms
3. Tornadoes

When flying aircraft under operational control of CNATRA, pilots are prohibited from filing or flying into areas covered by a CAWW in the same manner as if a WW had been issued. Although National Weather Service WWs (and SIGMETs, to be discussed later) are provided at non-Navy airfields, CAWWs may not be available. However, CAWW remarks are appended to Naval Training Meteorology & Oceanography Facility (NAVTRAMETOC) hourly observations when a CAWW is issued. Aircrew should request the servicing weather facility provide pertinent NAVTRAMETOC observations available via the civilian weather communication network.

Local Weather Warnings

For weather similar to a WW, local Navy airfields will issue a Thunderstorm Condition warning, which may restrict flight and ground operations, such as aircraft refueling, depending on the level of Thunderstorm Condition and local regulations. Although governed by local base instructions, the following conditions have generally been standardized throughout USN bases:

Thunderstorm Condition 2 – Thunderstorm conditions are possible within 6 hrs or within 25 miles of the airfield.
Thunderstorm Condition 1 – Thunderstorm conditions are possible within 1 hr or within 10 miles of the airfield.
Severe Thunderstorm 1 or 2 – Same as above including the possibility of:
Hail of 3/4 in or greater
Winds of 50 kts or greater
Tornadic activity

804. AREA FORECASTS

The Area Forecast (FA) is a teletype presentation that provides an overview of weather conditions that could impact flight operations within the United States and adjacent waters. These forecasts serve primarily for use in preflight planning the en route portion of flights by general aviation pilots, civil and military operations, and the NWS and Federal Aviation Administration (FAA) pilot briefers (Figure 8-2).

```
FAUS5 KMIA 131745
FA4W
MIAC FA 131745
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 141200
CLDS/WX VALID UNTIL 140600 … OTLK VALID 140600-141200
NC SC GL FL AND CSTL WTRS
.
SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN.
TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS.
NON MSL HGTS DENOTED BY AGL OR CIG.
.
SYNOPSIS … CDFNT XTNDS E/W FM NE GLF ACRS FL ALG A MLB PIE LN AND INTO ATLC
WILL BCMG STNRY
DURG PD. LRG HI PRES CNTR OVR UPR MI WILL MOV SEWD LE BY 12Z.
.
NC
NRN PTN … SCT 050 SCT 100 23Z CLR OCNL SCT045 MTNS. OTLK … VFR.
.
SC SCT-BKN 045-050 TOPS FL150. ISOLD -SHRA. AFT 01Z ERN PTNS BCMG CLR.
WRN PTNS BCMG SCT045. OTLK … VFR.
.
GA
NRN PTN … AGL SCT-BKN 030-040 BKN 100. ISOLD -SHRA. CU TOPS FL150. AFT 01Z
SCT045 SCT100. OTLK … VFR.
```

```
SRN PTN … CIG BKN020-025 CU TOPS FL150. WDLY SCT TSRA/SHRA. TS TOPS FL350.
AFT 01Z SCT-BKN100.
OTLK … VFR.
.
FL
CIG BKN010 SCT TSRA. AFT 01Z SCT020-030 SCT-BKN100 ISOLD TSRA AND SHRA CU
TOPS FL150. TS TOPS
FL450. OTLK … VFR.
.
CSTL WTRS
NC/SC WTRS SCT045-050 BCMG CLR. OTLK … VFR.
GA WTRS CIG BKN020. ISOLD TSRA/SHRA. TS TOPS FL350. OTLK … VFR.
FL WTRS CIG BKN010 SCT TSRA. TS TOPS FL450. OTLK … VFR.
```

Figure 8-2 Area Forecast Example

FA Format

The FA consists of two sections, the synopsis and VFR clouds/weather. Additionally every FA will always have the following three lines listed after the heading, before the synopsis and clouds/weather sections.

1. SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN.
2. TSTMS IMPLY SVR OR GTYR TURB SVR ICG LLWS AND IFR CONDS.
3. NON MSL HGTS NOTED BY AGL OR CIG.

A 6-hour categorical outlook follows each 12-hour specific clouds/weather forecast. At a minimum, the category of the expected prevailing condition–IFR, MVFR, or VFR–and the cause of the condition is stated in the outlook. These categorical terms correspond with those used elsewhere (such as the Weather Depiction Chart, chapter 7), and they are not used otherwise in the FA.

The FA is generally straightforward and easy to understand. Each uses only approved abbreviations and contractions, and the weather and obstructions to vision abbreviations are the same as those used in METARs. All times in the body of the forecasts are stated in two digits using whole hours of UTC and qualifiers such as BY, UNTIL, AFTER, THRU, and BYD (beyond). All distances are in nautical miles, speeds in knots, and visibilities in statute miles. Locations are described by using geographical locations, two-letter state and Great Lakes identifiers, and three-letter location identifiers. The altitude reference is MSL unless otherwise noted by the terms AGL or CIG (ceiling).

805. IN-FLIGHT WEATHER ADVISORIES

The Aviation In-Flight Weather Advisory program provides information for pilots of en route aircraft via voice communications of the possibility of encountering weather phenomena which may not have been forecast at the time of the preflight briefing of sufficient extent and/or intensity as to be potentially hazardous to aircraft operations. It is intended to serve the needs of both civilian and military aviation as a "common-system" aviation weather safety program.

There are five types of In-flight Messages:

1. Severe Weather Forecast Alerts (AWW)
2. Convective SIGMETs (WST)
3. Non-Convective SIGMETs (WS)
4. Center Weather Advisories (CWA)
5. AIRMETs (WA)

When these advisories are issued, they describe potentially hazardous forecast weather conditions. For this reason, you should always check the current WAs, WSs, and WSTs during your preflight planning, in addition to the WW (an indirect component of the Aviation In-Flight Weather Advisory system). CWAs and AWWs are used mainly by Air Traffic Control (ATC) agencies for dissemination of advisories to aircraft in flight, so they are not as readily available as the other three advisories.

Within the conterminous US, the National Aviation Weather Advisory Unit (NAWAU) at Kansas City, MO, has the responsibility for issuing the five warnings. The Weather Service Forecast Offices (WSFO) will issue them for Hawaii, Alaska, and Puerto Rico. These advisories take into account weather conditions up to and including 45,000 feet. All heights are referenced to MSL, except low clouds, where a ceiling layer designated by CIG is referenced to AGL. All distance measurements are in nautical miles, and directions reference a 16-point compass. All abbreviations are from the FAA Contractions Manual, while weather elements and obstructions to vision are the same as those used in METARs.

Severe Weather Forecast Alert (AWW)

The AWW is a preliminary message issued in order to alert pilots that a WW is being issued. These messages are unscheduled and are issued as required. Normally, pilots will have access to WWs during preflight planning, and thus will not need to reference AWWs.

Convective SIGMET (WST)

WSTs are issued only for thunderstorms and related convective phenomena (as described below) over the conterminous US. Appended to each WST is an outlook valid for up to 4 hours beyond the end of the WST (Figure 8-3). They are not scheduled, but rather issued as needed, when any of the following occurs and/or is forecast to occur for more than 30 minutes of the valid period regardless of the size of the area affected (i.e., including isolated areas):

1. Tornadoes
2. Lines of thunderstorms
3. Embedded thunderstorms
4. Thunderstorm areas greater than or equal to thunderstorm intensity (VIP level) of four or greater with an area of coverage of 40% or more
5. Hail greater than or equal to 3/4 inch in diameter or greater and/or wind gusts to 50 knots or greater

```
WSUS41 KMKC 221855Z
WSTC
MKCC WST 221855
CONVECTIVE SIGMET 20C
VALID UNTIL 2055Z
ND SD
FROM 90W MOT-GFK-ABR-90W MOT
INTSFYG AREA SEV TS MOV FROM 24045KT. TS TOPS ABV FL450.
WIND GUSTS TO 60 KT RPRTD. +FC…HAIL TO 2 IN…WIND GUSTS
TO 65 KT POSS ND PTN.

CONVECTIVE SIGMET 21C

VALID UNTIL 2055Z
TX
50SE CDS
ISOLD SEV TS D30 MOV FROM 24020KT. TS TOP ABV FL450.
HAIL 2 IN…WIND GUSTS TO 65 KT POSS.

OUTLOOK VALID 222055-230055
AREA 1…FROM INL-MSP-ABR-MOT-INL
SEV TS CONT TO DVLP IN AREA OVR ND. AREA IS EXP TO RMN SEV AND SPRD
INTO MN AS STG PVA MOV OVR VERY UNSTBL AMS WTH -12 LI.

AREA 2…FROM CDS-DEW-LRD-ELP-CDS
ISOLD STG SEV TS WILL DVLP OVR SWRN TX AND WRN TX THRU FCST PD AS

UPR LVL TROF MOV NEWD OVR VERY UNSTBL AMS. LI RMNS IN -8 TO -10
RANGE. DRY LN WILL BE THE FOCUS OF TS DVLPMT.
```

Figure 8-3 WST Example

For WSTs, a line of thunderstorms is defined as being at least 60 miles long with thunderstorms affecting at least 40 percent of its length. Embedded thunderstorms, for the purpose of WSTs, are defined as occurring within and obscured by haze, stratiform clouds, or precipitation from stratiform clouds. WSTs for embedded thunderstorms are intended to alert pilots that avoidance by visual or radar detection of the thunderstorm could be difficult or impossible. Note that the presence of thunderstorms implies the associated occurrence of severe or greater turbulence, severe icing, and low-level wind shear.

All issued and valid WSTs for a specified geographic area are collected and listed in one place: a Convective SIGMET Bulletin. The three Convective SIGMET bulletin areas are the Eastern (E), Central (C), and Western (W) US, separated by the 87 and 107° W lines of longitude (with sufficient overlap to cover most cases when a phenomenon crosses the boundaries). These area letters can be found in the heading portion of the message, after the message type (e.g., WSTC), and after the WST bulletin number (e.g., 20C). Each of these three *bulletins* is transmitted hourly (at +55 minutes) and is valid for up to 2 hours. If there are no conditions within a region meeting Convective SIGMET criteria at the time of issuance, then a negative bulletin is sent.

Non-Convective SIGMET (WS)

A SIGMET advises of SIGnificant METeorological information other than convective activity that is potentially hazardous to all aircraft. WSs are issued for the conterminous US by NAWAU and are valid for up to 4 hours when any of the following weather phenomena occur or are forecast over an area of at least 3,000 square miles (Figure 8-4):

1. Severe or extreme non-convective turbulence, or CAT not associated with thunderstorms

2. Severe icing not associated with thunderstorms

3. Widespread dust storms or sandstorms, lowering surface and/or flight visibilities to less than 3 miles

4. Volcanic eruption and ash clouds

Training Wing commanders are responsible for establishing local guidelines to ensure safety of flight in and through areas where SIGMETs are in effect.

```
DFWP WS 051700
SIGMET PAPA 2  VALID UNTIL 052100
AR LA MS
FROM MEM TO 30N MEI TO BTR TO MLU TO MEM
MDT OCNL SEV ICE ABV FRZLVL EXP. FRZLVL 080 TO 120 W. CONDS CONTG BYD 2100Z
```

Figure 8-4 WS Example

The first issuance of any non-convective SIGMET will always be identified as an Urgent SIGMET (UWS). Any subsequent issuance will be identified as WS unless the forecaster feels the situation warrants using UWS to trigger more expeditious communications handling.

Each SIGMET is assigned a unique header to ensure computer systems can distribute and replace the proper messages as required. Only the phonetic alphabet designators November, Oscar, Papa, Quebec, Romeo, Uniform, Victor, Whiskey, X-ray, and Yankee are used for non-convective SIGMETs (excludes those designators reserved for scheduled AIRMETs (Sierra, Tango, and Zulu)). These designators will follow the area designator (SFO, SLC, CHI, DFW, BOS, and MIA), which is used for distribution. It does not denote the office issuing the forecast; it denotes the geographical area affected (e.g., DFWP in Figure 8-4).

The first time a SIGMET is issued for a phenomenon associated with a particular weather system, it is given the next alphabetic designator in the series and is numbered as the first for that designator (e.g., PAPA 1). Subsequent messages are numbered consecutively, using the same designator (e.g., PAPA 2, PAPA 3, etc.) until the phenomenon ends or no longer meets SIGMET criteria. In the conterminous US, this means that a phenomenon that is assigned an alphabetic designator in one area will retain that designator even if it moves into another area. For example, the first issuance for a SIGMET that has moved into the DFW area from the SLC area might be SIGMET PAPA 4. While this is indeed the first SIGMET issued for this phenomenon in the

DFW area, it is actually the fourth issuance for the phenomenon since it met SIGMET criteria, and the previous three issuances occurred in the SLC area.

While SIGMETs may be issued up to 2 hours before the onset of any condition forecast to meet a criterion, note that the time in line 1 (Figure 8-4) is the issuance time, not the onset time. The time indicated in the VALID UNTIL 052100 statement is the SIGMET expiration time. The difference between the two will not exceed 4 hours. If it is expected to persist beyond 4 hours, a statement to this effect will be included in the remarks of the text. If the conditions do persist beyond the forecast period, then the SIGMET will be updated and reissued. However, if conditions end, a SIGMET cancellation will be transmitted.

Center Weather Advisory (CWA)

CWAs are unscheduled in-flight, flow control, air traffic, and aircrew advisory. By nature of its short lead-time, the CWA is not a flight-planning product. It is generally a nowcast for conditions beginning within the next 2 hours. CWAs will be issued:

1. As supplement to an existing SIGMET, Convective SIGMET, AIRMET, or FA.

2. When an In-flight Advisory has not been issued but observed or expected weather conditions meet SIGMET/AIRMET criteria based on current PIREPs and reinforced by other sources of information about existing meteorological conditions.

3. When observed or developing weather conditions do not meet SIGMET, Convective SIGMET, or AIRMET criteria; e.g., in terms of intensity or area of coverage, but current Pilot Weather Reports or other weather information sources indicate that existing or anticipated meteorological phenomena will adversely affect the safe flow of air traffic within the Air Route Control Center (ARTCC) area of responsibility.

The following example (Figure 8-5) is a CWA issued from the Kansas City, Missouri, ARTCC. The "3" after ZKC indicates this CWA has been issued for the third weather phenomenon to occur for the day. The "301" in the second line denotes the phenomenon number again (3) and the issuance number, "01," for this phenomenon. The CWA was issued at 2140Z and is valid until 2340Z.

```
ZKC3 CWA 032140
ZKC CWA 301 VALID UNTIL 032340
ISOLD SVR TSTM OVER KCOU MOVG SWWD 10KTS
```

Figure 8-5 CWA Example

AIRMET (WA)

AIRMETs also advise of significant weather phenomena other than convective activity but indicate conditions at intensities lower than those that trigger SIGMETs. Both are intended for dissemination to all pilots in the enroute phase of flight to enhance safety, and are available for preflight planning, as well.

```
WAUS1 KDFW 210745
DFWS WA 210745
AIRMET SIERRA FOR IFR AND MTN OBSCN VALID UNTIL 211400

AIRMET IFR...TN KY
FROM 30E TRI TO 20S CHA TO 40SW ABY TO MOB TO IGB TO MEM TO DYR TO 30E TRI
OCNL CIG BLW010/VIS BLW 3SM -RA/BR. CONDS SPRDG EWD AND CONTG BYD 14Z AND
IMPVG EXC ERN TN BY 20Z.

AIRMET MTN OBSCN...TN KY
FROM HNN TO 30E TRI TO 30E CHA TO CHA TO HNN
MTNS OCNL OBSCD IN CLDS/PCPN/FG. CONDS CONTG BYD 14A THRU 20Z.

DFWT WA 210745
AIRMET TANGO FOR TURB VALID UNTIL 211400

AIRMET TURB...AR OK TX TN MS LA AND CSTL WTRS
FROM 40S ICT TO ARG TO 20S BWG TO 80S LCH TO LRD TO 40S ICT
LGT OCNL MDT TURB FL140-FL350 ASSOCD WTH STG WNDSHR. CONDS CONTG BYD 14Z
IMPVG BY 20Z.

ELSW...NO SGFNT TURB EXC VC CNVTV ACT

DFWZ WA 210745
AIRMET ZULU FOR ICE AND FRZLVL VALID UNTIL 211400

AIRMET ICE...TN MS OK
OCNL LGT ISOLD MDT RIME ICGICIP FRZLVL TO ARND 120 MS AL AND TN. CONDS CONTG
BYD 14Z IMPVG BY 20Z.
```

Figure 8-6 WA Example

AIRMET bulletins, each containing one or more AIRMET messages, are issued on a scheduled basis every 6 hours beginning at 0145 UTC, and are effective for 6 hours, beginning at 0200 UTC. Unlike FAs, scheduled AIRMET bulletin issuances occur at the same UTC time, regardless of their area designator (Figure 8-6). Unscheduled amendments and corrections are issued as necessary, due to changing weather conditions or issuance/cancellation of a SIGMET.

There are three types of AIRMET messages that may be issued within a WA. An AIRMET is issued when one or more of the following listed conditions occurs (or is expected to occur) and affects an area of at least 3,000 square miles:

AIRMET Sierra – For widespread IFR conditions (ceilings less than 1,000 feet and/or visibility less than 3 miles) affecting over 50% of the area or for extensive mountain obscuration

AIRMET Tango – For moderate turbulence or for sustained surface winds of 30 knots or more

AIRMET Zulu – For moderate icing or for freezing level data

Even though these AIRMET items are issued for widespread phenomena–at least 3,000 square miles at any one time– if the total area to be affected during the forecast period is very large, it could be that only a small portion of this total area would be affected at any one time.

As with SIGMETs, the AIRMETs have unique headings that contain the bulletin type letter following the area designator. For example, when an AIRMET for turbulence is issued, the communications header might read “DFWT WA 210745,” where "T" indicated it is an AIRMET Tango bulletin. Also in the heading is the valid period expiration time, which is 6 hours after the scheduled "valid beginning" time, or 6 hours and 15 minutes after the scheduled issuance time. Each section begins with a text description of the type of AIRMET and a list of states and/or geographical areas affected. As a minimum, each bulletin may indicate that no significant weather of that type is expected, and AIRMET Zulu always contains a freezing level line.

There are a few specific rules that meteorologists follow when producing WAs that may be helpful for understanding what weather is and is not forecast. Whenever a SIGMET is in effect, the AIRMET bulletins for the same phenomena (in the same area) will contain a reference to the appropriate SIGMET series. For example, “SEE SIGMET XRAY SERIES FOR SEV TURB AREA.” Additionally, When non-convective low-level wind shear (LLWS–wind shear below 2,000’ AGL) is affecting or expected to affect an area of at least 3,000 square miles, the AIRMET Tango includes an LLWS potential statement as a separate line.

806. TRANSMISSION OF IN-FLIGHT WEATHER ADVISORIES

Since In-Flight Weather Advisories are designed primarily for en route information of changes in the forecasts, an initial alert is normally transmitted over ATC frequencies. These alert announcements give the type of advisory and frequency instruction, which indicates where further information can be obtained, such as through the Hazardous In-flight Weather Advisory Service (HIWAS). Upon hearing an alert notice, if you are not familiar with the advisory or are in doubt, you should tune in the appropriate frequency or contact the nearest FAA Flight Service Station (FSS) or pilot-to-forecaster service (PMSV) to check whether the advisory is pertinent to your flight. These advisories are broadcast during the valid periods, when they pertain to the area within 150NM of the FSS. Times, frequencies, and further information can be found in the DoD Flight Information Publication (Enroute) Flight Information Handbook, Section C, and other enroute publications, as taught in the Instrument Flight Rules course.

807. PIREPS

Pilot Weather Reports (PIREPs) are a valuable source of information used to supplement ground station weather observations. Air traffic facilities are required to solicit PIREPs whenever the following conditions are reported or forecasted: ceilings at or below 5,000 feet, visibility at or below 5 miles, thunderstorms and related phenomena, icing of a light degree or greater, turbulence of moderate degree or greater, and wind shear. All pilots are urged to cooperate and promptly volunteer reports on these conditions, and any other conditions pertinent to aviation, such as: cloud bases, tops, and layers; flight visibility; precipitation; visibility restrictions; winds at altitude; and temperatures aloft. Pilots are required to submit a PIREP under the following conditions:

1. In-flight when requested
2. When unusual or unforecast weather conditions are encountered
3. When weather conditions on an IFR approach differ from the latest observation

4. When a missed approach is executed due to weather
5. When a wind shear is encountered on departure or arrival

Your observed PIREPs should be given to any ground facility with which you have established communication (e.g., FSS, ARTCC, EFAS-Enroute Flight Advisory Service, etc.). After passing the immediately pertinent information, you should follow up with a radio call to a Meteorology Office (METRO) to ensure rapid dissemination to other using agencies. If you are not able to report while in the air, you should make a report to the nearest FSS or Weather Service Office upon landing, especially if weather encountered was different than forecast.

When airborne, you would consult the Flight Information Handbook for the proper format, which includes aircraft identification, location, time (UTC), altitude (MSL), type aircraft, sky cover, visibility & weather, temperature, wind, turbulence, icing, and remarks. Even though your pilot report should be as complete and accurate as possible, do not be overly concerned with strict format and phraseology. The important thing is that your PIREP is relayed so others may benefit from your report (Figure 8-7).

“Pensacola METRO, Rocket 501, a single T-39 Sabreliner at one-six thousand feet, 200 knots indicated, holding 20 miles south of Navy Pensacola, at 2100Z experiencing IFR in stratus clouds, temperature –15 °C, winds 330 at 25, no turbulence, Light Rime Icing.”

Figure 8-7 PIREP Example

STUDY QUESTIONS

Severe Weather Watches, Military Advisories, and PIREPs

```
WWUS 9 KMKC 181845
MKC WW 181845

BULLETIN - IMMEDIATE BROADCAST REQUESTED
SEVERE THUNDERSTORM WATCH NUMBER 29
NATIONAL WEATHER SERVICE KANSAS CITY MO
1245 PM CST THUR FEB 18 20XX

A...THE STORM PREDICTION CENTER HAS ISSUED A SEVERE THUNDERSTORM WATCH FOR

                          SOUTH CENTRAL KANSAS
                          CENTRAL OKLAHOMA
                          NORTH CENTRAL TEXAS
                          EAST TEXAS

EFFECTIVE FROM 1 PM CST UNTIL 6 PM CST THIS THURSDAY AFTERNOON

LARGE HAIL...DANGEROUS LIGHTNING…AND DAMAGING THUNDERSTORM WINDS ARE POSSIBLE
IN THESE AREAS.

THE SEVERE THUNDERSTORM WATCH AREA IS ALONG AND 70 STATUTE MILES EITHER SIDE
OF A LINE FROM 70 MILES WEST OF AUSTIN TEXAS TO 35 MILES WEST OF WICHITA
KANSAS.

REMEMBER...A SEVERE THUNDERSTORM WATCH MEANS CONDITIONS ARE FAVORABLE FOR
SEVERE THUNDERSTORMS IN AND CLOSE TO THE WATCH AREA. PERSONS IN THESE AREAS
SHOULD BE ON THE LOOKOUT FOR THREATENING WEATHER CONDITIONS AND LISTEN FOR
LATER STATEMENTS AND POSSIBLE WARNINGS.

B...OTHER WATCH INFORMATION...THIS SEVERE THUNDERSTORM WATCH REPLACES SEVERE
THUNDERSTORM WATCH NUMBER 28. WATCH NUMBER 28 WILL NOT BE IN EFFECT AFTER 1
PM CST.

C...A FEW SVR TSTMS WITH HAIL SFC AND ALF TO 2 IN. EXTRM TURBC AND SFC WND
GUSTS TO 70 KT. SCTD CBS WITH MAX TOPS TO 500 PSBL. MEAN WIND VECTOR 22040KT.

D...WITH CLD FNT MOVG SEWD FM WRN KS N CNTRL TX AND DVLPG LOW OK PANHANDLE
MOVG EWD STG CNVRGNC SHLD DVLP ALG CLD FNT AND NR INTERSECTION WITH WRM FNT.
CONTD STG INFLOW OF UNSTABLE AMS.
```

Figure 8-8 WW for Questions 1 - 3

1. What is the effective time period for this WW?

   a. 181900Z to 190000Z
   b. 181300 CST to 181800 CST
   c. 1 p.m. CST to 6 p.m. CST
   d. All of the above are correct

2. Which one of the following would be the best altitude to enable flight above the cloud tops in this WW?

a. FL 280
b. FL 350
c. FL 510
d. FL 700

3. Which one of the following conditions would allow a Naval Aviator to file for an IFR flight through the area covered by this WW?

a. The assigned aircraft has operable weather radar, enabling detection and avoidance of the line of thunderstorms.
b. The assigned aircraft has operable weather radar, and the weather brief, given by a NAVMETOC Forecaster at 5 p.m. CST, indicates that there is no line of severe thunderstorms, and that VMC should prevail.
c. No tornadoes have been reported.
d. No hail or lightning has been reported.

4. Which one of the following lists the conditions for issuing a WW?

a. Turbulence and hail
b. Hail and lightning
c. Tornadoes and severe thunderstorms
d. Icing and gusty surface winds

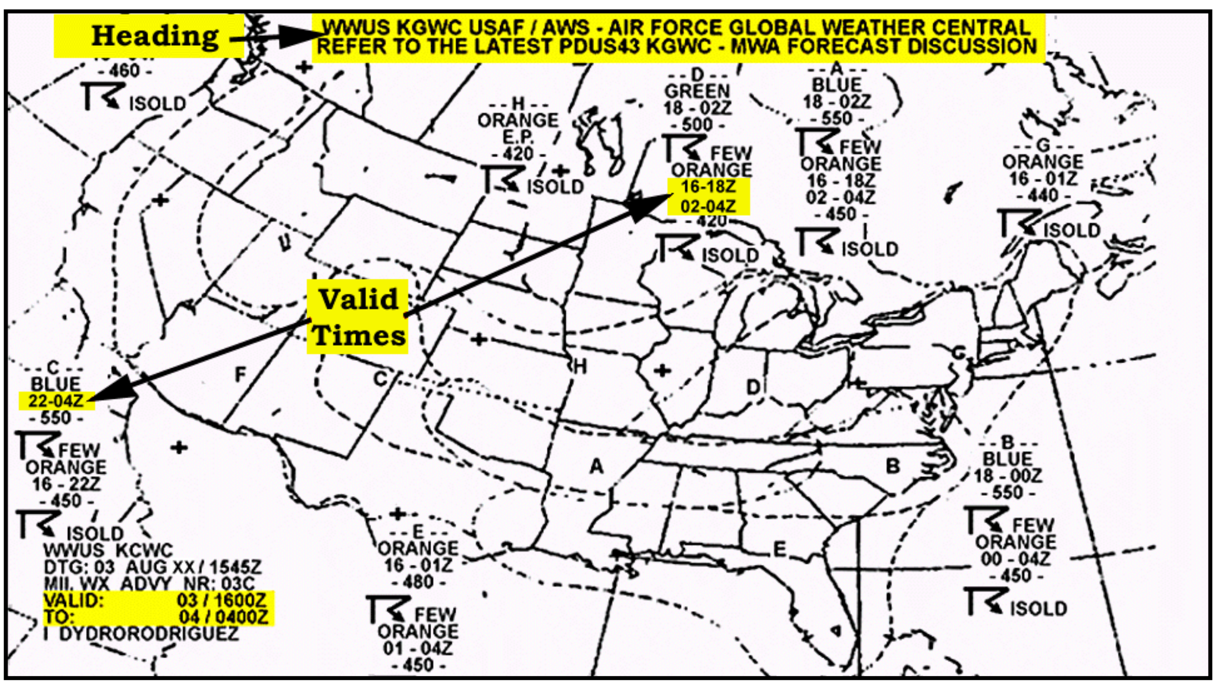

Figure 8-9 MWA for Questions 5 - 6

5. Which one of the following indicates the correct type of weather and its valid time for the Louisiana area?

a. Thunderstorms, 1600-0100Z
b. Severe thunderstorms, 2200-0400Z
c. Isolated heavy rain, 0100-0400Z
d. Tornadoes, 1600-0400Z

6. What are the maximum expected tops of thunderstorms for the Colorado/New Mexico/Texas area?

a. 45,000 feet
b. 48,000 feet
c. 50,000 feet
d. 55,000 feet

7. Which one of the following is NOT a teletype identifier for an In-Flight Weather Advisory?

a. WST
b. FA
c. WS
d. WA

8. Which one of the following conditions would warrant the issuance of a Convective SIGMET?

a. Tornadoes
b. Severe icing
c. Clear air turbulence
d. Extensive mountain obscuration

```
WSUS41 KMKC 221855Z
WSTC
MKCC WST 221855
CONVECTIVE SIGMET 20C
VALID UNTIL 2055Z
ND SD
FROM 90W MOT-GFK-ABR-90W MOT
INTSFYG AREA SEV TS MOV FROM 24045KT. TS TOPS ABV FL450.
WIND GUSTS TO 60 KT RPRTD. +FC…HAIL TO 2 IN…WIND GUSTS
TO 65 KT POSS ND PTN.

CONVECTIVE SIGMET 21C
VALID UNTIL 2055Z
TX
50SE CDS
ISOLD SEV TS D30 MOV FROM 24020KT. TS TOP ABV FL450.
HAIL 2 IN…WIND GUSTS TO 65 KT POSS.

OUTLOOK VALID 222055-230055
AREA 1…FROM INL-MSP-ABR-MOT-INL
SEV TS CONT TO DVLP IN AREA OVR ND. AREA IS EXP TO RMN SEV AND SPRD
INTO MN AS STG PVA MOV OVR VERY UNSTBL AMS WTH -12 LI.

AREA 2…FROM CDS-DEW-LRD-ELP-CDS
ISOLD STG SEV TS WILL DVLP OVR SWRN TX AND WRN TX THRU FCST PD AS
UPR LVL TROF MOV NEWD OVR VERY UNSTBL AMS. LI RMNS IN -8 TO -10
RANGE. DRY LN WILL BE THE FOCUS OF TS DVLPMT.
```

Figure 8-10 WST for Questions 9 - 11

9. WST 21C will be valid until __________ Z.

a. 1855
b. 1955
c. 2055
d. 2155

10. Which one of the following times could one expect the next bulletin regarding WST 21C to be issued?

a. 1855
b. 1955
c. 2055
d. 2155

11. Which one of the following locations should one expect to be affected by the future movement of the severe weather described in WST 21C?

a. 100 miles north of CDS
b. 100 miles east of CDS
c. 100 miles south of CDS
d. 100 miles west of CDS

```
DFWP WS 051700
SIGMET PAPA 2 VALID UNTIL 052100
AR LA MS
FROM MEM TO 30N MEI TO BTR TO MLU TO MEM
MDT OCNL SEV ICE ABV FRZLVL EXP. FRZLVL 080 TO 120 W. CONDS CONTG BYD 2100Z
```

Figure 8-11 WS for Questions 12 - 13

12. Which one of the following correctly indicates the expected duration of the severe weather?

a. 2 hours
b. 3 hours
c. 4 hours
d. More than 4 hours

13. Which one of the following correctly indicates the type of severe weather?

a. Moderate icing
b. Severe icing
c. Moderate, occasionally severe icing above the freezing level
d. Freezing conditions between 0800 and 1200 local

14. Which one of the following conditions would warrant the issuance of a Non-Convective SIGMET?

a. Severe thunderstorms
b. Moderate icing
c. Severe CAT
d. Extensive mountain obscuration

15. Which one of the following conditions would warrant the issuance of an AIRMET?

a. Tornadoes
b. Light icing
c. Light clear air turbulence
d. Extensive mountain obscuration

```
WAUS1 KDFW 210745
DFWS WA 210745
AIRMET SIERRA FOR IFR AND MTN OBSCN VALID UNTIL 211400

AIRMET IFR...TN KY
FROM 30E TRI TO 20S CHA TO 40SW ABY TO MOB TO IGB TO MEM TO DYR TO 30E TRI
OCNL CIG BLW010/VIS BLW 3SM -RA/BR. CONDS SPRDG EWD AND CONTG BYD 14Z AND
IMPVG EXC ERN TN BY 20Z.

AIRMET MTN OBSCN...TN KY
FROM HNN TO 30E TRI TO 30E CHA TO CHA TO HNN
MTNS OCNL OBSCD IN CLDS/PCPN/FG. CONDS CONTG BYD 14A THRU 20Z.

DFWT WA 210745
AIRMET TANGO FOR TURB VALID UNTIL 211400

AIRMET TURB...AR OK TX TN MS LA AND CSTL WTRS
FROM 40S ICT TO ARG TO 20S BWG TO 80S LCH TO LRD TO 40S ICT
LGT OCNL MDT TURB FL140-FL350 ASSOCD WTH STG WNDSHR. CONDS CONTG BYD 14Z
```

```
IMPVG BY 20Z.

ELSW...NO SGFNT TURB EXC VC CNVTV ACT

DFWZ WA 210745
AIRMET ZULU FOR ICE AND FRZLVL VALID UNTIL 211400

AIRMET ICE...TN MS OK
OCNL LGT ISOLD MDT RIME ICGICIP FRZLVL TO ARND 120 MS AL AND TN. CONDS CONTG
BYD 14Z IMPVG BY 20Z.
```

Figure 8-12 WA for Questions 16 - 18

16. Which one of the following types of weather has caused an AIRMET Sierra (IFR) to be issued for TN and KY?

a. Blowing snow
b. Light occasionally moderate turbulence associated with strong wind shear
c. Light rain and mist
d. Occasional light and isolated moderate rime icing in clouds and in precipitation

17. The turbulence in the AIRMET should improve by __________ Z.

a. 210745
b. 211345
c. 211400
d. 212000

18. Which one of the following types of weather has caused an AIRMET Zulu to be issued for TN, MS, and OK?

a. Blowing snow
b. Light occasionally moderate turbulence associated with strong wind shear
c. Light rain and mist
d. Occasional light and isolated moderate rime icing in clouds and in precipitation

19. Which one of the following systems or services would provide an aviator with the means to receive an In-Flight Weather Advisory?

a. FSS
b. HIWAS
c. Any ATC frequency
d. All of the above

20. Which one of the following situations would require an aviator to submit a PIREP?

a. Encountering unforecast IFR conditions on a VFR flight plan
b. Breaking out of an IFR layer on final 500 feet below the last reported ceiling
c. Flying through a microburst on final approach
d. All of the above

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CHAPTER NINE
FLIGHT WEATHER BRIEFING FORM, DD FORM 175-1

ASSIGNMENT SHEET

Flight Weather Briefing Form, DD Form 175-1
Assignment Sheet 9.1A

Introduction

This assignment will aid the student in the use and understanding of the Flight Weather Briefing Form, DD Form 175-1.

LESSON TOPIC LEARNING OBJECTIVES

Terminal Objective:
Partially supported by this lesson topic:

9.0 Describe indicated data on the DD 175-1, “Flight Weather Briefing Form,” and state the sources of hazardous weather information used to complete the form.

ENABLING OBJECTIVES:
Completely supported by this lesson topic:

9.1 List the five sections of the DD 175-1 and the information contained in each.

9.2 State the requirements for completing the takeoff data section of the DD 175-1.

9.3 State the first weather source that should be checked when flight planning.

9.4 State the teletype/facsimile sources for information on thunderstorm activity en route.

9.5 State the teletype/facsimile sources for information on turbulence en route.

9.6 State the teletype/facsimile sources for information on icing and the minimum freezing level.

9.7 State the teletype/facsimile sources for winds aloft and temperature en route.

9.8 State the considerations in the selection of a flight level.

9.9 Determine if an alternate is required and state the source used for selecting the best possible alternate.

9.10 State the OPNAV 3710.7 requirements for the assignment of a Void Time on a DD 175-1.

9.11 State who maintains the ultimate responsibility for the weather briefing.

STUDY ASSIGNMENT

Review Information Sheet 9.1I, and answer the Study Questions.

9-2 FLIGHT WEATHER BRIEFING FORM, DD FORM 175-1

INFORMATION SHEET

Flight Weather Briefing Form, DD Form 175-1
Information Sheet 9.1I

900. INTRODUCTION

In general, military aviators are required to submit an appropriate flight plan to the local air traffic control facility for all flights by using the DD-175 Military Flight Plan. The only exceptions allowed are use of the daily flight schedule, FAA Flight Plan, or an international flight plan. Since most training flights will use the daily flight plan, you may not learn about the DD-175 in detail until the instrument flight rules course. However, this flight plan will be the type–other than the daily flight schedule–used most often for military flights. Thus, it provides a realistic background for the introduction of its counterpart, the DD 175-1, the Flight Weather Briefing Form.

When embarking on flights outside the local area, you will most likely be required to file a DD-175. Flights of this nature also require an increased amount of preflight planning, as these flights tend to be unique, one-time events. While this provides aviators with a great deal of latitude in the selection of routes, it also increases the requirements for ensuring the plan includes sufficient alternative courses of action. Naturally, one of the major areas that require planning for alternatives is the weather.

In this chapter–the last chapter–we will be introducing a simple flight plan for which we will need a weather brief. For most situations, the local meteorology office will provide this briefing, but there may be situations for which the *pilot* may need to fill out the DD 175-1, such as when overseas, or when conducting a telephone briefing. In all situations, though, the aircrew will need to take an active part in the process of determining the weather. In marginal weather conditions, aircrew will check the weather before planning, before submitting the planned flight, before takeoff, and during the flight.

Before receiving the weather briefing from the meteorology staff, though, aircrew should make a point of building an overall picture of the weather for themselves in order to get the most from the weather briefing. In this manner, aircrew will have more time to consider how the weather conditions may affect their flight, and they will be better prepared to ask questions of the briefer, enabling a two-way conversation to occur. While meteorologists are certainly the most knowledgeable source for weather information, the aircrew are the most knowledgeable about their mission. The briefer can best prepare the aircrew for their flight only when aviators ask questions during the briefing about areas for which they would like further information or explanation.

REFERENCES

1. Chief of Naval Operations Instruction 3710.7 series, NATOPS *General Flight and Operating Instructions*
2. Aeronautical Information Manual

INFORMATION

901. DD-175 MILITARY FLIGHT PLAN

A mostly-filled out DD-175 is pictured below in Figure 9-1. The form is used to provide ATC agencies with the planned route of flight, for easier handling and direction of aircraft. It contains basic information on the top-right, such as the date, aircraft call sign, and the type of aircraft. The center section presents the route, including departure point, time, destination, and estimated time enroute (ETE), as well as requested altitude and route(s) of flight. At the bottom, above the list of crew members/passengers, the DD-175 provides space for other important details, such as the selected alternate landing field and an indication of a review of the weather.

PRIVACY ACT STATEMENT

AUTHORITY: 10 USC 8012 and EO 9397
PRINCIPAL PURPOSE: To aid in accurate identification of personnel participating in the filed flight
ROUTINE USES: To provide data required to process flight plans with appropriate air traffic service authorities. A file is retained by the agency processing the flight plan.
DISCLOSURE: Voluntary; however, failure to provide the SSN could result in denial of flight plan processing.

DATE	AIRCRAFT CALL SIGN	AIRCRAFT DESG AND TD CODE
25 JUL 20XX	VV3E276	T-6 / R

BASE OPERATIONS USE

	TYPE FLT PLAN	TRUE AIRSPEED	POINT OF DEPARTURE	PROPOSED DEPARTURE TIME (Z)	ALTITUDE	ROUTE OF FLIGHT	TO	ETE
	I	200	NQA	1230	**	NQA-1 MEM V54 LIT V74 FSM V74S		
						OKM V210 MAMBA TIK	TIK	2+12

REMARKS

RANK AND HONOR CODE

FUEL ON BD	ALTN AIRFIELD	ETE TO ALTN	NOTAMS	WEATHER	WT AND BALANCE	AIRCRAFT SERIAL NUMBER, UNIT AND HOME STATION
3+00	**	0+38	✓	**	ON FILE NSE	135276/VT-3/NSE

SIGNATURE OF APPROVAL AUTHORITY	CREW/PASSENGER LIST		ACTUAL DEP TIME (Z)	BASE OPERATIONS USE
I. Am Instructor	ATTACHED	SEE PSGR MANIFEST		

DUTY	NAME AND INITIALS	RANK	SSN	ORGANIZATION AND LOCATION
PILOT IN COMMAND	I. AM. INSTRUCTOR	LT	999-99-9999	VT-3/NSE
STUD	R. U. READY	ENS	000-00-0000	VT-3/NSE
	**(TO BE DETERMINED IN THE SEMINAR)			

DD Form 175, MAY 86 0102-LF-001-7500 *Previous editions are obsolete.* MILITARY FLIGHT PLAN

Figure 9-1 DD Form 175, Military Flight Plan

For this chapter, we will use the following scenario, which began as an assignment to fly from NAS Memphis, Tennessee (NQA), to Tinker AFB, Oklahoma (TIK). Before choosing the route of flight, our aviators first checked for any weather warnings/watches. Remember, the first step for any flight planning should always be to check for any WW, MWA, or In-Flight Weather Advisory that may affect the flight, because severe weather or a valid WW may result in a change of plans or the cancellation of the flight (as stated in chapter 8).

Our aviators found no weather warnings affecting these bases or the area in between them. However, at this point, they determined the weather was not unmistakably VFR, so two possible alternate airfields were chosen, along with the following data, which has already been entered on the DD-175 above:

Planned route–KNQA to KTIK
Departure time/date–1230Z, 25 July 20XX
ETE–2 hours, 12 minutes
Possible alternates–KSPS and KTUL
ETE to either alternate–38 minutes
Aircraft category/type–"B," T-6 T/A

It is at this point we join the scenario to see how weather fits in to the preflight planning process. As stated above, this DD-175 is *mostly* filled out. Notice there are three blocks that contain asterisks (**). Normally, when flight planning, the DD-175 can be completed to the point of leaving these three blocks empty, until the time of the weather brief. We will describe techniques for filling in these blocks later in the chapter. At this point–just before the weather briefing–a final check of the weather can be made, and two of those three blocks can be filled in. The alternate airfield block is selected according to the procedures described in chapter 6, and the altitude block will be discussed shortly. Then, a copy of the DD-175 is given to the weather office for a briefer to prepare a DD 175-1. After receiving the weather briefing, the last block can be filled in (the weather briefing number), and the flight plan can be turned in to Base Operations or the local ATC agency for filing and entering in to the ATC computer system.

902. DD 175-1 FLIGHT WEATHER BRIEFING FORM

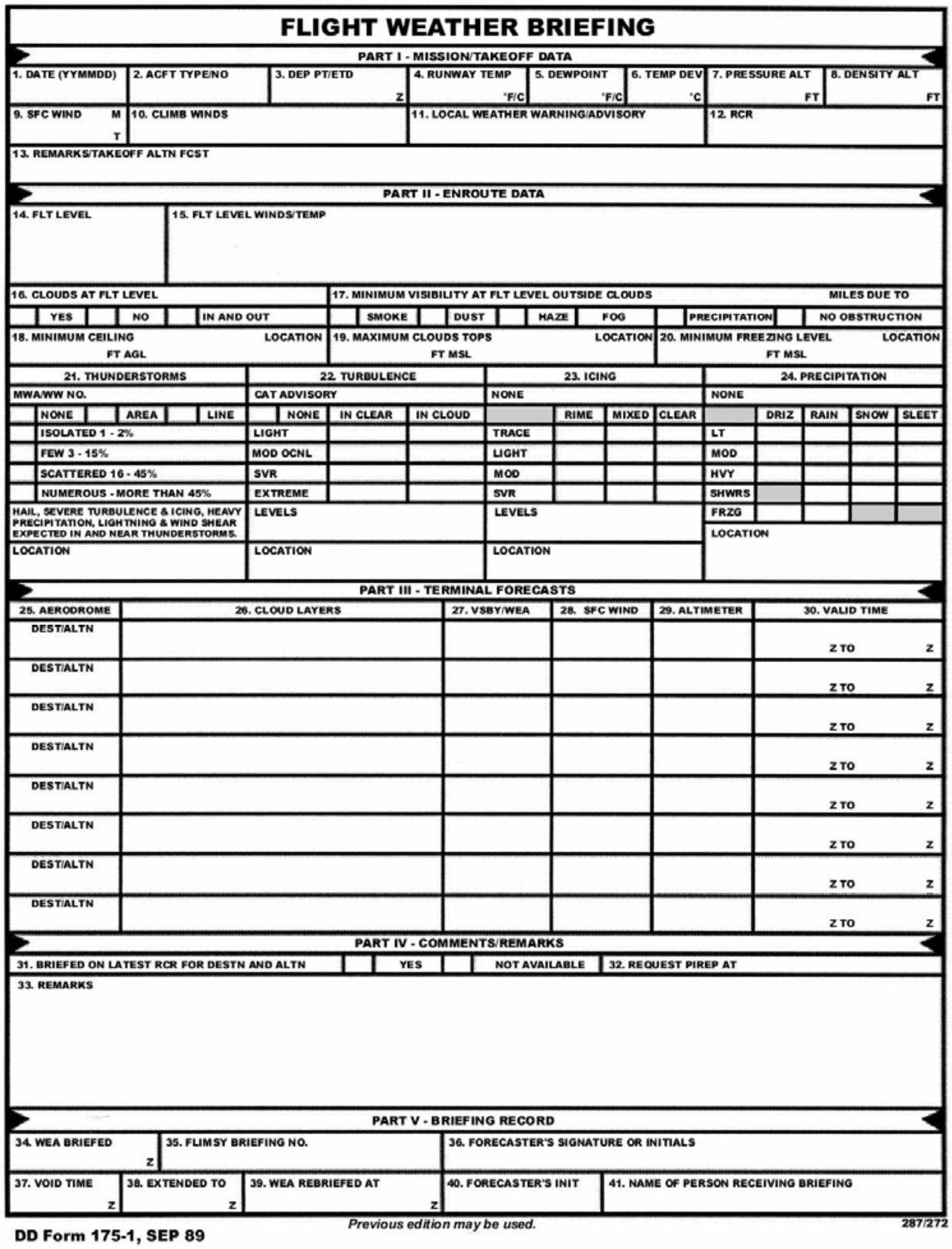
The DD 175-1 Flight Weather Briefing Form provides a common format for all military (and DoD) aircrew to receive a weather briefing–regardless of location–from the local meteorology office. However, when using other types of flight plans, such as the daily flight schedule, the DD 175-1 might not be filled out, but a substitute presenting this information must still be used to give the aircrew a complete picture of the expected weather. For this reason, OPNAVINST 3710.7 states the following requirements regarding the use of the Flight Weather Briefing form:

> A DD 175-1, flight weather briefing, shall be completed for all flights to be conducted in IMC [instrument meteorological conditions]....For VFR flights using the DD-175, the following certification on the flight plan may be used in lieu of a completed DD 175-1:
>
> BRIEFING VOID ________Z, FLIGHT AS PLANNED CAN BE CONDUCTED UNDER VISUAL FLIGHT RULES. VERBAL BRIEFING GIVEN AND HAZARDS EXPLAINED. FOLLOWING SIGMETS ARE KNOWN TO BE CURRENTLY IN EFFECT ALONG PLANNED ROUTE OF FLIGHT_____________________________.
> HAZARDS______________________________.
>
> ______________________________
> (SIGNATURE OF FORECASTER)

The above certification is known as the VFR Certification Stamp. In order to use the VFR Stamp, the pilot must file VFR for the entire planned route, the pilot must request the stamp, and the stamp is available only at the forecaster's discretion.

The flight weather briefing may be accomplished by a meteorological forecaster, when available, or through an autographic, telephonic, weather vision, or certified Internet/intranet system when no forecasters are available.

Figure 9-2 shows a blank Flight Weather Briefing Form, which is divided into five sections: Mission/Takeoff Data, Enroute Data, Terminal Forecasts, Comments/Remarks, and the Briefing Record. In fact, the DD 175-1 was designed to provide specific information corresponding to the three phases of any flight–takeoff, enroute, and landing–as found in the first, second, and third sections.



FLIGHT WEATHER BRIEFING

PART I - MISSION/TAKEOFF DATA

1. DATE (YYMMDD) | 2. ACFT TYPE/NO | 3. DEP PT/ETD Z | 4. RUNWAY TEMP °F/C | 5. DEWPOINT °F/C | 6. TEMP DEV °C | 7. PRESSURE ALT FT | 8. DENSITY ALT FT

9. SFC WIND M T | 10. CLIMB WINDS | 11. LOCAL WEATHER WARNING/ADVISORY | 12. RCR

13. REMARKS/TAKEOFF ALTN FCST

PART II - ENROUTE DATA

14. FLT LEVEL | 15. FLT LEVEL WINDS/TEMP

16. CLOUDS AT FLT LEVEL: YES / NO / IN AND OUT

17. MINIMUM VISIBILITY AT FLT LEVEL OUTSIDE CLOUDS MILES DUE TO: SMOKE / DUST / HAZE / FOG / PRECIPITATION / NO OBSTRUCTION

18. MINIMUM CEILING FT AGL LOCATION | 19. MAXIMUM CLOUDS TOPS FT MSL LOCATION | 20. MINIMUM FREEZING LEVEL FT MSL LOCATION

21. THUNDERSTORMS: MWA/WW NO.; NONE / AREA / LINE; ISOLATED 1 - 2%; FEW 3 - 15%; SCATTERED 16 - 45%; NUMEROUS - MORE THAN 45%; HAIL, SEVERE TURBULENCE & ICING, HEAVY PRECIPITATION, LIGHTNING & WIND SHEAR EXPECTED IN AND NEAR THUNDERSTORMS.; LOCATION

22. TURBULENCE: CAT ADVISORY; NONE / IN CLEAR / IN CLOUD; LIGHT; MOD OCNL; SVR; EXTREME; LEVELS; LOCATION

23. ICING: NONE; RIME / MIXED / CLEAR; TRACE; LIGHT; MOD; SVR; LEVELS; LOCATION

24. PRECIPITATION: NONE; DRIZ / RAIN / SNOW / SLEET; LT; MOD; HVY; SHWRS; FRZG; LOCATION

PART III - TERMINAL FORECASTS

25. AERODROME	26. CLOUD LAYERS	27. VSBY/WEA	28. SFC WIND	29. ALTIMETER	30. VALID TIME
DEST/ALTN					Z TO Z
DEST/ALTN					Z TO Z
DEST/ALTN					Z TO Z
DEST/ALTN					Z TO Z
DEST/ALTN					Z TO Z
DEST/ALTN					Z TO Z
DEST/ALTN					Z TO Z
DEST/ALTN					Z TO Z

PART IV - COMMENTS/REMARKS

31. BRIEFED ON LATEST RCR FOR DESTN AND ALTN: YES / NOT AVAILABLE | 32. REQUEST PIREP AT

33. REMARKS

PART V - BRIEFING RECORD

34. WEA BRIEFED Z | 35. FLIMSY BRIEFING NO. | 36. FORECASTER'S SIGNATURE OR INITIALS

37. VOID TIME Z | 38. EXTENDED TO Z | 39. WEA REBRIEFED AT Z | 40. FORECASTER'S INIT | 41. NAME OF PERSON RECEIVING BRIEFING

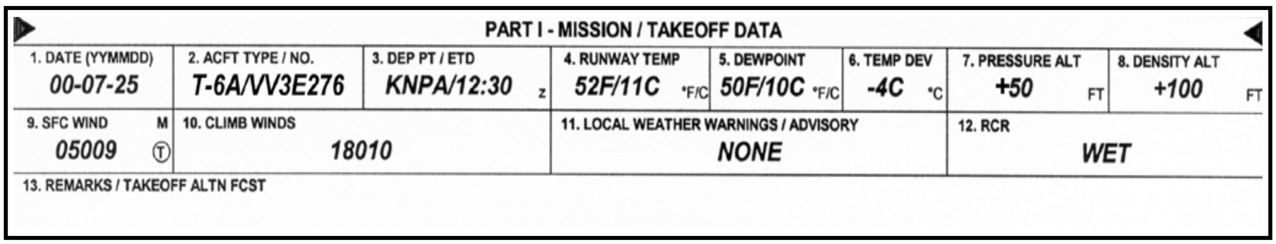
DD Form 175-1, SEP 89 — Previous edition may be used. — 287/272

Figure 9-2 DD 175-1 Flight Weather Briefing Form

While Figure 9-2 shows a blank form, from now on, this chapter will use a filled-out DD 175-1 so that you may become more familiar with the data presented therein. As might be expected, winds, altitudes, and other data will be presented in the common weather formats used throughout this book. For example, winds are given in a three-digit heading, two- (or three-) digit speed format, and altitudes are given in three digits, representing hundreds of feet MSL or the corresponding flight level.

903. PART I: MISSION/TAKEOFF DATA SECTION

The briefer uses the data from the DD-175 to complete the Mission/Takeoff Data section of the DD 175-1. This section identifies the flight for which the form is being prepared (first three blocks) and the forecast conditions for takeoff and climb out. Completion of the remaining takeoff data blocks is not normally required unless the pilot or person receiving the brief specifically states this information is needed or desired. However, local weather warnings that apply to the takeoff airfield, such as a CAWW or MWA, are always entered. This type of entry consists of the name of the warning and time that the warning is valid (e.g., TSTM COND II until 13Z). Although they are not required, the remaining blocks are usually filled in anyhow with data gathered from TAFs, FDs, and weather warning sources. Notice in Figure 9-3 that data from the DD-175 appears in Part I. The date, aircraft type, and departure point correspond with the flight plan submitted to METRO.



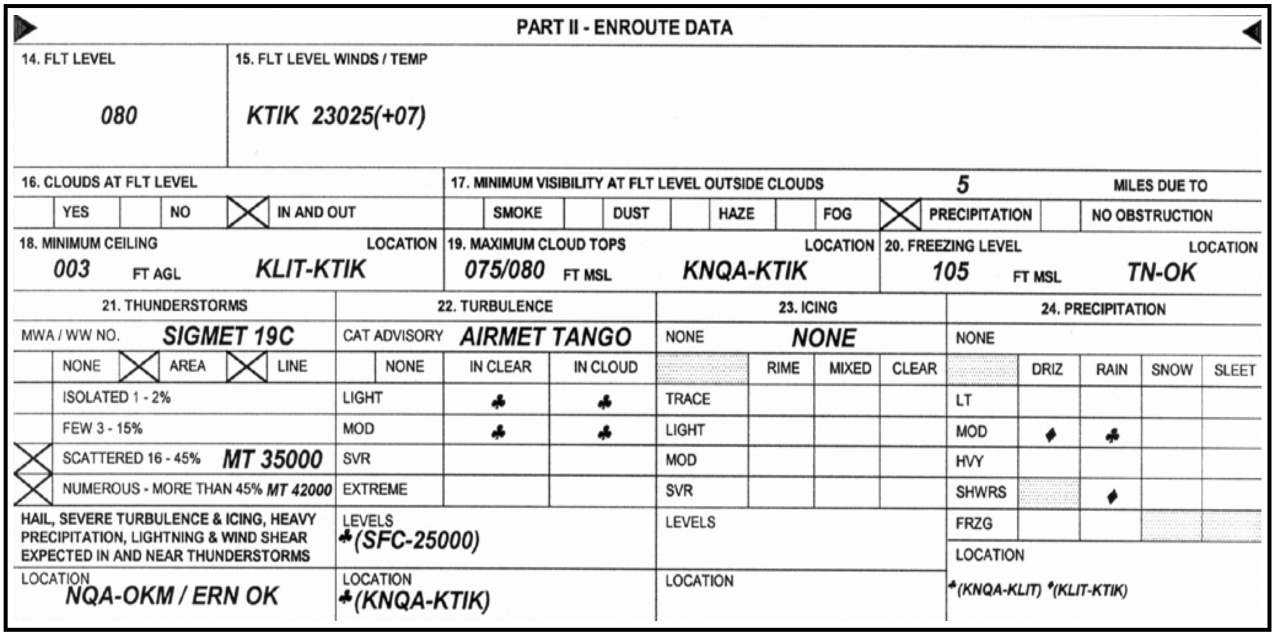
PART I - MISSION / TAKEOFF DATA

1. DATE (YYMMDD)	2. ACFT TYPE / NO.	3. DEP PT / ETD	4. RUNWAY TEMP	5. DEWPOINT	6. TEMP DEV	7. PRESSURE ALT	8. DENSITY ALT
00-07-25	T-6A/VV3E276	KNPA/12:30 Z	52F/11C °F/C	50F/10C °F/C	-4C °C	+50 FT	+100 FT
9. SFC WIND M: 05009 Ⓣ	10. CLIMB WINDS: 18010		11. LOCAL WEATHER WARNINGS / ADVISORY: NONE			12. RCR: WET	
13. REMARKS / TAKEOFF ALTN FCST							

Figure 9-3 Part I: Mission/Takeoff Data Section

904. PART II: ENROUTE DATA SECTION

The Enroute Data section of the DD 175-1 provides space for information about expected weather conditions within a range of 25 nautical miles of the intended route, and 5,000 feet above and below the intended flight path, plus destination conditions at altitude. (Note: 25 nautical miles and 5,000 feet are guidelines only–each mission is briefed on any phenomena that could occur, considering aircraft capability, mobility, versatility, and mission variations.) To avoid confusion among the various boxes in this section, briefers generally use different indicator marks to correlate entries, such as the club and diamond symbols in blocks 22 and 24 of Figure 9-4. Also, an up arrow (↑) indicates conditions during the climb, and a down arrow (↓) relates to the descent.



PART II - ENROUTE DATA

14. FLT LEVEL: 080

15. FLT LEVEL WINDS / TEMP: KTIK 23025(+07)

16. CLOUDS AT FLT LEVEL: YES | NO | [X] IN AND OUT

17. MINIMUM VISIBILITY AT FLT LEVEL OUTSIDE CLOUDS: 5 MILES DUE TO: SMOKE | DUST | HAZE | FOG | [X] PRECIPITATION | NO OBSTRUCTION

18. MINIMUM CEILING: 003 FT AGL LOCATION: KLIT-KTIK

19. MAXIMUM CLOUD TOPS: 075/080 FT MSL LOCATION: KNQA-KTIK

20. FREEZING LEVEL: 105 FT MSL LOCATION: TN-OK

21. THUNDERSTORMS

MWA / WW NO. SIGMET 19C

	NONE	
[X]	AREA	
[X]	LINE	
	ISOLATED 1 - 2%	
	FEW 3 - 15%	
[X]	SCATTERED 16 - 45%	MT 35000
[X]	NUMEROUS - MORE THAN 45%	MT 42000

HAIL, SEVERE TURBULENCE & ICING, HEAVY PRECIPITATION, LIGHTNING & WIND SHEAR EXPECTED IN AND NEAR THUNDERSTORMS

LOCATION: NQA-OKM / ERN OK

22. TURBULENCE

CAT ADVISORY: AIRMET TANGO

	IN CLEAR	IN CLOUD
NONE		
LIGHT	♣	♣
MOD	♣	♣
SVR		
EXTREME		

LEVELS: ♣(SFC-25000)

LOCATION: ♣(KNQA-KTIK)

23. ICING

NONE: NONE

	RIME	MIXED	CLEAR
TRACE			
LIGHT			
MOD			
SVR			

LEVELS

LOCATION

24. PRECIPITATION

NONE

	DRIZ	RAIN	SNOW	SLEET
LT				
MOD	♦	♣		
HVY				
SHWRS		♦		
FRZG				

LOCATION: ♣(KNQA-KLIT) ♦(KLIT-KTIK)

Figure 9-4 Part II: Enroute Data Section

Blocks 14 & 15: Flight Level Winds/Temperature

This block is filled in with data from the Winds-Aloft Forecasts (FDs) and Winds-Aloft Prognostic Charts. However, forecasters will generally not choose a flight altitude for you; that is your decision to make before handing in the DD-175 to METRO. Thus, the sources used to fill in the following blocks should be given an overview by the aircrew before the flight weather brief in order to select a flight altitude, as will be discussed in the next section, Selection of a Flight Level.

Blocks 16 & 17: Clouds and Visibility at Flight Level

Clouds at flight level and minimum visibility at flight level will generally be apparent from the overall weather picture provided during the weather briefing. This information may be supplemented with Pilot Weather Reports, which are also useful in obtaining other information not readily accessible in other specific charts and reports. These are available in teletype format under the heading "UA."

Notice there are three boxes within Block 16 that may be checked. A check in the "YES" box represents a forecast for greater than 45% of the time spent in clouds at the flight level in Block 14. A check in the "NO" box indicates less than 1% of the time will be spent in clouds, while a check in the "IN AND OUT" box indicates between 1% and 45% of the flight will be through clouds. If it is more practical to check more than one block to better represent cloud conditions, then the corresponding locations will be entered above the additional blocks.

Block 18: Minimum Ceiling

Information regarding the minimum ceiling can be derived quickly from the pictorial presentation of the Weather Depiction Chart. Additionally, the Area Forecasts (FA) and any AIRMET Sierras (WA) will also indicate conditions of IFR.

Block 19: Maximum Cloud Tops

The cloud tops indicated in Block 19 are given for clouds located around the aircraft's flight level. For observed data, maximum tops can be determined from the Radar Summary Chart. Pilot Reports are also a good source, when they are available. Forecasters may refer to satellite imagery to determine which observed clouds would be moving into the flight area, thus providing a forecast of tops. The Area Forecasts (FA) may also be used to provide forecast information.

Block 20: Freezing Level

To determine the minimum freezing level en route, there are a number of products available to meteorologists and aircrew. These include observed data from Winds-Aloft Prognostic Charts, and RADAT information from METARs, plus forecast data from AIRMETs Zulu (WA), Winds-Aloft Forecasts (FD), and Low Level Significant Weather Prognostic Charts. Recall that the AIRMET Zulu will always include freezing level information, even when icing is not forecast.

Notice that Blocks 18 through 24 will include a location as part of the information presented in each box, and that these locations are not required to coincide with each other, to give forecasters maximum flexibility in describing the weather. For example, while the flight is planned for NQA to TIK, the minimum ceiling will be found between LIT and TIK, while the maximum cloud tops should be experienced throughout the route, and the freezing level of 10,500’ MSL extends beyond the route of flight, from Tennessee to Oklahoma.

Block 21: Thunderstorms

Thunderstorms will be one of the patterns most obvious when building an overview of the weather. Of course, the Radar Summary Chart, as well as national NEXRAD composites and satellite imagery, gives a pictorial view of observed thunderstorm activity. Other sources, such as the Surface Prognostic Chart, Low Level Significant Weather Prognostic Chart, WW, MWA, and WST also provide thunderstorm information. A look at any one or more of these can give an instant indication when whether thunderstorms are present along the route of flight. Determining the extent of their severity and coverage, however, will likely be best described during the weather brief.

Block 21 provides means for communicating all pertinent facets of thunderstorm activity, starting with any thunderstorm warnings applicable to the route of flight (in addition to Block 11 in Part I, which is for warnings applicable to the local airfield). Any warnings listed here should also have comments made in the remarks section (Part IV) to elaborate on the warning. The next set of boxes can be checked to indicate the type and amount of coverage, in addition to providing the maximum cloud tops of the thunderstorms, when that information is available, along with the geographic location where the aircrew can expect to encounter the indicated thunderstorm activity. More than one box may be checked to indicate various possible conditions, so aircrew should be sure to ask for further details if the explanation given during the brief is unclear.

Finally, observe the typed notice above the location box that reads, "Hail, severe turbulence & icing, heavy precipitation, lightning & wind shear [can be] expected in and near thunderstorms." This is yet another reminder of the extremely hazardous nature of thunderstorms as described in chapter 4. Even though there is little extra space on the DD 175-1, some experienced aviators and meteorologist thought that it was very important for aviators to read this message every time their attention is focused on Block 21 (Figure 9-4 is repeated in Figure 9-5 for your convenience).

PART II - ENROUTE DATA

14. FLT LEVEL	15. FLT LEVEL WINDS / TEMP
080	KTIK 23025(+07)

16. CLOUDS AT FLT LEVEL	17. MINIMUM VISIBILITY AT FLT LEVEL OUTSIDE CLOUDS 5 MILES DUE TO
YES / NO / [X] IN AND OUT	SMOKE / DUST / HAZE / FOG / [X] PRECIPITATION / NO OBSTRUCTION

18. MINIMUM CEILING / LOCATION	19. MAXIMUM CLOUD TOPS / LOCATION	20. FREEZING LEVEL / LOCATION
003 FT AGL KLIT-KTIK	075/080 FT MSL KNQA-KTIK	105 FT MSL TN-OK

21. THUNDERSTORMS		22. TURBULENCE			23. ICING				24. PRECIPITATION				
MWA / WW NO.	SIGMET 19C	CAT ADVISORY	AIRMET TANGO		NONE	NONE			NONE				
NONE [X] AREA [X] LINE		NONE	IN CLEAR	IN CLOUD		RIME	MIXED	CLEAR		DRIZ	RAIN	SNOW	SLEET
	ISOLATED 1 - 2%	LIGHT	♣	♣	TRACE				LT				
	FEW 3 - 15%	MOD	♣	♣	LIGHT				MOD	♦	♣		
[X]	SCATTERED 16 - 45% MT 35000	SVR			MOD				HVY				
[X]	NUMEROUS - MORE THAN 45% MT 42000	EXTREME			SVR				SHWRS		♦		
HAIL, SEVERE TURBULENCE & ICING, HEAVY PRECIPITATION, LIGHTNING & WIND SHEAR EXPECTED IN AND NEAR THUNDERSTORMS		LEVELS ♣(SFC-25000)			LEVELS				FRZG				
									LOCATION				
LOCATION NQA-OKM / ERN OK		LOCATION ♣(KNQA-KTIK)			LOCATION				♣(KNQA-KLIT) ♦(KLIT-KTIK)				

Figure 9-5 Part II: Enroute Data Section

Block 22: Turbulence

The format of the Turbulence Block is similar to that of the Thunderstorm Block, beginning with a section for advisories, any of which should also have further remarks made in Part IV. Since turbulence will be experienced in all thunderstorms, this section is only for turbulence not associated with thunderstorms. Good sources of forecast information include the WS, WA (Tango), Surface Prognostic Chart, and Low-Level Significant Weather Prognostic Chart. PIREPs, when available, are also an excellent source of observed information on turbulence.

Blocks 23 & 24: Icing and Precipitation

Much like the sources for turbulence, the icing sources include the WS, WA (Zulu), Surface Prognostic Chart, and Low-Level Significant Weather Prognostic Chart, and PIREPs. Also, like the other blocks, Block 23 includes spaces for indicating types, intensities, and locations of icing.

Neither Block 23 nor Block 24 includes an area for advisories or warnings, as any that may be applicable to icing or precipitation would be listed in other areas of the DD 175-1. Expected precipitation for Block 24 can be determined from any or all surface weather products, including the Surface Prognostic Chart, Low-Level Significant Weather Prognostic Chart, Radar Summary Chart, MWA, and possibly even the WA (Sierra).

905. SELECTION OF A FLT LEVEL

Now that we have described the various weather sources used by meteorologists to fill out the Part II, Enroute Data section of the DD 175-1, it will be easier to discuss the various considerations in the selection of an enroute flight level. When building an overview of the weather after preflight planning, before turning in the flight plan to METRO, an aviator should strive to build a good idea of where the most hazardous conditions exist, in order to avoid them, when possible. Depending on the mission of the flight, and whether intending to fly IFR or VFR, the location, severity, and intensity of the following aspects of the weather will guide the selection of a flight level:

1. Wind component
2. Minimum ceilings/maximum cloud tops
3. Visibility at flight level
4. Minimum freezing level
5. Thunderstorms
6. Turbulence
7. Icing
8. Precipitation

Notice that this list of considerations corresponds with the set of Blocks 15 through 24 in Part II of the DD 175-1. Taking into account all the hazards associated with the foregoing conditions, an aviator can make an informed decision to select a group of altitudes that excludes as many of these hazards as possible.

906. PART III: TERMINAL FORECASTS SECTION

The Terminal Forecast section of the DD 175-1 provides space for information about forecast weather conditions at both the destination and alternate airfield, plus any planned intermediate stops. The format follows closely the TAF format from which the information is gathered, except that it is presented in columns, for easier reading (Figure 9-6).

PART III - TERMINAL FORECASTS

25. AIRDROME	26. CLOUD LAYERS	27. VSBY / WEA	28. SFC WIND	29. ALTIMETER	30. VALID TIME
DEST ALTN INFO KTIK	OVC004	1/2HZ FG	15010	2999 INS	13:42 Z TO 15:42 Z
DEST ALTN INFO KSPS	BKN008 OVC015	4BR	17015	2987 INS	14:20 Z TO 16:20 Z
DEST ALTN INFO KTUL	OVC009	2BR	14015	2986 INS	14:20 Z TO 16:20 Z
DEST ALTN INFO	TEMPO VV005CB	1/2 +TSRA	18020G35	2983 INS	15:00 Z TO 16:20 Z

Figure 9-6 Part III: Terminal Forecasts Section

Notice, though, that Part III does not list the whole TAF for the particular aerodrome. It will only list the one line (or more, including applicable change groups) that applies to the required valid time, based on the ETA stated on the DD-175 flight plan. As described in chapter 6, the military requires that destination (and alternate) weather be forecast for the flight to include the period of ±1 hour of the planned ETA.

Another feature of Part III is that the cloud layers are listed immediately after the airfield identifier, because ceilings are the primary weather factor used to determine whether an alternate is required. The next column lists the visibility at the field, as this is the other factor in the requirement for an alternate. Using Figure 9-6, which airfield, SPS or TUL, would be the best choice for an alternate (assume all airfields have minimums of 200-1/2)? Review chapter 6 if necessary, because when the weather is problematic, it will be at this point in the preflight process that the determination of the alternate is made. An aviator can wait until after the DD 175-1 is briefed to select an alternate, but it must be indicated by the time the DD-175 flight plan is submitted to Base Operations. The instructor will conduct a discussion of this decision during class.

To build a weather overview before the weather brief, an aviator would be duplicating the efforts of the meteorologist to leaf through the many lists of TAFs available. However, an overview of destination weather can be quickly gathered from the facsimile sources. Aviators can check the Surface Analysis Chart for observed pressure systems and fronts, and the Surface Prognostic Chart for a forecast of the same information. Additionally, since TAFs are transmitted less often than METARs, the reliability of a forecast can be determined during the weather briefing by comparing existing weather conditions with forecast weather conditions at the destination (or by comparing the METAR to the TAF).

For your convenience, a summary of the sources that may be used to forecast the weather for Parts II and III are shown in Figure 9-7.

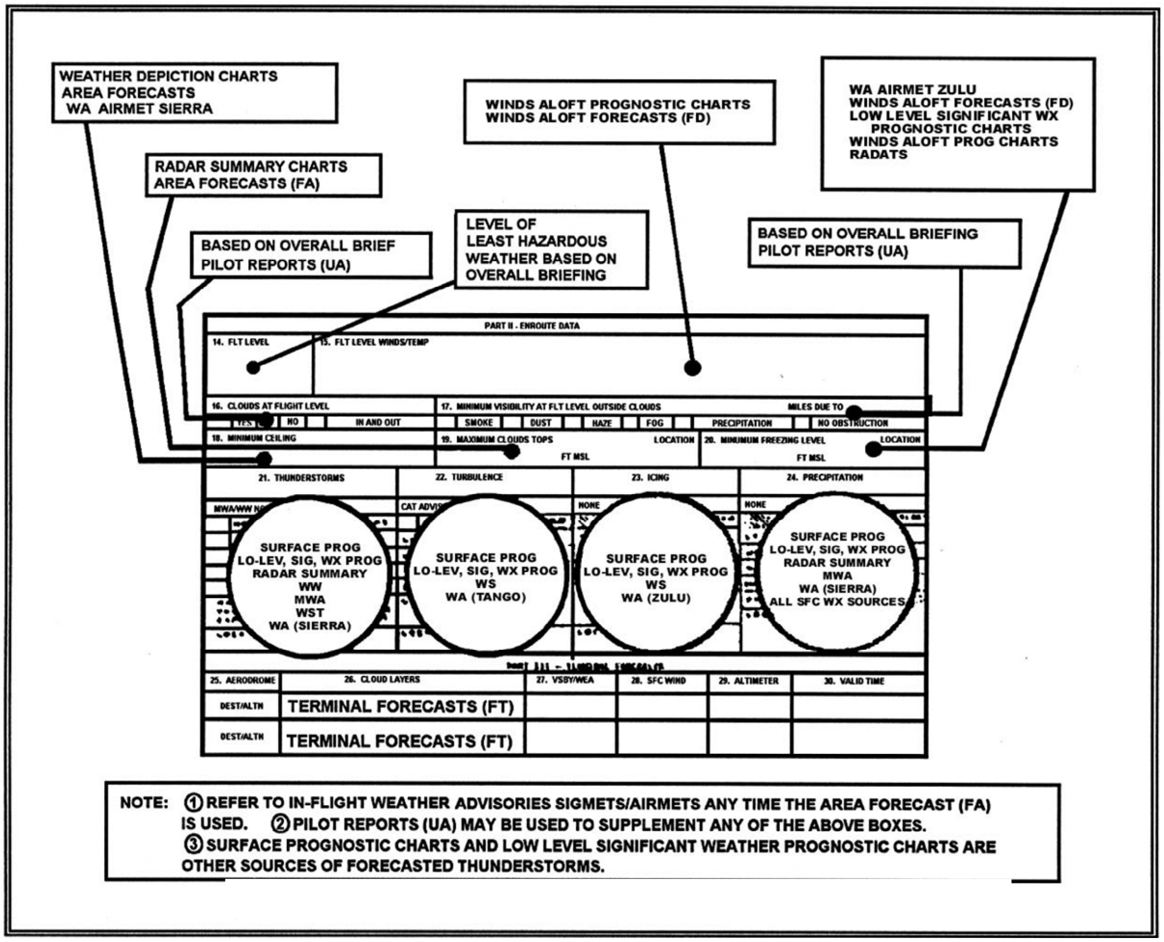


Figure 9-7 Sources for the Enroute Data and Terminal Forecast Sections

907. PART IV: COMMENTS/REMARKS SECTION

This section provides space for miscellaneous information concerning any portion of the flight (Figure 9-8). Remarks include any significant details or data not covered elsewhere and deemed pertinent, such as low-level wind shear, and runway conditions. When applicable and available, the latest braking action code will be given in Block 31. Weather personnel may request that you make a PIREP for a specific location along your route of flight where data is unavailable through other means. If so, the appropriate location, type weather, and METRO frequency will be listed in Block 32. Amplifying remarks on any WWs, SIGMETs, AIRMETs, or similarly issued warnings or advisories are required in Block 33. The latest hourly surface observation for the destination may also be included here. If space is a problem, an additional DD 175-1 will be used as a continuation sheet.

PART IV - COMMENTS / REMARKS

31. BRIEFED ON LATEST RCR FOR DESTN AND ALTN		YES	X	NOT AVAILABLE	32. REQUEST PIREP AT 359.6 SIG WX

33. REMARKS

KTIK 151058Z 09009KT 1 1/2SM R35/6000FT DZ BR VV003 12/12 A2999 RMK SLP156

SIGMET 19C VT25/1255Z
AIRMET TANGO VT25/1400Z
AIRMET SIERRA VT25/1400Z

Figure 9-8 Part IV: Comments/Remarks Section

908. PART V: BRIEFING RECORD SECTION

The actual time that the briefing is completed is entered in Block 34 of Part V (Figure 9-9). Block 35 provides the flimsy briefing number, which is the number identifying that particular weather brief. It is made up of a two-digit month, followed by a sequential number for that month (e.g., 02-35 indicates the 35th DD Form 175-1 completed in February). This flimsy briefing number should be transferred to the DD-175 flight plan before submitting it to Base Operations, to indicate that the aircrew has received a weather brief from a qualified forecaster.

PART V - BRIEFING RECORD

34. WEA BRIEFED	35. FLIMSY BRIEFING NO.	36. FORECASTER'S SIGNATURE OR INITIALS
11:27 Z	07-91	I. M. Good

37. VOID TIME	38. EXTENDED TO	39. WEA REBRIEFED AT	40. FORECASTER'S INIT	41. NAME OF PERSON RECEIVING BRIEFING
13:00 Z	Z	Z		ENS READY

DD Form 175-1, Sep 89 *Previous edition may be used.* S/N 0102-LF-008-4200

Figure 9-9 Part V: Briefing Record Section

<u>Assignment of Void Time</u>

Block 37 will show the void time of the weather brief. In accordance with OPNAVINST 3710.7, Navy and Marine Corps forecasters are required to provide flight weather briefings (DD 175-1 or VFR stamps) within 2 hours of ETD and to assign briefing void times that do not exceed ETD plus one-half hour. For example, for an ETD of 2200Z, the weather must be briefed no earlier than 2000Z, and actual departure must be no later than 2230Z.

If it appears that takeoff will occur outside this window of time–a total of 2 ½ hours after the brief time in Block 34–the weather brief needs to be updated. This can be accomplished via telephone before walking for the flight, or from the cockpit via radio before takeoff. If the weather brief as first given is still applicable, then it may be extended, and the aircrew should indicate this in Blocks 38 - 40. Depending on conditions, however, it may have to be re-briefed completely. In either case, the new valid time for a re-briefed forecast is subject to the same limitations as the original void time: one-half hour after the new ETD (provided to the forecaster so that the appropriate weather could be determined). This new void time needs to be entered into Block 38 by the aircrew, and the time in Block 39 should reflect the time at which the re-briefing is completed. Block 40 is provided for aircrew to indicate the initials of the forecaster who updated the weather brief. Finally, Block 41 is filled in at the time of the original brief to indicate the rank and last name of the person receiving the briefing, noted for METRO records.

Responsibility for the Brief

The ultimate responsibility for obtaining a complete weather briefing rests with the pilot in command. A forecaster will usually be present to provide the weather briefing, but this in no way relieves the pilot of the responsibility for the safe conduct of the flight. A recommended procedure for the professional pilot is to review pertinent weather information to build an overall picture of the weather, and then to consult with the forecaster for a complete briefing. A pilot using this technique can communicate with the forecaster on a two-way basis rather than relying on the forecaster to provide all the relevant information. In case conditions do not develop as forecast, a pilot will then be able to make an intelligent decision based on information gained during the preflight weather briefing. Upon completion of this unit, it is recommended that you visit your local meteorological office to get a feel for how it operates and how the staff displays weather information or otherwise makes data available to aviators.

STUDY QUESTIONS

Flight Weather Briefing Form, DD Form 175-1

1. Which one of the following correctly lists the five sections of the DD 175-1?

   a. Takeoff Data, Enroute Data, Landing Data, Flight Level Data, Void Time
   b. Mission Data, Takeoff Data, Enroute Data, Terminal Forecasts, Briefing Record
   c. Mission/Takeoff Data, Enroute Data, Terminal Forecasts, Comments/Remarks, Briefing Record
   d. Mission/Takeoff Data, Enroute Data, Terminal Forecasts, Briefing Record, Void Time

2. All information in Part I of the DD 175-1 must always be completed for all IFR flights.

   a. True b. False

3. Which one of the following should be the first source to check when beginning the flight planning process?

   a. WW
   b. WD
   c. FD
   d. FA

4. Which one of the following sources of information would be the best for determining the flight level winds and temperatures en route?

   a. Winds-Aloft Prognostic Charts
   b. Winds-Aloft Forecasts
   c. Weather Depiction Chart
   d. Radar Summary Chart

5. Which one of the following sources of information would be the best for determining minimum ceilings en route?

   a. Weather Depiction Chart
   b. TAF
   c. METAR
   d. PIREP

6. Which one of the following sources of information would be the best for determining the maximum cloud tops en route?

   a. Weather Depiction Chart
   b. METAR
   c. FD
   d. Radar Summary Chart

7. Which one of the following sources of information would be the best for determining the minimum freezing level en route?

   a. Weather Depiction Chart
   b. AIRMET Sierra
   c. Low Level Sig Weather Prog Chart
   d. Radar Summary Chart

8. Which one of the following sources of information would be the best for determining the intensity and coverage of thunderstorms en route?

a. Weather Depiction Chart
b. AIRMET Sierra
c. Low Level Sig Weather Prog Chart
d. Radar Summary Chart

9. Which one of the following sources of information would NOT be used for determining the intensity and location of turbulence en route?

a. SIGMET
b. AIRMET Tango
c. Low Level Sig Weather Prog Chart
d. Surface Analysis Chart

10. Which one of the following sources of information would be the best for determining if any icing will be encountered en route?

a. CWA
b. AIRMET Zulu
c. Weather Depiction Chart
d. Surface Analysis Chart

11. Which one of the following sources of information would NOT be used for determining the type of precipitation that may be encountered en route?

a. METAR
b. Surface Prognostic Chart
c. Low Level Sig Weather Prog Chart
d. Radar Summary Chart

12. Which one of the following types of information would NOT be a main consideration in the selection of the best flight level?

a. Wind component
b. Thunderstorms
c. RCR
d. Icing

13. Which one of the following would be the best choice for an alternate landing airfield, given the information presented throughout this chapter and the section discussing Figure 9-6?

a. An alternate is not required
b. KSPS
c. KTUL
d. KTIK

14. Which one of the following sources of information would be the best for determining whether an alternate is required?

a. METAR
b. TAF
c. FA
d. Weather Depiction Chart

15. Which one of the following correctly states the maximum length of time after the ETD that a DD 175-1 can be valid, according to OPNAVINST 3710.7?

a. ½ hour
b. 1 hour
c. 1 ½ hours
d. 2 ½ hours

16. Which one of the following correctly states the maximum overall length of time a DD 175-1 can be valid, according to OPNAVINST 3710.7?

a. ½ hour
b. 1 hour
c. 1 ½ hours
d. 2 ½ hours

17. Which one of the following people maintains the ultimate responsibility for the weather briefing?

a. Meteorologist
b. Navigator/co-pilot
c. Commanding Officer
d. Pilot in command

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APPENDIX A
SELECTED WEATHER INFORMATION RESOURCES

Current as of August 2000

Aviation Weather Center
  Homepage
    http://www.awc-kc.noaa.gov/index.html
  Frequently Asked Questions
    http://www.awc-kc.noaa.gov/info/faq.html
  Contractions frequently used in National Weather Service products
    http://www.awc-kc.noaa.gov/info/domestic_contractions.html

Direct User Access Terminal Service – Free access to GTE DUATS is available to U.S. pilots and student pilots who hold current medical certificates, flight instructors without current medicals, aviation ground instructors, glider/balloon pilots, and other approved users in the U.S. aviation community.
    http://www1.duats.com/

Landings.com Aviation Weather Information
    http://www.landings.com/_landings/pages/wthr/av_weather.html

National Hurricane Center/Tropical Prediction Center
    http://www.nhc.noaa.gov

National Oceanographic and Atmospheric Administration – Home Page
    http://www.noaa.gov/

National Weather Service
  Home Page
    http://www.nws.noaa.gov/
  Links to Current Weather Products
    http://www.nws.noaa.gov/data.html
  METAR/TAF Information
    http://www.nws.noaa.gov/oso/oso1/oso12/metar.htm

Naval Atlantic Meteorology and Oceanography Center home page – includes links to aviation weather and hurricane (tropical cyclone) data
    http://www.nlmoc.navy.mil/

Storm Prediction Center
    http://www.spc.noaa.gov/

USA Today Aviation Weather links
    http://www.usatoday.com/weather/wpilots0.htm

The Weather Channel – Home Page
    http://www.weather.com

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APPENDIX B
ANSWERS TO STUDY QUESTIONS

CHAPTER 1

1. A
2. B
3. D
4. B
5. B
6. C
7. B
8. C
9. D
10. B
11. C
12. D
13. A
14. D
15. B
16. D
17. C
18. D
19. D
20. B

CHAPTER 2

1. C
2. A
3. A
4. D
5. D
6. B
7. C
8. A
9. D
10. B
11. saturated
12. dew point temperature
13. D
14. stable
15. C
16. C
17. C
18. B
19. A
20. cumuliform, unstable
21. C
22. B

CHAPTER 3

1. D
2. B
3. A
4. C
5. A
6. A
7. C
8.

Type of Front	Wind Shift	Temper-ature Change	Pressure Change	Direction of Movement	Speed of Movement (kts)	Cloud Types	Turbulence Conditions	Color Code
Warm Front	SE to SW	Warmer	Falls then rises	NE	15	Stratiform	Smooth	Red
Cold Front	SW to NW	Colder	Falls then rises	SE	20	Cumuliform	Rough	Blue
Warm Front Occlusion	SE to NW	Warmer	Falls then rises	NE	15	Combination	Combination	Purple
Cold Front Occlusion	SE to NW	Colder	Falls then rises	NE	20	Combination	Combination	Purple
Stationary Front	180°	Either	Falls then rises	None	0 to 5	Stratiform	Smooth	R & B

CHAPTER 4

1. D
2. D
3. B
4. C
5. D
6. C
7. A

CHAPTER 5

1.	A	7.	A	13.	A	19.	D
2.	D	8.	B	14.	D	20.	B
3.	B	9.	B	15.	A	21.	B
4.	B	10.	D	16.	E	22.	A
5.	A	11.	A	17.	B	23.	B
6.	B	12.	C	18.	C	24.	A
						25.	C

CHAPTER 6

METAR Questions

1.	A	7.	C	13.	C	19.	D
2.	A	8.	B	14.	A	20.	A
3.	C	9.	B	15.	B	21.	A
4.	B	10.	D	16.	C	22.	D
5.	C	11.	C	17.	B	23.	A
6.	D	12.	D	18.	A	24.	D
						25.	B

TAF Questions

26.	D	30.	D	34.	A	38.	D
27.	C	31.	B	35.	A	39.	C
28.	B	32.	D	36.	C	40.	B
29.	A	33.	D	37.	C	41.	Yes

42. **NTU** ETA 1300Z: 100 / 1/2 (CIG) / (VSBY); ETA 1900Z: 700/3; ETA 0900Z: 700/4

43. **DOV** ETA 1400Z: 200 / 1/2; ETA 1800Z: 700/3; ETA 0100Z: 700/5

44. **NBE** ETA 1415Z: 500 / 1; ETA 1920Z: 2000/3; ETA 0130Z: 500/2

45. **TIK** ETA 1300Z: 400 / 1; ETA 1545Z: 400 / ½; ETA 0300Z: 5000/>6

46. **SPS** ETA 1310Z: 800/3; ETA 1730Z: 1500/>6; ETA 2300Z: 3000/>6

47.	**NQA**/ETA 0700Z	**NBG**/ETA 1600Z	**NMM**/ETA 0730Z
2 HOUR WINDOW	06-08Z	15-17Z	0630-0830Z
CEILING (MIN)	800	2500	NONE
VISIBILITY (MIN)/WEATHER(S)	1 / TSHRA	>6 / None	1 / BR
ALTIMETER (LOWEST)	30.08	30.25	30.18
WINDS (MAX)	200/25G35	130/12	CALM
ICING (TYPE/ALTITUDES)	NONE / N/A	MOD IN CLD / 13-22K FT	NONE / N/A

TURB (TYPE/ALTITUDES)	NONE /	MOD IN CLR OCNL/	SEV IN CLR /
	N/A	13-16K FT	20-25K FT

48. A. NQA - Yes
    B. NBG - No
    C. NMM - Yes

49. A. NQA - Yes
    B. NBG - Yes
    C. NMM - Yes

50. A. NQA - Ceilings and visibility
    B. NBG - Ceilings only
    C. NMM - Visibility only

CHAPTER 7

1.	C	9.	B	17.	C	25.	B	33.	D
2.	D	10.	B	18.	B	26.	A	34.	C
3.	A	11.	C	19.	D	27.	D	35.	D
4.	A	12.	C	20.	C	28.	A	36.	B
5.	B	13.	D	21.	A	29.	D	37.	D
6.	B	14.	B	22.	C	30.	C	38.	C
7.	D	15.	D	23.	D	31.	A	39.	A
8.	C	16.	A	24.	C	32.	D	40.	C

CHAPTER 8

1.	D	5.	A	9.	C	13.	C	17.	D
2.	C	6.	D	10.	B	14.	C	18.	D
3.	B	7.	B	11.	B	15.	D	19.	D
4.	C	8.	A	12.	D	16.	C	20.	D

CHAPTER 9

1.	C	7.	C	13.	B
2.	B	8.	D	14.	B
3.	A	9.	D	15.	A
4.	B	10.	B	16.	D
5.	A	11.	A	17.	D
6.	D	12.	C		

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APPENDIX C
GLOSSARY OF SELECTED METEOROLOGICAL TERMS

ACTUAL TIME OF OBSERVATION – For METAR reports, it is the time the last element of the report is observed or evaluated. For SPECI reports, it is the time that the criteria for a SPECI were met or noted.

ADIABATIC – The word applied in the science of thermodynamics to a process during which no heat is communicated to or withdrawn from the body or system concerned. Adiabatic changes of atmospheric temperatures are those that occur only in consequence of compression or expansion accompanying an increase or a decrease of atmospheric pressure.

AIRCRAFT MISHAP – An inclusive term to denote the occurrence of an aircraft accident or incident.

ALTIMETER SETTING – Pressure of the reporting station converted in order to produce a reading on altimeters of field elevation at 10 feet above the runway (normal installation height of the altimeter). Altimeter settings are given in inches of mercury and represent sea level pressure.

ATMOSPHERIC PRESSURE – The force exerted by the weight of the atmosphere from the level of measurement to its outer limits.

AUGMENTED REPORT – A meteorological report prepared by an automated surface weather observing system for transmission with certified weather observers signed on to the system to add information to the report.

AUTOMATED REPORT – A meteorological report prepared by an automated surface weather observing system for transmission, and with no certified weather observers signed on to the system.

BLOWING DUST – Dust raised by the wind to moderate heights above the ground and restricting horizontal visibility to less than 7 miles. If visibility reduced to between 5/8 and 5/16, then a Dust storm; if less than 5/16, then a severe Dust Storm.

BLOWING SAND – Sand raised by the wind to moderate heights above the ground and restricting horizontal visibility to less than 7 miles. If visibility reduced to between 5/8 and 5/16 then a Sandstorm; if less than 5/16, a severe Sandstorm.

BLOWING SNOW – Snow particles raised and stirred violently by the wind to moderate or great heights. Visibility is poor (6 miles or less) and the sky may become obscured when the particles are raised to great heights.

BLOWING SPRAY – Spray raised in such quantities as to reduce the visibility at eye level (6 feet on shore, 33 feet at sea) to 6 miles or less.

BROKEN LAYER – A cloud layer covering whose summation amount of sky cover is 5/8 through 7/8.

CALM – A condition when no motion of the air is detected.

CEILING – The height above the earth's surface (field elevation or ground elevation) of the lowest non-surface based layer that is reported as broken or overcast, or the vertical visibility into an indefinite ceiling.

CEILOMETER – A device used to evaluate the height of clouds or the vertical visibility into a surface-based obscuration.

CELSIUS – The ninth General Conference of Weights and Measures, held in October 1948, adopted the name **Celsius** in place of **centigrade** in honor of its originator, Anders Celsius (1704-1744), a Swedish astronomer who devised the scale.

CLEAR-AIR TURBULENCE (CAT) – Turbulence encountered when flying through air devoid of clouds, produced primarily by thermals and wind shear, including proximity to the jet stream.

CLEAR SKY (SKC) – The state of the sky when it is cloudless.

CLOUD-AIR LIGHTNING (CA) – Streaks of lightning which pass from a cloud to the air, but do not strike the ground.

CLOUD-CLOUD LIGHTNING (CC) – Streaks of lightning reaching from one cloud to another.

CLOUD-GROUND LIGHTNING (CG) – Lightning occurring between cloud and ground.

CLOUD HEIGHT – The height of the base of a cloud or cloud layer above the surface of the Earth.

CONTOUR LINE – A line connecting points of equal (constant) height on a Constant-Pressure Chart.

COORDINATED UNIVERSAL TIME (UTC) – The time in the zero meridian time zone.

CUMULUS – A principal cloud type in the form of individual, detached elements that are generally dense and possess sharp non-fibrous outlines.

CUMULONIMBUS – An exceptionally dense and vertically developed cloud, occurring either isolated or as a line or wall of clouds with separated upper portions. These clouds appear as mountains or huge towers, at least a part of the upper portions of which are usually smooth, fibrous, or striated, and almost flattened.

DESIGNATED RVR RUNWAY – A runway at civilian airports designated by the FAA for reporting RVR in long-line transmissions.

DEW POINT – The temperature to which a given parcel of air must be cooled at constant pressure and constant water-vapor content in order for saturation to occur.

DISPATCH VISUAL RANGE – A visual range value derived from an automated visibility sensor.

DRIZZLE – Fairly uniform precipitation composed exclusively of fine drops (diameter less than 0.02 inch or 0.5 mm) very close together. Drizzle appears to float while following air current, although unlike fog droplets, it falls to the ground.

DRY ADIABATIC LAPSE RATE – The rate of decrease of temperature with height, approximately equal to 3 °C. per 1,000 feet. This is close to the rate at which an ascending body of unsaturated air will cool by adiabatic expansion.

DUST STORM – An unusual, frequently severe weather condition characterized by strong winds and dust-filled air over an extensive area.

FEW – A layer whose summation amount of sky cover is 1/8 through 2/8.

FIELD ELEVATION – The elevation above sea level of the highest point on any of the runways of the airport.

FOG – A visible aggregate of minute water particles (droplets) which are based at the Earth's surface and reduce **horizontal visibility to less than 5/8 statute mile** and, unlike drizzle, it does not fall to the ground.

FREEZING – A descriptor, FZ, used to describe drizzle and/or rain that freezes on contact with the ground or exposed objects, and used also to describe fog that is composed of minute ice crystals.

FREEZING DRIZZLE – Drizzle that freezes upon impact with the ground, or other exposed objects.

FREEZING FOG – A suspension of numerous minute ice crystals in the air, or water droplets at temperatures below 0 °Celsius, based at the Earth's surface, **which reduces horizontal visibility**; also called ice fog.

FREEZING PRECIPITATION – Any form of precipitation that freezes upon impact and forms a glaze on the ground or exposed objects.

FREEZING RAIN – Rain that freezes upon impact and forms a glaze on the ground or exposed objects.

FROZEN PRECIPITATION – Any form of precipitation that reaches the ground in solid form (snow, small hail and/or snow pellets, snow grains, hail, ice pellets, and ice crystals).

FUNNEL CLOUD – A violent, rotating column of air which does not touch the ground, usually appended to a cumulonimbus cloud (see tornado and waterspout).

GLAZE – Ice formed by freezing precipitation covering the ground or exposed objects.

GRAUPEL – Granular snow pellets, also called soft hail.

GUST – Rapid fluctuations in wind speed with a variation of 10 knots or more between peaks and lulls.

HAIL – Precipitation in the form of small balls or other pieces of ice falling separately or frozen together in irregular lumps.

HAZE – A suspension in the air of extremely small, dry particles invisible to the naked eye and sufficiently numerous to give the air an opalescent appearance.

HECTOPASCAL – A unit of measure of atmospheric pressure equal to 100 newtons per square meter, abbreviated hPa.

ICE CRYSTALS (DIAMOND DUST) – A fall of unbranched (snow crystals are branched ice crystals in the form of needles, columns, or plates.

ICE PELLETS (PL) – Precipitation of transparent or translucent pellets of ice, which are round or irregular, rarely conical, and which have a diameter of 0.2 inch (5 mm), or less. There are two main types:

a. Hard grains of ice consisting of frozen raindrops, or largely melted and refrozen snowflakes.

b. Pellets of snow encased in a thin layer of ice which have formed from the freezing of either droplets intercepted by the pellets or of water resulting from the partial melting of the pellets.

IN-CLOUD LIGHTNING (IC) – Lightning which takes place within the thunder cloud.

INDEFINITE CEILING – The ceiling classification applied when the reported ceiling value represents the vertical visibility upward into surface-based obscuration.

INSOLATION – INcoming SOLar radiATION. The total amount of energy radiated by the Sun that reaches the Earth's surface. Insolation is the primary source for all weather phenomena on the Earth.

INTENSITY QUALIFIER – Intensity qualifiers are used to describe whether a phenomena is light (–), moderate (no symbol used), or heavy (+).

ISOBAR – A line on a chart or diagram drawn through places or points having the same barometric pressure. (Isobars are customarily drawn on weather charts to show the horizontal distribution of atmospheric pressure reduced to sea level or the pressure at some specified altitude.)

ISOTACH – A line joining points of equal wind speed.

ISOTHERM – A line on a chart or diagram drawn through places or points having equal temperature.

LOW DRIFTING – A descriptor, DR, used to describe snow, sand, or dust raised to a height of less than 6 feet above the ground.

LOW DRIFTING DUST – Dust that is raised by the wind to less than 6 feet above the ground; visibility is not reduced below 7 statute miles at eye level, although objects below this level may be veiled or hidden by the particles moving nearly horizontal to the ground.

LOW DRIFTING SAND – Sand that is raised by the wind to less than 6 feet above the ground; visibility is not reduced below 7 statute miles at eye level, although objects below this level may be veiled or hidden by the particles moving nearly horizontal to the ground.

LOW DRIFTING SNOW – Snow that is raised by the wind to less than 6 feet above the ground; visibility is not reduced below 7 statute miles at eye level, although objects below this level may be veiled or hidden by the particles moving nearly horizontal to the ground.

MANUAL STATION – A station, with or without an automated surface weather observing system, where the certified observers are totally responsible for all meteorological reports that are transmitted.

METAR/SPECI – An evaluation of select weather elements from a point or points on or near the ground according to a set of procedures. It may include type of report, station identifier, date and time of report, a report modifier, wind, visibility, runway visual range, weather and obstructions to vision, sky condition, temperature and dew point, altimeter setting, and Remarks.

MILLIBAR – (Bar – a unit of pressure equal to 1,000,000 dynes per square centimeter.) A millibar is equal to 1/1,000 of a bar.

MIST – A hydrometer consisting of an aggregate of microscopic and more-or-less hygroscopic water droplets or ice crystals suspended in the atmosphere that reduces visibility to **less than 6 statute miles** but greater than or equal to 5/8 statute mile.

MOIST ADIABATIC LAPSE RATE – See Saturated Adiabatic Lapse Rate.

NON-UNIFORM SKY CONDITION – A localized sky condition which varies from that reported in the body of the report.

NON-UNIFORM VISIBILITY – A localized visibility which varies from that reported in the body of the report.

OBSCURED SKY – The condition when the entire sky is hidden by a surface-based obscuration.

OBSCURATION – Any aggregate of particles in contact with the earth's surface that is dense enough to be detected from the surface of the earth. Also, any phenomenon in the atmosphere, other than precipitation, that reduces the horizontal visibility.

OVERCAST – A layer of clouds whose summation amount of sky cover is 8/8.

PARTIAL – A descriptor, PR, used only to report fog that covers part of the airport.

PARTIAL FOG – Fog covering part of the station and which extends to at least 6 feet above the ground and apparent visibility in the fog is less than 5/8 SM. Visibility over parts of the station is less than or equal to 5/8 SM.

PARTIAL OBSCURATION – The portion of the sky cover (including higher clouds, the moon, or stars) hidden by weather phenomena in contact with the surface.

PATCHES – A descriptor, BC, used only to report fog that occurs in patches at the airport.

PATCHES (OF) FOG – Fog covering part of the station which extends to at least 6 feet above the ground and the apparent visibility in the fog patch or bank is less than 5/8 SM. Visibility in parts of the observing area is greater than or equal to 5/8 SM, when the fog is close to the point of observation, the minimum visibility reported will be less than 5/8 SM.

PEAK WIND SPEED – The maximum instantaneous wind speed since the last METAR that exceeded 25 knots.

PRECIPITATION DISCRIMINATOR – A sensor, or array of sensors, that differentiates between different types of precipitation (liquid, freezing, frozen).

PRESSURE FALLING RAPIDLY – A decrease in station pressure at a rate of 0.06 inch of mercury or more per hour which totals 0.02 inch or more.

PRESSURE RISING RAPIDLY – An increase in station pressure at a rate of 0.06 inch of mercury or more per hour which totals 0.02 inch or more.

RADIOSONDE – A balloon-borne instrument used to measure the temperature, pressure and humidity aloft.

RAIN – Precipitation of liquid water particles, either in the form of drops larger than .02 inch (0.5 mm) or smaller drops which, in contrast to drizzle, are widely separated.

PREVAILING VISIBILITY – The visibility that is considered representative of conditions at the station; the greatest distance that can be seen throughout at least half the horizon circle, not necessarily continuous.

ROTOR CLOUD – A turbulent cloud formation found in the lee of some large mountain barriers. The air in the cloud rotates around an axis parallel to the mountain range.

RUNWAY VISUAL RANGE (RVR) – An instrumentally-derived value, based on standard calibrations, that represents the horizontal distance a pilot may see down the runway from the approach end.

SANDSTORM – Particles of sand ranging in diameter from 0.008 to 1 mm that are carried aloft by a strong wind. The sand particles are mostly confined to the lowest ten feet, and rarely rise more than fifty feet above the ground.

SATURATED ADIABATIC LAPSE RATE – A rate of decrease of temperature with height equal to the rate at which an ascending body of saturated air will cool during adiabatic expansion. This value will vary, but is considered to average about 1.5 °C. per 1,000 feet.

SCATTERED – A layer whose summation amount of sky cover is 3/8 through 4/8.

SCHEDULED TIME OF REPORT – The time a schedule report is required to be available for transmission.

SEA-LEVEL PRESSURE – The pressure value obtained by the theoretical reduction or increase of barometric pressure to sea-level; measured in hectopascals (millibars).

SECTOR VISIBILITY – The visibility in a specified direction that represents at least a 45-degree arc of the horizon circle.

SHALLOW – A descriptor, MI, used only to describe fog when the visibility at 6 feet above the ground is 5/8 statute mile or more and the apparent visibility in the fog layer is less than 5/8 statute mile.

SHALLOW FOG – Fog in which the visibility at 6 feet above ground level is 5/8 statute mile or more and the apparent visibility in the fog layer is less than 5/8 statute mile.

SHOWER(S) – A descriptor, SH, used to qualify precipitation characterized by the suddenness with which they start and stop, by the rapid changes of intensity, and usually by rapid changes in the appearance of the sky.

SIGNIFICANT CLOUDS – Cumulonimbus, cumulonimbus mammatus, towering cumulus, altocumulus castellanus, and standing lenticular or rotor clouds.

SKY CONDITION – The state of the sky in terms of such parameters as sky cover, layers and associated heights, ceiling, and cloud types.

SKY COVER – The amount of the sky which is covered by clouds or partial obscurations in contact with the surface.

SMOKE – A suspension in the air of small particles produced by combustion. A transition to haze may occur when smoke particles have traveled great distances (25 to 100 statute miles or more) and when the larger particles have settled out and the remaining particles have become widely scattered through the atmosphere.

SNOW – Precipitation of snow crystals, mostly branched in the form of six-pointed starts; for automated stations, any form of frozen precipitation other than hail.

SNOW GRAINS – Precipitation of very small, white opaque grains of ice; the solid equivalent of drizzle.

SNOW PELLETS – Precipitation of white, opaque grains of ice. The grains are round or sometimes conical. Diameters range from about 0.08 to 0.2 inch (2 to 5 mm).

SPRAY – An ensemble of water droplets torn by the wind from an extensive body of water, generally from the crests of waves, and carried up into the air in such quantities that it reduces the horizontal visibility.

SPECI – A surface weather report taken to record a change in weather conditions that meets specified criteria or is otherwise considered to be significant.

SQUALL – A strong wind characterized by a sudden onset in which wind speeds increase to at least 16 knots and are sustained at 22 knots ore more for at least one minute.

STANDARD ATMOSPHERE – A hypothetical vertical distribution of the atmospheric temperature, pressure, and density, which by international agreement is considered to be representative of the atmosphere for pressure-altimeter calibrations and other purposes (29.92 in-Hg or 1013 Pa).

STANDING LENTICULAR CLOUD – A more or less isolated cloud with sharp outlines that is generally in the form of a smooth lens or almond. These clouds often form on the lee side of and generally parallel to mountain ranges. Depending on their height above the surface, they may be reported as stratocumulus standing lenticular cloud (SCSL); altocumulus standing lenticular (ACSL); or cirrocumulus standing lenticular cloud (CCSL).

STATION ELEVATION – The officially designated height above sea-level to which station pressure pertains. It is generally the same as field elevation at an airport station.

STATION IDENTIFIER – A 4-alphabetic-character code group used to identify the observing location.

STATION PRESSURE – Atmospheric pressure computed for the level of the station elevation.

SUMMATION LAYER AMOUNT – a categorization of the amount of sky cover at and below each reported layer of cloud.

SUMMATION PRINCIPLE – This principle states that the sky cover at any level is equal to the summation of the sky cover of the lowest layer, plus the additional sky cover present at all successively higher layers up to and including the layer being considered.

SURFACE VISIBILITY – The prevailing visibility determined from the usual point of observation.

SYNOPTIC CHART – A chart, such as the ordinary weather map, which shows the distribution of meteorological conditions over an area at a given moment.

THUNDERSTORM – A descriptor, TS, used to qualify precipitation produced by a cumulonimbus cloud that is accompanied by lightning and thunder, or for automated systems, a storm detected by lightning detection systems.
TIME OF OCCURRENCE – A report of the time weather begins and ends.

TORNADIC ACTIVITY – The occurrence or disappearance of tornadoes, funnel clouds, or waterspouts.

TORNADO – A violent, rotating column of air touching the ground; funnel cloud that touches the ground (see funnel cloud and water spout).

TOWER VISIBILITY – The prevailing visibility determined from the airport traffic control tower when the surface visibility is determined from another location.

TOWERING CUMULUS – A descriptive term for a cloud with generally sharp outlines and with moderate to great vertical development, characterized by its cauliflower or tower appearance.

UNKNOWN PRECIPITATION – Precipitation type that is reported if the automated station detects the occurrence of light precipitation but the precipitation discriminator cannot recognize the type.

VARIABLE CEILING – A ceiling of less than 3,000 feet which rapidly increases or decreases in height by established criteria during the period of observation.

VARIABLE LAYER AMOUNTS – A condition when the reportable amount of a layer varies by one or more reportable values during the period it is being evaluated (variable sky condition).

VARIABLE PREVAILING VISIBILITY – A condition when the prevailing visibility is less than 3 statute miles and rapidly increases and decreases by 1/2 mile or more during the period of observation.

VARIABLE WIND DIRECTION – A condition when (1) the wind direction fluctuates by 60 degrees or more during the 2-minute evaluation period and the wind speed is greater than 6 knots; or (2) the direction is variable and the wind speed is 6 knots or less.

VERTICAL VISIBILITY – A subjective or instrumental evaluation of the vertical distance into a surface-based obscuration that an observer would be able to see.

VICINITY – A proximity qualifier, VC, used to indicate weather phenomena observed between 5 and 10 statute miles of the usual point of observation but not at the station.

VIRGA – Visible wisps or strands of precipitation falling from clouds that evaporate before reaching the surface.

VISIBILITY – The greatest horizontal distance at which selected objects can be seen and identified or its equivalent derived from instrumental measurements.

VOLCANIC ASH – Fine particles of rock powder that originate blown out from a volcano and that may remain suspended in the atmosphere for long periods. The ash is a potential hazard to aircraft operations and may be an obscuration.

VOLCANIC ERUPTION – An explosion caused by the intense heating of subterranean rock which expels lava, steam, ashes, etc., through vents in the earth's crust.

WATERSPOUT – A violent, rotating column of air that forms over a body of water, and touches the water surface; tornado or funnel cloud that touches a body of water (see funnel cloud and tornado).

WELL-DEVELOPED DUST/SAND WHIRL – An ensemble of particles of dust or sand, sometimes accompanied by small litter, raised from the ground in the form of a whirling column of varying height with a small diameter and an approximately vertical axis.

WIDESPREAD DUST – Fine particles of earth or other matter raised or suspended in the air by the wind that may have occurred at or far away from the station.

WIND SHIFT – A change in the wind direction of 45 degrees or more in less than 15 minutes with sustained wind speeds of 10 knots or more throughout the wind shift.

APPENDIX D
LOCATION IDENTIFIERS

KABI .... Abilene, TX
KABQ .... Albuquerque, NM
KABR .... Aberdeen, SD
KABY .... Albany, GA
KACT .... Waco, TX
KACY .... Atlantic City, NJ
KADM .... Ardmore, OK
KAEX .... England AFB, LA
KAGS .... Augusta, GA
KALO .... Waterloo, IA
KAMA .... Amarillo, TX
KANB .... Anniston, AL
KAND .... Anderson, SC
KAQQ .... Apalachicola, FL
KARG .... Walnut Ridge, AR
KART .... Watertown, NY
KATL .... Atlanta, GA
KAUG .... Augusta, TA
KAUS .... Austin, TX
KAVL .... Asheville, NC
KBAD .... Barksdale AFB LA
KBAL .... Baltimore, MD
KBFM .... Brookley VOR, AL
KBGS .... Big Springs, TX
KBHM .... Birmingham, AL
KBIS .... Bismarck, ND
KBIX .... Biloxi, MS
KBLD .... Boulder City, NV
KBLH .... Blythe, CA
KBNA .... Nashville, TN
KBOI .... Boise, ID
KBOS .... Boston, MA
KBPT .... Beaumont, TX
KBRO .... Brownsville, TX
KBSM .... Bergstrom AFB, TX
KBTR .... Baton Rouge, LA
KBWG .... Bowling Green KY
KCAE .... Columbia, SC
KCBM .... Columbus, MS
KCDW .... Caldwell, NJ
KCDS .... Childress, TX
KCEW .... Crestview, FL
KCHA .... Chattanooga, TN
KCHI .... Chicago, IL
KCHS .... Charleston, SC
KCID .... Ceder Rapids, IA
KCLL .... College Station, TX
KCLT .... Charlotte, NC
KCNU .... Chanute, KS
KCOT .... Cotulla, TX
KCOU .... Columbia, MO
KCRP .... Corpus Christi, TX
KCSV .... Crossville, TN
KCTY .... Cross City, FL
KCVG .... Cincinnati, OH
KDAB .... Daytona Beach, FL
KDAL .... Dallas, TX
KDCA .... Washington, DC
KDDC .... Dodge City, KS
KDFW .... Fort Worth, TX
KDHN .... Dothan, AL
KDLF .... Loughlin AFB, TX
KDOV .... Dover AFB, DE
KDRT .... Del Rio, TX
KDUA .... Durant, OK
KDYR .... Dyersburg, TN
KDYS .... Dyess AFB, TX
KEFD .... Ellington AFB, TX
KELP .... El Paso, TX
KEND .... Enid, OK
KEUG .... Eugene, OR
KFAT .... Fresno, CA
KFBG .... Fort Bragg, NC
KFDY .... Findley, OH
KFFO .... Wright Patterson AFB, OH
KFLO .... Florence, SC
KFMN .... Farmington, NM
KFMY .... Fort Myers, FL
KFOD .... Fort Dodge, IA
KFSI .... Fort Sill, OK
KFSM .... Fort Smith, AR
KFTY .... Fulton County VOR, GA
KFWH .... Carswell AFB, TX
KFYV .... Fayetteville, AR
KGAG .... Gage, OK
KGCK .... Garden City, KS
KGFA .... Great Falls, MT
KGFK .... Grand Forks, ND
KGGG .... Longview, TX
KGLS .... Galveston, TX
KGPT .... Gulfport, MS
KGRI .... Grand Island, NE
KGRK .... Gray AAF, TX
KGSO .... Greensboro, NC
KGUS .... Grissom AFB, IN
KGUY .... Guymon, OK
KGWO .... Greenwood, MS
KHAR .... Harrisburg, PA
KHAT .... Cape Hatteras, NC
KHLR .... Fort Hood AAF, TX
KHNN .... Henderson, WV
KHOT .... Hot Springs, AR
KHOU .... Houston, TX
KHQM .... Hoquiam, WA
KIAH .... Houston, TX
KICT .... Wichita, KS
KIGB .... Columbus, MS
KILM .... Wilmington, NC

KINK .... Wink, TX
KINL .... International Falls, MN
KJAN .... Jackson, MS
KJAX .... Jacksonville, FL
KLBE .... Latrobe, PA
KLBF .... North Platte, NE
KLBL .... Liberal, KS
KLCH .... Lake Charles, LA
KLEX .... Lexington, KY
KLFK .... Lufkin, TX
KLIT .... Little Rock, AR
KLRD .... Laredo, TX
KLRF .... Little Rock, AR
KLTS .... Altus, OK
KLUF .... Luke AFB, AZ
KMCB .... McComb, MS
KMEI .... Meridian, MS
KMEM .... Memphis, TN
KMGM .... Montgomery, AL
KMIA .... Miami, FL
KMKC .... Kansas City, MO
KMLB .... Melbourne, FL
KMLU .... Monroe, LA
KMOB .... Mobile, AL
KMOT .... Minot, ND
KMRB .... Martinsburg, WV
KMSP .... Minneapolis, MN
KMSY .... New Orleans, LA
KMXF .... Maxwell AFB, AL
KNBE .... Navy Dallas, TX
KNBU .... Navy Glenview, IL
KNBG .... New Orleans, LA
KNFB .... Navy Detroit, MI
KNFL .... NAS Fallon, NV
KNGZ .... NAS Alameda, CA
KNID .... NAF China Lake, CA
KNIP .... Navy Jacksonville, FL
KNKT .... MCAS Cherry Point, NC
KNKX .... NAS Miramar, CA
KNMM .... Navy Meridian, MS
KNPA .... Navy Pensacola, FL
KNQA .... Navy Memphis, TN
KNSE .... Navy Whiting Field, FL
KNSU .... NALF Monterey, CA
KNTD .... NAS Pt Mugu, CA
KNTU .... Navy Oceana, VA
KNUN .... NAS Saufley Field, FL
KNUW .... NAS Whidbey Island, WA
KNXX .... Navy Willow Grove, PA
KNZY .... NAS North Island, CA
KOFF .... Offutt AFB, NE
KOKC .... Oklahoma City, OK
KOKM .... Okmulgee, OK
KOMA .... Omaha, Ne
KONP .... Newport, OR
KORF .... Norfolk, VA
KORL .... Orlando, FL
KOUN .... Norman, OK
KOZR .... Cairns AFB, AL
KPAH .... Paducah, KY
KPAM .... Tyndall AFB, FL
KPBI .... Palm Beach, FL
KPDX .... Portland, OR
KPIE .... St. Petersburg, FL
KPHL .... Philadelphia, PA
KPHX .... Phoenix, AZ
KPIT .... Pittsburgh, PA
KPKB .... Parkersburg, WV
KPNS .... Pensacola, FL
KPOE .... Fort Polk, LA
KPRC .... Prescott, AZ
KPRX .... Paris, TX
KPSB .... Philipsburg, PA
KPUB .... Pueblo, CO
KPWM .... Portland, ME
KRAP .... Rapid City, SD
KRDR .... Grand Forks, ND
KRDU .... Raleigh, NC
KRIV .... March AFB, CA
KRND .... Randolph AFB, TX
KRNO .... Reno, NV
KRWI .... Rocky Mount, NC
KSAN .... San Diego, Ca
KSAT .... San Antonio, TX
KSBA .... Santa Barbara, CA
KSDF .... Louisville, KY
KSEA .... Seattle, WA
KSEM .... Craig AFB, AL
KSFO .... San Francisco, CA
KSGF .... Springfield, MO
KSHV .... Shreveport, LA
KSJT .... San Angelo, TX
KSKF .... Kelly AFB, CA
KSLC .... Salt Lake City, UT
KSLN .... Salina, KS
KSPS .... Sheppard AFB, TX
KSTL .... St. Louis, MO
KSUU .... Travis AFB, CA
KSVN .... Hunter AFB, GA
KTLH .... Tallahassee, FL
KTIK .... Tinker AFB, OK
KTOL .... Toledo, OH
KTOP .... Topeka, KS
KTPL .... Temple, TX
KTRI .... Bristol, TN
KTUL .... Tulsa, OK
KTUS .... Tucson, AZ
KVAD .... Moody AFB, GA
KVPS .... Eglin AFB, FL
KVRB .... Vero Beach, FL
KWRB .... Warner-Robbins AFB, GA
KWRI .... McGuire AFB, NJ

INTERNATIONAL IDENTIFIERS

EGLL ....Gatwick, England
PGUA ...Andersen AFB, Guam, Mariana Islands
LEMD .... Madrid, Spain
EDAH ....Amsterdam, Holland

State Abbreviations

Alabama .... AL	New Hampshire .... NH
Alaska .... AK	New Jersey .... NJ
Arizona .... AZ	New Mexico .... NM
Arkansas .... AR	New York .... NY
American Samoa .... AS	North Carolina .... NC
California .... CA	North Dakota .... ND
Colorado .... CO	Northern Mariana Island .... CM
Connecticut .... CT	Ohio .... OH
Delaware .... DE	Oklahoma .... OK
District of Columbia .... DC	Oregon .... OR
Florida .... FL	Pennsylvania .... PA
Georgia .... GA	Puerto Rico .... PR
Guam .... GU	Rhode Island .... RI
Hawaii .... HI	South Carolina .... SC
Idaho .... ID	South Dakota .... SD
Illinois IL	Tennessee .... TN
Indiana .... IN	Trust Territory .... TT
Iowa .... IA	Texas .... TX
Kansas .... KS	Utah .... UT
Kentucky .... KY	Vermont .... VT
Louisiana .... LA	Virginia .... VA
Maine .... ME	Virgin Islands VI
Maryland .... MD	Washington .... WA
Massachusetts .... MA	West Virginia .... WV
Michigan .... MI	Wisconsin .... WI
Minnesota .... MN	Wyoming .... WY
Mississippi .... MS	
Missouri .... MO	
Montana .... MT	
Nebraska .... NE	
Nevada .... NV	

APPENDIX E
COMMON WEATHER CONTRACTIONS

A

ABT .... about
ABV .... above
AC .... altocumulus
ACS .... across
ACFT .... aircraft
ACRS .... across
ACTVTY/ACT .... activity
ADJ .... adjacent
ADVY .... advisory
AFT .... after
AGL .... above ground level
AHD .... ahead
ALF .... aloft
ALG .... along
ALQDS .... all quadrants
AMS .... air mass
AOB .... at or below
APRNT .... apparent
AR .... Arkansas
ARPT .... airport
ATLC .... Atlantic
AUTO .... automated weather report

B

B .... began
BA .... breaking action
BC .... patches
BCM .... become
BCMG .... becoming
BGNG .... beginning
BHND .... behind
BINOVC .... breaks in overcast
BKN .... broken
BL .... blowing
BLDPS .... buildups
BLO/BLW .... below
BNDRY .... boundary
BR .... mist
BRFLY .... briefly
BTWN .... between
BYD .... beyond

C

C .... ceiling
CA .... clear above
CAT .... clear air turbulence
CBS/CB .... cumulonimbus
CDFNT/CFP .... cold front
CDT .... Central Daylight Time
CHC .... chance
CI .... cirrus
CIG .... ceiling
CIGS .... ceilings
CLD .... cold
CLDS .... clouds
CLR .... clear (used at automated stations)
CLSD .... closed
CNCL .... cancel
CNTRD/CNTR .... centered
CNTRL/CTRL .... central
CNSDBLY .... considerably
CNVGNC .... convergence
CNVTV .... convective
CO .... Colorado
CONDS .... conditions
CON/CONTD .... continue
CONS .... continuous
CONTG .... continuing
COR .... correction
CST .... Central Standard Time
CSTL .... coastal
CTC .... contact
CU .... cumulus
CUFA .... cumulofractus

D

D .... dust
DCRG .... decreasing
DEP .... depth
DMSHG .... diminishing
DR .... dropping rapidly
DR .... low drifting
DRFTG .... drifting
DS .... dust storm
DSIPTG .... dissipating
DSNT .... distant
DU .... (widespread) dust
DURG .... during
DURCG .... during climb
DURGD .... during descent
DVLP/DVLPG .... develop/developing
DVR .... dispatch visual range
DZ .... drizzle

E

E .... ended/east
EBND .... eastbound
ELSW .... elsewhere
ELY .... easterly
EMBDD .... embedded

ERN .... eastern
EST .... estimated
EWD .... eastward
EXCP/EXC .... except
EXPCD/EXPCTD/EXPTD/EXP .... expected
EXTM/EXTRM .... extreme
EXTDS .... extends

F

FAP .... final approach
FEW .... few clouds
FC .... funnel cloud(s)
FCST .... forecast
FG .... fog
FIBI .... filed but impractical to transmit
FL .... flight level/Florida
FLT .... flight
FM .... from
FNT .... front
FNTL .... frontal
FRQ .... frequent
FQTLY .... frequently
FRMG .... forming
FROPA .... frontal passage
FRTHR .... further
FRZLVL .... freezing level
FT .... feet
FU .... smoke
FXD .... fixed
FVRBL .... favorable
FZ .... freezing
FZRNO .... freezing rain sensor not available

G

G .... gust/gusting
GA .... Georgia
GND .... ground
GR .... hail (graupel)
GRT/GTR .... greater
GS .... small hail/snow pellets
GULFMEX/GLF .... Gulf of Mexico

H

H/HZ .... haze
HALF .... haze aloft
HGTS .... heights
HI .... high
HLSTO/GR/GS .... hailstone
HZ .... haze

I

IA .... Iowa
IC .... icing/ice crystals
ICGIC .... icing in clouds
ICGICIP .... icing in clouds & in precipitation
ID .... Idaho
IFR .... Instrument Flight Rules
IL .... Illinois
IMPVG/IPVG .... improving
INC .... in clouds
IN .... inch
IN .... Indiana
INCRG .... increasing
INTMT .... intermittent
INTSFYG .... intensifying
INSTBY .... instability
INVOF .... in vicinity of
ISLTD/ISOLD .... isolated

J

JSTR .... jet stream

K

K/FU .... smoke
KALF .... smoke aloft
KOCTY .... smoke over city
KS .... Kansas
KT .... knot
KTS .... knots

L

LCL .... local
LCLY .... locally
LE .... Lake Erie
LGT .... light
LI .... lifted index
LLWS .... low level wind shear
LN .... line
LOC .... location identifier
LO .... low
LRG .... large
LTG .... lightning
LTGCA .... lightning cloud to air
LTGCCCG .... lightning cloud to cloud and cloud to ground
LTGCG .... lightning cloud to ground
LTGIC .... lightning in cloud
LTL .... little
LTLCHG .... little change
LVL .... level
LWR .... lower
LWRG .... lowering
LYR/LYRD .... layer/layered

M

M .... minus; less than
MALSR .... medium intensity approach lighting system
MAX........ maximum
MDT/MOD........ moderate
MEGG .... merging
METAR .... aviation routine weather report
MI .... Michigan
MI .... miles
MI .... shallow
MO........ Missouri
MOGR........ moderate or greater
MOV........ move
MOVD........ moved
MOVG\MVG .... moving
MS .... Mississippi
MSL........ mean sea level
MST........ most
MSTLY .... mostly
MSTR .... moisture
MT .... mountains/Montana
MTN/MTNS .... mountain/mountains
MULTILYRD........ multi layered
MVFR........ Marginal Visual Flight Rules
MXD........ mixed

N

N .... north
ND .... North Dakota
NE........ Nebraska or northeast
NEG........ negative
NEWD .... northeastward
NJ........ New Jersey
NMRS........ numerous
NNEWD .... north-northeastward
NR .... near
NRLY .... nearly
NRN........ northern
NW .... northwest
NWD .... northward
NWLY .... northwesterly

O

OBSCD........ obscured
OBSCG........ obscuring
OBSCN........ obscuration
OCNL .... occasional
OCNLY .... occasionally
OMTS........ over mountains
OR .... Oregon
OTLK .... outlook
OTRW .... otherwise
OTS .... out of service
OVC........ overcast
OVHD .... overhead
OVR........ over

P

P........ plus; greater than
PCPN .... precipitation
PE .... ice pellets
PNHDL........ panhandle
PK........ peak
PK WND .... peak wind
PO .... well-developed dust/sand whirls
PR .... partial
PRCTN .... precautions
PRD .... period
PRES .... pressure
PRESFR........ pressure falling rapidly
PRESRR .... pressure rising rapidly
PSBL/POSS........ possible
PTN/PTNS........ portion/portions
PY .... spray

R

R .... runway
RA .... rain
RDG........ reading
REPTD/RPRTD/RPTD .... reported
RGD........ ragged
RMN........ remain
RMNDR .... remainder
RQR........ require
RTD .... routine delayed observation
RVR........ runway visual range
RVRNO .... RVR not available
RWU........ rain shower intensity unknown
RWY/RY .... runway

S

S........ south
SA........ sand
SCSL .... stratocumulus standing lenticular cloud
SCT........ scattered
SD........ South Dakota
SE .... southeast
SECS .... sections
SERN........ southeastern
SEWD........ southeastward
SEV/SVR........ severe
SFC........ surface
SG........ snow grains
SGFNT/SIG........ significant

SH .... shower(s)
SHD/SHLD .... should
SHFTG .... shifting
SHLW .... shallow
SHWRS .... showers
SIG CLD .... significant cloud
SKC .... sky clear
SLD .... solid
SLGT .... slight
SLP .... sea level pressure
SLPG .... sloping
SLPNO .... sea level pressure not available
SLY .... southerly
SM .... statute miles
SMTH .... smooth
SN .... snow
SPECI .... a special observation
SPRDG .... spreading
SQ .... squalls
SQLN .... squall line
SRN .... southern
SS .... sand storm
ST .... stratus
STFRA .... stratofractus
STG .... strong
STN .... station
STNRY .... stationary
SVRL .... several
SWD/SWRD/SWWD .... southwestward
SW .... snow showers or southwest
SYNS .... synopsis

T

TAF .... terminal aerodrome forecast
TCU .... towering cumulus
TE .... thunder ended
TEMPS .... temperatures
THN .... thin
THRU .... through
THSD .... thousand
TIL .... until
TS/TSTMS .... thunderstorms
TURB .... turbulence
TWR .... tower

U

UP .... unknown precipitation
UPR .... upper
UTC .... Coordinated Universal Time
UDDF .... updrafts and downdrafts
UNK/UNKN .... unknown
UNSTBL .... unstable
UP .... unknown precipitation

V

V .... variable
VA .... volcanic ash
VC/VCNTY .... vicinity
VFR .... Visual Flight Rules
VIS .... visibility
VLYS .... valleys
VOR .... Very high frequency Omni-directional Range
VR .... visual range
VRB/VRBL .... variable
VRY .... very
VSBYDR .... visibility decreasing rapidly
VV .... vertical visibility

W

W .... west
WA .... Washington
WBND .... westbound
WDLY .... widely
WL .... will
WM .... warm
WND .... wind
WRN .... western
WS .... wind shear
WSCONDS .... wind shear conditions
WSHFT .... wind shift
WTRS .... waters
WX .... weather

X

XCP/XCPT .... except
XTNDG .... extending

Z

Z .... Zulu Time (UTC)

WIND DIRECTIONS (8 POINTS)

N	–	NORTH	–	000° or 360°
NE	–	NORTHEAST	–	045°
E	–	EAST	–	090°
SE	–	SOUTHEAST	–	135°
S	–	SOUTH	–	180°
SW	–	SOUTHWEST	–	225°
W	–	WEST	–	270°
NW	–	NORTHWEST	–	315°

For additional contractions, acronyms, and locations not found in this Appendix, consult Section 14 of the AC 00-45E, Aviation Weather Services, available at the following location: http://www.faa.gov/avr/afs/afs400