Aviation Weather Observation and Reporting

Session Time: Four, 50-minute session(s)

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

Safe and efficient aviation operations require pilots use math, science, and technology.

Understanding how weather affects flight is one of the essential skills of a pilot.

Pilots must know how to use the weather services that are available to help form an understanding of the weather situation and make better flying decisions.

ESSENTIAL QUESTIONS

1. How much can you really tell about weather just by observing?

LEARNING GOALS

Students Will Know

- The four types of weather observations: surface aviation weather observations, upper air observations, radar observations, and satellites
- The common formats in which aviation weather observations are reported (e.g., METARs, PIREPs), and how they can be interpreted
- The types of information contained in weather observations from different sources

Students Will Be Able To

- *Compare* the different types of weather observations and explain how they work together to provide a more complete picture of the weather. (DOK-L3)
- *Decode* and *interpret* METARs and PIREPs. (DOK-L2)

ASSESSMENT EVIDENCE

Warm-up
Students will reference their weather diaries and discuss the day’s current weather. Through a series of questions, students will consider aviation weather observations and how they significantly impact flight planning and operations.

Formative Assessment
Students will decode and interpret various elements of three different METARs.

Summative Assessment
Working individually, students will write several paragraphs that compare and contrast the different types of weather observations and explain how they work together to provide a more complete picture of the weather for pilots.

LESSON PREPARATION

MATERIALS/RESOURCES

- Aviation Weather Observation and Reporting Presentation
- Aviation Weather Observation and Reporting Student Activity 1
- Aviation Weather Observation and Reporting Student Activity 2
- Aviation Weather Observation and Reporting Student Activity 3
- Aviation Weather Observation and Reporting Teacher Notes 1
- Aviation Weather Observation and Reporting Teacher Notes 2
- Aviation Weather Observation and Reporting Teacher Notes 3
- Aviation Weather Observation and Reporting Student Notes
- Student Daily Weather Diary

LESSON SUMMARY

Lesson 1: Introduction to Aviation Weather Services
Lesson 2: Aviation Weather Observation and Reporting
Lesson 3: Aviation Forecasts and Weather Charts

To begin this four-session lesson, students will consult their weather diaries and discuss the day's current weather. Through a series of questions, students will consider aviation weather observations and how they significantly impact flight planning and operations. Using their weather diaries once again, students will attempt to identify patterns or trends in all the weather information they've recorded since the beginning of the school year. Each student will then write three weather theories, or "rules," based on these observations.

Students will learn about the most commonly known surface observation, the airport METAR. Students will conduct a formative assessment that will ask students to decode and interpret three very different METARs.

Students will then explore upper air observations, with a particular focus on PIREPs, since those are the most common and frequently used upper air observations utilized by pilots. Students will also briefly learn about weather collected via radiosonde, which is an instrument carried by balloon or other means to various levels of the atmosphere that transmits measurements by radio. They will go on to deliver their own pilot reports to "ATC."

Students will cover the four types of radar observations: WSR-88D NEXRAD, FAA terminal Doppler weather radar, Airport surveillance radar, and airborne radar. A student activity will ask them to interpret four different radar pictures.

In the final session of this lesson, students will learn about satellite observations and three different types of satellite imagery used by pilots: visible, infrared, and water vapor. As a summative assessment, students will write several paragraphs that compare and contrast the different types of weather observations and explain how they work together to provide a more complete picture of the weather for pilots.

BACKGROUND

Weather observations are raw weather data collected by some type of sensor(s). The observations can either be made at the point where the instrument is located (e.g. surface or airborne) or remote (e.g. weather radar or satellite).

Temperature, humidity, precipitation, air pressure, wind speed, and wind direction are key observations of the atmosphere that help forecasters predict the weather. These same factors have been used since the first weather observations were recorded. However, the types and quality of weather instruments and the methods of analyzing observations have changed significantly. Basic weather observation instruments include thermometers, rain gauges, barometers, and anemometers (wind speed meters). Examples of more sophisticated equipment are wind profilers, weather balloons (radiosondes), Doppler radar, and satellites. Even with the highly technical equipment available, human observers still provide important information about sky conditions, clouds, and the type, size, and amount of precipitation.

The four varieties of weather observations (surface weather observations, upper air observations, radar weather observations and satellite observations) provide significant tools for every aviator to enhance both safety of flight and situational awareness.

Surface aviation weather observations can be taken manually, by a weather observer, by computer through the use of automated weather stations, or in a hybrid scheme using weather observers to augment the otherwise automated weather station.

In the United States, the FAA mandates the taking of weather observations at larger airports for safety reasons. The airport observations are then transmitted worldwide using the METAR observing code. METAR reports typically come from airports or permanent weather observation stations. Reports are generated once an hour; however, if conditions change significantly, they may be updated in special reports called SPECIs.

Upper air observations come in several forms. A radiosonde is a battery-powered telemetry instrument carried into the atmosphere usually by a weather balloon that measures various atmospheric parameters and transmits them by radio to a ground receiver. A very different kind of upper air observation is called a pilot report, commonly referred to as PIREPs. PIREPs are created by pilots, for pilots, and are a great source of real-time, in-flight weather conditions–offering a “sneak peek” of what a pilot may encounter in flight.

Radar weather observations come in four different varieties: NEXRAD (Doppler), FAA terminal Doppler weather radar, airport surveillance radar, and airborne radar.

Satellites are one of the most important sources of weather data worldwide, particularly over data sparse regions such as countries without organized weather data collection and the oceans. Satellites produce images that highlight various levels and cloud types in the atmosphere over a given location. When pilots study satellite images for their route or location, they gain a better understanding of current and short-term expected flight conditions inferred during the pre-flight briefing routine.

MISCONCEPTIONS

When students think of weather products, they probably think in terms of forecasts. In fact, most of the weather reports non-pilots receive are called “forecasts” even when they are observations. For example, you might watch the weather “forecast” on the local news to learn that the low temperature last night was below freezing. In fact, the reporter is sharing an observation of something that already happened. Forecasts are predictions. And they are based on observations and models. It is important for pilots to understand the distinctions between observations and forecasts when it comes to making decisions about flying.

DIFFERENTIATION

To help students become accustomed to the many abbreviations and acronyms used in aviation, consider having students write down aviation-specific acronyms and define them. Examples from this lesson include METAR or PIREP. Encourage that they keep these notes handy for use/reference with upcoming lessons.

LEARNING PLAN

ENGAGE

Teacher Material: Aviation Weather Observation and Reporting Presentation
Student Material: Student Daily Weather Diary

Slides 1-3: Introduce the topic and learning objectives of the lesson.

Slide 4-5: Conduct the **Warm-Up**.

Warm-Up

Students will begin by taking out their Daily Weather Diary (started in Unit 1 Lesson 1) and discuss the current weather conditions outside. Then, pose the following questions. The goal throughout the next several slides is to challenge students to consider aviation weather observations and how they significantly impact flight planning and operations.

- For a pilot, what are the most important qualities you might look for in a weather report? What are some ways that these qualities could be achieved?

Adjectives describing an effective weather report might include timely, accurate, relevant, location-bound, concise, and easy to interpret. Timeliness could be achieved by building reports with the latest observations available, accuracy might be attained through the use of technology in obtaining observations and strong modeling. To be relevant, a report would need to refer to the weather in the area where they will be flying. Reports and forecasts can be made both more concise and easy to interpret through format standardization and graphical formats.

- Given the current weather conditions, what would you expect to see on a local airport's weather observation? Explain to students that airport weather observations are referred to as Aviation Routine Weather Reports (also known as METARs, which formally stands for Meteorological Terminal Aviation Routine or Meteorological Aerodrome Report). Include details about temperature, cloud layers (few, scattered, broken, or overcast) and altitude, precipitation, winds, or other weather phenomena taking place.

Answers will vary based on current weather conditions. Inform students that they will learn about METARs in detail throughout this lesson.

Once the discussion is wrapping up, proceed to the next slide. Go online to a weather resource for METARs such as https://www.aviationweather.gov/metar and type in the nearest airport identifier to pull up the most recent METAR data. Ask students the following questions and lead a class discussion:

Do you understand this observation data?

What portions of the data can you discern based on what we've already learned?

Does this data align with your assumptions based on your weather diaries and discussion from the previous slide?

How do you believe such METAR data is obtained and disseminated to aviators, whether airborne or on the ground?

Answers will vary based on students' current knowledge.

[DOK-L2; *observe, predict*]

EXPLORE

Teacher Material: Aviation Weather Observation and Reporting Presentation
Student Material: Aviation Weather Observation and Reporting Student Notes

Slide 6: Distribute **Aviation Weather Observation and Reporting Student Notes**. In this activity, students will review the weather observations they recorded in their weather diaries from the beginning of the year until now. Ask them to see if they can identify patterns or trends in the information. Have each student write three weather theories, or "rules," based on these observations.

Example: After one or more days of steady rain, a sunny day typically follows.

Example: Relatively colder weather and lower pressures follow a frontal passage which produced significant thunderstorms.

Ask students to share their theories (perhaps their favorite or most compelling theory) with the class. Discuss which theories are the most innovate and hold the most merit. Write the top three theories on the whiteboard.

Questions

How would your observations help weather analysts produce more accurate forecasts?

Answers will vary based on students' theories.

Why is predictability in accurate weather forecasting important?

Predictability equates to preparedness. If those depending on accurate forecasts trust the data, then they are more likely to make proper decisions on whether or not to fly, or to onload extra gas for circumnavigation around storms or for the potential of diverting to another airport.

EXPLAIN

Teacher Materials: Aviation Weather Observation and Reporting Presentation, Aviation Weather Observation and Reporting Teacher Notes 1, Aviation Weather Observation and Reporting Teacher Notes 2
Student Materials: Aviation Weather Observation and Reporting Student Activity 1, Aviation Weather Observation and Reporting Student Activity 2

Slide 7: There are four types of weather observations that are used in the creation of aviation weather reports and forecasts:

1. Surface Aviation Weather Observations – these include METARs
2. Upper Air Observations – weather balloons and pilot reports (commonly referred to as PIREPs)
3. Radar Observations – these include Next-Generation Radar (NEXRAD), FAA Terminal Doppler Weather Radar, airport surveillance radar, and airborne radar
4. Satellite – includes visible, infrared and water vapor images

Slides 8-9: Timely and accurate weather reports are critical to making good decisions that keep flights safe. To help inform those decisions, the United States has a network of weather reporting stations, made up primarily of the automated weather observation system (AWOS) and automated surface observation system (ASOS), both of which are found at the majority of public-use US airports.

The AWOS and ASOS ground stations are located at most airports. Each system is a collection of sensors that offer temperature, dew point, cloud cover and altitude, visibility, wind speed and direction, any current precipitation, and location of lightning strikes. Some also have the ability to report icing and runway conditions.

AWOS and ASOS reports are updated and issued at intervals as often as one minute, so it's a good practice for pilots to monitor these weather broadcasts as they fly. Pilots can get an immediate, complete weather update, and can track changes in ceiling, visibility, wind, altimeter setting, and more. This is especially helpful when flying on instrument flight plans, in instrument meteorological conditions. ASOS and AWOS frequencies are printed on sectional and instrument en route charts.

The majority of weather stations transmits weather data to the FAA for dissemination. This allows pilots to access that airport's weather data through other sources such as the internet, phone, etc. via products like METARs.

Session 2

Slide 10: The most commonly known surface observation is the airport METAR. Thorough knowledge of METARs is vital for pilots because it is arguably the most frequently utilized ground observation data for takeoffs, arrivals, approaches, and landing phases of flight. For this reason, significant time will be spent exploring and analyzing this section.

METARs are scheduled observations which typically update every hour, or more often when there are rapidly changing conditions. A SPECI is an unscheduled observation taken when there is a significant change in the weather, such as low visibility, low clouds, significant precipitation, rapidly changing winds, or thunderstorms. SPECI reports help alert pilots about rapidly changing weather conditions at airports. Fortunately, METARs and SPECIs are coded using the same format.

This data includes:

- type of report
- station identifier (airport ID)
- date and time
- winds
- visibility
- weather phenomena (rain, thunderstorm, snow, etc.)
- sky condition (amount of cloud cover, altitudes of cloud bases)
- temperature and dew point
- altimeter reading
- remarks

Introduce students to reading METARs with this short video:

- "How to Read METAR Aviation Weather Reports" (Length 1:30)
  https://video.link/w/ijNq

For teachers who are unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/watch?v=oMrnQ8UsZ6A

Aviation Weather Services, Advisory Circular 00-45F, is published jointly by the National Weather Service (NWS) and the Federal Aviation Administration (FAA). This publication provides in-depth descriptions of each section of the METAR.
https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC%2000-45F.pdf

Additionally, students may also want to reference this METAR decoder from the National Weather Service (NWS): https://www.weather.gov/media/wrh/mesowest/metar_decode_key.pdf

Teaching Tips

Encourage students to take detailed notes in this next section because an assessment will immediately follow where they will decode METARs. The only notes that will be allowed are the ones that they take.

Slide 11: The next several slides will break down a METAR by the type of data it provides.

- TYPE OF REPORT - Reports sometimes (not always) begin with the type of METAR report. The first, most common one, is the routine METAR which is updated every hour. The second type begins with SPECI, and is a special report that can be updated anytime that helps alert pilots about rapidly changing weather conditions at airports.
- STATION ID - This is the location of the observation. Although usually an airport, many off-airport sites provide METARs as well.

The first letter in the station group is the country code. The country code identifies the country the observation came from. In this example, the highlighted country code is "K", meaning the airport is located in the continental United States. Airports in Alaska and Hawaii have a country code of "P". Country codes are assigned by the International Civil Aviation Organization (ICAO). If students want to look up more codes, they can be found on the ICAO website.

The three remaining characters identify the airport station. Each airport in the United States has a unique three-character station identifier. In this example, the station is coded OKC, which is Oklahoma City.

Examples of ICAO IDs are KMCO (Orlando Intl, FL), KORD (Chicago O'Hare Intl, IL), and KDEN (Denver Intl, CO).

While most airports have this ICAO 4-letter ID, smaller public-use airports and especially private airports or heliports have numbers in their ID, which means that they do not have an ICAO ID. Therefore, their airport/heliport codes do not start with a 'K'.

Examples of non-ICAO IDs are 74N (Bendigo Airport, PA), and 52F (Northwest Regional Airport in Roanoke, TX).

Questions

If you saw an airfield that only had a grass or dirt runway, do you think that airfield would be an ICAO airport or not? Would it start with the letter K or not? Why?

A grass or dirt runway airport would almost certainly be a non-ICAO airport, and therefore not start with a 'K' in its ID. This is because an airfield with only an unpaved runway is likely either a private-use airfield, or if a public-use airfield, does not support enough traffic or meet the federal requirements to receive an ICAO ID.

Slide 12:

- DATE AND TIME - The date and time group uses a six-digit group to identify when the observation was taken. This section starts with a two-digit date and ends with a four-digit time, in Zulu.

The first two digits in the group identify the day of the month the observation was taken. In this example, "01" indicates the observation was taken on the first day of the month. The remaining four digits in the group identify the time of day the observation was taken. In this example, "1955" indicates the observation was taken at 1955 UTC.

The Z represents that the time is in Zulu, also known as Coordinated Universal Time (UTC), as opposed to local time.

- REPORT MODIFIER - There are two modifier groups that can be used in observations: "AUTO" and "COR". The word "AUTO" means the weather station is fully automated, with no human observer present.

Weather stations aren't always perfect at reporting weather, especially when unusual conditions exist, like freezing precipitation or extremely heavy rain. When these conditions exist, a human observer may correct the observation so that it accurately reports current weather conditions. In that instance, a pilot would see "COR" in this location.

If a human observer is providing oversight at a weather station, but no corrections are made to the observation, the modifier is dropped from the report.

Teaching Tips

Students may have questions about Zulu (Z) or Coordinated Universal Time (UTC). Both time standards keep pilots —regardless of where in the world they are —using the same 24-hour clock, which helps avoid confusion between time zones. Z/UTC uses a 24-hour system of time notation. "1: 00 a.m." in UTC is expressed as 0100, pronounced "zero one hundred." Fifteen minutes after 0100 is expressed as 0115.

To convert from local time to Zulu/UTC, pilots add hours based on the time zone they are located. They subtract the same number of hours to convert from Zulu/UTC to local. An AOPA webpage provides a conversion chart for the United States: https://www.aopa.org/news-and-media/all-news/2009/july/02/time-conversion-to-zulu-utc

Questions

Why is it important to take note of the observation's time?

If the current Zulu time and the observation's Zulu time differ by almost an hour, the observation is stale and should soon be replaced by a new, more current observation.

Slide 13:

- WIND - Both direction and speed are presented in the wind section.

Wind direction describes the direction the wind is blowing from. Wind direction is reported in the first three digits of the wind group, on a true north compass (magnetic) direction. Direction is coded in 10s of degrees, with directions less than 100 degrees having a 0 in front of them (for example, "045" indicates the wind is blowing from 45 degrees.)

The two-digit speed is next. On this day the wind was from 220 degrees at 15 knots with gusts up to 25 knots.

The 'G' stands for gusts, and the following two numbers denotes the maximum/peak observed speed to which the winds are gusting. Gusts will not always be reported, only if the criteria are met in order for a significant gust to be reported.

The reported winds end in 'KT' to denote that the wind speed values are in knots.

When winds significantly change direction from one to another in short amounts of time, they will likely be denoted as 'VRB'. High-speed variable winds are coded with a "V", with the normal wind direction before the "V", and the varying wind direction after the "V". For example, "150V250" indicates winds are variable from 150 degrees to 250 degrees.

When winds speeds are 6 knots or greater, a possible observation may read 15020KT 120V180. This denotes that the winds are predominantly coming from 150 degrees at 20 knots, but the direction varies between 120 degrees and 180 degrees. For this to be denoted, the winds must have a 60-degree variation or more.

"WS" indicates wind shear.

Per FAA criteria, if winds are less than 3 knots, they may be described as 'calm', and will not be associated with a specific wind direction. Calm winds are denoted as "00000KT" on a METAR.

Questions

Why are winds reported in their magnetic values rather than true?

Because headings (compasses, heading indicators, etc.) and runway values are already in magnetic for the airport's location given its magnetic variation (MAGVAR). This way, the pilot does not need to convert true to magnetic.

At a hypothetical airport with no other traffic/airport conditions considered, if winds are reported at 180, should pilots takeoff/land on runway 18 or 36? Why?

Pilots should both takeoff and land on runway 18 because that is the direction that the winds are coming FROM, and aircraft typically perform better taking off and landing into a headwind rather than a tailwind.

Why would a pilot care if winds are varying at least 60 degrees? Please be specific.

Because this gives them a clue that they will need to adjust their crosswind inputs as the winds change direction. At one moment, they may need to input controls based on a left crosswind, and a short time later, they may need to input controls based on a right crosswind!

Slide 14:

- VISIBILITY - The visibility group is coded using one or two digits, followed by the letters "SM" for statute miles. When visibility is low, fractions are added to the report to provide a more detailed description of current conditions. In the example, "3/4SM" indicates a visibility of three quarters statute miles.

Observations use the letter "M" to indicate "less than" visibility. For example, "M1/4SM", indicates a visibility of less than one quarter statute mile.

- RUNWAY VISUAL RANGE (RVR) - The RVR group describes the distance that can be seen down a specific runway. RVR is only reported when an airport has RVR sensing equipment (typically found at larger airports) and when visibility is 1SM or less, or when RVR for an instrument runway is 6,000 feet or less.

The RVR runway is coded with the letter "R", followed by the runway number. In this example, "R17L" means RVR is being reported for runway 17 Left.

RVR visibility is coded using four digits, representing RVR distance in feet. In this example, "2600" indicates the RVR for runway 17L is 2600 feet.

Questions

Why would pilots need visibility to be measured in feet rather than SM? Can you think of a specific, hypothetical situation?

Because this more accurate and specific value allows pilots to take off and land in lower visibility environments. If fog were to be over an airport, specially trained and certified aircrew would be able to take off if the RVR were measured at 1000 ft or greater. However, if RVR equipment weren't available, the reported observation value would be < 1/4 SM, which would legally not allow for no takeoffs altogether!

Slide 15:

- PRESENT WEATHER - The present weather group describes precipitation, obscuration and other weather phenomena. If it's falling from the sky, suspended in the sky, or blowing around, it will be reported in the present weather group.

There are qualifiers (also known as descriptors) followed by the weather phenomena that they are describing.

The first qualifier describes the intensity or proximity. In regard to precipitation intensity, a minus sign (-) designates light, the absence of a symbol designates moderate, and a plus sign (+) designates heavy. If an event is nearby, specifically between 5 to 10 miles of the airfield, the designator 'VC' (in the vicinity) may be used.

The descriptor group helps describe the weather in more detail.

The precipitation group describes precipitation (water in any form) that is falling from the sky.

The obscuration group describes particles found in the sky that reduce visibility.

Not every weather phenomena falls into the "precipitation" or "obscuration" groups. Special weather phenomena appear as "other" codes.

Further details on specific weather phenomenon, especially precipitation (such as hail size), may be described in the 'remarks' section at the end of the METAR.

Review the table with your students.

Questions

Why do you think 'GR' stands for 'hail'? Does anyone know the common name for 'soft hail'?

'GR' denotes 'graupel', which is also known as soft hail.

What are some ways that you can think of to make it easier to remember what the less obvious qualifiers stand for?

The following are suggestions only. Challenge students to create their own.

BR = Baby Rain

FU = Fumes

Slide 16:

- SKY CONDITION - The sky condition group describes how many clouds are in the sky, and what AGL altitude the clouds are at.

Sky coverage describes the current sky cover using the following codes:

CLR - clear
FEW - few (1/8 - 2/8 of the sky is covered in clouds)
SCT - scattered (3/8 - 4/8 of the sky is covered in clouds)
BKN - broken (5/8 - 7/8 of the sky is covered in clouds)
OVC - overcast (8/8 of the sky is covered in clouds)

In this example, "OVC", means the sky condition is overcast.

Cloud height identifies the altitude at the bottom of clouds. Cloud height is coded with three digits, and indicates cloud height in hundreds of feet AGL. In this example, "010" means the bottom of the clouds are at 1,000 feet AGL.

The code "CLR" is used to indicate clear skies at or below 12,000 feet. However, at manual stations, the code "SKC" is used by human observers to indicate no cloud layers are present.

An indefinite ceiling is used to describe a condition of poor slant range visibility. Indefinite ceilings are coded with the letters "VV", followed by the ceiling height in hundreds of feet AGL.

At stations with human observers, towering cumulus (TCU) and cumulonimbus (CB) may be added to reports to describe the clouds. Towering cumulus clouds have significant vertical development, and often indicate the early stages of thunderstorm development. Cumulonimbus clouds are dense towering clouds that are associated with thunderstorms. Cumulonimbus clouds often generate dangerous weather such as lightning, strong winds, heavy rain, and hail.

Questions

Why do you think automated stations do not report cloud bases above 12,000 feet? Is this acceptable? Why or why not?

The sensors do not pick up clouds that high. It is considered acceptable because METAR data is utilized for the arrival and departure phases of flight, not the en route climb-to-altitude or cruise phases.

Slide 17:

- TEMPERATURE/DEW POINT - Temperature is coded with two digits, rounded to the nearest whole degree Celsius. In this example, "18" indicates the temperature is 18 degrees Celsius.

Dew point is also coded with two digits, rounded to the nearest whole degree Celsius. In this example, "16" indicates the dew point is 16 degrees Celsius.

If the temperature or dew point are below 0 degrees Celsius, they are preceded by the letter "M". The code "M08" means the temperature is minus 8 degrees Celsius.

- ALTIMETER - The altimeter group is the reported altimeter setting in inches of mercury (Hg).

  The altimeter is coded using the letter "A", followed by a four-digit number to represent atmospheric pressure. To read the altimeter setting, place a decimal between the second and third digits in the group.

In this example, "2992" indicates the current altimeter is 29.92 inches of mercury.

If pressures are rising or falling quickly, such as in stormy weather or during frontal passage, this may be denoted in the remarks section at the end of the METAR as ‘PRESRR’’ for ‘pressure rising rapidly’ or ‘PRESFR’ for ‘pressure falling rapidly’.

Questions

Why would it be important to take note of ‘PRESFR’ when it’s in a METAR? What would this mean for an aircraft on approach to land?

If pressure is falling rapidly, this means that there could be inclement weather overhead or very close by. Additionally, in a short amount of time, the actual barometric pressure could drop below what the altimeter was set to. Remember, ‘high to low, look out below’, so the aircraft could be lower than they think they are and could be below the minimum safe altitude for the approach.

Slide 18:

- REMARKS - The final section of the METAR is the remarks section, and should always begin with ‘RMK’. The remarks section is full of secondary information. This section may or may not be populated dependent on airport operations and weather conditions.

Common entries include a code such as A01 or A02. AO2 denotes that the site is automated and has a functioning precipitation sensor. This means the station can determine the type of precipitation falling from the sky, such as "RA" or "SN", and automatically include it in the report. AO1 would denote that there is no precipitation sensor. This section may include additional wind data, variable visibility, begin/end times of a particular phenomenon, pressure data, or other important information.

In the example, “TS OHD MOV E” means there is a thunderstorm overhead and it is moving east.

Another example of a remark regarding a weather phenomenon that would not fit in any other category, and should therefore be in the remarks section: OCNL LTGICCG.

Questions

What might OCNL LTGICCG stands for?

Occasional lightning in clouds and from cloud to ground.

Slide 19: Complete the **Formative Assessment**.

Formative Assessment

In this activity, students will demonstrate their knowledge of what they just learned regarding METARs by interpreting elements of three of them. Students may utilize the notes that they've taken from the lesson thus far to answer the following questions.

Have the students complete the **Aviation Weather Observation and Reporting Student Activity 1**. Answers are located in the **Aviation Weather Observation and Reporting Teacher Notes 1**.

If time allows, review the answers with the students.

[DOK-L2; *interpret*]

Session 3

Slide 20: In this next session, students will explore upper air observations, with a particular focus on PIREPs, since those are the most common and frequently used upper air observations utilized by pilots. Students will also briefly learn about weather collected via radiosonde, which is an instrument carried by balloon or other means to various levels of the atmosphere that transmits measurements by radio.

Questions

What do you think is some of the most valuable information for pilots in regard to data obtained from upper air observations?

Thunderstorms, precipitation, turbulence, volcanic ash, winds, and icing to name a few.

Slide 21: Radiosondes are electronic telemetry equipment carried aloft, typically via weather balloon. They measure and record temperature, pressure, moisture, wind speed, and direction data. This data is relayed to ground stations via radio signals. On average, more than 75,000 weather balloons are launched in the US every year. These balloons can travel as high as 115,000 feet and travel a distance of 125 miles.

This video provides an explanation of how this data may be interpreted:

- "Weather Balloons and Radiosondes" (Length 3:08)
  https://video.link/w/Jp4q

For teachers who are unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/watch?v=pcLkkoR2LS4

Questions

Other than for pilots, who else do you think can utilize this observation data?

Answers may vary, but scientists, meteorologists, weather prediction teams are possibilities.

Why is it important to take observations and gather data at different altitudes?

Answers may vary, but different career fields may need data at a variety of altitudes because of where they operate their aircraft or equipment.

Slide 22: Pilot Weather Reports (PIREP) are among the best weather reports a pilot can get, because they are made by pilots currently in the air. PIREPs are the best way to report any weather observation, good or bad, from the air. If weather conditions are forecast but don't occur, or if conditions are worse than expected, a PIREP is the best way to let other pilots know about what's happening in the sky. While radar can pick up reflectivity from precipitation, it is much harder to detect shearing winds which cause turbulence. This is why pilots often check in to ATC reporting their flight level followed by their ride condition (for example: "light chop", "smooth ride", "continuous moderate turbulence", etc.). Even these short transmissions/observations provide a wealth of data for nearby aircraft and the ATC controllers vectoring them.

PIREPs contain a lot of useful information, including:

- Message type
- Location
- Time
- Altitude / flight level
- Aircraft type
- Sky condition
- Flight visibility and weather
- Air temperature
- Wind
- Turbulence
- Icing
- Remarks (all the extra stuff)

Any pilot can make a PIREP, and are encouraged to do so.

Slide 23: There are two types of PIREPs and they are categorized based on their level of urgency. A "UA" is a routine pilot report. A "UUA" is an urgent pilot report.

A routine PIREP is issued when a pilot reports conditions that does not contain any urgent information. An urgent PIREP is issued when a pilot reports any of the following:

- Tornadoes, funnel clouds, or waterspouts
- Severe or extreme turbulence, including Clear Air Turbulence (CAT)
- Severe icing
- Hail

- Low Level Wind Shear (LLWS) within 2,000 feet of the surface. LLWS PIREPs are classified as UUA if a pilot reports airspeed fluctuations of 10 knots or more, or if air speed fluctuations are not reported but LLWS is
- Volcanic ash clouds
- Any other weather reported which is considered by the briefer as being hazardous, or potentially hazardous, to flight operations

Slides 24-25: There are several groups of a PIREP. The next few slides describes each group.

- LOCATION - When a pilot gives a PIREP, they must provide their location. The location is coded using the phrase " /OV", followed by the report location. A PIREP location can be reported as a fix such as over a VHF NAVAID or over an airport (by providing its four-letter code). For example, "/OV KORD" indicates the PIREP was reported over Chicago O'Hare Airport.

PIREPs can also be recorded using a fix with a radial and distance. PIREPs reported using a fix with a radial and distance are coded with the fix name, followed by three digits representing the radial, followed by three digits representing the distance in nautical miles. In this example, "/OV CYS360070" indicates the PIREP was reported at 360 degrees and 70 nautical miles from the Cheyenne VOR.

- TIME - The time group is coded with the phrase "/TM", followed by four digits, indicating the time in UTC. In this example, "0130" indicates the PIREP was reported at 0130 UTC.
- ALTITUDE - The altitude and flight level group describes what altitude the PIREP was reported. The group is coded using the phrase "/FL", followed by the altitude in hundreds of feet MSL. In this example, "FL035" indicates the PIREP was reported at 3,500 feet MSL.
- TYPE AIRCRAFT - The aircraft type group, as you might expect, describes the aircraft reporting the PIREP. The group is coded using the phrase "/TP", followed by the aircraft type. In this example, "/TP C172" indicates the aircraft type is a Cessna 172.
- WEATHER/REMARKS - Pilots can report sky conditions, visibility, weather phenomena, temperature, wind, turbulence, icing, low level wind shear (LLWS), thunderstorms, lightning, and more. Direct students to page 3-36 of Aviation Weather Services, Advisory Circular 00-45F for PIREP codes: https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC%2000-45F.pdf

Slide 26: Have students take a look at how PIREPs should be delivered and interpreted. Hand out the **Aviation Weather Observation and Reporting Student Activity 2** worksheet. Once all the students have this worksheet and are ready to write, have them write down all the relevant conditions/data from the following 'simulated flight' (read slowly so students have time to copy). Students can also refer to this information on the slide.

The current time is 0800 Local, or 1300 Zulu. You have taken off from KDFW, Dallas Fort Worth International Airport, and are about halfway to your destination of KORD, Chicago O'Hare International Airport. You are currently crossing over SPRINGFIELD (SGF) VORTAC. You are flying your Boeing 737 aircraft at flight level (FL) 330.

Your outside air temperature gauge reads -15 Celsius, and the winds are from the south (180 degrees) at 100 knots. Looking around, there are stratus clouds that take up half the sky which started at around FL180 and appear to top out at around FL350. Currently you're outside the clouds and have no restriction to visibility and are experiencing no precipitation or icing; however, there is continuous light turbulence.

Once they are done copying down all the conditions, pick one or two students to verbally deliver their PIREPs to ATC (the teacher).

Questions

How should you verbally deliver your PIREP to ATC? Assume they just said, "go ahead with your PIREP."

Currently over Springfield VORTAC at 1300 Zulu, we're at Flight Level 330 in a Boeing 737. Scattered stratus clouds from FL180 to FL350, unrestricted visibility outside clouds. Temperature -15 Celsius, Winds 180 at 100 Knots. Continuous light turbulence. How copy?

What if you're listening over the radio and hear an aircraft report hail? What parts of their report should you pay attention to or copy down? Why?

Their current location and altitude. It's critical to know this in case you're flying in that direction.

Slide 27: It's common for many new pilots to be intimidated to give a PIREP because they don't know the order of the information, or all of the information they are supposed to include. Basically, if you have important information that ATC or fellow pilots should know, it's better to deliver an abbreviated or incomplete PIREP rather than no PIREP at all. ATC will typically ask for more information if something critical was left out.

Show students a short video about how air traffic controllers can take the information and use it to help other pilots:

- "Ask ATC: Filing a PIREP with ATC" (Length 2:40)
  https://video.link/w/ss4q

For teachers who are unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/watch?v=2e5UwlKnsgQ&t=6s

As time allows, go to this the AOPA Air Safety Institute course on PIREPs help students become more familiar: https://flash.aopa.org/asf/skyspotter/swf/flash.cfm?_ga=2.10599159.239117691.1559572201-1524302561.1540235272

Teaching Tips

Utilize the same AOPA login that you've used in past lessons to access the content. Navigate the main sections of the content using the buttons on the left and the individual portions within the sections via the small buttons at the top.

If students wish to focus on a particular aspect of the content (for example, 'The elements of a PIREP' [section 2] or 'Using PIREPs' [section 3]), mouse-over the buttons on the left side to see which section covers which element and focus on that content.

EXTEND

Teacher Materials: Aviation Weather Observation and Reporting Presentation, Aviation Weather Observation and Reporting Teacher Notes 3
Student Material: Aviation Weather Observation and Reporting Student Activity 3

Session 4

Slide 28: Students may be familiar with radar observations from watching live weather reports from TV news stations when there is inclement weather in the local area. These weather reports have valuable information as they relay live radar imagery to viewers, which may include the appearance of frontal boundaries, squall lines, hook echoes (rotation indicative of vortexes and potential tornadoes), hail cores, and other hazardous weather phenomena. However, as pilots, it becomes even more critical to be able to interpret live radar images, since analyzing them will drive the decision on whether to fly through or circumnavigate weather systems.

Slide 29: There are four types of radar weather observations, which weather observers use to provide information about precipitation, wind, and other weather phenomena and systems.

- WSR-88D NEXRAD, also known as Doppler radar
- FAA terminal Doppler weather radar, also known as advanced Doppler radar
- Airport surveillance radar, which may detect both aircraft and precipitation
- Airborne radar, which is installed in most modern aircraft with avionics systems

Slide 30: Have students take notes on this WSR-88D NEXRAD / Doppler radar video which explains the basics of how it works. They will answer questions when complete:

- "How does a weather radar work?" (Length 3:01)
  https://video.link/w/zu4q

For teachers who are unable to access Safe YouTube links, this video can also be found here: https://www.youtube.com/watch?v=NZ7rNeQck2A

Questions

What does RADAR stand for?

Radio Detection and Ranging

What kind of waves does the dish use to measure precipitation?

Radio/electromagnetic waves

A new radar image is produced every __ to __ minutes.

6 to 10

Even in the optimal range, the radar can sometimes show ________, or rain that is evaporating before it hits the ground.

Virga

Permanent features such as _________ or __________ can impede the radar beam.

Buildings or mountains

Slide 31: The WSR-88D NEXRAD Doppler radar provides distinct observations that inform local areas of both current and impending weather. Doppler radar may operate in either the clear air or precipitation mode.

In clear air mode, the radar is in its most sensitive state. The radar dish rotates slower and takes in a more definitive sample of the atmosphere by absorbing more data. This is why, in this mode, images are typically updated about every 10 minutes.

In precipitation mode, the radar dish does not have to spin as slowly because precipitation provides a stronger return image than clear air. This faster dish rotation enables more timely updates, typically a new image generating every 4 to 6 minutes.

For both modes, the various color intensities are measured in dBZ (decibels) based on the radio waves it utilizes. While these radars are common around the world, the less common but more advanced FAA terminal doppler weather radar (TDWR) systems are utilized by major airports.

Show students this video of things that Doppler radar cannot see.

- "5 Things Radar Can't See" (Length 1:56)
  https://video.link/w/FdPq

For teachers who are unable to access Safe YouTube links, this video is also available here: https://www.youtube.com/watch?v=ch2n9g978FQ

Teaching Tips

In Student Activity 3, Picture 2, students may say that a tornado is the "weather phenomenon" in the black circled area. While this is most likely the case, students should recall the information from the video "5 Things Radar Can't See." From time stamp 1:14 to 1:33 tornadoes are discussed, and it is noted that a tornado is only confirmed if a visual sighting is made.

The radar detects rotation within a thunderstorm by "seeing" winds moving in opposing directions. Such a radar return would probably trigger a tornado watch from NOAA (National Oceanographic and Atmospheric Administration) or a tornado warning from the NWS (National Weather Service). Source: https://www.accuweather.com/en/weather-news/the-difference-between-tornado-1/61817

The colors in Picture 2 indicate the strength of radar returns, and the students should know by now that green will be light precipitation while red and magenta indicate heavy precipitation or hail. It is also possible that a lot of debris in the air could be heavy enough to generate red or magenta colors. Combine indications of rotation and large particles in the air, and you have a strong indication that a tornado is present or is about to form.

Fun Fact: The magenta color could be a TDS (tornado debris signature). This is a column of whirling debris can be tens of thousands of feet high and the TDS can only happen after a tornado has started; however, even after a tornado ceases to exist, the TDS may continue. The TDS can take time to dissipate. Source: https://www.spc.noaa.gov/faq/tornado/

Slide 32: TDWR systems, also known as advanced Doppler radar, are installed in approximately 45 of the largest commercial, high-traffic airports around the U.S. They provide severe weather alerts/warnings to ATC, who then relay the critical information to aviators. The 'T' in TDWR reveals that these radars are intentionally installed and utilized in the 'terminal' environment during the most crucial and low-altitude phases of flight such as takeoff, departure, arrival, approach, and landing. These terminal radars ensure that both pilots and air traffic controllers have the most accurate and timely data relating to the most pertinent and serious aviation weather phenomena. These radar systems alert them to wind shear, gust fronts, microbursts, heavy precipitation, and rotation/vortexes, which are all hazardous to terminal environment aircraft.

Slide 33: Another, more common type of radar utilized primarily by air traffic controllers is FAA airport surveillance radar. These are more common because almost every commercial airport with a control tower utilizes this radar to detect the location and altitude of aircraft in the terminal airport environment. However, even though this radar is used primarily to detect aircraft, it may also be used to detect the location and intensity of precipitation. The air traffic controllers may then overlay the aircraft and precipitation/weather data in order to route aircraft around severe weather during their departure and arrival phases of flight. This is a valuable asset for aircraft and helps to build situational awareness for pilots.

Slide 34: The last type of radar is installed in the majority of modern, complex aircraft: airborne radar. These systems typically consist of an antenna installed in the front, most often in the nose cone, of an aircraft. These radars are "live" looks, scanning and updating the picture on the weather radar display in the cockpit in real time.

Most of these systems operate in the C or X bands (around 6 GHz or 10 GHz), which allow the scanning beams to penetrate heavy precipitation so that pilots may determine the true severity and size of thunderstorms. This reflectivity is similar in scale to the NEXRAD Doppler radar. However, it is still possible for the most large and severe precipitation (such as high concentrations of large hail) to "attenuate" the radar picture. This attenuation means that the signal returns to the aircraft after bouncing off the heavy precipitation, and therefore whatever is on the backside of it will not "paint" on the pilot's weather radar screen. Therefore, pilots cannot assume that just because there is a blank spot on their weather radar screen that that area of the sky is clear.

Slide 35: Hand out the **Aviation Weather Observation and Reporting Student Activity 3**. Students will examine the radar pictures, determine what the most serious threats to pilots are based on those returns, and answer the questions. Sample answers are located in the **Aviation Weather Observation and Reporting Teacher Notes 3.** Encourage students to use the internet to help them in answering the questions in this activity.

Slide 36: Satellites are one of the most important sources of weather data worldwide, particularly over data sparse regions such as countries without organized weather data collection and the oceans. Many satellites are in a constant, blazing-fast orbit around the earth, continuously collecting weather data. That data is then transmitted to control agencies. Recent technologies have enabled commercial use of this data as well via weather uplinks. Users, both private and commercial, may pay the satellite and data owners a subscription service fee to receive the signals that the satellite transmits. This allows them to obtain nearly real-time global weather data and use it for their own desired operations.

This video reveals how a European system operates:

- "How do we monitor the weather from space?" (Length 4:31)
  https://video.link/w/7U4q

For teachers who are unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/watch?v=zfVeB4s8WWk

Slide 37: Satellites produce images that highlight various levels and cloud types in the atmosphere over a given location. When pilots study satellite images for their route or location, they gain a better understanding of current and short-term expected flight conditions inferred during the pre-flight briefing routine.

The National Oceanic and Atmospheric Administration (NOAA) operates two Geostationary Operational Environmental Satellites (GOES) in geosynchronous orbit over the Atlantic and Pacific basins. The sensors on the satellites "stare" at Earth and provide frequent cloud images, monitor Earth's surface temperature and water vapor fields, and sound the atmosphere for its vertical thermal and vapor structures.

There are three types of satellite imagery commonly used by pilots. Each will be covered in detail.

- Visible
- Infrared (IR)
- Water vapor

Show students this video about the new GOES-R satellite.

- "What is GOES-R?" (Length 2:54)
  https://video.link/w/IV4q

For teachers who are unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/watch?v=ttOHhnBwukU

Slide 38: Visible satellite images present clouds using the visible part of the spectrum. This type of satellite imagery uses reflected sunlight (this is actually reflected solar radiation) to see things in the atmosphere and on Earth's surface. The display is similar to what you would see with your naked eye peering out of the porthole of a spaceship, except most of these images come only in black and white. Advantages of visible satellite imagery include the ability to distinguish low-lying fog and stratus clouds. Visible imagery also can identify terrain features such as lakes and different vegetation. Visible imagery is also valuable for detecting smoke plumes, dust and thin layers of volcanic ash. Unfortunately, visible imagery is only available during the day when the sun illuminates the features. Also, the common black and white color scheme makes it difficult to separate fog and stratus fields from areas that are snow covered but basking under clear skies.

Slide 39: Infrared (IR) images display temperatures of Earth's surface, clouds, and particulate matter. Generally speaking, the warmer an object, the more infrared energy it emits. This satellite imagery senses surface and cloud top temperatures by measuring the wavelength of electromagnetic radiation emitted from these objects. High clouds are very cold, so they appear white. Mid-level clouds are somewhat warmer, so they will be a light gray shade. Low clouds are warmer still, so they appear as a dark shade of gray or black. Often, low clouds are the same temperature as the surrounding terrain and cannot be distinguished at all.

IR imagery comes in a variety of color schemes. Television weathercasts commonly display IR imagery in simple, varying shades of white to identify where clouds exist on the background map. Advanced color schemes used for research and forecasting usually enhance colder temperatures with different colors.

Infrared images are independent of visible light and thus are available day and night.

Slide 40: Water vapor imagery highlights the presence of water vapor in the upper atmosphere, usually above 20 thousand feet MSL. This product is mainly used by forecasters to analyze moisture trends. An advantage of looped water vapor imagery for pilot briefings is the ability to identify the presence of jet streams and headwinds aloft and the possibility of mountain wave turbulence even under clear skies. Rivers of atmospheric water vapor will often be visible on the water vapor images. A stream of water vapor crossing a high mountain range in a near perpendicular orientation may indicate the potential for mountain wave turbulence.

EVALUATE

Teacher Material: Aviation Weather Observation and Reporting Presentation

Slides 41-46: Quiz students on the Private Pilot Knowledge Test questions.

Slide 47: Conduct the **Summative Assessment**.

Summative Assessment

Working individually, ask students to write several paragraphs that compare and contrast the different types of weather observations and explain how they work together to provide a more complete picture of the weather for pilots. They should include commentary about the four different types of weather observations: surface aviation weather observations, upper air observations, radar observations, and satellite observations. They should describe how pilots can use these observations together to determine expected flight conditions.

[DOK-L4; *apply concepts*; DOK-L2; *interpret*]

Summative Assessment Scoring Rubric

Follows assignment instructions
Written explanation includes:

- A clear and accurate compare and contrast between the four different types of weather observations
- An explanation as to how pilots use these observations together to make sound flight decisions
- Organized explanation
- Correct spelling and grammar

Contributions show in-depth thinking including analysis or synthesis of lesson objectives

Points	Performance Levels
9-10	Consistently demonstrates criteria
7-8	Usually demonstrates criteria
5-6	Sometimes demonstrates criteria
0-4	Rarely to never demonstrates criteria

GOING FURTHER

Here is one site to explore with many varieties of worldwide METARs which reveal significant weather such as high winds, low visibility, low and high extreme temperatures, thunderstorms, etc.: https://www.badbadweather.com/ Students may explore some of the unique METARs from this site and utilize the FMH-1 (Federal Meteorological Handbook-1) to decode the complex ones.

While weather balloons are still the predominant method for transporting radiosondes, other agencies (such as the Navy) have been experimenting with unmanned aircraft to gather radiosonde observation data at lower altitudes:

- “UAV-radiosonde, the next weather balloon?” (Length 4:04)
  https://video.link/w/Sp4q

For teachers who are unable to access Safe YouTube links, this video is also available here: https://www.youtube.com/watch?v=2HMepUeHrcg

STANDARDS ALIGNMENT

NGSS STANDARDS

Three-Dimensional Learning

- **HS-ETS1-2** - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
  - Science and Engineering Practices
    - Asking Questions and Defining Problems
    - Constructing Explanations and Designing Solutions

- Disciplinary Core Ideas
    - ETS1.A: Defining and Delimiting Engineering Problems
- Crosscutting Concepts
    - None

- **HS-ETS1-3** - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
  - Science and Engineering Practices
    - Constructing Explanations and Designing Solutions
  - Disciplinary Core Ideas
    - ETS1.B: Developing Possible Solutions
  - Crosscutting Concepts
    - None

COMMON CORE STATE STANDARDS

- **RST.9-10.2** - Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
- **RST.9-10.4** - Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
- **WHST.9-10.6** - Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
- **WHST.9-10.8** - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
- **WHST.9-10.9** - Draw evidence from informational texts to support analysis, reflection, and research.

FAA AIRMAN CERTIFICATION STANDARDS

PRIVATE PILOT

- **PA.I.C.K1** Sources of weather data (e.g., National Weather Service, Flight Service) for flight planning purposes.
- **PA.I.C.K2** Acceptable weather products and resources required for preflight planning, current and forecast weather for departure, en route, and arrival phases of flight.
- **PA.I.C.K3** Meteorology applicable to the departure, en route, alternate, and destination under VFR in Visual Meteorological Conditions (VMC) to include expected climate and hazardous conditions such as:
  - **PA.I.C.K3a** a. Atmospheric composition and stability
  - **PA.I.C.K3b** b. Wind (e.g., crosswind, tailwind, windshear, mountain wave, etc.)
  - **PA.I.C.K3c** c. Temperature

- **PA.I.C.K3d** d. Moisture/precipitation
- **PA.I.C.K3e** e. Weather system formation, including air masses and fronts
- **PA.I.C.K3f** f. Clouds
- **PA.I.C.K3g** g. Turbulence
- **PA.I.C.K3h** h. Thunderstorms and microbursts
- **PA.I.C.K3i** i. Icing and freezing level information
- **PA.I.C.K3j** j. Fog/mist
- **PA.I.C.K3k** k. Frost
- **PA.I.C.K3l** l. Obstructions to visibility (e.g., smoke, haze, volcanic ash, etc.)

- **PA.I.C.K4** Flight deck displays of digital weather and aeronautical information.
- **PA.I.C.R1** Factors involved in making the go/no-go and continue/divert decisions, to include:
    - **PA.I.C.R1a** a. Circumstances that would make diversion prudent
    - **PA.I.C.R1b** b. Personal weather minimums
    - **PA.I.C.R1c** c. Hazardous weather conditions to include known or forecast icing or turbulence aloft
- **PA.I.C.R2** Limitations of:
    - **PA.I.C.R2a** a. Onboard weather equipment
    - **PA.I.C.R2b** b. Aviation weather reports and forecasts
    - **PA.I.C.R2c** c. Inflight weather resources
- **PA.I.C.S1** Use available aviation weather resources to obtain an adequate weather briefing.
- **PA.I.C.S2** Analyze the implications of at least three of the conditions listed in K3a through K3l above, using actual weather or weather conditions in a scenario provided by the evaluator.
- **PA.I.C.S3** Correlate weather information to make a competent go/no-go decision.

REMOTE PILOT

- **UA.III.A.K1** Internet weather briefing and sources of weather available for flight planning purposes.
- **UA.III.A.K2** Aviation routine weather reports (METAR).
- **UA.III.A.K3** Terminal aerodrome forecasts (TAF).
- **UA.III.A.K4** Weather charts.
- **UA.III.A.K5** Automated surface observing systems (ASOS) and automated weather observing systems (AWOS).

REFERENCES

https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/media/14_phak_ch12.pdf
https://www.wunderground.com/metarFAQ.asp
https://www.ofcm.gov/publications/fmh/FMH1/FMH1_2017.pdf
https://aviationweather.gov/