Aviation Forecasts and Weather Charts

Session Time: Four, 50-minute sessions

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.

Winds, clouds, precipitation and thunderstorms are the common weather phenomena that most affect flying.

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 are weather forecasts created?
2. What might be done in the future to make them more accurate?

LEARNING GOALS

Students Will Know

- The following types of weather forecasts: Terminal Aerodrome
- Forecasts (TAFs), inflight weather advisories, and winds and temperatures aloft forecasts
- The common formats in which aviation weather is forecast (e.g. TAFs, AIRMETs), and how they can be interpreted
- The information contained in different types of weather forecasts

Students Will Be Able To

- *Decode* and *interpret* TAFs, AIRMETs, SIGMETs, and winds and temperatures aloft forecasts. (DOK-L3)
- *Compare* the different types of weather forecasts and explain how one might use them to develop a complete picture of the weather during flight planning. (DOK-L3)
- *Analyze* weather forecasts and charts to determine whether or not to take a planned flight. (DOK-L4)

ASSESSMENT EVIDENCE

Warm-up
Students will fill in and assess their weather diary, first started in Unit 1, Section A, Lesson 1, and then assess the conditions to determine “Is it a good day to fly?” This will segue directly into predicting weather on future days, leading into the lesson on forecasts.

Formative Assessment
Students will identify the appropriate weather forecast product that provides required information during various stages of flight planning and apply that knowledge to a flight planning scenario.

Summative Assessment
Students will be provided with excerpts from weather forecast products and will use those products to assess the weather conditions along a cross-country route of flight. Using a combination of products, they will assess the weather forecast's impact to all phases of flight.

LESSON PREPARATION

MATERIALS/RESOURCES

- Aviation Forecasts and Weather Charts Presentation
- Aviation Forecasts and Weather Charts Student Activity 1
- Aviation Forecasts and Weather Charts Student Activity 2
- Aviation Forecasts and Weather Charts Student Activity 3
- Aviation Forecasts and Weather Charts Student Activity 4
- Aviation Forecasts and Weather Charts Student Activity 5
  - Internet-capable device for each student, or a classroom overhead display with internet access
- Aviation Forecasts and Weather Charts Student Activity 6
- Aviation Forecasts and Weather Charts Teacher Notes 1
- Aviation Forecasts and Weather Charts Teacher Notes 2
- Aviation Forecasts and Weather Charts Teacher Notes 3
- Aviation Forecasts and Weather Charts Teacher Notes 4
- Aviation Forecasts and Weather Charts Teacher Notes 5
- Aviation Forecasts and Weather Charts Teacher Notes 6
- 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

The lesson will begin with a warm-up in which students will continue to use rules to forecast the weather and track the accuracy of their forecasts. This will be followed by a brief review of reading a METAR, which will segue directly into how to read a TAF, the first of several weather forecasting products and services the students will learn about. The students will walk through TAFs, Inflight Weather Advisories (AIRMETs and SIGMETs), and the forecasts for wind and temperature aloft. For each, students will learn what it communicates, how to read it, and how it is useful to a pilot.

During the next part of the lesson students will learn about the various weather charts that provide useful weather information to a pilot during preflight planning, including Surface Analysis Charts, Weather Depiction Charts, and Significant Weather Prognostic Charts. Students will apply this information as they complete activities that demonstrate their understanding of different weather products and plan a trip that requires selection of appropriate weather products for preflight planning.

Students will then learn about Graphical Forecasts for Aviation (GFA), which provide fully interactive displays of forecasts and current observations. Students will interact with GFAs to determine the conditions for potential flights. Finally, students will complete a Summative Assessment, including test questions from the FAA's Private Pilot Knowledge Test.

BACKGROUND

The weather products that are available to pilots are largely divided into two segments: point information and area information. Point data, like METARs and TAFs, provide specific and detailed information about local flying around an airport. This is useful for determining the conditions for takeoff and landing at the departure and destination airports, for example. However, TAFs and METARs provide limited information for the weather conditions en route. Area weather products like inflight weather advisories, wind and temperature aloft forecasts, and the wide views of forecast charts can provide pilots with situational awareness on the weather covering large regions. However, that weather can be insufficiently specific for the actual route a pilot intends to fly. Ultimately, the ability to assemble a broad weather picture from a variety of different weather products, and to synthesize the information they contain, is key to deciding whether a flight is possible or advisable.

The abilities of aviation weather forecasters to accurately produce weather information improve as scientific knowledge about the atmosphere and the environment improves. In addition, the primary official source of aviation weather information, the government's Aviation Weather Center (AWC), is in a continual state of improvement. In the past few years, the AWC has begun to phase out some legacy products and incorporate their data into more modern, interactive products that pilots can customize to suit their particular requirements. As a result of these constant improvements, there may be some changes to the weather products even since the publication of this lesson.

Ultimately, all aviators need to determine what weather information they require to make a decision about executing their flight, and they need to know how to access that information. The aviation weather products and services discussed in this lesson meet those needs.

MISCONCEPTIONS

Weather sources are classified by the way they are primarily used. For example, "inflight weather advisories" are so named because they are often broadcast to pilots already in the air. However, these "inflight" advisories are also available to pilots on the ground prior to a flight, and should be used in the flight planning process. In addition, pilots planning a flight should look at current conditions as well as forecasts. For example, by reviewing current conditions published in METARs, comparing the METARs to the forecasts, and then observing the trend of METARs and forecasts, pilots can build a more comprehensive picture of the weather and how it may change. Pilots should not limit themselves based on the name or category of the weather product, but instead should review all weather information they can obtain to ensure the most complete preparation for the flight, and the highest situational awareness while in flight.

DIFFERENTIATION

To promote student engagement and motivation during the **EXPLAIN** section of the lesson, have students perform a Think-Pair-Share when responding to questioning. This will allow all students to participate in sharing their thoughts and ideas before having those ideas clarified during the group discussion.

To help students deepen their understanding of TAFs, AIRMETs, and SIGMETs in the **EXPLAIN** section of the lesson plan, have students translate text into one of these three weather forecasting products. This can help them understand patterns within the weather forecasting products.

LEARNING PLAN

ENGAGE

Teacher Material: Aviation Forecasts and Weather Charts Presentation
Student Material: Student Daily Weather Diary

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

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

In previous classes, students analyzed their weather diaries and created "rules" based on the patterns they observed. Now, students will use those rules to predict (that is, to forecast) the weather for the next day.

Warm-Up

Ask: Is this a good day to fly?

Discuss the day's weather. Students should refer to the weather diary they started in Unit 1, Section A, Lesson 1.

Questions for discussion:

How has the weather changed since yesterday? Does this match the rules you figured out based on your recorded weather patterns? Based on yesterday's weather and today's weather, what do you think the weather will look like tomorrow?

Answers will vary based on the actual weather conditions and student assessments of the weather.

How would this anticipated weather affect your plans to fly tomorrow?

Answers will vary based on the students' current understanding of the atmosphere.

[DOK-L2; *observe*]

Have students add a section to their weather diaries to create forecasts and then track their accuracy. This can take any format suitable to the students' style, but it could be a table or spreadsheet that allows them to write in the expected weather (for example, their predicted cloud coverage, precipitation, visibility, winds, temperature, etc.) based on the weather diary rules they've created. The document should also include space to include an evaluation of the accuracy of that forecast after the day passes.

EXPLORE

Teacher Material: [Aviation Forecasts and Weather Charts Presentation]()

Slide 5: Watch the following video to hear meteorologists discuss the challenges of accuracy in weather forecasting:

- "Why It's Hard to Forecast the Weather" (Length 1:56)
  https://video.link/w/Us0q

For teachers who are unable to access Safe YouTube links, this video can also be found here: https://www.youtube.com/watch?v=6ES_MIJQH_A&t=1s

Questions

Have you ever experienced the results of an incorrect weather forecast?

Answers may vary, but examples might include going to the beach on a day that was supposed to be sunny but became rainy, or canceling a trip due to forecast bad weather that turned out to be sunny.

Why do you think it is challenging to predict the weather?

Answers may vary, but may include the many variables that influence weather and the difficulty in accurately predicting their future outcomes. As technology and scientific knowledge have increased, and as historical data of previous weather patterns has expanded, atmospheric modeling has improved but still cannot account for the many factors that affect weather around the globe.

Do you think your rules will produce an accurate one-day forecast? How about a 3-day forecast? Why or why not? What other types of information would be helpful in improving your forecast accuracy?

Answers may vary, but may indicate that accuracy in forecasting may be challenging largely because of the short timespan over which students have been monitoring, tracking, and analyzing the weather. Historical data would help improve their forecasts, and knowledge of weather conditions in other areas around the region might also improve the local forecast.

Slide 6: Weather forecasts are based on scientific modeling, and one input to those models is historical data—in other words, actual observations of real weather. In fact, the forecast for this afternoon can be altered based on observations of the morning's weather.

Slide 7: With that in mind, have the students review how to read a METAR to obtain the most accurate current weather observation.

The slide includes a fictionalized METAR that reads:

KORD 060151Z 25005KT 10SM FEW140 SCT190 BKN250 28/19 A2995 RMK AO2 LTG DSNT NE SLP137

As a class, have the students walk through the METAR and attempt to identify each element it is communicating.

The METAR reads:

Chicago O'Hare International Airport, time of observation: 0151z on the 6th. Winds 5 knots from 250 degrees true. Visibility 10 statute miles. Few clouds at 14,000 feet, scattered clouds at 19,000 feet, and a ceiling of broken clouds at 25,000 feet. Temperature 28 deg Celsius, dew point 19 deg Celsius. Altimeter setting: 29.95 inHg. Remarks: AO2 (computer observation), lightning in the distant northeast. Sea Level Pressure 1137 mb.

EXPLAIN

Teacher Materials: Aviation Forecasts and Weather Charts Presentation, Aviation Forecasts and Weather Charts Teacher Notes 1, Aviation Forecasts and Weather Charts Teacher Notes 2, Aviation Forecasts and Weather Charts Teacher Notes 3, Aviation Forecasts and Weather Charts Teacher Notes 4
Student Materials: Aviation Forecasts and Weather Charts Student Activity 1, Aviation Forecasts and Weather Charts Student Activity 2, Aviation Forecasts and Weather Charts Student Activity 3, Aviation Forecasts and Weather Charts Student Activity 4

Slide 8: Aviation forecasts are built from several sources, including complex models built by meteorologists that use both the science of the atmosphere and historical data of weather patterns in a region. As already noted, meteorologists also use actual, real-time weather observations to update forecasts.

Aviation forecasts are designed to be used during preflight planning and also during en route flight. Weather products include:

- Terminal Aerodrome Forecasts (TAFs)
- Weather Advisories, such as AIRMETs, SIGMETs, and Convective SIGMETs

- Wind and Temperature Aloft Forecasts
- Weather Prognostic Charts

Slide 9: A Terminal Aerodrome Forecast (TAF) is a weather forecast that covers a 5-mile radius around an airport. It is intended to give pilots the information they need regarding the weather conditions they'll they are likely to encounter as they fly into or out of an airport. Much like the METARs students have already seen, TAFs are still published in the format used decades ago in teletype transmission, when the number of characters was limited (which is why everything is abbreviated or coded) and the font was fully capitalized. Forecasts use the same meteorological codes as METARs, but the information blocks and their order may be different.

Slide 10: Divide the students into pairs and have them complete **Aviation Forecasts and Weather Charts Student Activity 1** to the best of their ability, using what they know about weather products so far. A translation of the TAF is available on **Aviation Forecasts and Weather Charts Teacher Notes 1**. After giving the students an opportunity to translate the TAF in pairs, walk through each of the TAF elements and poll the groups, asking what they thought each term meant. See if there is consensus or disagreement on the terms. Finally, introduce the students to the application of the TAF with the "Going Further" question about how the forecast might affect a future flight plan. The following slides will clarify any questions about the elements of the TAF.

Session 2

Slides 11-17: These slides use the same TAF as Student Activity 1 to explain each term in the forecast.

- Type: Routine (TAF) or Amended (TAF AMD). TAFs are amended after they are published if the forecaster decides the original TAF is no longer a reasonable representation of the weather.
- Airport Identifier: Four-letter code for the airport covered by the TAF, using ICAO (International Civil Aviation Organization) format. Airports identifiers in the United States are preceded by the letter K.
- Date and time published: Six numbers—the first two are the calendar date, the last four are the time using the 24-hour clock. the "z" represents "Zulu" time, also called UTC (Universal Time Coordinated).
- Valid period: Two, four-digit numbers. The first four digits represent the starting time of the forecast, and the second four digits after the slash represent the "valid to" time. In both four-digit numbers, the first two digits are the calendar date, the second two are the hour. TAFs are normally valid for a 24- or 30-hour period, so a pilot could expect to see "0812/0912" – covering the 24-hour period from the 8th at 12Z to the 9th at 12Z. TAFs are typically created and published every 6-hours: 0000, 0600, 1200, and 1800 Zulu.
- Forecast wind: Five-digit number group. First three digits give the direction the wind is from in degrees; the second two digits give the speed of the wind in knots. If the winds are "gusty" a "G" might be added with the expected gust wind in knots at the end.
- Forecast visibility: Statute miles, normally whole numbers but could be fractions on a poor visibility day. Visibility greater than 6 miles is written as P6SM, or "plus 6 statute miles."
- Forecast significant weather: Same format as METAR
- Forecast sky conditions: Same format as METAR. TAFs do not include forecast for towering cumulonimbus.

Slide 18: This slide introduces how "forecast change groups" might be formatted in a TAF.

- Forecast change group: If the weather is expected to change significantly over the 24-hour valid period of the TAF, the forecast will contain lines that detail the type of change expected. "FM" indicates new weather "from" the noted time; "TEMPO" (temporary) indicates there is a greater than 50% chance new weather will occur, it will last less than an hour in each instance it occurs, and it will be less than half the forecast period.
- PROB30: Used when the forecaster expects a low probability occurrence (30 percent) of a thunderstorm or similar precipitation event.

More detailed descriptions of the TAF elements can be found on the Aviation Weather Center page at https://aviationweather.gov/static/help/taf-decode.php.

Teaching Tips

Why "P6SM" on the TAF?

The United Nations' (UN) World Meteorological Organization (WMO) defines the reporting format for METARs. The WMO format has visibility reporting in meters, with a limitation of 4 digits in the TAF. Thus, the highest visibility that can be forecast is 9999 meters, which is essentially 10km. Therefore, publishing "9999" represents any visibility "greater than 10km." The United States prefers English units, and 10km is approximately 6SM, so when the visibility is forecast to be greater than 10km, a U.S. TAF will show P6SM.

Notably, this limitation applies only to forecasts. Observations of weather will routinely report greater visibility than 6SM. Automated observations (those created by a machine) are generally limited by their detection capability to approximately 10SM, but manual (human-created) observations can routinely publish observed visibilities of 50SM or more.

Slide 19: The slide contains another example of a TAF:

KLAX 050300Z 0503/0606 26010KT P6SM FEW013

FM050500 25007KT 6SM HZ SCT017

FM051200 15005KT P6SM OVC020

Ask the students what the TAF represents and walk through its elements as a group.

Translation: *Los Angeles International Airport, published 0300z on the 5th. Valid from 0300z on the 5th to 0600z on the 6th. Winds of 10 knots from 260 degrees. Visibility plus 6 statute miles. Few clouds at 1300 feet. From 0500z, the winds will be 7 knots from 250 degrees. The visibility will be reduced to 6 statute miles due to haze. Scattered clouds at 1700 feet. From 1200z on the 5th, the winds will become 5 knots from 150 degrees, the visibility will increase to plus 6 statute miles, and the ceiling will lower to overcast at 2,000 feet.*

Translating the TAF is only the first step. The next thing to determine is what it means to the aviator.

Questions

Ask: What significant weather issues are identified in the KLAX forecast?

Answers may vary, but should include: a ***decrease in visibility*** *will occur at 0500z because of haze. At 1200z, the clouds will thicken from the prior scattered layer and* ***become overcast****. Also, the winds will* ***change more than 90 degrees*** *from 260 degrees at 0300z to 150 degrees at 1200z.*

If the forecast is correct, what might these significant weather forecast details mean to you as a pilot? What if you were planning to land at KLAX at 0500z? What if your arrival time was 1200z?

The decrease in visibility is still above VFR minimums, but the haze at 0500z could make it more difficult to see other aircraft or obstacles. In fact, the haze may be even more significant because this forecast is actually at night (0500z is 8pm Pacific Standard Time). If you had planned to arrive at the airport at 1200z as a VFR pilot, you might need to alter your plans because of the relatively *low ceiling. Finally, the winds determine the landing runway: pilots want to land into the wind. With that in mind, the landing runway will probably be different at 0500z than it will be at 1200z, which will impact the arrival and approach procedure. If this was a smaller airport than LAX, there might only be one runway, and the wind might be a crosswind that a pilot would have to factor into his landing.*

Slide 20: Distribute **Aviation Forecasts and Weather Charts Student Activity 2** and have the students work in pairs to analyze the TAF. The TAF translation and sample answer discussions are available in **Aviation Forecasts and Weather Charts Teacher Notes 2**.

Slide 21: Weather advisories are forecasts of potentially hazardous weather broadcast to airborne aircraft, though they are also available to pilots during preflight planning. These advisories cover weather conditions over widespread areas—3,000 square miles or more—even though the weather itself might only occur in certain regions at any one time.

The slide contains a graphical representation of some of the inflight weather advisories the lesson will discuss.

Slide 22: AIRMET is short for "Airmen's Meteorological Information." AIRMETs are issued every 6 hours and are useful for all aircraft, but they are targeted toward small aircraft or those with limited capabilities. (As a memory aid, think **AIR** METs are aimed at General **A**viation.)

There are three types of AIRMETs: **Sierra**, **Tango**, and **Zulu**.

- Sierra: IFR conditions (widespread areas < 1000ft ceiling or visibility < 3 miles) and mountain obscuration
- Tango: Turbulence, strong surface winds (sustained > 30kts), low level wind shear
- Zulu: Icing and freezing levels

As a memory aid, think about:

- Sierra: The **S**ierra Mountains (mountain obscuration, IFR)
- Tango: T, **T**urbulence
- Zulu: Z, Free**Z**ing

There are many times when these types of forecast conditions might be relevant to a pilot. While turbulence (TANGO) could be associated with storm systems, which pilots might anticipate, inflight weather advisories often cover the less predictable "clear air turbulence" (CAT). Environmental icing (ZULU) is always associated with visible moisture, though it is possible for airframe icing to occur if a wet aircraft (for example, one that passes through a rainstorm) climbs above the freezing level.

Slides 23-29: The slides present a step-by-step explanation of an example fictional AIRMET SIERRA covering a region in Kentucky and Tennessee.

Slide 30: This slide presents another fictional AIRMET for the students to attempt to translate as a group.

Translation: This AIRMET ZULU (freezing) was published for the Miami sector at 0245 on the 5th. It is valid until 0900z on the 5th. The freezing level ranges from 14,500 feet to 16,500 feet across the forecast region. The freezing level is 16,000 feet "along" a line described by 40 miles northwest of PZD to 70 miles west-northwest of PIE to 30 miles west of PIE to 160 miles east of OMN to 190 miles east-northeast of TRV to 140 miles east-northeast of PBI to 40 miles southwest of EYW.

Slide 31: Provide students with **Aviation Forecasts and Weather Charts Student Activity 3**, in which they will individually review and analyze an AIRMET by answering questions related to the AIRMET. If time allows, students will also address a scenario in which they will make decisions based on an in-flight weather advisory notification.

Sample responses are available on **Aviation Forecasts and Weather Charts Teacher Notes 3**.

The slide contains the AIRMET from the Activity.

After students have completed this exercise on the slide, distribute Student Activity 3. Ask students to work individually to interpret the AIRMET and answer the questions.

Session 3

Slide 32: SIGMETs (Significant Meteorological Information) are similar to AIRMETs but cover weather that is more severe. (As a memory aid, remember **S**IGMETS are for **S**EVERE weather.) SIGMETs forecast severe weather not associated with thunderstorms – icing, turbulence – and dust/sand storms that lower visibility below 3 miles, as well as volcanic ash. Unlike AIRMETS, which are scheduled every 6 hours, SIGMETS are unscheduled and only published when required. SIGMETs are valid for 4 hours unless related to a hurricane, in which case they are valid for 6 hours.

Slide 33: The slide contains an example fictional SIGMET from the *Pilot's Handbook of Aeronautical Knowledge.* Based on what the students have already learned, have the students attempt to translate the SIGMET. The SIGMET translation from the PHAK reads:

This is SIGMET Romeo 2, the second issuance for this weather phenomenon. It is valid until the 10th day of the month at 0530Z time. This SIGMET is for Oregon and Washington, for a defined area from Seattle to Portland to Eugene to Seattle. It calls for occasional severe clear air turbulence between FL280 and FL350 due to the location of the jet stream . These conditions will begin after 0200Z and continue beyond the forecast scope of this SIGMET of 0530Z.

Slide 34: Convective SIGMETs forecast weather associated with convective activity, which can be a hazard for any aircraft. Convective SIGMETs are issued for eastern (E), central (C), and western (W) United States. Convective SIGMETs are not issued outside the continental United States. (International SIGMETs, which generally combine SIGMET /Convective SIGMET information, cover Alaska and Hawaii.)

Convective SIGMETs are issued when there is thunderstorm-related activity. Conditions that warrant the issue of convective SIGMETs include embedded thunderstorms, or thunderstorms that are "embedded" in a larger cloud system and therefore not visible, lines of thunderstorms, and thunderstorms associated with heavy precipitation that cover more than 40% of the SIGMET region, as well as

- severe thunderstorms with surface winds greater than 50 knots
- hail inch or larger at the surface
- weather associated with tornadoes.

Slide 35: Unlike SIGMETS, convective SIGMETS are issued every hour at 55 minutes past the hour, and they are valid for 2 hours. If there is no convective activity, it simply states "CONVECTIVE SIGMET...NONE."

The slide contains an example convective SIGMET from the Pilot's Handbook of Aeronautical Knowledge (PHAK) that says

MKCC WST 221855

CONVECTIVE SIGMET 20C

VALID UNTIL 2055Z

ND SD

FROM 90W MOT-GFK-ABR-90W MOT

INTSFYG AREA SEV TS MOVG FROM 24045KT. TOPS ABV FL450. WIND GUSTS TO 60KTS RPRTD. TORNADOES...HAIL TO 2 IN... WIND GUSTS TO 65KTS POSS ND PTN

The "C" on "20C" indicates the convective SIGMET is for the Central United States.

The translation from the PHAK reads:

A convective SIGMET was issued for the central portion of the United States on the 22nd at 1855Z. This is the 20th Convective SIGMET issued on the 22nd for the central United States as indicated by "20C" and is valid until 2055Z. The affected states are North and South Dakota, from 90 nautical miles west of Minot, ND; to Grand Forks, ND; to Aberdeen, SD; to 90 nautical miles west of Minot, ND. An ***intensifying*** *area of severe thunderstorms* ***moving*** *from 240 degrees at 45 knots (to the northeast). Thunderstorm tops will be above FL 450. Wind gusts up to 60 knots were* ***reported****.*

Teaching Tips

A Modern Take on Text AIRMETs and SIGMETs

AIRMETs and SIGMETs are transmitted over the radio and also published in text in the format seen in this lesson. However, the government's Aviation Weather Center also produces graphical representations of the different weather advisories on www.AviationWeather.gov.

The interactive, graphical display of AIRMETs and SIGMETs on the AWC website may be more intuitive for most people, if it is available during preflight planning.

Slides 36-37: Pilots use forecasts for winds and temperature aloft to plan their flights at altitude. These forecasts are based on observations from radiosondes (recall Lesson 2) and are published twice a day: at 0000Z and 1200Z. On the temperature/wind charts, winds are not published for altitudes within 1,500 feet of the station elevation. Temperatures are not published within 2,500 feet of station elevation.

The winds and temperature aloft data is published in the format DDff+TT.

The wind direction is given in DD degrees (true, not magnetic, as with all forecasts), wind speed is in ff knots, and temperature is in TT degrees Celsius. The correct algebraic sign is used prior to the temperature up to 24,000 feet. Above that altitude, all temperatures are negative and the sign is omitted.

Example: 2420-05

Translation: Winds 240 degrees, 20 knots, –5 deg Celsius

If the wind speed forecast is between 99 and 199 knots, the computer coding changes the display of information by adding 50 to the direction and subtracting 100 from the speed.

Example: 7420-05

Translation: Winds 240 degrees, 120 knots, –5 deg Celsius

For winds above 200 knots, the forecast simply reads 199. Calm or "light and variable" winds (less than 5 knots) are displayed as 9900.

Slide 38: The slide shows an excerpt from a Winds and Temperature Aloft chart from AviationWeather.gov. The top row is the column header of altitude. The first column is the identifier for the reporting station.

Questions

Why are there no temperatures reported at 3,000 feet?

3,000 feet is within 2,500 feet of station elevation.

Why is the first column for station GCK blank?

3,000 feet is within 1,500 feet of station elevation, so no winds or temperatures are reported.

What are the winds and temperature at:

MCW, 9000 ft: *250/10, 12 degrees*

SPI, 30,000 ft: *250/05, –31 degrees*

IND, 18,000 ft: *light and variable, –6 degrees*

Teaching Tips

High Altitude Winds

The wind/temperature chart contained no values above 100 knots because it was taken from the Midwest US during the summer. During the summer, the jet stream moves further north and wind values tend to be lower. During the winter in some regions, wind values above 100 knots are routine at high altitudes, and occasionally exceed 200 knots. If your class takes place during the winter, consider accessing the Aviation Weather Center and showing students a wind/temperature chart for the northern Midwest or northern Pacific states, which may have stronger values.

Slide 39: The graphic shows a screen capture of a graphical presentation of the wind/temperature data from AviationWeather.gov, which some students may find more intuitive, particularly when trying to get a "big picture" of winds and temperature over an area. The altitude is set using the slider on the left side of the window, and the time can be set using the slider at the top.

Slide 40: Complete the **Formative Assessment**.

Formative Assessment

Provide students with **Aviation Forecasts and Weather Charts Student Activity 4**, in which they will individually determine which weather forecast products provide the information they need to assess the weather during various stages of flight planning. If time allows, students will also apply their knowledge of the products to a notional scenario.

Sample responses are available on **Aviation Forecasts and Weather Charts Teacher Notes 4**.

[DOK-L2; *infer, interpret*]

EXTEND

Teacher Materials: Aviation Forecasts and Weather Charts Presentation, Aviation Forecasts and Weather Charts Teacher Notes 5
Student Material: Aviation Forecasts and Weather Charts Student Activity 5

Slide 41: Weather charts graphically depict either current observations or forecast weather. The charts display the weather patterns and fronts across the United States, and can help show pilots the movement of the weather and systems throughout the forecast time period. They are ideal references for use during flight planning, as they paint a broad picture of the weather. This is especially helpful if a pilot is planning a long-distance flight.

The four primary referenced weather charts are

- Surface Analysis Chart
- Weather Depiction Chart
- Significant Weather Prognostic Chart
- Graphical Forecasts for Aviation

Slide 42: An analysis of current surface weather conditions is displayed on a **Surface Analysis Chart**, which is published every 3 hours. The surface analysis chart shows high/low pressure systems, fronts, temperatures, dew points, winds, and visibility. Detailed station information is displayed graphically for each reporting station on a "station model." The data shown on the station model varies depending on the intended audience. "Standard" station plots were discussed in the previous lesson on Air Masses and Fronts. The Weather Prediction Center (WPC) of the National Weather Service also produces an aviation-specific analysis at https://www.wpc.ncep.noaa.gov/html/avnsfc.shtml with a slightly modified station plot which shows:

- Sky cover: clear, scattered, broken, overcast, or obscured/partially obscured
- Ceiling: hundreds of feet
- Temperature point: in degrees Fahrenheit.
- Present weather: Reference the standard weather symbol legend.
- Visibility: in miles
- Wind: Same as standard; The "wind barb" acts like an arrow, with the head of the arrow indicating the direction of the travel of the wind. The feathers are barbs showing wind strength. A short barb is 5 knots, a long barb is 10 knots, and a filled-in triangle resembling a "pennant" is 50 knots.

The slide shows a graphic of the station plot and a portion of an aviation surface analysis provided by the WPC.

Slide 43: The Weather Depiction Chart was published every 3 hours to show current (not forecast) surface conditions based on METARs and observations, providing a quick-reference, graphic display of ceiling and visibility (IFR, marginal VFR, and VFR). However, the WDC is being phased out and replaced in part by a Ceiling and Visibility Analysis, which is essentially a modernized display of the same information. The WDC is more fully being replaced by the Graphical Forecast for Aviation (GFA), which will be discussed in subsequent slides.

Slide 44: Significant Weather Prognostic Charts—often simply called "prog charts"—are divided into two altitude bands: surface to 24,000 feet (flight level (FL) 240), and FL250 to FL630. The low-level chart is intended to be useful to the VFR pilot during flight planning, largely to assist the pilot in understanding hazards to avoid.

Low-level significant weather charts are published every six hours (0000, 0600, 1200, and 1800z) and have two graphics of the continental United States, with the one on the left showing a 12-hour forecast and the one on the right showing a 24-hour forecast.

Significant weather prognostic charts display the following information:

- the freezing level
- areas of IFR and MVFR
- areas of moderate or greater turbulence
- fronts
- pressure
- precipitation type and intensity
- weather type

The graphics on significant weather prognostic charts help pilots quickly assess the current and future weather they may experience on a flight. This gives pilots one more tool to help with risk analysis, as they balance their qualifications, skills, and the capabilities of their aircraft with the environmental conditions.

Slide 45: This slide presents an example graphic of a Significant Weather Prognostic chart. The 12-hour forecast is on the left, the 24-hour forecast on the right. A legend along the bottom of the chart aids in interpretation.

Session 4

Slide 46: Graphical Forecasts for Aviation (GFAs) are interactive, internet-based graphic charts intended to give users a comprehensive view of the weather that may impact their flights throughout the United States, up to FL420. These charts are updated continuously and provide various filters and options for displaying forecasts, observations, and other weather data (including wind, icing, and turbulence) from 14 hours in the past to 15 hours in the future in incremental altitudes.

GFAs are available at www.AviationWeather.gov/gfa. More instructions, if desired, are available in Advisory Circular 00-45H Change 1, paragraph 5.9.

Slide 47: The slide presents a screen capture of a live Graphical Forecast for Aviation. Across the top, users can select different views to display TAFs, ceiling/visibility, cloud cover, precipitation, thunderstorms, winds, turbulence, and ice.

Directly below that header, a slider enables the user to change the Zulu time represented on the chart.

A legend is below the chart with an explanation of the major symbols. The "Weather Symbols" graphic in the legend is clickable and provides a page that explains the station plot symbols.

Distribute **Aviation Forecasts and Weather Charts Student Activity 5** and have students access the internet to interact with a Graphical Forecast for Aviation, then answer questions about it. Sample responses and further information are available on **Aviation Forecasts and Weather Charts Teacher Notes 5**.

EVALUATE

Teacher Materials: **Aviation Forecasts and Weather Charts Presentation**, **Aviation Forecasts and Weather Charts Teacher Activity 6**
Student Material: **Aviation Forecasts and Weather Charts Student Activity 6**

Slides 48-53: Quiz students on the Private Pilot Knowledge Test questions.

Slide 54: Conduct the **Summative Assessment**.

Summative Assessment

Distribute **Aviation Forecasts and Weather Charts Student Activity 6**. In this summative assessment, students are provided excerpts from various weather forecast products, and they will analyze these products to determine potential effects on a cross-country flight from Oklahoma City, OK, to Chicago, IL.

Individually, students will answer freeform questions demonstrating their understanding of what the weather charts are describing and what effect that would have on their flight plan.

Sample answers are provided in **Aviation Forecasts and Weather Charts Teacher Notes 6**.

[DOK-L3; *Analyze, Assess*, DOK-L2; *Predict*]

Summative Assessment Scoring Rubric

- Follows assignment instructions
- Responses show evidence of one or more of the following:
    - Correct interpretation of the data presented by the weather products
    - Reasonable application of that data to a piloting decision
    - Evidence and explanation of the above that demonstrate understanding of the material
- Contributions show understanding of course of the concepts covered in the lesson
- Contributions show in-depth thinking including analysis or synthesis of lesson objectives

Points **Performance Levels**

9-10 Correctly understands all or almost all weather information provided in the charts and makes a reasonable application of that information to a flight decision, with explanation that accurately reflects the weather information provided.
7-8 Correctly understands most weather information provided in the charts, with some errors, and makes generally reasonable applications of that information to a flight decision, with some incomplete analysis or errors.
5-6 Correctly understands some weather information provided in the charts, with errors, or makes generally reasonable flight decisions but lacks adequate explanation.
0-4 Provides few, if any, correct interpretations of weather information provided in the charts, and /or makes poor flight decisions with inadequate explanation.

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

The applicant demonstrates the ability to:

- **PA.I.C.S1** Use available aviation weather resources, obtain an adequate weather briefing, and correlate weather information to make a competent go/no-go decision.

- **PA.I.C.S2** Discuss the implications of at least three of the conditions listed in K3a through K3k above, using actual weather or weather conditions in a scenario provided by the evaluator.

REFERENCES

Weather Rock Source: https://commons.wikimedia.org/wiki/File:Weather_Predicting_Rock_-_panoramio.jpg
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Aerodrome Reports and Forecasts: A Users' Handbook to the Codes, World Meteorological Organization (WMO) No. 782, 2019. Available at https://library.wmo.int/index.php?lvl=notice_display&id=716
https://video.link/w/Us0q
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