Practical Weather for UAS Pilots

Session Time: Three, 50-minute sessions

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

Remote pilots must consider weather conditions when planning sUAS operations, using observations, weather reports, and forecasts to form a complete weather picture.

Weather can impact small unmanned vehicles differently than manned aircraft, given their lightweight and the fact that they typically operate at very low altitudes.

ESSENTIAL QUESTIONS

1. How can a remote PIC—using weather reports, forecasts, and visual observations—determine if weather conditions are conducive to safe sUAS operations?
2. What should remote pilots consider when operating in different types of weather conditions (e.g., wind, heat, cold, etc.)?

LEARNING GOALS

Students Will Know

- How various weather conditions, including wind, thunderstorms, clouds, fog, icing, and temperature, can affect sUAS operations.
- Important aspects a remote PIC must weigh when confronted with weather decisions.
- Sources that remote pilots can use to gather information and form a complete weather picture.

Students Will Be Able To

- *Identify* weather conditions that could be problematic to drone operations. [DOK-L1]
- *Make observations* about the weather to determine if conditions are ideal for an sUAS operation. [DOK-L2]
- *Assess* weather conditions based on reports, forecasts, and observations to decide if an unmanned operation can be completed safely, and how it can best be conducted. [DOK-L3]

ASSESSMENT EVIDENCE

Warm-up
Students recall what they've learned about weather and weather hazards so far. They will create a list of conditions that can be the most hazardous to aircraft flight. They will then consider which pose the biggest risks to sUAS flight.

Formative Assessment
Working individually, students will answer the questions in **Student Activity 1** that review what they have learned in Session 1.

Summative Assessment
Working individually and assuming that they are sUAS pilots, students will review the scenarios in **Student Activity 2** and determine whether the weather is acceptable for sUAS operations.

LESSON PREPARATION

MATERIALS/RESOURCES

- Practical Weather for UAS Pilots Presentation
- Practical Weather for UAS Pilots Student Activity 1
- Practical Weather for UAS Pilots Student Activity 2
- Practical Weather for UAS Pilots Teacher Notes 1
- Practical Weather for UAS Pilots Teacher Notes 2

LESSON SUMMARY

Lesson 1: Practical Weather for UAS Pilots
Lesson 2: Small UAS Loading
Lesson 3: UAS Aerodynamics and Performance

The lesson will begin as students review their current knowledge of weather as they have learned from previous lessons. They will then draw conclusions based on how they think this weather applies to sUAS operations. Students will research weather around the school and make a decision as to whether sUAS flight would be safe. They will then discover how various weather conditions affect sUAS in comparison to manned aircraft. Next, students will complete the **Formative Assessment**.

Session 2 further explores threats to remote flying such as extreme heat, cold, and humidity. It also explores how susceptible sUAS craft are to icing. Students will then consider how to make go/no-go decisions based on available weather sources and visual observations. The **Summative Assessment** has them test these skills in a final evaluation.

BACKGROUND

Remote pilots in command (PICs) must use weather resources in order to build an overall picture/assessment of the weather and to make a decision whether to fly (also known as the go/no-go call). Weather sources should be familiar to students, as they learned about them in the first semester. If they have trouble locating weather data, remind them to use METARs, TAFs, enroute conditions and forecasts, as well as their own visual observations.

Part 107 states that a remote PIC should always preflight their aircraft prior to takeoff, just as they would with a traditional manned aircraft. Current and forecast weather data should both be used to form a complete weather picture.

MISCONCEPTIONS

Students learned about aviation weather reports and forecasts in the first semester. They might have a perception that these sources (e.g., www.aviationweather.gov, www.1800wxbrief.com, etc.) are intended for pilots of manned aircraft only. This is not the case, however. These aviation weather sources are also excellent ways for sUAS pilots to determine if weather minimums for drone operation will be met, and also what conditions to anticipate during an sUAS flight.

DIFFERENTIATION

To support student motivation and engagement during the EXPLORE section of the lesson plan, have students perform a Think-Pair-Share when answering the questions. This sort of activity will encourage class-wide participation, and allow struggling students to have some assistance recalling weather sources that they've learned about in earlier units.

To promote critical thinking in the EXPLAIN section of the lesson plan, have students compare and contrast the impact of weather conditions on manned and unmanned aircraft. Have students take a piece of paper and fold it in half vertically to form two columns with “Manned Flight” and “Unmanned Flight” as the headings. As you work through this section of the lesson plan, have students write down their insights and observations, and pause periodically to have them share their notes with the rest of the class.

LEARNING PLAN

ENGAGE

Teacher Material: Practical Weather for UAS Pilots Presentation

Session 1

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

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

Warm-Up

Ask students to recall what they’ve learned about weather and weather hazards so far and to brainstorm a list of conditions that can be the most hazardous to aircraft flight. Record students’ ideas on the board. Do not attempt to correct wrong answers here; this activity is intended simply to get students pondering and discussing the elements that will be addressed in this lesson.

Answers will vary based on students’ current knowledge and understanding but will likely include turbulence, high winds, thunderstorms, icing, etc.

When students have listed all the weather hazards they can think of, advance to the next slide and discuss these questions as a class:

- Of the conditions that students have listed, which do they think would pose the biggest risks to sUAS flight?
- Which could be more problematic for remote pilots than for pilots of manned aircraft?
- Which would have less of an impact on sUAS than on manned aircraft? Why?

All answers will vary based on students’ current understanding.

Allow a few minutes for the class to discuss.

In the following video, instruct students to note the weather conditions that they have not previously considered, in order to share them with the class after the video and generate discussion. This video reveals other weather conditions which can impact drone flight:

- “Weather conditions to think about when flying your drone” (Length 3:27)
  https://video.link/w/Vr3x
  For teachers unable to access Safe YouTube links, the video is also available here: https://youtu.be/qIAeUArq8ds

EXPLORE

Teacher Material: Practical Weather for UAS Pilots Presentation

Slide 6: Remote pilots in command (PICs) must utilize weather resources in order to build an overall picture /assessment of the weather and to make a decision whether or not to fly (also known as the go/no-go call). This is one of the most critical aspects of all pilot decision-making. The weather sources discussed in the first semester will help guide students to the proper weather data, including METARs, TAFs, enroute conditions and forecasts. Students can also use their own observations of local conditions to make a go/no-go call.

Slide 7: Ask students to imagine they are an sUAS pilot who needs to take off and photograph the school from all sides.

Questions

What weather sources would you check?

Answers may include going outside and doing a visual check, searching nearby airport METARs, or using other current aviation resources (e.g., prog charts). Other non-aviation resources depicting local weather could also be used.

What if the planned operation were 5 hours from now?

Checking aviation forecasts (e.g., TAFs, winds aloft) would be important, as it would allow a pilot to understand how conditions might change. Local forecasts (e.g., TV or radio broadcasts) could also be used to form a complete weather picture.

Slide 8: Next, have students use their knowledge from past lessons and resources (visual and electronic) to build a "picture" of the weather now and 5 hours from now, and determine if conditions would be ideal for safe operation.

Questions

How did you determine your go/no go call? Why?

Answers will vary, based on student knowledge and local conditions, but should include considerations of regulatory cloud restrictions (500 feet below and 2,000 feet horizontally from any clouds) and visibility requirements (3 SM of ground visibility from the control station). Also take into account winds, temperature, and chances of precipitation.

Teaching Tips

If students are having trouble recalling useful weather resources, remind them of NOAA's Aviation Weather Center (https://www.aviationweather.gov/), which they can use to check local airport METARs and TAFs. This may be a good opportunity for students to practice reading and decoding aviation weather reports, since this skill is likely to be required on the FAA's Part 107 exam.

EXPLAIN

Teacher Materials: Practical Weather for UAS Pilots Presentation, Practical Weather for UAS Pilots Teacher Notes 1
Student Material: Practical Weather for UAS Pilots Student Activity 1

Slide 9: As students discovered in Unit 6, Part 107 states that a remote PIC should always complete a preflight inspection of their sUAS prior to takeoff, just as they would with a manned aircraft. As always, a comprehensive "preflight" will include current and forecast weather data. These weather factors include precipitation, atmospheric stability, winds, surface heating, visibility, and cloud layers, just to name a few. The Part 107 exam includes information that was learned in semester 1; however, the weather factors discussed in this lesson are of particular significance for the sUAS pilot.

Slide 10: The sun is ultimately the driving factor of all weather and associated patterns and phenomena. Due to Earth's curvature and geography, the sun heats Earth unevenly. This creates a heat imbalance which creates large air-cell circulation patterns in the atmosphere which we commonly refer to as wind. Warmer air rises faster than cooler air, creating atmospheric instability. When rising warm air ascends through the cool air above it, the resulting instability creates large systems of pressure variations. While rising air is associated with low pressure systems, falling air is associated with high pressure systems.

Slide 11: Students have already learned general weather theory and how weather affects manned aircraft in previous lessons; therefore, this lesson will focus primarily on how weather impacts sUAS operations. Students should be able to associate their existing knowledge of weather as it relates to manned aircraft by applying the same principles to sUAS aircraft. One significant difference is that, due to the size of an sUAS aircraft, certain weather phenomena (especially turbulence) affect sUAS to a greater degree.

Like manned aircraft, sUAS's operating in low density altitude will have improved performance over those operating in high density altitude. Based on the knowledge they gained from previous lessons, have students specify the improved performance aspects that come with beneficial atmospherics/weather. These will include more power availability for thrust in acceleration and climb and better fuel conservation.

Slide 12: Surface heat is another weather phenomena that can have an impact on low altitude operations. Different surfaces radiate varying levels of heat, which results in small pockets of convective currents, or air circulation. These currents may create turbulence which may not matter much for larger manned aircraft, but may dramatically affect controllability for sUAS aircraft. Rocks, sand, pavement, barren land, and building rooftops radiate heat (due to their inherent properties as dense solids) which may result in updrafts. Water and regions with multiple trees, however, absorb more heat (due to their inherent properties as more porous or liquid solids) which results in downdrafts.

Slides 13-14: While wind has an impact on all aircraft, it is especially significant to sUAS operations. Small UAS are more susceptible to being blown off course or out of level flight due to gusts. They are also operated in areas which would be considered 'critical phases of flight' while piloting any aircraft, be it manned or unmanned: low altitudes, close to structures and terrain, and even in confined areas with limited maneuvering space.

Surface obstacles, whether natural or manmade, significantly alter wind path and intensity. Winds blowing against a structure or terrain near an sUAS on the upwind side could cause turbulent updrafts which may in turn cause ballooning (being pushed by winds from underneath) or even loss of control. Conversely, if the sUAS were operating on the downwind side, these winds could cause downdrafts and a sinking effect (being pushed by winds from above).

Questions

What phenomenon is caused when a powerful, significant volume of air (typically accompanied by precipitation) falls out of a thunderstorm at a rapid rate and balloons outwards when hitting the ground?

a microburst

What effect does this have on manned aircraft, even large commercial ones?

When close to the ground, manned aircraft see an initial increase in performance, followed by a dramatic decrease in performance (notably lift and airspeed). If close to the ground, impact may be inevitable.

How does this effect, though not as dramatic, relate to downdrafts felt by sUAS craft?

Like a microburst, downdrafts can push the much smaller craft towards the ground, which is why it is so critical to pay close attention to winds.

Slide 15: Like human-made obstacles, natural obstructions and terrain may alter the course and velocity of winds. Winds may flow smoothly up the windward (upwind) side of a mountain, however the winds on the leeward (downwind) side perform differently. Winds flowing down a mountain slope typically become increasingly turbulent, especially if the wind is moving significantly fast. This downward flow will exert downward pressure on the sUAS, driving it toward the terrain, causing the sUAS pilot to be forced to increase power in order to create more lift (assuming more power is available). If the sUAS is underpowered, or the winds are thought to be too powerful for the sUAS to handle, then pilots should distance their craft from such obstructions and terrain. Even relatively minor variations or oddly shaped terrain may alter wind speed and velocity, and therefore remote pilots should exercise caution.

Slide 16: In addition to low-level turbulence, sUAS pilots must also take into account wind speed and associated gusts. All pilots must know their aircraft's performance capabilities, because these will drive its wind capabilities and top speed. While flying downwind, the wind speed will be added to the drone's true airspeed (TAS), resulting in a relatively high groundspeed (GS). However, when flying upwind, its TAS will be decreased by the same amount, resulting in a relatively low GS.

It is possible, given a situation of extremely high winds and a low forward speed aircraft, that a small remote aircraft may not be able to make enough headway to return to the pilot's location.

Slide 17: This drives another factor that sUAS pilots must account for in windy conditions: battery life. As an sUAS aircraft struggles forward against the wind, its batteries deplete more quickly than when it flies downwind.

Have students copy down the potential concerns that pilots should consider in preflight planning and while flying in windy conditions. Students will then share these considerations (and why they believe they're significant) with the class after the following video.

- "Flying a drone in high winds is DANGEROUS" (Length 5:10)
  https://video.link/w/2C3x

For teachers unable to access Safe YouTube links, the video is also available here: https://youtu.be/fe9O_AN8kE8

Slides 18-19: Have students recall from the first semester that thunderstorms and their associated hazards should always be avoided because there is no greater weather-related threat to aircraft.

Questions

Recall what you learned about thunderstorms last semester. What three conditions must be met for thunderstorms to form?

water vapor, atmospheric instability, and a lifting force

Students should remember the “threes” that accompany thunderstorms; review this information as needed:

- Three conditions must exist for thunderstorms to form: water vapor, atmospheric instability, and a lifting force.
- Three different lifting forces can contribute to a thunderstorm: surface heating, mechanical lifting (such as wind blowing up a mountain slope), and frontal lifting (a cold front driving the warmer air ahead of it upwards).
- There are three stages in the lifespan of a thunderstorm: cumulus, mature, and dissipating.

Continue to review thunderstorms by asking students the following questions:

Questions

What is a squall line?

Long lines of typically severe thunderstorms which must be circumnavigated for safety.

Which type of lifting causes a squall line?

Frontal lifting causes squall lines to form.

What happens in each stage of a thunderstorm’s lifespan?

- *Cumulus: Continuous updrafts create low pressure areas and the thunderstorm gains rapid vertical development.*
- *Mature: Updrafts and downdrafts occur (significant wind shearing/turbulence) and rain begins*
- *Dissipating: The final stage is characterized primarily by downdrafts as the thunderstorm tops begin to descend.*

Slides 20-21: In manned aircraft, the shearing of high winds is one of the thunderstorm’s greatest threats, causing potentially extreme turbulence which can cause structural damage to any aircraft and loss of control for small aircraft.

While severe and extreme turbulence can potentially destroy an sUAS, an even more significant threat, both to the sUAS and the pilots themselves, is lightning. Thunderstorms always produce lightning to some extent, the amount of which is determined by the storm’s severity.

If sUAS pilots or operators observe lightning during operations, they should safely recover the aircraft at once (only if able to do so safely), and the crew should then take shelter.

Questions

How can an sUAS pilot check the severity of a thunderstorm or lightning output without the ability to fully see it from the air?

Pilots can check local forecasts, weather radar, and surrounding airport METARs for vertical development/top altitudes of these cumulonimbus clouds, along with lightning observations, when preflight planning.

The following video illustrates the danger that lightning poses to drones:

- "Drones vs Lightning" (Length 5:30)
  https://video.link/w/RK3x

For teachers unable to access Safe YouTube links, the video is also available here: https://youtu.be/L3iJjrQmEho

Slide 22: While operating the sUAS, it's handy to know the rule of thumb to determine how close lightning has just struck. Take the number of seconds between when the lightning is seen and when its resulting thunder is heard. Divide that number by 5 to roughly calculate the distance from you to the lightning strike in statute miles (SM). The following video reviews this process.

- "How to calculate the distance of a lightning strike?" (Length 3:56)
  https://video.link/w/JL3x

For teachers unable to access Safe YouTube links, the video is also available here: https://youtu.be/GdbkRoCTIjk

Slide 23: In addition to winds, turbulence, and lightning, other severe threats to sUAS and their operators include hail and tornadoes. Students should recall from previous lessons how these extreme weather hazards form.

Questions

What causes hail to form and then fall?

Hail is formed by the freezing, melting, and refreezing of water within updrafts and downdrafts of thunderstorms. Water continues to accumulate on the hail stone until the hail stone becomes too heavy for the updrafts to keep it aloft and it falls to Earth.

What causes tornadoes to form?

Where are they most often found (ahead of what thunderstorm phenomenon)?Tornadoes are formed by the rotating motion of air drawn into thunderstorms from different directions, most often ahead of a squall line where air near the surface is most unstable.

Due to all of these associated hazards, sUAS operators should closely monitor weather patterns before and during flight. If severe weather does develop, crews should be ready to halt operations at once to ensure safety, both for the sUAS aircraft and its crew.

Slide 24: Whenever unmanned operations are being conducted, visual line of sight (VLOS) must be maintained with the UAS. Remote PICs are ultimately responsible for separation from other aircraft, which can only take place if these aircraft are spotted in time to avoid them. Before launch, sUAS pilots must determine that visibility from the control station is 3 SM or greater. Additionally, akin to visual flight rules (VFR) for manned aircraft, the UAS must be operated at least 500 feet below and 2,000 feet horizontally from clouds.

From the ground, it's often difficult for an sUAS operator to judge cloud altitudes and exact visibility. Unlike manned aircraft that use airports where current weather conditions are sometimes available from systems such as ASOS or AWOS, sUAS tend to be flown in areas without these systems. Even considering this, sUAS pilots must still take cloud clearance and visibility requirements seriously to ensure the safety of the operation.

Session 2

Slide 25: Remote pilots may use local aviation weather reports (including current and forecast conditions) to determine whether cloud clearance and visibility requirements are met. Which report to choose? Look for a report from a weather reporting station with a location close to the operation and with terrain similar to that of the pilot's location (elevation, mountains, etc.).

Pilots may also determine visibilities and cloud clearances by using nearby objects. For instance, if a site that will be used frequently is 3 or more miles away from a known structure, that structure can be used as a rough estimate to determine whether or not the 3 SM visibility requirement has been met. Likewise, operators may use a sectional chart or other resource to determine the height of a visible tall tower or building to compare it to cloud heights. For instance, if a tower is reported on a chart to be 1,000 feet AGL, and the top of that tower is below the surrounding clouds, then the remote pilot can assume that if they fly the sUAS at or below the maximum altitude of 400 feet AGL, it will still be more than 500 ft below the base of the clouds.

Whether using visual references or local weather reports to determine visibility and cloud clearances, remote PICs should be conservative and err on the side of safety when estimating. An sUAS should never be flown over a cloud, since this breaks the VLOS rule, creating a potentially unsafe situation.

Slide 26: Students should recall that fog is essentially a cloud at ground level.

Questions

How/when does fog form?

Fog forms when air cools to its dew point, or when moisture is added to existing cool air.

During what time of day does radiation fog typically form?

It typically forms in the early morning before the sun rises.

Students should also recall the various forms of fog:

- Radiation fog—forms when the ground cools (such as at night) and cools the air around it to its dew point.
- Advection fog—forms when warm, moist air is moved by wind over colder areas such as frosted ground or water.
- Upslope fog—forms when moist air is cooled to its dew point as it moves across upsloping terrain.

Because fog can form rapidly and impedes visibility significantly, remote PICs should conduct a thorough preflight plan (including checking temperature and dew point for converging values) and use caution if conditions are favorable for the formation of fog.

Note: Be especially vigilant for fog when the temperature/dew point spread is less than 5° F (3° C), as this is when it is most likely to form.

Slide 27: Conduct the **Formative Assessment**.

Formative Assessment

[DOK-L1; *name*, DOK-L2; *explain*]

Distribute the **Practical Weather for UAS Pilots Student Activity 1** worksheet for students to complete. Instruct students to answer the questions individually. Answers are found in **Practical Weather for UAS Pilots Teacher Notes 1.**

Slide 28: Extreme hot and cold temperatures are both challenging for sUAS operators. Extreme heat significantly degrades power (thrust and lift) capabilities and threatens overheating of the internal components. Extreme cold poses the risk of icing in visible moisture, slows electronic component reactions, and drains batteries more quickly. The following video considers potential difficulties when flying sUAS in hot or cold temperatures.

- "DJI Tutorials – Flying in Hot and Cold Weather" (Length 2:58)
  https://video.link/w/FB5x

For teachers unable to access Safe YouTube links, the video is also available here: https://youtu.be/TmYlKhx_-l0

Slide 29: Have students recall that density altitude changes not only with elevation/altitude, but also with temperature. Like manned aircraft, sUAS performance depends on the surrounding environment and weather conditions. The conditions chosen by sUAS manufacturers to determine performance calculations are typically similar to those used for manned aircraft calculations. In both instances, standard temperature is 15 degrees C and standard pressure is 29.92"Hg (inches of mercury), also referred to as a "standard day." This standard day also refers to standard air density, although densities vary as air temperatures cool or warm. For instance, a low barometer and high temperature will result in a much higher density altitude than the sUAS's present altitude, causing degraded performance as it relates to power availability for thrust and lift generation. The inverse is true, as higher pressure and lower temperatures result in lower density altitudes, and therefore improved performance.

Questions

When does sUAS performance **decrease** as it relates to temperature, altitude, and atmospheric pressure?

Small UAS performance decreases as temperature rises, altitude increases, and pressure decreases. Humidity can decrease performance as well, but to a lesser degree.

When does sUAS performance **increase** as it relates to temperature, altitude, and atmospheric pressure?

Small UAS performance increases as temperature decreases, altitude decreases, and pressure increases.

Slide 30: Icing is another serious potential hazard in cold weather when visible moisture (even a fine mist) is present. Have students recall that structural icing occurs when supercooled condensed water droplets contact any sUAS surface that is below freezing. Depending on the amount of accumulation, surface icing can impair all aircraft performance by decreasing lift, increasing weight, and increasing drag.

Visible moisture must exist in the air in the form of clouds, fog, mist or rain in order for ice to form. Since sUAS pilots are required to operate clear of clouds and fog, they should be primarily concerned about icing that accumulates due to freezing rain or mist. Assuming an sUAS aircraft's surface temperatures are below freezing, icing is not a considerable risk from falling snow because significant amounts of snow will not stick to the surface of the craft.

Even small amounts of ice accumulation on sUAS aircraft surfaces can lead to a loss of control. Therefore, sUAS operators should avoid flight in visible moisture when the temperature is below freezing. If any amount of ice accumulation is noticed during flight, operations should immediately cease so that the craft can be safely recovered.

Cold weather operations are explained in this video:

- “Tips for Flying Your Drone in Cold Weather: From Where I Drone with Dirk Dallas” (Length 6:46) https://video.link/w/UG5x

For teachers unable to access Safe YouTube links, the video is also available here: https://youtu.be/BrcCPCAWM-U

EXTEND

Teacher Material: Practical Weather for UAS Pilots Presentation

Session 3

Slide 31: Students should now recognize that some weather conditions can impact sUAS aircraft to a greater extent than manned aircraft. Given this, have students consider the question: what other sources should sUAS PICs use to make a go/no go call (that is, to determine if the weather is favorable for flight)? In the first semester and previous session, students learned the importance of building a complete weather picture.

Small UAS pilots do well to understand how visual observations, weather reports, and forecasts combine to build a comprehensive weather picture during planning and preflight. Sources good for both manned and remote pilots include www.1800wxbrief.com and NWS Aviation Weather Center (AWC) at www.aviationweather.gov. However, remote pilots should not call Flight Service (at 1-800-wxbrief) because this telephone service is intended to be reserved for manned aircraft pilots only. Remote pilots may create a free account online if they wish to use this resource.

Slide 32: Student pilots should now understand that checking nearby airport METARs and TAFs is vital. However, it is also critical for sUAS operators, just like manned aircraft pilots, to review temporary flight restrictions (TFRs) for the flight area either at the FAA’s TFR website (http://tfr.faa.gov) or at www.skyvector.com (as reviewed in previous lessons).

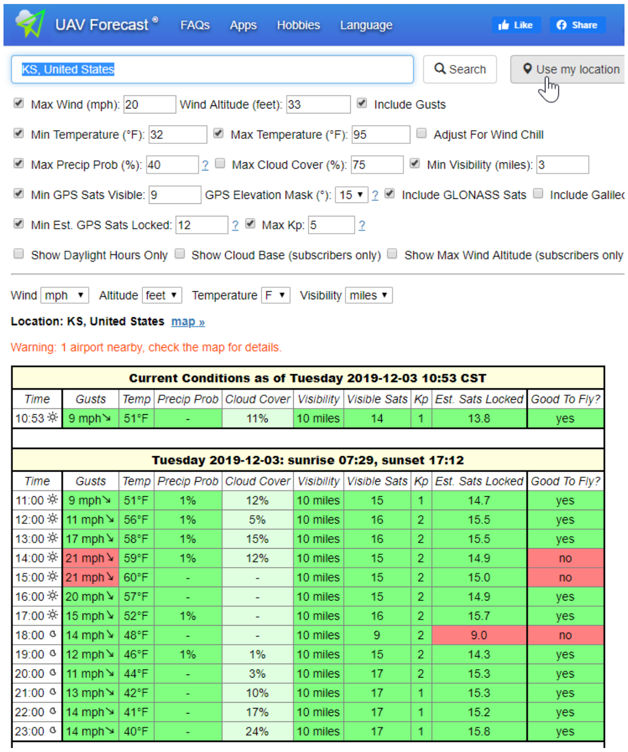
There are also websites and apps designed specifically for remote pilots. One such example is https://www.uavforecast.com.

Teaching Tips

Go to https://www.uavforecast.com and explore the site. Have students determine whether conditions around the school would be ideal for flying. Green cells are considered acceptable conditions, but red cells represent factors that fall outside either the set parameters or requirements necessary for sUAS operations. Specific parameters such as wind and temperature can be customized (see screenshots below).

If time permits, ask students to share what they have discovered:

- What elements of the site are particularly useful?
- Which data is better obtained from other sites/resources?



UAV Forecast® FAQs Apps Hobbies Language Like Share

KS, United States | Search | Use my location

Max Wind (mph): 20 Wind Altitude (feet): 33 Include Gusts

Min Temperature (°F): 32 Max Temperature (°F): 95 Adjust For Wind Chill

Max Precip Prob (%): 40 ? Max Cloud Cover (%): 75 Min Visibility (miles): 3

Min GPS Sats Visible: 9 GPS Elevation Mask (°): 15 ? Include GLONASS Sats Include Galileo

Min Est. GPS Sats Locked: 12 ? Max Kp: 5 ?

Show Daylight Hours Only Show Cloud Base (subscribers only) Show Max Wind Altitude (subscribers only)

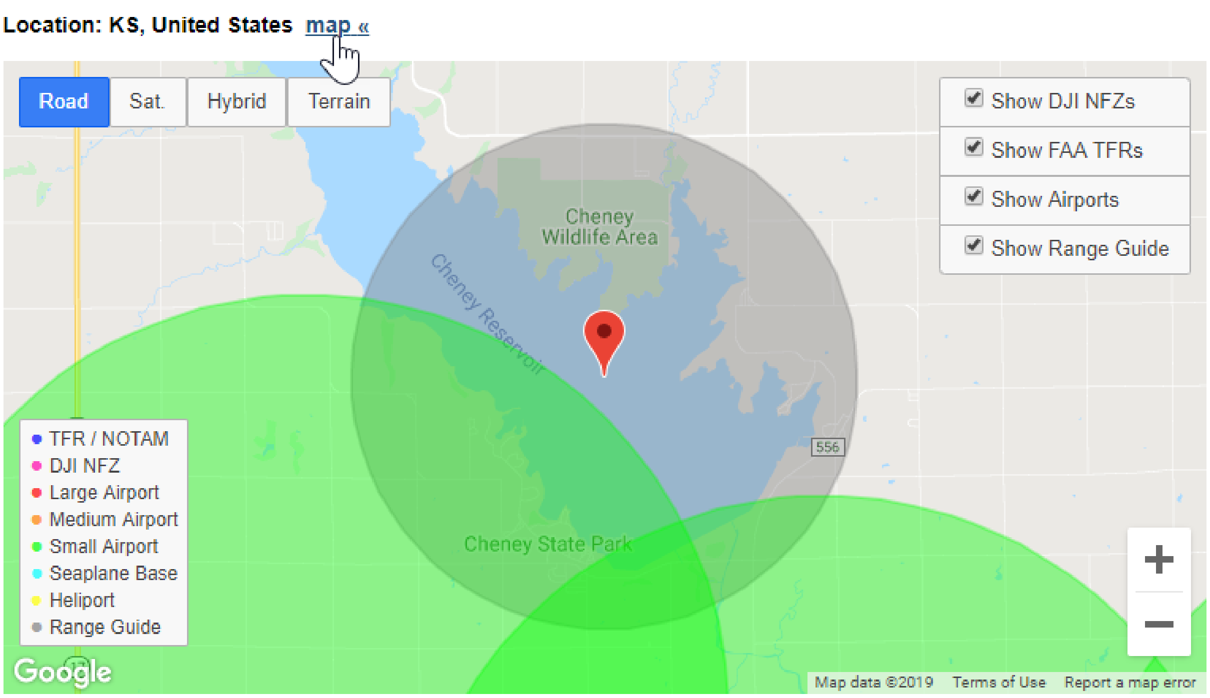
Wind mph Altitude feet Temperature F Visibility miles

Location: KS, United States map »

Warning: 1 airport nearby, check the map for details.

Current Conditions as of Tuesday 2019-12-03 10:53 CST									
Time	*Gusts*	*Temp*	*Precip Prob*	*Cloud Cover*	*Visibility*	*Visible Sats*	*Kp*	*Est. Sats Locked*	*Good To Fly?*
10:53	9 mph	51°F	-	11%	10 miles	14	1	13.8	yes

Tuesday 2019-12-03: sunrise 07:29, sunset 17:12									
Time	*Gusts*	*Temp*	*Precip Prob*	*Cloud Cover*	*Visibility*	*Visible Sats*	*Kp*	*Est. Sats Locked*	*Good To Fly?*
11:00	9 mph	51°F	1%	12%	10 miles	15	1	14.7	yes
12:00	11 mph	56°F	1%	5%	10 miles	16	2	15.5	yes
13:00	17 mph	58°F	1%	15%	10 miles	16	2	15.5	yes
14:00	21 mph	59°F	1%	12%	10 miles	15	2	14.9	no
15:00	21 mph	60°F	-	-	10 miles	15	2	15.0	no
16:00	20 mph	57°F	-	-	10 miles	15	2	14.9	yes
17:00	15 mph	52°F	1%	-	10 miles	16	2	15.7	yes
18:00	14 mph	48°F	-	-	10 miles	9	2	9.0	no
19:00	12 mph	46°F	1%	1%	10 miles	15	2	14.3	yes
20:00	11 mph	44°F	-	3%	10 miles	17	2	15.3	yes
21:00	13 mph	42°F	-	10%	10 miles	17	1	15.3	yes
22:00	14 mph	41°F	-	17%	10 miles	17	1	15.2	yes
23:00	14 mph	40°F	-	24%	10 miles	17	1	15.8	yes



See also: Airspace Sectionals (SkyVector.com)

EVALUATE

Teacher Materials: Practical Weather for UAS Pilots Presentation, Practical Weather for UAS Pilots Teacher Notes 2

Student Material: Practical Weather for UAS Pilots Student Activity 2

Slides 33-46: Quiz students on the FAA Remote Pilot Knowledge Test questions on slides.

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

Summative Assessment

Provide each student with a copy of the **Practical Weather for UAS Pilots Student Activity 2** worksheet. Instruct students to work individually to review the scenarios and answer the questions. Answers are provided in **Practical Weather for UAS Pilots Teacher Notes 2.**

[DOK-L3; *draw conclusions*, DOK-L2; *estimate*]

Summative Assessment Scoring Rubric

- Follows assignment instructions
- Postings show evidence of one or more of the following:
    - Knowledge of sUAS weather and requirements for operations
    - Provides details about the factors that affect sUAS weather and requirements for operations
    - Provides explanation of actions pilots can take to account for changing weather conditions
- Contributions show understanding of the concepts covered in the lesson
- Contributions show in-depth thinking including analysis or synthesis of lesson objectives

Points	Performance Levels
9-10	The student shows a strong understanding of how weather conditions can impact small unmanned vehicles; Answers all questions correctly.
7-8	The student shows sufficient understanding of how weather conditions can impact small unmanned vehicles; Answers 5-6 questions correctly.
5-6	The student shows partial understanding of how weather conditions can impact small unmanned vehicles; Answers 3-5 questions correctly.
0-4	The does not appear to understand the lesson objectives and goals; Answers 2 or fewer questions correctly.

GOING FURTHER

Slide 48: As time allows, have students break into groups and research other weather apps and sites created specifically for sUAS remote pilots. Then have students share the features they discovered with the class and explain whether they believe these apps and sites are effective and practical for use.

STANDARDS ALIGNMENT

NGSS STANDARDS

Three-Dimensional Learning

- **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.11-12.2** - Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- **RST.11-12.4** - 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 11-12 texts and topics*.
- **WHST.11-12.6** - Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
- **WHST.11-12.8** - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
- **WHST.11-12.9** - Draw evidence from informational texts to support analysis, reflection, and research

FAA AIRMAN CERTIFICATION STANDARDS

REMOTE PILOT – Small Unmanned Aircraft Systems Airman Completion Standards

I. Regulations, Task B. Operating Rules

- Knowledge The applicant demonstrates understanding of
    - **UA.I.B.K9** Daylight operation.
    - **UA.I.B.K10** Visual line of sight (VLOS) aircraft operations.
    - **UA.I.B.K20** Preflight familiarization, inspection, and actions for aircraft operations.
    - **UA.I.B.K21** Operating limitations for sUAS.
        - **UA.I.B.K21a** a. Maximum groundspeed
        - **UA.I.B.K21b** b. Altitude limitations
        - **UA.I.B.K21c** c. Minimum visibility
        - **UA.I.B.K21d** d. Cloud clearance requirements

III. Weather, Task A. Sources of Weather

- Knowledge The applicant demonstrates understanding of:
    - **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).

III. Weather, Task B. Effects of Weather on Performance

- Knowledge The applicant demonstrates understanding of:
    - **UA.III.B.K1** Weather factors and their effects of performance:
        - **UA.III.B.K1a** a. Density altitude
        - **UA.III.B.K1b** b. Wind and currents
        - **UA.III.B.K1c** c. Atmospheric stability, pressure, and temperature
        - **UA.III.B.K1d** d. Air masses and fronts
        - **UA.III.B.K1e** e. Thunderstorms and microbursts
        - **UA.III.B.K1f** f. Tornadoes
        - **UA.III.B.K1g** g. Icing
        - **UA.III.B.K1h** h. Hail U
        - **UA.III.B.K1i** i. Fog
        - **UA.III.B.K1j** j. Ceiling and visibility
        - **UA.III.B.K1k** k. Lightning

REFERENCES

ASA 2019 Remote Pilot Test Prep (3-3 – 3-23)

Weather conditions to think about when flying your drone
YouTube: https://youtu.be/qIAeUArq8ds (3:27)

Flying a drone in high winds is DANGEROUS
YouTube: https://youtu.be/fe9O_AN8kE8 (5:10)

How to calculate the distance of a lightning strike?
YouTube: https://youtu.be/GdbkRoCTIjk (3:56)

Drones vs Lightning
YouTube: https://youtu.be/L3iJjrQmEho (5:30)

DJI Tutorials – Flying in Hot and Cold Weather
YouTube: https://youtu.be/TmYlKhx_-l0 (2:58)

Tips for Flying Your Drone in Cold Weather: From Where I Drone with Dirk Dallas
YouTube: https://youtu.be/BrcCPCAWM-U (6:46)