S-190 Unit 3: Temperature and Moisture Relationships

Summary:

Weather is the most variable and, at times, the most difficult to predict component of the fire environment. Temperature and moisture are two weather components that are closely monitored by firefighters because they have a direct impact on fuels and potential fire behavior.

Incident Position Description (IPD) Alignment:

This unit aligns with the following FFT2 IPD specific duties (https://www.nwcg.gov/positions/fft2/position-ipd):

- Apply the knowledge of fuels, terrain, weather, and fire behavior to decisions and actions.

Objectives:

Students will be able to:

- Describe dry bulb temperature, wet bulb temperature, dew point, and relative humidity.
- Describe how temperature and relative humidity can influence wildland fire behavior.
- Determine relative humidity and dew point by using a Psychometric Table and given inputs.

Unit at a Glance:

Topic	Method	Duration
Unit Introduction	Presentation	5 Minutes
Introduction to Fire Weather	Presentation	5 Minutes
Measures of Atmospheric Moisture	Presentation	5 Minutes
Gathering Temperature and Moisture Observations	Presentation	35 Minutes
Factors That Impact Temperature and Relative Humidity	Presentation	10 Minutes
Total Unit Duration		**60 Minutes**

Materials:

- Belt Weather Kit (NFES 001154) and handheld weather measurement devices.
- *Incident Response Pocket Guide (IRPG)*, PMS 461, https://www.nwcg.gov/publications/461.
- *NWCG Standards for Fire Weather Stations,* PMS 426-3, https://www.nwcg.gov/publications/426-3.
- Psychrometric Table, https://www.nwcg.gov/publications/pms437/weather/temp-rh-dp-tables#TOC-Elevation-6101-8500ft.
- *NWCG Glossary of Wildland Fire*, PMS 205, https://www.nwcg.gov/glossary/a-z.
- Notebooks for participants.
- Ability to display images and video on large screen.
- White board or easel access for group breakout.

Slide 1


S-190 Unit 3: Temperature and Moisture Relationships
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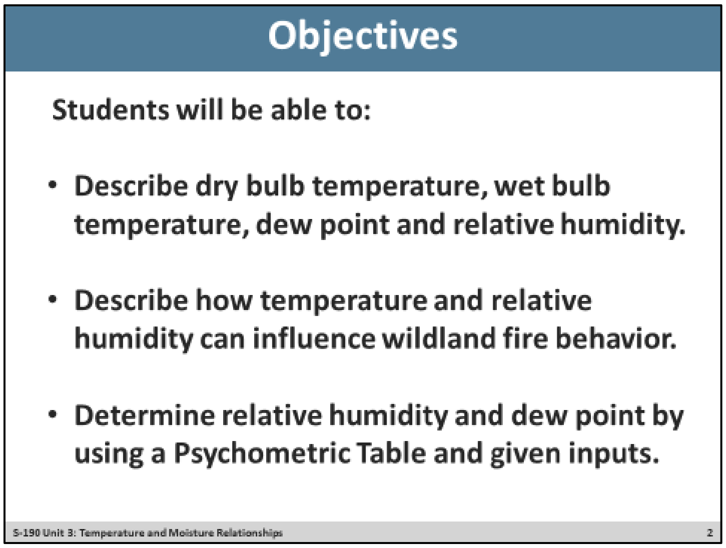
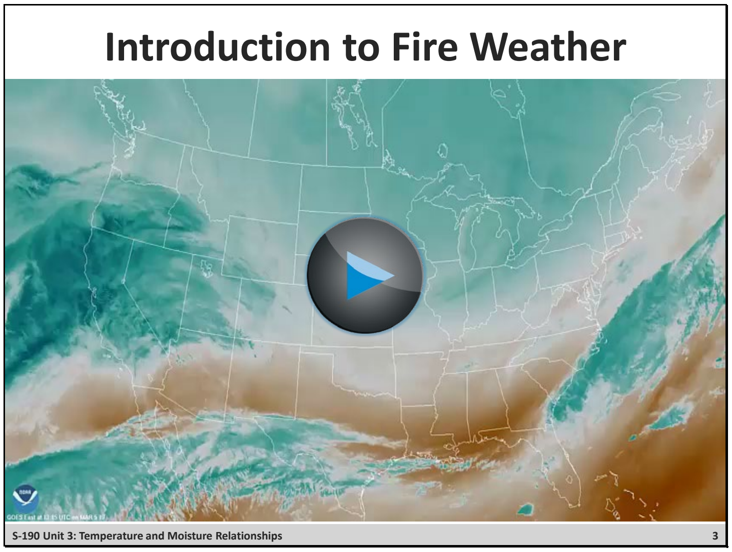
Slide 2



- [ ] Review unit objectives.

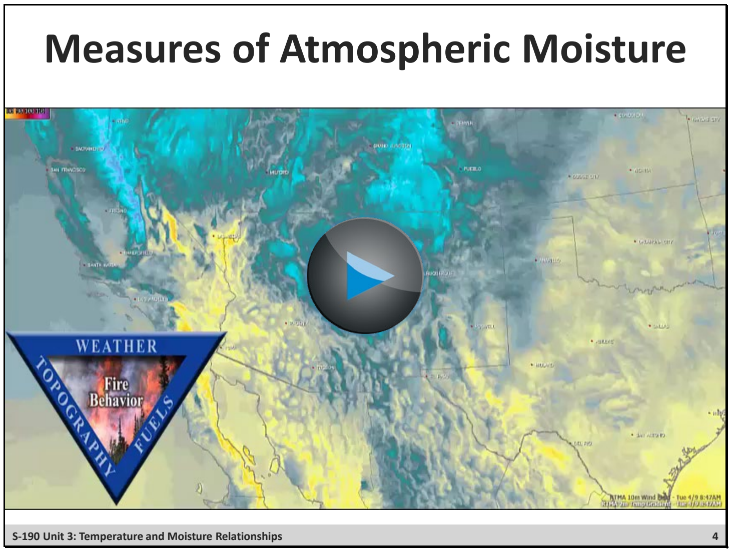
Slide 3



- ❑ **Play Video**

  Title Introduction to Fire Weather
  Summary A introduction to fire weather, its causes, impacts, and effects on the fire environment.
  Time (01:24)
  Audio

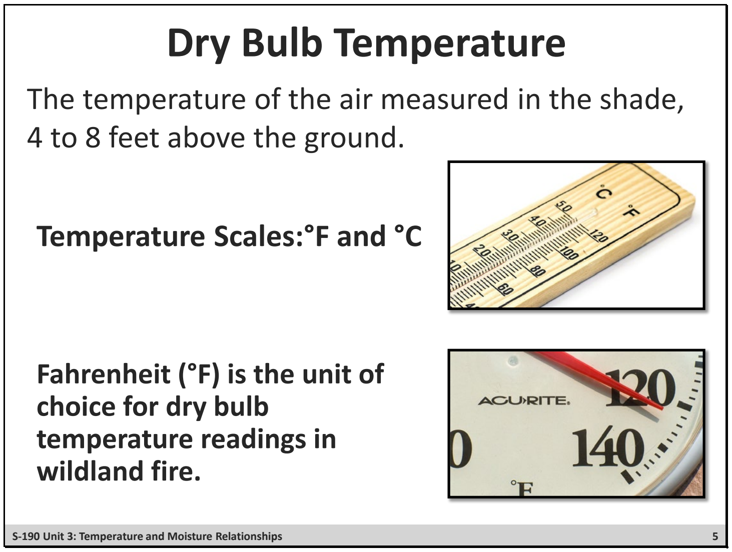
Slide 4



- ❑ **Play Video**

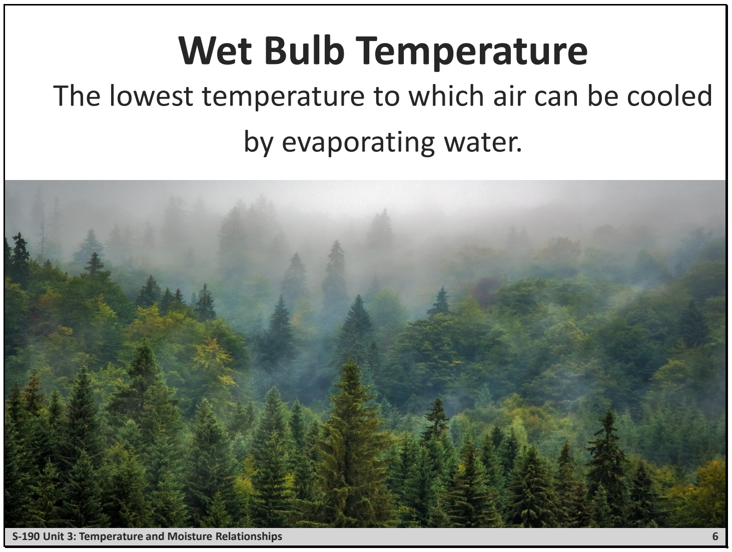
  Title Temperature and Moisture Relationships
  Summary A brief introduction to the relationship between temperature and moisture in the fire environment.
  Time (00:47)
  Audio

Slide 5



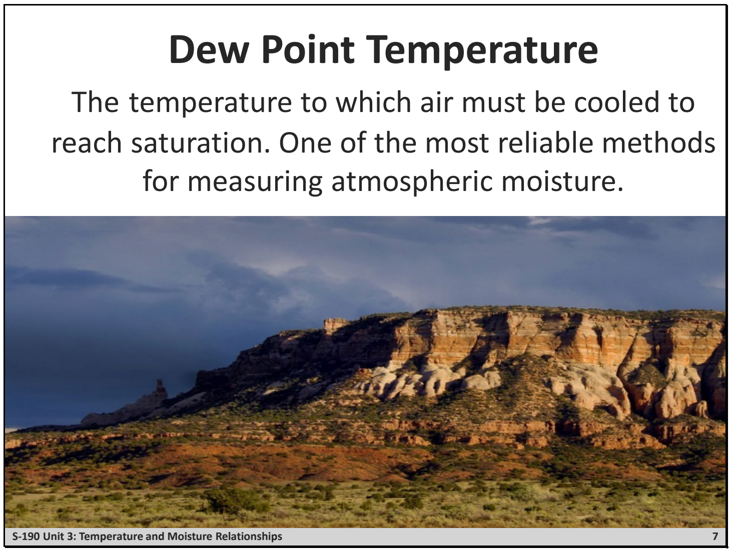
- Dry bulb temperature is the air temperature in our day-to-day lives. When it's 86 °F outside, it refers to the dry bulb temperature.
- Air temperature readings are taken 4 to 8 feet above the ground, either by manual observations, or by automated weather stations.
- Fahrenheit and Celsius are the most common temperature scales used in the world.

Slide 6



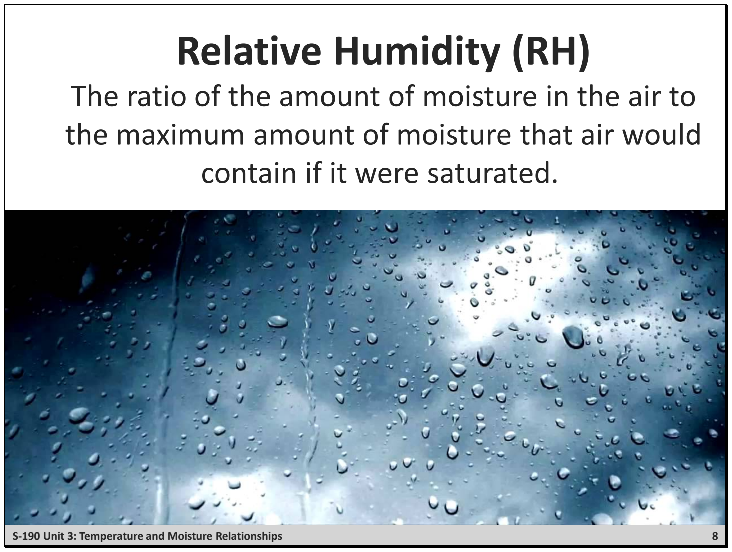
- Evaporation is a cooling process (the opposite of condensation) which results in a decrease in wet bulb temperature.
- Wet bulb temperature is a good indicator of atmospheric moisture but not a direct measurement. For example, little or no drop in wet bulb temperature indicates a moist air mass because little or no evaporation has taken place. On the other hand, a wet bulb decrease of 10° to 15° from the starting point would indicate a much drier air mass.
- It is important not to confuse wet bulb temperature with dew point temperature.

Slide 7



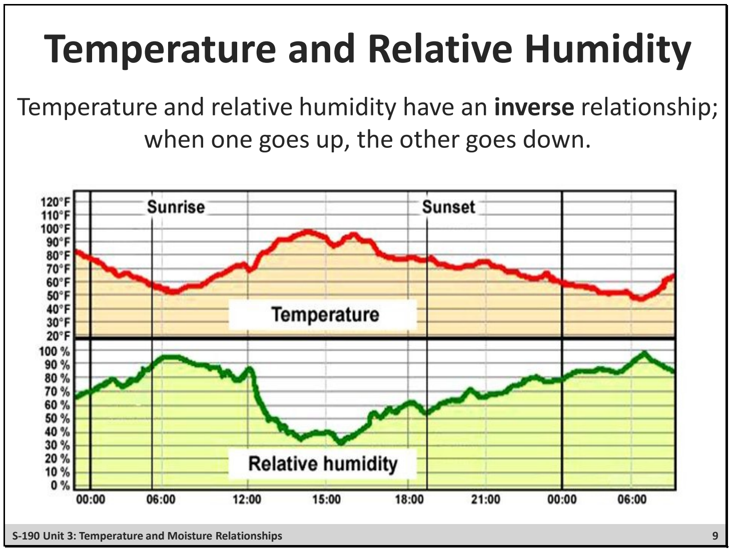
- For example, if the dry bulb temperature is 80 °F and the dew point temperature is 50 °F, the dry bulb temperature must decrease by 30 °F (down to 50 °F) for the air to become saturated.
- Dew point temperature is one of the most reliable methods for measuring atmospheric moisture.
- Dew point temperatures may change little from day to day.
- Dew point temperature can be determined with a sling psychrometer with the aid of Psychrometric Tables or Relative Humidity tables in the *IRPG*.
- A handheld electronic weather meter can also be used for providing dew point temperature. However, the handheld device must meet specifications in the *NWCG Standards for Fire Weather Stations*, PMS 426-3, https://www.nwcg.gov/publications/426-3.
- Dew point may impact a region with consistent dew point values (more predictable) day to day.

Slide 8



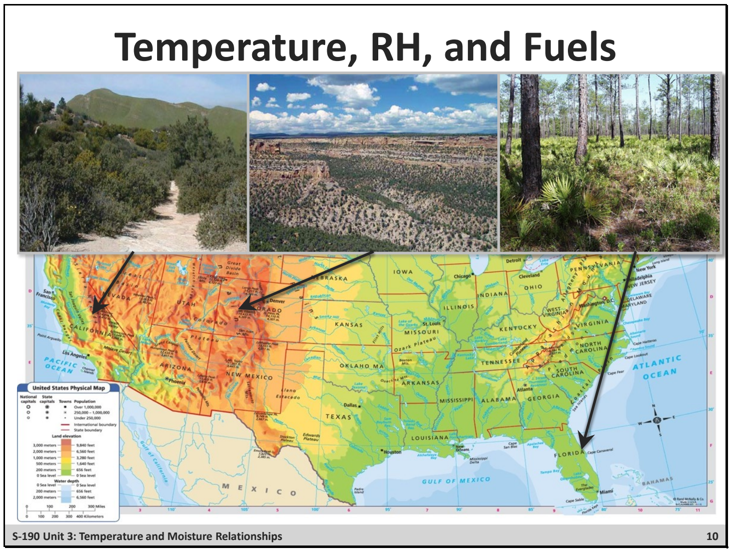
- Relative humidity is expressed as a percentage and can range from 1% (very dry) to 100% (very moist).
- Moisture in the air, whether in the form of water vapor, cloud droplets, or precipitation, is the primary weather element that affects fuel moisture content.
- The amount of moisture that fuels can absorb from or release to the air depends largely on relative humidity.
- Light fuels, such as grass, gain and lose moisture quickly with changes in relative humidity. Heavy fuels respond to humidity changes at a slower rate.
- Relative humidity is not a direct measurement of atmospheric moisture but a measure of how much moisture currently exists.

Slide 9



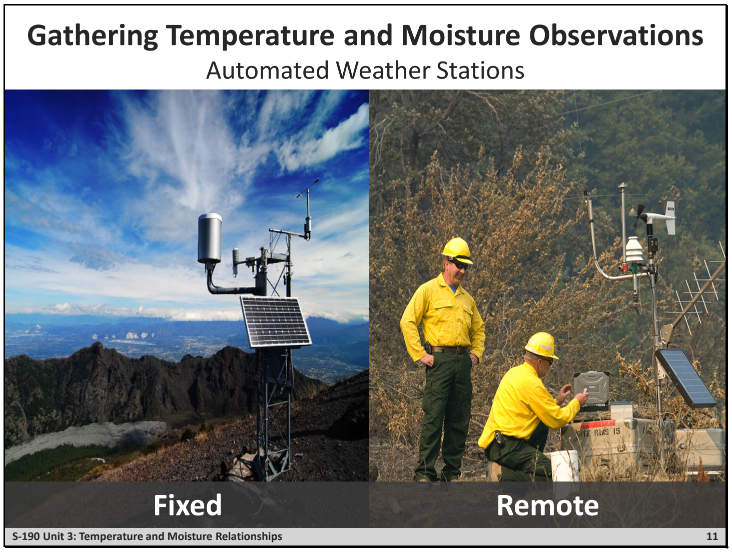
- There can be a large fluctuation of temperature and relative humidity based on time and location. However, the majority of large fires occur when air temperature is high and relative humidity is low.
- The graph depicted is an example of a reading from a hygrothermograph, which displays temperature, and relative humidity.
- Maximum temperature for the day typically corresponds to the lowest relative humidity reading for the day (usually occurs mid-afternoon, but dependent on time of year and aspect).
- Minimum temperature for the day typically corresponds to the highest relative humidity reading for the day (usually occurs just after sunrise, but also dependent on time of year and aspect).

Slide 10



- Changes in temperature and relative humidity have similar impacts on fuels from one part the country to the next. However, breakpoints for when fuels ignite and burn differ based on climate zone.
- Critical relative humidity values in Florida are typically 30% to 35%, while in the western U.S.; they are typically 15% or lower.

Slide 11



- It is very important to routinely monitor temperature and relative humidity trends.
- Fixed and Remote Automated Weather Stations provide hourly observations to a local database via satellite. The observations provide weather data on temperature, humidity, precipitation, wind speed, and solar radiation.
- The observations are monitored by meteorologists and dispatch centers and are used in planned ignitions, wildfires, and on other incidents, and projects to relay current weather information representative of an area of interest.
- **Fixed Automated Weather Stations** are located in permanent locations throughout the country.
- **Remote Automated Weather Station** (RAWS or Fire RAWS) are portable units set up in temporary locations to represent a small geographic area, such as a specific fire or incident.

Slide 12

Pre-Video Discussion

- A Belt Weather Kit is a belt-mounted case with pockets fitted for anemometer, compass, sling psychrometer, slide rule, water bottle, pencils, and book of weather report forms.
- Belt Weather Kits are used to take weather observations to provide on-site conditions to the fire weather forecaster or Fire Behavior Analyst (FBAN). Observations include air temperature, wind speed and direction, and relative humidity.
- The Belt Weather Kit is one of the most common methods of obtaining weather observations in the field.
- Use of a Belt Weather Kit is often referred to as slinging or spinning weather, due to the use of the sling psycrometer.

❑ Reference the needed weather observations from Spot Weather Forecast in the *Incident Response Pocket Guide (IRPG)*, PMS 461, https://www.nwcg.gov/publications/461.

❑ **Play Video**

Title Belt Weather Kit Tutorial
Summary A tutorial of the Belt Weather Kit and how to accurately sling and record weather.
Time (07:11)
Audio

Slide 13

Pre-Video Discussion

- A handheld fire weather meter is a electronic device that measures temperature, humidity, wind speed, and possibly other atmospheric variables, depending on brand, and model.
- Handheld fire weather meters are used to take weather observations to provide on-site conditions to the fire weather forecaster or Fire Behavior Analyst (FBAN). Observations include air temperature, wind speed and direction, and relative humidity.
- There are several manufacturers of these meters. A handheld weather meter is often referred to as a Kestrel, a common brand name.
- Regardless of make or model, all handheld weather devices must meet the specified NWCG performance standards, as outlined in the *NWCG Standards for Fire Weather Stations*, PMS 426-3, https://www.nwcg.gov/publications/426-3.

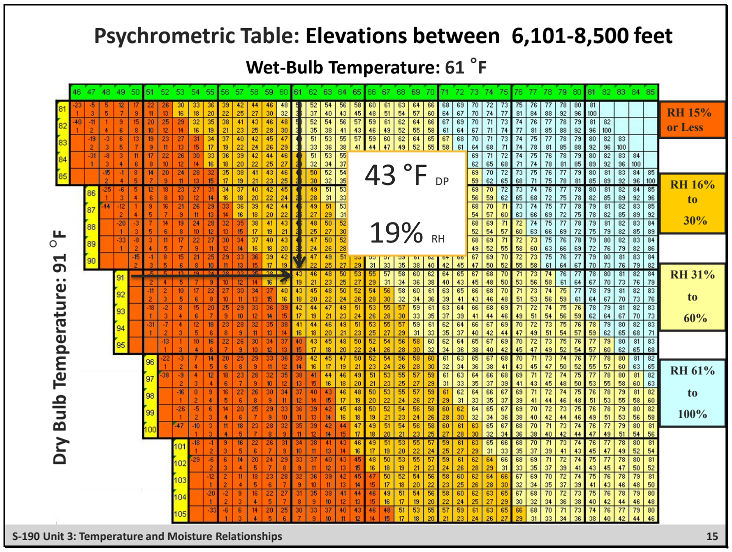
❑ **Play Video**

Title Digital Weather Meters
Summary An introduction to the abilities, guidelines, and uses of digital weather meters.
Time (05:26)
Audio

Slide 14

- ❑ Provide students with a printed copy of the psychrometric table valid for elevations between 6,101 and 8,500 feet, wet bulb temperatures 50 °F to 85 °F, and dry bulb temperatures 91°F to 109 °F, https://www.nwcg.gov/publications/pms437/weather/temp-rh-dp-tables#TOC-Elevation-6101-8500ft.
- Psychrometric tables are used to calculate dew point and relative humidity based on the observations obtained in the field by either a Belt Weather Kit or handheld fire weather meter.
- ❑ Provide students with familiarization on how to locate and read the following elements of table:
  - Location of dry bulb temperature.
  - Location of wet bulb temperature.
  - Location of dew point.
  - Location of relative humidity.
- ❑ The tables are a mandatory component of the Belt Weather Kit. All kits should be inspected prior to use in the field, to ensure the tables are available and intact.

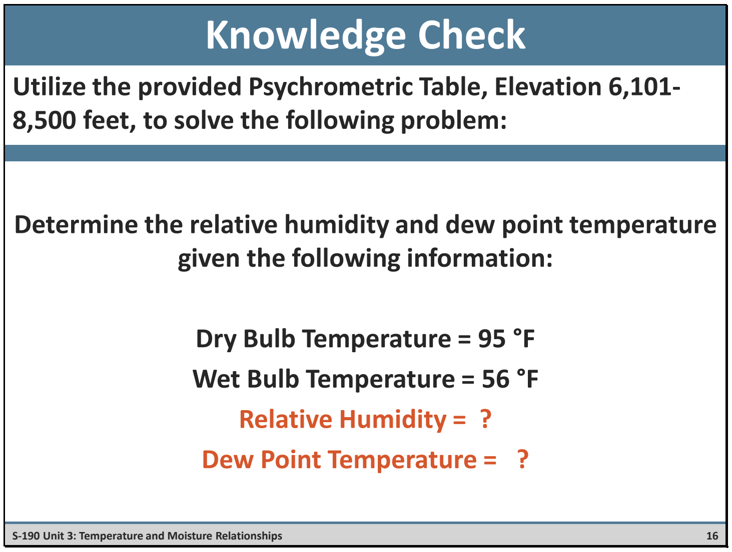
Slide 15



Exercise:

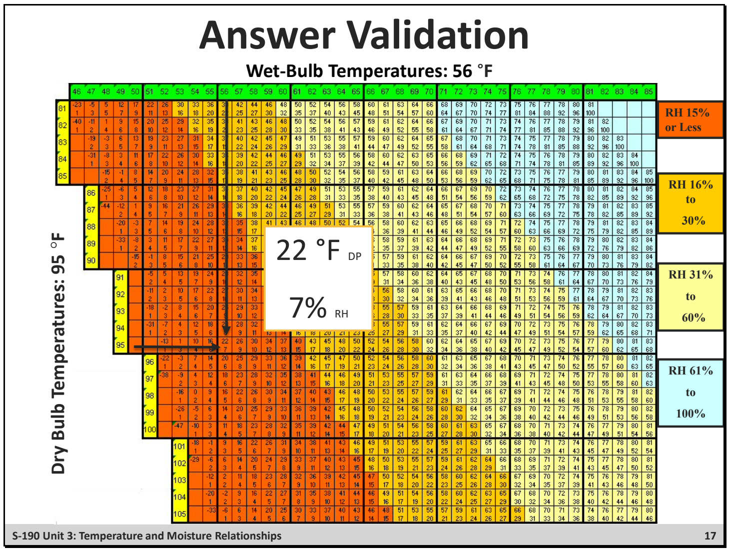
- ❑ Instruct students to reference the Psychrometric Table handout and follow along with the slide example.
- ❑ Instruct students to locate dry bulb temperature of 91 °F.
- ❑ Instruct students to locate wet bulb temperature or 61 °F.
- ❑ Instruct students to determine dew point and relative humidity.

Slide 16



- ❑ Instruct students to determine the dew point and relative humidity based on the dry bulb and wet bulb readings provided.
- ❑ Use next slide for answer validation.

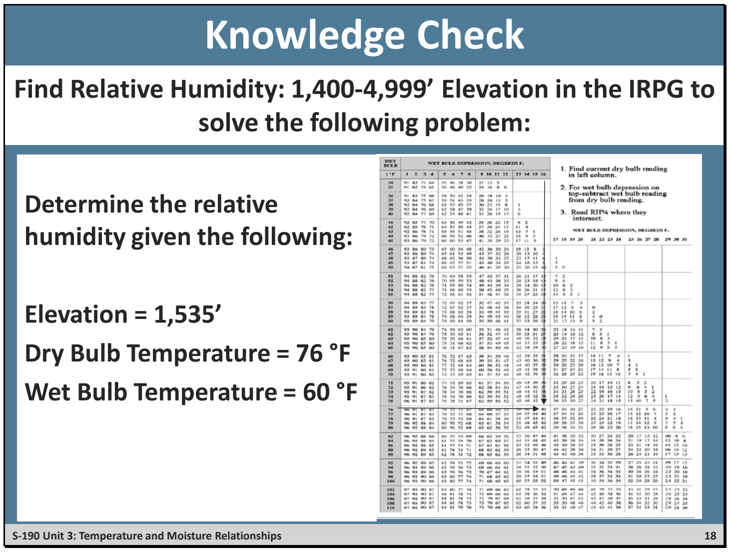
Slide 17



Answer Validation

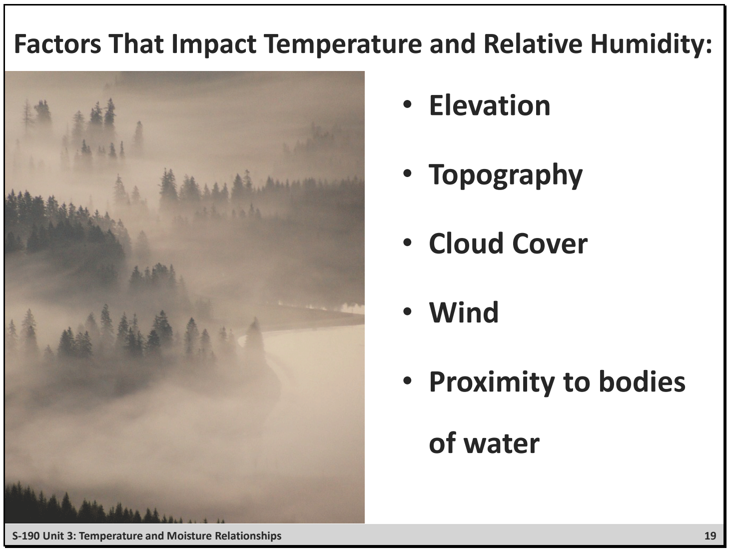
- Dew point temperatures = 22 °F
- Relative humidity = 7 %

Slide 18



- ❑ Reference Relative Humidity: 1,400-4,999’ Elevation in the *Incident Response Pocket Guide (IRPG)*, PMS 461, https://www.nwcg.gov/publications/461.
- ❑ Instruct students that in order to determine the wet bulb depression, subtract the wet bulb temperature from the dry bulb temperature.
- ❑ Dry bulb of 76 °F minus wet bulb of 60 °F = wet bulb depression of 16 °.
- ❑ Using the correct table, relative humidity = 40%.

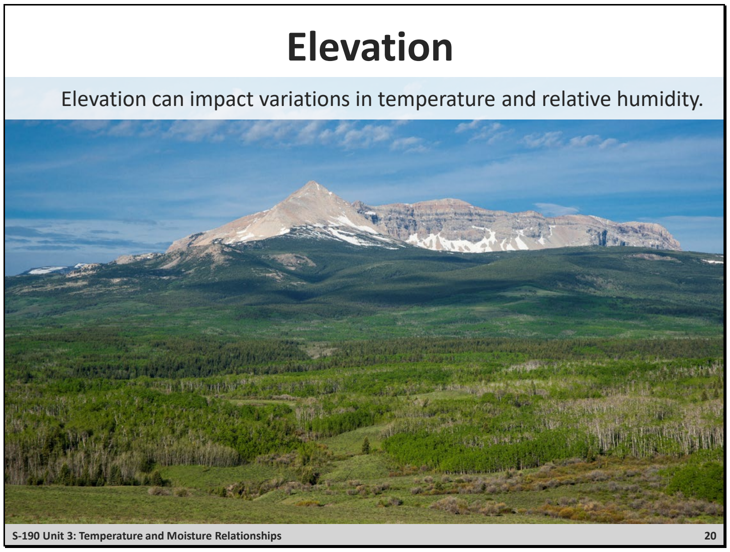
Slide 19



Note to Instructor

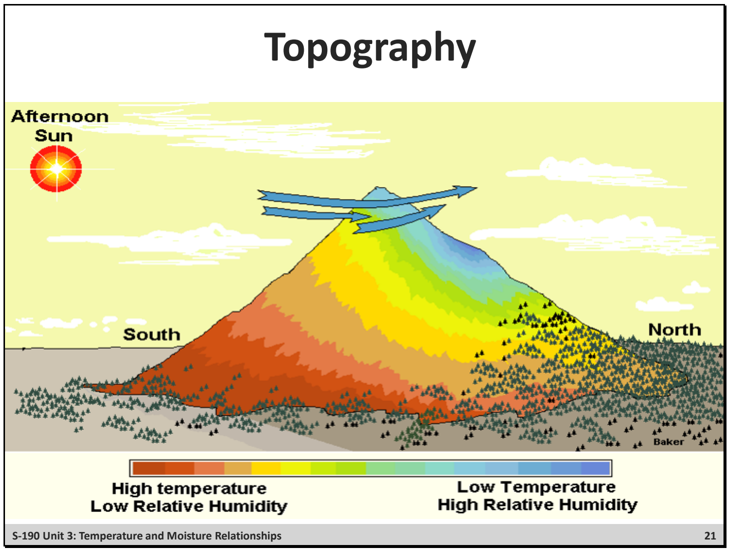
Each factor will be discussed separately on slides 20-24.

Slide 20



- Warmer temperatures and lower RH values are found in the lower elevations (lower valleys and lower foothill regions).
- Cooler temperatures and higher RH values are found in the higher elevations (upper third of slopes and ridgetops).

Slide 21

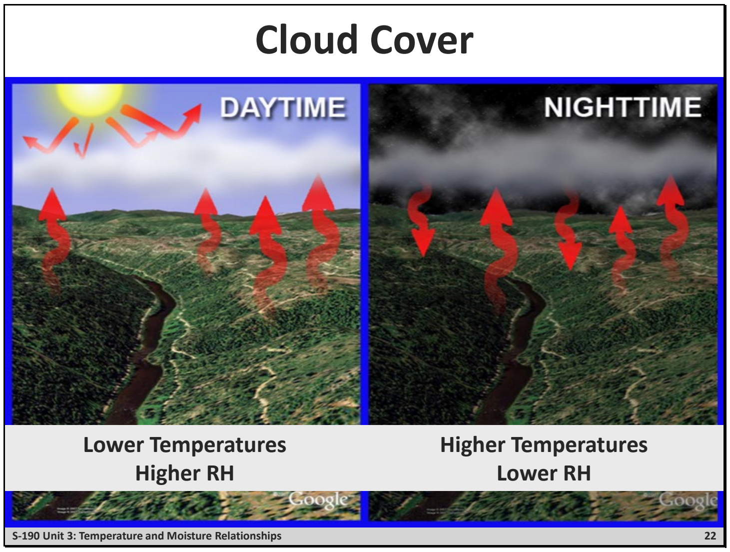


- Topography can influence variations in temperature and relative humidity.
- Aspect is a feature of topography, which determines how much direct sunlight, and solar heating is received.
- South and west-facing slopes receive more incoming solar radiation, especially during the afternoon, and have hotter temperatures, and lower RH values.
- North-facing slopes typically experience less solar radiation and have cooler temperatures and higher RH values.
- Different aspects represent different climate zones in terms of weather, fuel type, fuel moisture, and overall potential fire behavior.
- An understanding of aspect and time of day provides the firefighter knowledge of possible changes in fire behavior.

Question: If you are responding to a fire on a south aspect at 1000, what changes in temperature, and RH can you anticipate to have occurred by 1500?

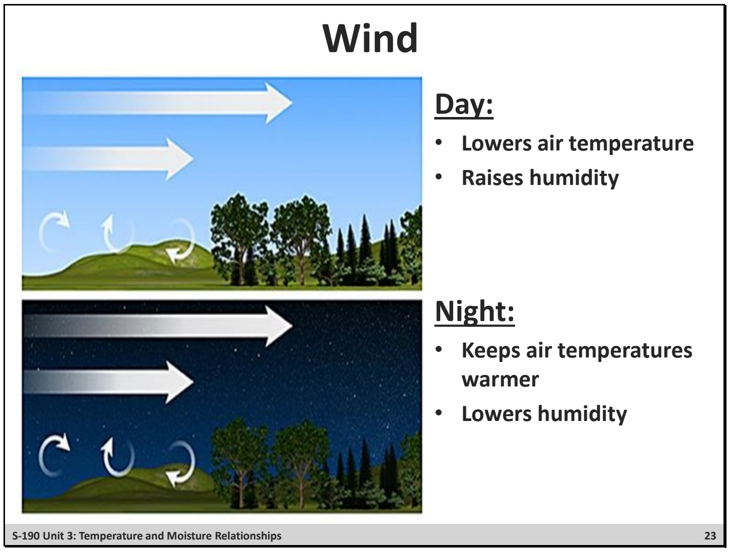
> *Answer: The south aspect would have received an increase in solar radiation between 1000 and 1500. Therefore, the temperatures have increased, and the RH has dropped, leading to drier fuels.*

Slide 22



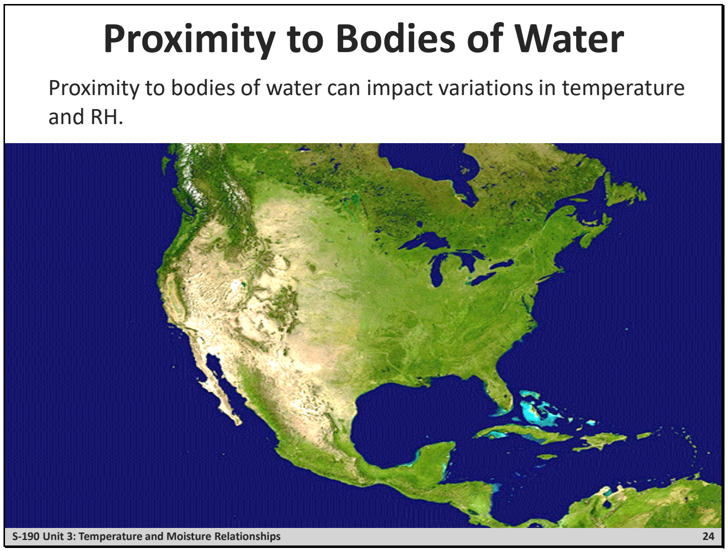
- Cloud cover affects temperature and relative humidity by reflecting incoming sunlight during the day and intercepting outgoing long-wave, terrestrial radiation at night.
- During the day, cloud cover keeps temperatures cooler and RH higher.
- At night-cloud cover keeps temperatures warmer and RH lower (clouds act as a blanket at night).

Slide 23



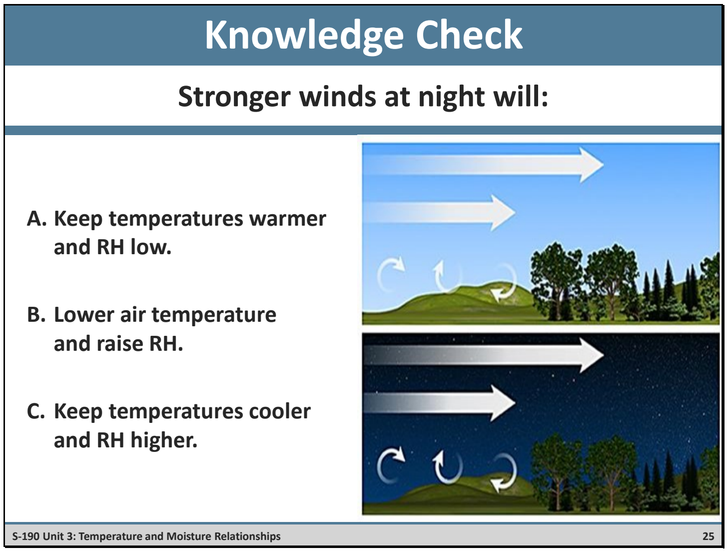
- Wind can influence variations in temperature and relative humidity.
- During the day, wind tends to disrupt surface heating by increasing mixing in the lower atmosphere. Wind mixes cooler air above the surface with air near the surface, which keeps temperatures cooler, and RH a little higher during the day.
- At night, wind tends to keep temperatures warmer and RH lower by disrupting radiative surface cooling. Wind helps prevent warm air from radiating away from the surface.

Slide 24



- An increase in dew point and RH is likely to occur near a large body of water.
- Air over the Gulf of Mexico can move northward into northern latitudes during the winter months, increasing temperature over the land mass.

Slide 25



- ❑ Instructor can choose to have questions on the next three slides answered by individuals or in groups.

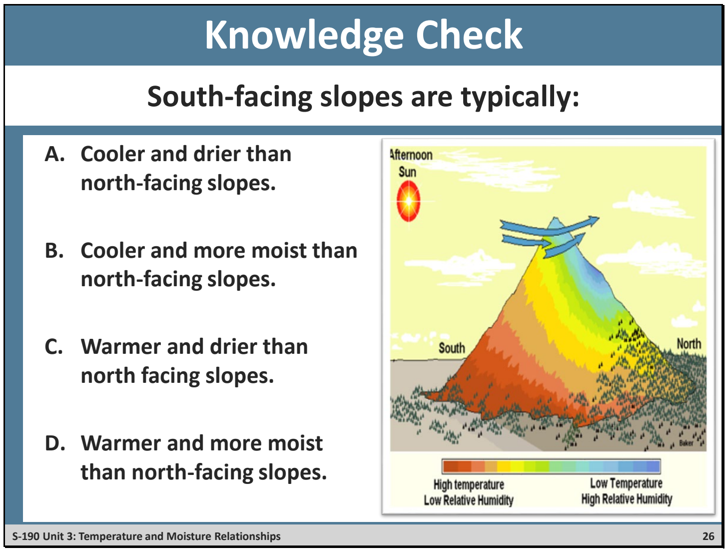
Question: Stronger winds at night will:

Answer: A. Keep temperatures warmer and RH low.

Answer Validation

Winds at night keep the air mixed near the surface and disrupt radiant cooling (reduces the amount of heat that escapes through radiant cooling by mixing the air near the surface). Without winds or under calm conditions, radiant cooling processes are more effective, allowing heat to escape the surface (surface cooling).

Slide 26



Question: South-facing slopes are typically:

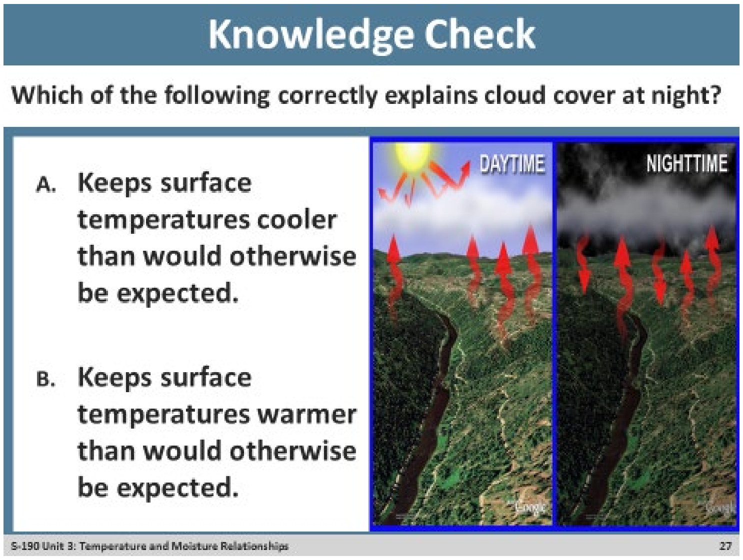
Answer: C. Warmer and drier than north-facing slopes.

Answer Validation

1. South-facing slopes receive more incoming solar radiation than north-facing slopes. High sun angle in the afternoon allows for south-facing slopes to receive the longest period of incoming solar radiation during the hottest and driest time of the day (which promotes hotter temperatures and lower RH).

2. Different aspects represent different climate zones. If applicable, the instructor should reiterate differing fuel types from north aspect vs. south aspect.

Slide 27



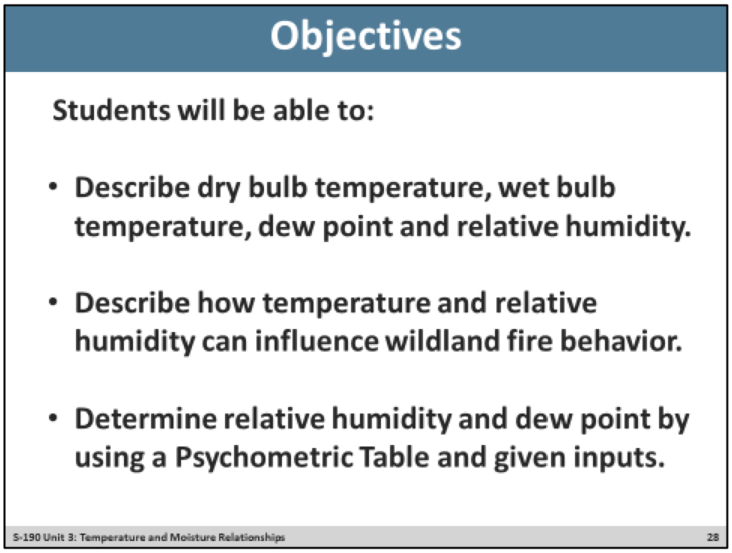
Question: Which of the following correctly explains cloud cover at night?

Answer: B. Keeps surface temperatures warmer than would otherwise be expected.

Answer Validation

Clouds at night act as a blanket, disrupting radiant cooling, thus keeping temperatures warmer, and RH lower.

Slide 28



- ❑ Review unit objectives.