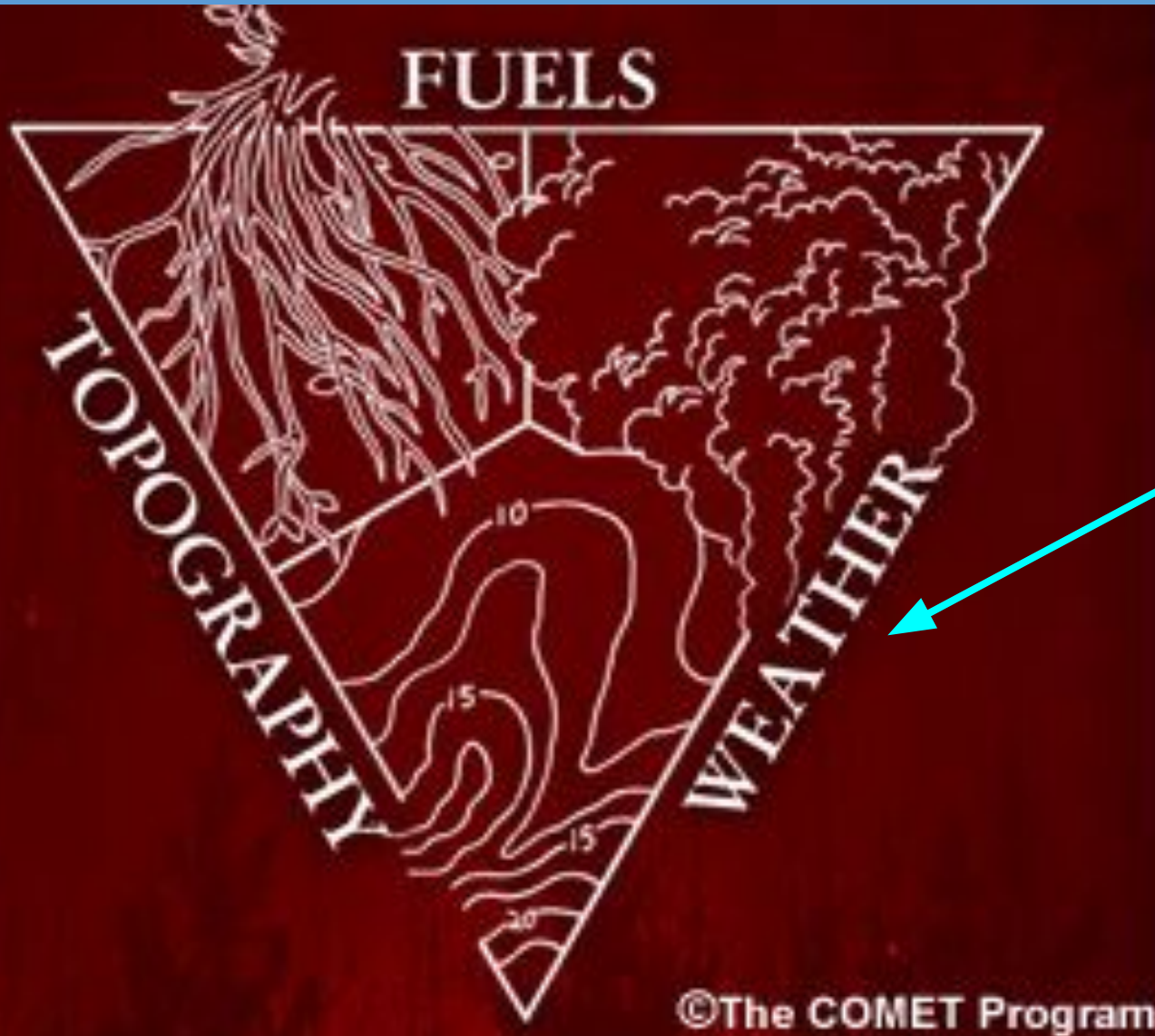


2022 TERF Fire Weather Training

Derek Hodges & Andrew Deemer - IMET
Meteorologists – NWS Phoenix

Fire Behavior Triangle



Weather is the *most variable*

Outline

Basic Weather Processes

- Temperature
- Moisture
- Wind
- Air Pressure
- Fronts

Fire Weather Parameters

- Haines Index
- ERC
- Fuel Moisture
- Lapse Rates
- Stability

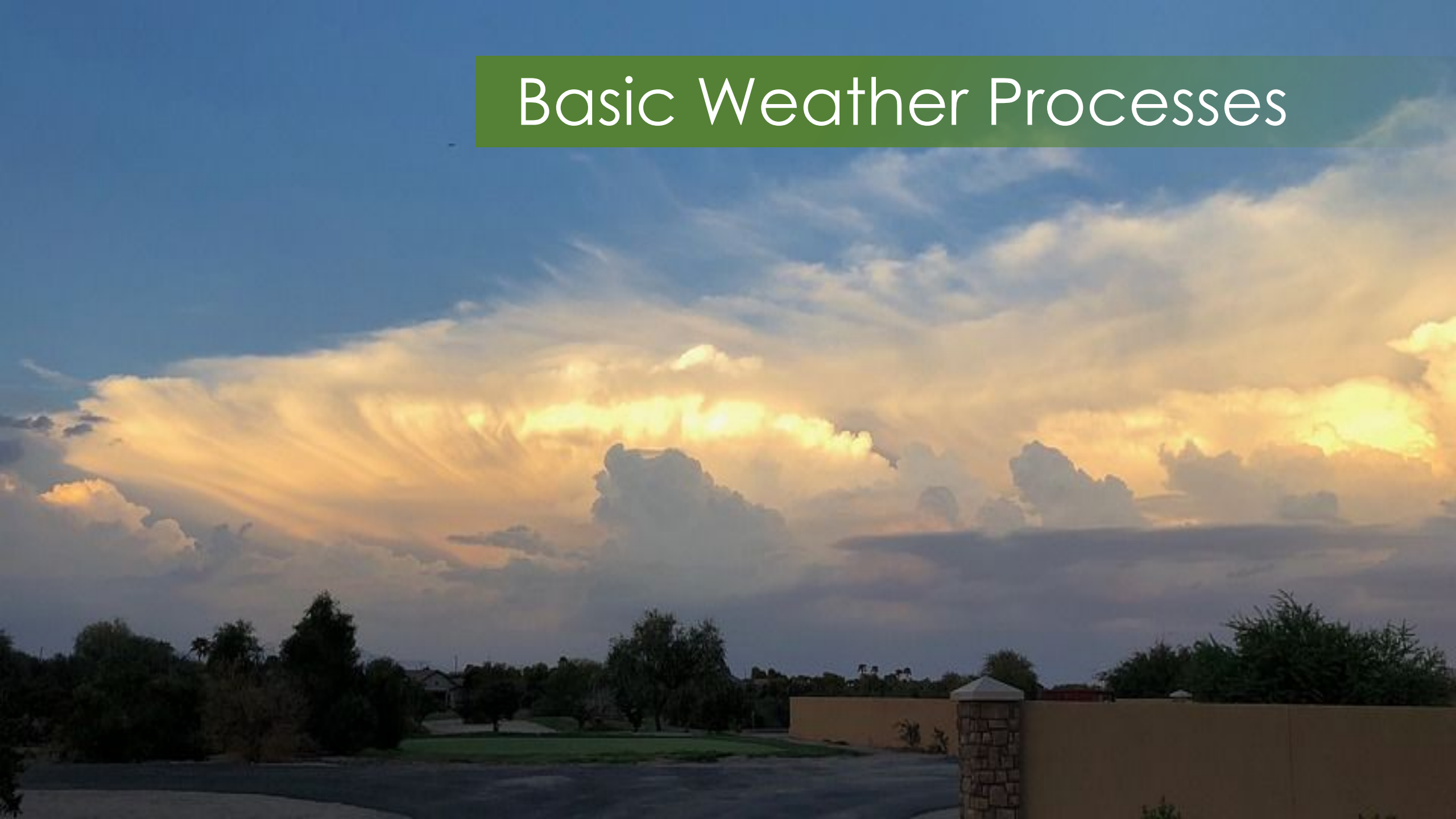
Weather and Fires

- Diurnal Cycle
- Impacts of weather
- Miscellaneous

National Weather Service

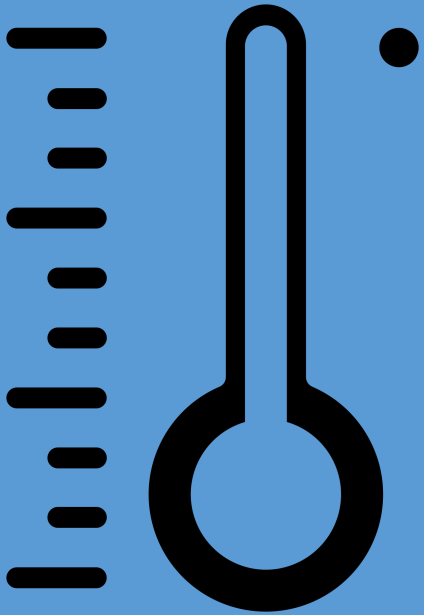
- Overview
- Fire Weather Program

Basic Weather Processes



Temperature

- The temperature varies depending on the sun angle and duration of sunlight.
- Other factors such as amount and health of vegetation, reflectivity, proximity to water, pollution, can all influence the temperature.



Moisture

- The relative humidity (RH) is a measure of the saturation of air with respect to water, and varies from 0-100%.
- Air can hold more water vapor at higher temperatures.
- RH is typically lowest in the afternoon and highest in the morning.
- RH is highly correlated with fuel moisture.



Wind

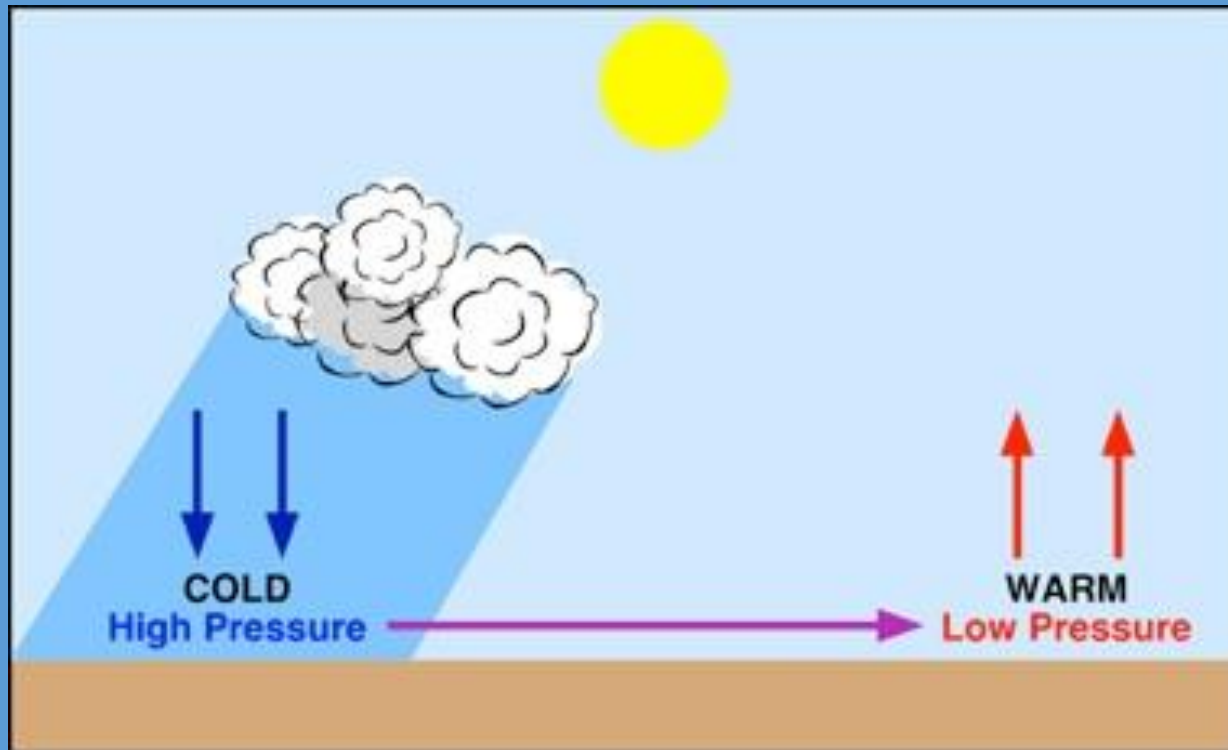
Wind is the most critical factor affecting fire behavior

- Wind can carry away moisture, drying fuels
- Aids combustion by supplying oxygen
- Spread fires by carrying heat: spotting, preheating fuels
- Smoke transport

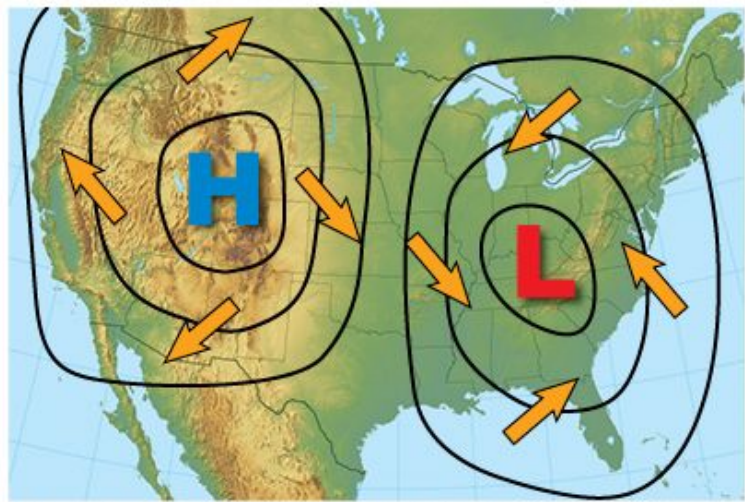


Wind

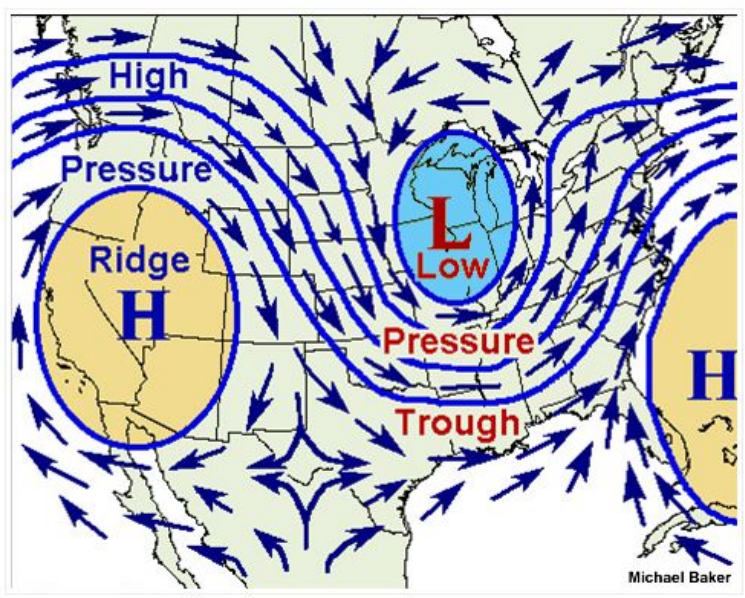
- Wind is caused by pressure differences between two locations.
- Wind blows from higher to lower pressure. I.E. a “west wind” is a wind blowing from west to east.
- Weather is never “textbook” neat! Often great variation over short differences.



Air Pressure

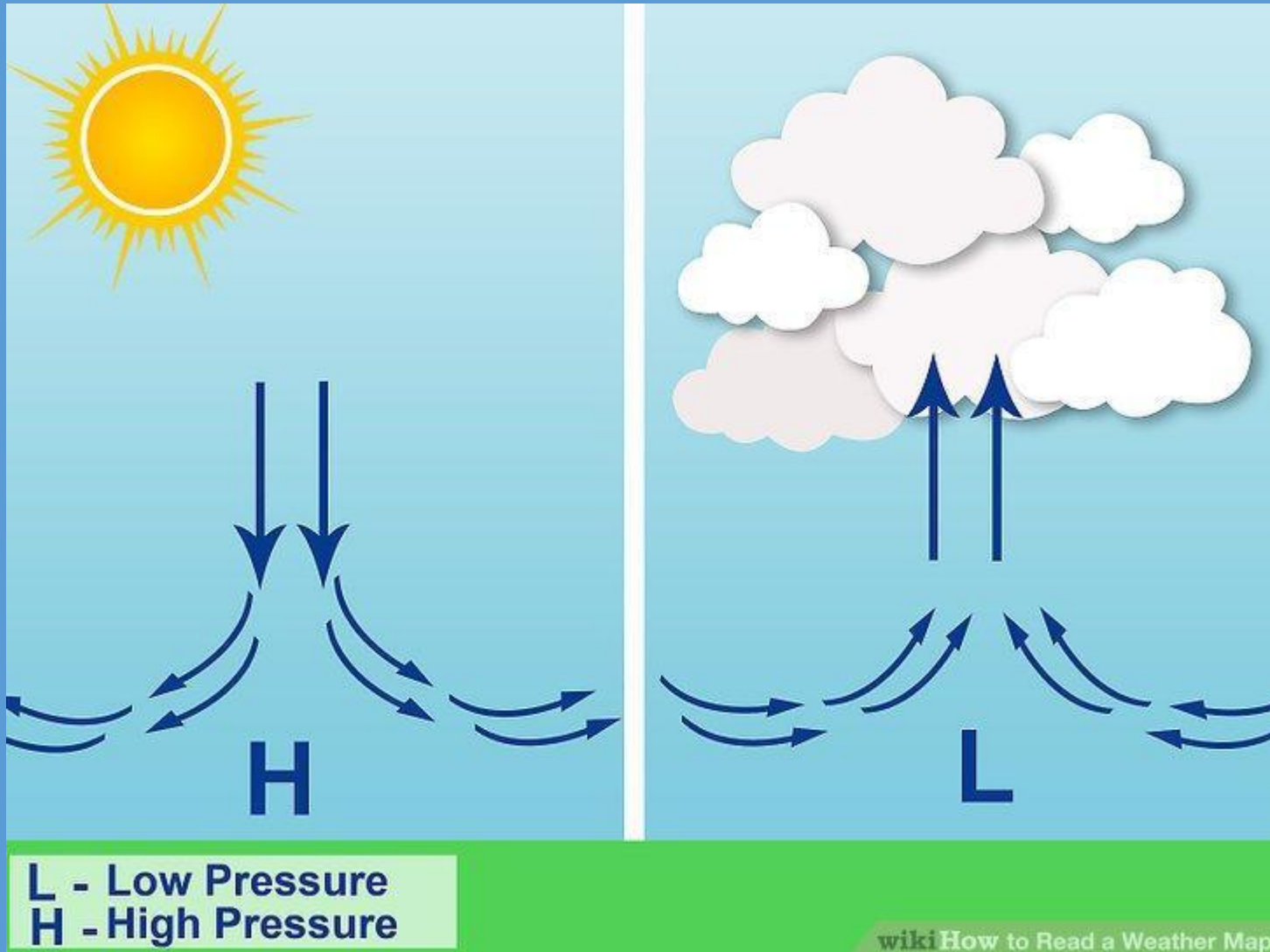


High and low pressure indicated by lines of equal pressure called isobars.



- Air pressure is the weight of all the air above a point in the atmosphere.
- Tighter pressure gradients imply stronger winds.
- Low pressure areas are referred to as a trough and high pressure as a ridge.

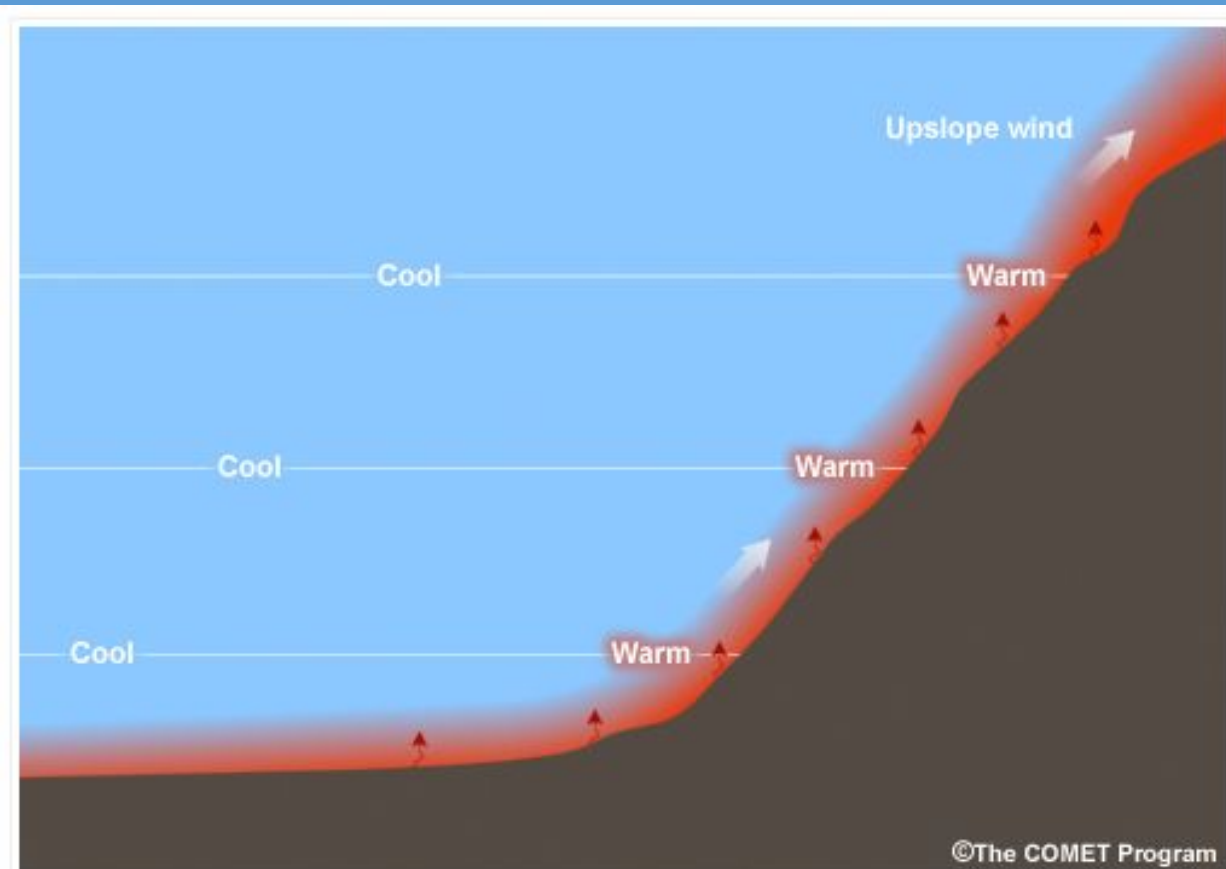
Wind and Pressure



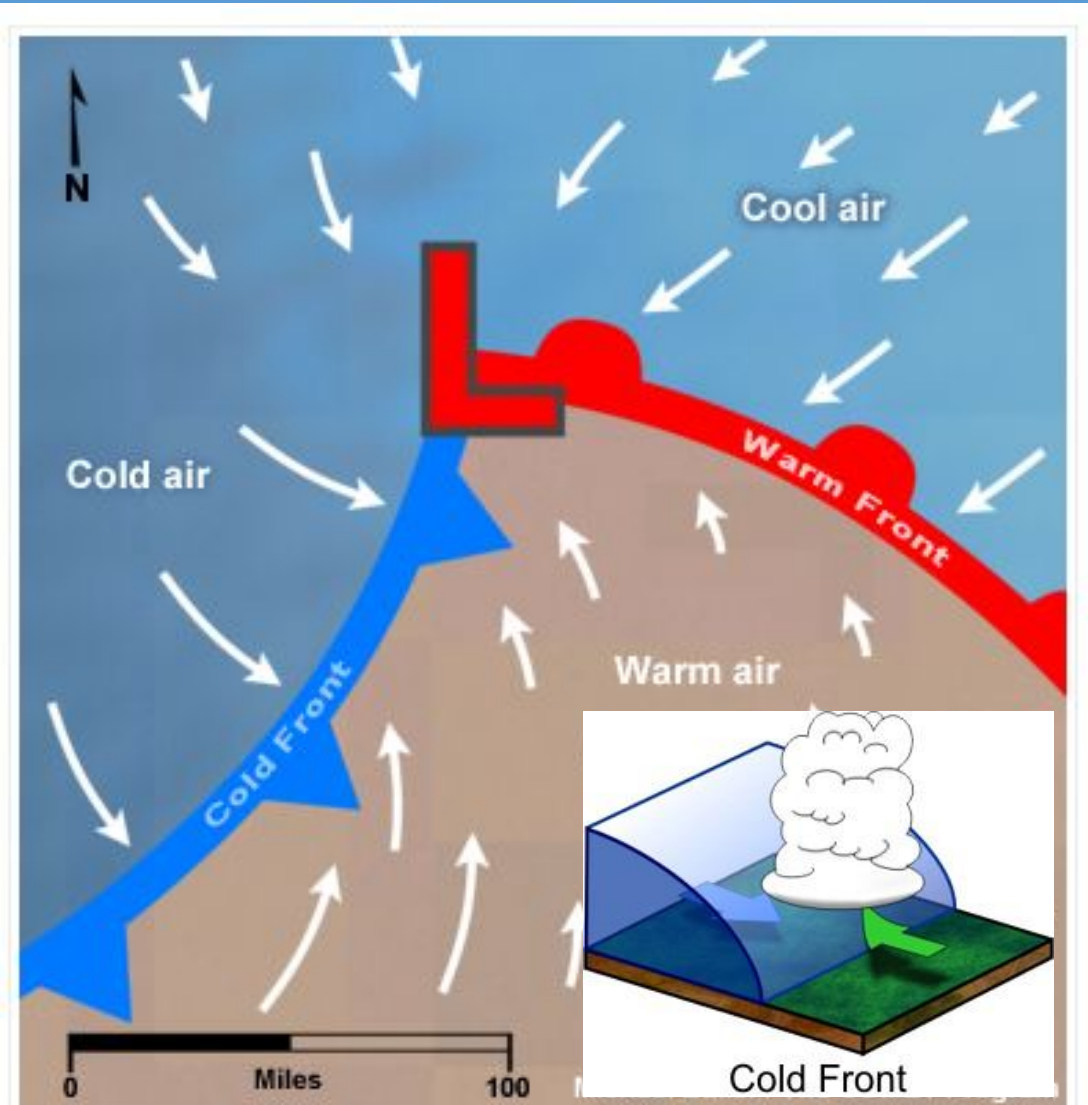
- Near higher pressure the weather is usually quiet because air sinks and dries out.
- Air rises near lower pressure. If conditions are right, clouds and precipitation can form.

Wind and Terrain

- Due to unequal heating of terrain versus air, wind blows up mountain slopes during the day and down them at night. In other words, winds usually reverse direction twice per day.
- Types of terrain influenced winds: Slope, along-valley, cross-valley, mountain-plain winds.



Fronts



- Fronts are boundaries between air masses of different density. Can bring increased wind and precipitation.
- Typical wind and temperature patterns around a frontal system.
- Dry cold fronts are most common in Arizona during the fire season.

Fire Weather Parameters



Haines Index

Haines Index: Attempts to approximate the rate of spread for a theoretical wildfire.

- Calculated by summing a stability term and a moisture term. Numbers are adjusted for different elevations, giving a low, mid, and high elevation Haines Index.
- *Interpretation: Values of 0-3 are very low, 4 is low, 5 is medium, and 6 is high.*

Fuel Moisture

Fuel Moisture: Measures the water content of fuels.

- Several types of calculations, such as 1, 10, 100, or 1000 hour fuels.
- Finer fuels are represented by the 1-10 hour calculations, while larger fuels are better represented by 100-1000 hour calculations.
- Units are usually given in percent. The lower the percent, the easier it is to burn.

Energy Release Component

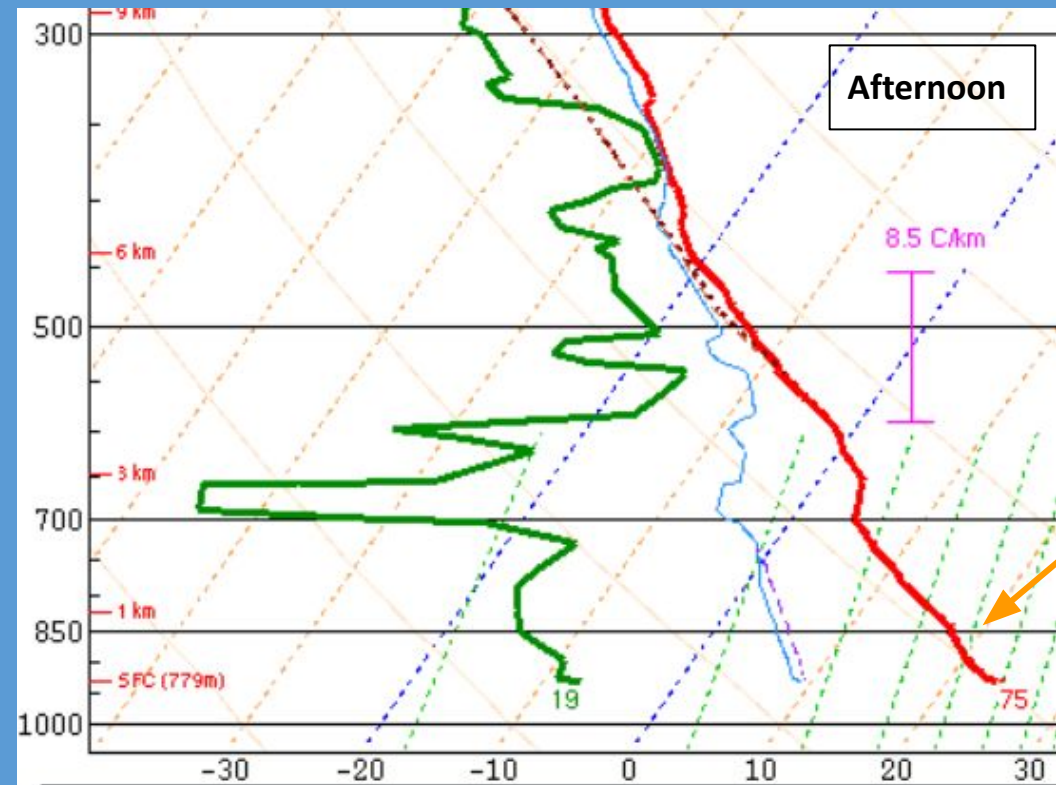
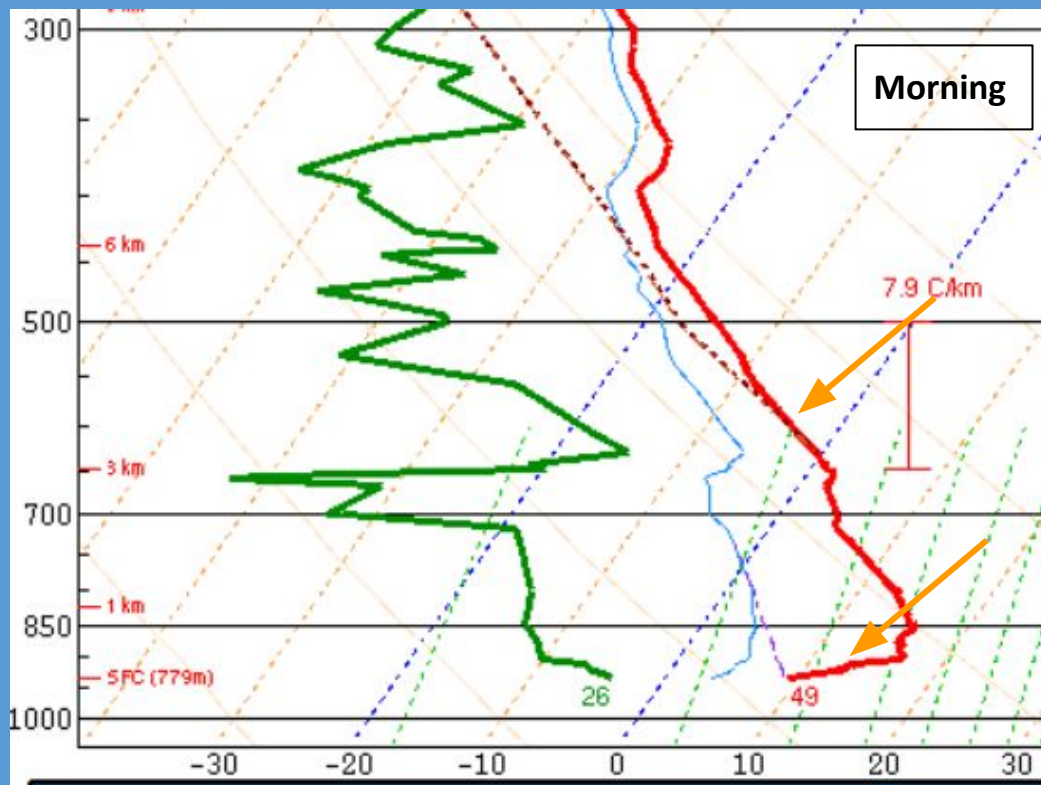
ERC: Measures the potential heat release of a theoretical fire.

- Often plotted as a percentile (0-100) relative to the time of year.
- Primary input is fuel moisture, for both alive and dead fuels.
- Drought affects the equation because it includes dead fuels.
- Does not take slope or wind into account.

Lapse Rates

Lapse Rate: Rate of change of temperature with height.

- Varies by altitude, time of day, and weather pattern.



Atmospheric Stability



Kyle Cannon

Atmospheric Stability is the resistance of the atmosphere to vertical motion. Stability is typically at a maximum in the morning and a minimum in the afternoon.

Unstable: will enhance or encourage vertical movement of air

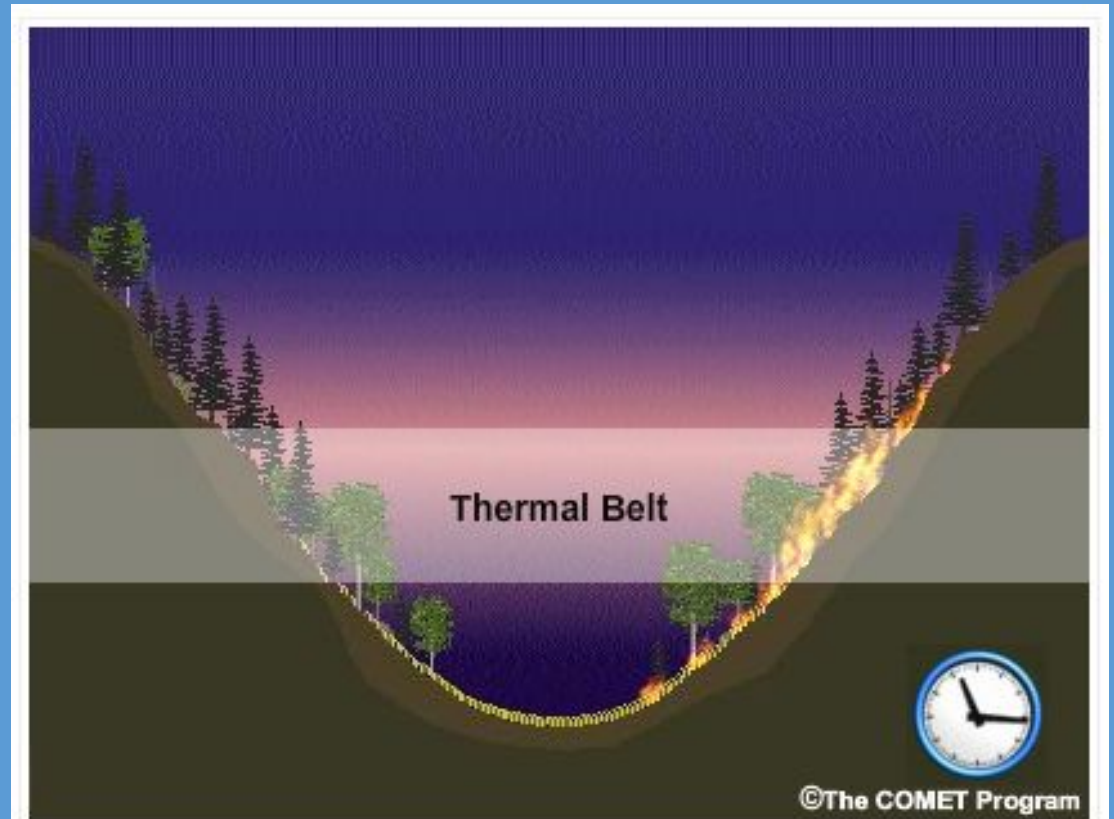
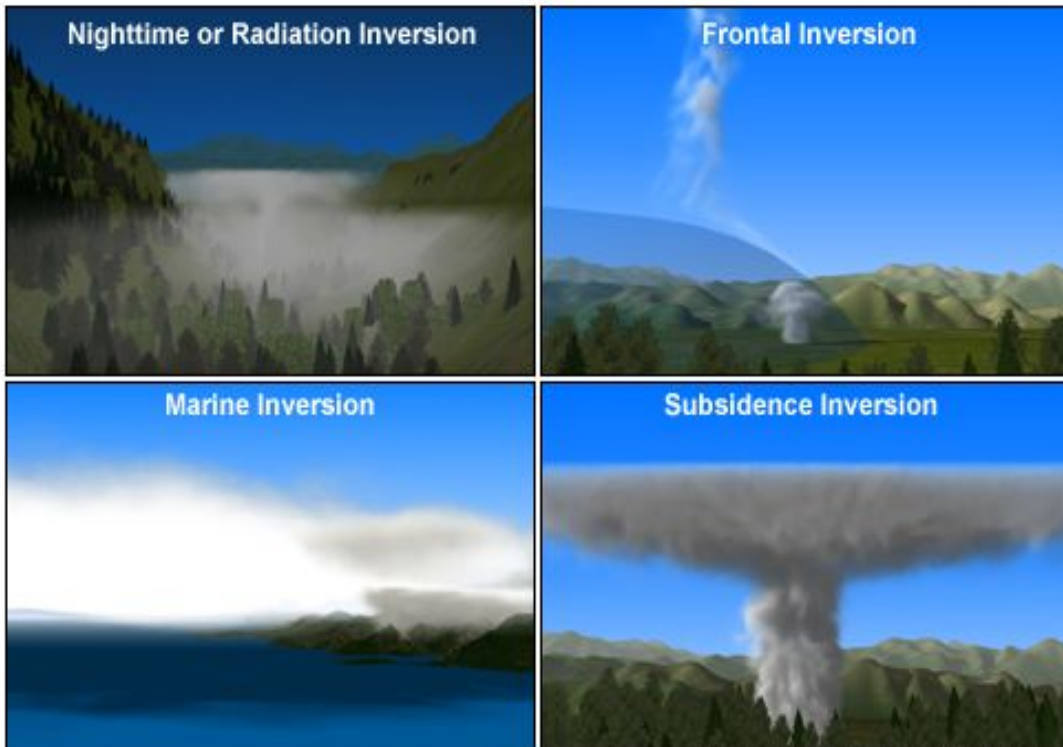
Stable: suppress or resist vertical motion

Atmospheric Stability

Inversions: A special case of stable air where the temperature increases with height. Completely traps pollutants and air becomes decoupled from upper atmosphere.

Thermal Belt: A zone of higher temperature and wind with lower RH that persists through the night along the middle slopes of a valley.

Four Types of Inversions



Weather and Fire



Diurnal Cycle

5 am

Morning winds blow down the valley



Diurnal Cycle

8 am

- Down Valley winds continue but weaken.
- Winds on east facing slopes reverse
- West facing slopes still downslope.



Diurnal Cycle

12 pm

- Upslope winds on both slopes continue.
- Stronger upvalley wind dominates.



Diurnal Cycle

2 pm

- Morning inversion finally breaks!
- Gusty westerly wind forms (mixing down from above).
- Temperature increases
- RH Drops quickly.



Diurnal Cycle

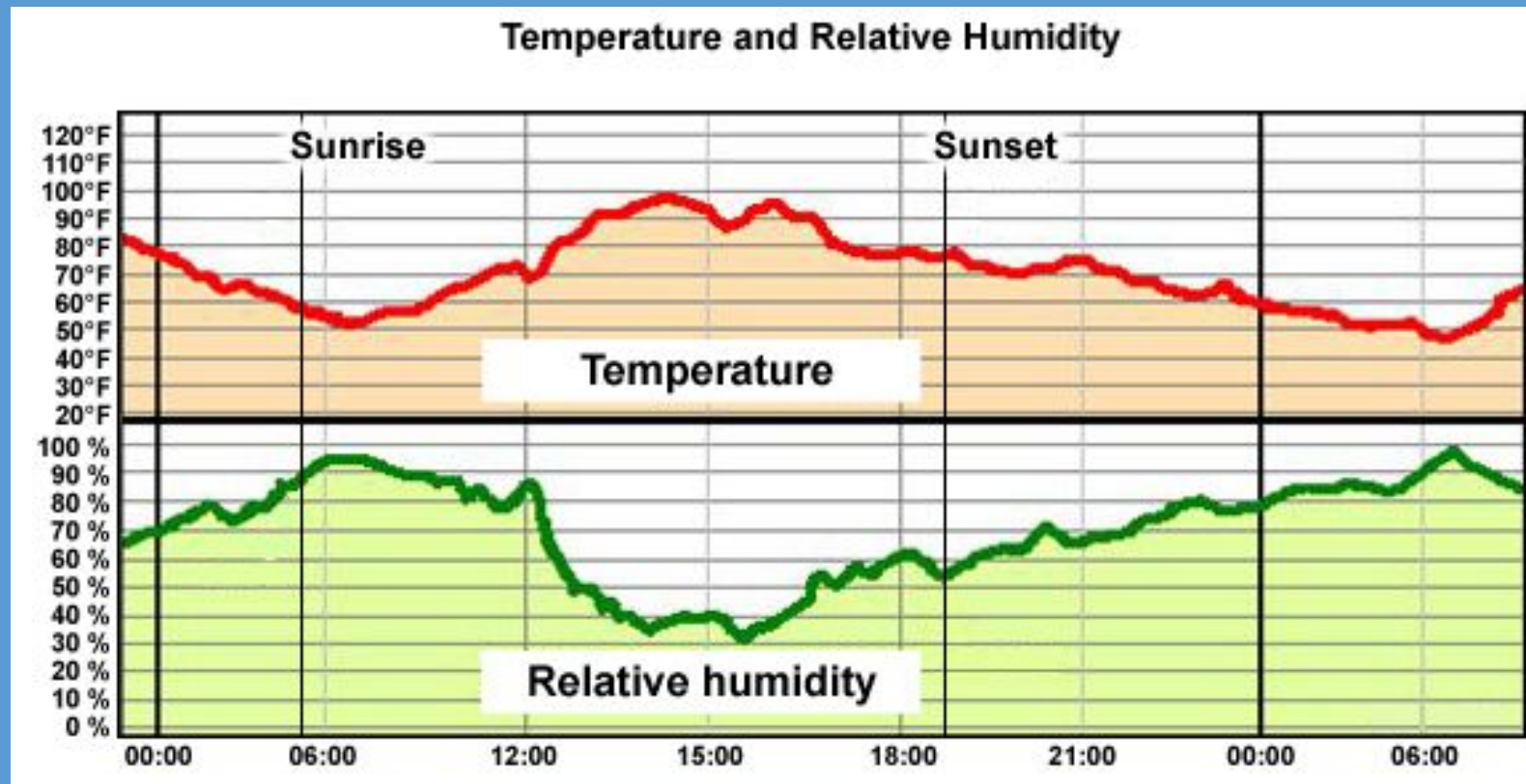
6 pm

- Breezy west wind continues at summit.
- Light downslope winds on east facing slopes.
- West/upslope winds continue otherwise.



Diurnal Cycle

- Temperatures typically rise during the day and cool at night.
- Relative humidity has the opposite tendency, with minimums during the afternoon and maximums overnight.



Impacts of Weather

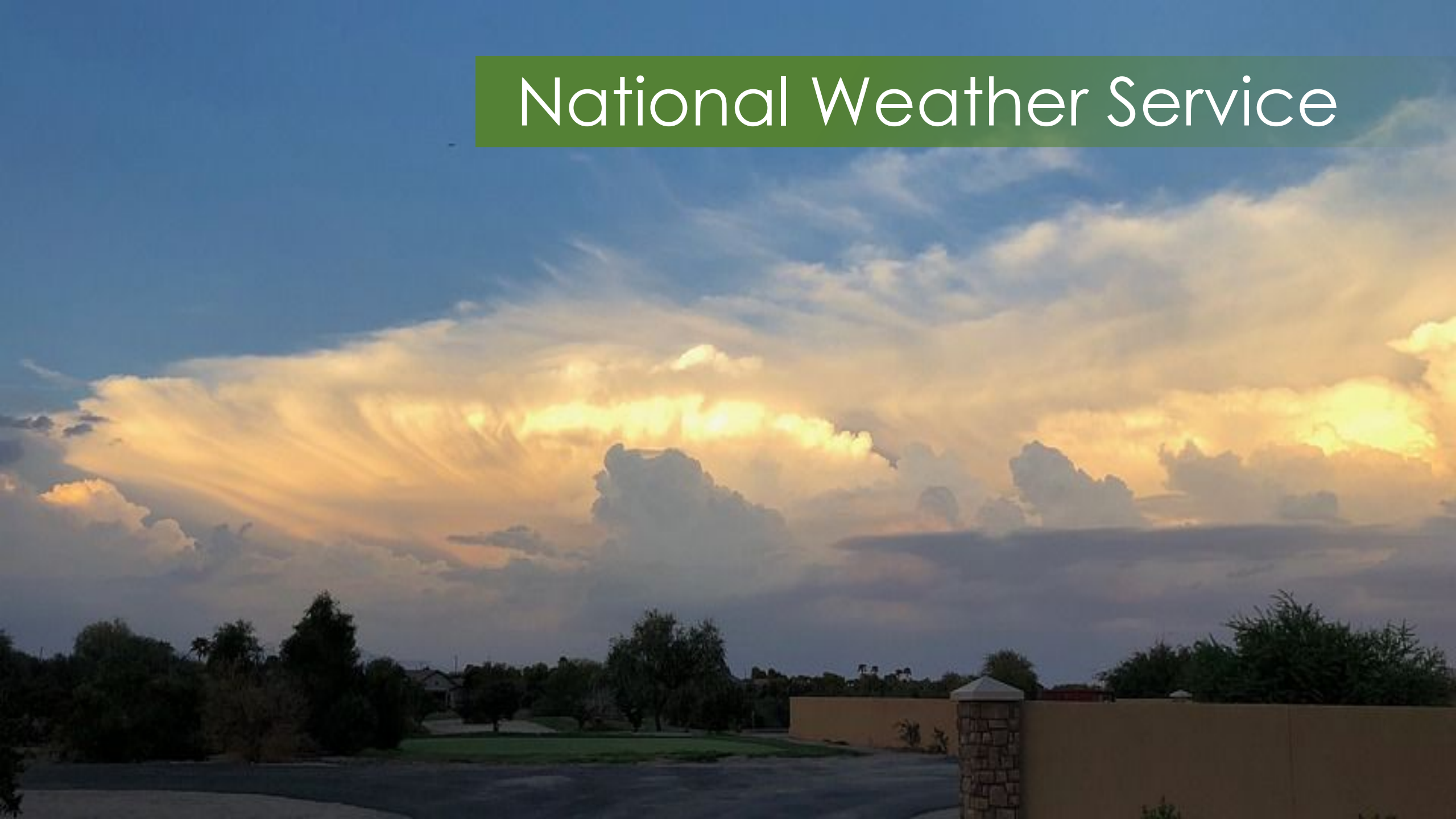
- The diurnal cycle can be influenced or overwhelmed by weather variations, such as frontal systems, which result in temperature, wind, and RH changes.
- Thunderstorms, especially during the monsoon, are characterized by low predictability and irregular spatial coverage. Can lead to dangerous and erratic wind shifts and sudden increases in wind speeds along outflow boundaries. The air behind gust fronts is cooler with higher humidity.
- During the mix out of the nighttime inversion, stronger winds (and from a different direction) can suddenly mix down to the surface. Fire activity can significantly enhance during and after this period.

Fire whirls



- As air is intensely heated along the fire line it acts it becomes a low pressure area, with air rushing inwards.
- As converging flow is stretched a fire whirl can develop. Sometimes these become very intense.

National Weather Service



National Weather Service

- **Our Mission**

- *To provide accurate and timely weather, water, hydrologic, and climate forecasts, warnings, and watches*
 - **For protection of lives and property**
 - **For enhancement of the economy**

- **Strategic goal: Weather Ready Nation**

- Ensure communities are “Ready, Responsive and Resilient” in the face of extreme weather, water and climate events.

National Weather Service Offices in Arizona

NWS Las Vegas

NWS Flagstaff

**NWS
San Diego**

NWS Phoenix

NWS Tucson



Fire Weather Program

Uses:

- Fire suppression and prevention
- Smoke management
- Placement and movement of resources
- Protect firefighters
- Land management activities

Fire Weather Program

- Daily forecasts
 - Several fire and smoke management variables
- Daily products
 - Fire Weather Forecast, AFD, Spots
- Watches and Warnings
- Incident Meteorologists

Spot Forecast Variables

SPOT FORECAST FOR BURNT...AZ-KNF
NATIONAL WEATHER SERVICE FLAGSTAFF AZ
547 AM MST MON AUG 3 2015

FORECAST IS BASED ON REQUEST TIME OF 1808 MST ON AUGUST 02.
IF CONDITIONS BECOME UNREPRESENTATIVE, CONTACT THE NATIONAL WEATHER SERVICE.

.DISCUSSION...DRY CONDITIONS ARE FORECAST TODAY THROUGH TUESDAY.
LIGHT AND VARIABLE WINDS EARLY THIS MORNING WILL BECOME SOUTHWESTERLY
AT 10 TO 20 MPH BY MID-MORNING. MINIMUM RH VALUES WILL BE AROUND
25 PERCENT.

.TODAY...

SKY/WEATHER.....MOSTLY SUNNY.
MAX TEMPERATURE.....AROUND 80.
MIN HUMIDITY.....25 PCT.
WINDS (20 FT).....SOUTHWEST WINDS AROUND 10 MPH WITH GUSTS UP TO
20 MPH.
LAL.....1.
HAINES INDEX.....4 LOW.
MAX VENT RATE.....EXCELLENT (140600 KNOT-FT).
CLEARING INDEX.....1406.
MIXING HEIGHT.....700 FT AGL INCREASING TO 9000 FT AGL.
TRANSPORT WINDS.....SOUTHWEST 5 TO 10 KNOTS INCREASING TO WEST 15
TO 20 KNOTS IN THE AFTERNOON.

.TONIGHT...

SKY/WEATHER.....MOSTLY CLEAR.
MIN TEMPERATURE.....AROUND 54.
MAX HUMIDITY.....54 PCT.
WINDS (20 FT).....SOUTHWEST WINDS AROUND 10 MPH BECOMING LIGHT.
LAL.....1.
HAINES INDEX.....3 VERY LOW.
MIN VENT RATE.....POOR (800 KNOT-FT).
CLEARING INDEX.....8.
MIXING HEIGHT.....6100 FT AGL EARLY IN THE EVENING DECREASING TO
700 FT AGL IN THE LATE EVENING AND OVERNIGHT.
TRANSPORT WINDS.....SOUTHWEST 10 TO 15 KNOTS DECREASING TO AROUND 5
KNOTS EARLY IN THE MORNING.

.TUESDAY...

SKY/WEATHER.....MOSTLY SUNNY.
MAX TEMPERATURE.....AROUND 82.
MIN HUMIDITY.....19 PCT.
WINDS (20 FT).....SOUTHWEST WINDS AROUND 10 MPH.
LAL.....1.
HAINES INDEX.....4 LOW.
MAX VENT RATE.....VERY GOOD (96200 KNOT-FT).
CLEARING INDEX.....962.
MIXING HEIGHT.....400 FT AGL INCREASING TO 7700 FT AGL.
TRANSPORT WINDS.....SOUTHWEST 5 TO 10 KNOTS.

.DISCUSSION...DRY CONDITIONS ARE FORECAST TODAY THROUGH TUESDAY.
LIGHT AND VARIABLE WINDS EARLY THIS MORNING WILL BECOME SOUTHWESTERLY
AT 10 TO 20 MPH BY MID-MORNING. MINIMUM RH VALUES WILL BE AROUND
25 PERCENT.

.TODAY...

SKY/WEATHER.....MOSTLY SUNNY.
MAX TEMPERATURE.....AROUND 80.
MIN HUMIDITY.....25 PCT.
WINDS (20 FT).....SOUTHWEST WINDS AROUND 10 MPH WITH GUSTS UP TO
20 MPH.
LAL.....1.
HAINES INDEX.....4 LOW.
MAX VENT RATE.....EXCELLENT (140600 KNOT-FT).
CLEARING INDEX.....1406.
MIXING HEIGHT.....700 FT AGL INCREASING TO 9000 FT AGL.
TRANSPORT WINDS.....SOUTHWEST 5 TO 10 KNOTS INCREASING TO WEST 15
TO 20 KNOTS IN THE AFTERNOON.

Fire Weather Forecast (FWF)

AZZ117-020100-
WHITE MOUNTAINS (FIRE WEATHER ZONE 117)-
INCLUDING THE CITIES OF...SHOW LOW...GREER...PINETOP
312 AM MST WED JUN 1 2011

...RED FLAG WARNING DUE TO STRONG WINDS AND LOW RELATIVE HUMIDITIES
IN EFFECT FROM 11 AM THIS MORNING TO 8 PM MST
THIS EVENING...

...FIRE WEATHER WATCH DUE TO STRONG WINDS AND LOW RELATIVE HUMIDITIES
IN EFFECT FROM THURSDAY MORNING THROUGH
THURSDAY EVENING...

.TODAY...
SKY/WEATHER.....MOSTLY CLOUDY UNTIL 1200...THEN PARTLY CLOUDY.
MAX TEMPERATURE.....78-88 BELOW 7000 FEET...73-83 ABOVE 7000 FEET.
24 HR TREND.....3 DEGREES WARMER.
MIN HUMIDITY.....9 PERCENT.
24 HR TREND.....LITTLE CHANGE.
WINDS (20 FT).....BREEZY. SOUTH WINDS 10 TO 15 MPH INCREASING TO
15 TO 25 MPH WITH GUSTS UP TO 35 MPH IN THE
AFTERNOON.
10000 FT MSL WIND...SOUTH 30 TO 40 MPH.
HAINES INDEX.....5 MODERATE.
CHANCE OF PRECIP....0 PERCENT.
LAL.....1.
MIXING HEIGHT.....3053 FT AGL INCREASING TO 8611 FT AGL IN THE
AFTERNOON.
TRANSPORT WINDS.....SOUTH 17 TO 22 KNOTS.
VENTILATION.....GOOD (52918 KNOT-FT) INCREASING TO EXCELLENT
(186464 KNOT-FT) IN THE AFTERNOON.

.TONIGHT...
SKY/WEATHER.....PARTLY CLOUDY.
MIN TEMPERATURE.....48-53 BELOW 7000 FEET...42-51 ABOVE 7000 FEET.
24 HR TREND.....10 DEGREES WARMER.
MAX HUMIDITY.....22-32 PERCENT.
24 HR TREND.....14 PERCENT DRIER.
WINDS (20 FT).....SOUTHWEST WINDS 10 TO 15 MPH. GUSTS UP TO 25
MPH IN THE EVENING.
10000 FT MSL WIND...SOUTHWEST 30 TO 40 MPH.
HAINES INDEX.....5 MODERATE.
CHANCE OF PRECIP....0 PERCENT.
LAL.....1.

.THURSDAY...
SKY/WEATHER.....PARTLY CLOUDY.
MAX TEMPERATURE.....75-84 BELOW 7000 FEET...69-79 ABOVE 7000 FEET.
24 HR TREND.....2 DEGREES COOLER.
MIN HUMIDITY.....11 PERCENT.
24 HR TREND.....3 PERCENT WETTER.
WINDS (20 FT).....BREEZY. SOUTH WINDS 10 TO 15 MPH SHIFTING TO
THE SOUTHWEST 15 TO 25 MPH WITH GUSTS UP TO 40
MPH IN THE AFTERNOON.
10000 FT MSL WIND...SOUTHWEST 35 TO 45 MPH.
HAINES INDEX.....5 MODERATE.
CHANCE OF PRECIP....0 PERCENT.
LAL.....1.
MIXING HEIGHT.....3383 FT AGL INCREASING TO 9333 FT AGL IN THE
AFTERNOON.
TRANSPORT WINDS.....SOUTH AROUND 12 KNOTS INCREASING TO SOUTHWEST
AROUND 24 KNOTS IN THE AFTERNOON.
VENTILATION.....GOOD (58108 KNOT-FT) INCREASING TO EXCELLENT
(221340 KNOT-FT) IN THE AFTERNOON.

.FORECAST DAYS 3 THROUGH 5.....
.FRIDAY...PARTLY CLOUDY. HIGHS 73 TO 83. SOUTHWEST WINDS 15 TO
20 MPH WITH GUSTS UP TO 30 MPH.
.SATURDAY...PARTLY CLOUDY. HIGHS 76 TO 86. SOUTH WINDS 10 TO
15 MPH. GUSTS UP TO 25 MPH.
.SUNDAY...PARTLY CLOUDY. SLIGHT CHANCE OF SHOWERS AND
THUNDERSTORMS. HIGHS 76 TO 86. SOUTH WINDS 10 TO 15 MPH.

AZZ117-020100-
WHITE MOUNTAINS (FIRE WEATHER ZONE 117)-
INCLUDING THE CITIES OF...SHOW LOW...GREER...PINETOP
312 AM MST WED JUN 1 2011

SKY/WEATHER.....MOSTLY CLOUDY UNTIL 1200...THEN PARTLY CLOUDY.
MAX TEMPERATURE.....78-88 BELOW 7000 FEET...73-83 ABOVE 7000 FEET.

24 HR TREND.....3 DEGREES WARMER.

MIN HUMIDITY.....9 PERCENT.

24 HR TREND.....LITTLE CHANGE.

WINDS (20 FT).....BREEZY. SOUTH WINDS 10 TO 15 MPH INCREASING TO
15 TO 25 MPH WITH GUSTS UP TO 35 MPH IN THE
AFTERNOON.

10000 FT MSL WIND...SOUTH 30 TO 40 MPH.

HAINES INDEX.....5 MODERATE.

CHANCE OF PRECIP....0 PERCENT.

LAL.....1.

MIXING HEIGHT.....3053 FT AGL INCREASING TO 8611 FT AGL IN THE
AFTERNOON.

TRANSPORT WINDS.....SOUTH 17 TO 22 KNOTS.

VENTILATION.....GOOD (52918 KNOT-FT) INCREASING TO EXCELLENT
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15 MPH. GUSTS UP TO 25 MPH.

.SUNDAY...PARTLY CLOUDY. SLIGHT CHANCE OF SHOWERS AND
THUNDERSTORMS. HIGHS 76 TO 86. SOUTH WINDS 10 TO 15 MPH.

Area Forecast Discussion (AFD)

AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE FLAGSTAFF AZ
300 PM MST THU JUN 2 2011

.SYNOPSIS...A LOW PRESSURE TROUGH WILL MOVE AWAY FROM ARIZONA THIS EVENING WITH WIND SPEEDS DIMINISHING AROUND SUNSET. SEASONABLY WARM TEMPERATURES WITH DRY HUMIDITY LEVELS AND BREEZY SOUTHWESTERLY WINDS WILL CONTINUE THROUGH THE WEEKEND.

&&

.DISCUSSION...A LOW PRESSURE TROUGH WILL MOVE NORTHEASTWARD AWAY FROM ARIZONA THIS EVENING AND STRONG WINDS WILL DIMINISH AROUND SUNSET. OUR WIND ADVISORY HAS BEEN EXPANDED TO INCLUDE THE MOGOLLON RIM AND WHITE MOUNTAIN ZONES THROUGH 8 PM THIS EVENING.

OVER THE WEEKEND...A LOW CENTER WILL POSITION ITSELF OFF THE SOUTHERN CALIFORNIA COAST AS A HIGH PRESSURE RIDGE BUILDS IN OVER THE SOUTHERN STATES. THIS PATTERN WILL CONTINUE TO KEEP US IN A SEASONABLY WARM AND DRY WEATHER PATTERN WITH BREEZY TO WINDY SOUTHWESTERLIES. FORECAST GUIDANCE CONTINUES TO SHOW SOUTHERLY FLOW AROUND THE RIDGE MAY TAP INTO GULF MOISTURE AND BRING A PLUME OF SUBTROPICAL MOISTURE UP INTO NEW MEXICO. FORECAST MODELS CONTINUE TO SUGGEST THAT THE WESTERN EDGE OF THIS MOISTURE PLUME MAY MOVE INTO EXTREME EASTERN ARIZONA ON SUNDAY...WHICH COULD PRODUCE HIGH BASED CLOUDS AND SLIGHT CHANCE FOR A FEW DRY THUNDERSTORMS IN APACHE COUNTY.

MONDAY THROUGH WEDNESDAY...EXTENDED FORECAST GUIDANCE SHOWS GOOD AGREEMENT WITH THE LOW MOVING NORTHWARD THROUGH CALIFORNIA...NEVADA ON MONDAY AND INTO MONTANA ON TUESDAY. HOWEVER THE LONG WAVE TROUGH WILL REMAIN ALONG THE WEST COAST WITH A LONG WAVE RIDGE CENTERED OVER THE CENTRAL STATES. THIS PATTERN WILL CONTINUE TO PRODUCE SEASONABLY WARM AND DRY CONDITIONS WITH BREEZY SOUTHWESTERLY WINDS EACH DAY THROUGH THE MIDDLE OF NEXT WEEK. SLIGHT CHANCES FOR HIGH BASED CLOUDS AND A FEW DRY THUNDERSTORMS REMAIN IN THE FORECAST ON MONDAY FOR APACHE COUNTY.

&&

.AVIATION...FOR THE 00Z PACKAGE...VFR CONDITIONS WILL CONTINUE OVER THE NEXT 24 HOURS UNDER SCATTERED CIRRUS. TIL 02Z ||
FRI...SOUTHWEST WINDS OF 15-30 KT WITH GUSTS 25 TO 35 KT THEN DECREASING. THE STRONGEST WINDS WILL BE LOCATED ALONG AND NORTH OF THE MOGOLLON RIM. APT 17Z FRIDAY...S-SW WINDS 10 TO 20 KT WITH GUSTS TO 25 KT. AVIATION DISCUSSION NOT UPDATED FOR AMENDMENTS.

&&

.FIRE WEATHER...TONIGHT THROUGH SATURDAY...SOUTHWEST FLOW ALOFT WILL PERSIST OVER NORTHERN ARIZONA. STRONG WINDS WILL CONTINUE THROUGH SUNSET TONIGHT AND THE RED FLAG WARNING WILL CONTINUE THROUGH 8 PM MST. OTHERWISE LOOK FOR POOR HUMIDITY RECOVERY TONIGHT. FOR FRIDAY AND SATURDAY...IT WILL REMAIN QUITE DRY BUT 20 FOOT WIND SPEEDS WILL DECREASE BELOW CRITICAL FIRE WEATHER LEVELS. THE HAINES INDEX WILL RANGE FROM 5 TO 6 ACROSS OUR AREA. MAX TEMPS WILL START A WARMING TREND.

SUNDAY THROUGH TUESDAY...ON SUNDAY...SOUTHERLY FLOW ALOFT IS EXPECTED TO BRING GOOD MID LEVEL MOISTURE AND INSTABILITY INTO APACHE COUNTY ALONG WITH A CHANCE OF AFTERNOON AND EVENING THUNDERSTORMS TO THIS AREA. OTHERWISE...THE AFTERNOON HAINES INDEX WILL RANGE FROM 5 TO 6 ACROSS NORTHEAST ARIZONA. ON MONDAY...ANOTHER LOW IS EXPECTED TO MOVE SOUTHWARD ALONG THE CALIFORNIA COAST. LOOK FOR INCREASING WINDS WITH CRITICAL FIRE WEATHER CONDITIONS POSSIBLE MONDAY AND TUESDAY AFTERNOON ACROSS NAVAJO AND APACHE COUNTY.

&&

.SYNOPSIS...A LOW PRESSURE TROUGH WILL MOVE AWAY FROM ARIZONA THIS EVENING WITH WIND SPEEDS DIMINISHING AROUND SUNSET. SEASONABLY WARM TEMPERATURES WITH DRY HUMIDITY LEVELS AND BREEZY SOUTHWESTERLY WINDS WILL CONTINUE THROUGH THE WEEKEND.

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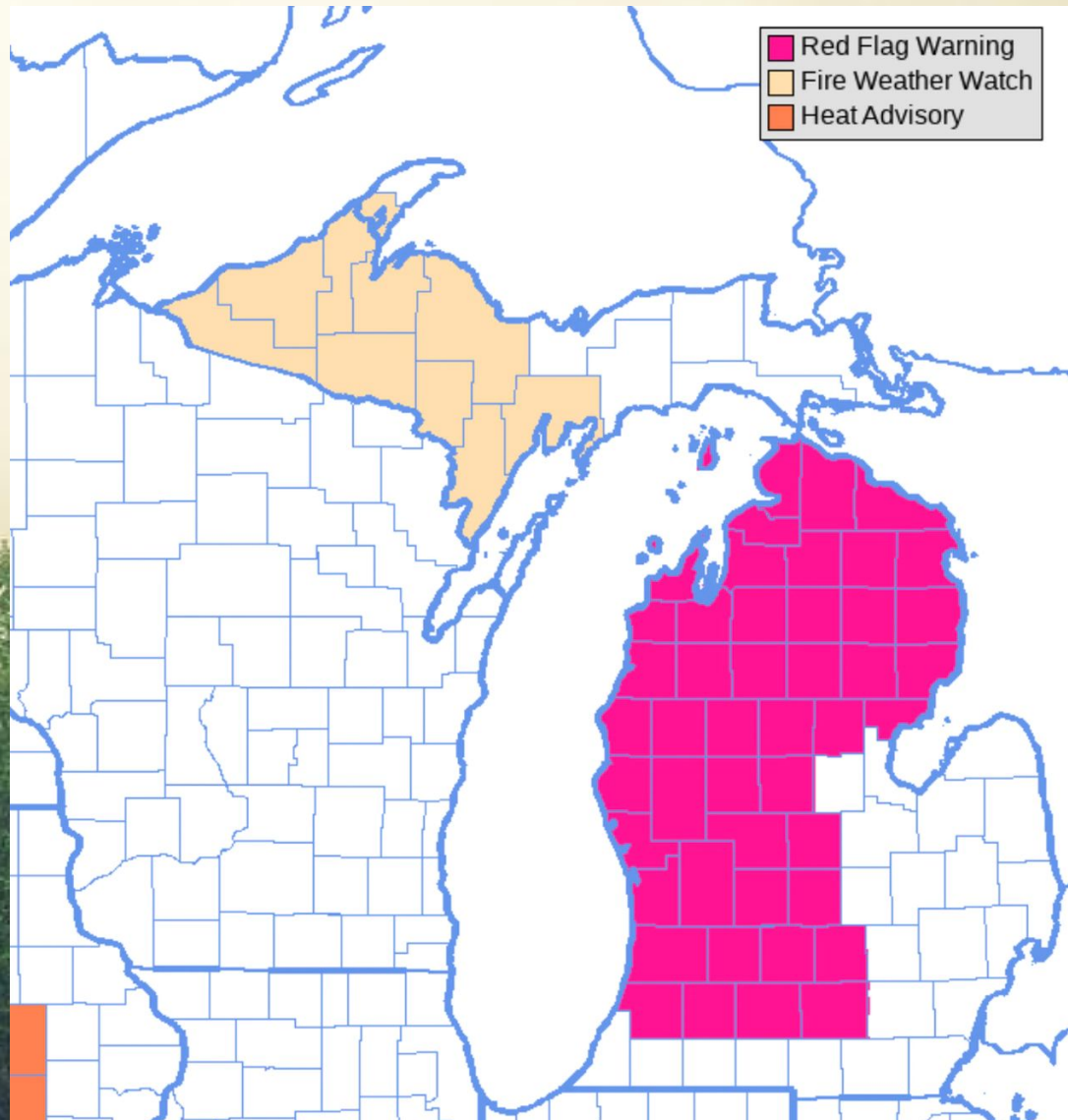
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&&

OVER THE CENTRAL STATES. THIS PATTERN WILL CONTINUE TO PRODUCE SEASONABLY WARM AND DRY CONDITIONS WITH BREEZY SOUTHWESTERLY WINDS EACH DAY THROUGH THE MIDDLE OF NEXT WEEK. SLIGHT CHANCES FOR HIGH BASED CLOUDS AND A FEW DRY THUNDERSTORMS REMAIN IN THE FORECAST ON MONDAY FOR APACHE COUNTY.

&&

Area Forecast Discussion (AFD)



Definitions of a Fire Weather Watch and a Red Flag Warning

A Fire Weather Watch or Red Flag Warning is issued when the combination of dry fuels and weather conditions support extreme fire danger.

1. Sustained 20 foot winds of 20 mph or higher.
2. Afternoon relative humidity less than 15%.
3. 10 hour fuel moisture at 8% or less for one day.

A Fire Weather Watch is issued up to 72 hours before the above conditions are expected to occur.

A Red Flag Warning is issued when the conditions above are expected to occur or are occurring within the next 24 hours.

Forecast Products

Summary:

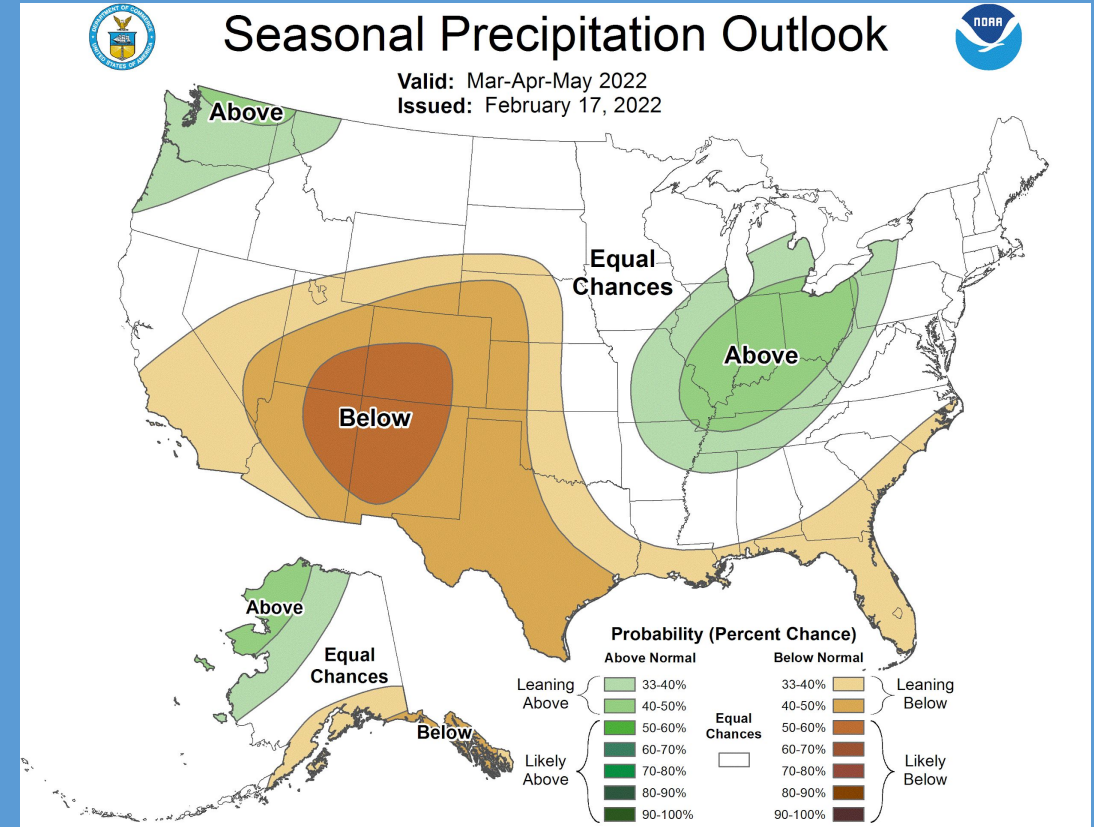
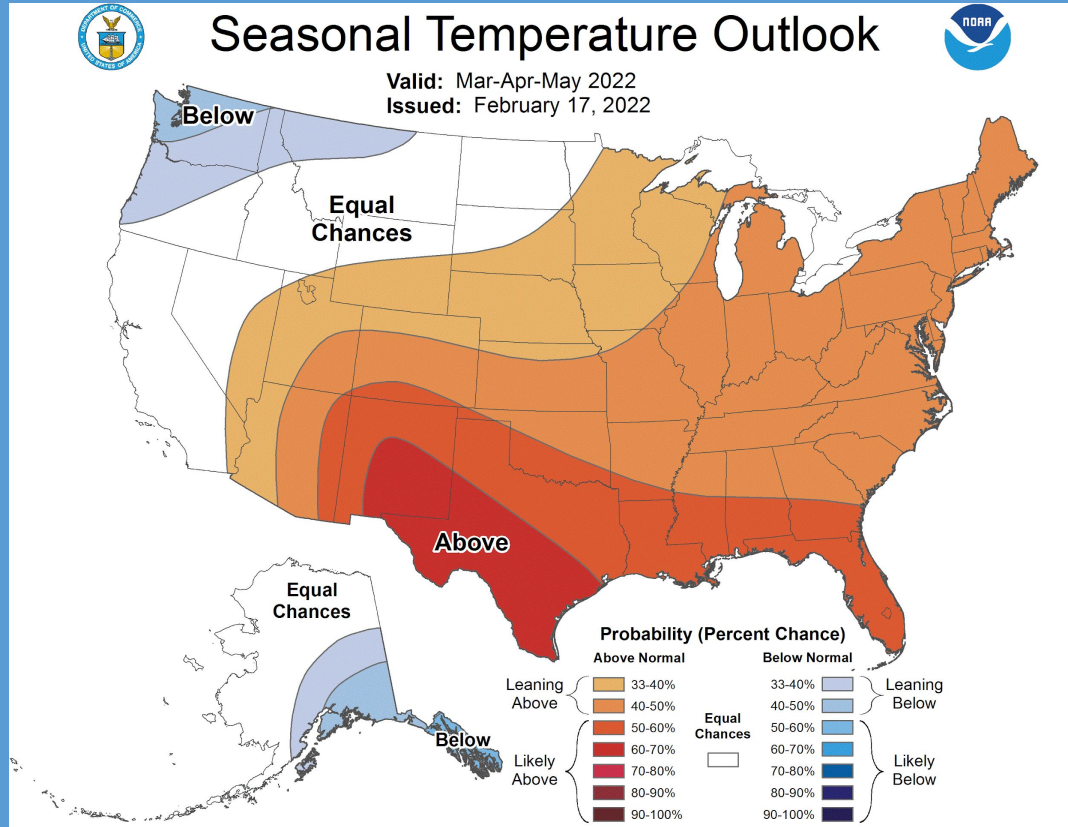
- Broad scale:
 - Area Forecast Discussion
- Finer scale:
 - Fire Weather Forecast
- Finest scale:
 - Spot Forecast

Spots

FWF

Discussion

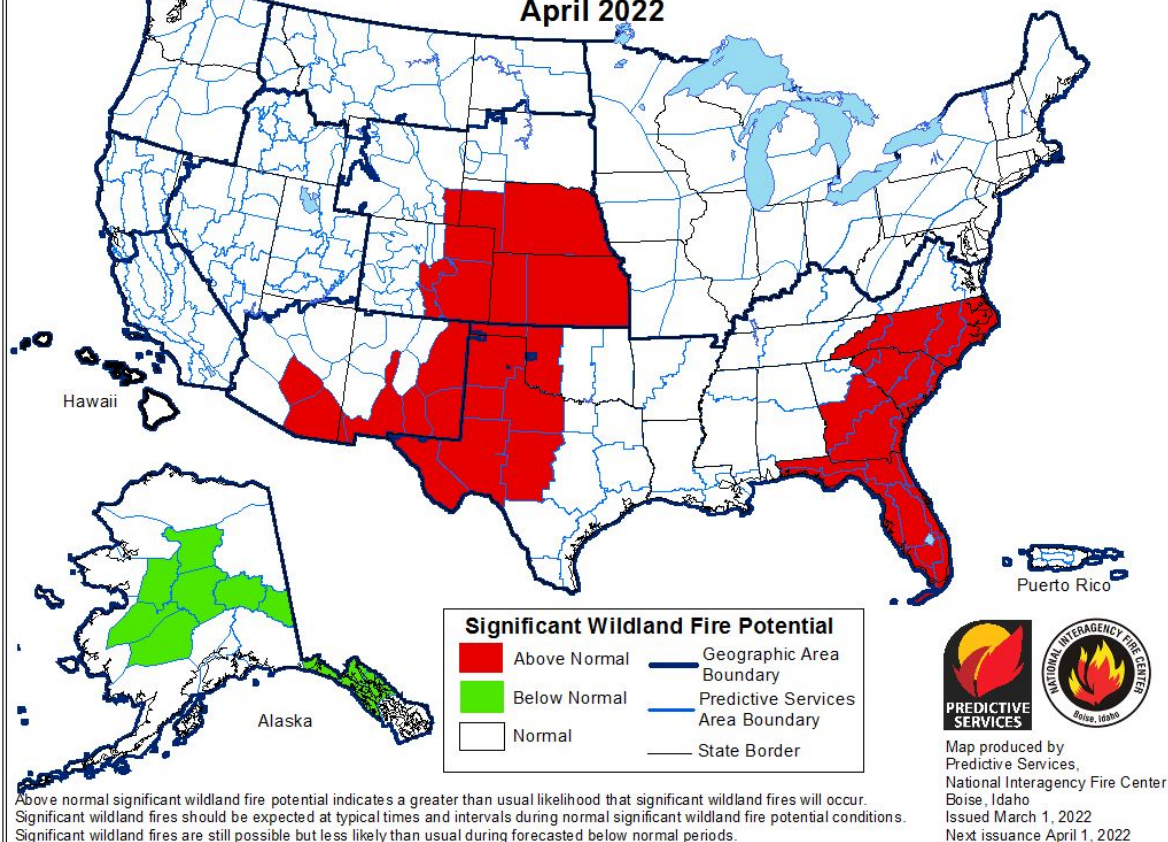
Weather Outlook



- Warmer than normal
- Below normal precipitation
- When/where matters (i.e., late season rain).

Seasonal Fire Outlook

**Significant Wildland Fire Potential Outlook
April 2022**



**Significant Wildland Fire Potential Outlook
June 2022**

