# Weather 101

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## Fire Weather

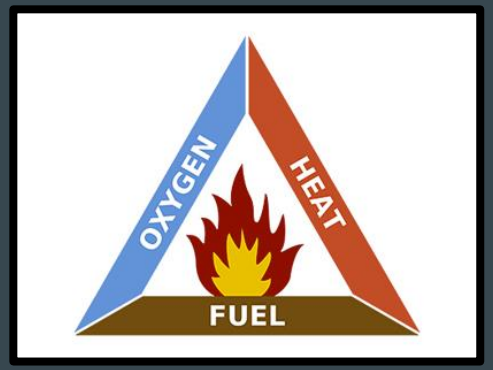
Caleb Cravens - Incident Meteorologist (IMET)- NWS Nashville

# Poll Question

Have you ever seen a wildfire? yes/no

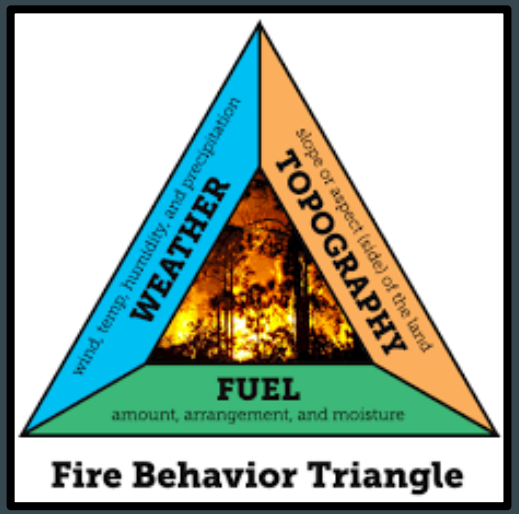
# Fire Triangle

- Oxygen
- Heat
- Fuel




# Fire Behavior

- Weather
- Topography
- Fuel



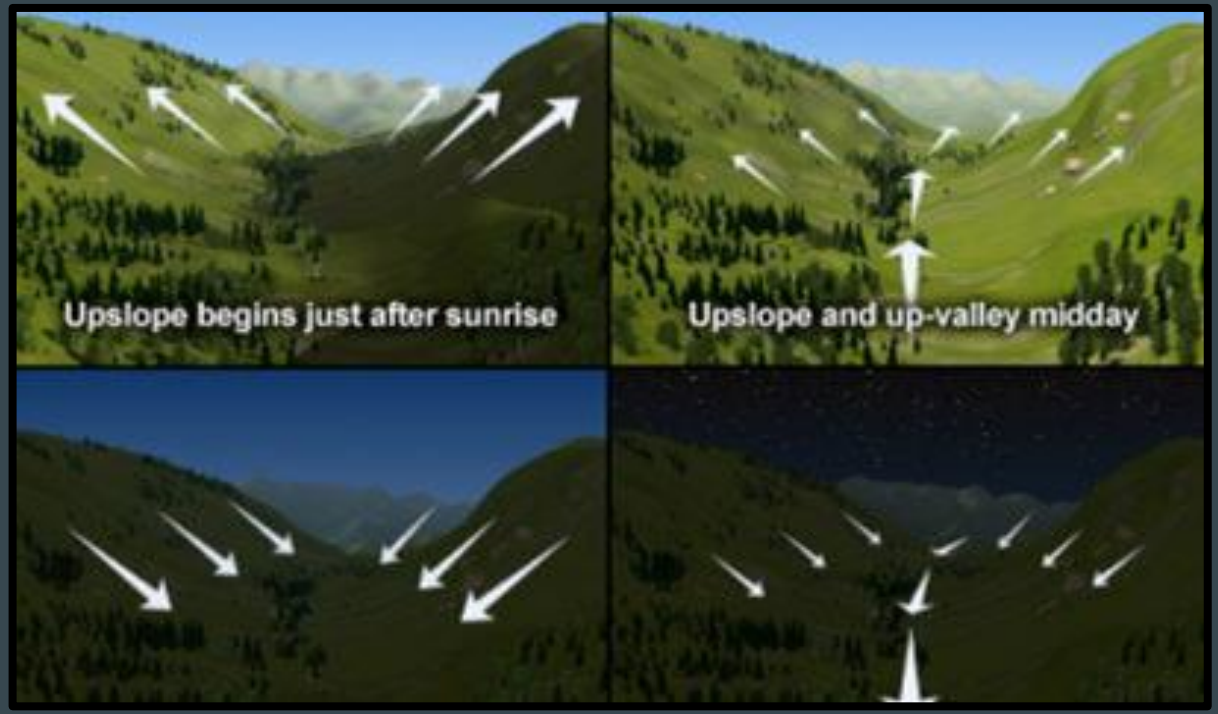
# Fuels - Vegetation

- Live fuel moisture
- Dead fuel moisture
  - 1 hr, 10 hr, 100 hr, 1000 hr, 10000 hr fuels
- ERC - Energy Release Component
  - The computed total heat release per unit area (British thermal units per square foot) within the flaming front at the head of a moving fire.
- BI - Burning Index
  - A relative number related to the contribution that fire behavior makes to the amount or effort needed to contain a fire in a specified fuel type.


# Role of Topography - Mountain and valley wind system

- Upslope after sunrise
- Upslope and up-valley around midday

- Downslope after sunset
- Downslope and down-valley later in the night

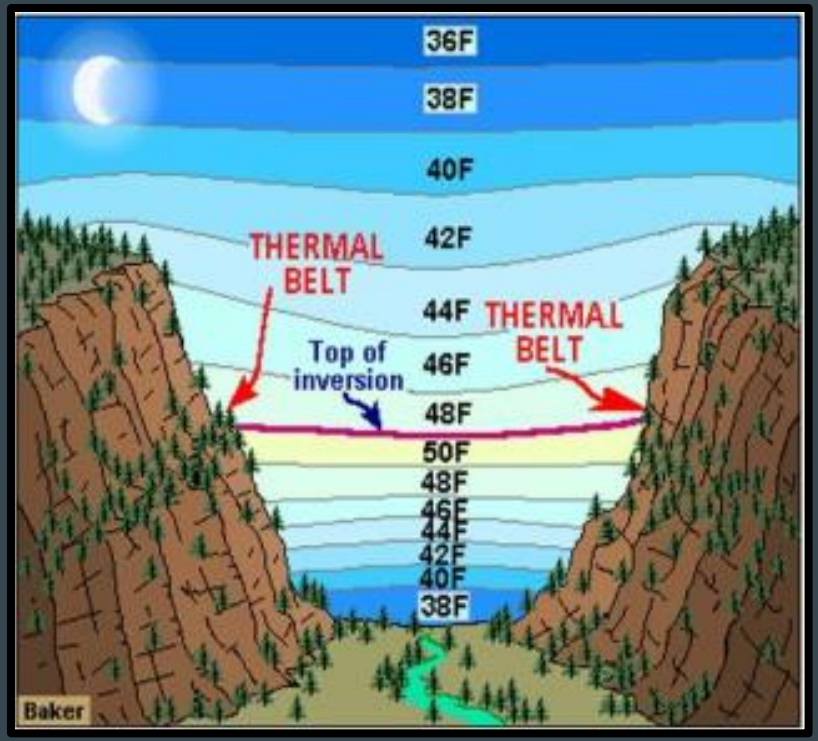


# Poll Question

What is a thermal belt?

# Role of Topography - Thermal Belts

- Layer of warmer air
  - Drier air and lower RH
- Cooler air near the surface
- Cooler air above the belt
- Acts as a lid on the fire
- Can trap smoke leading to smoke impacts and health concerns
- Can cause fires to flare up or continue to burn well into the night



# Elements of Fire Weather

## Temperature/Moisture

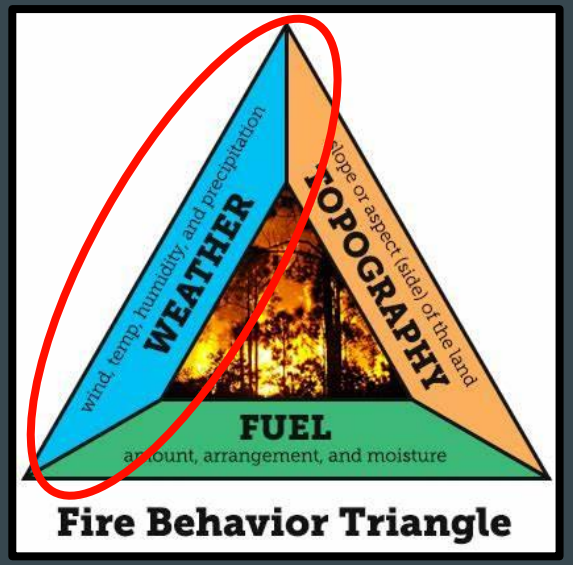
- Humidity
- Precipitation
  - Location
  - Type
  - Duration and Amount

## Atmospheric Stability

- Thunderstorms
- Atmospheric Ventilation

## Wind

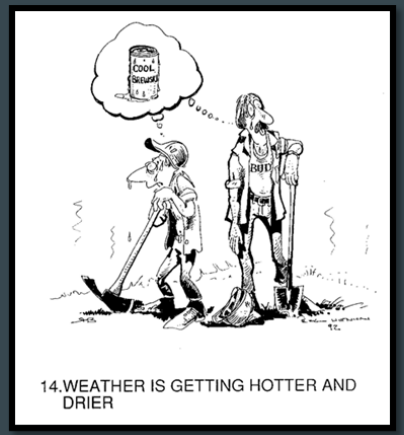
- Speed/Direction Hugely Influence ROS
- Extremely Variable
- Hard to Forecast In Detail



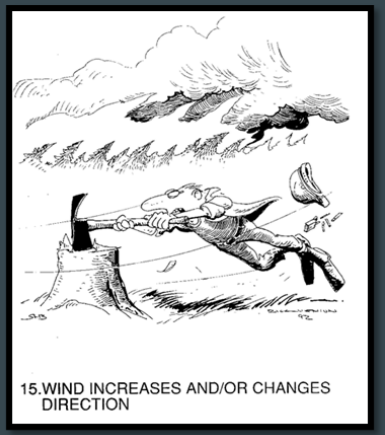
# Elements of Fire Weather

Weather Factors Affect the Ignition, Fire Intensity, and Rate of Spread in the Wildland Fire Environment.

- Ignition - Fuel temperature and moisture content
- Fireline Intensity - Fuel moisture content
- Rate of Spread - Wind speed (slope/topography)

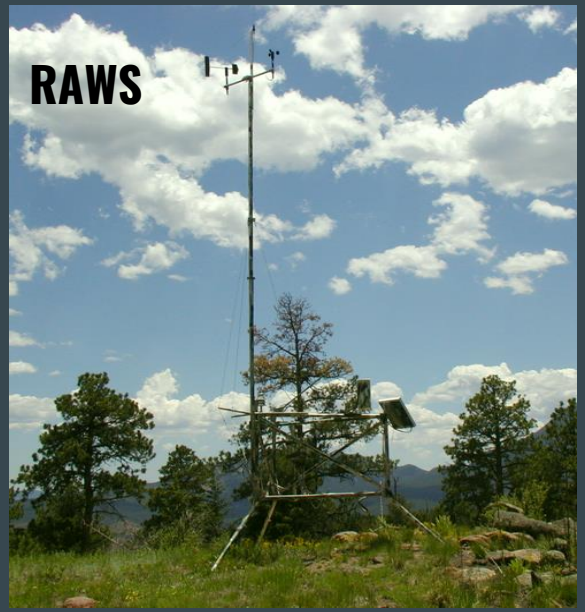


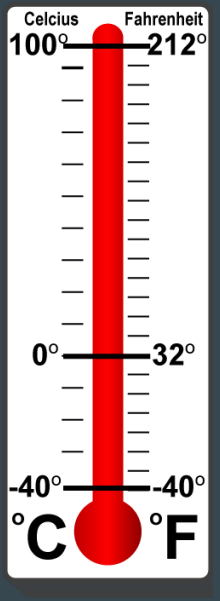
14.WEATHER IS GETTING HOTTER AND DRIER


15.WIND INCREASES AND/OR CHANGES DIRECTION

# Temperature

- Definition: The degree of hotness or coldness of a substance.
  - In weather we refer to this as air temperatures or dry-bulb temperature.
- Measured with a thermometer



# Moisture

- <u>Wet-bulb Temperature:</u> Lowest temperature at which air can be cooled by evaporation.
  - Dewpoint and relative humidity can be determined using the difference between dry and wet bulb.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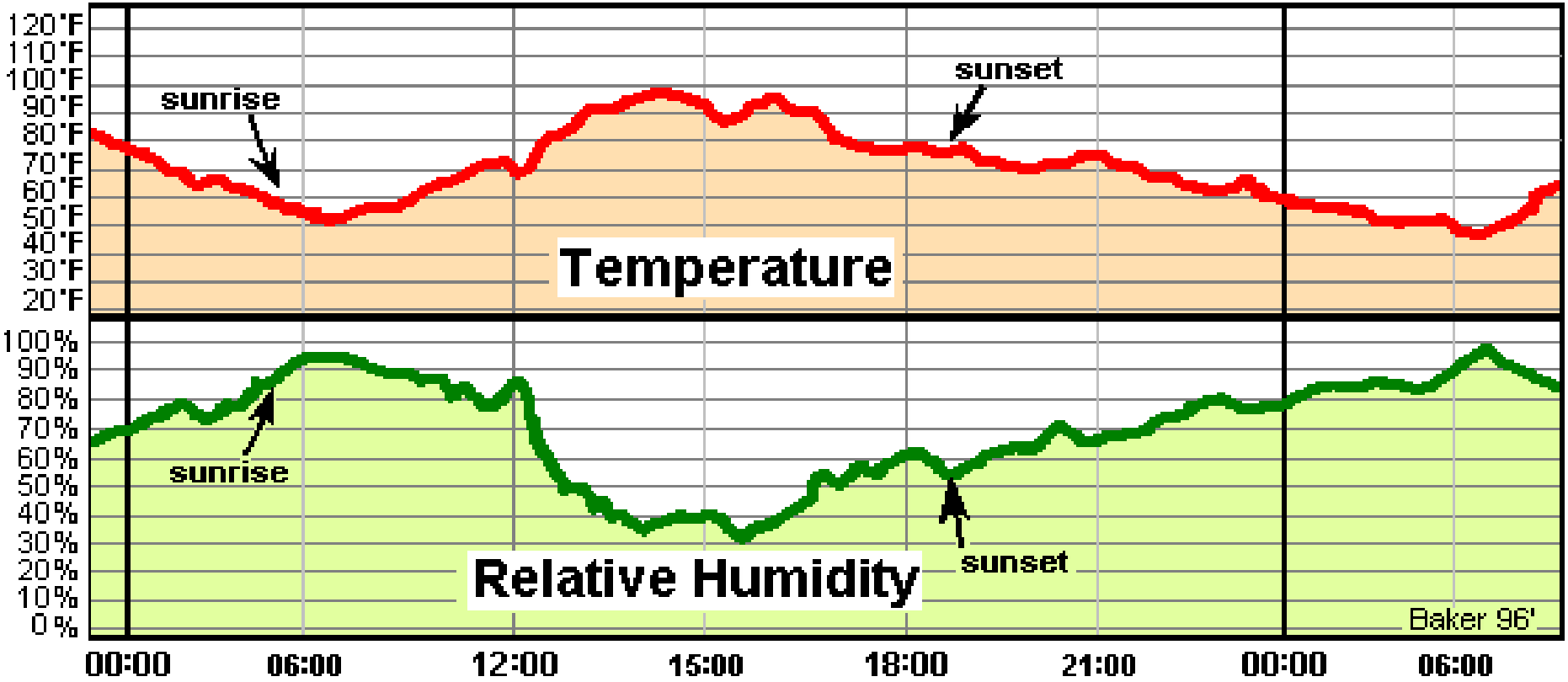
3 grams

50°F
RH 100%
(saturated)

70°F
RH 50%
(unsaturated)

90°F
RH 25%
(unsaturated)

Thermograph depicting 24 hours of temperature and relative humidity.




Note the diurnal relationship between temperature and relative humidity.

# Precipitation

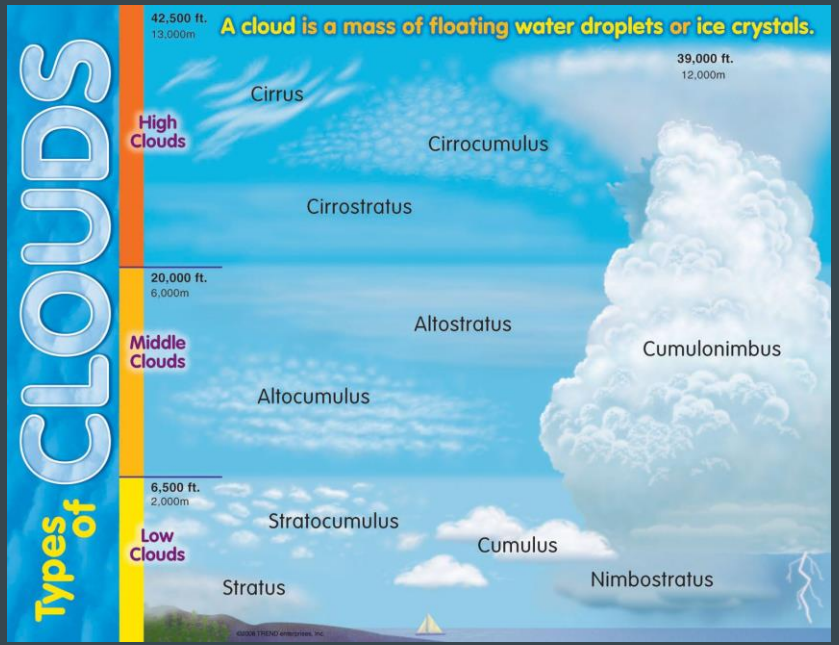
- Liquid or solid water particles that originate in clouds and become large enough to fall to the surface.
- Fire Influence
  - Fire starts
    - Lack of precip over and extended period leads to drier fuels and an increased chance of ignition, while moderate to heavy precip and extended precip will limit the chance of ignition.
  - Fire behavior
    - An Extended period of no precip will lead to active fire behavior. Moderate to heavy precip and extended precipitation will decrease fire behavior.
  - Firefighter safety
    - Moderate to heavy precipitation and extended periods of precipitation will lead to lower temps and an increased chance of hypothermia. It will also lead to poor footing.

# Precipitation and Fire Fuels

- Duration vs Amount
  - Duration > Amount impacts on fuel moisture
- Fine Fuels
  - Gain and lose moisture quickly
  - React quickly to precipitation
- Heavy Fuels
  - Gain and lose moisture slowly
  - React slowly to precipitation


# Atmospheric Stability and Instability

- Refers to the tendency of a parcel of air when it is lifted to either continue to rise or sink back down.

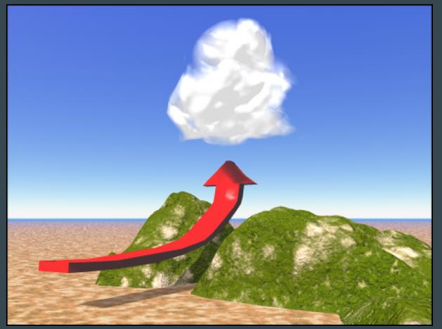



Stable Atmosphere

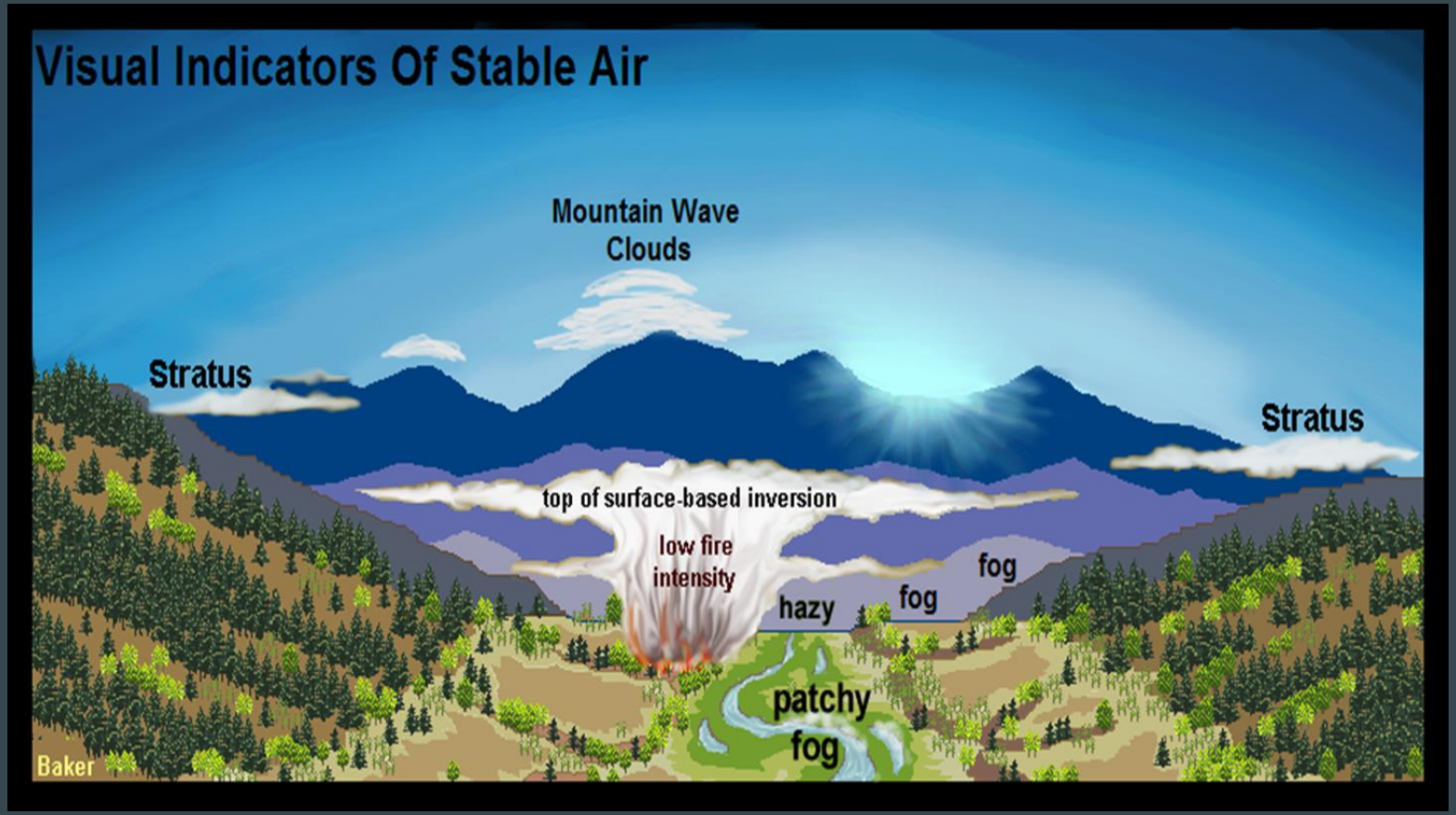
•Vertical motion is suppressed, so air displaced up or down will return to its original level

Unstable Atmosphere

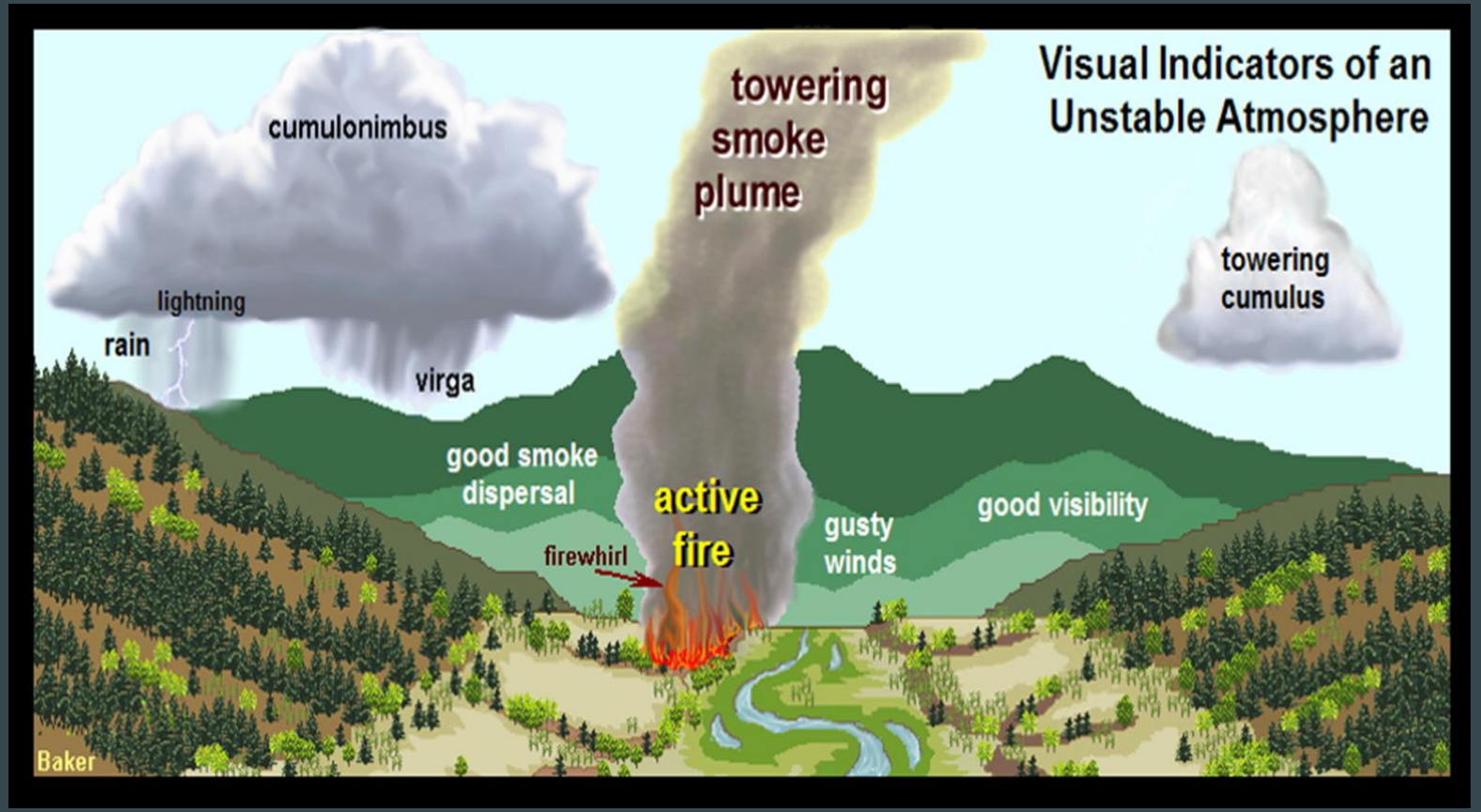
•Vertical motion is enhanced, so air displaced up or down will continue moving upward.



# Stable Atmosphere

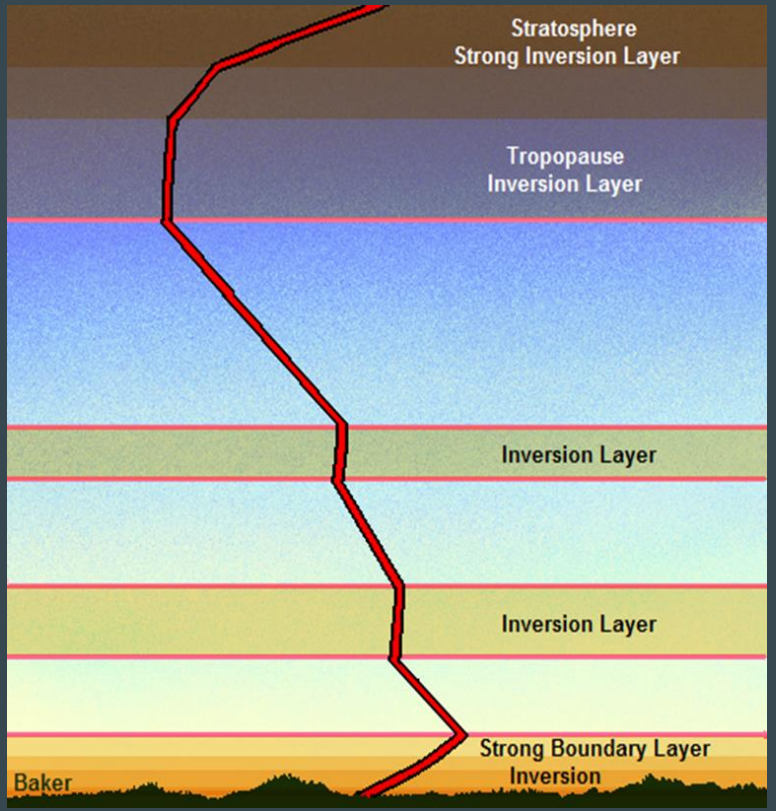


# Unstable Atmosphere



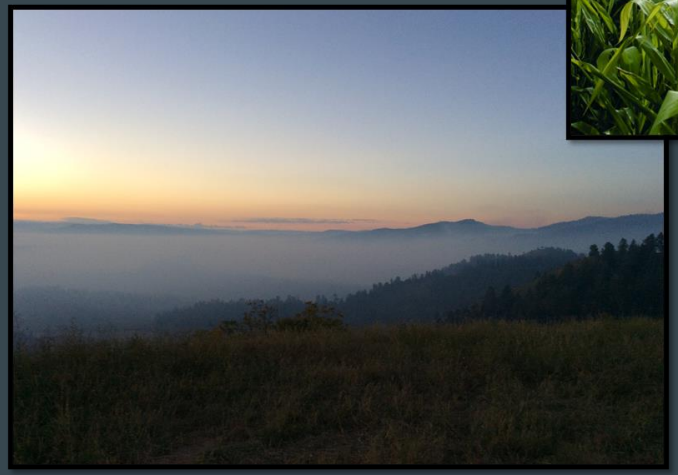
# Stability and Atmospheric Inversions

- Layer of very stable air in which temperatures increase with height.
- Acts as a cap or a lid to limit rising motion of air.
- Limits fire behavior.
- Inversion break can lead to rapid changes in the air mass below the inversion line.



# Stability Throughout the Day

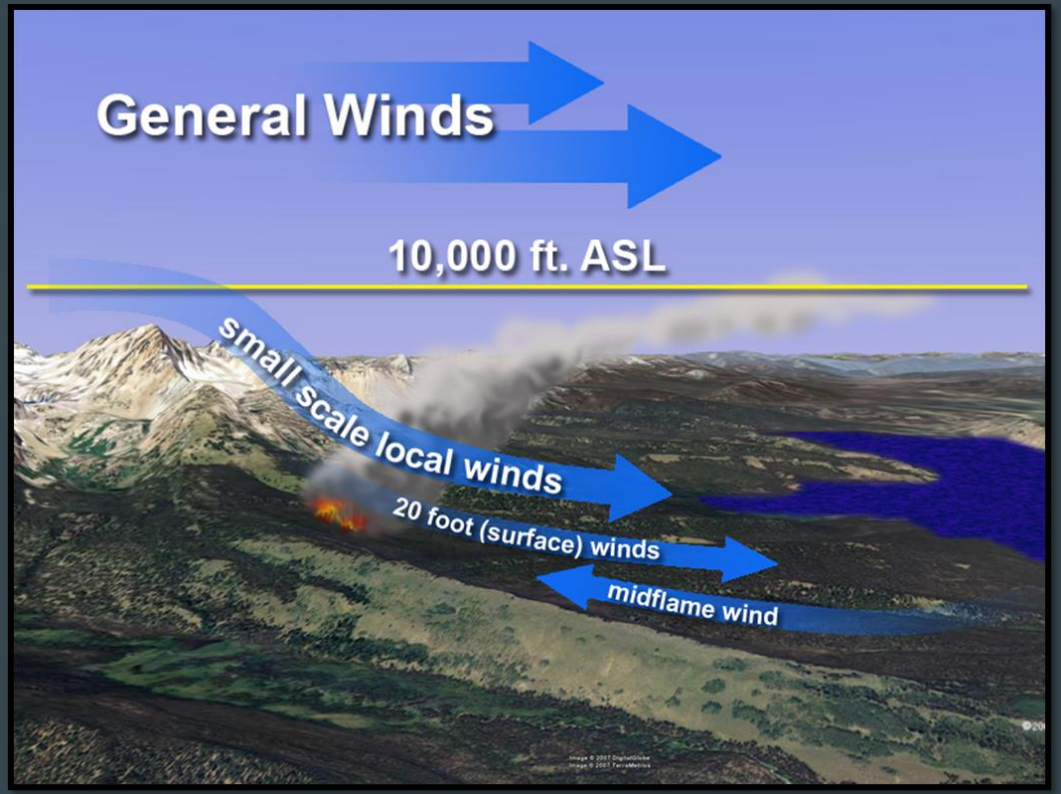
Day: often *unstable* due to strong surface heating



Night: often more *stable* due to night time inversions

# Wind

- Movement of air, the direction and speed of which is determined by:
  - Distribution of pressure centers
  - Local topography
  - Geography
- Wind is the most difficult weather variable to forecast
- Once a fire is ignited, wind is the most important weather variable governing fire behavior.
- Wind gusts and/or sudden changes in direction are responsible for most prescribed fire escapes.

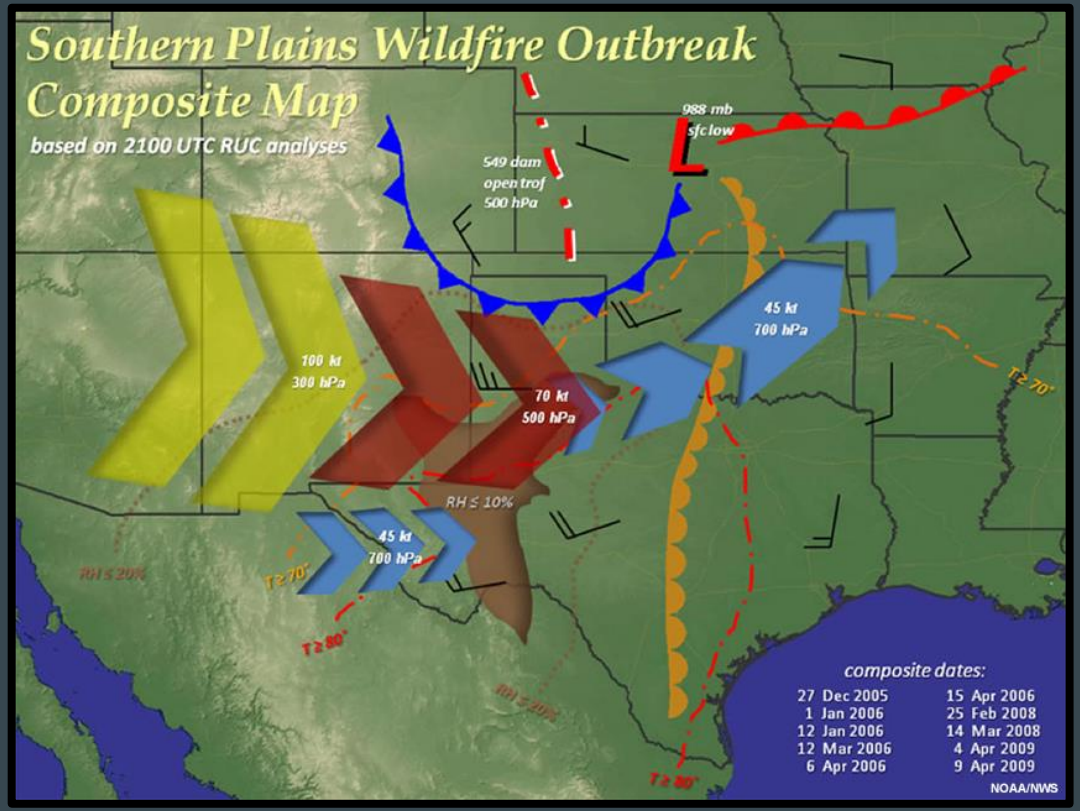


# Scale of Winds

- General Winds: higher in the atmosphere, not influenced by friction
  - Jet stream / low level jet
  - Free Winds / Ridgetop Winds / 10,000 ft Winds (Found in Forecasts)
- Local Winds: close to the surface and thermally driven
  - Diurnal / Slope - Valley
  - Land - Sea Breeze
- Critical Winds: dominate the fire environment
  - Mountain Waves
  - Frontal Passages
  - Thunderstorms and Convective Smoke Columns

# Fire Weather Patterns Across America

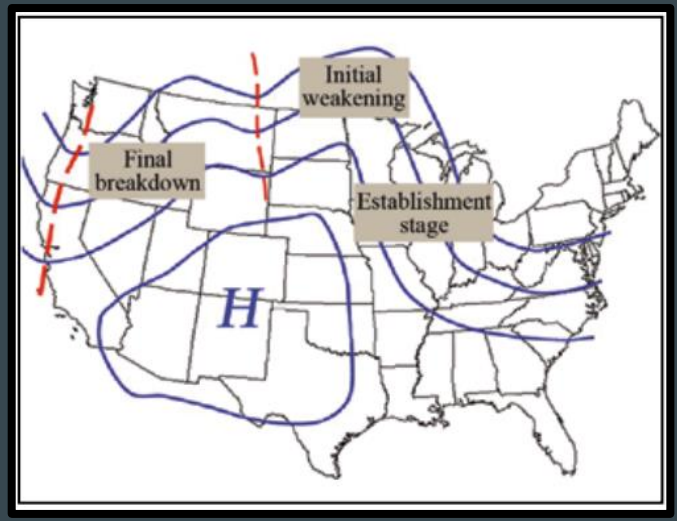
# Common Fire Weather Patterns



# Breakdown of 4-Corners High Pressure

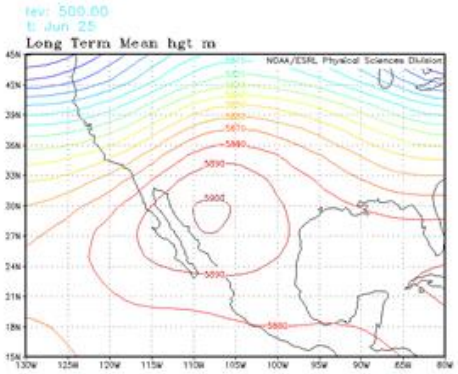
Breakdown of Upper Ridge and Cold Frontal Passage

- Stage 1 - warm,dry, breezy and unstable conditions.
- Stage 2 - wind speeds will increase while conditions remain warm-dry and unstable.
- Stage 3 - defined by a cold frontal passage.
    - Sometimes results in dry thunderstorms across the Great Basin. Can lead to widespread fire outbreaks. Strong winds behind the front worsens the situation.

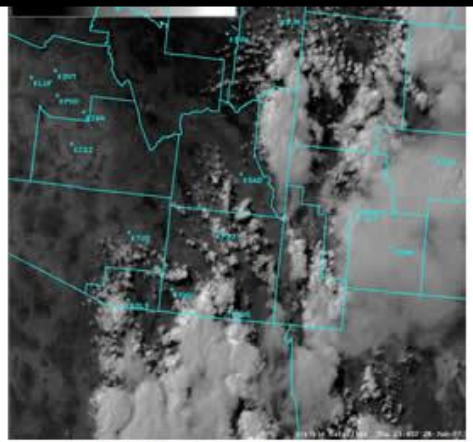


# Early Monsoon Moisture Surges - Southwest Fire Weather

Early season surges of moisture in June when fuels are still dry. Can lead to new fire starts in the Southwest.

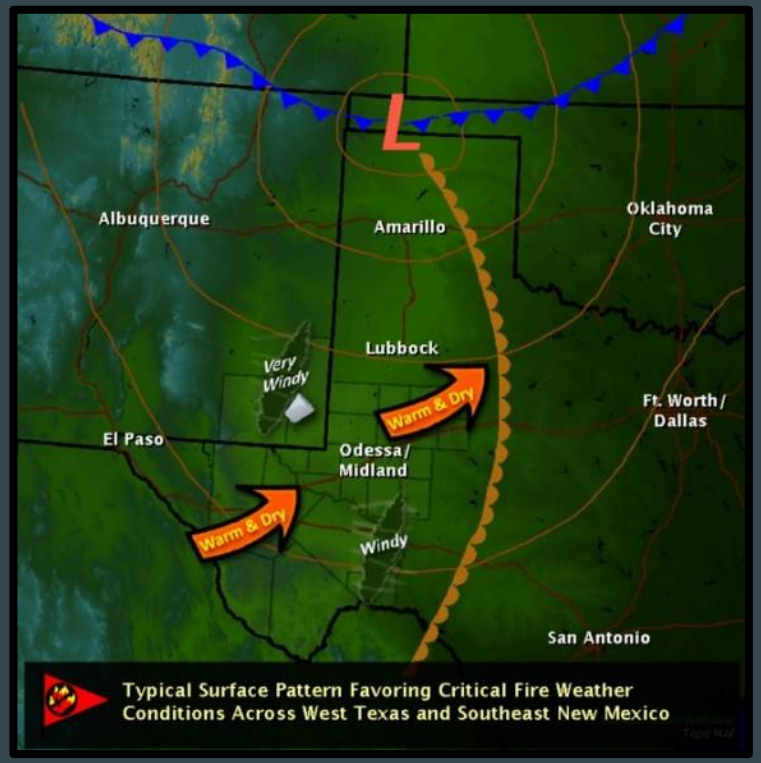


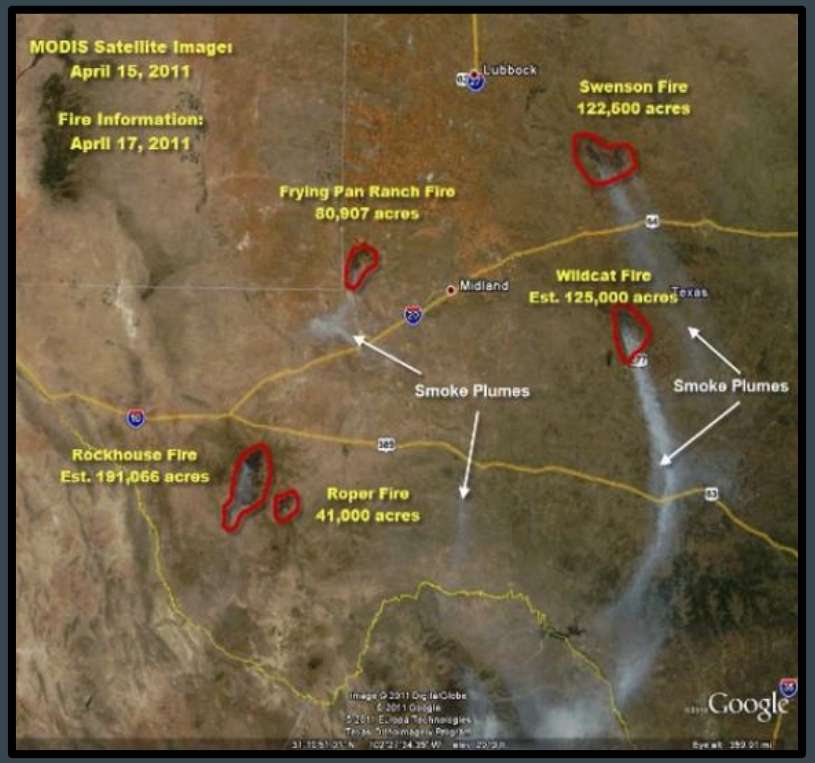

Mean 500mb heights, June 25 (monsoon ramp up)
Click image for larger version



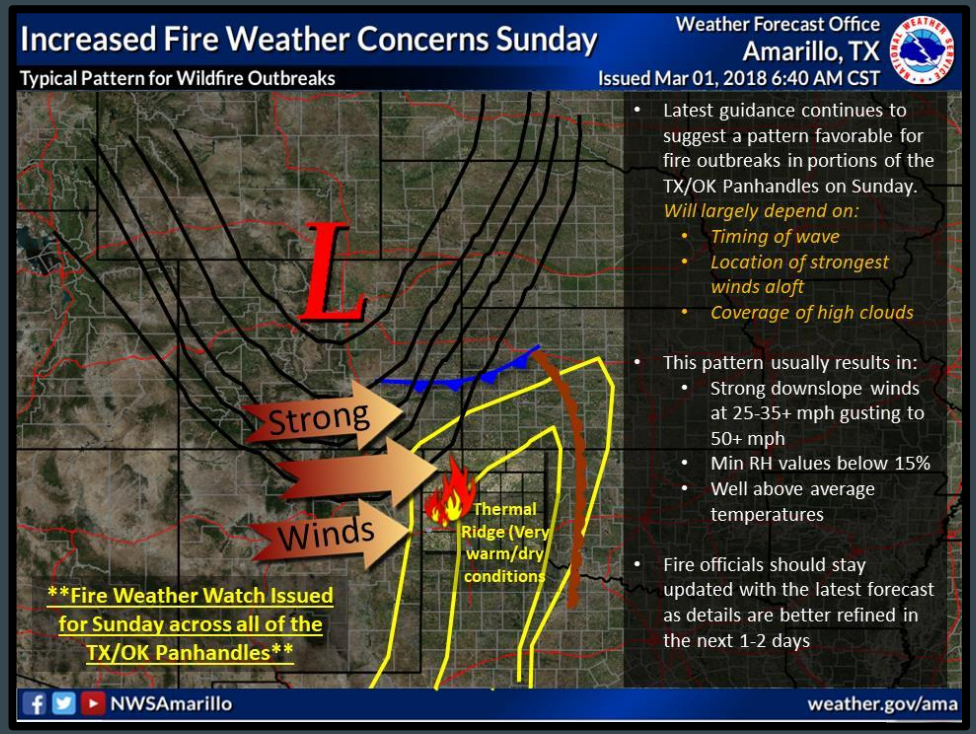
Visible satellite image of isolated thunderstorms during monsoon ramp-up, June 28, 2007

# Cold Frontal Passages and Fire Danger



# Cold Frontal Passages and Fire Danger

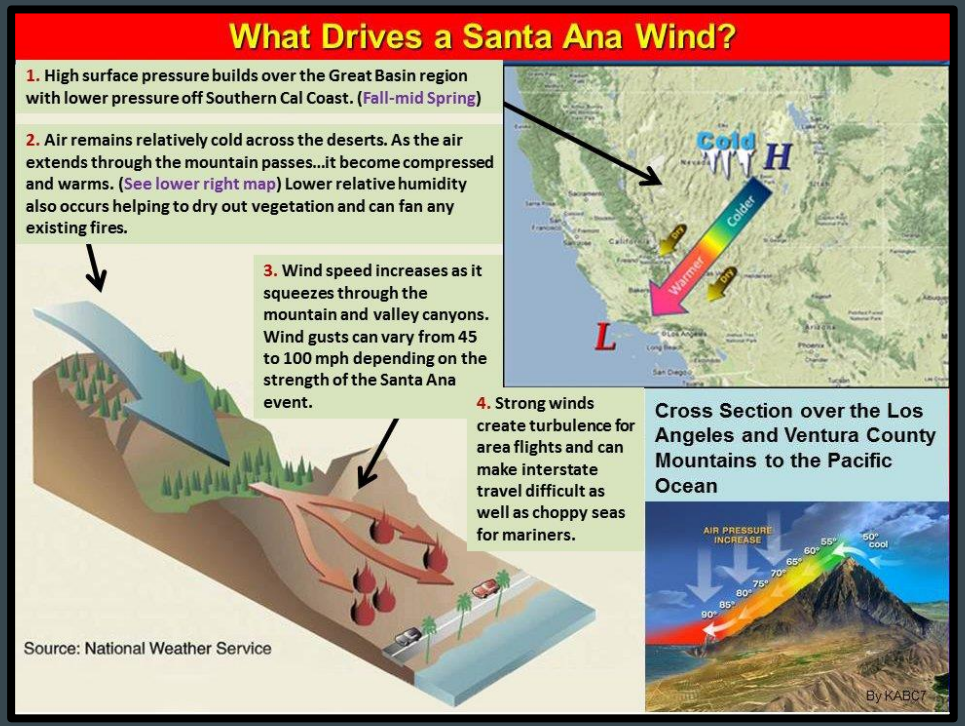


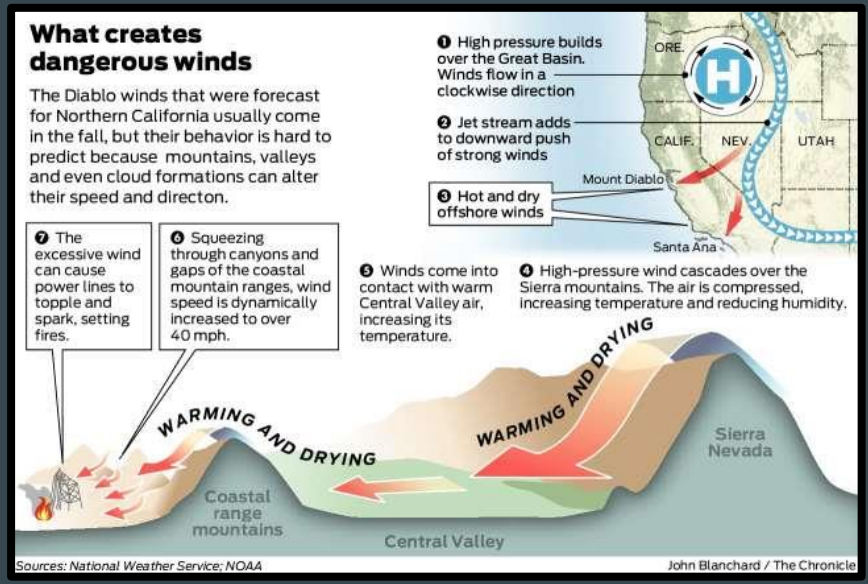

# Downslope Winds

Types

- Santa Ana and Diablo Winds
- Mountain Wave Winds
  - Occur over mountainous terrain. Ex: Sierra Nevadas and throughout Montana and Colorado

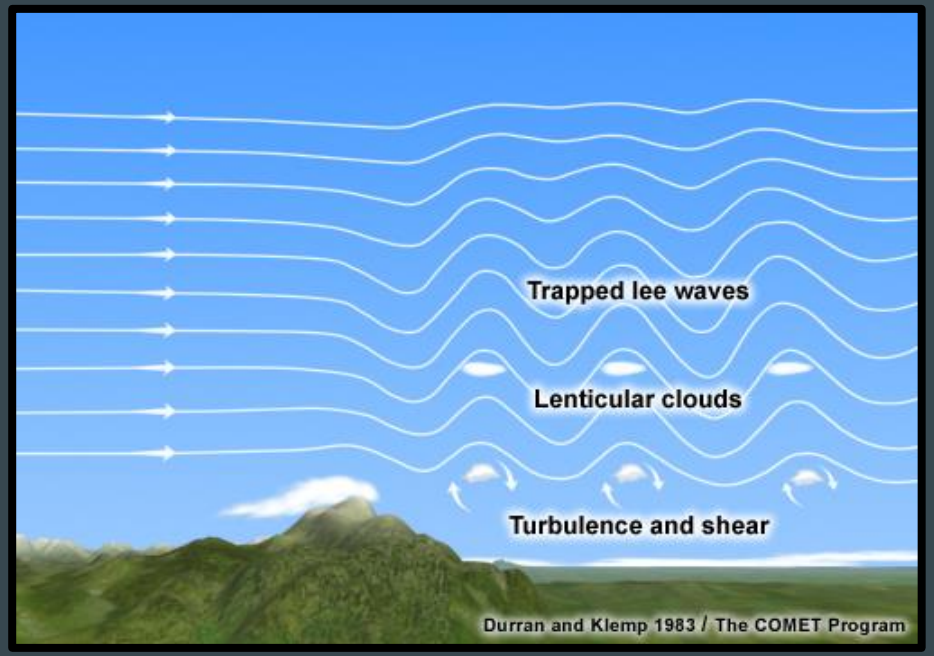
# Diablo and Santa Ana Winds



# Sierra Nevada (Mountain Wave Winds)

- Different mechanism compared to Santa Ana.
- Wind forced downslope with a cap around the mountain peak.
- Wave breaking, jumps, rotor winds.
- Winds in excess of 100 mph at times, even in the valleys.
- Also common in the western high plains like Colorado and Montana.

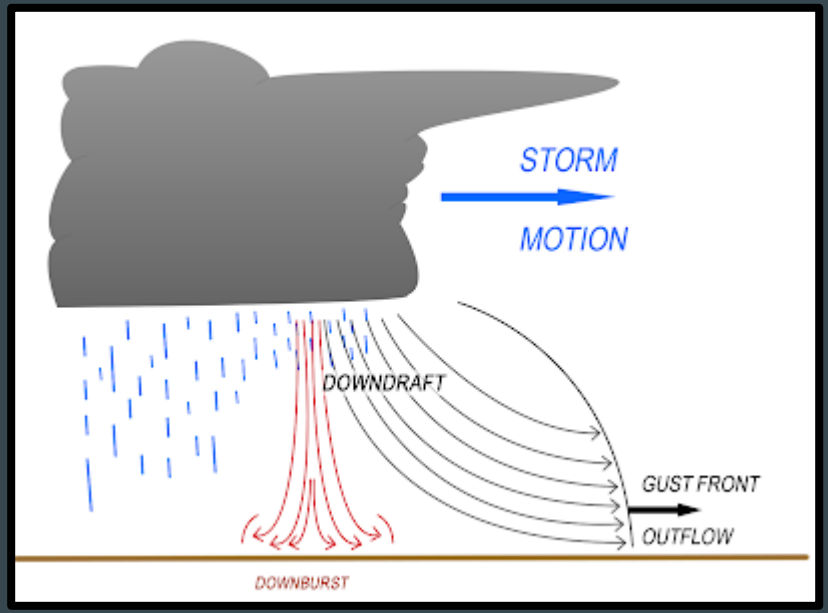


# Sierra Nevada Downslope Windstorm

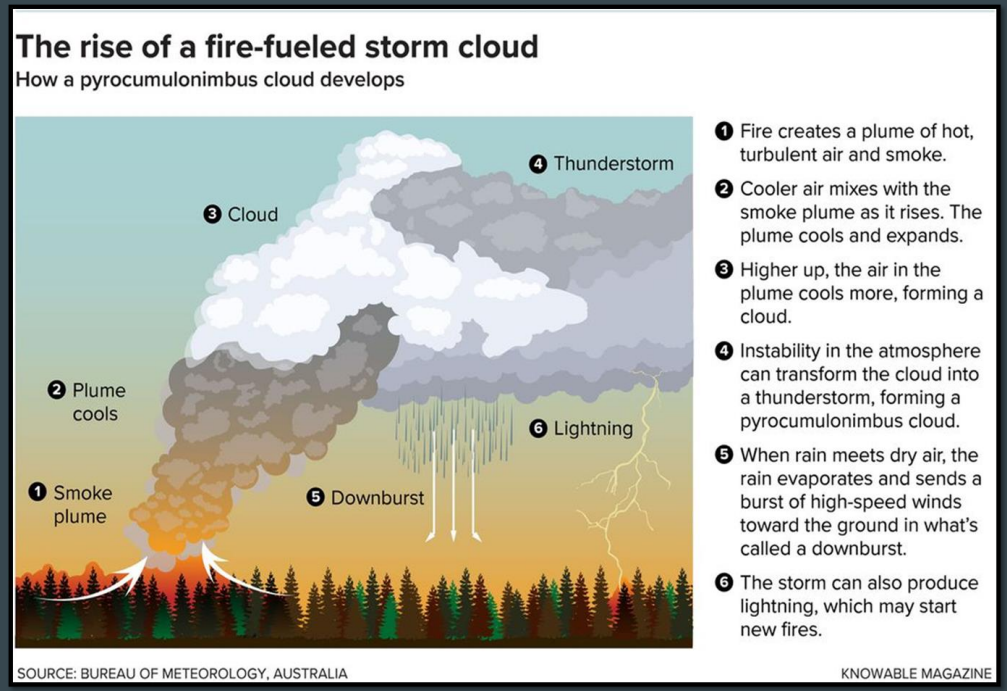
- Occurred in November in a downslope windstorm.
- Numerous wind gusts over 60 mph in the Reno area.
- Higher gusts 80+mph higher elevations.
- Fires spread rapidly in the wind.

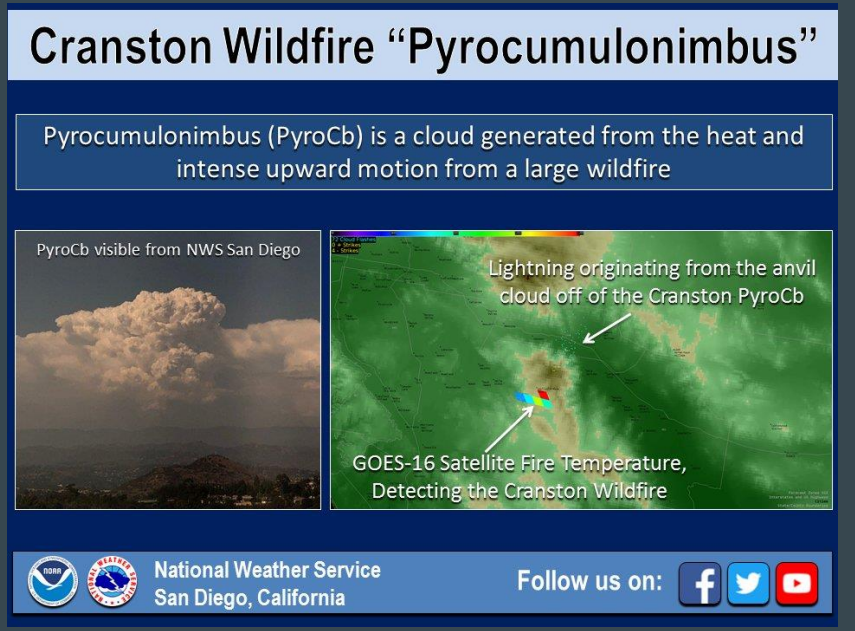
# Thunderstorms

- Gust fronts and microbursts - strong, gusty, and erratic winds
- Lightning which can lead to new fire starts
- Heavy rain and debris flows
- Complicate firefighting efforts



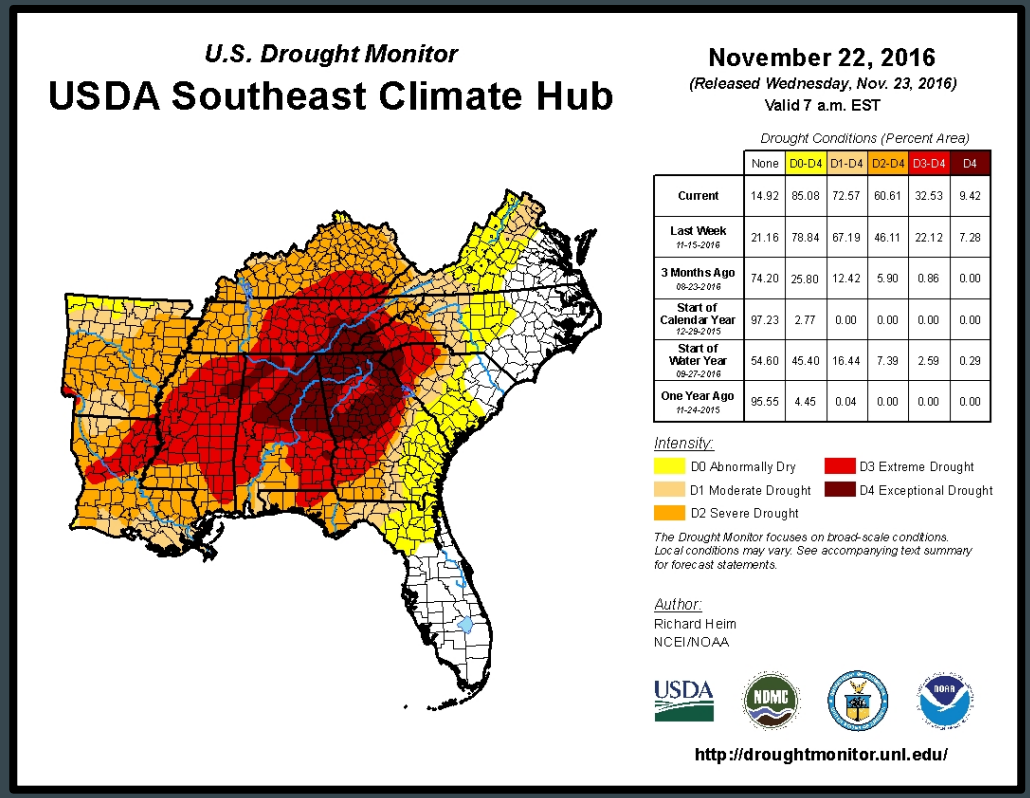
# PyroCB - Column collapse - Lightning



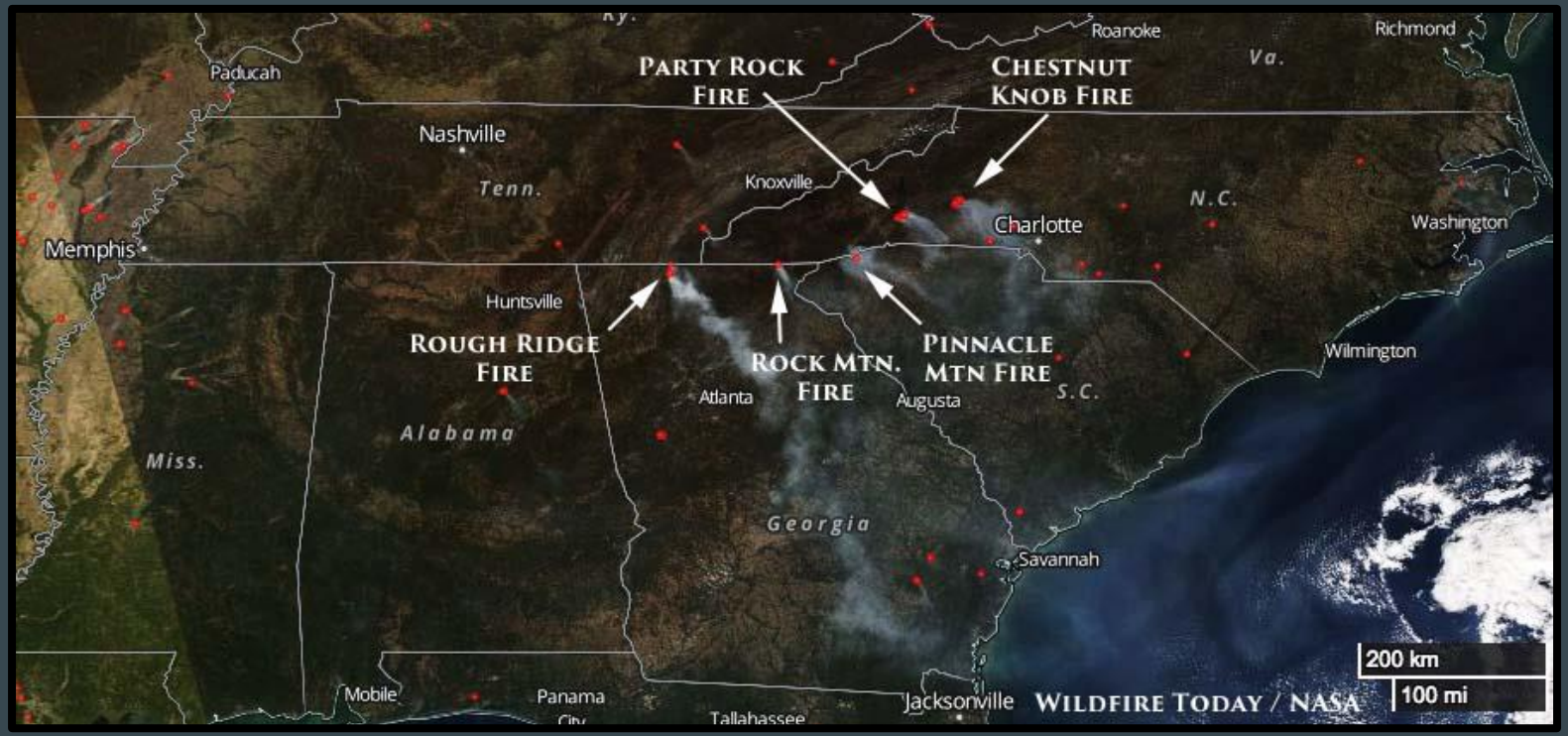



# Drought

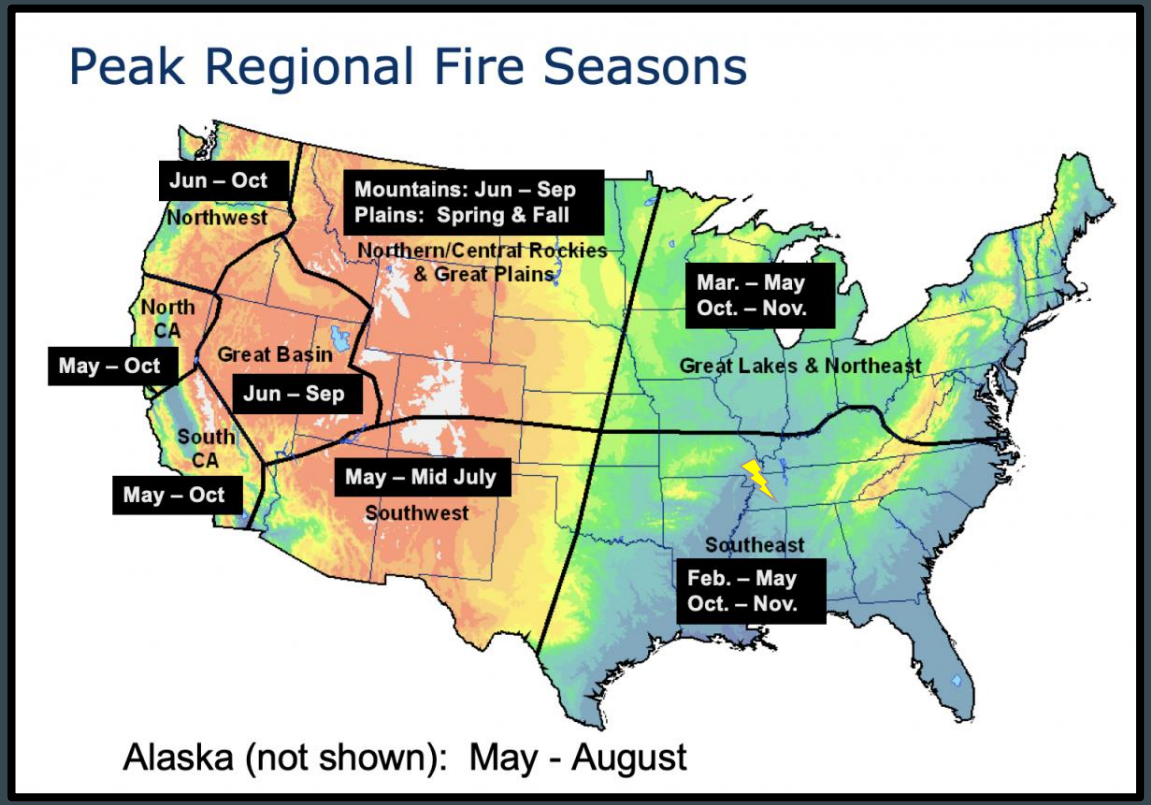
- Can kill trees.
- Worsen beetle/disease kill.
- Stress vegetation.
- Can set the stage for other regions of the US to see wildfires, like the 2016 southern Appalachian Wildfires.



# Drought - 2016 Southern Appalachian Wildfires



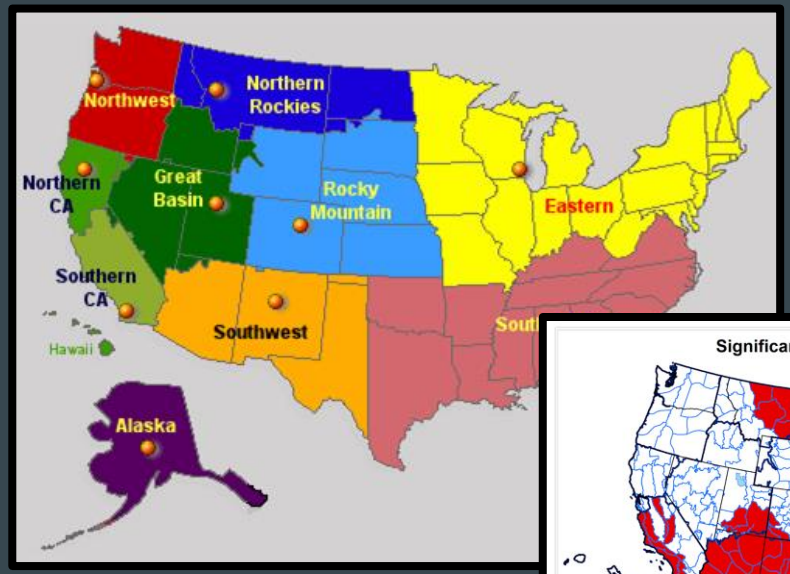
# Fire Weather Season Where You Live

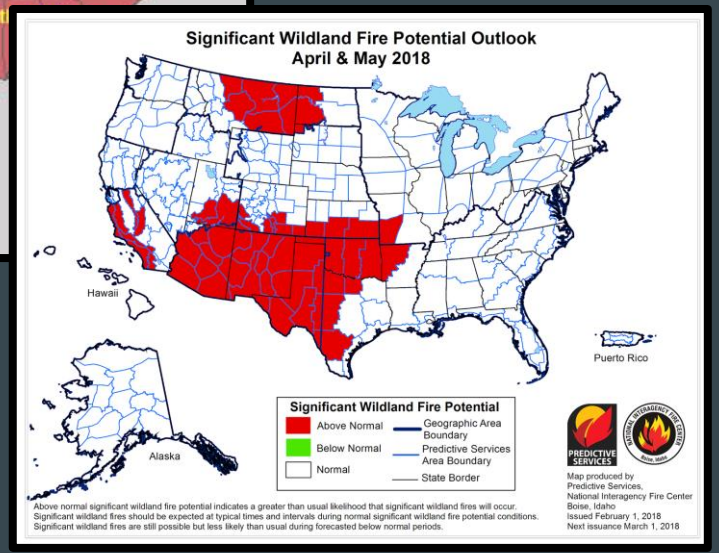


# Fire Weather Forecast Products

# Fire Weather Products and Services

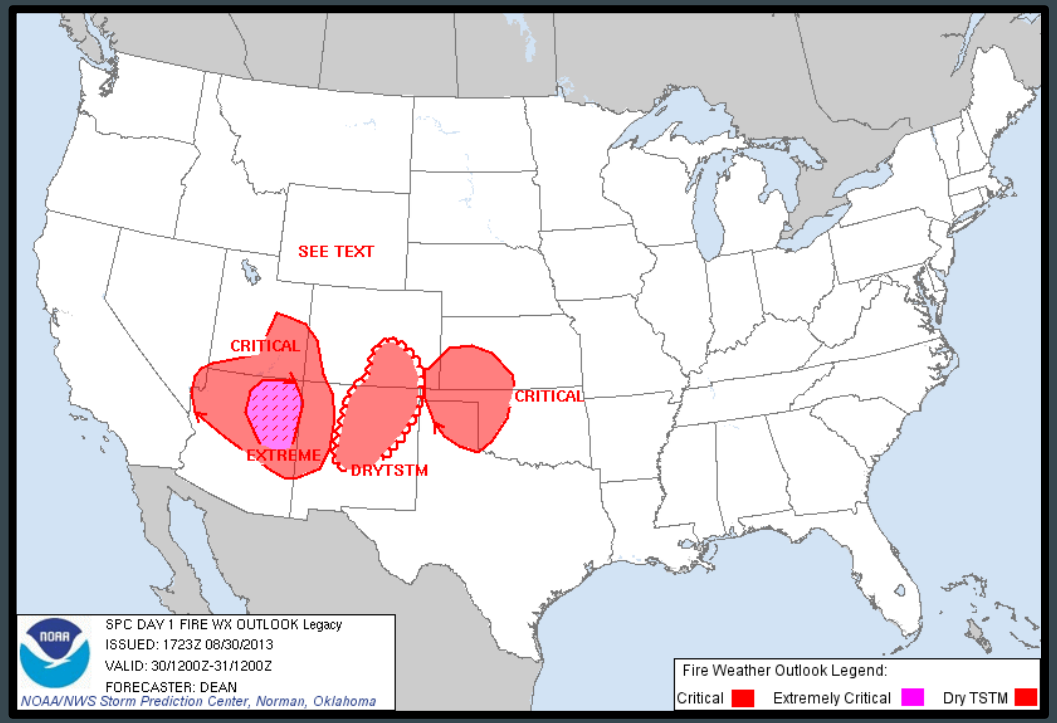
- National Weather Service
  - Local NWS Offices
  - Storm Prediction Center
- Predictive Services
  - Geographical Coordination Centers
  - Government/State Partners
    - USFS
    - BLM
    - BIA
    - Many more



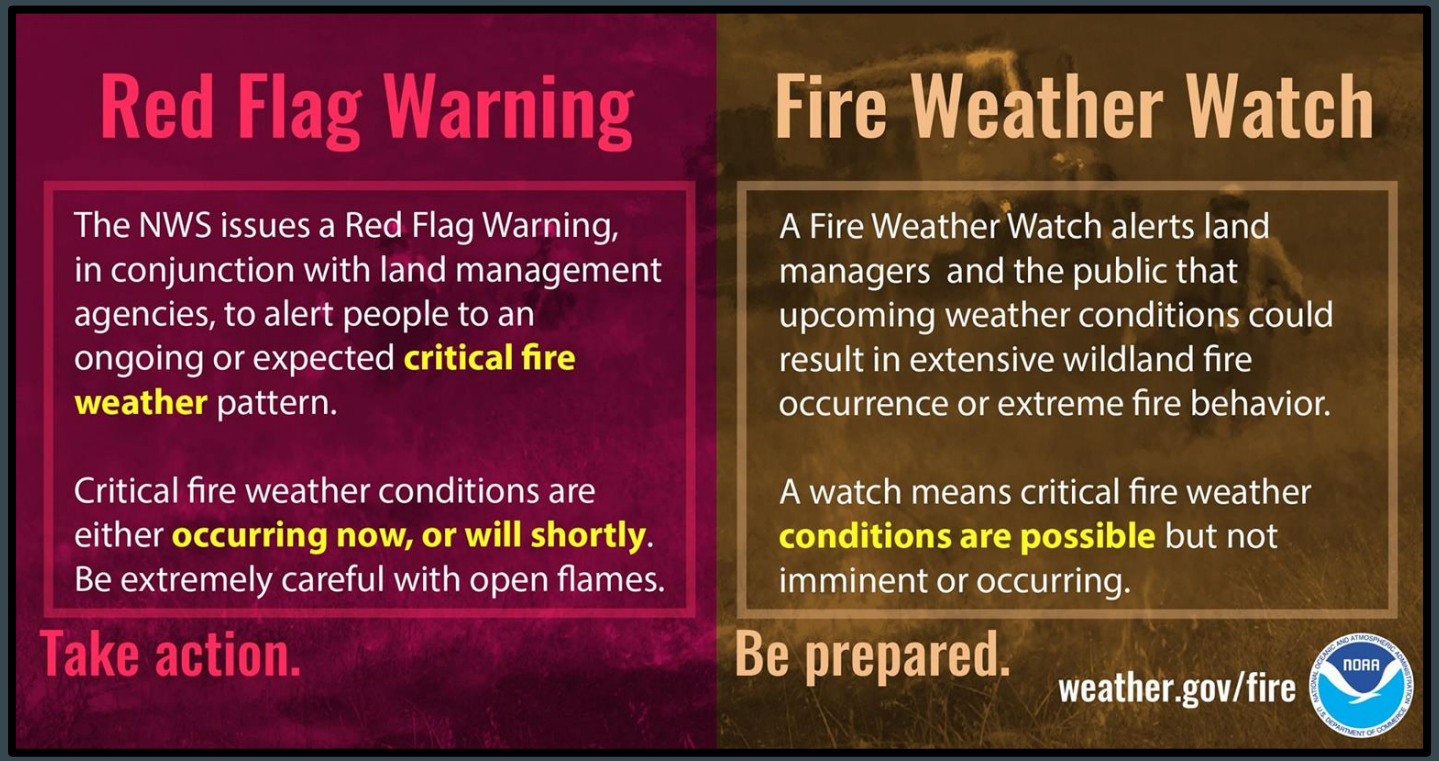



# Storm Prediction Center

- Fire Weather Outlook
  - Near-term (Days 1-3) situational awareness



# Fire Weather Watch and Red Flag Warning



# NWS Spot Weather

- Specialized for each office and region, but same look/feel.
- Detailed weather forecast for fire personnel.
- Can be used for many disaster types or for events.

```
Spot Forecast for Peeled Dogwood...USDA Forest Service
National Weather Service Jackson, KY
1004 AM EST Mon Nov 16 2020

Forecast is based on forecast start time of 1000 EST on November 16.
If conditions become unrepresentative...contact the National Weather
Service.

.DISCUSSION... Plenty of sunshine will allow drier air to mix
down from aloft this afternoon, leading to min rh near 25 percent
for the wildfire. Sustained winds should remain less than 10 mph,
however a few gusts to near 15 mph are expected between 1400 and
1600. A cold front will approach the area tonight, and drop south
of the commonwealth on Tuesday. High pressure building into the
area behind the front will usher in a colder airmass for Tuesday
on gusty west to northwest winds. However, with colder
temperatures expected, rh should not be as low on Tuesday. Dry
weather will continue through the week.

.REST OF TODAY...

Sky/weather.........Sunny.
Chance of pcpn......0 percent.
LAL.................1.
Max temperature.....Around 56.
Min humidity........25 percent.
Dewpoint............Around 31 decreasing to around 23 in the
                    afternoon.
Wind (20 ft)........West to southwest 4 to 8 mph, with gusts
                    up to 15 mph in the afternoon.
Ridgetop wind.......West to southwest 5 to 9 mph.
Mixing height.......1700-3000 ft AGL.
Transport winds.....West 12 to 15 mph.
Ventilation rate....Fair to good (22100-35200 knot-ft).
LVORI...............1.
ADI.................33 to 41 in the morning, increasing to 44
                    in the afternoon.
Haines Index........4 to 5 OR low to moderate potential
```

# Fire Weather Forecast

- Issued 1-2 times daily.
- Intendent for fire partners.
- Vary from office to office. Based on needs of fire partners in the region.
- A more generalized forecast based on a zone.
- A discussion is included, which is read over the radio to fire crews during fire season.

```
Fire Weather Planning Forecast for Southeast Arizona
National Weather Service Tucson AZ
150 PM MST Mon Nov 16 2020

++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
    20-FOOT WIND FORECAST OF `LIGHT WINDS` INDICATES MAINLY
    TERRAIN DRIVEN WINDS
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

.DISCUSSION...No fire weather concerns through the work week.
Dry weather is expected across southeast Arizona the next 7 days. A
strong warming trend will continue through Thursday, with near record
to record high temperatures Tuesday through Thursday. 20-foot winds
will be less than 15 mph through the work week, with easterly winds
into Tuesday morning then normal diurnal wind trends through Friday.
Some elevated westerly winds may occur over the weekend.

AZZ150-171415-
Arizona Fire Weather Zone 150
Sonoran FDRA-Most of Pima County-South Central Pinal County-
Tohono O`odham Nation-Tucson Metropolitan area-TDC-
150 PM MST Mon Nov 16 2020

.TONIGHT...
* Sky/Weather.............Mostly clear.
* Min Temperature.........51 to 61 degs.
*    24 hr Trend..........Up 3 to 6 degs.
* Max Humidity............24 to 34 pct.
*    24 hr Trend..........Little change.
* Wind (20 ft/10-min avg)..Southeast 10 to 15 mph.
* 10000 ft MSL Wind........South 15 to 20 mph.
* Chance of Precip.........0 pct.
* LAL.....................1.
* Haines Index............5 or moderate.
```

# Tornado Warning - Fire Tornado

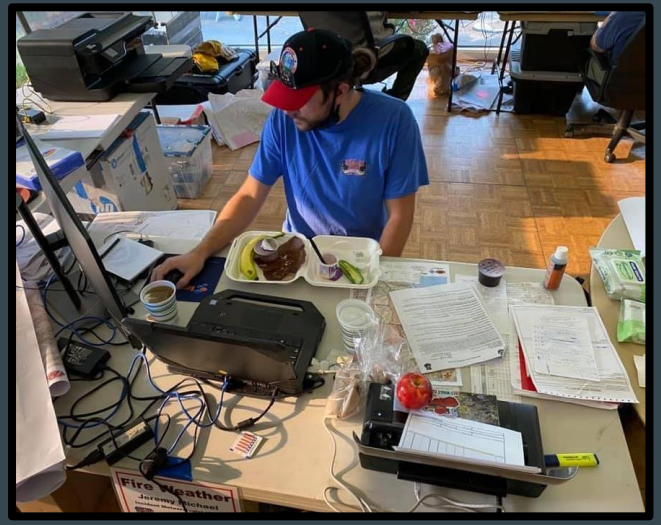
```
917
WFUS55 KREV 152135
TORREV
CAC035-152230-
/O.NEW.KREV.TO.W.0001.200815T2135Z-200815T2230Z/

BULLETIN - EAS ACTIVATION REQUESTED
Tornado Warning
National Weather Service Reno NV
235 PM PDT Sat Aug 15 2020

The National Weather Service in Reno has issued a

* Tornado Warning for...
  Southeastern Lassen County in northern California...

* Until 330 PM PDT.

* At 228 PM PDT, a pyrocumulonimbus from the Loyalton Wildfire is
  capable of producing a fire induced tornado and outflow winds in
  excess of 60 mph was located south of Chilcoot, and is nearly
  stationary.

  HAZARD...Tornado.

  SOURCE...Radar indicated rotation.

  IMPACT...Extreme fire behavior with strong outflow winds capable
           of downing trees and starting new fires. This is and
           extremely dangerous situation for fire fighters.

* This tornadic pyrocumulonimbus will remain over mainly rural areas
  of southeastern Lassen County in the vicinity of the fire.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

TAKE COVER NOW! Move to a basement or an interior room on the lowest
floor of a sturdy building. Avoid windows. If you are outdoors, in a
mobile home, or in a vehicle, move to the closest substantial shelter
and protect yourself from flying debris.

&&

LAT...LON 3975 12012 3972 12007 3970 12014 3971 12015
      3973 12015
TIME...MOT...LOC 2128Z 240DEG 0KT 3972 12013

TORNADO...RADAR INDICATED
HAIL...<.75IN

$$

WH
```

# Fire Warning

- Rarely issued.
- In coordination with local emergency managers.
- Issued when a rapidly developing and moving wildfire is threatening a town.
- Activates the warning tone alarms, similar to tornado or severe thunderstorm warnings.

# IMET Program

- Deployed to wildfires for two weeks, sometimes longer.
- Provides all weather forecast and support for the incident management team.
- Specialized training to be ready on a moments notice to deploy anywhere in the US. Even Australia when they have a busy season.




# IMET Products

***Woodward Fire Weather Forecast***

**FORECAST NO:** 20
**PREDICTION FOR:** Sunday Day/Night
**SHIFT DATE:** 9/13
**NAME OF FIRE:** Woodward
**UNIT:** CA-RNP
**SIGNED:**
Jeremy Michael
**FORECAST ISSUED:** 9/12/2020 at 1500
**Incident Meteorologist**

***WEATHER DISCUSSION:*** An area of smoke is forecast to move across the fire today. This may keep temperatures slightly cooler with an increase in moisture. Fog and stratus should still clear between 1000-1200 hours at the Bear Valley Visitor Center with clearing along the Inverness Ridge from 1200-1400 hours. This pattern will continue into early next week with a downward trend in regional smoke. By the middle to end of next week, a passing storm system will bring increased moisture and occasional drizzle as onshore flow increases.

***SUNDAY:***

**WEATHER:** Possible localized dense smoke and morning fog, clearing late morning into early afternoon.

**TEMPERATURES:** Coast: 55-62°F. Ridges/Inland: 65-75°F.

**HUMIDITY:** Coast: 80-95%. Ridges/Inland: 60-75%. Possibly dropping to 50% Ridgetops.

**20 FT WINDS:** West-northwest to northwest 4-9 mph, gusting to 15 mph.

**MARINE LAYER DEPTH/TIMING:** 900-1200 ft. Stratus/fog clearing 1000-1200 hrs. Along the Inverness Ridge possibly 1100-1300 hrs.

## Woodward Fire General Weather Outlook

See the IAP for the Official Forecast

Forecast made Sunday, Septemeber 06 - Incident Meteorologist Jeremy Michael

| *Afternoon Conditions* | MON *7-Sep* | TUE *8-Sep* | WED *9-Sep* | THU *10-Sep* | FRI *11-Sep* | SAT *12-Sep* |
|---|---|---|---|---|---|---|
| Clouds @ 1500 (%) | 10 | 30 | 40 | 45 | 60 | 70 |
| Max Temp (F) | 85 | 82 | 77 | 74 | 72 | 67 |
| Aftn Min RH (%) | 30 | 35 | 50 | 55 | 60 | 65 |
| Night 800 ft RH (%) | 30 | 45 | 70 | 80 | 100 | 100 |
| Marine Layer (ft) | 300 | 800 | 1200 | 1300 | 1400 | 1400 |
| Marine Erosion (hr) | 900 | 1000 | 1200 | 1300 | 1400 | 1400 |
| Precip Chance (%) | 0 | 0 | 0 | 0 | 0 | 0 |
| Ridge Wind (mph) | 12 | 13 | 10 | 10 | 14 | 15 |
| Wind Direction* | NW to NE | NE to NNW | WSW-W | WNW | WNW | WNW |
| LAL | 1 | 1 | 1 | 1 | 1 | 1 |

Matrix most representative for active burning areas

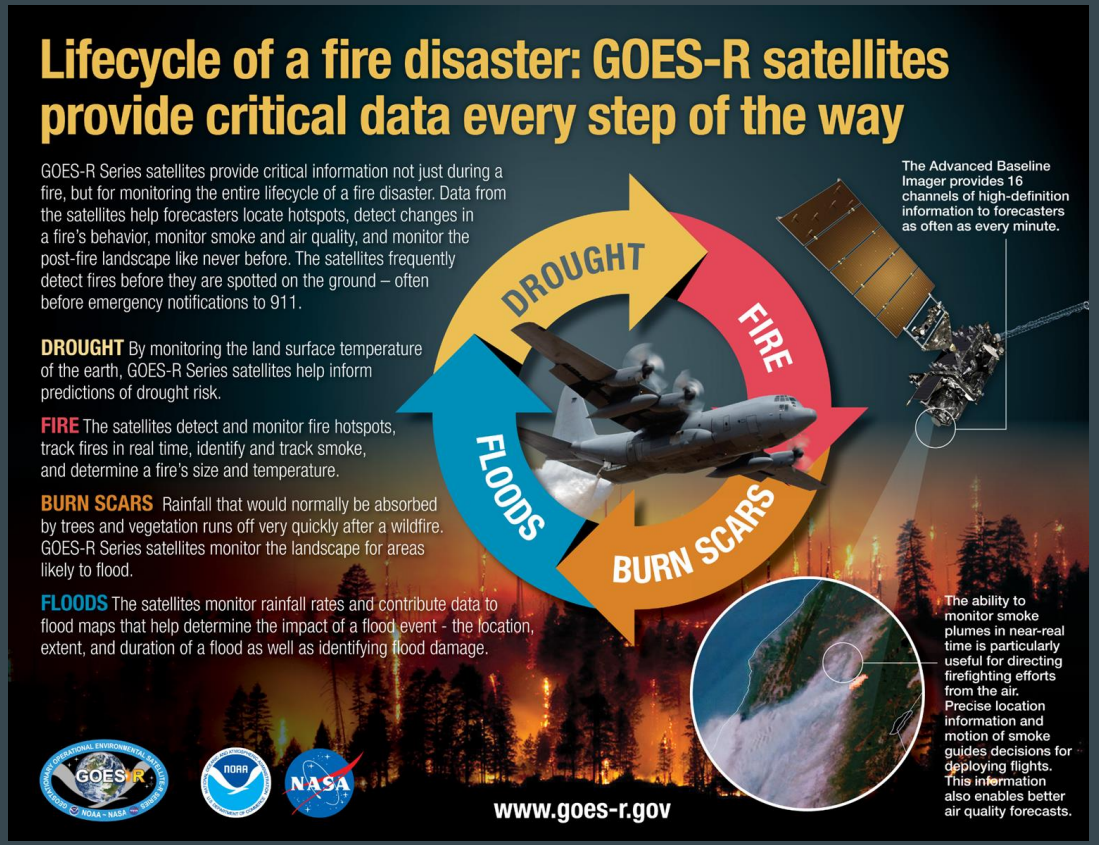
| KEY: | Moderate Burning Conditions | Elevated Burning Conditions | Extreme Burning Conditions |
|---|---|---|---|
| Clouds | > 51 % | 31 to 50 % | < 30 % |
| Avg Max Temp | < 69 F | 70 to 75 F | 76 F or warmer |
| Precip Chance | 50 % or greater | 0 to 29 % | |
| LAL | 3, 4, 5 | 2 | 6 |
| Ridge Wind | 14 mph or less | 15 to 24 mph | 25 mph or more |
| *Wind Direction | Critical wind direction highly dependent on burn operations and/or structures threatened | | |
| Min/Max Humidity | 60% or more | 40 to 59 % | 39% or less |
| Marine Depth | 1300 ft or greater | 600 ft - 1300 ft | None/500 ft or less |
| Marine Erosion | After 1300 hrs or NONE | 1100 hrs to 1300 hrs | Before 1100 hrs |

5 EXTREME blocks in a day signals potential for a Critical Weather Day

# Satellites and Fire Weather Monitoring

# Satellite Data

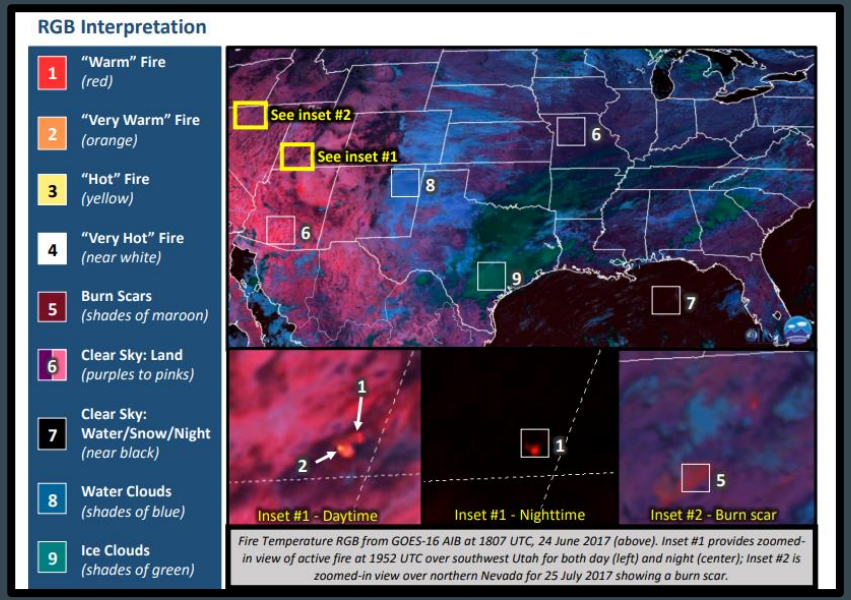
- GOES satellite can show images every 30-60 seconds.
- Can detect fires as small as 15 acres
- VIIRS satellite offers high resolution images
- GOES Fire Channels
  - Fire Temperature
  - Fire/Hot Spot Characterization
  - Day Land Cloud Fire
  - Shortwave Infrared



# Poll Question

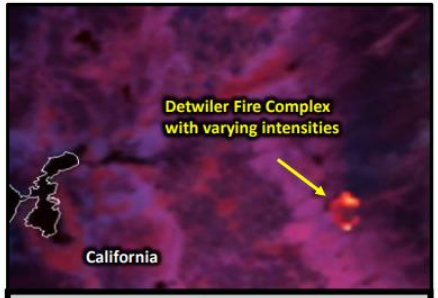
On average, how big does a fire have to be before GOES-16 or GOES 17 can detect?

# Fire Temperature RGB




## Why is the Fire Temperature RGB imagery Important?

This RGB allows the user to identify where the most intense fires are occurring and differentiate these from "cooler" fires. The RGB takes advantage of the fact that from 3.9 µm to shorter wavelengths, background solar radiation and surface reflectance increases. This means that fires need to be more intense in order to be detected by the 2.2 and 1.6 µm bands, as more intense fires emit more radiation at these wavelengths. Therefore, small/"cool" fires will only show up at 3.9 µm and appear red while increases in fire intensity cause greater contributions of the other channels resulting in white very intense fires.



*Fire Temperature RGB from GOES-16 on 19 July 2017 at 1957 UTC*

## Fire Temperature RGB Recipe

| Color | Band / Band Diff. (µm) | Min – Max Gamma | Physically Relates to… | Small contribution to pixel indicates… | Large Contribution to pixel indicates… (saturated) |
|---|---|---|---|---|---|
| Red | 3.9 | 0 to 60 C 0.4 | Cloud top phase and temperature | Cold land surfaces, water, snow, clouds | Hot land surface, (Low fire temperature) |
| Green | 2.2 | 0 to 100 % 1 | Particle size / land type | Large ice/water particles, snow, oceans | Small ice/water particles, (Medium fire temperature) |
| Blue | 1.6 | 0 to 75 % 1 | Particle size / land type | Ice clouds with large particles, snow, oceans | Water clouds, (High fire temperature) |

## Impact on Operations

**Primary Application**

**Fire hotspot locations are detected:** The saturation brightness temperature of the shortwave-IR 3.9 µm channel is low, around 500 K (i.e. relatively low intensity fire). Therefore, "hotspots" of wild fires look red in RGB.

**Fire intensity can be analyzed:** High intensity fires are near a maximum of 1400 K and this is near the peak emission detection (i.e. saturation) of the 1.6 µm channel. Therefore, active fires in the RGB transition from red to yellow to white as intensity increases and near-IR channels become saturated.

## Limitations

**Cloud cover blocks view of fire:** The fires will only be visible in the RGB in clear sky areas.

**Cloud features/type have less details:** While water vs. ice clouds can be identified, other RGB products are better at displaying cloud features.

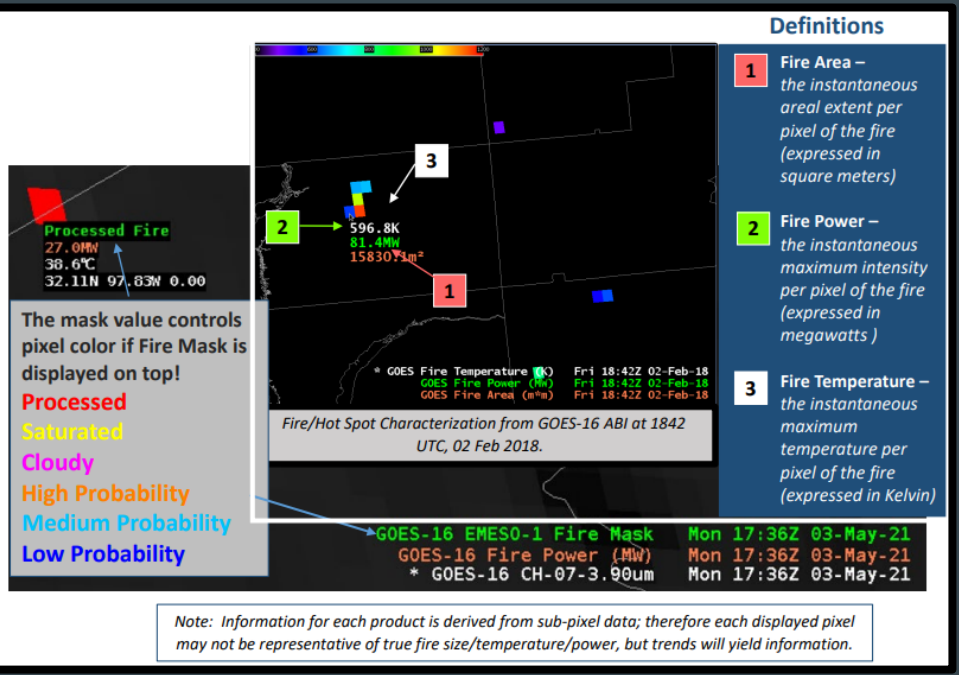
**Daytime only application for clouds:** The reflectance from clouds are not available at night in the near-IR bands used in the RGB.

**False "red" fires due to land type:** Some surfaces in arid, dry regions are highly emissive at 3.9 µm and will appear red but they are not on fire.

Contributor: NASA SPoRT https://weather.msfc.nasa.gov/sport/

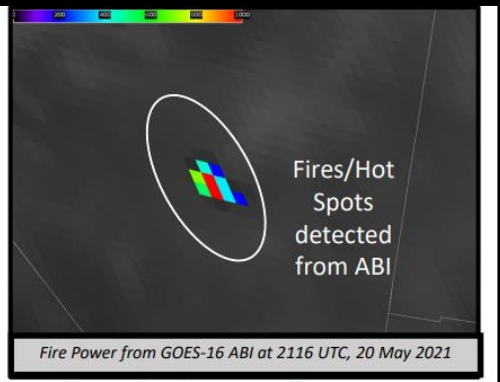
SPORT

# Fire/Hot Spot Characterization




## Why is the Fire/Hot Spot Characterization important?

The GOES-R Fire/Hot Spot Characterization consists of Fire Area, Fire Power and Fire Temperature products, along with Product Flags. Use these products that exploit the excellent spatial and temporal resolution of ABI to monitor wildfires and how they change. The Fire/Hot Spot Characterization relies on different sensitivities in Band 7 (3.9 µm) and Band 14 (11.2 µm) to high-temperature anomalies from fires allowing the detection of fires and their characteristics such as size, temperature, and intensity. Product flags ('Fire Mask') from the algorithm are included to help forecasters interpret the output.



*Fire Power from GOES-16 ABI at 2116 UTC, 20 May 2021*

## How is the Fire/Hot Spot Characterization created?

| ABI Band | Wavelength (µm) | Band Usage |
|---|---|---|
| 2 | 0.64 | Cloud identification and solar contamination reduction (when available) |
| 7 | 3.9 | Brightness temperature anomaly and cloud detection (required) |
| 14 | 11.2 | Brightness temperature anomaly and cloud detection (required) |
| 15 | 12.3 | Opaque cloud identification (when available) |

## Impact on Operations

**Primary Application**

**Fire Detection:** Provides information on fires/hot spots based on comparative differences between high temperature anomalies between the 3.9 µm ABI channel and 11.2 µm ABI channels. This product is based on IR channel information, and therefore available day or night.

**Fire Characteristics:** In addition to location, fire characteristics are provided such as fire size (based on detected fire pixels), fire temperature, and the radiative power (intensity) of the fire. These properties coupled with the high temporal refresh of GOES-R also aid in the tracking of fires in real time.

**Mask Flags:** The algorithm outputs fire detection characteristics as described on the next page. This gives a measure of detection confidence.

## Limitations

**Clear vs. Obscured Sky:** Performs best under clear-sky conditions. Undetected cloud or smoke contamination affects fire detection and characterization.

**Satellite Viewing Angle:** Fire detection performance decreases with increasing viewing angle/pixel size. Fire detection and characterization is limited to satellite viewing angles ≤ 80°.

**Very Small Fires may be missed:** A smoke plume may be visible before the fire grows hot enough to be detected.

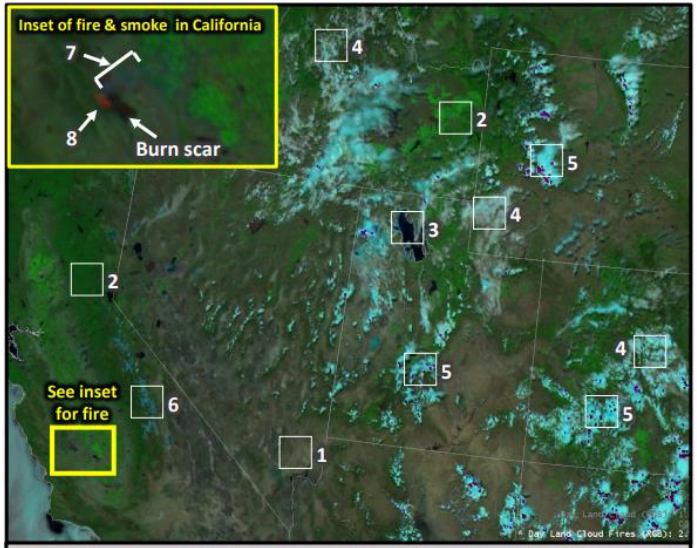
**Fire Detection Pixels:** Detection pixels are only shown for a portion of the detected fire. Data range restrictions and saturated fire pixels (hottest fires) preclude the assignment of fire properties to these pixels: entire hot spots apparent in Band 7 may not appear in the fire/hot spot product.

# Day Land Cloud Fire RBG

## RGB Interpretation

1. **Inactive vegetation or bare land** *(Olive green to browns)*
2. **Vegetation** *(shades of green)*
3. **Water bodies or flooded areas** *(dark blue to black)*
4. **Low/Mid clouds** *(gray shades of cyan)*
5. **High, thick ice clouds** *(bright cyan)*
6. **Snow** *(cyan)*
7. *Smoke (dark cyan)*
8. **Hotspot, Fire** *(red)*

*Note:, colors may vary diurnally, seasonally, and latitudinally*




*Day Land Cloud Fire RBG from GOES-16 ABI for 1822 UTC on 14 July 2017 centered over the western CONUS. An inset is provided to highlight the fire and smoke event in southern California. Note that the RGB has "noise" within convective clouds where the reflectance is greater than 1, (to be corrected).*

## Why is the Day Land Cloud/Fire RGB Imagery Important?

This RGB is similar to the original Natural Color RGB by EUMETSAT except the 1.6 µm band used in the red component is replaced with the 2.2 µm band. This change highlights the fire hotspots with a red pixel color, but also changes the interpretation of the water vs. ice clouds. For the 2.2 µm band, water clouds are less reflective than the 1.6 µm band, resulting in both water and ice clouds having cyan coloring, except for very small cloud particles. Thus, the change limits the use of the RGB for differentiating water vs ice clouds. Land/Ocean surfaces are in expected colors (but not true color).


*DLC/Fire RGB from GOES-16 center on southwest Utah*

## Day Land Cloud/Fire RGB Recipe

| Color | Band / Band Diff. (µm) | Min – Max Gamma | Physically Relates to… | Small contribution to pixel indicates… | Large contribution to pixel indicates… |
|---|---|---|---|---|---|
| Red | 2.2 | 0 -100 %, 1 | Particle size / land type | Large water/ice particles, water or snow | Small water/ice particles, hotspot |
| Green | 0.86 | 0 -100 %, 1 | Reflectance | Thin cloud, water, less green vegetation, bare soil | Thick cloud, highly vegetated, snow, desert |
| Blue | 0.64 | 0 -100 %, 1 | Reflectance | Thin cloud, water, Forest, bare soil | Thick cloud, snow, desert |

## Impact on Operations

**Primary Application**

**Surface and atmospheric features:** fire hotspots, smoke, burn scars, snow/ice cover

**High ice clouds, snow, and sea ice are cyan:** These features appear cyan because ice strongly absorbs in the near-IR 2.2 µm band, leading to little red contribution.

**Low water clouds are gray to dull white:** Water clouds with small droplets (i.e. fog) have a high reflectance in all three bands.

**Natural color surfaces:** Identify dark blue to black water bodies, green vegetation, and brown deserts.

## Limitations


**Daytime only application:** the RGB relies on solar reflectance from visible and near-IR channels.

**Less ice/water contrast than 1.6 µm:** The 2.2 µm reflectance of medium to large cloud particles is very similar, which results in less contrast of water and ice clouds and provides more overall cyan coloring to the scene. Suggest the use of a separate RGB when primarily interested in cloud phase information.

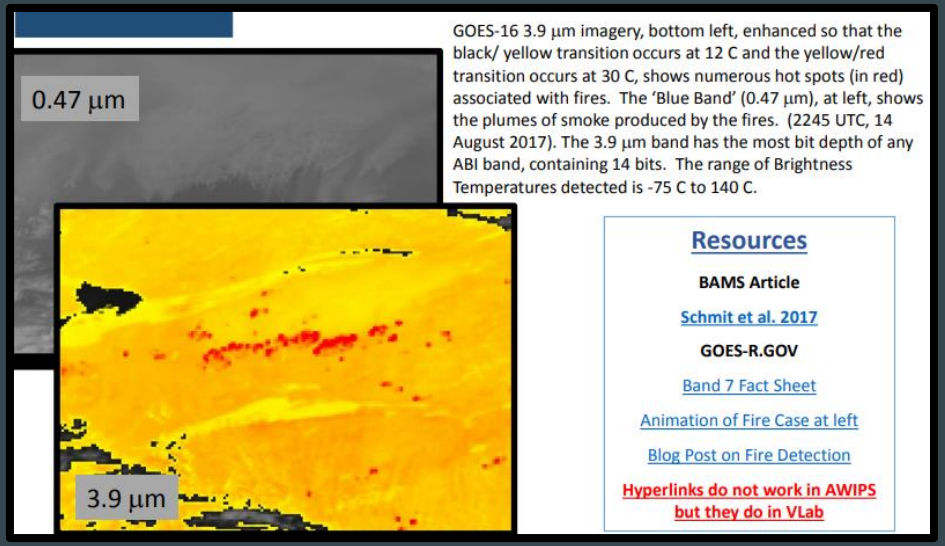
**Distinguishing snow and high ice clouds:** Both snow and ice clouds are bright cyan in the RGB, but geographic features may help identify snow.

**Dust appears similar color as bare land**

Contributor: Dr. Emily Berndt NASA SPoRT https://weather.msfc.nasa.gov/sport/

SPORT

# Shortwave Infrared




GOES-16 3.9 µm imagery, bottom left, enhanced so that the black/ yellow transition occurs at 12 C and the yellow/red transition occurs at 30 C, shows numerous hot spots (in red) associated with fires. The 'Blue Band' (0.47 µm), at left, shows the plumes of smoke produced by the fires. (2245 UTC, 14 August 2017). The 3.9 µm band has the most bit depth of any ABI band, containing 14 bits. The range of Brightness Temperatures detected is -75 C to 140 C.

## Resources

**BAMS Article**

Schmit et al. 2017

**GOES-R.GOV**

Band 7 Fact Sheet

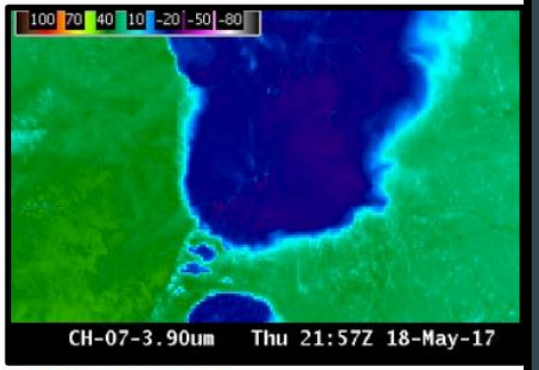
Animation of Fire Case at left

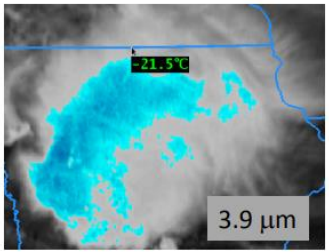
Blog Post on Fire Detection

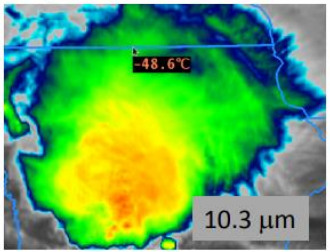
**Hyperlinks do not work in AWIPS but they do in VLab**

## Why is the Shortwave Infrared Band Important?

The 3.9 µm band can be used to identify fog and low clouds at night, identify fire hot spots, detect volcanic ash, estimate sea-surface temperatures, and discriminate between ice crystal sizes during the day. Low-level atmospheric vector winds can be estimated with this band, and the band can be used to study urban heat islands. The 3.9 µm is unique among ABI bands because it senses both emitted terrestrial radiation as well as significant reflected solar radiation during the day.




The daytime imagery at left shows the warming at 3.9 µm that results from solar reflection. The same color enhancement is used for the 3.9 µm and 10.3 µm GOES-16 imagery.

## Impact on Operations

**Primary Application:** This infrared channel is used for fire detection; its short wavelength is more sensitive than longer wavelength infrared channels to the hottest part of the pixel.

**Application:** Small ice crystals reflect more solar 3.9 µm radiation than large crystals during daytime.

**Application:** Stratus clouds do not emit 3.9 µm radiation *as a blackbody* so the inferred temperature is colder than the temperature inferred from the 10.3 µm radiation (Stratus clouds emit 10.3 µm radiation as a blackbody). Thus, at night, stratus clouds are apparent in the brightness temperature difference.

## Limitations

**Daytime:** Solar reflectance adds to the detected 3.9 µm radiation. Compare 3.9 µm (above left) and 10.3 µm (above right) brightness temperatures at right: The 3.9 is much warmer.

**Fire application:** 2-km resolution means that very small fires can be overlooked.


## Next classes:

The Radar, May 7 at 7 PM
Upper Air Soundings, May 12 at 7 PM
Quasi-Linear Convective Systems, May 13 at 10 AM

# Questions

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