January 31st 2009 “Off-season” Grassland Wildfire

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Abstract

Wildland fires can be high impact events no matter what the season or fuel type. While the first image that comes to mind of wildland fire suppression is timbered mountainous terrain on a late summer afternoon, this wildland fire occurred in relatively flat grasslands during the overnight and early morning hours, during the climatologically coldest time of year. Fire suppression is a high-risk activity no matter what the season or fuel type; however, risks are significantly higher when fighting fire at night and in strong winds with high rates of fire spread. Fuels and fire danger information are widely available during the summer months to assist forecasters in the Red Flag Warning decision-making process, but are not available in the winter. In addition, strong winds are quite common during the winter months on the Montana plains, leading to a decreased situational awareness of critical wildfire potential. This study examines the meteorological conditions that led to the strong winds and significantly warmer and drier than normal conditions which drove the fire. In addition, this study examines some of the remote sensing applications to aid in the detection of wildfires as well as decision support opportunities between forecasters and fire management entities. An initial set of guidelines using observable antecedent fuel and weather conditions as well as critical thresholds for winds, relative humidity and temperature is presented to aid forecasters in Red Flag Warning decision making. Winter season grassland wildfires have historically had a large impact on communities on the Montana plains and a higher degree of situational awareness of high wildfire potential during the wildfire “off-season” would allow for better decision support by weather forecast offices and increase safety for firefighters.

Introduction

A large grassland wildfire burned 20,000 acres in far southern Chouteau County, Montana, in the early morning hours of January 31 2009 (Great Falls Tribune, 2009). The fire initiated from a slash pile that was burned the week before and was thought to have been extinguished (Hall, 2009). The Meissner fire, named for a nearby ranch, burned an area nearly 10 miles long and three miles wide, including portions of Round and Square Buttes in southern Chouteau County (Fig. 1). Strong winds and very low relative humidity caused extreme rates of spread and severe fire weather conditions. The large area of heat and smoke generated by the fire and pockets of more intense burning due to combustion of haystacks caused the fire to be easily detectable on radar and satellite imagery. Over 60 firefighters from at least 12 different agencies including state, federal, county and local fire departments responded to the fire with suppression efforts taking place from around 2:00 am MST through the early afternoon hours on January 31 2009. While rare, extreme fire behavior and significant grassland wildfires occur outside of the typical summer fire season. These events usually occur during periods of high winds which coincide with unusually warm and dry conditions.

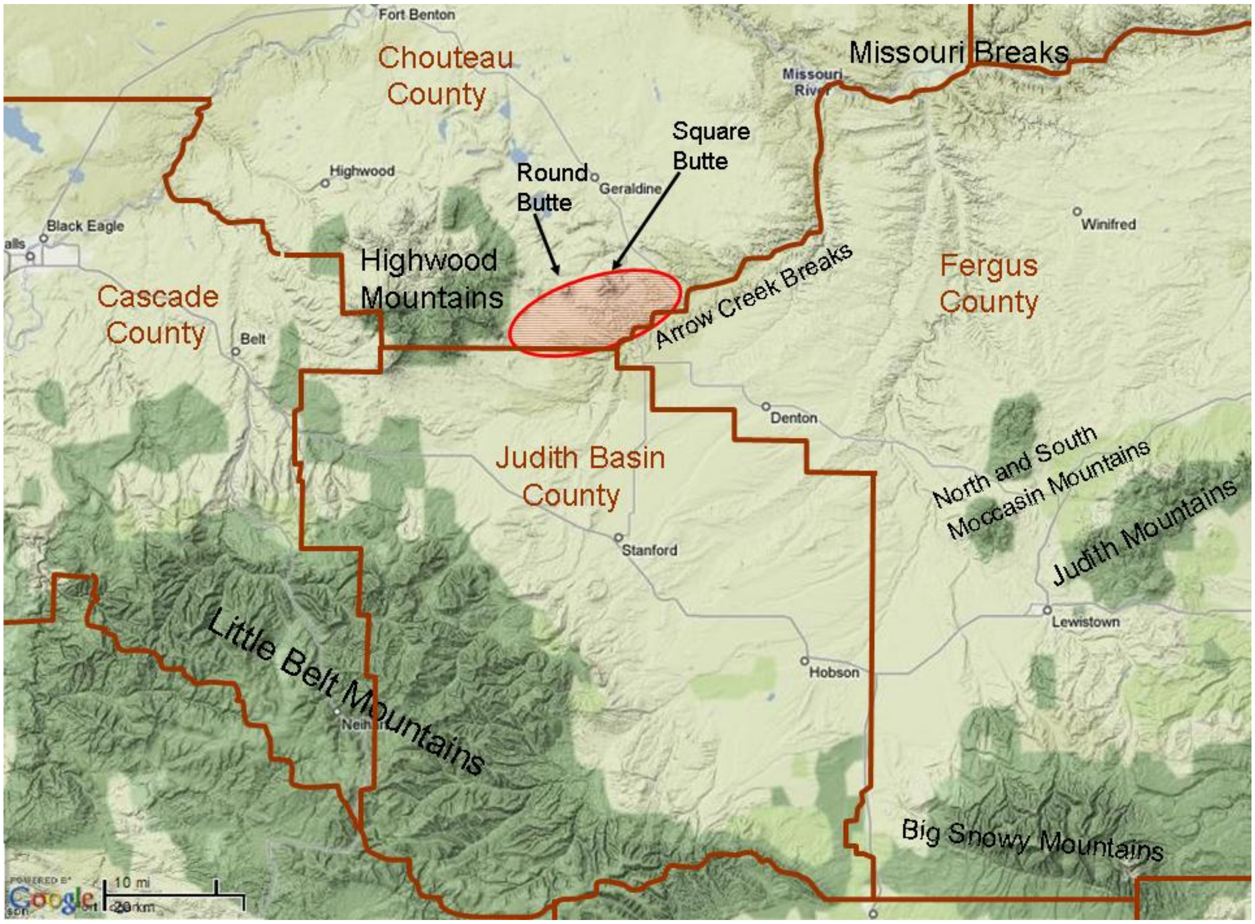


Figure 1 – Map showing general location of the fire and nearby terrain features.

Synoptic overview

The general upper level pattern featured the breakdown of an upper level ridge, which is a well-known critical fire weather pattern for the western United States (Schroeder, 1964). The flattening of the upper level ridge was evident at 300mb from 0000 UTC to 1200 UTC January 31 2009. This was initiated by an upper level jet maximum, which moved from southwest British Columbia inland along the Canadian/U.S. border through the 12-hour period (Fig. 2).

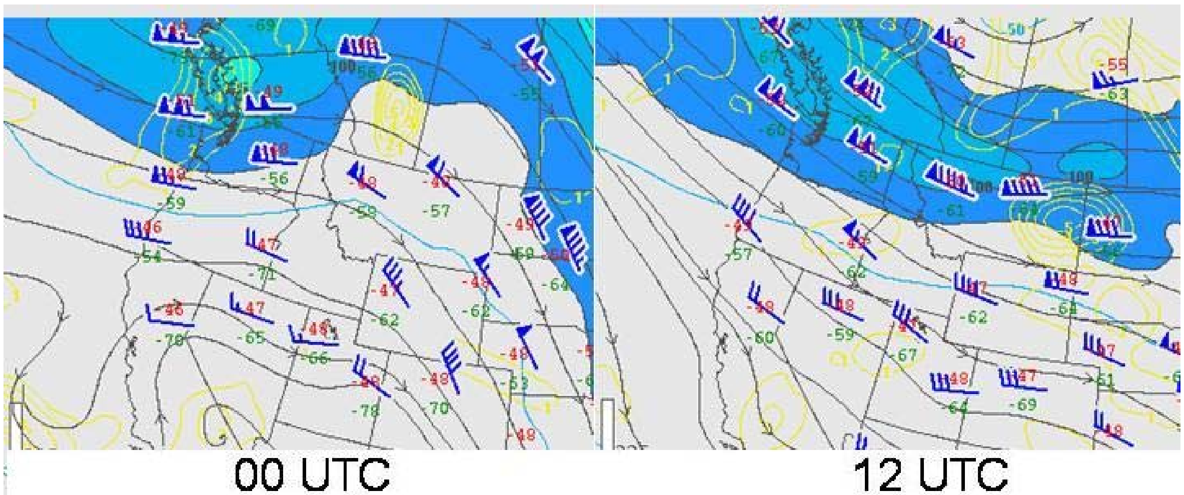


Figure 2 – 2009 January 31 0000 UTC and 1200 UTC 300mb analysis. Wind flags in knots using conventional display. (Courtesy SPC-Storm Prediction Center)

A 500mb shortwave trough was coincident with the 300mb jet max entering southwest British Columbia at 0000 UTC January 31 (Fig. 3). This shortwave progressed inland to a position along the Montana/Alberta border by 1200 UTC January 31 2009 (Fig. 3). 500mb winds increased from 45kts to 85kts at Great Falls (KTFX) between 00 UTC and 12 UTC on January 31 2009 (Fig. 3).

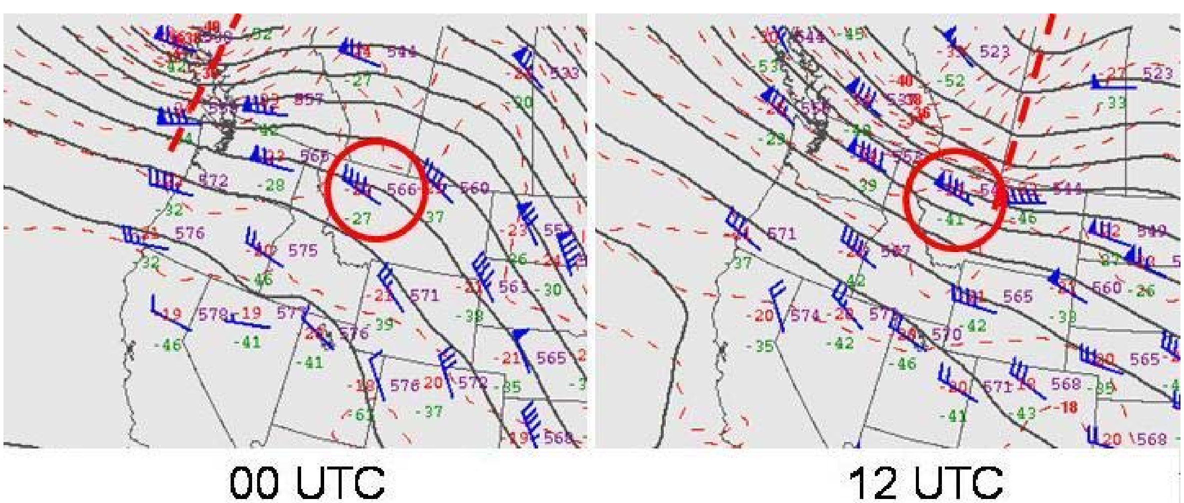
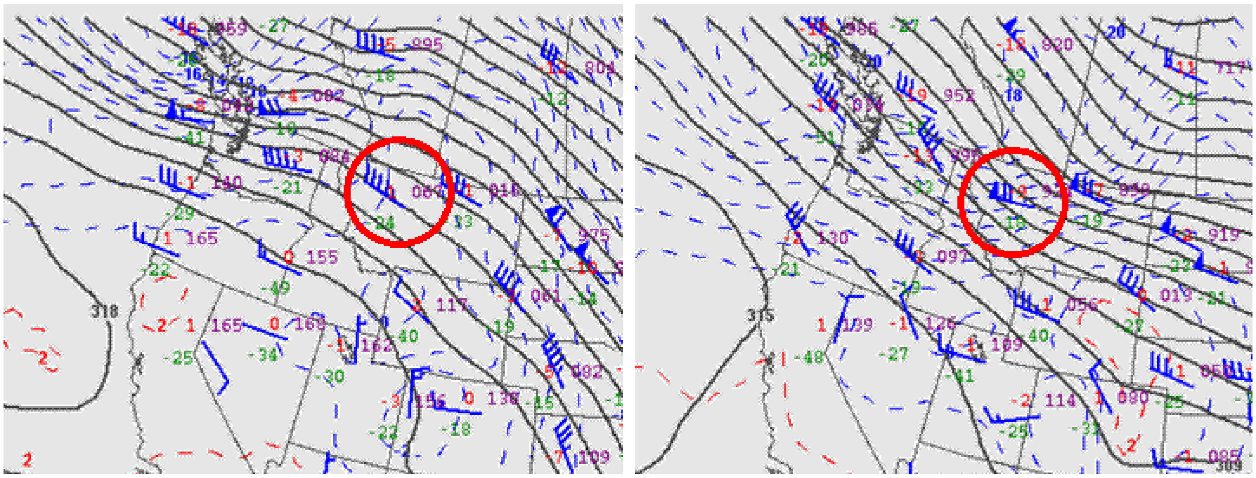


Figure 3 – 2009 January 31 0000 UTC and 1200 UTC 500mb analysis. The encircled point is the Great Falls observation (KTFX). (Courtesy SPC)

The shortwave feature was also reflected at the 700mb level, moving southeast from southwest Canada into Montana with cold advection evident across Montana behind this wave at 12 UTC January 31. In addition, 700mb winds increased from 40kts at 00 UTC to 70kts at 12 UTC January 31 at Great Falls (Fig. 4).



00 UTC 12 UTC

Figure 4 – 2009 January 31 0000 UTC and 1200 UTC 700mb analysis. The encircled point is the Great Falls observation (KTFX). (Courtesy SPC)

The Mean Sea Level Pressure analysis (Fig. 5) showed a deepening trough of low pressure to the lee of the Northern Rockies associated with the advancing upper level short wave (Shown in Figs. 2-4). An area of surface high pressure remained over the Great Basin and northern Intermountain region. By 12 UTC January 31 a cold front had moved southeast through central and eastern Montana (Fig. 5).

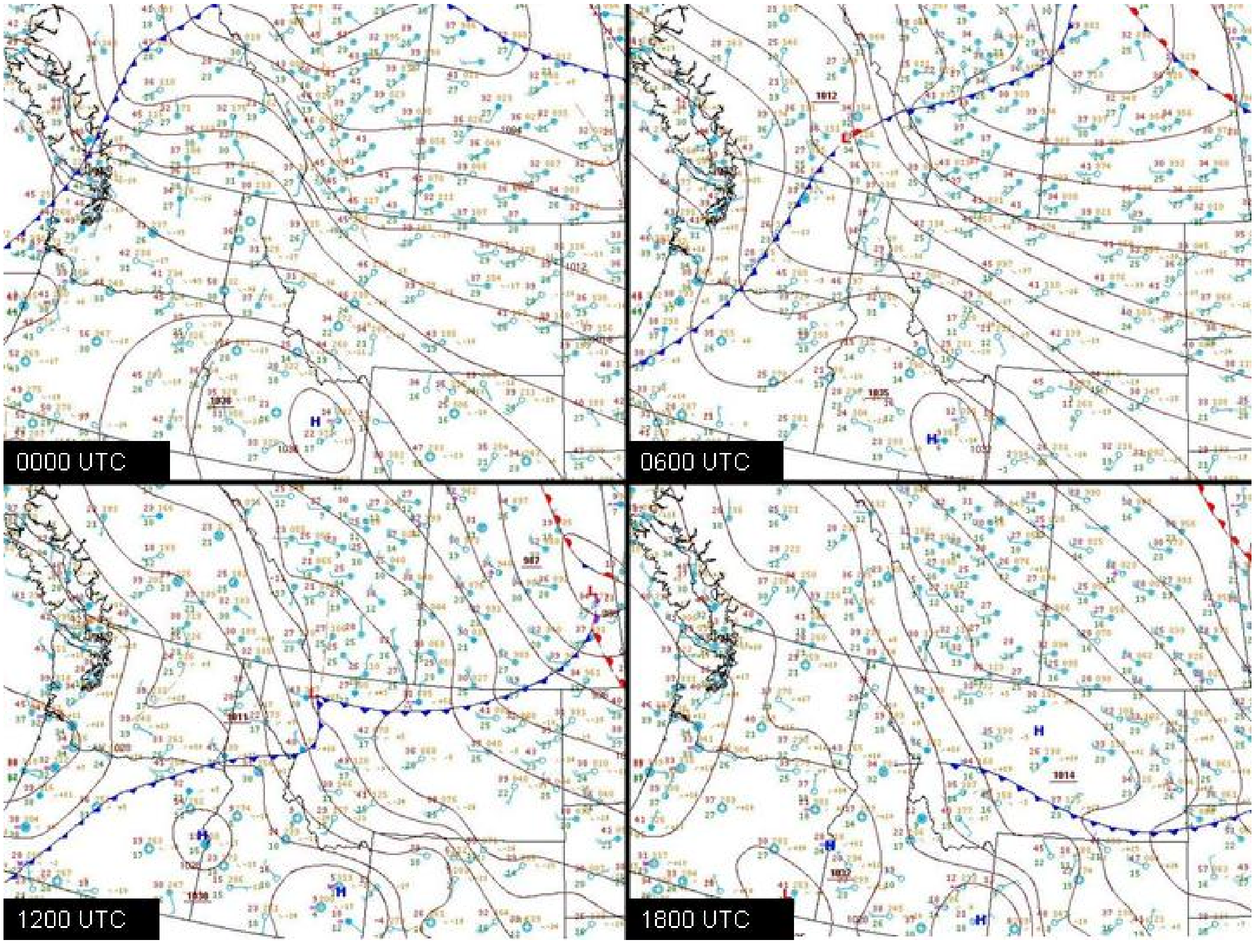
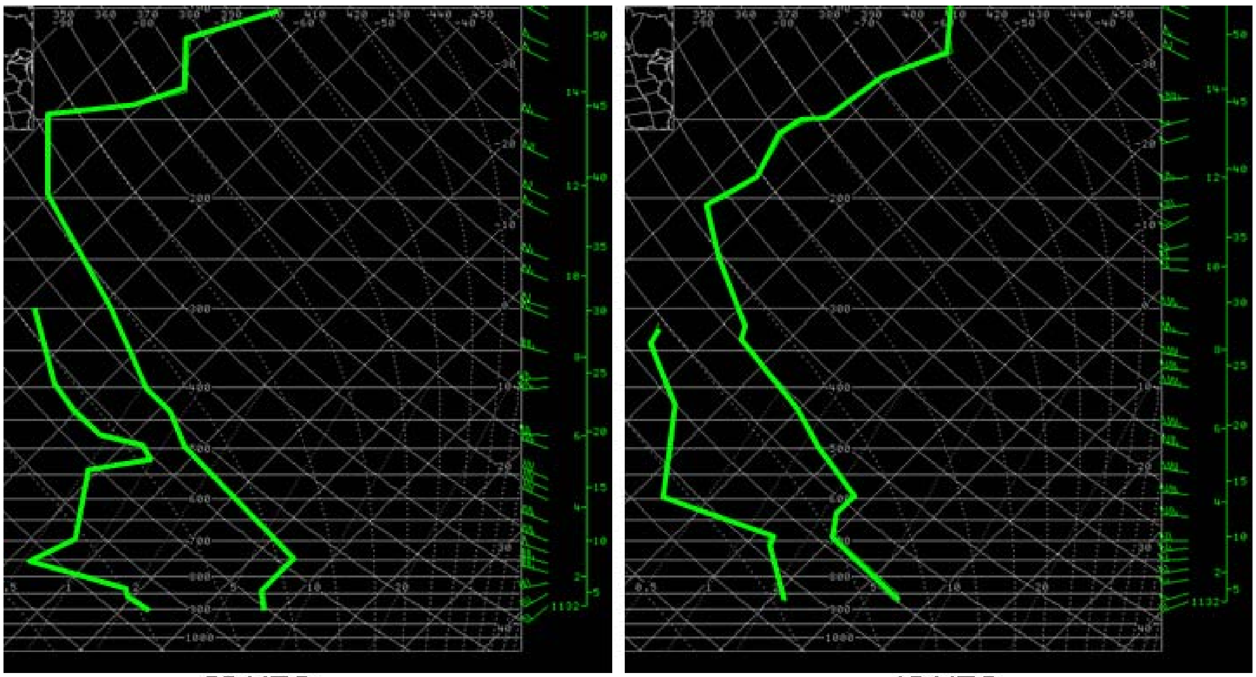


Figure 5 - Mean Sea Level Pressure (MSLP) and Frontal Analysis from 0000 UTC, 0600 UTC, 1200 UTC and 1800 UTC January 31 2009. (Courtesy Hydrometeorological Prediction Center – HPC)

Upper Air

The 0000 UTC January 31 2009 skew-T plot at Great Falls (KTFX) showed 30-50kt winds through much of the lower to mid levels of the troposphere and very dry conditions below 550mb as well as a nearly dry adiabatic lapse rate from 750mb to 500mb (Fig. 6). The dry and relatively unstable conditions between 500mb and 700mb produced a High Level Haines index of 6, which corresponds to an adjective description of "High: potential for plume dominated fire behavior" (Haines 1988). In this case, fire behavior was primarily driven by the strong winds; however, the Haines 6 conditions potentially did enhance fire behavior by providing good ventilation for the fire. By 1200 UTC, significant cooling had occurred below 600mb with some moistening as well. Wind velocity in the lower levels increased significantly by 1200 UTC with speeds in excess of 50kts just above the surface, increasing to 70kts or greater above 700mb (Fig. 6). A stable layer is also noted around 700mb (Fig. 6). The geographic area that the fire developed in and that experienced the strongest winds during the early morning hours of January 31 2009 is known locally as the Judith Basin (Fig. 7). The Judith Basin is an area of high plains in north central Montana bounded by the Highwood Mountains to the west, the Little Belt Mountains to the southwest and south, the Big Snowy Mountains to the Southeast and the Moccasin and Judith ranges to the east. An upstream temperature profile featuring an inversion or layer of strong stability near mountain top height is known to favor the development of vertically propagating mountain waves and enhanced down-slope winds to the lee of mountain ranges (Durran, 1986). Peaks in the Little Belt Mountains, immediately southwest and upstream of the Judith Basin in southwest flow, range from around 7000 to 9000 ft in elevation and the stable layer at 700mb would likely have acted to aid in the development of mountain-wave-induced-winds over the Judith Basin.



00 UTC 12 UTC

Figure 6 - 0000 UTC (left) and 1200 UTC (right) January 31 2009 KTFX RAOB

Surface Observations

Surface observations across the area showed strong winds in the late evening hours which continued into early Saturday morning. Wind gusts exceeded local High Wind Warning criteria (50kts) across northern and western portions of the Judith Basin (Fig. 7). In addition, temperatures were very mild for this time of year because of the upper level ridge in place over the region. Overnight temperatures were mild, likely the result of a well mixed atmosphere in the lower levels, down-slope warming to the lee of the Little Belt Mountains and compressional heating ahead of the cold front. In many locations, the 24 hr maximum temperatures occurred overnight with temperatures remaining in the mid to upper 40s though the night (Table 1). Average overnight minimum temperatures in late January are in the lower teens, making these temperatures about 30 degrees above seasonal averages. Even if these temperatures occurred during the daytime, they would be 10 to 15 degrees above average daytime maximums for late January. Relative humidity reached minimum values below 30 percent across much of the Judith Basin with values near or below 25 percent at locations closest to where the fire developed (Table 1). By around 7am MST (1400 UTC) January 31, a cold front swept through from the north, bringing a wind shift to the north, along with a rapid increase in relative humidity and decrease in temperature (Fig. 8).

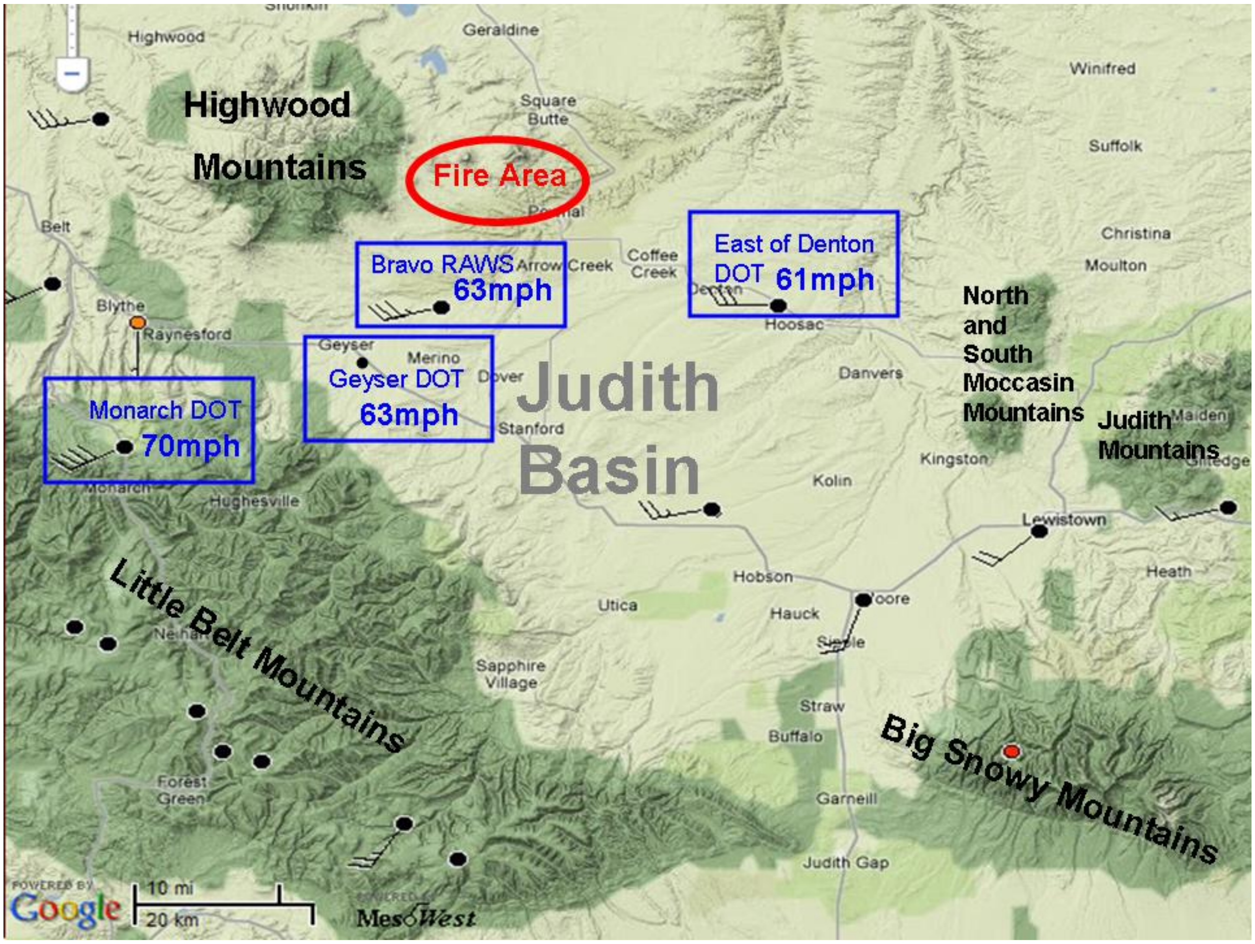


Figure 7 - Map of observation locations near the fire area including stations that exceeded local high wind criteria (50kts) with peak wind speeds during the overnight hours displayed. Wind flags are in knots using conventional display. Observational data courtesy of University of Utah MesoWest.

Location	Peak Gust (06UTC-12UTC)	Minimum RH (06UTC-12UTC)	Max Temp (06UTC-12UTC)
Bravo RAWS	63MPH	20%	48F
Geyser DOT	63MPH	19%	50F
East of Denton DOT	61MPH	26%	49F
Monarch DOT	70MPH	23%	43F
Great Falls ASOS	52MPH	29%	45F
Lewistown ASOS	46MPH	37%	42F

Table 1 - Peak wind gust, minimum relative humidity and maximum temperatures during the overnight hours (06UTC to 12UTC) of January 31 2009.

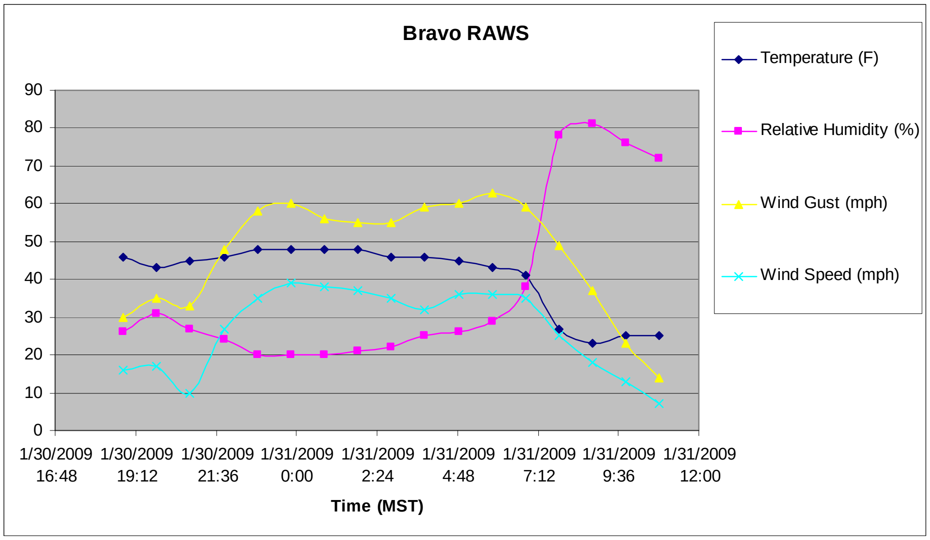


Figure 8 - Observations from Bravo Remote Automated Weather Station (RAWS), the nearest observing station to the fire area

Remotely Sensed Fire Detection

The fire produced enough heat over a large enough area to be detected via various satellite platforms. GOES Infra-red (IR) satellite imagery in the 3.9 micron window is particularly useful due to its dramatic response to sub-pixel hot spots and fifteen minute update frequency (Weaver, 1995). Fire or heat signatures are especially evident during the overnight hours when surrounding pixels are comparatively cooler. A heat signature was evident on the 3.9-micron imagery starting at 0830 UTC January 31 2009 which continued through 1315 UTC (Fig. 9). The cold front was also evident on satellite imagery, which reached the Canadian border around 1030 UTC and eventually crossed the fire area around 1400 UTC January 31 2009.

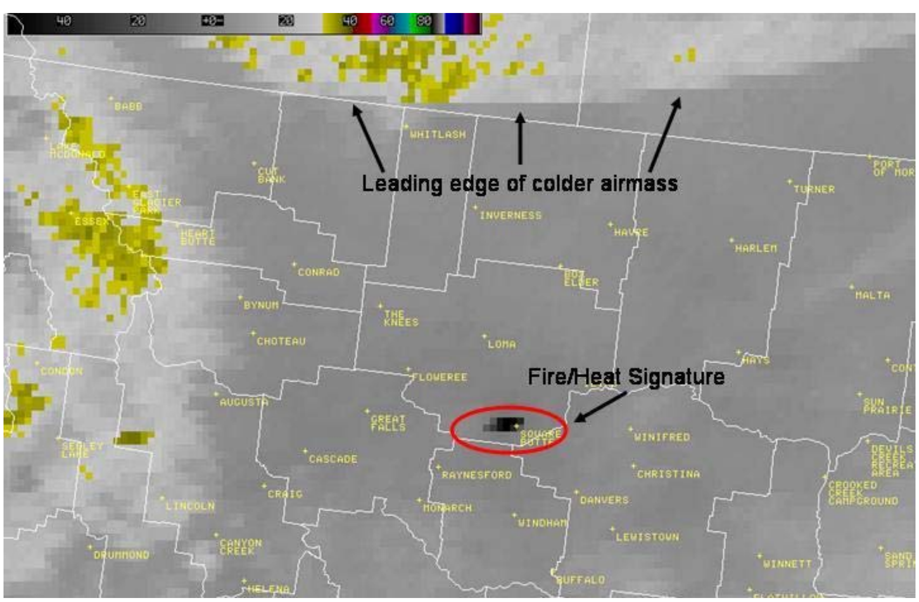


Figure 9 - 1030 UTC January 31 2009 3.9 micron IR Satellite imagery.

The U.S. Forest Service Remote Sensing Application Center (RSAC) utilizes Moderate Resolution Imaging Spectroradiometer (MODIS) derived fire detection data collected at 1000-meter resolution to produce geospatial fire products (Quayle, 2003). Active fire mapping imagery from RSAC showed several hot spots or fire detections in the fire area on the morning of January 31 2009 (Fig. 10). When viewed by the Google Earth™ mapping service, hot spots were displayed across an area about ten miles long and 3 miles wide.

Figure 10 - MODIS Hot Spot fire detections January 31 2009. Data courtesy of U.S. Forest Service Remote Sensing Application Center (RSAC).

KTFX WSR-88D base reflectivity radar data also showed evidence of the fire from 0847 UTC through 1157 UTC in the form of a plume of enhanced reflectivities. The maximum reflectivity was around 35 dBZ at 1100 UTC (Fig. 11). This is likely from particulate matter and other material from grass and hay combustion being transported upward and downstream in the strong winds.

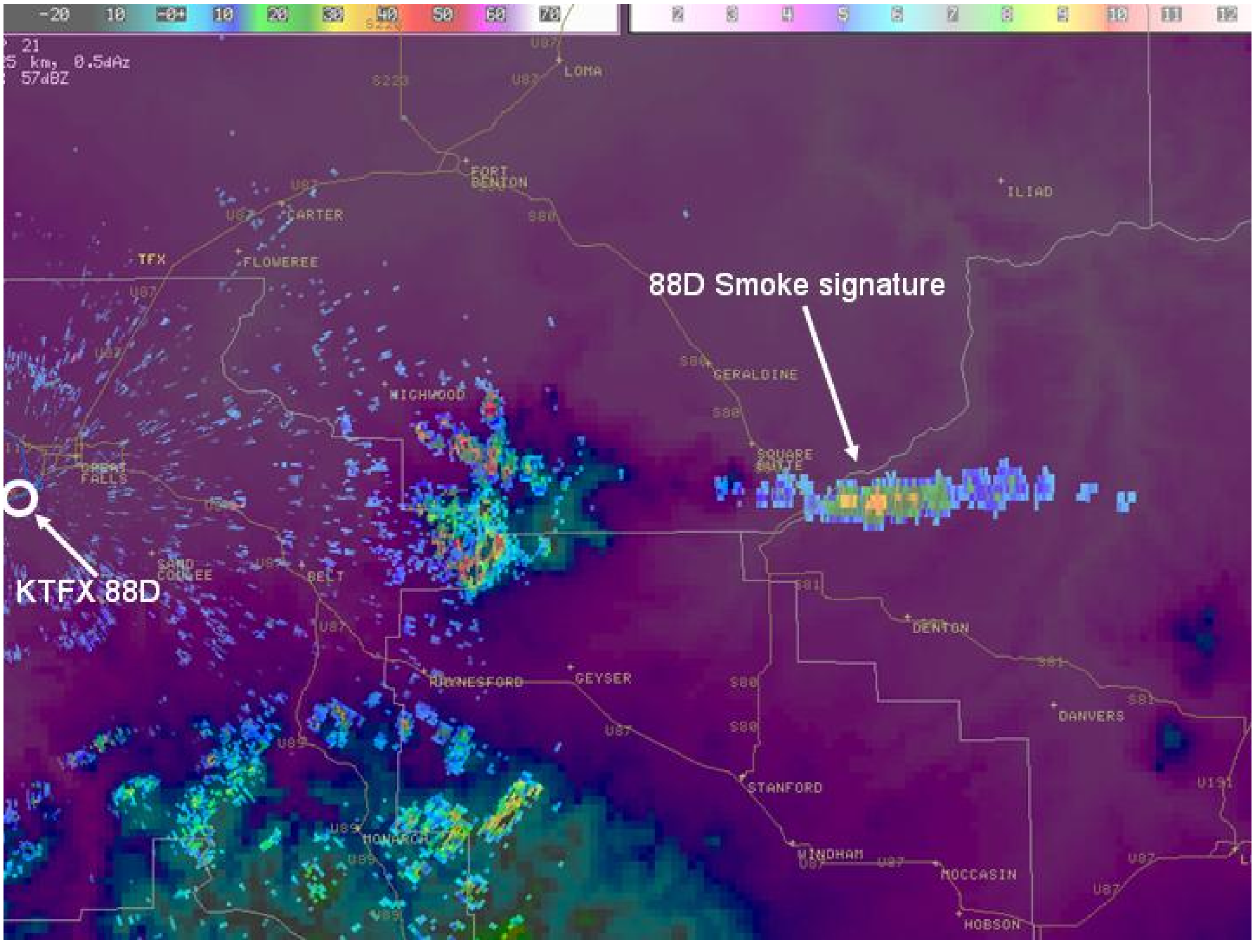


Figure 11 - KTFX WSR-88D base reflectivity 1100 UTC January 31 2009

<u>Decision Support</u>

A call from NOAA Environmental Satellite Data and Information Service (NESDIS) first alerted local staff of the satellite heat signature. Operational staff then notified Chouteau County dispatch of the incident around 1:30 am MST January 31 2009. Forecasters maintained communications with Chouteau County dispatch, meeting requests for additional information later that night. Forecasters updated the dispatch center on the cold front approaching from the north and its expected impacts, including a wind shift to the north followed by a sharp drop in temperatures and an increase in humidity as well as a slight chance for flurries or snow showers following the frontal passage. The dispatch office then relayed this information to fire suppression personnel. At 11:54 am MST January 31 2009, a spot forecast was requested for mop up activities and aerial fire monitoring.

Impacts

This fire had significant impacts on the surrounding rural communities as local volunteer firefighters (and their families and neighbors) were awoken at around 2:00 am MST by fire alarm sirens and pager alerts to respond to the large and growing grassland fire. These firefighters responded to the fire early Saturday morning and continued their efforts through mid-morning on Saturday. Volunteer firefighters were called from areas as far as 30 miles from the fire and from three counties, due to the size of the fire. Aside from the already heightened risks associated with fire suppression, fighting a rapidly spreading fire at night is very dangerous as it is difficult to assess terrain and fire behavior.

Quotes from firefighters:

"The wind was so strong it was picking up gravel and throwing it against the truck in higher gusts"   -Lea Mitchell, Stanford Volunteer Fire Department

"We heard the weather forecast over the radio mentioning the cold front and wind shift to the north that was expected. This was really important to us since we were refilling our water truck on the south side of the fire. When the wind shifted, the fire came racing towards us." - Kent Ridgeway, Stanford Volunteer Fire Department

Lessons learned

Fire danger and fuels information are important components of the Red Flag Warning decision-making process. During the summer months, this information is coordinated between land management agencies and forecasters, and as a general rule, a minimum threshold of "High or Very High" fire danger is required for the issuance of a Red Flag Warning for strong winds and low relative humidity. Fire danger and fuels information is generally not available or not updated during the winter season. In addition, wind speeds greater than 15 mph and wind gusts greater than 25 mph are common during the autumn, winter and early spring months. The lack of fuels information, frequent occurrence of wind events, and relative rarity of wildfire occurrences during the winter months leads to a decreased situational awareness of critical fire weather potential. However, some very large wildfires have occurred during this time of the year, especially in grassland fuels.

An initial set of guidelines has been developed locally and in coordination with surrounding forecast offices to aid forecasters in detecting "Red Flag Events" during this time of limited fuels and fire danger information. These guidelines assume that the grassy fine fuels are dormant and require:

- No snow on the ground for at least 10 days
- Significantly above normal temperatures (20 degrees or more)
- A high wind event (sustained winds greater than 30kts or gusts greater than 50kts)
- Relative humidity less than 25%

All of these conditions were met during this event, at least locally, supporting these thresholds as an indicator of critical fire weather conditions during the off-season.

Fire detection information gleaned from satellite and radar interrogation can be very useful to our customers and partners. This information is especially useful during the nighttime hours in remote areas where the public may not be the first to see or report the fire. Initial contact with the dispatch center or county in which the fire is detected paved the way for additional decision support throughout the incident, which helped fire suppression efforts and increased the safety of those fighting the fire.

Acknowledgements

The author would like to acknowledge Google Earth and Google Maps software which provided the background mapping layers for several figures in this document as well as the US Forest Service RSAC for providing the KMZ data files of MODIS heat detections and the University of Utah MesoWest for providing observational data viewable in Google Maps. Thanks to Kent Ridgeway and Lea Mitchell of the Stanford Volunteer Fire Department for relaying their experiences and sharing photographs of their fire suppression activities during this incident. The author would also like to thank NWS Great Falls, MT Science and Operations Officer Dave Bernhardt for reviewing and contributing to this paper.

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