The Northwest California Severe Convection Episode of August 7, 2006 – A Weather Event Simulator (WES) Case

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Introduction

a. Climatology. Thunderstorms are infrequent across northwest California. The 30-year thunderstorm average yields only five such days annually at Eureka and 10 days per year at Red Bluff (Conway and Liston 1990). Although a somewhat higher incidence of convection and associated thunderstorm development could reasonably be expected over the intervening higher terrain (see Figure 1), severe thunderstorm development is indeed very rare. Prior to this event, the last severe thunderstorm warning (suspected or confirmed winds of at least 50 kt and/or hail of ¾" or larger) issued by the National Weather Service office in Eureka was over 25 months earlier. Low to mid-layer instability accompanied by upper-level diffluence is a major contributor to thunderstorm outbreaks in northwest California, notwithstanding sometimes limited moisture availability. Areas in close proximity to the coast experience the vast majority of convective days during the winter and spring months, while inland areas show little seasonal preference for such activity.

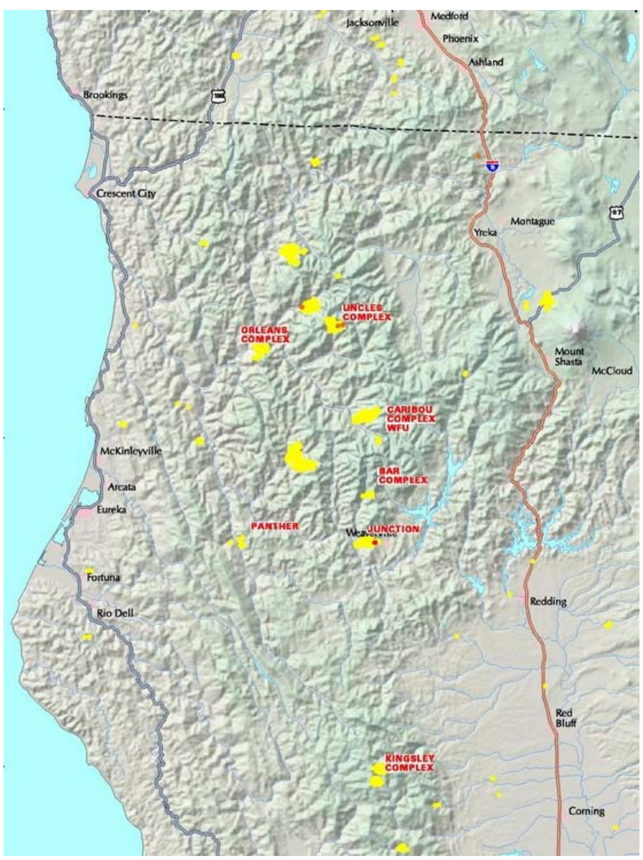

Figure 1. Topographical map of northwest California. Yellow regions represent fire-impacted areas for 2006 through August 7. Orange areas were actively burning on August 7. Courtesy USDA.

b. Background. Although the interior portions of Mendocino, Humboldt, Del Norte, and Trinity counties are very sparsely populated, 2006 was indeed a special year; numerous large wildfires were ongoing in these areas, and during this thunderstorm event, several thousand personnel were in wilderness areas, involved in the management and suppression of these fires. Figure 1 depicts ongoing large fires in northwest California leading up to this thunderstorm event. Given the obvious dangers of thunderstorm-induced lightning and erratic winds impacting aviation and ground operations in association with these fires, forecaster situational awareness and timely response were crucial.

c. Seasonal Review. High pressure aloft was the dominant weather feature across most of the western United States through July, with abnormally hot weather through much of the month across interior northwest California. At the Hayfork RAWS station, located at an elevation of 2,323 feet MSL to the southwest of the Junction Fire, 13 consecutive days of readings at or above 100 degrees Fahrenheit were recorded during the middle and latter portions of July. Many of the wildfires were initiated on July 23 or 24, as subtropical moisture was drawn north accompanied by several embedded upper level disturbances, inducing widespread thunderstorm activity. Seasonably warm temperatures with little, if any, rainfall occurred from late July into early August.

Synoptic and Mesoscale Description and Processes

a. Antecedent Conditions. Data from the Hayfork RAWS station indicate that progressively more surface and elevated moisture, in an absolute sense, was being advected into northwest California in the days leading up to the thunderstorm outbreak of August 7. On August 4, the minimum dew point temperature recorded at this valley station was 38 degrees Fahrenheit, with this value being achieved in the afternoon as morning radiation inversions break and somewhat drier air aloft mixes down to the surface. However, by August 6, this daily minimum dew point temperature had risen to 46 degrees Fahrenheit. Thunderstorms developed that afternoon to the north and east of the wildland fires. Shortly before midnight, an upper level disturbance moving up from the south interacted with the copious moisture and initiated rapid thunderstorm development over the northern portions of the Central Valley. The showers and thunderstorms continued to track north and moved into eastern portions of the Eureka forecast area during the night, serving to further enhance available low and mid-level moisture.

b. Analysis. The Storm Prediction Center’s Convective Outlook from 12Z favored much of the interior Eureka County Warning Area (CWA) for thunderstorms, with eastern portions marked as having a slight potential for severe thunderstorms.

As in any other portion of the country, several factors working in concert provide favorable conditions for thunderstorm development in California:

Lift
Instability
Moisture
Weak or non-existent capping aloft

As part of this discussion, we will examine each one of these factors.

Figure 2 shows the prevailing upper level pattern the morning of August 7. Upper level low pressure was situated off the Sonoma county, California coast during the morning hours on August 7, with high pressure extending across most of the remainder of the continental United States.

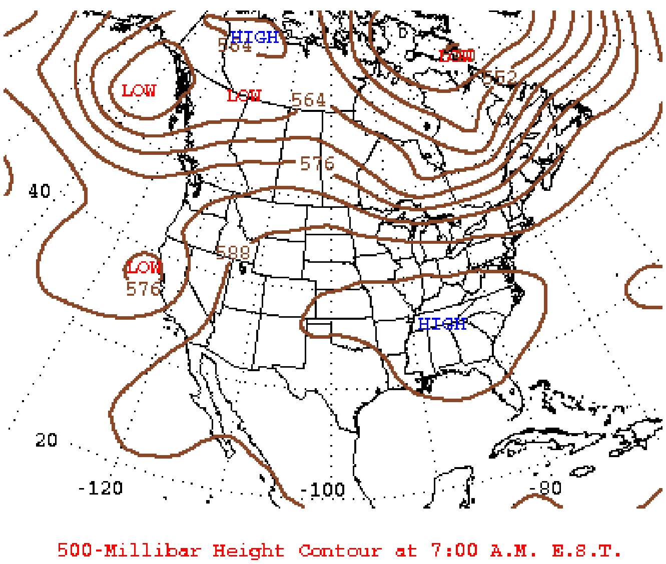

Figure 2. 500 mb height analysis for the morning of August 7, 2006. Courtesy NCEP.

The position of the upper level low provides favorable diffluence aloft for northwest California, thereby enhancing lift necessary for thunderstorm development.

The 12Z sounding from Medford, Oregon, as depicted in Figure 3, was highly unstable. The surface-based lifted index stood at -5.5 degrees Celsius, with surface-based Convective Available Potential Energy (CAPE) at 1562 J/kg. Convective Inhibition (CIN) was very weak, only 88 J/kg. Moreover, a significant amount of this CAPE was between the -10 degree Celsius and -20 degree Celsius isotherms…an area favored for the generation of large hail. These parameters are significant, especially considering the time of day these measurements were taken. As skies cleared during the morning, surface heating would allow the atmosphere to destabilize further.

The rawinsonde data also indicated there was no shortage of available moisture. Precipitable water at Medford stood at 1.01 inches, or nearly 150% of the seasonal normal. Moisture surging into the area on deep southeast flow combined with an increase in low level moisture from nearby thunderstorms overnight would provide the fuel for future thunderstorm development once convective debris clouds dissipated after sunrise.

Finally, the Medford sounding confirms no capping aloft, so once the nighttime radiation inversion dissipates, it would be expected that surface-based parcels would have little difficulty in reaching the Level of Free Convection (LFC) and, subsequently, thunderstorms would regenerate. This could be inferred to happen relatively early in the day, with weak Convective Inhibition (CIN) and the movement of the offshore low towards and over the region (700 mb temperatures were projected to drop from nine degrees Celsius to four degrees Celsius by the afternoon).

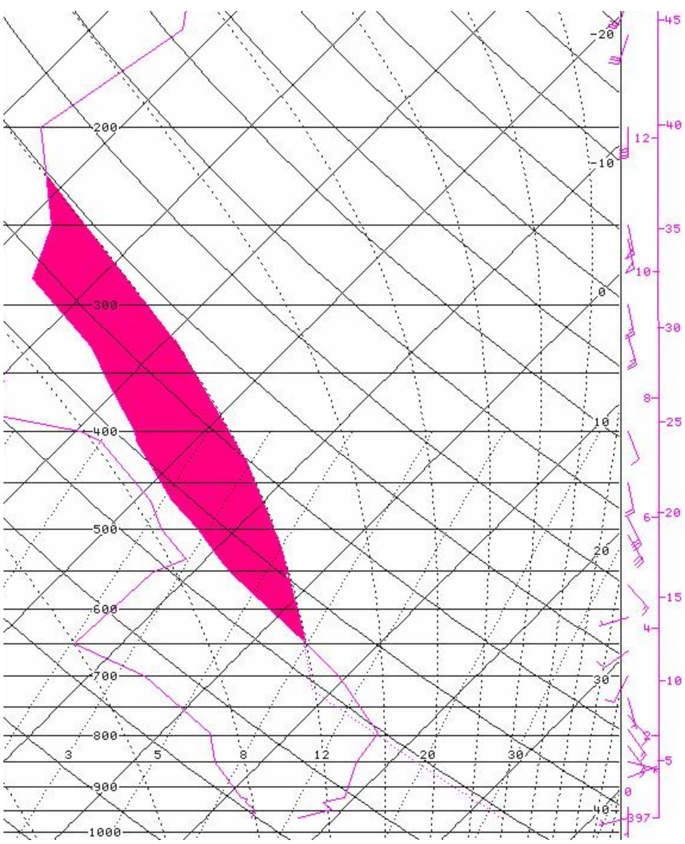

Figure 3. Medford sounding from 12Z August 7. Note the large area of CAPE (shaded red) between the -10 C and -20 C isotherms, ideal for the generation of large hail.

Event Chronology

By 19Z, convection began breaking out in the Yolla Bolly Wilderness, not far from the Kingsley Complex, and appeared to be initiated by an upper level disturbance spun off from the upper low. Figure 4 shows the developing thunderstorms from the Eureka (KBHX) radar. This activity propagated with the mean flow towards the northwest. On the 1944Z radar volume scan, a splitting cell is noted, with the right-mover possessing a 60-65 dbZ core suspended 25,000 feet MSL. On the next volume scan, at 1949Z, the

SCAN algorithm indicated a POSH/POH of 80 and 100, respectively, a VIL of 53 kg/m^2, and echo tops of 41,000 feet MSL in association with the primary thunderstorm complex; a severe thunderstorm warning was issued for this cell at 1959Z. Figure 5 shows KBHX imagery several minutes before this warning was issued. No severe weather was reported with this particular cell during the warned time, but this was quite likely due to the lack of spotters and/or people in its vicinity. However, later in the afternoon, field observers on several of these fires reported hail exceeding severe criteria with the resultant complex of thunderstorms.

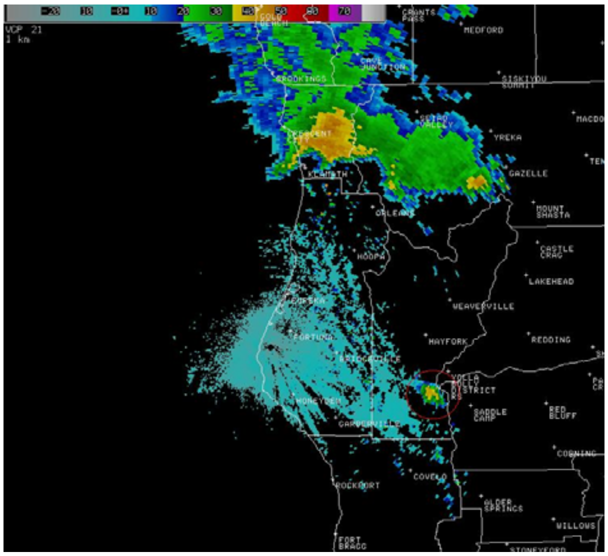

Figure 4. KBHX radar at 1903Z showing the developing thunderstorms of concern (circled).

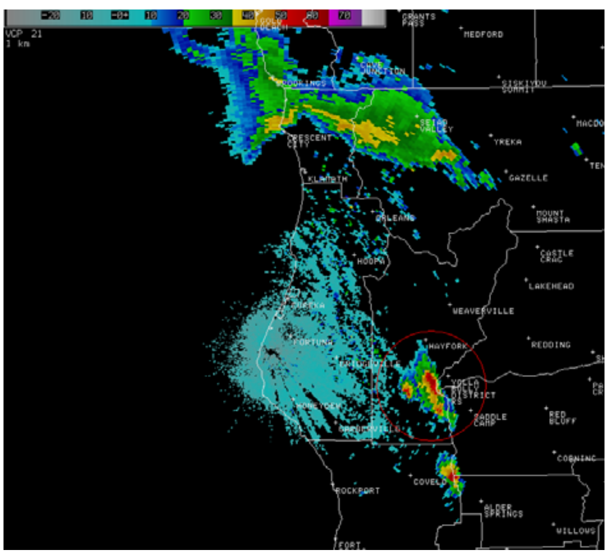

Figure 5. KBHX radar at 1955Z showing the thunderstorm complex which prompted the severe thunderstorm warning. The splitting left mover maintained its strength for the next hour before dissipating, while the other cells propagated north.

Training Opportunities

a. Modifying Soundings. The Eureka CWA is far from any rawinsonde launching sites, with Medford and Oakland the nearest available. Thus, forecasters must place some reliance on modeled output, and, more specifically, soundings. The NAM (WRF)-12 soundings are of high resolution and can be used to estimate convective parameters in three-hourly increments. As part of the station WES exercise, forecasters were asked to modify the WRF-12 sounding at Hayfork on AWIPS. This was especially important since the model suggested that clouds would restrict insolation to a greater extent than observations supported. By modifying the surface-based parcel at 21Z to reflect the actual high temperature of 85 degrees Fahrenheit, modeled CAPE rose from 1,318 J/kg to 1,836 J/kg while the lifted index fell from –5.75 degrees Celsius to –7 degrees Celsius. As an aside, forecasters were also instructed to raise the surface dewpoint from 50 degrees Fahrenheit to 55 degrees Fahrenheit. In so doing, the CAPE rose further to 2,547 J/kg with the lifted index dropping to –9.5 degrees Celsius. It is hoped that this exercise will help forecasters understand the importance of watching the environment for changes neither forecasted nor modeled, and anticipate in advance the probable effect.

b. Radar Checklist. Although it is mandated that a check be performed to ensure the radar's functionality each operational shift, parameters that are important for the accuracy of the SCAN algorithm may be incorrectly assumed to be valid. In particular, the height of the 0 degree Celsius and -20 degree Celsius level is important for determining POSH/POH and maximum hail size. Thus, unrepresentative environmental data entered for these temperature levels may adversely impact forecaster recognition of large hail events, subsequently resulting in over-warned or under-warned events. As a result, a special effort was made during training to emphasize the importance of accurately completing and updating convective parameters associated with the station's radar checklist.

c. Fire Weather. Although this effort is primarily intended to be a severe weather case to refresh the skills of forecasters, given the circumstances, it also provides a good opportunity to assess forecaster awareness of the unique weather concerns facing firefighters. Of course, it is always warranted to stress the importance of contacting fire personnel when thunderstorms are in the vicinity due to the threats associated with lightning and gusty, erratic winds. But, an overlooked perspective is how local, terrain-driven winds may initially promote the convection. The marine layer along the coast seldom penetrates as far inland as these thunderstorms initiated, and August 7 likewise provided negligible influence from marine effects. The area near the Kingsley Complex, where convection began, consists of several peaks (elevation approximately 7,000 feet MSL) significantly higher and more steeply sloped than the surrounding terrain (see Figure 1). Thus, on initially sunny days such as August 7, a cross-section of diurnally and terrain-induced winds often approximate the depiction in Figure 6. This convergence of upslope winds from opposing sides of the summits will produce enhanced lift, thus making these preferred areas for convection initiation. This additional lift, when coupled with broad upper ascent provided by the nearby low pressure center, was a likely contributor to the storms of August 7.

However, given the proximity of the large, normally hotter Sacramento Valley, winds on the east aspect of the interior coastal ranges may behave differently depending on the temperature differential between the valley and the coastal regions. This could also serve to modify convection potential. For instance, on the previous day, surface temperatures at 18Z were some 7 to 12 degrees Fahrenheit warmer in the northern Sacramento Valley than at the same time on August 7. More intense surface heating of the valley floor will result in thermal low development across the valley and a subsequent tendency for rising motion over the valley. If this heating is intense enough and/or the marine layer is deep enough across the adjacent coastal ranges (to maximize the temperature differential between the Sacramento Valley and the coast), a westerly or downslope afternoon wind may develop on the east aspect of the interior coastal ranges, as shown in Figure 7. This occurrence would serve to limit one mechanism for low to mid-level lift, and may help explain the lack of convection the previous day, despite similar positioning of the upper low from one day to the next. Such attention to observations may result in improved convection forecasts and provide more accurate wind forecasts to firefighters in these areas, which are often notorious for erratic winds, in part due to this phenomenon.

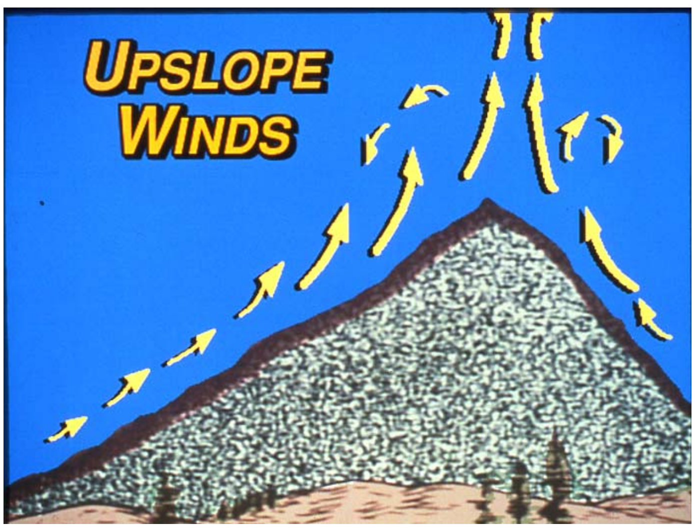

Figure 6. Idealized behavior of afternoon slope winds on opposing sides of a mountain summit. Courtesy National Wildfire Coordinating Group.

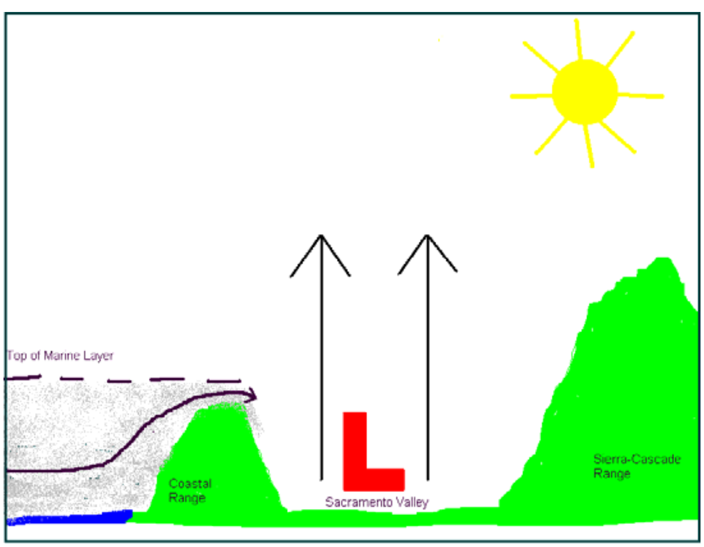

Figure 7. Simplified view of the disruption of afternoon upslope flow given intense surface heating in the Sacramento Valley or a deep marine layer along the coast. Courtesy Patrick Shreffler and Mike Smith.

Conclusion

Although severe thunderstorms are very unusual in northwest California, it is imperative that forecasters maintain proficiency in their prediction, as well as subsequent warning decisions. This is especially true in areas where wildfire suppression activities are ongoing, as was the case on August 7, 2006. Many of the techniques routinely used for severe weather forecasting east of the Rocky Mountains, such as rawinsonde analysis and modification of modeled soundings, can enhance forecaster awareness and understanding even near the west coast. However, the varied terrain often creates additional challenges for the convective forecaster. Therefore, a thorough understanding of terrain-driven winds is imperative for successful convective forecasting, resulting in improved service to, and safety for, land management agencies.

Reference

Conway, McKinley and Liston, Linda, 1990: The Weather Handbook, Conway Data Incorporated, Norcross, Georgia. pp. 87, 91.