An Analysis of a Heavy Precipitation Event over Interior South-Central California November 7-9, 2002

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I. Introduction

A well-known pattern for heavy precipitation over Central California is one where a long fetch of moisture over the Eastern Pacific embedded in a strong west to southwest flow, extends onshore over the West Coast. A well defined low pressure circulation is usually present and located in the Gulf of Alaska. This paper will attempt to show some of the finer details associated with a major precipitation producing pattern of this type utilizing an archived case which occurred during the first part of November in the year 2002. Many heavy precipitation occurrences over Central California have been associated with what has come to be known as the "Pineapple Connection". In the case presented here, the Hawaiian connection of subtropical moisture being tapped in the area of Hawaii is not present. In this case, the moisture fetch was mainly due west of central California, between 30 and 40N.

The majority of example figures used in this paper to illustrate the representative pattern are valid between 00Z and 06Z on Friday, November 8th. While the bulk of precipitation fell just beyond this time period - primarily on November 8th and 9th LST - the following charts depict the pattern just prior to the heaviest rainfall, and can be utilized comparatively as a precursor to help identify pattern similarities consistent with analogous heavy precipitation events.

II. Meteorological Synopsis

As shown in Figure 1a, the IR satellite picture illustrates the general upper air circulation associated with a heavy precipitation event in Central California. Note the broad low pressure circulation over the Gulf of Alaska. To the South, a strong zonal flow pattern exists with embedded moisture extending from Central California west to beyond longitude 150W.

At the same time, a strong 120kt+ 250mb jet axis is nosing into Central California. This places most of the forecast area under the left front quadrant, further enhancing upper level divergence. Reference Figure 1b.

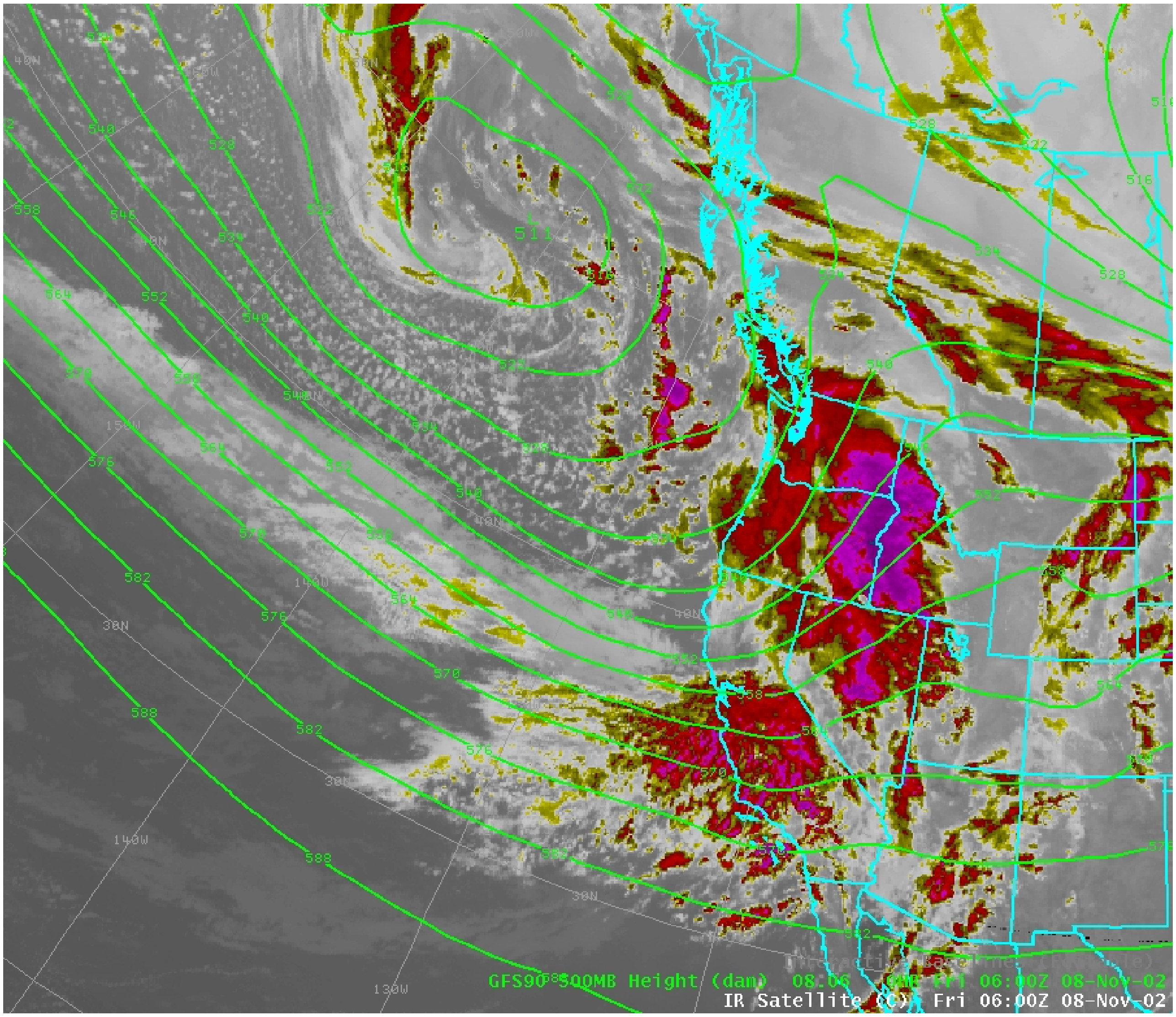

Figure 1a: IR Satellite with 500mb Heights valid 8 November 2002, 0530 UTC.

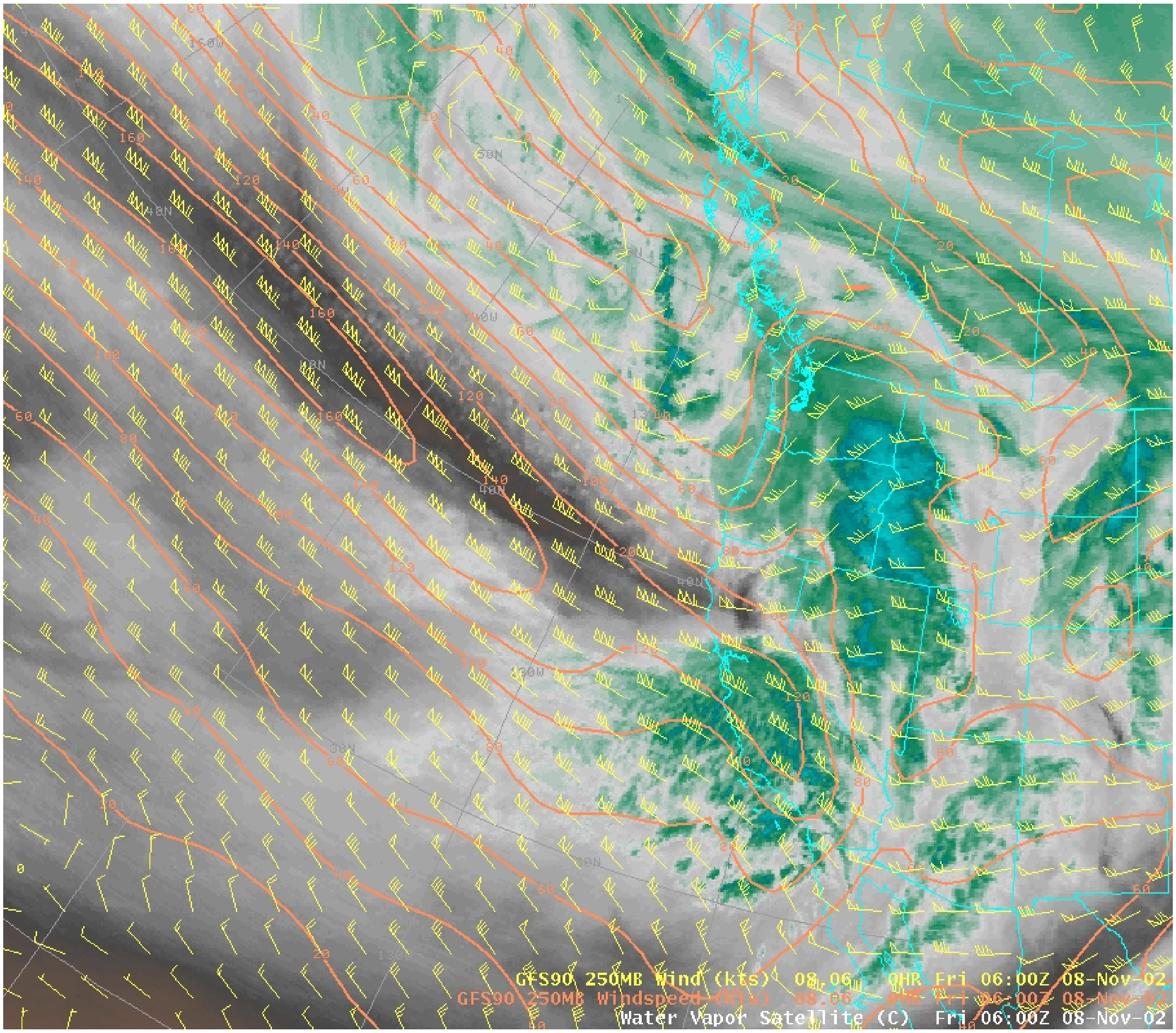

Figure 1b: Water Vapor imagery overlaid with 250mb winds. Valid 8 November 2002 at 0600 UTC. Note the strong jet axis nosing into Central CA, and the wind barbs indicating diffluence/divergence aloft.

Figure 2 provides some 3-Dimensional insight, clearly showing the divergence aloft, and the convergence in the lower levels associated with orographic uplift. As one might expect, the greatest divergence values aloft are in phase with the left exit region of the jet.

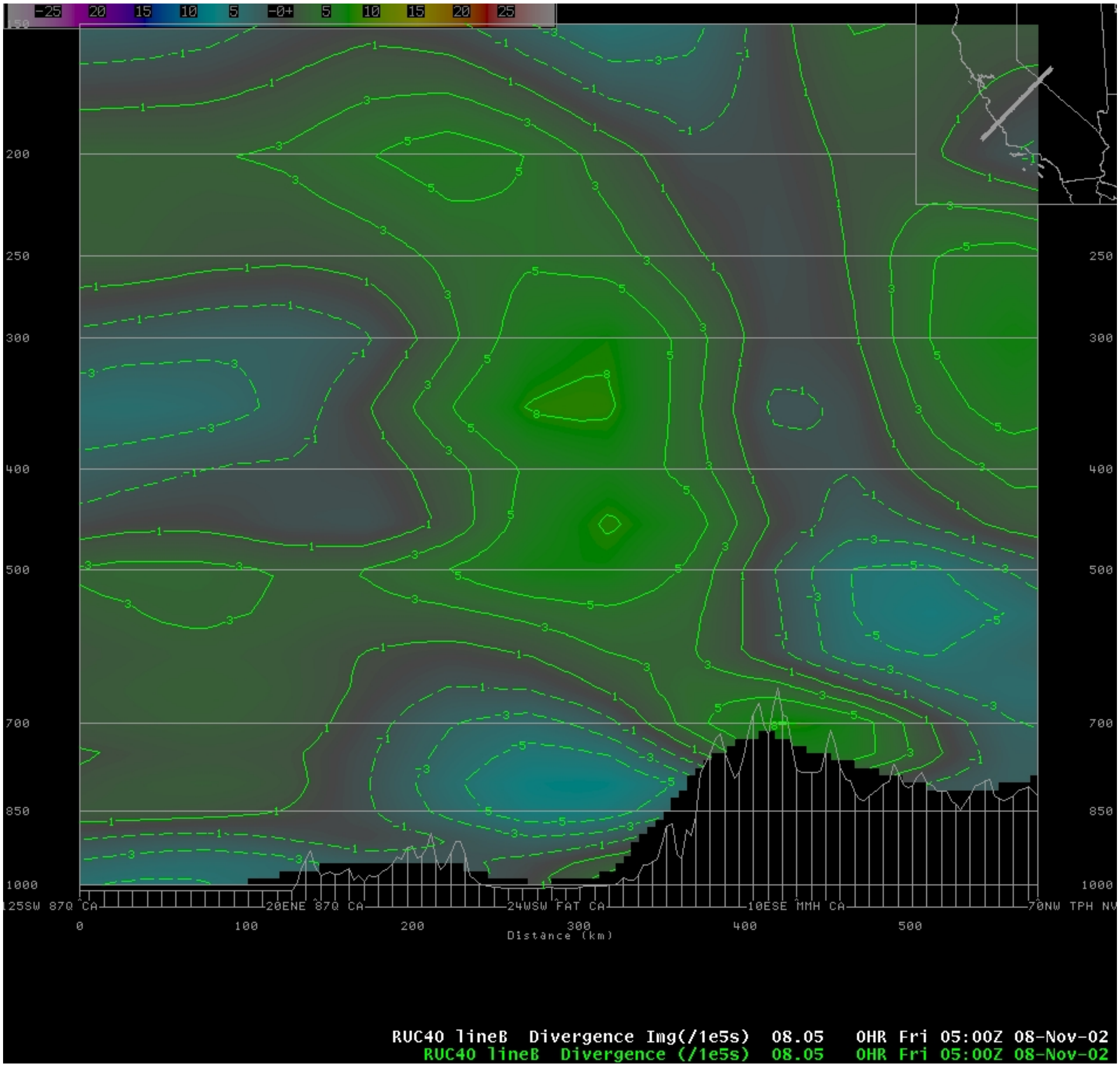

Figure 2: RUC40 Cross-sectional divergence analysis across a line oriented SW to NE as depicted in the upper right hand corner. Significant topographic features from left to right include the coastal mountain range, the San Joaquin Valley, and the Sierra Nevada. Valid 8 November 2002, 0500 UTC. Note the extensive divergence throughout the layer above 600mb, and the strong convergence associated with orographics.

Both the 850mb and 700mb RUC 40km omega analyses (Figures 3a and 3b) show relatively strong upward motion on the west (upwind) side of the Sierra

Nevada. The presence of strong omega at both levels is indicative of the orographic influences the Sierra Nevada was having on the flow. Low level winds at 850mb were more south-southwest with veering present up through the 700mb level which was evidence of the warm air advection which was taking place at the time.

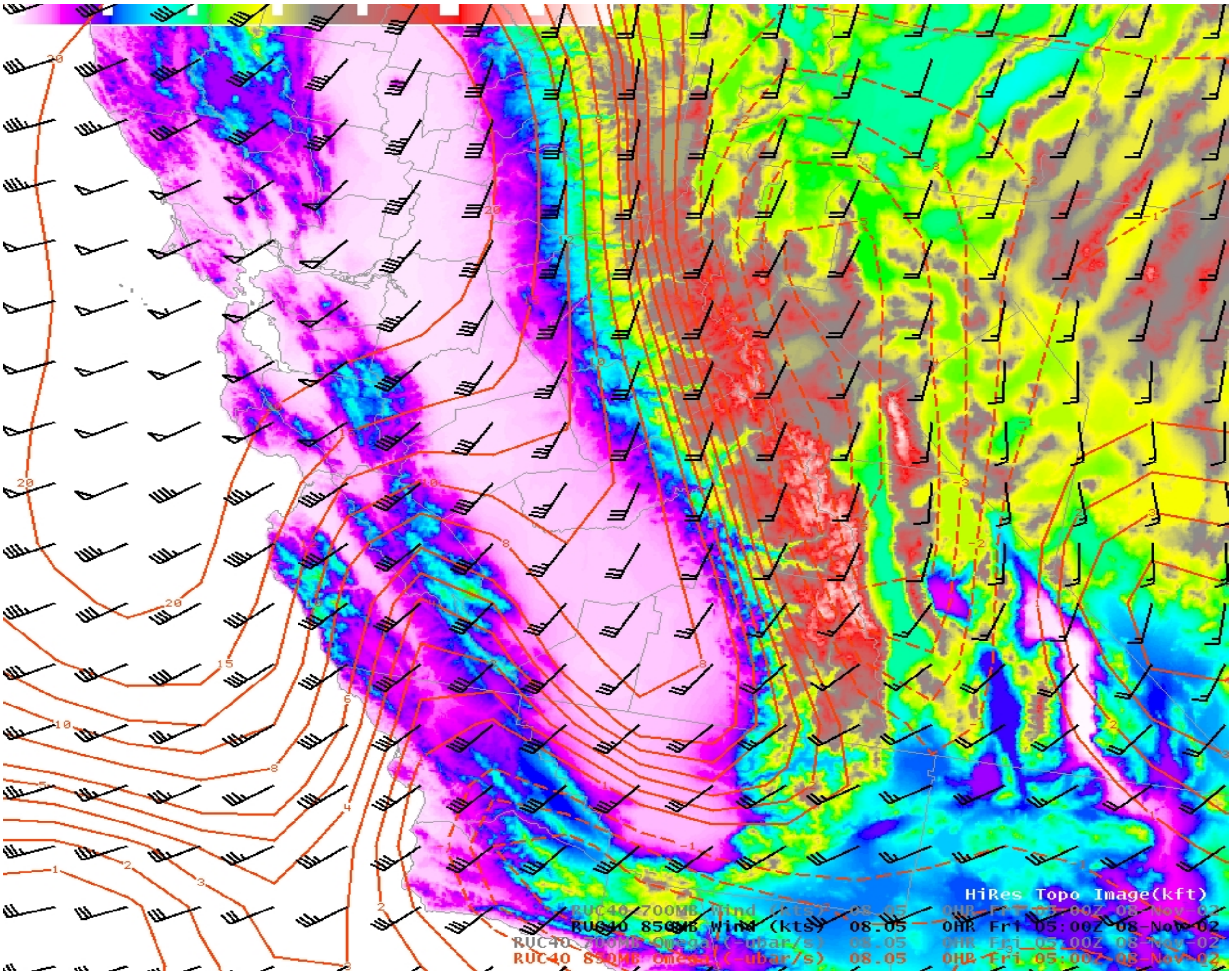

Figure 3a: RUC40 850mb winds and omega analyses valid 8 November 2002, 0500 UTC. Overlaid on a topographical display of central California

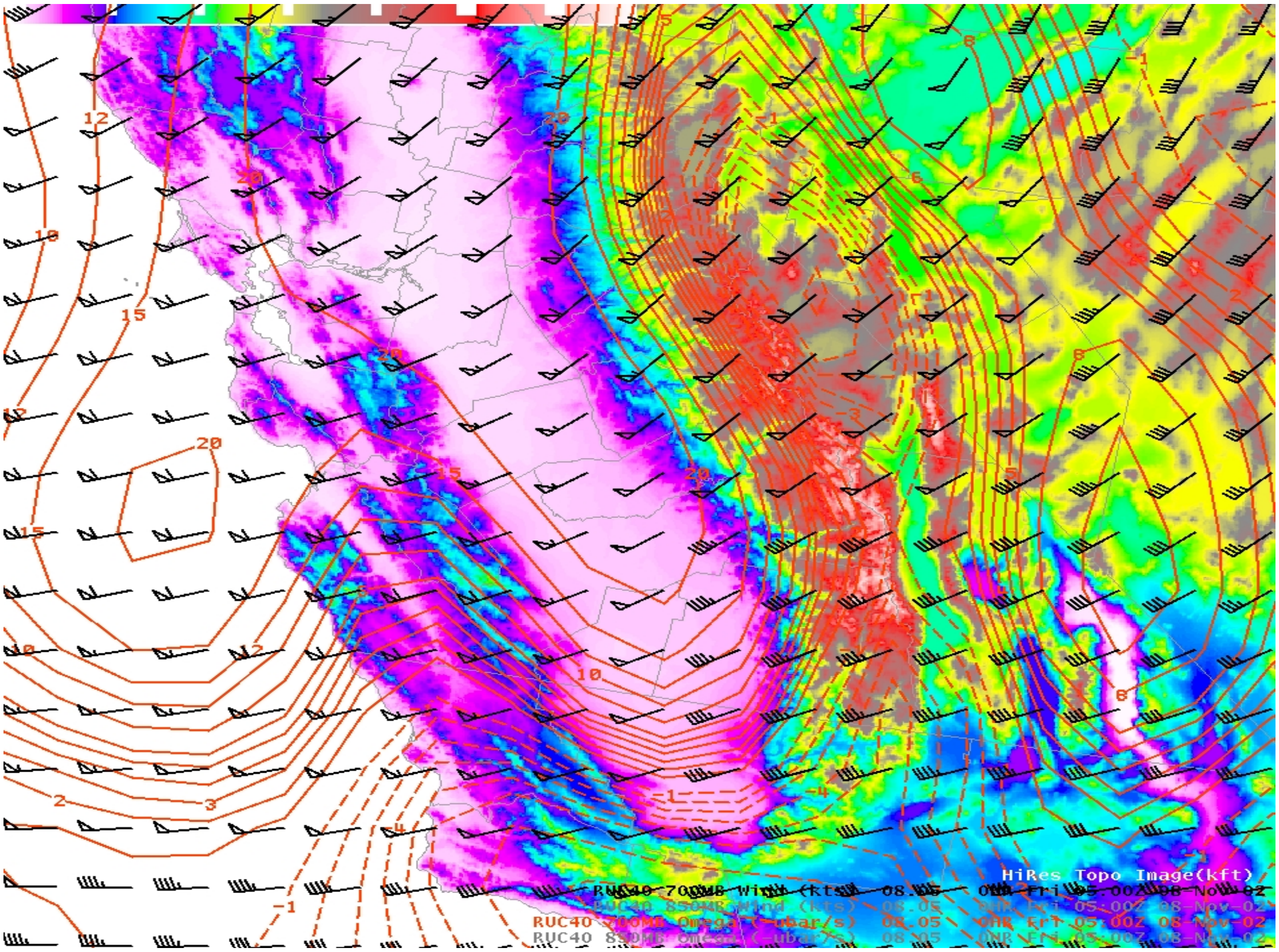

Figure 3b: RUC40 700mb winds and omega analyses valid 8 November 2002, 0500 UTC. Overlaid on a topographical display of central California.

Deep layer moisture is evident throughout the San Joaquin Valley at 0500 UTC, November 8 (Figure 4). High values of omega and veering winds with height, indicating warm air advection, are key players in producing high rainfall rates. Satellite estimated precipitable water amounts of 1-2 inches, as shown in Figure 5, extend from the West Coast to beyond longitude 150W, and are aligned with the prevailing westerly flow. Such a pattern suggests not only heavy rainfall rates, but also a prolonged event which can last for several days and produce widespread flooding.

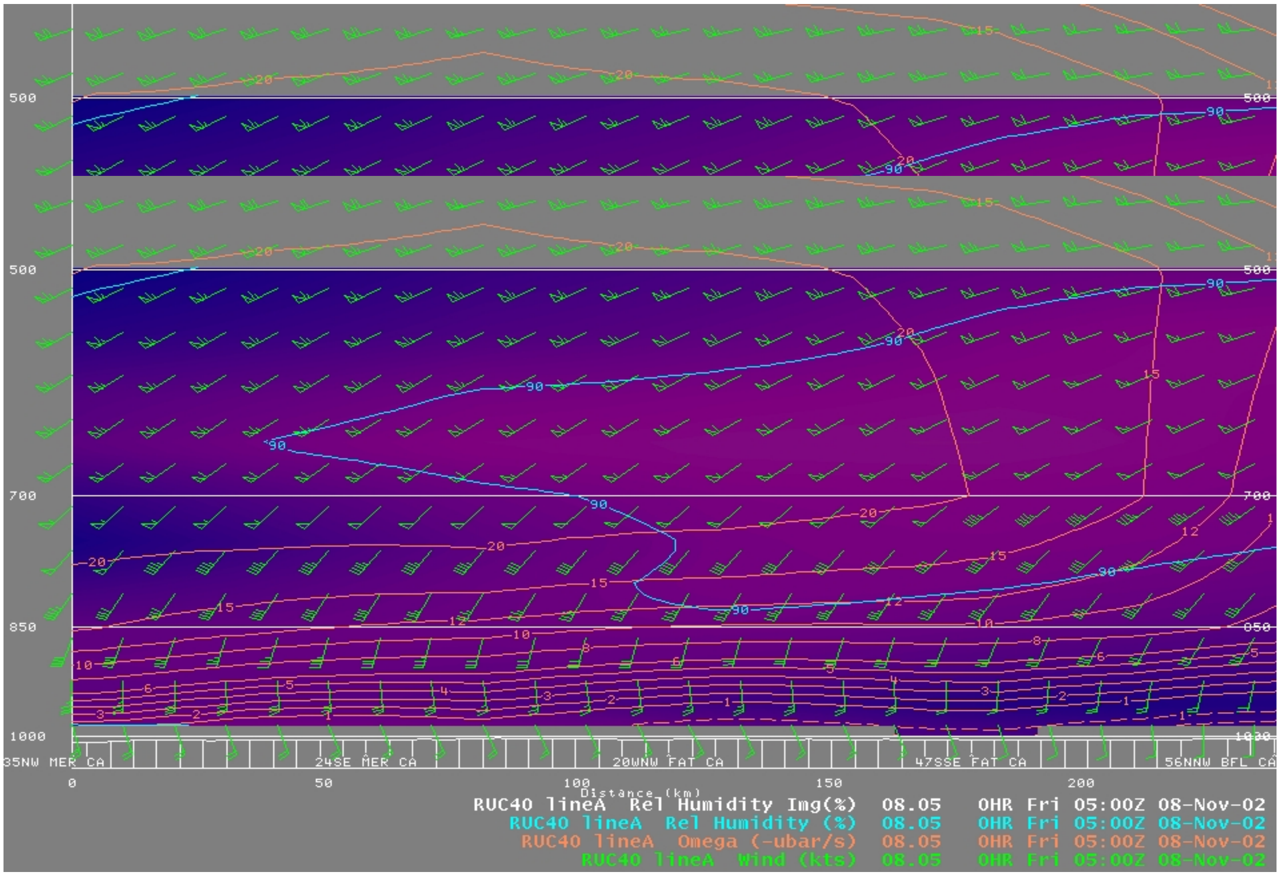

Figure 4: RUC40 Cross-sectional image analyzing Relative Humidity, Winds, and Omega down the San Joaquin Valley on a line from near Merced to near Bakersfield. Valid 8 November 2002, 0500 UTC. Note the depth of the saturated airmass, along with the high omega values and veering winds with height.

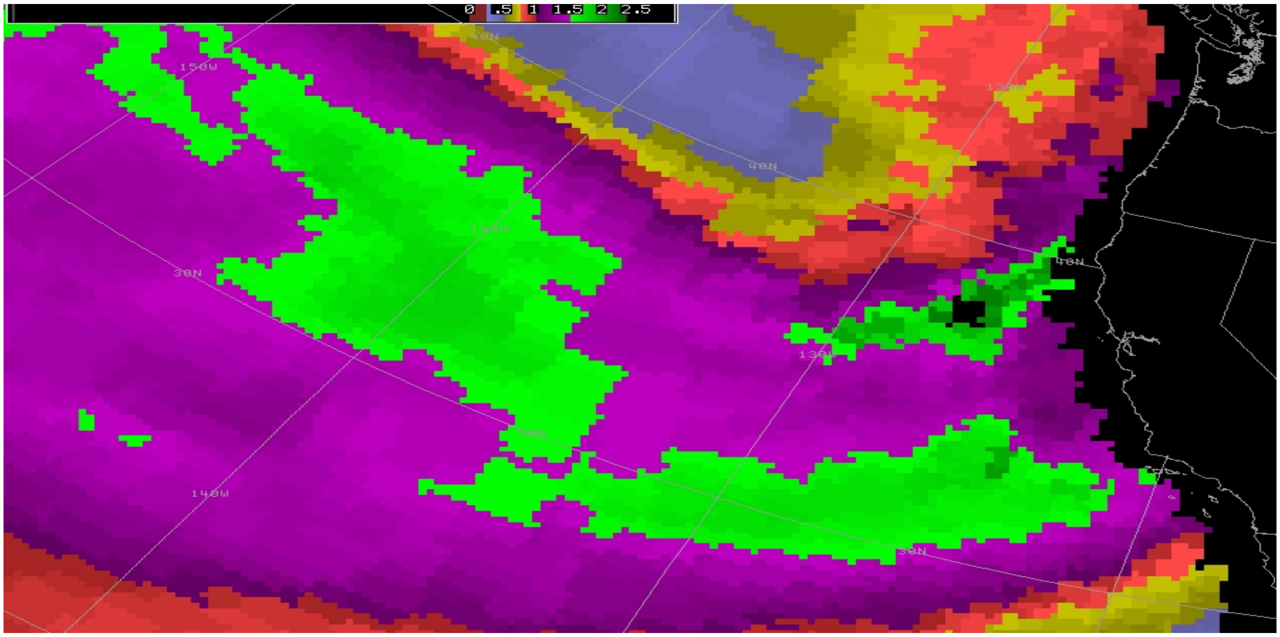

Figure 5: NOAA-15 AMSU Satellite total precipitable water amounts. Valid 8 November 2002, 0600 UTC.

Local soundings from Oakland, CA (Figure 6a) and Vandenburg, CA (Figure 6b) at the onset of the event indicate a warm, moist airmass with high freezing levels and wet-bulb zero heights. With warm air advection occurring along with projected raising snow levels, the focus shifted to a heavy rainfall/flooding event with significant run-off expected. Heavy snow was observed, but most fell above 9000 feet.

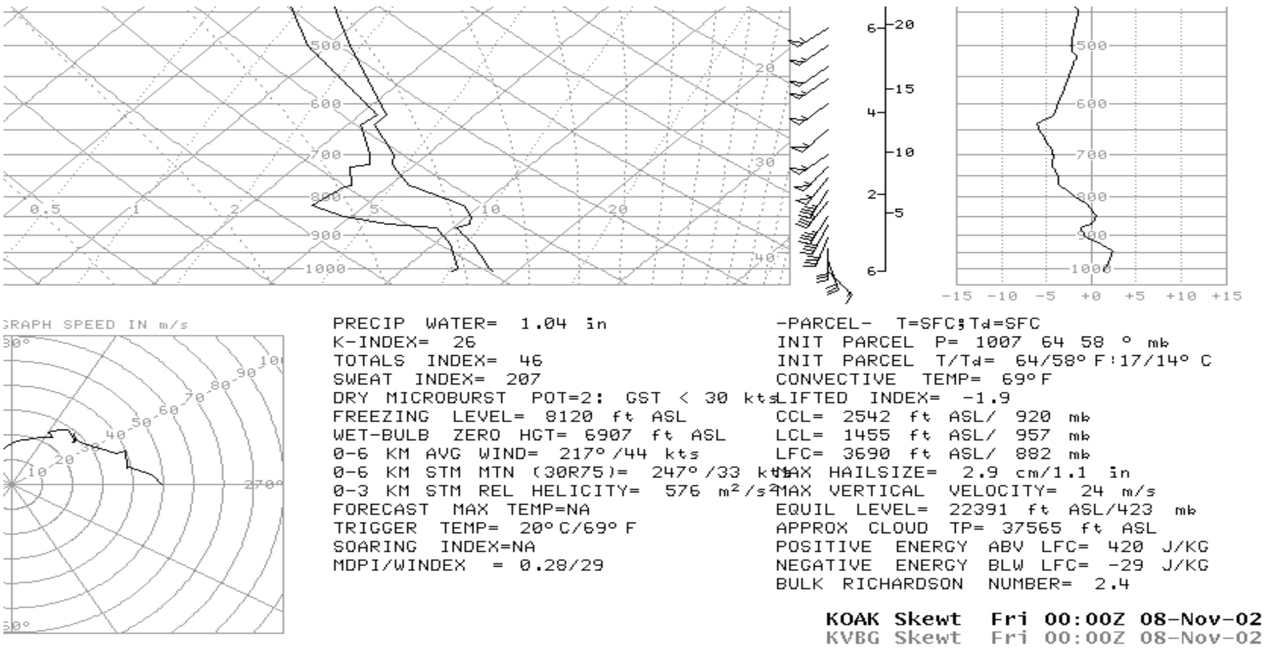

Figure 6a: KOAK Sounding valid 8 November 2002, 0000 UTC.

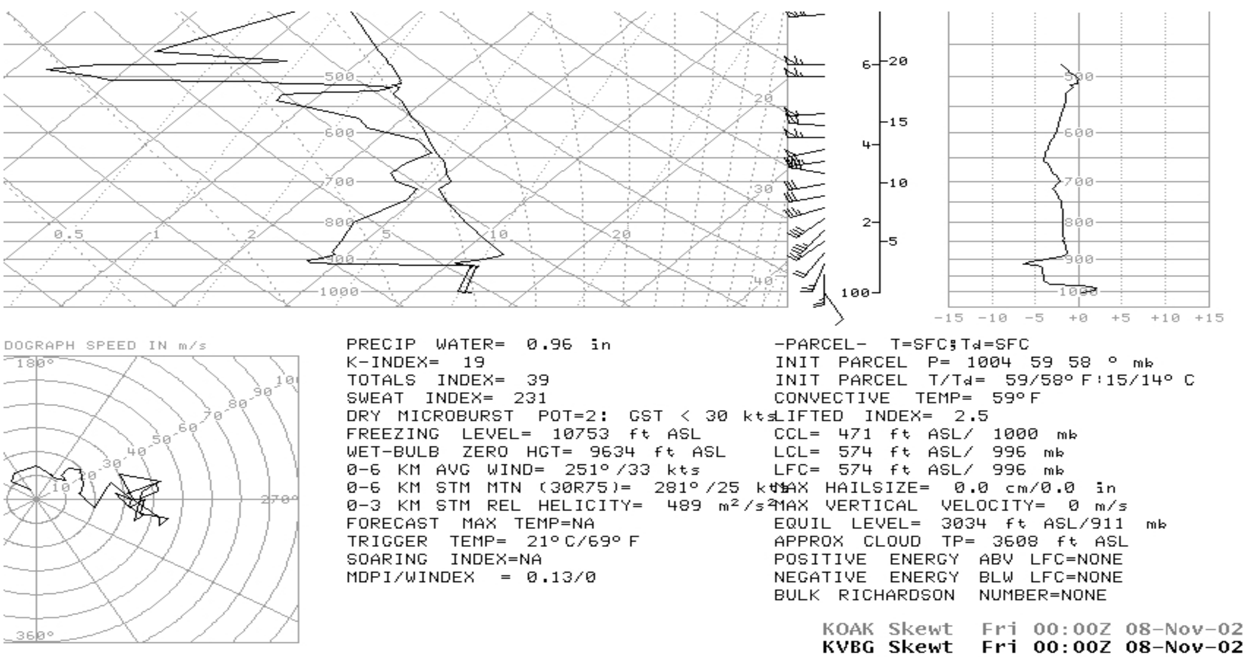

Figure 6b: KVBG Sounding valid 8 November 2002, 0000 UTC

While synoptic lift played a large role in providing the upward vertical motion, the key factor throughout the event was the orographic lift induced by the Sierra Nevada. This mountain chain in central California oriented from NW to SE boasts some of the continental United States' highest peaks, including Mt. Whitney with a summit elevation of 14,491 feet. The figures below show the Sierra Nevada's influence in producing a layered orographic lifting effect (Figure 7) across a cross-section. The significance of this is a lifting process not just limited to the west facing slopes of the mountains, but across a layer spanning as far as 100 km upstream from the actual mountain range. The tilting of the isentropic surface in this nearly zonal wind pattern produced isentropic upglide much like that found ahead of a warm front. In this case, this process resulted in steady, moderate to heavy rainfall across a broad area, not just locally along west facing slopes. Figure 8 below further demonstrates the orographic impacts of the Sierra.

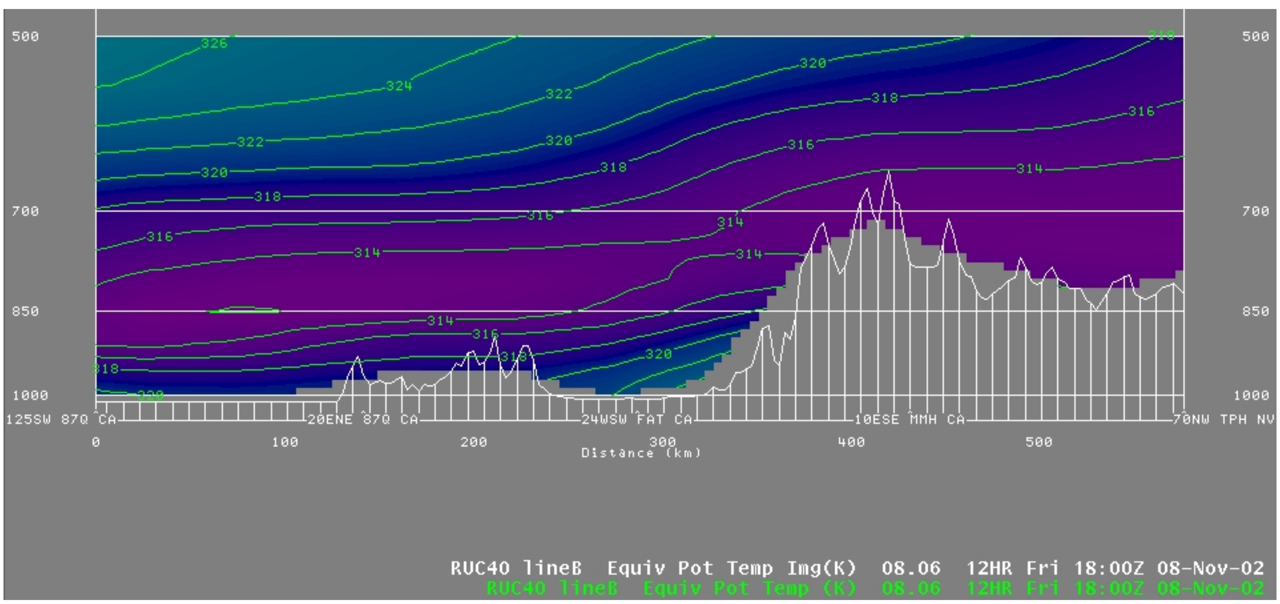

Figure 7: RUC40 Equivalent potential temperature cross-section spanning from the Pacific Ocean to the higher terrain of the Sierra Nevada. Valid 8 November 2002, 1800 UTC.

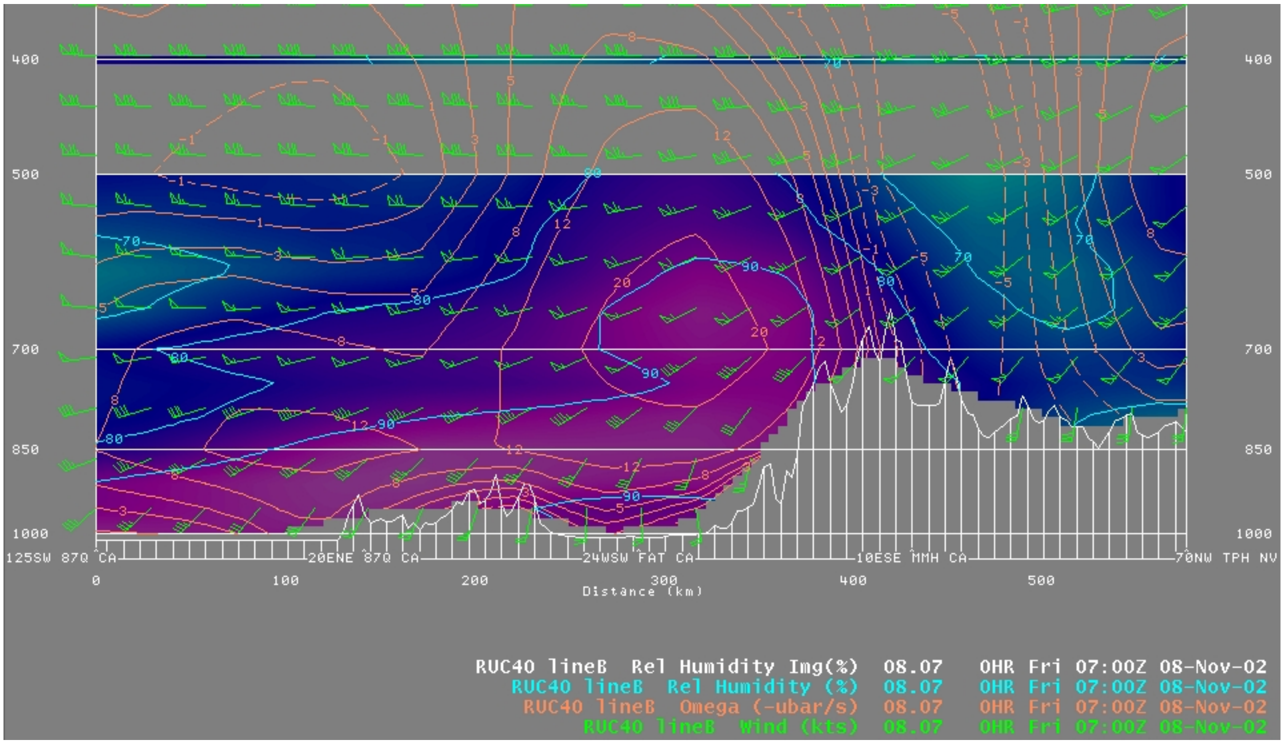

Figure 8: RUC40 Cross-sectional plot analyzing Relative Humidity, Omega, and Winds across a line from the Pacific Ocean to the higher terrain of the Sierra Nevada. Valid 8 November 2002, 0700 UTC.

III. Impacts of event

Prolonged, heavy rainfall affected most of the County Warning/Forecast Area from November 7th to November 9th. The heaviest rainfall occurred on November 8th, which happened to coincide with placement of the left-exit region of the upper level jet directly overhead. Rainfall totals for the 3 day event in the San Joaquin Valley were mostly between 1 to 2 inches. In the foothills of the Sierra Nevada, between 5 to 10 inches of rain fell in the 3 day period, while some locations in the Sierra received over 16 inches! (see Table 1). One such location was the Johnsondale RAWS in the Southern Sierra Nevada, where heavy rains caused road washouts along nearby Parker Pass. Mountain Rd. 99 was also closed from south of Johnsondale to the Kern County line. At Lodgepole, also located in the southern Sierra, over 11 inches of rain caused the road below Durwood Resort to be closed, and the area evacuated.

Flooding also occurred along Highway 178 near Kelso in Kern County, where nearby Glennville received 6 inches of rainfall. Rock/mudslides occurred on Highway 168 and Highway 180 in the southern Sierra foothills. The Generals Highway and Mineral King Highway located in the Tulare County foothills were closed. Sequoia National Park had to evacuate several persons from a flooded trailer park near Ash Mountain on November 9th. Erosion problems associated with the McNally Fire, a recent burn area, caused widespread debris flows across many mountain roads in the area, as well as contributing to a fish kill in the Kern River. Peak flow of the Kern River into Lake Isabella was 26,500 cfs on Friday, November 8th. Lake storage subsequently increased from 82,000 acre-feet to 109,000 acre-feet and the lake elevation increased 5 feet in a 2 day period.

Location	Elevation (ft.)	3 day Precip. Totals (in.)
Merced	153	1.80
Fresno	333	1.76
Hanford	242	1.44
Bakersfield	496	1.29
Balch Power House	1720	5.99
Yosemite H.Q.	3966	7.36
Tehachapi	4220	4.67
Johnsondale RAWS	4700	16.38
Cedar Grove	4720	6.43
Rogers Camp	6200	16.10
Wishon Dam	6550	10.55
Giant Forest	6650	13.50
Lodgepole	6735	11.33
Blackrock RAWS	8200	7.42

Table 1: 3-day precipitation totals for select locations, recorded from 7 November to 9 November, 2002.

Heavy snowfall was limited to locations primarily above 9000 feet. Table 2 indicates some of the higher snowfall amounts for the 3 day period.

Location	Elevation (ft.)	3 day Snowfall Totals (in.)
Upper Burnt Corral	9700	46"
Mitchell Meadow	9900	38"
Volcanic Knob	10500	46"
Chagoopa Plateau	10300	80"

Table 2: Snowfall totals for select locations in the Southern Sierra Nevada, recorded from 7 November to 9 November, 2002.

An impact that was not focused on in this paper but is worth mentioning were the strong winds produced at the surface, and especially over and below the mountain passes of Kern County. Tight on-shore pressure gradients combined with strong winds aloft mixed down along on the lee-side of the Tehachapi Mountains in Kern County to produce strong, gusty winds. Wind gusts to 40 mph were common, with spikes as high as 74 and 91 mph at Indian Wells Canyon during the early afternoon of November 9th. Gusts to 60 mph were also reported at the Inyokern Airport. Even locations in the San Joaquin Valley were affected by strong winds on November 8th. The Southern California Edison Utility Company reported 23 pole fires caused by wind and arcing, which ultimately affected 102,000 residents in the Central and Southern San Joaquin Valley.

IV. Conclusion

This case demonstrated that not all prolonged, copious precipitation events in central California are dependent on the “Pineapple Connection.” And while orographics associated with the Sierra Nevada play a key role, necessary components such as a long moisture fetch, jet dynamics, and strong westerly flow are vital to the longevity and severity of the event.

Situational awareness is critical in forecasting such an event. Local knowledge regarding recent burn areas and/or previous rains that may have saturated the ground could prove invaluable when estimating the flooding potential.

Furthermore, this paper illustrates the importance of recognizing and understanding subtle mesoscale features in determining the onset of a persistent, heavy rainfall event.