Southern California Wind Event - A WES Case Study
9-10 February 2002

BACKGROUND:

Strong offshore winds pose a significant threat to Southern Californians. These events occur on a fairly regular basis resulting in the usual downed trees and power lines, roof and sign damage, overturned 18-wheelers, extreme fire weather conditions, and, rarely, a fatality– usually due to someone coming in contact with downed power lines. Two types of high wind producing offshore wind events that have been particularly well documented are the Santa Ana Winds of Southern California and the Sundowner Winds of Santa Barbara.

In 1995, Ivory Small [SOO SGX] authored NOAA Technical Memorandum NWS WR-230 titled Santa Ana Winds and the Fire Outbreak of Fall 1993. In his memo, Ivory discussed several conceptual models regarding the nature of Santa Ana winds, favored synoptic and mesoscale patterns associated with Santa Ana wind events, and forecasting techniques used by local forecasters at the time. In 1996, Gary Ryan [DAPM at LOX] authored NOAA Technical Memorandum NWS WR-240, titled Downslope Winds of Santa Barbara, California, which described the strong Sundowner Winds that occur commonly below the passes and canyons of the Santa Ynez Mountains. Gary also discussed the synoptic patterns that favored Sundowners, some forecasting rules of thumb, and gave a brief history of significant Sundowner events. Finally, in January 2000, a team of researchers at the National Weather Service Office in Oxnard [LOX], headed by Gary Ryan and Dave Bruno [Lead Forecaster], authored a second NOAA Tech Memo, NWS WR-261, titled Climate of Los Angeles, California. This document contained a diagram showing the three main Santa Ana wind corridors that surround the Los Angeles Basin–(1) the Santa Clara River Valley corridor through western Los Angeles County and southern Ventura County, (2) the Cajon Pass corridor that separates the San Gabriel Mountains from the San Bernardino Mountains, and (3) the Banning Pass corridor that runs east-west between the San Bernardino Mountains and the San Jacinto Range. As a direct result of these studies and other research, the anticipation of strong offshore wind events over Southern California is usually well forecast. However, critical details of the wind event such as where, when and how strong it will be can be extremely difficult to determine.

INTRODUCTION:

The high wind event of 9-10 February 2002 was a fairly typical Southern California wind event. It began with strong northwest to north winds through and below passes and canyons of the Santa Ynez Range [Sundowner winds] and transitioned in about 24 hours to a Santa Ana wind event with northeasterly winds through and below the passes and canyons of the San Gabriel Mountains. From the base of the mountains the flow splits, either channeling through the Santa Clara River Valley and offshore over the Oxnard Plain in Ventura County, or through the San Fernando Valley where it usually splits again to flow either through Simi Valley then the Oxnard Plain, through the passes and canyons of the Santa Monica Mountains and Malibu, or simply through the Los Angeles Basin itself. The forecast challenge for these types of offshore wind event is not whether or not there was going to be a wind event; but rather, how strong an event would it be [advisory or warning?] and exactly where would the strongest winds occur?

There were several reasons why this particular event was chosen as a WES exercise.

1. As mentioned above, high wind events have a significant impact on Southern Californians. Therefore, it is very important that they be forecast accurately and with sufficient lead time. However, this was actually a marginal high wind event by Southern California standards. Therefore, it was not a slam dunk forecast; although it did result in widespread minor wind damage and one fatality due to a falling tree.

2. The fact that it was going to be windy on the 9th of February should not have been a surprise to any Southern Californian. Wind advisories for the region had been issued the preceding afternoon at 3:10 PM. This was plenty of time for viewers of even the early edition evening news to get the word. However, wind warnings were not issued until the 9th at 8:45 AM–which was about the same time that winds increased to warning levels in the mountains. Thus, the warning had insufficient lead time which made it a candidate for local forecast review. A WES Exercise seemed the logical choice for the forecast review process. Not only would it directly involve the participation of the entire forecast staff, but it would also give everyone a crack at improving warning lead time for the event–assuming that the individual actually elected to issue a warning, of course.

3. The initial studies of offshore wind events by Ryan and Small were done back in the PC-GRIDS era. Today, AWIPS offers forecasters much better tools for slicing and dicing model output to build displays of offshore winds and their critical forecast criteria. This WES Exercise specifically suggested several of the key AWIPS displays to look at for evaluating offshore wind events in order to make a better warn/no-warn decision.

4. Finally, this event gave everyone the opportunity to re-familiarize themselves with some of the unique terrain aspects of the various locations favored by high winds [Fig 1]. As was pointed out above, high wind events have been well-documented for both Sundowner Winds in Santa Barbara County and Santa Ana Winds through the Santa Clarita River and San Fernando Valleys. However, there is a tendency for forecasters to overlook the less well-documented winds that occur through the Tejon Pass in Northern Los Angeles County [neither Sundowner nor Santa Ana]. The Tejon Pass winds commonly occur in transitions from Sundowner to Santa Ana winds. While much more localized, these winds and can be significantly stronger than either the Sundowner or Santa Ana and can close the Grapevine section of Interstate 5, thus seriously disrupting commerce and travel on the main route north from the LA Basin. Forecasters were specifically asked to evaluate the gradients through this pass during the WES Exercise.

SYNOPTIC FEATURES:

There was nothing particularly unusual in the synoptic pattern of this event. Following the usual scenario, a surface ridge of high pressure moved onshore over Central California on the 8th of February and was building over the Great Basin. Aloft, there was an upper level ridge building over the Eastern Pacific. By 1500Z on the morning of 9 February, just before the warning level winds kicked in, there was a 1045 mb surface high over Idaho and, aloft, there was a north-south oriented 500 mb ridge with a 586 center located about 600 miles southwest of LAX. There were three key aspects of this pattern that the forecasters had to evaluate.

1. First, were offshore surface pressure gradients strong enough to generate strong offshore winds?

2. How well did the upper air pattern align with and support the low level winds?

3. Was the thermal structure of the atmosphere favorable for the downward transport of strong winds aloft to the surface?

DISCUSSION:

The initial review of the missed warning indicated that the models had actually done a very good job handling both the synoptic and mesoscale aspects of the event. Therefore, the event offered a particularly good opportunity to discuss the importance of evaluating the models and of monitoring the mesoscale data necessary for assessing the three major aspects of a Southern California high wind event.

THE EXERCISE:

Due to limitations of the available archive, the forecast time period had to be artificially truncated. This truncation eliminated the possibility of forecasters ever achieving the desired lead time of 8 hours. However, for the purposes of this exercise, it was still excellent training exercise for the forecast staff and provided everyone with the opportunity for improving on the lead time that was provided during the actual event. The exercise was in three parts.

1. Part 1 of the WES displaced real time [DRT] exercise "started" on a mid shift, about 1100 PM [0700Z] on Friday evening, the 8th of February. Forecasters were provided with the current situation–advisories in effect, an hour-by-hour history of the observed winds [ex. Fig 2], and the pressure gradient trends over the past 14 hours [Table 1]. The steps of this portion of the exercise were as follows:

a. Build a display on AWIPS similar to Figure 1 and then compare and contrast the different wind corridors that lie along or parallel to the axes B-B1 [LAX-BFL] and C-C1 [LAX-DAG].

b. Compute the forecast wind gradients from the 09/06Z Meso-Eta model forecast for 06Z, 12Z, 18Z, and 10/00Z [Fig 3, Fig 4, Fig 5, Fig 6].

c. Build a cross section along line A-A1, Point Mugu Naval Air Station to Lancaster [KNTD-KWJF] depicting Meso-Eta winds, wind speed, omega, and potential temperature [Fig 7a/7b, Fig 8a/8b]. [Note: Paired a/b displays used for clarity.]

d. Forecasters were then asked to comment on the cross section along with the Meso-Eta MSLP display and make a Warn/No-Warn decision regarding the need to upgrade the wind advisories to high wind warnings and indicate which zones would require upgrading.

2. For Part 2 of the exercise, the DRT clock was advanced to 1200Z and restarted. Additional gradient trends were provided [Table 2] along with hour-by hour displays of the observed winds [ex. Fig 9]. Forecasters were asked how the Meso-Eta forecast gradients compared with those observed in the intervening time period from 0700Z.

3. The final part of the exercise was a self-evaluation. Forecasters were given hourly wind displays up until 11/03Z that evening. They were then asked to verify whether or not a warning was required, for what zones, and they were asked to compute their own lead times, assuming they had issued the required warnings.

CONCLUSION:

Each part of the exercise was accompanied by a worksheet with questions to be completed by the forecaster. These worksheets [not shown] were used to evaluate each forecaster's understanding of the event and their warning lead times, if any. As it turns out, warnings were required for two zones and probably a third. Figure 10 shows the mapped winds for 1600Z on 9 Feb 2002. Accordingly, by this time winds have exceeded warning criteria in Zones 46 and 54, and probably in Zone 53; however, that could not be verified for sure due to lack of wind sensors. The time of 1600Z was used as the time of occurrence for the lead time calculations. As the day went on, the winds increased and advisories verified in most of the adjacent zones; however, winds exceeded wind warning criteria in only the three zones mentioned above.

Table 1

Table 2

Figure 1

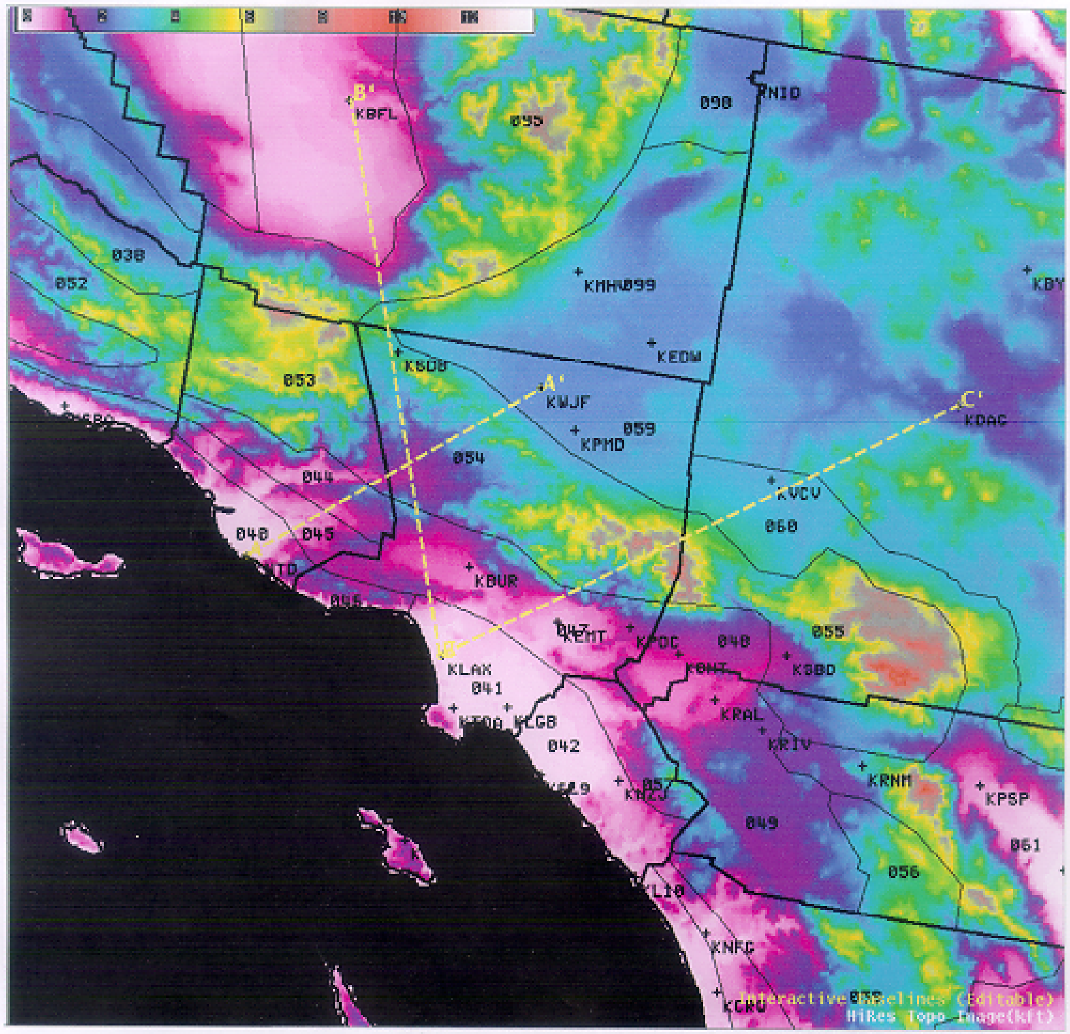

FIGURE 1.

This figure shows the main topographic features of a portion of Southern California centered on Los Angeles County. LOX forecasters have software the produces tables and graphs of the forecast [Meso-Eta and GFS] and observed pressure gradients between the Los Angeles International Airport [KLAX] and Bakersfield [KBFL] in the San Joaquin Valley [B-B'] and between LAX and Daggett [KDAG] in the Mojave Desert [C-C']. These are used to monitor onshore and offshore pressure gradient trends which, not only determines the low level wind patterns, but also determines the extent and impact of the marine influence on weather in the region. The axis A-A' extends from Point Mugu Naval Air Station [KNTD] on the coast of Ventura County to the city of Lancaster [KWJF] in the Mojave Desert portion of Los Angeles County. This bisects the Santa Clarita River Valley which was identified by Ivory Small as one of three favored corridors for strong Santa Ana winds.

Figure 2

FIGURE 2.

This figure shows the observed winds over the region at 0600Z on the 9th of Feb 2002. The yellow lines outline the counties of Ventura on the left and Los Angeles on the right. At this time, wind advisories are in effect for Santa Barbara zones 39 and 52; Ventura zones 40, 44, 45, and 53; and Los Angeles County zones 46, 47, 54 and 88.

Figure 3

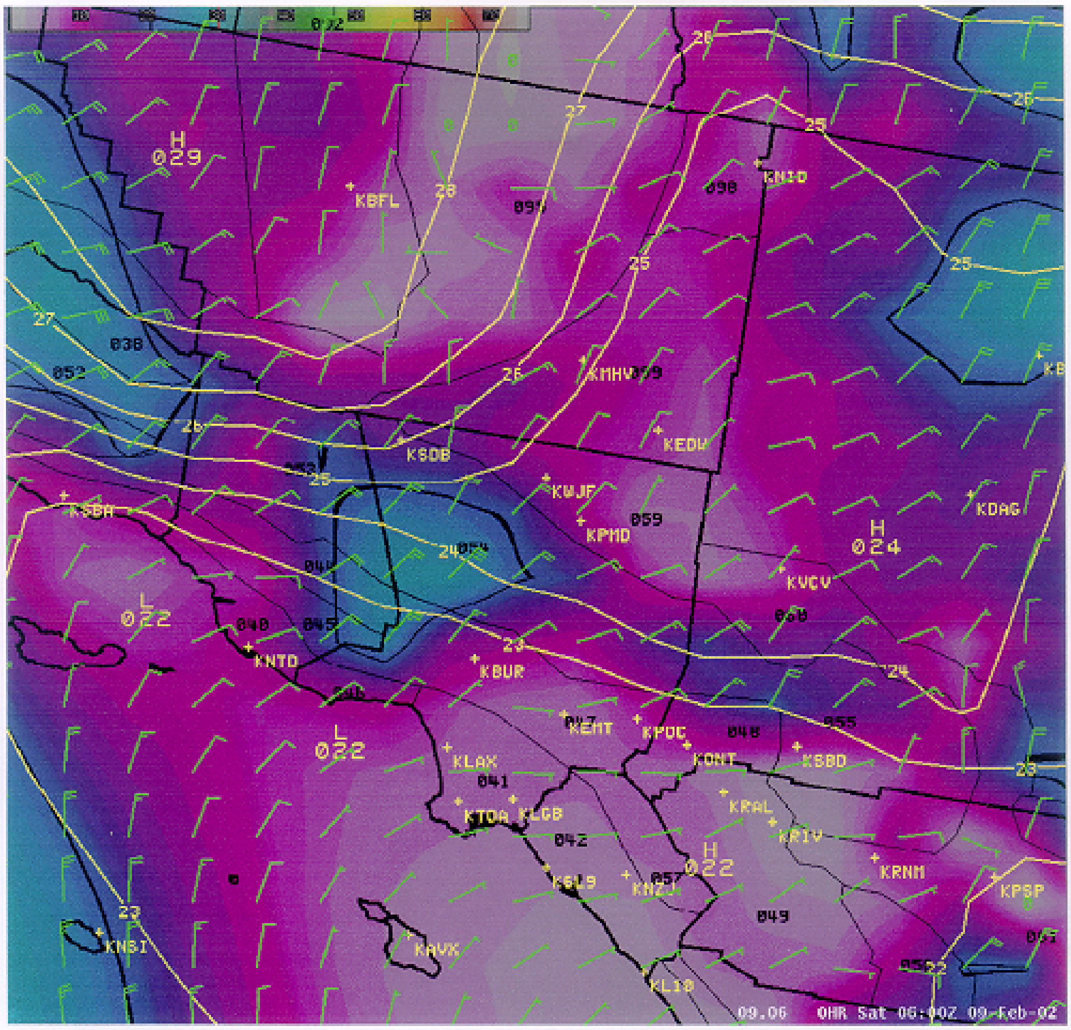

FIGURE 3.

This figure shows the Meso-Eta 0HR forecast for 0600Z on 9 Feb 2002. At this time the LAX-BFL gradients are running about 6 MB offshore and the LAX-DAG gradient is only 2 to 3 MB offshore. Winds depicted are 30MB AGL.

Figure 4

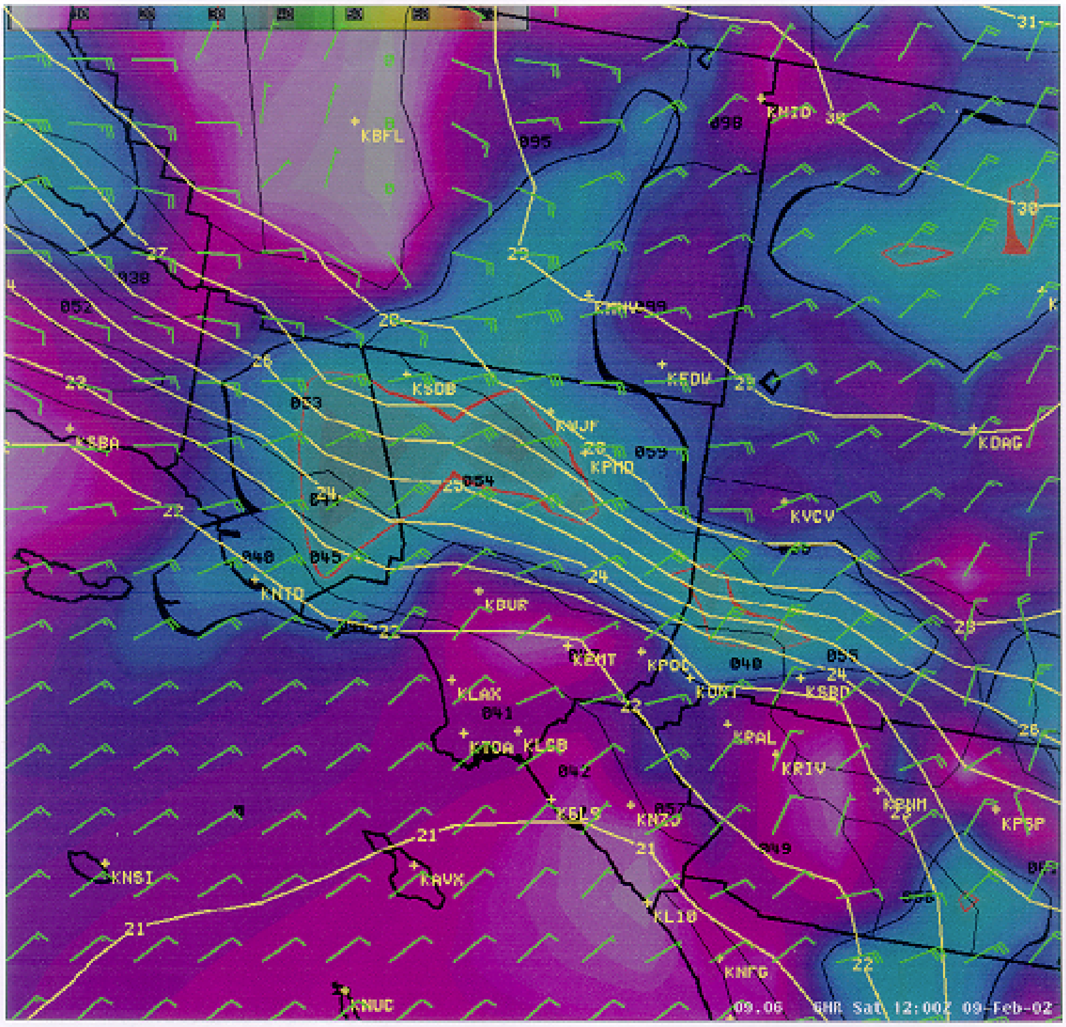

FIGURE 4.

This is the Meso-Eta Forecast valid at 1200Z, Saturday, 09 Feb 2002. Note that the LAX-BFL gradient remains strong offshore at about 7 MB. However, the model indicates that there will be a significant increase in the forecast offshore gradient between LAX-DAG between 0600Z and 1200Z. At 1200Z, the LAX-DAG gradient stands at almost 8 MB offshore. Winds depicted are 30MB AGL.

Figure 5

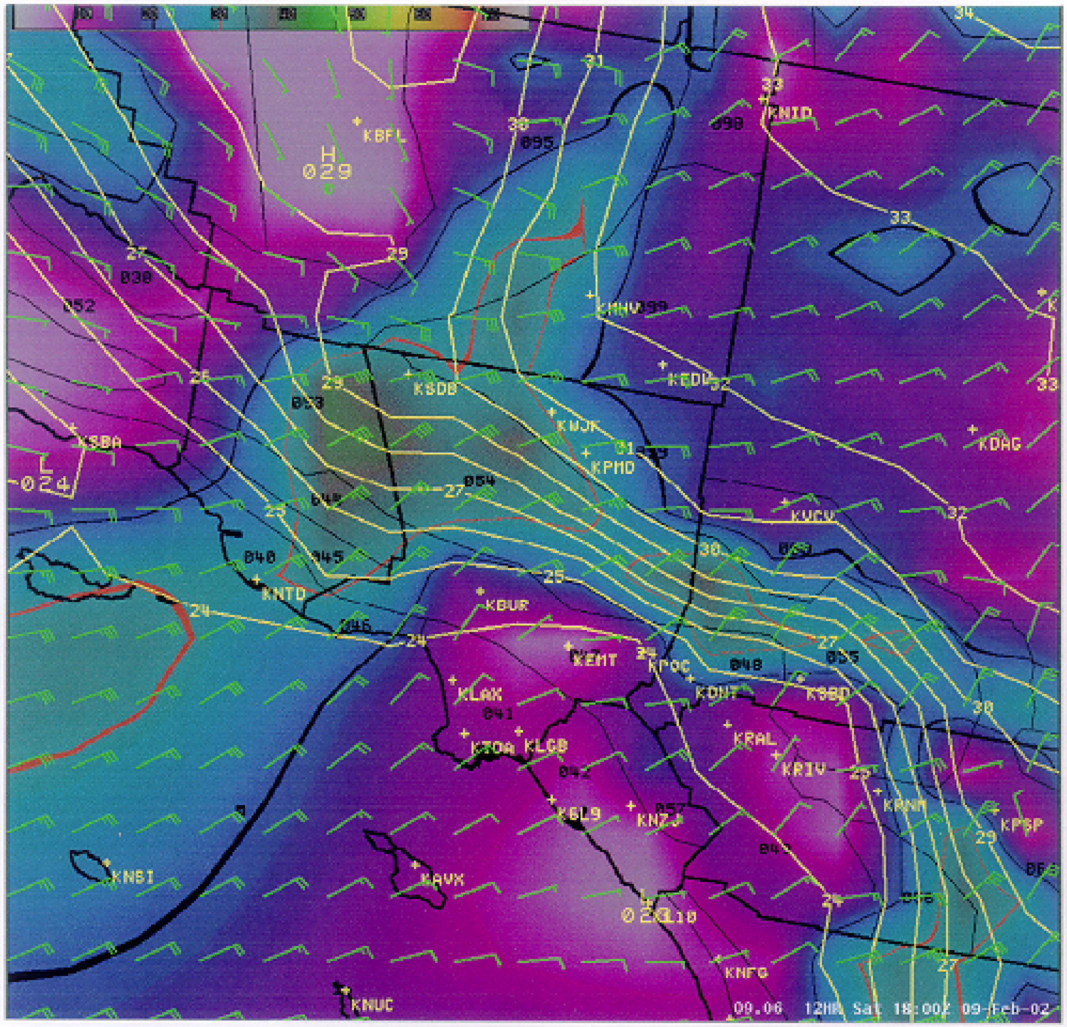

FIGURE 5.

By 1800Z, the forecast N-S surface pressure gradient between LAX-BFL stands at about 6 MB offshore, while the forecast LAX-DAG gradient has increased to around 9 MB offshore as the winds continue to shift to a more NE-SW orientation. Strong winds are now forecast over zones 053 and 054–the mountains of Ventura and Los Angeles Counties–extending locally into the coastal valleys [zones 044 and 045]. Winds depicted are 30MB AGL.

Figure 6

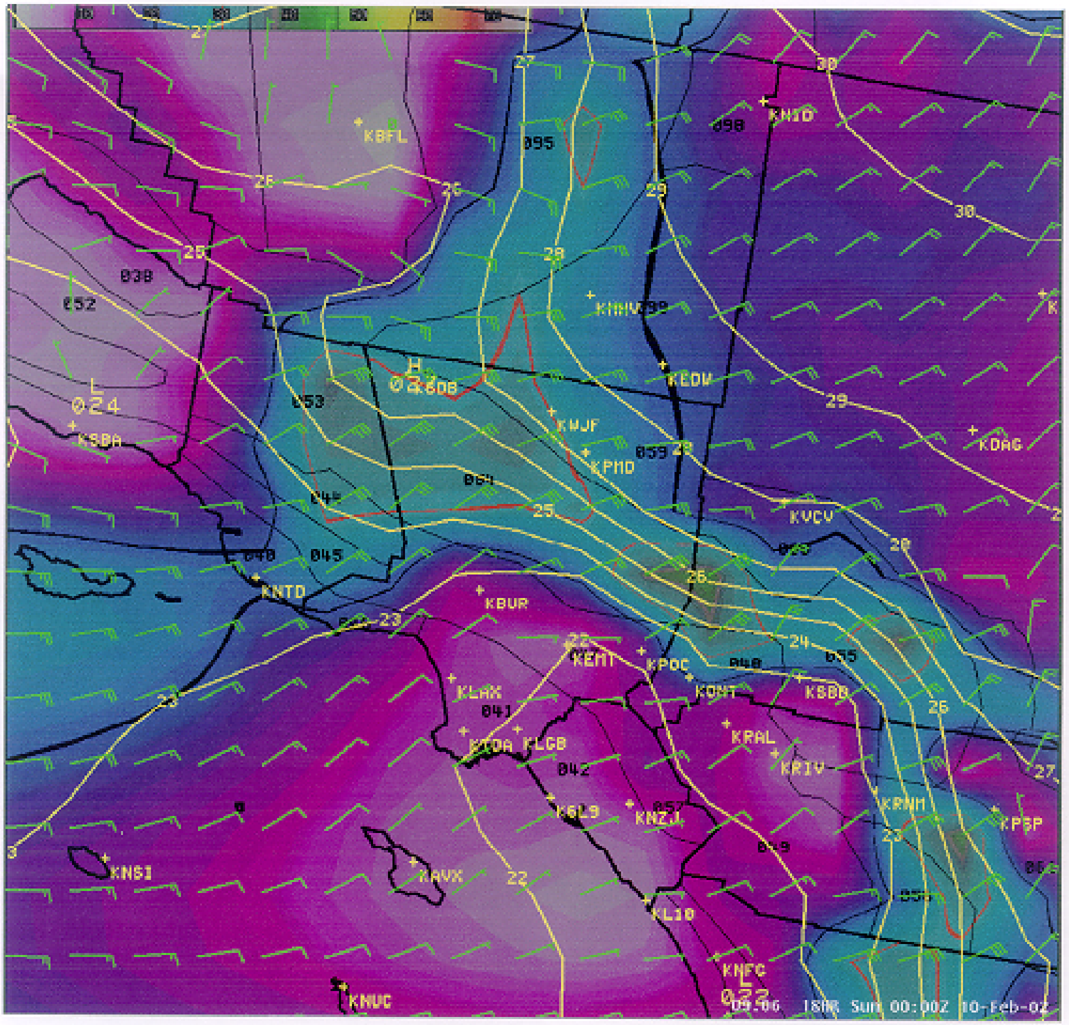

FIGURE 6.

By Saturday afternoon, 0000Z on the 10th of Feb 2002, the LAX-BFL offshore gradient is forecast to diminish to only 4 MB offshore. Whereas, the LAX-DAG gradient is expected to remain strongly offshore at between 7 and 8 MB. Winds depicted are 30MB AGL.

Figure 7s

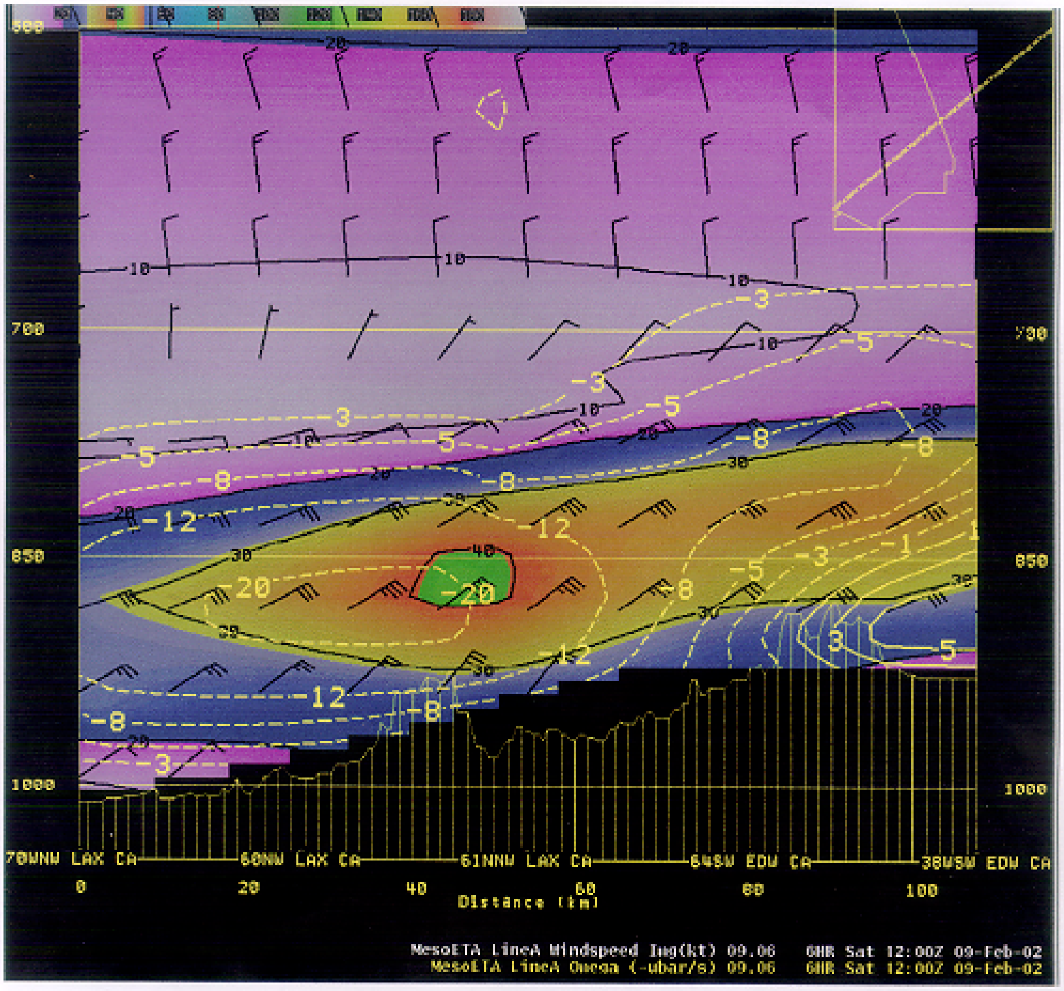

FIGURE 7a.

This figure shows the Meso-Eta 6 hour forecast of winds and vertical velocities along the A-A' corridor [Point Mugu NAS left to Lancaster right] at 1200Z the morning of 9 Feb 2002. Forecast winds have now increased to over 40 knots with forecast downward vertical velocities in excess of 20 micro-bars/sec.

Figure 7b

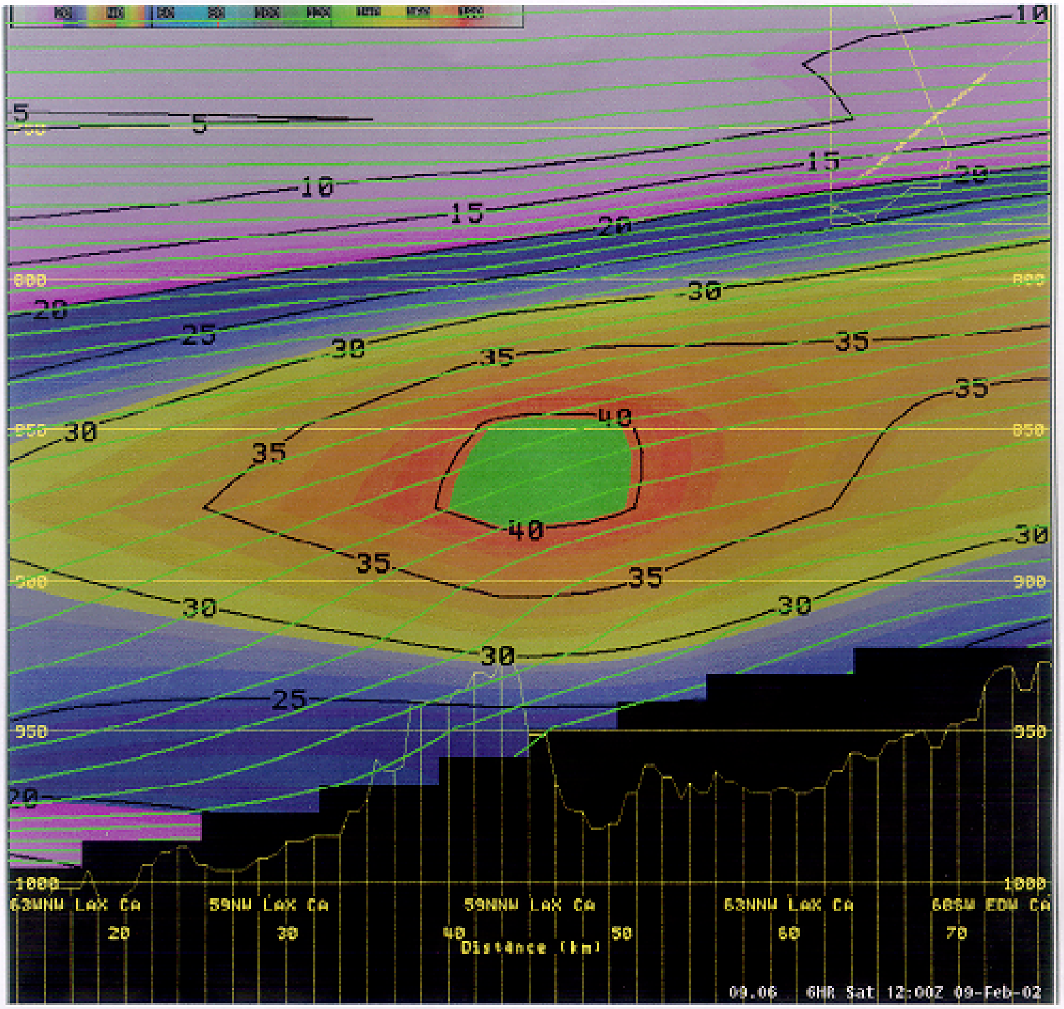

FIGURE 7b.

This figure zooms in on the strongest winds along corridor A-A[1] at 1200Z on the 9th of Feb 2002. The density of the potential temperature surfaces [green lines] has been maximized to show the greatest detail. Note that the potential temperature surfaces are beginning to intersect the "terrain." Thus, the surface winds should begin to increase.

Figure 8a

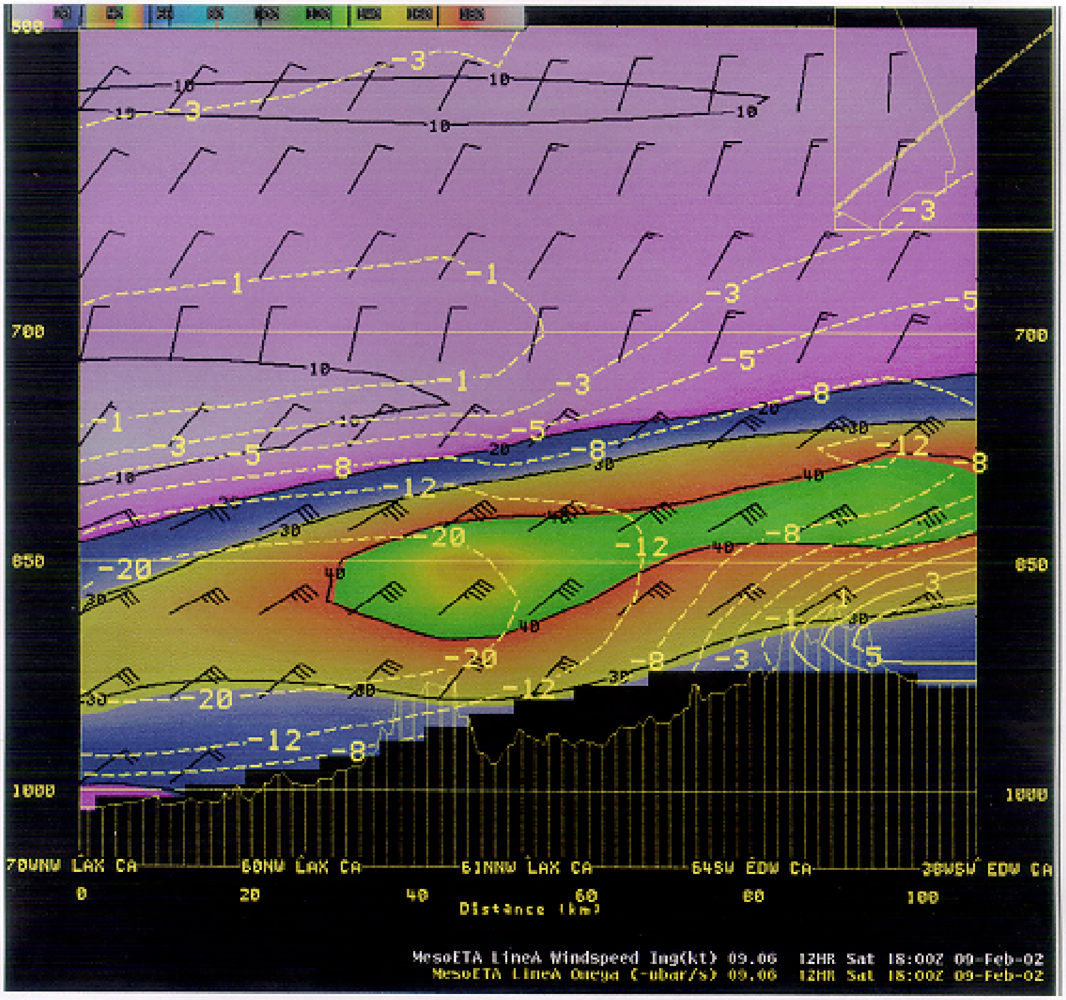

FIGURE 8a.

This figure shows the Meso-Eta 12 hour forecast valid at 1800Z on Saturday morning, the 9th of February 2002. Winds along the corridor are forecast to increase to around 50 knots [57 mph] and the area of negative vertical velocities is forecast to become even more extensive.

Figure 8b

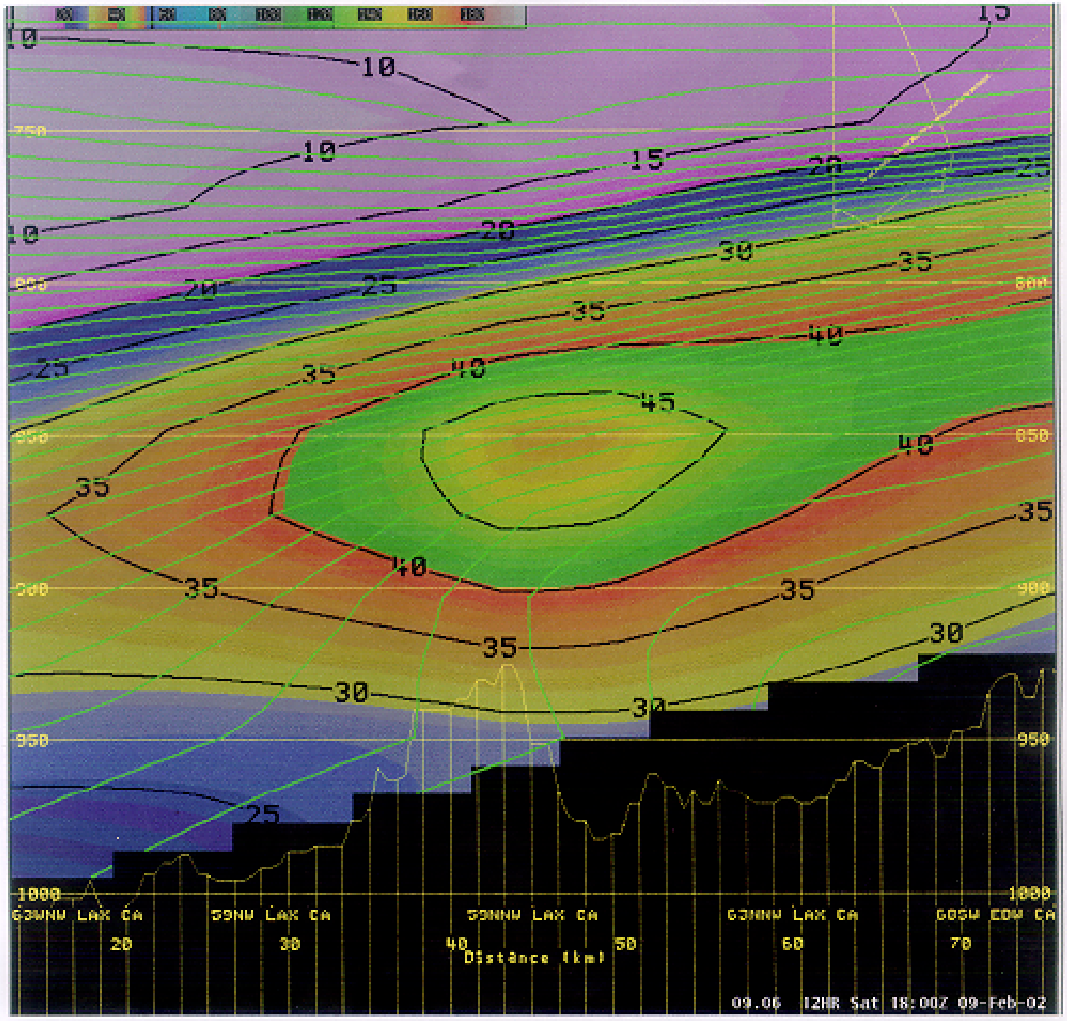

FIGURE 8b.

This figure zooms in on the strongest winds forecast to occur along corridor A-A[1] at 1800Z on the 9th of Feb 2002. The density of the potential temperature surfaces [green lines] has been maximized in order to best show how the potential surfaces intersect the terrain. Note that there has been a significant "steepening" of the potential temperature surfaces since 1200Z.

Figure 9

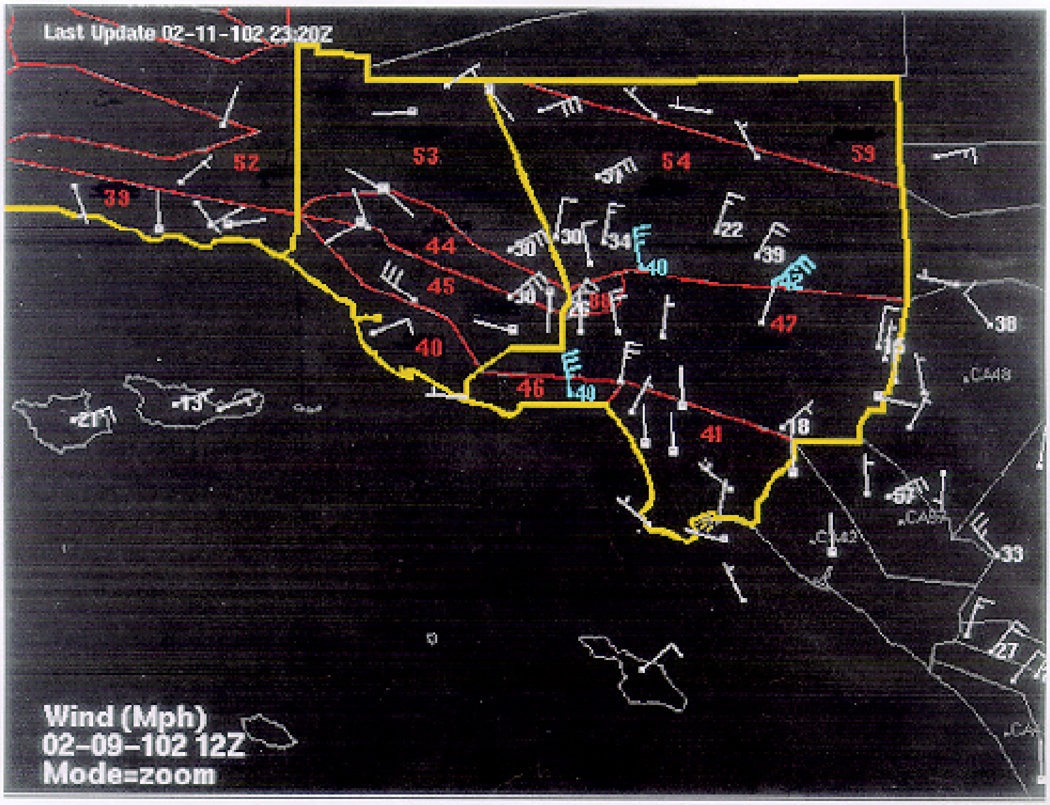

FIGURE 9.
This figure shows the mapped wind data as of 1200Z on 9 Feb 2002. Winds are gusting to 40 and 42 mph at Camp 9 and Chilao, respectively, in the Angeles National Forest [Zone 54], and to 40 mph in Malibu Hills in the Santa Monica Mountains [Zone 46].

Figure 10

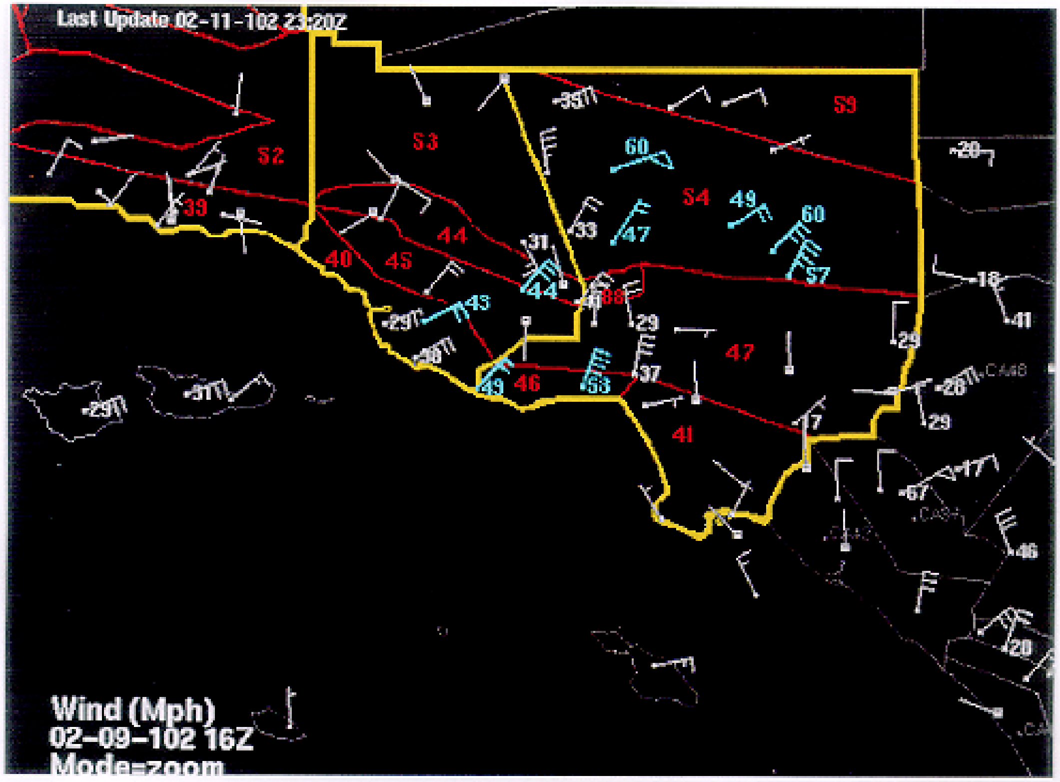

FIGURE 10.

This figure shows the mapped wind data as of 1600Z on 9 Feb 2002. Winds are now exceeding wind warning criteria in the Santa Monica Mountains [Zone 46] and the San Gabriel Mountains and Angeles National Forest [Zone 54]. It is also likely that the winds are exceeding warning criteria in the Ventura County Mountains [Zone 53] but this cannot be confirmed due to the lack of wind measuring equipment in that zone. Wind warnings should have been in effect by this time [8:00 AM PST] for these locations.