~Labor Day Weekend 2002~ An Exercise Involving Flash Flood and Lightning Potential Forecasts ["THE CURVE FIRE"]

September 3, 2003

INTRODUCTION

There are two major sources for rainfall over the Southwestern United States during the summer months. The first of these is the Southeast Monsoon. In Southern California, summer monsoon season kicks in between about mid July to early October—and sometimes it doesn't kick in at all. Usually what occurs is that a semi-permanent high pressure system aloft sets up over the "four corners" area where the states of Arizona, Colorado, New Mexico, and Utah share a common boundary. The circulation around this high brings moisture into Southern California from as far away as the Gulf of Mexico and as near as the Gulf of California. However, in the summer of 2002, the prevailing winds aloft over Southern California were from the southwest—a very dry pattern that was sufficiently strong to keep most of the monsoonal moisture confined to the east of the Colorado River. This was very unfavorable for monsoonal thunderstorms of the usual variety.

The second major source of summer rainfall in Southern California is from passing Eastern Pacific tropical storms. In the last hundred years, an average of one tropical storm approaches near enough to Southern California to cause measurable rain and sometimes local flooding. During Labor Day weekend 2002, dissipating tropical storm Genevieve was located about 800 NM southwest of Los Angeles heading out to sea. At that distance and intensity, it posed no apparent threat to Southern Californians. As this exercise will show, nothing could be further from the truth.

THREAT

The main threats from convective, monsoonal storms are fourfold: damaging winds, large hail, flooding rains, and lightning–especially dry lightning. Of these four, this exercise will review some simple techniques aimed at forecasting the potential for flooding rains and lightning.

METHODOLOGIES

Ivory Small, Science and Operations Officer from WFO San Diego, investigated techniques designed to provide early public notification of flash flood potential over the deserts, mountains, and adjacent foothills of Southern California. His investigation gathered data from two convective seasons—the summers of 2000 and 2001. He actually developed two techniques—one that looked at precipitable water only and a second that looked at both precipitable water and 500 MB winds. These techniques were used to calculate a flash flood potential index [FFPI] which gave a more objective way of determining the potential for flash flooding. These forecasts were later verified against actual flood events.

The LOX procedure, discussed later, is an adaptation of Ivory Small's second, more successful technique that looked at both 500mb wind flow and precipitable water. The theory behind this technique is very simple. Flooding rains should be expected to occur under conditions of high precipitable water and weak steering winds. These conditions should be most favorable for producing slow moving, heavy precipitation showers and thunderstorm capable of producing flash flooding.

WFO SAN DIEGO [SGX] FFPI METHODOLOGY

From the results of his experiments, Ivory Small developed Table 1 for quantitatively evaluating flash flood potential [FFPI] given various values of precipitable water and wind speed.

TABLE 1.

PW VALUES	PW CATEGORY	PW CODE	500MB WIND SPEED	WIND SPEED CATEGORY	WIND SPEED CODE
> or =1.66"	VERY HIGH	40	< 10 KT	VERY HIGH	40
1.50 - 1.65"	HIGH	30	10 - 14 KT	LIGHT	30
1.33 - 1.49"	MODERATE	20	15-19 KT	LOW MODERATE	10
1.25 - 1.32"	LOW	-20	20 - 24 KT	HIGH MODERATE	0
< 1.24"	VERY LOW	-30	> or = 25 KT	STRONG	-10

The Flash Flood Potential Index [FFPI] is computed by adding the precipitable water and wind speed codes contained in Table 1. Thus...

For example, if the value of precipitable water was 1.50 inches [PW Code = 30] and the 500mb winds were 12 knots [Wind Speed Code = 30], then...

$$FFPI = 30 + 30 = 60$$

Table 2 relates the calculated value of FFPI with the flash flood potential categories as follows:

TABLE 2.

FLASH FLOOD POTENTIAL INDEX [FFPI VALUE]	FLASH FLOOD POTENTIAL			
0 or NEGATIVE	NONE			
10 to 20	LOW			
30 to 50	MODERATE			
60	HIGH			
> 60	VERY HIGH			

Thus, for our calculated FFPI value of 60, the resulting flash flood potential forecast would be HIGH.

WFO OXNARD [LOX] TECHNIQUE FOR DETERMINING FFPI

Out of necessity, LOX forecasters use a slightly modified version of Ivory Small's technique for producing FFPI forecasts. Forecasters at WFO San Diego [SGX], issue FFPI forecasts twice daily based on wind and precipitable water information from the 0000Z and 1200Z Miramar [KNKX] soundings. However, the mountains and deserts of the LOX CWA are not well represented by the KNKX soundings—or any of the soundings in Southern California for that matter. Therefore, LOX forecasters issue their twice daily FFPI forecasts using the latest available model output of winds and precipitable water.

For illustration purposes, Figure 1 shows an example of an FFPI calculation using model forecast coverage over the Florida Peninsula. Note that the colors depict the critical PW threshold values as defined by Ivory Small. Specifically, the light bluegreen color depicts areas that have PW values of approximately 1.25 inches or less. PW values of 1.25 to 1.32 inches are in green, values from 1.33 to 1.49 inches are in yellow, values from 1.50 to 1.65 are in red, and values of PW 1.66 inches and above are in fuchsia. As the example in Figure 1 shows, this technique can theoretically be used to locate those specific regions of highest flash flood potential.

Generally, when developing the FFPI forecast, forecasters should look for the maximum values of FFPI in the forecast period with consideration given to the normal diurnal nature of thunderstorm development. Therefore, FFPI will usually be calculated for the hours at or just following maximum afternoon heating—between 2100Z and 0000Z. However, the potential for nocturnal thunderstorms also needs to be considered in some circumstances. This would require the evaluation of FFPI at different times of the day.

DETERMINING LIGHTNING POTENTIAL

Experience indicates that values of 850 MB dewpoint temperature can be used as a quick first guess for thunderstorm coverage—and, therefore, lightning potential—during the southeast monsoon. It can also be used to monitor the day-to-day progress of the monsoonal front—the leading edge of the monsoonal moisture. In general, in the absence of dynamic forcing, monsoonal airmass thunderstorms generally do not form when the 850 MB dewpoint temperatures are less than about +3 C. Figure 2 is an illustration of this technique over the Florida Peninsula. In Figure 2, the +3 C line is the thin blue line. When 850 MB dewpoint temperatures range from +3 C to +8 C, monsoonal thunderstorms tend to occur—with increasing coverage the higher the dewpoint value. The +8 C line is the black line in Figure 2. Areas with 850 MB dewpoint of +8 C or more are quite tropical in nature and are very prone to the development of airmass thunderstorms.

THE EVENT

Sunday morning on Labor Day weekend of 2002 showed basically a benign weather pattern over the southwestern portion of the United States. The dominant synoptic scale feature was dissipating tropical storm Genevieve, located about 800 NM southwest of Los Angeles. Figure 3 shows the visible image from about 8:30 AM PDT centered off the coast of Southern California. Figure 4 is the Tropical Prediction Center's "best track" for Genevieve. As the satellite shows and the best track indicates, Genevieve was in its final dissipating stage and posed no significant threat to Southern Californians.

However, zooming in to the LOX county warning area [CWA], the picture was not so benign. <u>Figure 5</u> is the first good visible image close-up of the LOX CWA taken at approximately 8:00 AM PDT 1 Sept 2002. This figure shows extensive cloud cover over both Ventura and Los Angeles Counties. <u>Figure 6</u> is the radar composite for the CWA [in black] taken at 1436Z [7:36 AM PDT]. This figure shows scattered showers occurring over portions of both Ventura and Los Angeles Counties. Fifteen minute lightning detection data taken at 1430Z [7:30 AM PDT] shows that thunderstorm activity is occurring to the north and outside the LOX CWA–over Kern County in WFO Hanford's CWA.

The 3:30 AM PDT morning forecast for the LOX CWA called for partly cloudy skies over most of the region with a 20 percent chance for thunderstorms over the mountains of Ventura and Los Angeles Counties [Zone 53 and 54, respectively]. However, between 1200Z and 1500Z, lightning detection had recorded strikes in Zone 53 and Zone 59—the Antelope Valley.

The day shift forecasters had three major concerns regarding the forecast. First was the anticipation of record high temperatures at inland locations—especially the interior coastal valleys, mountains and deserts. However, this aspect of the forecast had been handled nicely by previous shifts and a Hazardous Weather Outlook had been issue covering the anticipated Labor Day weekend heat wave. The two remaining problems both concerned the effects of anticipated convection. Specifically, what was the potential for flash flooding and what was the outlook for lightning activity?

Calculation of Flash Flood Potential Index [FFPI]. Using the technique developed by Ivory Small, Figure 7 and Figure 8 are the 12 hour forecasts of FFPI from the 1200Z model runs of the MesoETA and AVN models, respectively. Both of these models paint basically the same picture regarding FFPI. That is, both models are calling for light winds over the mountains of Ventura County [Zone 53] and Los Angeles County [Zone 54] at 02/0000Z [01/5:00 PM PDT]. These light winds will favor slow moving thunderstorms and increase the probability of flash flooding. However, both models also call for low values of precipitable water–less than an inch–which is not favorable for flash flooding. Doing the FFPI calculation for each model yields an identical FFPI of only 10. This corresponds to a low potential for flash flooding.

Looking at the radar imagery from the afternoon, Figure 9 shows the composite reflectivity data for 2233Z [3:33 PM PDT]. This shows a thunderstorm in progress in Zone 53, the mountains of Ventura County. As it turned out, this was the "wettest" storm that was detected by radar the entire afternoon. Figure 10 shows the maximum value of one hour precipitation [OHP] as determined by the Sulphur Mountain Doppler Radar [KVTX] to be only 1.5 to 1.75 inches an hour over a single range bin for only one volume scan. Due to the remote location of this storm, there is no verification of the event one way or the other, but it seems doubtful that this storm was sufficient to produce anything in the way of serious flash flooding. Regardless of the steepness of the terrain, the lack of sub-cloud moisture and extremely dry soils would tend to evaporate or soak up much of the rain that fell prior to ponding.

Of interest, during the WES exercise forecasters were asked to make an FFPI forecast for the afternoon. All determined that the value of FFPI was 10–which indicates low potential for afternoon flash flooding. However, it was almost unanimous that LOX forecasters would have issued a flash flood warning based mainly on <u>Figure 10</u>. Only one forecaster said that he would not issue a flash flood warning. During the actual event, the storms were handled with a series of simple NOWCASTs which highlighted gusty winds and lightning as the main hazards. This was probably sufficient.

The bottom line regarding flash flooding on this day was that not much was expected based on the FFPI calculations which showed a low potential for flash flooding. Storms did occur and were very slow movers—again, as expected. However, there seemed to be insufficient moisture to produce flooding and none was observed or reported.

Evaluation of Lightning Potential or Lightning Activity Level [LAL]. Figures <u>11</u>, <u>12</u>, and <u>13</u> are 850 MB dewpoint temperature fields from the RUC, the MesoETA, and the AVN models, respectively. The RUC is a 6 hour forecast from the 1500Z run valid at 2100Z, the MesoETA is a 9 hour forecast from the 1200Z run valid at 2100Z, and the AVN is a 6 hour forecast from the 1200Z run valid at 1800Z.

Even though there are significant differences in models, forecast times and valid times; it is still possible to make some rough model comparisons. All models agreed that there was sufficient moisture moving over the region to place much of the area within the threat zone for afternoon thunderstorms, base simply on 850 MB moisture. However, there are significant differences of opinion as to areal coverage and a slight disagreement in actual forecast values of maximum 850 MB dewpoint. In fact, there seems to be a bit more disagreement in model solutions than usually expected for normal monsoonal flow where the moisture invades the region from the south and east. It is likely that these differences are at least partially due to the fact that the moisture for this event is coming from a dissipating tropical storm. Local experience suggests that it is not uncommon for models to have difficulty dealing with moisture sources in the region offshore, west and south of Southern California.

During the WES Exercise, forecasters were asked to make thunderstorm coverage forecasts and lightning activity level [LAL] forecasts for the following mountain zones: Zone 52 in San Luis Obispo County, Zone 52 in Santa Barbara County, Zone 53 in Ventura County, and Zone 54 in Los Angeles County. Based on the results of the exercise, the mode forecasts for the event were as follows: LAL 2 for Zones 51 and 52 and LAL 3 for Zones 53 and 54.

For verification purposes, forecasters were asked to jump forward to between 2300Z and 2359Z [4:00 to 4:59 PM PDT], look at what lightning had occurred and what was occurring, and then evaluate their original LAL forecasts. Figures 14, 15 and 16 are model analyses or later model forecasts of 850 MB dewpoint temperatures from the RUC, MesoETA, and AVN models, respectively. Each of these are overlaid with lightning detection data to give an idea of how the models performed, as well as how the forecasts actually verified. However, these figures do not tell the whole story because the complete record of lightning detection data for the afternoon cannot be shown here.

Nevertheless, what lightning is seen on the data is fairly representative of the afternoon's lightning activity. There were no lightning strikes in Zones 51 and 52. In fact, there were no lightning strikes anywhere within either San Luis Obispo County or Santa Barbara County during the afternoon. One look at the satellite data should have eliminated these counties from any concerns regarding afternoon convection. Most of the lightning strikes in the LOX CWA occurred in the Ventura County mountains, Zone 53, with more isolated activity over the mountains of Los Angeles County, Zone 54. No lightning strikes in the LOX CWA occurred outside of these two mountain zones [Note, the apparent lightning strike in Zone 44, Figure 15, was actually in Zone 53. The AWIPS grids are in error there.].

Based on their own re-analysis of the event, the forecasters came up with the following mode values of "observed" LALs: LAL of 1 for Zones 51 and 52, LAL of 3 for Zones 53 and 54. While these values seem reasonable—as will be shown shortly—the thunderstorms that developed did produce some dry lightning strikes. So a LAL forecast of 6 for Zones 53 and 54 could have been justified based on lightning detection observations. Regardless, the quick and simple technique of looking at 850 MB dewpoint temperatures for defining areas monsoonal moisture, inferring lightning potential, and making LAL forecasts—while not perfect—worked as well as could be expected considering that the moisture source was highly variable due to the dissipating nature of the tropical storm [Note, this variability manifest itself in run-to-run model inconsistencies.]. Of course, 850 MB dewpoints were above the +3 deg C thresholds in zones other than the mountains and convection and thunderstorms did not occur. However, forecasters would have routinely discounted these areas since at this level of monsoonal moisture, convection should have been limited to the higher terrain.

DRY LIGHTNING AND THE CURVE FIRE

About 2000Z [1:00 PM PDT] the afternoon of 1 September 2002, forecasters on duty noticed a single positive lightning strike northeast of the Mount Wilson Observatory [KMWS]. This strike drew interest for several reasons. First, it was a positive strike known to be several times more powerful than a negatively charged lightning strike. Second, it occurred in the clear—miles away from any clouds or shower activity. Figure 17 is a composite reflectivity [CR] image centered on the strike taken at 2012Z [1:12 PM PDT]. Figure 18 is a GOES West visible image of the area taken at 2015Z [1:15 PM PDT]. Figure 19 is a side-by-side comparison of the radar and satellite images which confirms that the strike occurred "out-of-the-blue" in a cloud free area. Forecasters were also concerned with the strike because the region had just gone through one of the driest years on record and no rain had fallen on the south-facing slopes of the San Gabriel Mountains in months. It was felt that this particular lightning strike had the potential for starting a wild fire [Note, as Figure 20 shows, it was the only positive strike in the entire southwest portion of California.].

About the same time and location of the lightning strike, a very dangerous and destructive fire did ignite. <u>Figure 21</u> is a picture of the Curve Fire taken at 2356Z [4:56 PM PDT] from the Mount Wilson Observatory—about 4 hours after the first official estimated time of ignition, 2002Z [102 PM PDT]. Note that the camera is pointing to the northeast of the observatory

in the precise direction of the lightning strike relative to the observatory. Early on the official incident summaries said that the cause of the fire was "under investigation." However, for several days, media reports gave an unofficial cause for the fire as being due to a lightning strike. One account even claimed that the lighting started a fire which engulfed a propane tank which then exploded—talk about ignition sources!

The Curve fire posed an immediate threat to holiday campers who had been enjoying their Labor Day weekend in the Angeles National Forest. From the start, the fire exhibited extreme fire behavior with flame lengths estimated to be 80 to 100 feet. The fire occurred in very steep terrain which hampered fire fighters and slowed evacuations. Figure 22 is a picture of an airdrop being made on the fire. The extreme angle of the aircraft testifies to the steepness of the terrain. In the first ten hours of the fire, it burned approximately 10,000 acres. Between 7000 and 8000 people had to evacuate their camp sites—many leaving all their equipment behind.

Despite the evidence, above, the final official report of the fire does not conclude that it started due to the lightning strike. The cause is listed only as "human" and the ignition time has been re-set to 1235 hours PDT [1935Z]. The final cost of the fire was over \$14 million and it burned for most of the month of September 2002.

CONCLUSIONS

The WES exercise provided forecasters with a timely refresher of some of the techniques that can be used when dealing with monsoonal type thunderstorm situations. The FFPI and 850 MB dewpoint techniques, while imperfect, proved useful in handling the situation. One of the most interesting aspects of the exercise was that it dealt with moisture from a dying tropical storm that never came within 500 miles of the region, yet had a significant—potentially deadly—impact on local weather. While official reports of the Curve Fire did not credit lightning as the ignition source; still, intriguing evidence exists that the fire possibly was started by a lightning strike.

ACKNOWLEDGMENTS

One of the basic techniques used in this exercise was base on research done by Ivory Small, Science and Operations Officer at San Diego. In addition, student intern Ryan Kittell helped out with the graphics. The photo of the Curve Fire from the Mount Wilson Observatory is credited to the UCLA Department of Astronomy. Finally, the incredible shot of the air tanker drop on the fire is credited to Leo Jarzomb of the San Gabriel Valley Newspaper Group via the excellent website, WrightwoodCalif.com.

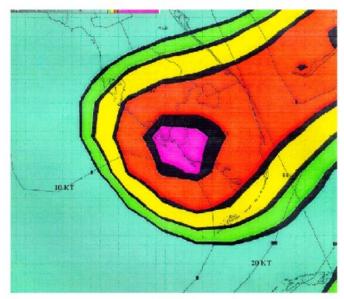


FIGURE 1.

For illustration purposes only, this figure shows the model precipitable water [PW] forecast image overlaid with 500 MB winds for the lower Florida Peninsula. The color thresholds are set according to those specified by Ivory Small in his FFPI technique: light blue-green corresponds to PWs less than 1.25 inches; green corresponds to PWs of 1.25 to 1.33 inches; yellow corresponds to PW amounts between 1.33 and 1.50 inches; red is for PW amounts between 1.5 and 1.65 inches; and fuchsia is for PW amounts greater than 1.65 inches. Using Ivory Small's methodology for calculating FFPI, the FFPI for the area in fuchsia in Figure 1 would be calculated as follows:

FFPI = PW Code + Wind Speed Code = 40 [fuchsia area] + 30 [winds 10 to14 kt]

Thus, FFPI = 70...or Very High.

Figure 2

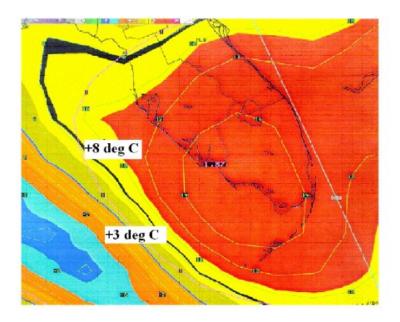


FIGURE 2.

For illustration purposes only, this figure shows an example of a model forecast 850 MB dewpoint temperature field over the Florida Peninsula. Color contours have been set such that the blue line corresponds to the $+3\ \rm deg\ C$ contour and the black line corresponds to the $+8\ \rm deg\ C$ contour. Based on very limited experience, it has been noted that monsoonal thunderstorms seldom form in regions with 850 MB dewpoints less than $+3\ \rm deg\ C$ [outside the blue line]. However, thunderstorm potential increases at increasing levels of 850 MB dewpoint—which is no surprise to anyone. However, while this display should never be used without considering other factors, it has shown some skill in defining the limits of expected monsoonal thunderstorm activity.

Figure 3

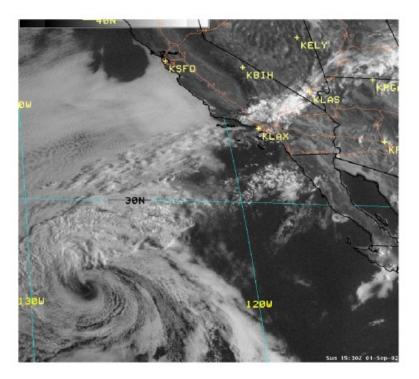


FIGURE 3.

This figure shows the visible imagery from 1530Z [8:30 AM PDT] on Sunday, 1 September 2002. It clearly shows the source for the moisture flowing over Southern California as being the dissipating tropical storm Genevieve located approximately 800 NM southwest of Los Angeles [KLAX]. The satellite clearly shows the exposed low level circulation of the storm with convection limited to the northern quadrant–clear signatures of a dying storm. The Tropical Prediction Center closed the books on this storm later in the day.

Figure 4



FIGURE 4.

This figure shows the Tropical Prediction Center's "best track" for Tropical Storm Genevieve. Note that on 1 September 2002, Genevieve was in its final stages of dissipation.

Figure 5

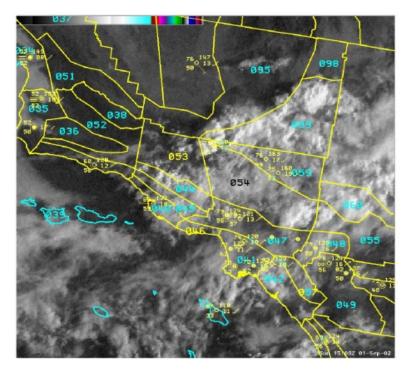


FIGURE 5.

This figure shows the visible imagery from 1500Z [8:00 AM PDT] on Sunday, 1 September 2002. Note the clouds and showers developing as the unstable tropical air encounters the mountains of Ventura and Los Angeles Counties [Zones 53 and 54]. Note, also, the stable marine layer on the central coast of California as illustrated by the fog being reported in Zones 34 and 35.

Figure 6



FIGURE 6.

This figure shows the composite reflectivity [CR] data returns over southwestern California at 1436Z [7:36 AM PDT] on Sunday, 1 September 2002. Fifteen minute lightning detection returns are overlaid on this imagery in red. Note that, at this time, lightning data indicated that all thunderstorm activity was confined to the mountains and desert areas of Kern County, which is outside and to the north of the LOX county warning area [CWA \sim counties in black].

Figure 7

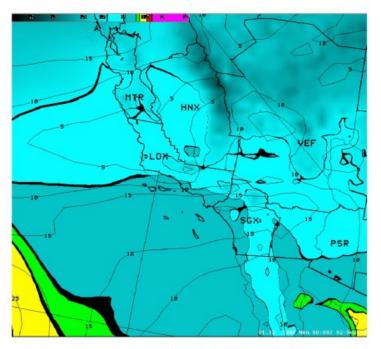


FIGURE 7.

This figure shows the 12 hour forecast from the 1200Z Meso Eta model run, valid at 0000Z on 2 September 2002. The numbered contours are wind speeds in knots at 500 MB. The image is precipitable water [PW]. The lighter blue areas correspond to PWs less than about an inch. The darker blue areas correspond to PW values of about 1.00 to 1.25 inches; green from about 1.25 to 1.33 inches; and yellow from about 1.33 to 1.50 inches. According to this model, winds over the CWA are less than 10 knots and the PWs are running mostly between 0.75 and 1.00 inches. This corresponds to a flash flood potential index [FFPI] of about 10 [FFPI = -30 [PW] + 40 [wind speed] = 10], which corresponds to a very low potential for flash flooding.

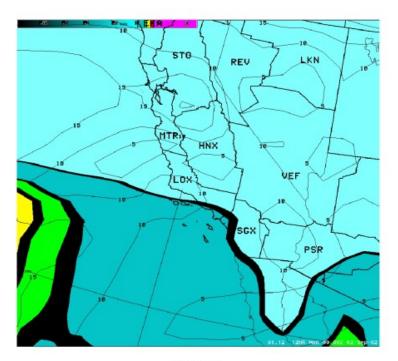


FIGURE 8.

This figure shows the 12 hour forecast from the 1200Z AVN model run, valid at 0000Z on 2 September 2002. The numbered contours are wind speeds in knots at 500 MB. The image is precipitable water [PW]. The lighter blue areas correspond to PWs of less than about an inch. The darker blue is from approximately 1.00 to 1.25 inches; green is from about 1.25 to 1.33 inches; and yellow is for PWs between about 1.33 and 1.50 inches of water. Over most of the LOX CWA the PWs are about 0.75 to 1.00 inches and the wind speed is about 10 knots or less. This corresponds to a flash flood potential index [FFPI] of approximately 10 [FFPI = -30 [PW] + 40 [wind speed] = 10], which corresponds to a very low potential for flash flooding.

Figure 9



FIGURE 9.

This figure shows the composite reflectivity [CR] Doppler radar returns over Ventura and Los Angeles Counties at 2233Z [3:33 PM PDT] on Sunday, 1 September 2002. According to radar returns, the thunderstorm in Zone 53—the mountains of Ventura County—was the "wettest" of the day and raised the most concern for potential flash flooding. See Figure 10 for corresponding one hour precipitation [OHP] data on this storm. Note that the lightning detection system is picking up two isolated lightning strikes in Zone 53. Oddly, the negative stroke is occurring well outside of the storm cell, while the positive stroke is nearly centered on the convective cell. This is the opposite of what we would normally expect.

Figure 10

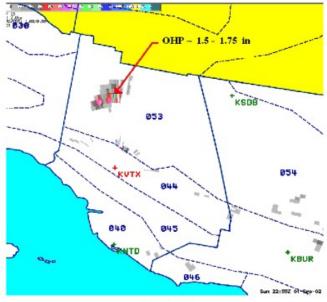


FIGURE 10.

This figure is an inverted image [CWA in white] of the one-hour precipitation [OHP] data from the Sulphur Mountain Doppler Radar [KVTX] valid at 2255Z [3:55 PM PDT] on 1 September 2002. At this time, the radar is detecting an OHP estimate of between 1.50 and 1.75 inches of rain per hour in Zone 53—the Mountains of Ventura County. During the associated WES exercise, all but one of the forecasters elected to issue a flash flood warning for this event. They did so because of the nearly stationary nature of the storm and the steep terrain. Due to the remote location of the event, there was no ground truth one way or the other. However, while the OHP rate is impressive, it was only for one volume scan and one range bin. Therefore, it is doubtful that this cell produced any flash flooding. During the actual event, several NOWCASTs were issued to advise anyone in the area of the storm and the potential for gusty winds, local downpours, and dangerous lightning.

Figure 11

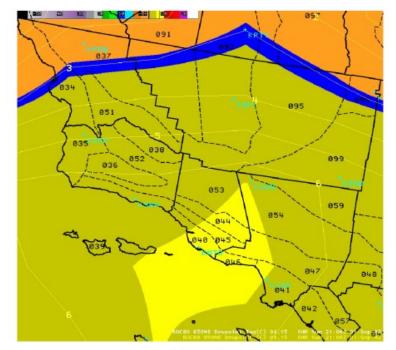


FIGURE 11.

This figure shows the 6 hour forecast from the 1500Z RUC model run valid at 2100Z, 1 September 2002. The numbered contours [yellow] are 850 MB dew point temperatures in Celsius overlaid on an image of the 850 MB dew point temperatures. The blue contour corresponds to the +3 deg C dewpoint contour. Note that this forecast puts almost the entire four county LOX county warning area in a region of elevated thunderstorm potential and lightning activity level [LAL].

Figure 12

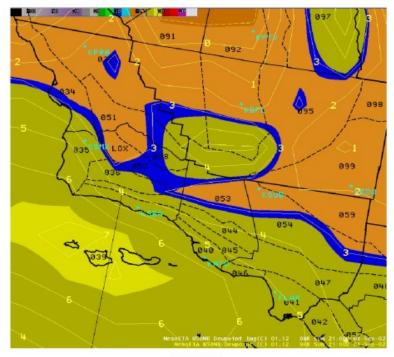


FIGURE 12.

This figure shows the 9 hour forecast from the 1200Z MESO-Eta model run valid at 2100Z, 1 September 2002. The numbered contours [yellow] are 850 MB dew point temperatures in Celsius overlaid on an image of the 850 MB dewpoint temperatures. The blue area corresponds to the +3 deg C dewpoint temperature contour. In most cases, monsoonal thunderstorms should be confined to the regions with the highest 850 MB dewpoints—or within the blue contours. Thus, this would be the area to concentrate on for thunderstorm potential and lightning activity level [LAL] forecasts.

Figure 13



FIGURE 13.

This figure shows the 6 hour forecast from the 1200Z AVN model run valid at 1800Z, 1 September 2002. The numbered contours [yellow] are 850 MB dew point temperatures in Celsius overlaid on an image of the 850 MB dewpoint temperatures. The blue area corresponds to the +3 deg C dewpoint temperature contour. In many cases, monsoonal thunderstorm activity is confined to the regions with the highest 850 MB dewpoints—or within the blue contours. Thus, this would be the area to concentrate on for lightning potential and lightning activity level [LAL] forecasts. From this figure, there is a potential for thunderstorms over 50% of the CWA. However, forecaster experience would narrow this focus to the mountains of Ventura and Los Angeles Counties [Zones 53 and 54] with activity perhaps spreading into the Antelope Valley [Zone 59] after development.

Figure 14

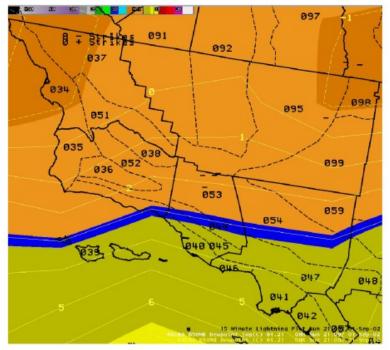


FIGURE 14.

This figure shows the RUC analysis valid at 2100Z on Sunday, 1 September 2002. Overlaid on this analysis is 15 minute lightning data. At this time, lightning within the LOX CWA is confined to Zone 53, the mountains of Ventura County—with some lightning strikes also being detected further north over the higher terrain of the Sierra Nevada Mountains. While all of the lightning strikes within the LOX CWA are falling outside [values less than] the $\pm 3 \deg C$ contour, they are still contained by the $\pm 1 \deg C$ contour.

Figure 15

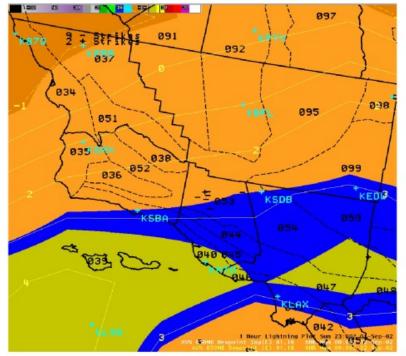


FIGURE 15.

This figure shows the 6 hour forecast from the 1800Z AVN model run valid at 0000Z on 2 September 2002. The numbered contours [yellow] are 850 MB dew point temperatures in Celsius overlaid on an image of the 850 MB dewpoint temperatures. The blue area corresponds to the $\pm 3~\rm deg$ C dewpoint temperature contour. One hour lightning returns from 2300Z are also overlaid on the image. As you would expect, most lightning strikes are occurring in regions of highest 850 MB dewpoint temperature. While most lightning strikes are occurring slightly outside of the $\pm 3~\rm deg$ C contour; they are all still within the $\pm 2~\rm deg$ C contour.

Figure 16

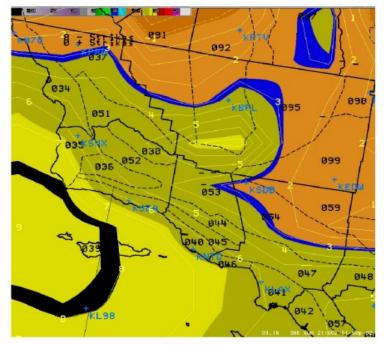


FIGURE 16.

This figure shows the 3 hour forecast from the 1800Z MESO-Eta model run valid at 2100Z, 1 September 2002. The numbered contours [yellow] are 850 MB dew point temperatures in Celsius overlaid on an image of the 850 MB dewpoint temperatures. The blue area corresponds to the +3 deg C dewpoint temperature contour. In most cases, monsoonal thunderstorm activity should be confined to the regions with the highest 850 MB dewpoints—or within the blue contours. As shown here, while the majority of lightning strikes fall within the +3 degree contour, almost half do not. However, all those that don't are occurring over the Sierra Nevada Mountains which are serving as a focus for the convective development.

Figure 17



FIGURE 17.

This figure is a composite reflectivity [CR] Doppler radar image taken at 2012Z on 1 September 2002. It is centered on the lightning strike [red +] that occurred at approximately 2000Z [1:00 PM PDT]. The strike is located a few miles northeast of the Mount Wilson Observatory [KMWS]. It is thought that this lightning strike may have started the major wildfire-later called the "Curve Fire." This fire forced the rapid evacuation of between 7000 and 8000 campers who had been enjoying the Labor Day weekend in the Angeles National Forest.

Figure 18

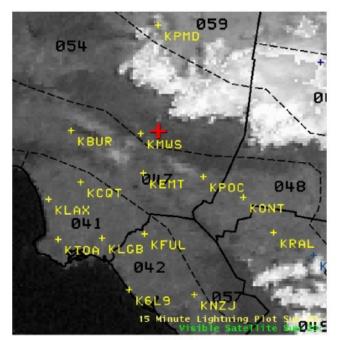


FIGURE 18.

This figure shows the GOES West visible image from 2015Z on 1 September 2002. The imagery is zoomed-in and centered on the positive lightning strike northeast of Mt Wilson [KMWS]. Note that the strike is a good 8 to 10 miles distant and upstream [southwest flow aloft] from the thunderstorm that caused it. Positive lightning strikes are usually many times more powerful than negative strikes and are more likely to occur miles away from the rain shafts associated with the active convection. Because they are more powerful and more likely to occur away from where it is raining, positive lightning strokes are more likely to start wild fires. Considering timing and proximity, that is why it is thought that this lightning stroke was the ignition point of the "Curve Fire."

Figure 19

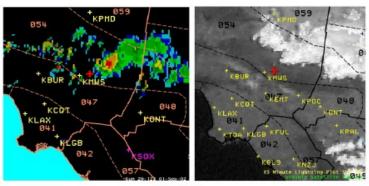


FIGURE 19.

This figure shows the comparison between the 2012Z Doppler radar composite reflectivity image on the left with the 2015Z GOES West visible data on the right. Each of these images is overlaid with 15 minute lightning detection data and each shows the positive [+] lightning strike immediately to the east and slightly north from Mt Wilson [KMWS]. With southwest winds aloft, cell movement was to the northeast. In the visible data you can see the cirrus anvil being blown to the northeast. However, the positive lightning strike does not come out of the anvil, which is typical. Instead, it hits the ground about 8 to 10 miles upstream [southwest] of the thunderstorm cell, itself. Since it occurs in an area that has received no rainfall from the thundershower, it is a prime candidate for ignition of a wildfire.

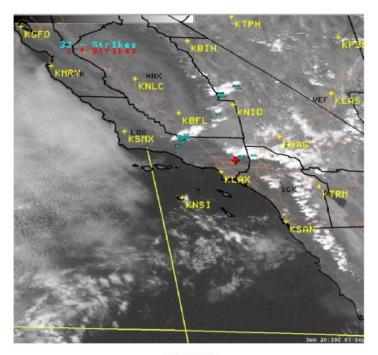


FIGURE 20.

This figure shows GOES West visible image covering Southern California at 2030Z [1:30 PM PDT] on 1 September 2002. This image shows several interesting features. First, note that the band of high clouds that had been so evident in earlier satellite imagery has decreased significantly during the day, indicating that the moisture from tropical storm Genevieve is decreasing over the region. However, there is still sufficient moisture to cause thunderstorms—mostly over the LOX CWA. Finally, note that the vast majority of lightning strikes are negative strokes with only a single positive lightning stroke being detected by the lightning detection system. That positive stroke, located northeast of Los Angeles [KLAX], being the one thought to have started the "Curve Fire."

Figure 21



FIGURE 21.

This photo of the Curve Fire was taken at about 5:00 PM PDT on 1 September 2002 from the web camera at the Mount Wilson Observatory , which is located in the San Gabriel Mountains of Los Angeles County. This camera is owned and operated by the UCLA Department of Astronomy. This picture, looking to the northeast from Mt Wilson, was taken only 4 hours after the fire started. It clearly shows that the fire has become plume dominated with towering pyrocumulus clouds—a sign of extreme fire behavior.



Photo by Leo Jarzomb, San Gabriel Valley Newspaper Group
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FIGURE 22.

This incredible photograph of a T-16 Tanker drop amply illustrates the steepness of the terrain encountered by the fire fighters who were fighting the Curve Fire.