The AMS Convention Storm of 11-13 February 2003
~A Weather Event Simulator [WES] Case Study~
by Dave Gomberg

BACKGROUND

The picture many folks have of Southern California is one of warm days, clear skies, unlimited sunshine, and fun days at the beach–or at one of the many other tourist attractions that the region is famous for. It seems to pose the ideal location for a winter get-together away from the cold and snow common to locations elsewhere during the season. And, of course, such a site would be an ideal location for an annual meeting or convention. Unfortunately, Southern California has its winter storms and this one occurred during the 2003 American Meteorological Society convention.

Figure 1 shows the annual rainfall distribution curves for four locations along the coast of California: the Los Angeles Civic Center [CQT], Oxnard [OXR], and Santa Barbara [SBA] on the southern coast; and Santa Maria [SMX] on the central coast. Although these locations only have average annual rainfall totals of roughly 14 to 17 inches, the curves clearly show that, on average, about two-thirds of the region's annual rainfall occurs during the months of January, February, and March. If the month of December is added in, the four month period accounts for almost four-fifths of the region's annual rainfall. And, of course, the wettest month is February where all the local annual rainfall curves are at their steepest.

This WES Case Study deals with a storm that occurred in the middle of the month of February 2003, at the very steepest part of the annual rainfall curve, and, coincidently, the same week as the American Meteorological Society Convention in Long Beach, California. The goal of this study was simply to provide local forecasters with a challenging rainfall event to bring their quantitative precipitation forecasting skills back up to speed.

INTRODUCTION

Heavy rainfall events pose a significant threat to Southern California. These events occur on a fairly regular basis during the winter months, often resulting in flooding of roadways, creeks, and small streams. Southern California is particularly vulnerable to these heavy rainfall events due to the east-west orientation of many of its mountains and its exposure to moist, subtropical air carried on southerly winds.

As noted above, this WES Case Study discusses the heavy rain event that occurred during the period of 11 to 13 February 2003–which happened to coincide with the national AMS conference that was being held in Long Beach, California. This case study will illustrate the difficulties encountered when trying to make reasonably accurate quantitative precipitation forecasts [QPF] in Southern California. While numerical weather models are absolutely critical in providing essential guidance on the timing and intensity of synoptic scale features, model QPF fields are usually too inaccurate to rely on for local rainfall forecasting purposes. This event illustrates the known bias of the models to underestimate heavy rain events in Southern California. This can often be explained by the models' inability to capture small scale features, as well as their inability to properly resolve important terrain features that can significantly enhance local rainfall amounts. In addition to model guidance, this case study will also look at the QPF guidance provided by the Hydrologic Prediction Center [HPC]. Finally, this paper will investigate some of the parameters that contribute to heavy rain events in Southern California, and demonstrate the value added by QPF forecasts provided by the local forecast office.

SYNOPTIC SITUATION

During the WES Exercise, forecasters were asked to make a 24 hour QPF forecast beginning at 4 PM on Tuesday afternoon, the 11th of February. Therefore, they would have at their disposal the 11/1800Z model runs from both the Meso Eta and AVN to use for their forecasts. Figures from the 1800Z run of these two models will be used to illustrate the key features of the storm.

The heavy rainfall event that occurred from 11 to 13 February 2003 was characterized by a slow moving cutoff low that, at 10 AM on the morning of February 12th, was located about 400 NM west-southwest of Point Conception [**Figure 2**]. This low was perfectly positioned to tap a large plume of subtropical moisture and draw it into the region. To illustrate the key rain-making features of the storm, a series of model snapshots were taken from 10 AM (18Z) on February 12th. These highlight some of the most important synoptic characteristics that directly contributed to the occurrence of the heavy rain.

First, **Figure 2** depicts the 24 hour 500 mb height forecast from the 11/1800Z Meso Eta run–the run used by the forecasters in the WES Case Study. Note the extensive fetch of southwesterly flow that commonly advects subtropical moisture over Southern California. Note, also, the strong upper level difluence in the wind pattern over much of California. **Figure 3** is from the AVN model. It shows the flow at the 250 mb level. Note the strong jet dynamics associated with this system, with a 130+ knot jet core over and just southeast of San Diego. This places the Los Angeles Basin in the favorable left front quadrant for enhancement of the rain due to jet dynamics. The dynamics of the system, along with the inherent orographics of the region, certainly points to an abundance of lift for any air passing through the region. All that is left for heavy rain is the moisture.

Figure 4, this time from the Meso Eta, shows a large area of moisture being carried northward on southerly winds. Precipitable water values in excess of 1.2 inches are being drawn northward along the coast from well south of the Mexican border to near Malibu–which lies along the south-facing coast immediately northwest of KLAX. Such high precipitable water values are certainly indicative of the potential for heavy rains given the inherent orographics of the region along with the dynamics of the system.

On **Figure 4**, note the axis **C'-C** which extends over 250 km from Santa Catalina Island offshore of San Diego, northward to Edwards Air Force Base [KEDW] in the Mojave Desert of Kern County. **Figure 5** is the vertical cross section taken along this axis. The city of Long Beach, California–the site of the National AMS convention–is located under this axis about 25 km east-southeast of the Los Angeles International Airport [KLAX].

Figure 5 clearly illustrates the combination of significant moisture along with a very strong upward vertical motion field centered over the Los Angeles Basin–just south of the San Gabriel Mountains. A maxima of 20 microbars/second near the 700 mb level is clearly illustrated. In addition to the strong dynamics, the south to southeast winds at the low levels would tend to add an orographic component to the rainfall enhancement. However, this contribution was somewhat reduced due to a significant easterly component of the winds at the lowest levels. East winds would be more parallel to the mountain ridge lines reducing the orographic effect.

Significantly, the low level winds earlier in the morning were even more easterly–and much, much drier. That was because the offshore flow associated with the surface low pressure system over the Pacific was being enhanced by a low level jet due to "barrier flow" as strong southerly winds encountered the east-west mountain range. As a result, very dry air from the desert to the east of the region was entrained into the lowest levels of the atmosphere at the immediate base of the mountains–significantly drying out the rainfall as it fell. Thus, the usual orographic enhancement of the rainfall was simultaneously being undercut and minimized for much of the early part of the storm [first 24 hours] due to the dry, low level, easterly jet. Because of this, as will be seen later in the paper, some low elevation sites–such as NWS Oxnard–actually received more rainfall than the mountains to their north. This is certainly not what would normally be expected if orographic enhancement of the rainfall was the dominant process. Thus, the combination of barrier flow and orographic enhancement combined to create unusual rainfall distributions during the early portions of the storm–posing a significant challenge for the QPF forecasters.

WES EXERCISE

While the rain event lasted for more than two full days, the WES Exercise and case study were limited to the initial 24 hour period of heavy rainfall–between 4 PM on Tuesday, February 11th and 4 PM on Wednesday, February 12th. This is the period the forecasters were asked to provide QPF forecasts for during the exercise.

As with all simulations, there is really no way to precisely duplicate the event. Some compromises have to be made. In this case, although forecasters had access to everything that was archived on the WES, two significant things were missing that forecasters routinely use to make their QPF forecasts during actual events. The first of these was the use of the LOXMET computer. This computer is a highly modified version of the old Hydromet computer. Over the years, programmers at Oxnard have developed a lot of useful tools that run on LOXMET–not the least of which is the precipitation mapper that forecasters use during rain events. However, LOXMET does not have an archival capability comparable to the WES. The second important item is actually two separate products. These are the AVN and Meso Eta model orographic QPF forecasts run by the California-Nevada River Forecast Center [CNRFC] in Sacramento using the Owen Rhea model. These important forecast tools had not been archived for the event. Additionally, just to add a twist, forecasters were asked to provide QPF forecasts for a number of locations that they normally do not have to forecast for. This, again, was due to some missing data in event archives. **Figure 6** shows the location of the eight QPF forecast points that were actually used in the WES Exercise relative to the terrain of the LOX County Warning Area [CWA].

The WES exercise was in two parts. The forecasters first had to assess the situation and make a QPF forecast for the 24 hour period from 4 PM on the 11th of February until 4 PM on the 12th of February. They next advanced 12 hours to make a 4 AM update to this forecast. Both forecasts will be "verified" below.

VERIFICATION

Forecasting QPF can be an easy task. Anyone can do it, as long as accuracy is not a concern. You just have to figure out some way of estimating the amount of water that will fall–from a storm system sometimes hundreds if not thousands of miles in dimension–and land inside the small tipping bucket of a rain gage tucked back on a hillside in the middle of nowhere...*piece of cake!* But forecasters are not without guidance in approaching this considerable task. That guidance comes in the form of numerical models and guidance QPF forecasts provided by the Hydrometeorological Prediction Center [HPC].

Below are tables containing the forecasts for the eight QPF points used during this exercise. These were provided to the forecasters as guidance for making their own QPF forecast.

Table 1 is the QPF Guidance from the AVN model forecast valid at 1800Z on Tuesday, the 11th of February 2003. Model forecast values from both the AVN and Meso Eta **[Table 2]** were obtained for each forecast point by simply using the AWIPS sampling function on a graphical display of model QPF.

TABLE 1. ~ 1800Z AVN MODEL QPF GUIDANCE

SITE	4 PM ~ 10 PM	10 PM ~ 4 AM	4 AM ~ 11 AM	11 AM ~ 4 PM	TOTALS
SANTA MARIA	.02	.05	.15	.05	0.27
SANTA BARBARA FC	.07	.05	.30	.10	0.52
SAN MARCOS PASS	.07	.05	.29	.10	0.51
NWS OXNARD	.10	.08	.39	.23	0.80
SULPHUR MOUNTAIN	.10	.06	.38	.20	0.74
LA CIVIC CENTER	.09	.10	.50	.44	1.13
NEWHALL	.10	.07	.45	.33	0.95
CHILAO	.07	.01	.48	.45	1.01

Table 2 is the QPF Guidance from the Meso Eta model forecast valid at 1800Z on Tuesday, the 11th of February 2003.

TABLE 2. ~ MESO-ETA MODEL QPF GUIDANCE

SITE	4 PM ~ 10 PM	10 PM ~ 4 AM	4 AM ~ 11 AM	11 AM ~ 4 PM	TOTALS
SANTA MARIA	0	0	.1	.06	0.16
SANTA BARBARA FC	.01	0	.05	.26	0.32
SAN MARCOS PASS	.01	0	.04	.23	0.28

NWS OXNARD	**.02**	**.07**	**.21**	**.28**	**0.58**
SULPHUR MOUNTAIN	**.02**	**.04**	**.16**	**.16**	**0.38**
LA CIVIC CENTER	**.05**	**.38**	**.52**	**.69**	**1.64**
NEWHALL	**.06**	**.28**	**.65**	**.35**	**1.34**
CHILAO	**.03**	**.38**	**.75**	**.53**	**1.69**

Table 3 is the QPF guidance from HPC for this event. In fairness, a lot of "guesstimation" was involved in deriving the specific values in this table. That is because QPF graphical guidance comes in the form of rainfall contours which are difficult to translate to the point values that were the goal of this forecast exercise. In the end, 24 hour totals **[in red]** were calculated by simply taking the average of the range of HPC estimated forecast QPF values [ex. for Santa Maria, range is 0.20 to 0.40; average is 0.30 for the Total].

TABLE 3. ~ HPC FORECAST GUIDANCE

SITE	4 PM ~ 10 PM	10 PM ~ 4 AM	4 AM ~ 11 AM	11 AM ~ 4 PM	TOTALS
SANTA MARIA	**~.1**	**~.1**	**~.1**	**~.1**	**~.20 ->.40 [.30]**
SANTA BARBARA FC	**~.3**	**~.2**	**~.1**	**~.1**	**~.35 -> .70 [.52]**
SAN MARCOS PASS	**~.3**	**~.25**	**~.1**	**~.1**	**~.40 -> .75 [.57]**
NWS OXNARD	**~.5**	**~.2**	**~.1**	**~.1**	**~.45 -> .90 [.68]**
SULPHUR MOUNTAIN	**~.35**	**~.3**	**~.1**	**~.1**	**~.43 -> .85 [.64]**
LA CIVIC CENTER	**~.6**	**~.25**	**~.2**	**~.2**	**~.63 -> 1.25**

					[.99]
NEWHALL	~.5	~.2	~.15	~.15	~.50 -> 1.00 [.75]
CHILAO	~.6	~.3	~.25	~.25	~.70 -> 1.40 [1.05]

As a basis for comparison with guidance and for verification purposes, an average of all LOX QPF forecasts was calculated. The results of the initial 4 PM forecasts are contained in **Table 4**. The **red numbers** in **Table 4** are actual rainfall totals for the event.

TABLE 4. ~ LOX 4:00 PM FORECASTS vs OBSERVED RAINFALL

SITE	4 PM ~10 PM	10 PM ~4 AM	4 AM ~11 AM	11 AM ~ 4 PM	TOTALS
SANTA MARIA	.06 [0]	.09 [.27]	.21 [.17]	.28 [.11]	.64 [0.55]
SANTA BARBARA FC	.11 [0]	.20 [.24]	.38 [.63]	.40 [.11]	1.09 [0.98]
SAN MARCOS PASS	.18 [0]	.41 [.79]	.72 [.83]	.66 [.43]	1.97 [2.05]
NWS OXNARD	.17 [0]	.30 [.67]	.47 [1.61]	.53 [1.13]	1.47 [3.41]
SULPHUR MOUNTAIN	.29 [.16]	.48 [.36]	.72 [2.08]	.79 [.43]	2.28 [3.03]
LA CIVIC CENTER	.20 [.04]	.39 [.42]	.62 [.79]	.61 [1.10]	1.82 [2.35]
NEWHALL	.24 [.03]	.48 [1.00]	.76 [1.64]	.80 [2.23]	2.28 [4.90]
CHILAO	.37 [.27]	.70 [.63]	1.07 [2.37]	1.02 [2.75]	3.16 [6.02]

Table 4 shows mixed results. The 24 hour total forecasts for the Santa Barbara County sites [Santa Maria, San Marcos Pass and Santa Barbara Flood Control] were quite respectable. However, the NWS

Oxnard, Newhall, and Chilao sites were significantly under-forecast. Note, also, that NWS Oxnard [at 50 feet elevation] actually received more rain than did either San Marcos Pass [2300 feet] or Sulphur Mountain [2700 feet]–the opposite of what would be expected if the rainfall pattern was purely orographic [see discussion, last paragraph of **SYNOPTIC SITUATION,** above]. Towards the end of the 24 hour period, the storm did become more orographic. This is shown in the rainfall totals observed at both Newhall and Chilao.

Table 5 shows the composite LOX QPF forecast numbers for the update forecast issued at 4 AM on Wednesday, the 12th of February.

TABLE 5. ~ 4 AM UPDATE FORECAST vs OBSERVED RAINFALL					
SITE	**4 PM ~ 10 PM**	**10 PM ~ 4 AM**	**4 AM ~ 11 AM**	**11 AM ~ 4 PM**	**TOTALS**
SANTA MARIA	[0]	[.27]	.39 [.17]	.27 [.11]	0.93 [0.55]
SANTA BARBARA FC	[0]	[.24]	.61 [.63]	.44 [.11]	1.29 [0.98]
SAN MARCOS PASS	[0]	[.79]	1.06 [.83]	.72 [.43]	2.57 [2.05]
NWS OXNARD	[0]	[.67]	.86 [1.61]	.60 [1.13]	2.13 [3.41]
SULPHUR MOUNTAIN	[.16]	[.36]	1.27 [2.08]	.83 [.43]	2.62 [3.03]
LA CIVIC CENTER	[.04]	[.42]	.84 [.79]	.71 [1.10]	2.01 [2.35]
NEWHALL	[.03]	[1.00]	1.15 [1.64]	.92 [2.23]	3.10 [4.90]
CHILAO	[.27]	[.63]	1.29 [2.37]	1.05 [2.75]	3.24 [6.02]

For final comparison purposes, all model and HPC guidance forecasts and the composite LOX QPF forecasts were graphically compared with the actual, observed rainfall totals. Figure 7 shows the results of this comparison. Note that in each case, LOX forecasters were able to make substantial improvements in the QPF forecast over guidance, resulting in substantial "value added" to the rainfall forecast for this event. Note, also, with the exceptions of the three Santa Barbara County sites [Santa Maria, San Marcos Pass, and Santa Barbara Flood Control] the update forecast [4 AM] was superior to the original forecast [4 PM]–as it should be.

AREAL QPF COMPARISON ~ HPC vs OBSERVED

As previously pointed out, the heavy rain event lasted a few days–from the 11th to the 13th of February. While the WES exercise dealt with only the first 24 hour period of the storm, an areal composite of the rainfall from the entire event was constructed based on a contour analysis using rainfall data from over 50 rain gages that recorded the event. Rainfall numbers were event totals as of 03:59 AM PST on 13 February 2003, as contained in the Public Information Statement issued at that time by the National Weather Service in Oxnard, CA. **Figure 8** shows the contoured rainfall analysis of these reports. Note the extensive area of accumulations greater than 4 inches. Significantly higher rainfall amounts are contained within the 4 inch contours. Some of these are as follows: In Ventura County ~ **5.10** inches at Piru; **6.50** inches at Sycamore Canyon; **5.55** inches at Chorro Grande; and **6.18** inches at Ortega Hill. In Los Angeles County ~ **5.26** inches at Sepulveda Dam; **5.53** inches at Chatsworth; **5.76** inches at Saugus; **6.10** at Pocoima Dam; **6.60** inches at Newhall; **6.93** inches at West Fork Heliport; **8.27** inches at Cogswell Dam; **9.75** inches at Thompson Creek Dam; and **10.35** inches at Mount Wilson.

While it is impossible to compare areal distributions with the point forecasts of the LOX forecast staff, HPC guidance is an areal product which lends itself to such comparisons. **Figure 9** is a composite areal forecast based on the graphical addition of 6 hour forecasts issued by HPC during the period roughly corresponding to **Figure 8**. It is easy to see from the comparison that the HPC forecast is underdone. While the storm produced rainfall totals of 5 to 10 inches over large portions of the LOX CWA, HPC guidance maxed out at only 3 inches. In addition, the maximum centers were mis-located in the complex terrain. This could be critical for accurate flood forecasting. For example, the 2 inch center located in Santa Barbara County is located north of the Santa Ynez ridge line. Any flooding that this heavy rainfall would produce would impact the Santa Ynez River that flows westward, parallel and north of the Santa Ynez Range. This could impact the Lompoc area, just to the north of Point Conception on the Central Coast of California. Whereas, the heaviest rain in this region actually occurred over the higher terrain of Ventura County–in the Ventura River watershed. Flooding of this watershed impacts the City of Ventura. Thus, even a small mis-positioning of the maximum of about 10 to 20 miles resulted in a shift in the flood threat of approximately 100 miles.

CONCLUSIONS

The WES exercise provided forecasters with a timely refresher of some of the parameters to use when assessing the potential for heavy rainfall Southern California. As the exercise demonstrated, while model data provides essential input on synoptic scale strength and timing of storm systems, the actual QPF fields are often greatly underestimated. However, the local forecast office has the necessary tools and the local forecast staff has the unique knowledge of the local area necessary to provide reasonably accurate rainfall forecasts that are a significant improvement over guidance. Thus, local forecasters provide essential "value added" to centrally generated or prepared QPF forecasts. This, in turn, has a direct positive impact on local emergency managers and other decision makers directly responsible for flood prediction, swift water rescue, and other emergency planning situations.