High Impact Verification Evaluation
Winter Storm January 22-27, 2008

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Introduction

Extremely dry weather had been the rule over Southern California since the last major winter storms raked the region in January and February 2005. The series of storms that hit Southern California in late January 2008 produced a six-day rainfall total of 5.81 inches in downtown Los Angeles. This easily exceeded the annual rainfall measured at that location of only 3.21 inches for the entire previous water year [July 2006 to July 2007]. The very dry conditions had resulted in an extended period of high fire danger culminating in the devastating wild fires of October and November of 2007. While several storms earlier in the season had temporarily reduced the fire danger, the local fire weather season really did not end definitively until the winter storm of January 22 to 27. For this reason, it is considered a high impact event worthy of examination and verification.

Storm Summary

…Heaviest snow amounts and lowest snow levels in years…
…Severe thunderstorm watch issued for SoCal…

A deep low pressure system dropped down the central California coast early in the week of January 21st resulting in significant heavy snow at low elevations and severe weather along the coast on Wednesday and Thursday, January 23rd and 24th [**Figure 1**]. A heavy rain band pounded Santa Barbara County on Wednesday with snow levels dropping to less than 1000 feet at times due to evaporative cooling. Several inches of snow were reported at 2500-3000 feet and several feet of snow fell above 4000 feet. Highway 33 to Rose Valley was closed for over a week due to 5 foot drifts and the "Grapevine," the section of Interstate 5 that runs through the Tejon Pass, was closed for a 36-hour period Wednesday night into Friday morning [**Figure 2**]. An estimated 300 to 500 trucks and cars were stuck overnight in a 40-mile stretch of the Grapevine on Wednesday night, January 23rd.

There were several convective cells that showed rotation on radar as the air mass turned more unstable Wednesday evening. Waterspouts were reported near the Oxnard coast on Tuesday afternoon, in the vicinity of the Palos Verdes peninsula on Wednesday evening, and then along the coastlines of both Ventura and Los Angeles Counties Thursday evening. One waterspout came onshore at Pt. Mugu NAS and damaged a roof and overturned heavy trash containers [**Figure 3**]. Heavy rains saturated Los Angeles County where many reports of flash flooding and small debris flows occurred Thursday night into Friday morning. In addition, three different avalanches occurred near Mountain High ski resort on January 25th, resulting in 3 deaths.

A day or two later, on Friday and Saturday, a second low pressure system dropped even further south and west than the storm earlier in the week [**Figure 4**]. This low pressure system pulled subtropical moisture and 140kt jet across southern California with steady rain developing quickly Saturday evening and raising snow levels above 8000 feet. As the subtropical jet shifted east before sunrise Sunday, an unstable air mass replaced it. Showers and isolated thunderstorms developed along the central coast by late morning. The upper low split and stretched apart off the coast with the first cold pool moving inland during the day, and the second later Sunday night. Thunderstorms were observed with both. Good speed shear, abundant CAPE, and several hours of sunshine prior to the arrival of the initial cold pool prompted SPC to issue a severe thunderstorm watch for Sunday afternoon. Fast-moving showers moved through the region with very heavy rainfall lasting 15 minutes or so, however no severe thunderstorms occurred and lightning strikes were minimal. The second cold pool moved through the area Sunday night with additional rainfall and isolated thunderstorms, but all flash flood watches were allowed to expire by Monday morning.

For the multi-day event, the forecast office issued 49 warnings which included 3 tornado warnings, 4 severe thunderstorm warnings, 7 winter storm warnings, 9 flash flood warnings, 11 high wind warnings, and 15 special marine warnings. Along with these warnings, forecasters issued numerous watches, advisories and special weather statements. Media interest was heavy with the staff providing over 60 media briefings including a number of live TV and radio interviews.

Impact Summary

The storms that hit Southern California during the period 22 to 27 January 2008 were the most powerful storms to visit the region in several years, and they produced a wide variety of impacts. Three skiers lost their lives in avalanches in the San Gabriel Mountains of Los Angeles County where over 4 feet of snow was measured. Interstate 5 through the Grapevine was closed several times—the longest period being 36 hours. Since I5 is the main north-south corridor in California, the closure of this roadway splits the state resulting in millions of dollars in lost revenues. Five waterspouts were observed with 4 touching down onshore causing highly localized wind damage. Finally, several mud and debris flows were reported—mostly in the vicinity of recently burned areas. Except for the recent devastating fires, these storms had the greatest impact on the local area since the winter of 2004-2005.

Verification Methodology

Using BOIVerify to analyze grid performance, one can generate a tremendous number of statistics—even when looking at just one event. Therefore, in analyzing this multi-day, high impact, multi-storm system, it was necessary to limit the analysis to a manageable level. Since the goal was to look at grid performance for both POPs and QPFs, it was decided to limit the analysis to the two six hour periods which saw the heaviest rains during the storms. These two periods are [1] the evening of Thursday January 24th, or from 00Z to 06Z, 25 January 2008 and [2] early Sunday morning from 06Z until 12Z, 27 January 2008. For each of these two time periods, both model and forecaster POP and QPF grids will be analyzed and compared. In addition, at distinct, measured time limits, collaboration with adjacent offices will be examined. Conclusions will be based on these analyses.

January 25th 00Z to 06Z

Probability of Precipitation Analysis

Figures 5, 6 and 7 look at the forecast POPs from the GFS40, the NAM, and the LA/Oxnard [LOX] office at three time periods: 60 hours, 36 hours, and 12 hours. These panels show that the office forecast was much more consistent in both coverage and trend when compared to the models. **Figure 8** shows the progression of POP forecasts out to 168 hours along with the observed rainfall coverage for the event of 95.7%. Forecasters hit the POPs pretty early and ramped up nicely for the event. A slight chance of rain was put in the forecast at the 6 day point and raised to above seasonal climatology over 5 days in advance of the event. From there, the official POP forecast trended steadily upwards—becoming categorical basically everywhere by the 12 hour point. Interestingly, both the GFS40 and the NAM actually lowered POPs at the 12 hour point. Therefore, despite guidance that was inconsistent in both coverage and trend, the forecasters had a very good POP forecast for this event.

Quantitative Precipitation Forecast Analysis

Figures 9, 10, and 11 look at the QPFs from the GFS40, NAM, and the official forecast at the 60, 36, and 12 hour points. As should be expected, the GFS40 QPF forecasts are fairly useless because the model cannot resolve the terrain sufficiently to get the orographic element of the rainfall properly distributed. The NAM QPF guidance was much better than the GFS, properly identifying the south facing slopes of the mountains as the favored location for the highest QPF values. However, the overall NAM QPFs were much too light and the 12 hour forecast trend was even drier and had the poorest overall QPF distribution when compared to earlier NAM forecasts. The NAM and GFS40 only forecast maximum amounts of between 0.50 to 0.60 inches of rain during the period, whereas observed maximum amounts ranged from 1.5 to around 2 inches.

Figure 12 shows how the official LOX QPF forecasts measured up. Except for a dip at the 36 hour point, LOX QPFs trended steadily upward with time. The dip at the 36 hour point correlates well to a corresponding dip in the guidance QPFs from both the GFS40 and NAM. It is probable that this contributed to the corresponding dip in the forecast QPFs. From the 36 hour point, the trend was steeply upward. However, when compared to observed QPFs, the results were mixed. As the graph clearly shows, forecasters tended to over-forecast lower QPF amounts while under-forecasting the extent of the higher amounts. For example, forecasters called for a tenth of an inch of rain everywhere, but that amount or higher was observed in only about 64% of the region. On the high end, forecasters only called for about 1 to 2 percent of the region to see rainfall in excess of an inch accumulation. However, about 5% of the region actually saw that amount or greater. Nevertheless, the official QPF forecast was much improved over model guidance. As can be seen from **Figure 12**, the official forecast had the highest QPF amounts properly located and the amounts, while leaving some room for improvement, were certainly much better compared to model guidance.

Event Collaboration

Figures 13 and 14 show a comparison of the LOX POP and QPF forecasts, respectively, with our neighbors from Monterey [MTR], Hanford [HNX], and San Diego [SGX]. These figures show that the event was fairly well coordinated, with a few small exceptions.

The biggest problem involved POP coordination with Hanford. While some disagreement along the LOX-HNX border should be expected and can be explained due to the hilly to mountainous terrain along much of that boundary, still, the eastern portion of this boundary lies in the relatively flat Mojave Desert where agreement should not be impacted by terrain. **Figure 13** shows that the 20% POP collaboration threshold was exceeded along the LOX-HNX border at both the 60 and 36 hour points. Verification shows that it actually rained across this border during the period in question. So, the higher LOX POPs worked out to be the better forecast. In fairness to the Hanford forecast staff, both the GFS40 and the NAM showed steep POP and QPF gradients across this border, as well. Finally, **Figure 14** shows that QPF coordination was excellent at those periods investigated with no boundaries exceeding the 0.25 inch collaboration threshold.

January 27th 06Z to 12Z

Probability of Precipitation Analysis

Figures 15, 16 and 17 look at the forecast POPs from the GFS40, the NAM, and the LA/Oxnard [LOX] office at three time periods: 66 hours, 42 hours, and 18 hours. Both the GFS40 and NAM hit the forecast real hard and early with widespread 80 to 100% POPs at the 66 hour point. Forecasters followed suit with widespread categorical POPs [85%] in most locations, except for 70% POPs in the Antelope Valley and interior portions of San Luis Obispo County. Forecasters then notched up POPs at least 10 percent across the board at 42 hours—then went with a rare 100% POPs at the 18 hour point. In contrast, the models, especially the NAM, actually lowered POPs as the storm approached. In fact, the NAM dropped POPs in most locations to the 30 to 50% range at the 18 hour point. Again, the LOX POPs showed both a better trend and coverage pattern than either of the models.

Figure 18 shows the impressive progression of forecaster POPs out to 174 hours before the event. The observed rainfall coverage for this event was a very high 96.8%--in other words, it rained just about everywhere. LOX forecasters exceeded seasonal POPs at day 7, went likely at the 90 hour point, and went categorical at 66 hours before the valid time of the forecast. Similar to before, however, the forecasters backed off POPs slightly to 90% just before the event. Again, this is likely due to the dramatic drop in POPs of the NAM at the 18 hour point. Normally, this model has a high degree of credibility with the forecast staff and should be expected to do well in the 0-24 hour time period of the forecast. However, the bottom line here is much the same as before. The forecaster POPs were superior in coverage and trend versus model guidance from the GFS40 and the NAM.

<u>Quantitative Precipitation Forecast Analysis</u>

Figures 19, 20, and 21 look at the QPFs from the GFS40, NAM, and the official forecast at the 60, 36, and 12 hour points. Again, due to model limitations, the GFS40 is basically unusable for QPF. The NAM, however, has the model terrain to do a respectable job with the orographic effects of storm systems, although amounts are usually on the light side. However, at the 66 hour point, **Figure 19**, the NAM is actually looking pretty good. It has widespread QPFs greater than an inch over the portion of the CWA south of Point Conception, with amounts to over 2 inches in the usual terrain enhanced areas along the south facing slopes of the Santa Barbara, Ventura, and Los Angeles County mountains. As the system approaches and the time period of the NAM forecast gets shorter, you would expect the model to be more accurate. But, in this case, that is not what you get. **Figures 20 and 21** clearly show the model losing its handle on the distribution of the forecast rainfall while greatly diminishing the amount of rain forecast. The end result is, at the 18 hour point, the NAM forecasts a small area of QPF greater than an inch over the San Gabriel Mountains in Los Angeles County, with lesser amounts over the mountains of Ventura and Santa Barbara Counties.

Figure 22 shows the progression of official LOX QPF forecasts. Amounts up to 2.00 inches or more are in the forecast as early as the 78 hour point. At the 30 hour point, the LOX QPF is calling for fairly widespread amounts greater than an inch [68% of the CWA] with over 10% of the area seeing 2 inches of rain or more. At the 18 hour point, forecasters backed off these amounts slightly. However, as the system bored in, LOX forecasters once again dropped QPFs precipitously at the 6 hour point. This is probably just another reflection of the even more dramatic decrease in model QPFs just before the storm hit. Nevertheless, as **Figure 22** shows, the LOX 18 hour forecast was pretty much right on. The maximum areas were well identified, and, while the forecast amounts over the San Gabriel Mountains were a tad high, the amounts elsewhere compared very favorable to the observed amounts.

Event Collaboration

Figures 23 and 24 show a comparison of the LOX POP and QPF forecasts with our three neighbors: Monterey [MTR], Hanford [HNX], and San Diego [SGX]. These figures show that, overall, the event was well coordinated. At the hours investigated, **Figure 23** shows that the POPs were always at or within the 20% limits.

The story with QPFs is similar, but with two exceptions. **Figure 24** shows that at the 66 hour point, there was a collaboration problem with MTR. That office was forecasting 0.20 inches of accumulation while LOX was forecasting 0.50 inches. What verified was between 0.40 and 0.50 inches of rain in the area. So the MTR folks were a little light and the LOX forecasters were slightly more accurate. At the 18 hour point, a similar problem developed between HNX and LOX in the Mojave Desert. Here, the HNX forecasters were calling for between 0.15 and 0.20 inches; whereas, the LOX forecasters were calling for 0.45 to 0.55 inches of rain in the adjacent Antelope Valley. What fell, according to verification, was between 0.30 and 0.40 inches—or about halfway in between. It looks like a little bit of compromise on both sides would have resulted in a superior forecast. Nevertheless, with these two exceptions, the forecasts were very well-coordinated.

Summary

The Pacific storm systems that hit Southern California between the 22nd and the 27th of January, 2008, were some of the most significant and challenging in the last several years. A number of lives were lost, damage was in the millions, and numerous watches, warnings and advisories were needed to keep the public abreast of the situation. Despite the heavy warning workload, forecasters did an excellent job with both the POP and QPF forecasts grids. Without exception, forecasters added significant value to the model forecasts with superior verification results across the board. Finally, while there were some flaws and there remains room for improvement, collaboration with adjacent offices was very good considering the workload and complexity of the event. Thus, the bottom line of this verification exercise is that the forecasters at Oxnard and the surrounding sister offices did an excellent job forecasting a very challenging event.

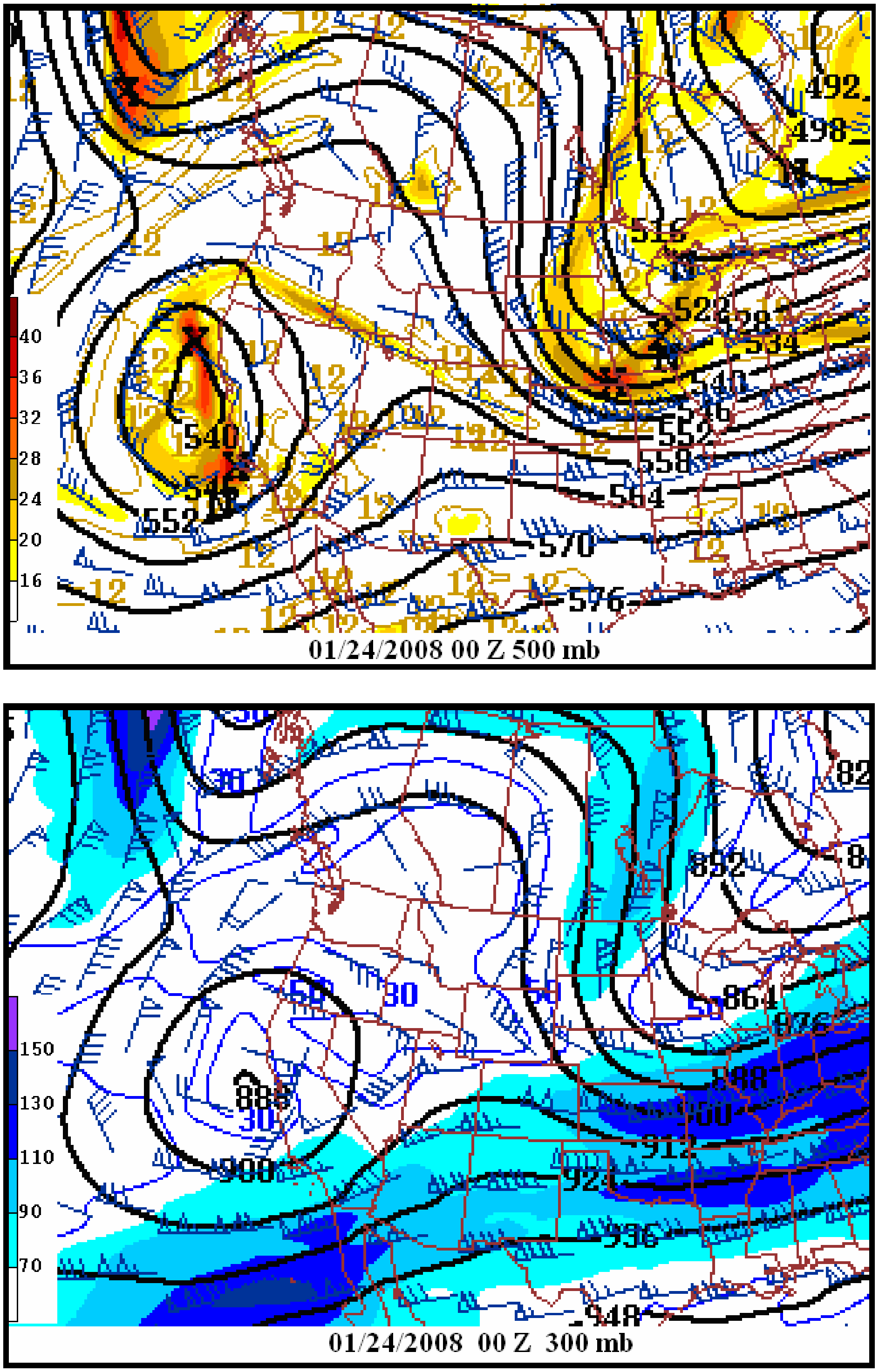
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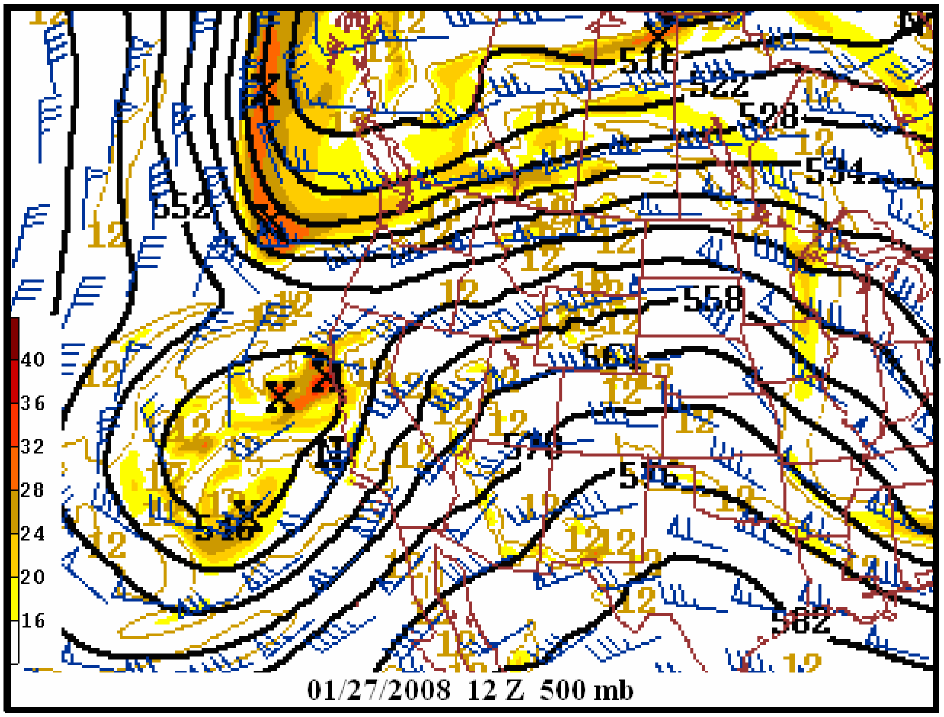
FIGURE 1

FIGURE 2

A plow clears snow along Interstate 5 near Gorman before officials close the Grapevine area on Wednesday evening, January 23, 2008 [LA Times]

FIGURE 3

Point Mugu Naval Air Station reported roof damage to several small buildings and overturned trash containers when a waterspout came ashore on Thursday evening, January 24, 2008.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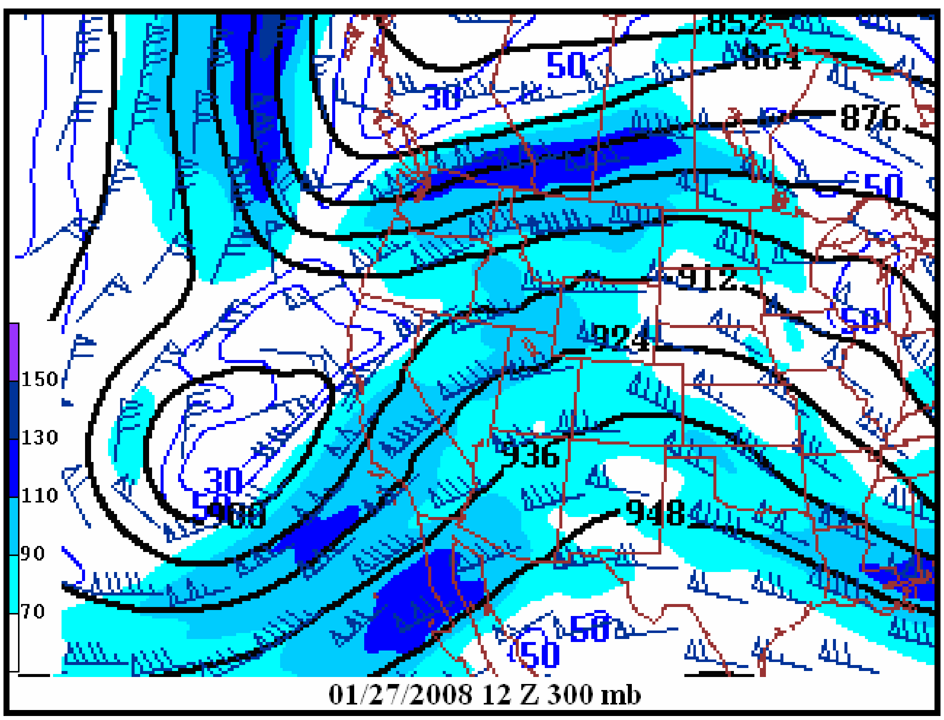
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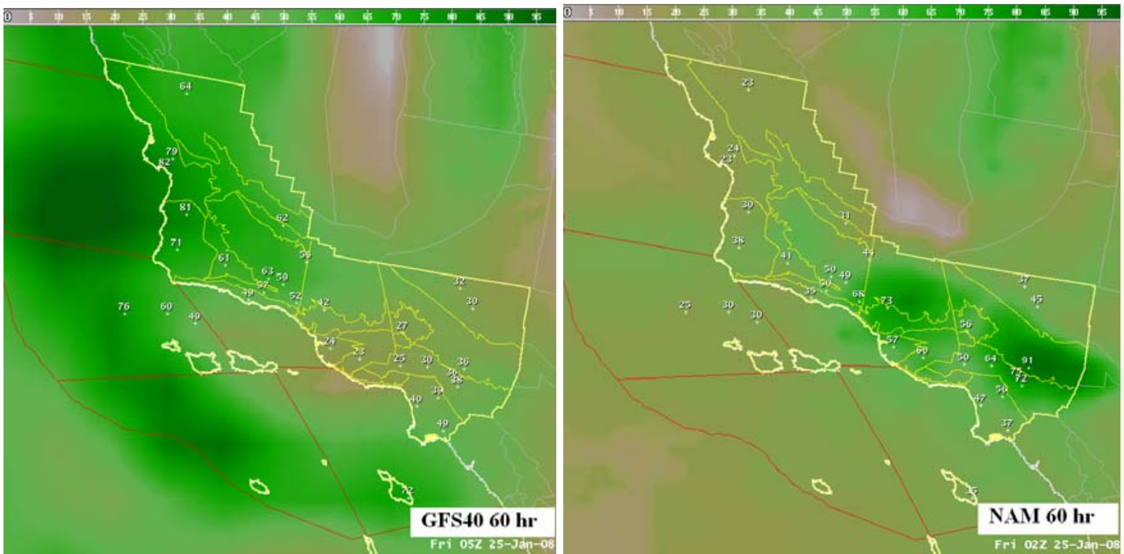
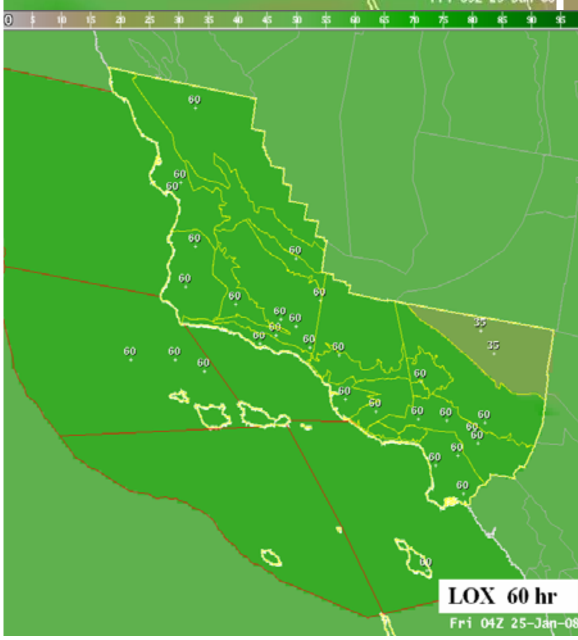
FIGURE 4

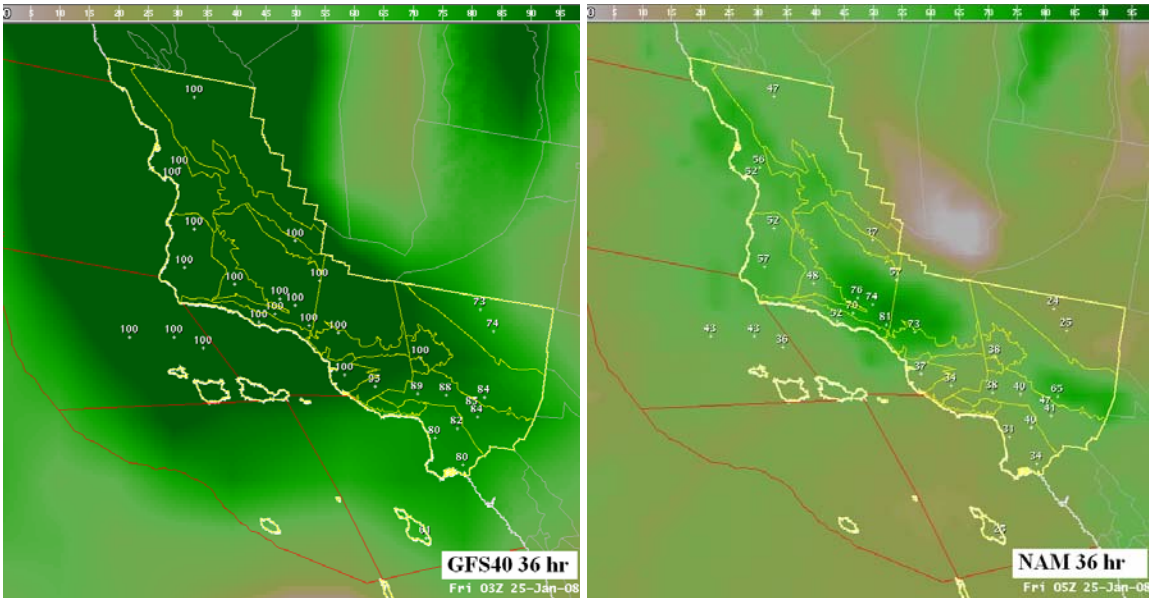


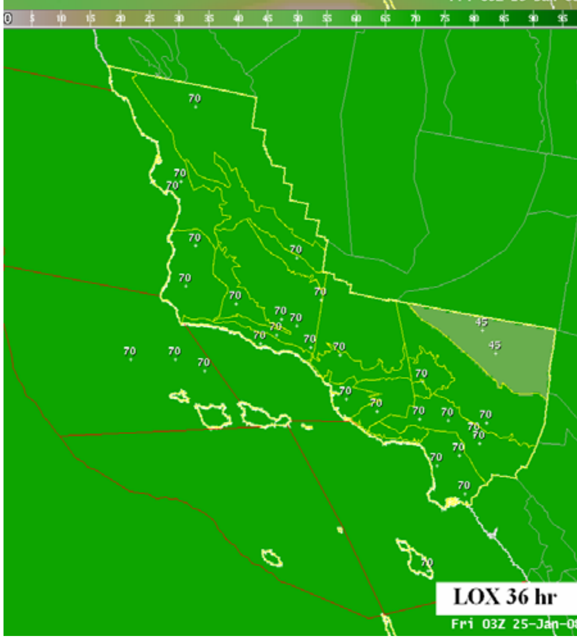


The forecast of 60% POPs for most of the CWA—with lower POPs in the Antelope Valley—seems reasonable at the 60 hour point considering the inconsistent model guidance. The thinking is that this will be a widespread event, so POPs are going to be dictated by the probability of the event. The lower POPs in the Antelope Valley are justified due to the shadow effect of the San Gabriel Mountains.

FIGURE 5

January 25th 2008 00Z to 06Z

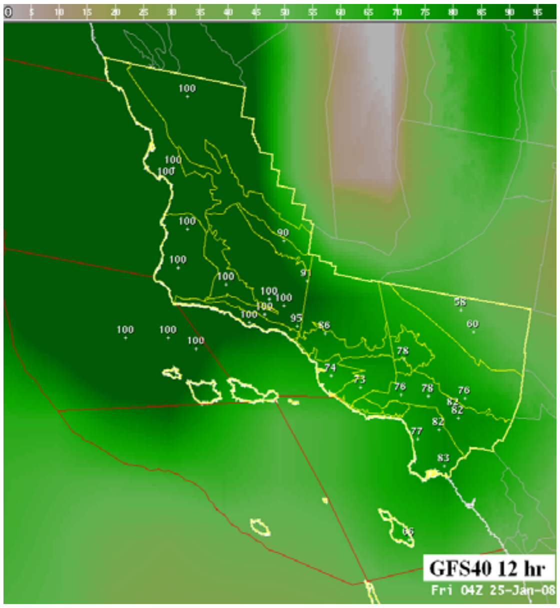


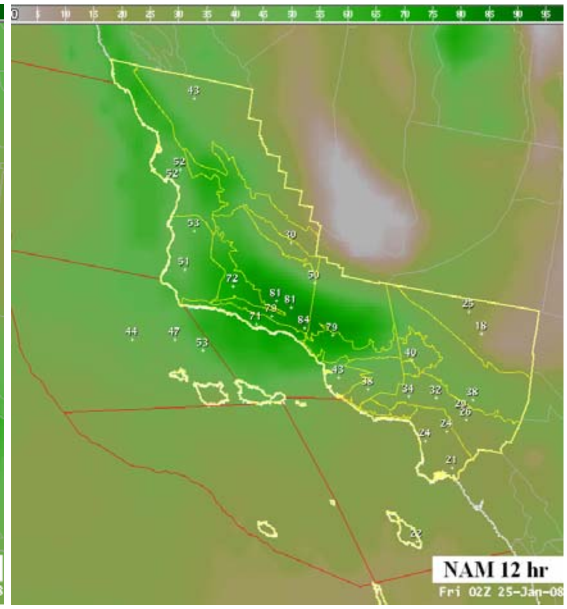


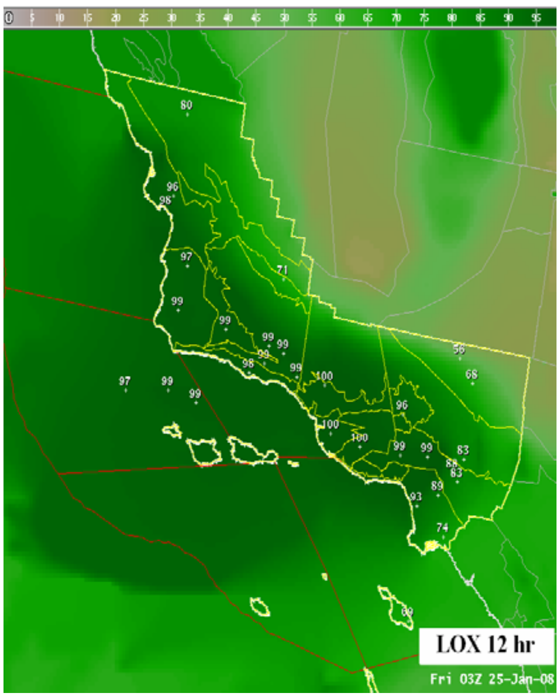
At 36 hours, forecasters have bumped POPs up 10 percent across the CWA, now calling for widespread 70% POPs with 45% POPs in the Antelope Valley. Model guidance is all over the place with little agreement in value and distribution of the POPs.

FIGURE 6

January 25th 2008 00Z to 06Z



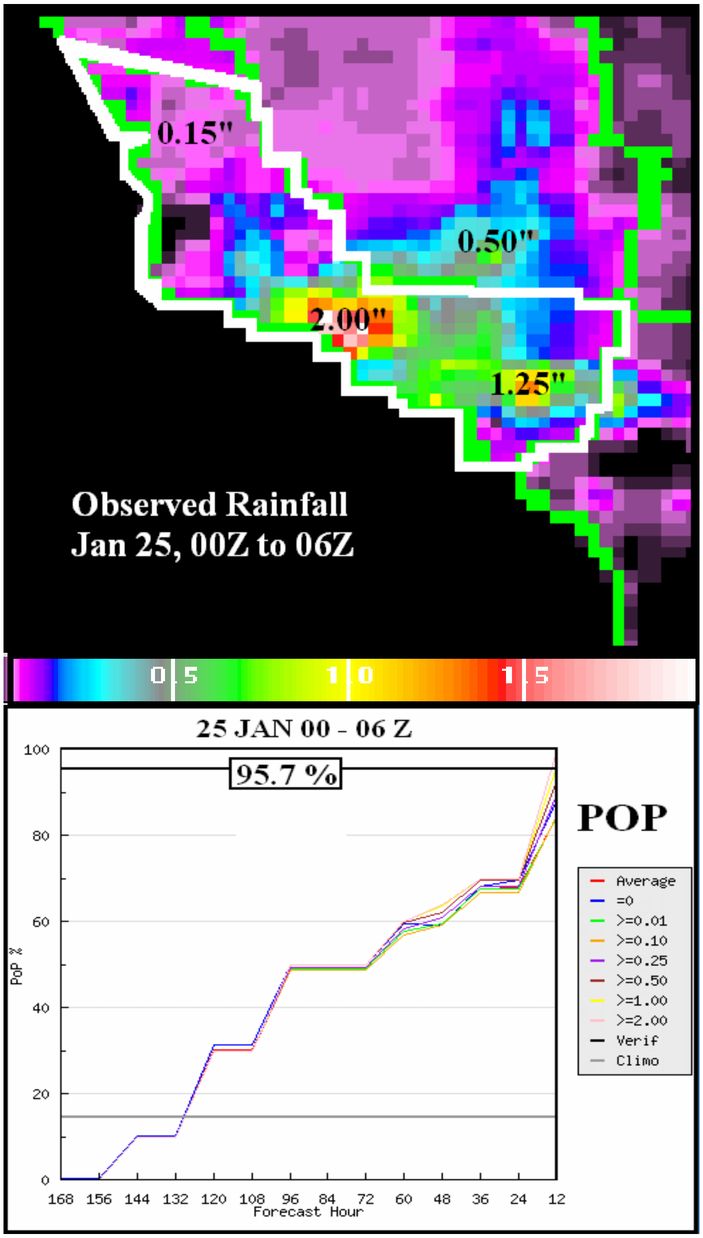




At 12 hours, forecasters have bumped POPs up everywhere—to categorical levels over most of the CWA, gradually tapering off to lower values in the Antelope Valley. This forecast looks fairly reasonable. However, the GFS40 dropped POP values over LA County, and the NAM lowered POPs significantly just about everywhere. It is testimony to forecaster confidence that forecast POPs were trended opposite to the poor model guidance.

FIGURE 7

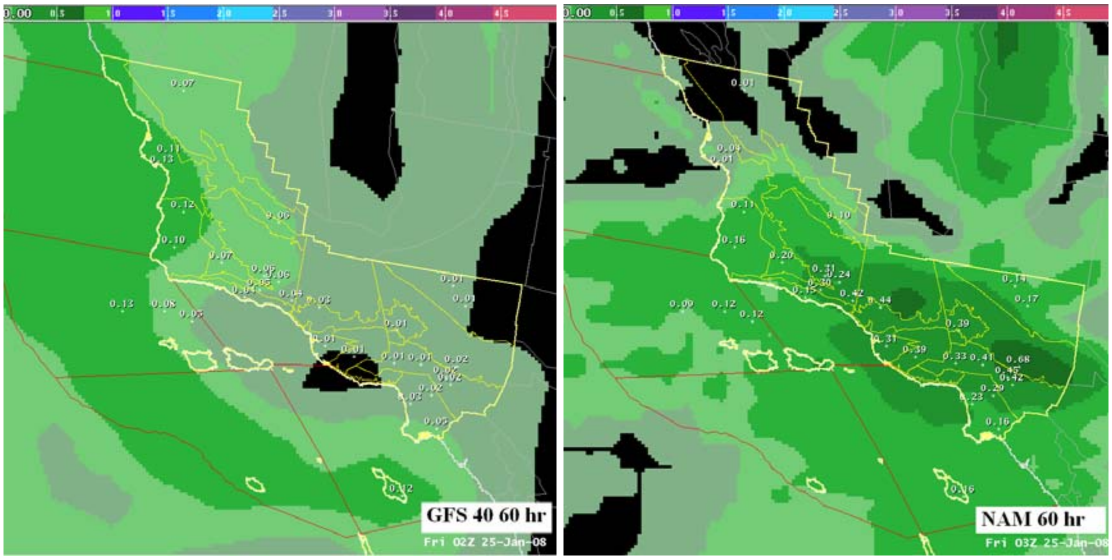
January 25th 2008 00Z to 06Z

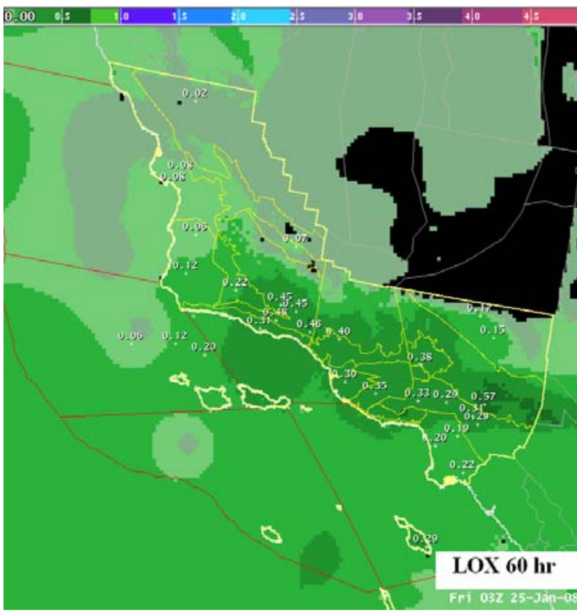


This figure compares observed rainfall to forecast POPs for time period 00Z to 06Z on the 25th of January. As the figure and the graph show, it rained just about everywhere in the LOX CWA. The observed rainfall coverage for this event was a very high 95.7%. Forecasters got a pretty good head start on the event with non-zero POPs at the 144 hour point. Forecast POPs exceeded climatology at 120 hours—5 days in advance of the storm. Then trended the forecast up nicely with very high POPs at the end—reflecting high forecaster confidence in the likelihood of a universally wet event for the CWA.

FIGURE 8

January 25th 2008 00Z to 06Z

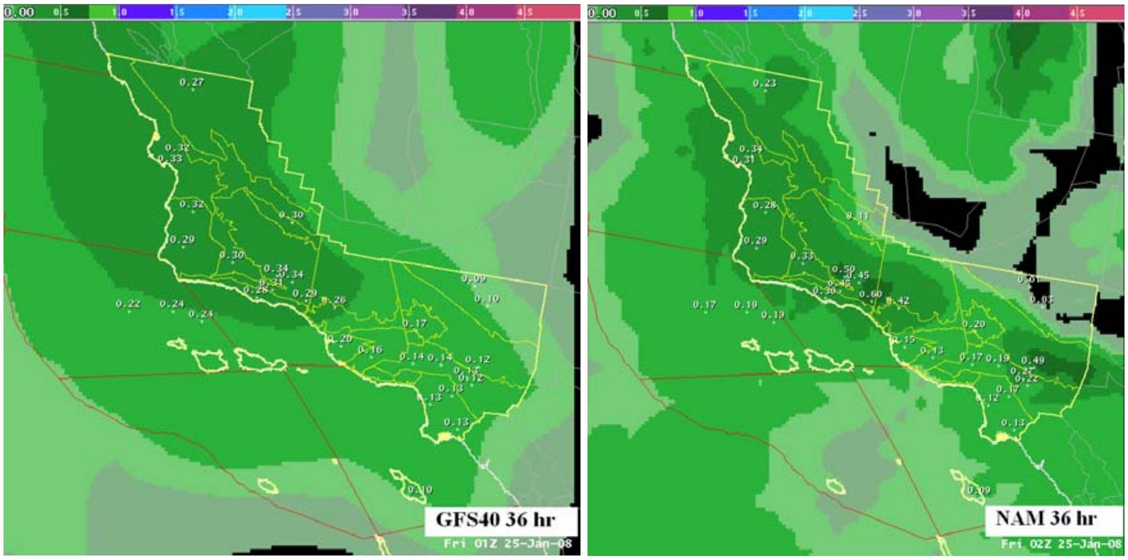


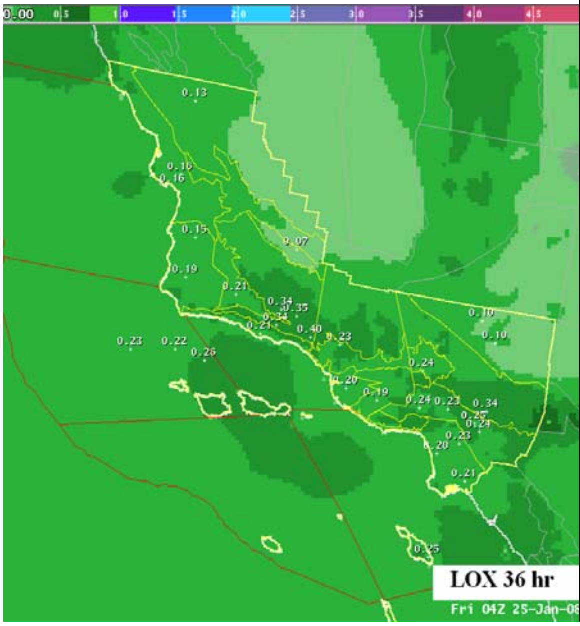


At 60 hours, the GFS40 QPF forecast is of uniform poor quality. While this is not that unusual, it does illustrate the poor guidance this model typically provides to Southern California forecasters. The NAM, with better model terrain, seems to be doing a respectable job. Forecaster QPFs look reasonable this far in advance of the storm.

FIGURE 9

January 25th 2008 00Z to 06Z

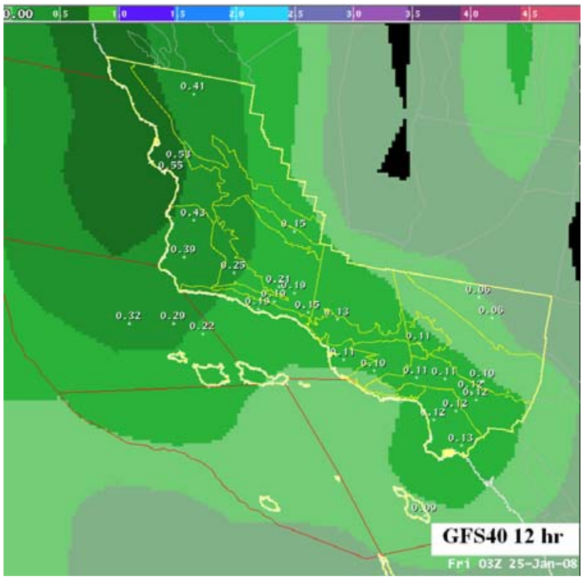


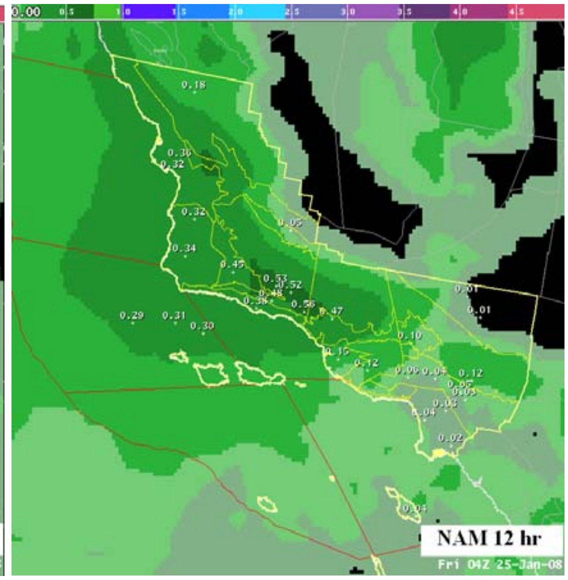


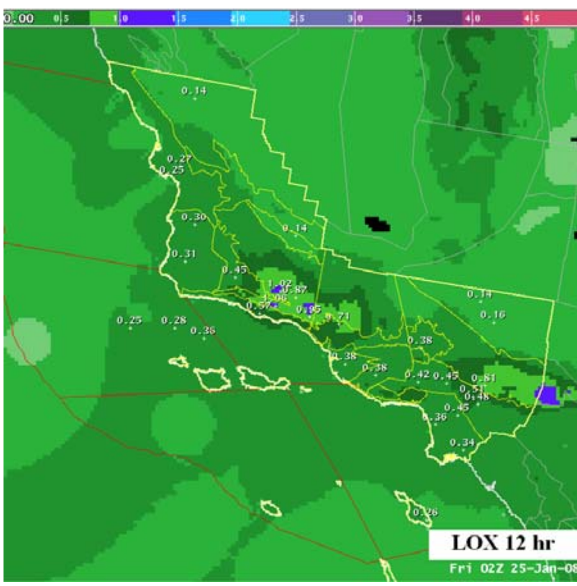
At 36 hours, the GFS40 at least begins to spread significant QPF values onshore. Again, the NAM seems to be doing a fair job with the distribution of the heavier rains to the south facing slopes of the mountains. Forecaster QPFs have been decreased slightly across the south facing slopes in Ventura and Los Angeles Counties, but increased over western Santa Barbara County and most of San Luis Obispo County.

FIGURE 10

January 25th 2008 00Z to 06Z



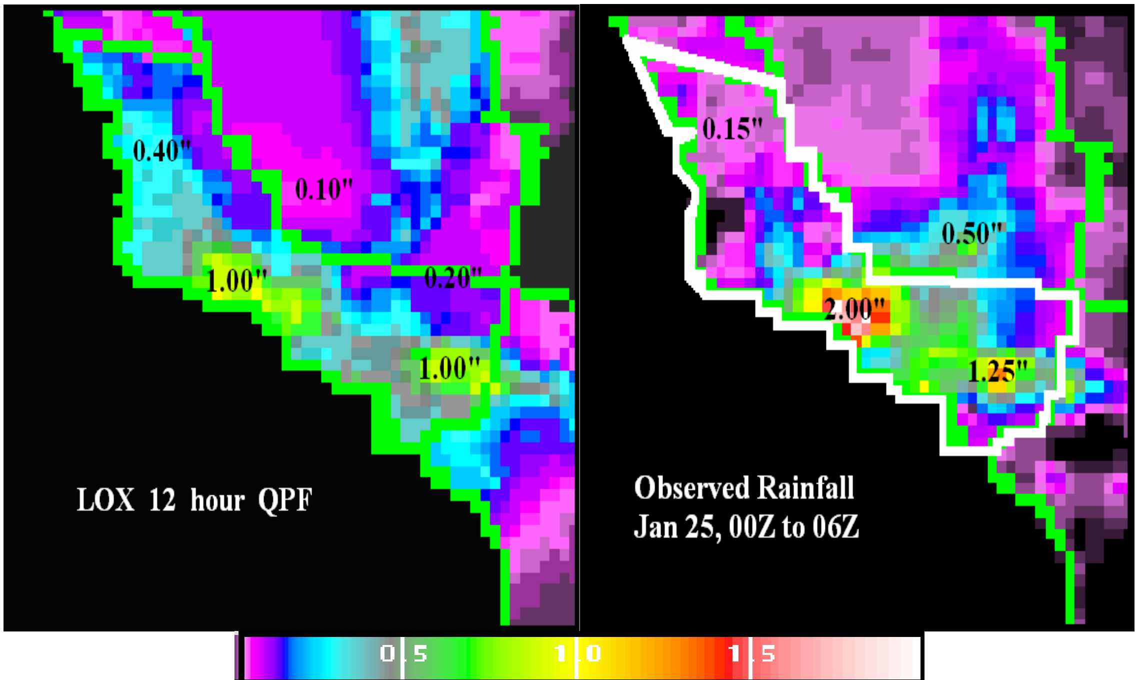


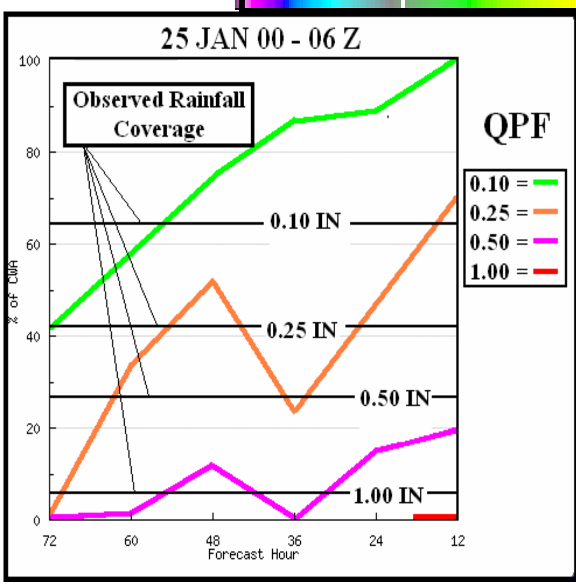


As close as only 12 hours prior to the event, model QPF guidance was pretty poor. Both models were only going for 0.50 to 0.60 inches of rain, at the most. And distribution was skewed to the western counties of San Luis Obispo and Santa Barbara. The official forecast called for amounts in excess of an inch well-distributed over the coastal slopes of eastern Santa Barbara, Ventura, and Los Angeles Counties.

FIGURE 11

January 25th 2008 00Z to 06Z

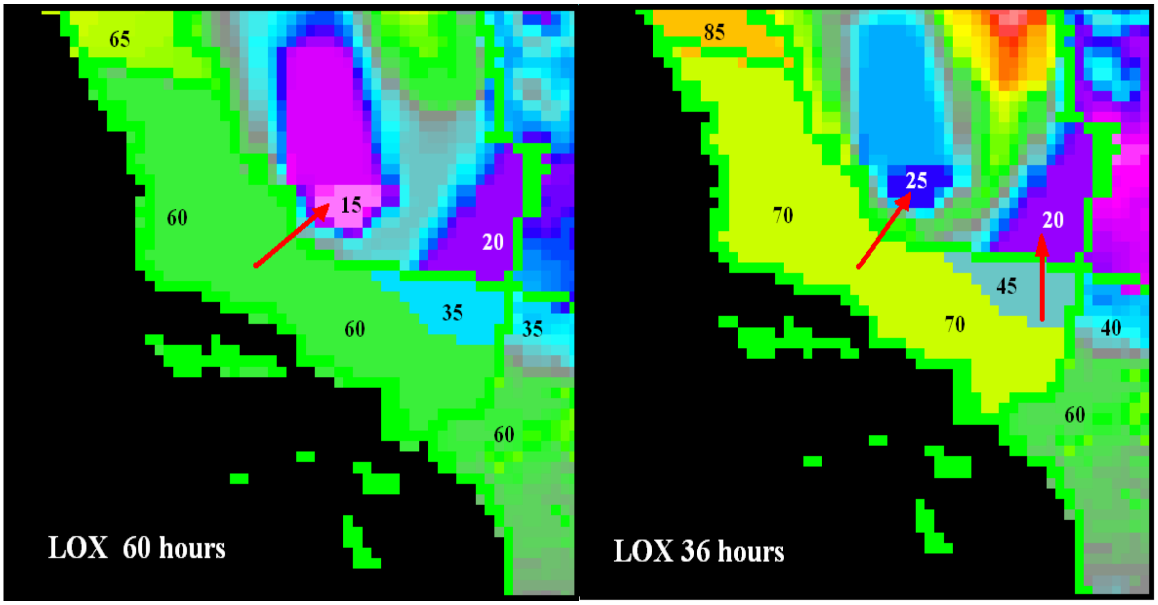


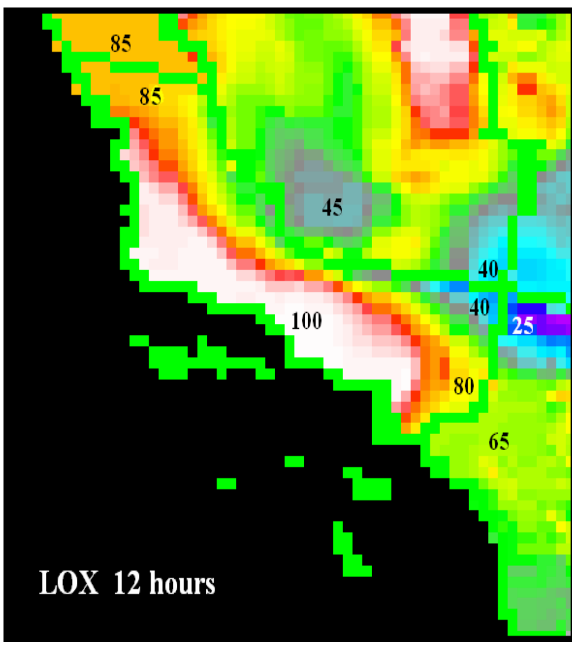


The observed rainfall coverage as percent of the CWA is compared to forecast QPFs for the time period 00Z to 06Z on the 25th of January. Forecast QPFs were lighter than observed, but the upward trend was in the right direction. However, LOX forecasters still bested model guidance. Both the GFS40 and NAM were only forecasting a maximum of between 0.50” and 0.60” of rain for the period.

FIGURE 12

January 25th 2008 00Z to 06Z

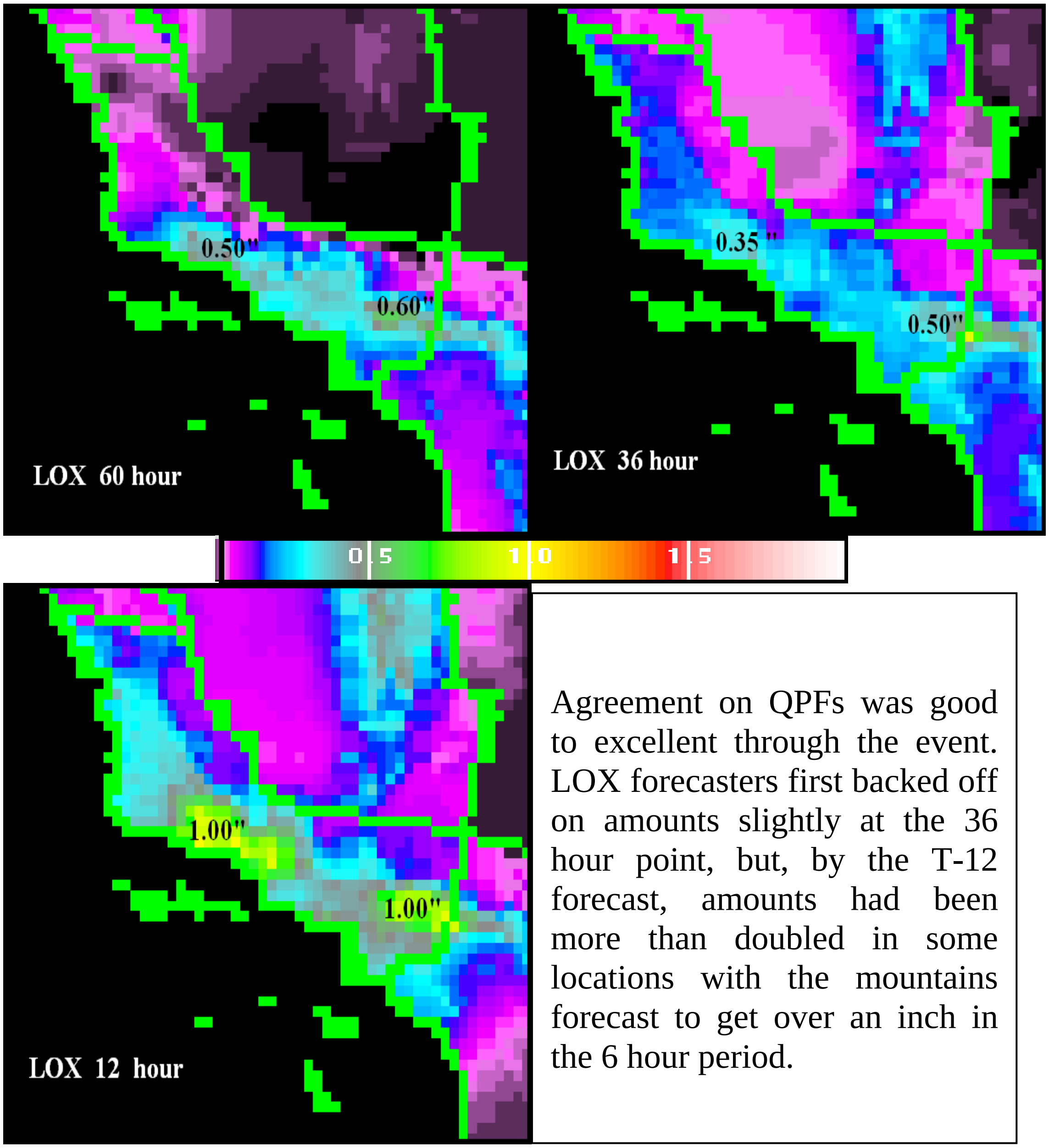




Coordination of POPs with MTR and SGX was pretty good for the entire event. There were some problems with HNX at 36 hours and beyond, but eventually their forecasters increased their POPs as the event developed. The lower POP values at HNX could be due to an over dependence on distributing POPs based on climatology. By the T-12 hour point, overall agreement was very good with all neighbors.

FIGURE 13

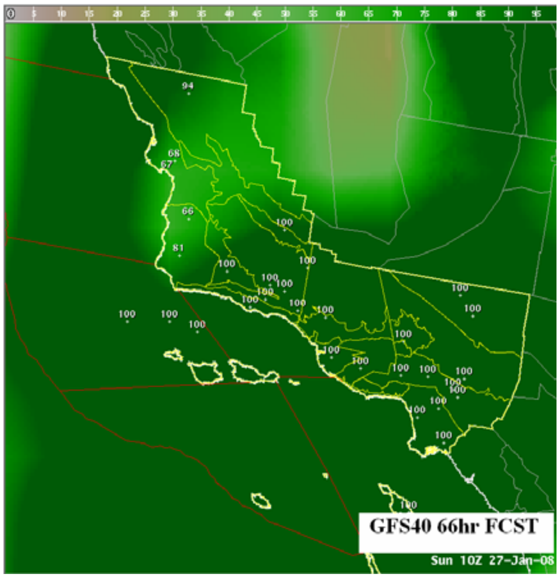
January 25th 2008 00Z to 06Z

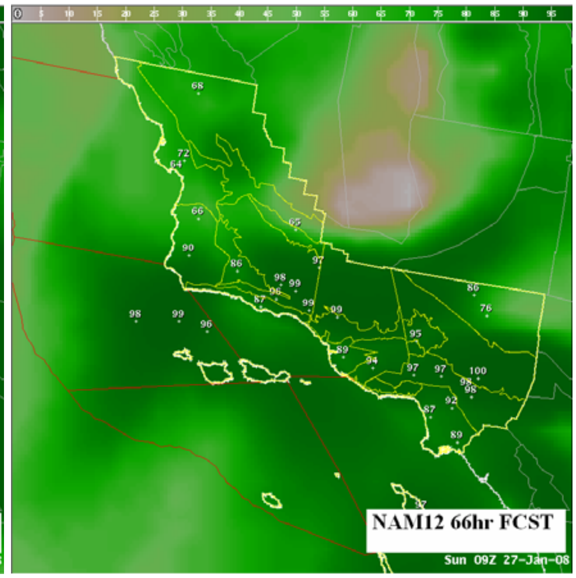


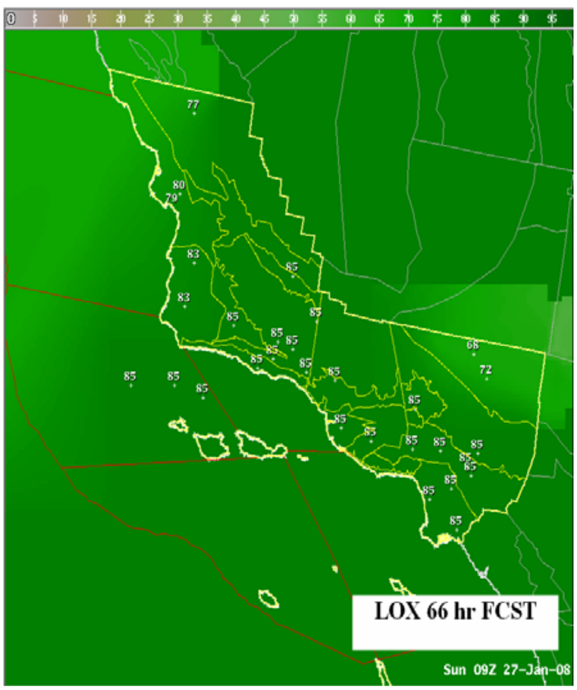
Agreement on QPFs was good to excellent through the event. LOX forecasters first backed off on amounts slightly at the 36 hour point, but, by the T-12 forecast, amounts had been more than doubled in some locations with the mountains forecast to get over an inch in the 6 hour period.

FIGURE 14

January 25th 2008 00Z to 06Z



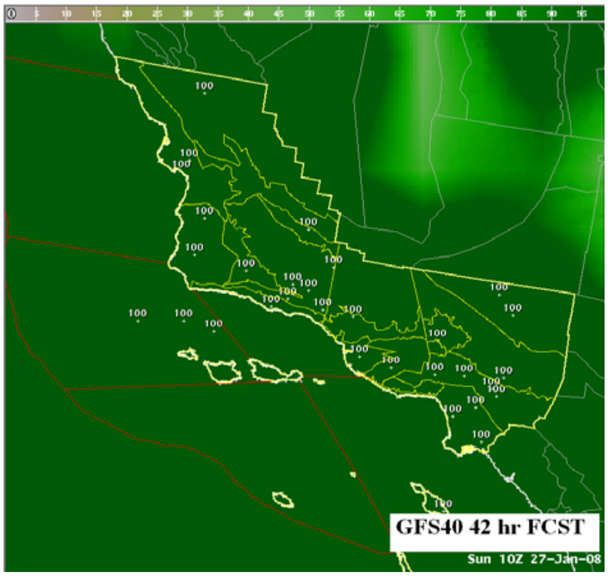


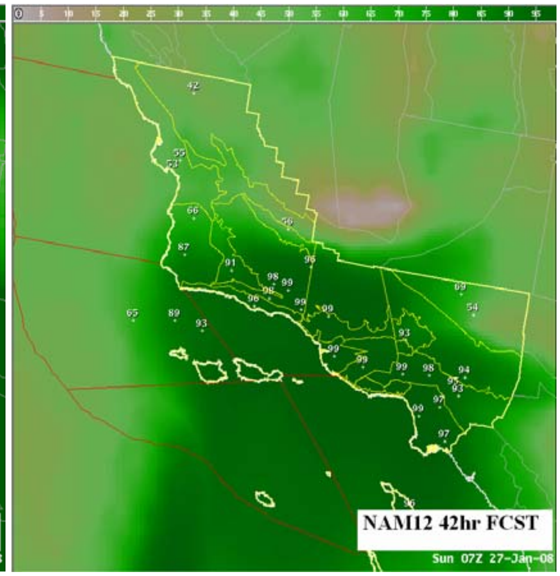


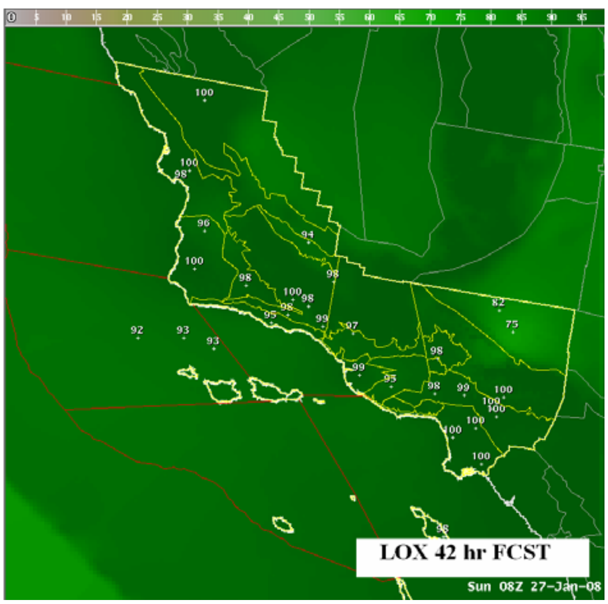
At 66 hours, both the GFS40 and NAM have unusually high POPs. This gives the forecasters fairly good confidence and they respond with high POPs, as well. The distribution of the model POPs is a tad odd with GFS40 100% POPs in the Antelope Valley at the 66 hour point. The NAM distribution is slightly better. The distribution of the official forecast POPs looks reasonable, putting the highest values in the mountains and along the south coast.

FIGURE 15

January 27th 2008 06Z to 12Z



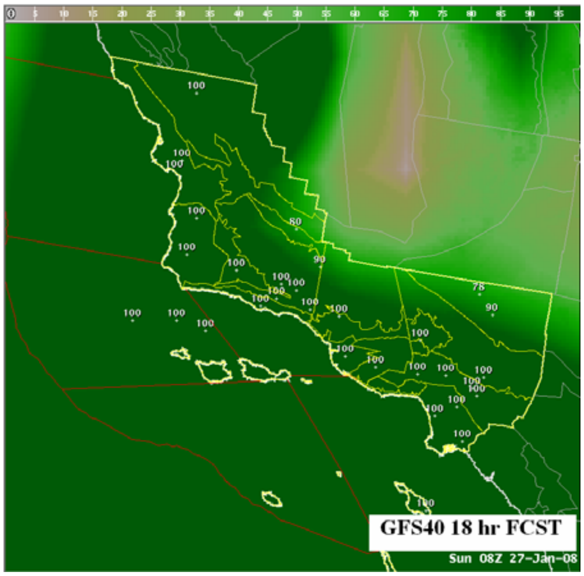


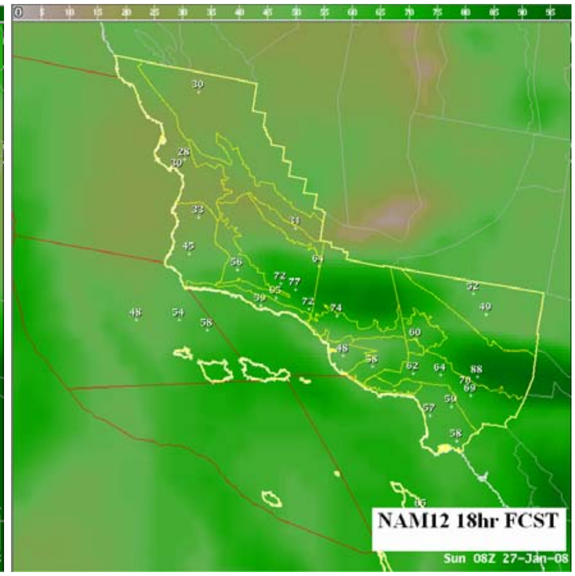


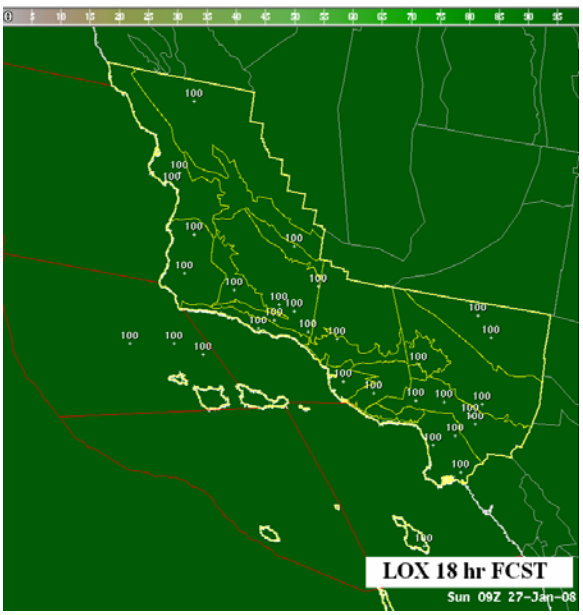
At 42 hours out, the GFS40 maxes out at 100% POPs everywhere. The NAM backs off a tad over Ventura and Los Angeles Counties, and drops POPs even further over San Luis Obispo County. But both models seem confident in a rain event for most of the CWA, and that is reflected in the official forecast.

FIGURE 16

January 27th 2008 06Z to 12Z



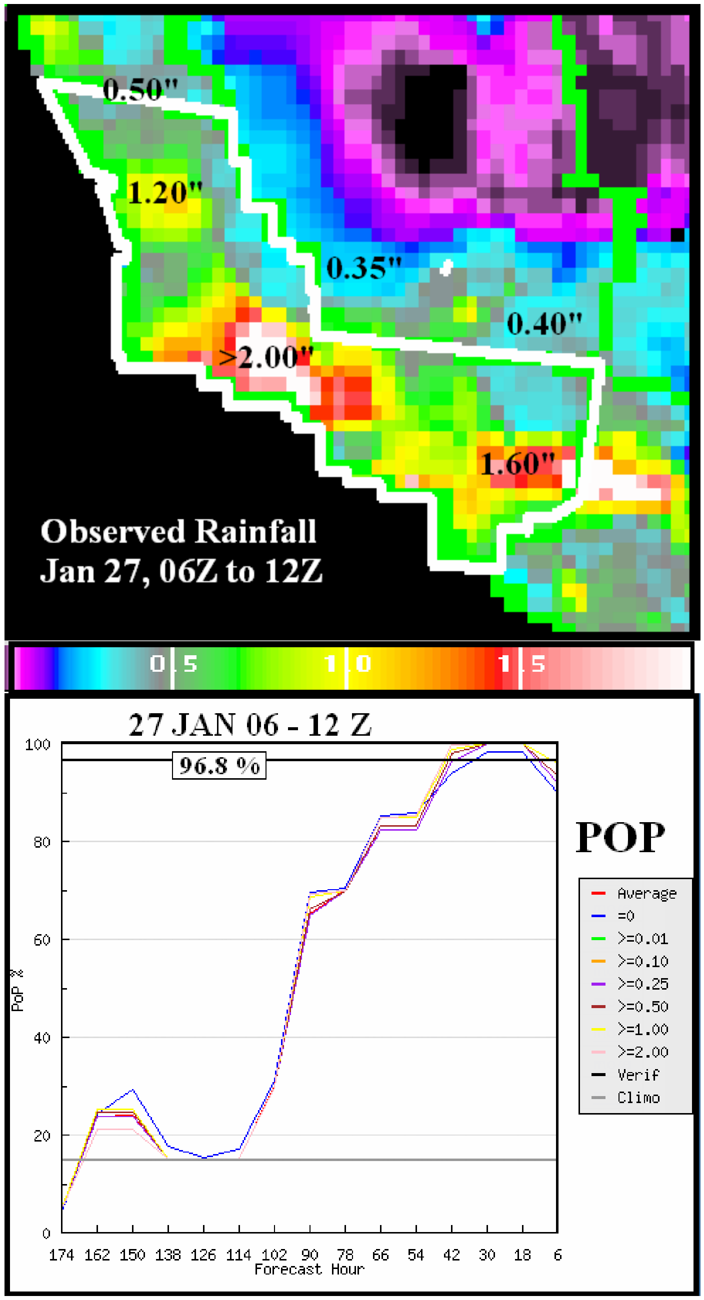




At 18 hours out, the GFS backs off a tad on POPs over the interior, but maxes out POPs everywhere else. The NAM, however, drops its POPs dramatically just about everywhere, except over the higher terrain. Once again going against model trends, the official forecast calls for 100% POPs over the entire CWA—a fairly uncommon forecast for the Oxnard office.

FIGURE 17

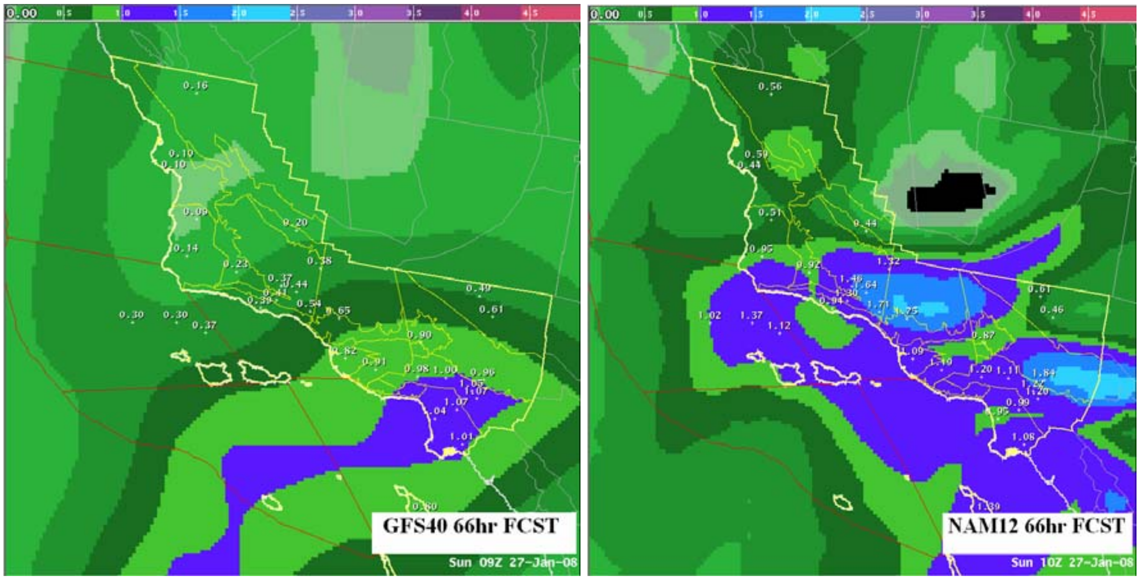
January 27th 2008 06Z to 12Z

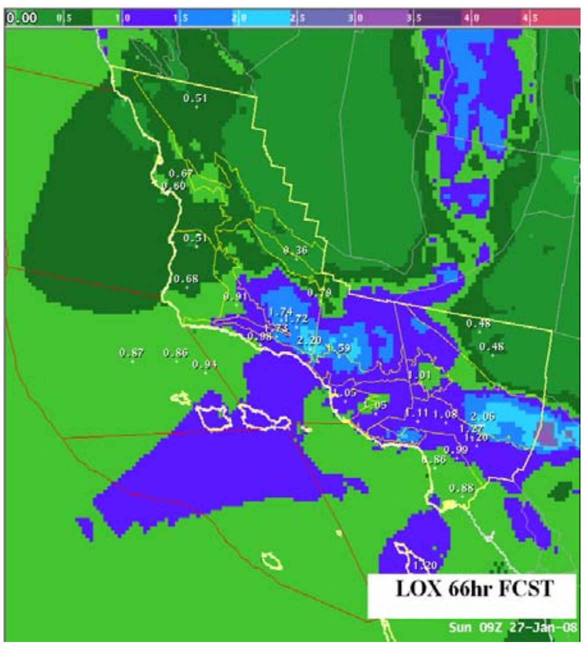


This figure compares observed rainfall to forecast POPs for time period 06Z to 12Z on the 27th of January. Again, it rained just about everywhere in the LOX CWA. The observed rainfall coverage for this time period was a very high 96.8%. Forecasters once again got an excellent head start on the event with forecast POPs exceeding climatology at the very early 162 hour point. At the 90 hour point, forecasters raised POPs to the likely level, and then trended to categorical POPs 66 hours in advance of the event. The unfortunate downward trend in POPs in the last few hours corresponds to a similar downward trend in the model POPs at that late hour.

FIGURE 18

January 27th 2008 06Z to 12Z

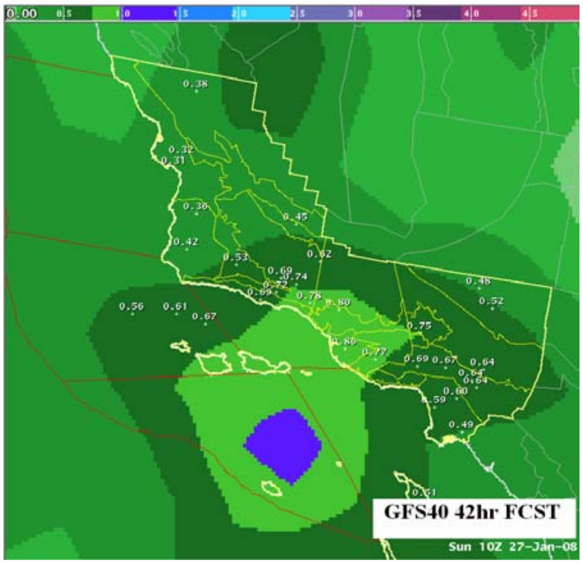


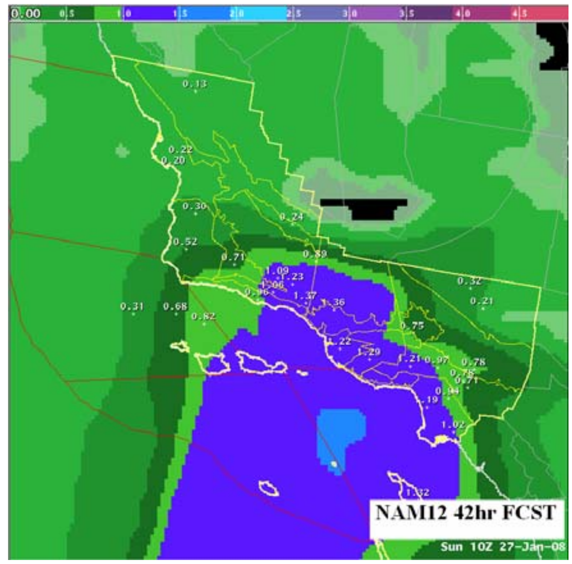


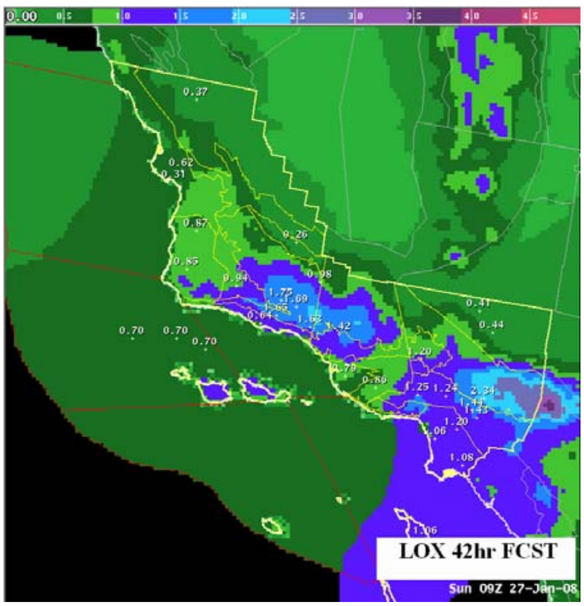
At 66 hours, both models are calling for over 1" of rain in certain areas. By far, the NAM distribution of the rainfall is superior to that of the GFS. Forecasters are hitting the event pretty hard, as well, with large areas of rain in excess of 1.5 inches. Note, also, that the forecaster has increased QPFs over areas such as the Santa Ynez Range and the Santa Monica Mountains—areas not well-handled by the models.

FIGURE 19

January 27th 2008 06Z to 12Z



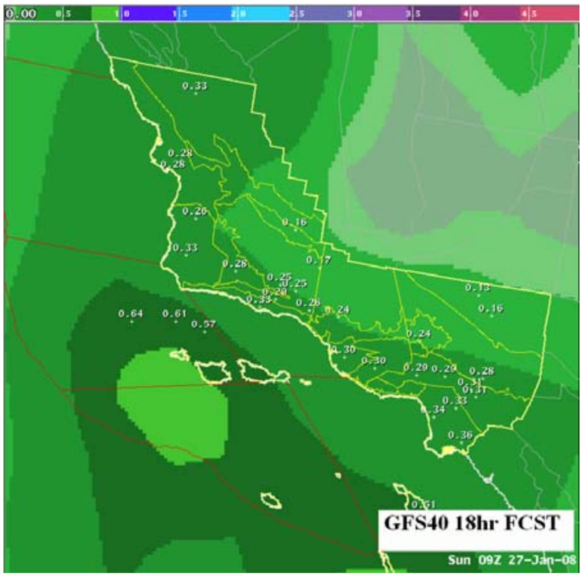


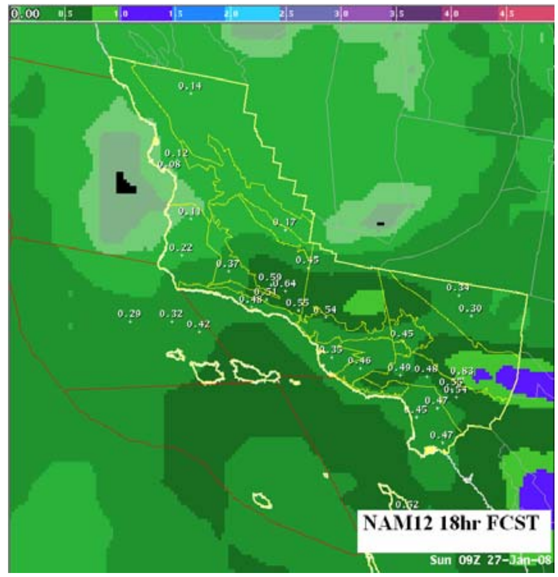


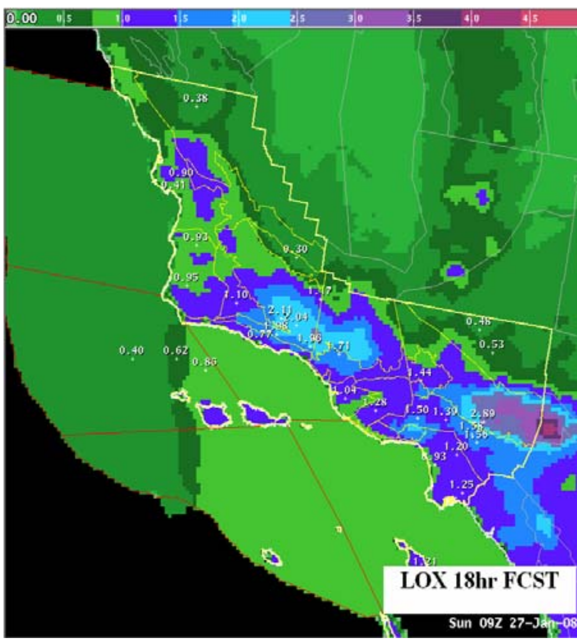
At 42 hours, both the GFS40 and NAM have fairly unrealistic QPF depictions. Neither shows the normal orographic enhancement that is common for major Pacific storms, such as this event. In direct contrast, the official forecast shows that a great deal of thought went into the location and amounts of forecast rainfall.

FIGURE 20

January 27th 2008 06Z to 12Z



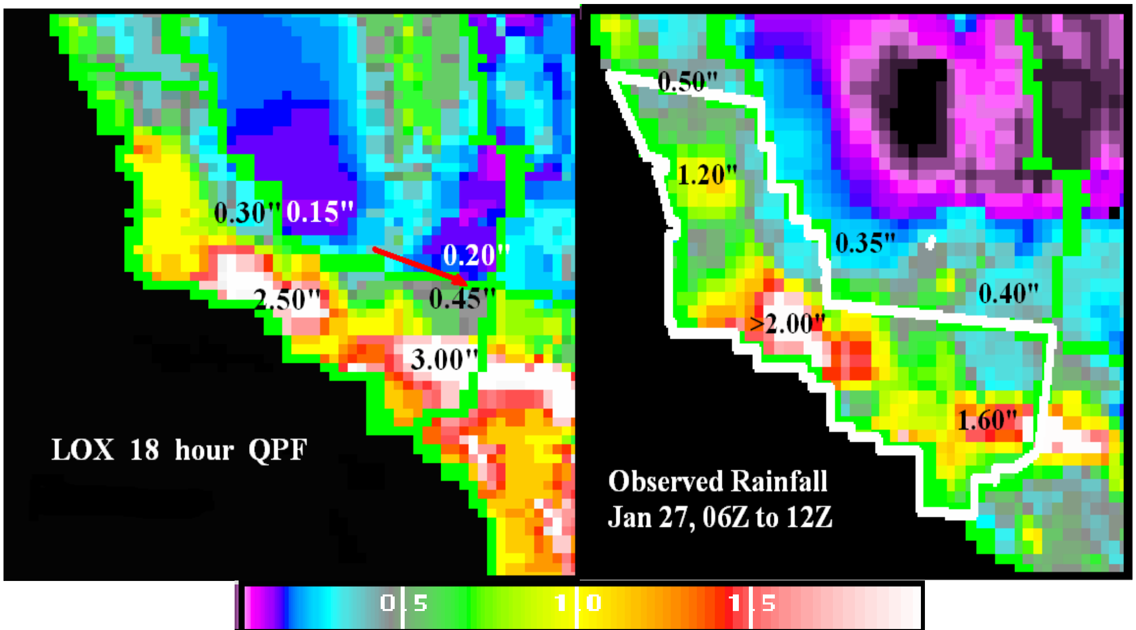


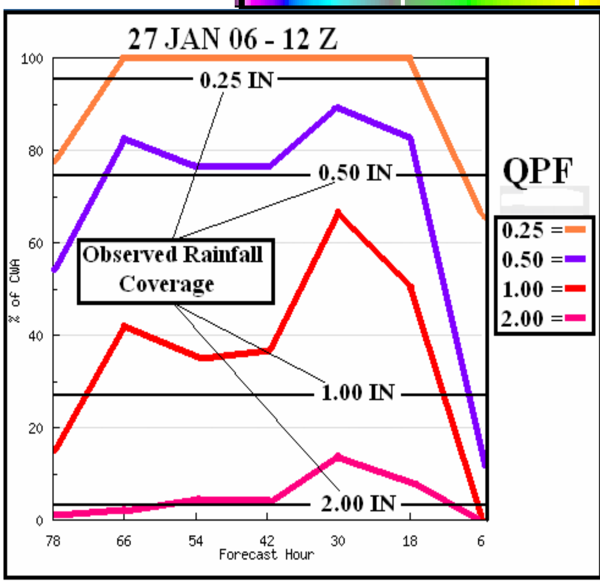


At 18 hours, the GFS40 forecast is unrealistic. The NAM QPF, while showing some orographic influence, does not realistically reflect the rainfall potential of the event. Only a very small area of accumulations greater than an inch is forecast. Again, the forecasters have gone against model trends and have hit the event pretty hard with widespread areas of rain in excess of an inch—with some areas in excess of three inches of rain—forecast.

FIGURE 21

January 27th 2008 06Z to 12Z

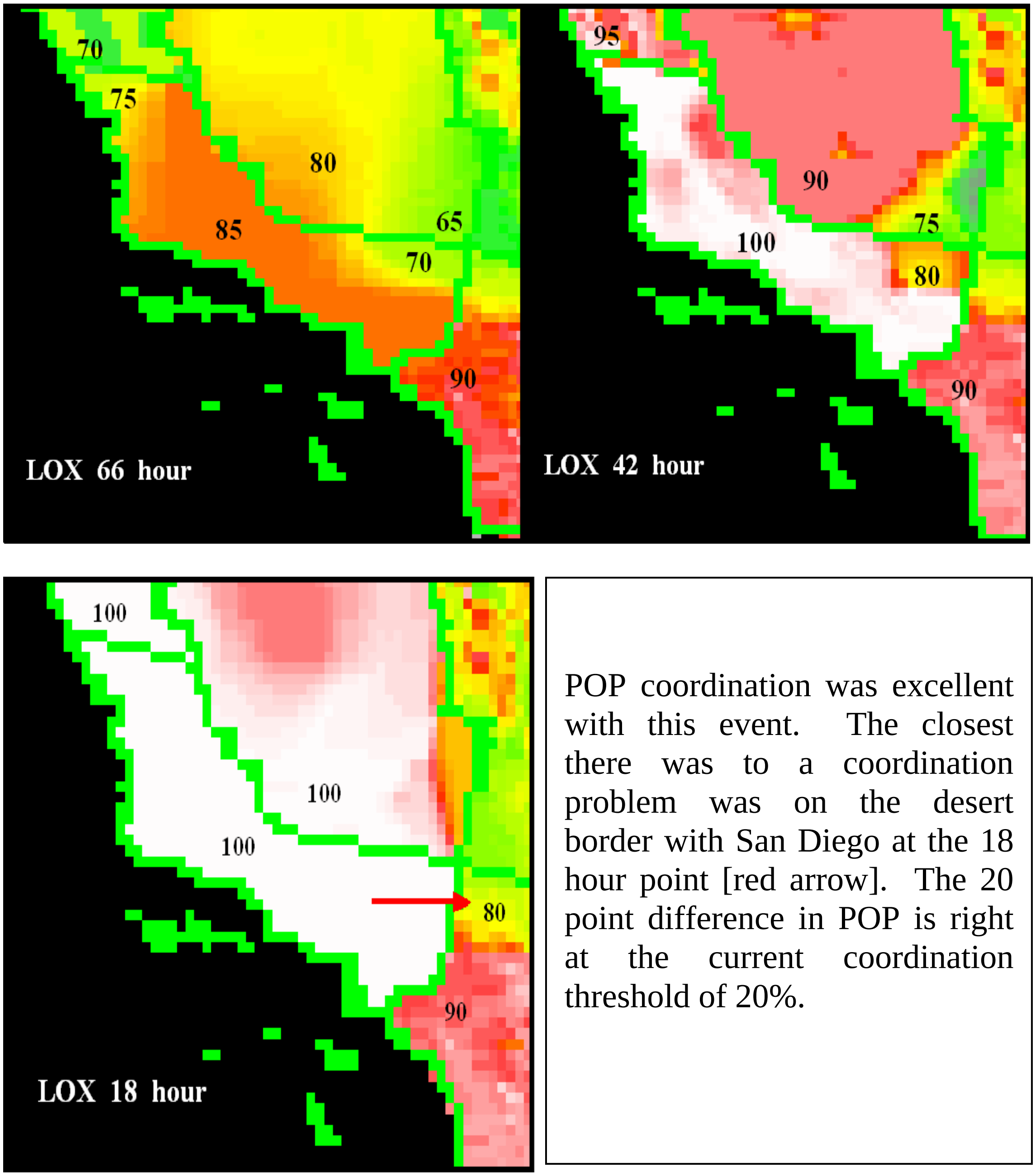




Observed rainfall amounts and coverage as percent of the CWA are compared to LOX forecast QPFs for the time period 06Z to 12Z on the 27th of January. Forecast QPFs were good, but a tad heavy as early as the 66 hour point. Even heavier rains were forecast at the 30 hour point. The sharp downward trend in QPFs in the last hours corresponds to a similar trend in the model QPFs.

FIGURE 22

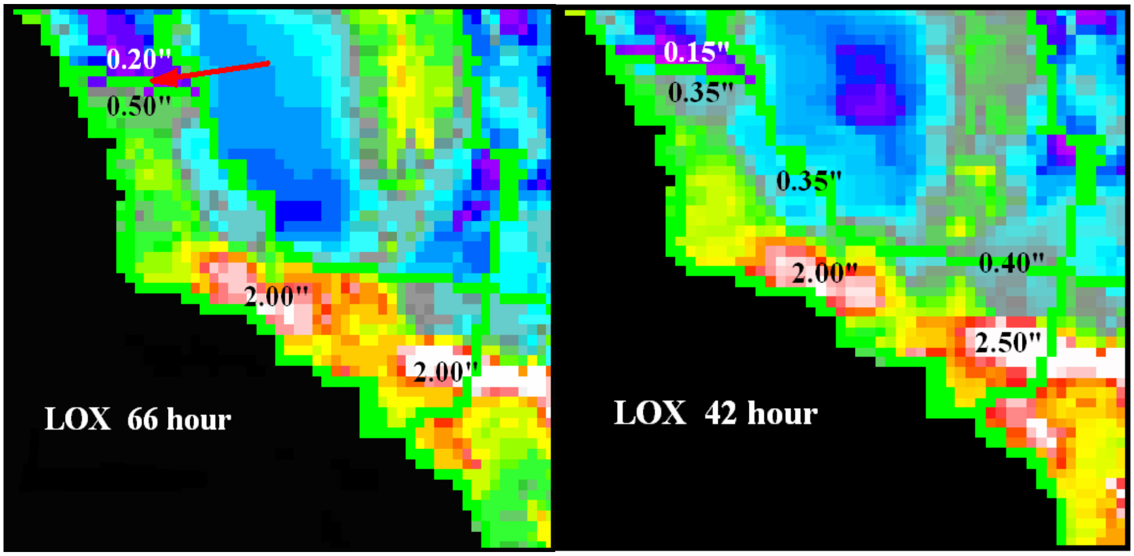
January 27th 2008 06Z to 12Z

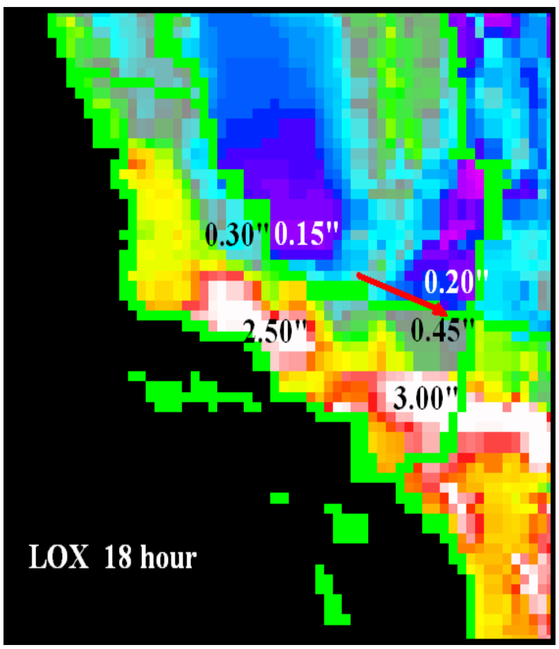


POP coordination was excellent with this event. The closest there was to a coordination problem was on the desert border with San Diego at the 18 hour point [red arrow]. The 20 point difference in POP is right at the current coordination threshold of 20%.

FIGURE 23

January 27th 2008 06Z to 12Z





Red arrows point to where the QPF coordination threshold of 0.25” in 6 hours is exceeded. Coordination was good, but not flawless. At 66 hours, there was a problem on the border with MTR. LOX lowered their QPFs to improve agreement at 42 hours. HNX trended their QPFs up from 66 to 42 hours, then down from 42 to 18 hours—creating disagreement along the border in the desert. This was likely in response to model guidance since both models also lowered QPFs at the 18 hour point.

FIGURE 24

January 27th 2008 06Z to 12Z