The Eastern Antelope Valley Eddy [EAVE]
And Its Impact on Severe Weather

INTRODUCTION.

Forecasters who work in regions of complex terrain are used to seeing familiar cloud formations that recur almost on a daily basis. For example, during much of the year, forecasters in Colorado Springs can set their watches by the formation of the day's first cumulus cloud over Pike's Peak. The deserts of Southern California are no different. In the warmer months, afternoon sea breezes filter through the coastal mountain ranges and then expand over the Mojave Desert in a series of looping sea breeze fronts. Eventually, these sea breeze fronts converge to produce cloud bands; and, on occasion, these bands develop into significant showers and thunderstorms. The cloud formations that are of specific interest to this study have been seen and documented in studies conducted by Ivory Small, the Science and Operations Officer at the San Diego Weather Forecast Office, among others. The specific zone of convergence that is of interest to this paper is the one that develops along the Los Angeles and San Bernardino County line just to the north of the Cajon Pass.

ADD A LITTLE TECHNOLOGY.

The general conditions and circulations that cause these cloud formations to develop have been well-known, even long before the advent of high resolution computer models such as the workstation Eta [WS-Eta]. However, with the advent of these computer models, not only has the degree of certainty of formation been substantially increased, but there has also been a deeper appreciation for the variables in the development of these cloud formations. Specifically, we now have the tools to not only understand why the cloud formation develops one way one day, but a slightly different way the next; but also, we are now able to predict these day to day variations. This paper will discuss the importance of being able to make these finely detailed predictions.

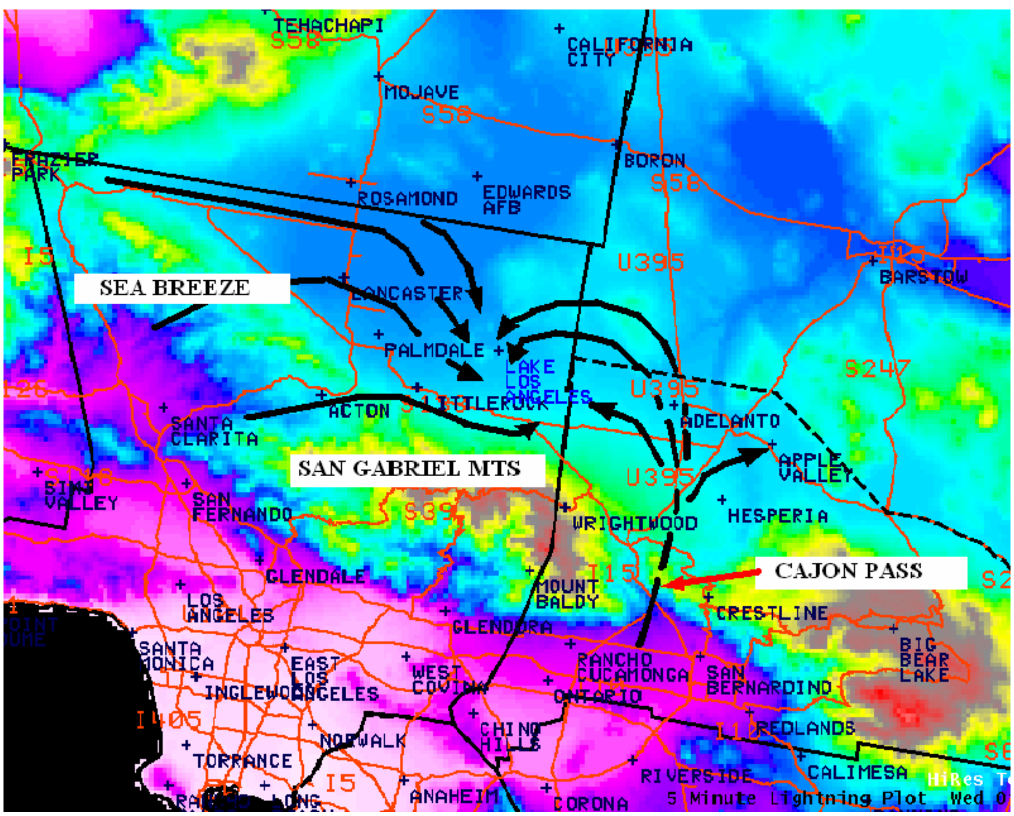
ABOUT "EAVE."

The WS-Eta has been an integral part of the National Weather Service forecast operations at the Los Angeles/Oxnard office since its installation in spring 2004. Over the summer of 2004, we were able to document an important barrier flow phenomena that is thought to directly impact the severity of weather in the eastern Antelope Valley. Specifically, the high resolution WS-Eta model was able to identify the formation of a lee eddy on the north side of the San Gabriel Mountains under strong sea breeze conditions when accompanied by moderate to strong southerly flow. This eastern Antelope Valley eddy [EAVE] circulation is expected to be the culprit in producing more severe conditions in the eastern Antelope Valley than otherwise would have been expected due purely to stability, precipitable water, or other conditions.

Twice during the summer of 2003, severe events occurred that would otherwise not have been expected given the conditions. Specifically, on 29 July, 2003 a severe thunderstorm formed in the eastern Antelope Valley that eventually produced hurricane force winds which downed trees and power lines in cities of Lancaster and Palmdale. Later that same summer, on the 20th of August, a flash flood occurred in the eastern portion of the Antelope Valley at a time when both soundings and models indicated that the available precipitable water levels were insufficient to produce flooding. In this latter case, EAVE was able to concentrate available moisture into a small area, locally bringing precipitable water levels above flash flood levels and causing the severe flash flooding that occurred.

During the summer of 2004, the WS-Eta was able to successfully forecast the formation of EAVE hours in advance. However, due to the weakness of the 2004 summer monsoon season, no severe weather events occurred. Therefore, the examples of EAVE, below, had to be taken from the severe flash flooding event of 20 August, 2003. This was before the WS-Eta was actually available locally.

Figure 1 shows the region where the eastern Antelope Valley eddy [EAVE] normally forms [black arrows]. EAVE forms under moderate to strong onshore flow which produces a sea breeze in combination with moderate to strong southerly winds through the Cajon Pass. The sea breeze enters the Antelope Valley through gaps in the Angeles National Forest ridgelines—in particular, the Soledad Canyon and Highway 14 pass.



On August 20th, 2003, forecasters at the Los Angeles/Oxnard office computed the probability of flash flooding for the Antelope Valley using a technique adapted from procedures developed by Ivory Small of the National Weather Service Forecast Office in San Diego. Based on this calculation, the threat for flash flooding in the Antelope Valley was low and a flash flood watch was not issued.

As the day progressed, a number of thunderstorms developed over the eastern portions of the Antelope Valley. These remained stationary over the same area in the vicinity of Saddleback Butte. When the KEYX Doppler radar [located near Edwards AFB] indicated locally heavy rainfall accumulations, a flash flood warning was issued just before 4 PM PDT. By 4:30 PM, news helicopters over the area showed live TV coverage of a classic desert flash flood with a wall of water and debris flowing down a previously dry arroyo. While no one was hurt or injured, the flood was significant enough to easily transport a large stake body truck down the arroyo.

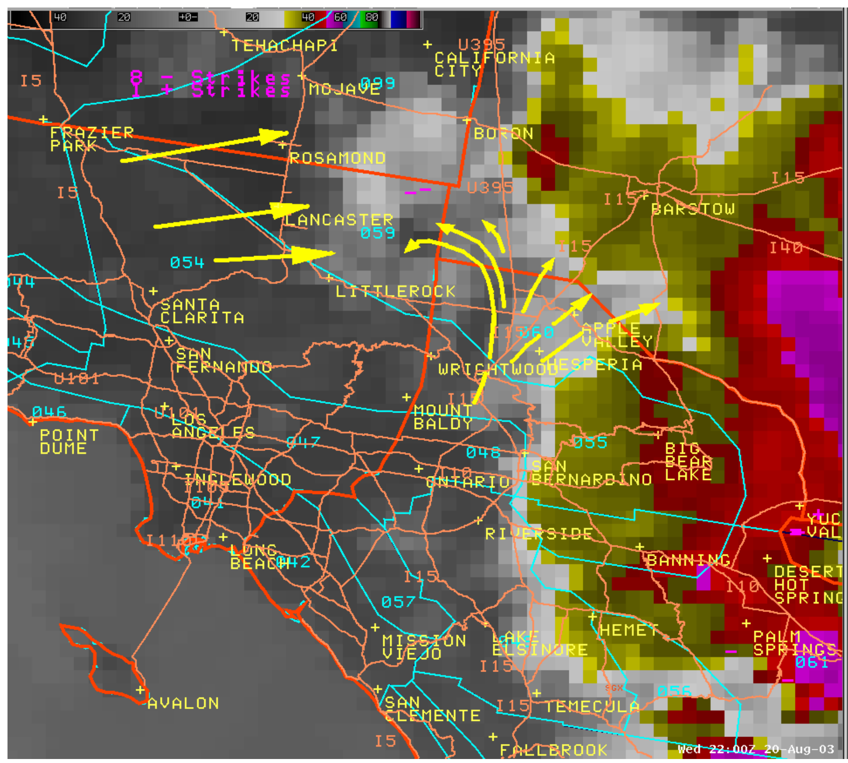


Figure 2 shows the Infrared satellite imagery from 2200 Z [3:00 PM PDT] on the afternoon of 20 August, 2003. Note that when you superimpose the wind flow field expected with an EAVE event, the pattern of the clouds follows the structure of the eddy. That the clouds were moving around the eddy circulation is easily confirmed by looking at available loops of the satellite imagery.

The effect of the EAVE circulation, in combination with a sea breeze over the western Antelope Valley, was to concentrate all of the available moisture [and precipitable water] into a relatively small convergence zone over the eastern portion of the Antelope Valley. Therefore, in this small convergence zone, precipitable water was able to local exceed flash flood thresholds and flash flooding became a possibility.

Similarly, **Figure 3** shows the radar imagery taken from the KEYX Doppler radar near the city of Boron, CA. The time is 3:00 PM PDT, the same time as the infrared satellite imagery in Fig 2. Again, superimposing the EAVE flow pattern over the radar data clearly shows the eddy flow pattern—again confirmed by available loops of the radar data.

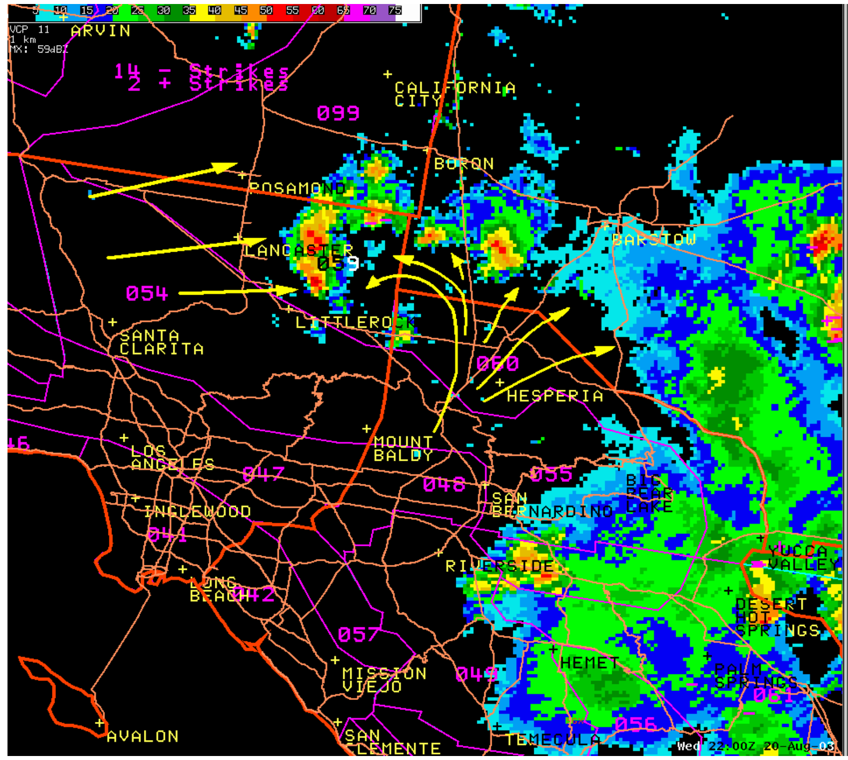


Figure 4 is the storm total precipitation data from the KEYX radar taken at 3:57 PM PDT on 20 August. Note the yellow pixel north of Lake Los Angeles. This pixel is near Saddleback Butte and indicates that between 1.5 and 1.7 inches of rain have fallen over a very small, localized area.

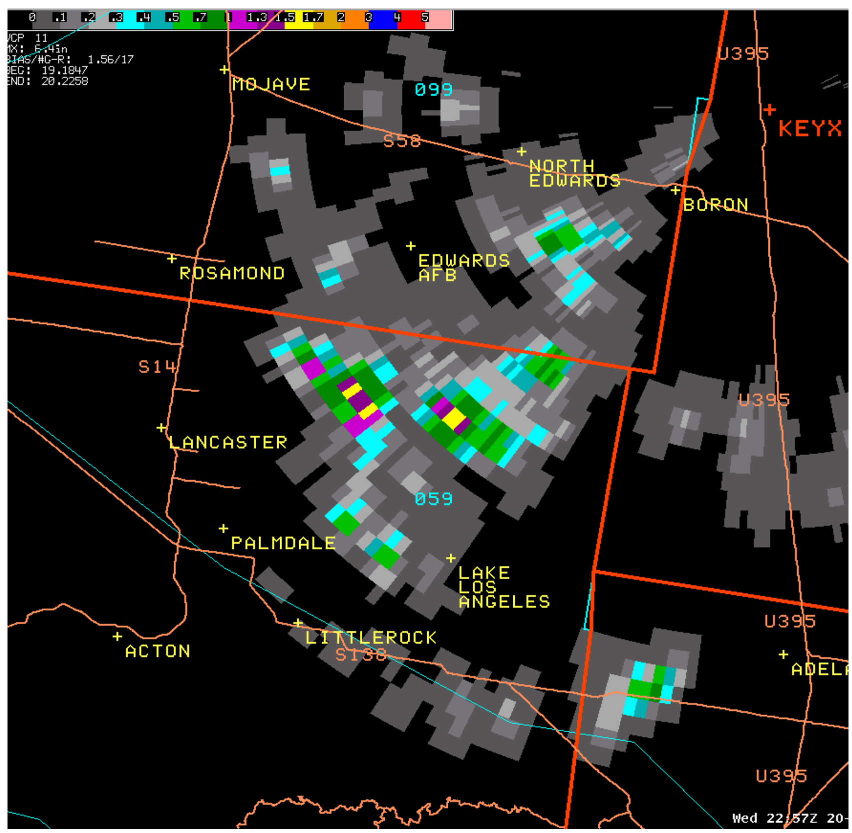
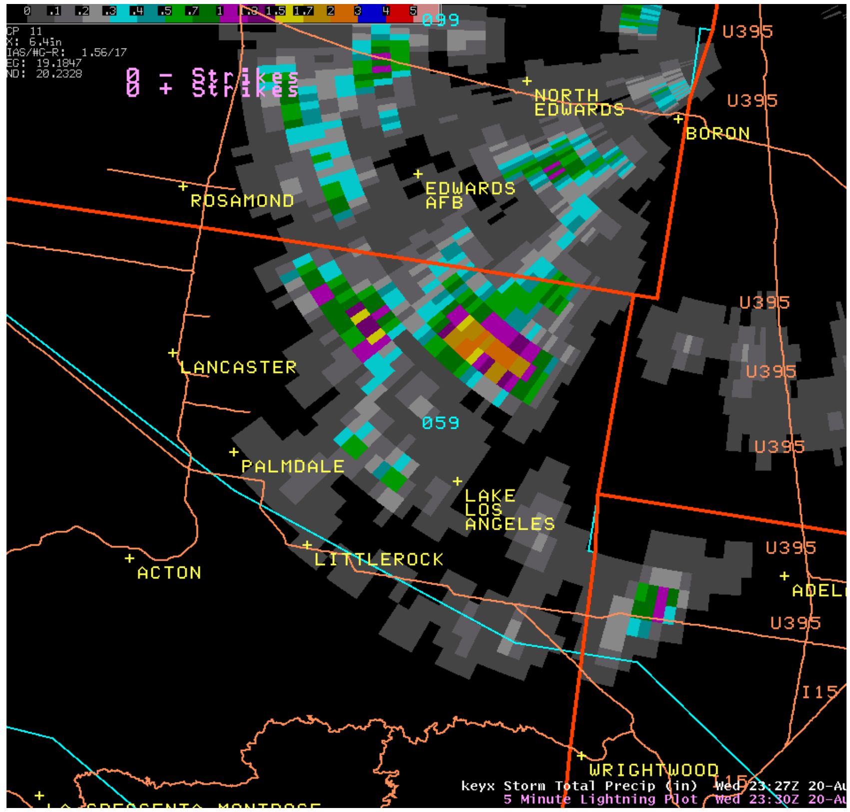


Figure 5 shows the same area as Fig 4, but just 30 minutes later at 2327Z [4:27 PM PDT]. The storm total precipitation for the area near Saddleback Butte has now recorded 2 to 3 inches, according to the radar storm total precipitation [STP] image. Therefore, in the intervening 30 minutes between the images, another 1 to 2 inches of rain has been measured. This deluge is what produced the flash flooding conditions that were observed over the eastern Antelope Valley at 4:30 PM PDT that afternoon.



CONCLUSION.

It is clear from both the radar and the satellite data, above, that it is very easy to pick out the characteristic EAVE circulation in the data during the event. The trick is knowing in advance whether or not an EAVE will occur. In 2004, the WS-Eta successfully forecast EAVE formation hours earlier, while the forecaster was still contemplating the issuance of a flash flood watch for the day. Thus, the WSEta is expected to be a valuable tool the forecaster can use to identify the potential for life threatening flash flooding.