

A GULF OF CALIFORNIA MOISTURE SURGE FROM 18-19 AUGUST 2003

Barry Pierce
NWS Las Vegas

Introduction

During the North America Monsoon Season, moisture surges from the Gulf of California add significant low-level moisture to the Desert Southwest which greatly increases the convective instability. This moisture enhancement is also critical in the development of thunderstorms that produce intense rainfall rates and amounts. Due to significant urbanization and the geologic formation of the Mojave Desert and Southern Great Basin the intense rainfall produces rapid runoff which leads to significant flash flooding. This paper will concentrate more on the gulf surge and increased convective instability rather than the actual flash flooding event.

On 17-18 August 2003, a surge of moisture raced up the Gulf of California reaching Southern Nevada on 19 August. The significant increase in low-level moisture aided in both the development and intensity of thunderstorms over the Las Vegas county warning area. One specific storm occurred over the Northwest portion of the Las Vegas Valley on the afternoon of 19 August. The Las Vegas WSR-88D radar (KESX) estimated over 3 inches of rain in one hour while Clark County Flood Control District gages measured greater than 2 inches of rainfall in less than one hour. These amounts overwhelmed the flood control facilities resulting in significant flash flooding. The Las Vegas Metropolitan Police Department made 9 swift water rescues by air, with nearly 60 total rescues in a 3 hour period. The Small Business Administration estimated total damage at 4.8 million dollars with 251 homes and 173 businesses sustaining damage.

Synoptic Overview

One of the most common synoptic patterns for gulf surges is an easterly wave over central Mexico and an intensifying thermal low over the Desert Southwest. But, gulf surges are difficult to forecast and track due to the sparse data network over Northwest Old Mexico and the Gulf of California region. Many disturbances in the sub-tropical easterlies that impact the Southwest U.S. in the summer originate over the Gulf of Mexico region. This was the case as Tropical Storm Erika was located in the western Gulf of Mexico on 15 August 2003. Erika made landfall just south of Brownsville, Texas on the morning of 16 August (Fig. 1) and weakened rapidly. The remnants of Erika continued west across Mexico and on 17 August helped generate strong, deep convection over the Mexican states from Sonora south to Jalisco in the afternoon and evening hours (Fig. 2). The southern convective complex in Figure 2 then moved out over the Sea of Cortez, off the central coast of Mexico, during the early morning hours of 18 August (Fig. 3).

Because of the weak large-scale environment over the Southwest in the summer, one of the best approaches to synoptic monitoring is to make use of 24-hour change data (Maddox and Howard).

In this case, the pressure fall/rise couplet was analyzed as the remains of Erika moved west. Using data from 1200 UTC as the analysis time, sea-level pressure data from 5 sites was used starting back to 15 August 2003. The five sites were Yuma and Kingman, Arizona, Blythe and Needles, California, and Las Vegas, Nevada. The sea-level pressure and 24-hour change is shown in Table 1. As Table 1 shows, sea-level pressure was highest on the morning of 16 August as Erika made landfall. Twenty-four hours later pressures fell significantly at locations in the lower Colorado River valley as the remains of Erika moved west across mainland Mexico. Further sea-level pressure falls were noted on the morning of 18 August as well.

Table 1. Sea-Level Pressure (hPa) 1200 UTC and 24-Hour Change 15-19 August 2003

	Aug. 15	Aug. 16	Aug. 17	Aug. 18	Aug. 19
Yuma	1013.1	1014.4/+1.3	1008.9/-5.5	1005.8/-3.1	1010.1/+4.3
Blythe	1014.3	1014.4/+0.1	1009.3/-5.1	1005.8/-3.5	1010.8/+5.0
Needles	1013.4	1012.6/-0.8	1008.2/-4.2	1004.0/-4.2	1007.8/+3.8
Kingman	1014.0	1012.6/-1.4	1011.3/-1.3	1007.4/-3.9	1009.9/+2.5
Las Vegas	1014.7	1016.9/+2.2	1012.3/-4.7	1007.5/-4.8	1008.0/+0.5

The 1200 UTC surface observations from Guaymas were not available, but upper air data was available. The 1200 UTC 17 August sounding (Fig. 4a) shows a northwest wind in the lowest 5000 feet with precipitable water at 1.41 inches. A day later, 1200 UTC 18 August (Fig. 4b) shows that the gulf surge had passed Guaymas. Note, the cooling of the temperature profile and increase in moisture below 5000 feet brought by the switch to southerly winds. The precipitable water value increased to 1.96 inches. A comparison of the two soundings overlaid can be seen in (Fig. 4c).

Using the VAD wind profile data from the Yuma WSR-88D radar (KYUX), a significant gulf surge can be detected as the depth of the southerly flow extending to greater than 6000 feet with wind speeds sustained at 40-45 knots. The strongest winds occurred between 0700 UTC and 0900 UTC (midnight - 2 am PDT) and occurred from the surface to 4000 feet (Fig. 5). Sea-level pressure rises behind the surge in the cooler, denser air are shown in Table 1 on 19 August. The greatest rises occurred in the lower Colorado River Valley from Yuma, north to Needles, with the passage of the surge at Needles occurring between 1100 UTC and 1200 UTC. The strong southerly winds continued to carry moisture northward up the Colorado River Valley during the morning hours. The moisture surge became evident in the Las Vegas Valley by 1800 UTC as the valley inversion broke and the moisture and southerly winds mixed to the surface. The Las Vegas surface dew point at 1200 UTC was 51 degrees F and 6 hours later it rose to 67 degrees F. Due to the location of the Desert Rock Sounding (75 miles northwest of the Las Vegas Valley), precipitable water data was obtained by an Integrated Precipitable Water Vapor (IPW) sensor located on the grounds of McCarran Airport (Fig. 6). Figure 6 shows, precipitable water values near 1.20 inches at 1200 UTC August 19, with values steadily rising to near 1.50

inches by 1800 UTC August 19.

Convective Instability and WSR-88D Summary

Based on the 1200 UTC August 19 Desert Rock sounding (closest sounding to Las Vegas) the forecast CAPE was 602 J/kg, which is not representative of conditions in Las Vegas. The LAPS analysis at 1800 UTC showed CAPE values over the Las Vegas valley was around 2400 J/kg (Fig. 7) with thunderstorms initiating over the Spring Mountains west of Las Vegas. In the early afternoon, the storms began to migrate away from the mountains and into the desert valleys. By 2100 UTC, CAPE values had increased to around 3000 J/kg (Fig. 8) and the IPW sensor (Fig. 6) showed values near 1.60 inches. Thunderstorms northwest of Las Vegas started to propagate southeast or toward the unstable air. At 2230 UTC, the intense rainfall producing thunderstorms began entering the extreme northwest part of the valley and the Clark County Regional Flood Control District network of gages began reporting rainfall amounts. By 2300 UTC, the Lone Mountain/Hualapai (#4054) gage recorded 1.50 inches in 30 minutes. By 2330, the Lone Mountain Detention Basin (#4269) gage reported 2.36 inches in one hour. The one-hour radar estimated rainfall from KESX between 2235 UTC and 2335 UTC indicated greater than 3.00 inches of rainfall over a large area of the northwest valley bounded by Summerlin Parkway on the south and U.S. Highway 95 to the east (Fig. 9). A ground truth report was received by a National Weather Service forecaster who reported 2.30 inches in 20 to 30 minutes.

Conclusion

Although the flash flooding from this episode was not as widespread as the 8 July, 1999 flash flood, this event demonstrates the value of tracking 24-hour change data and the usage of a variety of data sources like the WSR-88D VAD wind profile, IPW, and LAPS data. The utilization of these resources is needed to stay on top of rapidly changing mesoscale atmospheric conditions. Furthermore, the synoptic scale NCEP models do not properly represent these smaller scale features. From this paper, the National Weather Service in Las Vegas will use the Upper Air Analysis charts produced by NAME this summer and reinstate producing a Daily Observation Summary tracking the 24-hour changes.

Acknowledgments

The author would like to thank the Clark County Regional Flood Control District for providing rainfall data used in the paper. Thanks to Stan Czyzyk, Science and Operations Officer at WFO Las Vegas, for his assistance.

References

Maddox, R. and K. Howard, Online Monsoon Analysis and Forecasting Workshop. National Severe Storms Laboratory 1997.

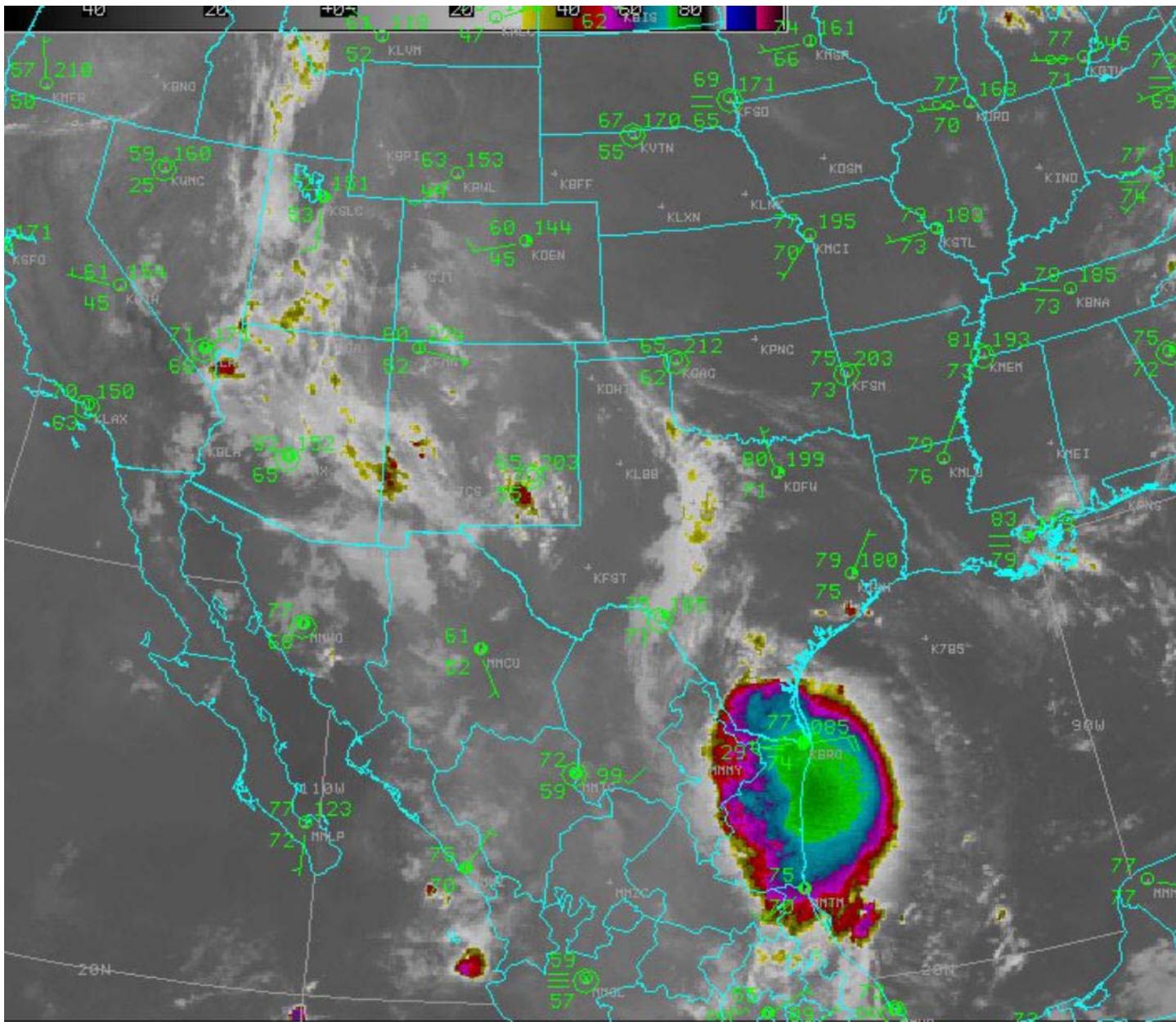


Fig. 1. Infrared Imagery showing Tropical Storm Erika making landfall on the

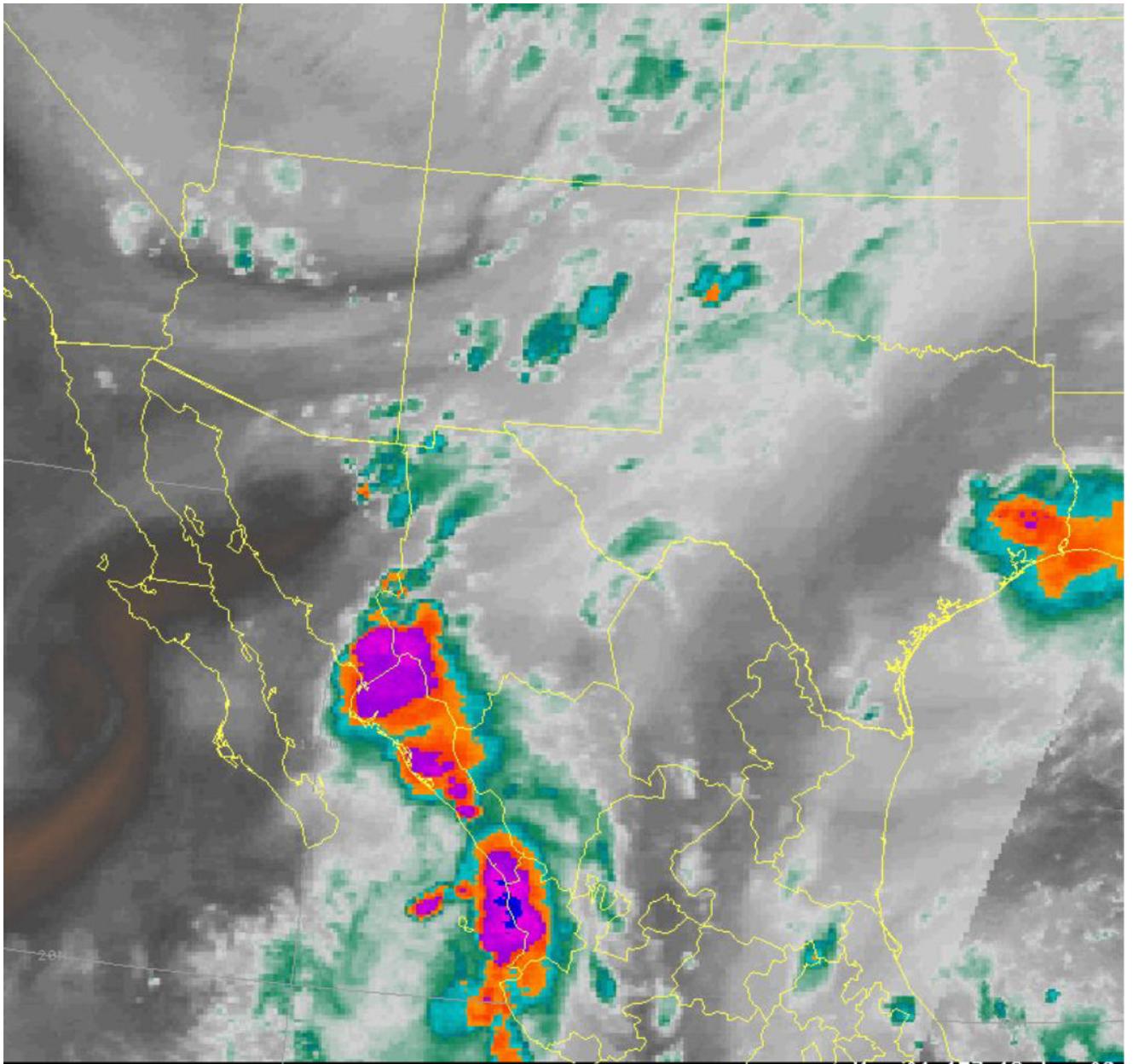


Fig. 2. Water Vapor Imagery showing convective complexes along West Coast of Mexico.

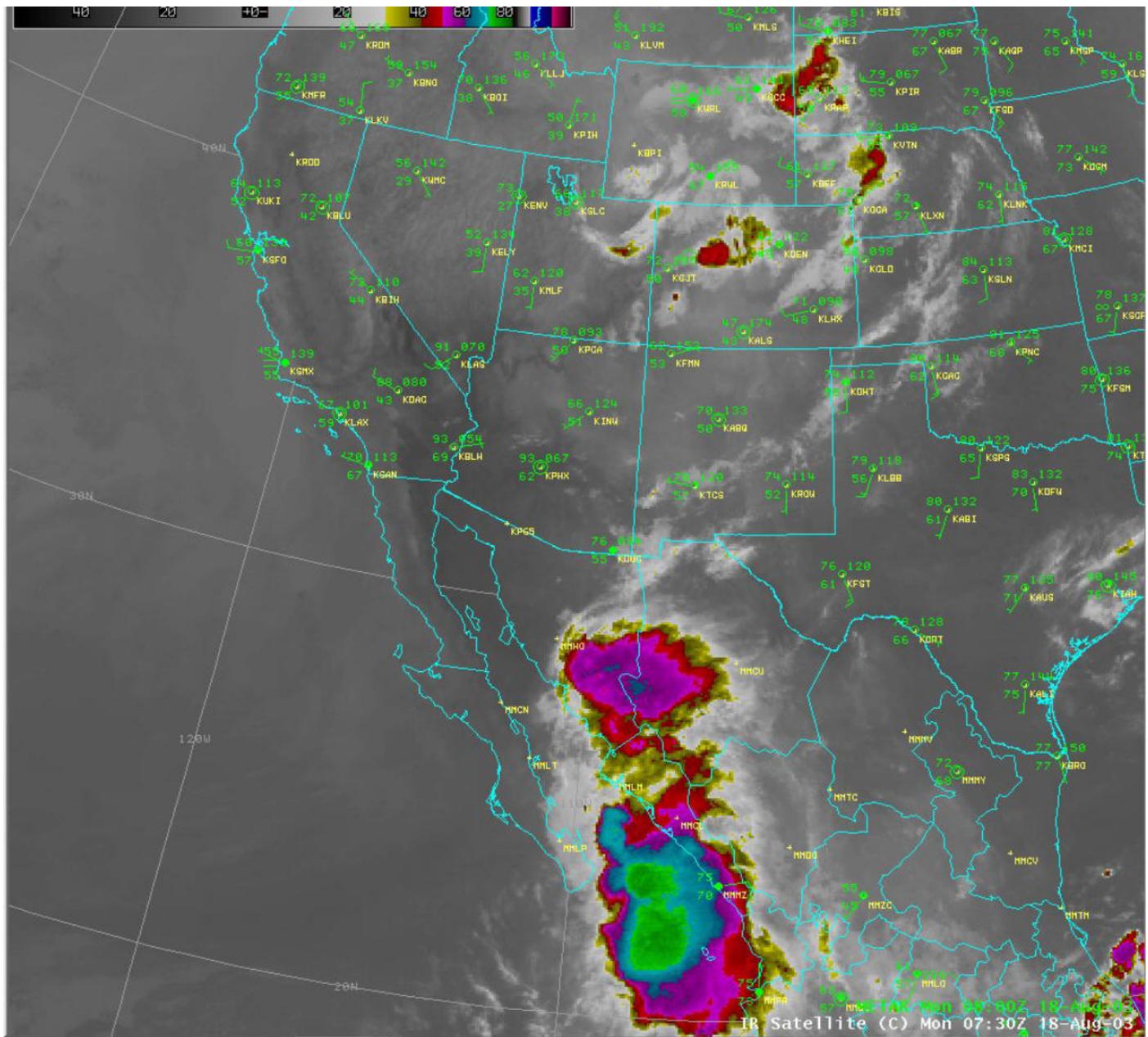


Fig. 3. Infrared Imagery showing convective complex near the opening to the Gulf of California.

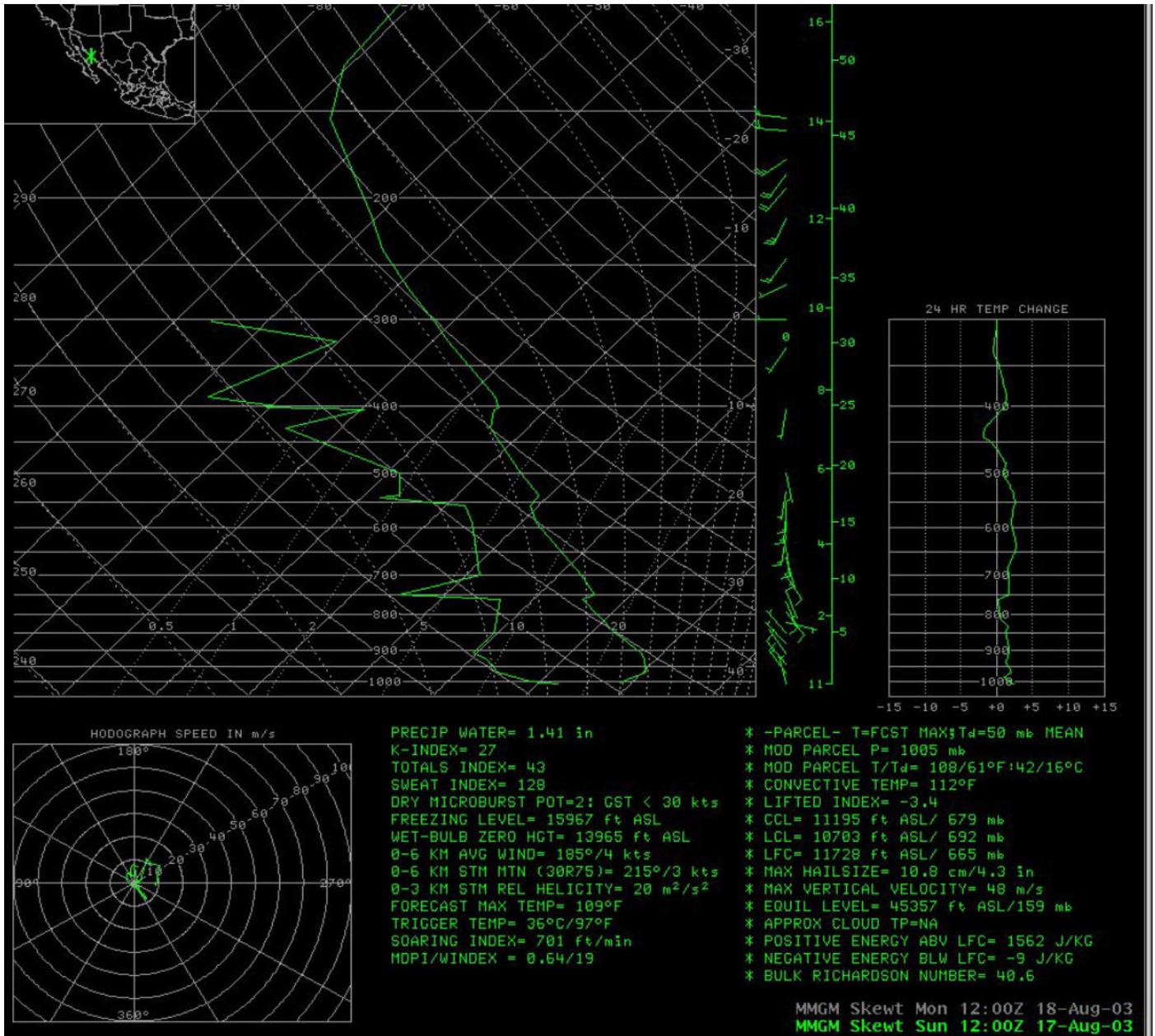


Fig. 4a. Sounding from Guaymas, Mexico from 12 UTC, August 17, 2003.

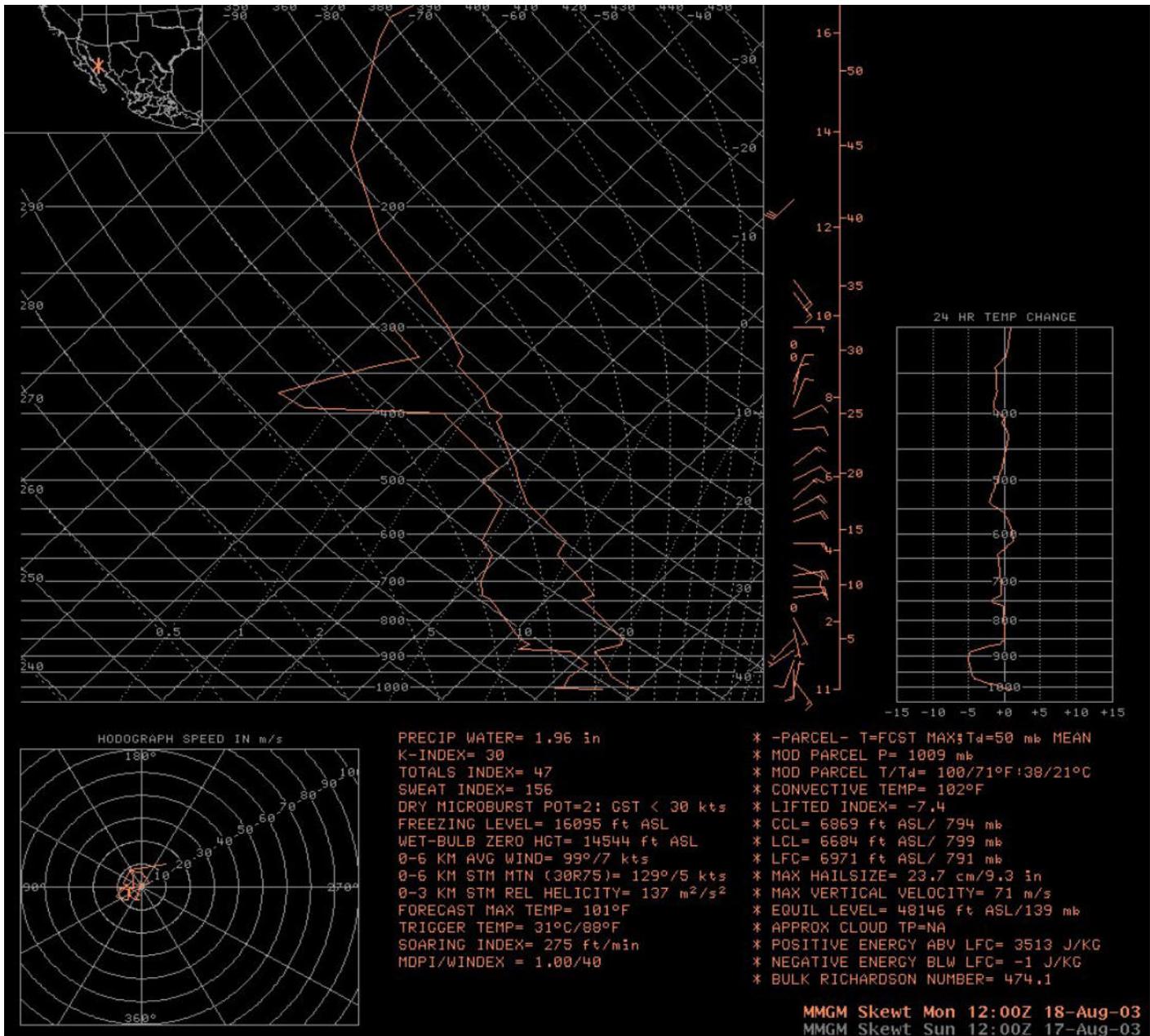


Fig. 4b. Sounding from Guaymas, Mexico from 12 UTC, August 18, 2003.

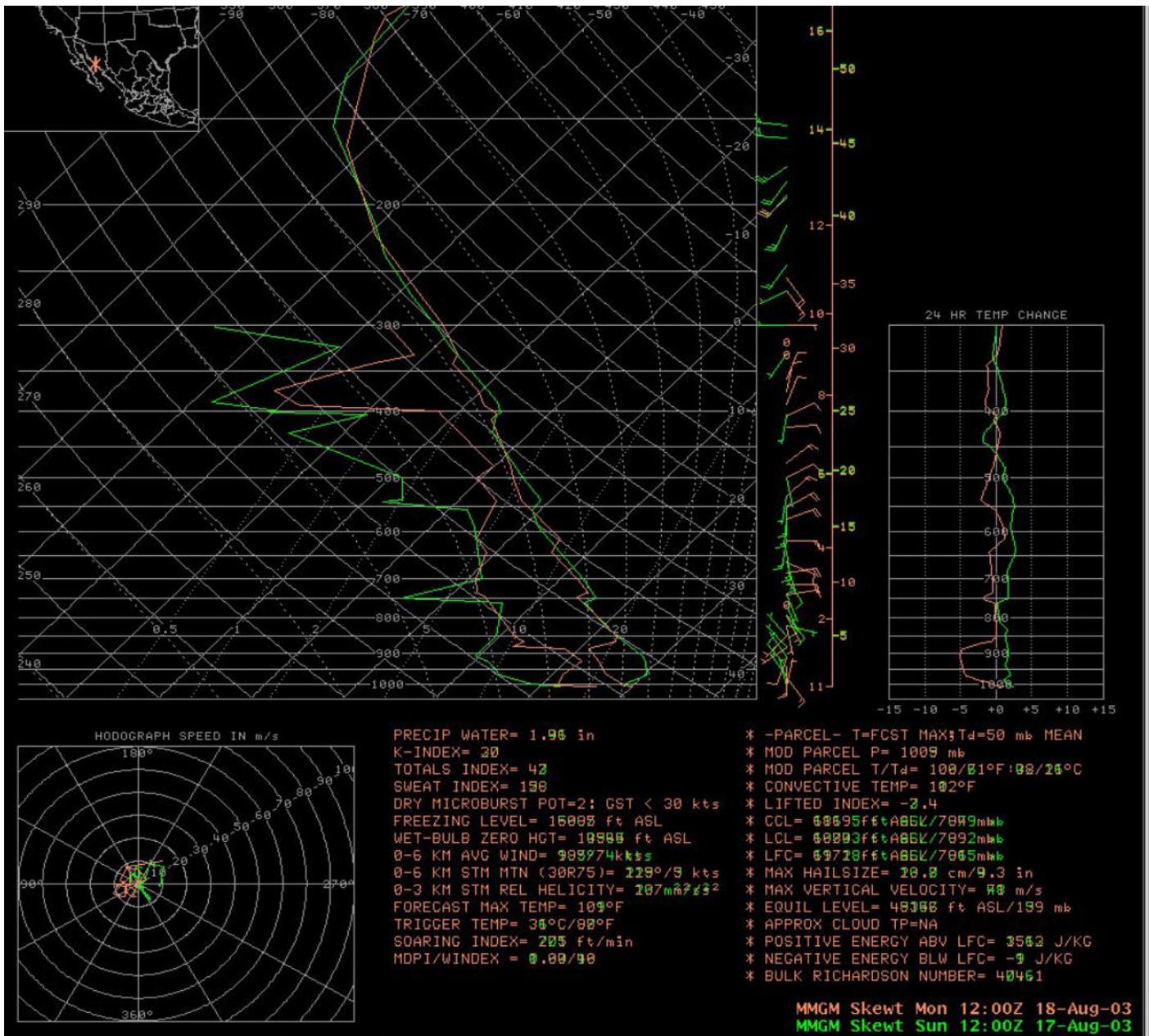


Fig. 4c. Guaymas, Mexico sounding from August 17 and August 18, 2003 overlaid.

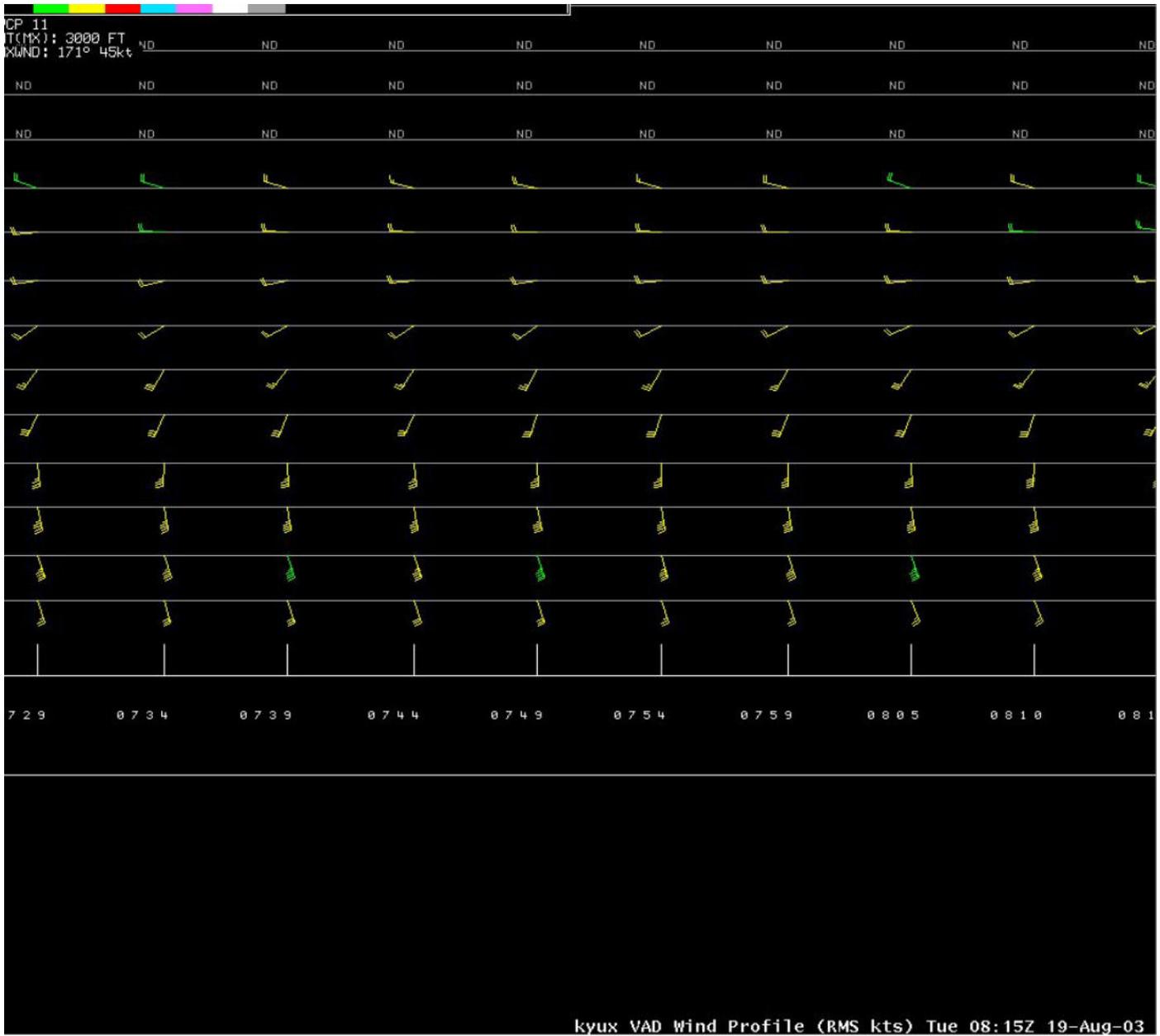
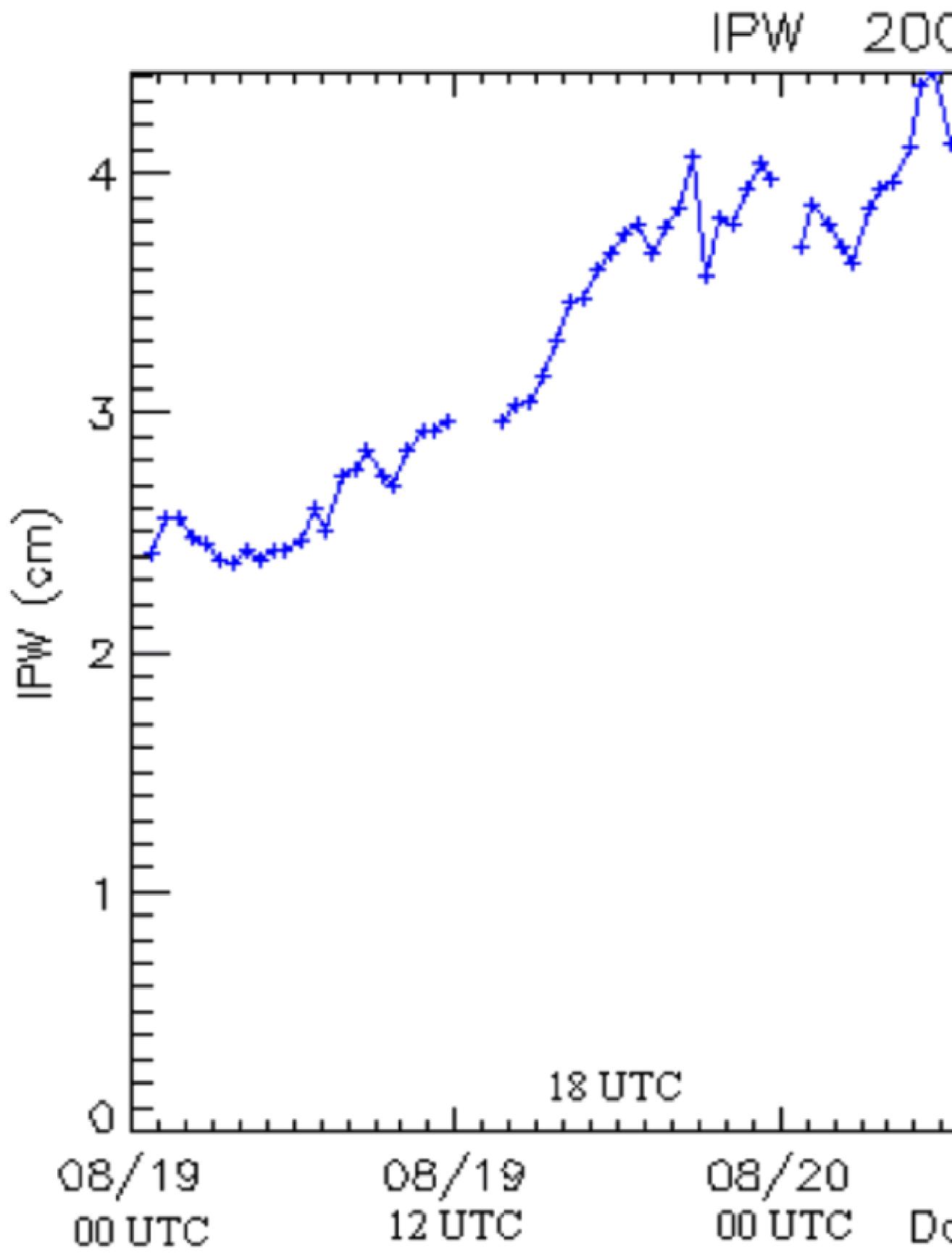


Fig. 5. Yuma WSR-88D VAD Wind Profile from August 18, 2003.

Las Vegas, NV



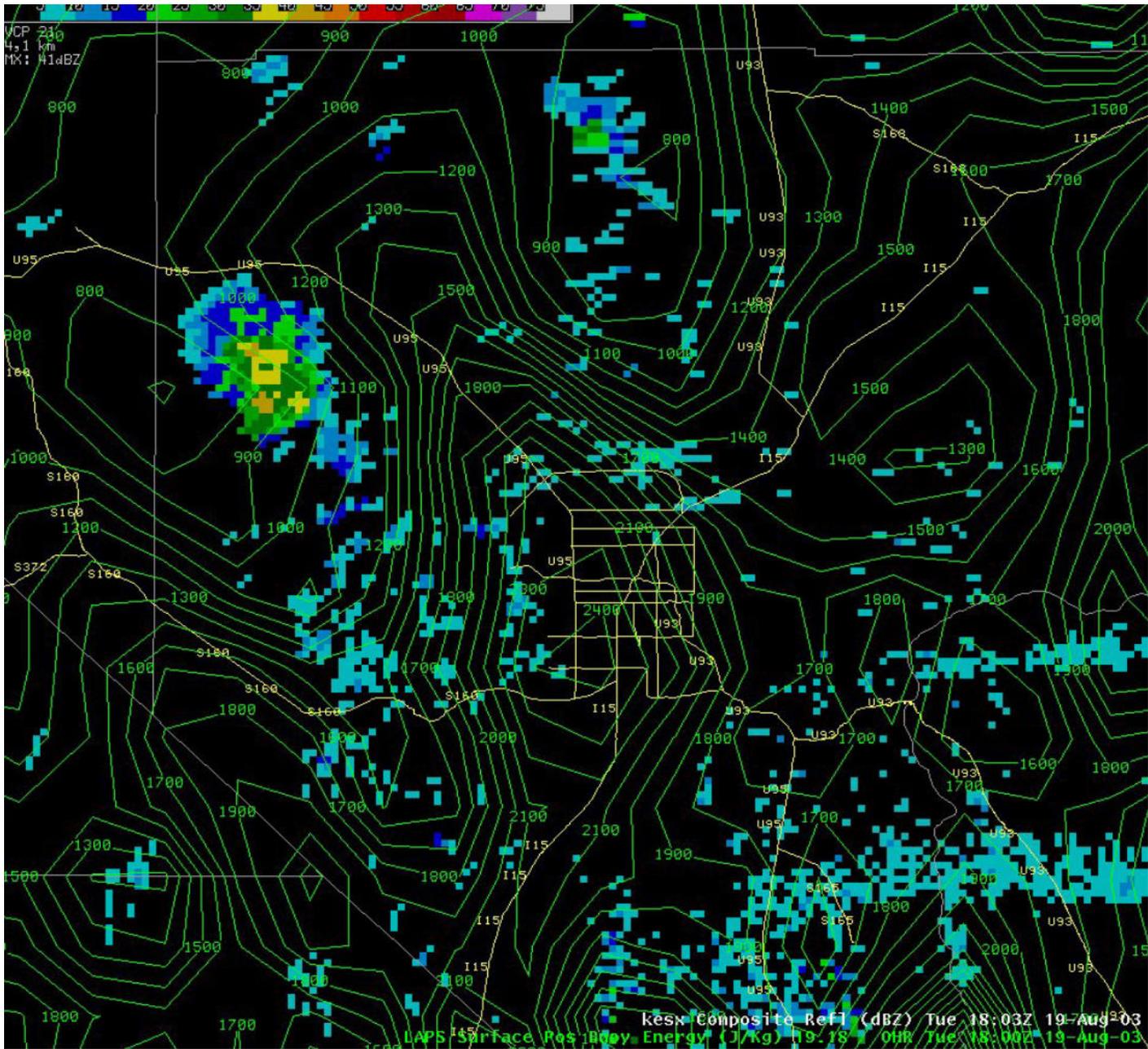


Fig. 7. LAPS CAPE and Las Vegas WSR-88D Composite Reflectivity at 18 UTC, August 19, 2003.

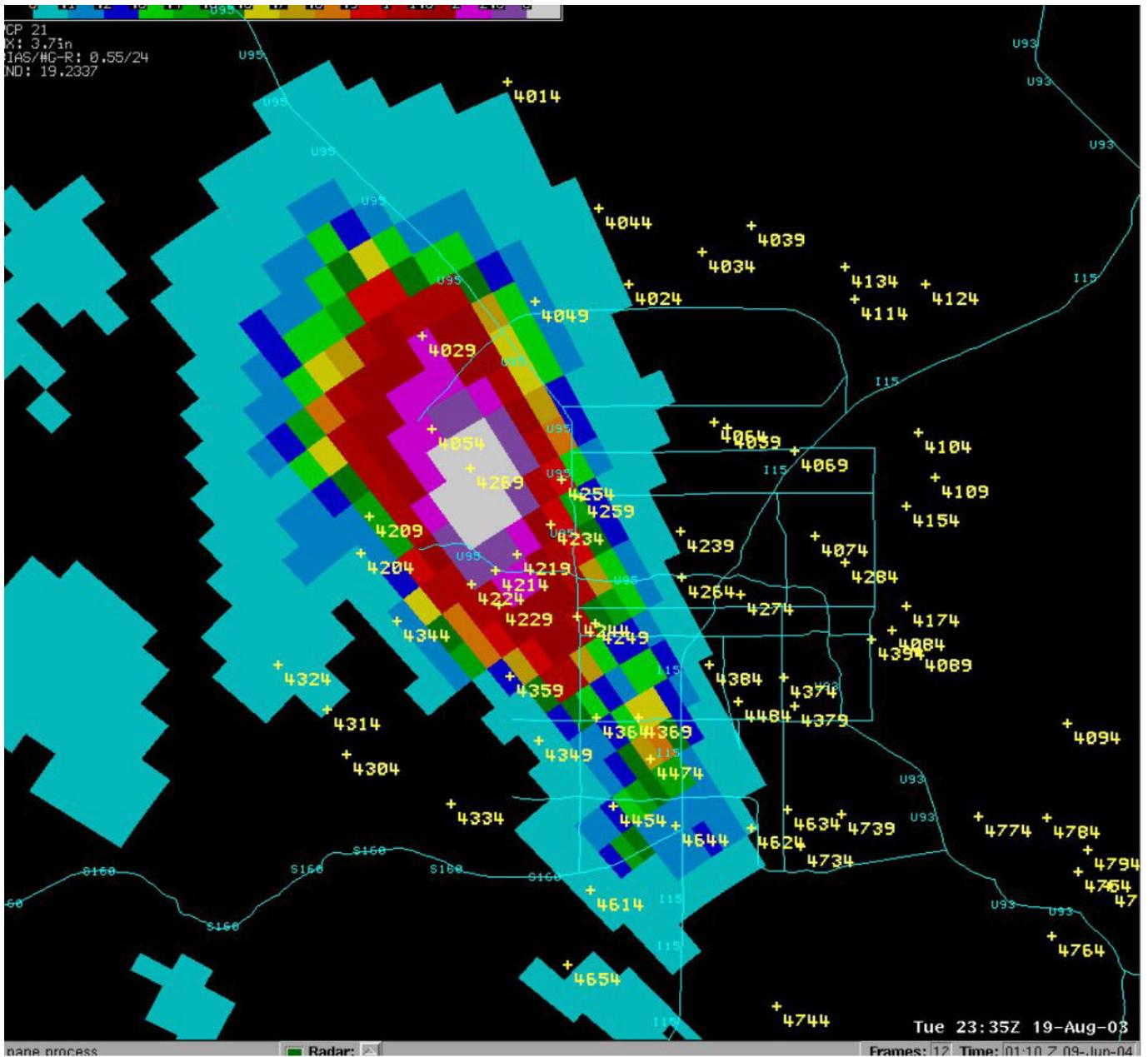


Fig. 9. Las Vegas WSR-88D one hour estimated rainfall with Clark County Regional Flood Control District Alert sites.