

# Severe Weather Outbreak in the Phoenix Area on 14 July 2002

Doug Green  
WFO Phoenix, Arizona

## Introduction

The most significant severe weather outbreak in the Phoenix CWA during the summer of 2002 occurred over and near the Greater Phoenix metropolitan area during the evening of 14 July. Several varieties of severe weather were observed: 1) widespread dust storm with near zero visibility and 40-60 mph sustained wind affected most of the metropolitan area; 2) microbursts, with peak wind estimated near 100 mph, caused extensive damage over and near Sky Harbor International Airport; and 3) heavy rainfall, which led to localized flash flooding, occurred over central and south Phoenix. Preliminary damage reports indicate \$70 million in property damage occurred as a consequence of the high winds at Sky Harbor. This TA-Lite provides a brief overview of this WES case.

## General Synoptic Situation

All-time record high temperatures were recorded across much of the western United States during the period 10-14 July 2002 as an anomalously strong area of mid-upper tropospheric high pressure affected the area. A peak 500 millibar height of 6020 gpm occurred over northern Nevada and southern Oregon on 11 July. The area of high pressure slowly weakened and drifted toward the southeast during the period 12-14 July; by 1200Z 14 July, the high was centered over southern Utah with a maximum height of 5940 gpm. As expected, daytime highs were above normal over Arizona, though they fell short of record levels. Low-level moist advection occurred over the lower Colorado River valley and far southeast California the evening of 13 July as Hurricane Christine tracked west-northwest over the eastern Pacific Ocean; even so, surface dew points over south central Arizona were only in the mid 50s F as of 0000Z 15 July (5 pm MST 14 July).

Stronger-than-normal east to northeast wind occurred throughout the mid-troposphere over much of Arizona during the period 12-14 July, which resulted in above-average vertical shear in the low-mid troposphere. The Storm Prediction Center (SPC), noting that vertical shear favored longer-lived multicellular storms/MCSs, issued severe thunderstorm watch boxes for a portion of Arizona on 12-13-14 July. The watch box location shifted toward the east and south each day as the anticyclone and associated core of most favorable vertical shear drifted toward the southeast. On 13 July, the watch box included the greater Phoenix area; however, organized severe thunderstorms remained north of the city. On 14 July, a severe thunderstorm watch was issued for southeast Arizona, where severe storms appeared to be most likely; WFO Phoenix opted not to have any of its CWA included.

## Severe Weather Outbreak and Ties to WES Training

The local atmosphere, as measured by a special rawinsonde release over Phoenix at 0000Z 15 July ([figure 1](#)), possessed modest low-level moisture, with a mixing ratio of 9 g/kg in the 950-800 mb layer. Computed MLCAPE was 640 J/kg, with the LFC at 560 mb; CIN was 180 J/kg, with the LCL at 635 mb. Although CAPE existed in the sounding, widespread convective activity over Phoenix was far from certain; as is usually the case, the approach of a strong and deep outflow (cold pool), or the intersection of 2 strong, deep outflows (cold pools), would be required to release potential instability over metro Phoenix. The 300-250 hPa analyses for 0000Z 15 July ([figure 2](#)) indicated the presence of upper divergence over southeast and north-central Arizona, while a mid-level disturbance was noted near the Arizona-New Mexico border on the 0000Z 15 July 500 hPa analysis ([figure 3](#)). The zone forecast for metro Phoenix called for a 30 percent chance of showers and thunderstorms the evening of 14 July (by comparison, MRF MOS climatology for Phoenix is 13 percent).

Strong thunderstorms were occurring over southeast Arizona during the late afternoon of 14 July (as expected; recall that a severe thunderstorm watch was in effect for the portion of Arizona south and east of the Phoenix CWA). To the northeast of Phoenix, over and near the Mogollon Rim, thunderstorms began to weaken between 2300 and 2400Z (4 and 5 pm MST); however, outflows from two areas of dissipating thunderstorms intersected over eastern Yavapai County, resulting in a strong area of thunderstorms centered 70 nmi north of Phoenix by 0100Z (6 pm MST). This thunderstorm complex began to propagate southward over the higher terrain of southeast Yavapai County, and storms associated with this propagation reached the far northeast portion of the greater Phoenix area by 0215Z (715 pm MST). Between 0215Z and 0315Z, storms propagated toward the south-southwest in a narrow band ([figure 4](#)), over progressively lower terrain, reaching central Phoenix by 0230Z (730 pm MST). The narrow band of thunderstorms then remained quasi-stationary for the next hour, while other thunderstorms began to propagate into northwest and north-central portions of the metropolitan area from southern Yavapai County. Evolution of the narrow convergent band of storms over and northeast of Phoenix was one focus of the WES-based training.

An unusually strong, deep cold pool, generated by strong to severe thunderstorms over southeast Arizona, moved northwest across the south-central desert southeast of Phoenix, reached the southeast Valley by 0245Z (745 pm MST), then overspread the metropolitan area by 0400Z (9 pm MST). Surface winds 40 to 60 mph, accompanied by dense blowing dust, were observed with the advancing cold pool over and just southeast of metro Phoenix ([figures 5, 6, 7, 8](#)). Winds appeared to increase just southeast of Phoenix as new convective storms rapidly developed in the wake of the leading edge of the outflow boundary (cold pool).

Rapid intensification of two convective storms on the southwest end of the pre-existing convergent band occurred as the outflow boundary (cold pool) moved through, resulting in intense microbursts, with peak wind speeds estimated near 100 mph, over and near Sky Harbor airport ([figures 9, 10, 11, 12](#)). Evolution of the cold pool, the cold pool's interaction with the pre-existing convergent band of storms, and the evolution and characteristics of the microburst-producing storm over Sky Harbor were focuses of the WES-based training.

Cold pool outflow from the southeast collided with outflow from the north, which was generated by storms over north-central Maricopa County, around 0330Z (830 pm MST); outflow collision occurred very close to the position of the pre-existing convergent zone over central Phoenix. Lightning activity increased dramatically shortly after the boundary collision, with peak lightning strike frequency occurring over Phoenix between 0330Z and 0400Z as thunderstorm updrafts rapidly developed and intensified. Rainfall rates at several automated rain gauges peaked at slightly above 6"/hr (0.5"/5 minutes) between 0350Z and 0415Z (850 and 915 pm). Ten automated rain gauges in central Phoenix recorded greater than 0.75" of rain in 15 minutes, while 2 automated gauges received over 1" of rain in 15 minutes ([figures 13, 14, 15, 16](#)). Interaction of the outflows with each other and the pre-existing convergent zone, as well as the noticeable increase in lightning frequency followed by a dramatic increase in rain rate, was another focus of the WES training.

## Summary and Discussion

The event of 14 July 2002 provided forecasters with a number of issues to review and discuss. Dust storms, damaging straight line winds, and excessive rainfalls are frequent occurrences to the south-central Arizona desert; initiation and evolution of all three can be closely examined on this day via the WES.

Although moderate CAPE of 640 J/kg existed in the 0000Z 15 July sounding, movement of a strong, deep outflow (cold pool) into the metropolitan Phoenix area was needed to trigger thunderstorms over the city, since CIN was present in the local environment and the LFC was quite high. The Phoenix WFO issued a hazardous weather outlook at 0007Z 15 July (507 pm 14 July) which highlighted the chance for damaging thunderstorms winds, dense blowing dust, and locally heavy rain over south central Arizona during the evening of 14 July. This outlook was predicated on the expectation that strong outflow from thunderstorms over southeast Arizona would move northwest toward Phoenix. However, outflow winds that generated the dust storm were stronger than expected over the Phoenix area; the winds appeared to be accelerated by new convective development just southeast of Phoenix. Also, the southward propagation of strong to severe thunderstorms over Phoenix from the north, prior to the onset of the dust storm, was somewhat unexpected. Figure 17 is the 0300Z infrared satellite image centered on Phoenix, and highlights the importance of convective interaction between systems approaching Phoenix from the north and south.

The thunderstorm that produced the intense microburst(s) over and near Sky Harbor airport developed at the south end of a pre-existing line of storms which had slowly propagated toward the southwest, then intensified rapidly shortly after it interacted with the dust storm-producing outflow from the southeast. No well-defined low-level divergence signature was noted in conjunction with the microburst-producing storm over and near Sky Harbor; however, mid-level convergence and maximum reflectivity aloft peaked about 10 minutes prior to microburst occurrence. A severe thunderstorm warning was in effect for the area at least 20 minutes before the microburst occurred, which reflected the importance of situational awareness in warning decision-making.

Intersection of two outflow boundaries, one from the southeast, and the other from the north, increased the probability that intense multicell thunderstorms would develop over metro Phoenix. In this case, the intersection took place over central Phoenix near the pre-existing line of storms, which triggered new updraft development and sudden increase in lightning, followed by an unusually heavy rainfall event and flash flooding.

Although dust storm, airport weather, severe thunderstorm, and flash flood warnings issued by WFO Phoenix on 14 July were timely and accurate, forecaster anticipation of future extreme events will undoubtedly improve as a result of reviewing various aspects of the 14 July 2002 case via WES.

Figure 1

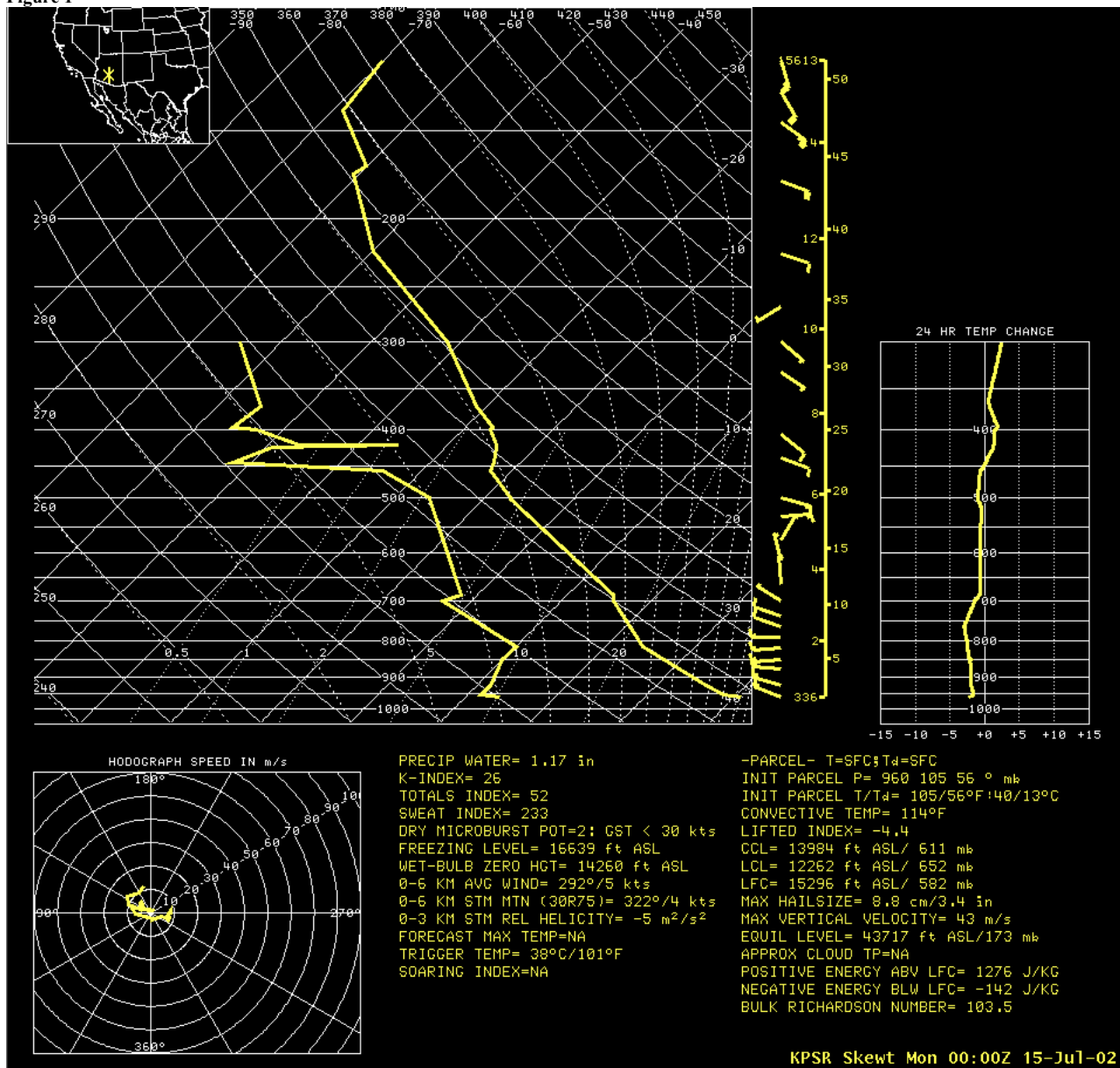


Figure 2

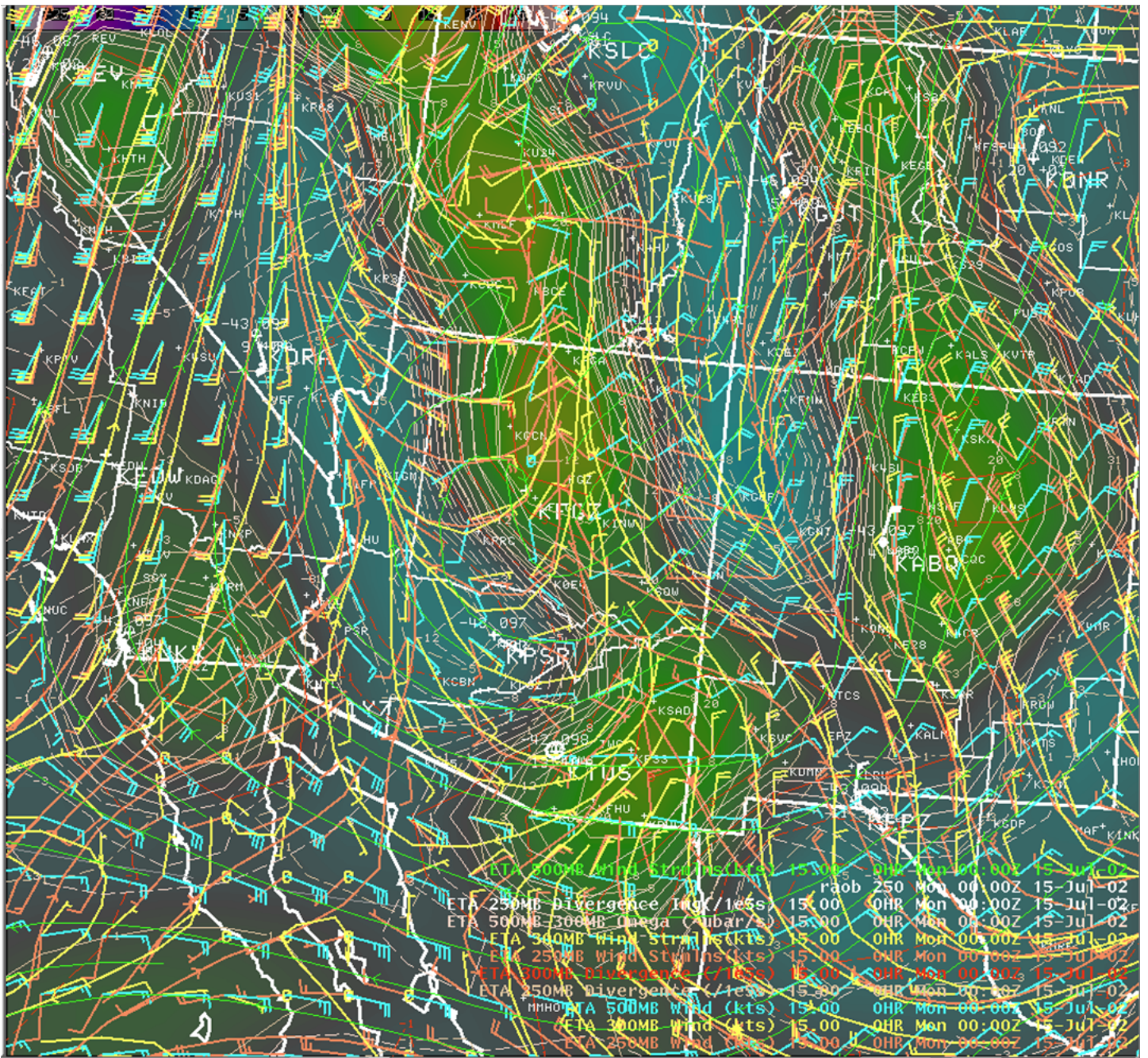


Figure 3

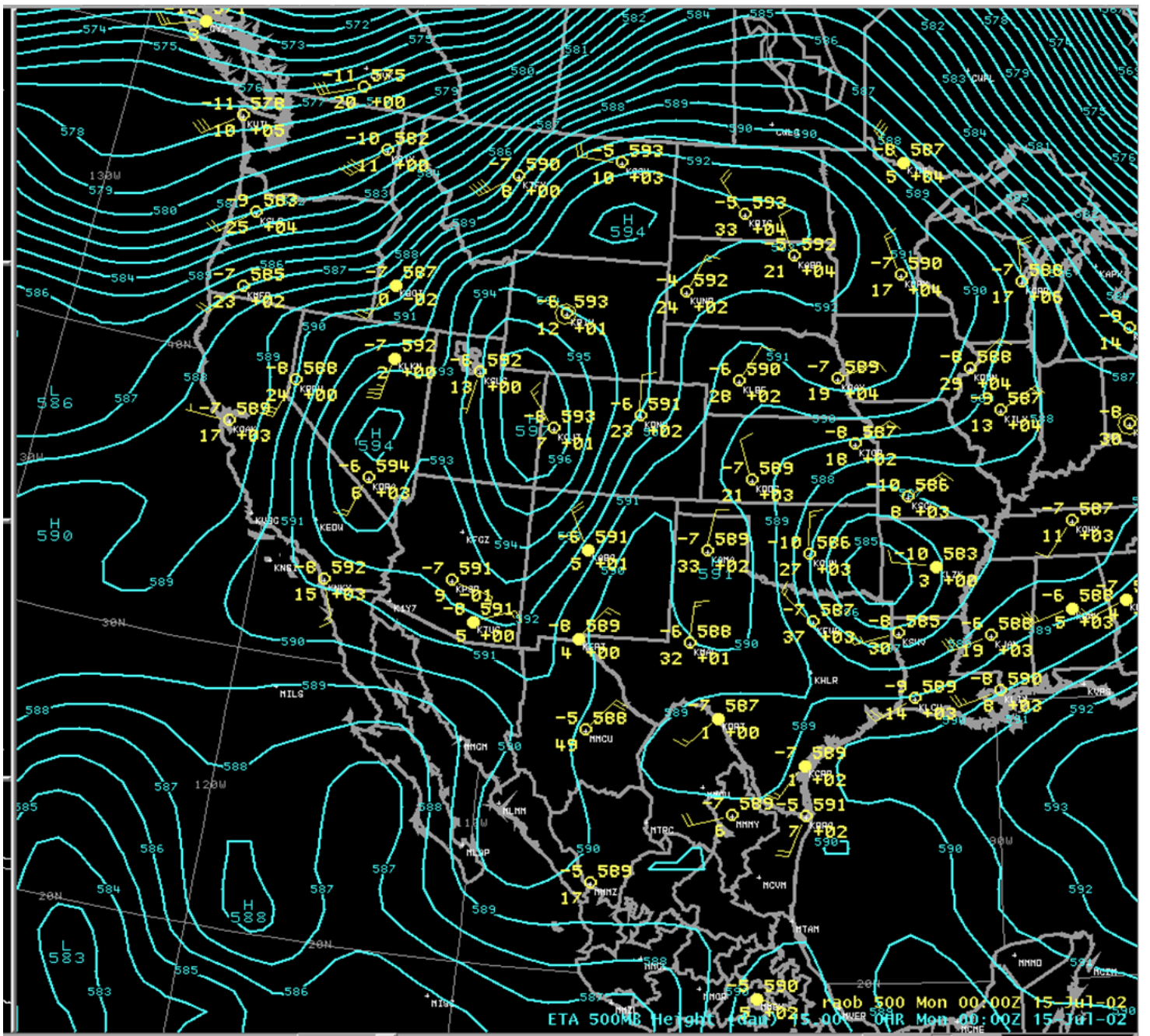


Figure 4

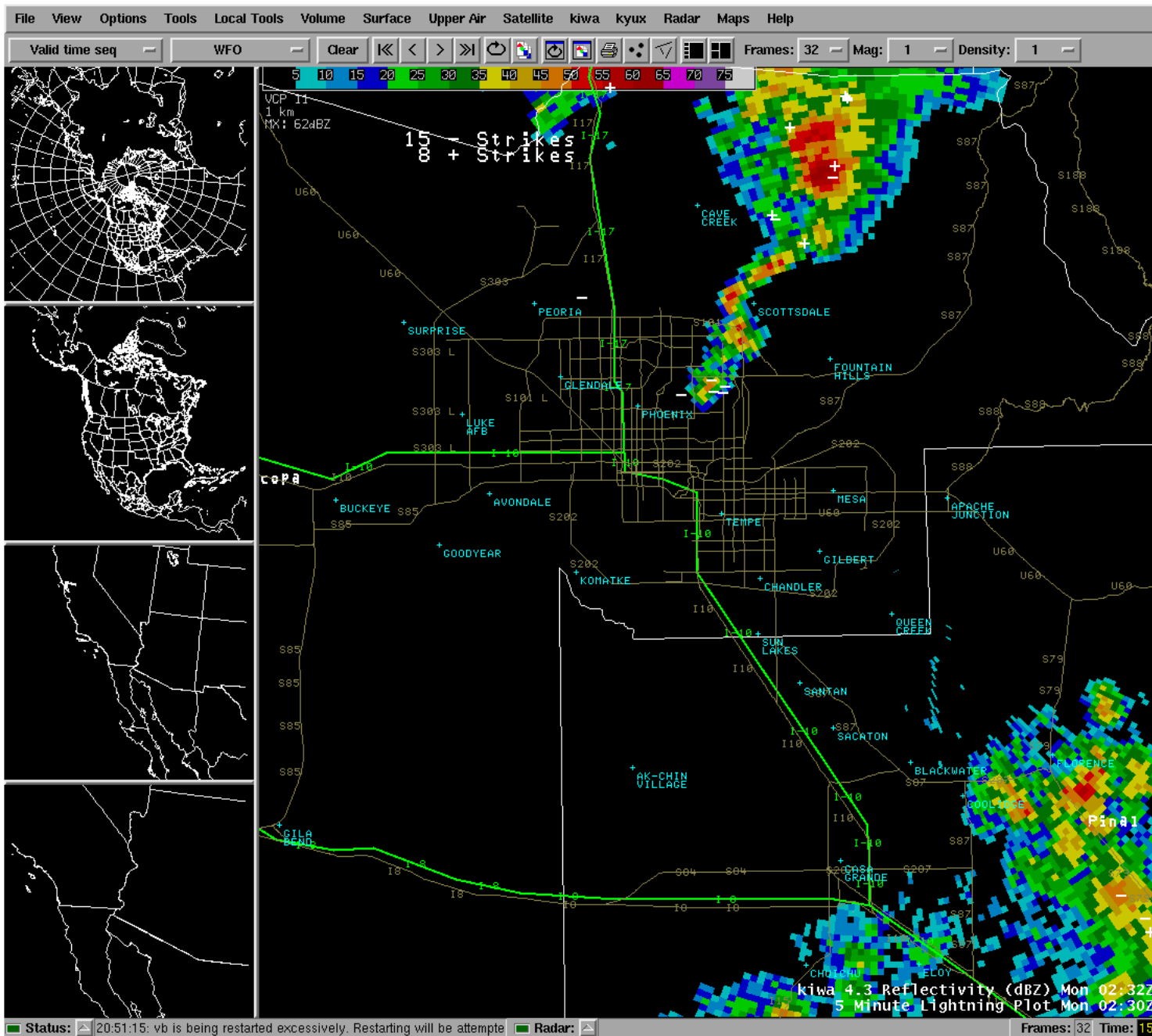


Figure 5

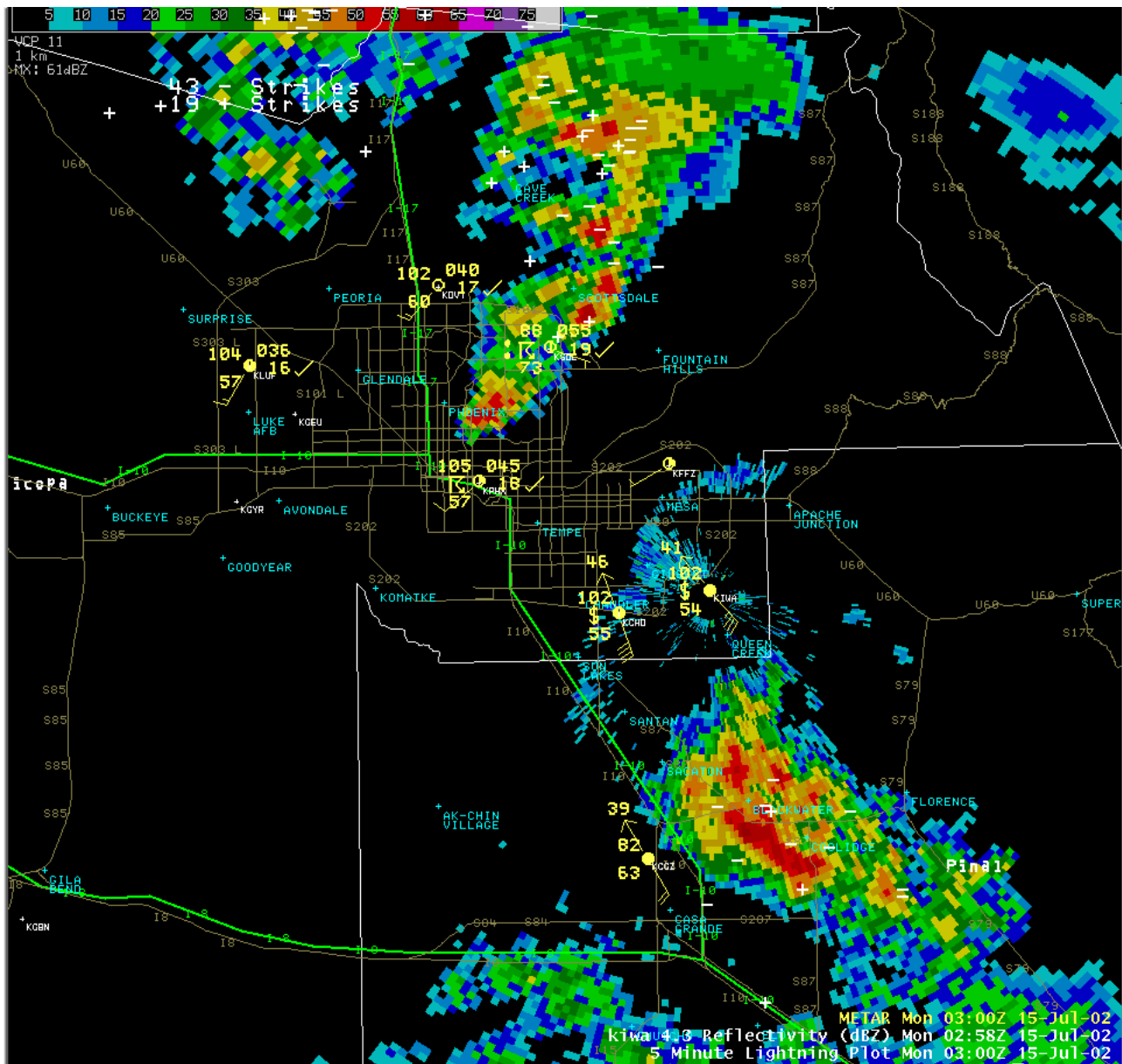


Figure 6

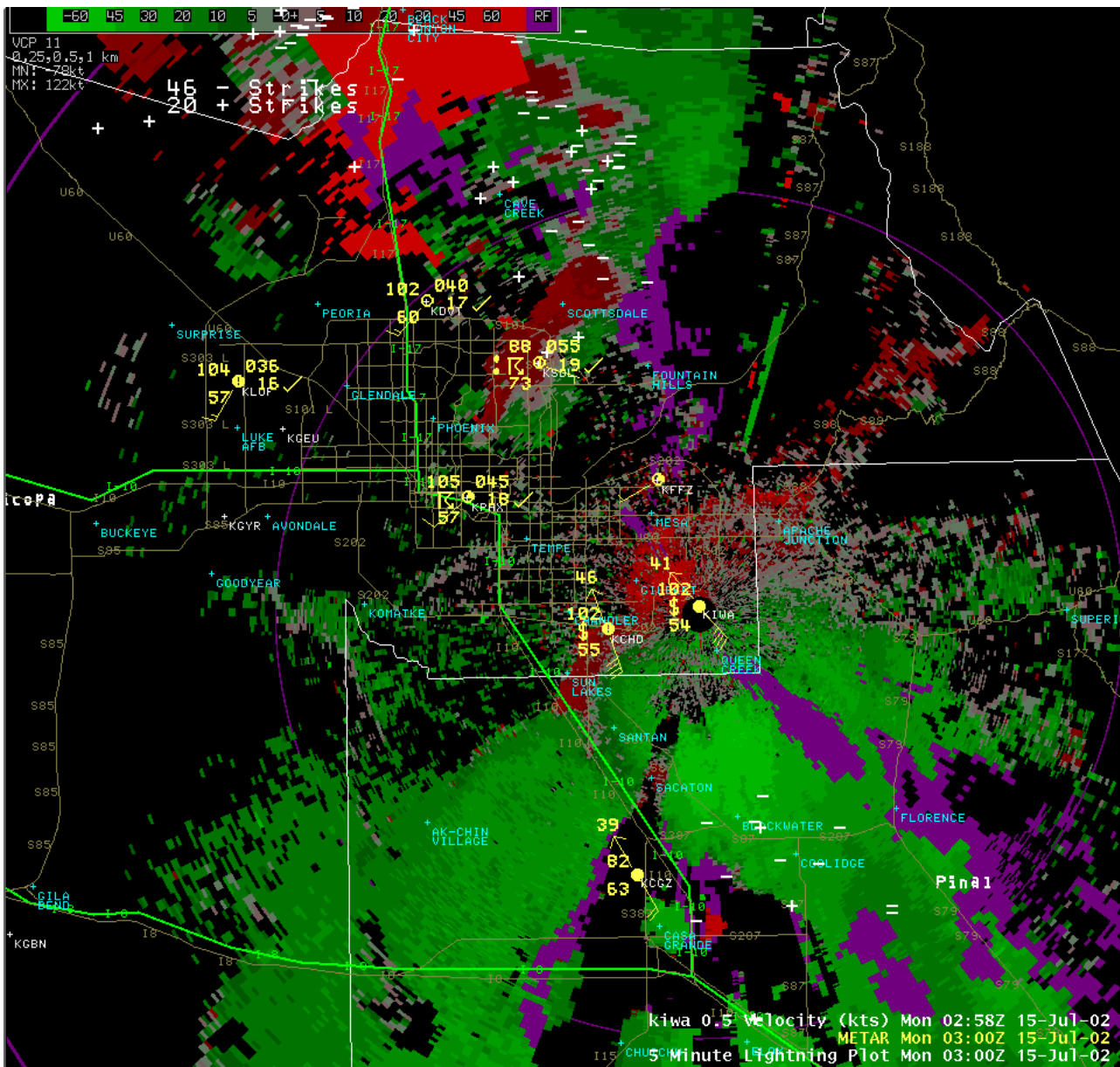


Figure 7





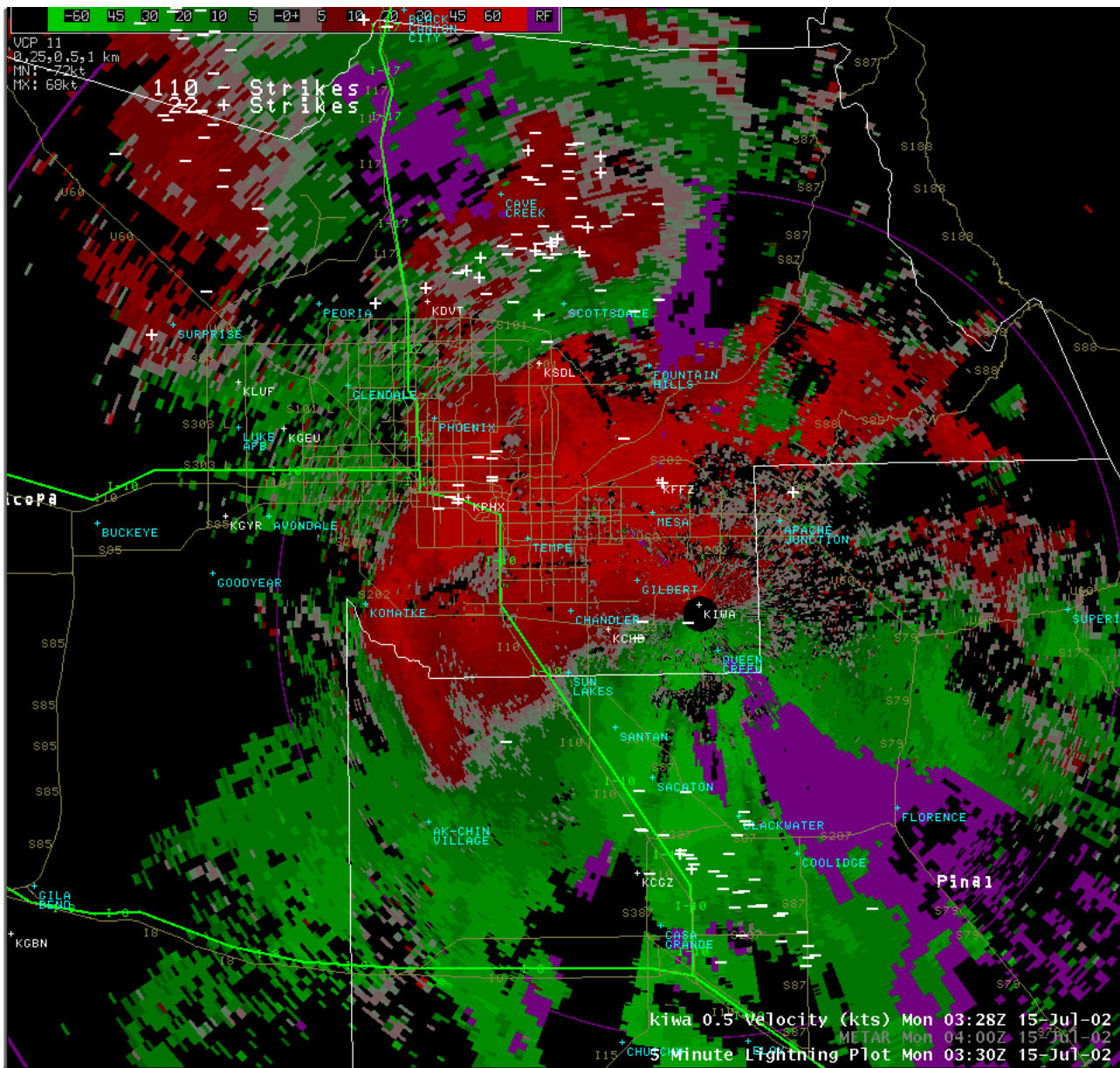


Figure 9

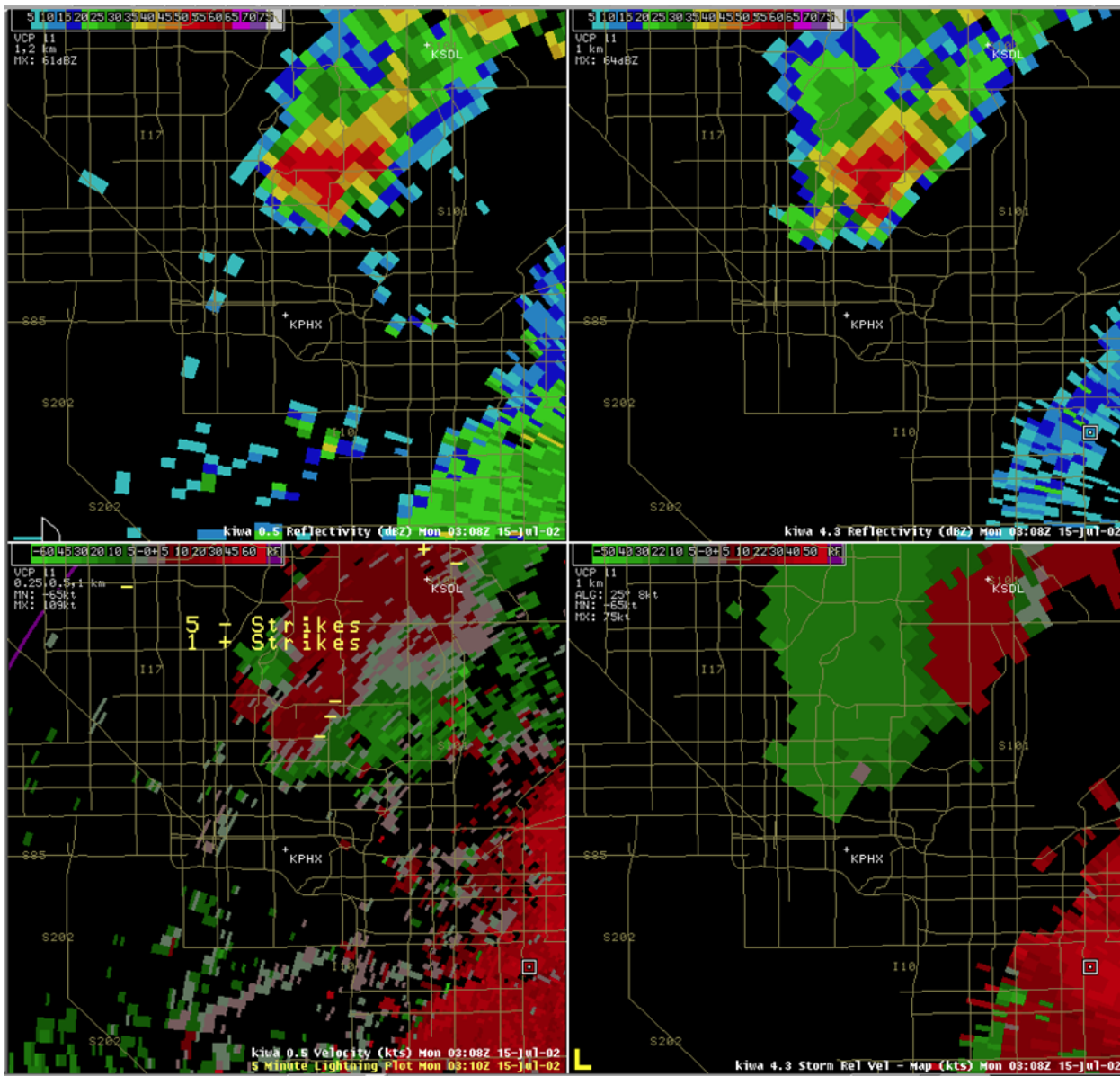


Figure 10

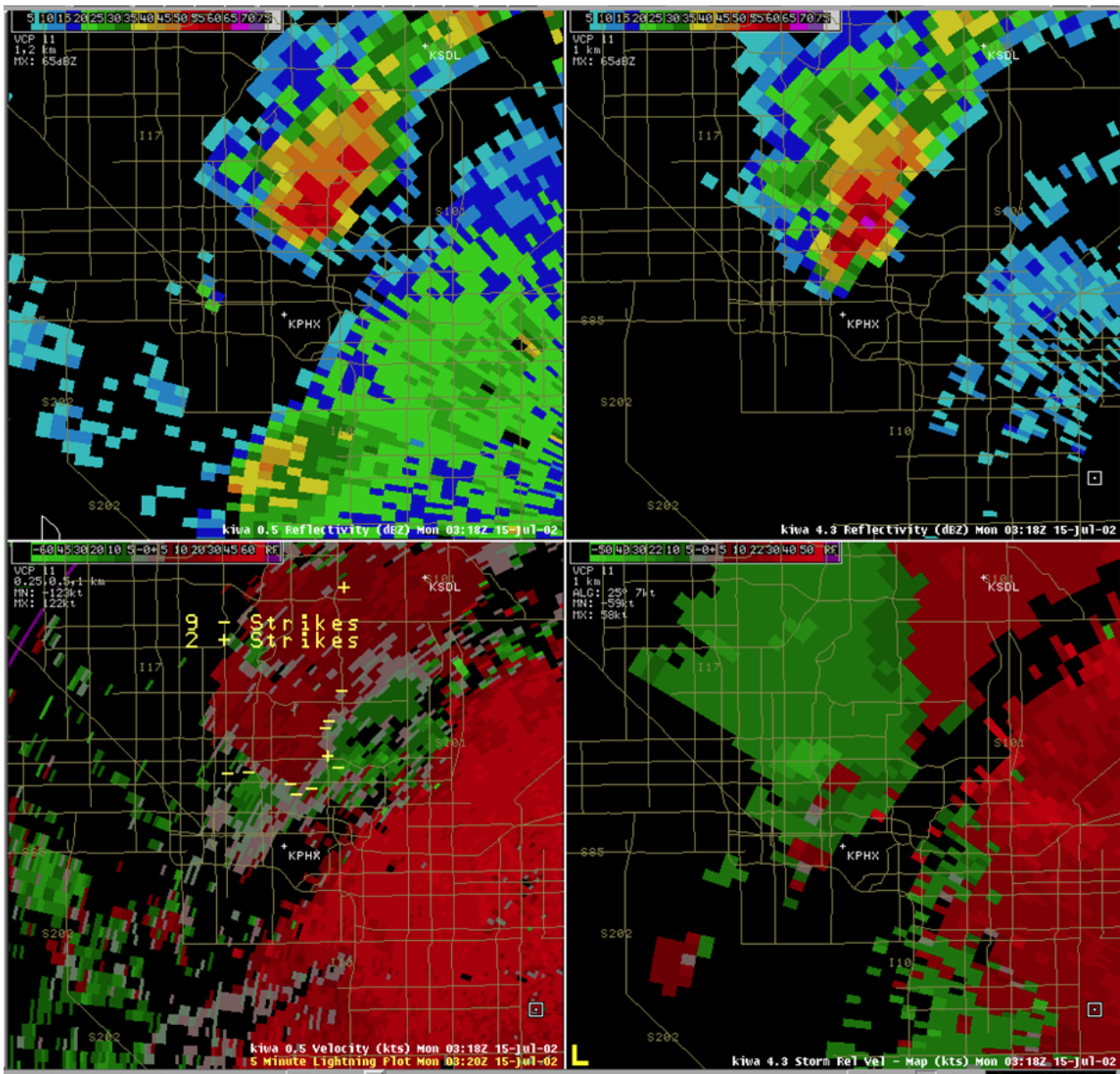


Figure 11

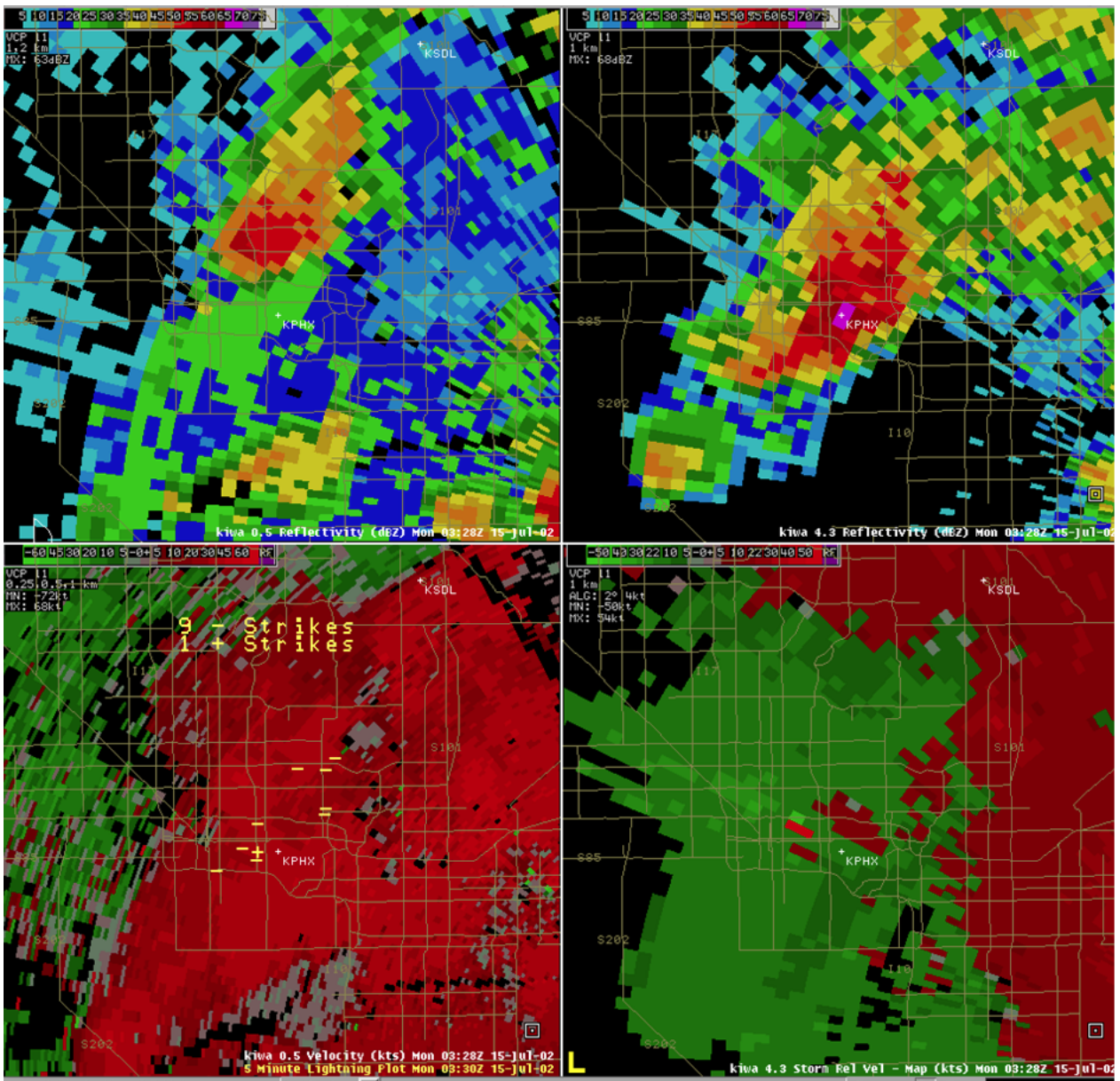


Figure 12

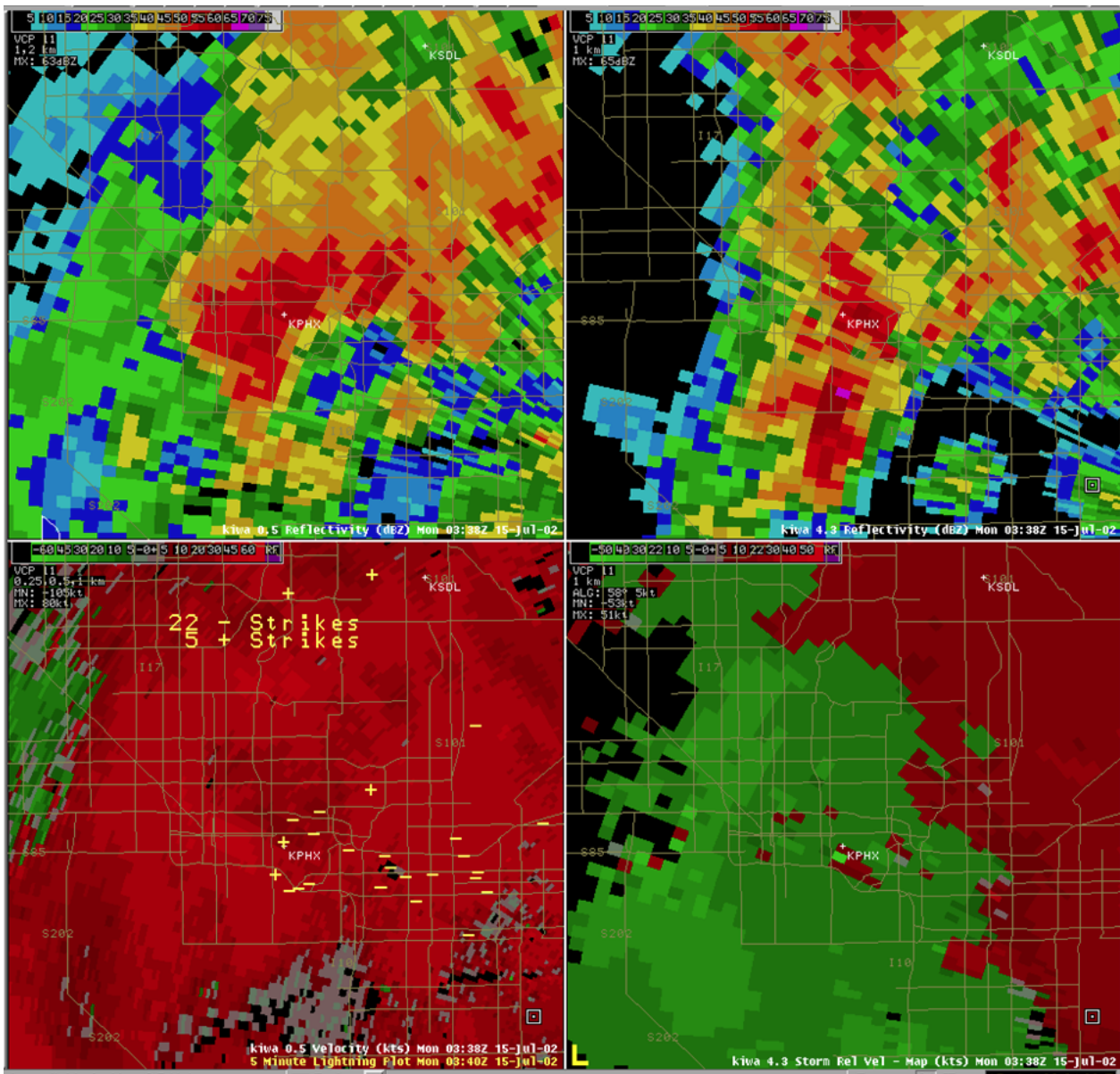


Figure 13









