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HIGH REFLECTIVITY/NON-SEVERE THUNDERSTORM IN COMPLEX TERRAIN

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Introduction

In the western U.S., high-reflectivity echoes on a WSR-88D display may or may not be associated with precipitation at the ground. This can be a problem for forecasters who have to issue severe thunderstorm or flash flood warnings. The key to correct interpretation of radar reflectivity information is knowledge of a storm's structure, its environment, and local terrain. This Technical Attachment describes an unusual but not atypical event that occurred in western Nevada. The KRGX WSR-88D display showed a 68 dBZ echo at the lowest tilt with little or no precipitation reaching the ground.

Case Study of the 8 July 1996 Reno Storm

On 8 July 1996, a high-reflectivity storm passed within 15 miles of the Reno National Weather Service Forecast Office. While no direct observations were available during the most intense period of the storm, forecasters had unobstructed visibility below cloud base suggesting little, if any, precipitation actually reached the surface. As the storm collapsed later, pea-size hail was reported.

The 9 July 00Z upper-air sounding (Fig. 1) was released within 2 hours of the event. The storm developed in conjunction with a strong surge of mid-level monsoonal moisture with cloud base very close to the freezing level. The sub-cloud air was well-mixed with a dry adiabatic lapse rate extending from the surface (~850 mb) to above 550 mb, a depth of nearly 8000 feet. However, the storm appeared to form in the mountainous terrain near the California-Nevada border and probably had a deeper moisture source.

The KRGX WSR-88D radar is on a mountain with elevation above mean sea level (MSL) of 8396 ft. The radar altitude is indicated on the sounding in Fig. 1. Base reflectivity from the 0.5 deg tilt at 0028 UTC is shown in Fig. 2. The maximum reflectivity is 68 dBZ. The echo is about 30 nmi west-southwest of the radar. At that range, the beam is ~2400 ft above the radar and ~2000 ft below cloud base and the freezing level. (The sounding release elevation is 4973 ft MSL.) Fairly high values of vertically integrated liquid (VIL; Fig. 3) were indicated by the radar. This storm also had a mesocyclone and TVS detection at 0057 UTC (not shown).

Discussion

A study comparing low-elevation reflectivity and hail at the ground using VORTEX (Verification of the Origin of Rotation in Tornadoes Experiment; Rasmussen et al., 1994) observations showed that hail was **always** reported where the reflectivity was at or above 60 dBZ (Witt 1996). The VORTEX study was conducted in the Midwest where thunderstorms are initiated from a deep layer of moisture near the surface. The Reno storm had a peak reflectivity of 68 dBZ and a VIL of 45. However, as mentioned above, no precipitation was observed to reach the surface.

These results underscore the importance of looking at the vertical structure of a storm in relation to the storm's environment and local terrain. In a modeling study by Rasmussen and Heymsfield (1987), 0.5 cm hail completely melted after falling 9000 feet through a boundary layer that went from 60 percent relative humidity at the surface to 100 percent relative humidity at the cloud base. In the case presented here, the surface relative humidity was less than 20%, supporting the hypothesis that pea-size or larger hail completely melted and evaporated.

Beyond the depth and dryness of the sub-cloud layer as derived from the sounding, there are two additional factors that can influence what hits the ground. First, if a thunderstorm happens to pass over high terrain, the precipitation will not fall as far and heavy rain and/or large hail may reach the surface. This is because the precipitation did not have enough time to melt or evaporate. Thus, the nature of the terrain in the storm's path must be taken into account when considering a warning. Second, the sub-cloud layer can change during the lifetime of a thunderstorm. It is speculated that when the Reno storm began to collapse, it modified (moistened) the sub-cloud layer. This reduced evaporation/melting and allowed pea-size hail to reach the surface.

Conclusions

The high reflectivity values associated with the Reno storm occurred just below the melting level. Research has shown that water-covered hail stones are much more reflective than pure water drops. The upper-air sounding showed a deep, dry, and well-mixed boundary layer causing most ,if not all, of the hail to melt and evaporate before it reached the surface.

A complicating factor is the terrain in the path of the storm; undulating terrain effectively changes the distance between the ground and cloud base. If the storm moves over higher terrain, hail and/or heavy rain may actually hit the ground having had less time to fall and melt and evaporate.

Also, a slow-moving storm modifying the sub-cloud layer (by way of a moist downdraft) can also reduce the effect of evaporation/melting.

Acknowledgments

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References

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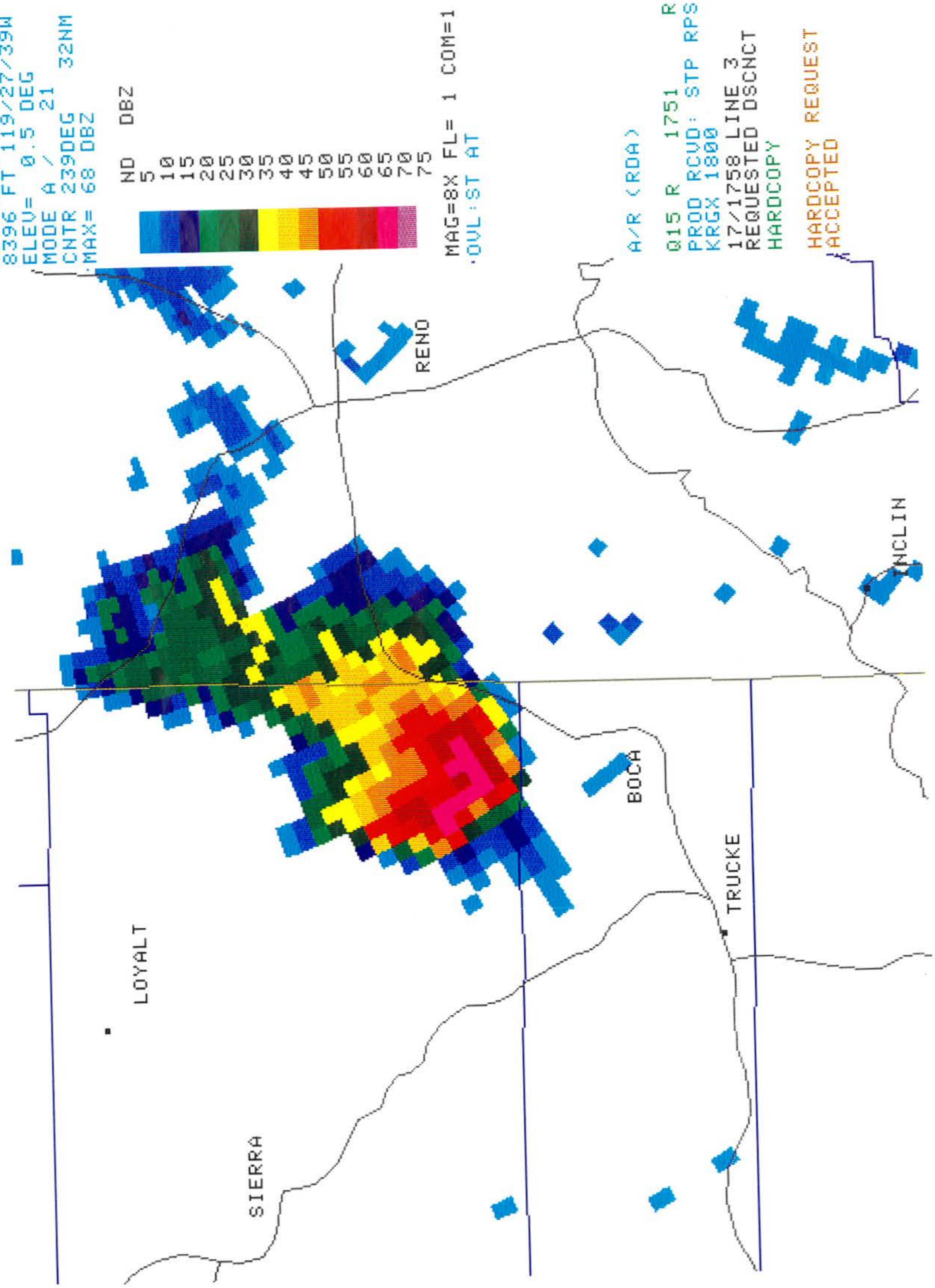
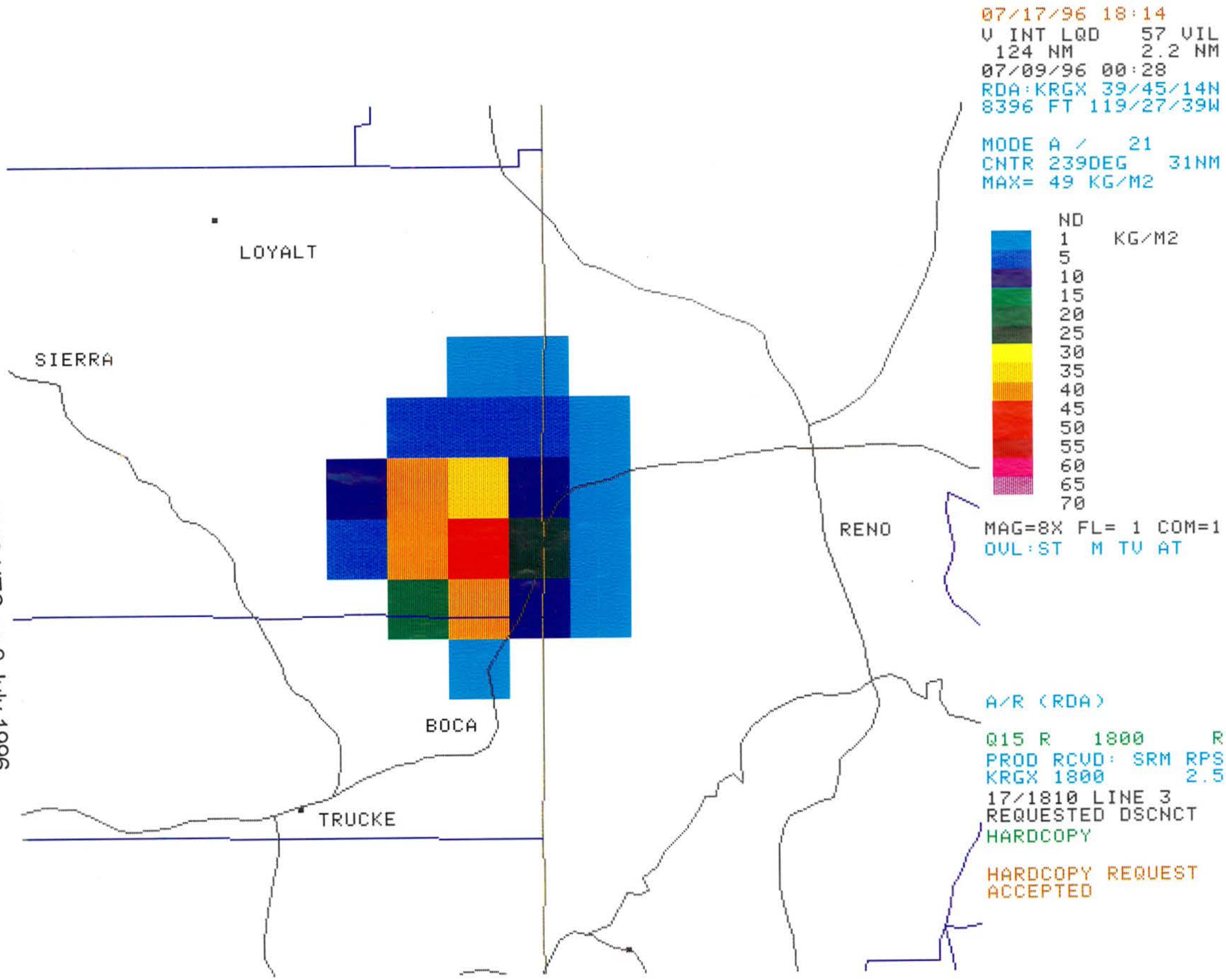
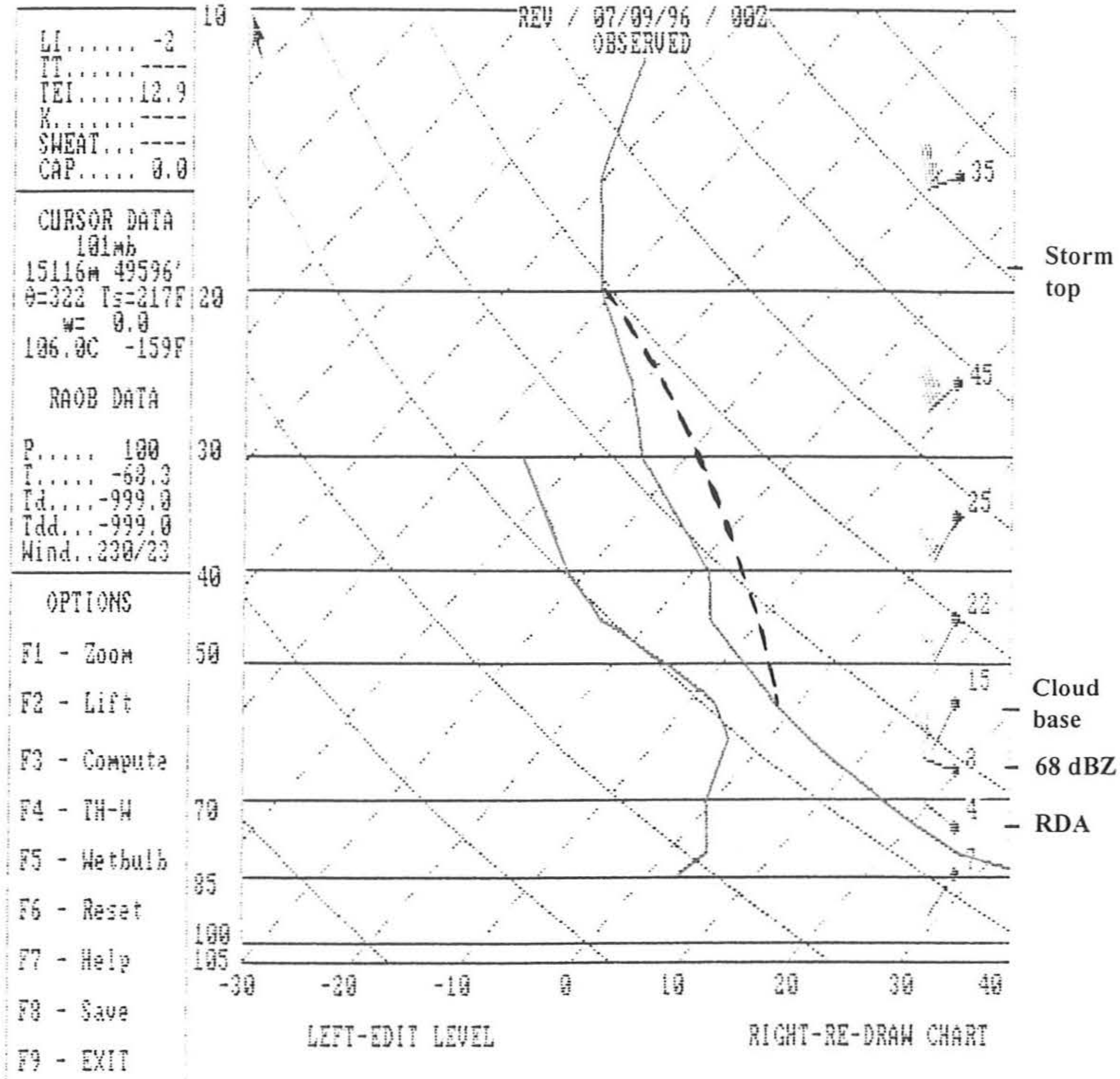


2. 0.5 degree sweep of base reflectivity at 0028 UTC on 9 July 1996 from the KRGX WSR-88D NE of Reno, Nevada. The center of the echo is ~ 30 nmi WSW of the radar site and ~15 nmi W of the Reno Weather Forecast Office.



3. Plot of vertically-integrated liquid (VIL) at 0028 UTC on 9 July 1996.



1. Sounding from the Reno, Nevada WFO taken at 00Z 9 July 1996. Heights above MSL of the radar site (RDA; 8396 ft MSL), 68 dBZ radar echo (10800 ft MSL) shown in Fig. 2, cloud base (12800 ft MSL), and storm top (40000 ft MSL) are indicated. The sounding release elevation is 4973 ft MSL. The moist-adiabatic parcel ascent is indicated by the heavy dashed line.