Monsoon Flow brings Golf Ball Hail and Damaging Winds to Greenview, CA July 23rd 2003: A Look at Microburst Potential Indices

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Severe thunderstorms developed over Siskiyou county of Northern California on the afternoon of July 23rd, 2003. Spotter reports and storm survey data from around the town of Greenview in the Scott Valley of western Siskiyou county revealed that dime to golf ball size hail occurred in addition to damaging outflow winds estimated at 80 mph. Large trees were blown down and/or snapped off and several barns were blown down. The event, which was not reported until the following day, was classified as a wet microburst.

The synoptic setting for the day showed broad high pressure centered over the Rockies with rather weak but moist south to southwest flow aloft over Northern California. There was also a weak vorticity lobe over Nevada that would be rotating through Northern California during the afternoon. The temperatures were quite warm; Medford, Oregon set a record high minimum of 69 degrees on this morning. (Fig. 1)

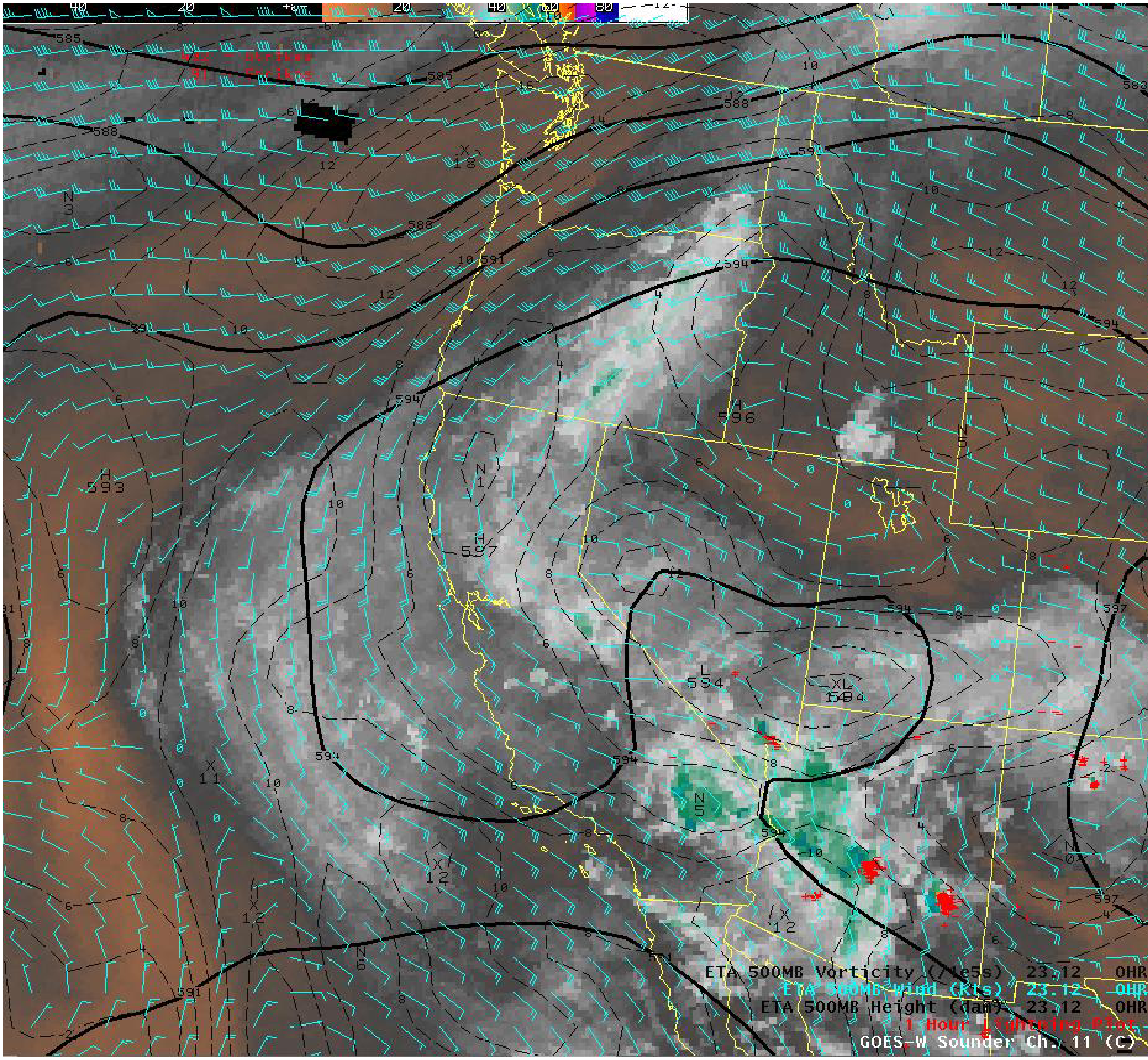

Figure 1. 12Z 23-Jul-03 Synoptic Setting

This pattern is representative of the "Summer Monsoon" for the west, showing precipitable water values well above normal with values between 1.0 to 1.4" rotating into Northern California around the 4-corners high. The normal July precipitable water value over Medford is .65". (Fig 2)

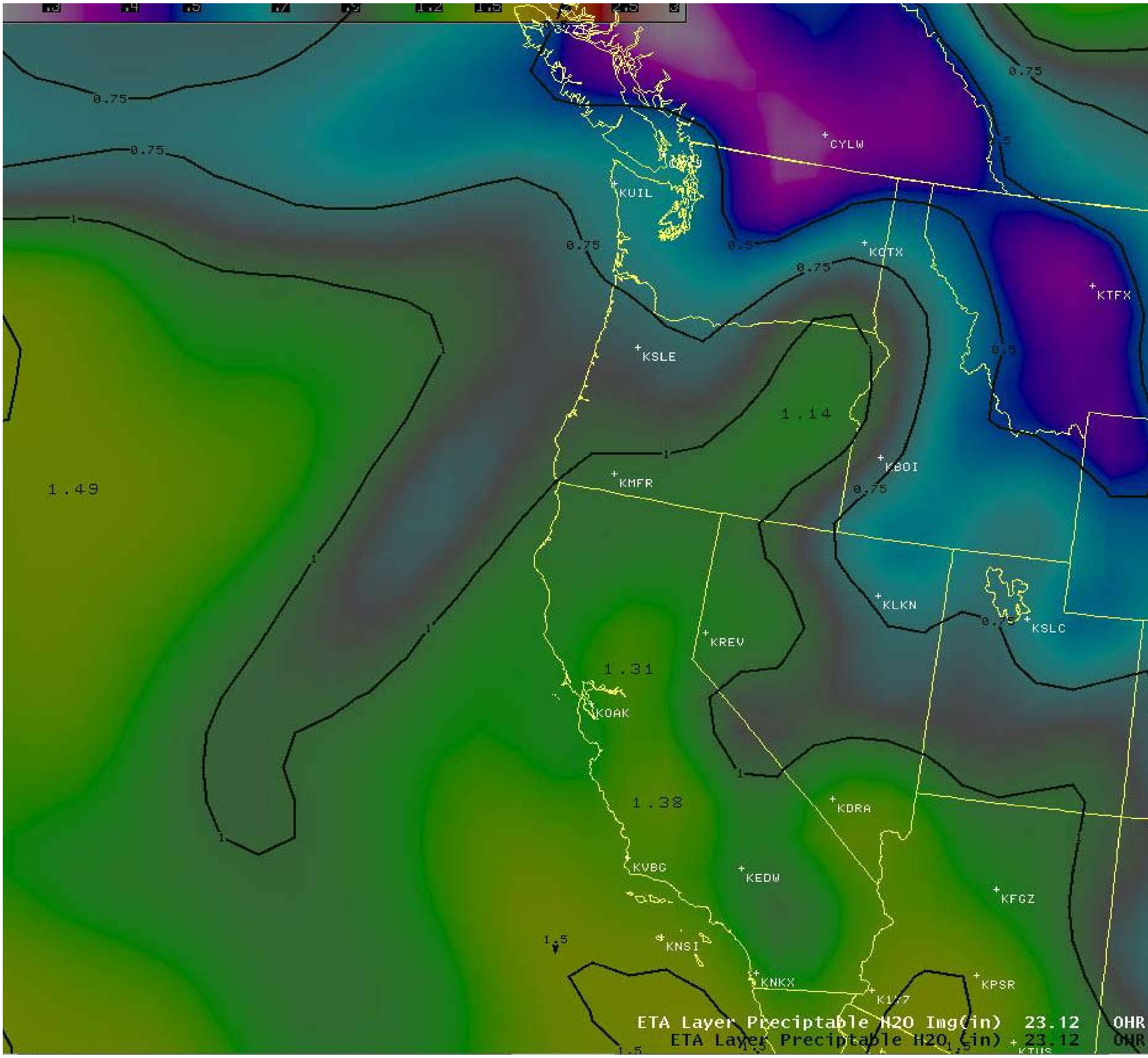

Figure 2. 12Z 23-Jul-03 Eta-Analyzed Precipitable Water

The pre-storm environment was warm, moist and unstable. The 12z Medford sounding showed precipitable water of 1.34 inches and a lifted index of -1.4 (with forecast high of 101). The CIN would remain high however, and the atmosphere in the region around Medford, north of the Siskiyou Mountains, would remain capped. (Figs. 3 & 4)

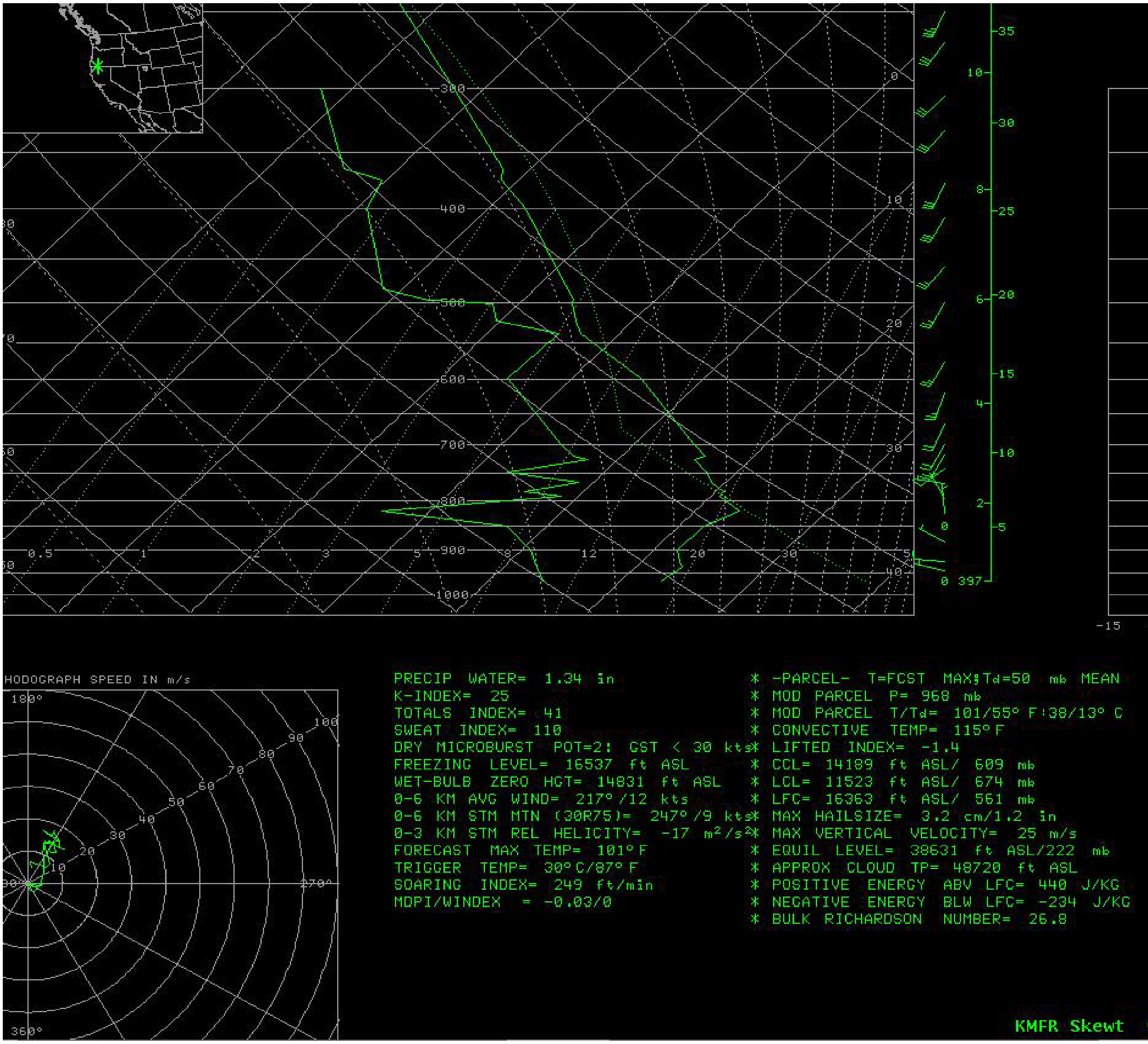

Figure 3. 12z 23-Jul-03 KMFR Observed Sounding

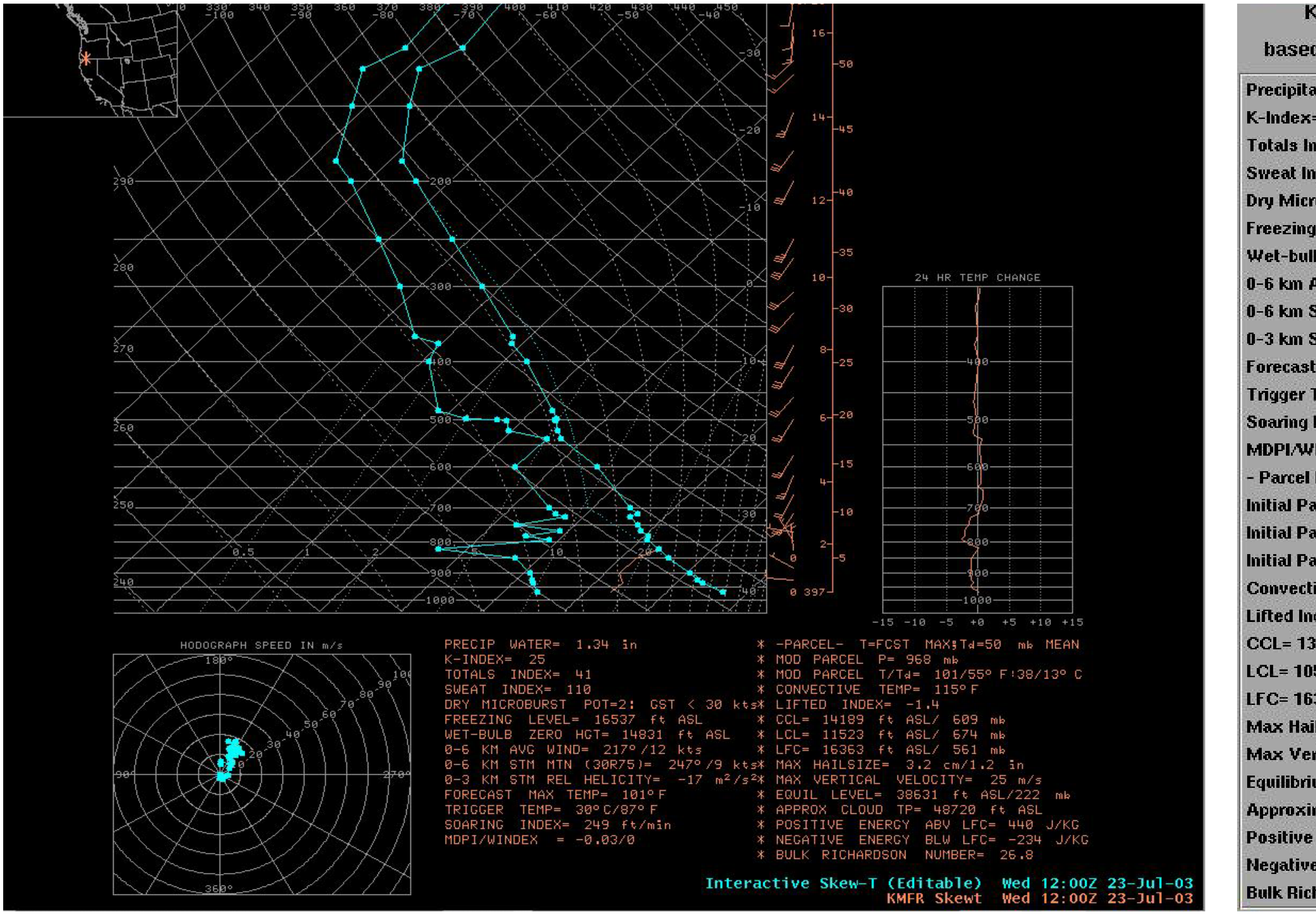

Figure 4. 12Z 23-Jul-03 KMFR Modified Sounding

Further south the air mass over Northern California would be less capped and more influenced by the Nevada short wave. The Eta forecast sounding over Montague, CA (SIY) had a forecast afternoon cape of 1500 J/kg, precipitable water of 1.29 inches, and a wet bulb zero height and freezing level over 15000'. Surface dewpoints were forecast in the middle to upper 50s, and vertical wind shear was marginal. Considering this data, forecasters would likely be expecting strong thunderstorms with the potential for heavy rain and hail. (Fig 5)

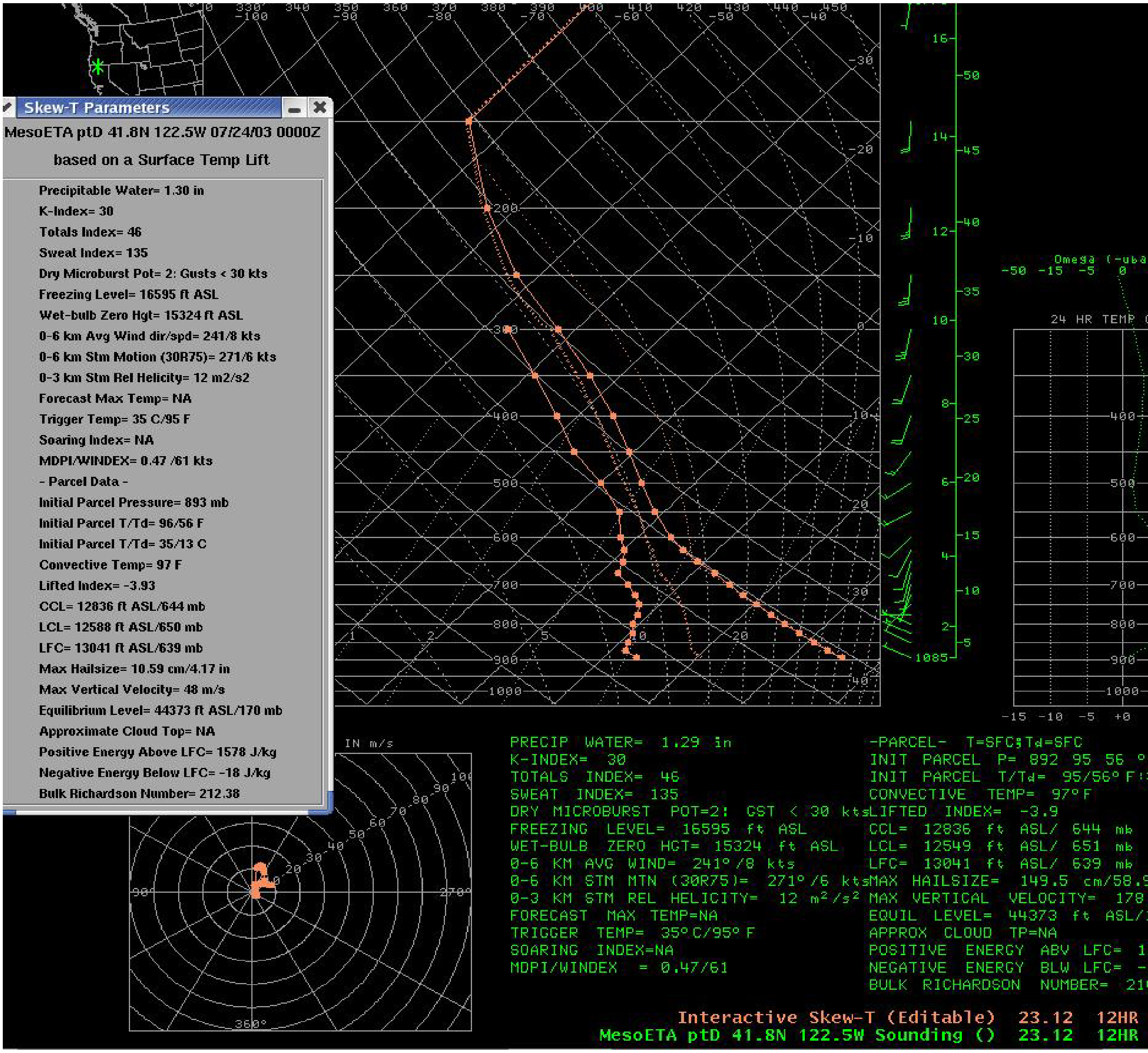

Figure 5. 12z 23-Jul-03 12-hr Eta Forecast Sounding for Montague, CA (SIY)

The Eta's 12-hr forecast sounding in figure 5 over Montague, CA verified nicely; the 00z observed T/Td at Montague was 95/57. The afternoon high there however was 102. The convective temperature was forecast at 97, and storms developed early over the higher terrain of Siskiyou County and intensified as the afternoon progressed with the arrival of the short wave.

Between 4 and 5 pm local time, storms had intensified and VIL values between 50 and 60 Kg/m2 were common along with maximum reflectivity values of 60 to 65 dBZ. Movement was with the general flow, north to northeast at 10 mph or less. A severe thunderstorm warning was issued at 2322z for Siskiyou and Modoc counties for a strong cell in the cluster over eastern Siskiyou county. Greenview is located along highway 3 between Ft. Jones and Etna. (Fig. 6)

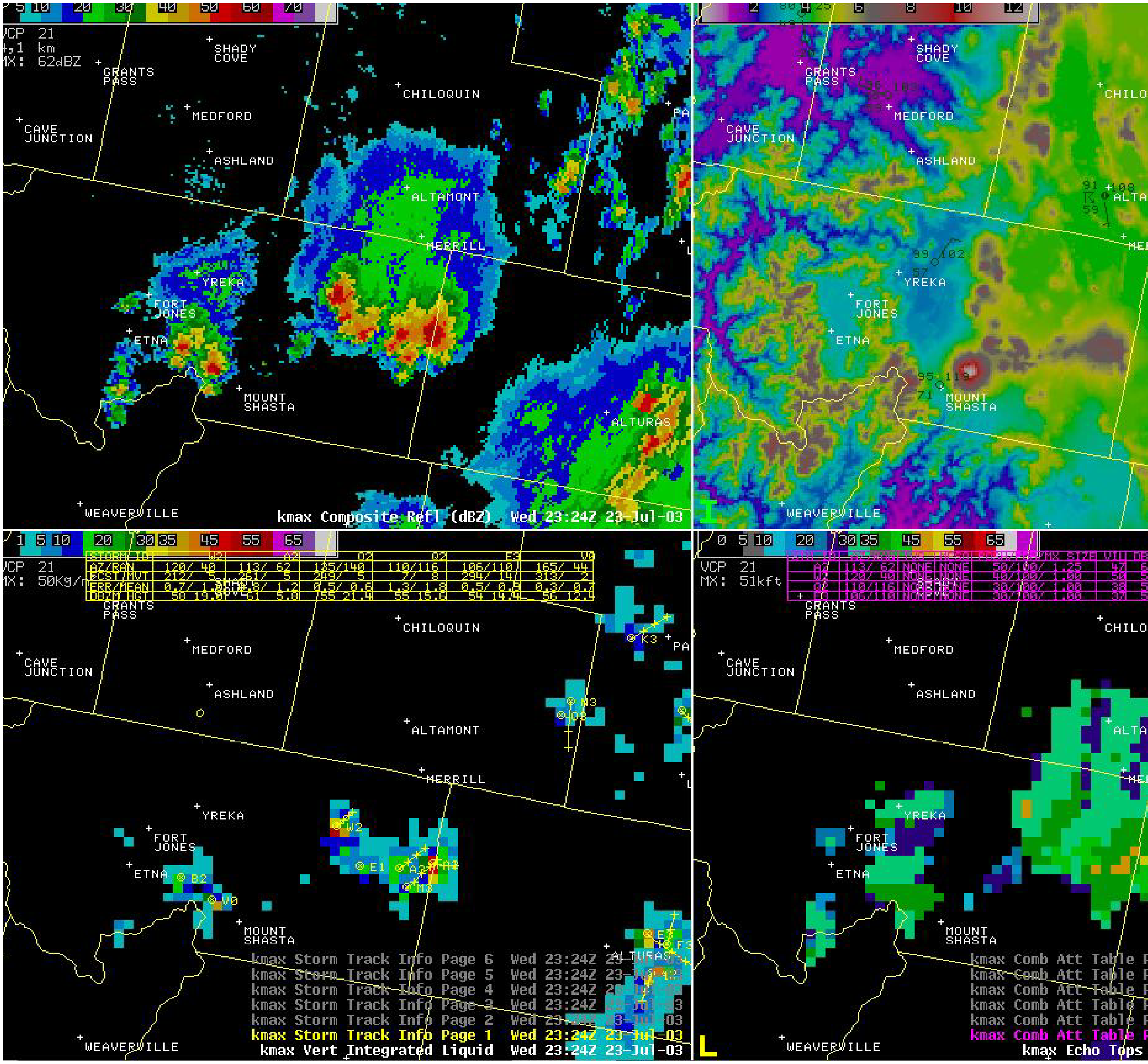

Figure 6. Radar 2324z 23Jul04. From upper left clockwise, Composite

Reflectivity, Topography/Metars, Vil/Storm track, Echo Tops/Combined Attribute Table.

The thunderstorms intensified between 00z and 01z with strong storms located over the Trinity Alps west of Mt. Shasta, the Scott Bar Mountains around Etna and Ft. Jones, and over the higher terrain of the Shasta National Forest east of Mount Shasta. Another severe thunderstorm warning was issued at 0034z for the cell 7 miles west of Mt. Shasta, citing possible very large hail and heavy rain with the potential for flooding in low lying areas. Notice from the hail index at 0029Z that the storm Z4 south of Fort Jones (over Greenview which is not on the map) showed a 100% probability of severe hail, while also showing a Vil of 56 and a max dBZ of 66. This was the strongest cell in the area at the time. (Fig. 7)

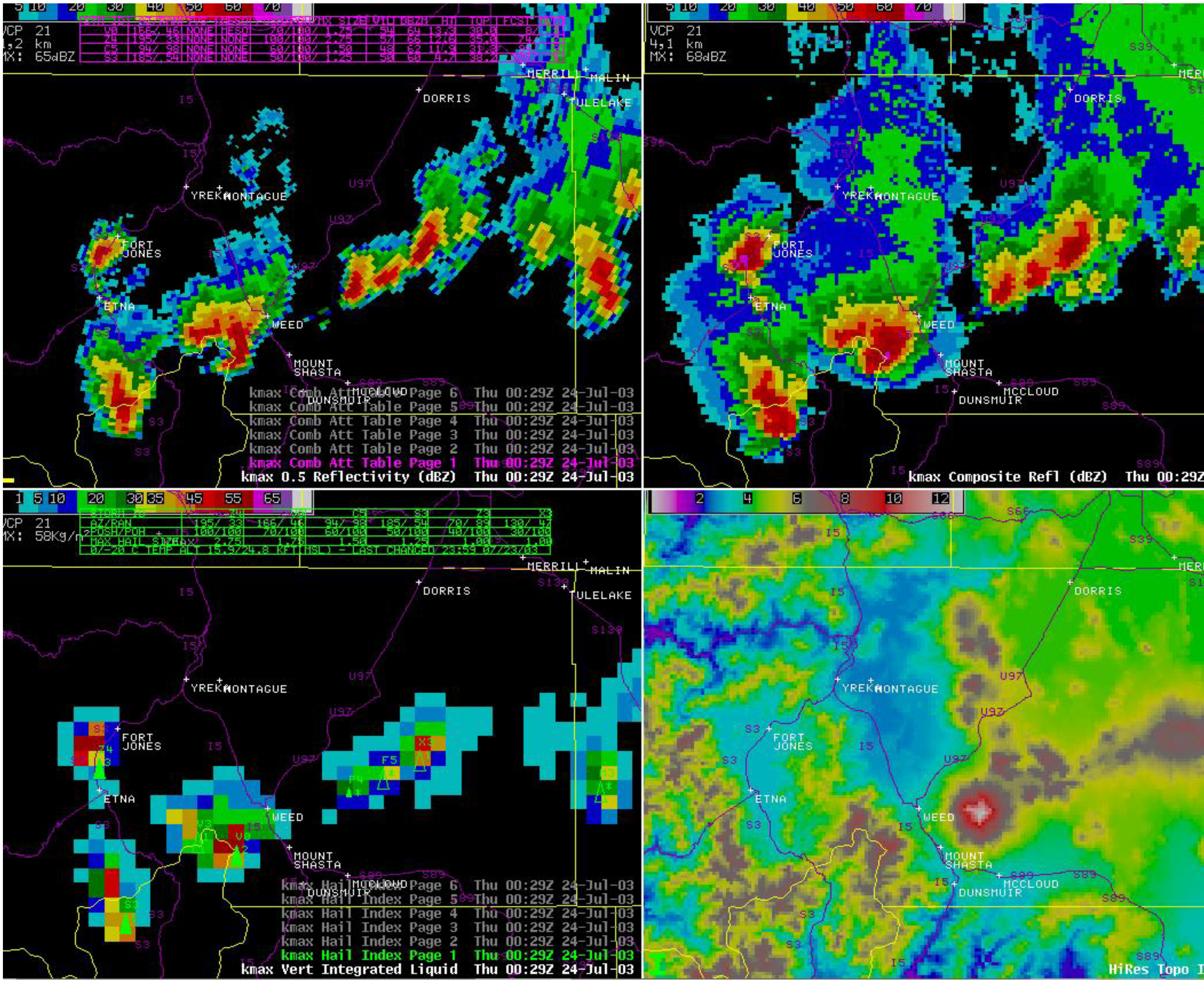

Figure 7. Radar 0029z 24Jul04. From upper left clockwise, 0.5 Degree Reflectivity/Combined Attribute Table, Composite Reflectivity, Vil/Hail Index, Topography

Shortly thereafter, (~6 pm local time) the Greenview damage began to occur.rea was still under a Severe Thunderstorm Warning through the course of the microburst. The vertical profile of velocity data failed to reveal anything striking in terms of mid level radial convergence. In addition, the KMAX WSR-88D is located at 7400 ft on top of Mt. Ashland, and the lowest beam slice rarely detects appreciable thunderstorm outflow wind velocities. In this case, the center of the lowest beam slice is centered at 7000 feet above Greenview. There was however a weak velocity couplet showing low-level divergence near the downburst area. (Fig. 8)

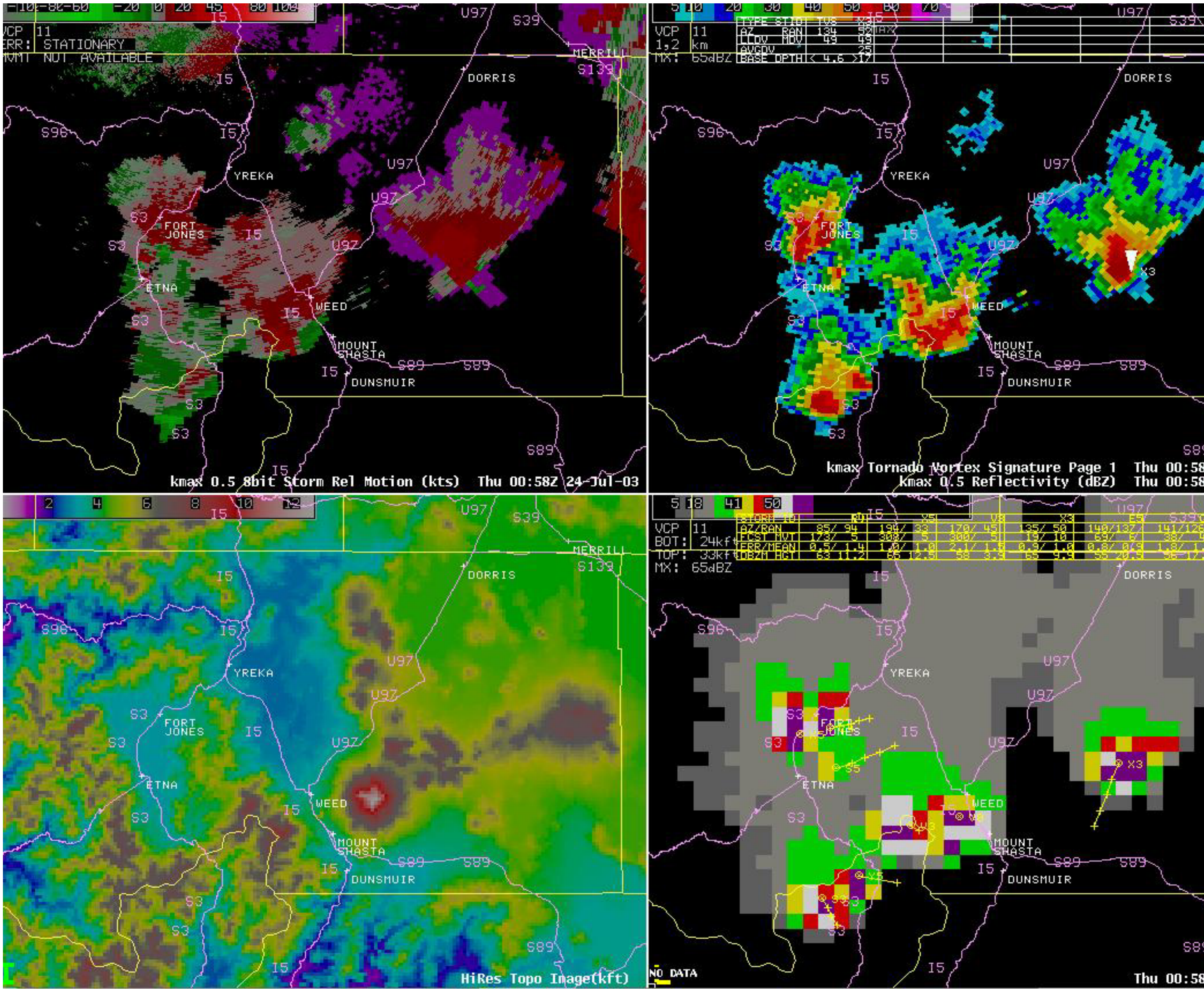

Figure 8. Radar 0058z 24Jul04. From upper left clockwise, 0.5 Degree Velocity, 0.5 Reflectivity, Topography, Vil

The mid-level reflectivity characteristics were quite revealing of the storm's storm collapse prior to the microburst. The maximum reflectivity at the 4.3 slice at 0029z was 67.5 dBZ, and the ensuing reflectivity pattern (clockwise with time) shows the storm dividing as the microburst developed. The home location is Greenview. (Figure 9)

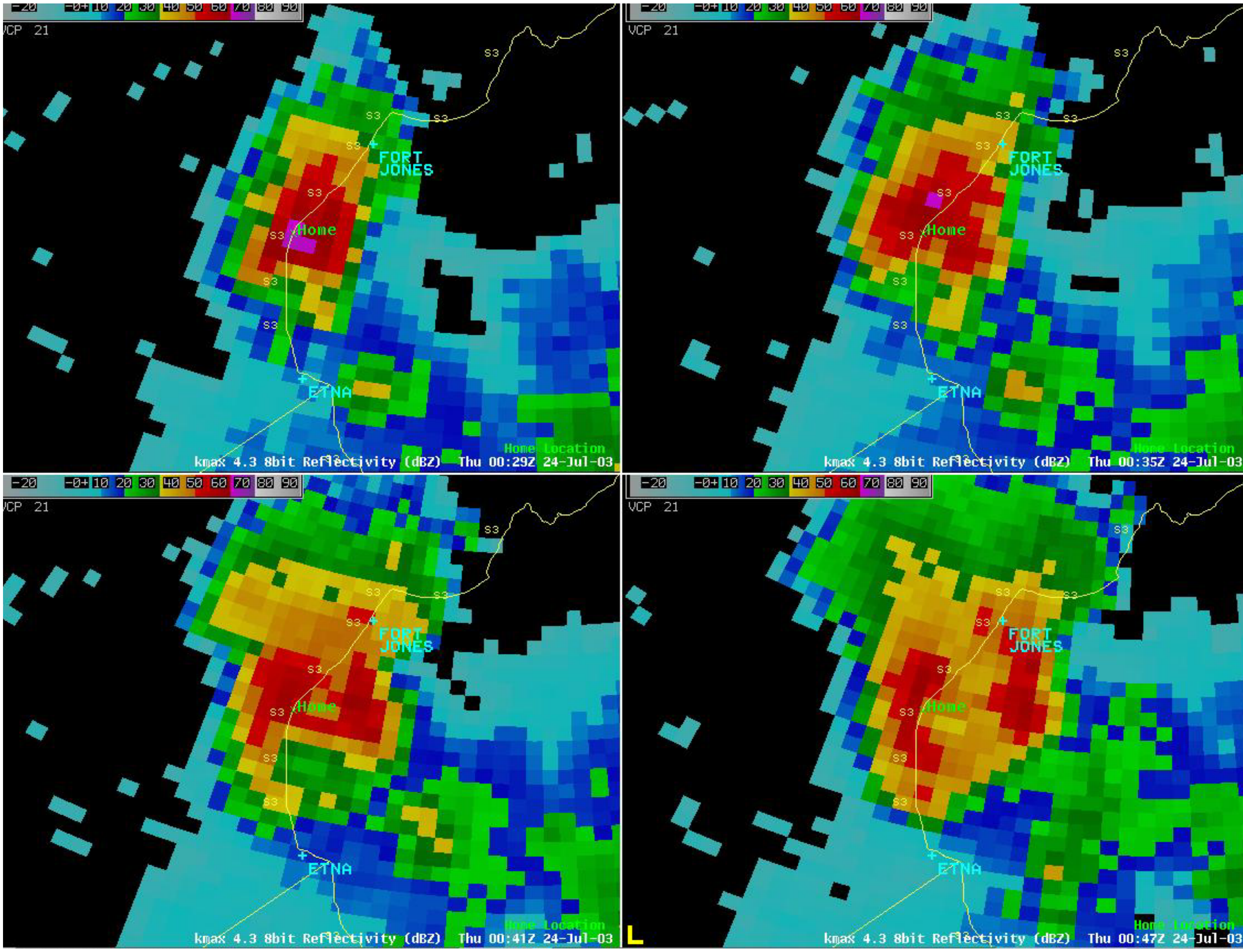

Figure 9. Radar 4-panel 0029z through 0047z depicting the storm's collapse prior to damage occurrence.

The storm survey revealed that the golf ball hail and severe winds occurred with the storm "around 6pm" local time (01Z). In the hour that followed there were no significant radar velocity signatures to be found to indicate the occurrence of damaging outflow winds. It is, however, a local rule of thumb that storms exceeding 65dBZ and vils of 40-50 should send up red flags for possible large hail. These criteria are more geared toward non-monsoon environments however, and during the monsoon, much higher vils and reflectivities can be common without producing severe hail.

One note about the archived radar data is that through the majority of this event, the KMAX 88D was in VCP21. Much better sampling would have occurred with VCP11, and in the present day with VCP12 or 121. The available velocity data were analyzed for a Mid-Altitude Radial Convergence Signature (MARC), but no significant features were discovered. The MARC is documented at http://www.crh.noaa.gov/lsx/science/marc.htm by Schmocker and Przybylinski, and is a radar-based precursor to the onset of damaging straight-line winds from a linear MCS or bow echo. Obviously, since these were pulse-type storms, MARC comparison is not ideally applicable here, but the mid level data were analyzed for convergence signatures nonetheless and nothing outstanding was discovered.

One tool forecasters may consider using in the future to gain insight to potential strong outflow winds in high-cape monsoon environments is the MDPI, the Microburst Day Potential Index (Roeder and Wheeler, 1998-1999, http://www.wdtb.noaa.gov/workshop/psdp/Roeder/index.htm), which uses vertical profiles of equivalent potential temperature to help predict a likelihood of downbursts of greater than 30kts. The MDPI should not be confused with the DMPI (Dry Microburst Potential Index), the latter of which can be found on NESDIS' Experimental GOES Microburst Products page. Please reference URL http://www.orbit.nesdis.noaa.gov/smcd/opdb/aviation/mb.html for examples of each. Note however, the MDPI is linked as "theta-e deficit" and currently available only over the Central and Eastern states, and Hawaii.

$$MDPI = [\text{Max } \theta e \text{ (Sfc – 850 mb)} – \text{Min } \theta e \text{ (660 - < 500 mb)}] / 30K$$

The 1st term in the numerator represents the warm moist low-level air, and the second term represents the dry cool mid level air. The denominator is a local tuning constant. The greater the difference between these two values, the greater the effect that the cooler and drier mid level air will have on a developing microburst. The study suggests when the MDPI is greater than or equal to one, microbursts are considered likely. Analyzing the Eta's forecast profile in figure 5, the MDPI for this day over Northern California would have reached 1 when the local tuning constant was set at 16. This may be useful for future consideration.

00Z SIY Forecast: MDPI = (353K – 337K)/ 16 = 1

Another tool forecasters may experiment with is a new algorithm being developed called the WMSI, Wet Microburst Severity Index (Pryor and Ellrod, 2003, http://www.orbit.nesdis.noaa.gov/smcd/opdb/kpryor/mburst/wmsipaper/wmsi).
An example of GOES-derived WMSI can be found at
http://www.orbit.nesdis.noaa.gov/smcd/opdb/kpryor/mburst/wmsipage.html
There are plans to add GOES-derived WMSI for the west in the future.

WMSI = (θe max – θe min) (CAPE) / 1000, where the max is the max theta-e at the surface and the min is the min theta-e in the mid levels.

WMSI	**Wind Gusts (kt)**
< 10	Convection/Microbursts Unlikely
10 – 49	< 35
50 – 79	35 – 49
> 80	> 50

The 00Z SIY Forecast WMSI:

(353K-337K)(1578 J/kg)/1000 = 25

This would have suggested gusts less than 35 kts. Although the index did not reveal the magnitude of the winds around Greenview, 3 RAWS stations from Siskiyou County captured thunderstorm gusts between 30 and 35 mph on this afternoon. Other than from around Greenview, no other high winds were reported in Northern California this day.

In conclusion, no radar velocity signatures were discovered that would have lent confidence to the onset of damaging winds near Greenview. However, forecasters should be aware that in a high cape/monsoon flow environment, high water loading and hail melt in pulse storms may contribute to wet microburst development during a storm's collapse. The onset of collapse can be monitored by watching the mid level decent of high reflectivity. Subjectively, the high dBZ, VIL and POSH values, and subsequent collapse signatures with the Greenview storm may have suggested it was candidate for the severe outflow.

Though the calculated MDPI and WSMI indices over Northern California did not suggest that severe outflow was likely, the storm environment may not have been ideal in order for the indices to perform well. It is suggested that forecasters consider investigating and using the MDPI and WMSI indices, both which utilize vertical profiles of theta-e, to help predict wet microburst environments. GOES-10 satellite-derived WMSI and DMPI are currently being produced experimentally and are available for some of the central and eastern states, and according to recent correspondence with NESDIS, will be available in the future for the west.

Lastly, in order to acquire the best resolution radar data available, forecasters should ensure that the radar is placed in VCP11, 12 or 121 during strong convective events. Higher resolution data will produce better algorithms, and may have provided additional velocity precursors and aid in storm and post-storm investigation.