A Close Examination of the 01 and 02 August 2009 Severe Convective Events Across the Medford CWA

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Introduction

Severe thunderstorms are a rare event for the western United States, particularly for the Pacific Northwest. More often the needed parameters for organized strong convection such as buoyancy and shear are not collocated or are missing. This paper will examine the synoptic and mesoscale features to look closer at a weekend in which large hail and severe wind events were reported. There were 10 hail events and 3 wind events reported on 01 August 2009 and 4 hail events and 5 wind events on 02 August 2009 across the Medford CWA (SPC, 2009). The large golf ball size hail that fell on 01 August 2009 distinguishes this event as a rare event when compared to other weaker convective events across the Pacific Northwest.

Synoptic Setup for 01 August 2009

A large 500 hPa upper level low was located off the western United States (see Figure 1). This is recognized as a classic synoptic scale setup for convection for the Medford CWA as moisture advection from lower latitudes occurs on the east side of the upper level low. The 12Z 01 August 2009 KMFR sounding (Figure 2) depicted this moisture advection quite well with southeast to south winds from 800 hPa all the way up to the upper levels of the atmosphere. The precipitable water value was 1.28 inches, which was 99 percent above normal for this time of year. It is important to know that the 12Z 01 August 2009 KMFR sounding showed 2855 J/kg of Convective Available Potential Energy (CAPE) using a modified parcel with a temperature of 95°F and a dewpoint of 61°F. This dewpoint was too high as actual observed dewpoints in the afternoon and evening were around 50°F leading to 1200 J/kg of CAPE noted on the 00Z 02 August 2009 KMFR sounding (Figure 3). The 00Z 02 August 2009 KMFR sounding captured the pre-convective environment very well as the balloon was launched at 23Z and the thunderstorms rolled in the Medford city limits around 02Z that evening. From the 00Z sounding, the Bulk Richardson Number was 27.6, which indicated that organized severe weather was a distinct possibility. The Lifted Index was -3.5°C. In addition, the 35 to 40 0-6 km bulk shear estimated from the 00Z sounding verified the 12Z 01 August 2009 GFS forecast well, which will be discussed in the forecast section.

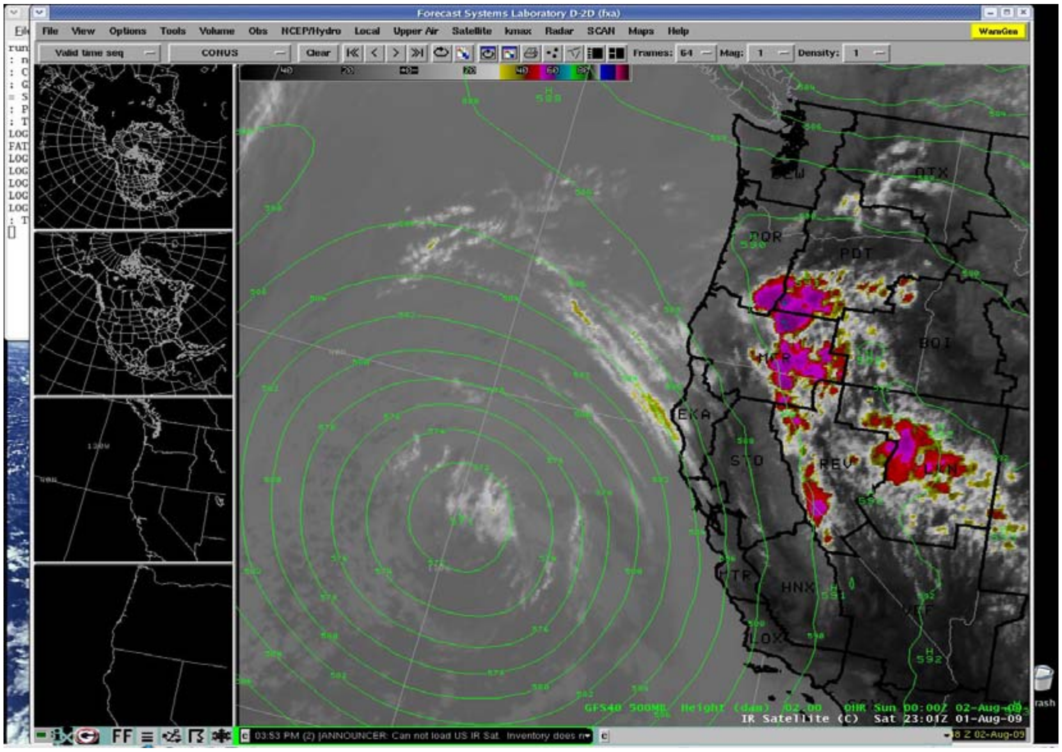

Figure 1. Synoptic setup for 01 August 2009 (500 hPa heights, satellite IR).

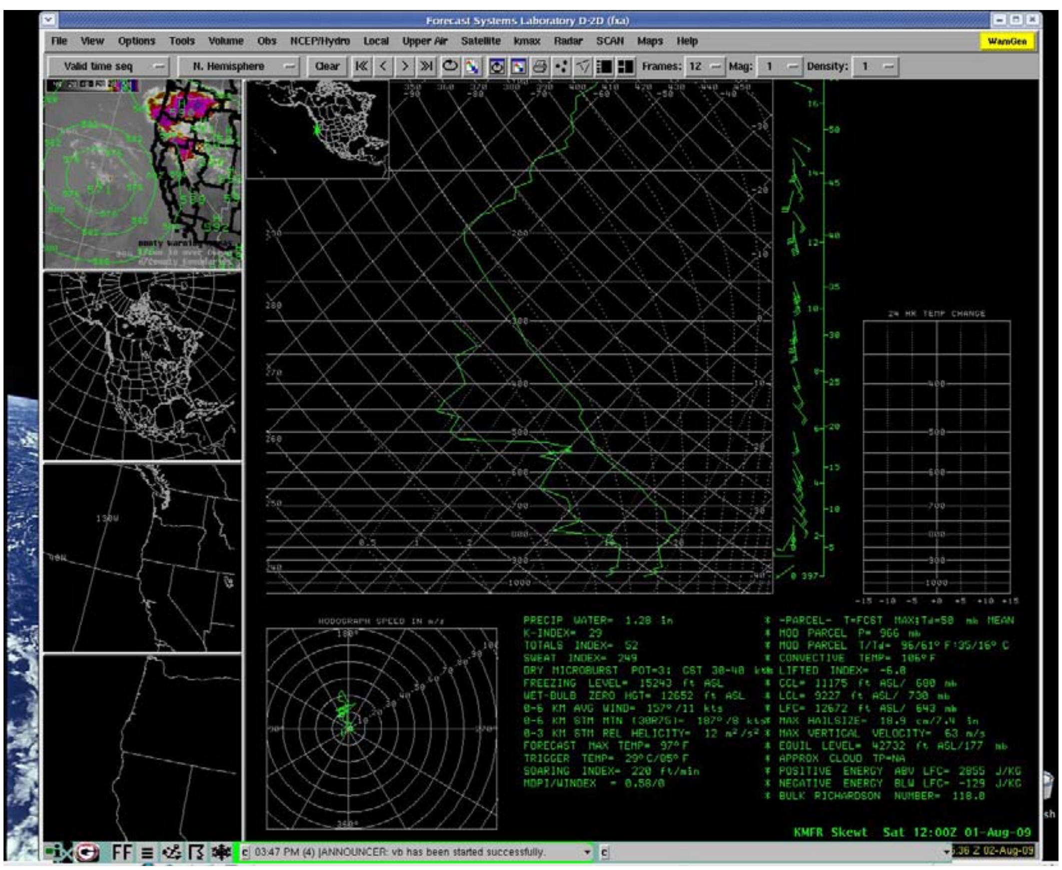

Figure 2. 12Z 01 August 2009 KMFR sounding.

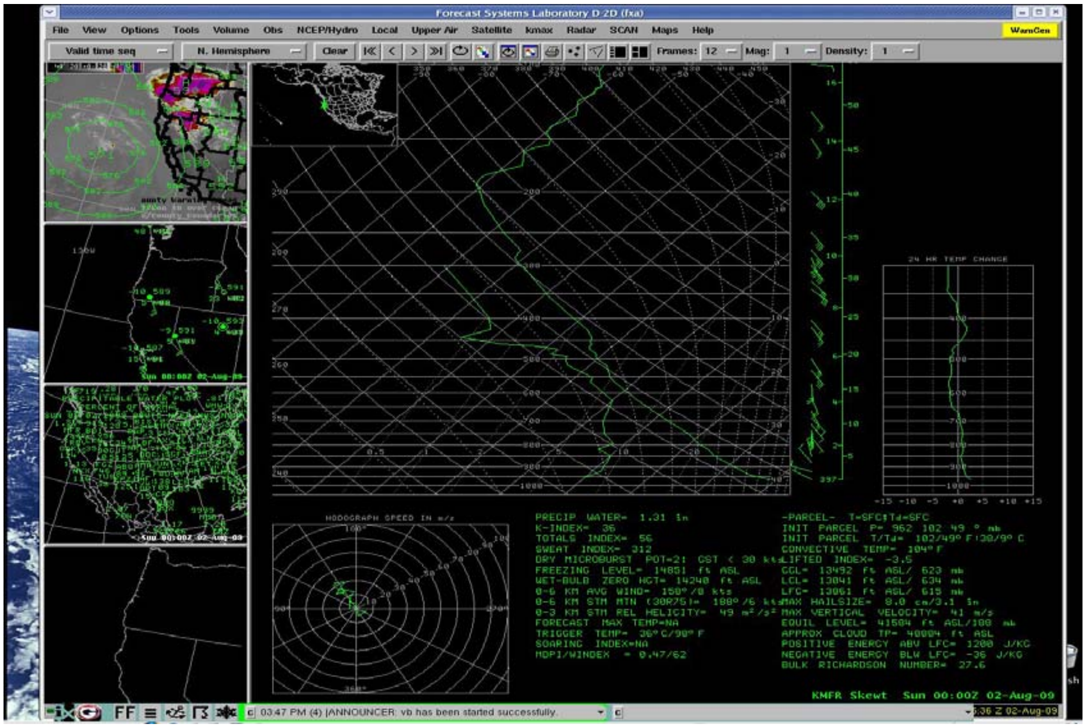

Figure 3. 00Z 02 August 2009 KMFR sounding.

At the surface, temperatures were quite hot that day with many sites at or above 90°F.At KMFR - the area of interest for the day - the temperature was 102°F at 23Z 01 August 2009, which was near the convective temperature of 104°F. Convection finally initiated off the higher terrain during the afternoon (Figure 4).

Mesoscale Setup for 01 August 2009

The west coast of the United States is very different from the central United States in regards to terrain and mesoscale features. The west coast does not experience drylines or sharp temperature and pressure gradients along a particular frontal boundary like the central United States experiences. The main mesoscale forcing for this event was terrain and differential heating. Figure 5 shows a topographical view of the Medford CWA. Notice the "V" shaped Rogue Valley were KMFR is located. The terrain surrounding the Rogue Valley helped to initiate convection and then channel the low level flow. This flow along with 35 to 40 knot 0-6 km GFS forecast bulk shear lead to dynamically induced splitting storms (Bunkers et al., 2000), which will be discussed later.

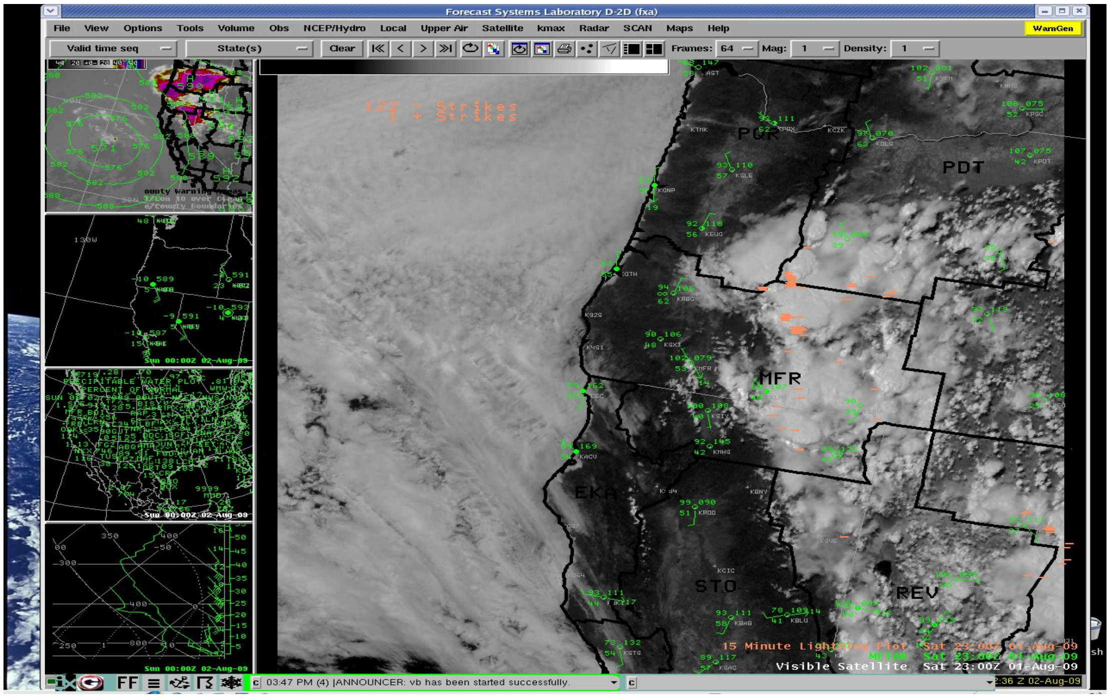

Figure 4. Convection initiated off the higher terrain (15 minute lightning, surface observations, visible satellite imagery).

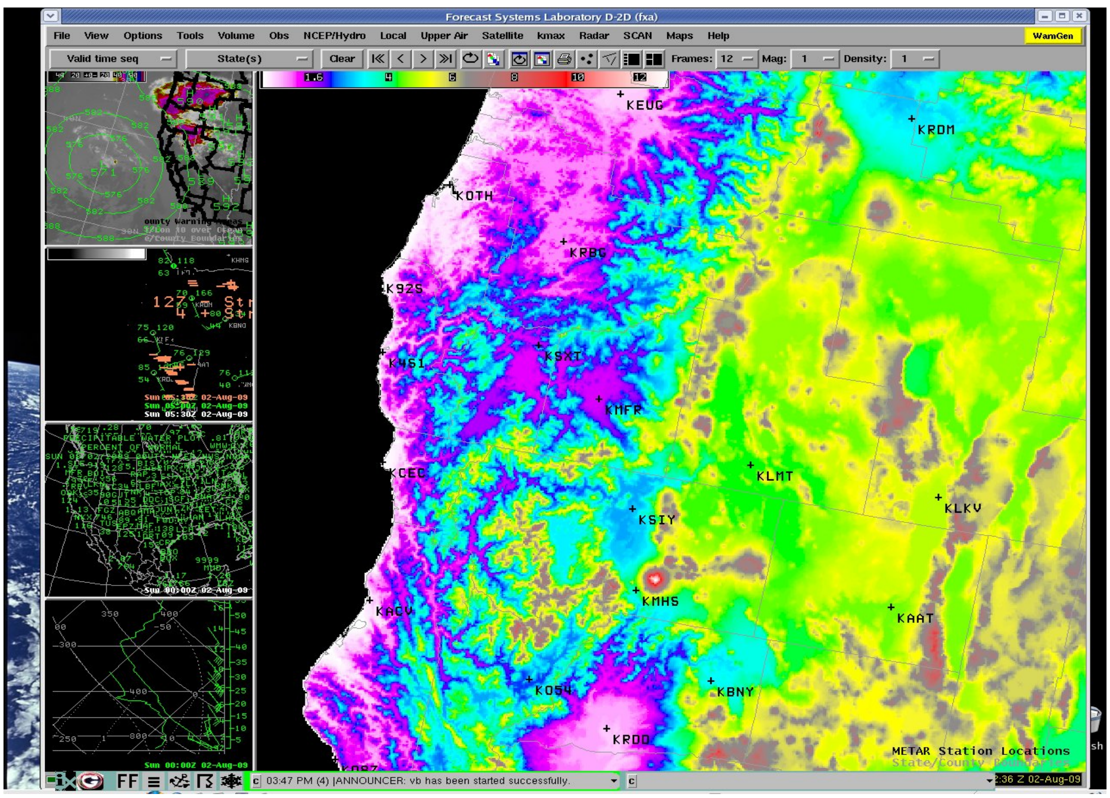

Figure 5. Topographical view of the Medford CWA.

Forecasts for 01 August 2009

The numerical weather prediction models (NWP) did a good job in the few days prior to the event at depicting the ingredients that would lead to a convective event. The 12Z 01 August 2009 GFS run (Figure 6) showed that KMFR was just on the outer band of a 35 to 40 knot 0-6 km bulk shear zone with about 1300 J/kg of CAPE forecast at 00Z 02 August 2009. The 12Z 01 August 2009 NAM run was similar to the GFS in terms of the 0-6 km bulk shear; however, this model will not be discussed in this paper as the NAM model had boundary layer moisture problems, which interfered with a realistic CAPE calculation. In this case, the 12Z NAM depicted 3000+ J/kg of CAPE at 00Z 02 August 2009, which was very unrealistic, given the observed surface dewpoints near 50°F during the main event and the 1200 J/kg CAPE observed from the 00Z 02 August 2009 KMFR sounding.

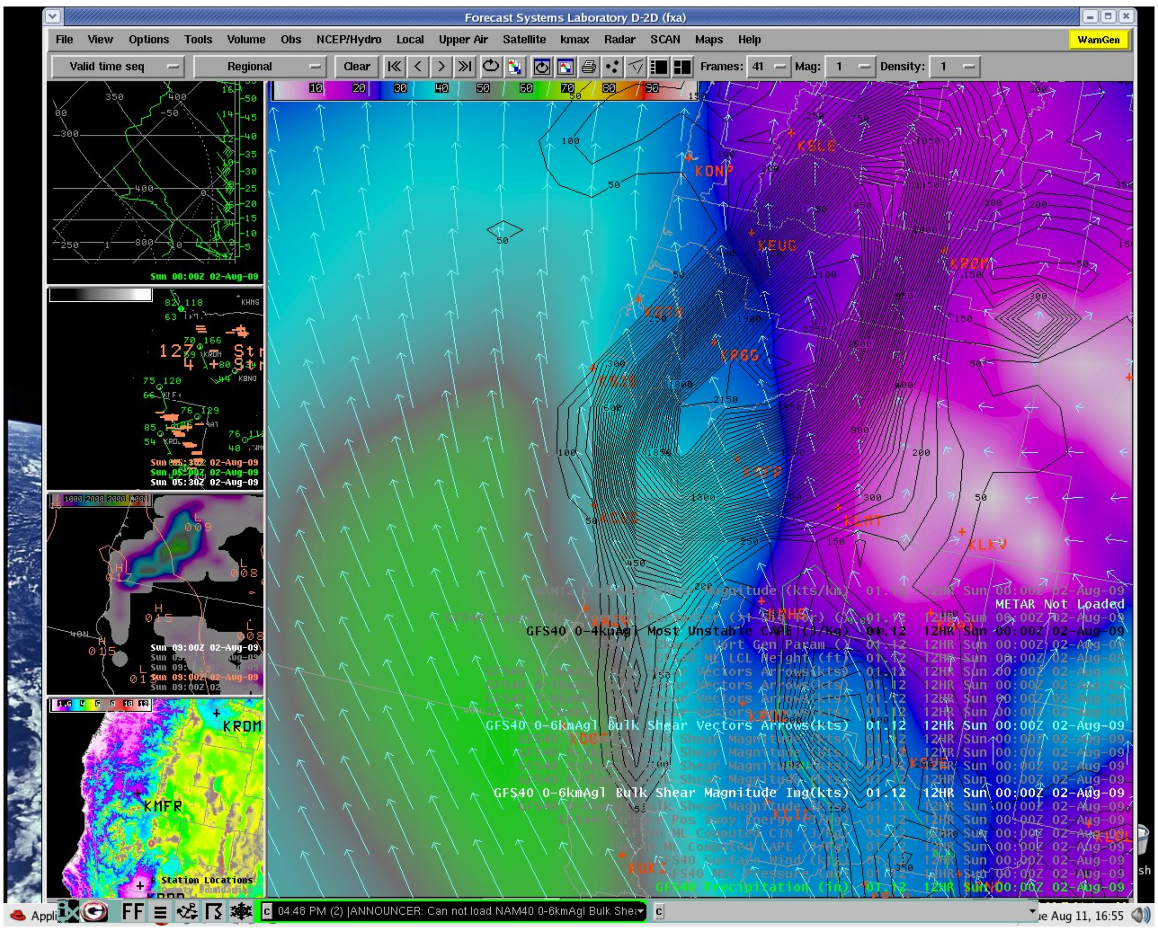

Figure 6. 12Z 01 August 2009 GFS (0-6 km bulk shear vectors, 0-6 km bulk shear image, black contoured MUCAPE, green contoured 6h surface precipitation).

Radar Imagery for 01 August 2009

Before radar imagery is presented, it is important to note that the best VCP for this convective event was not used. The VCP was left in 21, which is not the best option for a rapidly changing convective event. The most ideal VCP would have been VCP 11 or VCP 12, which are designed and configured for rapidly evolving convective situations. VCP 21 is designed for non-severe convective precipitation and has longer update times per volume scan than compared with VCP 11 or VCP 12. The VCP 21 choice selection was simply a situational awareness error during a busy situation for forecasters. In addition, with VCP 21, there were missing lower elevation scans; however, this paper can still convey the main point of the radar imagery despite the missing low elevation scans (note: FSI could not be used due to the large low elevation gaps in radar imagery, so plan views are presented instead). To clarify storm organization types for the day, two events will be examined - the hail producing storm over Eagle Point, Oregon and a splitting storm over the southern Rogue Valley.

Hail Producing Storm over Eagle Point, Oregon

A severe thunderstorm moved over Eagle Point, Oregon around 0230Z 02 August 2009 that produced golf ball size hail. This storm was selected because it had significant impacts to the populated centers of Central Point, Medford, White City, and Eagle Point (Mailtribune, 2009). Figure 7 shows the 0.5° KMAX reflectivity scan at its most severe intensity (75 dBZ). A Three Body Scatter Spike (TBSS) can be seen down radial from Eagle Point towards Shady Cove. This feature did have consistency in higher elevation reflectivity scans. A golf ball size hail report came into the WFO about the time of this radar image which indicated that this storm was severe.

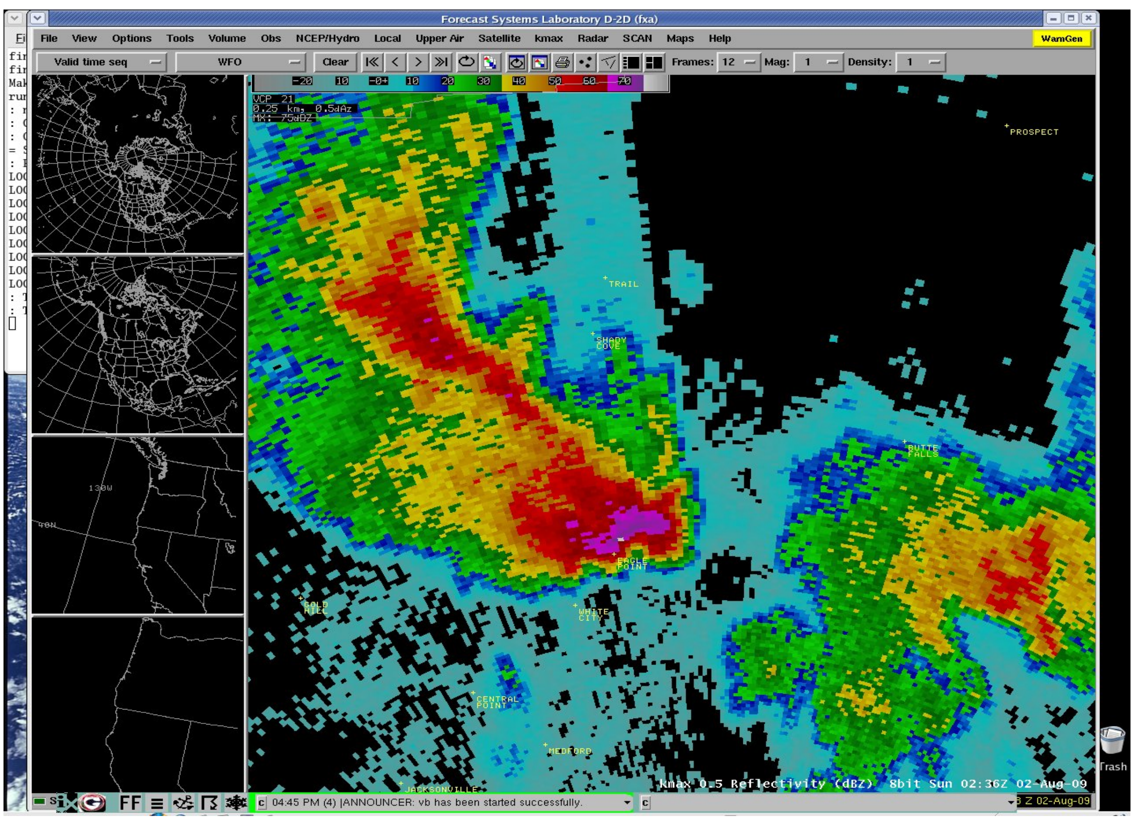

Figure 7. 0236Z 02 August 2009 0.5° KMAX reflectivity.

Figure 8 is a four panel display of the severe storm near Eagle Point, Oregon with elevation cuts of 0.5°, 1.5°, 3.4°, and 9.9°. One can see the notch in the reflectivity which indicated storm structure. This notch feature did have consistency in the higher elevation scans; however, did not completely resemble a Weak Echo Region (WER) or Bounded Weak Echo Region (BWER) typically seen in a classic supercell. It was also interesting to note the reflectivity of at least 40 dBZ on the 9.9° scan. This was about 33,000 feet agl (the radar location is about 7,500 feet agl). This level was about -38°C based on the morning 12Z 01 August 2009 sounding, which certainly passes the -10°C to -30°C hail growth zone rule of thumb. Positive energy was also observed in this zone from examining the 00Z sounding, further supporting the environment that was conducive for severe hail development.

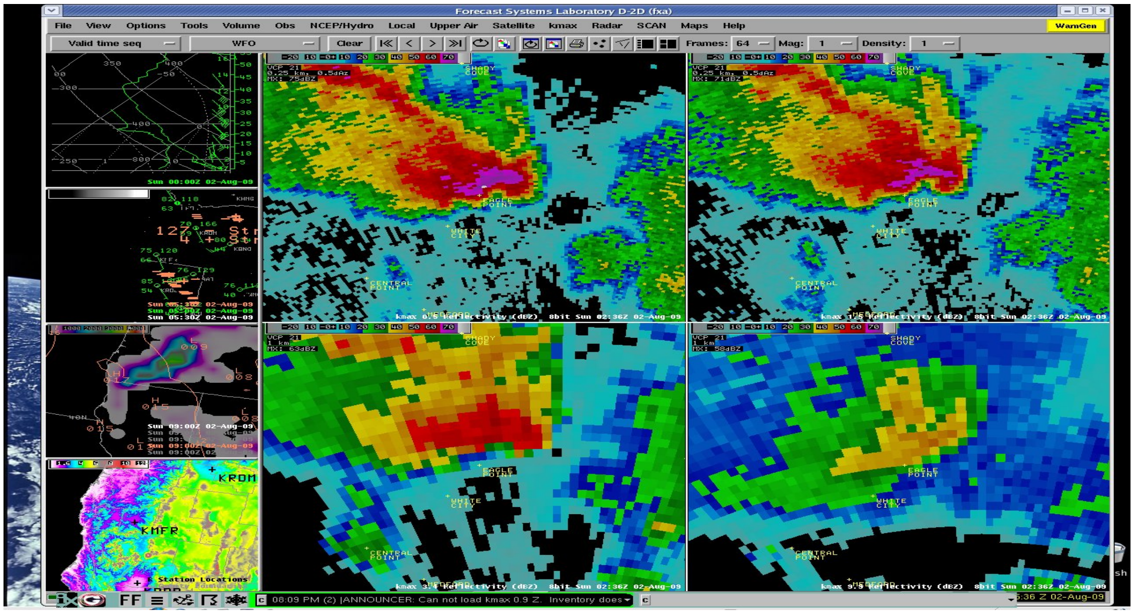

Figure 8. 0236Z 02 August 2009 0.5°, 1.5°, 3.4°, 9.9° KMAX reflectivity.

Figure 9 is the same as Figure 8 but with base velocities instead of reflectivity. There was no apparent rotation with this storm although it did display storm top divergence in the higher elevation scans, which indicated a healthy updraft. Storm relative velocities are not presented as there were no significant items noted in the imagery.

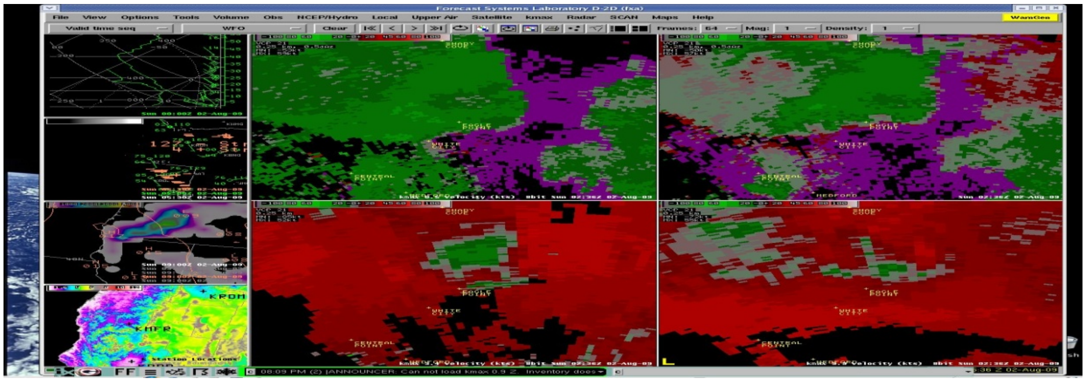

Figure 9. 0236Z 02 August 2009 0.5°, 1.5°, 3.4°, 9.9° KMAX velocities.

Figure 10 is the Hail Index and VIL Density derived radar products. Notice that the VIL Density was around 6.4 g/m³. The threshold of 4.0 g/m³ was found to be associated with severe hail (Amburn et al., 1996). It was found from staff working this event that the hail algorithms did a good job at predicting the hail sizes based off storm reports.

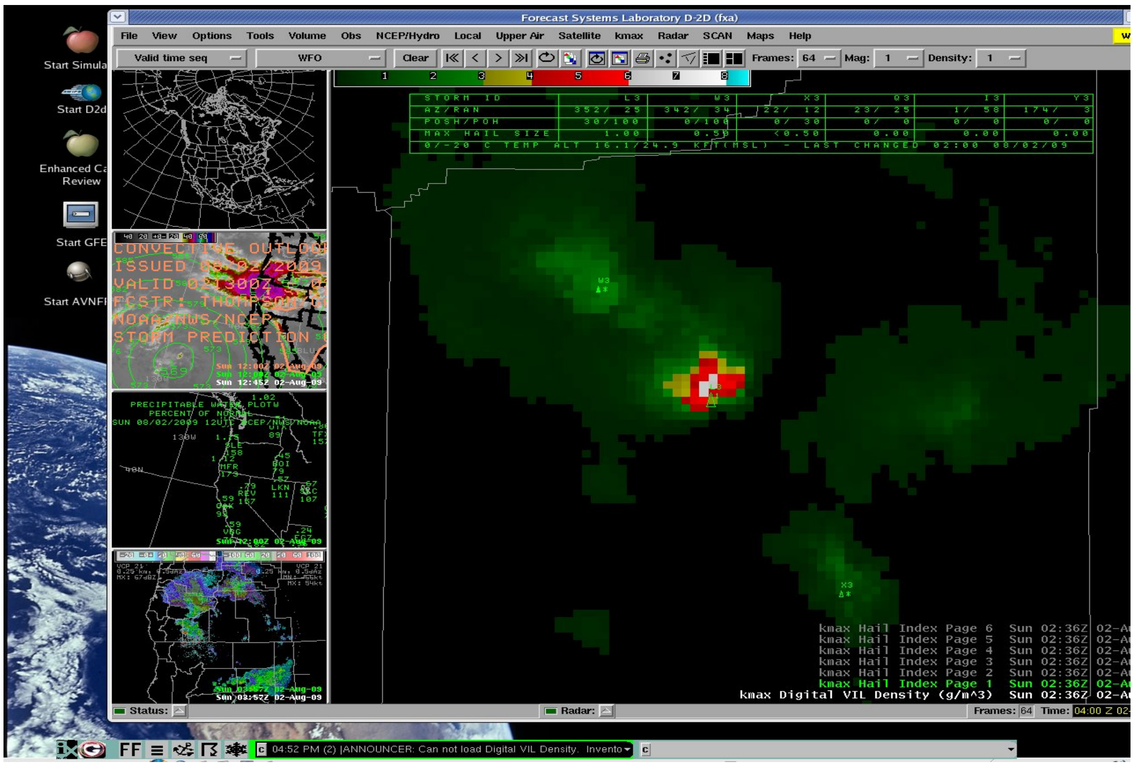

Figure 10. 0236Z 02 August 2009 KMAX Hail Index and VIL Density.

Figure 10a and Figure 10b show the hail observed in and around Eagle Point, Oregon (Mailtribune, 2009).

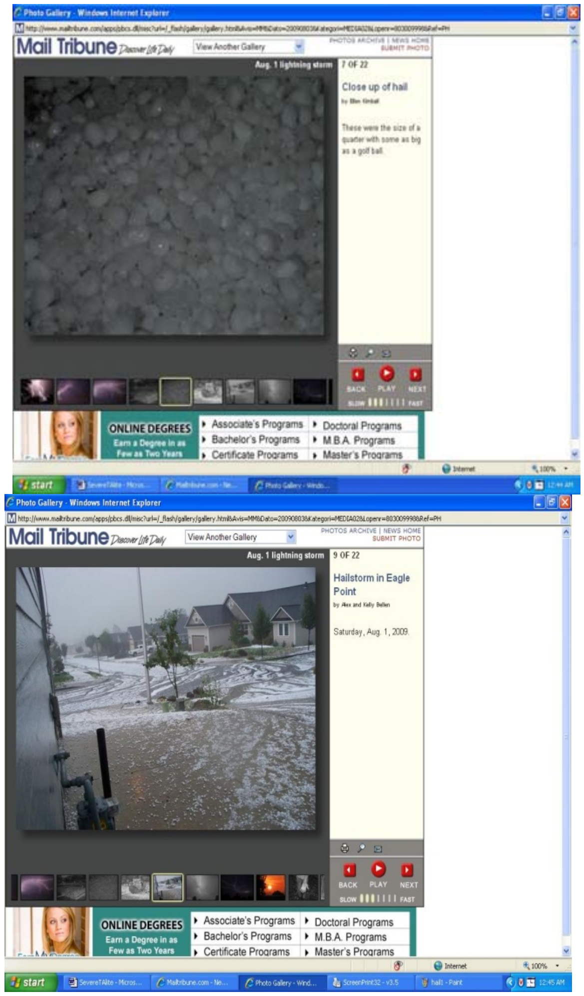

Figure 10a and 10b. Hail pictures from Eagle Point, Oregon.

Splitting Storm over the Southern Rogue Valley

At 0242Z 02 August 2009, another storm formed just south of the radar location. This storm split in two parts with obvious cyclonic and anti-cyclonic signatures in the velocity scan. Figure 11 shows the storm reflectivity before the split, while Figure 12 shows the storm reflectivity just northwest and northeast of the radar location after the split. Figure 12 also contains a Three Body Scatter Spike on the right storm, which indicated hail was in the storm. More impressively, Figure 13 shows the base velocity scan after the split with the anti-cyclonic rotation on the left storm and cyclonic rotation on the right storm. Figure 14 shows the 0.5° base reflectivity with left and right moving supercell vectors. The actual storms were moving slower than the forecast right and left moving supercell vectors, however, the direction of the right and left moving storm vectors was essentially spot on. There was probably a combination of both of the Internal Dynamics method (Bunkers et al., 2000) and terrain factors such as low level wind channeling through the Rogue Valley that caused these storms to split, since this day did not consist of classic supercells that are typically seen in the Midwest and Great Plains. In general, there was also a lack of large 0-3 and 0-6 km helicity from the observed sounding and lack of deep boundary layer moisture which all contributed to the non resemblance of classic Great Plains supercell development and structure.

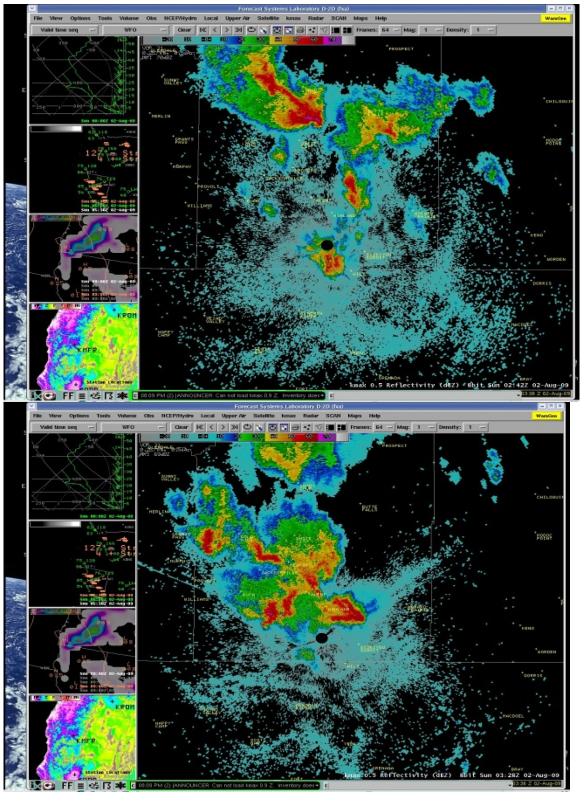

Figure 11 and 12. 02 August 2009 0.5° KMAX reflectivity (before and after storm split).

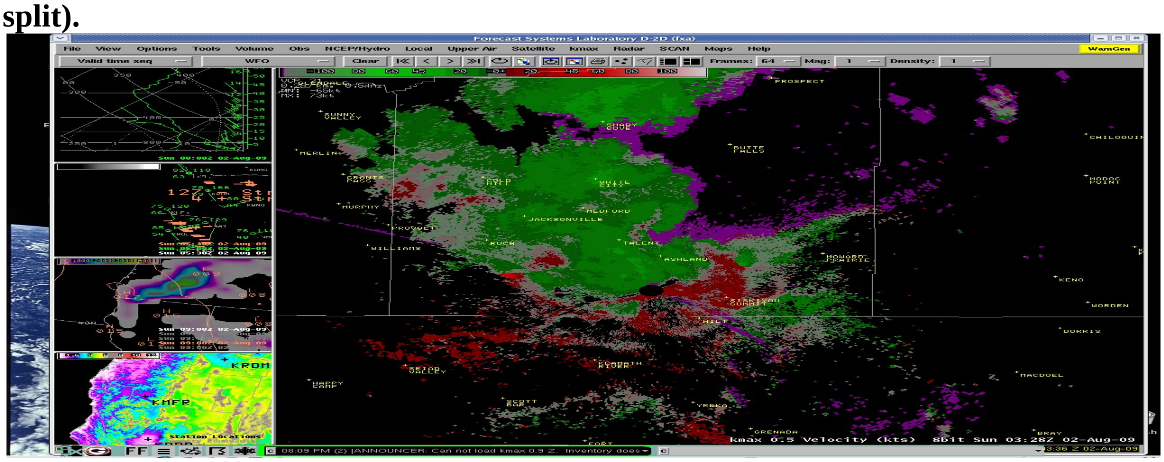

Figure 13. 02 August 2009 0.5° KMAX velocities (with cyclonic and anti-cyclonic signatures).

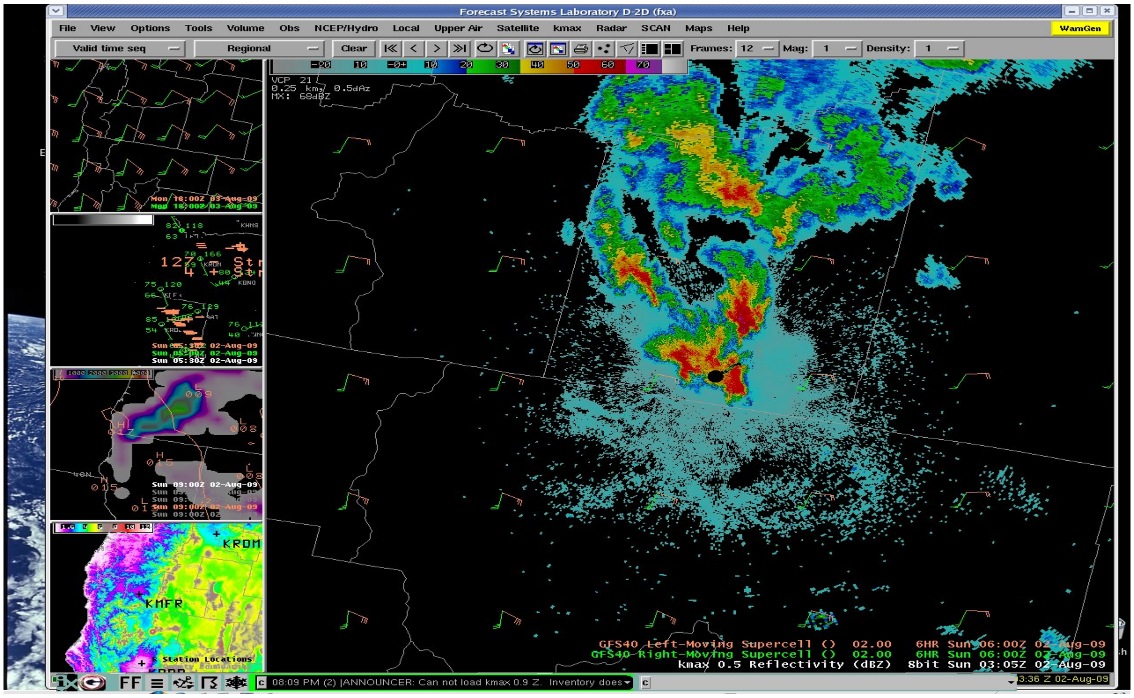

Figure 14. 0.5° KMAX reflectivity and left and right moving supercell vectors.

Conclusion for 01 August 2009 Storm Event

The severe and organized convection that occurred on 01 August 2009 was an impressive and rare event for the Medford CWA given the golf ball size hail that occurred. It was very interesting to the author to see fairly organized convection with splitting storms that are reminiscent of Great Plains convection. Lastly, the hail algorithms did a good job and were of operational benefit to warning meteorologists.

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Synoptic Setup for 02 August 2009

The same upper level 500 hPa low that caused the previous days sensible weather was a little closer to the west coast and a little deeper as well. In addition, the Storm Prediction Center had part of the Medford CWA under a slight risk at 12Z 02 August 2009 (Figure 15). A severe thunderstorm watch was issued by SPC at 2139Z 02 August 2009 (SPC, 2009). The 12Z 02 August 2009 KMFR sounding showed precipitable water at 1.22 inches (78 percent above normal) and was nearly saturated from 600 hPa and up and with a well mixed layer from 600 hPa down to 900 hPa (Figure 16). The severe parameters were less impressive this day with the Bulk Richardson Number observed from the 00Z 03 August 2009 KMFR sounding at 158 (Figure 19) and slightly weaker GFS forecast 0-6 km bulk shear of 30 knots.

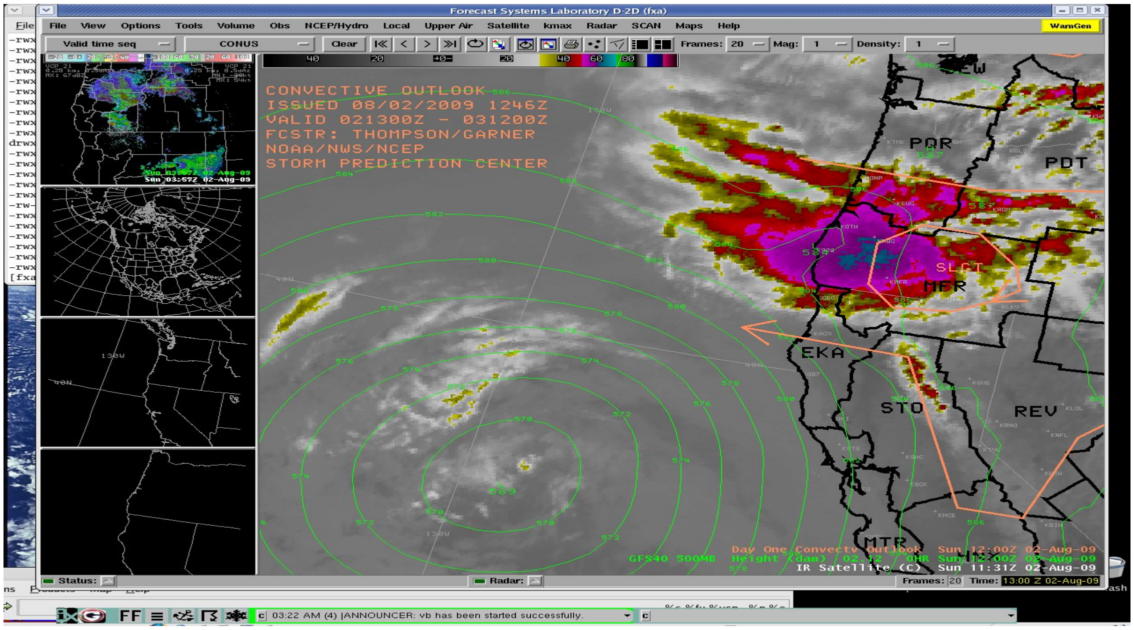

Figure 15. Synoptic setup for 02 August 2009 (500 hPa heights, satellite IR, SPC convective outlook).

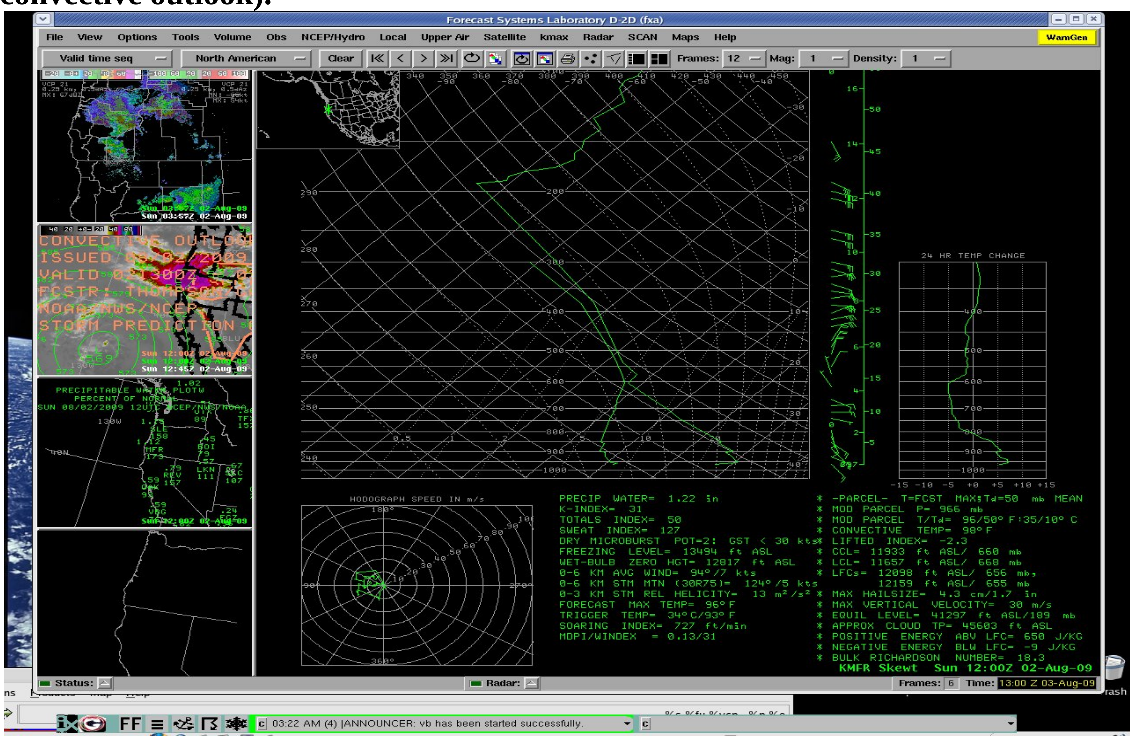

Figure 16. 12Z 02 August 2009 KMFR sounding.

Mesoscale Setup for 02 August 2009

Since the upper level low was further east, Medford forecasters thought the activity would be along the Cascades and points east. Terrain and differential heating were the primary mesoscale forcing as convection initiated off the higher terrain (Figure 17).

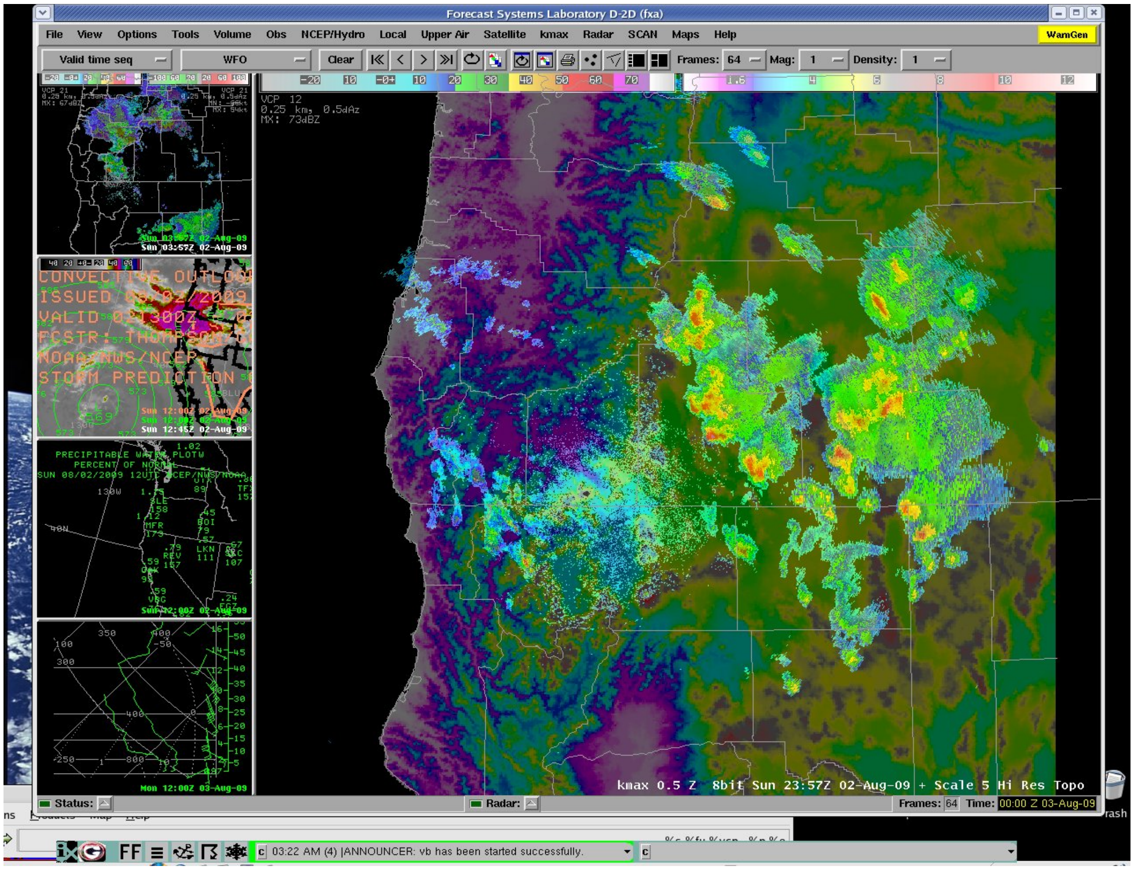

Figure 17. Convection initiated off the higher terrain on 02 August 2009.

Forecast for 02 August 2009

Figure 18 shows the 12Z 02 August 2009 GFS solution for 00Z 03 August 2009. The 0-6 km GFS forecast bulk shear was slightly weaker than the previous day, but still was around 30 knots, which tends to be the minimum threshold to support organized severe convection. The 12Z GFS forecast 4700 J/kg of CAPE was too high due to model boundary layer moisture issues. In actuality, the CAPE for the evening was around 2200 J/kg observed from the 00Z 03 August 2009 KMFR sounding and also displayed a Lifted Index of -6.2°C (Figure 19).

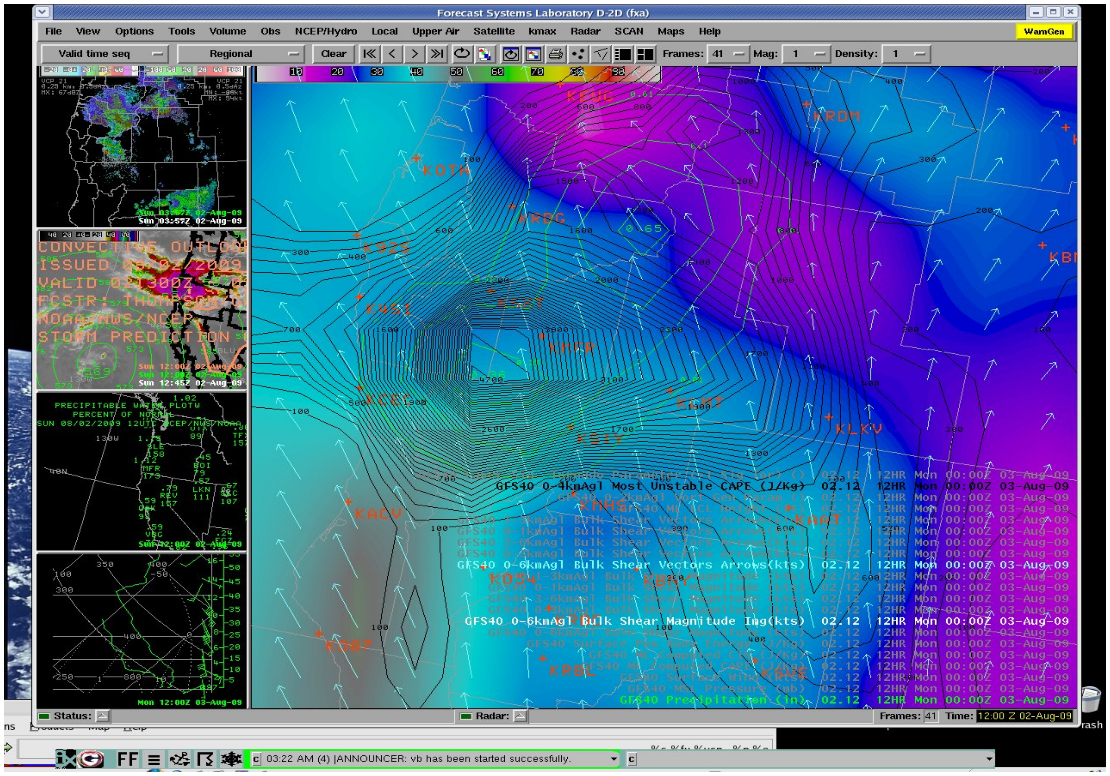

Figure 18. 12Z 02 August 2009 GFS (0-6 km bulk shear vectors, 0-6 km bulk shear image, black contoured MUCAPE, green contoured 6h surface precipitation).

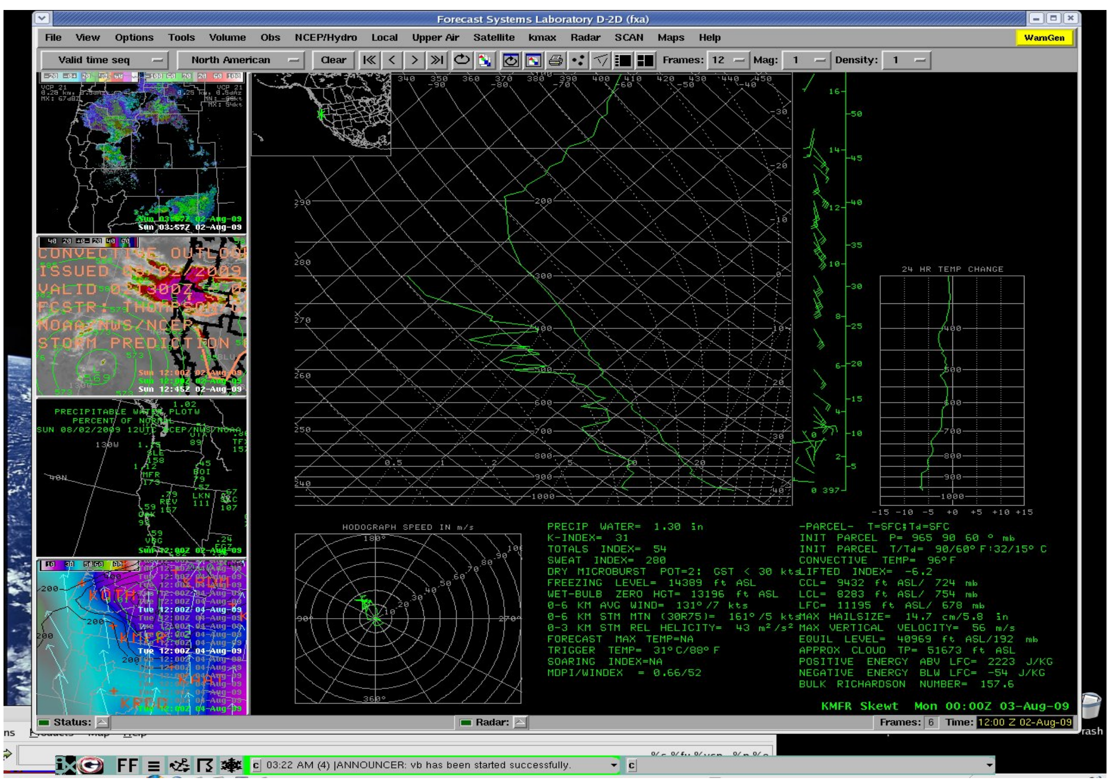

Figure 19. 00Z 03 August 2009 KMFR sounding.

Radar Imagery for 02 August 2009

VCP 12 was assigned from the KMAX RPG HCI, so the data contained more low elevation scans than the previous day when VCP 21 was used. Unfortunately, the storms were more distant from the radar this day, which partially negated the operational benefit of the low level elevation scans.

Higher Terrain Storms over the Eastern CWA

The largest size hail reported to the Medford WFO was hail the size of quarters in Klamath and Lake counties. Three Body Scatter Spikes were not observed through the entire event and the storms seemed to be more outflow dominate when compared to the previous day. Figure 20 shows an outflow boundary well west of the storm clusters in west central Klamath county. VIL Density and Hail Index sizes were generally smaller as well (around 5.5 g/m³ and around 1.5 inch max hail, respectively). Overall, the algorithms did a good job at predicting the 1 inch size hail for most of the event based on the storm reports (Figure 21).

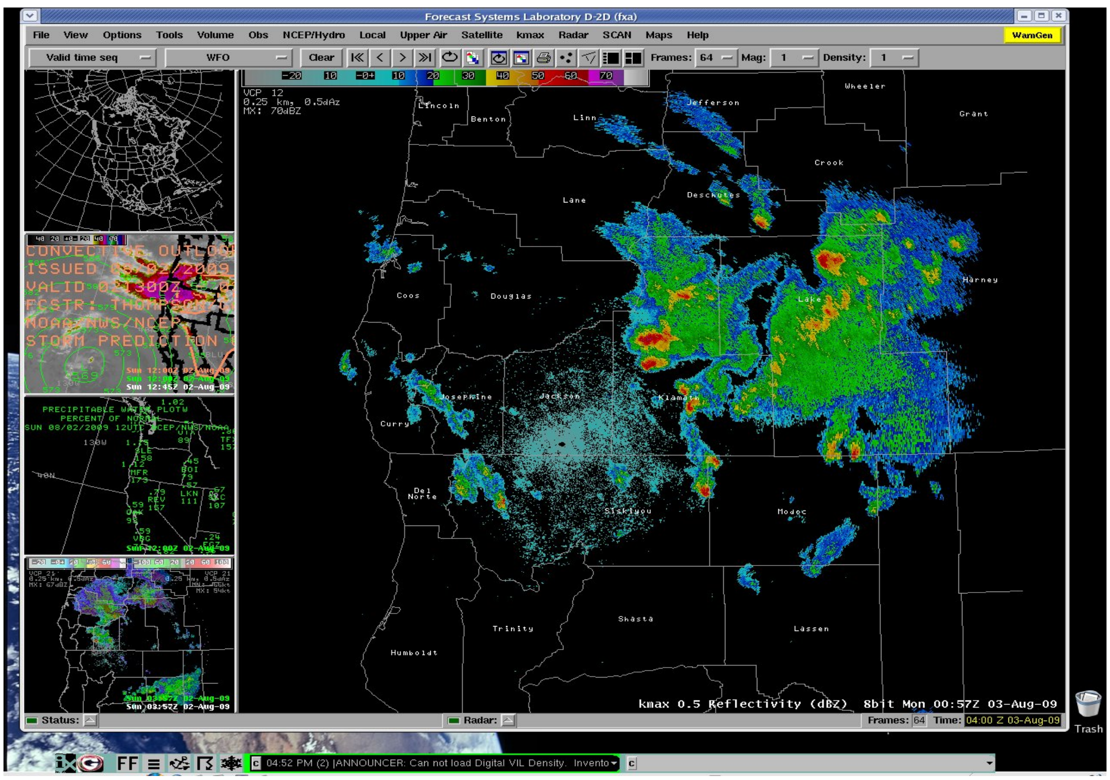

Figure 20. 0057Z 03 August 2009 0.5° KMAX reflectivity (notice outflow dominate storms with outflow boundary in west central Klamath county).

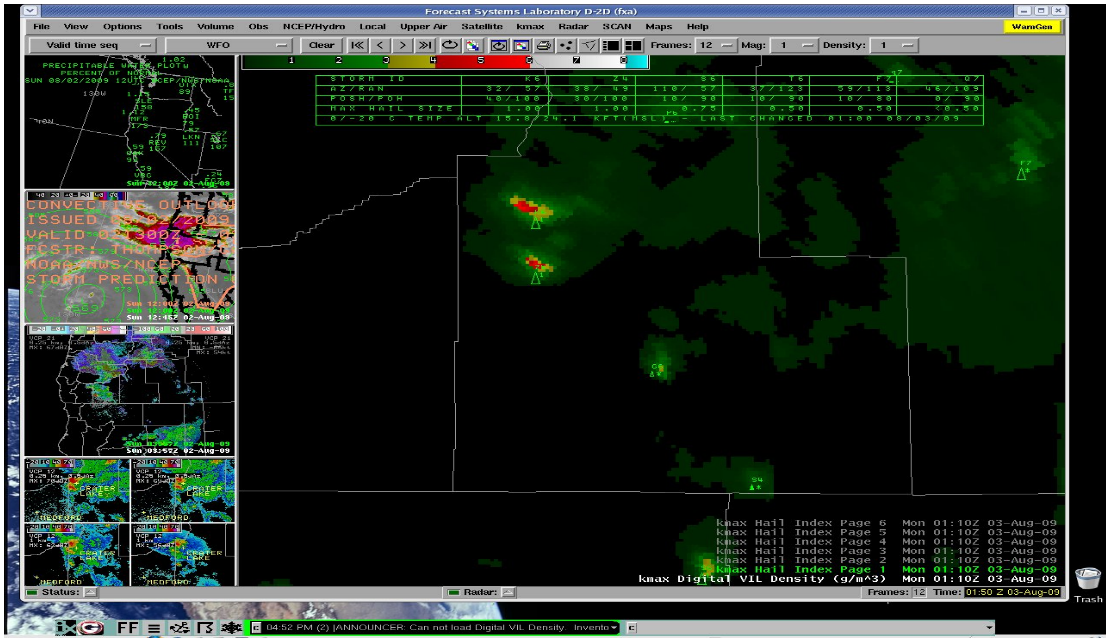

Figure 21. 0110Z 03 August 2009 KMAX Hail Index and VIL Density.

Figure 22 shows a four panel display of reflectivity (0.5º, 1.3º, 2.4º, 4.0º) from the storms around Crater Lake. 1.0 inch hail was reported around 0130Z 03 August 2009 from the storms. WERs and BWERs were not observed with these storms. In addition, the 40 dBZ reflectivity extended to only about 30,000 feet agl instead of 33,000 feet agl like the previous day, which indicated slightly weaker updrafts. The lower height location of the 40 dBZ reflectivity and the weaker hail algorithm values lead to a higher confidence of accurate, yet smaller size hail for 02 August 2009. A four panel of base velocities and storm relative velocities is not presented in this paper as no significant items of interest were observed in the imagery. Lastly, splitting storms were not seen this day due to weaker GFS forecast 0-6 km bulk shear and unfavorable terrain low level wind channeling.

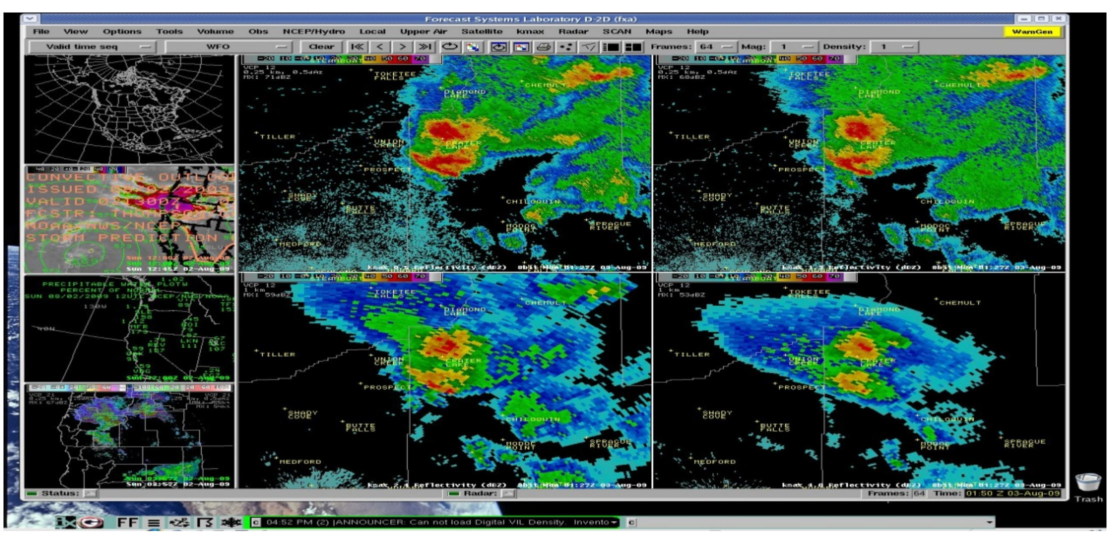

Figure 22. 0127Z 03 August 2009 0.5°, 1.5°, 2.4°, 4.0° KMAX reflectivity

Conclusion for the 02 August 2009 Storm Event

Smaller size hail was observed this day over the higher terrain of south central Oregon. A limiting factor in the hail growth was attributed to weaker 0-6 km bulk shear and outflow dominate storms. Despite weaker storms, it was still an active day which included a severe thunderstorm watch for the CWA, which in itself is a rare event for the area.

Acknowledgements

The author would like to thank Mike Stavish Lead Forecaster and Dennis Gettman Science and Operations Officer at WFO Medford for their assistance in archiving the storm, environmental, and model data.

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Storm Prediction Center http://www.spc.noaa.gov. Accessed August 2009.