Central Region Technical Attachment
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THE SEVERE THUNDERSTORM EVENT OVER CENTRAL WYOMING ON 6 JULY 2008

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1. Introduction

During the afternoon of Sunday, 6 July 2008, a severe thunderstorm event occurred over the high plains and basins of central Wyoming within the Riverton, Wyoming Weather Forecast Office (hereafter RIW) county warning area (CWA). No fewer than four supercells occurred across three counties: Hot Springs, Fremont, and Johnson (Fig. 1). The strongest of these storms developed over far east-central Fremont County and contained an 81-dBZ core with a radar-estimated 4.75" maximum hail size according to the RIW WSR-88D hail algorithm (Witt at al. 1998). Numerous other strong, nonsupercell thunderstorms developed as well. Twenty-one severe thunderstorm warnings (SVRs) were issued along with two flash flood warnings (FLWs) over a time period of approximately four hours. However, many of the thunderstorms occurred over sparsely populated locations, making storm verification very difficult. This study will document the synoptic and mesoscale conditions that occurred prior to and during this event. The life cycles of the event's strongest storms also will be detailed.

2. WFO Riverton CWA Overview

The map in Fig. 1 shows the portion of the RIW CWA covered by this study. The study area consists of the central basins (Wind River and Big Horn Basins), high plains (Johnson, Natrona, and southeastern Fremont Counties), as well as the central mountains (Absaroka, Bighorn, Green, Owl Creek, and Wind River Mountains). The Bighorn Mountains separate the Big Horn Basin from the high plains of Johnson County, and Hiland Divide and Beaver Creek Divide separate the Wind River Basin from the high plains of Natrona and southeastern Fremont Counties. The crests of the Green Mountains and Wind River Mountains approximate the Continental Divide.

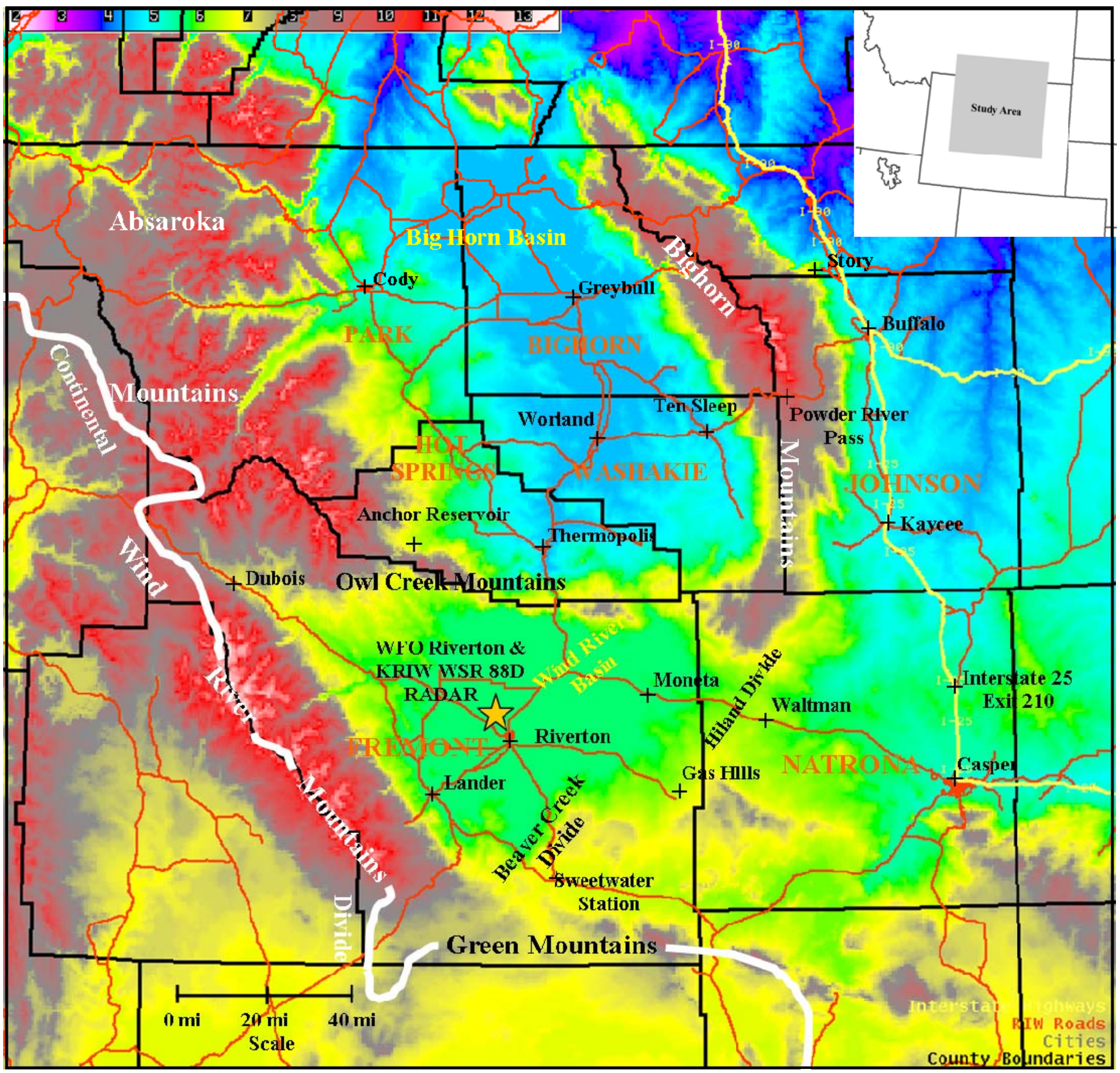

Fig. 1. Topographic map of the study area (elevation in kft, scale at upper left) showing counties (heavy black lines), county names (orange letters in caps), cities and places (black "plus" symbols, letters), basins (yellow letters), mountains and divides (white/black letters and lines), Interstate 25 (yellow lines) and US and state highways (red lines).

3. Synoptic Conditions

a. *Water Vapor Satellite Imagery*

At 1731 UTC on 6 July 2008, the water vapor satellite imagery (Fig. 2) shows a trough along the western CONUS and Canada, and a ridge over the central Plains. High and mid level moisture is evident in the southwest flow ahead of the trough over the eastern Great Basin and the central and northern Rockies. By 2323 UTC, the trough had advanced approximately two hundred miles east. Convection had fired ahead of the trough across the Rocky Mountains including Wyoming.

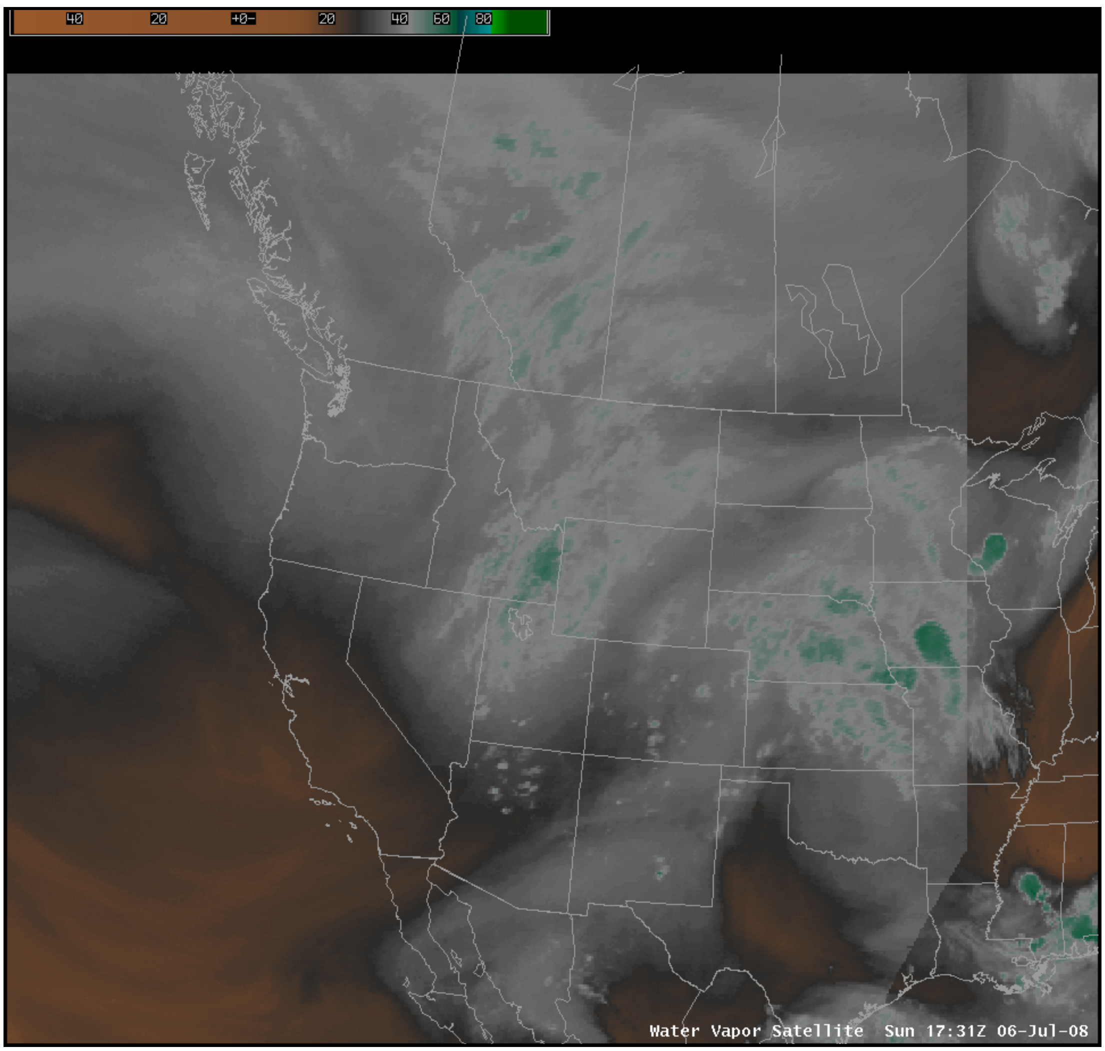

Fig. 2. Water vapor satellite image at 1731 UTC 6 July 2008.

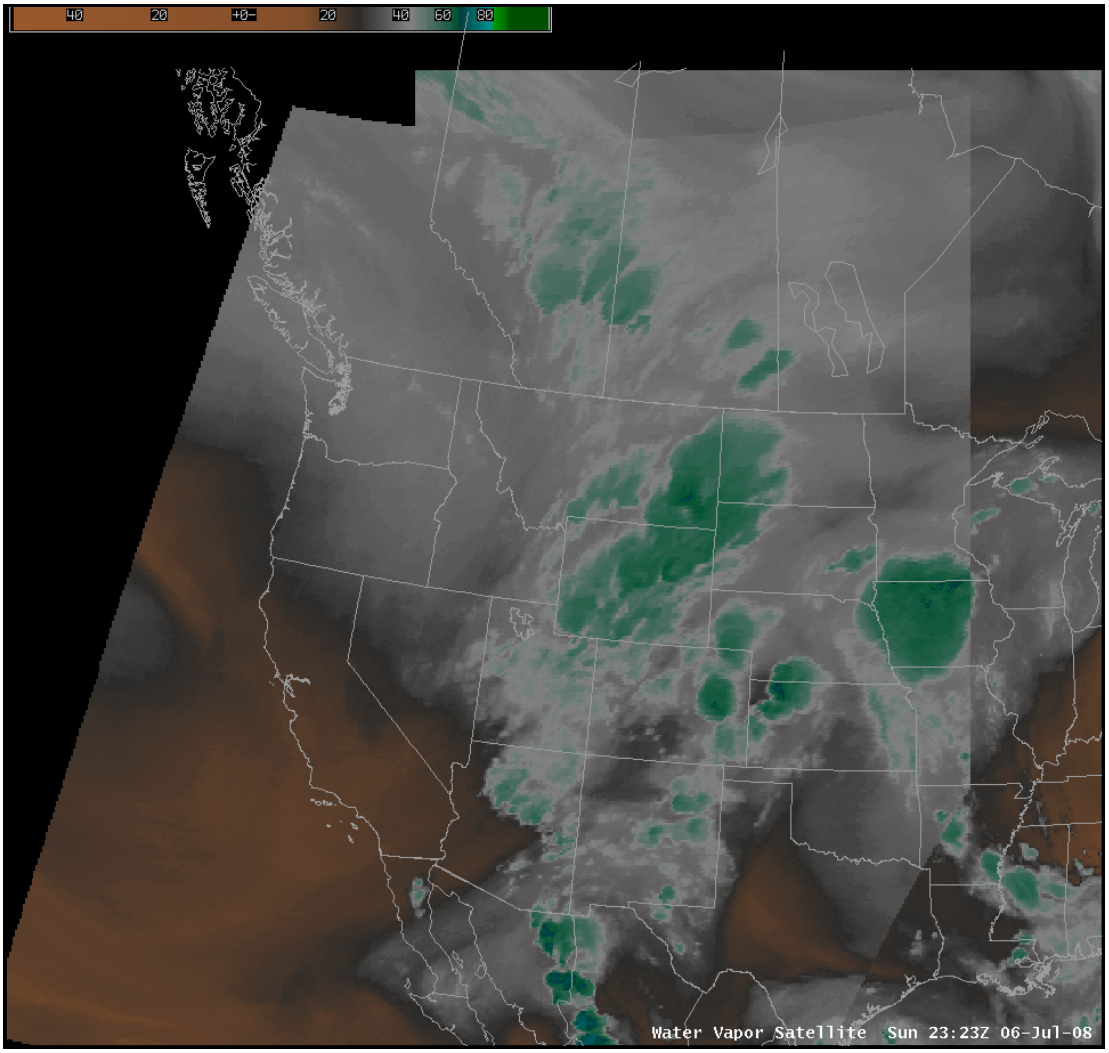

Fig. 3. Water vapor satellite image at 2323 UTC 6 July 2008.

b. ***250 mb***

A 250-mb trough was located over western Idaho and eastern Nevada at 1800 UTC on 6 July 2008 with southwest flow over the northern and central Rockies (Fig. 4). A 45-kt anticyclonically curved jet streak was located over northeastern lower Idaho and south-central Montana with a right entrance region over northern Wyoming. There was also a cyclonically curved 50-kt jet streak located over eastern Utah, with left exit region over southern

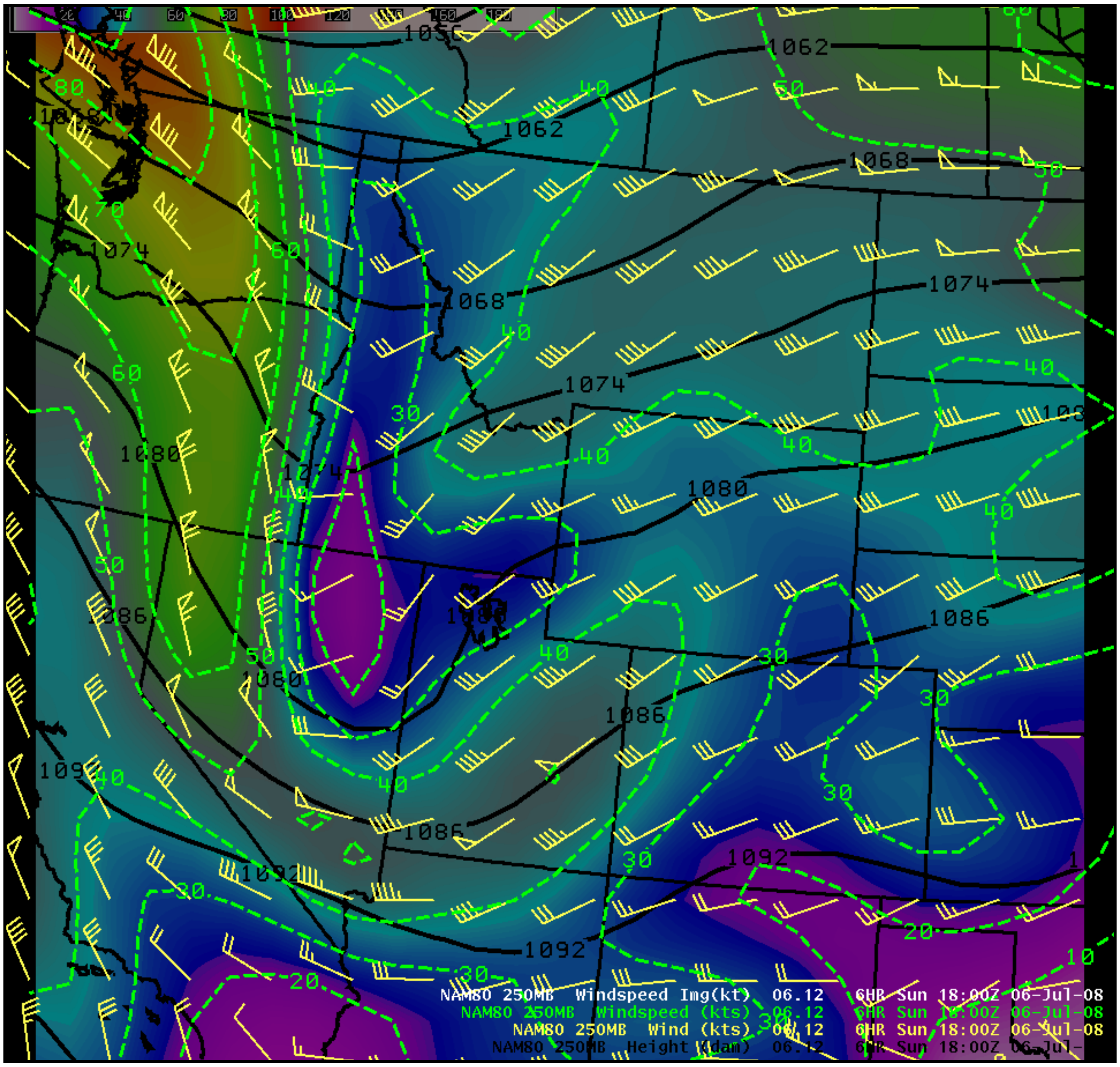

Fig. 4. NAM 6-h forecast at 250 mb valid at 1800 UTC 6 July 2008. Black contours are heights (every 6 dm); wind barbs (kt) are shown in yellow; and green dashed contours and image are wind speed (kt; scale at upper left). Data are plotted on an 80-km grid.

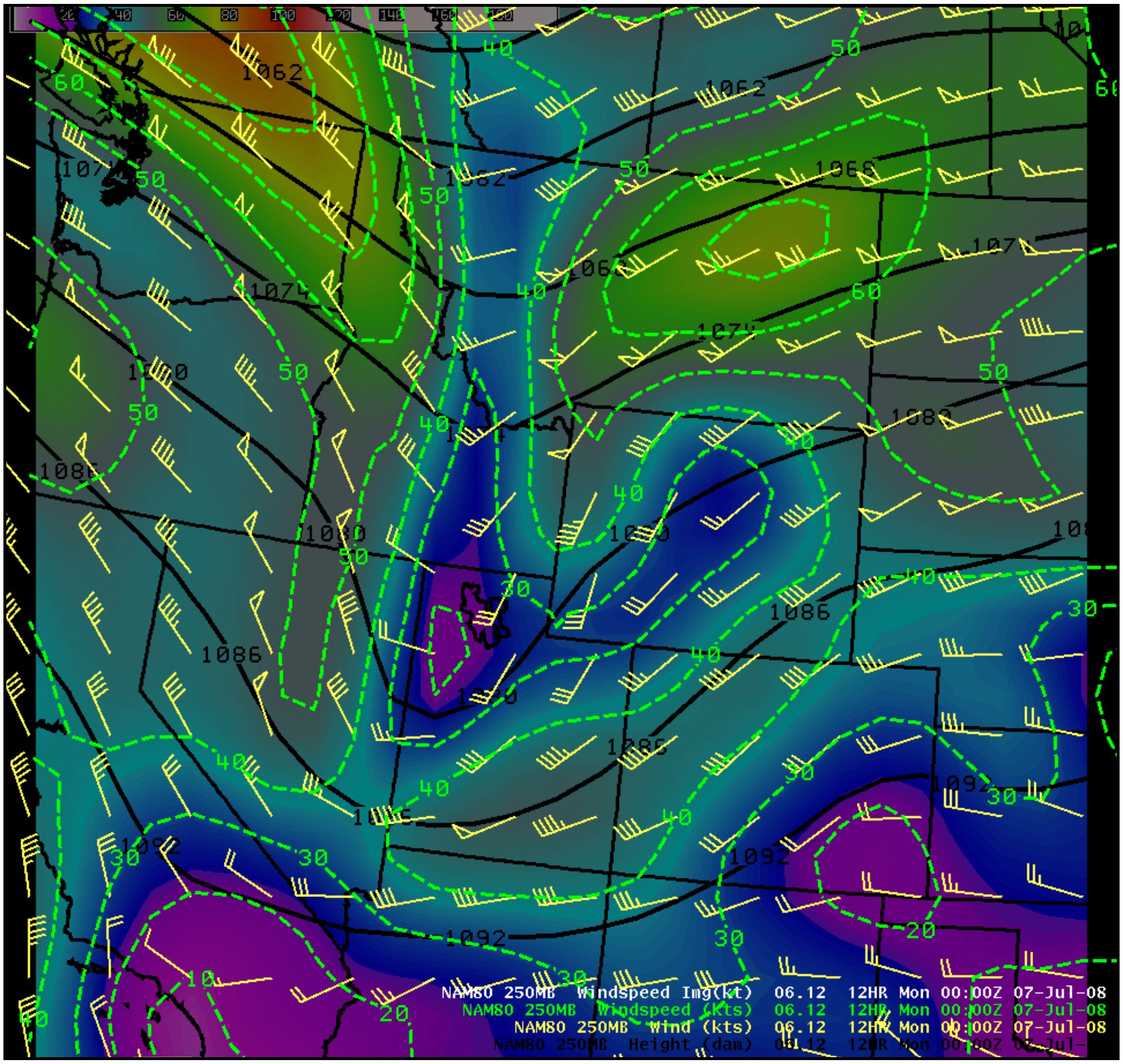

Fig. 5. Same as Fig. 2 except for the 12-h forecast valid at 0000 UTC 7 July 2008.

Wyoming. Although model forecast data did not indicate this, these two jets may have coupled to enhance vertical motion over central Wyoming, as suggested by Uccellini and Kocin (1987). The jet streak over Montana was forecast to strengthen during the afternoon with speeds increasing to 70 kt (Fig. 5). The southern jet weakened to between 35 and 40 kt.

c. *500 mb*

At 1800 UTC 6 July 2008, the 500-mb trough was located over eastern Oregon and western Nevada, with a west-southwest flow across the northern Rockies (Fig. 6). There were two vorticity maxima ahead of the trough. The stronger of the two was located over south-central Idaho, and the second was located over west-central Nevada at the base of the trough. The

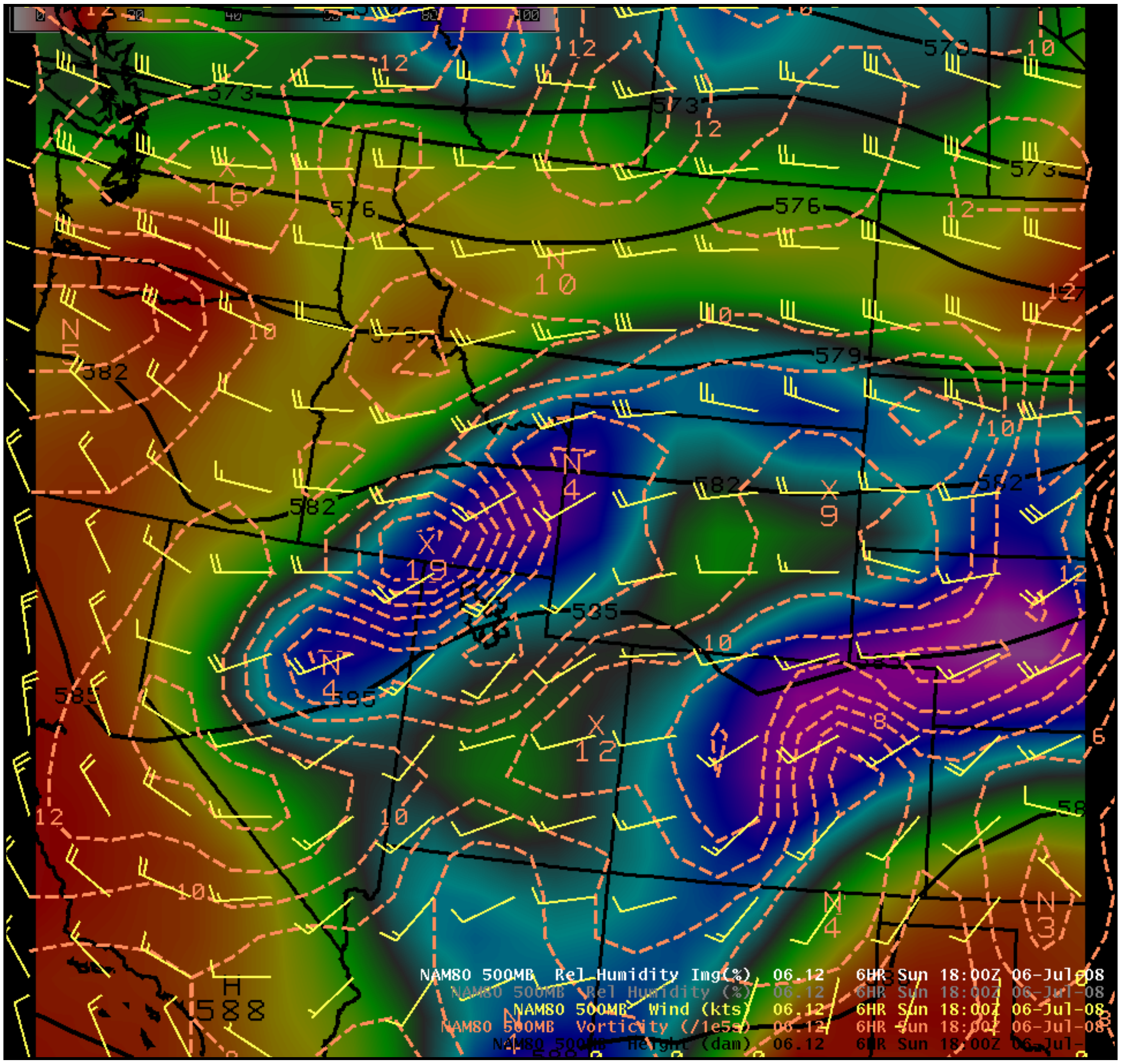

Fig. 6. NAM 6-h forecast at 500 mb valid at 1800 UTC 6 July 2008.
Black contours are heights (every 3 dm); wind barbs (kt) are shown in yellow; orange dashed contours are vorticity $[(1e^{5}s)^{-1}]$; and the image is relative humidity (percent; scale at upper left).

northern vorticity maximum moved into northern Wyoming, while the southern vorticity maximum moved into northern Utah through 0000 UTC 08 July 2008 (Fig. 7). Positive differential vorticity advection (PDVA) between 700 mb and 300 mb was forecast to occur over north-central Wyoming during the afternoon hours (not shown, see Holton 1992 and Doswell 1999), which may imply an increase in synoptic-scale vertical motion. In addition, the forecast of both Q-vector divergence and vertical velocity from the quasi-geostrophic equations at 500 mb (not shown) indicated the potential for enhanced vertical motion from southeast Montana into central Wyoming (Durran and Snellman 1987; E. Thaler 2011, personal communication).

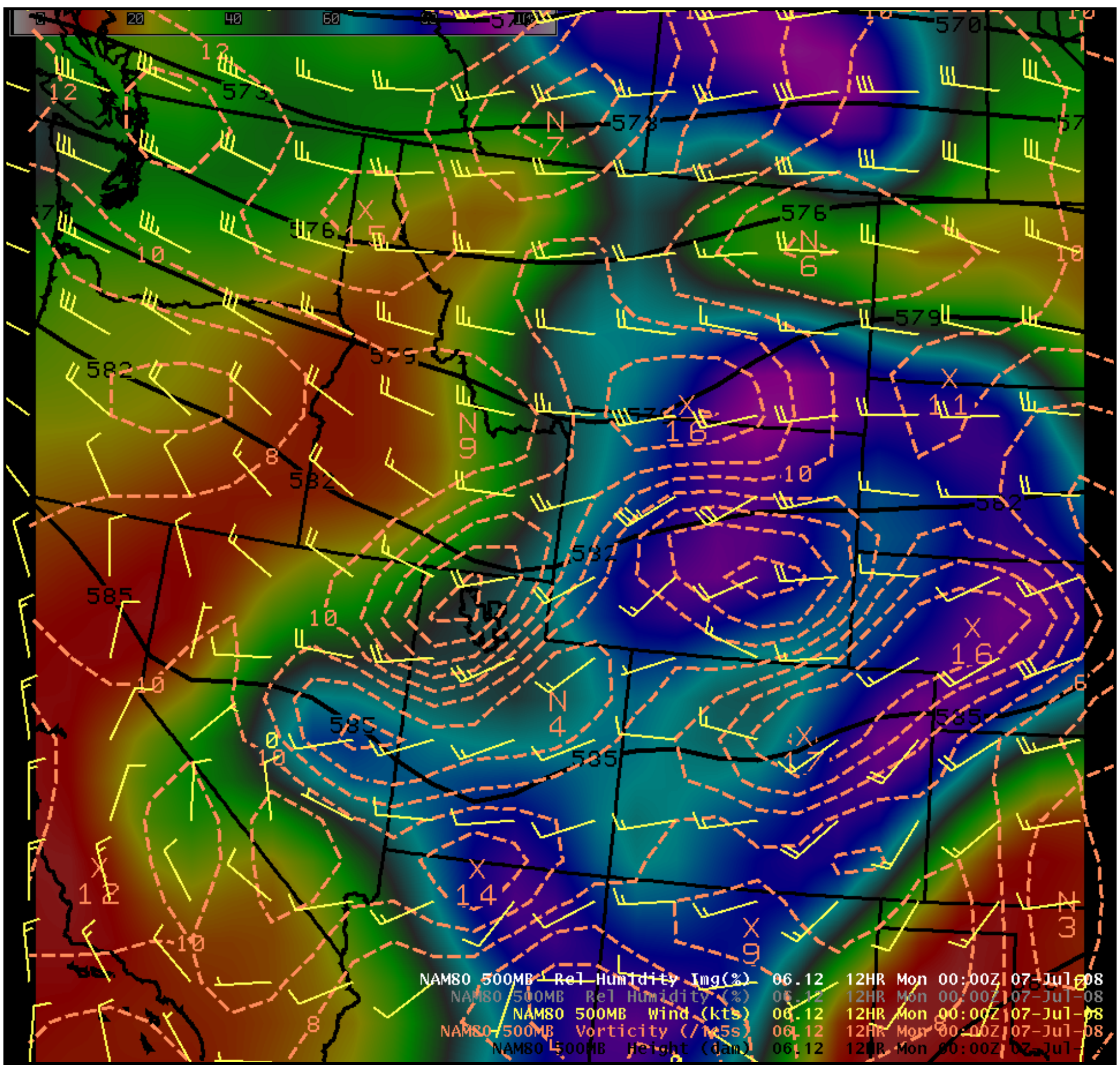

Fig. 7. Same as Fig. 4 except for the 12-h forecast valid at 0000 UTC 7 July 2008.

d. ***700 mb***

The 700-mb trough was oriented just lee (east) of the Wind River and Absaroka Mountains of western Wyoming at 1800 UTC (Fig. 8). It strengthened throughout the afternoon and eventually formed a nearly closed circulation over south-central Wyoming by 0000 UTC 7 July 2008 (Fig. 9). Southeast flow ahead of the trough advected moisture into central Wyoming up to the Continental Divide, and enhanced the low-level vertical wind shear, aiding supercell formation (Newton 1963, among many others).

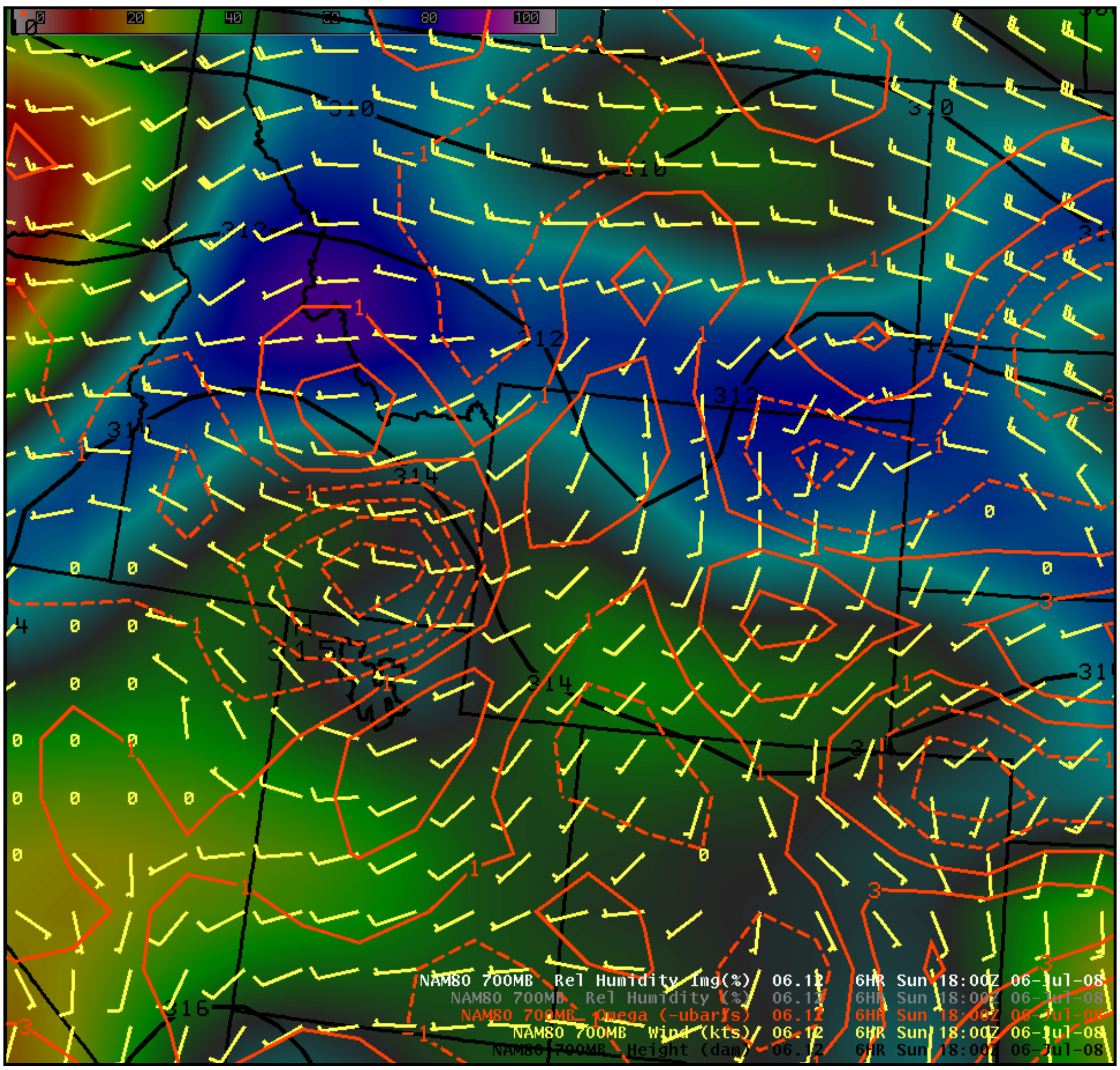

Fig. 8. NAM 6-h forecast at 700 mb valid at 1800 UTC 6 July 2008.
Black contours are heights (every 2 dm); wind barbs (kt) are shown in yellow; red solid/dashed contours are omega (-ubar s^{-1}); and the image is relative humidity (percent; scale at upper left).

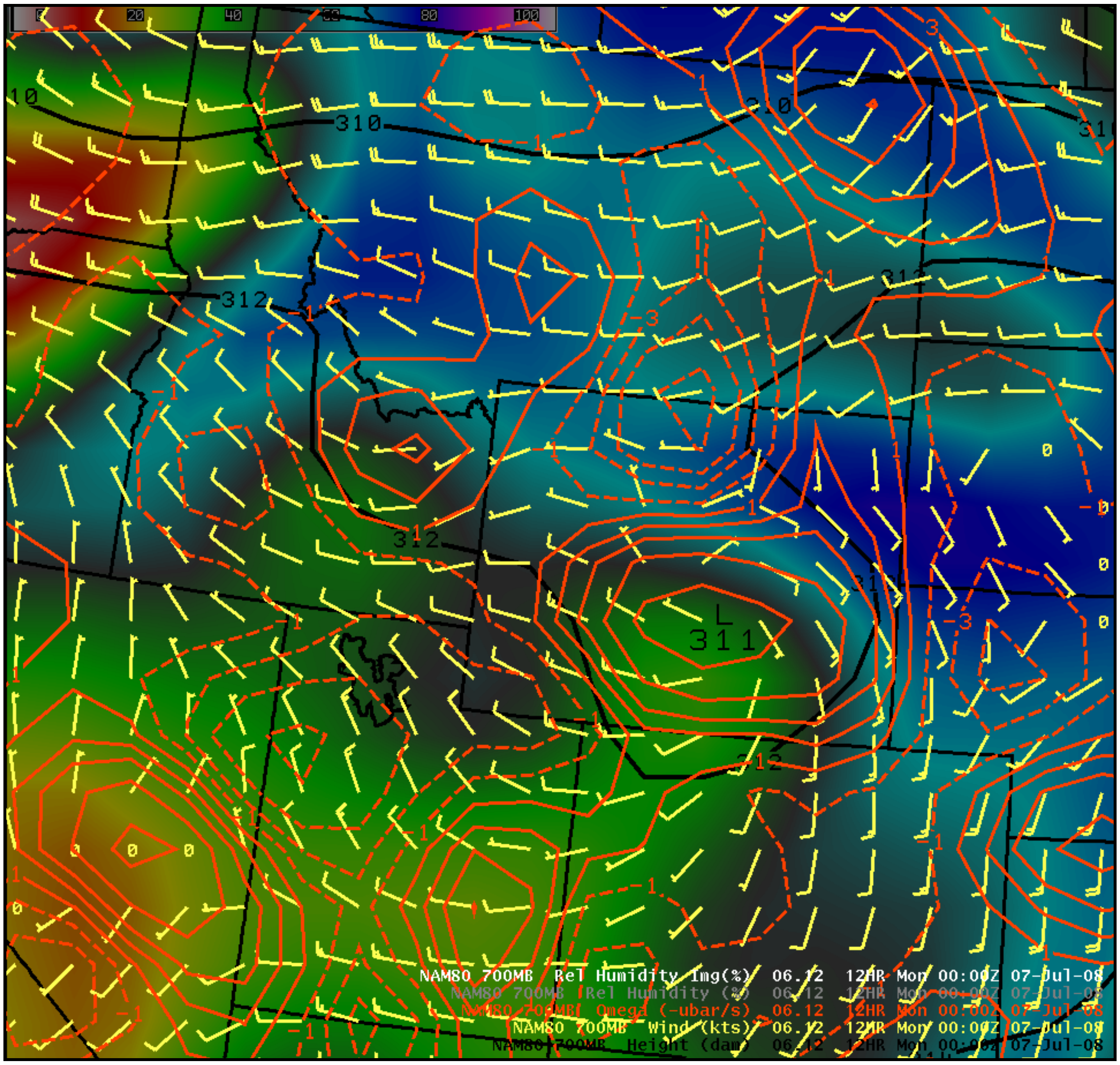

Fig. 9. Same as Fig. 6 except for the 12-h forecast valid at 0000 UTC 7 July 2008.

e. *Surface*

A 1004-mb surface low was located in south-central Wyoming at 1800 UTC (Fig. 10). Dry southwest winds were noted west of the Continental Divide along with dewpoints in the 30s °F. Relatively moist southeast to east winds were found east of the Continental Divide with higher

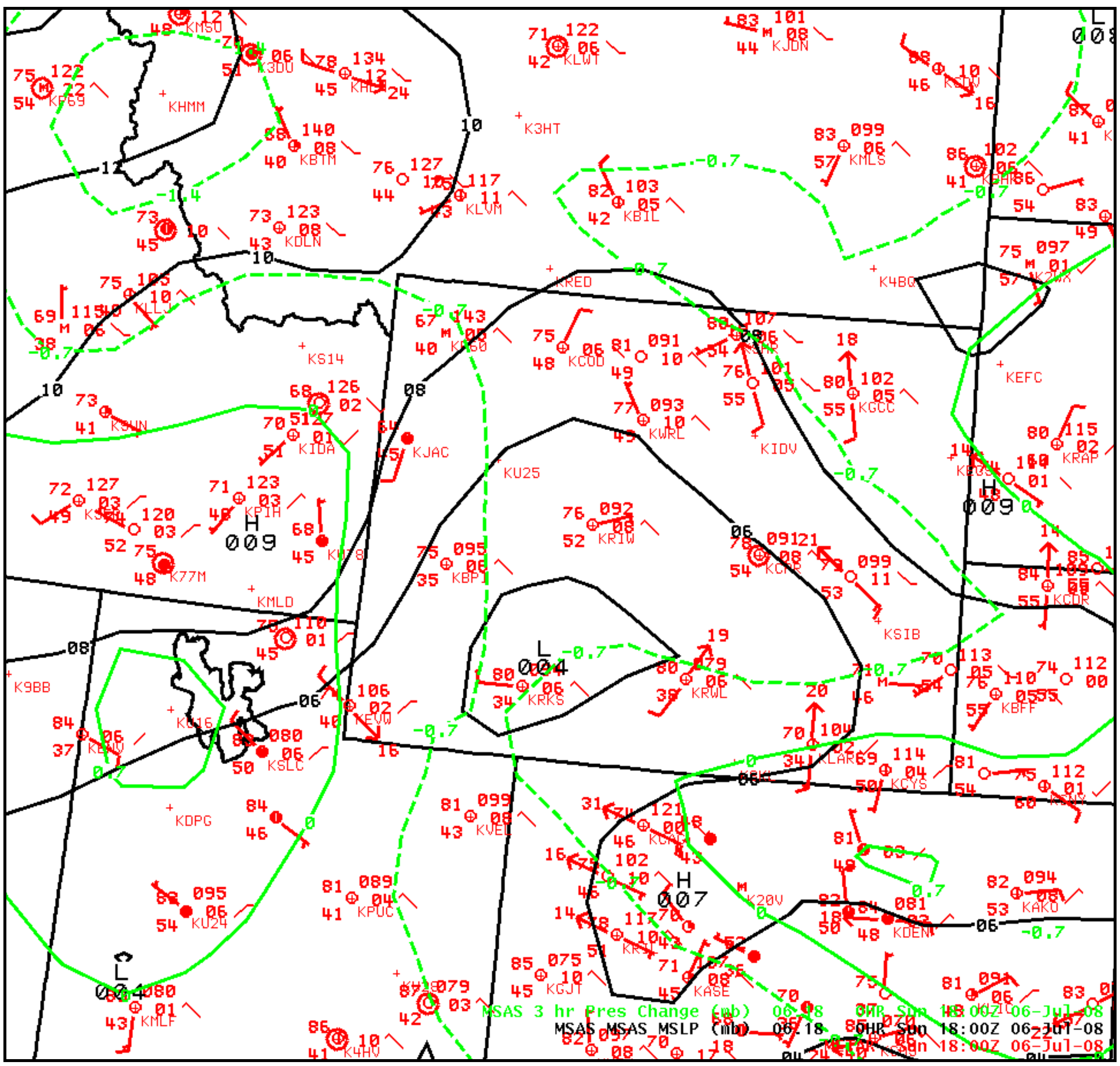

Fig. 10. Surface analysis at 1800 UTC 6 July 2008. METAR observations are shown in red; black contours represent the MSAS [Mesoscale Analysis and Prediction System (MAPS) Surface Assimilation] analysis of mean sea level pressure (mb); and green dashed/solid contours represent the MSAS analysis of 3-h pressure change (mb).

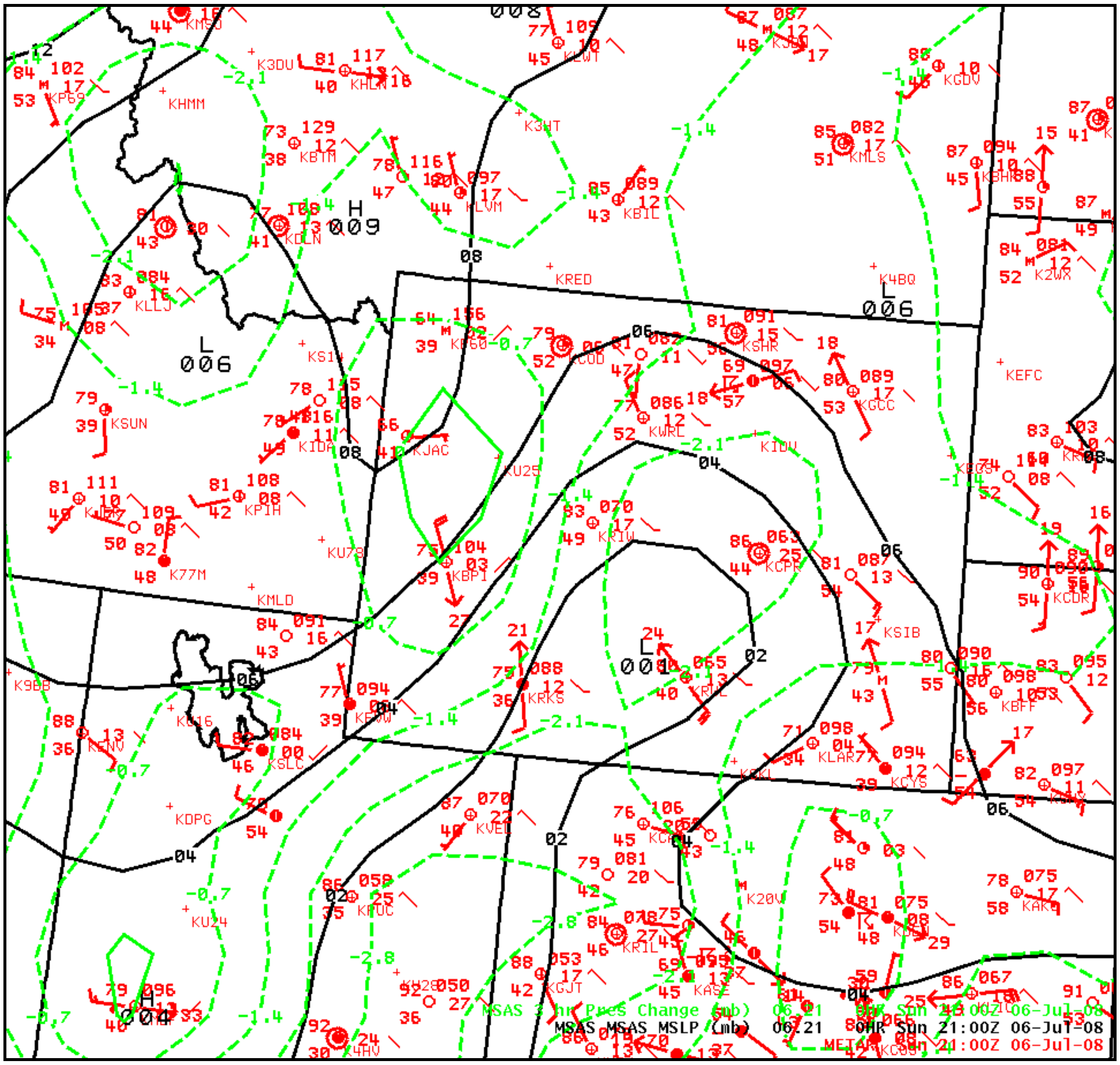

Fig. 11. Same as Fig. 8 except for the 12-h forecast valid at 2100 UTC 6 July 2008.

dewpoints ranging from 45 to 55 °F. The surface low deepened to 1001 mb through 2100 UTC, drifting slightly to the east southeast (Fig. 11). Dewpoints increased into the upper 50s °F over Johnson County (roughly north of KIDV) and decreased into the lower to upper 40s °F over the remainder of the area east of the Continental Divide.

f. ***Upper-Air Sounding***

The 1200 UTC 6 July 2008 KRIW sounding (Fig. 12) shows a lifted index (LI) of 0.2 °C and convective available potential energy (CAPE) of 125 J kg^{-1}. An 1800 UTC special sounding (Fig. 13) was taken and had a Lifted Index (LI) of -3.9 °C and a CAPE of 1235 J kg^{-1} . Convective inhibition (CIN) of -147 J kg^{-1} was also noted under a capping inversion around 740 mb at 1800 UTC. The cap was due to some warming and drying above 740 mb. The cap was expected to break rather easily in the early afternoon under increasing insolation and mixing. The environment below the cap was still relatively dry, with a minimum dewpoint depression of 8 °C.

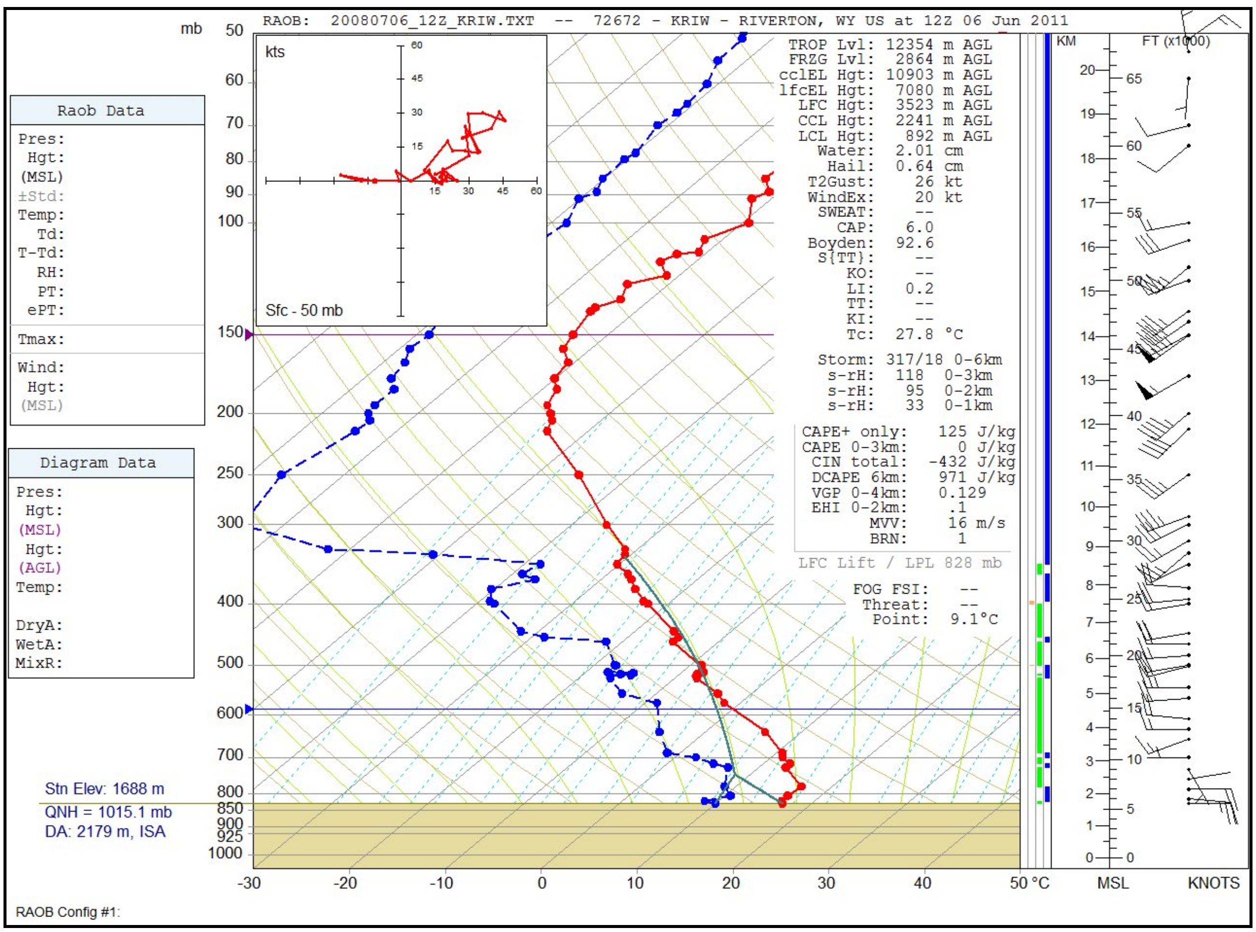

Fig. 12. Riverton, Wyoming (RIW) sounding at 1200 UTC 6 July 2008.

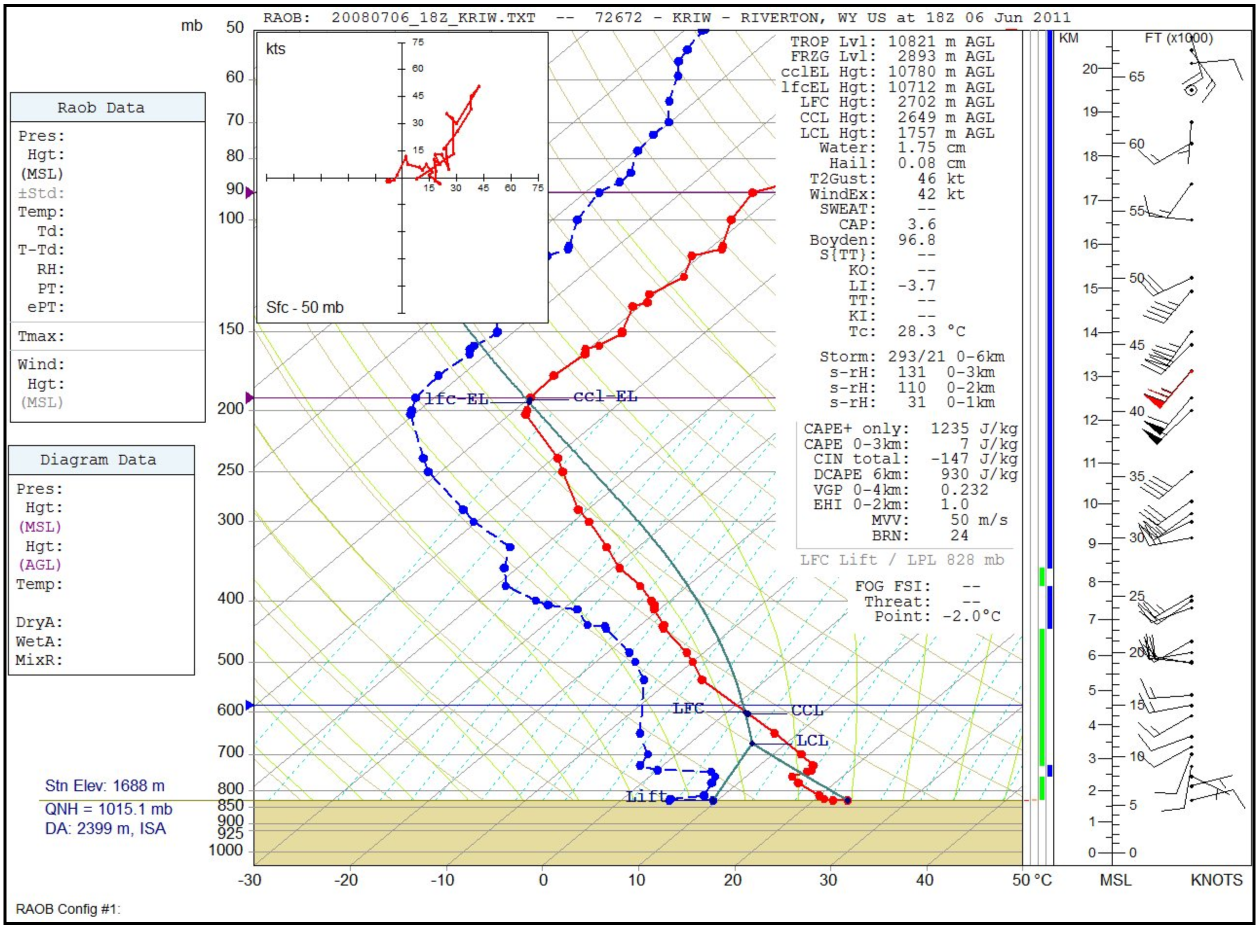

Fig 13. RIW sounding at 1800 UTC 6 July 2008.

g. *Hodograph*

A look at the 1200 UTC hodograph (Fig. 14) shows a slight veering profile with a 0–3-km storm-relative helicity (SRH) of 118 $m^2\ s^{-2}$ with a storm motion of 317° at 18 kts, a favorable SRH value for supercell formation (Bunkers 2002). On the 1800 UTC hodograph (Fig. 15), the 0–3-km SRH increased to 131 $m^2\ s^{-2}$. The 1800 UTC Local Analysis and Prediction System (LAPS) analysis (Fig. 16) indicated the highest SRH over the northern Big Horn Basin with an area near the Montana border exceeding 200 $m^2\ s^{-2}$. The higher SRH extended south into the Wind River Basin as well. By 2100 UTC, the higher SRH values shifted east into the eastern Big Horn Basin and Johnson County (Fig. 17).

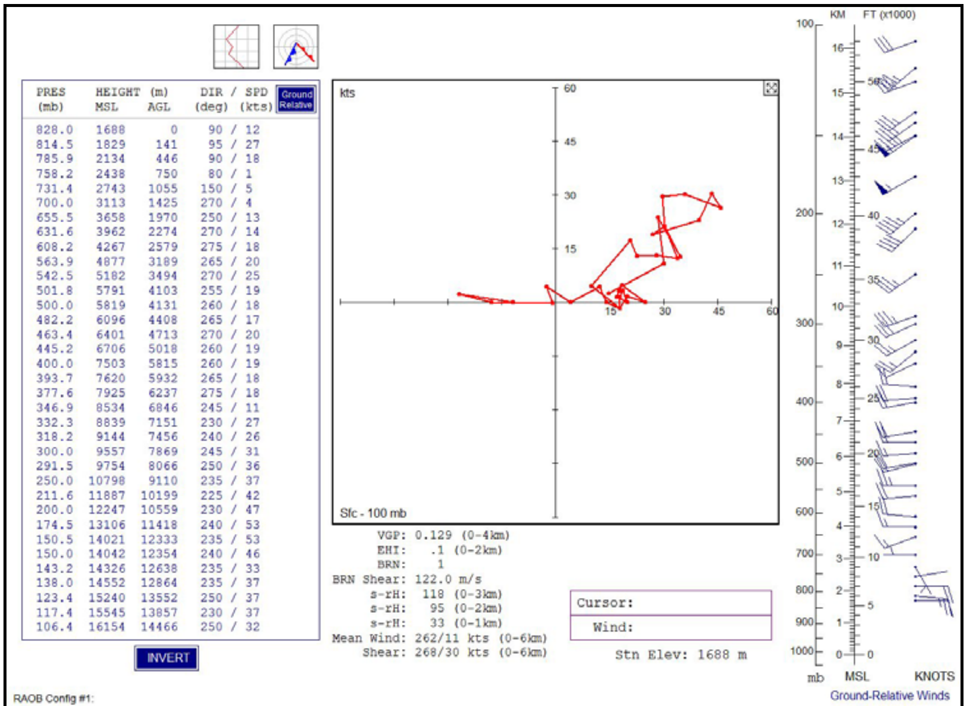

Fig. 14. RIW hodograph (m s^{-1}) at 1200 UTC 6 July 2008.

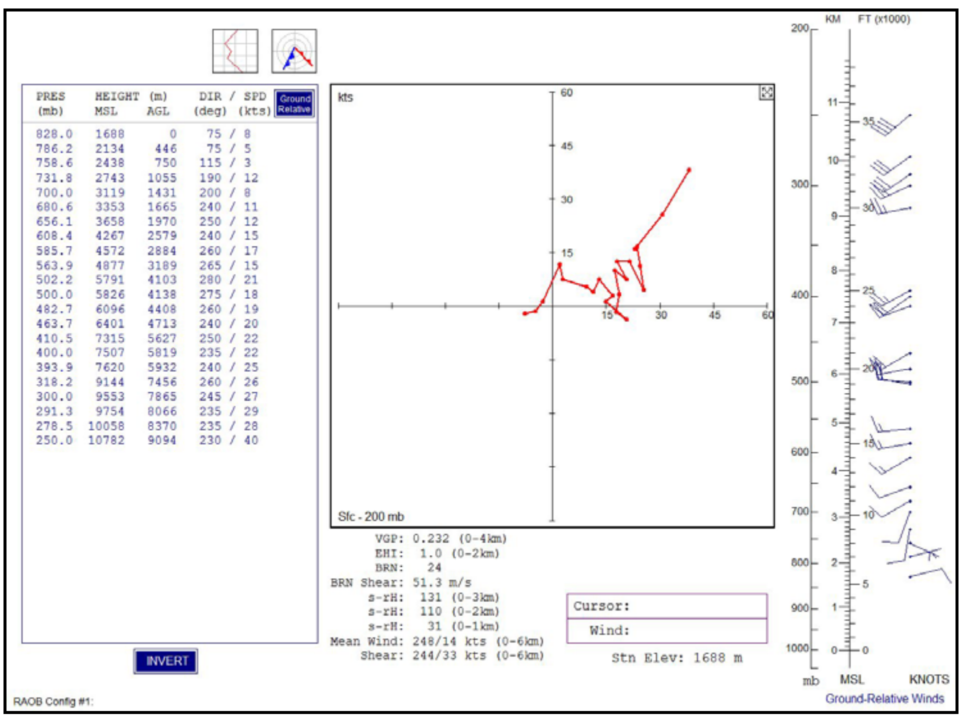

Fig. 15. RIW hodograph (m s^{-1}) at 1800 UTC 6 July 2008.

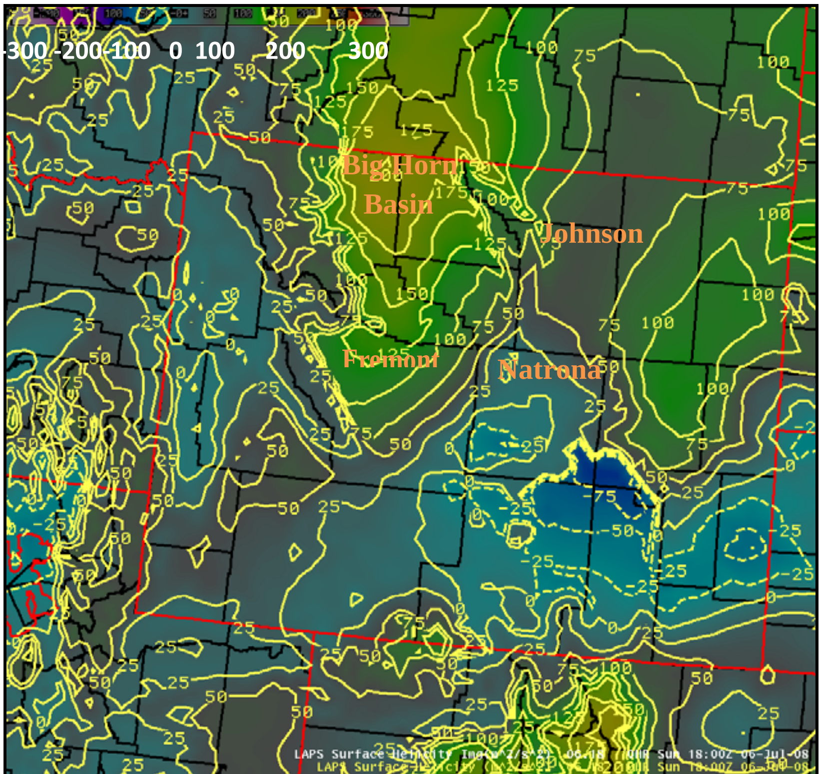

Fig. 16. LAPS analysis of helicity (every 25 $m^2 s^{-2}$; scale at upper left) at 1800 UTC 6 July 2008.

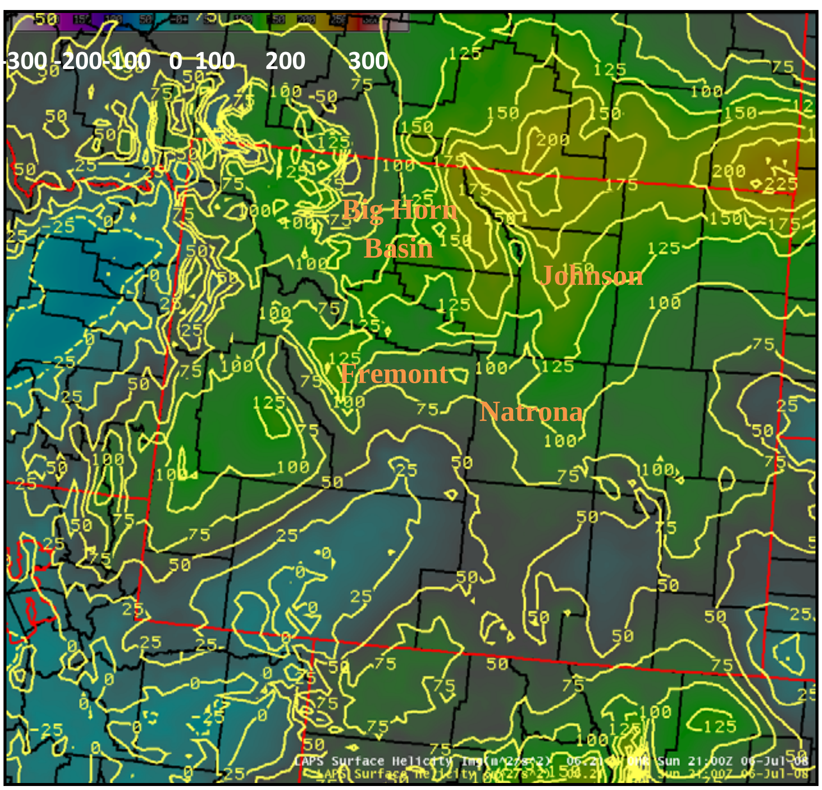

Fig. 17. LAPS analysis of helicity (every 25 $m^2 s^{-2}$; scale at upper left) at 2100 UTC 6 July 2008.

4. Mesoscale Analysis

a. *Instability*

The CAPE and LI from the LAPS analysis indicated moderate instability over eastern Fremont, Johnson and Natrona Counties. The 1800 UTC LAPS analysis for CAPE and LI (Figs. 18 and 19, respectively) had an LI <-4 °C LI over these areas, and CAPE values of >1500 J kg^{-1} over eastern Fremont and Natrona Counties along with CAPE >2000 J kg^{-1} over Johnson County. Across the Big Horn Basin, the LI increased and CAPE decreased somewhat through 2100 UTC (Figs. 18 and 19, respectively). This was likely due to cooling induced by the increased cloud cover and storm-modified environment (Figs. 20 and 21).

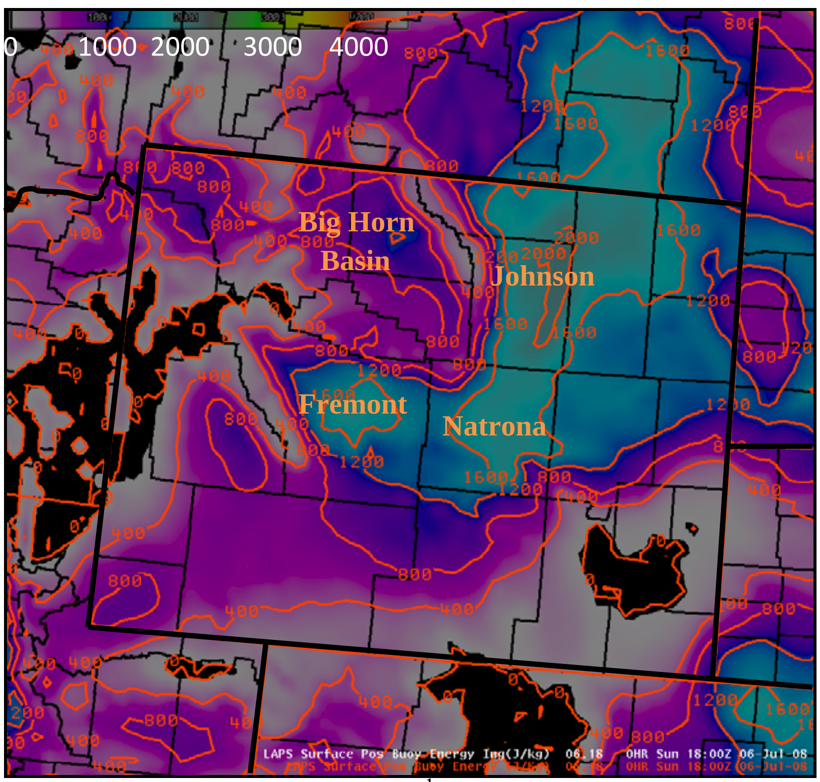

Fig. 18. LAPS analysis of CAPE (every 400 J kg^{-1}; scale at upper left) at 1800 UTC 6 July 2008.

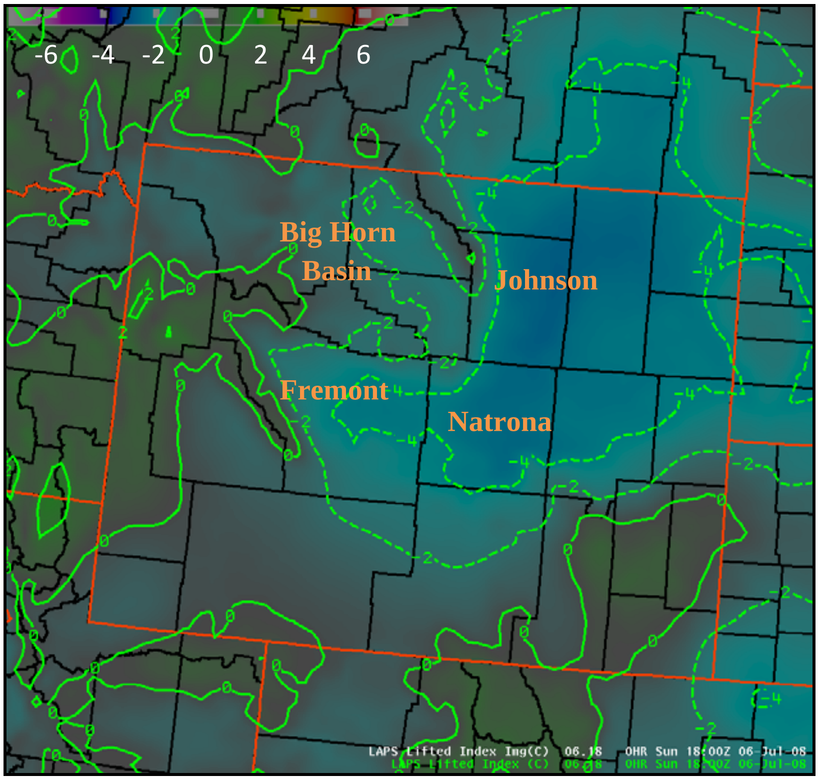

Fig. 19. LAPS analysis of LI (every 2°C; scale at upper left) at 1800 UTC 6 July 2008.

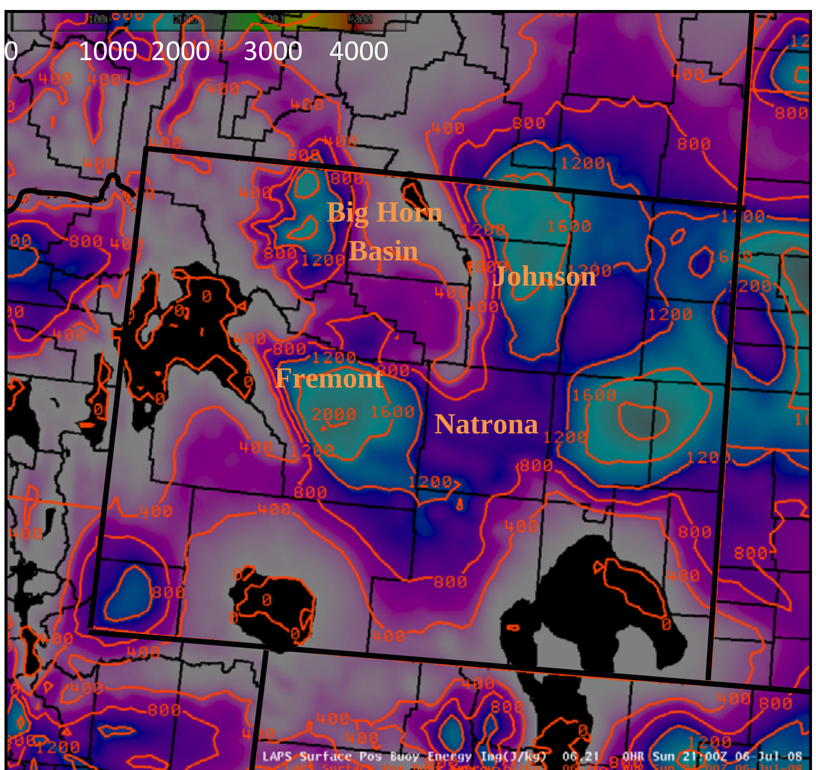

Fig. 20. LAPS analysis of CAPE (every 400 J kg^{-1}; scale at upper left) at 2100 UTC 6 July 2008.

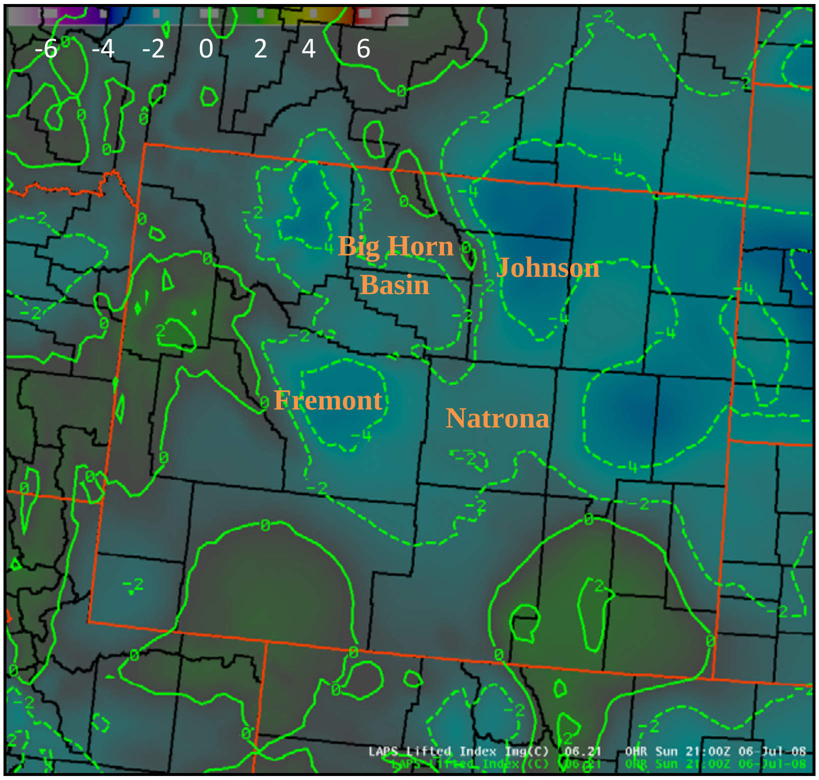

Fig. 21. LAPS analysis of LI (every 2°C; scale at upper left) at 2100 UTC 6 July 2008.

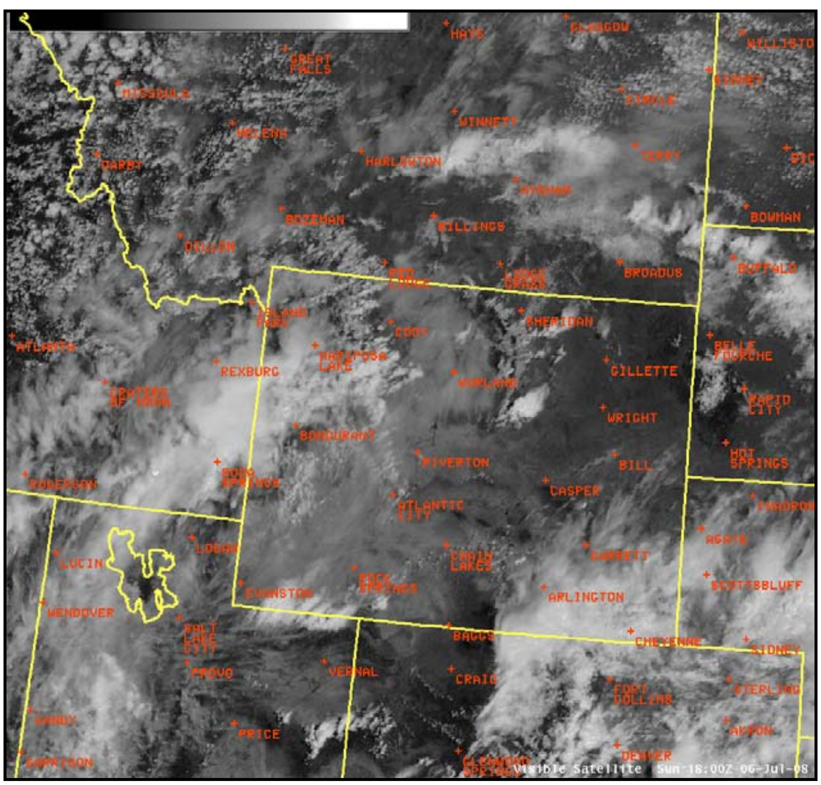

Fig. 22. Visible satellite image at 1800 UTC 6 July 2008.

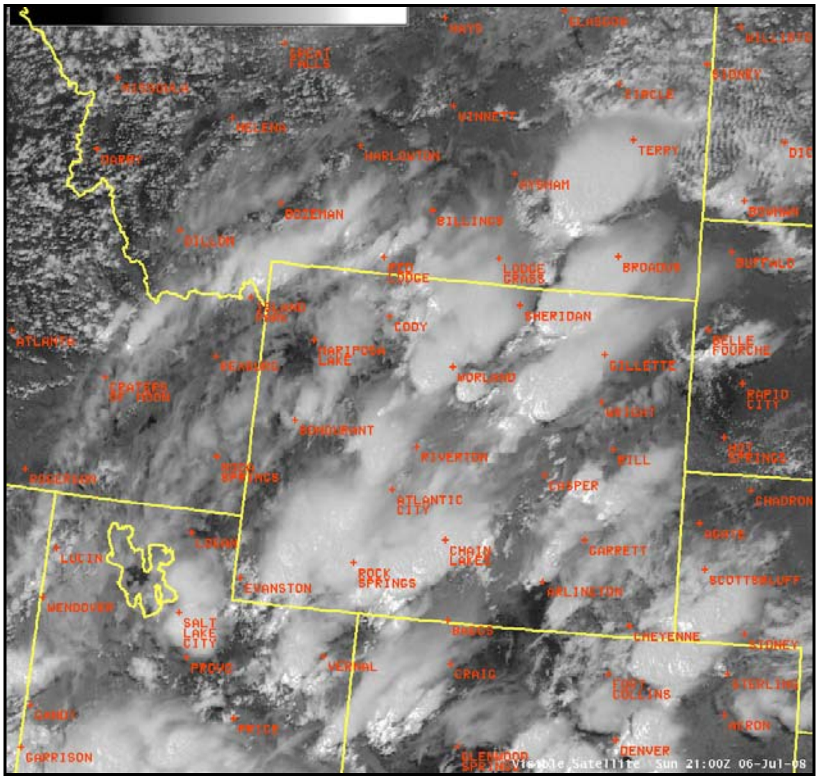

Fig. 23. Visible satellite image at 2100 UTC 6 July 2008.

5. The Event

a. *Southwestern Johnson County*

The first area of interest was over the southeastern Bighorn Mountains in extreme southwestern Johnson County, where a series of back-building cells developed through the early afternoon over favorable moist low-level easterly/upslope flow. The first cell (storm A in Table 1) developed at 1725 UTC and quickly moved away from the mountains and dissipated, only to have another cell form in its place. A typical thunderstorm, this one at 1903 UTC, which formed over this area, is shown in Fig. 24. This persistent back-building process continued through 2044 UTC, which prompted a flash flood warning (FFW) at 1919 UTC. Radar estimated 7.82 inches fell during the 3.5 hour period (Fig. 25). This estimate was possibly hail contaminated because Poker Creek remote automated weather station (RAWS), located nearly under the storms,

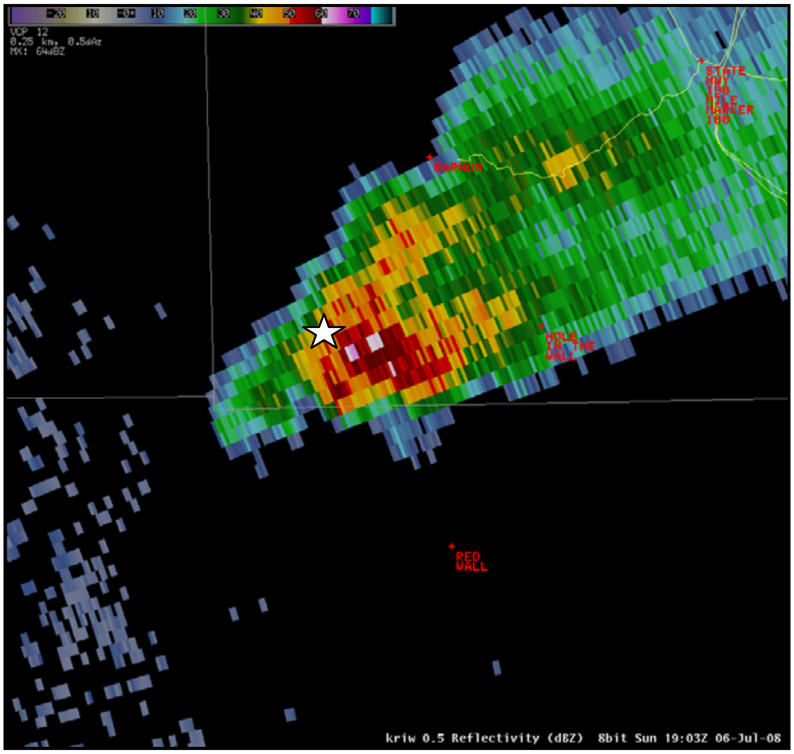

Fig. 24. RIW WSR-88D 0.5° reflectivity (dBZ) at 1903 UTC 6 July 2008.
Star indicates Poker Creek RAWS. Highways are in tan.

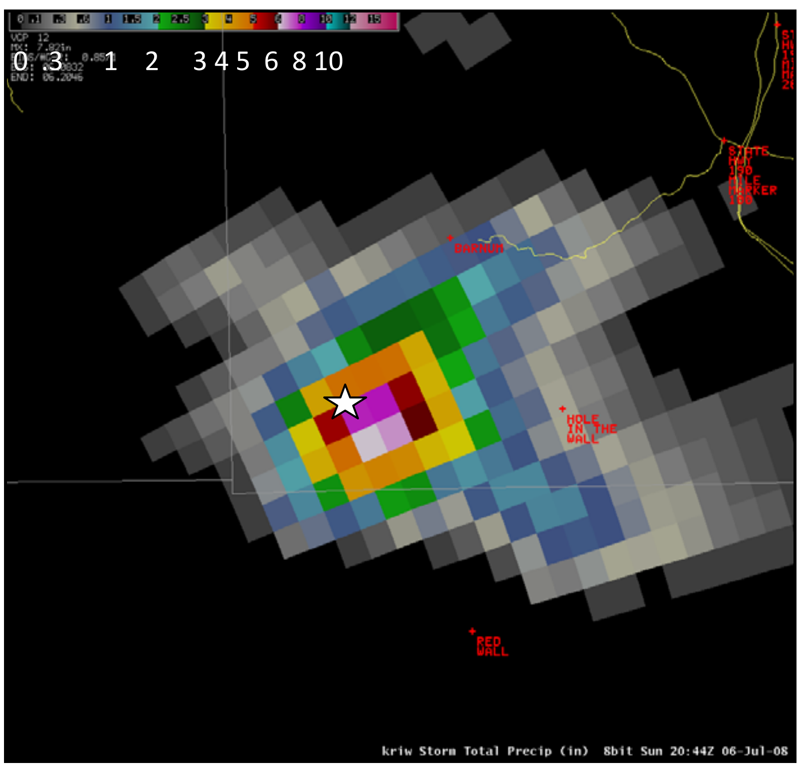

Fig. 25. RIW WSR-88D storm total precipitation (STP, inches) at 2044 UTC 6 July 2008.
Star indicates Poker Creek RAWS. Highways are in tan.

received only 1.26 inches between 1743 UTC through 2043 UTC. However, no reports of flash flooding were received from this sparsely populated area.

b. *Northern Johnson County*

Northern Johnson County was the next area of concern as several thunderstorms formed. Two of these storms became supercells and received warnings (SVRs). A series of three cells (storm B in Table 1) developed 14 miles north of Buffalo near the Sheridan County line around 1932 UTC (Fig. 26). The first moved northeast and exited the RIW CWA into Sheridan County by 1945 UTC. The second developed around Story around 1941 UTC and just clipped Johnson County before moving north. The third and strongest cell of this small cluster developed over Interstate 90 near the county line around 1958 UTC. It moved east about 10 miles and dissipated by 1923 UTC. The radar hail algorithm indicated a maximum diameter of 1.50 inches at 2006 UTC. An SVR was issued at 1939 UTC and a report of one-inch diameter hail was reported in Story, located just inside Sheridan County in the foothills of the Bighorn Mountains.

The next strong thunderstorm to develop was a supercell (storm C in Table 1), which formed at 2011 UTC 10 miles north-northeast of Buffalo, just east of Interstate 90 over rural portions of the county (Fig. 27). One of the most impressive mesocyclones of the event was associated with this storm (Fig. 28). The rotation was deep, evident up to the 1.8° storm-relative velocity elevation slice, to a height of ~40k feet AGL. There was also an impressive gate-to-gate velocity difference of ±114 kts at 0.5° elevation angle at a height of ~15k feet AGL; a tornado was certainly possible. This speed difference between the inbound (green shades) and outbound (red shades) velocity gives an indication of the strength of a mesocyclone. Unfortunately, there was no way to sample to the lower elevations of the storm since it was ~110 nm from the radar (as was the KBLX radar). The storm was relatively short-lived and rotation ceased by 2028 UTC.

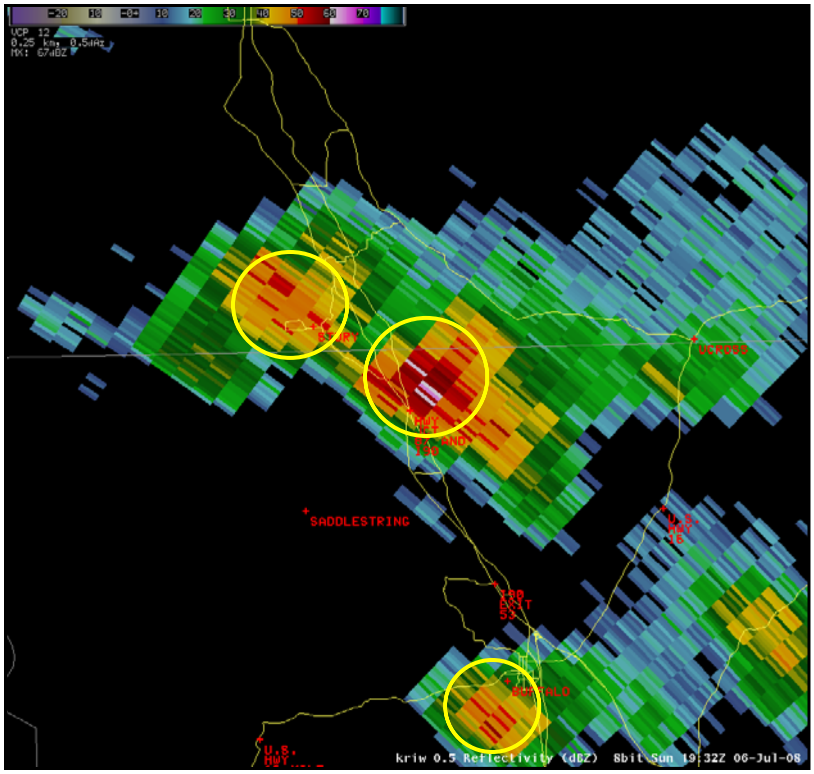

Fig. 26. RIW WSR-88D 0.5° reflectivity (dBZ) at 1932 UTC 6 July 2008. Highways are in tan.

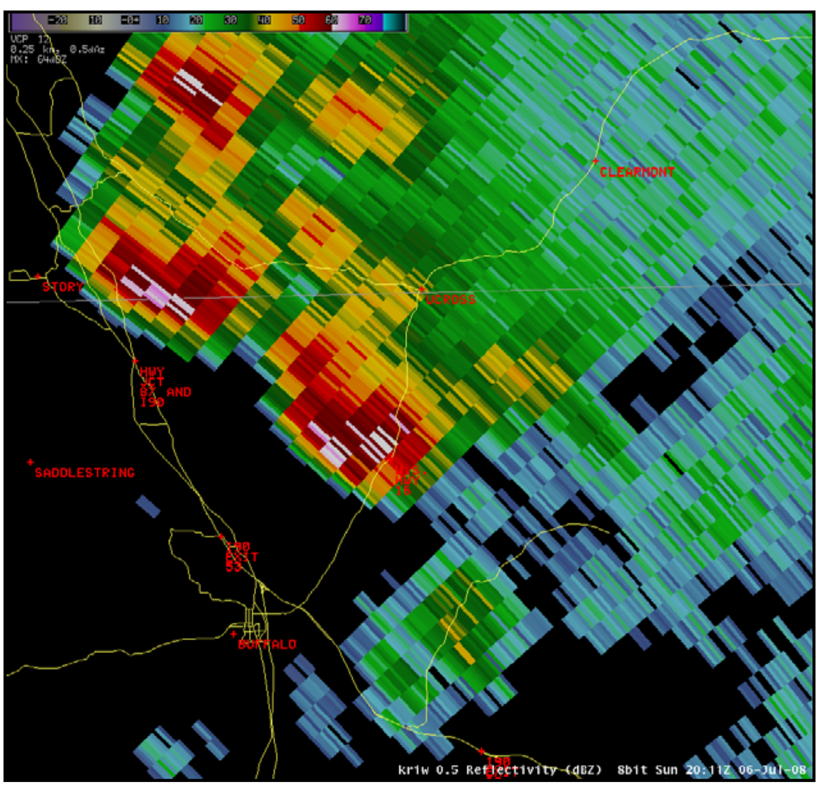

Fig. 27. RIW WSR-88D 0.5° reflectivity (dBZ) at 2011 UTC 6 July 2008. Highways are in tan.

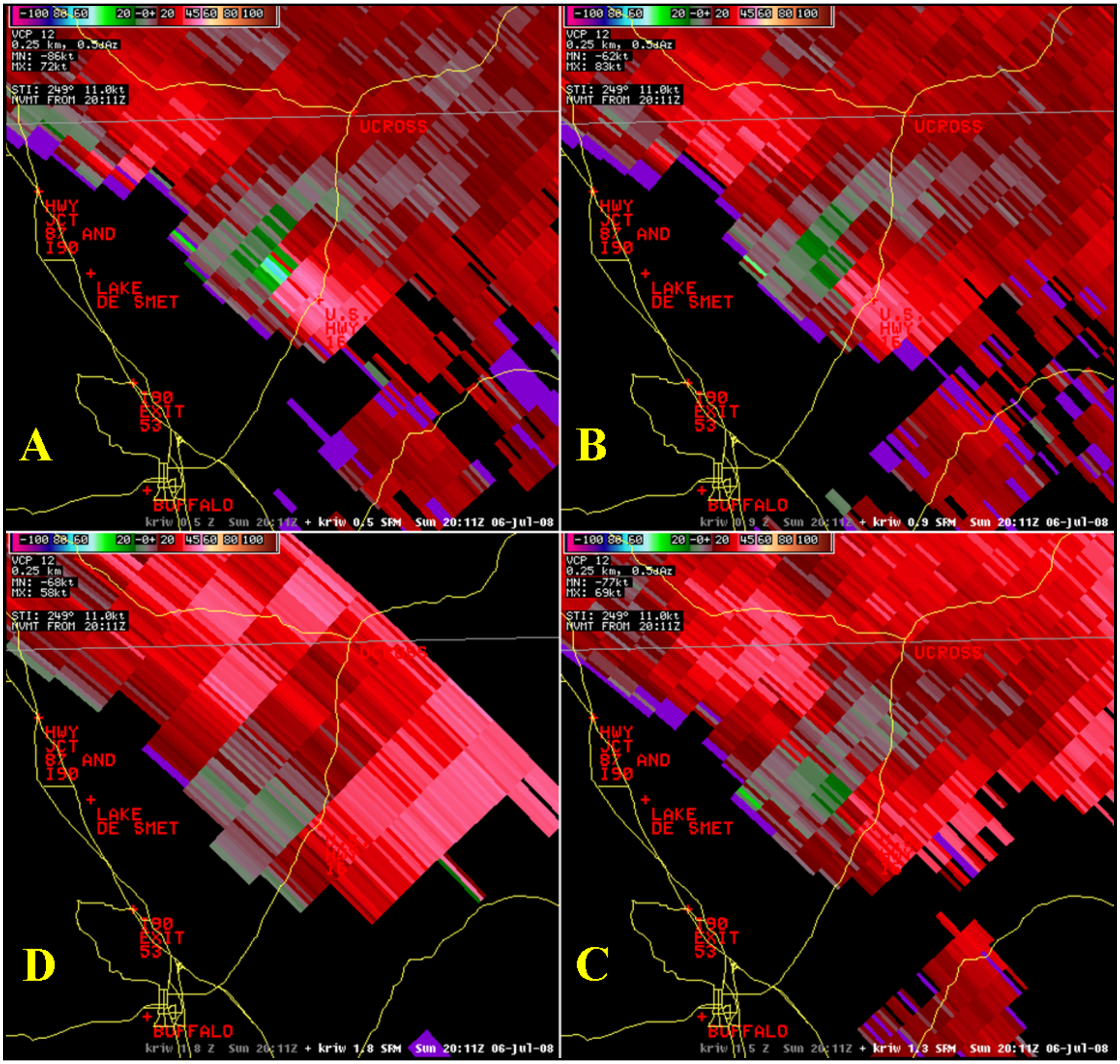

Fig. 28. RIW WSR-88D storm-relative motion (kts) at 2011 UTC 6 July 2008.
Center of each image is approximately 117 nm northeast of radar. Highways are in tan.
Note: Storm motion is 249° at 11kts.
A - 0.5° elevation; 16.5k ft AGL, B - 0.9° elevation; 21.4k ft AGL,
C - 1.5° elevation; 26.4k ft AGL, D - 1.8° elevation; 32.6k ft AGL

The second supercell (storm D in Table 1) in Johnson County developed around 2053 UTC 4 miles north-northeast of Buffalo (Fig. 29). The storm intensified quickly and maintained a rotating updraft up to the 1.8° elevation slice (Fig. 30). It began turning right of the mean flow (from the southwest) at 2101 UTC traveling to the east. The storm maintained this track long after it exited the Riverton CWA into Campbell County at 2243 UTC, staying well north of Interstate 90 over rural, sparsely populated terrain. Radar indicated a maximum hail size of 4.0 inches at 2140 UTC. A report of nickel-sized (0.88 inch) hail was received from a spotter at 2144 UTC 14 miles northeast of Buffalo.

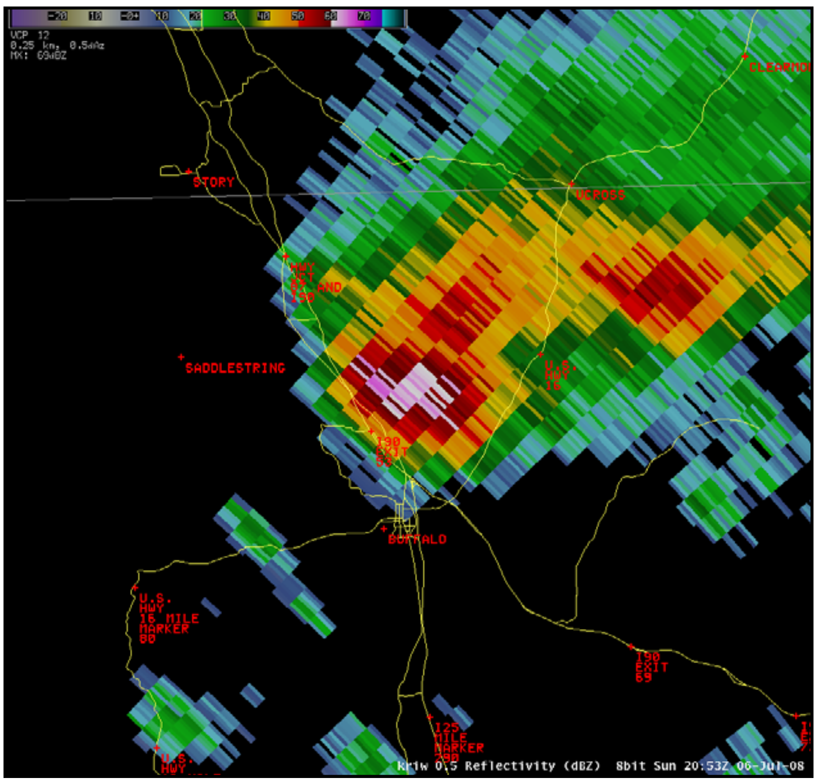

Fig. 29. RIW WSR-88D 0.5° reflectivity (dBZ) at 2053 UTC 6 July 2008. Highways are in tan.

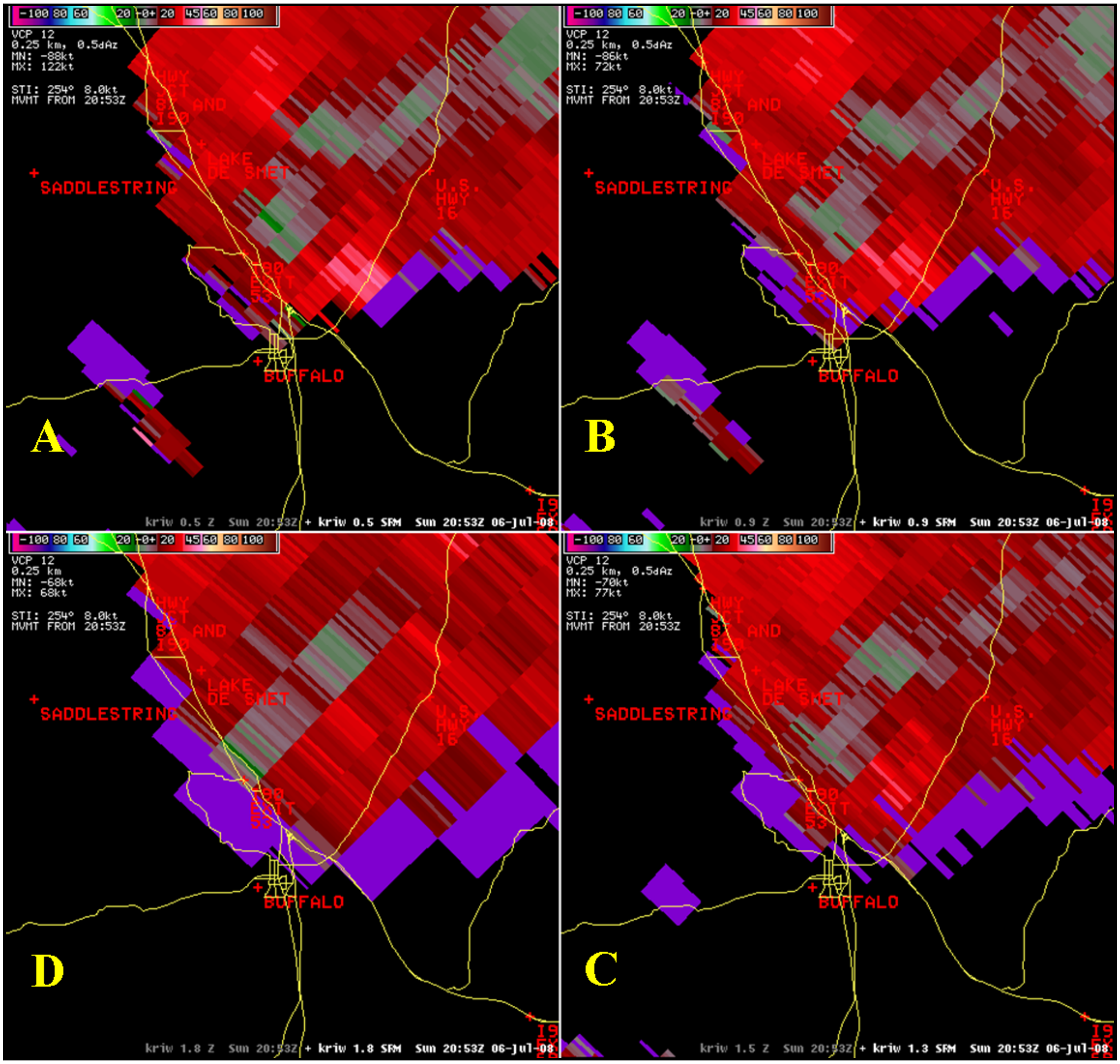

Fig. 30. RIW WSR-88D storm-relative motion (kts) at 2053 UTC 6 July 2008.
Center of each image is approximately 112 nm northeast of radar. Highways are in tan.
Note: Storm motion is 254° at 8 kts.
A - 0.5° elevation; 15.1k ft AGL, B - 0.9° elevation; 19.8k ft AGL,
C - 1.5° elevation; 24.6k ft AGL, D - 1.8° elevation; 30.5k ft AGL

c. *Hot Springs County*

Western and southern Hot Springs County was the next focus area where a supercell formed near Anchor Reservoir, and a strong nonsupercell thunderstorm formed over the southeastern portion of the county. A cluster of showers and weak thunderstorms that formed over the northern Wind River Mountains in the late morning moved northeast across the upper Wind River Basin and over the western Owl Creek Mountains, and began to intensify around Anchor Reservoir in western Hot Springs County. A few sub-severe thunderstorms produced pea-sized hail around the Anchor Reservoir and Grass Creek areas between 1850 UTC and 2030 UTC, before the first strong storm developed around Anchor Reservoir.

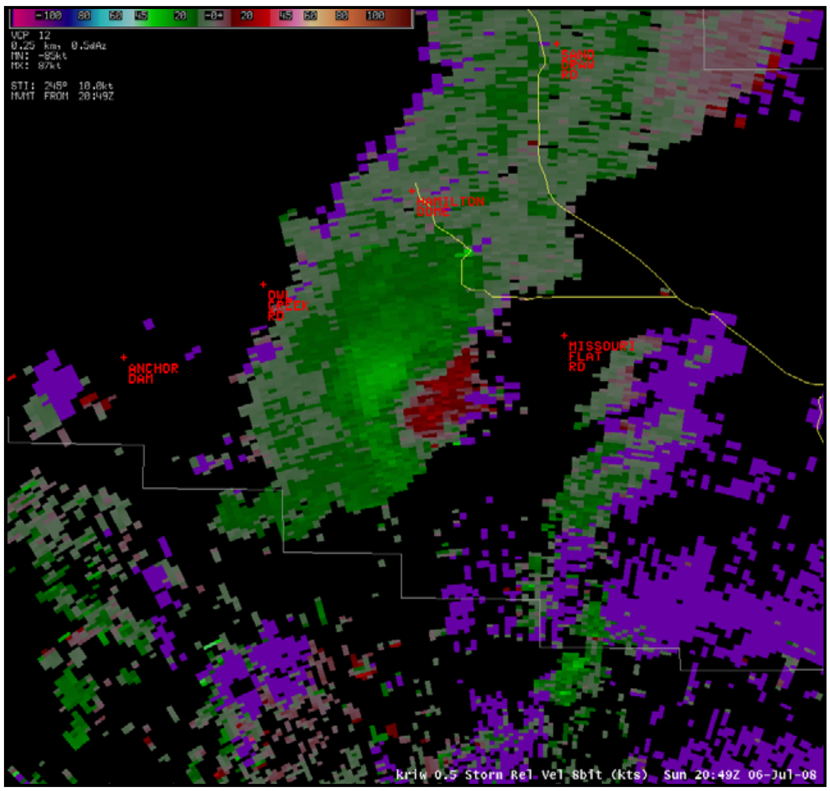

Fig. 31. RIW WSR-88D 0.5° storm-relative motion (kts) at 2049 UTC 6 July 2008. Highways are in tan. Center of image is ~35 nm north of the radar.

At 2049 UTC, rotation was first detected when the storm (storm E in Table 1) was 19 miles west of Thermopolis (Fig. 31). The core reflectivity intensified during the next volume scan at 2054 UTC with a maximum reflectivity of 78.5 dBZ (Fig. 32). The storm displayed supercell characteristics and its motion deviated to the right of the shear vector, traveling east along the north slope of the Owl Creek Mountains through 2118 UTC. Subsequently, the storm lost its mesocyclone and began moving with the mean southwest flow. A few reports of dime-sized hail were received from just northwest of Thermopolis as the storm crossed state highway 120.

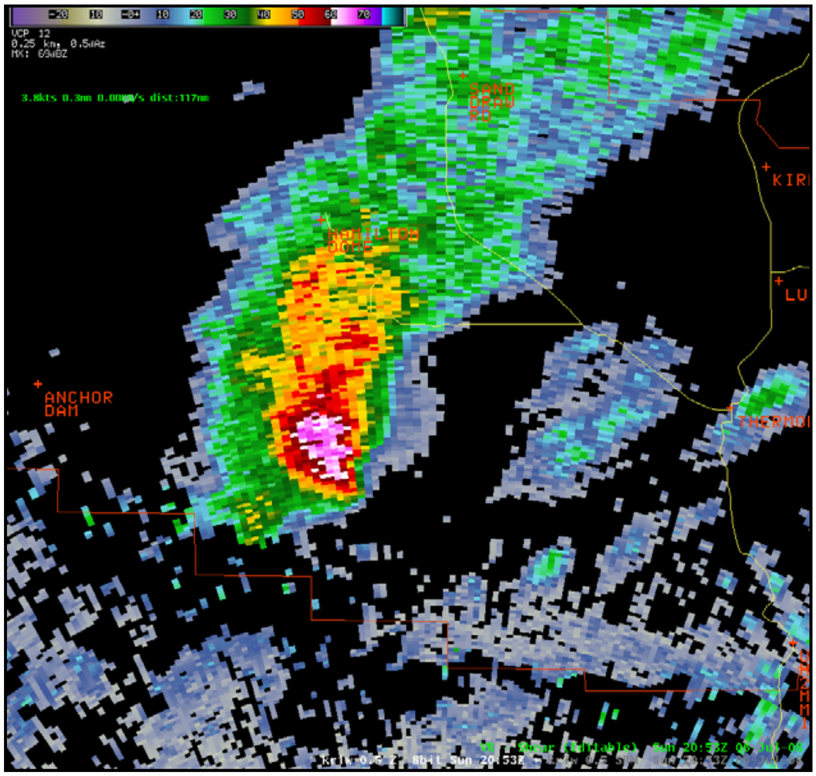

Fig. 32. RIW WSR-88D 0.5° reflectivity (dBZ) at 2053 UTC 6 July 2008. Highways are in tan.

Next, a strong thunderstorm (storm F in Table 1) rapidly developed 15 miles east-southeast of Thermopolis at 2044 UTC along the north slope of the Bridger Mountains. By 2114 UTC, the storm had a max reflectivity of 79 dBZ (Fig. 33) with a radar-estimated maximum hail size of 3.75 inches. At this same time, the reflectivity data indicated the storm was about to split, which it did on the next scan at 2118 UTC. However, the velocity data did not detect rotation with this storm. The right split was the dominant half, likely producing some small hail through 2148 UTC. The left split was weak and gradually dissipated as it moved into southern Washakie

County, which is supported by the veering profile indicated on the 1800 UTC hodograph (Fig. 15).

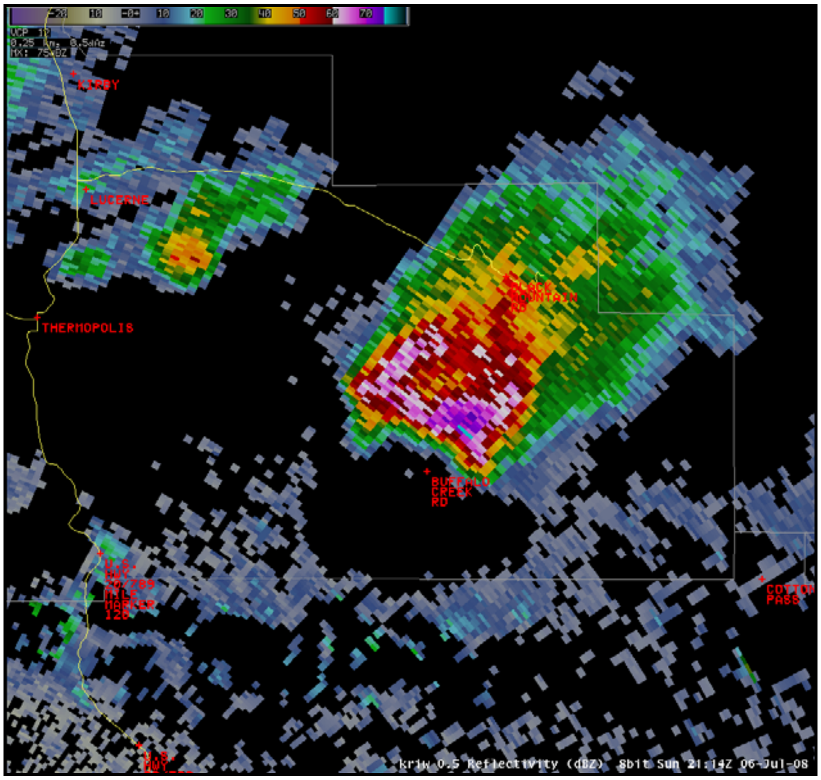

Fig. 33. RIW WSR-88D 0.5° reflectivity (dBZ) at 2114 UTC 6 July 2008. Highways are in tan.

d. *Natrona County*

The northern half of Natrona County became active after 2130 UTC where several short-lived (≤30 min) thunderstorms developed. The first of the stronger cells (not shown; storm G in Table 1) formed 17 miles north of Waltman at 2144 UTC and had split and weakened by 2205 UTC.

A stronger and longer-lived storm (storm H in Table 1) formed along Interstate 25, 11 miles southwest of Midwest around 2214 UTC. This cell went through three distinct intensification/weakening cycles in its life, with the third being the most impressive. The storm traveled south-southeast nearly parallel to Interstate 25. During the third and final pulse, it traveled southwest back over Interstate 25 near exit 210 at 2252 UTC. This occurred as a weaker cell, moving with the mean flow (from the southwest), and intersected the stronger storm. Both cells intensified rapidly (Fig. 34) at 2256 UTC just before they merged. Another weaker cell also underwent intensification just to the west of the interstate as it intersected and merged with the pair at 2313 UTC. The conglomerate maintained a 73-dBZ core for another two volume scans before weakening at 2326 UTC. Reports of accumulating nickel- and quarter-sized hail, as well as near zero visibility with the hail and very heavy rainfall, were received from motorists along the interstate at 2315 UTC.

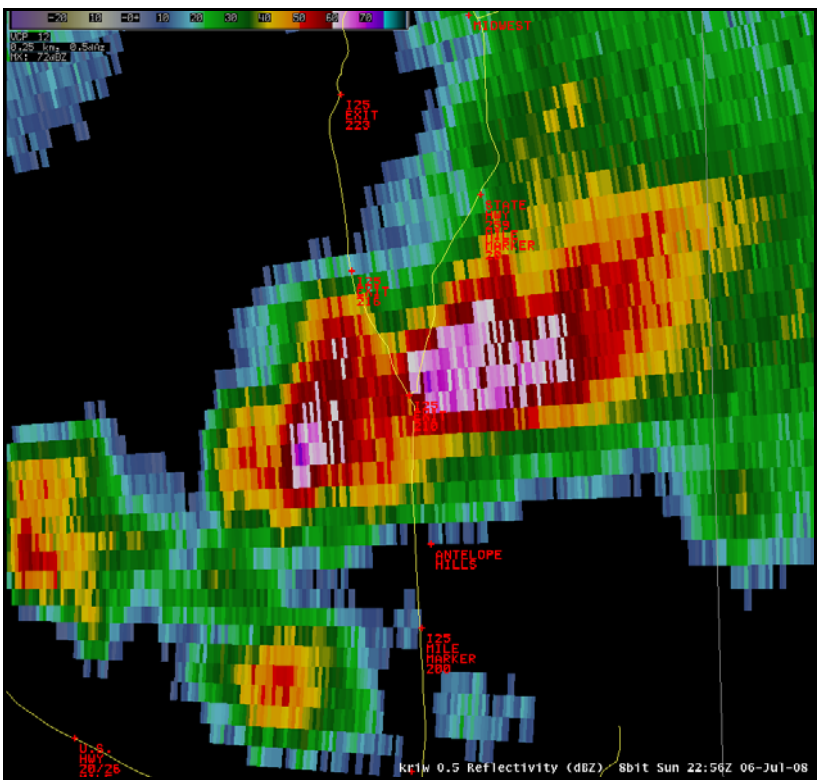

Fig. 34. RIW WSR-88D 0.5° reflectivity (dBZ) at 2256 UTC 6 July 2008. Highways are in tan.

e. ***Eastern Fremont County***

The final area of interest of the day was over southern and eastern Fremont County along the Beaver Creek Divide and the Gas Hills area where the most impressive storm of the day developed. The initial cell rapidly developed 8 miles northwest of Sweetwater Station around 2144 UTC, as outflow boundaries from the northwest and south collided along the Beaver Creek Divide (Fig. 35). Other storms developed along the divide over the next few volume scans. The second significant storm (storm I in Table 1) formed along US 287 at Beaver Creek Divide at 2205 UTC and was at its strongest at 2214 UTC (Fig. 36).

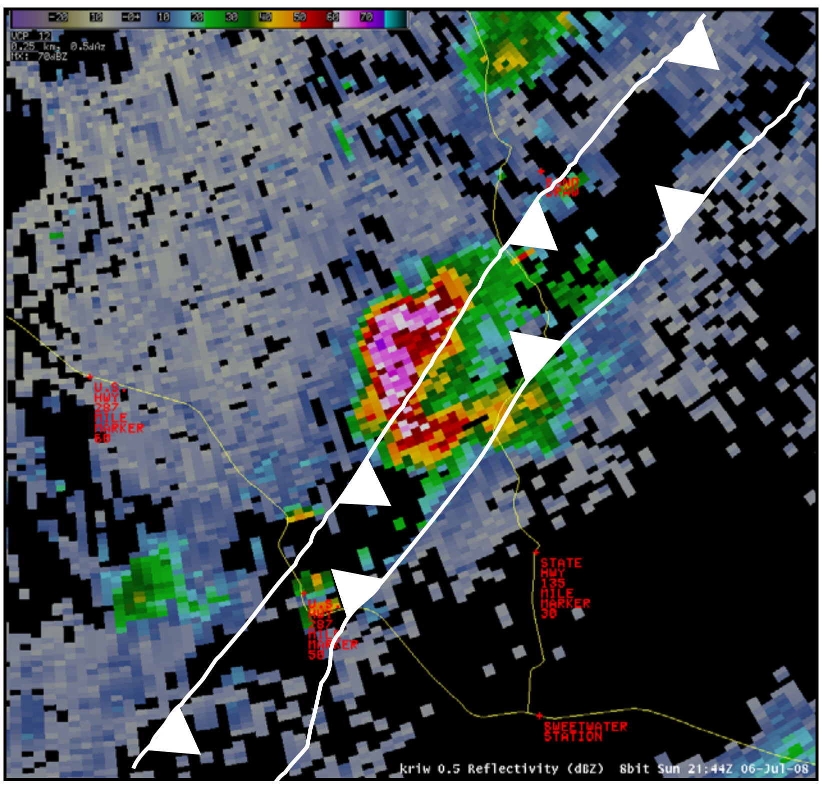

Fig. 35. RIW WSR-88D 0.5° reflectivity (dBZ) at 2144 UTC 6 July 2008. Highways are in tan. White lines and triangles represent outflow boundaries.

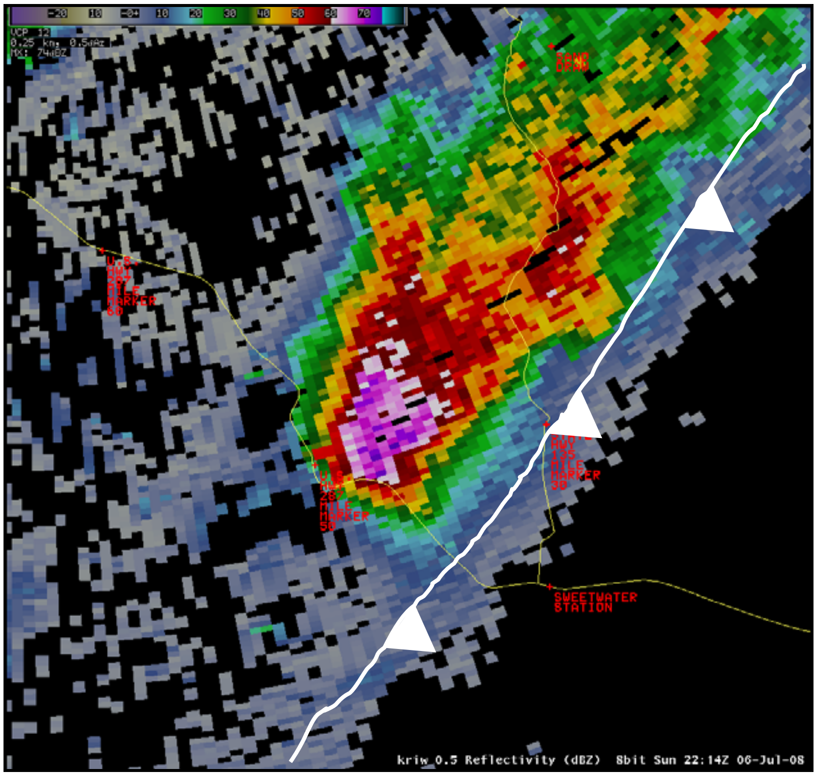

Fig. 36. RIW WSR-88D 0.5° reflectivity (dBZ) at 2214 UTC 6 July 2008. Highways are in tan. White line and triangles represent outflow boundary.

The storms further northeast along the Beaver Creek Divide interacted with outflow boundaries originating from the Hot Springs County storms to the north and the Natrona County storms from the east. By 2309 UTC, a rapid intensification of a few already strong cells occurred just north of Wyoming 135 as they met the two colliding outflow boundaries. The resulting intense storm rapidly developed a relatively large crescent-shaped 81-dBZ core and a well-defined mesocyclone by 2313 UTC (Figs. 37 and 38). The storm had a well-defined hook echo at the 2.4° and 3.1° elevation slices. The radar indicated an estimated maximum hail size of 4.75 inches at this time as well. The supercell maintained this intensity only through 2330 UTC, and then rapidly diminished as it entered a storm-modified, stable environment in western Natrona County. Like many of the earlier storms, this one occurred over a rural area void of spotters, so no ground truth was ascertained.

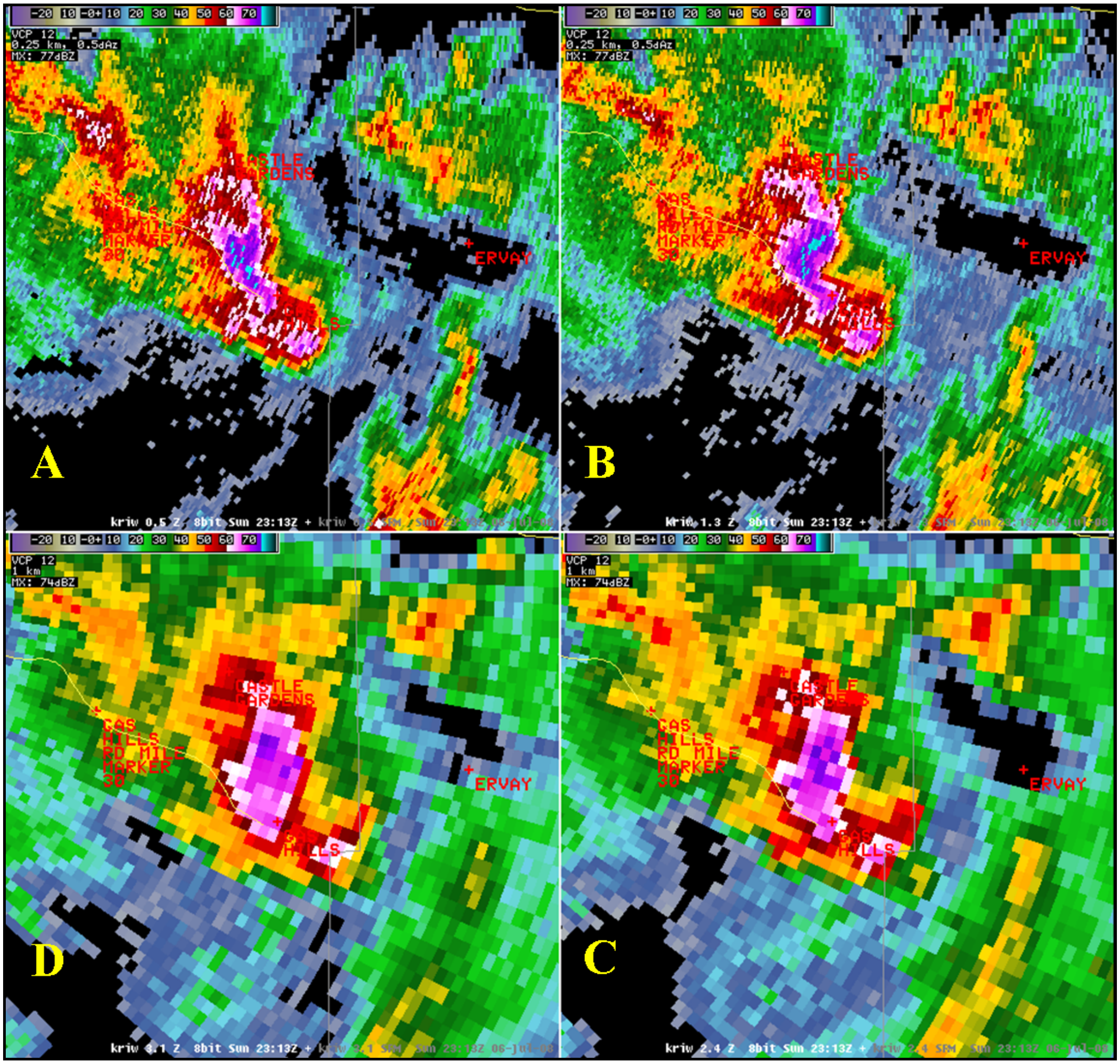

Fig. 37. RIW WSR-88D reflectivity (dBZ) at 2214 UTC 6 July 2008. Highways are in tan.
A - 0.5° elevation, B - 1.3° elevation, C - 2.4° elevation, D - 3.1° elevation

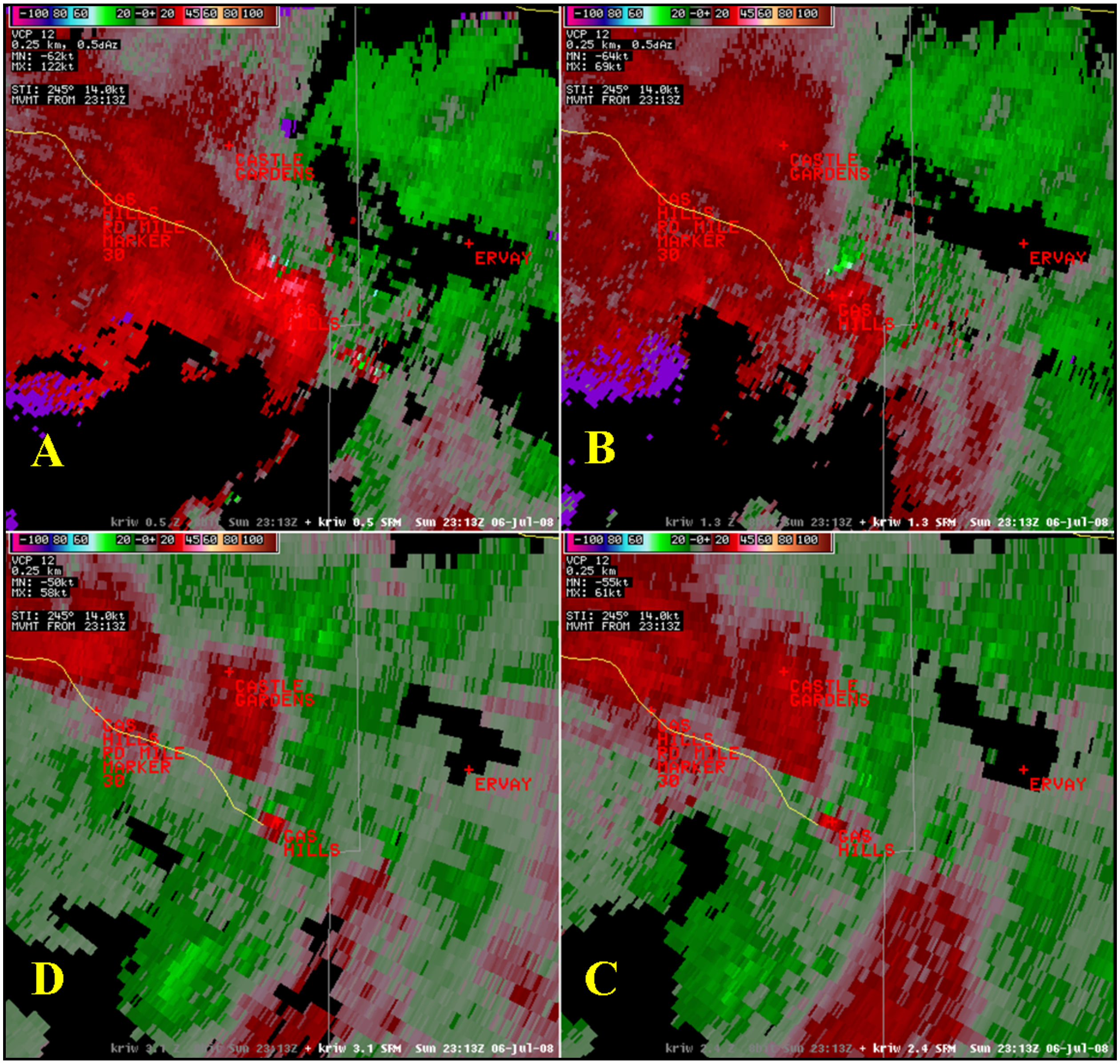

Fig. 38. RIW WSR-88D storm-relative motion (kts) at 2313 UTC 6 July 2008.
Highways are in tan. Center of each image is approximately 41nm east southeast of radar.
A - 0.5° elevation; 2.4k ft AGL, B - 1.3° elevation; 6.0k ft AGL,
C - 2.4° elevation; 10.8k ft AGL, D - 3.1° elevation; 13.9k ft AGL

6. Operations Overview

The event was forecast well in advance, with severe weather indicated in the Hazardous Weather Outlook (HWO) beginning on Thursday, 3 July 2008. In the late morning on the day of the event, the day shift at RIW called in an additional forecaster and intern to assist with operations. The warning team consisted of a coordinator, two warning forecasters, and two data collectors. Warning responsibilities for the RIW CWA were sectorized into two areas: Johnson and Natrona Counties and the Big Horn Basin and Fremont County.

The forecasters coordinated with the Storm Prediction Center (SPC) on the impending event and Severe Thunderstorm Watch 660 was issued at 1934 UTC, with an initial expiration time of 0300 UTC on 7 July 2008. Forecasters canceled the watch at 0048 UTC 7 July 2008 as the storms moved into a more stable atmosphere and weakened.

The radar operated in volume coverage pattern (VCP) 12 (NOAA 2006; Brown et al. 2005) throughout the entire event. There were no performance issues. The environmental wind and temperature data (inputs for radar-based algorithms) had been updated using values from the 1800 UTC sounding, which allowed for the most accurate radar-estimated storm motion and hail size. Range folding concerns were rare and were corrected by changing the pulse repetition frequency (PRF).

Between the two forecasters, 21 SVRs as well as two FFWs were issued between 1919 UTC and 2313 UTC across six counties. Numerous follow-up statements (SVSs and FLSs) were issued as well. Numerous calls were made across these areas soliciting reports. However, given the remoteness and lack of population under most of the storms, few of the warnings were verified. Fig. 39 displays the warning boxes (color corresponds to storms in Table 1) and spotter locations. Note the large expanses containing few or no spotters, as most of these areas are sparsely populated, if at all. This fact has made severe thunderstorm verification extraordinarily difficult in western and central Wyoming.

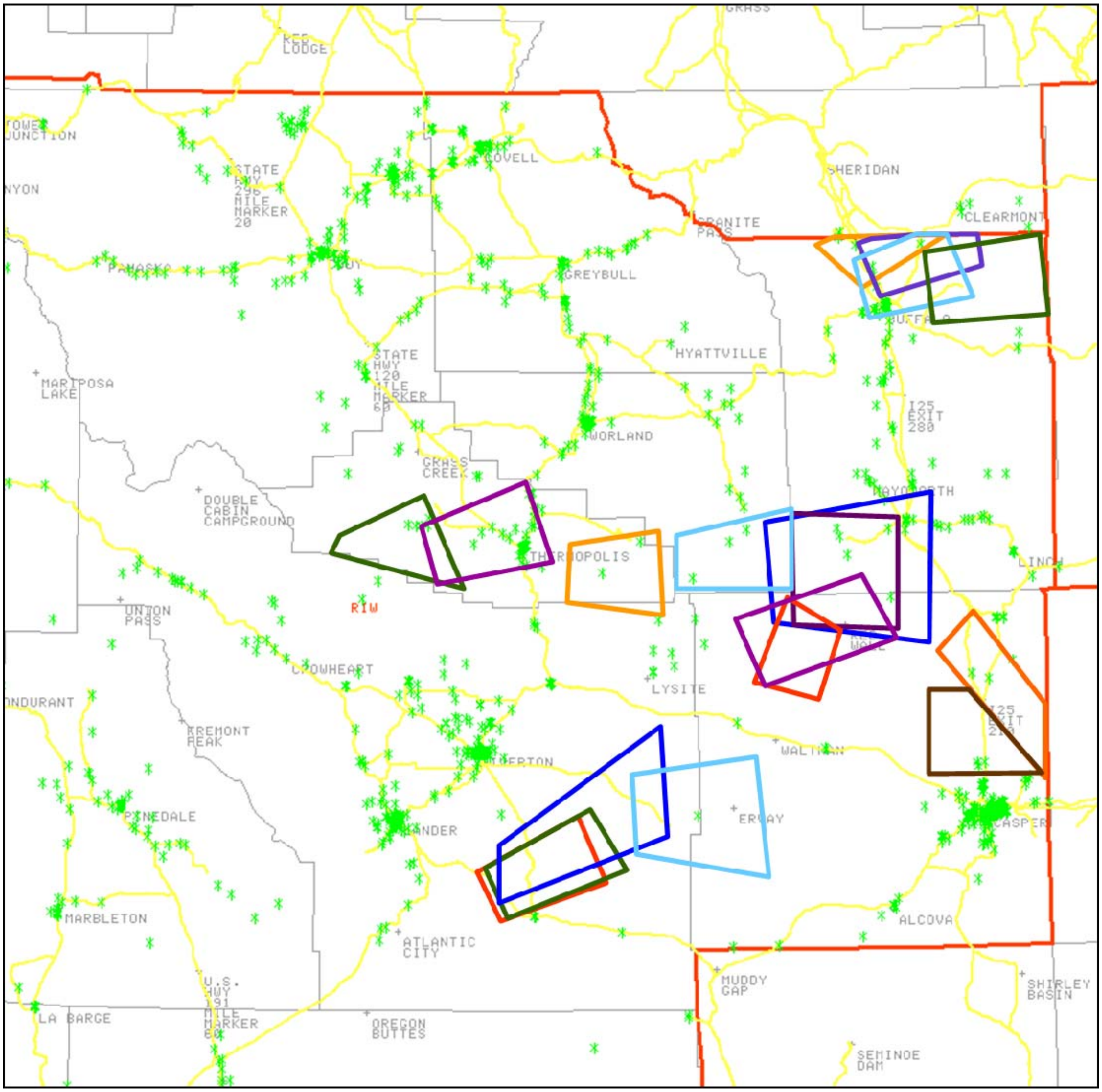

Fig. 39. Area map showing warning boxes (colored polygons, corresponds to storms in Table 1) and spotter locations (green asterisks) and highways (yellow lines). (*Note that boxes are shown only for the stronger thunderstorms included in this study*)

7. Summary and Conclusion

A Pacific trough embedded within a near zonal flow regime moved into the northern Rockies during the afternoon of 6 July 2008, producing a west-southwest flow over central Wyoming. Two upper-level jets combined with low-level directional shear east of the Continental Divide over central Wyoming, as well as moderate instability, and produced a favorable environment for supercell and strong thunderstorm development.

At least four supercells and numerous other strong/severe thunderstorms developed over portions of central Wyoming through the afternoon. Two of the supercells formed over northern Johnson County, one over western Hot Springs County and the strongest of the day over eastern Fremont County. Several intersecting outflow boundaries appeared to affect the development of the Fremont County supercell.

Obtaining storm reports/verification was the main issue during this event. Nearly all of the storms tracked over sparsely populated, spotter-void regions (Fig. 39), with only 3 of the 21 SVRs and none of the 2 FFWs verified.

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Storm	Type[1]	Approx Location of Development	Begin/ End Time (UTC)[2]	Warned Time (UTC)	Max Ref (dBZ) Time (UTC)	Max Hail (in)[3] Time (UTC)	Max Top (k ft MSL)[4] Time (UTC)	Ground Truth
A	M	19 SW Kaycee	1742 2127	1919-2045 2027-2245	64 Numerous	2.0 1941	56 2032	1.26" rainfall Poker Creek RAWS ~3hrs ending 2043 UTC
B	M	16 NNW Buffalo	1920 2023	1938-2030	71.5 206	1.5 206	56 2011	No reports
C	S	9 N Buffalo	1954 2057	2008-2100	68.5 2002	2.0 2002	56 2053	No reports
D	S	4 NNE Buffalo	2032 2351*	2059-2145 2149-2245	75.0 216	4.0 2140	57 2057	0.88 inch hail 14 NE Buffalo (2144 UTC)
E	S	28 W Thermopolis	2023 2209	2030-2115 216-2145	78.5 2054	3.25 2049	50 2101	Dime-size hail 24 W Thermopolis on WY 170 and 2-4NW of Thermopolis on Wyoming 120
F	C	15 ESE Thermopolis	2049 2256	2059-2145 2147-2230	78.5 2114	3.75 2110	54 2053	Pea-sized hail and intense rainfall with flooding, hay bales floating in fields 26.6 S Ten Sleep.
G	M	17 N Waltman	2118 2235	2119-2145 2156-2300	68.5 2157	1.5 2148	47 2157	No Reports
H	M	11 SW Midwest	2205 2330	2221-2315 2304-2345	72.5 2300	3.25 2256	56 2218	Nickel and quarter-sized hail and near zero visibility near exit 210 on Interstate 25.
I	M	8 NW Sweetwater Station	2201 2347	2211-2300 2247-2330	75.0 2214	3.25 2205	54 2231	No reports

Storm	Type[1]	Approx Location of Development	Begin/ End Time (UTC) [2]	Warned Time (UTC)	Max Ref (dBZ) Time (UTC)	Max Hail (in)[3] Time (UTC)	Max Top (k ft MSL)[4] Time (UTC)	Ground Truth
J	S	25 ESE Riverton	2205 2347	2259-2345 2313-0000	81.0 2317	4.75 2305& 2309	52 2300	No reports

Table 1 - Thunderstorm summary table (warning time colors match warning polygons in Fig. 39.)

1 - C = Single cell, M = Multi-cell, S = Supercell
2 - The times (UTC) the first and last ≥50 dBZ occurred
3 - Maximum hail estimated by the WSR-88D hail algorithm (HI).
4 - Cloud top based on the WSR-88D enhanced echo top algorithm (EET).
* - Cell exited Johnson County/CWA at 2248 into Campbell County

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