Environment Favorable for a Rare Tornado in Northern Montana 13 June 2006

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1. Introduction

Along Montana’s northern Rocky Mountain Front tornados are extremely rare. The Storm Prediction Center database (SPC 2005) shows that from 1950 to 2005, only two tornados were reported in Glacier County, Montana. This report will highlight the conditions that preceded the development of tornados in this area on the evening of June 13, 2006.

This portion of Montana is in a unique position relative to the advection of low level moisture. Elevation rises from east to west, so shallow low-level moisture to the east may not be of sufficient depth to influence this area as it advects from the east. Note the shading change from darker to light blue crossing into Glacier County on Figure 1. Higher terrain along the international border also blocks low level moisture in Alberta from southward movement (Fig.1). Additionally, westerly down slope winds often dry and cap whatever moisture may move in. All of these factors make the formation of a tornado even more of a rarity.

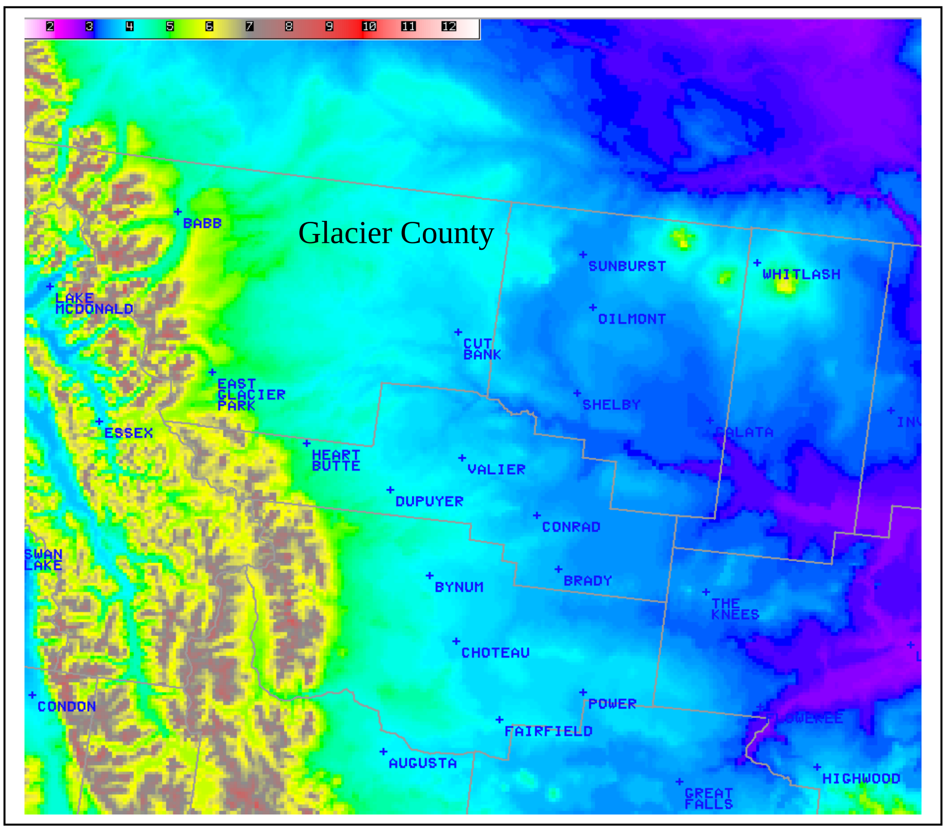

Figure 1. Topography of the area. The darker blues are elevations less than 3500 feet MSL, while the light blue and light green colors depict 4000 to 4500 feet MSL. Cut Bank is near the center of the graphic, Great Falls is in the lower right.

2. Discussion

On June 13, 2006, a surface trough of low pressure lay north-south over western Montana (Fig 2). East winds prevailed in a moist and unstable atmosphere around surface high pressure over Saskatchewan. Two surface boundaries existed, one associated with the surface trough in western Montana, and the other over southern Alberta. Aloft, an upper level trough was over the Pacific Northwest, with a relatively strong jet streak poised over the Great Basin. The pattern also indicated an area of diffluence aloft over the area of concern in northern Montana (Fig. 3). The mid-day sounding at Great Falls (Fig. 4) indicated a strong directional shear profile in the lower portion of the atmosphere. Strong instability was also of note as indicated by the forecast NAM lapse rates during the late afternoon (Fig. 5).

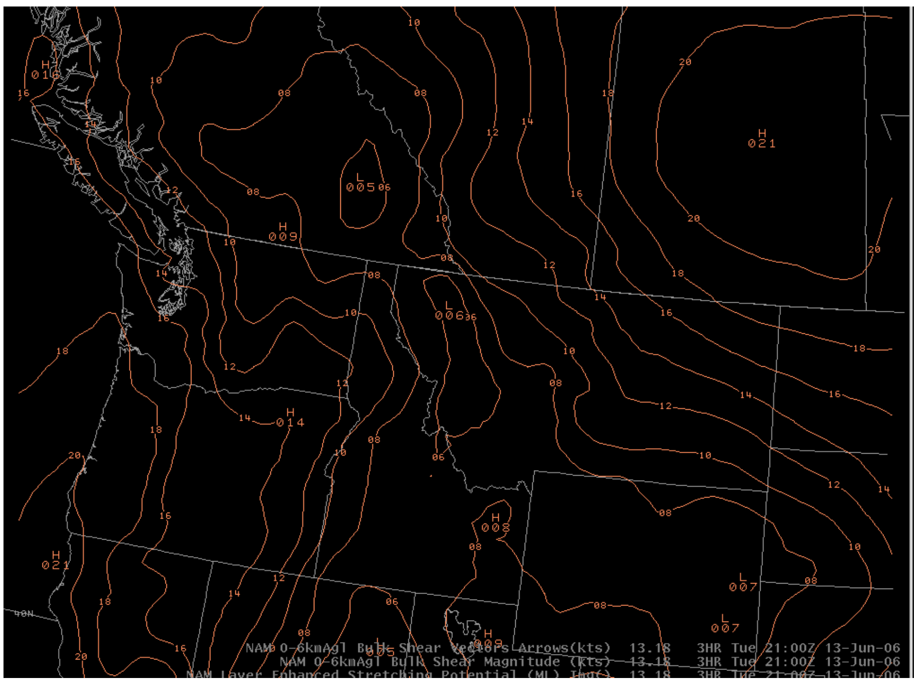

Figure 2. Surface patterns NAM forecast at 2100 UTC 13 June 2006.

As expected, thunderstorms developed across western Montana during the late afternoon. During the course of the day, the low-level shear profile strengthened, but lower clouds developed in an upslope area between Cut Bank and the Rocky Mountains. This would serve to delay convective development in this area. At the same time, moisture convergence continued with dew point temperatures nearing 60°F. MSAS and LAPS analyses were handicapped a bit due to missing observations from Cut Bank and Havre. Supplemental observations in the area served to fill in some of the gaps, but were not as timely.

The forecast sounding from the NAM (Fig. 6), showed the continued strong directional shear in the lower 2 km of the atmosphere. The CAPE (1580 J kg^{-1}) and helicity (145 m^2 s^{-2}) values were also relatively high at this time. Helicity values of 150 m^2 s^{-2} are considered the lower limit for super cell development (Thompson et al. 2003). CAPE values over 1000 J kg^{-1} are rare in this area. The surface boundary and the surface low pressure area continued to provide a focus for expected severe convection.

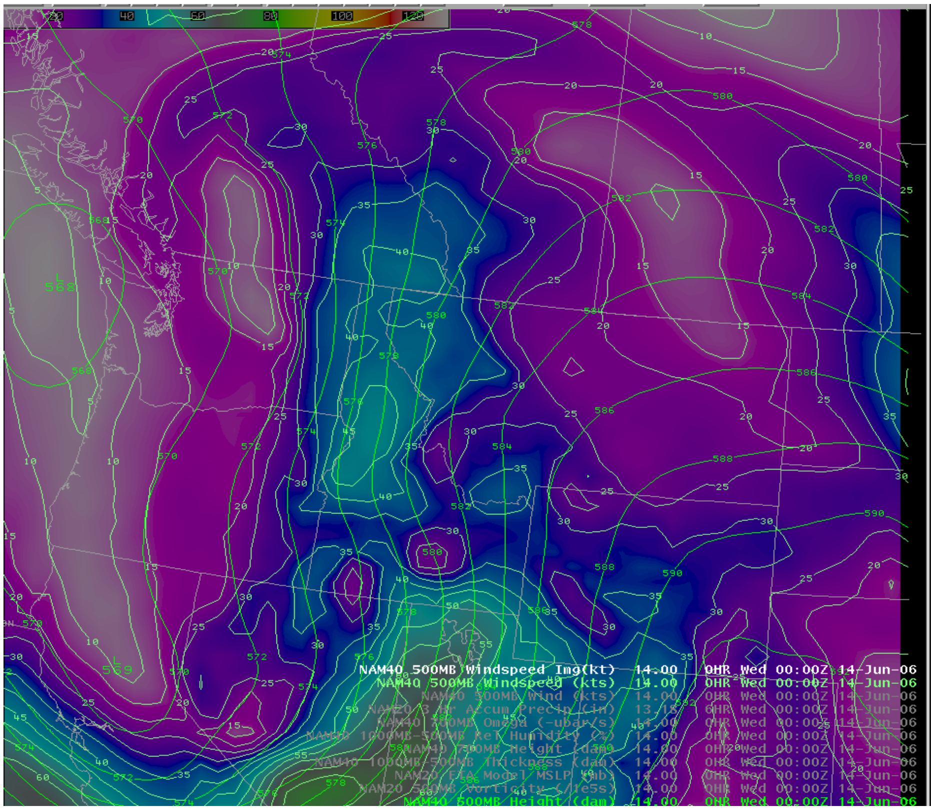

Figure 3. Upper level (500-300 mb) layer wind speeds NAM forecast at 2100 UTC 13 June 2006. The strongest winds are depicted in the lighter blue and green colors.

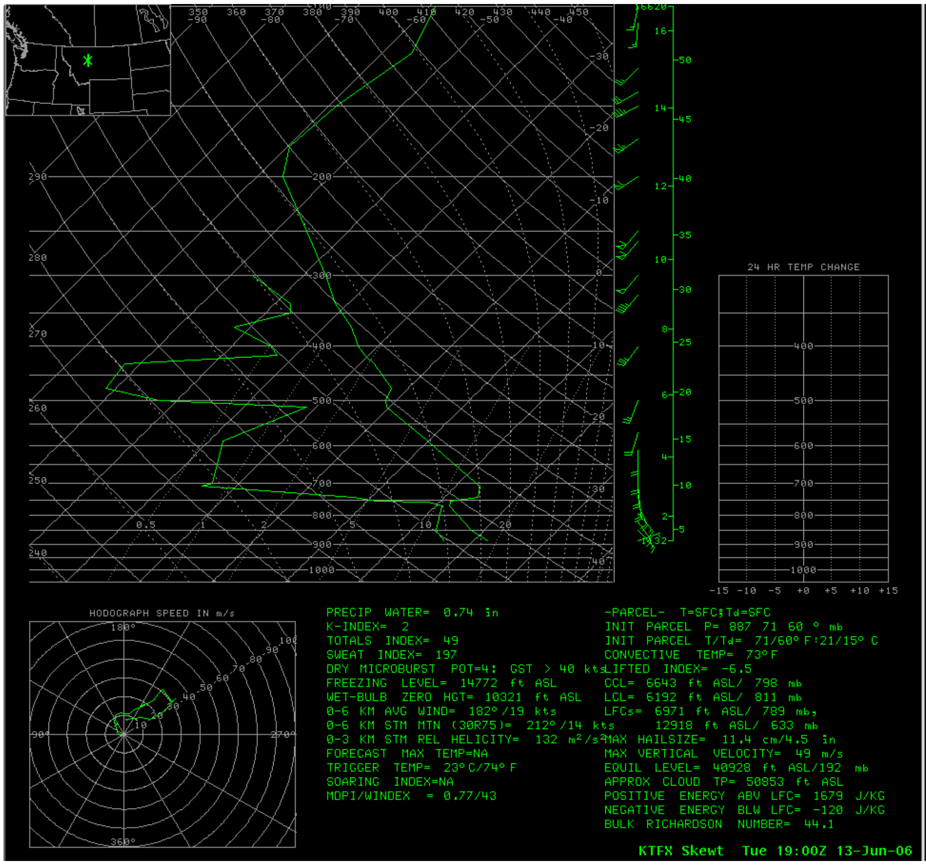

Figure 4. Great Falls sounding at 1900 UTC 13 June 2004. Note the strong directional shear in the lowest 2 km.

Shortly before 02Z 14 June 2006, a strong cell developed and moved slowly north into south central Glacier County. An unconfirmed funnel cloud report was received at 0146Z. The accompanying storm relative velocity radar imagery (Fig. 7) shows how the tornado appeared. The reflectivity structure (not shown) did not depict any form of a hook, but did show a very subtle weak echo region. No additional reports of a funnel or tornado were received from this storm in this very sparsely populated part of Montana.

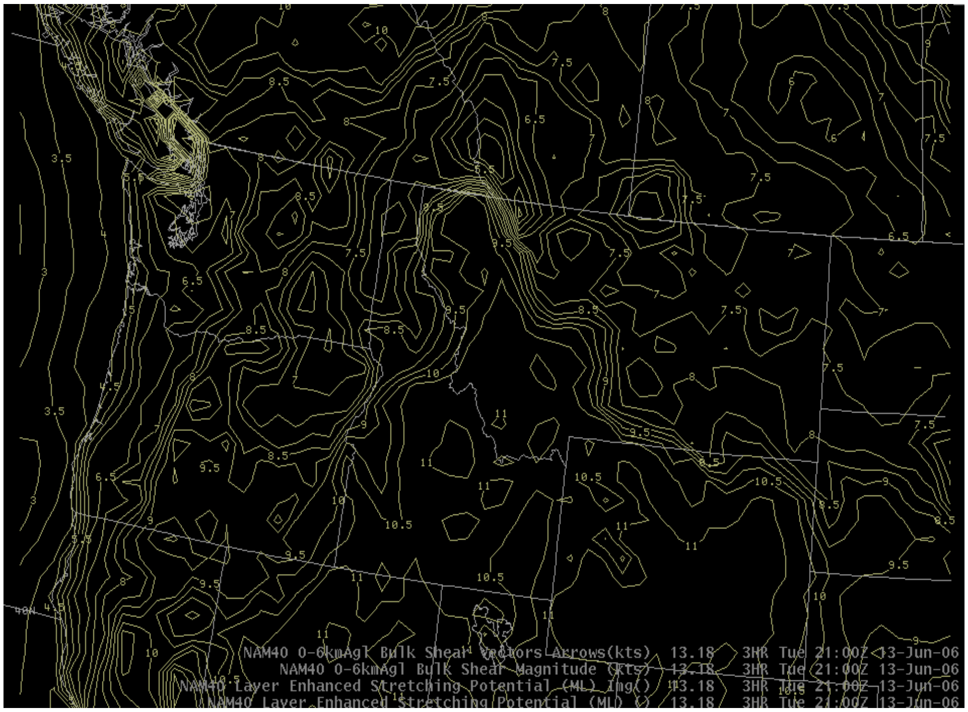

Figure 5. 0-2km Lapse Rates NAM forecast at 2100 UTC 13 June 2006.

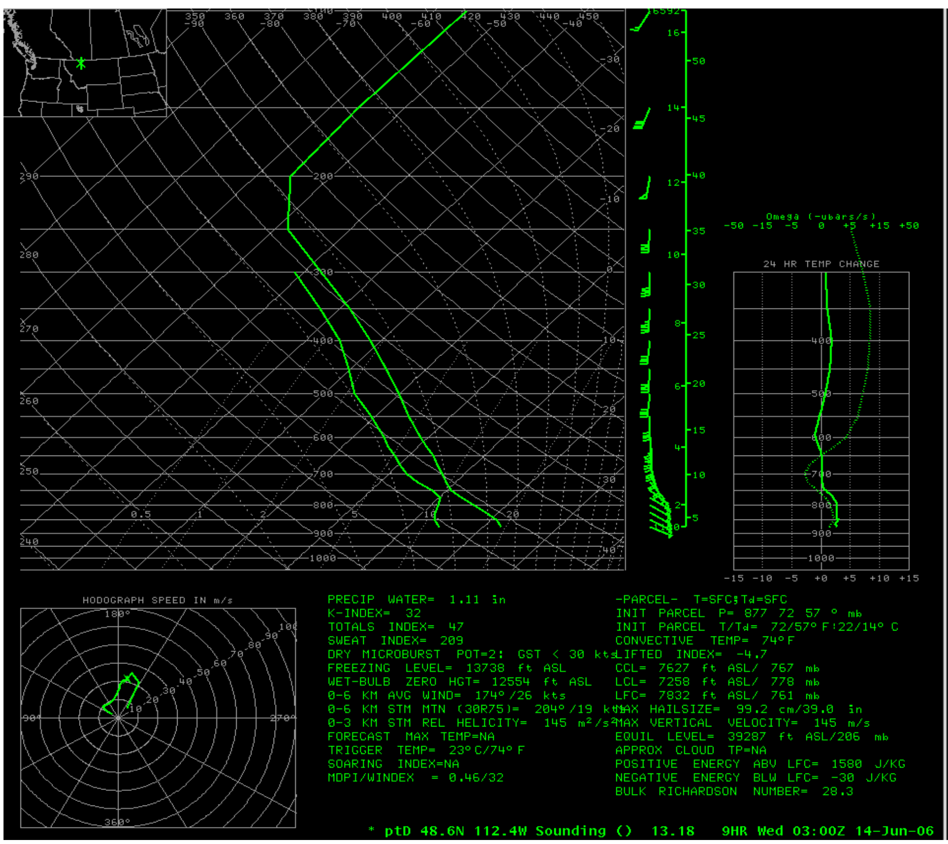

Figure 6. NAM forecast sounding for Cut Bank at 0300 UTC 14 June 2006.

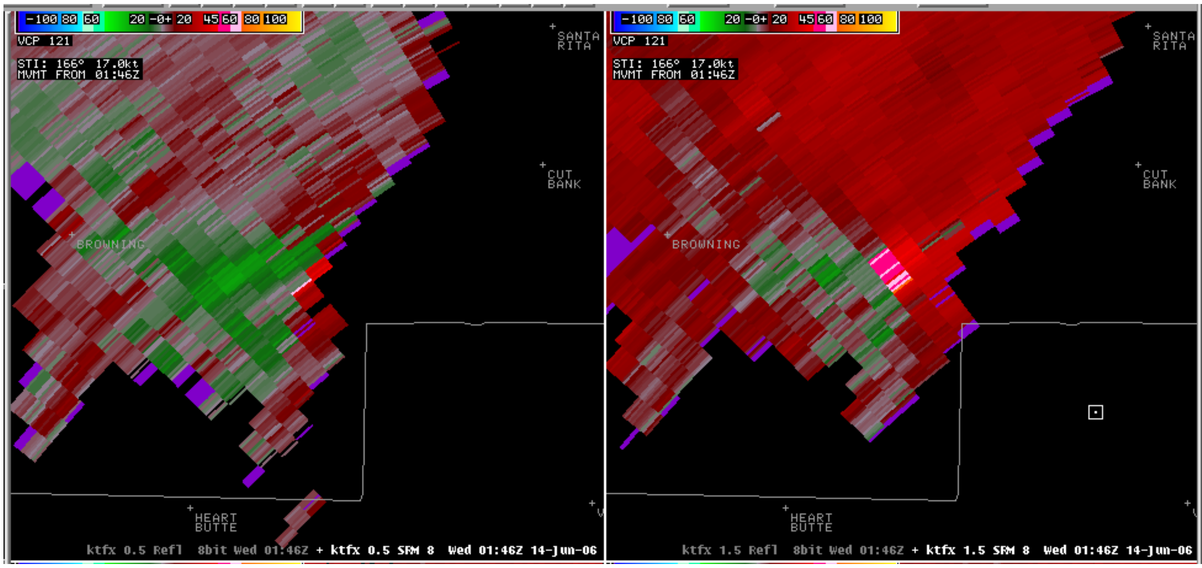

Figure 7. Storm Relative Velocity imagery at 0146 UTC 14 June 2006 from KTFX radar at 0.5° and 1.5° elevation. Note the gate-to-gate shear on the left image, which corresponds to a -2kt/+64kt couplet. The gate-to-gate shear was 83 nm from the RDA at an elevation of 8384 ft AGL at the 0.5° elevation angle. Note the location of Cut Bank in the right hand side of the image.

An hour later, this same storm moved north into central Glacier County and a report of a tornado was received in this moist unstable environment. Low-level convergence continued strong as the low pressure and boundary remained in the same area. A boundary with north winds behind it was moving southward into central Glacier County. The surface low pressure area lay between Great Falls and Missoula. Strong easterly flow continued to the north of the low pressure, just ahead of the advancing boundary from the north. Also, an area of high dew points is east of the low pressure area, in a northwest-southeast axis (Fig. 8).

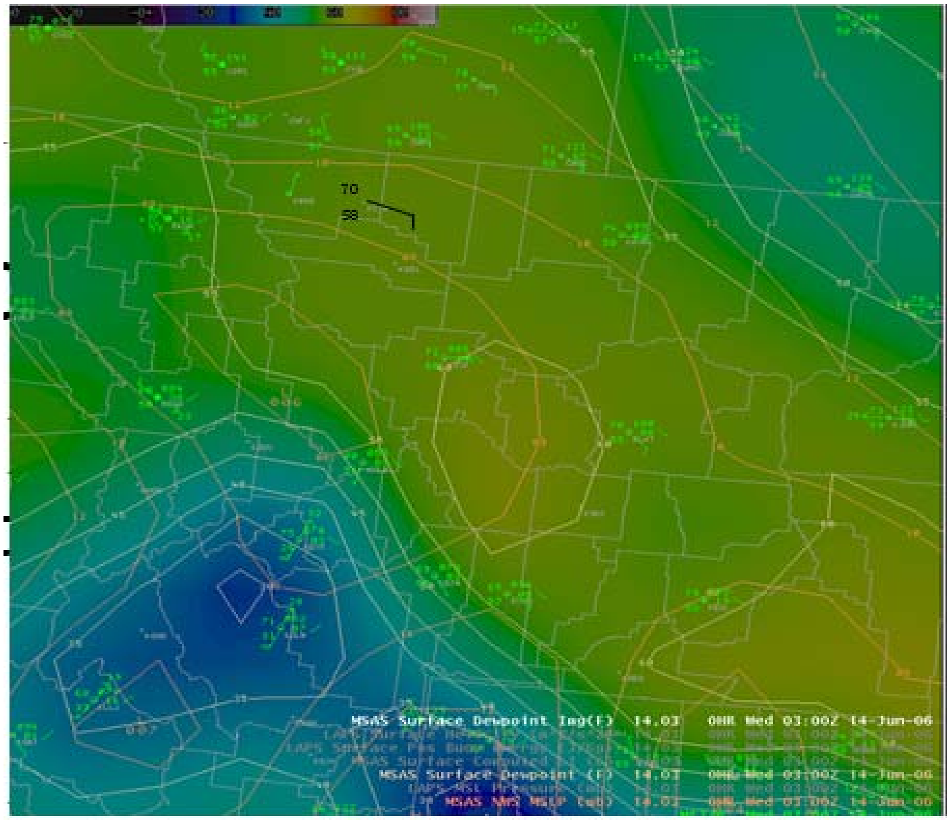

Fig 8. MSAS analysis at 0300 UTC 14 June 2006. The image shows an analysis of dew point temperatures. Mean Sea Level pressure contours in orange. Note the north winds over northern Glacier County. Even so, winds continued from the east at Cut Bank.

Figure 9 shows the radar imagery at the time of the confirmed tornado report. The strong low-level easterly flow contributed to the helicity necessary to produce the spin-up of the tornado. The sharp reflectivity gradient on the eastern side of the storm illustrates the sharpness of the storm gradient on the leading side. There was an inflow notch detectable at the 0.5° slice coincident with the gate-to-gate shear. As before, the velocity couplet measured in this storm did not persist for more than two or three scans, with the 0246 UTC scan showing the greatest intensity. Tornado warning guidance from WDTB (WDTB 2002) would have provided some assistance with this storm, but this document does point out the limitation of radar data below 2 km AGL beyond 65 nm from the RDA and its effect on tornadic storm detection. At this time, the storm was nearly 90 nm from the RDA. The radar beam is approximately 7000 feet wide at this distance, so a storm showing the characteristics of this storm would indeed, be severe. In a populated area, this storm could have caused major damage, but in this sparsely populated area of rural Montana, it produced some damage and no injuries. Figure 10 shows the size of the funnel near its peak intensity.

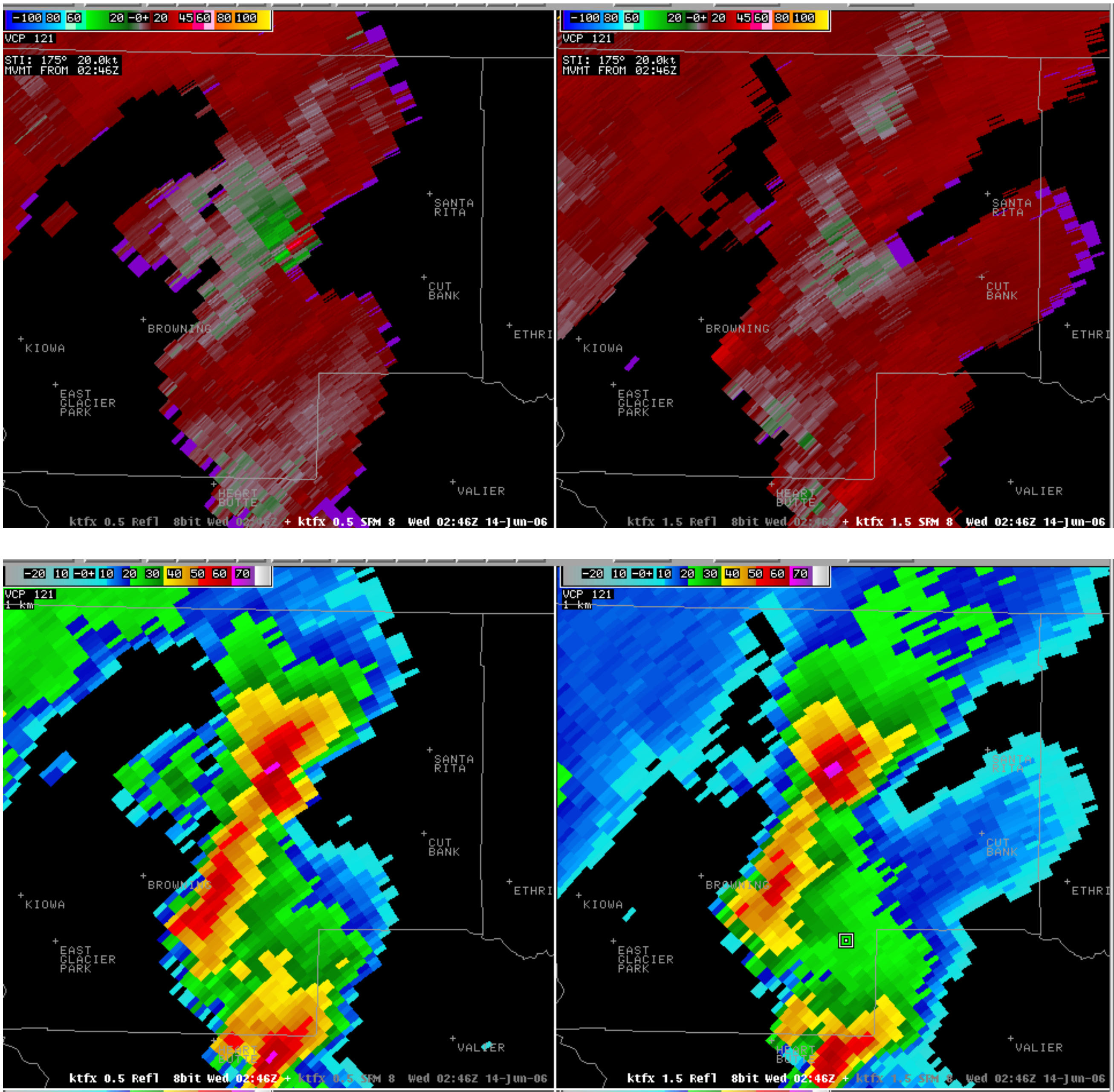

Figure 9. Storm Relative Velocity imagery at 0246 UTC 14 June 2006 from KTFX radar at 0.5° and 1.5° elevation (top). Note the gate-to-gate shear on the upper left, which corresponds to a -32kt/+59kt couplet. The 0.5° slice was 89 nm from the RDA at an elevation of about 8600 ft AGL. The accompanying reflectivity plots are shown in the bottom panels.

Figure 10. Tornado west of Cut Bank, MT (photo courtesy Glacier Electric Cooperative).

3. Summary

Though tornados are rare in north central Montana near the continental divide, they do occur. In this case, storm ingredients came together. The main factors were the low-level shear, ample low-level moisture, a surface boundary that focused development of convection, and upper level support in the form of a jet streak moving into an area of diffluence. Strong low-level convergence in this region with steep lapse rates produced an impressive tornado. Even with the limitations of radar data at extended ranges, the tornado was of sufficient size and depth as to be detected by the lowest elevation angle of the nearest radar. With appropriate situational awareness and radar data, enough information was available to convince forecasters of the tornado likelihood. In spite of the limitations presented, the WFO forecasters did issue a tornado warning prior to the first reports of the tornado.

References

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Thompson, R.L., R. Edwards, J.A. Hart, K.L. Elmore and P. Markowski. 2003. Close proximity soundings within supercell environments obtained from the rapid update cycle. *Wea. Forecasting.* 18, 1243-61.