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CHAFF AND THE WSR-88D PRECIPITATION PROCESSING SYSTEM

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Introduction

Very small, light strips of metallic foil called chaff have been used in radar studies of various atmospheric phenomena (e.g., Wu and Widdel 1992). Chaff is very reflective to the radar's microwave energy and is routinely released by military aircraft during training exercises in the West. While chaff is typically released during clear weather, Vasiloff and Struthwolfe (1997) showed that chaff can mix with storm clouds and exaggerate radar reflectivity values resulting in false hail detections. Maxwell and Atkin (1998) described a case where chaff may have affected thunderstorm echoes in southern California. Maddox et al (1997) suggested that chaff suppressed lightning activity in Arizona thunderstorms.

Another area of concern is the potential for chaff to cause false quantitative precipitation estimates (QPE). This paper documents the structure and evolution of chaff that occurred on 8 March 2002, and how that structure is interpreted by the WSR-88D precipitation processing system (PPS) (Fulton et al 1998). For example, a vertical continuity check ("tilt test") is a quality control procedure of the PPS that is designed to avoid accumulating rainfall for anomalous propagation echo that has not been successfully identified and removed during initial signal processing. If there is at least a 75 percent decrease (an adaptable parameter) in echo area from the first to the second elevation angle (tilt), the PPS will use data from only the second tilt. (The range interval in which the tilt test is applied is adaptable and nominally set to the interval between 40 km and 150 km.)

Chaff Evolution and PPS Products

Figure 1 shows chaff echoes immediately after its release at ~1920 UTC in northeast Nevada and southern Idaho. The KMTX WSR-88D (indicated by the letters "RDA") is on a mountain top in northern Utah ~2100 ft above the west desert floor (including the Union Pacific railroad), the location of restricted military areas. The height of the release was ~18000 ft above radar level (ARL) with maximum reflectivity of 40.5 dBZ. An hour later at 2020 UTC, the chaff had stretched into narrow bands (Fig. 2). The leading edge of the chaff had progressed ~90 n mi at a height of 15200 ft ARL. The speed of 90 kt was much faster than winds at that height (~30 kt from 290 deg) indicating that a slow moving aircraft was dropping the chaff along a southeastward trajectory. In fact, it appears that several aircraft were involved owing to the presence of several parallel chaff echoes. Much of the chaff in the band closest to the radar can be seen on the 1.4 deg tilt. The maximum reflectivity was 40 dBZ on the lowest tilt. A vertical cross section through the chaff illustrates the vertical extent of the chaff "curtains" (Fig. 3).

The PPS was run using a minimum reflectivity of 5 dBZ and the winter Z-R relation $Z=75R^2$. The 1-hr precipitation accumulation field between 2054 and 2154 UTC, with the tilt test OFF, is shown in Fig. 4. The maximum accumulation is .09" which, in winter storms, can be equivalent to an inch or more of snow. Reflectivity data at 2123 UTC (Fig. 5) are from the middle of the accumulation period and illustrate which data are producing precipitation estimates. For example, there are almost no accumulations south of the railroad line. This is because only data from the first tilt were used to produce estimates. With the tilt test ON, only data having vertical continuity (data mostly south of the railroad line and closest to the radar) have been converted into precipitation (Fig. 6). Data limited to the first tilt have not been converted to precipitation. Recall that the tilt test checks the reduction in area from the first to the second tilt: if the area is reduced by 75 percent or more, data from only the second tilt are used.

By 2301 UTC (Fig. 7), the chaff had a structure very much like weather echoes. Namely, the long, narrow shapes had become more rounded and wider--patterns often seen in snow bands. Reflectivity values were in the 20-25 dBZ range with a maximum of 29 dBZ. Since most of the echo is on the lowest tilt, there were no accumulations between 2200 UTC and 2300 UTC with the tilt test ON. With the tilt test OFF, there were two areas with accumulations and a maximum accumulation of nearly 0.1" (Fig. 8).

Operational Issues

The primary issue associated with chaff accumulations by the PPS concerns long-term hydrological products. For example, it is desirable to generate monthly or seasonal snow water equivalent fields for input to hydrological models during spring snow melt. Unfortunately, the frequency and extent of chaff releases are not well documented so the long-term implications are not known.

During this type of chaff curtain release, chaff settles downward spanning several elevation angles indicating that the PPS tilt test will not remove the chaff, at least not before the chaff settles and appears on only the lowest tilt. Also, chaff beyond 150 km range will always result in false precipitation accumulations. It is proposed that the National Weather Service, Western Region offices coordinate with the military to document the frequency of chaff releases and the percentage of these that cause false precipitation accumulation.

Acknowledgment

This paper benefitted from insightful comments by Dr. Robert Maddox.

References

Fulton, R. A., J. P. Breidenbach, D.-J. Seo, D. A. Miller, and T. O'Bannon, 1998: The WSR-88D rainfall algorithm. *Wea. Forecasting*, **13**, 388-395.

Maddox, R. A., K. W. Howard, and C. L. Dempsey, 1997: Intense convective storms with little or no lightning over central Arizona - A case of inadvertent weather modification? *J. Appl. Meteor.*, **36**, 302-314.

Maxwell, B, and D. V. Atkin, 1998: Chaff in the vicinity of thunderstorms in southern California on 6 June 1997. Western Region Technical Attachment WRTA 98-04, 2 pp.

Vasiloff, S. and M. Struthwolfe, 1997: Chaff mixed with radar weather echoes. Western Region Technical Attachment WRTA 97-02, 10 pp.

Wu, Yong-Fu, and H.-U. Widdel, 1992: Saturated gravity wave spectrum in the polar summer lower thermosphere observed by foil chaff during campaign "Sodium 88". J. Atmos. Sci., **49,** 1781–1789.

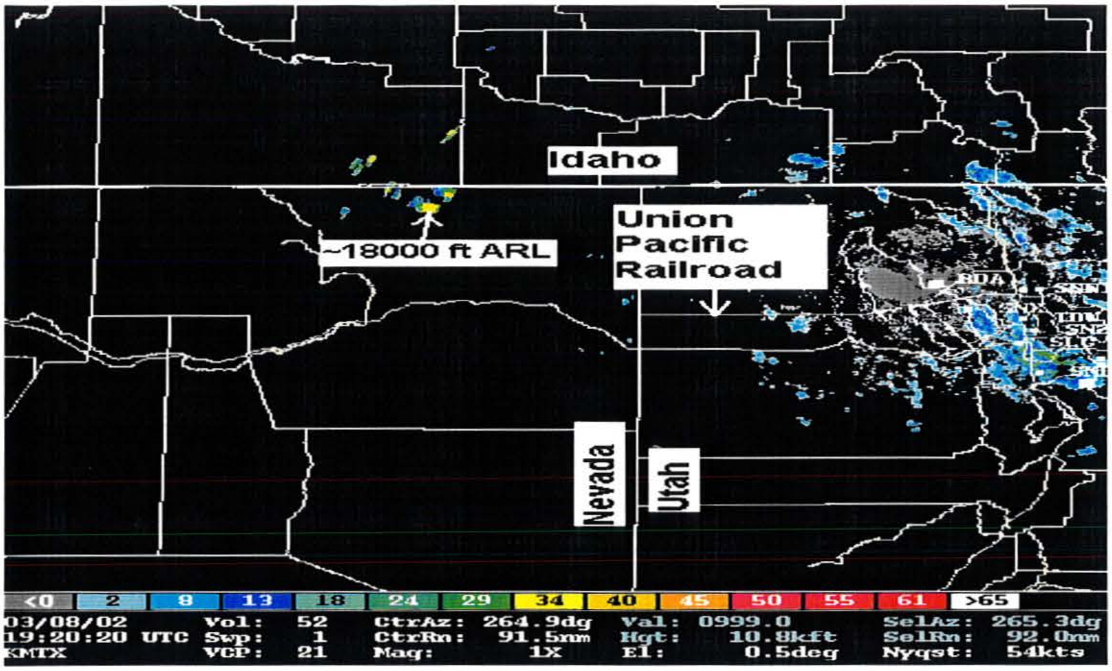

Figure 1. KMTX base reflectivity at 192020 UTC on 8 March 2002. The location of KMTX is indicated by the letters "RDA." Chaff release can be seen in northwest Nevada at ~18000 ft above radar level.

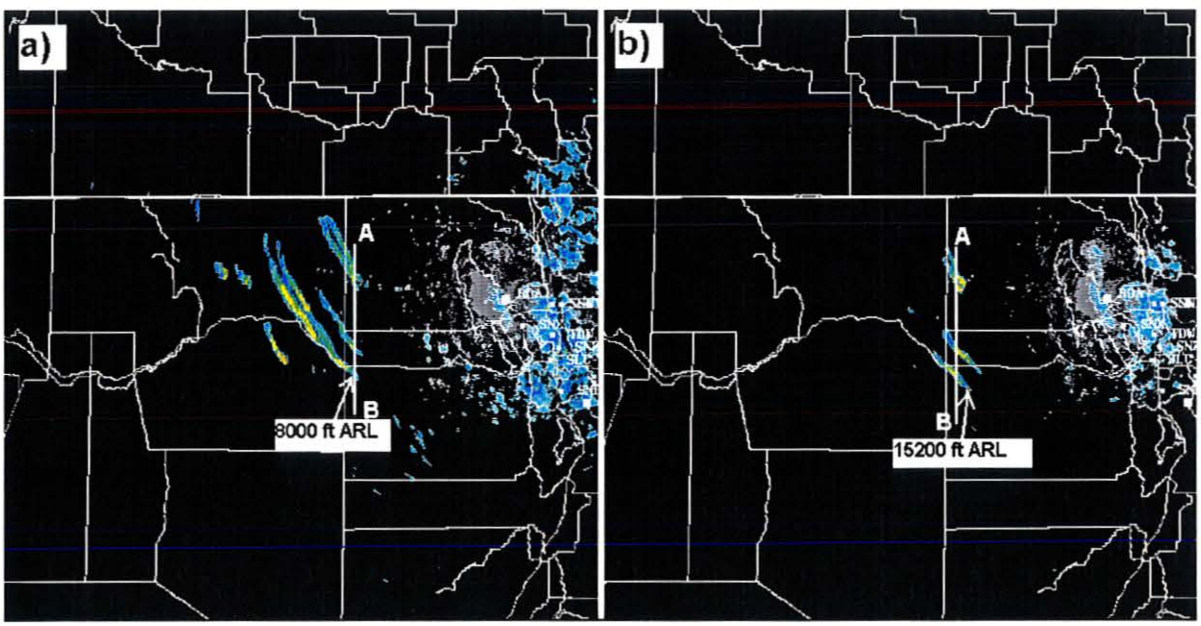

Figure 2. KMTX base reflectivity: (a) 0.5 deg at 201923 UTC; and (b) 1.4 deg at 202019 UTC. Line AB shows the position of the vertical cross section in Fig 3.

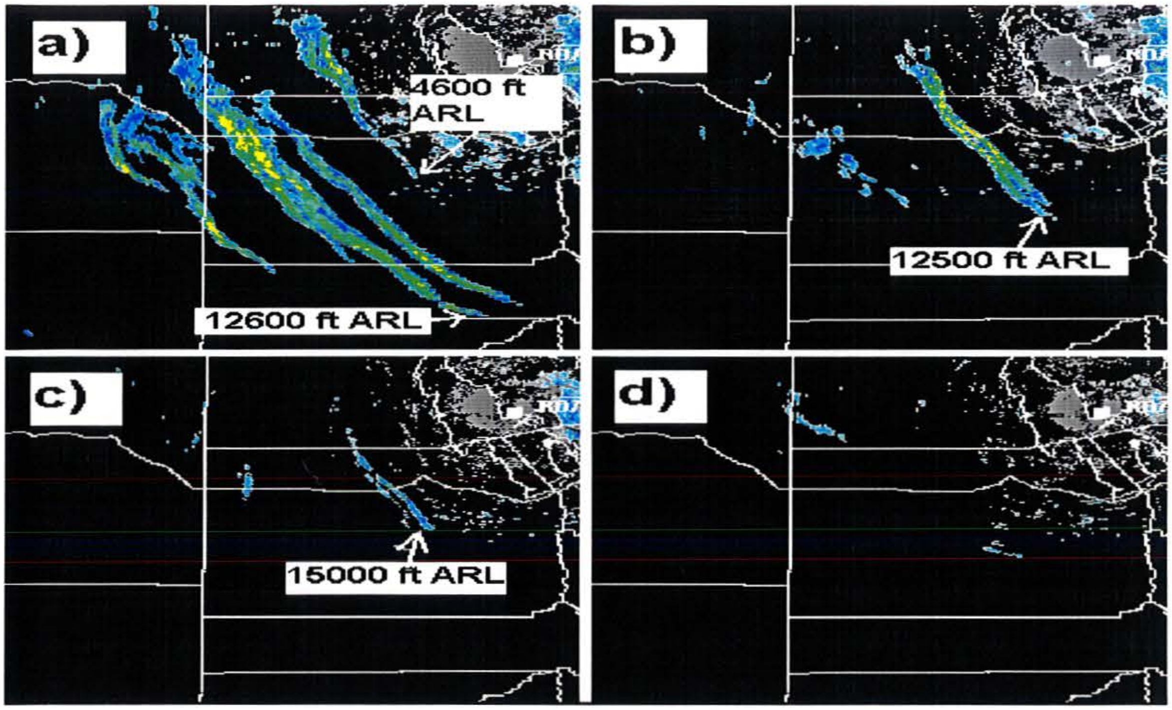

Figure 3. Vertical cross section through chaff curtains at ~2020 UTC along line AB shown in Fig. 2.

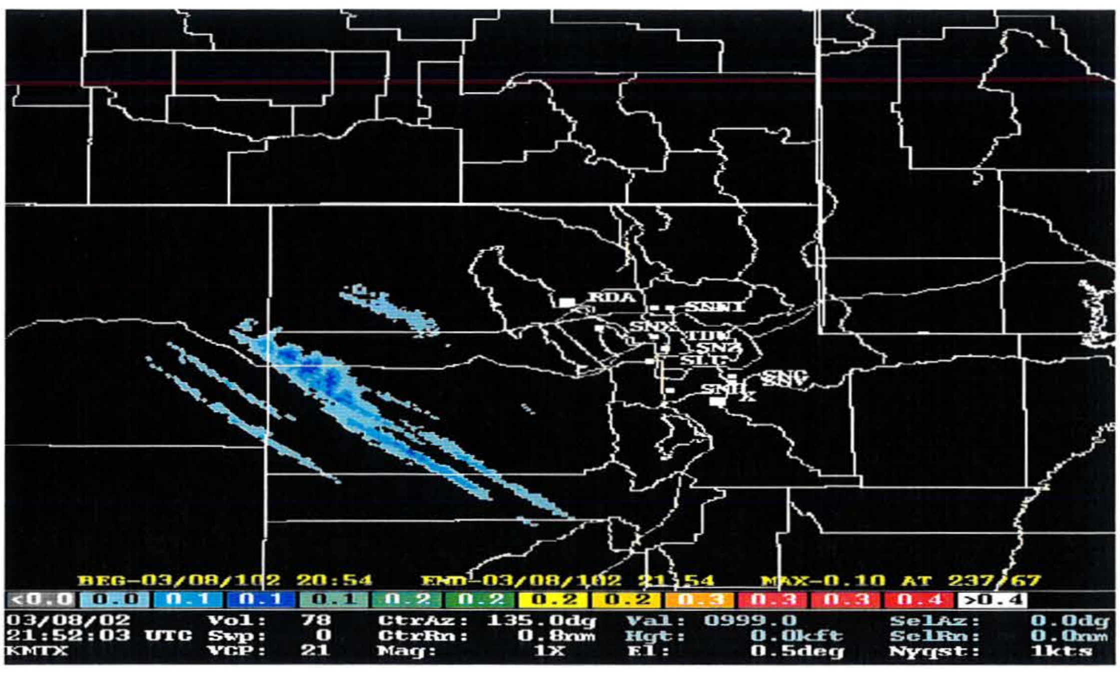

Figure 4. One-hour precipitation accumulation field during the interval 2054 UTC to 2154 UTC. The image was produced with the PPS tilt test OFF.

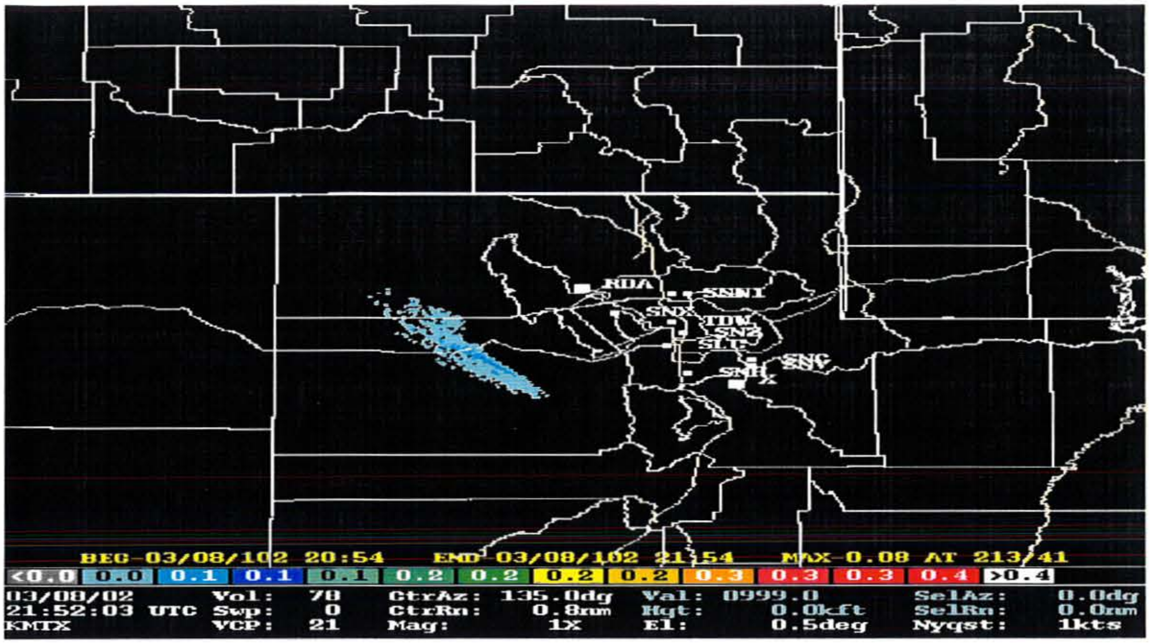

Figure 5. KMTX base reflectivity: (a) 0.5 deg at 212306 UTC; (b) 1.4 deg at 212411 UTC; (c) 2.4 deg at 212516 UTC; and (d) 3.3 deg at 212549 UTC.

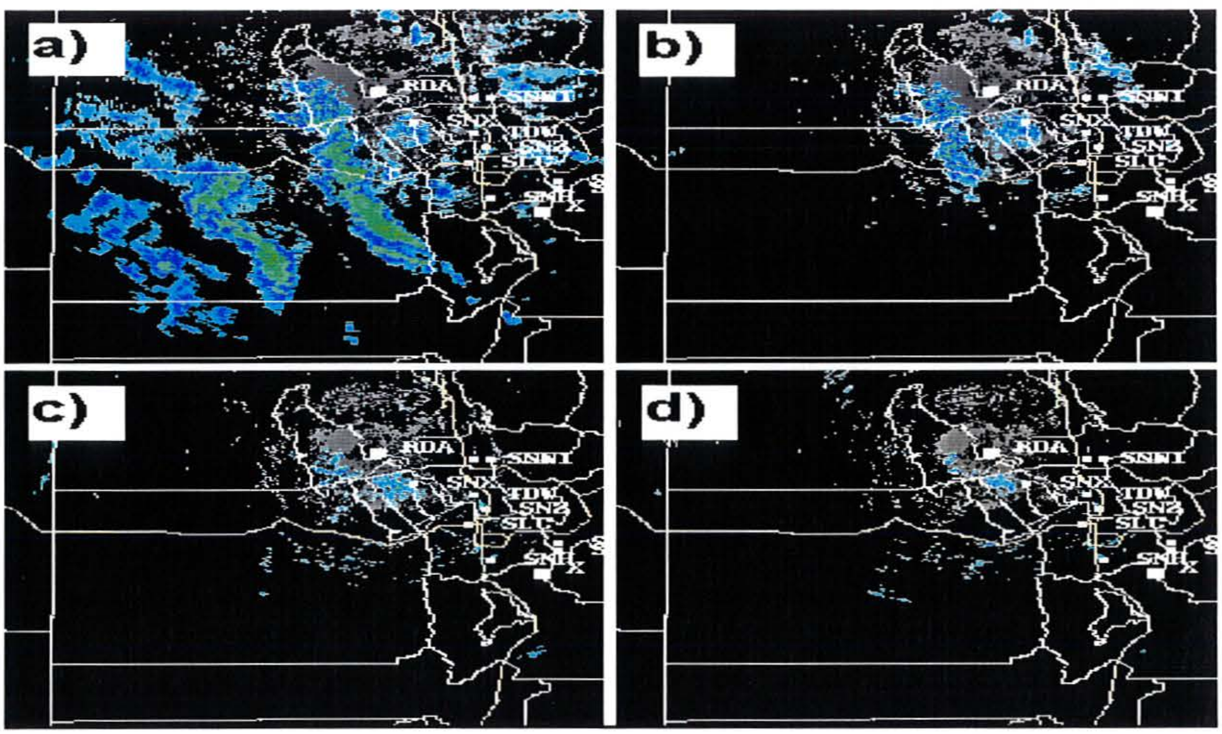

Figure 6. As in Fig. 4 except with the PPS tilt test ON.

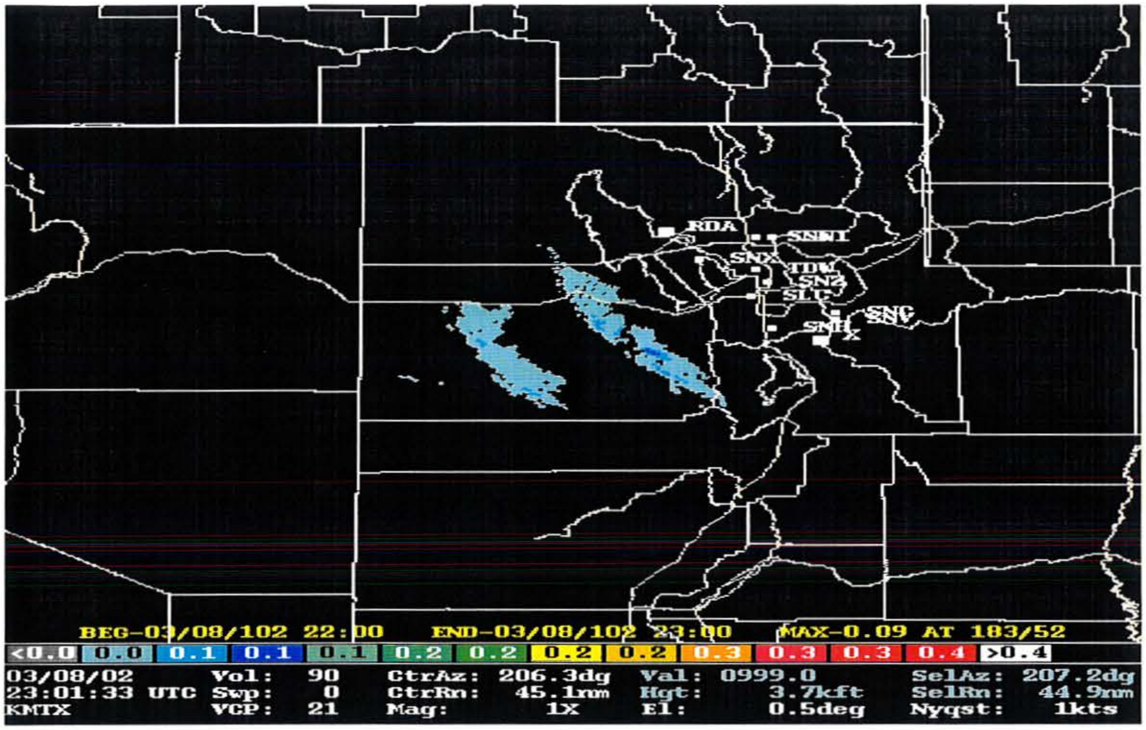

Figure 7. As in Fig. 5 except: (a) 230133 UTC; (b) 230238 UTC; (c) 230343 UTC; (d) 230416 UTC.

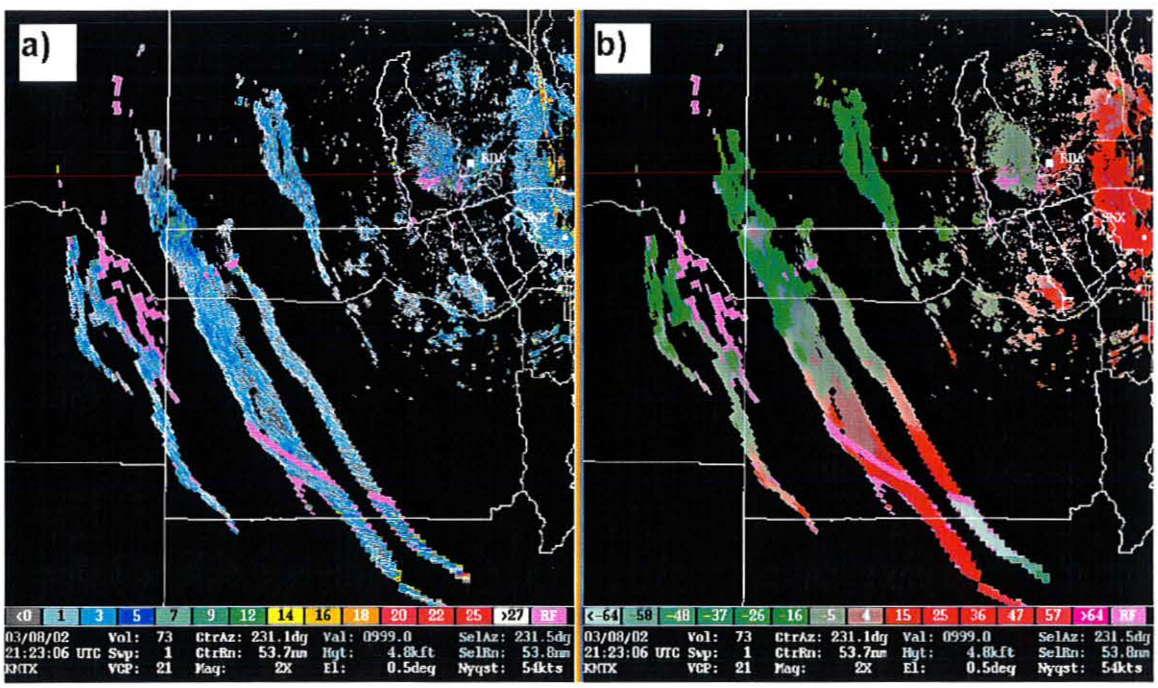

Figure 8. As in Fig. 4 except for the interval 2200 UTC to 2300 UTC.