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CHAFF MIXED WITH RADAR WEATHER ECHOES

Steve Vasiloff, NSSL/NWS-WRH-SSD
Mark Struthwolf, SLC WFO

Introduction

Chaff is frequently released by military aircraft in the desert area west of the Great Salt Lake (GSL). The chaff is seen on the radar display usually as narrow bands of high reflectivity that travel with the winds after emanating from a point source. Sometimes these chaff echoes can stretch for hundreds of miles. The bands are also very shallow and are usually seen on only one tilt of the radar, though this depends on the range from the radar and the amount of diffusion time. As chaff drifts closer to the radar site, it may be seen on several tilts making it more difficult to distinguish from actual weather.

Chaff events on two days are examined. On 7 May 1996, chaff mixed with real weather echoes increasing the echo intensity causing them to become indistinguishable from actual higher-reflectivity echoes. It is hypothesized that chaff entered the convective cells creating hybrid echoes through turbulent dissipation throughout the cloud. These echoes were detected by NSSL experimental algorithms. During one volume, a 60 percent probability of hail was indicated by the NSSL hail detection algorithm (now in Build 9).

On 9 May 1996, isolated chaff had structure much like that of actual weather echoes: the chaff had more-rounded shapes and was seen on multiple tilts of the radar. This situation required the use of a visible satellite image to distinguish chaff from the weather. In addition, the vertical tilt of the chaff was much greater compared to genuine echoes.

7 May 1996 Case

On this day, there were a few bands of weak reflectivity with virga and some light rain. However, it appears that some of the echoes have been mixed with chaff. The composite reflectivity at 1953 UTC from the KMTX radar is shown in Fig. 1. The chaff is seen on the radar as narrow bands of high reflectivity embedded in areas of weak reflectivity. Echoes from weather presumed to be free of chaff can be seen to the southwest at the100 nmi range. As these cells grew, they began to appear very similar to the chaff-infected echoes.

A 4-panel display of reflectivity at 0.5 deg (top-left), 1.5 deg (top right), 2.4 deg (bottom left), and 3.4 deg (bottom right) is shown in Fig. 2. The two highest tilts show the typical elongated chaff structure in the absence of background weather echoes. Note the cell number icons generated by the NSSL cell identification algorithm as a result of the chaff. Close inspection reveals that no single chaff echo appears on more than two consecutive tilts. Cells 2 and 6 appear on the 0.5 and 1.5 deg tilt, Cell 3 appears on the 1.5 and 2.4 deg tilts, and Cell 5 is seen on the 2.4 and 3.4 deg tilts. The high reflectivity core (45-50 dBZ) southeast of "MUS" appears mainly on the 3.4 deg tilt.

Some of the hybrid echoes triggered NSSL's hail detection algorithm. (This is the new WSR-88D hail detection algorithm recently implemented in Build 9). As seen in the cell table from NSSL's radar algorithm and display system (RADS; Fig. 3), there is a 60 percent probability of any size hail for Cell 5 in this volume scan. (For more information about NSSL algorithms and RADS please reply via the E-mail tool at the bottom.)

Figure 4 illustrates the difficulty in determining whether or not echoes have been affected by chaff. At 2051 UTC, it appears that most of the chaff was exiting the east part of the radar domain. The echoes to the south of the radar (e.g., Cell 2 due south) have higher reflectivity values than earlier and a more-rounded structure -very similar to the echoes developing to the southwest at the 100 nmi range which are believed to be free of chaff. Thus, it is inconclusive whether or not chaff remains in these echoes. The point is that the forecasters should at least be aware of the possibility that the echoes have been falsely enhanced by chaff. Eventually, all of the chaff appeared to have exited the area and the reflectivity values dropped to "pre-chaff" values (not shown), hinting at the possibility that the echoes were indeed affected by chaff.

9 May 1996 Case

On 9 May 1996 at 1700 UTC, mostly-clear skies prevailed over northern Utah with many land features easily distinguishable in the visible satellite imagery (Figure 5). Some shallow cumulus are evident near and along the mountains surrounding the GSL. South and southeast of the GSL, bigger cumulus exist while there are no clouds over the GSL.

The composite reflectivity for 1704 UTC is shown in Figure 6. Several cells are identified, two of which are associated with the cumulus developing south-southeast of the GSL (Cells 3 and 4). The other cells labeled are chaff, in particular, Cell 5 located over the southern end of the GSL, determined by the fact that there are no clouds associated with the echoes.

Figure 7 illustrates the usage of a 4-panel display to identify echo structure. Genuine echoes, identified as Cells 3 and 4 in Fig. 6, are clearly apparent on the lowest 3 tilts. At about 50 nmi range from the radar, the vertical distance between the lowest and third tilts is about 9,500 ft. There is minimal return at the highest tilt. Cell 5, located over the southern end of the GSL (~25 nmi south of the radar), shows moderate reflectivity on all 4 tilts. At this range, the vertical extent of the echo is about 8600 ft. Thus, both the real and chaff echoes have a similar vertical extent. Without the use of satellite imagery, the chaff echo could have been identified incorrectly since it had neither the typical elongated structure nor the locally-intense reflectivity. If clouds had been present, this chaff echo would have been very difficult to differentiate from real echoes.

Another method to recognize chaff is examination of the tilt of the echo. The chaff echo has a tilt extending about 10-15 nmi toward the northeast while the genuine echo is nearly vertically-stacked. This chaff structure may have been a function of sedimentation and/or aircraft flight patterns.

Summary

Chaff typically has a shallow vertical structure and an elongated worm-like horizontal appearance with maximum reflectivities 45-50 dBZ. In convective situations, these discerning attributes may not be readily apparent as turbulent diffusion spreads the chaff throughout the convective cloud. In these situations, chaff-infected weather echoes can be interpreted as storm cells by WSR-88D algorithms. In one instance, a 60 percent probability of hail was indicated by NSSL's hail detection algorithm. Chaff was also interpreted as storm cells even when no clouds were present.

Several ways to identify chaff echoes were illustrated: 1) watch for the narrow banded structure of the echoes which are usually seen on one or two elevation angles; 2) continuously monitor the radar in time lapse sequences (composite reflectivity seems to work best) to follow chaff from its initial release; 3) examine visible satellite imagery (rapid-scan imagery now available will offer the forecaster quick access of near real-time imagery every 6-8 min.); and 4) examine the vertical tilt of the echo--if the tilt is excessive or much different from most other echoes, the echo is probably chaff.

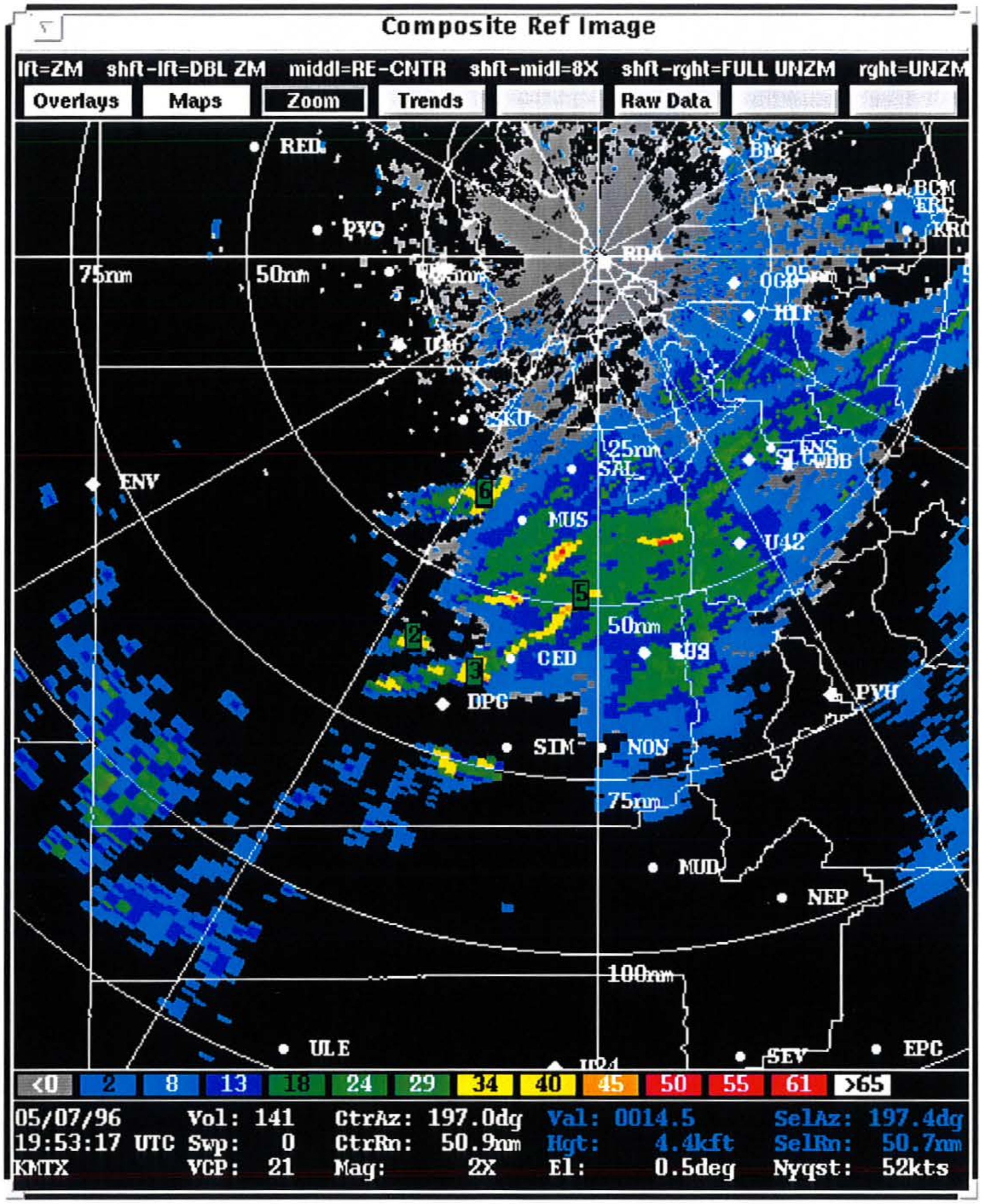

Figure 1. Composite reflectivity image at 1953 UTC on 7 May 1996 from the KMTX WSR-88D located on the east side of the Great Salt Lake. Image is from the National Severe Storms Laboratory's (NSSL) Radar Algorithm and Display System (RADS). Range rings are every 25 nmi. Numbers in green boxes represent cell identification numbers as determined by NSSL's storm cell identification and tracking algorithm.

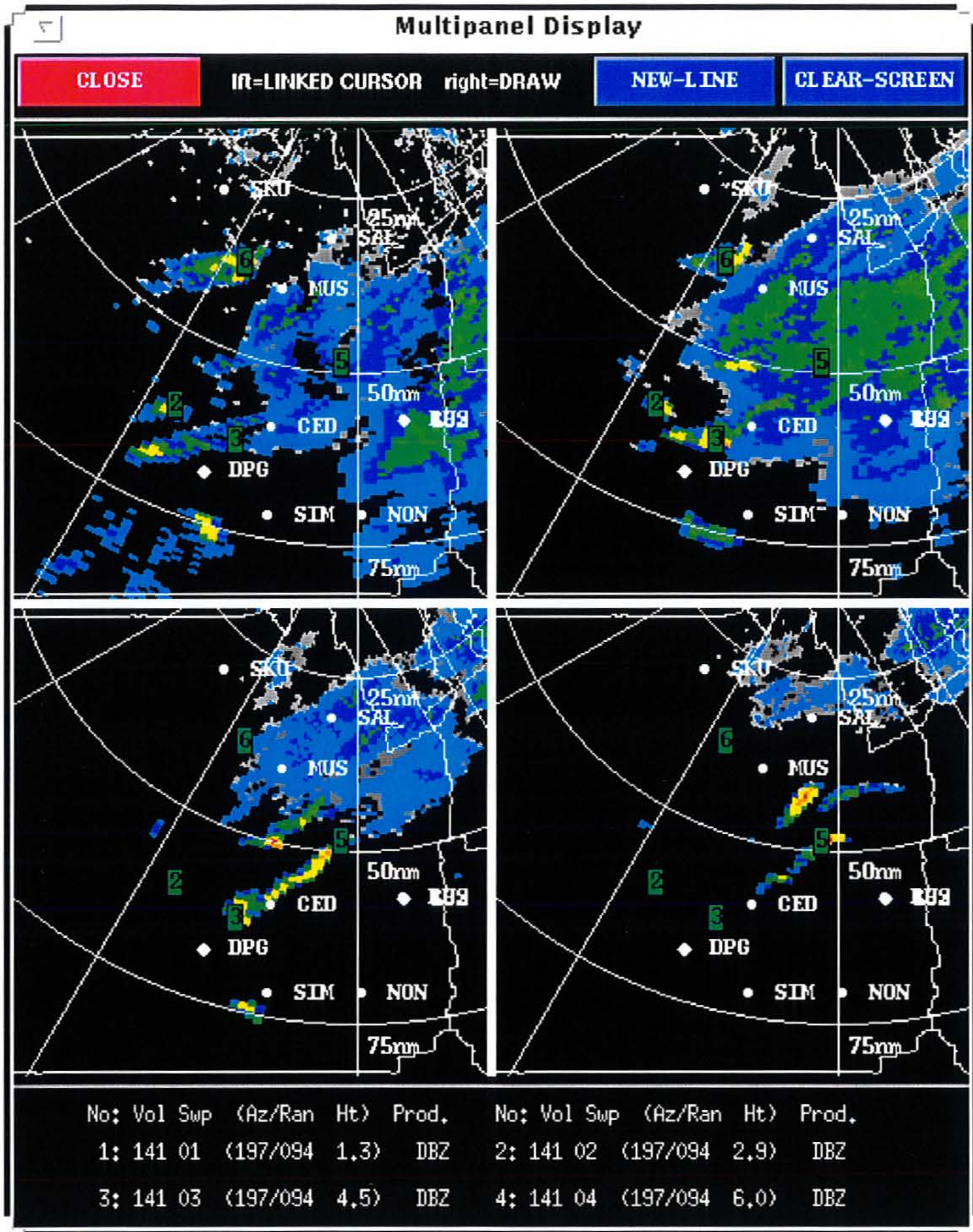

Figure 2. 4-panel display of reflectivity at 1953 UTC. The upper-left panel is 0.5 deg., upper-right is 1.4 deg., lower left is 2.5 deg., and the lower-right is 3.5 deg. Range rings are every 25 nmi.

NSSL Cell Algorithm Output for Volume 141

CELL ID	AZ	RAN	CIRC	BURST	SVRH	SIZE	HAIL	VIL	MAXZ	HT MXZ	BASE	TOP	DIR/SP	SREH	COUNTY
5	183	48			0%	<1.00	60%	3	46	19	14	19			
3	196	61			0%	<1.00	0%	4	46	13	13	18	256/45		
2	206	60			0%	<1.00	0%	3	43	12	6	12	245/31		
6	206	37			0%	<1.00	0%	2	41	3	3	7			

Figure 3. Cell table from NSSL's RADS at 1953 UTC. There is a 60 percent probability of ANY size hail in Cell 5.

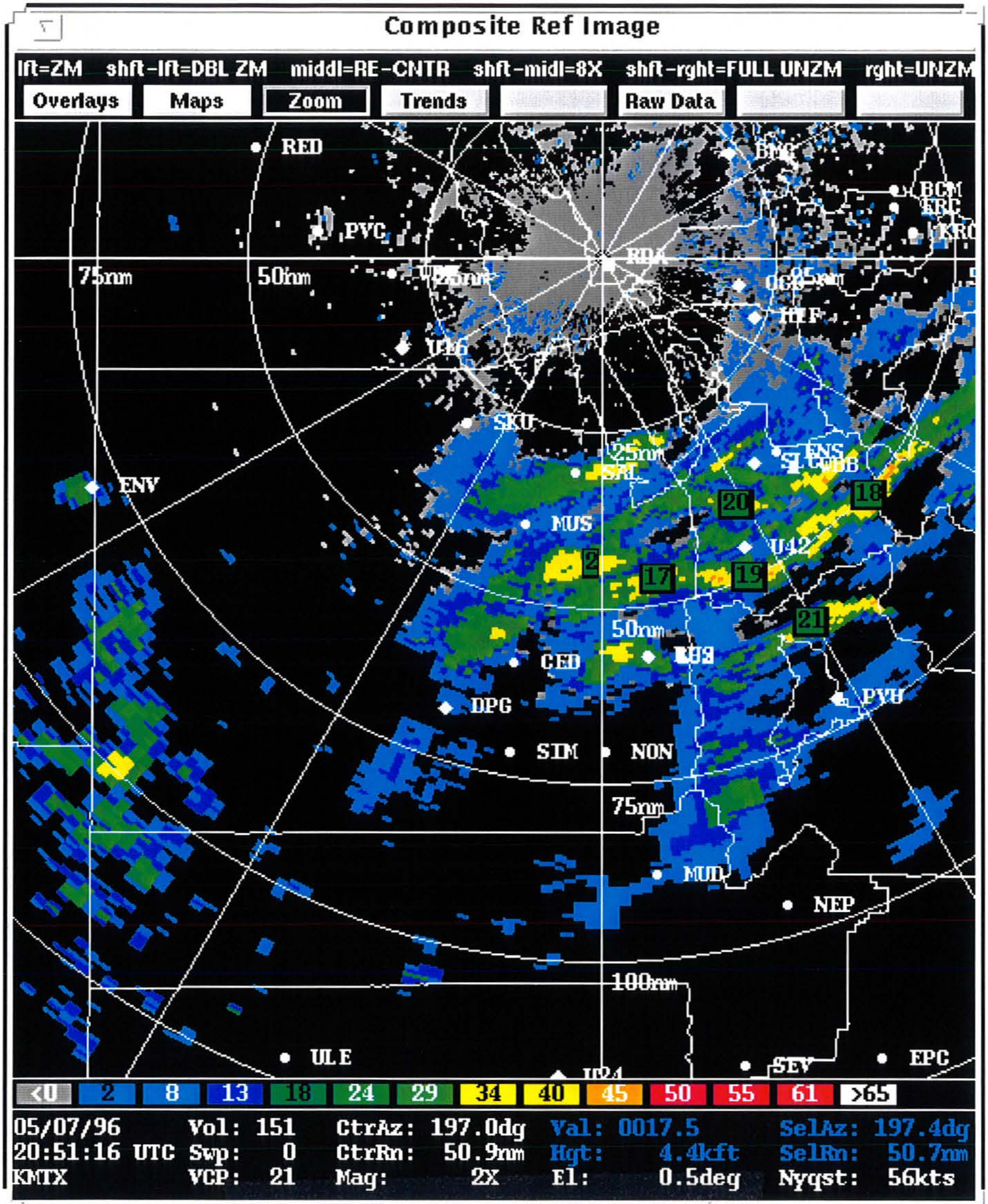

Figure 4. As in Fig. 1 except for 2051 UTC.

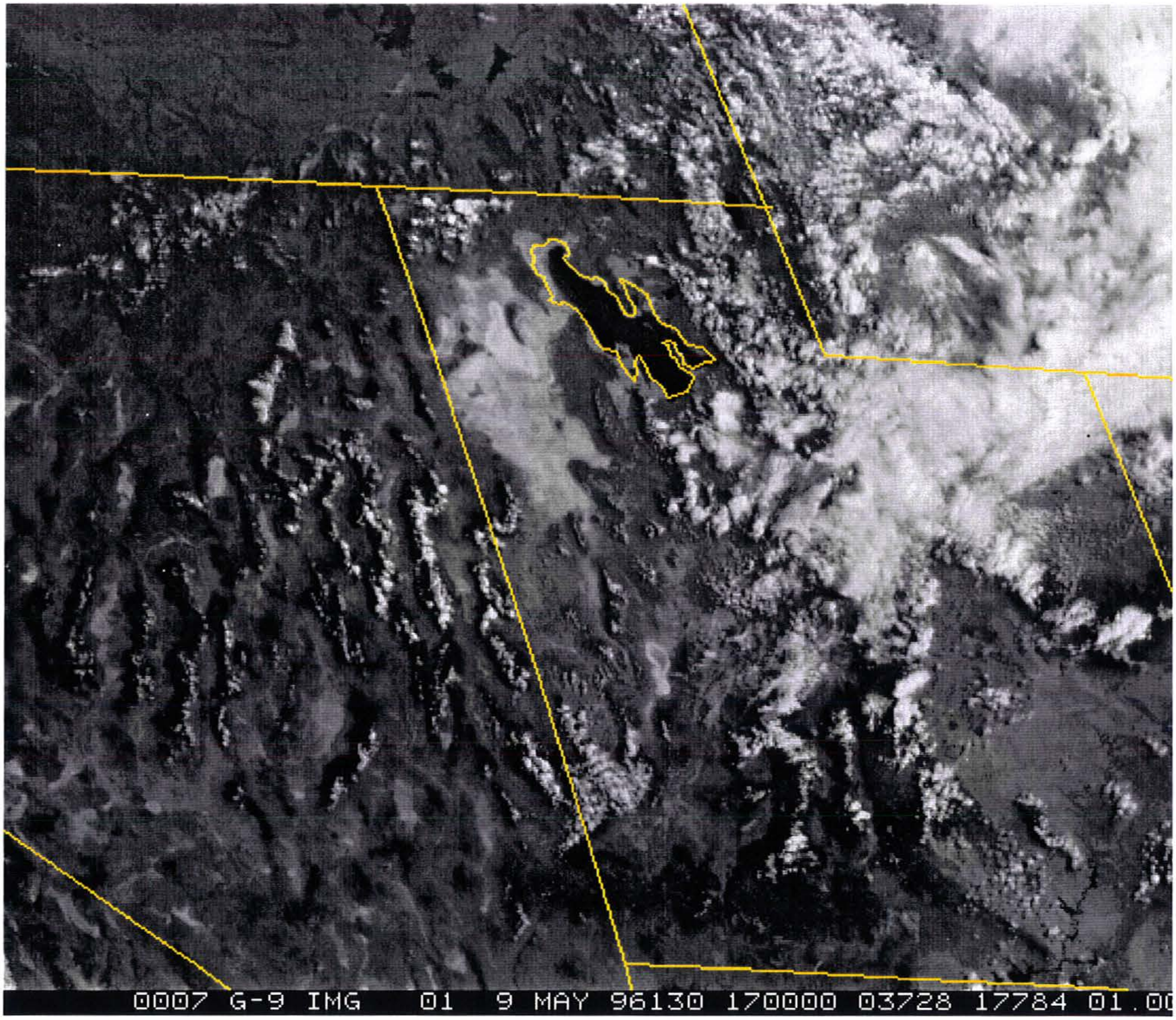

Figure 5. Visible satellite image at 1700 UTC on 9 May 1996. The Great Salt Lake is outlined in yellow near the upper center.

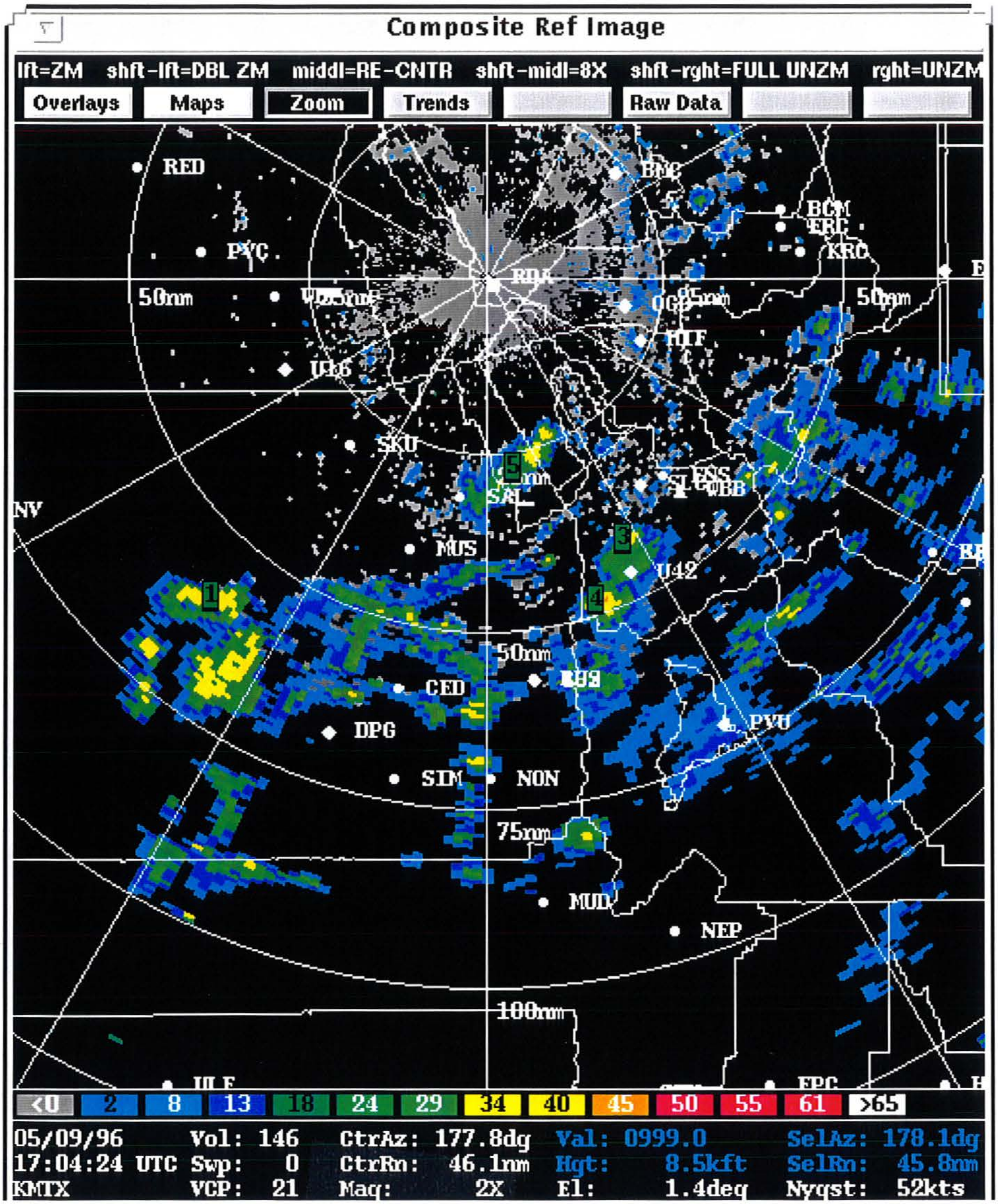

Figure 6. As in Fig. 1 except for 1704 UTC on 9 May 1996.

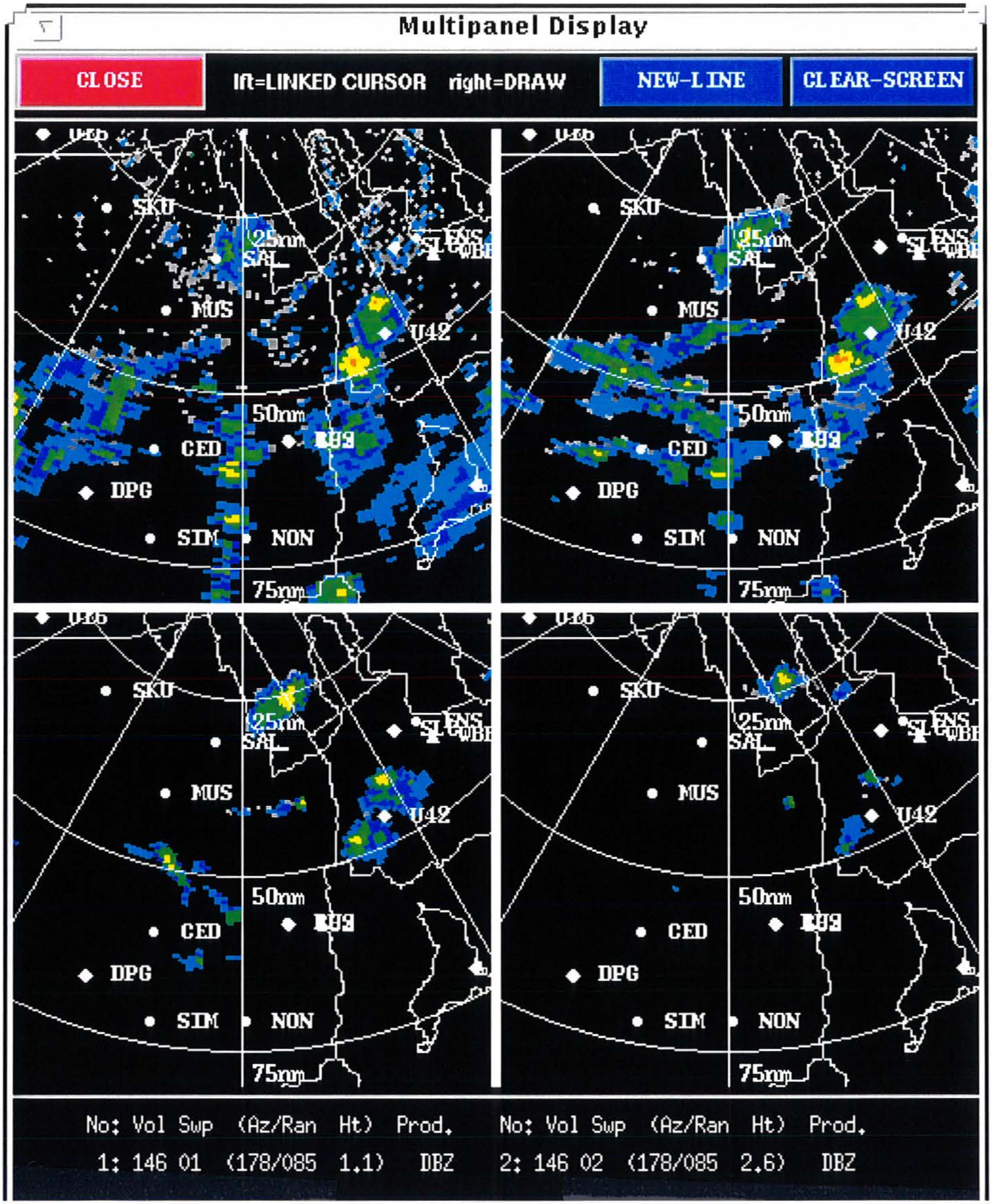

Figure 7. As in Fig. 2 except for 1704 UTC on 9 May 1996.