Analysis of the July 13th, 2002 Severe Wweather Event in Western Montana Using the Weather Event Simulator

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June 16, 2003

Introduction and General Meteorological Conditions

During the evening of July 13th, 2002, a line of thunderstorms moved through portions of western Montana producing high winds resulting in considerable damage in some communities. An organized line of storms producing widespread long lived thunderstorm outflow winds is not typical for this area. In this region of Montana, severe outflow, or microburst winds, most often occur with short lived cells and generally effect small areas.

From July 11th to July 13th a strong upper level high drifted slowly across the northern Great Basin bringing the hottest temperatures to western Montana since 1963. On the 13th, the upper level high shifted far enough east to allow upper level southwesterly flow ahead of a trough off the Pacific Northwest Coast to develop west of the ridge axis into western Montana. A plume of subtropical moisture above 600 mb and imbedded weak shortwaves were evident in the this flow. At the surface a thermal trough was analyzed over western Montana, and was expected to shift east during the evening as a shallow modified Pacific airmass moved into the region from the west.

At 00 UTC 14 July 2002 , a shortwave in the southwesterly upper flow was evident on water vapor imagery from southwest Washington to north central Idaho (Fig 1). The 14/00 UTC ETA captured this feature well. Deep convection had already developed along this shortwave at 00 UTC (Fig 2). Forecasted CAPE for 03Z from the ETA across northwest Montana was generally 2000 J/Kg, with low level convergence along the thermal trough axis from north central Idaho to the Glacier Park region (Fig 3). The models progressed the shortwave through western Montana through 06 UTC.

The pre-storm environment appeared to favor strong outflow winds enhanced by the dry airmass below 600 mb. The forecast sounding from the Eta at 03 UTC (Fig 4) indicates a moderately dry sub cloud layer, with significant moisture above 600 mb. Criteria for severe dry microburst potential was only moderate with a temperature dewpoint spread of only about 40 F at 03 UTC. Surface dew points rose dramatically during the evening in the valleys to the 60s to mid 70s due high soil and plant moisture conditions. These dew point values are extremely high for this area, but probably did not effect storm development or mitigate downward acceleration of outflow winds to any great extent as the moist layer was quite shallow. The forecast sounding also indicated some weak to moderate speed shear with height. According to Weisman (1996), moderate unidirectional speed shear in a high CAPE environment can be conducive to the development of organized lines of convection or bow echoes.

Event Description

The convection associated with the weak shortwave over southeastern Washington and north central Idaho at 00 UTC continued to organize into a broken line of storms along the Montana Idaho border by 03 UTC (Fig 5). Visible imagery before sunset clearly shows several overshooting tops associated with the strongest convection (Fig 6). Radar imagery at 0246Z (Fig 7), indicates a broken line of storms in what appears to be a Line Echo Wave Pattern. The strongest cells are southwest of Superior and Missoula, and west of Hamilton. The 0.5 degree elevation slice of base velocity does indicated a few pockets of inbound winds of 36 to 50 kts at 12,000' MSL just ahead of the cells heading directly towards the radar southwest of Missoula.

At 0256 UTC, the cells were the most intense during the event. The strongest cell, now west of Superior, had an elevated core of greater then 57 dBz, a VIL of 59 kg/m2, and an echo top of 53,000', resulting in a VIL density greater then 1 (Fig 8). Hail was considered only a secondary threat during this convective event due to the very high wet bulb zero, but indications were that this cell could have briefly produced large hail. As the area in the vicinity of the cell is unpopulated, no reports of hail were received.

Over the next 20 minutes the cell weakened as it moved off the mountains over the Clark Fork River Valley. The Layer 2 Reflectivity Maximum product at 0317 UTC (Fig 9) indicates the reflectivity core aloft associated with this cell weakened considerably, while the lowest three base reflectivity slices (Fig 10) indicates the highest reflectivity has now descended to the lower portion of the storm. At 0310 UTC, very strong winds were reported in Saint Regis, Montana, just in advance of the cell as it was weakening. Numerous large Ponderosa Pine were blown down on top of homes and across Interstate 90.

To the west of Missoula, the base velocity at 0317 UTC indicates a large area of inbound winds between 50 and 64 kts at 11,000' MSL and a few small areas of winds greater then 64 kts (Fig 10). A time loop of base velocity would show this region of high winds accelerating rapidly out ahead of the region of higher reflectivity southwest of Missoula. This could be associated with developing pressure perturbations enhancing the development of a mid level rear inflow jet, however storm relative velocity imagery did not indicate anything conclusive.
During other convective events, localized regions of strong outflow are apparent on the Missoula radar at the lowest elevation slices. Since the radar is sited on a mountain at 8000' MSL, or 5000' above the valley floor and the complexity of the terrain, these winds are often not realized at the surface. In this situation, high winds were reaching the surface over a large area along the gust front. By 0332 UTC (Fig 11) , the strong outflow produced very high winds from just east of Thompson Falls to Plains to the west side of Missoula (approximately 90 miles). Powerlines and trees were blown down in several communities. A barn was blown off it's foundation in Plains. Several fires were started by downed powerlines, as the storms were relatively dry. The highest wind gust measured directly was 72 MPH at the Nine Mile RAWS (near Alberton at 3300 feet elev). The strong outflow near Missoula was detected well by the radar, but was not detected northwest of Missoula, as the outflow winds are perpendicular to the radar beam. Despite this, 26 to 36 kt inbound velocities were still detected near the cluster of cells west of Plains, along with an anticyclonic convergent signature.

The broken line of storms and widespread strong outflow continued to move northeast through the next hour. At 0352 UTC (Fig 12), damaging winds were reported in Hot Springs and Arlee. By 0427 UTC (Fig 13), damaging winds were reported in Seeley Lake, Saint Ignatius, and Polson. At 0443 UTC (Fig 14) a strong cell developed at the northwest end of the broken line. Shortly afterward this cell weakened and collapsed with the resulting outflow producing high winds from Kila through Kalispell. Two square miles of trees were blown down near Kila (9 miles southwest of Kalispell). Localized structural damage and downed trees and powerlines were reported in Kalispell around 0500 UTC. The northern portion of the line weakened after this time while the southern cluster of cells moved into the Bob Marshall Wilderness (east of Polson) and persisted until after 0600 UTC (Fig 15).

Summary

The analysis of this event with the Weather Event Simulator proved quite useful. Typically when issuing a warning, the storms or line movement is determined via information on the base or composite reflectivity image. When reviewing this event in the WES, is was apparent that it would be beneficial in this situation to use the base velocity map instead. At times the leading edge of the strong outflow was up to 15 miles ahead of the higher reflectivity cores. Also, this event re-iterated the value of using base velocity during outflow or straight line wind events. Storm relative motion is very useful for determining rotation, and convergent/divergent signatures, but is often misleading during straight line or outflow wind events.

Weisman, M. L.: 1996: A Convective Storm Matrix: Buoyancy/Shear Dependencies. COMET Forecaster's Multimedia LIbrary.

Figure 1

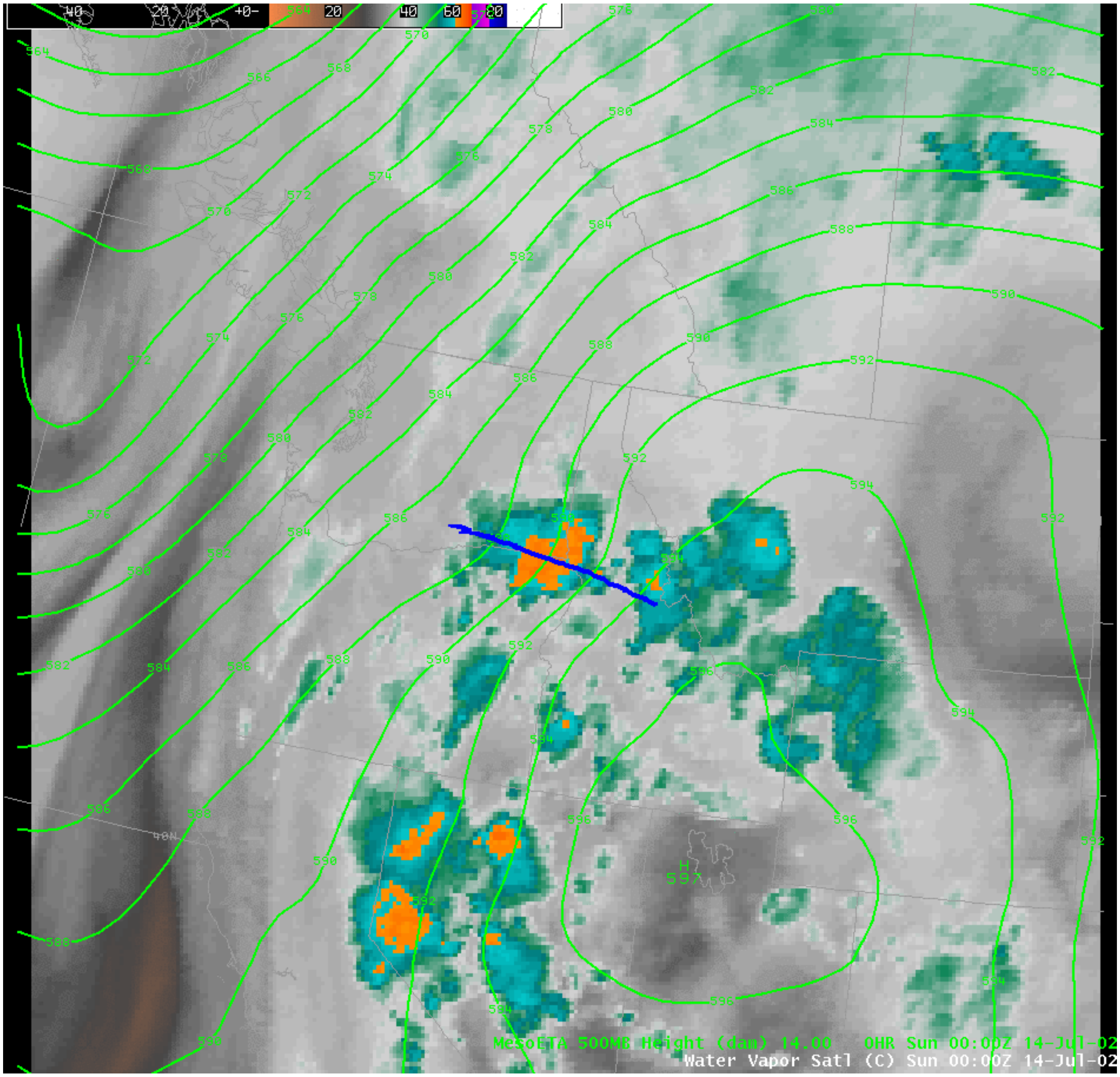
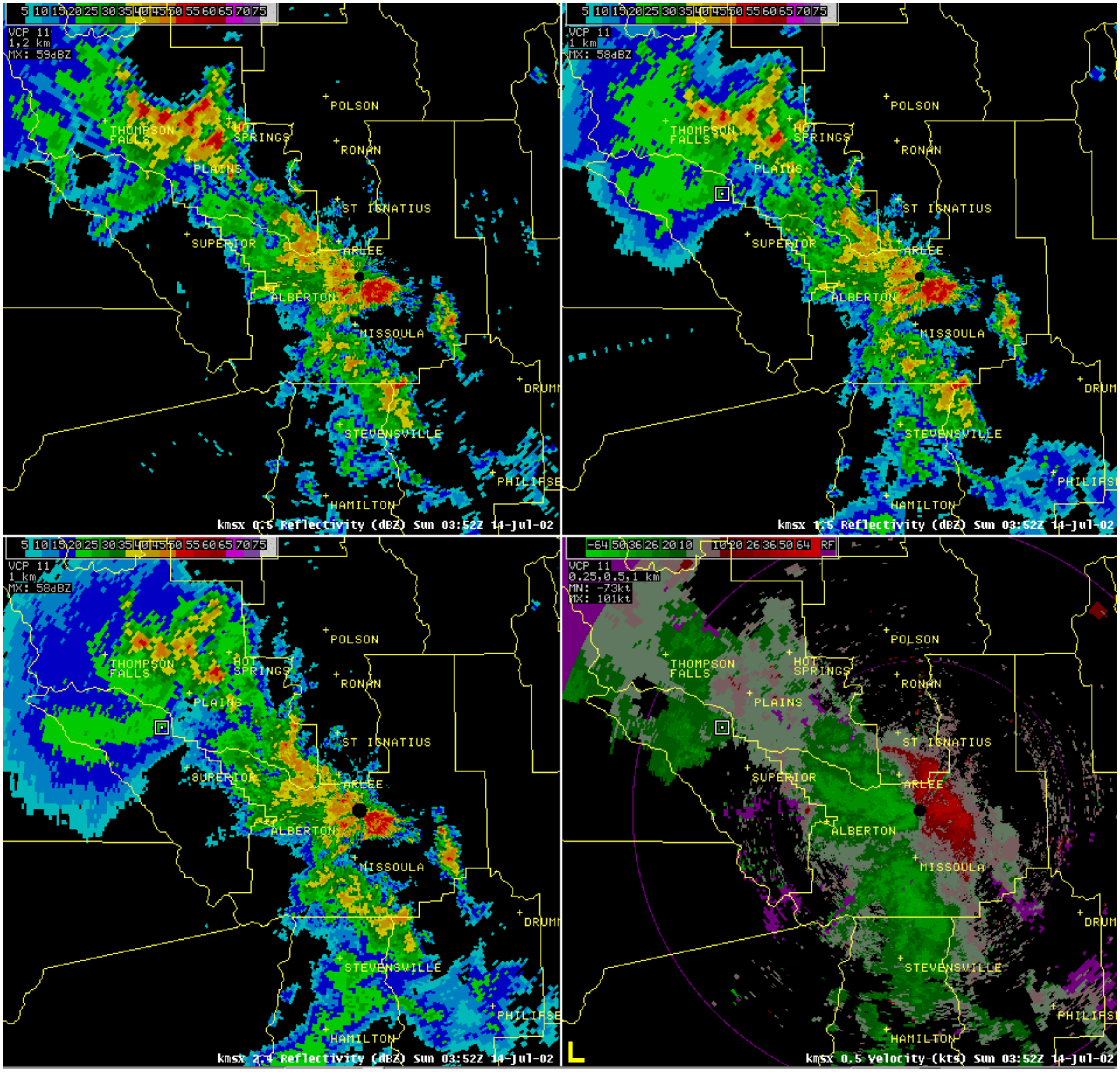

-40
-20
+0-
20
40
60
80
MesoETA 500MB Height (dam) 14.00 0HR Sun 00:00Z 14-Jul-02
Water Vapor Satl (C) Sun 00:00Z 14-Jul-02
H
597
40N

Figure 2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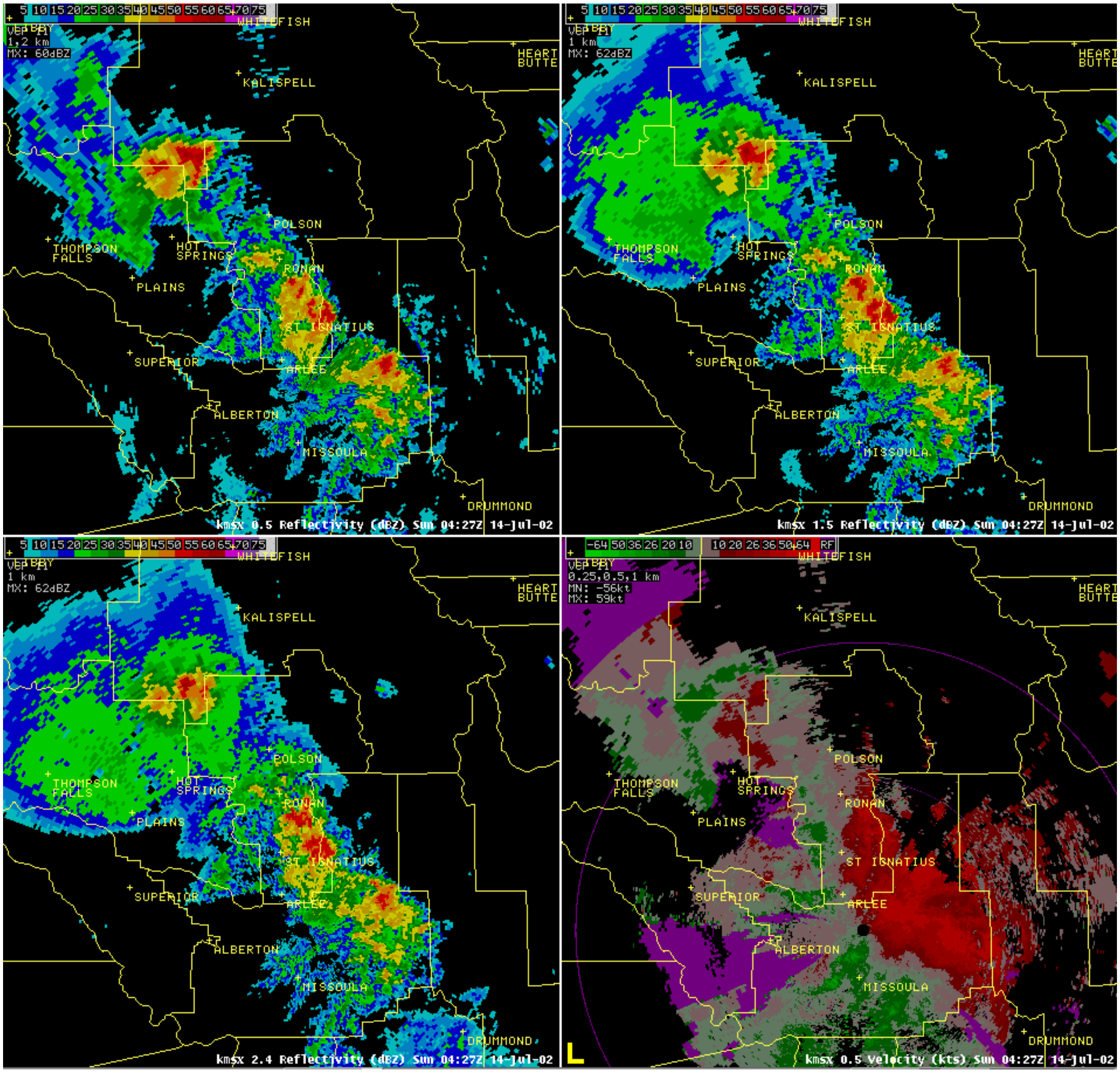
VCP 11
1,2 km
MX: 59dBZ
kmsx 0.5 Reflectivity (dBZ) Sun 03:52Z 14-Jul-02
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
VCP 11
1 km
MX: 58dBZ
kmsx 1.5 Reflectivity (dBZ) Sun 03:52Z 14-Jul-02
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
VCP 11
1 km
MX: 58dBZ
kmsx 2.4 Reflectivity (dBZ) Sun 03:52Z 14-Jul-02
-64 50 36 26 20 10 10 20 26 36 50 64 RF
VCP 11
0.25,0.5,1 km
MN: -73kt
MX: 101kt
kmsx 0.5 Velocity (kts) Sun 03:52Z 14-Jul-02
L
POLSON
RONAN
THOMPSON FALLS
HOT SPRINGS
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
DRUMM
STEVENSVILLE
PHILIPSB
HAMILTON

Figure 3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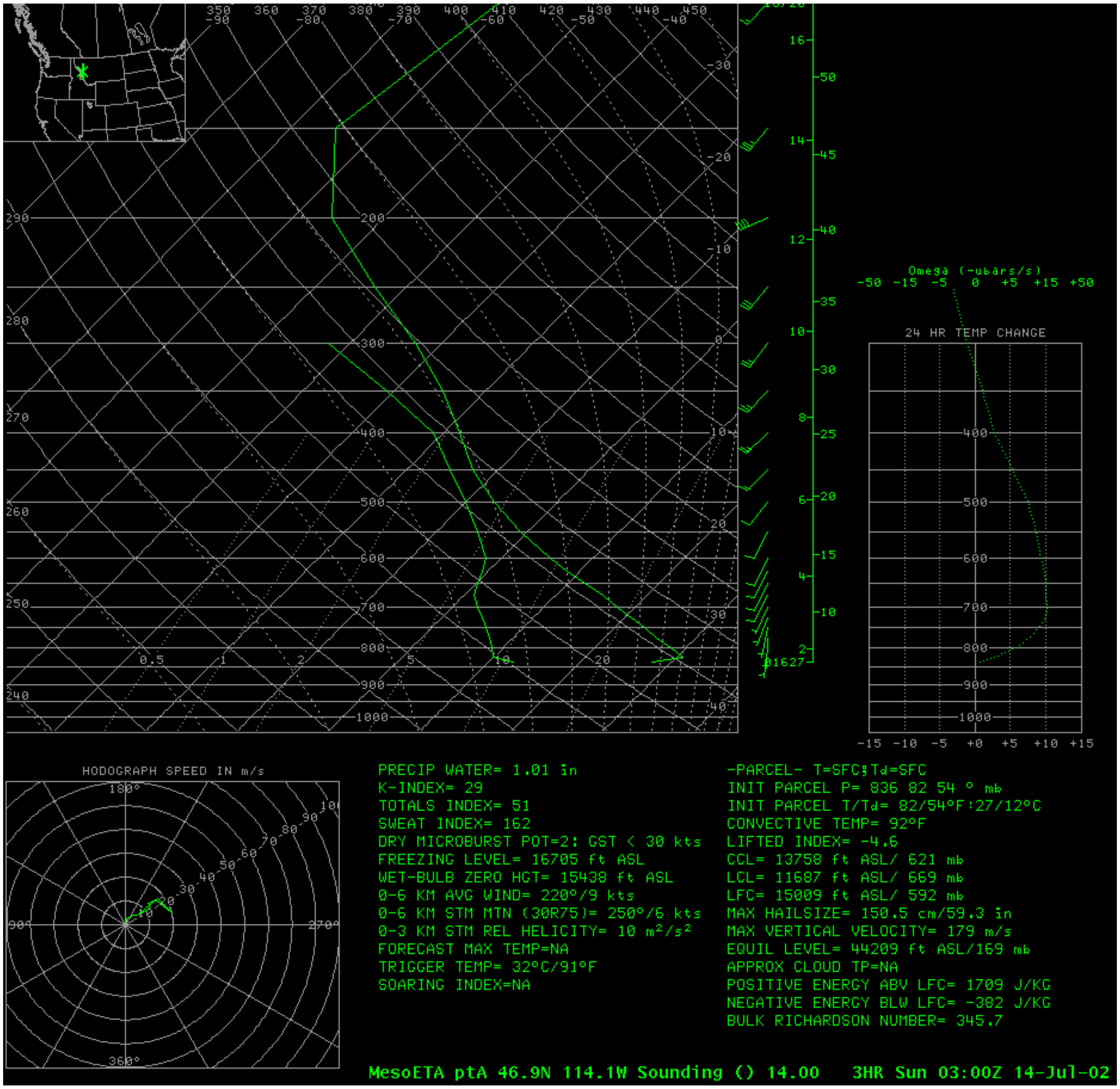
1.2 km
MX: 60dBZ
1 km
MX: 62dBZ
-64 50 36 26 20 10 10 20 26 36 50 64 RF
0.25,0.5,1 km
MN: -56kt
MX: 59kt
WHITEFISH
KALISPELL
HEART BUTTE
POLSON
THOMPSON FALLS
HOT SPRINGS
RONAN
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
DRUMMOND
kmsx 0.5 Reflectivity (dBZ) Sun 04:27Z 14-Jul-02
kmsx 1.5 Reflectivity (dBZ) Sun 04:27Z 14-Jul-02
kmsx 2.4 Reflectivity (dBZ) Sun 04:27Z 14-Jul-02
kmsx 0.5 Velocity (kts) Sun 04:27Z 14-Jul-02
L

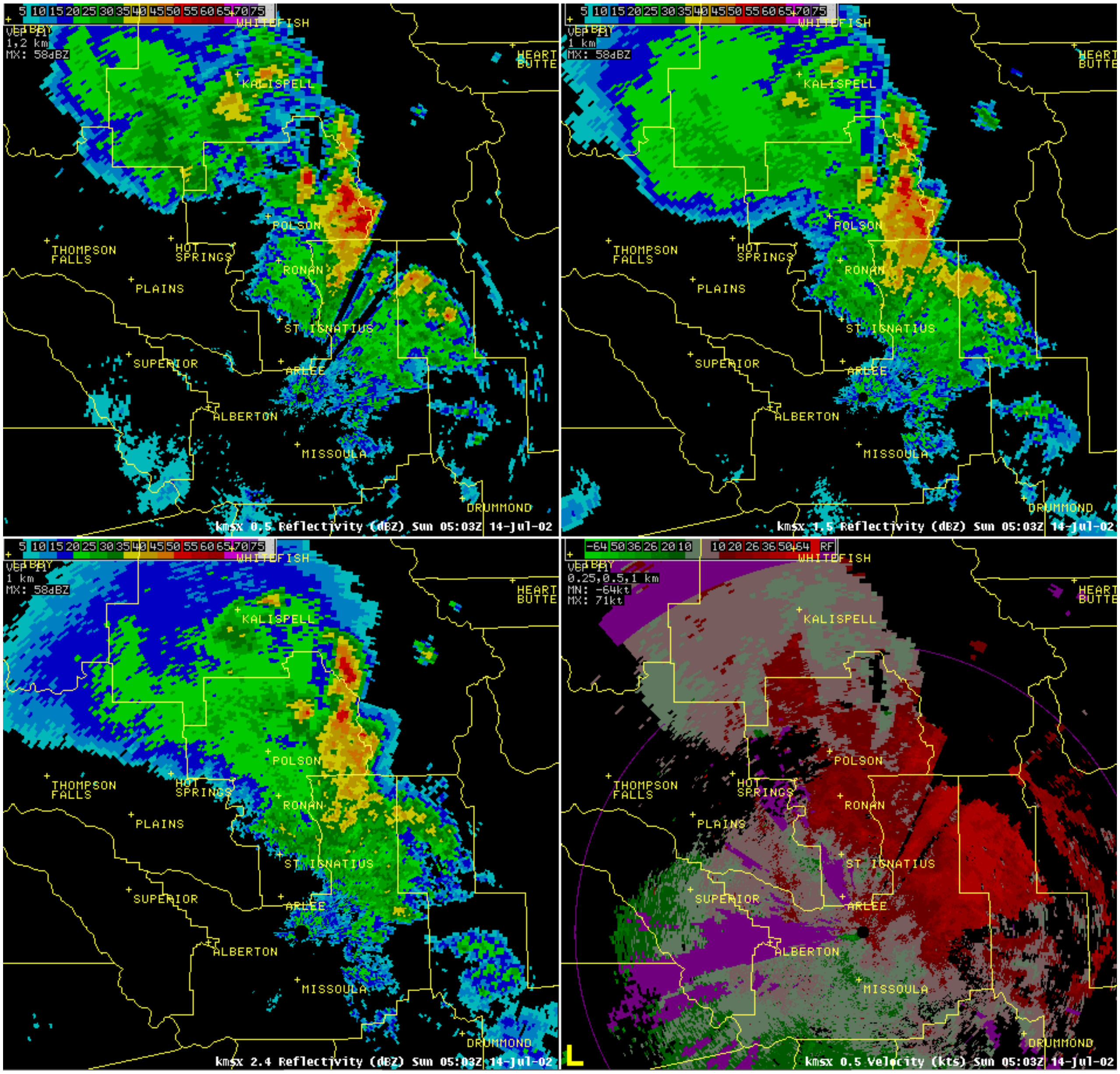
Figure 4



```
PRECIP WATER= 1.01 in                    -PARCEL- T=SFC;Td=SFC
K-INDEX= 29                              INIT PARCEL P= 836 82 54 ° mb
TOTALS INDEX= 51                         INIT PARCEL T/Td= 82/54°F:27/12°C
SWEAT INDEX= 162                         CONVECTIVE TEMP= 92°F
DRY MICROBURST POT=2: GST < 30 kts       LIFTED INDEX= -4.6
FREEZING LEVEL= 16705 ft ASL             CCL= 13758 ft ASL/ 621 mb
WET-BULB ZERO HGT= 15438 ft ASL          LCL= 11687 ft ASL/ 669 mb
0-6 KM AVG WIND= 220°/9 kts              LFC= 15009 ft ASL/ 592 mb
0-6 KM STM MTN (30R75)= 250°/6 kts       MAX HAILSIZE= 150.5 cm/59.3 in
0-3 KM STM REL HELICITY= 10 m²/s²        MAX VERTICAL VELOCITY= 179 m/s
FORECAST MAX TEMP=NA                     EQUIL LEVEL= 44209 ft ASL/169 mb
TRIGGER TEMP= 32°C/91°F                  APPROX CLOUD TP=NA
SOARING INDEX=NA                         POSITIVE ENERGY ABV LFC= 1709 J/KG
                                         NEGATIVE ENERGY BLW LFC= -382 J/KG
                                         BULK RICHARDSON NUMBER= 345.7

MesoETA ptA 46.9N 114.1W Sounding () 14.00   3HR Sun 03:00Z 14-Jul-02
```

Figure 5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kmsx 1.5 Reflectivity (dBZ) Sun 05:03Z 14-Jul-02
kmsx 2.4 Reflectivity (dBZ) Sun 05:03Z 14-Jul-02
kmsx 0.5 Velocity (kts) Sun 05:03Z 14-Jul-02
MX: 58dBZ
MN: -64kt
MX: 71kt
WHITEFISH
KALISPELL
HEART BUTTE
POLSON
THOMPSON FALLS
HOT SPRINGS
RONAN
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
DRUMMOND

Figure 6

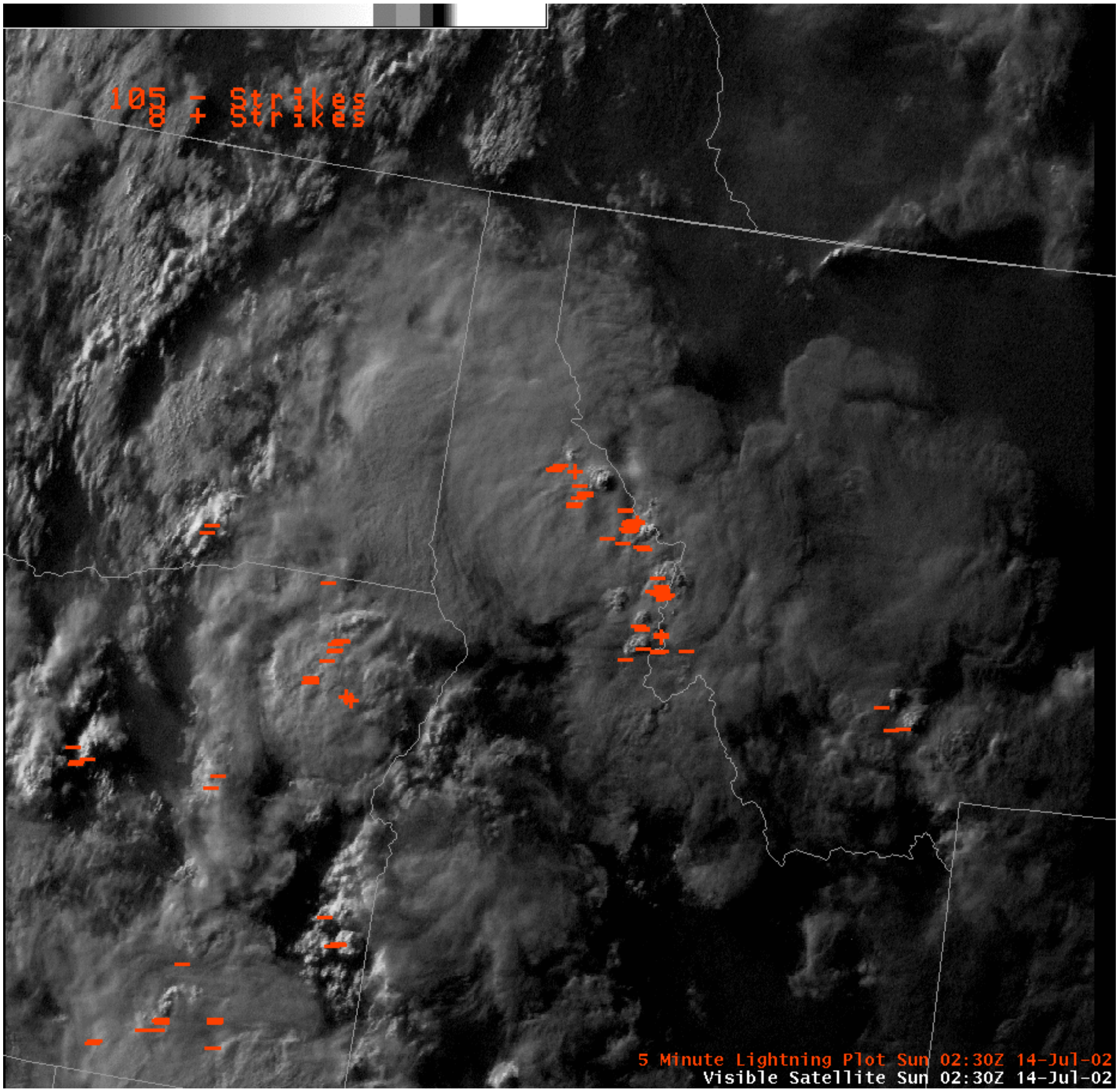
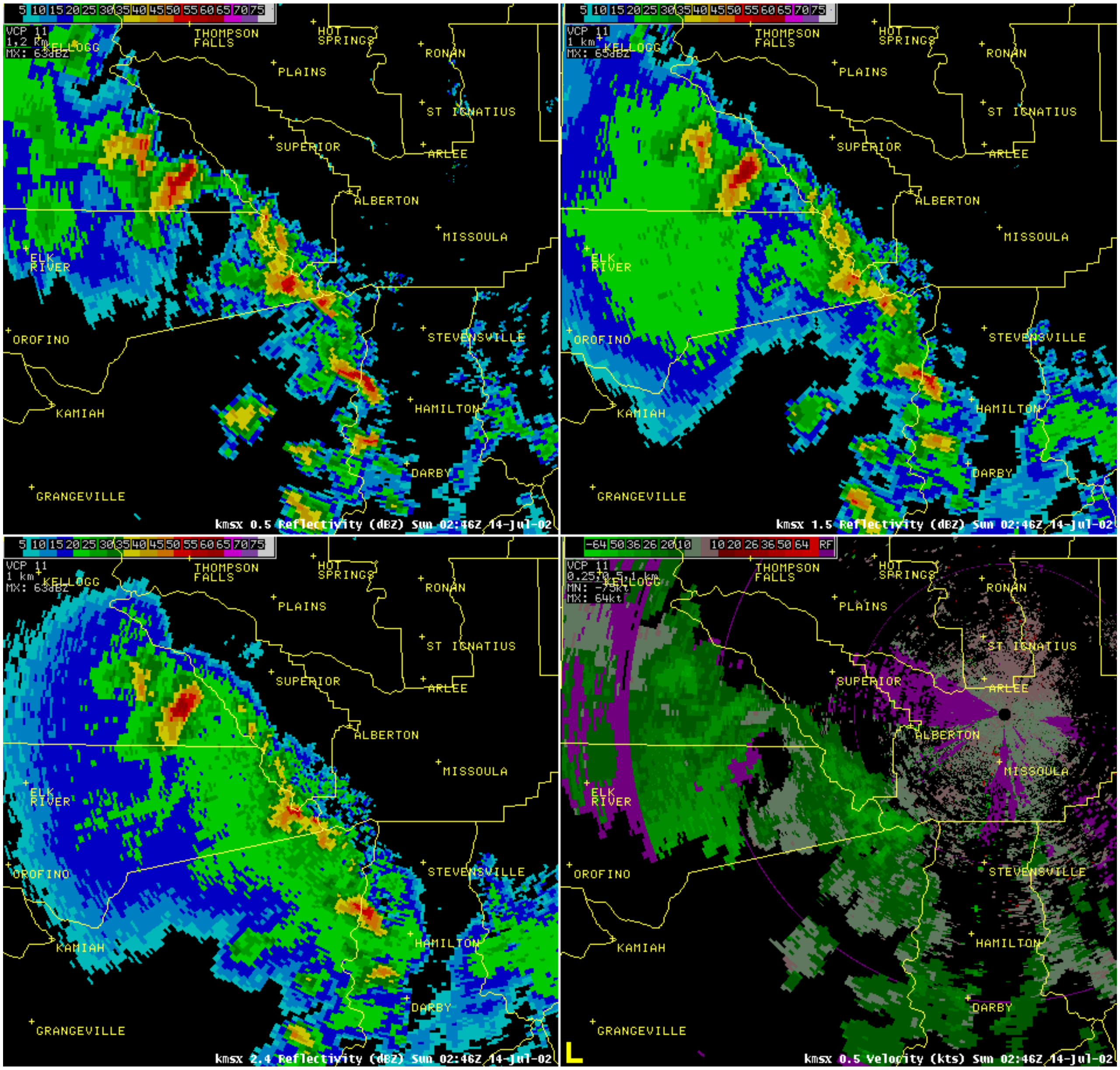

105 - Strikes
8 + Strikes
5 Minute Lightning Plot Sun 02:30Z 14-Jul-02
Visible Satellite Sun 02:30Z 14-Jul-02

Figure 7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VCP 11
1.2 km
MX: 63dBZ
kmsx 0.5 Reflectivity (dBZ) Sun 02:46Z 14-Jul-02
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
VCP 11
1 km
MX: 65dBZ
kmsx 1.5 Reflectivity (dBZ) Sun 02:46Z 14-Jul-02
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
VCP 11
1 km
MX: 63dBZ
kmsx 2.4 Reflectivity (dBZ) Sun 02:46Z 14-Jul-02
-64 50 36 26 20 10 10 20 26 36 50 64 RF
VCP 11
0.25/0.5:1 km
MN: -75kt
MX: 64kt
kmsx 0.5 Velocity (kts) Sun 02:46Z 14-Jul-02
KELLOGG
THOMPSON FALLS
HOT SPRINGS
RONAN
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
ELK RIVER
OROFINO
STEVENSVILLE
KAMIAH
HAMILTON
DARBY
GRANGEVILLE

Figure 8

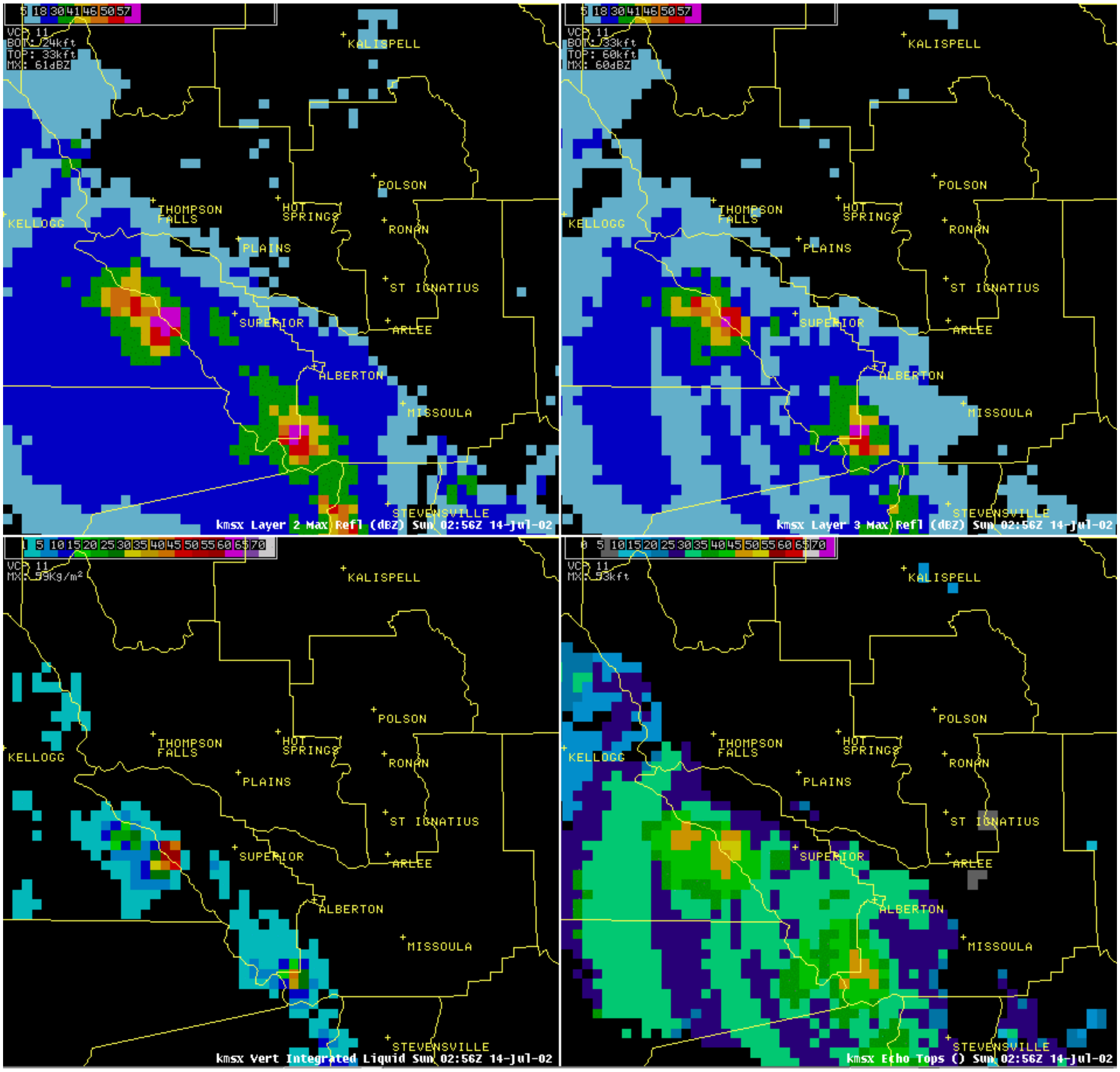

5 18 30 41 46 50 57
VCP 11
BOT: 24kft
TOP: 33kft
MX: 61dBZ
KALISPELL
POLSON
THOMPSON FALLS
HOT SPRINGS
RONAN
KELLOGG
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
STEVENSVILLE
kmsx Layer 2 Max Refl (dBZ) Sun 02:56Z 14-Jul-02
5 18 30 41 46 50 57
VCP 11
BOT: 33kft
TOP: 60kft
MX: 60dBZ
kmsx Layer 3 Max Refl (dBZ) Sun 02:56Z 14-Jul-02
1 5 10 15 20 25 30 35 40 45 50 55 60 65 70
VCP 11
MX: 59Kg/m²
kmsx Vert Integrated Liquid Sun 02:56Z 14-Jul-02
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
VCP 11
MX: 53kft
kmsx Echo Tops () Sun 02:56Z 14-Jul-02

Figure 9

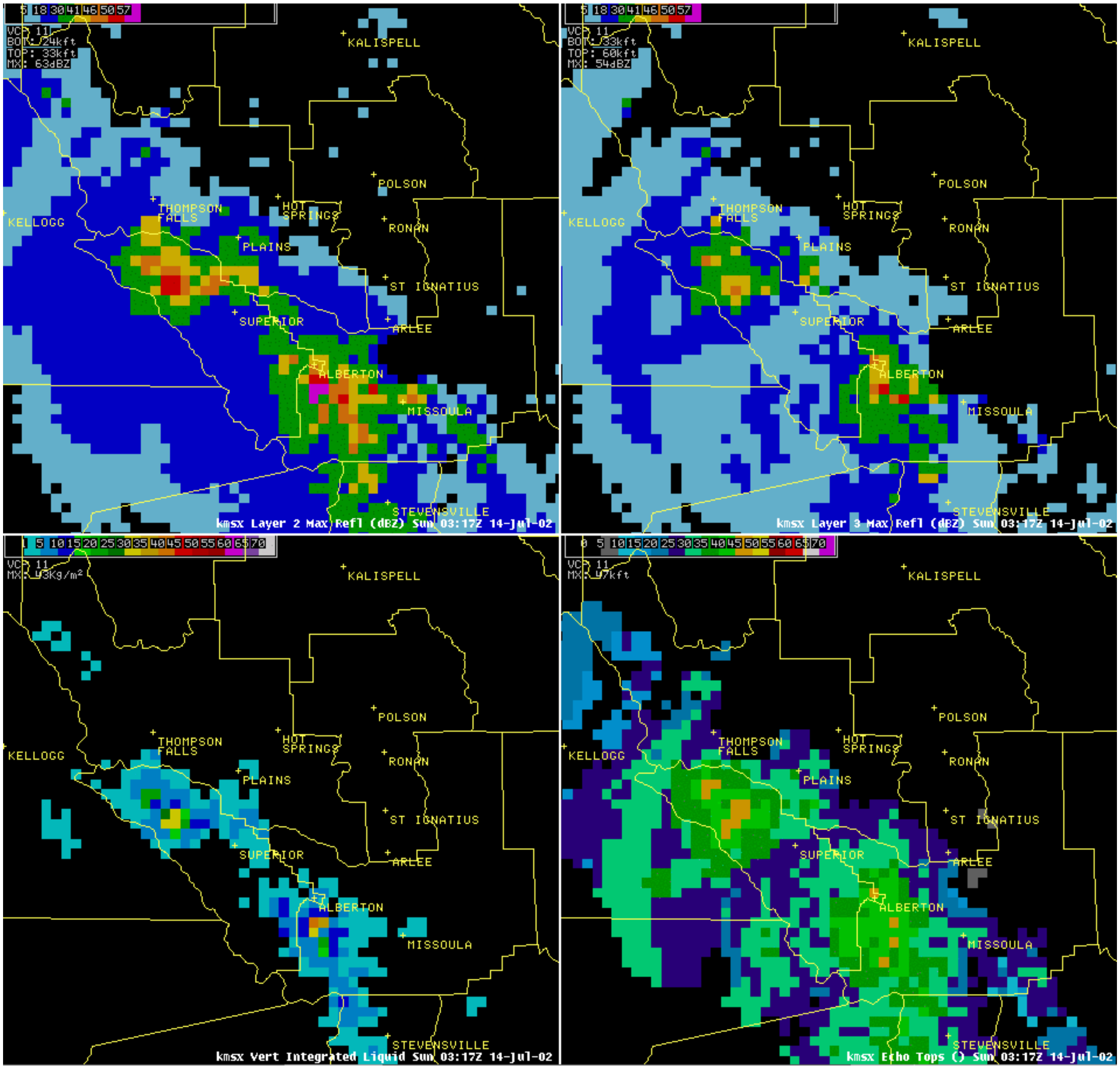

5 18 30 41 46 50 57
VCP 11
BOT: 24kft
TOP: 33kft
MX: 63dBZ
KALISPELL
POLSON
THOMPSON FALLS
HOT SPRINGS
KELLOGG
RONAN
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
STEVENSVILLE
kmsx Layer 2 Max Refl (dBZ) Sun 03:17Z 14-Jul-02
5 18 30 41 46 50 57
VCP 11
BOT: 33kft
TOP: 60kft
MX: 54dBZ
kmsx Layer 3 Max Refl (dBZ) Sun 03:17Z 14-Jul-02
1 5 10 15 20 25 30 35 40 45 50 55 60 65 70
VCP 11
MX: 43Kg/m²
kmsx Vert Integrated Liquid Sun 03:17Z 14-Jul-02
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
VCP 11
MX: 47kft
kmsx Echo Tops () Sun 03:17Z 14-Jul-02

Figure 10

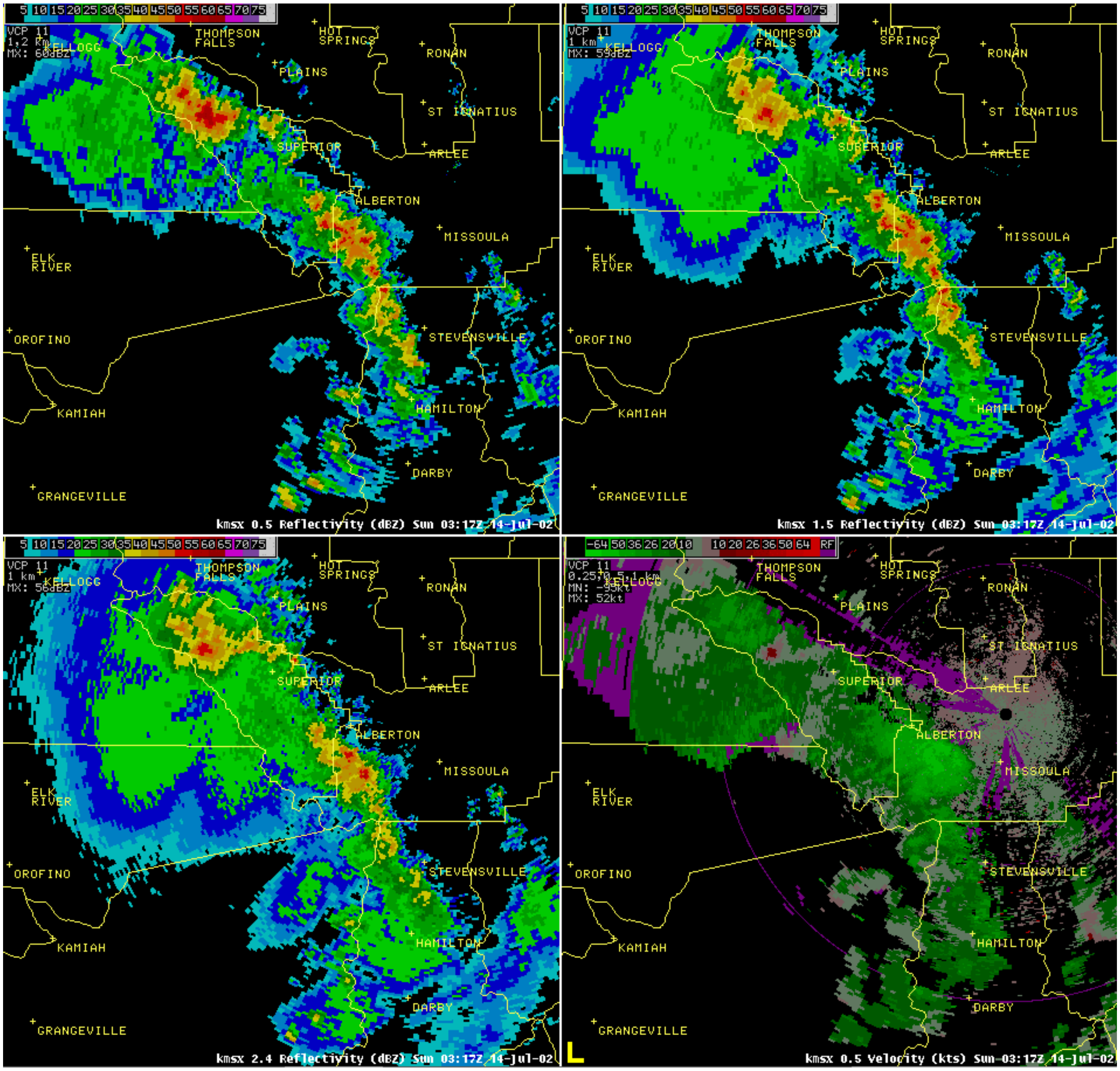
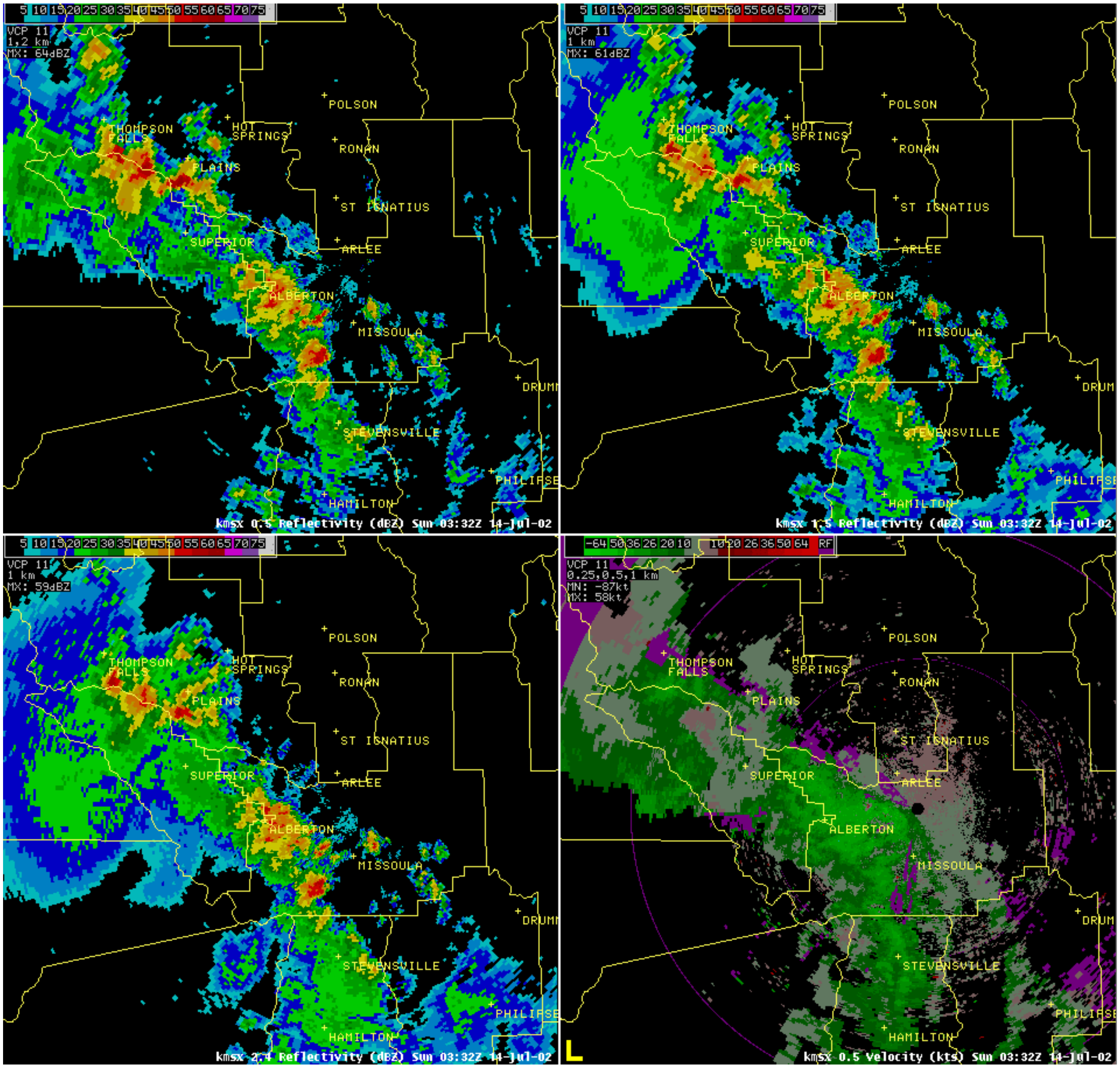

5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
VCP 11
1.2 km
MX: 60dBZ
KELLOGG
THOMPSON FALLS
HOT SPRINGS
RONAN
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
ELK RIVER
OROFINO
STEVENSVILLE
KAMIAH
HAMILTON
DARBY
GRANGEVILLE
kmsx 0.5 Reflectivity (dBZ) Sun 03:17Z 14-Jul-02
VCP 11
1 km
MX: 59dBZ
kmsx 1.5 Reflectivity (dBZ) Sun 03:17Z 14-Jul-02
VCP 11
1 km
MX: 56dBZ
kmsx 2.4 Reflectivity (dBZ) Sun 03:17Z 14-Jul-02
-64 50 36 26 20 10 10 20 26 36 50 64 RF
VCP 11
0.25,0.5,1 km
MN: -95kt
MX: 52kt
L
kmsx 0.5 Velocity (kts) Sun 03:17Z 14-Jul-02

Figure 11


5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
VCP 11
1.2 km
MX: 64dBZ
kmsx 0.5 Reflectivity (dBZ) Sun 03:32Z 14-Jul-02
VCP 11
1 km
MX: 61dBZ
kmsx 1.5 Reflectivity (dBZ) Sun 03:32Z 14-Jul-02
VCP 11
1 km
MX: 59dBZ
kmsx 2.4 Reflectivity (dBZ) Sun 03:32Z 14-Jul-02
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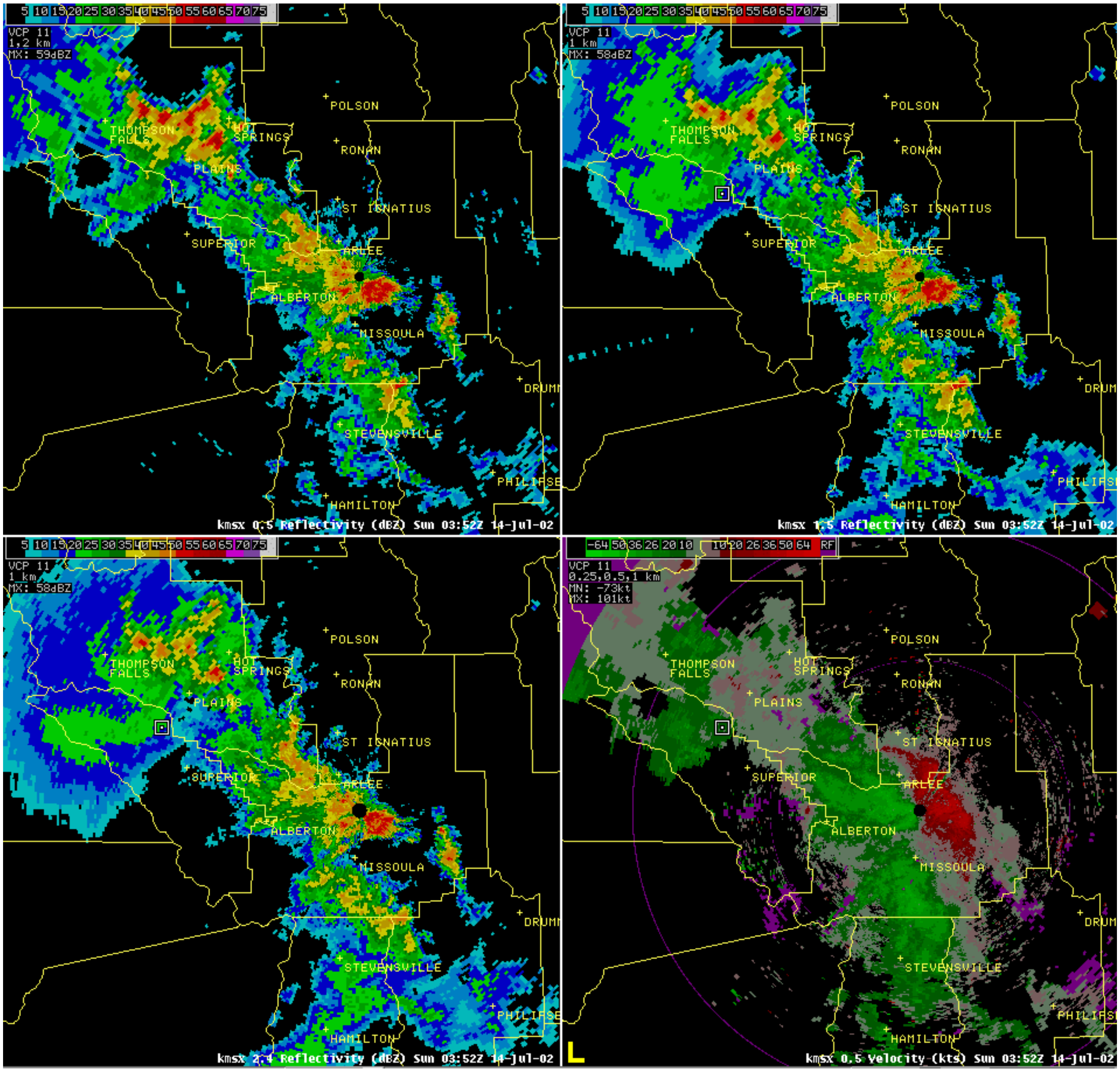
VCP 11
0.25,0.5,1 km
MN: -87kt
MX: 58kt
kmsx 0.5 Velocity (kts) Sun 03:32Z 14-Jul-02
L
POLSON
HOT SPRINGS
THOMPSON FALLS
RONAN
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
DRUMM
STEVENSVILLE
PHILIPSE
HAMILTON

Figure 12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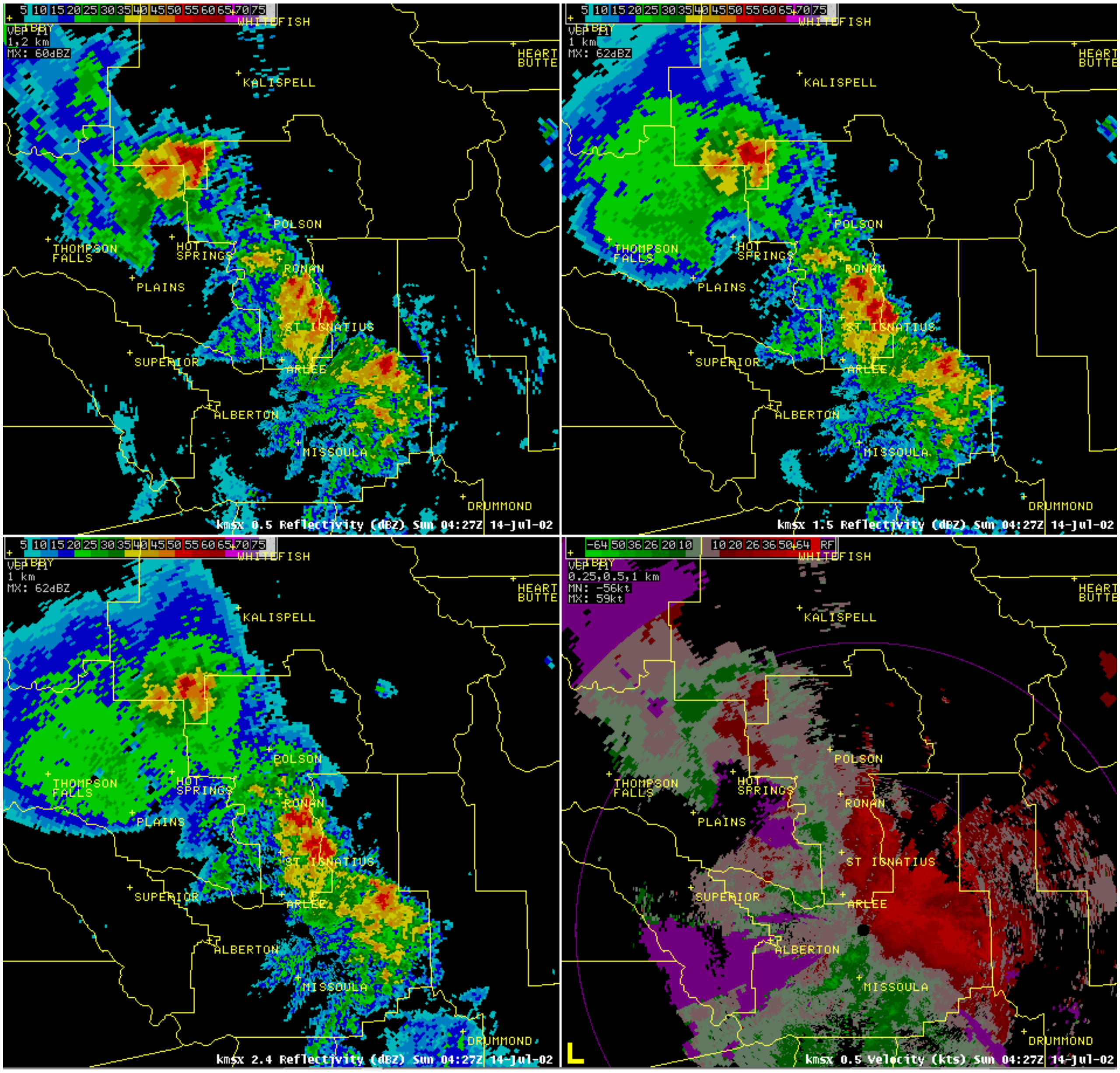
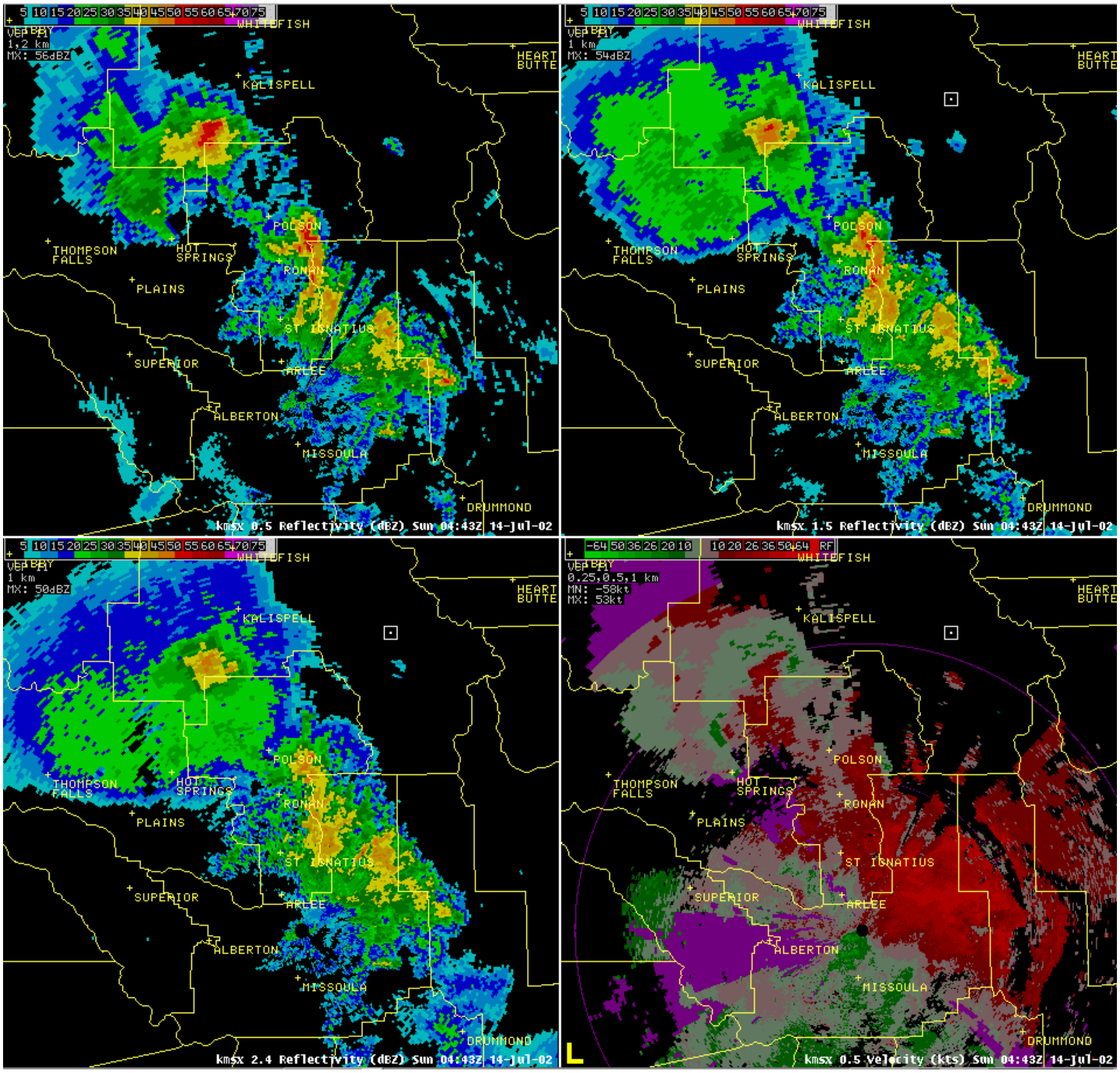
VCP 11
1,2 km
MX: 59dBZ
kmsx 0.5 Reflectivity (dBZ) Sun 03:52Z 14-Jul-02
VCP 11
1 km
MX: 58dBZ
kmsx 1.5 Reflectivity (dBZ) Sun 03:52Z 14-Jul-02
VCP 11
1 km
MX: 58dBZ
kmsx 2.4 Reflectivity (dBZ) Sun 03:52Z 14-Jul-02
-64 50 36 26 20 10 10 20 26 36 50 64 RF
VCP 11
0.25,0.5,1 km
MN: -73kt
MX: 101kt
kmsx 0.5 Velocity (kts) Sun 03:52Z 14-Jul-02
L
POLSON
THOMPSON FALLS
HOT SPRINGS
RONAN
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
DRUM
STEVENSVILLE
PHILIPSE
HAMILTON

Figure 13



5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
VEP 21 BBY
1.2 km
MX: 60dBZ
WHITEFISH
KALISPELL
HEART BUTTE
POLSON
THOMPSON FALLS
HOT SPRINGS
RONAN
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
DRUMMOND
kmsx 0.5 Reflectivity (dBZ) Sun 04:27Z 14-Jul-02
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
VEP 21 BBY
1 km
MX: 62dBZ
WHITEFISH
KALISPELL
HEART BUTTE
POLSON
THOMPSON FALLS
HOT SPRINGS
RONAN
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
DRUMMOND
kmsx 1.5 Reflectivity (dBZ) Sun 04:27Z 14-Jul-02
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
VEP 21 BBY
1 km
MX: 62dBZ
WHITEFISH
KALISPELL
HEART BUTTE
POLSON
THOMPSON FALLS
HOT SPRINGS
RONAN
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
DRUMMOND
kmsx 2.4 Reflectivity (dBZ) Sun 04:27Z 14-Jul-02
-64 50 36 26 20 10 10 20 26 36 50 64 RF
VEP 21 BBY
0.25,0.5,1 km
MN: -56kt
MX: 59kt
WHITEFISH
KALISPELL
HEART BUTTE
POLSON
THOMPSON FALLS
HOT SPRINGS
RONAN
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
DRUMMOND
L
kmsx 0.5 Velocity (kts) Sun 04:27Z 14-Jul-02

Figure 14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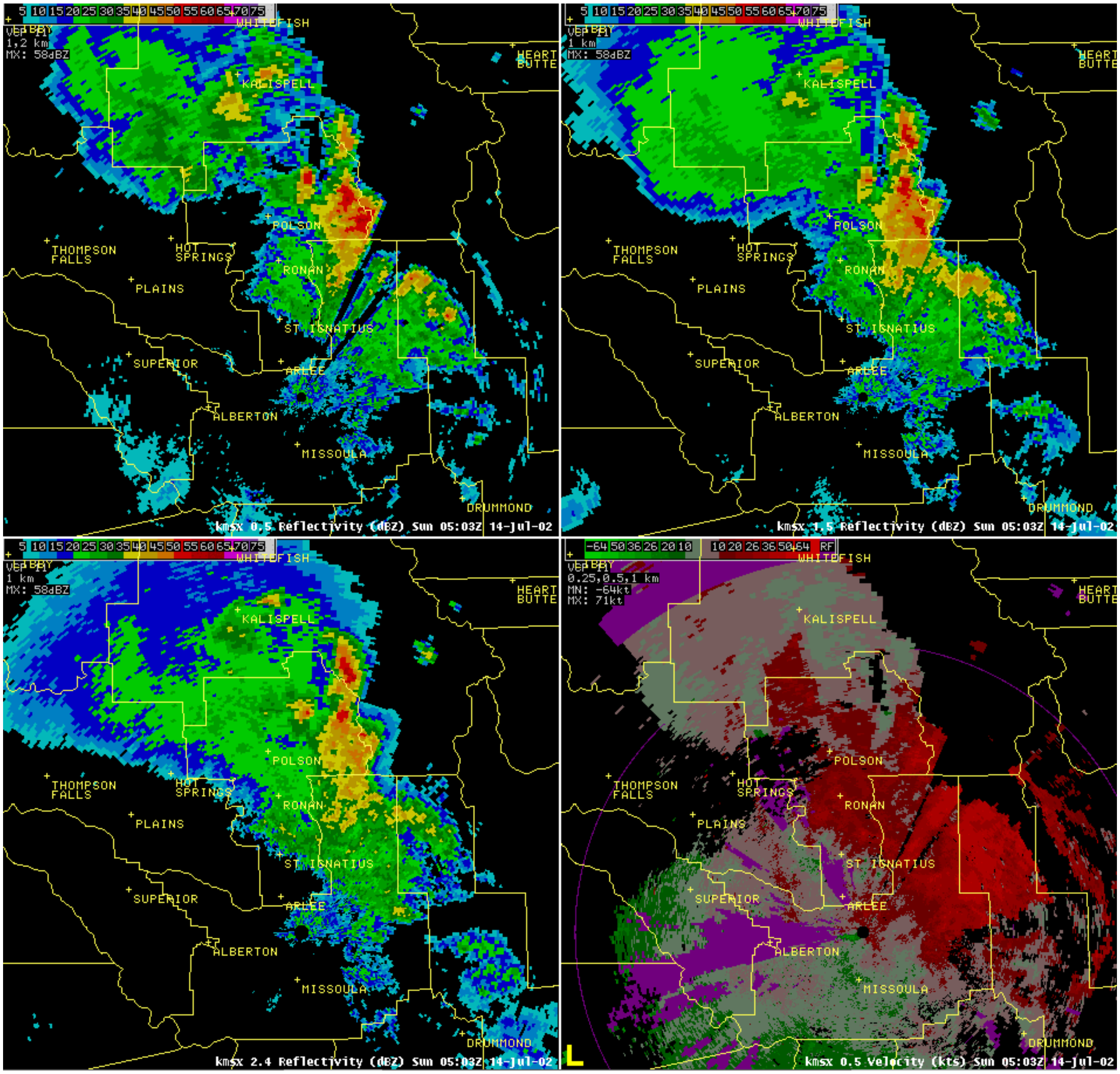
VCP 11
1,2 km
MX: 56dBZ
1 km
MX: 54dBZ
MX: 50dBZ
-64 50 36 26 20 10 10 20 26 36 50 64 RF
0.25,0.5,1 km
MN: -58kt
MX: 53kt
LIBBY
WHITEFISH
KALISPELL
HEART BUTTE
POLSON
THOMPSON FALLS
HOT SPRINGS
RONAN
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
DRUMMOND
kmsx 0.5 Reflectivity (dBZ) Sun 04:43Z 14-Jul-02
kmsx 1.5 Reflectivity (dBZ) Sun 04:43Z 14-Jul-02
kmsx 2.4 Reflectivity (dBZ) Sun 04:43Z 14-Jul-02
kmsx 0.5 Velocity (kts) Sun 04:43Z 14-Jul-02
L

Figure 15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VCP 21
1.2 km
MX: 58dBZ
1 km
MX: 58dBZ
-64 50 36 26 20 10 10 20 26 36 50 64 RF
0.25,0.5,1 km
MN: -64kt
MX: 71kt
WHITEFISH
HEART BUTTE
KALISPELL
POLSON
THOMPSON FALLS
HOT SPRINGS
RONAN
PLAINS
ST IGNATIUS
SUPERIOR
ARLEE
ALBERTON
MISSOULA
DRUMMOND
kmsx 0.5 Reflectivity (dBZ) Sun 05:03Z 14-Jul-02
kmsx 1.5 Reflectivity (dBZ) Sun 05:03Z 14-Jul-02
kmsx 2.4 Reflectivity (dBZ) Sun 05:03Z 14-Jul-02
kmsx 0.5 Velocity (kts) Sun 05:03Z 14-Jul-02
L