P4.3 MESOCYCLONE INDUCED SEVERE WINDS WITHIN DERECHO PRODUCING MESOSCALE CONVECTIVE SYSTEMS (DMCSs)

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1. INTRODUCTION

DMCSs produce a significant amount of severe wind damage across the U.S. annually and are capable of generating widespread severe winds, at times traveling over 1500 km and lasting upwards of 24 hours. It is therefore important to understand what mechanisms generate severe winds within these systems.

Although, DMCSs occasionally produce tornadoes, a preponderance of severe winds can be attributed to “straight-line” winds. Contributors to strong, straight-line winds include mesohighs (Johnson and Hamilton 1988) and downbursts (Fujita and Wakimoto 1981). Straight-line winds also occur near the apex of the bow echo (Fujita and Wakimoto 1981) and are thought to be produced when the rear inflow jet contacts the surface just behind the leading edge of the gust front (Weismann 1993) or by the gust front itself (Wakimoto 1982). However, it has been noticed that in numerous instances, severe wind damage also occurs north of the bowing apex, frequently causing wind related damage over a broad area. The position of these winds in relation to the bow apex nearly eliminates a rear inflow jet as the cause of the severe winds, and the large coverage of damage would also exclude downdrafts. Therefore, it is likely another dynamic is responsible for the creation of some severe straight-line winds within a DMCS squall line or bow echo.

A recent numerical modeling study by Weisman and Trapp (2003) suggests mesovortices may be responsible for at least some severe straight-line winds within quasi-linear convective systems (QLCSs), which include squall lines and bow echos. They found surfaced- based mesovortices within a QLCS may create large horizontal pressure gradients, thus inducing an acceleration of the horizontal surface wind. They also showed the strongest winds within a QLCS to be in association with a mesovortex.

2. METHODOLOGY

Four random DMCSs were examined in an attempt to determine the roots of the most intense severe wind reports, such as a rear inflow, mesovortex, or gust front. Only the ten highest measured severe wind speeds occurring among the four DMSCs were analyzed. WSR-88D radar data were analyzed near the time of each of the ten severe wind reports to determine the cause of the wind.

Radar data were obtained from the National Climate Data Center (NCDC) and viewed using the WSR-88D Algorithm Testing and Display System (WATADS), available from the National Severe Storms Laboratory (NSSL). Wind speeds were acquired from the Storm Prediction Center (SPC) storm reports. Each DMCS studied met the criteria set forth by Bentley and Mote (1998), as well as the criteria used by Johns and Hirt (1987).

3. OBSERVATIONS

During the evening of 8 August 2001, three discrete supercells merged into a MCS over eastern North Dakota (ND). By 0505 UTC, the northernmost cell showed a distinct cyclonic circulation near the surface (Figures 1 and 2). This circulation is clearly evident nearly an hour later as the line of storms moved east (Figure 3, 4, and 5). As the convective line continued east, strength and coverage of severe winds began to increase on the southwest side of the surfaced based mesovortex. By 0618 UTC, radar showed an extensive area with storm relative velocities exceeding 64 kts (Figure 6). At this time, a Davis weather station at Hillsboro, ND, reported an 87 kt sustained wind and a 96 kt gust.

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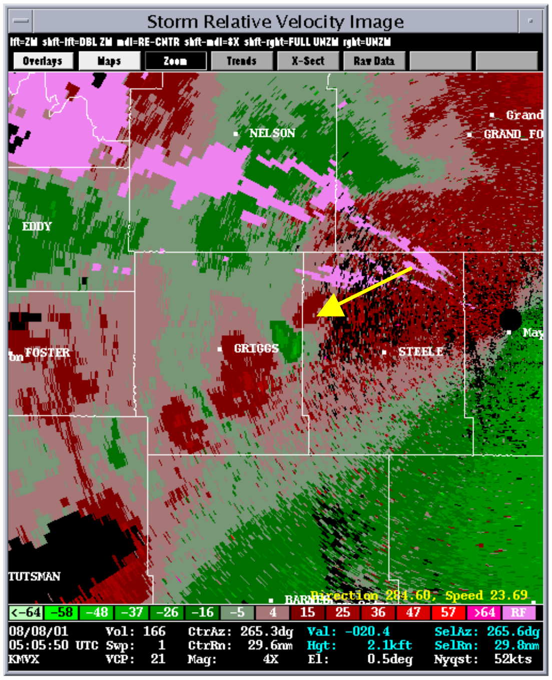

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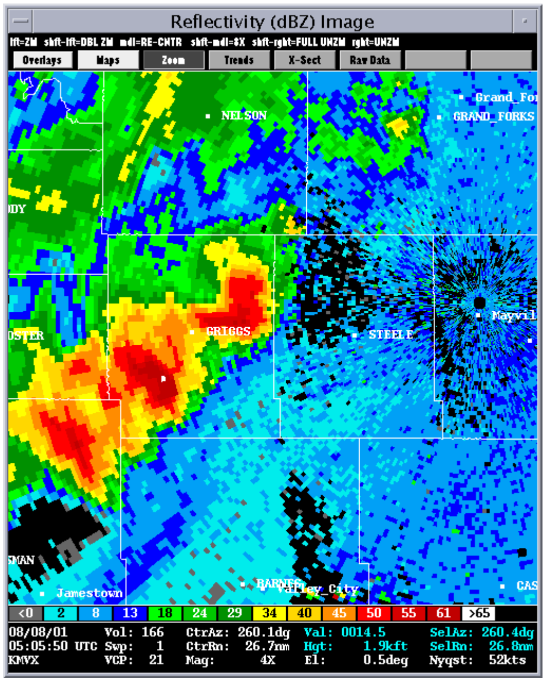
Direction 284.60, Speed 23.69
08/08/01         Vol: 166    CtrAz: 265.3dg  Val: -020.4     SelAz: 265.6dg
05:05:50 UTC Swp:   1    CtrRn:  29.6nm  Hgt:     2.1kft  SelRn:  29.8nm
KMVX             VCP:  21    Mag:        4X  El:      0.5deg  Nyqst:  52kts
```

Figure 1. Planview (0.5°) of storm-relative velocity (Kts) at 0505 UTC.



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08/08/01         Vol: 166    CtrAz: 260.1dg  Val: 0014.5     SelAz: 260.4dg
05:05:50 UTC Swp:   1    CtrRn:  26.7nm  Hgt:     1.9kft  SelRn:  26.8nm
KMVX             VCP:  21    Mag:        4X  El:      0.5deg  Nyqst:  52kts
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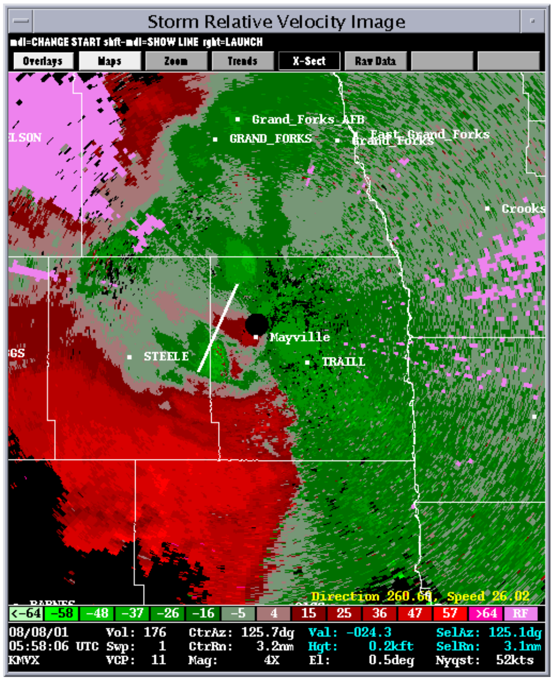
Figure 2. Planview (0.5°) of reflectivity (DBZ) at 0505 UTC.



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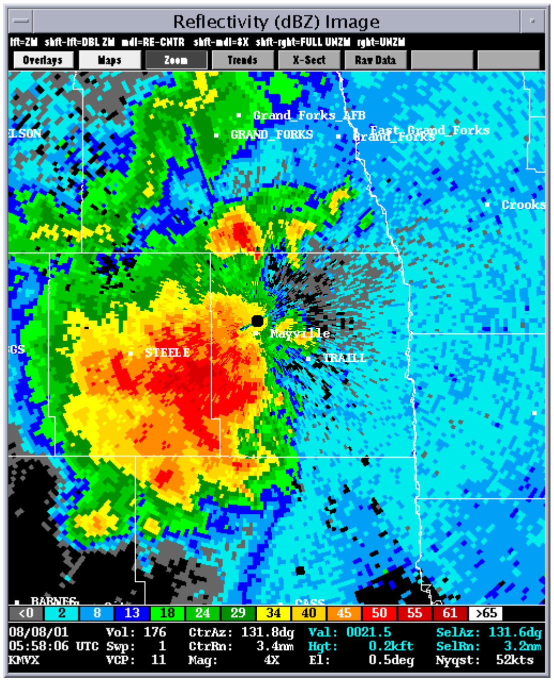
Direction 260.66, Speed 26.02
08/08/01         Vol: 176    CtrAz: 125.7dg  Val: -024.3     SelAz: 125.1dg
05:58:06 UTC Swp:   1    CtrRn:   3.2nm  Hgt:     0.2kft  SelRn:   3.1nm
KMVX             VCP:  11    Mag:        4X  El:      0.5deg  Nyqst:  52kts
```

Figure 3. Same as Figure 1, except at 0558 UTC.



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08/08/01         Vol: 176    CtrAz: 131.8dg  Val: 0021.5     SelAz: 131.6dg
05:58:06 UTC Swp:   1    CtrRn:   3.4nm  Hgt:     0.2kft  SelRn:   3.2nm
KMVX             VCP:  11    Mag:        4X  El:      0.5deg  Nyqst:  52kts
```

Figure 4. Same as Figure 2, except at 0558 UTC.

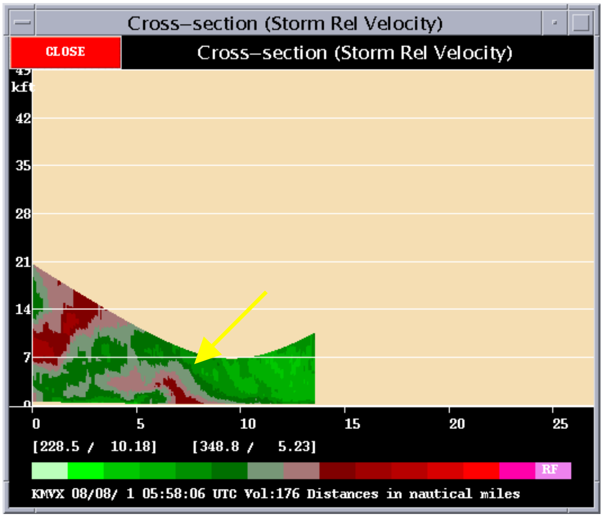
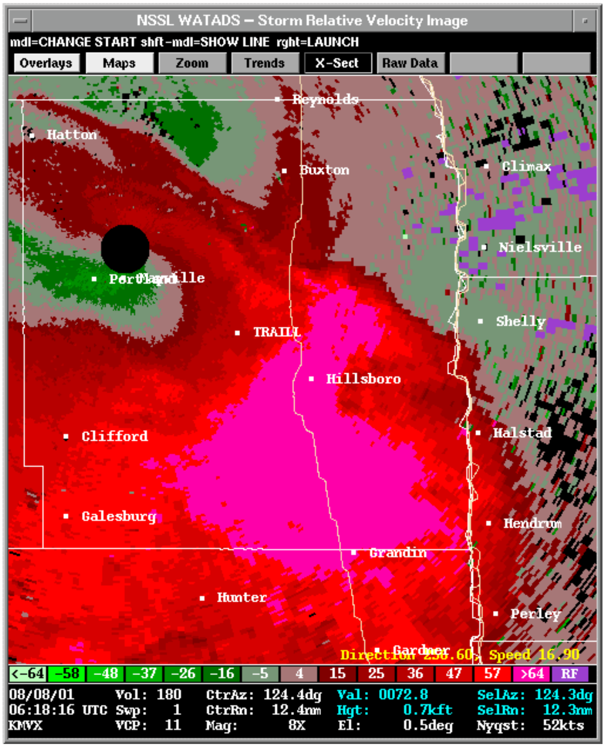


Figure 5. South to north vertical cross-section through a mesovortex at 0558 UTC. Cross-section placement can be seen in Figure 3 as depicted by the solid white line. Notice the vortex is surface-based.



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08/08/01        Vol: 180   CtrAz: 124.4dg  Val: 0072.8      SelAz: 124.3dg
06:18:16 UTC Swp:     1   CtrRn:  12.4nm  Hgt:     0.7kft  SelRn:  12.3nm
KMVX            VCP:   11   Mag:        8X  El:      0.5deg  Nyqst:  52kts
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Figure 6. Same as Figure 1, except at 0618 UTC.

The following evening, 9 August 2004, another DMCS traversed the same portions of ND. Again, storm relative velocities indicated a surface-based mesovortex within a squall line. This vortex was in association with extremely strong surface winds. The air force base outside of Grand Forks, ND, recorded a 99 kt wind gust while there was a 91 kt report at the Grand Forks airport.

Examination of radar in the eight remaining cases showed no mesovortices.

4. CONCLUSIONS

Analysis of WSR-88D data, suggest an acceleration of surface winds within a squall line or bow echo may at times be generated by mesovortices and it is found these winds can be extremely strong. This would support numerical model findings of Weisman and Trapp (2003).

5. REFERENCES

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