P 4.1 POST MESOSCALE CONVECTIVE SYSTEM CONVECTION

James G. LaDue
National Weather Service Warning Decision Training Branch
Norman, OK

1. INTRODUCTION

A Mesoscale Convective System (MCS) can be described as an efficient mechanism to remove moist gravitational instability over a large area by leaving a wake of low-level stable air in its cold pool and warming within the lower anvil canopy (Cotton et al. 1989). This is especially true of an MCS with a mature cold pool containing a convective line at its leading edge (Houze et al. 1990). Yet, a significant minority of these MCS passages is quickly followed by more Deep, Moist Convection (DMC), sometimes within 3 hours. This problem presents a significant forecast challenge in determining which localities may experience a second period of DMC quickly following the passage of an MCS

The post MCS convection defined in this study forms and moves over the same geographic locations that recently experienced the passage of a line of strong DMC, perhaps a period of stratiform precipitation, and is overlain by a fresh cold pool. Over a six month period from January to July of 2003, all MCSs were sampled to determine the frequency of post MCS DMC, and the general synoptic setting in which they are favored.

2. METHODOLOGY

b. MCS and Post MCS DMC criteria

An MCS is defined here as a meso-β convective system with a contiguous reflectivity area and a well defined cold pool. The contiguous reflectivity area should be a line of active convection. The MCS contains either a trailing, parallel or leading stratiform region. The MCS should be large enough and persist long enough such that the Coriolis force becomes significant. Roughly, the horizontal dimensions of the MCS should exceed 100 km and the lifetime should exceed 3 hours for the midlatitudes (Parker and Johnson 2000, hereafter as PJ2000).

In order to satisfy the criteria for post MCS DMC in this study, it must form immediately behind a mature MCS on top of its cold pool wake, and not immediately near the trailing surface outflow boundary. The cold pool should be fresh and not show signs of significant modification.

An elevated MCS over negatively buoyant synoptic surface air (cold side of a strong front) were not considered.

Positive post MCS DMC events were assigned confidence levels from 1 to 5 regarding how well they fit the criteria outlined in this study, where 5 represented the best fit. Negative post MCS DMC events were also compiled during the same period. Figure 1 shows an example of a negative, and three positive post MCS DMC events of different confidence levels.

The locations of MCS events were tracked similarly to PJ2000 while post MCS locations were subjectively estimated from the center of strongest activity. The start (end) times of the MCS and post MCS DMC were denoted, including the lag time between the passage of the intense DMC of the MCS and that of the post MCS DMC over a fixed geographical point.

MCS structure was split into Leading Stratiform (LS), Trailing Stratiform (TS) and Parallel Stratiform (PS) archetypes in a similar manner to PJ2000.

Determinations of MCSs, post MCS DMC and all tracks were determined from archived radar and satellite imagery online at the Storm Prediction Center (Crisp et al. 2002) and the University Corporation for Atmospheric Research (UCAR, 2004).

Corresponding Author Address
Warning Decision Training Branch, 3200 Marshall Ave. Suite 202, Norman, OK 73072
James.G.LaDue@noaa.gov

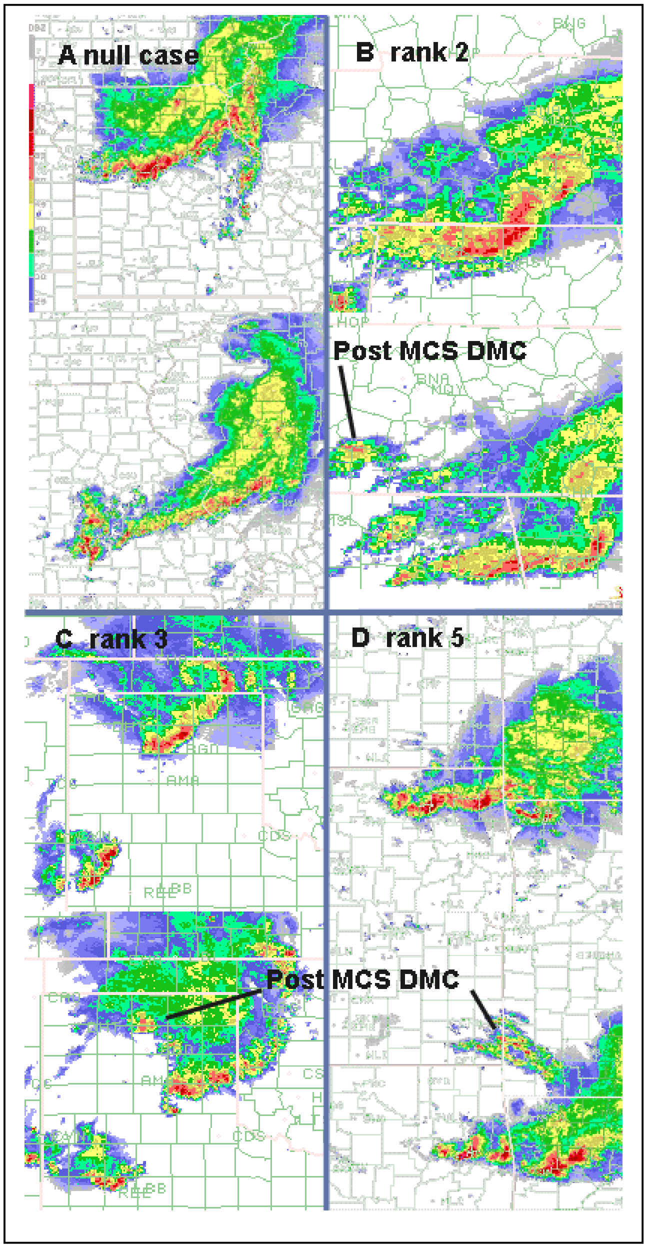

Figure 1 A sample of null and positive post MCS DMC cases starting with a) 10 June 2003 null case at 0930 and 1230 UTC, b) 06 May 2003 rank 2 case 1300 and 1600 UTC, c) 29 June 2003 rank 3 case for 0530 and 0730 UTC, and d) 13 May 2003 rank 5 case for 1830 and 2100 UTC.

b. Large scale forcing

The strength and scale of midaltitude short-wave troughs was broken into three categories, weak strong and hybrid systems in a similar way to Evans and Doswell (2001). Deep meridional troughs with large comma-shaped clouds were more likely to be classified as 'strong forcing', whereas the cases of strong low-level warm advection superimposed by weak or nonexistent midlevel shortwave troughs (Maddox 1983) were labeled as 'weak forcing'.

c. Near surface forcing

MCS events were associated with the nearest low-level boundary or other forcing mechanism (e.g., topography) at the point in which the MCS formed. Surface, satellite, and the 850 mb plots found on archival web sites (Crisp, et al. 2002; UCAR, 2004; Plymouth, 2004) were analyzed to determine the locations of surface forcing features.

d. Other parameters

The location of best Mixed Layer CAPE (MLCAPE) relative to the MCS location was determined from the 00 and 12 UTC RUC-based composite charts (Crisp, et al. 2002). If the RUC composite charts were unavailable or unusable, then a comparison of 500 mb temperatures and surface temperature/dewpoints was used to estimate a MLLI. The surface parameters were assumed to be well mixed in the lowest 100 mb. The MLCAPE and the proxy MLLI were estimated ahead of the MCS and rearward of the MCS on the most unstable side of the trailing outflow boundary. Low-level flow and midlevel flow in the MCS vicinity was estimated from the mandatory level RAOB plots and profilers where found. No attempt was made to attach a proximity sounding to the MCS environment. Instead, the flow was analyzed given the data to arrive at the best approximate value of the undisturbed environment around the MCS. The low-levels were defined as being at 925 mb for terrain less than 800 m AGL, 850 mb where the terrain was less than 1000 m AGL, and 700 mb for higher terrain. The midlevels were held at 500 mb.

3. RESULTS

There were 57 MCS events tracked from January to July 7, 2003. Of those, 21 MCSs exhibited some kind of post-MCS activity of rank 2 or higher, and 14 of rank 3 or higher.

a. Post MCS DMC characteristics

Post MCS convection typically formed in a broken line over the top of the fresh cold pool of an MCS with an orientation orthogonal to that of the parent MCS's leading convective line. Typically, it was nearly parallel to the orientation of the trailing outflow boundary of the parent MCS (figure1, b-d). As the ranking increased, the post MCS DMC exhibited more solid coverage over the top of the cold pool and persisted longer (note figure 1d). In fact, an unanticipated side effect of the ranking methodology was that the probability of post MCS DMC dominating the parent MCS increases as the rank increased (figure 2). The convection in figure 1d eventually grew upscale to become another MCS as its parent dissipated.

Post MCS DMC events usually lagged the passage of the parental MCS convective line by an average of 3 hours with a standard deviation of about 1 hour. The first sign of post MCS DMC was about 4.8 hours after the onset of an MCS as defined in this paper.

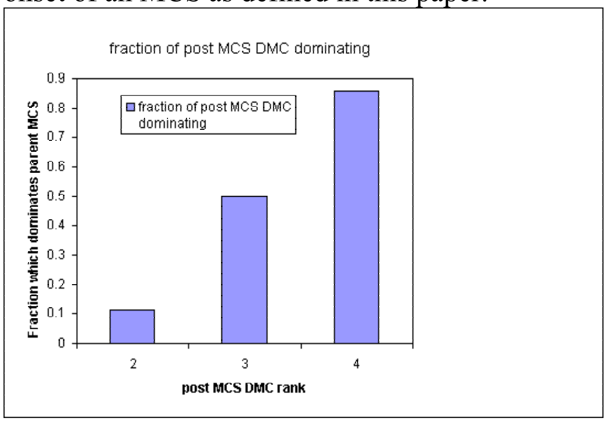

Figure 2 Relationship between post MCS DMC ranking and fraction of events that dominated their respective parent MCSs.

b. Post MCS DMC environment

Perhaps the most obvious result of the null cases was that none of the MCS events induced by cold fronts exhibited post-MCS convection. As a result, all cold frontal induced MCSs were discarded leaving 39 total events, 15 of those being non-cold frontal null events.

Most of the cold frontal MCSs exhibited long, linear intense lines with stratiform precipitation regions along or behind the surface front. The lack of a trailing surface outflow boundary, and the sharp post-frontal increase in stability could explain the lack of post MCS events with these types of MCSs.

To further distinguish the environmental and storm related characteristics, null, non-cold frontal post MCS DMC events were compared to positive events of rank 3 and higher. Table 1. shows that positive and null post MCS DMC events occur in strong, hybrid and weak midlevel forcing situations. Slightly more positive events occurred when the best MLCAPE was found behind the MCS, or along the trailing outflow boundary. However, the same conclusion could be said for when the best MLCAPE was ahead of the MCS as well.

	null post MCS (15)	rank 3 or higher (15)
strong forcing	4	2
hybrid forcing	3	4
weak forcing	8	8
best MLCAPE behind	6	9
best MLCAPE ahead	2	3

Table 1. Numbers of events vs. type of parameter.

One potential mechanism that could initiate post MCS DMC could be return low-level flow ascending over the trailing cold pool of an MCS. The trailing cold pool acts in a similar way to force ascent as a stationary front interacting with a low-level jet (Trier and Parsons, 1992). To test this hypothesis, the strength of the low-level flow across the trailing outflow boundary needs to be examined between the positive and null post MCS DMC events. Given the available data, the trailing outflow boundary was assumed to be roughly parallel to the MCS motion direction. This assumption has not been thoroughly tested but subjective analysis of outflow boundary orientations appears to show adequate agreement to MCS motion. The difference between the MCS direction of motion and the low-level flow orientation was used as a proxy for the angle of attack of the low-level flow on the trailing outflow boundary. The low-level speed provided more information needed to assess a proxy for the strength of ascent over the trailing cold pool. Plotted in figure 3, the scatter plot compares these two parameters with null post MCS DMC events with those positive events of rank 3 and higher. There appears to be no relationship with respect to the angle of attack. However, there seems to be some discrimination with respect to low-level wind speed. Except for one outlier, there were no null events with a low-level wind speed greater than 15 m/s.

Considerable overlap exists in figure 3 and thus, this finding is really a limiting factor and not strong on discrimination potential. The hypothesis remains inadequately addressed. The angle of attack was determined from only one level of data. However, MCS environments are rife with strong directional shear in the low-level flow, which leads to a variety of impact angles.

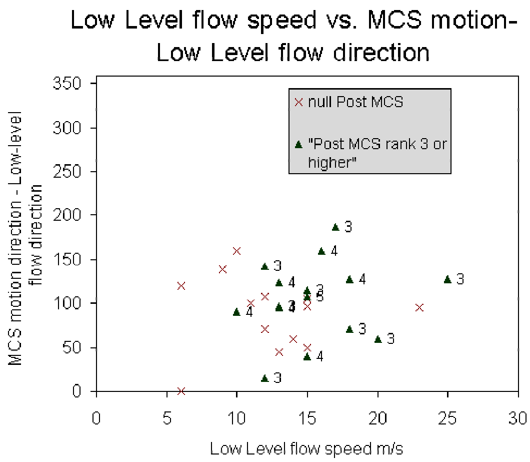

Figure 3. The occurrence of null and positive post MCS DMC events of rank 3 or greater as a function of low-level flow speed and the angle between the low-level flow direction and MCS motion.

4. SUMMARY

Post MCS DMC convection appears to be a relatively common occurrence soon after the passage of the intense portion of mature MCSs. The reoccurrence of DMC is 3 hours, sometimes much less after the parent MCS departs. This type of convection often manifests itself as short lines of discrete cells in a direction orthogonal to that of the parent MCS convective line.

The greatest discrimination between null and positive post MCS DMC events is the type of low-level forcing mechanism. Almost no cold frontal MCS events exhibited post MCS DMC behavior. However, there is very little discrimination potential in the near storm environment for non-cold frontal post MCS DMC events. One small signal could be the strength of the low-level flow but at this point, there are not enough cases to make a strong conclusion.

This study does point out the need to determine the shape and nature of the stabilization, and subsequent destabilization of the MCS environment by a more thorough investigation of individual null and positive cases.

5. REFERENCES

Cotton, M. S. Lin, R. L. McAnelly, and C. J. Tremback, 1989: A composite model of mesoscale convective complexes. *Mon. Wea. Rev.*, **117**, 765-783.

Crisp, C. A., P. R. Janish, G. W. Carbin, and A. Just, 2002: Creation of a severe thunderstorm event web page for research and training purposes at the National Severe Storms Laboratory and Storm Prediction Center. Preprints, *21st Conf. on Severe Local Storms*, San Antonio, TX, Amer. Meteor. Soc., P8.7.

Evans, J. S., and C. A. Doswell III, 2001: Examination of derecho environments using proximity soundings. *Weather and Forecasting*, **16**, 329-342.

Houze, R. A., B. F. Smull, and P. Dodge 1990: Mesoscale organization of springtime rainstorms in Oklahoma. *Mon. Wea. Rev.*, **118**, 613-654.

Parker M. D., and R. H. Johnson 2000: Organizational modes of midlatitude mesoscale convective systems. *Mon. Wea. Rev.*, **128**, 3413-3436.

Plymouth, cited 2004: Data archive. [Available online at http://vortex.plymouth.edu/u-make.html]

Trier, B. T., and D. B. Parsons, 1992: Evolution of environmental conditions preceding the development of a nocturnal mesoscale convective complex. *Mon. Wea. Rev.*, **121**, 1078-1098.

UCAR, cited 2004: Image archive. [Available online at http://locust.mmm.ucar.edu/case-selection/]