P5.19

ANALYSIS OF WARM-SEASON MORNING CONVECTION ACROSS THE SOUTHERN GREAT PLAINS

John A. Haynes*
Cooperative Institute for Mesoscale Meteorological Studies
University of Oklahoma, Norman, Oklahoma

Carl E. Hane
NOAA/National Severe Storms Laboratory, Norman, Oklahoma

David L. Andra
NOAA/NWS Forecast Office, Norman, Oklahoma

Edward Berry
NOAA/NWS Forecast Office, Dodge City, Kansas

Frederick H. Carr
School of Meteorology, University of Oklahoma, Norman, Oklahoma

Robert M. Rabin
NOAA/National Severe Storms Laboratory, Norman, Oklahoma

1. INTRODUCTION

Warm-season mesoscale convective systems (MCSs) impact much of the United States with heavy rains and often severe weather, primarily during nighttime hours. These systems typically dissipate or decline in intensity during the four hours or so before local noon. However, some are maintained or regenerate and continue into the afternoon. The Morning Convection Project (MCP) was begun for the purposes of better understanding the factors that influence late-morning MCS evolution, and to provide tools that can be used to improve short-term forecasting of these systems. The MCP is a collaborative effort among the National Severe Storms Laboratory (NSSL), the University of Oklahoma, and the National Weather Service Forecast Offices in Norman, Oklahoma, and Dodge City, Kansas. The MCP is supported by a grant from the Cooperative Program for Operational Meteorology, Education and Training (COMET).

In succeeding sections, input from Norman and Dodge City forecasters will be discussed. A climatology of MCSs from 1996-2000 as well as an overview of the study of RUC2 model analyses will be included. Finally, future work of the MCP will be outlined.

2. FORECASTER INPUT

An effort has been made to assess what factors forecasters believe are most important to short-term forecasts of MCS evolution. National Weather Service forecasters at the two offices provided real-time input (via an NSSL web site) on a subset of those convective systems that occurred within the period of interest during the summers of 1997-2000. Comments were received on 37 systems during the four summers. The primary input items provided for each system were: (1) the forecast evolution made at 0900 UTC for the 1200 UTC to 1600 UTC period for systems that were affecting or expected to affect the county warning area of either office, and (2) the major factors considered in formulating the forecast MCS evolution. The data relating to item (2) is summarized in Table 1. A total of 95 responses were received listing major factors considered in the forecasts. Not surprisingly, both radar and satellite trends were mentioned roughly half of the time as important factors in short-term evolution during the systems in which comments were recorded. However, environmental characteristics (e.g. stability, storm-relative flow, and upper-level features) were also listed often. “Climatology” refers to the forecasters’ experience, which suggests the tendency for MCSs to weaken or dissipate during the late morning. This factor is likely often taken as a starting point in an MCS forecast.

3. CLIMATOLOGY

A climatological study of 145 individual MCSs that occurred during the summers of 1996-2000 within the County Warning Areas (CWAs) of Norman and Dodge City was undertaken. In addition to occurrence within the CWAs in the 0900-1700 UTC period, included systems had to meet the following criteria: (1) movement greater than or equal to 5 m/s, (2) size of greater than or equal to 100 km in longest dimension,

---

**Corresponding author address*: John A. Haynes, NSSL, 1313 Halley Cr., Norman, OK 73069; email: jhaynes@ou.edu

Significant Factor	Number of Responses	Percent
Radar Trends	20	54
Satellite Trends	16	43
Stability	16	43
Storm Relative Flow and Shear	11	30
Upper-Level Feature	10	27
Climatology	8	22
Low-level Jet Strength	3	8
Lightning Trends	3	8
Baroclinicity and Frontal Strength	2	5
Upper Flow Strength	2	5
Other	4	11

Table 1: Significant factors in short-term MCS forecasts as provided by meteorologists at the NWSFO in OUN and DDC during the summers 1997-2000. "Percent" column denotes the percentage of time that the given factor was mentioned for the 37 systems where comments were recorded.

and (3) duration of at least three hours with an intensity of at least 40 dBZ for one hour within area and time period of interest. Systems were chosen based upon examination of hourly mosaic images from the National Climatic Data Center (NCDC) archive of NEXRAD national reflectivity and upon the NCDC archive of individual station WSR-88D Level II data. Surface and upper air charts were also examined, as well as maps indicating cloud-to-ground lightning within specified periods. The climatology for each system included the track, initiation mechanism, character of evolution, occurrences of severe weather, and occurrences of cloud-to-ground lightning.

Figure 1 shows the number of MCSs per month and year. Each year had a relatively constant number of systems (ranging from 26 to 35), however the majority of systems occurred during the months of June and July (53 and 56 MCSs respectively). A study of the number of hours in which each CWA was affected by MCSs showed that Norman's area was impacted twice as often as Dodge City's area. This was expected due to the fact that Norman's CWA (123320 km^2) is about twice the size of Dodge City's (58130 km^2). However, during the month of August, Dodge City's area was affected more frequently. This is due to the climatological conditions of August in which strong upper-level northwesterly flow resides further north than during the rest of the summer. Also, the upper-level ridge and cap are strengthened over the Plains in August and fewer fronts are able to penetrate into the Norman CWA.

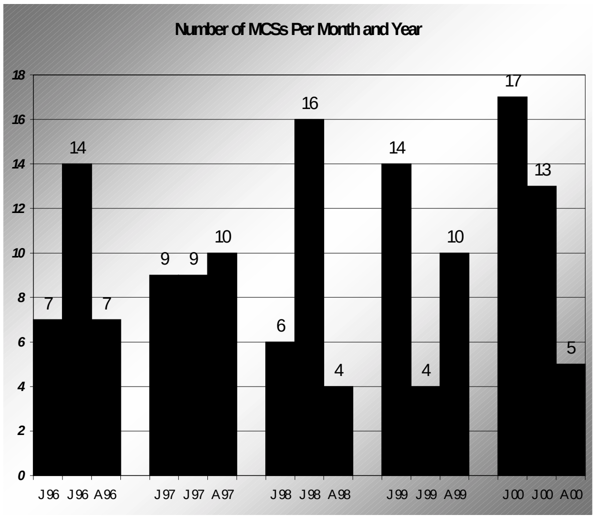

Figure 1: Number of MCSs affecting OUN and DDC CWAs by month and year.

Figure 2 shows the evolution tendencies of the systems between 1300 UTC and 1700 UTC. As expected, a majority of the systems decreased or dissipated during the late-morning hours. However, a significant percentage (26%) remained steady in intensity. This subset of systems is very significant, since a short-term forecast of these MCSs based on climatology alone would be inaccurate. Figure 3 shows the motion by month for the systems. Direction, in this case, is defined as the 45 degree sector centered on a specific direction. Overall, the largest number of systems affecting the southern Plains shows movement from west to east (47%). The number of systems moving from northwest to southeast falls off sharply in August as the upper-level ridge strengthens over the southern Plains and strong upper-level northwesterly flow resides farther north over Nebraska and the Dakotas. A breakdown of evolution of the MCSs by movement shows, once again, that a majority of systems in each movement category decreases or dissipates, while a significant percentage remains steady in intensity (especially for systems moving into the area from the west). Systems moving from southwest to northeast appear to have the highest likelihood to increase in intensity out of all the movement categories.

Figure 4 shows a breakdown of severe weather reports per month, year and CWA. Severe weather reports were collected for the entire lifetime of the systems. Two interesting anomalies appear in the data. One is the absence of severe weather reported in the Norman CWA during 1998. The other is the substantial increase in severe weather reports during July 2000 resulting from two extremely strong MCSs that pushed across the area. One of these systems caused wind gusts of over 90 knots in northern Oklahoma City. Figure 5 breaks down severe weather reports by type for the entire climatology. Wind damage represents the majority of all severe weather reports every year except 1999 when hail reports were the plurality. Hail reports represent the second most frequent type of severe weather in all other years.

4. RUC2 MODEL DATA / FUTURE WORK

RUC2 model data were obtained for summers 1999 and 2000. Model data for these two years only will be analyzed due to the fact that prior to April 1999, the RUC2 missed significant level temperature and dewpoint data from rawinsondes. RUC2 data are being used instead of actual rawinsonde observations due to the superior time and spatial resolution of the model data.

Using RUC2 sounding data, one objective of our analysis will be to determine the shear and stability impacting each MCS and how the evolution of the system is affected by changing amounts of shear and stability. RUC2 model soundings will be graphically reproduced using the GEMPAK utility NSHARP. In addition to the sounding, NSHARP calculates several stability parameters. It also yields a hodograph for the chosen location. Based on storm motion, NSHARP calculates storm-relative winds at several levels. Based on the model sounding, NSHARP calculates mean wind at three levels and environmental shear at four levels. Using this data, line-normal shear for each MCS under study will be calculated. How the line-normal shear changes over time will be compared to the evolution of the system and its impact evaluated. Once this is determined, it is hoped that it will be possible to ascertain which squall-line theory(s) (i.e. Thorpe-Miller-Moncreiff theory, Rotunno-Klemp-Weisman theory, or Xu-Xue-Droegemeier theory) best fits the morning MCSs of the southern Plains.

There are several items being planned for future research as part of this project-in-progress. This includes an assessment of an operational model in its ability to predict environmental fields that are significant factors in the evolution of these systems.

5. CONCLUSIONS

As revealed by forecasters at the NWS offices in Norman and Dodge City, climatology is a major factor in the short-term forecasting of MCSs. Climatology indicates, and our study supports, the notion that a majority of MCSs decrease in intensity or dissipate during the late-morning hours. However, our study also shows that more than a quarter of all MCSs actually retain or increase their intensity during this time period. Any short-term forecast for these systems based on the climatic probability of their dissipation would be inaccurate. Therefore, through study of shear and stability using RUC2 model archive data, factors will be evaluated that might be used in an operational setting to determine which systems will continue into the afternoon. This knowledge could aid greatly in short-term forecasting of these MCSs across the southern Plains during summer afternoons.

6. ACKNOWLEDGEMENTS

The authors would like to thank COMET for their generous support of this NWS Cooperative Project. The authors also thank Steve Fletcher for help in addressing computer-related problems, and are grateful to Paul Janish and Phillip Bothwell for help in data acquisition.

7. REFERENCES

Benjamin, S., 1999: Operational Use of the Rapid Update Cycle. COMAP Symposium 99-1.

NOAA, 1997-2000: NEXRAD National Reflectivity Mosaic Images. National Climatic Data Center.

NOAA, 1996-2000: *Storm Data*. National Climatic Data Center.

Rotunno, R., J. B. Klemp and M. L. Weisman, 1988: A theory for strong, long-lived squall lines. *J. Atmos. Sci.*, **45**, 463-485.

Thorpe, A. J., M. J. Miller and M. W. Moncreiff, 1980: Dynamical model of two-dimensional downdraughts. *Quart. J. R. Met. Soc.*, **106**, 463-484.

Thorpe, A. J., M. J. Miller and M. W. Moncreiff, 1982: Two-dimensional convection in non-constant shear: a model of mid-latitude squall lines. *Quart. J. R. Met. Soc*., **108**, 739-762.

Xue, M., 1990: Towards the environmental condition for long-lived squall lines: vorticity versus momentum. 16th Severe Storms Conference, 146-149.

Xue, M., 1999: Density currents: theory, numerical experiments, and role in squall line dynamics. University of Oklahoma/School of Meteorology Seminar.

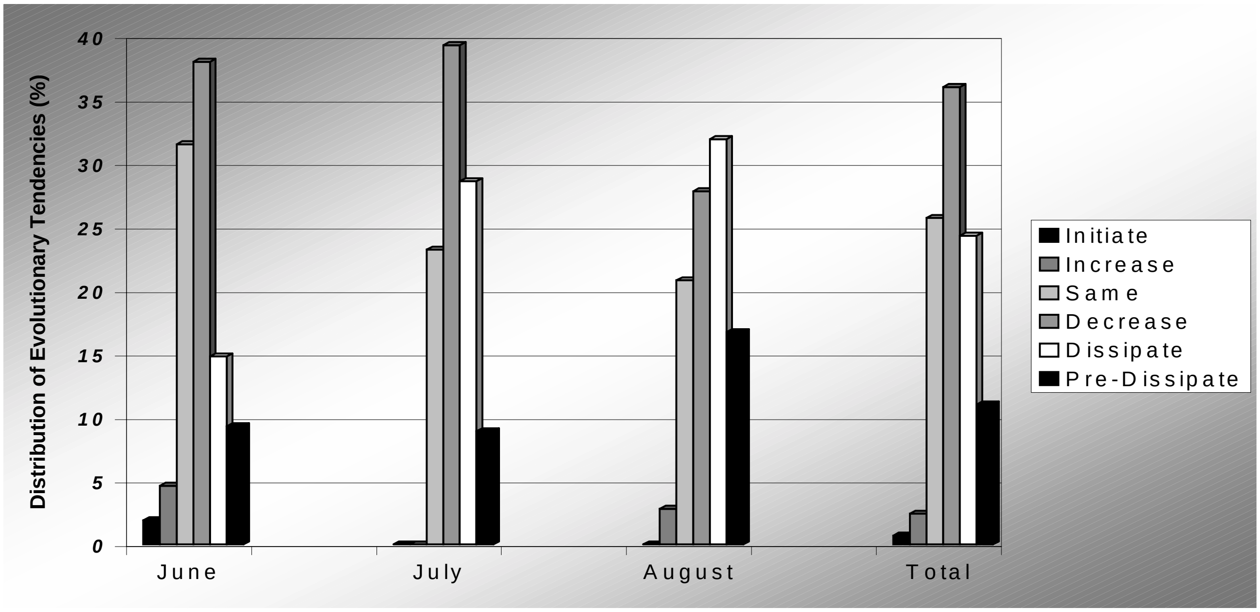

Figure 2: Distribution of evolutionary tendencies (by percent) for June, July, and August 1996-2000, as well as overall.

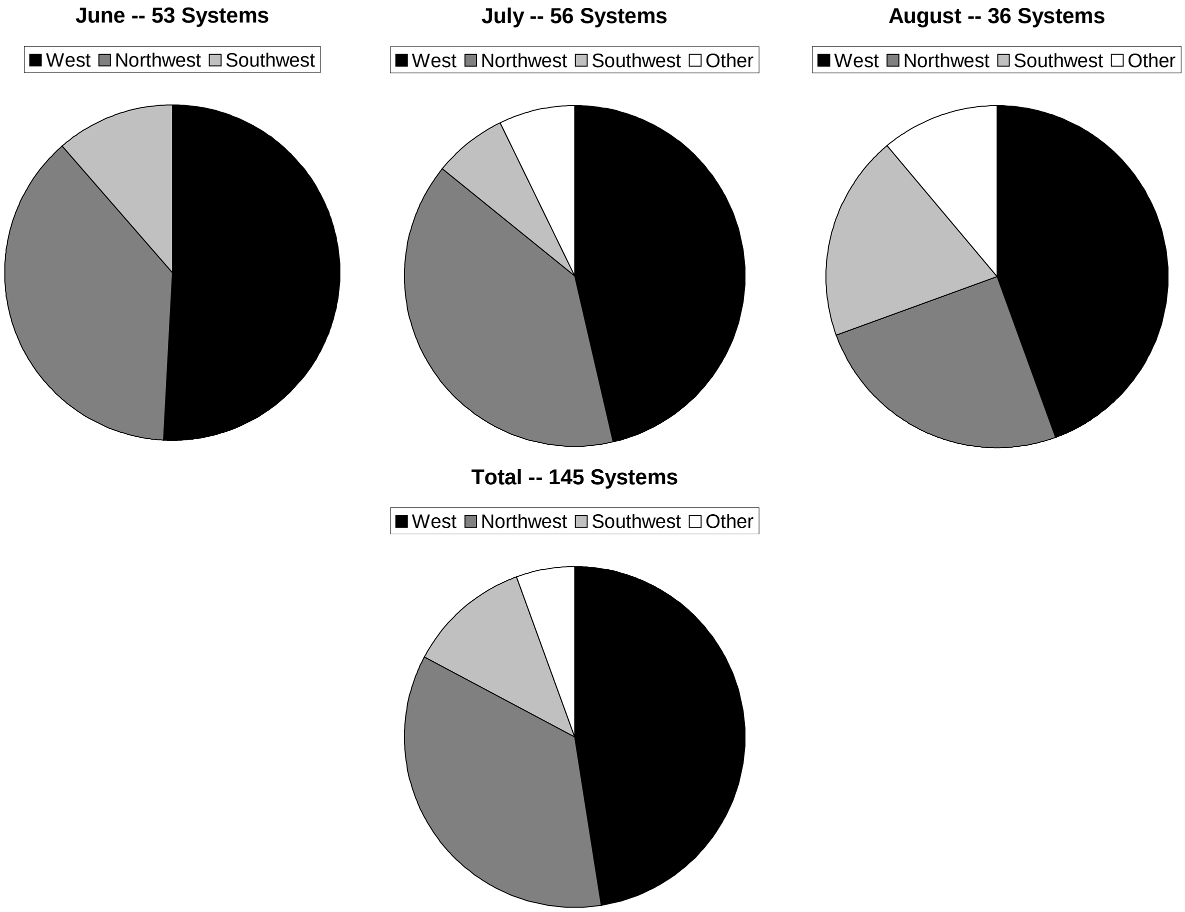

Figure 3: Distribution of direction from which system moved for June, July, and August 1996-2000, as well as overall.

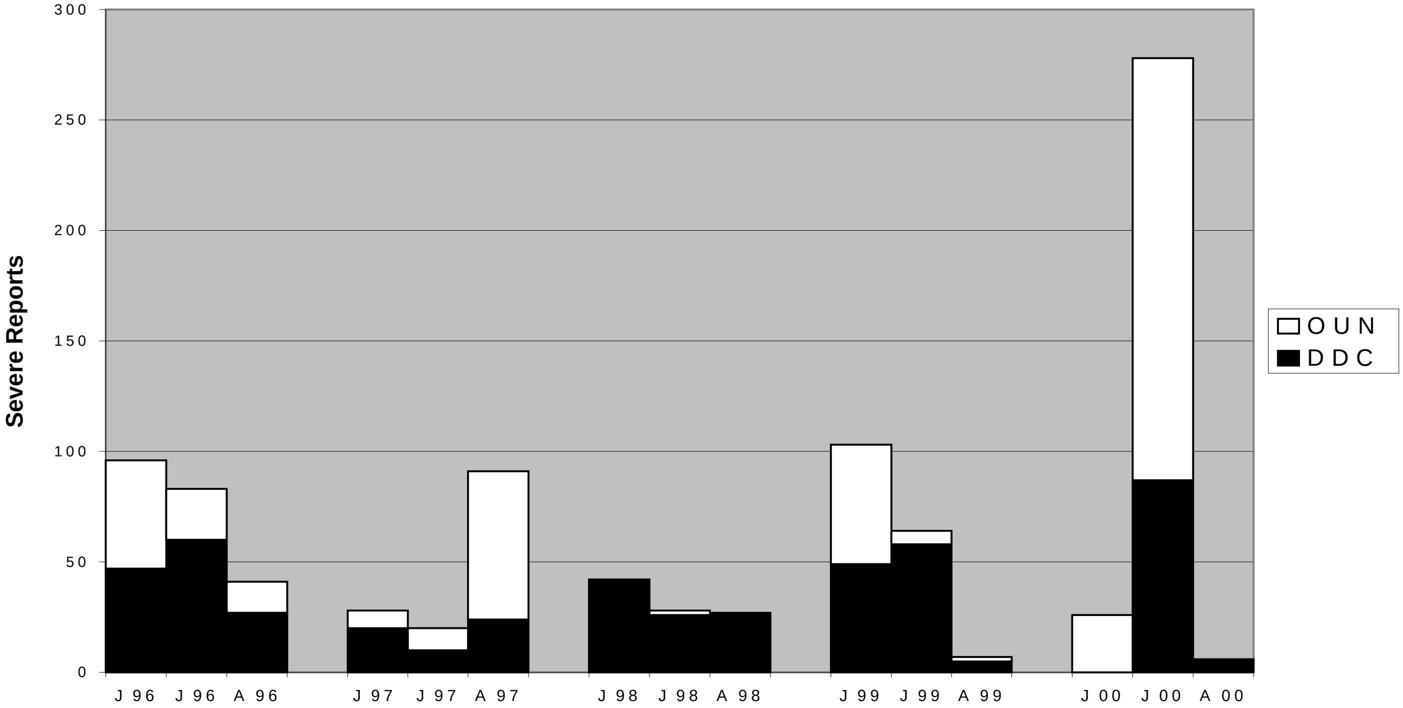

Figure 4: Breakdown of severe weather reports per month, year, and County Warning Area.

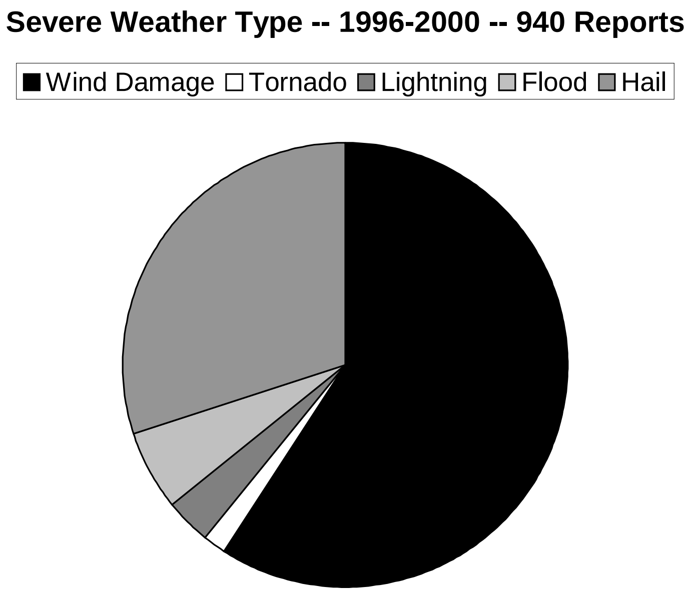

Figure 5: Severe weather type reported due to MCSs from 1996-2000 across the OUN and DDC CWA.