A U.S. Climatology of Mesoscale Convective Systems: 1997–2013

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Introduction

- Although previous research has examined the spatiotemporal distribution of MCSs in the U.S., few have examined the long-term climatology of these systems and even fewer have employed automated methods to detect and track MCSs.
- In general, prior investigations have used manual identification of MCSs and subsets of MCSs, limiting their scope and use in climatological investigations.
- We explore the utility of an automated MCS detection and tracking procedure and apply the algorithm using 17 years of national composite reflectivity data.

Data

- 2-km, 5-minute WSI NOWrad® national radar composites
- Examined warm season (May – September) from 1997-2013
- Over 56,000 hours of national composite radar observations

Detection and Tracking Method

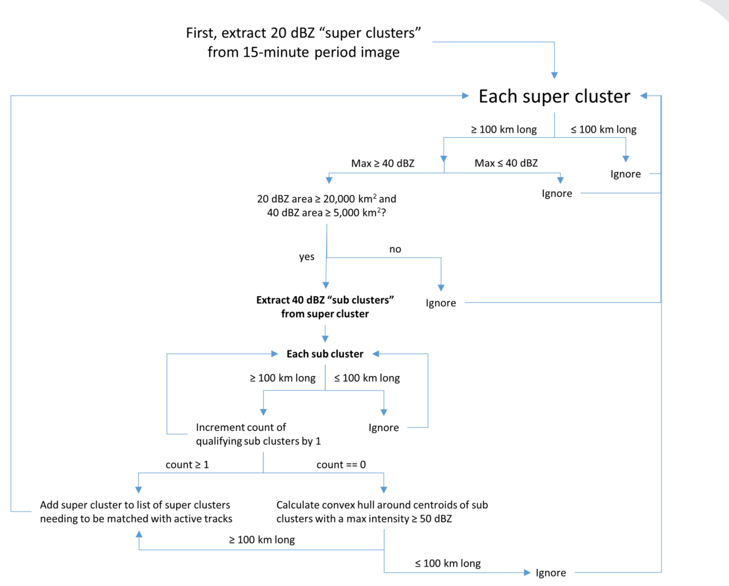

Fig. 1. Flow chart of the classification method employed by this study.

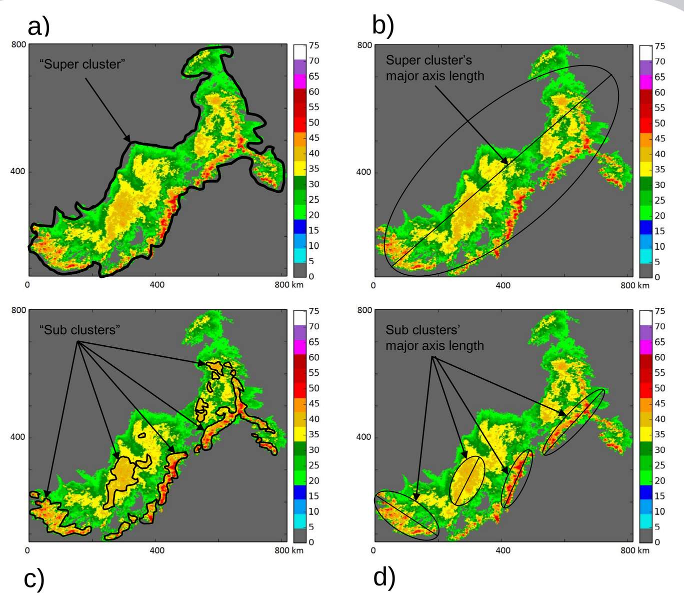

Fig. 2. Examples of cluster types and measurement approaches for super clusters (a,b) and sub clusters (c,d)

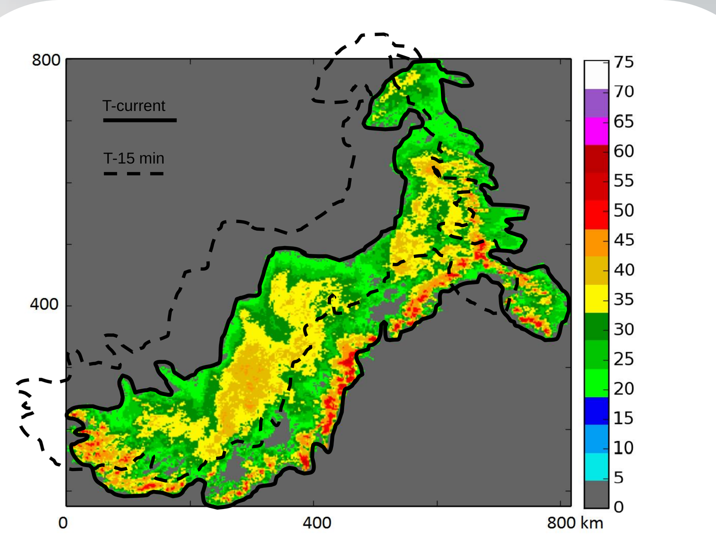

Fig. 3. Example of spatiotemporal overlap where the spatial extent of a super cluster from the previous scan (dotted line) overlaps the spatial extent of a super cluster from the current scan (solid line).

Our method (Figure 1) is based on MCS definition of Parker and Johnson (2000):

- Convective (40 dBZ) line ≥ 100 km in one dimension
- Meets this criteria for 3 hours

When a 40 dBZ threshold was applied, too many "convective systems" were found

- Many were related/within the same precipitating cluster

To improve tracking continuity between scans, our method identified all ≥ 20 dBZ clusters (i.e., "super clusters"; Figure 2.a) that met the minimum length requirement (Figure 2.b) in a given radar image. Further:

- Each super cluster must have at least 20,000 km^2 of stratiform (≥ 20 dBZ) pixel coverage
- Each super cluster must have at least 5,000 km^2 of convective (≥ 40 dBZ) pixel coverage
- Similar to the spatial requirements employed by Grams et al. 2006

Within each super cluster, find all ≥ 40 dBZ clusters (i.e., "sub clusters"; Figure 2.c)

- If at least one has a length ≥ 100 km (Figure 2.d)
  - Mark as MCS segment
- If not, draw convex hull around cells with ≥ 50 dBZ cores
- If convex hull length ≥ 100 km
  - Mark as MCS segment

Once MCS segments—qualifying super clusters—are identified, they are matched with existing, active super cluster tracks by testing for spatiotemporal overlap with the most recent segment (Figure 3).

If a new segment cannot be matched, it is labelled as the start of a new MCS track

After processing was completed, only tracks that spanned at least 3 hours were considered for the climatology

Warm-season Climatology

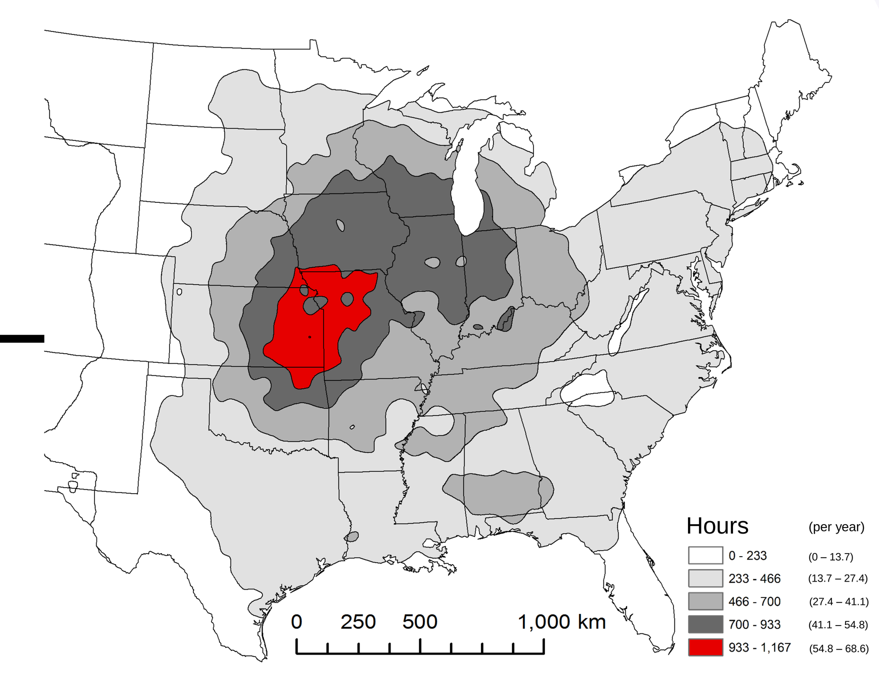

Fig. 4. Warm season MCS climatology for 1997-2013. The mapped values are the total time each 2-km grid is within the 20 dBZ shield of a qualifying MCS. The data were smoothed using a Gaussian filter.

How are these values calculated?

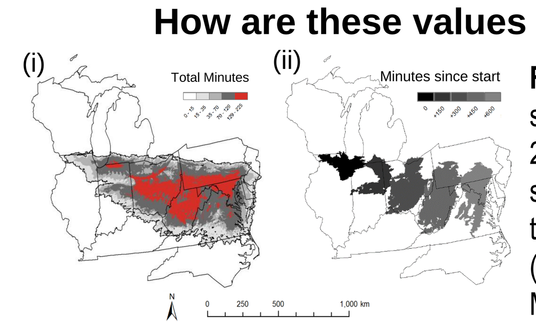

Fig. 5. Example of a "MCS swath" from the 29-30 June 2012 derecho. Panel (i) shows values that are added to the climatology and Panel (ii) shows the evolution of the MCS object through time.

Monthly Climatology

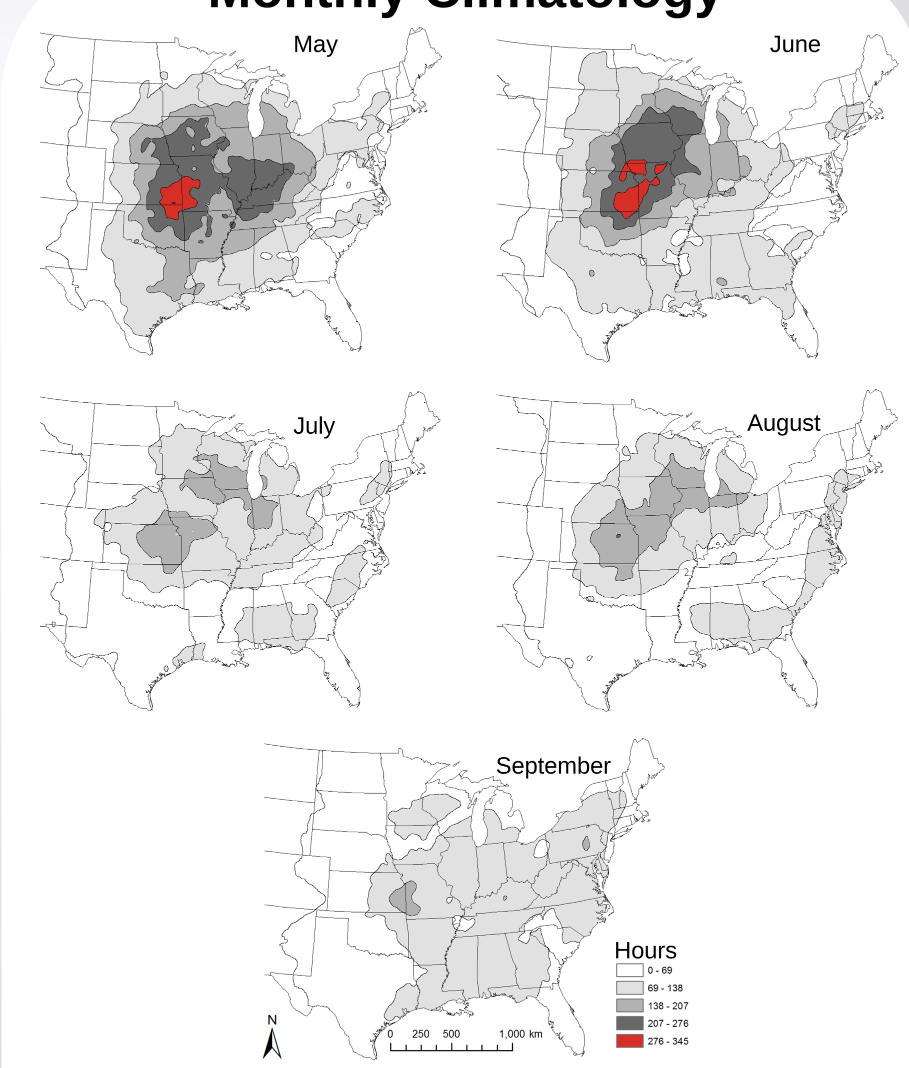

Fig. 6. As in **Fig. 4.**, but for warm-season months. May and June produced the most hours of MCS coverage (i.e., within 20+ dBZ area) in the warm season.

Yearly Warm-season Climatology

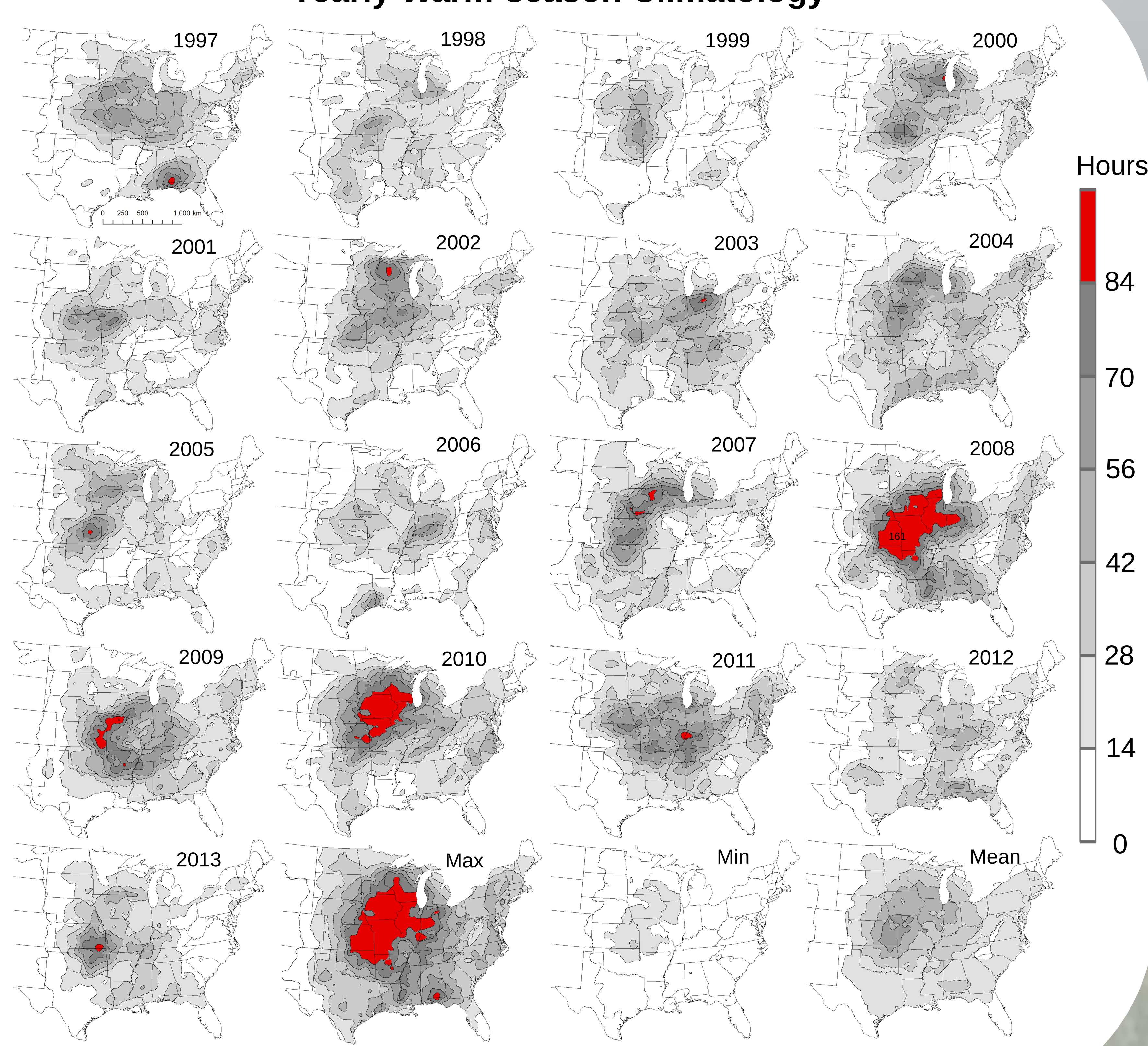

Fig. 7. As in **Fig. 4**, but by year, with max, min, and mean for each pixel included.

Yearly MCS Areal Coverage

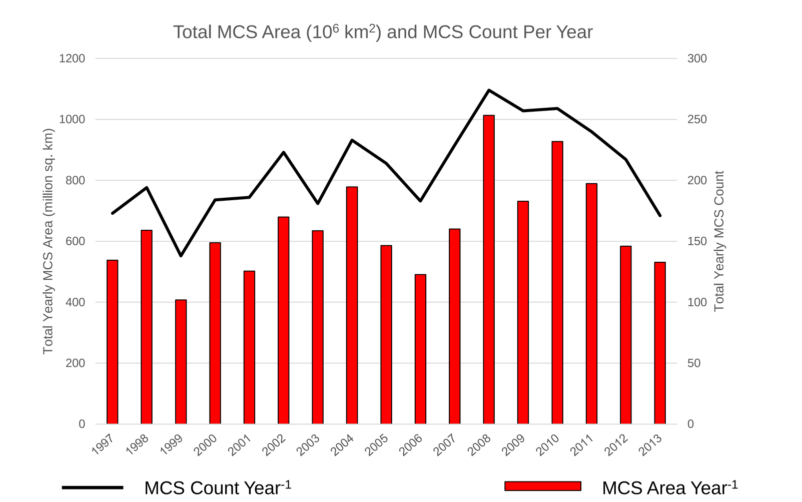

Fig. 8. Yearly total MCS area (left y-axis, red bars) and total MCS count (right y-axis, black line). Total MCS area was calculated by adding the total number of pixels associated with each ≥ 20 dBZ MCS shield every 15 minutes and multiplying this value by 4 to get the total square kilometers per year.

Diurnal Climatology

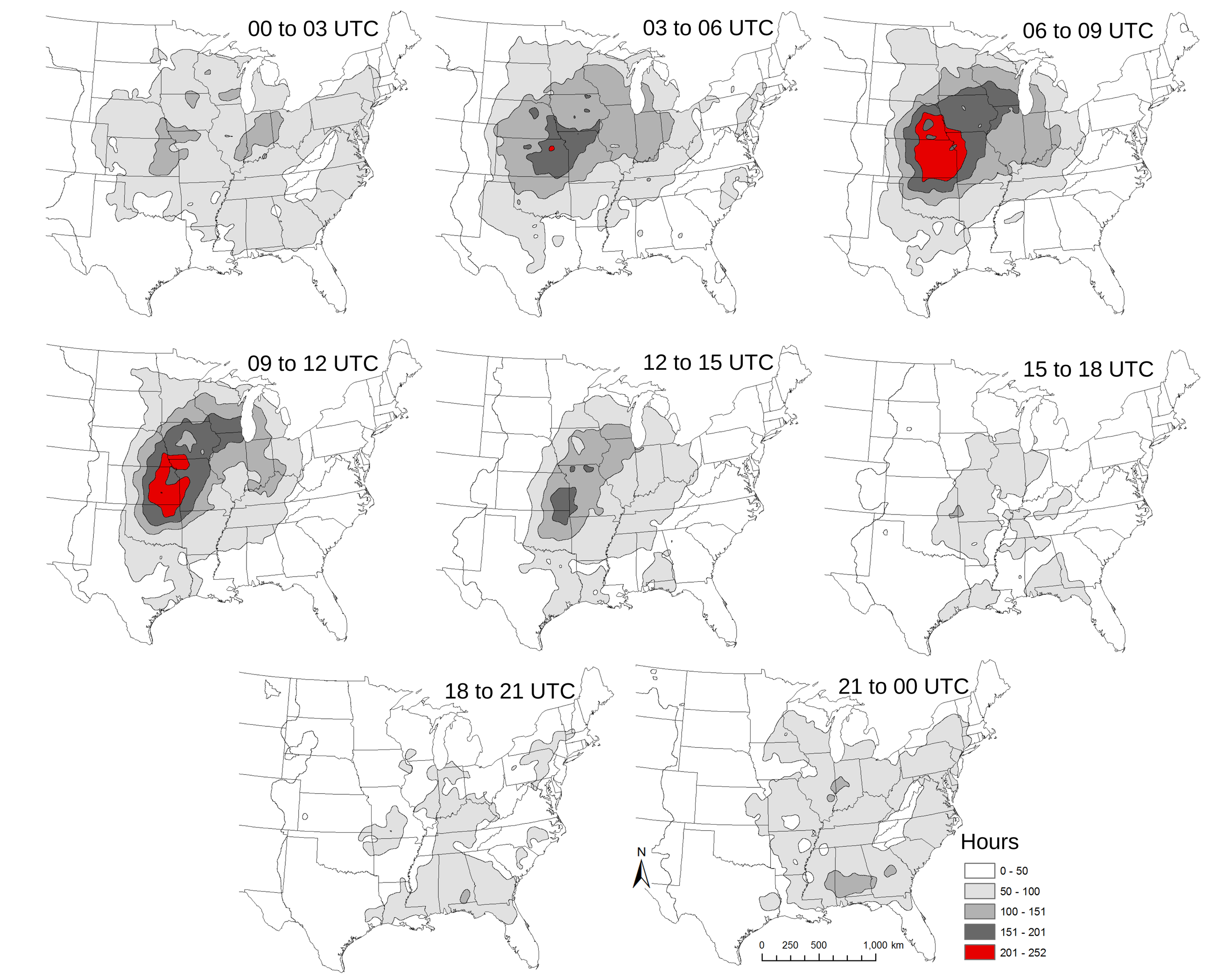

Fig. 9. As in **Fig. 4.**, but for specific three hour periods.

Conclusions

The location of maximum MCS activity is consistent with results presented by similar studies

- Ashley et al. (2003) and Fritsch et al. (1986) preferred location of MCC rainfall matches reasonably well
- Geerts (1998) estimated yearly MCS count for the Southeast U.S. in the warm-season (~220) same order of magnitude (171-274). Our values were lower due to a more strict MCS definition

The procedure effectively distinguishes between convective system rainfall and isolated convective rainfall

- A convective rainfall climatology by Parker and Knievel (2005) and U.S. precipitation climatology show increases in precipitation nearer to the Gulf of Mexico, which is not evident in our results.

The diurnal cycle of MCS occurrence and location matches well with previous radar climatologies that have inferred MCS occurrence:

- Carbone et al. (2002), Parker and Ahijevych (2007), Carbone and Tuttle (2008), and others show the west to east movement of convective systems and an overnight maximum in the Plains

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