Spatiotemporal Characteristics and Large-scale Environments of Mesoscale Convective Systems East of the Rocky Mountains

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The spatiotemporal variability and 3-dimensional structures of mesoscale convective systems (MCSs) east of the U.S. Rocky Mountains and their large-scale environments are characterized across all seasons using 13 years of high-resolution operational network radar and geostationary satellite observations. Long-lived and intense MCSs account for over 50% of warm season precipitation in the Great Plains and over 40% of cold season precipitation in the southeast. The Great Plains has the strongest MCS seasonal cycle peaking in May-June, while in the southeast, MCSs occur year-round. MCS genesis concentrates east of the Rocky Mountain Front Range and near the southeast coast in the afternoon (Figure 1). The strongest MCS diurnal cycle amplitude occurs in the summer and extends from the foothills of the Rocky Mountains to the Great Plains. Spring MCS features both large and deep convection, with large stratiform rain area and high volume rainfall. In contrast, summer MCSs have the largest and deepest convective features, the smallest stratiform rain area and the lowest rainfall volume.

Four types of synoptically-favorable environments for spring MCSs and two types each of synoptically-favorable and unfavorable environments for summer MCSs are identified using self-organizing maps (SOM). During spring, frontal systems providing a lifting mechanism and an enhanced GPLLJ providing anomalous moisture are important features for creating favorable dynamical and thermodynamic environments for MCS development. During summer, the two synoptically-favorable environments identified have frontal characteristics and an enhanced GPLLJ, but both shift north compared to spring. The two synoptically-unfavorable environments feature enhanced upper-level ridges but differ in the strength of the GPLLJ. This seasonal contrast suggests that summer convection may occur even with weak large-scale dynamical and thermodynamic perturbations so MCSs may be inherently less predictable in summer. We constructed a large-scale index using pattern correlation between large-scale environments and the synoptically-favorable SOM types, and found the index to be skillful for predicting MCS number, precipitation rate and area in spring, but its explanatory power decreases significantly in summer. The implications for this work to climate modeling will be discussed.

Keywords: mesoscale convection, storm tracking, radar observation, precipitation, large-scale environment

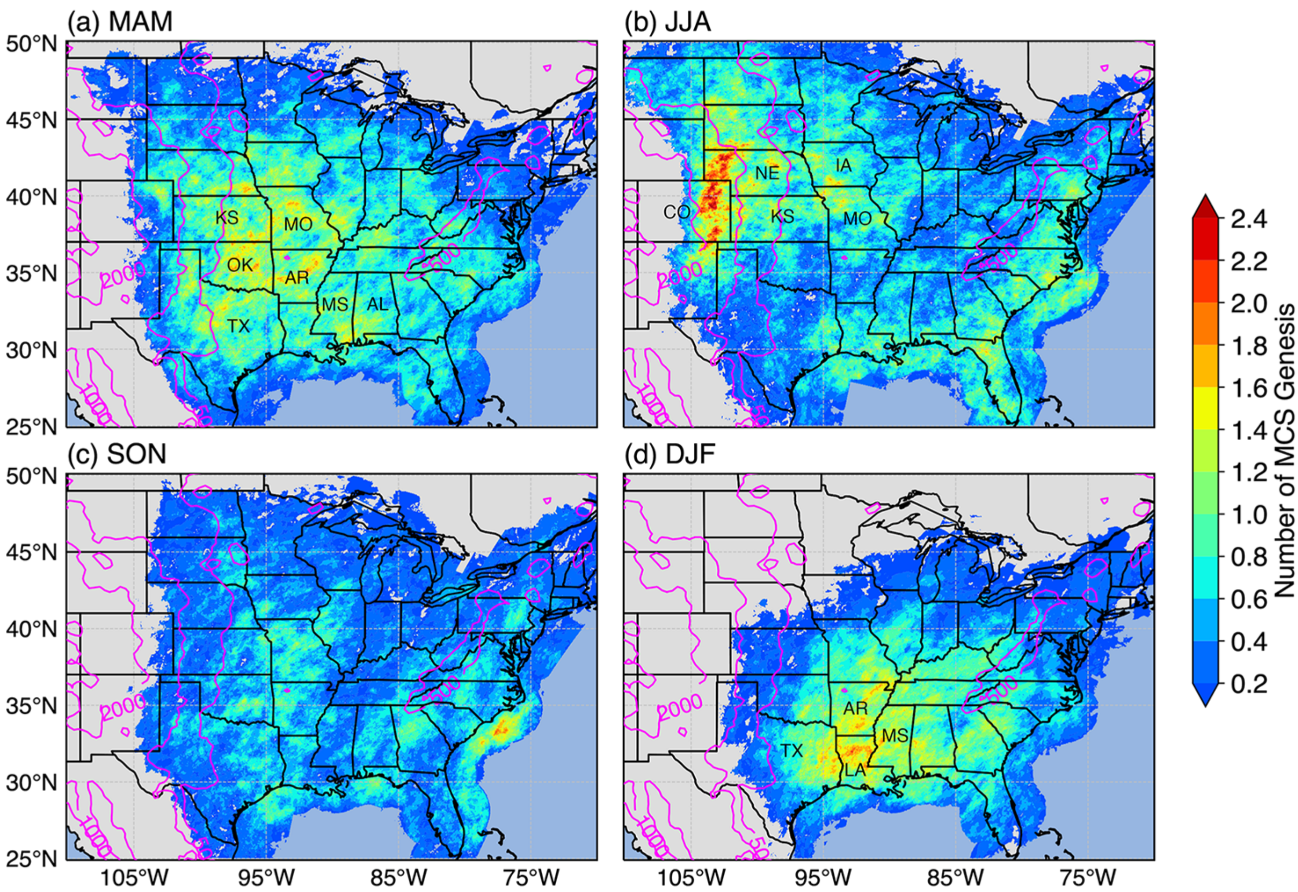

Figure 1. Spatial distribution of the average number of occurrences of MCS genesis for the four seasons from 2004–2016.