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A Five-Year Climatology of Precipitation Organization in the Southeastern U.S.: Initial Results

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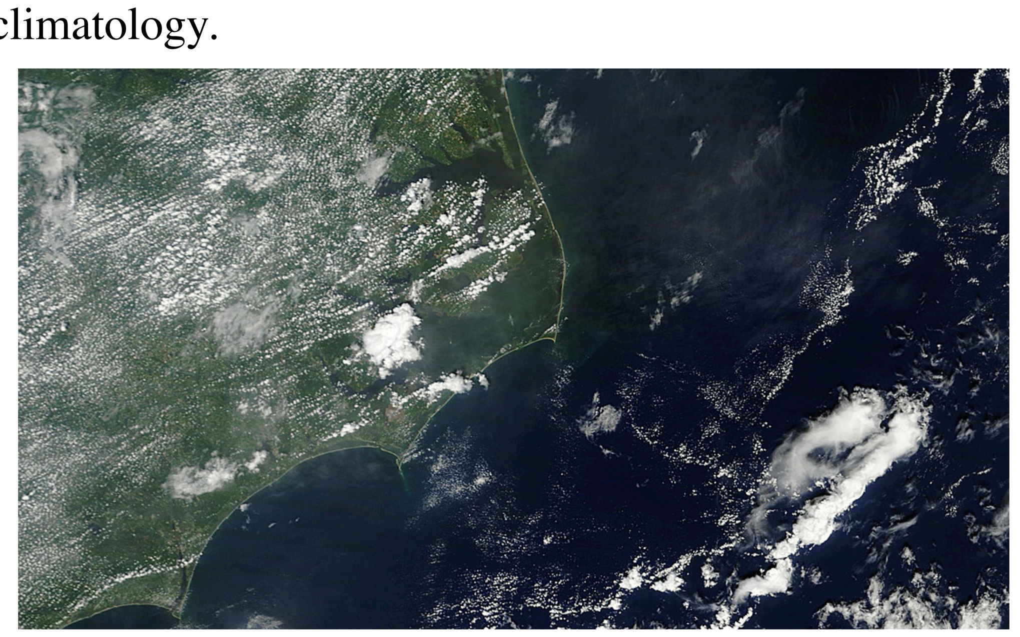
Introduction

This poster presents preliminary results from a five-year climatology (2009-2013) of precipitation system organization in the southeastern United States. Precipitation organization, in the context of this study, refers to the spatial scale of contiguous precipitation features observed by surface scanning radar, as well as convective vs. stratiform classification and hydrometeor phase.

We focus on two general categories of precipitation organization: transient and spatially heterogeneous precipitation on the one hand, and mesoscale convective systems (MCS) on the other (Figure 1). From hydrological and dynamical viewpoints, this distinction is useful. For example, both kinds of system may produce a similar daily precipitation total for a given location but have fundamentally different hydrological impacts. Furthermore, compared with isolated precipitation, MCS are well known to have fundamentally distinct feedbacks with the large-scale circulation. In the middle latitudes, MCS are hypothesized to be associated with large-scale baroclinic systems, with isolated precipitation driven more by local circulations and thermodynamic instability.

This poster describes early results of the monthly evolution over the annual cycle of MCS compared to smaller regions of more isolated precipitation over the southeastern U.S., and concludes with a discussion of a potentially important application for this kind of climatology.



<u>Figure 1.</u> MODIS visible image acquired on Sept. 1, 2013 from the NASA Terra satellite, showing isolated convection over eastern North Carolina and a narrow mesoscale convective system over the Gulf Stream.

Acknowledgements

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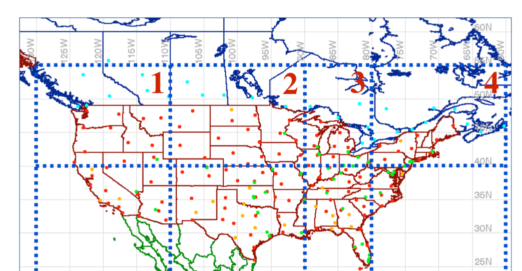
Data and Methods

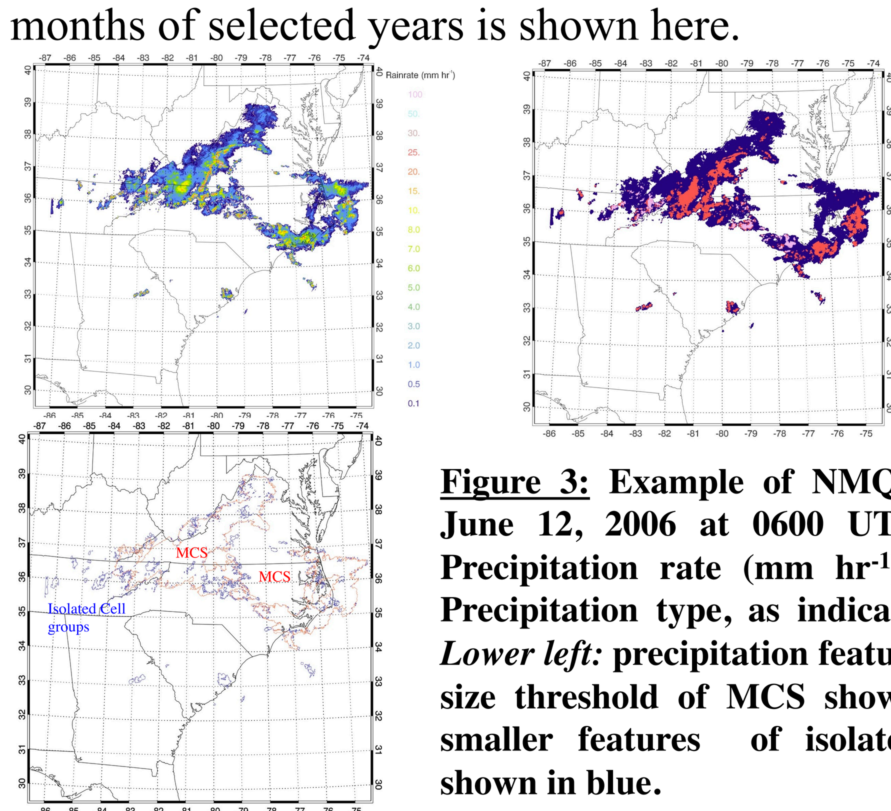
The climatology is based on the National Mosaic and Multisensor QPE (NMQ) dataset (Zhang et al. 2011), which is a precipitation and reflectivity composite of NEXRAD radar sites across the United States. NCDC implemented the NMQ system for the southeastern United States (tiles 7 and 8; Figure 2) for the period 2009-2013, specifically for use in this project.



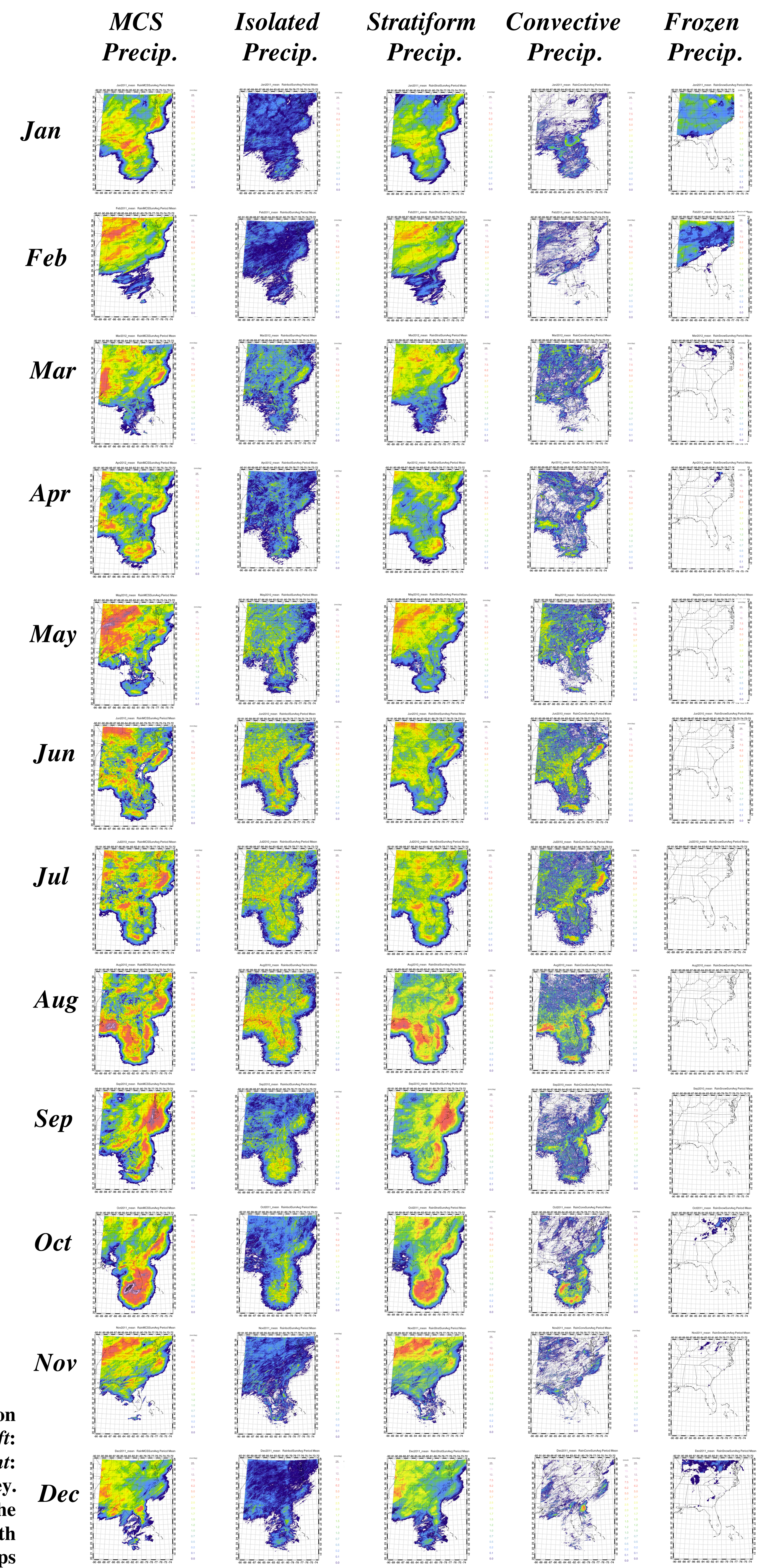
<u>Figure 2.</u> NEXRAD and Canadian Radar sites used in the NMQ product (based on Zhang et al. 2011). Tiles 7 and 8 were combined for use in this project.

The NMQ mosaic data incorporates 3-D radar measurements at about thirty NEXRAD sites, with soundings, rain guages, model analysis and other sources to produce low-level (nominally 1 km AGL) Cartesian maps of precipitation rate, radar reflectivity, water phase (liquid vs. frozen), tropical (warm, shallow) rain, echo top height, and convective vs. stratiform precipitation. The 2-D NMQ data sits on a 0.01° horizontal grid (approximately 1 km) with 5 minute temporal spacing.

We analyzed the NMQ data at 15 minute intervals to distinguish between groups of isolated convective cells and MCS. This was accomplished by imposing a maximum horizontal scale threshold of $\geq$100 km on all contiguous regions of precipitation $\geq$ 0.5 mm hr^{-1} to identify MCS (conceptually similar to Nesbitt et al. 2000). Figure 3 shows an example of precipitation rate, type, and water phase, as well as the identification of precipitation features identified as MCS and isolated cell groups. The data processing is not yet complete for 2009-2013, so only the annual cycle for individual months of selected years is shown here.



<u>Figure 3:</u> Example of NMQ 2-D fields on June 12, 2006 at 0600 UTC. *Upper left*: Precipitation rate (mm hr^{-1}). *Upper right*: Precipitation type, as indicated in the key. *Lower left*: precipitation features meeting the size threshold of MCS shows in red, with smaller features of isolated cell groups shown in blue.



<u>Figure 4:</u> Precipitation annual cycle for the years and fields indicated

Results

Shown in Figure 4 (left) are *preliminary* monthly composites for particular individual years of MCS and "isolated" precipitation over the southeastern U.S. These are compared with monthly averaged stratiform and convective precipitation. The annual cycle of frozen precipitation is shown to illustrate the transition from winter to summer regimes.

MCS: Though the southeastern U.S. receives significant precipitation year-round, a general summer maximum in August is evident, consistent with the TRMM satellite climatology. MCS occur with similar precipitation intensity all year, though in the winter months of DJF, MCS precipitation covers broad, SW-NE swaths indicating systematic propagation to the northeast. During July-August, MCS occur preferentially offshore, part of the summertime southeastward extension of the year-round Gulf Stream precipitation off the southeastern U.S. coast seen in the TRMM climatology. The only tropical cyclone influence in Fig. 4 is T.S. Nicole in September 2010 over eastern North Carolina.

Isolated systems: In clear contrast with MCS, isolated systems have a well-defined annual cycle. During DJF isolated rain is generally weak, occurring mostly over the Ohio valley, south Florida, and the Gulf Stream. In March-April isolated rain increases generally across the southeast during the spring transition. By May and into the summer months, isolated systems dramatically outline the coast from Florida to the Carolinas, revealing a clear "rain shadow" just off the southeast coast. In August, isolated systems are concentrated along the Gulf Coast region. These patterns strongly suggest that the isolated systems category clearly identifies warm-season local convection associated with thermodynamic instability and the sea-breeze circulation. By the fall season, isolated rain diminishes to the north, relegated to south Florida and the warmer Gulf Stream offshore. Along with its "grainier" pattern, this illustrates the connection of isolated rain with local instability and mesoscale circulation, rather than synoptic forcing.

Convective – stratiform: Comparing the MCS/isolated precipitation annual cycle with the standard convective – stratiform separation reveals the usefulness of the isolated category. The annual cycle of stratiform precipitation is quite similar to MCS, as expected. Since convective rain is also an important component of MCS, the isolated system category reveals local precipitation processes (e.g. coastal) more directly.

Conclusion and Next Steps

The results suggest a working hypothesis. While the convective – stratiform paradigm reveals how precipitation forces the large-scale circulation (via distinct modes of diabatic heating), the MCS – isolated framework relates more to how the large-scale and local processes force precipitation. We are pursuing the latter idea by examining the relationship between MCS/isolated and baroclinic systems in a parallel study. We hope to be able to apply the climatology to connect the good predictive skill of large-scale circulation in climate models to improving climate model's poor predictive capability of precipitation.

References

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