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A GIS-Based Analysis of Precipitation Organization and Regional Hydrology in North Carolina

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Introduction

The current study incorporates a climatology of precipitation organization into ArcGIS to examine how different modes of precipitation organization impact watershed hydrology. The precipitation organization climatology is based on the National Mosaic and Multisensor QPE (NMQ) dataset (Zhang et al. 2011) and defines precipitation organization by associating each pixel with a storm organization identification. The current study will focus on two modes of precipitation organization, Mesoscale Convective Systems (MCSs) and isolated convection, to assess how these precipitation systems affect watershed discharge.

Methods

- Data is produced by NCDC at a 1km x 1km x 5 min resolution
- NC watersheds are derived from the Watershed Boundary Dataset (WBD) and defined based on USGS categorizations (Fig. 1)
- Subwatersheds are created using ArcGIS watershed delineations techniques
- Average daily precipitation data is converted into ArcGIS compatible format
- Zonal statistics are run using the subwatershed boundaries
- Volumetric rainfall amounts are calculated for each watershed and combined with USGS stream gauge discharge data

Five subwatersheds were selected from the original seventeen North Carolina river basins and were delineated based on USGS stream gauge locations (figure 1).

Selected Subwatersheds
French Broad: The only one of the five that empties into the Gulf of Mexico. Complex mix of rocky soil with relatively low porosity. Located in the Blue Ridge Mountains.
Broad: Similar to the French Broad, however, terrain is less mountainous.
Yadkin-Pee Dee: Resides in the foothills and is the largest of the five subwatersheds. While the relief is not as drastic as the mountainous regions, the soil is composed of similar rocky constitutes.
Lumber: This watershed is located in both the Piedmont and Coastal Plain. In this gradually sloping region, soils transition from rocky piedmont soil to clay and higher porosity sandy soil.
Neuse: Similar orientation and soil composition to the Lumber, although this watershed has a higher population density and more urbanization.

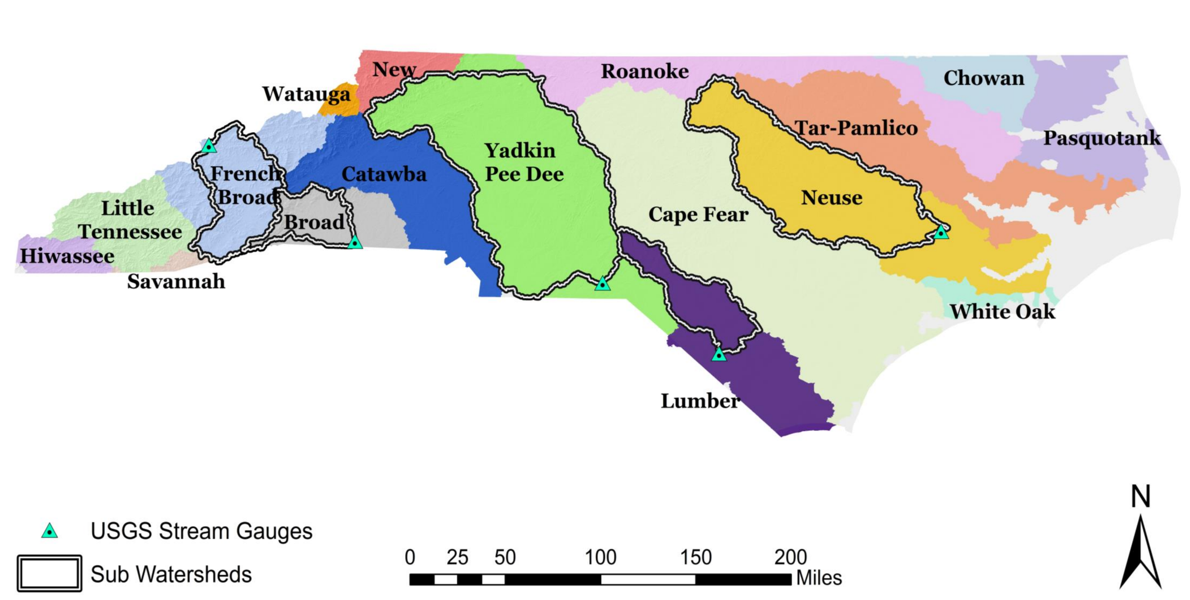

Figure 1. North Carolina river basins with selected subwatersheds.

Results

- Isolated convection and MCSs have substantial seasonal variability
  - Isolated convection: Summer maximum
  - MCS: Summer minimum

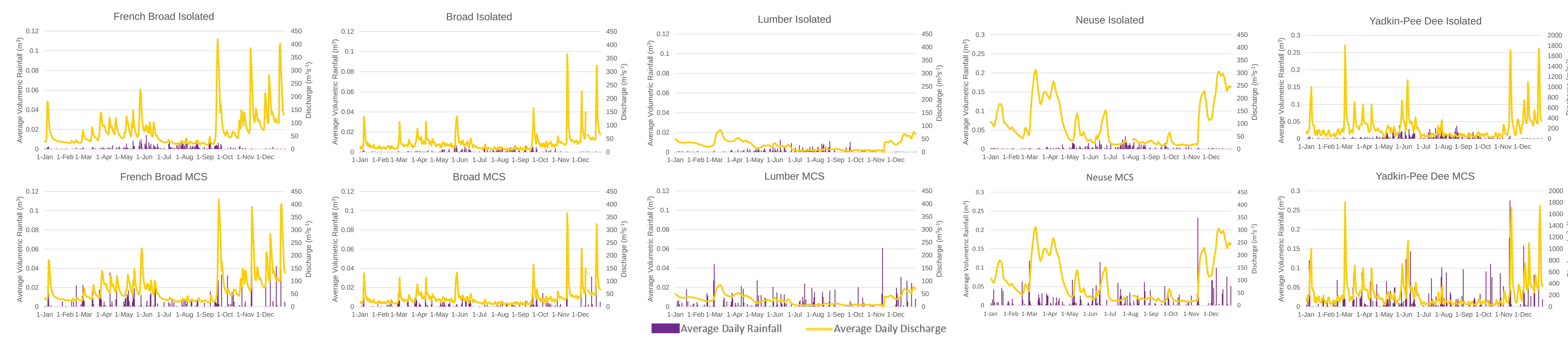

Figure 2. North Carolina subwatershed hydrographs.

- Western North Carolina has strongest relationships between rainfall and discharge
  - Relief of terrain helps enhance runoff and discharge
  - Soil characteristics allow for greater precipitation retention in eastern North Carolina
- Weak relationships between isolated convection and discharge

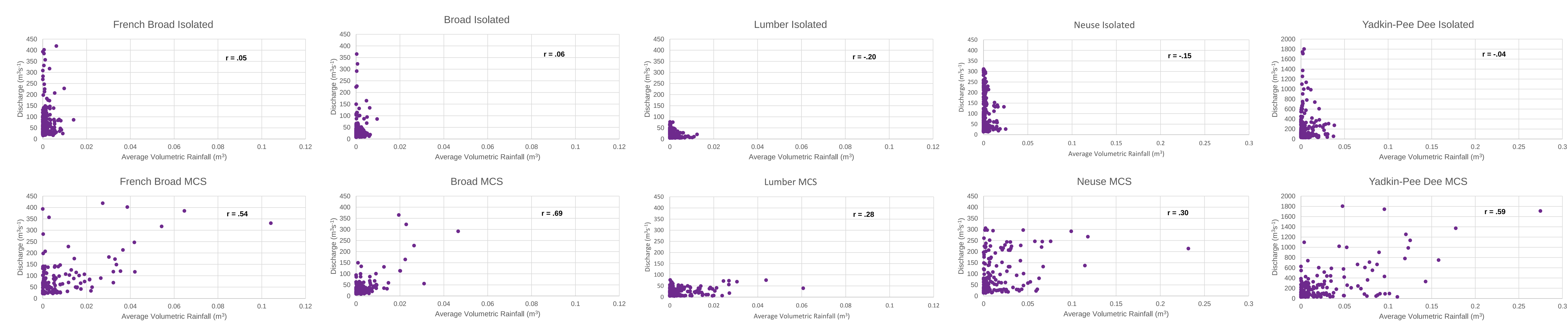

Figure 3. North Carolina subwatershed scatterplots. Plots and correlations are adjusted for time lags between rainfall and storm discharge.

- Time lags are evident for all subwatersheds
  - French Broad and Broad had time lags of about one day
  - Yadkin-Pee Dee had a two day time lag
  - The Lumber had a time lag of five days and the Neuse had a six day time lag

Conclusions

- Low summertime discharge in all watersheds is likely a response to the decrease in MCS activity
- While the Yadkin-Pee Dee is larger, its shorter time lag than its eastern counterparts is likely a reflection of land relief and soils differences
- Correlations between rainfall and discharge appear to be heavily influenced by topography and soil; however, relationships could also be affected by the location of rainfall. Events closer the gauge will have less time lag and may also produce more runoff and discharge

Next Steps

- Add precipitation and discharge data for 2010-2012
- Separate storm flow and base flow
  - Determine what percentage of the total discharge is a due to runoff
- Calculate and compare runoff ratios with USDA Curve Numbers for each watershed
- Assess how location of rainfall affects rainfall/discharge relationship
- Expand on seasonal analysis that suggest strong correlations between winter and springtime isolated convection and discharge