Climatology of Floods and their Associated Weather Systems in North Carolina

Alyssa L. Griffin[1] and Eric G. Hoffman[2]

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[1]North Carolina State University, [2]Plymouth State University

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Contact: agriffi7@ncsu.edu

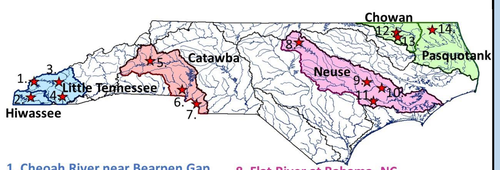
Introduction

- Flooding causes the most economic damage and loss of life and property of all natural disasters in the U.S. (U.S. Department of Security, 2022)
- Understanding flood frequency and their associated weather systems helps people prepare for flood events
- The commonly accepted U.S. flood agents are tropical cyclones, extratropical cyclones, and warm season convection (Miller, 1990)

This analysis aimed to develop a climatology of flood events and their associated weather systems in North Carolina from 2008 – 2022.

Data & Methodology: Flood Climatology

- Six river basins were selected to analyze: the Hiwassee, Little Tennessee, Catawba, Neuse, Chowan, and Pasquotank
- Several USGS gauge stations within each river basin were chosen (Fig 1.)
- 15-minute stream height data was downloaded from 01 January 2008 to 31 December 2022 (USGS, 2023)



1. Cheoah River near Bearpen Gap
2. Valley River at Tomotla
3. Tuckasegee River at Bryson River
4. Little Tennessee River near Prentiss
5. Johns River at Arneys Store
6. South Fork Catawba River at Lowell
7. Six Mile Creek near Pineville
8. Flat River at Bahama, NC
9. Contentnea Creek at Hookerton
10. Neuse River near Fort Barnwell
11. Trent River near Trenton
12. Potecasi Creek near Union
13. Ahoskie Creek at Ahoskie
14. Pasquotank River near South Mills

Figure 1. List of the six river basins and the USGS stream gauge stations analyzed.

- Flood events were defined as when the gauge height went above its 99th percentile value for at least an hour
- Flood events were categorized by their weather source which had to meet the following criteria:
  - Tropical Cyclone: Center of the low came within 500km of the gauge station +/- 48 hours from the start of the flood event (Liu *et al.* 2021)
  - Extratropical Cyclone: Same definition as above
  - Warm Season Convection: a non-tropical or extratropical cyclone precipitation event that occurred between April and September
  - Cold Season Convection: Same definition as above but occurring between October and March
- Archived surface analysis (WPC, 2023), radar imagery (UCAR, 2023), and HURDAT data (NHC, 2023) were used to identify the flood source

Data & Methodology: Catawba Flood Events

- Eighteen flood events occurred at the three gauge stations in the Catawba River basin
- These events were further analyzed to determine:
  - Flood duration
  - Whether flood and flash flood watches and warnings issued before and after the 99th percentile gauge height was reached

Flood Events: Seasonal Climatology

- All river basins saw a decrease in number of flood events during the summer (Fig 2.)
  - Could be explained by soil moisture minimum and evapotranspiration maximum during summer (Kunkel *et al.* 2020)
- Most of the tropical cyclone induced flooding events occurred in August through November (Figs. 2A-D)
- Most river basins had a decrease in floods caused by extratropical cyclones during the summer
- Pasquotank and Chowan basins had a clear maximum in February (Fig. 2D)
  - May be due to snowmelt

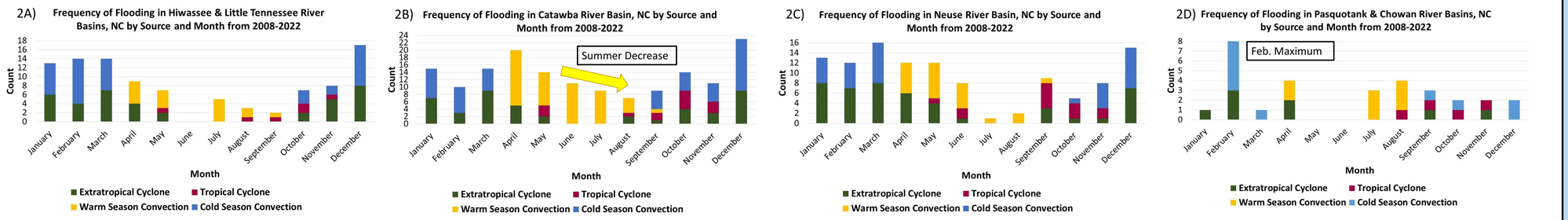


Figure 2. The total number of 99th percentile flood events in each month in the A) Hiwassee and Little Tennessee, B) Catawba, C) Neuse, and D) Chowan and Pasquotank river basins between 2008 and 2022 caused by extratropical cyclones (green), tropical cyclones (magenta), warm season convection (yellow), and cold season convection (blue).

Flood Events: Yearly Climatology

- Catawba and Neuse interannual variability are highly correlated with one another (Figs. 3B and 3C)
- Other river basins were not statistically correlated with one another
- In the Hiwassee and Little Tennessee river basins, the last four years have had more flood events than average (Fig. 3A)
- All river basins most common meteorological flood source were extratropical cyclones or cold season convection
- The Catawba river basin had the most amount of flood events with 158, demonstrating its flashiness
- The Pasquotank and Chowan river basins had only 30 events in 15 years (Fig. 3D)
- 2008 and 2012 were low flood event years across all basins (Figs. 3A-D)
- The active 2020 hurricane season was seen across all river basins (Figs. 3A-D)

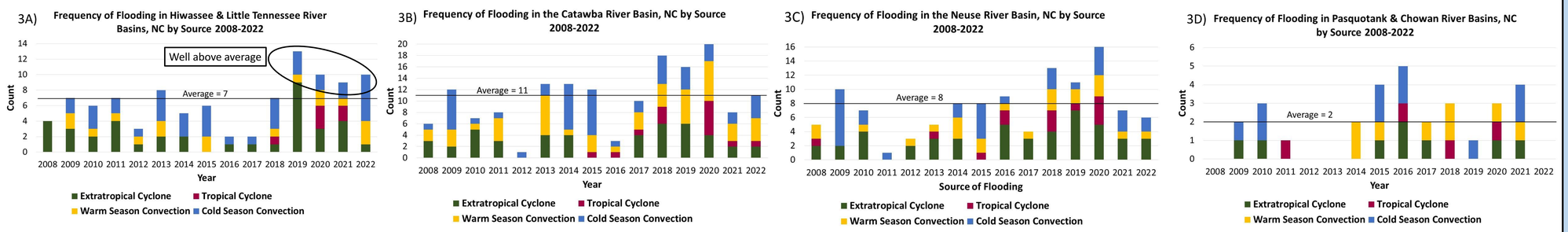


Figure 3. The total number of 99th percentile flood events in the A) Hiwassee and Little Tennessee, B) Catawba, C) Neuse, and D) Chowan and Pasquotank river basins between 2008 and 2022 caused by extratropical cyclones (green), tropical cyclones (magenta), warm season convection (yellow), and cold season convection (blue).

Duration of Catawba Flood Events

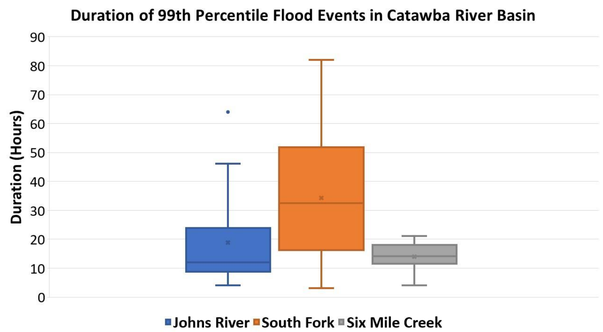


Figure 4. The distribution of the duration of select 99th percentile gauge height flood events in the Catawba river basin at the Johns River (blue), South Fork (orange), and Six Mile Creek (grey) USGS gauge stations.

- South Fork had the largest basin area of about 2,500km^2 and the longest average flood duration of 34 hours (Fig 4.)
- Six Mile Creek's had the smallest basin area of about 54km^2 and the shortest average flood duration of 14 hours (Fig 4.)
- Johns River drainage area was the steepest and most vegetation coverage (Model My Watershed, 2023)
- Flood event durations were related to basin drainage area, slope of land, and vegetation coverage

Watches & Warnings Issued during Catawba Flood Events

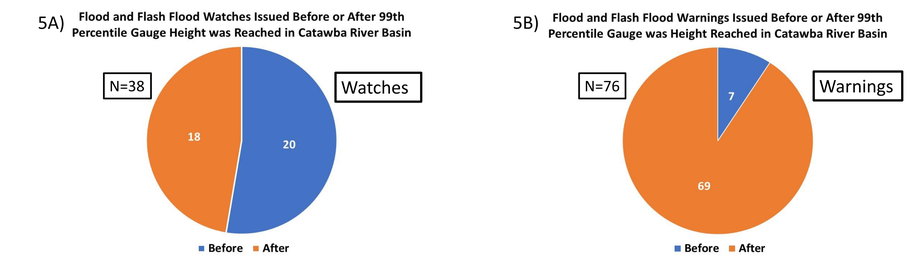


Figure 5. Timing of flood and flash flood watches (A) and warnings (B) that were issued before or after gauge stations reached their 99th percentile gauge height during 18 flood events that impacted the three watersheds of the Catawba River basin.

- Flash flood and flood watches were split almost 50/50 between being issued before or after the 99th percentile gauge height was reached (Fig 5A.)
- Majority of warnings were issued after the 99th percentile gauge height was reached (Fig 5B.)
- Since 99th percentile gauge heights are less than minor flood stage heights, it was expected for warnings to be issued after

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