Meteorological Causes and Atmospheric Conditions Associated with Extreme Precipitation Events in Southeast Michigan

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OBJECTIVE

1. What are the ***dominant storm types*** that generate extreme events in a Clinton river sub-basin?
2. What are the ***characteristics*** of the precipitation area, total, intensity, and duration for each phenomena?

BACKGROUND

- A 2022 DoD study identified ***flooding*** as current and future ***threat*** to DoD missions and industries.
- ***Temporal and spatial*** features of storms based on storm type (Chen et al., 2023). ***Flood frequency*** analyses need to consider spatial and temporal rainfall distributions (Zhou et al., 2021).
- ***Frontal*** boundaries generate ***deadly floods*** across the US (Ashley and Ashley, 2008; Kunkel et al., 2012; Brunner and Dougherty, 2022; Kunkel et al., 2022).
- ***Sensitivity*** of weather (WRF) and hydrological (SST) ***modeling*** to storm types (Liu et al, 2011; Wright et al., 2014).

METHOD

- ***Extreme Event Definition***

The 95th percentile of precipitation intensity and median area extent thresholds identify widespread extreme events (Moore et al., 2015).

- ***Objective 1: Phenomena Identification*** (Fig. 1)

Storm types are based on Kunkel et al., 2022, including:

1. TC (National Hurricane Center): HURDAT2,
2. ETC (Crawford et al., 2021) :CNECT database,
3. FRT (Sansom and Catto, 2024): TFP,
4. MCS (Feng et al., 2023): PyFLEXTRKR.

- ***Objective 2: Statistical Characteristics***

Spatiotemporal: Analyzed storm attributes (area, total volume, intensity, and duration).
Extreme Probability: PDF of the GEV distribution.

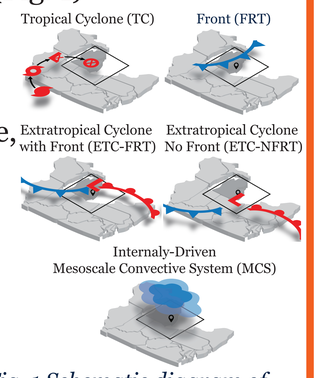
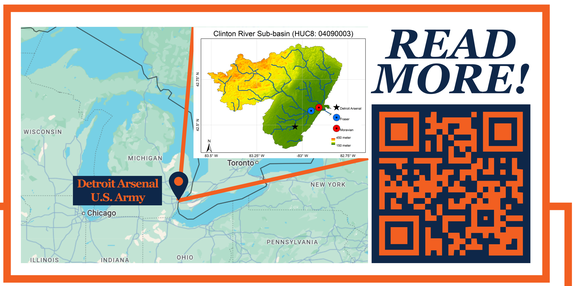


Fig. 1 Schematic diagram of phenomena classification

Fronts dominate extreme events, but every storm type tells a unique story of impact and seasonality!



RESULTS

1. The warm season is the most active period in producing extreme events
2. ***Front (FRT)*** is the ***dominant*** driver, and each phenomenon has a ***different seasonality*** (Fig. 2 and 3).
3. Each storm type yields different spatial distribution relative to the catchment (Fig. 4).

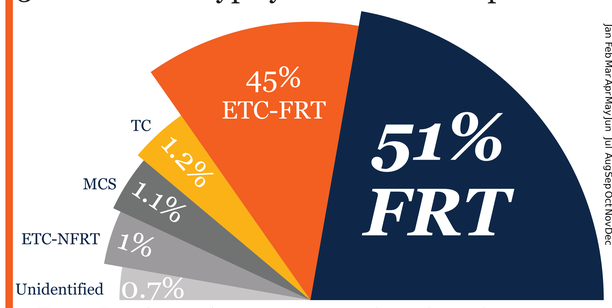


Fig. 2 Pie chart of extreme events based on phenomena

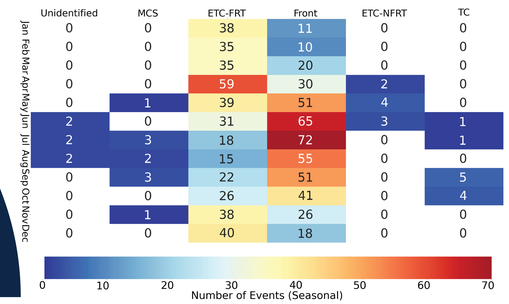


Fig. 3 Seasonal distribution of extreme events

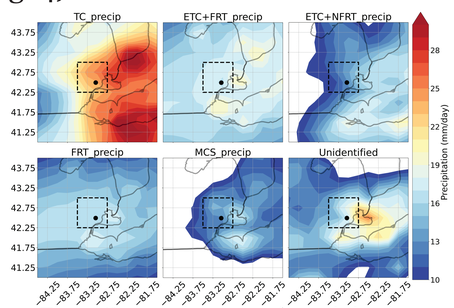


Fig. 4 Composite map of precipitation

4. The area of FRT varies widely due to the width of the system (Fig. 5).
5. TC is a fast-propagating phenomenon that produces the largest total volume of precipitation into the catchment (Fig. 5).
6. ***FRT, ETC-FRT and TC*** present a frequent ***likelihood of extreme precipitation*** due to the PDF analysis of average intensity (not shown) .

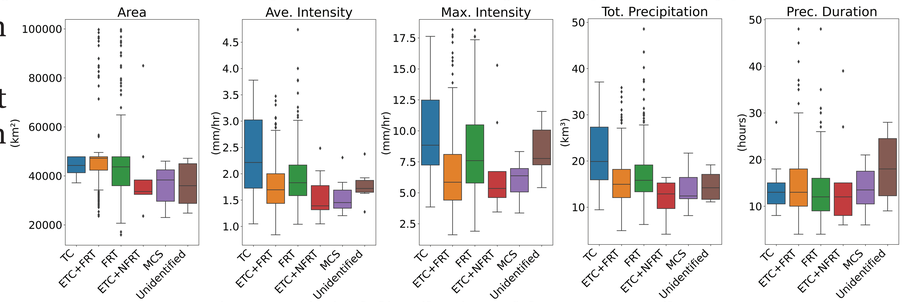


Fig. 5 Statistical distribution of the storm attributes

CONCLUSION

1. Storm types exhibit seasonal distributions, with FRT being the most dominant phenomenon.
2. Storm types show differences in spatiotemporal distributions, where FRT, ETC-FRT, and TC pose a higher risk of generating extreme conditions.

ILLINOIS

FUTURE WORK

1. WRF evaluation for various storm types.
2. Implement the method of this work for future climate projection using CMIP6.

ACKNOWLEDGEMENT

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