NCICS
North Carolina Institute for Climate Studies

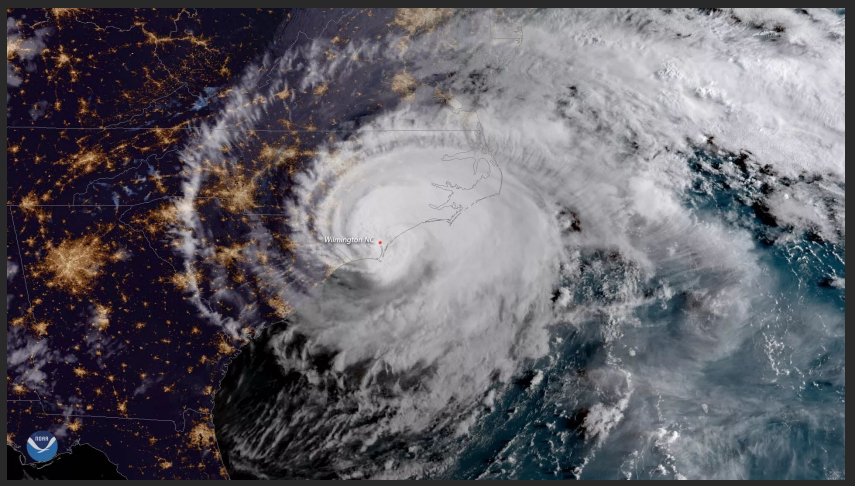
Observed Changes in Extreme Precipitation Associated with United States tropical cyclones

John Uehling and C. J. Schreck III

NC STATE UNIVERSITY

Enhanced Rainfall Metric for TC Precip

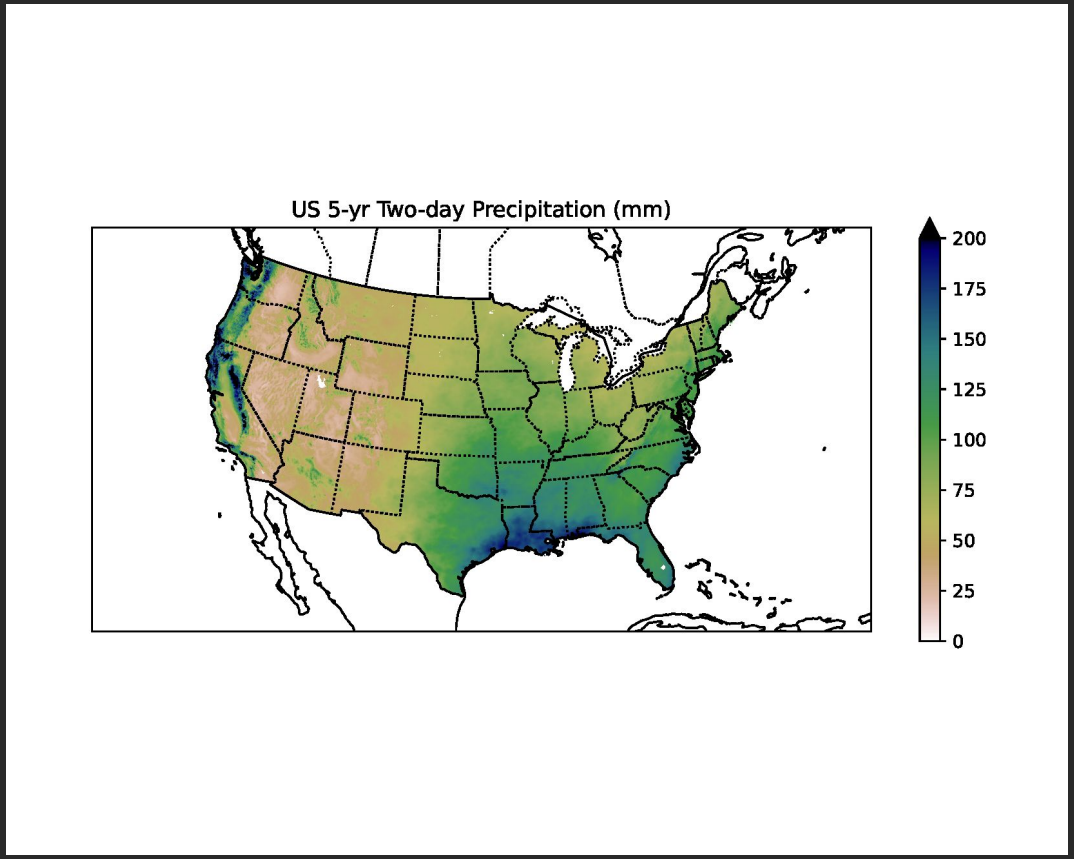
- Recent tropical cyclones (TCs) have highlighted the hazards that TC rainfall poses to human life and property.
- The Saffir-Simpson Hurricane Wind Scale does not adequately capture the rainfall risk.



US Rainfall Variations

The major advantage of using the ERM to define “extreme” is that it accounts for the geographic distribution rainfall magnitudes.

Areas that are prone to higher magnitude rainfall events are more resistant to their impacts



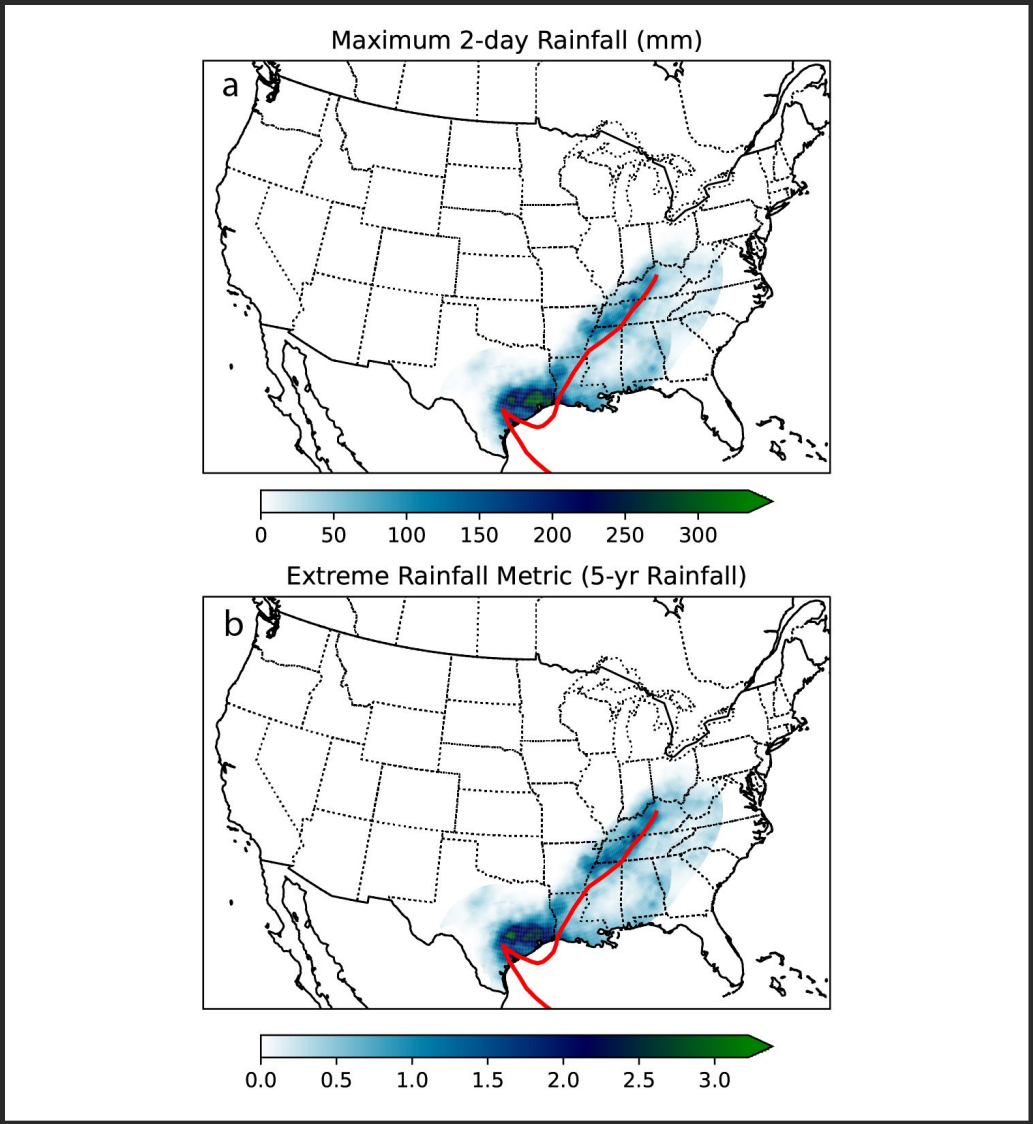
Map of five-year return levels of two-day accumulated precipitation (in mm) for the CONUS.

NCICS North Carolina Institute for Climate Studies

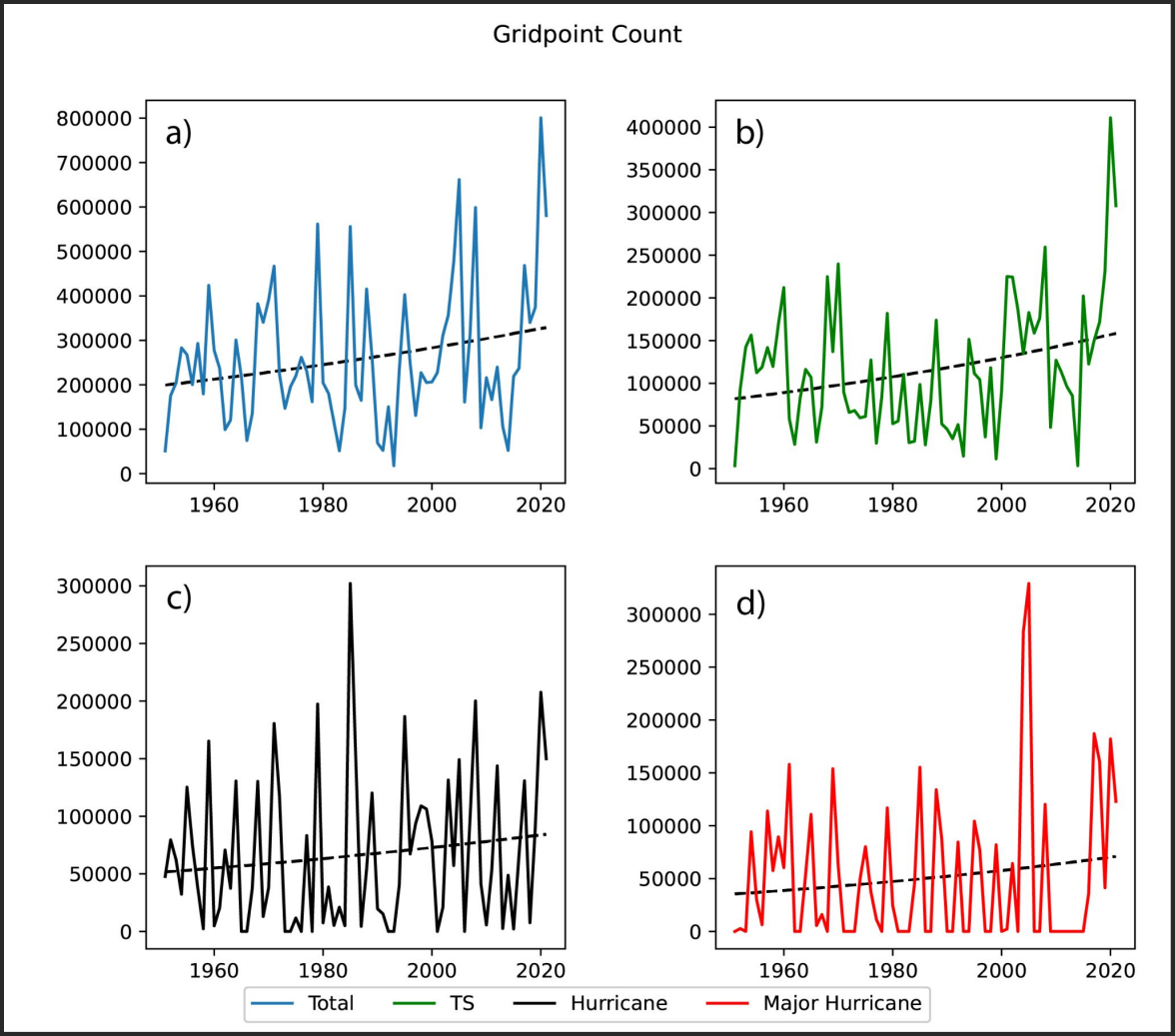
NC STATE UNIVERSITY

Enhanced Rainfall Metric

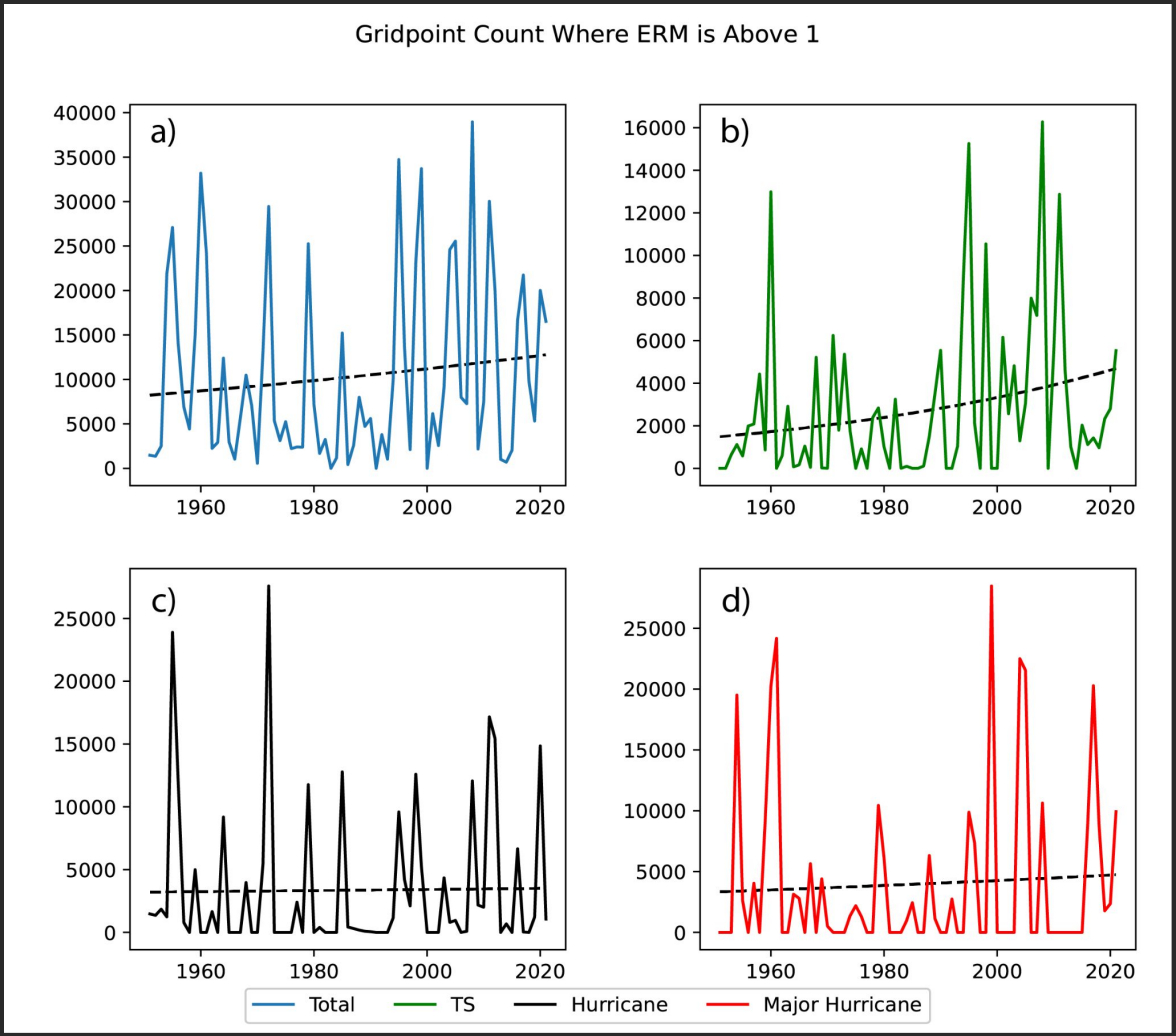
- The Extreme Rainfall Multiplier (Bosma et al. 2020) was the solution:
- ERM = (Rain depth from TC)/(Rainfall depth for a 2-yr recurrence interval rainfall)
- We modified this to a 5-yr recurrence interval
- I refer to this modified metric as the enhanced rainfall metric (ERM)



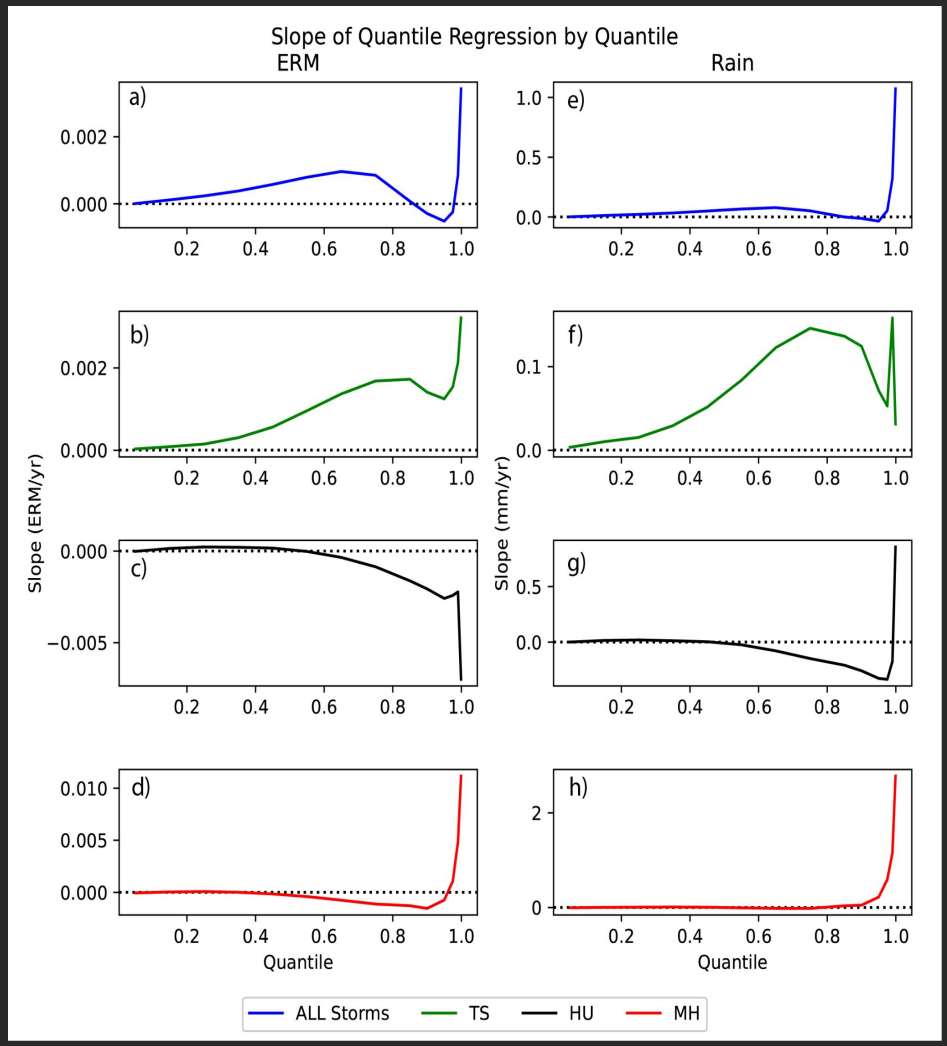
Map of a) 2-day rainfall and b) ERM associated with Hurricane Harvey (2017).



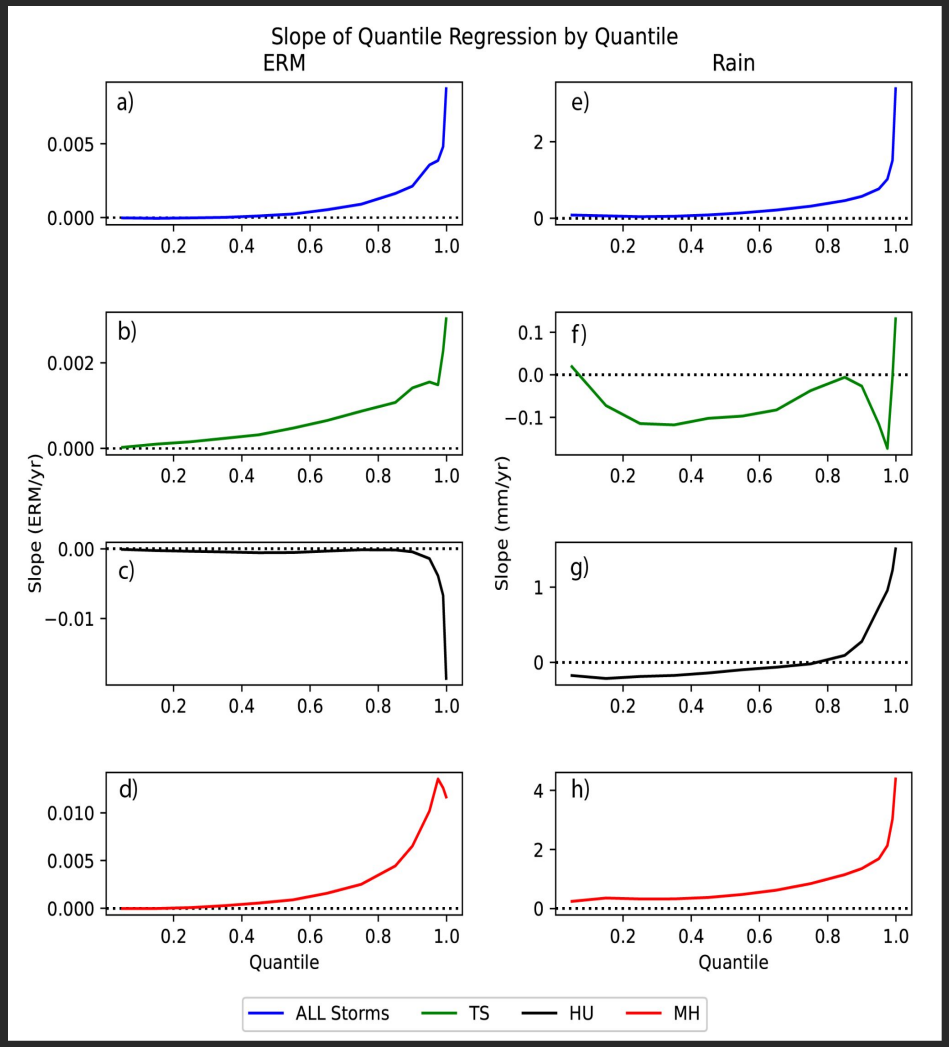
Annual counts of the number of grid points where rainfall associated with a TC occurred over the United States. The counts are broken down by (a) all storms , (b) tropical storm strength systems, (c) hurricane strength systems (category 1-2), and (d), and major hurricane strength systems (category 3-5). The Poisson regression curve is shown by the black dashed line.



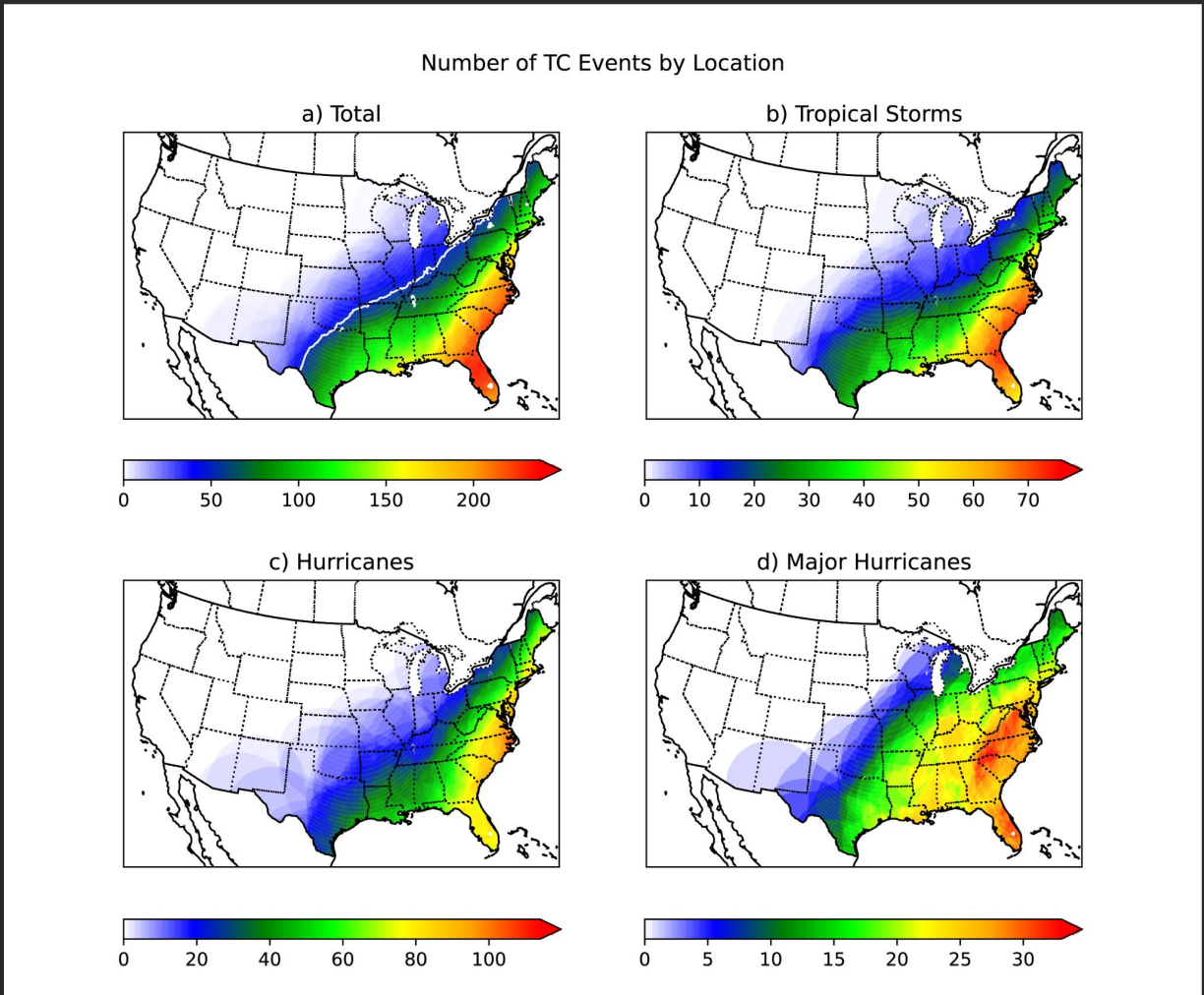
Annual counts of the number of grid points where rainfall associated with a TC occurred over the United States and the ERM > 1. The counts are broken down by (a) all storms , (b) tropical storm strength systems, (c) hurricane strength systems (category 1-2), and (d), and major hurricane strength systems (category 3-5). The Poisson regression curve is shown by the black dashed line.



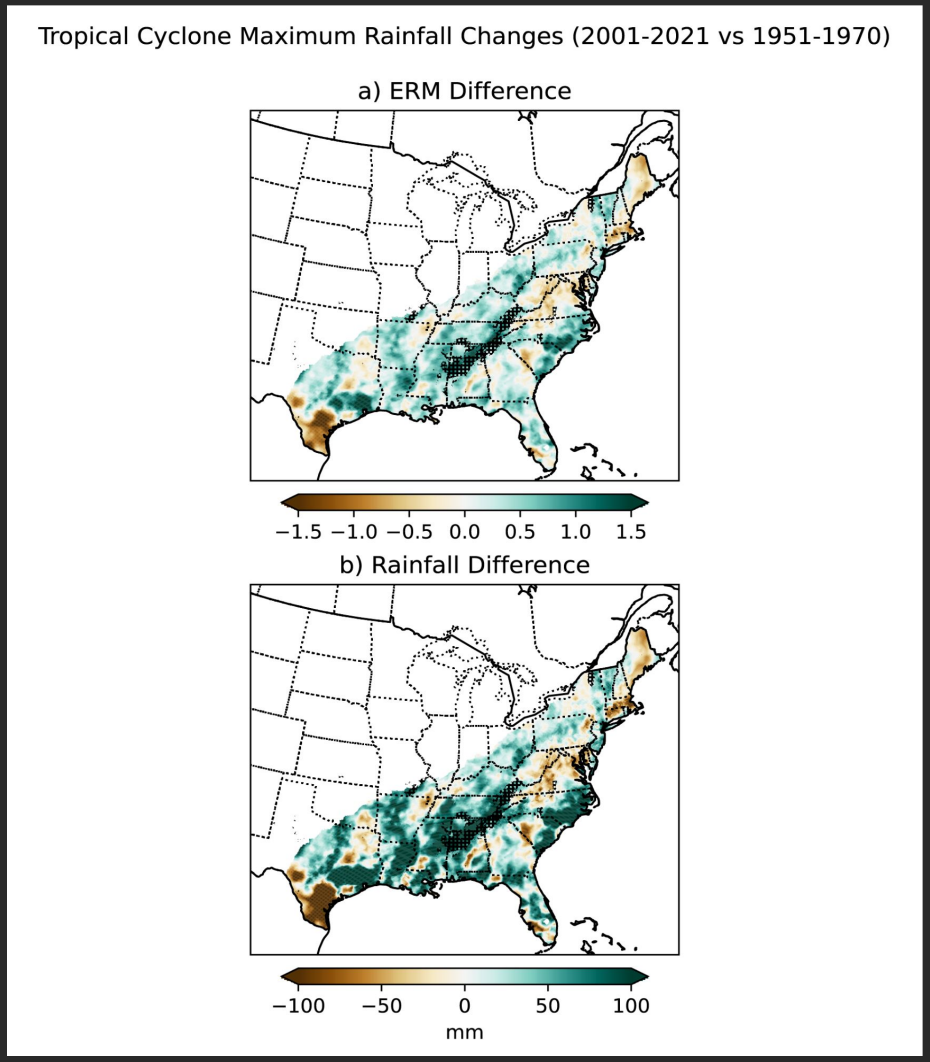
The slope of quantile regression by quantile (slope values given in change/year) of annual TC associated (left column) ERM and (right column) rainfall for (a,e) all storms, (b,f) tropical storms, (c,g) hurricanes, and (d,h) major hurricanes. The zero slope line is shown in black.



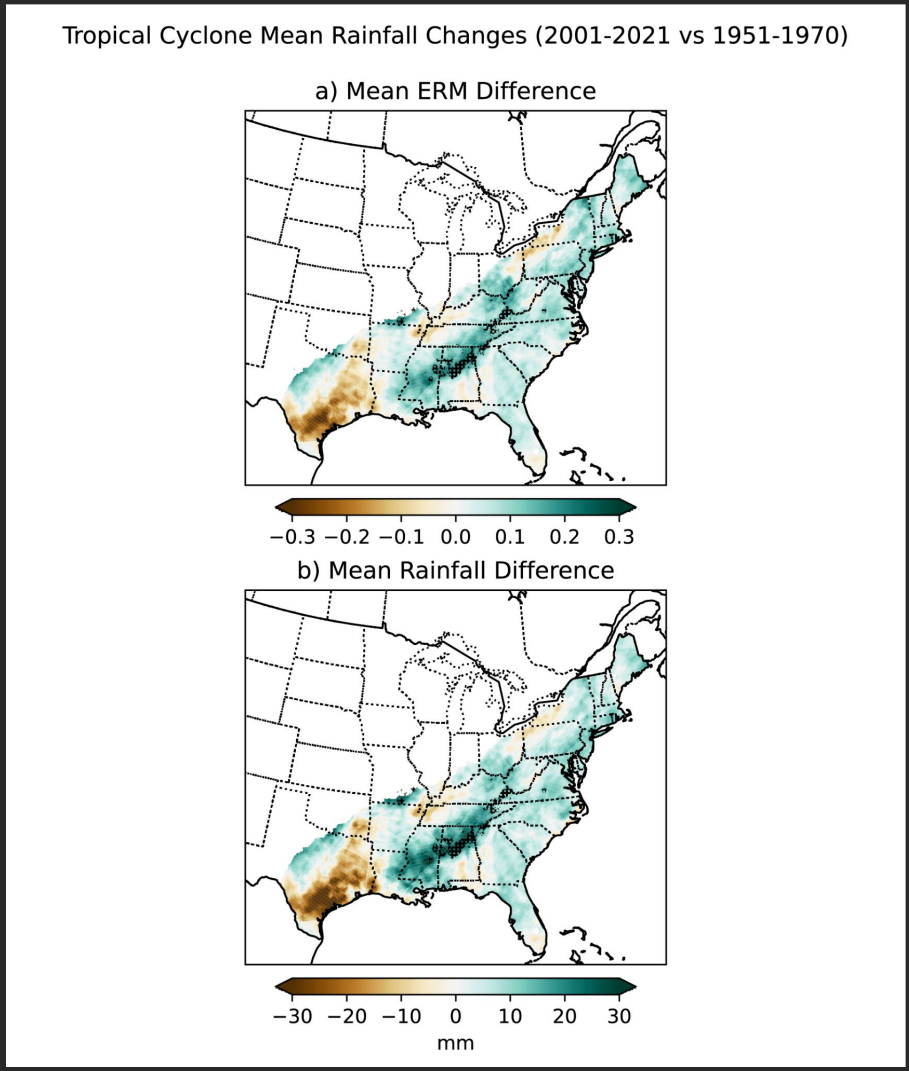
The slope of quantile regression by quantile where ERM > 1 (slope values given in change/year) of annual TC associated (left column) ERM and (right column) rainfall for (a,e) all storms, (b,f) tropical storms, (c,g) hurricanes, and (d,h) major hurricanes. The zero slope line is shown in black.



Map of the count of TC rainfall events by location and maximum storm intensity while affecting land in the United States. The count is shown for (a) all TCs, black contour shows 50 event line, (b) tropical storms, (c) hurricanes, and (d), and major hurricanes.



Map of the difference in maximum ERM (a) and maximum rainfall (b) associated with TC between 2001-2020 and 1951-1970, only the points where more than 50 TC rainfall events occurred are shown. Hatched areas are significant at 95% according to a bootstrap resampling test.



Map of the difference in mean ERM (a) and mean rainfall (b) associated with TC between 2001-2020 and 1951-1970, only the points where more than 50 TC rainfall events occurred are shown. Hatched areas are significant at 95% according to a bootstrap resampling test.

Conclusions

- Extreme rainfall associated with tropical cyclones poses a significant threat to life and property.
- The threats posed by these storms have been observed to be increasing in recent decades.
- The number of grid points impacted by tropical cyclone rainfall has shown a significant increase during the 1951–2021 time period, largely driven by tropical storms.
- The number of points experiencing 5-year events (ERM>1) also increased during the period, but at a slower rate.

Conclusions

- For tropical storms, rainfall rates and ERM have increased for all quantiles. Hurricanes and major hurricanes have seen decreases in moderately strong rainfall (roughly 50th–90th percentiles) but large increases in extreme rainfall (≥95th percentile).
- The increases in extreme precipitation become more clear when only considering points where the ERM>1.
- Future studies should examine the causes and pathways for the trends observed here.
- We are planning to turn this work into a climate indicator for NOAA's NCEI.

Questions?

Thanks for listening