Assessing Socio-economic Impacts of Compound Flooding for U.S. Coastal Communities

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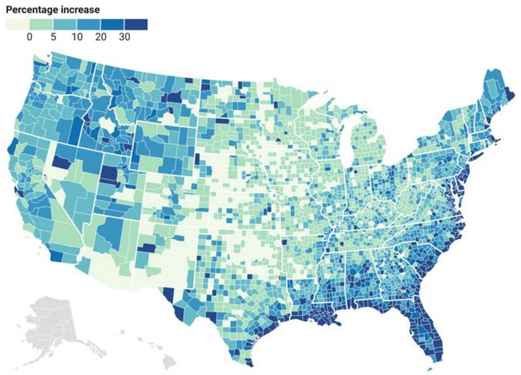
BACKGROUND

- Flooding, the most frequent and costliest natural disaster in the United States, incurs over $32 billion in annual losses. These losses are expected to rise by 26% in the next 30 years under RCP4.5 (Wing et al. 2022).



- Recent studies show a rise in compound flooding events, involving storm surges, heavy rainfall, and high river discharge, especially in coastal areas due to climate change effects (Naseri & Hummel 2022; Bevacqua et al 2020).
- Prior research, often focusing on single flood drivers and using statistical models, has generally failed to fully capture the complex interactions and cumulative impacts of multiple concurrent flooding drivers.

OBJECTIVES

- To identify and analyze the key drivers of compound flooding events along the U.S. coastal counties, particularly in the Gulf of Mexico and Atlantic coast areas, and to quantify their impacts on coastal infrastructure and communities using a novel impact-based methodology as proposed by Ali et al. (2023).
- To assess and compare the contributions of different flooding drivers in 235 U.S. coastline counties, and to contrast these findings with previous studies that utilized statistical and probabilistic approaches.

DATA

Two different datasets were used: (1) Reanalysis and observational data for 5 hydrometeorological drivers (Table below), and (2) socio-economic impact data from SHELDUS™.

Variable	Spatial resolution	Temporal resolution	Time period	Source
River discharge	0.05° x 0.05°	Daily	1980-2018	GLoFAS Copernicus
Precipitation	0.0625° x 0.0625°	Daily	1980-2018	(Pierce et al., 2021)
Soil moisture	0.25° x 0.25°	Daily	1980-2018	ERA5 ECMWF
Storm surge	2.5-km	Daily	1980-2018	CODEC
Wave Height	Station-based	Daily	1980-2018	WIS, USACE

METHODOLOGY

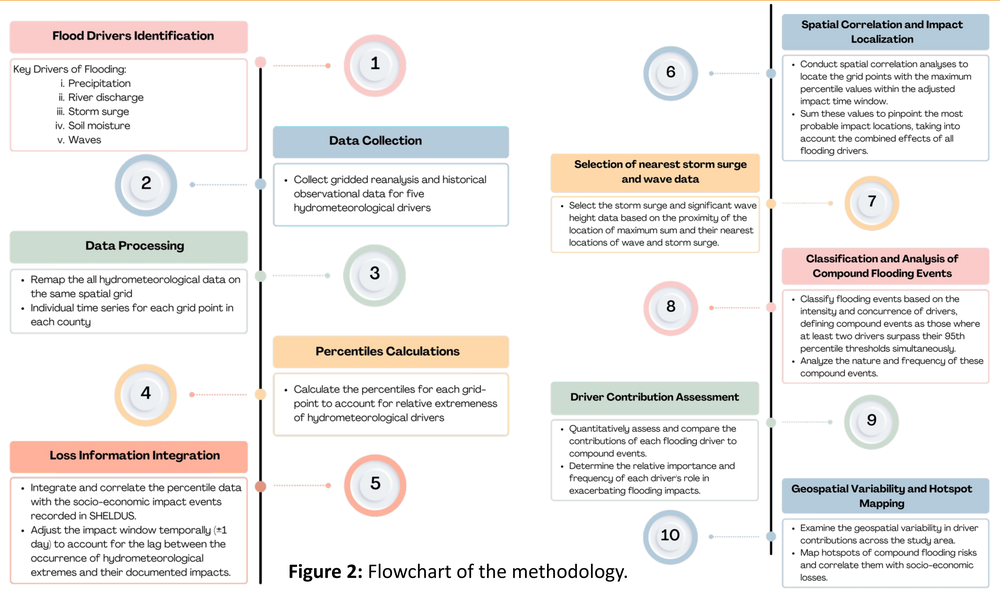


Figure 2: Flowchart of the methodology.

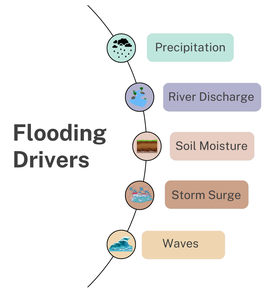


Figure 3: An overview of all key hydrometeorological drivers associated with flooding.

RESULTS

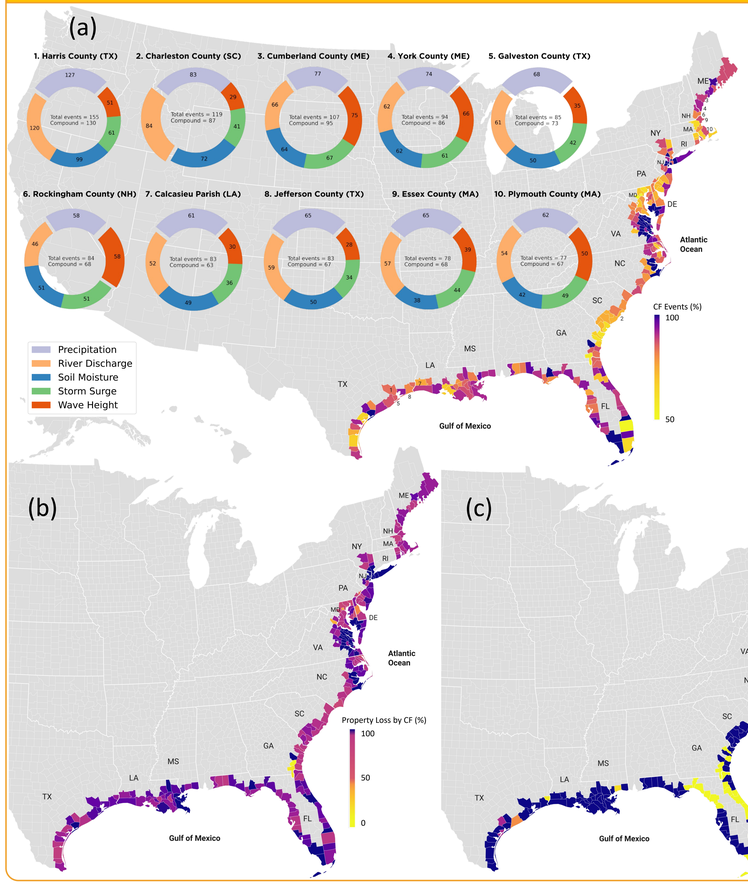


Figure 4: (a) spatial distribution of compound flooding (CF) events in the U.S. Gulf of Mexico and Atlantic coastal counties. The donut charts on the map (a) show the top 10 counties with the most flooding and CF events, each depicting relative contributions of various flooding drivers —precipitation, river discharge, storm surge, soil moisture, and significant wave height—that have exceeded the 95th percentile threshold during CF events.

(b) Percentages of property damage attributable to CF events.

(c) Percentages of crop damage attributable to CF events.

(d) Percentages of fatalities attributable to CF events in the U.S. Gulf of Mexico and Atlantic coastal counties.

CONCLUSIONS

- **Prevalence of Compound Flooding Events:** During 1980-2018, there were 6,126 recorded flooding events, out of which 5,147 (84%) were classified as CF. This high proportion underscores the significant prevalence of CF events in the U.S. Gulf of Mexico and Atlantic coastal regions.
- **Spatial Variability of CF:** Results show that CF frequencies are unevenly distributed across the U.S. Gulf of Mexico and Atlantic coastal areas, with a higher incidence observed in the southeastern regions. The results reveal a notable concentration of CF events in specific states, with Florida (809), Texas (700), and Louisiana (557) experiencing the highest frequencies.
- **Dominant Drivers of CFEs:** Precipitation is the main driver in CFEs, influencing 92.56% of cases in total and averaging 91.79% per county. River discharge follows closely, affecting 85.97% of CFEs overall and 86.11% on average per county. Soil moisture contributes to 78.34% of CF events in total and 79.35% on average per county, while storm surge and wave height impact 69.98% and 60.23% of total CF events, and an average of 71.50% and 62.67% per county, respectively. These findings highlight the need for multifaceted flood risk management strategies that address the diverse drivers of CF across different regions.
- **Socio-economic Impacts of CF:** Compound flooding events account for about 96% ($139 billion) of property damage and 68% ($1.87 billion) of crop damage. Furthermore, they contribute to approximately 95.87% of injuries and 95.81% of fatalities reported, emphasizing the extensive human and economic impacts of these events.

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