Human and Built Environment Flood Hazards and Impacts Across Return Periods

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Background

- Further open-source characterization of projected flood hazards at the structure level can inform resilience planning.
- Detailed historical flood characterization, including inundation and damage estimates are crucial for investigating spatiotemporal heterogeneity of community impacts.

Methods

- We linked Copernicus Emergency Management System (CEMS) global river flood hazard maps (GLOFAS) to structures in the National Structure Inventory.
- CEMS-GLOFAS is a 90m gridded inundation map with estimates of fluvial depths at the 10-, 20-, 50-, 75-, 100-, 200-, and 500-year return periods (RPs).
- We conducted a linear regression to establish the extensive margin (rate of increase in population exposed) and intensive margin (mean inundation depth among population exposed) of fluvial flood hazards across increasing RPs.
- To characterize historical exposures, we used the CEWS surface and subsurface runoff time series from 1979 to 2023 to characterize estimated runoff RPs based on generalized extreme value regression within the extRemes R package.
- Using the RPs derived from the historical runoff record, we assigned each day an RP exceedance level, then linked RP exceedance to CEMS inundation depths and structure-level damage estimates.

Applications

- Understanding how increasing severity of local fluvial flood risk is driven by rising numbers of population exposed vs. depth of inundation can help prioritize infrastructure investments as flood risk increases.
- Combining projected depths with historical runoff time series supports enhanced characterization of past flood events, including measures of severity based on structure-level inundation estimates.
- By measuring historical floods, we can better evaluate community vulnerability and resilience to impacts.

References + Acknowledgements

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References

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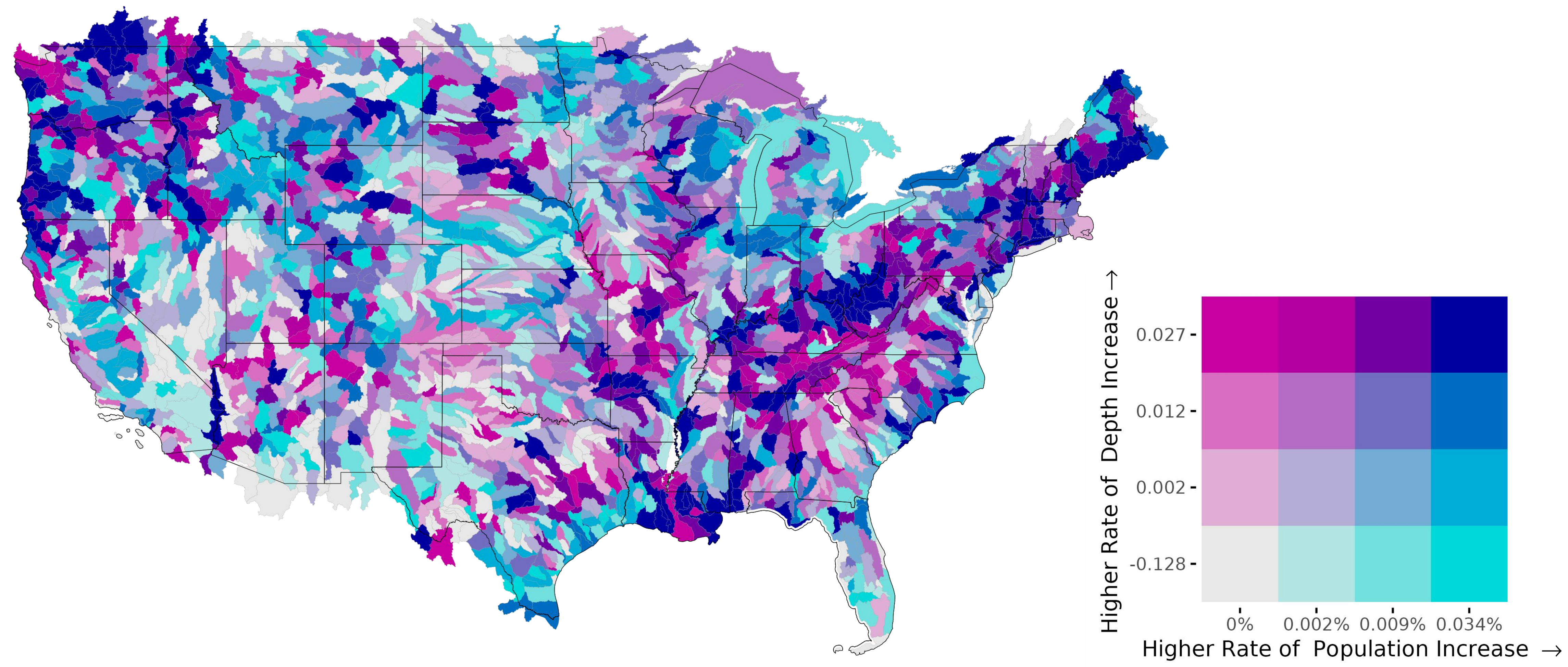
Results

Rate of Population Inundated and Mean Inundation Depth Across Return Periods for CONUS HUC8 Watersheds



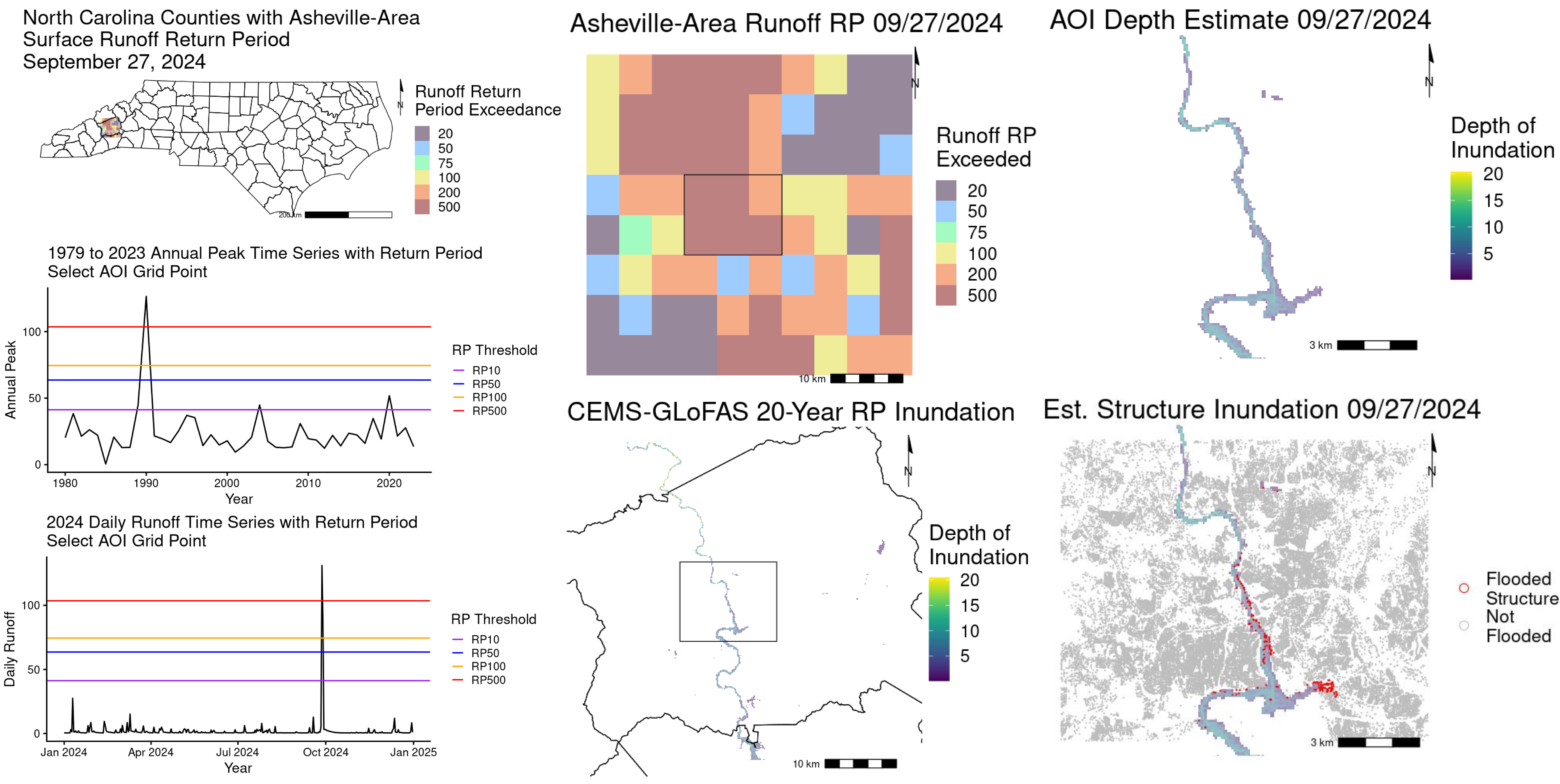
Patterns of projected fluvial flood hazard across return periods vary spatially. Increases in **both population inundated and depth of inundation** are seen across the Pacific Northwest, Appalachia, and New England

Top 10 States in Population Inundated and Mean Inundation Depth

States	Total Population Outside Leveed Areas	Population Flooded N Millions (%)	
		100-Year Return Period	500-Year Return Period
North Dakota	0.6M	0.1M (15.3%)	0.1M (17.8%)
Louisiana	2.3M	0.3M (13.9%)	0.4M (17.9%)
West Virginia	1.6M	0.1M (8%)	0.2M (9.8%)
Idaho	1.5M	0.1M (5.2%)	0.1M (6.2%)
Montana	1M	0M (4.8%)	0.1M (5.7%)
Connecticut	3.8M	0.2M (4.4%)	0.2M (6.1%)
Oregon	4M	0.2M (4.1%)	0.2M (5.3%)
Wyoming	0.6M	0M (3.9%)	0M (4.3%)
Indiana	6.7M	0.2M (3.3%)	0.3M (4.2%)
Kentucky	3.8M	0.1M (3.3%)	0.2M (4.9%)

States	Total Population Outside Leveed Areas	Depth Among Flooded (Feet)	
		100-Year Return Period	500-Year Return Period
West Virginia	1.6M	15.1	17.1
Tennessee	7.1M	12.1	13.8
Washington	7.4M	11.3	13.7
Virginia	8.1M	10.1	12.7
Ohio	12.3M	10.7	12.6
Kentucky	3.8M	11.6	12.5
Maryland	6.1M	9.6	11.4
Oregon	4M	8.8	11.4
Connecticut	3.8M	9.4	10.9
Maine	1.3M	9.2	10.8

Example Application of Paired CEWS Historical Runoff and CEMS-GLOFAS Inundation for Structure-Level Historical Flood Profile. Hurricane Helene Impacts on Asheville, NC



Generalized extreme values regression using the CEMS historical runoff time series identifies Helene as a 500-Year event across the Asheville area. Extent of inundation appears to be underestimated, likely due to fluvial-specific focus.