



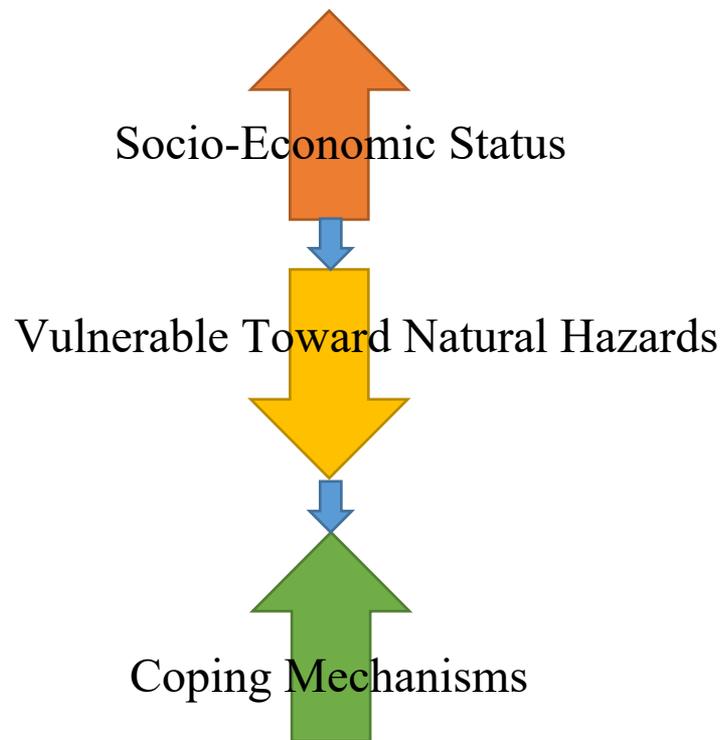
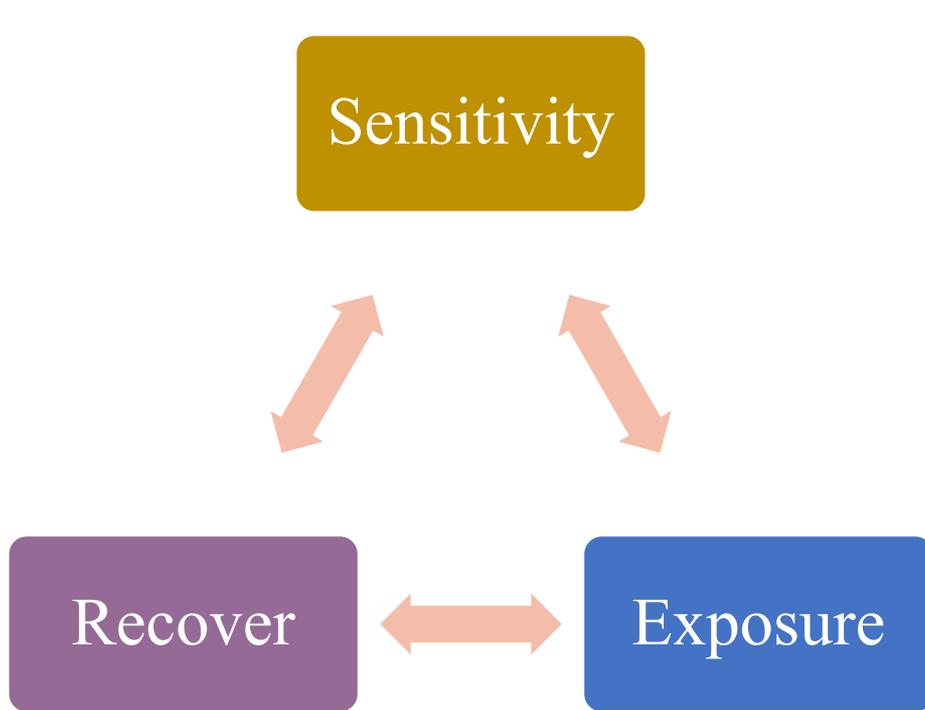
# Place-based Assessment of Flash Flood Hazard and Vulnerability in the Continental United States

Hamid Moradkhani, Sepideh Khajehei, Ali Ahmadalipour,  
Hamed Moftakhari, and Wanyun Shao

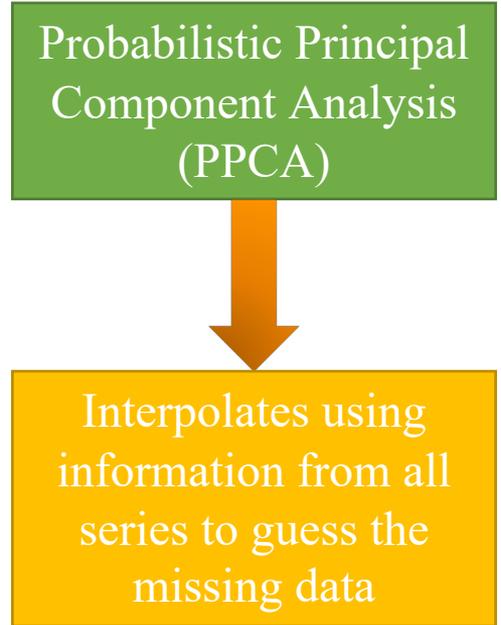
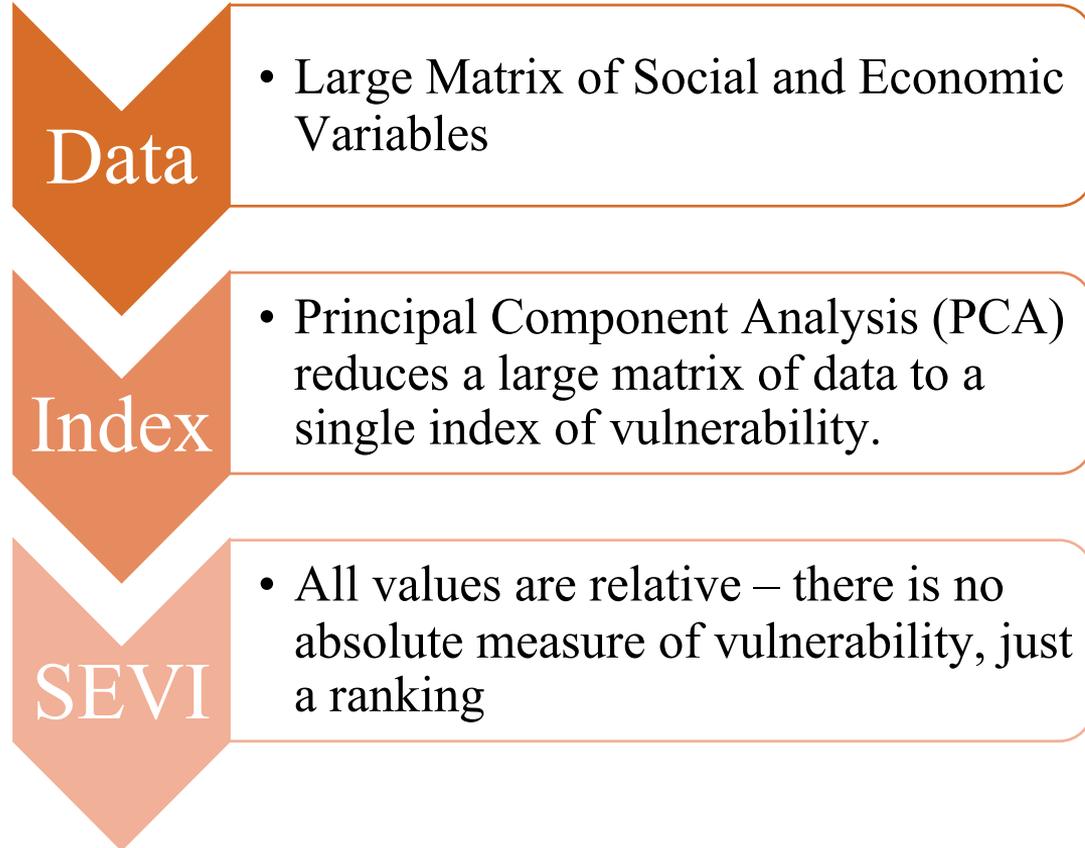
Center for Complex Hydrosystems Research (CCHR)  
Department of Civil, Construction and Environmental Engineering

[hmoradkhani@ua.edu](mailto:hmoradkhani@ua.edu), <http://www.moradkhani.net/>

# Vulnerability



# Socio-economic Vulnerability Index (SEVI)



# SEVI Framework

Categories	Variables	Influence	Categories	Variables	Influence
Demographic Socioeconomic Status	Poverty	+	Gender	Percentage female	+
	Per capita income	-		Percentage female participation in labor force	+
	Median household value	-		Percentage female-headed households	+
	Percentage of population aged 25 years or older with less than 12th grade education	+	Housing and Transportation	People per unit	+
	Percentage of households receiving social security	+		Percentage mobile homes	+
	Median gross rent	-		Percentage of housing units with no cars	+
	Percentage employment in extractive industries	+		Percentage of population living in nursing and skilled-nursing facilities	+
	Percentage of households earning greater than US \$200,000 annually	-		Percentage renters	+
	Percentage employment in service industry	+		Percentage unoccupied housing units	-
	Percentage civilian unemployment	+	Industrial Economy	Private industries	-
Percentage Asian	+	Agriculture, forestry, fishing, and hunting		+	
Percentage Black or African American	+	Transportation and food service		-	
Percentage speaking English as a second language with limited English proficiency	+	Accommodation and food service		-	
Race and Ethnicity	Percentage Hispanic	+	Governmental	-	
	Percentage Native American	+			
	Median age	-			
	Percentage of population under 5 years or 65 and older	+			
	Percentage of population under 18 years old	+			

- US CENSUS, 2015 American Community Survey (ACS) 5-year Estimates
- Bureau of Economic Analysis

# SEVI Framework

- PCA vs. PPCA:

The expectation maximization (EM) algorithm is used to estimate

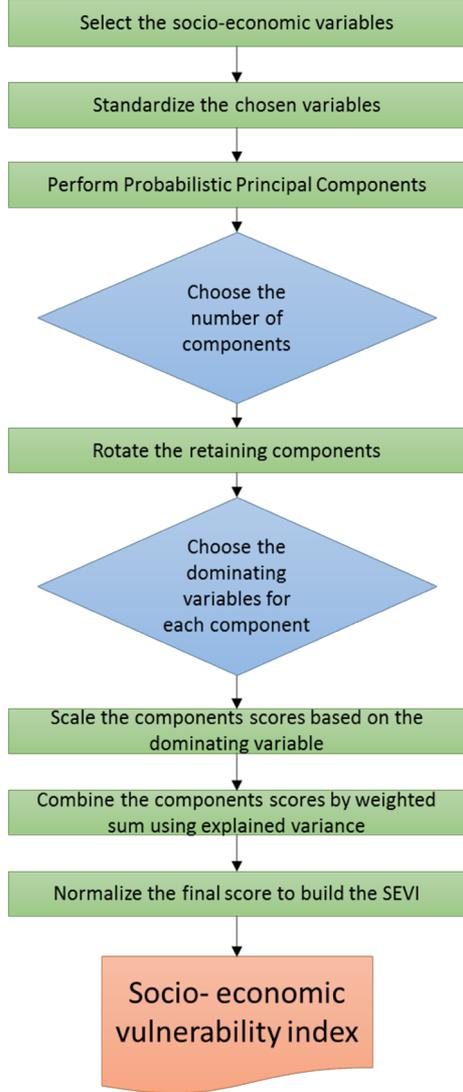
the parameters of PPCA model, which will consequently allow.

the framework to deal with the missing values.

- Rotation:

the varimax rotation was applied to the retaining components in order to

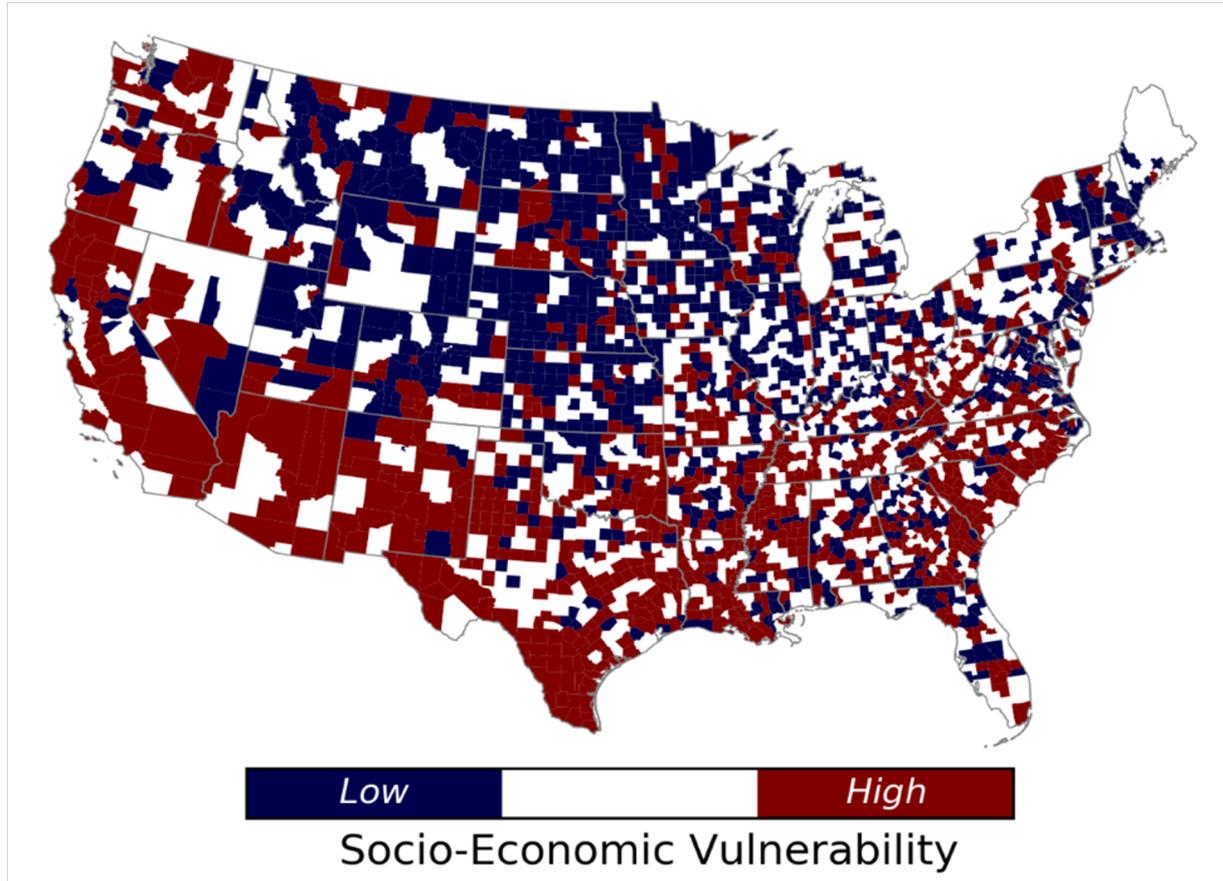
reduce the number of high-loading variables on each component.



# Remaining Components

Component	Category	% Variance Explained
1	Demographic Socioeconomic Status	16.15
2	Industrial Economy	14.27
3	Race and Ethnicity	12.13
4	Demographic Socioeconomic Status	10.46
5	Housing and Transportation	9.87
6	Demographic Socioeconomic Status	6.52
7	Age	5.32
8	Gender	3.49

# Socio-Economic Vulnerability (County Level)



# Flash Flood Dataset

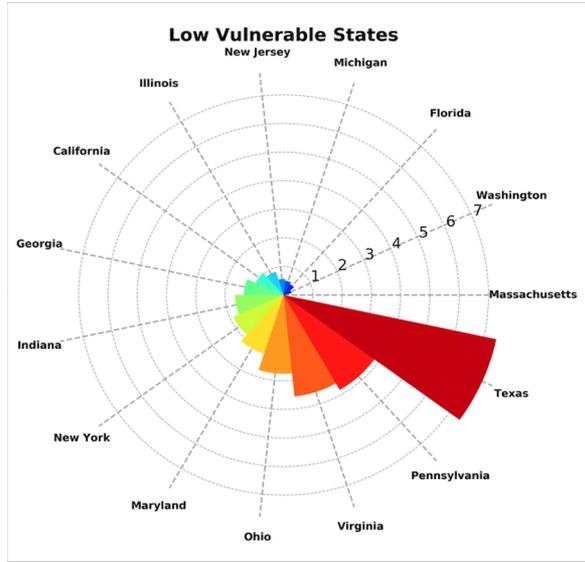
Source: Unified Flash Flood Database

[\(https://blog.nssl.noaa.gov/flash/database/\)](https://blog.nssl.noaa.gov/flash/database/)

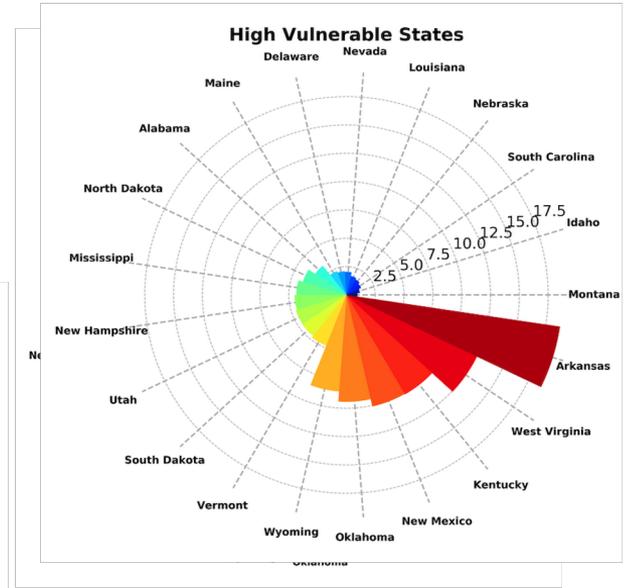
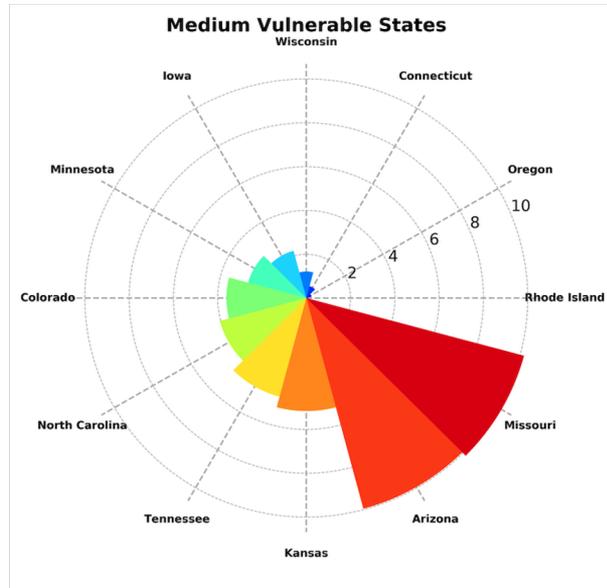
Flash Flood Characteristics:

- Frequency
- Magnitude (Peak Discharge)
- Duration : Difference between start time and peak time
- Severity : Magnitude/Duration

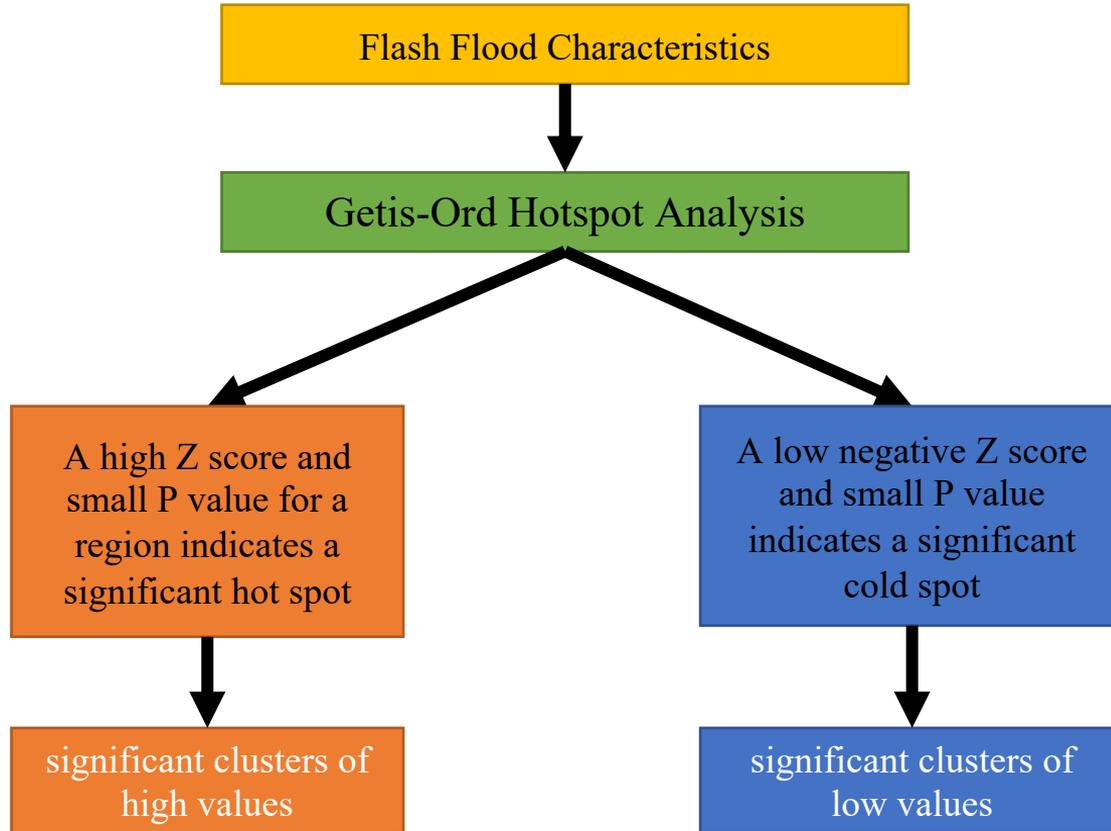
# Flash Flood Fatalities



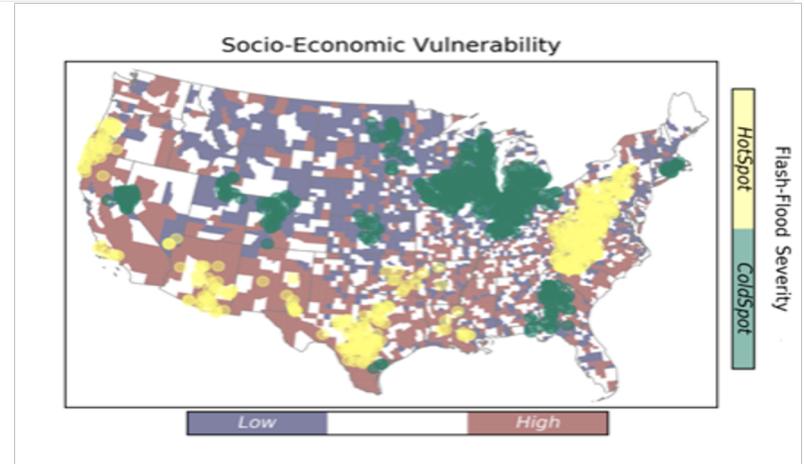
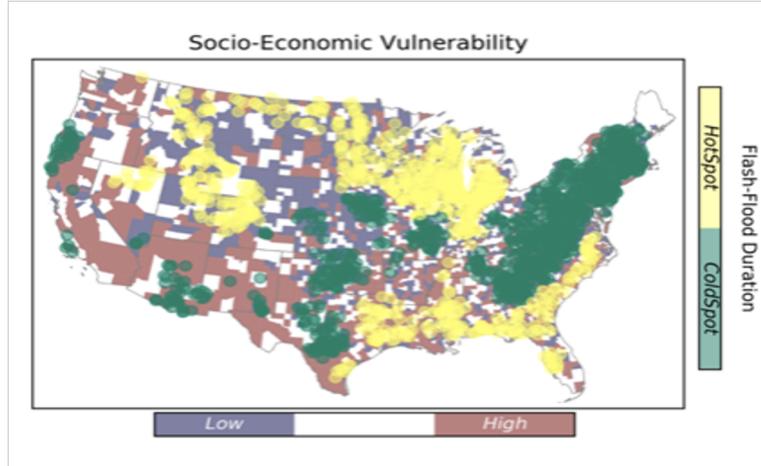
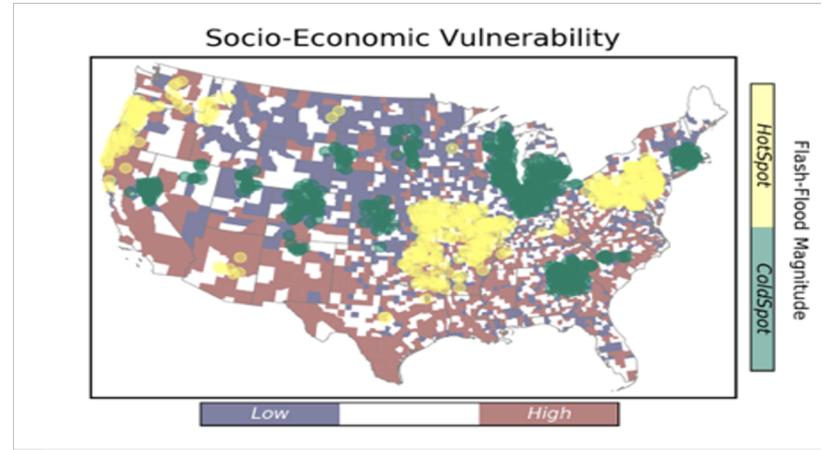
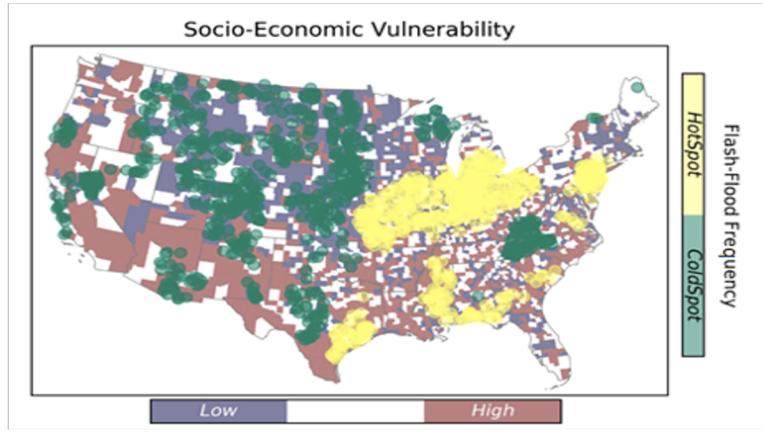
## Flash Flood Fatality per Million Capita



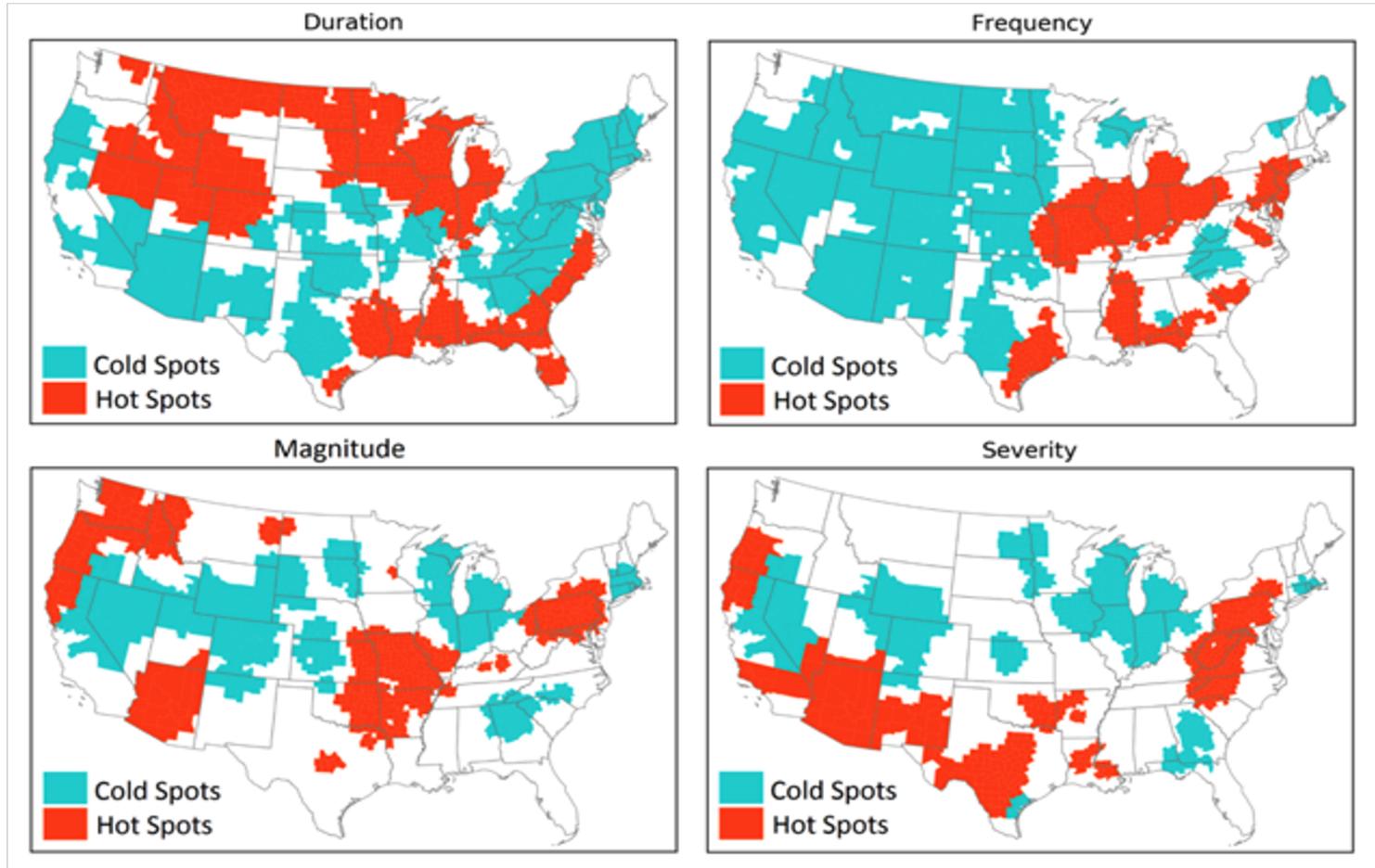
# Flash Flood Clustering



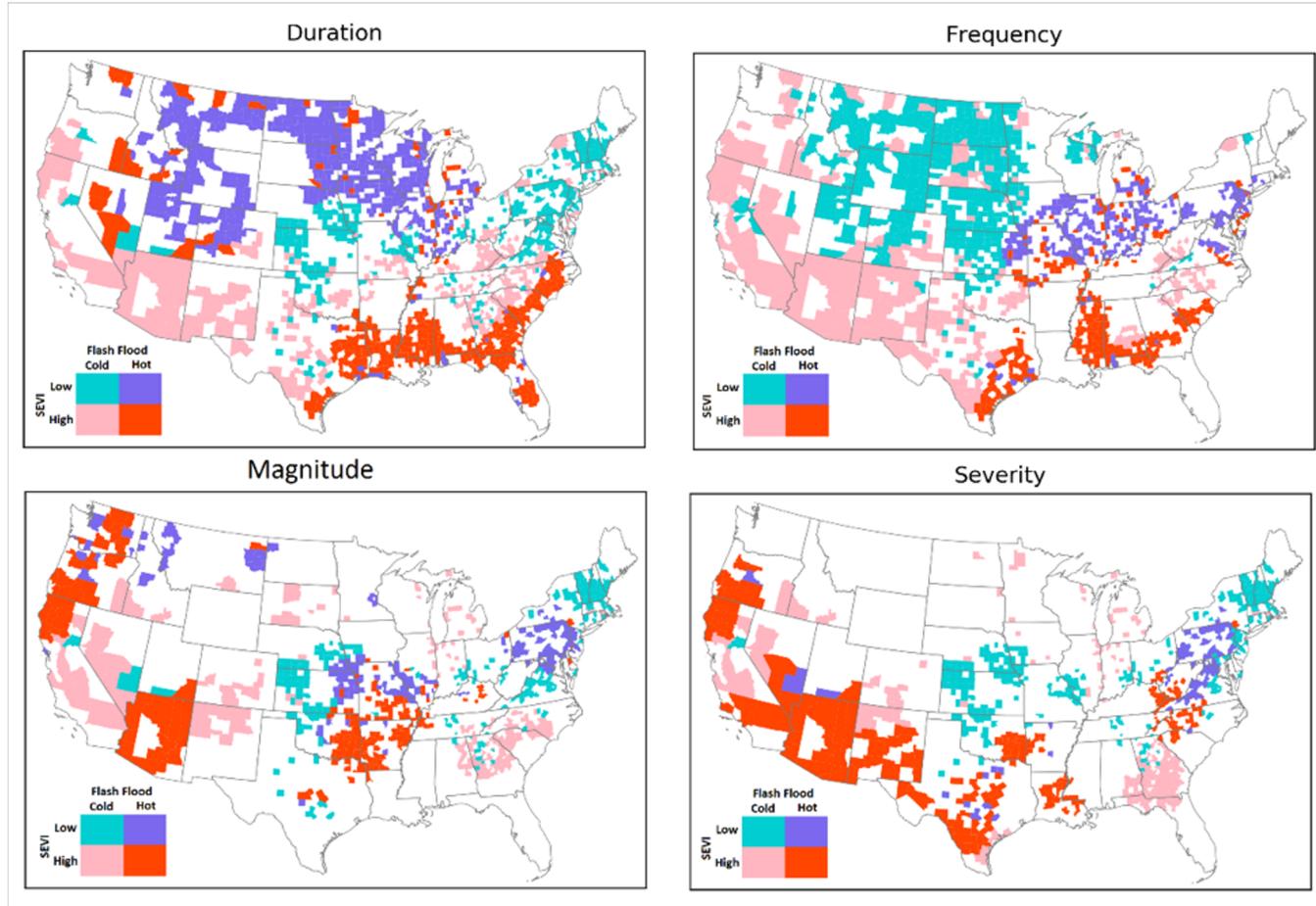
# Socio-Economic Vulnerability Clustering



# Flash Flood Characteristics (County scale)



# Confluence of Socio-Economic Vulnerability and Flash Flood Characteristics



# Conclusion

- Counties that are located in low vulnerable States are suffering from poor socio-economic status.
- The southwest region shows severe flash flooding with higher magnitudes, whereas the Northern Great Plains experience lower duration and frequency.
- Critical counties (high-vulnerable-hotspot) are mostly located in the southern parts of the U.S. The majority of counties in the Northern Great Plains are in the non-critical status. States with higher SEVI and critical counties experience higher rates of fatalities, such as Arkansas.

OPEN

# A Place-based Assessment of Flash Flood Hazard and Vulnerability in the Contiguous United States

Sepideh Khajehei<sup>1</sup>, Ali Ahmadalipour<sup>1</sup>, Wanyun Shao<sup>id</sup><sup>2</sup> & Hamid Moradkhani<sup>id</sup><sup>1\*</sup>

Flash flood is among the most catastrophic natural hazards which causes disruption in the environment and societies. Flash flood is mainly initiated by intense rainfall, and due to its rapid onset (within six hours of rainfall), taking action for effective response is challenging. Building resilience to flash floods require understanding of the socio-economic characteristics of the societies and their vulnerability to these extreme events. This study provides a comprehensive assessment of socio-economic vulnerability to flash floods and investigates the main characteristics of flash flood hazard, i.e. frequency, duration, severity, and magnitude. A socio-economic vulnerability index is developed at the county level across the Contiguous United States (CONUS). For this purpose, an ensemble of social and economic variables from the US Census and the Bureau of Economic Analysis were analyzed. Then, the coincidence of socio-economic vulnerability and flash flood hazard were investigated to identify the critical and non-critical regions. Results show that the southwest U.S. experienced severe flash flooding with high magnitude, whereas the Northern Great Plains experience lower severity and frequency. Critical counties (high-vulnerable-hotspot) are mostly located in the southern and southwestern parts of the U.S. The majority of counties in the Northern Great Plains indicate a non-critical status.