



# GeoAI for Disaster Response

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# Outline

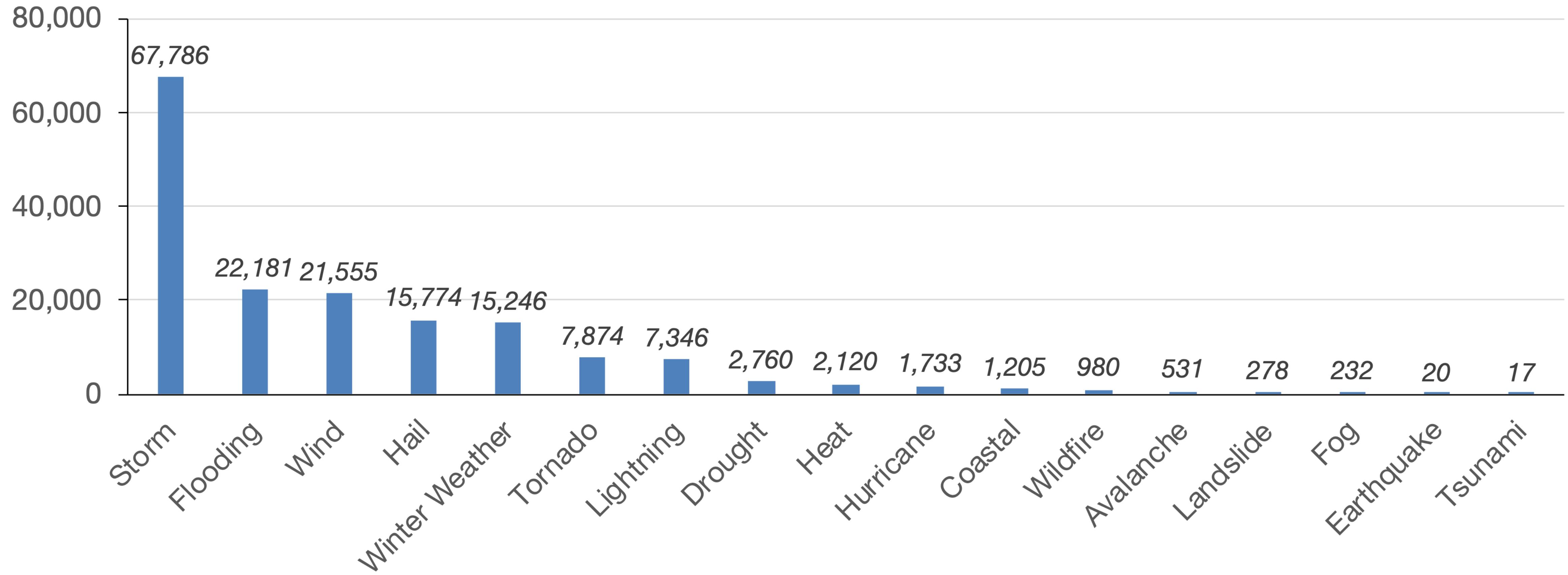
- Disaster Management
- GeoAI for Disaster Response

# Disaster Management

- **Definitions**
  - **Emergency:** small in geographic scale; handled by local officials
  - **Hazard:** any unusual event that has a potential to threaten people's lives, their property and livelihoods.
  - **Disaster:** larger in geographic scale; greater than the local capacity to cope with the event
  - **Crisis:** temporal aspect; lead to a dangerous situation
  - **Catastrophe:** like disaster but bigger in terms of the impacts on physical, social, and organizational systems
  - **Vulnerability:** the possibility of being influenced or experiencing loss during disturbances
  - **Disaster Risk:** Disaster risk is the potential for loss of life, injury, or damage to property and infrastructure, stemming from the interaction of hazards with vulnerable and exposed populations and assets ( $\text{risk} = \text{hazard} * \text{exposure} * \text{vulnerability}$ , according to IPCC)
  - **Resilience:** the capacity to prepare for, respond to, recover from, and more successfully adapt to adverse events

# Disaster Management

- **Disaster Frequencies in the United States (2000-2010)**

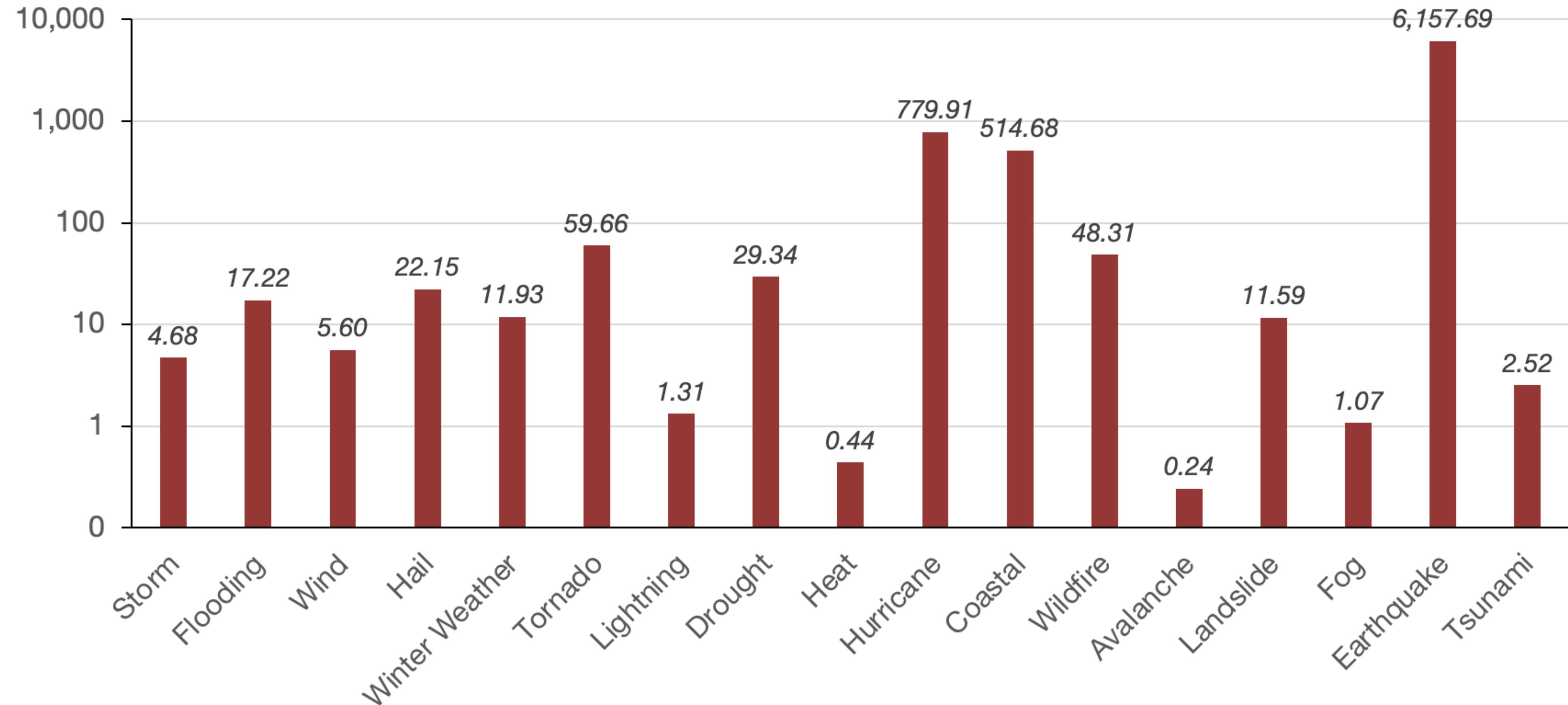


Zou, L., 2021. Mapping the disparities of community resilience to natural hazards in the United States. *Abstracts of the ICA*, 3, p.330.

<https://ica-abs.copernicus.org/articles/3/330/2021/ica-abs-3-330-2021.pdf>

# Disaster Management

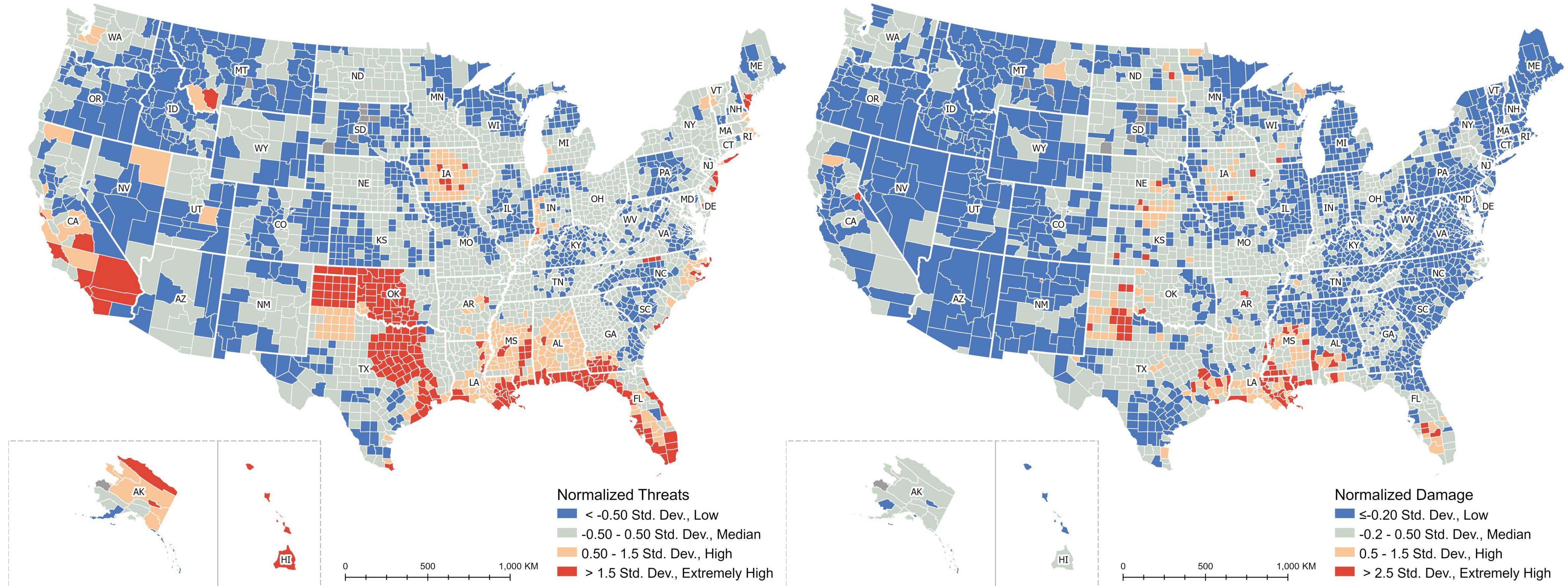
- **Disaster Impacts (Economic Losses [\$] Per Capita) in the United States (2000-2010)**



Zou, L., 2021. Mapping the disparities of community resilience to natural hazards in the United States. *Abstracts of the ICA*, 3, p.330.  
<https://ica-abs.copernicus.org/articles/3/330/2021/ica-abs-3-330-2021.pdf>

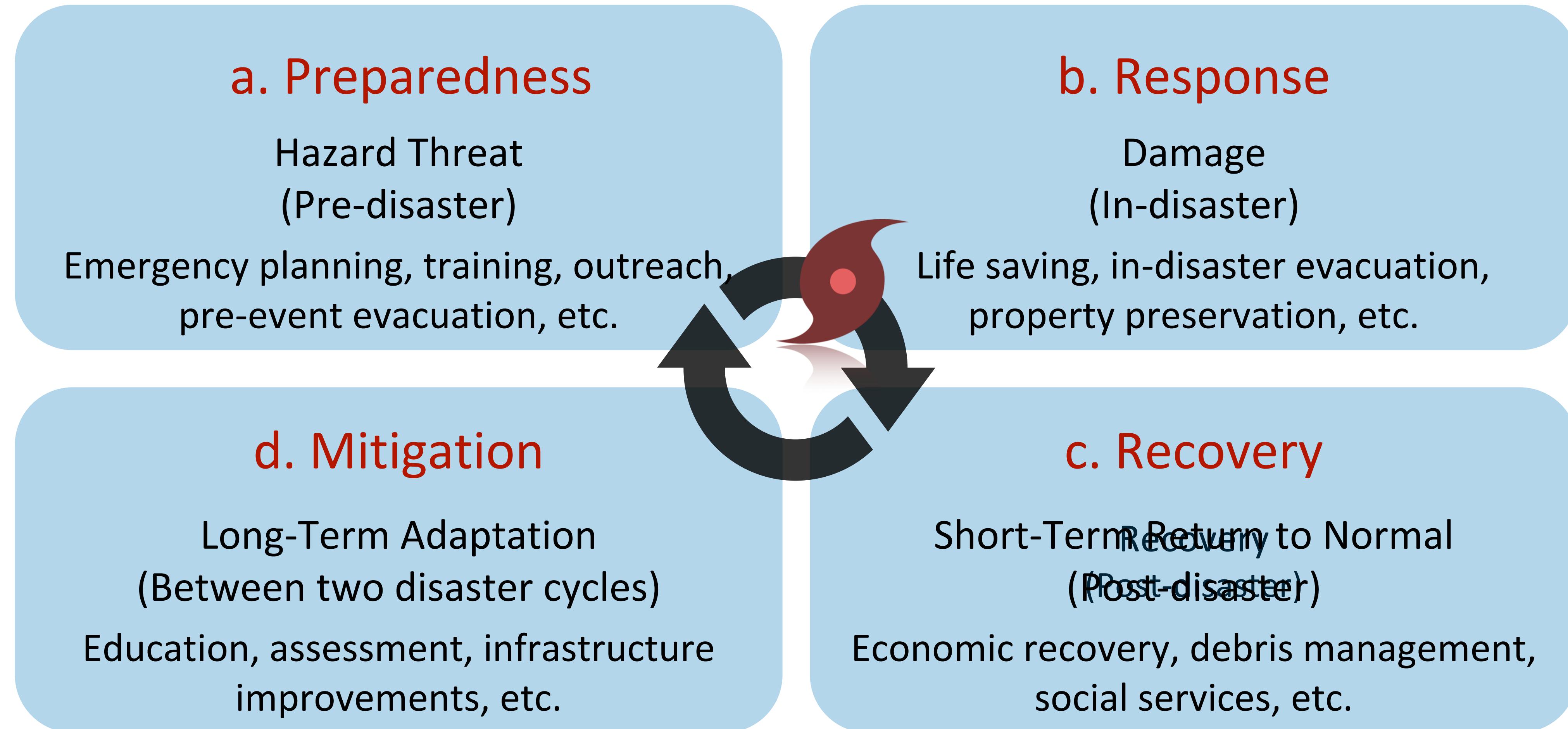
# Disaster Management

- Geographical Patterns of Disaster Threats and Damages in the U.S., 2000-2010



Zou, L., 2021. Mapping the disparities of community resilience to natural hazards in the United States. *Abstracts of the ICA*, 3, p.330.  
<https://ica-abs.copernicus.org/articles/3/330/2021/ica-abs-3-330-2021.pdf>

# Disaster Management



Four phases of emergency management (FEMA)

# Disaster Management

- **Preparedness**

The actions **taken in advance** that develop operational capabilities, enabling a more efficient, effective response to an emergency.

## Questions need to be solved

- A. What to do?
- B. Where to go?
- C. Who to call for help?

## Time for Preparedness

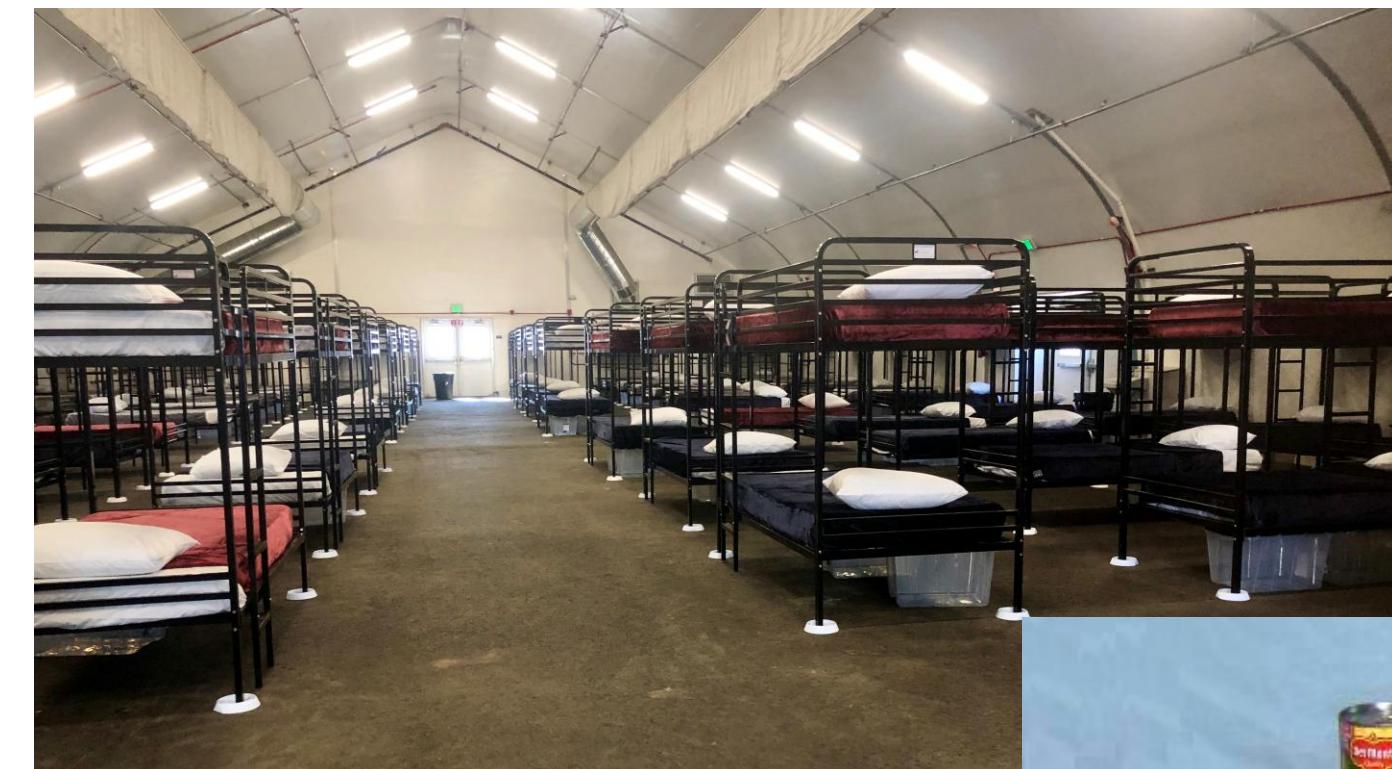
- A. Depends...
- B. Earthquake: Few minutes
- C. Hurricanes: One week



# Disaster Management

- **Response**

The response phase occurs **in the immediate aftermath of a disaster**. During the response phase, business and other operations do not function normally.



# Disaster Management

- **Recovery**

**Restoration efforts** occur concurrently with regular operations and activities.



# Disaster Management

- **Mitigation**

The actions taken to prevent or reduce the cause, impact, and consequences of disasters.

## Different Approaches

- A. Engineering
- B. Education & Training
- C. Assessment and Guidance
- D. Policy-Making



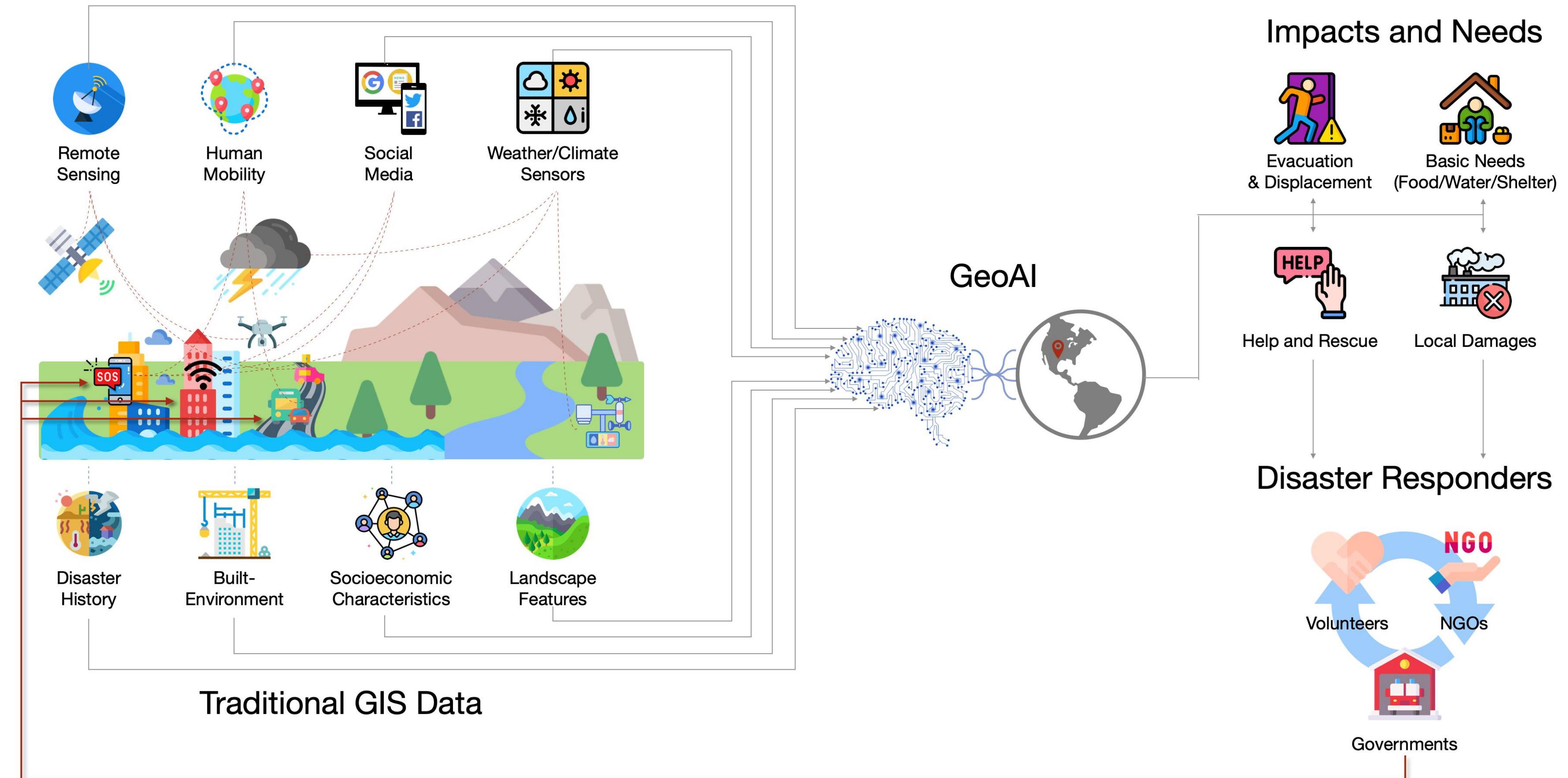
A Louisiana Tribe, **Isle de Jean Charles**, Officially Became America's First Climate Refugees (National Geographic, 2016)

# Outline

- Disaster Management
- **GeoAI for Disaster Response**

# GeoAI for Disaster Response

(Near) Real-Time Geospatial Big Data



stafavi, A., Zhou, B., Lin, B., Mandal, D., Yang, M., Abedin, J. and Cai, H., 2023. GeoAI for disaster response. In *Handbook of Geospatial Artificial Intelligence* (pp. 287-304). [taylorfrancis.com/chapters/edit/10.1201/9781003308423-14/geoai-disaster-response-lei-zou-ali-mostafavi-bing-zhou-binbin-lin-debayan-mandal-mingzheng-yang-joynal-abed](https://taylorfrancis.com/chapters/edit/10.1201/9781003308423-14/geoai-disaster-response-lei-zou-ali-mostafavi-bing-zhou-binbin-lin-debayan-mandal-mingzheng-yang-joynal-abed)

# GeoAI for Disaster Response - Social Media for Emergency Rescue

## Rescue Request on Social Media during Disasters



"@houstonpolice My friends grandma is stuck in her attic 5742 Braeswood Blvd 77096 Please try and help her"



"PLEASE PLEASE IN NEED OF RESCUE BEEN STRANDED FOR HOURS 6010 KASHMERE APT HOU TX 77026 @abc13houston @Fox26Houston @HoustonTX"



"#Houstonrescue 8518 Valley Forest Dr HTX 77078"



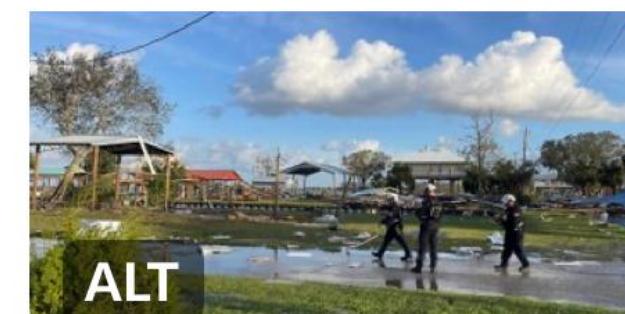
FEMA  
@fema

...

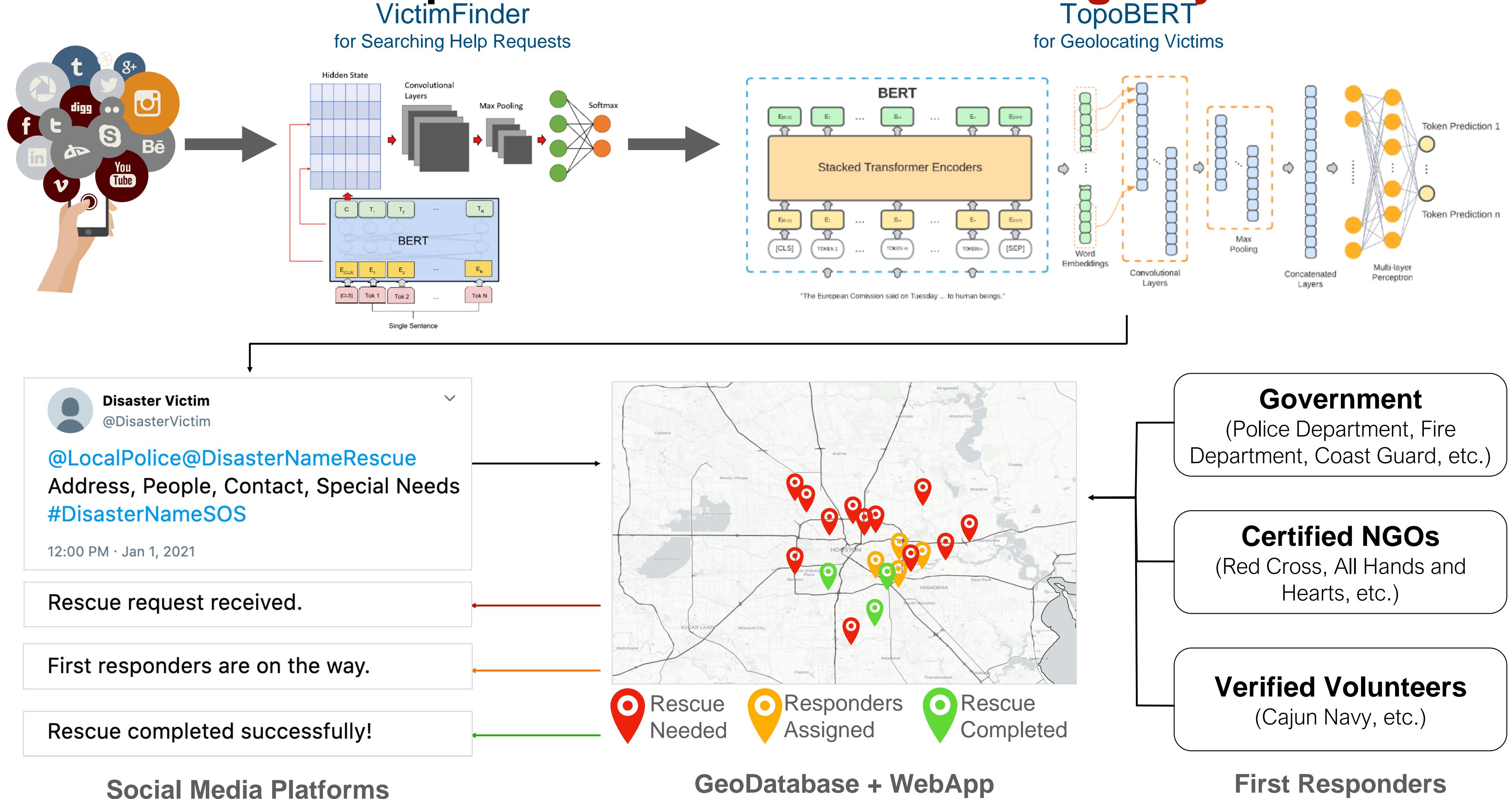
Across the Southeast, we're working closely with federal, state, tribal & local officials to respond to the impacts of #Helene.

Search & Rescue Teams continue life-saving missions in affected communities, completing more than 600 rescues so far.

→ [fema.gov/press-release/...](https://fema.gov/press-release/)



# GeoAI for Disaster Response - Social Media for Emergency Rescue

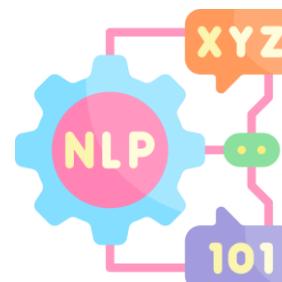


# GeoAI for Disaster Response - Social Media for Emergency Rescue

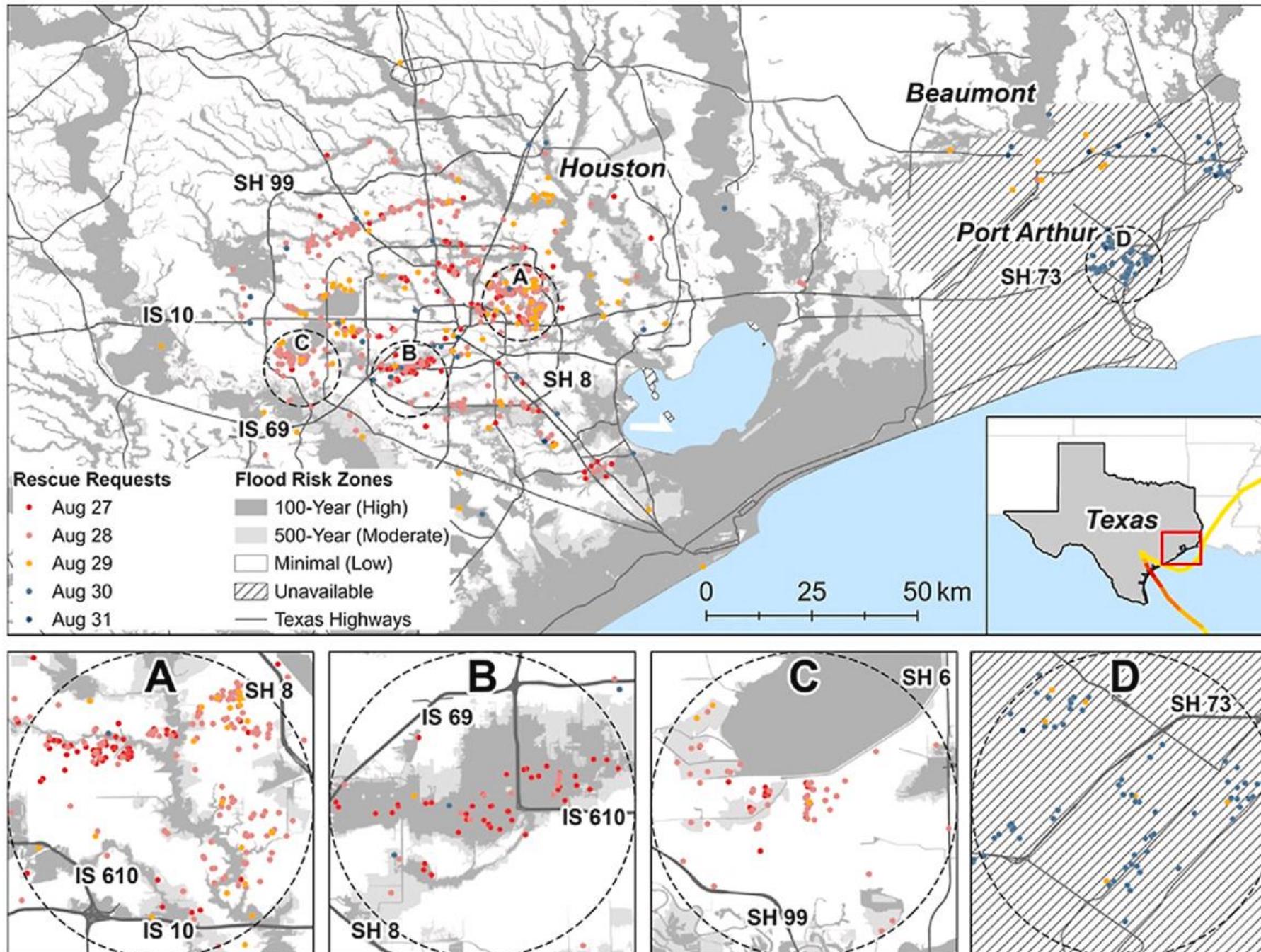
## Rescue Requests from Twitter during 2017 Hurricane Harvey in Texas



Social Media

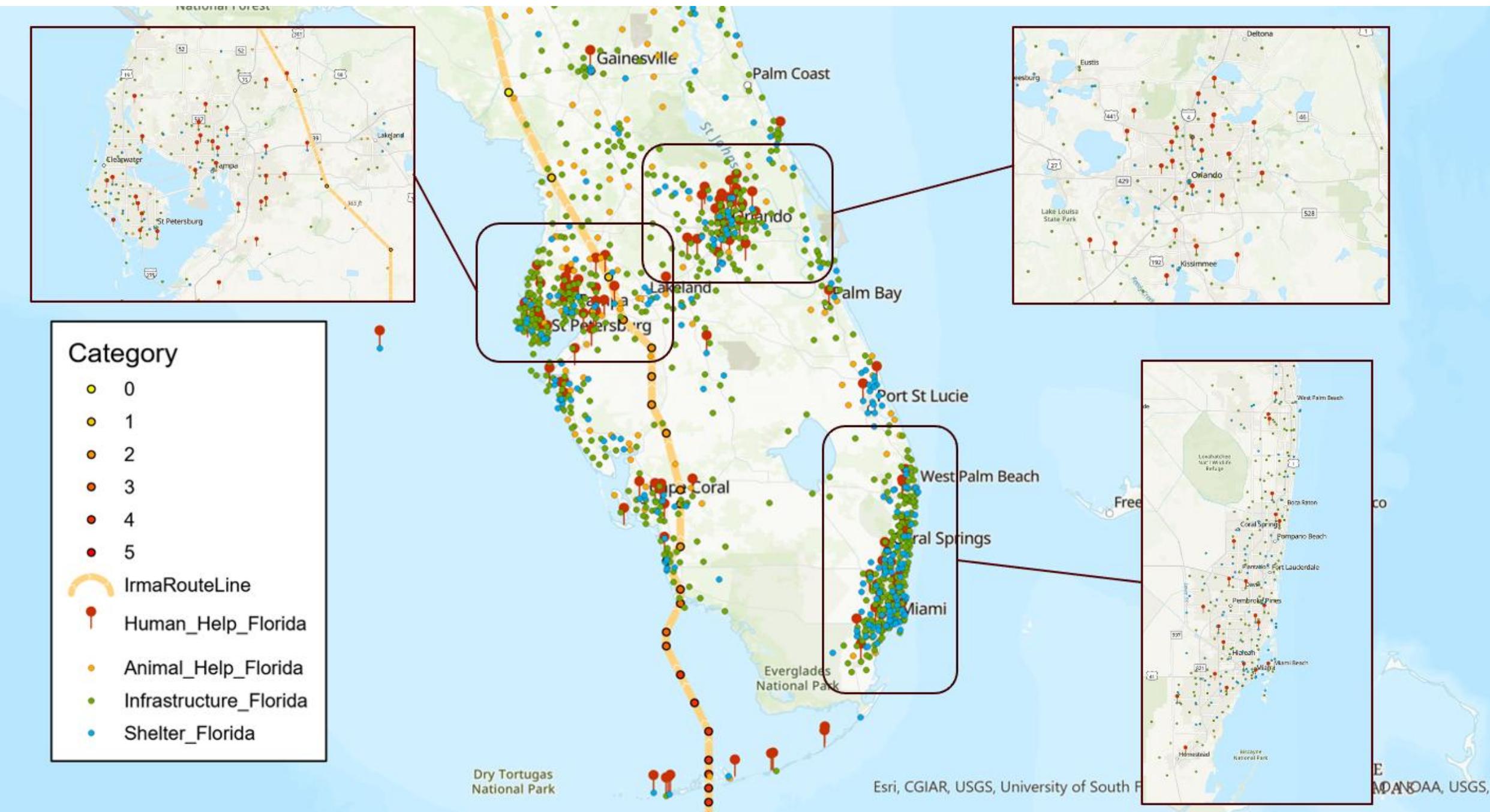


Natural Language Processing (e.g., Large Language Models)



Zou, L., Liao, D., Lam, N.S., Meyer, M.A., Gharaibeh, N.G., Cai, H., Zhou, B. and Li, D., 2023. Social media for emergency rescue: An analysis of rescue requests on Twitter during Hurricane Harvey. *International journal of disaster risk reduction*, 85, p.103513.  
<https://doi.org/10.1016/j.ijdrr.2022.103513>

## Rescue Requests, Infrastructure Damages, and Shelters from Twitter in 2017 Hurricane Irma in Florida



Zhou, B., Zou, L., Hu, Y., Qiang, Y. and Goldberg, D., 2023. TopoBERT: a plug and play toponym recognition module harnessing fine-tuned BERT. *International Journal of Digital Earth*, 16(1), pp.3045-3064.

<https://doi.org/10.1080/17538947.2023.2239794>

# GeoAI for Disaster Response - Remote Sensing for Damage Estimation

## Power Outages during Disasters



<https://abcnews.go.com/US/catastrophic-outages-texas-symptom-americas-aging-power-grids/story?id=75951380>



<https://www.accuweather.com/en/weather-news/how-to-survive-a-power-outage-in-the-winter/432226>

# GeoAI for Disaster Response - Remote Sensing for Damage Estimation



Nighttime Light  
Remote Sensing

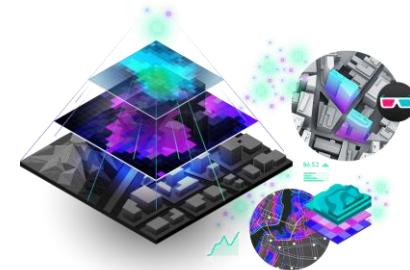
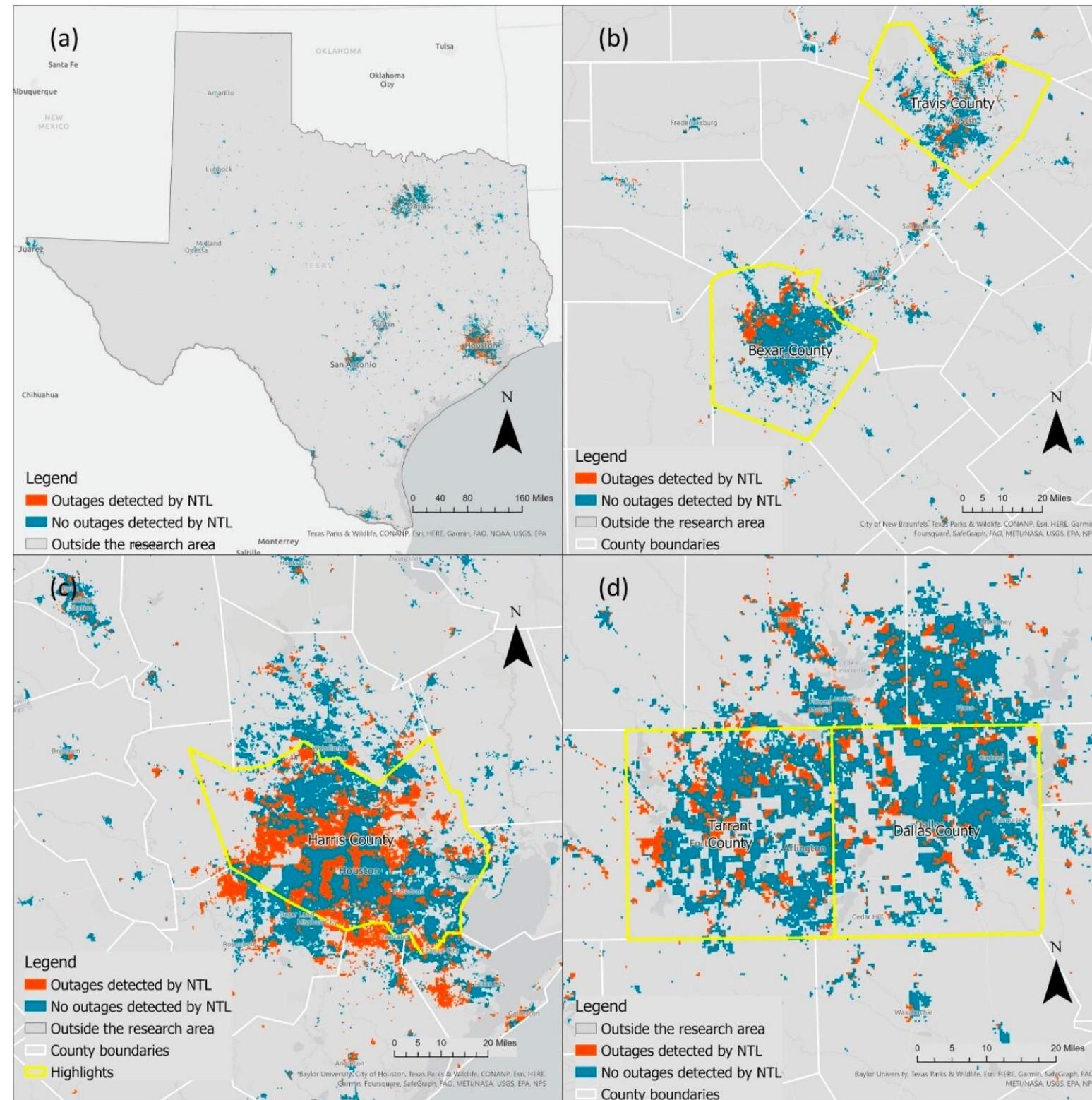


Image-Based  
Machine Learning



Xu, J., Qiang, Y., Cai, H. and Zou, L., 2023. Power outage and environmental justice in Winter Storm Uri: an analytical workflow based on nighttime light remote sensing. *International Journal of Digital Earth*, 16(1), pp.2259-2278.

## Power Outages in Texas during 2021 Winter Storm Uri

Socioeconomic characteristics of communities experiencing more severe power outages

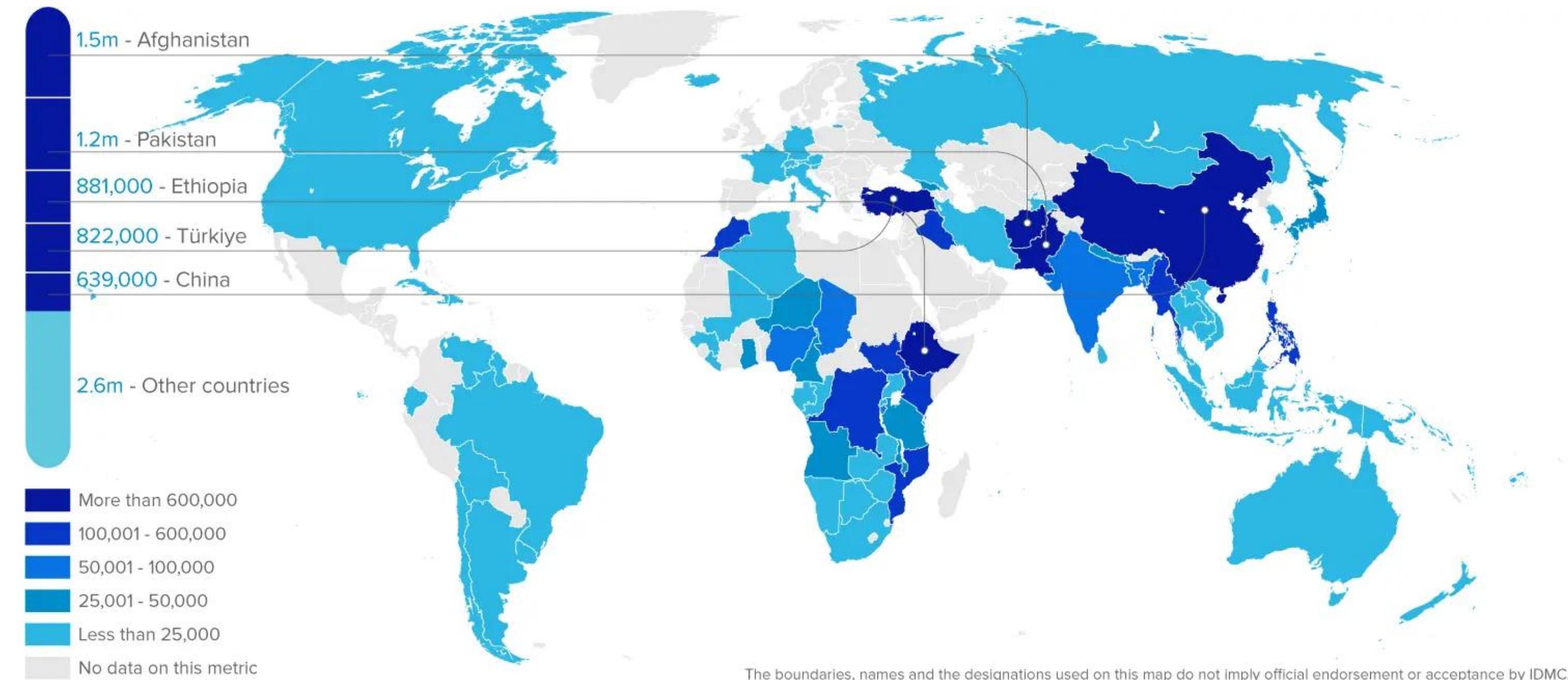
### County Level:

- Hispanic/Latino communities
- Communities with newer buildings

### Census Tract Level:

- Hispanic/Latino communities
- Communities with fewer white populations
- A longer commuting time
- Lower unemployment ratios
- Higher median housing value

# GeoAI for Disaster Response - Human Mobility for Disaster Displacement



**7.7 million internally displaced people by disasters in 2023**

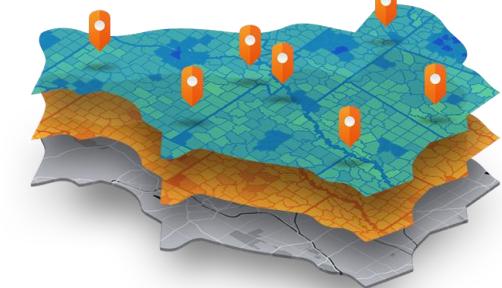
<https://www.scientificamerican.com/article/disasters-displaced-more-than-26-million-people-in-2023/>

<https://www.internal-displacement.org/global-report/grid2024/>

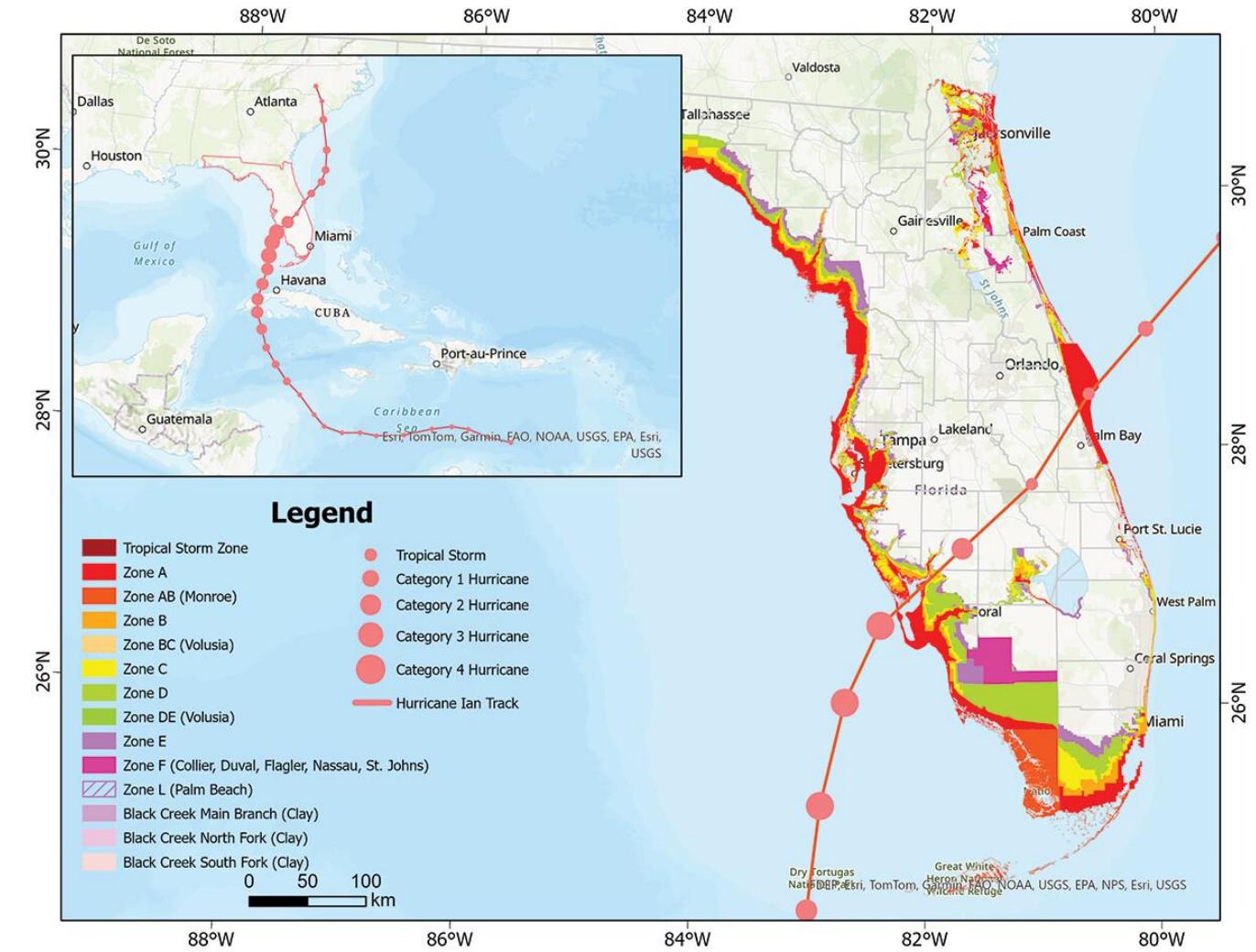
# GeoAI for Disaster Response - Human Mobility for Disaster Displacement



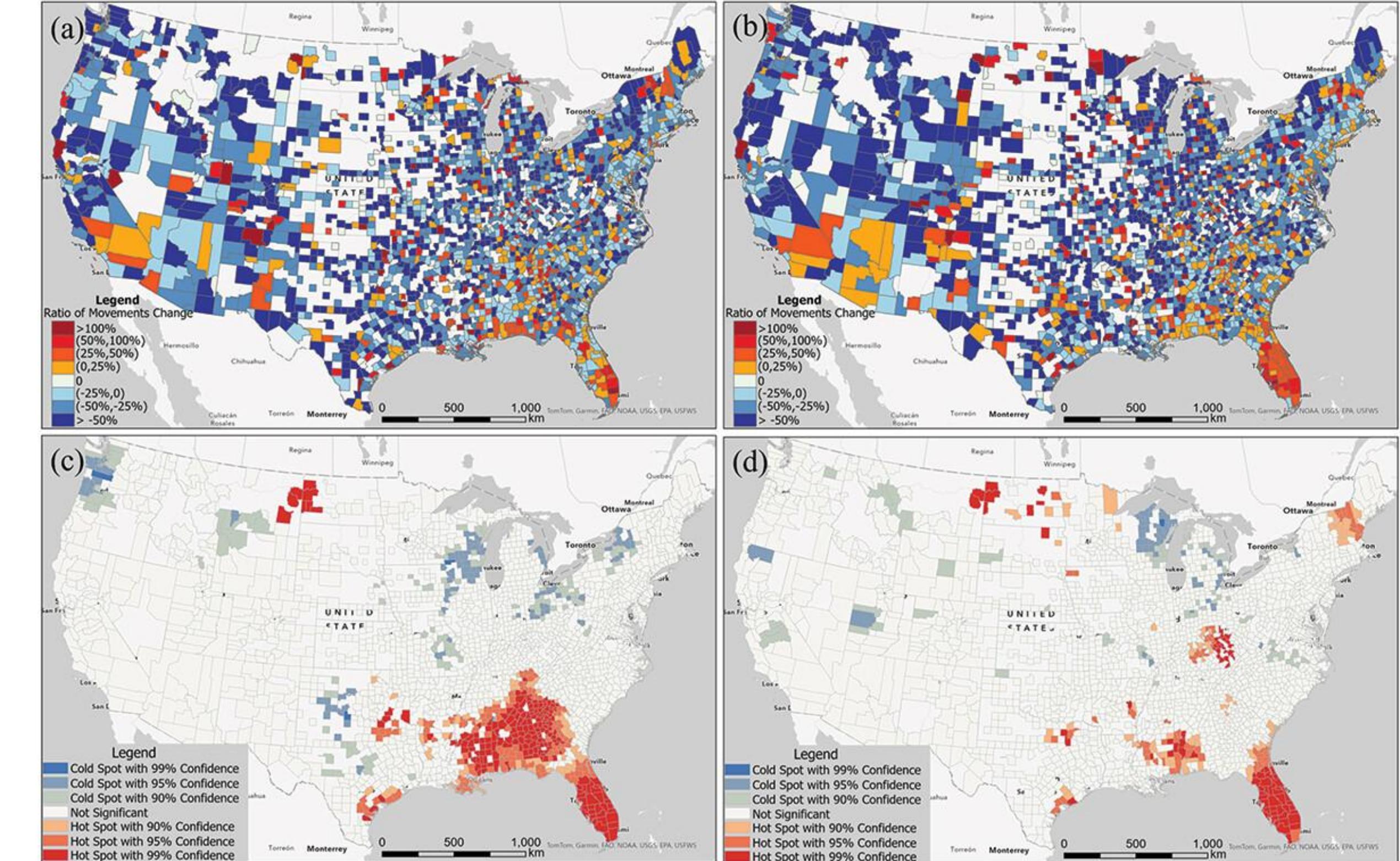
Human Mobility Dynamics



Spatial-Temporal Data Mining



2022 Hurricane Ian track and evacuation zones map

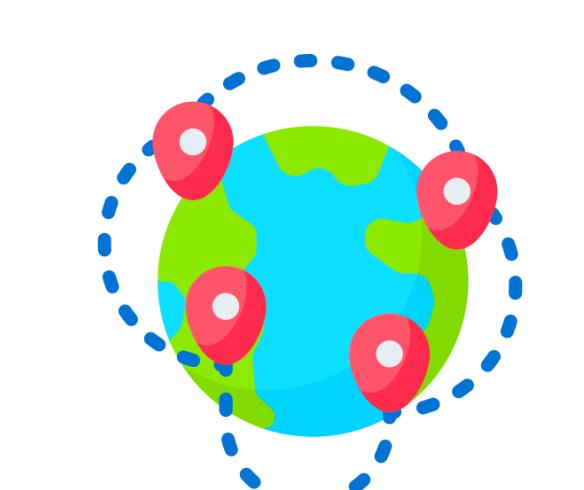


Percent changes of visitors from Florida in contrast to the baseline condition. (a): Percent changes of Florida visitors during the in-hurricane phase. (b): Percent changes of Florida visitors during the post-hurricane phase. (c): hot spot analysis of (a). (d): hot spot analysis of (b).

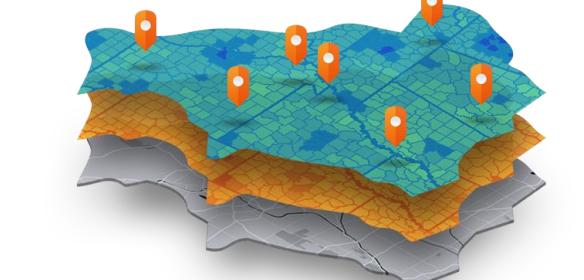
Li, X., Qiang, Y. and Cervone, G., 2024. Using human mobility data to detect evacuation patterns in hurricane Ian. *Annals of GIS*, 30(4), pp.493-511.

<https://doi.org/10.1080/19475683.2024.2341703>

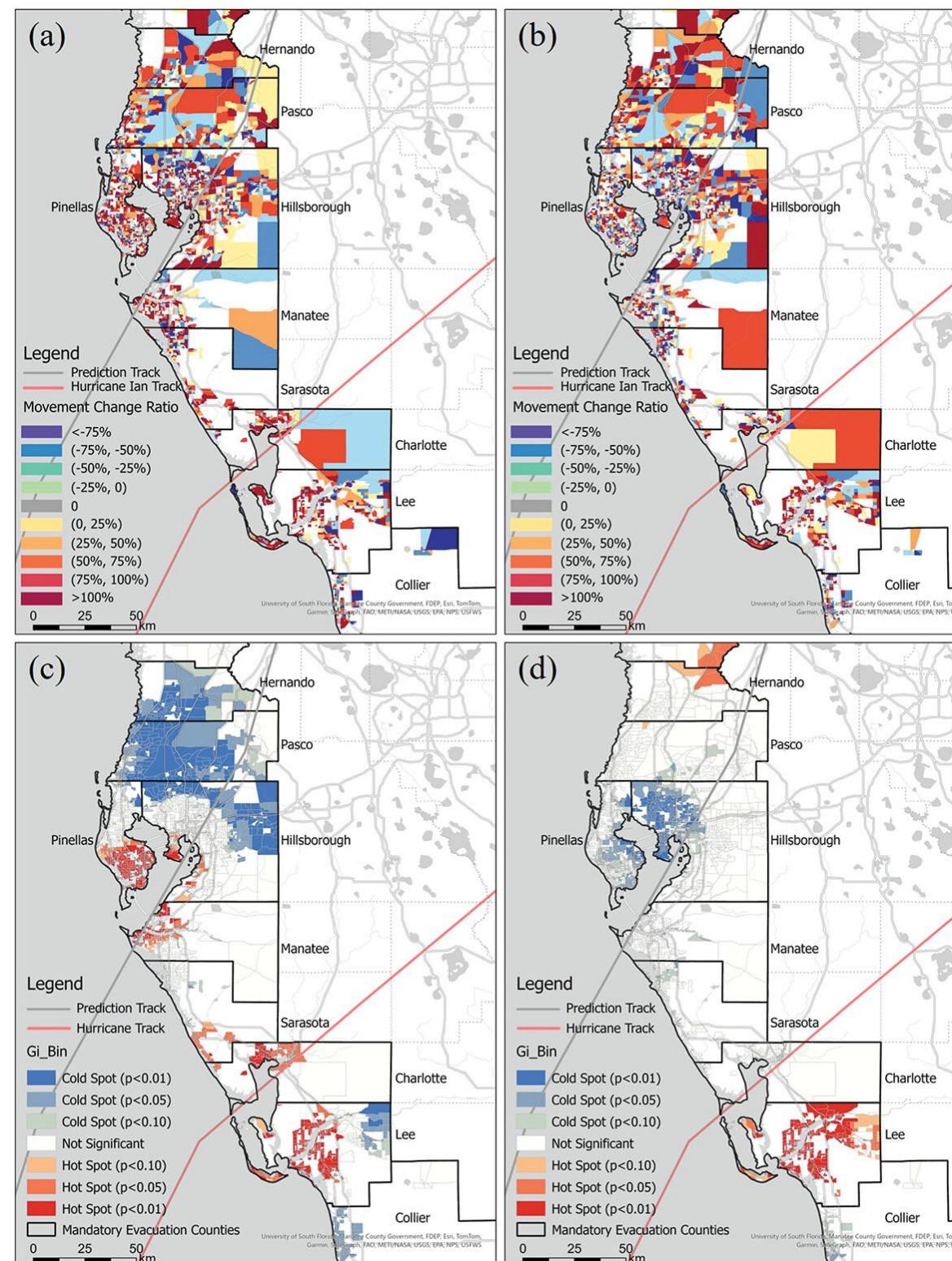
# GeoAI for Disaster Response - Human Mobility for Disaster Displacement



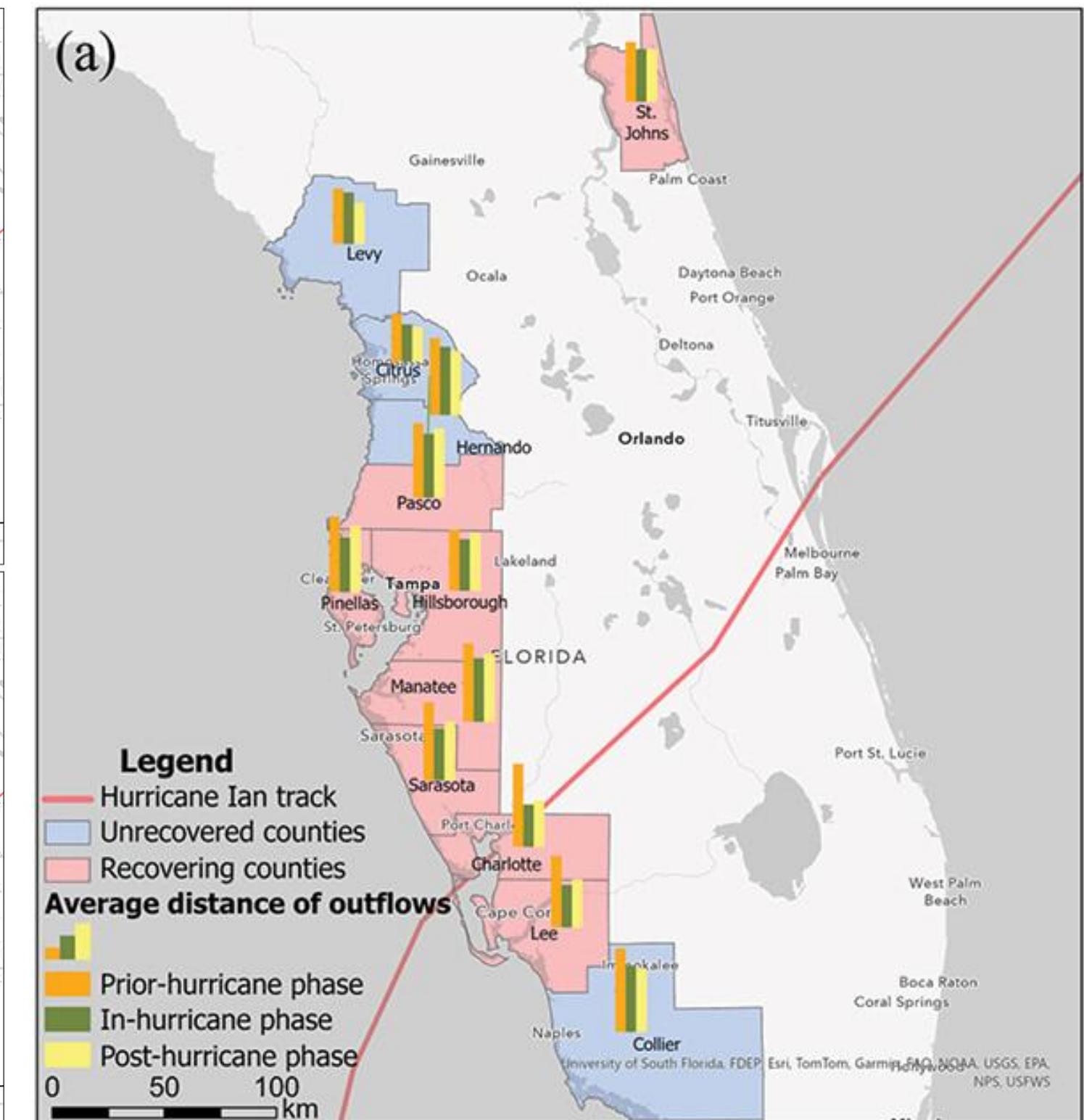
Human Mobility Dynamics



Spatial-Temporal Data Mining



Percent changes of population outflows in contrast to the baseline in block groups near the landfall location. (a): Percent change of population outflows during the in-hurricane phase. (b): Percent change of population outflows during the post-hurricane phase. (c) & (d): Hot spot analysis of (a) & (d) respectively.



Average distance of outflows (a) and % of population outflows to county population (b) in twelve counties under mandatory evacuation orders during three phases.

Li, X., Qiang, Y. and Cervone, G., 2024. Using human mobility data to detect evacuation patterns in hurricane Ian. *Annals of GIS*, 30(4), pp.493-511.

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