Combining CDC Social Vulnerability Index (SVI) with Earth Observations to Predict Social Outcomes from an Extreme Weather Event: A Study of Hurricane Harvey

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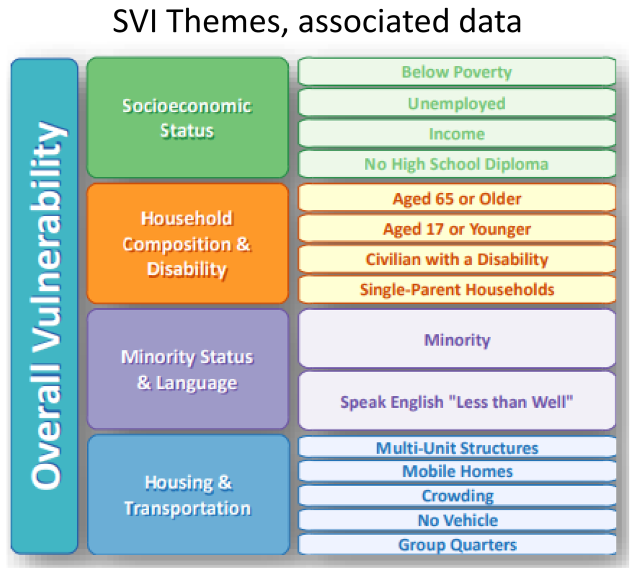
Motivation: As we experience more intense weather events, it is increasingly necessary to be able to assist vulnerable communities after these disasters. Both social vulnerability *and* earth observations must be considered when predicting these impacts.

Data/Methods

Data

- Social Vulnerability Index (SVI)
  - Ranks counties, census tracts
  - 0-1, 1 = most vulnerable
  - Summary SVI considers all themes
  - Source: Centers for Disease Control and Prevention (CDC)

SVI Themes, associated data



Source: SVI Documentation

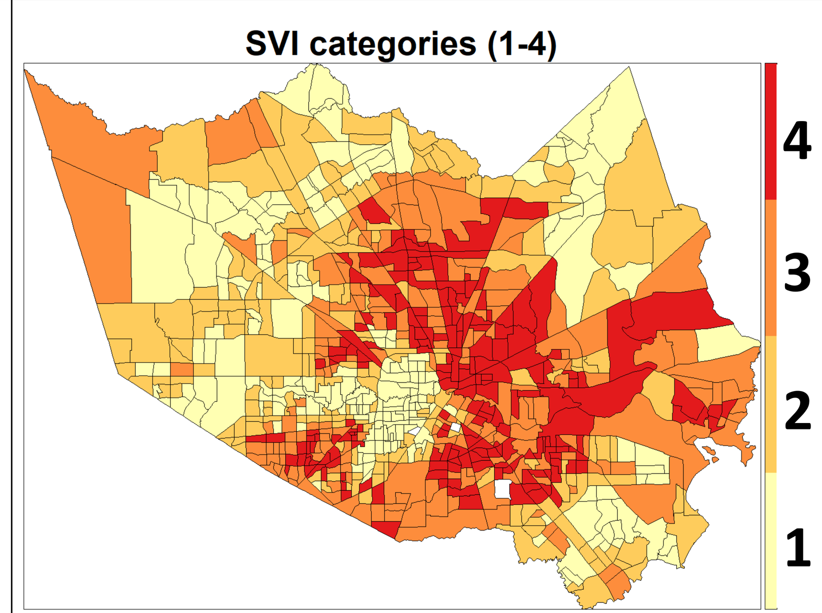
- Earth Observations/Predictors
  - Elevation (meters)
    - Source: USGS National Land Cover Database
  - Maximum flood extent (28 Aug - 8 Sept, 2017)
    - Source: Dartmouth Flood Observatory
  - Percent impervious surface (2016 product)
    - Source: USGS National Land Cover Database
  - Power outages (27 Aug - 4 Sept, 2017)
    - Intermediate predictor
    - Daily, by zip code
    - Source: Centerpoint Energy

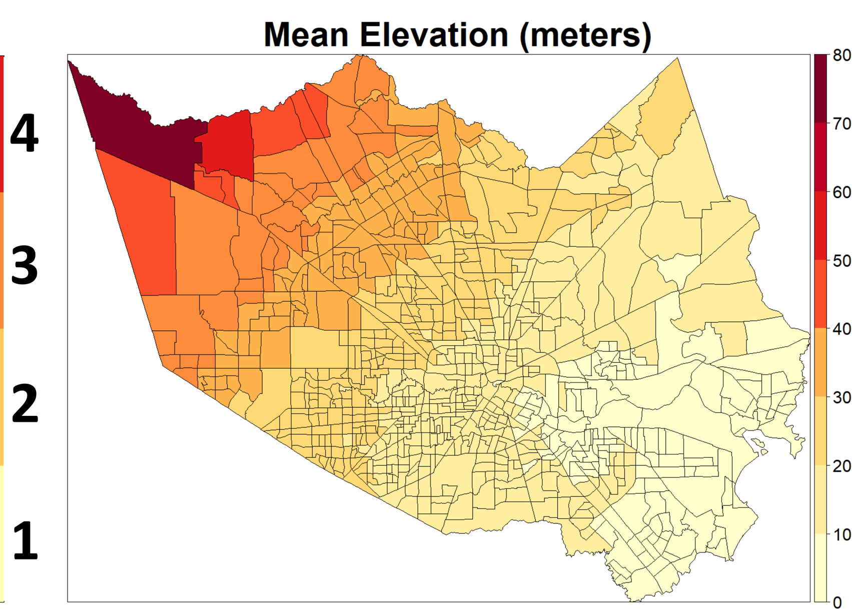
- Social Outcomes
  - Individual assistance applications
    - Source: FEMA

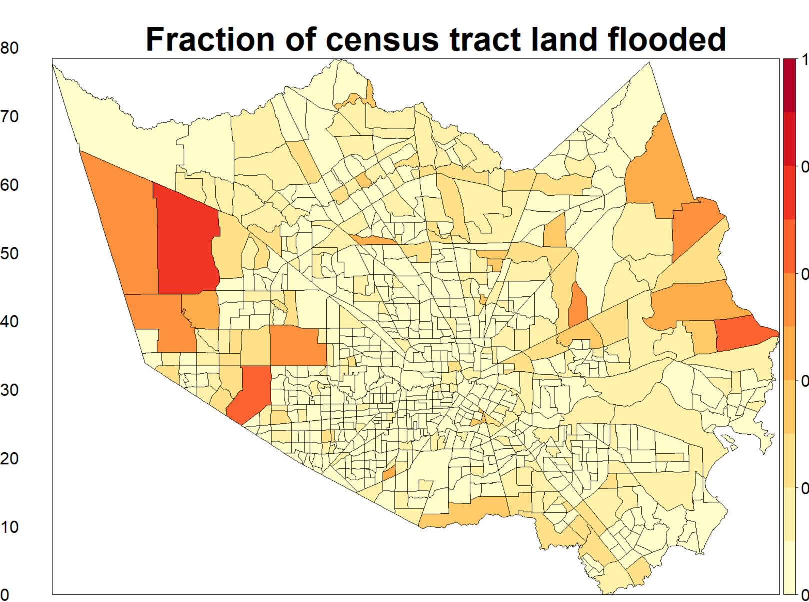
Methods

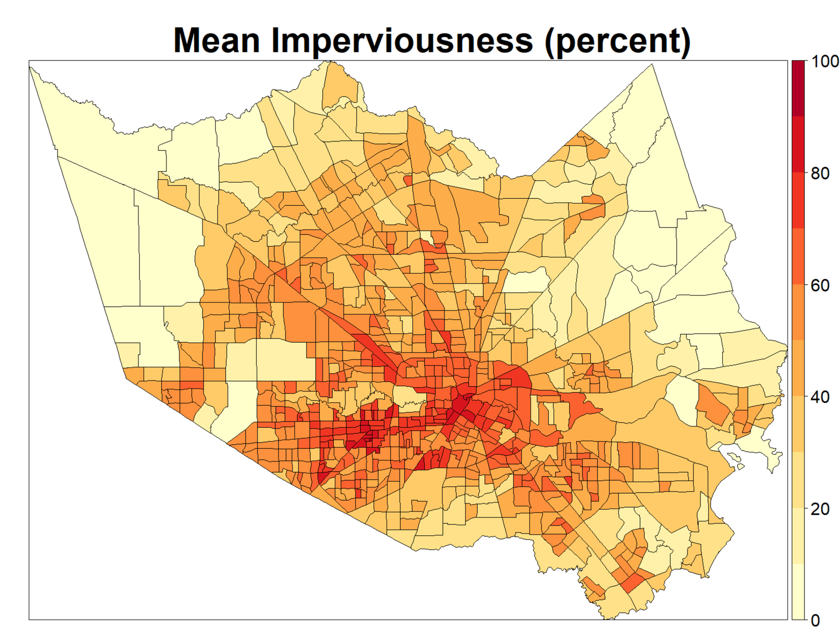
- Employed *lm* function (R) for linear regression between FEMA applications (per census tract) and predictors
  - Considered 783/786 census tracts in Harris County, TX (3 tracts lack a calculated SVI)
  - **SVI**: Categorized into 4 equally sized bins (assigned 1-4, 1 = 25% *least* vulnerable census tracts)
  - **Earth observations/predictors**: Calculated fraction of land flooded, mean percent imperviousness, mean elevation, maximum daily outage fraction; for each census tract
  - **FEMA applications**: standardized by dividing FEMA applications by the census tract population; natural log transformation

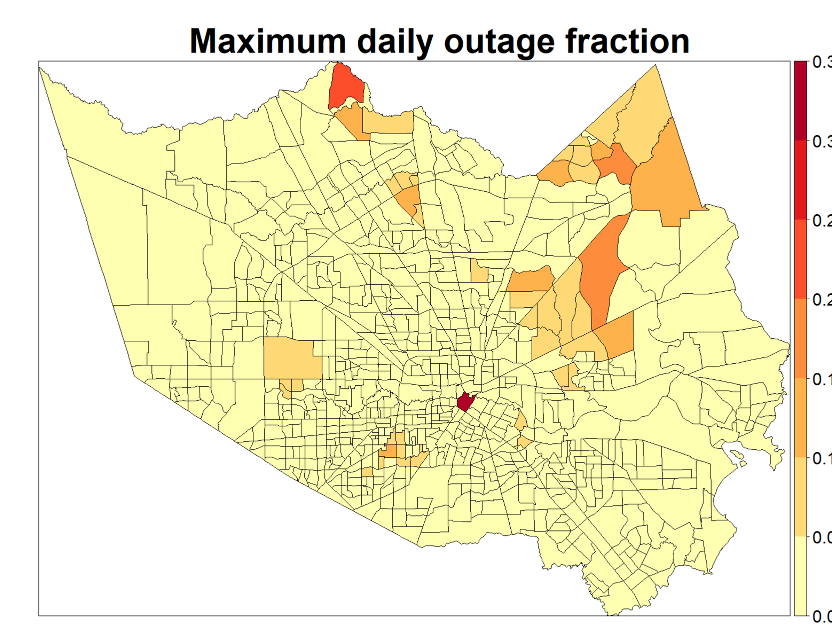
SVI + Earth Observations



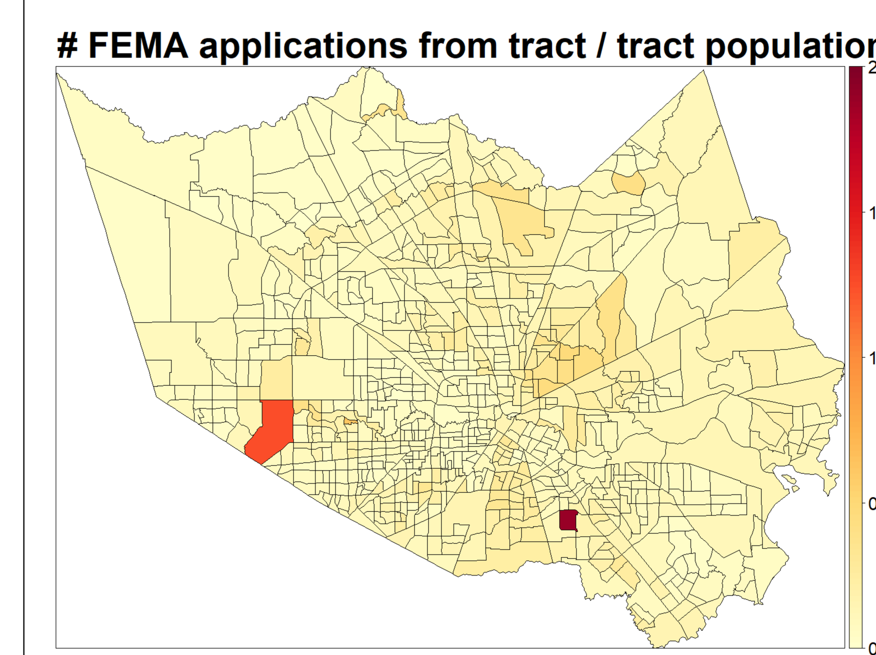








FEMA Applications



Results

Bolded: statistically significant at $p = 0.05$		Estimate	Std. Error	Multiple R^2
FEMA Applications / census tract population	SVI	**0.19**	0.02	0.2341
	Elevation (meters)	**-0.02**	0.002	
	Fraction Flooded	**1.09**	0.25	
	Imperviousness (percent)	**-0.01**	0.001	
	Maximum outage fraction	**2.25**	0.91	

1) Suggests that the 25% most vulnerable (highest SVI) census tracts submitted almost 2x as many FEMA applications (relative to population), compared to 25% least vulnerable tracts ($e^{4*0.19} = 2.14$, $e^{1*0.19} = 1.2$)

2) Fraction flooded and max. outage fraction in census tract were significantly associated with FEMA applications
- 1% increases in tract inundation or maximum outages suggest *increases* in FEMA applications (Flooding: $e^{0.01*(1.09)} = 1.01$; Outages: $e^{0.01*(2.25)} = 1.02$)

3) Elevation and imperviousness may not be best predictors of poor social outcomes
- A 1 m. increase in elevation or 1% increase in impervious surface suggest *decreases* in FEMA applications (Elevation: $e^{1*(-0.02)} = 0.98$; Impervious surface: $e^{1*(-0.01)} = 0.99$)

Key Takeaways / Future Work

Key Takeaways
- Earth observations, in addition to SVI, can multiply likelihood of poor social outcomes
- Modeling social outcomes is difficult
  - Each storm, city are different
- Broader applicability
  - Methods may help with hurricane preparedness

Future work
- Exploring predictor interactions
- Integrating streamflow data
- Exploring other social outcomes (e.g. housing damage)

This work was supported by NASA # 80NSSC18K1594.