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

<table>
<thead>
<tr>
<th>SVI + Earth Observations</th>
<th>DACA Applications</th>
<th>FEMA Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SVI Themes, associated data</strong></td>
<td><strong>SVI categories (1-4)</strong></td>
<td><strong>Mean Elevation (meters)</strong></td>
</tr>
<tr>
<td><strong>Mean Imperviousness (percent)</strong></td>
<td><strong>Maximum daily outage fraction</strong></td>
<td></td>
</tr>
</tbody>
</table>

#### 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)
- Earth Observations/Predictors
  - Elevation (meters)
    - Source: USGS National Land Cover Database
    - Source: Dartmouth Flooding 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: Centerpoint Energy

#### 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

#### Results

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

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 ($e^{0.19} = 2.14$, $e^{1.09} = 1.2$)

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 (Flood: $e^{0.01}(1.09) = 1.01$; 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)

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