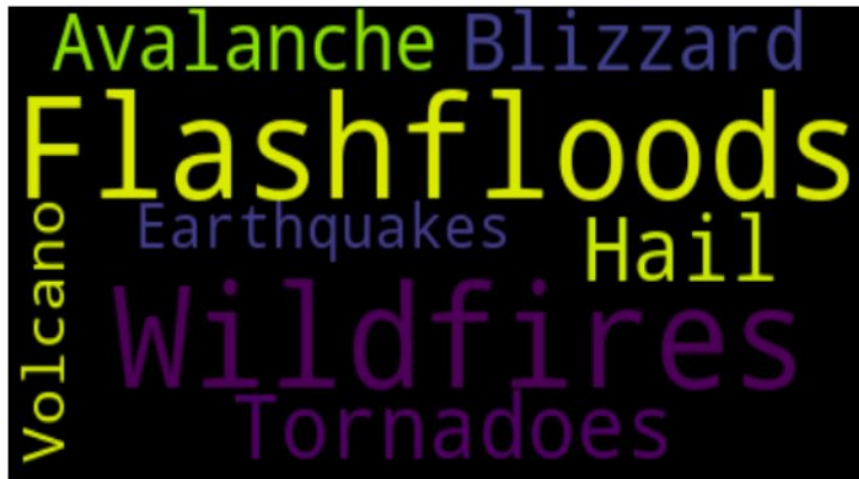


New Light Technologies

FEMA and GA

Lifeline Categorization & Flood Hazard



John Wertz
Magnus Bigelow

Megha Zavar
Scott Resenegrants

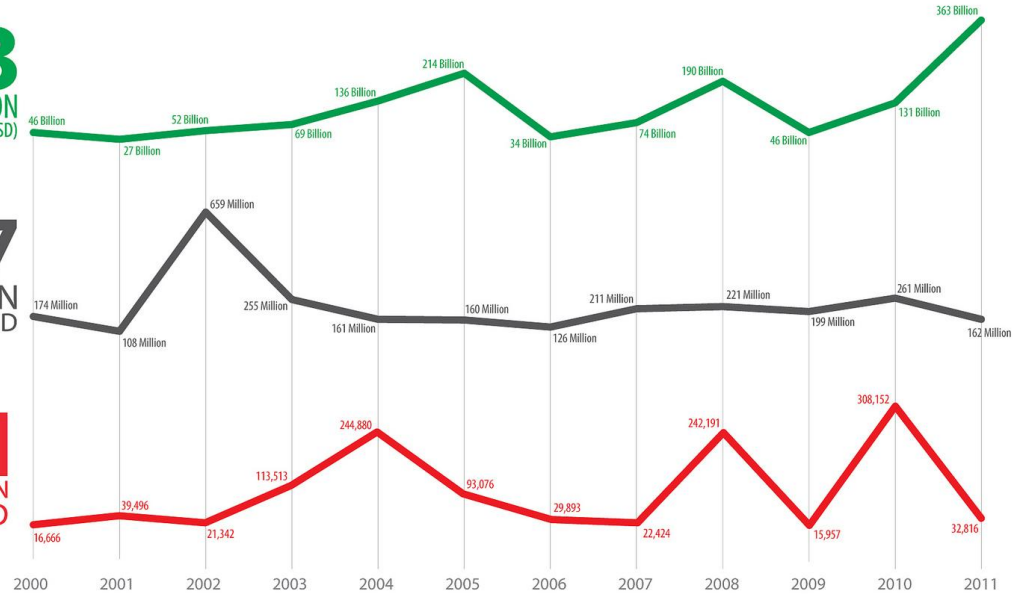
Inspiration from: https://github.com/micahluedtke/FEMA_lifelines

The Economic and Human Impact of Disasters* in the last 12 years

\$1.3
TRILLION
DAMAGE (USD)

2.7
BILLION
AFFECTED

1.1
MILLION
KILLED



*Disasters refers to Natural Disasters as categorized in EM-DAT
Data source: EM-DAT: The OFDACRED International Disaster Database
Data version: 10 January 2012 - v13.07
Humanitarian Symbol Set (2008): <http://www.unisdr.org/map/guideline.php>

KEY
DISASTER
EVENTS

South Asia
July 2002

Europe
Aug 2002

China
Aug 2002

Indian Ocean
Dec 2004

Bam (Iran)
Dec 2003

Kashmir
Oct 2005

Katrina
Aug 2005

Sidr
Nov 2007

Sichuan
May 2008

Nargis
May 2008

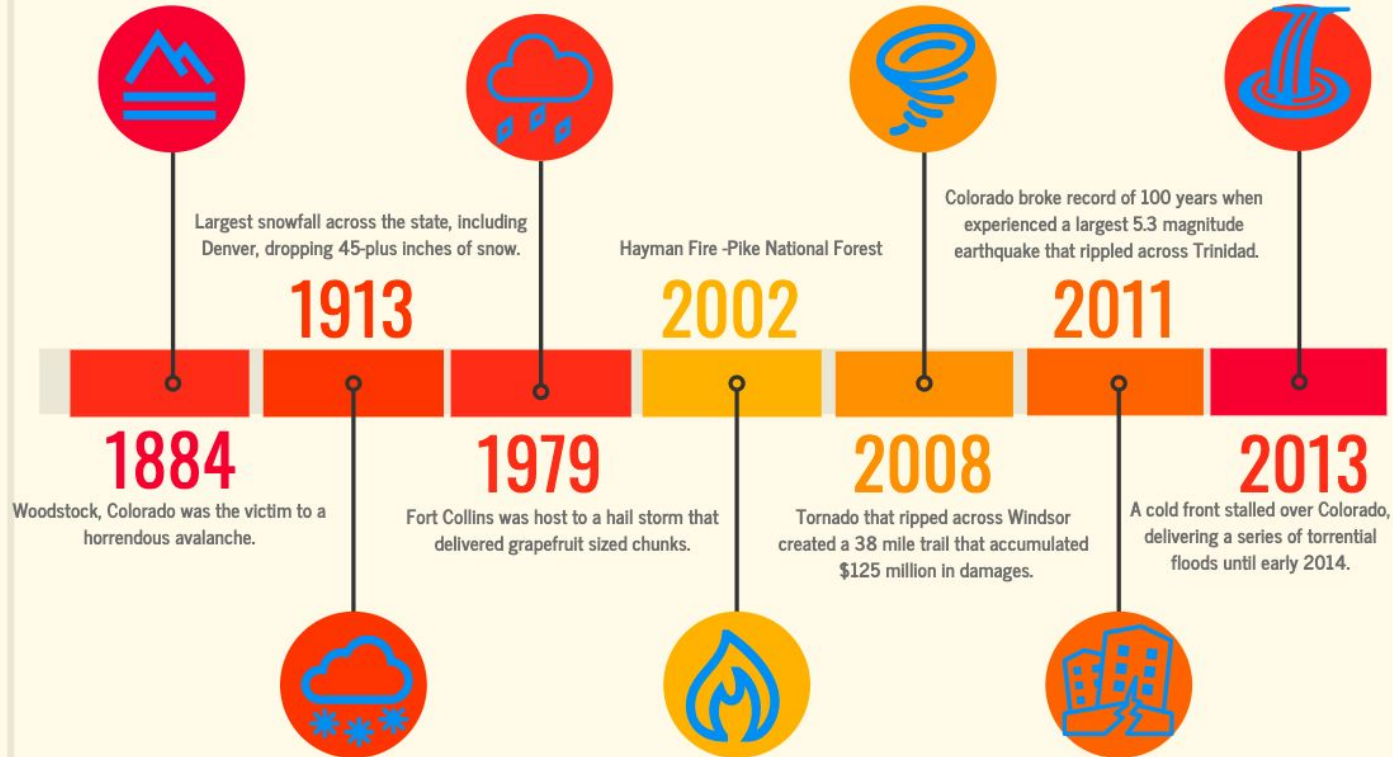
Pakistan
July 2010

Haiti
Dec 2010

Japan
March 2011

Colorado Natural Disasters

A look into the last 7 astounding natural disasters in Colorado



Project Goals

1. Find and categorize FEMA lifelines in Denver



2. Calculate flood risk for census tracts around Denver

$$\text{Risk} = \text{Hazard} \times (\text{Vulnerability} - \text{Resources})$$

Our Process

Data Gathering

Business locations
Business types
Elevation of collected
businesses
Vulnerability score

Data Wrangling

- Mapping to FEMA lifelines
- Assigning zones to collections of lifelines

Visualization

Mapping Visuals:

- Businesses
- Elevations
- Census tract boundaries
- Lifeline zones

DATA Gathering

Source:

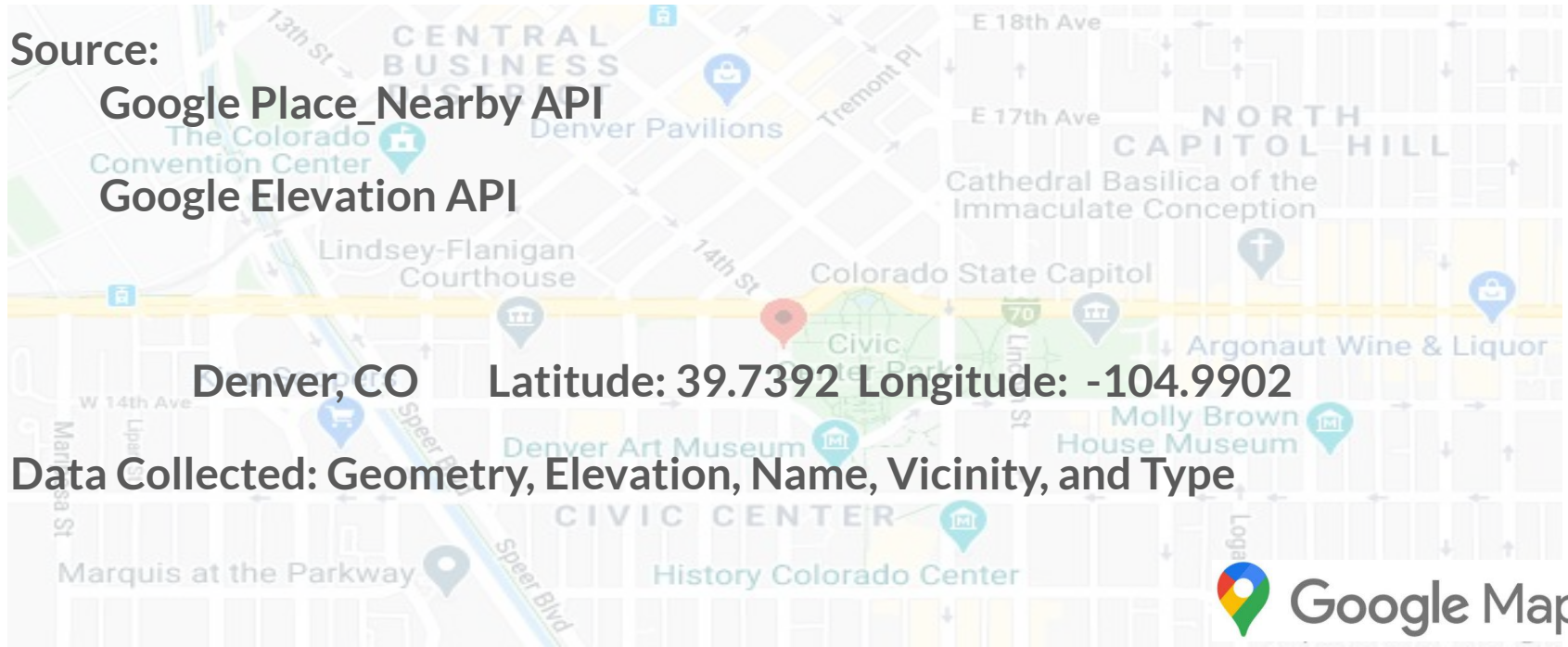
Google Place_Nearby API

Google Elevation API

Denver, CO

Latitude: 39.7392 Longitude: -104.9902

Data Collected: Geometry, Elevation, Name, Vicinity, and Type



Multiple components and subcomponents establish the parameters of the lifeline; component-level assessment is required to determine the condition of each lifeline.

1. Safety and Security

- Law Enforcement/Security
- Fire Service
- Search and Rescue
- Government Service
- Community Safety

2. Food, Water, Shelter

- Food
- Water
- Shelter
- Agriculture

3. Health and Medical

- Medical Care
- Public Health
- Patient Movement
- Medical Supply Chain
- Fatality Management

4. Energy

- Power Grid
- Fuel

5. Communications

- Infrastructure
- Responder Communications
- Alerts, Warnings, and Messages
- Finance
- 911 and Dispatch

6. Transportation

- Highway/Roadway/Motor Vehicle
- Mass Transit
- Railway
- Aviation
- Maritime

7. Hazardous Material

- Facilities
- HAZMAT, Pollutants, Contaminants

ASSESSMENT

| | |
|-------------------------|--------------------------|
| Status | <i>"What?"</i> |
| Impact | <i>"So What?"</i> |
| Actions | <i>"Now What?"</i> |
| Limiting Factors | <i>"What's the Gap?"</i> |
| ETA to Green | <i>"When?"</i> |



DATA Gathering

Cleaning and Evaluate:

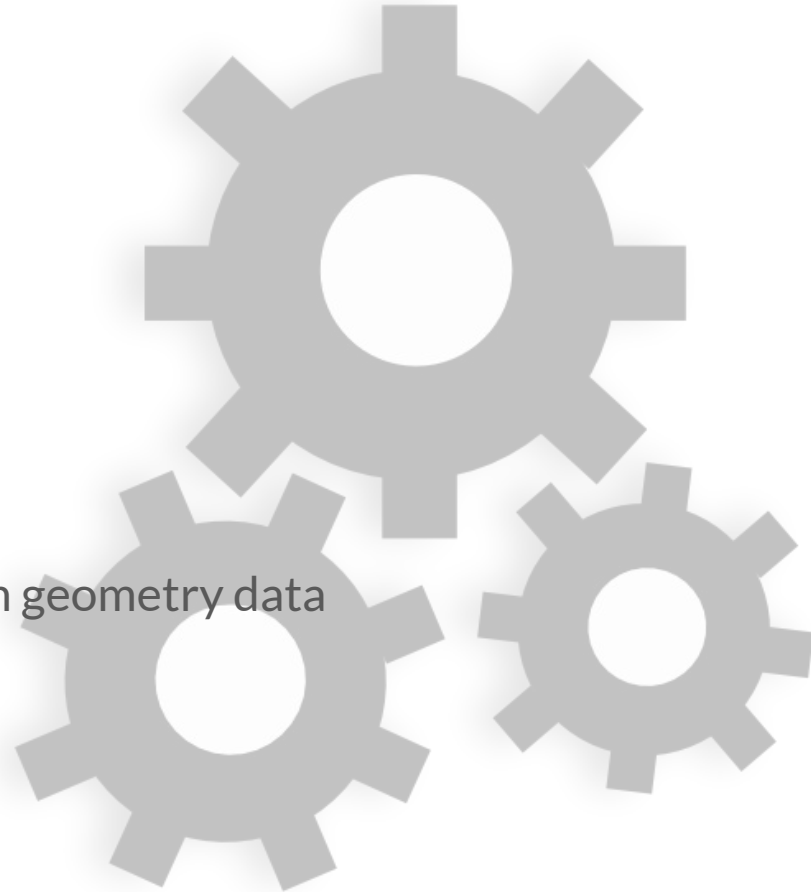
- Dropped unnecessary columns

- Remove duplicate rows

- Extract latitude and longitude data from geometry data

- Calculate distance from point of origin

- Clean up type data





Data Wrangling

Map the lifelines category and number to each businesses by business type

Developed a hierarchy to prevent duplicates across multiple lifelines

Saved cleaned data downstream for zone assignment





Zones

Data:

Hospitals were selected from the lifeline zones list, they were considered one of the most important but limited lifelines

Execution:

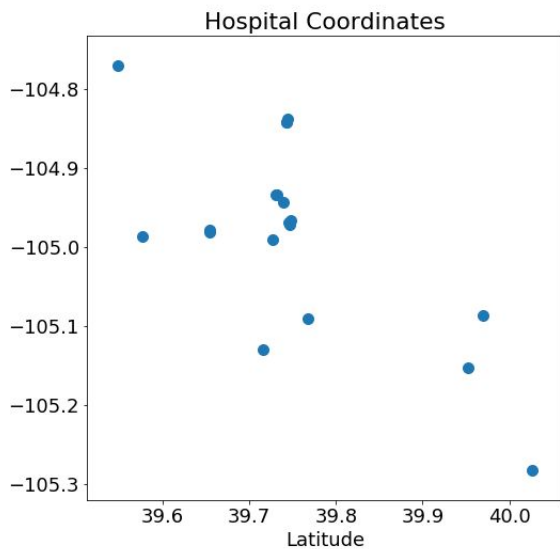
DBSCAN (unsupervised machine learning algorithm) was used to cluster hospitals together into zones based on their proximity to one another

Results:

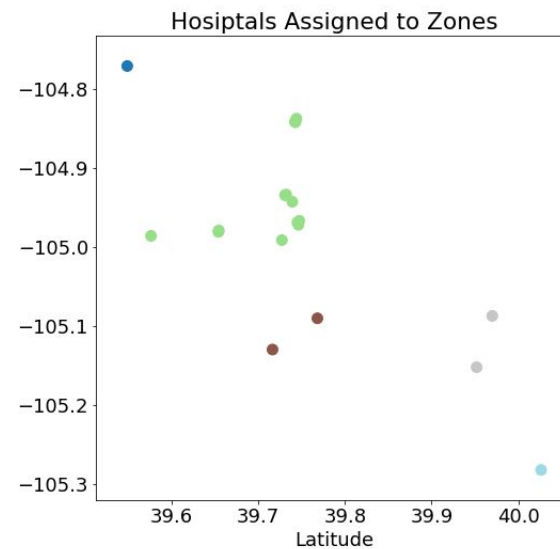
Zones in the shape of circles were created. Each zone is approximately 6.9 miles to the center or 14 miles wide. Lifelines could then be associated with each zone, the zones could then be scored



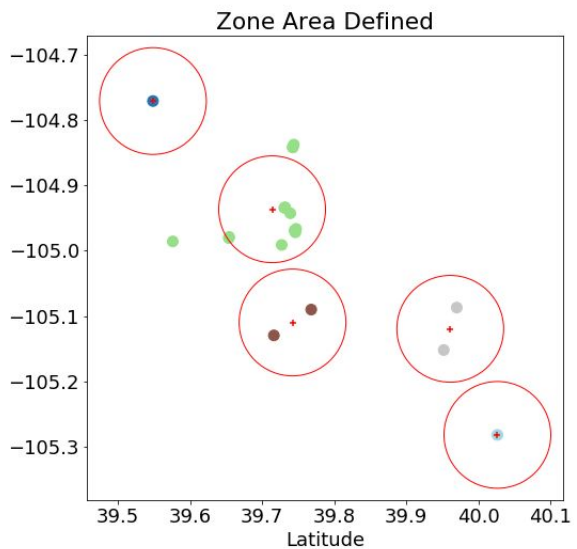
Zones



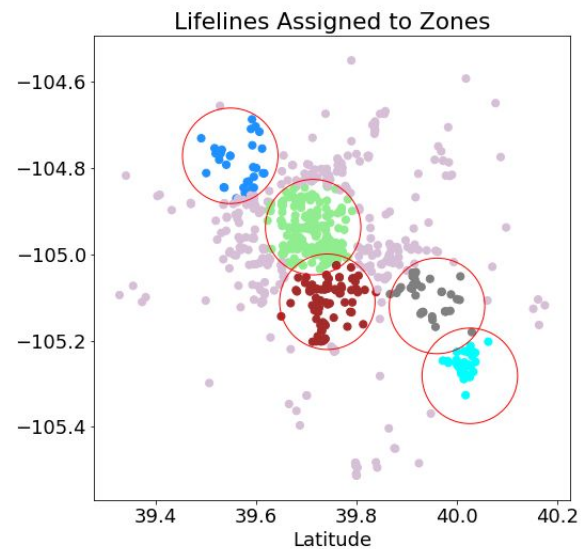
identify zones



Zones



add lifelines to
zones





Resource Score

Scores for each zone are based on the **lifelines they contain** multiplied by the **weight** assigned to each lifeline and then divided by the **total population** in the zone.

This gives a resource score that indicates the availability of lifelines based on the population density within a zone.

The resource score was then applied to each census tract

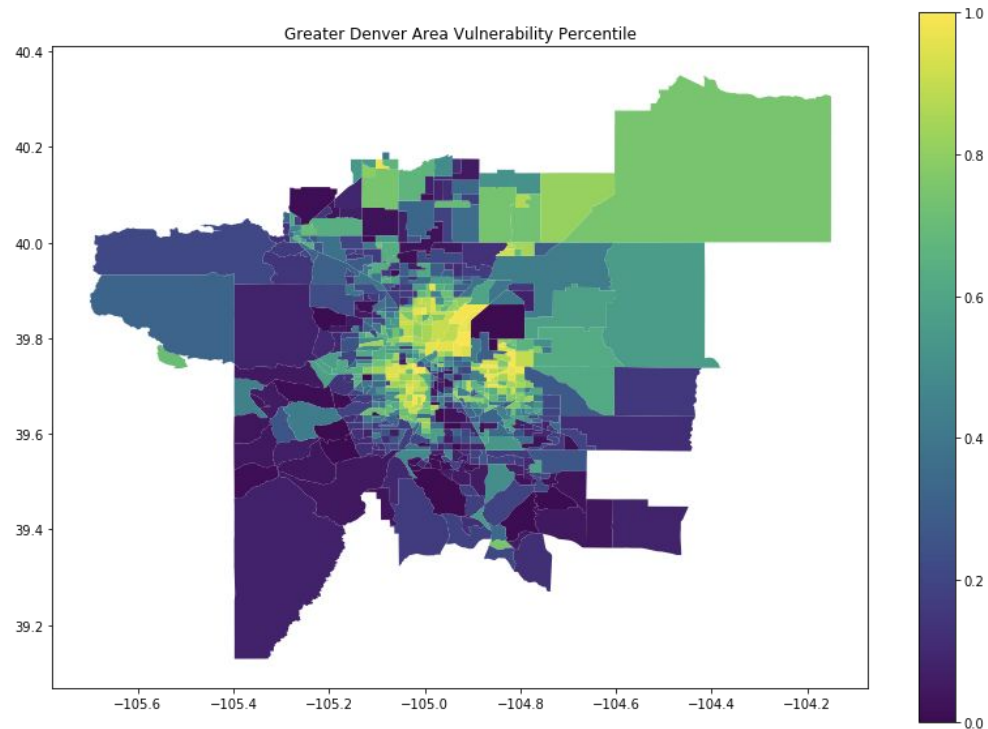
| Weight | Lifeline |
|--------|----------------------|
| 0.2 | Safety & Security |
| 0.2 | Food, Water, Shelter |
| 0.3 | Health & Medical |
| 0.1 | Energy |
| 0.1 | Communication |
| 0.1 | Transportation |
| n/a | Hazardous Materials |

Vulnerability

Data: Gathered directly from the CDC's Social Vulnerability Index (SVI)

Implementation: Directly took the census tract percentile rank (national comparison 0-1 with 1 being high vulnerability)

Note: Some tracts (such as the Rocky Mountain Arsenal National Wildlife Refuge) have no people and are assigned a -999 for SVI, we assigned these tracts a 0 i.e. no vulnerability





Flood Hazard

Data:

Took 20 random points within each census tract and called the Google Elevation API to get the elevation for each census tract in the Denver area

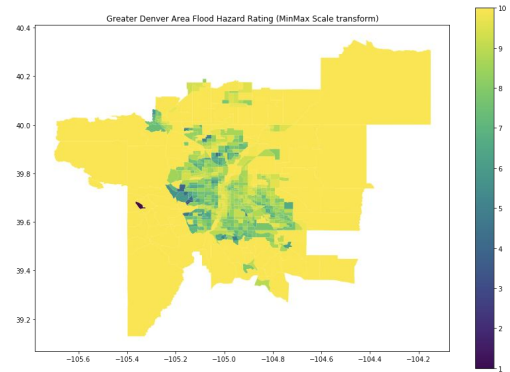
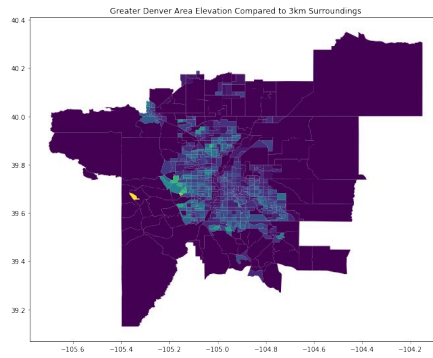
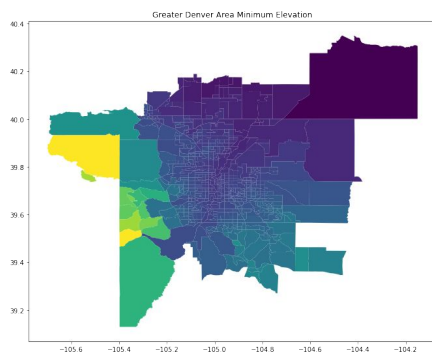
Execution:

- Calculated mean, median and min of each set of 20 elevation points
- Compared minimum altitude in the tract to the minimum altitude in the tracts in a 3km radius
- Standardized minimum altitude difference to a 0-1 scale and converted to 1-10 flood risk rating with 10 being the highest risk

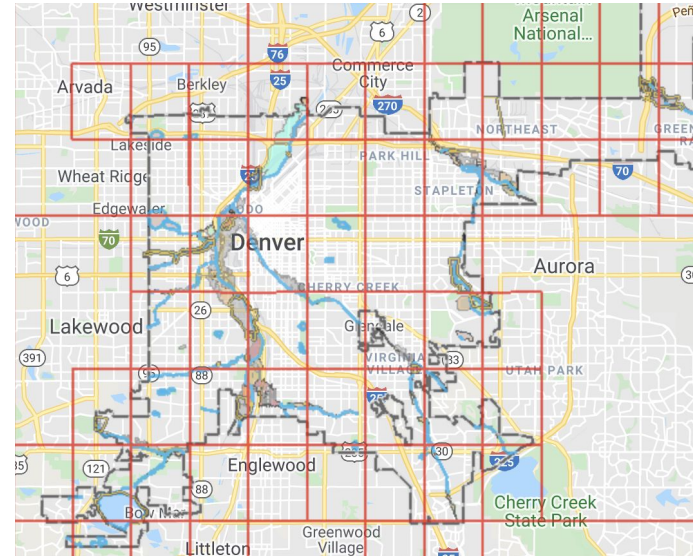
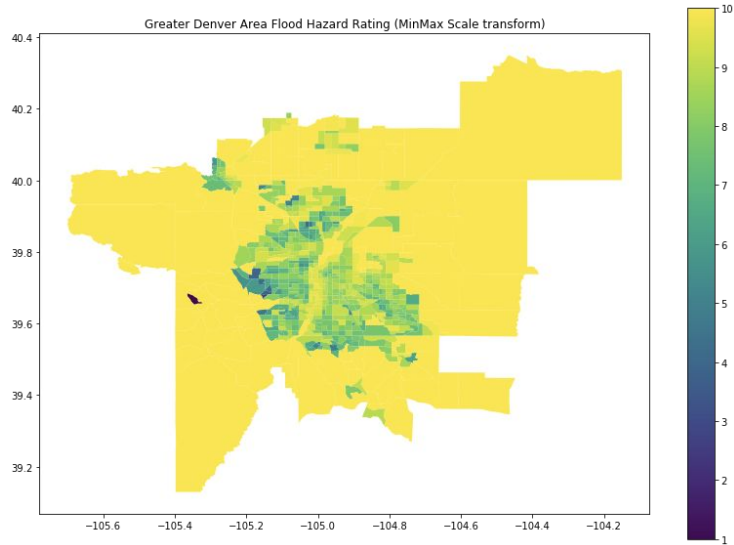
Results:

Provides quite an accurate view of flood risk in urban areas with a high density of census tracts but is not meaningful in more rural areas

Flood Hazard



Flood Hazard - Comparison with FEMA



Comprehensive Risk Score

| | FIPS | zone | hazard | vulnerability | zone_score | CALC | risk_score | risk_score_round |
|-----|-------------|------|--------|---------------|------------|---------|------------|------------------|
| 274 | 08013013401 | 20 | 9.5 | 0.9749 | 0.3893 | 0.58555 | 5.5627 | 6.0 |
| 630 | 08001008802 | 20 | 9.3 | 0.9911 | 0.3893 | 0.60175 | 5.5963 | 6.0 |
| 181 | 08005081800 | 20 | 8.8 | 0.9684 | 0.3893 | 0.57905 | 5.0956 | 5.0 |
| 47 | 08001008801 | 20 | 9.0 | 0.9765 | 0.3893 | 0.58715 | 5.2844 | 5.0 |
| 45 | 08001008706 | 20 | 9.4 | 0.9473 | 0.3893 | 0.55795 | 5.2447 | 5.0 |

$\text{Hazard} \times (\text{Vulnerability} - \text{Resources}) = \text{Risk}$



Visualizations





Next Steps

- Further research lifelines and resource score calculation
 - Refine resource zoning
- Improve flood hazard calculation
 - Bring in flood plains from FEMA directly
- Build production code that can be utilized for any municipality
 - Convert GeoPandas code to cython
- Build tool that can take in a location and output final dashboard



References

https://github.com/micahluedtke/FEMA_lifelines

<https://svi.cdc.gov/>

<https://www.aprestoration.com/the-history-of-natural-disasters-in-colorado/>

<https://www.fema.gov/lifelines>

<https://developers.google.com/maps>