Social Computing for Post-Earthquake Vulnerability and Resilience Assessment
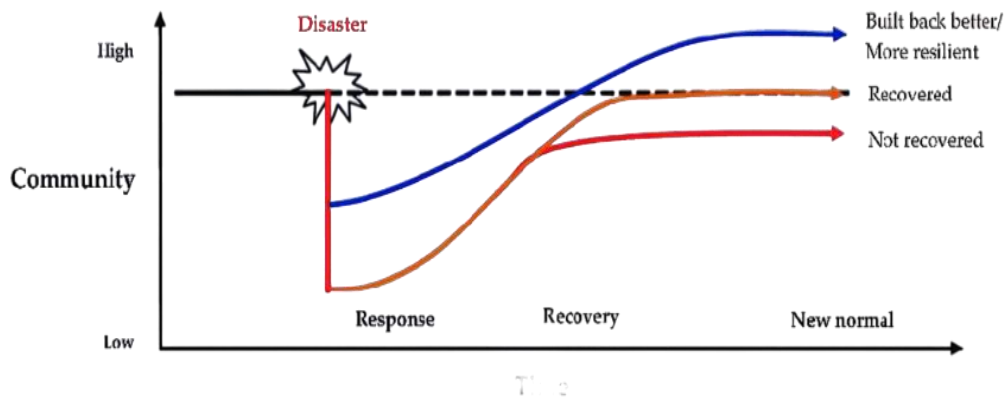
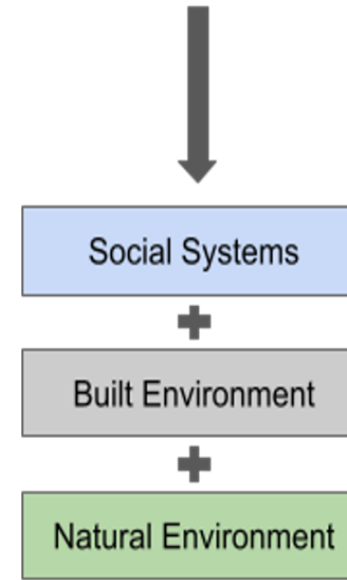Ankit Tripathi (RA), James Casey (RA), Kristina Lerman (Co-PI) and Sifat Muin (PI)

Motivation

Resilience

Resilience is the ability of a system, community, or society to resist, absorb, adapt to, and recover from hazards efficiently (Sendai Framework for Disaster Risk Reduction 2015–2030).
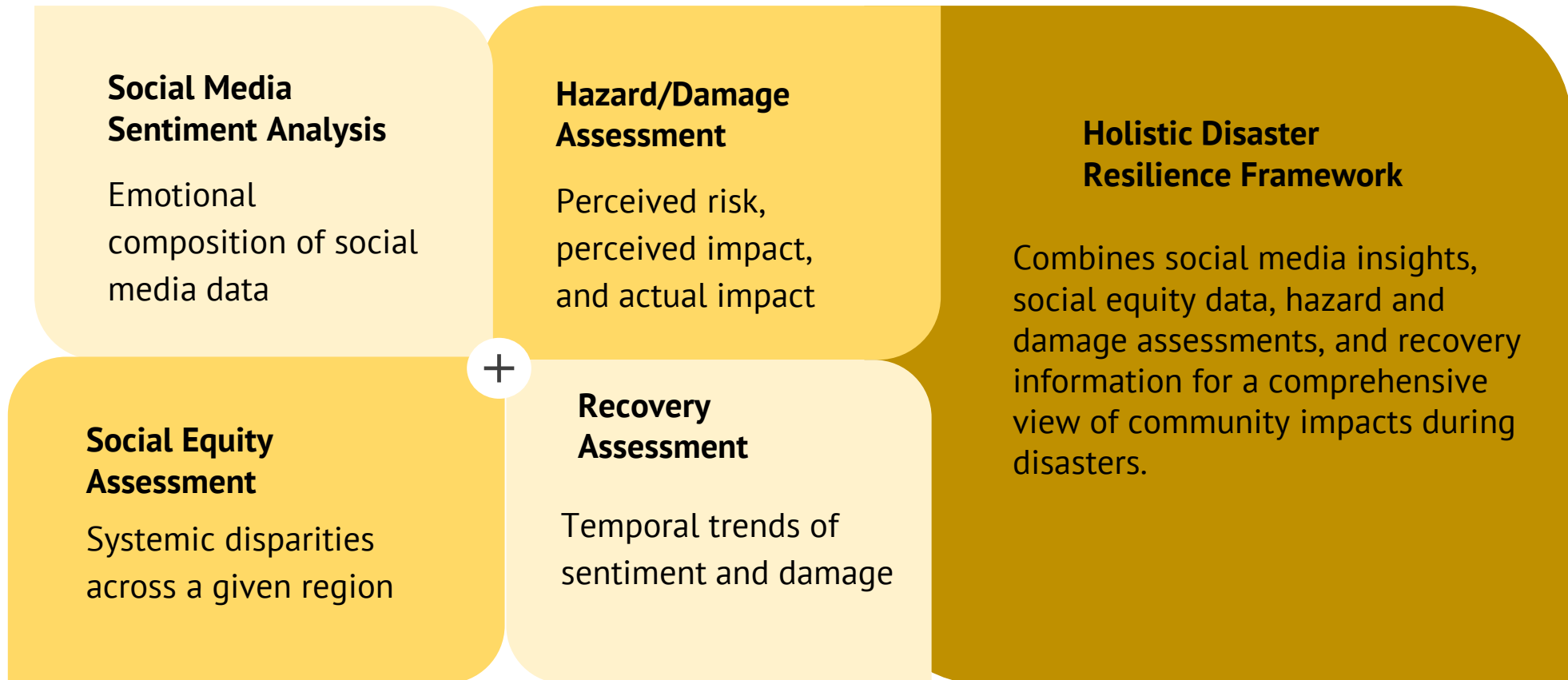

Vulnerability

The susceptibility of a system, community, or society to adverse effects caused by external stresses (e.g. natural disasters, climate shifts, economic fluctuations, and social disruptions).

Objective

## Human-Centric Disaster Resilience Framework

Introduces a novel framework that utilizes **social computing techniques**, particularly sentiment analysis, alongside **hazard, damage, damage perception, and systemic disparities** to identify vulnerable communities following earthquakes.

Social Media Sentiment Analysis

Emotional composition of social media data

Hazard/Damage Assessment

Perceived risk, perceived impact, and actual impact

Holistic Disaster Resilience Framework

Combines social media insights, social equity data, hazard and damage assessments, and recovery information for a comprehensive view of community impacts during disasters.

+

Social Equity Assessment

Systemic disparities across a given region

Recovery Assessment

Temporal trends of sentiment and damage

3

Social Computing and Natural Hazards

Literature Review

1. Most studies focus on hurricane & flood
2. Social media, social equity, and damage data are often not combined; more comprehensive studies are needed.

(A) Hurricane Harvey

Social Media-Based Sources

Literature Review Gaps
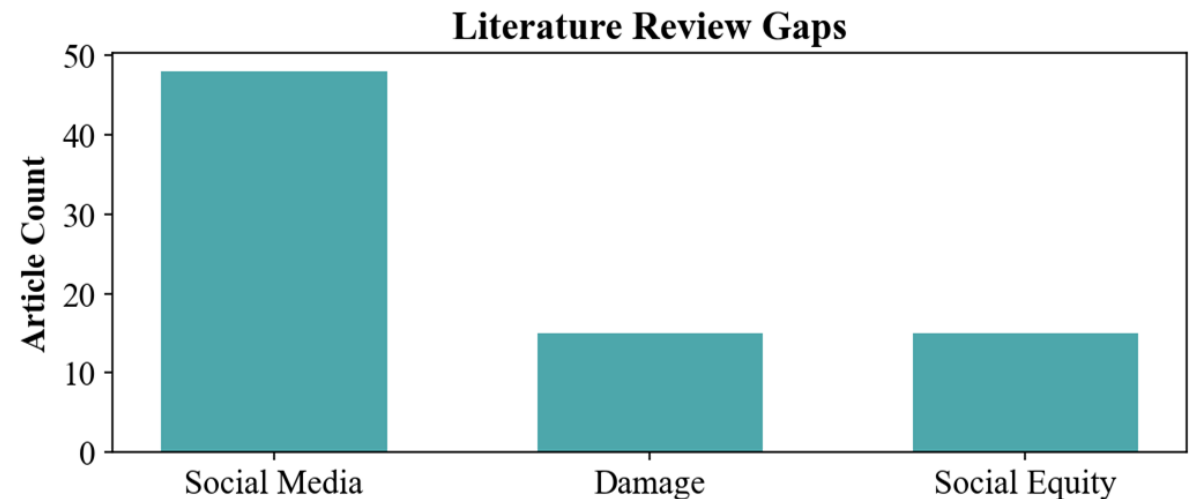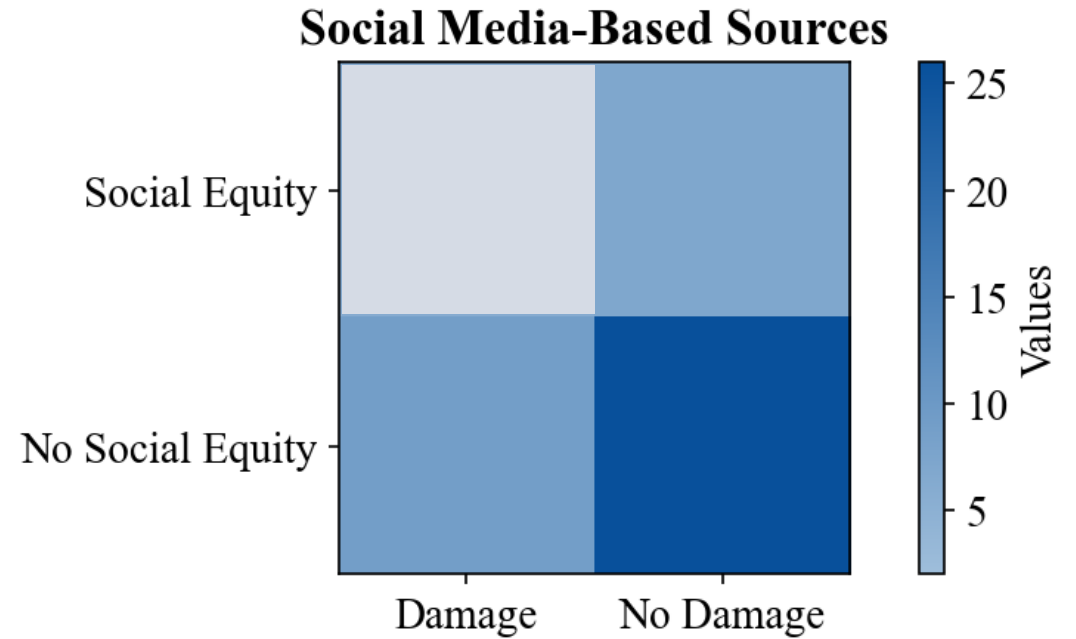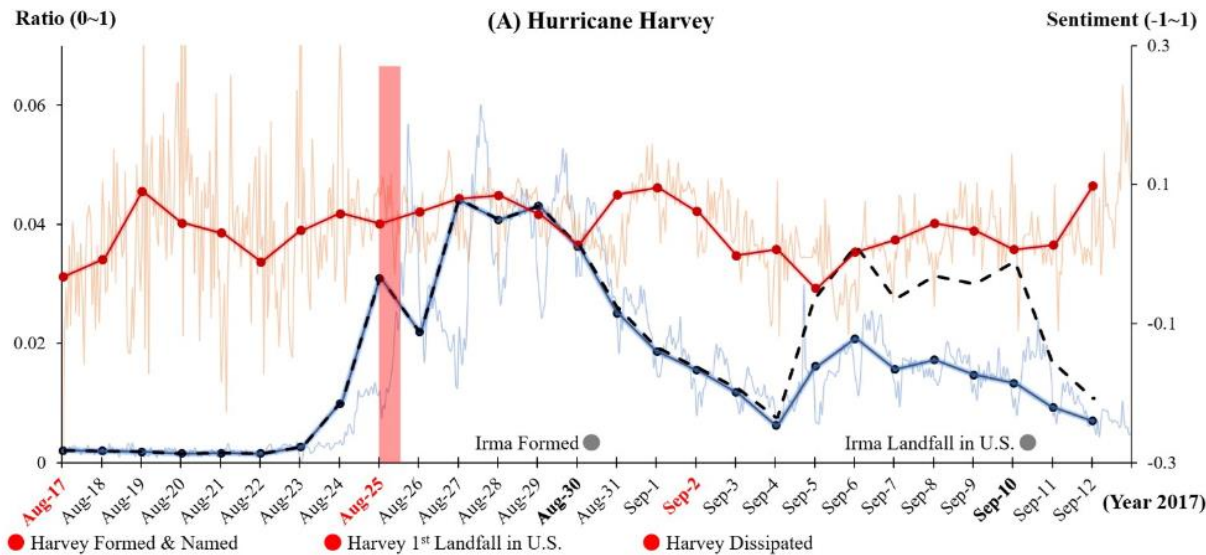
Driving Questions

Q1. Can sentiment analysis capture community response following earthquakes?

Q2. Can geotagged social media data be used to identify vulnerable areas or communities based on sentiment analysis?

Q3. Does sentiment analysis reflect hazard and damage?

Q4. How does the identification of vulnerable populations using sentiment analysis compare with ground truth data?

Post-earthquake Social Media

X.com

Nextdoor

USGS Earthquakes ✔ @USGS_Quakes · Aug 12
Notable quake, preliminary info: M 4.4 - 4 km SSE of Highland Park, CA
earthquake.usgs.gov/earthquakes/ev…

💬 9   🔁 106   ♡ 265   📊 31K

USGS Earthquakes ✔ @USGS_Quakes · Aug 12
M4.4 earthquake at 12:20pm PDT on 12 August, centered in the Highland Park/South Pasadena area. Did you feel it?
earthquake.usgs.gov/earthquakes/ev…

💬 20   🔁 90   ♡ 264   📊 22K

@MrEduardo21 · Aug 12
Checking in that I felt the #Earthquake

I've never been outside for one so that was a trip

💬   🔁   ♡ 1   📊 203

Aug 12
i felt that #earthquake

💬   🔁   ♡   📊 256

That was a big one in the area. #earthquake

[map of Los Angeles area showing 4.7 marker]

💬   🔁   ♡ 1   📊 252

tRLTR · Aug 12
Felt that one in Dana Point

Me in Orange County California, scrolling and feeling an earthquake and lazily trying to decide if it's violent enough to get out of bed for. It's my day off 😩🙇 #earthquake

💬   🔁   ♡   📊 332

4.7 #earthquake in #Pasadena was shaking here in #irvine

💬 1   🔁   ♡   📊 249

I'm feeling very slight movements in Newport Beach and hearing house creaks. #earthquake Is it an earthquake?

💬   🔁   ♡ 1   📊 240

That was a pretty big jolt and shake! Why didn't I get an alert??? #earthquake #socal

💬   🔁   ♡ 1   📊 301

#Earthquake just felt it!

💬   🔁   ♡   📊 224

ABC7 Eyewitness News ✔ @ABC7 · Aug 12
#EARTHQUAKE UPDATE: Shaking from #quake caused water pipe to burst at Pasadena City Hall. City official says leaking water has since been stopped abc7.la/3M2cuod

[LIVE news video]

BREAKING NEWS
4.4 QUAKE STRIKES NEAR HIGHLAND PARK
abc7.com

💬 11   🔁 155   ♡ 547   📊 101K

Montemalaga · 1 day ago · ⊕
Did we just have an earth quack?
💬 13

Reactions
❤️ 3   😄 0   👍 0   😆 0   😮 0   😢 0

See 3 previous comments

My quack app alert !! went off 😵 so I think we did!
Like   Reply   Share   🧡 11

👍
Like   Reply   Share   ❤️ 1

Definitely an earthquake - my seismometers recorded it nicely
Like   Reply   Share   ❤️ 1

A lot of ducks were flying overhead awhile ago, so I guess that's what it was! An earth quack! But in other news, we did have an earthquake earlier.
Like   Reply   Share   🧡 5
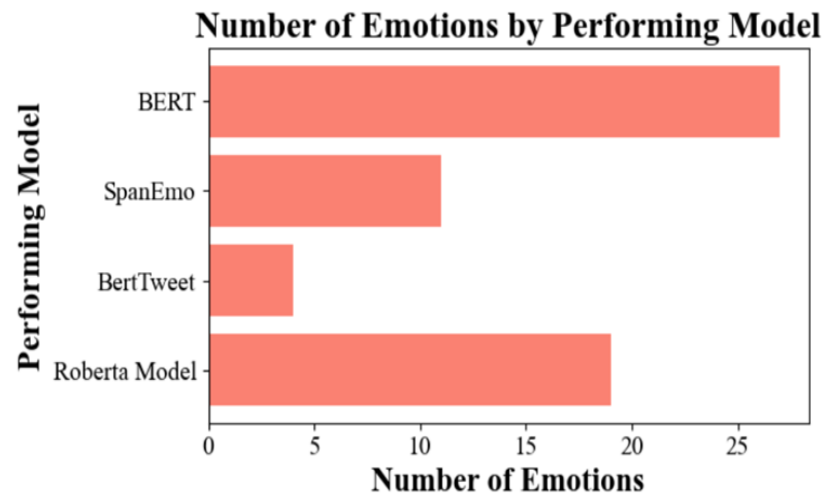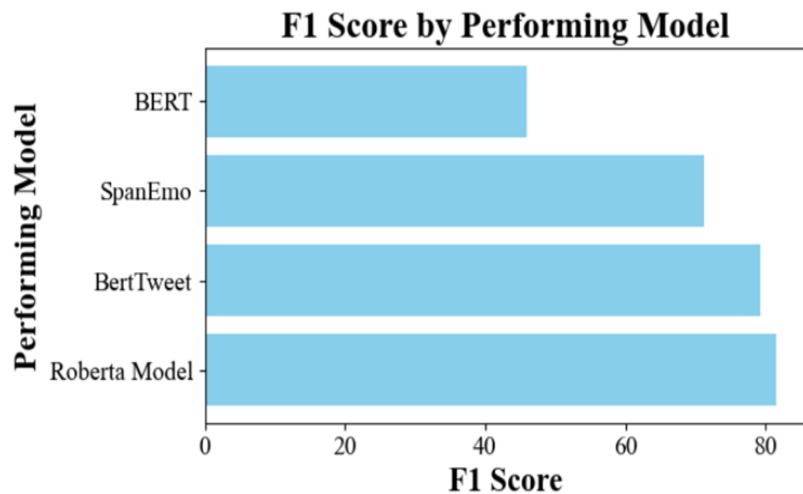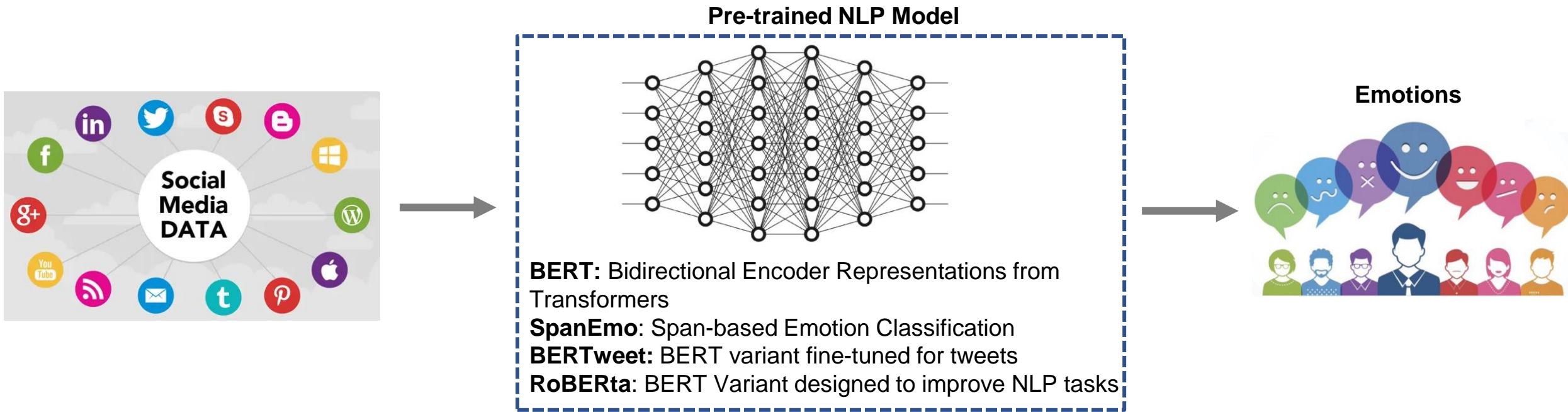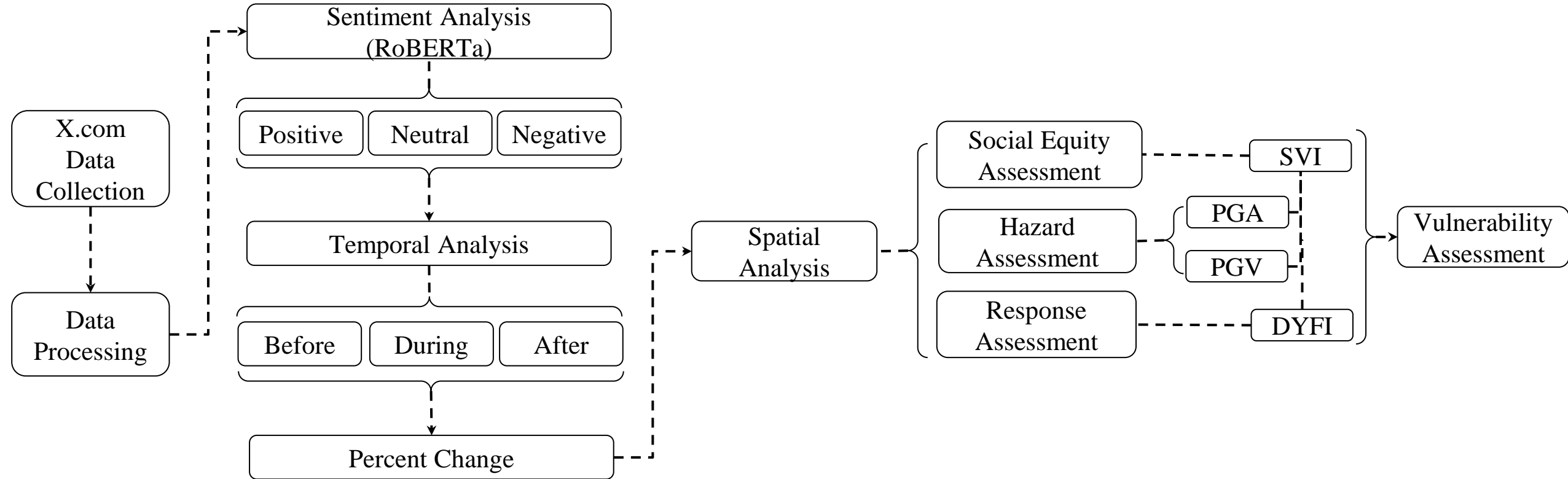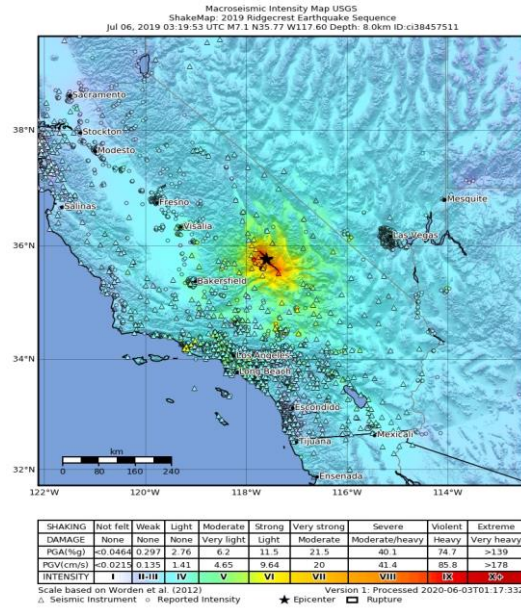
Quack quack!
Like   Reply   Share   ❤️ 1

Duck and cover!!!

6

Sentiment Analysis

Pre-trained NLP Model

Emotions

BERT: Bidirectional Encoder Representations from Transformers
SpanEmo: Span-based Emotion Classification
BERTweet: BERT variant fine-tuned for tweets
RoBERta: BERT Variant designed to improve NLP tasks

F1 Score by Performing Model

Number of Emotions by Performing Model

Methodology

Major Limitation: Data is expensive

Case Study

2019 Ridgecrest Earthquake

Event Overview:
- Foreshock: Magnitude 6.4 on July 4, 2019
- Main Shock: Magnitude 7.1 on July 5, 2019
- Location: Ridgecrest, California

Impact on Los Angeles:
- Minimal impact due to:
  - Distance (~150 miles from epicenter)
- No major collapses or widespread disruptions

Tweets per Day

Before   During   After

9
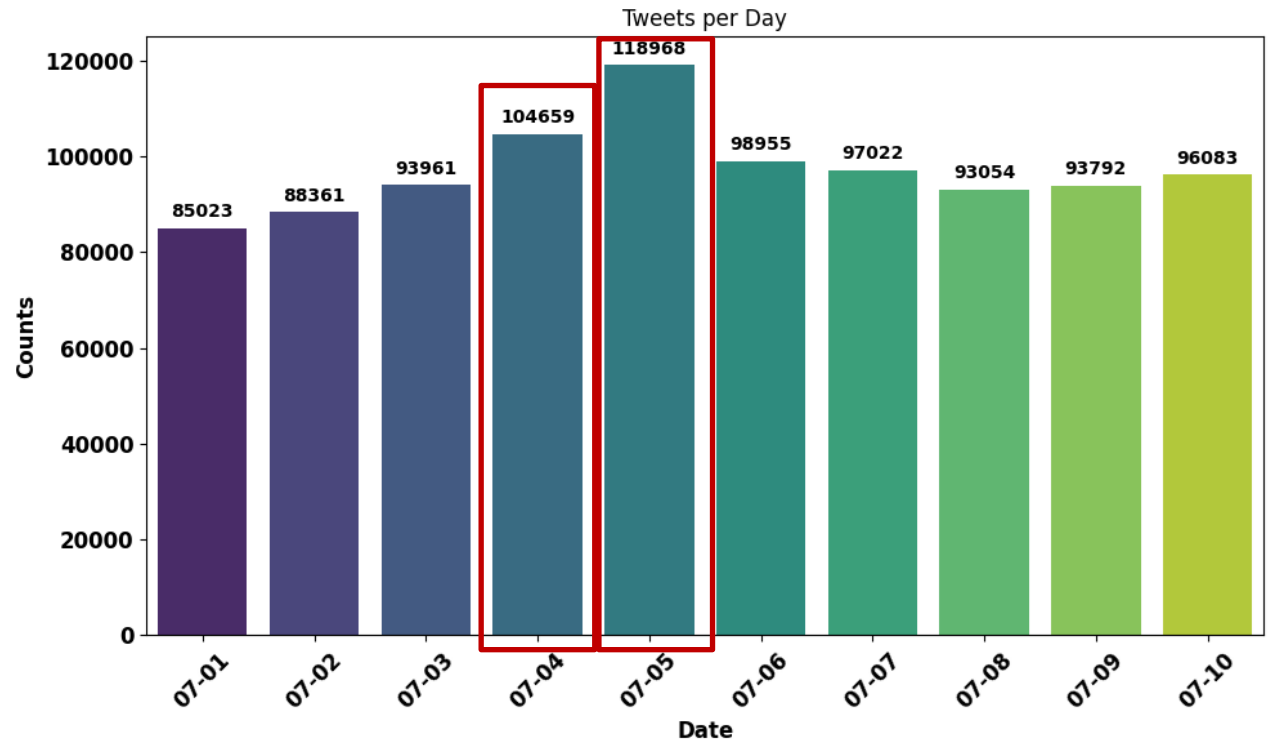
Sentiment Analysis

Percent Change in Sentiments - Before to During the Earthquake
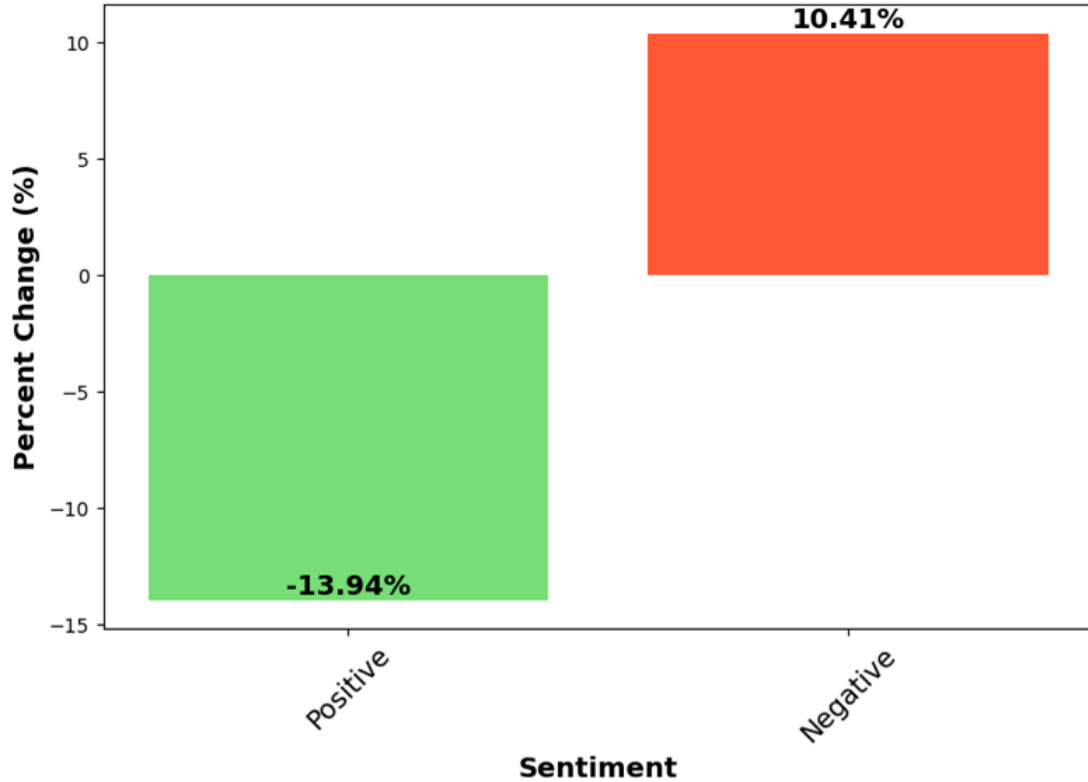
Between M6.4 and M7.1 Earthquakes: Positive sentiment decreased, negative sentiment increased.

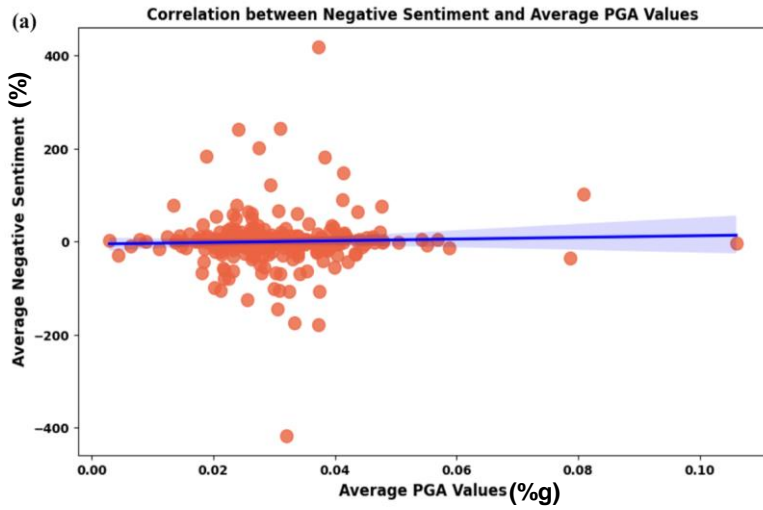Percent Change in Sentiments - During to After the Earthquake
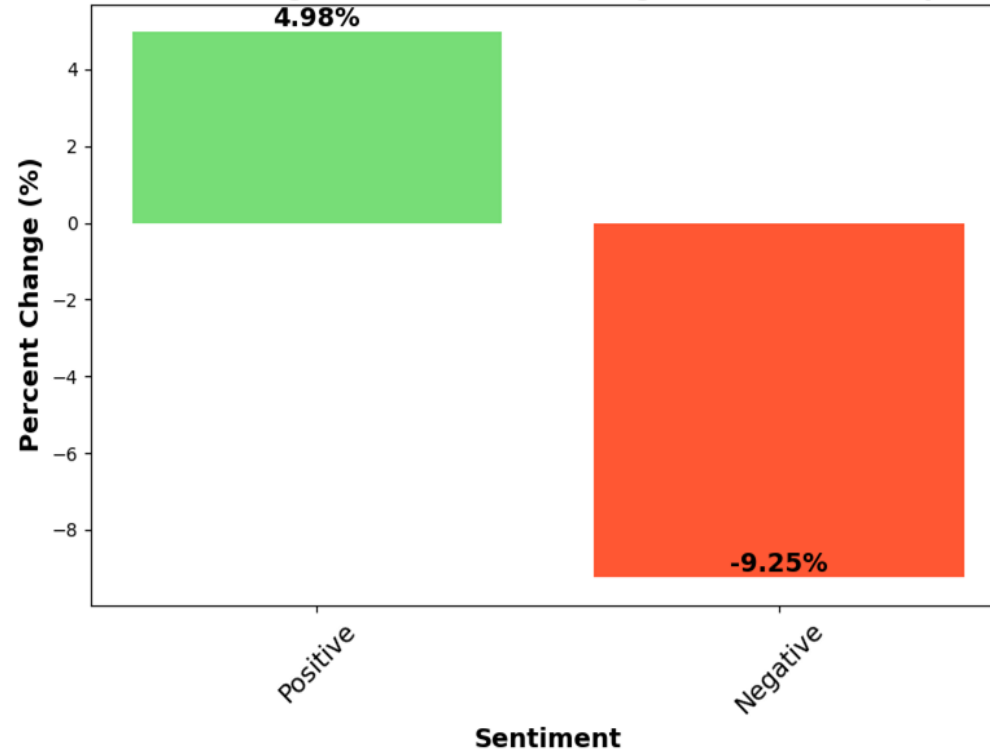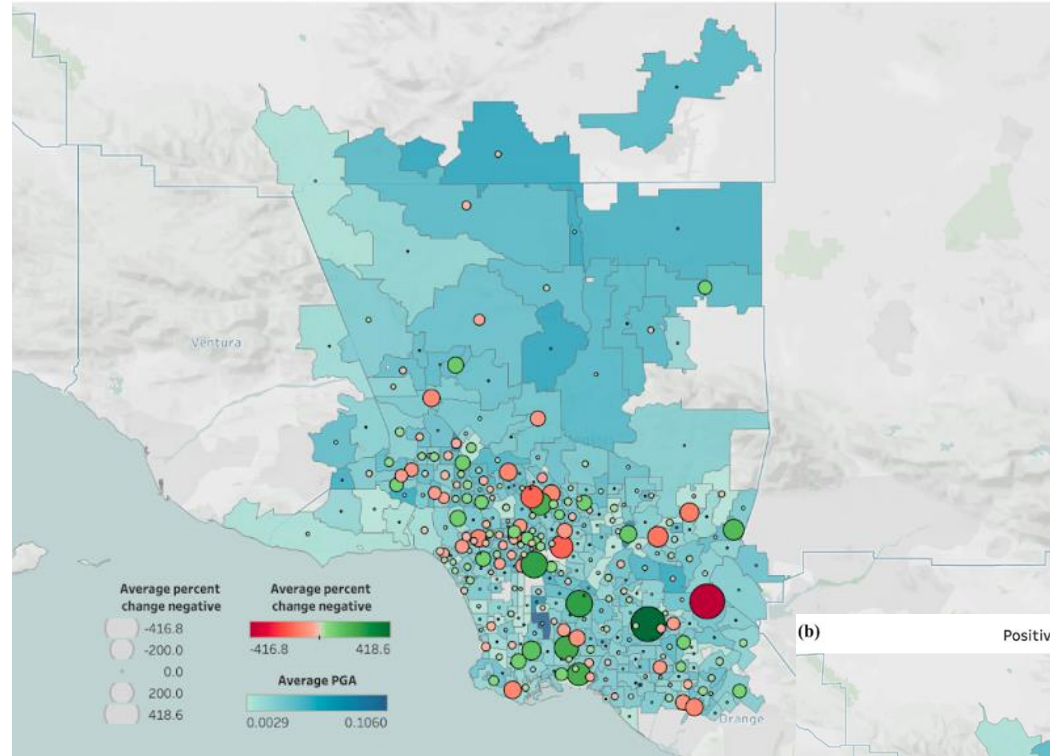
Sentiment Analysis
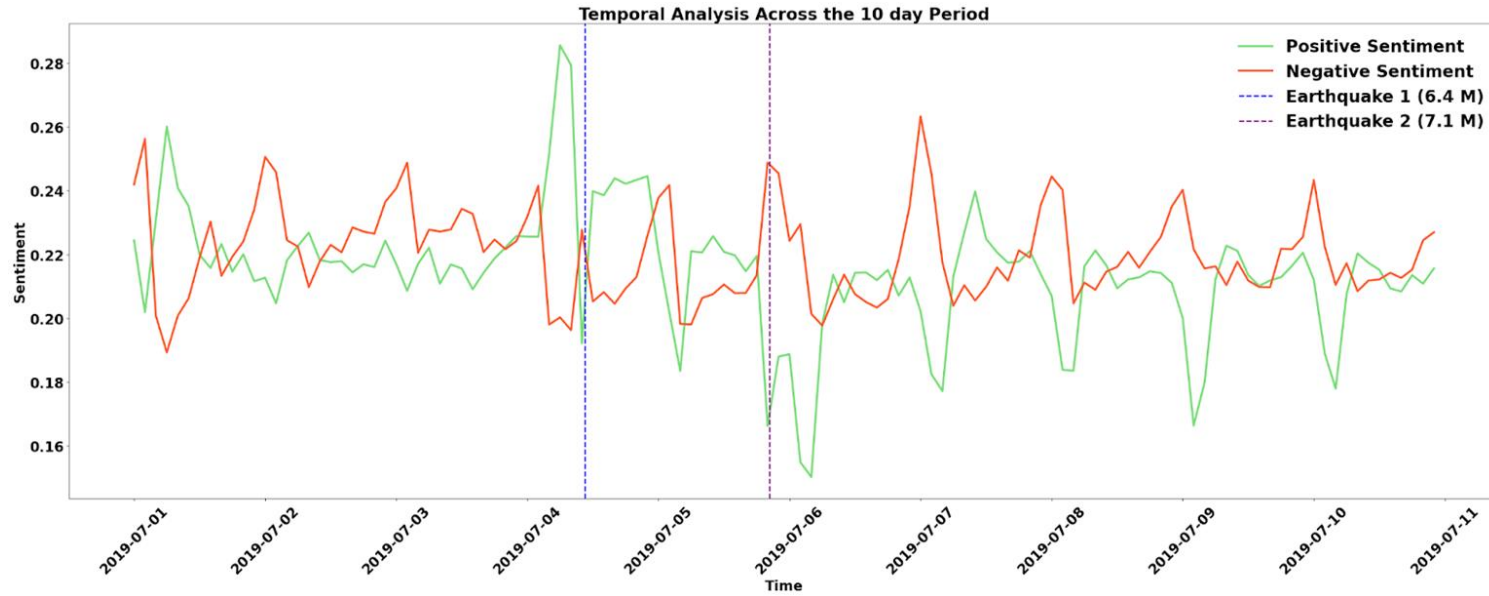
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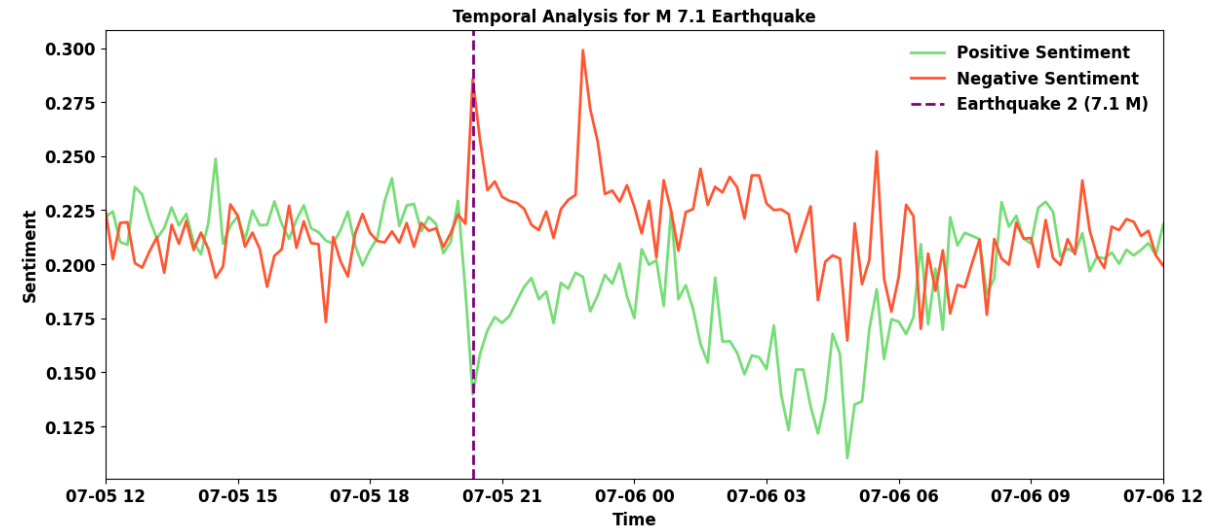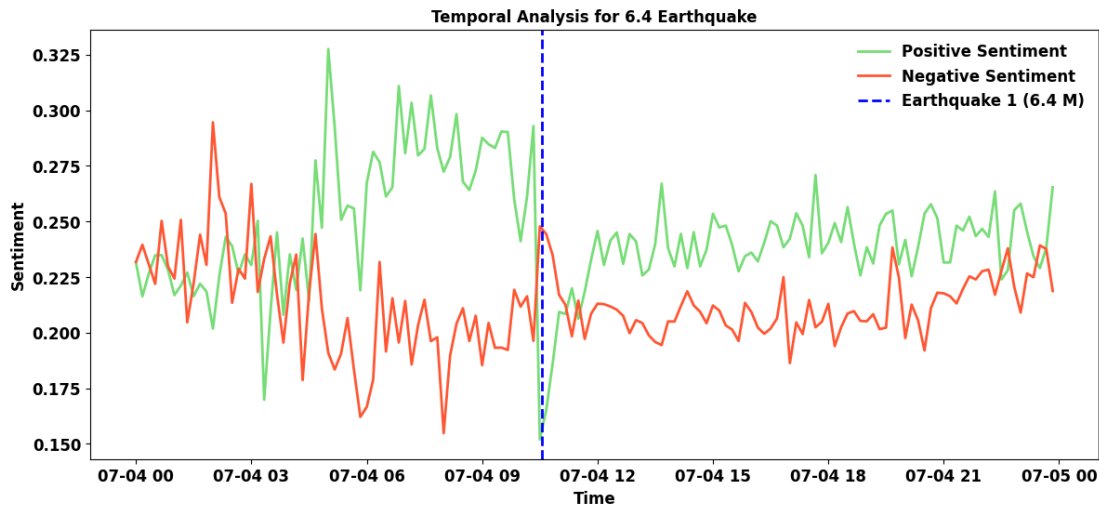
Hazard (PGA) Vs Sentiment
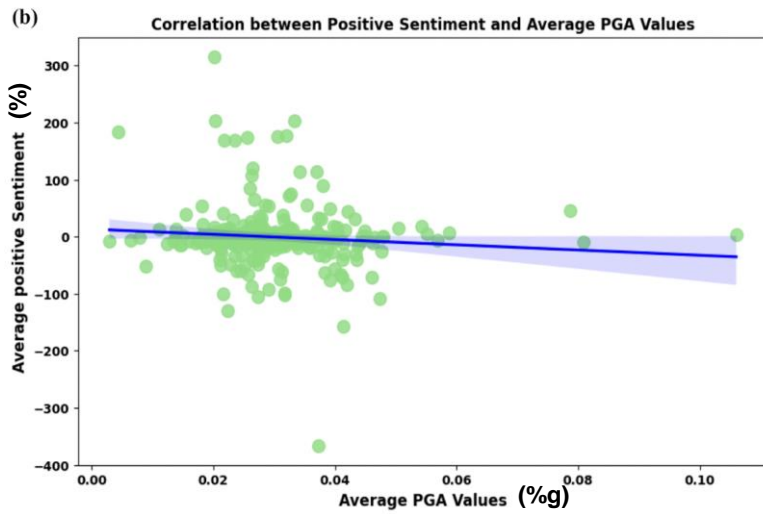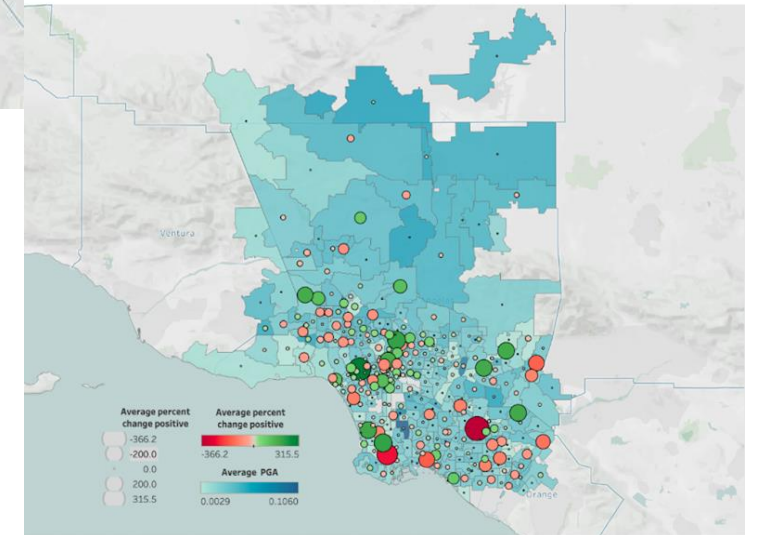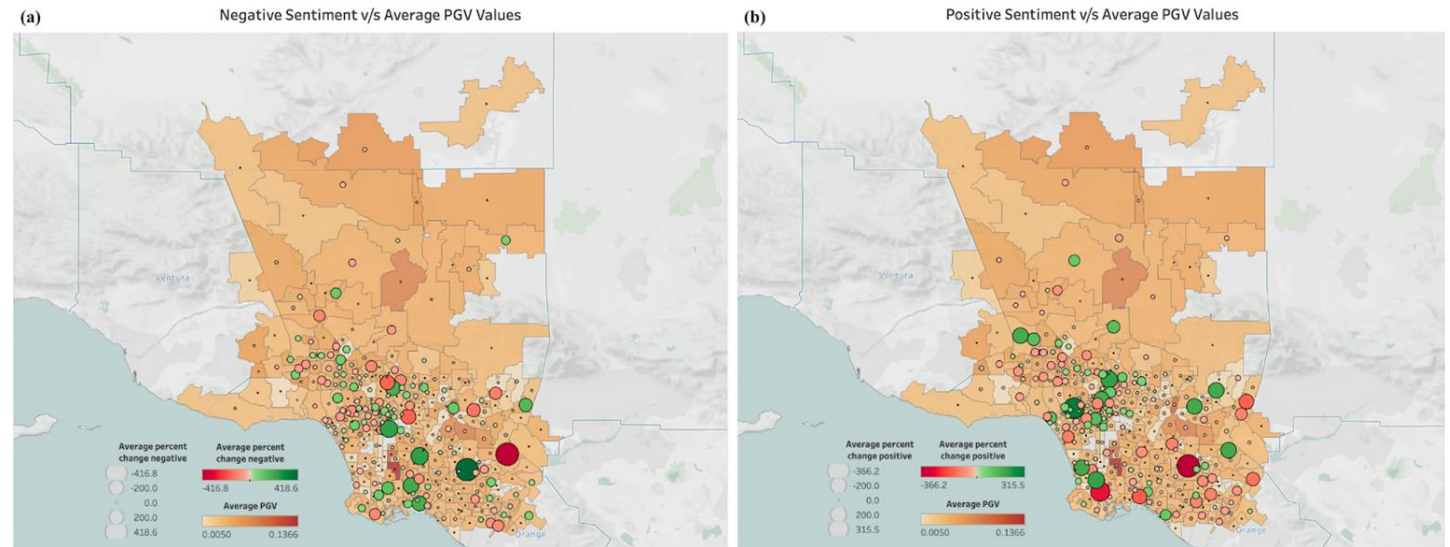
Hazard (PGV) Vs Sentiment
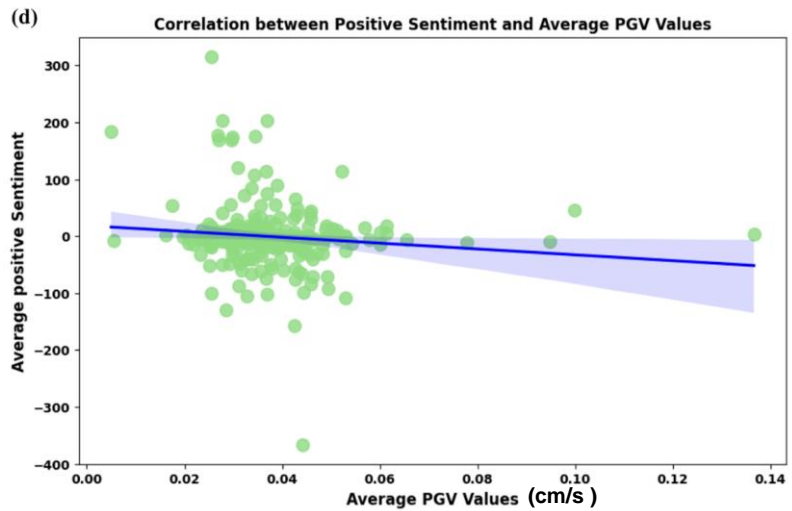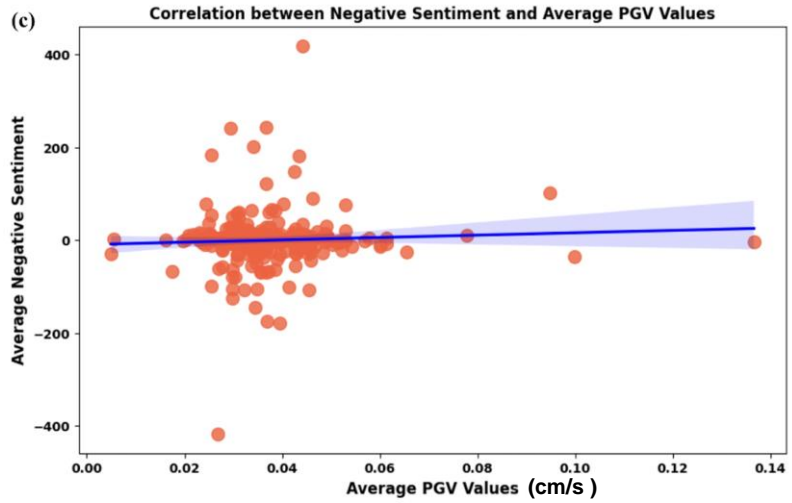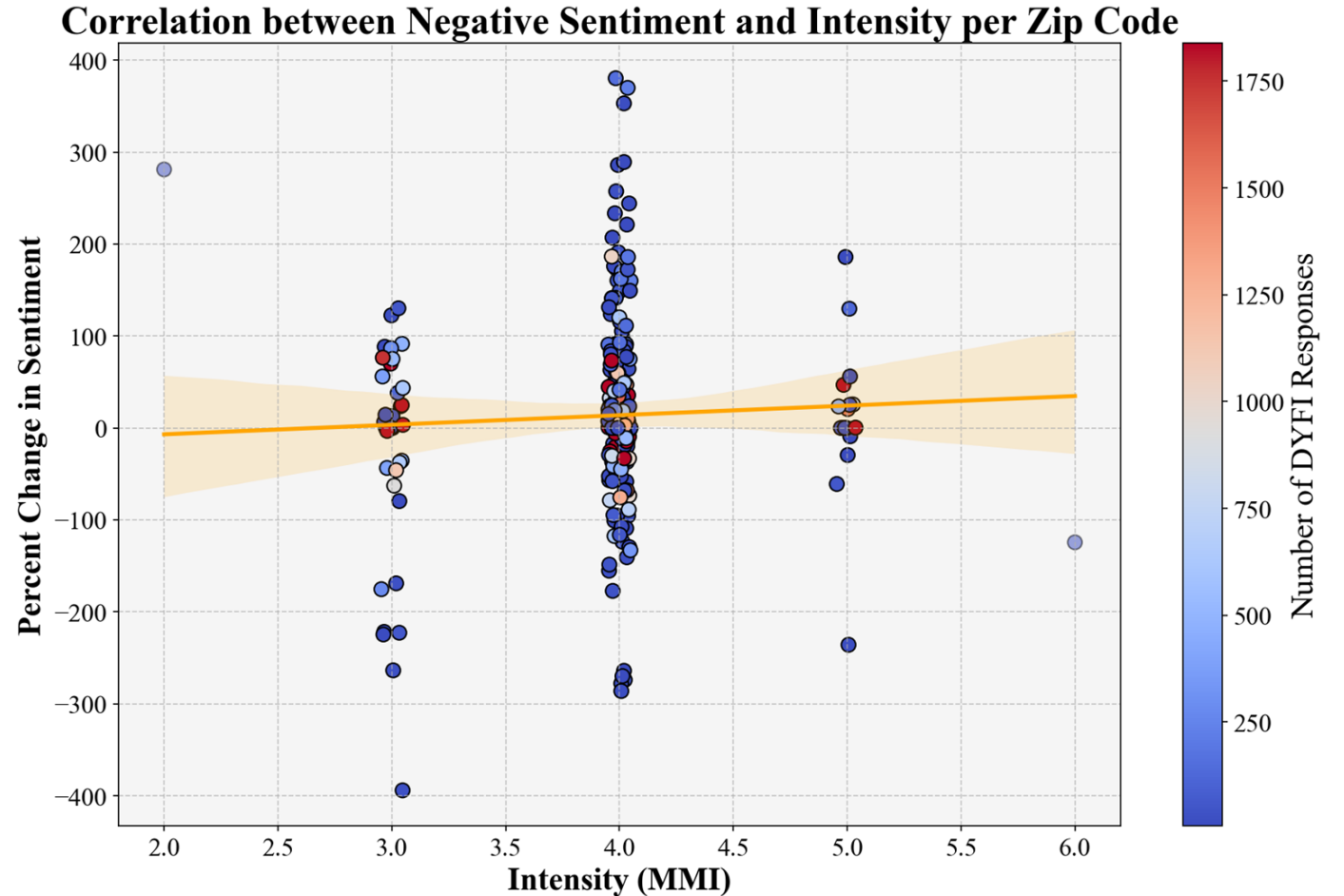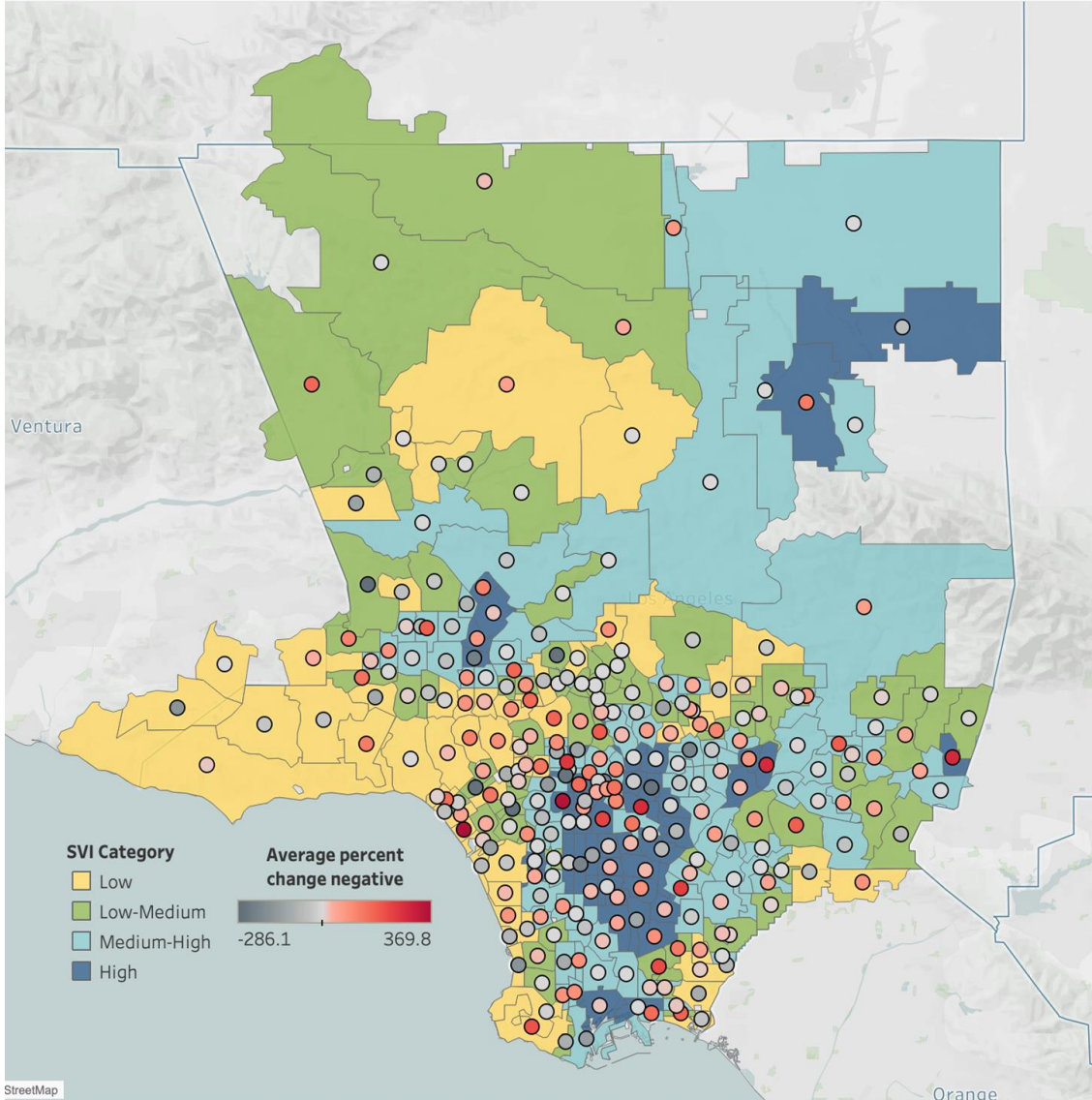
DYFI Vs Sentiment

Positive correlation between DYFI responses and negative sentiment.

- Stronger shaking or significant effects reported in DYFI surveys are associated with increased anxiety, fear, and stress.
- Subjective earthquake experiences (DYFI) better explain emotional reactions than objective measurements like PGA and PGV.

Correlation between Negative Sentiment and Intensity per Zip Code

SVI Vs Sentiment

SVI Vulnerability vs Negative Sentiment

SVI Category
- Low
- Low-Medium
- Medium-High
- High

Average percent change negative
-286.1 — 369.8

Social Vulnerability Index (SVI)

The current CDC SVI uses 16 U.S. census variables from the 5-year American Community Survey (ACS) to identify communities that may need support before, during, or after disasters.

Summary

- Sentiment analysis captures human response to earthquake sequence by increase of negative sentiment and decrease of positive sentiments.

- Sentiments are more correlated to hazard perception (DYFI) than measured hazard (PGA, PGV)

- Integrated approach of conventional vulnerability measures (SVI) and human response (social media insights, DYFI) is a promising tool for vulnerability identification and targeted resource allocation

- Limitation: Data access, representation.
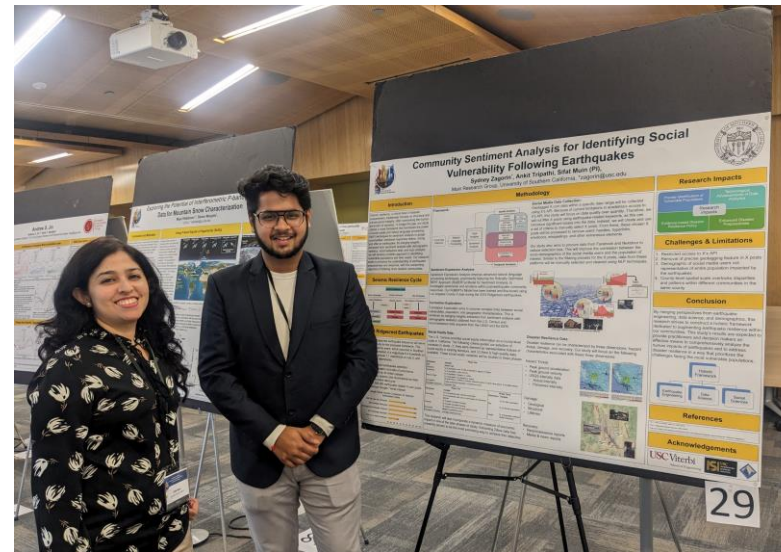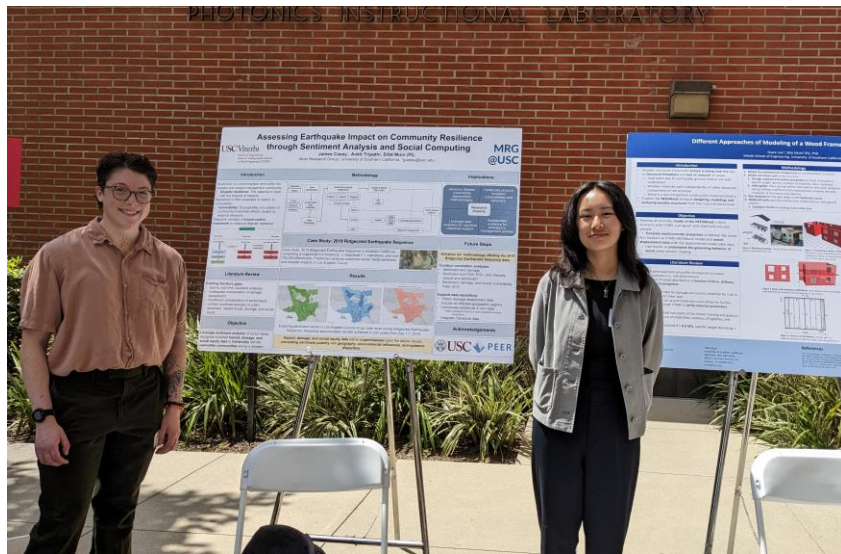
Acknowledgements:

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Thank You!