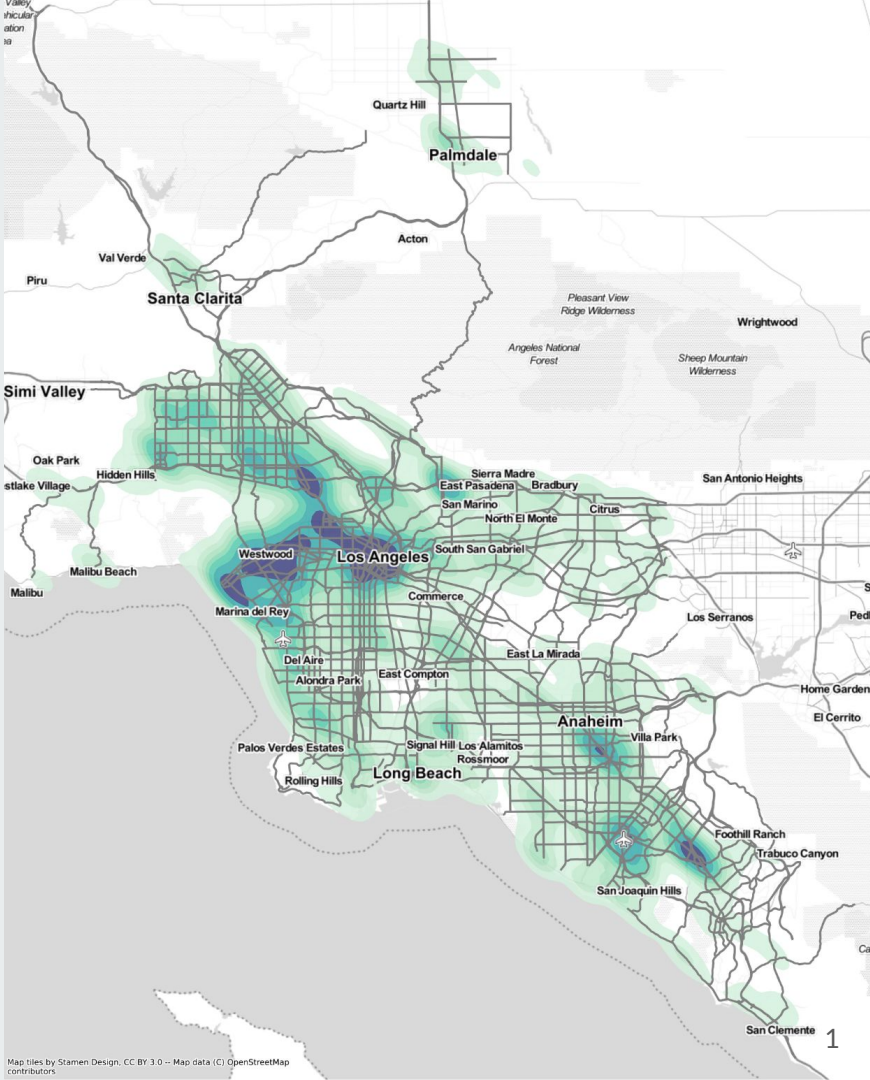
Southern California Electric Vehicle Charging Station (EVCS) Network Analysis

Group: Jarvis Yuan, Justin Wong, Danny Ha, Jing Xu



Team

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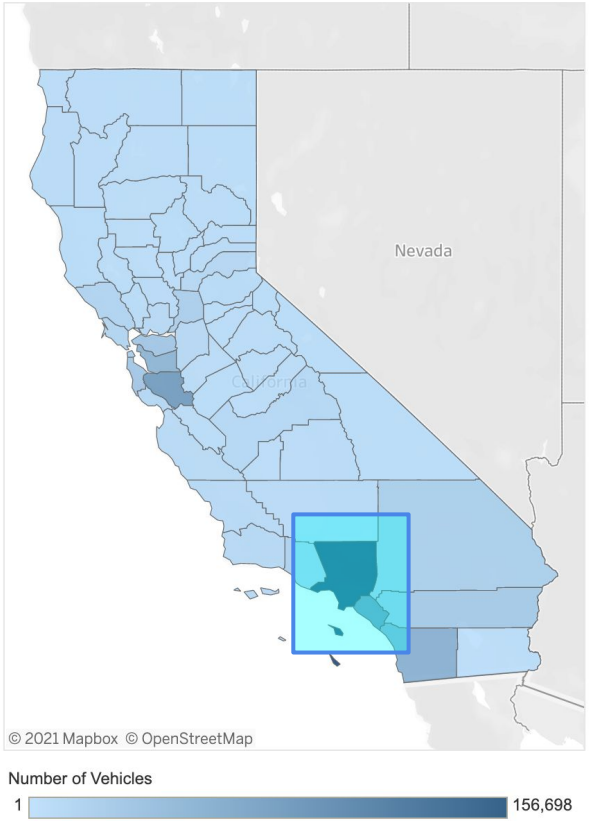
Agenda

1. Background and Motivation
2. Network Description
3. Data Sources
4. Methods and Results

Background and Motivation

- **Increasing charging station** in California
- Uneven distribution of charging stations, less informative in terms of level of service
- Charging Stations can be modeled as a **network**
- Charging stations are **relatively mobile and flexible** depending on demand and technology



Number of registered EV/plug in EVs per California County (CA DMV 2020)

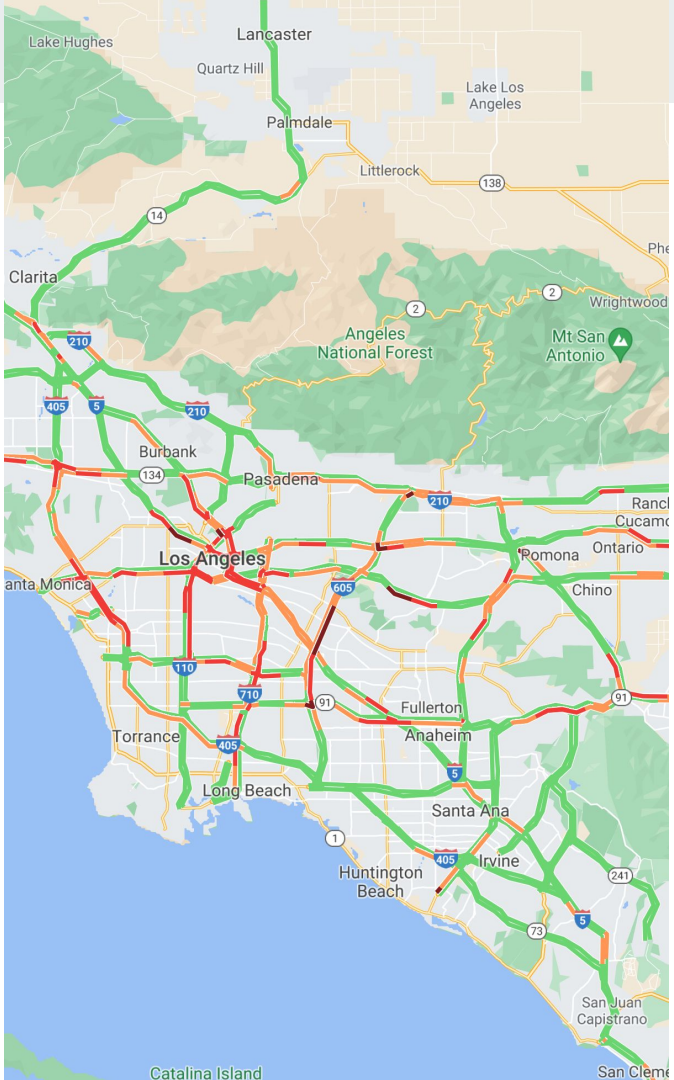
Data Sources

- OSMnx street network in Southern California (Los Angeles and Orange County, CA)
- Open Charge Map, https://openchargemap.org/site/develop#api
- ACS 2019 Census Tract Data (population by ethnicity, education, access to vehicles, household income, and commute)
- DMV Vehicle Registration Data (EV)
- Longitudinal Employer-Household Dynamics (LEHD) Origin-Destination Employment Statistics (LODES)

Network Description

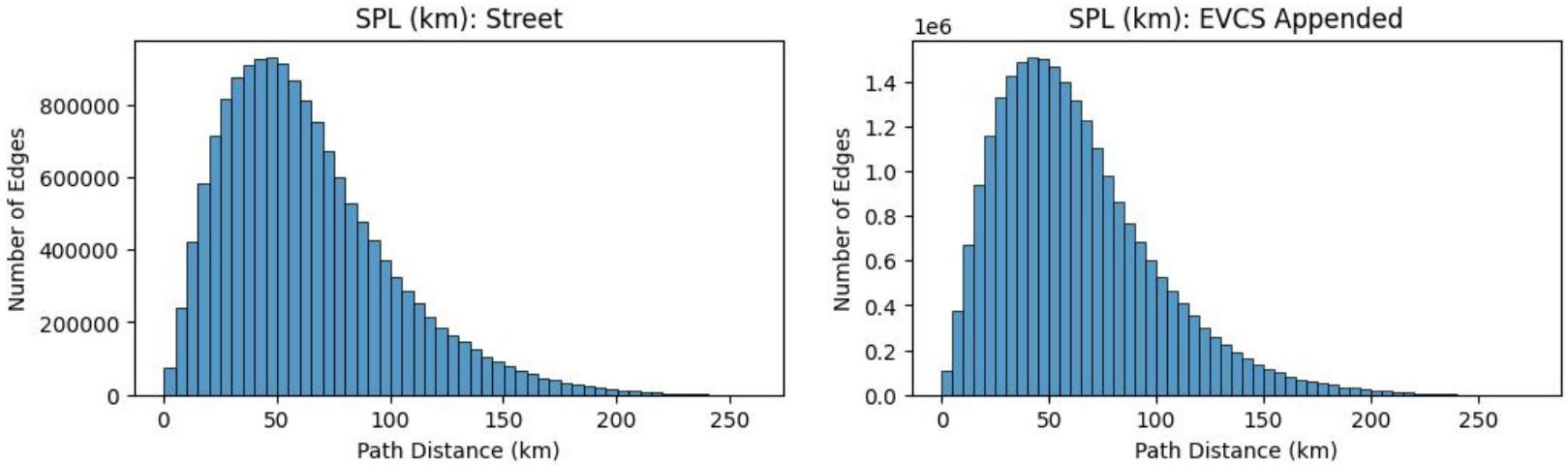
EVCS appended SoCal **driveable major roadway** street network

- 16,000 km^2, 2,152 intersections, average node degree of 4.4, N-S: ~100 miles, E-W: ~65 miles
- Nodes (4,025):
  - **Street intersections, onramps, junctions, etc**
  - Electric Vehicle Charging Stations (EVCS)
- Links/Edges (8,871):
  - **Street links**
  - Edge approximation from EVCS to closest street node
- After intersection consolidation



Network Properties

Physical Shortest Path Distribution: Street Network Only (Left), EVCS Appended Network (Right)

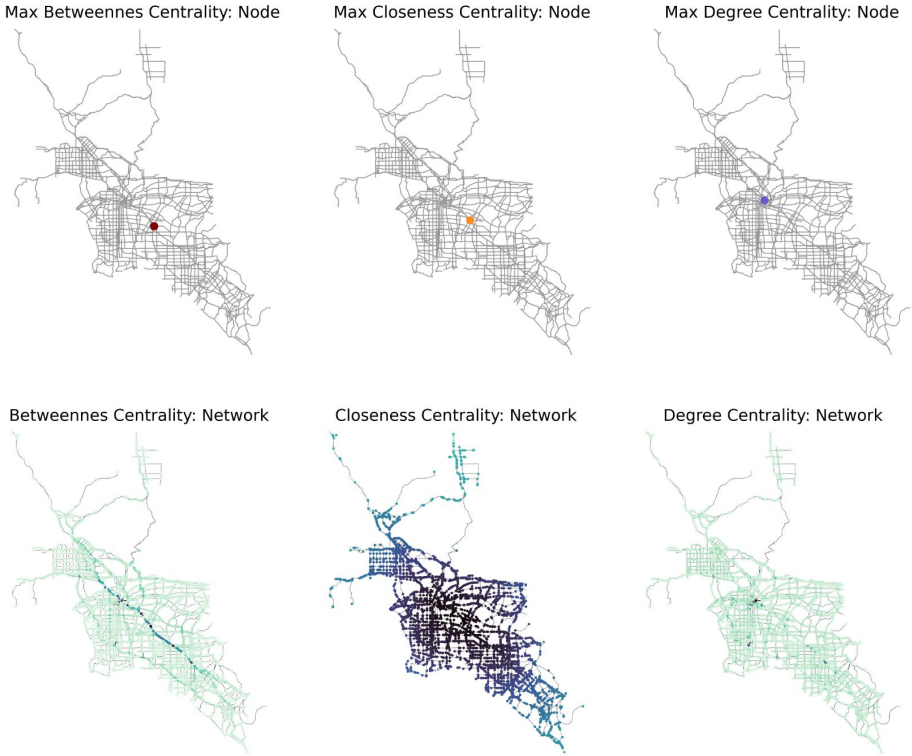


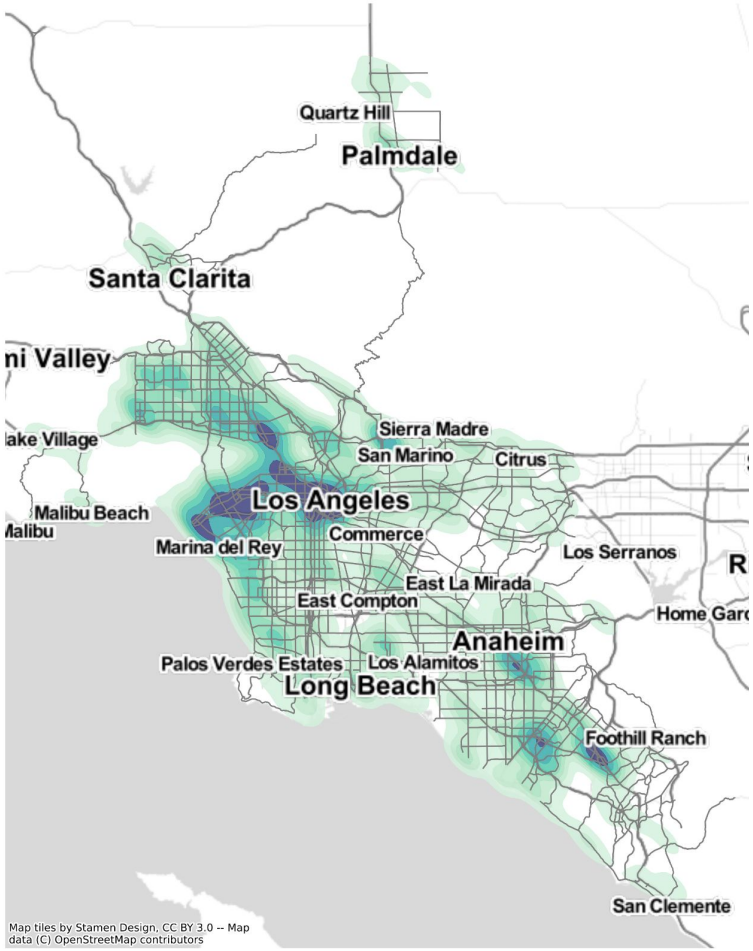
Methods & Results

1. EVCS and Street Network Centrality Approximation
2. EVCS K-Means Clustering Analysis
3. LEHD Traffic Flow Analysis
4. Clusters and EV Ownership

Network Analysis

- **High betweenness** along I-5 freeway through downtown Orange and Los Angeles
  - High utility and network importance and traffic flow
- **High closeness** measure in urban areas
  - Ease to access other nodes with shortest paths consideration
- Degree centrality does not entail much information due to the nature of street networks

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Palmdale
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Sierra Madre
San Marino
Citrus
Los Angeles
Malibu Beach
Malibu
Commerce
Marina del Rey
Los Serranos
East La Mirada
East Compton
Home Garc
Anaheim
Palos Verdes Estates
Los Alamitos
Long Beach
Foothill Ranch
San Clemente
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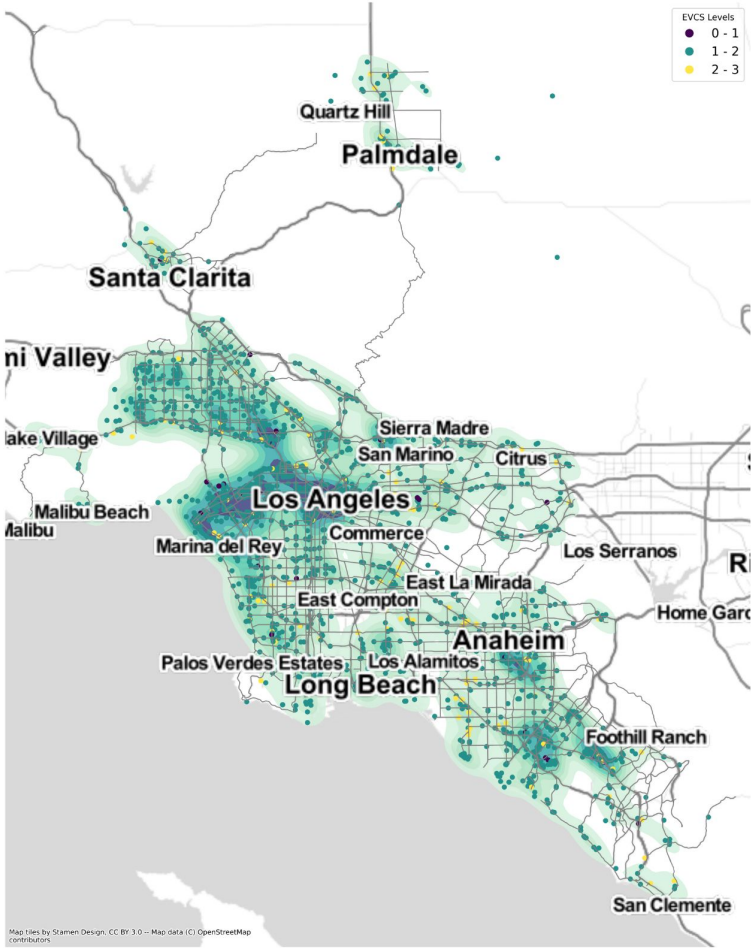
EVCS Levels
0 - 1
1 - 2
2 - 3
Quartz Hill
Palmdale
Santa Clarita
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ake Village
Sierra Madre
San Marino
Citrus
Los Angeles
Malibu Beach
Malibu
Commerce
Marina del Rey
Los Serranos
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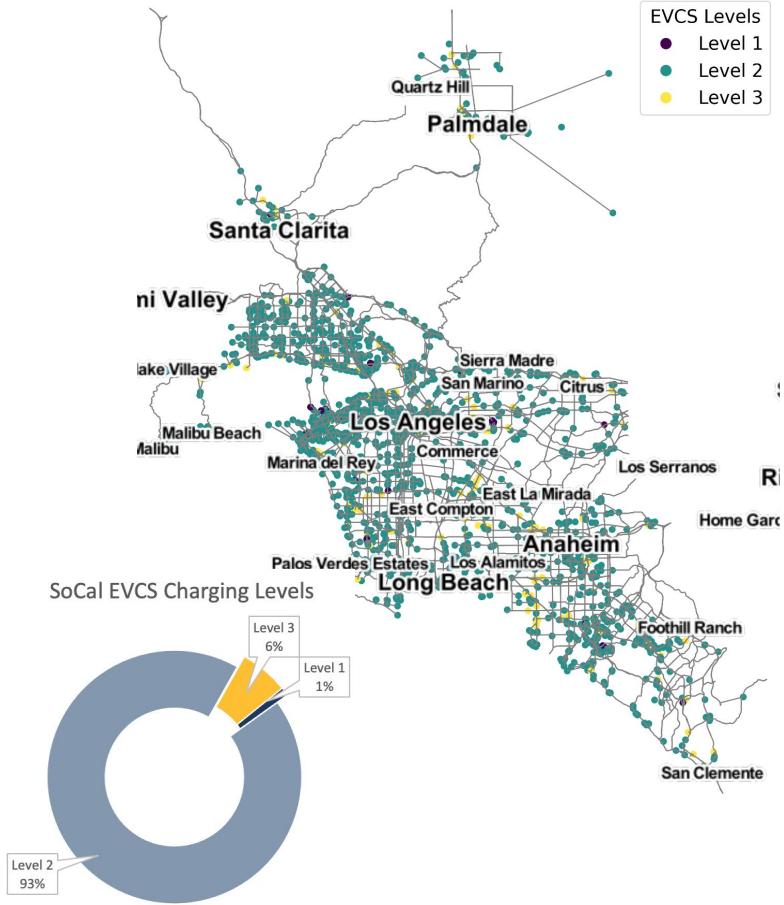
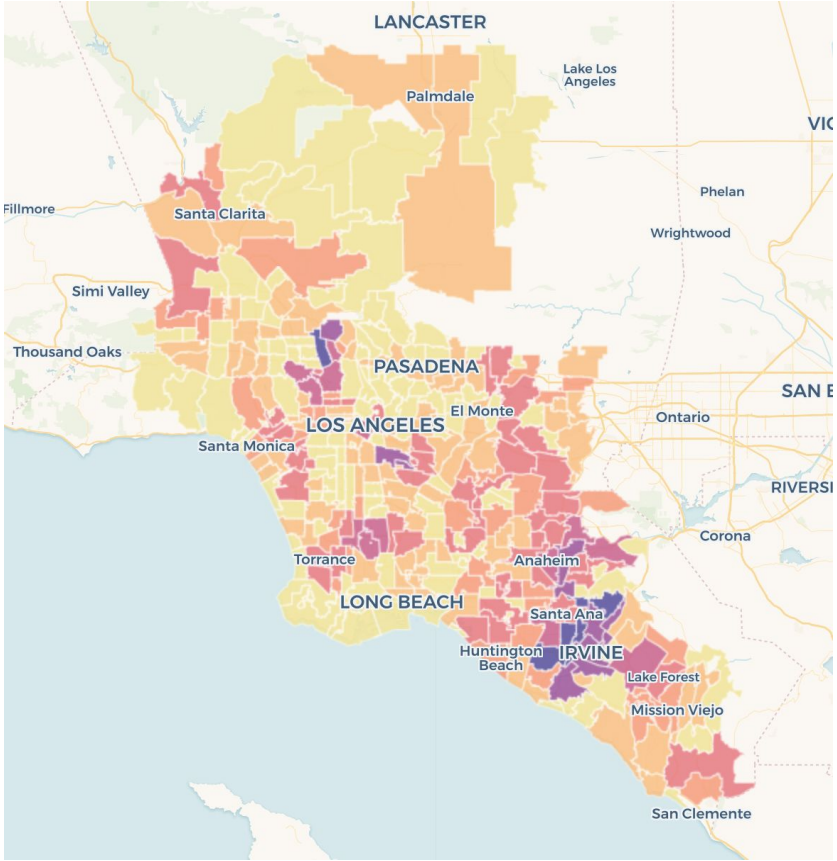
EVCS and Street Network Centrality Approximation

- 3,371 unique EVCS in study region
- Extracted charging levels (Level 1, 2, 3) and power outputs
- Approximating network centrality measures of the EVCS nodes with nearest neighbor approach
  - Compute street node centrality
  - Finding each nearest node of EVCS and extract centrality measures
  - Connect to network with haversince edge distance after projection
- **Extra layer of network importance measures that's inherent to the EVCS in reality but not apparent from available data**



LEHD Origin-Destination Analysis

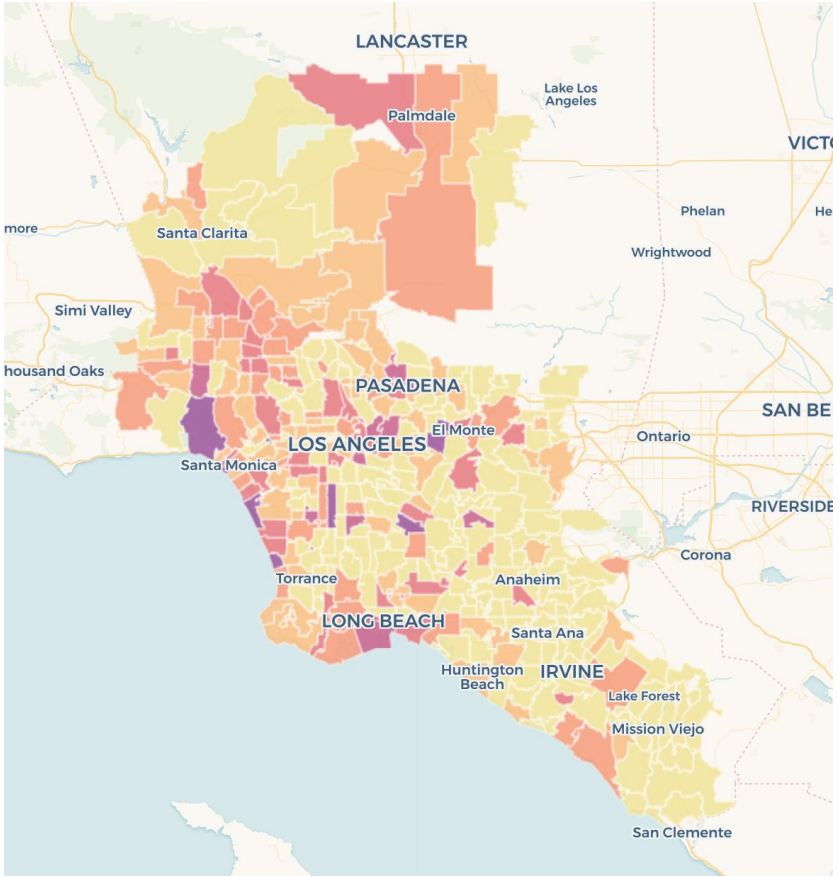
- Hot destination Zip Codes for jobs include NW, Central Los Angeles, and the Irvine area responsible for **3,000-4,000 jobs** per Zip Code
- Zip Codes with low job destinations are North Los Angeles and south of Santa Clarita in the valleys



Number of Destinations for Jobs

LEHD Origin-Destination Analysis

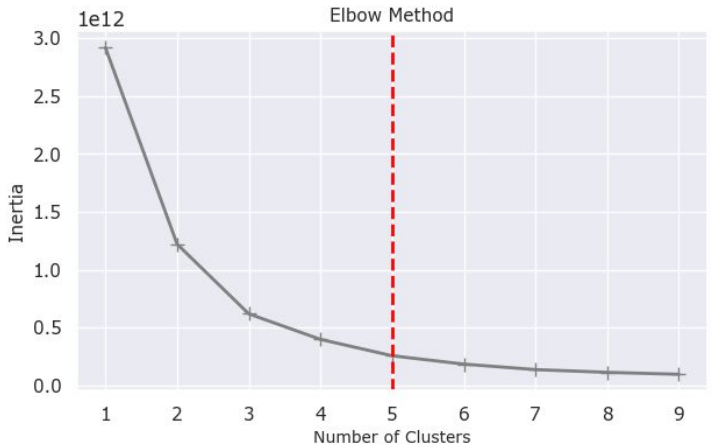
- Charger to Job ratio is highest in West Los Angeles→ **over serving this area**
- Charger to Job ratio low in Orange County area where lots of people are going to for work→ **undeserving this area**

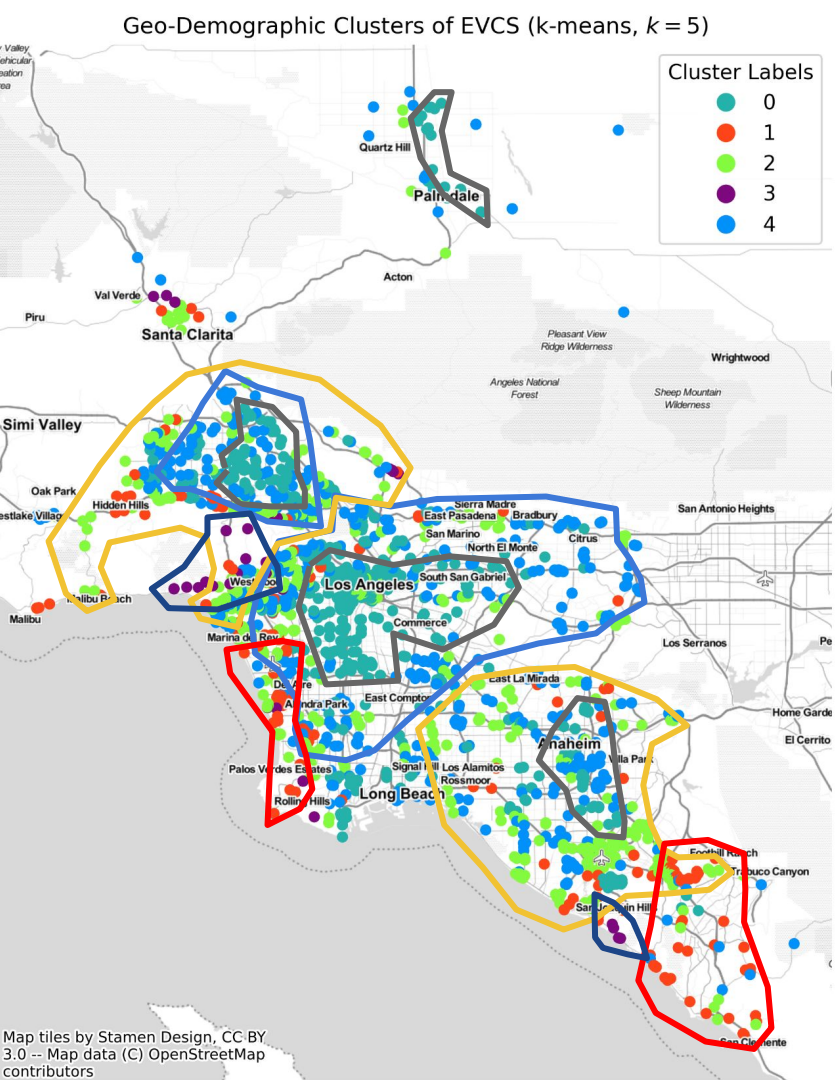


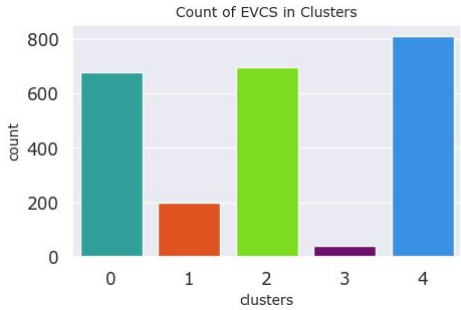
Charger to Job Number Ratio

EVCS K-Means Clustering Analysis

- ACS 2019 census tract data variables
  - % Population by ethnicity,
  - % Education,
  - % Access to vehicles,
  - Median household income,
  - Commute time,
  - Population Median age
- Network centralities
  - Betweenness nearest neighbor approximation
  - Closeness nearest neighbor approximation
- Spatial extrapolate EVCS nodes to census tracts within shape boundaries
- Elbow Method, **k = 5**





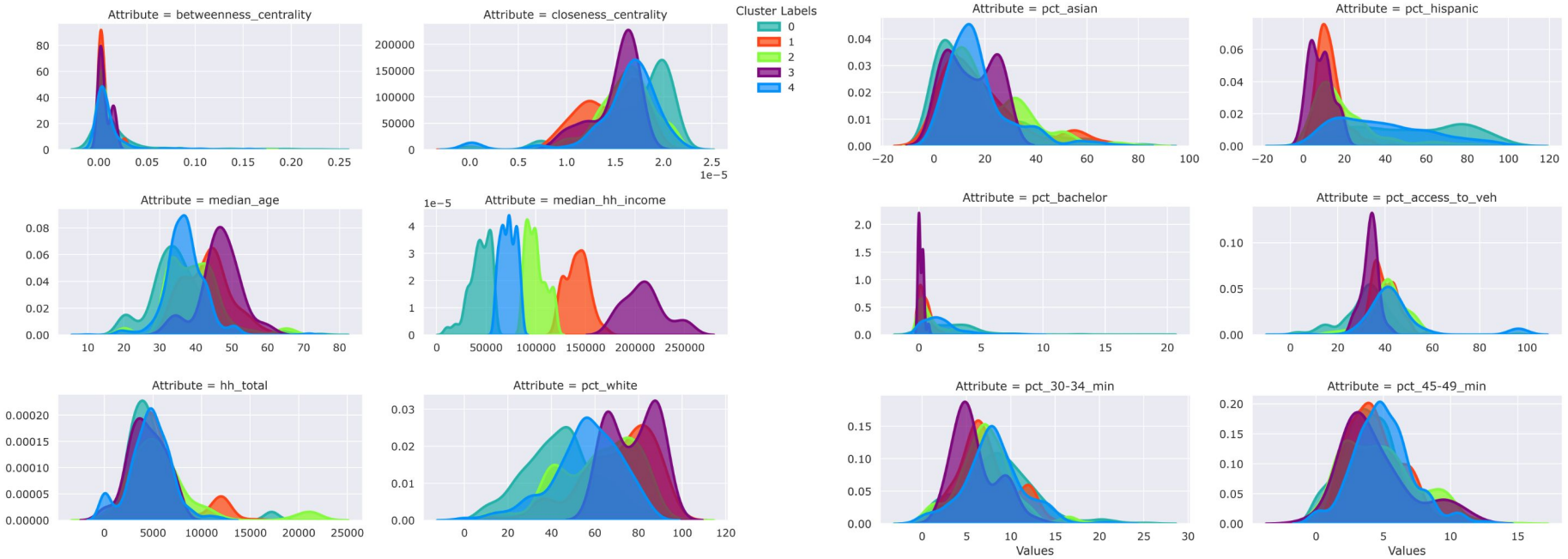


Spatial Clustering

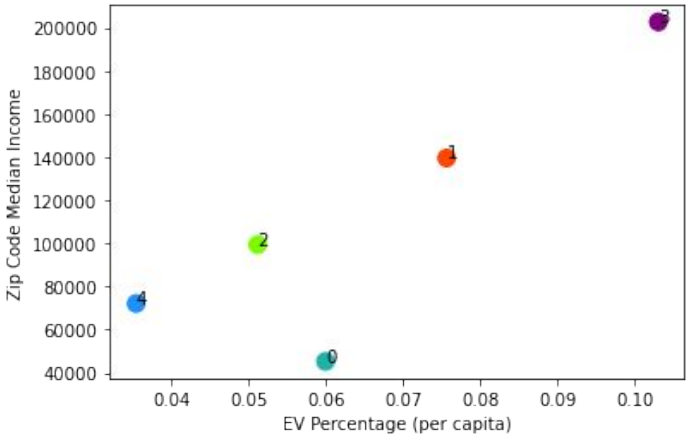
- **Circular "shell" separation** of EVCS nodes within city centers, mainly dominated by census variables

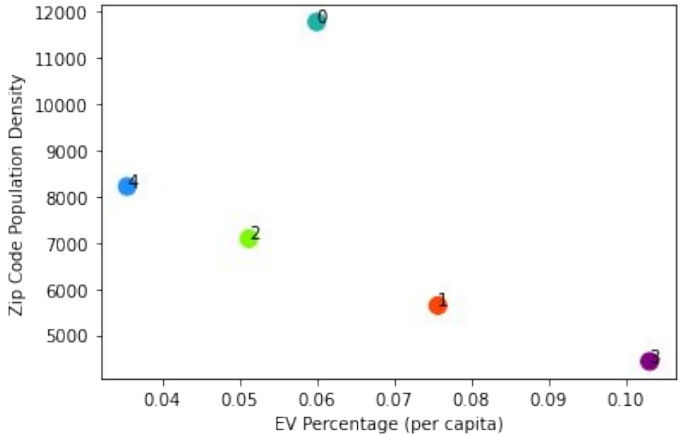
- Downtown: **0**
- Urban - suburbs: **1 and 4**
- Immediate outer edge of cities: **2**
- Beach area: **3**

Clustering Results



Clusters and EV Ownership



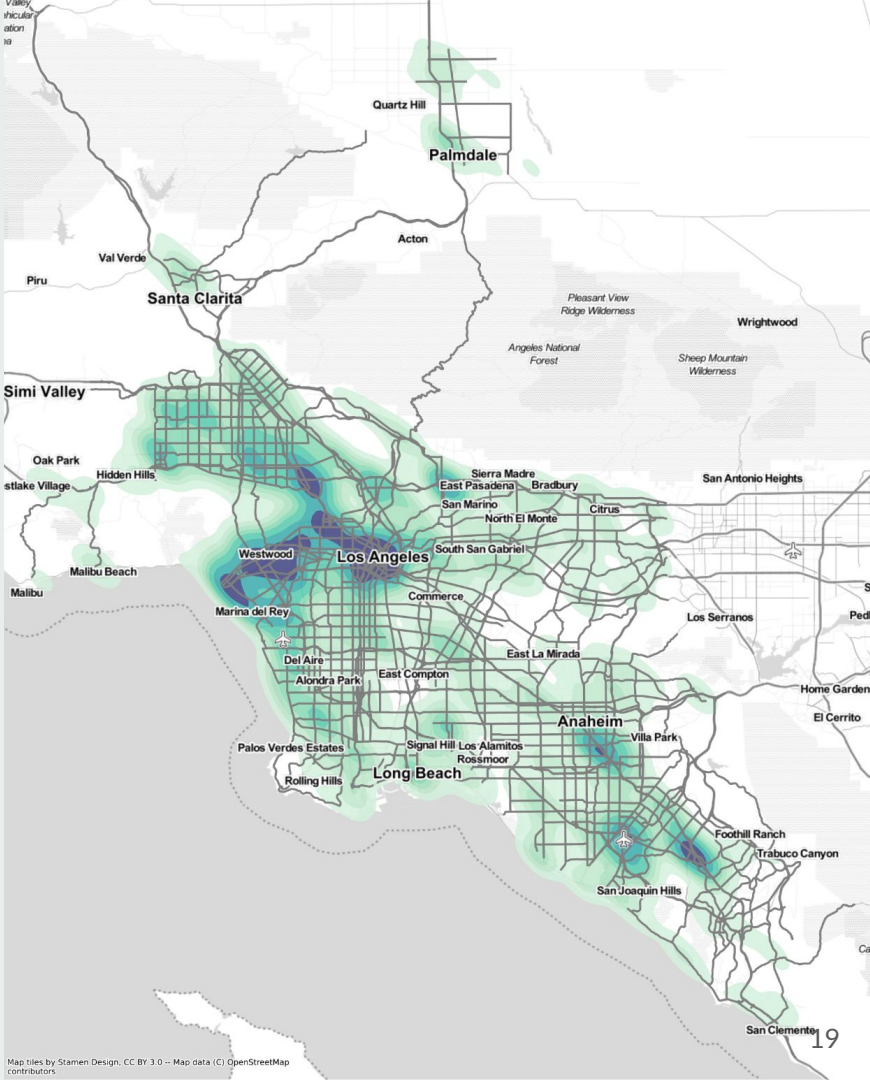


Conclusion

- Initial exploration shows **unequal distribution of wealth and certain demographic attributes** related to density of EVCS
- Chargers are currently **under-serving/over-serving** some neighborhoods in Southern California
- EV adoption is **limited and driven by EV infrastructure**
- Further analysis needed on improving EV adoption in **different population income groups** by adding more EV infrastructure and purchasing incentives
- Analysis done here can be repeated anywhere **to determine where future charging stations should installed to promote EV adoption equitably**

Thank You!

Time for Q&A!



Appendix: Interesting EVCS + Census Tract Findings

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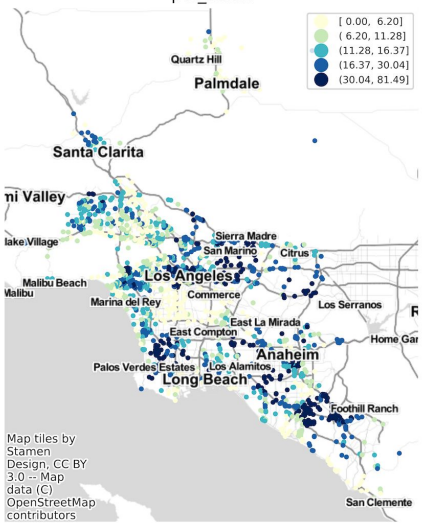

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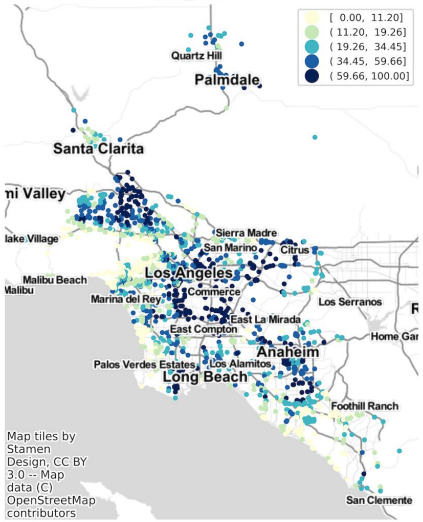

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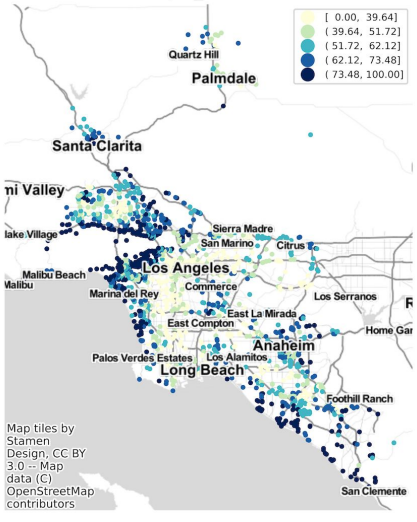

Charging Stations Distribution