Fire Emergencies in Seattle

Correlations with Human Activity and Rain Patterns

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supervised by

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Springboard

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Motivation

Can we identify trends in 911 fire calls in Seattle?
Can we find patterns, or correlate them with factors such as rain patterns?

Outline

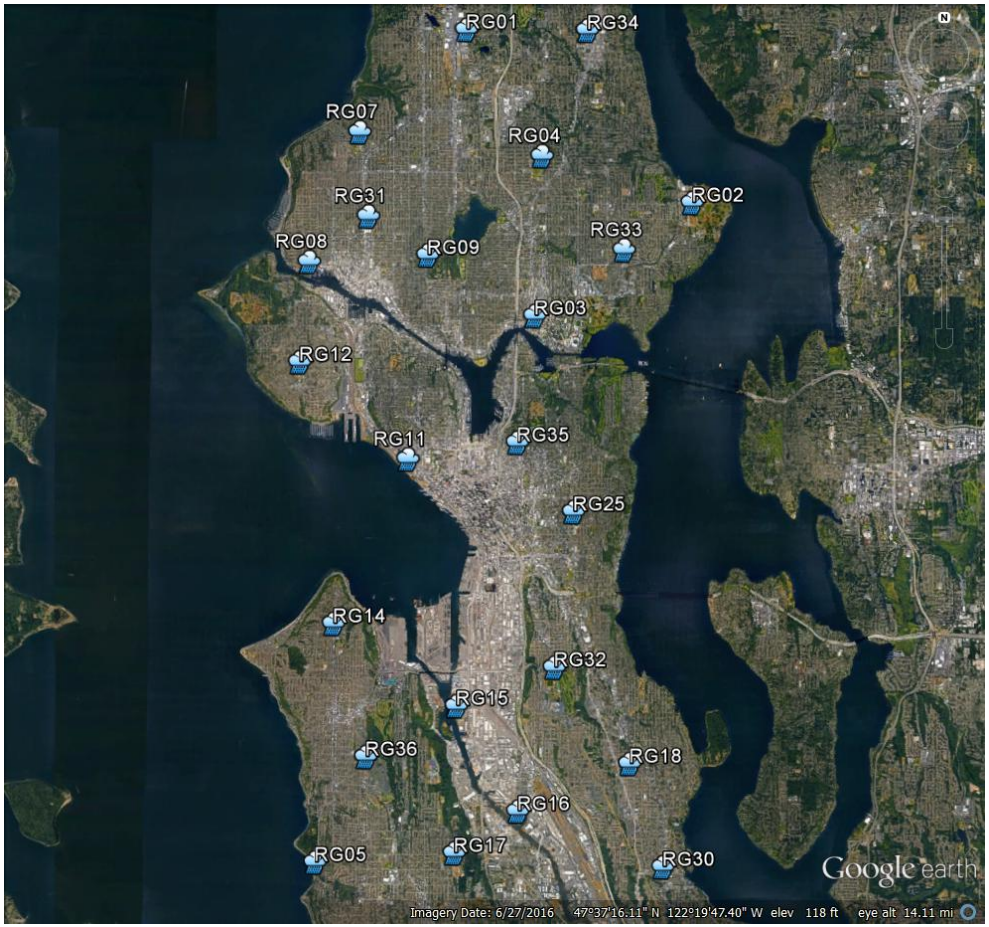
1. Sources and Data Sets
2. EDA Findings and Analysis
3. Machine Learning Analysis
   - Clustering Location only
   - Clustering with PCA
   - Clustering without PCA
4. Concluding Remarks

Sources and Data Sets

- Seattle Monthly Rain Gauge Accumulations [1]
- Seattle Fire 911 Calls in 2010 and 2011 [2]
- Washington State Holidays in 2010 and 2011 [3, 4]

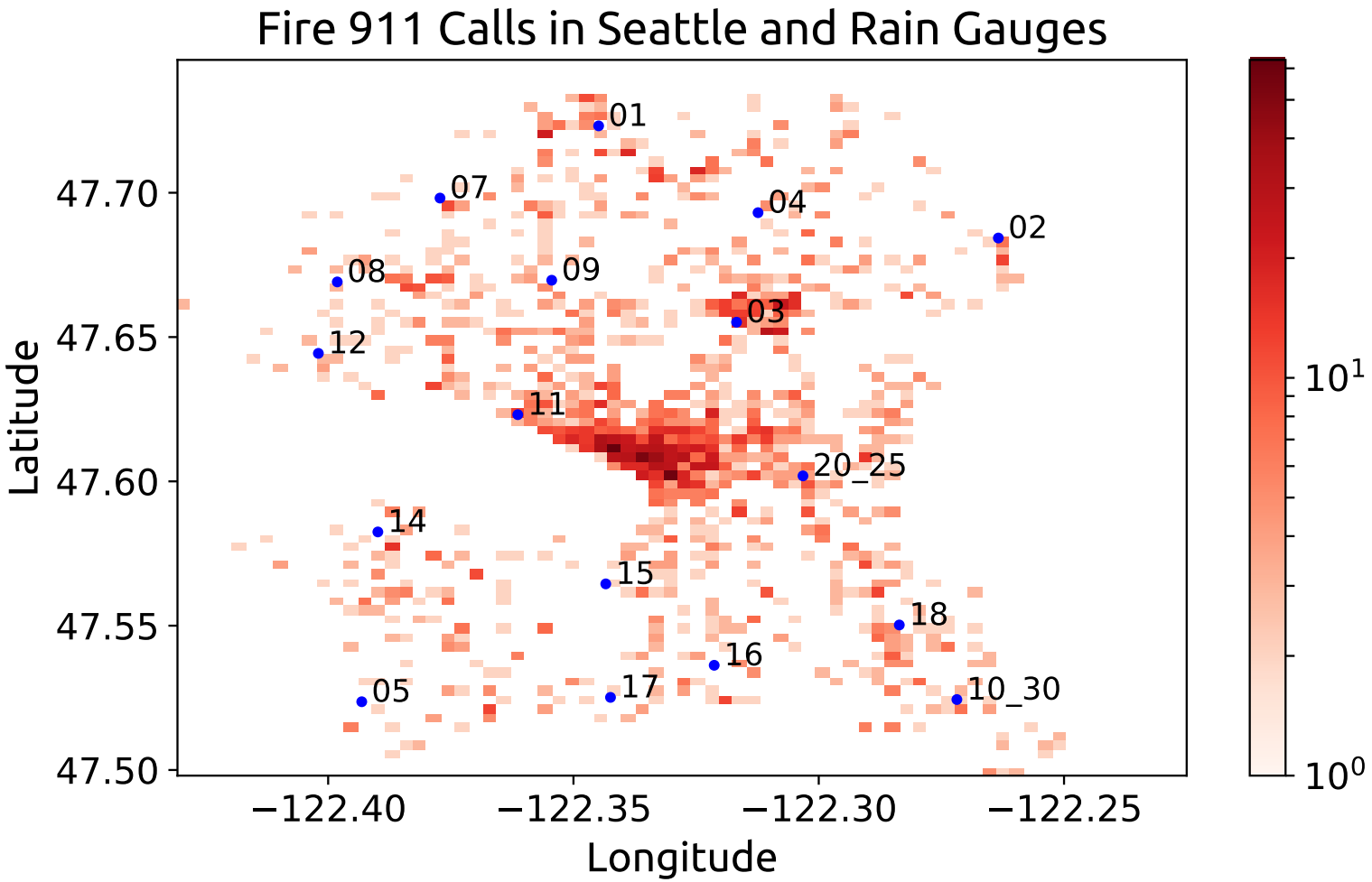
Sources and Data Sets

- Seattle Monthly Rain Gauge Accumulations [1]



Sources and Data Sets

- Seattle Fire 911 Calls in 2010 and 2011 [2]



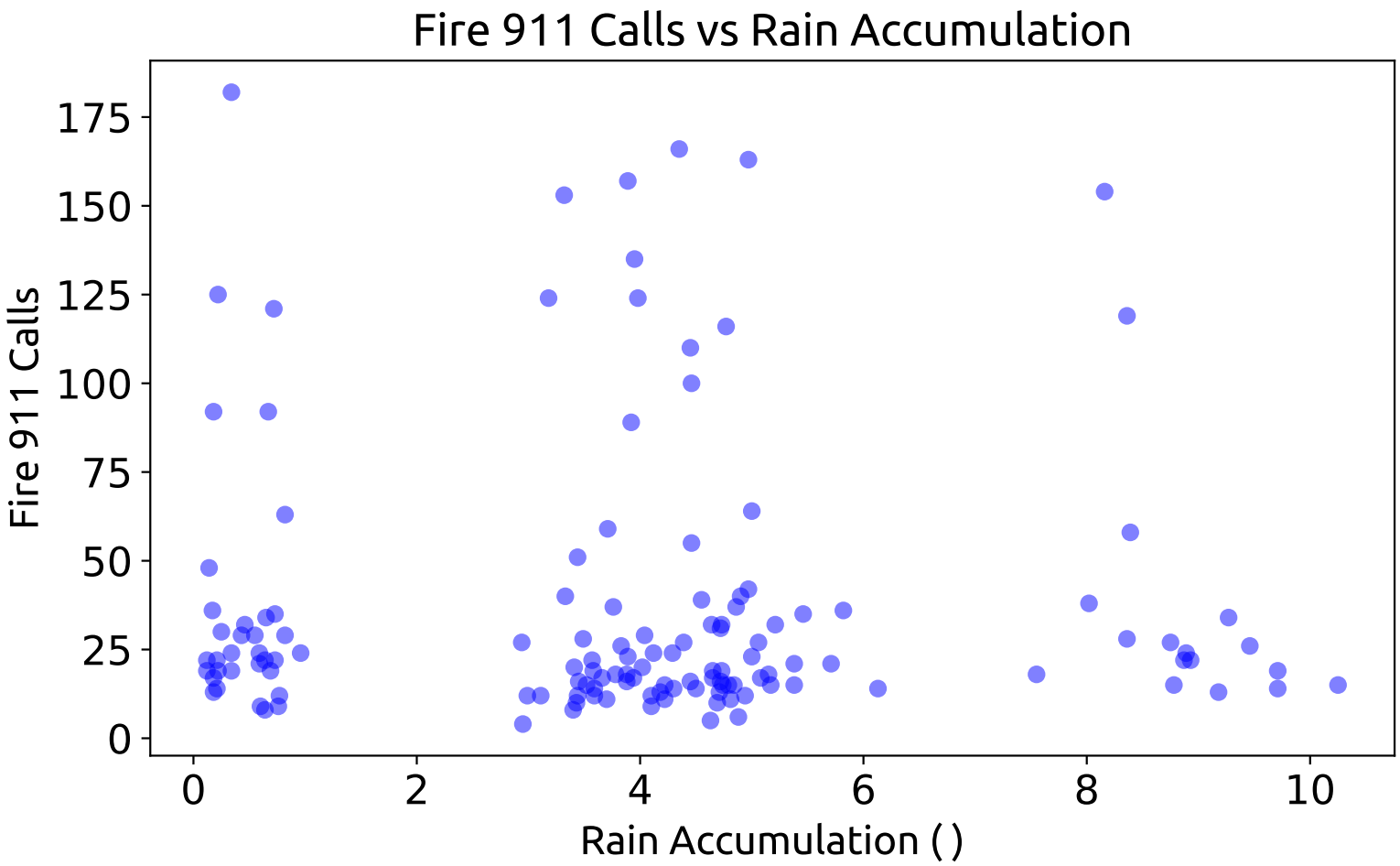
Sources and Data Sets

- Washington State Holidays in 2010 and 2011 [3, 4]

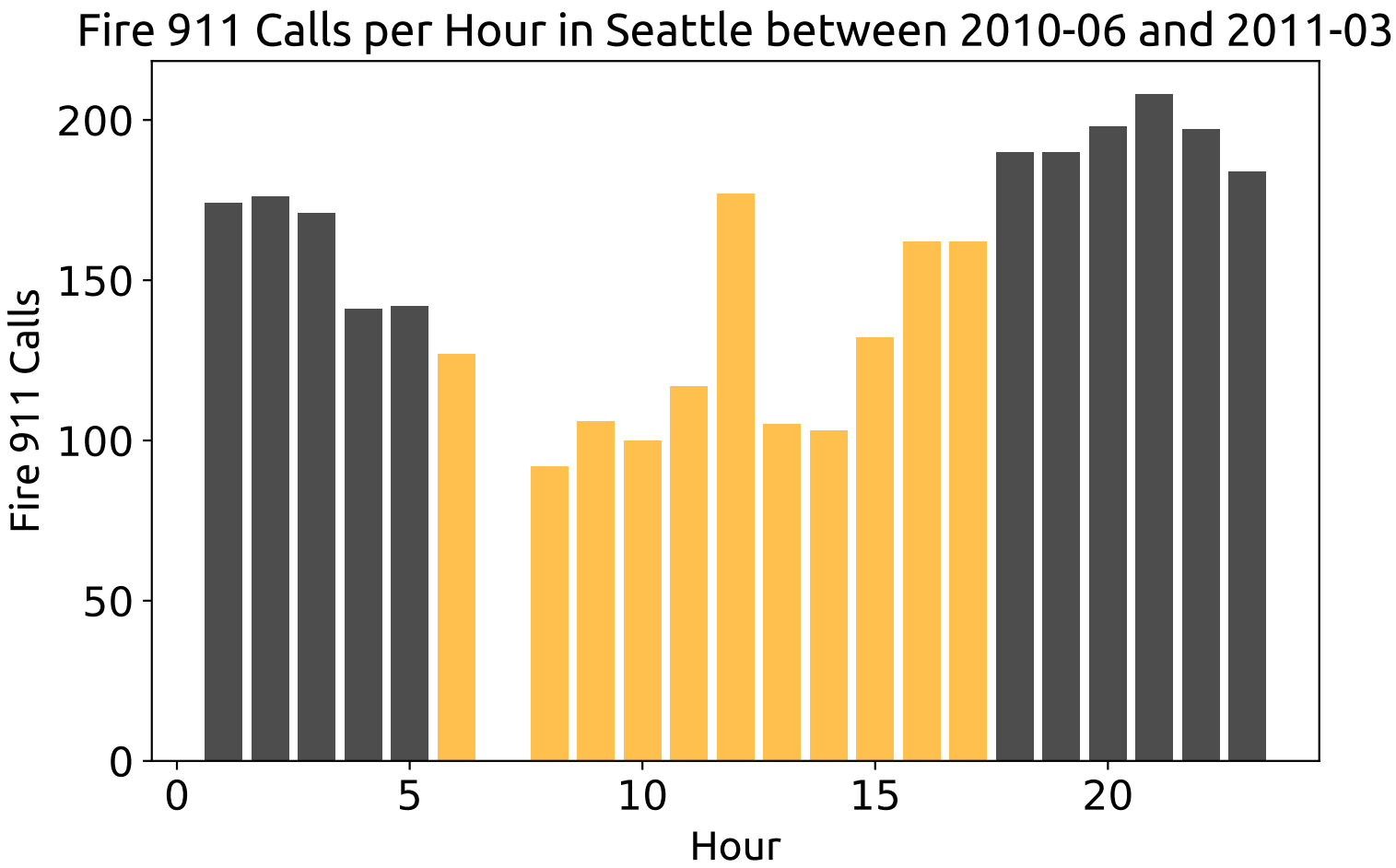
Holidays and Weekends accounted for 31.6% of 2010 and 2011.

Are there more fires on off days?

EDA Findings and Analysis: Rain and Fire



EDA Findings and Analysis: Time of the Day and Fire

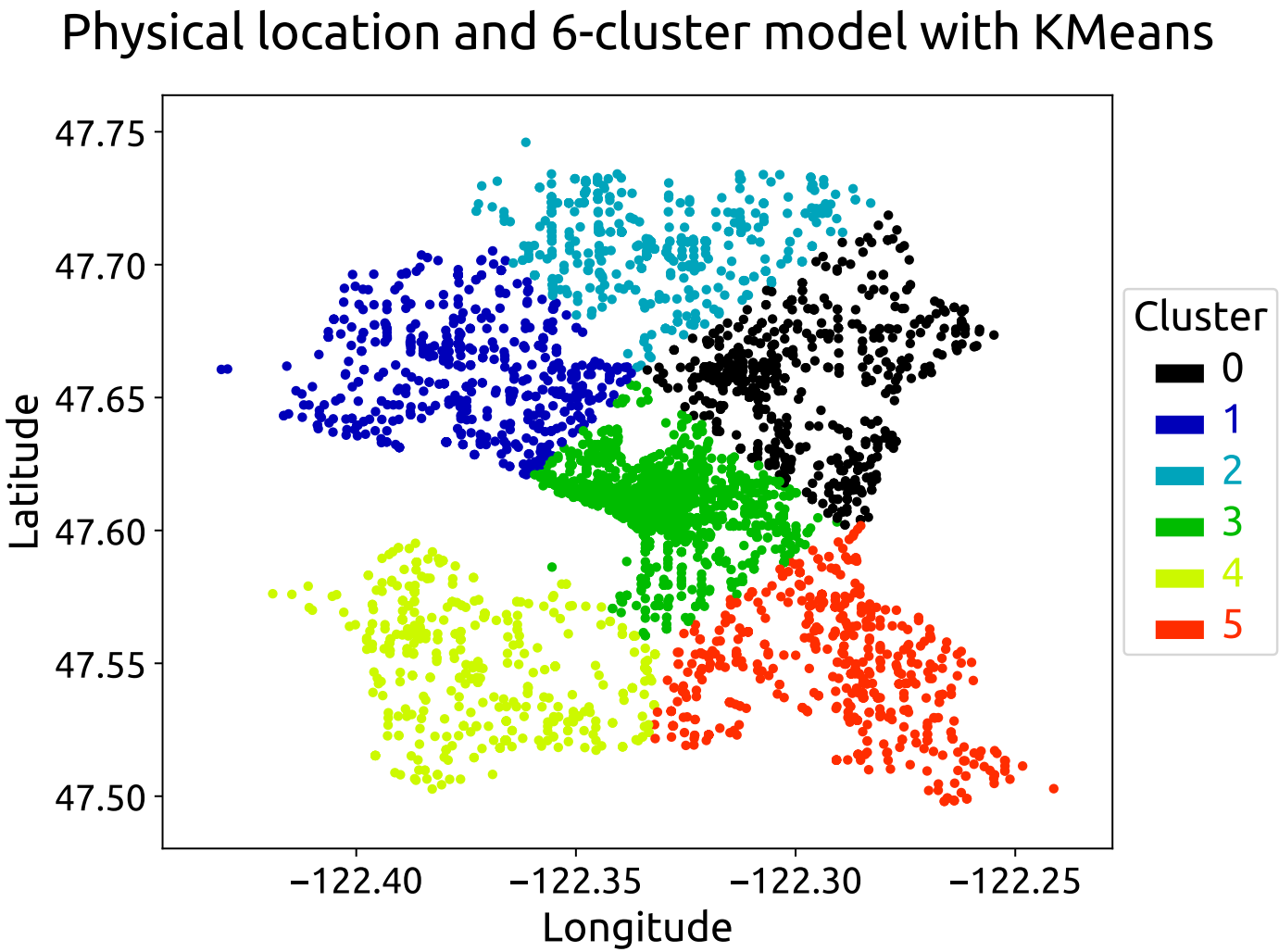


Implemented Clusterings

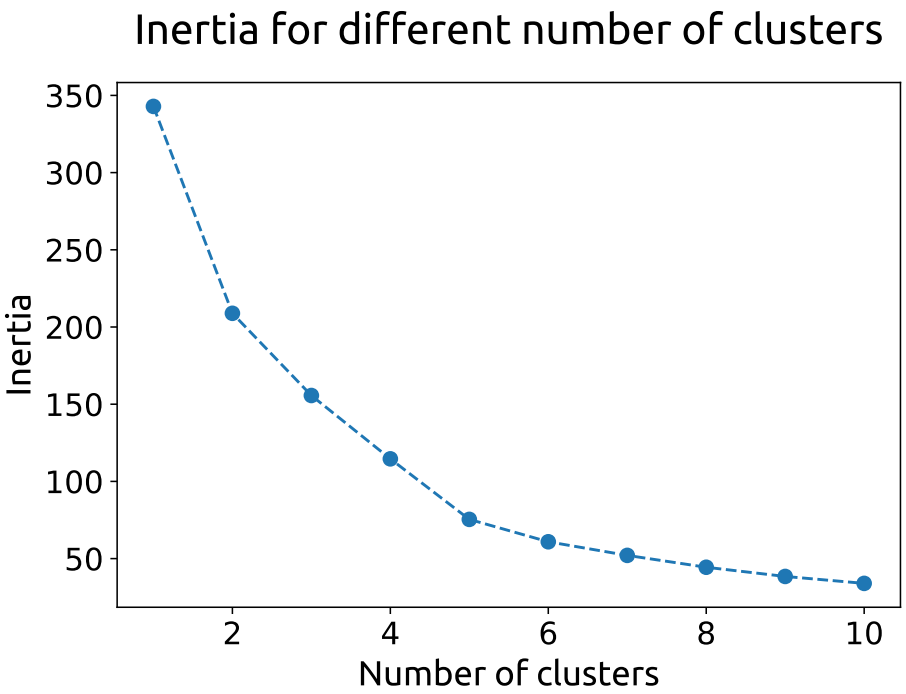
- Only on `Longitude` and `Latitude`: `MinMaxScaler` + `KMeans`.
- `PCA` dimensional reduction with and without previously scaling with `StandardScaler`. `MinMaxScaler` + `KMeans` on the projected 2D and 3D data.
- All data without PCA: `MinMaxScaler` + `KMeans`.

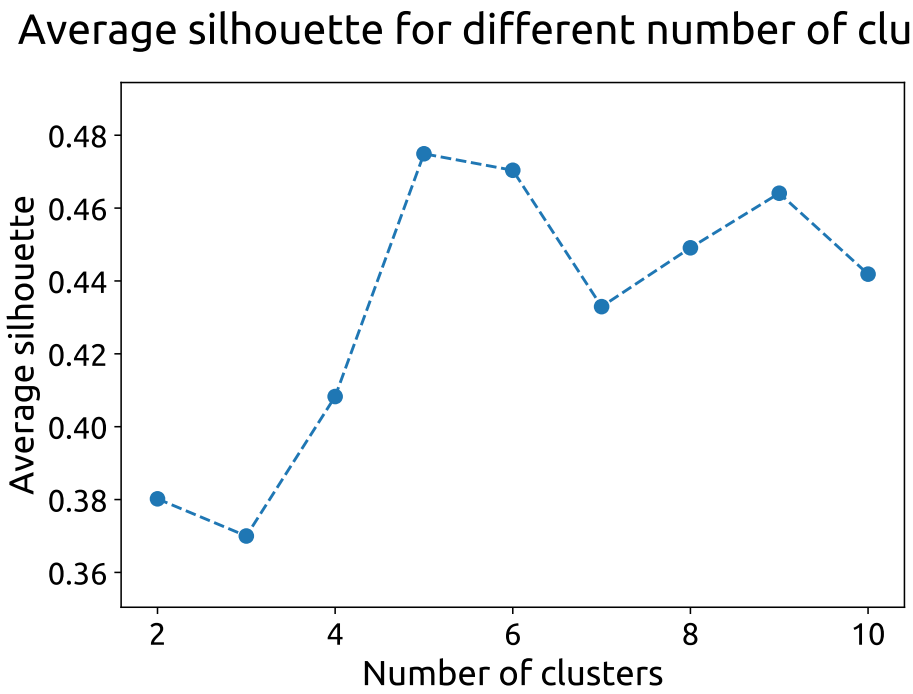
We decide the ideal k using inertia, silhouette, gap statistic and the gap criterium of Tibshirani, Walther, Hastie, 2002 [5].

Sectorizing the City

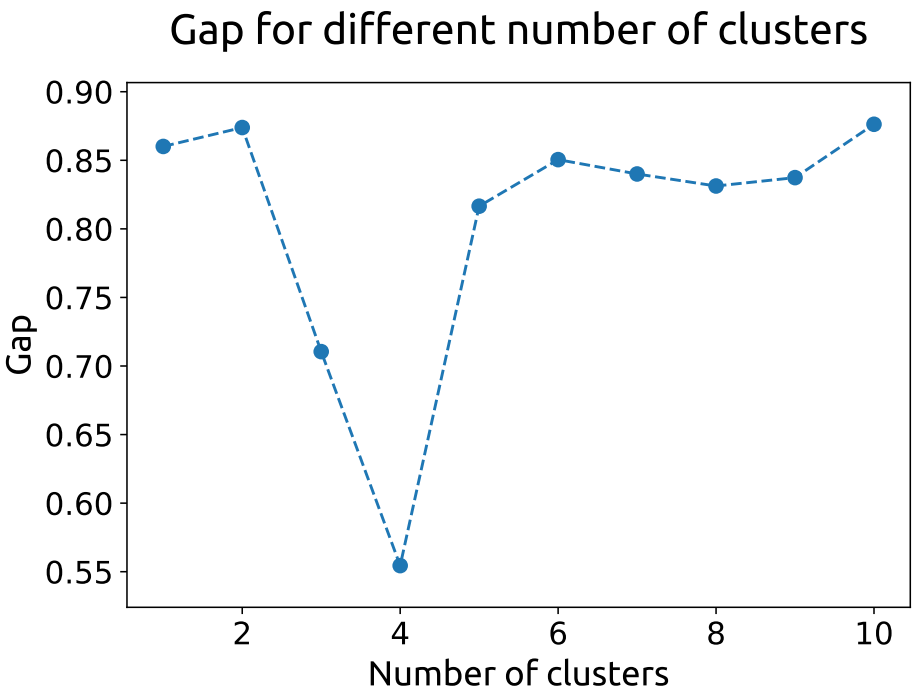


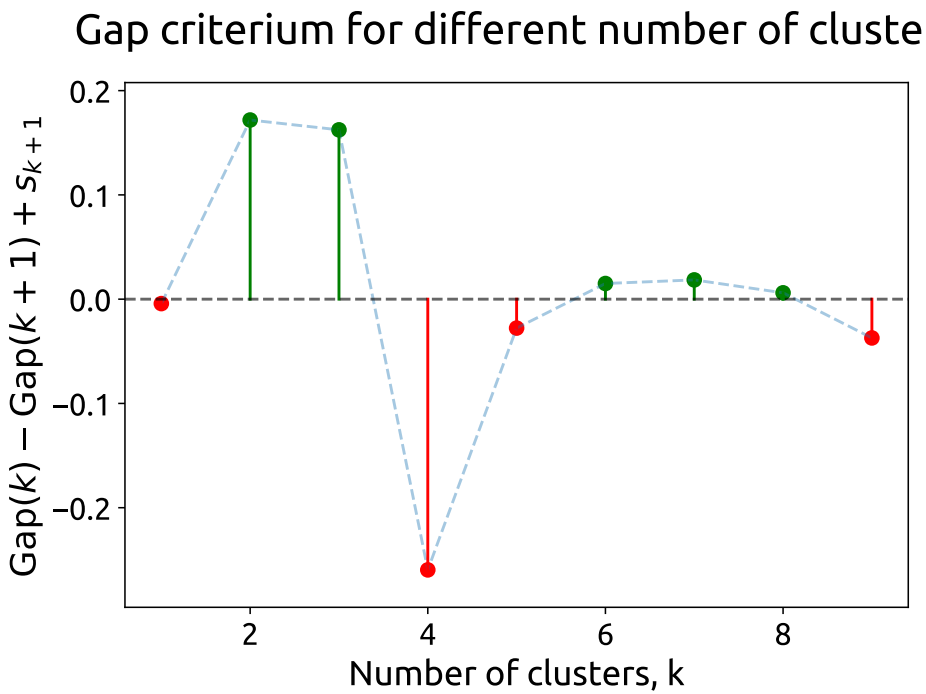
Inertia and average silhouette





Gap and Gap criterium

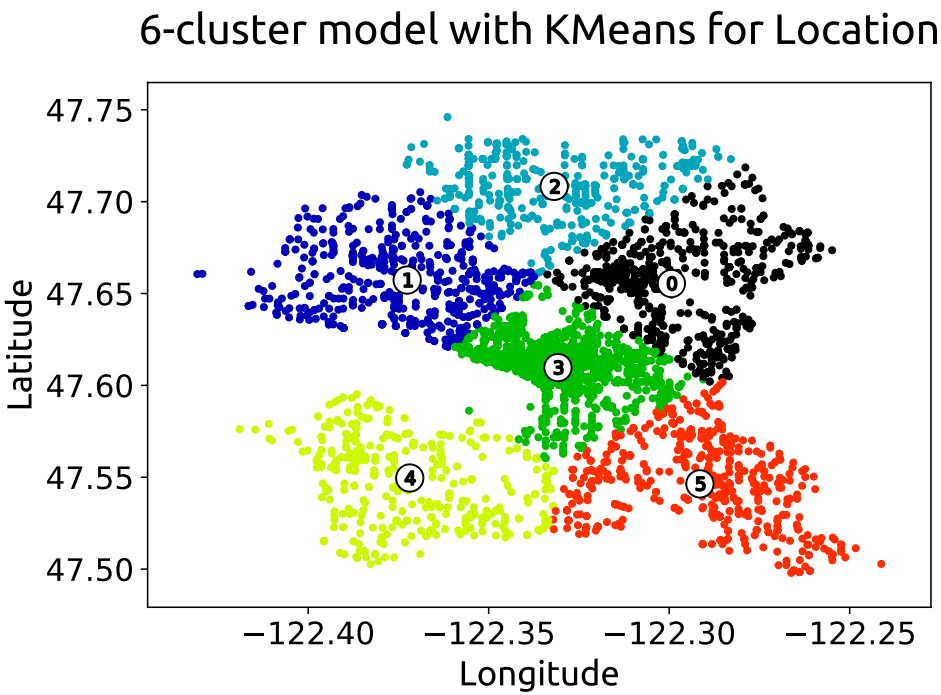


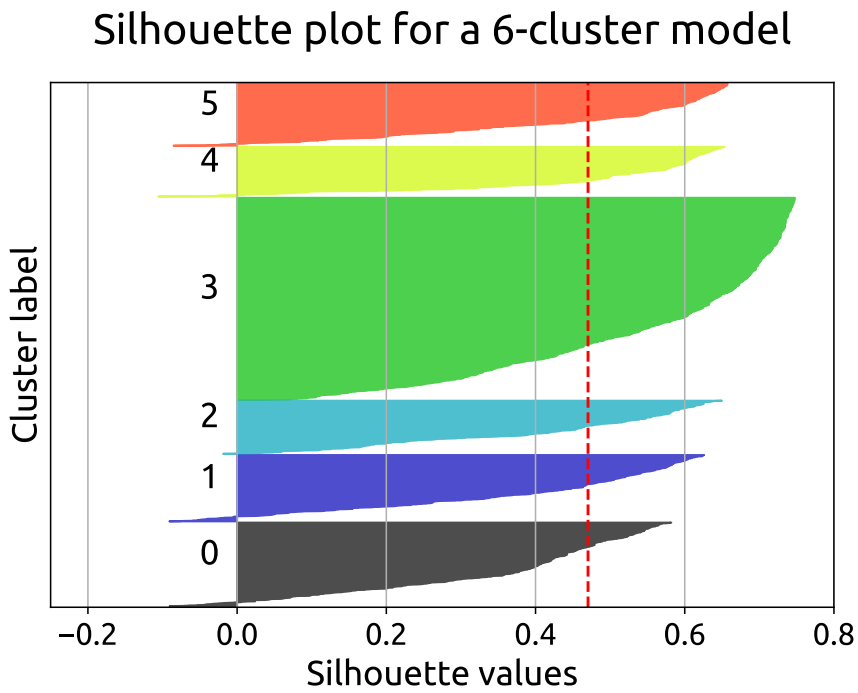


From [5]: Best k is the lowest one that satisfies

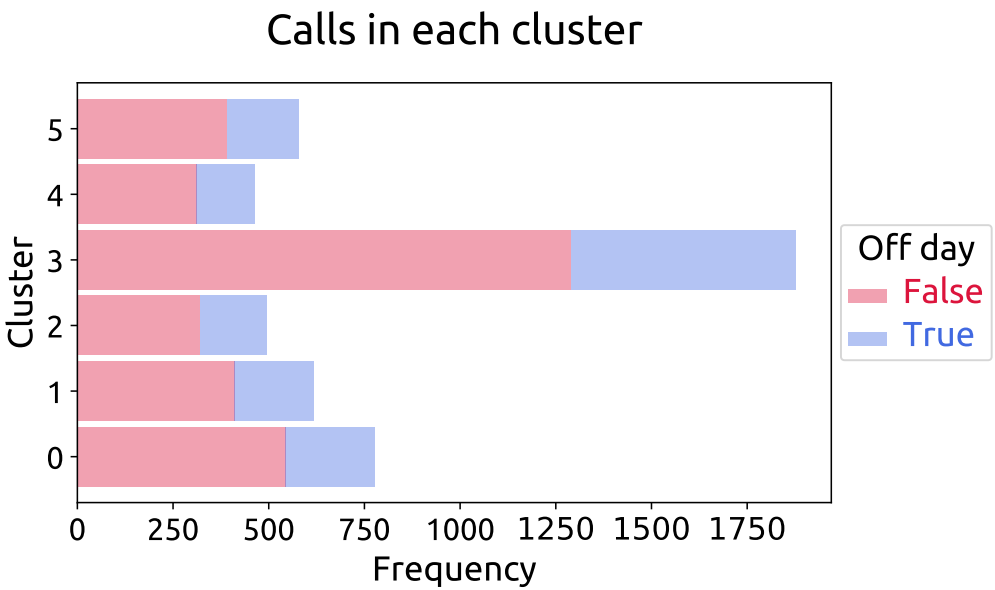
$$\mathrm{Gap}(k) - \mathrm{Gap}(k+1) + s_{k+1} \geq 0\,. \qquad (1)$$

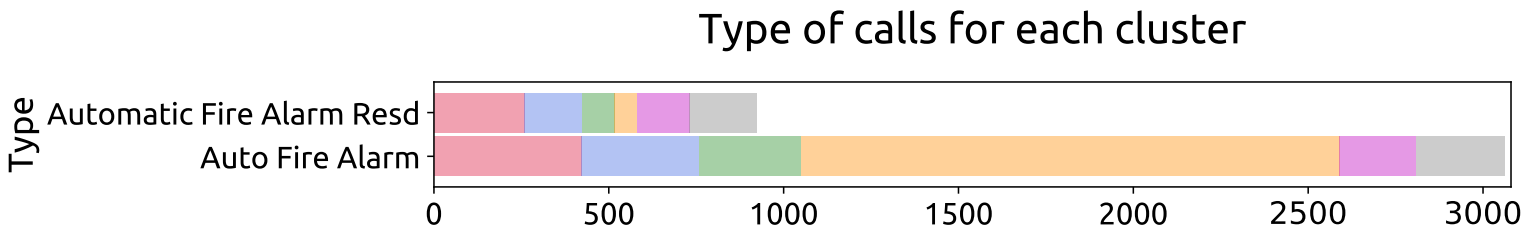
Silhouette Plot



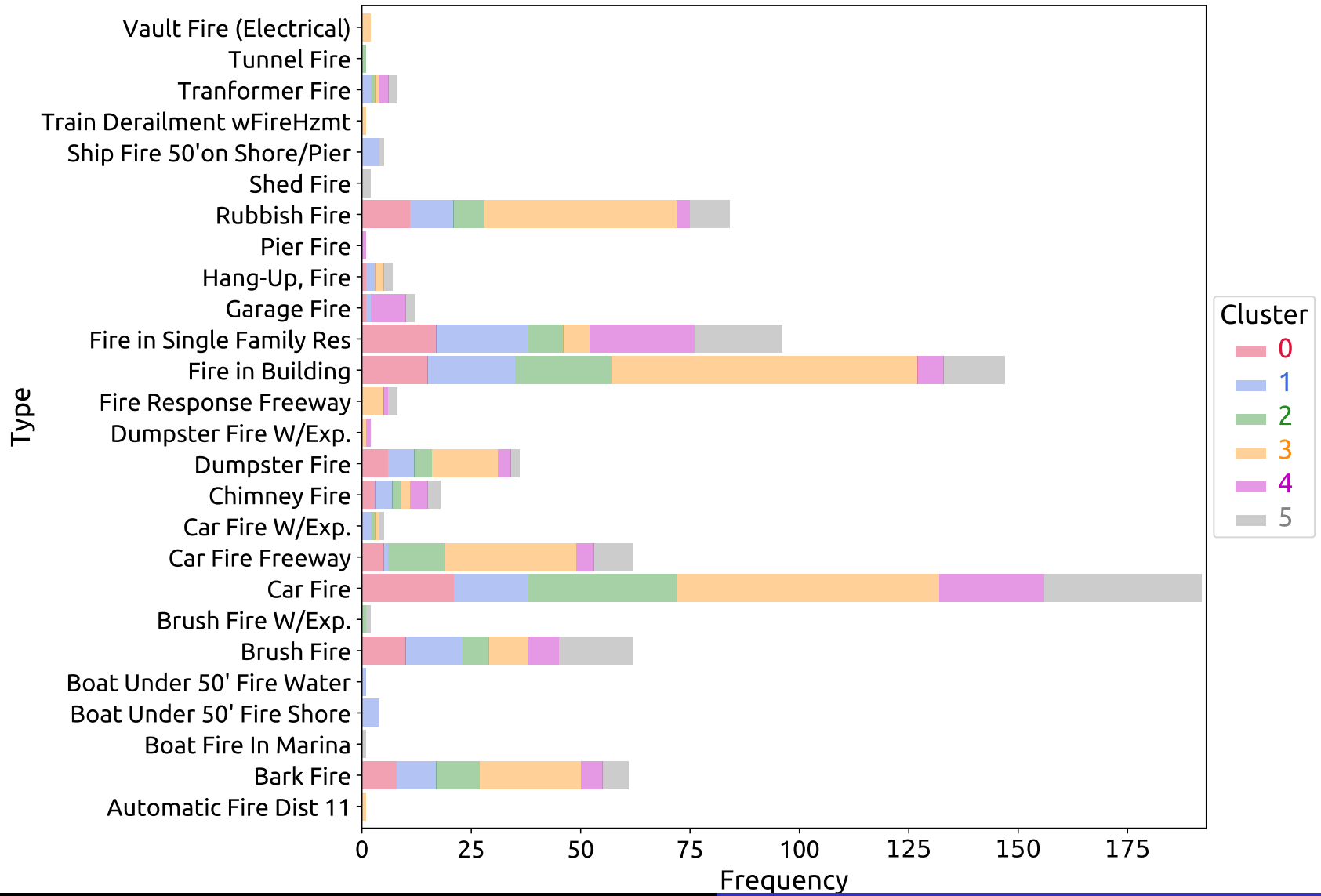


Location Clustering in other Features I



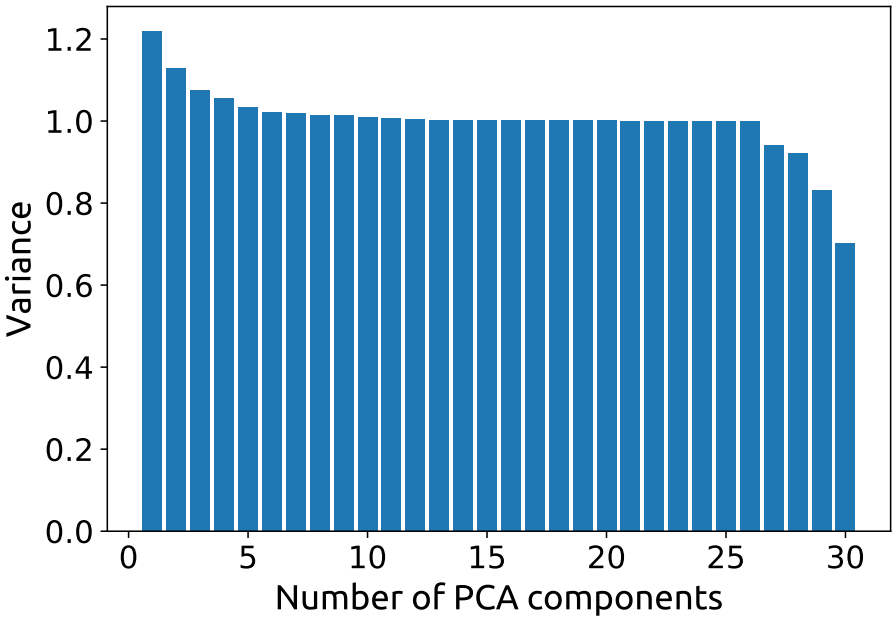


Location Clustering in other Features II

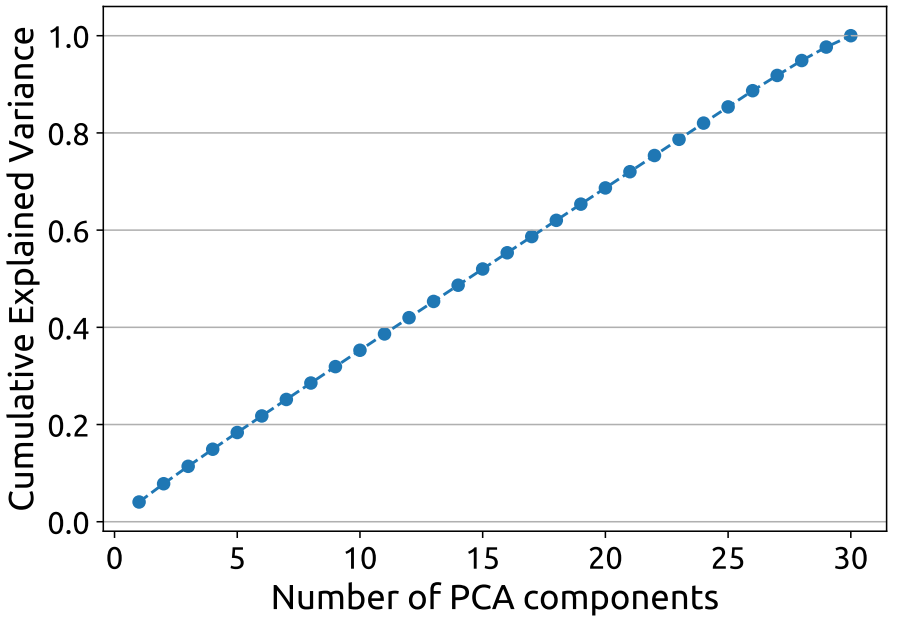


Clustering with PCA: With Previous Scaling

Variance for different number of PCA dimensions

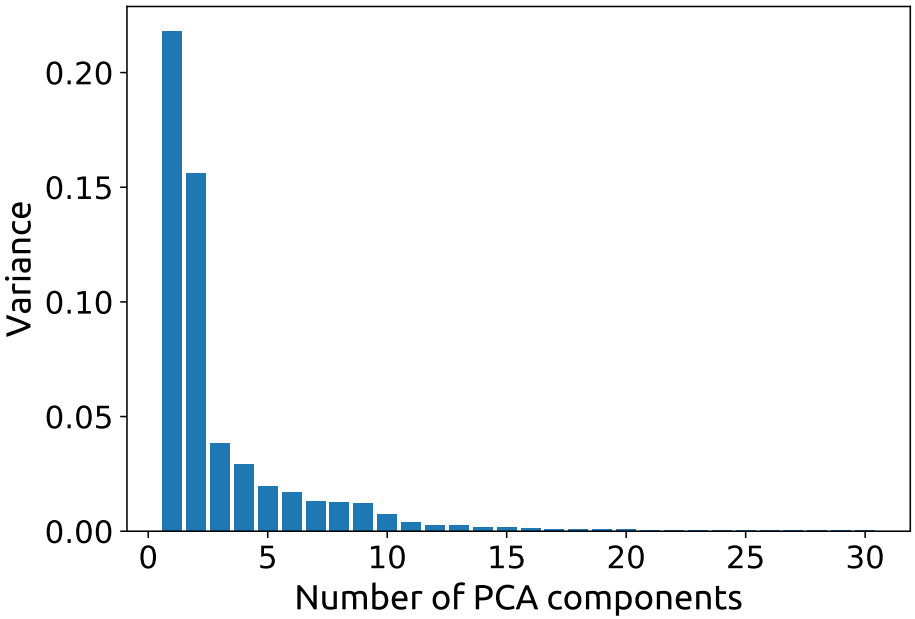


CEV for different number of PCA dimensions

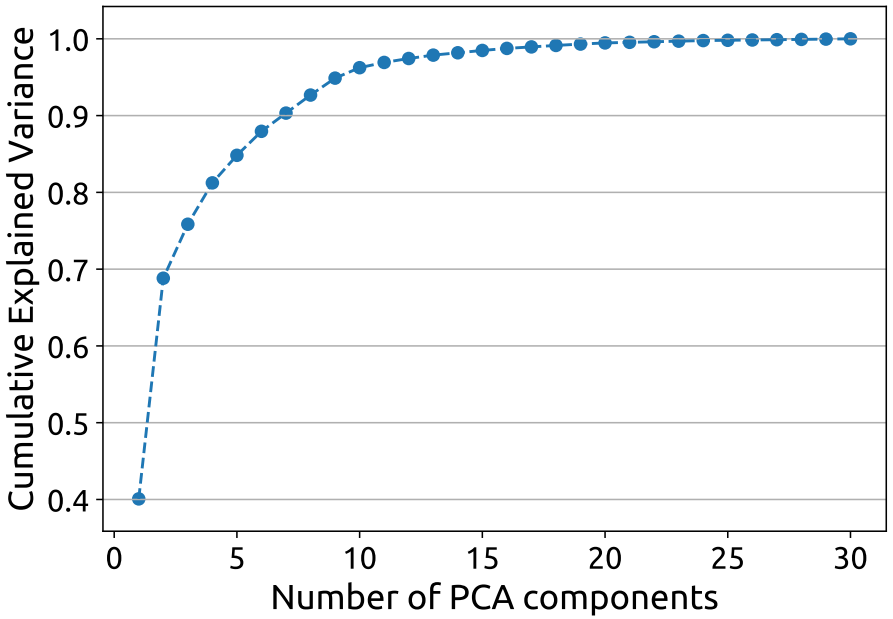


Clustering with PCA: Without Previous Scaling

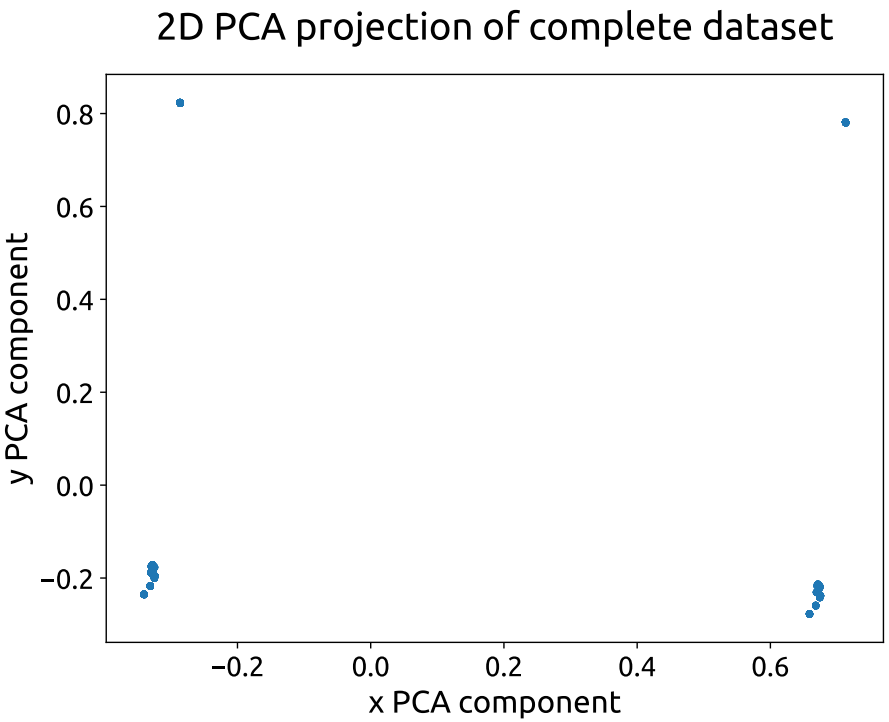
Variance for different number of PCA dimensions

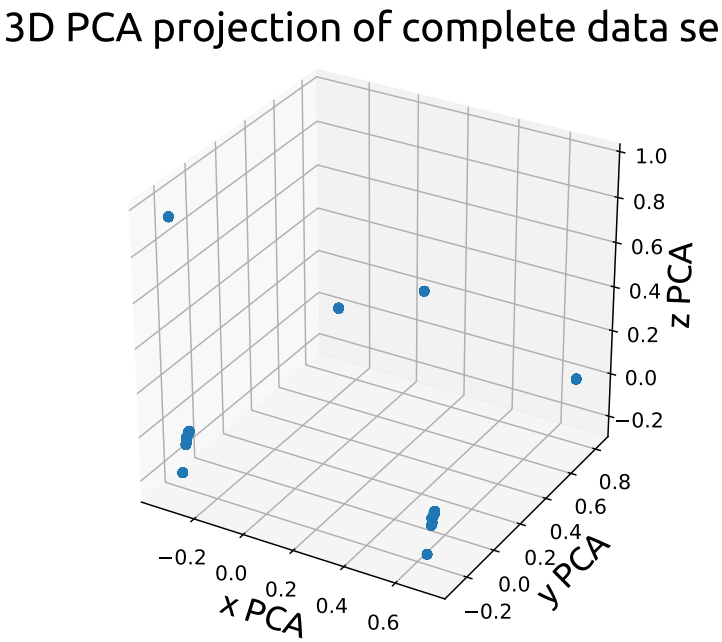


CEV for different number of PCA dimensions

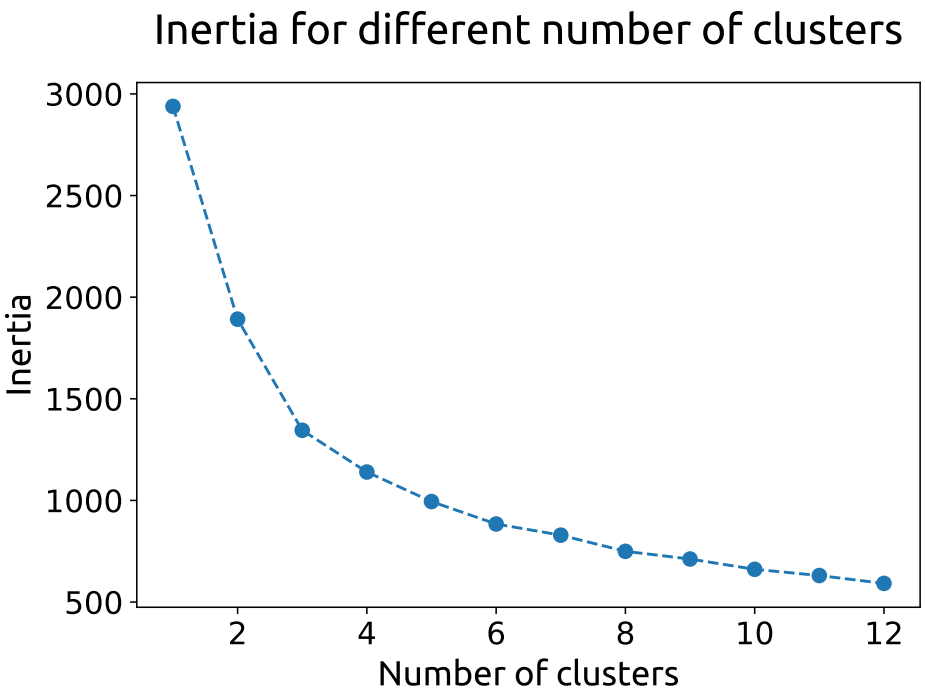


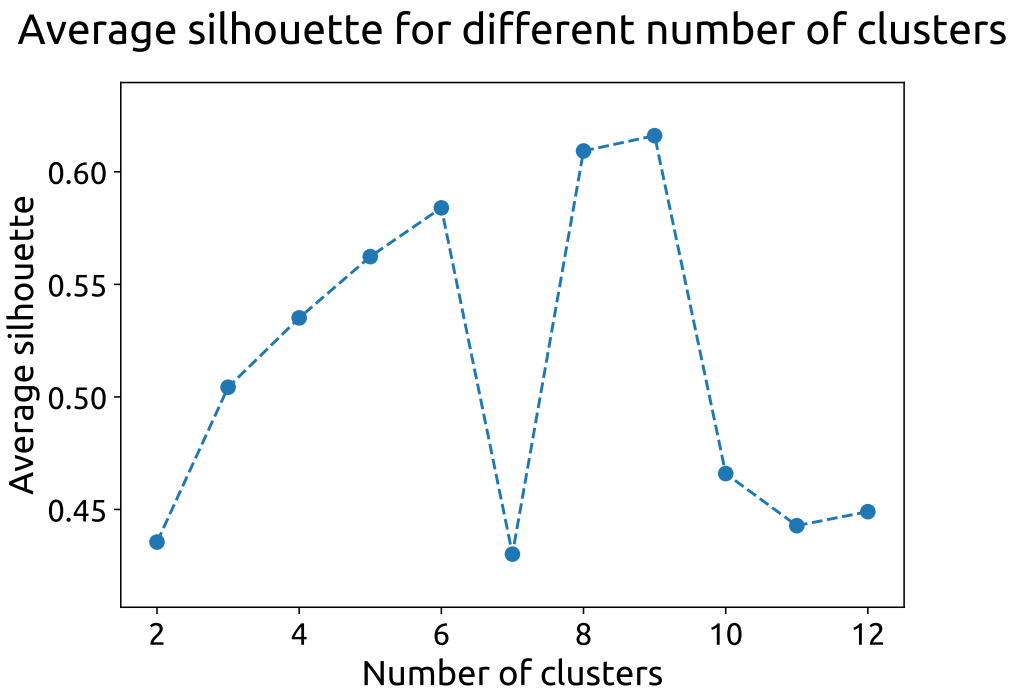
Clustering with PCA: 2D and 3D



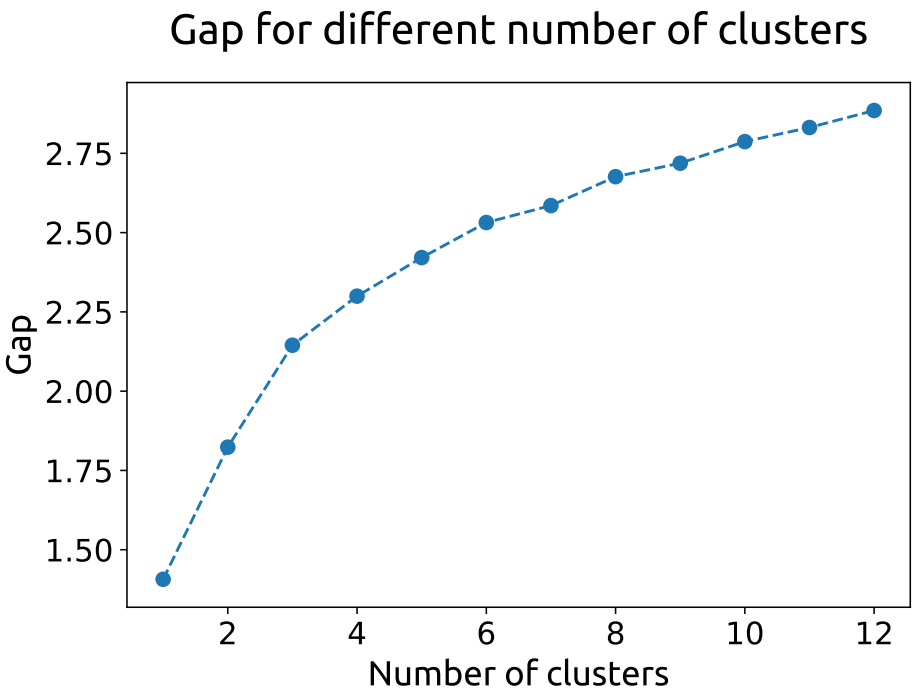


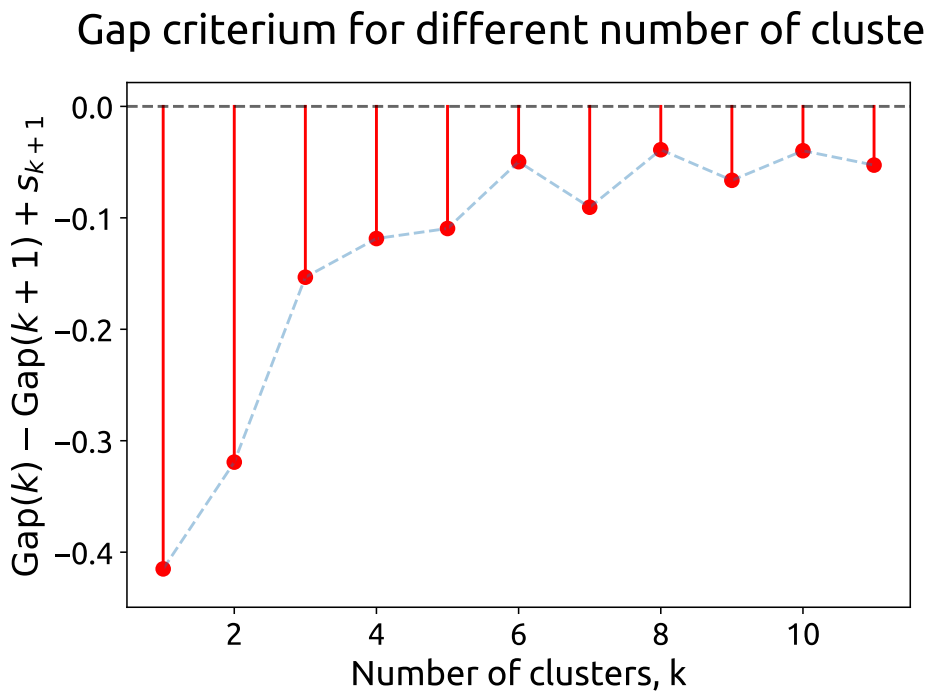
Clustering without PCA: Inertia and average silhouette





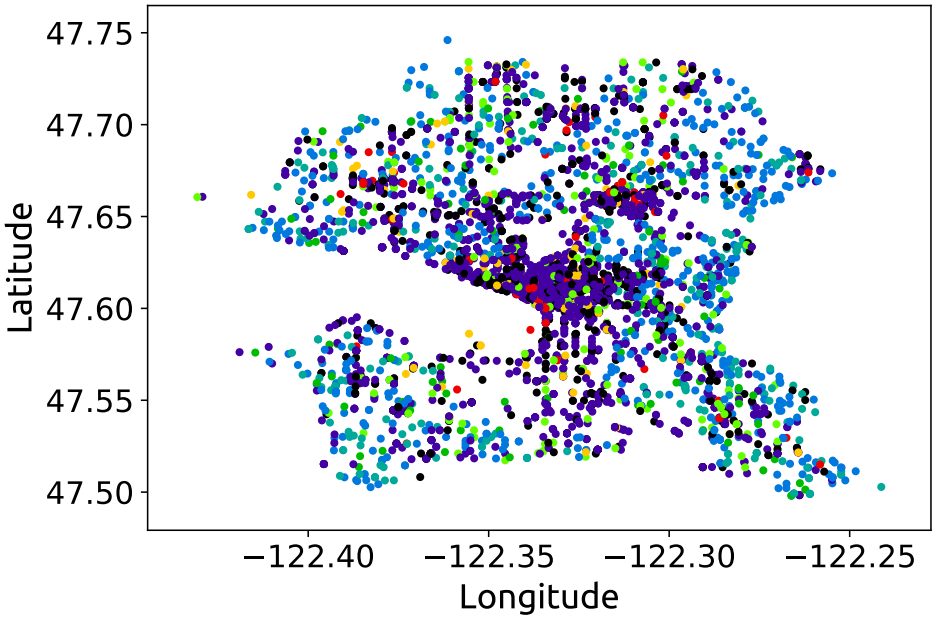
Clustering without PCA: Gap and Gap criterium



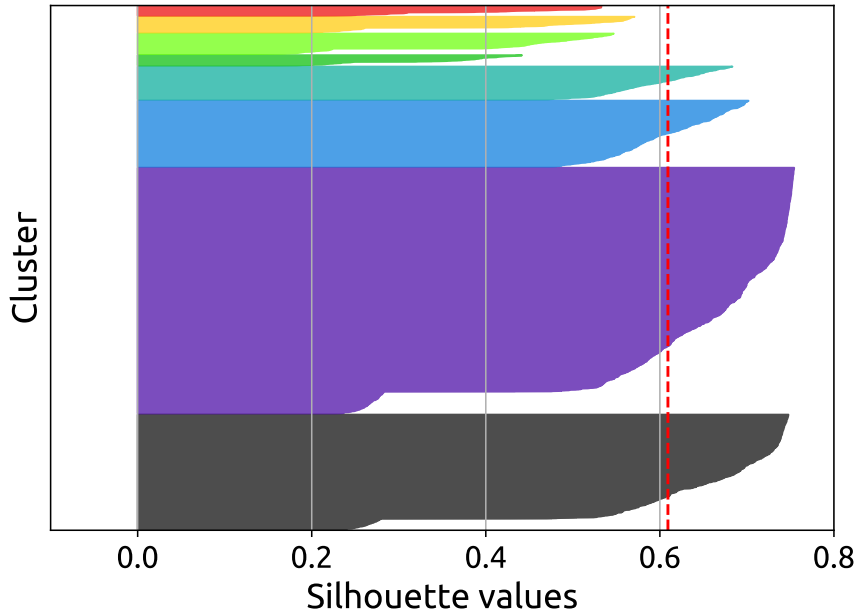


Clustering without PCA: Silhouette Plot

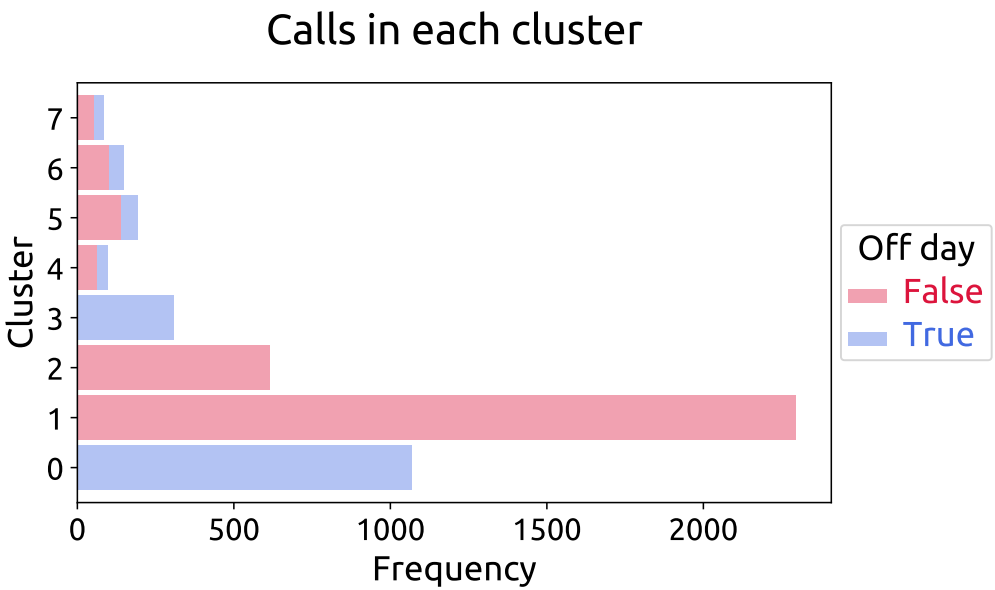
Physical location and 8-cluster model with KMeans

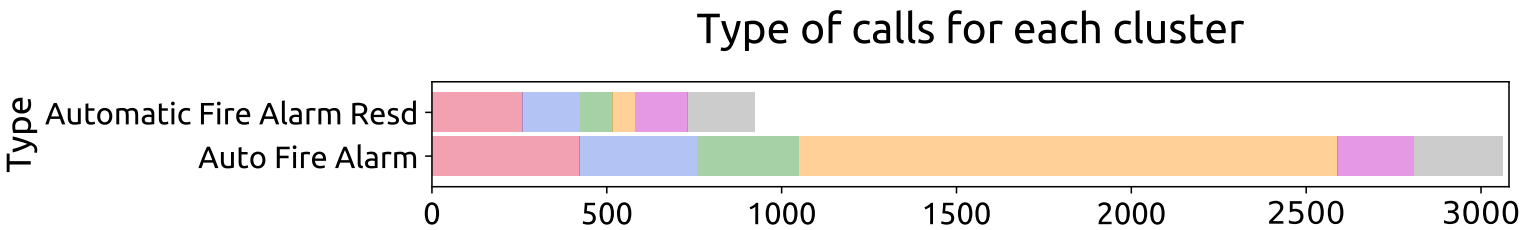


Silhouette plot for a 8-cluster model

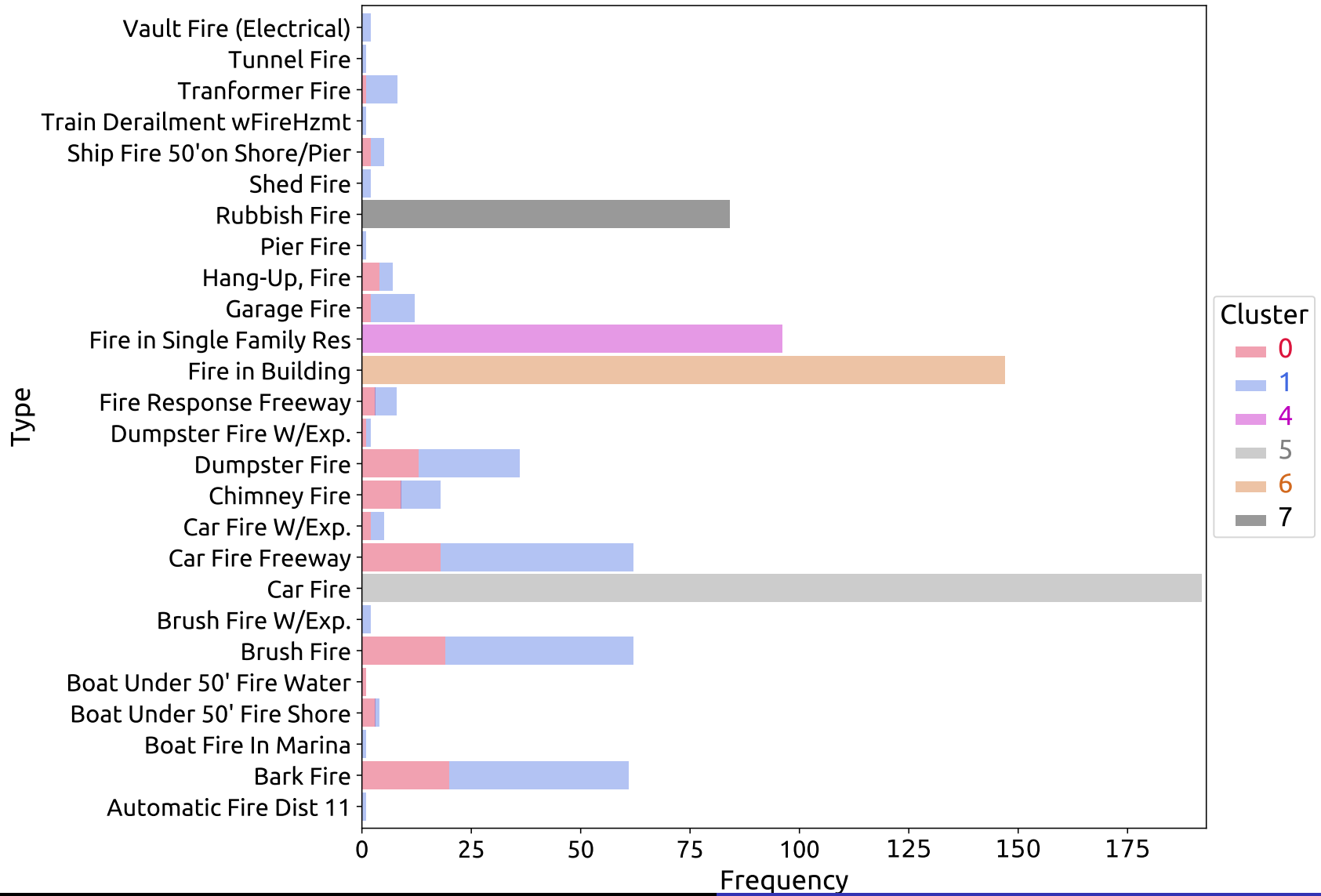


Clustering without PCA in other Features I





Clustering without PCA in other Features II



Concluding Remarks I

- We found no indication that rain accumulations and the number of fire 911 calls are correlated.
- Most of fire emergency calls happen during night time, which seems to reinforce the relevance of human factors over weather.
- The proportion of 911 fire calls is not affected by the day being a work day or not.
- Since 53.5% of the fire emergencies happen in central Seattle, we should study the correlation between 911 fire calls and population density.

Concluding Remarks II

- We obtained a data-based approach to the sectorization of the city in accordance to the number of fire emergency calls.
- Automatic fire alarms are the most significant cause of 911 responses, even after removing false alarm calls.
- Car fires contribute substantially in these events and Central followed by North Seattle are a priority in the amount of emergencies.
- Policies can be focused on fires related to urban activity, specially in highly populated regions of the city, as well as night time events and on better observance of waste disposal.

References I

Noah Daniels.
Seattle observed monthly rain gauge accumulations, July 2018.

Version 16. Retrieved August 20, 2018.

City of Seattle Fire Department Management Information Systems.
Seattle fire 911 calls from 3/1/2010 to 3/1/2011, September 2018.
Version: September 2, 2018 update. Retrieved September 2, 2018.

OfficeHolidays.
Public holidays in washington in 2010, October 2018.
Retrieved October 10, 2018.

References II

OfficeHolidays.
Public holidays in washington in 2011, October 2018.
Retrieved October 10, 2018.

Robert Tibshirani, Guenther Walther, and Trevor Hastie.
Estimating the number of clusters in a data set via the gap statistic.
Journal of the Royal Statistical Society: Series B (Statistical Methodology), 63(2):411–423.