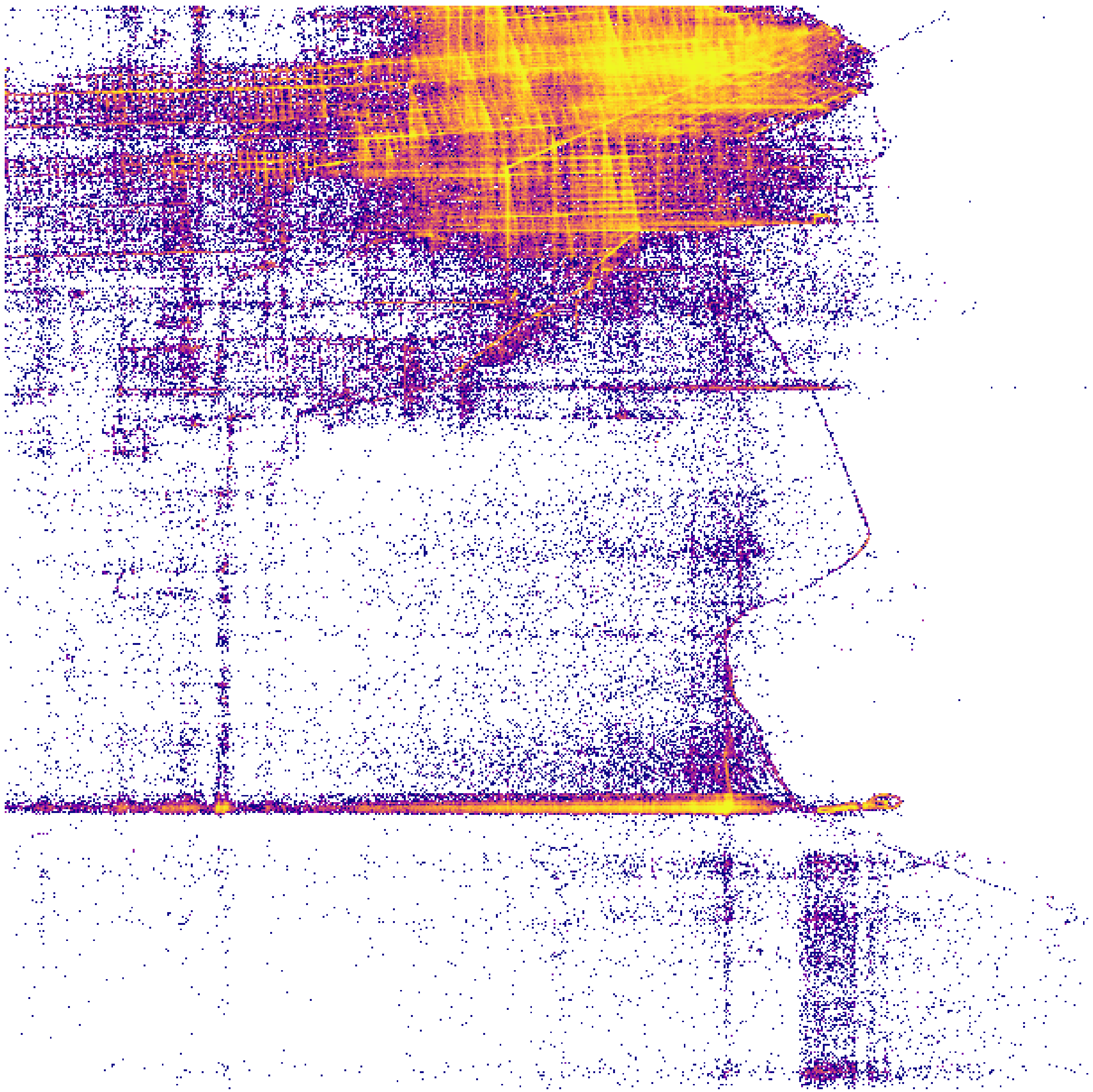
San Francisco Taxi Cabs



Pavel Troshenkov
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Data and Tasks

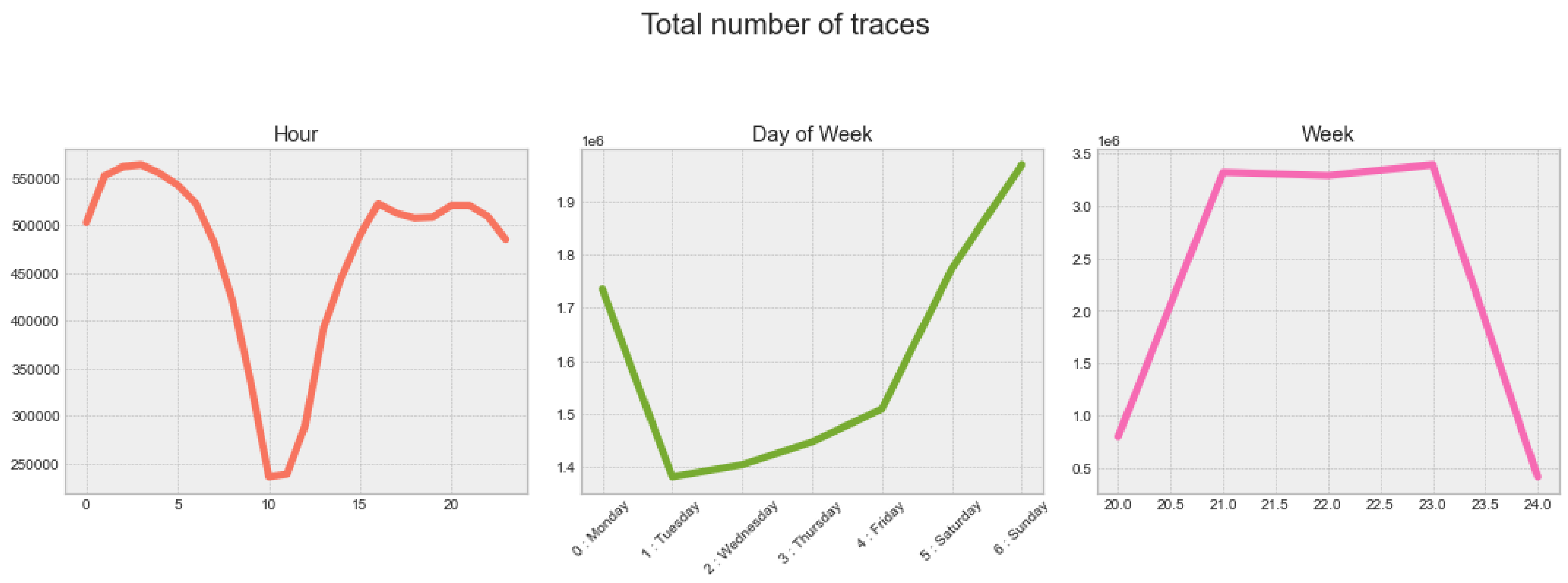
- 537 files with taxi mobility traces
- 11 million records with 5 weeks of history
- Only latitude, longitude, occupancy and time are known
- Data provided for a period from 2008-05-17 – 2008-06-10

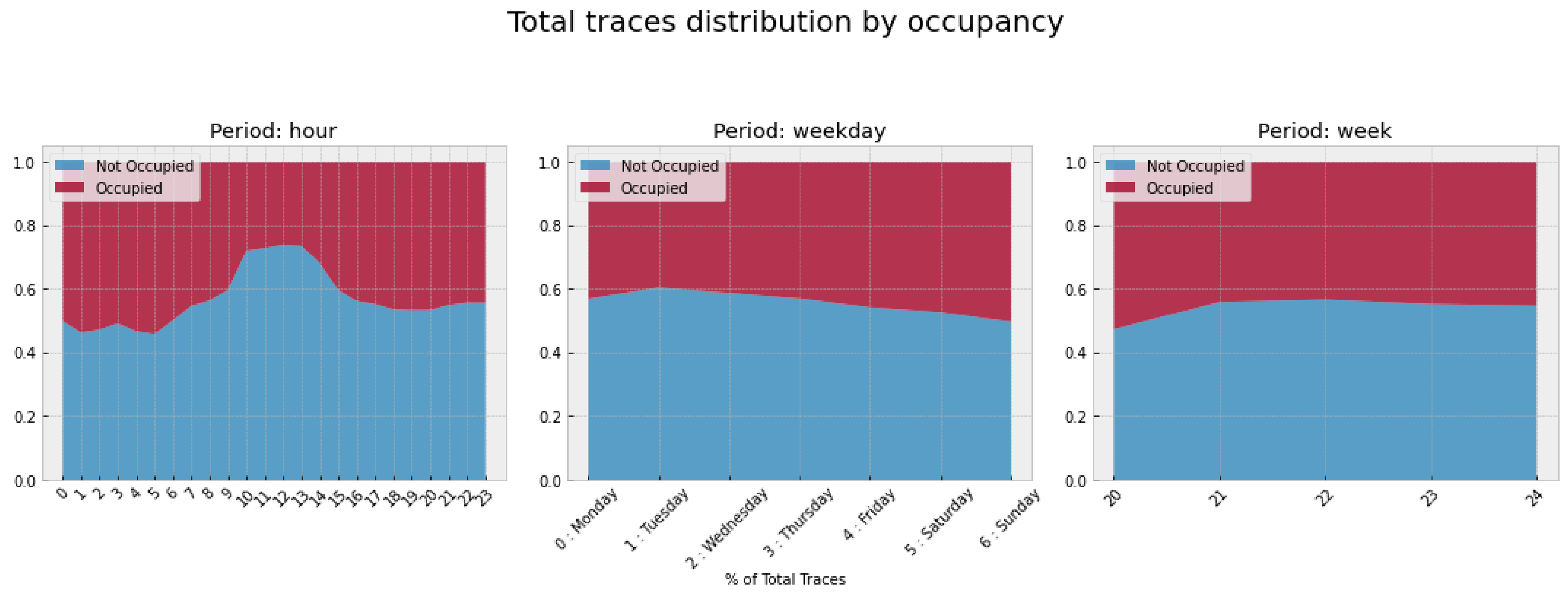
	latitude	longitude	occupancy	time	filename
0	37.75153	-122.39447	0.0	1.211034e+09	new_abboip.txt
1	37.75149	-122.39447	0.0	1.211034e+09	new_abboip.txt
2	37.75149	-122.39447	0.0	1.211034e+09	new_abboip.txt
3	37.75149	-122.39446	0.0	1.211034e+09	new_abboip.txt
4	37.75144	-122.39449	0.0	1.211035e+09	new_abboip.txt

There are 3 tasks:

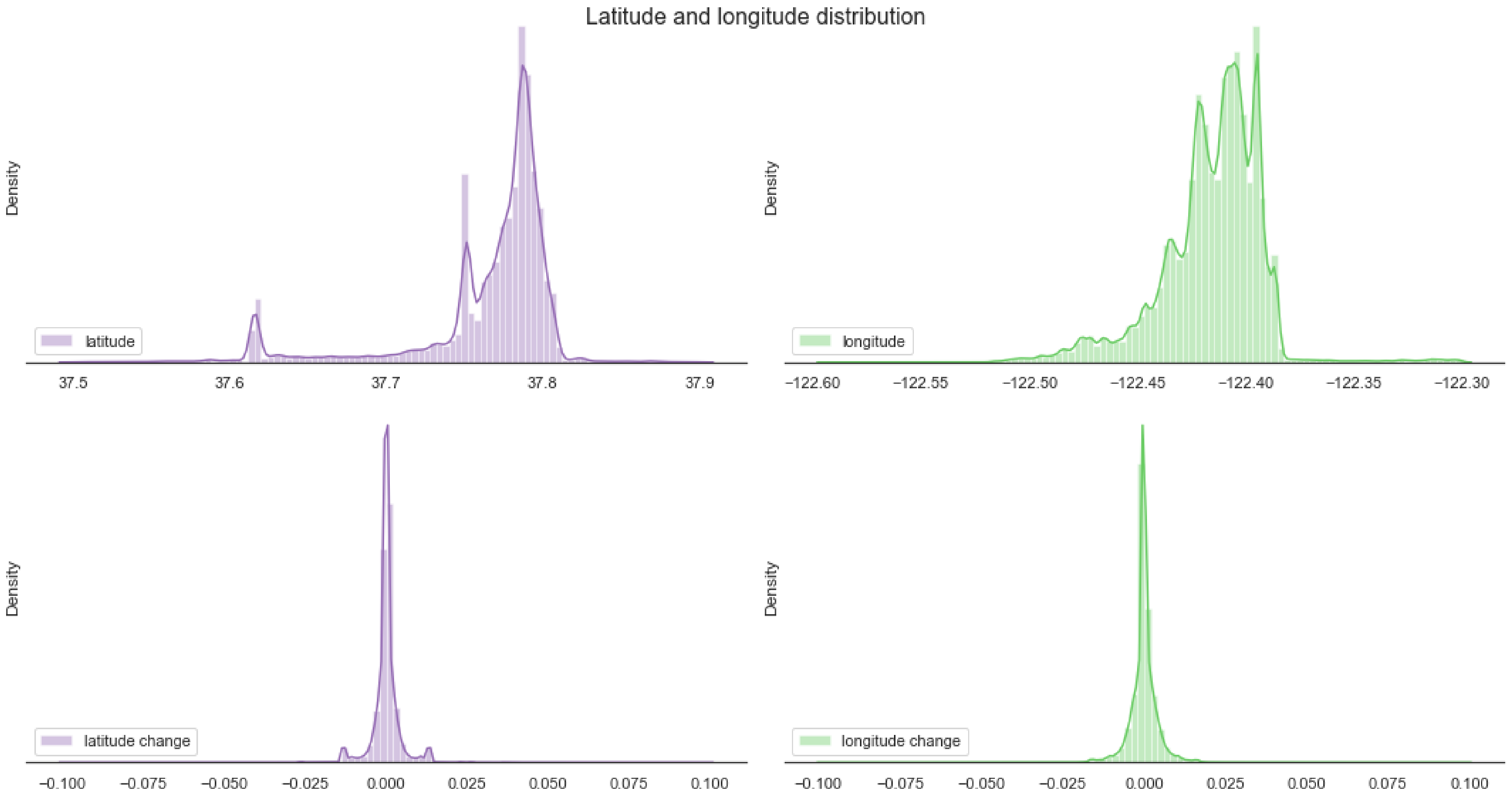
1. To calculate the potential for a yearly reduction in CO_2 emissions caused by the taxi cabs roaming without passengers
2. To build a predictor for taxi drivers, predicting the next place a passenger will hail a cab.
3. Identify clusters of taxi cabs that you find being relevant from the taxi cab company point of view.

Raw Data Brief Overview





Raw Data Brief Overview



Data Processing

Key assumptions

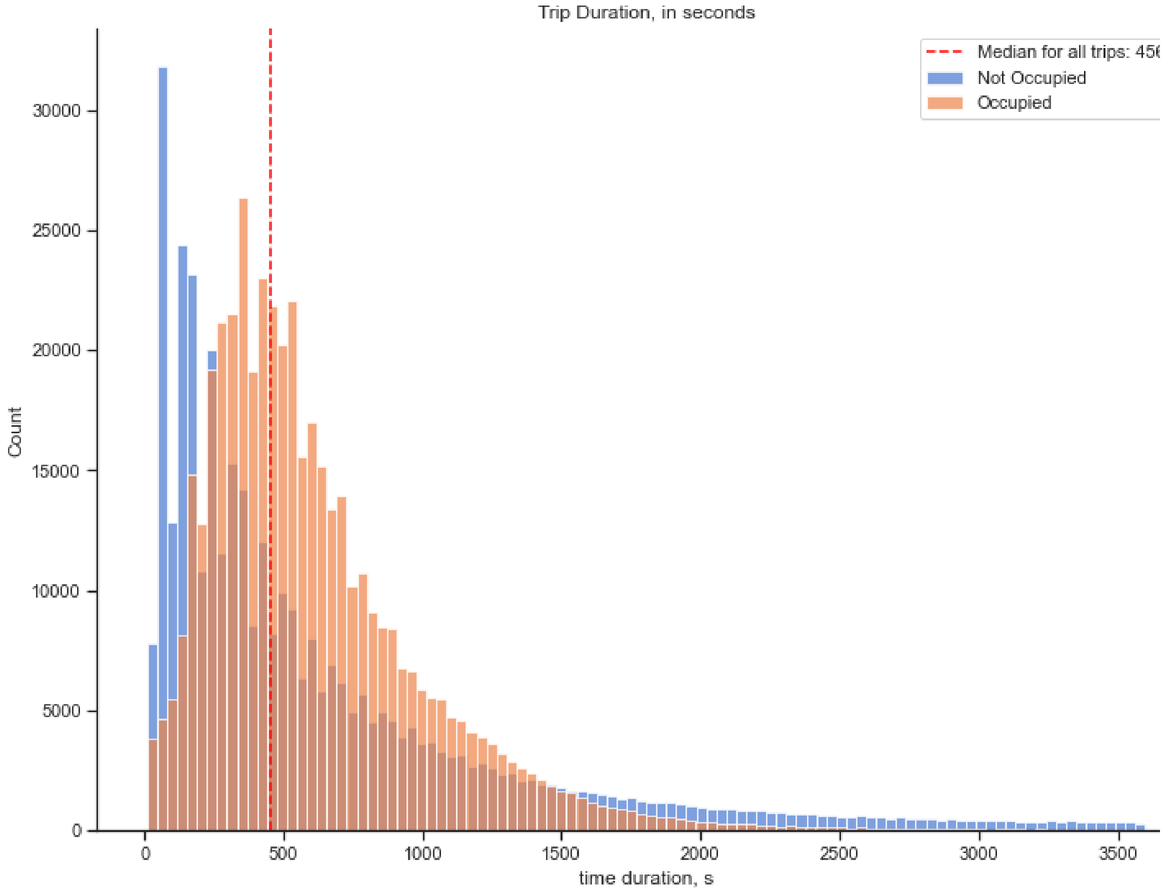
- trip is defined as a period with same sequential positive occupancy status
- there is always a break between trips thus we are excluding cases when next trips starts immediately after the previous one ends
- outliers ignored
- trip distance was calculated by haversine formula ignoring real landscape

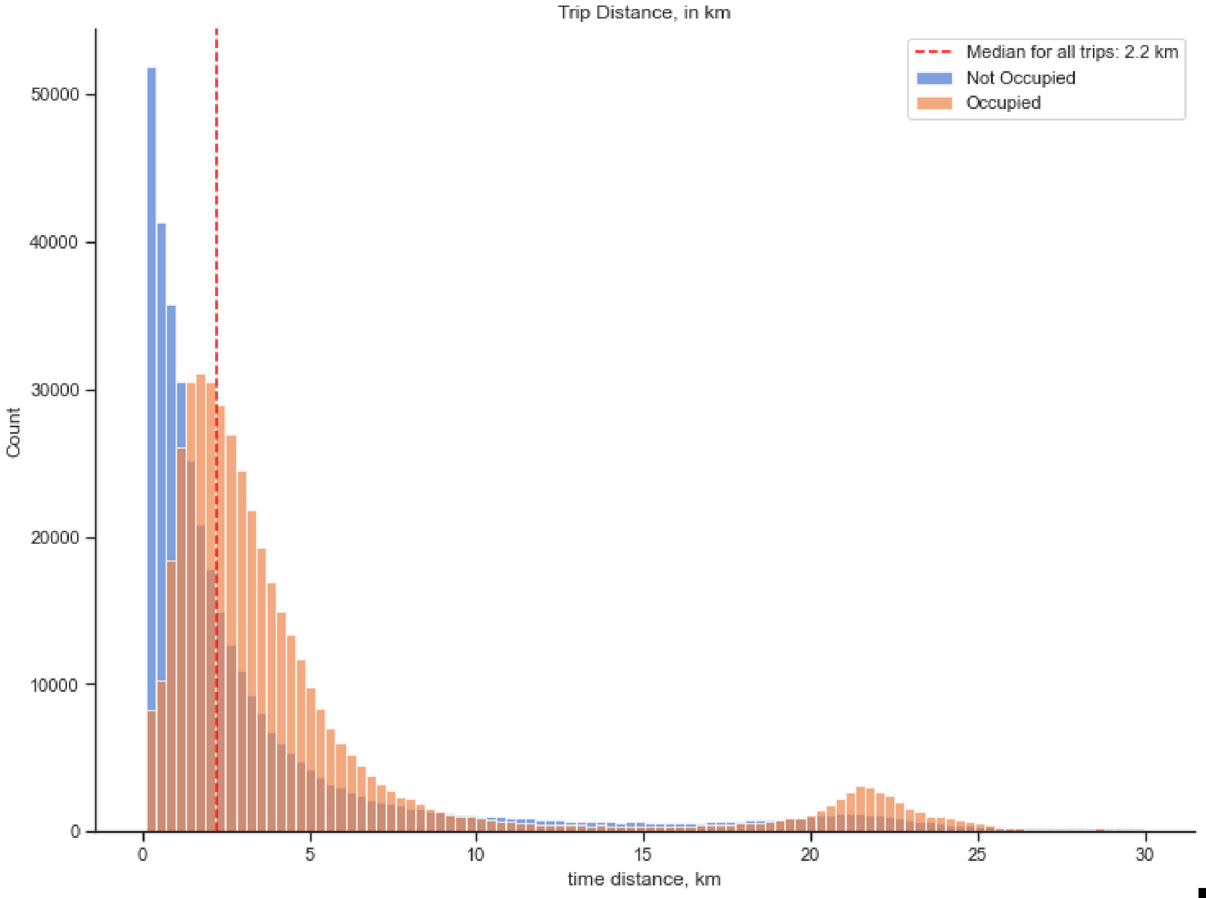
In this way raw data was reduced from 11kk to 900k records

	filename	trip_number	occupancy	latitude_start	latitude_end	longitude_start	longitude_end	start_time	end_time	trip_distance
0	new_abboip.txt	0	0.0	37.74978	37.75153	-122.39709	-122.39446	1.211034e+09	1.211036e+09	0.347694
1	new_abboip.txt	1	1.0	37.74831	37.75552	-122.41438	-122.39724	1.211036e+09	1.211036e+09	2.246390
2	new_abboip.txt	2	0.0	37.75042	37.76523	-122.42291	-122.41441	1.211036e+09	1.211037e+09	3.578681
3	new_abboip.txt	3	1.0	37.75053	37.75206	-122.43101	-122.42086	1.211037e+09	1.211038e+09	0.996433
4	new_abboip.txt	4	0.0	37.74833	37.77219	-122.43172	-122.41402	1.211038e+09	1.211039e+09	5.123720

EDA

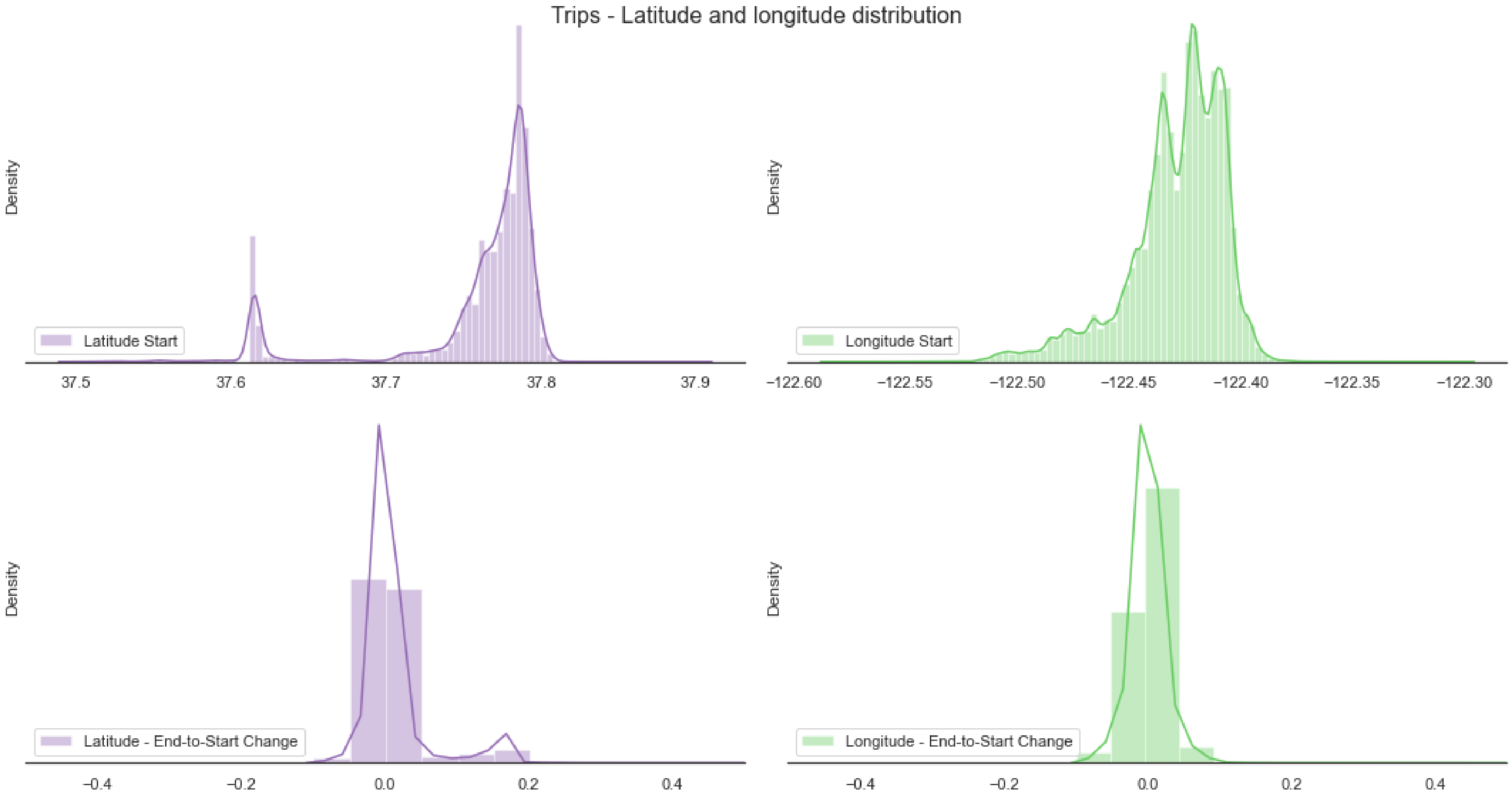
- Most of the trips lay down inside 10 km range and withing 30 minutes
- There are some outliers that can be ignored (~2% of records)





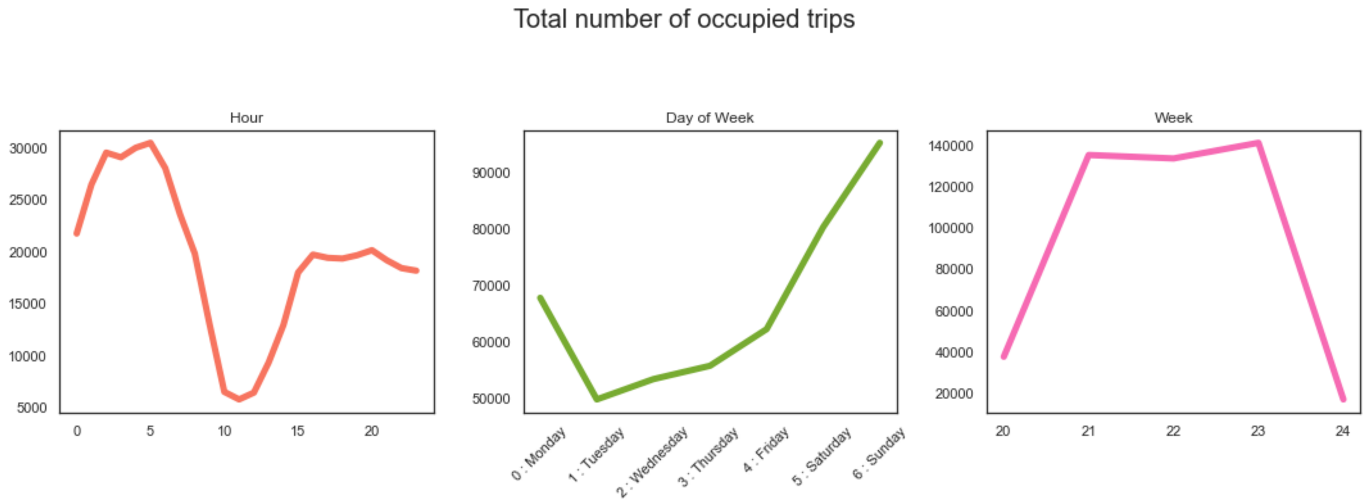
EDA

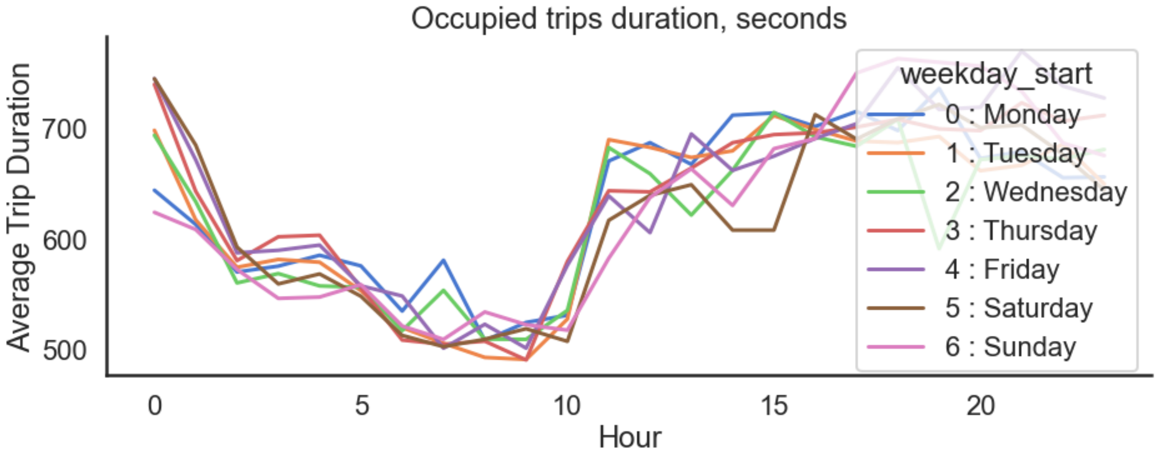
- Latitude and longitude changes seem to be close to normal distribution
- It makes sense to predict changes of coordinates instead of absolute values



EDA

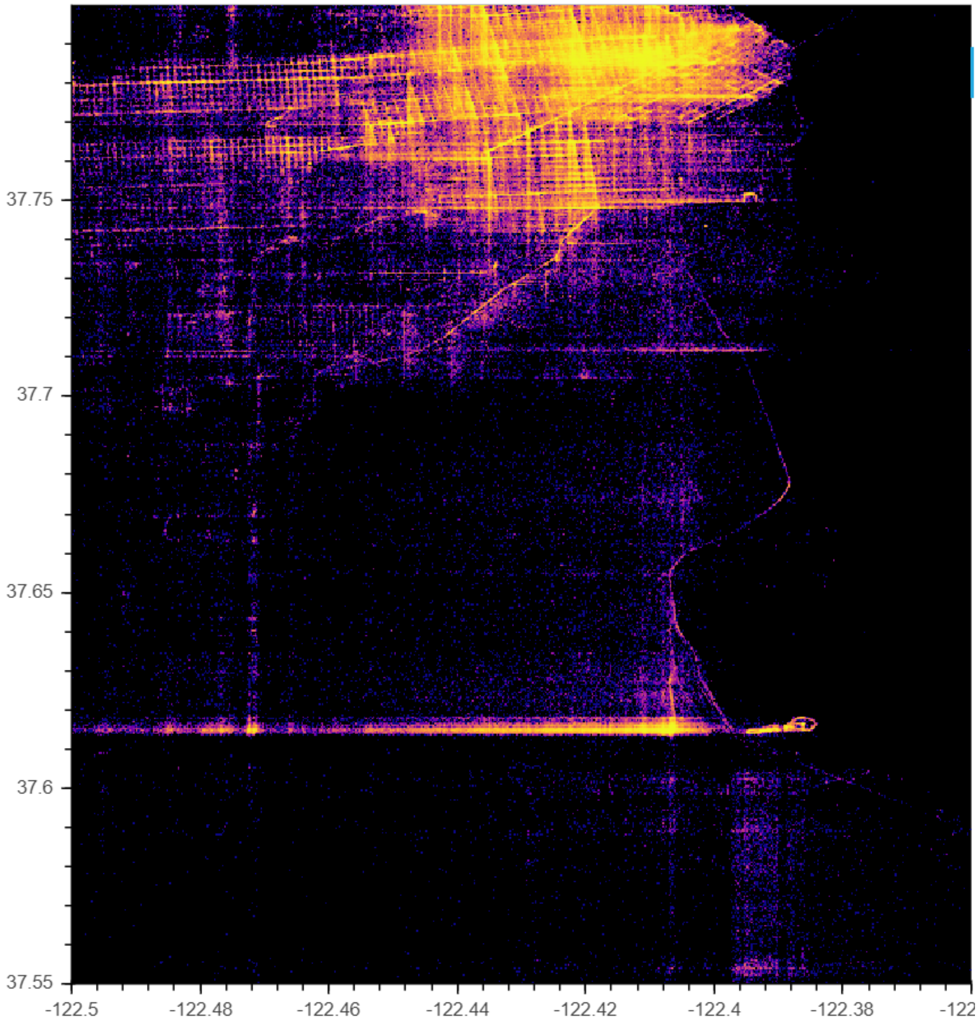
- Most of the trips happen between 3pm – 5am on weekends
- Trips are longer during busy hours which makes sense (traffic jams, people are going home/work, etc.)





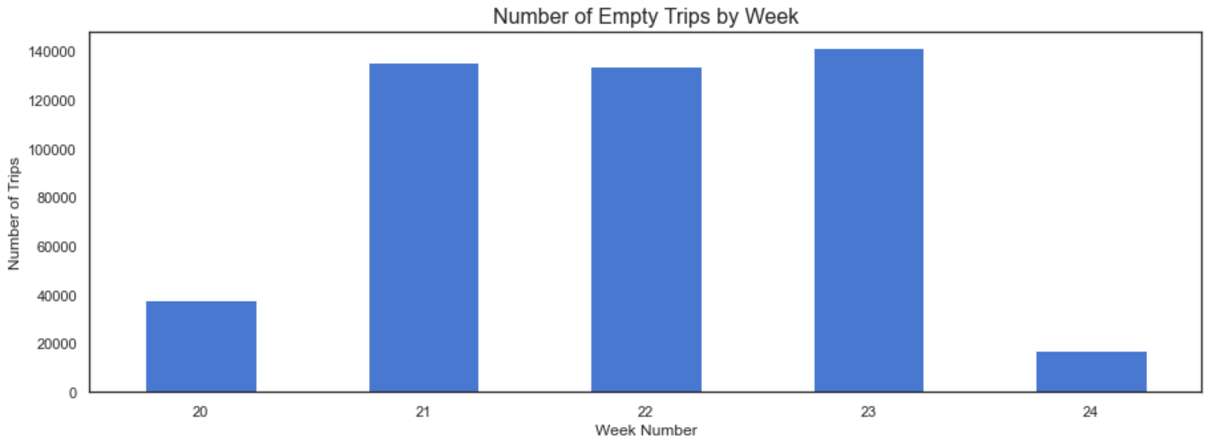
EDA

- Most of the trips located around the city center

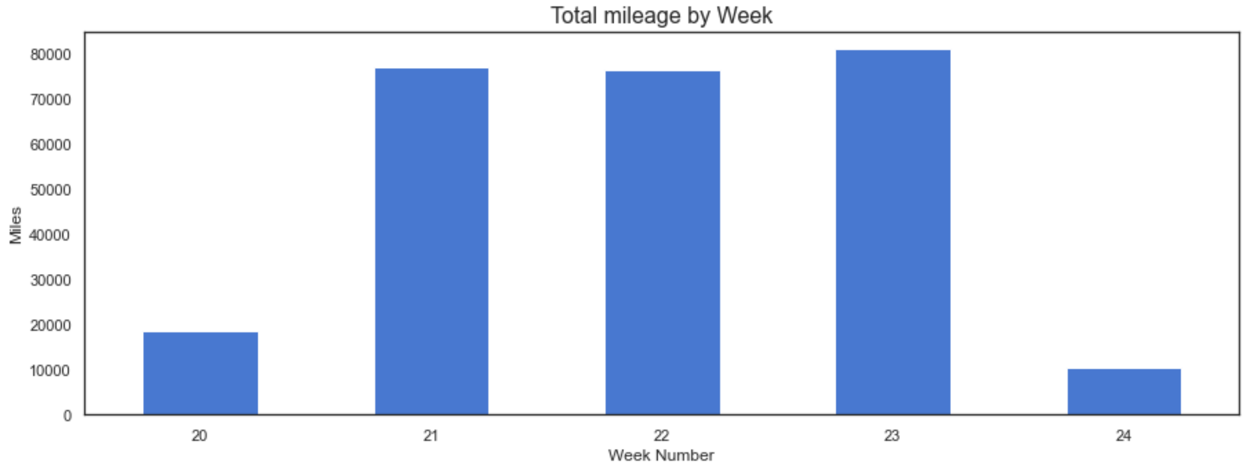


Task 1. The potential for a yearly reduction in CO_2 emissions

- We have 3 complete weeks of data for 500 cars



- We can calculate total mileage by



- We know that number of gasoline cars drops by 15% per month
- Also, we can consider that number of drivers grows by 1% in the pessimistic scenario[1]
- Another important assumption is how we are considering gaps between trips lasting more that 1 hour

The formula to follow:

$$M_t = M_{t-1} \times GrowthRate \times (1 - ReductionRate)$$

where
M – is a monthly CO2 emission,
Growth Rate – 0% or 1% (depends on scenario),
Reduction Rate – 15% based on this task

[1] - https://www.statista.com/statistics/943496/number-of-taxi-drivers-united-states/

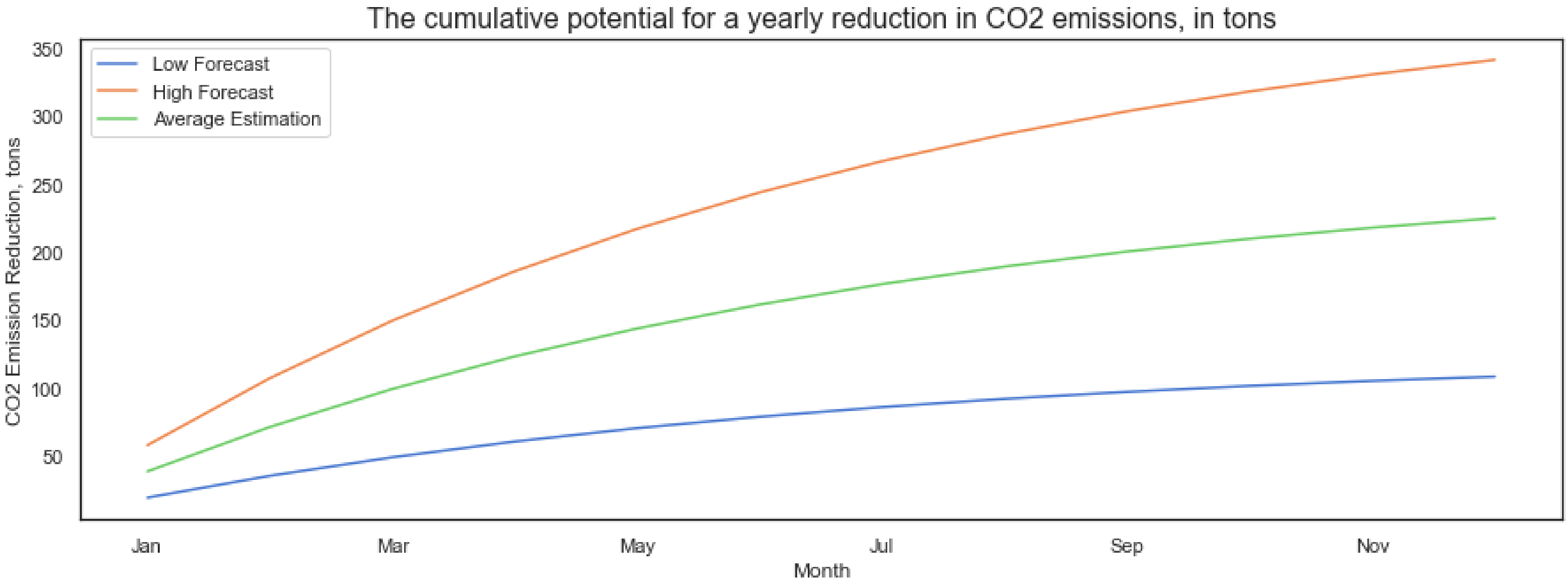
Task 1. The potential for a yearly reduction in CO_2 emissions

Example

For complete weeks 21, 22, 23 the average mileage is 77,942 miles with the low emission scenario.
Monthly mileage = 4 x 77,942 = 311,769 miles

Given this starting point we can predict CO_2 reduction for one month as:

311,769 x (1 - 0.85) x 404 (CO_2 grams) = 18.9 tones of CO_2



Task 2. Predict the next place a passenger will hail a cab

Key assumptions

- trip is a sequence of records with the same occupancy status
- driver's shift is a sequence of records separated by more than 5 hours gap
- ML predicts a delta of two sequences with occupancy = 1 status separated by a sequence with occupancy status = 0

What we want to predict

- Longitude change between dropoff and pickup locations
- Latitude change between dropoff and pickup locations

What we want to change

E.g. we can hope that CO_2 emission will be lower if drivers would use ML-based routing

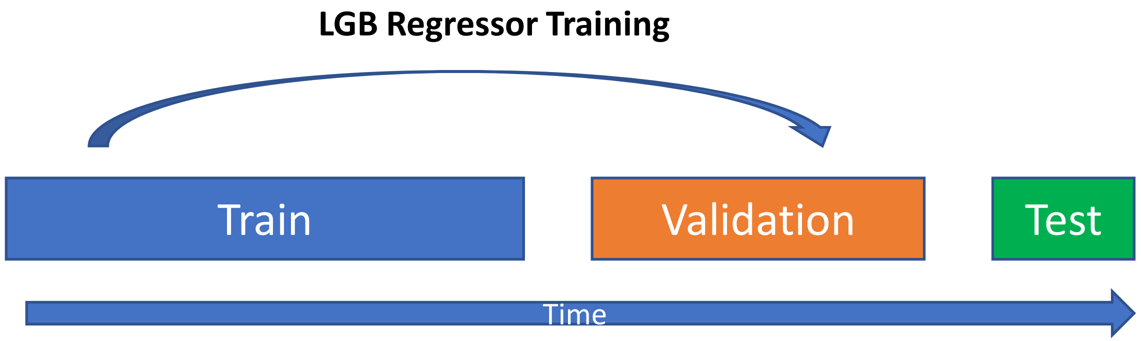
Task 2. Predict the next place a passenger will hail a cab

Features

- Latitude/longitude-based features
  - Previous pickup/drop-off coordinates
  - Previous trip duration / distance in different slices
- Driver's features
  - Average statistics
  - Number of trips before the current one
- Date and time
  - Week
  - Day of Week
  - Hour

Validation scheme

- Time-series validation



Loss

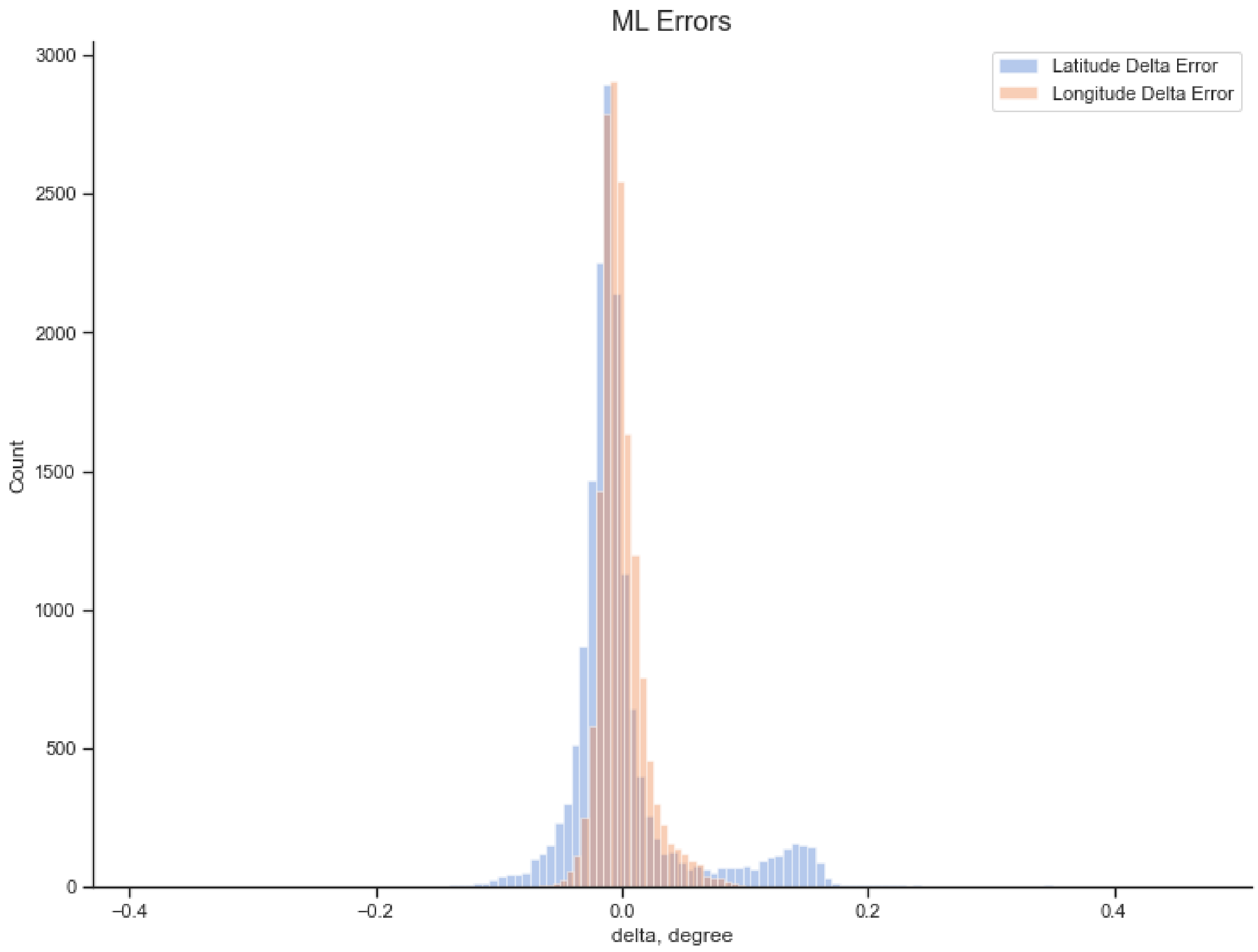
- RMSE

Business Impact

- Distance to get new passenger, in kilometers

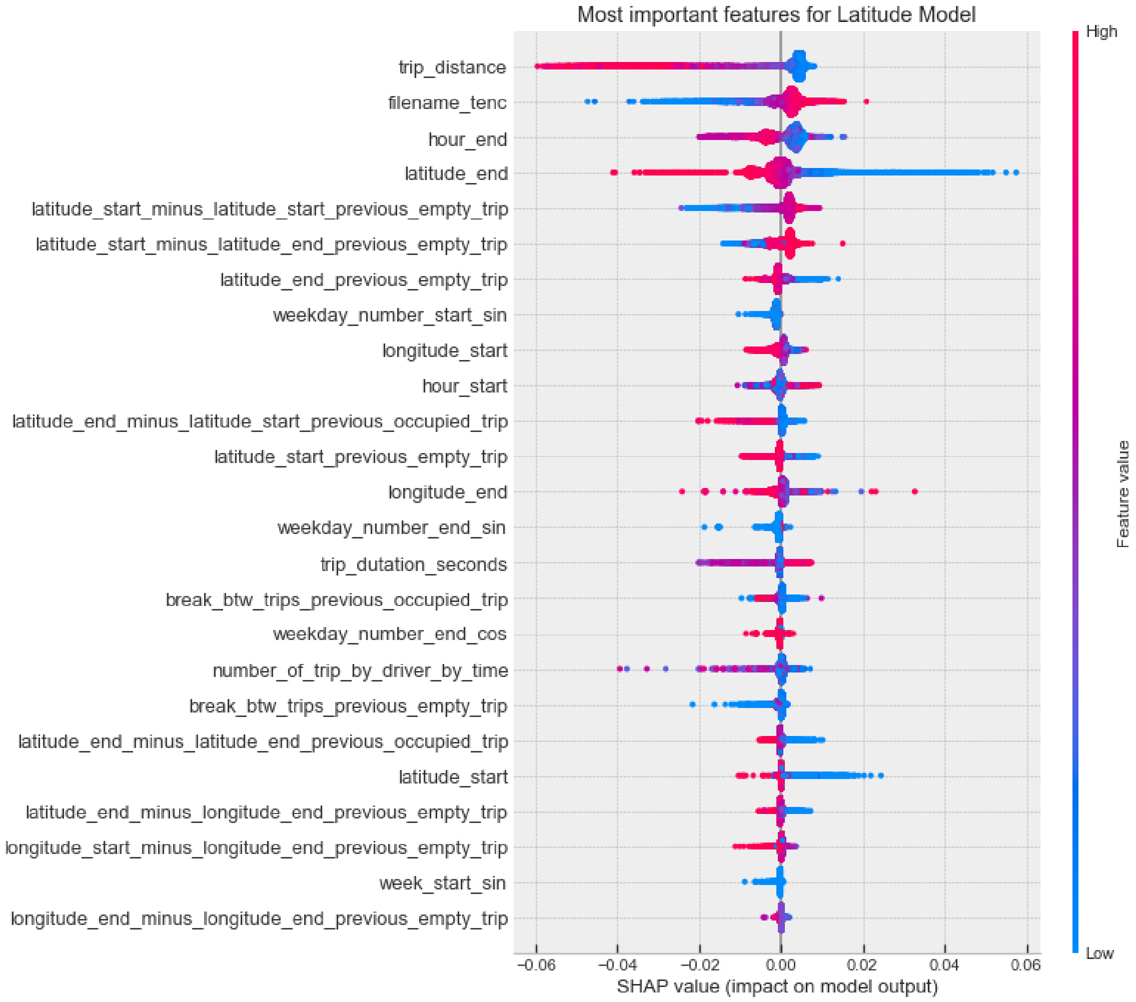
Task 2. Predict the next place a passenger will hail a cab

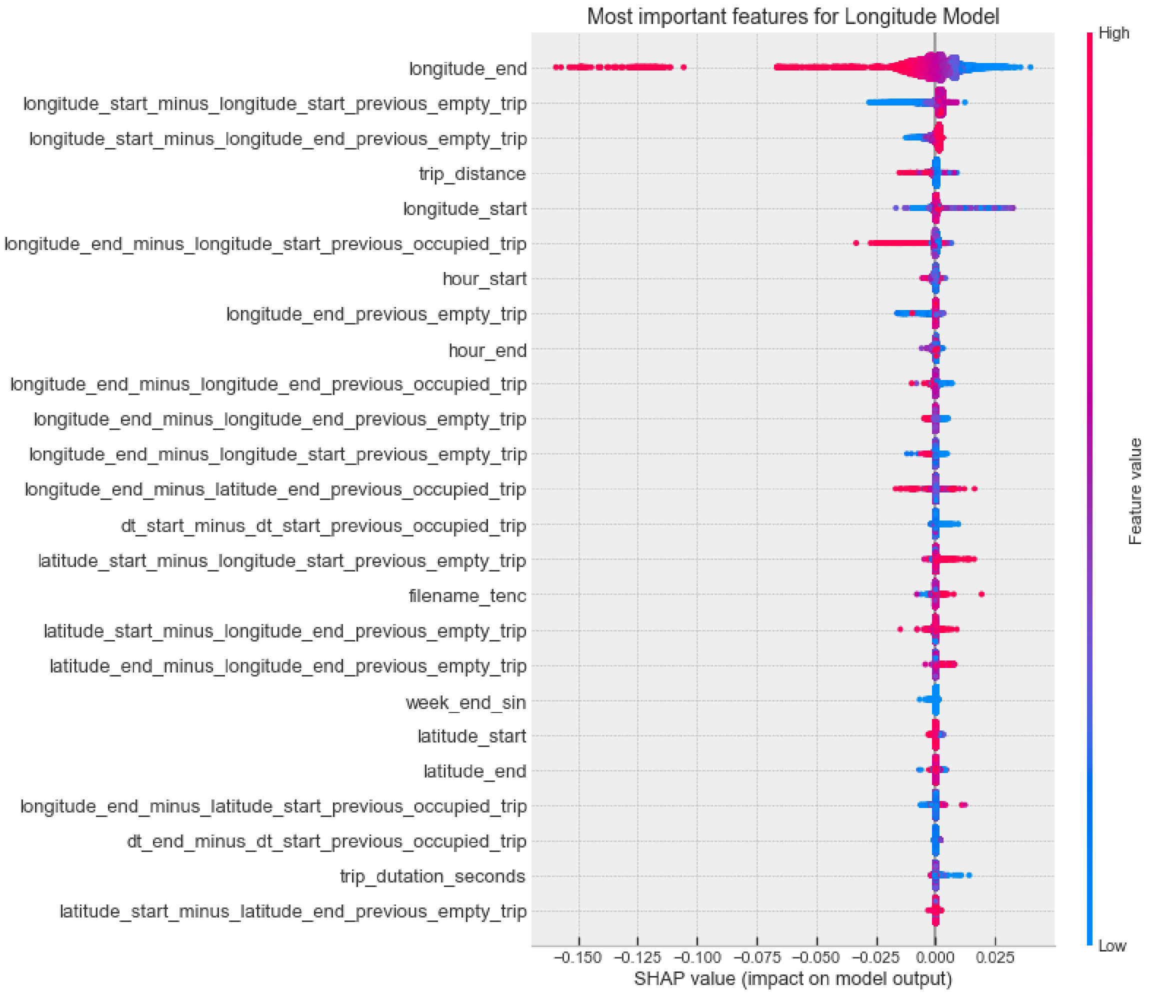
- Longitude residuals are equally distributed across 0
- Latitude is harder to predict



Task 2. Predict the next place a passenger will hail a cab

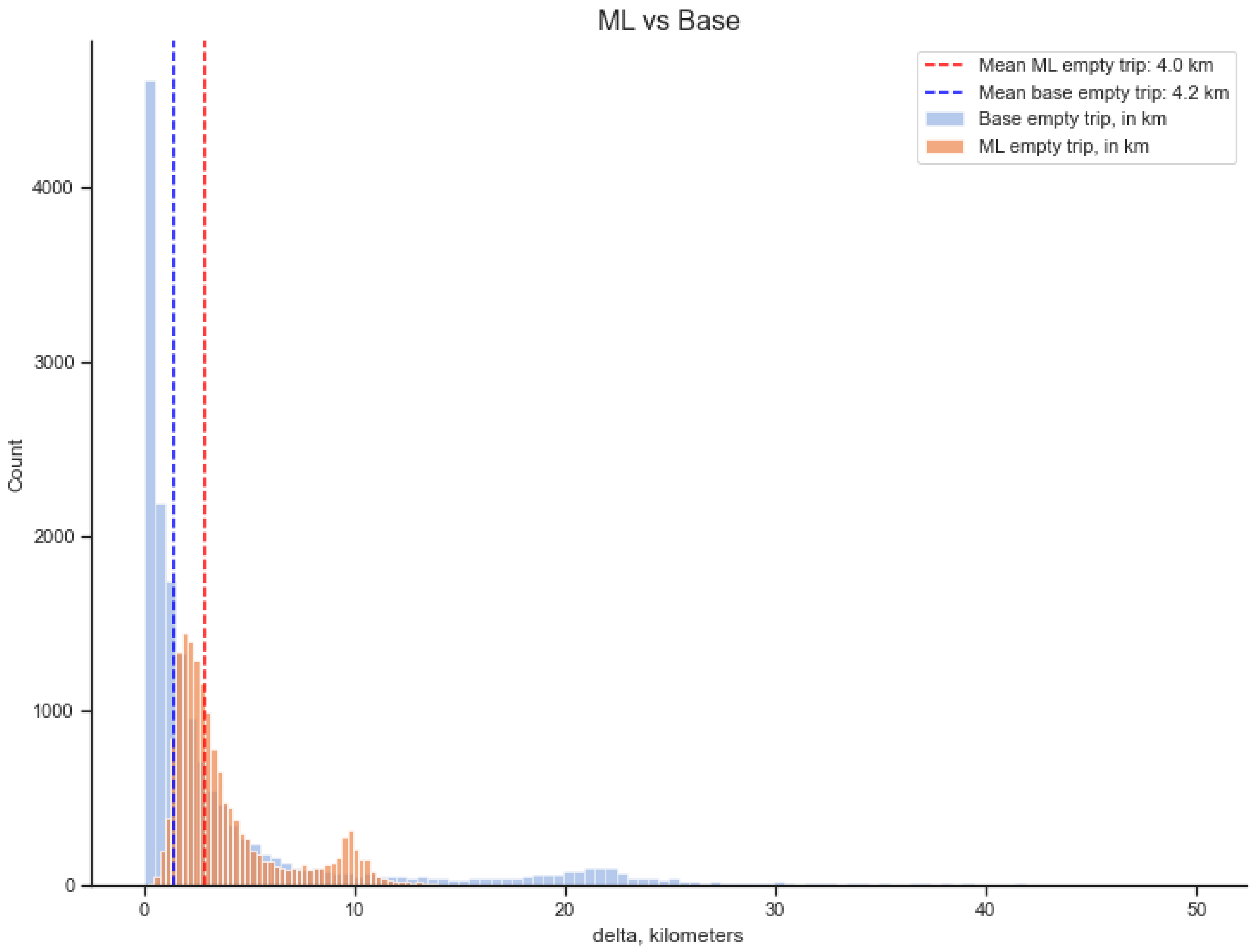
Feature Importance





Task 2. Predict the next place a passenger will hail a cab

Potential reduction of empty mileage is about 7% (based on predictions for trips after 2008-06-08)



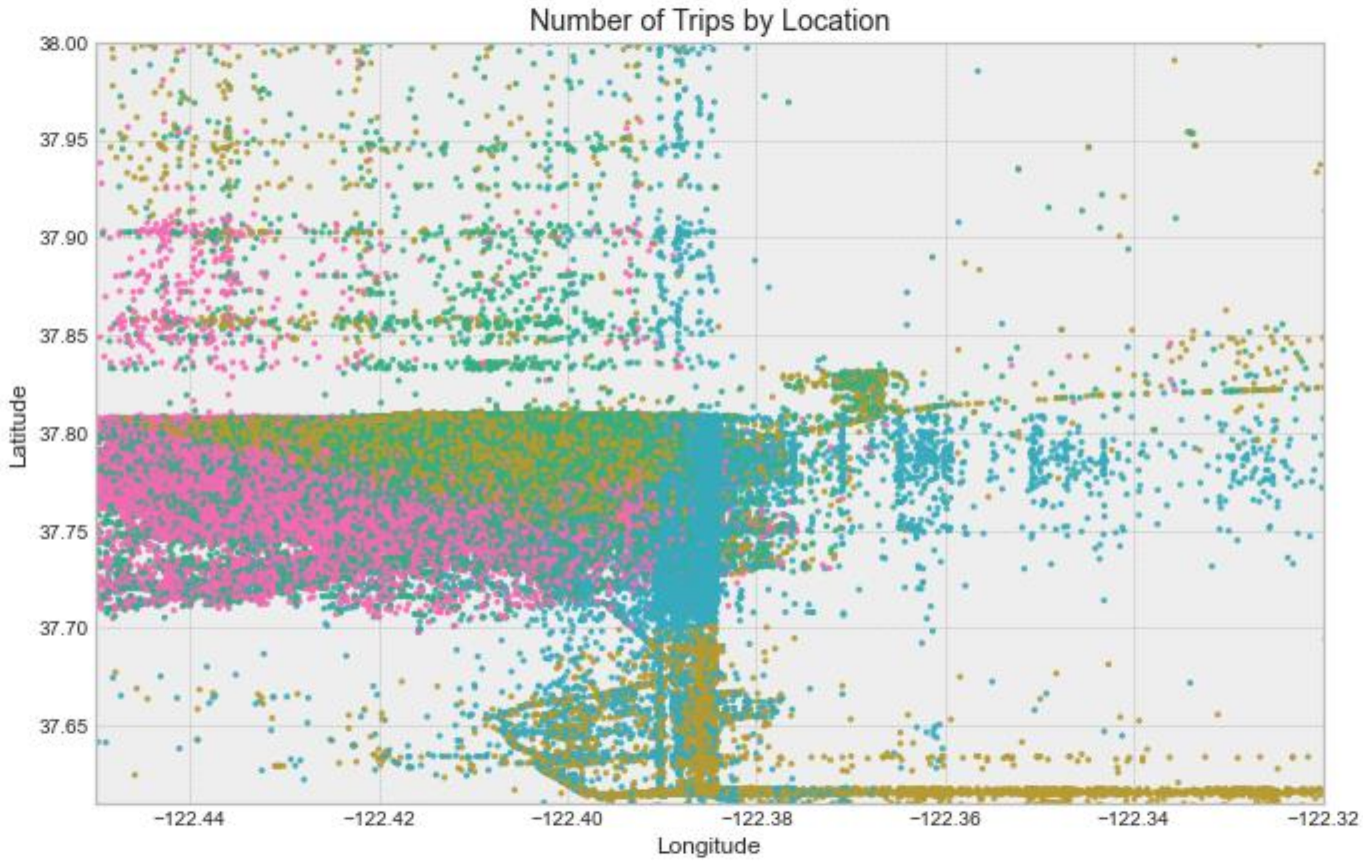
Task 2. Predict the next place a passenger will hail a cab

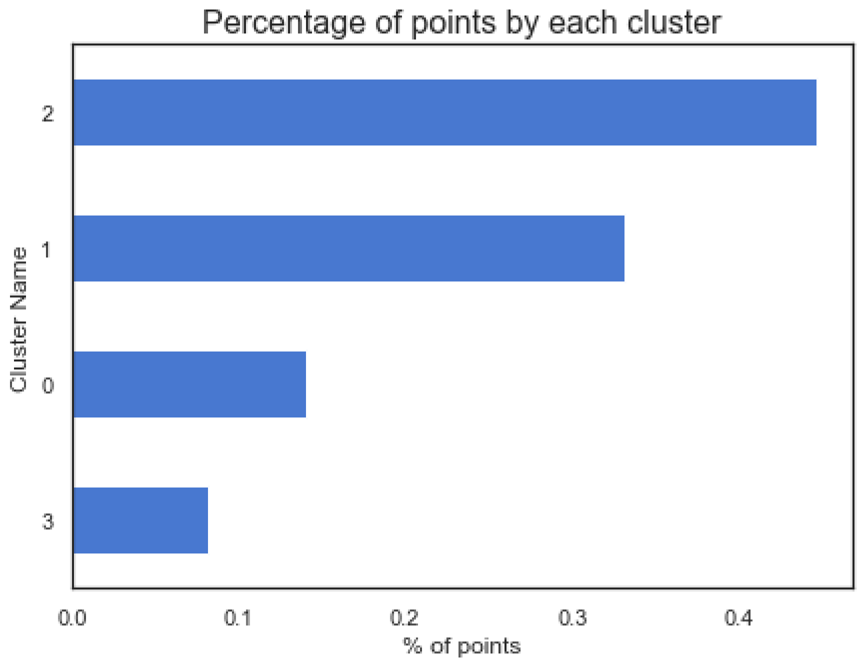
Areas for improvement

- Try RNN models
- More feature engineering
- External data (e. g. geo services to analyze routes based on real geographical landscape)
- Get more information for mobile traces, not just naive aggregation

Task 3. Identify clusters of taxi cabs

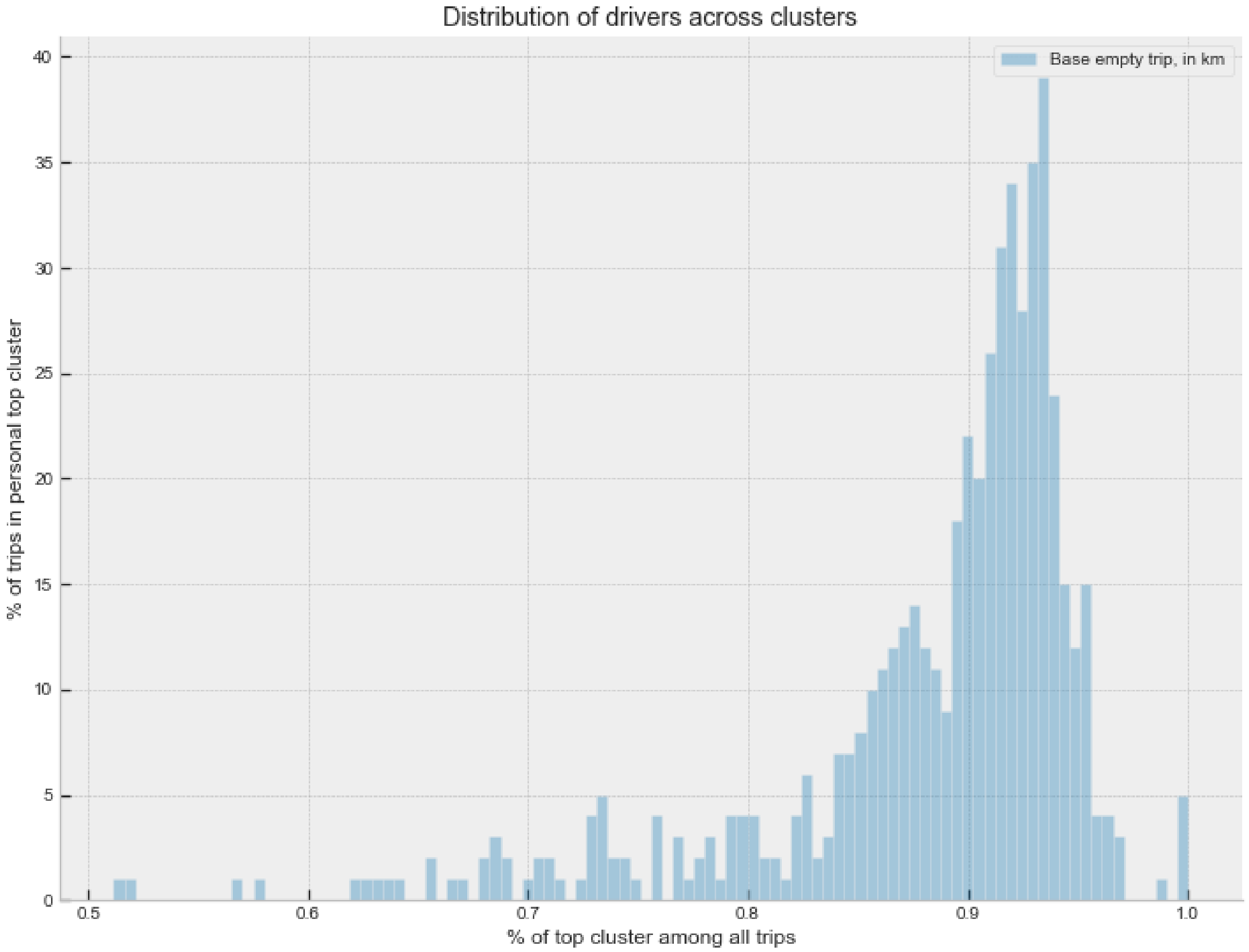
- KMeans clustering based on latitude and longitude (both pickup and drop-off) for all trips by 4 clusters





Task 3. Identify clusters of taxi cabs

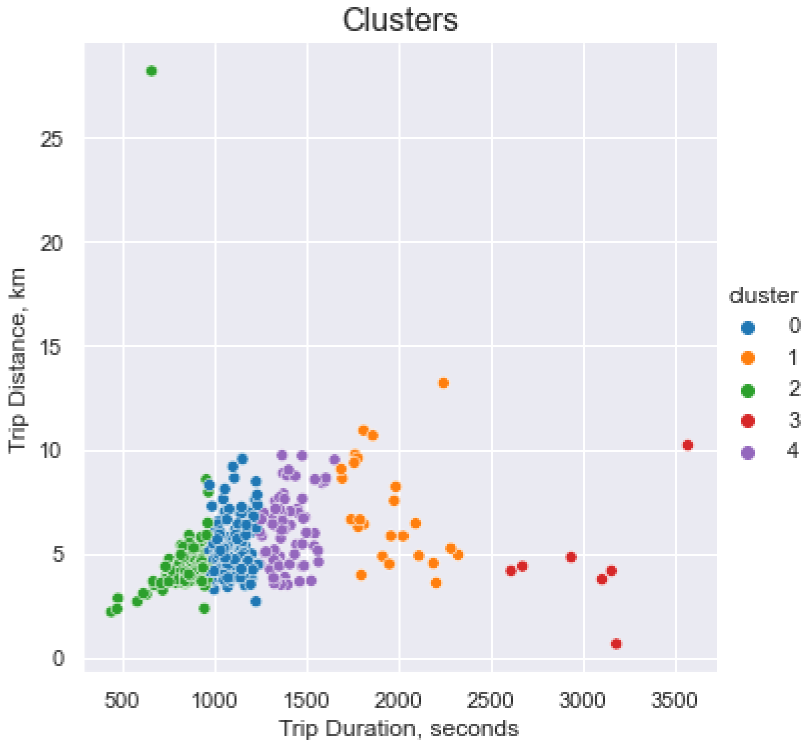
- Every driver has 4 clusters
- But 90% of trips by driver belong to only one cluster
- This one cluster can be used as a main one in each case



filename	cluster	occupancy	occupancy_share	rank
new_abboip.txt	0	0.0	0.000000	4.0
new_abboip.txt	1	3.0	0.003135	3.0
new_abboip.txt	2	893.0	0.933124	1.0
new_abboip.txt	3	61.0	0.063741	2.0

Task 3. Identify clusters of taxi cabs

- Clusters based on average trip distance and duration



Task 3. Identify clusters of taxi cabs

Areas for improvement

- Look at the drivers’ characteristics across clusters
- Another ways of clustering. E. g. embeddings from RNN

Questions

Thank you!