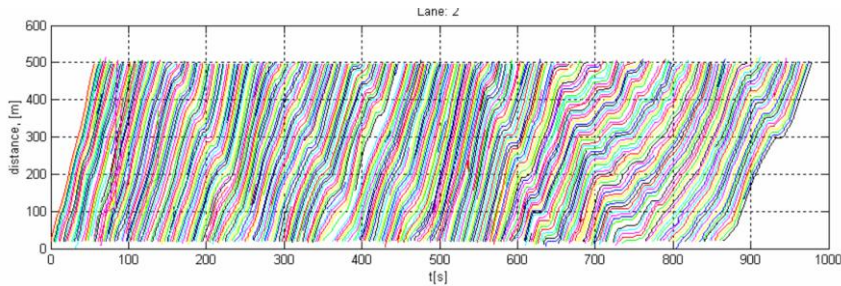
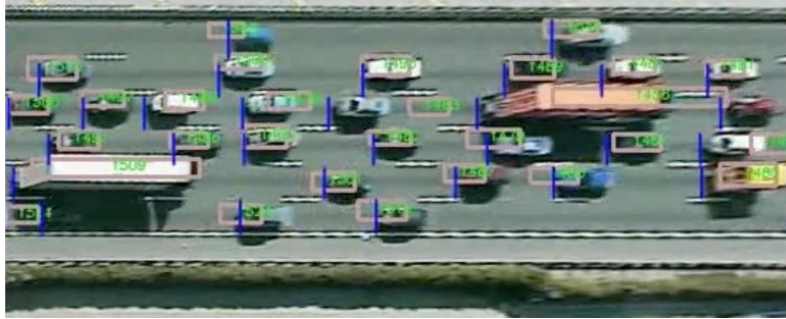


Zen Traffic Data: Comprehensive vehicle trajectory data from multiple locations

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Vehicle Trajectory Data Camp
ITSC2024 @Edmonton



NGSIM dataset

- Trajectories of all the vehicles in a road section for a certain duration
- It describes a complete state of traffic flow
- Fundamental of scientific studies on traffic flow (Li et al. 2020)
 - Micro/macro traffic flow modeling
 - Traffic estimation and prediction
 - Algorithms for automated vehicles
- Data collection is very challenging
 - Traffic flow is a wide-ranging, continuous spatial-temporal phenomenon

- **NGSIM (2005)**: The first well-known large scale dataset by US-DOT
 - Each dataset covers 15 mins and 600 meters
 - Approximately 600 vehicles

Vehicle trajectories in a single lane (approx. 100 vehs)

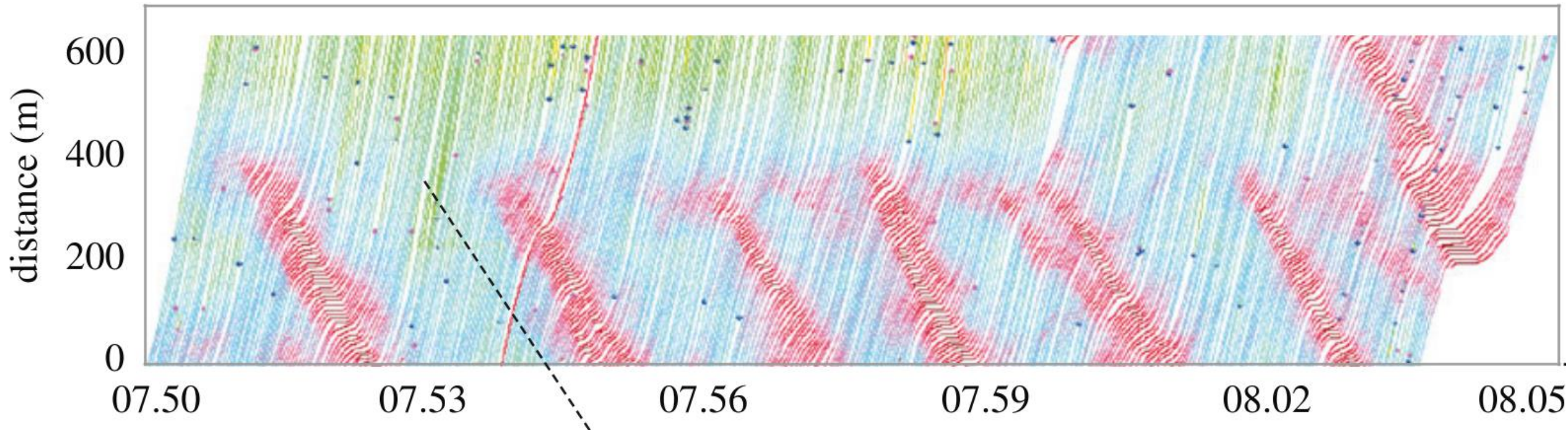
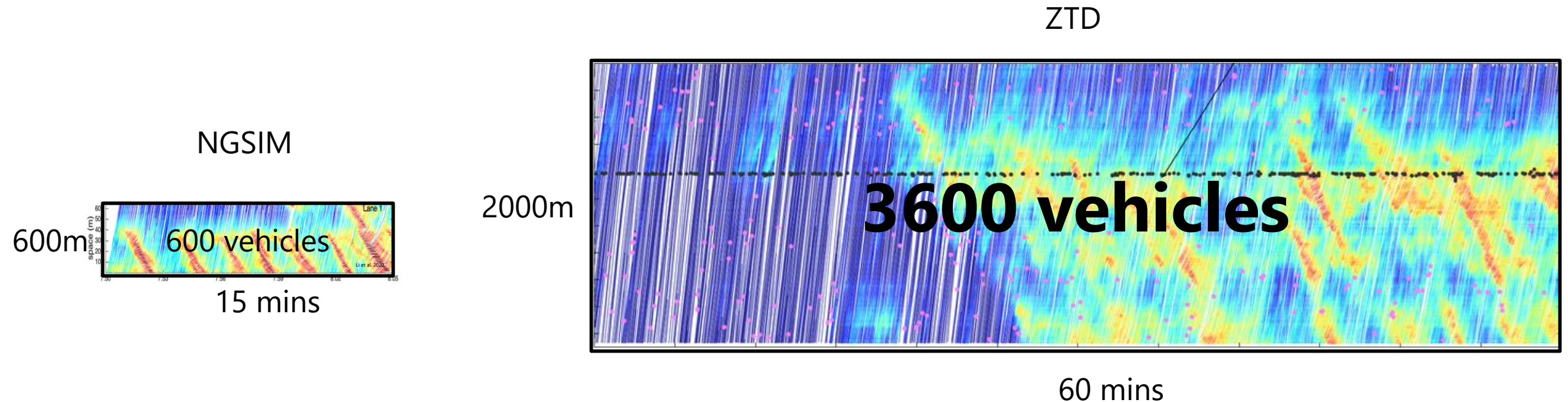


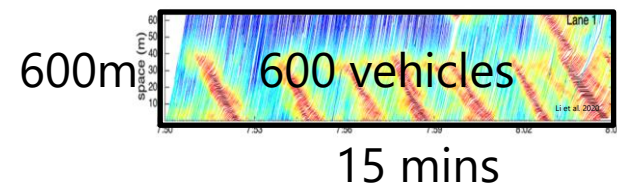
FIGURE SOURCE: J. A. Laval and L. Leclercq, "A mechanism to describe the formation and propagation of stop-and-go waves in congested freeway traffic," *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*, vol. 368, no. 1928, pp. 4519–4541, 2010.

- NGSIM (2005): The first well-known dataset by US-DOT
- **Zen Traffic Data (ZTD) (2018)**: Datasets by Hanshin Expressway Company, Japan
 - Each dataset covers 60 mins and 2000 meters
 - Approximately 3600 vehicles



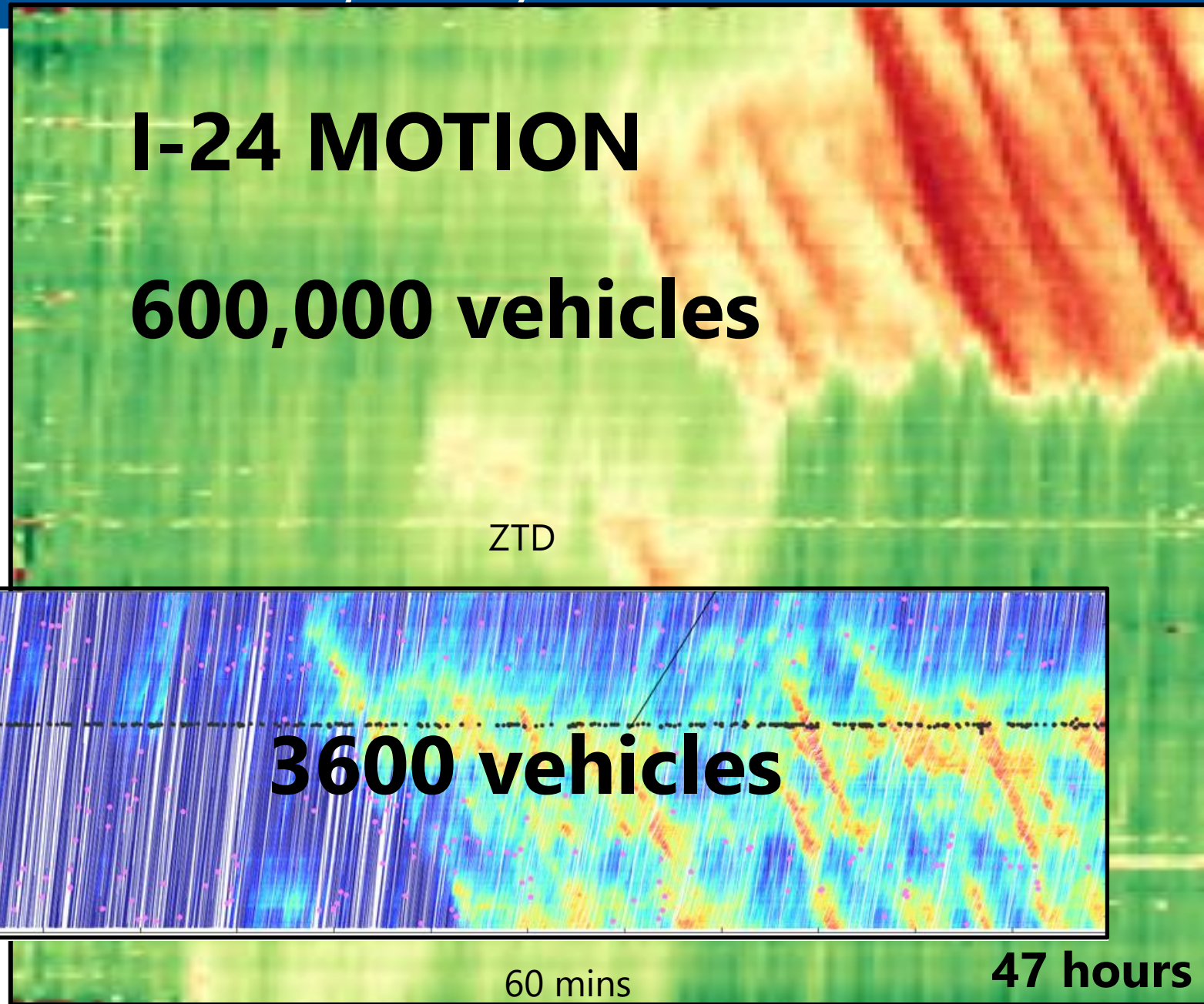
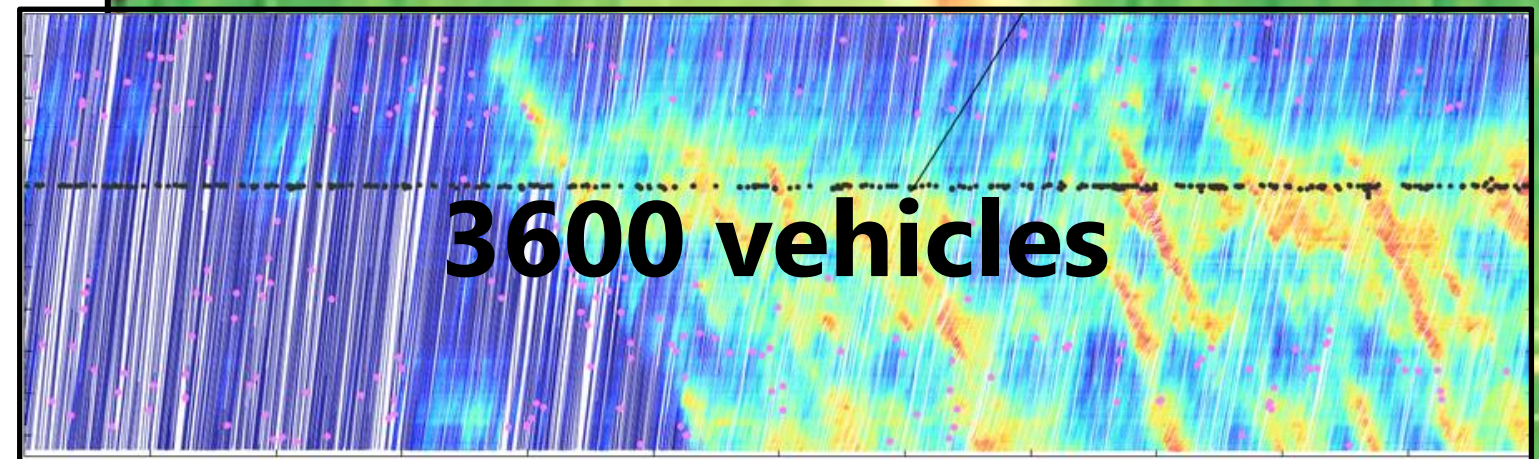
- NGSIM (2005)
- ZTD (2018)
- **I-24 MOTION (2022):**
The latest and largest!
 - 47 hours
 - 6.75 km
 - 600,000 vehicles
 - and it keeps growing

NGSIM

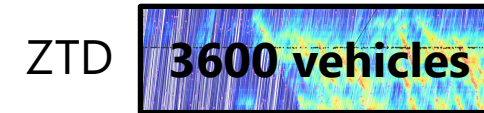


2000m

6.75 km

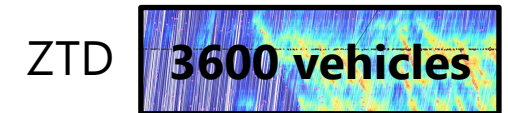


- ZTD includes datasets from multiple locations



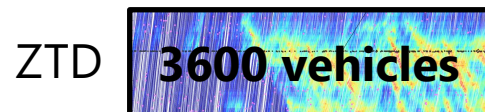
- The data collection system of ZTD is "portable"

- It is not firmly fixed to the infrastructure
- It can be relocated to collect data from different locations



- It has been collected from 3 locations, each with distinct interesting traffic features

- Road geometry and applied traffic control measures



- Introduction
- Data collection method
- Examples and applications

- Vehicle trajectory
 - 0.1 s interval

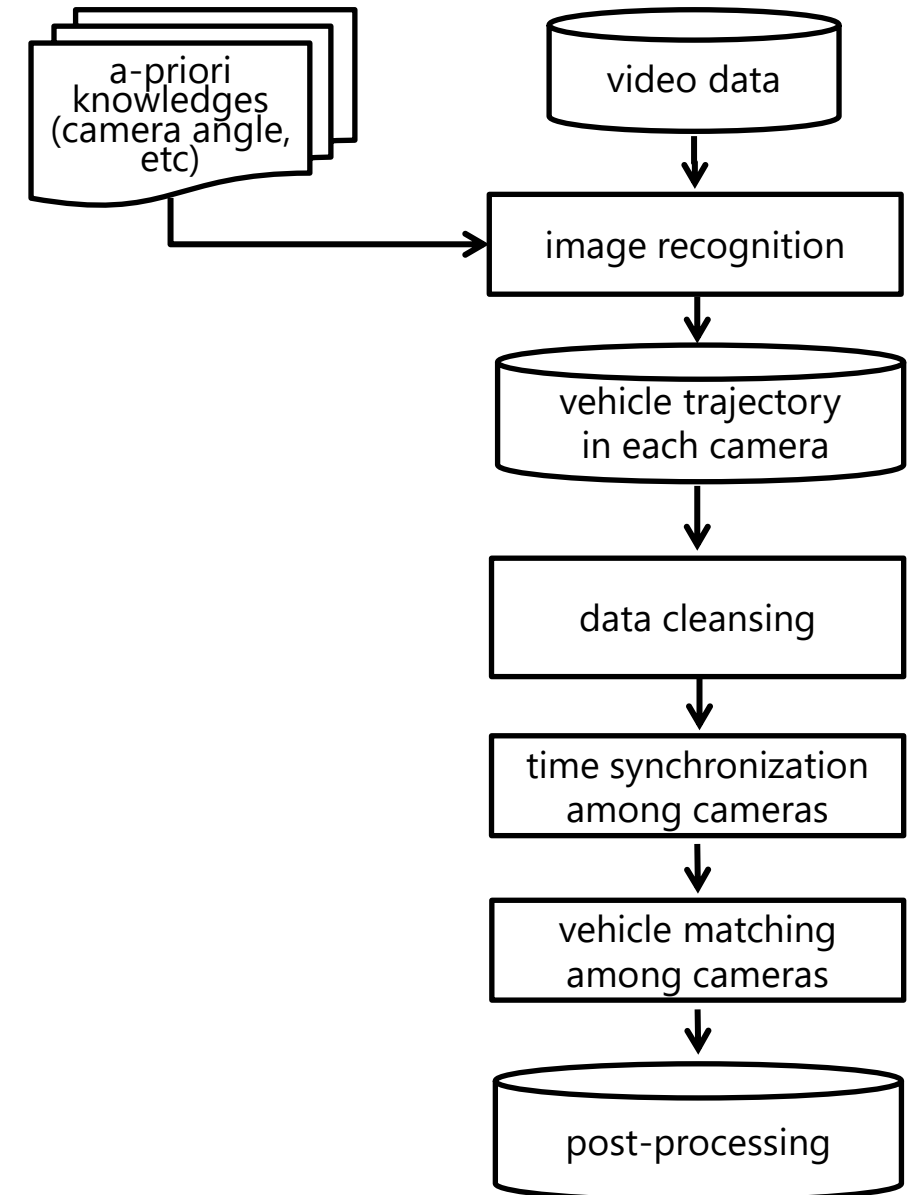
vehicle ID	time	position	lane	velocity	vehicle length	vehicle type	...
...							

- Road geometry

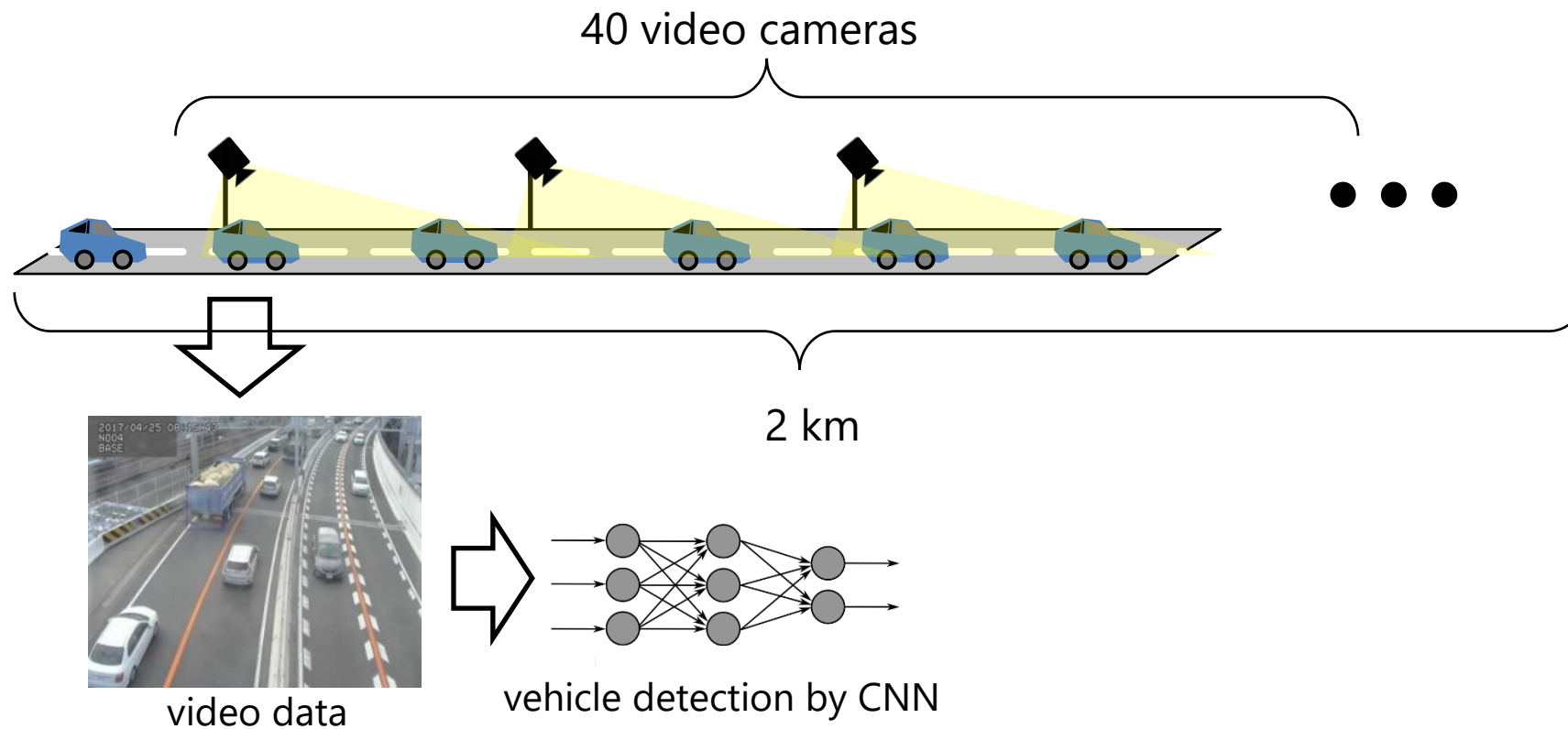
curvature radius	longitudinal slope	transverse slope
...		

- Detector data for reference
 - Vehicle passing timing, occupancy

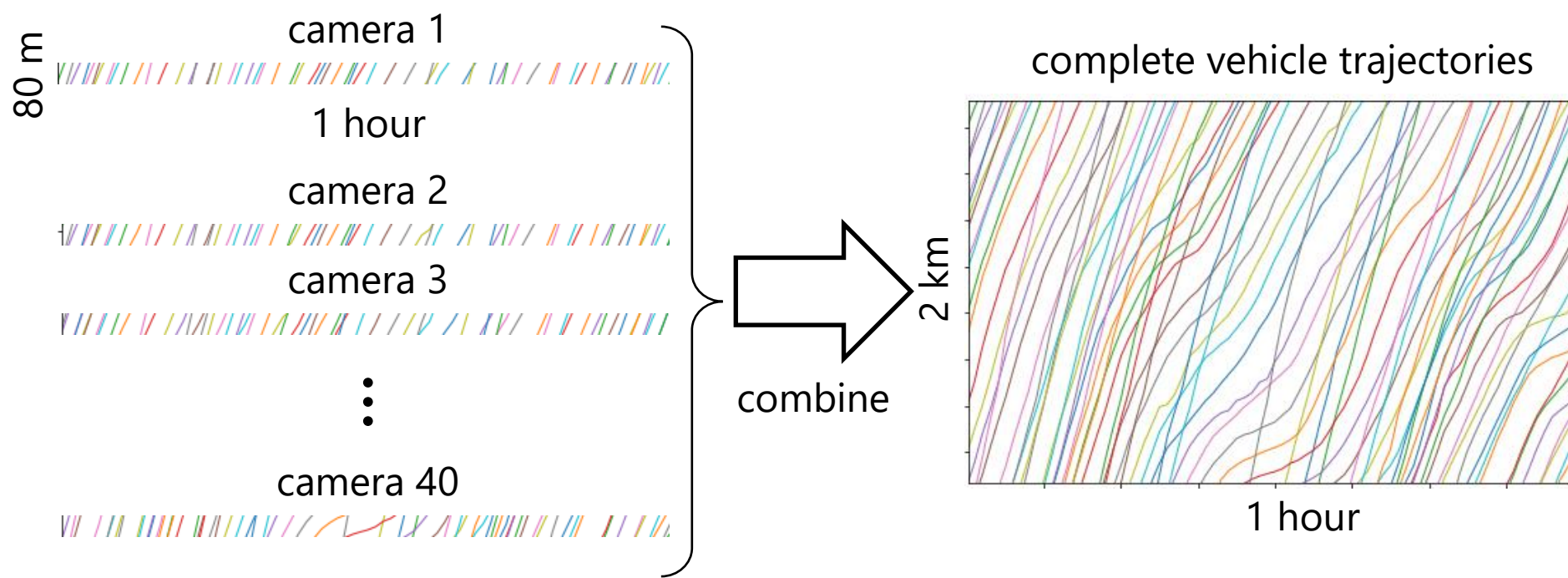
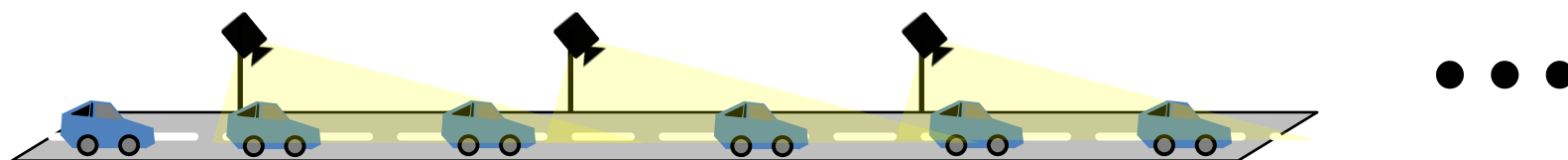
- It is very challenging to collect continuous trajectories over 2 km length section
 - We cannot cover the entire section with single camera
 - Approx. 40 cameras were used
- Method
 1. Trajectories in each camera are extracted
 2. Trajectories in different cameras are combined



- Around 40 video cameras were placed to the 2 km sections
 - Each camera covers ~80 meters
- In each camera,
 - vehicles are detected by deep learning (CNN) for each frame,
 - trajectories are reconstructed and interpolated by Kalman filtering-like technique

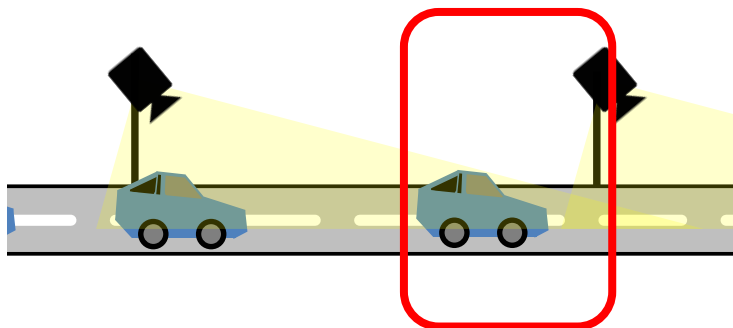


- Vehicles in the neighboring cameras need to be matched
- This was the most challenging part



- At the edges of a camera's field of view, vehicles are difficult to see
 - Occlusion due to large vehicles
 - Low resolution due to distance
- We matched vehicles based on the features of vehicles, mostly extracted by NN
 - trajectory (may be incomplete)
 - appearance and other vehicle features
 - combination of vehicles
- And correction was performed

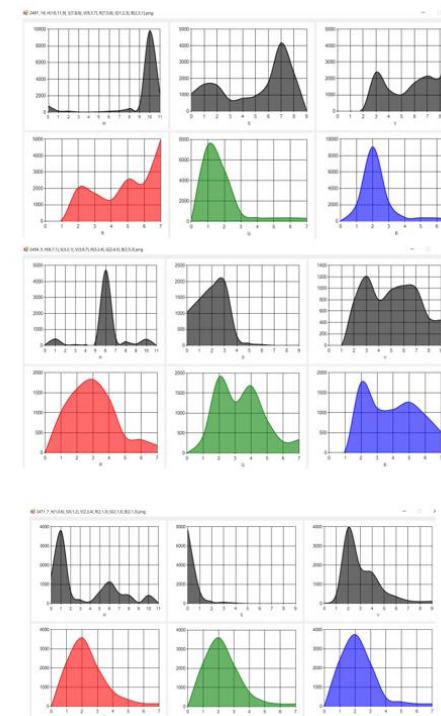
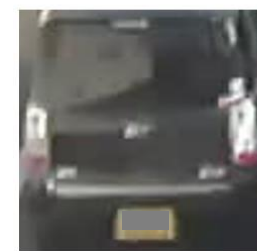
matching zone



matching zone

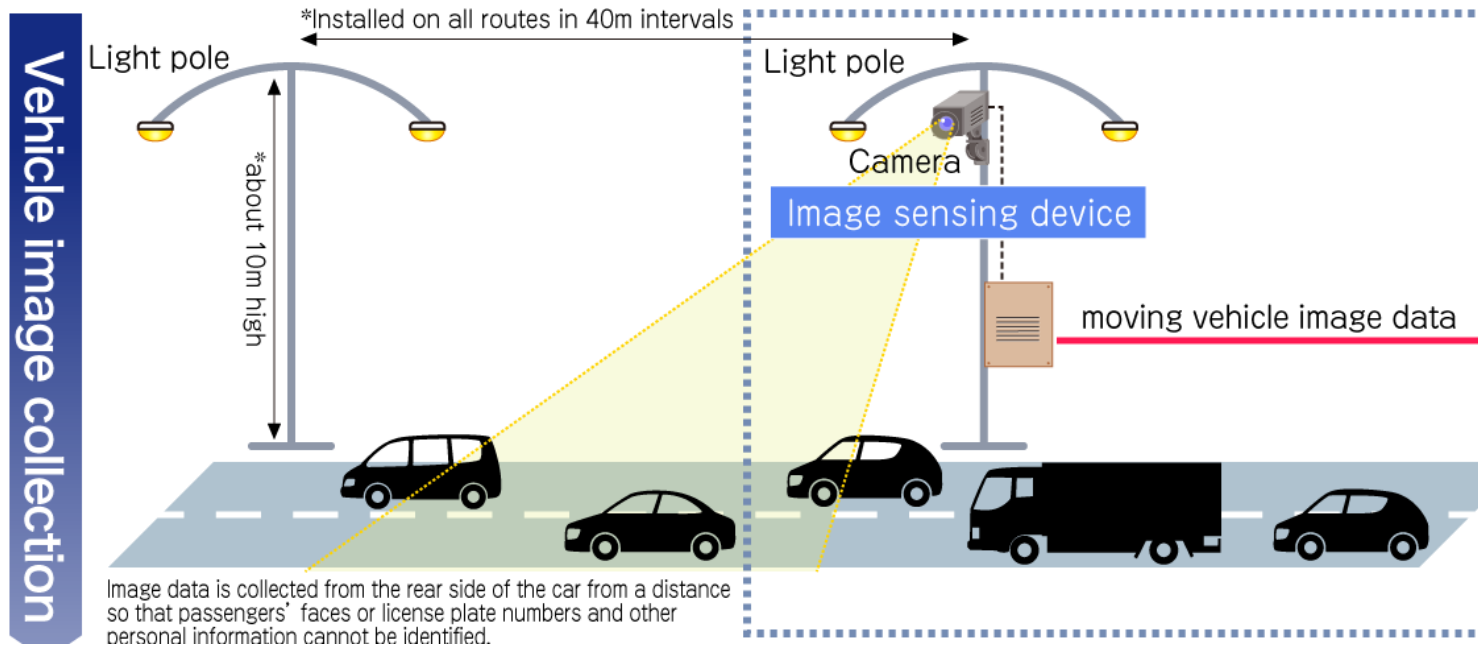


feature extraction

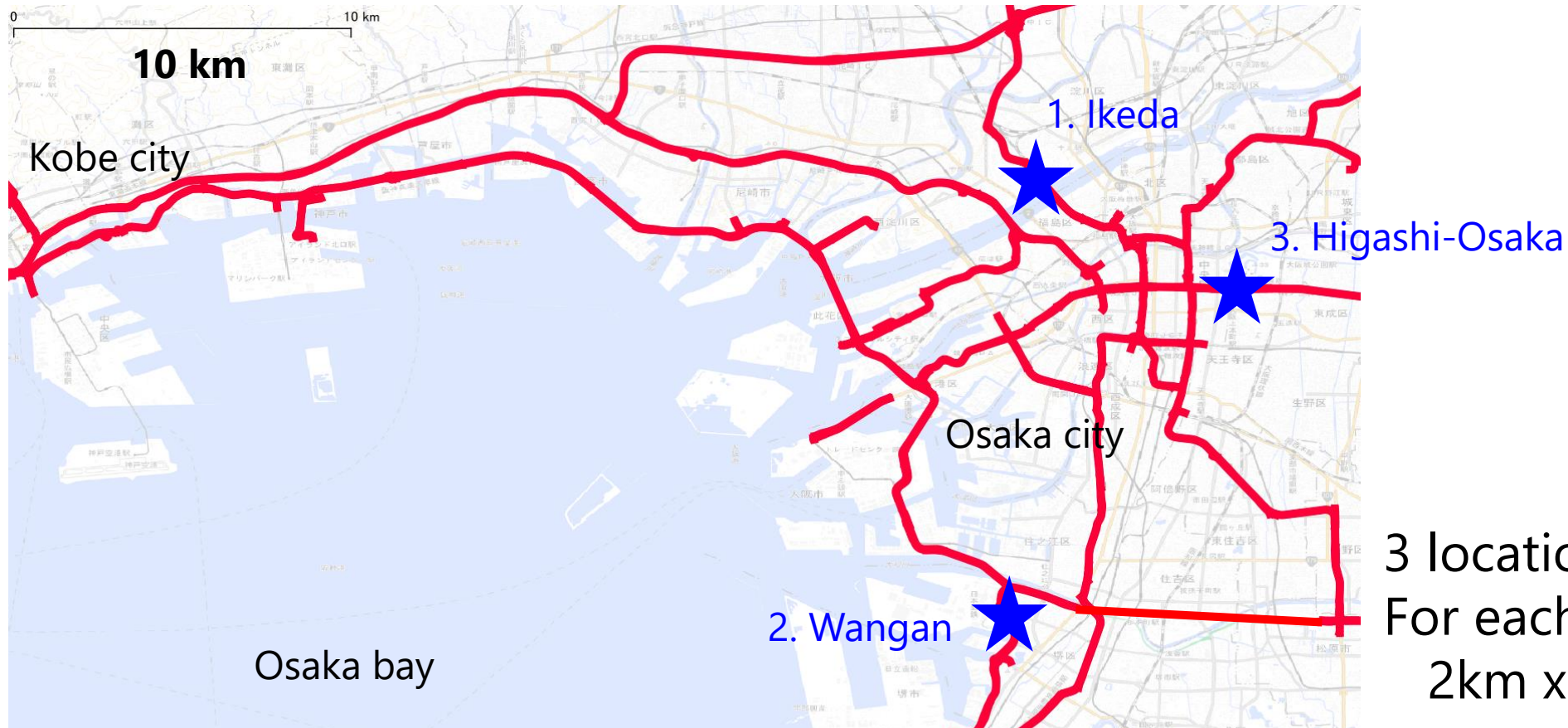


- Initial vehicle detection
 - Comparison to manually prepared small ground truth data
 - Recall rate: 96.8%
 - Precision rate: 97.1%
 - Insensitive to traffic conditions, weather conditions, and time of day
- Vehicle trajectory
 - Comparison to a GPS-mounted probe vehicle
 - RMS difference of positioning: 1.05 m
 - RMS difference of speed: 3.59 km/h
- Traffic volume
 - Comparison to an accurate detector
 - RMS difference: 1.04 veh/5min/lane

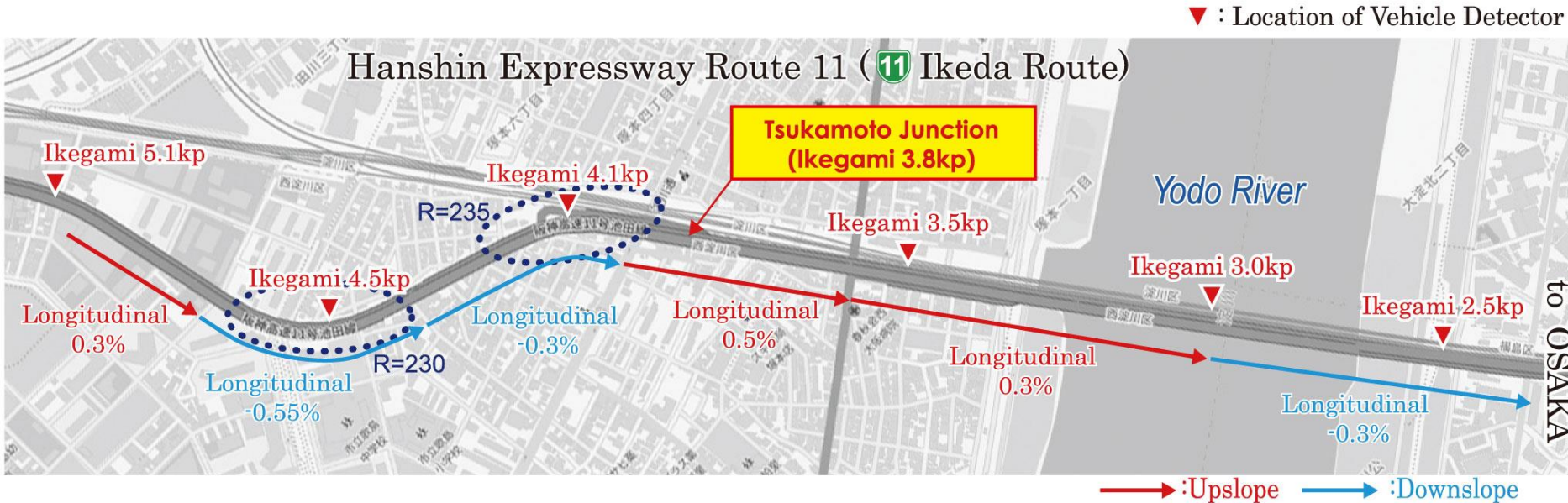
- A unique feature of the data collection system is that it is "portable"
 - It is not firmly fixed as infrastructure
 - Cameras are attached to existing light poles
 - It can be removed and re-installed to different locations, and start new data collection with minimum re-calibration



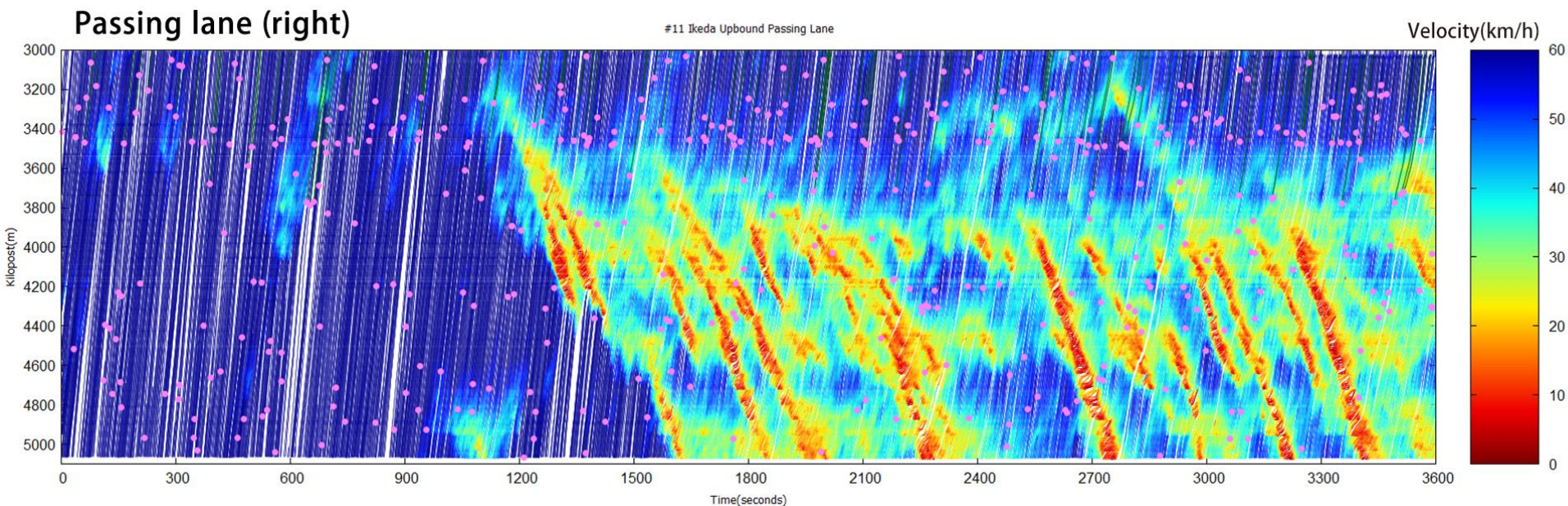
- Hanshin Expressway is an urban expressway in the Hanshin Metropolitan Area that covers Osaka and Kobe, with 15 million population
 - The entire road network size: 294 km length
 - Daily average traffic volume: More than 700,000 vehicles



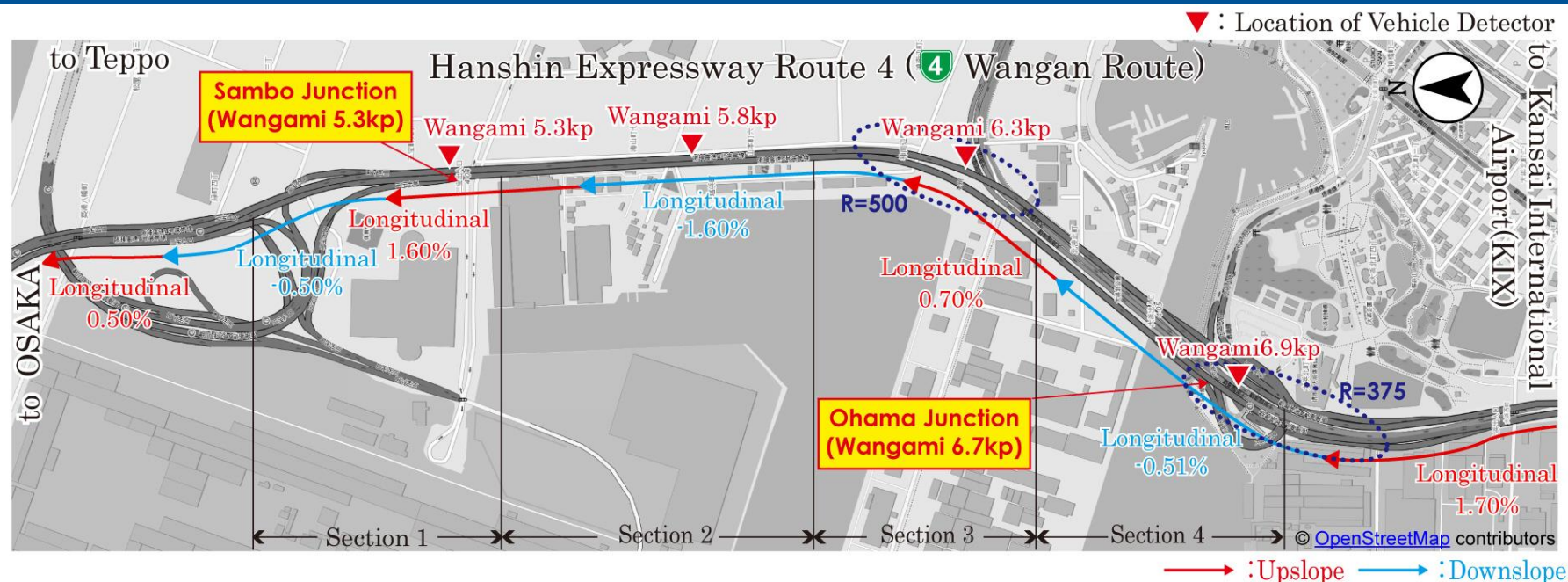
3 locations
For each location,
2km x 1 hour x 5 datasets



- Merging
- S-shaped curve
- Bridge



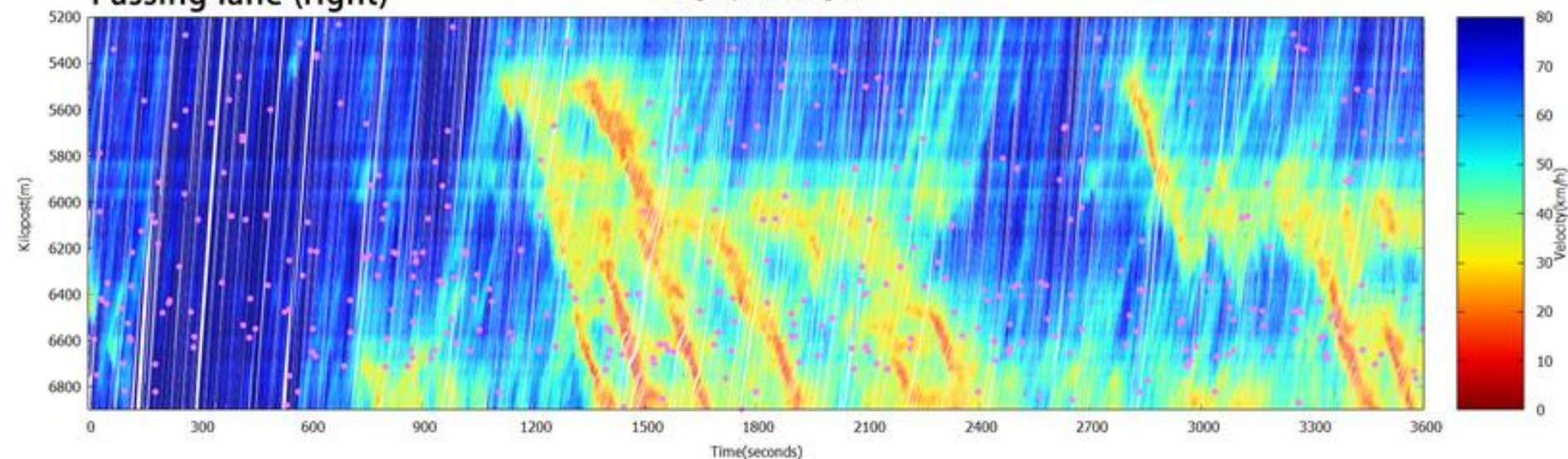




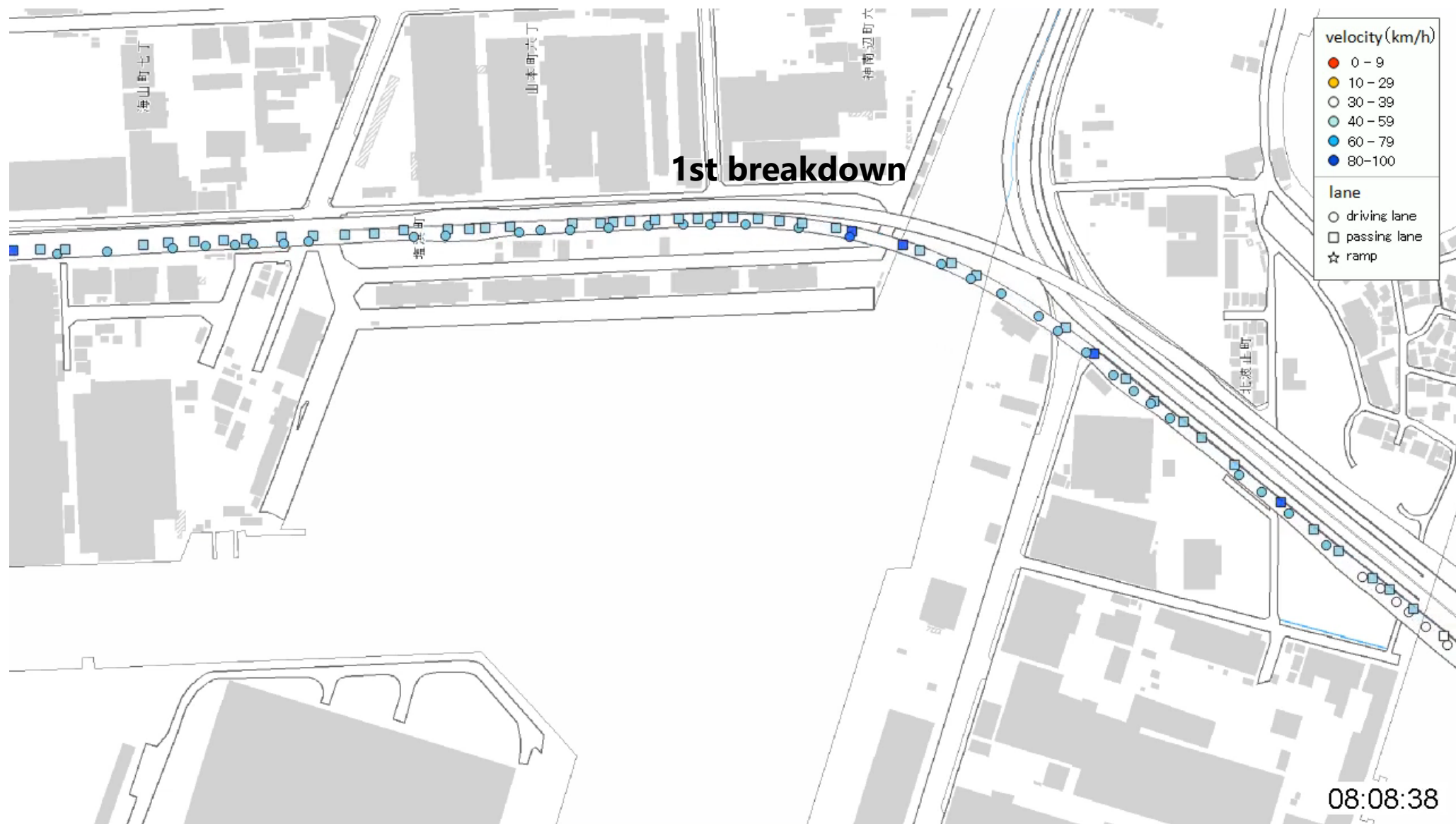
- Sharp curves
- Diverging
- Sag (downhill and uphill)

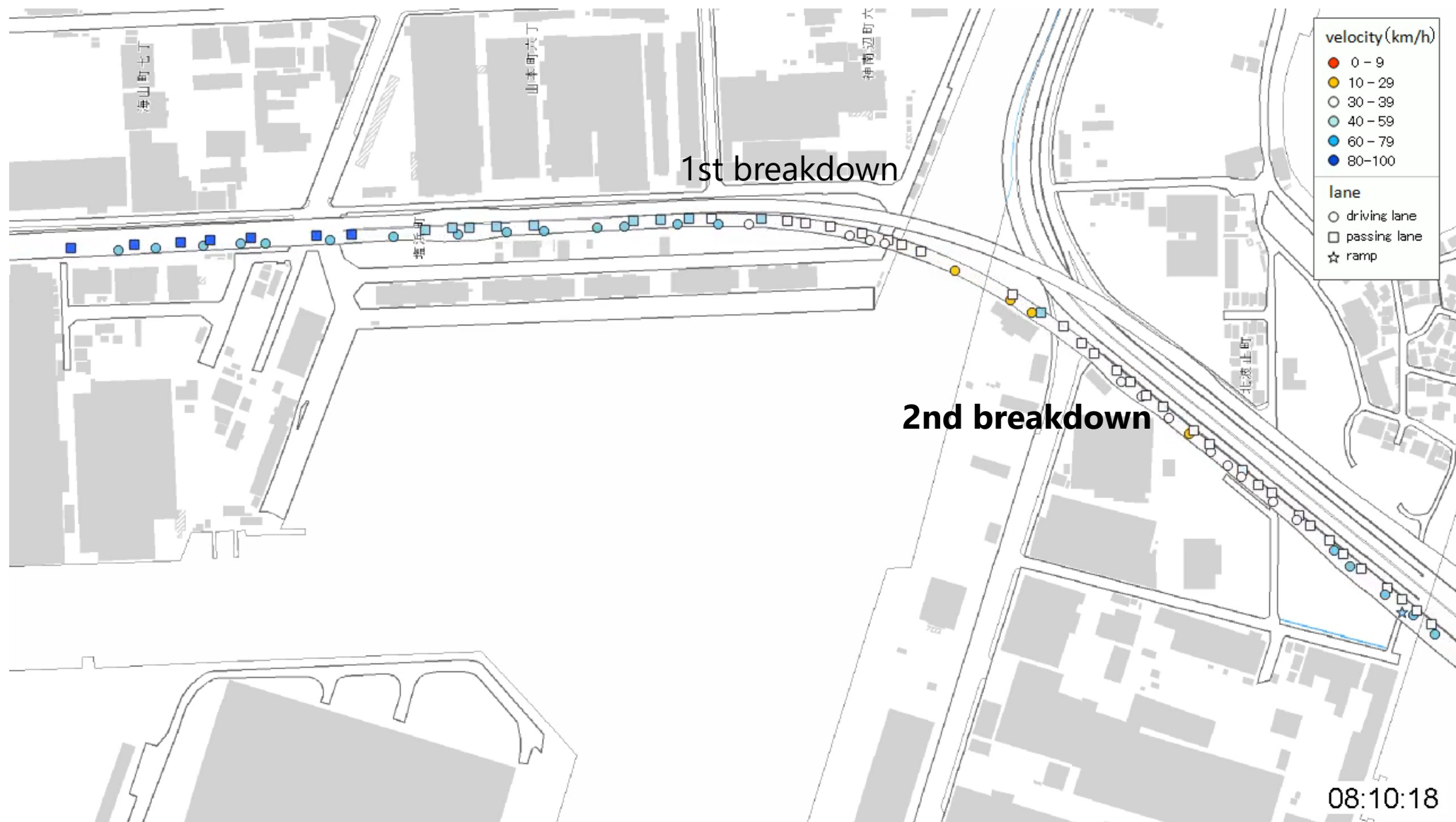
Passing lane (right)

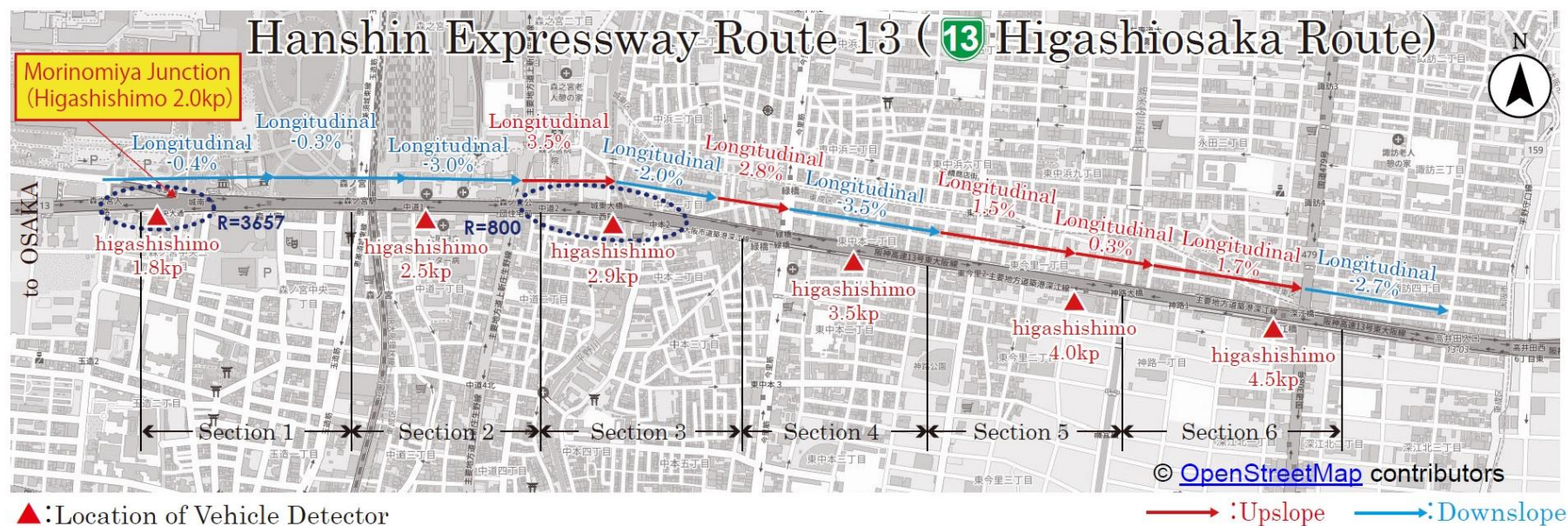
#4 Wangan Upbound Passing Lane



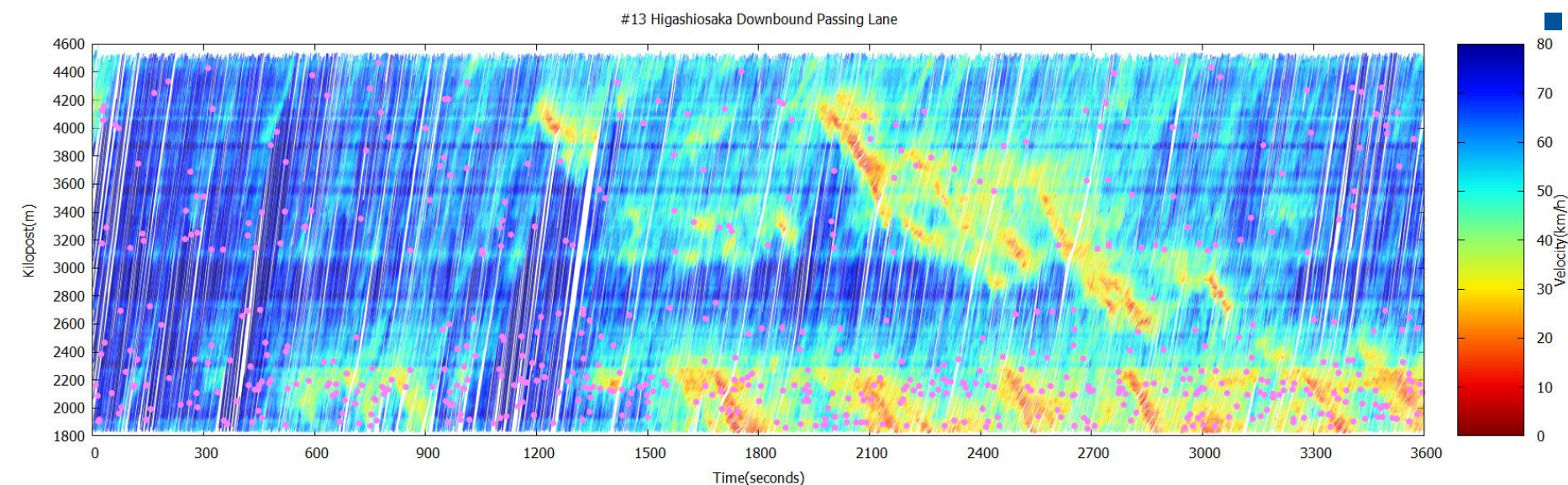
- Breakdown at 3 different locations
 - Their activation conditions and relations are not clear



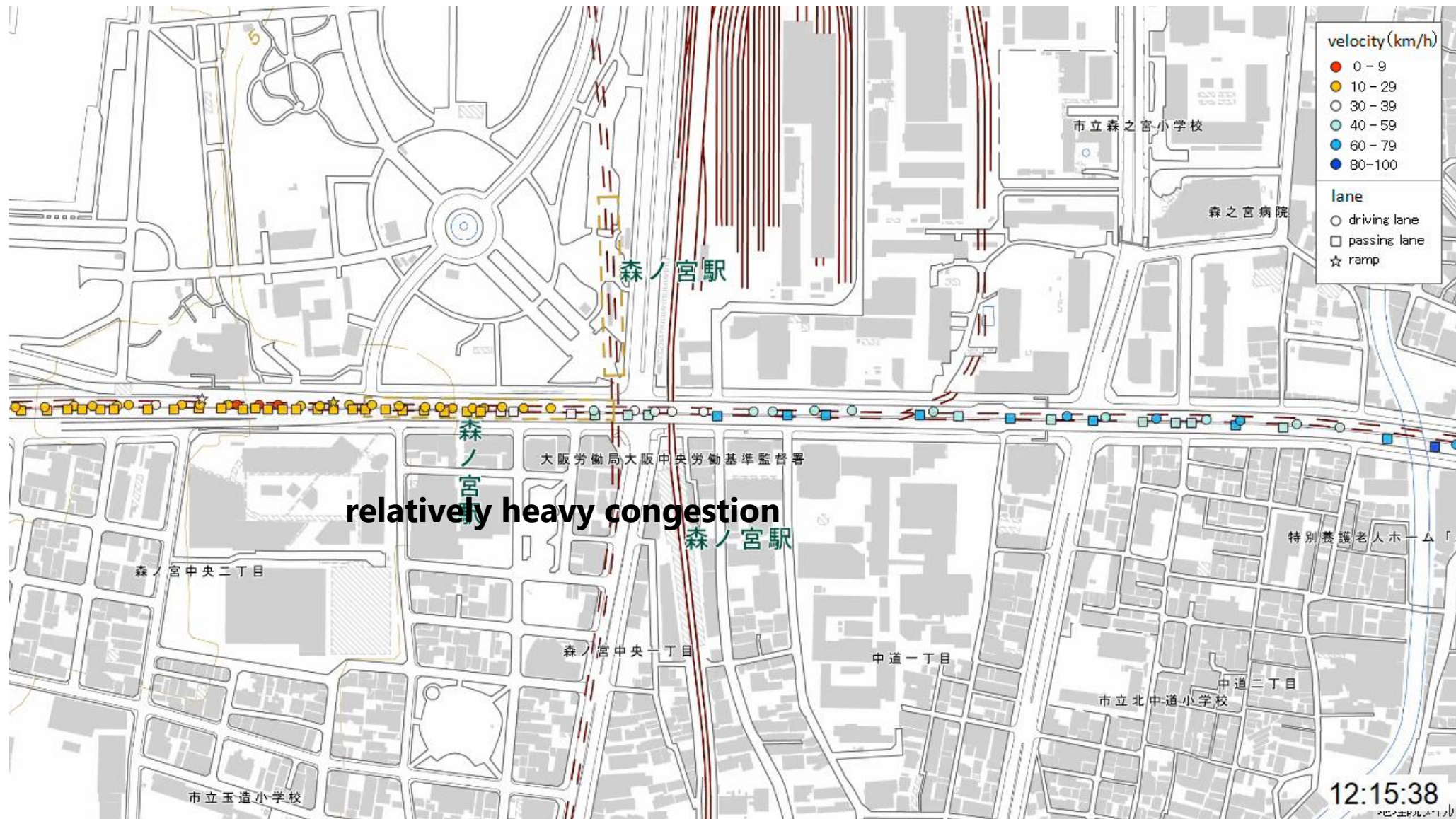




- Straight
- Merging
- Strong sag



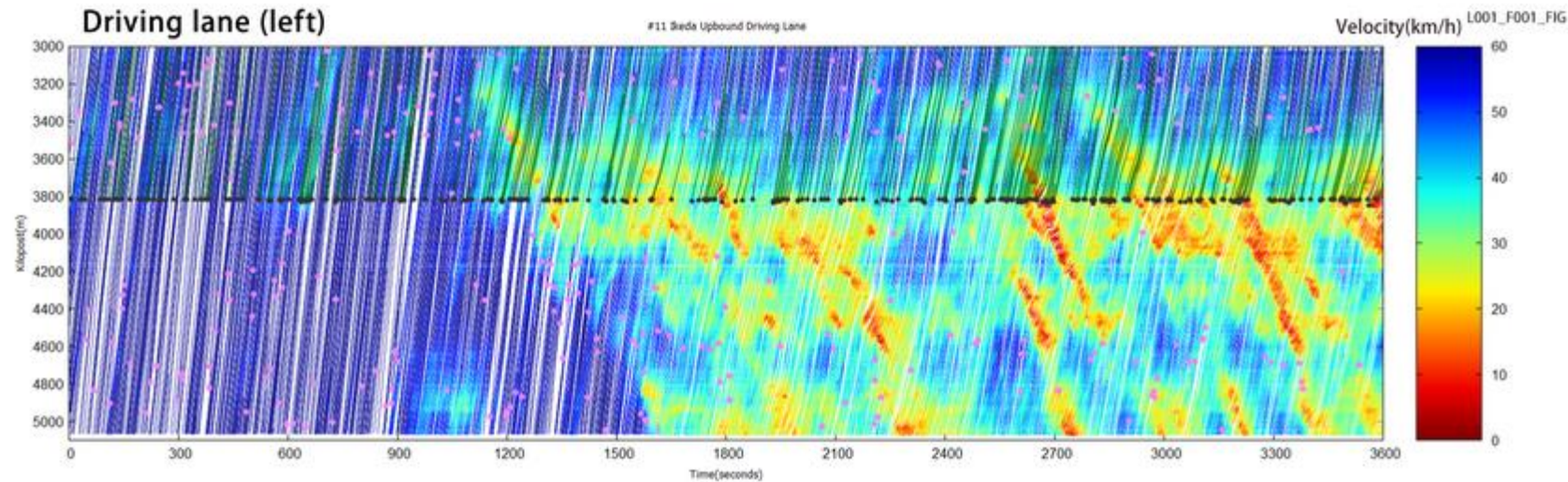
- Active traffic control measure was partially implemented and activated



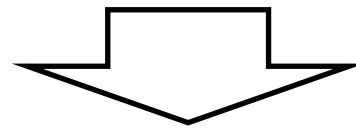


- Series of road-side lights flash so that they look like moving at a constant speed
- The system “nudge” the drivers to follow the lights, so that traffic breakdown is prevented or traffic jam dissipation accelerated
- The ZTD includes traffic with and without this system activated

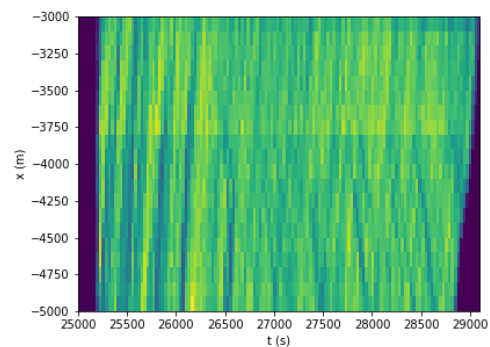
- Introduction
- Data collection method
- Examples and applications



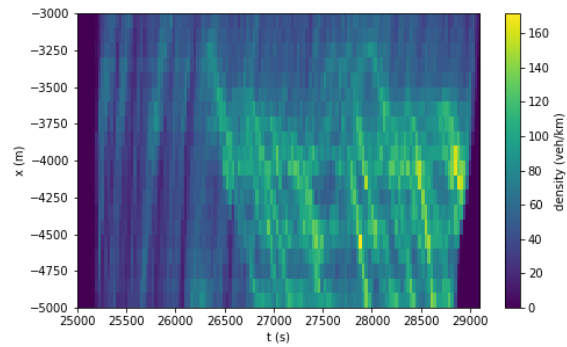
Trajectories



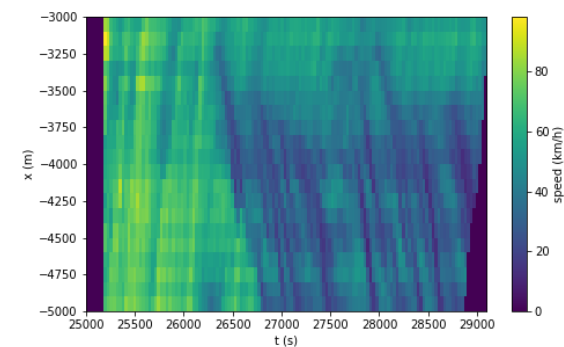
30 s × 100 m grid traffic state
(Edie's definition)



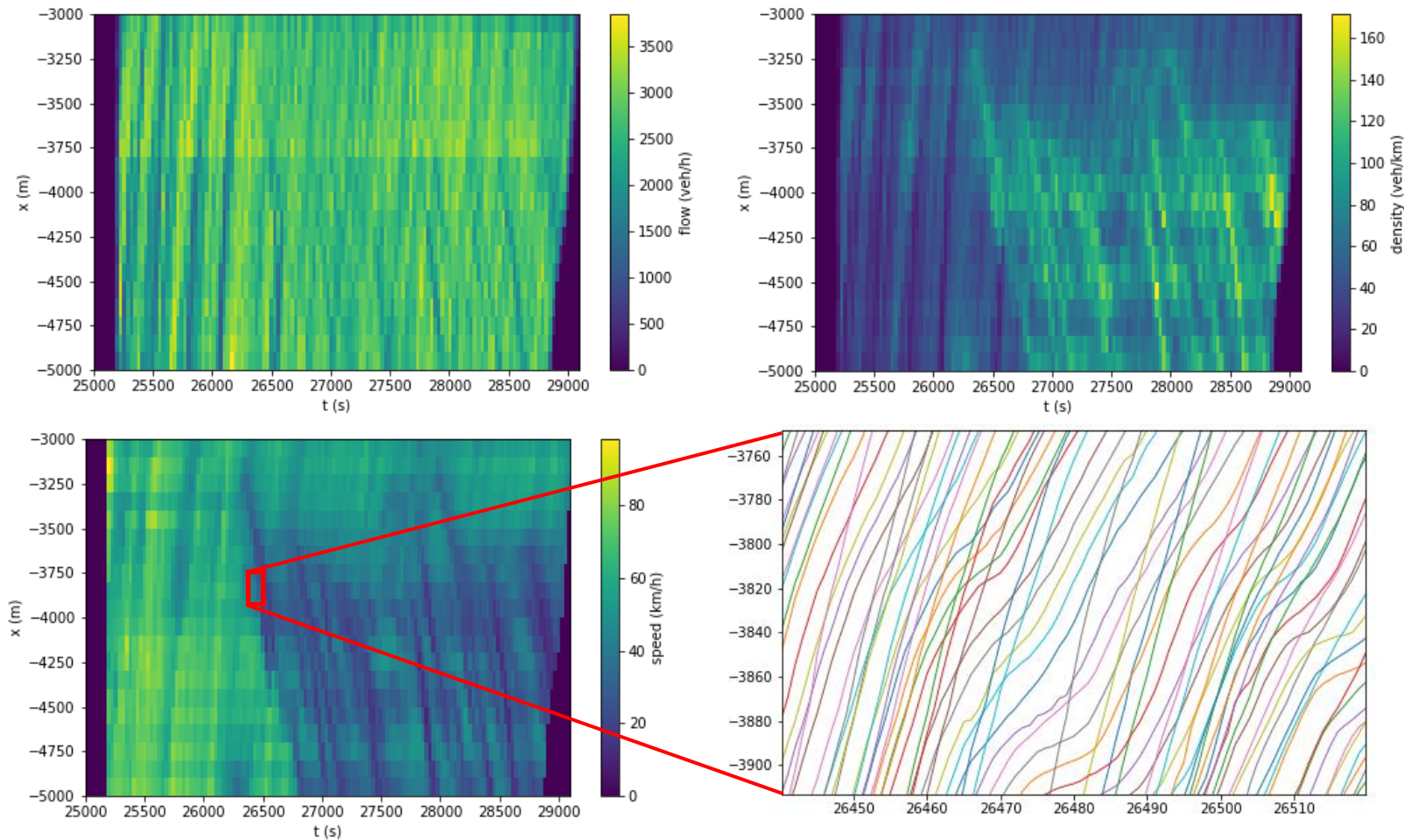
flow



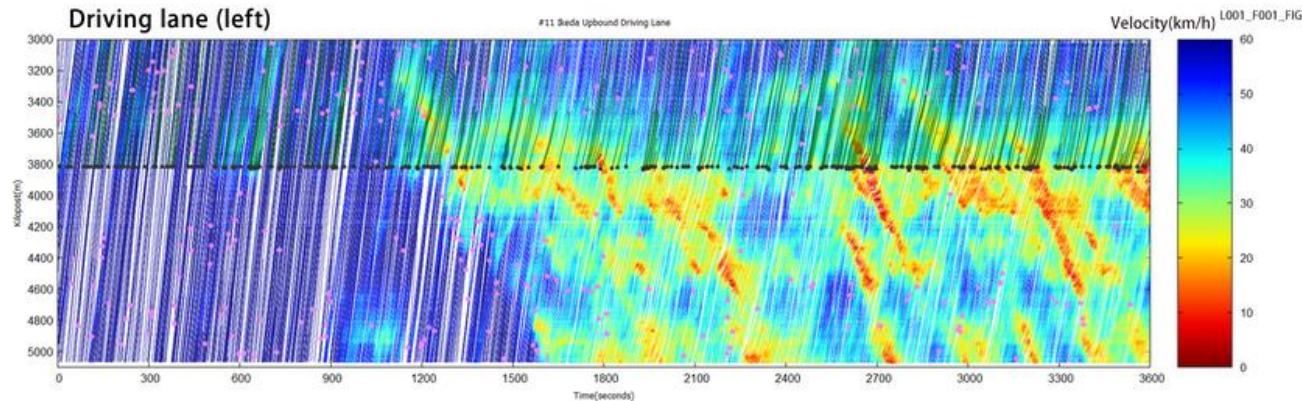
density



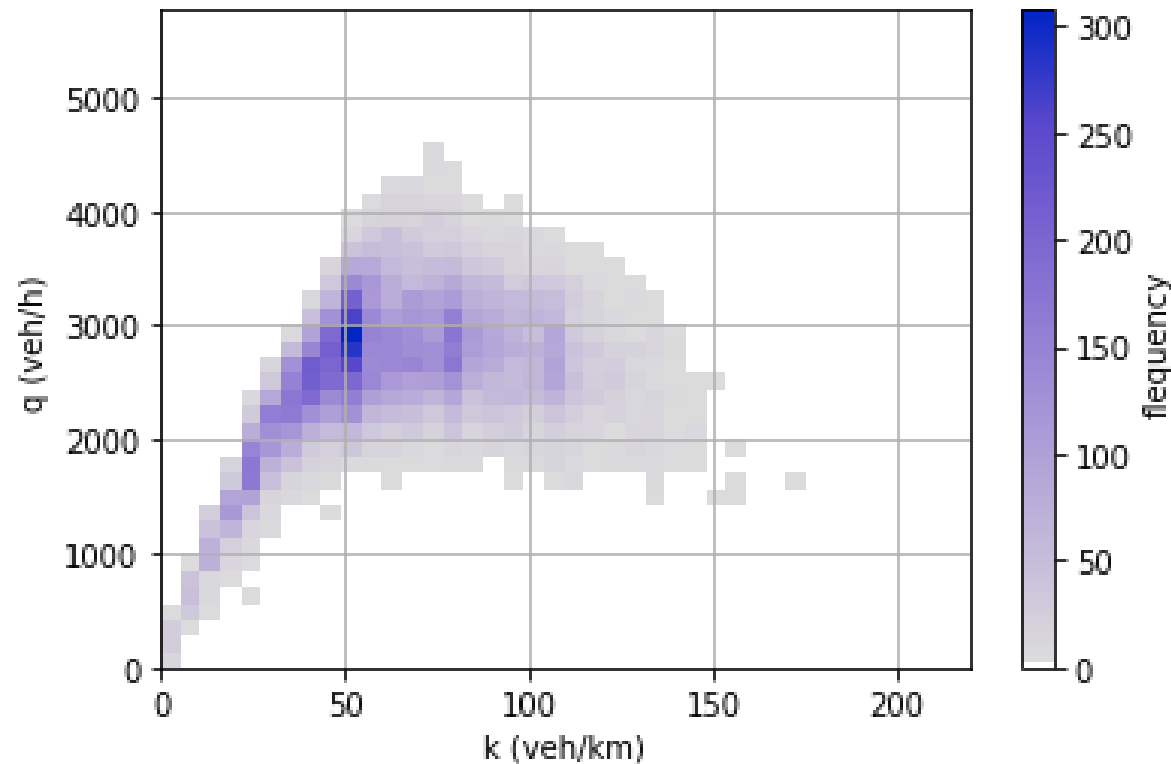
speed



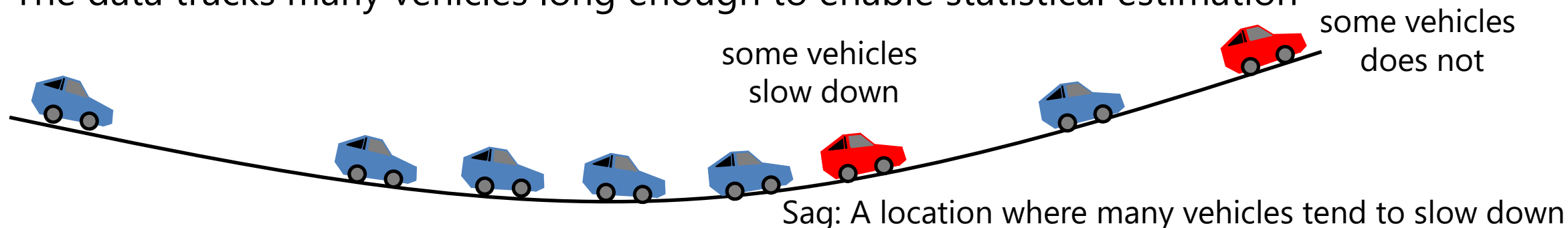
- Macroscopic phenomena were clearly observed



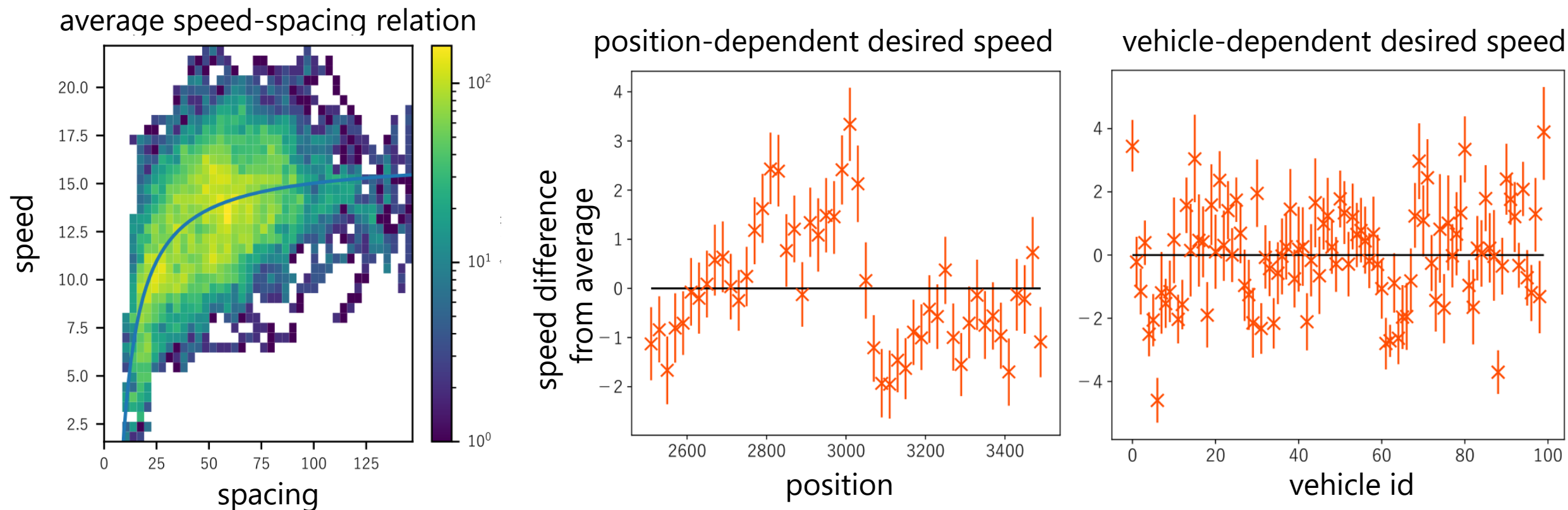
- Flow-density diagram
- A triangular-like shape was observed
- Traffic with various densities were observed



- Traffic breakdown usually happens at a specific bottleneck location
 - E.g., sag, a point where the road changes from downhill to uphill
 - Location-specific feature
- However, not all vehicles causes breakdown, even if the situations are the same
 - Vehicle-specific feature
- For better understanding of traffic breakdown, we need to investigate the cross effects of location- and vehicle-specific features
 - $v = V(x, n, s)$: Spacing s to speed v relation of vehicle n and position x :
- Data requirements
 - The data covers such complicated bottlenecks
 - The data tracks many vehicles long enough to enable statistical estimation

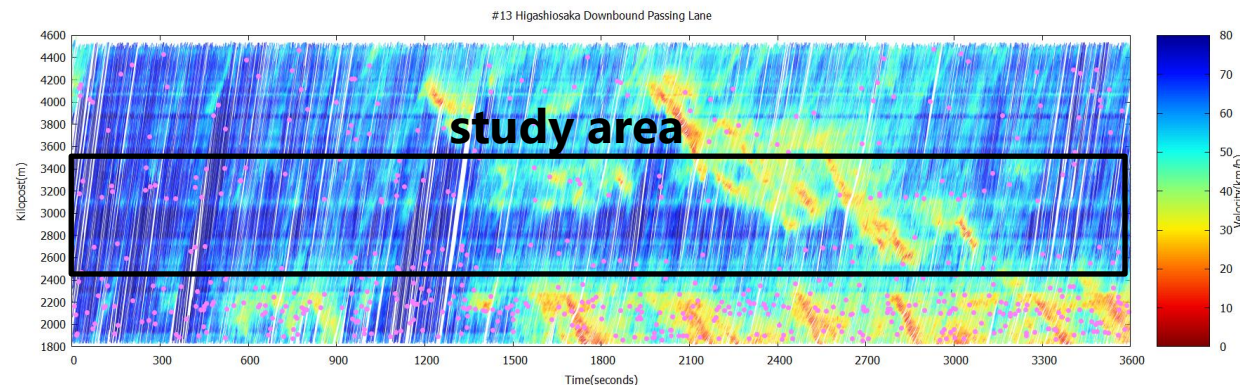
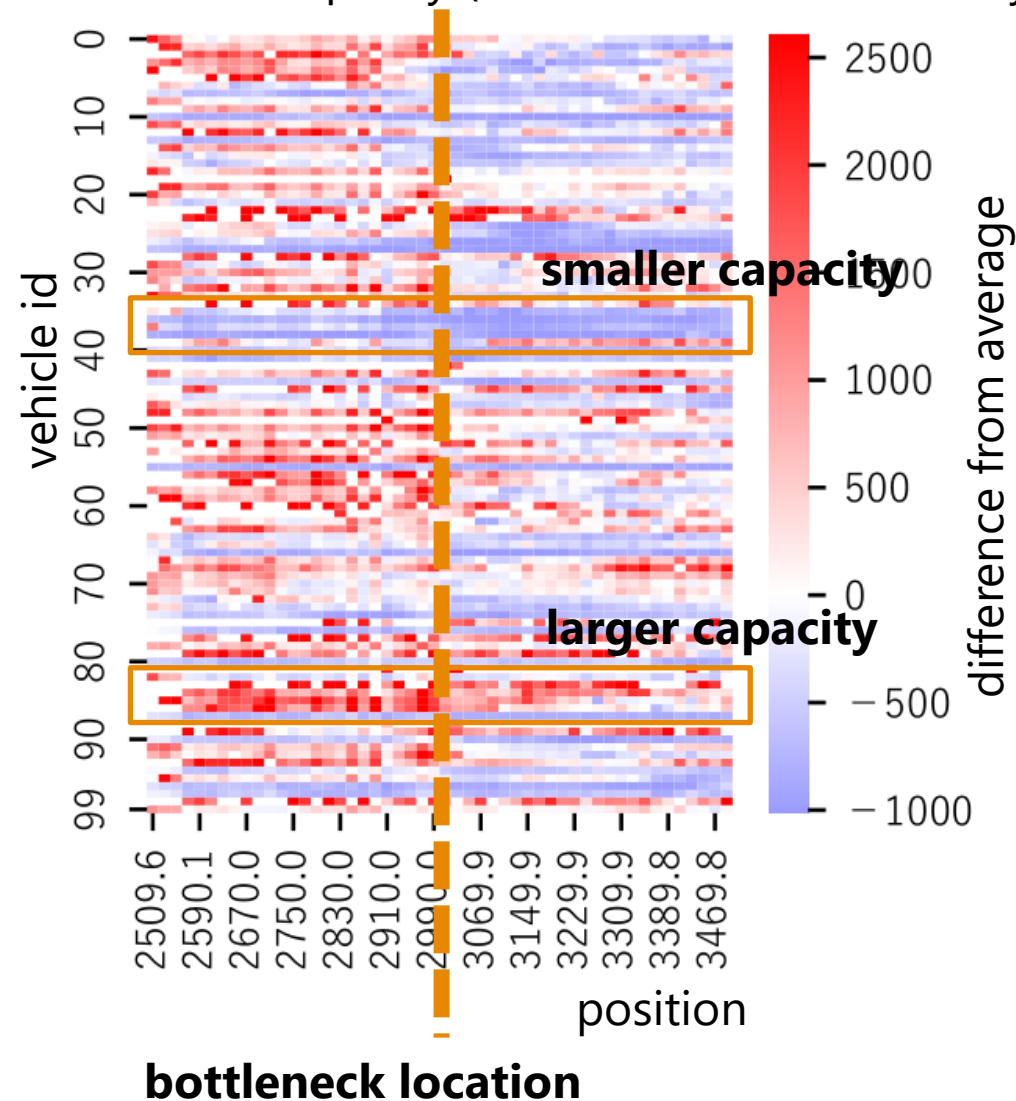


- We developed a car-following model incorporating vehicle- and location-dependent effects by a hierarchical Bayesian framework
- We estimated the model using ZTD



K. Hayashi and T. Seo, "Estimating source of traffic congestion from vehicle trajectory data using hierarchical Bayesian model," in *Proceedings of the 28th International Conference of Hong Kong Society for Transportation Studies*, Hong Kong, 2024, forthcoming

local traffic capacity (inverse of critical headway)



Findings

- There is a clear bottleneck location, where many the vehicles decelerate
- Some vehicles are insensitive to bottleneck location. They always have smaller or larger local capacity

- An overview and basic evaluation results on ZTD are provided
 - 2 km, 1 hour
 - 3 locations with distinct interesting features
- ZTD is especially useful to investigate particular traffic phenomena
- Credits & Acknowledgements
 - The data is published by Hanshin Expressway Co. Ltd. at:
<https://zen-traffic-data.net/english/>
 - More detailed specifications: Seo, T., Tago, Y., Shinkai, N., Nakanishi, M., Tanabe, J., Ushirogouchi, D., Kanamori, S., Abe, A., Kodama, T., Yoshimura, S., Ishihara, M., and Nakanishi, W. Evaluation of large-scale complete vehicle trajectories dataset on two kilometers highway segment for one hour duration: Zen Traffic Data. In 2021 International Symposium on Transportation Data and Modelling, 2021.
 - Hanshin Expressway Co. Ltd., Regional Futures Research Center, OMRON SOCIAL SOLUTIONS Co.,Ltd., Prof. Wataru Nakanishi , Prof. Masao Kuwahara, Prof. Yasuo Asakura