Comparison of MFD-based approaches with microscopic simulation data for real networks: Production hysteresis and trip length estimation.

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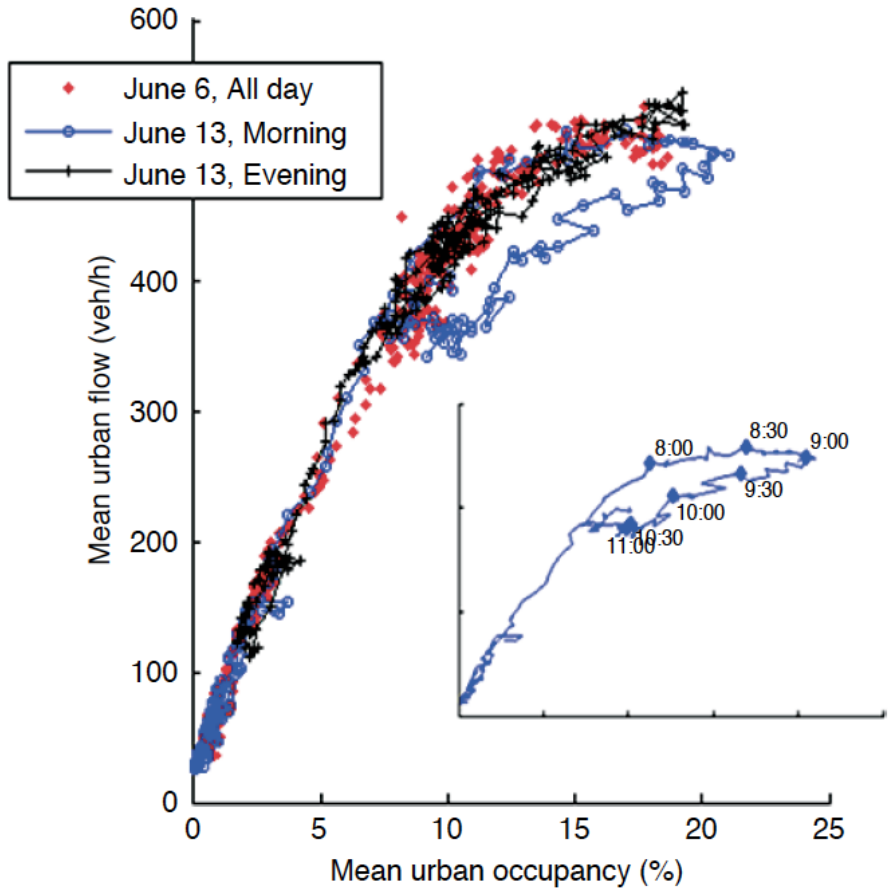
MFD-based models

- Core ingredient is the shape of Macroscopic Fundamental Diagram (MFD).
- Empirical studies showed clockwise hysteresis-like loops in production MFD.
- The validity of constant mean trip hypothesis.
- Verification of MFD-based models using real network data.

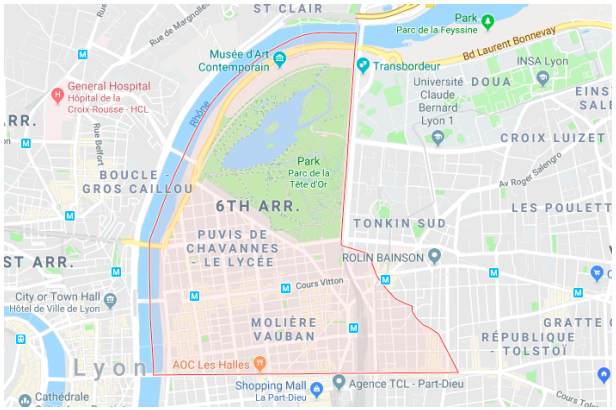


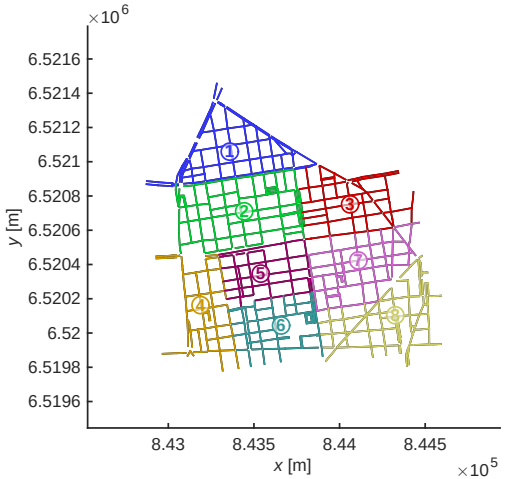
Toulouse city emprical data taken from Buisson and Ladier (2009).

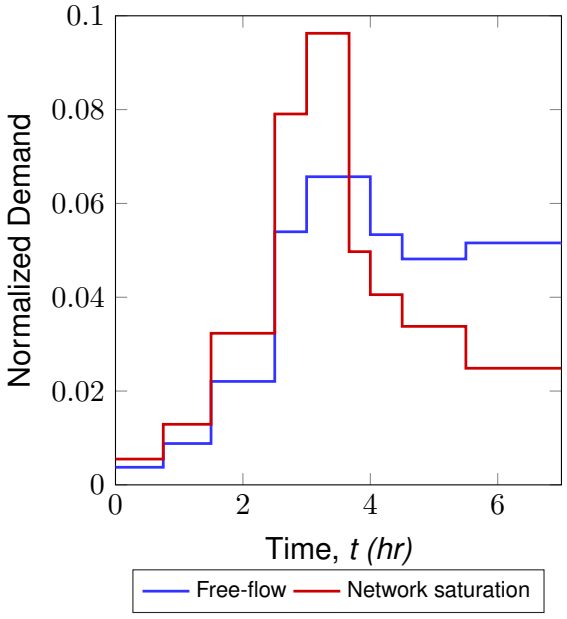
Objectives

- An investigation into calibration of MFD shapes. Unimodal and bimodal MFD shapes are considered.
- To integrate the bimodal MFD shape with production hysteresis into the frameworks of MFD-based models.
- To study the importance of level of trip length descriptions in MFD-based simulations.
- Importance of re-calibration of MFD and trip lengths to the changes in OD matrix.
- Verification of MFD-based models on 6th district of Lyon city network using microsimulation data.

Lyon 6 network attributes







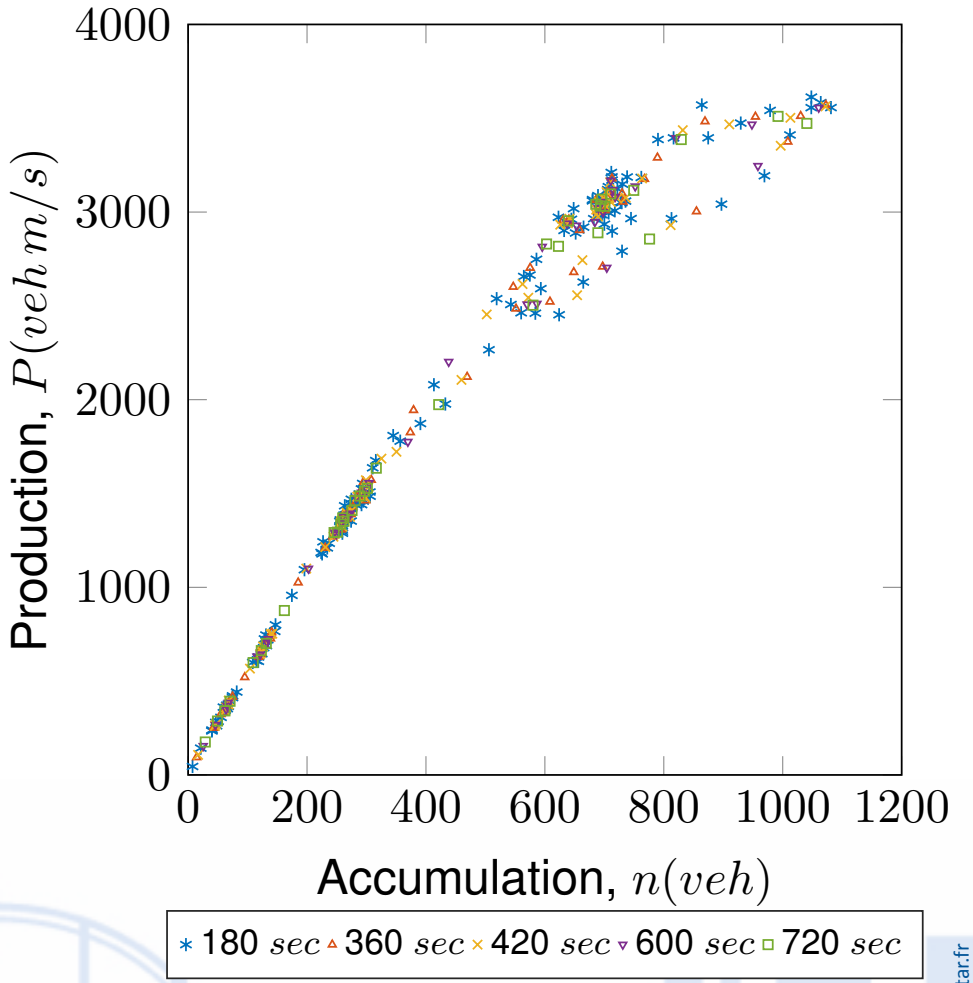
- OD matrix and demand are estimated from empirical data of Lyon city network.
- Lyon 6 has 21 OD zone pairs.
- Internal and transfer trips.

Microsimulation settings

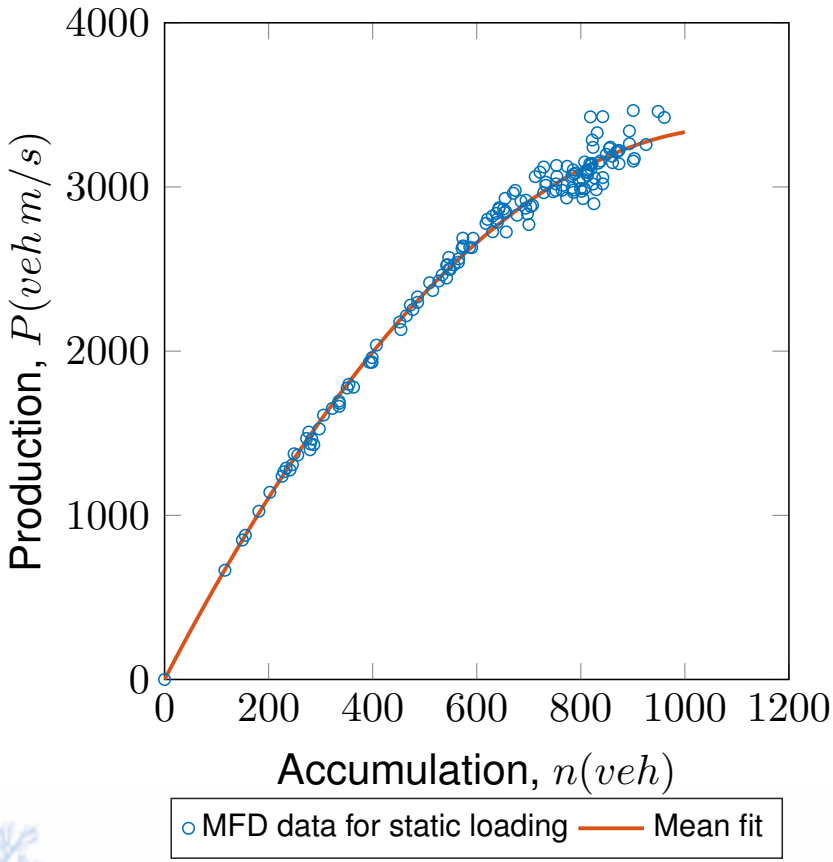
- Microsimulations are computed using Symuvia platform.
- FD parameters for cars: $u = 25\,m/s$, $w = 5.88\,m/s$ and $\kappa = 0.17\,veh/s$. Trucks: $u = 22\,m/s$, $w = 5.88\,m/s$ and $\kappa = 0.075\,veh/s$.
- Public transport is also considered in the simulation.
- Free flow speed is adjusted to link speed limits.
- Truck demand is assumed to be 5% of car demand.
- Signal settings are implemented based on real data.
- Morning peak hour duration from 06h30 to 13h30 is considered.

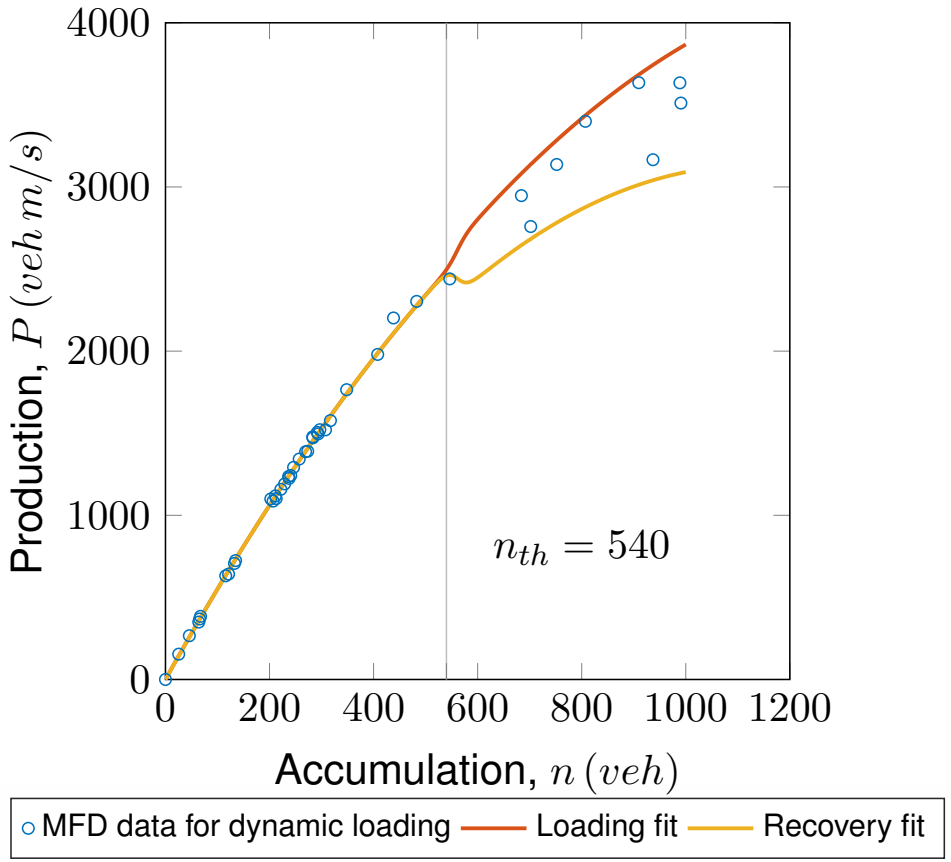
Influence of aggregation time

- A reference scenario with peak demand close to network saturation.
- Signal settings are in order of 100 sec.
- Microscopic variables: Total Travel Distance (TTD) and Total Travel Time (TTT).
- Aggregation period of 600 sec is used in all computations.



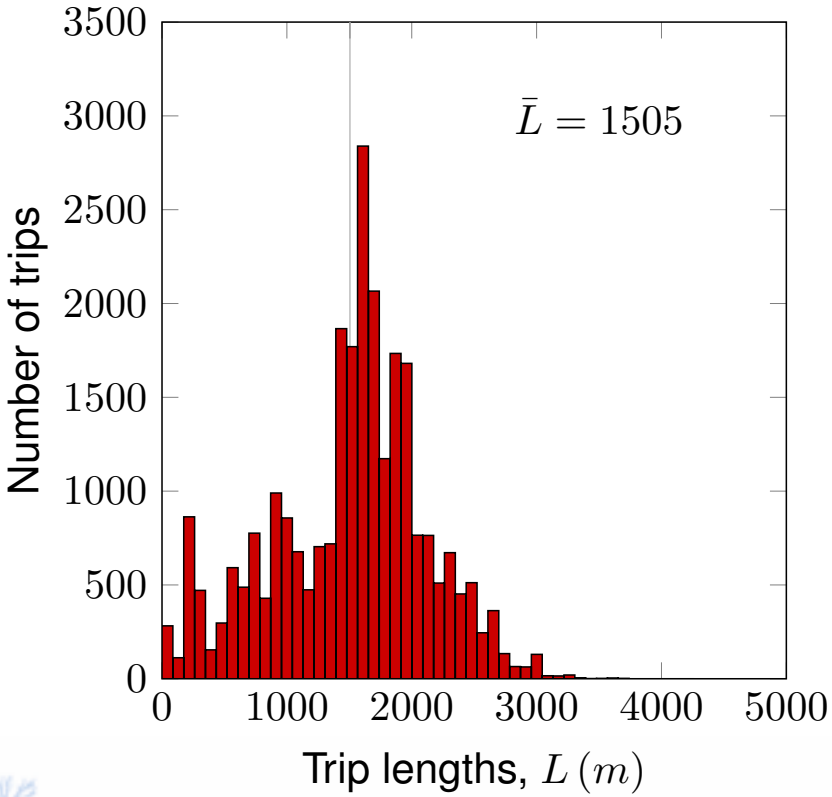
Unimodal and bimodal MFD fits



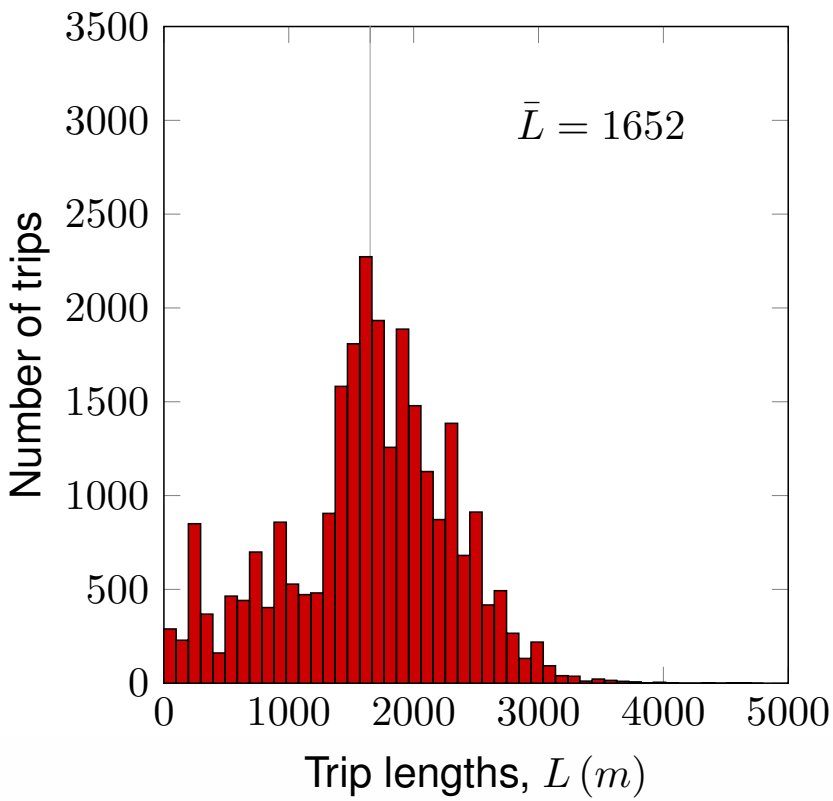


Relative change in accumulation, $\frac{\Delta n}{n}$, is monitored. $n_c = 900\,veh$ and $P_c = 3680\,veh\,m/s$.

Trip lengths distribution



Original OD matrix



Modified OD matrix

Trip lengths computation methods

- Mean trip: one trip length using arithmetic mean of all trips is used.
- OD trips: trips based on origin and destination with respect to Lyon 6 area. Four different trips are considered.
- Similar trips: trips having similar lengths are clustered into bins.
- Individual trips: each trip is considered explicitly.

Accumulation-based model

Daganzo, 2007; Geroliminis & Daganzo, 2008. Based on conservation equation

$$\frac{dn_i}{dt} = q_{in,i}(t) - q_{out,i}(t) \text{ for } i = 1, \ldots, ntrips$$

n_i: Accumulation on trip i
$q_{in,i}$: Demand on trip i, known *a priori*

$$q_{out,i} = \begin{cases} \frac{n_i}{n} \frac{P(n)}{L_i} & n < n_c \\ \frac{n_i}{n} \frac{P_c}{L_i} & n \geq n_c. \end{cases}$$

L_i: Length of trip i
n_c , P_c: Critical accumulation and production

Trip-based model

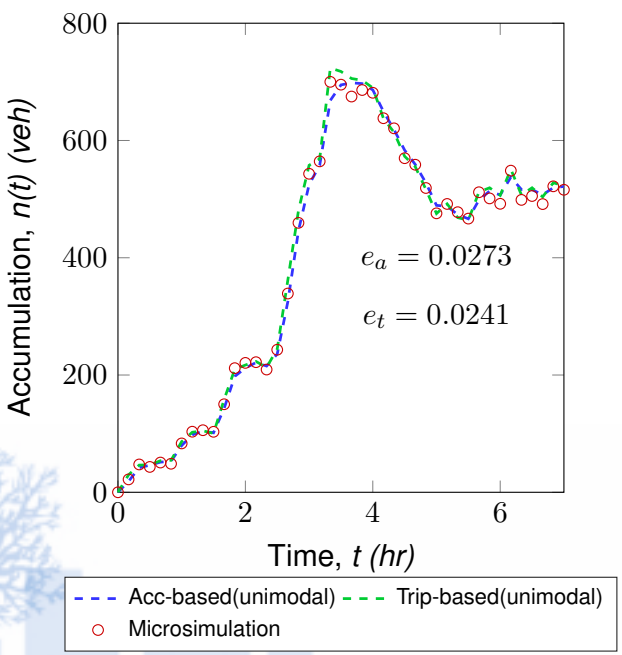
Arnott 2013, Mariotte & Leclercq 2017. Mathematically expressed as

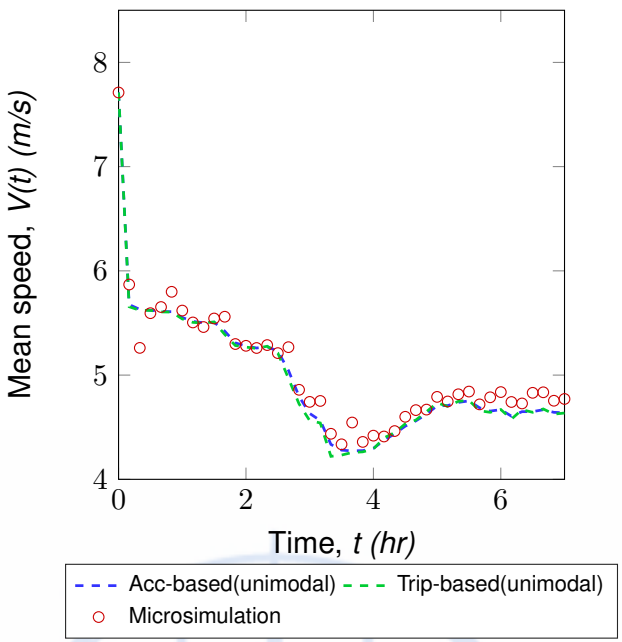
$$L = \int_{t-T(t)}^{t} V(n(s))\, ds.$$

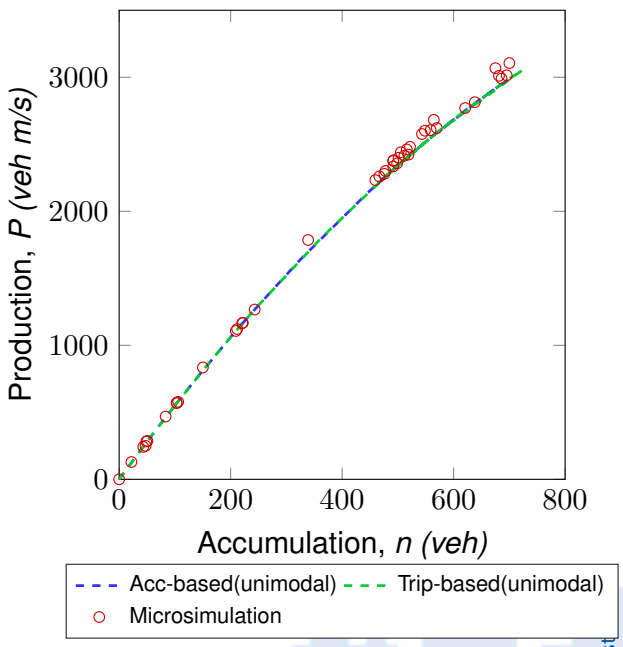
$V(n)$: Mean speed
Event-based framework is used in present work.
Input: Starting times of the trips and length of each trip.
Individual trips are considered.

Free flow traffic state scenario

- Only unimodal MFD fit is considered.
- OD trips are used.
- MFD-based results are also aggregated.

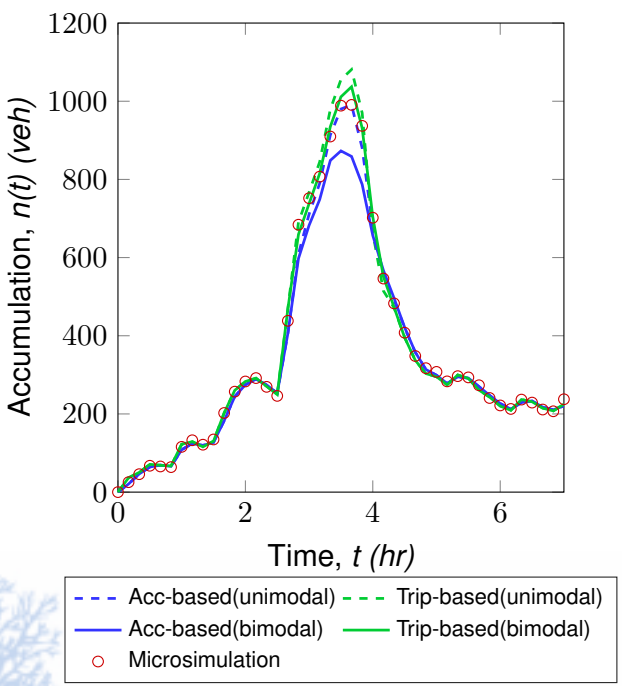


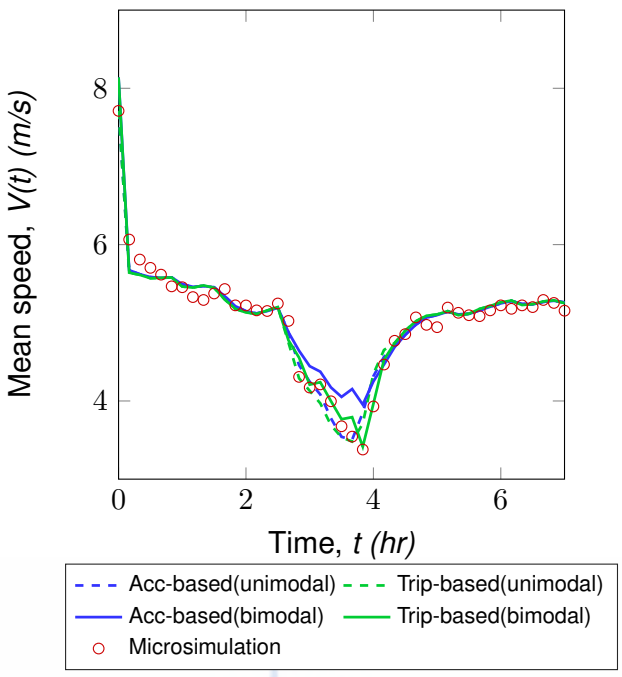


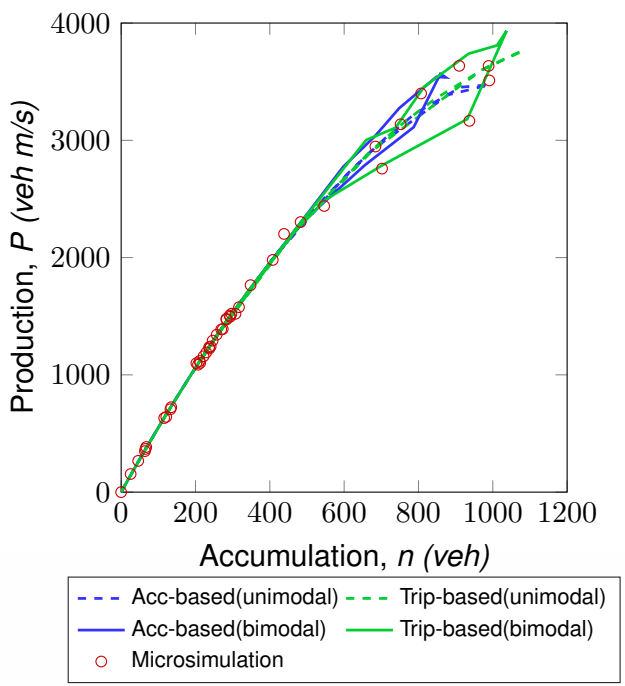


Network saturation traffic state scenario

- Both unimodal and bimodal MFD fits are considered.
- OD trips are used.



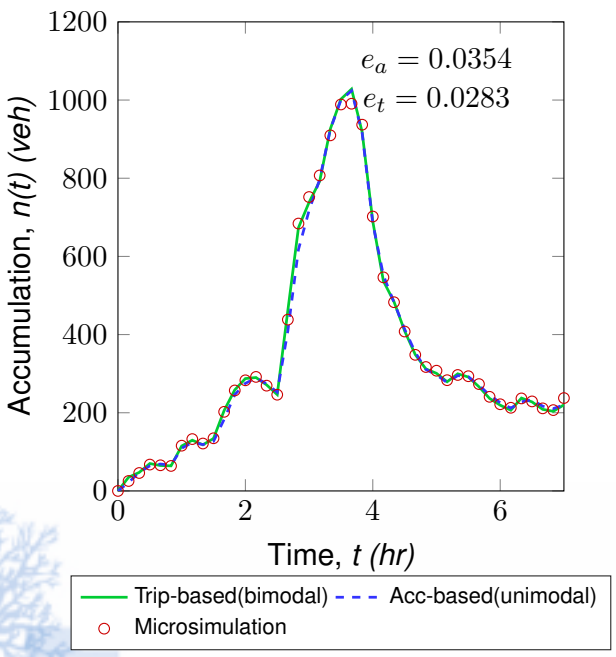


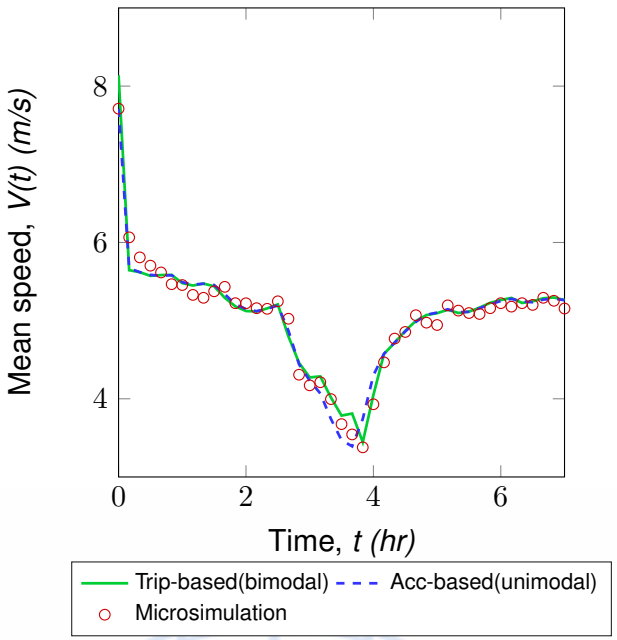


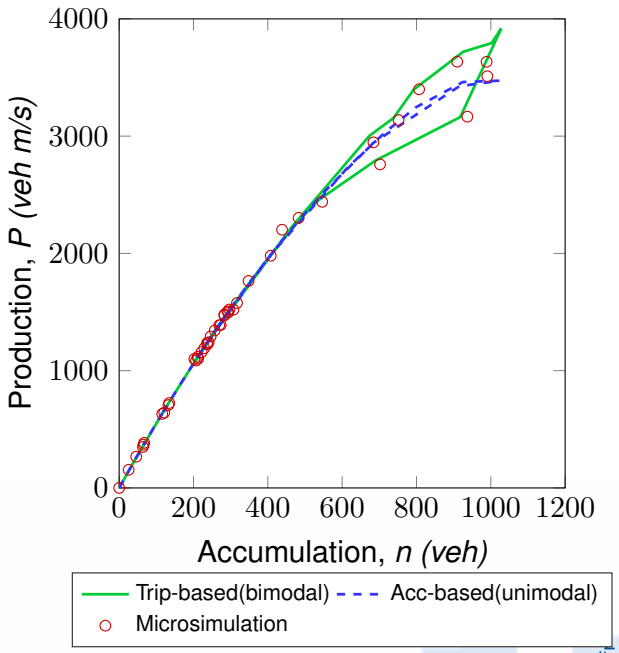
Accumulation-based with unimodal fit, mean trip and trip-based with bimodal fit,similar trips are the best results amongst considered ones.

Network saturation traffic state scenario

- Accumulation-based with unimodal fit and mean trip.
- Trip-based with bimodal fit and similar trips.

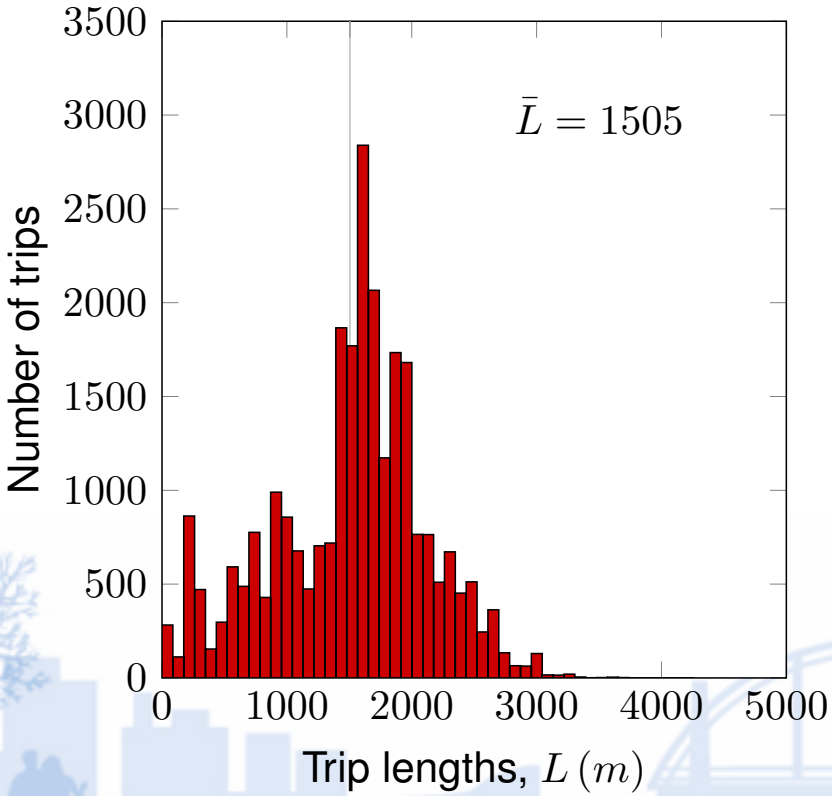




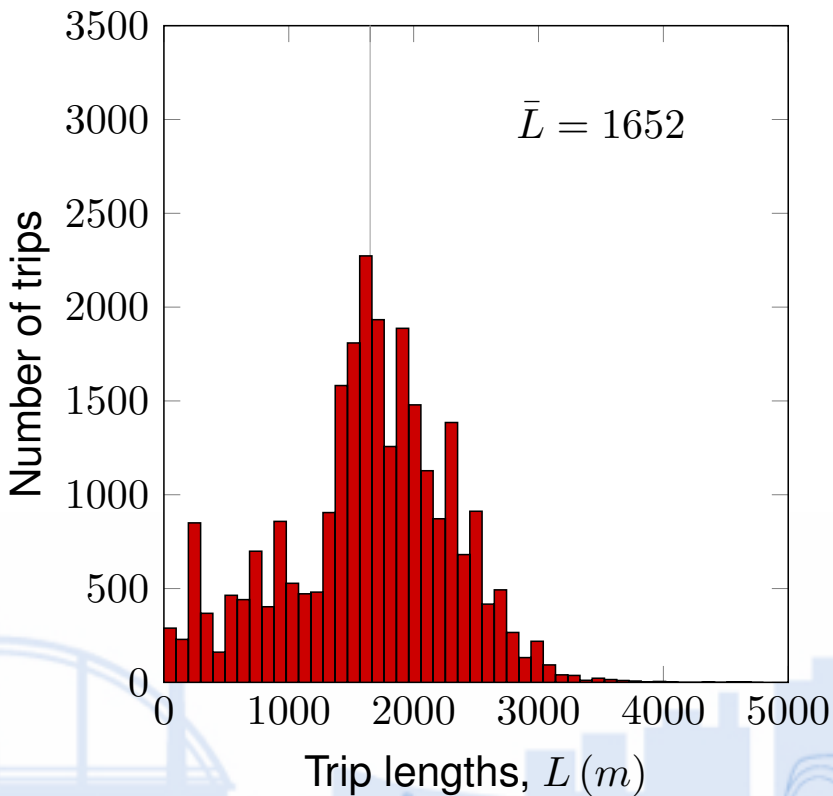


Network saturation traffic state scenario with modified OD matrix

- Mean trip length is increased in the modified OD distribution.
- Only accumulation-based with unimodal fit and trip-based with bimodal fit is considered.



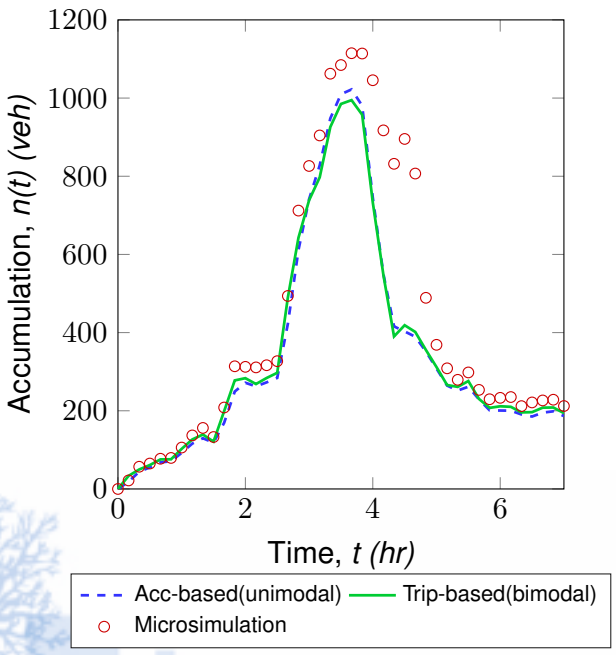
Original OD matrix

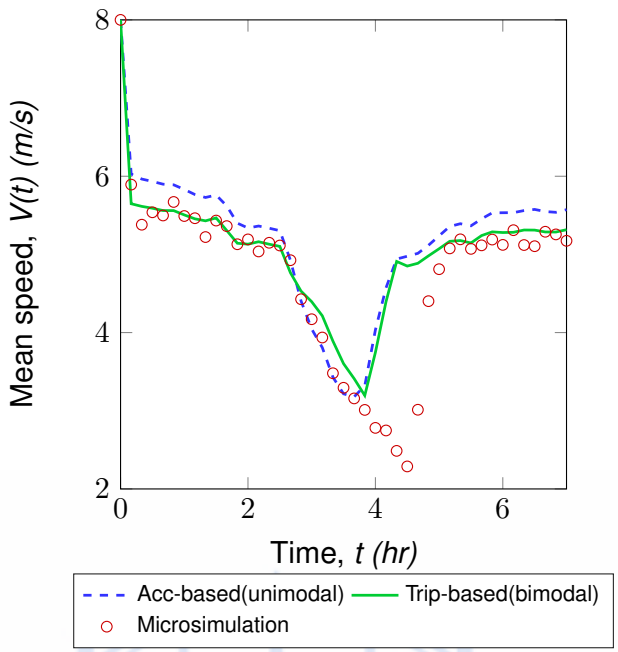


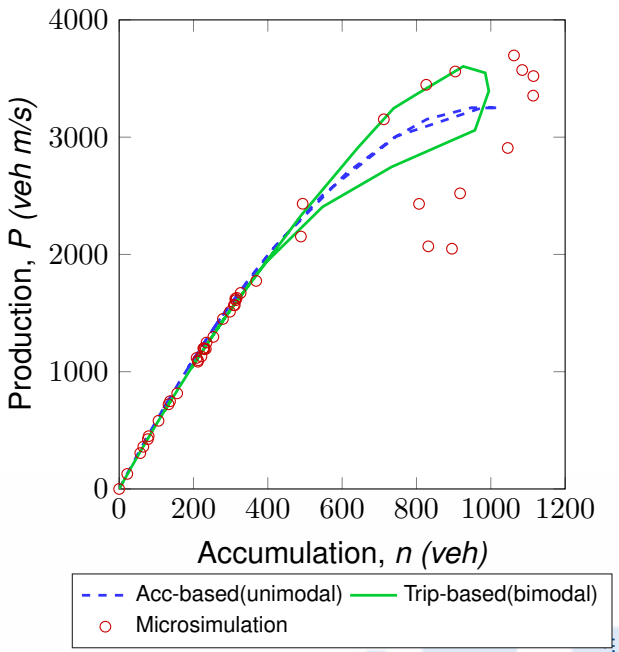
Modified OD matrix

Without recalibration of p-MFD fit and trip lengths

- OD trips are used. Trip lengths from original OD matrix are used.
- MFD fits from original OD matrix are used.

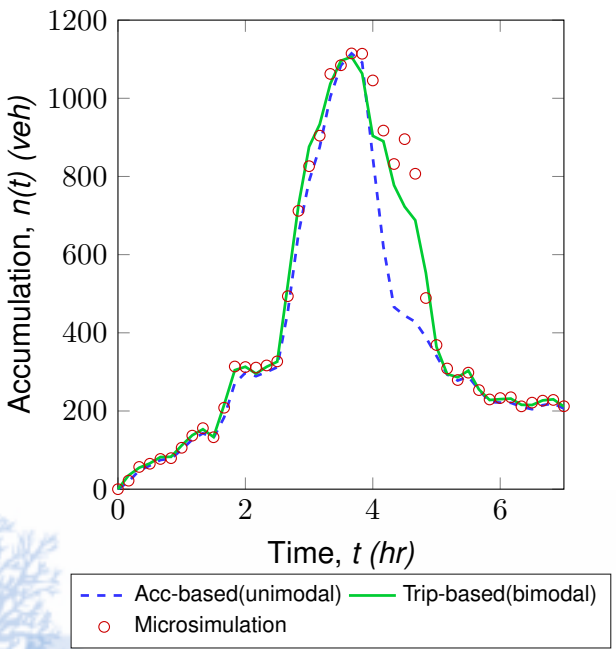


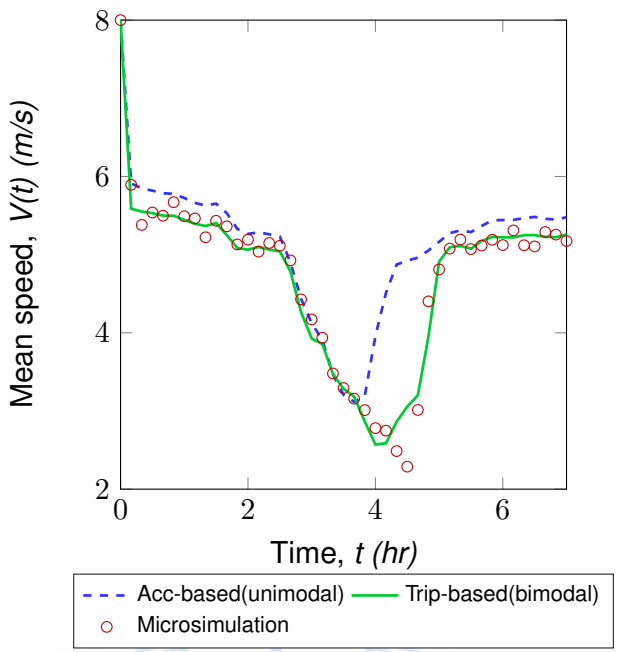


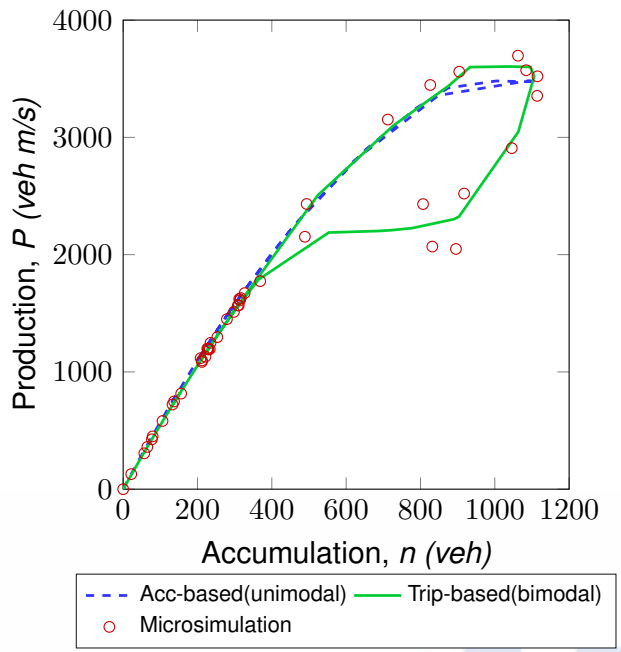


With recalibration of p-MFD and trip lengths

- Trip lengths and MFD fits are re-calibrated based on the modified OD matrix.







Conclusions

- Unimodal MFD fit is sufficient in the free flow regime of MFD-based models.
- Trip-based method with bimodal MFD fit results in hysteresis comparable to microsimulation.
- Refined trip length description produces more accurate results in trip-based.
- Mean trip length gives good approximation in accumulation-based.
- The importance of re-calibration of trip lengths and MFD fits is demonstrated when OD patterns are changed.

Acknowledgments

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Thank you for your attention.

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