愛媛大学
EHIME UNIVERSITY

Estimating Macroscopic Fundamental Diagrams of Brisbane, Australia:

Characteristics and limitations of data sources

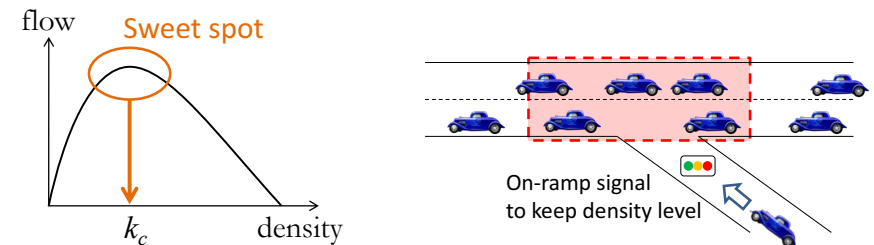Takahiro Tsubota

Ehime University

Congestion monitoring and control

- Traffic control and "ideal" traffic states
  - Traffic states (Flow(q), Speed(v), Density(k))
  - Fundamental diagram
  - Control strategy (e.g., local ramp metering)
    - ✓ Inflow control to merging section

flow — Sweet spot — k_c — density

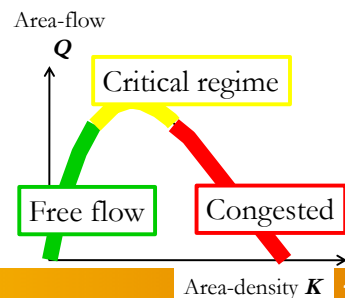On-ramp signal to keep density level

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Network-wide traffic monitoring

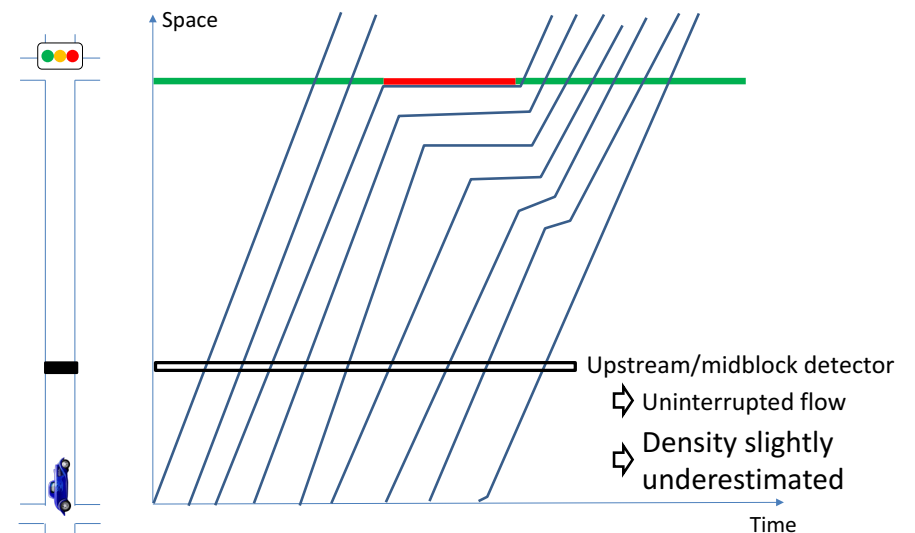- Macroscopic Fundamental Diagram (MFD)
  - Network-wide aggregated traffic states
  - Well-defined shape in homogeneously congested area
  - Useful for network-wide flow control
    - Inflow control to CBD

Challenge in real-world application
- How to estimate the MFD?
- Variables: Flow & Density

Area-flow Q

Critical regime

Free flow   Congested

Area-density K

Biased measurements from detectors

Space

Upstream/midblock detector

⇨ Uninterrupted flow

⇨ Density slightly underestimated

Time

Biased measurements from detectors

Space

Stopline detector

⇨ Queue during red light

⇨ Density highly overestimated

How to estimate variables for MFD from signalised sections?

Time

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Cumulative counts-base - Naïve method
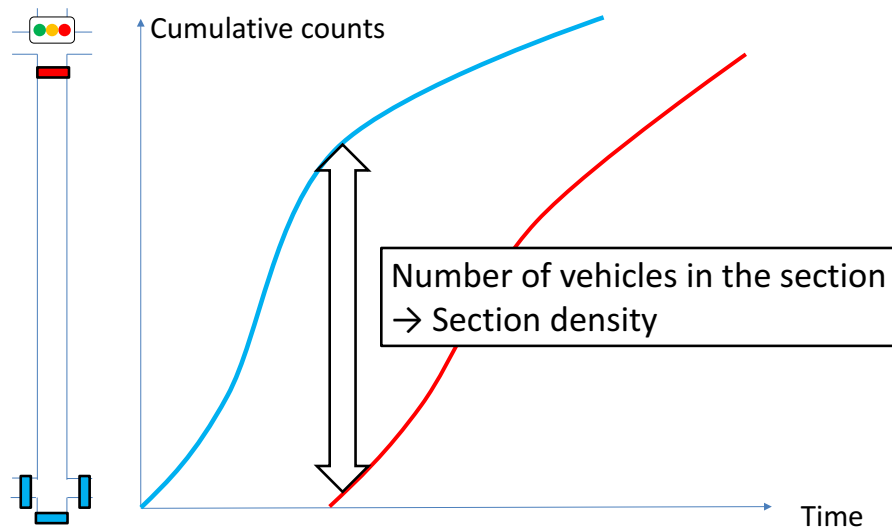
Cumulative counts
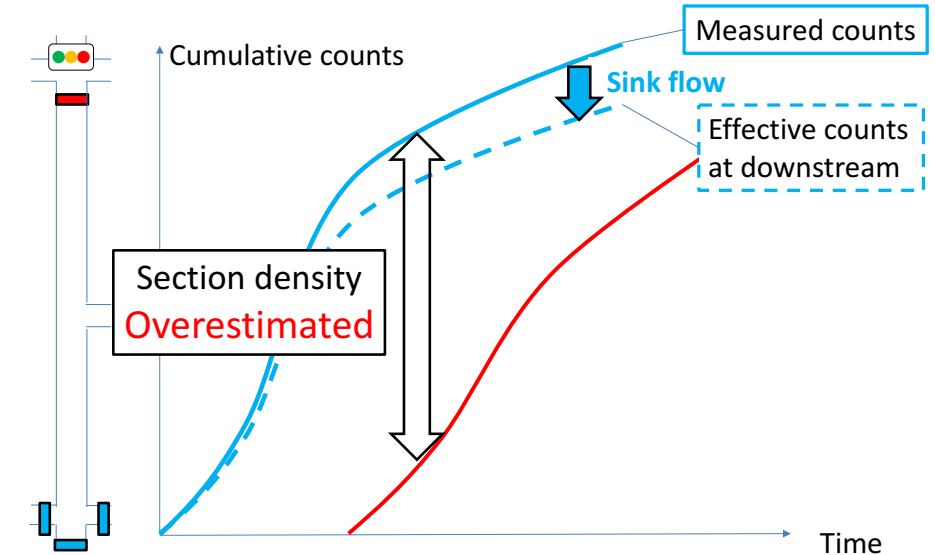
Number of vehicles in the section
→ Section density

Time

Cumulative counts-base – Midlink sink/sources

Cumulative counts

Measured counts

Sink flow

Effective counts at downstream

Section density
Overestimated

Time

Cumulative counts-base – Midlink sink/sources

Cumulative counts

Measured counts

Sink flow

Effective counts at downstream

Density should estimated **Based on effective flow curve**

Time

Cumulative counts-base – Midlink sink/sources

Cumulative counts

Measured counts

Modified counts

Probe travel time samples

Point to pass

Time
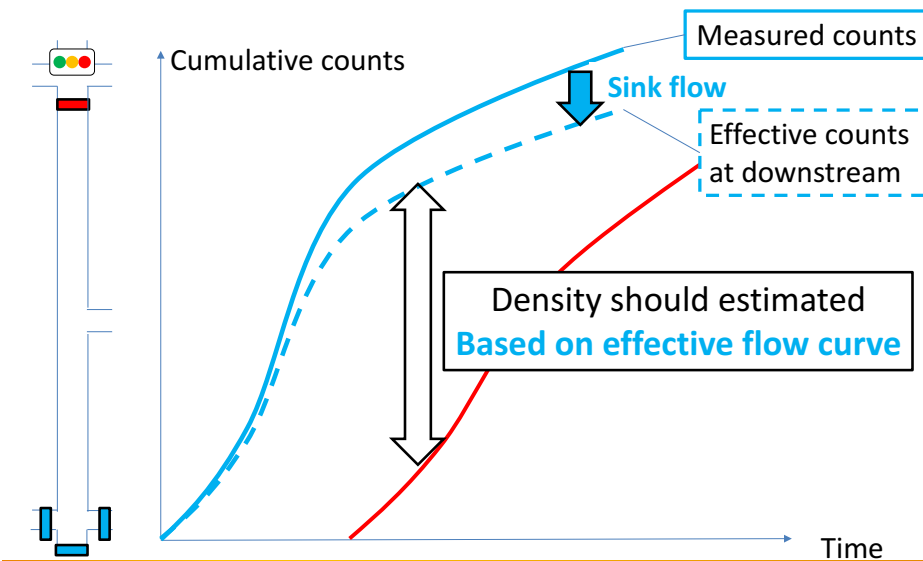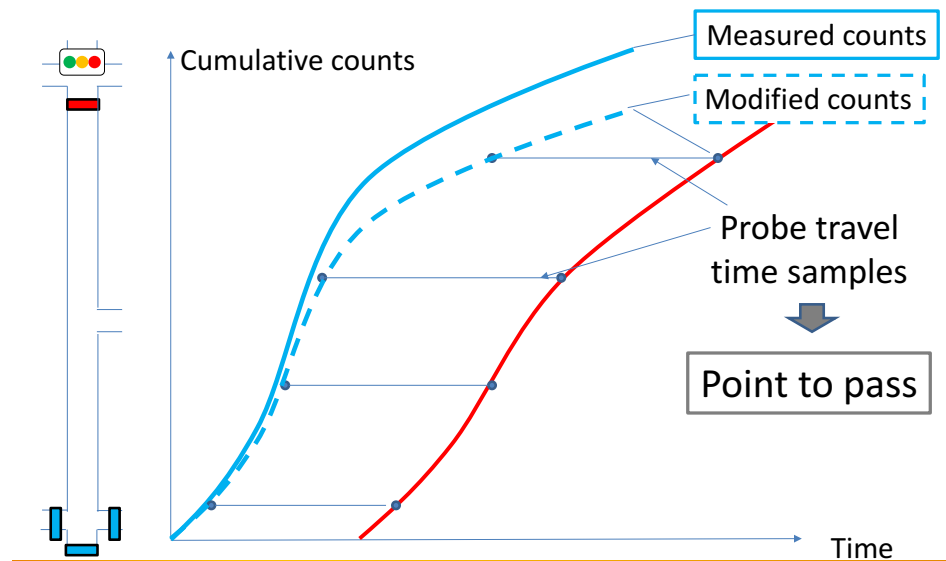
Traffic density estimation – Cumulative counts-based method

Loop detectors | Signal phase | Bluetooth data

Cumulative vehicle counts (up/down stream)

Timestamps at up/down stream

Cumulative vehicle counts

Define Point-to-pass

time

Number of vehicles at time t

Correct the errors in cumulative counts
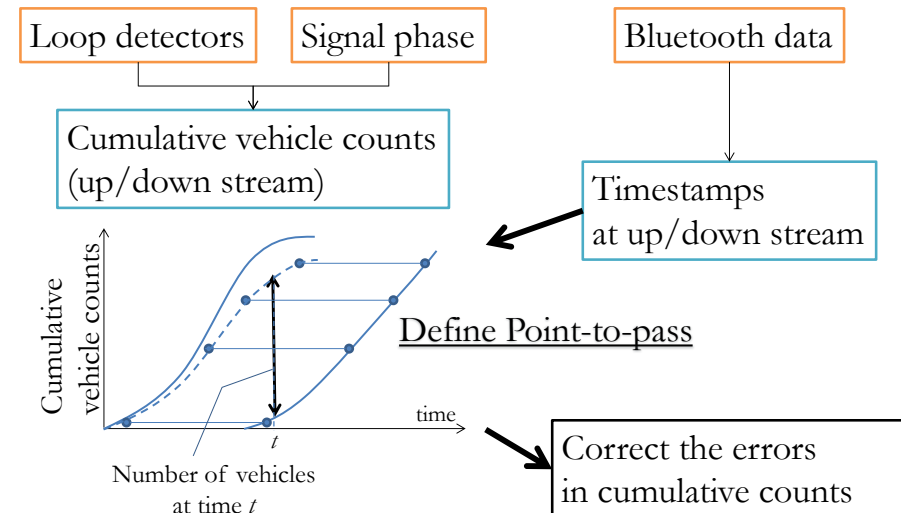
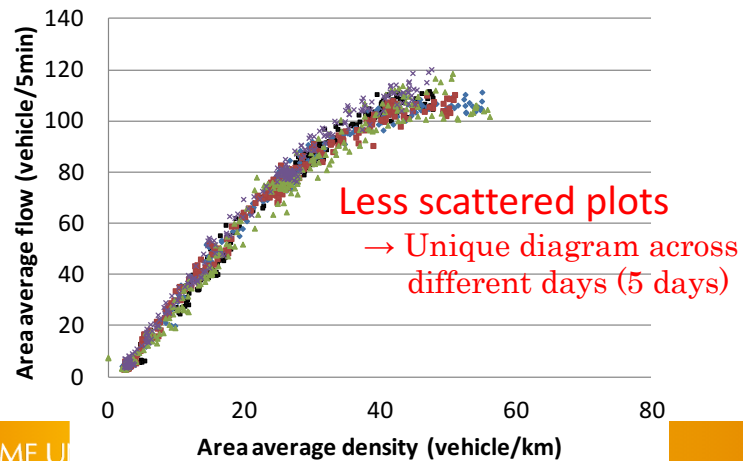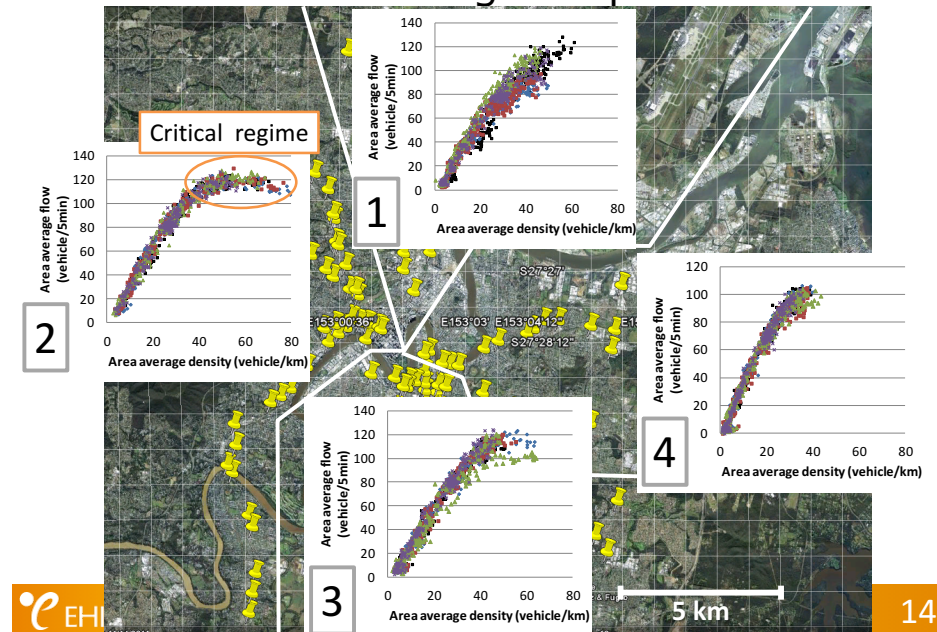## Study site – Brisbane network

Bluetooth scanners

Brisbane CBD

sections

5 km
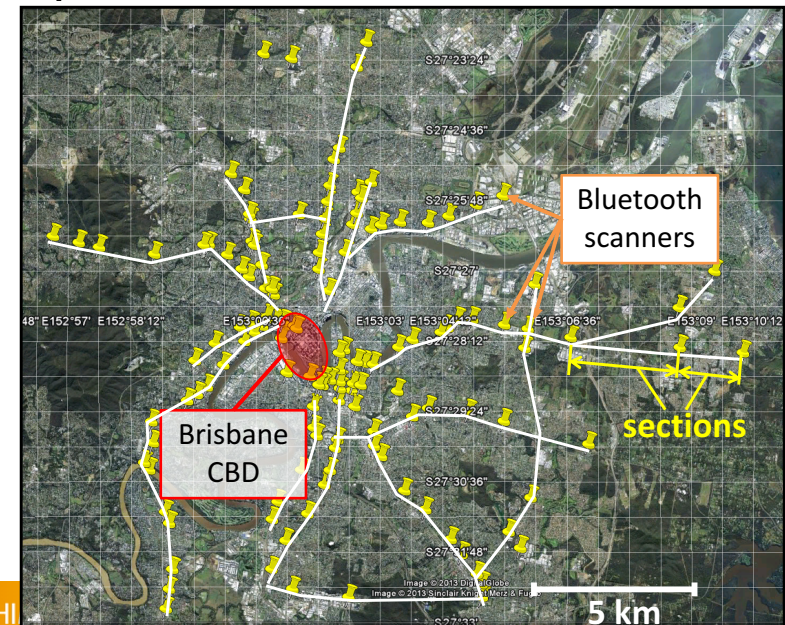
Brisbane MFD for 5 days
(Mon 22nd Oct – Fri 26th Oct, 2012)

- Different colours represent different day's plots

Less scattered plots
→ Unique diagram across different days (5 days)

Brisbane network – regional performance

Critical regime

Limitation of Stop-line loop & Bluetooth

- Spatial coverage of Bluetooth scanners
- Estimated MFD represents only a subset of network

Study site – Brisbane arterial network

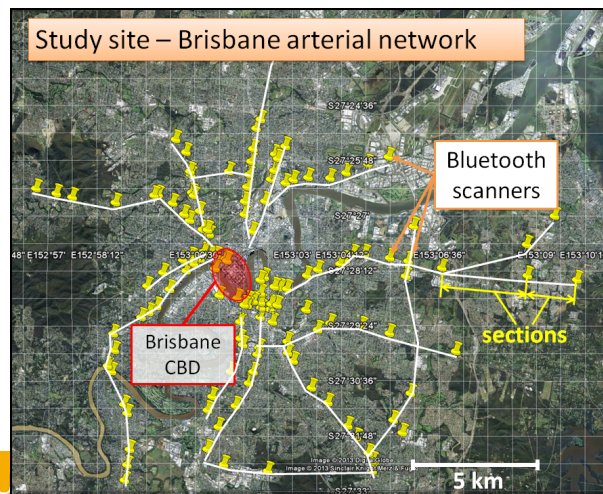Bluetooth scanners

Brisbane CBD

sections

5 km

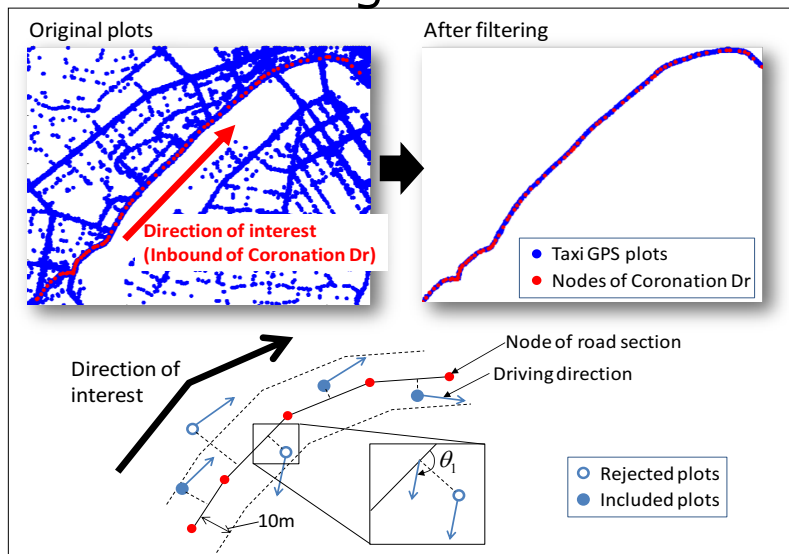## Table of contents

1. Cumulative counts-based method

2. Trajectory-based method

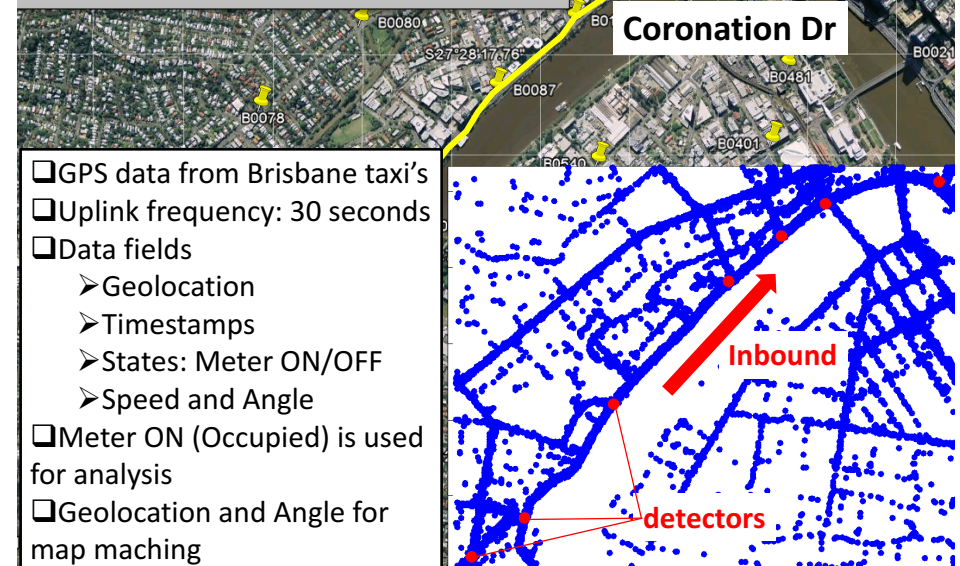3. Comparison of two methods and discussion

MFD from GPS probe data

- Vehicles equipped with GPS works as moving sensors
- High spatial coverage
- Detailed trajectory data within sections
  - GPS tells its location every uplink interval (i.e., every 30 seconds)

- Any limitations/problems in GPS data?

Taxi data analysis for traffic state monitoring

Coronation Dr

Inbound

detectors

- ❑ GPS data from Brisbane taxi's
- ❑ Uplink frequency: 30 seconds
- ❑ Data fields
  - ➢ Geolocation
  - ➢ Timestamps
  - ➢ States: Meter ON/OFF
  - ➢ Speed and Angle
- ❑ Meter ON (Occupied) is used for analysis
- ❑ Geolocation and Angle for map maching

Taxi data filtering

Original plots

After filtering

Direction of interest (Inbound of Coronation Dr)

- • Taxi GPS plots
- • Nodes of Coronation Dr

Node of road section

Driving direction

Direction of interest

θ_1

10m

- ○ Rejected plots
- ● Included plots

Flow and Density estimation from Taxi

Total Distance Travelled (*TDT*) and Flow (*q*) of Taxi samples

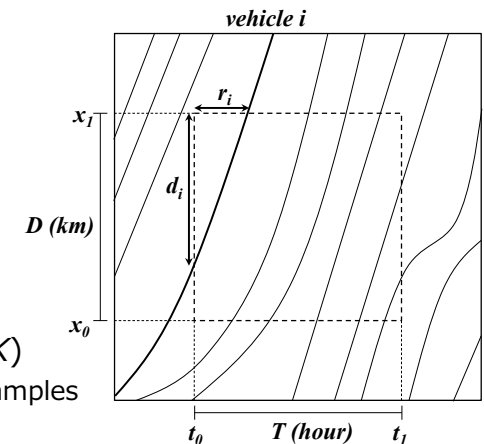$$TDT = \sum_i d_i \qquad q = TDT/DT$$

Total Time Spent (*TTS*) and Density (*k*) of Taxi samples

$$TTS = \sum_i r_i \qquad k = TTS/DT$$

Expansion to full traffic (*Q*, *K*)

Given the proportion of taxi samples to full traffic (*P*)

$$Q = q/P \qquad K = k/P$$

vehicle i

r_i

x_1

d_i

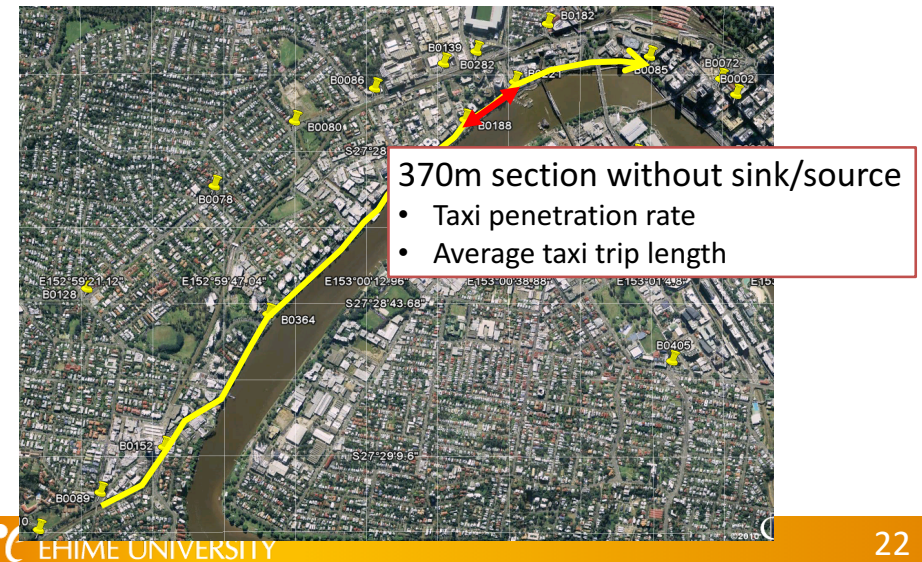D *(km)*

x_0

t_0

T *(hour)*

t_1

Results

– comparison of trajectory-based
   and cumulative counts-based methods

- Trajectory based method captures peak/offpeak
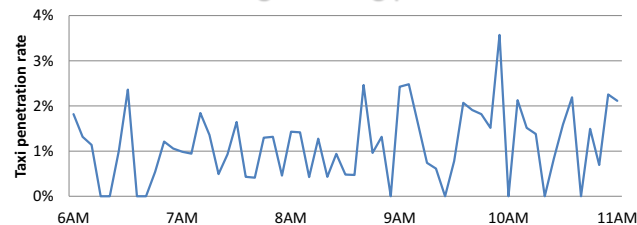- However, trajectory based method always underestimates the variables

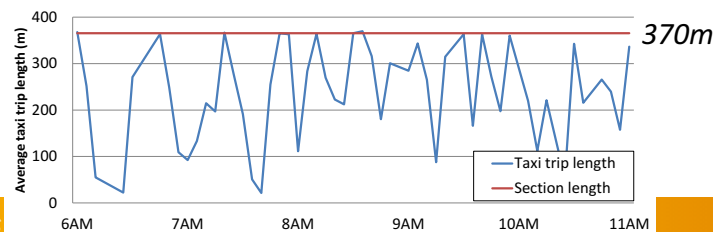Comparison in density estimation

Comparison in the corridor MFD

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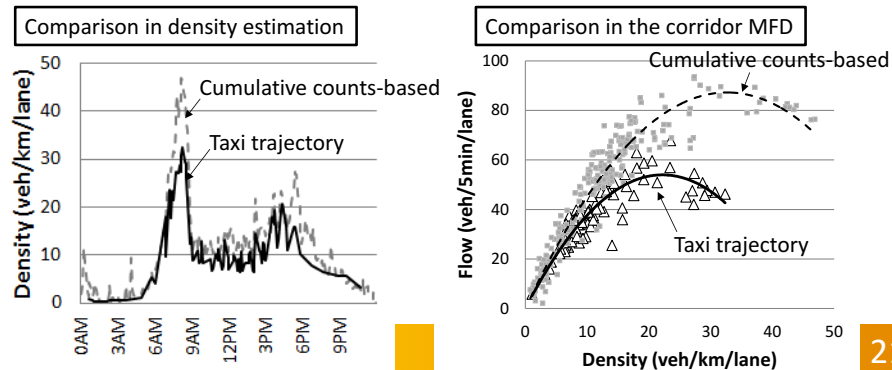
Quality and Quantity of trajectory data

Penetration rate: < 3% during morning peak hours

Average trip length vs section length: many incomplete trip data

370m

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Quality and Quantity of trajectory data

370m section without sink/source
- Taxi penetration rate
- Average taxi trip length

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Summary

- Brisbane MFD is estimated using cumulative counts-based method
  - The MFD with an unique shape exists in Brisbane arterial network

- Trajectory based method is successful in estimating peak/offpeak of traffic congestion

- Trajectory data has problems both in quality and quantity
  - Causes underestimation of the variables
  - May cause challenges in practical use

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Thank you

Research supported by
   Queensland University of Technology