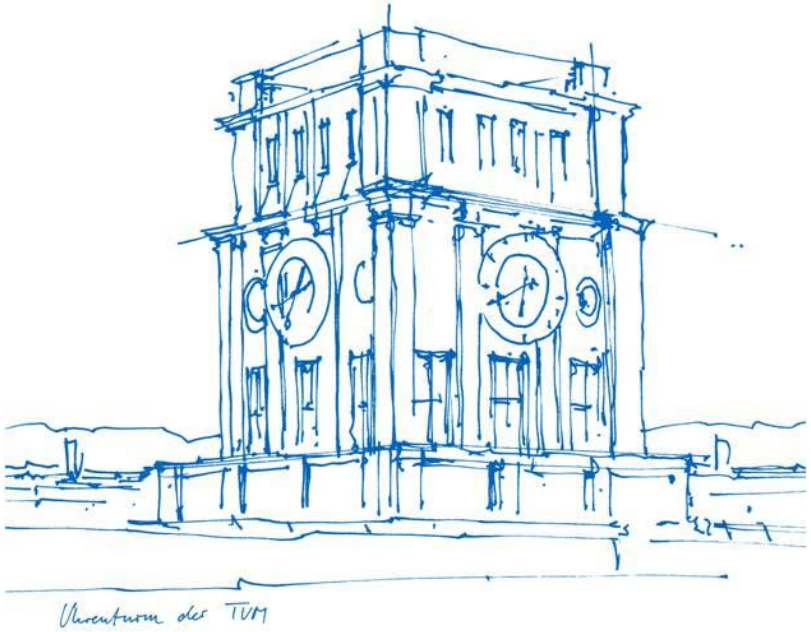
Technical University of Munich
TUM School of Engineering and Design
Department of Mobility Systems Engineering
Chair of Traffic Engineering and Control

Temporal Aggregated Analysis of GPS Trajectory Data using Two-fluid Model

TRBAM-22-04844



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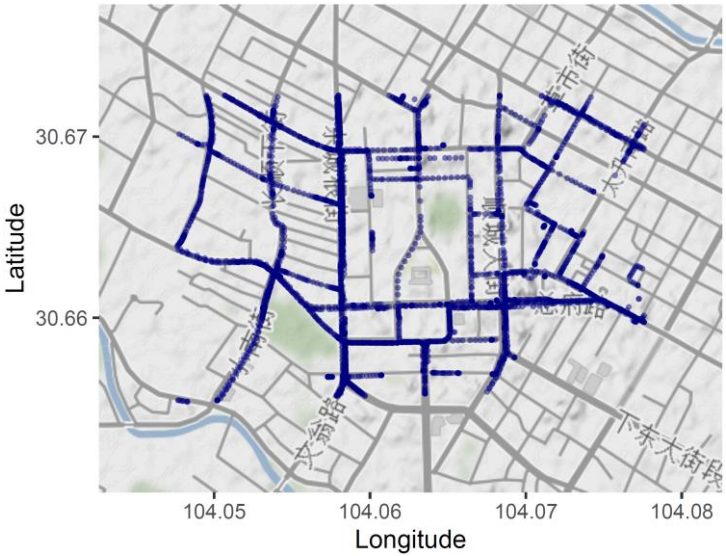
Outline

- Background
- Methodology
- Case study
- Conclusion

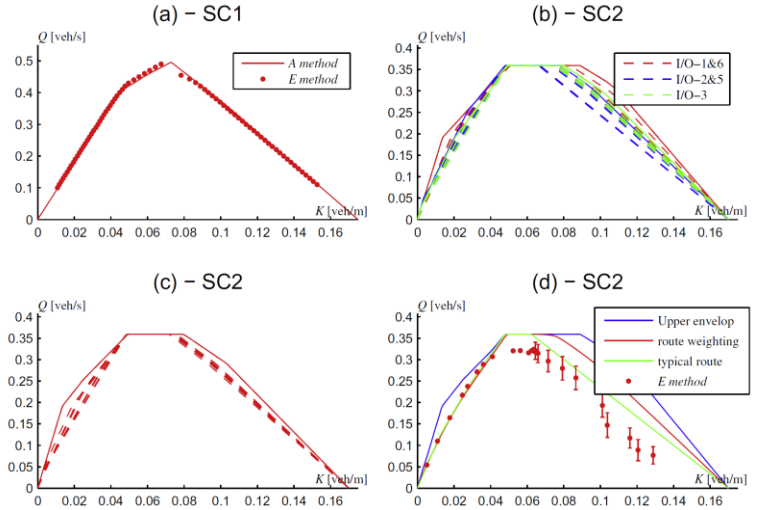
Two trends

Massive GPS (trajectory) data



Trajectory of 50 vehicles over 1 hour

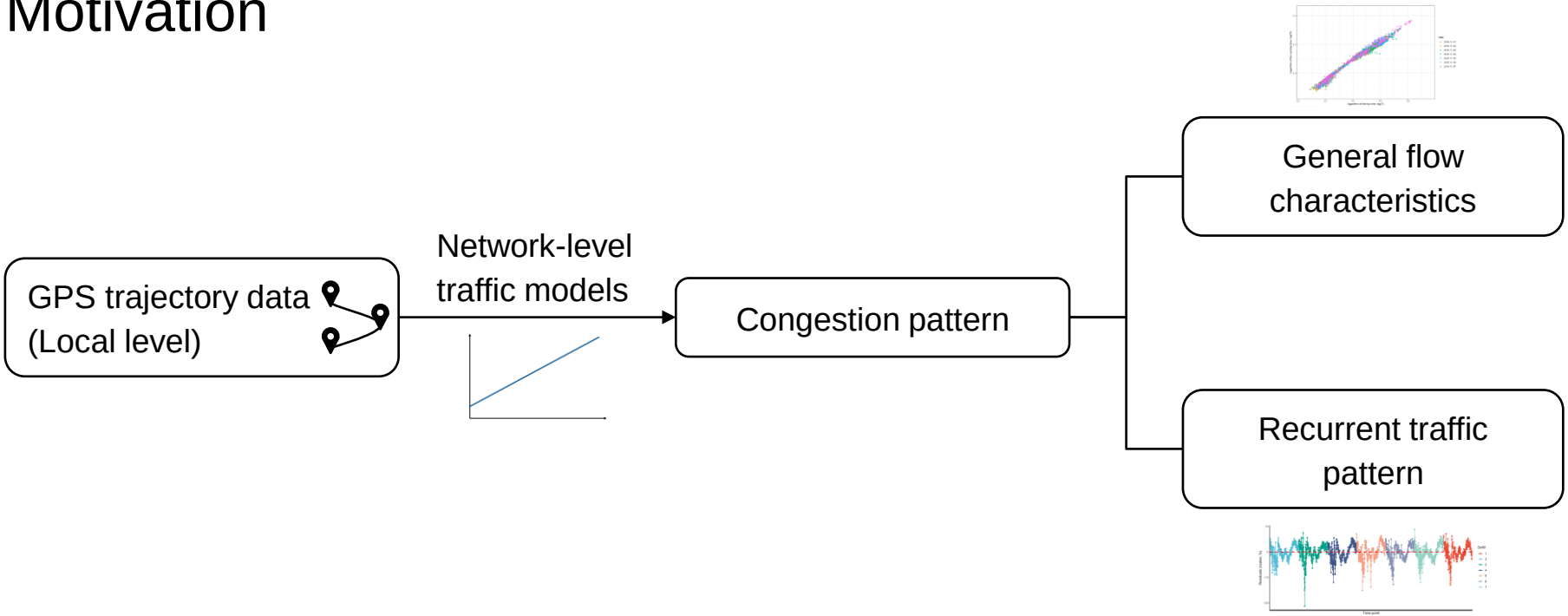
Network-level traffic models



Examples of Estimated MFD

Leclercq, L., Chiabaut, N., & Trinquier, B. (2014). Macroscopic fundamental diagrams: A cross-comparison of estimation methods. Transportation Research Part B: Methodological, 62, 1-12.

Motivation


GPS trajectory data
(Local level)
Network-level
traffic models
Congestion pattern
General flow
characteristics
Recurrent traffic
pattern

Network-level model: Two-fluid

Two fluids
- Average speed v
- Trip time per unit distance T

Running cars
- Fraction f_r
- Running speed v_r /
- Running time per unit distance T_r

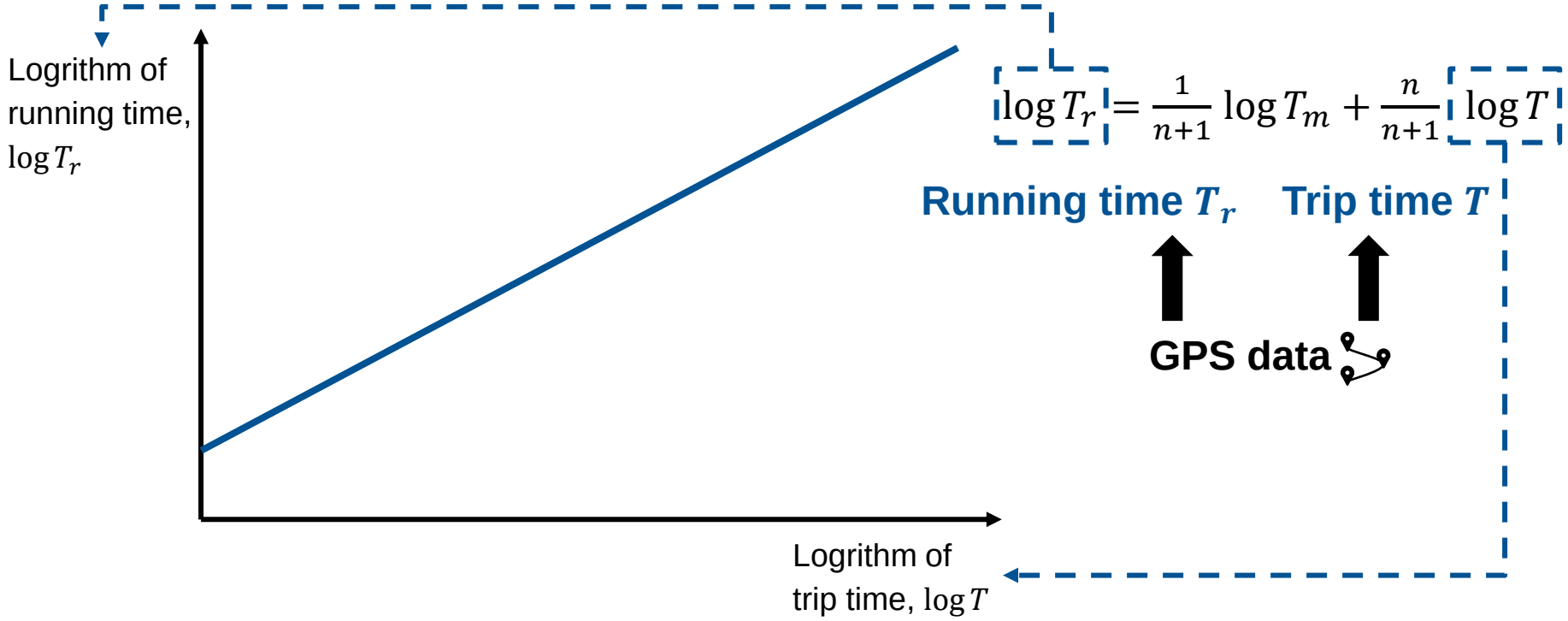
Stopped cars
- Fraction f_s
- Stop time T_s

$$\log T_r = \frac{1}{n+1} \log T_m + \frac{n}{n+1} \log T$$

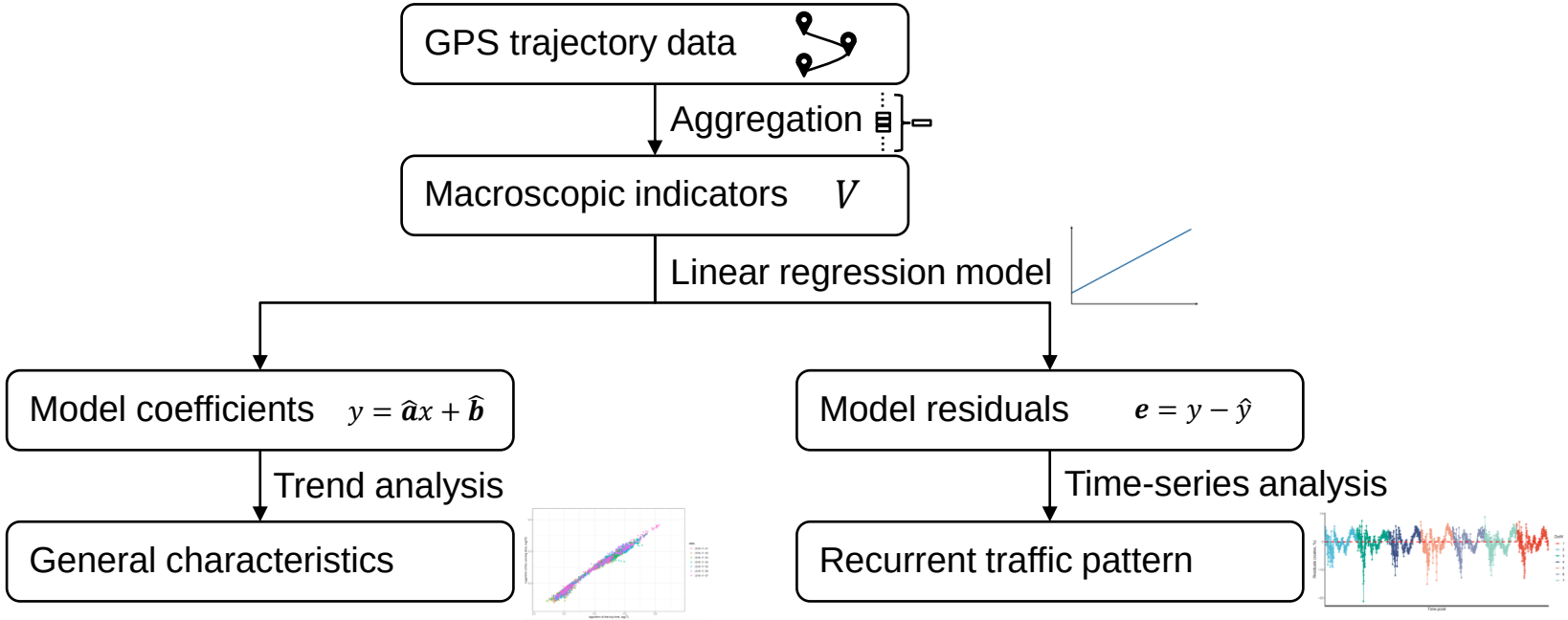
- T_m: minimum travel time per unit distance (with the maximum speed)
- n: coefficient specific to a certain network

Herman, R., & Prigogine, I. (1979). A two-fluid approach to town traffic. Science, 204(4389), 148-151.

Network-level model: Two-fluid



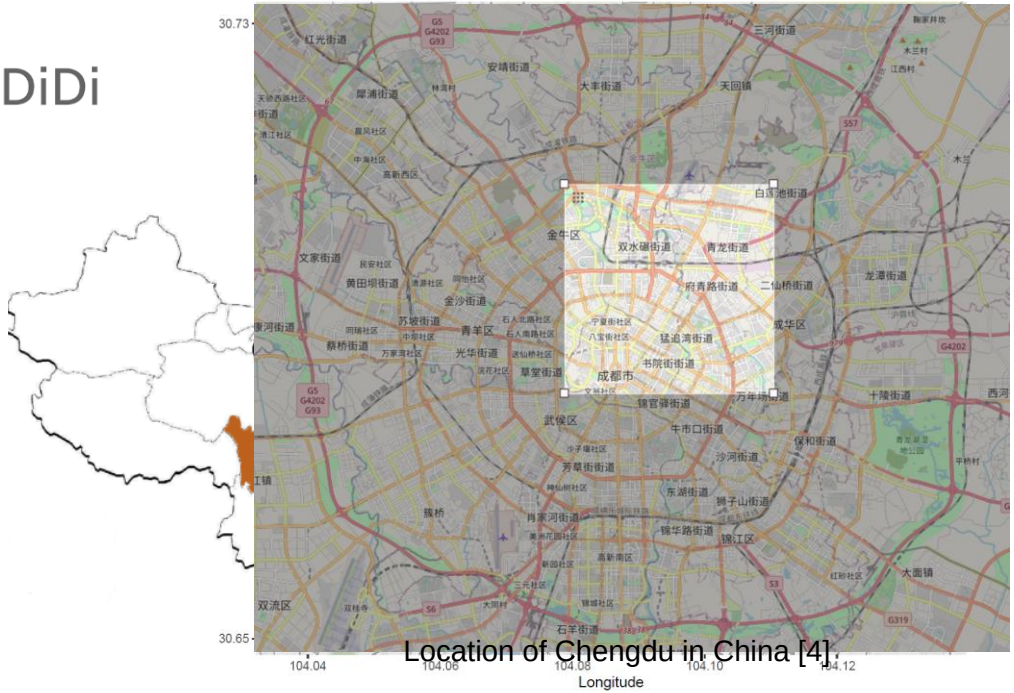
Methodology



Data set

- Data source: Didi Chuxing, GAIA Open Data Initiative [3]
- Location: Chengdu (16.3M), China
- Time period: November 2016
- Average frequency: 3.11 seconds
- Dimension: ~30M records/day
- Variables:

Variable	Example
Driver Id	“389b1a63fca70651270be4d9e64464a8”
Order Id	“13994a1c492c8901d5db1baf1c7c3ee”
Timestamp	1477962003
Longitude	104.05
Latitude	30.67

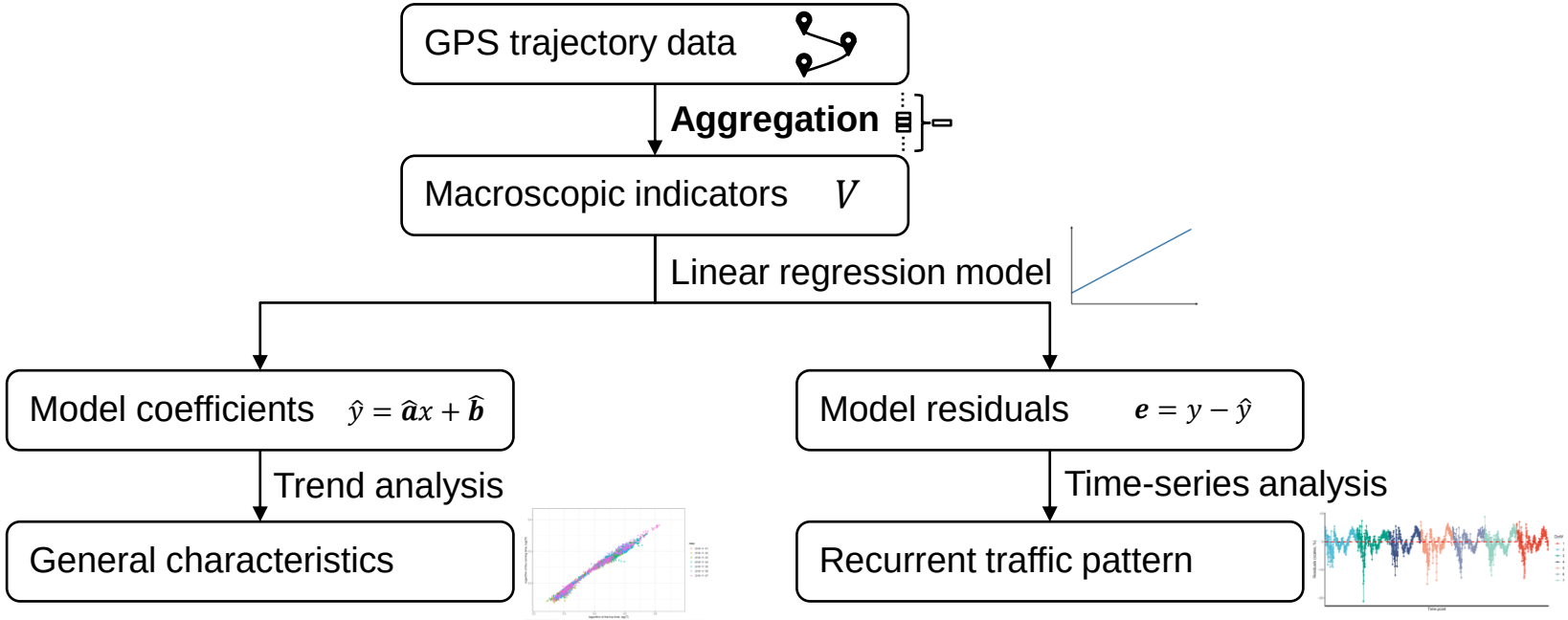


Location of Chengdu in China [4].

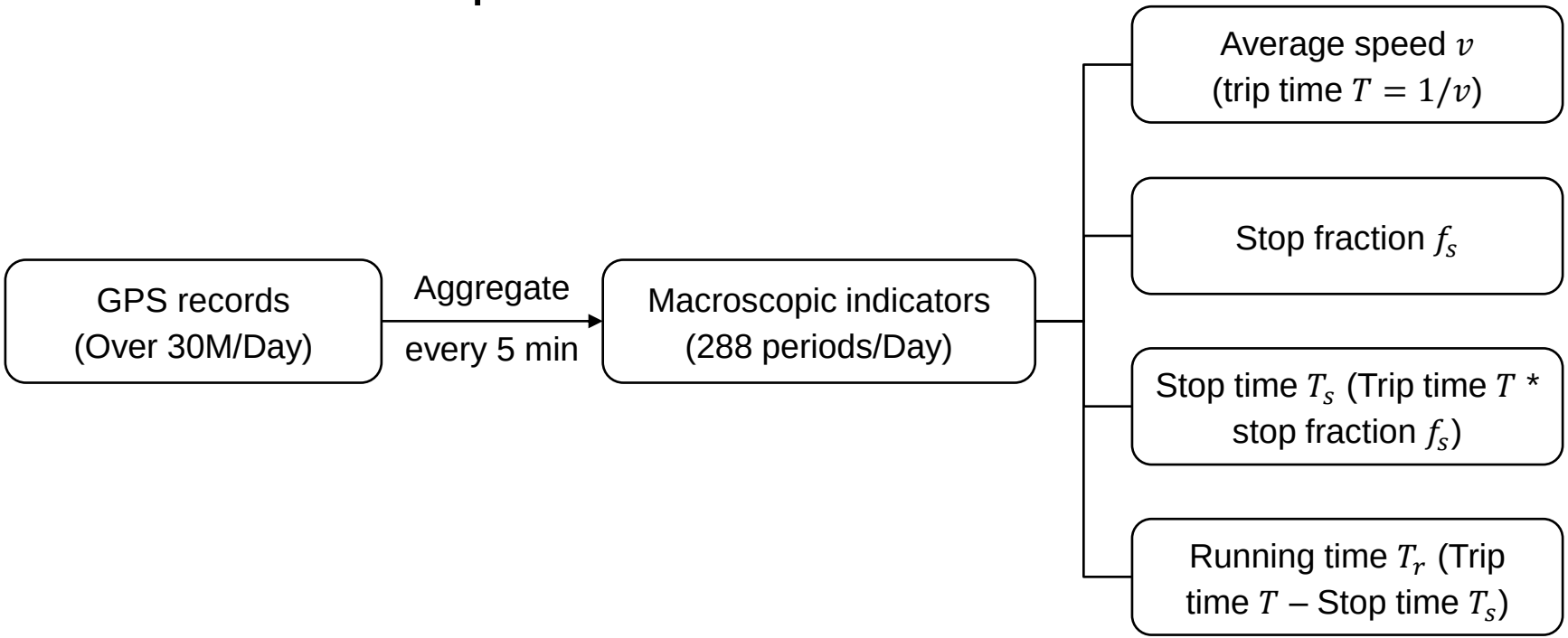
Didi Chuxing. (2021). The Gaia Initiative. https://outreach.didichuxing.com/research/opendata/en/. [Online; accessed 14-Dec-2021].

Liu et al. (2014). An Integrated Approach to Spatial Modeling of Urban Expansion in Urbanization Process. https://www.researchgate.net/figure/Location-of-Chengdu-Sichuan-China_fig1_277673826. [Online; accessed 04-Jan-2022].

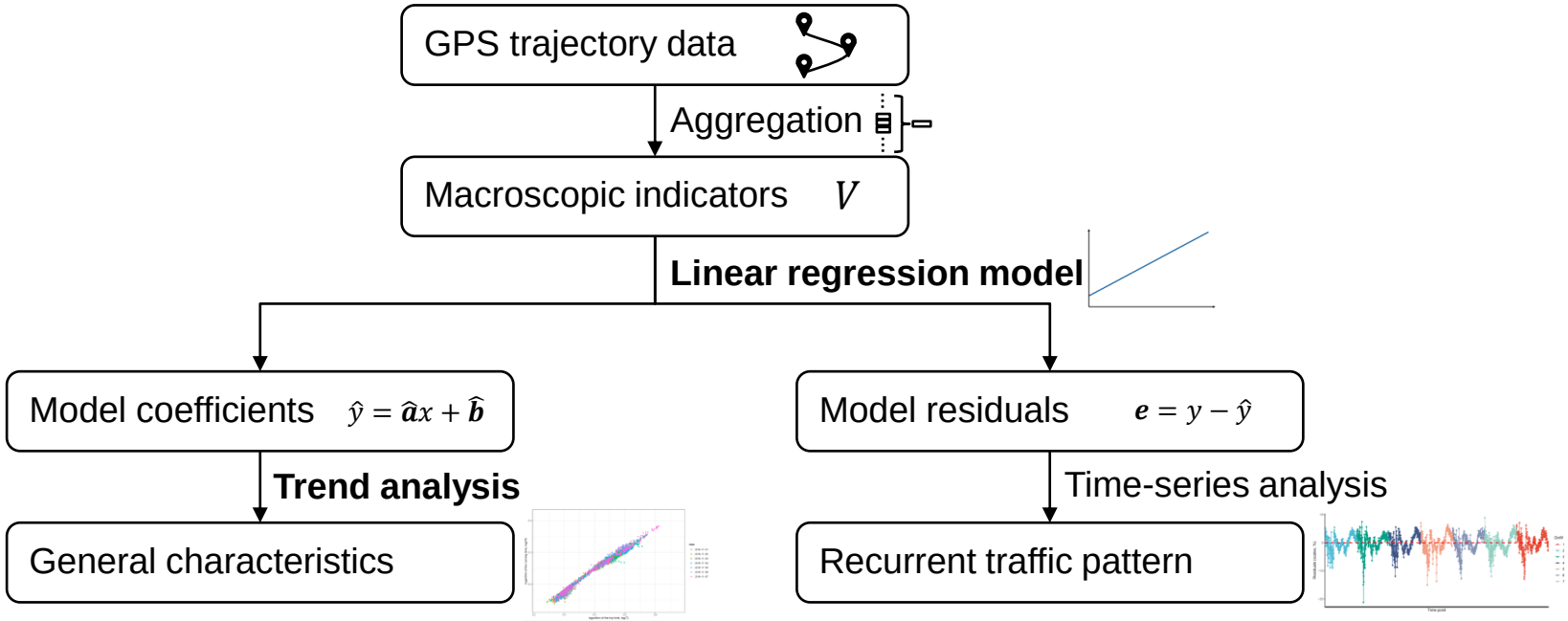
Methodology



Result: Macroscopic indicators



Methodology



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Result: General characteristics

Summary of variables

Theme	Variable	Description	Unit	
Two-fluid parameters	n	Model coefficient of network performance	-	
	T_m	Minimum trip time per unit distance	min/km	Reciprocal
	v_m	Maximum average vehicle speed	km/h	Reciprocal
Fraction	f_r	Fraction of moving cars	-	
	f_s	Fraction of stopped cars	-	
Velocity	u_0	Desired velocity	km/h	
	v	Average velocity	km/h	
	v_r	Average velocity of the moving cars	km/h	
	v_s	Average velocity of the stopped cars	km/h	
Trip time	T	Average trip time per unit distance	min/km	Reciprocal
	T_r	Average running time	min/km	
	T_s	Average stopped time	min/km	

Result: General characteristics

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	T_r	Average running time	min/km
	T_s	Average stopped time	min/km

Date	Day-of-Week	R^2	$\boldsymbol{n}$	$\boldsymbol{T_m}$
01.11.2016	Tuesday	0.986	2.13	0.814
02.11.2016	Wednesday	0.987	2.00	0.855
03.11.2016	Thursday	0.980	1.95	0.865
04.11.2016	Friday	0.979	1.80	0.907
05.11.2016	Saturday	0.987	1.98	0.846
06.11.2016	Sunday	0.986	**2.34**	**0.765**
07.11.2016	Monday	0.989	1.89	0.895

Result: General characteristics

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Two-fluid parameters	n	Model coefficient of network performance	-
	T_m	Minimum trip time per unit distance	min/km
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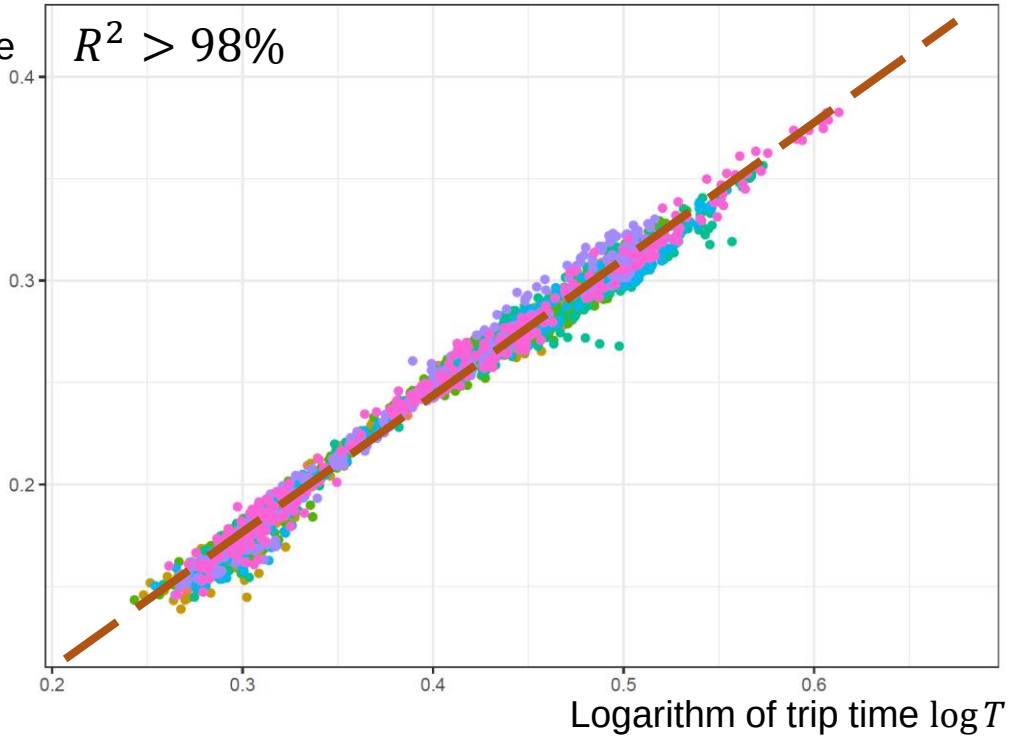
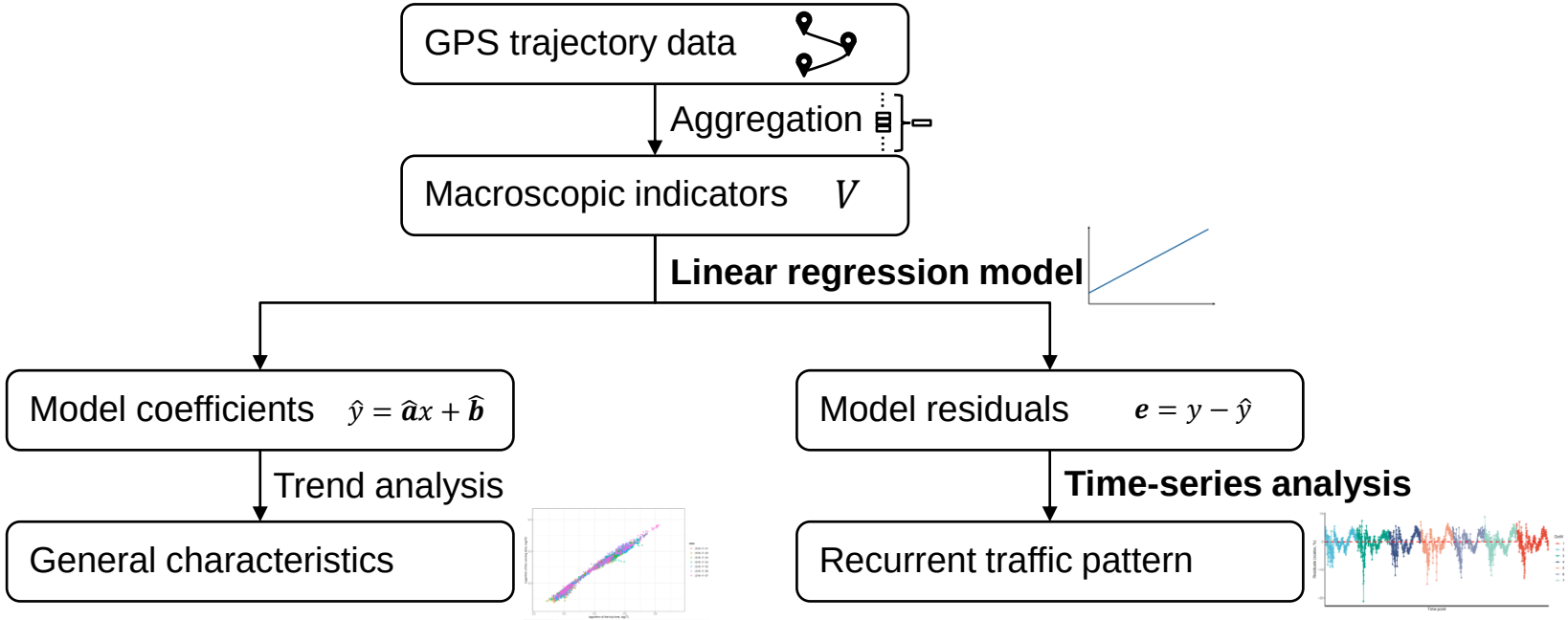
	$\boldsymbol{T_r}$	**Average running time**	**min/km**
	T_s	Average stopped time	min/km

Result: General characteristics

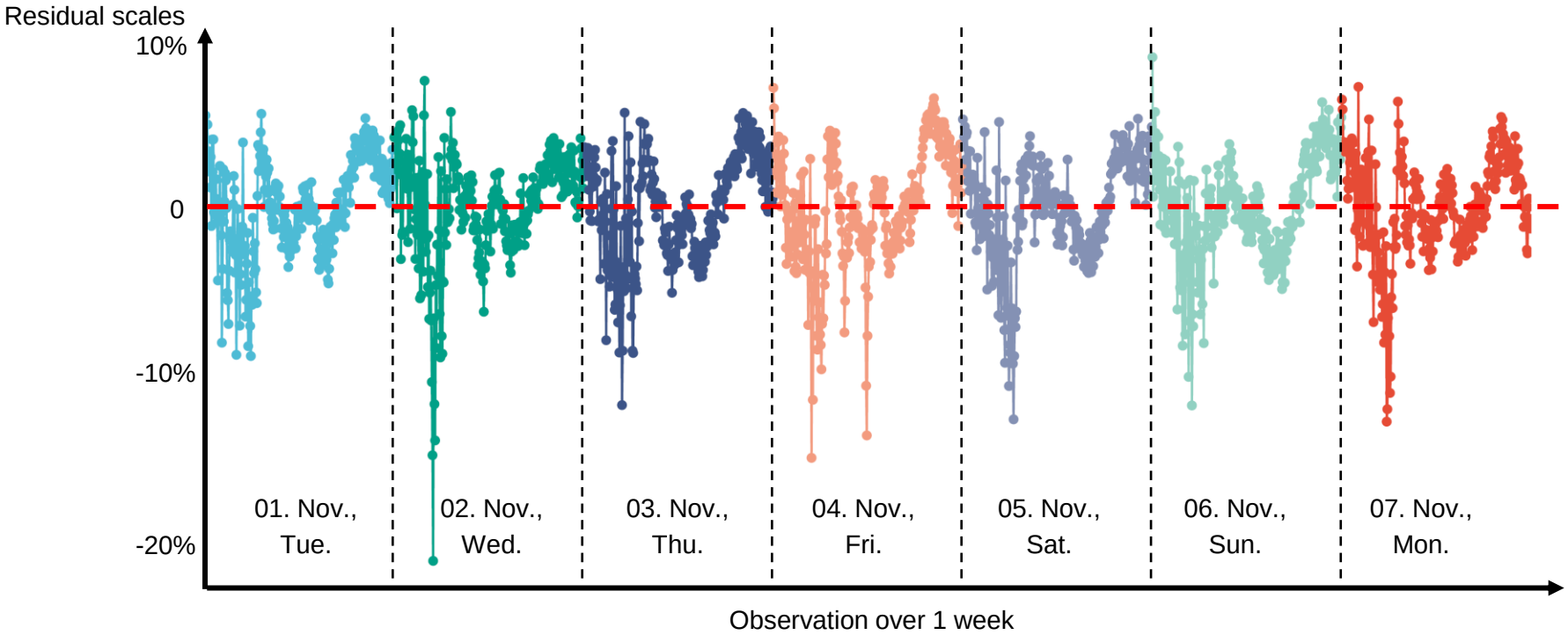
Logarithm of running time $\log T_r$



Methodology



Result: Recurrent traffic pattern



Result: Recurrent traffic pattern

- Differencing (degree d)
- AutoRegressive Integrated MovingAverage (ARIMA) model
- ARIMA (p, d, q) model

$$e_i' = e_i - e_{i-1}$$

AutoRegressive term (p steps)

$$y_t' = c + \varphi_1 y_{t-1}' + \cdots + \varphi_p y_{t-p}' + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q} + \varepsilon_t$$

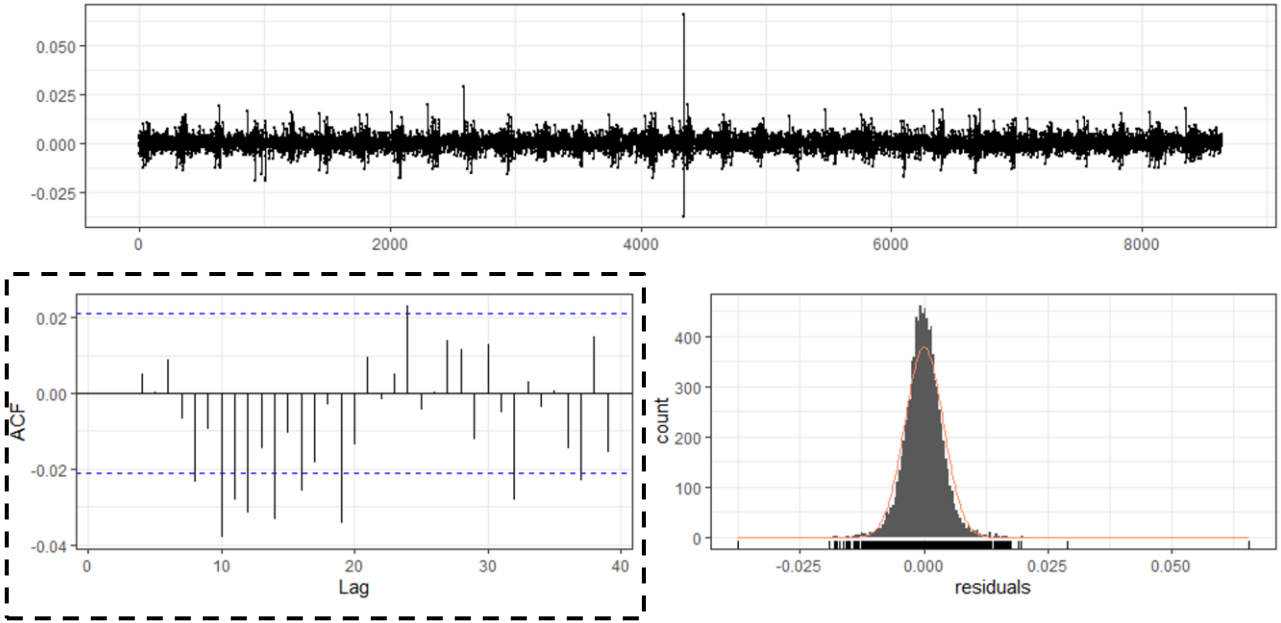
MovingAverage term (q steps)

Result: Recurrent traffic pattern

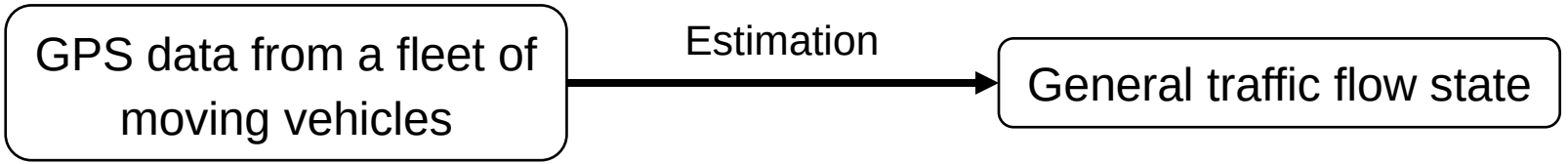
- ARIMA model: (0, 1, 4) (Moving average model)

- ACF: autocorrelation function existing in the differenced residuals (no AR term)

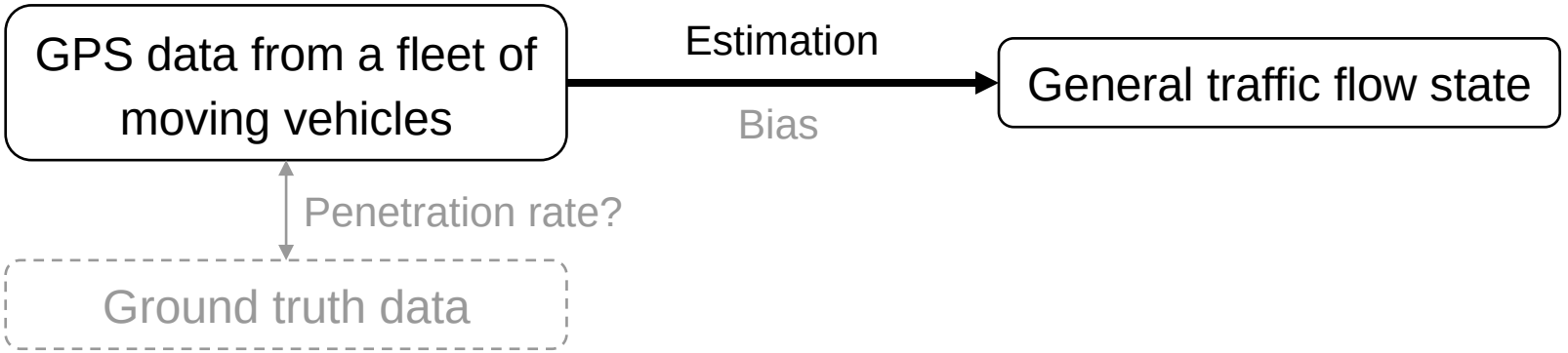
- Depends linearly on the current and past 4 values (20-minute duration) of stochastic terms



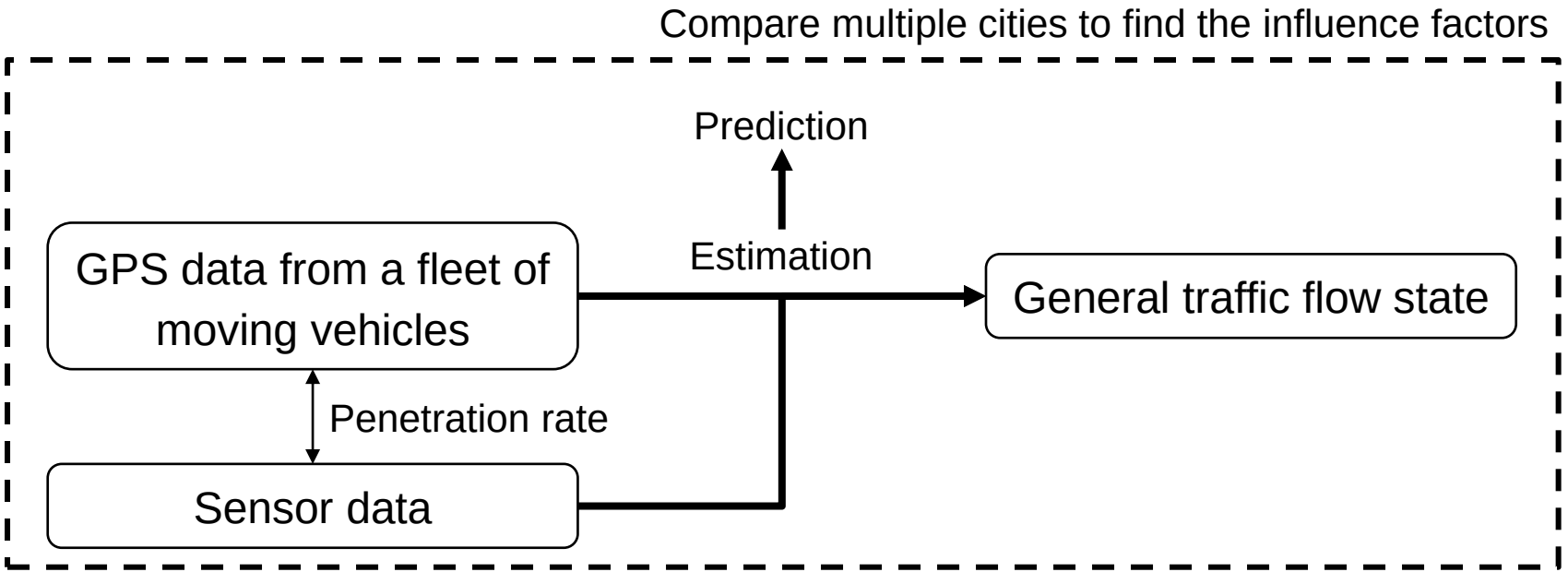
Contribution



Restriction



Further works



Thanks and any questions?

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Full paper: