United Nations International Meeting on the Applications of Global Navigation Satellite Systems

URBAN STUDIES. CENTER FOR SPATIAL DATA AND ANALYSIS
SCHOOL OF STRATEGIC AND GLOBAL STUDIES. UNIVERSITAS INDONESIA

Development of Integrated Technology of GNSS Receiver and Environmental Sensor: Navigation Study of Urban Traffic and Air Pollution in Jakarta

GARRIN ALIF NANDITHO

Brief Introduction

GARRIN ALIF NANDITHO, S.KOM, M.SC.

IT Programmer; Urban Analyst

Center for Spatial Data and Analysis

1. **Manager of Center for Spatial Data and Analysis (CSDA) Manages and supervises GNSS activities in CSDA research center, School of Strategic and Global Studies, Universitas Indonesia. Also, a senior expert in GNSS and researcher on GNSS Post-Processed Kinematic (PPK) and Precise Point Positioning (PPP)**

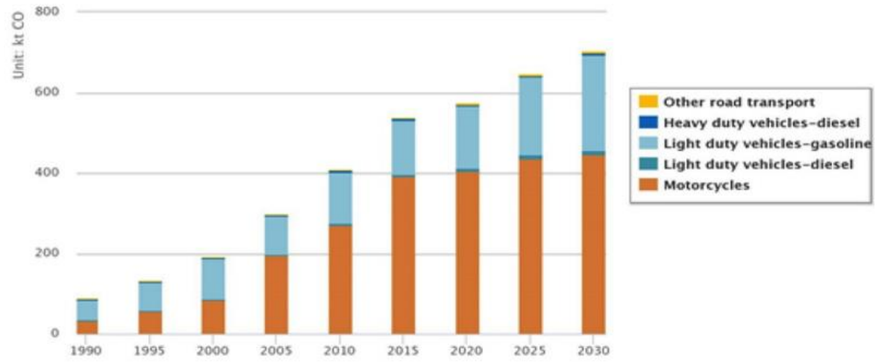
2. GNSS Team Teaching and Trainer/Facilitator, School of Strategic and Global Studies, Universitas Indonesia. Teaching on GNSS Technology and Application Class for Spatial Analysis for Urban Studies Subject in SSGS Universitas Indonesia, and main facilitator in internal and International GNSS seminars and workshops

CSDA is a strategic research center that mainly works on GNSS academic and research activities at School of Strategic and Global Studies (Postgraduate), Universitas Indonesia. Besides for academics within the faculty and UI campus, CSDA also works with private sectors and government agencies. Furthermore, CSDA has strong collaborations with international partners from various countries. Works with several significant international partners including government, private, and universities.

Research Background

Rapid development of Jakarta causes massive traffic congestion problems. Jakarta was ranked 4th most world wide congested city in 2017, then ranked 4th in 2018, in 2019 Jakarta saw the worst congestion on Wednesday, March 6, with a congestion rate reaching 91 percent (TomTom Traffic Index, 2021). The problems occurred due to the domination of private vehicles increase, which is not followed by the development of sufficient infrastructures.

In 2019, Jakarta also spotlighted as the worst polluted city in the world (The Jakarta Post, 2019). Pandemic has reduced the air pollution intensity in Jakarta due restriction of urban mobility. However, recently, in June 2022, Indonesia ranked 17th among the most polluted in the world (worst in South East Asia) (Tempo, 2022). The carbon emissions of Jakarta is mainly contributed by the transportation sector.

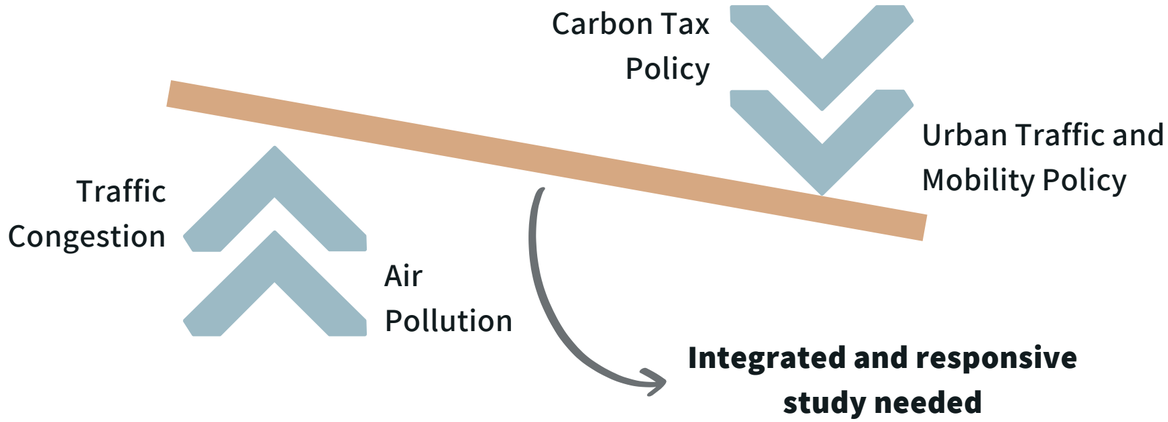


Estimation of CO2 Emissions from Road Transportation in Jakarta
(Cottrell & Streitferdt, 2019)

The Increase of Motorized Vehicles in Jakarta from 2017-2021

Types	Quantity (Units)				
	2017	2018	2019	2020	2021
Cars	2.827.399	3.082.616	3.310.426	3.365.467	4.111.231
Buses	31.593	33.419	34.905	35.266	34.667
Trucks	587.860	631.156	669.724	679.708	785.600
Motorcycles	14.137.126	15.037.359	15.868.191	16.141.380	16.519.197
Total	**17.583.978**	**18.784.550**	**19.883.246**	**20.221.821**	**21.450.695**

Source: BPS, 2022

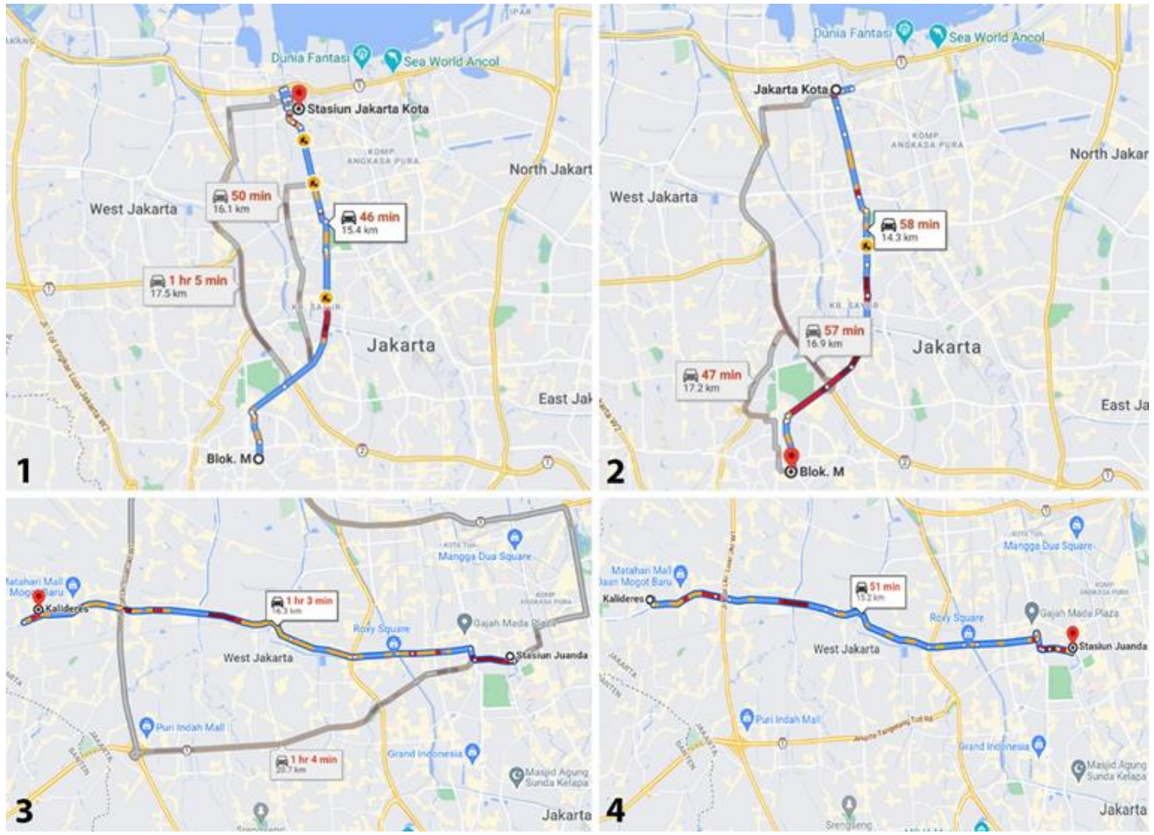


Integrated and Responsive Navigation Study

Traffic congestion and urban mobility problems, poor urban pollution, and strategizing urban traffic management and carbon policy, urges the need of the integrated and responsive navigation study

Scopes

(Case Study Conducted to closely see the synchronization between GNSS receiver and CO_2 sensor)



This study covers the selected main routes of Jakarta as follow:

- Blok M - Jakarta Kota (Urban Center - Remote Area)
- Jakarta Kota - Blok M (Remote Area - Urban Center)
- Juanda - Kalideres (Urban Center - Remote Area)
- Kalideres - Juanda (Remote Area - Urban Center)

Scope of the research investigations as follow:

Day

Monday, Friday, Saturday

Time

Morning Trip and Noon Trip

Social Mobility Restriction

PPKM (Pemberlakuan Pembatasan Kegiatan Masyarakat) or Community Activities Restriction Enforcement

Timeline

Timeline 1 (Mar & Apr 2021): PPKM Mikro
Timeline 2 (Sep & Nov 2021): PPKM Level 1 and PPKM Level 3
Timeline 3 (Mar 2022): PPKM Level 2 and PPKM Level 3

Mode of Transportation (Vehicle Navigator)

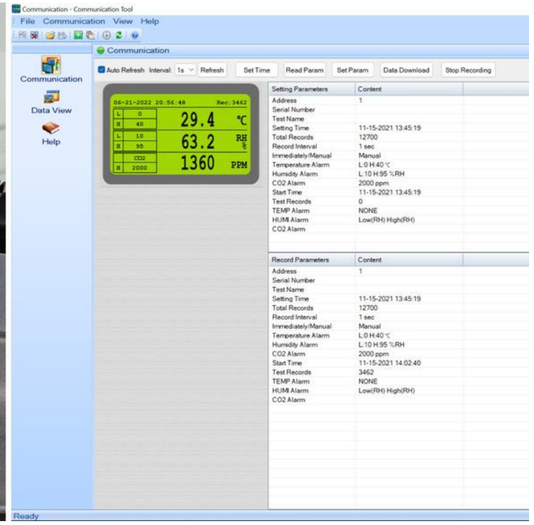
Private Car

Navigation Method

Environmental Sensor:

HT 2000 sensor which record the Carbon Dioxide (CO2) data as the environmental variable

HT 2000 (CO2 Sensor)



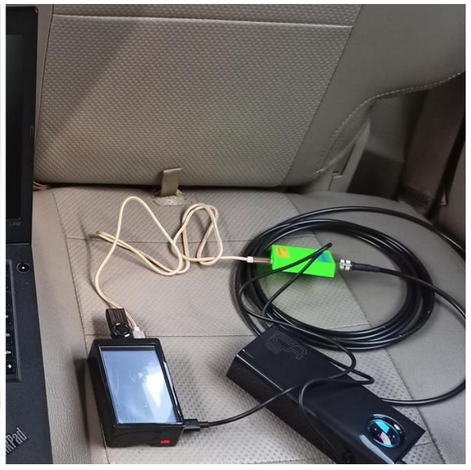
GNSS (Global Navigation Satellite System):

GNSS-PPK (Post Processed Kinematic) with GNSS Trimble NetR9 as Base Station Receiver and GNSS EVK-M8T U-Blox Evaluation Kit as Rover Receiver

GNSS MADOCA-PPP (Precise Point Positioning) with the aid of GNSS MADOCA-PPP receiver

PPK (Post Processed Kinematic)

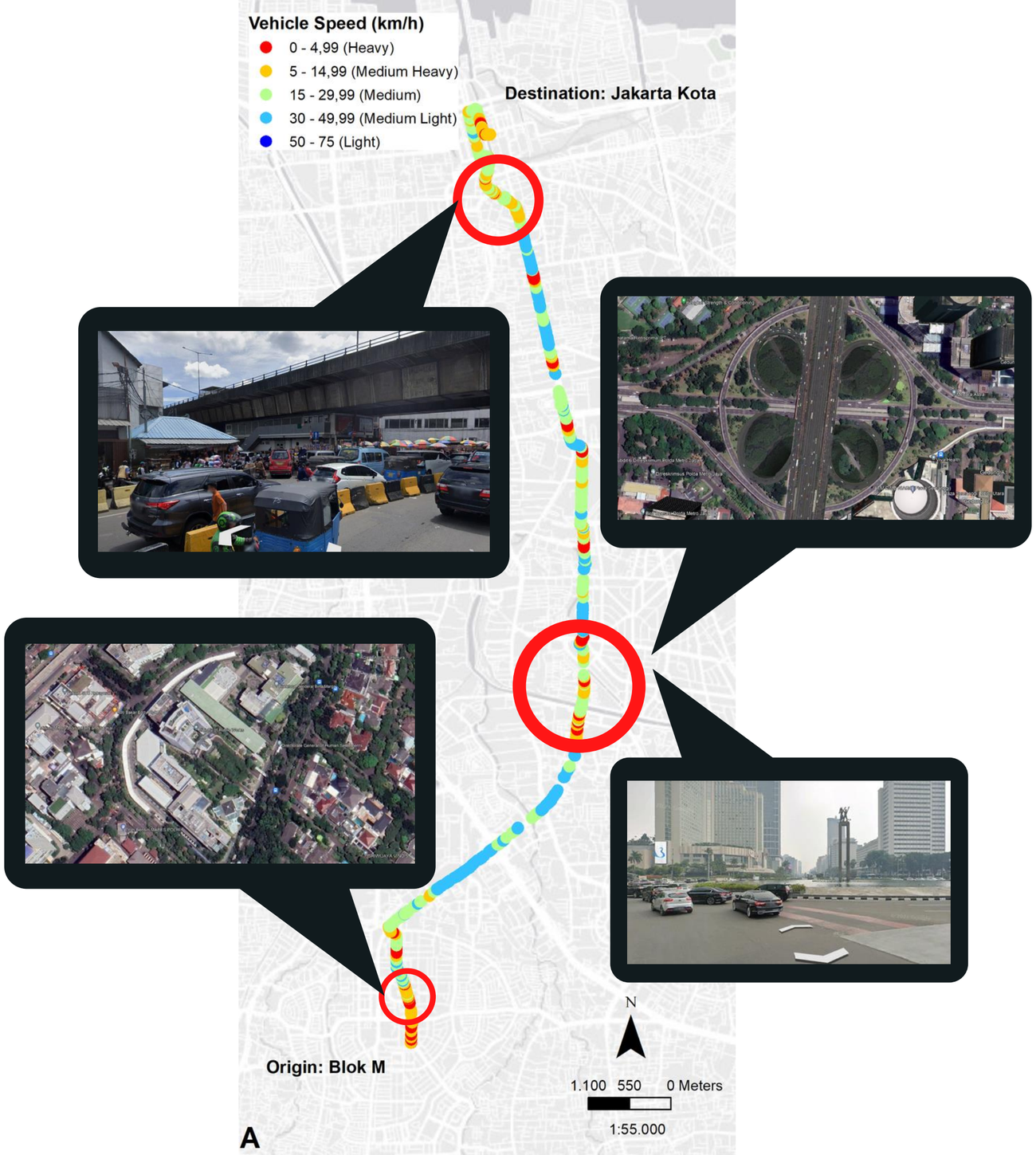
PPP (Precise Point Positioning)



Results. Highlights of the Congested Area

Blok M - Jakarta Kota Route

Vehicle Speed (km/h)
- 0 - 4,99 (Heavy)
- 5 - 14,99 (Medium Heavy)
- 15 - 29,99 (Medium)
- 30 - 49,99 (Medium Light)
- 50 - 75 (Light)



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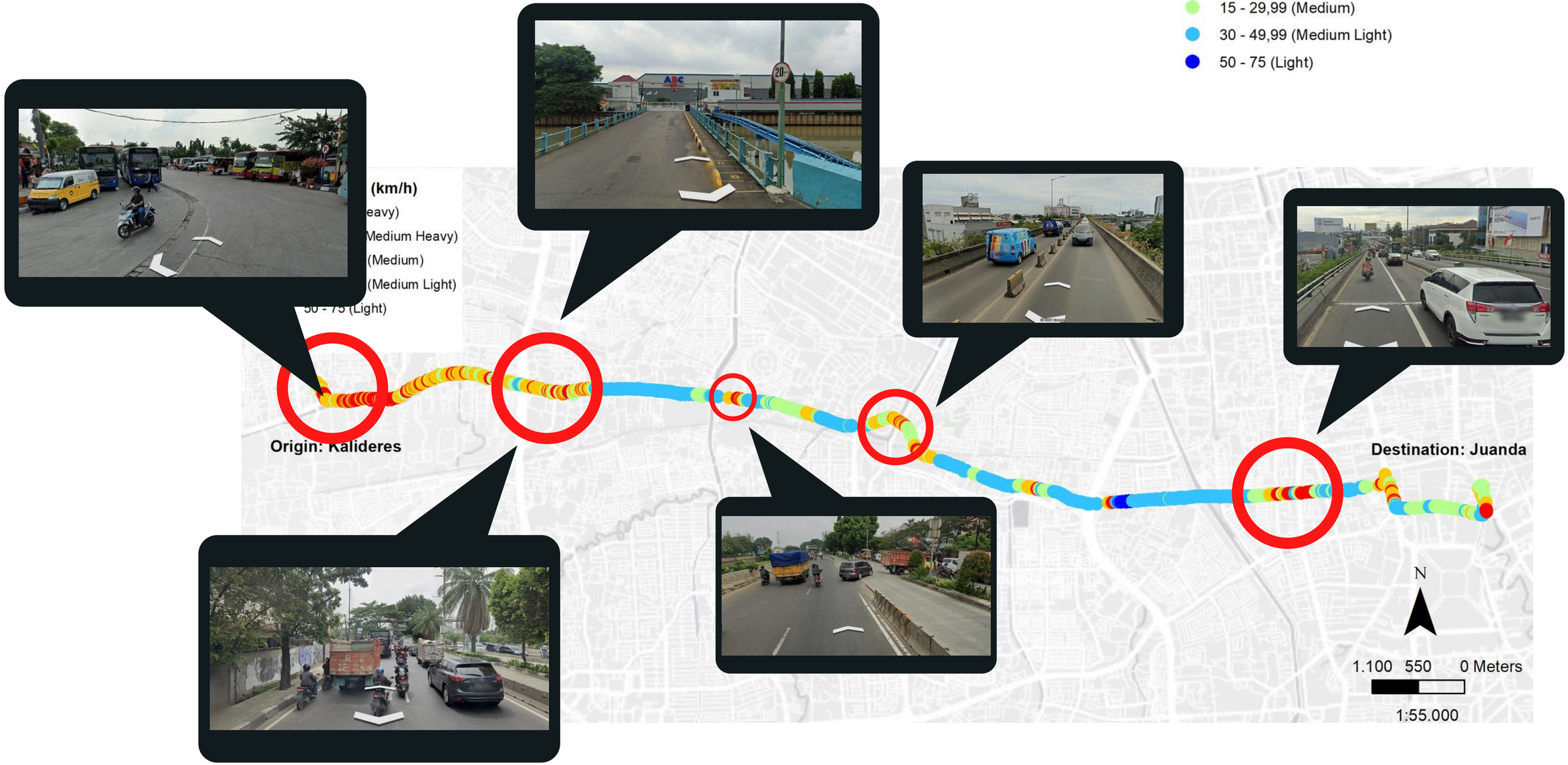
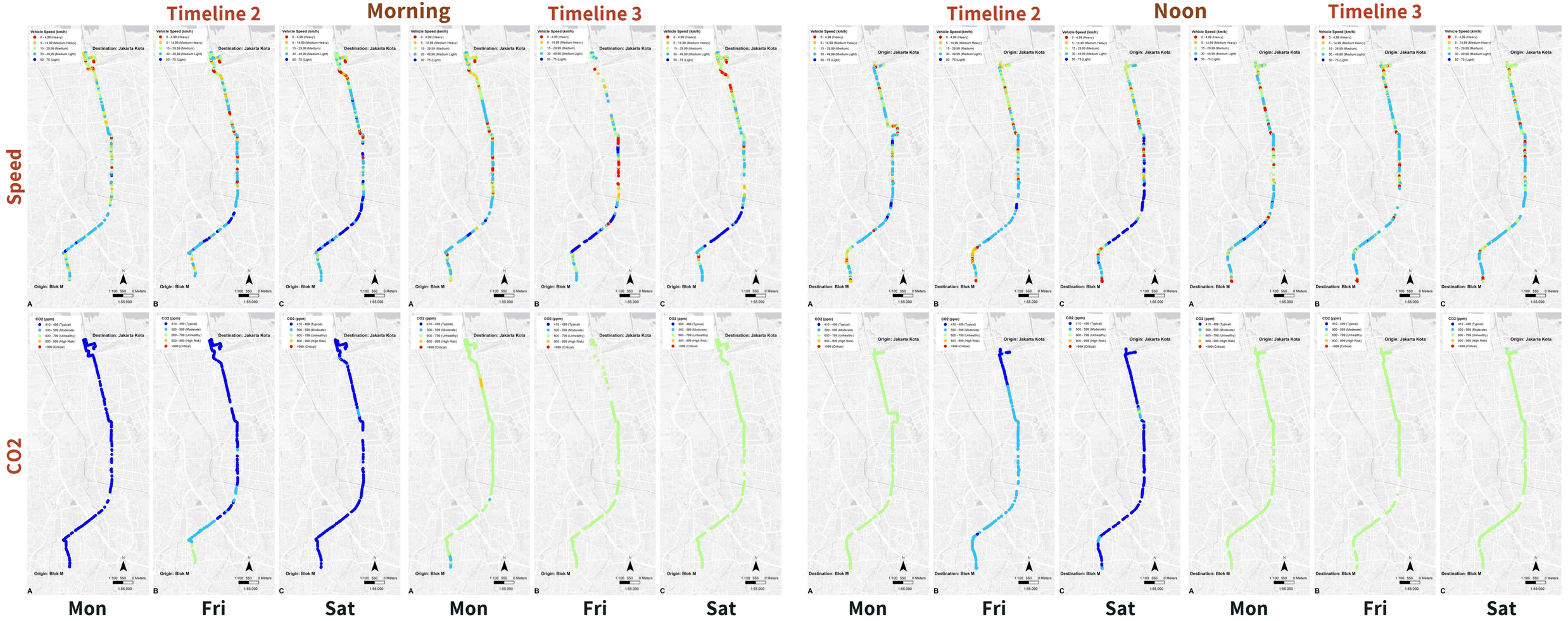


Urban Traffic (Speed) vs Air Pollution (CO_2)

Blok M - Jakarta Kota Round Trip Route

Vehicle Speed (km/h)
- 0 - 4,99 (Heavy)
- 5 - 14,99 (Medium Heavy)
- 15 - 29,99 (Medium)
- 30 - 49,99 (Medium Light)
- 50 - 75 (Light)

CO2 (ppm)
- 410 - 499 (Typical)
- 500 - 599 (Moderate)
- 600 - 799 (Unhealthy)
- 800 - 999 (High Risk)
- >999 (Critical)



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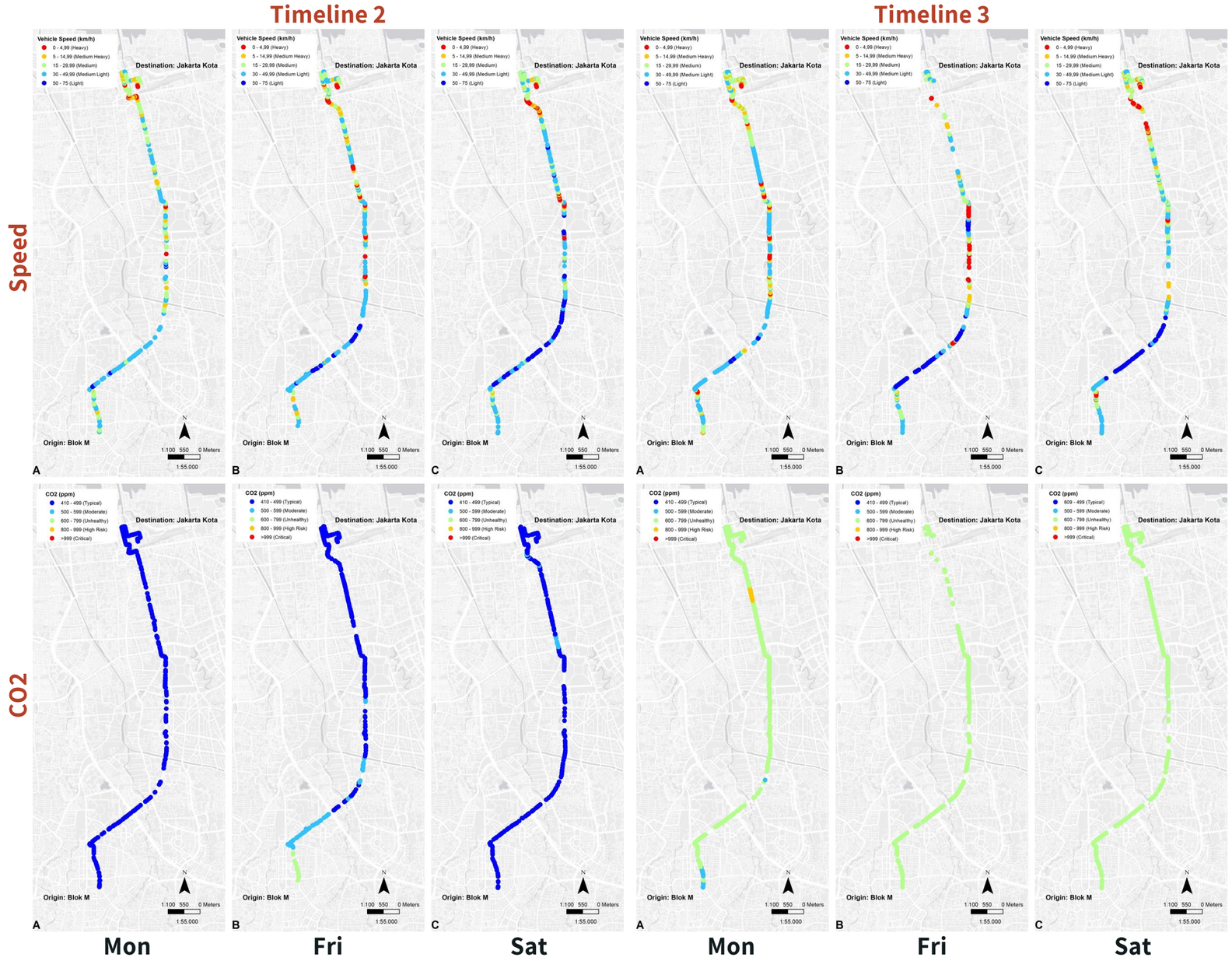

Blok M - Jakarta Kota Route

Morning Trip

Vehicle Speed (km/h)

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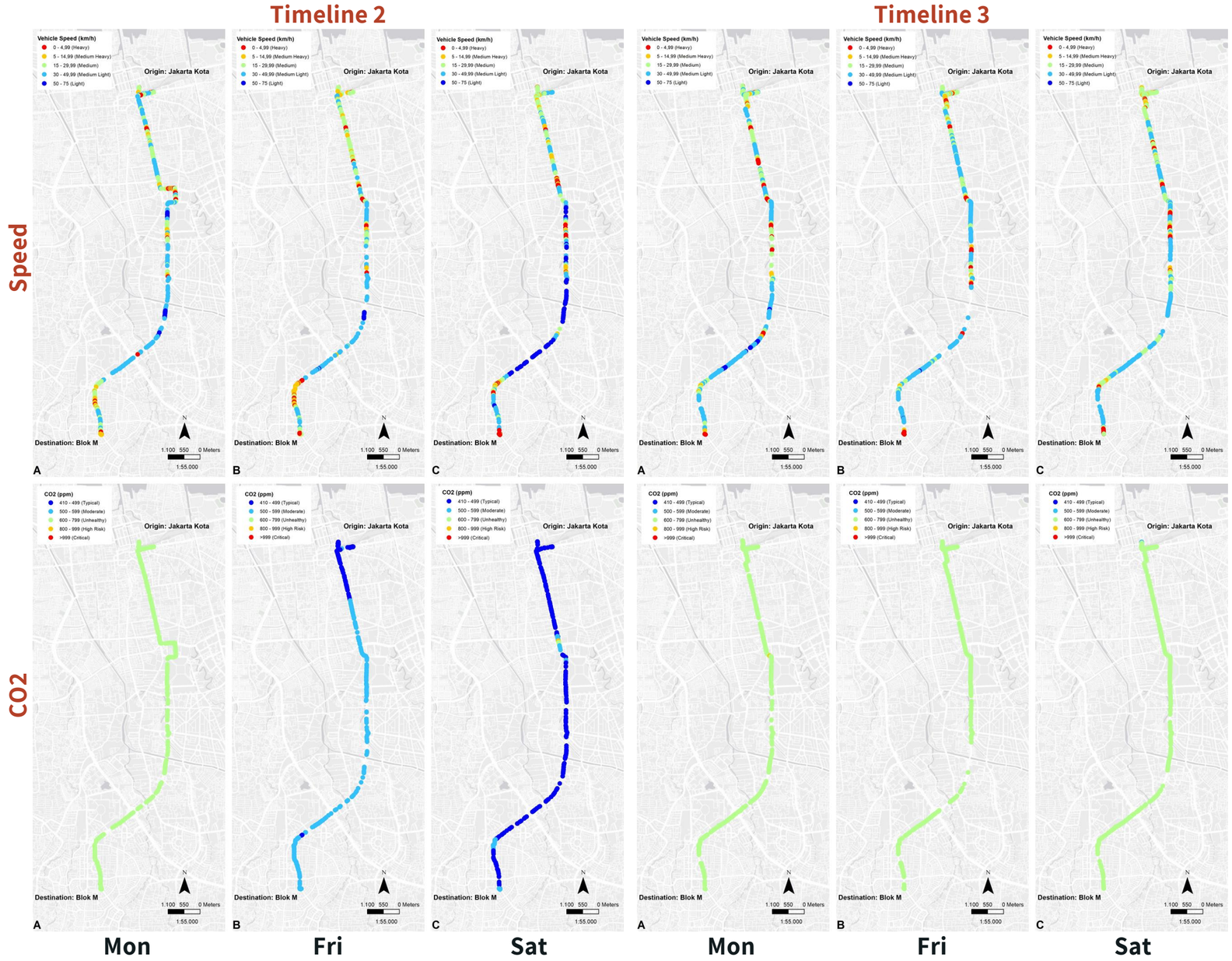

Blok M - Jakarta Kota Route

Noon Trip

Vehicle Speed (km/h)

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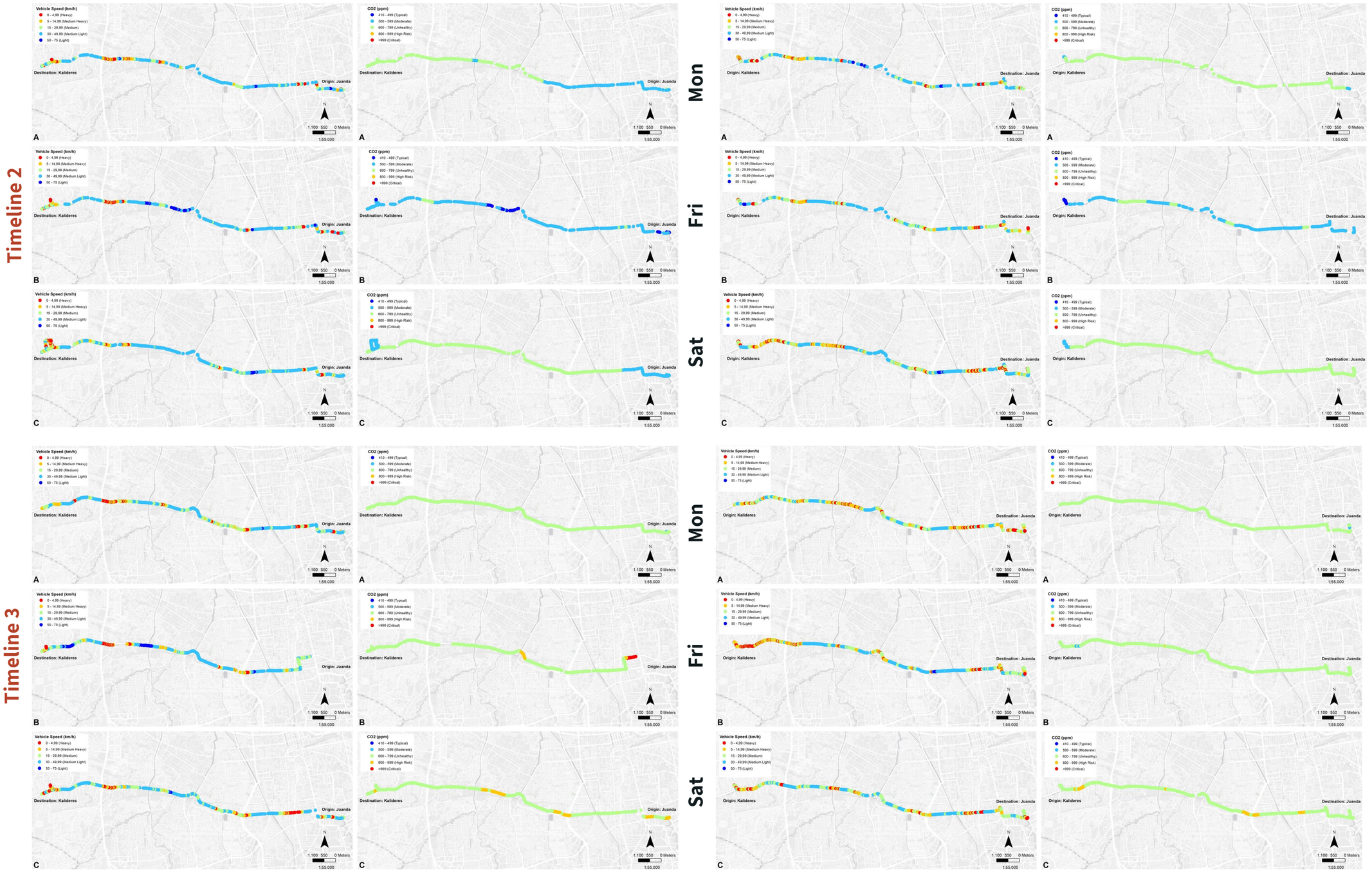

Urban Traffic (Speed) vs Air Pollution (CO_2)

Juanda - Kalideres Round Trip Route

Vehicle Speed (km/h)

- 0 - 4,99 (Heavy)
- 5 - 14,99 (Medium Heavy)
- 15 - 29,99 (Medium)
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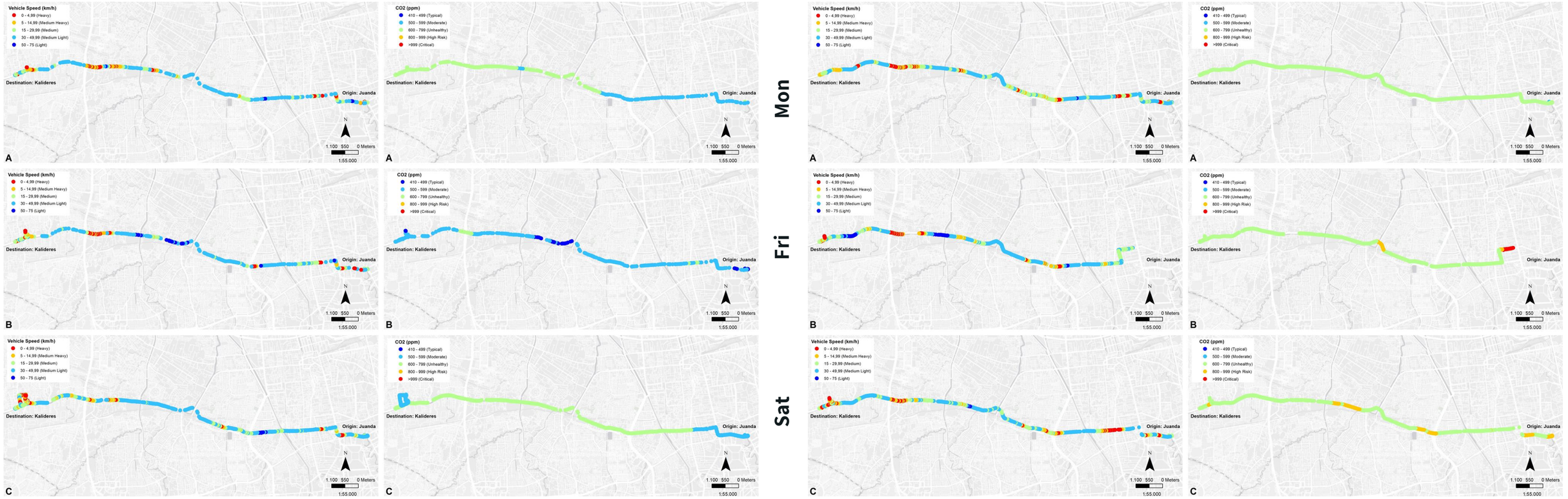
Juanda - Kalideres Route

Morning Trip

Timeline 2 | **Timeline 3**



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Juanda - Kalideres Route

Noon Trip

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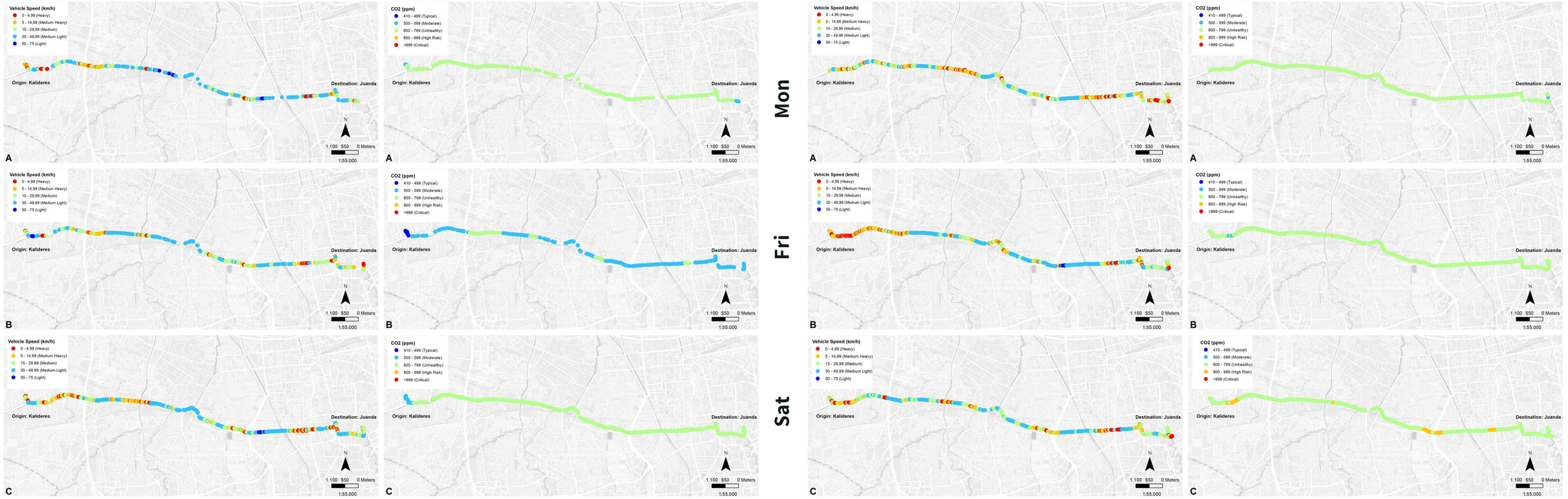
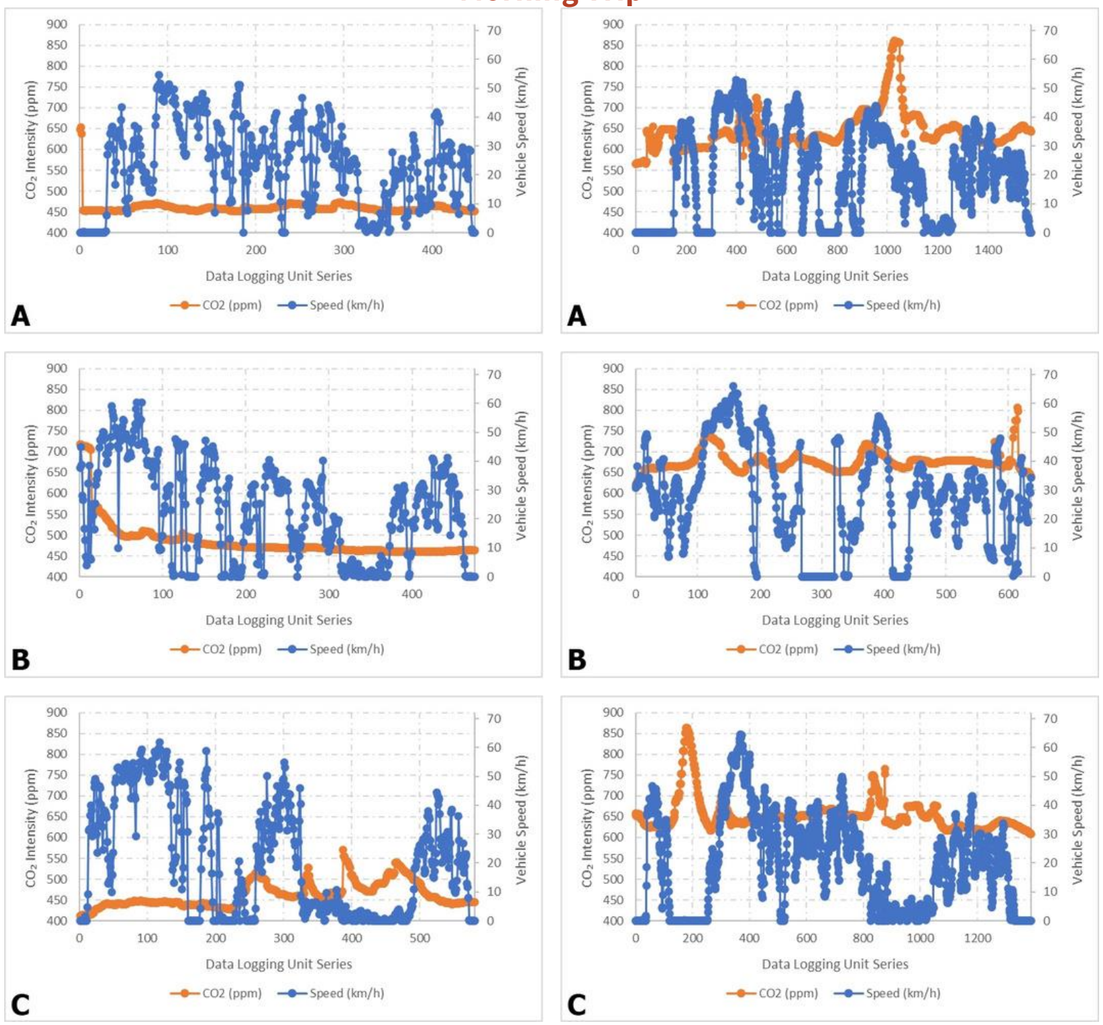


Graphic Pattern of Urban Traffic (Speed) vs Air Pollution (CO_2)

Blok M - Jakarta Kota Round Trip Route

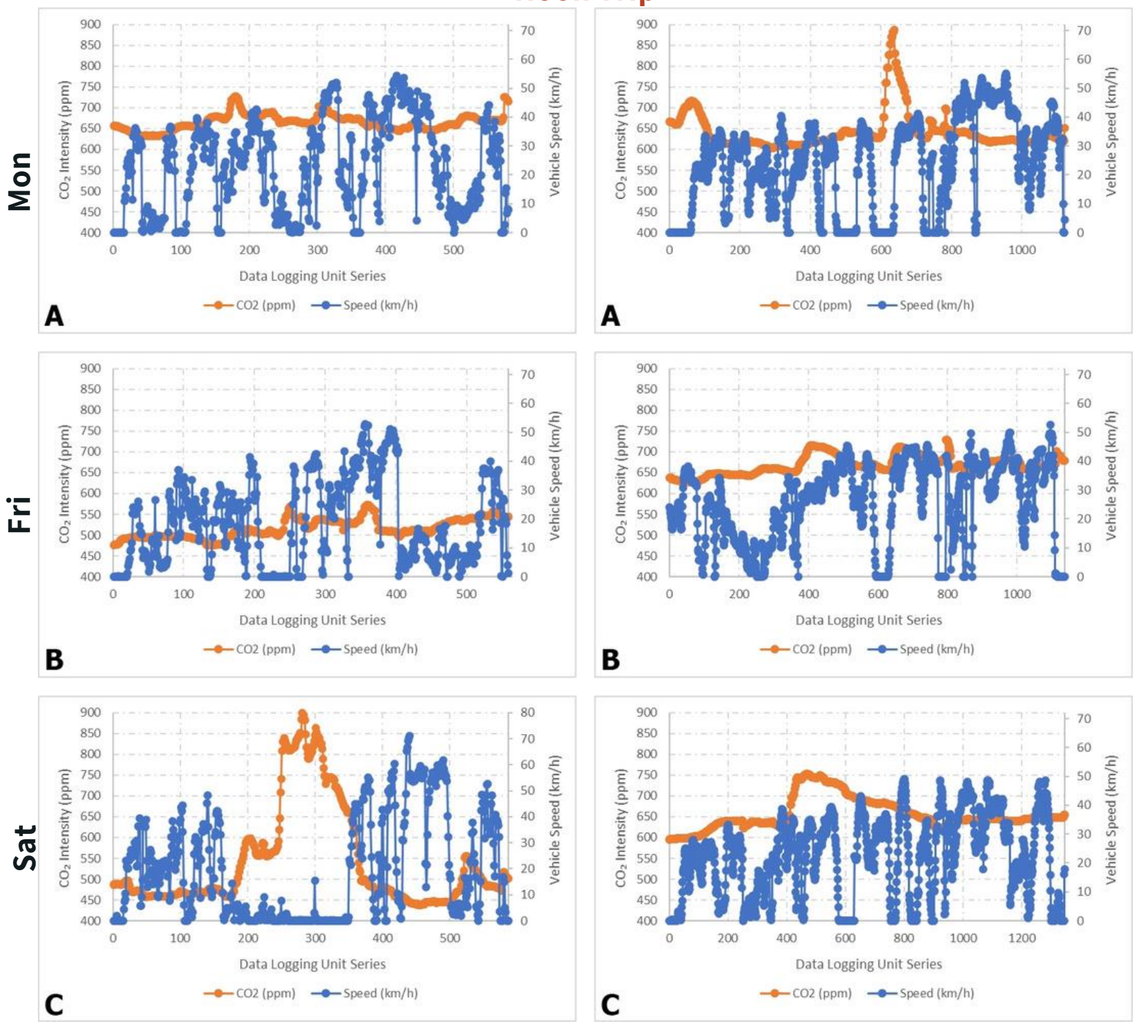
CO2(ppm) Speed (km/h)

Morning Trip



Timeline 2 Timeline 3

Noon Trip



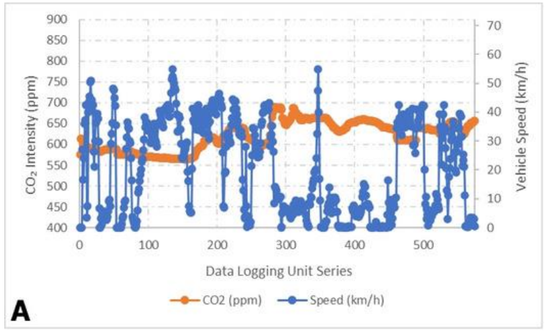
Timeline 2 Timeline 3

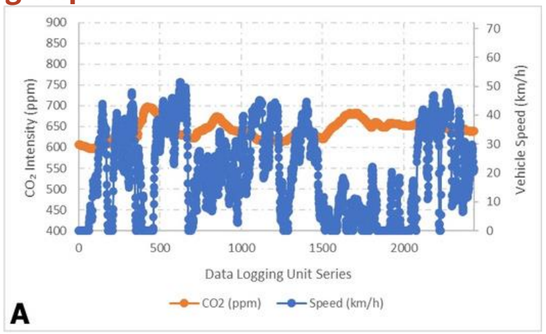
Graphic Pattern of Urban Traffic (Speed) vs Air Pollution (CO_2)

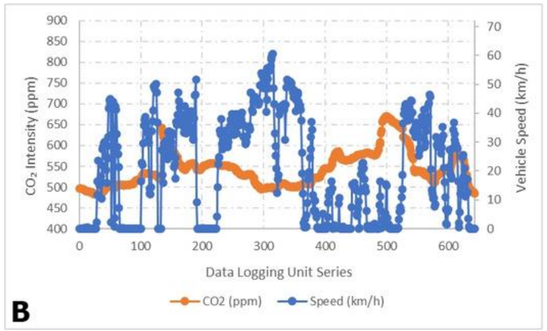
Juanda - Kalideres Round Trip Route

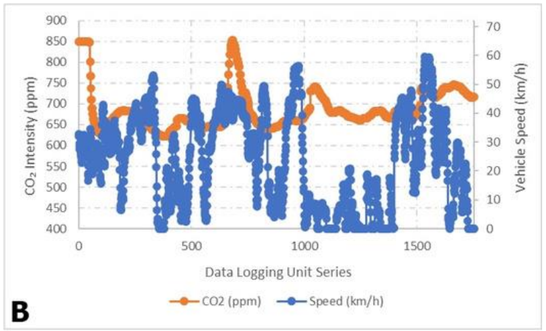
CO2(ppm) Speed (km/h)

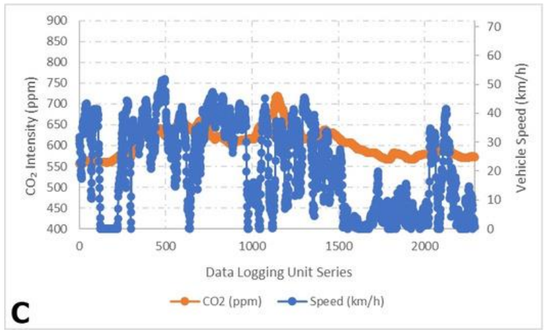
Morning Trip

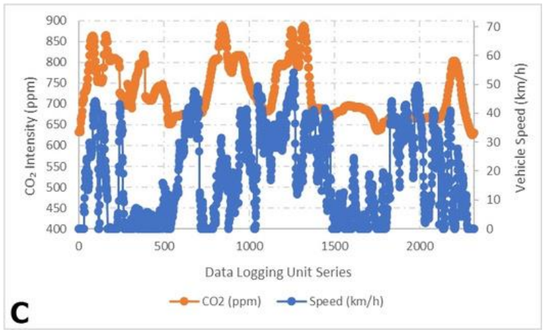








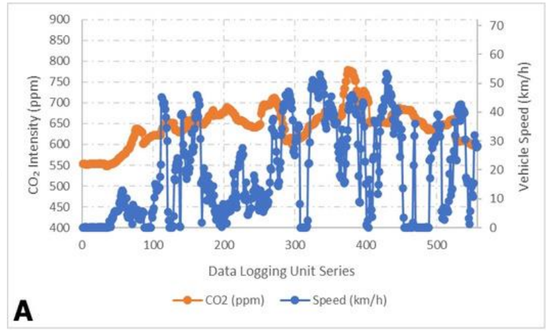


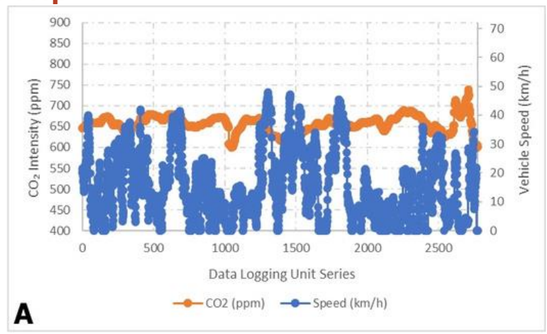


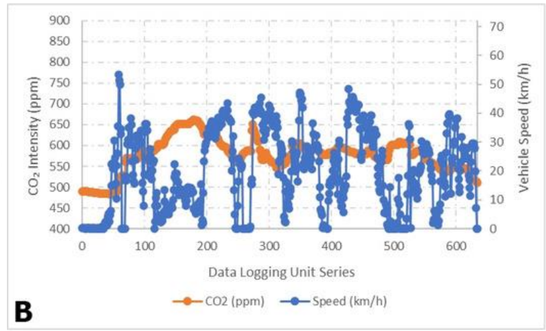
Timeline 2

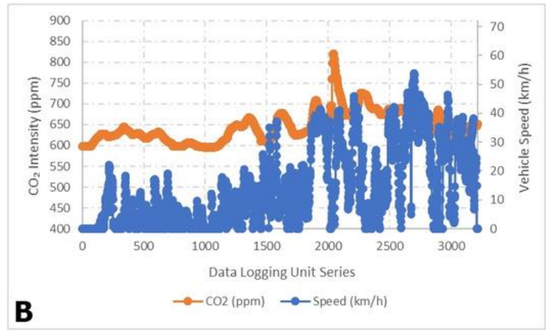
Timeline 3

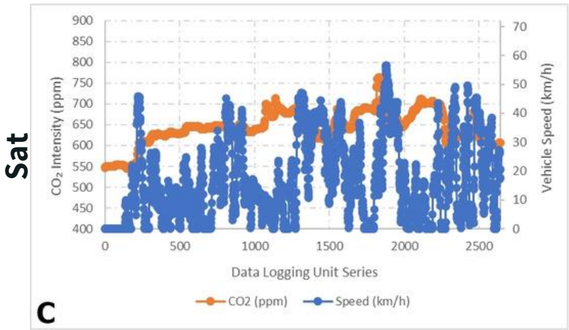
Noon Trip

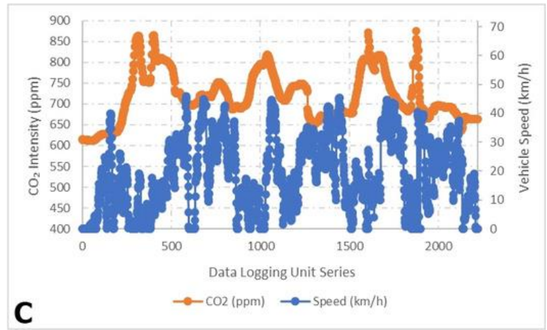










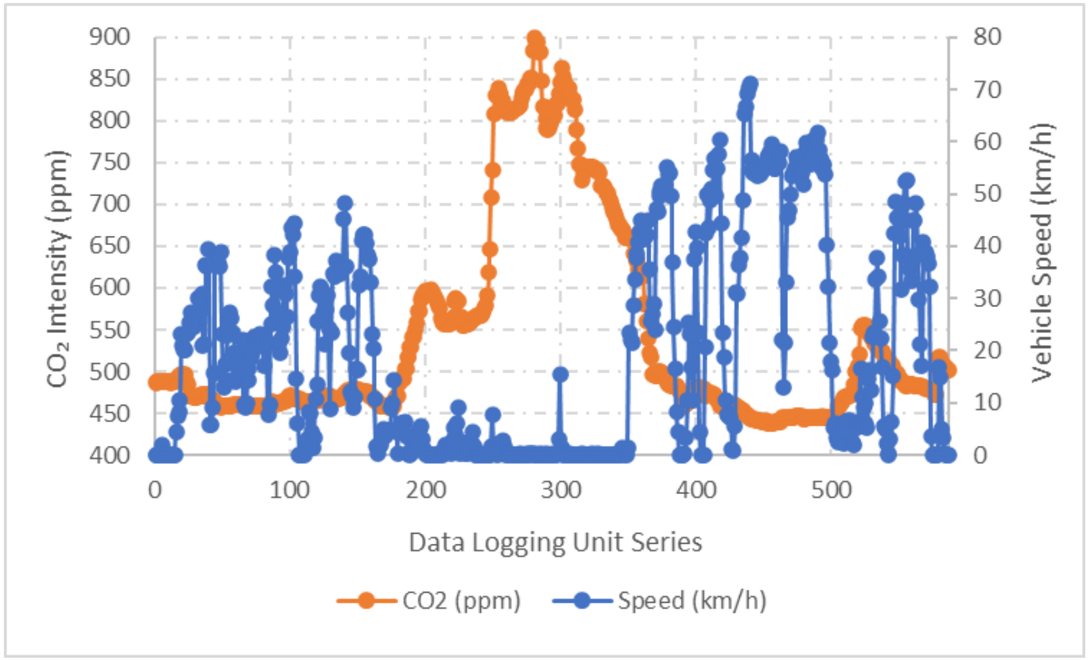


Timeline 2

Timeline 3

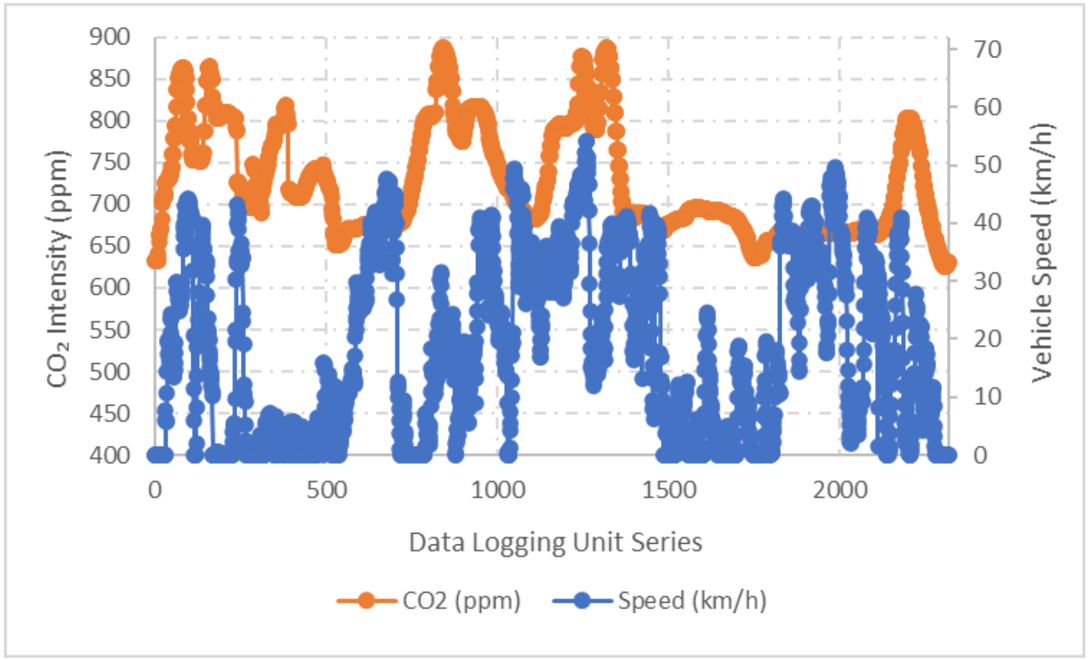
Graphic Pattern of Urban Traffic (Speed) vs Air Pollution (CO_2) (Sample Zoomed In)

Blok M - Jakarta Kota



Noon Trip

Juanda - Kalideres



Morning Trip

Statistical Regression Analysis of Urban Traffic and Air Pollution

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	speed[b]	.	Enter

a. Dependent Variable: co2

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.031[a]	.001	.001	94.880

a. Predictors: (Constant), speed

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	715737.172	1	715737.172	79.507	.000[b]
	Residual	768084595.466	85322	9002.187		
	Total	768800332.638	85323			

a. Dependent Variable: co2

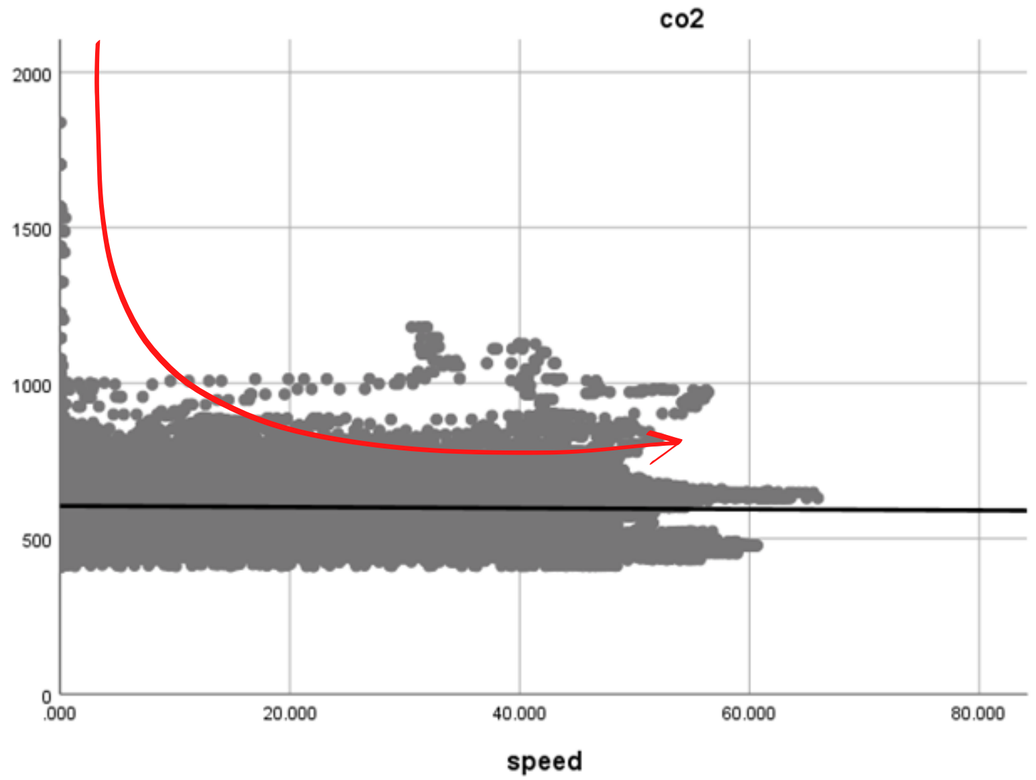
b. Predictors: (Constant), speed

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	605.099	.521		1161.322	.000
	speed	-.179	.020	-.031	-8.917	.000

a. Dependent Variable: co2

In this context of data setting, every increases of 1 km/h vehicle speed, reduces 0.179 ppm CO2



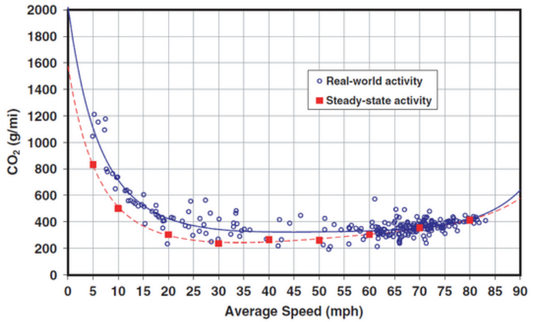


Figure 2.7. The Correlation of Average Speed and CO2 (Barth & Boriboonsomsin, 2010)

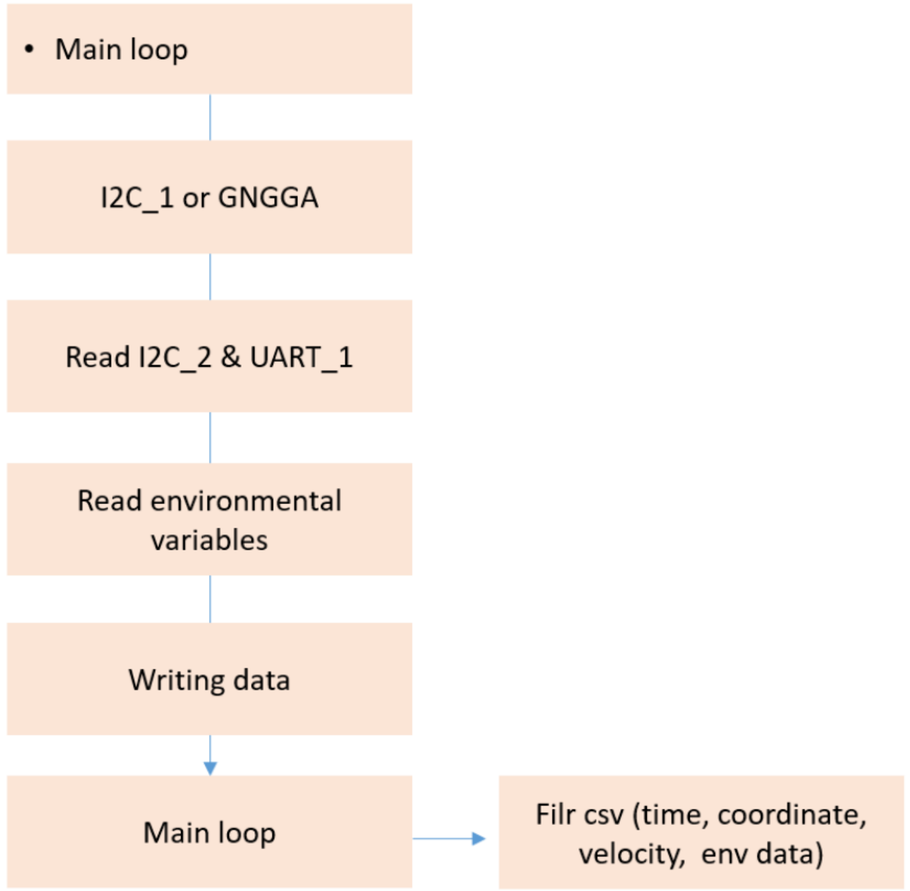
In Conclusion:

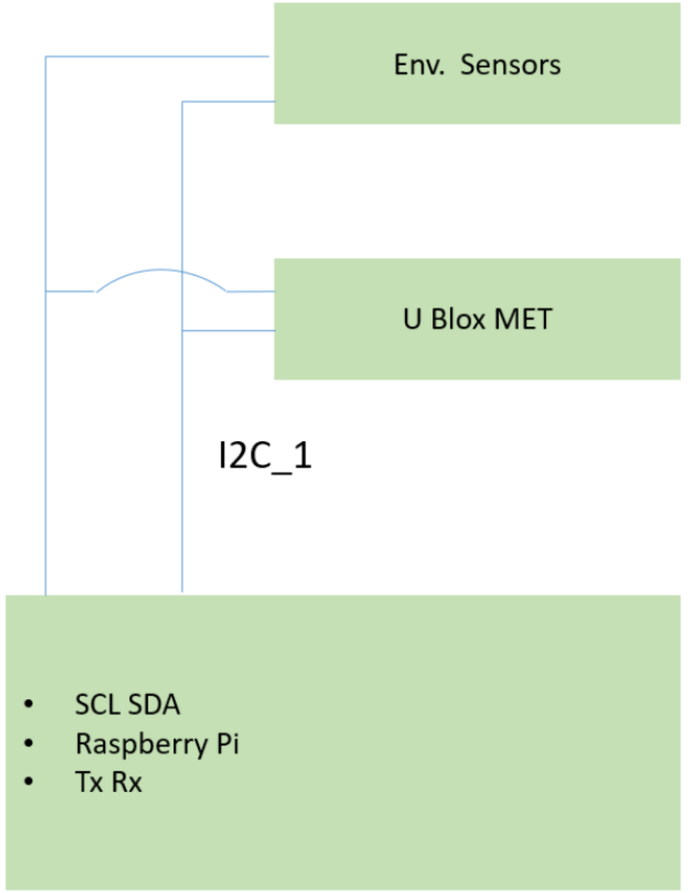
1. The lower the vehicle speed, the higher the concentration of CO2.

2. The higher the vehicle speed, the lower the concentration of CO2.

Proposed Integrated Technology

(Discussion with TUMSAT University GNSS Lab.)





Notes from the Study

The urban traffic congestion (with the variable of Vehicle Speed (km/h)) and the air pollution intensity (with the variable of CO2 (ppm)) in the selected main routes of Jakarta were significantly correlated. The high emissivity of CO2 emissions is significantly caused by the high duration of the trip and concentration of traffic volume and low vehicle speed in certain area of the route

The HT 2000 environmental is designed for indoor and static measure. However, the tool is reliable for this study, even though the specific designed tool is recommended for future study. Innovations of integrated technology between GNSS and environmental sensor with more spatial and non-spatial variable measure (Distance, CO, NO, SO2, etc) is highly recommended to get more precise and holistic findings

The integration of GNSS receiver and environmental sensor needs to be further investigated. It needs to be designed in form of one device, low cost, and offer more range of variables

CSDA is currently in the process of proposing further research to conceptual prototype of the integration technology between GNSS receiver and environmental sensor

Collaboration with potential partners (experts, professionals, private, etc) is invited


SCANIA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Thank You