

A multi-scale dynamic vehicle emission estimation method by combining real-time traffic big data and instantaneous emission factors

Fei Yu¹, Zhijiong Huang¹, Zhuangmin Zhong¹, Junwen Liu¹, Junyu Zheng^{1*}
 1. Institute of Environment and Climate Research, Jinan University, Guangzhou 510006, China

*Email: zheng.junyu@gmail.com

Introduction

In recent year, on-road vehicle has become the most important emission source in Chinese megacities, due to its increasing role in air pollution formation and adverse impact on public health. Influenced by the local driving cycle, road information and traffic characteristics, on-road vehicle emissions vary spatially and temporally. However, these spatio-temporal characteristics cannot be revealed by annual vehicle emissions compiled using vehicle population or fuel consumption. In this study, we developed a new method by combining real-time traffic big data and instantaneous emission factors to estimate near-real-time on-road vehicle emissions at link level. To estimate real-world vehicle emissions accurately, each road was divided into links (at most 100 m length) on this road link. The Baidu navigation system, one of the car-borne navigation giants in China, was used to resolve the real-time driving speed, road type and traffic congestion at the link level and minutely level. A city-based traffic flows model based on driving speeds and taxi GPS data were used to simulate the real-time traffic flow in each road link. Complemented with the VSP-based instantaneous emission factors developed by using real-world PEMS test results, the near-real-time on-road vehicle emission at each road link was estimated. These real-time link-based emissions can be upscaled to street, city and regional levels, which can be applied to promote air quality numerical simulations, exposure and air quality precise control.

Methodology

Fusion of multi-source traffic big data

GPS data
Baidu navigation
Road monitoring

Developing of Real-time traffic flow model

Development a real-time traffic flow model based on the relationship between traffic flow, density and velocity.

Analysis of Vehicle Transient Conditions

link_a, link_b, link_c
V_a, V_b, V_c

The transient operating conditions of vehicle in link level are calculated based on the changes of vehicles working conditions on two adjacent road link.

At link level emissions, the spatial resolution is less than 100 m and the time resolution is 15 min.

Real Driving Emissions (RDE) test

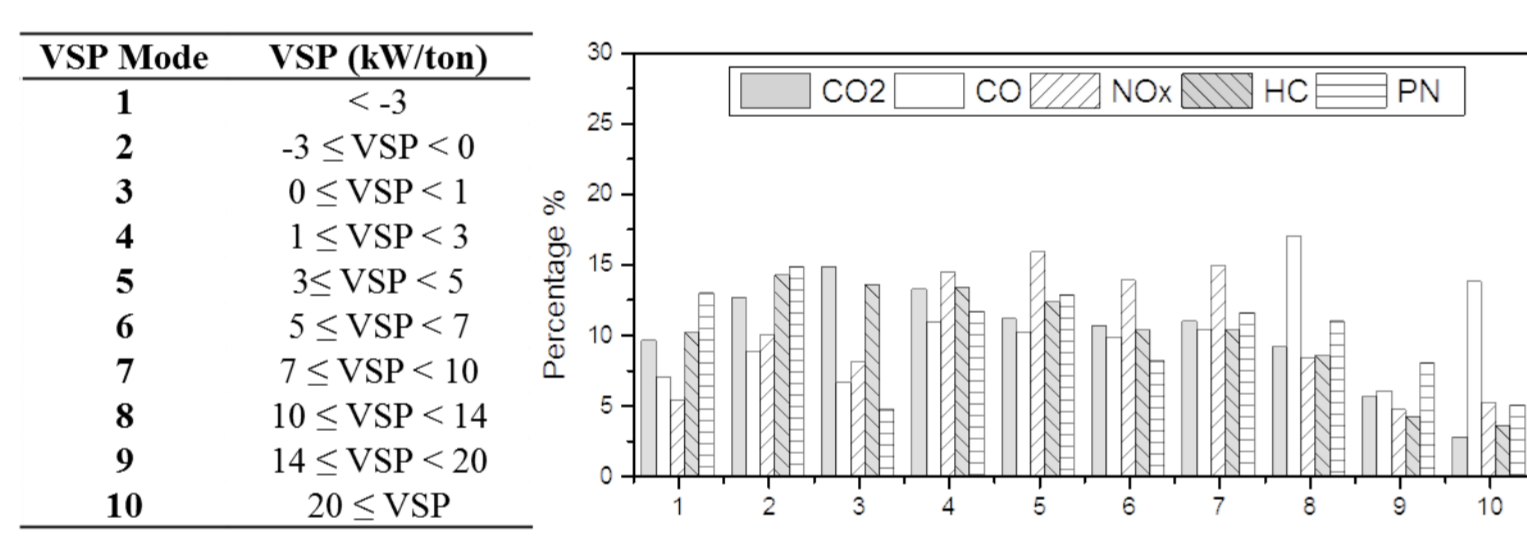
Instantaneous emission factors

Development a instantaneous vehicle emission factors model based on vehicle specific power (VSP).

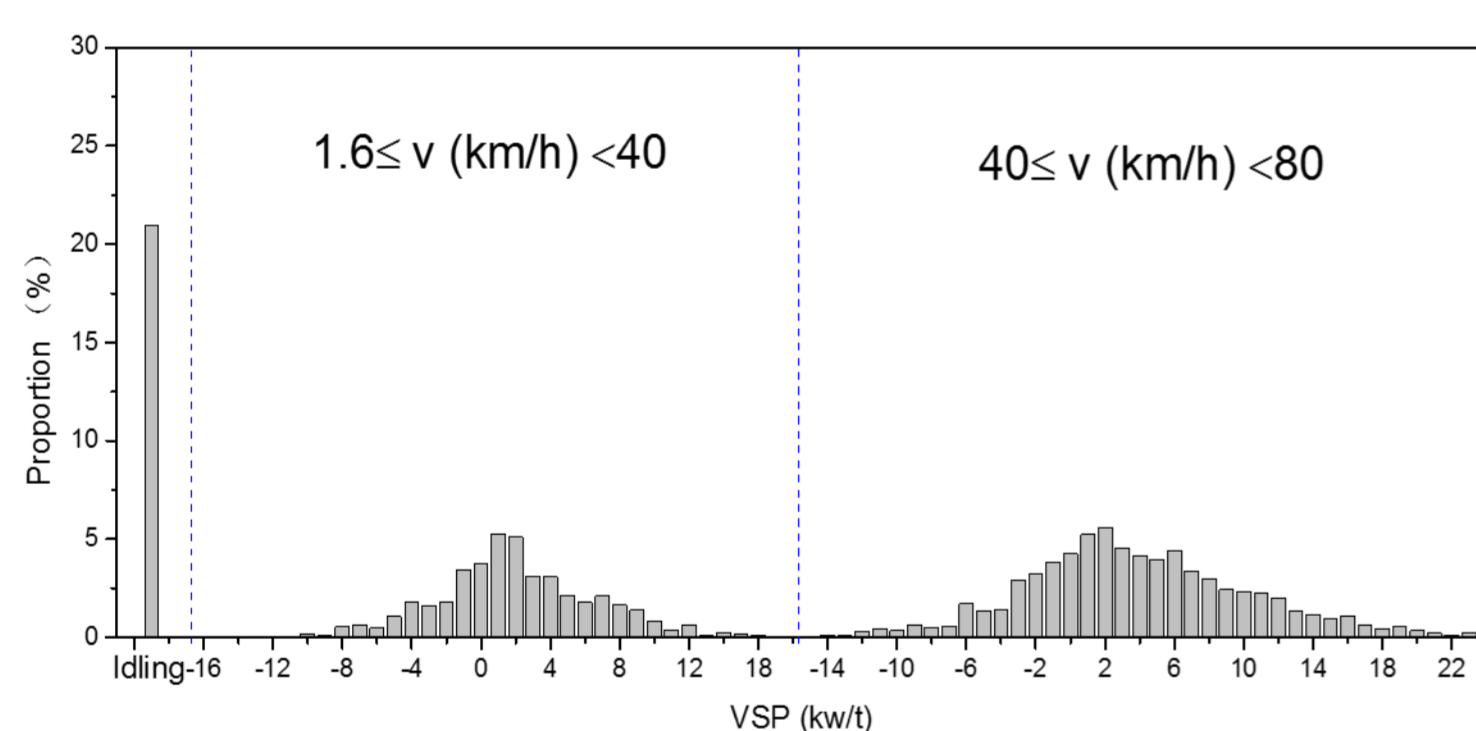
Real-time emissions of vehicle at link level

These link-based emissions can be upscale to street, city and regional levels.

Development of the PRD local VSP Bins Classification Approach



The division of local VSP mode and the contribution of each pollutant to the total emissions in each mode.

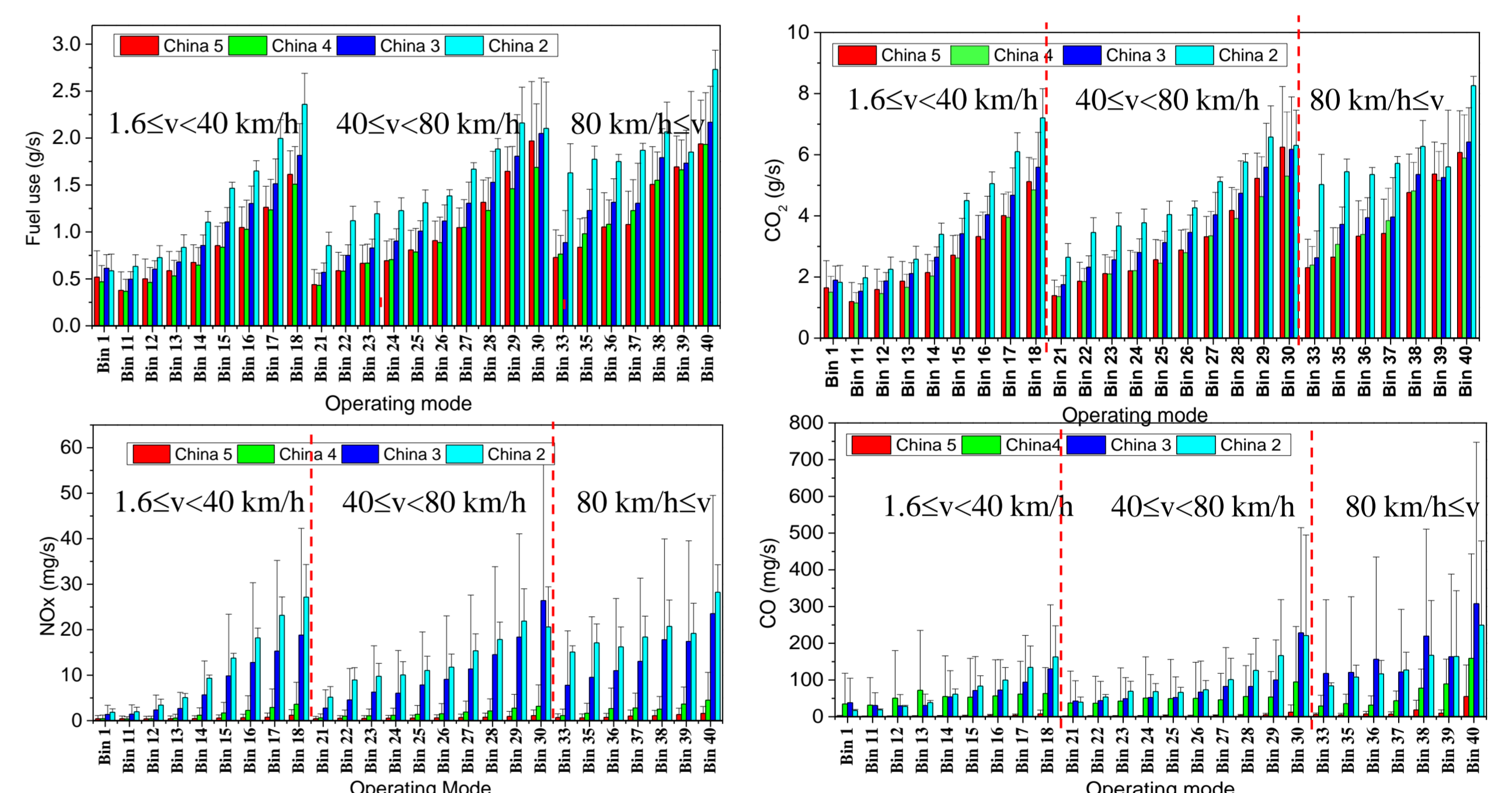


Time distribution characteristics of motor vehicles under local conditions.

PRD local VSP Bins classification.

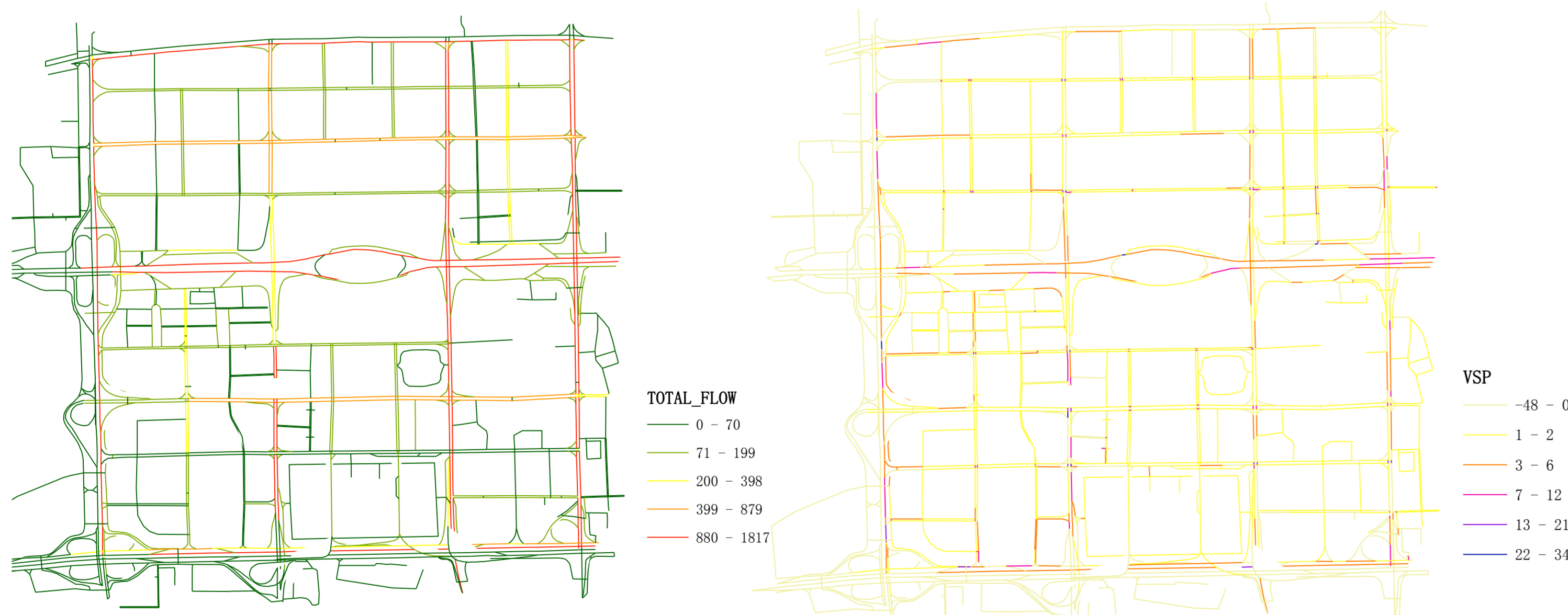
VSP (kw/t)	v (km/h)	bin
<-3	<1.6	bin 1
-3~0	1.6~40	bin 11
0~1	40~80	bin 21
1~3	80~100	bin 33
3~5	100~120	bin 12
5~7	120~140	bin 22
7~10	140~160	bin 35
10~14	160~180	bin 13
14~20	180~200	bin 23
≥20	200~220	bin 36
	220~240	bin 14
	240~260	bin 24
	260~280	bin 37
	280~300	bin 15
	300~320	bin 25
	320~340	bin 38
	340~360	bin 16
	360~380	bin 26
	380~400	bin 39
	400~420	bin 17
	420~440	bin 27
	440~460	bin 40
	460~480	bin 18
	480~500	bin 28
	500~520	bin 29
	520~540	bin 30
	540~560	bin 31
	560~580	bin 32
	580~600	bin 34

Development of vehicle instantaneous emission factors model



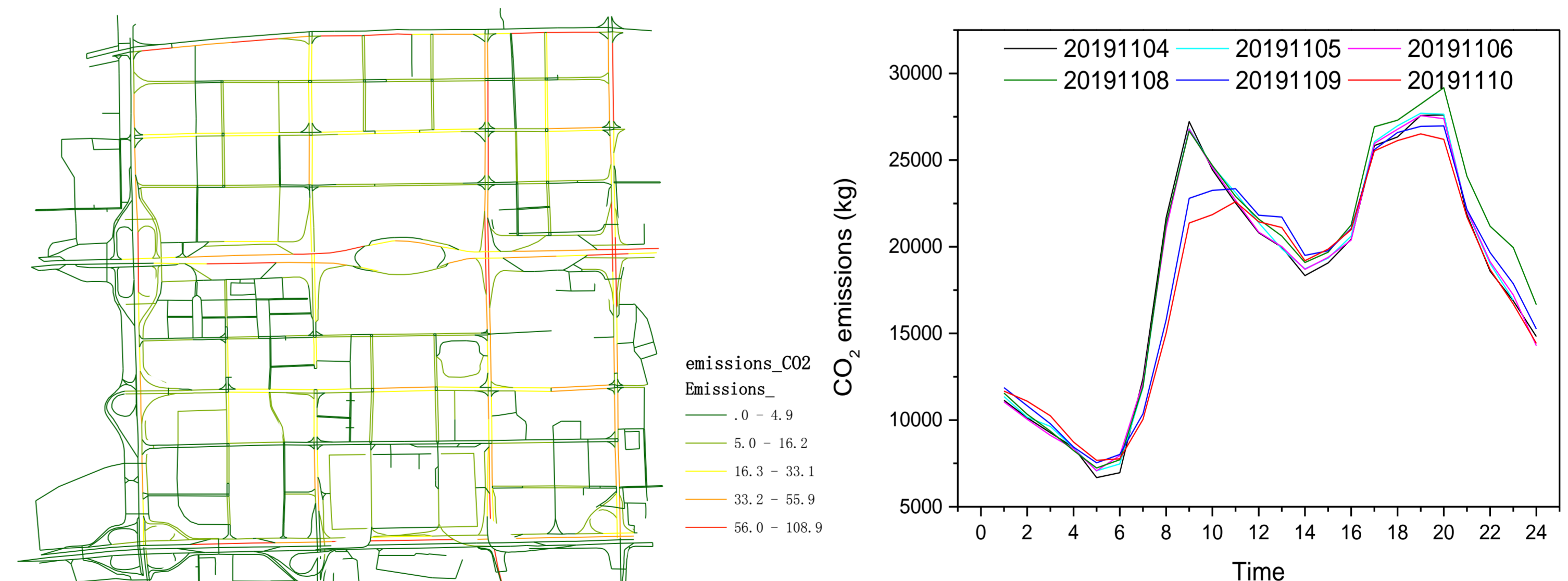
Taking the emission factors of light gasoline vehicles with different national standards as examples.

Vehicle traffic flow and vehicle transient conditions at the link level



Take the traffic flow and transient conditions of each road segment at a certain time in November 2019 in Futian District, Shenzhen as an example.

Vehicle emission at the link level take CO₂ as an example



Based on this method, the CO₂ emissions at a certain time at link level and the changes in CO₂ diurnal emissions from weekdays to weekends.

Conclusions

In this study, we developed a new method by combining real-time traffic big data and instantaneous emission factors to estimate near-real-time on-road vehicle emissions at link-level. This method realizes the calculation of near-real-time on-road with a spatial resolution of less than 100m and a time resolution of 15 minutes. This result is of great significance for guiding green travel and risk assessment of human health exposure. At the same time, the link level emissions can be upscale to street, city and regional levels, which can be applied to promote air quality numerical simulations and air quality precise control.