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Characteristics and Estimation Analysis of CO_2 and CH_4 Emission from Vehicle in Nanjing

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Outline

- Background
- Materials and Methods
- Results and Discussion
- Conclusion

Background

- **CO_2 and CH_4** are the most important greenhouse gases. Vehicles are their common source of emission(IPCC, 2013). Greenhouse gas emission from vehicles account for more than **70%** of total traffic emission (He, 2005).
- In recent years, the number of vehicles in China is growing rapidly(Li, 2013), particularly **the rapid growth of the number of natural gas vehicles**(Lu, 2015), further exacerbated the CH_4 emission of urban traffic.
- This paper aimed to clear the characteristics of **CO_2 and CH_4 on the road** and its influencing factors, and analysis the reliability of methods by contrasting two estimation methods.

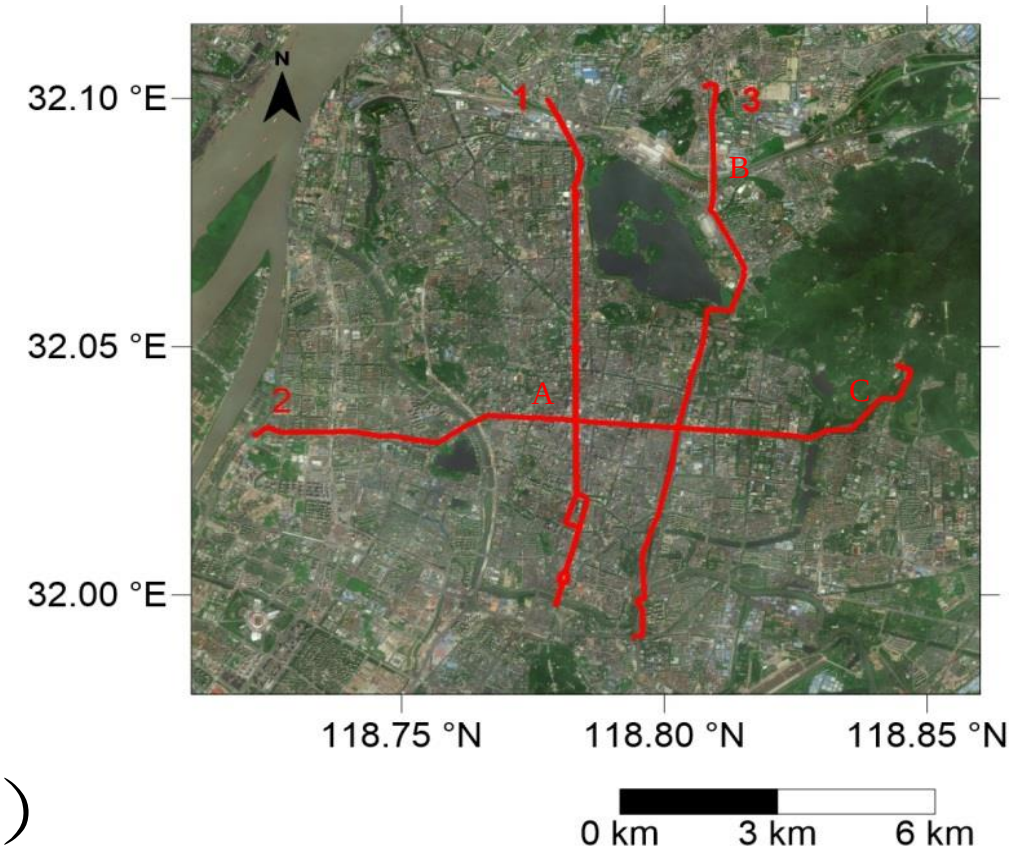
Materials and Methods

Observation site

1. **Main roads**（Figure 1）

2. **Tunnels**

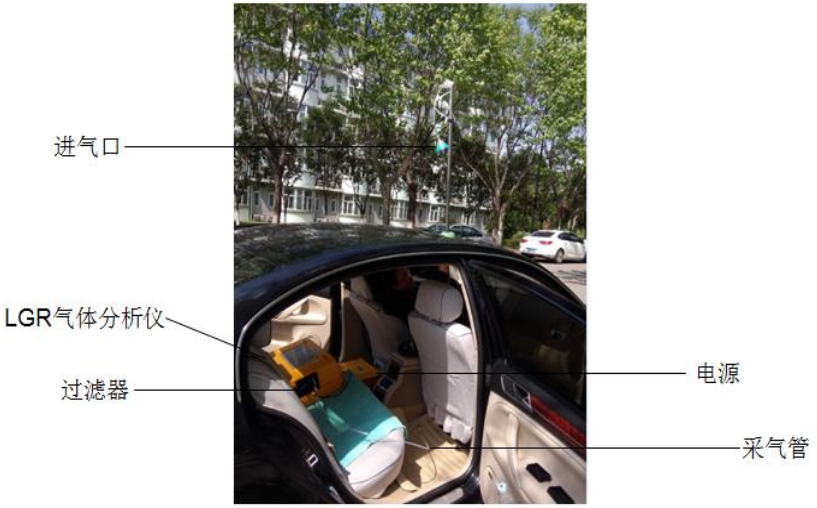
（ Changjiang River Tunnel、Yangtze River Tunnel、Xuanwu Lake tunnel Jiangshan Street Tunnel、Drum tunnel、 Tongji-men tunnel and Jiqing-men tunnel）



A, B, C represent typical sections of Xinjiekou, Hongshan street and Cemetery Road

Fig.1 Image of the observation route

Materials and Methods



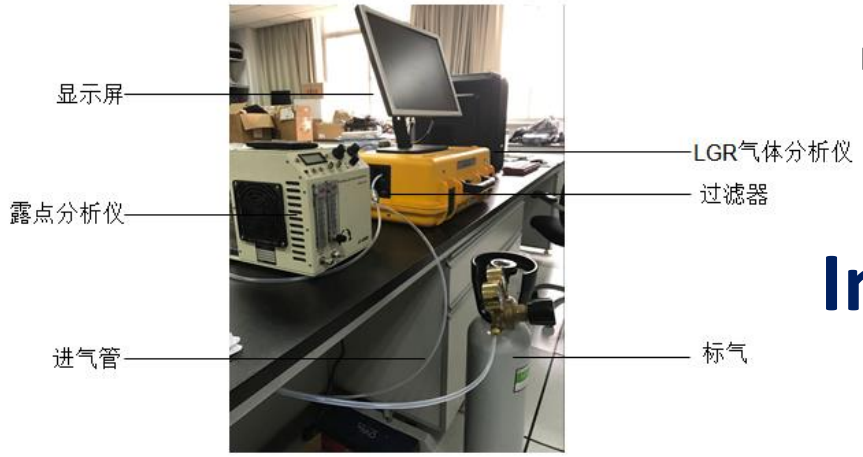


Fig.2 Schematic of instrument installation and calibration

experimental date：

1. October 17, 18, 20, 23, 2014
2. September 11, 2015
   April 18, 2016

Time:

Main roads: 06:00 07:30(morning rush hour); 11:30 17:30(evening rush hour); 22:00

Instrument: LGR gas analyzer computer、GPS video camera

Materials and Methods

Estimation method		Formula	Method	References
"Bottom-up"	IPCC method	$F_i = \sum_1^n f_i \times E_i$	CH_4:CO_2	WRI/WBCSD,2009…
"Top-down"	Atmospheric concentration observation method	/	ΔCH_4:ΔCO_2	Hsu et al., 2010、Wang et al., 2004、Pataki et al. 2005…

IPCC method :

$$f_i = W_i = P_i \times T_i \times M_i / g_i$$

$$E_i = e_i \times q_i$$

f_i : the activity data;
W_i: the amount of vehicle fuel consumption;
P_i : vehicle ownership;
T_i : fuel type coefficient of vehicle;
M_i: annual average mileage of vehicle;
g_i : fuel economy of vehicles;

E_i: proposed emission coefficient;
e_i : original emission coefficient;
q_i : calorific value of china.

Results and Discussion

◆Temporal variation of CO_2 and CH_4 on main road

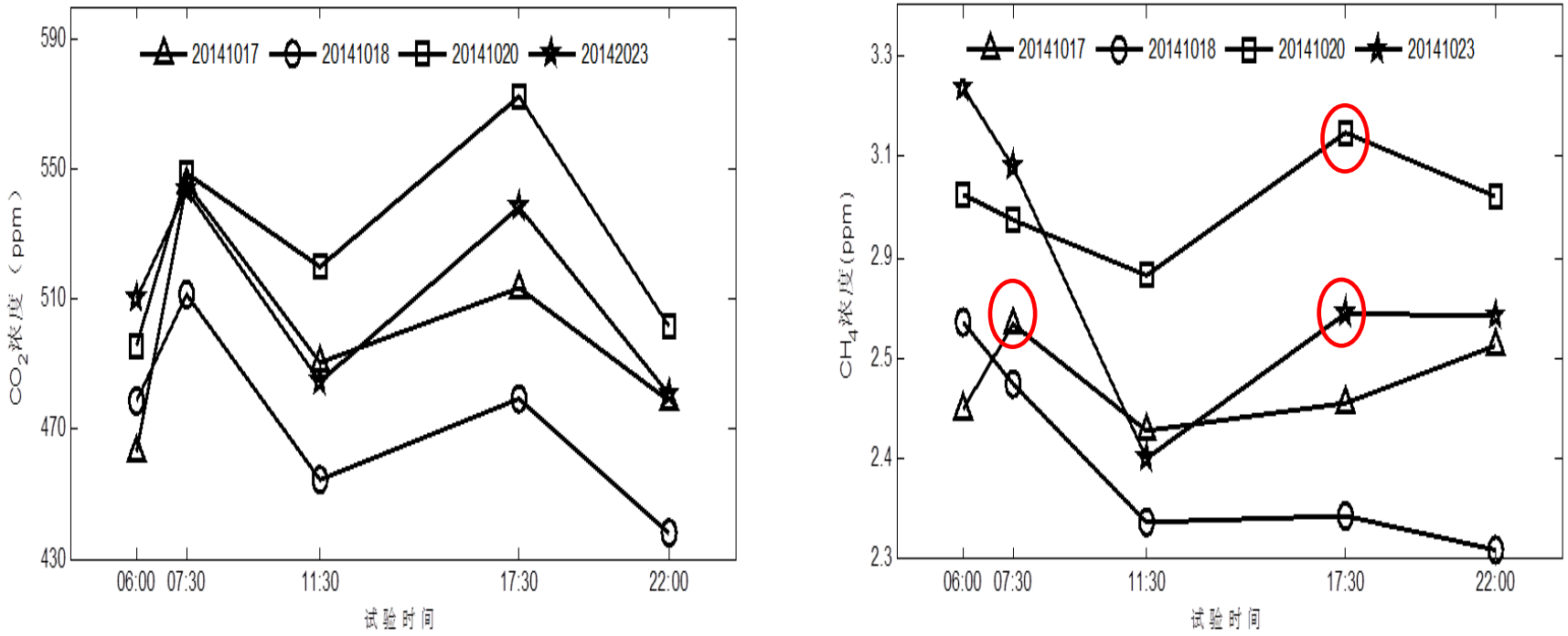


Fig. 3 Diurnal variation of mean CO_2 and CH_4 concentration on the main roads

Results and Discussion

◆Spatial variation of CO_2 and CH_4 on main road

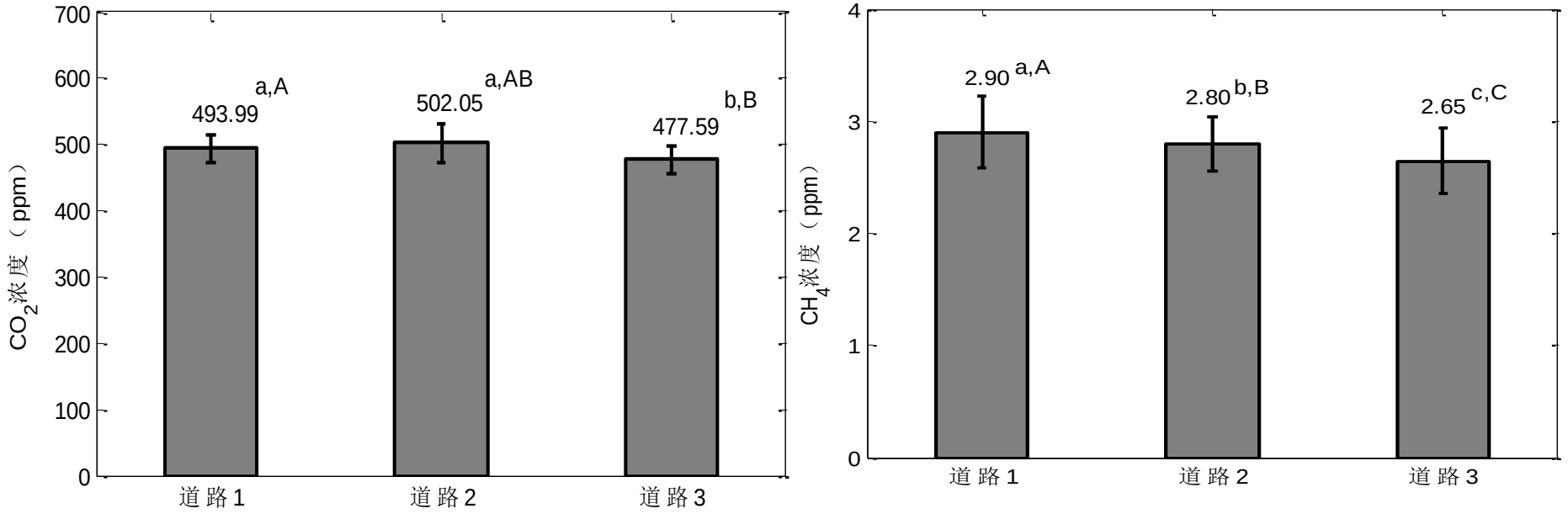


Fig. 4 Bar graph of mean CO_2 and CH_4 concentration on the different main road

Results and Discussion

◆Variation of CO_2 and CH_4 in Tunnel

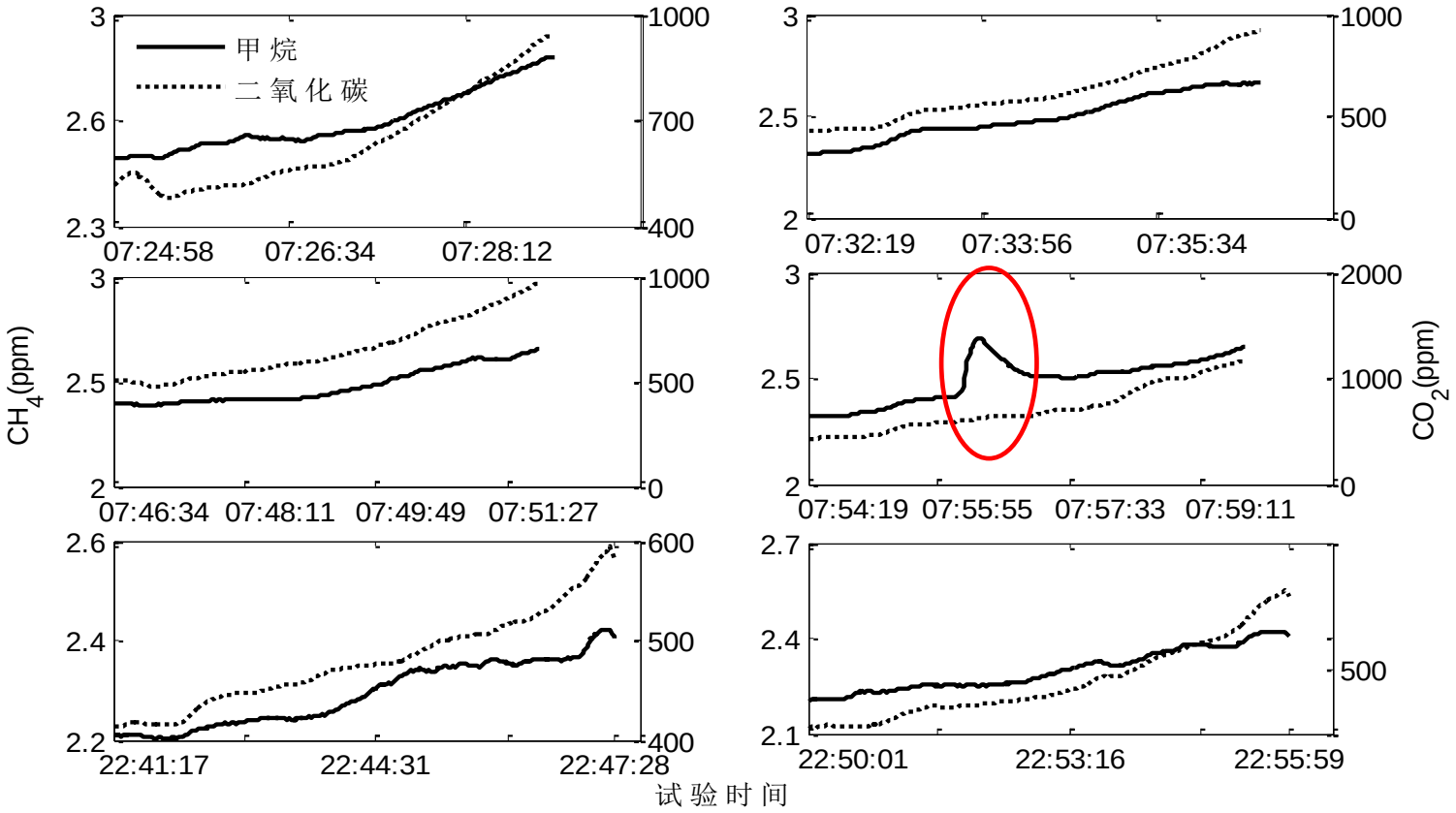


Fig.5 Time series of CO_2 and CH_4 concentration in Changjiang River Tunnel

Results and Discussion

◆Variation of CO_2 and CH_4 in Tunnel

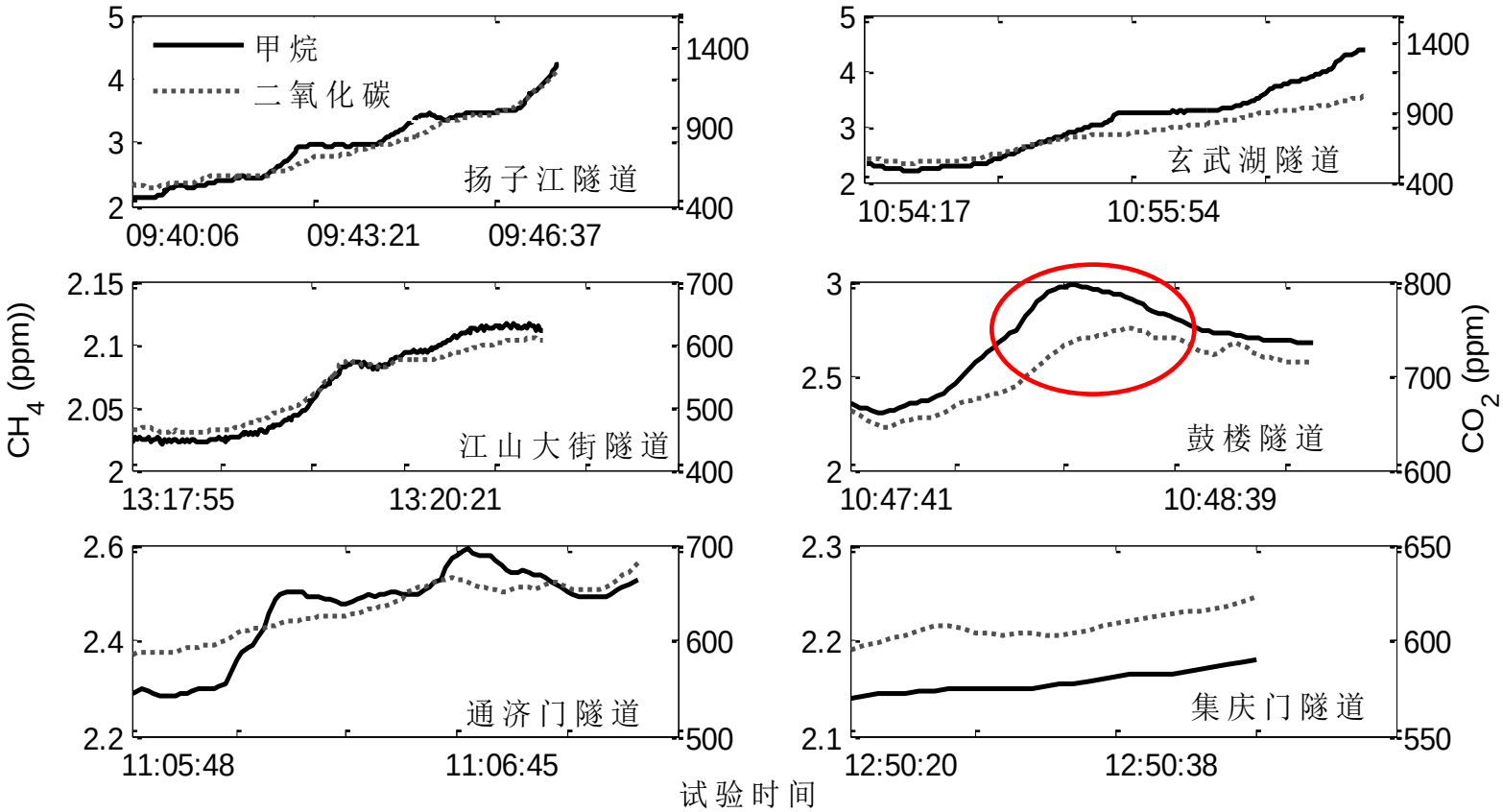


Fig.6 Time series of CO_2 and CH_4 concentration in Nanjing Tunnel

Results and Discussion

◆Influential factors of CO_2 and CH_4 on main road

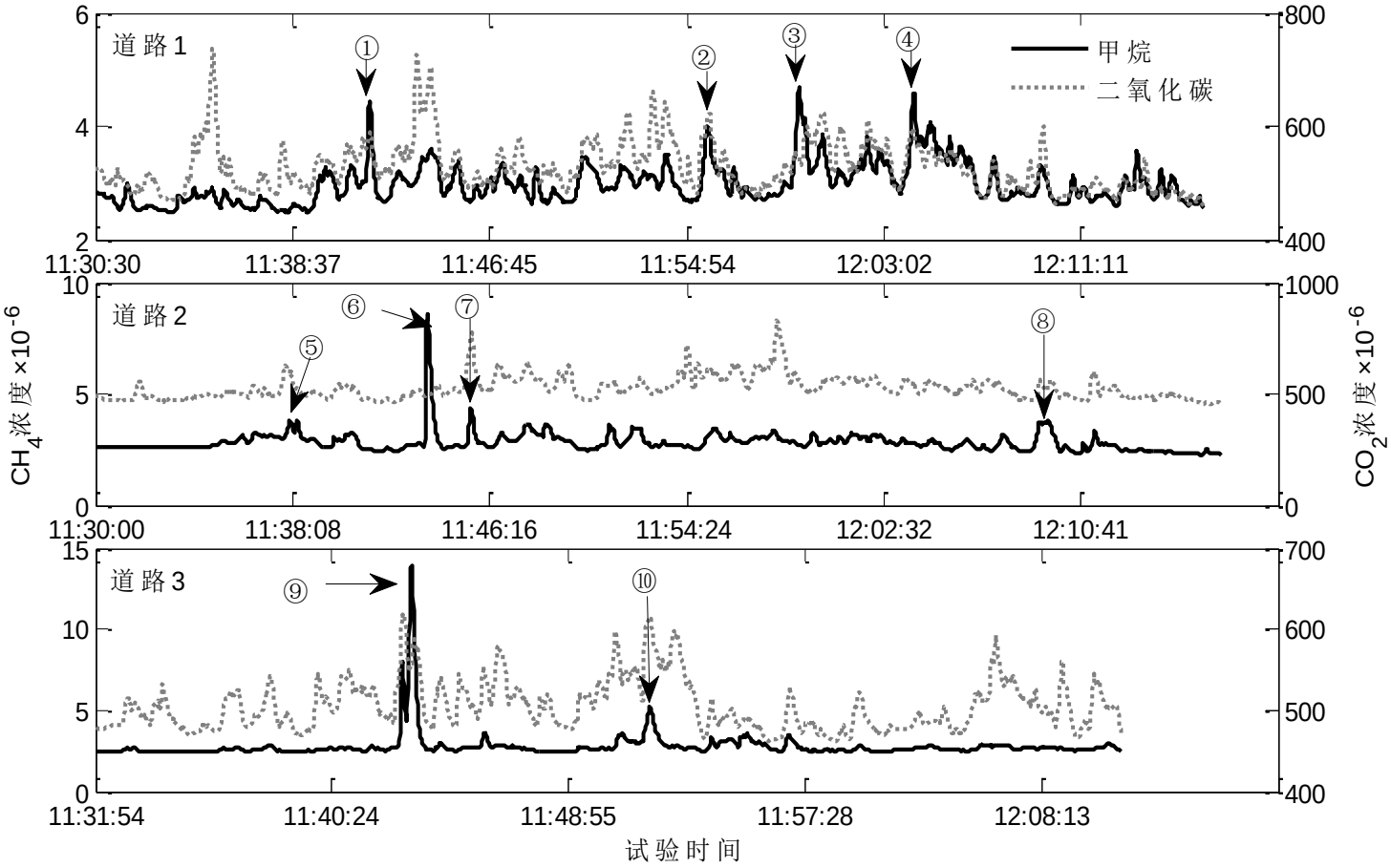


Fig.7 Time series of CO_2 and CH_4 concentration on the traffic main road in the 11:30 period of October 20, 2014

Results and Discussion

◆Influential factors of CO_2 and CH_4 on main road

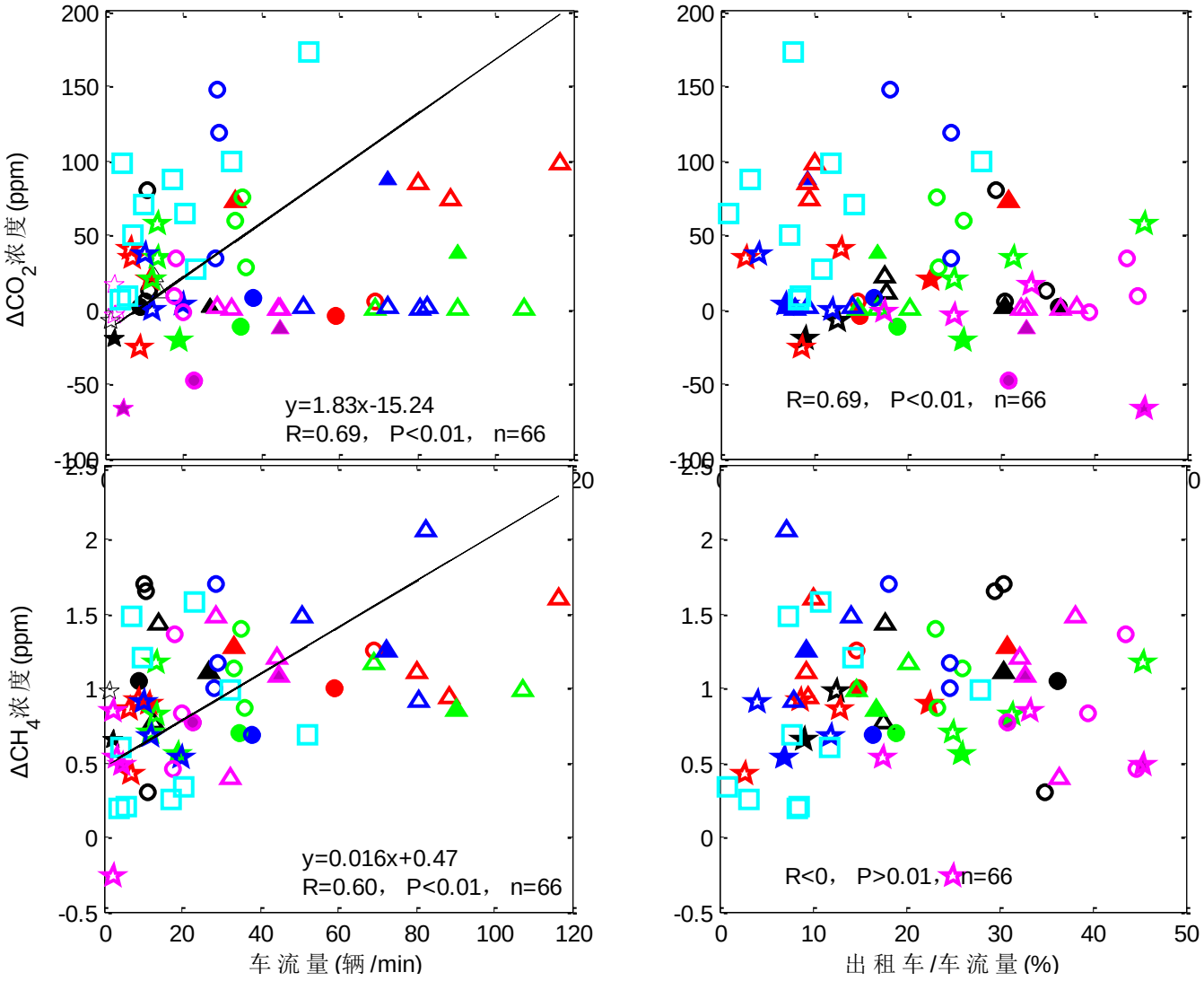
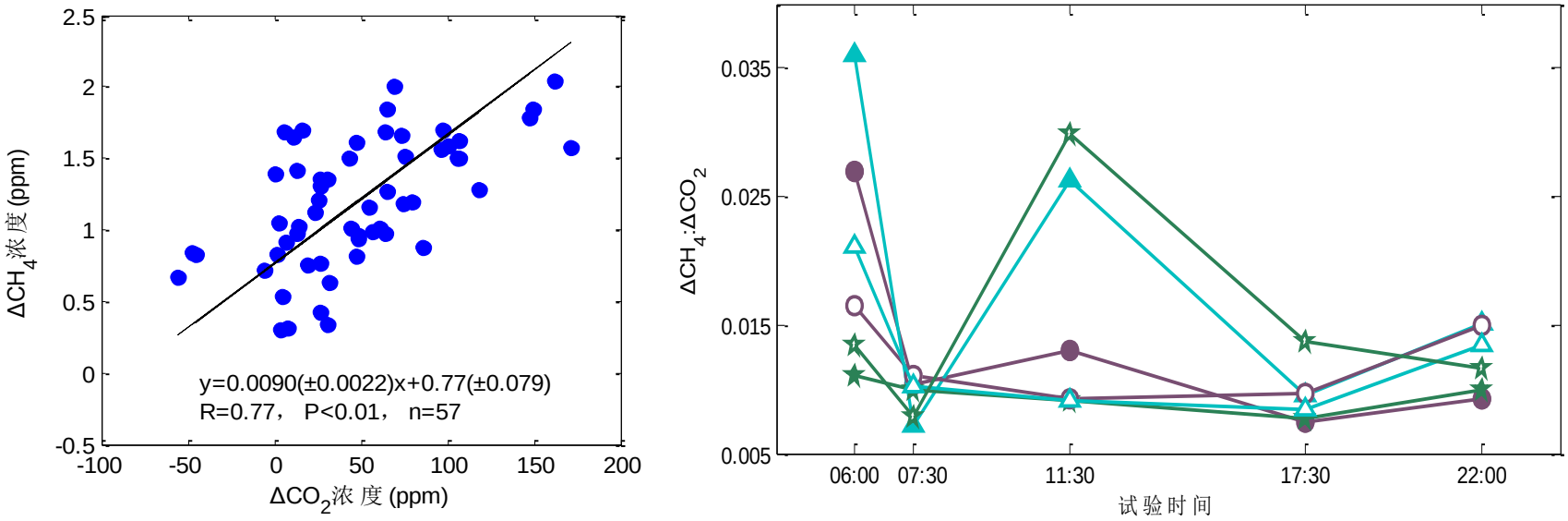


Fig.8 Relationship between ΔCO_2 , $\Delta CH_4$and traffic volume, taxi / traffic volume on the road

Results and Discussion

◆ΔCH_4:ΔCO_2 and its diurnal variation

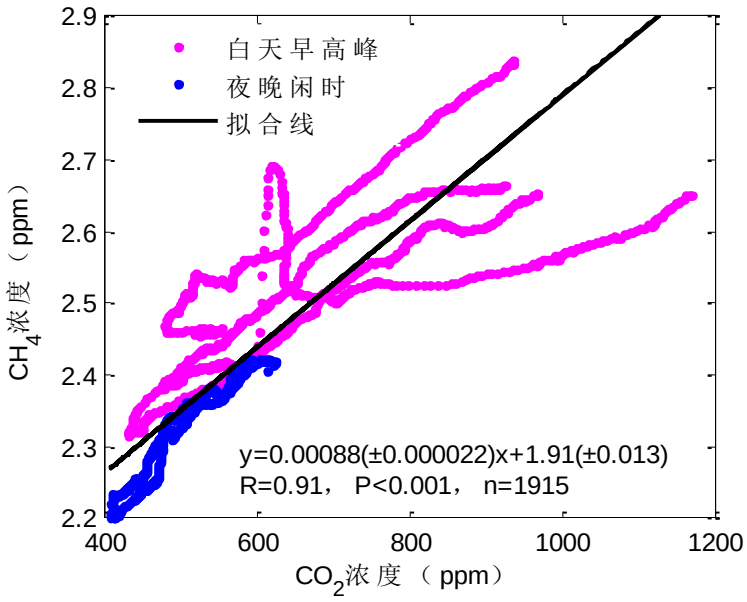


○、△、☆ represent road 1, road 2, road 3； hollow and solid means weekday and weekends

Fig.9 Fitting diagram of mean ΔCH_4 concentration and mean ΔCO_2 concentration on the traffic main road and its diurnal variation

Results and Discussion

◆ΔCH_4:ΔCO_2 in Nanjing Tunnel



Tunnel	ΔCH_4:ΔCO_2
Yangtze River Tunnel	0.0028
Xuanwu Lake tunnel	0.0043
Jiangshan Street Tunnel	0.00064
Drum tunnel	0.0062
Tongji-men tunnel	0.0035
Jiqing-men tunnel	0.0016

Fig.10 Fitting diagram of CH_4 and CO_2 in Nanjing Tunnel

Results and Discussion

◆Influential factors of ΔCH_4:ΔCO_2

Table.1 Atmospheric ΔCH_4:ΔCO_2 of Nanjing roads under different conditions

	ΔCH_4:ΔCO_2			
Road	Starting or braking	Smooth running	No NGV	Only NGV
1	0.0098	0.0062	0.0054	0.0124
2	0.0120	0.0056	0.0056	0.0072
3	0.0115	0.0063	0.0033	0.1387

Results and Discussion

◆Influential factors of ΔCH_4:ΔCO_2

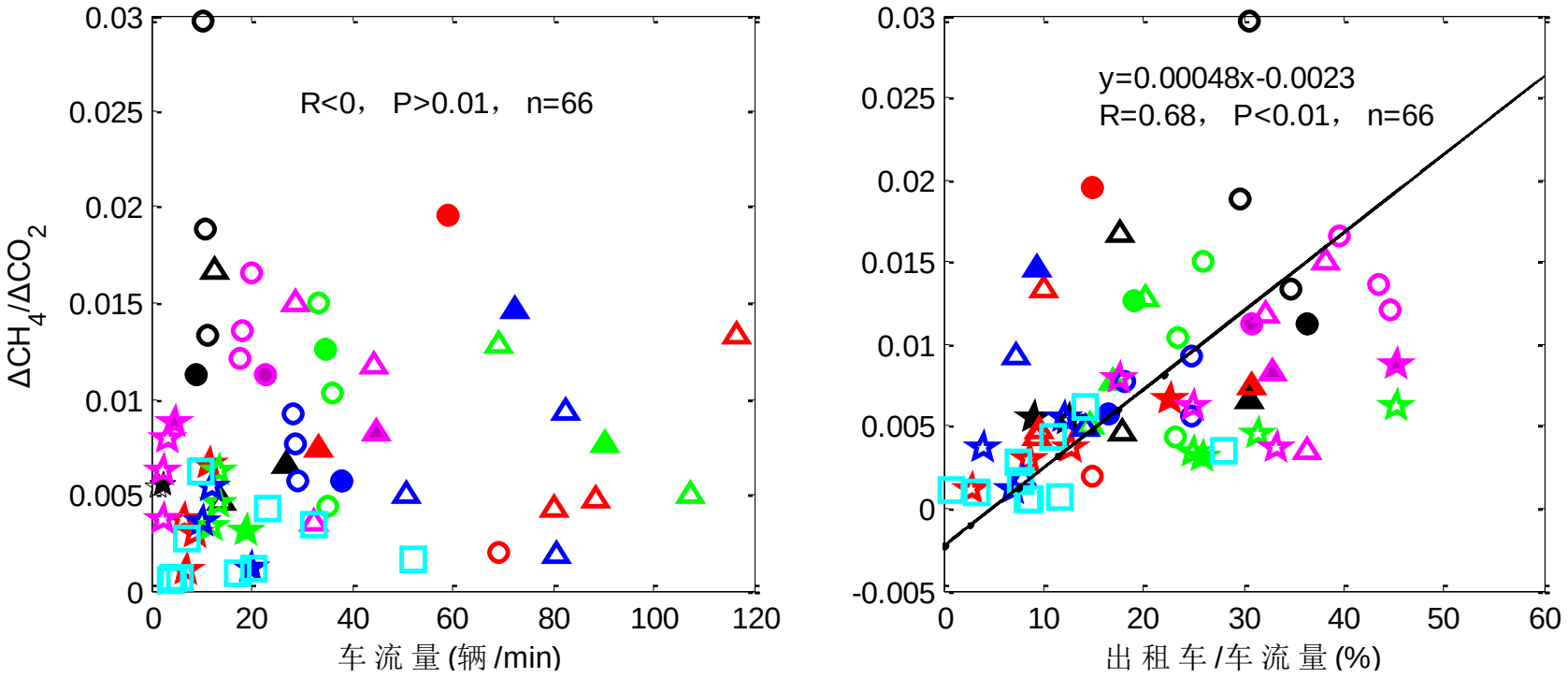


Fig.11 Relationship between ΔCH_4:ΔCO_2 and traffic volume， taxi / traffic volume on the typical road

Results and Discussion

◆Estimating CH4 emissions by IPCC method

Table.2 List of CH_4 emission of vehicle in Nanjing in 2014

Vehicle	Fuel	Total fuel consumption (L or m^3)	Proposed emission coefficient of CH_4 ($KgCH_4/(L$ or $m^3)$)	CH_4 emission (10^4 ton)
Passenger	Gasoline	9.27×10^9	8.16×10^{-4}	0.76
	Diesel	5.14×10^6	1.44×10^{-4}	0.000074
	CNG	1.21×10^8	3.81×10^{-3}	**0.046**
Cargo	Gasoline	5.37×10^8	8.16×10^{-4}	0.044
	Diesel	1.19×10^9	1.44×10^{-4}	0.017
	CNG	0	3.81×10^{-3}	0
Other	Gasoline	5.06×10^7	8.16×10^{-4}	0.0041
	Diesel	5.63×10^7	1.44×10^{-4}	0.00081
	CNG	0	3.81×10^{-3}	0
Total	/	/	/	**0.87**

Results and Discussion

◆Estimating CH_4:CO_2 emission ratio by IPCC method

Table 3 List of CH_4:CO_2 emission ratio of vehicle in Nanjing

	CO_2(10^4 ton)	CH_4(10^4 ton)	CH_4:CO_2
2010	1215.04	0.40	0.00090
2011	1682.64	0.54	0.00089
2012	1934.24	0.63	0.00090
2013	2240.42	0.74	0.00091
2014	2601.17	0.87	0.00092

Results and Discussion

◆Comparative analysis of estimation methods

（1）Atmospheric concentration observation

- Regional representation
- Natural gas leakage
- Other emission sources

（2）IPCC method

- Method applicability
- Emission coefficient
- Statistical data

Conclusion

- The diurnal variation of CO_2 concentration in the main road in Nanjing showed bimodal distribution, and the two peaks appeared in 07:30 and 17:30. The spatial variation of CH_4 concentration was higher than the spatial difference of CO_2 concentration on the road. Due to the "piston wind" in the tunnel, the CH_4 concentration in tunnel was gradually increased from the inlet to the outlet.
- There was a significant linear correlation between CH_4 concentration and CO_2 concentration on the road. The atmospheric ΔCH_4:ΔCO_2 value on the main road was 0.0090. The diurnal variation showed "W" type; The range of atmospheric ΔCH_4:ΔCO_2 value in Nanjing experiment tunnels was 0.00064-0.0062.
- Traffic volume was the main factors for the increase of CO_2 and CH_4 concentration on road. There was a significant positive correlation between the atmospheric ΔCH_4:ΔCO_2 value and the proportion of natural gas taxis, but the traffic volume was not.
- For CH_4 emission, the difference analysis of the two methods shows that the estimation of the IPCC method was underestimated, and the estimation of the atmospheric concentration observation method was credible.

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Thank you