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Development of database of real-world diesel vehicle emission factors for China

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ABSTRACT

A database of real-world diesel vehicle emission factors, based on type and technology, has been developed following tests on more than 300 diesel vehicles in China using a portable emission measurement system. The database provides better understanding of diesel vehicle emissions under actual driving conditions. We found that although new regulations have reduced real-world emission levels of diesel trucks and buses significantly for most pollutants in China, NOx emissions have been inadequately controlled by the current standards, especially for diesel buses, because of bad driving conditions in the real world. We also compared the emission factors in the database with those calculated by emission factor models and used in inventory studies. The emission factors derived from COPERT (Computer Programmer to calculate Emissions from Road Transport) and MOBILE may both underestimate real emission factors, whereas the updated COPERT and PART5 (Highway Vehicle Particulate Emission Modeling Software) models may overestimate emission factors in China. Real-world measurement results and emission factors used in recent emission inventory studies are inconsistent, which has led to inaccurate estimates of emissions from diesel trucks and buses over recent years. This suggests that emission factors derived from European or US-based models will not truly represent real-world emissions in China. Therefore, it is useful and necessary to conduct systematic real-world measurements of vehicle emissions in China in order to obtain the optimum inputs for emission inventory models.

Introduction

Diesel trucks have long been recognized as a major source of emissions in China, especially NOx and $PM_{2.5}$. It was found that diesel trucks contributed more than 20% of the total national NOx emissions in 2006 (Zhang et al., 2009). Diesel vehicles contributed 60% of the NOx and more than 90% of the $PM_{2.5}$ to the on-road emission inventory in 2009 (Ministry of Environmental Protection of China, 2010). In Beijing, diesel vehicles contribute more than 60% and 80% to 90% of the

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on-road NOx and PM emissions, respectively (Huo et al., 2011; Wu et al., 2011; Wang et al., 2010b). Although the emission factors of new vehicles have decreased since 2000 following the implementation of updated emission standards, the stock of diesel vehicles has increased considerably during the past decades because of China's rapid economic growth. Therefore, the total amount of emissions is expected to grow because of the significant increases in vehicle stock and distances traveled (Huo et al., 2012).

We tested the CO, HC, NOx, and fine particle ($PM_{2.5}$) emissions of 175 diesel vehicles in five cities using a portable emission measurement system (PEMS) (Huo et al., 2012). In other studies, a second Tsinghua University research team, including researchers from Beijing Institute of Technology, Wuhan University of Technology, China Automotive Technology & Research Center, Shanghai Academy of Environmental Sciences, Chinese Research Academy of Environmental Sciences, Zhejiang University, and Beijing University of Technology conducted on-board emission measurements of diesel trucks and buses, and the detailed information is shown in Table 1. The other groups tested 93 diesel trucks and 77 diesel buses; thus, more than 300 diesel trucks and buses have been tested using PEMS in the past decade in China.

Current emission inventory studies in China rely mostly on European or US vehicle emission databases, which might not reflect local conditions and technological performance (Huo et al., 2009). For example, Wang et al. (2008) used a bottom-up approach based on an International Vehicle Emission (IVE) model to develop a vehicle emission inventory for Shanghai. The modified and updated Computer Programmer to calculate Emissions from Road Transport (COPERT) and PART5 (Highway Vehicle Particulate Emission Modeling Software) models were used to estimate vehicle emission factors based on each major vehicle category in Beijing from 1995 to 2009 (Wu et al., 2011). The COPERT IV model was used by Wang et al. (2010a) to calculate the vehicular emission factors and trends in vehicular emissions in China's mega-cities from 1995 to 2005. Cai and Xie (2010) applied the COPERT IV model to calculate vehicular emission factors in China, which were used by Lang et al. (2012) to develop an emission inventory for the Beijing–Tianjing–Hebei region in 2008. Guo et al. (2009) used the MOBILE5 model to calculate vehicular emission factors in Chongqing, by comparing the differences between the emission factors derived from the MOBILE5 model and a chassis dynamometer. They found that the emission factors calculated by MOBILE5 are smaller than the actual emissions in Chongqing. Motor vehicle emission factors in Guangzhou were calculated using the COPERT IV model, which when integrated with information regarding the amounts and types of cars, were used to produce an emission inventory for Guangzhou for 2008 (Liao et al., 2011).

Although more than 300 diesel vehicles have been measured under real-world driving cycles in China, most data of emission factors used in inventory studies are derived from emission factor models, such as COPERT, IVE, and MOBILE; few emission inventories have been developed based on test results from China. It is very important and useful to understand real-world

Table 1 – Summary of PEMS testing by research teams in China.

		Total	THU	BIT	CATARC	SAES	ZJU	WHUT	CRAES	BJUT
LDDT[c]	China 0[a]	5	5							
<4500 kg	China I	45	44					1		
	China II	53	51				1	1		
	China III	11	8				1	2		
MDDT	China 0	8	7			1				
4500–12,000 kg	China I	11	11							
	China II	4	4							
	China III	4	4							
HDDT	China 0	3	1			2				
>12,000 kg	China I	43	34			8	1			
	China II	22	19				3			
	China III	55	51				1	1	2	
	China IV	2	2							
Diesel bus	China 0	2				2				
	China I	2						2		
	China II	14	9	2			1	2		
	China III	33	22	4	2		5			
	China IV	28	24	2						2
Total		345	296	8	2	13	13	9	2	2
References			1[b], 2, 3, 4	5, 6	7, 8	9,10,11	12	13,14	15	16

THU: Tsinghua University; BIT: Beijing Institute of Technology; WHUT: Wuhan University of Technology; CATARC: China Automotive Technology & Research Center; SAES: Shanghai Academy of Environmental Sciences, CRAES: Chinese Research Academy Environmental Sciences, ZJU: Zhejiang University; BJUT: Beijing University of Technology.

Reference: 1: Wu et al. (2012); 2: Huo et al. (2012); 3: Sebastian et al. (2007); 4: Sebastian et al. (2008); 5: Wang et al. (2011); 6: Ge et al. (2010); 7: Li et al. (2008); 8: Gao et al. (2011); 9: Jing et al. (2006); 10: Huang et al. (2007); 11: Chen et al. (2007); 12: Xue (2010); 13: Hou et al. (2010); 14: Yin et al. (2011); 15: Li et al. (2009); 16: Fan et al. (2012).

[a] The emission levels I to IV in China are equivalent to Euro I to IV standards, while China 0 means no emission control was applied.

[b] Only NOx emission factors were estimated; some data overlapped with other teams' results.

[c] LDDT: Light-duty Diesel Truck; MDDT: Medium-duty Diesel Truck; HDDT: Heavy-duty Diesel Truck.