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Interactive comment on “Emissions factors for gaseous and particulate pollutants from offshore diesel engine vessels in China” by F. Zhang et al.

F. Zhang et al.

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Thanks very much for your comments. Our replies are given as following according to your comments:

#the purpose of the study #

This study has given the on-board measurement of pollutants from different vessels in China, and also the impact of engine speed on NO_x emission. We are focusing on adding the measurement database of shipping emissions in China, because the engine type, fuel and vessel type are very different of Chinese vessels compared with other countries (such as Chinese commercial vessels have an average age of 19.2 yr compared with 8.0 and 8.9 yr for Japan and Germany, more small motor vessels are

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used in China, and diesel is the most common fuel used in offshore vessels but with no fuel stands), which makes the ship emissions unknown in China. When ship emissions inventory was calculated or contribution of ship emissions on environment was estimated in China, emission factors always need to adopt to other countries (Song, 2014; Yang et al., 2015; Ng et al., 2013; Zhou et al., 2007). We aim to give detailed emission factors data to establish the system local emission factor database in China, and also provide some data base for the policy making of emission stands of vessels in China. Though the number of test vessels in this study was small, it could reflect the real exhaust condition of offshore vessels in China. And this measurement is just a beginning, more number and more type of vessels' test will be carried out in our next work (two fishing vessels' measurement has been finished up to now).

#relationship of emission factors with engine load#

In this study, a rough discussion of NO_x emission factors with engine speed was given, in order to explain why the economic speed should be noticed. The inappropriate speed in a voyage will cause either high NO_x emissions or high fuel expense. Actually, most of the previous studies (Khan et al., 2013; Agrawal et al., 2008) were focusing on the impact of engine load on NO_x emissions that always had the trend that first descend then increase with the increasing of engine load. And they always had lower NO_x emissions at 25% to 50% load. But there was also study (Alfoeldy et al., 2013) showed that when the vessel in a high engine speed, the NO_x emissions would have a clearly decreasing trend with increasing crankshaft rpm.

#the test vessels#

As we mentioned in the manuscript, the vessel type, the engine type, the age of the engine and also the fuel in China are different compared with other countries. We assumed they were the main reasons that would cause the different emissions from vessel exhaust. The results in this study also showed that the emissions from the engineering vessel HH had much higher level than previous studies, such as CO, NO_x,

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TVOCs and PM, on the contrary, good maintenance and engine quality vessels such as DFH and XYH had much lower emissions of NO_x and PM compared with other studies. The test vessels in this study are not the majority of ships in use in China, but only the common offshore type. Because it is really hard to get the measurement data, not only for the difficulty of the instrument installation, but also for the not easy rent of the ships, several common vessels had been chosen in this study, which was also only a start of our real-world measurement. In the near future, more types and more number of ships including slow speed, medium speed and high speed engines will be tested to give more detailed data of emission factors.

#new references#

New references about the shipping emissions have been added in the context, such as: According to estimates from IMO (<http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Greenhouse-Gas-Studies-2014.aspx>), for the year 2012, total shipping emissions were approximately 938 million tonnes CO₂ and 961 million tonnes CO₂e for GHGs combining CO₂, CH₄ and N₂O. International shipping emissions for 2012 are estimated to be 796 million tonnes CO₂ and 816 million tonnes CO₂e for GHGs combining CO₂, CH₄ and N₂O. International shipping accounts for approximately 2.2% and 2.1% of global CO₂ and GHG emissions on a CO₂ equivalent (CO₂e) basis, respectively. Other studies about characteristic of gaseous species and PM (Anderson et al., 2015; Celo et al., 2015; Mueller et al., 2015; Reda et al., 2015), and also emission factors (Beecken et al., 2015) are added in the manuscript.

#uncertainties#

The detection parameters for the gaseous matters have been added as an accessory in Table R1, including the detection method, range, resolution and accuracy etc. We can see that all the detection uncertainties are within the relative error of 5%. During our sampling, 3 to 5 replicate samples for each operating mode were collected, which

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could give the total error shown in Table B1 and Table B2, including the detection error and the artificial error.

#incorrect references#

Thanks for pointing out the incorrect references in the manuscript. We will revise all the mistakes in the revised version.

#OC to EC ratio#

The residence time of soot particle in the pipe could affect the formation of PM, which led to the different composition of PM. The dilution sampling was not used in this study that might be one reason of the lower OC to EC ratio. Besides, TOR was used to measure OC and EC in PM, which always had a lower OC content compared with other methods because of the different definitions of OC and EC. Thanks again.

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Table R1 Detection parameters for the gaseous matters

Component	Method	Range	Resolution	Accuracy	Time (T ₉₀)	Conformity
O ₂	Electrochemical sensor	20.95%	0.01%	±5% rel.	45 s	ISO 12039, CTM-030
CO ₂	NDIR	5%	0.01%	±3% rel.	45 s	ISO 12039, OTM-13
CH ₄	NDIR	5%	0.01%	±3% rel.	45 s	
NO	NDIR	1000ppm	1ppm	±3% rel.	45 s	ISO 10849, Method 7E
NO ₂	NDIR	1000ppm	1ppm	±3% rel.	45 s	ISO 10849, Method 7E
SO ₂	NDIR	1000ppm	1ppm	±3% rel.	45 s	ISO 7935, Method 6C
N ₂ O	NDIR	2000ppm	1ppm	±3% rel.	45 s	ISO 21258
VOCs	PID	10000ppm	0.1ppm	±5% rel.	-	

NDIR, Non-dispersive Infra-red
PID, Photo Ionization Detectors

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Fig. 1.

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