

Editorial

# Shipping Emissions and Air Pollution: Latest Methodological Developments and Applications

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Shipping, which accounts for over 80% of international trade transportation, is the most cost-effective and efficient mode of transportation [1,2]. It has made remarkable contributions to the prosperity of the global economy and the advancement of human civilization [3]. However, engine combustion will produce a lot of harmful emissions such as particulate matter (PM), sulfur oxides (SO<sub>x</sub>), and nitrogen oxides (NO<sub>x</sub>), which cause severe pollution to the atmosphere and marine environment [4]. Ship emissions primarily consist of two categories: air pollutants such as SO<sub>x</sub>, NO<sub>x</sub>, PM, CO, and NMVOCs, as well as greenhouse gases, including CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O [5–8]. The former mainly consists of SO<sub>x</sub>, NO<sub>x</sub>, and PM, which primarily contribute to local air pollution and environmental disasters. Meanwhile, the latter is believed to have an impact on global climate change, with CO<sub>2</sub> emissions being particularly significant. Therefore, the reduction in air pollution and carbon emissions in the shipping sector holds significant importance in promoting the industry's green and low-carbon transition, achieving peak carbon emissions and carbon neutrality goals, and protecting the atmospheric environment.

This Special Issue (SI) was proposed to collect the latest methodological developments and applications in studying shipping emissions and air pollution. At present, global ship pollutant emission regulations are constantly comprehensive, meticulous, and strict, green shipping and efficient transportation having become the developmental direction. At present, and likely to continue in the future, the challenges shipping faces include determining how to cope with the continuous upgrading of pollutant emission regulations of marine engines, how to efficiently and economically achieve near-zero emissions of various pollutants of marine engines, and how to truly achieve green shipping, a safe operation, and efficient transportation. It is of great importance to resolve these scientific issues. Relevant achievements not only contribute to the development of international shipping and trade but also play an important role in solving global energy and environmental problems. The collection of papers covers several of these aspects, and the contributions of each specific paper are summarized in the following.

The first paper was written by Gagic et al. [9], who determined the correlation between cruise ship activities (hoteling and maneuvering) in ports with the ambient concentration of pollutants associated with marine diesel fuel combustion. The authors used a network of four low-cost PM sensors to determine the correlation between ambient PM<sub>2.5</sub> and PM<sub>10</sub> mass concentrations with cruise ship activities in the Kotor Bay area during 27 days in the peak summer season, with a 10 min resolution. The results showed that weather conditions play a significant role in local PM concentrations, so that, with predominant ENE wind directions, the west side of the Bay experienced on average higher concentrations of both PM<sub>2.5</sub> and PM<sub>10</sub>. Rain precipitation and higher winds tend to rapidly decrease ambient PM concentrations. Higher PM levels are associated mainly with lower wind speeds and the inflows from neighboring berths/anchorages.

The second paper was written by Qiao et al. [10], who provided a comprehensive evaluation of the performances of different models in simulating the most common air



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pollutants (e.g., PM<sub>2.5</sub>, NO<sub>2</sub>, SO<sub>2</sub>, and CO) in Guangzhou (23.13° N, 113.26° E), China. The authors used a numerical forecasting model (i.e., the Weather Research and Forecasting model with Chemistry (WRF-Chem)) and two artificial intelligence models (i.e., the back propagation neural network (BPNN) model and the long short-term memory (LSTM) model) to simulate temporal variations of the above-mentioned air pollutant concentrations in Guangzhou in September and October 2020. The results suggested that WRF-Chem has superior performance and better accuracy than the NN-based prediction models, making it a promising and useful tool to accurately predict and forecast regional air pollutant concentrations on a city scale.

The third paper was written by Liu et al. [11], who presented a simulated investigation on the influence of swirl on multiscale mixing and the concentration field, which provides a new supplement for mass transfer theory and engineering applications. The results suggested that the phenomenon of abnormal combustion occurs on account of the distribution of the mixture being uneven in a super-large-bore dual-fuel engine. Further analysis showed that the level of swirl at the late compression stage and the turbulence intensity are the decisive factors affecting the transmission process of natural gas (NG) and the distribution of methane (CH<sub>4</sub>) concentration.

The fourth paper was written by Galvão et al. [12], who developed the use of four different topologies of deep artificial neural networks (DNNs), analyzing the impact of feature augmentation in the prediction of PM<sub>2.5</sub> concentrations by using five levels of discrete wavelet transform (DWT). The results showed that wavelets improved the forecasting results and that discrete wavelet transform is a relevant tool to enhance the performance of DNN topologies, with special emphasis on the hybrid topology that achieved the best results among the applied models.

The fifth paper was written by Wang et al. [13], who studied the influence law of fuel injection on the emission characteristics of marine diesel engines. The authors used the orthogonal method to design the double-parameter structural optimization scheme of the fuel injection system. Twenty-two optimized cases were selected to further investigate using the CFD method by visualizing scalar distributions in cylinders, which was helpful to explain the reason for pollutant formation. The results showed that case D6 with a spray angle enlarging 5° showed the best performance. Compared with the original condition, there was no deterioration and a large reduction in soot emission by 65.4%, along with fuel consumption being lowered by 2.18% and more indicated power, which increased by 2.21%. Therefore, reasonable optimization of a spray angle can improve power, economy, and emission performance simultaneously.

The sixth paper was written by Shi et al. [14], who provided a review of the production methods for green power (green hydrogen, green ammonia, and green methanol) and analyzes the potential of green fuel for application to shipping. The review showed that the potential production methods for green hydrogen, green ammonia, and green methanol for the shipping industry are (1) hydrogen production from seawater electrolysis using green power; (2) ammonia production from green hydrogen + Haber–Bosch process; and (3) methanol production from CO<sub>2</sub> using green power. While the future of green fuel is bright, in the short term, the costs are expected to be higher than conventional fuel.

The seventh paper was written by Zhu et al. [15], who summarized the technical characteristics and application problems of marine diesel engine SCR systems in detail and tracked the development trend of the catalytic reaction mechanism, engine tuning, and control strategy under high sulfur exhaust gas conditions. This review showed that low temperature is an important reason for the formation of ammonium nitrate, ammonium sulfate, and other deposits. Additionally, the formed deposits will directly affect the working performance of the SCR systems.

In conclusion, the present SI provides new methodological developments and applications for studying shipping emissions and air pollution. The reported findings help to understand the treatment technology for studying shipping emissions and air pollution, especially in the context of near-zero emissions.

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