EGUsphere, referee comment RC2
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Comment on egusphere-2022-767

Anonymous Referee #2

Referee comment on "Determination of NO_x emission rates of inland ships from onshore measurements" by Kai Krause et al., EGUsphere,
https://doi.org/10.5194/egusphere-2022-767-RC2, 2022

General comments

Krause et al. present NOx emission rates derived from an on-shore measurement station at the river Rhine in Germany over the course of 4 years. Emission rates in grams per second are calculated from NOx measurements and AIS data using a Gaussian puff model. The results are compared to a number of on-board measurements and existing literature.

In the last decades, pollutant emissions from international shipping have moved further into focus of atmospheric research, especially with regard to sea-going ships. However, there is still a major lack of representative measurements regarding inland shipping. Krause et al. make an important contribution to this topic by providing a comprehensive long-term dataset of NOx emission rates and a method for calculation that is easy to apply. Overall, the manuscript is well written and the topic is suitable for publication in AMT. In my opinion the manuscript is worth publishing after some general issues have been addressed.

Specific comments

In general:

- I have the feeling that the method described here is very similar to the one presented in a former paper by Krause et al. (2021), except that the concentration at one specific

point (in-situ measurement) rather than the mean concentration along the light path (LP-DOAS) is considered in the Gaussian puff model. As the description of the method is a substantial fraction of the manuscript, the authors should highlight what is new about it and what the major improvements are.

- I also think that the uncertainty of the method should be discussed in more detail. This can be done in the supplement by showing examples of the Monte-Carlo-simulations and providing uncertainty estimates. See also specific comments below.
- The structure of the results section is a bit confusing. For the reader it is not clear at what point results from which station are presented. If I understand it correctly, most of the text as well as Fig. 5-8 are only about DURH. This should be pointed out. The authors should consider splitting it into two subsections DURH (ships traveling) and NERH (ships entering/leaving harbor) and potentially extent the conclusions drawn from the study at NERH which seems to be underrepresented (1 sentence and Fig. 9).
- The authors state that emission rates in grams per second are favored and have some advantages (e.g. no assumption about fuel consumption needed) over emission rates in grams per kilogram fuel (p.1, l. 11-13 and p.2, l. 45-47). I think this should be explained in more detail in the introduction, as most of the literature reports emission rates in g per kg or g per kWh. What are applications (model simulations, emission inventories etc.) the results can be used for and what are potential limitations on the other hand?

Specific:

- p.1, l.11-13: Here it is implied that for the derivation of emission rates in g per kg fuel the knowledge about the fuel consumption is required. However, it could be calculated from measured NOx to CO2 ratio without this knowledge. Only for the transformation from g per kg fuel into g per s (or vice versa) the fuel consumption would be needed.
- p.1, l.16: Talking about inland vessels explicitly, I would not consider SO2 as a significant source of emissions as the sulfur content in the diesel fuel is very low.
- p.2, l.53: What instrument was used? Specifications?
- p.5, l.87: What was done when the atmospheric variability was high and the threshold of 2 ppbv was exceeded due to other point sources?
- p.5, l.112: How is the funnel height estimated and what value is assumed in the model?
- p.6, l.140 “If the Monte-Carlo-simulations and the reference simulation do not show large deviations, the derived NOx emission rates for that specific case are used for further evaluation”: What does “large” mean in this context? Is a reasonable deviation more like 10 % or 50 %? I would especially be interested in the importance of the assumed plume height, as water level and funnel height are estimated and will change over the course of the year respectively differ from ship to ship.
- p.7, l.151: The calculation of uncertainties is presented in detail but quantitative values are not given anywhere. Although titled as “negligible”, I suggest presenting them in the supplement.
- p.7, l.153: What was the percentage of ship peaks identified relative to the total number of ship passages?
- p.9, l.177 “Ships that are not influenced by the current show similar NOx emission rates independent of direction of travel (e.g. Figure 9).”: It is not clear at first sight that this refers to ships leaving or entering the harbor at NERH (see general comment above)
- p.10, Fig. 5: The differences between ship classes and potential reasons should be further discussed in the text.

- p.10, l.179: What was the ratio of identified ship peaks for ships traveling upstream versus downstream?
- p.11, l.196: "as the uncertainty of the Gaussian-puff model is quite high": What does quite high mean (see above)?
- p.12, l.217-l.219: What water velocity and average speeds for ships traveling upstream and downstream are these specific fuel consumptions reported by Allekotte et al. based on? For me the difference between 108 kg per h and 162 kg per h for the low/high fuel consumption scenarios seems quite large, given an average ship speed over water of 3 m/s and 5 m/s at DURH station and assuming a water velocity of 1 m/s . Please clarify.
- p.13, l. 226 "rates fit into the range" and Table 4: For ships traveling downstream the deviation is much higher than for ships traveling upstream. The authors should discuss potential reasons for this (see above).
- p.13, l.229 "using a specific fuel consumption of 230 g per kWh": The uncertainty of the specific fuel consumption which is often used in literature should definitely be discussed at some point in the manuscript, since the authors say that their method has the advantage of not requiring the fuel consumption and the fuel consumption is used to convert their results to compare them with CCNR regulations.
- p.15, Table 3: Can you say anything about the typical motor operating conditions (e.g. engine load/rpm) during the on-board measurements? Did you maybe observe any difference in emission rates when varying these conditions?
- p.18, l.273: Have there been any point sources of NOx next to DURH or NERH that might also cause peak-like structures and if yes, how did you make sure to exclude them from the analysis?
- p.20, l.313-314: The authors should discuss to what extent the emission rates derived for Duisburg would be transferable to other locations along the Rhine.

Technical corrections

- Title: I would suggest to omit the word "sailing", it could be confused with ships using sails.
- p.2, l.27: […] which derived emission rates […]
- p.7, l.145: In Eq. 3 it should be dQmodel in the second term?
- p.8, l.162: […] majority of ships […]
- p.10, Fig. 5: Due to the large number of dots representing single measurements and the chosen range, for me it is hard to compare e.g. the median values of each ship class with each other. I would suggest adding a table in the supplement with corresponding statistics (mean, median, range).
- p.15, Table 3: on-board median is missing.
- p.20, l.316: […] emission rates […]