Point-by-point response for the comments of reviewer #2.
The font color of the reviewer's comments is in black and our response is in blue.

General comment

The paper is a prosecution of a previous work (Badeke et al. 2021) aimed to investigate the vertical distribution of ship emissions. In this paper the authors study the influence of the vertical distribution of emissions on the ground-level pollutant concentrations at a few kilometres distance from the mooring point. The topic is of interest for an accurate assessment of the impact of ship emissions at berth in port cities. The paper deals with the development of an atmospheric dispersion model chain, for this reason it fits with the arguments treated in GMD journal.

I suggest the publication of the paper after the authors will reply to the following comments.

The authors appreciate the reviewer's opinion about the paper's suitability for the Journal andthe relevance of the topic. We are grateful for the suggestion for publication and applied several changes based on the reviewer's suggestions.

Specific comments

Methodology 116-120. The authors would better explain which obstacles have considered using MITRASv2.0. I guess they considered only the shape of the ship. What happens if ships with different shape are considered? Could the eventual presence of buildings near to the dock influence the presented results?

In Badeke et al. (2021), the two extrema cases stack only and medium-sized cruise ship have been investigated and the strongest effect on the downward disturbance has been numbered to be 31 % downward dispersion under stack-only conditions against 55 % when considering lateral flow and a cruise ship. The shape of a cruise ship is considered to be similar to a fully loaded container ship, therefore, we assume this is the range of effect from the ship shape.

In a future study, a modification of the λ_2 parameter is planned to make the Expgauss parameterization applicable to different-sized ships. This will not change the general shape of the distribution but shift the height along the vertical axis to account for smaller ships.

The effects of buildings near the dock can affect the concentration similarly (e.g. due to channeling or building wake effects), but have not been considered in the MITRAS based parameterization. For a very specific harbor scenario, this might be better reproduced by including the buildings and cranes inside a harbor. However, this would lead to a reduced applicability of the parameterizations to more general cases. Increased turbulent diffusion is therefore only included via the surface roughness values in EPISODE-CityChem.

Line 145 “No chemical reactions occur in the simulations.” This assumption can be considered valid also in case of very low wind speed?

No, in a complete air quality study, chemical reactions need to be considered independent on the wind speed. In this study, the main focus lay on the effects of different distributions on the ground concentration. The emitted substance is NOx (95 % NO, 5 % NO_2) treated as a passive tracer gas. Adding the highly nonlinear NOx chemistry into this study would make the interpretation more difficult and need the inclusion of background chemistry and other sources to correctly calculate concentrations. This is planned for a future study.

Line 185 “No clear correlation was found for μ against the atmospheric stability, but a negative dependency has been found for stability against σ”. The absence of correlation of μ against the atmospheric stability is a logical consequence of the range of vertical height considered. If it contains all the plume also in case of high convective conditions then the result is logical. If the authors agree with this interpretation they could include it in the text. Otherwise give their interpretation.

We assume this to be caused by the selected default conditions (v_{wind} = 5 m/s, T_{exh} = 300°C, v_{exit} = 10 m/s and frontal flow for which effects of stability against mean and standard deviation of the Gaussian distribution have been tested (see Fig. 2i). Under these default conditions, stability has a very weak effect on the standard deviation. It might have an effect under low wind speed and convective conditions but still wind speed and exhaust temperature have a much stronger effect on the mean height of the initial emission profile in the near-field. The selected default conditions represent average meteorological and technical conditions for ships inside Hamburg harbor (Badeke et al., 2021).

For a better clarification, lines 204-206 now read:

“No clear correlation was found for μ against the atmospheric stability (Fig. 2 panel i). This means, that under otherwise default conditions, the atmospheric stability does not show a significant influence on the mean plume height. A negative dependency has been found for stability against σ.”

Line 195 “Especially in cases of strong winds and stable atmospheric conditions, the simple Gaussian distribution delivers good results.” But cases of strong winds are of less interest for the impact on air quality. This reduces significantly the value of the simple Gaussian distribution. It would be evidenced.

A very important comment to which we agree. Lines 220-224 have been adjusted:

“Especially in cases of strong winds and stable atmospheric conditions, the simple Gaussian distribution delivers good results. However, in cases of strong plume rise at neutral or instable atmospheric conditions, fitting concentration profiles with a simple Gauss can result in a poorer fitting quality of $R^2 = 0.8$ (e.g. case # 6 in Appendix B1). This reduces the applicability for Gaussian plume profiles especially in case of air quality studies, when situations of high concentration accumulation (e.g., due to low wind speed or strong downward dispersion) have to be evaluated.”

Line 315. It is not clear how initial vertical concentration profiles were converted into vertical emission profiles in EPISODE-CityChem. Could the author explain this point?

The following section has been added to the introduction (**lines 120-128**):

"In Eulerian city-scale models, the emission of a source like a stack are not necessarily inserted into only one grid cell, but can be vertically distributed to account for effects of plume rise and downward dispersion in the near-field. These initial emission profiles are herein defined as the relative vertical distribution of an emission value into one or multiple vertical grid cells. A Gaussian distribution, similar to the simple Gaussian plume models, would be the first guess for such a distribution. However, the results of Badeke et al. (2021), Bieser et al. (2011) and Brunner et al. (2019) led to the assumption, that for short ship stacks that are close to the obstacle itself, the downward dispersion may lead to a significantly different shape than a Gaussian distribution."

Furthermore, Appendix A1 has been adjusted to clarify how vertical emission profiles were derived.

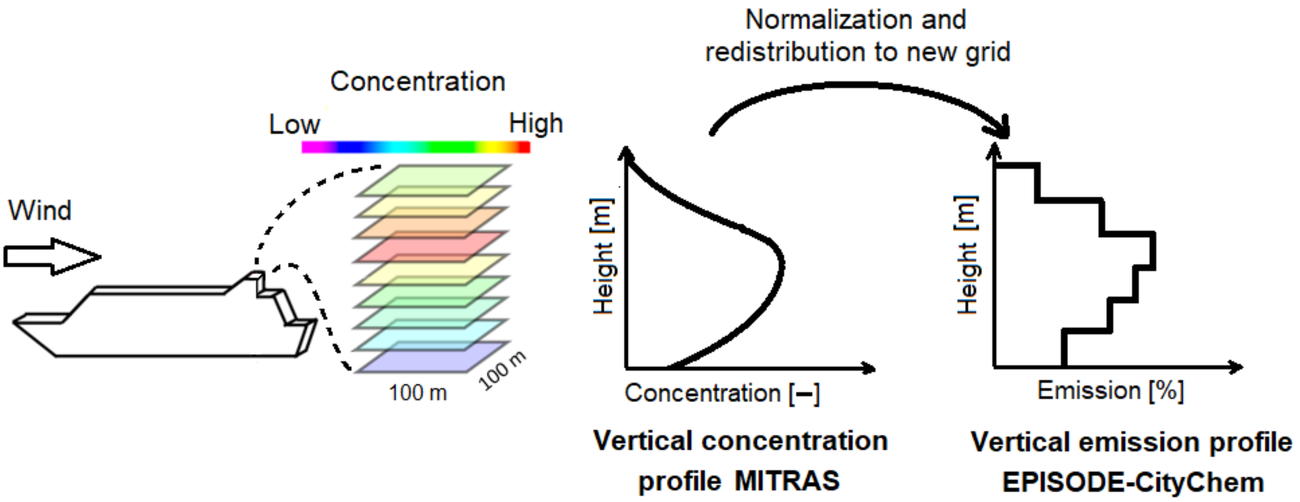

Figure A1: Scheme for deriving the vertical plume concentration profile from MITRAS and transformation into emission profiles in EPISODE-CityChem. Dimensionless concentration values are derived from mean column values of 100 m · 100 m horizontal and 10 m vertical size in a distance of 100 m downwind from the ship to include plume rise and obstacle-induced turbulence. Normalization of the concentration profile and redistribution into the coarser EPISODE-CityChem grid is done to derive the vertical emission profile in EPISODE-CityChem. Adjusted and expanded from Badeke et al. (2021).

It would be useful to introduce the definition of upper plume boundary height.

The upper plume boundary definition has been added in lines 267-270:

“The height at which the plume temperature equals the ambient temperature is herein defined as upper plume boundary height h_{up}. It was calculated based on the MITRAS model results and parameterized similar to the concentration profile functions. It can cause sharp concentration gradients in cases of a stable surrounding atmosphere.”

I did not find in the paper the exact definition of initial concentration profiles. It is necessary to introduce this definition at the first time the authors discuss about “initial concentration profile”

This definition is now included in lines 120-123.

“In Eulerian city-scale models, the emission of a source like a stack are not necessarily inserted into only one grid cell, but can be vertically distributed to account for effects of plume rise and downward dispersion in the near-field. These initial emission profiles are herein defined as the relative vertical distribution of an emission value into one or multiple vertical grid cells.”

It should also be clearer now with the adjustments on Fig. A1

The profile for the single cell emission model is reported in the caption of Fig. 7 but is not present in the diagram.

The profile is not shown in the figure, because it would be just a straight line or a point with normalized emission of 1.0 at the mean height of the Gaussian profile.

We adjusted the caption of Fig. 7:

“Figure 7: Initial vertical concentration emission profiles for Gaussian , and exponential Gaussian and single cell emissions under default conditions (see Table 1). The single cell emission profile lies at the mean height of the Gaussian profile with a normalized emission of 1.0 (not shown).”

A final observation. The authors evaluated, among others, the impact of surface roughness on pollutant ground-level concentration. Since the interest is focused on the local scale (few kilometres from the source) do they consider important or necessary a precise description of the buildings and the streets instead of the use of a simple parameter like the surface roughness?

We think that, if available, the use of a more complex obstacle-resolving model would lead to a better representation of turbulent effects and street canyons than a simple value like surface roughness. This is useful, if one is interested in a specific pollution situation of a certain city. However, these information are not widely available and processing time for this kind of analysis on a city-scale is very long. The surface roughness approach is more readily applicable to different cities. It can also be modified to include more land cover class information (and, therefore, roughness lengths) if available. One aim of this study was to make the parameterizations applicable in model scales that are not obstacle-resolving.