Responses to reviewer #1' comments on gmd-2021-47

General comment

The paper presents a new modelling approach to take into account movements of ships in simulation of transport and dispersal of atmospheric pollutants. Some specific cases have been simulated and compared to other modelling approaches such as fixed emission points and line source models. The paper is interesting, suitable for the Journal and could be of interest also for future studies. However, there are several aspects that could be made more clear and also an over-interpretation of results because I believe that it is not very clear that this new modelling approach is performing effectively better compared to other approaches at least when several ships are considered (see my specific comments). In conclusion, I believe that the paper should have a carful revision before publication.

Response:
The authors appreciate the many constructive comments and suggestions made by the reviewer. We have revised the manuscript and conducted some additional simulations to better present our results and conclusions. More details about the responses to the reviewer's detailed comments are listed below (the reviewer's comments are in "blue" and the responses are in "black").

Specific comments

1) One aspect that raised my curiosity is why SO2 has not been considered in this work. Shipping-related SO2 is quite important and the most recent international policy from IMO enforce the use of low-sulphur content fuel that will have a strong impact on the emission of SO2 (in addition to particulate matter). In addition, it is mentioned that simulations were performed also for PM2.5 but I only see NO2 in the results.

Response:
In our simulation, actually SO_2, NO_2, $PM_{2.5}$ and some other important species are predicted. However, the distributions of all species are very similar when using the same emission model (such as MPS model), and only the concentration values are different. Since the purpose of this paper is to demonstrate the development of the moving point source (MPS) model and its difference from the line source (LS) and fixed point source (FPS) models, only NO_2 is presented in the simplified cases (section 3.1 and 3.2), as the simulated results for all species show the same conclusions.

In addition, in the real case study (section 3.3), NO_2 and $PM_{2.5}$ curves showing comparisons of simulated results with measured data are presented as Figs. 17a - 17d, and new figures (Fig. 18 in the revised paper) showing the NO_2 and $PM_{2.5}$ concentration differences predicted by the LS and MPS models during the entire simulation period are added as well. In the revised paper, a new appendix (Appendix D) has been added to explain this and also shows the similarity of the predicted NO_2, SO_2 and $PM_{2.5}$ in the simulations.

2) In several parts of the paper there is a confusion between "emissions" and concentrations". In line 154, 162, 202-205 I believe that authors are mentioning actually concentrations rather than emissions. Lines 171-175. These limitations are effectively necessary? What are the reasons behind these choices?

Response:
Yes, we are mentioning about concentrations. In the revised paper, we have changed the words to "concentrations" (line 154, 162 and 202-205 in original paper). As shown in line 171-175, a simplified case is setup first by only keeping the moving ships, in order to better demonstrate the feature of the MPS

model and the differences when using MPS model to simulate the emission dispersion profiles generated from moving ships, compared to those predicted by using LS and FPS models. If too complicated situations (such as including ships at berthed and using different wind direction) are included or simulated, it is not easy to identify the differences of MPS model with LS and FPS models. Therefore, the paper used these choices as shown in line 171-175 in the simplified cases. New materials have been added to explain this in the revised paper (pg. 9, lines 180-181).

3) The simulations cover a very limited period (only a few hours). Will the results of the comparison among the different models similar if larger time span are used for simulations? Often daily or seasonal averages are used to investigate the impacts of specific sources to air quality. I ask this because, it seems that when a large number of ships are included, the differences of moving ship model and line emission model become negligible.

Response:
The authors thank the reviewer for the question. The results by using the MPS model and other two models (FPS and LS models) are different depends on the locations. Based on the figures in the simplified study (sections 3.1 and 3.2), it indicates that the instantaneous results predicted by the three different models are quite different, and the hourly-averaged results are still different (especially the concentration values) although the emission species distributes in a similar shape when using the MPS and LS models.

In addition, in the revised paper, new figures (Fig. 18) showing the differences of overall averages (6 hours) predicted by using the MPS and LS models for the real-case study are added. Based on the new figures, it shows that the predicted emission concentrations are very different in the locations close to the ships (or ship routes), due to the different treatments of the two models on emission sources, and the concentration differences become smaller in the locations far away from the ships, as the emissions are diluted and deposited. New materials have been added in the revised paper to explain this (pg. 20 and 21).

4) What are the emission conditions such as vertical exit velocity, height of emissions, buoyancy and so on? Are the same conditions used for each ship or a difference has been done according to the typology of ship (for example cargo, cruise, ferry and so on). Could author comment if the uncertainty arising from the assumption made on emissions is smaller or comparable with the differences observed among the different models?

Response:
In this study, the vertical exit velocity for all ships is assumed as 20m/s, and the chimney heights (where emission is emitted) are different for different ships (30m for large ships (such as cargo, container) and 10m for small ships (such as pleasure, fishing)). The buoyancy was calculated based on Briggs's algorithms [Briggs 1969, 1971 and 1975], which consider the different atmospheric stability conditions (such as neutral-unstable and stable conditions). In addition, stack downwash and plume penetration are estimated as well in EPISODE package. The emission conditions have been mentioned in pg. 4 (line 112-114), pg. 9 (line 193-196) and new Appendix C (pg. 26) in the revised paper.

The authors also conducted sensitivity studies that consider different emission heights which are affected by exit velocity, chimney height and buoyancy, and the simulated results showed that the uncertainty arising from the assumptions made on emissions is very small, which is much smaller than the differences among different models. The results of the sensitivity studies can be found in Appendix C of the revised paper.

5) Figure 7. It is actually difficult to compare results because the colour scale is very different. It should have been better to have all figures with the same colour scale. The same for Figs. 13, 14, 15

Response:
New figures with same color scale have been added to the revised paper for Figs. 7, 13-15.

6) Figures 16 and 17 are based on only a few points so that the correct line joining the points is a straight line rather than a "non-estimated" curve.

Response:
New figures with straight line connecting points have been added to the revised paper for Figs. 16 and 17.

7) Lines 349-360. The better performance of MPS is not really visible. Results of MPS and line source in Figure 17 are essentially the same with negligible differences especially if compared to the uncertainty rising from assumption on emissions. Therefore this part of the discussion should be revised.

Response:
The authors agree with the reviewer that the MPS and LS models perform similar when compared to the measured data in the observation stations, based on the results (Fig. 17) in this study. This has been clearly mentioned in the discussion part of the revised paper. In addition, new figures (Fig. 18) showing the differences of the 2D emission concentrations predicted by the MPS and LS models have been added to the revised paper as well. Based on the new figures, it indicates that the predicted concentrations by the two models are quite different in the locations close to the ships while the differences become smaller in the locations far away. The new figures and other results (those in the simplified simulations) in the paper suggest that the new MPS model is a more realistic representation of the emission source, allows for greater granulation of the emissions and is expected to be reasonably accurate, and hence it should be a valuable alternative for the environmental researchers to investigate and evaluate the dispersion of emissions generated by the moving ships. In the revised paper, the paragraph in the discussion (pg. 20 and 21) has been modified to better describe the results and important conclusions.

8) The same thing for the conclusions (line 370-373), it is possible that, for very short calculation periods and with a very limited number of ships, MPS could furnish more realistic results. However, this aspect is not really demonstrated by comparison with measurements. Regarding the conclusions (lines 383-387) of "real-world" simulation, I believe that it is not true that MPS furnish better results than line source model. The differences found among the two approach are negligible. This should be clearly stated in the conclusion of the paper.

Response:
The authors thank the reviewers for the comments. It is true that the differences predicted by the MPS and LS models are negligible, compared to the measured data (as shown in Fig. 17) when a large number of ships are included, and this has been clearly mentioned in the conclusion part. However, as mentioned in responses for Q7), the results in the paper also suggest that the new MPS model is a more realistic representation of the emission source, allows for greater granulation of the emissions and is expected to be reasonably accurate, and hence it should be a valuable option for the environmental researchers to investigate and evaluate the dispersion of emissions generated by the moving ships. In the revised paper, the conclusion part has been modified to better demonstrate the important results and conclusions about the new MPS model.