We thank the reviewers for their helpful comments. We have modified the manuscript as suggested. Below shows our responses to all the comments. The reviewer's comments will be shown in blue while our responses are in black, and changes made to the paper are shown in black block quotes. Unless otherwise indicated, page and line numbers correspond to the original manuscript.

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In this paper, the authors present ship emission calculations for the Yangtze River area by combining AIS ship location and other data from the China Classification Society (CCS). By using simple parameterizations based on the specific ship characteristics (type, engine, length, speed, etc.) they compile a monthly inventory for a section of the Yangtze River and compare it with an annual inventory (SEIM) and two monthly inventories (DECSO and MEIC). I enjoyed reading the paper, as it is a significant contribution towards understanding the significance of inland ship emissions on the $NO_x$, $SO_2$ and PM levels in the broader areas around rivers. The methodology has also potential of being used in other areas (e.g. central Europe) with significant ship traffic across densely populated areas. To this end the paper deserves to be published but has to be improved before. See my comments below:

1. The title is not appropriate. The authors should use a title describing the exact focus of their study, e.g. "Inland ship emissions across the Yangtze River area in China" or "Inland ship emissions: the case of Yangtze River area in China", etc.

   Thank you for the helpful suggestion. Yes, we agree that the title is not appropriate and we have revised the title to "**Significant contribution of inland ships to the total $NO_x$ emissions along the Yangtze River**". See also our response to reviewer 1.

2. The paper should be revised as the flow is not very pleasant and there are several minor expression mistakes. There are many very small phrases. E.g. "…Note the limitations of our method. Some ships would reduce their speed when going downstream…" which does not help the reader at all.

   Thank you for the comments. We have carefully checked the manuscript and made several revisions throughout the text.

3. The authors should consider discussing new developments in ship emission detection and attribution in their introduction. For example, it has been shown that today the AIS data combined with satellite data can give as an indication of the pollution produced by individual ships (see Georgoulias et al., 2020; Riess et al., 2022; Kurchaba et al., 2022). The use of ground-based DOAS methods to infer individual ship emissions from rivers and channels is also possible as shown in Krause et al. (2021).

   Thanks for the suggestion. We have added these and several other references to the introduction and discussion.

   In lines 35-41:

   > "… surrounding areas and increased traffic in the connected rivers. **Ship emissions in the YRD are much higher than those in the Bohai Bay and Pearl River Delta (PRD),**

**reaching about 50% of the total emissions in these three regions (Chen et al., 2017; Wan et al., 2020). Shipping emissions affecting air quality in the YRD region are mainly within 12 nautical miles of the coastline (Li et al., 2018). They can contribute between 30 % and 90 %, for example, over 75 % of ship-related $SO_2$ concentrations and 50 % of ship-related $PM_{2.5}$ concentrations (Lv et al., 2018; Feng et al., 2019). The data from the Ministry of Transport of China shows that by the end of 2021, the number of inland river transport vessels is 11.36 million vessels, which is higher than the sum of coastal transport and ocean transport in China (MOT, 2022). As one of the most economically developed regions in the east of China, the Yangtze River Delta (YRD) region is the busiest inland river ship transportation corridor in China.** Therefore, we focus on inland river ships…"

In line 54:

"…**Georgoulias et al. (2020) firstly combined observations from the TROPOspheric Monitoring Instrument onboard the Sentinel 5 Precursor satellite (TROPOMI/S5P) with AIS data to measure $NO_2$ plumes that could be detected and attributed to individual ships. In recent years, studies based on the method of combining satellite data with AIS data have been carried out mostly over seas (Kurchaba et al., 2022; Riess et al., 2022) but seldom over rivers.**"

In line 431:

"… or ground-based Differential Optical Absorption Spectroscopy (DOAS) observations **along the river (Cheng et al., 2019; Krause et al., 2021)**. "

4. When discussing the method and specifically the engine power (EP) calculations, it is not very clear how the authors calculate the related regression between EP and L^2 x v^3. Probably the authors used EP data from CCS to do the regression; however, in the beginning of the paragraph they write "Since the engine power is missing in the AIS data, we develop a method to relate the engine power to the ship type, length and speed. Those parameters are available in the AIS data." Are EP data available only for a fraction of the ships? Please refine this!

The AIS data provides real-time information such as vessel position, speed and heading, as well as static vessel information such as vessel name, vessel length and vessel type. Thus, for each ship, we can get its type, length and speed from the AIS data, but the ship main engine power is missing.

The CCS database provides data such as ship type, main engine power, maximum ship designed speed, ship length and year of ship built. Using the CCS database, we can derive the regression relationship for each category of ship by linear fitting of this proxy( $EP \sim L^2 \times V_{max}^3$).

We clarified this by modifying the text. In lines 169-170:

"Since the engine power is missing in the AIS data, we develop a method to relate the engine power to the ship type, length and speed. **These parameters are available in the AIS data unlike the engine power.**"

And in lines 179-182:

"… with its length and its speed as: $P \sim L_s^2 v^3$. **The China Classification Society (CCS, https://www.ccs.org.cn/ccswz/, last access: 27 February 2023) database of Chinese domestic ships provides data such as ship type, main engine power, maximum ship designed speed, ship length and construction year of the ship. Using these ship parameters, we can derive the average regression relationship for each category of ship by linear fitting of this proxy (**$P \sim L_s^2 v^3$**).** The fitted linear relation …"

5. On top of my previous comment, the authors might include in Table 3 apart from the slope the whole equation (slope + intercept + the corresponding uncertainties). The uncertainties induced by the use of this equations might be incorporated into the discussion in paragraph 3.4 where the authors discuss only two sources of uncertainty.

In the manuscript we fitted the intercept, but the fitted intercept was negligible and therefore not included. Specifically, you can see Figure S1 in the supplement.

For this method, it is equivalent to averaging over each ship type. When actually using this linear relationship, the main engine power of some ships will be on the high or low side. But in the overall perspective, it is not a big difference.

For the uncertainties of ship emissions, the contribution of this part is included but very limited, and other sources of uncertainty are described in the answer to the next question.

6. The uncertainty discussion is very limited. Please discuss more aspects or integrate this in another paragraph.

We have added an extra section of the uncertainties.

3.4 Uncertainty

"**In this section we will discuss the uncertainty on our emission inventory. Our calculations have been based on the main engine only. However, during the navigation of a ship, the main engine and auxiliary engine of the ship are working at the same time. For a moored ship, the main engine stops working. On average, 17 % of the ships in the observational area are in dock every day, and this part of the ship emissions have not taken into account, but the auxiliary engines are still working. Based on the study of Weng et al. (2020) in the Yangtze estuary, we estimate that our emissions show an underestimation of about 12 % because of ignoring the auxiliary engine and boiler emissions at berth and underway.**

**However, the locations of high ship emissions are consistent with previous studies. Zhu et al. (2019) pointed out that the distribution of ship emissions in the Jiangsu section of the Yangtze River in 2017 was uneven, with the emission rates in the Nanjing section of the Yangtze River and the Jiangyin section of the Yangtze River being relatively high. Xu et al. (2019) noted that for ports along the river, Nanjing port had the highest rate of ship emissions.**

**As the Yangtze River becomes wider when getting closer to the sea, the speed of the river will be reduced and thus the emissions from ships can be lower. In the extreme**

**cases of stagnant water, ship emissions can be reduced by a maximum of 3-33 % depending on the month. We estimate that this may lead to an overestimation of about 10 % in the ship emissions outside our study area around Nanjing.**

**Currently, the AIS-based approach is considered as the best practice for ship inventories. However, there is still a lack of reliable local emission factors, auxiliary engine power ratings and fuel correction factor in the YRD region, which contributes largely to the uncertainties in this study. The selection of accurate emission factors is critical to the calculation of the ship emission inventory and the uncertainty that comes with it. The emission factors are closely related to the age and rotation of the ship's engine as well as the engine load, and the fuel correction factor depends on the sulfur content of the marine fuel. Earlier heavy oil was a fuel of low quality with a sulfur content of about 2.7 %. In contrast, the fuel sulfur content in this study is only 0.001 %, while in the beginning of time period the fuel sulfur content may be as high as 1.5 %. For the scenario that the sulfur content is not regulated, we have calculated that the SO2 and PM emissions would be about a factor 700-1000 higher.**

**In conclusion, our derived emissions have an underestimation of 12 % due to ignoring the auxiliary engines and boilers and an overestimation in some regions of about 10 % due to the slower river flow. Adding this to the uncertainties in emission factors we estimate the total uncertainty to be 5-15 %.**"

7. The title of section 4 should be changed. E.g. "Importance of inland ship emissions" might be "Contribution of inland ship emissions relative to emissions from other sources".

We agree with this suggestion. Now the title of section 4 is "**Contribution of inland ship emissions relative to emissions from other sources**".

8. Please comment on the significant difference between JSEI and SEIM compared to the other two inventories.

The differences between the ship emission inventories (JSEI, SEIM) compared to MEIC and DECSO are illustrated below in two aspects. On the one hand, the differences between the two ship emission inventories themselves, and on the other hand, the comparison of the ship emission inventories to the total emission inventories (MEIC, DECSO).

○ Difference between JSEI and SEIM

Although both JSEI and SEIM are ship emission inventories, the difference in base year and ship type leads to some differences between them. In lines 355-359:

"When comparing the overlapping grid cells, JSEI accounts for in average about 99 %, 0.05 % and 0.06 % of the SEIM emissions for $NO_x$, $SO_2$ and $PM_{2.5}$, respectively. The average emissions from inland ships over rivers (JSEI) compare well with average emissions of sea-going ships (SEIM) for $NO_x$. SEIM has higher values than JSEI for $SO_2$ and $PM_{2.5}$ **because SEIM calculated the emissions for 2017, when only major ports**

**needed to strictly control the sulfur content of marine fuel. The sulfur content of marine fuel was 0.001 % in our study. In comparison, the sulfur content of ocean-going marine fuel in 2017 was about 2.7 %, much higher than that of inland river ship fuel. Ship pollutants that are greatly affected by the sulfur content of marine fuel, such as $SO_2$ and PM, will be reduced with the reduction of sulfur content. This shows that from 2017 to 2019, the policy was of a great significance for the ship emissions, effectively reducing the emissions of $SO_2$ and PM. For $NO_x$ emissions both inventories compare remarkably well**."

- Compare to MEIC and DECSO

The current publicly available version of SEIM with a resolution of year has the same base year as MEIC, both in 2017. SEIM v1.0 has fewer grid cells in inland rivers and could not represent the contribution of inland river vessel pollution emissions to total emissions when compared to the total emissions. Table R1 shows the contribution of ship emissions to the total $NO_x$, $SO_2$ and $PM_{2.5}$ emissions in the Jiangsu section of the Yangtze River (118.5°-121° E and 31.5°-32.5° N). In the inland segments where the SEIM inventory is missing, $NO_x$ emissions can reach about 7-10 % of the total $NO_x$ emissions, both compared to MEIC and DECSO. So inland ship $NO_x$ emissions cannot be ignored.

**Table R1.** Contribution of ship emissions to the total $NO_x$, $SO_2$ and $PM_{2.5}$ emissions in the Jiangsu section of the Yangtze River (118.5°-121° E and 31.5°-32.5° N).

| | **SEIM** | | **JSEI** | |
|---|---|---|---|---|
| | SEIM/(SEIM+MEIC) | SEIM/DECSO | JSEI/(JSEI+MEIC) | JSEI/DECSO |
| **$NO_x$** | 3.3 % | 4.5 % | 10 % | 14 % |
| **$SO_2$** | 13 % | | 0.14 % | |
| **$PM_{2.5}$** | 1.5 % | | 0.01 % | |

9. In Fig 12, the authors might add in the legend the resolution of the models to make clear that the difference in the bars is mostly related to the different resolutions.

We have replotted Figure 12 to make it easier for the readers to understand the difference in the bars due to the different resolutions.

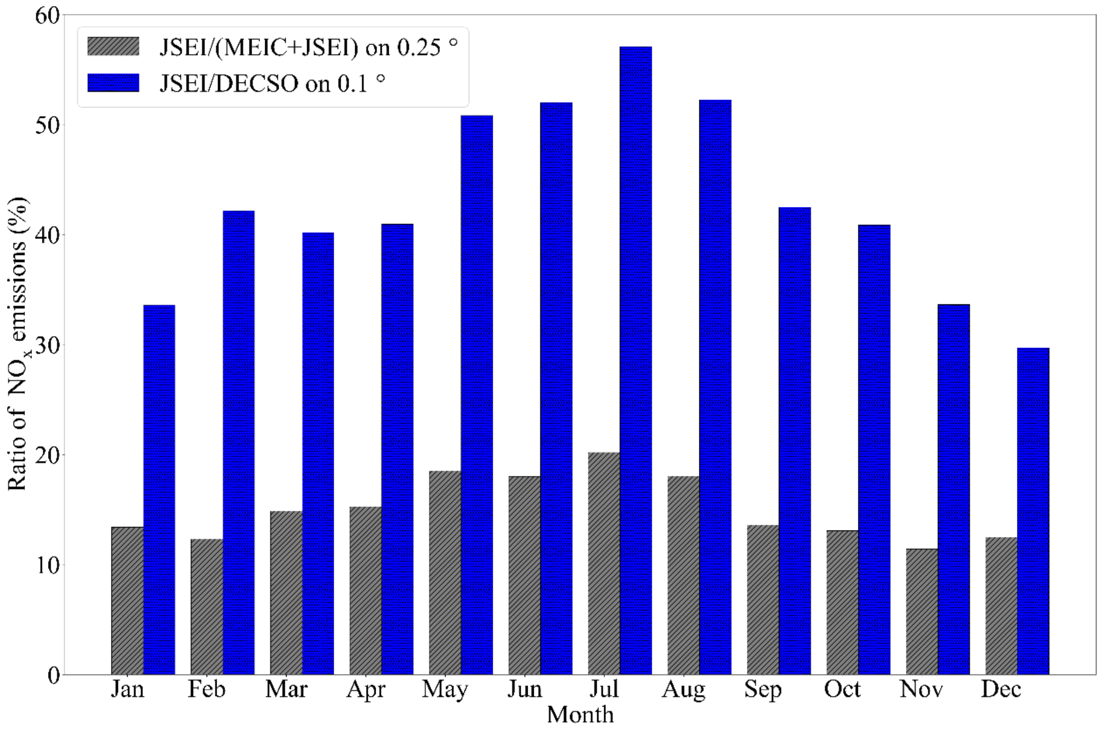


**Figure 12.** Monthly contribution of $NO_x$ ship emissions to the total emissions (MEIC + JSEI, DECSO) for the grid cells including the river. The resolution of JSEI/(MEIC + JSEI) is 0.25 °, the resolution of JSEI/(DECSO) is 0.1 °.

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