# Response to the reviewer's comments

## "Dramatic increase in reactive VOC emissions from ships at berth after implementing the fuel switch policy in the Pearl River Delta Emissions Control Area" *by* Zhen-Feng Wu et al.

## Reviewer #1

Ship emissions as important sources of air pollution at the coastal cities have raise widespread attention and their emission characteristics have been consistently studied by many researchers. Wu et al. presents the changes of VOC emissions from ships at berth after implementing the fuel switch policy at the ECA. They find that the apparent increase of reactive species in the VOC emissions due to the strategy and their second formation potentials including O3 and SOA are also estimated. This study is well motivated for the effect evaluation of emission control strategies. However, despite the potential meaning of results from this study, the presentation of this study needs be improved to a large extent, especially for the writing.

**Major Comments**

1. Description of VOCs. The author measured 68 VOC species used by GC-MS/FID, but the author is very chaotic for the description of VOC species in this manuscript, using the term NMHCs or VOCs in different sentences. Which one is the accurate expression? Generally, NMHC concentrations are determined by subtracting the amount of CH4 constituents from the THC measured by FID. The samples collected in canisters and analyzed by a preconcentrator coupled to GC-MSD/FID are speciated VOCs. Could the PEMS system measure THC and CH4 concentrations?

Reply: Thanks. Yes, generally NMHC concentrations are determined by subtracting the amount of $CH_4$ constituents from the THC measured by FID. In this study, we collected samples in canisters and measured 68 VOC species by a preconcentrator coupled to the GC-MSD/FID. We further measured $CH_4$ in the canister samples by a gas chromatograph (Agilent 6980GC, USA) with a flame ionization detector and a packed column (5A molecular sieve 60/80 mesh, 3m × 1/8 in.). We did not report $CH_4$ in the manuscript since our concern is focused on photochemically reactive species. As the 68 VOC

species we determined are C2-C12 hydrocarbons, sometimes we just used the term "NMHC" when referring to the 68 VOCs in our manuscript. To avoid confusion, in the revised manuscript we have replaced all "NMHCs" with "VOCs".

2. More information about sampling and analysis is needed, such as sampling flow, sampling time, sampling temperature, the auxiliary load, the devices used for conventional pollutants, and the standard gas for VOC measurement.

Reply: Thanks. As suggested, in the revised manuscript we have added more information about sampling flow, sampling time, devices used for conventional pollutants and standard gas for VOCs measurement as below:

"The ship exhaust first entered a Dekati® ejector dilutor (DI-1000, Dekati Ltd., Finland) from the sampling nozzle and then was spilt into four parts after being diluted with clean air: one part was for air sampling with 2 L canisters and 4 L Teflon bags for 3-5 min after passing through a filter; two other parts were for collecting $PM_{2.5}$ samples with 47 mm Teflon filters (Whateman, Mainstone, UK) and 47 mm quartz fiber filters (Whateman, Mainstone, UK), respectively, at a flow of 16.7 L $min^{-1}$ for 20-30 min, after the diluted exhaust was mixed well in a stay cabin, and then passing through a $PM_{2.5}$ separator; and the last part was the vent. Before dilution, the concentrations of $CO_2$, CO, $SO_2$ and $NO_x$ in the ship exhaust were directly measured by a flue gas analyzer (F-550, WOHLER, Germany) while air samples were also collected simultaneously by a 2L canisters and a 4L Teflon bags." (lines 120-127 in the revised manuscript).

We have added more information about the VOCs standards. "The calibration standards were prepared by dynamically diluting the 100 ppbv Photochemical Assessment Monitoring Stations (PAMS) standard mixture (57 NMHCs including 15 AHs) and TO-14 standard mixture (39 compounds) from Spectra Gases Inc., NJ, USA to 0.5, 1, 5, 15 and 30 ppbv. More details about the analysis are described elsewhere ( Zhang et al., 2013; 2015; Yang et al., 2018)." Line 131-138.

Besides, we have also added sampling temperature and the auxiliary load in Table S1 in the supporting information as showed below:

Table S1. More information during sampling.

| NO | Sampling | Auxiliary engine |
|---|---|---|

| | temperature (℃) | Power（kW） | Amount | Condition | Engine loads (%) | Fuel consumption rate($t*d^{-1}$) |
|---|---|---|---|---|---|---|
| Coastal vessels (before IFSP) | | | | | | |
| A | 17 | 1760 | 2 | Off | - | - |
| | | 1320 | 1 | On | 53 | 3.0 |
| B | 32 | 2045 | 2 | Off | - | - |
| | | 2045 | 1 | On | 40 | 4.1 |
| C-1 | 34 | 1760 | 2 | Off | - | - |
| | | 1320 | 1 | On | 55 | 4.0 |
| D-1 | 29 | 660 | 1 | Off | - | - |
| | | 660 | 2 | On | 34 | 2.2 |
| Coastal vessels (after IFSP) | | | | | | |
| E | 25 | 200 | 1 | Off | - | - |
| | | 200 | 1 | On | 39 | 0.4 |
| F | 21 | 200 | 2 | Off | - | - |
| | | 200 | 1 | On | 50 | 0.5 |
| C-2 | 29 | 1760 | 2 | Off | - | - |
| | | 1320 | 1 | On | 52 | 3.5 |
| G | 31 | 500 | 2 | Off | - | - |
| | | 500 | 1 | On | 65 | 1.8 |
| D-2 | 31 | 660 | 1 | Off | - | - |
| | | 660 | 2 | On | 37 | 2.4 |
| River vessels | | | | | | |
| H | 25 | 76 | 1 | Off | - | - |
| | | 144 | 1 | Off | - | - |
| | | 144 | 1 | On | 40 | 0.3 |
| I | 32 | 73.5 | 2 | On | 40 | 0.3 |
| J | 38 | 58 | 1 | Off | - | - |
| | | 58 | 1 | On | 32 | 0.1 |
| K | 35 | 58.8 | 1 | Off | - | - |
| | | 58.8 | 1 | On | 35 | 0.1 |

## Reference


Yang, W. Q., Zhang, Y. L., Wang, X. M., Li, S., Zhu, M., Yu, Q. Q., Li, G. H., Huang, Z. H., Zhang, H. N., Wu, Z. F., Song, W., Tan, J. H., and Shao, M.: Volatile organic compounds at a rural site in Beijing: influence of temporary emission control and wintertime heating, Atmos. Chem. Phys., 18, 12663-12682, https://doi.org/10.5194/acp-18-12663-2018, 2018.

Zhang, Y. L., Wang, X. M., Barletta, B., Simpson, I. J., Blake, D. R., Fu, X. X., Zhang, Z., He, Q. F., Liu, T. Y., Zhao, X. Y., and Ding, X.: Source attributions of hazardous aromatic hydrocarbons in urban, suburban and rural areas in the Pearl River Delta (PRD) region, J. Hazard. Mater., 250, 403-411,

https://doi.org/10.1016/j.jhazmat.2013.02.023, 2013.

Zhang, Y. L., Wang, X. M., Zhang, Z., Lv, S. J., Huang, Z. H., and Li, L. F.: Sources of $C_2$-$C_4$ alkenes, the most important ozone nonmethane hydrocarbon precursors in the Pearl River Delta region, Sci. Total Environ., 502, 236-245, https://doi.org/10.1016/j.scitotenv.2014.09.024, 2015.

3. As mentioned by the author, the fuel composition is a very important factor for VOC profiles, which is a possible reason for the different VOC compositions of the tested ships with the previous results. Then, is there apparent difference of VOC compositions for tested ships using four different fuels? What is the trendy of the VOC emissions when correlating the diesel composition?

Reply: We simply measured solvent-extractable fraction of the oils by GC-MSD as some fuels are very sticky residue oils before the fuel switch policy. Nonetheless, as showed in Figure S1, we could see that after the implementing the fuel switch policy, there is a tendency to have more factions of low molecular weight hydrocarbons (or hydrocarbons having lower carbon numbers). As for ship C, the residual oil used before the fuel switch policy was mainly composed of saturated $C_{11}$-$C_{36}$ alkanes; after implementing the new policy, however, the residue oil used by ship C was replaced with diesel oil with no peaks after heptacosane (C27) in its total ion chromatographs. For ship D, before implementing the fuel switch policy it used residual oil slightly different from that used by ships A, B and C in its compositions, particularly in relative high fractions of naphthalene and methylnaphthalenes apart from saturated alkanes. After implementing the fuel switch policy, ship D instead used low-sulfur heavy oil. Although the responses of the most hydrocarbons did not change very much, the responses of low carbon number species, including naphthalene, tridecanes and methylnaphthalenes, became relatively higher, and lower carbon number species such as indene (C8) were also detected. As a result, we found the mass percentages of $< C_6$ VOCs (VOCs with carbon numbers below 6) in the total VOCs in ship exhaust increased from 8.5%-27.3% to 44.4%-86.6% after implementing the fuel switch policy. As described in the manuscript, we noticed that the fuel used by the ships became more abundant in low molecular weight fractions, but we did not conduct a comprehensive analysis of the fuel compositions and we do not know if the fuels we samples are representative enough, so we feel it would be inappropriate to go further saying more in this aspect. As a matter of fact, after we report our results to local administrations, they determined to start a full-scale survey about fuels used by ships.

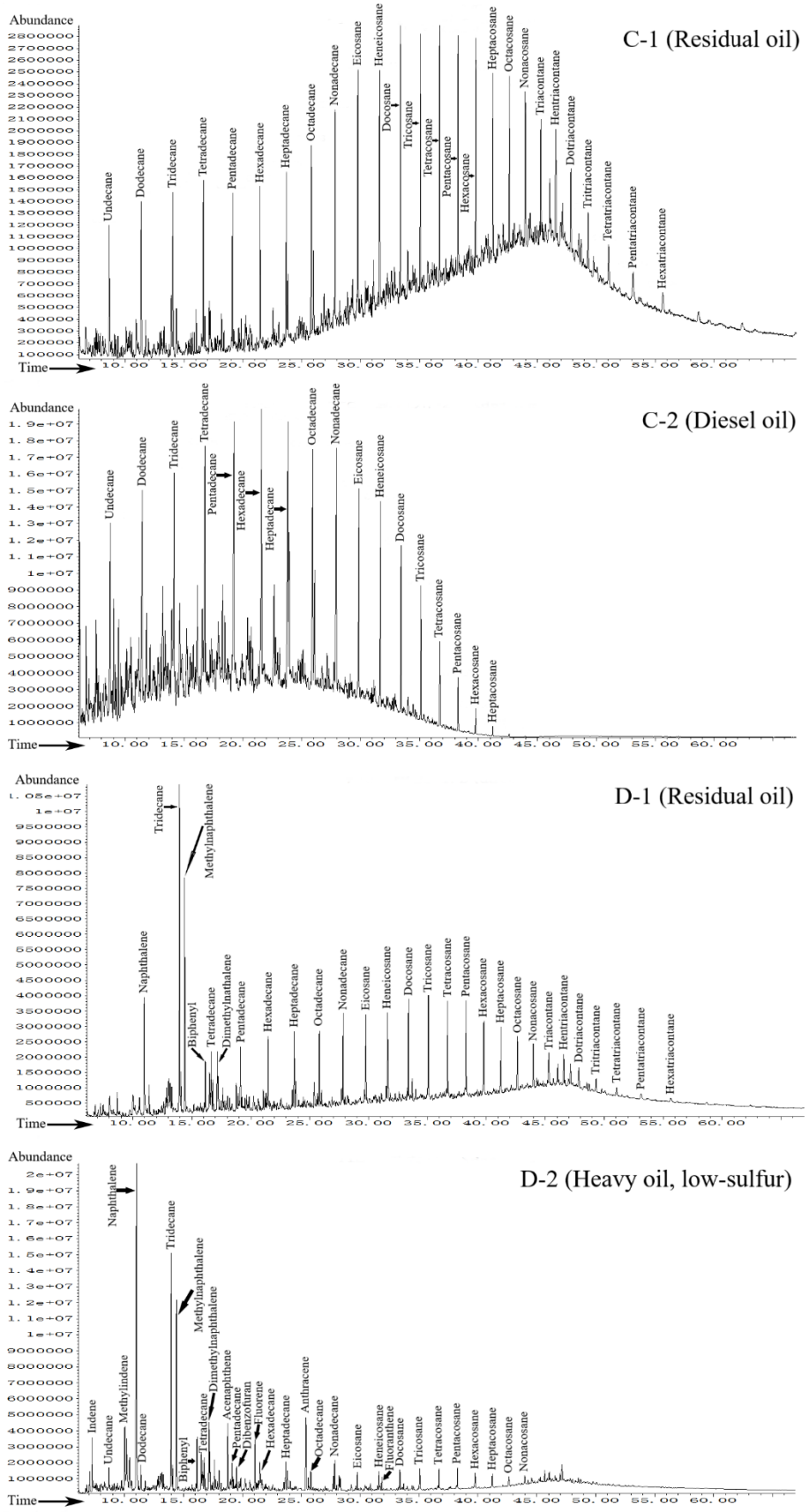



Figure S1. Typical total ion chromatographs of VOC species in fuel oils.

4. More concise. Academic writing is a big question for this manuscript. There are many simple mistakes appeared in substantial sentences, which are mostly summarized in minor comments. Polishing the language is strongly suggested.

Reply: Really sorry for making so many simple mistakes. Thanks a lot for your hard work in carefully checking the manuscript. We have also requested an academic editing service "SPRINGER NATURE Author Services (SNAS)" to improve the English language, grammar, punctuation, spelling, and overall style by one or more of the highly qualified native English speaking editors at SNAS. The verification code is 04C9-9B0B-7E9B-561C-1839.

5. The unified expression. The author wrote several types of phases to express the implementation of the fuel switch policy, such as after implementing the fuel switch policy, after the new policy, after implementing the policy, after the fuel switch, and after the implementation of the fuel switch policy. Choose a suitable phrase for this expression.

Reply: Thanks for the suggestion. In the revised manuscript, we use "the implementation of the fuel switch policy" to unify the expression.

**Minor Comments**

1. Line 24 The unit of EF is not unitized, mg/kg and mg kg-1.

Reply: As suggested, we have unitized the unit of EF in mg $kg^{-1}$.

2. Line 26 more rich… is it not richer?

Reply: As suggested, we have replaced "more rich" with "richer".

3. Line 34 The number of PM2.5 should be subscripted.

Reply: As suggested, we have replaced "PM2.5" with "$PM_{2.5}$".

4. Line 34 "may threatens"? It doesn't need the plural form for the term "threaten".

Reply: As suggested, we have replaced "threatens" with "threaten".

115 5. Line 46 ECAs?

116 Reply: As suggested, we have replaced “ECA” with “ECAs”.

117 6. Line 54 ship emissions?

118 Reply: As suggested, we have replaced “ship emission” with “ship emissions”.

119 7. Line 57 Is it suitable using the word “combat”?

120 Reply: As suggested, we have replaced “combat” with “control”.

121 8. Line 78 reveals?

122 Reply: As suggested, we have replaced “reveal” with “reveals”.

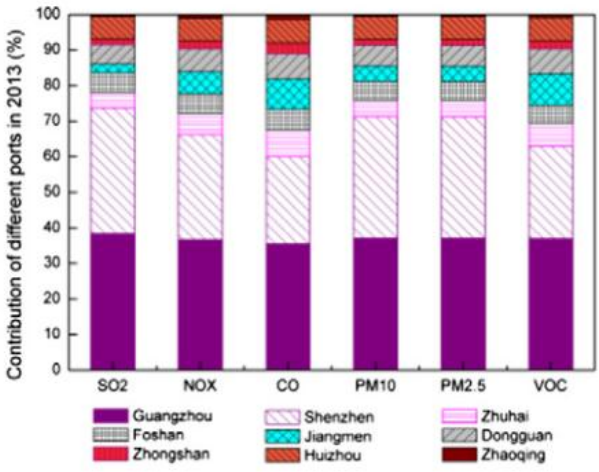
123 9. Line 84 emissions from ships?

124 Reply: As suggested, we have replaced “emissions from ship” with “emissions from ships”.

125 10. Line 99 Are all the pollutant emissions accounted for 40%?

126 Reply: Yes, all the pollutant emissions, including $SO_2$, $NO_x$, CO, $PM_{10}$, $PM_{2.5}$ and VOCs accounted for

127 nearly 40%, as shown below (Li et al., 2016a):




a) Ports

128

129 Reference

Li, C., Yuan, Z. B., Ou, J. M., Fan, X. L., Ye, S. Q., Xiao, T., Shi, Y. Q., Huang, Z. J., Ng, S. K. W., Zhong, Z. M., and Zheng, J. Y.: An AIS-based high-resolution ship emission inventory and its uncertainty in Pearl River Delta region, China, Sci. Total Environ., 573, 1-10, https://doi.org/10.1016/j.scitotenv.2016.07.219, 2016a.

11. Line 113 What is a PM2.5 cutting head? Please give an accurate description.

Reply: As suggested, we have replaced "$PM_{2.5}$ cutting head" with "$PM_{2.5}$ separator".

12. Line 120 Is the mass selective detector MSD? What about the mass spectrometer detector?

Reply: Here MSD represents mass selective detector. Both mass selective detector and mass spectrometer detector are often abbreviated as MSD.

13. Line 105 have already used?

Reply: As suggested, we have replaced "already used" with "have already used".

14. Line 133 The EF of CO2 is calculated not determined. As follows not as following.

Reply: As suggested, we have replaced "determined" with "calculated".

15. Line 136 Is the unit of Cf (g ~~k~~g-1)

Reply: It is $C_F$ instead of Cf. In the revised manuscript, we have changed the expression in line 154 as "$C_F$ is the carbon content per kg of fuel (g $kg^{-1}$);"

16. Line 140 concentration?

Reply: As suggested, we have replaced "concentrations" with "concentration".

17. Line 151-153 Why is the explanation of VOC composition change placed in this section?

Reply: As suggested, we have moved this part to line 200-202.

18. Line 161 The number of C6 should be subscripted.

Reply: As suggested, we have replaced "C6" with "$C_6$".

19. Line 156 What is NMHCs? Is the measured VOC species?

Reply: Yes, it refers to the measured VOC species. We have replaced "NMHCs" with "VOCs".

20. Line 158 limited…

Reply: As suggested, we have replaced "limit" with "limited".

21. Line 160 The EFs of CO2

Reply: As suggested, we have replaced "The EF of $CO_2$" with "The EFs of $CO_2$".

22. Line 160 Is it right "before to"?

Reply: We have deleted "before".

23. Line 159-163 It should give a summary rather than displaying the tested results of every ship.

Reply: Because ships C and D were tested both before and after the implementation of the fuel switch policy, the changes in emissions for the two ships would be more convincing in reflecting the influence of the fuel switch policy. This is why we particularly display the tested results of ships C and D.

24. Line 166 The term "that" should be "those".

Reply: As suggested, we have replaced "that" with "those".

25. Line 168 What is the carbonaceous aerosol? Does that mean OC and EC?

Reply: Yes, carbonaceous aerosol included OC and EC.

26. Line 169 "As shown" is the correct form, please revise all of the forms in this manuscript.

Reply: As suggested, we have replaced "As showed" with "As shown" in the whole manuscript.

27. Line 172 the EFs of?

Reply: As suggested, we have replaced “the EF of” with “the EFs of”.

28. Line 176 by marine gasoline?

Reply: The “marine gasoil” was mentioned in Copper et al. (2003) and it referred to a kind of diesel.

Reference

Cooper, D. A.: Exhaust emissions from ships at berth, Atmos. Environ., 37, 3817-3830, https://doi.org/10.1016/S1352-2310(03)00446-1, 2003.

29. Line 178 TVOCs? Does TVOCs denote the measured VOC species?

Reply: Yes, TVOCs denoted the total measured VOC species.

30. Line 180 the emissions?

Reply: As suggested, we have replaced “emission” with “emissions”.

31. Line 191 NMHCs?

Reply: As suggested, we have replaced “NMHCs” with “VOCs”.

32. Line 199 and 214 individual NMHCs?

Reply: As suggested, we have replaced “NMHCs” with “VOCs”.

33. Line 206 the fuel switch?

Reply: We have replaced “after the fuel switch” with “after the implementation of the fuel switch policy”.

34. Line 208 the only alkynes?

Reply: Yes, we only measured acetylene in this study.

35. Line 212 “were” should be revised to “was”.

Reply: As suggested, we have replaced “were” with “was”.

36. Line 217 might played?

Reply: We have replaced “might played” with “might play”.

37. Line 217 their emission are?

Reply: We have replaced “their emission are” with “their emissions are”.

38. Line 223 emission from ship

Reply: We have replaced “emission from ship” with “emissions from ships”.

39. Line 230 Ozone Formation Potentials (OFPs) is?

Reply: We have replaced “Ozone Formation Potentials (OFPs)” with “Ozone formation potential (OFP)”.

40. Line 245 ship-emitted VOCs at berth…

Reply: As suggested, we have replaced “ship-emitted VOCs” with “ship-emitted VOCs at berth”.

41. Line 247 Please give the literature for the calculated method of SOAFPs.

Reply: As suggested, we added “(Zhang et al., 2018a)” in line 283.

Reference

Zhang, Y. L., Yang, W. Q., Simpson, I., Huang, X. Y., Yu, J. Z., Huang, Z. H., Wang, Z. Y., Zhang, Z., Liu, D., Huang, Z. Z., Wang, Y. J., Pei, C. L., Shao, M., Blake, D. R., Zheng, J. Y., Huang, Z. J., and Wang, X. M.: Decadal changes in emissions of volatile organic compounds (VOCs) from on-road vehicles with intensified automobile pollution control: Case study in a busy urban tunnel in south China, Environ. Pollut., 233, 806-819, https://doi.org/10.1016/j.envpol.2017.10.133, 2018a.

42. Line 247 normalized secondary organic aerosol reactivity?

Reply: As suggested, we have replaced “normalized secondary organic aerosols (SOA)” with “normalized secondary organic aerosol reactivity ($R_{SOA}$, g SOA $g^{-1}$ VOCs)”.

43. Line 250 Like Zhang et.al reported?

Reply: We deleted “Like Zhang et.al reported”.

44. Line 258-260 What is the problem told by the SOAFP difference under the high NOx and low NOx conditions?

Reply: In this method, $Y_i$ is the SOA yield of VOC species i, as determined by chamber studies (Ng et al., 2007; Lim and Ziemann, 2009; Loza et al., 2014). SOA yields of VOCs depend on nitrogen oxide ($NO_x$) (Ng et al., 2007). Thus, we calculated the SOAFPs under high-NOx and low-NOx conditions, respectively.

Reference

Lim, Y. B., and Ziemann, P. J.: Effects of molecular structure on aerosol yields from OH radical-initiated reactions of linear, branched, and cyclic alkanes in the presence of NOx, Environ. Sci. Technol., 43, 2328-2334, https://doi.org/10.1021/es803389s, 2009.

Loza, C. L., Craven, J. S., Yee, L. D., Coggon, M. M., Schwantes, R. H., Shiraiwa, M., Zhang, X., Schilling, K. A., Ng, N. L., Canagaratna, M. R., Ziemann, P. J., Flagan, R. C., and Seinfeld, J. H.: Secondary organic aerosol yields of 12-carbon alkanes, Atmos. Chem. Phys., 14, 1423-1439, https://doi.org/10.5194/acp-14-1423-2014, 2014.

Ng, N. L., Kroll, J. H., Chan, A. W. H., Chhabra, P. S., Flagan, R. C., and Seinfeld, J. H.: Secondary organic aerosol formation from m-xylene, toluene, and benzene, Atmos. Chem. Phys., 7, 3909-3922, https://doi.org/10.5194/acp-7-3909-2007, 2007.

45. Line 256 This decline of RSOA?

Reply: As suggested, we have replaced “This decline in RSOA” with “This decline of $R_{SOA}$”.

50. Line 262 What is the NMHCs?

Reply: We have replaced “NMHCs” with “VOCs”.

237 51. Line 266-267 How about the comparison of Huang et al. results and this study results?

238 Reply: Huang et al. (2018a) also measured the emissions of VOCs from ship at berth using low-sulfur
239 fuels, so we could directly compare with the coastal vessels after the implementation of the fuel switch
240 policy. We have changed the expression in line 304-307 as below:

241 "As shown in Fig. S4, based on the VOCs emissions from ship at berth reported in Huang et al.
242 (2018a), we calculated a RSOA of 0.080 g SOA g-1 VOCs under high-NOx conditions and 0.228 g
243 SOA g-1 VOCs under low-NOx conditions for a coastal vessel also using low-sulfur fuels. This
244 relatively higher RSOA under low-NOx conditions was related to the higher fractions of aromatics in
245 the VOC emissions."

246 52. Line 268 What is the reason for the lower RSOA of Xiao's results?

247 Reply: The reason for lower $R_{SOA}$ of Xiao's results was that they adopted another method in Gentner et
248 al. (2012) using another set of SOA yield for hydrocarbons as shown in Table R1-1. In the revised
249 manuscript we added explanations for this in line 307-309 "Using another method in Gentner et al.
250 (2012), Xiao et al. (2018) reported an average $R_{SOA}$ of 0.017 g SOA $g^{-1}$ VOCs under high-$NO_x$
251 conditions, which was close to a $R_{SOA}$ of 0.015 g SOA $g^{-1}$ VOCs calculated by the same method for the
252 coastal vessels after IFSP.

253 Table R1-1. Average high-NOx SOA yields in Gentner et al. (2012)

| Carbon number | Straight-chain alkanes | Branched alkanes | Cycloalkanes (single straight alkyl chain) | Cycloalkanes (branched or multiple alkyl chain (s)) | Bicycloalkanes | Tricycloalkanes | Aromatics | Polycyclic aromatics compounds |
|---|---|---|---|---|---|---|---|---|
| 1 | - | - | - | - | - | - | - | - |
| 2 | - | - | - | - | - | - | - | - |
| 3 | - | - | - | - | - | - | - | - |
| 4 | - | - | - | - | - | - | - | - |
| 5 | - | - | - | - | - | - | - | - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6 | - | - | 0.0004 | - | - | - | 0.14 | - |
| 7 | - | - | 0.0007 | 0.0001 | - | - | 0.083 | - |
| 8 | 0.0006 | 0.0001 | 0.0015 | 0.0002 | - | - | 0.048 | - |
| 9 | 0.0012 | 0.0002 | 0.0031 | 0.0005 | 0.0005 | - | 0.077 | - |
| 10 | 0.0026 | 0.0004 | 0.0059 | 0.001 | 0.001 | - | 0.12 | 0.17 |
| 11 | 0.0053 | 0.0008 | 0.01 | 0.0018 | 0.0018 | - | 0.15 | 0.23 |
| 12 | 0.01 | 0.0017 | 0.016 | 0.0034 | 0.0031 | 0.0032 | 0.19 | 0.28 |
| 13 | 0.019 | 0.0035 | 0.026 | 0.0062 | 0.0056 | 0.0057 | 0.26 | 0.4 |
| 14 | 0.033 | 0.007 | 0.041 | 0.011 | 0.0097 | 0.0098 | 0.33 | 0.49 |
| 15 | 0.055 | 0.013 | 0.064 | 0.019 | 0.016 | 0.017 | 0.39 | 0.62 |
| 16 | 0.089 | 0.024 | 0.099 | 0.031 | 0.026 | 0.027 | 0.43 | 0.7 |
| 17 | 0.14 | 0.042 | 0.16 | 0.053 | 0.044 | 0.045 | 0.46 | 0.75 |
| 18 | 0.23 | 0.073 | 0.24 | 0.088 | 0.072 | 0.073 | 0.51 | 0.79 |
| 19 | 0.37 | 0.12 | 0.36 | 0.14 | 0.12 | 0.12 | 0.56 | 0.82 |
| 20 | 0.56 | 0.2 | 0.5 | 0.22 | 0.19 | 0.19 | 0.61 | 0.82 |
| 21 | 0.77 | 0.32 | 0.66 | 0.33 | 0.29 | 0.3 | 0.65 | 0.82 |
| 22 | 0.96 | 0.47 | 0.82 | 0.45 | 0.43 | 0.43 | 0.67 | 0.82 |
| 23 | 1.08 | 0.61 | 0.94 | 0.57 | 0.56 | 0.57 | 0.68 | 0.82 |
| 24 | 1.14 | 0.7 | 1.03 | 0.67 | 0.66 | 0.67 | 0.68 | 0.82 |
| 25 | 1.16 | 0.75 | 1.09 | 0.73 | 0.74 | 0.74 | 0.68 | 0.82 |

254

255 Reference

256 Gentner, D. R., Isaacman, G., Worton, D. R., Chan, A. W. H., Dallmann, T. R., Davis, L., Liu, S., Day,

257 D. A., Russell, L. M., Wilson, K. R., Weber, R., Guha, A., Harley, R. A., and Goldstein, A. H.:

Elucidating secondary organic aerosol from diesel and gasoline vehicles through detailed characterization of organic carbon emissions, Proc. Natl. Acad. Sci. U. S. A., 109, 18318-18323, https://doi.org/10.1073/pnas.1212272109, 2012.

53. Line 271 Ships?

Reply: We have replaced “Ships” with “Ship”.

54. Line 273 one the three?

Reply: We have replaced “one the three” with “one of the three”.

55. Line 278 the EF of VOCs and Line 281 the EF of NMHCs? Which one is right?

Reply: We have replaced “NMHCs” with “VOCs” in the whole manuscript.

56. Line 281 Why explained the unit of fuel-based EF here?

Reply: We have deleted “for VOCs emitted per kilogram fuel burned”.

57. Line 287 are not affected?

Reply: We have changed “For river vessels unaffected” to “For the river vessels were not affected”.

58. Table 2 g kg-1 fuel?

Reply: This shows the unit of the emission factor in the table.

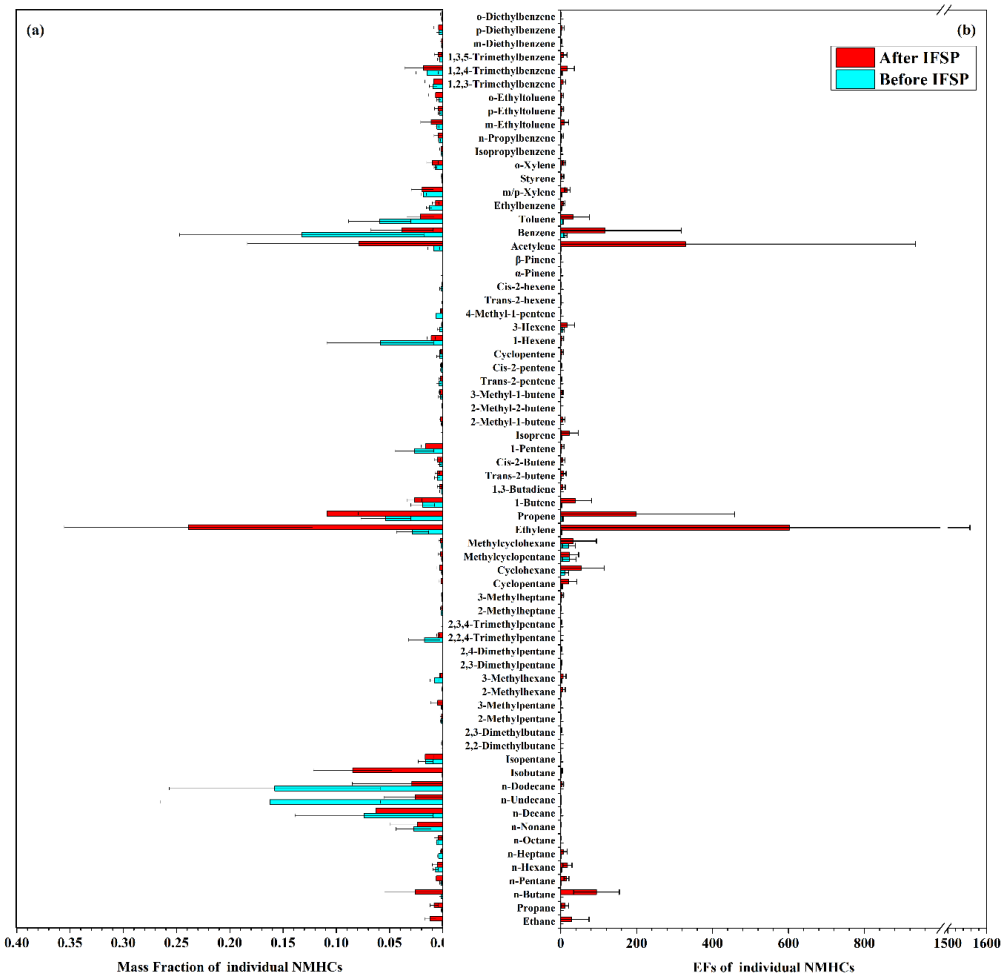
59. Figure 5 before and IFSP?

Reply: We have changed “before and IFSP” as “before and after the implementation of the fuel switch policy”.

60. Figure 4 The figure needs add the standard error bar. IFSP is the first appearance. Spell out all acronyms on first use in the abstract and in the body of the article.

Reply: Thanks for the suggestion. We have added the standard error bar in Figure 4 and spell out the

279 acronyms of IFSP on its first use in the abstract and in the body of the article in line 21 and line 86.




280

281 Figure 4. Comparison of VOCs emission factors before and after IFSP for coastal vessels.

282 61. Figure 2 diagrams?

283 Reply: We have replaced “diagrams” with “diagram”.

284

285