

Review on the manuscript “Ambient measurement of shipping emissions in Shanghai port areas” (ACP-2018-737). Authors: Wang et al.

### **General comments**

This study conducted field measurements from June to September in 2016 at Shanghai port in order to understand the impact of ship emissions on the air quality in portside. Trace gases, PM<sub>2.5</sub> and vanadium particle number concentrations were continuously monitored at the site. Ship plumes were clearly captured by the instruments. SO<sub>2</sub> and vanadium particle number concentrations correlated well with ship plumes. Four types of ship plumes were identified based on the mass spectra of Single Particle AMS. The contributions of ship emissions to different air pollutants in the atmosphere and in the air masses from port directions were quantified. Given that Shanghai port is the largest port in the world, this study will add values to existing literature of ship emission studies. However, the manuscript is not well organized/written and has room to be improved. In addition, there are quite a lot of grammar errors and technical mistakes, which sometimes make the reviewer confused. Furthermore, some discussions and conclusions are lack of evidence. As such, this manuscript can be considered for publication after the following specific comments are well addressed.

### **Specific comments**

#### **Abstract:**

Firstly, English needs editing by a native English speaking professional or company. For example, line 16: ... that shipping **emissions is** a major....”.

Secondly, there are also some technical mistakes. One example, lines 14-15: Gaseous (NO, NO<sub>2</sub>, SO<sub>2</sub>, O<sub>3</sub>) and particulate concentrations (PM<sub>2.5</sub>)... It should be “**The concentrations** of gaseous **pollutants** (NO....) and **fine** particulate **matters** (PM<sub>2.5</sub>)...”. Also, both shipping emission and ship emission are used throughout the manuscript which should be consistent. Another problem at lines 18-20, the subject is “Single particle mass spectra of **fresh shipping emission**” but the last words became “...and nitrate peaks in **aged particles**”. This is really confusing the reviewer.

Thirdly, the abstract should provide specific and detailed findings rather than common senses. The only specific finding described in the abstract is probably the last sentence. The others are all about common knowledge which is also applied to any other ports. What is the uniqueness of the study port?

#### **Introduction:**

As there are too many grammar errors, I have made some comments and revisions on the manuscript. I will submit my comments with the manuscript.

#### **Experimental:**

1) It is not clear whether the sampling site is downwind location of the port or not, or whether the ship plumes could really arrive at the sampling site or not. The authors should provide more

detailed description of the site. What were the prevailing winds during the sampling period and how to ensure the capture of ship plumes? There is also no information about the station. Is it a container or mobile vehicle? What is the height of the station if the outlet of the sampling tube was 3.5 m above the ground?

2) Was the CO measured? Though it was claimed that calibration and maintenance of the instruments were regularly performed, brief QA/QC procedures and detection limits are still requested. Nothing was mentioned about the QA/QC of PM<sub>2.5</sub> monitoring.

3) It is not clear how the components in particles such as vanadium were identified and quantified by the SPAMS. Detailed information is needed.

4) Data analysis: in the results, pollution and wind roses were presented while nothing is described about the method to draw pollution and wind roses, and how to explain the pollution and wind roses. In addition, the method of calculation of shipping contributions is improperly placed in the “Results” section, which should be described in the “Experimental”.

Page 5, line 3: what is ART-2a algorithm? This method was mentioned to be used to the searched clusters to generate sub-clusters of particles. However, no information at all about this method was provided.

## **Results and discussions**

Page 5, line 10: which typically persist for a few hours: can you tell us the specific hours in your study rather than vague value like this?

Page 5, lines 21-25: The discussion here is questionable. By looking at Figure 2, whenever ship plumes were captured, both NO and SO<sub>2</sub>/vanadium levels were high and correlated well. On what basis, the authors claimed the NO<sub>x</sub> in plumes reaching the site was aged? Using the NO/NO<sub>2</sub> ratio in the plumes? Compared to the ratio measured in other countries and probably different type of ships? This is not convincing. Besides, NO<sub>2</sub> is also emitted from shipping as a primary pollutant.

Page 5, line 26-29: given that shipping emission is a major source of PM<sub>2.5</sub>, it is odd that no PM<sub>2.5</sub> peaks were found during the ship plumes in Figure 2. The reason provided by the authors is quite confused. Is it because ship emits sub-micron particles or because the malfunction of the PM<sub>2.5</sub> monitor?

Page 5, lines 31-32: what is the basis for the definition of ship plumes using the minimum threshold of delta SO<sub>2</sub>? In particular, the authors later claimed that in some cases the SO<sub>2</sub> peaks were absent?

Page 6, lines 2-3: the reason for absent SO<sub>2</sub> is contradictory to Figure 2. If the ships complied with the new regulations, why would you still see SO<sub>2</sub> peaks in ship plumes? This kind of discussion is misleading.

Page 6, line 16: "This result suggests that shipping activities are the main source of SO<sub>2</sub> plumes in port". Please comment on the NO<sub>x</sub> emission from ships - is it not important, because of impacts of land-based traffics? But later in Page 10, lines 15-18, you claimed NO was higher than SO<sub>2</sub> in fresh ship plumes.

Page 6, line 18: it does not make sense to compare a site near sources with sites in a city without any detailed characteristics of the locations. It would be more meaningful to compare the ship emissions in this study with other similar studies conducted in Shanghai. In fact, there are a number of ship emission studies in this city.

Page 6, lines 21-24: the explanation of low PM<sub>2.5</sub> levels at the port site is not convincing at all. Why would other pollutants from shipping emissions be higher if this was caused by clean air?

Page 6, line 27: the title reads awkward. Should it be "Particles in the background air and the ship plumes"?

Page 6, lines 28-31: These should be in "Experimental" section.

Pages 6-7: the first paragraph of section 3.2.1 is messy and lack of logic. It should be re-organized.

Page 7, line 13: The wind rose distribution..... in figure 3. This should be merged with the description of mass spectra for Figure 3 earlier. When it is first mentioned, you should describe all once.

Page 7, lines 16-17: "Background vanadium particles, ... in all directions". This is not true in Fig 3(d).

Page 7, lines 20-21: There is no actual comparison at all. No idea about the particle size in background air, larger or smaller?

Page 7, line 22-23: "significant fine ship emission particles were still detected in fine size range". The terms have been randomly used everywhere. What do you mean fine ship emission particles? very non-professional description. It should be fine particles from ship emissions.

Is this contradictory to your previous claim that PM<sub>2.5</sub> in ship plumes is lower than that in urban air? In other word, the PM<sub>2.5</sub> in background air could be more significant and be detected more significantly?

Page 7, lines 24-27: These two sentences are repeated. the 2nd sentence contains grammar errors.

Page7, lines 28-30: these two sentences are not related. Lack of logic.

Page 7, line 30: "size distribution of fresh particles...". how do you define "fresh particles from ship exhaust" and "particles from ship emissions"?

Page 7, line 31:" ...that the number concentration mainly concentrated in UF mode (<100 nm)". very poor English writing. It is non-professional at all.

Page 7, lines 32-33: No idea at all why PM<sub>2.5</sub>, NO<sub>x</sub> and SO<sub>2</sub> were suddenly discussed here. This section is about SPAMS measurement data. Also, where showed that PM<sub>2.5</sub> had less

increase than NO<sub>x</sub> and SO<sub>2</sub>? Moreover, are you sure EF of PM are typically much lower than NO<sub>x</sub> and SO<sub>2</sub> in all types of ships with different fuel?

Line 34: Do not understand if there is any connection with less significant increase in PM<sub>2.5</sub> mass concentration.

Page 8, lines 1-3: Terrible explanation. The authors lack basic knowledge.

Page 8, line 9: "The negative mass spectra" how? To me it should be negative m/z value for HSO<sub>4</sub><sup>-</sup>. Mass spectra should not be negative. Please make it clearer. In addition, the whole sentence is confusing. "...other negative EC peaks...". Specifically what are they in the spectra?

Page 8, line 20: Firstly, this description is unclear. How could "chemical composition" suggest distinct physical properties"? Secondly, is Fig 6 about this? But it is clear that Fig 6 is about temporal pattern of particle number concentration.

Page 8, lines 26-27: Did you scan it using TEM? If not, how do you know yours is the same as other studies?

Page 8, lines 27-29: Again, you do not have evidence to say this - is the reason that the size distribution of V-OC is different from other types related to incomplete combustion?

Page 8, line 31: "... suggesting they are principally emitted in specific phases of engine operations." Any references support this?

Page 8, line 33: "UF size..." I guess it means ultra-fine. If correct, what is the size range of ultra-fine particles?

Page 9, line 1: "...product of combustion of RFO (Moldanova et al., 2013)." But your measurement was conducted after the implementation of sulfur reduction regulations. This means the fuel used at berth is not RFO but clean fuel.

Line 2: are mainly detected in larger size range (> 0.5 μm) (Fig. 6). The peak particle size for V-EC, V-ECFe and V-Ash looks similar in Fig. 6. How would you say this?

Lines 3-5: This fits other types of particles as well. I don't understand why you said this here. This is basic knowledge.

Lines 5-6: "The origin of V-ECFe types are probably the result of internal mixing between V-EC and V-Ash particles". Any possible reasons for this speculation?

Line 7: how do you know or do you believe it?

Lines 9-18: The whole paragraph is nothing to do with your results but information about other studies. This should be in "Introduction" section.

Lines 19-20: Very confused statement and unclear purpose.

Lines 22-23: "... clearly showed that they are under the overwhelming influences of land emissions on the sampling site." Why? How do we read the pollution roses in Fig 7? How do we know they were affected by other sources?

Lines 26-27: "Because the air pollution in this two conditions are so different,....." Which two conditions?

Page 9, lines 30-32 and page 10, lines 1-2: all these should be in "Experimental" section.

Page 10, lines 8-12: Quite confused discussion. Re-written.

Page 10, lines 15-17: Here you finally evidenced the major contribution of ship emissions to NO<sub>x</sub>. But if you went to section 3.1, you claimed that NO<sub>x</sub> were mainly from land traffics while ship contribution is not important. The two explanations are contradictory.

Page 10, lines 19-20: Do you compare the absolute concentrations of these pollutants attributed to ship emissions in these two studies? This kind of comparison using percentage is very dangerous! I bet the total concentrations of these pollutants in these two studies are totally different.

Lines 24-25: Did you do t-test to say this? ~4% vs. 5.9% is similar to me. Importantly, compare absolute concentrations. The comparison based on percentage does not make sense and can mislead readers.

## **Conclusions**

The conclusion section is poorly written. It must be re-organized and re-written.