

# ***Interactive comment on* “Effects of marine fuel sulfur restrictions on particle number concentrations and size distributions in ship plumes at the Baltic Sea” by Sami Seppälä et al.**

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## General comments

I recommend the paper to be published subject to only minor revisions.

I find the paper to be very important for the scientific aerosol measurement community, since it presents data from shipping emissions. It also is very important for policy making, since reductions in FSC is seen as a drastic decrease in air pollution levels. Modelling community will also value this paper highly due to the FSC content influence and ship emission pollution data, which can be used to validate the models. Finally, it

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gives insights to how particles from ship emissions are ageing in the atmosphere.

It is very well written language wise, and presents all contents in a structured manner.

Specific comments

Chapter 3.2

The reason why the Zanatta et al. reference shows slightly higher ship plume contributions than your paper or the paper by Ausmeel et al. is not only due to meteorological influences or variations in NSD size ranges. Important factors are likely also that Zanatta et al. might be closer to the ships, and/or that they observe several shipping lanes simultaneously (they don't exclude superimposed ship plumes), and/or that they have very few measurements, so it can be a statistical effect as well. Please write these explanations as well.

Chapter 3.3.

In Figure 6 you see a dramatically higher plume concentration for the 200 degree wind direction as compared to the 270 degree wind direction. This is very interesting and should be included in the discussions about the results, because logically it makes little sense. So, what could be the explanation? If the ships at 200 degrees are about the same size and type as the ships at 270 degrees, then the explanation for the difference must be meteorological; for example, plumes from 270 degrees are relatively more diluted vertically, and/or they are transported higher up in the marine boundary layer, partly missing to descend to Utö station measurement height. But, if it is an effect of difference in ship types or sizes, you should roughly explain the difference in fleet composition between different 10 degree wind sectors, because this could explain why you see such different concentrations in different wind sectors.

Mass concentrations

You should estimate the average contribution of the ship plumes to PM<sub>0.15</sub> and/or PM<sub>0.5</sub> mass concentrations during the three different FSC regimes by assuming a

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constant density of particles. This assessment of the importance of ship emissions to PM mass concentrations is extremely valuable for the scientific community, policy making, and health effects. These contributions can be compared to Ausmeel et al., 2020; Atmos. Chem. Phys., 20, 9135–9151, 2020. You have already calculated the volume concentrations, so should be straightforward to calculate the mass concentration by just multiplying with the density. Your contribution to PM<sub>0.5</sub> is about a factor 7-8 higher than at Falsterbo peninsula, which is likely due to the fact that ships in Falsterbo are smaller, and possibly due to the long average distance to the shipping lane in Falsterbo of around 10 km – however, I don't know the average distance to ships in your paper.

## Technical corrections

### Introduction

Lin et al., 2018 is an epidemiological study, while Partanen et al., 2013 present only a calculated expected outcome for health effects with reduced ship emissions. Hence, you can claim that Lin et al. show that you have a link between ship emissions and health effects, while you can not write that Partanen et al. have linked reduced ship emissions to reduced disease or mortality burden. Please rephrase. The same reasoning goes for the phrasing: "The reduction of PM<sub>2.5</sub> emissions from shipping has been shown to reduce the negative health effects". This hasn't been shown in the cited references, this has been estimated. Please rephrase. Otherwise, the reader might think that there is epidemiological evidence in all the referenced studies.

### Figure 1.

It is hard to understand what is meant with "every 10000 shown" and "every 500th shown" and "every 10th shown". Please explain in a different way.

### Chapter 3.2

Lines 186-187. It should be 700 and 1470 particles per cubic centimeter respectively for the Ausmeel study.

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### Chapter 3.3

Lines 244-245. You probably mean particles below 155 nm are not much affected by FSC instead of 134 nm, since they are actually affected at 134 nm?

### Chapter 3.6

Line 331. It should read secondary aerosol (SA), and not secondary organic aerosol (SOA).

### Conclusion

Line 396. You probably want to write  $\geq 155$  nm, and not  $> 155$  nm?

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