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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Effects of strengthening the Baltic Sea ECA regulations" *by* Jan Eiof Jonson et al.

Anonymous Referee #3

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Jonson et al. presented the effects of ship emissions in the BAS on air quality as well as oxidized nitrogen and sulfur over the countries around BAS. They used a combination of ground measurements and chemical transport modeling to estimate the influence of ship emission on air quality of NO2, PM2.5, and SO2 in the present and in the future 2030. Additionally, the effect of strict SECA on sulfur and PM2.5 concentrations was also investigated too. They showed that Baltic Sea shipping has largest impact on NO2 concentration over the central Baltic Sea as well as the coastal cities. The effects of current ship emissions are also shown in PM2.5 and deposition of oxidized nitrogen and sulfur. In terms of contribution of present and future ship emissions on species and depositions over the countries surrounding the BAS, they found that the effects of ship emission are larger in some countries.

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Discussion paper

Overall this study provides an investigation of BAS ship emissions on air quality and deposition over the BAS and the countries surrounding it and highlights the importance of ship emissions in BAS. However, this paper has some important points that have to be clarified or addressed.

Specific comments:

1. Page 3, line 10: Please specify what FMI stands for.

2. Page 3, line 17: Here the ship emissions in daily temporal scale was first introduced, but later in line 30, it was mentioned that ship emission data in hourly temporal resolution was aggregated into monthly resolution in the CTM. Please clarify the original temporal resolution of ship emissions and how it was implemented into the CTM.

3. Page 3, line 18: What is the spatial resolution of ship emissions?

4. Page 3, line 24-29: The description of future emission projections for the year 2030 is not clear. Although it was mentioned some changes such as vessel size growth and fleet size increase, it will be helpful to include the exact or estimated percentage of ship size growth in 2030 compared to current ship size.

5. Page 4, line 18: I understand the authors mainly focused on the influence of ship emissions, so they presented their results by averaging the three meteorological years. However, some important messages were missing if they took this approach. For example, the changes of observed SO2 and associated PM2.5 species before and after stricter SECA regulation was applied, which is highly relevant to the title of this paper and has critical policy implication. I suggest the authors add the comparison of observation between years to the paragraphs where the Present_HiSulphur and Present_Base simulation was compared.

6. Page 5, line 12: As it showed that the elevated PM2.5 by BAS shipping emissions are concentrated over the shipping routes and the coastal cities close to the routes, the location of the cities relative to major shipping routes is important. It will be helpful

to include a map showing the geographic location of the sites in Table 1 and 2. Also a discussion about whether the sites close to major shipping route would have larger impact of ship emission can be included.

7. Page 5, line 28: What are differences between your estimated contribution of PM2.5 by BAS shipping emissions and the estimation by Karl et al. (2019) that mentioned in page 2, line 24?

8. Page 5, line 30: The results showed that ship emissions contributed more on PM2.5 concentrations when the ship emissions were assumed to be at 2014 levels. Does it imply the PM2.5 contribution in 2014 (before strict SECA) was mainly from SOx? What is the fraction of sulfate in the modeled PM2.5 in Present_HiSulphur and Base simulation? Do the ground observations of PM2.5 show higher fraction of sulfate in 2014 and decreased fraction of sulfate in 2016 after the strict SECA?

9. Page 5, line 32: Here you compared the differences between Present_Base and Present_Noship for NO2 and PM2.5 at the measurement sites. As the magnitude of NO2 and PM2.5 are different (it is not appropriate to compare their difference directly) and it is hard to tell the differences by eyeballing the numbers, I suggest to have barplots over a map (i.e. every site has its relative difference of Base and Noship (Base minus Noship divided by Noship) for PM2.5 and NO2 presented by a barplot), if it would not be too messy on a map.

10. Page 5, line 34 & Page 6, line 1-2: It was stated that the model results underestimate the measurement at most of the sites listed. What is the criterion of evaluating Base model performance?

11. Page 6, line 33: This discussion would benefit from a quantitative indication than just describing the largest contribution are seen for smaller countries with long coastline. I suggest to add a quantitative assessment like the contribution weighted by coastline length or weighted by distance-to-major-shipping-route to strengthen the statement here.

12. Page 7, line 6: Figure 3b shows the reduction of NO2 caused by ship emission in 2030 (i.e. For each country, the green bar along with blue bar is shorter than the green bar with black bar). As it is stated here, the improvement of the pollution levels is caused by reduction of BAS ship emissions. However, in page 3, line 24-29, you mentioned increase of ship size and fleets, and in page 4, line 23, the future scenario was assumed with NECA (and strict SECA?) applied. How the vessel size growth and fleet size increase, which would lead to more emissions, are balanced with strict regulations to have emission reduction in the future?

13. Page 7, line 21: It was stated that increase of SOMO35 is more than annually averaged ozone. The units of SOMO35 and annually averaged ozone are different. What is the comparing criterion in this statement?

14. Page 7, line 23 & line 24: It was explained the changes in SOMO35 and annually averaged ozone by combination effect of ozone enhancement in the summer and decrease during the winter time. It would be supportive to add analysis of separating SOMO35 and ozone difference by two seasons into appendix and references to support the argument.

15. Page 7, line 25: There are some confusion for the discussion here. In Figure 4, both Germany and Denmark show decrease of annual mean ozone in 2030 (Present-2030, positive difference), but the statement here is "the additional emissions from BAS shipping lead to 'reductions' in annual ozone in Denmark. Furthermore, ... result in 'increased' annual ozone levels in Germany." Conflict arises from the differences between discussion mentioned above and Figure 4.

16. Page 7, line 27: It is not clear in the discussion here. Figure 4 shows that the SOMO35 increases in the future (also stated in Page 7, line 21) for the two cases, but the statement here – "Even though annual ozone..... lower emissions will result in SOMO35 'reductions' in both these two cases.....". – you mentioned 'reduction' in SOMO35 instead. Additionally, I didn't see the clear connection between SOMO35

reduction and winter titration events.

Technical comments:

1. Page 7, line 9: It should be Figure 3e, instead of Figure 3d.

2. Page 7, line 19: Please rewrite the sentence, “Also show are the effects. . ..”.

3. Figure 1: Please add X-axis and Y-axis label of longitude and latitude and remove the remaining cut-off headers in the plots.

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