

Interactive comment on “Effects of global ship emissions on European air pollution levels” by Jan Eiof Jonson et al.

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We, the authors, thank the reviewers for constructive comments and suggestions. Below we list the comments from reviewer 3, followed by our reply with references to changes made in the paper.

Comments to remarks from reviewer 3

Abstract Line 4:

C1

The authors should be consistent when presenting the pollutants. Please harmonize this along the text.

Reply:

We have harmonized the naming of the emitted species.

Line 7: The objective/purpose of the study is missing in the abstract!

Reply:

In the abstract we have now added that we in this paper quantify the contributions from international shipping to European air pollution levels and depositions.

Line 10: Something should be mentioned about the shipping emissions inventory used here (a particularly important input for this study).

Reply:

We now state that the ship emissions have been derived using ship positioning data.

Lines 18-22: this conclusion is too general and obvious. There are more specific and interesting conclusions at the end of the paper that should be here mentioned.

Reply:

We have extended the abstract, including some more points from the conclusions.

C2

Introduction Line 26: strange way of starting this Introductory section.

Reply:

Our intention is to point out that land based emissions in Europe have dropped significantly in past decades, whereas ship emissions have changed far less over the same period. Thus the relative contributions to air pollution and depositions have increased. This first paragraph has been slightly revised.

Line 30: land or maritime emissions?

Reply:

We have added land based emissions.

Line 44: reference should be added to support this.

Reply:

We have added a reference to the IMO decision in 2008.

Line 64-67: It is not clear which is the novelty of this study comparing to others recently published like for example Sofiev et al (2018). The authors should also explain why only focus on PM_{2.5} and ozone. Also the modeling system could be already mentioned/identified in this part.

Reply:

In (line 84 - 99 in revised manuscript) we list the main topics discussed in the paper, clearly stating in which aspects provides added value beyond previous publications. Specifically, in addition to PM_{2.5} and ozone we also include depositions of oxidised nitrogen and sulphur. We also attribute the effects of ship emissions from separate sea areas to specific European countries.

C3

Model description Lines 81-84: a reference is missing.

Reply:

References were given lower on the same page. We have moved the references to a few lines below what was suggested by the reviewer.

Line 144: which are higher: emissions per grid cell or total emissions?

Reply:

We now specify that it is the total emissions in the sea areas that are higher in the global model.

Line 151-152: please review this sentence.

Reply:

We have changed this to:

However, as shown in Table 1, the NMVOC to NO_x ratio is close to one for land based emissions, but very low for ship emissions.

Line 158: I do not understand this part "for several of the model runs" ...please clarify.

Reply:

We have clarified this point adding more text and referring to Table 2:

"The global model runs are made for a full calendar year (2017). As some of the species have a long lifetime in the atmosphere (one month or more), the model runs are preceded by a 5 months spin-up. But for model runs perturbing only a limited sea area, the spin-up from the Base model run is used (see Table 2)."

Line 218: how did the authors calculate this nitrate contribution?

Reply: *Nitrate chemistry is included in the EMEP model. We have now included figure panels (in Figure 8) showing the fraction (of PM_{2.5}) of nitrate and also the fractions of*

C4

PPM and ammonium.]

Line 253: Section 5 instead of Sections

Reply:

This is corrected.

Lines 271-272: Please review this sentence.

Reply:

We have split this part into several sentences, making it easier to understand.

Line 296: ozone is, in particular, high...

Reply:

We have added the missing word "production".

Lines 303-306: please quantify these contributions.

Reply:

We have added:

"This is shown in more detail for the country attributions section below. "

Line 322-323: please clarify/explain why these contributions are negative in these areas.

Answer:

We have added "as a result of ozone titration".

Line 328: please review this sentence.

Reply:

C5

We have broken up this sentence to make it clearer.

Line 332: please quantify the ozonereductions mentioned.

REply:

We have rewritten this part, quantifying contributions.

Lines 334-342: the same comment before applies here (quantifications would be important).

Reply:

We have now quantified the depositions in the text.

Line 366: please review this sentence.

Reply:

We have rewritten this sentence to: "In Figure 4 the contributions to PM_{2.5} from all ships to selected European countries are shown as a percentage of all anthropogenic contributions calculated with ship emissions before and after the implementation of CAP2020. "

Section 5.1/5.2:

the authors identified previously a group of (significant) differences between the global and regional simulations (namely land and shipping emissions, scenarios applications, boundary and initial conditions) but they do not use these differences to explain some of the differences found in results. These differences, in particular, the emission data should be discuss - and in particular why these difference do not invalidate the comparison between the simulations.

Reply:

We have added that for both PM_{2.5} and the depositions of oxidised nitrogen and sul-

C6

phur most of the difference is caused by the higher emissions used in the global model calculations.

Conclusions Line 462:

I would suggest to modify the sentence to "Assuming the fulfillment of the legislation, it is expected that this result in substantial..."

Reply:

We have changed the sentence as suggested.

Lines 481, 487: please review these sentences:

Reply:

We have changed this part of the paper to: "Thus the additional benefits of global model calculations are small compared to the improvements in accuracy that can be achieved with finer resolution on a smaller model domain. For ozone, enhancing the resolution improves the representation of localised variations in NO_x to NMVOC ratios, explaining the differences in particular in the high NO_x emitting countries and regions bordering the North Sea. On the other hand, with global scale calculations the contributions to ozone from all global sources can be included. For several countries/regions we show that for ozone, contributions from ROW shipping are comparable, and in some regions higher than, the contributions from sea areas close to Europe. "

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