

## ***Interactive comment on “A modelling system for the exhaust emissions of marine traffic and its application in the Baltic Sea area” by J.-P. Jalkanen et al.***

**Anonymous Referee #2**

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Review of the paper "A modeling system for the exhaust emissions of marine traffic and its application in the Baltic Sea area"

by J.P. Jalkanen et al.

### **General comments:**

The paper describes a detailed bottom-up approach for the determination of ship emissions in regions where signals from the automatic identification system (AIS) that is aboard of all larger ships are available. It is an interesting approach that is very promising for a future use in emission models for subsequent air quality modeling. It can also

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be used to analyse current emissions and for the development of emission reduction strategies. The model is overall well described and the article is written in an understandable way. But there are also some shortcomings that should be addressed before the paper can be published.

What is particularly missing and what should be added to the emission inventory is the information about the height in which the emissions take place. Ship stacks can be quite high and the transport of the emitted gases considerably depends on the emission height. The authors clearly state that their model can be used as input for studies of the regional and long range transport of pollutants. This requires information about the vertical distribution of the emissions and I am sure that they can be derived from the detailed information about the ship characteristics that underlies this model.

Additional to that I am missing a better description of the limitations of the model and a discussion of the error margins of the emissions themselves. It is for example not clear if the model could be globally applied if AIS signals can only be picked up 90 km from the coast. The uncertainty of the emission factors is also not discussed nor is a perspective for other important emissions like PM (incl. soot), NMVOC or CO given. The uncertainties of the emissions themselves might be large and in sharp contrast to the accuracy of the activity data presented here.

The attempt to use a wave model and correct for the additional fuel use caused by waves is extensively described and certainly costly to implement. In the end it is not used here or the effect are described to be of minor importance in almost all cases. This is an interesting result and it would be good to give advice to others whether waves need to be considered in ship emission inventories or not.

### **Specific comments:**

page 15340, line 15: Which time frame underlies the accuracy of 6 %. I assume it's an annual average but this should be stated. It should also be said more clearly from the beginning that data for the complete year 2007 is presented.

page 15340, line 24: "provided that AIS data are available": the reader cannot judge

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what this limitation means. Is the data freely accessible? What about regions far from the coast? This needs to be discussed and not only stated.

page 15341, line 10: "60000 premature deaths": in which time?

page 15342, line 10: Here it is said that a complete coverage with data from the AIS will not be possible in most regions. This contradicts the potentially global use that is described on page 15343, line 21.

page 15343, line 2: It is hard to see where a temporal resolution of one second would be needed. Additionally this resolution only holds for the position and the speed of the ship, so in my opinion this statement is misleading. In the real world, the ship emissions at the stack will certainly also fluctuate on a level of seconds but this cannot be reflected in the emission inventory and therefore the authors should not pretend an accuracy that cannot be reached with temporally constant emission factors. It is far more important that the **position** of the ships can be determined very accurately.

page 15343, line 21: As far as I understand the system might also be applied in other regions of the world but not globally in a sense of everywhere around the globe. It would be interesting to know if the AIS data from other regions than the Baltic Sea would be available.

page 15344, line 3: what is a "small craft"? Smaller than what, please be more specific. If I understand Fig. 8 correctly this might be 23 % of all ships which is quite a lot.

page 15344, line 6: Can you comment on the uncertainty of these emission factors? Have there been comparisons to real measurements at the stack or behind the ship?

page 15344, line 9: Please give a formula how the emissions of SO<sub>2</sub> and CO<sub>2</sub> are calculated.

page 15344, line 18: How often is the IMO curve not used? How often are measured emission levels available?

page 15345, line 1: "2.0.1": strange numbering, is most likely wrong.

page 15345, line 26: So how do you determine k? This is not described.

page 15346, line 21: " ... if the shipowner has made this data available." Again a limitation that cannot be judged by the reader if it is of importance or not. How often is data

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from the ship owners available? I would assume this is the minority of cases.

page 15347, line 4: How many ships are RoPax vessels? Is it enough to validate the dataset with these 6 ships?

page 15347, line 7/8: Same comment as page 15346, line 21

page 15347, line 22: I would like to see a graphic for the directional part of the speed penalty.

page 15348, line 13/14: Strange symbol for the displacement volume.

page 15348, line 23: What is the argument to restrict the speed penalty?

page 15349, line 8: How many (percentage) measured emission factors are in the data base? How much do they deviate from formula (1)?

page 15349, line 23: How often (percentage) are the average values used?

page 15349, line 16: if the share of small crafts (unidentified vessels) is at a maximum 10 % in summer, why is the number of vessels with unknown age 23 % of all vessels in Fig. 8?

page 15350, line 22: "fuel oil consumption of 200 g/kWh is used by default for all engines". Other authors (e.g. Endresen, 2003) differentiate between different speeds. Why is this not done here? This gives the reader the impression that the activity data is handled in very high detail while the emission factors are rough estimates. You should try to avoid this.

page 15351, line 5: "In the following ...". The sentence is misplaced here.

page 15351, line 12-14: This paragraph as well as Fig. 2 are not necessary and should be deleted.

page 15351, line 27: "kW value" is colloquial.

page 15352, line 14: The inclusion of wave effects leads to slightly worse agreement (in this single case) and the overall effect is of minor importance. This should be stated more clearly, it could also be said here that the following calculations neglect the effect of waves.

page 15353, line 27: Is Lloyd's ship register freely accessible in the www?

page 15354, line 1 and Fig 8/Fig 9: It would also be interesting to know the average

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power of the ships in the different categories because this should be directly related to the emissions. It is quite surprising that RoRo/Passenger ships have so high emissions despite their low share in total number.

page 15354, line 18: "Pushing engines to their limits rapidly increases the fuel consumption ...": I understood from page 15350, line 22, that fuel consumption depends only on installed power (or on used power?). How do you consider the effect of a tight schedule in your model?

page 15354, line 21: " .. the electricity ... cannot be obtained this way." What is the implication? What do you want to say with this statement?

page 15354, line 27, Fig 11/12: Why is this only given for NOx? You should also explain why the distribution into flag states is of interest.

page 15355, line 4: "Clearly, ..." Is this meant as excuse? What about Poland and the Baltic States?

page 15355, line 15: The vertical is also a spatial dimension that should not be left out if you claim an extremely high resolution of your data.

page 15356, line 16: It would be nice to give an estimate on the overall uncertainty of the emissions and state what the largest uncertainties are.

page 15357, line 5: "... provided that the AIS data ...": Again a limitation of which the reader does not know what it means. How realistic is it to use the model somewhere else?

#### **Technical corrections/ minor comments:**

page 15340, line 4,5: double use of "enable"

page 15340, line 14: explain RoPax here

page 15341, line 17: "IMO, 1973": shouldn't this be IMO, 2008? The current way to cite the IMO regulations implies that the emission reduction process that is currently under way was already decided in 1973.

page 15342, line 25: better: "one port of call per day and per vessel, even if a vessel was engaged ..."

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page 15347, line 10: "Waves tend to increase ...": imprecise statement

page 15347, line 18: "wet surface": it would be better to explain what is exactly meant with this expression.

page 15351, line 19: "423 h", "3632 h": give also percentages

page 15352, line 23: Would be good to mention the year 2007.

page 15353, line 19: Better: "... there were about 4500 ships traveling in the Baltic Sea, while ..."

References: missing title in Bewersdorff (2008) and in Kahma (1986).

Caption of Fig 7: the line with the SOx emissions is yellow.

Fig 9: Why are SOx and CO2 not always in the same proportion? Is this the influence of the auxiliary machines? Might be worth to explain it in the text.

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