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***Interactive comment on* “The impact of shipping emissions on air pollution in the Greater North Sea region – Part 1: Current emissions and concentrations” by A. Aulinger et al.**

A. Aulinger et al.

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R3 & A3 (missing model performance evaluation): Not good enough. Evaluating emission factors is one thing, but the second half of the emission calculations, power prediction, can be evaluated with ship owner fuel reports and these do not necessitate experimental measurements. Every vessel owner will keep a close eye on the fuel used and I am sure that the authors could contact some owners and check the validity of their predictions for a selected set of vessels. This is not beyond the scope of this paper, but is an essential step in checking the validity of predictions. I can accept the fact that some measurements are confidential, but in those cases vessels can usu-

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ally be treated as anonymous ships which is not a breach against a non-disclosure agreement.

Answer: We evaluated the outcome of both the emissions model and the subsequently applied chemistry transport model against real data, namely EMEP monitoring data by means of detailed statistical analyses. As pointed out before our emission and fuel consumption functions were derived from a large number of test bed measurements. On the one hand, it is certainly valuable to check these functions - gained under idealized conditions - with data collected under operational conditions. However, we do not share the experience that vessel owners are open about their fuel consumption data. In addition, we would need data from a large number of ships, because we think it is doubtful to extrapolate results from a few ships to the entire fleet in a statistically sound way. We are convinced that evaluating the end result (i.e. concentrations) is meaningful and gives enough confidence in the emission inventory.

R12i & A12 (BC double counting): Not good enough. The stance taken by the authors goes against the current best knowledge of BC emissions from marine engines. You should include at least some discussion of BC dependence on fuel sulphur and engine load and explain why your approach differs from the currently known literature. In this regard, papers from Lack, Corbett, Buffaloe, Petzold, Cappa are most relevant.

Answer: In the revised version in which we added a description of the emission factor functions, we mention also the relation between fuel S content and BC emissions (section 2.4.3) and we use different BC emission factors for MDO and HFO. The emission factors were developed in cooperation with Germanischer Lloyd (now DNV-GL) who also carried out the measurements. The thermo analytical method described is a certified method, which minimizes double counting of particulate components, and used by DNV-GL on a routine basis. We added a reference.

R14k & A14 (Aux engine load set to 0.3): Not acceptable. You are cutting corners here and introducing unnecessary uncertainty to your results. In the ENTEC report,

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which is more than a decade old anyway, no difference is made for the usage of aux engines in 2-stroke and 4-stroke engines and all are treated the same with arbitrary 0.3 engine load assignment. First, ENTEC lumps all aux engine power to one engine and does not consider the use of multiple engines. Second, there are fundamental differences in these two cases (2/4-stroke), because shaft generators can be used only in the latter cases because of the constant rotational speed of the main engines. For 2-stroke engines, this will increase the share of fuel burned in aux engines because this is the way to produce the electricity needed onboard. It is exactly the opposite for 4-stroke engines. I would suggest you take a look at the work done for the Port of Long Beach (<http://www.polb.com/civica/filebank/blobdload.asp?BlobID=13033>) which are based on vessel boarding programs to determine the actual use of aux engine power instead of fleet-wide 0.3 load assignment.

Answer: We answer to this remark and remark #R23v in the attached document Aux-Container.pdf.

R15n & A15 (BC emission factors): Authors have partly responded this question, but have not addressed the fuel sulphur and BC dependency in any way. See my comment R12i.

Answer: This is described in the new emission factor section 2.4.3.

R20s & A20 (contribution of ships to overall air quality): The authors are very close to nullifying their own emission work with the claim "Our primary goal was not to improve emission inventories". I find this odd, because significant effort was put to emission work but If the improvement of emission inventories was not the purpose of this paper then what was? You cannot shrug off the discussion of emission model performance evaluation by just declaring that this was not the purpose. What new information was produced which was not available with the use of EMEP ship emission inventories? Production of emission inventories for BC could be one benefit, but it is not discussed. I am sure there are other benefits, too, but the question about the reliability of newly

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generated emissions data sets remains.

Answer: Our work is meant to show both, a new ship emission inventory for the North Sea, which is very detailed in time and space, and the impact of ship emissions derived from this inventory on the concentrations of pollutants in the coastal atmosphere. In order to show the improvements in the simulation of pollutant concentrations that can be made with the new emission inventory we ran the CTM with ship emissions from the EMEP data base and compared the results with our base case run for some exemplary stations. However, we discovered that the numbers we found on the EMEP website in 2014 changed significantly to lower values with the revision of the EMEP emission inventory in 2015. We describe this in the text and provide both numbers in a table. For the comparison we used the revised EMEP emissions. The median difference of NO₂ concentrations between the two model runs – looking only at North Sea coastal stations that are influenced by ship traffic – is 0.09 $\mu\text{g}/\text{m}^3$. We added this finding to section 5.1.1 and remark that it cannot be clearly distinguished which model performs better (see the time series plots for Westerland and Cabauw: Westerlandobsmodts.pdf and Cabauwobsmodts.pdf). None the less, as every model has uncertainties we think that the introduction of a new modeling approach has an added value by itself – provided the model formulation is sound of course. Second, the presented model follows a bottom-up approach that is completely flexible in terms of spatial and temporal resolution and allows for developing scenarios (see “The impact of shipping emissions on air pollution in the Greater North Sea region - part 2”)

R23v & A23 (Aux engine allocation for cargo ships): Not acceptable. If you take a look at the port of Long Beach emission inventory mentioned in R14k, you will notice that there is almost an order of magnitude difference in aux engine need within the containership class alone. It becomes even worse if all cargo ship classes are involved. All cargo ships should not be treated the same way. Perhaps it could help if vessel size categories would be introduced and the aux engine usage were to be considered as a function of both vessel type and size?

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Answer: We answer to this remark and remark #R14k in the attached document AuxContainer.pdf.

Please also note the supplement to this comment:

<http://www.atmos-chem-phys-discuss.net/15/C9796/2015/acpd-15-C9796-2015-supplement.pdf>

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 11277, 2015.

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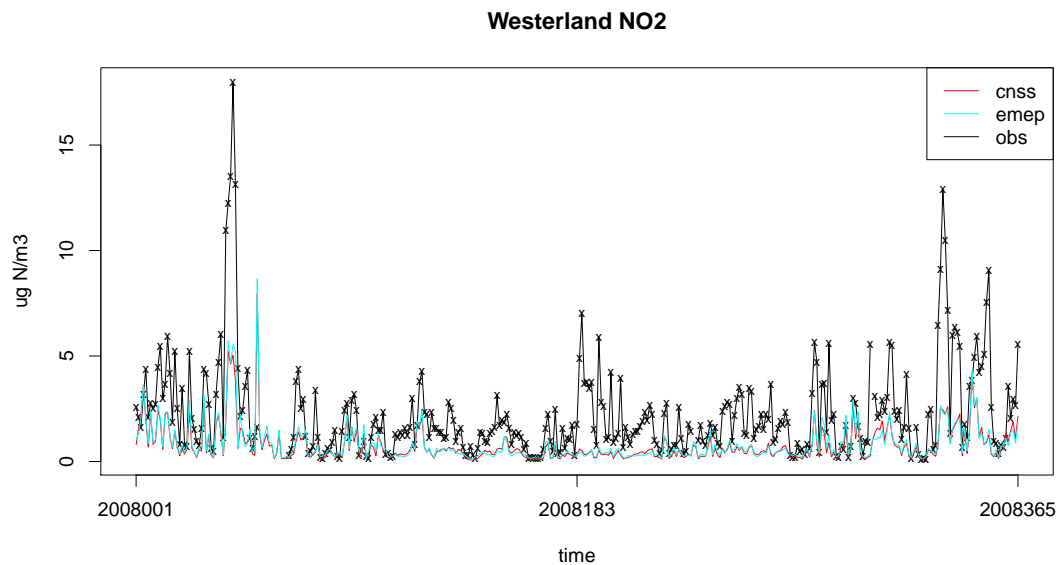


Fig. 1. NO₂ model comparison at Westerland

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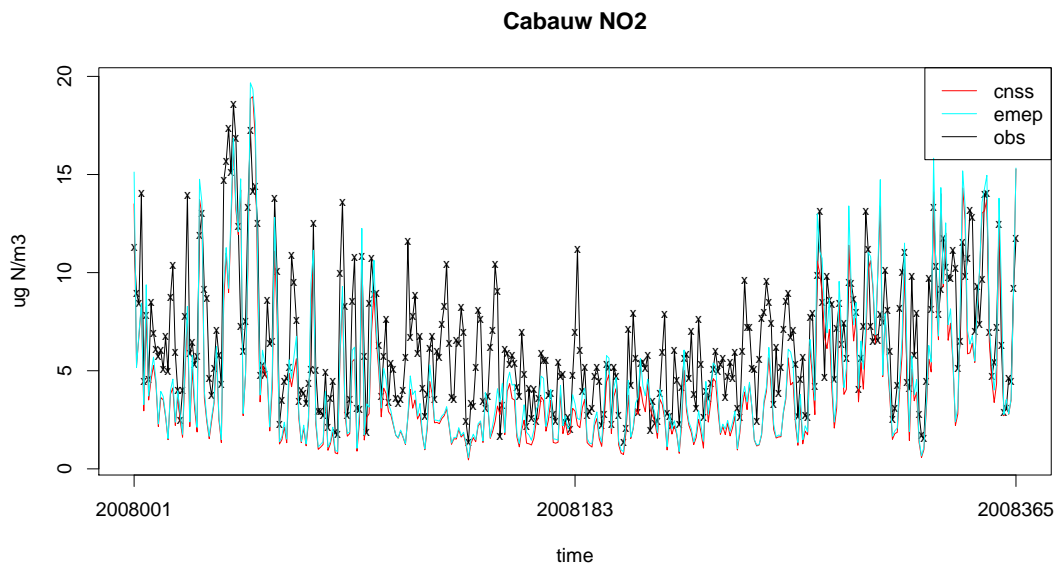


Fig. 2. NO₂ model comparison at Cabauw

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