

## ***Interactive comment on “Modeling the regional impact of ship emissions on NO<sub>x</sub> and ozone levels over the Eastern Atlantic and Western Europe using ship plume parameterization” by P. Huszar et al.***

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We would like to thank Referee #2 for the detailed and constructive comments and corrections. Our responses are as follows, point by point.

Scientific corrections

COMMENT 1.: Figure 7 (bottom row) potentially shows some model boundary effects. At the end of the shipping lanes in the western part of the domain there are changes over -25% which don't make physical sense, I think. Please explain if these are real

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changes or are a result of boundary conditions imposed at the western boundary.

RESPONSE: Boundary conditions were set to typical background conditions and are same in all runs performed. Therefore the simulated effects of ship NO<sub>x</sub> emissions and the parameterization itself is suppressed towards the boundaries due to fixed boundary values of NO<sub>x</sub> and ozone. For this reason, the simulated differences at the boundaries should not be accounted for as they are not realistic. This will be stated clearly in the revised manuscript.

COMMENT 2.: Figure 14. The lines and triangles are far too small for easy visual comparison both in online and in the pdf for printing versions of this article. Perhaps it would be better to separate these three graphs into three individual figures. I think that a comparison of model results with actual observations for a paper such as this is important enough to merit 3 separate easily readable figures. Otherwise, the impact of doing the comparison is lost. Also, colour could be used effectively here, but if the figures were larger, gray scale would be OK too.

RESPONSE: The plots presenting model's comparison with measurements were enlarged to form a single column. The plots are now more visible.

COMMENT 3.: It would be helpful to hear more about the meteorology that the authors hope to capture at the regional scale. Which processes do they believe that the meteorological model represents well? Which processes are missing? What are the simulated differences between coastal and remote ocean in the model atmosphere?

RESPONSE: Regional climate models (RCM) like RegCM are primarily intended to dynamically and physically downscale the coarse information provided by global circulation models or, in case of present and past simulations, the available reanalyses (NCEP or ECMWF). At substantially higher resolution at which RCMs can operate comparing to global models, many orographic and landuse features are "seen" by the model which are not resolved at coarse resolution these reanalyses represent. Model RegCM has been used at Charles University for a long time and we carried out multidecadal simulations at similar resolution and configuration (45 km grid step, same large scale and cumulus precipitation etc.) like in this study. We tested the

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model's performance focusing on Central Europe (Halenka et al., 2004; additional reference in the revised manuscript) and also on other parts of the continent that lies within the modelling domain (Bergant et al., 2006; additional reference in the revised manuscript). Both studies showed that RegCM is capable to capture the regional features of the mid-latitude climate over Europe. However, running such a RCM over the remote ocean, one must not forget that the only possible high resolution forcing there could be the sea surface temperature (SST), but SST is prescribed at coarse resolution and RCM is not coupled with ocean to downscale SST. In this case, we can expect that the model will reproduce the meteorology of the reanalysis, so its performance over these remote regions will be directly dependent on the quality of the global data. Two paragraphs were added in the model configuration section 3.3 to discuss this issue.

COMMENT 3a.: For a specific example, see Page 26748 line 26. "...during usual situations in the troposphere..." is a very vague statement. Are we to think large-scale, seasonal, midlatitude,...?

RESPONSE: By "usual" we rather mean "unpolluted" conditions. The sentence was reformulated to: "...As it was already mentioned, in unpolluted regions of the troposphere, the increase of nitrogen oxides at moderate levels leads to..."

COMMENT 3b.: Pg 26754 Line 25-27, what do "these variations" refer to? wind variability? cloud cover? stability of the boundary layer? And just to be clear, please state exactly what the phases of plume dispersion are on line 27. Are you thinking of early high concentrations, transition to heterogenous conditions, and a dilute or homogeneous phase?

RESPONSE: We clarified the points you raised and reformulated the corresponding paragraph as follows: "...In the future, it should be calculated online from the driving meteorological model to follow the variations of the local background conditions such as wind speed and direction, cloud cover and stability of the boundary layer. Another improvement could be achieved by considering different regimes of plume dispersion, for example the initial high-concentration regime with (essentially) vertical dispersion

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during plume rise, and the horizontal dispersion regime after the plume reaches the top of the boundary layer (see e.g. Chosson et al., 2008). This would require the introduction of multiple tracers and..."

COMMENT 4.: In Section 3, the models' resolutions are not described until section 3.3. I expected to read about this much sooner in a paper about ship plume parametrization. It would be helpful to have the models' resolutions briefly stated in section 3.1 and 3.2 and then a brief statement about how the resolution is discussed more deeply in section 3.3.

RESPONSE: A sentence was added to the first paragraph of section 3 to introduce the reader the spatial resolution of the models applied. We do not find it important to add statement about the resolution to sections 3.1 and 3.2, as they intend to describe models RegCM and CAMx in general without specification of the particular configuration.

COMMENT 5.: Pg 26748 Lines 23-25. Please be more specific about these "just small changes." Can you give a ratio of the values of surface to higher model level to illustrate the point? Also, absolut should read absolute.

RESPONSE: The sentence was reformulated and now clearly states that the NO<sub>x</sub> changes at higher model levels are less than 1/10 of the changes at the surface.

COMMENT 6.: Sometimes the word annual is used when referring to figures where seasonal results are displayed. This is confusing because I understand that the models are run for 2004, a single year with various parameters changed. There is no interannual variability being studied. For example, I found the reference to figure 5 on page 26749. line 11 confusing. "...contribution to total surface ozone as annual average makes 6–8% over the remote sea..." Do you mean that you have calculated an annual average which is not shown in this paper? Also, should write "is 6–8% over the remote ocean."

RESPONSE: The text has been corrected so that if annual average is not explicitly shown, this is clearly stated in the text (in case of Fig. 5.). Annual average of ozone change in Fig. 4 was removed and the results are only mentioned in the text without

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presenting them in a figure.

COMMENT 7.: Pg. 26754 Line 18 Do you mean NO or NO<sub>x</sub>?

RESPONSE: We mean nitrogen monoxide (NO) as this species has been compared to measurements.

General Technical Corrections:

COMMENT 1.: Use of the word "sea" in the context of "Remote sea" when authors really mean the remote Atlantic ocean. Should change references to "remote ocean". For eg. pg 26750 line 19.

RESPONSE: "Remote sea" changed to "remote ocean".

COMMENT 2.: Be consistent with usage. Choose either off-line or offline, on-line or online.

RESPONSE: On-line/off-line has been changed to online/offline where appeared.

COMMENT 3.: There are many places in the paper which need slight tuning to improve the English and make the paper more readable and clearer. For example on page 26737 line 6 should be "aircraft" not "aircrafts", and on the same page, line 26 should read "In the case of a chemically..." If possible, I would recommend the authors have a native English speaker provide some editing. This is a good paper which would improve with such fine tuning and possibly make it more likely to be widely read.

RESPONSE: The authors will consider the option of correction by a native speaker.

Specific Technical Corrections:

AUTHOR'S RESPONSE: All the specific technical corrections have been implemented in the revised manuscript. We would like to respond explicitly to the following comments:

COMMENT: 4. Information given in Table 3 would be much better as a simple graph showing the model height as a function of model level. This would provide a more intuitive and easier to visualize expression of model resolution. It would easily show how the model spacing varies as we go up in height.

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RESPONSE: Table 3 was replaced with a figure showing model heights as a function of model levels.

COMMENT: Pg. 26742. Line 17. What are the characteristics of the marine boundary layer that you are referring to? Please describe what you attempt to capture in the model.

RESPONSE: We changed the text to make clear what these characteristics are. "To evaluate Keff we have adapted the box model used by Cariolle et al. (2009) to take into account the values of *pressure, temperature and humidity*, as well as the chemical reactions occurring in typical marine boundary layers."

COMMENT: Pg. 26742. Line 3. "...must be consistent." What must be consistent? Is it the values of I and EI\_NO<sub>x</sub>? Can you give a set of specific values used in this study or tell us what constitutes a consistent set?

RESPONSE: The "...must be consistent" was deleted and a reference to Sect. 3.3 has been added where the relation between emission index (EI) and I is described in detail.

COMMENT: Pg. 26743 Line 1. The "rather short plume lifetime" is short because you assume it to be in this study. Please state that the shortness of the lifetime is a parameter chosen in the study.

RESPONSE: A statement has been added that clarifies that the plume lifetime was chosen by the authors based on the study of Chosson et al. (2008).

COMMENT: Pg. 26745 Line 13. "one of the most intense vessel traffic" should be qualified. Is it the most intense in the world? in Europe? in the Atlantic?

RESPONSE: It was clarified that this area represents one of the most intense ship traffic in the world.

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Interactive comment on Atmos. Chem. Phys. Discuss., 9, 26735, 2009.

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