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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Shipping emissions in the Iberian Peninsula and its impacts on air quality" *by* Rafael A. O. Nunes et al.

Anonymous Referee #2

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The study evaluates the impacts of shipping emissions on the air quality in the region of the Iberian Peninsula and the Strait of Gibraltar, one of the busiest maritime routes in the world. This chemistry-transport modelling study makes use of shipping emissions generated by the STEAM 3 model that allocates ship activities via the Automatic Identification System operating onboard the vessels. Among the valuable information presented in this manuscript are a comparison of ship emission intensities with those reported for ports in the Asian region and a calculation of the ship impact on exceedances of regulatory air quality limits. Unfortunately, it is not immediately apparent what the manuscript adds to already published chemistry transport modelling studies on the impact of ship emissions in Europe. Overall, the manuscript reads more like a good technical report than a research article, as the applied methods are not originally

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proposed and the uncertainties of model results are not comprehensively discussed and quantified.

The spatial resolution is the same as in prior studies that covered the whole of Europe. This is somewhat surprising, given that a prior study by Monteiro et al. (2018) in the same region used a finer resolution (3 km x 3km). The applied difference method for quantifying the shipping emission contribution is flawed since the effect of nonlinearities in ozone chemistry on the ship impact was not evaluated, despite the high photochemical activity in this region. For both daytime and nighttime, the instantaneous NOx lifetime in ship plumes is a strong function of the initial NOx concentration at ship stack, resulting in a very nonlinear loss rate for NOx in ship plumes (e.g. Song et al., 2003). Model procedures that shift ship plume levels by an order of magnitude, as can be expected for a 10-km wide grid cell, will quite likely overestimate NOx lifetime.

The heat release from ship stack exhaust of large ships represents a buoyancy flux that may result in plume rise. Therefore, we can expect that a significant fraction of the shipping emissions are emitted at upper heights. The STEAM 3 model should be able to take into account plume rise of ship exhaust in generalized form. A description of the treatment of the vertical distribution of shipping emissions and injection heights that are used for the corresponding vertical layers of the EMEP modelling system should be added to the method section. When shipping emissions have been fully transferred to the lowest vertical model layer, such a procedure has to be justified and the error due to this needs to be approximated.

The significance of the modelled ship contribution was not validated with measurements. Although the Norwegian Meteorological Institute regularly validates the air quality predictions with the EMEP MSC-W model for Europe, it is not sufficient to simply refer to this. The manuscript should include a validation of the modelled concentrations in the subdomain region with monitoring data from stations in Portugal, Spain and France for 2015 (EMEP network, EEA AirBase, EBAS database). The comparison should include model data from both runs with and without shipping emissions.

Specific Comments:

1.) P. 1 lines 24 - 26: Many studies can be found about the impacts of shipping emissions on air quality and health. It would be a good place here to discuss deviations and contradictions in the literature concerning the relevance of shipping for health impacts, and specifically the roles of primary versus secondary particulate matter.

2.) P. 4 lines 111 - 114: Which boundary conditions of the chemical concentrations were used for the subdomain runs?

3.) P. 5 line 157 to P. 6 line 173: Suggest to transfer the information of annual average emission intensities (per pollutant and per port/sea area) into a table to facilitate the comparison with shipping activity in the Asian region.

4.) Impact on Air Quality: Suggest to divide section 3.2 in topical subsections; for example “Annual average concentrations” (P. 7 lines 202 - 218), “Comparison with previous studies in the region” (P. 7 line 219 to P. 8 line 250), “Seasonal variation” (P. 8 lines 251 - 260), “Possible health impacts” (P. 8 line 261 to P.9 line 297). Some passages could be shortened.

5.) P. 9 lines 276 - 287: Suggest to illustrate the contribution of shipping emissions to the exceedances of limit values in form of a bar diagram, i.e. showing the increment of number of exceedances (NO2, PM2.5, PM10) and number of days of exceedances (SO2) due to ship traffic for the major ports of the Iberian Peninsula.

6.) Uncertainties and limitations: The uncertainties of the emission factors of pollutants from different ship types could easily dominate the uncertainty of the evaluated contribution from shipping. With the STEAM 3 model at hand, it should be possible to estimate the overall uncertainty in the modelled concentrations due to uncertain emission factors. To arrive at a more reliable margin of the contribution of shipping emissions in this region, my request to the authors is that they perform shipping emission calculations with the respective lower and upper bound of the emission factors of

NOx, SOx and primary particulates, then repeating the runs with EMEP MSC-W using the lower and higher emission dataset.

Technical Corrections:

P. 1 lines 17 - 18: “ktonnes y-1” is not a SI unit.

P. 1 line 27: on a global scale?

P. 1 lines29 - 30: reference(s) for this statement missing.

P. 3 lines 66 - 67: suggest to reference the study of Ramacher et al. (2019) on local scale for Baltic Sea ports.

P. 5 line 150: “ash” – what is this chemically? Please define.

P. 8 line 232: please replace “lower increases contributions” by “lower positive contributions”.

Conclusions: the word “verify” is used several times in the conclusions section (P. 10, line 321; P. 10, line 324; P. 11, line 330). Verification implies the comparison of model results to the true values, which are not known. Please change wording.

P. 11 line 340: what about the code availability of STEAM 3? Please include a statement here.

P. 15 lines 469-471: the citation of Marelle et al. is incomplete.

Table 1 and Table 2: “tonne y-1” is not SI unit.

Figure 1 and Figure 2: please use SI units in labels, axis annotations and captions.

Figure 4f: what is the cause for high O3 values along the North African coast over water?

References:

Ramacher, M. O. P., Karl, M., Bieser, J., Jalkanen, J.-P., and Johansson, L.:

Urban population exposure to NOx emissions from local shipping in three Baltic Sea harbor cities – a generic approach, Atmos. Chem. Phys., 19, 9153–9179, https://doi.org/10.5194/acp-19-9153-2019, 2019.

Song, C. H., Chen, G., Hanna, S. R., Crawford, J., and Davis, D. D.: Dispersion and chemical evolution of ship plumes in the marine boundary layer: Investigation of O3/NOy/HOx chemistry, J. Geophys. Res., 108 (D4), 4143, doi:10.1029/2002JD002216, 2003.

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