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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Air quality and radiative impacts of Arctic shipping emissions in the summertime in northern Norway: from the local to the regional scale" *by* L. Marelle et al.

Anonymous Referee #2

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General Comments:

This paper examines the impact of shipping emissions in northern Norway on air quality and aerosol radiative effects. Aircraft measurements taken during summer 2012 are combined with modeling using FLEXPART-WRF to derive ship emissions for NOx and SO2, which are then compared to an existing inventory (STEAM2). The STEAM2 inventory is then implemented in WRF-Chem to quantify the impact of these shipping emissions on pollutant concentrations and the impact on aerosol radiative effects. The paper is well-written and addresses an important issue for a warming Arctic since shipping emissions are expected to increase in the coming years. There are a few expla-

nations related to the analysis that are not fully developed as outlined in the specific comments below, such as the impact of black carbon from ships on the radiative budget. The scope of the paper is suitable for ACP and the paper should acceptable for final publication provided the following comments are satisfactorily addressed.

Specific Comments:

1) Abstract, L9: Consider noting here that the ship emissions implemented in the WRF-Chem simulations are STEAM2.

2) Abstract, L22: Could the impact on SO2 also be quantified here?

3) There is the large negative forcing (cooling effect) due to the ship emissions, but a substantial increase in black carbon. Could there be a few more details added about why the warming effect is not that great. How are the radiative effects for black carbon parameterized in the model? Is there any uncertainty related to these parameterizations for black carbon and how does that influence the analysis?

4) P 18411, L21: What is the time frame for the long-term cooling mentioned here due to reduced CO2 emissions?

5) P 18414, L4: The text mentions that 4 flights are used to derive emissions, it is not clear when these 4 flights occurred since the text seems to indicate that only July 11 (2 flights) and July 12 flight were used.

6) P 18415, L10: The analysis requires that the environmental conditions are not strongly varying. Was this condition met? Is that why the contributions from weather effects was neglected as mentioned in P 18418, L25?

7) P 18419, L25: Very strong SO2 emissions due to smelting are mentioned in relation to Fig 2d, but this is not evident in the related panel.

8) P 18421, L14: Are you able to quantify what you mean by 'Modeled and measured plume locations agree well'? Looking at Fig. 3C and 3D, the observed plume maximum

near 14E 68.8N looks to be further to the west than the simulated plume, whereas the agreement seems closer for the other panels (A and B, E and F).

9) Why does Fig. 4 not include the July 11, Z= 165m related to Fig. 3 panels C and D? Does this time series differ?

10) P 18422, L13: The methodology requires a linear relationship between emission flux and tracer concentration. Can you briefly note why this condition is satisfied?

11) Eq.(1): How is the background mixing ratio determined?

12) There is a large discrepancy for NOx between the derived emissions and the STEAM2 emissions. Since STEAM2 emissions are used in the subsequent calculation of impacts on air quality and radiation, how does this overestimation influence the results and what is the related uncertainty in the presented contribution to the ship emissions to air quality and radiative effects?

13) P 18428, L22 (Fig. 6): This comparison is only presented for NOx and O3 on July 11. How did the model and measured NOx and O3 compare for July 12? How does the comparison look for SO2?

14) P 18429, L8: Simulation CTL looks to agree more closely with the measurements than CTL3, although both have a negative bias. Is the NOx overestimation the source of this negative bias?

15) P 18430, L5: The text notes that PM1 and SO2 are overestimated by about 25% and 35%, respectively. How does this overestimation influence your subsequent analysis of the aerosol radiative effects.

16) Fig. 8 shows that the ships have little effect on the vertical profile of PM2.5 – how do we reconcile this with the magnitude of the aerosol radiative effects that are presented?

17) P 18431, L18: The analysis of the regional impacts is based a 15-day period.

How does the period chosen influence the results? Would the results for the radiative impacts and concentration enhancements be any different over a different time period?

18) Why does the PM2.5 appear to have little change near the surface in Fig. 8 but greater change for the 15 day average at the surface for Fig. 9?

19) P 18433, L 5: Can you explain why BC is not efficiently transported away from the source region? Is the lifetime really that short and why?

20) Section 5.2.2: Could the discussion and analysis be extended to include a comment of the role of black carbon. The paper attributes a 40% enhancement in black carbon to shipping – how does this influence the radiative effects presented?

21) P 18435, L20: The PM10 enhancements are 15% higher in the 3km x 3km simulations. How does this influence the results for the effects on the radiative budget calculated at 15 km x 15 km?

Technical Corrections:

1) P18415, L1: Was the acronym FNL defined?

2) P 18423, L1: Are the units correct in the text? Please check.

3) P 18423, L18: I have difficulty to see the 4 SO2 peaks above 1ppb for the Nanjing ship in Fig. 4 please check if this is shown and perhaps consider changing the colors since the pink and red lines are difficult to differentiate. Are not all of the peaks for the various ships mentioned in the text shown in the related figure?

4) P18427,L 24,25 and elsewhere: Consider removing the word 'see' as a directive to the reader.

5) P 18429, L3: The text comments on an overestimation of NOx in the plumes for simulation CTL. This is not clear in Fig. 6.

6) Fig 8: Consider presenting the measurements in black as opposed to color in keep-

ing with standard convention.

7) P 18433, L23: I found the terminology ‘averaged over the surface of the Earth’ to be somewhat confusing. Consider giving an equation to explain this calculation.

8) P 18435, paragraph 1: Consider quantifying the overestimation of NOx here and consider quantifying that is meant by STEAM2 emissions ’agreeing well with airborne measurements’ and ’reasonably well representing average emissions’.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 18407, 2015.