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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Multi-model simulations of the impact of international shipping on atmospheric chemistry and climate in 2000 and 2030" *by* V. Eyring et al.

Anonymous Referee #2

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General Comments:

The authors have assessed the impact of ship emissions for year 2000 as well as 2030 based on 10 state-of-the-art global atmospheric chemistry model simulations. The ensemble of the model simulations represents the most robust model prediction of the effect of ship emissions of NOx and SO2. The 2000 ship emission data was based on EDGAR 3.2 dataset developed by Olivier et al. (2001). For 2030 simulation, the authors devised two scenarios: constant emission at 2000 level and ramping up by 2.2% per year. The ensemble model simulation suggested an up to 5 - 6 ppbv near-surface ozone increases due to ship NOx emissions for 2000 and an 8 ppbv enhancement for 2030. Based on the model predicted ozone levels the authors further estimated the climate impact, i.e., ozone radiative forcing and OH enhancement which in turn shortens the lifetimes of greenhouse gases.

The manuscript is well structured and well written. The model descriptions are generally brief and concise. The presentation of model results is well organized. In addition, the authors have also contrasted different models and addressed several important aspects of uncertainties in the model simulations. The major flaw of this work lies in lack of comparison with NOx and SO2 observations, which is an effective way to give model predictions a reality check. The authors discussed the difficulties in comparison with satellite NO2 data. However, airborne datasets should have been considered as it becomes increasingly available in terms of geographical as well as temporal coverage. It is critical to include some level of comparison with in-situ observations before publication. A large portion of the data is archived at http://www-air.larc.nasa.gov/ in standardized and user-friendly formats.

Early ship emission works suggested large impact of ship emissions on ozone (e.g., Lawrence and Crutzen et al., 1999). These results were immediately challenged by Kasibhatla et al. (2000) and Davis et al. (2001) using the airborne observations available at the time. The later works pointed out that the model simulated NOx levels were about a factor of 3 - 10 higher than those recorded during airborne campaigns while the model SO2 levels were significantly lower than the observations. It was suggested that the model biases were likely caused by either one or a combination of the problems in ship emission inventories and missing sub-grid plume processes. Song et al. (2003) further demonstrated the importance of in-plume photochemical loss of NOx through a series of Lagrangian model simulations under a wide variety of conditions. Based airborne observations of ship plume, Chen et al. (2005) verified the rapid in-plume NOx destruction. It is clear that the authors recognize the importance of the in-plume chemical processes and the deficiency of the current global model in dealing with the ship emissions. It should be emphasized that with an ensemble of 10 state-of-the-art global atmospheric chemistry model simulations this is an ideal opportunity to re-examine the magnitude of model biases in NOx and SO2.

A quick look at NASA INTEX-NA data reveals that the 0 - 1 km NO2 (BL NO2 typically accounts for about 80% of NOx) data are in general agreement with the Table 1 cited in Kasibhatla et al. (2000). The data shown in the table (in the same format as that of Kasibhatla et al.'s Table 1) below were derived from the observations made between 60°W to 30°W over the North Atlantic in late July, 2004. The data files were downloaded from the NASA ftp site given earlier. As one can see in the table, these median values together with those shown by Kasibhatla et al. (2000) can be an order of magnitude lower than those predicted by models for year 2000. At minimum, the authors need to compare the ensemble model simulations for 2000 with airborne observations given by Kasibhatla et al. (2000) and Davis et al. (2001). It would make the comparison more robust if the authors can fold in the data from the more recent field campaigns (e.g., ICARTT, NASA TRACE-P, and ACE-Asia).

Percentile	NO2 (pptv)	SO2 (pptv)
5	4	88
16.5	8	133
50 (median)	22	613
83.5	49	2504
95	88	3324

Number of 1-minute averaged obseravations of NO2 and SO2 are 159 and 189, respectively.

Taking the airborne observations as a limiting case and based on the sensitivity analysis shown in the manuscript, the authors need to comment on in the "Uncertainties" section in terms of what magnitude of ozone production would be and consequently what the climate impact would be. These results will provide readers an even more realistic range of answers which can be expected. This reviewer recognizes that global

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model is the only effective tool to assess the ship emission impact in the global scale. Thus, it is imperative to develop innovative approach/parameterization to better simulate the enhancement in NOx and SO2 due to ship emissions. In addition, the authors are encouraged to recommend the location and type of in-situ (both airborne and ground based) measurements for future studies, which may help validate global model simulations of ship emission impact.

Specific Comments:

Page 8565-8566: Would the model meteorology difference have some effect on the predicted vertical distributions of NOx? The authors should consider expanding their discussion on the differences in model meteorology.

Page 8569, line 18-19: The saturation effect is NOT visible to this reviewer.

Page 8577, line 26: Chen et al., 2003 should be Chen et al., 2005.

Page 8578, section 4.1.2: How much difference between the model predicted NOx is due to the model grid size difference?

Page 8595: Figure 2 label is not completely consistent with the model list in the text. This reviewer can not find the UIO_CTM2 model results. The authors should check other figures and make the labels and text consistent.

Page 8600 and 8601: something needs to be done on Figure 7 and 8. It is very difficult to tell the difference in some of the colors. For Figure, the authors may consider put on larger legend instead 8 small ones. It is very very difficult for this reviewer to read the legend.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 8553, 2006.