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Update on emissions and environmental impacts from the international fleet of ships: the contribution from major ship types and ports

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Abstract. A reliable and up-to-date ship emission inventory is essential for atmospheric scientists quantifying the impact of shipping and for policy makers implementing regulations and incentives for emission reduction. The emission modelling in this study takes into account ship type and size dependent input data for 15 ship types and 7 size categories. Global port arrival and departure data for more than 32 000 merchant ships are used to establish operational profiles for the ship segments. The modelled total fuel consumption amounts to 217 Mt in 2004 of which 11 Mt is consumed in in-port operations. This is in agreement with international sales statistics. The modelled fuel consumption is applied to develop global emission inventories for CO_2, NO_2, SO_2, CO, CH_4, VOC (Volatile Organic Compounds), N_2O, BC (Black Carbon) and OC (Organic Carbon). The global emissions from ships at sea and in ports are distributed geographically, applying extended geographical data sets covering about 2 million global ship observations and global port data for 32 000 ships. In addition to inventories for the world fleet, inventories are produced separately for the three dominating ship types, using ship type specific emission modelling and traffic distributions.

A global Chemical Transport Model (CTM) was used to calculate the environmental impacts of the emissions. We find that ship emissions is a dominant contributor over much of the world oceans to surface concentrations of NO_2 and SO_2. The contribution is also large over some coastal zones. For surface ozone the contribution is high over the oceans but clearly also of importance over Western North America (contribution 15–25%) and Western Europe (5–15%). The contribution to tropospheric column ozone is up to 5–6%. The overall impact of ship emissions on global methane lifetime is large due to the high NO_x emissions. With regard to acidification we find that ships contribute 11% to nitrate wet deposition and 4.5% to sulphur wet deposition globally. In certain coastal regions the contributions may be in the range 15–50%.

In general we find that ship emissions have a large impact on acidic deposition and surface ozone in Western North America, Scandinavia, Western Europe, western North Africa and Malaysia/Indonesia. For most of

these regions container traffic, the largest emitter by ship type, has the largest impact. This is the case especially for the Pacific and the related container trade routes between Asia and North America. However, the contributions from bulk ships and tank vessels are also significant in the above mentioned impact regions. Though the total ship impact at low latitudes is lower, the tank vessels have a quite large contribution at low latitudes and near the Gulf of Mexico and Middle East. The bulk ships are characterized by large impact in Oceania compared to other ship types. In Scandinavia and north-Western Europe, one of the major ship impact regions, the three largest ship types have rather small relative contributions. The impact in this region is probably dominated by smaller ships operating closer to the coast. For emissions in ports impacts on NO_2 and SO_2 seem to be of significance. For most ports the contribution to the two components is in the range 0.5–5%, for a few ports it exceeds 10%.

The approach presented provides an improvement in characterizing fleet operational patterns, and thereby ship emissions and impacts. Furthermore, the study shows where emission reductions can be applied to most effectively minimize the impacts by different ship types.

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