Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-293-AC1, 2020

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Effects of global ship emissions on European air pollution levels" *by* Jan Eiof Jonson et al.

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Received and published: 1 July 2020

We, the authors, thank the reviewers for constructive comments and suggestions. Below we list the comments from reviewer 1 followed by our reply with references to changes made in the paper.

Comments to remarks from reviewer 1

My only major complaint is that the discussion section seems to be on the light

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Discussion paper

side.There is no comparison made between these modelling results with previous observational or model estimates. As such, the model results look to be qualitatively reasonable and sensible, but it's hard to know how quantitative they are.

Reply:
The EMEP model has been compared to measurements as well as to other models. References to several of these studies are given in section 2. In order to make this clearer we have separated the model evaluation and model inter-comparisons into a new subsection. Here we have also added additional material, referring to Karl et al. (2019), comparing the EMEP model to the SILAM model and the CMAQ model as well as measurements. In this paper model calculated effects of ship emissions in the Baltic Sea are also compared.

With reference to this new sub-section these results are further discussed in the conclusions.

Finally, while perhaps not the standard output of EMEP, it'd be interesting to explore some additional parameters that are also important for air pollution/atmospheric chem-istry with the model, such as:

Fraction of ship-derived PM that is secondary vs. primary as a function of distance from emission?

Reply:
In addition to the fraction of sulphate in PM2.5 we now also include three additional figures showing the fraction of nitrate, primary particles and ammonium in PM2.5. Note that sulphate emitted as primary particles (roughly 5% of the total sulphur emissions from ships) is included as sulphate and not primary particles.

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Estimation of ship-derived PM1 and total aerosol number concentration.

Reply:
Unfortunately PM1 and particle number are not included in the EMEP model.

Minor edits

Line 151
NMVOX corrected to NMVOC

Line 184.
What's the difference between NOx and ShipNOx? That ShipNOx doesn't participate in O3 chemistry, and only deposits? Assigning 50% of NOx to this channel seems like a very simplistic way of treating the non-linear nature of ship plume chemistry. Is this how terrestrial stack NOx emission gets treated also? Further works on plume chemistry modeling include (Charlton-Perez et al. ACP, 9,7505-7518, 2009; Song et al JGR, vol 108, D4, 2003)

Reply:
The reviewer is correct in stating that this is a very simplistic way of treating the non-linear nature of ship plume chemistry. In particular in pristine environments the chemical regime in the ship plumes will be very different from the surrounding airmasses. In the parameterization applied in the Vinken et al. paper they calculate a strong ozone titration in the first stages of the plume, followed by ozone production as

the plume expands. At this stage OH levels become higher than in the surroundings, resulting in a faster conversion of NO_2 to HNO_3, thus shortening the lifetime of NOx. The shorter lifetime of NOx and the increase of HNO_3 found by Vinken et al. is mimicked by the simplistic "SHIPNOX" parameterisation, removing NOx that would otherwise produce (too much) ozone and convert it directly to HNO_3. The parameterisation is included in order to give a range for the effects of ship emissions on ozone in otherwise pristine environments where there are no or few nearby sources. Terrestrial stacks are not (or very seldom) located in pristine environments, so we do not use a "SHIPNOX" type of parameterisation for these.

Line 373
NECA has been replaced by SECA

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