Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2018-416-SC1, 2018

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Impacts on cloud radiative effects induced by coexisting aerosols converted from international shipping and maritime DMS emissions" *by* Qinjian Jin et al.

K. Peters

peters@dkrz.de

Received and published: 4 August 2018

In their study, the authors investigate the uncertainties associated with estimating aerosol indirect effects (AIES) induced by global shipping emissions in a general circulation model. The uncertainties studied here are three-fold, in the sense that 1) AIEs from shipping emissions are shown to non-linearly depend on the background concentration of natural DMS emissions (an expected result and very valuable as it has not been quantified before), 2) AIEs from shipping emissions depend on the amount of sulphur contained in the fuel (as has been shown in earlier studies) and 3) estimated AIEs from shipping emissions depend heavily on the aerosol microphysics module applied

Printer-friendly version

Discussion paper

in the general circulation model.

As I have also worked on this topic in the past, I find the study extremely interesting and relevant and I have some comments/remarks concerning the results, the presented analysis and framing of the results presented here in the view of earlier studies.

Main point:

In my view, the discussion of the differences between the two aerosol modules and their impact on the results warrants a bit more investigation/explanation. In Peters et al (2012), P12 in the following, we investigated the uncertainties of AIEs from shipping emissions related to the assumed emission particle size distribution and the total amount of fuel burnt. We found a significant impact of the assumed particle size distribution on the estimated AIEs: assuming all sulphuric compounds being assigned to the soluble Aitken mode at point of emission (as supported by various field observations) leads to significantly more negative AIEs than assigning them half and half to the soluble Accumulation and Coarse modes as was done in the standard Aerocom emission setup (cf P12). This is due to the substantially higher number of primary emitted soluble particles. This was further substantiated in the corrigendum to P12 (Peters et al., 2013), in which a bugfix in the aerosol module lead to an even higher number of emitted particles. My question here is: what size mode are the shipping emissions (and the DMS emissions) assigned to at the point of emission in MAM3 and MARC? This is not described in Section 2, but is a critical point. Compare to the detailed analysis from emission all the way to the resulting effects on cloud properties detailed in Peters et al. (2012, 2014), because in the end, AIEs are the end product of a long chain of processes calculated in various parameterizations with, most certainly, inherent uncertainties. Are there diagnostics of aerosol numbers per mode (see P12) available for the current study so as to investigate the differences between then two aerosol microphysics modules in more detail? This would also help in investigating the interplay with different assumed DMS emission levels, especially for the case of zero DMS emissions where the differences between the two parameterisations are largest.

Can CCN diagnostics (see P12, Peters et al. 2014, P14 in the following) be provided to further investigate these points?

Minor points:

Lines 40-42: please also mention the Corrigendum to P12 – i.e. Peters et al 2013 - as the results from P12 suffered from a bug in the aerosol microphysics module. The results presented in Peters et al (2013) are thus more sound.

Lines 118 – 126: while investigating the effect of total sulfur content in bunker fuel is an important issue, please also mention uncertainties related to the total amount of fuel burnt (cf P12).

Lines 170-172: see my above comment regarding an analysis of the causal chain from emissions -> AIEs.

Lines 178-180: this reads like the increase in CWP leads to an increase in CDNC, but it should be the other way around (at least from the viewpoint of a parameterisation in which a causal connection of cause-and-effect has to be established by design)

Lines 181-182: this is obvious and is out of place at the end of this paragraph (compare to lines 30-34 in the Introduction)

Lines 187-192: This is a very interesting paragraph, specifically because DMS emissions are natural and thus an integral part of the climate system and are most probably also included when tuning the TOA radiation balance of the model. Capturing the "correct" background (pre-industrial) aerosol distribution is an extremely difficult task, see e.g. Stevens et al 2017 for the case of developing an aerosol climatology, and is critical for estimating anthropogenic AIEs (as is very nicely shown in this paper). Coming to the point, leaving out DMS emissions results in a quite large TOA radiative imbalance in excess of -5 Wm-2 (Figure 9). Although the model is constrained by prescribed SSTs, this imbalance, which is much larger on local scales, could have an effect on the results.

Printer-friendly version

Discussion paper

Lines 266-268: a very important point. Even more importantly, this calls for a re-evaluation of aerosol and cloud microphysics parameterisations in general circulation models.

Lines 269-272: I completely agree. In Peters et al 2011, P11, we applied a specific sampling routine to observational data in order to sample for the effect of shipping emission on cloud properties in “pristine” oceanic areas, where “pristine” was mean with regards to anthropogenic emissions. Looking at the maps displayed in Figure 2, shipping emissions are trumped by DMS emissions in two of the regions sampled in P11: the SE Pacific and the mid-Indian Ocean region. However, the third region investigated in P11, the mid Atlantic, shows a significant contribution of shipping emissions compared to DMS. We also focused more on that region in P14 and concluded that for “observational studies of AIEs, this highlights the ever so important and often discussed aspect of correctly defining the background (‘pre-industrial’) reference state against which to gauge the present-day observations.” The present study thus very convincingly corroborates our conclusions drawn in 2014.

References:

Peters, K., J. Quaas, and H. Graßl (2011), A search for largeâĂŘscale effects of ship emissions on clouds and radiation in satellite data, J. Geophys. Res., 116, D24205, doi: 10.1029/2011JD016531.

Peters, K., Stier, P., Quaas, J., and Graßl, H.: Aerosol indirect effects from shipping emissions: sensitivity studies with the global aerosol-climate model ECHAM-HAM, Atmos. Chem. Phys., 12, 5985-6007, https://doi.org/10.5194/acp-12-5985-2012, 2012

Peters, K., Stier, P., Quaas, J., and Graßl, H.: Corrigendum to "Aerosol indirect effects from shipping emissions: sensitivity studies with the global aerosol-climate model ECHAM-HAM" published in Atmos. Chem. Phys., 12, 5985–6007, 2012, Atmos. Chem. Phys., 13, 6429-6430, https://doi.org/10.5194/acp-13-6429-2013, 2013.

Peters, K., Quaas, J., Stier, P. and Graßl, H. :Processes limiting the emergence of detectable aerosol indirect effects on tropical warm clouds in global aerosol-climate model and satellite data, Tellus B: Chemical and Physical Meteorology, 66:1, DOI: 10.3402/tellusb.v66.24054, 2014.

Stevens, B., Fiedler, S., Kinne, S., Peters, K., Rast, S., Müsse, J., Smith, S. J., and Mauritsen, T.: MACv2-SP: a parameterization of anthropogenic aerosol optical properties and an associated Twomey effect for use in CMIP6, Geosci. Model Dev., 10, 433-452, https://doi.org/10.5194/gmd-10-433-2017, 2017.

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2018-416, 2018.

Printer-friendly version

Discussion paper