Atmos. Chem. Phys. Discuss., 15, C12639–C12643, 2016
www.atmos-chem-phys-discuss.net/15/C12639/2016/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "The global impact of the transport sectors on atmospheric aerosol in 2030 – Part 2: Aviation" *by* M. Righi et al.

M. Righi et al.

Mattia.Righi@dlr.de

Received and published: 22 February 2016

We are grateful to the reviewer for his/her constructive comments and suggestions which helped us to improve the manuscript. Please find below our replies (roman text) to the reviewer's comments (*italic* text).

First, a slightly better discussion on how the aerosol mass and number perturbations are applied to the model. The general reference to the RCPs I do not think fully describes the aviation number concentration perturbations for SO4, NO3 and BC. If they do, then the numbers should be stated.

This is a good point. We made several changes to address the reviewer's concerns on this issue: i) Fig. 2 has been extended showing also relative changes in particle number emissions; ii) we have added a paragraph in Sect. 2 to better characterize what is actually included in the inventories and what has been derived: "The CMIP5 aviation emissions data includes NO_x (an important aerosol nitrate precursor) and BC. We further derive SO_2 emissions by scaling the BC emissions with the ratio of the emission factors of the two species at each altitude level (see R13 for details) in all scenarios. This results in total aviation emissions of 0.168 Tg(SO_2) a^{-1} in 2000 which compares well with the ACCRI/AEDT value of 0.221 Tg(SO_2) a^{-1} in 2006 (Brasseur et al., 2015). We further assume that 2.2% of the sulfur mass is emitted as primary SO_4, based on Jurkat et al. (2011)."; iii) the derivation of SO_2/SO_4 as well as of number emissions is further recalled when discussing Fig. 2: "Since SO_2 emissions are derived here by rescaling BC emissions using the altitude-dependent ratio of the emission factors of the two components, the relative changes between 2000 and 2030 of BC and SO_2 are similar in Fig. 2. This also applies to number emissions (NUM), which are derived from the mass emissions of BC and primary SO_4 (as a fraction of SO_2)".

Second, I think some further work is necessary to properly characterize the conclusions. Two additional pieces of analysis would be valuable as noted below. (A) I think a figure with a map of radiative forcing from aviation would be valuable.

We thank the reviewer for this suggestion. We have inserted an additional figure in the paper (Fig. 9), showing zonal mean maps of the aviation-induced all-sky RF for the year 2000 and for the RCPs in 2030. A corresponding description is given in Sect. 4: "The bulk of the aviation-induced all-sky RF is generated in the northern mid-latitudes (Fig. 9): This was expected given the distribution of aviation-induced perturbation in aerosol particle number discussed in the previous section and depicted in Fig. 6."

(B) I think some sensitivity runs should be done with single aerosol forcing for NO3, BC and SO4. I think these need only be done for one RCP, so only 3 more runs. It would allow a decomposition into the different components, and I think is necessary.

In Righi et al. (2013), we already performed a sensitivity simulation with reduced aviation fuel sulfur content (this is recalled in Sect. 4 of the present manuscript) and in that case no significant aviation-induced RF could be found. This means that the aviation RF is mostly controlled by sulfur emissions, which can effectively perturb aerosol number concentrations and hence warm clouds. The contribution of BC to aerosol number concentration is small, and BC is not relevant for cirrus here, since our current model setup does not include heterogeneous freezing processes. Concerning nitrate, we showed in Righi et al. (2013) that aviation induces a decrease in aerosol nitrate, hence this component is also not relevant for the RF effect.
Performing additional simulations would also be technically difficult at this stage, since the HPC facilities (hardware and compiler) where we performed all the experiments for our series of studies (Blizzard at DKRZ Hamburg) is no longer in service. Additional simulations could only be performed on a new machine, which would raise comparability issues and would require the repetition of the complete set of simulations for consistency, which is clearly unaffordable.

(C) Please state numbers for the clear sky and all sky RF. It appears to be mostly all sky (i.e. cloud effects). You might highlight that more, and also show a map or statistics of the cloud forcing changes.

Thank you for this suggestion. We have added the numerical values for all-sky and clear-sky RF on top of each bar in Fig. 8.

Page 34039, L10: how are RCPs included if GHGs fixed and nudged? Just the aerosol emissions? This is clear later, but not initially.

This is already stated at the beginning of the paper (third paragraph of the introduction, p. 34038, line 20 and following): “Finally, we note that in the present study only the changes in the emissions of short-lived species (aerosol and precursor gases) are considered, whereas the investigation of the impact of a changing climate on aerosol distribution is not accounted for.”

Page 34042, L7: how do these scaled emissions compare to other inventories of aviation emissions in 2030 (ACCRI/AEDT, etc).

We have addressed this suggestion by extending the paragraph where emissions are described (see also the reply to the first comment above).

Page 34043, L15: how are aviation NO3 emissions estimated. Do you have mass and number emissions for all aviation aerosols? Please describe in more detail.

The now extended description of the emission setup (see reply to the first comment above) should address this comment. An additional sentence has been added in Sect. 2 to further clarify that number emissions are estimated from the mass of emitted BC and primary SO_4: “Namely, we have used the same size distribution parameters as for the reference case in R13 and applied them to both emitted primary aerosol species, i.e. BC and primary SO_4, in order to derive number emissions from mass.”

Page 34045, L25: but the n Atlantic is pretty heavily polluted and smaller than the pacific, so the explanation here doesn't make a lot of sense. Can you dive into the regional difference in contribution a bit deeper? Is the size of the region the same?

We are not sure to which explanation the reviewer is referring here. The size of the 3 regions is not the same, but they have been defined based on the geographical distribution of the emissions (not shown) in order to include those parts of the globe where aviation emissions are large. The selection was based on the year 2000 distribution, but can be applied also to 2030, as the geographical distribution does not change significantly.

Page 34046, L5: can you break the RF down by species with. A Sensitivty test? Perhaps in just one RCP.
Page 34047, L14: I definitely think you need to. Decompose the different aerosol effects on RF by species.

In regard to both comments, we refer to our answer given above to a similar comment.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 34035, 2015.