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Comment on acp-2021-329

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Community comment on "Exploring the uncertainties in the aviation soot–cirrus effect" by Mattia Righi et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-329-CC1, 2021

Obtaining robust estimates of the indirect effect of aviation soot on cirrus clouds is an important and timely issue [Lee et al., 2021]. This topic has been discussed for a number of years, mainly on the basis of global models and with conflicting results. The present paper is the latest attempt to arrive at a GCM-based solution and discusses, as a novel feature, how aspects of the model dynamics contributes, in idealized model experiments, to uncertainty in global radiative forcing from soot-cirrus interactions.

I'd like to point the authors to two publications [Marcolli et al. 2021; Kärcher et al., 2021] that offer an unprecedented opportunity to better constrain the radiative forcing from soot-cirrus interactions using the latest findings from laboratory studies and process modeling.

It is important to include atmospheric trajectories and size information of INPs in estimations of their ice activity. The authors are aware that (i) cloud processing has been found to be crucial to render aircraft-emitted soot particles ice-active and (ii) their ice-forming abilities are strongly size-dependent (Fig.1). There's also data available on the size (i.e., mobility diameter) distribution of aircraft-emitted soot particles, e.g., from recent aircraft campaigns carried out by NASA and DLR, or from recently developed soot models used in global emission inventories [see Kärcher, 2018, for references].

Stitching together these two pieces of information allows size-integrated ice-active fractions of aviation soot populations previously processed in contrails to be easily derived. In combination with soot ageing processes (i.e., the build-up of aqueous coatings and subsequent de-activation of ice formation), these fractions would allow the authors to more realistically constrain their range of RF estimates and improve on their parametric study of uncertainties due to ice nucleation properties of aviation soot particles that are superseded by new measurements and analysis [Marcolli et al., 2021].

I understand that the parameterization scheme used to estimate the ice nucleation behavior of soot INPs [Kärcher et al., 2006] does not capture the changing ice-activated INP number fractions with increasing supersaturation by assuming a sharp critical nucleation threshold. This parameterization does not allow for the INP-derived ice crystal concentrations to build up gradually over a range of supersaturation and, hence, precludes an accurate estimation of the INP impact on cirrus formation.

In spite of this situation, the relevance of the study can be increased by properly addressing the single key microphysical aspect of the simulations, whereby I recommend using more appropriate estimations of both, activated fraction and nucleation threshold. The former happens to be greatly overestimated while the latter is underestimated in the present study. In my opinion, interpretation of results is greatly aided by separating (1) the fraction of contrail-processed soot particles from (2) the fraction of soot particles that become ice-active at a given supersaturation and (3) the fraction that gets coated and is rendered inactive. (1) might be estimated from global models that track contrails and contrail cirrus as separate from other clouds. (2) follows from Marcolli et al. [2021] and Kärcher et al. [2021] for given soot particle size distributions. (3) would be estimated in the global aerosol-climate model based on the current representation of aerosol processes.

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