

Atmos. Chem. Phys. Discuss., referee comment RC1
<https://doi.org/10.5194/acp-2021-511-RC1>, 2021
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Comment on acp-2021-511

Anonymous Referee #1

Referee comment on "Aerosol–cloud interactions: the representation of heterogeneous ice activation in cloud models" by Bernd Kärcher and Claudia Marcolli, Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-511-RC1>, 2021

Review for "Aerosol-cloud interactions: the representation of heterogeneous ice activation in cloud models" by Karcher and Marcolli

This manuscript presents a derivation of "differential active fractions (AFs)" based on the concept of differential spectra (Vali 2019) when budgeting for ice particle number and INPs that are assumed to follow singular time-independent ice nucleation. This approach contrasts with previous laboratory experiments that have quantified the fraction of activated INPs using AFs that are cumulative in ice supersaturation. The authors then applied the differential AF concept and their budget equations assuming a lognormal distribution of contrail-processed aircraft soot particles and demonstrated that the differential AF approach results in smaller active fractions, which implies that homogeneous ice nucleation could be underestimated when cumulative AFs are used.

Overall, this is an excellent manuscript that is generally well-written and elegantly presents an important overlooked aspect of ice nucleation that is valuable to the modelling community. Some aspects of the manuscript could be elaborated and clarified as outlined below. I would recommend publication of the manuscript once these few minor points have been taken into consideration.

* A more specific discussion on how AFs are relevant to models on various spatial scales on lines 156-160 would be helpful for the reader to understand the feasibility of the approach.

* Why was soot used as the example in Figure 4? Given its relative low ice-nucleating

ability, perhaps dust aerosol particles could be used to better illustrate the effectiveness of differential AFs? I would also suggest including other examples of INPs and particle size distributions to determine the relative impact of differential AFs compared to cumulative AFs.