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Interactive comment on "A new approach to simulate aerosol effects on cirrus clouds in EMAC v2.54" *by* Mattia Righi et al.

Anonymous Referee #3

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This paper presents the implementation of a new cloud microphysical scheme for parameterizing ice formation in cirrus clouds for the use in the global chemistry model EMAC. The new scheme takes into account the aerosol type that serves as INP and the competition of homogeneous and heterogeneous ice formation that is relevant in cirrus clouds. As part of the model evaluation, results from a tuning exercise are reported, as well as the comparison to observational data.

The paper fits within the scope of GMD and tackles a challenging topic that is relevant for the community. I have the following comments that should be addressed before the paper can be accepted for publication:

1. As the authors state, the ice nucleating properties of BC are highly debated. In light of these uncertainties, it makes more sense to define the reference case without BC

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Discussion paper

as INP and show a sensitivity case where the impact of BC as INP is included. How important is BC as INP using the current assumptions?

2. The aerosol representation of MADE3 is quite complicated and an interesting feature of the work. I suggest explaining this in more detail (even though it has been explained in previous papers). In this context, the sentences on p. 23/lines 20-23 are hard to understand. Please clarify. It would also be interesting to learn more about if keeping track of the aerosol mixing state as done with MADE3 (as opposed to only tracking average composition using fewer modes) is yielding improved results.

3. Given that this is a model development paper on a new cloud microphysical scheme, more emphasis should be given presenting the underlying set of equations. Some of this is currently presented in Appendix A. This should move to the main manuscript, but more needs to be added to explain how the “potential ice-nucleating particles” are used to produce ice crystals. Overall the presentation of the modeling equations is fragmented and hard to follow.

4. More details need to be provided for the model tuning in section 4.1. What is the justification to choose specifically these four tuning parameters? And given that for each of the four tuning parameters five values are chosen, do you perform all 20 simulations (one for each parameter calculation)? Have you considered using a latin-hypercube sampling strategy of the parameter space of your tuning parameters? And on what basis is the optimal tuning configuration chosen?

5. How has including the new scheme changed the results compared to the previous version of the model? I.e. is the "new approach" an improvement over the old approach?

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