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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Cold cloud microphysical process rates in a global chemistry-climate model" *by* Sara Bacer et al.

Anonymous Referee #2

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This study quantifies and investigates the cold cloud microphysical process rates using one chemistry-climate model EMAC, and defines the hierarchy of sources and sinks of ice crystals. The analysis is carried out both at global and at regional scales. It is an interesting idea to quantify the important ice crystal sources and sinks globally so this is the work worthy of being published. However, before it can be accepted, there are a few major concerns to be addressed.

(1) The model result uncertainty could be very large from a few aspects.

1.1 The model grid spacing is very coarse (~300 km) and the output time frequency is very sparse (every 5 hours). Many times, the cloud lifetime can be even less than 10 hours, then the sampling cannot be representative with every 5-hour time frequency. I'd suggest look at the sensitivity to model resolution (such as 100 km) and output time

frequency (hourly) to meet the goal of quantification.

1.2 Need to do ensemble runs for quantification.

1.3 Need to discuss that the results might be changed with different models or different physical parameterizations such as cumulus or microphysics parameterizations.

(2) For the sink of ice crystal, sublimation should be considered.

(3) Result section: I feel a little surprised that the authors started the discussion of results for the source and sink of ice directly. It would be nice to understand the overall model performances in simulating radiation, clouds and precipitation first. Then get to the analysis of ice crystal number concentrations and its budget.

(4) Since one of the purposes of the study is to test the sensitivity to two other nucleation parameterizations, then some description about the two default and two tested schemes is needed, particularly about how different they are in terms of representing ice formation such as temperature dependent, supersaturation dependent, and aerosol dependent. If aerosol dependent, then what aerosols are considered? Why did you replace the immersion freezing scheme with a contact freezing scheme? Shouldn't they be considered together?

Minor comments,

1. Calling everything below -35 deg C as "cirrus clouds" is not accurate. I would suggest change to "pure ice clouds".

2. For the convective detrainment, does the model treat the detrainment at the levels with T> -35 deg C? If not, is there a reason? Theoretically convective detrainment of droplet and ice can occur from middle to top troposphere.

3. Line 210-215, does FREE include the droplet freezing in convective parameterization?

4. Section 4.2, how to reconcile that DETR is much larger than NCIR in zonal mean

(Fig. 2) but smaller than it in global spatial distribution (Fig. 1)?

5. Line 284-286, I am confused by this sentence. Earlier it is said LD06 is a contact freezing scheme which is for heterogenous freezing. Here you said LD06 parameterizes only homogeneous nucleation. Also P13 should be an immersion freezing scheme which should be much more efficient than the contact freezing LD06, but the results in section 4.4.1 did not even mention the differences they can make.

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