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Comment

## ***Interactive comment on* “Sensitivity of cirrus and mixed-phase clouds to the ice nuclei spectra in McRAS-AC: single column model simulations” by R. Morales Betancourt et al.**

### **Anonymous Referee #1**

Received and published: 7 August 2012

This paper discusses how different ice nucleation parameterization affects cirrus and mixed-phased clouds, by conducting single column global model simulations. Comparison of different ice nucleation parameterizations in models have conducted before, but the Barahona-Nenes parameterization is new in the McRAS-AC model and need to be tested, and these types of studies are important. I recommend that this paper be published with minor revisions after addressing a few comments.

Page 14931: In the introduction, the authors discuss different types of ice nucleation parameterizations. However, they chose to cite only a few parameterizations (the same as the ones used for the study in this paper). I suggest that you include (for citation

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purposes) several of the new parameterizations developed over the last few years. The discussion paper by Hoose and Möhler, “Heterogeneous ice nucleation on atmospheric aerosols: a review of results from laboratory experiments” in ACPD, 2012 offers a great source for a compilation of references for the latest parameterizations.

Page 14931, line 28: Since the term “homogeneous freezing of deliquesced aerosols” are used several times later in the paper when describing homogeneous freezing, I suggest you use the same term here instead of “solution droplets”.

Page 14932, first paragraph: I have some problem with how the logic is built in this paragraph: “Below  $T_{\text{hom}}$ , where ice-only clouds form, the supersaturation with respect to ice is the result of the competition between the rate of cooling of the cloud parcel and the condensation on the nucleated ice crystals. Therefore, it varies dynamically given the amount of IN present and the dynamical forcing available. Furthermore, since homogeneous and heterogeneous ice nucleation may occur simultaneously, the competition from both mechanisms and their impact on supersaturation further complicate the calculations.”

I think that “Therefore, it varies dynamically given the amount of IN present and the dynamical forcing available” should be moved to after the competition between heterogeneous and homogeneous nucleation has been explained.

Page 14933, line 28: Please indicate the location or region for where the TWP-ICE observations were made.

Page 14935, line 24: How is Meyers et al. (1992) used in the BN parameterization? Do you use it as described in equation (1) or as it is original in Meyers et al. (1992)?

Page 14937, line 7: It is stated that ice crystal concentration  $N_c$  is determined by ice nucleation, contact freezing and by melting of cloud ice. What about processes such as homogeneous freezing of deliquescent aerosols and homogeneous freezing of droplets, sedimentation of ice and accretion of cloud ice by snow

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Page 14937: I am surprised to see that you do not have dust as aerosol input for heterogeneous ice nucleation, or from the text it seems this way. From line 11, you describe the soot and sulfate aerosol distributions but have left out dust. The PDA08 scheme has nucleation from dust included in the parameterization, so I would think that the dust should be included.

Page 14939, Ice fraction: I question the steep curve for ice fraction, showing that the fraction of liquid is almost zero at as warm temperatures as  $-5\text{ }^{\circ}\text{C}$ . For example other studies from the same time period (i.e. van Diedenhoven, B., Fridlind, A. M., Ackerman, A. S., and Cairns, B.: Evaluation of hydrometeor phase and ice properties in cloud-resolving model simulations of tropical deep convection using radiance and polarization measurements, *J. Atmos. Sci.*, online first: doi:10.1175/JAS-D-11-0314.1, 2012) seem to indicate liquid at much lower temperatures. Would you care to comment on the different findings?

Page 14940, line 14: It is not given explicitly in Sect2.1 that the LP numerical correlations is immersion freezing. Please make this clearer in Sect2.1. Also the use of parenthesis is wrong, it should be after “2005”, not “Eq. 1”.

Page 14940, line 23: It seems that contact freezing is effective at temperatures warmer than 260K in this mode. In the temperature region of 270-265K, the Hallet-Mossop process can be an important source of ice crystals. Is this process included in the McRAS-AC model?

Page 14942, line 21: “rage” should be “range”

The authors use the term IN spectra and heterogeneous ice nucleation parameterizations. Are these terms the same or are there any differences between them? If they are the same, please be consistent and use only one of the terms. If they are different, can you explain how?

Summary and conclusion: In the last few years there have been many studies on depo-

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sition and immersion ice nucleation, but not so much on contact freezing. Since contact freezing in the model results seemed to be rather important at warmer temperatures, I think you should include a statement in the final remarks on the specific need for more observations of contact freezing.

A new paper in ACPD discusses the implementation of BN in CAM: "Sensitivity studies of dust ice nuclei effect on cirrus clouds with the Community Atmosphere Model CAM5", Liu et al 2012. This study seems to be along the same line as the work presented in this paper. If the Liu et al. 2012 paper is published before this paper, I would like to see a reference to this paper, and perhaps a short discussion where the result from these two papers of compared.

Figures:

Figure 4: Correct the title on the y-axis in figure a.

Figure 6: Correct the unit on the y-axis.

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