

## ***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.***

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Overall comment: This paper presents a single column modeling study of mixed-phase and cirrus clouds observed during the TWP-ICE campaign. Sensitivity simulations are presented exploring the sensitivity to the choice of ice nucleation schemes and spectra. The paper addresses a key issue within the field of aerosol-cloud-climate interactions currently, namely the topic of aerosol effects on cold clouds. The paper is well written and logically presented. However, I do have some concerns and questions that I would like to see addressed before this paper is published in ACP.

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Comments Questions:

- Typically the term “cold clouds” refers to all clouds with temperatures colder than 0 degrees C, whereas here the term seems to refer to cirrus clouds. Please clarify.
- In the Model description (Section 2), a thorough description of the treatment of the Bergeron-Findeisen process is missing. The BF process is referred to frequently in the discussion section, yet the reader has practically no information on how this process is represented in the model. Furthermore, it was not clear whether ice multiplication processes are included in this modeling framework. Both processes are crucial for phase transitions in mixed-phase clouds.
- Section 2.2: there is no mention of aerosol species other than BC and sulfate, yet later on contact freezing on dust particles is discussed. Furthermore, as the PDA08 ice nucleation parameterization also represents freezing on organics, were organic particles contributing to ice nucleation in this study? Please clarify.
- Section 2.2: While heterogeneous freezing on BC seems to be the focus of this study, most laboratory studies find BC particles to be very poor IN. Please discuss.
- Section 2.2: Is the vertical velocity distribution centered on 0m/s? Also, the choice of a standard deviation of 25cm/s seems arbitrary. The INCA campaign is mentioned, but surely the standard deviation varied through the campaign? As also mentioned below, I would like to see further sensitivity studies testing the robustness of your results to different choices of the standard deviation.
- Section 3: In general, some of the figures are not really (or only very briefly) discussed.
- Section 3: It is very difficult to spot any differences between the different plots in Fig. 1 and Fig. 2. I suggest using difference plots (Sensitivity test – Control) for the sensitivity simulations.
- Section 4: The Choi et al. (2010) paper studied the relationship between dust aerosol concentrations and ice fraction, not aerosol concentration in general.
- I am pretty sure the Bergeron-Findeisen process is more crucial in determining the ice fraction than is contact freezing. In fact, neglecting contact freezing only has a

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significant impact on the BN-PDA08 simulation, for which the nucleation rate is low enough that contact freezing makes a contribution. The fact that all simulations have very similar ice fractions, despite spanning a wide range of ice crystal concentrations, suggests that the BF process is very efficient. Are the simulated ice fractions consistent with what was observed during TWP-ICE?

- Section 4: In discussing the changes in cloud optical properties, it would be nice if you could compute clouds optical depths for each of the cases.

- Section 4: I am pretty sure the dominating ice nucleation mechanism in cirrus clouds will be crucially dependent on your assumptions on the vertical velocity distributions. Several studies have reported that the relative importance of heterogeneous vs. homogeneous freezing is controlled by the vertical velocity. I strongly recommend sensitivity tests with shifted, wider or narrower distributions.

Minor/specific comments:

- Add "by" before "modifying cloud optical. ...." on line 23, Page 14929.

- Page 14936, line 12: "its" should be "it is".

- Caption, Figure 1: The abbreviation "BN09" is used here but nowhere else.

- Figure 4a) I believe the Y-axis label should be  $N_{c,nuc}$ .

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Interactive comment on Atmos. Chem. Phys. Discuss., 12, 14927, 2012.