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Interactive comment on "Microphysical sensitivity of coupled springtime Arctic stratocumulus to modelled primary ice over the ice pack, marginal ice, and ocean" *by* Gillian Young et al.

Anonymous Referee #2

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The authors simulate three cases of mixed-phase cloud near Svalbard, based on observations conducted during March 23 and 29 of 2013 as part of the ACCACIA campaign. The focus of this work is on how ice nucleation parameterizations influence results from the UKMO LEM model in comparison with the observations. The authors use three basic parameterizations: Copper 1986; DeMott 2010; another empirical parameterization (ACC) based on the observations they evaluate against. They also evaluate some extremes of the D10 parameterization and the D10*0.1 is one of the better performers for the ocean case. Overall, D10 and C86 produce more ice, which leaves less liquid water, and ACC produces less ice and more liquid water. In general, ACC compares better with the number concentrations of measured ice particles larger

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Discussion paper

than 100 um, where the latter is used to put the observations and simulations on the same footing. It is perhaps expected and unfair to say ACC performs better, since it is based on the observations being compared against, but it provides an important perspective on the number concentrations of ice particles. The authors identify a "sweet spot" in the number concentration of ice particles, represented by either the ACC or D10*0.5 parameterizations, at which the balance of liquid and ice in these cold clouds over ocean is able to maintain a persistent mixed phase without glaciation or generating too much convection. In general, the study points to the strong sensitivity of Arctic mixed phase clouds to ice crystal number concentrations. Also, for the three cases studied, the authors show that ice nucleation under water saturated conditions must be implemented.

The paper is long and a little difficult because of the many tests and the bouncing back and forth among figures 6 through 9, but it is otherwise well organized, the discussions are good and the results are interesting and important. The paper is appropriate for ACP.

Specific comments:

1) Section 2.2 - Some clarification of the context of the model and observations is needed. The dropsonde data are used for model initialization. The model then simulates cloud for 24 hours, with the first 3 hours considered as "spin-up". During the 21 hours of simulation, is the model is maintaining the same underlying surface: i.e. ice for case 1, mixed ice and water for case 2 and water for case 3? It would seem that in reality the MIZ cloud may have moved from over the MIZ to open water during the time equivalent to the simulation period. Were the in-situ microphysical observations conducted near the locations of the dropsondes or farther downwind? There appear to be differences in the heights of the clouds between the microphysical measurements and the dropsondes with the microphysics suggesting deeper cloud.

2) Presumably, changes in the numbers and sizes of the cloud droplets will also affect

the WBF process. Why did you use a cloud droplet number concentration of 100/cc, when you have the measurements from the CDP that you could have used?

3) For case 1, how are you sure the liquid phase existed? The CDP is a one dimensional probe. What were the droplet number concentrations?

4) Section 4.1, line 12 – at or below 500 m?

5) Page 12, line 1 – provide a reference for the 2DS statement.

6) Page 14, line 1 – among rather than between.

7) Page 18, lines 1-3 - In figure 7, D10 produces the highest ice numbers for >100 um. Even using the total measured ice numbers, D10 is still high. D10 appears to do relatively well in case 1, and it is closer to the observations than C86 in case 3. Is your reference to case 2 a mistake? If not, please explain how you arrive at this statement. The statement on lines 2-3 of page 19 appears to contradict.

8) Page 19, line 7 – There may be fewer sources, but so little is known about INP in the Arctic that I think this sentence would be better removed.

9) Possibly of interest to the authors, INPs measured at Alert, Nunavut (Mason et al., Atmos. Chem. Phys., 16, 1637–1651, 2016) during spring to early summer vary from 0.2 per litre to 1 per litre for temperatures from 20oC to 25oC, which covers the range of average ice particle number concentrations you report for the three cases.

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