Response to comment #1

We would like to thank the reviewer for their useful and constructive comments. Our response and the subsequent modifications to the paper are structured as follows:

Blue for the reviewer comment

Normal text for our answers

Bold for the changes in the manuscript

-Page 2, lines14-19: I think there are some contradictions in these sentences: The authors mention the parameterization by DeMott (2010), which is dependent on the INP concentration (greater than a certain size). Then shortly after it is stated that, "However,studies have shown that cloud are sensitive to INP concentrations. " This is already included in the DeMott (2010) parameterization. What DeMott (2010) does not take into account is the variation in nucleation properties (as stated to be an important factor in the previous sentence). I think the sentences on these lines need to be rephrased.

Further, the sentence on line 29-30 is almost identical to the sentence on line 17-18.

We have rephrased these lines to clarify that these parameterizations currently do not represent the differences in the ice nucleating properties of different aerosol species. We also deleted the last sentence.

The current representation of heterogeneous freezing in climate models and operational numerical weather prediction models is usually based on parameterizations that depend on the temperature (Young et al. 1974, Meyers et al. 1992) or the size distribution of aerosol particles as well as the temperature (DeMott et al. 2010). These parameterizations treat aerosol particles all around the globe and across seasons as having the same ice-nucleating properties irrespective of the aerosol chemical composition. Representing these differences may lead to a better simulation of INP concentrations, thereby improving the representation of mixed-phase clouds.

-Page 3, line 12. I suggest including references to Marcolli et al. (2007) and Eidhammer et al. (2009), who also included distributions of contact angles in their studies.

References added.

-Page 3, line 15-16 and many other places: There are many citations where the parentheses are misplaced, such as for the Vali et al. (2015) citation. Here it should be "..approximation (Vali et al. 2015) in which the time …" Other places, such as page 5, line 6, it should be "…model described in Mann et al. (2010). " Please go trough the manuscript and fix all misplaces parentheses.

Done

-Page 3, line 33. I suggest including reference to Koehler et al. (2010), which also conducted studies of the ice nucleation ability of dust.

Done

-Page 3, line 32: I am confused by this sentence: Atkinson et al. (2013) found that a mineral component of desert dust, is responsible for most of ice nucleating activity of mineral dust aerosols. Should it be "..activity of desert dust aerosols"?

This has been rephrased to: **Atkinson et al. (2013) found that K-feldspars are far more effective at nucleating ice than any of the other minerals in desert dust.**

Page 4, line 1: What does "this type of mineral" exactly refer to?

Refers to K-feldspar, we have rephrased this sentence

Therefore the representation of K-feldspar in atmospheric models…

-Page 5, line 13-14: By Nucleation scavenging is suppressed for ice clouds, is it meant that it is not included, meaning that the ice nucleation parameterization is only based on temperature and not INP concentration. This should be explicitly stated. Also, by stating assumed to glaciate at -15C, is it implied that below -15C, the clouds comprise only of solid hydrometeors, and not mixed?

This refers to the model assumptions that we need to make in order to represent nucleation scavenging of aerosol particles in our model. As we are using a chemical transport model, aerosols do not interact with clouds in any way (other than being scavenged by precipitation) and all the meteorological fields (including cloud fields) come from ECMWF reanalysis. With these fields, we can predict the concentrations of different aerosol species and from the concentrations we calculate offline (after the model simulation) the INP concentrations. The discussion of the nucleation scavenging assumptions is included in Browse et al (2012), so we refer to it for a more detailed description.

Nucleation scavenging is suppressed for ice clouds, which are assumed to glaciate at -15ºC. A discussion of the nucleation scavenging assumptions in our model is included in Browse et al. (2012).

-Page 5, line 21: using "accurately" by stating that the model has been shown to reproduce dust concentration accurately is a strong statement. I suggest rephrasing/rewording.

Reworded to 'within an order of magnitude'

The model has been shown to reproduce dust mass concentrations within an order of magnitude

-Page 14, line 1: Are Figure 6 zonal averages?

Yes. Clarification has been added to figure caption

-Page 14: line 12: Please give a range for the mixed-phased range.

Done, added: "(0°C to -37°C)"

-Page 22, EqA1. I suggest moving Eq.A1 up to line 1, page 22, where the equation is first mentioned.
Done

Technical comments
Page 1 line 2: Replace "of their properties" to "of the cloud properties"
Done

Page 1, line 15: replace "
. . .
Southern Ocean at some time of the year" with
"
. . .
Southern Ocean at some part of the year"
Done

Page 2, line 10: remove "other"
Done

Page 2, line 27: "In future" should be "In the future"
Done

Page 4, line 6: Replace ";" with "and"
Done

Page 5, line 7: Suggest replacing "resolution" with "gridspacing"
Done

Page 6, line 3: Southern Ocean is "a" . Remove "a"
Done

Page 6, line 34: Include: "

. . .

..based parameterizations such as in Rinaldi et al. (2013)
and Gnatt et al. (2011) but scaled

. . .

"

Done

Page 8, line 12: I suggest replacing potassium feldspar with K-feldspar for consistency.
Done
Page 12, line 6: 5a should be in parenthesis.
Done
Page 14, line 22: Fig. 6 should be in parenthesis.
Done

Page 22, line 11 and 12. Missing parentheses before Fig.11a and Fig.11 b
Done

Page 25, line 6: Replace Where with Here.
Done

Page 25, line 13: switch : "be therefore" with "therefore be

Done