

Referee #2

Dear Dr. Marinou,

on behalf of all co-authors I would like to thank you for reviewing our submitted manuscript and providing constructive feedback. Thank you also for your very positive opening comments.

In the following please find a detailed reply on each of your comments. For ease of understanding, in cases the text of the manuscript was modified, I present the **original text in blue** and the **updated/added text in green** color.

Specific comments

- **Page 1 line 15 and Page 3 line 77:** “RH_i is affected by and can be used as an indication of the nucleation process and the structure of cirrus clouds” and “the distribution of RH_i in the resulting cloud is highly dependent on the nucleation process”: Rather than the RH_i is being affected by or is dependent on, one would argue that it affects the nucleation processes that will dominate. Suggestion for a (tense) revision.

Tenses have been revised as follows:

Ice formation occurs at certain RH_i values depending on the dominant nucleation process taking place. RH_i can thus be used as an indication of the nucleation process and the structure of cirrus clouds.

Nevertheless, the nucleation process taking place is strongly correlated to the distribution of RH_i in the resulting cloud, as for example HOM needs a much higher RH_i to initiate

- **Page 2, line 53:** “vertical speed omega”: consider revising to updrafts

Has been revised as suggested.

The nucleation process of each cloud is largely dictated by the ambient conditions, e.g. updraft, available INPs, available moisture and ambient temperature

- **Page 5, line 140:** While reading this part I was puzzled why the authors used temperature fields in different levels but wvmr in all atmospheric column (not in levels). Later on, in the results section wvmr in levels is also discussed. So I would suggest here to add (maybe even in parenthesis) the information that later on for the results section wvmr means for different altitude ranges are also discussed/used.

Following phrase added to this section:

... flight track of each flight. Results regarding the water vapor mixing ratio are also discussed on four levels from 0 km to 12 km.

- **Figure 2, Page 9 line 202, Table 3:** “Data from ERA-5”, “ERA-5 data”, and “ERA-5 reanalysis data”.. I would suggest that the authors change these parts to ERA-5 reanalysis dataset or ERA-5 fields.

Proposed changes adopted for all suggested points and similar occasions throughout the text.

- **Page 8, line 140:** “Here, we calculate three temperature-dependent thresholds.. which is more efficient as an INP needing lower RHi”: It would be great if the authors could mention here the temperature-dependent thresholds used refer to the RHi values. Also, it would be nice to mention these thresholds so the reader doesn’t necessarily search for Urbanek’s et al. work before reading the results.

Following table including the thresholds added to the manuscript:

Table 1: Temperature dependent thresholds for HOM nucleation and HET nucleation on mineral dust (MD) and coated soot (CS). Temperatures in K

$RH_i^{HOM} = 232 \% - 0.37 \% \times T K^{-1}$	Parametrization from (Urbanek et al., 2017) based on (Koop et al., 2000)
$RH_i^{HET (MD)} = 134 \% - 0.1 \% \times T K^{-1}$	From (Krämer et al., 2016)
$RH_i^{HET (CS)} = 230 \% - 0.43 \% \times T K^{-1}$	From (Krämer et al., 2016)

- **Page 8, line 181:** “Further, we define three RHi regimes” It seems that these regimes are an output of the previously defined thresholds. If this is the case, please revise the connection between the 2 parts of this paragraph to make it more clear (currently it reads as if this is a new threshold).

This was also identified as a problem by referee 1 and has been adequately addressed in the manuscript.

- **Figure 4 vs section 2.3.5, 3.2.2 (e.g. Page 9 line 230), and Table 4:** It is difficult to understand the connection between the thresholds presented in the plots/legends and the ones mentioned in section 2.3.5 and page 9 line 230. Specifically, in the text 3 regimes are described, the HOM nucleation regime defined with values over 147%, HET CS between 123% and 147%, and HET MD between 100% and 123%. On the contrary in Figure 4 the thresholds are discussed differently, than the ones mentioned in the main text, with the lower values of HET MD being higher than 100% and this propagates somehow in the other thresholds. Please revise to make clear and consistent the different regions in fig. and main text.

This has also been brought to our attention by referee 1 and changes have been made to address the problem.

- **Page 11, line 259:** “During AC conditions the cloud-free air is more frequently supersaturated but mostly up to the activation threshold for MD, whereas during WAI conditions the cloudfree air is less frequently supersaturated, but reaches values over the MD activation threshold and up to the CS threshold”: This is not visible when comparing the © and (f) plots by eye. I assume this is discussed base on the statistics of table 4, so maybe you could add the a reference on the table for this part.

The following phrase has been added to the end of this paragraph:

CS threshold. The differences are made clearer in the further statistical analysis.

- **Page 15 line 346:** “The difference in optical thickness ... hints to differences in the microphysical properties of the two cloud types leading to different extinction coefficients”: Did you find different extinction coefficients from the collocated WALES extinction measurements? if so, a comment on this would be interesting to be included.

The extinction coefficients on their own are not analyzed in this study. Explanatory text has been added to Sect 2.2 and 4 clarifying that the optical thickness is calculated from the two-way optical transmission due to particle extinction.

Technical corrections/suggestions (bold text & red “,”):

- Page 3, line 85: “..high ice supersaturations **values in their simulations**”.
- Page 4, line 113: “the measurements come in **the** form of... the whole atmospheric column, from the aircraft to the earth’s surface, when conditions are favorable. Thus, with a single overpass of a cloud, information ..”.
- Page 5, line 138: “For the temperature field we used ~~the data on~~ the pressure level”.
- Page 8, line 179: “and thus ~~makes~~ higher RHi values **are** necessary”.
- Page 8, line 196: “until ~~at~~ the 250 hPa pressure level **where** the arctic becomes”
- Page 8, line 140: “Here, we calculate three temperature-dependent **RHi** thresholds”
- Page 9, line 225: “WAI cirrus have ~~an~~ almost”.
- Figure 4: “under arctic conditions (~~Arctic cirrus AC~~), in-cloud (b) ~~Arctic cirrus AC~~ near-cloud (c) ~~Arctic cirrus AC~~ cloud-free (d) Cirrus clouds measured under WAI conditions (WAI ~~cirrus~~), in-cloud (e) WAI ~~cirrus~~ near-cloud (f) WAI ~~cirrus~~ cloud-free.” Because it is confusing reading “cirrus cloud-free” in the legend.

All technical corrections have been applied in the manuscript