For clarity, referees' comments are written in black, our comments to each concern are written in blue and extractions from the original paper are written in green.

Anonymous Referee #2

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This study is aimed to estimate the role of dust aerosol on the cloud thermodynamic phase using CALIPSO-GOCCP and DARDAR products for cloud phase and the MACC reanalysis for dust mixing ratio.There are some interesting results regarding the relationship between dust and cloud ice. However, I personally found the manuscript to be difficult to follow, which makes it difficult for me to evaluate the scientific merit of this study.

We thank Referee 2 for the useful comments. We believe that the revised version of the manuscript is now easier to follow.

I have the following major concerns for the authors to considered and clarified:

1. Since this paper talks about the role of dust aerosol on the cloud thermodynamic phase, I thought the analyses would focus on mixed-phase clouds. However, mixed-phase clouds are categorized into liquid clouds in this manuscript (Section 2.3).
    - Does the analysis focus on pure ice clouds?
        - If yes, what about the effect of dust on cloud phase?

Line 131: —" In this case, the pixel is categorized as supercooled or mixed-phase depending on the radar signal, which is assumed a priori to indicate the presence of ice particles. Otherwise, the pixel is categorized as ice (Delanoë et al., 2013; Mioche et al., 2014). For reasons that will become clear later, we will coerce the mixed-phase category into the liquid category."—

This may not have been clear enough in the text. We have now emphasized that we do not mean mixed-phase *clouds* but mixed-phase *pixels*. Coercing mixed-phase pixels (Supercooled droplets and ice particles) into supercooled liquid is a common simplification even when studying mixed-phase clouds — in which the pixels at cloud top are classified as liquid, while the pixels below are classified as ice. In other words, the analysis does include mixed-phase clouds, although they are only detected as such in the DARDAR product.

Nevertheless, the analysis is rather focused on the occurrence ratio between ice and supercooled liquid clouds in the CALIOP-GOCCP product at different temperatures and dust conditions. In this product, mixed-phase clouds are mostly detected as supercooled liquid cloud tops.

2. Why only stratiform clouds are considered in this study?

Firstly, including convective clouds from the study does not change the results significantly (not shown). This is because the phase ratio is calculated as an area ratio between ice and liquid pixels at each temperature. Therefore, the phase ratio is strongly dominated by the phase of stratiform clouds.

Moreover, stratiform clouds are a perfect target to study cloud glaciation thanks to the simpler microphysics compared to convective clouds. Because stratiform clouds are thinner than convective clouds, a larger fraction of the vertical structure can be penetrated by CALIOP.

We have now extended this explanation in the methodology section.

+(new Lines 282-287): *"These cloud types are frequently thin enough to be penetrated by lidar and radar systems and are therefore a good target to study cloud glaciation processes (Bühl et al., 2016; D.Zhang et al., 2010b). Moreover, stratiform clouds have also simpler microphysics compared to convective clouds, where the dynamical forcing is usually stronger."*

3. How would the uncertainties in MACC data, such as the significant overestimate of the fine-dust fraction, affect the analysis results?

We are aware that a significant overestimation exists on the fine-to-coarse dust ratio in the MACC reanalysis (lines 156-157). However, we focused on the relative variations on the dust loading. Therefore, we expect that such overestimations would cause merely a shift in the x-axis with respect to the true values (Fig 8-11), assuming that this overestimation is homogeneous along the dust loading spectrum, which of course would cause some uncertainty. We have now included this issue in the discussion section:

+(new Lines 579-583*):"Furthermore, biases such as the overestimation of the fine-mode dust aerosol in the MACC reanalysis (Ansmann et al., 2017; Kok, 2011) may shift the mixing-ratios shown in Sect. 4.4. However, as long as such biases are not limited to certain meteorologicalconditions, the cloud phase averaged inside each dust decile should remain unaffected."*

4. How would the authors ensure the consistency among the different datasets, i.e., satellite products and reanalysis data?

As discussed in the text, we expect that the assimilation of the total AOD from MODIS in the MACC reanalysis produce a fair estimation of the large-scale aerosol conditions. At least for the Northern Hemisphere, this has been validated with in situ measurements.

As for the different reanalyses, both the ERA-Interim and the MACC reanalysis are based on the IFS model and use a similar assimilation algorithm.

Among the different satellite products, both rely on CALIOP to determine the presence of clouds. Nevertheless, we are aware that several uncertainties remain, for example, between the meteorology in the reanalysis and in the real atmosphere, a topic that is also discussed in the manuscript.

- And how would the inconsistency affect the analyses and conclusions?

  In the worst-case that the reanalysis is entirely inconsistent with the retrievals of cloud phase, we expect the result would be the lack of correlation between dust and the ice occurrence (Fig 8-10). In other words, given the large dataset included in the study, we expect that mismatches between reanalysis and cloud retrievals would cause an underestimation of the dust-cloud-phase correlation.

We have included these points in the discussion section:

+(new Lines 560-570): "*In general, we expect that the assimilation of the total AOD from MODIS in the MACC reanalysis produce a fair estimation of the large-scale aerosol conditions on a day-to-day basis. At least for the Northern Hemisphere, this has been already validated with in situ measurements (Cuevas et al., 2015). As for the consistency among the different reanalyses, both the ERA-Interim and the MACC reanalysis are based on the IFS model and use a similar assimilation algorithm. Among the different satellite products, both CALIPSO-GOCCP and DARDAR-MASK rely on CALIOP to determine the presence of clouds. Nevertheless, the reader should be aware that several uncertainties remain, for example, between the meteorology in the reanalysis and in the real atmosphere, particularly on the sub-grid scale. In the worst-case that the reanalyses are entirely inconsistent with the retrievals of cloud phase, we expect the result would be the lack of correlation between dust and the ice occurrence (Fig 8-10). In other words, given the large dataset included in the study, we expect that mismatches between reanalysis and cloud retrievals would cause an underestimation — and not an overestimation — of the dust-cloud-phase correlation.*"