Review of: The impact of mineral dust on the day-to-day variability of stratiform cloud glaciation occurrence

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General Comments: This paper explores important relationships between aerosol properties (specifically mineral dust loading), cloud phase, and other dynamic and thermodynamic variables. I commend the authors for attempting to provide a global perspective on this challenging to measure and understand phenomenon. The satellite-based perspective on aerosol cloud interactions can provide more insight into the global extent of aerosol influences than obtainable from measurements from a single observatory. In general, I think that the analysis completed is interesting and potentially sheds some light onto the relationships between mineral dust and cloud properties. Having said that, I do have some reservations and questions about the manuscript, and therefore would like to see some additional work completed before this paper can be accepted for publication. Additionally, I found the manuscript to be very dense, and found myself having to reread sections on a regular basis. I'm not sure whether this was the result of the frequent use of abbreviations, or the writing style, or something else. However it was a challenge to read, which is unfortunate given the science that is in the paper.

Specific Comments:

- I wonder to what extent the different products used in this evaluation are consistent with one another. This is particularly a large question for the reanalysis derived estimates of temperature, humidity and vertical velocity. Since the reanalyses rely on models to provide input on clouds and dynamics, the values represented in these products must be internally consistent — however, this may not always match the real atmosphere. This is particularly true in areas of cloud cover, where the model clouds and real clouds may not match in time, location and phase. Therefore, I wonder whether there may be instances where the model (reanalysis)-produced thermodynamic state is inconsistent with the clouds detected from satellite measurements, potentially biasing the evaluation of observed cloud phase into different temperature regimes from reality. Some discussion on the potential for this to occur would be helpful.
- There is a substantial question related to the ability to truly detect relationships between dust and cloud phase in the absence of sufficient constraints on environmental state and dynamics. The co-variability that is demonstrated is interesting, but how can one be sure that this is the result of the aerosol, and not of the dynamical forcing on the cloud? Particularly at high latitudes, where figure 8 appears to show a relationship between dust mixing ratios and vertical velocities, it could be challenging to discern the impacts of the dynamics from those of the aerosols. I will say that it seems to me that the relationship is such that you would not necessarily expect that the dynamics and aerosols would work in the same direction – with increasing mineral dust loading you have increasing vertical velocities (upward), which would support enhanced supersaturation. Therefore,

the cloud liquid would increase in response to the updraft but decrease in response to the mineral dust loading. Assuming I have that correct, this could help to support the idea that the changes are the result of aerosols and not dynamics, but I think that a good amount of discussion on this topic is warranted.

- *Line 129*: What, if any, sensitivity is there to the order of the averaging?
- *Lines 139-140*: Please describe what cloud depth constitutes precipitating vs. non-precipitating in 2B-CLDCLASS
- *Line 179*: 30x1.825 deg — depending on latitude, this can be a very large amount of area. Therefore, I would be concerned about sub-grid variability, particularly at lower latitudes. For example, dust and cloud could be on different sides of a front within a given grid box. This is discussed a bit starting on line 370. Additionally, there could be significant gradients in phase over such a large horizontal extent, particularly around mid-latitude frontal zones, coastlines, etc. Such gradients may have little to do with the dust, but everything to do with changes in forcing.
- Figures 3 and 4: Recommend removing the dotted vertical lines to improve clarity.
- Figure 3: “Error bars” — this isn’t really error, is it? Just the standard deviation and variability?
- Figure 4: Same comment about “error bars”