Referee Comment on "A Microphysics Guide to Cirrus – Part 3: Occurrence patterns of cloud particles"

General Comments

This manuscript represents the third instalment in a well-established series providing a comprehensive microphysical perspective on cirrus clouds. Building upon the foundational work in Cirrus Guides I and II, this paper offers a novel and highly valuable exploration of cirrus particle size distributions (PSDs), leveraging an unprecedentedly large dataset (≈975,000 PSDs over 270 flight hours) from 11 field campaigns. The authors have developed a unique heatmap-based visualization methodology, supported by *in situ* measurements and model simulations, to uncover occurrence patterns of cloud particle sizes under various thermodynamic regimes.

The manuscript is scientifically robust, methodologically sound, and clearly written. It successfully connects microphysical processes with observed PSD features across temperature and IWC regimes, offering insights relevant to both process understanding and climate modelling. Particularly notable is the classification of PSD behaviour into nucleation/sublimation, overlap, and uplift/sedimentation size regimes, and the differentiation between *in situ*- and liquid-origin cirrus using a physically motivated threshold based on simulations.

The integration of measurements, theory, and model results is a major strength. This paper provides not only a valuable resource for the community but also a reference dataset that could serve as a benchmark for global models and remote sensing retrievals. The figures are generally informative, and the inclusion of synchronized PSDs enhances the coherence of multi-instrument data.

However, while the depth of analysis is commendable, some sections (notably in Section 5) could benefit from more concise summarization to maintain focus. Clarifications are also needed regarding the transition between cloud types and the uncertainties involved in origin attribution.

I am also concerned about the lack of the key mechanism of ice crystal aggregation in the model, and would like to be more convinced that comparing Dmax between model and observation is a sound metric for liquid vs in situ origin. The densities, shape factors and growth rate descriptions for ice crystals need a more thorough description for the modelling.

Specific Comments

1. **Section 2.3 (Simulations of in situ-origin ice particle sizes)**:
   In the modelling description of MAID you say that you consider diffusional growth, sublimation and sedimentation. But you don't mention aggregation, which can have a very important effect on Dmax, even for in-situ cirrus clouds. Maybe you could comment on this, and how it might affect your findings.
2. **Distinction between in situ- and liquid-origin cirrus**:
   You are using simulated Dmax to discriminate between in situ or liquid formed cirrus clouds. But you are missing aggregation, which may be a key mechanism.

A discussion on the robustness of this attribution in mixed or transitional conditions would be valuable. Is Dmax the best metric? Maybe the shape of the distribution would be more statistically significant? How well does the model reproduce the shape of the distribution? Knowledge of this would allow the reader to assess the methodology.

3. **Figures 7 & 8**:
   These figures are central to the paper's conclusions. At the higher temperature the threshold size for insitu cirrus is 230 micron, but we regularly see that in situ cirrus produce much larger particle sizes, due to aggregation – e.g. see the paper by https://rmets.onlinelibrary.wiley.com/doi/epdf/10.1256/qj.03.138. In addition what growth rates, shape factors and densities were used when modelling diffusional growth – since this is key for calculating Dmax.
4. **Table 3 (Median Nice, Rice, RHice)**:
   This table could benefit from a clearer explanation of how these median values were derived from the climatologies in Cirrus Guide II. Were percentile bounds applied uniformly across all IWC-T tiles?
5. **Cirrus cloud classification terminology**:
   The paper uses terms like "thin," "median thick," and "thick" cirrus. It would be helpful to define these in absolute IWC terms earlier in the paper, perhaps when the IWC-T matrix is first introduced.
6. **Potential for model validation and satellite application**:
   The final paragraph of the conclusions alludes to validation of climate models and remote sensing products. It would strengthen the impact of the paper to expand briefly on how the dataset might be practically used for these purposes (e.g., specific satellite retrieval algorithms or GCM parameterizations).

Technical Corrections

- **Start** "Correspnodence" → "Correspondence"
- **Line 66**: "perfom" → "perform"
- **Line 67**: "scienfic" → "scientific"
- **Line 212**: "agreemenent" → "agreement"
- **Line 147**: "liekly" → "likely"
- **Line 551**: "prepartion" → "preparation"
- ***In situ*** is a Latin phrase meaning "in its original place," and as such, **it should be italicised** especially in scientific contexts.
- "**Database**" is a **compound noun** that has long since been accepted as a single word in both technical and general usage. Similarly "data sets" → "datasets"