**RC1**

This study presents model-data comparisons on the scattering phase function of frozen-droplet and frozen-droplet aggregates in deep convective clouds. The data are obtained from the CIRCLE−2 field campaign. Gaussian random spheres and droxtals were proposed as possible candidates for representing the forms of observed frozen droplets and frozen droplet aggregates. The authors generate a total of 120 individual models of Gaussian random spheres and 129 models of droxtals and by attaching the individual models in both a homogeneous and heterogeneous manner, a total of 315 models of three different types of droplet aggregates model were generated. This study has some interesting findings, such as the differences between faceted particle and quasi-spherical particles on the phase function comparison. Given that the study provides quite many comparisons on different types of models, this study might have some reference value on this topic.

We sincerely thank the reviewer for the careful reading of the manuscript and the many helpful and constructive suggestions that have improved the quality of the manuscript substantially.

In response to the reviewers' comments, we have revised the manuscript, with the major modifications outlined as follows. First, we extended the calculations by increasing the distortion parameter ($t$) to a maximum of 0.95 in increments of 0.05, resulting in changes to Sections 4.1, 4.2, and 4.3. The analysis of these extended results has been incorporated into the revised manuscript. Additionally, as the reviewers pointed out, to avoid redundancy with Section 4.1, we have removed Sections 4.2.1 and 4.2.2, which compared results for homogeneous component aggregates represented by Gaussian random spheres or droxtals, from the main text and included them in the Supplement (S1 and S2). Another significant modification is the introduction of an additional criterion: the number of angles ($\omega$) falling within the ±20% uncertainty range of PN, which was added to assess the accuracy of our theoretical calculations against observational data. Further discussion on $\omega$ has been integrated into the revised manuscript. Lastly, we modified the method used to construct habit mixture models, as explained in Section 4.3, and the corresponding comparison results are now thoroughly discussed in that section. Although significant revisions have been made in this study, the core results presented in the original submission remain unchanged, demonstrating the robustness of our findings.

**Specific comments:**

1. What are relative measurement uncertainties in each region of scattering angle?

The following paragraph about the operation and measurement uncertainty of PN is added in Section 4.

"*The PN, as detailed by Gayet et al. (1997), is an airborne instrument designed to measure the angular scattering pattern, or scattering phase function, of an ensemble of cloud particles ranging from a few micrometers to about 1 mm in diameter. Operating at a wavelength of 0.8 μm, the PN captures scattering angles between ±15° and ±162° with a resolution of 3.5°, typically providing data at 32 distinct angles from among 56 photodiodes (Jourdan et al., 2010). Measurements at near-forward and backward angles ($\theta$ < 15° and $\theta$ > 162°) are less reliable due to diffraction effects caused by the edges of holes drilled in the paraboloidal mirror (Gayet et al., 1997). To ensure continuous sampling, the PN integrates the signals from each photodiode over periods selectable by the operator, commonly around 100 ms. The average measurement errors for the angular scattering coefficients range from 3% to 5% for angles between 15° and 162°, with a maximum error reaching 20% at the outermost angles (Shcherbakov et al., 2006). The instrument's ability to directly measure the scattering phase function allows for differentiation of particle types and calculation of essential optical parameters, such as the extinction coefficient and g. Gayet et al. (2002) reported an uncertainty of 25% for the PN-derived extinction coefficient, while the estimated absolute error for the g ranges from ±0.04 to ±0.05, depending on the prevalence of large ice crystals within the cloud (Jourdan et al., 2010).*".

2. Could you provide some in-situ images for the support of these idealized shape models?

Example images of frozen droplets and their chain-shaped aggregates captured by the Cloud Particle Imager (CPI) during field campaigns are shown below. As stated in the manuscript, although a high-resolution CPI (i.e., 2.3 μm) was used to image the frozen droplets, its resolution was not sufficiently high to fully resolve their three-dimensional morphological features.

Example CPI images of frozen droplets and their chain-shaped aggregates, sampled during the DC3 field campaign (Um et al., 2018), are shown below.

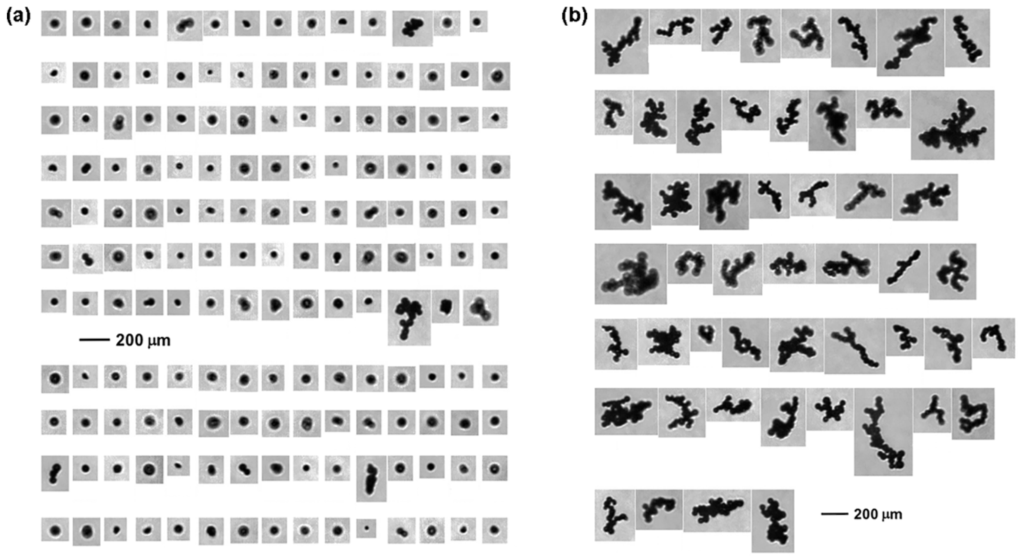


**Figure 1.** **(a)** Example CPI images of ice crystals observed at $T = -58.16\,°C$ (altitude of 12.11 km) between 22:12:13 and 22:12:19 UTC, and **(b)** example CPI images of ice crystals observed at $T = -57.72\,°C$ (altitude of 12.03 km) between 22:21:02 and 22:22:14 UTC. The 200 µm scale bar is embedded in each figure.

Example of CPI images from the CIRCLE-2 field campaign (Gayet et al., 2012) are also shown below.


**Fig. 10.** Typical examples of chain-like aggregates ice crystals from 2 up to 15 individual frozen droplets.

3. The model only considers surface scattering effects and aggregate configurations, what about internal scattering?

We did not consider the effect of any internal inclusions in this study. Multiple previous studies (Macke et al. 1996; Labonnote et al. 2001; Xie et al. 2009; Bi and Yang 2014; Panetta et al. 2016; Smith et al. 2016) have shown similar effects, i.e., featureless $P_{11}$ and lower $g$, as the surface effects.

Bi, L. and P. Yang: Accurate simulation of the optical properties of atmospheric ice crystals with the invariant imbedding T–matrix method, J. Quant. Spectrosc. Radiat. Transf., 138, 17–35, 2014.

Macke, A., Mishchenko, M. I., and Cairns, B.: The influence of inclusions on light scattering by large ice particles, J. Geophys. Res., 101, 23311-23316, 1996.

Labonnote, L. C., Brogniez, G., Buriez, J. C., Doutriaux–Boucher, M., Gayet, J.-F., and Macke, A.: Polarized light scattering by inhomogeneous hexagonal mono crystals: Validation with ADEOS–POLDER measurements, J. Geophys. Res., 106, 12139–12155, 2001.

Panetta, R. L., J.-N. Zhang, L. Bi, P. Yang, and G. Tang: Light scattering by hexagonal ice crystals with distributed inclusions. J. Quant. Spect. Radiative Transf., 178, 336-349, 2016.

Smith, H. R., A. J. Baran, E. Hesse, P. G. Hill, P. J. Connolly, and A. Webb: Using laboratory and field measurements to constrain a single habit shortwave optical parameterization for cirrus, Atmos. Res., 180, 226-240, 2016.

Xie, Y., Yang, P., Kattawar, G. W., Minnis, P., and Hu, Y. X.: Effect of the inhomogeneity of ice crystals on retrieving ice cloud optical thickness and effective particle size, J. Geophys. Res., 114, D11203, doi:10.1029/2008JD011216, 2009.

4. Why is the distortion parameter only set up to 0.3? Since high distortion provides the best fit, presumably higher distortion could give even better fit. It is suggested to increase the distortion up to at least 0.6 and perform the comparison again.

Following the reviewers' comment, we have extended the calculations with the distortion parameter increased up to 0.95 and the analysis of the results has been included in the revised manuscript. The following paragraph is added in Section 5.

"*The application of the distortion parameter (t) in the calculations of single-scattering properties facilitated the production of smoother* $P_{11}$*, reduces g, and increases ω, thereby enhancing the agreement with the PN measurements to certain extent (e.g., up to t = ~0.3). However, beyond this threshold, larger t values diminished the agreement.*"

5. It is suggested to have more discussion about the differences among the three different regions, that is, forward, lateral, backward scattering. How these angular regions related to the particle shapes.

Following the reviewer's comment, additional discussions have been incorporated throughout the manuscript.

6. It would be better reducing the number of significant findings to highlight the most important ones in the conclusion section.

Following the reviewers' comment, the number of significant findings stated in Section 5 Summary and Conclusions have been reduced without losing the importance of the findings.

7. It may be more useful to not just state the relative differences, but also state the signs of relative differences in three different scattering regions.

Following the reviewer's comment, the signs of the relative differences have been added throughout the manuscript.