Answers to RC1 (Anonymous Referee #2, supplementary comments)

The authors are grateful for the Referee's attentive inspection of the text, for the generous appreciation of this work and mostly for the Referee's additional comments and suggestions for further improvement to the paper. In the following, detailed responses to those comments are presented.

Referee's comment #1: We know that droplet spectrometers, such as the CAS, have a very small sensitive volume where the forward scattered light of droplets is measured. This significantly limits their ability to measure droplet size spectra over short in-loud distances. The authors note the droplet spectra is "conveniently" measured in-cloud every "sampling instance" of1s, which at a typical research-aircraft velocity of 100 m/s is equivalent to 100m. The total sample volume seen by the CAS over this distance appears to give enough droplets ("thousands") for the CAS to sample, giving meaningful spectra for "normal clouds" as noted by the authors. Some spectrometer data has been published at 10 Hz, but here the ambient droplet concentration must be quite large for meaningful results. Given that ambient droplets can be described as being approximately distributed randomly in space means that the CAS must measure enough droplets to achieve acceptable statistical uncertainty in the resulting spectra. For that reason, obtaining CAS spectra over distances < 10m at the given aircraft velocity usually appears unrealistic.

The preceding comments apply directly to PdP data files that the authors describe as containing scattered light (and time arrival data) data for each of the first 292 droplets for each "sampling instance" of 1s. Clearly, such a low number of droplets for each 1s will not yield much useful information on desired high-resolution size spectra, therefore PdP from multiple 1-s "sampling instances" must be combined to achieve statistical significance. In the authors' given spectral plots this is apparently done because of the flight duration of the measurements covering "several minutes".

The authors state that their effort included a "…complicated and time-consuming analysis of the PbP files…". Thus, their PbP approach may be of limited practicality; although, it still may be useful if a limited number of high-resolution spectra are needed corresponding to lengthy sampling periods.

In addition to showing the spectra from the authors' measurements over several minutes, it would be useful for the reader if the authors also included spectral data for a 1-s interval and its associated companion PbP spectra, given that droplet spectra are often presented for this time interval. An estimate of how many intervals must be combined to obtain useful high-resolution PbP spectra would also be useful.

Answer to comment #1: As the Referee correctly pointed out, the PbP data becomes statistically significant for relatively large sequences of one-second sampling instances. This observation has been used to construct detailed dimensional distributions of droplets during flight lines which typically take "several minutes" each. The methodology described in the paper has been designed for dealing with such large cloud sections. Analysing the data for each one-second sampling instance would eventually bring information on spatial fluctuations of cloud properties, a matter which is beyond the purpose of our study. Moreover, with the highly improbable exception of a very spatially homogeneous cloud, such one-second spectral data is more likely statistically incompatible with the distribution of the ***first*** ~ 290 particles detected in the sampling instance, which are stored in the PbP file. These particles are not randomly picked from the set detected in the whole sampling instance, they are only the first in this set and one may suspect that this very choice might induce a statistical bias. However, when combining many consecutive sampling instances, one can expect that the statistical bias (if any) is effectively eliminated and that the PbP data behaves statistically in a similar way as the bulk data file.

A further related question could be: How many sampling instances are necessary to achieve statistical consistency of the PbP data? The answer, as pointed out by the referee, would clearly depend on the density of the droplet population in the given flight segment. The denser the corresponding cloud area, the longer the recording should be in order to achieve a statistically consistent PbP data file. In general, by assuming that in a sampling instance the instrument can measure enough particles to produce a significant distribution, we conjecture that the total length of the PbP data file should be at least equal to the average number of qualified particles during a single sampling instance.

In order to make those points clearer in the text, the authors have added a new paragraph starting on line 278: *"In this connection, we note that the statistical consistency of the PbP data might be questioned due to the fact that the corresponding particles are not randomly picked from the set detected in the whole sampling instance. They are the first ~ 290 in this set and one may suspect that this very choice might induce a statistical bias. However, when combining many consecutive sampling instances, one can expect that the statistical bias (if any) is effectively eliminated and that the PbP data behaves statistically in a similar way as the bulk data file. A further related question could be: How many sampling instances are* *necessary to achieve statistical consistency of the PbP data? The answer would clearly depend on the density of the droplet population in the given flight segment. The denser the corresponding cloud area, the longer the recording should be in order to achieve a statistically consistent PbP data file. In general, by assuming that in a sampling instance the instrument can measure enough particles to produce a significant distribution, we conjecture that the total length of the PbP data file should be at least equal to the average number of qualified particles during a single sampling instance."*

Regarding the "…complicated and time-consuming analysis of the PbP files…" that would limit the practicality of the method, we would like to point out that this statement is made at the end of Section 5 and refers only to the ***accuracy evaluation*** of the cloud microphysical parameters, which is indeed a lengthy (nevertheless automatic) process. The spectral analysis itself, based on the PbP files, is much more straightforward, but is still only doable in the post-flight stage.

Referee's comment #2: Droplet spectra from spectrometers are often given as continuous data without error bars. Since cloud droplets are approximately distributed randomly in space (~ Poisson distribution) it is possible to estimate from the droplets' count in each size bin the uncertainty of the count. This is rarely ever done. Please discuss how this statistical uncertainty affects the accuracy of your spectra measurements, especially those associated with PbP.

Answer to comment #2: The authors assert that error bars are not a proper way to express uncertainties related to distributions. An error bar can be used for indicating the local imprecision of a certain quantity whose values are pointwise independent. For example, in the emission spectrum of a certain sample expressed as a function of the wavelength, each measured intensity fits into a certain precision interval, which usually depends on the wavelength, and can be shown graphically as an error bar. Otherwise, the values taken by the intensity at different wavelengths are independent. The situation is different for statistical distributions (for which reason it would be recommended to avoid terms as "dimensional spectrum" and replace them with "dimensional distributions") where, due to the normalization requirement (there is always a ***given number*** of objects to be distributed over a certain range of a variable), a variation at a certain point determines a change in ***the diagram as a whole***. For this reason, we consider that the error bars are not suited (they can actually be misleading!) for illustrating the imprecision of a statistical distribution and this is a possible reason for which they are not normally used in the literature.

However, to compensate for this deficiency and to attempt a graphical illustration for the imprecision of a size distribution, the authors constructed Figure 6 in the manuscript, where the "nominal" and "distorted" (due to the errors induced by the proposed method) versions of a size distribution have been shown on the same diagram. Obviously, similar distortions can be observed in size distributions over any structure of dimensional bins. The choice of 50 equal bins for Figure 6 was made mainly for reasons of graphical relevance.

Referee's comment #3: In Fig. 6 the authors show the effect of a 10% error in the scattered light measurement on the droplet spectra. This amount of error is less than the error spec provided by the CAS manufacturer as noted by the authors. Figure 7 shows a relative error of 20% for the flight-line sample volume, and shows the expected result on cloud parameters when the scattered-light error increases to large values. Are the abscissa error values realistic? Given these substantial errors, does the detailed analysis of the Mie "ripples" in the paper lead to errors of the same magnitude, or can they be ignored in comparison? Please comment.

Answer to comment #3: Thank you for pointing this out. The diagrams of Figure 7 show some kinds of lookup diagrams where the errors in the measured scattered light determine the accuracy of the methodology proposed in the paper (or, in the Referee's words, the detailed analysis of the Mie "ripples"). As stated in the Introduction (lines 64-67), the paper is not attempting to deal with the CAS errors in the scattered light measurements. Various manufacturers give different values for these errors (which have also a strong variation with the level of the intensity of the scattered light). The scattered light measurement errors are expected to decrease with time, when more precise instruments will become available commercially. The values on the abscissa of Figure 7 are therefore mainly generic. The diagrams can be of interest if a certain CAS user knows the errors with which the instrument measures the scattered light on its different amplification stages. The user can then simply read the ordinate indications for the final errors of the various cloud parameters. Of course, the diagrams have been constructed for a certain value of the sample volume, which is another (essentially functional) parameter of the instrument whose knowledge needs to be continuously improved. The error diagrams should be reconstructed for every level of error of the sample volume.

To improve the discussion, we have added: *"It is also remarkable that, while the generic range of the relative errors of the FWSCS measurements is relatively wide, some cloud parameters (like the extinction coefficient or the effective diameter) tend to be determined with better final* *accuracy through this methodology (at least over some ranges) than that provided for the measured FWSCS values."* on line 485.

Referee's comment #4: Section 6 uses Mie theory to estimate the effect of different refractive indexes on various droplet properties. For example, Fig. 11 illustrates the obvious strong effect on droplet properties for small values of the imaginary index. To put this result into perspective, can the authors indicate where typical ambient cloud droplets fit into the 3-D plots of Fig. 11?

Answer to comment #4: It was the initial authors' intention to look for some regularity in the optical properties of contaminated cloud droplets. If their complex refractive index would have depended only on the nature of the incorporated aerosol particles, then there could have been chances to find some typical behaviour. Unfortunately, the variability of the droplets' optical properties equally depends on the amount of "ingested" aerosol, which is strongly correlated to the aerosol load in the atmosphere at various altitudes. These factors make the definition of "typical ambient cloud droplets" very difficult, at least to the authors' knowledge.
Instead, we propose in the manuscript (lines 623-628) that the (average) optical properties of the cloud droplets measured in a flight line be estimated through post-flight optical analysis of collected samples of cloud droplets/cloud water during that flight line.

Referee's minor comments:
L52 - what is meant by "…cast into the generic name…" Suggest removing this part and using '…instrument is the Cloud…'
Answer: The correction suggested by the Referee has been performed.

Fig. 3 - The numerical values of the ordinate axis of the right-hand LWC plot are incorrect.
Answer: The number of decimal digits in the values on the ordinate axis has been set to 1, by mistake. The error has been corrected in the new version of the text.