Manuscript Review

Laboratory and In-flight Evaluation of a Cloud Droplet Probe (CDP)
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Overview

This study of the Cloud Droplet Probe (CDP) is a follow-up to an earlier study by Lance et al. (2010) who established the technique that is used in the present study. Using a droplet generator on a micro-positioner, the authors repeat the measurements published in the earlier Lance et al. paper. As far as I can determine, the only difference in the two studies is that the current study uses a computer controlled positioner, the number of droplet sizes used is larger, covering almost the entire range of the CDP, and a different CDP serial number was used. There do not appear to be any results that contradict those in the earlier study, nor are there any new results that would suggest the need for any serious correction procedures. Hence, I would label this a confirmatory study.

Major comments

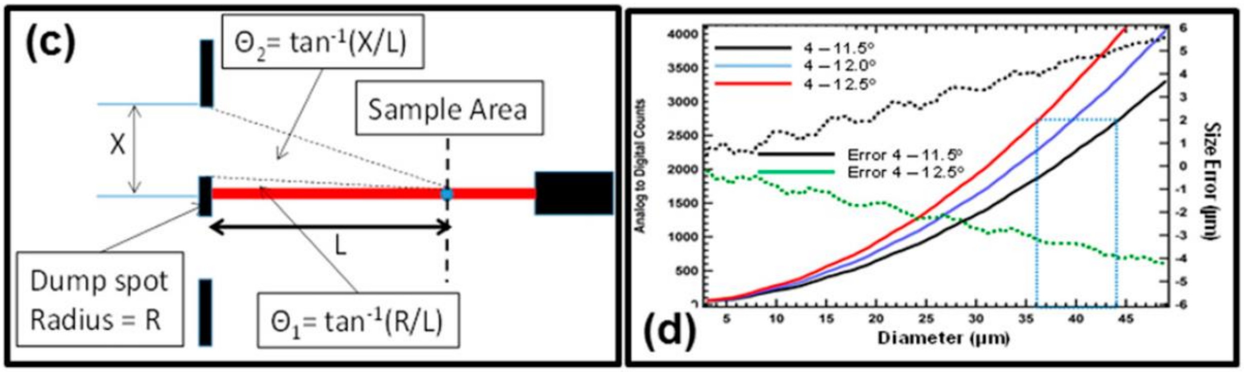
Uncertainty in collection angles

As I state in the overview, it doesn't appear that the current study differs in any significant way from that of Lance et al. If I err in this conclusion, then I suggest that the authors be more clear in the abstract, introduction and summary with respect to how this study distinguishes itself from Lance et al. I am a firm believer in confirmatory experiments even though they are rarely published. Even though it appears to me that the results support those of Lance et al., the broader size range used in this study justify its publication.

There are several points that are either missing or understated in this paper. Although the authors allude to our Chapter 9 in the AMS monograph, I don't think that they fully evolve the discussion of how important the collection angles are in introducing variations in the derived sizes from the scattering signal. The sizing accuracy for single particle light scattering spectrometers has been estimated as 20% and the concentration accuracy as 16% (Baumgardner, 1983; Dye and Baumgardner, 1984) and every publication since these have used these numbers, including the most recent book on aircraft measurements and our Chapter 9 in the monograph.

The figure from our Chapter 9, shown below, illustrates clearly the issue. With only a 0.5^0 change in the outer collection angle, there can be differences as much as ±4 um, depending on the size range and whether the actual collection angle is larger or smaller than the nominal. The length of the sample area, i.e. the DOF, is about 1.5 mm. Given that the particle distance from the dump spot determines the collection angle, ±0.75mm changes the amount of scattered light collected and contributes to this uncertainty, particularly for the larger droplets, consistent with the observations.

I am frankly quite surprised that the average differences are so small between the actual versus the measured. These differences are well within the expected uncertainty.



It should be possible to reanalyze the results after recalculating the Mie curves for the correct collection angles and setting new size thresholds to the 30 channels. How to do this? Very straight forward. Just run Mie calculations over a range of angles from perhaps 2 – 15^{o}, in 0.5^{0} steps and fit the results to the droplet measurements, using the particle by particle values that are given in digital counts without pre-binning. The collection angles that produce the best fit are the ones optimum for this particular CDP.

If this unit doesn't have the PbP, the digital scattering values can be interpolated from the channels where the counts fall. With this optimization I predict excellent agreement over all sizes.

<u>Laser intensity map</u>

Completely overlooked in this study is the impact of the laser intensity on the sizing and sample area accuracy. This was overlooked in Lance et al. other than a brief mention at the very beginning acknowledging that laser beam intensity gradients can contribute to sizing uncertainty; however, the laser intensity was never mapped in their study.

Given that the intensity distribution is Gaussian across and along the beam, there will be a gradient within the sample area, although the design is meant to minimize missizing by centering the sample area in the flattest intensity region. That being said, without an intensity map that shows how the laser intensity varied within the sample area, it is pure speculation to hypothesize the edge effects on misalignment when some can be explained just be changes in collection angles within the area and others may be do to inhomogeneous laser intensity. This is an issue that can't be dismissed without some serious discussion.

<u>Summary</u>

I think that it should be clearly stated that the sizing and sample area uncertainties fall well within those that have been published over the past 25 years. I also think that the issue of broadening is overstated without and actual estimate of the degree of broadening. Otherwise, it is misleading and possibly even insignificant.

Minor comments

Page 1. Line 25: Nominal size range for CDP is 2-50 um.

Page 2, Line 28. Dead-time has not been an issue in the FSSPs since the late 1980's when DMT introduced the SPP-100 replacement electronics for the FSSP.

Page 3, Line 3. "indexes" should be "indices".

Page 4, Line 3, "568" should be "658

Page 4, line 5, "…in an ~12° arc, remove photons in the innermost 5 ~4°, and..". This is poorly worded and confusing. The CDP collects forward scattered light over a solid angle from 4-12^0, determined by the distance of the center of focus from the dump spot, the diameter of the dump spot and the aperture in the arm of the CDP.

Page 4, Line 10. "The qualifier's rectangular mask is designed to reduce the collection angles of the detector so that responses are maximized when droplets pass through the qualified sample area.". This is not correct. The mask is designed to accept for sizing only those droplets that pass through the optimum simple area.