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Proposed post-flight data analysis for improving reliability of sizing the cloud droplets using cloud & aerosol spectrometers for in situ measurements

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Cloud microphysics is one of the key components in both our understanding of global aspects of climate change and pursuing daily domestic activities ranging from agriculture to energy harvesting and aviation. The microphysical processes taking place in clouds always interfere with the spatiotemporal variation of the size distribution of the cloud droplets. Therefore, detailed knowledge of such phenomena requires intimate information on the cloud structure. Such data can be obtained with sufficient spatiotemporal accuracy only through in situ measurements. One of the most useful types of instruments is casted into the generic name of Cloud and Aerosol Spectrometer (CAS) that can be mounted on specialized research aircraft. Basically, a CAS sorts out cloud droplets upon their optical diameters, by measuring the forward scattering intensity of a laser beam of known wavelength from cloud droplets entering the sample volume of the instrument. The usual range of particle diameters that can be analysed by CAS is between 0.5-50 μm. Comparison with theoretical scattering cross section of light (computed within the classical Mie formalism) by water spheres is thus an intrinsic part of the measurement procedure. The comparison stage is usually source of quite large errors due to the rather complicated quasi-monotonic dependence of the scattering cross section on the diameter of the target sphere: In most cases, a measured value of the cross section corresponds to several diameters. To alleviate this drawback of the method, the size distribution is commonly constructed over a partition of uneven widths called bins. In order to minimize the ensuing errors, the lengths of the bins should be carefully chosen prior to the measurement session. In doing this, one should account both the expected range of sizes to be found in the sampled cloud and the large ambiguities generated by the diagram of the scattering cross section vs. diameter. The choice of the bin structure is therefore quite difficult to be made and is usually the main cause of imprecision in the resulting size distribution. However, it can be shown that a great deal of improvement can be achieved through post-flight processing of the acquired data. The purpose of the present research is to propose data processing methods for improving the accuracy of the obtained droplet size distribution in clouds. The proposed methodologies were used to analyse a data set recorded with CAS instrument during a flight with a Beechcraft C90 GTx in a water cloud in the southern part of Romania. As the post-flight procedures lead to more accurate droplet size distributions, we expect that they can be extended to other particle types like ice crystals and aerosol.