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Characterization of flow distortion effects associated with airborne passive probes for aerosol and cloud measurements

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In the past decades, a number of airborne in-situ instruments for the detection of aerosol and cloud properties have been developed and deployed during various studies at research aircraft flying at speeds of more than 200 m/s.

Flow distortion occurring at the fuselage of research aircraft and specifically at the instruments mounted under the aircraft wing affects the measurements producing artifacts in aerosol and cloud particle size distributions recorded. First, the pressure and temperature conditions at the probe differ from the undisturbed conditions. Moreover, the size-dependent inertia of the particles can result in locally increased or decreased concentration in certain particle size ranges. Finally, large liquid particles can be deformed by the rapid changes of the flow velocity. Passive inlets and optical array probes directly rely on knowledge of sampling conditions which strongly depend on the probe geometry and its mounting location. Consequently, wrong pressure and velocity values lead to errors in concentration and in sizing.

Several studies have investigated the above-mentioned effects assuming that air is incompressible. Our aim is to extend the analysis for fast-flying aircraft where the effect of air compressibility is important. We adopted a combined approach comparing flight data with numerical simulations of the flow around a wing probe for a number of realistic flight conditions. We propose a validated correction scheme for data from airborne in-situ measurements with aerosol and cloud probes.

Results show a sorting effect on the aerosol depending on particle size and flight conditions. For example, when flow conditions at the probe are used for the calculation of particle number concentration, on average, this results in an overestimation of 25 % for particles larger than 10 μm in diameter. An extended analysis is presented for liquid droplets investigating the shape distortion caused by the rapid flow change.

The presented results refer to the configuration of the German Aerospace Center (DLR) Falcon research aircraft during the SALTRACE campaign but general conclusions can be used for any research airplane. In this perspective we validate the correction strategy using two datasets collected during the A-LIFE campaign with the DLR-Falcon and during the ATom campaign with the NASA DC-8 research aircraft. Finally, we discuss the biases in mass estimation and radiative forcing for uncorrected and corrected data.