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Spatial distributions of cloud droplet size distributions from cloudbow observations measured with specMACS

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The evolution of clouds and their impact on weather and climate is closely related to the cloud droplet size distribution, which is often represented by two parameters: the cloud droplet effective radius (reff) and the effective variance (veff). The droplet radius (reff) determines the radiative effect of clouds on climate. The effective variance is a measure of the width of the size distribution which is, for instance, important to understand the formation of precipitation or entrainment and mixing processes. We present an airborne remote-sensing technique to determine reff and veff from high-resolution polarimetric imaging observations of the LMU cloud camera system specMACS.

Recently the spectral camera system has been upgraded by a wide-field polarization resolving RGB camera which was operated for the first time on the HALO aircraft during the EUREC^{4}A campaign. The new polarimeter is ideally suited for observing the cloudbow - an optical phenomenon which forms by scattering of sunlight by liquid water cloud droplets at cloud top. The cloudbow is dominated by single scattering which has two implications: Its visibility is significantly enhanced in polarized measurements and its structure is sensitive to the cloud droplet size distribution at cloud top. This allows the retrieval of reff and veff by fitting the observed polarized cloudbow reflectances against a look-up table of pre-computed scattering phase functions.

The characteristics of the polarimeter are optimized for the measurement of the cloudbow. The wide field-of-view is key for observing the cloudbow (scattering angle 135° -165°) for a wide range of solar positions. Another advantage is the high spatial and temporal resolution which allows the study of small-scale variability of cloud microphysics at cloud top with a horizontal resolution of up to 20 m. Combining the polarimetric cloudbow technique with an existing stereographic retrieval of cloud geometry allows to derive vertical profiles of the droplet size distribution at cloud top. Observations of different EUREC^{4}A cloud fields are used to demonstrate the retrieval technique and to present first spatial distributions and vertical profiles of cloud droplet size distributions.