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Airborne remote sensing of cloud optical thickness, effective radius, thermodynamic phase and cloud droplet number concentration with SMART-HALO.

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Solar spectral measurements of upward and downward irradiance and upward radiance in the wavelength range from 0.3 μm to 2.2 μm by the Spectral Modular Airborne Radiation measurement system (SMART) on board the High Altitude and Long Range Research Aircraft (HALO) were performed during two campaigns dedicated to investigate cloud properties in different cloud regimes. During NARVAL-II shallow convection in the trade-wind region and deep convection along the ITCZ were investigated over the Atlantic Ocean in August 2016. The NAWDEX campaign focused on clouds along warm-conveyor belts in the North Atlantic and the Norwegian Sea in September and October 2016.

Applying an iterative retrieval the Liquid Water Path was derived from measurements of the reflected radiation from cloud top at a wavelength of 0.8 μm sensitive to the optical thickness and 1.2 μm, 1.6 μm, and 2.1 μm sensitive to the effective radius with different vertical weighting functions. Using ratios of upward radiance instead of absolute values reduces retrieval uncertainties noticeably. The thermodynamic phase at cloud top was determined by measuring the spectral slopes in the wavelength range between 1.0 μm and 2.2 μm. The statistical cloud situation / frequency of occurrence along the flight track was determined by a cloud discrimination scheme using the different spectral behavior of liquid water clouds and sea surface at wavelengths of 0.8 μm, 1.1 μm and 1.3 μm. All derived cloud properties were used to investigate the spectral cloud top albedo measured simultaneously by SMART-HALO. A statistical analysis of how strong the different cloud properties affect the cloud albedo will be presented.

In conjunction with measurements of the Liquid Water Path by the HALO Microwave Package (HAMP) a first estimate of the cloud droplet number concentration for selected flight sections over non-precipitating liquid trade-wind cumulus was achieved.