ELS-XV-2015 Abstracts
ELS-XV-2015-82
Electromagnetic & Light Scattering XV 2015, Leipzig

Comparison of droplet size retrievals from total and polarized reflectances measured by the Research Scanning Polarimeter: effects of cloud heterogeneity and 3D structure

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Most of currently operational satellite remote sensing methods for cloud droplet size retrievals are based on the multispectral measurements in absorbing and non-absorbing bands by e.g., the Moderate Resolution Imaging Spectroradiometer (MODIS), and do not include polarization. These retrievals have certain limitations owing to the influence of the cloud heterogeneity and 3D structure on the reflected radiation, which is not accounted for in their 1D radiative transfer models. There were several studies comparing the droplet effective radii retrieved using different absorbing bands of MODIS (1.6, 2.1, and 3.7 micron) and interpreting the differences based on the observed cloud structures. However, for a heterogeneous cloud field all radiometric droplet size estimates are biased. This precludes quantitative evaluation of the retrieval accuracy due to the lack of ground truth. On the other hand, retrieval of cloud droplet size from polarized reflectances in the rainbow region (at scattering angles between 135 and 165 degrees) allows to avoid the uncertainties associated with 3D effects, since the shape of the rainbow is dominated by single scattering of light.

The Research Scanning Polarimeter (RSP) provides an excellent opportunity to study the sensitivity of radiometric droplet size retrievals to cloud structure, since this instrument measures both polarized and total reflectances simultaneously. While the total reflectances in 1.6 and 2.1 micron absorbing bands (together with 865 nm channel) are used for radiometric retrievals of the cloud droplet size, the polarized reflectances in the visible spectral range provide the simultaneous rainbow-based retrievals. The RSP's high angular resolution allows for retrievals of the droplet effective radius and variance using parametric fitting that assumes a prescribed size distribution shape (gamma distribution), and also for derivation of the size distribution itself using a non-parametric method, Rainbow Fourier Transform (RFT). The latter is important when clouds have complex spatial and microphysical structure.

We will present results from the recent NASA field campaigns: Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC4RS, based in Houston, Texas in August - September 2013), where the RSP was onboard the high-altitude NASA's ER-2 aircraft, and from Airborne Instrument Technology Transition (AITT) program's field campaign based on Terceira island of Azores archipelago in October 2012 (the RSP was onboard NASA's P-3B aircraft). These campaign datasets provide vast variety of different cloud types and structures, which can be independently evaluated using correlative lidar profiles.