ELS-XV-2015 Abstracts
ELS-XV-2015-25
Electromagnetic & Light Scattering XV 2015, Leipzig

Long-term observations of aerosol-cloud interaction with dual-FOV Raman lidar at Leipzig: Liquid water cloud characterization by means of drop-size-dependent multiple scattering

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A state-of-the-art aerosol Raman lidar was equipped with an additional receiver field of view (RFOV, a ring-like second RFOV around the narrow lidar RFOV). The second RFOV signal channel, which does not see the photons backscattered within the first, narrow RFOV, only detects backscatter photons in case of multiple scattering. Furthermore, the second-RFOV signal channel only detects lidar return signals that are purely Raman backscattered by nitrogen molecules of which the backscattering behavior is well known. Thus, the signal strength in this multiple scattering channel is exclusively influenced by forward scattering by cloud particles (droplets, ice crystals). In this presentation, we concentrate of liquid clouds only. The smaller the droplets, the broader is the forward scattering peak of the scattering phase function, and the larger is the signal of the second channel. By using a simulation model, designed for this dual-FOV Raman lidar configuration, the input profiles of the effective cloud radius and cloud extinction coefficient are changed until the observed two nitrogen Raman signal profiles for the two RFOVs are matched by the simulated ones. In this way, we can derive profiles of the single-scattering cloud extinction coefficient, the droplet effective radius, the liquid water content, and finally the cloud droplet number concentration (assuming a gamma size distribution). Case studies will be presented to show the potential of the Raman lidar regarding cloud research. Results of three-year observations of layered liquid clouds (altocumulus) are used to quantify the direct influence of aerosols (we use the particle extinction coefficient below cloud base as aerosol proxy) on cloud microphysical properties, i.e. on cloud droplet effective radius and cloud droplet number concentration. For the layered clouds that we observed, the most direct link between aerosol proxy (particle extinction coefficient) and cloud proxy (cloud droplet number concentration) was found at cloud base, but only during updraft periods, monitored with an accompanying Doppler lidar measuring the vertical-wind component. Above cloud base, additional processes resulting from turbulent mixing and entrainment of dry air make it difficult to determine the direct impact of aerosols on cloud processes.