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Optical detection and characterization of ice crystals in LACIS

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Tropospheric ice and mixed phase clouds are an integral part of the earth system and their microphysical and radiative properties are strongly coupled e.g. through the complexities of the ice nucleation process. Therefore the investigation of influences of different aerosol particles which act as ice nuclei (IN) on the freezing behaviour of cloud droplets is important and still poses unresolved questions.

The Leipzig Aerosol and Cloud Interaction Simulator (LACIS) is used to investigate the IN activity of different natural and artificial aerosol particles (mineral dust, soot etc.) in heterogeneous freezing processes (immersion or deposition freezing). A critical part of LACIS is the particle detection system allowing for size-resolved counting of activated seed particles and discrimination between ice crystals and water droplets. Recently, two instruments have been developed to provide these measurements at the LACIS facility.

The Thermally-stabilized Optical Particle Spectrometer (TOPS) is measuring the particle size based on the intensity of light scattered by individual particles into a near-forward (15° to 45°) direction. Two symmetrical forward scattering channels allow for optical determination of the sensing volume, thus reducing the coincidence counting error and the edge zone effect. The backscatter channel (162° to 176°) equipped with a rotatable cross polarizer allows for establishing the change in linear polarization state of the scattered light. The backscatter elevation angle is limited so that the linear depolarization of light scattered by spherical particles of arbitrary size is zero. Any detectable signal in the depolarization channel can be therefore attributed to non-spherical particles (ice crystals). With consideration of the signal in the backscatter channel the separate counting of water drops and ice particle is possible.

The Leipzig Ice Scattering Apparatus (LISA) is a modified version of the Small Ice Detector (SID3), developed at the Science and Technology Research Institute at the University of Hertfordshire, UK. The SID instruments have been developed primarily as wing-mounted systems for airborne studies of cloud ice particles. SID3 records the forward scattered light pattern with high angular resolution using an intensified CCD (780 by 582 pixels) at a rate of 20 images per second. In addition to the SID3 capabilities, LISA is able to measure the circular depolarization ratio in the range of scattering angles from 166° to 172°. Whereas particle size, shape and orientation are characterized by the angular distribution of forward-scattered light, the measured value of the circular depolarization can be used to validate the existing theoretical models of light scattering by irregular particles (RTDF, GSVM, T-Matrix, DDA). The first measurements done at the LACIS facility have demonstrated a promising sensitivity of LISA's depolarization channel to the shape of ice crystals. Results showed an increase of the mean circular depolarization ratio from 1.5 (characteristic for the liquid water droplets above 3 μm) to 2.5 for the "just frozen" almost-spherical droplets in the same size range.

The presentation will describe details of instruments set up and present some exemplary results from experiments carried out at LACIS and AIDA (KIT) facilities.