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The Particle Habit Imaging and Polar Scattering probe PHIPS: First Stereo-Imaging and Polar Scattering Function Measurements of Ice Particles

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Cirrus clouds impact climate by their influence on the water vapour distribution in the upper troposphere. Moreover, they directly affect the radiative balance of the Earth's atmosphere by the scattering of incoming solar radiation and the absorption of outgoing thermal emission. The link between the microphysical properties of ice cloud particles and the radiative forcing of the clouds is not as yet well understood and the influence of the shapes of ice crystals on the radiative budget of cirrus clouds is currently under debate.

PHIPS is a new experimental device for the stereo-imaging of individual cloud particles and the simultaneous measurement of the polar scattering function of the same particle. PHIPS uses an automated particle event triggering system that ensures that only those particles are captured which are located in the field of view – depth of field volume of the microscope unit. Efforts were made to improve the resolution power of the microscope unit down to about 3 μm and to facilitate a 3D morphology impression of the ice crystals. This is realised by a stereo-imaging set up composed of two identical microscopes which image the same particle under an angular viewing distance of 30°. The scattering part of PHIPS enables the measurement of the polar light scattering function of cloud particles with an angular resolution of 1° for forward scattering directions (from 1° to 10°) and 8° for side and backscattering directions (from 18° to 170°). For each particle the light scattering pulse per channel is stored either as integrated intensity or as time resolved intensity function which opens a new category of data analysis concerning details of the particle movement.

PHIPS is the first step to PHIPS-HALO which is one of the in situ ice particle and water vapour instruments that are currently under development for the new German research aircraft HALO. The instrument was tested in the ice cloud characterisation campaign HALO-02 which was conducted in December 2008 at the AIDA cloud chamber in the temperature range from -5°C to -70°C. In a series of experiments small externally generated seed ice crystals were grown in AIDA at distinct temperature and saturation ratio conditions. For these experiments the long known ice morphology diagram with the temperature dependent morphology changes and the supersaturation dependent structural complexity could clearly be reproduced by PHIPS. Structural details like hollow crystals, crystals with inclusions, and crystals with stepped surfaces (Hopper crystals) could be resolved by PHIPS. Moreover, the advantage of stereo-imaging in terms of habit classification and particle orientation deduction could be demonstrated. The scattering function measurement reveals ice particle orientation dependent specular reflection peaks which might contain information about the surface roughness.

The presentation will describe the instrument set up in detail and highlight some preliminary results.