schnaiTEC

Environmental Research Solutions



In-Situ Laser Polarimetry for Cloud Microphysics: The Hyper-Angular Cloud Polarimeter (HACP)

HACP Series

The Hyper-Angular Cloud Polarimeter (HACP) is an advanced laser-based polarimeter developed for high-resolution particle light scattering analysis. It facilitates non-invasive, in-situ characterization of particle ensembles by capturing the full polarization phase matrix at high angular resolution.

Cloud microphysical parameters such as effective radius and liquid water content are globally retrieved from satellite remote sensing by using modern polarimetric detectors.

The HACP applies the same polarimetric measurement principles, but performs them in-situ. This provides unique benchmark data for validating existing satellite retrieval algorithms and enhancing our understanding of liquid and mixed-phase cloud microphysics.

Applications and Advantages

Versatile Deployment: Adaptable to various platforms, including aircraft, mountain top stations, and cloud and aerosol chambers.

Non-Intrusive Measurements: The instrument eliminates the need for traditional sampling, ensuring observations free from sampling artefacts.

Cloud Droplet Size Distribution: Obtain real-time cloud droplet size distribution parameters from the polarization ratio ($-S_{12}/S_{11}$) in the cloud bow region.

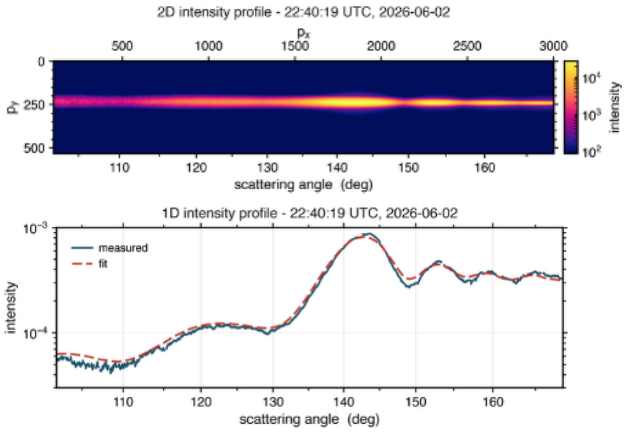
Real-time Cloud Phase Information: Receive real-time information on cloud phase (liquid, mixed, ice) through quasi-simultaneous measurements of the linear and circular depolarization ratios S_{22}/S_{11} and S_{44}/S_{11}.

Validation of Optical Models for Non-Spherical Particles: Full phase matrix measurement constraints the optical model used for parameterizations of the particle optics in radiative transfer algorithms.

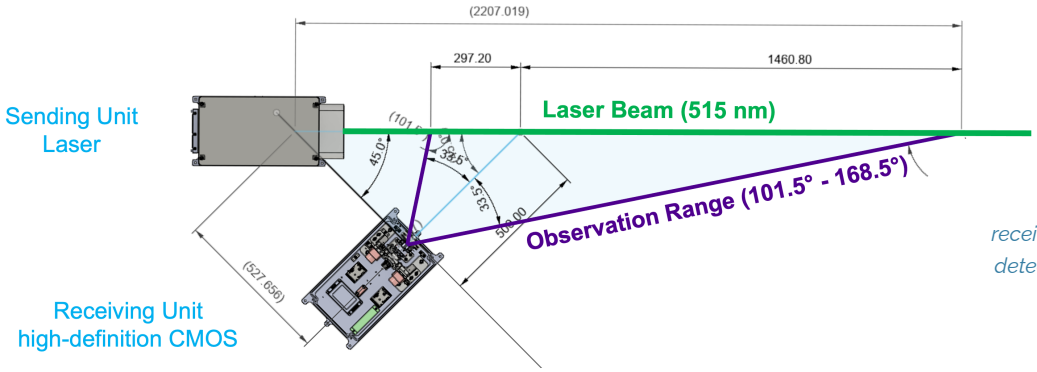
schnaiTEC
Environmental Research Solutions

Operation

A laser beam with a defined and adjustable polarization state is emitted by the Sending Unit. As the beam interacts with cloud particle ensembles, the Receiving Unit captures the scattered light using a wide-angle lens with a high-definition CMOS sensor. Each pixel on the CMOS corresponds to a specific scattering angle, allowing for the precise measurement of the angular scattering function across a range of 100° to 170°, with an angular resolution better than 0.1°. The scattered light passes through an adjustable polarization filter and a quarter-wave retarder, enabling the measurement of the full scattering phase matrix. This setup allows for comprehensive analysis of the polarization-dependent scattering properties of cloud particles, which are essential for understanding cloud microphysics and validating optical models.

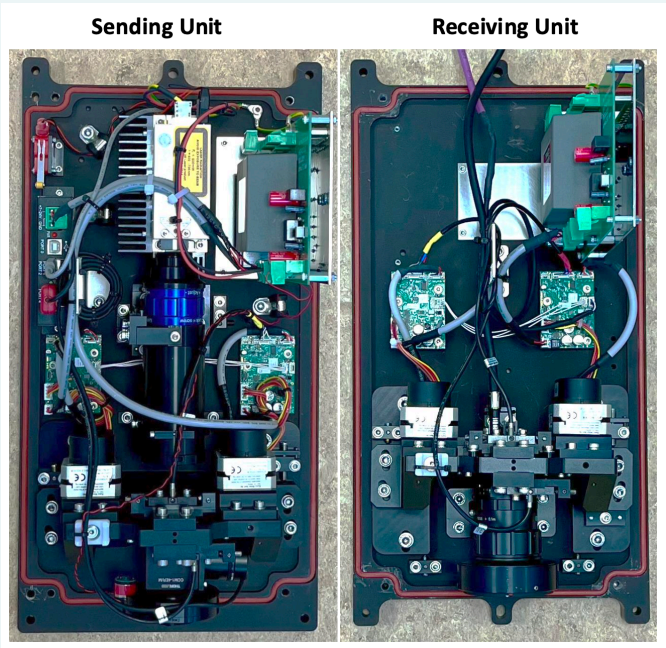


Example data from a real cloud situation. Shown is the 2D intensity profile measured by the CMOS sensor and the extracted intensity profile.



A potential HACP configuration. By placing the receiving unit at 45° angle to the sending unit allows detection of the backscattering range from 101.5° to 168.5°.

Set-Up



The HACP units without cover

Sending Unit

Laser: 25 – 150 mW, 515 nm, cw, TEM_{00} profile. Beam expanded to 12 mm ($1/e^2$) diameter. Polarization state adjustable.

- Laser safety precautions:

✓ Beam divergence adjustable to the on-site safety regulations by adding diverging lens.

✓ Interlock circuit assessable. Lid-switch interlock implemented.

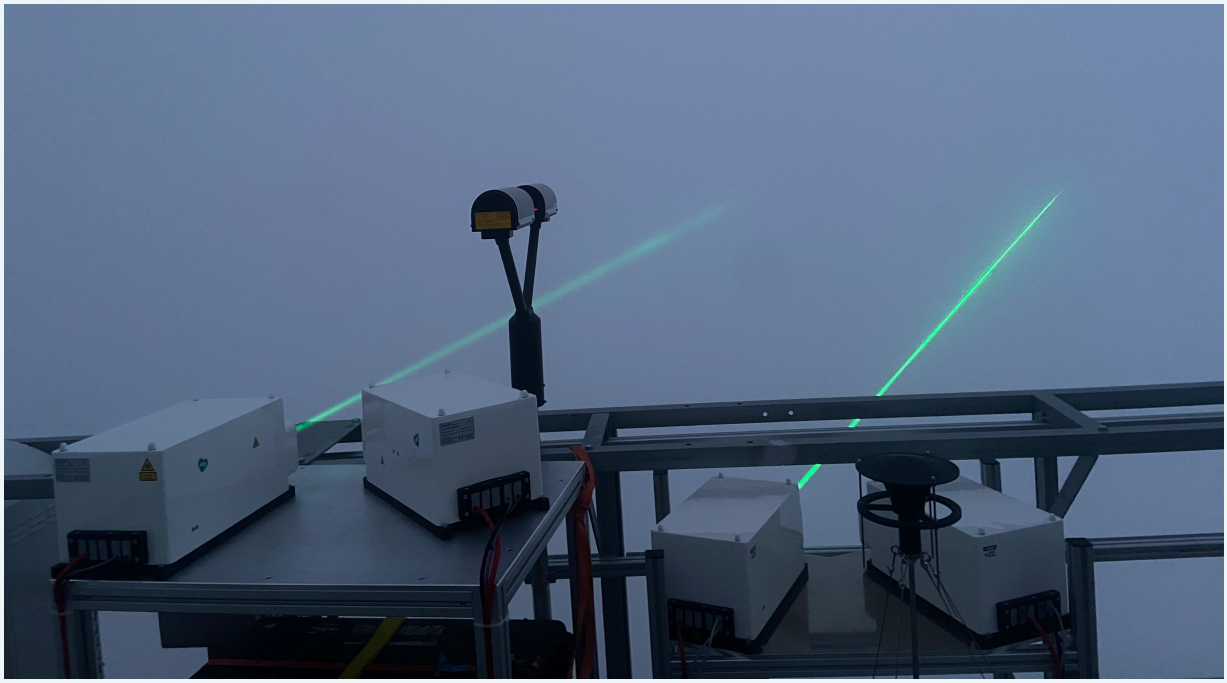
Receiving Unit

- 83.9° wide-angle lens with 8 mm focal length.
- 1.1” CMOS monochrome sensor with 4112 x 3008 pixel resolution, 12 bit depth.
- Thin film linear polarizer and thin film λ/4 retarder sandwich implemented.
- Orientation adjustable via stepper motors.
- Scheimpflug Principle of tilted image plane implemented and adaptable to the actual observation setting.

schnaiTEC
Environmental Research Solutions

HACP Specifications

Concept	The HACP is a cutting-edge laser-based optical instrument designed for precise, non-contact measurement of cloud particle scattering properties to advance atmospheric research and climate modeling.
Angular Resolution	< 0.1°
Observation Range	100° to 170°
Observation Volume	Observation volume approximately 200 cm^3 (depending on the actual installation settings)
Laser	25 – 150 mW, 515 nm, cw, TEM_{00} profile.
Sensor Specifiation	1.1” CMOS monochrome sensor, 4112 × 3008 pixel resolution, 12 bit depth
Temperature	-40 °C to +40 °C (heating system in operation)
Humidity	20 % to 100 % relative humidity (r.h.)
Altitude	< 3500 m asl
IP Protection Rating	IP66: dust-tight and protected against strong water jets
Installation Place	Outside or indoor installation; installation base plates, allowing for flexible adaptation to on-site conditions.



Two HACP instruments operated during the European Centre for cloud ambient Intercomparison (ECCINT) campaign at the Sonnenblick observatory in 2026

schnaiTEC
Environmental Research Solutions



Discover Next-Generation Cloud Analysis

Contact Us for More Information:

+358 40 550 5507
schnaitec.com
info@schnaitec.com

schnaiTEC Oy
Mesitie 21
38910 Ala-Honkajoki, Finland