

Leipzig Aerosol Cloud Interaction Simulator (LACIS)

Leibniz-Institut für Troposphärenforschung e.V., Leipzig

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www.tropos.de

Description of institution

The Leibniz Institute for Tropospheric Research (IfT) was founded in 1991 for the investigation of physical and chemical processes in the polluted troposphere. The institute comprises three different departments, i.e. Physics, Chemistry, and Modelling.

The IfT physics department investigates meteorological and physical processes of tropospheric aerosols and clouds in the field and in the laboratory. The scientific results emerging from individual experimental studies are used to develop and validate tropospheric process models. The experimental methods include ground-based or airborne in-situ aerosol and cloud characterizations, radiation measurements, and remote sensing of meteorological data and microphysical aerosol and cloud parameters. Additionally, remote sensing methods are used to determine trace gas concentrations that are related to aerosol and cloud processes in the atmosphere. The instrumentation is largely based on in-house developments. The models used in the physics department simulate fluid mechanical, thermodynamic, aerosol dynamical processes, and radiative transfer.

1. Research activities of laboratory

Research facility

The Leipzig Aerosol Cloud Interaction Simulator (LACIS) is a unique facility to study aerosol cloud interactions. It was designed and built to achieve a better understanding of the mechanisms controlling aerosol and cloud interactions and to validate and if needed modify existing and/or derive new expressions for the description of aerosol cloud interactions in detailed process and larger scale models.

With LACIS we offer a facility for the investigation of complex phase transition processes such as particle/droplet hygroscopic growth, activation, and ice nucleation. Thermodynamic parameters such as temperature, pressure, relative humidity, critical super-saturation, composition and concentrations of particles/droplets and of chemical composition of the carrier gas can be varied in ranges similar to the atmosphere.

LACIS (see Fig. 1 and 2) consists of laminar flow tube with thermostated walls. The length of the flow tube can vary from 0.5 up to 10 m. Residence times up to 60 s and temperatures down to -40 °C are feasible. Using high precision instruments, the thermodynamic conditions in the LACIS flow tube are controlled with extremely high accuracy.



Figure 1: View of LACIS. In the front the thermostats can be seen, which are used for conditioning of aerosol, sheath air flow and chamber. The pink tube in the back is the chamber itself.



Figure 2: Particle generation unit of LACIS.

Particles to be investigated with respect to, e.g., their potential to act as cloud condensation and/or ice nuclei, are introduced into LACIS in form of a narrow 2 mm wide beam surrounded by particle free sheath air (see Fig. 3). Both, the particles and the sheath air flows are humidified using saturators the temperatures of which are controlled by thermostats.

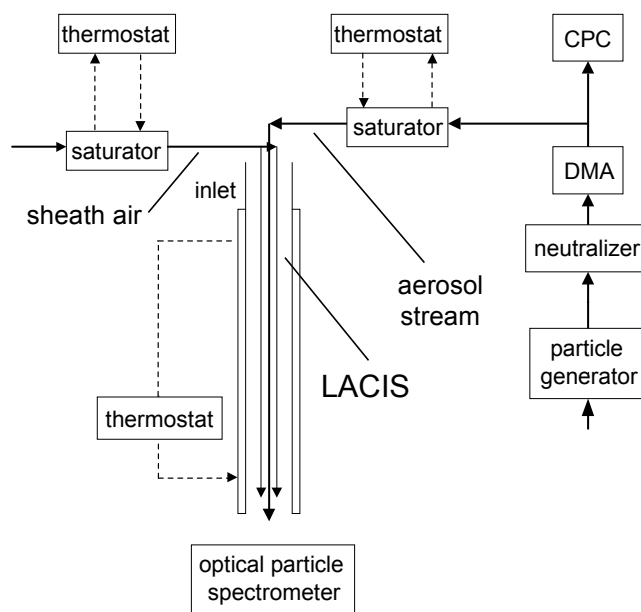


Figure 3: Setup of LACIS

LACIS may be operated under both, sub-saturated and super-saturated conditions with respect to water and therefore combines the capabilities of measuring hygroscopic and dynamic post-activation growth in one instrument. Relative humidities up to 99% (sub-saturated) and super-saturations down to 2 % can be adjusted reproducibly.

An optical particle spectrometer which was designed and built for LACIS (see Fig. 4) can be mounted along the LACIS-tube and allows measuring of the particle/droplet sizes in-situ. From this, e.g. growth factors and growth rates and eventually hydrometeor phase can be determined. In the near future a number of these particle spectrometers will be available and mounted where needed.

To describe the fluid flow, heat / mass transfer and particle/droplet dynamics in LACIS, a detailed process model has been developed. It combines the computational fluid dynamics (CFD) code FLUENT with a microphysical particle/droplet dynamics model, the so-called Fine Particle Model (FPM). Using this model, microphysical expressions to describe the microphysical process of interest (e.g., particle/droplet activation and ice nucleation) can be validated, and new expressions can be derived and tested. This model, together with extensive expertise in modelling of particle and droplet dynamics are available at the facility for the interpretation of experimental results gained with LACIS.

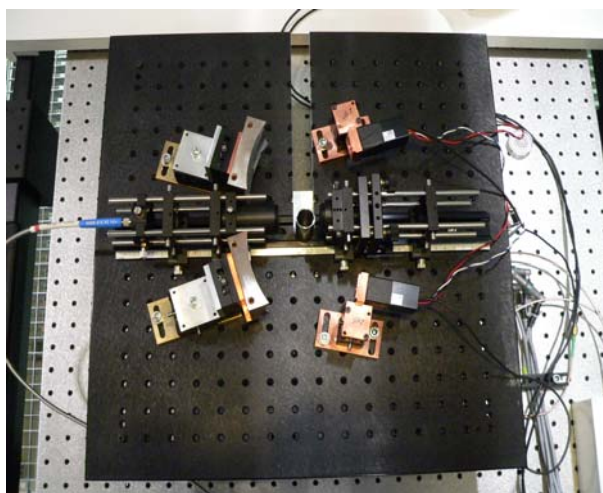


Figure 4: Especially designed optical particle spectrometer for in-situ measurement of particles/droplets in LACIS.

The facility offers instruments and expertise regarding the production of well-defined multi-component, multiphase aerosol particles. For particle generation and coating, instruments such as atomizers, nucleation/condensation type generators and a spark generator are available.

For particle characterization with respect to size, structure and optical properties, the facility offers expertise and instruments such as differential mobility analyzers (DMAs), condensation particle counters (CPCs), a low pressure impactor (LPI), a thermophoretic particle sampler, optical particle counters and nephelometers.

In addition to LACIS itself, the new LACIS building (see Fig. 5) offers laboratory space for setup, calibration, etc. of guest experiments and instruments.



Figure 5: LACIS building, including LACIS tower, laboratories and offices.

Research interest

The main research interest is to study aerosol particle and cloud interactions with the goal to achieve a better understanding regarding the mechanisms influencing and controlling cloud formation and evolution. Examples for such interactions are complex phase transition processes such as particle/droplet hygroscopic growth and activation, and the various mechanisms involved in the freezing of cloud droplets.

Utilizing LACIS, current and future research concerns the activation of well defined aerosol particles to cloud droplets, i.e., the hygroscopic and dynamic growth of aerosol particles. The particles may consist of single inorganic or organic components and various combinations of inorganic and organic materials including soot. The goal of these investigations is to validate, and/or derive new growth laws and/or parameterisations for use in process and larger scale models.

Also of interest are the structural and optical properties of uncoated, coated, dry and wet (i.e., after the condensation of water vapour) soot particles. A focus is given to the in-situ structural characterization of such particles and the determination of their optical properties as function of size, structure and composition.

In the future experimental and theoretical investigations will also focus on ice nucleation and here e.g., evaporation freezing of cloud droplets.

Experiments in collaboration with groups using other techniques for particle generation and coating, physical (e.g., size, structure, optical properties) and chemical characterisation (composition) are highly welcome. Examples are hygroscopicity tandem DMAs, cloud condensation nucleus (CCN) counters, mass spectrometers, ice detectors.

Collaboration with respect to the theoretical description of microphysical processes such as e.g., the calculation of activities for complex mixtures of organic and inorganic substances and the description of droplet freezing processes on the process level also is highly desirable.

2. Specific information of laboratory

Policy in relation to data availability and data access:

All participants of a research project are obliged to make their data available for all participants with the goal of joint publications. Data will be centrally collected at the IfT and made accessible via ftp.

URL of lab: <http://www.tropos.de/eng/PHYSICS/clouds/lacis.html>

Access to the facility:

Lodging is possible on campus in a guesthouse and can be organised if desired. Transportation on the research area and technical assistance is supplied on request.

Fee for using the facility:

No fee is charged for using the research facility.

Scheduled scientific activities at the infrastructure:

- Nov 14, 2005 to Dec 2, 2005 LExNo (LACIS Experiment in November)
- Nov. 2006, LExNo -Ice

Indication on specific issues for which collaboration is sought:

- hygroscopic growth and activation of particles consisting of various combinations of inorganic and organic materials including soot; comparison of measurements obtained with different techniques

- determination of the composition of model aerosol particles consisting of various combinations of inorganic and organic materials including soot.
- determination of the optical properties of particles consisting of various combinations of inorganic and organic materials including soot under dry and wet (i.e., after the condensation of water vapour) conditions.
- theoretical description of microphysical processes such as e.g., the calculation of activities for complex mixtures of organic and inorganic substances and the description of droplet freezing processes

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