Annual Report (Part 1: Scientific Report)

Type of grant:	**Virtual Institutes**	
Project No.: VH-VI-233	Project title: Role of aerosol particles as condensation and ice nuclei in tropospheric clouds (Aerosol-Cloud Interactions ACI)	
Leading Scientists:	Prof. Thomas Leisner, Dr. Ottmar Möhler	
Reporting period:	April to December 2007	

Scientific Report (max 2 pages)

a) Work progress according to work programme

During the year 2007 the activities within the Helmholtz Virtual Institute on Aerosol-Cloud Interactions (VI-ACI) were started and proceeded as outlined in the work programme of the proposal. The progress achieved in the different work packages is briefly summarised:

WP-L1: AIDA
The 4th International Ice Nucleatoin Workshop ICIS-2007 was succussfully conducted at the AIDA facility during September 2007 as part of the VI-ACI experimental activities. The data analysis is almost finished and first results are available. The first AIDA campaign (IN11) on CCN and IN properties of various soot particles was performed during November 2007 and first data sets are available for process modelling within WP-M1. Further AIDA CCN and IN studies and experiments with single levitated particles are planned for October 2008.

WP-L2: LACIS
Closure based on the Köhler equation has been achieved for selected single component systems. Work is now in progress concerning coated soot and mineral dust particles as investigated during e.g. the AIDA IN11 and FROST campaigns (for related modelling work see WP-M1). In the framework of the FROST campaign, first freezing experiments have been performed successfully at LACIS regarding the quantification of the influences of uncoated and coated Arizona Test Dust particles on droplet immersion freezing (for related modelling work see WP-M1).

WP-L3: ZINC
New set-ups for immersion and contact freezing experiments have been built and tested. The ZINC chamber was used to measure deposition mode ice nucleation on aerosols like soot, Arizona Test Dust, kaolinite, and silver iodide. During the ICIS-2007 campaign at Forschungszentrum Karlsruhe, the ZINC chamber contributed heterogeneous ice nucleation measurments of various aerosols. Data is processed and evaluated.

WP-L4: SAPHIR
FZJ contributed to the AIDA campaign IN11 (see WP-L1) and measured aerosol hygroscopicity with an improved semi-automated Hygroscopicity Tandem Differential Mobility Analyzer (HTDMA), as well as aerosol composition measurements with an aerosol mass spectrometer (WToF-AMS). The WToF-AMS was used to monitor the aerosol generation process with respect to organic carbon content of the soot cores and with respect to the mass of coatings per particle of sulphuric acid and succinic acid. The evaluation of the data is in progress

WP-M1: Processes
An improved cirrus parameterization scheme is available and successfully used in climate model ECHAM (Milestone M1A), and the role of aviation soot aerosols in cirrus cloud formation was thoroughly investigated (Kärcher et al., 2007). Progress was made in assessing ice nucleation properties in cirrus clouds. Data sets from the first AIDA campaign (see WP-L1) are available to start CCN and IN process modelling as planned. New IN thresholds derived from AIDA experiments were implemented into the process model MAID and applied to data set of CR-AVE field experiment (Gensch et al., 2008).

WP-M2: Clouds
A Lagrangian ice particle tracking module for Large Eddy simulations of cirrus clouds was developed. The model provides novel analysis tools to study the impact of different nucleation pathways on cirrus development, among other issues. A contrail module has been developed which is computationally efficient enough to explore a wide range of environmental conditions controlling the transition of line-shaped contrails into contrail cirrus. These activities have led to a publication quantifying the loss of ice crystal number and mass in the vortex phase of persistent contrail formation (Unterstrasser et al., 2008). The CIRRUS II campaign was analysed with first 2D simulations using the model EULAG including a new ice microphysics scheme (Spichtinger and Gierens, 2008a). For a better understanding of field measurements, the bulk ice microphysics in the multiscale model EULAG was used in order to simulate the competition of different ice formation mechanisms within the same environment (Spichtinger and Gierens, 2008b). A 2D cloud model was used to develop and test the so-called "Factorial Method" (Teller and Levin, 2008), which allows to better estimate the relative contributions of various cloud processes to precipitation development, not only for each important factor (e.g CCN, IN, temperature profile) but also for their interactions.

WP-M3: Climate
ECHAM4 was expanded with the microphysical cloud module of Lohmann et al. (2004) and a parameterization describing the competition between heterogeneous and homogeneous ice nucleation (Kärcher et al, 2006). Different ice types are tracked using a multimodal microphysical ice scheme. First test applications suggest a significant impact of heterogeneous nucleation on cirrus properties. A parameterization for supersaturation and contrail cirrus was implemented in ECHAM4. Supersaturated areas were found to agree well with AIRS and MOZAIC observational data (Burkhardt et al., 2008). First simulations suggest that the coverage due to contrail cirrus is significantly larger than coverage due to line shaped contrails and is dominated by major contrail outbreak events. Using ECHAM5-HAM, a coupled atmospheric-aerosol model, the effect of varying the mineral composition of dust aerosols acting as ice nuclei (IN) was studied (Hoose et al., 2008). It was found that IN can be quasi-deactivated due to coating by anthropogenic soluble material. This contrasts an earlier study by Lohmann (2002) that found an increase in IN and thus increased glaciation resulting from anthropogenic black carbon aerosols.

b) Achieved milestones

There was only one milestone during the year 2007 (M1A: Cirrus parameterisation scheme available for use in ECHAM, month 6) which was reached as planned.

c) Fulfilment of budget and work plan

There are no changes to the work plan. An amount of 35000 € has been tranferred from consumables to personal costs. A financial report and budget justification for the year 2007 is provided by the Financial Department of Forschungszentrum Karlsruhe.

d) Publications (peer-reviewed papers, conference contributions,…)

Peer-reviewed papers:

1. Kärcher, B., O. Möhler, P. J. DeMott, S. Pechtl, and F. Yu (2007), Insights into the role of soot aerosols in cirrus cloud formation, *Atmos. Chem. Phys.*, *7*, 4203-4227.
2. Spichtinger, P., and K. Gierens (2008a), Modelling Cirrus Clouds. Part 1: Model description and validation, *Atmos. Chem. Phys. Discuss.*, *8*, 601-686.
3. Spichtinger, P., and K. Gierens (2008b), Modelling Cirrus Clouds. Part 2: Competition of different nucleation mechanisms, *Atmos. Chem. Phys. Discuss.*, *8*, accepted.
4. Teller, A., and Z. Levin (2008), Factorial method as a tool for estimating the relative contribution to precipitation of cloud microphysical processes and environmental conditions: Method and application, *J. Geophys. Res.*, *113*, D02202, doi:02210.01029/02007JD008960.
5. Gensch, I., H. Bunz, D. Baumgardner, L. E. Christensen, D. W. Fahey, R. L. Hermann, P. Lawson, P. Popp, J. B. Smith, C. R. Webster, E. M. Weinstock, J. C. Wilson, T. Peter, and M. Krämer (2008), Supersaturations, Microphysics and Nitric Acid Partitioning in a Cold Cirrus observed during CR-AVE 2006: An Observation-Modeling Intercomparison Study, *Environ. Res. Lett.*, *submitted*.
6. Unterstrasser, S., K. Gierens, and P. Spichtinger (2008), The evolution of contrail microphysics and structure in the vortex phase, *Meteorol. Z.*, *in press*.
7. Burkhardt, U., B. Kärcher, M. Ponater, K. Gierens, and A. Gettelman (2008), Contrail cirrus supporting areas, *Geophys. Res. Lett.*, *submitted*.
8. Hoose, C., U. Lohmann, R. Erdin, and I. Tegen (2008), Global influence of dust mineralogical composition on heterogeneous ice nucleation in mixed phase clouds, *Environ. Res. Lett.*, *in press*.

PhD Theses

Hoose, C. (2008), Aerosol processing and its effect on mixed-phase clouds in a global climate model, ETH Zurich.

Diploma and Masters Theses

Lauer, C. (2007), Setup and validation of a calibration-free extractive 1.4 µm laser hygrometer for the aerosol chamber AIDA, Ruprecht-Karls Universität, Heidelberg, Germany.

Bachelor Theses

Erdin, R. (2007), Anteile von Kaolinit, Illit und Smektit in Aerosolen: Vergleich von Messdaten und Modellwerten, ETH Zurich.

Conference Contributions

1. Hoose, C., U. Lohmann, R. Erdin, and I. Tegen (2007), Global Influence of Dust Mineralogy on Heterogeneous Ice Nucleation, paper presented at IUGG, Perugia, Italy.

2. Ulanowski, Z., C. Stopford, E. Hesse, P. H. Kaye, E. Hirst, and M. Schnaiter (2007), Classification of small ice crystal shapes using Fourier analysis of azimuthal scattering patterns, paper presented at Faraday Discussions 137 - Spectroscopy and Dynamics of Microparticles, Bristol, UK.
3. Ulanowski, Z., C. Stopford, E. Hesse, P. H. Kaye, E. Hirst, R. S. Greenaway, and M. Schnaiter (2007), Small Ice Detector 2: Characterization of Ice Crystals Using Analysis of Azimuthal Scattering Patterns, paper presented at EGU General Assembly, Vienna, Austria.
4. Krämer, M., S. Schlicht, C. Schiller, A. Mangold, O. Möhler, H. Saathoff, V. Ebert, and N. Sitnikov (2007), Aerosol impact on supresaturation in cirrus: Laboratory and field observations, paper presented at European Aerosol Conference, Salzburg, Austria, September 9-14, 2007.
5. Lauer, C., D. Weber, S. Wagner, and V. Ebert (2007), Open-path Laserabsorptionsspektrometer zur Absolutbestimmung klimarelevanter Spurengase wie CH4 und CO, paper presented at 8. Dresdner Sensor-Symposium Dresden, Germany, December 10-12, 2007.
6. Hunsmann, S., S. Wagner, K. Wunderle, and V. Ebert (2007), Kompaktes, fasergekoppeltes Laserabsorptionsspektrometer für die probenahmefreie, absolute Gasfeuchtemessung, paper presented at 8. Dresdner Sensor-Symposium Dresden, Germany, December 10-12, 2007.
7. Möhler, O., J. Schneider, S. Walter, A. J. Heymsfield, C. Schmitt, and Z. Ulanowski (2008), How coating layers influence the deposition mode ice nucleation on mineral particles, paper presented at 15th International Conference on Clouds and Precipitation, Cancun, Mexico.