COMBINING UPCOMING SATELLITE MISSIONS AND AIRCRAFT ACTIVITIES

Future Challenges for the EUFAR Fleet

by Manfred Wendisch, Paola Formenti, Tad Anderson, Alexander Kokhanovsky, Bernhard Mayer, Peter Pilewskie, Steve Platnick Jens Redemann, John Remedios, Peter Spichtinger, Didier Tanré, and Filip Vanhellemont

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This supplement gives additional information on the International Workshop on Combining Upcoming Satellite Missions and Aircraft Activities: Future Challenges for the EUFAR Fleet, which was held within the framework of the EUFAR (see appendix A for acronym expansions) project in Paris, France, from 13 to 15 September 2006. It includes a list of participants (Table S1), the agenda of the workshop (appendix B), and a summary of the presentations. After a welcome and introductions to the workshop, the EUFAR project, and the workshop objectives, three overview talks of the state of the art and challenges in the current knowledge on measurements (both in situ by aircraft and remotely by satellite) of aerosol particles and clouds were given. Subsequently, 21 invited speakers gave oral presentations in three thematic sessions on i) clouds, ii) aerosol particles, and iii) combined aerosol and cloud studies. Short talks (about 10 minutes in length) were given, followed by lively discussion. Each session was lead by two chairpeople. They gave a summary of the main outcome of each session during the round-table discussion on the last day of the workshop.

OVERVIEW. A review talk on the current status and issues in cloud remote sensing was given by Steve Platnick. Typical cloud products retrieved by passive satellites, generally in order of increasing level of difficulty of the retrieval, include cloud detection/masking, cloud thermodynamic phase, cloud-top properties (pressure, temperature, effective emissivity), and cloud optical and microphysical properties (optical thickness, effective particle size, and water path). Active sensors can provide information on the vertical cloud structure (e.g., high spatial resolution cloud boundaries and structure from lidar, and water path from cloud radar). Several examples from MODIS observations were used to illustrate and discuss passive retrievals and their validation. Particular concerns remain for i) retrieval of cloud phase at supercooled

Table S1. List of participants.

Participant(s)	Institute, Location	Country
Phil Brown, Olivier Boucher	Met Office, Exeter	United Kingdom
John Remedios	University of Leicester	
Didier Tanre, Oleg Dubovik	LOA	France
Paola Formenti, Jean-Marie Flaud	LISA	
Christiane Textor	IPSL	
Jean-Louis Brenguier, Qiangyan Han	Météo-France	
Alain Protat	CEPT	
Olivier Jourdan	LaMP	
Manfred Wendisch, Ina Tegen	IFT	Germany
Bernhard Mayer, Andreas Petzold	DLR	
Andreas Macke	IFM-GEOMAR	
Jurgen Fischer	FUB	
Alexander Kokhanovsky	University of Bremen	
Patrick Wursteisen	ESA	Italy
Paul Snoeij		
Pascal Lecomte		
Francesco Cairo	ISAC/CNR	
Tad Anderson	University of Washington	United States
Peter Pilewskie	University of Colorado	
Irina Sokolik	GeorgiaTech	
Steve Platnick	NASA	
Jens Redemann	BAERI	
Chip Trepte	NASA	
Filip Vanhellemont	BISA	Belgium
Peter Spichtinger	ETH Zurich	Switzerland
Gerrit de Leeuw	TNO	The Netherlands

temperatures and large effective radii (liquid clouds) in the MODIS 2.1-μm retrievals; ii) ice cloud models; iii) the effect of vertical inhomogeneity on total radiance effective radius retrievals, especially cirrus, and cloud-top vertical structure on polarization retrievals; and iv) 3D effects on temporal/spatial statistics. By virtue of using different instruments, techniques, and spatial/temporal mismatches, validation is always an exercise in comparing apples to oranges. Even if all quantities are measured without error, no single instrument or technique is capable of resolving the full 3D cloud structure; in this sense, there is no measured "truth" of the complete state of a cloud that would allow unambiguous comparisons among different observations. Platnick concluded that the final result of a successful satellite validation effort would be an improved understanding and quantification of retrieval uncertainties. However, this is only possible if the uncertainties in the in situ measurements and nonsatellite remote methods (aircraft and ground based) are known. That is, the so-called validation datasets must also be validated.

Tad Anderson reviewed the prospects for extending aerosol measurements and estimates of their direct radiative forcing to the global scale. Satellites are crucial to this goal (Anderson et al. 2005). However, two recent studies using satellite data (Kaufman et al. 2005; Bellouin et al. 2005) illustrate the ambiguities that still exist, even in apparently simple problems. An example is the question of how to identify the anthropogenic fraction of aerosol particles. Satellite instruments, such as MODIS, retrieve the fine-mode fraction out of optical depth, which is certainly related to anthropogenic fraction. However, neither the accuracy of the satellite product nor the nature of the relationship have been adequately studied. The relationship is complex because fine-mode aerosol particles can be derived from natural sources, such as the small particle tail of dust and sea salt, as well as accumulation-mode aerosol from biogenic sulfur or organics. Clearly, in situ measurements of size-segregated aerosol composition could play an important role in resolving the complexities of this relationship. Rigorous validation of column properties from satellites with aircraft in situ measurements is extremely challenging, even when included in the planning phase of an experiment. For example, the ACE-Asia field campaign produced only 6 useful aircraft and satellite comparisons of the aerosol fine-mode fraction of 19 nine-hour-long flights. The problem is that spatial and temporal coincidence under suitable conditions is difficult to obtain. In perspective, Anderson suggested that more efforts should be put into validating the ground-based

AERONET aerosol retrievals, which, he stated, "are taken as the most robust, global-scale knowledge of aerosol optical properties, but are almost entirely unvalidated." This statement proved itself to be very controversial and initiated an animated discussion within the EUFAR group, which was pursued after the meeting by e-mail exchange among a much larger group, including the AERONET PI, Brent Holben. Because the issue is controversial, it was suggested that a specific session could be held and dedicated thereto. Finally, Anderson recommended that a high-leverage use of airborne measurement capabilities would characterize single scattering albedo of aerosol layers situated above boundary layer clouds. The new CALIPSO satellite will be able to detect these layers, but assessment of their radiative impact requires knowledge of single scattering albedo, which only airborne methods can directly measure.

In her presentation, Ina Tegen showed the potential of models in helping in the integration and interpretation of measurements to help understand the aerosol–cloud–climate system. In remote sensing applications, model assimilation provides homogenized maps where satellite retrieval is not possible, whereas 3D forward models provide a first guess of aerosol properties and their vertical distribution. Also, models are a useful tool for aircraft measurements. They support flight planning, and after the flight they help in clarifying the meteorological and chemical regimes, and indicate sources and sinks. Most importantly, models are tools for data interpretation and integration, prediction of future climate scenarios, and forecasting weather. Various examples of model applications, strengths, and weaknesses were discussed. From the perspective of using models in combination with satellites and airborne measurements to derive cloud and aerosol properties, Tegen recommended the use of model radiances rather than optical thicknesses. The optical thickness is already a product of remote sensing, and as such might already be biased by retrieval assumptions. She also suggested focusing research on near-source and vertically resolved aerosol measurements, including large particles.

CLOUDS. Issues related to clouds and their observation were presented by seven invited speakers. Alain Protat presented the investigation of cloud processes from ground, airborne, and spaceborne active remote sensing in France. Measurements and modeling of cloud properties within the SIRTA, RALI, CALIPSO, and CloudSat projects are being conducted. New instrumentation (RALI; synergy of the RASTA 95-GHz cloud radar and the new LEANDRE lidar) has been developed in order to investigate ice cloud properties and provide airborne validation for CALIPSO and CloudSat on the A-Train. The methodology still has to be adapted to water clouds. There is a strong need for the direct measurement of cloud parameters using airborne in situ observations to validate active retrievals.

Filip Vanhellemont showed results on stratospheric aerosol particles, stratospheric polar clouds, and subvisual cirrus clouds as observed by GOMOS on ENVISAT. GOMOS uses the well-known occultation technique, but uses stars instead of the sun as the light source. The occultation method is very attractive, because of the good vertical resolution, the self-calibrating nature of the method, and the relatively simple forward model. Because stars are rather weak light sources, the signal-to-noise ratio is relatively low; however, this is compensated for by the fact that lots of stars are available (leading to 400-500 occultations per day). GOMOS is basically a spectrometer operating in the following three wavelength ranges: a) UV/Vis: 248–690 nm, with 0.9-nm resolution and 0.31-nm sampling, primarily intended to retrieve O_3, NO_2, NO_3, aerosol extinction, mesospheric Na, and OCIO; b) IR: 750–776 and 916–956 nm, with 0.14-nm resolution and 0.06-nm sampling, for the retrieval of O_2 and H_2O; and c) two fast photometers operating at 1000 Hz, with 470–520 and 650–700-nm range, to perform scintillation correction and to retrieve high-resolution temperature profiles. Stratospheric aerosols, tropical subvisual cirrus clouds, and PSCs are clearly detected in the extinction profiles. Zonal mean plots of optical extinction provide a good picture of the global distribution of aerosols, cirrus, and PSCs, and the temporal behavior of all of these phenomena is beautifully revealed. In particular, PSC evolution has been clearly demonstrated by GOMOS. Typical descent rates in the Antarctic vortex are in the range of –1 to –2.7 km $month^{-1}$. There is a promising possibility to retrieve particle size distribution information from the extinction spectra. Although still preliminary, anomalous events, such as pyrocumulonimbus intrusion (resulting from large forest fires) into the stratosphere, have been detected.

Jurgen Fischer reported on observations of clouds with SEVIRI and MERIS. He concentrated on the retrieval of cloud phase, cloud optical thickness, effective particle sizes (ice and liquid), and LWP. For the CTH, Fischer showed examples of data retrieved from MERIS and a comparison with lidar measurements of CTH. For cases excluding cirrus, a correlation of 0.97 was found, though with a bias of roughly 150 m. In cases with cirrus present, the bias strongly increased and the correlation between MERIS-derived and lidar-measured CTH significantly weakened. Fischer concluded that SEVIRI is sufficient for cloud observations (high temporal resolution of ~15 min) of the cloud mask, cloud optical thickness, effective radius, and cloud diurnal cycle. MERIS is a useful tool for cloud observations (high spatial resolution of ~300 m) of the cloud optical thickness and CTH (low and high clouds with high optical thickness).

In his talk, John Remedios reported on the validation of cloud/aerosol information from the MIPAS–ENVISAT cloud retrieval. The influence of clouds is observed as a distinct spectral offset that is dependent on optical depth (extinction), on pressure-broadened gas absorption lines from tropospheric radiation scattered into the limb path (cloud location, cloud-top temperature, mean particle size), on characteristic spectral features for NAT PSCs and for cirrus/aerosol, and through unexpected variability in trace gas retrievals. The retrieval yields several cloud products, such as a) CTH, b) cloud-top temperature, c) cloud mean size (given a size distribution), d) cloud optical depth, e) cloud/aerosol composition, and f) aerosol extinction (as a function of wavelength). Remedios concluded that there are specific aircraft flight paths and payloads that can help with validation of limb-viewing instruments. He pointed out the need for profiling structure and that the simultaneous validation of both nadir and limb instruments could be very helpful for the future. The combination of in situ and remote sensing observations is crucial. He furthermore concluded that coincident measurements of temperature and trace gas profiles could be very helpful.

Bernhard Mayer described uncertainties in cloud remote sensing and how aircraft observations can help to reduce them. Mayer summarized the need for validating satellite retrievals of cloud properties. This is because cloud tests are often based on nonobjective methods. The retrievals need a priori assumptions, for example, ice crystal size/shape distribution. Independent observations of optical thickness, etc., at satellite pixel scale are difficult to obtain, primarily because clouds are highly variable in space and time. Three-dimensional radiative transfer effects are not considered. Mayer showed the benefits of satellite validation using combined simulated data and in situ or remotely sensed airborne measurements.

Andreas Macke concentrated on modeling and observing the radiation budget of the cloudy atmosphere. He formulated the following four requests to EUFAR: a) establish a correlation between particle size and an extinction coefficient; b) characterize the cloud-top radiation budget and scene type (images); c) synchronize with scientific ship cruises (e.g., *Polarstern*); and d) investigate the cloud life cycle and radiation budget/remote sensing.

Peter Pilewskie stressed the validation of satellite cloud remote sensing via airborne spectral irradiance. He showed 3D radiative transfer simulations using a "cloud generator" based on 2D satellite retrieval fields. The results of the simulations were compared to direct measurements of spectral irradiance. Such a comparison is important for testing the suitability of satellite-derived cloud properties for use in radiative energy budget analysis.

AEROSOL PARTICLES. Nine speakers gave talks in the aerosol particle session. Gerrit de Leeuw presented the retrieval of aerosol properties from the (A)ATSR sensors onboard the ERS-2 and ENVISAT. These sensors retrieve aerosol properties over the oceans as well as over land using their dual-view capabilities. Examples of validation activities using ground-based and aircraft observations were presented for areas dominated by industrial aerosols. Validation of retrieval algorithms is possible when the need for it is explicitly stated as one of the field campaign objectives, and dedicated observations can therefore be scheduled. Difficulties in distinguishing aerosols from clouds were also discussed.

Didier Tanré illustrated the ongoing validation program of the cloud and aerosols products of the PARASOL instrument, which is part of the A-Train. Comparisons with MODIS products are encouraging for water clouds, whereas for ice clouds MODIS is retrieving larger optical thicknesses, which is due to the microphysics properties of the ice model, which are different. Regarding aerosols over the ocean, excellent agreement in the total and fine-mode aerosol optical depth is obtained for biomass burning–dominated aerosols, but not when dust is present. A case study for 13 March 2006 shows that over the ocean MODIS and PARASOL are in good agreement in retrieving the total aerosol optical depth, but not the fine-mode aerosol optical depth (higher for MODIS than for PARASOL). Over land, for biomass burning, the correlation is still significant, but the dispersion between the two instruments is larger. There is sometimes no correlation whatsoever in the fine-mode aerosol optical depth (MODIS values up to 1.5 are obtained, whereas for PARASOL values stay below 0.5) over desert regions when dust is present. Regarding validation, both the level-1 validation of radiances using similar instruments and the level-2 validation of retrieved parameters using in situ measurements are very challenging tasks. The use of remote sensing measurements, such as an airborne spectral sun photometer, yielding the same column-resolved and/or vertically integrated quantities, is suggested. This type of instrument should become part of the standard aircraft payload anytime a satellite validation field experiment is planned.

Andreas Petzold presented an overview of results from various aerosol field campaigns (LACE 1998, ITOP 2004, and SAMUM 2006) conducted by the Falcon aircraft of the DLR, combining aerosol lidar and in situ methods. The measurements provided validation data for satellite retrievals of aerosol optical depth; vertical distributions of aerosol extinction, absorption, backscatter, and depolarization ratio; aerosol type assumed in the retrieval scheme, including main chemical components and aerosol absorption; vertical distribution of aerosol size distribution and effective radius; vertical distribution of aerosol mass for spaceborne PM2.5 monitoring; surface reflectance; and profiles of thermodynamic properties (p, T, RH). For satellite validation purposes, the DLR Falcon provides measurements of the precise size distribution from < 10 nm to ≥ 100 μm, preferably at ambient conditions; scattering coefficient either measured by the polar nephelometer (wing mounted) or calculated from size distributions; multiwavelength absorption coefficient; volatility and/or humidity growth; chemical composition; nadir-looking advanced lidar with preferred direct extinction measurement; and surface reflectance. The aircraft is flown from ground to the tropopause level, and flight patterns are stacked profiles with constant-level sequences.

Manfred Wendisch presented the potential of parameterization of aerosol solar radiative forcing at the TOA and BOA as a function of the column-integrated particle backscatter coefficient obtained by lidar measurements, and its application to CALIOP data. Altogether, 132 profiles of particle backscatter and extinction measurements obtained by the IfT spectrally resolving ground-based lidars as part of the EARLINET program, as well as by the INDOEX, have been examined. Simple relationships can be found between the two parameters, which are independent of surface albedo, aerosol vertical distribution, and Ångström exponent. However, dependence on the aerosol type exists. Uncertainties of the TOA and BOA solar radiative forcing are of the order of 30% when varying the single scattering albedo, lidar ratio, and asymmetry parameter.

Olivier Boucher submitted a presentation highlighting recent findings on the aerosol direct effect based on aircraft measurements, ground-based remote sensing from AERONET, a combination of observations from various satellites (MODIS, MISR, TOMS), and global modeling. Satellite-based estimates of the direct aerosol forcing have been helpful and have raised important questions regarding model estimates. Work is ongoing to understand the discrepancies. Large uncertainties remain in estimating the aerosol direct radiative forcing, particularly regarding the aerosol absorption and vertical profile. The aerosol indirect effect is still a major challenge; aircraft data of the aerosol vertical profile, and the aerosol properties in the vicinity of clouds and of mixed and ice clouds are needed.

Irina Sokolik discussed the remaining and emerging challenges in measuring and modeling mineral dust aerosol. Mineral dust has complex mineralogy and extended size distribution; therefore, it can impact both the solar and the terrestrial radiation budget, and has an important role in biogeochemical cycling. Observing the dust is challenging, especially near source regions over land where satellites cannot resolve aerosols from bright desert surfaces and aircraft cannot fly due to limited visibility. However, the synergy between satellites and aircraft must be implemented. Satellites can provide the spatiotemporal distribution and transport pattern of dust outbreaks at the regional and global scales, whereas aircraft can target regional experiments for process studies, such as aerosol–cloud and dust–gas interactions, or aging processes. The development of novel aircraft instrumentation and satellite products dedicated to mineral dust is mandatory.

Oleg Dubovik presented the application of inverse modeling for retrieving global aerosol emissions from satellite observations. MODIS radiances and GOCART emission/transport fields are used to retrieve refined aerosol emission fields at the global scale. Dubovik showed various examples to illustrate the potential of the technique and to express ideas for possible refinement. Including the inversion of satellite radiances other than MODIS (MISR, CALIPSO, POLDER, Meteosat) would allow for improved spatial coverage (e.g., retrieval over bright sources) and sensitivity to the aerosol type and vertical profile. In situ measurements of optical properties, size distribution, and chemical composition should provide the link between the retrieved aerosol mass emission fields and their optical efficiencies.

Christiane Textor showed results from AeroCom. In the AeroCom project, 16 global aerosol models are compared with the goal of reducing uncertainties in the simulated radiative forcing. Models are evaluated with various ground-based and satellite observations in order to improve critical parameters and processes. Validation with experimental data is crucial, but often very difficult. Data are often inaccurate or not accompanied by a statement of uncertainties, or refer to scales that are inapplicable to global model grids. Broadly speaking, communication between experimentalists and modelers needs improvement. Data preparation work will help modeling, but this is often not possible because of limited funding.

Francesco Cairo described the M55 Geophysica aerosol and cloud payload. With a ceiling of 21 km and a cruise altitude of 17.5 km, the M55 Geophysica is the only high-altitude aircraft of the EUFAR fleet. The aircraft is equipped with two modified FSSP SPP100/300, two COPAS probes, one CIP, one backscatter sonde, one near-range lidar, and various gas-phase sensors. The aircraft has taken part in various ENVISAT validation campaigns, providing airborne validation for MIPAS, GOMOS, SCHIAMACHY, and MERIS, as well as for the ongoing validation activities for CALIPSO. Lessons learned from these activities suggest that airborne calibration/validation of aerosol and cloud properties is difficult. Perhaps it would be better to design satellite validation experiments that combine the use of high-altitude aircraft as a satellite simulator together with low-level observations of the aerosol and cloud properties of interest.

COMBINED AEROSOL AND CLOUD STUDIES. Finally, five authors gave talks on combined aerosol and cloud studies. Chip Trepte presented the CALIPSO cloud/aerosol measurements and validation requirements. CALIPSO consists of a lidar to provide global, high-resolution vertical profiles of aerosols and clouds from the surface to 30 km, and an infrared imaging radiometer to obtain information on the properties of cirrus. A two-level extensive validation program is planned using ground-based, but mostly airborne, measurements to confirm key system parameters and also to provide independent validation of system performance. Validation flights are planned in various regions of the globe from June 2006 to July 2007 using U.S. and European aircraft. Requirements for the validation program are as follows: coincident underflying in order to reduce sampling uncertainties; profile measurements; flights in a variety of aerosol/cloud conditions in order to examine instrument and algorithm performances, stability, and sensitivity; day/night observations; traceability of measurements to either reference standards or established records; and values larger than uncertainties for statistical comparisons.

Alexander Kokhanovsky presented results of aerosols and cloud studies using MERIS and SCHIAMACHY or ENVISAT. MERIS and SCHIAMACHY are spectral sunsynchronous sensors operating since March 2002. The spatial resolution of MERIS in the reduced resolution mode is 1.04 km × 1.16 km. The spatial resolution of SCHIAMACHY depends on the channel. It is 30 km × 60 km for most channels.

Peter Spichtinger presented results of experiments and simulations on aerosol–cloud interactions, which are carried out at the Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland. Laboratory experiments to study ice particle formation are conducted in the recently developed ZINC. A mobile version of the ZINC, the PINC, is currently being developed for field and airborne measurements. Several other instruments, such as CVI, an ATOFMS, and grid sampling for the transmission electron microscopy analysis are available for studying aerosol cloud interactions. Modeling activities are carried out on different scales, ranging from box/trajectory calculations over 2D/3D cloud resolving modeling of cirrus clouds to global modeling (ECHAM) of cloud aerosol interactions. One example was shown combining global modeling results with POLDER satellite data; here, the anthropogenic indirect aerosol effect is estimated.

Jean-Louis Brenguier reviewed the past and current knowledge of aerosols as CCN, and their potential to alter cloud properties (first aerosol indirect effect) and affect the onset of precipitation (second aerosol indirect effect). The review identified major gaps in the link between the aerosol optical properties and the CCN activation spectrum, in the accurate diagnostic of updraft intensity, in the link between CDNC and effective radius, and finally in the discrimination between precipitating particles in a cloud and precipitation at the ground.

Jens Redemann presented case studies of simultaneous satellite and airborne aerosol remote sensing in the vicinity of clouds, which were conducted off California in April 2004. Airborne measurements of direct solar beam transmission yielding AOD were conducted at 14 wavelengths in the visible and near-infrared by the AATS-14 NASA Ames sun photometer. In 75% of cases when suborbital AOD near cloud edges was examined, a 5%–25% increase in AOD was observed in the closest 2 km near the clouds. Concurrently, the MODIS-observed midvisible reflectances in the vicinity of suborbital cloud observations showed an increase with decreasing distance from cloud edge. Possible causes include 3D radiative effects, but also increased aerosol concentration or size near clouds. The study of the aerosol–cloud boundary is essential for understanding appropriate cloud screening methods in aerosol remote sensing and for investigating the aerosol indirect effect on climate.

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APPENDIX A: LIST OF ACRONYMS.

ACE	Asian-Pacific Regional Aerosol Characterization Experiment
AeroCom	Aerosol Model Intercomparison Study
AERONET	Aerosol Robotic Network
AOD	Aerosol optical depth
AATS	Ames Aerosol Tracking Sunphotometer
(A)ATSR	(Advanced) Along-track scanning radiometer
ATOFMS	Aerosol time-of-flight mass spectrometer
BAERI	Bay Area Environmental Research Institute
BISA	Belgium Institute for Space Aeronomy
BOA	Bottom of the atmosphere
CALIOP	Cloud–Aerosol lidar with Orthogonal Polarization
CALIPSO	Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observations
CCN	Cloud condensation nuclei
CDNC	Cloud droplet nuclei concentration
CEPT	Centre d’Etudes des Environnements Terrestre et Planétaires
CESBIO	Centre d’Etudes Spatiales de la Biosphère
CIP	Cloud imaging probe
COPAS	Condensation Particle Detection System
CTH	Cloud-top height
CVI	Counterflow virtual impactor
EARLINET	European Aerosol Research Lidar Network
DLR	Deutsches Zentrum für Luft- und Raumfahrt
ENVISAT	Environmental Satellite
ERS	European Remote Sensing Satellite
ESA	European Space Agency
ETH	Swiss Federal Institute of Technology
EUFAR	European Fleet for Airborne Research
FSSP	Foward Scattering Spectrometer Probe
GOCART	Georgia Institute of Technology–Goddard Global Ozone Chemistry Aerosol Radiation and Transport
GOMOS	Global Ozone Monitoring by Occultation of Stars
IFM-GEOMAR	Leibniz-Institut für Meereswissenschaften an der Christian-Albrechts Universität zu Kiel
IfT	Leibniz Institute for Tropheric Research

INDOEX	Indian Ocean Experiment
IPSL	L'Institut Pierre-Simon Laplace
ISAC	Istituto di Scienze dell'Atmosfera e del Clima
ITOP	Intercontinental Transport of Ozone and Precursors
LACE	Lindenberg Aerosol Characterization Experiment
LASP	Laboratory for Atmospheric and Space Physics
LEANDRE	Lidar Embarqué pour l'étude des Aérosols, Nuages, Dynamique, Rayonnement et Espèces minoritaires
LISA	Laboratoire Interuniversitaire des Systèmes Atmosphériques
LOA	Laboratoire d'Optique Atmosphérique
LWP	Liquid water path
MERIS	Medium Resolution Imaging Spectrometer
MIPAS	Michelson Interferometer for Passive Atmospheric Sounding
MISR	Multiangle Imaging Spectroradiometer
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeroenautics and Space Administration
NAT	Nitric acid trihydrate
OCIO	Chlorine oxide
PARASOL	Polarization and Anisotropy of Reflectances for Atmospheric Sciences Coupled with Observations from a Lidar
PI	Principal investigator
PINC	Portable Ice Nucleation Chamber
POLDER	Polarization and Directionality of the Earth's Reflectances
PSC	Polar stratospheric clouds
RALI	Radar–lidar
RASTA	Radar Statistics Program
SAMUM	Saharan Mineral Dust Experiment
SCHIAMACHY	Scanning Imaging Absorption Spectrometer for Atmospheric Carthhography
SEVIRI	Spinning Enhanced Visible and Infra-Red Imager
SIRTA	Site Instrumental de Recherché par Télédétection Atmospherique
TOA	Top of the atmosphere
TOMS	Total Ozone Mapping Spectrometer
TNO	Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek
ZINC	Zurich Ice Nucleation Chamber

APPENDIX B: WORKSHOP AGENDA. All presentations are available online (www.eufar.net, under "Consult Expert/Workshop"; workshop names are listed). Registration as an EUFAR member is necessary to access the presentations.

Session 1: Introduction. Chairs: P. Formenti, and M. Wendisch.
- J.-M. Flaud (LISA, Créteil, France): Welcome.
- P. Brown (Met Office, Exeter, United Kingdom) and Jean-Louis Brenguier (Météo-France, Toulouse, France): Introduction to EUFAR and activities of the Expert Working Groups.
- M. Wendisch (IfT, Leipzig, Germany) and P. Formenti (LISA, Créteil, France): Objectives of the workshop, logistics.
- S. Platnick (NASA Goddard, Greenbelt, Maryland): Satellite measurements of cloud properties: Overview and needs for validation.
- T. Anderson (University of Washington, Seattle, Washington): A review of aerosol measurements: Extending to the global scale.
- I. Tegen (IfT, Leipzig, Germany): How can modelers fill the gaps of the aerosol and cloud measurements?

Session 2: Clouds. Chairs: S. Platnick and B. Mayer.
- A. Protat (CETP, Paris, France): The investigation of cloud processes from ground, airborne, and spaceborne

active remote sensing in France: SIRTA, RALI, CALIPSO, and CloudSat projects.

- F. Vanhellemont (BISA, Brussels, Belgium): Stratospheric aerosols, PSCs, and subvisual cirrus clouds as observed by GOMOS on ENVISAT.
- J. Fischer (Free University, Berlin, Germany): Observation of clouds with SEVIRI and MERIS.
- J. Remedios (ESA, University of Leicester, Leicester, United Kingdom): MIPAS cloud retrieval.
- B. Mayer (DLR, Oberpfaffenhofen, Germany): Uncertainties in cloud remote sensing and how aircraft observations can help to reduce them.
- A. Macke (IFM-GEOMAR, Kiel, Germany): Modeling and observing the radiation budget of the cloudy atmosphere.
- P. Pilewskie (Colorado Uniersity, LASP, Boulder, Colorado): Validation of satellite cloud remote sensing via airborne spectral irradiance.

Session 3: Aerosol particles. Chairs: I. Sokolik and I. Tegen.

- G. de Leeuw (TNO, The Hague, Netherlands): Retrieval of aerosol properties from satellite data: Needs for algorithm development and validation.
- D. Tanre (LOA, Lille, France): Validation of CALIOP and PARASOL aerosol products by means of spectral airborne photometry.
- A. Petzold (DLR, Oberpfaffenhofen, Germany): Combining aerosol lidar and in situ methods for the validation of current and future satellite-borne aerosol instruments: Lessons learned from LACE 1998, ITOP 2004, and SAMUM 2006.
- M. Wendisch (IfT, Leipzig, Germany): Parameterization of aerosol solar radiative forcing using CALIOP lidar data.
- O. Boucher (Met Office, Exeter, United Kingdom): Recent findings on the aerosol direct effect (not presented at the workshop, but available online at www.eufar.net).
- I. Sokolik (Georgia Tech, Atlanta, Georgia): Remaining and emerging challenges in measuring and modeling mineral dust aerosol.
- O. Dubovik (NASA Goddard, Greenbelt, Maryland): Application of inverse modeling for retrieving global aerosol emissions from satellite observations: Potential and issues.
- C. Textor (IPSL, Paris, France): Results fom the AeroCom model intercomparison.
- F. Cairo (ISAC, Rome, Italy): The M55 Geophysica aerosol payload: Instrumentation and results.

Session 4: Combined aerosol and cloud studies. Chairs: T. Anderson and J. Redemann.

- C. Trepte (NASA Langley, Hampton, Virginia): Requirements for validation of CALIPSO cloud/aerosol measurements.
- V. Kokhanovsky (ESA, University of Bremen, Bremen, Germany): Aerosols and clouds studied using MERIS and SCHIAMACHY on ENVISAT.
- P. Spichtinger (ETH, Zurich, Switzerland): Aerosol cloud interactions–experiments and simulations.
- J.-L. Brenguier (Météo-France, Toulouse, France): What are satellites missing to assess the impact of aerosols on the hydrological cycle?: Potential of airborne measurements.
- J. Redemann (BAERI, Sonoma, California): Simultaneous satellite and airborne aerosol remote sensing in the vicinity of clouds.

Roundtable discussion. Chairs: P. Formenti and M. Wendisch.

- Discussion and conclusions.