ILRC 25
Conference Program
and Abstracts

Monday, 05 July 2010

7:30 – 8:30 Registration

8:30 – 9:15 Welcome, ICLAS announcements

9:15 – 9:45 Keynote I: Georgii S. Golitsyn

BASIC PHYSICAL LAWS AND FEEDBACKS IN THE GLOBAL CLIMATE CHANGE

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Despite four IPCC reports and the Nobel Price there are until now even among scientists misbeliers and misunderstandings of the reasons of the global climate change. Many do know that the major greenhouse gas is the water vapour, but forget about Clapeyron – Klausis dependence of the saturated vapour pressure exponential dependence on the temperature. This is the principle feedback in the climate system which about triples the thermal effect of any other greenhouse gas. The effect of the solar variability was recently reliably estimated by finding that the mean global surface temperature is by 0.2 K higher at solar maximum than during its minimum.

9:45 – 10:05 Coffee Break

Session 1O: Advances in Lidar Components and Techniques – Oral Presentations
Co-Chairs: Geary Schwemmer, Edwin Eloranta

10:05 – 10:20
S01O – 01

AN EYE-SAFE DIODE-LASER-BASED MICRO-PULSE DIFFERENTIAL ABSORPTION

Amin R. Nehrir, Kevin S. Repasky

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A second generation diode laser based master oscillator power amplifier (MOPA) configured micro-pulse differential absorption lidar (DIAL) instrument for profiling of lower tropospheric water vapor is presented. The DIAL transmitter is based on a continuous wave (cw) external cavity diode laser (ECDL) master oscillator that is used to injection seed two cascaded tapered semiconductor optical power amplifiers which deliver up to 2 μJ pulse energies over a 1 μs pulse duration at 830 nm with an average power of ~ 40 mW at a pulse repetition frequency of 20 kHz. The DIAL receiver utilizes a commercial 28-cm diameter Schmidt-Cassesgrain telescope, a 250 pm narrowband optical filter, and a fiber coupled single photon counting Avalanche Photodiode (APD) detector, yielding a far-field full-angle field of view of 170 μrads. A brief overview of the second generation Montana State University (MSU) DIAL instrument is presented. Calibrated total atmospheric backscatter plots as well as water vapor number density profiles collected with the water vapor DIAL instrument are also presented and compared with co-located radiosonde measurements, demonstrating the instruments ability to measure night-time and day-time water vapor profiles and aerosol properties in the lower troposphere.

S01P – 02

NEW POLARIZATION MEASUREMENT TECHNIQUE DEVELOPED USING THE STOKES VECTOR LIDAR EQUATION

Matthew Hayman[1], Jeffrey P. Thayer[2], Ryan R. Neely III[3]

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Polarization lidar descriptions that are based on a scalar approach cannot accurately account for the variety of polarization effects and their interactions between the scattering process and the lidar system. Here, a new approach, called the Stokes Vector Lidar Equation (SVLE), is developed that provides a complete polarization description of the entire optical path. This approach allows for characterization of polarization dependencies in the scatterers as well as the lidar optical system. By applying the SVLE, the ambiguous nature of the depolarization ratio is demonstrated and a physical construct to represent atmospheric particle scattering and optical system polarization effects is described. Furthermore, a measurement methodology for distinguishing oriented scatters in the atmosphere is proposed by quantifying linear diattenuation. This features simplicity in measurement and an insensitivity to retarding and depolarizing system effects and is demonstrated on a cirrus cloud with oriented and randomly oriented structure. This proposed approach demonstrates the utility and benefit of the SVLE.

10:35 – 10:50
S01O – 03

AIRBORNE DOPPLER LIDAR BASED ON IODINE FILTER

Zhi-shen Liu, De-cang Bi, Xiao-quan Song, Zhi-gang Li, Jin-jia Guo, Jin-bao Xia, Song-hua Wu, Xi-tao Wang, Qi-wei Yin, Yang Chen

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On the basis of the development of ground-based Doppler lidar, an iodine filter-based airborne Doppler lidar is designed and developed in Ocean University of China in order to demonstrate the feasibility for wind measurements. The lidar abroad airplane "Y-12" is fixed to look sideways with 21° nadir angle. In the unit, seeded injection and frequency locked laser (Nd: YAG pulsed laser, 1.8mJ per-pulse, 2.8kHz) is set to be transmitter, while the receiver mainly includes a telescope, an interference filter and an iodine filter. An airplane frame designed for vibration absorption combined with navigation system constitutes the airborne platform. This paper describes the airborne Doppler lidar system and provides the main results of the flight campaign. The airborne Doppler lidar carried out the campaign measurements over Yellow Sea from Qingdao to approximately 300 km southeast on June 3 2009. Backscatter signal and line-of-sight wind ratio with 50 m range resolution and 3 km height were obtained. The airborne lidar operated with different flight status, which demonstrated the capacity of iodine filter-based airborne Doppler lidar to perform reliable wind measurements. This paper describes the airborne Doppler lidar system and provides the main results of the flight campaign.

10:50 – 11:05
S01O – 04

IMPROVING OCEAN-ATMOSPHERE CARBON FLUX ESTIMATES WITH LIDAR MEASUREMENTS OF OCEAN SUBSURFACE AND OCEAN–ATMOSPHERIC INTERACTION

Yongxiang Hu

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Profiling lidars in space (e.g., LITE, GLASS and CALIOP) have greatly enhanced our understanding of aerosols and clouds. With minor changes to the configuration, the space-based profiling lidars can also provide unique information for improved understanding of ocean biogeochemistry and air-sea interaction. These measurements enhance the scientific payoffs of space-based lidar missions through their advanced capability in understanding physical processes and monitoring seasonal and inter-annual changes of carbon cycle, energy cycle, water cycle and their feedbacks. This study introduces the ocean profiling measurement concept and its potential scientific applications.

11:05 – 11:20
S01O – 05

NOTES ON RAYLEIGH SCATTERING IN LIDAR SIGNALS

Mariana Adam

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The correct formulation for Rayleigh scattering using the classical approach [1] is used to analyze the molecular contribution in the lidar signals. Within classical approach, three atmospheric scenarios are considered: 2, 4 and 5-component atmosphere ($N_2 + O_2$, $N_2 + O_2 + Ar + CO_2$ and $N_2 + O_2 + Ar + CO_2$ +water vapor). Two case studies are performed to see the relative difference between retrievals using these scenarios. First case study considers 23 days measurements of air pressure, temperature and relative humidity at 31.8m. The second case study uses a radiosounding of air pressure, temperature and relative humidity. Retrievals of the aerosol extinction and backscatter coefficient are compared, using lidar signals at 355nm and 387nm. The quantum approach is used to compute the aerosol backscatter coefficient and the correction factors for the temperature-dependence of the molecular cross-sections [2]. The results show that for water vapor between 10 and 20g/kg, the relative difference between 5-component and 2-component atmosphere is between 0.5% and 1% for molecular scattering and between -0.9% and -0.4% for molecular backscattering. For aerosol backscatter (extinction) coefficient, the difference is bellow 1%. Thus a two-component atmosphere is a good approximation. Temperature correction can be ignored for N_2.

11:20 – 11:35
S01O – 06

DETERMINATION OF QUARTZ CONCENTRATION IN ASIAN AND SAHARAN DUST FROM MEASUREMENTS OF QUARTZ RAMAN SCATTERING WITH LIDAR AT TWO WAVELENGTHS

Detlef Müller[1], Ina Mattis[2], Boyan Tatarov[3], Dong-Ho Shin[4], Sung-Kyun Shin[4], Youngmin Noh[4], Taejin Choi[5], Namyi Chae[5]

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The multi-wavelength Raman lidar of the Gwangju Institute for Science and Technology (GIST) has been equipped with two Raman channels at 360 and 546 nm for measurements of the concentration of quartz in mineral dust layers. First measurements with the new channels have been performed during the Asian dust season from March to May 2009. We detected Asian dust in the polluted boundary layer. The measurement example of March 31, 2009 is presented in more detail in our contribution. We implemented a 360-nm Raman quartz channel into the multi-wavelength Raman lidar of the Leibniz Institute for Tropospheric Research (IfT). We present a measurement example that shows that the new method is also applicable for the characterization of Saharan dust.

11:35 – 11:50
S01O – 07

COMBINED VISIBLE AND UV PURE ROTATIONAL RAMAN LIDAR CHANNEL FOR AIR TEMPERATURE PROFILING

Ilya Serikov, Holger Linné, Friedhelm Jansen, Björn Brügmann

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We present a temperature channel of the Raman lidar designed at the Max Planck Institute. We discuss the system setup and demonstrate experimental data achieved with the instrument. Combining the measurements performed with UV and visible channels extends the measurement capability of the lidar to be compatible to doubling the laser power. Parallel measurements with four independent temperature channels allowed the reduction of measurement uncertainty as well as an improved data quality control.

11:50 – 12:05
S01O – 08

2-MICRON HIGH-REPETITION RATE LASER TRANSMITTER FOR BIOSPHERE–ATMOSPHERE FLUX MEASUREMENTS

Dimitri Edouart[1], Fabien Gibert[1], Florian Le Mounier[1], Didier Bruneau[2], Pierre Flamant[1]

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We describe the laser transmitter development of a new Heterodyne Differential Absorption Lidar (HDiAL). This new system is called COWI and is designed to make

simultaneously atmospheric CO_2 concentration and wind velocity measurements. The goal is to reach 10 ppm accuracy with 150 m – 10 s time and space resolutions and to be able to make CO_2 fluxes measurement thanks to the wind velocity measurement capability. The 2 µm Ho:YLF ring laser is pumped by a Tm:fiber laser at 1940 nm. We describe our experimental set-up and the performances in the CW and pulsed regime. The injection seeded operation is currently under development and the first results will be presented. Instrumental simulations and experimental results show that a trade-off has to be found between the pulse lengths, the pulse energies and the pulse repetition rate to optimize CO_2 fluxes measurements accuracy.

12:05 – 12:20
S01O – 09

END-PUMPED SOLID-STATE LASERS FOR LIDAR APPLICATIONS

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A variety of high-power end-pumped solid-state lasers developed by the laser sources group of the National Laser Centre in South Africa are presented. These include a diode-end-pumped Nd:YLF laser delivering 10.4 mJ at 5 kHz, a fiber-end-pumped Ho:YLF laser delivering 23.7 mJ at 1 kHz and Ho:YLF ring laser delivering 70 mJ single-frequency pulses at 50 Hz. All of these lasers operated with diffraction-limited beam quality.

12:20 – 12:35
S01O – 10

GENERALIZED K DISTRIBUTION FOR RETURN FADING SIGNALS IN COHERENT LIDARS

Aniceto Belmonte

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As a model for the return signal in a coherent lidar, the generalized K distribution is derived from the fundamental principles of atmospheric scattering and turbulent propagation. We analyze the effects of amplitude and phase fluctuations, in addition to local oscillator shot noise, for both passive receivers and those employing active modal compensation of wave-front phase distortion. The model results in a three-parameter probability distribution for the coherent signal-to-noise ratio in the presence of atmospheric turbulence and affected by target speckle. We obtain exact expressions for statistical moments and outage probability for lidar fading, and evaluate the impact of various parameters, including the ratio of receiver aperture diameter to the wave-front coherence diameter, the speckle effective area, and the number of0 modes compensated.

12:35 – 12:50
S01O – 11

IMAGE PROCESSING FOR AUTOMATIC CLOUD DETECTION FROM LIDAR DATA

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The purpose of this paper is to demonstrate a technique for automatic cloud detection from Lidar (Light Detection And Ranging) measurements. Most of the algorithms used for the detection of clouds are based on an analysis of each Lidar signal (*S*), and a detection

technique is often based on the study of the first and second derivatives of *S*. The technique that we used is based on the analysis of a set of consecutive measurements. The algorithm responsible for the detection of clouds uses a single-image processing.

12:50 – 13:05
S01O – 12

MULTI-CHANNEL LIDAR SPECTROMETER FOR ATMOSPHERIC AEROSOL TYPING ON THE BASIS OF CHEMICAL SIGNATURES IN RAMAN SPECTRA

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We present a first experimental data on chemical signatures characteristic for trace gases or particulate pollution (aerosol types). Measurements were made with a system that is based on a combination of a multi-channel spectrometer and a High Spectral Resolution Lidar. Measurements were also made with a combination of the multi-channel spectrometer and a multi-wavelength Raman lidar.

13:05 – 14:00 – Lunch Break

Session 11O: Space - Based Missions, Validation, and Global Monitoring – Oral Presentations
Co-Chairs: Patrick McCormick, Stuart Young

14:00 – 14:20
S11O – 01 (invited)

ACTIVE SENSING TECHNOLOGY INVESTMENTS SUPPORTING THE EARTH SCIENCE DECADAL SURVEY

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In 2007, the National Research Council, administered jointly by the United States National Academy of Sciences and the United States National Academy of Engineering, published its first-ever Earth Science Decadal Survey. The study recommended a series of future remote sensing missions to obtain key environmental measurements. Once the Decadal Survey recommendations were published, the National Aeronautics and Space Administration (NASA) Earth Science Technology Office (ESTO) focused all three of its technology development solicitations – for new instruments, advanced technology components, and advanced information systems – on Decadal Survey measurements. By December 2008, ESTO had invested more than $105M in new awards that would directly reduce risk or improve measurement capability for every one of the Earth Science Decadal Survey missions. A decade of ESTO investments has contributed to the current Decadal Survey mission concepts and technology heritage. A significant number of the Decadal Survey mission measurements are based upon active sensing technologies, such as lasers and radars. These active sensing missions, and the technology developments supporting Decadal Survey science measurements, are highlighted in this paper.

14:20 – 14:35
S11O – 02

CALIPSO AT FOUR: RESULTS AND PROGRESS

Dave Winker[1], Yong Hu[1], Mike Pitts[1], Jason Tackett[2], Chieko Kittaka[2], Zhaoyan Liu[3] and Mark Vaughan[1]

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Aerosols and clouds play important roles in Earth's climate system, but limitations in our ability to observe them globally limit our understanding of the climate system and our ability to model it. The CALIPSO satellite was developed to provide new capabilities to observe aerosol and cloud from space. CALIPSO carries the first polarization-sensitive lidar to fly in space, which has now provided a four-year record of global aerosol and cloud profiles. This paper briefly summarizes the status of the CALIPSO mission, describes some of the results from CALIPSO, and presents highlights of recent improvements in data products.

14:35 – 14:50
S11O – 03

CHARACTERIZATION OF CIRRUS AND POLAR STRATOSPHERIC CLOUDS USING CALIPSO'S CALIOP MEASUREMENTS

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Using the measurements made by the lidar aboard the Earth-orbiting Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite called the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP), we study the global and temporal characteristics of cirrus clouds and polar stratospheric clouds (PSCs) including their latitude-longitude and vertical distributions. Cirrus clouds were identified as one of the most uncertain components in weather and climate studies. Few instruments can detect cirrus clouds on a global scale, especially those of low optical thickness. Our study shows that multi-layer cirrus clouds have maximum occurrence frequency of up to 93.5% near the tropics at the 100° - 180° longitude band. We investigate the time series of the cirrus frequency and observe large latitudinal movement of cirrus cloud cover with the changing seasons. Likewise, there are few remote sensors capable of retrieving the vertical and spatial distribution of PSCs over the local winter and early spring periods on a daily basis, especially over poles. It is well known that PSCs are very important as sites for heterogeneous chemistry and polar ozone loss. Satellite lidar is particularly useful for the detection of PSCs over the poles. We study the statistical distribution of PSCs by particle composition using the depolarization ratio and backscatter ratio from the CALIPSO lidar data at 532 nm wavelength for the 2006-2009 polar winter seasons.

14:50 – 15:05
S11O – 04

LIDAR ATMOSPHERIC MEASUREMENTS ON MARS

James Whiteway[1], Leonce Komguem[1], Cameron Dickinson[1,2], Michael Daly[1,2], Allan Carswell[1,3], Thomas Duck[4]

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A lidar system for atmospheric measurements was operated from the surface of Mars as part of the Phoenix mission. Vertical profiles of backscatter were recorded from ground to a height of 20 km. This provided new knowledge of the distribution of dust and water ice clouds in the atmosphere of Mars. It was found that the dust was well mixed through the atmospheric boundary layer to a height of about 4 km. Water ice clouds were observed to form at the top of the boundary layer and near the surface. The clouds formed at temperatures of around –65 ^{o}C and the structure exhibited fall streaks that were similar to what is observed in cirrus clouds on Earth. This indicated that precipitation is a process that occurs within the hydrological cycle on Mars.

15:05 – 15:20
S11O – 05

ESA'S WIND LIDAR MISSION ADM-AEOLUS: ON-GOING SCIENTIFIC ACTIVITIES RELATED TO CALIBRATION, RETRIEVAL AND INSTRUMENT OPERATION

Olivier Le Rille[1], Anne-Grete Straume[1], Maria Ofelia Vieitez[2], Wim Ubachs[2], Willem van de Water[3], Benjamin Witschas[4], Oliver Reitebuch[4], Gert-Jan Marseille[5], Jos de Kloe[5], Ad Stoffelen[5], Karim Houchi[5], Heiner Körnich[6], Harald Schyberg[7]

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The Earth Explorer Atmospheric Dynamics Mission (ADM-Aeolus) of ESA will be the first-ever satellite to provide global observations of wind profiles from space. Its single payload, namely the Atmospheric Laser Doppler Instrument (ALADIN) is a direct-detection high-spectral-resolution Doppler Wind Lidar (DWL), operating at 355 nm, with a fringe-imaging receiver (analysing aerosol and cloud backscatter) and a double-edge receiver (analysing molecular backscatter). In order to meet the stringent mission requirements on wind retrieval, ESA is conducting various science support activities for the consolidation of the on-ground data processing, calibration and sampling strategy. Results from a recent laboratory experiment to study Rayleigh-Brillouin scattering and improve the characterisation of the molecular lidar backscatter signal detected by the ALADIN double-edge Fabry-Perot receiver will be presented in this paper. The experiment produced the most-accurate-ever-measured Rayleigh-Brillouin scattering profiles for a range of temperature, pressure and gases, representative of the Earth's atmosphere. The measurements were used to validate the Tenti S6 model, which is implemented in the ADM-Aeolus ground processor. First results from the on-going Vertical Aeolus Measurement Positioning (VAMP) study will be also reported. This second study aims at the optimisation of the ADM-Aeolus vertical sampling in order to

maximise the usefulness of the retrieved winds, taking into account the atmospheric dynamical and optical heterogeneity. The impact of the Aeolus wind profiles on Numerical Weather Prediction (NWP) and stratospheric circulation modelling for the different vertical sampling strategies is thus being estimated.

15:20 – 15:35
S11O – 06

LONG-TERM AEROSOL AND CLOUD DATABASE FROM CORRELATIVE EARLINET–CALIPSO OBSERVATIONS

Anja Hiebsch[1], UllaWandinger[1], Ina Mattis[1], Albert Ansmann[1], Gelsomina Pappalardo[2], Lucia Mona[2], Fabio Madonna[2], Giuseppe D'Amico[2], Aldo Giunta[2], Holger Linné[3], Ilya Serikov[3], Arnoud Apituley[4], Keith Wilson[4], Lucas Alados Arboledas[5], Francisco Navas Guzmán[5], Dimitris Balis[6], Elina Giannakaki[6], Anatoli Chaikovsky[7], Ferdinando De Tomasi[8], Maria Rita Perrone[8], Volker Freudenthaler[9], Matthias Wiegner[9], Franziska Schnell[9], Ivan Grigorov[10], Dimitar Stoyanov[10], Marco Iarlori[11], Vincenzo Rizi[11], Rodanthi-Elizabeth Mamouri[12], Alexandros Papayannis[12], Francisco Molero[13], Manuel Pujadas[13], Aleksander Pietruczuk[14], Francesc Rocadenbosch[15], Sergio Tomas[15], Dhiraj Kumar[15], Nicola Spinelli[16], Xuan Wang[16]

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[16]Consorzio Nazionale Interuniversitario per le Scienze Fisiche della Materia, Napoli, Italy

The European Aerosol Research Lidar Network, EARLINET, performs correlative observations during CALIPSO overpasses based on a sophisticated measurement strategy since June 2006. Within a dedicated activity supported by the European Space Agency (ESA), sixteen EARLINET stations contributed about 1500 measurements during an intensive observational period from May 2008 to October 2009. From these measurements, we establish a long-term aerosol and cloud database of correlative EARLINET-CALIPSO observations. This database shall provide a basis for homogenizing long-term space-borne observations conducted with different lidar instruments operating at different wavelengths on various platforms over the next decade(s). The database is also used to study the quality and representativeness of satellite lidar cross sections along an orbit against long-term lidar network observations on a continental scale.

15:35 – 15:50
S11O – 07

THE CALIPSO CLOUD AND AEROSOL DISCRIMINATION: VERSION 3 ALGORITHM AND TEST RESULTS

Z. Liu[1], R. Kuehn[2], M. Vaughan[3], D. Winker[3], A. Omar[3], K. Powell[3], C. Trepte[3], Y. Hu[3], and C. Hostetler[3]

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A new five-dimensional (5D) PDF-based cloud and aerosol discrimination (CAD) algorithm has been developed for use in the version 3 CALIPSO lidar data release. Because the separation between clouds and aerosols is better in the new 5D space than in the 3D space previously used in the version 2 algorithm, significant improvements have been achieved in the classification of dense aerosol layers. These improvements are particularly noticeable for very dense dust layers, which were frequently misclassified as cloud by the 3D algorithm in the V2 data release. This paper describes the V3 CAD algorithm and presents test results.

15:50 – 16:05
S11O – 08

A COMPARISON OF SPACE-BORNE AND AIRBORNE LIDAR OBSERVATIONS OF COMPLEX, HIGH CLOUD FIELDS DURING CLASIC

Stuart A. Young[1], Dennis L. Hlavka[2], Mark A. Vaughan[3], Matthew J. McGill[4]

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Estimates of high-cloud optical depths retrieved from analyses of lidar data acquired during the Cloud and Land Surface Interaction Campaign (CLASIC) by the space-borne Cloud-Aerosol Lidar Infrared Pathfinder Satellite Observations (CALIPSO) lidar and the Cloud Physics Lidar (CPL) flown on the high-altitude ER-2 aircraft are compared. Differences in the optical depths and in the integrated attenuated backscatter derived by the two instruments are interpreted by considering the large difference in signal-to-noise ratios and possible errors in CALIPSO's calibration during these daytime observations, along with differences in the contributions of multiple scattering to the two instruments and the inferred presence of oriented crystals in the relatively complex cloud fields.

notes

16:05 – 16:20
S11O – 09

ICE CLOUD MICROPHYSICS FROM CLOUDSAT AND CALIOP: ANAYSIS OF ORIENTED CRYSTALS

Hajime Okamoto[1], Kaori Sato[2], Yuichiro Hagihara[1], Maki Hirakata[1]

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Global distribution of ice microphysics was analyzed for one-year of CloudSat and CALIOP data. The new radar-lidar algorithm can be applied to the specular reflection of lidar signals often observed by CALIOP with large backscattering coefficients and small depolarization ratios. Analyses of CloudSat and CALIPSO data by our former radar-lidar algorithm [1] showed problems retrieving ice cloud microphysics when specular reflection was present. The new radar-lidar algorithm requires depolarization ratios measured by CALIPSO, in addition to the radar reflectivity factor and backscattering coefficient at 532 nm. We implemented additional look-up tables for horizontally oriented plates on the basis of Kirchhoff approximation [2]. Global analyses of ice microphysics for CloudSat-CALIPSO overlap regions were presented. The largest mixing ratio of oriented particles occurred between -20 and -5^{o}C. The ice water content (IWC) had two maxima in the tropics above 15 km and around 5 km. Distinct seasonal differences in IWC and effective radius were found. Small IWC corresponded to the small of cloud fraction in subsidence region. We also examined the differences in ice microphysics over land and ocean. The effective radius in high-level was similar over land and ocean, but the IWC tended to be larger over land.

16:20 – 16:35
S11O – 10

FEATUREMASK ALGORITHM FOR THE EARTHCARE LIDAR

Gerd-Jan van Zadelhoff and D.P. Donovan

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The Earth Clouds, Aerosol and Radiation Explorer (EarthCARE) is a combined ESA/JAXA mission to be flown in 2013. In this work, the FeatureMask algorithm for the EarthCARE high spectral resolution lidar is discussed which was developed within the ESA sponsored CASPER study. A feature mask identifies `significant return' in the lidar signal. It does not specify the nature of the feature. In order to be able to derive reliable extinction and backscatter profiles, as well as a target classification, which specifies the nature of the feature (ice cloud, liquid cloud or aerosol layers etc.); an accurate feature mask is essential. The algorithm relies on image reconstruction techniques and not solely on signal to noise ratios and thresholds. The algorithm and results for a number of different scenes including ice clouds, liquid clouds and aerosol layers will be presented.

16:35 – 16:50
S11O – 11

IN ORBIT PERFORMANCE OF THE LUNAR ORBITER LASER ALTIMETER

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The Lunar Orbiter Laser Altimeter on board the Lunar Reconnaissance Orbiter has made over a billion laser altimetry measurements of the Lunar surface since LRO launch in June 2009. It has also collected over two hundred hours of laser ranging data from Earth stations to the spacecraft for precision orbit determination. This paper gives a performance assessment of the instrument from the in-flight measurement data.

16:50 – 17:05
S11O – 12

THE EARTHCARE HIGH SPECTRAL RESOLUTION LIDAR

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The EarthCARE mission is the sixth Earth Explorer Missions of the ESA Living Planet Programme, with a launch date planned in 2013. It addresses the interaction and impact of clouds and aerosols on the Earth's radiative budget. ATLID (ATmospheric LIDar), one of the four instruments of EarthCARE, shall determine vertical profiles of clouds and aerosols physical parameters (altitude, optical depth, backscatter ratio and depolarisation ratio) in synergy with other instruments.

17:05 – 19:00 – Poster Session I

Session 1P: Advances in Lidar Components and Techniques – Poster Presentations
Co-Chairs: Scott Spuler, Valentin Mitev

S01P – 01

AIRBORNE LIDAR SIMULATOR FOR THE LIDAR SURFACE TOPOGRAPHY (LIST) MISSION

Anthony W. Yu[1], Michael A. Krainak[1], David J. Harding[2], James B. Abshire[3], Xiaoli Sun[4], John Cavanaugh[1], Susan Valett[1], and Luis Ramos-Izquierdo[5]

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In 2007, the National Research Council (NRC) completed its first decadal survey for Earth science at the request of NASA, NOAA, and USGS. The Lidar Surface Topography (LIST) mission is one of fifteen missions recommended by NRC, whose primary objectives are to map global topography and vegetation structure at 5 m spatial resolution, and to acquire global surface height mapping within a few years. NASA Goddard conducted an initial mission concept study for the LIST mission in 2007, and developed the initial measurement requirements for the mission. We are in the 2nd year of a 3 year instrument incubator program to develop technologies for LIST. We will report the progress on the technologies development and also discuss planned airborne instrument simulator for the final year of the IIP.

S01P – 02

NEW INTEGRAL INVERSION TECHNIQUES OF MULTIPOSITION LIDAR PROBING

A.D. Yegorov, V.M. Ignatenko, I.A. Potapova, Y.B. Rzhonsnitskaya

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This paper discusses the problem of the reliability with which the characteristics of atmospheric aerosols are determined from the results of mono- and multiposition measurements of backscattering signals. Approximate integral and differential solutions of the lidar equation are analysed. The results of determining the transparency of atmospheric air contaminated with industrial discharges, and automotive exhausts are presented. Substantial variations are found in the relationship between the backscattering coefficient and the extinction coefficient in an inhomogeneous atmosphere. The integral solutions of the lidar equation were used for simulations of multiposition measurements based on the data of the lidar probing of an aerosol that has been carried out in a number of experiments. It is concluded that the efficiency of lidar method for probing the atmosphere based on a new solution of the problem is determined by the definiteness of the region in which they are applicable.

S01P – 03

LIDAR RATIO ESTIMATION USING A TWO-POINT CALIBRATION IN A TURBID LAYER ALOFT

Francesc Rocadenbosch, M. Nadzri, Md. Reba, Michaël Sicard, Sergio Tomás, Dhiraj Kumar

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In a previous work from Ansmann et al., 1992, Appl. Opt., 31(33), p. 7123, a range-independent lidar ratio estimation method was qualitatively proposed by iteratively solving the lidar equation in forward and backward form in a cloud layer. The method provides independent aerosol extinction and backscatter using a simple backscatter lidar. Here, the method is analytically re-formulated in terms of an objective function (whose root is the sought-after lidar ratio) ready to be solved by conventional numerical techniques. A 532-nm case example is discussed.

S01P – 04

WATER VAPOR DIFFERENTIAL ABSORPTION LIDAR MEASUREMENTS AT 935 NM USING A ND:YGG LASER

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A novel diode-pumped, single-frequency laser system emitting at 935 nm was developed to serve as the transmitter for water differential absorption lidar measurements. This laser uses Nd:YGG ($Y_3Ga_5O_{12}$) as the active medium. The system was directly diode-pumped at 806 nm and was built up in a master-oscillator power-amplifier configuration. It consists of a stable resonator in rod geometry and employs as the amplifier a stable-unstable hybrid resonator in an end-pumped slab design. Single frequency operation is achieved by injection seeding. The range of continuously tunable single-frequency radiation extends to ~0.4 nm centered around 935.31 nm. More than 30 mJ of pulse energy at 100 Hz repetition rate with a beam quality (M^2) of better than 1.4 and Q-switched pulse duration of 52 ns in single frequency mode were generated. Since water vapor DIAL demands for stringent requirements for the spectral properties those were carefully investigated. Values of the spectral purity of >99.995% were determined using long-pass absorption measurements in the atmosphere exceeding the requirements by a large margin. Finally, first time water vapor DIAL measurements were performed using a Nd:YGG laser. The reported results show much promise of these directly pumped lasers at 935 nm for future space-borne and airborne water vapor lidar systems.

S01P – 05

MESOSPHERIC TEMPERATURE AND AEROSOL SOUNDINGS DURING DAY AND NIGHT: SPECTRAL AND SPATIAL FILTERING TECHNIQUES

Michael Gerding, Josef Höffner, Maren Kopp, Ronald Eixmann, Franz-Josef Lübken

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Mesospheric lidar applications like Rayleigh-Mie-Raman soundings are often limited to the nighttime as solar background is many orders of magnitude larger than typical laser backscatter. Background suppression crucially depends on the ability to keep the backscatter signal as high as possible because of the typically poor signal from mesospheric altitudes. Actually, we set up an RMR lidar at Kühlungsborn, Germany (54°N, 12°E) for soundings of mesospheric temperature and Noctilucent Clouds continuously during day and night. We will present spatial filtering techniques with a lidar field of view (FOV) of only ~60 mrad. Active beam stabilization fixes the laser within the telescopes FOV. The remaining jitter of the optical axis is ~5 mrad. Because of the small FOV the background level is reduced by a factor of ~100 compared to our old RMR lidar. Further background reduction is realized by a double Fabry-Perot-Etalon and a narrowband interference filter. The etalons have ~4 pm FWHM and a peak transmission of about 95 %. By this, the laser backscatter is only slightly reduced. We will present an overview on the applied techniques and the observed capabilities. In summer 2009 first measurements are performed, e.g. showing NLC with high signal-to-noise ratio.

S01P – 06

DETERMINATION OF THE SMOKE-PLUME HEIGHTS WITH SCANNING LIDAR USING ALTERNATIVE FUNCTIONS FOR ESTABLISHING THE ATMOSPHERIC HETEROGENEITY LOCATIONS

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Data-processing techniques for the scanning lidar data are considered that allow determining the upper and lower boundaries of the smoke plume or smoke layering in the vicinity of wildfires. The task is fulfilled by utilizing the Atmospheric Heterogeneity Height Indicator (AHHI). The AHHI is a histogram, which shows a number of heterogeneity events defined by scanning lidar at the consecutive height intervals in a heterogeneous atmosphere. Different variants of creating the AAHI plots for investigating the atmospheres contaminated with the smoke plume are considered. Because the boundaries of the dispersed smoke plume are often not well defined, user-defined criteria are considered, which allow utilizing the automatic data processing procedure. The smoke boundary height is defined as the location where a special function, determined from the scanning lidar signals, varies within acceptable limits, and the standard deviation of the calculated height does not exceed an established value. The best results are achieved when different variants of the AHHI are used to determine the upper and the lower height of the smoke plume.

S01P – 07

A REDESIGNED RAMAN LIDAR FOR CLOUD AND AEROSOL PROFILING IN THE ARCTIC

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Since 1999, the Koldewey Aerosol Raman Lidar (KARL) contributes tropospheric aerosol and water vapor measurements to the atmospheric observations performed at the AWIPEV research base in Ny-A° lesund, Spitsbergen (78.55 N, 11.56 E). KARL was significantly upgraded since 2008 to provide the opportunity of cloud analysis as well as observations of the boundary layer. For the first time, an aperture, variable in size and position was included in a lidar system, enabling it to switch between near and far field measurements. Furthermore, fast switching between different fields of view allows us to determine multiple scattering effects of clouds. The system has been successfully tested in the international PAM-ARCMIP campaign in spring 2009, some preliminary data are presented.

S01P – 08

OVERLAP FUNCTION OF A LIDAR WITH A FIELD STOP SHIFTED FROM THE FOCAL PLANE

Aleksey Malinka[1] and Jörg Schmidt[2]

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The case when the lidar field stop is shifted from the receiver's focal plane is considered. The general recipe to obtain the receiver sensitivity function, when the field stop is out of the focal plane, is given. It is shown that for the overlap function the shift of the field stop produces the decrease of the effective spatial characteristics of the collecting optics (particularly, radius) by the factor of | 1- z/D | (z, the backscattering height, D, the lidar focus).

S01P – 09

A HIGH ALTITUDE CLOUD-AEROSOL TRANSPORT LIDAR SYSTEM

John E. Yorks[1], Matthew J. McGill[2], Dennis L. Hlavka[1], William D. Hart[1]

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A lidar system in development at NASA Goddard Space Flight Center is capable of resolving both the basic intensity information of backscattered photons and the Doppler shift caused by the mean motion of the scattering medium. The instrument, called the Cloud-Aerosol Transport System (CATS), is a lidar that is both a Doppler lidar and, by its very nature, a high spectral resolution lidar (HSRL). The latter aspect of CATS will provide information on cloud and aerosol height, internal structure, and optical properties (e.g. extinction) while the Doppler aspect adds capability to derive wind motion. A high-resolution interferometer is used for the direct-detection system to resolve the Doppler shift and to provide the spectral discrimination needed for an HSRL measurement. The CATS lidar will be ready for integration to the NASA ER-2 aircraft in 2010 and will provide data for analysis of aerosol transport and cloud motion.

Additionally, CATS should contribute to future space-based missions by advancing component technologies and by producing an airborne instrument directly applicable to prototyping and validation for NASA's Aerosol-Cloud-Ecosystem (ACE) and 3-D Winds missions.

S01P – 10

FEASIBILITY ANALYSIS OF A NOVEL SYSTEM FOR AUTOMATIC BEAM ALIGNMENT AND SPATIAL MODE ANALYSIS IN RAYLEIGH AND RESONANCE LIDAR

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The feasibility of a dither-type transmitter-receiver beam alignment and optimization system is investigated. Hardware and theoretical descriptions of the system and algorithm are presented. A signal-to-noise ratio of $5.87*t^{1/2}$ is estimated for the Arecibo potassium lidar assuming 10% loss of signal due to dither action.

S01P – 11

LIDARS IN 3D AIRBORNE TERRESTRIAL MAPPING AND GROUND-BASED IMAGING

Arkady Ulitsky

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In recent decades laser radar developments have opened numerous application opportunities. Lidars have turned into instrumentation widely used in a broad variety of applications in addition to atmospheric measurements. This paper reviews the most current lidar developments in airborne terrestrial mapping applications, when the lidar instrument is installed in aircraft for collecting airborne topographic data to produce highly accurate 3-dimensional terrain maps. The other class of lidars presented here is the most current lidar instrumentation developed for highly accurate 3D imaging of various terrestrial objects using ground-based systems. In the paper the main technical capabilities of both types of lidar instruments are presented. Several examples showing the unique 3D capabilities of the airborne and ground-based instruments are also presented.

S01P – 12

ANALYTICAL ERROR ANALYSIS SCHEME TO BE USED IN THE INVERSION OF MULTIWAVELENGTH RAMAN LIDAR DATA: FIRST RESULTS FOR MICROPHYSICAL PARAMETERS

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Inversion algorithms are used for the retrieval of microphysical particle properties from optical data collected with multiwavelength aerosol Raman lidar. One major obstacle in data inversion is how to derive reasonable error bars of the microphysical particle properties. Up to this point error bars are generally derived on the basis of numerical simulations which is a time consuming procedure, and does not allow for operator independent objective data analysis. For that reason we are developing an analytical error computation scheme, which in future will be included in an operational, automated version of our inversion software. Such automated retrievals are needed in view of the enormous amount of data to be expected from multiwavelength Raman lidar networks, airborne applications of multiwavelength aerosol lidar, and possible future space-borne applications. Preliminary tests of our first version of an automated error computation scheme are promising. In the case of unknown complex refractive index and measurement errors of 10% (one-standard deviation) for an optical data set consisting of backscatter coefficients at 355, 532, and 1064 nm and extinction coefficients at 355 and 532 nm we retrieve particle effective radius to ± 22%, number concentration to ± 71%, surface-area concentration to ± 52%, volume concentration to ± 55% and single-scattering albedo to ± 0.04 accuracy, respectively. Our goal is to reduce the uncertainties to better than 50%.

S01P – 13

MOBILE DOPPLER LIDAR WITH INERTIAL NAVIGATION SYSTEM FOR MOVING MEASUREMENTS

Bing-Yi Liu, Zhi-Shen Liu, Xiao-Quan Song, Song-Hua Wu, De-Cang Bi, Xi-Tao Wang, Qi-Wei Yin, Yang Chen

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For measuring wind with a normal mobile Doppler lidar, the vehicle must be level-adjusted and be equipped with a two-axis scanner to direct the laser beam and a north-finder to determine the orientation. In this paper, a mobile Doppler lidar with GPS and inertial navigation system is developed for measuring wind during movement. The speed and attitude of the vehicle are recorded and used to calculate the direction of the laser beam and to correct the line-of-sight (LOS) velocity. As a result, wind measurements can be performed by the mobile Doppler lidar during movements without scanner and north-finder. This development of the mobile Doppler lidar simplifies the construction of the system and makes the lidar more flexible for wind measurements.

S01P – 14

TDLS SYSTEM FOR REMOTE DETECTION OF HF IN OPEN ATMOSPHERE ON THE BASE NEAR-INFRARED DIODE LASERS

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The results of an investigation of manufacturability of a prototype device for prompt (in the on-line mode) remote measurements of HF trace amounts in atmosphere (with the path length up to 100 m, and a cat's eye as a retroreflector) with the use of near-infrared diode lasers (DL) was reported. The results of preliminary studies have shown that the minimal HF absorption value detectable within 30 ms in the remote mode corresponded to the HF concentration below 10.0 ppb which makes 0.02 of the MPC (500 ppb). Different approaches to remote detection of HF molecules in open atmosphere, the major factors specifying the HF remote analysis sensitivity, feasibilities of using other types of DL, quantum cascade DL among them, and potentialities of application of a hardware and software system of this type on mobile ground-based and air-based facilities are discussed.

S01P – 15

LIDAR BACKSCATTERING SIGNAL DENOISING BASED ON INTRINSIC MODE FUNCTIONS DECOMPOSITION

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Empirical mode decomposition (EMD) is one of self-adaptive signal processing methods and is effective in analyzing the nonlinear and non-stationary time series. Traditionally, intrinsic mode functions (IMFs) in EMD are achieved by sifting the mean of upper and lower envelopes. By this means, the cubic spline interpolations must be done two times in every sifting process, and this leads to that both border effect and efficiency aren't satisfactory. Therefore two other different methods are introduced for calculating the local extremum mean and the mean values are further used to get IMFs. In this paper, IMFs are employed for denoising Mie LIDAR backscattering signal. The denoising is based on the fact that most of the noises in the backscattering signal distribute on the higher frequency IMFs, so how to determine the noise IMFs is key point. A correlation coefficient criterion is subsequently proposed and applied to real experimental data processing. The processing results of Mie LIDAR backscattering signal show that this method is effective.

S01P – 16

PROFILES OF MICROPHYSICAL PARTICLE PROPERTIES DERIVED FROM INVERSION WITH TWO-DIMENSIONAL REGULARIZATION OF MULTIWAVELENGTH RAMAN LIDAR DATA: EXPERIMENT

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We present the theory of inversion with two-dimensional regularization [1]. It is used to retrieve profiles of microphysical properties of atmospheric particles from profiles of optical properties acquired with multiwavelength Raman lidar. This novel method has some advantages over the standard method of inversion with classical one-dimensional regularization [2, 3]. It is more robust to inversion errors, and the work load in data processing is reduced. In this contribution we compare for the first time the performance of the algorithm on the basis of experimental data. Lidar data were taken of an aged biomass-burning plume that was transported from Canada to West/Central Europe in July 2004. Particle in-situ measurements taken during a research aircraft flight in that smoke plume serve as comparison to the results inferred with our new method. To this date we have only a very limited number of airborne in-situ measurements of key microphysical particle properties that can be used for comparison/ validation studies of retrieval products of our inversion algorithm. In that respect the measurement case presented here is extremely valuable for validation purposes, despite the fact that there was considerable distance between the airborne measurement and our lidar instrument.

S01P – 17

PERIODICALLY POLED NONLINEAR CRYSTALS FOR PARAMETRIC LIGHT GENERATION

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Periodically poled nonlinear crystals (PPNC crystals) with quasi-phase-matching enable efficient generation of a broadband tunable infrared radiation. It is the key property of the PPNC crystals that any constraints on the polarization of interacting waves are removed. Besides, quasi-phase-matching is realizable along any direction with respect to crystal optical axes, which allows maximizing efficient nonlinearity and fitting the domain period to an optimal value. The calculated results are presented on the realization of quasi-phase-matching wave interaction in GaAs, $LiNbO_3$, $KNbO_3$, $CsTiOAsO_4$, $LiTaO_3$, and other crystals as well as periods of nonlinear susceptibility modulation.

S01P – 18

DEVELOPMENT OF RAYLEIGH LIDAR FOR CLEAR AIR TURBULENCE DETECTION

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The conditions of the Clear air turbulence (CAT) in the atmosphere are due to various phenomena: gravity waves breaking, shears associated with jets, convection etc…. Therefore, we propose systematic investigation from the ground with Rayleigh back-scattering lidar, in order to better characterize this atmospheric phenomenon. Rayleigh lidars are able to measure the vertical profile of light emitted by a pulsed laser and backscattered by atmospheric molecules. The Rayleigh signal intensity variations are proportional to the CAT. This paper describes a new technique developed at The Haute-Provence Observatory (OHP). This technique is based on using of a Rayleigh lidar to detect density at 8-12 km height and monitor the index turbulence along the laser beam.

S01P – 19

315 MJ, 2-MM DOUBLE-PULSED COHERENT DIFFERENTIAL ABSORPTION LIDAR TRANSMITTER FOR ATMOSPHERIC CO_2 SENSING

Mulugeta Petros[1], Jirong Yu[2], Bo Trieu[2], Yingxin Bai[3], Grady Koch[2], Songsheng Chen[3], Paul Petzar[4], Upendra N. Singh[2], Michael J. Kavaya[2], Jeffrey Beyon[2]

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The design of a double pulsed, injection seeded, 2-µm compact coherent Differential absorption Lidar (DIAL) transmitter for CO_2 sensing is presented. This system is hardened for ground and airborne applications. The design architecture includes three continuous wave lasers which provide controlled 'on and 'off' line seeding, injection seeded power oscillator and a single amplifier operating in double pass configuration. As the derivative a coherent Doppler wind lidar, this instrument has the added benefit of providing wind information. The active laser material used for this application is a Ho: Tm:YLF crystal operates at the eye-safe wavelength. The 3-meter long folded ring resonator produces energy of 130-mJ (90/40) with a temporal pulse length around 220 ns and 530ns pulses for 'on' and 'off' lines respectively. The separation between the two pulses is on the order of 200µs. The line width is in the order of 2.5MHz and the beam quality has an M^2 of 1.1 times diffraction limited beam. A final output energy for a pair of both 'on' and 'off' pulses as high as 315 mJ (190/125) at a repetition rate of 10 Hz is achieved. The operating temperature is set around 20°C for the pump diode lasers and 10°C for the rod. Since the laser design has to meet high-energy as well as high beam quality requirements, close attention is paid to the laser head design to avoid thermal distortion in the rod. A side-pumped configuration is used and heat is removed uniformly by passing coolant through a tube slightly larger than the rod to reduce thermal gradient. This paper also discusses the advantage of using a long upper laser level life time laser crystal for DIAL application. In addition issues related to injection seeding with two different frequencies to achieve a transform limited line width will be presented.

S01P – 20

DEVELOPMENT OF A COHERENT DIFFERENTIAL ABSORPTION LIDAR FOR RANGE RESOLVED ATMOSPHERIC CO_2 MEASUREMENTS

Jirong Yu[1], Mulugeta Petros[2], Songsheng Chen[3], Yingxin Bai[3], Paul J. Petzar[4], Bo C. Trieu[1], Grady J. Koch[1], Jeffery J. Beyon[1], Michael J. Kavaya[1], Upendra N. Singh[1]

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A pulsed, 2-µm coherent Differential Absorption Lidar (DIAL) / Integrated Path Differential Absorption (IPDA) transceiver, developed under the Laser Risk Reduction Program (LRRP) at NASA, is integrated into a fully functional lidar instrument. This instrument will measure atmospheric CO_2 profiles (by DIAL) initially from a ground platform, and then be prepared for aircraft installation to measure the atmospheric CO_2 column densities in the atmospheric boundary layer (ABL) and lower troposphere. It can provide the image of the pooling of CO_2 in low-lying areas and performs nighttime mass balance measurements at landscape scale. This sensor is unique in its capability to study the vertical ABL-free troposphere exchange of CO_2 directly. It will allow the investigators to pursue subsequent in science-driven deployments, and provides a unique tool for Active Sensing of CO_2 Emissions over Night, Days, and Seasons (ASCENDS) validation that was strongly advocated in the recent ASCENDS Workshop.

S01P – 21

DEMONSTRATION OF A HIGH POWER 1.5344 MICROMETER OUTPUT ND:YAG PUMPED OPO

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Lidar remote sensing is gaining wider acceptance in environmental monitoring community. Therefore, eye-safety is an increasingly important requirement for lidar systems. High power laser pulses (> 200 mJ/pulse) are often required to achieve adequate signal-to-noise at meaningful ranges (>15 km) with a single laser shot. Nd:YAG based systems are a convenient and reliable way to achieve high power pulses, but there are substantial challenges to address when using a Nd:YAG to generate eye-safe (1.4-2.1 mm) pulses. Here we demonstrate an optoparametric oscillator (OPO) with >20% conversion efficiency designed to be used as transmitter in a lidar remote sensor. The OPO is a regenerative circulating design using two KTA (theta=90°, phi=0°) as the non-linear media. The OPO is pumped by 45 W (1.5 J/pulse, 30 Hz) of 1064 nm light generated by an injection-seeded Nd:YAG laser. Significant performance enhancement was seen when the OPO was externally seeded using an external 1.5344 mm DFB telecom laser.

S01P – 22

LASER COMPLEXES FOR THE SOLUTION OF THE INVERSE PROBLEM OF ECOLOGICAL MONITORING

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Last decades the problem of the atmosphere monitoring with purpose of the gas-aerosols compound control and registration of the environmental pollution with ecotoxicant and biogenic particles arises dramatically. Application of remote sounding methods and technologies based on optics-electronical and lidar approaches for diagnostic of gas-aerosol compounds of environment provides a new possibility for controlling ecological safety and revealing dangerous events. The solution of pointed problems in regional scale could be provided on the network of the ecological safety stations. Regional observatories of ecological safety make up the fundament of this network. Every observatory includes the research laboratory on the base of the Academic institution and the network of measuring stations and points situated in the representative sites of the observing system. The using a laser complex in observatories of ecological safety is one of perspective field in the ecological monitoring. The laser complex allows registering even mall concentrations of gas and aerosol pollutants in the atmosphere in real time. Namely:
– retrieving of small gases in the atmosphere, particularly SO_x, NO_x, O_3, H_2O and others and determining of transfer directions;
– determination of concentration, identification, localization and transfer direction of aerosol pollutants in the atmosphere; retrieving atmospheric aerosols, their morphology and microphysics and finding the dependence between microphysical and optical parameters of atmospheric aerosols in local and global scales.

S01P – 23

UNIFORM DATA ACQUISITION MODULES FOR LIDAR MEASUREMENTS

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Uniform photo-receiving modules and specialized software were developed for lidar systems to provide data uniformity and quality assurance at the CIS-LiNet lidar network. Specific features of the equipment are wide-range controlled linearity and its protection from external electromagnetic interference due to laser power supply impact and digital signals transmitting. Three variants of a module for analog and photo counting receiving modes on the base of analog and photon counting PMT and an avalanche photodiode were designed and a series of equipment was produced and installed at some CIS-LiNet and EARLINET stations.

S01P – 24

A NEW LIDAR FACILITY TO INVESTIGATE THE MIDDLE ATMOSPHERE OVER BUCKLAND PARK, AUSTRALIA, 35◦ S

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This article reports the ongoing development of the lidar facility at Buckland Park (35°S, 138°E), the first of this kind in Australia. Within The University of Adelaide, the Atmospheric Physics Group, in collaboration with the Optics and Photonics Group, is setting up a facility with the potential to host three lidar systems. The aim of this facility is to measure atmospheric temperature and dynamical processes with high spatial and temporal resolution from 15 to 110 km altitude. The current work focuses on the development of a Rayleigh/Mie/Raman (RMR) backscatter lidar for temperature measurements in the altitude range from approximately 15 to 75 km. The derived temperature profiles will be used to establish a climatology and to study dynamical processes such as gravity waves at this unique geographic location. Although the RMR lidar technique is well established, most of these lidars are predominantly situated in the northern hemisphere. There are very few lidar stations in the southern hemisphere with the capability to investigate the middle atmosphere. The scientific outcomes of this project will greatly enhance our understanding of the middle atmosphere and will contribute to the evaluation of meteorological satellites and models in this southern subtropical region.

S01P – 25

LIDAR CALIBRATION AT 1064 NM CHANNEL USING COMBINED CIRRUS AND LOW ALTIDUE WATER CLOUDS

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Measurements of low-altitude cloud and its interaction with aerosol are analyzed with a multiple-wavelength elastic-Raman lidar. Using the numerical experiment approach, we first evaluate the retrieval accuracy of cloud extinction from the Raman-lidar algorithms, in particular at the cloud edges. For the low-level water-phase cloud, the simulation also shows the dramatic variation of lidar-ratio, color-ratio and extinction-ratio with the small droplet size and their correlation. In particular, measurement examples by CCNY elastic-Raman lidar illustrate that significant increase in small droplets formation occurs at the cloud edges as well as enhanced hygroscopic aerosols near the cloud interface. Finally, we observe weak but positive correlations between small droplet formation and enhanced aerosol loading indicative of indirect aerosol cloud interaction.

S01P – 26

OPTICAL PROPERTIES OF BIOMASS BURNING AEROSOLS IN RESPECT TO THEIR SOURCE DISTANCE OVER ATHENS, GREECE USING A 6-WAVELENGTH RAMAN LIDAR SYSTEM

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A 6-wavelength Raman lidar was used to obtain the optical properties (backscatter, extinction coefficient, lidar ratio-LR, Ångstöm exponent-AE) of biomass burning aerosol in the troposphere over Athens (37.9°N, 23.6°E, 200 m above sea level-asl.), Greece, during biomass burning events in the summer periods 2007-2009. Three cases of sampled air masses from forest fires were selected: originating 100, 1300 and 30 km from the source (biomass burning) region, thus, the aging of the pyrogenic aerosols was much different. The Raman technique was engaged for the independent calculation of the extinction and backscatter coefficient and thus, to obtain the lidar ratio of the aerosols inside the smoke layers. The NOAA HYSPLIT model was used for the air mass back trajectory analysis. The purpose of this paper is to compare the pyrogenic aerosol optical properties coming from various distances. Regarding the LR values they ranged from 60-120 sr (at 355 and 532 nm), while the AE values were of the order of 1-2, indicating the presence of rather small particles.

S01P – 27

A HIGH SPECTRAL RESOLUTION LIDAR FOR THE DEPARTMENT OF ENERGY

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The Arctic High Spectral Resolution Lidar (HSRL) has already operated for five years at the Eureka Weather Station *(80°N, 86°W)* in Canada on Ellsemere Island. Two more instruments will be built for the Department of Energy for ARM program (DOE HSRL lidars). In this paper we briefly describe the new lidar. The DOE and Arctic HSRL lidars have similar concept. However, the design of the new lidar system is significantly improved and it avoids the mistakes of the Arctic lidar. The DOE lidar is designed to have more stable characteristics, like a lidar geometry function. Also, the new system will receive a more compact design and improved reliability.

S01P – 28

CHARACTERIZATION OF A SINGLE PHOTON AVALANCHE DIODE RESPONSE UNDER OVERLOAD CONDITIONS

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A single telescope transceiver design of the HSRL lidar with a beam expansion through the telescope makes the lidar system eye-safe and mechanically stable. However, a drawback of this design is that a portion of the transmitted light pulse is scattered back to the receiver, which overloads the detectors and induces spurious pulses at a later time. This produces the characteristic decaying tail and adds extra signal in the measured data profile. In this work, we investigate the properties of a detector from Perkin Elmer (SPCM-AQR-12) under overloaded conditions. In a series of tests, using a wide range of intensities, the detector was illuminated with short light pulses. Measured detector responses are explained as a superposition of processes proportional to the number of incident photons in a light pulse and to the number of counted photons. Two time constants for the processes were derived from the measurements.

S01P – 29

MOBILE SCANNING UV AEROSOL-FLUORESCENT LIDAR

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The scheme and functioning of mobile scanning aerosol-fluorescent lidar are described in the report. Lidar is intended for detection aerosol formations in the atmosphere, definition of their position and discrimination among them the biogenic aerosol. General application of the developed lidar is real-time detection of the biogenic aerosol in the atmosphere, in particular of physiologically active substances, with the purposes of people protection against terrorist unlawful acts. High energy lidar potential allows effectively using it for:
· operative estimation of an atmosphere optical condition;
· estimations of emissions intensity of pollution local sources and chart-making of their aerosol trails;
· researches of background atmosphere parameters up to 20-30 km altitude.
Other fundamental and applied tasks can be solved with this lidar.
The simultaneous supervision of the lidar signals of both elastic scattering and fluorescence is realized at an irradiation of environment on laser wavelengths 1064 and 266 nm accordingly, and the signal in IR channel is formed by aerosols of any nature, and in UV channel - only biogenic aerosols. The transceiver, system of a scanning and the lidar control are structurally incorporated in the uniform module assembled to the automobile carrier. While moving, the active volume of the cabin is closed. For measurements the vehicle is stopped and fixed with jacks, and then the lidar is pulled out of the roof hatch. Two gasoline-electric generators which is transported by the same vehicle enter into a lidar complete set. Under city conditions the lidar can be connected to a single-phase 220 V network.

S01P – 30

THE POSSIBILITIES OF REMOTE SENSING OF CHEMICAL WARFARE AGENTS WITH A CO2 LIDAR BY DIFFERENTIAL ABSORPTION METHOD

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The possibilities of remote sensing of chemical warfare agents by the differential absorption method are analyzed. The CO2 laser emission lines suitable for sensing chemical warfare agents with accounting for disturbing absorption by water vapor were chosen. The detection range of chemical warfare agents is obtained for a lidar based on CO2 laser. Factors influencing upon the sensing range have been analyzed.

S01P – 31

LIDAR AT POLISH POLAR STATION, INSTRUMENT DESIGN AND FIRST RESULTS

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Lidar at Polish Polar Station at Hornsund, Southern Svalbard, Norway, its design and specification are decribed in this work. Exemplary results taken by the mentioned lidar are also presented. Placing the multi-wavelength Raman lidar at polar station with collocated Sun-photometer allows using synergic capabilities of the instruments in investigation of the atmospheric aerosol. Moreover both instruments are complementary one to each other as Sun-photometers operate during polar day while lidar works mainly during polar night.

S01P – 32

LIGHT SOURCE MODULE FOR LED LIDAR

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In this study, we aim to develop a compact lidar system that used a LED light source. In the fast approach, we developed the pulse oscillation circuit. And we measured characteristics of several kinds of LEDs as a lidar light source. As a result, it was confirmed that lamp type LEDs of NUV and Red colors had the pulse power of more than 100mW with the pulse width of 10-50ns. In the next, we designed the self-pulse-oscillation circuit as a compact light source module. Eventually, the circuit size is 30×45 mm (L×W) with a low voltage supply. The oscillating frequency and pulse width was 112 kHz and 10.2 ns, respectively

S01P – 33

SOFTWARE DEVELOPMENT TOOL FOR LIDAR SYSTEM CONSTRUCTION AND PERFORMANCE CHECKING

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The laser remote sensing (lidar) technique of the atmosphere is a very efficient tool to monitor the aerosol optical and microphysical properties both below the Planetary Boundary Layer (PBL) and the free troposphere. To check and optimize the optical performance of a lidar system, as well as the quality of the aerosol measurements, mainly in the near-field (i.e. in the lower troposphere), several quality assurance (QA) tests have been adopted in the frame of the EARLINET-ASOS project. Through an optical design code, based on paraxial approximation, we were able to simulate the ray-tracing of the laser backscattered signals. Simulating the light paths using the extreme rays through the different parts of the lidar receiving optics (i.e. the receiving telescope, the optical fiber or diaphragm, the collimating optics, the interference filters, the eyepiece and the photodetectors), in order to discriminate differences between the computated theoretical values (distance, diameter and focal length of the optical parts consists a lidar system), with the real ones. Any differences could affect both the distance of full overlap and the optical properties retrieved from the measured lidar system. The developed software is based on a paraxial approximation and can be compiled with Microsoft Excel 2003 and/or 2007 (with macros permitted), through Visual Basic for Application (vba) code.

S01P – 34

ALTOCUMULUS CLOUD AND LOW-ALTITUDE ATMOSPHERE MEASUREMENT BY IN-LINE TYPED MICROPULSE LIDAR

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Low-altitude atmosphere is the important meteorological parameter associated with heavy rain and lightning strike. In this study, low-altutude atmosphere measurement has been conducted with in-line typed Micro Pulse Lidar (MPL) for a long time. But the near range signal should be corrected because the receiver is out of focus at near range. Here, it was corrected by overlap function Y(R). In addition a transient recorder was introduced as a substitute for an oscilloscope. By photon counting measurement, low-altitude atmosphere measurement can be accomplished. In this study the overlap function was calculated with fine and windy day measurement data in the horizontal direction. The observed overlap function was good agreement with the simulated one after propagation distance of 1km. Therefore near range lidar signal was corrected by the estimated overlap function. Altocumulus cloud and low-altitude atmosphere measurement was conducted by the in-line typed MPL with transient recorder. By using the transient recorder and stabilizing cooling and heat insulating systems on APDs, this lidar could pick up weak signals from the atmosphere. Furthermore the correlation between altocumulus cloud's altitude and atmospheric pressure was examined.

S01P – 35

COMPACT RAMAN LIDAR FOR HYDROGEN GAS LEAK DETECTION

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We developed a compact Raman lidar for hydrogen leak detection. The lidar is compact because the optical system is in-line type, which is the common optics for laser transmitter and echo receiver. Simulated result of Signal to noise ratio for the near range Raman lidar indicated that it had the enough sensitivity in the range of 0–50 m. We developed the concrete lidar system based on the simulated result. The lidar could detect Raman scattering echo from the molecule of nitrogen in the atmosphere, and it was able to detect the nitrogen and hydrogen gas in a gas cell compressed at 2–3 kg/cm^2.

S01P – 36

LIDARS ON THE BASIS OF HARMONICS OF ND:YAG LASER WITH SRS CONVERSION IN HYDROGEN FOR SENSING OF ATMOSPHERIC AEROSOL AND OZONE

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The report presents the description of the three-frequency aerosol lidar for sensing of the optical and microphysical characteristics of the stratospheric aerosol (SA) and lidar designed for study of the vertical ozone distribution (VOD) in the upper troposphere-lower stratosphere; these instruments use the harmonics of Nd:YAG laser with their stimulated Raman scattering (SRS) conversion in hydrogen-filled cells. The lidars operate as part of the measurement complex at Siberian Lidar Station (SLS) [1] of Institute of Atmospheric Optics SB RAS, Tomsk (56.5ºN; 85.0ºE). Some results of determination of the SA microphysical parameters and VOD in the upper troposphere - lower stratosphere are presented.

S01P – 37

RECEIVING CHARACTERISTICS IN HIGH PRECISION POLARIZATION LIDAR

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The in-line typed high-precision polarization lidar for lightning detection has been constructed. This lidar measure Faraday effect, which is the correlation between the propagation beam and the magnetic flux density caused by the electromagnetic pulse of the discharge. The Faraday effect causes the rotation of the polarization plane of the propagating beam. As the Faraday effect for the visible light is small, the detection device is needed high discrimination accuracy of the polarization plane of the order of less than 1 degree. In this study, the transmitting beam is balanced on the orthogonal polarizations. The orthogonal polarization echoes are obtained by the simultaneous detections. Based on these algorithms, the high precision polarization lidar with the polarization extinction ratio of 30dB has been accomplished. The lidar system has started the routine observation, while the actual lightning detection are still challenging.
In this report, we show several fundamental receiving characteristics of the high precision polarization lidar in the viewpoint of the deviation of the atmospheric extinction coefficient, the depolarization of the multiple scattering and ice-cloud, and the trial estimation of the rotation angle due to the Faraday effect. The results corresponded to the nominal values in the meteorological agency and the other researcher's ones.

S01P – 38

TEACHING LIDAR INVERSIONS

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During the 1970s and 1980s, iterative techniques were developed for inverting lidar data. These developments led to the Klett inversion algorithm, which has become standard in lidar research. However, the key published literature on inversion of lidar data amounts to just a few papers, and they are confusing and difficult for beginners to understand. For example, following the standard approach in science and engineering, some early investigators converted the lidar equation to a differential equation so that they had recourse to the extensive body of literature on solving such equations. That approach requires a working knowledge of differential equations, and it is not necessary. Here, we revisit earlier lidar inversions and present an updated derivation that requires only a basic knowledge of integration and differentiation. Our new derivation is intuitive and hence very teachable, so it provides a good introduction to lidar inversions for newcomers.

S01P – 39

SUPRAGLACIAL LAKE WATER DEPTH MEASUREMENT USING MODULATED POLARIZATION LIDAR

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A novel configuration of a bathymetric lidar system transmitting a single wavelength at 532 nm and detecting with a single photon multiplying tube using polarization modulation is employed for applications of water depth measurements of supraglacial lakes. Water depths of 1 cm are demonstrated using this technique.

S01P – 40

STABLE COAXIAL LIDAR TRANSCEIVER

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A coaxial lidar is proposed with a beam expansion via the receiving telescope, and with the transmitting and the receiving sections located on the opposite sides of an optical bench. Using a unique arrangement of the optical elements it is possible to nearly eliminate the influence of the diurnal thermal instability of the optical bench on an the lidar measurements. This scheme is based on analysis of the existing GV-HSRL (Gulfstream High Spectral Resolution Lidar) and is proposed for the future DOE-HSRL (Dept. of Energy High Spectral Resolution Lidar).

S01P – 41

A NEW GENERATION OF MOBILE RAMAN LIDAR

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The Commissariat à l'Energie Atomique (CEA) and the LEOSPHERE Company have recently developed a new generation of mobile Raman lidar. This eye-safe instrument is based on a 16 mJ Nd:Yag laser at 355 nm and is composed of three reception channels: two dedicated to the measure of the two cross-polarizations and one to the nitrogen Raman backscattered signal. This compact and light lidar is easily transportable in a small truck or a commercial vehicle and allows the retrieval of aerosol optical properties and atmospheric structure with a spatial sampling of 1.5 m along the line of sight. It is particularly well adapted to air quality and pollution study thanks to its full-overlap reached at ~150 m. This prototype has been recently tested in the suburb of Paris. We will present and analyze here daytime and nighttime observations performed with this new Raman lidar at Saclay in the south-west suburb of Paris.

S01P – 42

DEVELOPMENT OF THE GLOBAL OZONE LIDAR DEMONSTRATOR (GOLD) INSTRUMENT FOR DEPLOYMENT ON THE NASA GLOBAL HAWK

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A compact ozone (O3) and aerosol lidar system is being developed for conducting global atmospheric investigations from the NASA Global Hawk Uninhabited Aerial Vehicle (UAV) and for enabling the development and test of a space-based O3 and aerosol lidar. GOLD incorporates advanced technologies and designs to produce a compact, autonomously operating O3 and aerosol Differential Absorption Lidar (DIAL) system for a UAV platform. The GOLD system leverages advanced Nd:YAG and optical parametric oscillator laser technologies and receiver optics, detectors, and electronics. Significant progress has been made toward the development of the GOLD system, and this paper describes the objectives of this program, basic design of the GOLD system, and results from initial ground-based atmospheric tests.

S01P – 43

BACKSCATTER AND COLUMN HEIGHT ESTIMATES FROM A PULSED AIRBORNE CO_2 LIDAR

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A pulsed direct detection CO2 lidar using the integrated path differential absorption technique has been developed to determine the average CO2 column abundance. The lidar uses a line in the 1570 nm band, 1-usec wide laser pulses and a photon counting receiver. A new correlation analysis technique is used to estimate the laser pulse time-

of-flight from its measurements. Results show it is robust and allows column length (range to the surface) to estimated to <1 m precision for stationary targets in the field and to <3 meters in airborne experiments.

S01P – 44

OPTIMIZATION OF A 2-MICRON LASER FREQUENCY STABILIZATION SYSTEM FOR A DOUBLE-PULSE CO_2 DIFFERENTIAL ABSORPTION LIDAR

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A carbon dioxide (CO2) Differential Absorption Lidar (DIAL) for accurate CO2 concentration measurement requires a frequency locking system to achieve high frequency locking precision and stability. We describe the frequency locking system utilizing Frequency Modulation (FM), Phase Sensitive Detection (PSD), and Proportional Integration Derivative (PID) feedback servo loop, and report the optimization of the sensitivity of the system for the feed back loop based on the characteristics of a variable path-length CO2 gas cell. The CO2 gas cell is characterized with HITRAN database (2004). The method can be applied for any other frequency locking systems referring to gas absorption line.

S01P – 45

MULTI-WAVELENGTH SCANNING RAMAN LIDAR DEVELOPMENT AT CEILAP (CITEFA-CONICET)

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A new multi-wavelength scanning Raman lidar is being developed at CEILAP (CITEFA–CONICET) in Buenos Aires, Argentina, to measure atmospheric extinction coefficients in the frame of CTA (Cherenkov Telescope Array) [1] and Pierre Auger [2] projects. These projects involve international collaborations to study galactic and extragalactic gamma rays and high energy cosmic rays. This paper presents the specific requirements for this kind of lidar, the main design parameters and the actual state of the lidar construction.

S01P – 46

THE REMOTE ELEMENT ANALYSIS OF SUBSTANCES ON BASIS OF STIMULATED RESONANCE ELECTRONIC RAMAN SCATTERING ON EXCITED ATOMIC STATES OF BROADBAND PROBING PULSE

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The transmitter of the scanning water vapor DIAL (differential absorption lidar) of the University of Hohenheim (UHOH) consists of a dynamically stable ring resonator Ti:Sapphire laser operating at 820 nm. The Ti:Sapphire crystal is pumped with a frequency-doubled diode-pumped Nd:YAG laser. The transmitter unit is mounted on a mobile trailer with 3D-scanning capability. This paper describes the theoretical considerations which were made during the development phase as well as the experimental performance during a recent field campaign in summer 2009.

S01P – 47

TIME-DOMAIN SPECTROSCOPY IN METHOD OF DIFFERENTIAL ABSORPTION OF BROADBAND PULSE

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There has been considered one of the laser modulation spectroscopy methods: the spectroscopy of amplification(easing) through stimulated resonant electronic Raman scattering on excited atomic state on atoms in excitedconditions broadband probing pulse, reflex from surface of terrigenos elements in aerosol particals. It is shown thatthis spectroscopic study is closely connected with lasar emission analysis and has practically all of its advantages, however he exceeds remote spectrochemical analysis on nonequilibrium emissive spectrum of a laser spark in levelof registered optical signal, in spectral and spatial resolution, in completeness of received with its help ofspectroscopic information.

S01P – 48

TRANSMITTER OF THE SCANNING WATER VAPOR DIAL OF THE UNIVERSITY OF HOHENHEIM

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One-pulse attribute method is offered to concentration integrated on line of molecules on measurement of time of arrival of signals, received at sensing of determined gas with broadband pulse radiation. It is shown that at broadband excitation slightly absorbing two-level environment width frequency spectrum of signal on line of absorption of determined gas not exceed width of line of resonance transition, time of delay of signal on line of absorption of determined gas depends from spectroscopic parameters of transition, length of environment and spectral density broadband pulse.

S01P – 49

2-MICRON LASER DEVELOPMENTS FOR CO_2 AND WIND MEASUREMENTS

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We have developed a ground-based CO_2 DIAL/Wind Doppler lidar system (Co_2DiaWiL) with a conductive-cooled 2.05-micron solid-state laser. The laser uses a Tm,Ho:YLF rod cooled down to –80 °C and emits 50-100 mJ output at 20-30Hz. The lidar system is working well for observations of wind and CO2 concentrations. We are also developing a mobile CO2 DIAL/Wind Doppler lidar system similar to Co2DiaWiL, but more compact and small. The laser oscillator will be operated in 50-100 mJ output at 30-40 Hz. The lasers are conductive-cooled, laser diode pumped and eye-safe.

S01P – 50

INJECTION SEEDERS BASED ON DFB LASERS FOR DIAL OF WATER VAPOR AT 820 NM AND CO_2 AT 1580 NM

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A distributed feedback (DFB) laser at 820 nm has been developed as injection seeder for the water vapor DIAL system (differential absorption lidar) of the University of Hohenheim. The DIAL transmitter is realized by a Nd:YAG-pumped Ti:Sapphire laser. To narrow the spectral linewidth, the injection seeding technique is used. In a previous stage of the system, injection seeding was done by external cavity diode lasers (ECDL) which have recently been replaced by DFB lasers. With DFB lasers, the frequency stability could be improved to a standard deviation of 6.3 MHz. The wavelengths between 817.7 and 819.0 nm are reachable without mode hops. Because movable parts are not used, the DFB laser is unaffected by mechanical vibrations. A DFB laser at 1580 nm was also characterized for future CO_2 DIAL.

S01P – 51

DIFFRACTION MODEL FOR THE LIDAR TRANSMITTER

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The High Spectral Resolution Lidar of the University of Wisconsin-Madison is designed to have a single telescope to transmit and to receive light. The quality of the lidar transmitter was estimated by pointing the laser beam to a water tower, which is

located at 7 km from the instrument. The laboratory transmitter model with a scale of 1:40 was built for comparison with the actual lidar transmitter using the Lommel's similarity theory for the diffraction patterns. The telescope diameter of the laboratory model is 1 cm and the distance from the model's telescope to the screen is 4.3 m. The water tower test result and the laboratory result has a good correspondence. The influence of the aberrations on the laser beam was estimated and the optimal field-of-view for the lidar receiver was chosen from the results.

S01P – 52

MULTIWAVELENGTH AEROSOL RAMAN LIDAR FOR OPTICAL AND MICROPHYSICAL AEROSOL TYPING OVER EAST ASIA

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We develop a novel multiwavelength aerosol Raman lidar at the Gwangju Institute for Science and Technology (GIST), Republic of Korea. The system is specifically designed for characterizing East Asian haze which consists of a complex mix of different aerosol types. The system is based on a tripled Nd:YAG laser. It provides particle backscatter coefficients at 355, 532, and 1064 nm, and extinction coefficients at 355 and 532 nm. This information is used for retrieving profiles of microphysical properties such as effective radius and complex refractive index, from which we may infer profiles of the wavelength dependent single-scattering albedo. We measure Raman signals from water vapor and we equipped the system with novel Raman channels that measure return signals from Raman scattering of mineral quartz at 360 and 546 nm. These channels allow us to quantify the mineral dust content in the complicated haze conditions that prevail over East Asia. Results from the Saharan Mineral Dust Experiment (SAMUM) suggest that a combination of 3 backscatter plus 2 extinction plus 2-3 depolarization channels can be used for a microphysical characterization of non-spherical mineral dust particles. Instrument upgrades therefore will include the installation of depolarization channels at 355 and 1064 nm in addition to the currently used channel at 532 nm.

S01P – 53

QPM-OPGBASED HIGH POWER 1.6 MMLASER TRANSMITTER FOR CO_2-DIAL

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We report on a new high-power 1.6 μm laser transmitter based on a parametric master oscillator-power amplifier (MOPA) system for CO2 differential absorption lidar (DIAL). Only high-end active remote sensing systems such as the DIAL techniques can measure vertical profiles of CO2 concentration. Particularly, a high overall efficiency in combination with excellent beam quality and high average power must be achieved, which are currently not available for 1.6 μm CO2-DIAL. The master oscillator is an optical parametric generator (OPG), based on a MgO-doped periodically poled LiTaO3 (PPMgLT) crystal. The 1.6 μm emission is amplified by multi-stage optical parametric amplifiers (OPAs). Single-frequency oscillation of the OPG is achieved by the injection seeding with the FBG diode laser. Stabilization of seed lasers was estimated to within 4.0 MHz rms at the absorption line center and within 1.8 MHz rms at the absorption line slope using the wavelength control unit. We demonstrated single-longitudinal-mode

emission with the OPG laser. The beam quality was TEM00 mode, the pulse energy was 8 mJ at 400 Hz repetition rate and the frequency stability was better than 10MHz rms. The unique performances of this optical parametric system make a relevant transmitter for CO2-DIAL.

S01P – 54

ACHROMATIC LASER BEAM EXPANDER FOR IR AND UV SPECTRAL RANGES

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One of the issues of the day in systems of distant optical location and communication is the directed long-distance power transmission by laser radiation. To achieve maximum range, angular resolution, and spatial power density, a transmitted beam is to be powerful, of a large diameter, and with maximally compensated wave-front aberrations. Possibilities to obtain the above required parameters depend on laser beam expanders. In their designing initial are such parameters of an emergent laser beam as its diameter, angle of divergence, and radiation wavelength. Recently pulsed lasers generating simultaneously at different wavelengths, namely, from UV to IR spectrum range, are used as sources of sensing radiation to enhance laser location. Operation of an optical system at strongly differing wavelengths specifies additional requirements to the optical schematic of the collimator, i.e., minimization of both geometrical and chromatic aberrations and optimization of the parameters of optical components which allows operation without refocusing at different wavelengths.

S01P – 55

COMPACT LIDAR SYSTEMS AND THEIR APPLICATIONS

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Compact lidar systems are intended for distance diagnostic of dangerous matters. In such lidars tunable semiconductor lasers (DFB and QCL) are used. These lasers provide single-mode fixed-frequency emission in spectral range from 200 nm up to 12 μm. Inside this range absorption lines of main dangerous matters (poisons, explosives, industrial gases etc.) are disposed. So it's possible to use differential absorption lidar method for determination of gases in the optical direction. Small distance of detection determined by small output power of the semiconductor lasers (~10…1000 mW) is compensated by compactness of such lidars. Lidar systems on the base of semiconductor lasers can be mounted on the special types of bearers like pilotless airplanes or can be used as individual equipment.
In this work results of compact lidars development in "Laser systems Ltd" are presented. The questions of ethanol vaporization detection in the moving cars are considered.

S01P – 56

WIDEBAND CO LASER IN PROBLEMS OF LASER SENSING OF MINOR GASEOUS COMPONENTS IN THE ATMOSPHERE

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In the present work it is demonstrated that a wideband CO laser operating at fundamental and overtone vibrational transitions is a promising source of laser radiation for remote laser sensing of the atmosphere. Wavelengths for sensing of nitrous oxide, nitrogen dioxide, methane, formaldehyde, and some other gases on near-ground propagation paths are determined. Our experiments and calculations confirm that CO laser is promising for laser gas analysis.

S01P – 57

ANALYSIS OF SYSTEMATIC ERRORS OF LIDAR GAS ANALYSIS IN THE ATMOSPHERE BY THE DIFFERENTIAL ABSORPTION METHOD

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In the present work, systematic errors of lidar gas analysis in the atmosphere by the differential absorption method in the near- and middle-IR ranges of the spectrum are analyzed. It is demonstrated that the systematic errors depend on many factors, including the meteorological parameters and concentrations of the examined gases along the sensing path, instability of the spectral parameters of laser radiation lines, shift of the absorption line centers caused by the air pressure, Doppler broadening of backscattered signals, and other sources of errors. Methods of minimization of errors in reconstructing lidar profiles of the examined atmospheric gas concentrations are suggested.

S01P – 58

FEMTOSECOND LASER RADIATION FREQUENCY CONVERTERS FOR LIDAR MONITORING OF THE ATMOSPHERE

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Possibilities of using superbroadband nonlinear_optical frequency converters for femtosecond laser pulses in lidar sensing of the atmosphere are analyzed. New biaxial nonlinear crystals in which the conditions of phase and group matching can be satisfied simultaneously are basic elements of frequency converters. A technique for the broadband lidar sensing of the gas composition of the atmosphere based on the differential optical atmospheric spectroscopy and the differential absorption methods is described. The lidar sensing of gas constituents of the atmosphere using frequency converted femtosecond laser radiation is simulated numerically.

Session 10P: Atmospheric Water Vapor and Tropospheric Temperature – Poster Presentations
Co-Chairs: Takuji Nakamura, Valentin Simeonov

S10P– 01

COMPARISON OF METHODS FOR EVALUATION OF TEMPERATURE USING ROTATIONAL RAMAN SCATTERING SPECTRA

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An optimal algorithm for the evaluation of temperature using the pure rotational spectra of Raman light scattering by atmospheric nitrogen and oxygen molecules is investigated within the framework of statistical estimation. Using the simulation modeling, the optimal evaluation algorithm is compared with the method of parameter fitting and heuristic algorithm routinely used for the determination of temperature using rotational spectra. Calculations performed allowed to judge the efficiency of different algorithms of signal processing in the lidar used for remote detection of temperature using pure rotational Raman scattering spectra. Statistical errors of the temperature evaluation are numerically estimated for an algorithm based on the Bayes optimal procedure, a method of the model parameter fitting, and a heuristic algorithm routinely used for temperature calculations.

S10P– 02

INITIAL RESULTS FROM ARCLITE TROPOSPHERIC WATER VAPOR PROFILING AND BALLOON VALIDATION

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A new capability has been implemented in the Arctic Lidar Technology (ARCLITE) facility in Sondrestrom, Greenland (67.0° N, 50.9° W) to measure atmospheric water vapor. A balloon campaign was simultaneously conducted to calibrate and validate the new lidar water vapor channel. Initial results show that profiles up to 9–10 km with single-digit error are easily obtained with 30 minute integration.

S10P– 03

STROZ LIDAR RESULTS AT THE MOHAVE III CAMPAIGN, OCTOBER, 2009, TABLE MOUNTAIN, CA

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During October, 2009 the GSFC STROZ Lidar participated in a campaign at the JPL Table Mountain Facility (Wright wood, CA, 2285 m Elevation) to measure vertical profiles of water vapor from near the ground to the lower stratosphere. On eleven nights, water vapor, aerosol, temperature and ozone profiles were measured by the STROZ lidar, two other similar lidars, frost-point hygrometer sondes, and ground-based microwave instruments made measurements. Results from these measurements and an evaluation of the performance of the STROZ lidar during the campaign will be presented in this paper. The STROZ lidar was able to measure water vapor up to 13-14 km ASL during the campaign. We will present results from all the STROZ data products and comparisons with other instruments made. Implications for instrumental changes will be discussed.

S10P– 04

ULTRAVIOLET RAMAN LIDAR FOR QUANTITATIVE MEASUREMENTS OF ATMOSPHERIC WATER VAPOR AND AEROSOL EXTINCTION PROFILES

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A vibrational Raman lidar system at a wavelength of 354.7nm has been developed at Xi'an, the northwest part of China for quantitative detection of water vapor and aerosol extinction profiles. A newly designed spectroscopic filter with a high-resolution grating and two narrow band reflective filters has been developed to separately monitor the elastic scattering signal and the vibrational Raman scattering signal of N_2 and H_2O molecules. The aerosol extinction is finely retrieved from the elastic scattering signal and the vibrational Raman scattering signal of N_2, and the water vapor mixing ratio is derived from the vibrational Raman scattering signal of N_2 and H_2O. Some preliminary experiments have been carried out in order to obtain atmospheric water vapor density and the properties of aerosol at nighttime in Xi'an area. Vertical profiles of the water vapor mixing ratio and aerosol extinction have been analyzed and the experiments results indicate a feasibility of the UV Raman system for quantitative detection of atmospheric water vapor and aerosol profiles in the atmospheric boundary layer.

S10P– 05

LOW TROPOSPHERIC TEMPERATURE MEASUREMENTS USING A PURE ROTATIONAL RAMAN LIDAR IN UV

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Pure Rotational Raman scattering of N2 and O2 of light from the third harmonic of a Nd:YAG laser is used to measure day-time atmospheric boundary temperature. The method relies on taking the ratio of light which is proportional to atmospheric temperature, and is insensitive to variations in atmospheric transmission. A double-grating monochromator (DGRM) in the lidar is used to isolate two portions of the pure rotational Raman spectrum (PRRS) of N2 and O2 and suppress the line of elastic light scattering. Preliminary results show good agreement with closest radiosonde measurement.

S10P– 06

PRELIMINARY STATISTICAL STUDY OF SUBTROPICAL WATER VAPOR PROFILES FROM RAMAN LIDAR AT LA REUNION (21°S, 55°E) OVER THE PERIOD 2002–2005

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Ground based lidars can provide continuous observations of tropospheric water vapor profiles using the Raman scattering by water vapor and nitrogen molecules. A Raman water vapor lidar was deployed at La Reunion over the period 2002-2005 in aim to perform a preliminary study of water vapor monitoring and evaluate the needs in view of a more specific lidar system to be implemented at the Observatory of Physique de l'Atmosphère de La Reunion (OPAR). A statistical study of the distribution of water vapor profiles is presented, and some investigations concerning the calibration have been evaluated. The data set having several long acquisition measurements during nighttime, an analysis of the diurnal cycle of water vapor has also been investigated. Based on these results, the characteristics and the design of a future lidar system to be implemented at the new observatory (2000 meters) for long-term water vapor monitoring are presented.

S10P– 07

MULTI-SENSORS INVESTIGATION OF ATMOSPHERIC WATER VAPOR PROBABILITY DISTRIBUTION FUNCTION IN THE FREE TROPOSPHERE FOR A MEDITERRANEAN COASTAL SITE

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Parameterization of sub-grid variability processes is a critical issue for large-scale atmospheric numerical models, when used for climate studies, particularly. Indeed, the non-linearity of moist processes and the effects of clouds in energy and mass transport processes cause sensitivity to the definition of Probability Distribution Function (PDF) assumed in the model. The presented study investigates the possibility of deriving a description of the PDF from a set of observations representative of a Mediterranean coastal site. In order to describe the water vapor variability within a given atmospheric volume from a single sensor measurements, PDF's are derived from a set of high resolution (temporal and/or vertical) observations by mean of a set of assumptions on space/time correspondence derived from the analyses of local wind intensity measurements. Observations used in this study are: Time series (from 2002 to date) of radiosoundings from the coastal station of Pratica di Mare (WMO station #16245, 41.67 N, 12.45 E, 35 m a.s.l), with high-resolution data (10-s sampling, roughly corresponding to 30 m in vertical sampling). <>- A set of measurement sessions, lasting typically 3-4 hours (1-min 75 m resolution original sampling) of water vapor profiles from the ISAC-CNR Raman Lidar [1] in Rome-Tor Vergata (41.8 ° N, 12.6 ° E, 107 m a.s.l.), extending up to the free troposphere with a nominal vertical resolution of 75 m. PDF's are derived assuming typical characteristics of the Climate Model LMDZ [2] in terms of horizontal and vertical (σ-levels) resolution. The investigation focuses on the description of the functional form of the PDF and on the parameterization of the PDF characterizing parameters. Limits and assumptions in the PDF definition technique are discussed, and in particular: The representativeness of the Raman derived results due to the clear sky/night-time biased sampling. The results are confronted to the PDF's currently used in the LMDZ General Circulation Model.

S10P – 08

TEMPERATURE AND AEROSOL BACKSCATTER RATIO MEASUREMENTS WITH THE SWISS RAMAN LIDAR FOR METEOROLOGICAL APPLICATIONS

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The EPFL-MeteoSwiss automated water vapor Raman lidar RALMO has been recently upgraded with a temperature/aerosol channel. The temperature profiles are derived from the temperature dependent pure rotational Raman spectra of atmospheric oxygen and nitrogen using calibration with collocated radiosondes. Aerosol scattering ratio is derived from the ratio of elastic scattering (Cabannes and Mie lines) to temperature independent sum of pure rotational Raman lines.

S10P– 09

HIGH-SPECTRAL-RESOLUTION LIDAR FOR TEMPERATURE MEASUREMENT WITH POTASSIUM ABSORPTION FILTERS

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We are operating the multi-purpose lidar system for survey of atmospheric structure over troposphere, stratosphere, mesosphere and low thermosphere over Kototabang (100.3E, 0.2S), Indonesia in the equatorial region. The Rayleigh and Raman lidar are used for stratospheric and mesospheric temperature measurements and the Fe Boltzmann lidar is used for temperature measurements in the mesopause region. We propose a high-spectral-resolution lidar with two potassium atomic absorption filters for temperature measurements in the lower troposphere. This lidar system consists of a Ti:sapphire laser and two potassium vapor cells. The preliminary result using this temperature lidar is shown.

Session 11P: Space-based Missions, Validation, and Global Monitoring – Poster Presentations
Co-Chairs Upendra Singh, Gennadii Matvienko

S11P – 01

MULTIPLE-SCATTERING EFFECTS IN CALIPSO MEASUREMENTS OF DESERT DUST

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We present correlative measurements of CALIPSO (Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observations) and a ground-based multiwavelength Raman lidar performed in the Saharan dust plume at Praia, Cape Verde, 15.0 N, 23.5 W, during SAMUM–2 (Saharan Mineral Dust Experiment). Comparisons of 532-nm backscatter coefficients generally show good agreement between space-borne and ground-based observations. However, the respective extinction coefficients and thus the optical depth are systematically underestimated in the CALIPSO products by about 30% compared to Raman lidar measurements. The effect can be explained with the influence of multiple scattering on the CALIPSO observations caused by the presence of large, non-spherical dust particles. Effective particle radii between 1.2 and 6.8 μm, as obtained from airborne in-situ observations during SAMUM, lead to a multiple-scattering-related extinction reduction in the CALIPSO lidar signals of 10%–40%. The multiple-scattering effect also explains the discrepancies between lidar ratios of the order of 50–60 sr usually measured from ground and the lidar ratio of 40 sr that is applied in the CALIPSO algorithms. CALIPSO extinction products can be corrected for the multiple-scattering influence, if two different lidar ratios are applied. The effective, multiple-scattering-related value of 40 sr is adequate for the backscatter-coefficient retrieval. The single-scattering value of 55 sr must be used for the conversion of backscatter to extinction.

S11P – 02

SPACE-BORNE REMOTE SENSING OF GREENHOUSE GASES BY IPDALIDAR: A POTENTIALITIES ESTIMATE

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Possibilities of measuring the greenhouse gases (CO2, CH4, N2O, CO) column content by spaceborne integrated path differential lidar (IPDA) signals in the near IR absorption bands are investigated. Influence of potential sources of systematic errors which may arise from unknown temperature profiles, surface pressure, instrument design characteristics, water vapour and aerosols interference on potentialities IPDA-lidar is considered.

S11P – 03

SPACEBORNE MULTIWAVELENGTH AEROSOL HSRL: FEASIBILITY STUDY IN THE FRAMEWORK OF ICAROHS

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A simulation study was performed to investigate the potential of a spaceborne 355/532 nm High Spectral Resolution Lidar (HSRL) with additional 1064 nm and depolarization channels regarding aerosol type identification and the retrieval of microphysical properties and aerosol single scattering albedo. The study is part of the ICAROHS (Inter-Comparison of Aerosol Retrievals and Observational requirements for multi-wavelength HSRL Systems) project of the European Space Research and Technology Centre (ESTEC). Results of a case study are presented.

S11P – 04

ADVANCES IN RESEARCH PRODUCTS FROM CALIPSO: OPTICAL DEPTH DIRECT RETRIEVAL OVER OCEAN, WATER CLOUDS AND LAND

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We present a general overview of the recent advancement we made on direct optical thickness retrieval of optically thin atmospheric features (aerosol, cirrus clouds) using CALIPSO lidar return from dense targets (liquid water clouds, ocean and land surface). Data fusion with this direct optical thickness retrieval and collocated passive remote sensing measurements (e.g., PARASOL) will enable an AERONET-like of retrieval concept from A-train measurements. We first present the theoretical advances we made on lidar equation for surface and its significance for ocean color research, then the status of our advancement on aerosol optical depth retrieval along with, an example of cirrus optical depth retrieval over the ocean and a few words on over land AOD retrieval.

S11P – 05

THE IMPACT OF MULTIPLE SCATTERING ON SPACE-BASED HSR LIDAR POLARIZATION MEASUREMENTS: IMPLICATIONS FOR EARTHCARE

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The Earth Clouds and Radiation Explorer (EarthCARE) mission is a joint European and Japanese satellite planned for launch in the 2013-2014 time frame. EarthCARE is focused on investigating the interactions between clouds, aerosol and long and short-wave atmospheric radiation. The platform instruments include a polarization sensitive high spectral resolution lidar (ATLID) and a cloud profiling radar along with various passive sensors. Even though ATLID will have a narrower field-of-view and be deployed at a lower altitude compared to the case with the CALIPSO lidar, multiple scattering effects will still be significant. In particular, multiple scattering processes will impact the characteristics of the polarization as well as the spectral signature of the return signal compared to the single-scatter case. In this paper, a Monte-Carlo lidar multiple-scatter model is applied in order to quantify the impact of Multiple-scattering on ATLID measurements focusing on the impact on the polarization and spectral signature of the return.

S11P – 06

VALIDATION OF THE DUST LAYER STRUCTURE OVER THE TAKLIMAKAN DESERT, CHINA FROM THE SPACE-BORNE LIDAR CALIOP USING A GROUND-BASED LIDAR

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A ground-based lidar observation was carried out in the northwest of China to validate the space-borne li-dar CALIOP on 23 March 2009. Combining backscatter profiles of the ground-based lidar and CALIOP, lidar ratio (extinction to backscattering ratio) was retrieved for 532nm and 1064nm wavelengths by using performance function that minimizing the difference between the ground-based lidar and CALIOP for backscattering corfficient. The correlation coefficients between them were 0.98 for 532nm and 0.95 1064nm, respectively. Using the retrieved lidar ratio, the color ratio and aerosol optical depth (AOD) were calculated. The observed aerosols and clouds were classified into three groups (boundary layer dust, free tropospheric aerosol and cirrus cloud) according to a relationship between color ratio and 532nm-backscattering coefficient.

S11P – 07

STRATEGY AND DEVELOPMENT OF AN ALGORITHM FOR BIOMASS BURNING AEROSOL TRANSPORT TRACKING WITH CALIPSO SATELLITE, SUNPHOTOMETER AND A BACKSCATTER LIDAR SYSTEM IN BRAZIL

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In this paper will be presented the development of an algorithm and a strategy as an effort to map the aerosol biomass burning plumes transported in the brazilian territory. It has been choosen 2 sites as possible aeorosol biomass burning sources and 3 sink sites. As each site has an AERONET sunphotometer, it has been put a criterion which is based on the medium values of the Angstrom Exponent and Aeorosol Optical Thickness to determine possible presence of biomass burning plumes in the atmosphere. The possible biomass burning cases has been cross-checked with the CALIPSO satellite. It has been analyzed the mean values of products from CALIPSO to validate the presence of this type of aerosol indicated by the sunphotometer. The air mass trajectories analyses provided by the HYSPLIT model confirm the transport of air masses loaded by biomass burning from source sites to the southeastern region that has been detected by backscatter lidar measurements. It has been identified 9 possible cases in August, September and October of 2007. It will be presented as a case study a period in the beginning of August. However, further studies will be made for the whole year of 2006, 2007, 2008 and 2009.

S11P – 08

NOAA'S GLOBAL MONITORING DIVISIONS'S LIDAR NETWORK FOR THE DETECTION OF UPPER TROPOSPHERIC AND STRATOSPHERIC AEROSOLS

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NOAA's Global Monitoring Division maintains and operates four lidars located in Pago Pago, American Samoa, Mauna Loa, HI, Boulder, CO and Summit, Greenland. This network is dedicated to collecting a long-term record of weekly observations of aerosols in the upper tropopause and stratosphere. These records include events such as major volcanic eruptions, including El Chichón and Mt. Pinatubo, numerous smaller eruptions, pyrocumulonimbus injections. More recently, in the lull of major volcanic activity since Mt. Pinatubo in 1991, an annual cycle and trend in the background stratospheric aerosol layer has also been evident in the data. This trend is an increasing average trend in aerosol backscatter above 20 km after 2000 of about 4–7% per year.

S11P – 09

SMOKE INJECTION HEIGHTS FROM AGRICULTURAL BURNING IN EASTERN EUROPE AS SEEN BY CALIPSO

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High frequency of agricultural fires is observed every year during the summer months (mainly July and August) over Western Russia and Eastern Europe. This study investigates the initial injection height of aerosol generated by the fires over these regions during the biomass burning season, for the years between 2006 and 2008, derived from observations made by the CALIOP instrument on board the NASA CALIPSO satellite. MODIS data are synergistically used for the detection of the fires and the characterization of their intensity. The vertical distributions of the smoke plumes generated by the active fires are analyzed to investigate the aerosol top height which is considered dependent on the heat generated by these fires. In most cases, the aerosol plumes are observed within the boundary layer, with no evidence for direct injection to the free troposphere. However, the range of top heights of the smoke layers found to range between 1.6 and 5.9 km indicating also cases when smoke penetrates in the free troposphere. Our results are compared with mixing layer heights taken by the European Centre for Medium-range Weather Forecast (ECMWF), indicating that ECMWF underestimates the mixing layer under strong fire activity, since the model does not take into account the strong updrafts generated by the fires.

S11P – 10

MULTIPLE SCATTERING OF LASER PULSES IN SNOW OVER ICE: MODELING THE POTENTIAL BIAS IN ICESAT ALTIMETRY

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The primary goal of NASA's current ICESat and future ICESat2 missions is to map the altitude of the Earth's land ice with high accuracy using laser altimetry technology, and to measure sea ice freeboard. Ice however is a highly transparent optical medium with variable scattering and absorption properties. Moreover, it is often covered by a layer of snow with varying depth and optical properties largely dependent on its age. We describe a modeling framework for estimating the potential altimetry bias caused by multiple scattering in the layered medium. We use both a Monte Carlo technique and an analytical diffusion model valid for optically thick media. Our preliminary numerical results are consistent with estimates of the multiple scattering delay from laboratory measurements using snow harvested in Greenland, namely, a few cm. Planned refinements of the models are described.

notes

S11P – 11

LIDAR TECHNOLOGY FOR MEASURING TRACE GASES ON MARS AND EARTH

Haris Riris[1], Steve Li[1], Kenji Numata[2], Stewart Wu[1], Antonios Seas[1], and James Abshire[1]

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Many fundamental questions about planetary evolution require monitoring of the atmosphere with unprecedented accuracy at both high and low latitudes, over both day and night and all seasons. Each planetary atmosphere presents its own unique challenges. For the planets and moons that have relatively low surface pressure and low trace gas concentrations, such as Mars or Europa, the challenge is to have enough sensitivity to measure the trace gas of interest. For other bodies, such as Earth or Titan, which have relatively high surface pressure the challenge, is to detect the trace gas of interest without interference from other species. Trace gases and isotopic ratios in planetary atmospheres offer important but subtle clues as to the origins of the planet's atmosphere, hydrology, geology, and potential for biology. An orbiting laser remote sensing instrument is capable of measuring trace gases on a global scale with unprecedented accuracy, and higher spatial resolution that can be obtained by passive instruments. For Mars our proposed measurement technique uses Differential Absorption Lidar (DIAL) in the 3-4 um spectral range to map various trace gas concentrations from orbit on a global scale. For earth, we can use the same technique at 1.65 um to measure methane concentrations, a strong greenhouse gas. The instrument uses Optical Parametric Amplifiers (OPA) for the transmitter along with photon counting detectors to achieve the necessary sensitivity.

S11P – 12

AIRBORNE LIDAR EXPERIMENTAL MEASUREMENT OF THE SEA SURFACE REFLECTANCE

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The airborne campaigns of the ALADIN Airborne Demonstrator (A2D) were successfully performed in November 2007, December 2008, and September 2009. In this paper, the sea surface return measured during the campaigns is well analyzed. The results were compared to sea surface reflectance models, including the contribution from whitecaps, specular reflection, and the subsurface volume backscattering. It is shown that the sea surface reflectance stressed by wind followed the models which take account of subsurface reflectance contribution. The validation of sea surface reflectance is necessary for the future spaceborne wind lidar-ALADIN.

S11P – 13

CALIPSO LAND SURFACE MAPPING PRINCIPLE AND FIRST RESULTS

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The quantification of aerosol radiative properties, especially aerosol optical depth (AOD) is of high importance for climate change analysis. Several approaches are now possible, using active (lidar) and passive (spectro-radiometers) sensors. The objective of this study is to analyze the potential of using the CALIPSO lidar land surface return signal to improve the AOD retrieval. First, an analysis of land surface properties is explored and then an application to AOD retrieval is presented.

S11P – 14

RECEIVER PERFORMANCE ANALYSIS OF A PULSED PHOTON COUNTING LIDAR TO MEASURE ATMOSPHERE CO_2 CONCENTRATIONS

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The receiver performance is analyzed for a DIAL lidar using the IPDA technique for measuring atmosphere CO2 and O2 column densities from space. The photon counting receiver model is also used to calculate the performance of an airborne instrument and the results are in agreement with the measured data.

S11P – 15

GLOBAL AND SEASONAL CHARAΠCTERISTICS OF THE CLOUD PHASE AND ICE ORIENTATION OBSERVED BY CALIPSO

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The global distribution and the seasonal dependence of cloud particle type were analyzed using CALIPSO data from June 2006 to May 2007. Yoshida et al. [2010] developed an algorithm for discriminating the cloud particle type by using CALIPSO and analyzed from September to November 2006. The discrimination scheme was applied to pixels that were classified as “cloud” by Hagihara et al. [2010]. Using the depolarization ratio and the ratio of attenuated backscattering coefficients for two vertically consecutive layers, the cloud particles were classified into 7 types: warm water, supercooled water, randomly oriented ice crystals (3D-ice), horizontally oriented plates (2D-plate), mixture of 3D-ice and 2D-plate, Unknown1 and Unknown2. This paper extended Yoshida et al. [2010] to apply the classification scheme for one-year dataset from June 2006 to May 2007 and focused on the seasonal characteristics of these types. The occurrence ratio of total ice cloud relative to the total cloud occurrence and its dependence on latitude were investigated. We found that the water to ice ratio varied symmetrically relative to the equator in spring and autumn but neither in summer nor winter seasons where the strong peaks were shifted.

notes

S11P – 16

COINCIDENCE NTUA'S GROUND BASED AND CALIOP'S SPACE BORNE LIDAR MEASUREMENTS IN THE FRAME OF THE EARLINET-ASOS AND ESA-CALIPSO PROJECTS

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Routine lidar measurements of the aerosol vertical distribution have been performed over Athens, Greece using a multi-wavelength Raman lidar system, since 2000 in the frame of the EU funded EARLINET (2000-2003) and EARLINET-ASOS (2006-2011) projects. Additionally, since June 2006, correlative measurements for CALIOP lidar on board the CALIPSO satellite are performed over 12 selected EARLINET-ASOS sites [1], including Athens [2]. At the National Technical University of Athens (NTUA) EARLINET-ASOS station, a 6-wavelength Raman lidar system has been used to retrieve independently the optical (backscatter coefficient at 355-532-1064 nm and the extinction coefficient and lidar ratio at 355 and 532 nm) properties of aerosols in the troposphere over an urban site (37.9oN, 23.6oE, 200 m a.s.l.) for the investigation of the optical parameters (lidar ratios and Ångström exponents) and their dependences on the specific aerosol. From the available correlative CALIOP level-2 and EARLINET-ASOS multi-wavelength Raman lidar aerosol data over Athens, we selected to present cases that have been identified as different types of aerosols (Saharan dust, biomass burning), using air mass backward trajectories in order to identify their source region. Additionally, satellite and models data (ATSR data and DREAM model) were used complimentary in order to characterize the aerosol sources.

S11P – 17

CRITICAL LIDAR TECHNOLOGY DEVELOPMENTS IN SUPPORT OF ESA'S EARTH OBSERVATION MISSIONS

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The development of advanced lidar systems for space applications and their evaluation by airborne or ground based test campaigns is an important strategic element of the ESA Earth Observation Programme. Since the early eighties, ESA has been supporting the development of the critical subsystems of any lidar, i.e. lasers and detectors. Several missions, involving different kinds of lidars and currently in different phases of implementation or study, provide the requirements to be addressed in the lidar risk mitigation activities. These missions are: ADM-Aeolus flying ALADIN a Doppler Wind Lidar, in Phase C/D; EarthCARE embarking ATLID an Atmospheric Backscatter Lidar, in Phase B; three missions studied for their feasibilities: WALES, A-SCOPE and ACCURATE, all using Differential Absorption Lidar in different ways to measure respectively profiles of water vapour, total column of CO2 and greenhouse gases in an occultation geometry. This paper gives an overview of the progresses of the technology risk mitigation activities in support of the above-mentioned missions. In particular, this paper lays the emphasis on laser diodes, transmitters and detectors.

S11P – 18

ERROR ANALYSIS SIMULATION FOR A FLUORESCENCE LIDAR SYSTEM OF THE PROPOSED GLEME ESA MISSION

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In this paper, we present for the first time, an error analysis procedure for the wind and temperature estimation of a space-borne resonance fluorescence lidar system. This fluorescence lidar system is proposed to be the space-borne sensing instrument on-board the proposed GLEME ESA mission. A novel simulation platform, called "PROTEAS", was developed in order to find numerically the optimum values of a multi-parameter optimization problem with constrains, which arise from the physical constrains of the system. Our error analysis results shows that a spaceborne lidar system in low earth orbit (LEO) configuration will be able to retrieve the mesospheric temperature, wind, and sodium density with a high enough horizontal and vertical resolution, thus enabling to obtain a significant part of the gravity wave spectrum and therefore, answer open key questions on upper atmosphere dynamics. Finally, our error analysis should be combined with a sensitivity analysis in order to define the optimum lidar parametric values through a complete error analysis.

S11P – 19

STRATEGIES FOR IMPROVED CALIPSO AEROSOL OPTICAL DEPTH ESTIMATES

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In the spring of 2010, the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) project will be releasing version 3 of its level 2 data products. In this paper we describe several changes to the algorithms and code that yield substantial improvements in CALIPSO's retrieval of aerosol optical depths (AOD). Among these are a retooled cloud-clearing procedure and a new approach to determining the base altitudes of aerosol layers in the planetary boundary layer (PBL). The results derived from these modifications are illustrated using case studies prepared using a late beta version of the level 2 version 3 processing code.

S11P – 20

EXTINCTION-TO-BACKSCATTER RATIOS OF SAHARAN DUST LAYERS DERIVED FROM IN-SITU MEASUREMENTS AND CALIPSO OVERFLIGHTS DURING NAMMA

A. Omar[1], Z. Liu[2], M. Vaughan[1], Y. Hu[1], S. Ismail[1], K. Powell[1], D. Winker[1], C. Trepte[1], B.E. Anderson[1]

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We determine the aerosol extinction-to-backscatter (Sa) ratios of dust using airborne in-situ measurements of microphysical properties, and CALIPSO observations during the NASA African Monsoon Multidisciplinary Analyses (NAMMA). The NAMMA field experiment was conducted from Sal, Cape Verde during Aug-Sept 2006. Using CALIPSO measurements of the attenuated backscatter of lofted Saharan dust layers, we apply the transmittance technique to estimate dust Sa ratios at 532 nm and a 2-color method to determine the corresponding 1064 nm Sa. Using this method, we found dust Sa ratios of 39.8 ± 1.4 sr and 51.8 ± 3.6 sr at 532 nm and 1064 nm, respectively. Secondly, Sa ratios at both wavelengths is independently calculated using size distributions measured aboard the NASA DC-8 and estimates of Saharan dust complex refractive indices applied in a T-Matrix scheme. We found Sa ratios of 39.1 ± 3.5 sr and 50.0 ± 4 sr at 532 nm and 1064 nm, respectively, using the T-Matrix calculations applied to measured size spectra. Finally, in situ measurements of the total scattering (550 nm) and absorption coefficients (532 nm) are used to generate an extinction profile that is used to constrain the CALIPSO 532 nm extinction profile.

S11P – 21

THE FRENCH-GERMAN CLIMATE MONITORING INITIATIVE ON GLOBAL OBSERVATIONS OF ATMOSPHERIC METHANE

Gerhard Ehret[1], Pierre Flamant[2], Axel Amediek[1], Philippe Ciais[3], Fabien Gibert[2], Andreas Fix[1], Christoph Kiemle[1], Mathieu Quatrevalet[1], and Martin Wirth[1]

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Knowledge of concentrations and fluxes of the most important long-lived greenhouse carbon dioxide (CO2) and methane (CH4) is a key element of climate change research. We report on the status of the French-German Climate Monitoring Initiative which aims on global observations of atmospheric methane. This mission which has recently been selected for joint Phase0/A studies at CNES and DLR is intended to improve our understanding of the Global Methane Cycle and the exploration of the nature of the processes which govern the exchange of methane between atmosphere and biosphere. As a novel feature, the observational instrument of this mission will be an Integrated Path Differential-Absorption (IPDA) lidar system embarked on the French spacecraft MYRIADE for the measurement of the column-weighted dry-air mixing ratio of CH4. This data will be provided by the lidar technique with no bias due to particles scattering in the light path and can directly be used as input for flux inversion calculation. Other geophysical quantities which can be derived from the measurements comprise information on vegetation height, cloud layers, and surface retro-reflectance.

S11P – 22

ATMOSPHERIC PRESSURE MEASUREMENTS USING THE OXYGEN ABAND

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We report on the atmospheric pressure measurements using a fiber-based laser system using the oxygen A-band. Remote measurements of atmospheric temperature and pressure are required for a number of scientific applications including greenhouse gas monitoring (mainly CO2), weather prediction, and climate modeling. The ultimate goal of CO2 remote sensing is to derive CO2 concentration in the atmosphere in terms of mole fraction in unit of parts-per-million (ppmv) with regard to dry air. Therefore, both CO2 and dry air number of molecules in the atmosphere are needed in deriving this quantity. O2 is stable and uniformly mixed in the atmosphere. The measurement of O2 absorption in the atmosphere can thus be used to infer dry air number of molecules and then be used to calculate CO2 concentration. With the knowledge of atmospheric water vapor, we can further estimate the total surface pressure that can be used to better define both O2 and CO2 line shape for better retrievals, as both CO2 and O2 absorptions in the near infrared are a function of pressure as well as temperature. Our measurements compare favorably with a local weather monitor mounted outside our laboratory and a local weather station.

S11P – 23

STUDY RESULTS FOR THE GLOBAL LIDAR EXPLORATION OF THE MESOSPHERE

T.E. Sarris[1,2], E.R. Talaat[3], A. Papayannis[4], X. Chu[5], M. Daly[6], P. Dietrich[6], J. Penson[7], V. Antakis[4], A. Vouldis[4], M. Koukouli[8], Ch. Kalaitzidis[9], E. Armandillo[10]

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We present the mission concept of GLEME, the Global Lidar Exploration of the Mesosphere, a spacecraft designed to study mesospheric dynamics and chemistry by use of a spaceborne resonance fluorescence lidar. The primary motivation and science focus of this mission which has driven the preliminary mission design is the determination of small scale waves in the mesosphere. The lidar is designed to obtain high spatial and temporal resolution temperature and horizontal winds in the mesosphere, allowing the determination of gravity wave characteristics, heat and momentum wave flux, and the effects on the background atmosphere. We have developed and simulated a novel measurement scheme that allows the determination of the vector winds at high resolution through the observation of winds along two lines of sight. Finally we discuss instrument and mission definition details, including the laser concept, required pointing accuracy, Doppler-shift compensation, and future flight opportunities.

S11P – 24

CALIPSO VALIDATION MEASUREMENTS WITH THE RAMAN LIDAR MULIS IN MAISACH, GERMANY

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The lidar CALIOP on board the satellite CALIPSO offers new prospects in global aerosol observations. However, as CALIOP is a backscatter lidar, validation of the retrieved aerosol profiles is required. In the framework of dedicated EARLINET activity measurements with the Raman lidar MULIS of the Meteorological Institute of the Ludwig-Maximilians-Universität München are performed during CALIPSO overpasses. The measurements take place in Maisach close to Munich, with a minimum distance to the CALIPSO footprints in the order of 30 km. In this paper data from nighttime measurements in 2008 are considered, when no low clouds were present. The comparison of MULIS and CALIPSO data concerns attenuated backscatter (Level 1B data of CALIPSO) and extinction coefficients (Level 2 data). Attenuated backscatter profiles show very good agreement, under stable atmospheric conditions even in the boundary layer. When MULIS data indicate a high temporal variability of the aerosol layering, the comparison reveals high spatial variability as well. Furthermore, the comparisons show that the detection of weak aerosol layers near the ground from CALIPSO data is critical and consequently they are often missing in the Level 2 data. The validation of extinction coefficient profiles is still limited to very few cases. They show a good agreement, indicating a good choice of lidar ratios from the CALIPSO database.

S11P – 25

DEVELOPMENT OF A COMBINED CLOUDSAT/CALIPSO CLOUD MASK AND REVISIT CLOUD TOP HEIGHTS FROM CLOUDSAT AND CALIPSO

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We examined the differences in the cloud top heights (CTHs) detected by CloudSat and by CALIPSO. It has been generally accepted that CTHs detected by the CloudSat were lower than the CTHs detected by CALIPSO. However, theoretical studies suggested that CloudSat could detect cloud top part and CALIPSO could not detect it when cloud top portions consist of large particles with small number concentration and CloudSat-detetced CTHs could be higher than CALIPSO-detected CTHs. We examined the global distribution of CTHs determined by CloudSat with the ones by CALIPSO using developed cloud mask schemes during September-November 2006. The clouds in which CloudSat-determined CTHs are larger than CALIPSO-determined ones turned out to be not rare unexpectedly, i.e., the global mean fractions were 32% and 48% in low- and middle levels and the corresponding CTH differences were 0.58 km and 0.81 km respectively.

S11P – 26

THE CALIOP 532-NM CHANNEL DAYTIME CALIBRATION: VERSION 3 ALGORITHM

Kathleen A. Powell[1], Mark A. Vaughan[1], Raymond R. Rogers[1], Ralph E. Kuehn[1], William H. Hunt[1], Kam-Pui Lee[1], Timothy D. Murray[2]

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The CALIPSO lidar (CALIOP) makes backscatter measurements at 532 nm and 1064 nm and linear depolarization ratios at 532 nm. Accurate calibration of backscatter measurements is essential for layer detection and the subsequent retrieval of optical properties. A revised 532-nm daytime calibration algorithm has been developed for the version 3 CALIPSO lidar level 1 data release. This revised algorithm produces calibration coefficients by scaling the daytime clear-air scattering ratios to the match the values measured at the same latitude during the nighttime orbit segments. This paper describes the version 3 daytime calibration algorithm and its implementation within the CALIPSO Automated Processing System (CAPS). The results obtained from the revised algorithm are discussed and comparisons are made to validation data acquired by NASA's Airborne High Spectral Resolution Lidar (HSRL).

Tuesday, 06 July 2010
7:30 – 8:30 – Registration

Session 7O: Lidar Networks and Assimilation of Observations into Forecast Models – Oral Presentations
Co-Chairs: Adolfo Comeron, Raymond Hoff

8:30 – 8:45
S7O – 01

THE NASA MICRO PULSE LIDAR NETWORK (MPLNET): SUMMARY OF THE LAST 10 YEARS, CURRENT STATUS, AND FUTURE PLANS

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The NASA Micro Pulse Lidar Network (MPLNET) is a federated network of Micro Pulse Lidar (MPL) systems designed to measure aerosol and cloud vertical structure continuously, day and night, over long time periods required to contribute to climate change studies and provide ground validation for models and satellite sensors in the NASA Earth Observing System (EOS). At present, there are eighteen active sites worldwide, and several more in the planning stage. Numerous temporary sites are deployed in support of various field campaigns. Most MPLNET sites are co-located with sites in the NASA Aerosol Robotic Network (AERONET) to provide both column and vertically resolved aerosol and cloud data. MPLNET data and more information on the project are available at http://mplnet.gsfc.nasa.gov. Here we present a summary of the first ten years of MPLNET, along with an overview of our current status, specifically our version two data products and applications. Future network plans will be presented, with a focus on our activities in South East Asia.

8:45 – 9:00
S7O – 02

EARLINET AND AERONET: FIRST COMPARISON AND INTEGRATED STUDY

Lucia Mona[1], Dimitris Balis[2], Philippe Goloub[3], Marco Iarlori[4], Stefan Kinne[5], Zhengqiang Li[3], Holger Linné[5], Fabio Madonna[1], Ina Mattis[6], Alexandros Papayannis[7], Maria Rita Perrone[8], Nicola Spinelli[9], Gelsomina Pappalardo[1]

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Aerosol optical depth is a key parameter for understanding the aerosol role on radiation budget. AERONET (AErosol RObotic NETwork) is the reference network of Sun-photometer ground-based aerosol measurements. EARLINET (European Aerosol Research NETwork) is the first European lidar network for aerosol study. The simultaneous presence over Europe of EARLINET lidar network and of a large number of AERONET sites provides an optimal benchmark for comparison and integration of passive and active remote sensing techniques for aerosol study. Comparisons for AOD measurements available at sites equipped with both EARLINET and AERONET instruments show a good agreement. Observed differences are investigated in terms of two additional parameters: the diurnal variability, estimated by AERONET measurements, and the free troposphere contribution, calculated thanks to the vertical profiling capability of lidar techniques. All together these quantities provide a good description of the aerosol content over Europe. Finally, a climatological study including also no co-located AERONET and EARLINET AOD sites allows one investigate in some way the representativeness of the AOD measurements collected at each site and observational gaps in both networks.

9:00 – 9:15
S7O – 03

REPRESENTATIVENESS OF AEROSOL MEASUREMENTS: EARLINET-CALIPSO CORRELATIVE STUDYV

Gelsomina Pappalardo[1], Ulla Wandinger[2], Lucia Mona[1], Anja Hiebsch[2], Ina Mattis[2], Holger Linné[3], Arnoud Apituley[4], Lucas Alados Arboledas[5], Dimitris Balis[6], Adolfo Comeron[7], Volker Freudenthaler[8], Elina Giannakaki[6], Aldo Giunta[1], Juan Luis Guerrero Rascado[5], Fabio Madonna[1], Rodelize-Elizabeth Mamouri[9], Francisco Molero[10], Alexandros Papayannis[9], Manuel Pujadas[10], Francesc Rocadenbosch[7], Nicola Spinelli[11], Xuan Wang[11], Matthias Wiegner[81]

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The high variability of tropospheric aerosols, both in space and time, is the main cause of the high uncertainty about radiative forcing related to tropospheric aerosols and their interaction with clouds. Because of the lack of high resolution aerosol global vertical profiles, the vertical mixing has not been considered so far in studies of spatial and temporal variability. The CALIPSO mission provides the first opportunity to investigate the 4-D aerosol and cloud fields in detail. However, because of the CALIOP small footprint and the revisit time of 16 days, correlative ground-based lidar observations are necessary in order to investigate the representativeness of these satellite observations. EARLINET, the European Aerosol Research Lidar Network, started correlative measurements for CALIPSO in June 2006, right after the CALIPSO launch. An integrated study of CALIPSO and EARLINET correlative measurements opens new possibilities for spatial (both horizontal and vertical) and temporal representativeness investigation of polar-orbit satellite measurements also in terms of revisit time.

9:15 – 9:30
S07O – 04

SALINAS: AN EMERGING AEROSOL LIDAR NETWORK SUPPORTING THE SEVEN SOUTHEAST ASIAN STUDIES (7SEAS) CAMPAIGN

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The Seven Southeast Asian Studies (7SEAS; http://7-seas.gsfc.nasa.gov) field campaign is an international and multi-disciplinary initiative designed to study the influence of aerosol particles on a wide range of physical and biospheric processes in the South China Sea (SCS) region. Research partners representing seven Southeast Asian countries (Indonesia, Malaysia, the Philippines, Singapore, Taiwan, Thailand and Vietnam), in partnership with colleagues in Japan and the United States, have offered or are presently deploying resources to support 7SEAS field activities. Begun in 2009, 7SEAS will coordinate intensive field deployments through 2013, with legacy activities planned at regional host institutions beyond that date. This paper describes the Southeast Asian Lidar Network for Atmospheric Studies (SALiNAS; http://salinas.gsfc.nasa.gov), a newly-formed lidar cooperative project tasked with coordinating 7SEAS lidar applications; including scientific priorities and collaborative research opportunities. We will highlight three topics that we envision SALiNAS having the greatest impact on 7SEAS science: aerosol observability and instrument validation, particle transport and evolution, and data assimilation and transport model evaluation. This introduction to the community will consider initial observations and measurements collected from network instruments that relate each of these objectives. Furthermore, we will describe the role for current and future satellite lidar-based measurements, including most prominently, the NASA Cloud and Aerosol Lidar with Orthogonal Polarization (CALIOP) instrument, which will be considered to expand SALiNAS coverage over the SCS.

9:30 – 9:45
S7O – 05

EARLI09 - DIRECT INTERCOMPARISON OF ELEVEN EARLINET LIDAR SYSTEMS

Volker Freudenthaler[1], Silke Gross[1], Ronny Engelmann[2], Ina Mattis[2], Ulla Wandinger[2], Gelsomina Pappalardo[3], Aldo Amodeo[3], Aldo Giunta[3], Giuseppe D'Amico[3], Anatoli Chaikovsky[4], Fiodor Osipenko[4], Alexander Slesar[4], Doina Nicolae[5], Livio Belegante[5], Camelia Talianu[5], Ilya Serikov[6], Holger Linne[6], Friedhelm Jansen[6], Keith Wilson[7], Martin de Graaf[7], Arnoud Apituley[8], Thomas Trickl[8], Helmuth Giehl[8], Mariana Adam[9]

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Eleven EARLINET lidar systems were directly compared during EARLI09 in Leipzig, Germany, in may, 2009. The measurement and signal comparison strategies are presented and some examples shown.

9:45 – 10:00
S7O – 06

POLLY^{NET} – A CONTRIBUTION TO GLOBAL, VERTICALLY RESOLVED AEROSOL TYPING

Dietrich Althausen[1], Ronny Engelmann[1], Holger Baars[1], Birgit Heese[1], Thomas Kanitz[1], Detlef Müller[2], Mika Komppula[3], Andreas Hänel[4]

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To improve our knowledge about vertical aerosol profiles lidar networks connect and support the measurement efforts. The *po*rtab*l*e aerosol Raman *l*idar s*y*stem with e*xt*ended capabilities *Polly*^{XT} is a stand alone system which can be deployed to remote sites. The use of these systems in worldwide projects need a net-like controlling. For this purpose the network and database *Polly*^{NET} was established. In this contribution the main characteristics of *Polly*^{NET} are explained. One of the Polly^{XT} systems was deployed to a remote site in the Amazon rainforest for 11 months. The presented measurement example shows the benefits of the net-like controlling of the Polly^{XT} systems within Polly^{NET}.

10:00 – 10:20 – Coffee Break

Session 4O: Aerosol Characterization and Direct and Indirect Effects on Climate – Oral Presentations
Co-Chairs: Juan Carlos Antuna, Toshiyuki Murayama

10:20 – 10:35
S4O – 01

RADIATIVE FORCING ASSOCIATED WITH A SPRINGTIME CASE OF BODÉLÉ AND SUDAN DUST TRANSPORT OVER WEST AFRICA10 YEARS, CURRENT STATUS, AND FUTURE PLANS

C. Lemaître[1], C. Flamant[1], J. Cuesta[2], J.-C. Raut[1], P. Chazette[3], P. Formenti[4], and J. Pelon[1]

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The radiative forcing due to mineral dust over West Africa is investigated using the radiative code STREAMER, as well as remote sensing and in situ observations gathered during the African Monsoon Multidisciplinary Analysis Special Observing Period (AMMA SOP). During daytime, the warming associated with the presence of elevated dust layers was found to be between 1.5 K day-1 and 4 K day-1, on average, depending on altitude and latitude. Obviously, during nighttime much smaller values of heating/cooling are retrieved (less than -1 K day-1). Cooling is observed as the result of the longwave forcing in the dust layer, while warming is observed below the dust layer due to the absorption of surface emission in the monsoon layer. Such features are expected to have a significant impact on the low troposphere dynamics.

10:35 – 10:50
S4O – 02

MULTIWAVELENGTH RAMAN AEROSOL OBSERVATION OF SAHARAN AND PATAGONIAN DUST ABOARD THE RESEARCH VESSEL POLARSTERN DURING ITS MERIDIONAL CRUISE ANT-26/1

Thomas Kanitz, Dietrich Althausen, Ronny Engelmann, Holger Baars, and Andreas Macke

Leibniz Institute for Tropospheric Research, Permoserstrasse 15, 04318 Leipzig, Germany

In the framework of the Oceanet experiment the mass and energy fluxes between ocean and atmosphere are investigated. For the first time, the shipborne radiation measurement platform Oceanet-Atmosphere took part in the meridional cruise ANT-26/1 of the research vessel Polarstern. This platform is equipped with a multiwavelength Raman lidar. The cruise of the RV Polarstern across the Atlantic ocean started at Bremerhaven, Germany on 16 October 2009 and ended at Punta Arenas, Chile on 25 November 2009. Two lidar measurements taken at this cruise are presented. On 31 October 2009 a Saharan dust plume was observed close to the Cape Verde islands between 10◦ to 20◦ N. The lofted

aerosol layers extended from 0.8 km to 2.5 km. This Saharan dust plume was characterized by an aerosol optical thickness of 0.26, a lidar ratio of 55 sr at 532 nm and an °Angstroem exponent of 0.2 of the extinction at 355 and 532 nm. Radiative transfer calculations were made by using an ocean albedo of 0.05 and a solar zenith angle of 30◦. At the surface the radiative forcing was about -59.2 W/m2. The measurement on the 20 November 2009 at 40◦ S and 51◦W, about 700 km southeast from Montevideo showed a Patagonian dust plume. In comparison to the Saharan dust plume, observed Patagonian dust plumes were optical thinner. They are characterized by AOTs of about 0.02 and comparable vertical extents.

10:50 – 11:05
S4O – 03

RAMAN LIDAR OBSERVATIONS OF A SAHARAN DUST OUTBREAK EVENT: CHARACTERIZATION OF THE DUST OPTICAL PROPERTIES AND DETERMINATION OF PARTICLE SIZE AND MICROPHYSICAL PARAMETERS

Paolo Di Girolamo[1], Donato Summa[1], Rohini Bhawar[1], Tatiana Di Iorio[2], Marco Cacciani[2], Igor Veselovskii[3], Alexey Kolgotin[3], Oleg Dubovik[4]

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The Raman lidar system *BASIL* was operational in Achern (Black Forest) between 25 May and 30 August 2007 in the frame of the *Convective and Orographically-induced Precipitation Study* (*COPS*). The system performed continuous measurements over a period of approx. 36 hours from 06:22 UTC on 1 August to 18:28 UTC on 2 August 2007, capturing the signature of a severe Saharan dust outbreak episode. Data clearly reveals the presence of the dust cloud between 18:00 and 03:00 UTC, with the presence of two almost separate aerosol layers: a lower layer located between 1.5 and 3.5 km and an upper layer extending between 3.0 and 6.0 km. An inversion algorithm was used to retrieve particle microphysical parameters, i.e., mean and effective radius, number, surface area, and volume concentration, complex refractive index, as well as the parameters of a bimodal particle size distribution, from the multi-wavelength lidar data of particle backscattering, extinction and depolarization. The retrieval scheme employs Tikhonov's inversion with regularization and makes use of kernel functions for spheroidal particles. Size and microphysical parameters of dust particles are estimated as a function of altitude at different times during the dust outbreak event. Retrieval results reveal the dominance in the upper dust layer of a coarse mode with radii 3-6 mm. Effective radius, number density and volume concentration vary with altitude in the range 0.1-1.4 mm, 200-1500 cm^{-3} and 6-80 mm^3/cm^3, respectively, while real and imaginary part of the complex refractive index are in the range 1.45-1.62 and 0.005-0.012, respectively.

11:05 – 11:20
S4O – 04

VOLCANIC AEROSOL LAYERS OBSERVED WITH MULTI-WAVELENGTH RAMAN LIDAR OVER EUROPE SINCE SUMMER 2008

Ina Mattis, Patric Seifert, Detlef Müller, Matthias Tesche, Anja Hiebsch, Thomas Kanitz, Jörg Schmidt, Fanny Finger, Albert Ansmann, Ulla Wandinger

Leibniz Institute for Tropospheric Research (IFT), Permoser Str. 15, 04318 Leipzig, Germany

In the framework of regular EARLINET observations aerosol layers were observed with a ulti-wavelength Raman lidar in the upper troposphere - lower stratosphere (UTLS) region over Leipzig, Germany since summer 2008. FLEXPART transport simulations show that the origin of those layers are eruptions of different volcanoes on the Aleutian Islands, Kamchatka, Alaska, and on the Kuril Islands. The aerosol layers typically occured between 5 and 25 km and extended up to a maximum height of 30 km. Optical depth at 532 nm was in the range between 0.004 and 0.025. Multi-wavelength Raman lidar observations over Leipzig show backscatter-related Ångström exponent of 1-2. Lidar ratios at 355 nm show values of 30-60 sr and are significantly larger than those at 532 nm with values of 30-45 sr. The effective radius was estimated to be 0.1-0.2µm.

11:20 – 11:35
S4O – 05

AN INTEGRATED ANALYSIS OF SPHERICALAEROSOL DISTRIBUTION IN EASTERNASIA BASED ON GROUND/SPACE-BASED LIDAR AND ACHEMICAL TRANSPORT MODEL

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Seasonal variation of spherical aerosol distribution in East Asia was investigated based on ground/space-based Lidar measurements and Community Multi-scale Air Quality Modeling System (CMAQ) chemical transport model simulation during July 2006 - December 2008. The model results successfully capture the observed typical seasonal variation of Asian spherical aerosols at four NIES lidar sites surrounding East China Sea (Beijing, Guangzhou, Seoul, Hedo/Okinawa). Integrated results of NIES lidar and the chemical model show that a critical composition difference exists among lidar sites; especially, various aerosols exist at Beijing with 25% of dust and 75% of spherical aerosols composed by 20% of carbonaceous aerosol and 80% of sulfate in annual average. The integrated result also showed that seasonal variation pattern of spherical AOT can be classified into ‘summer peak’ type like that at Beijing and ‘summer trough’ type, like that at Hedo/Okinawa. The two-month mean horizontal distribution of spherical extinction coefficient indicates that Asian summer/winter monsoon system contributes strongly to the seasonal variation of spherical aerosol; the westerly winter monsoon dilutes the polluted air intensively, the concentration level at high latitude is low in winter. In summer, southern summer monsoon transports pollutants northward. The AOT level at higher continental latitudes increases significantly.

11:35 – 11:50
S4O – 06

DEPOLARIZATION LIDAR AT SUMMIT, GREENLAND FOR THE DETECTION OF CLOUD PHASE AND STRATOSPHERIC AEROSOLS

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Measurements of cloud properties over Summit, Greenland are necessary to document the full range of cloud conditions and characteristics throughout the Arctic. A new lidar system has been developed to measure depolarization and backscatter of clouds in the lower troposphere and aerosols in the upper troposphere and lower stratosphere. This lidar uses recent developments in optical methods to characterize system polarization effects in order to compensate systematic phase shifts. This allows the lidar to accurately measure aerosols and cloud polarization ratios below 0.02. The lidar is located at Summit, Greenland as part of the Integrated Characterization of Energy, Clouds, Atmospheric State, and Precipitation at Summit project and NOAA's Global Monitoring Division's stratospheric lidar network.

11:50 – 12:05
S4O – 07

BACKSCATTERING LINEAR DEPOLARIZATION RATIO MEASUREMENT OF MINERAL DUST, SEA SALT, AND AMMONIUM SULFATE PARTICLES GENERATED IN A LABORATORY CHAMBER

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Backscattering linear depolarization ratios of major types of tropospheric aerosols were measured using a laboratory chamber. The aerosols examined were Asian and Saharan mineral dust, sea salt, and ammonium sulfate. The values obtained for the Asian and Saharan mineral dust were both 28 ± 3% (mean ± standard deviation) in supermicrometer and 12–15 ± 2% in submicrometer-size range. Those for the sea-salt and ammonium sulfate crystals in the submicrometer-size range were 8 ± 1% and 4 ± 0.2%, respectively, and those for the droplets were both 1 ± 0.1–0.2%. These values serve as a reference for interpreting the lidar measurement of the tropospheric aerosols.

12:05 – 12:20
S4O – 08

MULTIWAVELENGTH POLARIZATION RAMAN LIDAR MEASUREMENTS OF DUST AND SMOKE AT CAPE VERDE DURING SAMUM–2

Matthias Tesche[1], Albert Ansmann[1], Dietrich Althausen[1], Detlef Müller[2], Volker Freudenthaler[3], Silke Groß[3]

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Polarization Raman lidar measurements at various wavelengths were performed during the SAharan Mineral dUst experiMents (SAMUM) 1 and 2 to study the optical properties of desert dust aerosol. While SAMUM-1 in summer of 2006 was devoted to the investigation of pure and freshly emitted Saharan dust, SAMUM-2 in winter of 2008 at Cape Verde focused on the characterization of a mixture of aged dust from North Africa and biomass burning aerosol from Central Africa. Identical column closure experiments were conducted during the two campaigns. The findings of SAMUM-1 could be applied to separate the ratio of dust and smoke to the total optical properties measured with lidar during SAMUM-2. If this method is employed for multiwavelength measurements a dataset for the inversion of optical parameters (corrected for the contribution of dust particles whose non-sphericity impede reliable inversion results) can be obtained to yield microphysical particle properties. Additional lidar measurements at Cape Verde were performed in summer of 2008 to capture the seasonal change in intercontinental dust transport.

12:20 – 12:35
S4O – 09

33 YEARS OF STRATOSPHERIC AEROSOL MEASUREMENTS AT GARMISCHPARTENKIRCHEN (1976-2010)

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The powerful backscatter lidar at Garmisch-Partenkirchen (Germany) has almost continually delivered backscatter coefficients of the stratospheric aerosol since 1976. The time series is dominated by signals from the particles injected into the stratosphere by major volcanic eruptions, in particular those of El Chichon (Mexico, 1982) and Mt. Pinatubo (Philippines, 1991). The volcanic aerosol disappears within about five years, the removal from the stratosphere being modulated by the phase of the quasi-biennial oscillation. During the long-lasting background period since the late 1990s the stratospheric backscatter coefficients have reached a level even below that observed in the late 1970s. This suggests that the predicted potential influence of the strongly growing air traffic on the stratospheric aerosol loading is very low. Some correlation may be found with strong forest fires. Since 2003 there is some indication of a growing background that is tentatively ascribed to the growing air pollution in East Asia

12:35 – 12:50
S4O – 10

AEROSOL VERTICAL DISTRIBUTION EFFECTS ON RADIATIVE BUDGET AND HEATING RATE VERTICAL PROFILES: STUDY CASE

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Aerosol optical and microphysical properties by ground-based sun-/sky-photometer measurements and aerosol vertical profiles by lidar measurements, performed within AERONET and EARLINET respectively, are used to analyze aerosols effects on radiative budget and atmospheric heating rate profiles. The instantaneous and daily evolution of both the solar and infrared aerosol direct radiative effect (DRE) is examined at the top of the atmosphere (ToA), within the atmosphere and at the Earth's surface in clear-sky conditions. Particular attention is given in this paper to the dust outbreak of 16 July 2009 that has spread a large amount of dust particles over the Central Mediterranean. Aerosol DREs are evaluated at different day hours to investigate as a function of time aerosol effects on heating rate vertical profiles. Results on daily averaged DREs and on the impact of the aerosol vertical distribution on heating rate profiles are also reported.

12:50 – 13:05
S4O – 11

STRATOSPHERIC AEROSOL LAYERS OVER SOUTHERN ITALY DURING THE SUMMER OF 2009: LIDAR OBSERVATIONS AND MODEL COMPARISON

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During the summer of 2009, aerosol layers in the upper troposphere and the lower stratosphere have been observed by the two multi-wavelength Raman lidars operational at CNR-IMAA. The stratospheric layers were also observed over the same altitude ranges by the CALIPSO lidar during its overpasses on our site. The model HadGEM2-A confirms that the origin of these layers is the eruption of the Sarychev volcano in the Kuril Islands. The aerosol layers extended up to a maximum height of 24 km. The lidar measurements indicate a quite strong wavelength dependence of the backscatter coefficients. For two cases it has been possible to measure the lidar ratio at 355 nm obtaining 60(11) and 43(12) sr.

13:05 – 14:00 – Lunch Break

Session 2O: Atmospheric Winds and Turbulence – Oral Presentations
Co-Chairs: Agnes Dolfi-Bouteyre, Bruce Gentry

14:00 – 14:15
S2O – 01

FLIGHT TESTING OF THE TWILITE AIRBORNE MOLECULAR DOPPLER LIDAR

Bruce Gentry[1], Matthew McGill[1], Roman Machan[2], Daniel Reed[2], Ryan Cargo[2], David J. Wilkens[2], William Hart[3], John Yorks[3], Stan Scott[4], Shane Wake[5], Michael Hardesty[6], Alan Brewer[6]

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In September, 2009 the TWiLiTE (Tropospheric Wind Lidar Technology Experiment) direct detection Doppler lidar was integrated for engineering flight testing on the NASA ER-2 high altitude aircraft. The TWiLiTE Doppler lidar measures vertical profiles of wind by transmitting a short ultraviolet (355 nm) laser pulse into the atmosphere, collecting the laser light scattered back to the lidar by air molecules and measuring the Doppler shifted frequency of that light. The magnitude of the Doppler shift is proportional to the wind speed of the air in the parcel scattering the laser light. TWiLiTE was developed with funding from the NASA Earth Science Technology Office (ESTO) Instrument Incubator Program (IIP). The primary objectives of the TWiLiTE program are twofold: 1) to advance the development of key technologies and subsystems critical for a future space based Global 3-D Wind Mission, as recommended by the National Research Council in the recent Decadal Survey for Earth Science [1] and 2) to develop, for the first time, a fully autonomous airborne Doppler lidar and to demonstrate tropospheric wind profile measurements from a high altitude downward looking, moving platform to simulate spaceborne measurements. In this paper we will briefly describe the instrument followed by a discussion of the results from the 2009 engineering test flights.

14:15 – 14:30
S2O – 02

SET-UP OF A GROUND-BASED RAYLEIGH LIDAR TO DETECT CLEAR AIR TURBULENCE

Alain Hauchecorne[1], Charles Cot[1], Francis Dalaudier[1], Jacques Porteneuve[1], Thierry Gaudo[2], Richard Wilson[1], Claire Cénac[1], Christian Laqui[1], Philippe Keckhut[1], Jean-Marie Perrin[3], Agnès Dolfi[2], Nicolas Cézard[2], Laurent Lombard[2], Claudine Besson[2]

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Atmospheric gravity waves and turbulence generate small-scale fluctuations of wind, pressure, density and temperature in the atmosphere. These fluctuations represent a real danger for commercial aircrafts and are known under the generic name of Clear Air Turbulence (CAT). They are not resolved in weather forecast models and are therefore unpredictable. A ground-based Rayleigh lidar was designed and implemented to remotely detect and characterize the atmospheric variability induced by gravity waves and turbulence in vertical scales between 10m and 1000m. Field measurements at Observatoire de Haute-Provence (France) have shown that the built lidar device was actually able to detect episodes of turbulence. This is to our knowledge the first Rayleigh lidar system able to detect clear air turbulence. The built lidar device may serve as a test bed for the definition of embarked CAT detection lidar systems on board airliners.

14:30 – 14:45
S2O– 03

COMPACT, HIGH ENERGY 2-MICRON COHERENT DOPPLER WIND LIDAR DEVELOPMENT FOR NASA'S FUTURE 3-D WINDS MEASUREMENT FROM SPACE

Upendra N. Singh[1], Grady Koch[1], Jirong Yu[1], Mulugeta Petros[2], Jeffrey Beyon[1], Michael J. Kavaya[1], Bo Trieu[1], Songsheng Chen[3], Yingxin Bai[3], Paul Petzar[4], Edward A. Modlin[1], Bruce W. Barnes[1], and Belay B. Demoz[5]

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This paper presents an overview of 2-micron laser transmitter development at NASA Langley Research Center for coherent-detection lidar profiling of winds. The novel high-energy, 2-micron, Ho:Tm:LuLiF laser technology developed at NASA Langley was employed to study laser technology currently envisioned by NASA for future global coherent Doppler lidar winds measurement. The 250 mJ, 10 Hz laser was designed as an integral part of a compact lidar transceiver developed for future aircraft flight. Ground-based wind profiles made with this transceiver will be presented. NASA Langley is currently funded to build complete Doppler lidar systems using this transceiver for the DC-8 aircraft in autonomous operation. Recently, LaRC 2-micron coherent Doppler wind lidar system was selected to contribute to the NASA Science Mission Directorate (SMD) Earth Science Division (ESD) hurricane field experiment in 2010 titled Genesis and Rapid Intensification Processes (GRIP). The Doppler lidar

system will measure vertical profiles of horizontal vector winds from the DC-8 aircraft using NASA Langley's existing 2-micron, pulsed, coherent detection, Doppler wind lidar system that is ready for DC-8 integration. The measurements will typically extend from the DC-8 to the earth's surface. They will be highly accurate in both wind magnitude and direction. Displays of the data will be provided in real time on the DC-8. The pulsed Doppler wind lidar of NASA Langley Research Center is much more powerful than past Doppler lidars. The operating range, accuracy, range resolution, and time resolution will be unprecedented. We expect the data to play a key role, combined with the other sensors, in improving understanding and predictive algorithms for hurricane strength and track.

14:45 – 15:00
S2O – 04

COHERENT DOPPLER LIDAR MEASUREMENTS OF THE WIND VELOCITY VECTOR AT LOW SIGNAL-TO-NOISE RATIO

Victor A. Banakh[1], W. Alan Brewer[2], Yelena L. Pichugina[2], and Igor N. Smalikho[1]

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The performance of wind velocity vector measurement by a 2-mm pulsed coherent Doppler lidar (1.5 mJ pulse energy and 200 Hz pulse repetition frequency) at low signal-to-noise ratio is investigated. It is shown that the use of the filtered sine wave fitting to radial velocities measured during one revolution of the probing beam around vertical axis for 1 min allows us to obtain estimates of the wind velocity and wind direction with acceptable accuracy at signal-to-noise ratio down to values of -20 dB.

15:00 – 15:15
S2O – 05

WIND FIELDS MEASURED USING MULTI-BEAM COMMERCIAL AEROSOL LIDAR

Geary K. Schwemmer, Matthew Banta, Alex Achey, Sangwoo Lee, Nikhil Mehta, Mikhail Yakshin, Jumani Blango

Science and Engineering Services, Inc., 6992 Columbia Gateway Drive, Columbia, MD, USA

Wind vectors are measured as a function of range with a low-cost aerosol lidar system that uses aerosol backscatter signals to trace localized atmospheric wind. Cross correlations between the time-dependent signals from two closely spaced beams are used to measure the cross and line of sight wind components. This approach enables wind to be measured with effective resolution and range for a variety of needs. 2-D wind vectors are obtained along a line of sight without scanning and without Doppler information. A breadboard system using commercial Micro-Pulse Lidar components was used to successfully test this concept by comparing the lidar wind measurements with anemometer measurements, and in a self-check test by making orthogonal measurements of winds aloft.

notes

15:15 – 15:30
S2O – 06

OFFSHORE WIND MEASUREMENTS BY DOPPLER LIDAR

Yelena L. Pichugina[1,2], R.M. Banta[2], W.A. Brewer[2], S.P. Sandberg[2], and Mike Hardesty[2]

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The High Resolution Doppler Lidar (HRDL) has demonstrated the ability to provide continuous measurements of wind flow characteristics from the surface up to several hundred meters with high spatial and temporal resolution. Analysis of HRDL data from two experiments in the flat terrain of the Great Plains show that HRDL is well suited for wind energy research needs and HRDL data can adequately describe the atmospheric processes that may impact the operational reliability and lifetime of wind turbines and their components. Development of offshore wind farms and growing demand for measurements up to 300 m or more above the water surface, motivated a detailed re-analysis of ship-borne HRDL measurements of wind profiles obtained during past years experiments. The paper will present results related to wind energy issues such as distributions of wind speed and direction at rotor heights, and low-level jet (LLJ) nocturnal evolution obtained from HRDL measurements made from a ship-based platform during the New England Air Quality Study in the summer of 2004. These results will improve the knowledge of wind flow at the turbine heights and create the foundation for an archive of high resolution wind and turbulence data recovered from past-field experiments.

15:30 – 15:45
S2O – 07

OPERATIONAL OBSERVATIONS OF THREE DIMENSIONAL WIND WITH INCOHERENT DOPPLER WIND LIDAR

Zhishen Liu[1], Songhua Wu[1], Huang Li[2], Zhangjun Wang[1], Decang Bi[1], Rongzhong Li[1], Bingyi Liu[1], Zhigang Li[1]

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[2]Chinese Academy of Meteorological Sciences, No. 46 Zhongguancun South Street, Beijing, China,

A mobile incoherent (direct detection) Doppler wind lidar is developed for operational meteorological applications by Ocean University of China / Ocean Remote Sensing Institute. The lidar is implemented to achieve the three dimensional wind measurements in troposphere with high resolution and high updating rate. The lidar components are compact design and integrated into a minibus. The observation modes and data products conform to the criteria for weather radar for easy readout and comprehension by forecaster and routine assimilation model. The Doppler wind lidar is deployed to detect the sea surface wind using horizontal scans for race organization and sailing athletes training at 2008 Olympic sailing competition in Qingdao. Another wind campaign including profiles and volume scans is carried out for weather service at inner-Mongolia plateau. These campaigns qualify the direct detection Doppler lidar for operational wind surveillance which is currently dominated by the coherent heterodyne technology with high precision but altitude limitation.

15:45 – 18:00 – Poster Session II

Session 02P: Atmospheric Winds and Turbulence – Poster Presentations
Co-Chairs: Victor Banakh, Mike Hardesty

S2P– 01

WIND PROFILES WITH AN ELASTIC BACKSCATTER LIDAR USING AUTO AND CROSS CORRELATION TECHNIQUES

Bruce Morley, William Brown, Scott Spuler

National Center for Atmospheric Research, 3450 Mitchell Lane, Boulder, CO 80301

This paper presents initial results from the development and testing of an eye-safe, direct-detection, Lidar Wind Profiler (LWP) at the National Center for Atmospheric Research (NCAR). In general, laser wind instruments measure Doppler shifts either through direct or heterodyne detection. Doppler systems measure radial wind speed toward or away from the instrument. The LWP uses direct-detection and auto and cross-correlation data analysis techniques developed for multi-beam radar wind profilers to determine wind speed and direction that are normal to the lidar beam. One advantage to this technique is that a horizontal wind profile can be retrieved from a small sample volume using a nearly vertical pointing multi-beam lidar - the LWP beams are pointed a few milliradians (mrad) from the zenith. Details of the laser wind profiler hardware design, preliminary results comparing profiles measured with a radar wind profiler and future plans will be presented.

S2P– 02

EXPERIMENTAL WIND PROFILE RECONSTRUCTION FROM TURBULENT INTENSITY FLUCTUATIONS OF LASER BEAM

D.A. Marakasov, A.L. Afanasiev, V.A. Banakh, A.P. Rostov

V.E. Zuev Institute of Atmospheric Optics SB RAS, 1, Academician Zuev square, Tomsk 634021, Russia

The profiling algorithm allows one to reconstruct both profiles of wind velocity and refraction index structure characteristics from turbulent spatio-temporal intensity statistics of rapidly divergent laser beam is proposed in the paper. Experimental results of wind profile reconstruction are presented and compared to the wind profile, directly measured by the system of acoustic anemometers.

S2P – 03

AUTOMATED AND FULL-AZIMUTH-SCANNED WIND MEASUREMENTS IN PPI AND RHI MODES WITH A MOBILE DOPPLER WIND LIDAR BASED ON IODINE FILTERS

Zhangjun Wang[1,2], Zhishen Liu[1], Songhua Wu[1], Bingyi Liu[1], Zhigang Li[1], Xinzhao Chu[2], and Wentao Huang[2]

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[2]University of Colorado at Boulder, 216 UCB, CIRES, Boulder, Colorado 80309, USA

Full-azimuth-scanned wind measurements in Plane Position Indicator (PPI) and Range Height Indicator (RHI) modes have been achieved with an iodine-filter-based mobile Doppler wind lidar developed by the Ocean Remote Sensing Institute at Ocean University of China. The detection range of line-of-sight (LOS) wind velocity in PPI and RHI modes can reach 8-10 km at night and 6-8 km during the daytime with 10-m and 3-min resolutions. Besides presenting the initial results, this paper will introduce the architecture of the data acquisition and analysis software (DAAS). This sophisticated and userfriendly DAAS enables continuous and automated wind measurements for many days.

S2P– 04

CLEAR AIR TURBULENCE DETECTION AND CHARACTERISATION IN THE DELICAT AIRBORNE LIDAR PROJECT

Patrick Vrancken[1], MartinWirth[1], Dimitry Rempel[1], Gerhard Ehret[1], Agnès Dolfi-Bouteyre[2], Laurent Lombard[2], Thierry Gaudo[2], David Rees[3], Hervé Barny[4], Philippe Rondeau[4]

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[4]THALES Avionics, 25 rue Jules Vedrines, 26027 Valence Cedex, France

We report on a development of a long-range airborne UV high spectral resolution lidar, intended for the detection and characterisation of clear air turbulence (CAT). The detection of turbulence is based on the measurement of density fluctuations associated with the movement of turbulent air masses. These density fluctuations are measured by the variations in the molecular backscatter coefficient which is determined from the lidar signal by spectrally separating it from the aerosol backscatter. After an introduction, we review the CAT detection principle and describe the lidar system design. We then present the expected performance of the system and give an overview on the planned measurement campaign.

S2P – 05

APPLICATIONS OF A SHORT-RANGE LIDAR AT THE HONG KONG INTERNATIONAL AIRPORT

P.W. Chan

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A short range LIDAR with a spatial resolution down to 30 m was tried out at the Hong Kong International Airport (HKIA) in the summer of 2009 to study microscale airflow disturbances, e.g. in association with buildings at the airport. It performed generally satisfactory during the test period and was used to capture many interesting features of the low-level winds that were not observed with the existing LIDAR systems at HKIA, which have coarse spatial resolution and are mainly used to monitor mesoscale weather features. This paper presents some preliminary study results with the short-range LIDAR, namely, the observation of "bursts" (or jets) in the south to southwesterly flow that may be related to windshear encountered by the aircraft, short waves (with a spatial scale of about 100 m) in the southwesterly flow that seems to be associated with low-level wind effects of the buildings, and turbulent flow based on the eddy dissipation rate (EDR) maps as determined from the radial velocity measured by the LIDAR. Future developments in the application of short-range LIDAR would also be discussed.

S2P– 06

FORECASTING HEADWIND PROFILES AND LOW LEVEL WINDSHEAR USING LIDAR VELOCITY DATA AND A CHAOTIC OSCILLATORY-BASED NEURAL NETWORK

P.W. Chan[1], K.M. Kwong[2]

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[2]Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China

Two Doppler LIght Detection And Ranging (LIDAR) systems have been operated by the Hong Kong Observaotry (HKO) at the Hong Kong International Airport (HKIA) for the detection and alerting of low-level windshear to be encountered by the aircraft. The windshear alerting algorithm is based on the automatic identification of abrupt changes of headwinds along the glide paths of HKIA, which are measured by glide-path scan of the LIDARs. In order to give earlier windshear alerts to the aircraft, forecasting of the headwind profiles would be required. The present paper discusses the forecast of headwinds based on the past LIDAR data and a chaotic oscillatory neural network (CONN). The LIDAR's headwind data in the previous 30 days or so are used to train the CONN, which is then used to forecast the headwind profiles in the next hour. For two selected cases as presented in the paper, the CONN forecasts successfully capture the evolution of the headwind profiles. Moreover, the use of CONN forecast to give windshear alerts in demonstrated in one sea breeze case. The forecast alerts are generally comparable with those based on the actual LIDAR observations. As such, based on the limited number of episodes considered in the paper, the application of CONN to LIDAR data has the potential of forecasting the major features of the evolution of the headwind profiles and thus providing windshear alerts up to 1 hour in advance.

notes

S2P – 07

DOPPLER WIND LIDAR MEASUREMENTS OF THE LAND AND SEA BREEZE IN QINGDAO COASTAL AREA

Songhua Wu[1], Zhishen Liu[1], Huang Li[2], Zhangjun Wang[1], Decang Bi[1], Rongzhong Li[1], Bingyi Liu[1], Zhigang Li[1]

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[2]Chinese Academy of Meteorological Sciences, No. 46 Zhongguancun South Street, Beijing, China

The Doppler wind lidar is developed and deployed by Ocean University of China/Ocean Remote Sensing Institute to study the land and sea breeze behavior at city coastal area. The lidar site locates at city seashore of Fushan Bay, the northwestern shore of the Yellow Sea, adjacent sea to the Northwest Pacific Ocean. The Doppler lidar performed nearly horizontal scans through the atmosphere. Analysis of Doppler velocity data from these scans revealed details on the growth of the sea breeze and on the horizontal variability of the sea breeze. Three different stages of the land-sea-breeze circulation are discussed: the offshore land-breeze flow, the transition to the onshore flow, and an onshore sea-breeze. Simultaneous measurements from buoys and predictions from numerical weather models have supported the interpretations. This research shows the direct-detect Doppler lidar's capability to observe small-scale and mesoscale dynamics by employing horizontal or three dimensional scans of wind field.

S2P – 08

HORIZONTAL MOTION VECTORS FROM CROSS-CORRELATION: FIRST APPLICATION TO EYE-SAFE AEROSOL LIDAR DATA FROM CHATS

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Results are presented from the application of the cross-correlation technique to data collected with an eye-safe ground-based scanning aerosol backscatter lidar at 1.5 microns wavelength. The resulting motion vectors are compared with sonic anemometer measurements collected from a tower located within the lidar scan area. This paper describes the image processing and numerical steps implemented thus far in a software program to compute the horizontal motion vectors from the aerosol lidar data and two comparisons of the resulting vectors with corresponding anemometer data. In one case spanning 2.5 hours, speed and direction are plotted every 17 s using lidar data from a 250 × 250 m^2 area during weakly stable and nearly quiescent evening conditions. In the other case spanning 3 hours, speed and direction are plotted every 30 s from a 500 × 500 m^2 area during more turbulent afternoon conditions and the passage of a density current front. While a previous study demonstrated comparable spatial resolution using a non-eye-safe lidar system, this paper shows higher temporal resolution results from an unattended lidar system that is eye-safe.

S2P – 09

DEVELOPMENT OF A COHERENT DOPPLER LIDAR TO MEASURE WINDSHEAR

Jiqiao Liu, Xiaopeng Zhu, Jun Zhou, Fu Yang, Yan He, Weibiao Chen

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Airborne Doppler lidar for measuring windshear ahead of aircraft could improve flight safety. A 1064nm pulsed coherent Doppler lidar prototype was designed and developed to measure windshear of 2km range in the lower troposphere layer. An injection-seeded pulsed Nd:YAG laser was built with pulse duration of 80ns, pulse energy of 0.5mJ and pulse repetition rate of 200Hz. The lidar system was assembled and preliminary experiment result with hard target reflected signal at the range of 250m was presented. Wind speed and windshear measurement experiment would be implemented in the next four months.

S2P – 10

A WIND LIDAR COMPARISON EXPERIMENT AT THE HOWARD UNIVERSITY BELTSVILLE ATMOSPHERIC OBSERVATORY

B. Demoz[1], B. Gentry[2], T. Bacha[1], K. Vermeesch[2,6], H. Chen[2,6], D. Venable[1], G. Koch[3], U. Singh[3], M. Boquet[4], L Sauvage[4], E. Joseph[1]

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A wind lidar experiment was completed at the Howard University Beltsville Campus. Three lidars were used: the NASA/Goddard Laboratory for Observation of Winds (GLOW), the NASA/Langley Validation Lidar (VALIDAR), and a commercial lidar from Leosphere (WLS70). The lidars compared well with each other, with radiosonde data, a 915 MHz wind profiler and data from the Aircraft Communications Addressing and Reporting System (ACARS), as transmitted by NOAA's the Meteorological Assimilation Data Ingest System (MADIS) database. VALIDAR and GLOW are also used to demonstrate a combined profiling of wind from ground to 15km altitude.

S2P– 11

ATMOSPHERIC WIND SPEED ESTIMATION FROM LASER BEAM IMAGE CENTROID MEASUREMENTS

A.L. Afanasiev, A.V. Petrakov, A.P. Rostov

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The results of experimental tests of optical method for integrals wind speed measurement, based on measurement of coordinates variation speed of laser beam image centroid in turbulent atmosphere are presented. Comparison of obtained wind speed values with synchronous data from independent optical method based on spatial and temporal correlation analysis of intensity fluctuations is done. Its shown, that there is a satisfactory match between wind speed estimates, acquired from different methods based on analysis of spatial-temporal structure of distortions of laser beam image for the same experimental realizations as well as with the data from acoustic anemometers placed on beam propagation path at the time of optical measurements.

S2P – 12

METHOD OF TRACING ON ENERGY FLUX STREAMLINES IN AN OPTICAL WAVE PROPAGATING IN TURBULENT ATMOSPHERE THROUGH GRADIENT OF MUTUAL COHERENCE FUNCTION

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In our report methods of evaluation of mutual coherence function and construction of streamlines of energy-flux vector of optical wave propagating in turbulent atmosphere are presented. First method is based on using of conversation of Fresnel integral and 2-D Fast Fourier Transformation procedure (FFT), and the second one is based on relation between gradient of mutual coherence function and real part of average Umov-Poynting vector of partially coherent optical field propagating in turbulent atmosphere. Proposed methods are suitable for optical waves with arbitrary initial distribution of amplitude and phase, and for various spectra of correlation function of refractive index fluctuations and profiles of structural characteristic of refractive index. For verification of developed methods, evaluations of coherence function and streamlines of energy-flux vector of first Laguerre-Gaussian mode of laser beam carried out and the results are presented in our report.

S2P– 13

CROSS-CORRELATION TECHNIQUE FOR WIND VELOCITY OPTICAL MEASUREMENT ALONG THE ATMOSPHERIC PATH

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The cross-correlation technique when applied to optical devices working in turbulent atmosphere has a fast-growing area of applications in last years. In this paper we discuss three different algorithms for optical measuring average wind velocity along the ground atmospheric propagation path using both intensity and phase fluctuations of coherent laser source. Computer simulation of different cross-correlation algorithms has been performed based on a numerical solution of scalar parabolic wave equation using a split-step method in conjunction with a dynamic “frozen” turbulence media model. The influence of wind changes along the propagation path on an accuracy of different measurement algorithms has been estimated.

S2P– 14

1.5 MM INCOHERENT DOPPLER LIDAR USING A FBG FILTER

Y. Shibata[1], C. Nagasawa[1], M. Abo[1], M. Tsukamoto[2], T. Honda[2]

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We develop a compact incoherent Doppler lidar with all-fiber type receiver at the wavelength of 1.5 μm since this wavelength range has advantages such as eye-safety, availability of reliable fiber optics, and high measurement accuracy. A Fiber Bragg Grating (FBG) filter is used as a Doppler shift detection device. The laser frequency tunes at the slope midpoint of the FBG filter, and the Doppler shift component can be detected with the change in the ratio of the transmitted light and reflected light in the FBG filter. The light source which pulsed the output of a DFB-LD by an acousto-optic modulator (AOM), and amplified it by an erbium-doped fiber amplifier (EDFA) was developed. The output power of the AOM was amplified 500 times by the EDFA and

the final output obtained 16.0 dBm (40 mW) at 20 kHz. The light source which has high power, high repetition, small size, and narrow spectrum has achieved. Moreover, we compared the wind profiles measured in the field using the Doppler wind lidar and an ultrasonic anemometer. The average wind difference between the lidar and the ultrasonic anemometer was 0.24 m/s.

S2P– 15

DEVELOPMENT OF A MOLECULAR DOPPLER WIND LIDAR

Dong Ji Hui

Anhui Institute of Optics and Fine Mechanics, Chinese Academy of Sciences

A mobile doppler lidar based on molecular backscattering for measurement of wind in the stratosphere is under development in Hefei, China. The configuration of lidar system is described at first. Then the analysis, optimization and simulation of the system are introduced. Finally, the primary experimental results are provided. The result indicated that the detection range of the designed doppler lidar reached 50km altitude.

S2P – 16

TWO-COLOR ADAPTIVE PHASE CORRECTION. NUMERIC ASSESSMENT OF EFFICIENCY

V.A. Sennikov, P.A. Konyaev, V.P. Lukin

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In the report the results of numerical simulation are presented of two-color adaptive correction for distortions of a laser beam propagating through a turbulent atmosphere. The turbulence-distorted phase of a beacon with wavelength 1 was used for adaptive phase correction of the main Gaussian or Super-Gaussian beam with wavelength̃ In our numeric experiments focused and collimated main laser beams were considered. Results of calculations were obtained under conditions of weak and strong turbulence. Efficiency of the two-color adaptive optics system was estimated using Strehl ratio for different wavelength. We compared these data with results of traditional phase correction when.

S2P– 17

POSITION OF THE SHARP IMAGE PLANE FOR LASER BEAMS IN TURBULENT ATMOSPHERE

Grigory A. Filimonov, Vadim V. Dudorov, Valeriy V. Kolosov

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The results of numerical simulation of propagation of limited laser beams of different radius through the turbulent atmosphere and their focusing by a receiving optics are presented. The sharp image plane, where a beam image is of minimum angular size, has been searched. The dependence of sharp image plane position on atmospheric turbulence strength has been studied. The numerical simulation results are compared with approximate analytical estimations. It is shown that the position of sharp image plane is defined by a constant for all limited laser beams within the region of strong turbulent fluctuations.

S2P– 18

ANISOPLANATIC TURBULENCE COMPENSATION IN INCOHERENT IMAGING

Vadim V. Dudorov, Valery V. Kolosov

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The efficiency of phase compensation for optical incoherent imaging based on reference field scattered by the rough surface of a finite-size object is investigated. The research is carried out based on the method which is further improvement of algorithm for numerical simulation of incoherent imaging through the atmosphere in conditions of anisoplanatic turbulence [Lachinova S.L., Vorontsov M.A., Dudorov V.V., Kolosov V.V., and Valley M.T. Proceedings of SPIE. 2007. V. 6708. 67080E]. The efficiency of image correction based on incoherent reference source, significantly exceeding the diffraction-limited size, is shown. A possibility of phase compensation of incoherent images of an object illuminated by radiation with different wavelengths is investigated as well. The dependence of degree and region of the image quality improvement on the ratio of the reference wavelength to the image-forming radiation one is shown.

S2P – 19

CALCULATION OF OROGRAPHIC WAVE PARAMETERS FOR ATMOSPHERIC APPLICATIONS

Koval A.V., Gavrilov N.M.

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Internal atmospheric waves play an important role in the formation of variations of wind and other parameters in the atmosphere. Interpretation of observations of atmospheric waves requires the development of simple numerical schemes, which provide a satisfactory description of wave oscillations with minimum computer time. One important source of atmospheric waves is the topography of the Earth's surface. Wind interacts with the irregularities of the relief and the result is a stationary atmospheric wave. In our study the method developed by Scinocca and McFarlane is used as a basis. In this method a concept of so called "subgrid" topography is used, which involves variations of the heights of the terrestrial surface with horizontal scales smaller than a step of the horizontal grid, which is used in atmospheric dynamical models. In the vicinity of each grid point the “subset” orography is characterized by elliptical mountain barriers. After that, the horizontal force acting on an elliptical mountain by the incident horizontal flow is calculated. Then, using the polarization ratio for stationary gravity waves, one may obtain expressions for the total wave-energy transfer, wave-amplitudes and wave acceleration in the case of stationary waves. The main new feature of the developed method is usage of the theory of stationary waves propagation in an inhomogeneous atmosphere for calculating orographic wave amplitudes and other parameters at different altitudes up to the middle and upper atmosphere. Using the dispersion equation and polarization relations for stationary waves in a rotating atmosphere we obtained the equation of wave action (or energy) change in the inhomogeneous atmosphere similar to that one obtained previously for nonstationary waves. This equation is solved to obtain wave parameters for different atmospheric applications. Results we achieved show important wave fluctuations that should be taken into account in atmospheric dynamic models. Developed method may be useful for interpretation of for laser radar measurements of atmospheric dynamics.

Session 4P: Aerosol Characterization and Direct and Indirect Effects on Climate – Poster Presentations
Co-Chairs: Igor Veselovskii, Boyan Tatarov

S4P– 01

DUST STORMS IMPACT ON RADIATIVE PROPERTIES OF THE ATMOTHPERE AT FAR EAST REGION

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This paper the results of vertical ozone distribution and its dynamics investigations are presented. In the beginning we present atmosphere elements that can impcat on ozone vertical distribution and dynamics at the Primorskiy krai. These are jet streams and dust aerosols. Second part of the report is conected with processes of clouds transformation under dust aerosol and jet treams condition. Then we show and describe process of cirrus cluds formation and development at the coastal zone at the Primorskiy krai.

S4P – 02

REFINEMENT OF DUAL-WAVELENGTH AEROSOL RETRIEVAL MODELS THROUGH ANALYSIS OF HIGH SPECTRAL RESOLUTION LIDAR DATA FROM THE TEXAQS/GOMACCS CAMPAIGN

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The Constrained Ratio Aerosol Model-fit (CRAM) technique is a method for making aerosol retrievals from elastic backscatter lidars and which relies upon characteristic dual-wavelength aerosol models to constrain the retrievals. The NASA Langley Airborne HSRL is an airborne high spectral resolution lidar capable of directly measuring aerosol backscatter and extinction profiles at 532 nm and having the capability for elastic backscatter measurements at 1064 nm. Aerosol measurements from the HSRL instrument during the TEXas Air Quality Survey/Gulf Of Mexico Atmospheric Composition and Climate Study (TEXAQS/GOMACCS) campaign are used to validate existing aerosol retrieval models for application of the CRAM technique, in particular to data from CALIPSO.

S4P– 03

AEROSOLS AND CLOUDS STUDIES DURING WINTER USING INDIGENOUSLY DEVELOPED MICRO PULSE LIDAR

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This paper reports the results of lidar profiling during winter season at New Delhi (28°65' *N*, 77°28' *E*). A MPL (micro-pulse lidar) has been indigenously designed and developed for aerosol studies at National Physical Laboratory, New Delhi, India using a low energy Pico-second pulsed Nd: YAG laser at 532 nm. The conventional receiver optics is used along with PMT in single photon detection mode. Stanford research

system's multi-channel scalar (MCS) is being used with a personal computer for data acquisition. Due to short laser pulse and fast MCS high spatial resolution of 0.75 meter has been achieved. The control circuit has been designed to sense telescope cover status (open or closed) to avoid mistake in dark count and background data acquisition. The complete control software and Graphical User Interface (GUI) has also been developed in Visual Basic. The Micro Pulse Lidar developed is being used for aerosols studies. This system provides backscatter intensity profiles and both parallel and perpendicular polarization corresponding to each state of polarization of the transmitted laser radiation. From the elastic backscattered signals in P and S channels, depolarization ratio is derived which in turn provides the aerosol structure. On 16th November, a cloud is found at about 2 km. The boundary layer is found to be decreasing from 0.6 to 0.2 km from evening to morning and depolarization ratio shows higher value at higher altitude indicating non-spherical particle at the altitude.

S4P – 04

ATMOSPHERIC AEROSOL LOAD MORPHOLOGICAL CLASSIFICATION AND RETRIEVED VISIBILITY BASED ON LIDAR BACKSCATTER MEASUREMENT

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In this paper, the tropospheric aerosol load morphological classification and its impact on temporal variation of visibility are investigated using a continuous 23-hour single channel CSIR-NLC mobile LIDAR backscatter measurement. The trajectory of the air mass that arrived at the measurement site (Pretoria, 25º 44' S; 28º 11' E) was traced back using on-line HYSPLIT model. The visibility range has been calculated and presented, using average aerosol extinction co-efficient profile and assuming that the atmosphere is homogeneous. The results show that the measurement site is loaded predominantly in the middle and upper troposphere by a transported hazy air mass.

S4P – 05

FORECASTING OF AEROSOL EXTINCTION AT MARINE AND COASTAL ENVIRONMENT

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The focus of our study is the extinction and optical effects due to aerosol in a specific coastal region. The aerosol microphysical model of the marine and coastal atmosphere surface layer is considered. The model is made on the basis of the long-term experimental data received at researches of aerosol sizes distribution function (dN/dr) in the band particles sizes in 0.01 - 100 μk. The model is developed by present time for the band of heights is 0 - 25 m. Bands of wind speed is 3 - 18 km/s, sizes fetch is up to 120 km, RH = 40 - 98 %. Key feature of model is parameterization of amplitude and width of the modes as functions of fetch and wind speed. In the paper the dN/dr behavior depending at change meteorological parameters, heights above sea level, fetch (X), wind speed (U) and RH is show. On the basis of the developed model with usage of Mie theory for spheres the description of last version of developed code MaexPro (**M**arine **A**erosol **Ex**tinction **Pro**files) for spectral profiles of aerosol extinction coefficients a(l) calculations in the wavelength band, equal λ = 0.2 - 12 μm is presented. The received results are compared models NAN and ANAM. Also a(l) profiles for various wind

modes (combinations X and U) calculated by MaexPro code are given. The calculated spectrums of a(l) profiles are compared with experimental data of a(l) received by a transmission method in various geographical areas.

S4P – 06

OPTICAL PROPERTIES OF MARINE AEROSOLS, SAHARAN DUST, AND DUST AND BIOMASS BURNING AEROSOLS-LIDAR MEASUREMENTS DURING SAMUM 2

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The second field campaign of the Saharan Mineral Dust Experiment took place in Praia, Cape Verde Islands, In January and February 2008. Range resolved measurements of the extinction-to-backscatter ratio Sp (lidar ratio) and the linear particle depolarization ratio δp were performed with the two lidar systems MULIS and POLIS of the Meteorological Institute of the Ludwig-Maximilians Universität München. During the campaign we found good conditions to observe three types of aerosols: aerosol of the marine boundary layer with a mean lidar ratio of 15–30 sr and a linear particle depolarization ratio of 0.014–0.035 at 355 nm and 532 nm, pure transported dust with Sp of 55–70 sr for both wavelengths, δp of 0.23–0.27 at 355 nm and 0.3–0.35 at 532 nm, and mixtures of dust and biomass burning aerosols with Sp between 60 and 90 sr and δp between 0.13 and 0.2.

S4P – 07

ANALYSIS OF SPATIOTEMPORAL DYNAMICS OF AEROSOL OPTICAL DEPTH ACCORDING TO SATELLITE AND LIDAR DATA IN PRIMORSKY KRAI DURING SPRING 2009

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Institute of Atmospheric Optics SB RAS studies for a few years the spatiotemporal dynamics of the atmospheric parameters at different locations around the world. For this, different data sources are used (e.g., satellite and ground-based measurements, model data). In spring 2009, in collaboration with Institute for Automation and Control Processes FEB RAS, complex aerosol experiment was undertaken to study the spatiotemporal dynamics of the radiation components of the atmosphere for the littoral region in Primorsky Krai and Sea of Japan. In the first part of the work, the photometric measurements were performed in combination with the satellite data to estimate the spatiotemporal variability of aerosol optical depth (AOD) in the study region. Satellite data also allowed us to identify the dominating aerosol sources in the atmosphere. The second part considers a joint analysis of the data of lidar atmospheric sensing, back trajectory analysis of the motion of air masses, and satellite monitoring of the state of the atmosphere. The analysis results gave more complete information on the scales and character of the atmospheric processes, responsible for enhanced variability of the optical and microphysical characteristics of the atmospheric aerosol, which was recorded in the integrated measurements during spring 2009.

S4P – 08

VERTICAL PROFILES OF PM10 CONCENTRATIONS DERIVED FROM MOBILE LIDAR MEASUREMENTS IN THE FRAMEWORK OF THE MEGAPOLI EXPERIMENT

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A compact and mobile lidar has been deployed around Paris onboard a van during the MEGAPOLI (Megacities: Emissions, urban, regional and Global Atmospheric POLlution and climate effects, and Integrated tools for assessment and mitigation) summer experiment in July 2009. The measurements performed with this Rayleigh-Mie lidar have been converted into PM_{10} concentrations profiles using optical to mass relationships determined during previous campaign around Paris. This method is here described and an example of application on the 1st July 2009 is presented and compared with ground-based stations from Airparif network. Such an approach is a powerful way for the validation of air quality mesoscale models.

S4P – 09

VERTICAL CHARACTERIZATION OF DUST INTRUSIONS: SYNERGETIC GROUND-BASED LIDAR AND AIRBORNE MEASUREMENTS

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In the frame of VALIDAR (Vertical measurements by Airborne and Lidar Instrumentations for Dust Aerosol Research) campaign, synergetic height-resolved measurements have been performed in the Atmospheric Sounding Station 'El Arenosillo' (ESAt-INTA) (37.0ºN 6.7ºW, 40 m a.s.l.), located at the Southwest of the Iberian Peninsula, in July 2008. Furthermore, AERONET (AErosol Robotic NETwork) columnar-integrated measurements are also used. This campaign is focused on the identification and vertical characterization of dust intrusions by both ground-based lidar and airborne measurements under heavy dust loading conditions in summertime. Results reveal the strength and weakness on aerosol vertical characterization for each type of instrumentation (ground-based lidar and airborne particle counter probe) used during VALIDAR campaign. In general, a good agreement is achieved between both datasets of height-resolved measurements, depending on the aerosol scenario proposed for data inversion. Comparison between MPL-retrieved extinction and AERONET-derived Aerosol Optical Depth (AOD) daily evolutions reflects a similar behavior along the day except at around noon times, when MPL data present higher values (likely due to an artifact on lidar measurements at low solar zenith angles). Main results can be directly applied in aerosol radiative forcing assessment, aerosol modeling validation and dust short- to long-range transport monitoring.

S4P – 10

RETRIEVAL OF DUST PARTICLE PARAMETERS FROM MULTI-WAVELENGTH LIDAR MEASUREMENTS USING MODEL OF RANDOMLY ORIENTED SPHEROIDS

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The algorithm based on a model of randomly oriented spheroids for the inversion of multi-wavelength lidar data is presented. The aerosols are modelled as a mixture of two components: one composed only of spherical and second composed of non-spherical particles. The non-spherical component is an ensemble of randomly oriented spheroids with size-independent shape distribution. The accuracy of the retrieved particle surface, volume concentration, and effective radius for 10% measurement errors is estimated to be below 30%. If the effect of particle non-sphericity is not accounted for, the errors in the retrieved aerosol parameters increase notably. The algorithm was tested with experimental data from a Saharan dust outbreak episode, measured with the BASIL multi-wavelength lidar.

S4P – 11

AEROSOL-LAYER PROPERTY STUDIES BY POLARIZATION LIDAR AND SKY-RADIOMETER OVER HEFEI, CHINA IN SPRING

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Aerosol depolarization ratio (δ) and aerosol back-scattering coefficient (β) were measured by Polarization Lidar at Hefei (32°N, 117°E), China during the period from 2007 to 2008. From the time-series of profiles observed in spring (Mar., Apr., May), aerosol-layers are picked out, which are different from background aerosol. Then the layer-integrated depolarization ratio (δ′) and average layer-integrated backscatter (β′) are calculated and analyzed, including the averaged heights and geometric depths of these aerosol-layers. Three types of aerosol-layers are given occurring in 2-8km with different values of these parameters. Meanwhile, a groud-based Sky-radiometer was uesd to measure direct and diffuse solar irradiances at the same place. The aerosol optical and physical parameters were simultaneously retrieved using the SKYRAD.PACK code and their statistical characteristics were studied corresponding to the three types of aerosol-layers. At last, the aerosol components and sources of these three types are analyzed preliminarily. These results can provide an important informantion to estimate radiative forcing due to different aerosols.

S4P – 12

RETRIEVAL OF TIME-SEQUENCES OF PARTICLE PARAMETERS FROM MULTI-WAVELENGTH LIDAR MEASUREMENTS USING PRINCIPAL COMPONENT ANALYSIS

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The aerosol backscattering and extinction coefficients measured by a Raman lidar at multiple wavelengths are inverted with regularization and principal component analysis (PCA) techniques to get the vertical profiles of the particle microphysical parameters. The comparison performed demonstrates that the integral particle parameters, such as volume density, effective radius and the complex refractive index retrieved with both techniques are in agreement. Meanwhile, PCA is faster and more tolerant to the errors in input data, thus it may be preferable when large amounts of lidar data must be managed. The developed PCA algorithm was applied to the data acquired during measurements in Turkey in June-July 2009. The 3b+2a lidar data sets were inverted to evaluate the temporal variation of vertical profiles of the particle parameters.

S4P – 13

STATISTICAL CHARACTERISTICS OF ATMOSPHERE AEROSOLS ACCORDING TO COMPLEX AEROSOL EXPERIMENT AT THE PRIMORSKY KRAI IN SPRING, 2009

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In this paper resuts of aerosol experiment in ocean-continent zone at the Sea of Japan coast are presented. Measurements were taken at two regions: Gornotayozhniy village (about 80~km from sea) and from a board of the vessel ``Nadezhda''. Experiment includes both active and passive measurements of atmosphere aerosols properties. It was shown, that major part of aerosol loading of the atmosphere is provided by forest fires. This kind of aerosol was transported in lower troposphere. At high altitudes was transported from Taklamakan desert.

S4P – 14

COMPARISON OF DEPOLARIZATION RATIO MEASUREMENTS WITH MICRO-PULSE LIDAR AND A LINEAR POLARIZATION LIDAR IN LANZHOU, CHINA

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Measurements of mineral dust and cirrus cloud with a Micro-Pulse Lidar (MPL4) and a linear polarization lidar were compared at the Semi-Arid Climate and Environment Observatory of Lanzhou University (SACOL) site in Lanzhou, China. The linear depolarization ratio converted from the MPL depolarization ratio agreed with that measured with the linear polarization lidar within 10%. However, slight systematic differences were seen in cirrus cloud and mineral dust measurements in different senses. Non-random orientation of ice particles in cirrus cloud may be the causes of the differences, but the reason for the mineral dust particles is not known. The difference does not significantly affect the total lidar signal power of MPL4, and the attenuated backscattering coefficients from the two lidars agreed reasonably.

S4P– 15

LONG-TERM VARIATIONS OF ATMOSPHERIC AEROSOL CONDENSATION ACTIVITY IN WEST SIBERIA

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Transformation of atmospheric aerosol under impact of the relative humidity of air change its scattering and absorbing properties and, hence, its climatic effects. Correct account for the aerosol in radiative and climatic models needs knowledge of the seasonal and regional peculiarities of the aerosol hygroscopicity. The data of long-term measurements of the dependence of the submicron aerosol scattering coefficient on relative humidity in the near-ground layer of the atmosphere carried out at the Aerosol monitoring station of IAO SB RAS are analyzed. To study the dynamics of the optical characteristics under the effect of relative humidity, the approach was applied based on separate investigation of the optical parameters of the dry matter of aerosol particles and their change during the process of humidification. The characteristic peculiarities of the annual behavior of the parameter of submicron aerosol condensation activity are revealed. Their stability from year to year is shown. The quasi-periodic structure of interannual variations of the parameter of condensation activity is revealed. Their relations with aerosol microphysical characteristics are considered.

S4P – 16

OPTICAL, MICROPHYSICAL AND CHEMICAL PROPERTIES OF SAHARAN DUST AEROSOLS USING A MULTI-WAVELENGTH RAMAN LIDAR, *IN SITU* SENSORS AND MODELLING

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A very strong Saharan dust event occurred over the city of Athens, Greece (37.9°N, 23.6°E, 200 m above sea level-asl.), between March 27 and April 3, 2009. The dust event was followed by the National Technical University of Athens (NTUA) 6-wavelength Raman lidar system which was used to retrieve the optical (extinction and backscatter coefficients) properties of aerosols in the troposphere. The DREAM model was used to forecast the dust event and to provide the vertical profile of the aerosol concentration. The hybrid regularization technique was used to derive the mean aerosol microphysical properties (mean and effective radius, number, surface and volume density, and mean complex refractive index) in different layers between 1.8 and 3.5 km asl. The final data set of the aerosol optical and microphysical properties along with the water vapor profiles were incorporated into the ISORROPIA II model to infer the chemical parameters of the aerosols (water content, dry chemical composition) that are consistent with the retrieved refractive index values. Additional, *in situ* sampling of dust aerosols was performed to infer the mass concentration and the chemical and morphological properties of the dust particles near ground.

S4P – 17

FIRST REGULAR MULTI-WAVELENGTH RAMAN LIDAR MEASUREMENTS IN PORTUGAL - OVERVIEW

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A new lidar station was setup up at Évora and provides for the first time regular measurements in Portugal. Capabilities and features of the 3+2 Raman lidar with a depolarization channel will be presented with respect to atmospheric aerosol properties and meteorological features in general. An outlook providing future directions of the use of this instrument will be given as well.

S4P – 18

AUTOMATIC AEROSOL CLASSIFICATION USING MULTIWAVELENGTH LIDAR DATA

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Rapid and automatic procedures for the estimation of aerosol class are sometimes preferable to complicated algorithms. This paper presents a fully automatic algorithm which provides real time classification of aerosols in a delimited layer. It is based on previous knowledge about optical properties of various aerosols' and uses 4 parameters to extract the "probable class". Level 2 optical parameters such as Angstrom coefficients, color ratios, particle depolarization and AOD are calculated and compared to the typical range for various aerosol classes. Algorithm's outputs were checked against air masses circulation (HYSPLIT) and satellite (MODIS) for several dust or smoke cases.

S4P – 19

THE COMBINED USE OF CALIPSO, MODIS AND OMI LEVEL 2 AEROSOL PRODUCTS FOR CALCULATING DIRECT AEROSOL RADIATIVE EFFECTS

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We describe a technique for combining CALIPSO aerosol extinction and backscatter, MODIS spectral AOD (aerosol optical depth), and OMI AAOD (absorption aerosol optical depth) measurements for the purpose of calculating direct aerosol radiative effects. We show sensitivity studies and first results of the methodology applied to airborne observations collected in the ARCTAS field campaign. Radiative fluxes modeled based on the multi-sensor aerosol retrievals compare reasonably well with radiative fluxes measured by an airborne spectral flux radiometer aboard the same aircraft.

S4P – 20

AEROSOL OPTICAL PROPERTIES IN MOSCOW AND BACKGROUND REGION

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Aerosol is one of the most variable atmospheric substances affecting the radiative budget and climate of the planet. Passive ground-based aerosol optical sounding is, along with lidar and satellite observations, one of the main methods for monitoring of the columnar aerosol. The data obtained by means of sun-sky photometers can also be used for calibration and validation of other ground and space based instruments. One of the problems in aerosol climatology is correct account of the contribution of big cities and megalopolises in regional aerosol loading. The megalopolis effect can be studied by means of simultaneous measurements of the aerosol extinction over city and in near-by rural region free of significant sources of aerosol pollution. In the present paper we compare the results of measurements by two CIMEL sun-sky photometers, included into the global AERONET network. Photometers are located at the Meteorological Observatory of the Moscow State University (MO MSU) and at the Zvenigorod Research Station (ZRS) of the Institute of Atmospheric Physics in 50 kilometres to the west from the MO MSU. The level 2.0 data obtained in 2008 were involved in the analysis.

S4P – 21

STUDY ON SPECTRAL LIDAR-RELATED OPTICAL PROPERTIES OF MINERAL DUST AEROSOL WITH COMPLEX MICROPHYSICAL PROPERTIES

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Due to the complex microphysical properties of mineral dust aerosol, simplifications of the microphysical properties are necessary to simulate dust properties in optical models. However, these simplifications may affect the model results. In the present study, spectral lidar-related optical properties, i.e. the Angstrom exponent, the lidar ratio, and the linear depolarization ratio of mineral dust aerosol with varying microphysical properties are simulated. Spheroids and complex-shaped particles, as well as homogeneous and external mixtures, are considered in the simulations to investigate the effect of simplifications. It is found that the consideration of external mixtures influences the spectral dependence of the lidar ratio. Differences between complex-shaped particles and spheroids are calculated for the absolute values of the lidar ratio and the linear depolarization ratio. Comparisons with SAMUM lidar measurements show that it is possible to find aerosol ensembles that are in agreement with the parameters measured by lidar. An aerosol ensemble consisting of externally-mixed complex-shaped particles achieves agreement with SAMUM 2006 lidar measurements.

S4P – 22

POTENTIAL OBSERVATIONS OF CLOUD-AEROSOL INTERACTION WITH A MULTIPLE-WAVELENGTH RAMAN-ELASTIC LIDAR

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Measurements of low-altitude cloud and its interaction with aerosol are analyzed with a multiple-wavelength elastic-Raman lidar. Using the numerical experiment approach, we first evaluate the retrieval accuracy of cloud extinction from the Raman-lidar algorithms, in particular at the cloud edges. For the low-level water-phase cloud, the simulation also shows the dramatic variation of lidar-ratio, color-ratio and extinction-ratio with the small droplet size and their correlation. In particular, measurement examples by CCNY elastic-Raman lidar illustrate that significant increase in small droplets formation occurs at the cloud edges as well as enhanced hygroscopic aerosols near the cloud interface. Finally, we observe weak but positive correlations between small droplet formation and enhanced aerosol loading indicative of indirect aerosol cloud interaction.

S4P – 23

LIDAR RATIO OF SUBMICRON AEROSOL CONTAINING BLACK CARBON IN A CONDENSATION PROCESS

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The paper is devoted to numerical simulation of the lidar ratio of aerosol containing black carbon (BC) in visible wavelength range as function of relative humidity at different assumptions about the content of BC in aerosol particles. Transformation of the lidar ratio under the effect of increasing relative humidity of air is studied. The proposed technique is applied to the aerosol size distributions obtained from inversion of the data of nephelometric measurements in the real atmosphere. The results can be useful when interpreting the data of lidar measurements.

S4P – 24

ONE YEAR OF RAMAN LIDAR MEASUREMENTS AT GUAL PAHARI CLOSE TO DELHI IN INDIA

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We have established a one year campaign to measure aerosol vertical profiles in Gual Pahari, India. The station is located about 40 km south of Delhi and represents a semi-urban environment, surrounded mainly by agricultural test fields and light vegetation. The measurements were conducted with a seven-channel Raman lidar called Polly^{XT} from March 2008 to March 2009. The output of the instrument includes vertical profiles of the particle backscattering coefficient at three wavelengths (355, 532 & 1064 nm) and of the particle extinction coefficient at two wavelengths (355 & 532 nm). In addition, such size/composition-dependent, intensive particle quantities as the Ångström exponents, the lidar ratio and depolarisation can be determined. Boundary layer heights derived from the lidar measurements were compared with values from ECMWF (the European Centre for Medium-Range Weather Forecasts) model and radio soundings. In Gual Pahari, up to 5 km thick aerosol layers were observed, with AODs well above one. The lidar-based AOD values were in line with the values obtained from MODIS (The Moderate Resolution Imaging Spectroradiometer) satellite instrument. Often multi-layer aerosol structures were observed. Furthermore, statistics of the boundary layer evolution and the typical backscattering and extinction profiles for the different seasons were defined.

S4P – 25

CALIPSO OBSERVATIONS OF AEROSOL PROPERTIES NEAR CLOUDS

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Clouds are surrounded by a transition zone of rapidly changing aerosol properties. Characterizing this zone is important for better understanding aerosol-cloud interactions and aerosol radiative effects as well as for improving satellite measurements of aerosol properties. We present a statistical analysis of a global dataset of CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) lidar observations over oceans. The results show that the transition zone extends as far as 15 km away from clouds and it is ubiquitous over all oceans. The use of only high confidence level cloud-aerosol discrimination (CAD) data confirms the findings. However, the results underline the need for caution to avoid biases in studies of satellite aerosol products, aerosol-cloud interactions, and aerosol direct radiative effects.

S4P – 26

LIDAR MEASUREMENTS OF ATMOSPHERIC AEROSOLS

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This paper discusses the problem of the reliability with which the characteristics of atmospheric aerosols are determined from the results of lidar, photoelectric, and filter measurements including data comparisons. The efficiency of lidar methods for probing the atmosphere is determined by the definiteness of the region in which they are applicable. The correlation between the optical characteristics of the atmospheric aerosols and the aerosol concentration is discussed. The results of determining the characteristics of atmospheric air contaminated with industrial discharges, and automotive exhausts are presented.

S4P – 27

CALIPSO LIDAR OBSERVATIONS OF MINERAL DUST AND BIOMASS BURNING AEROSOLS DURING THE WEST AFRICAN DRY SEASON

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We present aerosol vertical profiles obtained from the space-based lidar CALIOP onboard CALIPSO during the dry season (January 2007) over West Africa. CALIOP identified the presence of depolarizing [particle depolarization (*d*) ~ 30%], large-sized [lidar Ångström exponent (*LAE*) £ 0] dust particles at low levels (< 1.5 km), originating from the Sahara desert, and elevated layers of biomass burning smoke aerosols (*d* <10%, *LAE*: 0.6~1.1), transported from the biomass burning regions to the south (<10ºN), between 2 and 5 km. The layer-averaged aerosol backscatter to extinction ratio (*BER*) values were 0.015~0.018 sr^{-1} for the elevated biomass burning aerosol layers and 0.026~0.028 sr^{-1} for the dust-rich surface layers. The ultra-light aircraft (ULA)-based lidar system and airborne in-situ measurements during the AMMA dry season campaign in Jan-Feb 2006 also confirmed that this aerosol vertical distribution is a repeating feature of the African monsoon dry season. These dust and biomass burning aerosol layers seem to mix to form a single layer of mixed highly-scattering aerosol over the Tropical Atlantic Ocean, as indicated by intermediate values of particle depolarization ratio (10~17%), lidar Ångström exponent (0.16 ~ 0.18), and layer-averaged *BER* value (0.021~0.022 sr^{-1}).

S4P – 28

CHARACTERIZATION OF ATMOSPHERIC AEROSOLS FOR A LONG-RANGE TRANSPORT OF BIOMASS-BURNING FROM NORTH AMERICA OVER THE IBERIAN PENINSULA

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This work presents the characterization of atmospheric aerosols performed over the Iberian Peninsula in the framework of EARLINET (European Aerosol Research LIdar NETwork) for a special episode on 20th August 2007. The assessment of aerosol radiative impact requires an accurate determination of their optical and microphysical properties, which are presented here for a variety of instrumentation including passive remote sensors, as sun-photometers, and active systems both ground-based and on board CALIPSO satellite. Measurements highlight the presence of a multilayered structure with a well-defined planetary boundary layer and biomass-particles in elevated layers, extending up to 7 km asl over the central Iberian Peninsula, and even higher, up to 9 km asl at the south-eastern part of the peninsula. The backward trajectories analysis reveals as main source region the East coast of North-America, where many forest fires were active during the first part of August 2007, as MODIS sensor indicates. Lidar computations reveal a contribution to the aerosol optical depth around 10-40% for these biomass-burning particles, with backscatter-related Angström exponents around 2-3 for different spectral ranges.

S4P – 29

AEROSOL CHARACTERIZATION WITH DUAL-WAVELENGTH AND POLARIZATION LIDAR DURING JAPANESE CLOUD SEEDING EXPERIMENT

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Dual-wavelength and polarization lidar measurements of aerosol and clouds were made during the warm cloud seeding experiments of Japanese Cloud Seeding Experiment and Precipitation Augmentation (JCSEPA) in 2008/09. The aerosol optical properties obtained with the lidar were compared with the microphysical properties obtained from the aircraft-based measurements in order to assess the utility of the lidar measurement for characterizing the background aerosol condition relevant to the cloud seeding. The result of the comparison shows that the backscattering coefficient at 532 nm correlated well the particle number concentration with diameter larger than 0.3 mm (correlation coefficient of determination r=0.87) for the period June to July. The case study on 1 July 2008 showed that the depolarization ratio (d) was as high as 20% and the backscatter wavelength exponent ($å$) $å$ was mostly lower than 0.5 at an altitude range of 4–6 km, suggesting that supermicrometer-sized nonspherical dust were present, whereas d was low (~2.5%) and $å$ ~0.7 at an altitude range of 0.5–1.0 km, suggesting that

submicrometer-sized sulfate particles and supermicrometer-sized sea-salt droplets are predominant. These are qualitatively consistent with the results of electron microscopic analysis of the aerosols collected with the aircraft. Further study is needed for the quantitative estimation of the aerosol microphysical properties.

S4P – 30

DETERMINATION OF BACKSCATTER-EXTINCTION COEFFICIENT RATIO FOR LIDAR-RETRIEVED AEROSOL OPTICAL DEPTH BASED ON SUNPHOTOMETER DATA

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Backscattered power data from the Doppler LIght Detection And Ranging (LIDAR) systems at the Hong Kong International Airport (HKIA) could be used to obtain the extinction coefficient of the troposphere by combining with the meteorological optical range (MOR) data from the nearby forward scatter sensors. The Range-height Indicator (RHI) scan of the LIDAR is then utilized to derive the vertical profile of extinction coefficient, which is integrated with height to obtain the aerosol optical depth (AOD). In the retrieval of extinction coefficient profile, there is a power exponent of unknown value relating the backscattered power and the extinction coefficient. This exponent (called the backscatter-extinction coefficient ratio) depends on the optical properties of the aerosol in the air, and is normally assumed to be 1. In the present study, the value of this ratio is established by comparing the AOD measurements by a hand-held sunphotometer and the LIDAR-based AOD estimate in one winter (October 2008 to January 2009) at HKIA, which is the season with the largest number of haze episodes. It is found to be about 1.4. The sensitivity of extinction coefficient profile to the value of the ratio is also examined for two cases in the study period, one good visibility day and one hazy day.

S4P – 31

SHIP-BORNE LIDAR-DERIVED OPTICAL PROPERTIES OF SOUTHERN BIOMASS BURNING AEROSOLS

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The aerosol extinction properties are documented in the southern Indian Ocean. A unique set of ship-borne measurements aboard the research vessel Marion Dufresne has been collected with a dual polarized Rayleigh-Mie lidar in the framework of the « Kerguelen Aerosol Measurement from African Sources and plUmes Trajectory Reverse Analysis » (KAMASUTRA) campaign during the Southern Hemisphere (SH) biomass burning (BB) season. A BB aerosol layer has been observed in the region between [38° S; 77° E] and [28° S; 64° E] within an altitude range between 0.5 and 2 km above the mean sea level. Both vertical structure and aerosol optical properties have been retrieved from the inversion of the lidar signals. Sun photometer-derived optical thickness (AOT) at 355 nm is used to constrain the lidar inversion and leads to a mean value of the backscatter-to-extinction ratio (BER) of 0.026 sr^{-1} with a standard deviation of 0.014 sr^{-1}. The presence of BB aerosols is confirmed when comparing lidar observations with the simulations performed with the reGIonal ReAl time Fire plumEs (GIRAFE) model, based on the FLEXPART code and the Moderate-Resolution Imaging Spectroradiometer (MODIS) fire counts, which confirms the African BB origin of the encountered aerosol layer.

S4P – 32

ON POSSIBILITY TO RETRIEVE THE AEROSOL OPTICAL CHARACTERISTICS FROM DIFFUSE RADIATION MEASUREMENTS IN SOLAR ALMUCANTAR IN THE CLOUDY ATMOSPHERE

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As is well known, the spectral measurements of direct and diffuse solar radiation can be used to retrieve many optical and microphysical characteristics of atmospheric aerosol. The existing methods are developed for application under clear-sky conditions; so their utility in many regions of the globe, where clouds are ubiquitous, is very limited. In this regard, an important problem is to explore the usability of well-known methods of retrieving the aerosol characteristics under conditions of broken clouds. We present the results of the studies of angular structure of downward diffuse radiation in solar almucantar during appearance of clouds. To construct the cloud realizations, we used the model based on the Poisson point fluxes in space. The calculations of the spectral brightness of the molecular-aerosol (B_{clr}) and the cloudy (B_{cld}) atmospheres were performed using original Monte Carlo methods under assumption that clouds are approximated by simplest geometric bodies (ellipsoid, inverted truncated paraboloid of rotation). It is shown that, for low cloud fractions outside relatively small region of the cloud effect, the difference between $B_{cld}(\lambda,\varphi)$ and $B_{clr}(\lambda,\varphi)$, φ is the viewing azimuth angle, is within the brightness measurement error (5%). With growth of the cloud amount, the region of viewing azimuth angles where $B_{cld}(\lambda,\varphi)$ substantially differs from $B_{clr}(\lambda,\varphi)$ markedly increases. This result indicates that, for *little-cloud* situations, there is a possibility to develop the procedures of eliminating the cloud contamination from diffuse brightness measurements and to use them subsequently for retrieval of aerosol optical characteristics.

S4P – 33

BIOMASS BURNING MEASUREMENTS IN BRAZIL - ANALYSIS FROM NEAR AND FAR SOURCES WITH TWO LIDAR SYSTEMS

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Brazil has an important role in the biomass burning aerosol activity. During the Dry Season (June- September) of 2007 at Sao Paulo-SP and during the Dry season of 2009 at Rio Claro-SP, both in Brazil, aerosol profiling campaigns were carried out using a backscattering LIDAR system. The objective of this work is to evaluate the effects of the biomass burning in the southeastern Brazil, over distant (Sao Paulo - SP) (23 33'S, 46 44'W) and near (Rio Claro - SP) (22 23S, 47 32W) regions of the source of burnings mainly through laser remote sensing (LIDAR).

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LONG–RANGE SCANNING MIE LIDAR FOR QUANTITATIVE MEASUREMENTS OF ATMOSPHERIC EXTINCTION OVER VIPAVA VALLEY, SLOVENIA

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A Mie lidar system with vertical scanning and long-range detection capabilities is used for the study of atmospheric conditions in the lower troposphere. Atmospheric properties can be deduced from the 2-dimensional (2D) Cartesian range-height-indicator (RHI) diagrams of the weighted logarithm range-square-corrected lidar return signals, obtained by scanning through the elevation angles between 0º and 20º with an angular step of 0.5º. Based on the multiangle method and the assumption of horizontal atmospheric homogeneity, the optical depth and the atmospheric extinction are calculated using the data extracted from the 2D RHI diagrams. The changing of the atmospheric conditions and the variation of the elevated aerosol layer in lower troposphere are presented in the successive atmospheric extinction profiles.

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AEROSOL MODELS FOR PROCESSING OF DATA OF TWO WAVELENGTH SENSING

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New approach to processing of data of two wavelength sensing is proposed, which is based on *a priori* information summarized in a number of aerosol models for different aerosol types. Backscattering coefficients are determined by means of iteration procedure with use of approximation relations between lidar ratios and ratio of backscattering coefficients at sensing wavelengths. Similar approximations obtained from aerosol models are used for calculations of integral spectral parameters of aerosol.

S4P – 36

LONDON POLLUTION OBSERVED USING THE SYNERGY BETWEEN GROUND-BASED MOBILE LIDAR AND AIRBORNE MEASUREMENTS

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A field campaign (EM25) was conducted in London between 15 and 23 June 2009 in order to study the influence of emissions from within the London orbital motorway (M25) in terms of both aerosol and gaseous concentrations within the planetary boundary layer (PBL). The main instrumental set-up was distributed between two mobile platforms: the airborne platform FAAM (British Facility for Airborne

Atmospheric Measurements, BAe 146) and a van that was driven around the M25. FAAM was equipped to perform in situ measurements of aerosol scattering, size and composition properties and also ozone, nitrous oxides and carbon monoxide concentrations within the planetary boundary layer. The van was equipped with an eye safe backscatter lidar emitted at 355 nm with two cross polarisations. The synergy between airborne and ground based measurements makes it possible to identify the origin of aerosol origin during this original experiment. Aged aerosol appears associated with a small depolarized ratio (some %) whereas younger aerosol showed a value significantly larger (~8%). Such difference is confirmed when analysing the airmass origin and the airborne measurements.

S4P – 37

STUDY OF CORRELATION BETWEEN PM10 MASS CONCENTRATION NEAR THE GROUND AND AEROSOL OPTICAL DEPTH (AOD)

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This work aims to analyze the relationship between in situ measurements of PM_{10} mass concentrations near the ground and daily mean AERONET Aerosol Optical Depth (AOD) values. Measurements were performed with sun-photometers part of the Aerosol Robotic Network (AERONET) for AOD, and low-volume samplers near-ground for in situ PM_{10} mass concentrations. The analysis was applied for summer months of the years 2007 and 2009. Although, several factors like aerosol vertical distribution or hygroscopic growth factor could affect the link between PM_{10} ground measurements and aerosol optical depth, our linear regression analysis results have shown significant correlation coefficient, around 0.70. Therefore, the columnar observation can be transferred to near surface conditions, for the meteorological situations observed during our analysis. This study showed that it is possible to use sun photometric measurements in order to improve existent air quality surveillance or to extend their spatial coverage.

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AEROSOL LIGHT-ABSORPTION PROPERTIES OF EAST ASIAN AEROSOLS DERIVED FROM MULTI-WAVELENGTH RAMAN LIDAR DATA

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We present optical and microphysical particle properties, especially the particle single-scattering albedo, of atmospheric aerosol particles observed with multi-wavelength Raman lidar at Gwangju, Korea (35.10°N, 126.53E°) and Anmyeon island (36.32°N, 126.19°E). The results present aerosol properties in various altitudes of the atmospheric pollution layers observed over the Korean peninsula. We categorized the observed aerosol layers into three types: anthropogenic urban/industrial pollution transported from China, smoke transported from Siberia, and local haze. The origin of the particle plumes was determined with HYSPLIT 5-day backward trajectory analysis. The source regions of the particles result in rather clear differences between the optical and microphysical properties of the pollution layers. The mean value of the single-scattering albedo of anthropogenic aerosols from China (0.90 ± 0.02 at 532 nm) is much lower than the mean value of the single-scattering albedo of smoke aerosols advected from Siberia and northern China (0.94 ± 0.02 at 532 nm). For local haze aerosols we find an

even higher mean single-scattering albedo (0.96 ± 0.01 at 532 nm). We assume that most of the differences in the light-absorption characteristics of aerosol pollution from Korea and China are caused by hygroscopic particle growth rather than the particle aging effect during transport.

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INVESTIGATIONS OF THE VERTICAL DISTRIBUTION OF TROPOSPHERIC AEROSOL LAYERS USING THE DATA OF MULTIWAVELENGTH AEROSOL SENSING

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From March 2006 to October 2007 regular lidar observations of vertical aerosol distribution at Tomsk (56^0N, 85^0E), West Siberia, have been performed within the framework of CISLINET, the lidar network in the CIS territories. A statistical analysis concerning the vertical distributions of the backscatter and extinction coefficients, and lidar ratio derived from multiwavelength Raman lidar measurements (355/387nm and 532/607nm and 1064nm) for the planetary boundary layer and free troposphere is presented here.

S4P – 40

COMPARISON OF AEROSOL OPTICAL PROPERTIES BETWEEN RAMAN LIDAR AND SUN PHOTOMETER MEASUREMENTS OVER BEIJING, CHINA

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The comparison of aerosol optical properties between Raman lidar and sun photometer measurements were conducted from 17 April to 12 June 2008 over Beijing, China. The comparison provides the complete knowledge of aerosol optical and physical properties. The averaged aerosol optical depth (AOD) at 675nm was 0.81 and Angstrom exponent between 440nm and 675nm was 0.99 during experiment. The lidar derived AOD at 532nm in planetary boundary layer (PBL) was 0.48, which implies the half of total AOD is contributed by the aerosols in PBL. The negative correlation between lidar ratio and TDR indicates the lidar ratio decreases with aerosol size because that the high TDR associates with the nonspherical and large aerosols. It's proved by the observed volume size distribution of aerosols showing the coarse mode radius located near 3mm in dust case, bi-mode with fine particle centered at 0.2mm and coarse particle at 2mm in pollution and clean cases. In conjunction with the observed surface wind field near lidar site, most of pollution aerosols were produced locally or transported from the southeast of Beijing, whereas the dust aerosols associated with the clean air mass were transported by the northwestly or southwestly wind.

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RAMAN LIDAR MEASUREMENT OF WATER VAPOR AND AEROSOLS IN DAYTIME

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A multi-wavelength Raman lidar has been developed for the measurement of high vertical and temporal resolution profiles of water vapor and aerosol in daytime and nighttime. Water vapor mixing ratio and aerosol multi-parameters (e.g. extinction, backscatter, lidar ratio, and Angstrom exponent) can be derived from the lidar data. Using these measurements, different kinds of aerosols can be distinguished. A daytime measurement is presented, and four aerosol volumes are divided according to their optical properties and surrounding water vapor mixing ratio. Combining Raman lidar measurements with the volume depolarization ratio and wind measured by polarization elastic-backscatter lidar and wind profiler radar, the properties of the particles in these four volumes and their probable sources are discussed.

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FINE-DETECTION OF AEROSOL OPTICAL PROPERTIES USING AN ULTRAVIOLET ROTATIONAL RAMAN LIDAR

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A method for fine-retrieval of aerosol optical properties using rotational Raman signals is demonstrated. Because the high and low quantum number lines of rotational Raman spectrum (RRS) signals have opposite temperature sensitivity, the sum of these RRS signals can be employed to eliminate their dependence on temperature. An ultraviolet rotational Raman lidar (RRL) system, which was ever used to measure the atmospheric temperature, was employed to retrieve the optical properties of aerosol by use of the Raman method usually used to retrieve the aerosol. Some experiments were carried out for verifying the feasibility of the method, and the observation results show that the fine detection of aerosol optical properties can be realized using the UV RRL system.

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CALIBRATION OF 1064NM CHANNEL AND RETRIEVAL OF AEROSOL EXTINCTION FROM CALIOP

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We described an algorithm to retrieve aerosol type and extinction by using CALIOP data. The algorithm consists of three parts; aerosol detection, re-calibration of 1064nm channel and retrieval of aerosol type and their extinction. The aerosol mask method was based on the aerosol/cloud discrimination schemes originally developed for analyses of the ship-based radar and lidar data. Retrieval algorithm of aerosol type and extinction was based on a three-channel algorithm developed using the ship-based lidar data. The unique feature of the algorithm was that the algorithm used two backscattering

coefficient at 532nm and 1064nm and depolarization ratio at 532nm and it allowed the mixture of three different types (small particles, dust and sea-salt) in the same grid. In order to apply the retrieval algorithm to CALIOP data, re-calibrate the CAIOP 1064nm signal was performed using water clouds. The water clouds were discriminated by the cloud particle type algorithm. We examined a ratio of derived values of backscattering coefficient at 1064nm to the value in the CALIOP standard product. The mean value of the ratio was about 0.8 and the ratio showed a latitudinal dependence. The aerosol retrieval algorithm was successfully applied to one-year of CALIOP data.

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ÅNGSTRÖM TURBIDITY COEFFICIENT AND WAVELENGTH EXPONENT DERIVED FROM A 355NM-532NM LIDAR AND A SUNPHOTOMETER IN MANILA, PHILIPPINES

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This paper presents real-time measurements of air quality in terms of the Ångström turbidity coefficient (B) and wavelength exponent (a) in Manila, Philippines using the De La Salle University (DLSU) 355nm-532nm Mie LIDAR and Middleton SP02 4-channel sunphotometer. Experiments were conducted last 2010 January 08, 12 and 22. The average B (B_{ave}) and average a (a_{ave}) up to 400 meters horizontal range from the LIDAR site was determined. For January 08, the LIDAR a_{ave} was 1.86 while the sunphotometer a_{ave} was 1.986. The LIDAR and sunphotometer $\underline{a_{ave}}$ for January 12 was 1.38 and 1.8, respectively. Finally, for January 22, the LIDAR a_{ave} was 1.98 while an average of 2.14 was observed for the Sunphotometer. These wavelength exponent values are within the range of values obtained by previous researchers. However, there is greater variability in the LIDAR a compared with the sunphotometer a. These a-values indicate that urban aerosols dominate the local atmosphere. In terms of the B_{ave}, the LIDAR values were 0.184, 0.23, and 0.0295, respectively for the three dates. The corresponding sunphotometer values are 0.191, 0.235, and 0.0280, respectively. The January 08 and 12 B-value show a turbid atmosphere while the January 22 indicate a relatively clear atmospheric condition.

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GEOMETRICAL AND OPTICAL PROPERTIES OF DIFFERENT AEROSOL LAYERS OVER THESSALONIKI LIDAR STATION

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In this study we present combined Raman/elastic backscatter lidar observations which were carried out at the EARLINET station of Thessaloniki, Greece, during the period 2001-2007. We have analyzed 340 lidar profiles in regard to geometrical features and optical properties of well defined aerosol layers. We present statistical information for the temporal and vertical variability of the geometrical thickness, base and top of the layers, along with the layer averaged aerosol extinction, lidar ratio and Ångström exponent. Finally we examine the dependence of these geometrical and optical characteristics on the air mass origin.

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STRONG DUST EVENT OVER ABASTUMANI/SOUTHERN CAUCASUS, GEORGIA, DURING MAY 2009. SUN-PHOTOMETRIC AND LIDAR MEASUREMENTS AND MODEL VALIDATION

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A strong dust event over Southern Caucasus (Geor-gia), extending to southern Russia, during May 2009, was captured and followed by concurrent lidar and sun photometry and finally used to validate a dust forecast model. During this event, high aerosol optical depth (AOD) values (0.45-0.57) were measured by the closest AERONET site, over Erdemli, Turkey. The mean size distribution of the particles remained close to 2.5 um, while the mean value of the Ång-ström exponent (a) was smaller than 1, indicating the dominance of large aerosols over the area. More spe-cifically, a, as retrieved from AERONET using the wavelength pair 440 and 870 nm, varied from 0.2 to 1.4. The coarse particles contribution to the total AOD was estimated approximately to 57%. The centre of mass of the dust plume was detected one day later, by a lidar system, located at the Na-tional Astrophysical Observatory of Georgia at Abas-tumani. The aerosol backscatter coefficient retrieved from the lidar measurements indicated the existence of strong particle load inside the Planetary Boundary Layer (PBL). The DREAM forecast model was applied to predict the movement of the dust aerosols from their source region to the studied area. Thus, the dust plume origi-nating from the Saharan and Arabic region deserts, under unusual meteorological conditions moved over Southern-South-eastern Turkey and arrived to Abas-tumani, Georgia before reaching Southern Russia, covering a vast total distance of more than 5500 km.

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OPTICAL PROPERTIES OF BIOMASS BURNING AEROSOLS IN RESPECT TO THEIR SOURCE DISTANCE OVER ATHENS, GREECE USING A 6-WAVELENGTH RAMAN LIDAR SYSTEM

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A 6-wavelength Raman lidar was used to obtain the optical properties (backscatter, extinction coefficient, lidar ratio-LR, Ångstöm exponent-AE) of biomass burning aerosol in the troposphere over Athens (37.9^{o}N, 23.6^{o}E, 200 m above sea level-asl.), Greece, during biomass burning events in the summer periods 2007-2009. Three cases of sampled air masses from forest fires were selected: originating 100, 1300 and 30 km from the source (biomass burning) region, thus, the aging of the pyrogenic aerosols was much different. The Raman technique was engaged for the independent calculation of the extinction and backscatter coefficient and thus, to obtain the lidar ratio of the aerosols inside the smoke layers. The NOAA HYSPLIT model was used for the air mass back trajectory analysis. The purpose of this paper is to compare the pyrogenic aerosol optical properties coming from various distances. Regarding the LR values they ranged from 60-120 sr (at 355 and 532 nm), while the AE values were of the order of 1-2, indicating the presence of rather small particles.

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STATE OF STRATOSPHERIC AEROSOL LAYER IN 2006–2009 ACCORDING TO DATA OF LIDAR OBSERVATIONS IN TOMSK (56.5 N, 85.0 E)

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Based on data of regular lidar observations of the stratospheric aerosol layer at midlatitudes of Tomsk, we recorded an elevated aerosol content in periods: late 2006 – spring 2007, August – autumn 2008, associated with explosive eruptions of tropical-belt volcano Rabaul (October 2006) and midlatitude volcanoes: Okmok (June 2008) and Kasatochi (August 2008); as well as subsequent explosive eruptions of volcanoes in 2009. The background state of the stratospheric aerosol layer, which was observed from 1997 to September 2006 under the conditions of long-term volcanically quiescent period, was interrupted, which should be taken into account in trend analysis of variations of the background component of the stratospheric aerosol.

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RAMAN LIDAR DATA RETRIEVAL AS INVERSE PROBLEM

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The retrieval of aerosol extinction and backscatter coefficients from a Raman lidar is formulated as an inverse problem. The starting point are the single scattering lidar equations for elastic and inelastic scattering. It is shown with a simulated example of lidar signals without noise, that it provides a better height resolution than the commonly used algorithm. In addition the formulation of the Raman lidar data retrieval as inverse problem might open up the possibility to use established methods to solve inverse problems.

S4P – 50

AEROSOL SOUNDING AT ARURAL SWEDISH AREA AND IN AMAJOR CHINESE CITY – ACOMPARATIVE STUDY WITH THE LUND LIDAR SYSTEM

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The vertical distribution of atmospheric aerosol particles was measured with the Lund mobile lidar system both at a mainly rural location in southern Sweden and in a major city in the south-east of China. Thereby, two sites with completely different prerequisites regarding, e.g. population density, could be compared straightforwardly. Since exactly the same system and sampling methods were used, the lidar signals obtained at the two sites could be compared already in their raw form and still provide information about the differing scattering properties. Results showing the extinction coefficient profiles at the two sites are also presented.

notes

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AEROSOL AND CIRRUS OBSERVATION BY THE CEILOMETER CHM15K

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Ceilometers are compact low-power one-wavelength elastic-backscatter lidars designed for long term stand-alone operation under a wide range of environmental conditions. Their main purpose is the detection of clouds and other restrictions of the vertical visible range like fog or haze. The high sensitivity of the laser ceilometer CHM15k in eye safe operation results from the use of a narrow bandwidth solid state laser source instead of a diode laser that is more often used. Long uninterrupted time series of high-quality, stable measurements in a network with suitable spatial resolution are important for a number of scientific disciplines like climate and environmental research as well as weather or air quality prediction. Ground-based and space-borne remote sensing instruments are essential tools of modern earth sciences. Sophisticated research instruments usually need trained operators, cannot be run in any weather condition and their price limits the application in networks. Current laser ceilometers could fill some of these gaps for lidar observations, if their sensitivity, calibration and errors are well investigated and documented. This article compares cirrus and aerosol observations, which are beyond the usual capabilities of ceilometers, with Raman lidar measurements.

S4P – 52

SAHARAN DESERT DUST MICROPHYSICAL PROPERTIES FROM PRINCIPLE COMPONENT ANALYSIS (PCA) INVERSION OF RAMAN LIDAR DATA OVER WESTERN EUROPE

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A large Saharan desert dust outbreak in May 2009 was detected using a Raman lidar, deployed in Leipzig, Germany. The optical data showed three distinct vertical layers, two with little spectral variation in the extinction, and one with a large spectral variation in both the scattering ratio and extinction measurements. Furthermore, the layer with the large spectral variation showed much larger particle depolarisation ratios and lidar ratios than the two other layers, which is typical for Saharan desert dust. Backtrajectory and dust distribution forecast and hindcast models showed that the different layers all originated over the Sahara, but had different transport histories. The measurements were inverted to derive microphysical properties of the particles in the layers. The method derives integral properties of the aerosols using principle component analysis, adapted for use in the troposphere. It accounts for varying refractive indices of the ambient aerosols, as shown in this paper.

S4P – 53

PROPERTIES OF ARCTIC AEROSOL MEASURED DURING PAM-ARCMIP CAMPAIGN

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During the international PAM-ARCMIP campaign in March and April 2009 data of Arctic Haze events have been recorded by the Koldewey Aerosol Raman Lidar (KARL), located in Ny-Ålesund, Spitsbergen, at 78.9N, 11.9E. In this paper a case study of the Arctic Haze properties is discussed. Lidar ratios (LR), which are quite variable in altitude but surprisingly constant with time, and slightly lower than normal (25sr to 56sr at 532nm) were found. An inversion of the microphysical properties of this aerosol was performed. The variability in LR is suggested to be an effect of particle size (and not chemical composition), as the derived refractive index did not vary with time or altitude.

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CHAITÉN VOLCANIC AEROSOL TRANSPORT STUDY DURING MAY 2008

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During May 2008 several aerosol plumes were observed along the Argentinean territory moving from mid-west of the country. These air masses affected incident solar radiation, local air quality and visibility. Their origin was the Chaitén Volcano which last eruption took place on May 3rd. CEILAP (CITEFA-CONICET) Lidar Division remote sensing instruments monitored this aerosol intrusion. The results of these measurements combined with backtrajectories and space born satellite instrument measurements are presented to show a comprehensive analysis of this event.

S4P – 55

THE COMMON CALCULUS CHAIN DEVELOPED IN THE FRAME OF THE EARLINET-ASOS PROJECT

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EARLINET-ASOS (European Aerosol Research Lidar Network - Advanced Sustainable Observation System) is a 5-year EC Project that started in 2006. Based on the EARLINET infrastructure, it will provide appropriate tools to improve the quality and availability of continuous lidar observations. The project addresses optimizing instruments and algorithms existing within EARLINET-ASOS, exchanging expertise, with the main goal to build a database with high quality aerosol data. One of the core activities is the optimization of the algorithms for the retrieval of the aerosol optical and microphysical properties. The main goal is to develop a common processing chain for the evaluation of lidar data within the network, from raw signals to final products. Raw signals may come from different types of systems, and final products are profiles of

aerosol optical properties, like backscatter and extinction, and, if the instrument properties permit, of microphysical properties. Several modules have been developed and are now operative after they have been tested on the synthetic lidar signals used during the algorithm intercomparison performed in the frame of the project.

S4P – 56

AEROSOL AND ATMOSPHERIC BOUNDARY LAYER TEMPORAL EVOLUTION IN BUENOS AIRES, ARGENTINA DURING MAY 12, 2006

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In this work, we identify an aerosol layer microphysical properties change in a heavily polluted atmosphere by means of a Multiwavelength Lidar and a sunphotometer. The dual wavelength attenuated backscatter resolved aerosol layer permitted to identify the region of interest even without using Raman channels. Additional sunphotometer network information as well as ground based meteorological information permitted to induce the changes produced on this layer. In this work, we identify an aerosol layer microphysical properties change in a heavily polluted atmosphere by means of a Multiwavelength Lidar and a sunphotometer. The dual wavelength attenuated backscatter resolved aerosol layer permitted to identify the region of interest even without using Raman channels. Additional sunphotometer network information as well as ground based meteorological information permitted to induce the changes produced on this layer.

S4P – 57

ASIAN DUST MEASURMENTS BY TWO WAVE LENGTHS DEPOLARIZATION LIDAR OVER SUWON, KOREA IN 2009

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Since 2002, we have measured the Asian dust using by the ACA lidar at Suwon, Korea. The ACA is compact Mie lidar system operating 24 hours continuously. In 2009, we have measured four cases of Asian dust using the lidar. Especially, autumn and winter dust cases were observed and examined. The dust layer was located in lower altitude below 2 km except the cases measured on March. The depolarization ratios of the Asian dust are in the range of 20-30%. And the ratio of backscatter coefficient (1064/532 nm) is below 0.6 in the cases of autumn but about 1 in winter and March. The ratio of depolarization ratio (1064/532 nm) is in the range about 1–3.4.

Session 6P: Trace Gas Sensing for Climate and Air Quality – Poster Presentations
Co-Chairs: Edward Browell, Anatolii Boreisho

S6P – 01

CARBONYL COMPOUNDS AND GENERATION OF TROPOSPHERIC OZONE

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Correlation between ozone concentration and ethylene in the urban atmosphere is both demonstrated and supported by a photochemical smog model. Experimental results hence ascertain that ethylene as hydrocarbon plays a role in tropospheric ozone generation.

S6P – 02

SUPERCONTINUUM LIDAR ABSORPTION SPECTROSCOPY FOR GAS DETECTION & CONCENTRATION ESTIMATION

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Supercontinuum Lidar absorption spectroscopy (SLAS) appears as a promising tool for air composition monitoring and trace gas remote sensing in industrial environment. In this paper, we first propose to evaluate the performances of SLAS for the simultaneous estimation of multiple-species gas concentrations. The precision of maximum-likelihood estimators is assessed through numerical simulation and compared to the theoretical bounds. We also study the ability of SLAS to detect efficiently the presence of an "anomalous" gas cloud. These theoretical results show the good detection capabilities of SLAS-based gas remote sensing and will be useful for the design of upcoming SLAS systems.

S6P – 03

VERTICAL LIDAR MEASUREMENTS OF HG AND NO IN THE ATMOSPHERE OF A MAJOR CHINESE CITY

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Vertical range-resolved measurements of atmospheric pollutants were performed in a major city in southern China, employing a lidar system operating with an optical parametric oscillator transmitter. Recordings of atomic mercury and nitrogen monoxide absorbing in the deep UV region were taken yielding concentration profiles only attainable with lidar techniques. In particular, the potential influence of molecular oxygen in low-concentration mercury monitoring was elucidated. Diurnal observations are discussed in view of weather parameters.

S6P – 04

REMOTE SENSING OF NITROGEN DIOXIDE PROFILES WITH THE RIVM MOBILE LIDAR

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The RIVM mobile lidar system is capable of measuring NO2 profiles in the troposphere, up to about 4 km, with high vertical resolution in the boundary layer. The purpose of these measurements is to provide tropospheric NO2 profiles for the interpretation and validation of satellite data. The instrument participated in the CINDI campaign, held in June and July 2009. During this campaign, the lidar measurements were compared with measurements from NO2 monitors equipped with photolytic converters. The results show an excellent agreement between both instruments. Further, a great number of NO2 profile measurements were obtained to monitor the development of the NO2 profiles during the day.

S6P – 05

INSPECTION METHOD OF RADIOACTIVE EMISSION FROM NPP

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The problem of radioactive pollution of the lower atmosphere by emission from enterprises of nuclear fuel cycle is the most important and urgent ecological problem in the recent years. Nuclear power plants (NPP) working continuously is a stationary source of gas-aerosol emission which presented in a ground surface layer persistently. In the result of radioactive emission the untypical effects of the standard atmosphere can be observed, for example: occurrences of areas with increased ionization, increased concentration of some gases caused by photochemical reactions. The gases itself and their characteristic radiation can be markers of radioactivity and can be registered by passive method. For example the atomic hydrogen and hydroxyl in unexcited states are formed by radiolysis of water molecules and other hydrogen-containing air components and spontaneously radiate at 1420 MHz and 1667 MHz respectively. The passive method of remote monitoring by radiofrequencies radiation of H and OH from radioactive emission of nuclear power plant is described. The model data indicative of the registrability of radiation on these frequencies are produced.

S6P – 06

HIGH SPEED REMOTE MONITORING OF HAZARDOUS URANIUM HEXAFLUORIDE BY LIDAR

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Uranium hexafluoride molecule is highly toxic and escape to the atmosphere has environmental and health significant . This paper proposes an ultraviolet differential absorption lidar (UV-DIAL) long range remote sensor for quick spatial distribution monitoring and identification of UF6 leaked into the atmosphere as well as detection of leakage location to repair it. The system uses a frequency-quadrupled Nd:YAG laser for the on wavelength and a Nd:YAG-pumped Coumarin dye laser using a grating Littrow mounting operating in the frequency doubled mode for the off wavelength. It is synchronously pumped with the 532-nm light from the diode-pumped Nd:YAG system to achieve tunable light around 245 nm. By mapping the UF6 distribution concentration

over an area, the leakage location can be determined due to UF6 absorption at 245 nm. This is particularly true in UF6 leak detection applications such as UF6 - storage container, -cylinder and -pipeline.

S6P – 07

ATMOSPHERIC AIR MONITORING IN CUBATΓO CITY USING LIDAR

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The Lidar technique is an efficient tool for continuous monitoring of air pollution over urban areas, with high temporal and range resolution. In this paper, based on the Lidar methodology, we present the first results obtained with mobile Lidar. A Raymetrics, LR101-V-D200 was used in the tests. The laser source is a pulsed Nd:YAG laser emitting short pulses at 532 nm, vertically pointing optical remote sensing device to derive vertical profiles of aerosols by measuring backscattered radiation for monitoring industrial pollutants emissions in Cubatão city, that is one of the largest petrochemical and industrial in Brazil that has been subject of severe damage caused by massive emissions of pollutants, as a result of the progressive industrialization in the area. Therefore it is necessary to monitory the area to be able to control and to prevent ambient problems. In a partnership with the University of Sao Paulo (USP) the Brazilian oil company PETROBRAS has started off an Environmental Research Center located in the industrial site. This work show the first results obtained with a mobile lidar in Cubatão City.

S6P – 08

AIRBORNE MEASUREMENT OF THE WEIGHTED COLUMN CARBON DIOXIDE MIXING RATIO USING 1.57 MICRON DIRECT DETECTION AMCW LASER ABSORPTION SENSOR

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Greenhouse gases observing satellite (GOSAT) has been continued to measure global CO2 column abundances since the launch on 23 January, 2009. Various calibration and validation activities have been conducted during its Cal/Val phase. During the phase, we conducted aircraft measuement in August 2009 in order to take vertical profiles of CO2 with in situ devices. The demonstration of the 1.57um laser absorption sensor is carried out to show the properly validated performance of weighted column averaged CO2 mixing ratio. The resultant indicates the system with the moderate altimeter can identify the return signal whether the signal is land or others. In addition, during this campaign we collected vertical profiles of CO2 in the altitude range from 0.5 to 7km. The weighted column CO2 mixing ratio obtained from some spiral flights are also agreement with that from theoretical value of in situ measurements.

S6P – 09

DIFFERENTIAL OPTICAL ABSORPTION SPECTROSCOPY (DOAS) MEASUREMENTS OF ATMOSPHERIC CO2 USING A COHERENT WHITE LIGHT CONTINUUM

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We have been developing a coherent "white light" lidar using a terawatt laser system at 800 nm with a 9 m length krypton gas cell, which emits a coherent white light continuum from UV to near infrared regions. Current research is focused on finding applications in near infrared region of the white light. We have observed the infrared lidar signals at 950 nm ~ 1200 nm using the white light lidar system. The observed infrared signals were enough for future differential absorption lidar DIAL observations. Also, a differential optical absorption spectroscopy (DOAS) system has been built to measure near-surface (1-m height) CO2 concentrations in the atmosphere using a coherent white light continuum.

S6P – 10

CHARACTERISTICS AND TRANSPORT PROCESSES OF ASIAN DUST AND AIR POLLUTANTS TO TAIWAN

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Long-range transport of Asian dust and air pollutants are major environmental concerns of Taiwan during the winter monsoon season when northeasterly winds prevail following passages of cold fronts. Based on meteorological data and hourly measurements of Taiwan Environmental Protection Administration (TEPA) air quality monitoring stations, Lidar and in-situ IC, two long-range transport dust events with significant different atmospheric conditions types have been identified. For the dry case, dramatically elevated concentrations of PM10, CO and SO2 along with the strong northeasterly on March 19 were observed over background Wanli station, with peaks of about 200~250μgm-3, 1.0 PPM and 19 ppb, respectively. Results from TEPA ground stations, RCEC/ASNTU Lidar, and sampling monitoring consistently showed that the transport of this dust episode accompanied with significant air pollutants after the frontal passage. For the wet case, actually it is a "mud rain" episode, air pollutants stayed at the low levels (NOx<5 ppb, SO2 <3ppb, CO <0.3 PPM) when PM10 concentration peaked around 300 ug/m3 on April 2, 2007. Meteorological conditions analysis indicated that significant precipitation occurred on the episode day. Trajectory analysis showed that most of the paths are over the ocean before reach Taiwan. The most effective washout and rainfall result in the low air pollutants concentration in wet case. Results from NAQPMS air quality model suggests that the predicted time series of Asian dust distribution agree excellent with the observation of Lidar that was measured in northern Taiwan. As dust and air pollutants are from different sources whether air pollutants are consistently carried by dust storms or not; it is strongly depended with the paths of the air masses transport and boundary dynamic.

S6P – 11

APPLICATION OF TUNABLE INFRARED LASER-DIODE ABSORPTION SPECTROSCOPY FOR CO CONCENTRATION MEASUREMENT IN NEAR-WALL LAYER OF POWER BOILER

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The paper presents application of the modified correlation method for CO concentration measurements aimed to use in power industry. Several experiments have been made to estimate errors caused by unequal temperature and pressure during calibration and measurement stage. Measurements were obtained for high CO concentrations (exceeding 50%) and for short optical path (1m and 2m long). The measurements can be treated as a reference for measurements for lower concentrations and longer optical paths. Simulations have showed, that the proposed method can be utilized in industrial condition for CO estimation in a near-wall layer of a power boiler.

S6P – 12

DEVELOPMENT OF COHERENT 2 MM DIFFERENTIAL ABSORPTION LIDAR WITH LASER FREQUENCY OFFSET LOCKING

Shoken Ishii[1], Kohei Mizutani[1], Hirotake Fukuoka[2], Takayoshi Ishikawa[3], Philippe Baron[1], Hironori Iwai[1], Tetsuo Aoki[1], Toshikazu Itabe[1], Atsushi Sato[4], and Kazuhiro Asai[4]

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We developed a coherent 2-mm differential absorption and wind lidar to measure CO2 concentration and line-of-sight wind speed. Measurable range of the developed lidar is limited due to the wavelength of on-line laser set at the R30 absorption line center of CO2. A laser frequency offset locking system was installed into the laser system to improved measurable range of CO2 concentration. Two single-frequency continuous wave lasers are used for the laser frequency offset locking. One laser (λCenter) of the two continuous lasers is directly locked to the R30 absorption line center of CO2 and the other (on-line, λOn) is frequency-shifted to λCenter laser. Although a long-range CO2 measurement depends on the frequency offset, the lidar realized to measure CO2 concentration in the range of up to about 7 km from the observation site.

S6P – 13

REMOTE DETECTION OF EXPLOSIVE VAPORS IN THE AIR

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This paper discusses the efficiency of the use of LIDAR methods for remote detection of explosives vapor trace amounts at atmospheric pressure and room temperature. The LIDAR detection principle is based on the combination of the one color laser fragmentation and the laser induced fluorescence of explosives fragments. To obtain the necessary sensitivity and to reduce the measurement time we have been applied a powerful tunable eximer KrF laser, which have a narrow line (5 pm) at the fringe of the

amplification envelope. This allows us to detect the 2,4,6-trinitrotoluene (TNT) vapors at distances of about 5m at room temperature in the first few experiments. We hope that further development and modification of the LIDAR system will allow us to reach higher sensitivities at longer distances.

S6P – 14

THE EFFECT OF COMPLEX TERRAIN ON OZONE DISTRIBUTION AND TRANSPORT IN THE LOS ANGELES BASIN

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Co-deployment of Doppler and DIAL lidars on aircraft platforms offers the potential to directly measure trace gas emissions and transport. Such measurements could be useful for characterizing emissions of greenhouse gases in remote areas or in situations where transport and dispersion of gases is not easily modeled. Extending earlier measurements of moisture transport based on airborne lidar measurements, we investigated application of the technique for characterizing horizontal flux of ozone from a NOAA Twin Otter aircraft. Performance tests with a commercially available Doppler lidar showed that deploying the instrument on the Twin Otter alongside the NOAA TOPAZ lidar could provide observations of horizontal ozone transport in the boundary layer. Our intention is to build on a preliminary study of ozone distribution in Southern California by deploying both instruments for two months during summer 2010 to study flux of ozone into and out of air basins.

S6P – 15

MEASURING TRACE GAS EMISSION AND TRANSPORT WITH AIRBORNE DOPPLER AND DIAL LIDARS

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We use airborne lidar measurements of ozone to characterize the distribution and transport pathways of ozone in and above the Los Angeles Basin. Data from several flights in July 2009 show orographic lifting of ozone along the slopes of the mountain ranges surrounding the Los Angeles Basin. We observed transport of ozone over two major mountain passes (Cajon and Banning Passes), lifting of ozone over the San Bernardino Mountains and subsequent transport into the Mojave Desert, and venting by the San Gabriel Mountains of high levels of ozone from the surface to ~4 km above mean sea level (ASL). The latter observation is in excellent agreement with a published model study, confirming that orographic venting is a potentially important pathway for removal of pollutants from the Los Angeles Basin. The lofting of ozone into the free troposphere also greatly increases the potential for long-range transport from the Basin, and trajectory calculations suggest that some of this ozone may have been transported ~1000 km to eastern Utah and western Colorado.

S6P – 16

A MOBILE LIDAR FOR MONITORING ATMOSPHERIC POLLUTANTS

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A mobile lidar for monitoring atmospheric pollutants in lower troposphere is presented. Its transmitter is based on stimulated Raman scattering laser. Five wavelengths is generated in high-pressure CH4, H2 and D2 gases, pumped by the fourth abd third harmonic of the pulsed Nd:YAG laser. The some results of SO2, O3 and aerosol measurements are presented. The lidar for monitoring pollutants in lower troposphere based on Raman laser makes its commercialization possible.

S6P – 17

DEVELOPMENT OF A 1.6MM DIAL FOR NIGHTTIME AND DAYTIME MEASUREMENTS OF VERTICAL CO2 PROFILES IN THE ATMOSPHERE

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The accurate vertical CO2 profiles are highly desirable in the inverse method to improve quantification and understanding of the global budget of CO2 and also global climate change. We have developed a 1.6 μm differential absorption lidar (DIAL) technique to perform high accurate measurements of vertical carbon dioxide (CO2) concentration profiles in the atmosphere. Our 1.6 μm DIAL system consists of the OPG (Optical Parametric Generator) transmitter that excited by the LD pumped Nd:YAG laser with high repetition rate (500Hz) and the receiving optics that included the near-infrared photomultiplier tube with high quantum efficiency operating at the photon counting mode and the narrowband interference filter (bandwidth:0.5nm). This 1.6 μm DIAL system is available to measure the vertical CO2 concentration profiles for nighttime and daytime. We also report the developing next generation 1.6 μm DIAL that can measure simultaneously the temperature and pressure profiles with the CO2 concentration profiles in the atmosphere because of improvement of the CO2 measurement accuracy.

S6P – 18

TROPOSPHERIC OZONE DIAL FOR AIR QUALITY AND CLIMATE MONITORING, AND VALIDATION STUDIES

Arnoud Apituley, Mink Hoexum, Charlos Potma, Keith Wilson

National Institute of Public Health and the Environment (RIVM), Bilthoven, The Netherlands

A Differential Absorption Lidar (DIAL) called tropO3 for routine profiling of tropospheric ozone is presented. The instrument is located at RIVM in Bilthoven, The Netherlands (52° N, 05° E). The instrument was built for routine observations and validation purposes. Recently, the system was modernised and upgraded for a study to validate tropospheric ozone products from AURA/OMI and to analyse the temporal and spatial variability and representativeness of satellite measurements of tropospheric

ozone. Under clear sky conditions, a full ozone profile from 1 km up to 12 km can be created in about 30 min., which enables high-resolution time series of tropospheric ozone profiles needed for the variability and representativeness study. Operation under low level cloud conditions with coverage up to 4 octa is possible. A description of the modernisation of the system is given and a re-assessment of the instrument performance is shown utilizing ozone sonde data from nearby stations in de Bilt (NL) and Uccle (B). Data is presented from an intensive observation period (CINDI) that will be used in the analysis of satellite data.

S6P – 19

FIELD TESTING OF A TWO-MICRON DIAL SYSTEM FOR PROFILING ATMOSPHERIC CARBON DIOXIDE

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A 2-μm DIAL system has been developed at NASA Langley Research Center through the NASA Instrument Incubator Program. The system utilizes a tunable 2-μm pulsed laser and an IR phototransistor for the transmitter and the receiver, respectively. The system targets the CO2 absorption line R22 in the 2.05-μm band. Field experiments were conducted at West Branch, Iowa, for evaluating the system for CO2 measurement by comparison with in-situ sensors. The NOAA's CO2 in-situ sensors were located on the WBI tower at 31, 99 and 379 m altitudes, besides the NOAA's aircraft was sampling at higher altitudes. Preliminary results demonstrated the capabilities of the DIAL system in profiling atmospheric CO2 using the 2-μm wavelength. Results of these experiments are presented and discussed.

S6P – 20

LIDAR REMOTE SENSING FOR ENVIRONMENTAL MONITORING AND AVIATION SAFETY

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Applications are increasing in the areas of urban and industrial air pollution, natural and anthropogenic accidents and disasters resulted in sudden emission of the toxic substances. Last decades have forced us to face the fact that it is necessary to be prepared for a terrorist attack in high populated areas. Capabilities of remote monitoring of pollutants and toxic agents minimize the damage that a catastrophe could cause. Lidar monitoring allows fast estimation of the size of the polluted area, detection of direction and measuring of speed of movement of the cloud of pollutant. Vehicle mounted, airborne and space systems could acquire the necessary data for monitoring and prognosis of the spreading of the pollutants and warfare agents. Laser Systems Ltd developed the vehicle mounted mobile complex for monitoring the environment conditions and analyzing meteorological parameters of the atmosphere. Multi-wavelength lidar system working in the spectral regions from middle-UV to middle-IR solves different tasks of atmosphere monitoring, including gaseous, aerosol and macromolecular polluting admixtures detection, measuring of wind speed and direction. Newly developed ground-based CW wind Doppler lidar is designed for wind profiling at low height under clear air conditions. The wind lidar being installed near the airports will allow measuring of the vertical profile of the wind and detection of the wake vortex that reduces aviation hazards.

S6P – 21

TRACE GASES REMOTE SENSING IN THE ATMOSPHERE OVER URAL

K.G. Gribanov, V.I. Zakharov, S.A. Beresnev*, V.A. Poddubny, R. Imasu***, P.A. Chistyakov****, G.G. Skorik****, and V.V. Vasin******

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Ural Atmospheric Fourier Station (UAFS) is arranged in Kourovka Astronomical Observatory of Ural State University. The UAFS situated at 57.038N and 59.545E in forest area and operated since July of 2009. The UAFS is equipped with commercial Bruker Optics IFS125M with spectral resolution of 0.0035cm-1 and automated solar tracker A547N. UAFS is intended for teledetection of trace gases in the atmosphere to validate satellite data (in particular TANSO-FTS/GOSAT data) and to accumulate the time series data on concentration of trace gases in the atmosphere for climate research. The groundbased FTIR technique and main features of the methodology of teledetection of water vapour isotopomers and retrieval of their concentration in the atmosphere are discussed. Set of passed through the atmosphere solar spectra from the range of 4000-11000cm-1 with resolution of 0.05 -0.0035cm-1 was recorded during clear sky conditions using the FTIR from July 2009. Based on independent data of AERONET spectrometer in Kourovka, the spectra corresponding to weak aerosol atmosphere have been selected for further analysis with GFIT. The GFIT outputs for column mean concentration of CO2, CH4, CO, N2O, H2O and other trace gases are obtained. Original method realized with modified version of FIRE-ARMS software (http://remotesensing.ru) for determination of HDO to H2O ratio in the atmosphere from the FTIR spectrum is suggested. Validation of TANSO-FTS/GOSAT regarding CH4, CO2 and HDO/H2O retrievals are discussed. This study was partially supported by RFBR grants No. 09-01-00474-a, No. 09-01-00649-a, RF Education Agency contracts No. P1151 and No. P1571 and by grant of Mathematical Science Division of Russian Academy of Sciences.

Session 07P: Lidar Networks and Assimilation of Observations into Forecast Models – Poster Presentations
Co-Chairs: Gelsominia Pappalardo, Yurii Balin

S7P – 01

THE CANADIAN OBSERVATIONAL RESEARCH AEROSOL LIDAR NETWORK (CORALNET): FIRST RESULTS

Kevin B. Strawbridge, Michael S. Travis, and Bernard J. Firanski

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The Canadian Operational Research Aerosol Lidar Network (CORALNet) was established in 2008 to look at the degree of long-range transported aerosols. Some occur naturally (biogenic), coming from volcanoes, dust storms, forest and grassland fires, living vegetation and sea spray while others result from human activities (anthropogenic), such as burning fossil fuels and altering natural surface cover. The establishment of CORALNet is critical for understanding the roles of man-made, locally-produced air pollutants as well as those which move into the area via meteorological "highways" and their impacts on air quality. Environment Canada along with other university, federal and provincial partners is beginning a new initiative to locate a network of lidars at strategic places across Canada to study and monitor the impact of aerosols on air quality on local, regional and national scales. The remote sensing technique of Lidar provides vertically-profiled information with high temporal resolution making it well-suited for understanding the optical characteristics of aerosol layers aloft. Every 10 seconds the system provides vertical aerosol profiles from near ground to 20 km into the sky. It operates 24 hours a day, seven days a week except during precipitation events and when aircraft fly over the site. The system is operated remotely and the data, which are updated every hour, are publicly available on the website www.coralnet.ca.

S7P – 02

DEVELOPMENT OF MULTI-WAVELENGTH HIGH-SPECTRAL RESOLUTION LIDAR SYSTEM (2A+3B+2Δ)

Tomoaki Nishizawa, Nobuo Sugimoto, and Ichiro Matsui

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A multi-wavelength High-Spectral-Resolution Lidar (HSRL) system for the next-generation lidar network is being developed. This lidar system provides 2α+3β+2δ data: extinction coefficients (α) at 355 and 532 nm, backscatter coefficients (β) at 355, 532, and 1064 nm, and depolarization ratios (δ) at 532 and 1064 nm. We realize this system by combined use of the previously developed HSRL techniques using an iodine absorption filter for 532nm and a Fabry-perot-etalon for 355nm. We completed constructing the 532nm HSRL and 1064nm receiver systems of this lidar. We also developed a system to tune the laser wavelength to an iodine absorption line in this lidar system. We conducted preliminary measurements using the constructed systems. The temporal and vertical variation of aerosols could be grasped. The constructed 532nm HSRL system could measure molecule Rayleigh backscatter signals blocking aerosol Mie backscatter signals with the iodine absorption filter, indicating that the developed laser wavelength tuning system worked well. Thus, we reached to the preliminary conclusion that we could construct the 532nm HSRL and 1064nm receiver systems appropriately.

S7P – 03

SOLUTIONS TO OVERLAP TEMPERATURE SENSITIVITY IN MICRO PULSE LIDARST

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NASA's Micro Pulse Lidar Network (MPLNET) is an autonomous network of eighteen elastic backscatter lidars worldwide used to measure aerosol and cloud vertical structure. Most of the sites within the network are co-located with sites in the NASA Aerosol Robotic Network (AERONET) providing observations of aerosol optical depth (AOD). MPLNET data and more information about the network can be found online at http://mplnet.gsfc.nasa.gov. The network's small portable systems have been deployed in many field campaigns and site installations where larger systems would not be feasible. Micro Pulse Lidar (MPL) systems use Cassegrain style telescopes that vary in focal length as a function of temperature and small changes give rise to significant signal errors. The telescope is the main contributor to this temperature instability - because of the large thermal expansion of the Aluminum tube, changes as little as +/- 1˚C about the instrument's ideal temperature cause the focal point of the receiver to shift away from the field stop. Here we present a follow up to a previous study discussing the impact of temperature variations on the MPL overlap. MPL data taken with both conventional and athermal telescopes are shown. The results demonstrate improved thermal performance from the athermal design with minimal change in MPL overlap over +/- 5˚C variations.

S7P – 04

DETAILED DESCRIPTION OF DATA PROCESSING SYSTEM FOR LIDAR NETWORK IN EAST ASIA

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More than 20 Mie-scattering lidars are operated continuously in East Asian region including Japan, Korea, China, and Mongolia. Vertical distribution of aerosols and clouds detected by these lidars are utilized in wider ways. All observed data are transferred to National Institute for Environmental Studies (NIES), and processed in order to distinguish cloud and aerosols, to eliminate signal from rain/snow, and to obtain two components (dust / spherical) extinction coefficients. Here the methodology of data processing is precisely described including various threshold values for reference of further network development in the world.

S7P – 05

POTENTIAL OF CEILOMETERS FOR AEROSOL REMOTE SENSING: A PRELIMINARY ASSESSMENT

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The potential of JenOptik ceilometers CHM15k and CHM15kx for the determination of aerosol profiles is investigated for a few cases when both systems were running co-located and simultaneously at Hohenpeißenberg, Germany. Comparisons with similar measurements at Munich give hints on the homogeneity of the tropospheric aerosol distribution over scales in the order of 50 km. It was found, that due to the very low overlap, the CHM15kx is better suited to monitor aerosol distributions. Backscatter

coefficient profiles $\beta_p(z)$ can be determine from nighttime measurements under favorable conditions, provided that signals can be averaged over typically 60 minutes. At daytime, $\beta_p(z)$ cannot be derived, as Rayleigh calibration fails due to the low signal-to-noise ratio. This problem might be overcome if the lidar constant of the ceilometers can be assessed. These findings should be considered as preliminary, as the data set available for this study was quite limited.

S7P – 06

GALION: THE GAW AEROSOL LIDAR OBSERVATION NETWORK

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The GAW aerosol program strives "to determine the spatio-temporal distribution of aerosol properties related to climate forcing and air quality up to multidecadal time scales". The specific objective of GALION, the GAW Aerosol LIdar Observation Network, is to provide the vertical component of this distribution through advanced laser remote sensing in a network of ground-based stations distributed at global scale.

S7P – 07

TESTING THE IFU HIGH-SPECTRAL-RESOLUTION LIDAR AT THE 2009 LEIPZIG FIELD CAMPAIGN

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The mobile three-wavelength aerosol lidar of IMK-IFU has been converted into a high-spectral-resolution lidar in recent years. The system now features four simultaneously operated data-acquisition channels, for the backscatter measurements (355 nm, 532 nm and 1064 nm) and for a spectrally filtered second 532-nm extinction channel. The system was successfully tested during the EARLINET-ASOS validation field campaign in Leipzig in May 2009.

S7P – 08

TOWARDS A LIDAR FEDERATION IN LATIN AMERICA

Juan Carlos Antuña[1], Eduardo Quel[2], Eduardo Landulfo[3], Barclay Clemesha[4], Francesco Zaratti[5], and Alvaro Bastidas[6]

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Coordinated actions by the Latin American lidar community have been conducted during almost a decade with the aim of creating a Latin American Lidar Network. Although that final goal has not been reached, there are several other achievements resulting for the actions conducted. We describe the evolution of such efforts highlighting the progress and difficulties, discussing the strategy applied during these years. In the process of adapting to the complex economic situation worldwide, new short term goals have been set to maintain the achievements already reached and to continue the capacity building process already in course.

S7P – 09

RETRIEVAL OF AEROSOL EXTINCTION COEFFICIENT PROFILES FROM RAMAN LIDAR SIGNALS BY REGULARIZATION

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We regard the problem of numerical differentiation of noisy measurement data occurring in the retrieval of aerosol extinction coefficient profiles from inelastic lidar signals by looking for a stable solution of the Volterra integral equation. An algorithm based on a projection method and iterative regularization together with L-curve method has been performed on lidar signals.

Wednesday, 07 July 2010 – Excursion (full day)

Thursday, 08 July 2010

7:30 – 8:30 – Registration

8:30 – 9:00 – Keynote II: Jack A. Kaye

NASA'S FUTURE ACTIVE OPTICAL REMOTE SENSING MISSIONS: SCIENCE, VISION AND CHALLENGES

Earth Science Division, Science Mission Directorate, NASA Headquarters, Washington, DC 20546 USA

Active optical remote sensing is an important technique for advancing our knowledge of Earth system science. It allows scientists to get three-dimensional information about a wide range of environmental parameters, and also allows for acquisition of data under conditions in which passive sensors cannot obtain data because of lack of signal. NASA has pioneered the use of active optical remote sensing in ground-based, airborne, and space-based measurements. In this talk a review of how NASA has used this technique on these platforms, as well as near- and farther-term plans for its implementation will be presented. In particular, the extensive contribution of active optical remote sensing to the set of missions described by the US National Research Council in its first-ever "Decadal Survey" for Earth Science, released in 2007, ("Earth Science from Space: National Imperatives For the Next Decade and Beyond" will be presented. The way in which ground-based, airborne, and space-based measurements will be used in complementary and synergistic ways in the future will also be presented.

Session 5O: Cloud Microphysics and Radiative Properties – Oral Presentations
Co-Chairs: Gilles Roy, Kenneth Sassen

9:00 – 9:15
S5O – 01

COMBINED HIGH SPECTRAL RESOLUTION LIDAR AND MILLIMETER WAVE RADAR MEASUREMENTS OF ICE CRYSTAL PRECIPITATION FROM MIXED-PHASE ARCTIC CLOUDS

Edwin W. Eloranta

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Precipitating, thin, mixed-phase clouds are prevalent in the Arctic and have a large effect on climate. Weather and climate models have difficulty maintaining stable mixed-phase clouds. Small changes in model assumptions yield clouds that, either become all water and too dense, or rapidly change to all ice and disappear. Better measurements are needed to improve the understanding of these cloud systems. This paper describes the use of high spectral resolution lidar (HSRL) and millimeter wavelength cloud radar (MMCR) data to estimate ice water and ice particle number fluxes from cloud base. A ratio formed from HSRL and MMCR backscatter cross sections provides a robust measurement proportional to the fourth root of the average mass-squared over the average area of the ice crystals. This ratio is used along with radar measured Doppler velocity spectra to make the measurements. In the past it was necessary to assume a particular shape for the ice crystals in order to derive the ice water content of the precipitation. In addition, it was difficult to eliminate errors in particle fall speed cause by vertical air motions. This paper describes an approach to overcome these problems.

9:15 – 9:30
S5O – 02

RETRIEVAL OF CLOUD AND AEROSOL PROPERTIES FROM COMBINED IIR, LIDAR AND WFC OBSERVATIONS OF CALIPSO

A. Garnier[1], M. Faivre[1], P. Dubuisson[2], J. Pelon[1], N. Scott[3], R. Armante[3], L. Doppler[1], N. Pascal[4], T. Tremas[5], D. Josset[1], S. Ackerman[6], H. Chepfer[3], O. Chomette[3], V. Giraud[7*], Y. Hu[8], D. Kratz[8], V. Noel[3], F. Parol[2], M. Platt[9], C. Stubenrauch[3], M. Vaughan[8], M. Viollier[3*], D. Winker[8], P. Yang[10].

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We present a general overview of the recent advancement in the retrieval of the radiative and microphysical parameters of ice clouds and desert aerosols derived at the global scale from the combination of the Infrared Imaging Radiometer (IIR), Wide Field camera (WFC) and Cloud and Aerosol Lidar with Orthogonal Polarization (CALIOP) onboard the CALIPSO platform.

9:30 – 9:45
S5O – 03

POTENTIALITIES OF POLARIZED LIDAR SOUNDING OF CRYSTAL, WARM, AND MIXED CLOUDS

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Potentialities of mixed cloud sounding with polarized lidars are studied using a previously developed analytical theory of polarized lidar return with multiple scattering from media with elongated phase functions and up-to-date models of crystal clouds. The computer modeling of the lidar systems performance is developed that allows one to simulate polarized lidar returns in lidars of any configuration from warm, crystal and mixed clouds with any stratification of their components. Particular attention is given to the possibility of detecting super-cooled water in ice clouds. The necessity of the protection of aircraft from icing in cold clouds and safety of flights provides the high priority to this problem.

9:45 – 10:00
S5O – 04

LIGHT BACKSCATTERING BY HEXAGONAL ICE CRYSTALS

Anatoli G. Borovoi[1], Natalia V. Kustova[1], and Ariel Cohen[2]

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At present, backscatter by ice crystal particle of crystal clouds has not been calculated yet both theoretically and numerically. The reason of this is that the backscatter within the framework of the geometric optics approximation is singular. Therefore conventional numerical calculations by ray tracing technique result in uncertainties because the values of the histograms depend essentially on a histogram calculation step. In this presentation, these uncertainties are eliminated by means of the physical optics approximation.
This work is supported by the Russian Foundation for Basic Research (Grant 09-05-00051).

10:00 – 10:20 Coffee Break

Session 9O: Combining Lidar with Other Techniques and Unique Lidar Applications – Oral Presentations
Co-Chairs: Andreas Behrendt, Robert Menzies

10:20 – 10:35
S9O – 01

OBSERVING THE FOREST CANOPY WITH A NEW ULTRA-VIOLET COMPACT AIRBORNE LIDAR

Juan Cuesta[1,2], Patrick Chazette[3], Tristan Allouis[4], Pierre H. Flamant[1], Sylvie Durrieu[4], Joseph Sanak[3], Pascal Genau[2], Dominique Guyon[5], Denis Loustau[5], and Cyrille Flamant[2]

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A new airborne ultra-violet lidar has been deployed to study the forest canopy in the Landes forest, France. The lidar is flown onboard an ultra-light airplane. The laser emission at 355 nm is 16 mJ per pulse at 20 Hz repetition frequency that fulfills eye-safety regulations. Laser footprints at ground were 2.4 m wide for a flying altitude of 300 m. Canopy top heights of three test areas of ~500 x 500 m2 with Maritime pines of different ages were characterized by the lidar with mean absolute accuracy of ~1m. This UV-lidar is intended for future applications of simultaneous observation of forest canopy, laser-induced vegetation fluorescence and aerosols.

10:35 – 10:50
S9O – 02

LIDAR AND RADAR MEASUREMENTS OF THE MELTING LAYER IN THE FRAME OF THE CONVECTIVE AND OROGRAPHICALLY INDUCED PRECIPITATION STUDY

Paolo Di Girolamo[1], Donato Summa[1], Rohini Bhawar[1], Tatiana Di Iorio[2], Geraint Vaughan[3], Gerhard Peters[4]

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During the Convective and Orographically-induced Precipitation Study (COPS), lidar dark and bright bands were observed by the Univ. of BASILicata Raman lidar system (BASIL) on several IOPs and SOPs (among others, 23 July, 15 August, and 17 August). Dark/bright band signatures appear in the lidar measurements of the particle backscattering. Lidar data are supported by measurements from the University of Hamburg cloud radar MIRA 36 (36 GHz), the University of Hamburg dual-polarization micro rain radars (24.1 GHz) and the University of Manchester Radio UHF clear air wind profiler (1.29 GHz). Results from BASIL and the radars are illustrated and discussed to support in the comprehension of the microphysical and scattering processes responsible for the appearance of the lidar dark band and radar bright band. Simulations of the lidar dark and bright band based on the application of a concentric/eccentric sphere Lorentz-Mie codes and a melting layer model are also provided.

10:50 – 11:05
S9O – 03

LONG RANGE TRANSPORT OF AIR POLLUTION IN THE EAST EUROPEAN REGIONS: FOUR YEARS OBSERVATIONS

Vitali Kabashnikov[1], Anatoli Chaikovsky[1], Sergei Denisov[1], Oleg Dubovik[2], Philippe Goloub[2], Arkadi Ivanov[1], Vladimir Kusmin[3], Bogdana Kazeruk[4], Michail Korol[1], Yana Karol[1,2], Anton Lopatsin[1,2], Natalia Miatselskaya[1], Fiodor Osipenko[1], Alexander Pietruczuk[5], Alexander Slesar[1], Piotr Sobolewski[5], Didier Tanre[2]

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[5]Institute of Geophysics, Warsaw, Poland

Four years observation campaign during 2006 – 2009 was implemented to study the effect of long range pollution transport on the air quality in the East European regions. Lidar and sun-radiometer data of the EARLINET, CIS-LiNet and AERONET/PHOTONS stations in the East European area, space observations and local in-situ measurements were used to characterize transformations of the atmospheric impurity. A significant effect of pollution transport on the air quality in non-industrial regions in Belarus and Poland was observed. Concentration of PM-10 particles exceeded maximum permissible concentration (MPC) defined as 50 μg/m3. The main emission sources of the priority pollutants were determined by statistical processing of the observation data and back trajectories calculated.

11:05 – 11:20
S9O – 04

INTEGRATING RAMAN LIDAR AND MICROWAVE OBSERVATION TECHNIQUES FOR THE IMPROVEMENT OF WATER VAPOUR PROFILING IN CLOUDY CONDITIONS

Fabio Madonna, Aldo Amodeo, Carmela Cornacchia, Giuseppe D'Amico, Aldo Giunta, Lucia Mona, and Gelsomina Pappalardo

Consiglio Nazionale delle Ricerche - Istituto di Metodologie per l'Analisi Ambientale (CNR-IMAA) C.da S. Loja, 85050, Tito Scalo, Potenza, Italy

To combine observations provided by a lidar and a passive sensor is a powerful method for providing advanced retrievals of atmospheric parameters exploiting both the high vertical resolution of lidar measurements and the typical operational capabilities of passive sensors. This combination offers a high potential for profiling atmospheric parameters in an enlarged vertical range nearly independently on the weather condition. In this work, two different integration approaches for improving the profiling of water vapour during cloudy condition by combining Raman lidar and microwave profiler measurements are described. These approaches are based on the use of Kalman filtering and Tikhonov regularization methods for the solution of the radiative transfer equation in the microwave region. The accuracy of the retrieved water vapour profiles during cloudy conditions is improved by the use, as a constraint to the obtained solution set, of the water vapour Raman lidar profiles retrieved up to a maximum height level located around the cloud base region depending on their optical thickness. This approach allows us to provide physically consistent solution to the inverse problem in the microwave region with an high accuracy as well as to overrun the issue of the low lidar performance in retrieving water vapour in presence of thick clouds.

11:20 – 11:35
S9O – 05

LIDAR AND AIRBORNE INVESTIGATION OF SMOKE PLUME CHARACTERISTICS: KOOTENAI CREEK FIRE CASE STUDY

Shawn Urbanski, Vladimir Kovalev, Wei Min Hao, Cyle Wold, and Alex Petkov

U.S. Forest Service, RMRS Fire Sciences Laboratory, Missoula, MT 59808, US

A ground-based scanning lidar was utilized with a set of airborne instruments to acquire measurements of smoke plume dynamics, smoke aerosol distribution and chemical composition in the vicinity of active wildfires in the western U.S. A new retrieval technique was used for processing lidar multiangle measurements. The technique determines the location of atmospheric heterogeneity versus height, which is retrieved from the entire vertical scan taken from a selected azimuthal direction. The vertical profiles of smoke plumes derived from heterogeneity events detected from lidar are consistent with aerosol mass concentrations, derived from airborne measurements in smoke plumes. The measurements are made with the purpose of acquiring the data necessary for the evaluation of plume rise and smoke dispersion models.

11:35 – 11:50
S9O – 06

EZ LIDAR AND SUN-PHOTOMETER MEASUREMENTS OF THE OPTICAL PROPERTIES OF THE TROPOSPHERIC AEROSOLS IN THE GANGE BASIN ALONG CALIPSO SATELLITE TRACK IN THE FRAME OF NASA TIGER-Z CAMPAIGN

S. Lolli, L. Sauvage, F. Faijan

LEOSPHERE, 76 rue Monceau, 75008 Paris, France

Lidar investigation of aerosol optical and microphysical atmospheric properties on continuous basis both spatially and temporally will play a key role in the future for monitoring the whole planet through world ground based networks. In this framework, an EZ Lidar™, manufactured by LEOSPHERE, validated in several campaigns as that one in Southern Great Plains (ARM) or at Goddard Space Flight Center (NASA) with cross-polarization capabilities was deployed in Kanpur, India in the frame of TIGER-Z campaign, organized by NASA/AERONET In addition, 12 sun-photometers were deployed during this campaign and CALIPSO (The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) data were also acquired. In this work we present the results in retrieving aerosol extinction and backscattering coefficients from EZ Lidar™ measurements, and the validation of the space borne instrument CALIPSO under the satellite track in the Gange basin. EZ Lidar™ is also coupled with the photometers to provide the measurements of the Aerosol Optical Depth over the selected region. In the paper is shown that the sun-photometer is a powerful tool to calibrate the lidar in the UV region.

11:50 - 12:05
S9O – 07

THE CO-PRESENCE OF WILDFIRE AND SAHARAN AEROSOLS OBSERVED BY MEANS OF LIDAR, IN-SITU INSTRUMENTS AND SATELLITE IMAGERY

Massimo Del Guasta[1], Alessio Baglioni[1], Francesco Castagnoli[1], Paolo Cristofanelli[2], Angela Marinoni[2], Jgor Arduini[3], Michela Maione[3], Paolo Bonasoni[2]

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Since 2007, IFAC's automatic depolarization LIDAR (532 nm) has provided continuous monitoring of tropospheric clouds and aerosols. As a by-product, Saharan dust and wildfire events are easily detected due to their depolarization signatures. In this study, we examine a particular case in which a mixing of wildfire aerosols and Saharan dust occurred for the days of 23-24 July 2009. LIDAR observations were interpreted with the aid of satellite and in-situ aerosol data measured by means of DMA and Optical counters at the Mt. Cimone station (MTC, 2165 m asl), which is located 50 km away from the IFAC LIDAR site. Ozone, CO and Black carbon data from MTC were also used in this study. Compared with the surrounding Saharan dust, the wildfire plumes produced in dramatic 2009 wildfires in Sardinia (I) and Corsica (F) showed a much lower depolarization ($\delta<5\%$), a higher scattering ratio ($R>2$), and a more marked spatial and temporal variability. Wildfire aerosols, were found to be associated with enhanced MTC concentrations of fine (<1 μm AED) particles, BC and CO. Clouds composed of both aerosol types were also observed as the result of N-africa wildfires that occurred in presence of southern, dry winds.

12:05 - 12:20
S9O – 08

SYNERGISM OF NIGHTTIME STARPHOTOMETRY AND LIDAR MEASUREMENTS

K. Baibakov[1], N.T. O'Neill[1], A. Saha[1], D. Daou[1], B. Firanski[2], K. Strawbridge[2], and E. Eloranta[3]

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The problem with common elastic-backscatter lidar techniques is that the return signal is a function of both the backscattering coefficient, b(R) and the two way transmission (T(R)) between the lidar and the scattering particles. Certain assumptions or additional lidar channels are needed to separate these two quantities. One approach is to estimate the value of the aerosol extinction to backscatter or lidar ratio, defined as the ratio of the extinction to backscatter coefficient; Sa = ka(R)/ ba(R). Molecular Sm can be estimated from Rayleigh scattering theory, however Sa is dependent on particle size, shape and refractive index and is not easy to estimate. Sunphotometers / sky radiometers such as those employed in the AERONET network, provide aerosol optical depth (AOD) measurements as well as sky radiance data from which vertically averaged Sa values can be estimated. The synergy between the sunphotometers and lidars and the optical models employed to interpret these data provide insight into fundamental aerosol properties which characterize a given event. Sunphotometry measurements, are however, limited to daylight hours while night-time AOD measurements are very rare. The problem is further aggravated in the Arctic where the Polar night lasts several months. Recently developed starphotometry techniques based on extinction measurements of bright-star radiation help to mitigate the lack of consistent and regular night-time measurements. Two starphotometers were installed in the Canadian High Arctic at Eureka, Nunavut (79°59'N, 85°56'W), and at the mid-latitude site of Egbert, Ontario (44°14'N, 79° 45'W). Both of these locations are equipped with continuously operating lidar systems, allowing side-by-side synchronous comparisons with starphotometer measurements. AOD and fine (sub-micron) and coarse (super-micron) aerosol optical depths were derived from the star extinction measurements. The lidar profiles of attenuated backscatter coefficient and depolarization ratio were matched in time with the derived starphotometry parameters. The presentation will focus on the analysis of the starphotometer and lidar data acquired during several nighttime field campaigns from 2007 to 2009. Case studies will be employed to illustrate how the synergy of these passive and active measurements can improve our understanding of night-time aerosol properties and day/night continuity of aerosol dynamics.

12:20 – 12:35
S9O – 09

CONTRIBUTION OF LIDAR OBSERVATIONS TO URBAN BOUNDARY LAYER NO2 ANALYSIS

E. Dieudonné, F. Ravetta, J. Pelon, F. Goutail, A. Pazmino

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The Paris agglomeration is a major source of pollutants that can stay trapped in the atmospheric boundary layer (BL), making BL depth a crucial parameter that modulates pollutant concentrations and peak intensity. It is commonly assumed that pollutants, except very short-lived species, are well mixed in the BL, implying that the BL integrated content (column) can easily compare with ground-based in-situ measurements using BL depth. On a few day case study chosen during the MEGAPOLI field campaign, we analyze Airparif in-situ air quality measurements at ground level and at the Eiffel Tower summit and interpret the differences using BL observations from an elastic backscatter lidar located in Qualair station, in central Paris. NO2

concentrations are generally higher in the surface layer than in the mixed layer meaning NO2 is not well distributed in the BL. During the afternoons of pollution peak days, the gradient is around -41 µg/m^3/km but when the morning BL is rising there is no gradient. Then we calculate NO2 integrated columns, first assuming a constant concentration in the mixed layer and no surface layer. These calculated columns reproduce the temporal structure of the columns measured by the Qualair UV-visible spectrometer (SAOZ) but they are 4 time higher in average. Columns calculated using a linearly decreasing concentration profile fit better with the SAOZ and confirm the existence of a vertical NO2 gradient.

12:35 - 12:50
S9O – 10

COMBINATION OF WIND LIDAR WITH CFD TOOLS FOR IMPROVING MEASUREMENTS IN COMPLEX TERRAIN

Matthieu Boquet[1], A. Albergel[2], Rémy Parmentier[1], Laurent Sauvage[1], Jean-Pierre Cariou[1]

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Accuracy of Lidar remote sensors for wind energy has been previously reported. Coherent Doppler Lidars have shown very high correlation with calibrated cup anemometers in flat terrain, both onshore and offshore. However, in more complex terrain, not only more turbulent air flow but also loss of flow homogeneity occurs, and remote sensors measurement process needs to be closely examined. In this paper, we compare and simulate cup's point and Lidar's volume measurements to understand and explain for the two sensor's response. We emphasize the main error term in the horizontal and vertical wind speed retrieval. Geometrical solutions are studied to take into account the air flow variations and reduce their negative influences. Through CFD simulations, we show that accessing to the vertical wind speed distortions leads to a considerable improvement in the horizontal wind speed linear correlation and dispersion. It is important to note that, for remote sensors, terrain complexity is impairing the wind velocity retrieval process more than the measured radial velocities. Based on this fact, we present an innovative combining approach to reduce Lidar bias in complex terrain.

12:50 - 13:05
S9O – 11

FLUORESCENCE LIDAR FOR STUDIES OF MOVEMENTS OF INSECTS AND BIRDS

Zuguang Guan[1], Mikkel Brydegaard[1], Patrik Lundin[1], Maren Wellenreuther[2], Anna Runemark[2], Erik Svensson[2], Susanne Akesson[2], Sune Svanberg[1]

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For the first time, fluorescence lidar is tested, to study the migration of insects and birds. A three-photomultiplier system is developed to analyze the fluorescence signatures, from which sexes and species may be classified. Range resolved measurements of lidar reveal the spatial distribution. For feasibility, damselflies are firstly tested at a distance of 60~m. Subsequently, measurements are performed with three geometrical arrangements over a river surface in southern Sweden, and the results are statistically analyzed. In addition to insect monitoring, 26 bird samples belonging to 12 species are measured at test ranges for species classification. Future research includes a study of night migrating of birds in the spring of 2010.

13:05 – 14:00 – Lunch Break

Session 3O: Observations of Boundary Layer Structure and Dynamics – Oral Presentations
Co-Chairs: Ulla Wandinger

14:00 – 14:15
S3O – 01

INTERNAL GRAVITY WAVES CONVECTIVELY FORCED IN THE ATMOSPHERIC RESIDUAL LAYER DURING THE MORNING TRANSITION

Fabien Gibert, Nicolas Arnault, Juan Cuesta, Pierre H. Flamant, Dimitri Edouart

IPSL-LMD, Ecole Polytechnique, Palaiseau, France

Combined observations by a 2-µm Doppler lidar and a 0.5-µm backscatter lidar and linear theory are used to examine the occurrence of gravity waves in the residual layer during the morning transition on two days, 10 and 14 June 2005. Thermal forcing frequencies are estimated using vertical velocity power spectra from lidar measurements and typical time – velocity scales from similarity theory in the convective boundary layer. The comparison between eddies and Brunt-Vaïsala frequencies is used to explain three different cases: no wave, evanescent wave and propagating wave. The results illustrate the necessary condition of statically stable and stratified residual layer to generate convectively forced gravity waves. The horizontal wind shear contribution is addressed. In the case of evanescent wave, the intrinsic frequency agreed well with thermal forcing frequency calculations. In the case of wave propagation, the results confirm previous numerical studies that the phase lines are tilted upstream and against the wind shear. Typical horizontal wavelength and line phase direction with respect to the vertical are 2.4 km and 32 °, respectively. Wave trapping in the residual layer is seen as a possible mechanism to explain differences between theoretical vertical group velocity (1.6 m s-1) and measured wave velocity anomalies (< 1 m s-1). Unexpectedly, we found that wave-associated vertical velocity and 0.5 µm-depolarization ratio or 2-µm-backcatter fluctuations are in phase. Possible explanations include 1) aerosol particles are not passive with respect to temperature or water vapour fluctuations or 2) a non-linear wave-turbulence interaction is at work and needs further investigation.

14:15 – 14:30
S3O – 02

CHARACTERIZATION OF VERTICAL-VELOCITY FIELDS AT AND BELOW CUMULUS CLOUD BASE WITH DOPPLER LIDAR

Ronny Engelmann, Albert Ansmann, Julia Fruntke

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Vertical-wind fields measured with Doppler lidar at and just below the base of cumulus clouds, which developed at the top of the boundary layer, are analyzed. The measurements were performed at Leipzig (51.4°N, 12.4°E), Germany, during the AVEC (Aerosol Vertical ExChange) campaign in the summer half year of 2006. More than 60 diurnal cycles of boundary-layer evolution have been analyzed. In 43% out of these observation no clouds occurred, in 23% a moderate number and in 34% a high number of cumulus clouds developed. Case studies of cloud-base vertical wind observations are presented. Profiles of the vertical velocity variance (one-hour means) for the entire AVEC period are analyzed to obtain statistics on vertical velocity scale w* and mixing-layer height z_i. These results are presented in addition.

14:30 – 14:45
S3O – 03

OBSERVATION OF BL DYNAMICS WITH A LONG RANGE WIND LIDAR

M. Boquet[1], J.P. Cariou[1], S. Lolli[1], L. Sauvage[1], R. Parmentier[1], Thomas Nostrand[2]

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To fully understand atmospheric dynamics, climate studies and weather prediction, the wind field is one of the most important atmospheric state variables. Studies indicate that a global determination of the troposphere wind field to an accuracy of 0.3 m/s is critical for improved numerical weather forecasting. Moreover air quality monitoring and power production optimization of wind turbines rely on the ability to forecast the wind velocity, shear and turbulences several hours in advance and as such would highly benefit from accurate and unattended Boundary Layer wind profiler. Lidar systems measuring wind profiles with high accuracy and up to 200m are being largely deployed worldwide for applications in the wind energy industry. Based on the accumulated know-how of these ground-based remote sensors, an extended long range version of them is now available. Such new equipment however needs to be inter-compared and validated against usual Boundary Layer profilers. In this paper we present results of measurement campaigns that happened in Europe and the US.

14:45 – 15:00
S3O – 04

DENSE MOTION ESTIMATION FROM EYE-SAFE AEROSOL LIDAR DATA

Pierre Dérian[1], Patrick Héas[1], Étienne Mémin[1], Shane D. Mayor[2]

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Results of the application of optical flow methods to eye-safe aerosol lidar images leading to dense velocity field estimations are presented. A fluid motion dedicated formulation is employed, taking into account the deforming shapes and changing brightness of flow visualization. The optical flow technique has the advantage of

providing a vector at every pixel in the image, hence enabling access to improved multiscale properties. In order to assess the performances of the method, we compare vectors with punctual sonic anemometer measurements. Power spectra of the velocity data are also calculated to explore the spectral behavior of the technique.

15:00 – 15:15
S3O – 05

AIRBORNE WATER VAPOUR AND WIND LIDAR MEASUREMENTS OF LATENT HEAT FLUXES DURING COPS 2007

Christoph Kiemle, Martin Wirth, Andreas Fix, Stephan Rahm

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During the Convective and Orographically-induced Precipitation Study (COPS) in July 2007 over the Black Forest Mountains in south-western Germany, tropospheric profiles of water vapour and wind were measured with a differential absorption lidar (DIAL) and a heterodyne detection 2-µm Doppler wind lidar collocated on board the DLR Falcon research aircraft. The DIAL "WALES" is a newly developed four-wavelength system operating on three water vapour absorption lines of different strengths, one offline wavelength at 935 nm (each 50 Hz, 40 mJ), and 532 and 1064 nm for aerosol profiling. It is designed as an airborne demonstrator for a possible future spaceborne water vapour lidar mission. For the study of summertime convection initiation over complex terrain, latent heat flux missions were flown where both lidars were pointed nadir-viewing. Using eddy-correlation of the wind and water vapor fluctuations beneath the aircraft, an area-representative water vapor or latent heat flux profile can be obtained by a single over-flight of the convective boundary layer in complex terrain. The lidars' horizontal and vertical resolution is about 200 m which resolves the dominant circulation patterns and flux contributions. This novel instrumentation allows obtaining profiles of the latent heat flux beneath the aircraft from one single over-flight of the area of interest.

15:15 – 15:30
S3O – 06

TURBULENT ATMOSPHERIC BOUNDARY LAYER EVAPORATION (TABLE) EXPERIMENT: PRELIMINARY RESULTS

M. Froidevaux[1], C. Higgins[1], V. Simeonov[1], I. Serikov[2], H. van den Bergh[1], R. Calhoun[1,3], P. Ristori[1,4], E. Pardyjak[1,5], and M. Parlange[1]

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This paper will present the initial results from the Turbulent Atmospheric Boundary Layer Evaporation (TABLE) experiment aimed to study the response of the atmospheric surface layer to forcing associated with heterogeneous terrain. The experiment took place during August 2008 in a moist agricultural valley in Switzerland (Seedorf). During this experiment, a high resolution Raman LIDAR recently developed at EPFL was successfully used to measure water vapor concentrations at high spatial and temporal resolutions. Additionally a suite of state-of-the art boundary layer measurement equipment (including sonic anemometers, scintillometers, RASS/SODAR, NDIR open-path water vapor monitors) was deployed to measure turbulent transport of water vapor, momentum and energy.

15:30 - 15:45
S3O – 07

SOUNDING OF AEROSOLS, CLOUDS AND AIR QUALITY USING A SUPER SPACE-TIME RESOLUTION POLARIMETRIC LIDAR

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This paper purports results of some recent studies carried out in the direction of aerosol-cloud-turbulence interactions in the atmospheric boundary layer at a tropical urban station, Pune, India utilizing a dual polarization micro pulse lidar (DPMPL). The high space-time resolution data have been utilized to investigate (i) detailed cloud structures and their association with vertical distributions of thermo-dynamical parameters, and (ii) key parameters of the boundary-layer that play a critical role in air quality over the place. The results reveal that besides long-range transport of air-mass, the cloud condensation nuclei (CCN) in the sub-cloud region also contributes significantly to the development of cloud cells aloft under favorable meteorological conditions. The mixing- and stable-layer structures show close association with surface-level temperature variations and exhibit an important bearing on the regional air quality. The refractive index structure parameter (Cn2), an efficient index of atmospheric turbulence, evaluated from the lidar backscatter signal strength variations, indicates intense in-cloud turbulence as compared to the regions of shallow clouds over the experimental site.

15:45 – 18:00 – Poster Session III

Session 3P: Observations of Boundary Layer Structure and Dynamics – Poster Presentations
Co-Chairs: Sara Tucker

S3P – 01

FIRST REGULAR MULTI-WAVELENGTH RAMAN LIDAR MEASUREMENTS IN PORTUGAL – A CASE STUDY

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For this work, multi-wavelength Raman lidar measurements performed in Évora, Portugal, from noon of the 24th to noon of the 25th September 2009 were investigated. Hourly profiles of the backscatter coefficients at three different wavelengths, time-height plots of the range corrected lidar signal and the gradient of the lidar signal were analysed to investigate the boundary layer development in the course of the day. The backscatter values indicate a well mixed day-time boundary layer and a shallow night-time boundary layer with aerosol layers on top. Furthermore, volcanic aerosol was detected in the lower stratosphere above 14 km. The backscatter coefficients in the stratosphere were found to be in the order of 10% of the backscatter coefficients in the boundary layer. This is a high amount of aerosol considering, that the layer stretched over 5 to 6 km whereas the boundary layer was about 2 to 3 km high during the day. The average of the height integrated backscatter coefficient, from 14 to 20 km was (2.4 +/- 0.4)E-4 1/sr at 532 nm and (1.0 +/- 0.3)E-4 1/sr at 1064 nm.

S3P – 02

LIDAR AND CEILOMETER BACKSCATTER COEFFICIENT AND SIGNAL-TO-NOISE RATIO INTERCOMPARISON

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A new generation of ceilometer instruments has been developed by Jenoptik, Germany. These instruments of type CHM15k use a solid state laser at the wavelength of 1064nm and an avalanche photodiode for photon counting detection. To study their performance in terms of aerosol backscatter coefficient retrieval we compared ceilometer profiles to simultaneously measured lidar profiles. The lidar used for this intercomparison was IfTs three wavelength Raman lidar PollyXT. During the EARLINET lidar intercomparison campaign EARLI09 in Leipzig, Germany, a Jenoptik ceilometer of type CHM15kx was taking part. This ceilometer has an improved optical setup for the lowermost altitudes resulting in a complete overlap at 150m height. Elastic backscatter profiles during daytime as well as night-time Raman lidar backscatter profiles compare well with the ceilometer profiles in atmospheric structures like aerosol layers and the boundary layer height. However, the particle backscatter coefficient can only be determined from ceilometer data by calibrating the profiles with an independent measurement of the aerosol optical depth. A comprehensive signal-to-noise ratio study was carried out to characterize the signal performance of the ceilometer. A sufficient signal-to-noise ratio of 2 or more was found where a considerable aerosol layer was present.

S3P – 03

AN AUTOMATIC PLANETARY BOUNDARY LAYER HEIGHT DETECTION WITH A COMPACT UV AEROSOL LIDAR

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The Planetary Boundary Layer (PBL) height is a complex meteorological fundamental for air quality modelers. Its diurnal variations induce vertical dilution of the pollutants at daytime, and concentrate them at nighttime. Urbanized cities in the world are exposed to atmospheric pollution events. For these proposals, a compact and rugged eye safe UV Lidar, the EZLIDAR™, was developed together by CEA/LMD and LEOSPHERE to retrieve structural and optical properties of clouds and aerosols and PBL time evolution. In order to provide an automatic retrieval of the PBL layers, a new 2D method of PBL detection has been developed, based on image processing. It allows the use of the temporal correlation between the profiles and the integration of atmospheric parameters about PBL evolution in the detection algorithms. This method is using a unique automatic threshold algorithm that will adapt to any atmospheric conditions. No a-priori parameterization is required and the final result is more robust than a profile per profile method. We have validated our algorithm during the second campaign of the ICOS (Integrated Carbon Observation System) project. This campaign took place in Mace Head (Ireland) under very different and complicated atmospheric situations, with frequent showers, windy situations and un-significant inversion layer.

S3P – 04

DEVELOPMENT OF PM2.5 ESTIMATES USING STATISTICAL CLIMATOLOGY OF AEROSOL PROPERTIES AND LIDAR PBL HEIGHTS

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To provide reasonable forecasts of near surface PM2.5 levels, it necessary that satellite measurements provide a reasonable estimator of PM2.5 which can be coupled to a transport model. Unfortunately this requires that the aerosol be homogeneously mixed and that the extent of the PBL be sufficiently accurate. For example, the IDEA product (Infusing satellite Data into Environmental Applications) used by the EPA relies on a static relationship connecting PM2.5 to MODIS aerosol optical depth (AOD) which relies on a static model of the PBL aerosol height. In this paper, we show that the PBL height is far from static and by taking the variable PBL height climatology into account, a better estimator taking into account PBL estimation of PM2.5 measurements is obtained. Further improvements occur whn hygroscopic growth climatologies are used.

S3P – 05

COHERENT STRUCTURE IN MOUNTAIN ATMOSPHERIC BOUNDARY LAYER

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Experimental data of the surface measurements of the key turbulence characteristics in various geographical areas and meteosituations published earlier in articles of authors is shown, that in the open atmosphere the extensive areas are often observed in which one coherent structure has the defining influence. Turbulence in such areas usually is called as coherent. In present article the short review of properties of the coherent turbulence is given. New data of the experimental observations of the coherent structures arising in the presence of obstacles for air streams and roughnesses of the underlying surface are adduced.

S3P – 06

TURBULENT SCALES IN THE ANISOTROPIC BOUNDARY LAYER

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On the basis of the experimental data received in long-term measurements in different climatic conditions and regions new data for turbulent scale of temperature field T* and the velocity field V*, which is the important turbulence characteristics in the Monin-Obukhov similarity theory, are obtained. All registered values of scales irrespective of type of a meteosituation and an underlying surface are stably grouped near the theoretical dependences. The range of the observable Monin-Obukhov numbers is considerably expanded as in the field of stable and unstable atmospheric stratification. Data confirm the conclusion made earlier by us [1] about local applicability of the Monin-Obukhov theory of similarity in the atmospheric anisotropic boundary layer (in some vicinity of each point of a layer) is confirmed and expand it on extreme temperature stratification.

S3P – 07

STUDY OF THE ATMOSPHERIC BOUNDARY LAYER AT REUNION ISLAND USING LIDAR OBSERVATIONS AND MESO-SCALE MODELING

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As preliminary study to the development of a high-altitude atmospheric observatory (OPAR) at Reunion Island, a dynamic modeling program of airflows above the island has been undertaken using the non-hydrostatic and anelastic model MesoNH. It aims at understanding to what extent, and when, the future station will be under the influence of the boundary layer, clouds, and the upward transport of low-level air masses. The experiment ECLAIR (Expérience sur la Couche Limite Atmosphérique à l'Ile de la Réunion) was held from 26 November to 5 December 2008. The main goals were to validate the model and characterize the vertical structure and temporal evolution of the local planetary boundary layer around and inside the island. The key instrument was a mobile-like Ez-lidar® aboard a pick-up. Low-level atmospheric motions were observed through their influence on aerosol distribution and related back-scattering properties. Features of the planetary boundary layer dynamics over the very marked reliefs of Reunion Island are presented in two case studies. Lidar data and high-resolution model outputs are compared, and this reveals the excellent capacity of the three-dimensional atmospheric model MesoNH to reproduce complex features of airflows over Reunion Island. The model outputs are then used to interpret the features observed by lidar.

S3P – 08

JOINT LIDAR AND SODAR OBSERVATION OF THE BOUNDARY LAYERS

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Using the LOSA-S lidar and three-channel Doppler Volna-4 sodar, we performed joint observations of the altitude-temporal transformation of aerosol concentration and structure of temperature-wind field. Data are obtained on the co-ordination or differences in the dynamics of aerosol concentration at different altitudes at daytime and the processes of convective heat exchange in the atmospheric boundary layer.

S3P – 09

DETERMINATION OF BOUNDARY LAYER HEIGHT IN MANILA FROM TWOWAVELENGTH LIDAR MEASUREMENT USING NORMALIZED CONCENTRATION GRADIENT METHOD

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The boundary layer height (BLH) in Manila was determined from two-wavelength LIDAR using the normalized concentration method (NCG) at 355 nm. The normalized concentration gradient method provides an estimate of the evolution of the BLH from our lidar data. Initial results indicate that during a period of stable stratification not much variation was observed in the BLH. The BLH was found to be stable at about 400 m. The boundary layer aerosols had a depolarization ratio of 10-20% at 532 nm. Low lying clouds were also observed which had a depolarization ratio of 30-40%.

S3P – 10

LIDAR INVESTIGATIONS OF THE AEROSOL FIELDS OF THE ATMOSPHERE IN ARID ZONE OF GOBI DESERT

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Investigations of the spatial-temporal structure of aerosol fields in the troposphere over arid area of Gobi desert, Mongolia (44°54′ N, 110°07′ E) were carried out in summer 2008 and 2009 by means of the “LOSA-M2” lidar. Under conditions of stable weakly cloudy weather, the diurnal dependence of aerosol filling of the troposphere was revealed, including the characteristic heights of the aerosol accumulations in the range 0.2, 1.2, 2.2 and 4-5 km. Under conditions of the atmospheric front passing, the cases of penetration of tropospheric aerosol into the stratosphere were observed caused by the specific manner of the observation place, break between tropical and polar tropopauses and strong streams in the upper troposphere. In the lower troposphere, the rare cases of formation of the aerosol fields were also observed in the form of wave processes with the period about 6-8 minutes caused by the effect of gravitational – shift atmospheric waves.

Session 5P: Cloud Microphysics and Radiative Properties – Poster Presentations
Co-Chairs: Nobuo Sugimoto, Ignatii Samokhvalov

S5P – 01

THE ANALYSIS OF OBSERVED DATA OF THE BACKSCATTERING MATRIXES: ESTIMATES OF OCCURRENCE AND DIRECTIVITY OF NONSPHERICAL PARTICLES AT VARIOUS PENETRATION DEPTHS IN THE CI CLOUDS

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The data analysis of ice clouds long-term measurements spent by means of a unique polarization lidar of Tomsk State University, allows to dilate considerably representations about a composition and processes of shaping of ice clouds. The given sondages from 1991 have undergone to handling. As a result of handling it is gained more than 600 backscattering matrixes of Ci clouds. The resolution on height has made 96 m. The data analysis of systematically spent measurements allows to choose prominent features in a structure of ice clouds, to come out with guesses of a composition, morphological singularities of ice particles, directivity in ensemble of ice particles in space.

S5P – 02

CLOUD BOUNDARIES DETECTION ALGORITHM FOR MIE SCATTERING LIDAR

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Detecting cloud boundaries from lidar data is an attractive and important topic. It is the base of the studies of cloud and aerosol using lidar data. This paper introduced a cloud boundaries detection algorithm for single wavelength Mie scattering lidar. Both the character of the lidar received signal and physical property of the cloud were considered in the algorithm. The cloud region detected using this algorithm was validated by the volume depolarization ratio (VDR) measured synchronously using the same lidar. The validation showed that the cloud boundaries could be detected well using this algorithm, about 95% VDRs which are larger than 0.2 were found in the detected cloud region. The percent of the VDRs which are less than 0.15 was less than 10% in the detected cloud region, and about 80% VDRs in the ice phase cloud region ranging from 6 km to 13 km above ground level varied between 0.2 and 0.4, while the temperature in this range varied from about -20 degree to -70 degree centigrade.

S5P – 03

ANALYTICAL APPROXIMATION OF THE PHASE FUNCTION, SPECIFIED BY FRAUNHOFER DIFFRACTION BY CLOUD ICE CRYSTALS

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Simple analytical formula, describing the diffraction by arbitrary shaped chaotically oriented particles is obtained. The formula expresses the angular dependence through three well defined microphysical characteristics of an ensemble: the average cross-sectional area, average square of the cross-sectional area, and the average length of the contour, bordering the particle projection. These three are calculated for the case of a hexagonal prism and the approximation is compared to the strict diffraction simulation.

S5P – 04

SPECULAR REFLECTED LAYERS AND PARTICLES IN CRYSTAL CLOUDS

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Crystal (cirrus) clouds were observed with polarized lidar LOSA-S. Layers with particles preferably oriented in the horizontal plane demonstrate mirror-like reflection. It is shown that element a44 of the normalized backscattering phase matrix (BSPM) can be measured. Results of measurements are independent of the presence or absence of azimuthal particle orientation. Temporal and spatial variability of the orientation of crystal particles is demonstrated. Results of using both linear and circular polarization are compared. Specular reflection from single crystal particles can be recorded.

S5P – 05

THE INFLUENCE OF THE MICROPHYSICAL PARAMETERS OF LARGE CRYSTALS ON EXTINCTION OF THE OPTICAL RADIATION

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In the framework of the physical optics method, we performed a numerical study of extinction of the optical radiation by large crystals. The certain behavior of the dependence of extinction is connected to orientation, optical parameters and the form of crystals in IR wavelength range. For certain combinations of the particle microphysical, optical, and orientation parameters, the off-diagonal elements of the extinction matrix differ from the first element within one order of magnitude.

S5P – 06

ASYMPTOTIC MODEL FOR ESTIMATION OF MULTIPLE SCATTERING CONTRIBUTION TO LIDAR SIGNALS FROM WATER-DROP CLOUDS

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In the last few years, methods of lidar sensing aimed at obtaining information on optical and microphysical properties of clouds from characteristics of multiply scattered (MS) radiation have intensively been developed. Despite the achieved successes, the correct account of MS contribution to lidar signals remains an urgent problem. The existing approaches are quite often based on the application of simplified semi-empirical models. More strict methods call for the application of cumbersome analytical formulas and their complex calculations. For this reason, they cannot always be used in practice for real-time processing of field experiments on cloud laser sensing. Therefore, new theoretical models are required to consider MS contribution to lidar signals, which provide reasonable compromise between physical validity and mathematical strictness with high computing efficiency. In the report, one of the possible methods of solving this problem is described, and a new mathematical model of the correction factor which describes the relative MS contribution to lidar signals in water-drop cloud sensing is suggested. To construct the model, the correction factor obtained in the small-angle approximation of the radiative transfer theory with allowance for single scattering at large angles was taken for the initial well-known integral expression. An asymptotic series in powers of the small parameter – the field-of-view angle of the lidar receiver – was derived by the method of successive expansion of the given integral expression. The possibility of constructing the asymptotic series is based on the properties of the optical transfer function of a scattering medium at high spatial frequencies. The coefficients of asymptotic series depend on the integral microstructure parameters of the medium and can be easily calculated from simple analytical formulas. The established property can be especially useful for the development of lidar methods of determining the effective size of water-drop cloud particles.

S5P – 07

CRYSTALS ORIENTATION INFLUENCE ON BACKSCATTER COEFFICIENT AND DEPOLARIZATION RATIO: ANALYSIS OF MEASUREMENT BY GROUND-BASED LIDAR

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In the work, we interpret lidar data that were obtained with the ground-based zenith – pointing polarization lidar operating at the visible wavelengths in time of subsatellite investigations of atmospheric aerosol layers, i.e. concurrently with measurements by the space-based lidar CALIOP (the Cloud-Aerosol Lidar with Orthogonal Polarization). Considered lidar data demonstrate the presence of a cirrus cloud in the tropopause and lower part of the stratosphere, which is likely to have oriented crystal particles. Obtained from them altitude profiles of the backscatter coefficient and linear depolarization ratio are characterized by depolarization ratio decrease and backscatter coefficient increase in some ranges. These profiles are interpreted supposing that the observed feature - low depolarization and high backscatter – may mark the presence of the preferred orientation of ice plates and columns with respect to the horizontal plane in a cirrus. This hypothesis is substantiated with the simplified cloud model and approximate numerical estimate. It is also shown that property of lidar profiles consisting in that increase or decrease of the backscatter is accompanied with decrease

or increase, respectively, of the depolarization ratio can be connected in some cases with manifestations of non- diagonal form of the backscatter matrices of crystals accumulations.

S5P – 08

PECULIARITIES OF USING THE SCATTERING THEORY FOR CLOUD MEDIA

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Experimental facts concerning spectral radiative and optical characteristics of cloud that obtained during two last decades demonstrate a disagreement with optical parameters calculated with Mie scattering theory. The spectral dependence of the cloud optical thickness together with high values of the single scattering albedo, retrieved from airborne, satellite and ground-based radiation observations, does not coincide with results of model calculations with applying scattering theory. Possible physical explanation of the disagreement between observations and calculations is based on the analyzing sizes of different kind particles and distances between them within cloud. Breaking the axiomatic relations between characteristic scales of different cloud components (droplets, molecules and aerosols), which were assuming for constructing the scattering theory, is recognized. The elementary volume chosen for calculation differs for particles of different size: for cloud droplets (size ~ 10-20 mkm) it is around 10^3–10^4 mkm^3; for density fluctuation (10^{-3} mkm) it is 10^{-9} mkm^3 and for aerosol particles (0.1-1 mkm) it is 10^{-3}–1 mkm^3. Thus, sizes of elementary volumes, corresponding to different particles within cloud vary within 12 orders of the magnitude! Because the elementary volume size is chosen corresponded to droplets in standard approach, it is too big for molecules and aerosols and the multiple scattering is necessary to account within the elementary volume for these two components. The no-account of the break leads to the difference between calculated and observed values of the cloud absorption of the shortwave solar radiation and erroneous estimation of the radiation budget of cloudy atmosphere.

S5P – 09

SPATIAL AND TEMPORAL ATMOSPHERIC CLOUD COVER OVER CHIBA, JAPAN FROM PORTABLE AUTOMATED LIDAR (PAL) SYTEM

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A portable automated lidar (PAL) system is continuously operated at the Chiba Prefectural Environmental Research Center to monitor boundary layer aerosols and clouds in the area. A cloud base algorithm is developed to count the occurrence of cloud and to produce a temporal and spatial map of cloud of cloud occurrence. The percentage of cloud occurrence is obtained by taking the ratio of the number of cloud base and the total number files. The result shows that in 2003, that most of the clouds over Chiba occur at a height below 2km. Moderate occurrence of clouds are found between 2 and 8 km. Between 8 and 15km, the calculation showed a negligible occurrence of clouds. Temporal analysis shows that the months of July, August and September has a low cloud cover below 2km.

S5P – 10

CONTROL ON THE PARAMETERS OF PHOTONIC NANOJETS FROM WATER MICRODROPLETS

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One of the priority problems of atmospheric optics is the study of peculiarities in the interaction of the laser radiation with atmospheric constituents, in particular, with droplet aerosol particles. Various remote sensing methods are used for this purpose. The recent studies have shown that, in addition to aerosol particles, the atmosphere contains a great amount of biological particles (algae, bacteria, single-celled animals, spores, pollen, and so on), in particular, those hazardous to human health. Moreover, it is found that bacteria can serve centers of formation of ice crystals and rain drops in clouds. In this connection, it is urgent to develop efficient facilities for the remote detection and identification of a wide class of molecular compounds, in particular, fluorescent methods for the diagnostics of biogenic aerosol. The solution of this problem will open new capabilities of fluorescent lidars in atmospheric optics. This report presents the results of numerical calculations of the distribution of the relative intensity of laser radiation in the vicinity spherical water droplets of different size. The influence of the shell thickness of composite microparticles (silicon core and water shell) on characteristics of a photonic nanonjet has been studied.

S5P – 11

FOUR YEAR CLOUD COUNT ANALYSIS OF MANILA OBSERVATORY LIDAR DATA AND CLIMATOLOGICAL RELATIONSHIP

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Cloud percentages were taken from April 1997 until April 2000 at the Manila Observatory (14.64° N, 121.07° E) using a Mie scattering lidar system. Cloud percentages generally ranged from 0 to 1.6%. The Oceanic Niño Index (ONI) showed an inverse relation with cloud percentages during the occurrence of La Niña. In the case of El Niño, seasonal effects dominated over the effects coming from the ONI. Seasonal trends in the Philippines showed significant effects on the cloud cover found for 1997 to 2000. Low percentages were noted during the hot dry season and higher percentages were observed during the cool dry and wet seasons.

S5P – 12

APPLICATION OF OPTIMAL ESTIMATION TO RETRIEVE HYDROMETEOR PROPERTIES FROM LIDAR/RADAR METHOD

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As widely known, since lidar and cloud profiling radar have deferent sensitivity of detecting ice clouds, development of methods to deal with cloud portion seen only by one of the sensors and therefore with small number of observables are necessary to obtain global statistics of ice cloud microphysics as those excepted from CloudSat/CALIPSO for example. This paper introduces such a method, which make optimal estimations of cloud microphysics also for the radar-only and lidar-only cloud region by making the most of the information available in the lidar-radar overlapped cloud region. The method incorporates ice particle nonsphericity for radar and lidar data analysis based on forwards models of previously developed algorithms applicable to lidar-radar overlapped region or radar-only region with multi-parameter [1][4]. Inclusion of ice particle nonsphericity is especially important to correctly estimate the vertical variation of ice cloud microphysical properties using lidar when contribution from horizontally oriented particles to the lidar backscatter cannot be neglected. Validation of the retrieval performance of the new algorithm against earlier methods was performed and it was found that the new method can estimate cloud microphysical properties comparably well.

S5P – 13

DUAL-FIELD-OF-VIEW RAMAN LIDAR FOR MEASUREMENT OF CLOUD DROPLET SIZE AND LIQUID-WATER CONTENT

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The Raman lidar MARTHA (Multiwavelength Atmospheric Raman Lidar for Temperature, Humidity and Aerosol Profiling) of the Leibniz Institute for Tropospheric Research (IfT) has been upgraded to perform dual-field-of-view measurements. Light that is multiply scattered in the forward direction by water droplets and inelastically backscattered by N2 molecules is simultaneously detected with two different fields of view (FOVs). From the two Raman signals, profiles of the single-scattering extinction coefficient, the effective droplet radius, and the liquid-water content at the base of warm clouds are derived. By coupling the new technique with the capabilities of MARTHA to determine high-resolved profiles of various aerosol properties in the vicinity of clouds—such as extinction and backscatter coefficients at multiple wavelengths, from which particle microphysical properties are derived—the unique instrument enables us to investigate aerosol–cloud interaction and thus the aerosol indirect effect.

S5P – 14

A FIRST LOOK AT CALIOP/CALIPSO CLOUD ICE WATER CONTENT

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The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) Mission will release Version 3 (V3) of its Level 2 data products during the spring of 2010. Cloud ice water content (IWC) is a featured new geophysical parameter offered at 60 m vertical resolution in the 5-km cloud profile product. IWC is calculated using a parameterization of the optical extinction at 532 nm as retrieved by the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP). Currently this temperature-independent IWC parameterization is a beta/provisional data product, with evaluation and validation efforts underway. Preliminary results show that CALIOP IWC amounts are physically reasonable, and that the high vertical resolution and sensitivity to IWC < 0.010 gm-3 provides a unique picture of cloud morphology. Statistical attributes of CALIOP V3 IWC are shown for global data during August, 2007. We also evaluate IWC distributions as a function of ambient temperature, and discuss cloud particle phase and orientation. Preliminary evaluation of CALIOP/CALIPSO V3 IWC suggests that it will prove to be most accurate between 0.001-0.200 gm-3 for randomly-oriented ice cloud particles (ROI), corresponding to retrieved extinctions of 0.07-5.3 km-1. Comparisons with IWC data from other satellite instruments have been initiated as the next step in the validation process.

S5P – 15

RADIATIVE FORCING DETERMINATION OF THE ATMOSPHERIC BROWN CLOUD WITH MULTIWAVLENGTH LIDAR SOUNDING DATA

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Multiwavelength lidar sounding of the tropospheric aerosol at Teploklyuchenka station in Kyrgyz Republic has been carried out. Vertical profiles of the aerosol microphysical parameters were retrieved. Radiative characteristic models for tropospheric aerosol including Atmospheric Brown Cloud has been worked out. Aerosol radiative forcing on the top and bottom boundary of the atmosphere and also in the atmospheric column for background aerosol and for Atmospheric Brown Cloud (ABC) was evaluated. Data received were compared with published investigation results of the atmospheric aerosol radiative forcing.

S5P – 16

STUDYING ON THE LASER SCATTERING IN AN ANISOTROPIC MEDIA

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with a lot of special environmental factors such as high concentration aerosol, toxic ases (methane CH4, carbon oxide CO…), changed temperature, high moist... There for all applications of laser techniques are demanded to learn about the interaction of laser beam with the coal mining media. The laser beam propagation in the atmosphere is determined by a H.C. Van de Hulst model. The laser extinction properties in an aerosol media can be found from the simulated calculation. This paper presents the result of the study on the scattering coefficient, the absorption coefficients and asymmetry factor.

Session 8P: Middle and Upper Atmosphere Physics and Chemistry – Poster Presentations
Co-Chairs: Chikao Nagasawa, Valerii Marichev

S8P – 01

LIDAR TEMPERATURE OBSERVATIONS DURING WINTER STRATOSPHERIC WARMING OF 2005–2006 YEARS

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Middle atmosphere temperature measurements data for a winter months 2005-2006 obtained by Yakutsk Lidar (61.4N; 129.7 E geogr.) are used in this work. The spatial and temporal characteristics and behavior of winter stratospheric temperature variations intensity have been studied. The winter stratospheric warming analysis using Yakutsk station Lidar and aerologic radiosounding data showed that the observing warming caused by upward propagating planetary waves dissipation and consist of some short time localized warmings and that is modulates by a planetary wave with wavenumber 1 and period about 90 days.

S8P – 02

FE DOPPLER-FREE SPECTROSCOPY AND OPTICAL HETERODYNE DETECTION FOR ACCURATE FREQUENCY CONTROL OF FE-RESONANCE DOPPLER LIDAR

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For a Major Research Instrumentation (MRI) mobile Fe-resonance/Rayleigh/Mie Doppler lidar, we developed a novel approach to accurately calibrate and stabilize the lidar pulse frequency to the peak of 372-nm Fe absorption line. Our revolutionary idea is to achieve the Fe Doppler-free spectroscopy, and then apply such high-resolution spectroscopy and optical heterodyne detection technology to accurately analyze and control the frequency and spectrum of each lidar pulse. This is a significant improvement over the traditional method of controlling the cw seed laser only. Such

concept will help produce the first bias-free resonance Doppler lidar for advancing middle and upper atmosphere science. Here we present the Fe Doppler-free spectroscopy and the pulsed optical beat signals that we believe are achieved for the first time in resonance lidar.

S8P – 03

RESPONSE OF MESOSPHERIC SODIUM LAYER TO THE PASSAGE OF GRAVITY WAVES OVER SAO JOSE DOS CAMPOS, BRAZIL (23°S, 46°W)

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In this work we study the mesospheric sodium layer in the in the presence of overturning gravity wave using lidar. Under the assumption that the sodium density is a passive tracer of the dynamics (except when chemistry is considered important) we can use the structure of the sodium layer to visualize the dynamics. We show examples of very special shapes in the height-time evolution of the sodium layers measured by lidar installed at São José dos Campos (23°, 46°w), Brazil. These data are compared to the layer response predicted by the theory. Both sets of experimental data show a downward progression of wavelike structures that is typical of gravity waves which is moving the Na density peak downward in time. Since the linear layer response is not always adequate to describe gravity wave sodium layer interactions (by linear response, it is meant that the layer density perturbations have the same temporal and spatial frequencies as the gravity wave), nonlinear components of the layer density response must be considered in interpreting sodium lidar data. In this work, these observed morphologies are presented and discussed under linear and nonlinear layer density response.

S8P – 04

AVERAGE BEHAVIOR OF SPORADIC SODIUM LAYERS FOR THREE STRENGTH FACTORES

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Since we first saw and reported sporadic sodium layers it was generally assumed that profiles containing sporadic layers contain additional sodium as compared to normal profiles. In a series of two papers we showed that on average this was not the case. With our new laser for measuring mesospheric sodium temperature we have two years of high quality data (2007-2008) which have excellent calibrations which we added to the analyzed data set (1993-2008 and all times). We chose three strength factor (SF) intervals SF 2-4, 4-6 and > 6 (the first paper was all data separated into average normal and sporadic profiles; the second was normal, SF 2-4 and SF > 4 individually averaged). Except for the new results reported here, which have peak amplitudes greater than the previous studies (~20%), the results show very similar results for the three studies. For the new study the third interval showed an increase in abundance as well as an increase in centroid height as compared to figure 4 of the second paper (SF > 4). There was also a more pronounced shift of sodium to higher heights for the SF > 6 when compared to figure 4 of the second paper.

S8P – 05

A GLOBAL VIEW OF ORIENTED ICE CRYSTALS FROM SPACEBORNE LIDAR

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We investigated the geographical and seasonal distributions of oriented crystals on a global scale using observations of layer-integrated backscatter and depolarization ratio from the CALIOP spaceborne lidar. Oriented crystals appear in ~6% of all ice cloud layers. The geographical pattern of crystal orientation is very stable over the year. The presence of oriented crystals appears primarily driven by temperature: mostly nonexistent in ice clouds colder than -30°C, and very frequent in warmer ice clouds, appearing in 30% of such clouds in the Tropics and up to 50% at higher latitudes. The temperatures where oriented crystals are found (-30°C to -10°C) are conducive to the formation of planar crystals.

S8P – 06

SODIUM DENSITY VARIATIONS OVER 9 HOURS DURING JAN, 2010 AT BEIJING, CHINA

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A sodium Doppler lidar has been built up to measure mesopause wind, temperature and sodium density over Beijing, China (40°N, 116°E). A strong variation of sodium density has been measured during Jan.12, 2010 night. We calculate the sodium column abundance, centroid height and peak altitude to study the variation. The sodium column abundance changed about 42% in 2 hours. And the centroid height decreased 3.2km. The peak of sodium layer dropped quickly, from 87.8km to 77.9km in7hours. So the sodium density distribution shape liked triangle instead of Gaussian shape when the peak at lowest altitude. From the SABER temperature data, we found there was a 95K temperature inversion at around 80km altitude. This paper mainly gives out the details about the sodium density variations.

S8P – 07

DURBAN RAYLEIGH LIDAR MEASUREMENTS OF STRATOSPHERE-MESOSPHERE TEMPERATURE STRUCTURE

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The observation of a stratosphere-mesosphere temperature structure over Durban (29.9° S, 31.0° E, South Africa) using the Durban Rayleigh LIDAR data collected from April 1999 to July 2004 (277 nights) is presented in this paper. The contour plots of month versus vertical temperature structure depict two temperature maxima in the stratosphere (~45 to 50 km), found over February to July and September to December. The stratopause temperature and height varies within 269-278 K and 43-48 km height, respectively. A comparison with SABER, HALOE and CIRA-86 shows agreement above the stratopause for most of the months. However comparisons show larger difference below the stratopause.

S8P – 08

COORDINATED MEASUREMENTS OF MESOSPHERIC NEUTRAL CALCIUM AND ITS ION ALONG WITH ELECTRON CONCENTRATIONS FROM ARECIBO

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We used resonance lidars to study the temporal and altitudinal characteristics of neutral calcium (Ca) and its ion in the mesospheric and lower thermospheric regions (MLT). The unique location of these lidars at Arecibo allowed us to compare the neutral/ion concentrations with electron concentrations obtained using Incoherent Scatter Radar. A few examples of our comparison between neutral Ca, its ion, and electron concentration in June 2009 revealed an absence or very weak (< 5 atoms cm^{-3}) neutral layers, while strong sporadic layers often exist above 90 km. A good correlation is observed between the distribution of Ca ions below 95 km and the neutrals. However, above 100 km, Ca ions do not always have a corresponding neutral layer. On the night of 21 June 2009, a sudden appearance of neutral Ca at ~100 km is seen when the ions exceed 1000 cm^{-3}, as compared with the early part of the night where an ion layer with concentrations less than 500 ions cm^-3 existed. The average abundance ratio for the electron concentration and Ca ions is in the range of 300 - 900 for altitudes above 90 km. The Ca+ to neutral abundance ratio for altitudes < 90 km is ~ 0.5, while for heights > 90 km, it is in the order of 5. This reflects that on most occasions, the neutral Ca layer is stronger above 90 km whenever there is a strong sporadic in the ions.

S8P – 09

CLIMATOLOGY OF STRATOSPHERIC OZONE PROFILES IN RÍO GALLEGOS, ARGENTINA

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The Río Gallegos experimental site is located in South Patagonia (51º 55'S, 69º 14'W), in subpolar region and it is a convenient monitoring site of the atmosphere in the southern hemisphere. This experimental site operates a differential absorption lidar instrument (DIAL) for the measurement of ozone vertical distribution. The altitude range of the ozone measurement is 14-45 km, which provides the opportunity to monitor the perturbations due to the passage of stratospheric polar air over Río Gallegos. In this paper, we study the stratospheric ozone distribution in height, maximum ozone number density values in the peak and peak altitude, for austral spring time period. We present the climatology of stratospheric ozone profiles in Río Gallegos. The monthly mean profiles were calculated averaging around forty ozone profiles grouped in clusters for each month from late winter to spring. Three years (2005-2007) of measurements were taken into account. These monthly mean profiles were intercompared with similar profiles from High Resolution Dynamic Limb Sonder (HIRDLS/NASA). The coincidences and agreements of this intercomparison are discussed.

S8P – 10

RAYLEIGH LIDAR TEMPERATURE PROFILES BETWEEN 15–60 KM DURING SOLAR CAMPAIGN IN RIO GALLEGOS (51°55′ S, 69°14′ W), ARGENTINA. METHODOLOGY AND RESULTS

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Since 2005 the lidar division of CEILAP with researchers from France and Japan and with the financial support of JICA (Japanese International Cooperation Agency) conducted the installation of an experimental site measurements of atmospheric parameters in the Patagonian city of Rio Gallegos in southern Argentina. The measurement campaign period from 2005 to 2007 was called SOLAR (Stratospheric Ozone Lidar in ARgentina). The main objective was to study the evolution of the polar vortex on the continent and the stratospheric ozone profile between 15-45 km altitude. In 2006 we began to obtain other products such as aerosol content and temperature profile in the stratosphere. The determination of temperature measurements from Rayleigh scattering is an important remote sensing technique to obtain stratospheric profiles. This technique is applied to signals acquired by a lidar (Light Detection and Ranging) called DIAL (Differential Absorption Lidar) for determination of stratospheric ozone profiles. Currently the site is part of the UVO3Patagonia in collaboration with the laboratory of Ozone and UV Radiation in the city of Punta Arenas, Chile at 200 km, www.uvo3patagonia.com. In this paper we show the technique to measure temperature profiles in the stratosphere between 15-60 km altitude. The inversion temperature from photoncounting is detected from light scattered by the Rayleigh line at 355 nm generated from a Quantel YG-980 laser. An analysis of the errors involved in the

inversion process and analysis of a case of study are shown for the period 2005-2007. The results presented in this paper are compared with measurements made by HIRDLS instrument (High Resolution Dynamics Limb Sounder) onboard the NASA AURA satellite platform, Ballon-borne and NCEP database.

S8P – 11

WIND AND TEMPERATURE FROM 10 TO 45 KM SIMULTANEOUSLY MEASURED WITH A NA-DEMOF-BASED 3-FREQUENCY DOPPLER LIDAR

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In ILRC 2008, we proposed to implement a Na double-edge magneto-optic filter (Na-DEMOF) into the receiver of a 3-frequency Na Doppler lidar for wind and temperature measurements in lower atmosphere. We then successfully demonstrated the simultaneous wind and temperature measurements in 10-45 km range from October 2008 to January 2009 using a prototype Na-DEMOF setup. To improve its performance, a second generation of the Na-DEMOF was constructed and used to collect considerable amount of data at Fort Collins, Colorado from November 2009 to February 2010. We compare two data retrieval algorithms, and discuss how the influence from the nonlinear response of the detector and the alignment factors may be dramatically reduced using a new experimental procedure and new data retrieval algorithm without sacrificing temporal resolution. The continuous wind and temperature measurements covering the whole night are presented and discussed. In November 2009, an abnormally high tropopause (~16 km) observed forms a distinct contrast to the tropopause (~11 km) measured in February 2010.

S8P – 12

MESOPAUSE TEMPERATURE TREND UNCERTAINTIES USING BOOTSTRAP MONTE CARLO

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Determination of long-term temperature trends requires estimates of their uncertainties. This is complicated by fitting to a set of non-orthogonal functions of time including a solar effect, a volcanic eruption effect, as well as the trend. Unknown are the uncertainties in the individual measurements which include short-term geophysical variations such as tides and gravity waves in addition to experimental uncertainties due to photon noise. A standard method of estimating the uncertainties in the fitting coefficients is to do a least-squares fitting with the same uncertainty at each time, so. Then so is determined by assuming that the model is good and setting the chi-square to the number of observations minus the number of parameters determined, N-M. The present method, bootstrap Monte Carlo, does not require the assumption that the model is good, but does require independent and identically distributed data points. It involves determining the distribution of the coefficients from fitting sets of data obtained from re-sampling the original data set for time-temperature pairs with replacement. For an 11-parameter fit to 17 years of sodium-lidar temperature measurements in the mesopause region, the two methods give substantially the same results. The distributions of all fitting coefficients closely approximate gaussians.

S8P – 13

DYNAMICS OF LIDAR REFLECTIONS OF UPPER ATMOSPHERE IN KAMCHATKA AND ITS CONNECTION WITH IONOSPHERIC PHENOMENA

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The results of Rayleigh lidar sounding of the upper atmosphere over Kamchatka are analyzed in comparison with ionosonde data. The correlation of light backscattering signals at the wavelength of 532 nm with the parameters, determining plasma content in the night F2 layer of the ionosphere was determined. On the basis of the analysis of lidar data and geophysical conditions a hypothesis on a possible role of Rydberg atoms in lidar reflection formation at ionospheric heights is discussed.

S8P – 14

LIDAR OBSERVATIONS OF VOLCANIC AEROSOL LAYERS IN THE STRATOSPHERE OVER TOMSK IN 2008–2009

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The main results of lidar sensing of the vertical aerosol structure in the upper troposphere and stratospheric over Tomsk in 2008-2009 are presented. The modernized lidar complex is described. Results of observations over the background and volcanic aerosol with a modern lidar complex are discussed. Seasonal peculiarities of the aerosol stratification in the upper troposphere and stratosphere over Tomsk, revealed previously, are confirmed. Dynamics of transfer of the eruptive aerosol from volcanic eruptions in islands of Aleutian and Kuril chains is traced over western Siberia.

S8P – 15

LIDAR OBSERVATIONS OF THE VERTICAL TEMPERATURE DISTRIBUTION IN THE LOWER AND MIDDLE ATMOSPHERE OVER WESTERN SIBERIA IN 2008–2009

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The employed technique of temperature sensing based on the Rayleigh and Raman light scattering is briefly described. The special features of the modernized lidar complex intended for temperature sensing are discussed. Results of stratospheric temperature sensing in 2008-2009 are presented. Results of observations of stratospheric warming in winter months are given.

S8P – 16

A PROPOSAL OF ALL SOLID RESONANCE SCATTERING LIDAR USING A QUASI-PHASE-MATCHED OPTICAL PARAMETRIC GENERATOR

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In stead of resonance scattering lidars consisting of a dye laser and a Ti:Sapphire laser for observations of metal atomic layers such as Fe, K, Ca and Ca ion in the mesopause region, we propose the resonance scattering lidar system consisting of the second harmonics and the third harmonics of a frequency-locked injection-seeded, pulsed optical parametric generator (OPG) pumped by a high repetition Nd:YAG laser. The maintenance of the dye laser is not easy for long observation time. As the output power of the Ti:Sapphire laser has a low damage threshold of a crystal, it is difficult to increase the output average power. On the other hand, the OPG system with the periodically poled lithium niobate quasi-phase-matched crystal can address the above-mentioned shortcomings of previous dye or Ti:Sapphire laser systems.

S8P – 17

LONG TERM OBSERVATIONS OF STRATOSPHERIC AND MESOSPHERIC TEMPERATURE BY NIES OZONE DIAL OVER TSUKUBA, JAPAN

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The paper presents results from differential absorption lidar (DIAL) observations of time series of temperature at the National Institute for Environmental Studies (NIES) in Tsukuba (36° N, 140° E), Japan. The lidar system has been making routine observation more than 20 years. From beginning of the measurements in 1988 up to now, more than 600 vertical profiles of stratospheric and mesospheric temperature as well as stratospheric ozone were obtained. This lidar observation is a part of international Network for the Detection of Atmospheric Composition Change (NDACC). The temperature data are compared with satellite data (NCEP). Comparison of the temperature profiles measured by lidar and NECP showed agreement 7 K in the 35- to 50-km altitude range.

S8P – 18

ABSORPTION OF OZONE, NITROGEN DIOXIDE, AND SULPHUR DIOXIDE MOLECULES IN THE UV SPECTRAL REGION 250–400 NM

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The critical analysis of temperature dependence of the absorption cross-sections of ozone, nitrogen dioxide, and sulphur dioxide molecules has been done using available experimental data in the selected ultraviolet spectral region. For each considered gas the optimal parametrization of temperature dependence has been chosen in the selected wave region. On the base of chosen paraterization the computer code for the absorption cross-section calculations has been generated. The absorption cross-sections data bank in the ultraviolet spectral region 250-400 nm for ozone, nitrogen dioxide, and sulphur dioxide molecules has been created. This compilation contains all available on this time experimental data of the absorption cross-sections and the values evaluated by the computer code.

Session 9P: Combining Lidar with Other Techniques and Unique Lidar Applications – Poster Presentations
Co-Chairs: Joe Shaw, George Krekov

S9P – 01

AEROSOL OPTICAL DEPTH BY LIDAR, AERONET SUN-PHOTOMETER, AND MODIS MEASUREMENTS: INTERCOMPARISON STUDY

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Aerosol Optical Depths (AOD) by a lidar system operating in the framework of EARLINET, an AERONET sun/sky photometer, and the Moderate Resolution Imaging Spectroradiometer (MODIS) are compared to investigate aerosol vertical distribution effects on AODs retrieved by passive remote sensing techniques. In particular, AODs retrieved from ground-based lidar and a sun/sky photometer measurements performed at the Physics Department of Salento's University (40.33 N, 18.1 E, Italy), are compared to AODs collocated in space and in time, retrieved by MODIS aboard Terra and Aqua satellites. It is shown that AODs from sun/sky photometer measurements are in satisfactory accordance with the ones by the lidar. Conversely, it has been found that both Terra- and Aqua-MODIS measurements can lead to under- or over-estimates of AODs. The intercomparison study has not revealed any marked dependence of MODIS-AOD underestimates on aerosol profiles and/or aerosol type. The reported quantitative analysis, besides highlighting the limitations occurring when AODs from MODIS-satellite measurements are used, allows also inferring that MODIS-AOD underestimations can probably due to the retrieval inversion algorithm: quite different AOD values have been retrieved by MODIS measurements performed on the same satellite within less than two hours under clear-sky and stable aerosol load conditions.

S9P – 02

ADAPTIVE OPTICS CORRECTION USING LASER BEACON WITH RANDOM CENTER

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Residual phase distortions at the adaptive optics (AO) correction with artificial spherical sources –Laser Guide Star (LGS) are calculation. We take into account that, from the viewpoint of diffraction, the laser guide star is a spherical source with a random center. The coordinates of the instantaneous position of this point source will be set by the vector that determines the position of the center of gravity of the laser beam that is focused through the atmosphere. To produce an analytical expressions Furutsu–Novikov theorem are used. The dependence of the variance on parameters describing the optical experiment is analyzed. The analysis of this problem is of interest for solving of a number of practical tasks including the analysis of the possibility of solution of the tilt problem in the framework of the development of atmospheric AO systems using a laser guide star.

S9P – 03

THE RETRIEVAL OF AEROSOL MICROPHYSICAL PROPERTIES IN THE VERTICAL COLUMN USING COMBINED LIDAR/PHOTOMETER DATA: A STEP TO INTEGRATING PHOTOMETER AND LIDAR NETWORKS

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A methods and test version of software for processing data of combine lidar and sun-photometer measurements have been developed. The code is aimed at dealing with data gathered at joined AERONET and EARLINET stations. The program package includes specialized programs for preliminary processing of AERONET and EARLINET data files and calculating module for retrieving of vertical profiles of aerosol modes concentrations. The results of retrieving profiles of fine and coarse modes concentrations for different aerosol types are presented.

S9P – 04

LIDAR RATIOS AND DEPOLARIZATION RATIOS OF SAHARAN DUST MEASURED WITH LIDAR AND INFERRED FROM AERONET SUN PHOTOMETER DURING SAMUM 2006

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We present a comparison of lidar ratios and linear dust depolarization ratios for Saharan mineral dust. The parameters were measured with three ground-based Raman lidars and one airborne high-spectral-resolution lidar during the Saharan Mineral Dust Experiment (SAMUM) in Morocco in 2006. The same parameters were inferred from measurements of a collocated AERONET Sun photometer. For analysis of the Sun photometer data the standard AERONET retrieval algorithm was used. This algorithm employs the latest version of a light-scattering model that is used for the analysis of non-spherical mineral dust particles. We find deviations of the lidar ratios and the linear dust depolarization ratios measured with lidar and inferred from the Sun photometer measurements. The deviations cannot be explained by measurement uncertainties of the lidars. A clear identification of the possible error sources, such as deficiencies in the light-scattering model is not yet possible due to the enormous complexity of the given task.

S9P – 05

FIRST SIMULTANEOUS MEASUREMENT OF WATER VAPOR CONCENTRATION, EXTINCTION COEFFICIENT AND TRANSPORT OF A VOLCANIC PLUME BY DIFFERENTIAL ABSORPTION LIDAR

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The differential absorption lidar ATLAS has been used to profile the plume of Stromboli Volcano (Sicily, Italy) in September 2009. Thanks to scan optics, water vapor content, spatial morphology and temporal evolution of the plume have been determined with a spatial resolution of 15 m and a temporal resolution of 10 s up to a range of 3 km.

S9P – 06

2D AND 3D AIR QUALITY MONITORING USING A LIDAR IN INDUSTRIAL AND URBAN AREAS

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In order to characterize urban and industrial pollution, several measurements campaigns have been realized from December 2008 to July 2009 in association with ADEME and two French air quality agencies, ATMOPACA and COPARLY. These measurements have been realized with a lidar ALS300 from Leosphere. This instrument, equipped with a scanning device, allows realizing map of particles. These measurements have been conducted in industrials sites for plumes detection, urban sites in Nice, Lyon and Grenoble in order to show pollution from traffic and also in a tunnel with big circulation in order to track the opacity change.

S9P – 07

ON THE LIDAR RATIO ESTIMATION FROM THE SYNERGY BETWEEN AERONET SUN-PHOTOMETER DATA AND ELASTIC LIDAR INVERSION

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The method of aerosol lidar ratio estimation from combined backscatter lidar/sun photometer measurements is analytically reformulated in terms of an objective function ready to be automated by standard numerical tools. Lidar aerosol optical thickness (AOT) extrapolation methods in the lowermost part of the boundary layer where lidar data is usually no longer valid are also presented. Finally, a 532-nm case example compares the estimated lidar ratio with that from a 532/607-nm elastic/Raman lidar.

S9P – 08

LIDAR AND *IN SITU* SENSING OF BAIKAL LAKE WATER

G.P. Kokhanenko, Yu.S. Balin, I.E. Penner, and V.S. Shamanaev

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Spatial distribution of the attenuation coefficient of Baikal Lake water was observed in 2003 with lidar, placed onboard the scientific vessel. Some observations were accompanied by simultaneous measurements with submerged apparatus. Laser sensing of water based on the effect of elastic scattering of light by hydrosol is an efficient method of investigation of the upper ocean/lake layer and detection of underwater scattering layers and anomalies. The main factor preventing successful retrieving of the vertical attenuation profiles is an unpredictable changeability of the hydrosol lidar ratio. This is especially significant in the open (far from the coast) water, because the variation of the concentration of large organic particles weakly affects the value of the backscattering coefficient. Therefore, this sort of scattering layer may be indistinguishable in the backscattering signal, but can be observed using polarization measurements. The relations between attenuation and backscattering coefficients for upper 300 m layer of Baikal water are presented in this report.

S9P – 09

COMBINED DOPPLER LIDAR AND PHASED ARRAY, DOPPLER RADAR WIND MEASUREMENTS IN TORNADIC SUPERCELLS USING TWOLF AND MWR-05XP

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Our understanding of tornado formation and structure is limited in large part by the difficulty in observing tornadoes. For over a decade, mobile Doppler radars have been used to map out the wind field in tornadoes. More recently, a rapid-scan, phase-array mobile (truck-mounted) X-band Doppler radar (MWR-05XP) has been used to document tornado formation in supercells on time scales as short as 6-7 seconds, which is necessary to resolve the rapid evolution of tornado vortices. There are, however, three major limitations of using radar alone to probe tornadoes: (1) Radar's ability to detect motions in clear air is limited and significant portions of the domain influencing tornado formation are in clear air. (2) In rapidly rotating vortices, scatterer motion is not the same as air motion owing to centrifuging. (3) The wind field in a tornado varies rapidly in the surface friction layer and is not well resolved by radar owing to ground clutter. To reduce these limitations, a Doppler lidar system (TWOLF) has been added to the MWR-05XP. Data from a test conducted in Colorado in the summer of 2009 and preliminary results from a major tornado field campaign conducted in the Plains region of the U. S. in spring of 2010 (VORTEX-2) will be discusse.

S9P – 10

MONITORING OF HIGHER AND LOWER ATMOSPHERE USING THE YAKUTSK EAS ARRAY DATA

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In this work we present preliminary results on atmospheric spectral transparency, seasonal variations of aerosol optical depth, stratospheric temperature and ground-level electric field obtained in composite measurements at the Yakutsk EAS setup.

S9P – 11

REABSORPTION OF LASER-INDUCED FLUORESCENCE IN A PLANT COVER: STOCHASTIC MODEL

G.M. Krekov, A.A. Lisenko, G.G. Matvienko

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A system of interrelated radiative transfer equations is proposed. This system gives a formal basis for a numerical analysis of a wider range of spectroscopic effects that accompanies the propagation of laser radiation in the environment, such as the reabsorption of fluorescence in dense disperse media containing two and more fluorophores. As applied to the problem of lidar monitoring of the state of a plant cover, an optical model is developed in which a leaf is not treated as an individual scattering element, but rather as a local volume of a multiphase medium with a complex polydisperse structure. The Monte Carlo algorithms have been modified so that they have achieved the simulation of fluorescence and reabsorption processes. Test calculations have demonstrated the adequacy of the proposed approach.

S9P – 12

STUDY OF THE AEROSOL LOAD AT AN URBAN AND A NEARBY SUBURBAN SITE USING LIDAR, SUNPHOTOMETER MEASUREMENTS AND MODEL PM10 ESTIMATES

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An aerosol campaign was held from July 14-25, 2006, at Thessaloniki, Greece, as part of the integrated project SCOUT-O3 (Stratosphere-Climate Links with Emphasis on the Upper Troposphere and Lower Stratosphere) including ground-based and air-borne measurements. In this study we have compared aerosol profiles retrieved with an elastic-Raman lidar and optical depth data derived from two CIMEL sunphotometers with PM10 concentrations simulated by the Comprehensive Air quality Model (CAMx). The model simulations were performed with a fine resolution of 2x2 km. Estimates at various levels in the lower troposphere for an urban (Thessaloniki's centre) and a rural (Epanomi) grid point were extracted. Backscatter and extinction profiles from a ground-based and airborne lidars were used to estimate the free tropospheric contribution of aerosols in the greater area of Thessaloniki. The dataset and the model estimates were used to study the spatial variability of the aerosol loading and its optical properties, as well as to compare and investigate the difference in the diurnal variability between the centre of the city and the suburbs.

S9P – 13

SAHARAN DUST BACKSCATTER AS MEASURED BY LIDAR AND CALCULATED FROM IN-SITU AEROSOL SIZE DISTRIBUTIONS

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Saharan dust is a common presence in the Mediterranean troposphere. Since 2007, the automatic IFAC LIDAR (60 m asl) has provided a continuous monitoring of tropospheric clouds and aerosols. As a byproduct, Saharan dust events are easily detected due to their peculiar depolarization signature. In this experiment, the LIDAR parallel and perpendicular backscatters of desert dust are compared with calculated quantities derived from aerosol observational activity in high mountain site during the period 2008-2009. Aerosol size distribution is continuously measured by means of DMA and Optical counters at the Mt. Cimone (MTC) station (2165 m asl), which is located 50 km away from the LIDAR site. LIDAR quantities were calculated from MTC size distributions by splitting them into three lognormal modes. The LIDAR backscatter was simulated by means of the Mie theory for the two small modes and by T-Matrix simulations for the dust mode. A closure experiment was then attempted on a sample of Saharan dust events by comparing the calculated and measured LIDAR quantities at the altitude of Mt. Cimone.

S9P – 14

AN AUTOMATED LIDAR FOR THE MONITORING OF TROPOSPHERIC CLOUDS AND AEROSOLS AT CONCORDIA STATION (ANTARCTICA)

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Since 1988, elastic backscatter LIDARs developed at IFAC CNR have been used in several campaigns along the coasts of the Ross Sea for monitoring stratospheric and tropospheric clouds . Within the framework of the TAVERN ("quantification of Tropospheric Aerosol and thin clouds Variability over the East antarctic plateau, including Radiation budget") project, in 2007 an automated IFAC depolarization LIDAR was installed at the Concordia international Antarctic station, which is located on the eastern plateau (75°S,123°E, 3000 m altitude) . The aim of this LIDAR activity is to monitor continuously tropospheric aerosols from an altitude of 30 m a.g. up to an the altitude of ≈7000 m. Due to the harsh environmental conditions of the winter period (with temperatures down to -85°C), the LIDAR was placed inside a shelter and was operated through ventilated double-glass windows. Several problems (all related to the low environmental pressure (670 mb) and to the absence of an efficient electrical ground) arose during the winter periods, when the instrument was virtually unattended. Most of these problems resulted from unexpected discharges that occurred inside the high-voltage part of the laser. Despite these problems, a first time-series of vertical profiles of aerosols and clouds was produced in 2008-2009. Diamond dust events, wind-drifted snow, power-plant plumes and cloud structure were evidenced.

S9P – 15

RAMAN-LIDAR, SUNPHOTOMETRIC AND AIRBORNE DATA IN COMBINATION WITH INVERSION MODELS FOR THE ESTIMATION OF THE AEROSOL PROPERTIES OVER ATHENS, GREECE

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A novel procedure has been developed to retrieve, simultaneously, the optical, microphysical and chemical properties of tropospheric aerosols using a 6-wavelength Raman lidar system in the troposphere over an urban site [Athens, Greece (37.9oN, 23.6oE, 200 m a.s.l.)]. Our results are validated using in situ airborne data obtained during the European Space Agency (ESA) THERMOPOLIS project which took place between 15 and 31 July 2009 over the Greater Athens Area (GAA). The National Technical University of Athens (NTUA) 6-wavelength Raman lidar system has been used to provide the vertical profiles of the optical properties (extinction and backscatter coefficients) of aerosols and the water vapor mixing ratio. Two inversions algorithms were used to derive the mean aerosol microphysical properties (effective radius, surface-area concentration, volume concentration, single-scattering albedo (ω) and mean complex refractive index) in selected heights in the lower free troposphere. The final data set of the aerosol microphysical properties along with the water vapor and temperature profiles were incorporated into the thermodynamic model ISORROPIA II to infer the chemical parameters of the aerosols (water content, dry chemical composition) that are consistent with the retrieved ω and refractive index values. Finally, our results concerning the aerosol properties are compared with in situ airborne data obtained during the THERMOPOLIS research project.

S9P – 16

REMOTE SENSING AND IN SITU INVESTIGATION OF THE ATMOSPHERE OVER MOUNTAIN VALLEY (SOFIA-BULGARIA)

Tsvetina Evgenieva[1], Boyan Tatarov[2], Bo L.B. Wiman[3], Nikolay Kolev[1], Evgeni Donev[4], Danko Ivanov[4], Ventsislav Danchovski[4], Doyno Petkov[5], Vera Grigorieva[1], Ivan Kolev[1]

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The paper presents the results from planetary boundary layer (PBL) height and aerosol optical depth (AOD) measurements carried out in two different experimental sites in Sofia as well as from three-point measurements of aerosol number concentration. The main aim of the present investigation is to determine optical and microphysical characteristics of the atmospheric aerosol in three points of the valley and their variation during the PBL formation over urban area, park zone and mountain site. Four instruments (lidar, ceilometer, aerosol particle counter and sun photometer) were used in this study. The experimental AOD data obtained at λ=500 nm gave values in the range from 0.22 to 0.41 in case of cloud-free skies and up to around 0.8 under partly cloudy conditions. Aerosol particle counter data on aerosol-particle concentration variations in the size range 0.3-1μm provided supportive information on the evolution of the valley-mountain aerosol in time and height during the mixing layer development. Joint interpretation of sun photometer, aerosol lidar and ceilometer CHM 15k data allow the influence of the main part of the atmospheric aerosol in the planetary boundary layer to be accounted as well as the significant influence of aerosol layers and high clouds on AOD values.

S9P – 17

LIDAR AND TWO SUN PHOTOMETERS OBSERVATIONS IN SOFIA (BULGARIA)

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This paper presents the observation of the atmosphere by lidar and two sun photometers Microtops II situated at distance of about 7km in the region of Sofia. The objective of this investigation is to compare optical characteristics of the atmospheric aerosol in two regions having different underlying surface during the planetary boundary layer (PBL) development. The measurements were implemented in two stages. The first one was comparison of the results obtained and calibration of the sun photometer Microtops II. The second one was carried out in the regions of Institute of Electronics and

Astronomical Observatory, Borisova gradina Park. An aerosol lidar, a sun photometer, an ozonemeter Microtops II, a pyranometer and an automatic meteorological station were used. The results from the first stage of the campaign show high correlation coefficients and in some days quite close aerosol optical depth (AOD) values at wavelengths λ=500nm and λ=675nm. The results from the second stage of the campaign show that in clear sunny days the AOD values differ at the two sites in the morning hours and become close when mixing layer is developed. The comparison between AOD behavior and PBL development show that the two kinds of data qualitatively complement each other.

S9P – 18

ON THE SYNERGIC USE OFPASSIVEANDACTIVE REMOTE SENSING FOR ATMOSPHERIC AEROSOL RADIATIVE EFFECT COMPUTATIONS

F. Navas-Guzmán[1,2], D. Pérez-Ramírez[1,2], F.J. Olmo[1,2], H. Lyamani[1,2], J.L. Guerrero-Rascado[3], J.A. Bravo-Aranda[1,2], and L. Alados-Arboledas[1,2]

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The characterization of physical and optical properties of diverse aerosol types is necessary in order to know their potential capability to perturb the radiative balance of the Earth-Atmosphere system. In this work we analyse the complex situations associated to the presence of different aerosol types due to the combination of medium-long range transport of aerosol particles from different sources. Data analysed in this study have been gathered at Andalusian Centre for Environmental Research (CEAMA), located in the city of Granada (37.16ºN, 3.61ºW, 680 m a.s.l.). We use a CIMEL CE-318 radiometer to perform solar extinction and sky radiance measurements and a Raman lidar system based on a Nd:YAG laser source to derive profiles of several atmospheric aerosol properties. Night-time columnar aerosol characterisation was done by means of a star photometer. The combination of active and passive remote sensing is fully exploited in this study.

S9P – 19

COMBINED LIDAR AND SUN/SKY PHOTOMETER MEASUREMENTS OVER PORQUEROLLES, FRANCE: OBSERVATION OF AN AFRICAN DUST OUTBREAK BETWEEN 21–25 MAY 2007.

O. Lado-Bordowsky, Myriam Kervella, and Céline Klein

ENSSAT - Université de Rennes 1, BP 80518, 22305 Lannion Cedex, France

During the Porquerolles Aerosol Campaign Multi-Instrument Analysis Network (PAC-MAN), tropospheric aerosols have been measured in May 2007. Combined observations of an aerosol lidar and an AERONET (AErosol RObotic NETwork) sun /sky photometer were made from 21 to 28 May 2007. Here we present a case study of an African dust event observed between 21-25 May. The lidar operates at the wavelength of 355 nm; it was the Easy Lidar of the French company LEOSPHERE. The sun photometer measurements were performed at five different wavelengths ranging from visible to near infrared (440, 675, 870, 1020 and 1610 nm). The results were extrapolated at the 355 nm wavelength for comparison with the lidar data. We provide lidar aerosol backscattering profiles, lidar ratios at 355 nm for “fine”, “coarse” and “total” particles. A comparison of column aerosol optical thickness (AOD) is obtained using the two instruments.

S9P – 20

ON FORWARD KLETT'S INVERSION OF CEILOMETER SIGNALS

Iwona S. Stachlewska and Krzysztof M. Markowicz

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The extinction coefficient profiles up to 3 km were retrieved from the CHM_15k JENOPTIK ceilometer signals averaged over 15m/15min using the forward Klett's approach with calibration value at a near-range obtained from ceilometer signal itself with known instrumental constant. The method seem to have a potential for evaluation of the ceilometer data obtained under the clear sky conditions for low and significant boundary aerosol load, high aerosol load under an inversion in boundary layer, and elevated aerosol layer.

S9P – 21

ON THE WAY TO COMBINED DIAL AND RAMAN LIDAR SOUNDING OF WATER VAPOUR AT THE NDACC STATION ZUGSPITZE

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A new high-power Raman lidar system is currently under construction at the high-altitude research station Schneefernerhaus (Garmisch-Partenkirchen, Germany) at the side of the existing wide-range differential-absorption lidar. A combination of a 350-W XeCl laser and a 1.5-m-diameter receiver is expected to allow us to extend the measurement range for water-vapour sounding to more than 25 km, with an accuracy level of the order of 5 %. In addition, temperature measurements in the free troposphere and to altitudes beyond 80 km are planned.

S9P – 22

DAILY BEHAVIOUR OF FLUORESCENCE CHARACTERISTICS OF PINE FROM LIDAR SENSING DATA

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The laser-induced fluorescence (LIF) method is successfully used in lidars to study the plants. The measurements were performed using the fluorescence channel of the Siberian Lidar Station (SLS), Tomsk, Russia. Typical representative of trees growing in the West Siberia, namely, pine (Pinus silvestris L.) was taken as the object of study. The emission of the second harmonic of Nd:YAG laser with wavelength 532 nm was used as the source of excitation. In the experiment, we studied the most intense fluorescence phase, namely the fluorescence of nanosecond range. The fluorescence spectra of chlorophyll in the range 600-800 nm were detected. The measurements were performed under natural conditions. The positions of the chlorophyll fluorescence emission maxima are found at 685 and 740 nm. The daily variations of fluorescence characteristics were detected.

18:30 – 22:00 – Banquet

Friday, 09 July 2010
7:30 – 8:30 – Registration

Session 6O: Trace Gas Sensing for Climate and Air Quality – Oral Presentations
Co-Chairs: Gerhard Ehret, Pierre Flamant

8:30 – 8:45
S6O – 01

PULSED AIRBORNE LIDAR MEASUREMENTS OF ATMOSPHERIC CO2 COLUMN ABSORPTION FROM 3–13 KM ALTITUDES

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We have developed a pulsed lidar technique for measuring the tropospheric CO2 concentrations as a candidate for NASA's planned ASCENDS space mission. We have developed an airborne lidar to demonstrate the CO2 column measurement from aircraft. In 2009 we measured atmospheric CO2 column absorption and line shapes on a series of flights at altitudes from 3-13 km.

8:45 – 9:00
S6O – 02

CHARM-F: THE AIRBORNE INTEGRAL PATH DIFFERENTIAL ABSORPTION LIDAR FOR SIMULTANEOUS MEASUREMENTS OF ATMOSPHERIC CO2 AND CH4

Mathieu Quatrevalet[1], Axel Amediek[1], Andreas Fix[1], Christoph Kiemle[1], Martin Wirth[1], Christian Büdenbender[1], Sebastian Schweyer[1], Gerhard Ehret[1], Dieter Hoffmann[2], Ansgar Meissner[2], Jens Löhring[2], J örg Luttmann[2]

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CHARM-F (CO2 and CH4 Atmospheric Remote Monitoring – Flugzeug) is DLR's airborne Integral Path Differential Absorption lidar for simultaneous measurements of the column weighted-average dry-air mixing ratios of atmospheric carbon dioxide and methane, designed to be flown on board DLR's new High-Altitude, LOng-range research aircraft, HALO. After recalling the context of the project, the measurement principle and the technological challenges, we report on the design of the instrument.

9:00 – 9:15
S6O – 03

AIRBORNE VALIDATION OF LASER REMOTE MEASUREMENTS OF ATMOSPHERIC CARBON DIOXIDE

Edward V. Browell[1], Jeremy Dobler[2], Susan Kooi[1], Yonghoon Choi[1], F. Wallace Harrison[1], Berrien Moore III[3], T. Scott Zaccheo[4]

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This paper discusses the development and measurement validation of a unique, multi-frequency, single-beam, laser absorption spectrometer (LAS) that operates at 1.57 micron, which has been developed for a future space-based mission to determine the global distribution of regional-scale CO2 sources and sinks. A prototype of this space-based LAS system was developed by ITT, and it has been flight tested in eight airborne campaigns since May 2005. This paper focuses on the results obtained during the last 2½ years of flight testing where the remote LAS measurements of CO2 were evaluated against high-quality airborne in situ CO2 measurements made on spirals near the center of the LAS flight tracks. Flight tests over various land and water regions of Oklahoma and Virginia showed the high correlation of the LAS-measured CO2 optical depths (ODs) with altitude, and a high correlation between the remote and in situ CO2 ODs. In the latest test flights, the average difference between the remote and in situ CO2 ODs was found to be less than 0.09% or 0.32 ppmv of CO2 with a standard deviation of less than 0.62% or 2.4 ppmv. These high-accuracy active remote CO2 measurements represent a major step towards the realization of the needed capability for space-based laser measurements of the global distribution of CO2.

9:15 – 9:30
S6O – 04

CAN CO2 TURBULENT FLUX MEASUREMENTS BE MADE BY LIDAR? A PRELIMINARY STUDY

Fabien Gibert[1], Grady J. Koch[2], Jeffrey Y. Beyon[2], Timothy W. Hilton[3], Kenneth J. Davis[3], Arlyn Andrews[4], Pierre H. Flamant[1], Upendra N. Singh[2]

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The vertical profiling of CO2 turbulent fluxes in the atmospheric boundary layer (ABL) is investigated using a Coherent Differential Absorption Lidar (CDIAL) operated nearby a tall tower in Wisconsin, USA, during June 2007. A CDIAL can perform simultaneous range resolved CO2 DIAL and velocity measurements. The lidar eddy-covariance technique is presented. The aims of the study are i) an assessment of performance and current limitation of available CDIAL for CO2 turbulent fluxes; and ii) the derivation of instrument specifications to build a future CDIAL to perform accurate range resolved CO2 fluxes. Experimental lidar CO2 mixing ratio and vertical velocity profiles are successfully compared with in situ sensors measurements. Time and space integral scales of turbulence in the ABL are addressed that result in limitation for time averaging and range accumulation. A first attempt to infer CO2 fluxes using an eddy-covariance technique with currently available 2-µm CDIAL data set is reported.

9:30 – 9:45
S6O – 05

REMOTE SENSING OF SULPHUR DIOXIDE EMISSIONS OF SEAGOING VESSELS ON INLAND WATERWAYS

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National Institute for Public Health and the Environment RIVM, P.O. Box 1, 3720 BA Bilthoven, The Netherlands

RIVM developed an lidarinstrument to measure sulphur dioxide emissions of seagoing vessels. Between 2006 and 2008, the emissions of 102 ships were determined. As it turned out, a significant number of ships emitted large quantities of sulphur dioxide. Seagoing ships are not allowed to use sulphur-rich fuel on inland waterways, in territorial waters, or in an SOx Emission Control Area (SECA), such as the North Sea. This relatively cheap fuel may be on board, though, for use at sea. Scanning the exhaust plume of a passing ship with a lidar instrument determines the emission, unnoticed. On land, sulphur dioxide emissions of industrial installations are limited by licences allowing the emission of 0.5 gram per second. The emissions of all measured ships turned out to be higher than that. The highest emission measured was 36 gram per second. This indicates the importance of recognising ocean shipping as a source of air pollution, both when issuing rules and when enforcing them. Sulphur dioxide is a source of acidification and is harmful to the environment. Various measures have driven back emissions from other sources, such as traffic, industry and electricity generation. This caused the share of shipping in the total of the emissions to increase.

9:45 – 10:00
S6O – 06

PROGRESS IN MEASUREMENT OF CARBON DIOXIDE USING A BROADBAND LIDAR

William S. Heaps[1], Elena Georgieva[2], Wen Huang[3], William S. Heaps[1], Elena Georgieva[2], Wen Huang[3]

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In order to better understand the budget of carbon dioxide in the Earth's atmosphere it is necessary to develop a global high precision understanding of the carbon dioxide column. In order to uncover the 'missing sink" that is responsible for the large discrepancies in the budget as we presently understand it calculation has indicated that measurement accuracy on the order of 1 ppm is necessary. Because typical column average CO2 has now reached 380 ppm this represents a precision on the order of .25% for these column measurements. No species has ever been measured from space at such a precision. In recognition of the importance of understanding the CO2 budget in order to evaluate its impact on global warming the National Research Council in its decadal survey report to NASA recommended planning for a laser based total CO2 mapping mission in the near future. The extreme measurement accuracy requirements on this mission places very strong requirements on the laser system used for the measurement. This work presents an overview of the characteristics necessary in a laser system used to make this measurement. Consideration is given to the temperature dependence, pressure broadening, and pressure shift of the CO2 lines themselves and how these impact the laser system characteristics We have been examining the possibility of making precise measurements of atmospheric carbon dioxide using a broad band source of radiation. This means that many of the difficulties in wavelength control can be treated in the detector portion of the system rather than the laser source. It also greatly reduces the number of individual lasers required to make a measurement. Simplifications such as these are extremely desirable for systems designed to operate from space.

notes

10:00 – 10:15
S6O – 07

LIDAR TECHNOLOGIES OF REMOTE MONITORING

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The number and variety of situation, when operative data accessing of the atmosphere state and characteristics is required, are constantly increasing. Ecology, meteorology, military conflicts and terrorist activity, natural and anthropogenic accidents which lead to the air pollution, various safety aspects. At this time, technologies of remote monitoring are the most important and the most used. The experience in development, tests and practical use of the various lidar complexes for operative remote detection the physical characteristics and chemical solution of the atmosphere is represented. The universal multi-wavelength lidar complexes for remote atmosphere monitoring in the interest of ecology and safety, and the principal technologies are described. Also different methods are presented and constructions securing high parameters of real complexes, including mobile, for solving the complex problems of remote monitoring are realized. Variants of compact lidar systems on the base of the modern semi-conductor lasers for solving problems of remote detection of various substances are presented. The developed lidar complexes for measuring wind speed and direction in the interest of flight safety securing are described, including vortex safety for airports which becomes relevant after appearing the large wide-body aircrafts.

10:15 – 10:35 Coffee Break

Session 8O: Middle and Upper Atmosphere Physics and Chemistry – Oral Presentations
Co-Chairs: Alex Papayannis, Thomas McGee

10:35 – 10:50
S8O – 01

THIRTY YEARS ANNIVERSARY OF CONTINUOUS TEMPERATURE LIDAR MEASUREMENTS OVER SOUTH OF FRANCE

Philippe Keckhut, Alain Hauchecorne, Jacques Porteneuve, and Marie-Lise Chanin

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10:50 – 11:05
S8O – 02

LIDAR OBSERVATION OF SUDDEN STRATOSPHERIC WARMING EVENTS' IMPACTS ON MIDLATITUDE MESOPAUSE REGION TEMPERATURE, AND WINDS

Chiao-Yao She, Tao Yuan, David A. Krueger

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A Sudden Stratospheric Warming (SSW) event is considered one of the most dramatic meteorological events in polar stratosphere; it typically impacts temperature and winds in the polar mesopause region. The major SSW in January 2009 is believed to be among the strongest, so it can potentially impact midlatitude mesosphere and lower thermosphere (MLT) as well. Using the unique full-diurnal-cycle observations of Colorado State University (41ºN, 105ºW) Na lidar, we follow the evolution of the tidal-removed mean temperature and wind fields during the peak of this major warming event and compare them to respective climatology. Our study shows that this major SSW event indeed impacts the midlatitude mesopause region, leading to excessive cooling in the MLT below 90 km, reversing the mean zonal wind profile, followed by a change in meridional flow from northward to southward.

11:05 – 11:20
S8O – 03

LIDAR POLARIZATION APPROACHES FOR POLAR MESOSPHERIC CLOUD DETECTION

Jeffrey P. Thayer[1] and Matthew Hayman[2]

[1]University of Colorado at Boulder, Aerospace Engineering Sciences Department Boulder Colorado 80309, USA
[2] University of Colorado at Boulder, Electrical Engineering Department Boulder Colorado 80309, USA

An evaluation of lidar polarization measurements of polar mesospheric clouds (PMC) is performed, that considers system effects and detection schemes, to assess the ability to estimate polarizing effects caused by PMC particulates. Hardware optical and software compensation methodologies are demonstrated in the Greendland ARCLITE lidar and system effects of polarization are reduced to less than 1% making unbiased estimates of PMC depolarization possible.

11:20 – 11:35
S8O – 04

PROGRESS IN MRI FE-RESONANCE/RAYLEIGH/MIE DOPPLER LIDAR

Xinzhao Chu[1], Wentao Huang[1], Jeffrey P. Thayer[1], Zhangjun Wang[1], and John A. Smith[1]

[1]University of Colorado at Boulder, 216 UCB, CIRES, Boulder, CO 80309, USA

Ambitiously aiming to achieve bias-free resonance Doppler lidar for advancing the middle and upper atmosphere physics and chemistry, we started the development of a Major Research Instrumentation (MRI) mobile Fe-resonance/Rayleigh/Mie Doppler lidar about two years ago at the University of Colorado at Boulder. We report the significant progress made in the last two years, especially on the revolutionary ideas of pulsed alexandrite ring laser, Fe Doppler-free spectroscopy, and optical heterodyne detection for accurate frequency control and spectral analysis of the lidar pulse.

Substantial efforts have also been spent to construct large-aperture receiver, state-of-the-art data acquisition and control system, and mobile lidar laboratory. We introduce the overall lidar architecture to inspire future lidar advancement worldwide.

11:35 – 11:50
S8O – 05

STUDIES OF NORTHERN HEMISPHERIC POLAR STRATOSPHERIC CLOUDS WITH GROUND-BASED AND SPACE-BORNE LIDAR

Peggy Achtert[1], Farahnaz Khosrawi[1], Ulrich Blum[2], K.H. Fricke[2]

[1]*Department of Meteorology, Stockholm University, Sweden*
[2]*Physikalisches Institut der Universität Bonn, 53115 Bonn, Germany*

Polar Stratospheric Clouds (PSCs) play a key role for heterogeneous chemistry and ozone depletion in the lower stratosphere. Their type as well as their temporal and spatial extent are of importance for the understanding of the amount of activated chlorine. This study was performed using ground-based (Esrange lidar) and spaceborne (CALIPSO) lidar measurements. Between 20 and 23 January 2008 PSCs consisting of liquid particles were observed by CALIPSO between Greenland and the western side of the Scandinavian mountains. Between 21 and 23 January 2008, the Esrange lidar observed a PSC composed of distinct mixed layers of liquid and solid particles on the eastern side of the mountain range. Microphysical box model simulations show that the cloud had formed at least 40 hours before the observation at Esrange. Furthermore, the model showed a high HNO3 uptake which was stable during the 20 hours before the observation inside the liquid layer. The observed liquid layer was formed at synoptic temperatures between 185 and 190 K. In the observed mixed (liquid and solid) layer, which was located below and above the liquid layer, the calculated HNO3 uptake was reduced. No HNO3 was simulated in the NAT layer and the synoptic temperature increased close to the NAT existence temperature. Backscatter ratios calculated from the output of the box model simulation show good agreement with the values observed at Esrange. On two occasions during these 20 hours CALIPSO observed PSCs when its measurements tracks crosses the air parcel back trajectory starting at the Esrange lidar.

11:50 – 12:05
S8O – 06

STRATOSPHERIC AND UPPER TROPOSPHERIC AEROSOLS IN THE LAST TWO DECADES OVER MID-LATITUDES OF THE SOUTHERN HEMISPHERE

J Ben Liley[1], Tomohiro Nagai[2], Tetsu Sakai[2], Osamu Uchino[2,3]

[1]*National Institute of Water & Atmospheric Research, Lauder, NZ*
[2]*Meteorological Research Institute, Tsukuba, Japan*
[3]*National Institute of Environmental Research, Tsukuba, Japan*

Lidar observations of the stratosphere and upper troposphere from Lauder (45° S, 170° E) have been made since November 1992. The data series to February 2009, using a single instrument to measure backscatter at 532 nm, provides a uniform data record from the Pinatubo aftermath through recent stratospheric aerosol change. The data correlate well with backscattersonde measurements and with SAGE data in the years to 2000. The upper tropospheric record shows an annual spring maximum, as reported for this site and attributable to tropical biomass burning. The correlation of lidar-derived aerosol optical depth with values from analysis of sun photometer data is strongest for the column above the presumed boundary layer. The stratospheric aerosol burden after the Pinatubo eruption declined with an e-folding time of about 1.4 years, to a minimum integrated backscattering coefficient (IBC) of about 1.4x10-4 sr-1. In the decade to 2009, stratospheric IBC increased at a rate of around 4% per year.

12:05 - 12:20
S8O – 07

SEASONAL VARIATIONS OF GRAVITY WAVE ACTIVITY AND SPECTRA DERIVED FROM SODIUM TEMPERATURE LIDAR AT 23°S

Guotao Yang[1], Barclay Clemesha[2], Paulo Batista[2], and Dale Simonich[2]

[1]State Key Laboratory of Space Weather, Center for Space Science and Applied Research, Chinese Academy of Sciences, Beijing, China
[2]Instituto Nacional de Pesquisas Espaciais, São José dos Campos, 23337-010 SP, Brazil

Gravity wave measurements were carried out by a newly developed sodium temperature lidar at São José dos Campos (23 °S, 46 °W). The seasonal variations of gravity wave activity and spectra derived from temperature data are investigated. The total temperature perturbation, and temperature vertical power spectra, Ft(m) at 2π/(8km), 2π/(4km), and 2π/(2km) all show that the semiannual maxima occur near the equinoxes, which agrees with our earlier study [Yang et al., 2006] when only sodium concentration data were used. Large nightly variability of the temperature perturbation spectral slope was also found, in common with other sodium concentration lidar studies. We have discussed several probable reasons that may result the equinoctial maxima of gravity activity in the mesopause region. But whether these explanations are responsible for the equinoctial maxima are still unclear, as many atmospheric parameters cannot be detected simultaneously.

10:20 – 10:35
S8O – 08

HIGHLY-RELIABLE PUMP LASER DIODES FOR SPACEBORNE LIDAR APPLICATIONS

Eckard Deichsel and Petra Hennig

JENOPTIK Laserdiode GmbH, Göschwitzer Straße 29, 07749 Jena, Germany

Spaceborne solid state laser applications, such as light-detection and ranging (LIDAR), require highly reliable pump sources. Passively cooled laser diodes with a special designed package are prerequirement for reliable operation. For this purpose an intensive test program was performed regarding reliability on laser bar and stack level. Special laser diode stacks for spaceborne applications have been developed. The new laser stack design is compatible to harsh environmental conditions in space and the high demands on reliability. Environmental tests, such as mechanical loads and thermal cycles were applied without any degradation of performance. In an ongoing lifetime test more than 15GShots reliable operation was achieved up to now.

12:20 – 13:30 – Lunch Break

Session 10O: Atmospheric Water Vapor and Tropospheric Temperature – Oral Presentations
Co-Chairs: Arnoud Apituley, Paolo Di Girolamo

13:30 – 13:45
S10O – 01

MEASUREMENTS OF HUMIDITY IN THE ATMOSPHERE AND VALIDATION EXPERIMENTS (MOHAVE)-2009: OPERATIONS AND RESULTS OVERVIEW

Thierry Leblanc[1], I.S. McDermid[1], H. Vömel[2], T.J. McGee[3], C. Straub[4], N. Kampfer[4], G. Nedoluha[5], S. Gutman[6], D.N. Whiteman[3], T.M. Van Hove[7], and J.J. Braun[7]

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[7]University Corporation for Atmospheric Research, P.O. Box 3000, Boulder, CO, 80307, USA

The MOHAVE 2009 campaign took place at the Jet Propulsion Laboratory Table Mountain Facility (California) in October 2009. The campaign hosted a large number of instruments and techniques which allowed intensive measurements of water vapor mixing ratio between the ground and the mesopause, as well as Total Precipitable Water (TPW). Six ground-based lidars from three different Research groups provided over 350 hours of water vapor, ozone, and temperature measurements. Over 50 balloons were launched with RS92 PTU sondes onboard. Twenty of them included Frost-point Hygrometers (FPH), allowing thorough validation of the lidar measurements. The water vapor profiles obtained from the JPL lidar showed no systematic bias with the FPH up to 20 km. One-hour time integration allowed the JPL profiles to reach 14-15 km, and 50-hour averages allowed the profiles to reach 20 km with approximate 20% precision. Outstanding water vapor-ozone correlations were observed, and revealed a major stratospheric intrusion on October 20. Two GPS receivers, two microwave radiometers, and two Fourier Transform Spectrometers provided near-continuous measurements of TPW. Excellent agreement between all instruments was found, suggesting that these techniques can become important complements to the radiosonde for routine lidar calibration

13:45 – 14:00
S10O – 02

LASE OBSERVATIONS OF INTERACTIONS BETWEEN AFRICAN EASTERLY WAVES AND THE SAHARAN AIR LAYER

Syed Ismail[1], Richard Ferrare[1], Edward Browell[1], Susan Kooi[2], Mrinal Biswas[3], T. N. Krishnamurti[3], Anthony Notari[2], Andrew Heymsfield[4], Carolyn Butler[2], Sharon Burton[2], Marta Fenn[2], and Jason Dunion[5]

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The Lidar Atmospheric Sensing Experiment (LASE) participated in the NASA African Monsoon Multidiscipplinary Analysis (NAMMA) field experiment in 2006 that was conducted from Sal, Cape Verde to study the Saharan Air Layer and its influence on the African Easterly Waves (AEWs) and Tropical Cyclones (TCs). During NAMMA, LASE collected simultaneous water vapor and aerosol lidar measurements from 14 flights onboard the NASA DC-8. We present three examples of the interactions of the AEWs regarding: moistening of the SAL and transfer of latent heat; injection of dust in an updraft; and influence of dry air intrusion on an AEW. A brief discussion is given on activities related to the refurbishment of LASE to enhance its operational performance and plans to participate in the next NASA hurricane field experiment in the summer of 2010.

14:00 – 14:15
S10O – 03

A RAMAN LIDAR AS OPERATIONAL TOOL FOR WATER VAPOR PROFILING IN THE SWISS METEOROLOGICAL OFFICEA RAMAN LIDAR AS OPERATIONAL TOOL FOR WATER VAPOR PROFILING IN THE SWISS METEOROLOGICAL OFFICE

V. Simeonov[1], T. Dinoev[1], B. Calpini[2], S. Bobrovnikov[3], Y. Arshinov†[3], P. Ristori[1], H. van den Bergh[1], and M. Parlange[1]

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The paper will present a narrow field of view, narrowband UV Raman lidar for day and night operational profiling of water vapor and aerosol, developed by the Swiss Federal Institute of Technology-Lausanne and operated by the Swiss Meteorological Office. The lidar has been operated in an automatic mode since October 2007. Results addressing the technical availability, alignment and calibration stabilities will be discussed. Intercomparison with a microwave radiometer, GPS, standard radiosonding and an airborne DIAL will be presented and discussed.

14:15 – 14:30
S10O – 04

FIRST WATER VAPOR AND CLOUD MEASUREMENTS WITH THE NEW FAR-RANGE RECEIVER OF THE GERMAN METEOROLOGICAL SERVICE RAMAN LIDAR RAMSES

Jens Reichardt[1], Robert Begbie[1], UllaWandinger[2], Volker Klein[3], Bernhard Hilber[4], Dirk Engelbart[5]

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5Bundesministerium f¨ur Verkehr, Bau und Stadtentwicklung, Robert-Schuman-Platz 1, 53175 Bonn, Germany

Since August 2005, RAMSES, the Raman lidar for atmospheric moisture sensing, has been monitoring the water vapor field and clouds at the Richard Aßmann Observatory of the German Meteorological Service at Lindenberg. Although the early technical design of the lidar allowed of high-quality measurements on a routine basis, the range of application was limited because, (1) the lidar operated only at night, and (2) the set of measured parameters was restricted to water vapor mixing ratio, particle backscatter coefficient and extinction coefficient. To overcome these limitations, the RAMSES receiver was upgraded in 2009 to permit also observations of temperature and depolarization ratio, and to allow of daytime observations. In a previous conference contribution, we described the optical layout of the new RAMSES receiver, summarized the changes to the operational system control and to the signal processing software, and showed examples of temperature measurements. Here we focus, after a short instrumental summary, on first water vapor and cloud measurements with the new RAMSES lidar.

14:30 – 14:45
S10O – 05

THREE YEARS OF WATER-VAPOR SOUNDING WITH THE DIFFERENTIAL ABSORPTION LIDAR (DIAL) ON MT. ZUGSPITZE

Hannes Vogelmann[1], Thomas Trickl[1], Martin Wirth[2]

[1]Karlsruhe Institute of Technology (KIT), IMK-IFU, Garmisch-Partenkirchen
[2]German Aerospace Center (DLR), Oberpfaffenhoffen, Germany

The differential absorption lidar (DIAL) on Mt. Zugspitze (Germany, 2675~m asl.) was designed to cover the altitude range of the entire free troposphere (3~km to 12~km). Its vertical resolution varies from 50~m near the ground to 300~m in the tropopause region. The system features a full daytime-capability and the temporal resolution of the system is about 15~min. The lidar is in routine operation since January 2007 and has proved its accuracy within a lidar intercomparison campaign (LUAMI). We present results from the first three years of operation considering different large-scale circulation patterns over central Europe as well as small-scale atmospheric dynamics in the alpine surroundings of Mt. Zugspitze.

14:45 – 15:00
S10O – 06

SCANNING DIFFERENTIAL ABSORPTION LIDAR FOR 3DOBSERVATIONS OF THE ATMOSPHERIC HUMIDITY FIELD

Andreas Behrendt, Volker Wulfmeyer, Andrea Riede, Gerd Wagner, Sandip Pal, Heinz Bauer, Florian Späth

Institute of Physics and Meteorology, University of Hohenheim, Stuttgart, Germany

The scanning water vapor differential absorption lidar (DIAL) system of University of Hohenheim (UHOH) allows for 3-dimensional observations of the atmospheric water vapor field both at day and night. Each scans consist of absolute humidity profiles with range resolution of 15 to 300 m, temporal resolution of 1 to 10 s, and a maximum range of several kilometers. The data acquisition program allows for a large variety of different scan patterns. Beside humidity, also the backscatter field and thus aerosols and clouds are observed. The UHOH DIAL is mounted on a trailer and can be moved to a certain region of interest during field campaigns. First successful scanning measurements were performed in summer 2009. In this paper, the instrument is described and its capabilities are illustrated with measurements examples.

15:00 – 16:00 – Awards & Closing

AUTHOR INDEX