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9° Simposio Internazionale sul Profilamento Troposferico

Ridotto del Teatro Comunale

3-7 September 2012

L'Aquila

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Monday, September 03, 2012

08:00	**On-site Registration**	
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[1]*LATMOS-IPSL, FRANCE;* [2]*USTV, FRANCE;* [3]*RISH, Kyoto University, JAPAN;* [4]*Department of Electrical, Electronics and Computer Engineering, Fukui University of Technology, Japa, JAPAN;* [5]*Osaka Electro-Communication University, Japan, JAPAN;* [6]*RISH, Kyoto University, Japan, JAPAN;* [7] *Department of Electrical, Electronics and Computer Engineering, Fukui University of Technology, Jap, JAPAN*

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11:15	**A Neural Network Algorithm to Retrieve Tropospheric Ozone from the Ozone Monitoting Instrument: Design and Validation** Di Noia, A.[1]; Sellitto, P.[2]; Del Frate, F.[1]; de Laat, J.[3] [1]Tor Vergata University, ITALY; [2]Laboratoire Interuniversitaire des Systèmes Atmosphériques, FRANCE; [3]KNMI, NETHERLANDS	69
11:30	**Retrieval of Tropospheric Water Vapour Profiles by Using Spectra from a Microwave Spectro-radiometer at 22 GHz** Bleisch, R.; Kämpfer, N.; Scheiben, D. *Institute of Applied Physics, University of Bern, SWITZERLAND*	70
11:45	**Vertical Resolution of Tropospheric Humidity Profile Retrievals Using Ground-Based Microwave Radiometers** Sahoo, S.[1]; Bosch-Lluis, X.[1]; Reising, S. C.[1]; Vivekanandan, J.[2] *[1]Colorado State University, UNITED STATES; [2]National Center for Atmospheric Research, UNITED STATES*	70
12:00	**Final Discussion**	
12:30	**Lunch and Adjourn**	

Poster Session

Thermodynamics, turbulence, and radiation

ABSTRACTS

Estimation of Particle Physical Properties from Multiwavelength Lidar Measurements: Expectations and Challenges

Veselovskiy, I.

Optosystems, RUSSIAN FEDERATION

Theoretical and experimental studies of the last decade have demonstrated that multiwavelength Raman and HSRL lidars based on a tripled Nd:YAG laser are able to provide the height distribution of particle microphysical parameters. However for the global characterization of particle parameters with such systems the certain obstacles must be overcome. Thus existing algorithms are quite time-consuming, a fact that becomes an issue when large volumes of data need to be analyzed, as for example from an air- or space-borne lidar system. Installation of multiwavelength lidars on air or space-borne platforms poses another problem: the retrieval algorithm should be more tolerant to noise in the input data since reasonable averaging times are likely to be smaller for moving lidar systems. One of the ways to overcome this issue is to estimate the bulk particle parameters from a linear combination of aerosol characteristics measured by multi-wavelength lidar. The corresponding weight coefficients can be determined by expanding the PSD in terms of the measurement kernels. In the presentation we will illustrate the application of this method to extended lidar measurements to derive the height-temporal variations of the particle parameters. The possibility of input data reduction will be also discussed. Another issue in inversion of lidar data is non-sphericity of the particles. Many existing lidar algorithms model aerosols as an ensemble of spheres, even though it is well established that backscattering by irregularly shaped particles is weaker than that predicted by the Mie theory. In this presentation the examples of application of an algorithm based on a model of randomly oriented spheroids for the inversion of multi-wavelength lidar dust measurements will be given.

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Multi-beam Raindrop Size Distribution Retrievals on the Doppler Spectra: Influence of Averaging and Mean Horizontal Wind Correction.

Unal, C.

Delft University of Technology, NETHERLANDS

Acquiring the raindrop size distribution (DSD) from radar data is still a challenge. For profiling radar, this distribution can be estimated from the Doppler spectra. However the Doppler spectrum is not a direct measure of the DSD. The radial component of the wind shifts the Doppler spectrum related to the raindrop size distribution along the Doppler velocity interval. Furthermore, the Doppler spectrum may be broadened by turbulence effect.

The Doppler spectra of rain are modeled using Rayleigh scattering, the gamma distribution for the raindrop size, a size-shape relationship and a Gaussian kernel for the turbulence. Comparing the measured Doppler spectrum with the modeled one, a non-linear least-square fit technique is employed to obtain the parameters of the raindrop size distribution, the radial wind component (v_0) and the turbulence broadening factor of the raindrop size spectrum (σ_0). This approach has been proposed in (Moisseev et al, 2006). So far, this technique has not been further developed, exploited and validated. It is our intention to investigate this methodology using the S-band Doppler-polarimetric TARA radar to retrieve raindrop size distribution from drizzle to heavy precipitation. Since TARA can profile in three directions, three raindrop size distribution profiles are estimated, which can give insight in the microphysical homogeneity of the precipitation.

Because TARA can be used as wind profiler, the mean horizontal wind is estimated and a correction to remove the effect of the radial mean horizontal wind is implemented in the retrieval procedure. Comparison with and without correction is done. Another issue is averaging. Should the Doppler spectra be averaged before the non-linear least-square fit? How should they be averaged and how many averages should be carried out? These questions will be discussed. Finally high resolution multi-beams raindrop size distribution profiles are illustrated and discussed.

Moisseev, D. N., V. Chandrasekar, C. M. H. Unal, and H. W. J. Russchenberg, 2006: Dual-Polarization spectral analysis for retrieval of effective raindrop shapes. J. Atmos. Oceanic Technol., 23, 1682-1695.

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The Use of Raman Lidar for the Characterization of Convection-related Parameters: Analysis of Selected Case Studies from COPS

Di Girolamo, P.; Summa, D.; Stelitano, D.

University of Basilicata, ITALY

This work illustrates an approach to determine the convective available potential energy (CAPE) and the convective inhibition (CIN) based on the use of data from a Raman lidar system. The use of Raman lidar data allows to provide high temporal resolution (5 min) measurements of CAPE and CIN and follow their evolution over extended time period covering the full cycle of convective activity. Lidar-based measurements of CAPE and CIN are obtained from Raman lidar measurements of the temperature profile and the surface measurements of temperature, pressure and dew point temperature provided from a surface weather station. The approach is tested and applied to the data collected by the Raman lidar system BASIL, which was operational in Achern (Black Forest, Lat: 48.64 ° N, Long: 8.06 ° E, Elev.: 140 m) in the period 01 June - 31 August 2007 in the frame of the Convective and Orographically-induced Precipitation Study (COPS), held in Southern Germany and Eastern France. Attention was focused on four selected case studies: 19 June, 30 June-1 July, 14-15 July and 25-26 July, with a specific focus on 15 July 2007. Reported measurements are found to be in good agreement with simultaneous measurements obtained from the radiosondes launched in Achern and with estimates from different mesoscale models. An estimate of the different random error sources affecting the measurements of CAPE and CIN is also been performed, together with a detail sensitivity study to quantify the different systematic error sources. Preliminary results from this study will be illustrated and discussed at the Symposium.

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Inversion of Two-Dimensional Spheroidal Particle Distributions from Backscatter, Extinction and Depolarization Profiles via Regularization

Böckmann, C.; Osterloh, L.

Potsdam University, GERMANY

Studying the influence of non-spherical cloud and aerosol particles on the radiation budget of Earth's atmosphere is of growing importance in remote sensing. Polar stratospheric clouds and Cirrus clouds, for example, may contain large populations of non-spherical ice crystals which have a major impact on how those clouds scatter radiation. Saharan dust storms as well as volcanic eruptions are other sources of non-spherical aerosol particles which are of importance for a better understanding of the direct and indirect climate effects of such global events. There exist essential differences in the light scattering behavior between spherical and non-spherical particles. We can observe an increasing side scattering behavior and the appearance of a backscattering depolarization if non-spherical particles are considered.

For this purpose, we consider an ensemble of spheroidal particles characterized by the complex refractive index, the aspect ratio and the size parameter of the volume equivalent spheres, i.e., the aspect ratio is the additional microphysical parameter which goes beyond the conventional Mie theory. Such spheroidal particles are used as microphysical models in recent measurement campaigns like AERONET, EARLINET, and SAMUM to study the effect of non-spherical particles on different measurement scenarios and to estimate their influence on the radiative forcing.

The inversion of optical profiles to retrieve microphysical parameters of spheroidal particles by regularization using a two-dimensional model will be performed with the following data: direct-polarization and cross-polarization backscatter at 355, 532 and 1064 nm as well as extinction at 355 and 532 nm (3+3+2 wavelengths) or (3+1+2 wavelengths) for a complex refractive index.

We investigated the role that depolarization profiles play in this inversion. Experiments have shown that the importance of depolarization profiles is highly dependent on each individual case; this, of course, implies the high significance of availability of these profiles, as results can be completely invalidated in some cases if there is no depolarization data present. This is a very important result for inversion of remote sensing data, as we showed that the availability of good depolarization data is what makes inversion of optical profiles of ensembles of spheroidal particles workable.

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Simulation study of a 2D Tomographic Microwave Radiometer Water Vapor Retrieval

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[1]*McGill University, CANADA;* [2]*National Severe Storm Laboratory (NSSL), UNITED STATES*

Microwave radiometers are routinely used to retrieve vertical profiles of water vapor and temperature of the atmosphere. Recently, groups of a few microwave radiometers are combined to retrieve either 2D and 3D water vapor fields depending on the position of the instruments. This project examined the possibility of retrieving curtains (2D fields) of water vapor using tomographic measurements from microwave radiometers. This was done using high temporal resolution large-eddy simulation model runs to provide the atmospheric conditions to a 2D optimal estimation based microwave radiometer inversion retrieval algorithm. The simulation framework gave the flexibility to study the instrument parameters (microwave radiometer angles, frequencies, beam widths, bandwidths), the instrument set-up (instrument spacing, number of instruments) and the possibility of adding additional information to the retrieval algorithm (adding AERI measurements, using real atmospheric temperatures compared to mean atmospheric temperatures). This framework was used to evaluate how changes in various parameters affect the information available to retrieve the water vapor curtain, including information on the vertical and horizontal resolutions.

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Combining Ground-based and Satellite Measurements in the Atmospheric State Retrieval: Assessment of the Information Content

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[3]*Leibniz-Institute for Tropospheric Research, GERMANY*

The combination of multiple wavelength active and passive remote sensing instruments offers the unique opportunity to derive the atmospheric state as completely as possible. In particular, the Integrated Profiling Technique (IPT, Löhnert et al., 2008) has been successfully applied to derive profiles of temperature, humidity and liquid water by a Bayesian based combination of ground based microwave radiometer, cloud radar and a priori information. Within the project ICOS (Integrating Cloud Observations from Ground and Space - a Way to Combine Time and Space Information), we develop a flexible IPT, which allows for the combination of a variety of ground based measurements from cloud radar, microwave radiometer (MWR) and IR spectrometer as well as satellite based information from the Meteosat SEVIRI instrument. In this way, thermodynamic and cloud property profiles, i. e. hydrometeor content and effective radius, can be derived with higher accuracy throughout the profile.

As ground based observations are mainly sensitive to the lower parts of the troposphere, the satellite measurements provide complementary information and are thus expected to improve the estimates of the atmospheric state considerably in both clear sky and cloudy conditions. In order to understand the improvement by integrating the measurements of the above mentioned instruments into the IPT, sensitivity studies on information content and retrieval error estimates are performed. To this end, different measurement combinations and different assumptions in the error covariance matrix are used. Furthermore, the potential of downlooking microwave observations from satellite (AMSU-A and -B) in the retrieval is investigated. The information gain due to the incorporation of these existing instruments in the upper troposphere / lower stratosphere region is analysed. Similarly the impact of future satellite configurations, e.g., the frequencies of the High Altitude LOng range research aircraft (HALO) Microwave Package or hyperspectral resolution, can be studied.

By means of these sensitivity studies, which are performed on the basis of synthetic data for a mid-latitude site, the information content is calculated and the optimal combination of instruments will be identified for the retrieval of the atmospheric profiles. The information improvement in the retrieval due to the combination of ground and satellite based measurements will be shown. Preliminary results indicate, for example, that the number of degrees of freedom, i. e. the independent pieces of information, in the retrieved temperature (humidity) profile increases by about 1 (2), if the MWR measurements are combined with the SEVIRI measurements.

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Tropospheric Relative Humidity Profile Statistical Retrievals and their Confidence Interval from Megha-Tropiques Measurements

Sivira, R.[1]*; Brogniez, H.*[1]*; Mallet, C.*[1]*; Oussar, Y.*[2]

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[2]*ESPCI, FRANCE*

Water vapor has a great role in the atmosphere dynamics and thermodynamics processes and it is the main greenhouse gas regulating the Earth's climate. Measuring water vapor present important problems which hinder detailed and intensive studies. The water vapor's principal aspect is its strong variability spatio-temporal and passive remote sensing helps measuring vast areas per day; but passive remote sensing obtains indirect measures, yielding to use restitution methods. Regarding detection problems is important to keep in mind the water vapor vertical behavior, near surface the absolute humidity is bigger than in higher altitudes; in consequence, instruments must have an expanded work scale to obtain acceptable precision values for all cases.

The SAPHIR microwave radiometer onboard the recent Megha-Tropiques plateform observes the tropospheric relative humidity with six channels in the strong water vapor absorption band (near183.31, ranging from ± 0.2 GHz to ± 11GHz). With respect to MHS and AMSU-B radiometers, this configuration is aimed at providing an improved retrieval of the tropospheric relative humidity. The Megha-Tropiques' tropical orbit is an important advantage with an enhanced sample rate, it allows 3 to 6 observations each day for any point between 23°S and 23°N.

In this work we focus on the retrieval of relative humidity profiles distribution given a set of 22 levels of relative humidity obtained by tropical radiosoundings in clear sky scenes and the associated set of simulated satellite brightness temperatures using the RTTOV model. Retrieval of the relative humidity profiles from satellite measurements are commonly based on neural network algorithms (ex: Aires2001). Alternative statistical models exist such as support vector machines (SVM) and additive models (ex: Generalized Additive Model).

A comparison of three models was performed, in equal conditions of input and output data sets, through their statistical values (error variance, correlation coefficient and error mean) obtaining a seven layers profile of relative humidity. The three models show the same behavior with respect to layers, mid-tropospheric layers reach the best statistical values suggesting a model-independent problem. The smallest relative humidity error standard deviation (2.45% from 4st layer) is obtained thanks to an improved version of the SVM while the neural network reveals higher values for almost all layers. GAM model has better results than the neural network for high layers. In a general way, the improved SVM method obtains better results respect to other models.

Finally, retrieval's confidence intervals are studied through the characterization of the probability density function of the relative humidity at given atmospheric pressure.

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The Improvement of Lidar Analysis Through Non-Linear Regression

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Lidars are ideally placed to investigate the effects of aerosol and cloud on the climate system due to their unprecedented vertical and temporal resolution. Dozens of techniques have been developed in recent decades to retrieve the extinction and backscatter of atmospheric particulates in a variety of conditions. These methods, though often very successful, are fairly *ad hoc* in their construction, utilising a wide variety of approximations and assumptions that makes comparing the resulting data products with independent measurements difficult and their implementation in climate modelling virtually impossible.

As with its application to satellite retrievals, the methods of non-linear regression can improve this situation by providing a mathematical framework in which the various approximations, estimates of experimental error, and any additional knowledge of the atmosphere can be clearly defined and included in a mathematically `optimal' retrieval method, providing rigorously derived error estimates. In addition to making it easier for scientists outside of the lidar field to understand and utilise lidar data, it also simplifies the process of moving beyond extinction and backscatter coefficients and retrieving microphysical properties of aerosols and cloud particles.

Such methods have been applied to a prototype Raman lidar system. A technique to estimate the lidar's overlap function using an analytic model of the optical system and a simple extinction profile has been developed. This is used to calibrate the system such that a retrieval of the profile extinction and backscatter coefficients can be performed using the elastic and nitrogen Raman backscatter signals. The use of a simple Mie code is then used to estimate the effective radius and number density of the aerosols. Current results will be presented and briefly evaluated against other techniques.

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FlexAOD: A Chemistry-transport Model Post-processing Tool for A Flexible Calculation of Aerosol Optical Properties

Curci, G.

University of L'Aquila, ITALY

Remote sensing of atmospheric aerosol properties uses retrieval algorithms that often relies on one or more "aerosol models". These models define the optical properties of a "typical" or "average" aerosol layer present at the scene of observation, assuming a certain range of chemical compositions and size distributions. The chemical composition determines both the refractive index and the hygroscopic characteristic of the aerosol, while size distribution introduces the spectral dependence of the extinction of radiation. The aerosol models are introduced into radiative transfer models in order to simulate synthetic radiances directly comparable with the remotely sensed measurements. Aerosol optical depths and other physical and optical properties are then retrieved minimizing the difference of observed radiances with the available spectrum of simulated radiances. Moreover, these models may also be preliminarily used in the calculations of atmospheric correction, when Earth' surface reflectance is the target of the retrieval process.

Chemistry-transport models (CTM) provide a time-resolved and three-dimensional simulation of the atmospheric chemical composition, including the aerosol phase. However, there is currently a lack of interface between the aerosol remote sensing and the modelling community, mostly because of the peculiar difficulties in dealing with reciprocal algorithms. Here we describe a new tool aimed at filling this gap. Optical calculation from CTM output has become a routine activity in the modelling community, motivated by the increasing abundance of satellite (MODIS, MISR, CALIPSO, etc.) and ground-based (e.g. AERONET) information regarding aerosol scattering and absorption of radiation in the visible and near infrared wavelengths. These algorithms are mostly aimed at the comparison with observation for model validation.

FlexAOD is designed to meet the needs of the modelling and remote sensing communities as it offers an easy and customizable way to (1) calculate aerosol optical properties, such as aerosol optical depth, extinction profile, LIDAR backscattering, single scattering albedo, etc., from CTM model output, and (2) calculate input for radiative transfer models (e.g. asymmetry factor, phase function, etc.) for specific locations and times. The package is applied to the GEOS-Chem global model output and it is used in comparison with multi-spectral aerosol measurements from satellites and AERONET network for several test cases. A number of options regarding the assumed size distributions, the species refractive indices and hygroscopic growth factors, and the aerosol mixing are proposed to the user, that may be useful to estimate uncertainties both in model validation and remote sensing activities. The development of the code is highly user-driven and the source is publicly available on the web (http://pumpkin.aquila.infn.it/flexaod/), released with same policy usage of the GEOS-Chem model (http://acmg.seas.harvard.edu/geos/geos_welcome.html).

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UWPHYSRET: A Tool to perform Physical Retrieval of High Spectral Resolution Space-borne Infrared Data

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UWPHYSRET is a research tool built on a matlab implementation of a Bayesian retrieval system. It allows for retrieval of atmospheric parameters from high spectral resolution infrared observations. The package is based on LBLRTM and Optimal Spectral Sampling (OSS) for the computation of simulated radiances and jacobians. It allows for simultaneous retrievals of: vertical profiles of temperature, water vapor mixing ratio, Carbon Dioxide, Ozone, and surface temperature and emissivity. The presented works aims to describe the benefits and limitation of the current applications of UWPHYSRET to spacecraft observations (IASI, CrIS, and AIRS), and aircraft observations (S-HIS).

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Assimilation of Remote Sensing Data for Improved Probabilistic Quantitative Precipitation Forecasting

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This presentation gives an overview on Probabilistic Quantitative Precipitation Forecasting (PrQPF) focusing on the convection-permitting scale. PrQPF skill depends on the quality of model physics, initial fields, and the data assimilation system. Resulting errors are interwoven resulting in a complex error propagation chain.

Nevertheless, various observations and model studies allow for studying the relative importance of these ingredients. With respect to initial fields, it can be shown that a considerable improvement of PrQPF can be expected by simultaneous observation of land-surface variables, clear air dynamics in the preconvective and convective environment as well as thermodynamics and microphysics. This can be addressed by the design and set up of a synergy of hyperspectral passive remote sensing and lidar and polarization radar networks. Suitable data assimilation techniques are also discussed.

With respect to model physics, field studies indicate deficiencies in the simulation of the energy balance closure requiring an improvement of the representation of vegetation. Furthermore, errors are found in ABL parameterizations feeding back to incorrect simulations of convection initiation.

The future challenge is the development of ensemble forecast systems with consistent assimilation of land-surface and atmospheric variables in combination with an optimal perturbation of model boundaries, initial states, and model physics. A set up is proposed based on an ensemble 3DVAR system currently under development at IPM.

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Enhancing Short Term Wind Energy Forecasting with Remote Sensing: the Wind Forecast Improvement Project (WFIP)

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It is widely recognized within the wind energy and electric utility operations communities that current skill levels of wind energy forecasting are adding increased costs to the integration of wind energy onto the U.S. electrical grid. To address this, the U.S. Department of Energy has implemented a joint research program with NOAA and private industry to improve wind energy forecasts. The key elements of this program are 1) a one-year deployment of extensive meteorological observing systems in two regions with significant wind energy production; 2) assimilation of these observations into the hourly-updated NOAA High-Resolution Rapid Refresh (HRRR) Model, run nationwide at 3 km resolution; and 3) evaluation of the benefits of these improved wind forecasts on electrical utility operations, especially for ramp-events in the 0-6 h forecast time-frame.

In this presentation we will describe early results from the one-year field program, which began in August 2011. In particular we will describe:

- The regions selected and local meteorological forecast problems
- Instrumentation deployed, including a network of ten 915 MHz wind profiling radars, two 449 MHz wind profiling radars, twelve sodars, one wind profiling lidar, 17 surface meteorological stations, over 120 industry provided meteorological tall (60-80m) towers and 400 nacelle-mounted anemometers.
- Data quality control procedures.
- The HRRR model and its data assimilation system.
- Identification of ramp events, and the meteorology associated with them.
- Metrics used in numerical weather prediction model evaluation.

A preliminary analysis of HRRR model forecast skill versus the NOAA/National Weather Service operational Rapid Refresh model that does not assimilate the special observations, and the resulting potential economic benefits.

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Recent Developments in Radar Wind Data Quality Control and Analysis

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A real-time radar wind analysis system has been developed for monitoring low-level wind conditions at high (up to 2 km) spatial and (5-10 min) temporal resolution. The system has capabilities to integrate multi-sensor observations to produce vector wind field. In additional to real-time level II data from six NWS operational WSR-88D radars and one FAA TDWR radar (at the OKC airport), Oklahoma Mesonet data and NPN (NOAA Profiler Network) data are also ingested into the system to improve the accuracy of analyzed wind field and derived products. This system can display the retrieved horizontal vector wind field at each selected vertical level (or conical surface of radar scans) overlapped with real-time radar reflectivity. The early version of the system was delivered to the Pacific Northwest National Laboratory to provide the very needed real-time radar wind retrieval capability to derive high-resolution emergency response dispersion models for homeland security applications. The key techniques in the system include (i) a new variational dealiasing method for radar wind data quality control, (ii) an innovation method for estimating radar wind observation error and background wind error covariances, and (iii) successive 2dVar for vector wind analysis. Recent developments in these techniques and their applications will be presented at the conference.

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Interpretation of Microwave Remote Sensing Observations of Volcanic Ash using the ATHAM Simulations of the Erupting Plumes.

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The impact of the volcanic eruptions on the social life has a long history that can be dated back to 79 ac. when the famous Vesuvio eruption took place. From that time the volcanic activity is probably not changed in terms of the frequency of events and hazard. Instead, the quality of life is continuously improved over years. One of the drawbacks for this is that the impact of natural hazards are more and more pronounced with respect to the past. An example of this, are the recent eruptions in Iceland that caused the total or partial closure of air traffic in the north and middle Europe with non negligible economic loss.

However, progress have been bringing a series of countermeasures to alleviate the consequence of a volcanic eruption. They include direct inspection, remote sensing observations and modelling efforts. The synergy of these different tools is probably the best way to fulfil the top level requirements imposed by the civil and scientific communities, such as to issue timely warnings, to monitor the ash plume during its evolution and to quantitatively estimate tephra (fragmented material produced by a volcanic eruption). Remote sensing measurements of tephra can provide useful inputs for ash dispersal model initialization or be used as target reference for model validation purposes. Moreover, models can provide the physical basis to build estimators of ash cloud parameters from remote sensors.

In this work, a first attempt of combined use of Ash dispersal model and remote sensing observations is shown. A special attention is given to the interpretation of ground radar measurements as well as satellite brightness temperatures at microwaves. The non-hydrostatic Active Tracer High-Resolution Atmospheric Model (ATHAM) is used as generator of virtual scenarios capable of reproducing the ash dispersion in the atmosphere in terms of physical variables. ATHAM is then coupled with a forward model sensor simulator suite, such as the Satellite Data Simulator Unit (SDSU). Some case studies from the the Grímsvötn eruption, in May 2011 in Iceland, are discussed with this aim.

With respect to past similar work, the joint use of an ash dispersion model, a radar simulator and actual observations, can represent a relevant step forward for more accurate ash retrievals.

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A Met Office forward Operator for Attenuated Backscatter

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UK Met Office, UNITED KINGDOM

The Met Office operates a relatively dense network of basic and inexpensive lidar systems called ceilometers which are used to measure cloud base height. As well as cloud droplets, these instruments are also sensitive to atmospheric aerosols. This ability was exploited during the Spring 2010 Eyjafjallajökull eruption to detect aerosol layers above the UK, which would indicate the presence of volcanic ash. A subset of the ceilometer network was modified to send the raw backscatter observations to Exeter for ash detection and this system has remained in place. This new source of observations could potentially be assimilated into the Met Office Unified Model (UM) to improve forecast accuracy. However, in order to implement these backscatter observations within the assimilation cycle, a forward operator is required to calculate synthetic observations which allow comparison of the model state with the observations.

A forward operator has recently been developed at the Met Office to achieve these goals for aerosols and cloud droplets in the UM. The number of aerosol particles at each grid point and level in the

atmosphere is available as a diagnostic variable. Furthermore, the size distribution of these particles is modelled using a log-normal size distribution with parameterised geometric mean radius and geometric standard deviation. The aerosol is assumed to exist entirely of ammonium sulphate, which is a hygroscopic aerosol and will swell as RH increases. The magnitude of this particle growth as a function of RH is described by existing literature and utilised by this forward operator. The UM contains radiative transfer code which can calculate the extinction, scattering and phase function of this modelled distribution, for the same wavelength as a collocated ceilometer. Repeating this process for each model level allows a profile of backscatter and extinction due to aerosol to be calculated.
A similar process is followed for liquid water clouds. These liquid droplets are described by a cloud drop number concentration (CDNC) and liquid water content (LWC) within the UM. Their size distribution is also modelled using a modified gamma distribution which contains positive and non-zero parameters. The moments of the distribution can be related to the CDNC and LWC which in turn allows calculation of the distribution parameters. The distribution can then be passed to the radiative transfer code to calculate the scattering properties.
The extinction from each type of target is summed to give an extinction coefficient at each level, as is the backscatter. The two profiles are then combined to provide an attenuated backscatter profile, analogous to the observations made by the ceilometer network.

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Observation of Aerosol-Cloud-Turbulence Interaction with Integrated Remote-Sensing Instrumentation

Wandinger, U.; Seifert, P.; Engelmann, R.; Buehl, J.; Schmidt, J.; Ansmann, A.
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LACROS, the Leipzig Aerosol and Cloud Remote Observations System, comprises a set of state-of-the-art active and passive remote-sensing instruments, including multiwavelength Raman polarization lidar, 1064-nm ceilometer, 2-μm Doppler lidar, 35-GHz cloud radar, AERONET Sun photometer, and microwave radiometer. The instrumentation is complemented with radiosondes, an all-sky imager, visible and infrared spectrometers and radiometers, meteorological sensors, and an optical disdrometer.

The focus of LACROS applications is on the study of aerosol-cloud interaction, the heterogeneous formation of ice in mixed-phase clouds, and the influence of atmospheric turbulence on cloud microphysical properties. Based on exemplary case studies and statistical findings we will demonstrate how integrated long-term observations are used to investigate the interaction of aerosols, clouds, and atmospheric dynamics.

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Comparison of Different Cloud Vertical Models through Radiation Closure Experiment

Placidi, S.; Brandau, C.L.; Russchenberg, H.W.J.

TU Delft Climate Institute, NETHERLANDS

The major focus in a changing climate is on the quantification of the Earth's energy budget. The interaction of clouds with radiation is the key parameter to understand how clouds modify the Earth's energy budget. Liquid water cloud properties are retrieved from ground-based remote sensing observations by means of vertically pointing active and passive sensors under the assumption of a model which describe the distribution of the liquid water within the cloud. An important aspect in studying cloud-radiation interactions is the vertical variation of the cloud microphysical and optical properties and how this influences the amount of radiation reaching the surface and, in turn, reflected back to space. Liquid water clouds are, in fact, represented in literature as being adiabatic (liquid water content increases linearly), or sub-adiabatic (liquid water changes due to mixing events) or simply vertically uniform (liquid water content is constant within the cloud).

In this work, we present a method to assess and evaluate the assumptions considered in the vertical variation of microphysical properties of liquid water clouds by mean of surface radiation closure experiment and their impact on radiation. Profiles of microphysical and optical properties of liquid water clouds are retrieved using the synergy of ground-based cloud radar, ceilometer, microwave radiometer and radiosondes, while a model is used to describe the different in-cloud vertical variations of these properties. The use of different cloud models, in which the integrated cloud properties are kept constant, leads to different in-cloud vertical variations of cloud properties, and to different interactions with radiation. The considered models refer to homogeneous/inhomogeneous mixed, vertical uniform and stratified adiabatic clouds.

In order to quantify the effect of using different cloud models on the retrieval process, the retrieved profiles of cloud microphysical and optical properties of different cloud models are directly input into a modified version of the EarthCARE simulator (ECSIM), and used to calculate the broadband surface irradiances and Top-of-Atmosphere fluxes. ECSIM is a fundamental tool for such experiment since it allows to run the radiative transfer models on high-resolution user-defined atmospheric scenes with separate cloud and aerosol scattering regions.

The ECSIM simulated broadband surface irradiances for the different vertically modeled clouds are compared with the correspondent surface irradiances measured by the pyranometer to perform a radiation closure and to assess the impact of the in-cloud vertical variations of cloud properties on the surface radiation. The deviations in the comparisons will tell more about which model represents the vertical variation within the liquid water clouds best, and how much it influences the radiation.

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Vertical Correlation of Raindrop Size Distribution Parameters Retrieved from Vertically Pointing Multi-Frequency Profiling Radars

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In April-June 2011, two vertically pointing radars operating at 449 MHz and 2.8 GHz were deployed next to the permanently installed 35 GHz radar at the DOE ARM site in Northern Oklahoma in support of the Mid-latitude Continental Convective Cloud Experiment (MC3E). The Doppler velocity power spectra from all three radars were analyzed to retrieve the vertical air motion and the raindrop size distribution (DSD) as a function of altitude. The 449 MHz profiler provided vertical air motion estimates at low altitudes during light to moderate rain rates. The 2.8 GHz profiler provided unattenuated reflectivity estimates that were absolutely calibrated against a surface disdrometer. The 35 GHz profiler provided attenuation estimates that were used as an additional constraint in the DSD retrievals.

The DSD can be described as a Gamma function with three parameters (e.g., Nw, Dm and mu). Previous studies have shown that these three parameters are correlated. But there is controversy in the research literature over why the three parameters are correlated. Some studies suggest that the correlation is a statistical artifact due to correlation between the raindrop spectrum moments. Other studies suggest that the correlation is not a statistical artifact and have developed slope-shape (lambda-mu) relationships so that the three parameter Gamma function can be described as a constrained two parameter function. Analysis of vertical profiles of DSD estimates and surface disdrometer observations from MC3E and other field campaigns suggests a correlation between the mass-weighted mean diameter (Dm) and the mass spectrum standard deviation (sigma mass). This correlation is not a statistical artifact due to correlations between spectrum moments and suggests a physical relationship between the two DSD parameters. The radar observations, the DSD parameter retrievals, and the vertical correlation between the DSD parameters will be presented at the symposium.

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Ground-based Remote Sensing Profiling of Aerosols, Atmospheric Boundary Layer and Liquid Water Clouds Using Synergistic Retrieva

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The suite of ground based remote sensing installed at the GAW atmospheric station of Mace Head includes a microwave radiometer for profiling meteorological parameters such as temperature and humidity; a LIDAR-ceilometer for profiling atmospheric aerosol backscatter and extinction and cloud base; and a Ka-band Doppler cloud RADAR for profiling cloud fields, phase, drizzle. Multiple techniques for retrieving the vertical structure of the atmospheric boundary layer (ABL), to invert the lidar signal to retrieve the extinction coefficient profiles, to retrieve warm cloud microphysics using synergistic ground based remote sensing instruments are presented. The Temporal Height Tracking (THT) algorithm (Martucci et al., 2010) is applied to the lidar profiles to retrieve the vertical ABL structure during daytime and nighttime; the calculation of the extinction coefficient profile allows the characterization and categorization of different aerosol layers including the volcanic (O'Dowd et al., 2011); the SYRSOC (SYnergistic Remote Sensing Of Cloud) technique (Martucci and O'Dowd, 2011, Ovadnevaite et al 2011, Martucci et al., 2012) utilises a Ka-band Doppler cloud RADAR, a LIDAR/ceilometer and a multichannel microwave radiometer. SYRSOC retrieves the main microphysical parameters such as cloud droplet number concentration (CDNC), droplets effective radius (Reff), cloud liquid water content (LWC), cloud optical thickness, cloud albedo and cloud LIDAR multiple scattering. Three comparisons are presented to validate the retrieved microphysics: between surface-sampled cloud condensation nuclei concentration and the retrieved CDNC; between the MODIS-retrieved and the SYRSOC-retrieved Reff ; between the CLOUDNET-retrieved and the SYRSOC retrieved LWC.

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Observation of Prevailing Snow Growth Processes from Combined Doppler and Dual-polarization Radar Observations

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Weather radar quantitative precipitation estimation in snowfall is notoriously difficult. Radar observations depend on phase, size, shape, and density of precipitating particles. Variability in these physical properties is one of the major error sources in quantitative snowfall estimation with radar . The physical properties of ice precipitation are governed by growth mechanisms, i.e. water vapour deposition, aggregation and riming processes. One approach, to limit this variability, is to divide winter precipitation according to hydrometeor classes, such as aggregates, crystals, rimed particles, as inferred from dual-polarization radar observations. Despite the successful application of fuzzy logic hydrometeor classification algorithms to summer time precipitation , there have been a very limited success in using them in winter precipitation. As the experience has shown, polarimetric radar signatures are not very different for many types of ice particles, i.e. aggregates and rimed ice particles. This is seriously affecting the ability of dual-polarization classification to improve quantitative radar observations of snowfall. The goal of this work is not to explain measured properties of populations of hydrometeors present in a radar volume. Instead, we focus on growth processes, and study vertical and spatial structure of polarimetric radar observations of precipitation to infer dominating growth mechanisms, namely vapour deposition, aggregation, riming and secondary ice production. In addition to improving the QPE, the identification of riming, and therefore of presence of larger supercooled drops, is of great importance in other application areas, such as aviation and transportation safety.

In this study, we have analyzed several winter storms from years 2005, 2009 and 2010 using coinciding measurements of University of Helsinki C-band dual-polarization and vertically pointing Doppler radars. During winter 2010-2011, the extended observation period of Light Precipitation Validation Experiment took place. During the experiment we have complimented radar observations with measurement of LWP by Passive Microwave Radiometer ADMIRARI and surface-based observations of particle shapes and size distributions by using NASA particle video imager. Based on the analysis of the data, it is demonstrated that polarimetric measurements can be used to identify growth patterns of aggregation, riming and vapor deposition.

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Non-spheroidal Scattering Effects in Millimeter-wave Measurements of Snowfall

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Millimeter-wave cloud radars are being increasingly used for remote observations of falling snow. Lately, it has been debated whether spherical or spheroidal model snowflakes are sufficient for the interpretation of observations using these radars or if full models of realistic snowflakes are needed. Published results have been somewhat conflicting; in particular, there has been a lack of experimental confirmation of non-spheroidal effects.

We analyzed simultaneous observations of snowfall at 13 GHz, 35 GHz and 94 GHz, measured with vertically pointing airborne radars during the Wakasa Bay experiment in January 2003. After collocating the measurements and controlling for data quality and for attenuation by snow, water vapor and atmospheric gases, we compared the dual-frequency ratios (13 GHz and 35 GHz vs. 35 GHz and 94 GHz) of the data to those predicted by different scattering models using realistic particle shapes, size distributions, orientations and densities.

The results indicate that the applicability of spheroid models varies on a case-by-case basis. In three of our five closely studied cases, there were varying degrees of behavior that is not compatible with the modeled spheroidal snowflakes with any free parameters. In the other cases, spheroid models could be consistently fitted to the observations.

Although spheroid models must be usable for small snowflakes, there is no evident connection in our data between the radar reflectivity and the applicability of the spheroid models. Our results suggest that measurements of the dual-frequency ratio can yield some information about the compatibility of the measurements with different models. Simultaneous measurements at three frequencies separate the models much more effectively, which suggests that they can yield more information about the microphysical structure of the snowflakes being measured. This finding also implies that the spheroids fitted to radar measurements are not necessarily physically compatible with the actual snowflakes. Furthermore, the best-fitting spheroids at one frequency may be inconsistent with the best spheroids at other frequencies. Thus, care should be taken while interpreting measurements of snowflakes using these models. We suggest that further studies combining radar observations with in-situ measurements of the size and structure of snowflakes be conducted to explore the applicability of the scattering models and the resulting limits for retrieval.

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Detection of Potentially Hazardous Convective Cells with a Dual-Polarized C-band Radar

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Local heavy rainfalls in urban area have become an important issue for most cities. Indeed, many people have been injured or even died recently in Tokyo and Kobe, Japan due to flush floods associated with local heavy convective rainfalls. Mitigating loss of life and damages requires rainfall forecasting and rainfall warnings with lead-time at least several minutes depending on response time of catchments. The rainfall forecasting for urban applications has been addressed by various approaches. The widely used methods include advection methods, which extrapolate the movement of rain area derived from horizontal radar echoes. However the performance of the advection methods depend on the rainfall type with much better results for stratiform cases than fore convective ones, which produce heavy rain. On the other hand, the vertically integrated liquid (VIL) water contents has been used to discriminate between severe and non-sever thunderstorms. The VIL is a parameter obtained from a radar performing volume scanning. Some very short-term rainfall forecasting models use the VIL as an indicator. However, this kind of model is vulnerable to ice precipitation, which plays an important role in convective clouds. It is well know that dual-polarized radars can distinguish ice precipitation from rain and improves the accuracy of rainfall estimation (Bringi and Chandrasekar 2001).

In the present study, dual-polarized C-band radar measurements at the Meteorological Research Institute (MRI) in Tsukuba, Japan is used to analyze a local heavy rainfall event that occurred on 7 July 2010 as a case study. The effect of ice precipitation is identified and removed from reflectivity field to retrieve vertical profile of rainfall intensity with elevation and attenuation corrections. The estimate of rainfall intensity derived from the dual-polarized radar in the event agrees well with the disdromters (PARSIVEL) located at about 30 km and 60 km away from the radar, respectively, with time intervals of 2 minutes. A high rainfall intensity region was clearly analyzed aloft several minutes prior to the local heavy rainfall on the ground. This result suggests that the vertical profile of rainfall intensity observed with dual-polarized radar can be a good index to discriminate between hazardous convective cells and others and to forecast subsequent heavy precipitation events on the ground

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Electromagnetic Modeling of Pristine Ice Crystals with Multiple Mass-dimensional Relationships

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Advances in electromagnetic scattering techniques for arbitrary objects (e.g., Draine and Flatau 1994, Xu 1995) have led to the creation of accurate models for complex ice particles such as pristine ice crystals (e.g., Liu 2008, Botta et al. 2011). These types of models have the potential to provide essential information on the microphysics of ice particles through comparison with radar measurements and cross-comparison with cloud models and in situ measurements (e.g., Avramov et al. 2011). Therefore particular care is necessary when approaching this modeling problem.

A very common approach to complex electromagnetic modeling of pristine ice crystals consists in characterizing a particular type of crystal (e.g., stellar, dendrite, or planar) in terms of a single mass-dimensional (M-D) relationship (e.g., Liu 2008). However, the literature provides many different M-D relationships (e.g., Pruppacher and Klett 1997, Mitchell and Heymsfield 2005) for the same type of crystal, making the single M-D relationship approach substantially limited. An overview of the many M-D relationships available in the literature shows that a given class of crystals can cover a relatively big region in the M-D plane. Ideally, electromagnetic models of pristine ice crystals should be able to appropriately sample a significant set of points in this region in order to provide cloud modelers with appropriate scattering computations that match the desired microphysical parameters (i.e., the shape of the crystals and their M-D relationship). In an effort to close the gap between electromagnetic and cloud models, several electromagnetic models of different classes of pristine ice crystals (dendrites, plates, columns, etc.) were developed using the generalized multiparticle Mie (GMM) method for scattering computations (Xu 1995, Botta et al. 2011). These models were tailored to cover as much area of the M-

D plane region defined by the multiple M-D relationships available for each class. Electromagnetic back-scattering computations at vertical and side incidence for pristine ice crystals modeled using this approach are presented.

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Ground-based Thermodynamic Profiling: Current Status and Future Directions

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Ground-based remote sensing offers the potential to address the need for highly resolved profiles of temperature and moisture in the lower troposphere. Such profiles are central to some of the most important research and operational goals for atmospheric and Earth system studies, mesoscale weather prediction, and monitoring of regional climate variability. Although research instruments can play a major role both in assessing instrument performance and capabilities as well as improving understanding of important atmospheric processes, networks of operational instruments providing observations on a regular basis are likely to have the most impact on the broad range of weather and climate activities. A workshop was convened in spring, 2011, in Boulder, CO to assess the merits of different ground-based remote sensing technologies for eventual deployment as part of an observing network. A number of active and passive remote sensing instruments and technologies were identified as suitable network candidates. Microwave radiometers and infrared spectrometers have a heritage of unattended operation for profiling both temperature and water vapor with higher resolution near the surface. Lidar systems profiling temperature and water vapor have typically operated as research instruments, although long term observations utilizing Raman lidar techniques have been demonstrated at a limited number of sites. New instrument designs and technology are showing the potential for low energy, high pulse rate DIAL instruments to observe water vapor profiles in the boundary layer up to heights of several km. Additional research investigating the benefits of combined retrievals including radiometers, spectrometers along with wind and DIAL lidars is likely to prove worthwhile. Integration of radiometers and lidars along other with methods involving radar and acoustic techniques may be necessary to provide comprehensive observations. Development of a testbed to compare instruments, determine the best implementation, and evaluate the impact of new profiling capabilities is a logical step toward a more operational network. This testbed could be mobile to provide a capability to optimize the suite of instruments for different in different regions. In addition to moving forward on a testbed, targeted research and development to improve and evaluate techniques, increase reliability, and decrease instrument costs are also important for eventual operational implementation. Observing systems simulation experiments (OSSEs) can provide information on instrument synergy, network implementation, impact of different configurations.

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FORCING MECHANISMS OF PLANETARY BOUNDARY LAYER DEPTHS IN THE LOS ANGELES BASIN AND CENTRAL VALLEY OF CALIFORNIA

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Four months of observations from a network of eight 915-MHz boundary-layer radar wind profilers equipped with radio acoustic sounding systems (RASS) operating in California's Central Valley and Los Angeles (LA) basin during the CalNex experiment of 2010 are used to investigate the variability of convective boundary-layer depth and its correlation to meteorological parameters and conditions. Surface meteorological variables such as pressure, temperature, relative humidity, wind speed, wind direction, solar radiation, net radiation, and precipitation, were measured by surface sensors at the same sites, or nearby. A previous study conducted over the entire year 2008 for five of the eight sites examined here showed that the boundary-layer height reaches its maximum in the late-spring months and then unexpectedly markedly decreases during the summer months, with July Planetary Boundary Layer (PBL) depths nearly equal to those in December. Similar results are found for all the eight sites, including those in the LA basin, over the late-spring to summer period of year 2010. Forcing mechanisms driving the seasonal behavior of boundary-layer depth are investigated, including the effect of marine layer intrusion in the LA basin, and the reduction of solar radiation due to marine stratus. To find out if the numerical model predictions are able to mimic the observed behavior of the PBL depth and associated forcing mechanisms, the first hour forecast fields of the High-Resolution Rapid Refresh (HRRR) model, run at 3 km resolution over continental USA, are evaluated.

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Automated Retrieval of Convective and Stable Mixing Layer Depth using Lidar, Microwave Radiometer and Ancillary Surface Data

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The mixing layer depth defines the thickness of the layer near the surface where surface emitted species get distributed through small and large scale turbulent mixing. In recent years, algorithm development for estimating mixing layer depth has been actively pursued by many authors using various remote sensing techniques, though the automatic detection of the top of the mixing layer still remains challenging.

Mixing layer height can be determined using temperature, humidity, aerosols and wind profiles from in-situ or remote sensing instrumentation (such as backscatter and doppler Lidars, wind profiling radars, sodars). Elastic-backscatter lidars and ceilometers provide vertical profiles of backscatter from aerosol particles. Since aerosols are mostly concentrated in the mixing layer, the aerosol backscatter profiles can be used to trace its depth, using either threshold, variance or gradient methods. However, since the aerosol may lay in multiple stratifications, this technique leads to an intrinsic ambiguity of the results. In fact, the correct attribution of the layer at the top of the mixing layer is not trivial, and deriving retrieval uncertainties from lidar profiles alone certainly remains a challenge.

Automatic profiling Lidars and ceilometers are now operated continuously in many networks around the globe. Some atmospheric research atmospheric observatories (eg. ARM program in the US, SIRTA observatory in France) have archived unique combinations of long term (more than 10 years) high quality lidar data and the concurrent measurements of the state variables. So there is a strong need of more robust mixing height retrievals, associated with retrieval uncertainties and reliability flags.

In particular, mixing height is especially difficult to estimate in stable boundary layer conditions. In fact, the lidar overlap makes the top of the mixing layer undetectable below this limit. In case of very low mixing layer heights, which may occur under stable conditions, this offset can actually mask the early growth of the mixing height.

In this presentation, we highlight work pursued to improve the attribution of Lidar derived aerosol gradients using measurements from a ground-based multichannel microwave radiometer, surface sensible heat flux derived from irradiance and temperature measurements, and combinations of variance and gradient analyses of Lidar data. Results based on long time series of collocated profiling measurements at the SIRTA observatory show that the use of ancillary data makes the aerosol-based estimations of mixing layer depth more physically reliable under a wide spectrum of conditions.

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Ground-based Raman Lidar Water Vapor Turbulence Profiles Over the US Southern Great Plains

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The operational Raman lidar at the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) site in north-central Oklahoma measures profiles of water vapor mixing ratio at 10-s, 7.5 m resolution. This lidar has been operational over 90% of the time since September 2004, and hence has collected tremendous dataset that can be used to characterize boundary layer and tropospheric properties. A recent publication has demonstrated that this lidar has the proper signal-to-noise characteristics to measure the water vapor turbulent structure in the convective boundary layer.

We have analyzed data in quasi-stationary (i.e., non-growing) convective mixed layers from multiple years. This dataset demonstrates that while the atmospheric variance profile is quite variable, especially at the top of the boundary layer, and is not well correlated with any of the traditional ground-based convective scales. However, the skewness of the water vapor profile narrows significantly at the top of the boundary layer, and seems to be quite repeatable. These data are also being used to investigate the differences in the profiles of water vapor variance and skewness in stationary boundary layers that are both cloud-free and are topped by cumulus clouds.

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Analysis of Sodar-Derived Boundary Layer Depths at Summit Station Greenland: Climatologies, Radiative Forcing and Depth Estimation Approaches

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Over the past several years, a mini-sodar has operated at Summit Station Greenland allowing for development of an annual climatology. This instrument has also supported both atmospheric chemistry programs (Van Dam et al, 2012, in preparation) and clouds and radiation studies (Shupe et al., 2012, BAMS, submitted). This paper addresses first seasonal variations in boundary layer depth (BLD) applying an automatic detection routine to the sodar intensity data, followed by an evaluation of several scaling laws, followed by case studies showing how remotely sensed cloud and radiation data can help interpret variability in boundary mixing layers. In the development of a seasonal climatology, we found that the average BLD depended strongly on monthly averaged wind speed, that simple BLD estimators applied to South Pole data (Neff et al, 2008) did not transfer to data from Summit Station, and finally, hourly variations in BLD and mixing processes correlate strongly with sky temperatures (affecting the surface energy budget).

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High Frequency Boundary Layer Profiling with Reusable Radiosondes

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During the Boundary Layer Late Afternoon and Sunset Turbulence (BLLAST) field experiment (2011, Lannemezan, France), a new system for high frequency boundary layer profiling based upon radiosondes and free balloons was tested.

The system consists in a conventional Vaisala receiver and a GPS radiosonde (pressure, wind, humidity and temperature) tied to two balloons. The principle of the sounding is to release the first balloon at a preset altitude, and to let the rawinsonde fall down with the second balloon in order to perform a second sounding and to recover the instrumentation. The expecting landing area is anticipated by using a forecasted wind profile and by triggering the balloon separation at a specific height using a pressure sensor. The real landing point is determined by the last transmission of the radiosonde GPS.

About 60 hourly soundings were performed during BLLAST with a recovery of ~ 80%, All recovered radiosondes were re-used several times, often immediately after recovery. After a detailed description of the sounding system and a summary of sounding activities during BLLAST, this contribution will discuss the potential of this new tool for atmospheric research applications with emphasis on the upcoming Hydrological Cycle in the Mediterranean Experiment (HyMeX) field phase to be conducted in fall 2012.

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Radio Sounding and Mesoscale Model Vertical Profiles for Sofia, Bulgaria

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The aerological station of Bulgaria is located in a suburb of Sofia, at the premises of NIMH. Only one radio sounding is performed (at noon) and these are the only troposphere data available for evaluation of model profiles. The aerological station is situated in the east-south-eastern part of the city of Sofia and is influenced by the urban canopy for westerly winds. Apart from the urban canopy of a 1.5 million inhabitant city, additional factors forming the complex structure of the vertical profiles of all meteorological parameters are the vicinity of Vitosha Mountain (2290 m) to the south and the flow regimes in Sofia valley in general.

In this study, the operational MM5 vertical profiles forecast for about one year period is evaluated against the noon radio soundings in Sofia as the Models 3 system (MM5-SMOKE-CMAQ) of EPA is used in air pollution studies in Bulgaria for almost 10 years. The profiles of wind speed and direction, temperature and humidity for the aerological site are obtained by interpolating between the nearest 4 grid points.

The analysis is performed classifying the cases by thermodynamic stability in the boundary layer, derived from the radio soundings. The mesoscale model profiles of wind speed and direction, temperature and humidity are then evaluated against the radio sonde data up to about 10 km height.

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Microwave Remote Sensing of the Boundary Layer

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The boundary layer temperature profile is usually changing on small time scales, which makes the rapid and precise measurement of it a key necessity. In the past years, Radiometer Physics GmbH (RPG) has developed microwave radiometers with a unique receiver hardware, which is specifically addressing these needs: Elevation-scans with noise less than 0.01 K RMS and narrow-beam elevation scans to less than 5 degrees elevation angle. Parallel data acquisition allows for individual filter bandwidths, which are absolutely needed when using the 58 GHz Oxygen absorption complex for high precision sounding. The required narrow beam is resulting from a large aperture optical system. Specific retrievals algorithms retrieve the temperature profile with a vertical resolution of about 50m and an accuracy of 0.3 K RMS close to the surface. Today, RPG will show the latest improvements in the used retrieval technology. The impact of low-elevation scans is shown, and the optimum angle selection strategy is discussed

In addition to passive soundings systems, RPG is currently developing a microwave scintillometer for the direct measurement of latent heat flux close to the surface. In cooperation with the University of Wageningen, RPG is assembling and testing a 160 GHz transmit-receive system which will be able to measure extremely small intensity fluctuations and thus allows (when used together with an optical scintillometer) the direct calculation of latent heat flux.

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A New Type of Dropsonde Using Lightweight Hard Ball as Parachute

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It is interesting and important to obtain the direct measurement data of both horizontal and vertical wind (VW) speed. A dropsonde has been developed using a 0.5-m diameter hard ball made by foamed plastics as the parachute. The dropsonde hung under the hard ball rises with the balloon, and will be cut off when they reach the upper troposphere, while a multi-channel receiver records the data continuously. The VW is derived from the different fall rates between observed and calculated in still air based on fluid dynamics. Deduction of the accurate drag coefficient (*Cd*) of dropsonde is facilitated by symmetrical shape of parachute. Computational fluid dynamics model and lab tests are employed to investigate the Reynolds number regimes in different levels.

A dozen of dropsonde launches have been done intensively under convective and inconvective conditions over the Northeast Plain in China during 26-31 May 2010. Despite some considerable uncertainties in weak vertical air motion, good agreement was obtained between the retrieved VW in lower atmosphere and the mean result of an in-situ VHF radar. The ability of quasi-synchronous monitoring several soundings in the convective boundary layer demonstrates potential for general applicability to detect the fine structure of thunderstorm.

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Precipitation and Boundary Layer Studies Using UHF Wind Profiler Radar /ISS, and TEAM-Radar in Taiwan

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The NCU(National Central University) ISS(Integrated Sounding System) and X-band Polarimetric Doppler Radar were deployed in the southwestern area of Taiwan during May 15 to June 30, 2008 for the Terrain Induced Monsoon Rainfall Experiment(TiMREX). This 915 MHz wind profiler radar had been deployed in Dongsha island during May 5 to June 25, 1998 for the SCSMEX and deployed in the southeastern coast of Taiwan(Cheng-Kung station) during May 5 to June 30,2001 for the GIMEX. It was also deployed in the southern part of Taiwan for air pollution meteorology observation. A wide variety of convective systems were observed during TiMREX, SCSMEX and GIMEX. The primary goal of these deployments were to measure the mesoscale structure of convective weather system and detail kinematic and thermodynamic structure change of the boundary layer flow and the local circulations. The detail boundary layer structure associated with several major convective events and severe air pollution episods will be discussed and compared in this investigation. The Tawian Experimental Atmospheric Mobile-Radar (TEAM-R) is Taiwani's first mobile meteorolgical radar. TEAM-R is a X-band dual-polarimetric radar. After completing its construction in March, 2008, TEAM-R participated the SoWMEX/TiMREX, conducted from May to June, 2008 in southern Taiwan. TEAM-R stationed at four different sites in the field for 50 consecutive days. The accumulated operational time was approximately 620 hours. This study will demonstrate a few cases study of the TEAM-R measurements during SoWMEX/TiMREX, and typhoons passing around Taiwan in the past few years.

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Lidar Measurements of Cirrus Cloud Properties at the High Alpine Research Station Jungfraujoch

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The Jungfraujoch research station is situated at 3580 m a.s.l. in the Swiss alps. This unique location lies above the polluted boundary layer which enables lidar measurements with higher signal-to-noise ratios than usual lidar measuring sites. Our elastic Lidar (Leosphere ALS450) is measuring continuously at Jungfraujoch since the end of October 2011. The aim is to achieve a midlatitude cirrus climatology based on the optical properties of the measured clouds. For this purpose, measurements are planned on the Jungfraujoch until the end of October 2012.
The optical depth of the measured clouds are examined and categorized according to Sassen and Cho (1992). To date we observed a large amount of subvisible cirrus, i.e. with optical depths smaller than 0.03. The smallest optical depth we ever observed so far was 2*10^{-3} with the cloud extending over a time span of 30 min. These clouds are of particular interest, as they are difficult to observe at sites more effected by pollution. They also have a warming effect on the climate as they are only weakly reflect incoming solar radiation.
We will present an overview of our lidar measurements on Jungfraujoch, a unique dataset of thinnest cirrus clouds.

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Retrieval of Aerosol Height with TROPOMI

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The Tropospheric Monitoring Instrument (TROPOMI), to be launched in 2015, will feature a new aerosol product that is specifically dedicated to retrieval of the height of aerosol layers. The Aerosol Layer Height product will be based on absorption by oxygen in the A-band (759-770 nm). Algorithm development for the aerosol height product is currently underway at KNMI. In this presentation we will introduce the product, highlight the algorithm and some of its development issues and discuss possible applications and example aerosol cases.
TROPOMI is a hyperspectral imager with channels in the ultraviolet, visible, near-infrared and shortwave infrared wavelength ranges, dedicated to remote sensing of the troposphere. It will have daily global coverage with small 7 x 7 km ground pixels. It is the successor to OMI and the precursor to ESA's Sentinel-5 mission. Aerosol Layer Height and the Absorbing Aerosol Index will be TROPOMI's main aerosol products.
Aerosol height observations from the near-infrared wavelength range will help to interpret the Absorbing Aerosol Index. Furthermore, they will improve retrieval of other aerosol properties, particularly retrieval of absorption optical thickness in the ultraviolet wavelength range. An increase in absorption can be due to a higher imaginary part of the refractive index or to the aerosol layer being at a higher altitude. Independent height observations will therefore further constrain retrieval of the single scattering albedo.

In addition, aerosol height information is an important parameter when estimating radiative forcings and climate impacts of aerosol, it is a significant source of uncertainty in trace gas retrieval and it helps in understanding atmospheric transport mechanisms. Finally, timely available, global observations of aerosol height will be of interest to aviation safety agencies.
The retrieval algorithm will be based on a spectral fit of reflectance (resolution 0.5 nm) across the O2 A absorption band. Aerosols are assumed to be confined to a single layer. The retrieval method will be optimal estimation to ensure a proper error analysis. The retrieval algorithm will be particularly sensitive to elevated, optically quite thick aerosol layers.
Sensitivity studies have indicated that accuracy and precision of retrieved height for cloud-free scenes will be well below the TROPOMI science requirements (1 km). They have also shown that retrieval is robust against inaccurate knowledge of the single scattering albedo and that precise knowledge of the phase function or the surface albedo is not needed. Thus, specific knowledge of the aerosol type is not needed for a reliable height retrieval.

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The 8-Year Arctic Ice Cloud Lidar/Radar Climatology from AFARS, Fairbanks, Alaska, US: This Can't Be Kansas

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Our knowledge of the Earth's clouds has until recently been dominated by midlatitude research, but it is becoming clear from the global CALIPSO and CloudSat satellite datasets that the distribution and physical properties of various cloud types is a strong function of latitude and geography. In this research we examine the differences between high (i.e., cirrus) and midlevel (altostratus) ice clouds based on multi-year polarization lidar and Doppler W-band radar measurement programs from FARS in Salt lake City, Utah (40.82°N, 111.88°W), and AFARS (the Arctic Facility for Atmospheric Remote Sensing) in Fairbanks, Alaska (64.86°N, 146.84°W). Although the average monthly cloud base and top temperatures of cirrus (defined as cloud top temperatures <-40°C and optical depths <~3.0 based on FARS research) are similar, the heights, pressures, and wind speeds/directions are very different. Of course, these discrepancies are a reflection of differences in tropopause heights (normally about 2-km lower at AFARS), and the weather patterns locally responsible for cirrus generation. A primary cause of the latter is the comparative lack of Arctic jet stream systems for much of the year, versus midlatitudes. Major differences are also indicated in the frequency and properties of midlevel altostratus ice clouds, which at high latitudes often are optically thin or even subvisual particularly during the winter season, and appear to occur in small mesoscale cloud organizations. We will provide and compare ice cloud climatologies from FARS and AFARS and discuss the implications for the improved global characterization of ice clouds, and raise the question whether our midlatitude definition of cirrus is appropriate for cirrus clouds in the Arctic.

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Performance of Cloud Liquid Water Retrievals from Ground-based Remote Sensing Observations over Leipzig

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Since August 2011, liquid water clouds are observed continuously at Leipzig Institute for Tropospheric Research by mainly using cloud radar, passive microwave radiometer and lidar ceilometer data. Applying algorithms which were developed within the CLOUDNET program, parameters like cloud type, liquid water content, and ice water content are calculated semi-operationally for these data.

The challenge to retrieve cloud liquid water content (LWC) and its vertical distribution from ground-based cloud radar observations is the non-linear relationship between the radar reflectivity Z and LWC. Using additional information like cloud base height (from lidar), integrated cloud water (from microwave radiometer), or temperature profiles allows estimating the LWC distribution within a cloud.

In this work, different approaches to retrieve LWC are compared. In particular, the differences between adiabatic cloud water distributions and a combined radar-lidar method are discussed.

Case studies of liquid water clouds under different atmospheric conditions are presented, with the focus on the dependence of retrieval performance on parameters like season, water vapor content, or cloud height and depth.

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Aerosol Classification Using Airborne High Spectral Resolution Lidar (HSRL) Measurements

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The NASA Langley Research Center (LaRC) airborne High Spectral Resolution Lidar (HSRL) on the NASA B200 aircraft has acquired extensive datasets of aerosol extinction (532 nm), aerosol optical depth (532 nm), backscatter (532 and 1064 nm), and depolarization (532 and 1064 nm) profiles during 18 field missions that have been conducted over North America since 2006. The lidar measurements include aerosol intensive parameters that vary with aerosol type but not with concentration. These are the lidar ratio, aerosol depolarization ratio, backscatter color ratio, and spectral depolarization ratio (the ratio of aerosol depolarization at the two wavelengths). They are used to qualitatively classify the extensive set of HSRL aerosol measurements into eight separate composition types. The ability to accurately characterize and discriminate aerosol type can improve both satellite measurement retrievals and modeling. The HSRL classification methodology is based on aerosol models formed from a subset of observations having known or easily inferred aerosol type. The remainder of the data is then classified by comparison with these models using the Mahalanobis distance. Several examples are presented showing how the aerosol intensive parameters vary with aerosol type and how these aerosols are classified according to this new methodology. Vertical variability of aerosol types and partitioning of aerosol optical depth according to type are illustrated using the HSRL aerosol classification results. Comparisons with aerosol types derived from coincident measurements by the Particle Analysis by Laser Mass Spectroscopy (PALMS) in situ instruments aboard the NOAA P3 during the ARCTAS/ARCPAC field mission and from a ground site in Pasadena during the CalNex field mission support the HSRL aerosol type results. The HSRL instrument regularly flies over the CALIPSO satellite ground track for validation, including more than 100 coincident flight track segments to date, and this provides an opportunity to compare aerosol type inferences with the CALIPSO Vertical Feature Mask product. Finally, comparisons with aerosol models are also illustrated.

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Three Wavelength Lidar Measurements for Atmospheric Aerosol Characterization

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Lidar measurements performed at three wavelengths (355 nm, 532 nm and 1064 nm) at the Physics Department of the University of Salento, Lecce, in southeastern Italy (40.2° N, 18.6°), are used to characterize the dependence on altitude of the atmospheric aerosol size distribution, by applying the graphical method proposed by Gobbi et al. (2007). The graphical method is based on the combined analysis of the Angstrom coefficient α and its spectral curvature $\delta\alpha$ and was developed to classify columnar-averaged aerosol properties derived from AERONET direct sun measurements. In particular, the method allows inferring the aerosol fine mode radius (Rf) and the fine-mode fraction contribution (eta) to the total Aerosol Optical Depth (AOD), from the α-$\delta\alpha$ scatterplot. The availability of three-wavelength lidar measurements, which allow calculating altitude-resolved α-$\delta\alpha$ data points, permits estimating altitude-resolved Rf and eta values. Results on several case studies representative of different advection patterns over the monitoring site are presented in this study. More specifically, the graphical method by Gobbi et al. (2007) is applied to selected lidar measurements performed by mean of the UNILE lidar, in the framework of the European Aerosol Research Lidar Network (EARLINET). Analytical back trajectories are used together with volume depolarization ratio vertical profiles to infer the advection of different aerosol types (such as desert dust, marine, and continental aerosol) over the monitoring site in the year 2011. The analyzed study cases reveal that the retrieved Rf and eta values are on average quite dependent on altitude, since mixed advection patterns are dominant over the monitoring site. Coarse and fine particles populations at various heights are shown to well represent the particle properties associated to backtrajectory-inferred origins.

In particular, we show that during mixed advection patterns α varies with altitude in the range (0.5-1.5) and consequently eta and Rf vary within the (50-70) % and (0.1-02) μm range, respectively.

Altitude-resolved Rf and eta values are compared to corresponding columnar averaged Rf and eta values retrieved from AERONET measurements, to support and highlight the benefits of multi wavelength lidar measurements.

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Quantitative Volcanic Ash Estimation by Operational Weather Radar

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Operational weather radar data of 27 big eruptions from Shinmoedake volcano in the Kirishima range in Kyushu, Japan in the period from January to March 2011 are analyzed to examine possibility of radar for quantitative volcanic ash estimation. The radars used in the analysis are C-band radars located at Kunimiyama and Shakadake, which are operated by the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT). The eruption time period, maximum and accumulated reflectivity, and differential reflectivity were collected for each eruption. It is concluded from the radar data analysis that operational weather radar has potential ability to quantitative detection of volcanic ash amount. An empirical relationship between the reflectivity and ash amount is proposed based on comparisons of radar data with ground ash distribution measured after the eruption on 26-27 January. Meanwhile the radar could not detect eruptions in such a case where the ash particle size is too small to be detected by the radar: the ash reflectivity is lower than the minimum detectable signal of the radar receiver. Naturally, it is impossible to detect an eruption when its height is below the radar beam height. It is also hard to detect eruptions under rain conditions when erupted ash particles are contaminated with precipitation particles. Differential reflectivity which is one of polarimetric radar parameters fluctuates over the crater in space and time while it shows significant distributions over downwind regions from the crater which suggests sorting of ash particles.

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Estimation Of Mass Concentration Profiles For 2-Components External Mixtures Of Aerosols, Based On Multiwavelength Depolarization Lidar

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The shape, size distribution and composition of aerosol particles in the atmosphere are highly variable and influence their scattering characteristics and thus the radiative impact. Atmospheric layers often contains mixture of different aerosol types, having completely different scattering and absorption properties. We used the method of (Tesche et al, 2009), to quantitatively separate high-depolarization (e.g. dust) and low-depolarization (e.g. smoke) component's contribution to the 532-nm backscatter coefficient, based on measured linear particle depolarization ratio profile, and apriori knowledge of the mean optical characteristics of the 2 assumed components. Different cases of mixtures were analyzed.

The method requires high accuracy input data, therefore accurate estimation of the backscatter and particle depolarization profile, as well as complementary information on the type of components. Calculation of the backscatter coefficient profile can be done with a good accuracy even for simple backscatter lidars, where a lidar ratio has to be assumed along with the calibration in far range. Particle depolarization ratio instead, is very sensitive to instrument's function and to the calibration procedure. Several sources of systematic errors have to be considered for a non-ideal lidar system.

Data used in this paper were provided by a multiwavelength depolarization Raman lidar. Linear volume depolarization ratio was computed using the relative amplification factor introduced by (Freudenthaler et. al. 2009), and the system-dependent molecular depolarization was considered for the calculus of the linear particle depolarization ratio. For all the cases in this paper, we considered that the aerosol population is an externally mixture of low and high depolarizing particles, with different mixing ratios. Generally, the low depolarizing component was identified as continental polluted with a LR of 60sr and a mean δp of 3%, while for the high depolarizing component (e.g. Saharan dust or volcanic dust) a LR of 30sr and a mean δp of 45% was considered.

To calculate mass concentration profiles, we used OPAC (Optical Properties of Aerosols and Clouds software) classification and conversion factors. We found that the retrieval method can distinguish between smoke-reach aerosol during the winter and dust-reach aerosol during the summer, as well as between elevated aerosol layers having different origins. Special attention was paid to the period of April-May 2010, when a mixture of continental polluted aerosol and volcanic dust, with variable mixing ratios, was persistent over SE Europe.

Comparison of the total mass concentration measured by an Aerosol Mass Spectrometer (AMS) and the lidar derived mass concentration extrapolated to the ground was performed. We found good agreement in cases of atmospheric stability, when the extrapolation of the lidar profiles to the ground was not introducing large errors. Cases with high content of low depolarizing particles - as derived from lidar - were consistent with AMS retrievals for organics and sulphates - which are considered good markers for smoke. Cases when volcanic dust mixed with continental polluted aerosol was pointed by the lidar, were confirmed also by the signature (SO4) identified by the AMS at ground-level, after the nighttime dry deposition.

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The Signatures of Wind and Aerosols in Long-term Cloud Radar Observations of Trade Cumuli

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Since April 2010, our polarized scanning K-band cloud radar measures the structure of trade-wind cumuli clouds. Along with a suite of other instruments it complements a long-term data record of various measurements from the MPI-M cloud observatory on the windward side of Barbados; allowing for facilitating the development of a statistical description of trade-wind cumuli.

In this analysis, we investigate how strong different conditions in wind, aerosol loading and origin of airmass arriving in Barbados influence the appearance of footprints in the radar signature. To retrieve wind speed we use the data record of the locally employed 17 m high wind mast, whereas the particle backscatter and linear depolarization ratio measured by a Raman lidar allows us to describe the ambient aerosols. Additionally, the airmass arriving in Barbados are calculated from backward trajectories using the Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT) driven by meteorological variables from the ERA-INTERIM reanalysis database of the European Centre for Medium-Range Weather Forecasts (ECMWF).

We distinguish between maritime and continental source areas, as well as dusty and non-dusty days by conditional sampling of the cloud radar data using the backward trajectories and an dust index, derived form the Raman lidar. First results show a bimodal distribution in frequency of occurrence of small reflectivities (Ze -15dB) with peaks at ~ 800 m and ~ 1900 m height under maritime conditions for signals up to 5 km. A more detailed analysis, derived from ground-based in-situ data during November 2010, infer that the bimodal distribution in Ze occurs most often in case of total particle number concentration greater than 200 cc-1; which includes often many "newly" formed particles smaller than 80nm in diameter. We analyze if the magnitude in wind speed could cause this interesting radar signature. Furthermore, there exists a pronounced increase in radar reflectivity for Ze -10 dB with height, which we explore as a function of the aerosol loading.

Additionally, for testing the signals of statistical significance we apply a bootstrap like method in selecting the times of measurements, showing how much the results depend on sampling and length of data recording.

In summary, this study aims to show how statistical derived properties of clouds can be used in order to gain a better understanding of the interplay between clouds and aerosols.

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Raman LIDAR Observations Of Aerosol Optical Properties In The Lower Troposphere Over The Argentinian Pampa.

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A year-round database of aerosol backscatter and extinction profiles in the UV range is presented. The measurements have been taken with a Raman lidar from August 2006 to July 2007 at the AUGER observatory located in the Argentinian pampa (35.32S, 69.30W, 1416m a.s.l.), Malargue, Mendoza, Argentina. The analysis of the aerosol backscatter profiles reveals the peculiar structure of the planetary boundary layer over this region (dry pampa plateau). The climatology of the vertical aerosol optical depth as well as of the boundary layer height clearly indicate a seasonally variability.

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Volcanic Ash Monitoring by Ground-based Polarimetric X-band Radar

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The detection and quantitative retrieval of volcanic ash clouds is of significant interest due to its environmental, climatic and socio-economic effects. Ash fallout might cause hardship and damages in volcano's surrounding area representing a serious hazard to aircrafts. Real-time monitoring of such phenomena is crucial, also for the initialization of dispersion models.
Ground-based microwave weather radars may represent an important tool to detect and, to a certain extent, mitigate the hazard from the ash clouds. The possibility of monitoring in all weather conditions at a fairly high spatial resolution (less than few hundreds of meters) and every few minutes after the eruption is the major advantage of using ground-based microwave radar systems. Ground-based weather radar systems can also provide data for determining the ash volume, total mass and height of eruption clouds.

The potential benefit derived by the use of dual-polarization radar systems at X band is tested in the present work. An overall algorithm, named VARR- PX (VARR Polarimetric at X band), for X-band radar polarimetric retrieval of volcanic ash clouds from measured dual-polarization reflectivity, was recently proposed. This work is aimed at 1) qualitatively verifying the microphysical and scattering model assumptions of VARR-PX by comparing polarimetric radar signatures from simulations and observations, 2) testing the sensitivity of the retrieval algorithm with respect to input polarimetric variables. For these purposes, data from the first polarimetric X-band radar specifically devoted to ash cloud observation and installed near the Mt. Etna volcano in south Italy, are analyzed.

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Recommendations for European ground-based profiling networks by the EU-COST action EG-CLIMET

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This action has as its main objective the specification, development and demonstration of cost-effective ground-based integrated profiling networks to provide essential observations for both climate and weather. Two classes of network are recommended. Firstly, a sparse network of high specification cloud radars and advanced lidars measuring accurate profiles of the characteristics of clouds and aerosols and which samples the different climate regimes over Europe is recommended. The continuous observations from this network can then be compared with the representation of clouds and aerosols in operational numerical weather prediction models so that the ability of the models to predict the correct clouds and aerosols at the right time and the right place may be evaluated. These skill scores can then be rapidly fed back to the NWP centres and any improvement in the performance of new versions of the model can be quantified. Secondly, there is a requirement for denser networks of profilers supplying real time data to be assimilated into the new generation of high resolution NWP models having grid meshes of about 1km. The aim would be a better representation of the current state of the atmosphere leading to improved forecast of hazardous weather. Economic conditions preclude the development of new networks but there is a need to better exploit existing instruments. The data quality of the current wind profiler network can be improved. There are many hundred of ceilometers deployed over Europe but at present they do not report in near real time. If these ceilometers were networked, accurately calibrated and a common data format defined, then near real time profiles of cloud and aerosol have the potential to be assimilated into NWP models. Finally there are 20-20 microwave radiometers which give information on the vertical profiles of temperature and humidity together with the total paths integrated vapour and cloud water. Again calibrated data with careful quality control have the potential to be assimilated into NWP models.

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The Boundary Layer Height and Entrainment Zone Assessment from Lidar, Meteorological and Forecast Model Data

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Planetary boundary layer (PBL) processes control energy, water, and pollutant exchanges between the surface and free troposphere. The assessment of boundary layer height is a key element to climate, weather, and air quality. The most direct way to detect the PBL height is from the thermodynamic profile taken during radiosonde launches, but lidar systems have been widely used to examine the structure and variability of the PBL top and to derive the entrainment zone depth. Currently, at Magurele, Romania (lat. 44.35 N, long 26.03 E, 90 m asl) the PBL cannot be measured directly and it is estimated from a multiwavelength Raman lidar system (RALI).

In this study the thickness of the entrainment zone and the top of the atmospheric mixed layer are analyzed using lidar, meteorological and model forecast data, focused on three years of measurements performed during 2009-2011.

One of the simplest but efficient gradient methods for PBL detection involves an accurate assessment of the sharp gradients in the the first derivative of the lidar range corrected signal. For the purposes of this study and to improve the regular retrieval affected by the incomplete overlap region, we applied the gradient method to the ratio of 1064 nm channel to 532nm channel's range corrected signals: RCS_{1064}/RCS_{532p}. First, the entrainment zone thicknesses and PBL heights are compared with the ones determined from Meteorological data base (NOAA). Data have been obtained from the GDAS (Global Data Assimilation System), National Weather Service's National Centers for Environmental Prediction (NCEP). R^2value of approximately 0.86 has been found for orthogonal regressions between GDAS data-derived PBL heights and lidar-derived PBL heights but it is much lower (about 0.40) when comparing entrainment zone thicknesses probably due to the capability of the GDAS data to take into account local influences.

Second we compare the daytime lidar measurements with the output from the Weather Research and Forecasting (WRF) model, a mesoscale numerical weather prediction system, for validation purposes. The PBL scheme used for WRF is the Yonsei University scheme (non-local-K scheme with explicit entrainment layer and parabolic K profile in unstable mixed layer). The results shown a sufficiently good correlation thus confirming the quality of the forecast of PBL generated by the meteorological model implemented in the ROMAIR project. However, the analyses showed that the model slightly overestimates the PBL during convective periods, and underestimates it during winter periods. This study has allowed the fine-tuning and evaluation of model options for calculating the PBL.

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A Model-based Approach to adjust Microwave Observations for Operational Applications: Results of a Campaign at Munich Airport in Winter 2011/2012

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In the frame of the project "LuFo iPort VIS" which focuses on the implementation of a site specific visibility forecast, a field campaign was organised to offer detailed information to a numerical fog model. As part of additional observing activities a 22-channel microwave radiometer profiler (MWRP) was operating at the Munich airport site in Germany from October 2011 to February 2012 in order to provide vertical temperature and humidity profiles as well as cloud liquid water information. Independently from the model-related aims of the campaign, the MWRP observations were used to study their capabilities to work in operational meteorological networks. Over the past decade a growing quantity of MWRP has been introduced and a user community (MWRnet) was established to encourage activities directed at the set up of an operational network. On that account, the comparability of observations from different network sites plays a fundamental role for any applications in climatology and numerical weather forecast.

In practice however, systematic temperature and humidity differences between MWRP retrievals and co-located radiosonde profiles were observed and reported by several authors. This bias can be caused by instrumental offsets as well as by the absorption model used in the retrieval algorithms. At the Lindenberg observatory besides a neural network provided by the manufacturer, a measurement-based regression method was developed to reduce the bias. These regression operators are calculated on the basis of coincident radiosonde observations and MWRP brightness temperature measurements. However, MWRP applications in a network require comparable results at just any site, even if no radiosondes are available.

The motivation of this work is to study the suitability of the DWD numerical forecast model COSMO-EU for the calculation of model-based regression operators in order to provide unbiased vertical profiles during the campaign at the Munich airport. The results of this algorithm as well as the retrievals of a neural network, specially developed for the site, are compared with radiosondes from Oberschleißheim located about 10 km from the MWRP site. The bias of the retrievals could be considerably reduced and the accuracies which have been assessed for the airport site is quite similar to those of the operational radiometer at Lindenberg above 1 km height. Additional investigations are made to determine the lenght of the training period necessary for generating best estimates. Thereby three months have proven to be adequate. The results of the study show, that on the basis of NWF model data, available everywhere at any time, the model-based regression method is capable to provide comparable results at a multitude of sites. Furthermore, the approach offers auspicious conditions for automation and updating.

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Lidar-radar Synergy for Characterizing Properties of Ultragiant Volcanic Aerosol

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Atmospheric aerosols have a relevant effect on our life influencing climate, aviation safety, air quality and natural hazards. The identification of aerosol layers through inspection of continuous measurements

is strongly recommended for quantifying their contribution to natural hazards and air quality and to establish suitable alerting systems.
In particular, the study of ultragiant aerosols may improve the knowledge of physical-chemical processes underlying the aerosol-cloud interactions and the effect of giant nuclei as a potential element to expedite the warm-rain process. Moreover, the identification and the characterization of ultragiant aerosols may strongly contribute to quantify their impact on human health and their role in airplane engine damages or in visibility problems, especially in case of extreme events as explosive volcanic eruptions.
During spring 2010, volcanic aerosol layers originating from the Eyjafjallajökull volcano were observed over most of the European countries, using lidar techniques. From 19 April to 19 May 2010, they were also observed at the CNR-IMAA Atmospheric Observatory (CIAO) (40.60N, 15.72E, 760 m a.s.l),in Southern Italy with the Potenza EARLINET multi-wavelength Raman lidar systems. During this period, ultragiant aerosols were also observed at CIAO using a co-located Ka-band MIRA-36 Doppler microwave radar operating at 8.45 mm (35.5 GHz). The Ka-band radar observed in four separate days (19 April, 7, 10, 13 May) signatures consistent with the observations of non-spherical ultragiant aerosols characterized by anomalous values of linear depolarization ratio (LDR) higher than -4 dB, probably related to the occurrence of multiple effects as particle alignment and presence of an ice coating.
7-days backward trajectory analysis shows that the air masses corresponding to the ultragiant aerosols observed by the radar originated from the Eyjafjallajökull volcano area. Only in one case the trajectories do not come directly from Iceland, but from Central Europe where many lidar observations confirm the presence of volcanic aerosol in the previous days. Therefore, both CIAO lidar observations and the backtrajectory analysis suggest a volcanic origin of the ultragiant aerosols observed by the radar, revealing that these particles might have travelled for more than 4000 km after their injection into the atmosphere.
Radar measurements could provide a valuable tool for expanding the lidar observational capability in terms of meteorological conditions and aerosol size. Aerosol radar observations could fill an important observation gap in the study of aerosol role on the weather and climate system with the added value that they are available in all weather conditions.

In the described context, the overall aim of this paper is to assess and quantify for the first time the feasibility of a synergic use of lidar and radar techniques for the study of atmospheric aerosol. A physical interpretation of the anomalous LDR values observed by the radar is discussed on the basis of simulation results based on the T-matrix scattering theory. An assessment of the capability of lidar technique in typing ultragiant aerosols, using simulations based on the Mie scattering theory, is also provided.

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Managing Accuracy and Stability of Micro-wave Radiometers for Operational, Real-time Retrieval of Temperature Profiles at MeteoSwiss Payerne

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Recently MeteoSwiss achieved the installation of an observing network with three remote sensing sites that combine radar wind profiling and microwave temperature profiling. The main goal of this network is to monitor horizontal and vertical wind structures, as well as atmospheric stability in a near-real-time in the vicinity of the Swiss nuclear power plants in order to characterize the propagation conditions in case of a nuclear leak. As part of this network MeteoSwiss has been continuously operating a Humidity And Temperature PROfiler (HATPRO) multi-channel multi-angle MicroWave Radiometer (MWR here after) since August 2006 at Payerne. This microwave profiler allows temporally highly resolved (currently 15 min) retrievals of the tropospheric temperature profile.

Based on MWR measurements from 2006 to 2009 at Payerne, we show what are the long-term random and systematic errors of temperature profiles retrieved from the MWR by comparing the radiometer against temperature measurements from a radiosonde. The main findings are that HATPRO delivered reliable temperature profiles in 88% of all-weather conditions with a temporal resolution of 15 min. Random differences between HATPRO and radiosonde are 0.5 K in the lower boundary layer and rise up to 1.7K at 4 km height. Systematic temperature differences in the order of 0.5 K are observed throughout the retrieved profile . These systematic errors are due to biases in the measured microwave radiances. Based on brightness temperatures calculated from radiosondes, a bias correction has been calculated and applied to each radiometer channel. The corrected measurements have been reprocessed and it is shown that the resulting temperature profiles are almost bias free. Abrupt changes in the radiance bias have been found after liquid nitrogen calibrations, which indicates the need for a careful execution of the calibration procedure.

Furthermore, we show how quality and reproducibility of absolute calibration is managed on an operational basis at MeteoSwiss. Instrument stability is monitored by routinely automatic comparisons with brightness temperatures calculated from radiosondes under clear sky conditions. Biases in the measurements of the microwave radiances are recalculated at short intervals and taken into account in the operational data processing. We present preliminary results with 2-3 months of real-time operationally produced unbiased MWR temperature profiles.

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The ParisFog Field Experiment: Better Understanding of Key Physical Processes Driving Fog Life Cycle

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Fog is a weather phenomenon that produces weather conditions with significant socio-economic impacts, associated with increased hazards and constraints in road, maritime and air traffic. Air quality is also affected by fog occurrence. While current numerical weather prediction models are able to forecast situations that are favourable to fog events, these forecasts are usually unable to determine the exact location and time of formation or dissipation.

The fog is influenced by numerous factors, spanning multiple spatial and temporal scales. Its life cycle is driven by the competing interactions between thermodynamics, dynamics, microphysics, radiative fluxes and chemistry all of which are difficult to model. The field campaign, ParisFog (http://sirta.ipsl.polytechnique.fr/parisfog/), aims at better understanding the role of aerosol on radiative processes and the interactions between turbulence and aerosol/droplet microphysical properties during the fog life cycle.

Several ParisFog field campaigns have taken place at SIRTA site since 2006 with an instrumental settling which grows significantly each year. An efficient collaboration with IPSL, IPGP, LRPC, CEREA and CNRM laboratories allows us to sample approximately 200 hours of fog during each six month period (October to March). On the one hand, automated measurements have been specifically deployed to better characterise aerosol and droplet properties (size distribution, mass, scattering), including turbulence profiles up to 2km. On the other hand, some specific events have been sampled using manual sensors such as tethered balloon or droplet chemistry sensors.

A significant work has been conducted to combine:

(1) in-situ measurement at ground level dedicated to document aerosol microphysic and aerosol lidar/ceilometer to characterize vertical profiles of extinction during radiative cooling before fog formation,

(2) close to surface droplet properties (size, concentration) and cloud radar reflectivity/Doppler velocity to estimate liquid water profiles up to fog top,

(3) cup/sonic anemometer, Doppler lidar and sodar to quantify accuracy of each system and calculate turbulence for clear-sky and stable event and inside fog layer.

Process studies conducted here aim at answering to these specific questions :

Radiative processes

- What is the impact of hydrated aerosols on infrared radiative cooling before radiative fog formation and the impact of interstitial aerosols on solar radiative warming during fog dissipation?

Dynamical processes

- What is the vertical structure of turbulence during fog life cycle (stable conditions before radiative fog event, entrainment zone near the fog top, heat fluxes close to the surface) and what is the impact on fog life cycle

Microphysical and chemical processes

- What is the impact of dry aerosol microphysical and chemical properties on hydratation/condensation process and fog characteristics

In this presentation, we will present some results on radiative fog processes (infrared radiative cooling, structure of turbulence for stable conditions, effect of air mass origin) but also some results on stratus-lowering fog processes (effect of drizzle and precipitation, role of surface heat fluxes).

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Synergetic Observations of Spatial and Temporal Cloud Characteristics at the Jülich ObservatorY for Cloud Evolution (JOYCE)

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The atmospheric observatory JOYCE is a specifically equipped site for investigating the processes leading to cloud formation and cloud evolution. An array of various instruments has been set up at the Research Centre Jülich to continuously monitor water vapour, clouds, and precipitation over many years. JOYCE is operated jointly by the University of Cologne, the Research Centre Jülich and the *Transregional Collaborative Research Centre Patterns in Soil-Vegetation-Atmosphere-Systems: Monitoring, Modelling and Data Assimilation*. The core instruments of JOYCE are a scanning cloud radar, a micro rain radar, a ceilometer, a pulsed Doppler lidar, a scanning 14-channel microwave radiometer (MWR) with an attached 2-channel infrared thermometer (IRT), an infrared spectrometer (AERI), a Doppler lidar, a total sky imager and radiation sensors. These measurements are supplemented by the standard meteorological measurements from the 120 m measurement tower. In addition, the polarimetric weather radar of the Research Centre Jülich provides information on the spatial distribution of precipitation. Thus, the JOYCE instrumentation is ideally suited for the analysis of water vapour variations, the development of boundary layer clouds, cloud radiation interaction, and precipitation formation.

These collocated measurements of multiple wavelength active and passive remote sensing instruments allow for the combination of the different sensors in an optimal way in order to derive the best estimate of the thermodynamic state such as temperature and water vapour profile, but also cloud properties and their associated uncertainties. Furthermore, analysing synchronous hemispheric scans of the cloud radar, the MWR and the attached IRT provides a 3D picture of water vapour and boundary layer clouds. Typical cases studies concerning the spatial and temporal development of boundary layer clouds are analysed and retrieval methodologies are discussed. These scanning measurements provide a high potential for meso-scale model evaluation, especially concerning processes such as cloud formation, cloud entrainment and auto-conversion.

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Boundary Layer Height Retrieval with Ceilometer and Doppler Lidar: An Intercomparison

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Ceilometers are low cost lidars designed for the detection of cloud base height. They also see aerosol but only close to their detection limit. It is widely assumed that this aerosol information can be used to derive the height of the boundary layer i.e. the height of the layer where vertical mixing leads to direct influence of the surface.

Basis for this assumption is that the main amount of aerosol is produced at the ground and can be found in the boundary layer. This assumption is mainly true for a fully developped convective boundary layer but fails e.g. during night time when the residual layer still holds a lot of aerosol. In this case vertical mixing might be stronlgy reduced and restricted to a shallow layer close to the ground within the night time inversion.

Since November 2011 we run a doppler wind lidar and a ceilometer in parallel at the Juelich ObservatorY for Cloud Evolution (JOYCE) in Germany. The doppler lidar measures vertical velocity and thus gives a direct measure for vertical mixing. We show some typical situations and how the methods compare to each other. A statisitcal analysis will show when the boundary layer height derived from the ceilometer is succesful and when it is not possible to use it.

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Composite Temperature Profiles from Raman Lidar and Microwave Radiometer

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MeteoSwiss deployed two collocated ground based remote sensing techniques for continuous and operational profiling of the temperature in the troposphere. The Raman lidar (light detection and ranging) is an active method, that provides a temperature profile every 30 min in an altitude range of 60 - 10'000 m agl during nighttime (7000 m during daytime) with a vertical resolution of 60 m. The temperature profiles have to be calibrated externally and the calibration constants are routinely determined once per month based on intercomparisons with collocated radiosoundings. However, instabilities in the analog detection channels, that are used for the lower part of the profile, introduce an uncertainty both in the shape of the lower part of the profile itself and in the calibration constants. Best performance of the lidar system is found above approximately 2000 m agl where the signals are not saturated. The microwave radiometer is a passive instrument that measures the microwave radiation at several frequencies. From such a spectrum, a temperature profile from the surface up to 10'000 m agl is retrieved. The radiometer is calibrated with internal references and does not need any external measurements. However, due to its passive nature, the vertical resolution of the retrieved temperature profile degrades rapidly with altitude and is in the order of several hundreds of meters above 2000 m agl. Hence best performance of this technique is between the surface and approximately 2000 m agl. It has been recognized that these two techniques are highly complementary: the lidar provides high vertical resolution profiles while the microwave radiometer provides an absolute calibration and an accurate temperature profile from 2000 m agl down to the ground. Two methods to combine lidar and radiometric measurements of atmospheric temperature are presented. The first method consists of two steps: the calibration constants of the lidar is recalculated for each profile using the coinciding radiometer temperature profile. This reduces the uncertainty in the calibration constants and guarantees agreement between lidar and radiometer temperature profile. The obtained calibration constants are validated against those obtained from radiosonde intercomparisons twice a day to estimate the effect of the limited altitude coverage of the radiometer compared to the radiosonde. In a second step, a smooth composite profile is built using radiometer data below approximately 2000 m agl and the calibrated lidar profile above. In the second method, the lidar profile is used as a priori profile in an optimal estimation retrieval of the radiometer. The result is a consistent temperature profile that is based on the best information source at each altitude. Both methods are characterized and evaluated using the operational radiosondes as reference.

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Impact of Drizzle on Lidar-derived Aerosol Properties below Clouds Validated with Cloud Radar

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Aerosol properties as well as up- and downdraft characteristics are the driving parameters for cloud formation. They are inevitable input parameters for numerical model studies of aerosol-cloud interaction. Air parcels that rise in an updraft are subject to increasing relative humidities. Depending on their hygroscopicity the aerosol particles suspended in the air parcel swell until cloud droplet formation occurs when the relative humidity above liquid water approaches 100%.

Lidar is a suitable tool for the observation of the transition region where the aerosol particles transform into droplets. Doppler lidar provides information on the vertical motions below clouds whereas Raman or elastic backscatter lidar provide data about optical and consequently microphysical properties of the aerosol mixture present.

However, often drizzle formation occurs in long-lasting stratus or in convective cumulus clouds. Drizzle droplets may precipitate out of the clouds without reaching the ground which would make them undetectable by precipitation sensors. Such drizzle may not be identified by the lidar because the number concentration of the large droplets is low. They do however contribute to some extent to the observed aerosol optical properties and may thus affect the interpretation of the evolution of the aerosol properties below the cloud base.

Here, we present a combined theoretical and experimental study that assesses the quantitative effect of drizzle droplets on the optical properties derived with lidar. The frequency of the occurrence of drizzle below clouds that does not reach the ground is investigated based on 6 months of continuous measurements with the cloud radar MIRA35 and an optical disdrometer at Leibniz Institute for Tropospheric Research, Leipzig (51.3°N, 12.4°E), Germany. The radar is sensitive to backscattering of the drizzle droplets whereas aerosol particles remain undetected. From comparisons with a co-located ceilometer the impact of the drizzle on the observed lidar signal is investigated.

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Features of Atmospheric Temperature Profiling in Polar Regions

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The most important part in investigations of climate and meteorological conditions in Polar Regions is a monitoring of atmospheric boundary layer (ABL) parameters. Characteristic feature of an atmospheric boundary layer in polar latitudes is a presence of strong temperature inversions which are important for interactions with radiation cooling processes, advection of worm air and katabatic winds. On the continental Antarctic stations repetition of days with surface temperature inversions amount up to 96% while temperature drop between upper and lower limits runs to 25-300. Most often a layer with maximum values of a temperature inversions gradient in polar regions spreading to heights 300-400 m. For explorations of temperature inversions ordinary were used radiosondes data. One of major feature of this method is a high vertical resolution and wide range of measuring heights. But this method has considerable disadvantages: a lot of consumables needs, presence of qualified personal for sounds launching, difficulties of launching in hurricane winds. Besides, radiosounding doesn't provide continuity of temperature profile measurements because usually sondes launches not often than two times in 24 hours. In this connection scientists of Central Aerological Observatory jointly with specialists from Radiophysical Research Institute in the end of '90th years of the last century designed new remote method of measuring temperature profiles of ABL based on measurements of self-emitting heat radiation of atmosphere on frequency near 60 GHz. On a basis of this method were created industrial development types of temperature profilers MTP-5 which successfully passed serial of international comparison tests, certificated by Federal Agency on Technical Regulation and Metrology of Russia and Federal Service of Russia for Hydrometeorology and Environmental Monitoring. It was also manufacturing special polar version of microwave temperature profiler with more good vertical resolution in the first 100 m and more wide range of outside temperature. Results of temperature profiles measurements with the using of polar version of microwave profilers in 2000-2012 are presented in the report.

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Diurnal Composites of Boundary Layer Turbulence in Different Climatic Regions

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Vertically-pointing 1.5 um Doppler lidars can provide measurements of turbulent kinetic energy dissipation rate at high temporal and spatial resolution from an analysis of the short term fluctuations in the mean Doppler velocity. At this wavelength, the instruments are sensitive to aerosol and can profile the full depth of the boundary layer, as well as the lower portion of cloud layers.
Turbulent mixing of the air within the boundary layer transports and redistributes moisture, trace gases and aerosol particles of natural and anthropogenic origin. Further mixing with the free troposphere provides an additional dispersion mechanism. Thus, boundary layer dynamics can wield a major influence on atmospheric chemistry and interactions between the atmosphere and the surface.

The intensity of turbulence varies over many orders of magnitude in the atmosphere, and analysis of the gradient in intensity provides a very good indicator of the mixed-layer height, where we define the mixed-layer as the region of the atmosphere that is in continual turbulent contact with the surface. This parameter is a crucial input, for example, in modelling the dispersion of surface sources of aerosol and pollution in air quality models.

We will present diurnal time-height composites of dissipation rate in the boundary layer derived from a number of sites encompassing a variety of climatic regimes, including mid-latitude marine and continental, Arctic and tropical. We will also highlight some typical differences found in the diurnal pattern of dissipation rate encountered in rural and urban areas.

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Turbulence Measurement Using a Pulsed Doppler Lidar and the Contribution of Vertical Beam on its Accuracy for short Range Lidar

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Assessment of climatic conditions for a wind farm project and monitoring Planetary Boundary Layer for meteorology includes the study of the wind characteristics. It concerns not only mean wind speed and direction statistics but also other parameters like shear values, flow-inclination and turbulence intensities.
For Boundary layer monitoring, long range Lidars showed good correctness to track wind vortex and measure turbulence intensities; many measurement campaigns have shown great capabilities for detecting and observing convective and turbulent phenomena.
Regarding wind farms assessing, accuracy and spatial resolution of wind parameters like turbulence intensities are critical standard. Short range sodars and Lidars are generally used. Theses remote sensors have shown a deficit in the ability to accurately retrieve this parameter especially on complex terrain.

Indeed, the study of turbulence intensities requires a good estimation of the vertical wind speed. For this reason the configuration of WINDCUBE® V2 Lidar has been improved by adding a vertical beam that measures directly vertical component.
In order to validate the effectiveness of the vertical beam, two measurement campaigns were held in Risoe's test field in Hovsore (Simple terrain) and in CRES's test field in Lavrio (Complex field). During these campaigns, WINDCUBE TI measurements were compared to Mast cup anemometer on different altitudes. This new method results on better accuracy of turbulence where error percentage is decreased by 30% in average and permitted better correlation coefficient. Further software improvement are being developped in order to better TI accuracy.

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Measuring Wake Vortices and Wind Shears in Real-Time with a Scanning Wind Doppler Lidar

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Measuring and foreseeing wind conditions near airports are crucial issues for air traffic safety. Since aircraft maneuverability is the worst during takeoff and landing phases, strong air movements near airports such as wind shears or wake vortices can have dramatic consequences on aircrafts. These phenomena are nevertheless very different since wind shears are generated by geography around airports, whereas wake vortices are created by aircrafts themselves. Wind shears usually appear in airports located near coasts, valleys, or mountains. These geographical items induce different winds in direction and in intensity depending on meteorological conditions. Wake vortices are generated by all the planes. Size and intensity of wake vortices are directly linked to the flight speed and also by plane characteristics, such as weight and wingspan. Even if strong efforts have been done to study and model wind shears and wake vortices, on-site measurements remain the best way to detect them as they depend a lot on meteorological conditions near airports especially wind and turbulence.

Coherent laser radars or LIDARs can be very powerful devices for measuring wind shears on dangerous airports or wake vortices. LEOSPHERE has developed a scanning wind doppler lidar, the Windcube200S for these needs. Deployed on a french airport in the framework of the european project SESAR, this lidar has been used to detect wake vortices and follow them under various atmospheric conditions. Given specific swept scenarios, the Windcube200S has been able to detect the wake vortices of heavy, medium and small aircrafts during takeoff and landing. Wake vortices have been monitored for a period of 30 to 60 seconds that allowed to analyze theirs trajectories and theirs shapes evolution. Several analysis have been achieved in order to determine the influence of the wind conditions on the trajectories of wake vortices. A variety of trajectories have been put in front. Finally, a dedicated post-treatment has been developed for identifying the cores of wake vortices and for calculating theirs circulations.

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Evaluation of Wind Lidar instruments at the Howard University Beltsville Research Site

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The measurement of tropospheric wind is of great importance to numeric weather prediction, air transportation, and wind-generated electricity. Wind lidar technology allows higher temporal measurement of wind profiles with greater spatial localization than the radiosonde. In this presentation, we report on a wind lidar inter-comparison between different types of wind lidar technologies (namely the molecular based double edge techniques and the aerosol based) and standard sonde/aircraft or radar measured data.

The experiment was performed to serve as a ground check and inter-comparison for proposed NASA satellite wind lidar systems. In the presentation, a statistical performance of the lidars with the standard wind technologies will be made. Application of the data to case studies (e.g. frontal passage) and other clear sky phenomena will be discussed.

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Properties of Mountain Waves Observable with a Network of Wind Profiler Stations

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In a 2006 experiment (T-REX) we were able to observe the structure of a mountain wave in Owens Valley, California using three boundary-layer radar wind profilers. Features include the amplitude, wavelength, and phase (position) as they evolved over many hours. A larger network of deployable wind profilers has been proposed (the Modular Profiler Network), and been partially developed. In anticipation of this network and making use of a simulated mountain wave case, we examine several deployment configurations of radars relative to a wave of changing position and wavelength.

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Small ScaleTturbulence Observed Simultaneously by Radiosondes and the MU Radar

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Soon after their conceptions, ST VHF radars have been used simultaneously with instrumented balloons for measuring atmospheric parameters. Intercomparisons improved our knowledge on the radar backscattering mechanisms at VHF which, in turn, provided some information on atmospheric dynamics and structures at various scales. Various methods were then developed for retrieving small-scale turbulence parameters from ST radars. However, the dominant sources and characteristics of the turbulent events detected by the ST radars in the troposphere are still poorly documented partly due to the lack of resolution of these instruments.

A Japanese-French field campaign devoted to the study of turbulence and instabilities in the troposphere and lower stratosphere was conducted in September 2011 for three weeks at the Shigaraki MU observatory (Japan). The MU radar was operated in range imaging (FII) mode, allowing a range resolution of several ten meters with a time resolution of about 25 seconds. The turbulence was detected from the radiosounding profiles by applying a Thorpe analysis to the raw in situ data (3-6 m vertical resolution). An original method for selecting the "true" turbulent events within the profile is presented. Turbulent regions of vertical extent larger than ~ 40 m in the troposphere, ~15 m in the lower stratosphere, are detectable.

We shall present some results of this campaign including direct comparisons of turbulent events observed simultaneously by radiosondes and MU radar.

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Aerosol Direct Radiative Effect During Sahara Dust Intrusions at a site in the Central Mediterranean: Anthropogenic Particle Contribution

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The clear-sky, instantaneous Direct Radiative Effect (DRE) by all and anthropogenic particles is calculated during selected dust intrusion events over a South-Eastern Italian site in the Central Mediterranean, to evaluate the role of anthropogenic particle's radiative effects and obtain a better estimate of the DRE by desert dust. The Mediterranean basin is continuously influenced by long-range transported emissions from continental Europe and northern Africa, as a consequence mineral dust is among the major aerosol components over the Mediterranean. The clear-sky aerosol DRE is calculated by a two stream radiative transfer model in the solar (0.3 - 4 ìm) and infrared (4 - 200 ìm) spectral range, at the top of the atmosphere (ToA) and at the Earth's surface (sfc), during typical weak and strong dust intrusion events. Aerosol optical properties by AERONET sun-sky photometer measurements and aerosol vertical profiles by EARLINET lidar measurements, both performed at Lecce (40.33°N, 18.10° E) in the Central Mediterranean, are used to perform radiative transfer simulations. Instantaneous solar DREs are negative as a consequence of the cooling effect by aerosol particles and span the - (25-11)Wm-2 and - (53-25)Wm-2 range at the ToA and surface, respectively during the investigated dusty days. Infrared DREs offset the solar DRE from 8% up to 14% at the ToA and from 9% up to 22% at the surface. A methodology has been implemented to estimate the contribution of anthropogenic particles during dusty days since their contribution can be significant over the Central Mediterranean. We have found that the Aerosol Optical Depth (AOD) by anthropogenic particles is from 35% up to 65% of the AOD by all particles. The solar DRE by anthropogenic particles represents from 44% up to 83% and from 28% up to 60% of the DRE by all particles, at the ToA and sfc, respectively. If we assume that the DRE by natural and anthropogenic particles can be linearly added, the contribution of natural particles to the whole aerosol DRE is lower than 56% and 72% at the ToA and sfc, respectively during the tested dusty days. Finally, we believe that these results can contribute to the characterization of the aerosol DREs over the Mediterranean: one of the most responsive regions to climate change.

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ISSUES WITH REMOTE SENSING AND CLIMATE PREDICTION

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This paper discusses issues in the relationship between climate prediction models (GCMs) and remote sensing. Four issues will be discussed.First, to be relevant to long-term climate predictions, physical measurements must be calibrated /in situ/ against international standards. This is difficult in the laboratory and more so in space, but the climate community is beginning to accept that it constitutes an inescapable cost for measurements that support climate prediction. Three satellite measurements that already achieve this goal will be discussed.
Second, space measurements are expensive. Can we develop criteria for selecting the measurements most capable of improving climate predictions? This question can be answered within the framework of Bayesian inference, with some surprising results.Third, how can new data, once obtained, be used to improve the quality of a climate prediction? We discuss system tests on actual predictions and how data can be used to improve the forecast directly, and we discuss component tests, on physical processes used by the model which can lead to improvements of the model itself.Fourth, the forgoing ideas lead to the optimal use of space (or other) data in the process of climate prediction, but there is no way to eliminate all uncertainties in a climate prediction. We discuss the use of data to make a climate prediction as credible as is possible.

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EARLINET: COORDINATED LONG TERM LIDAR OBSERVATIONS OF ATMOSPHERIC AEROSOLS OVER EUROPE

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EARLINET, the European Aerosol Research Lidar Network, is the first aerosol lidar network, established in 2000, with the main goal to provide a comprehensive, quantitative, and statistically significant data base for the aerosol distribution on a continental scale. At present, 27 stations distributed over Europe are part of the network.

The five years EARLINET-ASOS (Advanced Sustainable Observation System) EC Project project (2006-2011) has strongly contributed to optimize the operation of the network.

EARLINET is now a key component of the ACTRIS (Aerosols, Clouds and Trace gases Research InfraStructure Network) research infrastructure project aiming at integrating European ground-based stations equipped with advanced atmospheric probing instrumentation for aerosols, clouds, and short-lived gas-phase species.

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On the Consistent and Traceable Data Processing of Ozone, Temperature and Water vapor Lidar Long-Term Measurements: Current Incentives and Future Expectations

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Over the past two decades, the lidar technique has become essential for the long-term monitoring of atmospheric composition and thermodynamics. Many global observation networks have now integrated lidars (e.g., NDACC EARLINET, GALION, etc.). As a result of contributing to large networks over extended periods of time, it is increasingly difficult to archive measurements and analysis information consistently from one research group (or instrument) to another, and to maintain a fully traceable history of instrumental and operational changes that may affect the measurements.

The need for developing consistent operating procedures and consistent definitions has therefore strengthened as datasets of various origin (e.g., satellite and ground-based) are being used for long-term variability studies (e.g., climate), intercomparisons, validation, and are ingested together in global assimilation systems.

In such a framework, several recent initiatives have focused on the development of standardized definitions, consistent data processing, and sustained traceability. A team of lidar experts was recently created to address issues in three critical aspects of the NDACC lidar ozone and temperature data retrievals: the vertical filtering of lidar signals and products, the quantification and propagation of the uncertainties, and the consistent definition and reporting of filtering and uncertainties in the NDACC-archived products. Additionally, a recent initiative within GRUAN focused on the development of an integrated system that will ensure the archiving of fully validated, traceable and consistent GRUAN water vapor, ozone and temperature lidar products.

A review of these initiatives will be presented. The current progress of these expert groups will be reviewed, and a synthesis will be made on how the expert groups' outcome will eventually be merged together to constitute a fully integrated framework for GRUAN and NDACC

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The DWD Ceilometer Network for Aerosol Profiling

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The German Meteorological Service (DWD) operates a dense network of ceilometers for cloud base height observations. About 50 of these ceilometers are CHM15K-Nimbus by Jenotptik, Germany. Those very powerful ceilometers allow for the detection and characterization of aerosol layers.

The CHM15K-Nimbus are equipped with a diode-pumped Nd:YAG solid state laser that emits laser pulses with an power of about 8 µJ/pulse at 1064 nm with a repetition rate of 5-7 kHz. The back-scattered light is collected with a Newtonian receiving telescope, then filtered with a narrow-band interference filter before it is detected with an avalanche photodiode in photon counting mode. Limited by the overlap between the laser beam and the telescope field of view, the signal can be used from about 600 m above ground level up to 15 km with a vertical resolution of 15 m. Raw data of all network ceilometers are transferred online to the data analysis center Hohenpeißenberg.

The DWD ceilometer network has been used for the detection and estimation of mass concentrations of volcanic ash layers after the eruptions of Eyjafjallajökull (2010) and Grimsvötn (2011) over Germany. The CHM15k-Nimbus allow for the detection of Sahara dust layers in the free troposphere over Germany. Such events occur at about 30 days per year. A further application of the ceilometer network is the detection of the spatial distribution and temporal evolution of mixing layer heights and the estimation of aerosol concentrations within the planetary boundary layer for air pollution studies and for the validation of numeric weather prediction models. The DWD ceilometer network will be used for the validation of model simulations in the framework of MACC-II.

All those applications require the calibration of ceilometer signals as a first step in the automated data analysis procedure. CHM15k-Nimbus ceilometers can be calibrated with ancillary data, e.g., with optical depth from sun photometer measurements or with extinction profiles from Raman lidar anchor stations in the network. Further options are the calibration in clouds or in aerosol free regions of the atmosphere. We will present tests on several calibration methods that are based on different ancillary data and can be applied under various meteorological conditions.

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Overview of ROSA Radio Occultation Profiling Capabilities on Noard OCEANSAT-2

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This contribution is focused on the description of the results obtained by processing, for the first time, ROSA Radio Occultation observations performed on-board the Indian mission OCEANSAT-2. This summarizes the outcomes obtained from an in-depth quality check analysis of ROSA data, performed thanks to a Visiting Scientist activity wanted by ROM-SAF (Radio Occultation on Meteorology - Satellite Application Facility), EUMETSAT and Italian Space Agency, focused on the analysis of ROSA data quality for their use in operational weather forecasting. The ROSA Radio Occultation instrument was developed by Thales-Alenia-Space, Italy and was funded by the Italian Space Agency (ASI). Such instrument is actually flying on-board three opportunity missions: the Indian OCEANSAT-2, the Argentinean SAC-D and the Indian-French MEGA-TROPIQUES.

A data set of ROSA raw data was processed using the EUMETSAT YAROS processor. This is a prototype processing chain created to develop new algorithms and test them before their introduction into the EUMETSAT operational processing chain. Some updates into such processing package were implemented in order to make it able to properly manage ROSA raw observations. Such adaptations were performed for the analysis of ROSA closed loop data only. Adaptation to open loop data, navigation bits acquisition and potentially ionospheric measurement will be performed in the next future. YAROS output files were phases and amplitudes (level 1a data) and bending angles over impact parameter (level 1b data). Robust bias and standard deviation of bending angles to corresponding data obtained forward propagating ECMWF atmospheric collocated data were the statistical indicators generated to evaluate the quality of the ROSA observations.

Moreover, during the activity, also the ROM-SAF ROPP (Radio Occultation Processing Package) processor run at Danish Meteorological Institute was updated for ROSA data processing. This second part was instead focused on bending angles, refractivity and higher level product generation obtained considering level 1a input data coming from YAROS. The validation against ECMWF and co-located occultation profiles allowed to validate also atmospheric products obtained considering ROSA observations.

For the first time, one month of ROSA data have been deeply analyzed by two state-of-the-art Radio Occultation processing software and results will be described in the framework of this contribution.

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MPLNET UV Lidar Integration: Tests and Preliminary Results of First Inter Comparison at NASA GSFC in Spring 2012

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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 twenty-one active sites worldwide. Numerous temporary sites have been deployed in support of various field campaigns. Most MPLNET sites are co-located with sites in the NASA Aerosol Robotic Network (AERONET). In this paper, are presented some preliminary results of the first full scale effort by MPLNET to integrate other commercial UV Lidar than MPL systems in the network in order to provide more dense observations and, when possible, take advantage of different wavelengths to study aerosol optical and microphysical properties. A Leosphere ALS-450 UV Lidar was operated next to the standard MPLNET lidar and AERONET sunphotometer at NASA Goddard Space Flight Center during spring 2012. In addition, both lidars will be deployed separately across numerous MPLNET sites in support of the NASA SEAC4RS field campaign in summer 2012, to study aerosol impacts in South East Asia (SEA).

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EXPECTED PROFILING RETRIEVAL PERFORMANCE OF THE METEOSAT THIRD GENERATION INFRARED SOUNDER

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The Meteosat Third Generation geostationary satellite will be equipped with an infrared sounder sensing the Earth infrared emission in two bands between 670-1210 cm-1 and 1600-2250 cm-1 with a sampling rate of 0.625 cm-1. The main objective of the infrared sounder is to retrieve water vapour profiles and temperature. The paper provides an overview of the expected performance for surface properties and thermodynamic atmospheric state.

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Scientific and Engineering Overview of Three Frequency Precipitation Pprofiling Radar at Helsinki

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Precipitation profiling at the frequency bands of Ku, Ka and W bands are becoming increasingly popular to study microphysics. Ever since the introduction of Ku / Ka pair of frequencies for Global precipitation mission and the success of W band in Cloudsat, the interest in precipitation profiling using these frequencies has increased. While lower frequency radars, such as those at S and C bands have been successful in mapping higher intensity precipitation looking horizontally, the full understanding of microphysical evolution as well as the cloud to precipitation transition is still an active topic of development. In order to get better information for retrieving ice microphysics as well as enhance sensitivity, we need to move to higher frequencies. In addition, the profiling observations will serve as ground validation instruments for several space missions such as GPM and EarthCARE. While observations can be made at multiple frequencies, the science of retrievals at multiple frequencies need to be advanced also. The concept of multi frequency profiling is already shown preliminary success (Leinonen et al, 2011, Chandrasekar et al 2003). Thus there is great potential for combined observation at all three frequencies to develop the science of Multi-frequency profiling.

In order to support the development of multi-frequency profiling, with radars, a Consortium of research, academic and private industries in Finland have embarked on a three frequency radar development, where the goal is not only development of the three frequency platform, but also develop the corresponding technologies to incorporate the latest technical development in the process, in order to develop a cost effective platform for subsequent deployment. Thus the consortium of private Industries, research institutions and academia have embarked on the development of the technology and integration of a fully solid state, multi-frequency radar system, under the coordination of scientists from Finnish Meteorological Institute and University of Helsinki. This paper will describe the salient features of the three frequency radar system being developed as well as describe the engineering and scientific challenges, and trade studies associated with this development.

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Level 1B Product for MetOp Second Generation Microwave Imager Radiometer

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In the framework of the Phase A of Metop 2G CORISTA is developing a Level-1b processor for the radiometer microwave imager MWI and submillimeter ice and cloud imager radiometer ICI, installed on board the satellite of the Met-Op mission. The instrument measurements (counts) have to be converted to engineering units (temperatures), auxiliary data have to be separated from measurements and selected calibration have to be applied to the measurements.
Furthermore channels measurements has to be geolocated and coregistered to account for different pointing of antenna beams.
Level 1b data are not re-sampled, but only geometrically characterised, annotated with satellite position and pointing, geolocation inferred from satellite pointing information and preliminary pixel classification (e.g. land/water/cloud mask). More specifically, in the case of imaging radiometer such as MWI/ICI for the Met-OP second generation mission, Level 1b data represent calibrated and geo-located scene brightness temperature.
In this paper the algorithm developed for the Software will be described and the processor architecture will be showed and discussed.

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The NCAR Modular Profiling Network (MPN), a Report on Progress with Observations from a Mid-troposphere Prototype

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NCAR is developing a Modular Profiling Network (MPN) that can be deployed for a broad range of lower atmospheric observation needs. The central component of the system consists of 449 MHz wind profiler that uses modular antenna panels and distributed TX and RX electronics that can be easily reconfigured. The system could be deployed as a single ST radar capable of probing up to the lower stratosphere, or the system can be redeployed into a broad network of 6 boundary layer profilers. A low side-lobe antenna design and advanced signal processing methods would be used, bringing new capabilities to NCAR's user community. The MPN would also include several low power Doppler lidars and in-situ instrumentation capable of measuring land-atmosphere exchange and surface layer turbulence and fluxes. It would meet diverse needs for the studies of the surface layer, boundary layer, free troposphere, and tropopause. So far a mid-troposphere prototype system has been developed and this talk will provide an update on the system and initial observations.

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Continuous and Automatic Measurement of Atmospheric Structures and Aerosols Properties with R-Man510 Nitrogen Raman Lidar

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Leosphere, FRANCE

The eruption of the Eyjafjallajökull volcano that occurred on April-May 2010 in Europe has highlighted the interest of atmospheric lidars for the detection of volcanic ashes and the assessment of their mass concentrations in order to avoid disrupting totally the air traffic.
For addressing these needs, a new compact and light nitrogen Raman lidar (R-Man510) has recently been developed by Leosphere company. This UV-lidar system is based on a low energy diode pumped Nd:YAG laser at 355 nm. Measurements are typically performed with a vertical resolution between 15 and 60 m and a temporal resolution between 30 seconds (for elastic channel) and 10 minutes (for Raman channel). The elastic channel of the lidar is used to automatically detect up to 9 atmospheric structures (Planetary Boundary Layer height, aerosol and cloud layers) in quasi real-time. Aerosols are classified in 6 types (pollution aerosols, desert dusts, volcanic ashes, marine aerosols, biomass burning and no aerosols) considering informations on depolarization ratio determined with the two cross-polarized elastic channels and on aerosols optical properties (extinction-to-backscatter ratio, aerosol backscatter and extinction coefficients) determined thanks to the nitrogen Raman channel at 387 nm. The Nitrogen Raman channel offer the opportunity to retrieve independently particle extinction and backscatter coefficients and not to require an assumption on aerosol type.

We will present here the first results obtained with this new commercial lidar system in the framework of intercomparison campaigns. The lidar capabilities and performances will be discussed regarding atmospheric conditions and compared with numerical simulations.

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Results of ST Radar Sub-array Testing

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Aryabhatta Research Institute of Observational Sciences (ARIES) located at Nainital , in the state of Uttarakhand, in the foothills of Himalayas, is establishing a Stratosphere Troposphere (ST) radar system for studying the atmospheric dynamics over Himalayas. This radar is designed at 206.5 MHz , to take advantage of the reduced noise temp as compared to 50MHz to cover a height of 20kms. It is designed as an Active Aperture Phased Array Radar (APAR), with 588 Yagi antennas arranged in a circular aperture with triangular grid , capable of an off zenith scan angle of ~ 30deg, with one way beam width of 3deg. Each antenna is connected to a Transmit - Receive Module (TRM) with a peak power of 400 Watts. Receiving system consists of a Low Noise Amplifier (LNA) in each TRM followed by a a combiner network feeding into a high gain RF amplifier and a Four Channel Digital Receiver doing Band width sampling of 206.5MHz received signal with Doppler at a sub Nyquist sampling frequency of 70MHz, to generate DDC based IQ samples to estimate the three moments of the Power Spectrum, after decoding the complementary coded wave from and doing the pre - requisite of coherent integration etc in dedicated firmware using FPGA.

As a confidence building exercise before the entire system is built and installed at the site at ARIES - Naintal, a sub array of 49 elements (antennas & TRM's) was integrated along with the receive system and trials were conducted. The paper presents results of this subarray testing which provided data upto ~ 6 Kms in the conventional DBS mode of operation, in the dry months of Feb- March 2012, at the test site at Hyderabad. The results vindicates the design approach and the sensitivity as per design. Some of the effects of clutter and emmissions from TV broad casts are high lighted and methods to overcome them in the final system are presented.
Results of the five beam spectra taken during a 24 hour continuous opration of the radar are also summarised.

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IASI Retrieval of Temperature, Water Vapor and Ozone Profiles over Land with Φ-IASI during the COPS Campaign

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The tool Φ-IASI is a package intended for the generation of IASI (Infrared Atmospheric Sounding Interferometer) synthetic spectra and for the inversion of geophysical parameters: temperature and water vapour profiles, low vertical resolution profiles of ozone, carbon monoxide, methane and nitrous oxide. The generation of synthetic radiance is carried out by the forward model σ-IASI. It is a monochromatic radiative transfer model designed for fast computation of spectral radiance and its derivatives (Jacobian) with respect to a given set of geophysical parameters. It represents a compromise between the accuracy of the exact line-by-line radiative model and the fastness of the hyper-fast radiative transfer model. This compromise is achieved by means of a look-up table of pre-computed pressure dependent monochromatic optical depths and an interpolation procedure. The optical depth look-up-table takes into account also effects depending on the gas concentration, such as the line self-broadening of the water vapour.

The module δ-IASI is the inverse module. It has been designed to retrieve: skin temperature, atmospheric profiles of temperature, water vapour and ozone by inverting highly resolved infrared radiance.

The algorithm is mostly intended for the IASI, but the code is well suited for any nadir (or zenith) viewing satellite airborne and ground based infrared sensor with a sampling rate in the range of 0.1-2 cm-1. The inversion scheme is based on a Netwon-Raphson scheme in which the Radiative Transfer Equation is step-linearized by Taylor expansion.

In this paper we show the application of Φ-IASI to IASI data recorded over the land during the COPS (Convective and Orographically-induced Precipitation Study) observation campaign in the period between June and August 2007 over the region at boundaries among France Germany and Switzerland.

Temperature and Water Vapor profiles are compared with co-located GPS tomography, lidar and radiosonde profiles.

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Demonstration of an Eye-Safe Micro-Pulse Differential Absorption Lidar (DIAL) for Water Vapor Profiling in the Lower Troposphere

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Improved measurements of water vapor are a long-standing observational challenge to the meteorological and climate research and forecasting communities. In an effort to obtain continuous, long-term, high-resolution water vapor and aerosol profiles in the lower troposphere, an eye-safe all semiconductor-based micro-pulse differential absorption lidar (DIAL) instrument has been developed at Montana State University. A collaboration with NCAR has been established to field harden the DIAL instrument to allow for autonomous measurements of water vapor and aerosol profiles. The water vapor profiles with 150-m vertical resolution are averaged for 10 minutes. Aerosol profiles are retrieved with 1 minute temporal averaging. A description of the current status of the water vapor DIAL instrument and future collaborative development efforts will be presented.

Month-long field tests of the DIAL instrument at multiple sites will be performed during the summer and fall of 2012. Supplementary datasets for intercomparisons and validation include radiosondes, radiometers and Raman lidars. WSR-88D radar data and satellite imagery will be used to characterize the larger-scale conditions during the DIAL observations. Preliminary intercomparisons and analyses from the 2012 observational periods will be presented.

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Characterization of Water Vapor Variability through a Multichannel Raman-Mie-Rayleigh Lidar System.

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The characterization of water vapor atmospheric variability in time and space has been studied through high-resolution Raman lidar measurements. The Rayleigh-Mie-Raman (RMR) lidar, located in the suburban area of Rome-Tor Vergata (41.8 ° N, 12.6 ° E, and 107 m altitude), utilizes a Nd:YAG laser with second and third harmonics generators which emits two pulsed beams in the green (532.2 nm) and in the UV (354.7 nm). The green beam is used to receive the elastic backscatter from the air molecules and aerosol particles; the UV beam is used to obtain Raman backscattering signals from water vapor and nitrogen molecules and to calculate the water vapor mixing ratio. A multiple telescope configuration is adopted in the receiver to collect the signal return from different altitude layers and obtain profiles of the interesting parameters over a wide altitude atmospheric interval. The acquisition vertical and temporal resolutions are 75 m and 1 min, respectively.

In order to optimize the information content on vertical and temporal water vapor short-term variability, different methods of data preprocessing (spike and trend removals, high-frequency filtering) and data integration (fixed and dynamical approaches) have been adopted.

A spectral data procedure has been, then, developed to analyse water vapour lidar sessions in terms of Fourier spectra, autocovariance and structure functions. The aim has been firstly to characterize the different sources (instrumental and physical) of the signal variability measured by the instrument and, secondly, to investigate the high frequency fluctuation of the atmospheric water vapour. In addiction, the aerosol variability, simultaneously measured by the elastic channel of RMR, has been studied and compared to water vapor results. This procedure has been performed to more than 1000 hours of RMR lidar sessions taken from 2002 to 2011.

In this work, the validation of the spectral analysis and the characterization of different atmospheric regimes in terms of water vapor and aerosol variability are presented.

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Five Years of Water-Vapor profiling with DIAL on Mt. Zugspitze

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The differential absorption lidar (DIAL) at the Schneefernerhaus Research Station (UFS) on Mt. Zugspitze (Germany, 2675m a.s.l.) has been routinely recording water-vapor profiles since January 2007. More than 600 free-tropospheric profiles (3km - 12km a.s.l.) have been measured on more than 200 days. The DIAL operates in the near infrared with a Ti:sapphire laser (817nm, 20Hz, < 250mJ) and a bistatic receiving geometry (telescope: 0.65m, integration time 17min.). While the laser system and the lidar receiver were left substantially unchanged the retrieval was gradually improved as a result of intercomparison and validation activities during this period. In 2008, the Zugspitze DIAL took part at the LUAMI (Lindenberg Upper Air Method Intercomparison) campaign. After this and a statistical comparison of three years of integrated water-vapor data with the nearby (680m) mid infrared solar Fourier-transform spectrometer (FTIR) on the Zugspitze summit have clearly confirmed our choice of the line parameters by Ponsardin and Browell (1997). These line parameters differ even from the latest version of the HITRAN database around 817 nm. Furthermore, a numerical method for reliably squelching magnetic interferences in the receiver electronics was implemented. The data from the first five years of water-vapor measurements yield very interesting details about variability, atmospheric transport and atmospheric dynamics. We present simultaneously recorded aerosol and ozone profiles, the latter from the nearby (10km) ozone DIAL at Garmisch-Partenkirchen. We also show a statistical analysis of the dataset as well as detailed studies regarding particular scenarios such as stratospheric intrusions, advection of Saharan dust or other atmospheric transport events.

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Tropospheric Ozone Budget: Nighttime Observation During the RONOCO Campaign On-board the BAe-146 Aircraft

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RONOCO (ROle of Nighttime chemistry in controlling the Oxidising Capacity of the atmosphere) was an airborne campaign aimed to study the role of nighttime chemistry on the oxidation capacity of the atmosphere. The campaign was ran from July to September 2011 and in January 2012 in the UK. During the 27 research flights the main constituents of the atmosphere were observed (O3, NO, NO2, CO, CO2, HNO3, nitrates, several VOCs) and also chemical and physical proprieties of aerosols, ranging from few meters above the ground and the sea to up to 4000 m.

We describe the instrumental setup on the BAe-146 aircraft of a new Laser Induced Fluorescence system developed by CETEMPS (University of L'Aquila) to observe NO2, peroxy nitrates, alkyl nitrates and HNO3.

We will analyses the processes and parameters that control the ozone budget during the nighttime: in details we will show the role of alkyl nitrates and the role of NO3 and N2O5 on the understanding of the nighttime ozone loss in the lower troposphere.

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A Neural Network Algorithm to Retrieve Tropospheric Ozone from the Ozone Monitoting Instrument: Design and Validation

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Ozone is a very important constituent for tropospheric chemistry. First, relatively high ozone concentrations near the Earth's surface are detrimental for both humans, animals and crops. Second, ozone in the troposphere is a precursor of the hydroxyl radical, which is the most important tropospheric oxidant, and as such removes several tropospheric pollutants. Third, tropospheric ozone is an important greenhouse gas.

Quantifying tropospheric ozone concentrations from satellite observations is difficult. High spectral resolution measurements are required in order to separate the tropospheric ozone signal from the much stronger stratospheric contribution in the measured radiance spectra, and a pixel size of about 10 km or better is required in order to study the small scale variability of tropospheric ozone. The latest atmospheric hyperspectral sounders, operating in the ultraviolet (UV), visible (VIS) and thermal infrared (TIR) spectral ranges usually meet these requirements, and thus are suitable to study tropospheric ozone.

There are various ways to retrieve tropospheric ozone from satellite data, for example by subtracting a stratospheric ozone column measurement from a total ozone measurement performed with a different sensor, or by attempting to extract tropospheric ozone information from nadir reflectance spectra acquired by a single instrument. The latter can be done via physical algorithms or statistical methods, like Neural Networks (NNs).

In this work, the development and validation of a NN algorithm for tropospheric ozone retrievals from the Ozone Monitoring Instrument (OMI) will be discussed. The algorithm - named the OMITROPO3 NN - performs daily global tropospheric ozone retrievals using OMI measurements in the UV2 channel, together with ancillary information on tropopause pressure and atmospheric temperature profile. In order to validate the algorithm, the retrieved tropospheric ozone columns were compared to ozonesonde measurements over the entire globe, and daily tropospheric ozone fields simulated using the TM5 Chemistry and Transport Model (CTM). The validation results suggest that the tropospheric ozone columns retrieved by the OMITROPO3 NN are well correlated with ozonesonde observations and model simulations.

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Retrieval of Tropospheric Water Vapour Profiles by Using Spectra from a Microwave Spectro-radiometer at 22 GHz

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We present an approach to retrieve the tropospheric water vapour content from spectra observed at 22 GHz by the groundbased microwave radiometer MIAWARA (Middle Atmospheric Water Vapour Radiometer), located in the south of Bern (CH) and operated by the Institute of Applied Physics. MIAWARA observes the 22.235 GHz water vapour emission line and is equipped with a FFT-spectrometer (bandwidth 1 GHz, 16000 channels). The operational retrieval of middle atmospheric water vapour profiles, done in the frame of NDACC (Network for Detection of Atmospheric Composition Change), uses only a small part of the available bandwidth (i300 MHz).

Our retrieval approach uses the entire bandwidth of the spectrometer to additionally retrieve tropospheric water vapour profiles. Thereby total power spectra from tipping curve calibration (usually used to determine tropospherical opacity) are used.

Validations with balloon soundings showed, that our retrieval approach is able to deliver reasonable results up to i7 km with limited altitude resolution. The integrated water vapour amount calculated from the retrieved profiles corresponds well with GPS measurements performed at the same location.

In addition to a standard a priori profile, we try to improve the performance of our retrieval approach by using external informations as additional retrieval constraints. One attempt is to use informations about cloud coverage delivered by a Ceilometer (installed close to the instrument) and an infrared sensor, which is attached to the instrument with the same line-of-sight. Thereby the cloud-base height together with an assumed relative humidity of 100% deliver a "fixed-point" with known profile value as additional a-priori information.

Further, it is planned to combine the operational middle atmosphere retrieval with the tropospheric retrieval approach to an integrated retrieval algorithm delivering water vapour from the surface to the mesosphere. This work is part of COST-Action ES0604 project.

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Vertical Resolution of Tropospheric Humidity Profile Retrievals Using Ground-Based Microwave Radiometers

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Thermodynamic properties of the troposphere, particularly water vapor mixing ratio and temperature, change in response to physical mechanisms, including frictional drag, evaporation, transpiration, heat transfer, pollutant emission and flow modification due to terrain. The planetary boundary layer (PBL) is characterized by a greater rate of change in the thermodynamic state of the atmosphere than higher altitudes in the troposphere are. Typically, such changes in the PBL occur on time scales of less than one hour; whereas, changes in the upper troposphere occur on much longer time scales. Observation of these changes, such as large horizontal gradients in vertical wind speed, is important for improved weather prediction. Additionally, high spatial resolution, temporal resolution and accuracy of measured thermodynamic profiles, especially water vapor and temperature, are also important for initialization of numerical weather prediction models. Observations of water vapor at high spatial and temporal resolution using microwave radiometer networks deployed in areas where there is substantial severe weather may lead to improved prediction accuracy, which may be utilized to avoid loss of life and property.

The HUMidity EXperiment 2011 (HUMEX11) was conducted to validate remote sensing of tropospheric humidity using a ground-based network of scanning, compact microwave radiometers. A network of microwave radiometers was deployed to measure an atmospheric volume using various scanning patterns near the U.S. Department of Energy (DOE)'s Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) Climate Research Facility. Scientific objectives included measurement of both water vapor profiles in the lower troposphere with high vertical and temporal resolution and the planetary boundary layer (PBL) height. For that purpose, an extension of the Backus-Gilbert (BG) method was implemented to combine measurements from multiple radiometers at multiple elevation angles with a-priori information from other instruments. In addition, retrievals using the extended BG method will be constrained by another retrieval using Bayesian optimal estimation. The extended BG method focuses on improving the spatial resolution of the retrieval, while Bayesian optimal estimation strives to improve its accuracy. Merging the two techniques improves both spatial resolution and retrieval accuracy. This combined method improves the trade-off between improving vertical resolution and decreasing noise in order to improve estimation of PBL height. Results will be compared with other instruments deployed at the ARM SGP, including the Atmospheric Emitted Radiance Interferometer (AERI) infrared profiler, Raman lidar and four daily radiosondes. Preliminary results, comparisons and statistical analysis of the field experiment will be presented and discussed.

Retrieval of Aerosol Polarized Phase Function and Single Scattering Albedo from Polarized Sun-photometer Measurements

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Aerosol optical depth, Angstrom exponent, polarized phase function, and single scattering albedo have been retrieved from polarized sun-photometer measurements for the atmosphere of Zanjan (36.70°N, 48.51°E, and 1800 m above mean sea level) during March to December 2011. The maximum (minimum) value of measured aerosol optical depth at 870 nm is 0.28 (0.02) with an average value of 0.12. The measured Angstrom exponent varies from 0.13 to 1.63 with an average value of 0.99. The retrieved values of single scattering albedo at 870 nm are within the range of 0.74-0.97 and its average value is 0.87 which suggests, part of the aerosols in the Zanjan atmosphere are absorptive. This could be due to existence of anthropogenic aerosols. The maximum value of polarized phase function varies from 0.05 to 0.35 with an average value of 0.16. To ensure that the measured range of scattering angle is sufficient, the solar zenith angle, è_0, has been chosen larger than 65°. There is a considerable positive correlation between Angstrom exponent and the maximum value of retrieved polarized phase function. In other words as the particle sizes have been increased the scattered light had a lower degree of polarization. The polarized phase function also had a negative correlation with the single scattering albedo. Also the obtained results somehow show a correlation between the polarized phase function and the AOD. Mie scattering calculations illustrate that the polarized phase function is sensitive to aerosol size distributions and complex refractive index. In other words when the particles are small and strong absorbers (i.e. large absolute value of the imaginary part of refractive index), the polarized phase function is increasing and vice versa. Therefore the polarized phase function is an effective and unique aerosol parameter and it can be used in addition to aerosol optical depth and phase function to improve the accuracy of retrieved aerosol size distributions and complex refractive index from inversion algorithm.

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Mixing Layer Height Retrievals in Stable Boundary Layer by Multichannel Microwave Observations

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The atmosphere boundary layer is characterized by turbulent fluctuations that induce mixing. During daytime the mixing layer tends to be unstable as a result of convection and is capped by an entrainment zone. At night a shallow stable layer forms near the surface in which mixing occurs through intermittent turbulence, leaving a residual layer above.

The mixing layer height (MLH) defines the top of the layer near the surface where turbulent mixing is occurring. The MLH is a key parameter for boundary layer applications, including meteorology, weather prediction and air quality. The determination of the MLH is crucial to study exchanges between the surface and the atmosphere.

In the recent years, new algorithms have been developed for estimating MLH, though the automatic detection of the top of the mixing layer still remains challenging, with frequent missing estimates when the mixing layer is not well defined.

Mixing layer height can be determined either using temperature, humidity, and wind profiles from insitu vertical profiles or by tracing gradients in atmospheric constituents or structures using remotely sensed vertical profiles (lidar, wind profiling radar, sodar). For example, MLH can be estimated from detection of the aerosol layers by the detection of the inflection points of the lidar signal.

However, the mixing height is specially difficult to estimate in stable boundary layer conditions. In fact, the lidar overlap limit causes an offset in the measures of the MLH because stratifications below this height cannot be detected. In case of very low MLH, which may occur under stable conditions, this offset can actually mask the early growth of the mixing height. Thus, a synergy between different techniques, based on different aspects of the boundary layer, may be useful to improve the MLH estimate in stable conditions.

In this presentations, we show results for MLH estimates obtained from measurements by a ground-based multichannel microwave radiometer (MWR). A variety of techniques are implemented, as for example direct inversion of MWR brightness temperature or gradients of potential temperature computed from MWR retrieved temperature and humidity profiles. The results of these techniques are compared with radiosonde observations as well as estimates based on other instruments.

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A General Purpose Analysis Package Suitable for Mesoscale Applications

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A data assimilation system combines all available information on the atmospheric state in a given time-window to produce an estimate of atmospheric conditions valid at a prescribed analysis time. Sources of information used to produce the analysis include observations, previous forecasts (the background), their respective errors and the laws of physics.

Nowadays, increased computing power coupled with greater access to real-time asynoptic data is paving the way toward a new generation of high-resolution (i.e., on the order of 10 km or less) operational mesoscale analyses and forecast systems. Moreover, better initial conditions are increasingly considered vital for a range of NWP applications, in particular at the short range (0-12 h).

We present a general-purpose analysis package able to solve two- and three- dimensional analysis problems. The system can use the following methods of solution: Successive Approximation (SA), Optimal Interpolation (OI), and 3D-Var. Analyses are given for the following parameters: zonal and meridional wind components, temperature, relative humidity, and geopotential height.

The analysis package is able to ingest profiles of the analysed variables, and in particular those distributed through the Global Telecommunication System (GTS). In order to show the potential of the system, both in the analysis and forecast, we have applied it to produce analyses of temperature, relative humidity, zonal and meridional wind components, and geopotential height over Central Europe. For this application the background field is given by a short-range forecast (6h) of the Regional Atmospheric Modeling System (RAMS) with 10 km horizontal resolution. The considered period is August 2008 (two-runs per day starting at 00 UTC and 12 UTC), because of the data availability.

The analyses are produced by 3D-Var and the parameters entering the analysis scheme are optimized for the used background. Analyses have 0.5° horizontal resolution and extend over the whole troposphere.

Results show the validity of the analysis solutions that are closer to the observations (lower RMSE) compared to the background (higher RMSE), and the differences of the RMSEs are consistent with the analysis package setting. To quantify the impact of improved initial conditions on the forecast, the analyses are then used as initial conditions for a short-range (6 h) forecast of the RAMS model. In particular two sets of forecasts are produced: a) the first uses the ECMWF analysis/forecast cycle as initial and boundary conditions; b) the second uses the analyses produced with the package introduced in this work as initial conditions, then is driven by the ECMWF analysis/forecast cycle.

To quantify the improvement of using the analyses introduced in this work, we only consider the horizontal components of the wind, which are measured at asynoptic times by the European wind profiler network. The results show that the RMSE is effectively reduced at the short range (0-3 h), the improvement depending on the height.

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Monitoring and Data Assimilation of Wind Profiler

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The monthly monitoring against model data show that wind profilers are giving wind with an accuracy comparable to radiosonde wind measurements. The wind profiler winds have been assimilated as radiosonde winds with an error which varies with height but is independent of the site. Variation in quality exists between wind profilers due to contamination associated with specific site (ground clutter, sea clutter, RFI, aging of the antenna). As a first approximation and because when the error exceed a certain threshold wind profilers are blacklisted automatically, the use of non site dependent error might be valid. However different wind profilers have different vertical resolutions and a better error characterisation should improve the assimilation of the wind profiler.

In this paper we show some results of the operational monitoring. We will present very preliminary results on adjoin tools sensitivity and show the potential use of such technique to better design a wind profiler network. We look in more detail at the observed quantity and its equivalent model. In particular we show how wind profiler winds are actually used in the UK Met Office UM. One example of wind profiler data assimilation and forecast impact in the very high resolution model (1.5km) is presented.

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Radar Data Assimilation Using a Modular Programming Approach with Ensemble Kalman Filter

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To evaluate quantitative precipitation forecasts (QPF) of a selected extreme rainfall event, we tried to vary data assimilation methods to generate forecast initial conditions. In a prior work we investigated the impact of radar data (reflectivity and radial wind) assimilation using 3DVAR for a heavy precipitation case using WRF-ARW. Sensitivity on the forecast to the assimilation of radar data using 3DVAR for several days prior the event have been completed, as well as an investigation of simple warm and cold start using ECMWF data analyses. Sensitivity to the background error length-scale factor together with a multiple outer loops technique is performed. This research showed a positive impact on QPF forecasts if using warm-start and a 3h-DA cycle. Our goal now is to utilize the Data Assimilation Research Testbed (DART) toolkit to assimilate conventional observations for several days prior to the event to better represent the mesoscale background environment. DART is a software environment that makes it easy to explore a variety of data assimilation methods and observations with different numerical models and is designed to facilitate the combination of assimilation algorithms, models, and real observations to allow increased understanding of all three. DART employs a modular programming approach to apply an Ensemble Kalman Filter which nudges the underlying models toward a state that is more consistent with information from a set of observations. Comparisons will be made between the initial conditions generated using a continuously cycled DART analysis versus those drawn from ECMWF data analysis. Thereafter, tests with and without Doppler radar assimilation over a short window (~1 hour) will determine the impact of radar observations in a DART assimilation framework for a case study of a heavy rainfall event in Central Italy. Comparisons between forecasts with 3DVAR and DART generated initial conditions, and with and without radar observations, will be made to better understand the predictability of extreme rainfall events with varying observations and assimilation methods.

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NO3 Oxidation of Isoprene and Monoterpenes: Model Analyses of Aircraft Observations During RONOCO Campaign.

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Isoprene and monoterpenes are the most abundant biogenic volatile organic compound and those with the highest reactivity. Their oxidation may have a significant impact to the tropospheric ozone production. Observations of total peroxy nitrates and total alkyl nitrates carried out during summer 2010 above the United Kingdom (RONOCO campaign, on-board the Bae-146 aircraft) are analyzed using a detailed chemical model (MCM).

In order to investigate the oxidation of isoprene and monoterpenes by NO3, sensitivity tests involving the yield of the reactions and the recycling of the alkyl nitrates derived from isoprene and monoterpenes are carried out. The impact of isoprene and monoterpenes on the production of ozone, alkyl nitrates and peroxy nitrates is discussed.

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A Method for Calibrating a Continuous Operation Elastic Scattering Lidar in the Absence of Corrections for transmitted Laser Power Changes

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Lidar systems requiring medium to high power levels commonly use flashlamp-pumped Nd:YAG lasers as a light source. During the lifetime of a flashlamp, typically several weeks of continuous operation, the output power can decrease significantly, often by a factor of two or more. If no monitoring of the transmitted laser power is made by hardware within the lidar and applied as a correction to the measurements, an error of the same magnitude as the power loss is introduced. A method to calibrate an elastic scattering lidar to account for this power loss has been developed. It is best applied to an instrument which is operated continuously, in order to obtain sufficient data to reliably apply the method. Since it is based on the measurements of Rayleigh scattering from the molecules in the lower parts of the troposphere, it can only successfully be applied to lidars using ultraviolet or blue lasers. At longer wavelengths the signal due to Rayleigh scattering is much smaller and cannot usually be detected by a lidar. The Rayleigh scattering cross-section can be calculated analytically if the atmospheric number density is known, so the measured elastic scattering signal can be compared with this prediction at a range of heights within the troposphere. In our calibration method, signals from 1.0, 1.5 and 2.0 km are used. Only clear sky cases can be used to produce a calibration. Such cases are selected by looking for data where the standard deviation between the calibration factors calculated at each of the three heights does not exceed a threshold value. The presence of clouds or significant aerosol contents below the maximum height used in the calibration will result in the measurement being excluded from the calibration. When the calibration factors which meet the clear sky criterion are plotted as a function of measurement time, a mathematical fit can be produced. We find that a linear fit is adequate for the lidar used in our trial of this method. Having applied the fit to the data a further check is made of the calibrated data to ensure that no significant residual long-term trend in the measured sensitivity of the elastic backscattering measurements is present.

The method has been applied to data collected using a Leosphere ALS450 lidar which has been operated at Chilbolton Observatory in the Southern UK since 2007. It has been found that the resulting datasets shown no discernible long-term trends in lidar sensitivity. It is estimated that the uncertainty in the lidar calibration produced using this method does not exceed 10%.

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Studies on Factors Responsible for Climate and Human Health

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Weather and climate play important roles in determining patterns of air quality over multiple scales in time and space. Air quality is strongly dependent on weather and is therefore sensitive to climate

change. There is growing recognition that development of optimal control strategies for key pollutants like fine particles now requires assessment of potential future climate conditions and their influence on the attainment of air quality objectives. Climate change induced by anthropogenic warming of the earth's atmosphere is a daunting problem. In addition, other air contaminants of relevance to human health, including smoke from wildfires and airborne pollens and molds, may be influenced by climate change. While further research is needed, climate change coupled with air pollutant exposures may have potentially serious adverse consequences for human health in urban and polluted regions. Climate change producing alterations in: food webs, lipid dynamics, ice and snow melt, and organic carbon cycling could result in increased PMs level in air. In this study, the focus is on the ways in which health-relevant measures of air quality, including particulate matter, and aeroallergens, may be affected by climate variability and change. The small but growing literature focusing on climate impacts on air quality, how these influences may play out in future decades, and the implications for human health is reviewed. In the present study to find out the particulate dust in air, the sampling of particulate matters from different locations were carried out during December, 2006 - February, 2007 in Raipur city, one of the most industrialized parts of India, to characterize the ambient mass concentrations of coarse particulate matter (PM10) and their sources. Techniques i.e. thermal method, proton induced X-ray emission spectrophotometry and ion chromatography was used for monitoring the species i.e. trace elements and water soluble ions, respectively and it is observed that the particulates are accompanied by high fractions trace elements (9.7%) and water soluble ions (15.5%), which play an important role in climate change.

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Optical Properties of Free Tropospheric Aerosol from Multi-wavelength Raman Lidars over the Southern Iberian Peninsula

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Lidar measurements at the EARLINET (European Aerosol Research Lidar Network) [http://www.earlinet.org] stations Granada and Évora were combined for an estimation of the horizontal and vertical distribution of free tropospheric aerosols. The distance between Granada and Évora is about 410 km, which is short compared to intercontinental transport paths. The multi-wavelength Raman lidars at Granada and Évora both enable the determination of the extinction coefficient at 355 and 532 nm, the backscatter coefficient at 355, 532 and 1064 nm as well as the depolarisation ratio at 532 nm. The vertical distribution of aerosol layers in the free troposphere and their optical properties as linear particle depolarisation ratio and Angström exponent were investigated.

Two example cases are discussed - one case of smoke from North America and one case of Saharan dust. On 13 June 2011 a strong aerosol layer was observed between 5.3 and 7.2 km above sea level (asl) over Granada and between 4.7 and 6.3 km asl over Évora. HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) [http://ready.arl.noaa.gov/HYSPLIT.php] backward trajectories, MODIS (Moderate Resolution Imaging Spectroradiometer) [http://modis.gsfc.nasa.gov] fire-maps and images of the visible composite of MODIS suggested a huge forest fire in East Arizona, US, as aerosol origin. The backscatter-related Angström exponent at the pair of wavelengths 355 and 532 nm, $å_\beta$(355-532 nm), was 1.7 ± 0.3 over Granada and 1.1 ± 0.4 over Évora and $å_\beta$(532-1064 nm) was 1.1 ± 0.2 and 1.2 ± 0.1, respectively. Values of $å_\beta$ around 1 indicate a similar contribution of coarse and fine particles. The linear particle depolarisation ratio was below 0.05 at both stations, which signifies mainly spherical particles.

In the night from 26 to 27 June 2011 a dust layer was detected in the range of 2.4 to 4.7 km asl and 2.5 to 5.0 km asl over Granada and Évora, respectively. Layer mean values and standard deviation of $å_\beta$(355-532 nm) detected over Granada was 0.2 ± 0.1. It was slightly higher than those observed over Évora (-0.1 ± 0.1). However, $å_\beta$(532-1064 nm) was 0.1 ± 0.03 over Granada, slightly lower than over Évora with 0.5 ± 0.1. Those low values of $å_\beta$ indicate a strong contribution of large particles within the dust layer. The linear particle depolarisation ratio was around 0.11 ± 0.01 over Granada and 0.18 ± 0.01 over Évora, indicating the presence of non-spherical particles, as expected for mineral dust. The lower linear particle depolarisation ratio observed over Granada could be due to higher humidity or mixing of other aerosol types within the dust layer observed there.

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Profiling of Aerosols and Water Vapor over Athens Using Synergy of Raman Lidar, Radiosounding, Sun Photometry and CALIPSO Lidar

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The Laser Remote Sensing Unit (LRSU) of the National Technical University of Athens (NTUA) is founding partner of the Greek lidar network (ARIADNE) which provides systematic measurements of aerosol, water vapor and ozone profiles, as well as particle characterization over urban, semi-urban and rural sites, over the Greek territory. LRSU is equipped with an advanced 6-wavelength elastic-Raman lidar (EOLE) system. This lidar system permits vertical profiles of aerosols to be retrieved in the troposphere (from near ground up to 10-18 km height), concerning the aerosol optical properties (backscatter coefficient at 355-532-1064 nm, extinction coefficient at 355-532 nm, lidar ratio at 355-532 nm and the Ångström-related exponent at 355nm/532nm, 532nm/1064nm), as well as of water vapor mixing ratio up to about 8-10 km height. Moreover, the use of an advanced mathematical code permits the retrieval of the aerosol microphysical properties (mean/effective radius, mean refractive index, surface/volume density, and single scattering albedo). Profiling of aerosol properties and water vapor mixing ratio data, in synergy with local radiosonde data, during the overpass of the CALIPSO space-borne lidar over Athens, Greece, are presented for a selected case study analysis. As atmospheric aerosols and water vapor play a crucial role in Earth's radiation budget, the data collected by EOLE, within ARIADNE, in synergy with other platforms (ground-based and space-borne) can be used as input parameters in models, to estimate radiative transfer changes in climate models in vulnerable region of the Eastern Mediterranean.

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Detection Submicron's of Water Clusters Clouds in the Atmosphere

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Water vapor in the atmosphere is usually located in a transient state due to condensation and evaporation processes in the clouds, on the aerosols and on the Earth's surface.
The absorption of the thermal radiation of the atmosphere in the microwave range can be shorter wavelengths with big variation during the process of phase transitions. The spectral composition of this radiation contains information about the phase transition of vapor - water - vapor.
We performed spectral radiometric study of unsteady state of the atmospheric water vapor. The simultaneous measurement of the intensity of radio emission of the atmosphere in the fields of microwave absorption lines of water vapor 183 GHz and 22.2 at frequencies of 140, 95, 20.75, and 22.23 GHz has been carried out. The substantial up to ~ 50% the deviation of the spectrum of microwave radiation of the atmosphere from its steady-state (theoretical) values for the clear atmosphere has been detected.
The measured microwave spectrum for these areas, in most cases corresponds to the spectrum of a "clear" atmosphere in the presence of water clusters with submicron dimensions of about 0.5 microns.
The measured values of the integral water content (LWC) of such clouds in the presence of water clusters was about ~ 0.05 ÷ 0.2 kg/m2 , i.e. close to the integral water content of clouds with dimensions of conventional drops ~ 8 m and LWC ~ 1 kg/m2.

In the visible region of the spectrum the clouds in the presence of water clusters are not visible, because scattering of sunlight on the water cluster has a resonant character with a maximum in the blue region of the spectrum (wavelength ~ 0.5 microns). In view of this the color is blue for the clouds in the presence of water clusters, the same as color of the clear atmosphere.

The typical spatial - temporal scale of the clouds cluster is 4 ÷ 50 min. The clouds in the presence of water clusters are present during well-developed convection, in the presence of the internal gravity waves and after the passage of atmospheric fronts.

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One-year Analysis of Rain and Rain Erosivity in A Tropical Volcanic Island from UHF Wind Profiler Measurements

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La Réunion Island located in the tropical zone (21° S, 55° E) has a volcanic origin that explains its roughly circular shape of 60 km mean diameter and its culmination at 3000 m altitude. The conjunction of the quasi permanent humid trades wind and elevated orography induce rain water accumulation exceeding 300 mm a month when averaged over all the territory. Living activities, vegetation, terrain use and modelling through soil erosion, are here more than in other regions of the world strongly conditioned by the precipitation regime. We present an analysis of one-year precipitations and the consequence in terms of soil erosivity based on measurements made by a UHF wind profiler sited at sea level. Drop vertical kinetic energy flux related to the drops terminal fall speed combined with air velocity and drop horizontal kinetic energy flux related to drop entrainment by horizontal wind are essential parameters of rainfall erosivity. Reflectivity, vertical and horizontal wind allow us, with suitable assumptions, to determine these two quantities. Rain echoes selection are made with tests on reflectivity, vertical velocity, spectral width and spectra skewness. Profiler calibration using ground raingauge data is also presented.

The analyzed year, from May 2009 through April 2010, have 89 days of convective or stratiform precipitations. Austral summer, the rainy season, concentrates most of the strong precipitation events with June associated with the passage of frontal rains. Analysis of the vertical evolution of the skewness will allow us to observe whether there is evolution of the << droplet >> with altitude (for exemple if we see ice in the upper part). The precipitation rate will be compared to the ground raingauge data to determine whether all of the rain reaches ground, and if not, why (stratiform)? Finally, we will try to analyse which of the parameters, horizontal or vertical kinetic energy, is the most important (as a function of altitude).

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The Role of Urban Boundary Layer Investigated by High Resolution Models and Ground Based Observations in Rome Area: A Step for Understanding Parameterizations Potentialities.

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The urban forcing on thermo-dynamical conditions can largely influences local evolution of the atmospheric boundary layer. Urban heat storage can produce noteworthy mesoscale perturbations of the lower atmosphere. The new generations of high-resolution numerical weather prediction models (NWP) is nowadays largely applied also to urban areas. It is therefore critical to reproduce correctly the urban forcing which turns in variations of wind, temperature and water vapor content of the PBL. The new generation model WRF has been used to reproduce the circulation in the urban area of Rome. A sensitivity study is performed using different PBL and surface schemes. The significant role of the surface forcing in the PBL evolution has been verified by comparing model results with observations coming from many instruments (LIDAR, SODAR, sonic anemometers, soundings and surface stations). The mesoscale model MM5 is used as further mean of comparison. The crucial role of a correct urban representation has been demonstrated by testing the impact of different urban canopy models (UCM) on the prevision. Three meteorological events have been studied, chosen as statistically relevant for the area of interest. The WRF model shows a reiterated tendency in overestimating vertical transmission of horizontal momentum from upper levels to low atmosphere, that is partially corrected by local PBL scheme coupled with an advanced UCM. Depending on background meteorological scenario, WRF shows a reversed behavior in correctly representing canopy layer and upper levels when local and non local PBL are compared. Moreover a tendency of the model in largely underestimating vertical motions has been verified.

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Comparison of Elemental Carbon Concentrations Retrieved by Aeronet with Surface Measurements

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Carbonaceous particles, as organic carbon (OC) and elemental carbon (EC), constitute an important component of the fine particulate matter (PM). They play an important role in environmental issues like air quality, human health and global climate change. Direct emissions from fossil fuel combustion and biomass burning, and secondary production from anthropogenic and natural gaseous precursors are the main sources of OC and EC particles.

In this study, organic carbon (OC) and elemental carbon (EC) mass concentrations have been determined in 24-hour PM2.5 and PM1 samples simultaneously collected from July 2008 to May 2010 over southeastern Italy. The PM sampling has been carried out by means of a low-volume (2.3 m3 h-1) dual-sampler (HYDRA, FAI Instruments, Italy) located on the top of the Physics Department building of University of Salento, at about 10 m from ground. OC and EC mass concentrations have been quantified by the thermal-optical transmission (TOT) method using the Sunset Laboratory carbon analyzer and the NIOSH 5040 protocol. The OC and EC mass concentrations have been compared with OC and EC concentrations derived applying the methodology introduced by Schuster et al. (2005, 2009). We used the Maxwell-Garnett (MG) effective medium approximation for a mixture of organic carbon, elemental carbon and ammonium nitrate embedded in water host. The volume fraction of OC (fOC) and EC (fEC) of mixture is retrieved by matching the mixture refractive index with complex refractive index, at four retrieval wavelengths 0.44, 0.67, 0.87 and 1.02 ìm, retrieved by AERONET sun/sky radiometer, operating on the roof of the Physics Department of University of Salento. The OC and EC column integrated concentrations have been calculated multiplying computed volume fraction of OC and EC by their density (rOC, rEC) and column integrated aerosol volume size distribution, available from the AERONET inversion product. The good agreement obtained comparing retrieved OC and EC and in situ measurements lead us to conclude that retrieval technique can be an alternative method of retrieving OC and EC concentrations in absence of in situ measurements.

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Ka-band Radar Moment Statistics and and Aspects of Accuracy

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During the last decades millimeter-wave radars have been established as useful systems to detect hydrometeors and to derive macro- and microphysical cloud parameters. Since November 2003 the Meteorologische Observatorium Lindenberg (DWD) is operating continuously a 35.5 GHz coherent and polarimetric cloud radar to measure vertical profiles of reflectivity, Doppler velocity, spectral width and the Linear Depolarisation Ratio (LDR) (named as moments in the following) between 250 m and 15 km height. The accuracy of the cloud parameters depends - besides of the inherent uncertainties in the retrieval algorithm - essentially on the accuracy of the primary variables. It will be shown that moment statistics are useful for obtaining insights in the performance of the system and the behaviour of the atmospheric targets. Time series can be used as a valuable method to monitor the long term stability of the radar and to identify system or processing failures and deficits, respectively. A discussion of different error sources, partly illustrated by examples, will highlight various aspects of errors in cloud radar measurements.

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Modelling and Observing Key Processes Driving the Fog Life Cycle

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An effort is made to deepen the understanding on the processes that induce fog formation and development, related to the interaction among turbulence, microphysical mechanisms and aerosol influence. The study focuses on a 5-day period between 13 and 17 November 2011 characterized by two successive dense radiation fog events which in total lasted almost 28 hours at the SIRTA Observatory (Instrumented Site for Atmospheric Remote Sensing Research), near Paris, in France. At SIRTA, the radiative, microphysical and dynamical processes driving the fog life cycle are fully monitored near the surface by in-situ sensors and throughout the boundary layer by remote sensing backscatter Lidar (aerosol profiles), Doppler Lidar (wind and turbulence profiles), Doppler radar (liquid/ice water profiles), and microwave radiometer (temperature and humidity profiles). An analysis combining these measurements and numerical simulations with the single-column mode of the Meso-NH non-hydrostatic, fully compressible model has been performed. The model is forced with radiosonde profiles and 30 m mast vertical profiles of temperature, humidity and wind and the numerical simulations are validated against real measurements of parameters such as: temperature and relative humidity at different levels up to 30 m, horizontal visibility, liquid water content, shortwave and longwave radiation, droplet number concentration. Moreover the model's ability to represent the fog characteristics such as the onset and dissipation times, the fog development and height, the depth and strength of the thermal inversion is examined.

Model sensitivity tests in combination with measurements lay the basis for a better understanding of the complex nature of the radiation fog events and their life cycle. The present sensitivity tests aim at identifying the influence of the CCN activation parameterizations available in the model, the role of the aerosol distribution and the type of the aerosols (maritime or continental) on fog formation and further development, as well as the interaction of these processes with turbulence kinetic energy in the vertical.

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Investigation of Cirrus Cloud Structure by Airborne Water-vapour DIAL Measurements During the HALO Techno-Mission

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Despite the large scientific awareness of the importance of cirrus clouds on the Earth's climate system, especially their radiative effect is still only poorly understood. The main question regarding the radiation balance of the Earth is, whether cirrus clouds have a cooling or a warming impact on the Earth's atmosphere. It was found out, that the radiative properties of cirrus clouds highly depend on their microphysical composition, e.g. the ice crystal shape, the size distribution and the number concentration, which are strongly dependent on ambient vertical movement. Furthermore small-scale

turbulence plays an important role concerning the cirrus cloud's structure, influencing the distribution of the microphysical properties and therewith their radiative effect. Our knowledge of the climate effect of cirrus clouds is mainly based on theoretical simulations. To better represent cirrus clouds in these theoretical simulations and in general circulation models it is crucial to improve our knowledge on small-scale processes within cirrus clouds and on their fine-structure. We present measurements of the airborne aerosol and water-vapour Differential Absorption Lidar (DIAL) system WALES, which can be used to study the fine-structure of cirrus clouds. The combination of DIAL water-vapour measurements and model temperature enables further to investigate relative humidity variability and ice super-saturation within cirrus clouds, crucial properties to study cirrus cloud formation. The presented measurements were performed during the first mission of the German research aircraft HALO (High Altitude and Long range), the so-called HALO Techno-Mission, in October and November 2010. Five scientific flights were performed in restricted airspace over northern and southern Germany. Three synchronous flights with the Falcon F20 aircraft enabled simultaneous in-situ samplings in air-masses remotely probed from HALO. They are used to compare the quantities retrieved from HALO measurements, and to estimate the impact of temperature fluctuations on the variability of relative humidity.

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The Use of Raman Lidar for the Characterization of Particle Hygroscopicity: Assessment of Case Studies Collected During COPS

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The characterization of particle hygroscopicity has primary importance for climate monitoring and prediction. Model studies have demonstrated that relative humidity has a critical influence on aerosol climate forcing. The relationship between aerosol backscattering and relative humidity has been investigated in numerous studies (among others, Wulfmeyer and Feingold, 2000; Pahlow et al., 2006; Veselovskii et al., 2009). Hygroscopic properties of aerosols influence particle size distribution and refractive index and hence their radiative effects.

Aerosol particles tend to grow at large relative humidity values as a result of their hygroscopicity. Raman lidars with aerosol, water vapour and temperature measurement capability are potentially attractive tools for studying aerosol hygroscopicity as in fact they can provide continuous altitude-resolved measurements of particle optical, size and microphysical properties, as well as relative humidity, without perturbing the aerosols or their environment. Specifically, the University of Basilicata Raman lidar system (BASIL) considered in the present study has the capability to perform all-lidar measurements of relative humidity based on the combined application of the rotational and the vibrational Raman lidar techniques in the UV.

BASIL was operational in Achern (Black Forest, Lat: 48.64 ° N, Long: 8.06 ° E, Elev.: 140 m) between 25 May and 30 August 2007 in the framework of the Convective and Orographically-induced Precipitation Study (COPS). During COPS, BASIL collected more than 500 hours of measurements, distributed over 58 measurement days and 34 intensive observation periods (IOPs). The present analysis is focused on selected case studies characterized by the presence of different aerosol types with different hygroscopic behaviour. The observed behaviour, dependent upon aerosol composition, may range from hygrophobic to hygroscopic, with monotonic (smoothly varying) or deliquescent (step change) growth. Results from the different case studies will be illustrated and discussed at the Symposium.

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A Framework for Cloud-aerosol Interaction Studies

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The aim of this paper is to present a research plan for defining a framework for water cloud-aerosol interaction studies. This investigation is done as a part of the ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure Network) European Project, aiming at integrating European groundbased stations equipped with advanced atmospheric probing instrumentation for observing aerosols, clouds, and short-lived gas-phase species.

This work focuses on the evaluation of the aerosols indirect effect on the climate system (cloud albedo and lifetime effect). In order to have better understanding of these processes it is crucial to measure detailed vertical profile for radiative transfer and microphysical evolution of clouds. Best results can be achieved by using advanced sensors' synergy techniques. Essential remote sensing instruments used in this study include cloud radars and different types of lidar to obtain vertical structure of the atmosphere, as well as microwave radiometers and radiation sensors for improving the accuracy of the retrieved profiles. Several advanced combined retrieval algorithms will be used to quantify physical characterization of water clouds and aerosols. The relevant cloud properties needed for this study are droplet number concentration, effective radius, optical thickness and liquid water content. Aerosol properties will be investigated based on the extinction profiles retrieved with Raman lidar which will also be used for deriving water vapor profiles. Observation methods will have to determine if variations in the aerosol background result in variations of the cloud structure. For this step it is necessary to divide cloud types into categories where factors such as liquid water path, vertical extent, presence of drizzle and level of adiabaticity are kept uniform. This paper will focus on this categorization methods.

Further work will finally be required on the understanding of the relation between cloud and aerosol. It will be assessed by mean of the indirect aerosol effect index described by Feingold et al, 2003. It quantifies the change in cloud drop size retrieved from cloud radar and microwave radiometer in response to a change in aerosol optical thickness represented by the extinction profiles obtained from Raman lidar.

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In Situ Vertical Profile of Aerosol Size Distribution Measured During the MORE Campaign

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The Marine Ozone and Radiation Experiment (MORE) airborne campaign was aimed at investigating the vertical distribution of aerosol and ozone in a rural coastal zone of the Mediterranean Sea. The campaign, supported by the EUFAR project, was held in conjunction with the validation campaign of the National Integrated Assessment Modeling system for Policy Making (MINNI) project over the coast of Basilicata (Southern Italy) close to the ENEA Trisaia Center, were a large set of ground-based and remote sensing instruments were installed less than 2 km from the airstrip.

From 12 to 26 June 2010 twelve flights of the KIT ENDURO ultralight were performed, acquiring vertical profiles of several physical and meteorological parameters: ozone concentration, aerosol size distribution, temperature and humidity. Flight plan included several ascents and descents from the ground up to 1000 m, along a rectangular path, having the longer side parallel to the coastline, above the sea and inland about 20 km from the coastline. In three days an early morning and an afternoon flights were possible, allowing to study the diurnal evolution of the boundary layer structure and the aerosol distribution within it. The relatively low speed of the KIT ENDURO and its capability to fly at a very low altitude (about 100 m), permitted a detailed investigation of the thermo-dynamical structure of coastal boundary layer, evidencing the deep influence played by the orography in determining the boundary layer structure and the aerosol vertical distribution.

The campaign was characterized by two main meteorological situations. The first part was characterized by stable conditions inducing a well developed sea breeze regime, and by the presence of a considerable amount of desert dust. After the 17th of June there was a change in the general circulation inducing a northerly wind regime that stopped the flights from the 21st to the 24th, due to the occurrence of rain or too strong wind conditions. The last two days of flights, the 25th and 26th of June, were both characterized by a continuous air flow from north.

We present and discuss vertical profiles of total number of particles with diameter larger than 10 nm and of aerosol size distribution ranging from 300 nm to 20 micron respectively measured by a TSI 3010 particle counter and a model 1.108 Grimm optical counter.

The aerosol particles and size distributions behavior is discussed as function of temperature and humidity profiles and it is interpreted also with the support of lidar and radiometer measurements as well as by means of meteorological simulations. Particular attention is devoted to the behavior of particles having dimension between 10 and 300 nm, which are interesting for their implication with secondary aerosol formation.

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Simultaneous Determination of Lidar Ratio and the Aerosol Extinction Profile from the Combination of CALIPSO and AERONET Measurements.

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Aerosols in the atmosphere play a main role in the global radiative balance. However, aerosols are is still a key issue in the radiative forcing uncertainties mainly due to the great space-time variability in their distribution and typology. Satellite measurements of the aerosol properties are essential to deal with this problem in a global scale. The uncertainties in the estimation of radiative forcing using satellite measurements of column-integrated aerosol properties are still large and accurate measurements of the vertical distribution of aerosol may help to reduce them.

The CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarisation) Lidar was launched on board the CALIPSO platform to perform measurements of aerosol and cloud vertical profiles. CALIOP works at 532 nm and 1064 nm, and retrieves level 1 data with a horizontal along-track resolution of 333 meters and a vertical resolution of 30 meters from the surface up to 8 km altitude. Level 1 data is processed by a series of algorithms to obtain level 2 data, among which we can find aerosol extinction profiles and total column aerosol optical depth (AOD). However, validations show great discrepancies between CALIOP level 2 data and surface measurements, especially for daytime cases. These differences are mainly attributed to the aerosol models used by CALIOP algorithm. More accurate aerosol extinction profiles can be obtained based on CALIOP measurements since level 1 data can be combined with values of AOD obtained from an independent source. In this work, a methodology has been developed to combine CALIOP level 1 data and AERONET measurements over the metropolitan area of Valencia, in the Mediterranean coast of Spain. CALIOP total attenuated backscatter at 532 nm has been averaged along the area within a distance of 25 km from the AERONET station in Burjassot (39.5°N, -042°W) to improve signal-to-noise ratio. Cloudy data has been removed. For daytime cases, the AOD has been calculated averaging along one hour centered in the CALIPSO overpass. For night-time cases, the AOD has been linearly interpolated using the last measurements of AOD of the day before and the first measurements of AOD of the next morning. Finally, the lidar inversion is performed assuming a Lidar Ratio (LR, which is the ratio between the aerosol backscattering and the extinction coefficients) that not vary along the entire atmospheric column.

A total of 26 daytime and 37 night-time combinations of CALIOP and AERONET measurements have been successfully used to perform the lidar inversion. The values of LR were found to be in agreement with the values found by Pedrós et al. (2010) over Valencia, for a 70% of the daytime cases. The mean value of LR for those cases is found to be 54 ± 11 sr-1. For night-time cases, the percentage of agreement raised to a 89%, with a mean value of 48 ± 11 sr-1.

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The Effect of Droplet Clustering on the Statistics of Radar Backscatter from Water Clouds

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The applicability of the basic concepts of radar theory to the scattering on water clouds is discussed in view of the recently observed radar discrepancy. The term *radar discrepancy* refers to the deviation between the value of the radar reflectivity factor measured by the cloud radar and the one predicted by the standard radar scattering theory. Here, the applicability of the incoherent Rayleigh scattering assumption is questioned in the case of scattering on water clouds. In water clouds, the concentration of particles is of the order of several hundred of droplets per cm^3, which denotes that if the cloud radar operational wavelength is of the mm order, inter-particle distance between droplets may be less than a wavelength. Moreover, atmospheric turbulence randomizes the droplet velocities inside the illuminated cloud volume. Consequently, the assumption that droplets move fast enough to change the inter-particle distance by more a wavelength might be violated. A hypothesis could be due to formation of clusters, which behave as coherent substances because the position of the particles does not change randomly enough to result in uniformly distributed phase difference. Therefore, the classic radar theory demonstrating incoherent summation of radar backscattered waves should be questioned for the case of water clouds.
In this study, the total backscattered electric field measured at the receiver is estimated as the coherent summation of the individual electric fields and a comparison between incoherent and coherent backscattered power is presented. The spatial correlation of cloud particles is investigated through the random walks approach, a valuable tool for extracting the statistical properties of electromagnetic waves scattered by objects containing few scattering centers. In this paper, the investigated cases are:

Totally correlated N particles moving as one cluster.

Partially correlated particles distributed in n=2,3,..., N-1 clusters.

Completely uncorrelated N particles moving independently from each other.

The computational outcomes confirm that the probability density function (PDF) of the power resulting from the coherent summation of backscatter electric field is consistent with the probability density function of the squared distance to the origin in an N-step isotropic Pearson's random walk over the two-dimensional phase space. In case of N totally correlated particles, the power distribution is a delta function (consistent with a single-step random walk), while in the case of N particles split in two and three mutually independent clusters, the PDF of the backscattered power is consistent with the analytical expressions for two- and three-step random walks respectively. Other degrees of correlation (corresponding to more clusters) are investigated until the power PDF converges to the one of N completely uncorrelated particles. The preliminary conclusion of this study is: the clustering of particles inside the cloud volume results in a radar response deviating from the one predicted by the standard radar theory. Not only the PDF of the power reflected by partially correlated particles differs from the well-known exponential distribution, but there are systematic discrepancies in the mean (expected) power as well.

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Parameters of Vertical Profiles of Temperature, Humidity and Refractive Index of Air in the Lowest Troposphere

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Spatial distribution of the refractive index of air has an influence on the propagation of electromagnetic waves in atmosphere. Due to prevailing stratification of atmosphere, the vertical profiles of the refractive index in the lowest troposphere are particularly important for assessment of terrestrial radio propagation paths. The refractive index is known to be related to temperature, pressure and relative humidity of air. Their vertical profiles are measured regularly by radiosondes but typically only four times a day. In order to investigate the time evolution of the atmospheric layers with small vertical extent occurring in the first 100 meters above the ground, a measurement with better time and spatial resolution is needed.

We report the results of the measurement of vertical profiles of temperature, and relative humidity carried out in Podebrady, Czech Republic (50 km east from Prague) on a tower of former radio transmitter. The quantities are measured continuously by Vaisala HUMICAP sensors located in 19 different heights up to 150 meters above the ground level with an average separation less than 8 meters. The vertical profiles of temperature and relative humidity are sampled every minute. Near ground temperature inversions are observed together with decreasing humidity with height. The refractive index of air is calculated using standard relations recommended by International Telecommunication Union. The obtained vertical profiles of refractivity are analysed by means of nonlinear regression to extract the parameters of the ducting layers with a nonstandard value of the vertical gradient of the refractive index. Ground based and elevated ducting layers are observed. Temporal evolution of ducting layers is described by means of typical examples. Long term empirical statistics of layer parameters are provided and interrelations between different parameters of vertical profiles are pointed out.

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Raman Lidar Characterization of PBL Height and Structure During COPS: Comparison between Different Approaches

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The planetary boundary layer includes the portion of the atmosphere which is directly influenced by the presence of the Earth's surface. Aerosol particles trapped within the PBL can be used as tracers to study boundary-layer vertical structure and time variability. Aerosols can be dispersed out of the PBL during strong convection or temporary breaks of the capping temperature inversion. As a result of this, elastic backscatter signals collected by lidar systems can be used to determine the height and the internal structure of the PBL. Our analysis considers a method based on the first order derivative of the range-corrected elastic signal (RCS), which is a modified version of the method defined by Seibert et al. (2000) and Sicard et al. (2006).

The analysis is focused on selected case studies collected by the Raman lidar system BASIL during the Convective and Orographically-induced Precipitation Study (COPS), held in Southern Germany and Eastern France in the period 01 June - 31 August 2007. Measurements were performed by the Raman lidar system BASIL, which was operational in Achern (Black Forest, Lat: 48.64 ° N, Long: 8.06 ° E, Elev.: 140 m). During COPS, BASIL collected more than 500 hours of measurements, distributed over 58 measurement days and 34 intensive observation periods (IOPs), covering both night-time and daytime and the transitions between the two. Therefore BASIL data during COPS represent a unique source of information for the study of the boundary layer structure and evolution.

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ESYRO-LIDAR Investigation of Planetary Boundary Layer over Iasi - Romania Urban Areas

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This paper will present both the advantages and performances of the ESYROLIDAR system configuration and the PBL related lidar profiles measured in Iasi-Romania urban area. The correlation of PBL dynamics as observed by lidar with PM point monitor existing data in the area will be presented and interpreted. The PBL related lidar profiles are recorded using our new up-graded ESYROLIDAR system based on a multi -wavelengths (1064, 532 and 355 nm) powerful (200, 100 and 45 mJ/pulse) and relatively high variable repetition rate (up to 30 Hz) Nd: YAG pulsed laser, a large Newtonian telescope (40 cm diameter of collector mirror) and a new opto-mechanics detection module is used to evaluate the planetary boundary layer dynamics. The measurement site is located on the Science and Technology Park TehnopolIS Iasi, area situated in the north-eastern part of Romania - Moldavia region (47° 7'17.16"N, 27°34'15.35"E, ASL 60m). The simulation of PBL height results at regional scale performed with the meteorological model MM5 included in the INOE2000 (National Institute for Research and Development for Opto-Electronics Magurele, Romania) Air Quality Forecast system will be compared with lidar data in daytime.

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Boundary Layer Characterization in Ny-Ålesund

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The research village of Ny-Ålesund (Spitsbergen) is located in the high European Arctic at 78.9° N, 11.9°E, but it is influenced by warm currents from the Gulf Stream. Hence the site resembles tundra climate and the boundary layer shows a pronounced annual cycle in terms of altitude and stability. Moreover, a complicated terrain with mountains, glaciers and a fjord make a precise interpretation of boundary layer processes difficult.

To improve our knowledge about boundary layer processes at that place a radiometer (RPG Hatpro, Radiometer Physics, for temperature and humidity profiles) and a wind lidar (Windcube 200, Leosphere) for continuous operation have been installed recentlyat the AWIPEV base in the village. Moreover, daily a RS-92 radiosonde (Vaisala) is launched and occasionally also a tethered balloon carrying up to six radiosondes in predefined altitudes.

In this work we present new data from spring 2012 obtained at the site. Remote sensing profiles of wind, temperature and humidity will be compared to the measurements obtained in situ by balloons. Additionally an Eddy covariance system for measurements of turbulent fluxes of the surface and a Raman lidar for aerosol properties and water vapor are available. This set of instrumentation will be used to address the following questions:

1) Use the radiosonde to determine resolution and reliability of the remote sensing techniques

2) Outline a strategy for producing a homogeneous dataset of the meteorological quantities

3) Analyze the diurnal cycle and the influence of snow-melt / thawing to the vertical profiles of the key meteorological parameters in the boundary layer

4) Analyze hygroscopic growth of aerosol in the transition between spring (polluted with Arctic Haze) and the cleaner summer

These measurements will be carried out in April and May 2012, partly incorporated to the international PAMARCMiP Campaign (Polar Airborne Measurements and Arctic Regional Climate Model Simulation Project).

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Influence of the Micrometeorological Phenomena on the Aerosol Concentration of PM10 in the Planetary Boundary Layer: Observatio

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The characterization of the influence of micrometeorological conditions on the local space-time distribution of particulate matter air pollution was one of the major goal of a campaign of investigation held at the experimental field of the ISAC-CNR of Rome Tor Vergata since March 2010 to April 2011. Housed inside a special enclosure housing air-conditioned, specially designed and manufactured for use in pitched outside, a real time analyzer of particulate matter air pollution model 5030, Thermo SHARP Scientific has acquired concentration measurements on a continuous observation period of over one year. During the same period of observation, using the meteorological instrumentation already present in the area, were acquired measurements (simultaneously) of some micro-meteorological variables selected. Among these, the continuous measurement (every 10 min) of profiles of atmospheric temperature by means of a microwave radiometer MTP5 Polar Attex, operating in the band of 60 GHz, together with those provided by a weather tower provided with a thermo-hygrometer and an anemometer triaxial sonic. The above data on concentrations of atmospheric particulate PM 10 collected in different seasons were then interpreted at the light of a comparative statistical analysis on the basis of observation of the presence (or not) of mixing phenomena in the lower layers related to the thermodynamic conditions the lower troposphere. Particular attention was paid to those parameters which are directly on the atmospheric stability in the lowest layers of the PBL

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Static stability in the Po Valley: Comparison between Radiosounding and Passive Microwave Radiometer Observations.

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The Po Valley, bordered by Italy's major mountain ranges with the Alps to the north and west and the Appennines to the south, host almost one third of the Italian population. It is also the most industrialized part of the country and subject to important emission of atmospheric pollutants. This flatland is ill-famed, much like the Ruhr area and other European hot spots, for not respecting the EC limits for air quality, especially for PM10, PM2.5, ozone and benzene. Among other, measured concentration of these compounds are significantly affected by the meteorological conditions. The static stability of the atmosphere is one important variable for assessing the atmosphere's mixing potential.

Static stability can be retrieved from temperature profiles as observed by radio soundings or microwave radiometers (MWRs). There are four radio sounding stations in the Po Valley, i.e. from the west to the east Cuneo, Milano, Bologna and Udine, with less than 200km distance between the sites and more than 10 years of data. As to the MWRs ARPA Veneto have installed four instruments in 2005, two of which (MTP-5 HE) are still working with an elevated continuity.

This work will focus on the nocturnal static stability, as retrieved from radio soundings for the last decade, and highlight differences from site to site. This will be analysed together with the height, strength, and frequency of temperature inversions, as well as the stability, for instance following the Pasquill classification. Comparison with radio sounding outside of the Po Valley will be done using the radio sounding Rome, a large urbanized area which is also affected by pollutant problems, but in a distinctively different geographical and climatological setting. It will be discussed to what extent the static stability is sufficient to highlight the meteorological conditions that lead to reduced mixing of the atmospheric boundary layer and, therefore, enhanced pollutant concentrations. The comparison of the radio sounding with the MWRs data will be show to what extent the latter can be used for more local and, particularly, more frequent assessment of the dispersive action of the boundary layer.

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Accuracy of Boundary Layer Humidity Profiles retrieved by GNSS Meteorology and Microwave Radiometry

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The motivation of the study is to investigate the potential of combining atmospheric observations from GNSS (Global Navigation Satellite System) receivers with atmospheric temperature profiles from a microwave radiometer in order to derive the vertical distribution of humidity, and to assess the contribution of this information to the understanding and prediction of meteorological phenomena in the boundary layer and at its top.

GNSS receivers are able to deliver integrated atmospheric water vapor information at temporal resolution of ~30 minutes [Bender et al. 2011]. With a receiver network, this information can be used to reconstruct a 3D field of wet refractivity [Bender et al. 2011, Perler et al. 2011]. Wet refractivity is a measure that depends on the two atmospheric parameters temperature and humidity (water vapor pressure). The spatial resolution of such a field depends on the number of antennas that are deployed. In Switzerland, where the alpine topography allows antennas to be placed at various heights ranging from about 400 m to 3'500 m amsl, we can derive vertical information about the wet refractivity field in this height range.

Lower V-Band microwave radiometers deliver reliable and accurate temperature profiles at high temporal resolution [Löhnert et al. 2011], especially in the range from ground to 3'000 m agl , though vertical information content decreases with height.

In this study, we resolve the wet refractivity field in the region of Payerne as provided by GNSS measurements using stations from the Automatic Geodetic Network of Switzerland (AGNES, swisstopo) and use the vertical temperature profile from a microwave radiometer operated at Payerne, Switzerland, to obtain a vertical humidity profile. We then compare this solution to other collocated observation methods, 1) radiosonde humidity profiles 2) LIDAR humidity profiles 3) humidity distribution from K-band microwave radiometer, in order to evaluate reliability and accuracy. The analysis relies on continuous measurements from the years 2009 to 2011.

We discuss prospects and challenges of using this additional information with respect to different applications, including the aim of assimilating upper-air temperature and humidity observations in NWP models. A special focus is on determining Boundary Layer Height and associated meteorological phenomenon such as fog or low stratus, which we believe can be improved with the assimilation of this data.

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Quality Aspects of the Measurements of a Wind Profiler in a Complex Topography.

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It is well known for the scientific community that some remote sensing instrumentation have considered the assumption of homogeneity conditions in the sample volumes to achieve a consensus of a meteorological profile but generally, in a complex topography and extreme meteorological conditions, this assumption is critical and it could happened that it faults in the lower layers. This paper shows the results of a work that test the homogeneity wind field over a boundary layer wind profiler radar sited in a complex terrain at a coast, over different meteorological conditions. The result of this work reveals how important is for quality purpose to know the deviations of the assumption and evaluate its effect in the final product. Patterns of behavior of the data are identified to simplify the complex signal along the sample volumes.

This information is useful as the starting point to look for the best alternative that the system offers to build the wind profile. The methodology used is crucial, taking into account that the amount of data is high and not all of them are comparable, many decisions are assumed to avoid misinterpretation. Finally the results are being considered to integrate in a quality algorithm implemented at a product level.

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A Comparison of the Wind Profiles Registered in the Basque Country.

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In The Basque Country it is registered two wind profiles, one through the wind profiler sited at the coast and the other one from a Doppler weather Radar on a top of Kapildui Mountain inside the community and therefore, away from sea reflectivity. Besides the study incorporates as a reference, wind profile data from the WMO radiosonde, which is the Santander station and it is closer to them. A comparison between the three systems is studied to achieve improvement of the performance and therefore better quality of the profiles registered by the wind profiler and the weather radar. The methodology applied in this comparison of wind profiles takes into account: the different technologies, the different locations of the systems and the differences caused by meteorology due to the distance between the systems. The goal of the studied is the design of a tool that integrates all the information available and at the same time reveals abnormal behaviours of the data. Suspicious data will be checked by quality procedures of each system later.

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Composite Profile Derived from Lidar and Ceilometer Signals

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The aim of this study was to explore the possibility to extract as much information as possible from the two systems, Ceilometer and Lidar, by combining the best of their characteristics: continuous monitoring capabilities and low overlap of the ceilometer, and the good accuracy and calibration of the Lidar. For this purpose we measured optical backscattering intensity of the air using first a Vaisala CL 31 ceilometer, single lens technology, 910nm wavelength. Recorded data can cover the range from 0 to 7500m altitude with 20m vertical resolution and 2s temporal resolution. The Lidar system is based on a short-pulses high power laser operating at 3 elastic wavelengths (1064, 532 and 355nm) with full overlap around 700m and reaches SNR (signal-to-noise-ratio) above 20km altitude.

The measurements were performed at Faculty of Physics - Ceilometer, and INOE (National Institute of Research and Development for Optoelectronics) —Lidar (26.029E, 44.348N, ASL: 93m, Bucharest-Magurele, Romania) for three typical spring, summer and autumn days under clear and sunny conditions during a stable high-pressure period: 23 April, 8 July, and 21 September 2009.We selected Lidar signals at 1064nm wavelength, which is the closest to the sounding wavelength of the ceilometer (910nm), Ceilometer data (backscatter) were averaged over 60 min, and the ceilometer wavelength (910nm) was translated to the Lidar wavelength (1064nm).

Based on the Lidar and Ceilometer signals, the composite profiles were constructed as follows. First, an altitude interval was selected comprised between the last Lidar measurement and the maximum value of backscattering coefficient. All backscatter values between these limits were averaged. Between the same altitude limits, all ceilometer derived backscatter coefficients were averaged as well. For each Ceilometer and Lidar signal a confidence function was constructed. The confidence function for Ceilometer is different for three selected layers: from ground level (20m) and the last LIDAR measurement (840m), 840m and 2000m and from 2000m and the first Lidar measurement (5000m). Conversely the confidence function for Lidar signal has opposite features for these layers. The Ceilometer and Lidar signals were weighted by the corresponding confidence functions and then the two resulted profiles were added. This way between 20m and 840m the information is given by the ceilometer, then between 840m and 2000m the information is composed from both Ceilometer and Lidar and above 2000m the information is assured by the Lidar signal. Consequently, a composite signal was built combining the two backscattering coefficient distributions from Lidar and Ceilometer. This way the mixing height and PBL height could be determined using Lidar even if they descend below 700m.

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Quantifying the Value of Redundant Observations for GRUAN Operations

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GRUAN (GCOS Reference Upper Air Network) has the aim to characterize the thermodynamic state of atmosphere using both in-situ and remote observation techniques. GRUAN backbone is represented by 15 highly instrumented observatories with a strong observing capability equipped with GPS, lidars, radiometers, spectrometers, radars. So far, the contribution of ground based remote sensing has been identified as a priority in the frame of GRUAN for providing reference-quality profiling and columnar observations of atmospheric essential climate variables, in particular temperature and water vapour, from the surface into the stratosphere, to enhance the monitoring and the understanding of climate variability and change.

To this aim, GATNDOR (GRUAN Analysis Team for Network Design and Operations Research), a research team supporting the development and implementation of GRUAN on scientifically sound foundations, is working for providing a quantification of the value of the so-called "complementary observations", identified as ground based remote sensing techniques available at GRUAN sites. This research aims at estimating uncertainty of vertical profiles of both temperature and moisture using data from selected highly-instrumented GRUAN sites (e.g. ARM sites, Beltsville, Payerne, Potenza, Sodankyla) and to quantify the error reduction resulting from increasing redundancy of measurements. This requires the assessment of the uncertainty of the temperature and moisture vertical profiles retrieved using each of the considered techniques and then the investigation of possible sensors' synergies to reduce the uncertainty. The investigation is carrying out focusing on the most common instruments available at the GRUAN sites: radiosoundings and microwave profilers, for temperature; radiosoundings, Raman lidars, microwave profilers and GPS receivers, for moisture.
The quantification of the value added by redundant observations will be assessed with respect to the following issues:

1. identification of possible biases;
2. representativeness of measurements;
3. sensor calibration/inter-calibration;
4. quality control/assurance with a focus on instrument performance in different meteorological conditions.

The aim of the investigation is the to provision provide of recommendations for an optimal observation strategy related to GRUAN phase 1 and 2, increasing accuracy of measured parameters and reducing uncertainties through redundancy. Moreover, recommendations for the equipment to operate/acquire at the GRUAN sites will be also provided.
In this work, the level of redundancy achievable using different measurement techniques together is analyzed at both the levels of providing independent observations, able to improve the atmospheric profiling through the merging or integration of different measurements, and of providing duplicative observations, ensuring continuous measurements of an atmospheric parameter without temporal gaps. The real benefit in performing redundant measurements will be outlined in terms of uncertainty reduction, instrument types and equipment costs. Moreover, the improvements in radiative transfer modeling resulting from the use of radiosonde humidity profile alone or in combination with Raman lidar measurements will be discussed.

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Toward a Combined Retrieval Scheme from the Dual-pol Multi-wavelength Radar D3r and the Dual-pol Multi-frequency Radiometer Admirari

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Theoretical studies have highlighted the possibility to estimate the cloud liquid water content from dual-wavelength radar observations. The advantage of that kind of techniques is that they don't require assumptions about the nature of the size distribution but simply that observations fall into the Rayleigh regime for both frequencies. Other authors have made first attempts for the application of multi-wavelength techniques to stratiform rain conditions by exploiting radar differential attenuation of droplets and raindrops and differential backscattering of raindrops; however, large uncertainties are typically introduced in the cloud product depending on the rain rate.

The passive microwave ADMIRARI radiometer from University of Bonn, has successfully taken advantage from the polarization information produced by non-spherical raindrops to partition rain and cloud from the total liquid water content. ADMIRARI's triple-frequency helps to cover the atmospheric microwave signatures at different rain regimes. Its Bayesian retrievals have a good performance for large cloud and rain water content, while it is prone to larger uncertainties in the cloud component when low liquid water contents are observed. In such cases, dual-wavelength radar techniques can improve the performance of retrievals by adding information to the passive instrument. On the other hand, the Dual-wavelength dual-pol doppler radar (D3R) from the Colorado State University has recently taken part in the NASA field campaign GPM Cold Precipitation Experiment (GCPEx) last winter in Canada. D3R is a novel Ku/Ka-band radar which has been taking measurements following diffent scan strategies, among them, the D3R performed elevation scans toward the same observational direction of ADMIRARI. That gave us a unique opportunity to collect synchronized data from snow precipitation. Moreover, after the GCPEx campaign, ADMIRARI and D3R have been transported to the CHILL radar facility in Colorado, to continue the synchronized measurements for rainy cases. The present work present the first results from the aforementioned field campaigns with a first attempt to combine these multi-sensor, multi-frequency, dual-polarized measurements in a common retrieval approach; limitations and pitfalls will be critically discussed as well.

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Standing Wave Patterns at Liquid Nitrogen Calibration of Microwave Radiometers

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A standard method for the absolute calibration of passive microwave radiometers is the hot-cold-calibration where two blackbody calibration targets with different physical temperatures are used.
Usually, a liquid nitrogen target with a well-known boiling temperature provides the cold calibration point. In the standard calibration procedure for a ground-based passive microwave radiometer (HATPRO), the integration time on each target is 30-60 seconds.
However, when observing the cold target for a longer time, an oscillation of the incoming power signal with a period of 2-7 minutes is detected. This period is linearly correlated with the microwave wavelength indicating a standing wave between the receiver and the liquid nitrogen surface.
The amplitude of this oscillation corresponds to a brightness temperature range of up to 1.5 K which can lead to an error in the retrieved integrated water vapor of up to 1 kg/m^2.
In order to consider this effect it is necessary to integrate over one whole oscillation cycle and taking the mean value as the reference power which corresponds to the boiling temperature of liquid nitrogen.

Some measurement examples and an overview of other error sources and accuracies of microwave radiometer calibrations are presented.

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The Ground-based and Airborne Measurements of Aerosol Radiative Forcing (GAMARF) campaign at Lampedusa island

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The Ground-based and Airborne Measurements of Aerosol Radiative Forcing (GAMARF) campaign was held at Lampedusa island, in the Central Mediterranean, from 28 April to 7 May 2008, with the aim of measuring the shortwave (SW) and longwave (LW) direct aerosol radiative forcing (ARF) using a large dataset from instruments deployed at the surface and on an airborne platform. The EUFAR project supported 6 flights (for a total of 12 flight hours) performed by the IMK-IFU ultralight ENDURO-KIT, instrumented for airborne aerosol and radiation research. Ground-based measurements were performed at the ENEA Station for Climate Observations (35.5° N, 12.6° E, 40 m asl), where long time series of atmospheric composition, aerosol optical properties, and radiative fluxes from well-maintained and calibrated instruments are available. The campaign focused on the measurements of LW irradiance, which are absent in the Mediterranean, and on the estimation of the LW ARF, which is smaller than the SW ARF.

The ENDURO-KIT aircraft is equipped with instruments measuring meteorological parameters, ozone mixing ratio, upwelling and downwelling SW irradiances and actinic fluxes, and for the characterization of the aerosol optical properties (size distribution, absorption and scattering).

Two pyrgeometers were added on the aircraft gimballed platforms to measure LW fluxes: a Kipp&Zonen CGR4 for downwelling irradiance, and an Eppley PIR for upwelling irradiance.

The aerosol backscattering, temperature, and humidity vertical distribution above the aircraft top altitude were measured by lidar and radiosonde, respectively. Columnar aerosol properties, water vapour, and ozone, together with surface values of SW and LW irradiance, meteorological parameters, aerosol size distribution, and soil temperature, were continuously monitored at the ENEA Station.

All the available measurements have been used to initialize the MODTRAN radiative transfer model in order to compute the aerosol-free SW and LW fluxes. The ARF has been estimated at the surface, the top of the atmosphere, and in the atmospheric aerosol profile.

Saharan dust was present in three of the six flights. On 3 May the aerosol optical depth at 500 nm was as large as 0.6, with the aerosol layer top altitude of 5.5 km. The downward LW irradiances measured during the flight decreases from 337.4 Wm^{-2} at the surface level to 184.7 Wm^{-2} at the aircraft top altitude of 4015 m. The LW ARF is positive throughout the flight altitude range, being nearly zero at the top of the dust cloud, and increases with decreasing altitudes to a value of 13.2 Wm^{-2} at the surface. During the flights the Eppley PIR measurements presented an hysteresis in the voltage signal due to the time dependence of the thermopile response to temperature changes, which was negligible in the Kipp&Zonen CGR4. A correction procedure for the PIR has been implemented to remove the hysteresis; the procedure is based on the assumption of a 2 minute time lag in the thermopile response to temperature changes.

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The Heating and Cooling Profiles Computed Using Radiative Transfer Model MODTRAN4 for Magurele, Romania

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Clouds and aerosols impact on the energy balance of the earth is still incertitude in climate studies. To better understand how the atmospheric components affect the radiative fluxes and consequently energetic budget it is very important to analyze the aerosol spatial distribution and clouds properties from local to regional scale. Therefore we used the radiative transfer model, MODTRAN4, to estimate the tropospheric irradiances and the heating / cooling profiles for Magurele (44.348N, 26.029E) Romania, during the winter season 2008.

Ground measurements and satellite combined data were used in this paper as input parameters on the radiative transfer model MODTRAN4. Due to its complexity and accuracy (better than 15%), its outputs can be used to characterize radiative effects of aerosol and clouds. Sensitivities studies were performed for different atmospheric conditions: aerosol loading, clean atmosphere, the presence of clouds and cloud free atmosphere. Ceilometer's data were used to determine the cloudy periods, the type of clouds and some optical properties of the clouds.

The key parameters used in MODTRAN4 are: the atmospheric levels extracted from LIDAR recorded data, the solar irradiance on the top of the atmosphere, the surface albedo derived from satellite data (MODIS), the atmospheric optical parameters (absorption and extinction coefficients, normalized to extinction coefficient at 550 nm, aerosol asymmetry factor) and the vertical profile of atmospheric constituents (aerosol and molecular gases). The extinction and the absorption coefficients at the ground level for the considered spectral range (0.2 - 40 m) were derived from Mie theory and nephelometer and aethalometer results. The standard mid - latitude atmospheric profile was chose from Anderson database to describe the thermal and atmospheric molecular composition on the vertical column. In order to solve the radiative transfer equation, the Discrete Ordinate Radiative Transfer algorithm was used. Otherwise, the net integrated radiative fluxes at the bottom and at the top of the atmosphere were determined. The maximum value obtained for the radiative forcing in Magurele for the analyzed period were equal to - 82.47 W/m2 at the bottom of the atmosphere and 205.12 W/m2 at the top of the atmosphere.

The direct radiative fluxes were compared with the measurements and the results showed a good agreement.

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Determination of Time Evolution of Atmospheric Refractive Index Structure Constant Cn2 During 24 Hours Using a moiré Deflectometer.

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Optical turbulence is an atmospheric effect that acts on the propagation of light waves. It is brought about by fluctuations in the refractive index in air, i.e., air density, which affects the speed at which light wave fronts propagate. In turn, these effects can significantly degrade (blur, shimmer, and distort) images in imaging systems through the atmosphere. In many atmospheric studies, the knowledge of time series of optical turbulence Cn2, is of great interest. In this paper we have determined time evolution of optical turbulence Cn2 during 24 hours using a moiré deflectometer. We discussed case studies with regard to variations in daytime and nighttime turbulence intensity, wind speed, and temperature.

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Estimation of the Turbulence Energy Dissipation Rate from the Pulsed Coherent Doppler Lidar Data Measured at the Conical Scanning

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The use of conical scanning by a sensing beam of the coherent Doppler lidar (CDL) around the vertical axis at the fixed angle of sight allows the information about wind direction and velocity to be obtained. If measurements are conducted by a pulsed CDL, then the vertical profiles of these wind parameters can be reconstructed from the data obtained for one full scan (azimuth angle varies from 0 to 360 degrees). In [1], it is shown for the continuous-wave CDL that not only the wind speed and direction, but also the turbulence energy dissipation rate within the atmospheric boundary layer (ABL) can be estimated from the data measured at the conical scanning. Then in [2], using the approach [1], it is shown that the information about wind turbulence can be retrieved from pulsed CDL data obtained at sectorial conical scanning. In [3,4], it is shown that estimation of the dissipation rate can be obtained from the lidar data measured at the vertical scanning of sounding laser beam.

In this paper we present the theoretical description of the used approaches for the estimation of the turbulence energy dissipation rate from the transverse and longitudinal structure function of the radial wind velocity measured by the 2-micron pulsed CDL at the conical scanning (both one full scan and multiple sectorial scanning). We compare the results of profiling the dissipation rate in the ABL based on the estimation of both the transverse and longitudinal structure function of the radial wind velocity measured by CDL with the estimation of the dissipation rate obtained from the sonic anemometer data. We present the results of estimating the dissipation rate at the given height from the transverse and from the longitudinal structure function calculated based on the same data of the radial wind velocity measured by CDL during long temporal period and compare these results with each other.

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Sodar Wind Profile at the Black Sea Coast in Bulgaria

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Sodar (SCINTEC MFAS) data at Ahtopol meteorological observatory (Bulgarian Black Sea coast) performed since summer 2008 allowed climatological analysis of the wind profile up to 400 – 600 m under different conditions: breeze circulation (sharp onset of the sea breeze after nocturnal land breeze), combination of local and synoptic forcing (gradual onset in wind speed and wind direction for the sea breeze) and no sea breeze (at synoptic flow from the sea and flow the land). The data are used for validation of wind profile parameterizations at this site, depending on the wind direction.

The sodar and turbulence observation programmes start a climatological record for the structure of the boundary layer at the Bulgarian Black Sea coast. The monitoring will develop further to cover temperature and humidity profiles, ozone and aerosol concentrations, etc. in order to study the internal boundary layer development, the ozone and aerosol concentrations, and the inland extend of the sea breeze.

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Detecting Turbulence on Air Routes by 1.3GHz Wind Profilers for Aviation Safety

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Wind profiler is one of the observation instruments that can frequently measure the vertical profiles of wind speed and direction using radio waves. It has been installed at airport and used for aviation weather observation such as monitoring low-level wind shear as well as for synoptic and mesoscale weather observations. Wind profiler can obtain additional atmospheric information called as spectral width which broadens owing to atmospheric turbulence. Spectral width also grows wider in accordance with other factors. However it is possible to evaluate the strength of atmospheric turbulence from the spectral width by adding the appropriate correction to it. So it was reported that there is good agreement between eddy (energy) dissipation rate derived from the spectral width of wind profiler data and low-level turbulence in the vicinity of the airport (Chan and Chan, 2004).

Japan Meteorological Agency (JMA) has been operating a network (WINDAS) consisting of more than thirty 1.3GHz wind profilers throughout the Japanese islands from 2001 (Ishihara et al., 2006). This system makes it possible to observe the wind speed and direction up to 9 km altitude at the maximum, or up to 5 km altitude on the average through a year. In addition JMA has been sharing PIREP (PIlot REPorts; information on turbulence from pilots) data with the airlines for ten years. From the comparison of these data sets, it is found that there is good correspondence between the spectral width retrieved from wind profilers and the intensity of turbulence in PIREP data, irrespective of altitude. With spectral width we can catch not only clear air turbulence caused in the areas with strong vertical wind shear but also other turbulence which may not be related to the vertical wind shear. It is concluded that wind profiler has the potential to become an effective tools of monitoring atmospheric turbulence on the air routes. On the other hand, because of weaker signal from dry air (especially in high altitude), it cannot often obtain the data even if turbulence occur frequently in the upper layer. So the current performance of the wind profilers is not sufficient for monitoring high altitude turbulence. We will show our efforts to overcome the problem, and new WINDAS stations installed this spring.

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Continuous Vertical Profiles of Temperature and Humidity at Lampedusa Island

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Lampedusa island has a small surface area (about 22 km2) and has a low elevation (the island is a plateau which degrades from North to South, with the maximum altitude of 133 m). The ENEA Station for Climate Observation (www.lampedusa.enea.it) in Lampedusa offers a unique opportunity to provide long time series of atmospheric parameters representative for the marine background conditions of the Mediterranean.
A large set of observations is continuously carried out at the station, starting in 1992. Since 1998 the station furnishes a relatively extended time series of several atmospheric parameters such as greenhouse gases concentration, aerosol optical properties, radiative fluxes, columnar water vapour, meteorological variables, total ozone, UV irradiance, and aerosol chemical composition.
High temporal resolution measurements of absolute humidity and temperature vertical profiles by an HATPRO-RPG microwave radiometer (MWR), as well as integrated water vapour, liquid water content and cloud base height were started in May 2009. Since September to November 2010 the measurements at Lampedusa were interrupted, due to the participation of MWR in the validation campaign of the MINNI air quality model.
The MWR is newly operating at Lampedusa since November 2010. The almost 2 years of data of absolute humidity and temperature vertical profiles will be presented. When operating in the Boundary Layer scanning mode the HATPRO provides temperature profiles with relatively high spatial resolution in the first 2 km (nominally 50 m in the first 1200 m).
A detailed analysis of the temperature evolution in the first 2 km will be presented: in particular the occurrence of temperature inversion will be investigated in terms of altitude of the maximum of temperature profile in the first 2 km, and of the strength of the inversion, i.e. the difference between the maximum temperature and the temperature of the lowest level. Preliminary results evidence the annual cycle of temperature inversion governing the boundary layer structure over the remote sea site.

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Towards an Integrated European Network of Automatic Profiling Lidars/Ceilometers for NWP Applications

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The number of automatic Lidars and ceilometers with profiling capability installed over Europe has increased over the past two years. National Meteorological and Hydrological Services (NMHS) in Germany, France, the Netherlands and the United Kingdom, in particular, are deploying simple automatic Lidars and ceilometers to cover their national territories with the objective to reach a spatial density of nearly one device every 100 km. These investments have been made because of the

Lidars/ceilometers ability to detect volcanic ash, but the network is potentially of great value in monitoring clouds and pollution and evaluating their representation in numerical weather prediction models. Ultimately, incorporation of such data could lead to improved prediction of air quality and hazardous weather.

Although the name ceilometer suggests that their sole purpose is to detect cloud-base, modern ceilometers are able to provide continuous accurate and reliable profiles of backscatter from aerosols and clouds. In the past, Lidars were strictly research instruments. Similarly modern Lidars are becoming more automated and can now contribute efficiently to continuous monitoring of air quality and weather. The simple automatic Lidars and ceilometer are complementary to more powerful and capable research Lidars that typically operate at multiple wavelengths with both elastic and Raman detections, and that are coordinated in Europe by the EU FP7 Aerosol, Clouds and Trace-gases Research Infrastructure (ACTRIS) network, and the European Aerosol Research Lidar Network (EARLINET) program and worldwide by the GAW Aerosol Lidar Observation Network (GALION).

The EU COST action ES-0702 (EG-CLIMET - European Ground-Based Observations of Essential Variables for Climate and Operational Meteorology; 2008 - 2012) has financed a series of expert meetings attended by those operating automatic profiling Lidars/ceilometers. The following results have been established and will be presented:

a) Automatic profiling Lidars/Ceilometers are reliable and inexpensive instruments which can operate unattended for many months and provide accurate and calibrated backscatter profiles every 30 seconds with a vertical resolution typically of 30m.

b) Means of monitoring data quality and self calibrating the absolute Lidar/ceilometer sensitivity have been implemented and tested, based on various techniques (integrated cloud returns, sunphotometer optical depth, ...).

c) Initial work forward modeling the aerosol and cloud backscatter profile predicted from operational NWP models and comparing with observations are very encouraging suggesting that the observations can be used for evaluating model performance, and, more importantly, for data assimilation.

At a recent COST expert meeting representatives of European NMHSs involved in Lidar and ceilometer activities and Lidar data analysis experts involved in EU FP7 ACTRIS/EARLINET discussed ways to harmonize procedures. The participants agreed to work towards harmonization of data formats, data exchange, using common retrieval algorithms and calibration procedures. Further discussion will be focused on quantifying the benefits of Lidar/ceilometer profiling to improve forecasts of severe weather and poor air quality situations.

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Evaluation of CALIOP L2 Aerosol Extinction Profiles with Ground Based Lidar Measurements in India and South Africa

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Modeling of atmospheric aerosols and their climate effects are demanding tasks. The models have to use numerous simplifications that can have significant effects on the results. The vertical structure of aerosols is one of them. For the validation of aerosol profiles used in climate models, spaceborne lidar CALIOP provides the best data set because it is global and measured with a single instrument. However, before CALIOP measurements can be used for model validation, the measurements have to be validated with ground-based measurements at as many locations as possible.

In this study, the Level 2 aerosol extinction profiles (V3.01) from CALIOP measurements are evaluated with ground-based multi-wavelength Raman lidar measurements done at two locations: Gual Pahari, India (28.43N, 77.15E) and Elandsfontein, South African Republic (26.25S, 29.43E). The measurements in India and South Africa were performed in the periods March 12th 2008 - March 31st 2009 and December 11th 2009 - January 31st 2011, respectively. The measurements were conducted with a seven-channel Raman lidar called "POLLY^{XT} - Portable Lidar sYstem eXTended".

For the comparison, we selected all the CALIOP overpasses which were inside a 1x1 degree or 2x2 degree box centered on the lidar sites. We screened our data for clouds and stratospheric features using Atmospheric Volume description (AVD). Cloud Aerosol Discrimination (CAD) score, which reflects our confidence that the feature under consideration is either an aerosol or a cloud, was also used. In this study we screened out features with CAD score greater than -80. CALIPSO extinction Quality Control (QC) flags were also used. We used solutions where the lidar ratio is unchanged during the extinction retrieval (extinction QC = 0) or if the retrieval is constrained (extinction QC = 1). For Gual Pahari we obtained 40 overpasses for the 1x1 degree box and 79 for the 2x2 degree box while for Elandsfontain there were 28 and 101 overpasses, respectively. Hourly averaged backscatter and extinction profiles centered on the CALIOP overpass time were calculated from the Polly^{XT} measurements. Due to cloudiness and technical issues, Polly^{XT} data was not available for all the overpasses. Next, we calculated averaged CALIOP profiles from the measurements inside one latitude degree path centered on the lidar sites. In the end, we had 10 useful overpasses from both sites for the evaluation with the 1x1 degree boxes. For this set, typical distances between the CALIOP tracks and lidar sites were around 50 km. The use of the 2x2 degree box provided 20 additional profiles for Elandsfontein and 6 profiles for Gual Pahari with typical distances around 100 km.

In Gual Pahari, the preliminary results look promising. CALIOP is able to measure similar aerosol profiles as Polly^{XT} for most of the cases. There were some differences in the CALIOP lidar ratios and measured lidar ratios which caused differences in the extinction profiles. In Elandsfontein, the evaluation was more difficult due to persistent cloudiness. However, for the overpasses with clear sky, the agreement between the instruments was good, both in the location of the layers and in the amount of extinction.

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AN INTERNATIONAL NETWORK OF GROUND-BASED MICROWAVE RADIOMETERS FOR THE ASSIMILATION OF TEMPERATURE AND HUMIDITY PROFILES INTO NWP MODELS

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Temperature and humidity retrievals from an international network of ground-based microwave radiometers (MWR) have been collected and synchronized to exploit the potential for data assimilation into Numerical Weather Prediction (NWP) modeling. This activity is carried on in preparation to the HyMeX Special Observing Period starting in September 2012. The domain under analysis is the HyMeX West Mediterranean (WMed) target area, using data assimilation tools developed for the Météo-France Arome-WMed NWP system. In this paper we introduce the data set and discuss preliminary results.

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CALIPSO Level 3 Data Exploitation by EARLINET Correlative Measurements

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The almost six-years long database of aerosol and cloud vertical profiles provided by CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization) is at the present the longest database of aerosol optical properties at global scale. This database is a unique tool for the characterization of aerosol 4D distribution at global scale. Since December 2011, a new product is released by NASA: the CALIPSO Lidar Level 3 Aerosol Profile Product. This is a tropospheric product that reports monthly mean profiles of aerosol optical properties on a uniform spatial grid at altitudes below 12 km. Four types of level 3 data files are generated each month depending on sky conditions and temporal coverage and are separated into day/night segments. The information contained in these Level 3 data could be really interesting from a climatological point of view, but their reliability and uncertainty should be studied and quantified. In particular, the representativeness of the data should be investigated into details because of the long (16 days) revisiting time of this polar satellite.Because of its geographic coverage and the large number of advanced Raman aerosol lidars, EARLINET, the European Aerosol Research Lidar Network, (www.earlinet.org) [Bösenberg et al., 2003] offers a unique opportunity for the validation and full exploitation of the CALIPSO mission. EARLINET provides long-term, quality-assured aerosol data and, because of its geographical distribution over Europe, allows us to investigate a large variety of different aerosol situations with respect to layering, aerosol type, mixing state, and properties in the free troposphere and the local planetary boundary layer. With a network on a continental scale it also becomes possible to study the representativeness of the limited number of satellite lidar cross sections along an orbit against long-term network observations. EARLINET developed a specific observational strategy for CALIPSO correlative measurements, which started already from June 2006 [Pappalardo et al., 2010]. While the majority of EARLINET stations contributed on a voluntary basis to this measurement program in the first two years of the mission, a dedicated ESA activity supports correlative EARLINET-CALIPSO observations at 16 selected EARLINET stations from April 1, 2008 to October 31, 2010. Since June 2006, EARLINET has been always active in the CALIPSO data exploitation. In particular, the good performances of CALIPSO and the absence of evident biases in the CALIPSO raw signals were demonstrated through devoted comparison with EARLINET ground based data applying an ad-hoc methodology [Mona et al., 2009; Pappalardo et al., 2010]. Aerosol optical properties provided by CALIPSO (i.e. Level 2 products) are typically in agreement within errors and uncertainties with ground based reference lidar stations. Comparisons performed in cases of high dust load showed the influence of multiple scatter on the aerosol retrieval from space borne lidars and how this effect can be mitigated within the retrieval [Wandinger et al., 2010]. Representativeness of vertical profiles of aerosol optical properties were investigated through a CALIPSO-EARLINET integrated approach. In particular, we used both version 2 (horizontal resolution of 40 km) and version 3 (5 km as horizontal resolution) CALIPSO data. The main outcome of this investigation was that the optimal balance between the signal-to-noise ratio and the resolution is an essential factor for the data representativeness. Monthly mean averaged profiles provided within Level 3 CALIPSO data products will be investigated by taking advantage of this expertise and of the availability of the wide database of CALIPSO correlative measurements performed within the EARLINET network. The study will furthermore benefit from the availability of the 12-years long-term database of EARLINET climatological data available from May 2000.

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ARC S-band Vertical Rain Rate Radar

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The Advanced Radar Corporation has designed and built a Vertical pointing Rain Rate radar system using a 30 kw S-band magnetron. The S30VRR computes Doppler spectra, removes the vertical wind speed, and computes the density of precipitation particles based on their terminal velocities. Examples of the VRR radar data will be shown.

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The New Real-time Measurement Capabilities of the Profiling TARA Radar

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In the past 10 years, the S-band FMCW TARA (Transportable Atmospheric RAdar) provided in real-time vertical profiles of the Doppler moments. It was also possible to acquire raw data. Based on them, new algorithms were developed using spectral polarimetry and the multi-beam capabilities of this radar. They have been tested during the COPS (2007) and EUCAARI-IMPACT campaigns (2008).
To measure in real-time the Doppler moments of three beams, the differential reflectivity, the linear depolarization ratio, the horizontal wind and the vertical mean Doppler velocity, it became necessary to upgrade TARA. This resulted in a new design of the radar control unit and a new processing based on spectral polarimetry. This major upgrade took place in 2011. TARA can now deliver multi-parameters profiles and raw data in real-time. They are stored with the Netcdf format. Furthermore, detailed quick-looks are available in real-time at http://ftp.tudelft.nl/TUDelft/irctr-rse/tara/index.html.
Because TARA stays a research radar, the main requirements of the new design of the radar control unit and processing, are flexibility of the system and the ability to directly use developed Matlab codes. Parts of the new design are a PXI, Labview software, a DDS (Direct Digital Synthesizer) and Matlab codes. The signal is defined by user input (range resolution, measurement cycle, ...) and generated by the DDS. The main tasks of the PXI are timing and synchronization in the radar control unit, and the analog to digital conversion of the received signal. The Labview software is employed for the radar control unit and the graphical interface. It uses Matlab codes for the data processing and the data storage in Netcdf files (processed data, noise data, raw data).

The processing is mainly carried out on the spectrograms (Doppler spectra for every range bin). New techniques of clutter and noise suppression, and de-aliasing, using spectral polarimetry are real-time implemented for the radar main beam. Classical techniques are developed for the two other beams, not polarimetric. TARA has a single receiver channel. Most of the time, the measurement sequence is VV, HV, HH, OB1, OB2, where OB1 and OB2 are measurements performed by the offset beams. One measurement is obtained each 0.5 ms and the sequence each 2.5 ms. This leads to an unambiguous maximum Doppler velocity of 9 m s^{-1}, which is not sufficient for all the atmospheric events to be measured. The spectral polarimetric dealiasing of the main beam supplies a maximum Doppler velocity of 45 m s^{-1}. The mean Doppler velocity profile of the main beam is going to be used to enhance the de-aliasing of the offset beams in case of strong horizontal wind. With this sequence, the time resolution of the profiles is 5.12 s.

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MTP-5PE - New Instrument for Temperature Profiling in Polar Region

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Study of the thermal structure of the polar atmospheric boundary layer (PABL) is requiring instruments with special capability. Such instruments are needed to produce the representatives' data not only in wide range of the negativities temperatures but also during precipitations.
Much more important to have with instruments the equal density of the data by time for adequate study of PABL process dynamic and also to have good vertical resolution for decryptions of the stratifications.

In the end of the past century in Central Aerological Observatory was designed microwave temperature profiler MTP-5P assigned to measure temperature profiles in polar regions. MTP-5P successfully worked in 2001-2005 on Antarctic station Concordia where ambient temperature fells down to -78 C in winter time. Experience of creation and usage of this device allow to make a new upgraded version of temperature profiler: MTP-5PE. MTP-5PE also has good vertical resolution in first 100 meters (10 m) due to antenna system with a narrow beam (less than 1 degree) and can operate in an ambient temperature range from -80 to +45 degrees. In MTP-5PE installed new radiometer with increased sensitivity and stability, antenna system and scanner system were redesigned completely thus considerably decrease dimensions of device and enhance calibration accuracy. New profilers have passed successful tests and comparisons with radiosondes data including operation in polar conditions. The details technical specifications of a new profiler will be presented in the report.

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Development of Turbulence Detection and Prediction Techniques with Wind Profiler Radar for Aviation Safety

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There are various meteorological phenomena which may cause serious trouble to aircraft operations. Especially, atmospheric turbulence (including wind shear) sometimes brings significant aircraft accidents because it is difficult to detect it by current operational meteorological observations. In 2000-2009, more than half of accidents in large aircrafts were brought by atmospheric turbulence. At present, PIlot weather REPort (PIREP) is a major method for observing atmospheric turbulence, but it is not suitable for monitoring atmospheric turbulence because it cannot continuously observe a specific area or altitude. Therefore, the development of a new observation instrument, which continuously covers wide altitude range, is needed. On the other hand, various forecast techniques for atmospheric turbulence have been developed based on PIREP data, so there is still room for improving its prediction accuracy.

The project supported by 'the Program for Promoting Fundamental Transport Technology Research of the Japan Railway Construction, Transport and Technology Agency (JRTT)' started in July 2011. In the present study, the prototype of the next generation 1.3-GHz wind profiler radar (WPR) that can be observed up to the cruising altitude of the aircraft is developed, and it aims at the establishment of the atmospheric turbulence detection technique by the remote sensing. In addition, the observational data with the WPR is used as verification data to improve the prediction accuracy of atmospheric turbulence. It aims to become the foundation of the aircraft accident prevention.

It is expected that the result achieved by the present study will be built into the WPR network of Japan Meteorological Agency (JMA) for the meteorological observations. In addition, it is expected to contribute to a safe service of the aircraft operation through the improvement of the prediction accuracy for atmospheric turbulence.

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A Lidar Technique for Measurements of Vertical CO2 Concentration and Temperature Profiles in the Troposhere

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Inverse techniques using atmospheric transport models are developed to estimate the carbon dioxide (CO2) sources and sinks based on the observed data. The accurate vertical CO2 profiles in the troposphere are highly desirable in the inverse techniques to improve quantification and understanding of the global budget of CO2 and also global climate changes. In comparison with the ground-based monitoring network, CO2 measurements for vertical profiles in the troposphere have been limited to campaign-style aircraft and commercial airline observations with limited spatial and temporal coverage.

We have developed a direct detection 1.6 μm differential absorption lidar (DIAL) technique to perform range resolved measurements of vertical CO_2 concentration profiles in the atmosphere. Our 1.6 μm DIAL system consists of the Optical Parametric Generator (OPG) transmitter that excited by the LD pumped Nd:YAG laser with high repetition rate (500 Hz) and the receiving optics that included the near-infrared photomultiplier tube with high quantum efficiency operating at the photon counting mode.

In this paper, the new 1.6 μm DIAL system that can measure simultaneously the temperature profiles with the CO_2 concentration profiles in the atmosphere because of improvement of the CO_2 mixing ratio (ppm) measurement accuracy are reported. Characteristics of this 1.6 μm DIAL system are to use the transmitter with three wavelengths and to apply the iteration method for their deduction.

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A Method for Ongoing Validation of Profiling Microwave Radiometer Water Vapour Products Using Radiosonde Data

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Profiling microwave radiometers provide a valuable method for determining the integrated water vapour, integrated liquid water and water vapour profile above an observation site. They are frequently deployed at both operational and research meteorological sites. The method for the retrieval of water vapour and liquid water data from the sky brightness temperature measurements at microwave frequencies (typically in the frequency range 22 - 30 GHz) is somewhat complex. Typically a retrieval algorithm is developed using a neural network that is trained using radiosonde data from a site close to where the instrument is located. The algorithm is then used to retrieve the water vapour and liquid water quantities from the radiometer sky brightness temperature measurements. The resulting water vapour profiles are low in resolution compared with radiosonde observations and can suffer from errors, particularly during precipitation and when the water vapour profile is complex or has sharp features. Uncertainties can also occur when the microwave radiometer is used at a site which has a markedly different climate from the one for which the retrieval algorithm was developed.

The method reported here provides a way of comparing the integrated water vapour and water vapour profile measurements between the microwave radiometer and nearby radiosondes. Although individual comparisons at each radiosonde launch time can be subject to uncertainties caused by precipitation or differences in the meteorological conditions between the locations of the microwave radiometer and the radiosonde launches, if the comparisons are made over periods of months or longer any systematic differences between the measurements can be discerned. To provide an easily interpreted method of comparison of water vapour profiles, comparisons are made of the average water vapour content in 3 height ranges: 0 - 2 km, 2 - 4 km and 4 - 6 km. A system has also been developed to filter out radiosonde water vapour profiles which contain no features (i.e. rapid changes with height) that are sharper than a certain threshold. These are the profiles most accurately measured by the microwave radiometer. Hence making comparisons between the two techniques only under these atmospheric conditions provides a realistic way of assessing the on-going performance of the microwave radiometer only under conditions where it is likely to successfully measure the water vapour profile.

The method has been applied to measurements made at Chilbolton Observatory in the southern UK, where a Radiometrics MP-1516A profiling microwave radiometer has been operated since 2007. Agreement between the two measurement systems is good, with no long-term discrepancies between the two methods in excess of 10%. A comparison of integrated water vapour is also made between the microwave radiometer and the co-located AERONET sunphotometer. Agreement is again good between the two systems.

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Accuracy of Water Vapor Observations from in-situ and Remote Sensing Techniques: First Results from the DEMEVAP 2011 Campaign

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Measuring water vapour in the atmosphere is still a challenging topic for ever more demanding geophysical applications requiring high absolute accuracy, both at high and low water vapour concentrations, and long term stability. Calibration and validation of satellite sensors and correction of radiosonde biases are major issues both for climate monitoring and weather forecasting. Changes in instruments or sonde types make this task very difficult and require a reference technique for inter-calibration purposes. Scanning Raman lidars have been shown in the past to be a potential candidate technique for transferring absolute calibration from ground-based sensors to other systems such as profilers (e.g. radiosondes and remote-sensing techniques like spectrometers and radiometers) and/or integrated water vapour measurements (e.g. from GPS or dual-channel microwave radiometers).

The DEMEVAP project (MEthodogical DEvelopment for the remote sensing of water VAPor) aims at developing an improved reference humidity sounding system based on the combined used of a scanning Raman lidar, ground-based sensors and GPS. The ultimate goal is to achieve absolute accuracy better than 3% on the total column water vapour. The project is conducted by a consortium of research groups and operational services from IGN, IPSL, Météo-France and OAMP. An intensive observing period was conducted in September-October 2011 at Observatoire de Haute Provence (OHP) which involved two Raman lidars, four radiosonde measurement systems, five GPS stations, a stellar spectrometer, and several ground-based capacitive and dew-point sensors. Observations were collected over 17 nights during which 26 balloons were released which carried a total of 79 radiosondes. Most of the balloons carried 3 or 4 different sonde types simultaneously (Vaisala RS92, MODEM M2K2-DC and M10, and Meteolabor Snow-White) for comparison purposes.

The dataset collected during DEMEVAP 2011 will be used to assess several Raman lidar calibration methods and evaluate the humidity bias of different operational radiosonde types. Classical lidar calibration methods using radiosonde or integrated GPS measurements will be compared to a new hybrid method combining GPS and lidar data at the observation level. This method provides an original means for calibrating simultaneously total column water vapour from GPS measurements and Raman lidar profiles. Dew-point measurements from ground-based sensors and Snow-White radiosonde will allow assessing the absolute accuracy of the method. The first results of this analysis will be presented at the conference.

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Retrieving 2-D Water Vapor Fields with Two Microwave Radiometers

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Water vapor plays a key role in the the hydrological cycle, but its influence on initiation and strength of atmospheric convection is poorly known. A better understanding of this process would help to improve the quantitative precipitation forecast. To this end, highly resolved measurements of the water vapor field are mandatory.

In order to derive 2-dimensional water vapor fields on the meso-scale, a tomographic method with two microwave radiometers is investigated with synthetic observations. First, simulations of measurements between 22 and 31 GHz are carried out with a radiative transfer model using water vapor fields, for a Large Eddy Simulation (LES) model. The LES has been setup with a horizontal resolution of approximately 500 m for realistic cloud free cases around the Jülich Observatory for Cloud Evolution (JOYCE), Germany. A baseline of 6.7 km between two microwave radiometers that perform elevation scans towards each other is considered. Second, the measurement simulations are input to an algorithm in order to compute the water vapor field. This algorithm, which is based on the optimal estimation approach, requires additional information, i. e. an a priori water vapor field that is derived from the LES model.

This methodology allows to compare the retrieval performance for various measurement geometries. The structure of the original field is better reproduced by using two microwave radiometers, than by one radiometer. The uncertainty in the derived water vapor field decreases and the information content increases by 65 %. Even doubling the number of elevation angles for one radiometer does not reach this quality level. However increasing the number of elevation angles for two radiometers cannot infinitely improve the results. For the atmospheric conditions investigated, the optimal number of angles lies between 18 and 36. Apart from the number of elevation angles, the distribution of the angles over the measurement field is crucial for the quality of the computed water vapor field. The angles should be distributed in such a way that most measurements stem from those regions where the a priori field exhibits the largest uncertainties.

To validate the results of the theoretical study, a measurement campaign is planned, in which a scanning water vapor differential absorption lidar (DIAL) will measure simultaneously with two microwave radiometers. Furthermore, comparisons to GPS measurements and model output will be performed.

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NO2 Concentration Tropospheric Profiles in the Lagoon Environment of Venice

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An optimal estimation based inverse method, which can be used to retrieve the vertical profiles of a specific trace gas in the lower troposphere is presented. The vertical distribution of trace gases, such as NO2 and other gases has been retrieved by means of the spectral measurements performed with a spatial scanning DOAS system. The latter is composed by an UV-Vis spectrometer TROPOGAS (TROPOspheric Gas Analyzer Spectrometer) coupled by optical fiber to a scanning telescope SODCAL (Scanning Optical Device Collecting Atmospheric Light). Measurements have been carried out during summer of 2007, 2008 and 2009 in series of field campaigns performed in the lagoon area of Venice, Italy. The developed retrieval technique requires a set of spectral measurements toward the elevation angles of 1, 2, 4, 8, 16, 32, 90 degrees above the horizon. The obtained spectra have been analyzed according to the DOAS methodology, yielding the so-called Slant Column Density of the analyzed atmospheric compounds. The application of the inversion method, together with the a-priori assumption and the radiative transfer calculations provides the tropospheric profiles. The results show high pollution levels especially in the NO2 concentration, probably due to the numerous sources in the neighboring area such as the power plant, the harbor, the boat traffic, etc. Finally, the integrated tropospheric NO2 column obtained from the gas profile has been compared with the simultaneous tropospheric column provided by the OMI satellite sensor. Discussions about the method, the retrieved results, the comparison with OMI data and the factors that could influence the previous items (e.g. cloud cover, visibility, etc.) are provided.

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A 6-Year Water Vapor Raman Lidar Climatology (3-20 km) at the JPL-Table Mountain Facility, California

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As part of the Network for the Detection of Atmospheric Composition Change (NDACC), a water vapor Raman lidar has been operating routinely since 2005 at the Jet Propulsion Laboratory Table Mountain Facility (TMF) in California (34.4N). This lidar system was built to measure water vapor up to the lower stratosphere (3-20 km), and optimized several times since 2005, in particular through the three MOHAVE validation campaigns (2006, 2007 and 2009). It has now produced several years of stable, high quality water vapor mixing ratio profiles up to 15-20 km altitude.

The lidar system configuration, calibration, and data processing will be reviewed. A first climatology will be presented. Seasonal variations are characterized by maximum water mixing ratio values throughout the entire troposphere in late summer and fall, and minimum values in winter. The observation of deep stratospheric intrusions can be frequent at TMF as the site is located in the vicinity of the subtropical jet, a region of tropopause folding and subsequent stratosphere-to-troposphere exchange. Long nights of operation combined with short ozone and water vapor data acquisition intervals allows investigating short term variability (minutes to hours), and provides excellent documentation of these intrusions

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AIRCRAFT OBSERVATIONS OF NOY ABOVE UK DURING RONOCO CAMPAIGN: IMPLICATION FOR ΣANS AND OZONE PRODUCTION

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During RONOCO (ROle of Nighttime chemistry in controlling the Oxidising Capacity) campaigns (summer 2010 and winter 2011) a comprehensive group of NOy (NO, NO2, HNO3, total peroxy nitrates (ΣRO2NO2), total alkyl nitrates (ΣRONO2), N2O5 NO3, PAN) were measured on board the FAAM aircraft BAe-146. A diurnal flight (B548 **on** 03/09/2010) is studied in order to investigate the net production of Ozone and Alkyl nitrates in the London urban plumes. The analysis shows two regions, over London, characterized by different dependence between the Ox and the ΣANs, photochemical air masses age and dependence between NOx and aerosol nitrates. Here will be show the chemical mechanisms that can explain the observations in the two London areas.

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Caeli Water Vapour Raman Lidar Calibration at the Cabauw Experimental Site for Atmospheric Research

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Water vapour is a crucial parameter in atmospheric physics. Concentrations are low at upper tropospheric altitudes, but radiation effects are sensitive to water vapour abundance at these levels. Obtaining reliable data of low water vapour concentrations in the upper troposphere is challenging. The Raman lidar technique for water vapour can meet this challenge, however, the Raman lidar water vapour data rely on an external source for calibration. For the Raman lidar Caeli in Cabauw, operational radiosondes launched in De Bilt, about 22 km North-East of the lidar location are routinely used for this. Differences in space and time between the observations influence the consistency and quality of the calibration.

Various in-situ and remote observations of humidity are available at Cabauw that are better collocated and synchronized with the lidar measurements. These collocated observations could also be used for the lidar calibration as an alternative to the radio soundings. Among the possibilities are GNSS and microwave radiometer and tower based in-situ humidity measurements. In this paper we explore the possibilities for applying those for the Raman lidar calibration in Cabauw.

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Airborne Lidar Observations of Water Vapour Variability and Transport

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Water vapor, though a minor constituent of Earth's atmosphere, plays a major role in meteorology and the global water cycle. Tropospheric water vapor concentrations are highly variable due to the complex interplay between their sources (evaporation at Earth's surface) and sinks (condensation and precipitation) in relation with transport and mixing. Accurate measurement of water vapor is essential for better understanding its transport and cloud formation in the atmosphere and their impact on both weather and climate. For process studies dedicated to these topics, the DLR water vapor differential absorption lidar (DIAL) was combined with a Doppler wind lidar on board the DLR Falcon research aircraft in the field experiments COPS 2007 (Central Europe), THORPEX-IPY (Norway) and T-PARC (Japan) in 2008, focusing on boundary layer processes over complex orography, polar lows, and observations in the vicinity of tropical cyclones, respectively. The lidars can portray the two-dimensional water vapour and wind variability, as well as the horizontal and vertical moisture transport with high accuracy and spatial resolution along the flight path in cloud-free areas. The wind lidar is operated either in conical-scanning mode with 20° off-nadir angle for tropospheric wind field profiles, or in nadir-viewing mode for profiles of vertical wind velocity in the convective boundary layer (CBL). Eddy correlation of vertical velocity and water vapour provides profiles of the CBL latent heat flux above land or water. On 30 July 2007, during the COPS experiment, the lidar-derived latent heat fluxes over the mountains vary between 100 - 500 W/m^2 but are found roughly constant with height throughout the CBL. The fluxes moistened the growing CBL by upward transport of humidity from surface evaporation due to rain on the previous days. On 19 July 2007, a flight over the Iberian Peninsula intersected the inflow region of a warm conveyor belt (WCB), a key flow structure associated with extratropical cyclones. Comparison of the lidar humidity measurements with ECMWF analysis fields reveals a significant overestimation of the modelled specific humidity in the WCB inflow region of about 1 g/kg on average and with peak deviations of up to 7 g/kg. This substantial bias occurs in a potentially dynamically highly relevant airmass that will be subsequently lifted within a WCB to the upper troposphere. Spectral analyses of long-range water vapour lidar cross-sections obtained during the above experiments at altitudes from 2 to 10 km show power-law scaling between ranges of about 10 to 100 km. Structure functions reveal that humidity smoothness typically increases with height, while intermittency decreases. The results suggest a water vapor distribution determined at upper levels by advective mixing, but increasingly influenced at lower levels by local injection of humidity by moist convection. It appears that the structure function exponents provide a compact statistical description of moisture variability on scales just below the resolution of weather and climate models. This can be directly applied, for example, to the design of stochastic parameterisations for clouds and convection by using the spectral information to construct realisations of the small-scale moisture field.