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Welcome to the 3rd Annual Innovation in Atmospheric Measurement Techniques Workshop

Dear Colleagues,
Dear Friends,

It is with great pleasure that we welcome you for a third consecutive year to the Innovation in Atmospheric Measurement Techniques Workshop.

Firstly, we would like to thank all of you for your participation at the workshop. In this book of abstracts, we are delighted to share with you an exciting program, reporting the main innovations in the field of atmospheric sciences, with the participation of 33 presentations discussing recent relevant advances in the field.

All this has been possible thanks to your contribution.

We do hope that you enjoy your attendance at the Workshop!

The Hosts & Organizers

SCIENTIFIC PROGRAMME COMMITTEE

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Zahn Andreas, KIT - Karlsruher Institut für Technologie, Germany

AGENDA

Opening Session		
09:00	Workshop Introduction & Opening	**Jean Sciare** CARE-C, The Cyprus Institute
Session#1: International Initiatives and Opportunities (Chair: J. Sciare)		
09:10	ACTRIS ERIC and the next steps towards wider impacts	**Tuukka Petäjä** ACTRIS-ERIC
09:20	Status and future prospects of the WMO Greenhouse gas initiative	**Alex Vermeulen** ICOS-ERIC
09:30	Private sector opportunity to access the services of the leading Atmospheric Research Infrastructures in Europe	**Léo Rivier** LSCE
09:40	Harmonia Cost Action: International Network for Harmonisation of atmospheric aerosol retrievals from ground-based photometers	**Stelios Kazadzis** PMOD World Radiation Center
09:50	Measuring bases in sub-pptv mixing ratios – The BAE Project	**Tuija Jokinen** CARE-C, The Cyprus Institute
10:00	J-WADI – The Jordan Wind Erosion and Dust Investigation	**Frederik Weis** Palas GmbH
Coffee break		
Session#2: Reactive Gases & Air Quality (Chair: St. Sauvage)		
10:30	A new, compact user-friendly instrument for the measurement of atmospheric OH reactivity	**Hendrik Fuchs** Forschungszentrum Juelich
10:40	Development and validation of on-line auto-GC for the analysis of BVOCs and trace level OVOCs for laboratory and field measurements	**Ahmad LAHIB** Chromatotec
10:50	Cost-effective Air Quality sensors: Challenges and Advances	**Spyros Bezantakos** CARE-C, The Cyprus Institute
11:00	AEROMANCY: A context-aware Air Quality Forecasting model	**Vladimir Kuzmanovski** Vaisala
11:10	Lessons learned from highly resolved quasi-simultaneous formaldehyde measurements in suburban outdoor and indoor environments	**Alexandre DEMBICKI** Picarro Inc.
Session#3: Aerosols & Clouds – Part I (Chair: U. Bundke)		
11:20	PM-induced oxidative potential with particle chemical composition and sources: results from long-term measurements in Athens, Greece	**Nikos Mihalopoulos** University of Crete
11:30	Design, characterization and first atmospheric measurement using the Airmodus PSM 2.0	**Joonas Vanhanen** Airmodus Ltd
11:40	A new PM sampler with a built-in black carbon continuous carbon monitor - GIANO BC1	**Lorenzo Caponi** PM_TEN srl
11:50	Chemical characterization of atmospheric mineral dust by Raman Spectroscopy	**Avinash Yadav** University of Hertfordshire
12:00	Intensive profiling of Black Carbon over the city of Nicosia during a cold winter day	**Maria Kezoudi** CARE-C, The Cyprus Institute
Lunch break		
AFTERNOON		
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13:30	The Cloud Droplet Analyzer – In-situ cloud monitoring	**Ziegler Volker** Palas GmbH
13:40	Results from winter field collocations of the Aethlabs MA350 MicroAeth and AE33 rack mount Aethalometer in Lyon and Clermont-Ferrand, France	**Drew Hill** AethLabs
13:50	An autofluorescence Nephelometer	**Darrel Baumgardner** DMT
14:00	Light aircraft surveys of eDNA using a new high integrity capture system	**Kimberly Metris** Airborne Science LLC

14:10	First results from the ground-based fog and aerosol spectrometer	**Dagen Hughes** DMT
Session#5: Mass Spectrometry (Chair: T. Petäjä)		
14:20	Fast-SRI Fusion PTR-ToF 10K: Improved monitoring of VOC	**Markus Leiminger** Ionicon Analytik
14:30	Quantification of extractive electrospray ionization to determine monomer / dimer distributions in secondary organic aerosol	**David Bell** Paul Scherrer Institute
14:40	Laboratory characterization of SOA tracers from biogenic precursors using a Proton Transfer Reaction Mass Spectrometry couple to a Charon inlet	**Maria Carolina Ramirez Romero,** MPIC / IMT
14:50	Multiple reagent ions at once: New fast-switching chemical ionization mass spectrometer for OVOC and Inorganics	**Leah Williams** Aerodyne Research, Inc.
15:00	Quantification of atmospheric trace gases using filter-based thermal desorption multi-ion scheme chemical ionisation	**HJ Jost** Karsa ltd
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15:30	PMEYE: A novel commercial LIDAR scanner for PM Pollution monitoring in Urban and Industrial environments	**Vassilis Kostopoulos** Raymetrics S.A.
15:40	Absolute humidity comparison between cellular microwave link measurements and Israeli meteorological service stations measurements in Jerusalem	**Konstantin Romantsov** Tel Aviv University
15:50	Profiling atmospheric fluorescence: A key for improving our knowledge on aerosols and their interactions with the environment	**Qiaoyun Qiaoyun** CNRS - Univ. of Lille - LOA
16:00	Possibilities of modern ceilometers	**Minttu Tuononen** Vaisala Oyj
16:10	A lidar depolarization calibration using a reference system	**Alkistis Papetta** CARE-C, The Cyprus Institute
16:20	Mobile automated photometry: A key for improving our knowledge on aerosols distribution over the oceans	**Luc Blarel** CNRS - Univ. of Lille - LOA
16:30	Aerosol and cloud monitoring by multi-wavelength Raman and Fluorescence LIDAR	**María Soledad Fernández Carvelo,** Univ. of Granada
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Oral Presentations *(in order of appearance in the Agenda)*

ACTRIS ERIC and the next steps towards wider impacts

Tuukka Petäjä
University of Helsinki

The Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS) is the pan-European research infrastructure (RI) producing high-quality data and information on short-lived atmospheric constituents and on the processes leading to the variability of these constituents in natural and controlled atmospheres. On April 28, 2023, the European Commission took a long-anticipated decision to establish the ACTRIS as a European Research Infrastructure Consortium, ERIC.

During the coming years, the infrastructure development in ACTRIS should provide the European contribution to the global observations in the ACTRIS relevant fields. Within Europe, the network development should include improved integration of ACTRIS components and co-location with other European RI observation sites. Regionally the observation network should include observation sites both at remote and urban sites.

A target for the service development is to enhance comprehensive utilisation of ACTRIS data and to expand the user base of the ACTRIS data and tools. A focus should be placed upon interoperability across ENVRI domains.

As a whole, ACTRIS needs to remain at the state-of-the-art in 4D atmospheric aerosol, trace gas and cloud measurements via innovation actions in collaboration with the private sector, ACTRIS Central Facilities and Research Performing Organizations. We should develop and implement an innovation pipeline that allows on-boarding of novel instrumentation and technologies.

ACTRIS needs to contribute to scientific breakthroughs via ACTRIS observations, services, tools and integrative analyses in the field of atmospheric sciences. Particularly the focus remains in aerosol particles, trace gases and clouds with contributions to advances in air quality, atmospheric composition and climate change.

The overall ACTRIS strategy including the scientific strategy will be finalised in next one-two years, by engaging the ACTRIS community and which will be discussed and approved in the ACTRIS ERIC General Assembly.

Authors

Tuukka Petäjä[1], Paolo Laj[1,2], Ilona Ylivinkka[1], Silja Häme[1], Niku Kivekäs[3] and Eija Juurola[3]

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Private sector opportunity to access the services of the leading Atmospheric Research Infrastructures in Europe

Léo Rivier
Laboratoire des Sciences du Climat et de l'Environnement

ATMO-ACCESS is a EU funded project which combines the three major Atmospheric RIs in Europe: ACTRIS, IAGOS and ICOS. It provides coordinated physical, remote and virtual access to 43 state-of-the-art facilities and services in the atmospheric RIs and further enhances their range of products, capabilities and accessibility for a wide range of users, with a special focus on the private sector.
ATMO-ACCESS investigates how access activities can be more efficiently organized to offer a wider and integrated set of opportunities to conduct leading-edge, multidisciplinary research, thereby addressing scientific questions and societal issues in an innovative manner.
ATMO-ACCESS supports users from the private sector offering great opportunities for innovation and knowledge transfer with industry (especially SMEs) thanks to tailored support and services, unique insights into new or existing products, help to solve technical challenges, thus supporting pre-competitive and pre-commercial R&D. This special access program establishes and strengthens the links between the private sector and research institutions, especially in cross-border collaborations, fostering a successful transition from knowledge to innovation.
A wide range of services is available for access (e.g. instruments and sub-components testing, intercomparison of performance, co-development of new solutions, etc.) by our numerous facilities: 22 observational platforms, 14 simulation chambers, 4 mobile platforms and 12 central laboratories.
The accelerated access procedure for the private sector includes:

- **Spontaneous application**: Users from the private sector can submit their project proposals without following any specific call schedule.
- **Shorten evaluation**: Proposals are processed soon after submission, an independent review will be conducted as rapidly as possible (foreseen decision time: ~2-3 weeks).

The presentation will describe the services and opportunities offered by ATMO-ACCESS which address the specific needs of the private sector.

Authors

L. Rivier, J. Wenger, S. Philippin

Harmonia Cost Action: International Network for Harmonisation of atmospheric aerosol retrievals from ground-based photometers

Stelios Kazadzis
PMOD World Radiation Center

Harmonia is a EU COST Action dealing with sun-photometric aerosol remote sensing. The project started in November 2022 and will last for four years. Major goal of the action is to establish a network involving institutions, instrument developers, scientific and commercial end users, in order to improve and homogenize aerosol retrievals using mainly solar and sky but also lunar and star photometers from different networks.

Major objectives include:

- The homogenization of existing aerosol optical properties instrument networks through establishing a network of experts
- Suggest improvements for solar, lunar and star photometry measurement quality based on exploiting past datasets
- Stimulate discussion between aerosol measuring scientists and users in order to understand the user needs and to present the current level of uncertainty in different aerosol remote sensing parameters
- To promote innovation on aerosol measurement technology through collaboration with the major software and hardware manufacturers
- To disseminate higher-level products and HARMONIA related results to different audiences

The action involves currently more than 100 scientists most of them from Europe and deals with aspects dealing with aerosol metrology, WMO atmospheric composition and measurement quality and ACTRIS Center of aerosol remote sensing calibration, processing, operation, quality control and analysis procedures. Also deals with aerosol related climate science, satellite validation, modeling assimilation and aerosol data and accuracy needs of different end users (e.g. the solar energy sector, the health sector and others).

Authors

S, Kazadzis and Harmonia core group

Measuring bases in sub-pptv mixing ratios - the BAE Project

Tuija Jokinen
CARE-C, The Cyprus Institute

Aerosol formation and growth mechanisms need to be better understood to improve air quality and weather prediction models, and reduce uncertainty of radiative forcing in climate change projections. Globally, half of the aerosol population is formed via gas-to-particle conversion and the fraction exceeds 90% in high latitudes. In many locations, the initial molecular cluster forms from sulphuric acid and ammonia or dimethylamine. Growth to an aerosol particle is often explained by the condensation of sulphuric acid, methanesulfonic acid and highly oxygenated organic compounds. While the roles of strong acids and organic compounds and their oxidation channels are quantified in laboratory and field studies, cation detection and neutral atmospheric base measurements are notably under-represented. An important innovation of the role of bases in aerosol formation "BAE"-project will be the direct measurement of cations and neutral base molecules and clusters based on mass spectrometry.
Ammonia, a base predominantly emitted by agriculture, is a key air pollutant in the formation of fine particulate matter (PM2.5). In Western Europe, up to half of PM2.5 is attributed to ammonia pollution because of its ability to form aerosols in reactions with common atmospheric acids. Current atmospheric models do not include amines, which can form aerosol particles at a 1000-times faster rate than ammonia. To uncover the composition and level of toxicity of PM2.5, as well as the scattering and absorption of sunlight by aerosol particles, it is critical to understand the atmospheric chemistry and molecular pathways that control their formation and growth. The project will focus on the role of base molecules in the formation of new particles and their fate in the atmosphere. It will underpin the modelling of atmospheric aerosol processes, which are subject to major precursor emission changes in Europe and beyond.

Authors

Jokinen, T., Deot, N.

J-WADI - The Jordan Wind Erosion and Dust Investigation

Frederik Weis
Palas GmbH

Knowledge about the particle-size distribution and mineralogical composition of mineral dust at emission are fundamental to advance our understanding and quantification of dust climate effects, yet comprehensive measurements are still largely lacking, especially of super-coarse and giant particles and particle composition. Here, we introduce the Jordan Wind erosion And Dust Investigation (J-WADI), an intensive field measurement campaign conducted in September 2022 north of Wadi Rum in Jordan. The aim of J-WADI is to improve our fundamental understanding of the emission of mineral dust, in particular its full-range size distribution (from fine to giant dust particles) and mineralogical composition. For this purpose, in-situ and ground-based remote sensing instrumentation was installed to measure aerosol properties, e.g. particle numbers and sizes up to about 100 µm, optical properties, and aerosol distributions; collect soil and aerosol samples for laboratory analysis and experimentation; and to measure meteorological parameters including wind cross sections at high temporal and spatial resolutions and near-surface turbulence. In this contribution, we will present an overview of the J-WADI measurement setup and campaign conditions, together with preliminary results of observed dust events. In the future, J-WADI measurements will serve as a basis to investigate, e.g., (a) the mechanisms leading to the emission and continued suspension of super-coarse and giant dust particles and the possible variability of the emitted dust particle-size distribution; (b) the size-resolved mineralogy of dust at emission, its relationship with the parent soil, and spectroscopic measurement, and (c) dust-radiation and dust-cloud interactions

Authors

Weis, F., Klose, M., Hussein, T., Wieser, A., Alastuey, A., Böhmländer, A., Dupont, S., Ehlmann, B., Etyemezian, V., Gamer,T., Gonçalves, M., González Flórez, A.C., Romero, A.G., Goßmann, A., Greenberger, R., Ilic, L., Irvine, M., Kandler, K., Keebler, A., Meyer, H., Miller, R.L., Möhler, O., Mueller, J.M., Nikolich, G., Panta, A., Querol, X., Scheer, S., Villa, R.S., Stopford, C., Vergara, S., Vogel, F., García-Pand, C.P.

A new, compact user-friendly instrument for the measurement of atmospheric OH reactivity

Hendrik Fuchs
Forschungszentrum Juelich

OH reactivity, the inverse chemical lifetime of the most important daytime oxidant in the atmosphere, the hydroxyl radical (OH), gives a measure of the total load of pollutants. It is complementary to the measurement of single reactants because these can be compared to calculations of the OH reactivity from measured OH reactant concentrations. Gaps between measured and calculated OH reactivity indicate that important pollutants are missing in the suite of measurements of single compounds. These could be primary emissions or secondary products and their lack in chemical models will results in wrong prediction of secondary pollutants. The OH reactivity weights the reactant concentration with their reaction rate constant with OH and is therefore directly connected to the ozone production potential.
There are no commercial instruments available for the measurement of OH reactivity. Several methods have been developed, some of which require special knowledge, high maintenance, or pre-knowledge of the reactants composition to apply accurate corrections to the measured signal. We developed a new, compact instrument for the measurement of atmospheric OH reactivity that makes use of laser-flash photolysis of ozone to produce OH radicals in a flow tube and of the time-resolved measurement of OH by laser-induced fluorescence. The OH reactivity is the time constant, with which the OH concentration decays. Previous versions of this instruments have shown that this method gives accurate measurements without the need of corrections for typical ambient reactant concentrations but requires special knowledge on how to measure OH radicals. We further developed the instrument, specifically the 308nm dye laser used to excite the OH radicals such that it can be operated and maintained with little manpower and no special knowledge on laser technology. The new instrument fits in one 19” rack and will be optimized to be operated for long term measurements at monitoring stations. In addition to measure ambient air quality, the instrument can be used in laboratory experiment to determine for example reaction rate constants of organic compounds with OH at ambient conditions or it can be used chamber experiments to monitor the development of OH reactivity, while organic compounds are oxidized.

Authors

Hendrik Fuchs, Frank Holland, Anna Novelli, Aaron Stainsby

Development and validation of on-line auto-GC for the analysis of BVOCS and trace-level OVOCS for laboratory and field measurements

Ahmad Lahib
Chromatotec

Atmospheric air pollution is a major environmental issue that adversely impacts air quality, climate, and human health. Volatile Organic Compounds (VOCs) are significant gaseous pollutants that are emitted into the atmosphere from both anthropogenic and natural sources. They play a major contribution in the formation of ground-level ozone and secondary organic aerosols. Biogenic volatile organic compounds (BVOCs) and oxygenated volatile organic compounds (OVOCs) are important subgroups of VOCs. Real-time measurements of OVOCs and BVOCs concentrations are highly sought to understand source profiles and emissions and to control atmospheric pollution.

This study presents the development and validation of an online dual thermal-desorber gas chromatograph equipped with two Flame Ionization Detectors (FID) and one Mass spectrometer (MS) for the identification and quantification of BVOCs and OVOCs in ambient air. The system was designed to enable automated, continuous sampling and analysis of these compounds in real-time, thus allowing high temporal resolution and improved accuracy of measurements. The system uses specific software and algorithm to automatically identify co-eluted compounds and select results from either FID or MS. Furthermore, the study presented results from a specific online complementary analyzer dedicated to measuring light OVOCs which is replacing ordinary measurement techniques, e.g., DNPH cartridge derivatization. The analysis technique presented here deviates from the traditional and time-consuming process of DNPH cartridge derivatization, followed by offline HPLC/UV analysis for the measurement of aldehydes and ketones.

The validation of results using standard gas mixtures showed that the system can measure OVOCs with high accuracy and precision and provides detection limits lower than 0.1 ppbv. Additionally, the system effectively detected various monoterpenes during its online atmospheric analysis in a pine forest.

Authors

A.Lahib, F. Bachelier, J.P. Amiet, F. Amiet ,V. Daele, M.Mascles, D. Bazin

Cost Effective Air Quality Sensors: Challenges and Advances

Spyros Bezantakos
CARE-C, The Cyprus Institute

The development and commercialization of low cost and lightweight, miniature sensors for probing Air Quality (AQ) exhibits a constantly increasing trend during the last decade, due to the potential of such sensors in increasing the spatiotemporal resolution of AQ observations in highly diverse outdoor and indoor environments at a fraction of the cost necessary for deploying laboratory grade instrumentation. The operating principles and materials of these sensors are primarily selected for achieving high portability, minimum cost and energy consumption. However, the performance of low cost AQ sensors is found in many cases to be inferior when directly compared with laboratory grade/standard and scientifically proven, AQ instruments. In this work we present results from low-cost AQ sensors operating under real-life conditions in the diverse and extreme, in respect to the prevailing conditions, environment of Cyprus, as well as from extensive laboratory tests. Based on our results, we highlight the main reasons behind the performance limitations of low-cost AQ sensors, which are associated with their operating principles, auxiliary systems (e.g., sampling flow systems, electronics, software) and implementation of the sensors (e.g., in different environments; for different scopes). In addition we present recent technological advances for improving the performance and accuracy of low-cost AQ sensors, while expanding their applicability, like the development of cost-effective AQ instruments and use of Machine Learning algorithms.

Authors

Bezantakos, S., Papaconstantinou, R., Kipkemoi, L. V., Hadjigeorgiou, N., Costi, M. and Biskos, G.

AEROMANCY: A context-aware Air Quality Forecasting model

Vladimir Kuzmanovski
Vaisala

According to the WMO Global Air Quality Forecasting and Information System (GAFIS) Report No. 277 an optimal "Air quality forecasting and information systems correspond to integrated systems responsible for the prediction, validation, and dissemination of air quality insights." (Huneeus et al., 2020). Verified global forecasting models like CAMS (Copernicus Atmosphere Monitoring Service) (Peuch et al., 2022), GEOS-CF (Knowland et al., 2022) and SILAM (Sofiev et al., 2005) are run once or twice per day providing 120-hour forecasts with grid resolution from 20 to 40km, depending on the region. However, the latency of assimilated data and the provided forecasts, made the above models less accurate when compared to the observations. Additionally, the low resolution of their outputs could not support decision-making on local scales, where multiple emission sources could be concentrated within a single grid cell provided by the long-range transportation models. Therefore, with Aeromancy, Vaisala improves the latency of the forecast and spatial resolution. This is achieved by using pollution observations from reference stations around the world for the following species: Natrium dioxide (NO2), Natrium monoxide (NO), Carbon monoxide (CO), Ozone (O3), Particulate matter < 2.5um (PM2.5) and < 10um (PM10), and Sulphur dioxide (SO2). Additionally, data layers like CAMS long-range transportation model, and geographical, topographical, and demographic global characteristics are used in constructing a spatial context around each point on the globe, capturing all necessary information for estimating how pollution evolves spatially. Methodologically, the solution is a data-driven set of models built using statistical and machine learning methods, i.e., linear, cubic splines (Schumaker, 2015) and Locally Linear Embedding (Roweis and Saul, 2000) for interpolation and representation learning of the points' spatial context, Extreme Gradient Boosting (Chen and Guestrin, 2016) as a predictive model, followed by a Gaussian kernel (Stockman and Shapiro, 2001) for smoothing. The solution is built into an optimal architecture which enables updates every 3 hours and a local resolution of 5km, producing a forecast of 72 hours. The performance of the Aeromancy is validated via a leave-out approach, whereby a random 10% of the observation stations available for training purposes are left out of the training process, achieving an average improvement that ranges from approximately 5% on PM2.5, 11% on O3 to 20% (on SO2 and NO2) against CAMS forecasts throughout the 72-hour forecast horizon - aggregated on monthly time periods. The performance improvement is quantified in terms of Root Mean Squared Error and Root Relative Squared Error and compared against the quantified error of the CAMS long-range transportation model. Conclusively, Aeromancy overcomes the disadvantages of the publicly available global numerical models that are facing forecast and data assimilation latency, as well as low spatial resolution, and significantly improves forecast accuracy.

Authors

Vladimir Kuzmanovski, Laura Alku, Timo Roschier

Lessons learned from highly resolved quasi-simultaneous formaldehyde measurements in suburban outdoor and indoor environments

Alexandre Dembicki
Picarro Inc.

The Picarro G2307 formaldehyde (HCHO) Cavity Ring Down Spectrometer (CRDS) analyzer has shown an excellent correlation with the EPA Method TO-11A in the past. Extensive intercomparison with trusted standards, and key opinion leader laboratory instruments, and a traceable calibration process has led to a revision of the instrument scaling that matches TO-11A methods very closely and consistently. In this study, we will present indoor and outdoor formaldehyde measurements with a lower detection limit and an improved accuracy by correcting the analyzers' drift over time.

Over the past years, we implemented a full auto-zero correction procedure and identified the most effective and selective scrubbing medium. In this study, we used a catalyst containing 0.5% Pd on alumina pellets operated at 180°C to obtain highly resolved, and baseline corrected HCHO measurements. The catalyst's HCHO removal efficiency averaged 100 ±2 %, and the lower detection limit expressed as uncertainty in the frequent (2min every 15min) zero modes was <600 ppt for both indoor and outdoor air. Equally frequent standard addition span (recovery) checks confirmed unaltered HCHO transfer of 80-100% through sample lines including air matrix effects.

While outdoor HCHO levels showed the expected diurnal and seasonal variability due to its known photochemical production and destruction mechanisms, indoor sources and sinks governed the clearly elevated and more highly variable HCHO levels indoors. Indoor data suggest a strong dependency of HCHO off-gassing to temperature, causing average "background" HCHO levels indoors to vary from ~30 ppb in summer to ~15 ppb in winter. On top of these background indoor levels, household activities such as cooking with natural gas stove and/or oven cause large short-term spikes up to low 100s ppb.

Authors

Alexandre Dembicki, Jan Woźniak, Juan Carlos Guerrero, Jonathan Bent, Karsten Baumann

PM-induced oxidative potential with particle chemical composition and sources: results from long-term measurements in Athens, Greece

Nikos Mihalopoulos
University of Crete

It has been well established that increased PM concentrations are linked to increased rates of cardio-vascular diseases, acute respiratory disorders (e.g., asthma), mitochondrial damage and oxidative stress. Although a direct mechanism linking PM exposure to health outcomes is not yet well established, it is believed that reactive oxygen species (ROS), generated from photochemical reactions or present in polluted air, such as redox-active components like metals and several organic species, can induce oxidative stress in exposed populations and ecosystems. The capacity of PM to oxidize target molecules in living tissue, i.e. by generating ROS, has been proposed as a more health relevant metric than PM mass, and numerous methods have been developed for its measure.. ROS activity represents the major plausible mechanistic biological process leading to adverse responses to PM exposure, and integrates over all chemical species that possess the property. To measure the oxidant-generating potential (OP) of PM, both cellular and acellular methods have been developed, with the latter offering, the advantage of limited need for controlled environments, and faster/more robust measurements. Here a short overview of the methods available for acellular OP measurements will be presented along with long term OP measurements performed in Athens continuously since 2016. At this dataset which is among the longest in the literature, statistical analysis was applied to identify the sources of fine aerosols and determine the contribution of each source to aerosol OP. During winter, wood combustion to found to be the major source of water-soluble OP, both as primary and secondary sources. On the other hand, the significant impact of water-soluble metals on OP was revealed during the warmest period of the year.

Authors

Despina Paraskevopoulou[1,2], Aikaterini Bougiatioti[1], and Nikolaos Mihalopoulos[2]

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Design, characterization and first atmospheric measurements using the Airmodus PSM 2.0

Joonas Vanhanen
Airmodus Ltd

Various processes from natural new particle formation (e.g. Kulmala et al., 2013) to anthropogenic sources such as combustion engines (Rönkkö et al., 2017) have been found to produce large numbers of particles in the sub-3 nm size range. The Particle Size Magnifier (PSM) technology (Vanhanen et al., 2011) has been a cornerstone of new particle formation studies up to date. Here, we introduce a significantly improved version of the PSM, built on a modified Airmodus A10, able to provide size information up to 12 nm.
The PSM provides size information by selectively activating particles of different size by changing the supersaturation inside the instrument. This is done by varying the amount of heated air flow, saturated with Diethylene Glycol which is mixed with the sample air. The mixed saturator flow and sample air is subsequently cooled to produce a supersaturation resulting in particle activation and growth. In the PSM 2.0, the temperature, and flow controls have been improved, along with extending the saturator flow range, to provide an extended size selection range, overall stability and improved data quality.
First atmospheric measurements using the PSM 2.0 prototype were conducted at the SMEAR III station in Helsinki. During the one week measurement period the PSM 2.0 data was compared to the current commercial PSM, a DMPS system as well as Neutral Air Ion Spectrometer. The results show that in addition to the extended size range compared to the A10, the sensitivity of the PSM 2.0 to the sub 2 nm particles and clusters was better. Also the comparison against the NAIS and DMPS showed good correlation especially in the 5-12 nm size range.

Authors

Vanhanen, J., Enroth, J. and Pajunoja A.

A new PM sampler with a built-in black carbon continuous monitor - GIANO BC1

Lorenzo Caponi
PM_TEN srl

Aiming to overcome the well known present limitations on different carbonaceous aerosol measurement, we designed, developed, and patented a new instrument by coupling a standard low-volume PM sampler with an optical module able to monitor the Black Carbon (BC) concentrations in the airborne particulate matter (PM) during the sampling on a 47-mm filter. The concentration of PM and BC are usually measured by separate instruments with possible systematics differences even in the collecting inlets. The new equipment is based on a low-volume sequential PM sampler, fully compliant with the EU-CEN and US-EPA regulatory standards, with a built-in optical BC monitor. The BC concentration is continuously measured during the sampling of the PM accumulated on the filter while the PM concentration can be obtained off-line by a standard gravimetric analysis. The optical set-up, upstream the collecting filter, is composed by a single wavelength light source (at 635 nm) and a photodiode, placed in way to receive the light backscattered by the filter surface at a fixed angle. The mechanical arrangement does not introduce any perturbation to the PM sampling. Thanks to an original calibration curve, the sample absorbance is deduced from the output signal of the photodiode. Finally, the BC concentration is obtained through the Mass Absorption Coefficient (MAC). After the sampling and the PM gravimetric determination, the same filter can be sent to other compositional analyses. Thermo-optical quantification of the Elemental and Organic Carbon (EC and OC) in the filter sample can thus be exploited to tune the MAC value to the PM composition of a particular site. The main features of the new instrument and the set of validation tests against other PM samplers and BC monitors of widespread use (i.e.,: Multi Angle Absorption Photometer and aethalometer) are detailed and discussed.

Authors

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Chemical characterization of atmospheric mineral dust by Raman Spectroscopy

Avinash Yadav
University of Hertfordshire

Mineral dust is a key constituent of the atmosphere and possesses numerous characteristics, including shape, size, and chemical composition, which influence human health, atmospheric processes, and climate. The optical and microphysical properties of atmospheric particles have been explored and understood to a considerable degree in previous studies. To date, investigations of the chemical properties of aerosol pollution have been limited by the availability of samples and the use of laboratory analysis techniques. The chemical characterization of atmospheric aerosols is highly crucial in atmospheric research and requires multi-pronged technological and instrumentational complexities. Raman spectroscopy is a non-destructive technique that can identify the chemical compositions of individual particles in the analyzed sample.

This study aims to investigate the chemical compositions of various dust samples by means of Raman spectroscopy under controlled laboratory circumstances using a Raman and fluorescence microscope. Additionally, to explore the possible application of Raman lines for remote sensing detection in the atmosphere, in which the Raman spectroscopy technique serves as the technological foundation. This research examined the Raman spectra of the main components of mineral dust, such as quartz, corundum, hematite, albite, baryte, and titanate as a first step in this research.

The outcomes of this study have provided insights into the composition of atmospheric pollution. Raman spectroscopy is a proven approach to identifying the compositions of mineral dust, either in pure form or in a mixed state. The vertical distribution of atmospheric pollution and its chemical compositions, particularly dust in the context of this research, will be investigated with state-of-the-art spectroscopic lidar developed at the University of Hertfordshire in the following phase of work.

Authors

Yadav, Avinash, Müller, Detlef, Tatarov, Boyan, Ghita, Adrian

Intensive profiling of Black Carbon over the city of Nicosia during a cold winter day

Maria Kezoudi
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Black Carbon, or soot, consisting of fine particles generated by inefficient combustion, is linked to adverse health effects, while being one of the main light-absorbing aerosol species playing a substantial role in warming the atmosphere. During recent years, miniaturized sensors on board Unmanned Aerial Vehicles (UAV) have allowed for vertical profiling of BC (Pikridas et al., 2019), providing valuable information that can be used in constraining chemistry transport models developed for assessing pollution impacts in the climate-sensitive region of the Eastern Mediterranean and Middle East (EMME).

On 25 January 2023, an intensive UAV campaign was performed at the Athalassa Park in Nicosia, to capture the vertical dispersion of pollution from the surface up to an altitude of 1,300 m AGL. The measurement campaign targeted the concentration of Black Carbon (BC) emitted by the Nicosia urban area. The one-day-long campaign was supported by the Unmanned Systems Research Laboratory (USRL), which developed a high-performance multi-copter UAV (Kezoudi et al, 2021). The UAV was integrated with a novel miniaturized filter absorption photometer, the MA200 microaethalometer (Aethlabs Inc.). The instrument measures light absorption by particles at five different wavelengths spanning over the near UV to near IR range (375 – 880 nm), enabling the quantification of BC emitted by both fossil fuel combustion (vehicular traffic etc) and biomass burning (residential wood burning, RWB) implementing the aethalometer model (Sandradewi et al., 2008). A total of 17 flights was performed, starting shortly before 06:00 EET and continuing until midnight, with one flight every hour. The selected flight frequency permitted to monitor the evolution of BC concentrations during a typical winter day.

BC concentrations started out low (< 1 μg m-3) early in the morning, and started to increase around 08:00, coinciding with the onset of the morning traffic. Very high concentrations (> 6 μg m-3) were observed from ground up to 200 m altitude at 09:00. Consequently, BC was found to be more evenly distributed inside the developing planetary boundary layer (PBL) with concentrations close to 2 μg m-3 being recorded as high as 800 m a.g.l. during the 10:00 LST and 11:00 EET flights.

Concentrations were reduced between 12:00 and 17:00 EET, while a gradually increasing trend was observed from 18:00 onwards, when the contribution from traffic and fireplace emissions started to rise. Elevated concentrations were confined below 500 m, inside a shallower PBL during the evening. Maximum concentrations were recorded close to 200 m AGL during the 21:00 EST flight, again reaching up to 6 μg m-3, highlighting the importance of Residential Wood Burning (RWB) emissions in the area. Recorded BC levels deescalated when moving towards midnight, with BC varying around 1 μg m-3 very close to ground level.

Results demonstrate the effectiveness of suitably equipped UAV systems to capture the variability of pollutants all the way to the top of the PBL facilitating regular vertical monitoring of BC levels, that can substantially contribute to our better understanding of the inferred climate forcing in the EMME region.

This work has received funding from the “ACCEPT” project (Prot. No: LOCALDEV-0008), co-financed by the Financial Mechanism of Norway (85%) and the Republic of Cyprus (15%), in the framework of the programming period 2014 - 2021.

Authors:

M. Kezoudi, F. Marenco, C. Keleshis, P.Y. Quehe, I. Stavroulas1, M. Pikridas and J. Sciare

The Cloud Droplet Analyzer – In-situ cloud monitoring

Ziegler Volker
Palas GmbH

Motivation:
How do clouds form? When and why exactly does rain and snow occur? In order to answer these questions, instruments are needed which are robust enough, to detect under harsh and extreme conditions, insitu important factors of the cloud and ice formation process.

Instrument:
The Cloud Droplet Analyzer is a high-resolution optical aerosolspectrometer optimized for measuring size distribution and number concentration of cloud aerosols like droplets and ice crystals. Based on the measurement principle of optical light scattering (90°) on single particles and high resolution components, droplets and ice crystals can be distinguished.Additionally the cloud water content as well as mean droplet diameter is reported. This optical sensor is also used in research applications from KIT for Ice Nucleation Studies at AIDA -Chamber, insitu measurements at eleveated observatories (e.g. ACTRIS stations - Europe, Storm Peak - US) or under arctic conditions in Marambio Base Antarctic - Argentina. The instrument is implemented in a robust weather housing which can be easy installed at any location.

Specifications:

Measurement Range Concentration (CN):	0 – 200 particles/cm3
Measurement Range Size:	0.6 – 40 µm, 0.8 – 100 µm
Reported Data:	Particle size distribution, number concentration, water content, mean volume equivalent diameter
Volume Flow:	5 l/min
Data acquisition:	Digital, 20 MHz processor, 256 raw data channels
Interfaces:	USB, Ethernet (LAN), Wi-Fi, RS-232/485

Applications:
- Insitu-Cloudmonitoring
- Environmental Research
- Climate Research
- Cloudformation
- Ice Nucleation Events

Authors:

Sergej Sel, Frederik Weis, Maximilian Weis, Henrik Hof, Volker Ziegler

Results from winter field collocations of the Aethlabs MA350 Microaeth and AE33 rack mount Aethalometer in Lyon and Clermont-Ferrand, France

Drew Hill
AethLabs

The AethLabs MA350 microAeth® is a real-time black carbon (BC) monitor that concurrently measures BC concentrations across 5 wavelengths from UV to IR. The MA350's 85 location auto-advancing filter cassette allow it to be operated in stationary settings for long-term monitoring for months and upwards of a year, depending on concentrations and settings, without a filter cartridge change, while its low flow rates, lower power draw, and battery allow it to be used in portable and mobile measurement applications. A recent firmware update enables wireless data communication via WiFi and onboard source apportionment by fossil fuel combustion and biomass combustion. These features may benefit action-oriented users like government agencies and community organizations seeking to quantify local concentrations and sources of BC. Filter loading corrected concentrations of total BC and BC specific to biomass combustion measured by the MA350 microAeth® were compared with those measured by the AE33 Aethalometer® -- a common rack mount solution for measuring BC and source apportionment – during extended field collocations in urban sites at Lyon and Clermont-Ferrand, France. Data were aggregated to a 15 minute timebase as commonly reported in French air quality monitoring network datasets, including AE33 measurements. AAEwb = 2 and AAEff = 1 were used for all instruments. Measurements were conducted at the Lyon site in Feb and Mar 2022. Data at the Clermont-Ferrand site were collected between Feb – Apr in 2023, but were limited to Feb and Mar to reduce differential seasonal effects between the two sites. Preliminary correlations assessed linearly and with intercept set to 0 show strong agreement between the AE33 and MA350 in BC concentration measurements (880nm as corrected for filter loading effects) in both Lyon (slope = 1.11, r2 =0.96) and Clermont-Ferrand (slope = 0.99, r2 = 0.95), and reasonable agreement in source apportionment (% BC from biomass burning [BB%]) with stronger performance in Lyon (slope = 1.10, r2 = 0.65) than Clermont-Ferrand (slope = 0.72, r2 = 0.45).

Authors

L. Drew Hill, Vincent Crenn, Mario Duval, Alexandre Marpillat, Ivan Iskra, Olivier Favez, Jeff Blair

An autofluorescence Nephelometer

Darrel Baumgardner
Droplet Measurement Technologies

The Autofluorescence Nephelometer (AFN) is a single particle optical spectrometer that is being developed to measure the properties of sulfuric acid droplets that contain organic compounds in the clouds of Venus. The AFN uses a 440 nm diode laser to illuminate the particles and an optical system that collects backscattered light at two polarizations and fluorescence at wavelengths between 470 and 600 nm. An algorithm is employed that extracts the complex refractive from the polarized, scattered light and from this information estimates the composition of the organic material in the droplet. The AFN is now being adapted for deployment on UAVs, using different wavelength lasers, to extract the complex refractive index from aerosols in the Earth's atmosphere, measure the fluorescence of biological and other organic particles, and qualitatively provide information on shape. Laboratory studies with the AFN are underway to evaluate its response to a microplastics composed of a range of polyolefins.

Author

Darrel Baumgardner

Light aircraft surveys for eDNA using a new high integrity capture system

Kimberly Metris
Airborne Science LLC

Air is a medium for dispersal of environmental DNA (eDNA) carried in bioaerosols, yet the atmosphere is mostly unexplored as a source of genetic material encompassing all domains of life. In this study, we designed and deployed a robust, sterilizable hardware system for airborne nucleic acid capture featuring active filtration of a quantifiable, controllable volume of air and a high-integrity chamber to protect the sample from loss or contamination. We used our hardware system on a light aircraft across multiple height transects over major aerosolization sources to collect air eDNA, coupled with high-throughput amplicon sequencing using multiple metabarcoding markers targeting prokaryotes and eukaryotes to test the hypothesis of large-scale genetic presence of these bioaerosols throughout the planetary boundary layer. Here, we demonstrate that the multi-taxa DNA assemblages inventoried up to 2500 m using our airplane-mounted hardware system are reflective of major aerosolization sources in the survey area. We also pioneer an aerial survey flight grid standardized for atmospheric sampling of genetic material and aeroallergens using a light aircraft and limited resources. Our results demonstrate the usefulness of light aircraft in monitoring campaigns. However, our work also underscores the need for improved marker choices and reference databases for species in the air. Overall, this work establishes a foundation for light aircraft campaigns to comprehensively and economically inventory bioaerosol emissions and impacts at scale, enabling transformative opportunities in airborne DNA technology.

Author

Metris, K. Metris, J.

First results from the groundbased fog and aerosol spectrometer

Dagen Hughes
Droplet Measurement Technologies

Except for the most pristine, warm environments, fog can be a mixture not only of liquid water droplets, but will often be mixed with dust, ash, unactivated, hydrophobic aerosol particles and ice crystals in sub-zero temperatures. In addition, the fog droplets mixed with pollution particles (smog) will have optical properties different than more pristine fog. Hence, there has long been a need to measure the properties of these types of complex fog/smog particles to better understand their composition and forecast their occurrence.

Droplet Measurement Technologies LLC (Droplet) has recently developed a single particle optical spectrometer that is a ground-based version of Droplet's airborne Cloud and Aerosol Spectrometer with Polarization (Baumgardner et al., 2001,2014). The Ground-based Fog and Aerosol Spectrometer (GFAS) directly measures or derives:

- Equivalent optical diameter (EOD) of particles 0.5 – 60 μm.
- Number and volume concentrations > 3000 cm
- Shape factor using polarization detection.
- Complex refractive index

The shape factor is used to differentiate liquid droplets from ice crystals, dust particles or ash from biomass burning. The complex refractive index determines if fog droplets are mixed with either dissolved or insoluble material. In addition to its unique measurements of polarized, scattered light from individual particles, the integrated wind sensor detects the direction and velocity of the wind, and this direction is used to rotate the GFAS on its base to point into the wind and avoid inertial separation and bias.

This presentation will use data from preliminary field measurements to highlight the unique features of the GFAS, including auto-calibration and extraction of index of refraction.

Authors

Hughes, D. and Baumgardner, D.

Fast-SRI fusion PTR-ToF 10K: Improved monitoring of VOC

Markus Leiminger
Ionicon Analytik

We present a novel instrument for detecting volatile organic compounds on a molecular composition level in real-time based on proton-transfer-reaction mass spectrometry (PTR-MS). PTR-MS is a soft chemical ionization technique that gained growing attention in recent years because of its capability to quantitatively measure gaseous samples in lowest concentrations without any pre-preparation.
This instrument, the so-called FUSION PTR-TOF 10k, combines several enhancements compared to state-of-the-art PTR-MS technology: an optimized Fast-SRI (selective-reagent-ion) ion source capable of fast switching between four ionization modes with H3O+, NH4+, NO+, and O2+ primary reagent ions (>98% purity); and a novel reaction chamber called FUSION where a traditional DC drift field can be superimposed with RF voltage creating a fully-controlled environment for ion-molecule reactions. Still, only FUSION provides the essential clean ion chemistry with ion-molecule reactions at predictable reaction rates and energies that are crucial for quantitative operation of a PTR-MS.
The performance of the FUSION PTR-TOF 10k was characterized using a 12-component gas standard. We found lowest limits of detection (<1 pptV in 1 s) and sensitivities >70,000 cps ppbV-1 while conserving the qualities of a traditional PTR-MS. Using pure chemicals, interferences with neutral radicals like OH or O3 are determined to be well below 0.5%, e.g. DMS and limonene show interferences of DMSO and DMSO2 of 0.06% and 0.04%, and limonene oxide levels of 0.13%. The unique capabilities of FUSION PTR-TOF 10k are demonstrated via a one-week characterization of ambient air in Innsbruck, Austria. Based on this dataset we present the linear detection capability of this instrument down to 100 ppqV levels even when characterizing complex VOC mixtures with multiple isobaric interferences.
Concluding, this FUSION PTR-TOF 10k fuses the advantages of a well-studied ion-chemistry of a traditional PTR-MS with the high sensitivities and low limits of detection of a (near-) atmospheric pressure CIMS.

Authors

Leiminger, M., Reinecke, T., Müller, M.

Quantification of extractive electrospray ionization to determine monomer / dimer distributions in secondary organic aerosol

David Bell
Paul Scherrer Institute

Quantification of electrospray ionization techniques is difficult and generally requires authentic standards to be confident in identification and sensitivity. However, when applied to systems comprising a mixture of unknowns, such as atmospheric aerosols, quantification and disentangling mass spectra represents a daunting task.

Measurements were performed using an extractive electrospray ionization time-of-flight mass spectrometer (EESI-ToF), along with a scanning mobility particle sizer (SMPS) and aerosol mass spectrometer (AMS). The intensity measured by the EESI was compared to the SMPS and AMS to assess the sensitivity of the EESI toward different compounds. A series of experiments were performed using a mixture of known standards (polyethylene glycol – PEG 300). For PEG-300, we show we can constrain the EESI sensitivity to each PEG sub-unit present.

Additionally, we performed experiments with secondary organic aerosol generated from the ozonolysis of a α-pinene in an atmospheric simulation chamber. Instead of providing quantification on a molecular level, the molecular constituents are aggregated according to their volatility (e.g. monomers, dimers, trimers, etc…) For α-pinene SOA, we show the EESI-TOF initially measures 60.1% monomers, 33.4% dimers, and 7.5% trimers and tetramers, but after sensitivity correction the distribution present from SOA in our experiment is 37.4% monomers, 56.1% dimers, and 6.5% trimers and tetramers. These results provide a path forward for quantification of aerosol components with the EESI-TOF in other applications and potentially for atmospheric measurements.

Authors

Bell, D. M., Zhang, J., Surdu, M., Top, J., Bogler, S., Slowik, J. G., Prevot, A. S. H., El Haddad, I.

Laboratory characterization of SOA tracers from biogenic precursors using a Proton Transfer Reaction Mass Spectrometry coupled to a Charon inlet

Maria Carolina Ramirez Romero
Max Planck Institute for Chemistry MPIC / IMT Nord Europe

Globally, organic aerosol (OA) particles contribute between 10-90% of submicron particulate matter (PM1), depending on ecosystems and atmospheric conditions. OA consists of a complex mixture of thousands of molecules from different sources and atmospheric transformation processes. OA can originate from direct emissions, such as combustion, cooking, and biological activity, and is then referred to as primary organic aerosols (POA). It can also be formed in the atmosphere through the oxidation of volatile organic compounds (VOCs) and subsequent condensation and is then referred to as secondary organic aerosol (SOA). These transformations involve multiple oxidation reaction pathways in the gas phase that decrease their volatility and promote the condensation and reactive uptake reactions in the particle phase.

Despite the current knowledge, the SOA mixture's complexity, growth mechanisms, evolution, and multi-phase chemistry involved hinder a detailed characterization of the SOA. Mass spectrometric techniques coupled to Aerosol inlets with thermo desorption (TD) systems, for instance, have allowed the identification of tracers and low-volatility species at the molecular level in the particle phase. A notable example is the CHemical Analysis of aeRosols ONline (CHARON) coupled to a proton-transfer-reaction time-of-flight mass spectrometer PTR-QiTOF-MS which can measure and chemically characterize sub-micrometer particles in real-time.

Here we present for the first characterization of a range of SOA from biogenic precursors employing PTRMS-CHARON. In the Teflon DOUAIR Chamber (Douai, France), we explore the reaction pathways for the monoterpene ozonolysis and the isoprene SOA formation through IEPOX and non-IEPOX mechanisms. For example, during IEPOX-SOA formation experiments, m/z 83.049, m/z 101.062, and m/z 117.055 were identified, whereas monoterpenes ozonolysis experiments identified m/z 87.044, m/z 99.044, m/z 153.09. This presentation will focus on the chamber experiments, the results and proposed usage for interpreting field campaign observations.

Authors

C. Ramirez-Romero, J.F. de Brito, S. Dusanter, M. Jamar, A. Tomas, H. Bouzidi, A. Lahib, L. Fayad, C. Pöhlker and S. Sauvage

Multiple reagent ions at once: New fast-switching chemical ionization mass spectrometer for OVOC and Inorganics

Leah Williams
Aerodyne Research, Inc.

Measurements of volatile organic compounds (VOC) at different levels of oxidation and inorganic compounds are critical for understanding the atmospheric pathways from precursors to new particle formation. Chemical ionization mass spectrometry is a powerful technique that can, depending on the reagent ion used, measure across a wide range from very volatile to highly oxygenated low volatility species. However, accessing different parts of the volatility spectrum requires either multiple mass spectrometers or switching reagent ions, a process that can take minutes to hours. Tofwerk has recently developed the Vocus Adduct Ionization Mechanism (AIM) inlet and coupled it to a fast polarity switching time-of-flight mass spectrometer, enabling simultaneous detection of positive and negative ions. We recently deployed the new fast switching CIMS (FS-CIMS) on a field campaign in Antarctica and collected data with three reagent ions, iodide (I-), benzene (C6H6+), and acetone dimers ((C2H6O)2H+), at a 2 second data acquisition rate. We will present preliminary results demonstrating the capability of this instrument for ambient detection of low concentrations of inorganics, such as NH3 and DMS, and oxygenated organics.

Authors

Leah Williams, Manjula Canagaratna, Anita Avery, Mitch Alton, Phil Croteau, Harald Stark, Felipe Lopez-Hilfiker, Veronika Pospisilova, Urs Rohner, John Jayne and Doug Worsnop

Quantification of atmospheric trace gases using filter based thermal desorption multi-ion scheme chemical ionisation

HJ Jost
Karsa Ltd

The quantitative detection of atmospheric trace gases that are relevant to climate and air quality remains a challenge, often because of only minute concentrations and the spatial variability of abundances making it difficult to collect representative data.
There is a need for instrumentation that combines sensitivity, selectivity, ease of operation, and cost-efficiency.
The approach of filter sampling allows the collection of a large set of field samples for the centralized offline-analysis under well-controlled laboratory conditions.
We developed instrumentation and a measurement strategy that (1) maximizes the retention of ambient trace gases to tenax filters, (2) thermally desorbs the collected filter deposit, (3) prepares the analyte for mass-spectrometric detection using a high-efficiency multi-scheme chemical ionization inlet, and (4) unambiguously analyses the composition using a high-resolution mass spectrometer.
The chemical ionization inlet and mass spectrometer allow to rapidly switch between reagent ions - including ions of different polarity - to leverage compound-specific sensitivities.
In pilot experiments investigating pesticides and chemical warfare agents, we show that the methodology is selective and sensitive for a wide range of chemical compounds. The measurement approach combines the proven measurement approach of chemical ionization mass spectroscopy (employing MS-MS to further identification) with the flexibility to collect filter samples virtually anywhere and on any platform. Therefore, the technique is likely also useful for the characterization of the air composition and air quality.

Authors

HJ Jost, Joona Mikkilä, Fariba Partovi, Jussi Kontro, Henning Finkenzeller, Juha Kangasluoma

PMEYE: A novel commercial LIDAR scanner for PM Pollution monitoring in Urban and Industrial environments

Vassilis Kostopoulos
Raymetrics S.A.

Particulate Matter (PM) pollution adverse effects on human's health, wellbeing and economy are well known and accurate mapping is essential to monitor, enforce air quality regulations and mitigation measures, and minimize citizen's exposure.

While low-cost sensor technologies can provide real-time PM measurements and allow higher spatial coverage than the traditional in-situ methods, they also have several weaknesses such as questionable data quality compared to regulatory-grade instruments, inability to detect large particles, high uncertainties and require regular and frequent maintenance and field calibration which can be challenging and costly. Remote sensing PM from space also has several limitations, with spatial resolution typically of the order of several kilometers, infrequent coverage for short-term pollution events or diurnal variations monitoring and limited usefulness for monitoring aerosols close to the ground.

Remote sensing of PM absolute concentrations at the horizontal plane addresses the need of continuous wide area monitoring right above urban and industrial sites, with high accuracy, spatial and temporal resolution. Raymetrics PMeye lidar is a novel, state-of-the art, commercial scanning lidar system that successfully tackles this goal. Designed around a state-of-the-art polarization scanning UV lidar. PMeye uses an innovative inversion scheme for transforming raw signals to PM concentrations and offers large area PM concentrations monitoring and high spatial resolution (minimum radial 3.75m and azimuth 0.1°) sources localization. The system is designed for 24/7 unattended operation and its quality is assured using the EARLINET/ACTRIS Quality Assurance procedures.

The achieved range, spatial resolution, Signal to Noise Ratio (SNR) and scanning duration mainly depend on the sector range, the desired azimuth step and acquisition time per step. For example, using 2.5° azimuth step and 6 seconds acquisition time, the range of detection with SNR over 10 in a moderate polluted atmosphere will be around 3 km and a 360° scan could be repeated every 30 minutes.

Following data acquisition, PMeye runs automatic data processing, using a chain of processors to retrieve higher-level products from the raw lidar signals. All data are available in NetCDF4 format, and their internal structure follows the Climate & Forecast (CF) convention. Basic signal processing at levels L1a (dark correction, background subtraction, range corrected signal) and L1b (gluing, total signals and depolarization ratio) is followed by level L2, where optical and microphysical quantities like backscatter coefficient and particle concentration are produced.

Aerosol concentration retrievals is being performed using a two-step approach. First, a proprietary novel inversion algorithm estimates the aerosol backscatter coefficient based on raw lidar signals, treating the inversion as an optimization procedure, and regularizing the solution based on physical considerations. In this way, the inversion runs without explicit boundary conditions, as typically required by vertical lidar inversion schemes. The second step is to derive source-specific calibration factors based on reference measurements, performed alongside a portable in-situ PM counter sensor.

The achieved accuracy and effectiveness of PMeye in highly variable in terms of emission sources and in urban and industrial environment will be presented. Finally, PMeye monitoring in Cyprus is planned during Horizon 2020 funded project "Edu4Climate" late in 2023.

Authors

V. Kostopoulos, G. Georgoussis, O. Soupiona

Absolute humidity comparison between cellular microwave link measurements and Israeli meteorological service stations measurements in Jerusalem

Konstantin Romantsov
Tel Aviv University

This work is part of the I-CHANGE Living-Labs project in Jerusalem-Israel, our work with citizens spread to the cellular providers as well. Using the data from the cellular networks, it is possible to monitor humidity in high-resolution unlike with surface station's low spatial resolution observations.
Humidity is an important variable in atmospheric processes and is related to the development of clouds and rain. The humidity above ground level is highly influenced by surface characteristics and measuring the near-surface humidity at high resolution, where most of the sinks and sources of humidity are found can be done via a new approach of the usage of commercial microwave links (CML), which are a large part of the cellular networks backhaul.
The data used includes values of the Absolute Humidity (AH) measured at four different links at and around the IMS station (Israeli Meteorological Service). Using said data, plots were created which show the AH values for each link against the AH values measured via the IMS stations, and the differences between the AH measured for the links and stations. The mean AH values are used to find correlation between the measurements of CML and of IMS stations, as well as their RMSE. By averaging the finds we see how accurate the CML measurements are against the IMS stations measurements.
Surface stations which are few in numbers provide point observations, thus they suffer from low-spatial representation, on the contrary CML data is high-resolution measurements and there are many such links. Therefore, cellular networks data represents reality more fully than surface stations.
Results show that the AH derived from the CMLs are similar to the IMS AH, this shows that the CML data is mostly accurate and can be used, especially at places that have many cellular links and no meteorological stations available.

Authors

Romantsov, K. Alpert, P. and Rubin, Y.

Profiling atmospheric fluorescence: A key for improving our knowledge on aerosols and their interactions with the environment

Qiaoyun Qiaoyun
CNRS-University of Lille-LOA

Lidar technology is the only technique capable of accessing the vertical distribution of aerosols. However, the lidar still suffers from handicapping limits (low level of automation, reduced quantity of accessible quality information. The research and innovation activities, carried out by LOA in the frame of the CaPPA project led to the creation of a joint AGORA-Lab laboratory combining expertise and forces of the LOA and the CIMEL company. In particular, in the field of atmospheric observation by Lidar, with the development, supported by the national initiative OBS4CLIM-ACTRIS, and the promotion of a new class of multi- spectral Mie-Raman-Depolarized-Fluorescence lidar. Such instrument has shown the relevance of combining fluorescence, elastic and Raman scattering to study aerosol (Veselovskii et al., 2020), more precisely organic aerosols such as i) biomass burning aerosols (Hu et al., 2019; 2022, Veselovksii 2023a) and their interaction with ice particles in cirrus cloud (Veselovskii et al., 2022), ii) pollen (Veselovskii et al., 2021). This enhanced information allows improvement of the retrieval of aerosol microphysical properties (Chang et al., 2022), aerosol classification at much better time resolution (Veselovskii et al., 2023b) and the detection of aerosols particles within cloud layers. All these results demonstrate the relevance of the proposed instrumental concept to overcome the current limits of lidars, in terms of automation of measurement, processing and performances to better assess aerosol properties. This partnership is at the origin of the CE710 industrialized product, flexible, automated for operational purposes. The presentation aims to share results and potentials offered by this new instrumentation.

Authors

Hu, Q., Goloub, P., Veselovskii, I., Podvin, I., Victori, S., Popovici, I., Dubois, G., Boissière, W., Miri, R., Chang, Y., Ducos, F.

Possibilities of modern ceilometers

Minttu Tuononen
Vaisala Oyj

Ceilometers are known to be robust, stand-alone and cost-effective lidar-based remote sensing instruments. Typically, ceilometers are used in aviation to detect cloud base heights. Ceilometers are also used, however, for atmospheric profiling and the applications of profile information are increasing. Ceilometer attenuated backscatter profile data can be used to obtain much more information than simple cloud base heights. In this presentation, the focus is on new potential developments for operational ceilometer networks, such as the use of depolarization ratio profiles.

High-quality total attenuated backscatter profiles enable atmospheric profiling, including applications of cloud, boundary-layer, and elevated aerosol layer profiling. Further developments in conventional ceilometers, such as the addition of profiling capability to the depolarization ratio, enables more effective sensing of the atmosphere and new application areas can be more accurately covered. The depolarization ratio measurement capability enables differentiation of hydrometeors, especially differentiation of liquid and ice clouds, and precipitation type. These are important for a wide range of applications in the fields of aviation, meteorology, and air quality.

The differentiation of liquid cloud droplets and ice crystals and the differentiation of rain/drizzle and snowfall is now more accurate and easier with the depolarization measurement. In addition, the detection of the melting layer and potential icing conditions are easier to identify. The structure of the boundary layer and elevated aerosol layers can be monitored in more detail. The depolarization ratio measurement using a new wavelength can be used to investigate the aerosol characteristics and type.

In this presentation we demonstrate the depolarization ratio profile measurements using a CL61 ceilometer with depolarization ratio profiling capability. We show how different conditions can be distinguished – from hydrometeor and precipitation type analysis to measurement examples of forest fire smoke and dust.

Authors

M. Tuononen, R. Lehtinen, J. Kallio, P. Tuominen, R. Roininen

A lidar depolarization calibration using a reference system

Alkistis Papetta
CARE-C, The Cyprus Institute

Accurate characterization of lidar depolarization parameters is essential for quality measurements and for removing instrument artefacts. Such measurements serve as a great tool for the research community for classifying and quantifying different aerosol types like dust and volcanic ash. This presentation will provide an overview of a new approach of depolarization characterization by evaluating the system's gain ratio and channel cross-talk against a reference calibrated depolarization lidar, whereas the ±45° method requires a priori known system's cross-talk parameters. The method is utilized for the characterization of the Nicosia CIMEL CE376 lidar system, using a well-characterized lidar, PollyXT in Limassol, as a reference instrument.

We use observations of transported dust from desert regions for our calibration, with layers in the free troposphere. Above the boundary layer and the highest terrain elevation of the region, we expect that for long-transport aerosols, local effects should not affect the aerosol mixture, so that we can expect similar depolarization properties at the two stations in Cyprus: the Cyprus Atmospheric Observatory (CAO) of the Cyprus Institute (CYI) and the Cyprus Atmospheric Remote sensing Observatory (CARO) of the ERATOSTHENES Centreer of Excellence (ECoE) of the Cyprus University of Technology (CUT) which have a horizontal distance of about∼60km. Algebraic equations are used to derive calibration parameters from the comparison of the volume depolarization ratio of the two systems. The applied methodology offers a promising opportunity to evaluate the depolarization calibration parameters of a lidar system, in the case where a priori knowledge of the cross-talk parameters is not available. This method is applied retrospectively to the valuable measurements obtained for the past years, including the 2021 Cyprus Fall campaign, during which data were acquired during important dust events over Cyprus using UAV in-situ and ground-based remote sensing instrumentation.

Authors

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Mobile automated photometry: A key for improving our knowledge on aerosols distribution over the oceans

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Atmospheric aerosols play an important but difficult to understand role in bio-geo-chemical cycles, the Earth's climate and air quality. Their detailed characterization and monitoring are limited by several aspects of available measurement technologies. Space observation is global but its acuity is limited. Ground-based photometer networks (e.g AERONET) constitute a relevant support for the preparation and evaluation of space Earth observation missions, for the improvement of forecasts by atmospheric models and ultimately the improvement of knowledge on aerosols and their interactions with their environment. However, the vast expanses of the ocean, in particular the Indian and Southern Oceans, are almost not covered by systematic surface reference measurements. The research and innovation activities carried out by the LOA within the framework of the joint AGORA-Lab laboratory, combining the strengths of LOA and CIMEL company, have enabled the development of a maritime version of the CE318T photometer. First used in campaign mode, this autonomous equipment has now been in permanent operation on the Marion Dufresne R/V since the beginning of 2021, as part of the MAP-IO program. The instrument, compatible with AERONET, allows unique high frequency acquisition of aerosol optical thickness, water vapor and downward atmospheric radiance measurements. The presentation aims to share results offered by this instrument which, autonomous, can be deployed on different types of ships. In addition, we will show the planned developments that will allow its use on other types of mobile platforms (plane, car, etc.) and the relevance of its coupling with automatic mobile lidar.

Authors

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Aerosol and cloud monitoring by multi-wavelength Raman and Fluorescence LIDAR

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The ALHAMBRA system is a 3β+3α+2δ Dual-LMRD multispectral lidar (Raymetrics S. A., Greece) recently incorporated at the ACTRIS/EARLINET Granada station, Spain (37.164° N, 3.605° W), as part of the AGORA (Andalusian Global Observatory of the Atmosphere) Observational Facility. Not only does this advanced system incorporate depolarization capabilities, but also utilizes two different methodologies for fluorescence analysis, which results in a challenge regarding to aerosol and clouds observation [1].
The system includes two modules. The near-field module focuses on PBL, with the emission of laser radiation at 355, 532 and 1064 nm. The emitted pulses have 85.9, 82.4 and 105.9 mJ of energy, respectively, working at a repetition frequency of 20 Hz. It includes three elastic channels (355, 532 and 1064 nm), two N2 vibrational Raman channels of 355 (387) and 532 (607) nm and water vapor detection (408 nm). Depolarization capabilities are included in both 355 and 532 nm channels, being both signals split into both parallel and perpendicular components. The far-field module covers until low stratosphere with a powerful laser emitting at the same wavelengths than the near-field configuration. In this case, the energy is higher than previous one, with 229, 230 and 227 mJ per pulse, respectively, and a repetition frequency of 10 Hz. The detection is carried out by three elastic channels (355, 532 and 1064 nm), three N2 vibrational Raman channels of 355 (353.5), 532 (530.2) and 1064 (1056) nm. The 355 nm signal is split into parallel and perpendicular components. Linear particle depolarization ratio can be determined by two sub-systems and two different channels which is considered to be one of the most interesting approaches for aerosol characterization and aerosol-cloud interactions [2-4]. The presence of two modules within the same system enables a significant reduction in the full overlap height, currently about 200 m a.g.l., which allows for deriving information of the lowermost atmospheric layers. As an added value, it should be highlighted the near-field subsystem fluorescence capability, through a broadband interferential filter centered at 470 nm. Both subsystems can focus via optical fiber to HORIBA 1250M imaging spectrometer with two exchangeable gratings of 1200 and 300 g/mm. In case of operation with 1200 g/mm diffraction grating together with a 32-multi-anode PMT detector, the observation of a 20-nm spectral range with a resolution of 0.62 nm/channel is feasible.
The combination with another remote sensing and in-situ equipment is expected to be a great opportunity to deepen the knowledge of atmospheric processes [5].

Keywords: aerosol-clouds interaction, depolarization, fluorescence, Raman lidar, remote sensing

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