INNOVATION IN ATMOSPHERIC SCIENCES

18 May, Virtual Workshop

#EUGreenWeek

2021 PARTNER EVENT

ACTRiS

EMME-CARE
EASTERN MEDITERRANEAN MIDDLE EAST – CLIMATE & ATMOSPHERE RESEARCH CENTRE

The Cyprus Institute
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Book of Abstracts

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Welcome to the Innovation in Atmospheric Sciences Workshop

Dear Colleagues,
Dear Friends,

It is with great pleasure that we welcome you to our first Innovation in Atmospheric Sciences Workshop. First, we would like to thank all of you for your participation at the workshop. In this booklet we are delighted to share with you an exciting program, reporting the main innovations in the field of atmospheric sciences in the form of 30 talks and a selection of 23 virtual PICO presentations with recent relevant advances in the field.

All this has been possible thanks to your contribution.

We do hope that you enjoy your attendance at our Virtual Workshop!

Jean Sciare - CARE-C, The Cyprus Institute
Tuukka Petäjä – University of Helsinki

This workshop is funded by the European Union's Horizon 2020 research and innovation programme under grant agreements 871115 and 856612 and the Cyprus Government

Scientific Committee

Jean Sciare, CARE-C, The Cyprus Institute, *Cyprus*

Jean-Daniel Paris, LSCE (CEA-CNRS-UVSQ), *France*

Tuukka Petäjä, University of Helsinki, *Finland*

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Andri Charalambous, CARE-C, The Cyprus Institute, *Cyprus*

Program

OPENING SESSION

09:00	**Welcome & Introduction to the Workshop**	
	Workshop Introduction & Opening	**Jean Sciare** CARE-C, The Cyprus Institute
	R&I strategy of EU Research Infrastructures in Atmospheric Sciences	**Paolo Laj** Université Grenoble Alpes University of Helsinki

ORAL PRESENTATIONS

09:30	**International initiatives and opportunities**	
	ATMO-ACCESS TransNational Access Opportunities	**Sabine Philippin** CNRS
	The International Methane Emissions Observatory	**Stefan Schwietzke** Environmental Defense Fund
	PROBE: advancing ground-based atmospheric boundary layer profiling at the European scale through EU COST	**Simone Kotthaus** Institut Pierre Simon Laplace
	EUPHORE simulation chambers: An innovative tool for testing instruments and environmental solutions	**Amalia Muñoz** CEAM Foundation - EUPHORE Labs
	Research & Innovation Funding Opportunities in Atmospheric Sciences	**Pierantonios Papazoglou** CARE-C, The Cyprus Institute
10:30	**COFFEE BREAK**	
10:40	**Miniaturized in-situ atmospheric sensors**	
	Laser technology advances for UAV-based greenhouse gas analysis	**Frederic Despagne** ABB
	A new mobile platform of ACTRIS for UAV-based atmospheric profiling	**Maria Kezoudi** CARE-C, The Cyprus Institute
	Miniaturized air sampling techniques: Key to successful determination of Volatile Organic Samples in Air Samples	**Jose Ruiz Jimenez** University of Helsinki
	Characterization of a cost-effective condensation particle counter	**Juha Kangasluoma** University of Helsinki
	Miniaturized Sensors for Probing Air Quality: Potential Applications and Methods for Assessing their Performance	**Spyros Bezantakos** CARE-C, The Cyprus Institute
11:40	**New atmospheric database**	
	Towards an observation-based monitoring capacity for anthropogenic emissions of CO2	**Richard Engelen** ECMWF
	EUMETSAT Innovation in Aerosol and Cloud Characterisation	**Thierry Marbach** EUMETSAT
	Integrated In-Situ Observations, An Asset to Verify the Climate Policy Actions and Adopting Green Economy	**Hanna Lappalainen** University of Helsinki

	NRT provision of aerosol remote sensing profiles to CAMS: An ACTRIS/EARLINET pilot system	**Lucia Mona** CNR
12:20	**LUNCH BREAK**	
13:00	**Recent developments in Remote Sensing and Mass Spectrometry**	
	Tropospheric temperature and humidity profiling with a new compact, relatively low cost lidar system developed by Raymetrics S.A.	**George Tsaknakis** RAYMETRICS S.A.
	Innovation solutions for Air Quality monitoring and LIDAR calibration	**Guido Di Donfrancesco** ALA Advanced Lidar Applications s.r.l.
	Single analyzer for gas-phase and the condensed organics	**Jens Herbig** IONICON Analytik Ges.m.b.H.
	Observe twice as many molecular species with your high resolution mass spectrometer by using a MION?	**HJ Jost** Karsa Ltd
	Recent Developments for the Aerosol Chemical Speciation Monitor	**Philip Croteau** Aerodyne Research, Inc
14:00	**Advances in Atmospheric Modelling**	
	Aria Technologies: Experience In The Middle East And Latest Innovations In Air Quality Modelling	**Fanny Velay** ARIA Technologies
	Origins, monitoring the near-real-time greenhouse gas emissions for a low-carbon transition	**Jinghui Lian** Origins Earth
	Insights on multi-time resolution PMF: testing different time resolutions and uncertainty weightings	**Marta Via** IDAEA-CSIC
14:30	**COFFEE BREAK**	
14:40	**New in-situ aerosol instrumentation**	
	Harmonization of in-situ number concentration and size distribution measurement techniques	**Sebastian Schmitt** TSI GmbH
	The M2AS: Mass and Mobility Aerosol Size distribution measurement with the CPMA	**David Walker** Cambustion Ltd
	A dual-wavelength photo-thermal interferometer for the determination of aerosol optical absorption coefficient and the absorption agnstrom exponent	**Luka Drinovec** Haze Instruments d.o.o.
	Improved sampling of aerosol nanoparticles - Example of a collaboration between academic and industry	**Katrianne Lehtipalo** University of Helsinki & Finnish Meteorological Institute
15:30	**New in-situ gas instrumentation**	
	All-in-one instruments for monitoring of air pollutants and greenhouse gases	**Morten Hundt** MIRO Analytical AG
	SPECTRONUS™ - A high precision multi species GHG analyzer for the next generation of observation networks and process studies	**Jost Lavric** Ecotech
	Continuous Monitoring Of Greenhouse Gases And Hazardous Air Pollutants With Cavity Ring-Down Spectroscopy	**Magdalena Hofmann** Picarro
	Development of on-line and field TD-GC-FID/MS for automatic and continuous ambient air monitoring	**Franck Amiet** Chromatotec Group

vPICO SESSIONS

16:10	**New Analytical Techniques & Data Analysis**	
	Nanoscale IR-imaging and spectroscopic characterization of air-filtered pollution nanoparticles using s-SNOM	**Adrian Cernescu** Attocube systems AG
	Spectral Aerosol Optical Depth and Angstrom Exponent From Ground-Based Fourier Transform Infrared Spectrometry	**África Barreto** AEMET (Izaña Observatory)
	Intercomparison between online GC and PTR-TOF in a station of Switzerland's National Air Pollution Monitoring Network (NABEL)	**Felipe Lopez** TOFWERK AG
	Peak concentrations measured at a station of Switzerland's National Air Pollution Monitoring Network (NABEL)	**Mark Gonin** TOFWERK AG
	HERMES: an integrated tool dedicated to online data treatment and display of submicronic aerosol chemical composition	**Benjamin Chazeau** Aix-Marseille University
	A software tool for the aerosol microphysical retrieval from atmospheric lidar data	**Alessia Sannino** Università degli Studi di Napoli Federico II
	Combination of two Doppler lidars to simultaneously retrieve wind vector and turbulence	**Johannes Bühl** Leibniz-Institute for Tropospheric Research (TROPOS)
	Instrument combination through inversion methods: Innovative improvement of our understanding of aerosol dynamics	**Dominik Stolzenburg** Institute for Atmospheric and Earth System Research, University of Helsinki
16:30	**New Developments in Atmospheric Instrumentation and Infrastructure**	
	Characterization of a chemical modulation reactor for the measurement of atmospheric hydroxyl radicals with a laser-induced fluorescence instrument	**Changmin Cho** Forshungszentrum Juelich
	A new high-resolution sampler for the study of fine and coarse aerosol composition: STRAS (Size and Time-resolved aerosol sampler)	**Fabio Giardi** University of Florence
	The BOx of Clustered Sensors (BOCS). A low-cost air quality system for long-term monitoring	**Sebastian Diez** University of York
	Cork city's low-cost air sensor network shows PM2.5 levels vary significantly across the city	**Dean Venables** University College Cork
	Engineering, Construction, and Operation of Cloud Simulation Chambers for Atmospheric Research	**Ottmar Möhler** Karlsruhe Institute of Technology (KIT)
	Towards a new FRM4DOAS site in the Po Valley	**Paolo Pettinari** University of Bologna, ISAC-CNR
16:45	**Recent Research Achievements In Atmospheric Sciences**	
	High resolution unattended particle-bound total carbon measurements and source identification at the Jungfraujoch global GAW station	**Alejandro Keller** University of Applied Sciences Northwestern Switzerland
	The presence of microplastic in the Total suspended particles	**Jagoda Worek** AGH University of Science & Technology

	The feedback of clouds on the Heating Rate of black and brow carbon	**Luca Ferrero** University of Milano-Bicocca
	Dynamic of the atmospheric boundary layer over two rural sites with doppler lidar	**Pablo Ortiz Amezcua** University of Warsaw
	Modeling and spatial characterization of aerosol at Middle East AERONET stations	**Chukwuma Anoruo** University of Nigeria, Nsukka
	The characteristics of the urban atmosphere in Moscow megacity and their radiative and meteorological properties according to modelling and measurement in different conditions including the 2020 Spring lockdown due to COVID-19	**Natalia Chubarova** Lomonosov Moscow State University
	On the role of the ocean in simulating extreme atmospheric events	**Antonio Ricchi** University Of L'Aquila/CETEMPS
	Assessment of GHG emissions from transport sector of Azerbaijan	**Sadig Hasanov** The İnstitute of Radiation Problems
	Seasonality of PM10 sources at traffic and urban background air monitoring stations: Case study from Krakow, Southern Poland	**Lucyna Samek** AGH University of Science & Technology
17:10	**Q&A Parallel Sessions**	
17:30	**End of Workshop**	

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ORAL PRESENTATIONS

ATMO-ACCESS Trans-National Access Opportunities

Sabine Philippe

CNRS, France

ATMO-ACCESS is the organised response of the atmospheric research community to establish a comprehensive and sustainable framework for access to distributed atmospheric Research Infrastructures (RI). ATMO-ACCESS aims at ensuring integrated and facilitated access to the best atmospheric research facilities and at enabling an optimised use of the services they provide. ATMO-ACCESS will develop and test innovative modalities of access to facilities and complementary and more advanced services, including research, technological, training and digital services, developed as part of the cross-RI efforts. ATMO-ACCESS will open physical and remote access to 43 operational European atmospheric research facilities, comprising ground-based observation stations, simulation chambers, mobile facilities and central laboratories that are fundamental elements in distributed RIs. Innovative cross-RI cloud services and the use of new, integrated data products, but also virtual tools for training, are offered through virtual access. ATMO-ACCESS intends to facilitate access to wide user communities and to continuously engage with users from academia, public sector, business and industries, as well as with national and international stakeholders to propose optimal conditions for a coherent and effective framework of access. The project particularly enhances the innovation potential of atmospheric RIs by facilitating access to atmospheric research facilities that are of special interest to users from the private sector for technological developments, instrument testing, and development of new atmospheric measurement techniques. The overarching objective is to ensure a long-term sustainability of access within the European RI landscape.

The International Methane Emissions Observatory

Stefan Schwietzke
Environmental Defense Fund

The International Methane Emissions Observatory (IMEO) is a data-driven, action-focused mechanism that will accelerate reductions in methane emissions globally by integrating and reconciling various methane emissions data streams. By interconnecting robust data, scientific measurements, companies' reporting, and government action, IMEO will be a powerful agent for change in the ecosystem of partners and institutions engaged on the methane challenge. The core function of IMEO is to take near-real time data and integrate it to create a public dataset of empirically verified methane emissions, which will be done by taking multiple data streams and integrating them using advanced data science methodologies. It will provide a comprehensive understanding of where and how much methane is being emitted and will work with governments and companies around the world to connect these data to effective mitigation actions. This presentation will describe the three main data streams coming from intensive field studies, company reporting, and satellite data. A focus will be on insights derived from recent international oil and gas supply chain methane field measurements and satellite data, which provide examples of the types of data expected from future IMEO activities.

Authors

Schwietzke, S., Zavala-Araiza, D., Hamburg, S., Caltagirone, M.

PROBE: advancing ground-based atmospheric boundary layer profiling at the European scale through EU COST collaborations

Simone Kotthaus
Institut Pierre Simon Laplace (IPSL)

Atmospheric boundary layer (ABL) dynamics impact the transport of pollutants and greenhouse gases and are important for the understanding and forecasting of both weather and climate conditions. Despite its importance, the ABL continues to be the most under-sampled part of the atmosphere given surface sensor networks and satellite observations do not provide sufficient information on the high temporal variability and strong vertical gradients that characterise the ABL. Advances in ground-based atmospheric remote sensing now allow for profiles of temperature, humidity, wind, turbulence, clouds and aerosols to be measured at very high temporal and vertical resolutions. Information on spatial variability in ABL dynamics associated with geographic location and land cover characteristics are increasingly provided by coordinated measurement networks. the EU COST action PROBE (PROfiling the atmospheric Boundary layer at European scale) aims to enhance the exploitation of new remote sensing networks by facilitating the harmonisation of measurements, ensuring consistent quality control procedures, and by developing advanced data products. Through intense knowledge exchange with a wide range of end-users, PROBE aims to increase the use of innovative products from ground-based profilers in all European countries and beyond for a wide range of applications.
Here, we highlight how various technologies such as microwave radiometers, Doppler wind lidars, Doppler cloud radars, automatic lidars and ceilometers, water vapour lidars, or drones can help us gain insights into ABL processes and their implications for air quality and cloud dynamics by applying innovative data processing tools. Additionally, we show how harmonised network data can benefit model evaluation and data assimilation for various applications.

Authors

Authors: PROBE core group* and working groups' members
*PROBE core group:
Chair: Martial Haeffelin (IPSL, Palaiseau, France)
Vice chair: Domenico Cimini (CNR-IMAA, Potenza, Italy)
Grant Holder: Anca Nemuc (INOE, Bucharest, Romania)
WG1 chairs: Simone Kotthaus (IPSL, Palaiseau, France), Henri Diemoz (ARPA, Aosta, Italy)
WG2 chairs: Pauline Martinet (CNRM, Université de Toulouse, Météo-France, CNRS, Toulouse, France), Ewan O'Connor (FMI, Helsinki, Finland)
WG3 chairs: Anne Hirsikko (FMI, Helsinki, Finland), Ulrich Löhnert (IGM, University of Cologne, Cologne, Germany)
WG4 chairs: Christine Knist (DWD, Lindenberg, Germany), Christopher Walden (UK Research and Innovation and NCAS, Chilbolton Observatory, UK)
Science communication manager: Claudia Acquistapace (GM, University of Cologne, Cologne, Germany)
ITC Grant coordinator: Klara Jurcakova (CAS-IT, Prague, Czech Republic)
STSM coordinator: Iwona Stachlewska (University of Warsaw, Warsaw, Poland)
Training school coordinator: Ekaterina Batchvarova (BAS-CU, Sofia, Bulgaria)

EUPHORE simulation chambers: An innovative tool for testing instruments and environmental solutions

Amalia Muñoz

CEAM Foundation - EUPHORE Labs

New development of instruments requires thorough tests under real conditions and study of interferences before being released to the market and simulation chambers are very suitable for this purpose. EUPHORE comprises two of the major outdoor simulation chambers worldwide. Its features allow simulating quasi-real conditions thanks to its high volume (200 m3 each) and to the use of sunlight. The facility is equipped with a large number of analytical instruments, both well-stablished and state-of-the-art, and on-line and off-line techniques to characterize gas and particle phase compounds. These instruments include different monitors, optical systems (FTIR, DOAS, CEAS, LIF for OH and HO2 radicals), chromatographic techniques (HPLC, LCMS, GC-MS/MS, chromatographic techniques (HPLC, LCMS, GC-MS/MS), mass spectrometry (PTRMS and ToF, CIMS) and particulate matter instruments (TEOM, SMPS). This makes it a very effective tool for investigating environmental chemical and physical processes. Besides, EUPHORE plays an important role as testbed, allowing the intercomparison of instrumentation, with possibility of accommodating a large number of external instruments. It has demonstrated versatility and is continuously evolving to adapt to specific user's and industry demands. The chambers are a perfect scenario for the development and characterization of state-of-the-art research instruments and new technologies, including low-cost sensors, depolluting solutions, etc… and results can be easily transferred to reality, being a step close to market. This work presents the characteristics of the EUPHORE chambers as an innovative testing tool. Examples of collaboration through projects and with industries will be done, e.g. intercomparisons of different instruments for the measurement of aldehydes and OVOCs (oxygenated volatile organic compounds), assessment of the effectivity of photocatalytic materials (textiles, outdoor furniture) to remove NOx, test of commercial CO2 sensors motivated by their use as a measure of ventilation to fight the COVID-19 pandemic, test of an instrument to measure different aromatics, etc.

Authors

Amalia Muñoz, Mila Ródenas

European Funding Opportunities for Climate and Atmosphere Research

Pierantonios Papazoglou

Climate & Atmosphere Research Centre of Excellence - The Cyprus Institute, Cyprus

The European Union offers a variety of Funding Opportunities targeting to support scientific research and innovation. The presentation will briefly showcase "Horizon Europe", as the latest competitive Framework Programme for funding R&I, and it will focus on Pillars, Clusters and thematics of interest to Climate and Atmosphere Research.

Authors

Papazoglou, P.; Christou, M.T.; Papageorgiou, M.; Charalambous, A.; Nicolaou, S.; Manoura, M.

Laser Technology Advances for Uav-Based Greenhouse Gas Analysis

Frederic Despagne
ABB

We present applications of an innovative analytical solution that combines patented laser technology, wind velocity, Global Navigation Satellite System sensors and advanced data analytics for airborne quantification of greenhouse gas fluxes or natural gas leak detection in hard-to-reach locations. The compact trace gas analyzer is designed to operate on low-cost commercial unmanned aerial vehicles capable of carrying a payload of 3 kg. It provides spatially resolved concentration measurements -as opposed to path-averaged approximation- by rapidly sampling the local air as it flies.

Authors

Baer D., and Despagne, F.

A new mobile platform of ACTRIS for UAV-based atmospheric profiling

Maria Kezoudi

Climate and Atmosphere Research Center, The Cyprus Institute, Cyprus

In-situ data can provide a great deal of information about the atmospheric environment that affects almost all aspects of human life. Although, there is a clear lack of measurements conducted within the first kilometres of the troposphere. Unmanned Aerial Vehicle (UAV) sensor systems can provide cost-effective vertically-resolved in-situ atmospheric observations which are essential for ground-based observational platform networks.
The Unmanned Systems Research Laboratory (USRL; https://usrl.cyi.ac.cy/) of the Cyprus Institute is a new mobile exploratory platform of the EU Research Infrastructure Aerosol, Clouds and Trace Gases Research InfraStructure (ACTRIS). This offers UAV-sensor solutions that can be used everywhere in Europe for intensive field campaigns through a transnational access scheme and compliance with the drone regulation set by the European Union Aviation Safety Agency (EASA).
Since its establishment in 2015, the USRL is participating in national and international research projects dedicated to:

1) the better understanding of aerosol-cloud interactions (EU FP7 BACCHUS)
2) the profiling of aerosol absorption properties in contrasted atmospheric environments (H2020 ACTRIS-2)
3) the vertical distribution of air pollutants below and above the planetary boundary layer over Cyprus (national RIF AQ-SERVE and ACCEPT)
4) the aerosol size distribution over the Mediterranean Sea / Red Sea, and Arabian Gulf (AQABA oceanographic cruise)
5) the validation of Aeolus satellite (dust) products (ESA project ASKOS)
6) the characterization of ship emissions (JPI Oceans Mate)
7) the provision of transnational access for research, development, and training (EU H2020 ACTRIS IMP and ATMO-ACCESS).

Authors

Kezoudi, M., Keleshis, C., Vrekoussis, M., and Sciare, J.

Miniaturized Air Sampling Techniques: Key To Successful Determination Of Volatile Organic Compounds In Air Samples

Jose Ruiz Jimenez
University of Helsinki, Finland

For the understanding of the fundamental science of atmosphere, indoor and outdoor air quality and diseases diagnostic, comprehensive and time-dependent information (e.g. chemical composition, concentration) of volatile organic compounds (VOCs) in atmospheric, indoor and breath air is needed. The collection of ambient air samples plays an important role in air analysis and miniaturized air sampling (MAS) techniques, based on miniaturized samplers and configurations, have been developed to overcome the problems related to conventional air sampling systems, such as their size, long sampling times, high cost, and artifacts. In addition, the sampling steps can be simplified and fully automated. MAS techniques can be also on-line coupled with analytical instruments for in-situ analysis, resulting in reduced analysis time, errors, and labor-cost. Further, the sampling and sample preparation steps are then merged into one step decreasing even further the total analysis time and total analytical errors. Solid phase microextraction Arrow (SPME-Arrow) and in-tube extraction (ITEX) systems belong to MAS techniques, and the selection of coating/packing materials affect their selectivity towards different compounds and the sensitivity of the method and offers great flexibility. They can be used also in combination with other carrier devices, such as aerial drones, allowing their exploitation in remote and/or difficult access areas. Moreover, their simultaneous use enables the clarification of the distribution of VOCs between gas phase and particles. The useful sampling accessories in ITEX can improve its performance even further by removing gas phase compounds or aerosol particles, air moisture, and/or by protecting samples from side reactions during the collection. Other common problems, related to the reliability of the identification and quantitation of a large number of compounds can be partially overcome by strict and well documented criteria during data processing and machine learning tools, even in the absence of standards and reference materials. The MAS systems with miniaturized pumps, integrated with separation techniques and detectors, open up new avenues for the development of novel, efficient and reliable hand-held total analysis systems for air analysis.

Authors

Pusfitasari, Eka Dian; Ruiz-Jimenez, Jose; Jussila, Matti; Hartonen, Kari; Riekkola, Marja-Liisa

Characterization of A Cost-Effective Condensation Particle Counter

Juha Kangasluoma

University of Helsinki, Finland

Particulate pollution causes millions of premature deaths annually. Particulate monitoring efforts are focused at monitoring particulate mass below 2.5 micrometers, which on large parts omits the potential adverse health effects caused by the submicron particles. Lack of cost effective instrumentation for the submicron particles prevents large scale monitoring efforts of submicron particles, and therefore assessment of their potential adverse health effects. The purpose of this study is to build and optimize condensation particle counting technology for cost-effective and large scale monitoring of submicron particles.
The CPCs count particles by first growing the particles using typically butanol, and subsequently optically detect the droplets. Our CPC simplifies the optical design and other aspects of the technology to lower the manufacturing costs, and optimizes butanol consumption for minimum operational maintenance costs.
Laboratory characterization of the instrument demonstrates accurate single particle counting up to around 10 000 particles per cm3, and accurate measurement of larger concentrations using the photometric mode.
Once commercially available, the CPC will likely reduce the costs of establishment and operation of large scale submicron particle concentration monitoring networks.

Authors

Kangasluoma, J., Wu, Y., Haataja, J.

Miniaturized Sensors for Probing Air Quality: Potential Applications and Methods for Assessing their Performance

Spyros Bezantakos

Climate and Atmosphere Research Center, The Cyprus Institute, Cyprus

Recent advances in aerosol science and technology have led to the development of an array of miniature, lightweight and low-cost sensors for probing air quality. These sensors can be employed for increasing the temporal/spatial resolution of air quality measurements in complex and/or highly variable environments, both outdoors and indoors and/or for assessing personal exposure. In addition, these sensors can be employed onboard lightweight, unmanned aerial systems (UASs) for probing the air quality on the vertical plane. The operating principles and materials of these sensors are primarily selected for achieving high portability, minimum cost and energy consumption. However, such an optimization may lead in compromising their performance in respect to laboratory grade/standard and scientifically proven, air quality instruments. Therefore, the performance of these low cost-sensors should be evaluated by taking into account their potential application(s) in relation to the desired level of accuracy. Under such evaluations, it is also important to highlight the causes that contribute into a sensor's performance deterioration, since this may contribute to further developments that will improve its performance, after - for example- minor modifications. In this work, we propose different methods for assessing the performance of miniaturized and low-cost sensors with respect to their potential applications, while highlighting the abilities for improving their performance by simple modifications. In brief, we have developed a protocol for assessing the accuracy of low cost gas and particulate matter (PM) sensors, under different conditions (i.e., temperature, relative humidity; RH and pressure), thus emulating real-life ground and aerial sampling conditions) These observations, obtained under well-defined conditions, can significantly contribute in revealing the potential causes that affect the low-cost sensors performance, leading to potential improvements.

Authors

Bezantakos, S., Papaconstantinou, R., Hadjigeorgiou, N., Erotokritou, K., Costi, M. and G. Biskos

Towards an observation-based monitoring capacity for anthropogenic emissions of CO2

Richard Engelen
ECMWF

To enable the European Union (EU) to move towards a low-carbon economy and implement its commitments under the Paris Agreement, a binding target to cut emissions in the EU by at least 55% below 1990 levels by 2030 was set by the European Commission. This was consolidated with the release of the Commission's European Green Deal in December 2019, setting the targets for the European environment, economy and society to reach zero net emissions of greenhouse gases in 2050, outlining all needed technological and societal transformations that are aiming at combining prosperity and sustainability.
To independently assess the progress of countries and regions towards their targets, an objective way to monitor anthropogenic CO2 emissions and their evolution over time is needed. Such a capacity would deliver consistent and reliable information to support informed policy- and decision-making processes, at national and European level, but also addressing user requirements at smaller (e.g., cities) and global scales. The Commission is therefore establishing an observation-based operational anthropogenic CO2 emissions Monitoring and Verification Support capacity (CO2MVS) as part of its Copernicus programme.
The 'Prototype system for a Copernicus CO2 service' (CoCO2) project, which started in January 2021, builds on the recommendations from the CO2 Task Force and the developments and recommendations from the EU Horizon 2020 research projects CHE and VERIFY, to deliver further research activities and prototype systems for the CO2MVS that can be implemented by the Copernicus programme as a pre-operational service by the end of the project. We will describe the plans and recent results of CoCO2 with a special focus on some of the innovative aspects needed to provide policy-relevant information using such an integrated system approach.

Authors

Engelen, R.

EUMETSAT Innovation in Aerosol and Cloud Characterisation

Thierry Marbach
EUMETSAT

Aerosol composition and associated spatial distribution are key parameters for the improvement of the air quality and climate products. Therefore, EUMESAT will increase the number of parameters provided operationally. EUMETSAT currently releases two operational products from EPS and Sentinel-3 satellites. First, the Polar Multi-sensor Aerosol product (EPS/PMAp) combines GOME-2, AVHRR, and IASI measurements to derive the AOD based on a synergistic use of the spectral and spatial information. Second, the AOD is derived from the dual-view scanner SLSTR. The products together provide complementary information on aerosol type, are operational over ocean and demonstrational over land. In the near future, a new generation of aerosol products will be derived from EPS-SG sensors and will complement the operational product suites. The 3MI polarimeter will allow a better description of the microphysics and improved AOD. The Multi-sensor Aerosol Product (MAP) will combine 3MI, METimage, IASI-NG and Sentinel-5 observations and provide a unique improved aerosol characterisation like fine mode fraction, refractive and absorbing index. Also aerosol layer height will be retrieved providing new possibility for aerosol altitude estimation towards clouds.
As a key parameter for almost all product generation from satellite imagery the identification, or masking, of cloud presence per pixel is available for all EUMETSAT sensors. Cloud properties such as pressure, optical depth and micro-physics are produced for MSG SEVIRI and will continue with the next generation imagers FCI and METimage with improved spectral and spatial capabilities. A key addition for METimage will be cloud top pressure derived from the oxygen absorption band and whilst initially this will provide a standalone estimate, it is planned to integrate this novel and complementary information into the standard visible-infrared products aiding the characterisation of the vertical structure especially in the case of multi-layer cloud.

Authors

Bertrand Fougnie, Philip Watts, Thierry Marbach, Loredana Spezzi, Soheila Jafariserajehlou, Margarita Vazquez Navarro, Julien Chimot, Alessio Bozzo, John Jackson, Andriy Holdak, Hans-Joachim Lutz, Gillali Abdelaziz, Bojan Bojkov

Integrated In-Situ Observations, An Asset to Verify The Climate Policy Actions

Hanna Lappalainen

University of Helsinki, Finland

"INAR at the University of Helsinki runs a comprehensive, integrated in-situ observation system called Station Measuring Ecosystem Atmosphere Relations (SMEAR) in Hyytiälä, Finland called SMEAR-II. The year around measurements, carried out 24/7, are an ensemble of the ICOS, ACRIS and eLTER standardized measurements together with meteorological observations. SMEAR-II station has proved to be a novel big data pool and a unique asset to tackle land – atmosphere interactions and feedbacks relevant to global climate and air quality. The Paris Agreement sets framework for the climate policy targets keeping the global warming below 2 degrees. As known the factors effecting the climate warming are connected to greenhouse gas and atmospheric aerosol concentrations in the atmosphere. The atmospheric composition is adjusted by complex interactions and feedbacks between Earth surface and atmosphere and by the anthropogenic emissions. In order to better meet the future needs for the atmospheric- ecosystem monitoring and to verify the effects of the climate policy actions we need SMEAR-II type of comprehensive measurements. Furthermore, to be pro-active in our climate actions we need, at the same time, big data to increase our scientific understanding of the atmospheric system. The spearheading companies are looking for new innovative for the sustainable operations, and explore ways to determine verify their carbon footprint. Recently established Atmospheric Climate Competence (ACCC) is developing a novel concept to allow companies working in the forestry sector and other land use related businesses to take advantage of the comprehensive measurements towards carbon neutrality. The ACCC is testing and piloting the measurement techniques on the forest and agriculture surfaces land exploring up-scaling of these concepts in a global context."

Authors

Hanna K. Lappalainen, Jaana Bäck, Anna Lintunen, Joni Kujansuu, Sami Paatero, Tuukka Petäjä and Markku Kulmala

NRT Provision of Aerosol Remote Sensing Profiles to CAMS: An ACTRIS/EARLINET Pilot System

Lucia Mona

CNR

A pilot provision of ACTRIS/EARLINET aerosol optical properties profiles to CAMS started in October 2020. Starting from very heterogeneous lidar stations in terms of system set-up and data processing, large efforts were done in ACTRIS/EARLINET over the years for gaining in harmonization of the data processing and provision. Nowadays, ACTRIS/EARLINET has reached a degree of maturity that makes it suitable for near real time data provision.

The activities are focused on the automatic centralized data processing and data provision, ensuring the full traceability of the products from the data acquisition level up to the final quality-controlled data level. New modules and submodules of the ACTRIS/EARLINET Single Calculus Chain (SCC) as well as optimized algorithms for cloud screening have been designed for the provision. Additional procedures were implemented for improving the quality of data provided in NRT, and for the quality control of the Level 2 products (delivered with 6-month time delay).

For accommodating also measurements from non-continuous operation systems, a measurement schedule has been set up, compromising between the need of a large number of measurements and costs/efforts at each station. The measurement schedule has been designed through a representativeness study and foresees 6 slots of measurements per week, 3 in daytime and 3 in nighttime conditions.

Data provision started in October 2020 at the test site of Potenza. In January 2021, the provision started for a group of 9 stations which are seen as representative for the whole network in terms of instrumental capability, but also ensuring a good geographical coverage of the European continent.

Provision of aerosol optical property profiles are of interest for the assimilation, near real time evaluation and re-analysis evaluation of several CAMS products, like the aerosol load over Europe for air quality issues, atmospheric composition, climate forcing and solar and UV products.

Authors

Mona L., D'Amico G., Gagliardi S., Amato F., Amodeo A., Ciamprone S., De Rosa B., Ripepi E., Summa D., Alados-Arboledas L., Amiridis V., Baars H., Kompula M., Mattis I., Nicolae D., Pietras C., Stachlewska I., Peuch V.H.

Tropospheric Temperature and Humidity Profiling with a New Compact, Relatively Low Cost Lidar System Developed by Raymetrics S.A.

George Tsaknakis

RAYMETRICS S.A.

A new lidar system has been developed by Raymetrics S.A. capable of metigating scientific requirements in a robust and cost-effective way.
The new system has the capability of providing profiles of:

- temperature,
- water vapor mixing ratio & relative humidity,
- aerosol optical properties (backscatter, extinction, depolarization).

The system is based on the Rotational Raman technique for temperature sensing and uses as light source a SLM Nd:YAG laser emitting UV radiation @ 355nm.
Instrument development follows thorough Quality
Assurance and Quality Control procedures, and conforms to EARLINET /ACTRIS standards.

Authors

Tsaknakis G., Binietoglou I., and Georgoussis G.

Innovative Solutions for Air Quality Monitoring and Lidar Calibration

Guido Di Donfrancesco

ALA Advanced Lidar Applications s.r.l.

"The LIDAR market is constantly growing, according to both increasing fields of Lidar applications, ranging from aerospace to terrestrial air quality monitoring, and development of new technologically innovative products. This is where ALA - Advanced Lidar Applications - company comes offering the international market its technologically advanced systems, characterized by compactness, lightness and easy portability.

A critical aspect of Lidar systems in retrieving the atmospheric parameters with a high level of accuracy, consists of the integration inside one device of a wide number of independent components that have to work well all together. So a Lidar system needs periodic control on optical and electronic components and in addition a comparison with a “Reference System” (when Lidar is part of an international network), in order to keep the highest quality of the measures and to ensure measure compatibility among several Lidars operated all over the world.

In this context a Lidar echo simulator would represent a breakpoint for testing LIDAR systems components, such as the optical alignment of the receiver unit, the linearity of the acquisition system and the calibration of all the optical parameters likely representing the main source of bias in LIDAR measurements.

We report on design of both the ultra-compact transportable LIDAR systems for environmental applications and the LAST-LidAr SimulaTor, recently developed by ALA for the national and international market."

Authors

G. Di Donfrancesco, P. Castellano, C. de Marco, F. Di Guida, G. Passeggio

Single Analyzer for Gas-Phase and The Condensed Organics

Jens Herbig

IONICON Analytik Ges.m.b.H.

"Proton-Transfer-Reaction Time-of-Flight Mass Spectrometry (PTR-TOF) is a highly sensitive and robust technique for real-time monitoring of the plethora of atmospheric non-methane organic compounds at pptV levels and below. IONICON Analytik, based in Innsbruck (Austria), is the market-leader in PTR-TOF with almost 25 years of experience. IONICON develops new products to enhance the knowledge on the composition and the dynamics of atmospheric organic compounds.

IONICON's PTR-TOF series covers a range of systems for different applications: From robust and compact systems for routine analytical analysis, industrial monitoring, and mobile applications, to high-end systems for cutting-edge scientific applications, such as the PTR3-TOF 10K, our new high-performance trace VOC-ELVOC analyzer that is optimized for the direct and contact-free detection of organics of even the lowest volatilities.

In this lecture I will introduce another innovation: IONICON's Automated Measurement and Evaluation (AME) approach and its recent translation to atmospheric applications. AME is a software framework originally designed for unattended industrial monitoring. It can cycle through different modes, such as ionization settings, sample streams, background etc. It consolidates and processes the acquired data. This includes simple averaging and background correction, and accurate quantification, but also smart pattern matching algorithms to greatly enhance compound specificity. The evaluated data is available online through a simplified user interface and industrial data protocols.

We have implemented AME on a PTR-TOF 6000X2 equipped with IONICON's particle inlet system CHARON. That combination allows to characterize the full set of gas-phase and condensed particulate organics at a time resolution of only 10 min - automated, with one single analyzer.

This will be illustrated by results acquired from recent measurements at the TROPOS Research Station in Melpitz (Germany) that is part of the ACTRIS network."

Authors

Herbig, J.

Observe twice as many molecular species with your high resolution mass spectrometer by using a MION?

HJ Jost

Karsa Ltd

"Chemical ionization (CI) is a method in which a reagent chemical is used to produce reagent ions, that are mixed with the air sample. It is a soft ionization method, meaning that the molecules of interest will stay intact and cluster with the reagent ion. Another important aspect is selectivity. Certain reagent ions tend to cluster only with molecules having distinct properties. The obvious drawback is that a certain reagent only works for a limited number of molecules, and thus several reagent schemes are needed for detecting a broad range of chemicals with varying properties. A further complication of using conventional CI and SESI (Secondary Electrospray Ionisation) is neutral reagent mixing with sample flow which potentially alters the sample chemistry and complicates using more than one ionisation scheme.

KARSA have developed the multi-scheme chemical ionization inlet (MION, Rissanen et al. 2019) to tackle these limitations by utilizing ion injection, where only charged reagent enters the sample flow. This enables fast and automated electrical switching between two or more reagents.

In this presentation, we demonstrate proof of concept measurements of rapid (<1s) switching between positive and negative ionization of compounds given off by orange peel, a source of many highly oxidised molecules and frequently used to demonstrate detection capabilities of these species in the atmosphere. While not doubling the number of species detected, acquiring negative and positive mode CI data quasi simultaneously enables detection of different classes of molecules, opening up an exciting field of research."

Authors

Jost H.J., Mikkilä J., Rissanen M., and Mikkilä J.

Recent Developments for the Aerosol Chemical Speciation Monitor

Philip Croteau

Aerodyne Research, Inc

Over the past ten years, the aerosol chemical speciation monitor (ACSM) has become a valuable tool for understanding aerosol chemistry. Its adoption within ACTRIS has led to important insights into the phenomenology of aerosol chemistry across Europe and long-term trends at specific locations. However, ACSM instrument response factor calibrations require expensive and complicated instrumentation, and the low mass resolution of the ACSM detector limits the chemical specificity of the measured mass spectra. Here, we present two improvements being developed for the ACSM technology to address these shortcomings. First, we discuss a new calibration system for the ACSM based on a compact, lower-cost SMPS system integrated into the ACSM hardware and software system. This system is designed to be easily operable in the field without requiring highly-trained personnel or extra equipment. When not being used for calibration, this system will also provide measurements of ambient aerosol size distributions that can inform interpretation of the chemical composition measurements. Second, we present data from a new version of the ACSM, the TOF-ACSM-X, that uses a higher mass resolution mass spectrometer. The detector in that system is designed to provide enough mass resolution to dramatically improve the quantification of ammonium by separating NH2+ and NH3+ signals from the isobaric O+ and OH+ interferences and to allow for more accurate quantification of the elemental ratios O:C and H:C in the organic aerosol.

Authors

Croteau, P., Nault, B., Williams, L., Canagaratna, M., Jayne, J., Worsnop, D.

Aria Technologies: Experience in the Middle East and Latest Innovations in Air Quality Modeling

Fanny Velay

ARIA Technologies

ARIA Technologies is a company developing solutions in the atmospheric environmental field for 30 years with applications in air quality, emission inventory, applied meteorology and climate change. At the core of ARIA's knowhow is the digital processing of the atmospheric environmental data, expertise that involves powerful, accurate models as well as emission inventory development and temporal and spatial distribution of emissions. ARIA Technologies has in the past years conducted projects for numerous French and international air quality networks. AT has also conducted projects in the Middle East for different countries over the past years: Israel, Jordan, Egypt… More recently, we started a collaboration with the Cyprus Institute in order to build an emission inventory for Cyprus for modeling purpose, and a consolidated inventory for the whole Middle East region as well. For the ACTRIS innovation workshop, we will present ARIA Technologies' activity with a focus on the Middle East activity. We will also present briefly our latest on-going project in Mexico that is a good illustration of ARIA Technologies latest innovation skills. The objective of the project is to establish an air quality analysis, modeling and forecasting system platform for the city of Guadalajara, in the state of Jalisco, Mexico. This platform, including the implementation of innovative measurement tools (fixed and mobile micro-sensors on vehicles), already tested in France and in particular in Paris, constitutes both an operational tool for the state of Jalisco and a showcase of French technologies in the field of the "Sustainable City".

Authors

Velay F.

Origins, monitoring the near-real-time greenhouse gas emissions for a low-carbon transition

Jinghui Lian

Origins Earth

Quantitative monitoring of CO2 sources and sinks over cities is needed to support the urban adaptation and mitigation measures, but it is a challenging task. Origins S.A.S is a French start-up created by Suez to support cities in accelerating their low-carbon plans. Origins has developed the first urban monitoring service, Météo Carbone®, for piloting, measuring and reporting CO2 emissions. In 2019, a pilot project, Origins.earth, was implemented in Paris in partnership with the Laboratory of Climate and Environmental Sciences (LSCE), the city of Paris and the Paris Climate Agency. An atmospheric monitoring network with 17 sensors has been deployed for continuous monitoring CO2 concentrations over Paris and its vicinity. Based on the intense measurement data, the near real-time CO2 emission inventory, a sophisticated modeling system and the marketing analysis, the Origins Météo Carbone® service opens up new perspectives for monitoring and verification of city CO2 emissions in a timely mode and presenting the findings in a user-friendly way through a web-based dashboard. The production of a monthly carbon index for the city of Paris provides an aggregated view of the scientific complexity and allows the city's decision makers to continually monitor emissions, trends and progress towards carbon emission reduction goals. We also conducted a detailed assessment of CO2 emissions trajectory in the Paris metropolitan area during the two COVID-19 lockdown periods. The optimized CO2 emissions estimated by our near real-time monitoring system show decreases of around -53%±7% and -22%±9% in fossil fuel CO2 emissions during the first and second lockdown respectively when compared with the same period in 2019.
In addition, benefiting from the unique expertise for combining algorithms for computing CO2 emissions from multiple and complex data sources, Origins is also producing a high-resolution inventory of fossil fuel CO2 emissions for the metropolitan France, which aims to provide the state of up-to-date regional and national CO2 emission maps for modeling, monitoring, and designing mitigation strategies.
After the successful implementation of the technology chain in Paris, Origins joins CARE-C to produce starting July 2021 a collaborative design study for setting up a global greenhouse gas monitoring solution for Cyprus.

Authors

Lian J. and Utard H.

Insights on multi-time resolution PMF: testing different time resolutions and uncertainty weightings

Marta Via

IDAEA-CSIC

The multi-time resolution Positive Matrix Factorization (PMF, Paatero & Tapper (1994)) technique consists of a modification of the standard PMF developed to merge data provided by different instrumentation while keeping their original time resolution (Zhou et al., 2004). Srivastava et al. (2019) combined Aerosol Chemical Speciation Monitor (ACSM, Aerodyne Research Inc.) and offline PM10 measurements and showed an improvement with respect to the conventional source apportionment results.

The present study aims to assess the outputs of the multi-time PMF, implemented in the software package Source Finder (SoFi) (Canonaco et al., 2013), based on a systematic approach. We use data from an urban background site in Barcelona (PR, 41º23'14'' N, 02º06'56''E, 78 m a.s.l), with data coverage extending from September 2017 to October 2018. This 13-months-long dataset combines Quadrupole ACSM 30-minute fine OA, SO42-, NO3-, NH4+ and Cl-, 1-minute fine black carbon (BC) separated into fossil fuel (BCff) and wood burning (BCwb) BC (Sandradewi et al., 2008) from an Aethalometer (AE33); and PM1 offline 24-hours chemical speciation using quartz microfiber filters measurements every four days. The evaluation performed covers the henceforth specified ranges of: i) the coefficient regulating the weight of the uncertainties of the lowest time resolution dataset (C values, from 10-4 to 102); ii) the resolution of the highest resolution dataset (R1) with respect to an invariant resolution of the lowest time resolution dataset (R2) (from 30 min to 24 h). The resulting profiles would represent an environmentally reasonable apportionment to fine particles.

The performance of the model, whose aim is to minimize the Q value, can be evaluated by assessing the normalized Q quantity (Q/Qexp), which can be related to the variables C and R1 as

$$Q/Q_{exp} = (Q_{ACSM}+Q_{Filters}/C^2)/ ((〚24/R_1 \cdot n〛_d 〚+n〛_F)\cdot m-p\cdot(〚24/R_1 \cdot n〛_d+n_F+m)), \quad (1)$$

where nd is the number of days in the period, nF the number of filters samples datapoints, m the number of species considered and p the number of factors used. Multi-time resolution PMF was run for 4 to 9 factors, and all the combinations of the aforementioned ranges of C, R1 and the Q/Qexp output for each run were evaluated. Broadly speaking, the tendency is to get the lower Q/Qexp values towards high time resolutions and low C values. Nevertheless, the minimum Q/Qexp (1.3) is attributed to the combination of 30-minute time resolution and downweights of a 10% and 100% the actual value for the filter samples uncertainties. Comparison with the theoretical expression was performed by running PMF separately for both data sub-sets. However, there is no evidence that the strictly lowest Q/Qexp runs return the most environmentally-realistic PMF solutions, which will be addressed in further work.

Authors

Via, M., Yus-Díez, J., Canonaco, F., Alastuey, A., Petit, J.E., Hopke, P., Reche, C., Pandolfi, M., Querol, X., Minguillón, M.C

Harmonization of In-Situ Particle Number Concentration and Size Distribution Measurement Techniques

Sebastian Schmitt

TSI GmbH

The continuous monitoring and characterization of atmospheric aerosol has been a focus for ACTRIS and other in-situ monitoring networks for many years. With the experience gained during this time, the next step is harmonizing these measurements on the European level. This includes the identification of critical requirements and defining one common standard for everything from the sampling inlet to the measurement and data processing from raw to final data. In addition, maintenance procedures and calibrations of the measurement devices need to be provided. The CEN/TS 16976:2016 and CEN/TS 17434:2020 guidelines describe the determination of particle number concentration (PN) and particle size spectra using Mobility Particle Size Spectrometers (MPSS) in ambient air, respectively.

A commercially available MPSS for ACTRIS was created following the CEN/TS recommendation by integrating a commercial version of the Vienna Differential Mobility Analyzer (Winklmayr et al. 1991) as a custom-design (Model 3083, TSI Inc., Shoreview, MN, USA) with an existing classifier platform (Model 3082, TSI Inc.). The CEN-compliant Condensation Particle Counter (CPC, Model 3750-CEN, TSI Inc.) is part of the system. This CPC is well established in atmospheric monitoring as the successor of the CPC models 3772 and 3010. This presentation will provide details of the newly developed wide-range Scanning Mobility Particle Sizer (SMPS, model 3938W50, TSI Inc.) with recommended accessories such as the inlet sampling system. A novel software version for monitoring applications considers all requirements from CEN and ACTRIS and will provide the appropriate data output for near real-time data and the EBAS database. We will describe the in-situ measurement technology, CPC for particle number concentration and SMPS for particle size distribution measurement. A special focus will be on the capabilities of this novel SMPS, including its scanning range from 10 to 800 nm, RH and temperature control in aerosol and sheath air.

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- CEN/TS 17434. Ambient air - Determination of the particle size spectra of atmospheric aerosol using a Mobility Particle Size Spectrometer (MPSS), published June, 2020.
- Winklmayr, W., et al. (1991). A New Electromobility Spectrometer for the Measurement of Aerosol Size Distributions in the Size Range from 1 to 1000 nm, J. Aerosol Sci. 22:289–296.

The M2AS – Mass and Mobility Aerosol Distribution Measurement with The CPMA

David Walker

Cambustion Ltd

As a measurement of aerosol particle size, mass has several advantages over various definitions of 'diameter' – it is more clearly defined for non-spherical particles and is necessary to determine the mass concentration of the aerosol material which is important for, for example, modelling or health effects. Mass / charge classifiers such as the Cambustion CPMA or the APM offer the potential for particle mass distribution measurement, but uncertainty in the charge: mass relationship has made this difficult up to now.

We have developed a new instrument configuration which uses unipolar charging with the CPMA followed by parallel measurement of the selected aerosol with a CPC and dual mobility classified aerosol electrometers. We refer to this system as the Mass Mobility Aerosol Spectrometer. It provides measurement of both the mass and mobility distribution of an aerosol from a single scan of the CPMA, and because the aerosol charge is directly measured, the measurement does not depend on an assumed model of the charge distribution.

The system has been used to measure solid and liquid aerosols and combustion particles. The integrated aerosol distributions have been compared with total number concentration measurements and gravimetric aerosol mass distributions.

Further work is ongoing to improve the methods of data inversion and improve the instrumentation to extend the size range and sensitivity.

Figure 1. Heatmap of the median of logarithmic values for Q/Qexp response to R1 and C values.

This work was supported by COST Action CA16109 COLOSSAL, Generalitat of Catalunya (AGAUR 2017 SGR41), Spanish Ministry of Science and Innovation and FEDER Funds, through EQC2018-004598-P and PID2019-108990RB-I00 projects. IDAEA-CSIC is a Centre of Excellence Severo Ochoa (Spanish Ministry of Science and Innovation, Project CEX2018-000794-S).

Authors
David Walker, Kingsley Reave

A Dual-Wavelength Photo-Thermal Interferometer for The Determination of Aerosol Optical Absorption Coefficient and The Absorption Ångström Exponent

Luka Drinovec

Haze Instruments d.o.o.

Measurement of aerosol light absorption is still challenging due to systematic artifacts influencing current measurement methods. A photo-thermal interferometer (PTI) probes the change of the refractive index caused by light absorption in (and the subsequent heating of) the sample – the detection is linear and can be traced to first principles. PTI can be calibrated with absorbing gases like NO2, which absorbs strongly in the blue-green part of the spectrum.

Photo-thermal aerosol absorption monitor (PTAAM-2λ) is based on a folded Mach-Zehnder interferometer design. The He-Ne laser probe beam is split in two beams, one of which passes the sample chamber, while the other serves as the reference. Two pump lasers at 532 and 1064 nm are modulated at different frequencies and focused inside the sample chamber using an axicon (patented) for concurrent measurement. The interferometer signal is detected by two photodiodes and resolved by a dual-channel lock-in amplifier measuring at the two respective frequencies.

The green channel is calibrated using 1 ppm NO2. The calibration is transferred to the infrared channel using aerosolized nigrosin and its relative green-to-infrared absorption ratio. This ratio was determined using a Mie calculation based on the size distribution measurement and nigrosin optical properties.

We have determined imaginary part of the refractive index for nigrosin film and its aqueous solution. The solvent caused up to 25% enhancement in the green and up to 35% reduction in the infra-red spectral regions. Optical properties of aerosol constituents must therefore be determined in the solid form. The difference between the calculated absorption coefficient of aerosolized nigrosin at 532 nm and the one measured by PTAAM-2λ was found to be in very good agreement, with a difference of only 6%.

Instrument performance was validated using several laboratory aerosol sources. Winter ambient measurements were performed at an urban background location in Ljubljana, Slovenia. The results (Figure 1) show that the absorption coefficient and absorption Ångström exponent can be reliably measured.

We demonstrate an artifact-free determination of the aerosol absorption coefficient and absorption Ångström exponent in laboratory and ambient studies using PTAAM-2λ. The instrument can be used to directly study the absorption enhancement caused by particle coating.

This work was supported by the European Space Agency, Eurostars, Swiss National Science Foundation, and EMPIR Black Carbon and AeroTox.

Authors

Drinovec, L., Jagodič, U., Pirker, L., Kurtjak, M., Vidović, K., Ferrero, L., Visser, B., Röhrbein, J., Weingartner, E., Kalbermatter, D.M., Vasilatou, K., Močnik, G.

Improved sampling of aerosol nanoparticles - Example of a collaboration between academic and industry

Katrianne Lehtipalo

University of Helsinki & Finnish Meteorological Institute

The availability of new measurement techniques to detect aerosol particles smaller than 3nm in diameter has revolutionized our view on when and where new particles form and enabled us to identify processes producing nanoparticles. Particle formation can happen both outdoors, indoors and related to traffic and combustion processes. Recent studies show that in urban environments even the majority of particle number can be smaller than 10nm. However, the sampling of nanoparticles is not straightforward and the standard procedures established for larger particles cannot usually be directly applied. The aim of this project, funded by the Finnish Research Impact Foundation, is to study and improve the sampling of nanoparticles. The project is a collaboration between INAR at the University of Helsinki and Airmodus Ltd. As a first step, we have tested and characterized the new Airmodus Nanoparticle Diluter (AND) in the size range from 1nm to several hundreds of nm. A set of experiments was performed to measure particle diffusion losses and concentration reduction factors for different dilution ratios. The results show that using AND one can achieve high detection efficiency even in the sub-3nm size range at several dilution ratios between 1-10. This enables accurate measurements with a condensation particle counter (e.g. a PSM or ultrafine-CPC) in environments with high particles concentrations, for example in urban air, and also reducing the sample relative humidity. Additionally, AND can be used as an ion precipitator to remove small ions to study neutral and ion processes separately, which can bring valuable information about the particle formation pathways and sources.

Authors

Lehtipalo K., Lampimäki, M., Baalbaki, R., Ahonen, L., Cai, R., Stolzenburg, D., Petäjä, T., Vanhanen, J. and Kangasluoma, J.

All-In-One Instruments for Monitoring of Air Pollutants and Greenhouse Gases

Morten Hundt

MIRO Analytical AG

Monitoring of air pollutants and greenhouse gases with high sensitivity and selectivity is important to identify their sources and sinks. Measurements of trace gases at various spatial and temporal scales are required, for instance, for modelling of air pollution and validation of emission inventories.
MIRO Analytical AG is offering new trace gas analyzers that are capable of monitoring up to 10 gases simultaneously. These analyzers use direct laser absorption spectroscopy and combine several Quantum Cascade Lasers as light sources. Thanks to their operation in the mid-infrared spectral range the analyzers provide high precision combined with high selectivity.
Due to their compactness and low weight our analyzers are well-suited for mobile monitoring. The multi-compound ability opens new possibilities for emission source attribution and for studies of interactions of different trace gases. In this contribution we will shortly introduce the new multi-compound gas analyzer and will present examples of mobile measurement campaigns that were recently performed by our customers with their MIRO gas analyzers.

Authors
Morten Hundt, Maria Timofeeva, Oleg Aseev

SPECTRONUS™ - A High Precision Multi Species Ghg Analyser for The Next Generation of Observation Networks and Process Studies

Jost Lavric

Ecotech, ACOEM Group, 1492 Ferntree Gully Road, Knoxfield, Vic, Australia, 3180

High quality measurements of atmospheric biogeochemical trace gases are key for a wide spectrum of scientific applications, ranging from basic research to routine monitoring and accounting of anthropogenic emissions in support of decision making related to public health and climate change-related political action. A high degree of measurement standardization is required to assure data compatibility between different measurement networks and applications. Such measurement systems must often be able to measure unattended for prolonged periods of time in various types of environments and on different platforms.

Our ICOS network-approved Spectronus™ measures simultaneously air mole fractions of the key greenhouse gases (GHGs) carbon dioxide (CO_2) and monoxide (CO), methane (CH_4) and nitrous oxide (N_2O), and the carbon/oxygen stable isotope composition of CO_2, while meeting the network compatibility goals for GHG measurements within the scope of WMO/GAW. The instrument's new 19" rackmount compatible design improves its mobility and reduces its installation footprint without compromising the quality of the measurement. Our integrated software and hardware solutions allow measurement automatisation, remote control, integration and control of peripheral parts of your custom measurement setup, and provide integrated tools for data recording, evaluation and validation. This allows the end users to reduce the time between data acquisition and the availability of validated data products, and provides them with flexibility to configure a high quality measurement setup according to their particular needs, while keeping it affordable, relatively simple to run and robust.

Authors

Lavric, J.V., Kassell, G., Edwards, C., Schneider, P., and Griffith, D.

Continuous Monitoring of Greenhouse Gases and Hazardous Air Pollutants with Cavity Ring-Down Spectroscopy

Magdalena Hofmann

Picarro

Cavity Ring-Down Spectroscopy (CRDS) allows to measure in real-time a range of greenhouse gases and hazardous air pollutants, such as carbon dioxide, methane, nitrous oxide, ammonia, formaldehyde, and ethylene oxide. Picarro CRDS analyzers often act as a "gold standard" measurement technology at atmospheric stations around the world (e.g. WMO, GAW) due to the highest level of precision, portable form factor and ease of use. Here we provide an overview of the performance and use cases of Picarro CRDS analyzers relevant to atmospheric sciences, with a focus on the newly released G2910 ethylene oxide analyzer.

Authors

Hofmann, M. E. G., Woźniak, J., Lucic, G., and van Zwieten, R.

Development of On-Line and Field Dual TD-GC-FID/MS for Automatic and Continuous Ambient Air Monitoring

Franck Amiet

Chromatotec Group

Ambient air is polluted by many semi-Volatile and Volatile Organic Compounds (SVOCs and VOCs) coming from anthropogenic and natural sources. VOCs from PAMS, TO14 and TO15 lists can be measured in many ranges of concentration, from pg/m3 up to mg/m3 depending on the location of the measurements. The goal of this study is to perform automatic and continuous identification and quantification of SVOCs and VOCs using a miniaturized dual Thermal-Desorber Gas Chromatograph equipped with two Flame Ionization Detectors (FIDs) and one Mass Spectrometer (MS). The device is required to identify automatically coeluted compounds by MS technology adapted to industrial context. The coupling of two different FID GCs to a single Quadrupole MS allowed by an elaborated multiplexing system is the originality of the project: one TDGC for light compounds (C2-C5) and one TDGC for heavy compounds (C6-C20+) with specific analytical conditions for each system. A third analytical module is added to the system for the measurement of formaldehyde, methanol and acetaldehyde. Linearity, stability and low quantification limits have been studied on more than 100 compounds. The results of the study show that the system can monitor automatically ambient air at low ppt levels with excellent stability, reliability and precision.

Authors

Amiet F., Amiet, JP. and Bazin D.

vPICO PRESENTATIONS

Nanoscale IR-imaging and spectroscopic characterization of air-filtered pollution nanoparticles using s-SNOM

Adrian Cernescu

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Scattering-type scanning near-field optical microscopy (s-SNOM) has become a key technology to study the chemical composition of nanoscale materials. This AFM-based technology exploits the strong confinement of light at the end of a sharp, metallic AFM tip to generate a nanoscale optical hotspot on the sample surface. Importantly, the amplitude and phase of the light within the optical hotspot is strongly influenced by the dielectric properties (absorption, reflectivity) of the sample directly below the tip. With the development of Fourier transform infrared nanoscale spectroscopy (nano-FTIR) and hyperspectral nanospectroscopy, we have successfully extended s-SNOM towards a complete spectroscopic analysis tool that is capable of analyzing air filtered pollution nanoparticles with <20 nanometer precision. With tremendous nanoscale sensitivity, the nano-FTIR spectroscopy enables us not only to explore local distribution but also the spectroscopic signatures or air pollutants. Various examples of s-SNOM measurements on different samples will be presented. In this work, the PTFE filters (air particle deposition by an impactor system) was used to retain micro and nano particles in the ambient air originating from a residential area (burning of wood, coal, lignite, coke etc.). To analyze the main compounds from the PFTE filters a scanning electron microscopy and an energy-dispersive spectroscopy was used. Preliminary results show the presence of Al, K, Na, Fe, Ca (10%), nitrogen oxides (~ 9%), sulfur oxides (~ 24%), NH4 + ammonium (~11%), heavy metals (~6%) and organic mass (~37 %) and other chemical elements such as Mg, Zn, Ti (negligible concentration).

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Authors

Cernescu, A., Cimpoesu, N., Rosu, A.I., Mihaila, L., Unga, F., Burduhos Nergis, D.P., Cazacu, M.M.

Spectral Aerosol Optical Depth and Angstrom Exponent from Ground-Based Fourier Transform Infrared Spectrometry

África Barreto

AEMET (Izaña Observatory)

A long dataset (1 year) of Aerosol Optical Depth (AOD) and Angstrom Exponent (AE) measurements in the 1020–2314 nm spectral range from ground-based Fourier Transform Infrared (FTIR) solar spectra have been provided in this study at the high-mountain Izaña Observatory (IZO, Spain). The high-resolution FTIR measurements were carried out in coincidence with Cimel CE318-T photometric observations in the framework of the Aerosol Robotic Network (AERONET). The spectral FTIR AOD was calculated in seven narrow FTIR micro-windows (centred at 1020.90, 1238.25, 1558.25, 1636.00, 2133.40, 2192.00, and 2314.20 nm). The FTIR system was absolutely calibrated by means of the Langley–Plot analysis. The cross-validation of AERONET-FTIR databases showed an excellent agreement between the two AOD products, with mean AOD differences below 0.004. A mean AE value of 0.53 ± 0.08 for pure mineral dust in the 1020–2314 nm spectral range was calculated in this work. A subsequent cross-validation were carried out using the MOPSMAP (Modeled optical properties of ensembles of aerosol particles) package, ensuring the reliability of the FTIR dataset.

The new database generated in this study has shown the enhanced multi-parameter capability of the FTIR technique for atmospheric monitoring (simultaneous trace gas and aerosol retrievals), providing important additional information to estimate the radiative effects of aerosols and trace gases on climate. Another possible applicability of this new database will be the validation and subsequent improvement of satellite products and its use as proxy for atmospheric chemistry.

Authors

Barreto, A., García, O.E., Schneider, M., García, R.D., Hase, F., Sepúlveda, E., Almansa, A.F., Cuevas, E. and Blumenstock, T.

Intercomparison between online GC and PTR-TOF in a station of Switzerland's National Air Pollution Monitoring Network (NABEL)

Felipe Lopez

TOFWERK AG

The Bern-Bollwerk station of the National Air Pollution Monitoring Network (NABEL) includes an online GC for monitoring benzene, toluene, xylenes (BTX). A PTR-TOF was placed in the station for a week in order to make an intercomparison between the regulated GC measurement and the PTR-TOF.
The results of this Intercomparison are presented.

Authors
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Peak concentrations measured at a station of Switzerland's National Air Pollution Monitoring Network (NABEL)

Marc Gonin
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Peak concentrations measured with PTR-TOF exceed peak concentrations measured with GC for approximately a factor of 20. This is due to the much faster measuring cycle of the PTR-TOF (0.5 s) compared with the GC (20 min) whereby the GC averages and thereby dillutes the real peak signals during the 15 min trapping period.

Authors
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HERMES: an integrated tool dedicated to online data treatment and display of submicronic aerosol chemical composition

Benjamin Chazeau

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The development of a new generation of instruments dedicated to the near real-time measurement of fine particles has opened new perspectives for air quality monitoring and authorities settlement. The large amounts of data these instruments generate however necessitate advanced follow-up and data analysis, preventing the immediate communication of these results to the general public. The Hermes tool ("HERald of the MEasurement Station") programmed with Igor Pro 6.37 (Wavemetric Inc.) and Python 3.8 (Python Software Foundation) programming languages aims to automatically compile, validate and create original visual outputs out of the raw datasets. Data processing is performed through integrated procedures applied for treating and correcting the outputs. Currently, 11 online instruments dedicated to the chemical composition (Time of Flight - Aerosol Chemical Speciation Monitor, ToF-ACSM; Aethalometer AE33; Xact 625i metals analyser) and physical properties (Scanning Mobility Particle Sizer; SMPS) of submicronic aerosol, gas (NOx, O3 and SO2) and meteorological measurements are implemented in the Hermes protocol. A framework already exists to implement more instruments. The tool provides the user with an alert and information email system to monitor the good operation of the remote instruments and the integrity of their data. Graphical outputs are displayed on a dedicated website application with customization options available to the user.

Authors

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A Software Tool for The Aerosol Microphysical Retrieval from Atmospheric Lidar Data.

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Aerosol microphysical parameters are essential for a complete aerosol characterization and useful to understand their effect on the climate. Atmospheric LIDAR (LIght Detection and Ranging) provide spatially resolved information on aerosol optical properties with high spatial and temporal resolution over distance of several kilometers. Aerosol microphysical features are related to their optical properties through integral equations that cannot be solved analytically and whose numerical solution leads to a so-called ill-posed problem. This leads to a strong sensitivity to the uncertainty of the input data and non-uniqueness of the solution. Therefore, mathematical and physical constraints and regularization methods are generally applied to obtain stable and physically acceptable solutions.
A software package has been developed and tested in the frame of a R&D cooperation between the Department of Physics of the University of Naples "Federico II", the National Research Council (CNR), the academic spin-off company ALA Advanced Lidar Applications s.r.l., the Department of Mathematics of the University of Genoa (DIMA) and the Beijing Research Institute for Telemetry (BRIT). The software uses a Monte Carlo algorithm and is able to estimate atmospheric aerosol microphysical properties from LIDAR data at three wavelengths and at different altitude ranges. The software tool provides as output concentration and number size distribution of aerosol particles and refractive index of the target atmosphere, also estimating the corresponding uncertainties. Several examples of application to real LIDAR data will be illustrated in which the retrieved aerosol microphysical properties allow characterizing the contribution of different aerosol types, coming from local and remote sources, along the atmospheric profile. Comparison with columnar AERONET derived properties will be also discussed.

Authors
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Combination of two Doppler lidars to simultaneously retrieve wind vector and turbulence

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A single Doppler lidar can retrieve the 3D wind vector with the help of a conical scan. For retrieving the wind vector from such a scan, highly developed algorithms are available. However, a full conical scan typically takes at least one-minute time to perform with state-of-the-art Doppler lidar systems, hence, a critical gap in observation of small-scale turbulence occurs during this time. In this paper, we report on the results of a one-week measurement campaign conducted at TROPOS, deploying one scanning and one vertical-stare Doppler lidar together. The potential of retrieving eddy-dissipation rate in the mixing layer and in clouds on 3 min resolution is demonstrated.

Authors

Bühl, J., and Bollig, C.

Instrument combination through inversion methods: Innovative improvement of our understanding of aerosol dynamics

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Accurate measurements of the aerosol particle size distribution are important to understand dynamic aerosol processes such as new particle formation. Especially in the size-range below 100 nm, aerosol size distribution measurements are challenging due to high diffusional losses and low charging or detection efficiencies. Several instruments have been developed in recent years in order to improve size-distribution measurements. However, no single instrument can provide high counting statistics, low systematic uncertainties and high size-resolution at the same time (Kangasluoma et al., J. Aerosol Sci., 2020). Here, we show that parallel application of several instruments can be exploited by innovative combining inversion algorithms.

Using artificial and ambient data from Hyytiälä and Helsinki, Finland, we tested several inversion approaches, combining up to four differential mobility particle sizers (DMPS) and several particle counters, including a particle size magnifier (PSM). We find that depending on the method, this can provide more accurate results compared to the size-distribution retrieval by individual instruments. Among the six tested inversion routines, a recently developed Fixed Interval Kalman Smoother (Ozon et al., Atmos. Chem. Phys. Discuss., 2021) Tikhonov regularization yield the most reliable results among inclusion of more instrument information. Further, we develop a Poisson formulation of Tikhonov regularisation, which is more reliable for mobility spectrometer combination where low counting statistics (<10 counts per channel) dominate.

Overall, we demonstrate that the combination of several instruments clearly improves our understanding of aerosol dynamics processes, enabling a clearer identification of new particle formation events and the retrieval of accurate sub-10 nm aerosol concentrations. Thus, we recommend a wide application of combining instrument inversions for ACTRIS aerosol size-distribution measurements in the future.

This work received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement no. 895875 ("NPF-PANDA").

Authors

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Characteriztion of A Chemical Modulation Reactor for The Measurement of Atmospheric Hydroxyl Radicals with a Laser-Induced Fluorescence Instrument

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Forshungszentrum Juelich

Precise and accurate hydroxyl radical (OH) measurements are essential to investigate mechanisms for oxidation and transformation of trace gases and processes leading to the formation of secondary pollutants in the troposphere. Laser induced fluorescence (LIF) is a widely used technique for the measurement of ambient OH radicals and was used for the majority of field campaigns and chamber experiments. Recently, most LIF instruments in use for atmospheric measurements of OH radicals introduced chemical modulation to separate the ambient OH radical concentration from possible interferences by chemically removing ambient OH radicals before they enter the detection cell. In this study, we describe the application, and characterization of a chemical modulation reactor (CMR) applied to the Forschungszentrum Jülich (FZJ) LIF instrument in use at the atmospheric simulation chamber SAPHIR. Besides dedicated experiments in synthetic air, the new technique was extensively tested during the year-round Jülich Atmospheric Chemistry Project (JULIAC) campaign, in which ambient air was continuously flowed into the SAPHIR chamber. It allowed for performing OH measurement comparisons with Differential Optical Absorption Spectroscopy (DOAS) and investigation of interferences in a large variety of chemical and meteorological conditions. Good agreement was obtained in the LIF-DOAS intercomparison within instrumental accuracies which confirms that the new chemical modulation system of the FZJ-LIF instrument is suitable for measurement of interference-free OH concentrations under the conditions of the JULIAC campaign. All observed interferences could be fully explained by the known O3 + H2O interference, which is routinely corrected in FZJ-LIF measurements when no chemical modulation is applied. No evidence for an unexplained interference was found during the JULIAC campaign. In addition, the potential production and dissociation of ambient OH radicals in the chemical modulation reactor, which could introduce fictitious interferences, especially in high OH reactivity environment, will be investigated and discussed.

Authors

Cho, C., Hofzumahaus, A., Fuchs, H., Dorn, H.-P., Glowania, M., Holland, F., Rohrer, F., Vardhan, V., Kiendler-Scharr, A., Wahner, A., Novelli, A.

A New High-Resolution Sampler for The Study of Fine and Coarse Aerosol Composition: STRAS (Size and Time Resolved Aerosol Sampler)

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Most air quality studies in urban areas are based on 24-h averaged data; however, most PM emissions as well as their atmospheric dilution processes change within a few hours. Further, receptor models benefit of high inter-sample variability in the source contributions, which is enhanced when increasing the sampling time resolution.

The joint use of high-time resolution samplings and Ion Beam Analysis techniques, such as PIXE (Particle Induced X-ray Emission), has allowed the study of the composition of atmospheric aerosols with hourly resolution in several locations worldwide.

There are few samplers allowing samplings with hourly resolution, such as the Streaker and DRUM samplers. The most widely used is the Streaker sampler by PIXE International Corporation, which is designed to separate the fine (<2.5 μm) and the coarse (2.5-10 μm) fractions of PM with 1-hour resolution and to collect samples in a continuous deposit ("streak") for each fraction. Both the Streaker and DRUM samplers are not produced anymore and do suffer from several technical limitations.

Therefore, we designed and realised a new sampler able to operate with hourly resolution (the temporal resolution is actually selectable) and to overcome the aforementioned limitations. The inlet was designed in order to perform an inertial separation between fine and coarse particles. The coarse fraction is thus collected for impaction on a polypropylene foil, while the fine fraction for filtration on a polycarbonate filter. Impaction and filtration foils rotate between a sampling point and the following one, so to obtain a series of deposits (instead of a continuous streak as it happens with the streaker sampler).

The new sampler was tested to verify the cut-point with an atmospheric simulation chamber by injecting particles of known dimensions. Further tests were performed by simultaneous, parallel sampling with the STRAS and Streaker samplers.

Authors

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The BOx of Clustered Sensors (BOCS). A Low-Cost Air Quality System for Long-Term Monitoring

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Every year ~9 million people globally die prematurely because of air pollution, with the poor and vulnerable disproportionately affected: 92% of pollution-related deaths occur in low and middle-income countries (LMICs). Furthermore, regardless of the country's income, air pollution health effects are overwhelmingly prevalent on minorities and the marginalized. But due to lack of resources in many LMICs long-term monitoring using traditional reference-grade instrumentation is prohibitive, and the concentrations, sources and effects of air pollution are poorly understood. Low-cost sensors (LCS) could potentially fill this gap by providing the necessary air quality data to inform local mitigation. Unfortunately, the majority of LCS systems currently available are “black-box” in nature, making them difficult to maintain in-country and expensive to operate long-term. In this study, we present a new fault-tolerant and easy to maintain instrument, the Box of Clustered Sensors (BOCS), which combines clusters of LCS to redundantly quantify CO, NO, NO2, Ox, CO2 and VOCs in a modular design, in order to provide robust and reliable measurements of air pollutants. The open-source design and calibration algorithms used in the BOCS significantly reduce operation and maintenance costs, enabling pollutant monitoring in LMICS to be performed by local air quality managers. This approach also provides a transparent and reproducible data processing pipeline, in order to deliver reliable uncertainty estimates on the data provided. In this presentation we will introduce the BOCS and the simple calibration models applied for CO, NO, NO2 and O3 employing the multiple BOCS signals.

Authors

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Cork City's Low-Cost Air Sensor Network Shows PM2.5 Levels Vary Significantly Across the City

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Air quality in Cork city (population ca. 210,000) is dominated by extensive burning of solid fuels for domestic heating and by the city's valley topography. Air quality on winter evenings is characterised by steep rises in PM2.5 concentrations, often to highly polluted levels. In 2019, Cork City Council partnered with the Centre for Research into Atmospheric Chemistry (CRAC) to develop an innovative network of 14 Purple Air (PA) sensors to monitor PM2.5 levels. The principal goal of the network was to provide greater spatial coverage of air quality measurements across the city.

In this work, we confirm that PM2.5 measurements by PA sensors were highly correlated with co-located measurements by an Irish Environmental Protection Agency (EPA) BAM instrument. The PA response was corrected (incorporating the effect of humidity and temperature) to agree more closely with the BAM instrument.

Analysis of the PA network data shows significant variability in PM2.5 diurnal profiles across Cork city. Maximum winter PM2.5 concentrations varied by a factor of 2 to 3 between the cleanest and most polluted sites. Winter air quality is generally worse in parts of the city with higher levels of economic deprivation, reflecting a greater reliance on coal and other solid fuels for heating. All PA sensors measured sharp fluctuations in PM2.5 levels on the 10 min time scale during the evening coal burning period, showing the effect of individual pollution plumes on local air quality. This study demonstrates the insight that a low-cost sensor network provides into the spatial and temporal variability in air quality across a city. This work also raises the question of the relationship between the information from low-cost sensor networks and that from regulatory monitoring.

Authors

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Engineering, Construction and Operation of Cloud Simulation Chambers for Atmospheric Research

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The formation of ice plays important roles for the climatic impact of clouds and the formation of precipitation. In many cases, ice formation requires the presence of ice-nucleating particles (INPs), a minor fraction of atmospheric aerosol particles. The INP abundance can be calculated in cloud, weather and climate models with appropriate parameterizations as function of aerosol properties. The AIDAc (Aerosol Interaction and Dynamics in the Atmosphere classic design) cloud chamber with a volume of 84 m3 is operated at the Karlsruhe Institute of Technology (KIT) since about 20 years to develop such ice nucleation parameterizations by measuring the ice nucleation activity of various aerosol types at simulated cloud formation conditions. However, AIDA has limitations for controlling constant cooling rates or updraft velocities that occur in real clouds. Therefore, the new and innovative dynamic cloud chamber AIDAd with a volume of about 4 m3 was engineered and constructed during the recent years in collaboration of KIT with the Bilfinger Noell GmbH. It came into operation end of 2019 and was successfully tested for cloud formation at well controlled cooling rates of up to 10 K min-1, which corresponds to updraft velocities of about 15 m s-1 that occur in deep convective clouds. Both the AIDAc and the AIDAd are worldwide unique cloud simulation chambers regarding their engineering, temperature range, operational capabilities and instrumentation. More recently, the first mobile and fully automated cloud simulation chamber called PINE (Portable Ice Nucleation Experiment) was engineered and is now commercially available from the Bilfinger Noell GmbH. PINE measures the ice nucleation efficiency of aerosols or the concentration of INPs in fully automated series of cloud expansion runs with either lab-generated or sampled atmospheric aerosols. In this presentation, the engineering and first application of both AIDAd and PINE will be explained.

Authors

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Towards A New FRM4DOAS Site in The Po Valley

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The Po valley (Italy) is one of the most polluted regions in Europe. High NO2 concentrations are often found, due to both industrial and urban activities and to its particular geographical position.
Since information on this pollutant gas can be retrieved from ground-based visible spectra, exploiting the Differential Optical Absorption Spectroscopy (DOAS) technique, DOAS instruments are located in the most polluted areas of Europe.
However, a similar instrument, compliant to the Fiducial Reference Measurements for Ground-Based DOAS (FRM4DOAS) standards is not yet present in the Po Valley.
Hence, the purpose of this ESA project is to fill this gap by using an existing custom-made spectrometer (TROPOGAS) operating in a measurement configuration that is as much as possible compliant with the FRM4DOAS requirements.
The objectives of this exercise are to demonstrate the importance of the DOAS measurements in this polluted region, re-enforce the Italian know-how on the Multi-AXis (MAX)-DOAS technique and go towards the provision of standardized data for validation networks.
We assessed the performances of TROPOGAS, currently located at ISAC-CNR in Bologna, proving that it meets all the FRM4DOAS requirements except the Field Of View (FOV) dimension that is wider than what required. However, its impact on the retrieved products, that will be evaluated through radiative transfer simulations, does not prevent the use of this instrument for the mentioned objectives.
Two measurements campaigns are planned: the first, at ISAC-CNR in Bologna, will focus on the evaluation of the synergies between ground based remote sensing and in-situ and satellite data. In the second one, TROPOGAS will be inter-calibrated with other instruments within the Boundary-layer Air Quality-analysis Using Network of Instrument (BAQUNIN) supersite located in Rome. At the end of the project, standardized DOAS measurements will be finally available in the Po Valley.

Authors
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High resolution unattended particle-bound total carbon measurements and source identification at the Jungfraujoch global GAW station

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Total aerosol carbonaceous mass (TC) is a major constituent of atmospheric fine aerosol not yet continuously monitored with adequate time resolution. Adding a TC measurement to existing measurement programs is crucial for comprehensive interpretation of the impact of aerosols. To fill this gap, we developed the "fast thermal carbon totalizator" (FATCAT) for long-term unsupervised monitoring of TC. FATCAT has been deployed since 2019 at diverse sites including the Jungfraujoch global GAW station (JFJ). FATCAT collects particles on a metallic filter, and subsequently heats it to 800°C under an oxidizing atmosphere. The limit of detection is LoD=0.2 µg of carbon (µg-C). At the reduced atmospheric pressure of the JFJ, which limits the sampling flow, this corresponds to TC=0.3 µg-C/m3 using a time resolution of two hours.

We discuss our experience during the first two year of continuous TC measurements and the possibility of using our instrument to distinguish carbonaceous aerosol from different source using fast, 50 seconds, thermograms (see supporting document). This unique feature allows us to identify source specific fingerprints. Several high TC episodes during September 2020 at JFJ show the typical pattern for biomass combustion. Back trajectories attribute them to long-range transported emissions from Californian wildfires. Graphitic carbon from, e.g., local fossil fuel combustion evolves at higher temperatures. The data collected at the JFJ is already the longest produced TC dataset for this site without instrument related interruptions.

The dataset generated by our instrument and post-analysis data products represent an improvement to the available measurement inventory. It can serve as quality control for other measurement systems. Prominently, measurements of eBC via MAAP or Aethalometer and organic mass using ToF-ACSM. TC data can be used in parallel to these devices as a quality check, and to warrant carbon mass closure and reduce systematic biases.

Authors

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The presence of microplastic in the Total suspended particles

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The negative effects of mass production of plastics have been known since the beginning of the 70s. Due to their wide application in many fields, there is a continuous increase in their production. In 2019, the global production of plastics amounted to 360 tons. The presence of microplastics in the environment has been extensively analyzed by scientists. Mainly research on microplastics is based on the analysis of their content oceans, seas and rivers. A very important and overlooked issue is the analysis of microplastics in soil or air samples. The aim of the conducted research was the quantitative and qualitative determination of microplastics from transport in Total suspended particles (TSP) samples. They were collected during the summer period, at the turn of June, near a busy road in a city with a population of over 800,000 people. The samples were collected with a low volume sampler located on the roof of a five-storey building. In order to separate the plastic fragments, a density separation with a saturated solution of CaCl2 salt was used. The oxidative digestion method was used to digest the biological residue. Optical and spectroscopic methods were used for the quantitative and qualitative identification of the obtained fraction. For this purpose, a confocal microscope and μATR FTIR were used. The samples showed a significant content of black fragments of various sizes and similar shapes. The fragments were later identified by Raman spectroscopy as SBR rubber fractions. It is estimated that the source of the identified particles is the emission of microplastics from traffic routes, mainly car tires.

Authors

Worek, J., Badura, X., Białas, A., Chwiej, J., Kawoń K., and Styszko, K.

The feedback of clouds on the Heating Rate of black and brow carbon

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Black carbon (BC) and Brown Carbon (BrC) absorbs sunlight and heat the atmosphere. We experimentally quantified the impact of cloud fraction and cloud type on the heating rate (HR) of black and brown carbon (HR_BC and HR_BrC). High time-resolution measurements of the aerosol absorption coefficient at multiple-wavelengths were coupled with spectral measurements of the direct, diffuse and surface reflected irradiance, and with lidar-ceilometer data during a field campaign in Milan, Po Valley (Italy). The experimental set-up allowed to work in all sky conditions (from clear-sky to cloudy). The highest total HR values were found in the middle of winter (1.43±0.05 K day-1) and the lowest in spring (0.54±0.02 K day-1). HRBrC accounted for 13.7±0.2% of the total HR. To investigate the role of clouds, sky conditions were classified in terms of cloudiness (fraction of sky covered by clouds: oktas) and cloud types: stratus (St), cumulus (Cu), stratocumulus (Sc), altostratus (As), altocumulus (Ac), cirrus (Ci) and cirrocumulus-cirrostratus (Cc-Cs). During the campaign, clear sky conditions were present just 23% of the time. The average cloudiness was 3.58±0.04 oktas. St were mostly responsible of overcast conditions.

HR measurements showed a constant decrease with increasing cloudiness of the atmosphere enabling us to quantify for the first time the overestimation (in %) of the aerosol HR introduced by the simplified assumption of clear-sky conditions in radiative transfer model calculations: by 50% in low cloudiness (oktas=1-2) and up to 500% in complete overcast conditions (oktas=7-8).

The impact of different cloud types on the HR was also investigated, e.g. Cirrus were found to have a modest impact, decreasing the HR_BC and HR_BrC by -5% at most while the highest impact was associated to stratus, suppressing the HR_BC and HR_BrC by -85±5 and -83±3%, respectively. The presence of clouds caused a decrease of both HRBC and HRBrC (normalized to the absorption coefficient of the respective species) of -11.8±1.2% and -12.6±1.4% per okta. This simplifies the models and reduces the number of details that need to be considered: once the HRBC and HRBrC are determined in clear-sky conditions, their dependence on the cloudiness can be determined from the simple reduction of the HR normalized to the absorption coefficient (about 12% per okta for both species).

Authors

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Dynamics of The Atmospheric Boundary Layer Over Two Rural Sites with Doppler Lidar

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The characterization of the Atmospheric Boundary Layer (ABL) under different conditions is important for weather and climate models, wind energy applications or air quality studies. One of the most important features that makes ABL description complex is the turbulent mixing, responsible for the redistribution of momentum, mass, temperature and humidity. Turbulent mixing sources exhibit temporal and spatial variations, and include buoyancy, wind shear or radiative cooling in stratocumulus clouds.

In this context, lidar (light detection and ranging) technique represents a powerful tool to retrieve profiles of several ABL properties. In particular, Doppler lidars can be used to retrieve the 3D wind field inside the ABL and turbulent properties with high temporal and vertical resolution, which can be combined to classify turbulence basing on its source.

In this work, we used a standard classification methodology to characterize ABL over two sites with different features in terms of mean horizontal wind and turbulence sources with Doppler lidar measurements. The first location was an irrigated olive orchard in Úbeda, Spain (37.90°N, 3.31°W, 370 m a.s.l.), representing one of the most important crops in the Mediterranean basin with Mediterranean climate. The second location was PolWET peatland site in Rzecin, Poland (52.75°N, 16.30°E, 54 m a.s.l.), representing one of the largest natural terrestrial carbon storages that have a strong interaction with the climate system.

The results showed typical situations for clear-sky cases, where ABL is fully developed during daytime due to convection, with high turbulent activity and strong positive skewness indicating frequent and powerful updrafts. The cloud-topped cases showed the strong influence that clouds can have on ABL development, preventing it to reach the same maximum height and introducing top-down movements as a contribution to mixing. The statistical analysis allowed for characterizing the ABL diurnal cycle in terms of prevailing mixing sources and wind patterns.

Authors

Ortiz-Amezcua, P., Andújar-Maqueda, J., Manninen, A., Pentikäinen, P., O'Connor, E., Stachlewska, I.S., Moreira, G.A., Benavent-Oltra, J.A., Casquero-Vera, J.A., Harenda, K.M., Poczta, P., Chojnicki, B.H., Schüttemeyer, D., Alados-Arboledas, L., Guerrero-Rascado, J.L.

Modeling and spatial characterization of aerosol at Middle East AERONET stations

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Modeling and characterization of aerosol loading over four (4) selected stations in Middle East are analyzed in the present study. AutoRegressive Integrated Moving Average (ARIMA) model was used to simulate time series monthly-mean Aerosol Optical Depth (440 nm) and Angstrom Exponent (AE, 440-675) from surface-based AErosol RObotic NETwork (AERONET) from (2012-2021). The autoregressive time series model used deterministic pattern and analyzed aerosol characterization using AE and validated cloud interaction from space-based Moderate Resolution Imaging Spectroradiometer (MODIS) over the study stations for the first time. Details of data management have been presented in Anoruo (2021). Results shows weighted average of AOD (≥ 0.2), AE (≥ 1.0), CF (≥ 0.6) and PW (≥ 0.7) for fine-mode aerosol spray in IASBS (36.705N, 48.507E), AOD (> 0.2), AE (< 1.0), CF (< 0.5) and PW (< 0.2) for dust aerosol in Nes_Ziona (31.922N, 34.789E), AOD weighted (> 0.4), AE (> 0.5 < 1.0), CF (≥ 0.7) and PW (≥ 0.2) for dust and maritime aerosol for Masdar _Institute station (24.442N, 54.617E) and weighted AOD (≤ 0.5) AE (< 1), CF (≥ 0.5) and PW (≤ 2.5) for dust in Hada_EL-Sham.

Authors

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The Characteristics of the Urban Atmosphere in Moscow Megacity and their Radiative and Meteorological Properties According to Modelling and Measurements in Different Conditions Including the 2020 Spring Lockdown due to COVID-19

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Using the data on gas and aerosol composition measurements at the Moscow State University Meteorological Observatory, we determined the level and main features of urban gas/aerosol pollution, and assessed its magnitude in typical and in lockdown conditions of 2020 in Moscow megacity (Chubarova et al., 2021). A special attention is paid to separating the effects of atmospheric circulation and the influence of pollution emission on aerosol and gas concentration. The effects of the air pollution decrease on solar radiation and air temperature during the lockdown period have been analyzed on the base of modern COSMO and COSMO-ART mesoscale models using Russian (-Ru) configurations. We evaluated the radiative and temperature effects observed due to aerosol in typical conditions during the spring of 2018-2019 and during the period of lockdown in the spring of 2020 under various meteorological conditions and emission scenarios. We also discuss the aerosol indirect effects on cloud properties using an experimental scheme of COSMO-Ru model and their influence on cloud optical properties during this period.

Authors
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On The Role of the Ocean in Simulating Extreme Atmospheric Events

Antonio Ricchi

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In this presentation we show an overview of works related to the implementation of atmosphere-ocean-wave coupled numerical models for the prediction of extreme events over the Mediterranean Sea basin. The use of coupled numerical models aims to implement, with better consistency, the complex interactions that appear at the air-sea interface. These interactions are modulated by the wave fields, which affects the mixing phenomena in the marine mixed layer and in atmospheric planetary boundary layer (PBL). The use of coupled models, particularly in the study of the dynamics that generate extreme atmospheric events, seems to produce more skills in the simulations, but opens up new physical and numerical questions. In this presentation we show the consolidated results obtained using different levels of coupling, from uncoupled stand-alone atmospheric simulations up to the fully-coupled approach. The study will focus on four extreme events, in which air-sea interactions play a crucial role, namely three cases of Tropical-like cyclones (TLC) and one High Precipitation Event (HPE). The TLC case studies concern the IANOS TLC developed over the Ionian Sea from 15 to 20 September 2020, ROLF TLC from 06 to 10 November 2011 (Ricchi et al 2017), the ILONA TLC of 18-23 January 2014 (Ricchi et al 2019). They show different physical characteristics and the role of coupling appears to impact not only the intensity of the cyclone but also the rainfall. Similar results are shown in the HPE of 26 September 2007 (Ricchi et al 2021), which caused massive flooding in the mainland area of Venice. In this case, only the coupled models were able to simulate the event adequately. This happens because the implementation of the ocean in the atmospheric model induces a conditioning of the wind in the first layers of the atmosphere and in the energy fluxes at the interface that feed these phenomena. In conclusion, we suggest some approaches that can be implemented in operational numerical models.

Authors

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Assessment of GHG emissions from transport sector of Azerbaijan

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The contribution emissions including the GHG-emissions by transport sector in Azerbaijan has been evaluated. As a result of conducted surveys, it is ascertained that car wastes are the main pollution sources of worsening air quality. Thus, over 80% (1 mln ton) of the total emissions has been exhausted by vehicles. Especially in the cities, (Baku, Ganja, Sumgait, Mingachevir) the amount of exhaust gases are over 80%. In the frame of our survey and inventarization COPERT 4 software evaluation program has been applied to calculate Carbon-Dioxide (CO2) and Methane (CH4) which are main source of Global Warming and Climate Changes.

According to the development of oil industry, number of atomobiles have been sharply increased in Azerbaijan. Statistics figures out that the number of cars tripled between 2000 and 2017. Thus, the number of registered vehicles was just 440 thousand in 2000, however in 2015 it reached to 1.34 million and continue to go up by 50-80 (6-8%) thousand per year. Apart from this, the main fuel consumption –especially gasoline- accounts for transportation and reports shows that 1.36 mln ton gasoline, 897-thousand-ton diesel fuel and 23.1 thousand ton LPG (Liguefied Petroleum Gas) was consumed in 2014 by cars. G

Currently, gradual growth at fuel consumption is irrational by economical and air quality aspects. COPERT 4 software program has been applied to calculate Carbon- Dioxide (CO2) and Methane (CH4) from transport sector since 2010. As a consequence, the amount of greenhouse gases exhausted by cars have been calculated and measurements have been suggested in order to reduce them. Gasoline usage is the main source of CO2 and due to the 70% of cars are gasoline engined in Azerbaijan, amount of greenhouse gases is expected to grow and trend has been determined by us.

Chart 1 figures consequences of CO2 emissions evaluated by COPERT 4. According to the results, 59.9% of CO2 exhausted by light cars, the share of buses is twice as low as cars and just 7.4% of total emission expelled by trucks. Furthermore, 42.8% of car emission occurs at urban, 33.49% is in rural areas and 23.65% is in highways. Chart 2 shows amount of CH4 in various transport systems calculated by COPERT 4 software program. Thus, light cars are the main source of methane by 96.1 % of total. On the contrary, methane gas exhausted by buses and trucks are not significant, around 2%. In addition, 57.7 % CH4 expelled at urban areas and shares of CH4 emissions at rural areas and highways are nearly same (22.28% and 20.01% respectively).

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Seasonality of PM10 Sources at Traffic and Urban Background Air Monitoring Stations: Case Study from Krakow, Southern Poland

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In large urban agglomerations, car traffic is one of the main sources of particulate matter. It consists of particulate matter directly generated in the process of incomplete liquid fuel burning in vehicle engine, secondary aerosols formed from exhaust gaseous pollutants (NOx, SO2) as well as a products of tires, brake pads and pavement abrasion. Krakow is one of the cities in Europe with the highest concentrations of particulate matter. There are several air monitoring stations in the city. The article presents the results of combined elemental, chemical and isotopic analyses of particulate matter PM10 at two contrasting urban environments during winter and summer seasons. One station was located on the avenue with heavy car traffic, and the other in the residential area. Daily PM10 samples were collected at both stations during summer and winter seasons of 2018/2019. Mean PM10 concentration at traffic related station were equal to 35±7 μg/m3 and 76±28 μg/m3 in summer and winter, respectively. Mean PM10 concentration at urban background station were equal to 25.6±5.7 μg/m3 and 51±25 μg/m3 in summer and winter, respectively. The source attribution of analysed PM10 samples was carried out using two modeling approaches: (i) Positive Matrix Factorization (PMF) for elemental and chemical composition (the concentration of elements, ions, as well as organic and elemental carbon in daily PM10 samples), and (ii) Isotope Mass Balance (IMB) for 13C and 14C isotope composition of carbonaceous fraction of PM10 particulate matter were used in the research. The first is the receptor method of positive matrix factorization (PMF). For its application. Five sources of particulate matter for each station were identified for each station: fossil fuel combustion, secondary inorganic aerosols, traffic exhaust, soil and the fifth source which included road dust, industry, construction work. The IMB method allowed partitioning of the total carbon reservoir of PM10 into carbon originating from coal combustion, from biogenic sources (natural emissions and biomass burning) and from traffic. Both apportionment methods gave consistent results.

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