

Milestone MS4.5: Final report on the use of ACTRIS facilities and calibration centres for testing novel instruments.

Simone Gagliardi (CNR), Gelsomina Pappalardo (CNR), Sabine Philippin (CNRS),
Ariane Dubost (CNRS), Livio Belegante (INOE)

Work package no	WP4
Milestone no.	MS4.5
Lead beneficiary	CNR
Deliverable type	<input checked="" type="checkbox"/> R (Document, report) <input type="checkbox"/> DEC (Websites, patent fillings, videos, etc.) <input type="checkbox"/> OTHER: please specify.....
Dissemination level	<input checked="" type="checkbox"/> PU (public) <input type="checkbox"/> CO (confidential, only for members of the Consortium, incl Commission)
Estimated delivery date	Month 46
Actual delivery date	20/06/2019
Version	V3
Comments	<i>Submission delayed due to late inputs from TNA WPs.</i>

Table of contents

1. Introduction	3
2. Opportunities of access to ACTRIS-2 facilities for instrument calibration, testing, and development	3
3. Use of ACTRIS-2 facilities by SMEs.....	4
3.1 Use of Lidar Calibration Centre (LiCal) by SMEs.....	4
3.2 Use of the AERONET-Europe calibration facility by SMEs	7
3.3 Use of the European Centre of Aerosol Calibration (ECAC) by SMEs.....	8
3.4 Use of the advanced observational stations.....	11
3.5 Other ACTRIS-2 partnerships with SMEs.....	16
4. Conclusions	17

1. Introduction

The objective of this document is to report on the use of ACTRIS facilities and calibration centres for testing novel instruments. These ACTRIS facilities are an opportunity for access especially to SMEs and science-based companies to test and develop new innovative products that are relevant to ACTRIS observations and to promote sharing knowledge and collaboration with the private sector.

2. Opportunities of access to ACTRIS-2 facilities for instrument calibration, testing, and development

For SMEs and industrial companies, innovation and development of innovation capabilities through technology transfer and knowledge-sharing activities depend on dedicated facilities for testing, quality assurance, and calibration. Such centres are often very costly. Within ACTRIS-2, a number of dedicated calibration centres and observational facilities are accessible free-of-charge to different kind of users beyond the academic communities such as the private sector, particularly SMEs, and operational networks. The ACTRIS-2 offers access to the following platforms:

- **Lidar Calibration Centre (LiCal)** for testing, calibration, and maintenance, and optimization of lidars and ceilometers (operated by partners CNR, INOE, LMU);
- **AERONET-Europe calibration facility** with outdoor/indoor platforms for sun/moon/sky photometer calibration of AERONET-Cimel photometers (operated by CNRS, Lille1, UVA, AEMET);
- **European Centre of Aerosol Calibration (ECAC)** for calibration, QA, capacity building related to high-quality measurements of physical, optical, and chemical in-situ aerosol parameters (operated by TROPOS, CNRS, JRC);
- **18 advanced observational stations** at different geographical locations and altitudes in Europe equipped with state-of-the-art instrumentation for measurements of aerosols, trace gases, and aerosol-cloud interaction, for instrument testing and inter-comparisons under real conditions (operated by CNR, CNRS, UHEL, FMI, PSI, KNMI, TROPOS, NOA, CHMI, AEMET, UGR, CSIC, ULUND, CYI, NUIG).

ACTRIS has an history of joint collaborations with the private sector for calibrating commercial instruments, testing new instrumentation, and developing novel methods and equipment, as it provides a platform for exchange between those marketing the products and software related to ACTRIS and its leading experts.

The most relevant activities are summarized below.

3. Use of ACTRIS-2 facilities by SMEs

Since the beginning of the project, various SMEs have used ACTRIS-2 facilities for calibration of commercial instruments, testing/calibration of new instruments, and instrument development (including performance testing, software updates, and hardware improvement).

The most relevant results related to ACTRIS-2 partnerships with SMEs are listed below.

3.1 Use of Lidar Calibration Centre (LiCal) by SMEs

- Andøya Space Center (Norway)

Andøya Space Center (ASC), the former Andøya Rocket Range is a non-profit company and a service provider for universities and institutes based in Norway. ASC was established in 1962 and provides sounding rocket, balloon and RPA (Remotely Piloted Aerial System) operations from mainland Norway and from Svalbard. ASC owns and operates the ALOMAR Observatory (Arctic Lidar Observatory for Middle Atmosphere Research), which hosts a number of ground-based scientific instruments from universities and research institutes around the world [Gold2004]. ALOMAR is located at the summit of Ramnan mountain, 380 meters asl. Further instruments are distributed on other locations on the island.

ASC customers and partners comprise of DLR, NASA, JAXA as well as many universities and research institutions worldwide. Organised as a limited company, ASC is owned 90% by the Norwegian Ministry of Trade, Industry and Fisheries, and 10% by the Kongsberg Group. ASC is an ISO 9001:2008 certified company. The company's turn-around is about NOK 150 million and the number of employees is 75.

ASC headquarters is located on the island Andøya, three degrees north of the Arctic Circle, with good connections to the mainland by plane, sea and land based transport. Traditionally ASC provides services for scientists and during the last years we have extended our services with the development of rocket payloads, unmanned aircrafts and initiation and participation in research projects, networks and in Cal/Val activities. Alomar requested access to the quality assurance infrastructure (LiReQA) for the ALOMAR Tropospheric Lidar. The ALOMAR Tropospheric lidar is a three-color system based on a Nd:YAG power laser with five receiving channels: 1064 nm elastic, 532nm elastic with parallel and cross-parallel polarization channels, 355 nm elastic and 387 nm N₂ Raman channel. The systems focal length is 600 mm and the system covers an altitude range from 700 m. asl. to the lower stratosphere.

- Campbell Scientific Ltd. (UK / France)

Campbell Scientific is an international group of companies with offices worldwide for scientific instrumentation and solutions, in particularly optical sensors for cloud height, visibility and present weather. Campbell participated in the intercomparison campaign INTERACT II with its CS135 ceilometer (see Figure 1) in order to assess in details the aerosol sensitivity and boundary layer aerosol profiling capability of the instrument. The CS135 measures cloud height and vertical visibility for meteorological and aviation applications using lidar technology. It is a low-cost instrument that transmits fast, low-power laser pulses into the atmosphere and detects back-scattered returns from clouds and aerosols above the

instrument. The intercomparison with a higher specification reference instrument such as the MUSA fixed lidar system is required to assess in great detail the sensitivity and stability of the ceilometer. Such detailed performance analysis and evaluation will allow deploying such instruments in aerosol networks.

- [CIMEL Electronique S.A.S \(France\)](#)

As a manufacturer settled in the heart of Paris, [CIMEL](#) innovates since 1959 in designing field equipment for meteorological and atmospheric observation networks. The micro-LIDAR developed by CIMEL uses a Crystallaser laser emitting at 532 nm, with a repetition rate of 4.5 kHz. It is an eye-safe lidar, so the energy is of the order of 20 μ J, and the laser beam is expanded through a 200 mm refractive telescope. The lidar configuration is mono-axis (we also have using bi-axis configuration for low range observations). The emission and reception is done through a 10 m fiber optics and a refractive telescope. The beam divergence is 55 μ rad in emission and 110 μ rad in reception. The detector used is an APD, the acquisition and counting is done by a FPGA and data transferred through USB port.

Another CIMEL micro-LIDAR has been recently in operation in Lille (it is still in testing and calibration phase). This second Lidar operates at 808 nm with an energy in the range of 4-5 μ J, it is in a bi-axis configuration, with polarization channel. It uses a pulsed laser diode at a repetition rate of 4.5 kHz; the detectors are APDs.

The company accessed the LiCalTrain unit for knowledge transfer for the two lidar instruments on common problems and solutions, ACTRIS-EARLINET QA tests (theory, tools, hands-on, analysis), good practices in operation and maintenance.

- [Lufft Mess-und Regeltechnik GmbH \(Germany\)](#)

The Ceilometer CHM 15k "NIMBUS" is a cloud height sensor / lidar based ceilometer that was involved in the INTERACT-II campaign. It is a simple, one-wavelength backscatter lidar to detect multiple cloud layers, cirrus clouds, and aerosol layers.

- [Raymetrics SA \(Greece\)](#)

[Raymetrics](#) is one of the lidar producers and integrators in Europe. The company is in close collaboration with EARLINET and the research community and is continuously integrating all scientific developments at European and international level. Raymetrics has been in operation since 2002. Back then, the only people using aerosol LIDARs were researchers. The company came from a background in LIDAR science - and to this day maintained strong links with the academic community. The key scientific advisor is Professor Alex Papagiannis from the National Technical University of Athens (NTUA), who was in 2015 elected President of the International Coordination Group for Laser Atmospheric Studies (ICLAS) - the most important atmospheric LIDAR organization in the world. Raymetrics had several TNA at LiCalCheck and LiReQA on quality assurance and hardware assessment.

- [Sigma Space Corporation \(USA\)](#)

[Sigma Space Corp.](#) is an aerospace engineering company that participated in an intercomparison campaign (INTERACT II, July 2016) held at the LICAL facility in Potenza to study the performances of the SIGMA micro-pulse mini lidar system (MiniMPL) under

different atmospheric conditions. The commercial MiniMPL is a small, compact device, which has been launched by the SME in 2010 and is intended for field deployment (e.g., Atmospheric Boundary Layer measurements up to 10 km). The intercomparison took place in a period characterized by Saharan outbreaks over the Mediterranean basin, complemented by the fire season in surrounding areas, in East Europe and North America, thus allowing to observe different sources of aerosol affecting the site. The intercomparison allowed the characterization of its system performance through quantitative assessment with the reference MUSA advanced research lidar system to evaluate its stability, sensitivity, uncertainties, and accuracy of products, including active collaboration and exchange of expertise between LICAL and the users. As Sigma micro-pulse Lidars have been used by the NASA global aerosol network "MPLNET" and for the DOE Atmospheric Radiation Measurement (ARM) program, the development of a reliable and cost-effective lidar system is under demand and expected to be deployed by the aerosol monitoring community.

- VAISALA (Finland)

Two ceilometers have been deployed by [VAISALA](#) during the INTERACT-II campaign: the VAISALA CL51 and an older VAISALA CT25K (latter no longer commercially available, replaced by CL31). These ceilometers are designed to measure high cirrus clouds and report backscatter profiling over full measurement range up to 15 km.

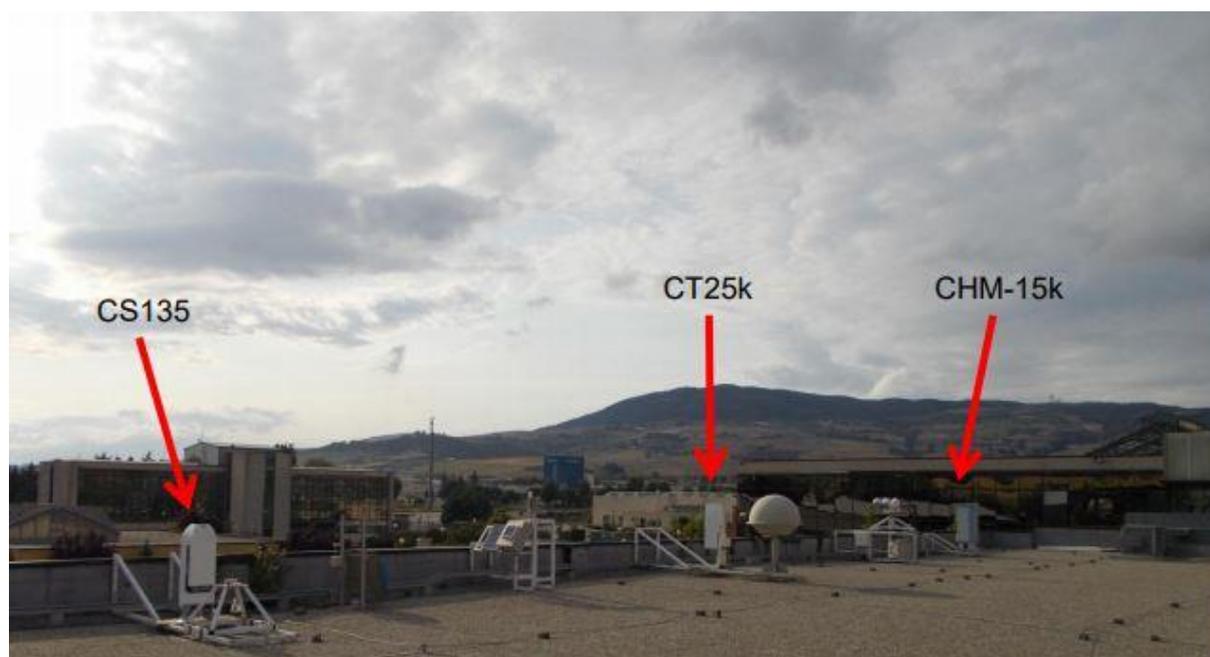


Figure 1: Ceilometers Campbell CS135, VAISALA CT25K and Lufft GmbH CHM 15k "NIMBUS" on the CNR-IMAA Potenza observatory roof during the InterACT-II campaign

The above manufacturers have provided their support in the evaluation of the data resulting from the [INTERACT-II campaign](#).

3.2 Use of the AERONET-Europe calibration facility by SMEs

- CIMEL Electronique S.A.S (France)

CIMEL is a manufacturer automatic meteorological instrumentation with expertise in the field of meteorology, atmosphere optics, design of integrated systems, software solution development and production control. For over 25 years, CIMEL has developed specific instruments for atmospheric monitoring that are deployed by leading scientific organisations in the world. In particular, the CIMEL CE318 is a multiband photometer that is today the worldwide reference instrument for all aerosol observing networks, which is, deployed at most ACTRIS-2 remote sensing stations for AOD measurements, which required calibration by AERONET-Europe. Since recently, CIMEL sells the CIMEL CE318T, a new combined sun/sky/lunar-photometer having both sun and lunar capabilities. CE318T is the only commercially available photometer to perform moon measurements and to provide AOD also at night-time. In collaboration with CIMEL, AERONET-Europe has developed a new retrieval software for the CE318T. All CIMEL instruments provide high quality measurements with field-proven reliability and very low maintenance requirements (CIMEL provides direct support for installation, training and maintenance for its instruments).

During ACTRIS-2, the manufacturer CIMEL has requested access to use AERONET-EUROPE for calibration of 13 of its instruments (of which 10 were used to test the new CE318T). A number of ACTRIS-2 stations are deploying the new CIMEL318T and require calibration services by AERONET-EUROPE: Leipzig, Munich (Germany), Potenza, Napoli, Lecce (Italy), Magurele (Romania), Granada (Spain), Lille (France). Furthermore, the calibration of this instrument at AERONET-EUROPE has been required for various (ACTRIS and non-ACTRIS) field campaigns: (i) [SLOPE](#) (Sierra Nevada Lidar AerOsol Profiling Experiment) campaign in Granada, Spain; (ii) INTERACT II field campaign (Intercomparison of aerosol and Cloud Tracking), Italy, at CIAO, the CNR-IMAA Atmospheric Observatory for the study of the atmosphere through the use and integration of active and passive remote sensing techniques; (iii) calibration and loan of instruments for an [Aerosol Absorption Campaign](#) in Athens, Greece; (iv) calibration of a lunar photometer for the SHADOW (Study of SaHaran Dust Over West Africa) campaign in Senegal. AERONET-Europe also provides training on the basics of the instrument, common problems and solutions, quality assurance tests (theory, tools, hands-on, analysis), and good practices in operation and maintenance.

- TENUM (France)

[TENUM](#) is a design office specialized for more than 20 years in telemetry and digital systems collaborating with, e.g., CNES, Airbus, DGAC, Eurocopter, ALCATEL, NASA. TENUM has developed “Calitoo”, a series of small, hand-held and low-cost photometers. TENUM has used AERONET-EUROPE during five accesses for absolute calibration of Calitoo and intercalibration with the CIMEL photometer (see Figure 2). In mid-2016, close to 200 Calitoo handheld sun photometers have been manufactured by TENUM, sold and distributed in and outside Europe, and designed for teaching and for small budget research projects.



Figure 2: Calibration campaign of Calitoo instruments (TENUM) at AERONET-Europe (Izaña Observatory, Spain)

- GRASP (France)

GRASP SAS is a startup company which works around algorithms and computer tools developed by researchers in the area of remote sensing. GRASP SAS is a company which provides extra services around GRASP code (<https://www.grasp-open.com/>) and other similar areas. GRASP offers consultancy services about atmosphere and surface properties retrieved from different instruments and in addition also offer engineering experts to build final products. GRASP algorithm is widely used by ACTRIS community.

3.3 Use of the European Centre of Aerosol Calibration (ECAC) by SMEs

- ADDAIR (France)

ADDAIR is a distributor of high-quality monitoring for air quality and aerosol metrology (e.g., PALAS, Aerodyne). ADDAIR has participated in the inter-laboratory comparison workshops organized by ECAC-ACMCC for improvement and development of inorganic calibration methods for ACSM instruments.

- Aerosol d.o.o (Slovenia)

Aerosol d.o.o is a SME that develops and manufactures Aethalometer® instruments that are used in air monitoring network stations for sampling and measurement of the mass concentration of black carbon particles. Aethalometers are widely used within ACTRIS-2 and Aerosol d.o.o. have closely been interacting with ECAC-WCCAP during the intercomparison workshops for scientific development work.

- Aerodyne Research Inc. (USA)

[Aerodyne Research Inc.](#) is an instrument manufacturer that provides instrumentation and consulting for environmental air quality monitoring and measurement. The Aerodyne Aerosol Mass Spectrometer (AMS) has been deployed worldwide at fixed sites, and on mobile laboratory, ship and aircraft platforms to obtain quantitative size and chemical mass loading information in real-time for non-refractory sub-micron aerosol particles. The AMS couples size-resolved particle sampling and mass spectrometric techniques into a single real-time measurement system. The more recent Aerodyne Aerosol Chemical Speciation Monitor (ACSM) is smaller, lower cost and more robust than the AMS and measures particle mass loading and chemical composition in real-time for non-refractory sub-micron aerosol particles. Although the ACSM is designed for long-term unattended deployment and routine monitoring applications, it regularly requires calibration. The ECAC-ACMCC is worldwide the only facility providing on-site calibration and intercomparison workshops with reference instruments and manufacturer support.

Within ACTRIS-2, a first intercomparison has been organized by ECAC in spring 2016 in which Aerodyne participated to intercompare ACSM instruments used within the scientific community and to test/develop new inorganic calibration procedures for ACSM (Aerosol Chemical Speciation Monitor) and TOF (Time-of-Flight)-ACSM (figure 3). Three times more users of ACSM instruments have demanded access to the calibration facility than initially planned for calibration of their devices intended.



Figure 3: Aerodyne instruments during first ECAC-ACMCC intercomparison campaign in 2016

- Brechtel (USA)

[Brechtel](#) develops and manufactures aerosol devices for sampling, particle counting and sizing, and absorption measurements and its products are widely deployed with ACTRIS-2. ECAC-WCCAP closely interacts with Brechtel for scientific development work on multi-wavelength absorption photometers.

- TSI Inc. (USA/Germany)

[TSI Inc.](#) is a company specialized in the design and production of precision measurement instruments for aerosol science, airflow, chemical analysis, indoor air quality, fluid dynamics, biohazard detection, and even scrap metal sorting and plastics identification. TSI collaborates with most ACTRIS-2 partners that widely use the TSI aerosol particle counters and sizers. During ACTRIS-2, TSI has been closely cooperating with the World Calibration Centre for Aerosol Physics (ECAC-WCCAP) at TROPOS: to calibrate a number of various TSI CPCs and particularly to verify, test, and calibrate their new ultrafine Condensation Particle Counter 3772-CEN. This newly developed instrument is compliant with the proposed Technical Specification CEN/TS 16976, drafted by the European Committee for Standardization, for harmonization of measurement and sampling of ultrafine particles. The testing and development of TSI technology at ECAC ensures reliable data in thousands of installed units around the world.

- TOFWERK AG (Switzerland)

[TOFWERK](#) is a provider of Time-Of-Flight Technology and offers custom instrumentation for research laboratories and high performance end-user instruments. TOFWERK has been involved ACTRIS ACSM intercomparison workshops to improve their ToF-ACSM through use of mass analyser with greater sensitivity and resolution, hardware development for measurement of atmospheric metals and black carbon, and software development for automated data reduction.

3.4 Use of the advanced observational stations

- Aerodyne Research Inc. (USA) @ Monte Cimone/Po Valley facility (CMN, Italy)

[Aerodyne Research Inc.](#) is an instrument manufacturer that provides instrumentation and consulting for environmental air quality monitoring and measurements. The Aerodyne Center for Sensor Systems and Technology (CSST) designs and develops innovative sensors utilizing proprietary technology for its own use and for delivery to private, academic and government customers. It has built and marketed state-of-the-art monitors that employ cavity attenuated phase shift (CAPS) techniques. One of such CAPS monitors is the CAPS SSA, a single scattering albedo monitor for direct, combined measurements of both extinction and scattering in the same volume. Particle absorption can be obtained by subtraction of the two measured quantities (extinction minus scattering), with an uncertainty of 5-6%. Upcoming in July 2017, Aerodyne participates in an international field campaign at the Monte Cimone and Po Valley sites to assess the accuracy of aerosol absorption and black carbon measurements. The CAPS SSA is collocated with other instrumentation for aerosol measurements of optical, physical, and chemical properties: a nephelometer, an Aerosol Chemical Speciation Monitor, an optical particle counter. The presence of multiple techniques for measuring aerosol absorption (by difference with the CAPS SSA and on a filter) will allow measurement intercomparison and observe the changes in optical properties with changes in the chemical composition of the sub-micron aerosol as determined by the ACSM. In particular, the specific goal of the campaign is a comprehensive closure between absorption coefficient and BC concentration and an assessment of the reasons for the variability of the mass absorption efficiency using commercial instrumentation.

- Aerodyne Research Inc. (USA) @ KNMI – Cabauw Experimental Site for Atmospheric Research (CESAR, The Netherlands)

AVVICATO (Application of a VOCUS VOC Integrated Calibration system at a Tower Observatory) involved the manufacturer [Aerodyne Research Inc.](#) using their automated PTR-MS calibration and background system in cooperation with other PTR instruments. The constructed PTR time-of-flight mass spectrometer (PTR-ToFMS) has a unique ionization source compared to other instruments in attendance, and has never been quantitatively evaluated against other PTR instruments.

- Aerosol d.o.o. (Slovenia) @ Cyprus Atmospheric Observatory (CAO, Cyprus)

[Aerosol d.o.o.](#) is a SME that develops and manufactures Aethalometer® instruments that are used in air monitoring network stations for sampling and measurement of the mass concentration of black carbon particles. The SME supplied a platform, installed at CAO in December 2018 in the frame of the CADB project led by Grisa Mocnik, from the J. Stefan Institute, using Aethalometers AE33 with different inlets to:

- measure fine aerosol absorption (AE33 with a PM1 inlet),
- measure concentrated coarse fraction absorption (AE33 with a virtual impactor inlet and calculating the coarse fraction absorption as a difference between the

concentrated sample (which contains some fine fraction) and the fine fraction. In addition to the measurements of absorbing aerosols, additional measurements of all carbonaceous aerosols at high time resolution have been implemented at Nicosia.

- Aerosol d.o.o. (Slovenia) @ CSIC Montseny (MSY, Spain)

This private company supplied a platform, installed at MSY in February 2019 in the frame of the CADB-2 project led by Grisa Mocnik, from the J. Stefan Institute, using Aethalometers AE33 with different inlets to measure fine aerosol absorption (AE33 with a PM1 inlet), and to measure concentrated coarse fraction absorption (AE33 with a virtual impactor inlet). Aerosol d.o.o has supplied two additional platforms installed at BCN urban background sites and MSC mountain site. This approach together with concurrent aircraft measurements will permit to determine the pure Saharan dust optical properties before it is mixed into the receptor site mixing layer, discriminating whether internally mixed dust and BC are from the source or receptor regions, respectively.

- Droplet measurement technologies, (USA) @ Puy de Dome high altitude station (PUY, France)

[Droplet measurement technologies](#) is an instrument manufacturer based in Colorado, USA, specialized in the production of cutting-edge instruments for measuring water droplets, ice crystals, CCN, black carbon, bioaerosols and other aerosols. The company provides accessories for these instruments such as calibration devices and power distribution systems, as well as high-quality software.

The company accessed the Puy de Dome high altitude station in France with a Spectrometer for Ice Nuclei (SPIN), which is one of the ice nuclei spectrometers commercially available. Given the wide variety of ice nucleation instruments in use, differences in ice nucleation observations arise, in part, from the different techniques used. The TNA project proposal aimed at describing the differences between one SPIN unit versus another, as well as to compare SPIN with other types of CFDCs. Understanding the source of these differences helps with data quality of SPIN in particular and CFDCs in general. Furthermore, an improved SPIN enables scientists interested in conducting measurement with access to an instrument that is well characterized by experts in this field. Specific objectives of the project have been i) the characterization of the differences in particle concentrations measured by SPIN units and other CFDCs under different meteorological conditions; ii) the characterization and investigation about features of the parallel plate type CFDC to better learn how to calibrate instruments of this type and in what detail the calibration is necessary; iii) the improvement of methods and procedures to minimize frost background in SPIN, isolating the effects that lead to frost formation and implementing changes in the procedure that might arise in frost; iv) improved measurement of ice crystal concentrations by utilizing advanced analysis techniques of particle-by-particle polarization ratio.

- [EKO Instruments EUROPE BV \(The Netherlands\) @ Izaña Subtropical Access Facility \(ISAF, Spain\)](#)

[EKO Instruments EUROPE BV](#) is a Dutch company established in 1927 with three core business areas, which are remote sensing, evaluation and measurement of photovoltaic performance, and radiation and spectral measurements.

The research project main purpose is the evaluation of the EKO MS-711 spectroradiometer measurements at the Izaña Subtropical Access Facility (ISAF, Spain). The project foresees an intercomparison between instruments provided by EKO as well as other radiometers already installed at IARC-AEMET testbed in order to perform i) comparison of the direct normal irradiance measurements performed by the collimated and rotating shadow band EKO spectroradiometers; ii) evaluation and comparison of current methods for the retrieval of aerosol optical depth (AOD), precipitable water vapor (PWV), and the spectral irradiance extension, based on spectral DNI measurements from both collimated and RSB MS-711, iii) comparison between indoor and outdoor spectroradiometer calibrations; and to iv) quantify the measurement improvements in the measurement accuracy of the stray light corrected DNI measurements of the EKO spectroradiometer in the UV range against the NASA Pandora spectrometer; v) quantify the measurement improvements in the measurement accuracy of the stray light correction measurements of the EKO spectroradiometer. During the visit has been foreseen the assembly of instrumentation on site for the measurement campaign. Two spectroradiometers will be provided by EKO Instruments to be installed in Izaña testbed. One collimated EKO MS-711 will be installed with collimation in an EKO STR-22G sun tracker and one EKO MS-711 will be installed in the EKO RSB-01S rotating shadow band.

- [Envicontrol SA \(Belgium\) @ CNR IMAA Atmospheric Observatory \(CIAO, Italy\)](#)

[Envicontrol](#) is specialized in measuring equipment for gases, air and dust (sampling, analysis, calibration and generating of gases), as well as in acquisition and management systems for monitoring and warning networks. The SME has exclusive dealership for about 15 manufacturers in Benelux, France, and Africa. Envicontrol has participated in the measurement campaign INTERACT-II (INTERcomparison of Aerosol and Cloud Tracking) where a number of commercial instruments were involved: two multi-wavelength Raman lidars, a Raymetrics UV scanning Raman lidar, a VAISALA CT25K ceilometer, a VAISALA CL51 ceilometer, a JENOPTIK CHM15k ceilometer, a Campbell CS135s ceilometer, and a Sigma Space mini-Micro Pulse Lidar. Envicontrol has been in charge of operating the mini-MPL system to study the system performance for the measurements of aerosols and clouds, instrument stability, and accuracy of calibration. Envicontrol furthermore received training for advanced Raman lidar operation and use of calibration procedure for the lidar depolarization technique.

- [GRASP S.A.S \(France\) @ FINOKALIA Atmospheric Observatory \(FKL, Greece\)](#)

The objective of the GLAM (Comparison of GARRLIC Absorption Profiles with Airborne In-situ Measurements during the DETECT Campaign in Crete) campaign was the evaluation of the GARRLiC retrievals with high-quality airborne and in-situ measurements of aerosol absorption performed during the campaign at Finokalia. The TNA was carried out by the start-up company GRASP S.A.S.

- [IONICON Analytik \(Austria\) @ TROPOS Research Station Melpitz \(MEL, Germany\)](#)

The main scientific objective of this TNA is to field test and validate the new CHARON PTR-TOF 6000 X2 instrument. The instrument detects gas-phase organics at single-digit ppt levels and particle-phase organics at triple-digit pg/m³ levels. The instrument exhibits a series of user friendly features such as automated zeroing, automated switching between gas phase and particle inlet and real-time display of concentrations. IONICON will provide a PTR-TOF 6000 X2 instrument that is equipped with the latest version of the CHARON particle inlet. The CHARON (“Chemical Analysis of Aerosol On-line”) inlet consists of i) a gas-phase denuder for removing gaseous organics, ii) an aerodynamic lens for enriching the particle concentration in the instrument subsampling flow and iii) a vaporization unit for evaporating particle-bound organics [Eichler et al.; doi: 10.5194/amt-8-1353-2015; Müller et al., doi: 10.1021/acs.analchem.7b02582] The commercial instrument offers a variety of new features (automated zeroing, automated switching between gas phase and particle inlet, real-time display of concentrations, sub-ng detection limit, new vaporizer design) that have not been field-tested and validated. Dr. Markus Müller, the developer of both the PTR-TOF-MS instrument and the CHARON inlet, will set-up, calibrate and operate the CHARON-PTR-ToF-MS analyzer during week 1. During week 2 remote operation will be tested. During week 3, the PhD student Felix Piel will be on site for training purposes together with his supervisor Prof. Armin Wisthaler who has also multi-year experience in PTR-ToF-MS and particle analysis using the CHARON inlet. This will be the first medium-term field test and validation exercise of the new CHARON-PTR-ToF-MS analyzer. Data analysis and write-up (method/intercomparison paper) will be carried out in joined work by IONICON, the University of Oslo and TROPOS. The TNA will end the 1st of March 2019 and a complete scientific report will be published.

- [Palas GmbH \(Germany\) @ Puy de Dome high altitude station \(PUY, France\)](#)

[Palas GmbH](#) is a company specialized in particle measurement technology and the development and production of filter test systems and optical aerosol spectrometers. In October 2016, Palas participated in an intercomparison field campaign of cloud microphysical probes with two of its Fidas[®] 200 S instruments. Fidas[®] 200 S is a fine dust monitoring and ambient air measurement system for ambient air monitoring of fine dust for regulatory purposes. Goal of this campaign is to evaluate a new automatic instrumentation for clouds droplet real time analysis. The new Fidas[®] 200 analyser supplies a particle size distribution (mass and/or number) between 0,4 and 40 µm. The aim is to study the interaction between droplets size and condensation nucleus with two analysers, installed side by side. One is configured to measure droplets size, the other to dry droplets and to evaluate condensation nucleus size. If successful, the low-cost and low maintenance instrument could be an efficient solution for long-term measurement of cloud droplets at ACTRIS stations.

- [Palas GmbH & Airclip Service GmbH \(Germany\) @ Pallas-Sodankylä Global Atmospheric Watch Station \(PAL, Finland\)](#)

The 7th Pallas Cloud Experiment combined in-situ and remote-sensing observations to provide the best basis for process-level research on cloud-atmosphere interaction.

Palas GmbH together with Airclip Service GmbH & Co KG provided a Fidas Fly 200 instrument and flight robot (HORUS 2.0 octocopter), respectively during this campaign.

Fidas Fly200 provided the continuous and simultaneous measurement of the PM-fractions PM1, PM2.5, PM4, PM10, as well as in addition the particle number concentration as well as the particle size distribution in 32 size classes per decade within the particle size range of 0.18 – 18 µm or 0.5 – 40 µm - and all this in an additional spatial dimension. Besides the experiments were the first time to actually use the new Fidas Fly 200 in combination with HORUS in such weather conditions, regarding humidity and temperature. This proves that the system works and shows what needs to be improved.

- [Raymetrics](#) (Greece) @ [SIRTA Atmospheric Research Observatory \(SIR, France\)](#)

The objective of this TNA has been the development of new software and hardware tools for improving lidar alignment mechanism and strategies and optimizing lidars field of view. In many lidar systems optimizing day light background suppression mechanism is based on reducing the lidar's field of view. However, minimizing field of view requires an improved "mechanism" for lidar alignment. By using a combination of a special designed CCD camera and multi-anode PMT, lidar signal optimization and accurate positioning of the field stop of the lidar was accomplished. Monitoring the image of the telescope focal plane and detecting the position of the lidar return signals in respect of Field Stop Diameter allows user to check the "correct" position of the Field Stop and the quality of the lidar alignment. The use of a multi anode PMT and specially developed software allows real time alignment monitoring and correction by a motorized laser beam steering mechanism.

The unique combination of a CCD and a multi anode PMT opens new ways for checking lidar alignment, lidar setup integrity and lidar signal background suppression. A better positioning of the Near Range field stop achieved even from the very first day of these TNA. Near ranges signals were improved significantly and telecover test performed successfully. CCD camera solutions were deployed and checked. It was proved that such solutions can be used successfully for visible but also for ultra violet signals day and night for IPRAL lidar.

- [Sunset Laboratory Inc. \(The Netherlands\)](#) @ [CSIC Montseny \(MSY, Spain\)](#)

[Sunset Laboratory Inc.](#) is a company specialized for manufacturing devices for organic carbon and elemental carbon (OC-EC) aerosol analysis and in the field of aviation, mining, marine, astronomy, construction, and weather research. Their equipment is suitable for the laboratory or in the field, and ready for use with different methods, among others the EUSAAR2 protocol developed within the ACTRIS-1 predecessor EU project. Sunset Laboratory has developed the Sunset SemiContinuous Field OCEC analyzer. To evaluate its performance with the EUSAAR2 protocol, Sunset Laboratory has used the ACTRIS-2 site MSY during a TNA project "SLOPE". The EUSAAR2 is a required protocol for the networks of all EU member states to measure EC and OC in particulate matter at background sites according to the Council Directive 2008/50/EC on ambient air quality and cleaner air for Europe. The European Committee of Standardization (CEN), has recently adopted EUSAAR2 as the reference temperature protocol to be used when performing the offline, thermal-optical/transmittance (TOT) Organic and Elemental Carbon analysis (OCEC) (CEN/TC 264/WG 35 prEN16909:2016). Sunset investigates the comparison of the online OCEC analysis method with the offline, reference method at a challenging rural environment, dominated

by biogenic emissions, for their comparability and to evaluate the hightime resolution concentrations.

3.5 Other ACTRIS-2 partnerships with SMEs

ACTRIS-2 has active cooperation with other SMEs for testing of new instrumentation is in progress, for example with [HALO Photonics](#), a manufacturer of Lidar based remote sensing instruments (UK) regarding the improvement of the Doppler lidar retrievals; with the Lidar company Raymetrics (Greece) for developing new lidar technical solutions in particular regarding the aerosol lidar polarization calibration; and with the manufacturer of high quality in-situ sensors and remote sensing profilers [METEK](#) (Germany) for testing new polarimetric cloud radar systems.

Overall, ACTRIS-2 actively collaborates with more than 50 SMEs for technological developments, continuous cooperation and exchange for hardware improvements and software updates and developments, and supply of instrumentation and components. A summary of collaborating SME partners is given in table 1.

Table 1. List of SME partners collaborating with ACTRIS-2

Company	Country
Abacus Laser	Germany
ADDAIR	France
Aerodyne Research, Inc.	USA
Aerosol Consulting ML SarL	Switzerland
Aerosol d.o.o	Slovenia
Airclip Service GmbH	Germany
Air Lorraine	France
Air Quality Design	USA
Airmodus Oy	Finland
Alpes Lasers S.A	Switzerland
Andøya Space Center	Norway
Brechtel	USA
Campbell Scientific Ltd.	UK, France
Catalysts	Austria
CIMEL Electronique	France
CNC Solutions	Greece
Cooper Environmental	USA
Dekati Oy Finland	Finland
Droplet Measuring Technologies	USA
Ecophysics: CLD	Germany
Ecotech Pty Ltd	Australia
EKO Instruments EUROPE BV	The Netherlands
Envicontrol	Belgium
EnviMeS: ICAD	Germany

Environnement S.A	France
GRASP-SAS	France
GWU-Umwelttechnik GmbH	Germany
Halo Phototonics	UK
IONICON Analytik	Austria
LEOSPHERE	France
Licel GmbH	Germany
Los Gatos: CAPS, CEAS	USA
Lufft GmbH	Germany
LuftBlick OG	Austria
METEK GmbH	Germany
Meteomodem	France
Metrohm Applikon	The Netherlands
ML SaRL	France
Nicarnica Aviation	Norway
Palas GmbH	Germany
Perkin Elmer	USA
Raymetrics SA	Greece
Remote Sensing Consultants Limited	UK
Ricardo-AEA Ltd.	UK
RPG Radiometer Physics GmbH	Germany
Sigma Space Cooperation	USA
Sunset Laboratory Inc.	The Netherlands
Teledyne Api CLD	USA
Tenum	France
Tera Environnement France Consultancy services	France
Thermo Electronics: Thermo Fisher CLD	USA
TOFWERK AG	Switzerland
TSI GmbH / TSI Inc.	Germany / USA
VAISALA	Finland

4. Conclusions

To date, 21 different SMEs have used the ACTRIS facilities and calibration centres for testing, developing, calibrating, and intercomparison of commercial and new innovative products that are relevant to ACTRIS observations. Sigma Space and Campbell Scientific have participated with commercial automated remote sensing instrumentation at intercomparisons organized by LiCal to assess their performance for tropospheric profiling of aerosols and clouds in different environmental conditions. Both instruments are able to provide an extended spatial and temporal coverage for long-term observations in scientific and operational networks. The direct comparison with the reference lidar has been essential to assess in great detail the sensitivity and stability of these commercial instruments that are expected to be widely deployed by the aerosol measurement networks.

The photometer manufacturer CIMEL regularly uses AERONET-Europe for calibration of its photometer, the world-wide reference instrument used in aerosol monitoring networks, and particularly for testing of the new CE318-T Sun Sky Lunar photometer available since very recently and increasingly deployed in atmospheric. AERONET-Europe has calibrated the small, low-cost photometer produced by TENUM, which is now widely marketed. ECAC has regularly been collaborating with several manufacturers and distributors of physical, chemical, and optical aerosol instruments that have participated during ACTRIS-2 in the calibrations and intercomparison workshops: for the improvement and S&T development of inorganic calibration methods for ACMS and ToF-ACSM (Aerodyne Research Inc., ADDAIR, TOFWERK AG), and testing and development of innovative aerosol particle counters and sizers and multi-wavelength absorption photometers (TSI Inc., Aerosol d.o.o, Brechtel).

Eleven SMEs have used the ACTRIS-2 observational facilities to test and intercompare their commercial and new instrumentation in the field: an evaluation of the newly developed the Sunset Laboratory Semi-Continuous Field carbon analyzer with the EUSAAR2 protocol at a rural site in Spain; evaluation and testing of the Palas GmbH automatic instrumentation for clouds droplet real time analysis; an intercomparison of active and passive remote sensing commercial instrumentation including three commercial ceilometers (VAISALA, JENOPTIC, Campbell, ENVICONTROL) and two commercial lidars (Sigma Space, CIMEL) with two advanced research systems from ACTRIS-2; an intercomparison of an Aerodyne CAPS SSA with other physical and optical measurements of aerosol absorption and black carbon measurements to the accuracy of the commercial instrument and variability during field deployment at the Monte Cimone and Po Valley sites in Italy, an intercomparison at Puy de Dôme Station of a Spectrometer for Ice nuclei (SPIN) instrument (Droplet Measurements) . Moreover, Aerosol d.o.o. installed different Aethalometers AE33 at MSY and CAO stations for testing their performance in the Mediterranean area.

Furthermore, active cooperation with other SMEs for testing of new instrumentation is in progress (HALO Photonics, Raymetrics, METEK), and overall, ACTRIS-2 has active partnership with a large number of private sector partners for standardisation and deployment of long-term monitoring equipment for atmospheric observations in the field of aerosols, clouds, and trace gases.

In conclusion, the opportunities offered by ACTRIS-2 through its physical and remote access programme to ACTRIS-2 facilities are crucial to interaction with SMEs, allowing the participation of users from the private sector for innovative research, new technological knowledge, instrument testing and development. Although the use of ACTRIS-2 facilities by SME users is smaller than by public and academic users (up to 10% are used by SMEs), substantial efforts are devoted towards innovation and transfer of knowledge to SMEs, based on a long history of joint technological developments, continuous cooperation and exchange for hardware improvements and software updates and developments. The standardisation and establishment of reference standards is a key to promote the use of ACTRIS facilities by SMEs. The manufacturer suppliers of remote sensing and near-surface measurement equipment are actively involved within ACTRIS-2 to develop new algorithms and products as well as calibration standards. ACTRIS-2 offers the best facilities and expertise for supporting SMEs in this field in Europe.