Deliverable 9.3: Report on the results of the flagship actions

Authors: Stephane Sauvage, Carmela Cornacchia, Simone Gagliardi

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1. Introduction

This report is prepared in the framework of the ACTRIS IMP project, within the work package 9 dealing with innovation and cooperation with the private sector. The objective of this work package is to strengthen innovation within ACTRIS both to support innovation and to promote the best observations and services to respond to the challenges of atmospheric pollution and Climate. The work carried out for this purpose allowed an inventory of technological development activities, proposed recommendations (MS9.3), develop a catalogue of services (D9.4) and tools facilitating the establishment of partnerships between ACTRIS and private sector.

ACTRIS IMP project as well as currently ongoing ATMO-ACCESS project (by atmospheric RIs ACTRIS, IAGOS and ICOS) have specifically launched TNA calls for promoting access and technological development projects by the private sector. In addition, specific events were organized to present technological innovation and to promote networking between the private sector and RI. In addition to deliverable 9.1 describing the positioning of ACTRIS in the innovation ecosystem, this report offers an analysis of the TNA projects submitted and the events organized over the period 2021-2023. This involves categorizing the types of developments and evaluating to what extent the innovations respond to the challenges identified in the medium term for ACTRIS.

This document will first outline the challenges ACTRIS is facing, and then the analysis of the TNA activities. An analysis of the TNA projects and workshops related to the private sector is presented, highlighting the main techniques developed, and the typology of developments. These developments are then put into perspective with the challenges for ACTRIS in order to highlight the directions still needed to foster innovation and better meet the needs.

2. Main technological challenges for ACTRIS

Observation systems are facing a number of challenges addressing the issues of atmospheric pollution and climate change. New observations are expected and needed to better understand the evolution of atmospheric composition and the driving processes. The article "From Global Atmospheric Composition Observations", Carmichel et al. published in 2022 (BAMS, 2022) pointed out the need for global coverage of a range of atmospheric constituents. There is a need to fill in the gaps on spatial coverage of observations and to enhance observations of the vertical distribution of atmospheric compounds to better link observations from space to surface measurements. Another need is to develop standards and tools to ease and advance the use of reliable observations. This includes extending methods (calibration, quality assurance) to more diverse data streams and develop tools using diverse data sources to produce new services. Recently, Kahn et al, 2023 reinforced the need of 3D distribution of optical, microphysical, and chemical particle properties. They pointed out that research will have to better integrate satellite observations, measurements, and modelling, to reduce uncertainty in aerosol climate forcing.

The ability to better observe and predict atmospheric composition and its influence on weather, air quality and climate is a major challenge to our society and economy. This challenge poses several technological

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needs that range from short-term warnings about hazardous weather or adverse air quality to long-term evaluation of climate change and policy effectiveness. High-quality observational data are the foundation of reliable model predictions, and thus the basis for environmental policies and strategies that will reduce emission of pollutants and climate forcers, improve air quality, and slow down climate change. Moreover, such data are indispensable to generate services and products necessary for strengthening societal resilience to environmental changes.

The ACTRIS challenges and strategy have already been discussed in the Deliverable 7.2 of the ACTRIS PPP project « ACTRIS strategic report from current status to 30-year vision ». As a summary, the key goals in the ACTRIS strategy for the future are:

- to develop ACTRIS towards an infrastructure with global relevance,
- to further develop the ACTRIS services and facilitation of innovation
- to remain state-of-the-art
- to enhance the ACTRIS scientific impact.

It is worth noting that a very fast evolution of technologies providing new capabilities for observing new variables, in higher time resolution, may improve the potential for developing more robust observations and elaborated services. These technologies include for example a new generation of low-cost sensors which are already widely used. Their performance is still questionable in terms of data robustness, but they are valuable tools for measuring 4D distribution of atmospheric components. These developments come together with growing computing performance as well as the growing utilisation of artificial intelligence. New developments are on-going for data processing allowing new advanced tools capable to combine different kinds of observations for a better representation/understanding of the atmospheric composition.

ACTRIS needs to develop metrology needed for cutting-edge research on short-lived atmospheric constituents [Deliverable 3.4: ACTRIS strategy on scientific added value, impact, attractiveness and relevance] and it is already a reliable metrology partner in EU-projects and in standardisation processes. The methodology harmonisation work in ACTRIS needs to be connected with the latest developments in EMPIR and EURAMET standardisation procedures.

In this context, user demand is going more and more towards near real time data provision for rapid diagnostic, for satellite data that needs to be validated, for model validation up to rapid decision tools. With higher time resolution instruments together with fast data workflow, ACTRIS will have to develop new near real time products for direct application such as source apportionment or pollutant health impact assessment. ACTRIS will also have to handle the “big data” evolution in the environmental science. That will open new potential of services possibly cross-research infrastructure to provide more integrated information, for instance for risk evaluation in case of extreme events.

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3. Analysis of innovation activity through TNA projects

Three TNA calls have been launched within ACTRIS IMP. Within these calls only three TNA projects from private sector were proposed, not enough to carry out a representative analysis. This is understandable considering the that the key objective of ACTRIS IMP was to implement, test and improve the ACTRIS service provision, not to provide wide TNA program. However, at the same time, different TNA calls were organised as a part of the ATMO-ACCESS project, of which one was specifically addressed to private sector. The aim of the ATMO-ACCESS project is to develop a strategy and methods of access to Research Infrastructure (RIs) in the atmospheric domain (ICOS, ACTRIS, IAGOS) for different types of users.

TNA projects submitted in the ATMO-ACCESS project, have been examined in order to see to what extent the current developments of recent years feed the ACTRIS technological challenges. 21 TNA projects were carried out within the ACTRIS perimeter. These projects were categorized and analysed by topic (aerosol, gases, clouds, in-situ and remote sensing technologies) and according to three types of developments: developments for better performance, for new instruments and for new variables.

Table 1 presents eight TNA projects aimed at improving the performances of instruments. Several TNA projects requested by Aerosol d.o.o. and Sunset Lab BV focused on improving the distinction of organic aerosols at high temporal resolution. These developments are essential for identifying aerosol typology and improving source apportionment. One project was requested by LICEL GmbH to test automatic LIDAR adjustment allowing remote control and performance enhancement. One project for trace gases in-situ allowed TofWerk to test a new dual ionization system for a mass spectrometer. This instrument performs chemical characterization of gases with high temporal resolution. The improvement will enable better identification of the observed species.

Most of the projects rely on observational platform for the implementation under real conditions, with the benefit of reference measurements running on this site. For specific developments, simulation chambers (such as QUAREC in Germany or EUPHORE in Spain) are particularly useful for initial testing of different methods under simulated conditions. The Topical Centres provide support for testing these improvements with reference instruments or during in intercomparison experiments.

Aerosol d.o.o. (Slovenia) is very active, having requested 4 projects. This company uses the full potential of ACTRIS accessing several NFs to test different conditions, or by working with the Topical Centre for their new instrument validation.

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Table 1. Private sector TNA projects submitted to ACTRIS IMP call and ATMO-ACCESS recurrent calls to develop higher performance of observing system.

Compagny	Country	Access type	Platform access	Year	Project title	Topic
Aerosol d.o.o.	Slovenia	Access CF	WCCAP, DE (CF)	2022	Intercomparison of optical absorption measurements using newly developed portable Aethalometer AE43 and Aethalometer prototype with extended wavelength range (Inter-AE)	Aerosol IS
Aerosol d.o.o	Slovenia	Access CF	WCCAP, DE (CF)	2023	Intercomparison of optical absorption measurements using newly developed Aethalometer AE36 and AE36s withextended wavelength range (9-wavelengths)	Aerosol IS
Aerosol d.o.o	Slovenia	Access NF (obs & ASC)	SMEAR II, FI (OBS) and EUPHORE, ES (ASC)	2022	Atmospheric aerosol precursor and security research – proof of concept	Aerosol IS
SUNSET Lab BV	Netherland	Access NF (obs)	BCN, SP (Obs)	2022-2023	Prototype field analyzer application for simultaneous real-time measurements of Organic Elemental, Black and Brown Carbon fractions using a dual-wavelength laser set-up	Aerosol IS
Aerosol d.o.o	Slovenia	Access NF (obs)	BCN, SP (Obs)	2022-2023	Long-term and high-time-resolution validation of advanced total carbon–black carbon (TC-BC(λ)) method for apportionment of primary and secondary carbonaceous aerosols in the western Mediterranean basin (WMB: TC-BC(λ))	Aerosol IS
Aerosol d.o.o	Slovenia	Access NF (obs)	JFJ, SW (OBS)	2022	Carbon balance field campaign in free troposphere with intermittent planetary boundary layer influence –Total carbon measurements with TCA08	Aerosol IS
Licel GmbH	Germany	Access NF (obs)	WOS, PL (OBS)	2023	Test a new APD Cassette ground concept for remote control to improve the baseline flatness if for the 1064nmsignal in lidar	Aerosol RS
TOFWERK AG	Switzerland	Access NF (ASC)	QUAREC, DE (ASC)	2023	TEsting of a Dual Ionization MS prototype by coupling with an Atmospheric Simulation Chamber	Gaz IS

Table 2 lists projects dealing with the observation of new variables. These developments are based on new instrument capabilities, for example Karsa's proposal regarding the development of the multi-scheme chemical ionization inlet (MION) - mass spectrometer. The method will provide new information for iodic acid and HOM (Highly oxidized molecules) and sulfuric acid.

Multi-species instruments for in-situ gas measurements are constantly being developed, to provide information on new compounds of interest. This is the case for the MEVOC TNA project performed by the UK company Terra Modus Consultants Ltd., aiming at measuring specific anthropogenic tracers using the gas chromatograph MEDUSA. The purpose of this project is to increase the number of compounds measured, which will improve the identification of source chemical fingerprint and emission quantification.

The TOWERK mass spectrometer has a high analytical potential, but difficulties in identifying isomers. An evaluation based on standards provided by the OGTAC-CC (Organic Tracers and Aerosol Constituents Calibration Center) Unit of CAIS-ECAC will enable to better identify the oxidation products of isoprene (a highly reactive biogenic compound with a significant impact on atmospheric chemistry and the formation of secondary pollutants such as ozone).

Thanks to the TNA project taking place at ISAF (Izana Subtropical Access Facility, Spain) Cimel company improved the direct and polarized signals of the CE376 micro Lidar in order to contribute in the aerosol characterization of the subtropical North Atlantic free troposphere.

Through the TNA project, SchnaiTech Gmbh tested PAAS (Photoacoustic Aerosol Absorption, Spectrometer) at FMI Pallas-Sodankylä Atmosphere-Ecosystem (PAL-SOD) Supersite in Finland to demonstrate that the instrument is suitable for measurements in clean environment such as Arctic and capable to distinguish fossil fuel from biomass burning sources.

NFs equipped for in-situ cloud measurements are not yet widespread. These are nevertheless measurements of interest for a better understanding of cloud formation and its impact on climate. Liquid Water Content is one of the minimum variables required for Cloud In-situ, but not yet that much

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measured. Instrumentation that is still under development for measuring these parameters needs to be compared in-situ (Pallas Gmbh project). Vaisala offers a new generation of ceilometer with new depolarization capabilities that enable differentiation between solid and liquid particles. This opens new possibilities for distinguishing meteorological characteristics between liquid and solid precipitation, cloud phases, sand layers, volcanic ash…

Some developments combine several types of observation. Thanks to the project, Stüv SA and university of Namur performed both gas and particles new instruments to better document processes (such as effluent of wood combustion) in simulation chambers. GRASP SAS proposes integration tools and model combining remote sensing and in situ aerosol measurement.

Table 2. Private sector TNA projects submitted to ACTRIS IMP call and ATMO-ACCESS recurrent calls to develop new variables.

Compagny	Country	Access type	Platform access	Year	Project title	Topic
SchnaiTECH Gmbhc	Germany	Acces NF (obs)	FMI-PAL-SOD (Obs)	2022	Source appotionmeent of carbinceous aerosol using the Angström exponent (SUPPOSE)	Aerosol IS
CIMEL	French	NF Access for instrument tes	ISAF - IZO, ES (OBS)	2022	Characterization Of AerosoLs In The subtropIcal nOrth atlaNtic (COALITION)	Aerosol RS
Palas GmbH	Germany	NF Access + CIS unit ECCINT for insturment test	SBO, AT (OBS)	2022-2023	Cloud Droplet Analyzer (CDA)	Cloud IS
Vaisala Oyj	Finland	Access NF (obs)	SIRTA, FR (OBS)	2022	CL61-4UrbanABL: testing the added-value of novel CL61 automatic ceilometer measurements for atmospheric boundary layer profiling in an urban environment	Cloud RS
Terra Modus Consultants Limited	UK	Access NF (obs)	CMN-PV, IT (OBS)	2022	Medusa Enhanced Volatile Organic Compounds (MEVOC)	Gaz in-situ
TOFWERK GA	Switzerland	Access CF	ACD-C/OGTAC-CC, DE (CF)	2022	Structural characterization and quantitation of isoprene-derived oxidation products using a newly developed mass spectrometer (STRUCTURE)	Gaz IS
JB Hyperspectral Devices GmbH	Germany	Access NF (Obs)	CESAR, NL (OBS)	2023	Hyperspectral Assessment of Vertical Atmospheric Reabsorption of Sun Induced Chlorophyll Fluorescence	Met
Karsa Oy	Finland	Access NF (obs)	CAO, CY (OBS)	2022	Thermo Desorption – Multischeme chemical IONization inlet – Mass Spectrometer (TD-MION-MS) for	Aerosol IS
Stûv S.A. and University of Namur	Belgium	Access NF (ASC)	PACS-C2, CH (ASC)	2023	Catalytic solutions for the cleansing of wood stove emissions: a physico chemical characterization of effluentsgenerated by wood combustion and their maturation in the atmosphere	Aerosol and Gas IS
GRASP SAS	France	Acces NF (Obs)	AGORA, ES (OBS),ISAF - IZO, ES (OBS), WCCAP, DE (CF)	2023-2024	Calibration and validation activities of nephelometers using ground based insturments and their synergy	Aerosol RS and IS

Altogether three projects deal with new instrument development (Table 3). The variables are not necessarily new, but the innovation may be a new principle of the technique. Other developments focus on more compact instrument, opening the possibility to be imbedded for mobile measurements (e.g. measurements on Unmanned Aircraft System). This type of mobile vectors should be further developed to better document the vertical profile of physical and chemical properties, as well as to be able to map pollution or to track plumes during extreme events.

An infrared aerosol measurement method (AeroSpec) is proposed by EPFL (École polytechnique fédérale de Lausanne) for combined analysis of particle mass, organic matter, elemental carbon, minerals and metal oxides.

In general, developments may focus on a new instrument competing with instruments already widely implemented (eg. the photometer). The Validation of a such instrument by ACTRIS on one hand represents a strong selling point for this supplier and on another hand will open further the market.

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Table 3. Private sector TNA projects submitted to ACTRIS IMP call and ATMO-ACCESS recurrent calls to develop new instruments.

Compagny	Country	Access type	Platform access	Year	Project title	Topic	Catégorie
EPFL, Lausanne	Switzerland	Access NF (Obs)	ATMOS, GR (OBS)	2023	Monitoring of Aerosol Chemical Composition with Infrared Spectroscopy	Aerosol IS	New instrument
LEN s.r.l.	Italy	Access CF	WCCAP, DE (CL)	2023	Evaluation of Dual Beam Absorption Photometer	Aerosol RS	New instrument
Menapia Ltd.	Great Britain	Access NF (Obs)	CESAR, NL (OBS)	2023	Repeated vertical profiles of amulti-copter UAS	Met and Gas IS	Mobile measurement

4. Analysis of innovation activities through presentations given at innovation workshops

ACTRIS has also organized three workshops on Innovation in atmospheric sciences with several talks and a selection of virtual PICO presentations with recent relevant advances in the field. These workshops have been very successful, with more than 300 attendees. 30 to 35 presentations were given on each workshop, half of them by participants from the private sector. An analysis of these presentations is made to give a complete picture of the ACTRIS flagship actions towards innovation. It is worth noting that some talks are linked to the TNA projects presented above. Following the categorization presented above, the list of presentations (private sector only) has been divided into three categories: developments for better performances, for new instruments or for new variables.

Table 4 groups together projects involving the optimization of existing instrumentations. This may involve methodological harmonization of techniques, as in the case of in-situ aerosol measurements, or new calibration methods for aerosol remote sensing. Instruments are constantly under optimization to improve performances in terms of temporal resolution or chemical speciation, like for mass spectrometers (Ionicon Analytik, Aerodyne, TofWerk) for the observation of organic gaseous compounds or the chemical composition of aerosols (Aerodyne). These improvements push forward the performances and therefore increase the potential for process studies. On-going instrument improvements focus on a variable of interest such as formaldehyde which is still poorly measured. New capabilities of instrument are developed and tested at the topical centres (eg. through intercomparison), with the objective to achieve the required performance for relevant and robust measurements.

A specific model for a better representation of aerosol physical properties, transport and transformation is under development by GRASP SAS/Airphoton Inc. The model aims at integrating ground-based measurements with satellite measurements. Vaisala proposes the new Aeromancy model, based on the assimilation of in-situ observations from reference stations to improve prediction performances and the spatial resolution.

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Table 4. Presentation given during the innovation workshop on atmospheric observation, related to higher performances.

Year	Topic	Company/RPOs	Title of the presentation
2021	Aerosol IS	Aerodyne Research, Inc	Recent Developments for the Aerosol Chemical Speciation Monitor
2021	Aerosol IS	TSI GmbH	Harmonization of in-situ number concentration and size distribution measurement techniques
2021	Aerosol IS	University of Helsinki & Finnish Meteorological Institute	Improved sampling of aerosol nanoparticles - Example of a collaboration between academic and industry
2022	Aerosol IS	TSI Inc.	Harmonized Measurements of Ultrafine Particles in the Atmosphere
2022	Aerosol IS	Aerodyne Research Inc	Performance of a New Higher-Resolution Aerosol Chemical Speciation Monitor for Long-Term Measurements of Non-Refractory Aerosol
2022	Aerosol IS	Brechtel Manufacturing Inc.	Recent Advances at Brechtel MFG in UAS-deployable aerosol instruments
2023	Aerosol IS	DMT	An autofluorescence Nephelometer
2021	Aerosol RS	ALA Advanced Lidar Applications s.r.l.	Innovation solutions for Air Quality monitoring and LIDAR calibration
2021	Aerosol RS	Haze Instruments d.o.o.	A dual-wavelength photo-thermal interferometer for the determination of aerosol optical absorption coefficient and the absorption agnstrom exponen
2022	Aerosol RS	Haze Instruments d.o.o	Calibrated measurements of the aerosol absorption coefficient with a multi-wavelength photo-thermal interferometer
2022	Aerosol RS	AirPhoton Inc	The GRASP-SAS High-resolution Air Quality product
2022	Cloud RS	Jet Propulsion Laboratory	Retrieving Vertically Resolved Cloud Condensation Nuclei Concentrations from Spaceborne Lidar measurements
2021	Gas IS	Karsa Ltd	Observe twice as many molecular species with your high resolution mass spectrometer by using a MION?
2022	Gas IS	Karsa Ltd	Karsa multi ion chemical ionization inlet (MION2) for ultrasensitive trace vapor detection
2022	Gas IS	Tofwerk	Versatile chemical ionization time of flight mass spectrometer for detecting organic and inorganic trace gases
2023	Gas IS	Picarro Inc.	Lessons learned from highly resolved quasi-simultaneous formaldehyde measurements in suburban outdoor and indoor environments
2023	Gas IS	Ionicon Analytik	Fast-SRI Fusion PTR-ToF 10K: Improved monitoring of VOC
2023	Gas IS	Aerodyne Research, Inc.	Multiple reagent ions at once: New fast-switching chemical ionization mass spectrometer for OVOC and Inorganics
2022	Gas IS and Aerosol IS	Acoem Australasia (Ecotech Pty Ltd)	Pushing scientific boundaries needs continuity and excellent tools
2023	Model	Vaisala	AEROMANCY: A context-aware Air Quality Forecasting model

The presentations listed in Table 5 show developments for new variables. For instance, methods under development are presented to identify and measure bioaerosols (eg. Rapid E+ by Plair SA). The bioaerosols are among the variables not yet within the ACTRIS perimeter but are definitely of interest in order to complete the comprehensive physical and chemical characterization of aerosols and their impact on atmospheric processes. This variable is topic for a working group in the ACTRIS community with a long-term perspective of possible integration into the observation program. New instruments have still to be tested and optimized for long term observation.

Ammonia is also a species of interest, as it plays a major role in the formation of secondary inorganic aerosols. Measurement stations equipped with ammonia monitor are few mainly due to the lack of robust instruments, sensitive enough to capture the spatial and temporal variability for this variable. That is why several instrument manufacturers such as PICARRO, DURAG/AP2E, LGR, are proposing regular upgrades that are currently being tested.

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Table 5. Presentations given during the innovation workshop on atmospheric observation, related to new variables.

Year	Topic	Company	Title of the presentation
2022	Aerosol IS	Plair SA	Development of RAPID-E+ for in-situ measurements of bacteria, fungi, pollen, and other bioaerosols
2022	Gas IS	Airyx GmbH	A new instrument for in-situ HONO measurements by iterative cavity enhanced DOAS
2022	Gas IS	TNO*	Ammonia dry deposition measurements using two new instruments

There were many presentations of new instruments during the three workshops. They show that manufacturers are constantly developing new, more robust and more autonomous instruments, with improved performances. Several types of developments can be identified:

- The development of automatic on-line instruments (eg. Chromatotec), which are autonomous and stable, reducing the calibration procedures (Airyx).
- Instruments such as LIDARS, initially considered for research purposes, now being developed to make them more compact and operational (eg. Raymetrics)
- Instruments to better document physical properties of aerosols in clouds (e.g. Palas, DMT)
- "All in one" instruments for multi-species measurements (MIRO SA, Chromatotec) to replace multiple instruments
- Low-cost instruments as alternatives to costly reference methods (Naneaos Particle Solutions)
- New-generation of instruments (Oberon, Vaisala) using artificial intelligence for data processing and performance improvement or based on new measurement principles (BIRA ASB)

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Table 6. Presentations given during the innovation workshop on atmospheric observation, related to new instruments.

Year	Topic	Company	Title of the presentation
2021	Aerosol IS	Cambustion Ltd	The M2AS: Mass and Mobility Aerosol Size distribution measurement with the CPMA
2022	Aerosol IS	Oberon Sciences	AeroTape: a real-time IoT atmospheric particle analyzer
2022	Aerosol IS	Naneos particle solutions	A new robust UFP measuring device for long-term low-cost ambient monitoring
2022	Aerosol IS	Palas GmbH	Monitoring the Spatial aerosol distribution of volcanic ashes and Sahara dust on La Palma Island
2023	Aerosol IS	Airmodus Ltd	Design, characterization and first atmospheric measurements using the Airmodus PSM 2.0
2023	Aerosol IS	AethLabs	Results from winter field collocations of the Aethlabs MA350 MicroAeth and AE33 rack mount Aethalometer in Lyon and Clermont-Ferrand, France
2023	Aerosol IS	Airborne Science LLC	Light aircraft surveys of eDNA using a new high integrity capture system
2023	Aerosol IS	PM_TEN srl	A new PM sampler with a built-in black carbon continuous monitor - GIANO BC1
2021	Aerosol RS	RAYMETRICS S.A.	Tropospheric temperature and humidity profiling with a new compact, relatively low cost lidar system developed by Raymetrics S.A.
2023	Aerosol RS	Raymetrics S.A.	PMEYE: A novel commercial LIDAR scanner for PM Pollution monitoring in Urban and Industrial environments
2023	Aerosol RS	Vaisala Oyj	Possibilities of modern ceilometers
2022	Cloud IS	Palas GmbH	A new high-resolution Cloud Droplet Analyzer for stationary in-cloud Monitoring
2023	Cloud IS	Palas GmbH	The Cloud Droplet Analyzer – In-situ cloud monitoring
2023	Cloud IS	DMT	First results from the ground-based fog and aerosol spectrometer
2021	Gas IS	MIRO Analytical AG	All-in-one instruments for monitoring of air pollutants and greenhouse gases
2021	Gas IS	Chromatotec Group	Development of on-line and field TD-GC-FID/MS for automatic and continuous ambient air monitoring
2022	Gas IS	Airyx GmbH	The ICAD NO2 / NOX instrument: calibration free in-situ measurements of trace gases for atmospheric and emission studies
2022	Gas IS	MIRO Analytical AG	New solution for simultaneous monitoring of greenhouse gases and air pollutants with extremely high precision
2023	Gas IS	Chromatotec	Development and validation of on-line auto-GC for the analysis of BVOCs and trace level OVOCs for laboratory and field measurements
2023	Gas IS	Karsa ltd	Quantification of atmospheric trace gases using filter-based thermal desorption multi-ion scheme chemical ionisation
2021	Gas IS and Aerosol IS	IONICON Analytik Ges.m.b.H.	Single analyzer for gas-phase and the condensed organics
2022	Gas RS	schnaiTEC GmbH	The four-wavelength photoacoustic aerosol absorption spectrometer PAAS-4Λ for long-term monitoring of the absorption coefficient in the UV-VIS-NIR spectral range
2022	Gas RS	BIRA-IASB	The NO2 camera: A spectral imager for mapping urban pollution
2022	Gas RS	Airyx GmbH	The SKYSPEC instrument: Atmospheric monitoring with passive DOAS remote sensing

5. Does on-going innovation development fulfil ACTRIS needs?

The projects submitted and the presentations given show ongoing and continuous developments of instruments using new technologies, and new data processing resources e.g. to increase the efficiency in terms of temporal resolution and sensitivity and enabling the detection of new species. Efforts are also being made to make instruments more autonomous, with the development of remote-control systems.

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Similarly, instruments historically reserved for research are now being developed to make them more compact for operational use, less costly and requiring less specific skills to operate.

These developments are driven by the need to improve performances of the instruments as well as to expand the scope of potential application and in turn expand the market. Most of the companies have partnerships with RPOs involved in ACTRIS. ACTRIS platforms (NF obs and ASC, CF) are relevant support for testing and validating new developments.

Call and process for access have been successfully developed thanks to ACTRIS IMP and ATMO-ACCESS projects. The analysis above shows several projects of access leading to successful technological improvements and tests. However, there is a need to manage innovation with a process for incorporating instrument development and improvement officially in ACTRIS operations. Recommendations have been proposed for the Central Facilities in Milestone 9.3 to clearly define the scope and the meaning of an instrument validation for ACTRIS, and this work should be continued beyond ACTRIS IMP.

A good number of projects indicates significant activity of innovation related to ACTRIS needs. However, there is still some gaps in the development.

- The low-cost sensors are now widespread despite that they are often considered not metrologically reliable. However, this technology is evolving fast. In addition, computing resources and data analysis tools (learning methods) significantly improve the potential of sensors. ACTRIS must be able to evaluate these sensors and integrate them into its observation strategies.
- There is an urgent need to develop new tools to better integrate all types of data coming from different kind of instruments, even dealing with datasets from several RIs.
- To make innovation more relevant to the challenges of RIs, RPOs/Company partnerships can be sought on the basis of application cases. Specific developments can then be oriented and tested until their applicability is demonstrated. These case studies are to be identified in the ACTRIS perspectives to better meet user needs and orient the innovation.

6. Conclusion

The aim of the report was to examine innovation projects linked to ACTRIS, through projects submitted by the private sector and through the three workshops organized to connect the private sector with the atmospheric RI community (ACTRIS, ICOS, IAGOS). This analysis shows continuous developments associated with technological evolutions (new electronic components, new instruments, extension of data processing, etc.). ACTRIS is for sure recognized as a support for innovation, with observation platforms equipped with reference instruments, exploration platforms for testing under simulated conditions, and Topical Centres comprising scientific and technical expertise. The pathway of the new techniques and instruments towards ACTRIS network need to be coordinated by ACTRIS Central Facilities as it ensures compatibility and harmonisation.

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Partnerships between the private sector and ACTRIS components could be more closely aligned with ACTRIS needs in order to develop its observations and user services. ACTRIS needs to identify applications/showcases that will call for technological innovation. These showcases will then be the subject of specific projects with targeted partnerships for specific developments.

This kind of analysis although not extensive has to be carried out regularly in order to ensure the positioning of ACTRIS with respect to the market needs and to feed the ACTRIS Innovation Strategy on long term planning.

7. References

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- Book of Abstracts – Innovation in Atmospheric Measurement Techniques, held the 2nd of June 2022
- Book of abstracts - Innovation-Workshop, held the 8th of June 2023

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