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D4.1.2: Implementation plan for the enhancement of CNR IMAA atmospheric observatory (CIAO) for the provision of RIs integrated and synergistic data products [B2]

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1. INTRODUCTION

This deliverable is prepared in the context of the ITINERIS project, within the Work Package 4 (WP4) that deals with the integration of Research Infrastructures (RIs) working in the atmospheric domain through synergistic approaches and cross boundaries developments with the aim of setting up an integrated national system for the atmospheric observations to address the current national and international open issues on atmospheric characterization and impacts on several sectors: from climate change to human health, from agriculture to renewable energy production.

To achieve this aim, five environmental RIs (ACTRIS, ICOS, CeTrA, EUFAR and SIOS) and nine Operating Units (CNR-IMAA, CNR-ISAC-BO, CNR-ISAC-LT, CNR-ISAC-LE, CNR-ISMAR-Roma, CNR-ISP-BO, INFN-FI, INFN-GE, and UNIVE-DAIS) participate to WP4 activities.

The **aim** of this deliverable is to **describe the implementation plan for the enhancement of the CNR IMAA Atmospheric Observatory** (CIAO) in view of the supply of RI integrated and synergistic data products.

The document, beyond this introduction, is structured into four different chapters.

Annexes and references are reported at the end of the document.

2. CNR IMAA ATMOSPHERIC OBSERVATORY AND ITS ROLE IN ATMOSPHERIC RIS

CIAO is in Tito Scalo, 6 km far from Potenza, Southern Italy, on the Apennine mountains (40.60N, 15.72E, 760 m a.s.l.) and less than 150 km from the West, South and East coasts (Figure 1).

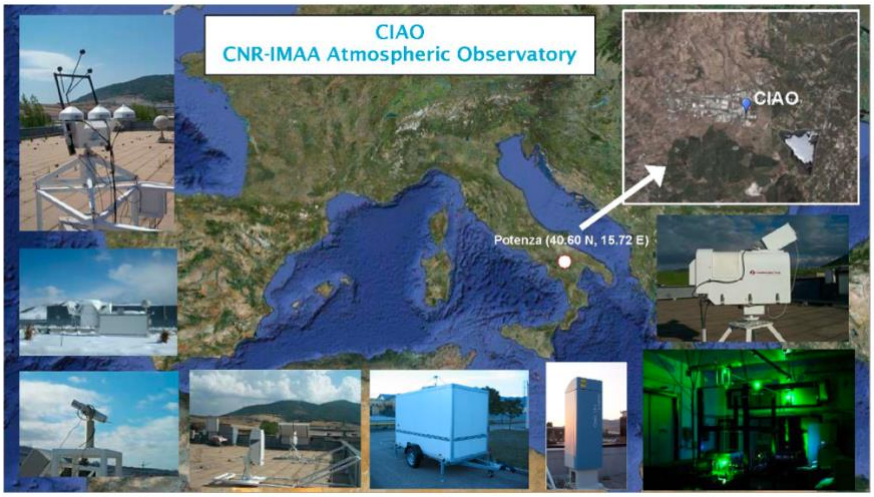

Figure 1. *Location of CIAO. Pictures of several active and passive instruments operative at the observatory are also reported (Madonna et al., 2011)*

The site is in a plain surrounded by low mountains (<1100 m a.s.l.). The observatory operates in a typical mountain weather strongly influenced by Mediterranean atmospheric circulation, resulting in generally dry, hot summers and cold winters. In this location, phenomena like orographically-induced effects on cloud formation can be studied.

The site is representative of the Mediterranean area and is affected by many Saharan dust intrusions each year *(Mona et al., 2006; Binietoglou et al., 2015; Soupiona et al., 2020)*. Moreover, the site was reached by volcanic aerosol at the level of free troposphere during the eruptions of Etna *(Pappalardo et al., 2004)* and Eyjafjallajökull *(Mona et al., 2012)* volcanos in 2002 and 2010, respectively, and within stratospheric layers *(e.g., Sawamura et al., 2012)*. In recent years, the observatory has become actively involved in the study of smokes originated by wildfires occurring both at short-range, spreading with increased frequency in the surrounding forestry areas during the summer period *(De Rosa et al., 2022)*, and long-range, such as the autumn 2020 California wildfires whose smokes transported in the stratosphere reached the site within 13 days *(De Rosa et al., 2021)*.

CIAO represents one of the largest ground-based remote-sensing station in the Mediterranean Basin, and one of the first atmospheric observatories in Europe. The observatory consists of a combination of advanced systems able to provide high quality long-term observations of aerosol and cloud properties. In fact, since 2000, systematic observations of aerosol, water vapor and clouds have been collected and then the acquisition of active and passive microwave profilers strengthened the equipment required for performing accurate aerosol and cloud observations.

The main scientific objective is the long-term measurement for the climatology of aerosol and cloud properties. The observation strategy is mainly organized to provide quality assured measurements for satellite validation and model evaluation and to fully exploit the synergy and integration of the active and passive sensors for the improvement of the atmospheric profiling.

The main research lines currently active at CIAO include:

- design and implementation of lidar systems for aerosol, water vapor and cloud measurements
- development of algorithms for the integration of lidar and microwave radiometer measurements
- definition of measurement protocols, quality assurance programmes and data managing strategies
- definition of a suitable strategy for the satellite cal/val activities
- analysis of the physical and dynamical processes related to aerosol transport, their modification and classification.
- analysis and physical interpretation of observations provided by both active and passive sensors for the study of aerosol and cloud interactions and nucleation processes.
- organization and participation in measurement campaigns
- development of methods for the evaluation of aerosol transport and mesoscale weather prediction models

- networking.

CIAO provides access to data, services and to the research facility for carrying out measurement campaigns and instrument testing (https://www.atmo-access.eu/observational-platforms/).

At CIAO, research activity is conducted in cooperation with the main ground-based observation networks (EARLINET, ACTRIS, CloudNet, AERONET, NDACC, GRUAN, GALION), with the main goal to provide long-term observational data relevant to climate and air quality research, supporting satellite missions (NASA, ESA, JAXA) and in cooperation with the modelling community (ECMWF, AEROCOM, SDS-WAS etc.). Data quality also matches the protocols developed in the frame of the international networks in which active and passive instruments are operational.

The CIAO infrastructure hosted international satellite validation experiments, it has been involved in several international experiments for the study of aerosols and clouds and their modelling, and it is among the fifteen backbone stations involved in the operations of GRUAN (GCOS Upper-Air Reference Network).

CIAO is an important node of ACTRIS. Within ACTRIS, the CNR IMAA hosts 3 ACTRIS Central Facilities units. IMAA hosts the SAMU (Service and Access Management Unit) in the Head Office of the ACTRIS ERIC, handling the access programme for the entire ACTRIS. IMAA also hosts the unit of the ACTRIS Data Center for the aerosol profiling (ARES) providing access to data to worldwide users, and it hosts a unit of the Center for Aerosol Remote Sensing (CARS) operational at European level.

As observational platform, CIAO already provides measurements and data for aerosol and clouds through remotes sensing observations. Furthermore, thanks to the recent upgrading of the observatory funded by the project PER-ACTRIS-IT - Potenziamento della componente italiana della Infrastruttura di Ricerca Aerosol, Clouds and Trace Gases Research Infrastructure", COD. PIR01_00015, CUP B17E19000000007 - PON "Ricerca e Innovazione 2014-2020" Notice D.D. n. 424 del 28/02/2018, CIAO is now implementing instruments and methods for the measurement and characterization of aerosol at ground-level, and for trace gases remote sensing (Figure 2).

Finally, CIAO is candidate as ACTRIS Exploratory Platform for aerosol and/or clouds remote sensing measurements with the CIAO Mobile platform.

Figure 2. *Picture of some of the measurement systems recently acquired and operational at CIAO*

Since 2020, an ICOS atmosphere station of Level 1 is being equipped at CNR-IMAA and its labelling process according to the guidelines provided by the ICOS Atmosphere Thematic Centre (ATC) is officially started in 2023 (Figure 3). As continental ICOS atmospheric site, CAIO is equipped with a tall tower with air sampled at about 10, 50 and 100 m above the ground.

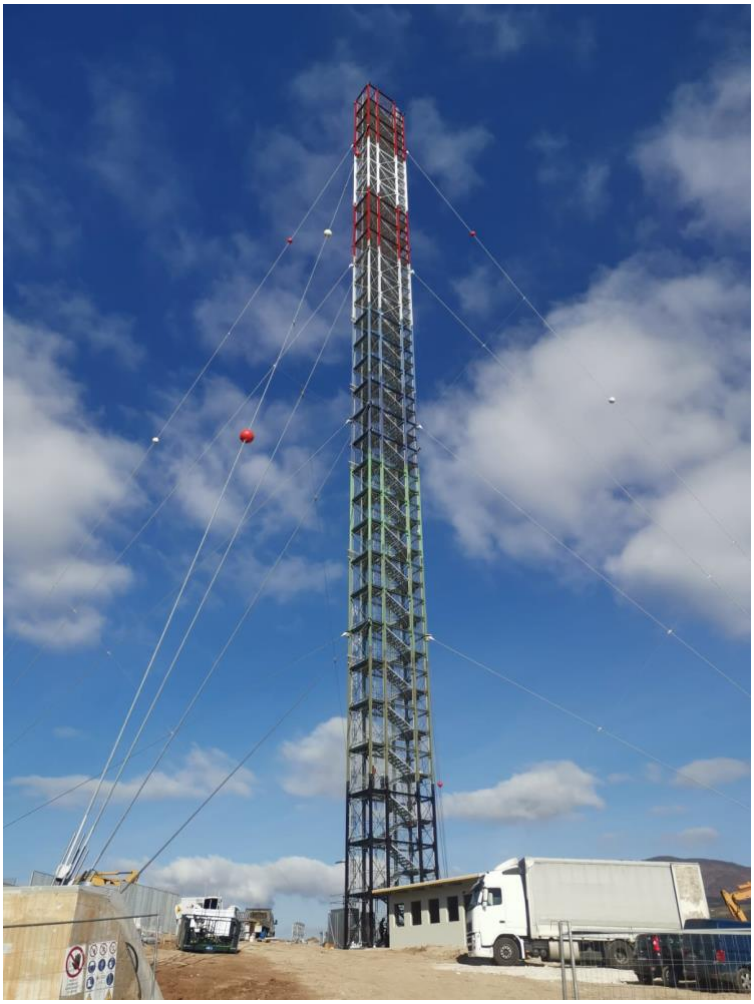

Figure 3. *Picture of the Potenza ICOS atmosphere station under construction*

The list of current available instruments, including their corresponding status (operational or under implementation), the Data Centre (DC) where data are stored and link to data and metadata examples are reported in the

ANNEX 1.

3. IDENTIFIED GAPS AND NEEDS FOR INTEGRATION

The expected result of WP4 is the enhancement of the provision of atmospheric synergistic products, while also providing the resources to address open issues about atmospheric state, processes and knowledge about related risks and impacts related to it.

To contribute to the achievement of these results, the CNR IMAA will be involved in various strengthening actions to fill various gaps from an instrumental, digital, and infrastructural point of view.

This has resulted in:

- instrumental needs for fostering integration:
    a) advanced instruments for synergistic products development and observation tailored for the pilots.
    b) mobile instruments for Pilot I-II-III.
    c) spare parts for Italian aerosol remote sensing component.
- digital needs for CIAO and for WP4 as total (ACTRIS remote sensing DC service for ARES component and provision to hub for atmospheric domain).
- infrastructural needs for CIAO observatory.

To all this is added the transversal need to enhance the human resources (both fixed-term and doctoral students) dedicated to the activities of the CNR IMAA in WP4 (more details can be found in chapter 4). This will produce a significant increase of level of competencies and expertise in the new researcher/technologist and technicians' generation and will consolidate the Italian human resources capability in the atmospheric field.

Consistently with what has been previously stated, the observational capability of CIAO observatory will be upgraded.

In fact, within WP4, CNR IMAA will acquire a large variety of instruments aimed at producing specific and integrated data products on identified relevant topics specifically addressed in the three WP4 Pilots (aerosol typing and sources, atmospheric boundary layer height and its impacts at the ground, and forest fires emissions) and at the integration of several RIs. The provided datasets will be a concrete outcome of the WP4 of interest of different communities of users, like air quality authorities, climate change stakeholders, meteorological agencies, solar plants managers, citizens at large and obviously national and international researchers.

3.1 INSTRUMENTS FOR SYNERGISTIC PRODUCTS DEVELOPMENT AND OBSERVATION TAILORED FOR THE PILOTS

To mainly improve the observation of the physical and chemical properties of atmospheric aerosols at ground level, CNR IMAA will enhance the ACTRIS in-situ aerosol component of the CIAO observatory (see Annex I for the list of the instruments currently available) by

acquiring both additional on-line instrumentation and equipment for off-line chemical analyses.

It is planned to acquire:

- a **14-stage cascade impactor** for real-time particle size distribution and concentration measurements in the particle size range of 6 nm - 10 μm classified into 14 size fractions in a cascade impactor,
- a **total carbon analyzer** for real-time measurements of the Total Carbon (TC) content of suspended aerosol particles,
- an **on-line system for multi-metals measurements in PM** with high time resolution.
- a **bioaerosol in-situ** detection and characterization advanced system as of interest for integration and synergy with florescence lidar measurements potentially available at CNR-IMAA and of interest for the typing Pilot

In addition:

- an **aethalometer** at seven-wavelength from 370 to 950 nm for real-time measurement of black carbon (BC) concentration,
- an **Aerodynamic Particle Sizer** (APS) spectrometer for real-time measurements of the aerodynamic particle size from 0.5 to 20 μm,
- a **Multi Wavelength Integrating Nephelometer** for measurements of aerosol total and back scattering coefficients at three wavelengths (450 nm, 525 nm, and 635 nm)

will be acquired to be located on the ICOS atmospheric tower at an altitude of 100m together with a **system for the determination of ^{13}C in CO_2 and CH_4 by Cavity Ring-Down Spectroscopy (CRDS) technique**.

Focusing on the aerosol chemical characterization, the Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) and the organic carbon (OC) and elemental carbon (EC) analyzer - already operational at CNR IMAA - will be accompanied by instrumentation for non-destructive multi-element analyses on atmospheric aerosol samples and for the determination of the ionic and organic components of aerosol.

It is planned to acquire:

- an **X-ray fluorescence spectrometer**
- an **Ion chromatography system**
- a **Triple Quadrupole GC-MS**.

All these instruments will be placed inside a chemical laboratory set up in a **shelter** which will also be purchased within the ITINERIS project.

The shelter will be equipped with all the necessary **chemical laboratory equipment** such as an ultrapure water production system, a chemical fume hood, a stove, a microbalance, etc.

Furthermore, to allow the extraction of insoluble or poorly water-soluble organic compounds from PM samples for subsequent GC-MS analyses, an **extraction and evaporation system** will also be acquired.

In addition to enhancing the capability to observe aerosols at ground level, the CNR IMAA intends to fill its gap relating to the lack of in situ measurements of gas species by acquiring:

- **gas in situ monitors** for the measurements of the concentration at surface level of NO-NO_2-NO_x, SO_2, CO, O_3, CO_2, N_2O, NH_3, BTEX, CH_4 and Non-methane volatile organic compounds (NMVOCs)
- a **detector of stable gas, NO_x, and aromatic pollutants.**

For enhancing the provision of synergistic products and for addressing the Pilot hot topics, the following remote sensing instrumentation will be acquired:

- **ceilometer equipped with depolarization channel**, important for testing the capability of aerosol typing provision with such kind of instrument whenever advanced lidar measurements are not possible.
- **ceilometer for determining cloud layers and ABL height**, specifically of interest for the atmospheric boundary layer height Pilot.
- **microwave radiometer**, needed for replacing the old system running at CIAO since 2006
- ACTRIS compliant **dysdrometer**, missing at the present time in CIAO equipment.
- **tethered aerostatic balloon with** sensors for atmosphere characterization, of great interest for the investigation of ABL characteristics in terms of aerosol and gas content.
- **PANDORA automatic measurement system** capable of measuring total columns and profile information of trace gases such as nitrogen dioxide, ozone, formaldehyde, and others, of interest for integration with ICOS measurements at the tower and aerosol remote sensing measurements.

3.2 MOBILE INSTRUMENTS FOR PILOT I-II-III

Portable instruments will be acquired by CNR-IMAA as an additional tool for synergies with the other RIs and for application in specific locations as of interest for the purposes of activities 4.11- 4.16 and for potential interested users.

An **ACTRIS compliant multi-wavelength Raman mobile lidar** will be acquired as a tool to be used at National level for observations at different sites. This could be used as replacement of ACTRIS National Facility system in case of long stop for maintenance problem, but also for the aim of ITINERIS scientific purposes for specific measurements campaigns in the frame of WP4 Pilots.

A **small compact and easy to be transported lidar system equipped with Raman and depolarization channels** will be acquired as powerful tool for short campaigns of scientific interest for BLH aerosol characterization and for filling observational gaps in the aerosol typing methods, or easily moving close to aerosol local sources like forest fires.

3.3 SPARE PARTS FOR ITALIAN AEROSOL REMOTE SENSING COMPONENT

Being part of the ACTRIS Topical Center for the Aerosol Remote Sensing, CNR-IMAA will act as hub of instruments, spare components and testing facilities for the Italian aerosol

remote sensing community. This will allow at Country level a better data provision of aerosol remote sensing data in terms both of temporal coverage and quality.

Within WP4, CNR IMAA will acquire some back-up instruments and main instrument components for guarantying the effective data provision of ACTRIS aerosol remote sensing stations on the Country. Additionally, instrument for testing and complementing lidar systems will improve the quality of data provided and will be also a support for the Italian atmospheric observational network.

- **laser source for lidar** system as a spare part to be used when the stable one goes under maintenance.
- a **system for lidar characterization**, lidar signal simulation and automatic remote control
- a **photometer**, to replace the ones of Italian stations during calibration procedures and then to substitute the old CIAO one
- **spare LOM** for CHM 15K (as one of the most common ceilometers used at Italian ACTRIS sites)
- a **microwave radiometer**
- a **ceilometer** equipped with depolarization channel.

3.4 DIGITAL INFRASTRUCTURE ENHANCEMENT

Among the technological equipment for enhancing distributed system for atmospheric data monitoring and provision, and for improving the level of data availability and data stream considered in WP4, CNR-IMAA connectivity will be enhanced for guarantying a stable, fast, and protected connection of all the instruments to the respective European Research infrastructure, but also to the digital resources to be developed in ITINERIS like the VRE (WP8) and the ITINERIS HUB (WP2). This requires a large investment in digital devices and infrastructural adaptations, and it is crucial being CNR-IMAA a node of ACTRIS DC and acting in ITINERIS as central node for the provision of the atmospheric data products.

In particular, the improvement of accessibility to data products will be achieved through the macro-interventions described below.

A large investment for the ACTRIS DC node hosted at CNR-IAMA was done thanks to the project PER-ACTRIS-IT - Potenziamento della componente italiana della Infrastruttura di Ricerca Aerosol, Clouds and Trace Gases Research Infrastructure", COD. PIR01_00015, CUP B17E19000000007 - PON "Ricerca e Innovazione 2014-2020" Notice D.D. n. 424 del 28/02/2018. The DC equipment currently available is reported in Annex 1. Anyhow advancement and increasing request for speed in digital communication and processing call for significant upgrade of CNR-IAMA digital infrastructure. Moreover, enhanced capability in data storing and processing is specifically needed for the aim of ITINERIS, for new advanced and synergistic data product provision to the ITINERIS hub and VRE.

It is right to mention here that enhancement of CNR-IMAA digital infrastructure is needed for WP4 but also for WP2 and WP8 objectives. For a better efficiency of the good acquisition and procedures, digital purchases will be done without distinction for WP, avoiding also

what is called tender split. In. the following, all these digital enhancements are listed underline the specific needs for WP4.

DC Hardware

DC hardware procedures will be in co-working with WP2 but the goals of WP4 for DC implementation are:

- Virtualization environmental based on Server Infrastructure and Storage Area Network Infrastructure, to improve the functionalities of the repository and to increase IT efficiency and redundancy.
- Storage infrastructure based on an enterprise Scale-Out Network Attached Storage, to archive data and backup will be a fully redundant architecture.
- High speed Network Infrastructure, to have a redundant and resilient network able to satisfy the needs of the HUB in terms of bandwidth and latency.

Specifics of the equipment to be acquired are reported below.

N. 20 Bare metal rack server with this minimal technical requirement:

- 2 CPU
- 24 Core
- 1 TB of RAM
- 2 SSD Hard Drive for OS
- 2x25G SPF28
- 2x16G HBA FC
- Redundant power supply

N. 2 Storage Area Networks with this minimal technical requirement:

- Fully redundant
- iSCSI and FC
- 100TB SSD

Scale-OUT Network Attached Storage with this minimal technical requirement:

- Fully redundant
- iSCSI 10G
- NFS/SMB export path
- 2PB RAW

CLOS SPINE/LEAF network infrastructure with this minimal technical requirement:

- SPINE with 32x100G QSFP
- LEAF with 48x25G SFP + 8x100G QSPF
- ROUTER with 48x25G SFP + 8x100G QSPF
- N. 4 CAMPUS LEAF mGigabit
- WiFi 6 access point for indoor and outdoor

New Generation Cluster Firewall with this minimal technical requirement:

- 50Gbps firewall throughput
- 26Gbps threat prevention throughput
- 3.6M max sessions
- 270.000 new sessions per second
- 10 virtual systems

- 12x10G SPF+
- 4x40/100G QSPF
- 1:1 fully redundant

Eco Data Center

The new Eco Data Center Infrastructure should have a TIER 4 classification that guarantee an uptime of 99,995%, because all path and components are fully redundant. Thanks to this, we can guarantee a high availability level of the services provided by our DC.

Specific equipment to be acquired are reported below.

Aisle Containment System with rack-independent system with this minimal technical requirement:

- N. 14 RACK 42U
- N. 2 UPS 150kW
- N. 3 cooling system with a thermal capacity of 160kWf
- N. 28 PDU 11/22kW
- N. 2 300kVA diesel fuel generator
- Fire suppression system

Upgrade of Electric Power Distribution and copper and optical fiber infrastructure

To build the new data center, the entire power distribution system needs to be upgraded to provide the new power supply required for the new Data Center.

As for the power supply, the copper and fiber infrastructure will also need to be upgraded to meet the new demand.

Thanks to these upgrades, our power and passive copper/fiber infrastructure can be improved in terms of reliability and maximum capacity.

Network interconnection between CNR-IMAA Data Center and ICOS Infrastructure

This interconnection will extend the Local Area Network (LAN) from our main Data Center to the ICOS Infrastructure to provide high speed and high availability remote control and data transfer.

The equipment to be acquired are reported below in terms of minimal technical requirements:

- 4 couples of single mode optical fiber with a capacity of 10Gbps for each couple.
- The interconnection will start from optical patch panel in the CNR-IMAA DC and will end to the optical patch panel int the ICOS tower shelter.

3.5 INFRASTRUCTURAL NEEDS FOR CIAO OBSERVATORY

Finally, the enhancement of observational systems calls for some civil infrastructures and related systems for the observatory including platforms and internet and electricity supplying

systems, and upgrade of electrical alimentation and distribution system. These procedures (3 procedures) are expected later in the project for allowing a clear definition of them.

4. PROCEDURES FOR THE PERSONNEL

The enhancement of the CIAO atmospheric observatory also concerns the engagement of new personnel with specific skills who will be involved in the WP4 activities. In view of this, the recruitment of a total number of 8 personnel units has been planned: 3 researchers, 2 technologists and 3 technicians.

The big role of CNR-IMAA in aerosol remote sensing activities both as observational facility and topical center require at least 2 researchers working on this topic and connected to the 2 tasks related to the aerosol typing and BLH determination. The recent implementation of aerosol in situ and ICOS Level 1 station requires the hiring of 1 researcher for the study of atmospheric aerosols and/or greenhouse gases and for the use of them in the context of ITINERIS project.

A technologist will be hired as support to the activity of management and organization of WP4. 1 additional technologist will be hires for supporting ICT development related to the aerosol typing and BLH data provision. 2 technicians will be hired as personnel dedicated to the implementation of all digital infrastructural systems needed for the WP4 activities and for the digital connection of the enhanced CIAO observatory.

Finally, it will be hired a technician as fundamental and necessary support for installing, running, and maintaining the enhanced CIAO observatory.

Except for one ICT technician and one researcher, all the rest of the staff will be recruited at the same time and immediately start working on WP4 activities.

Since the beginning of the project, IMAA permanent staff has worked on the preparation of 6 calls which were published in the Official Gazette of the Italian Republic on 23 December 2022 with the deadline for submitting applications set for 23 January 2023.

The applications were managed via the Internet, using an online application system of the National Research Council of Italy for the staff recruitment available in a dedicated area of the CNR website (*https://selezionionline.cnr.it*).

At the date of drafting this report, the evaluation commissions for the received applications had been identified and is waiting to proceed with the examination of the documentation submitted by the candidates and with the interviews. The individual fixed-term employment contract will be signed by the end of April 2023.

A summary of the procedures for recruiting temporary staff who will work on WP4 activities, sorted by call number, is provided in Table 1.

Number of positions	***Professional profile***	***Required degree***	***Required experience***	***Call publication details***	***Call number***	***Hiring date (planned)***	***Duration of the contract (months)***
1	Technologist, level III	Master's Degree relevant to the required experience	Project management and/or experiences in economics and financial management or PhD relevant to the requested field of experience	Official Gazette of the Italian Republic n. 101 of 23/12/2022	400.1 IMAA PNRR	By the end of April 2023	30
1	Technologist, level III	Master's Degree relevant to the required experience	Design and management of Data Center, network infrastructure and/or database management and/or design and implementation of full stack (backend and frontend) web applications, or PhD relevant to the field of experience requested	Official Gazette of the Italian Republic n. 101 of 23/12/2022	400.4 IMAA PNRR	By the end of April 2023	36

1	Technician, Level VI	Secondary school Diploma	IT system administrator/network administrator for the management and configuration of ICT infrastructures and Data Centers and/or web application developer	Official Gazette of the Italian Republic n. 101 of 23/12/2022	400.5 IMAA PNRR	By the end of April 2023	30
1	Technician, level VI	Secondary school Diploma	Technical support for the management of instrumentation for the observation of atmospheric variables (aerosols and greenhouse gases)	Official Gazette of the Italian Republic n. 101 of 23/12/2022	400.6 IMAA PNRR	By the end of April 2023	30
2	Researcher, level III	Master's Degree relevant to the required experience	Experience in design and implementation of methodologies for the study of atmospheric aerosols and/or thermodynamic parameters with lidar technique or PhD relevant to the requested field of experience	Official Gazette of the Italian Republic n. 101 of 23/12/2022	400.7 IMAA PNRR	By the end of April 2023	30

1	Researcher, level III	Master's Degree relevant to the required experience	Design and implementation of in situ methodologies for the study of atmospheric aerosols and/or greenhouse gases and/or chemical characterization of organic compounds and/or environmental pollutants by means of spectroscopic techniques and mass spectrometry or PhD relevant to the requested field of experience	Call to be published by the end of 2023	/	/	24
1	Technician, level VI	Secondary school diploma	WEB developer with particular reference to Java, Python, PHP technologies and associated frameworks	Call to be published by the end of 2023	/	/	24

Table 1. Fixed-term personnel specifically hired at CNR IMAA for the implementation of WP4 activities.

Finally, 4 PhD co-funding grants are planned for boosting the quality of data collected at the OU and the related scientific research activities at national and international level. Procedures for the assignment of these 5PhD positions started in cooperation with university of Naples "Federico II", Università degli Studi de L'Aquila and Università degli Studi della Basilicata. The agreement with such universities, whenever not already existing, have been prepared. 1 PhD grant was already assigned with university of Naples in the XXVIII cycle. The others will be assigned in the next PhD cycle.

5. EQUIPMENT PROCEDURES

CNR-IMAA will acquire goods and equipment for the different WP4 purposes as reported in previous sections. The equipment will concur the achievement of different objectives, linked namely task 4.1, task 4.11 and task 4.15. In the following all the goods and not only the ones related to task 4.1 are reported for giving a complete overview of the CNR-IMAA implementation plan in WP4. IN order to clarify the specific attribution of goods to tasks, Table 2 reports the related task for each good.

The purchasing procedures were split over two years (2023 and 2024), according to the project objectives to be achieved.

Starting from the instrumentation to be acquired for the **enhancement of CIAO observational capability** and listed in paragraph 3, the instruments were classified using the Common Procurement Vocabulary (CPV, a European classification system for categorizing the subject of public procurement contracts).

The CPVs used were:

- 38340000-0 Instruments for quantity measurements
- 38430000-8 Analysis and detection apparatus

Then, three types of purchasing procedures were identified:

1. European multi-lot tender
2. Request for Offer
3. single purchase procedure.

aggregating the goods by CPV, where necessary (i.e., European multi-lot tenders).

A summary is reported in Table 2.

As Table 2 shows, two European multi-lot tenders, three single purchase procedure and one request for offer have been planned in 2023. In these cases, the starting of all the procedures is planned by the end of June. Then, one European multi-lot tender, two single purchase procedures and two requests for offer have been planned in 2024. In these cases, the start of all procedures has not been defined yet.

Regarding the technological equipment for improving the accessibility to data products, the planned procedures are summarized in Table 3.

Year	*CPV*	*Type of procedure*	*Lot number*	*Description*	*Start of the procedure*	*Task*
2023	38430000-8	European multi-lot tender n.1 *(Atmo_RS)*	1st lot	Transportable lidar system with Raman and depolarization channels	by 30 June 2023	4.11
	38430000-8		2nd lot	n. 2 ceilometers equipped with depolarization channel	by 30 June 2023	4.11 & 4.15
	38430000-8		3rd lot	ACTRIS compliant MW Raman mobile lidar for observations in different sites	by 30 June 2023	4.1
	38430000-8		4th lot	Ceilometer for determining cloud layers and PBL height	by 30 June 2023	4.15
	38430000-8		5th lot	Microwave Radiometer	by 30 June 2023	4.15
	38340000-0	European multi-lot tender n.2 *(Atmo_IS)*	1st lot	Total Carbon Analyzer	by 30 June 2023	4.1
	38340000-0		2nd lot	Gas in situ monitors for the measurements of the concentration at surface level of NO-NO_2-NO_x, SO_2, CO, O_3, CO_2, N_2O, NH_3, BTEX, CH_4, NMVOC	by 30 June 2023	4.11
	38340000-0		3rd lot	14-stage cascade impactor	by 30 June 2023	4.1
	38340000-0		4th lot	detector of stable gas, NO_x, and aromatic pollutants	by 30 June 2023	4.1
	38340000-0		5th lot	Chemical laboratory equipment	by 30 June 2023	4.1
	38340000-0		6th lot	Aethalometer	by 30 June 2023	4.1

	38340000-0		7th lot	Aerodynamic Particle Sizer (APS) spectrometer	by 30 June 2023	4.1
	38340000-0	Single purchase procedure	-	Multi Wavelength Integrating Nephelometer	by 30 September 2023	4.1
	38340000-0	Single purchase procedure	-	CRDS for ^{13}C in CO_2 and CH_4	by 30 September 2023	4.1
	38430000-8	Single purchase procedure	-	Spare LOM for CHM 15K	by 30 June 2023	4.1
	38340000-0	Request for Offer	-	Shelter equipped for chemical analyses	by 30 June 2023	4.1
2024	38430000-8	European multi-lot tender n.3 *(Atmo)*	1st lot	System for lidar characterization, lidar signal simulation and automatic remote control	by 31 October 2023	4.1
	38430000-8		2nd lot	X-ray fluorescence spectrometer	by 31 October 2023	4.11
	38430000-8		3rd lot	Triple Quadrupole GC-MS	by 31 October 2023	4.11
	38430000-8		4th lot	On-line system for the high time resolution multi-metals measurements in PM	by 31 October 2023	4.11
	38430000-8		5th lot	Ion chromatography system	by 31 October 2023	4.11
	38430000-8		6th lot	Bioaerosol in-situ detection and characterization advanced system	by 31 October 2023	4.11
	38430000-8		7th lot	Microwave Radiometers	by 31 October 2023	4.15
	38430000-8		8th lot	Laser source for lidar system as a spare part to be used when the stable one goes under maintenance	by 31 October 2023	4.1

	38340000-0	Request for Offer	-	Extraction and evaporation system	by 30 May 2024	4.1
	38340000-0	Request for Offer	-	Tethered aerostatic balloon with sensors for atmosphere characterization	by 31 June 2023	4.15
	38340000-0	Request for Offer	-	Dysdrometer	by 30 November 2023	4.11
	38430000-8	Single purchase procedure	-	PANDORA automatic trace gases	by 30 November 2023	4.1
	38430000-8	Single purchase procedure	-	Photometer for aerosol measurements	By April 2024	4.1

Table 2. Summary of the purchasing procedures for the acquirement of instrumentations for the enhancement of the observational capability of CIAO. CPV stands for Common Procurement Vocabulary

Year	***CPV***	***Type of procedure***	***Lot number***	***Description***	***Start of the procedure***	***Task***
2023	30200000-1	European multi-lot tender n.1 *(ICT_1)*	1st lot	Storage Area Network (SAN) and Scale-OUT Network Attached Storage (NAS)	by 30 March 2023	4.11
	30200000-1		2nd lot	Share Network Storage	by 30 March 2023	4.11 & 4.15
	32400000-7		3rd lot	High availability firewall and system for management and analytics of the traffic data and security issues	by 30 March 2023	4.1
	32400000-7		4th lot	Expansion of network infrastructure EVPN/VXLAN and automatization SDN systems	by 30 March 2023	4.15

	48200000-0		5th lot	DNS, DHCP and IPAM (DDI)	by 30 March 2023	4.15
	48200000-0		6th lot	Virtual Machine backup system	by 30 March 2023	4.1& 4.11 & 4.15
	30200000-1	European multi-lot tender n.2 *(ICT)*	1st lot	Data Center upgrade	by 30 September 2023	4.1
	48820000-2		2nd lot	HPC system	by 30 September 2023	4.11 &WP8
	30200000-1	CONSIP convention	-	Server for virtualization environment	by 30 March 2023	4.1
	30200000-1	CONSIP convention	-	Server for virtualization environment with GPU	by 30 March 2023	4.1

Table 3. Summary of the purchasing procedures for the acquirement of technological equipment for improving the accessibility to data products. CPV stands for Common Procurement Vocabulary

Given the amount of instrumentation and equipment to be purchased and the number of purchase procedures, the scientific-administrative staff involved in this activity will be numerous. To optimize the flow of information, a reference has been identified for each class of instrument/type of intervention, a summary of which is provided in Table 3

Instrument class/equipment	***Contact person for the scientific team***	***Contact person for the administrative team***
Aerosol remote sensing	Dr Aldo Amodeo	Dr Antonella Gorga
Aerosol in situ	Dr Lucia Mona/Dr Serena Trippetta	Dr Antonella Gorga
Cloud remote sensing	Dr Marco Rosoldi	Dr Antonella Gorga
Technological equipment for improving the accessibility to data products	Mr Ermann Ripepi	Dr Antonella Gorga
Civil infrastructures and related systems	Mr Ermann Ripepi	Dr Antonella Gorga

Table 4. *Organization of the scientific-administrative team that will work on the purchasing procedures for the various class of instruments and equipment.*

ANNEX 1 – CIAO AVAILABLE INSTRUMENTS

In the following, the list of current available instruments at CIAO is reported.

ACTRIS Aerosol remote sensing	
Operational instrumentation	**Under implementation**
MUSA MW Raman lidar 3+2+dep 532	Reference Mobile MW Raman lidar 3+2+3 depol and water vapour
Raymetrics Raman lidar 355 + dep	Lidar laboratory for testing lidar configurations
Cimel Triple mode photometer	Optical laboratory for testing AHL optical components
Cimel Sun- photometer	

ACTRIS Cloud remote sensing	
Operational instrumentation	**Under implementation**
Ka-Band Doppler radar	Radar Doppler MIRA-36 upgrade (fixed NF)
Ceilometers	MRR (ancillary)
Microwave profiler	Compact radar Doppler MIRA 35 (mobile NF)
GPS antenna/receiver (ancillary)	RPG94 (fixed NF)
Radiosounding systems (ancillary)	Microwave radiometer (Fixed NF)
Meteo station (ancillary)	Ceilometer CL51 (fixed NF)
Radiosounding systems (ancillary)	Ceilometer CHL 15k (fixed NF)
All sky camera (ancillary)	Ceilometer CL31 (ancillary - mobile)
	Transportable radiosounding station (ancillary - mobile)
	Automatic sounding station (Ancillary)
	BSRN (ancillary)
	Doppler lidar (ancillary)
	Ultrasonic anemometer (ancillary)
	Trimble R8s GNSS (ancillary - mobile)
	Disdrometer (Fixed)
	Total Sky Imager TSI-880 (ancillary)

ACTRIS aerosol in situ		
Operational instrumentation	**Under implementation**	
	On-line instrumentation	**Off-line instrumentation**
PMx monitor	Aethalometer	Inductively Coupled Plasma Optical Emission Spectrophotometer (ICP OES)

	Nephelometer	OC/EC Analyzer
	Aerodynamic Particle Sizer - APS	
	Time-of-Flight Aerosol Chemical Speciation Monitor - ToF ACSM	
	Scanning Mobility Particle Sizer - SMPS	
	Particulate matter samplers (PM_{10}, $PM_{2.5}$ and PM_1)	

ACTRIS trace gases remote sensing	
Operating instrumentation	**Under implementation**
	FTIR

ICOS Atmospheric Class 1 site	
Operational instrumentation	**Under implementation**
	Atmospheric 100m tall tower
	Picarro G2401 gas concentration analyzer for CO_2, CH_4 and H_2O (sampling at 10, 50, 100 m)
	Los Gatos Research N_2O and CO analyzer (sampling at 10, 50, 100 m)
	^{14}C analyzer (sampling at 100 m)
	^{222}Radon monitoring system (sampling at 100 m)
	Autosampler for periodical gas analysis (sampling at 100m)
	Ceilometer
	Meteorological stations at 10, 50 and 100 m

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