



D4.2.3: Report on the operation in the laboratory and in the field of the acquired instruments at CNR ISAC Bologna and calibration/comparison with reference methods[B14].



Finanziato
dall'Unione europea
NextGenerationEU



Ministero
dell'Università
e della Ricerca



Italiadomani
PIANO NAZIONALE
DI RIPRESA E RESILIENZA

Deliverable number:	D4.2.3
Work package:	WP4 – Atmosphere
Intermediate Objective:	IO4.4
Deliverable type:	<input checked="" type="checkbox"/> Document, report
	<input type="checkbox"/> Websites, patent filings, videos, etc.
	<input type="checkbox"/> Other: please specify
Dissemination level:	<input checked="" type="checkbox"/> Public
	<input type="checkbox"/> Restricted
Estimated delivery (bimester):	B14
Actual delivery date:	February, 19 2025
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Note:	

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System - CUP B53C22002150006 (D.D. n. 130/2022)
 Funded by EU - Next Generation EU
 Mission 4 “Education and Research” - Component 2: “From research to business” -
 Investment 3.1: “Fund for the realization of an integrated system of research and innovation infrastructures”

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INTRODUCTION

This deliverable is prepared in the context of the ITINERIS project, within Work Package 4, which focuses on the integration of research infrastructures working in the atmospheric domain through synergistic approaches and cross-boundary developments.

This report provides an update on the operation of the newly acquired equipment at the CNR ISAC Bologna unit, detailing its integration into both laboratory and field settings. The equipment will be harmonized with the network as part of Task 4.2, which aims to enhance the observational capacity of the Po Valley Observatories and mobile exploratory platforms (AEROLAB). These efforts are designed to strengthen Italy's contribution to key Research Infrastructures: ACTRIS, EUFAR, and ICOS. The Task 4.2 is strictly connected and operates synergically with the scientific Task 4.14.

The document is structured in five different chapters and annexes are reported at the end of the document.

1. SCIENTIFIC EQUIPMENT ACQUISITION OVERVIEW AND ACQUISITION PURCHASING PROCEDURE STATUS

The Bologna Operating Unit, in collaboration with the Lecce and Lamezia Terme Units, coordinated the procurement processes at the ISAC level. This involved planning and managing 3 EU tender procedures, 3 derogation purchases for uniqueness, and 16 sub-threshold procurement procedures within the Italian public administration framework. A summary of the completed and closed procedures is provided in Table 1.

Table 1: Procedures completed.

<i>INSTRUMENT DESCRIPTION</i>	<i>CPV code</i>	<i>Base price</i>	<i>PROCEDURE</i>	<i>Activity</i>	<i>Start of procedure</i>	<i>End of procedure</i>
Uninterruptible Power Supply	31680000-6	75.000€	AD	4.2	B3	B8
Solar Lunar sunphotometer	38340000-0	55.000€	AD	4.14	B3	B7
Platforms for data analysis	30230000-0	20.000€	Mepa RdO	4.2	B3	B7
Upgrade mobile lab for data acquisition, air conditioning and meteorological detection	38340000-0	10.000€	Mepa RdO	4.2	B3	B8
Ceilmeter	38340000-0	52.000€	AD	4.14	B5	B11
2 CPC (aerosol number concentration)	38340000-0	66.000€	AD	4.2	B3	B9
Calibration Unit for Volatile Organics Compounds	38340000-0	36.500€	AD	4.14	B6	B13
2 analyzers G2401 (CRDS CO, Co2, CH4) + 1 analyzer 13C	38432100-3	430.000€	Unicity	4.14	B4	B11

(CRDS for 13C in CO2 and CH4)						
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Table 2 lists the instruments that have been delivered, but whose procurement processes remain open due to pending administrative procedures required for payment processing.

Table 2: Delivered but unpaid procedures.

<i>INSTRUMENT DESCRIPTION</i>	<i>CPV code</i>	<i>Base price</i>	<i>PROCEDURE</i>	<i>Activity</i>	<i>Start of procedure</i>	<i>Delivery</i>
2 x nephelometers (aerosol scattering and back scattering coefficient)	38340000-0	64.000€	EU tender	4.2	B5	B13
observatories data storage	30230000-0	20.000€	AD	4.2	B3	B14
Coupled system for cloud droplets and aerosol sampling*	38340000-0	70.000€	AD	4.2	B6	B12

*The aerosol sampling system has been delivered, but the cloud sampling system is still pending.

Table 3 outlines the procurement procedures that are still ongoing or awaiting delivery. These primarily consist of lots that were tendered through EU procurement procedures, with offers received and evaluated by the committees. The respective administration and the responsible of each tender are currently in the process of awarding contracts and verifying compliance with the administrative specifications and documentation.

Table 3: Procedures published, for which the bidder identification is in progress.

<i>INSTRUMENT DESCRIPTION</i>	<i>CPV code</i>	<i>Base price</i>	<i>PROCEDURE</i>	<i>Activity</i>	<i>Start of procedure</i>	<i>Delivery</i>
The Portable Ice Nucleation Experiment (PINE)	38340000-0	285.000€	EU Tender	4.2	B3	B16
Fog monitor, LWC, Reff, DROPLET SIZE DISTRIBUTION	38340000-0	200.000€	EU tender	4.2	B7	B16
SP-2 D (Refractory BC, mixing state)	38340000-0	360.000€	EU Tender	4.14	B3	B15
aethalometer for black carbon concentration, BB fraction	38340000-0	40.000€	EU tender	4.2	B3	B15
CASS (Total Carbon Content ("TC"), the	38340000-0	75.000€	EU tender	4.2	B3	B15

Elemental Carbon content (EC), the Organic Carbon content (OC) and the Black Carbon content (BC) of suspended aerosol particles in near-Real Time)						
SMPS (aerosol size distribution 10-800 nm)	38340000-0	80.000€	EU tender	4.2	B3	B15
Meteorological probes	38340000-0	10.000€	AD	4.2	B8	B15
Lidar Raymetrics	38340000-0	328.000€	EU tender	4.14	B3	B17
Webcam for internal and external visual monitoring	30230000-0	7.050€	AD	4.2	B9	B15
FTIR for GHG and RGs	38432100-3	550.000€	EU Tender	4.14	B4	B17

Finally, Table 4 outlines the five procedures that will be republished due to supplier changes or because the dedicated EU tender process received no bids.

Table 4 : Procedures that will published in 2025.

<i>INSTRUMENT DESCRIPTION</i>	<i>CPV code</i>	<i>Base price</i>	<i>PROCEDURE</i>	<i>Activity</i>	<i>Start of procedure</i>	<i>End of procedure</i>
Container FTIR	45214630-5	40.000€	AD	4.2	B6	B17
Doppler Cloud radar	38340000-0	278.000€	AD	4.14	B7	B17
Aerosol sampler	38340000-0	47.500€	AD	4.2	B3	B17
SOFI software	30230000-0	25.000€	AD		B7	B17
Construction works for FTIR observatory	38340000-0	45.000€	AD	4.14	B6	B17

2. IMPLEMENTATION OF ACQUIRED INSTRUMENTATION

Thanks to the upgrade made available through ITINERIS project, the CNR-ISAC-BO OU is deeply implementing the observational capacity of both ground based and mobile platforms. Currently, condensation particle counter (CPC) and liquid calibration unit have been deployed and are fully operational at the CNR Monte Cimone Observatory (ACTRIS CMN-PV facility Fig. 1). Additionally, the integration of UPS systems has enhanced the observatory's power supply reliability, ensuring real-time measurements 24/7.

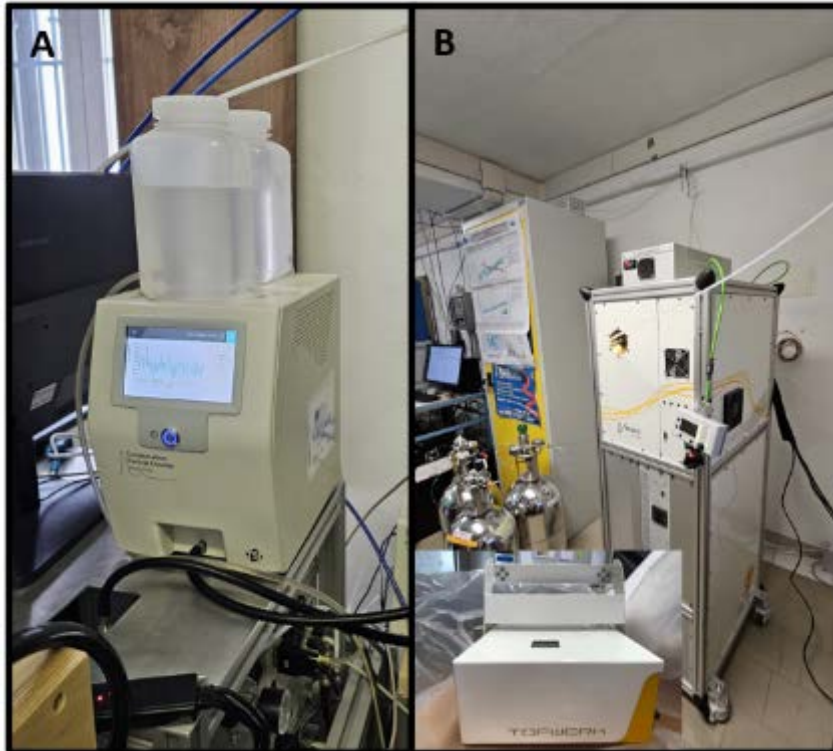


Fig. 1 A) ITINERIS CPC and B) liquid calibration unit at CMN-PV national facility.

Ceilometer and solar-lunar photometer have been integrated within AEROLAB mobile platform, enhancing the observatory's remote sensing capabilities (Fig. 2). Thanks to the synergy with the PRIN GAIA project, a marine version of the AEROLAB platform has been developed, incorporating the ITINERIS ceilometer, which was deployed during an Arctic measurement campaign aboard the icebreaker Research Vessel Polarstern, further extending observational capabilities over marine environments. For a filed campaign in Sicily the solar-lunar photometer is running since september 2024 at the Observatory "Rita Atria" located in Capo Granitola, Sicily.

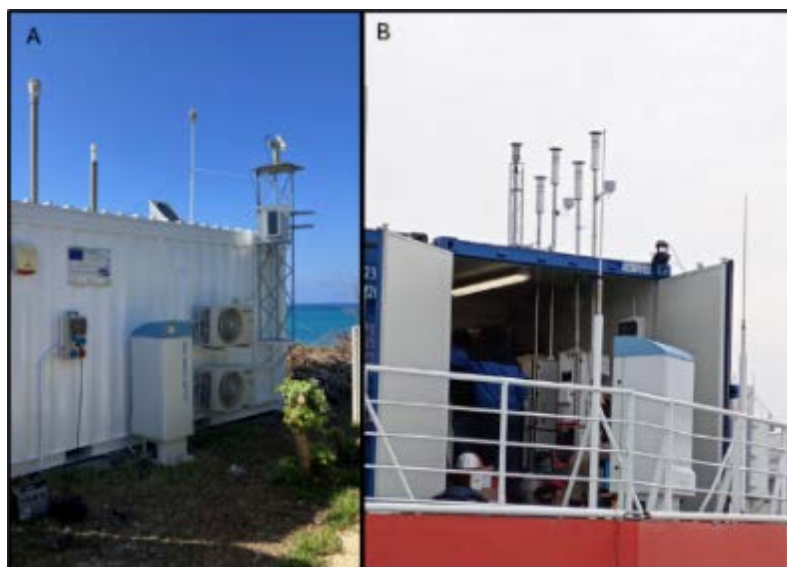


Fig. 2 A) ITINERIS sun photometer(@AEROLAB) at CNR-ISAC observatory of Capo Granitola and B) ITINERIS ceilometer onboard icebreaker Polarstern.

3. CALIBRATION AND INTERCOMPARISON PROCEDURES AND PERFORMANCE EVALUATION

Calibration is a critical process to ensure the accuracy, reliability, and comparability of data collected at ACTRIS facilities. All aerosol instrumentation acquired through the ITINERIS project, including CPCs, nephelometers, Scanning Mobility Particle Sizers (SMPS), and reference aethalometers from both AEROLAB and CMN-PV, will undergo the same comprehensive calibration procedures that were successfully carried out on the CPCs at TROPOS in Leipzig in April 2024. The front page of one of the final report is reported in Fig. 3.

Performance Characteristics	Criteria	Candidate	Unit
Concentration response (linearity)	100% ± 5%	98	%
Detection efficiency at < 10 nm	$D_{50} = 10 \pm 1 \text{ nm}$	9.87	nm
Detection efficiency at < 20 nm	≥ 90%	91	%
Detection efficiency at 40 ± 10 nm	≥ 95%	98	%

* bold = passed; underlined = failed

Fig. 3 Frontpage of the WCCAP report delivered after calibration and intercomparison at TROPOS.

In addition to the calibration at specialized reference centers, the instrumentation will be periodically calibrated at the CNR-ISAC laboratories. This calibration process, following the ACTRIS recommendations and Standard Operative Procedures, ensures that all instruments meet international standards, providing high-quality, consistent, and comparable measurements. Such procedures are essential for accurate atmospheric monitoring and for enabling effective intercomparison of data across various research platforms globally.

In this context, the new calibration units acquired through the ITINERIS project will also allow enable the calibration of the Volatile Organic Compound Uncertainty System (VOCUS) instrument, through liquid samples of different compounds, integrating the already implemented gas calibration

4. RESULTS

As part of the enhanced observational capabilities enabled by the ITINERIS project, the newly integrated instruments are already providing valuable data for aerosol characterization across different environments. Fig. 4 shows the time series of the CPC aerosol concentration measurement at the CNR Monte Cimone Observatory, while Fig. 5 displays the backscatter signal recorded by the ceilometer at 90°N during the measurement campaign aboard the Polarstern. The deployment of the ceilometer at 90°N provides crucial data for understanding cloud properties and their impact on the Arctic climate system. Continuous backscatter measurements allow for the detection of cloud base height, vertical structure, and temporal evolution, which are essential for assessing cloud radiative effects and their role in the Arctic energy balance. Given the region’s sensitivity to climate change, these observations contribute to improving climate models and refining predictions of Arctic atmospheric processes.

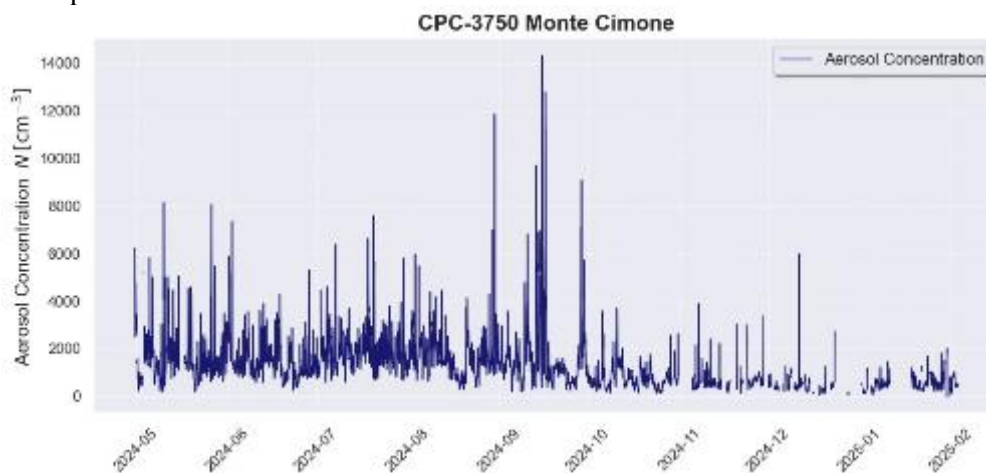


Fig. 4 Timeseries of aerosol concentration at CMN-PV facility.

Similarly, the CPC, together with the other aerosol characterization instruments acquired through the ITINERIS project, is essential for monitoring aerosol particle number concentrations and their temporal variability. These data provide insights into aerosol sources, transport pathways, and atmospheric processing, supporting studies on air quality, climate forcing, and long-range pollution transport. The high-altitude location of the Monte Cimone observatory offers a strategic position for capturing background aerosol conditions and detecting episodic events, such as biomass burning plumes or pollution intrusions, which can significantly influence regional and global atmospheric composition.

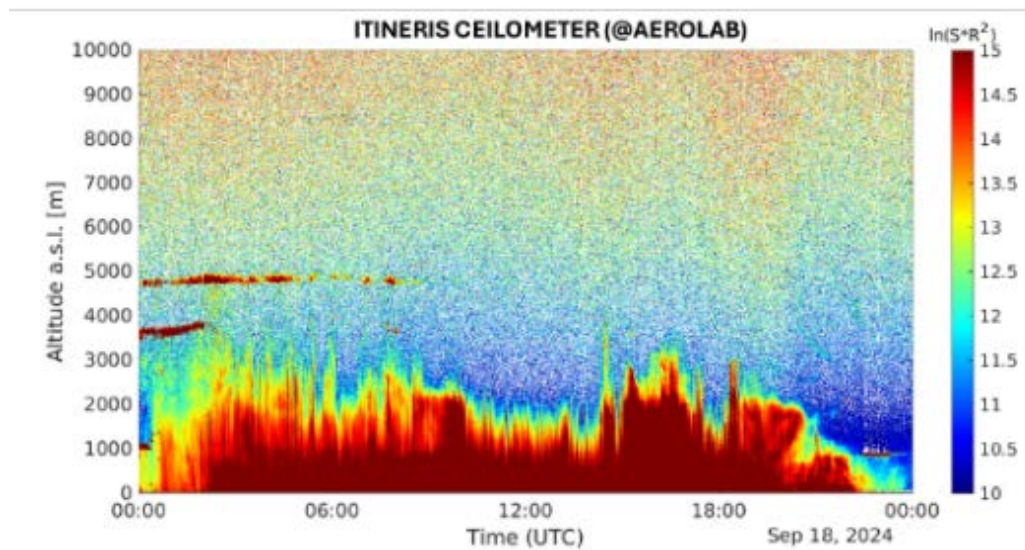


Fig. 5 Ceilometer backscatter measurements ($\ln RCS$) at $90^\circ N$ onboard the icebreaker Polarstern.

5. NEXT INSTRUMENTATION DELIVERIES AND TECHNICAL/SCIENTIFIC GOALS

Thanks to the upgrades made possible by the ITINERIS project, the CNR-ISAC-BO OU will significantly enhance its observational capacity across both ground-based and mobile platforms. A substantial part of the instrumental and technical improvements has already been deployed and is fully operational at the CMN-PV facility and exploratory mobile platform AEROLAB. The remaining instrumentation will be installed as soon as the procurement procedures are completed, ensuring full deployment before the project's conclusion. This infrastructural strengthening will not only expand observational capabilities but also increase the attractiveness of these facilities for external users through access programs within ITINERIS and European Research Infrastructures (e.g., ATMO-ACCESS). Additionally, these developments will support the harmonization of standards, metadata, and policies across different research infrastructures. While these infrastructures operate at varying levels of maturity, they face common challenges in ensuring FAIR compliance and efficient access management. By promoting integration and coordination, the ITINERIS project will contribute to strengthening Europe's capacity for high-quality atmospheric research and long-term environmental monitoring.

ANNEX 1 – UPDATED LIST OF CNR-ISAC BO INSTRUMENTS

Monte Cimone

- Aethalometer Magee AE33: aerosol absorption coefficients, Black carbon, Brown Carbon, multiwavelength
- MAAP Thermo 5022 : aerosol absorption coefficients, Black carbon, scattering corrected
- Nephelometer, TSI 6735:
- Aurora 3000 Ecotech Aerosol light scattering coefficients, 3 w
- SMPS Tropos: Aerosol size-distribution (range: 10 - 800 nm)
- CPC-TSI 3772: Fine particles Number concentration
- Optical Particle Counter, GRIMM 1108: Aerosol size-distribution (range: 0.3 - 30 μm), PM10, PM2.5
- Aerodynamic Particle Sizer, TSI 3321: Aerosol size-distribution (range: 0.5 - 30 μm)
- CCN-200, Droplet Measurement Technique: CCN concentration at 6 super saturation degree
- NAIS (Neutral cluster and Air Ion Spectrometer): size distribution of neutral particles and +/- ions (range 0.8-40 nm)
- Picarro G2401 (CO₂, CH₄, CO, H₂O),
- Picarro G5310 (N₂O, CO, H₂O),
- Thermo 49i (O₃),
- Thermo 42i-TL (NO, NO₂),
- Teledyne T200UP (NO, NO₂),
- Thermo 43i-TLE (SO₂).
- ICOS Flask Sampler,
- ¹⁴C ICOS sampler,
- Calibratore Thermo 49i-PS,
- Diluitore Thermo 146i
- Celiometer Luft CHM15K.

Bologna

- Thermo 49i (O₃),
- Teledyne T200UP (NO, NO₂),
- DOAS "TROPOGAS",
- Calibratore Thermo 49i-PS,
- Diluitore Thermo 146i
- Q-ACSM for the online chemistry
- AE-33 for the equivalent black carbon concentration

San Pietro Capofiume

- DOAS "SkySpec-2D-210"
- MAAP Thermo 5022 : aerosol absorption coefficients, Black carbon, scattering corrected
- SMPS, custom built
- GRIMM EDM 164 Optical Particle Counter
- Advanced LiDAR Raimetrics LR 221-D300
- CIMEL 318 sunphotometer

Aerolab

- Aethalometer Magee AE33: aerosol absorption coefficients, Black carbon
- Nephelometer, Ecotech Aurora 3000: Aerosol light scattering coefficients
- SMPS Tropos: Aerosol size-distribution (range: 8 - 800 nm)
- Optical Particle Counter, GRIMM 11R: Aerosol size-distribution (range: 0.3 - 30 μm), PM10, PM2.5
- Aerodynamic Particle Sizer, TSI 3321: Aerosol size-distribution (range: 0.3 - 30 μm)
- CPC-TSI 3750: Fine particles Number concentration
- Wind lidar Metek HALO
- Thermo tei42i: NO, NO₂,NO_x
- Thermo tei450i: SO₂, H₂S

ANNEX 2 – FULL LIST OF CNR-ISAC BO INSTRUMENTS IN ACQUIRED WITHIN ITINERIS

1. The Portable Ice Nucleation Experiment (PINE)
2. Fog monitor, LWC, Reff, DROPLET SIZE DISTRIBUTION
3. SP-2 D (Refractory BC, mixing state)
4. Cloud sampler
5. aethalometer for black carbon concentration and BB fraction
6. CASS (Total Carbon Content (“TC”), the Elemental Carbon content (EC), the Organic Carbon content (OC) and the Black Carbon content (BC) of suspended aerosol particles in near-Real Time)
7. SMPS (aerosol size distribution 10-800 nm)
8. FTIR for GHG and RGs
9. Container for FTIR
10. 2 x Nephelometers (aerosol scattering and back scattering coefficient)
11. 2 x condensation particle counters (aerosol number concentration)
12. Ceilometer
13. Solar Lunar sunphotometer
14. Advanced Lidar Raymetrics
15. Doppler Cloud radar
16. UPS for mountain observatory
17. 2 greenhouses gases analyzers G2401 (Cavity Ring Down Spectrometers CO, CO₂, CH₄, H₂O) + 1 analyzer G2201-I (CRDS for ¹³C in CO₂ and CH₄)
18. Aerosol sampler
19. Meteorological probes
20. Data storage for ISAC BO observatories
21. Webcam for internal and external visualisation
22. Data analyses platforms
23. Upgrade mobile Platform Voyager III, for data acquisition of internal and external meteorological monitoring
24. Calibration system for organic volatile compounds
25. Construction works for FTIR observatory
26. SOFI software