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WP4 - Atmosphere

- Lucia Mona (CNR-IMAA)
- Daniele Contini (CNR-ISAC)
- Giuseppe D'Amico ->Benedetto De Rosa (CNR-IMAA)

+ all WP4 participants

imaa | ISAC | CNR ISMAR ISTITUTO DI SCIENZE MARINE | ISP Istituto di Scienze Polari Consiglio Nazionale delle Ricerche | INFN Istituto Nazionale di Fisica Nucleare | Università Ca'Foscari Venezia Dipartimento di Scienze Ambientali, Informatica e Statistica

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

Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani

WP4 Structure

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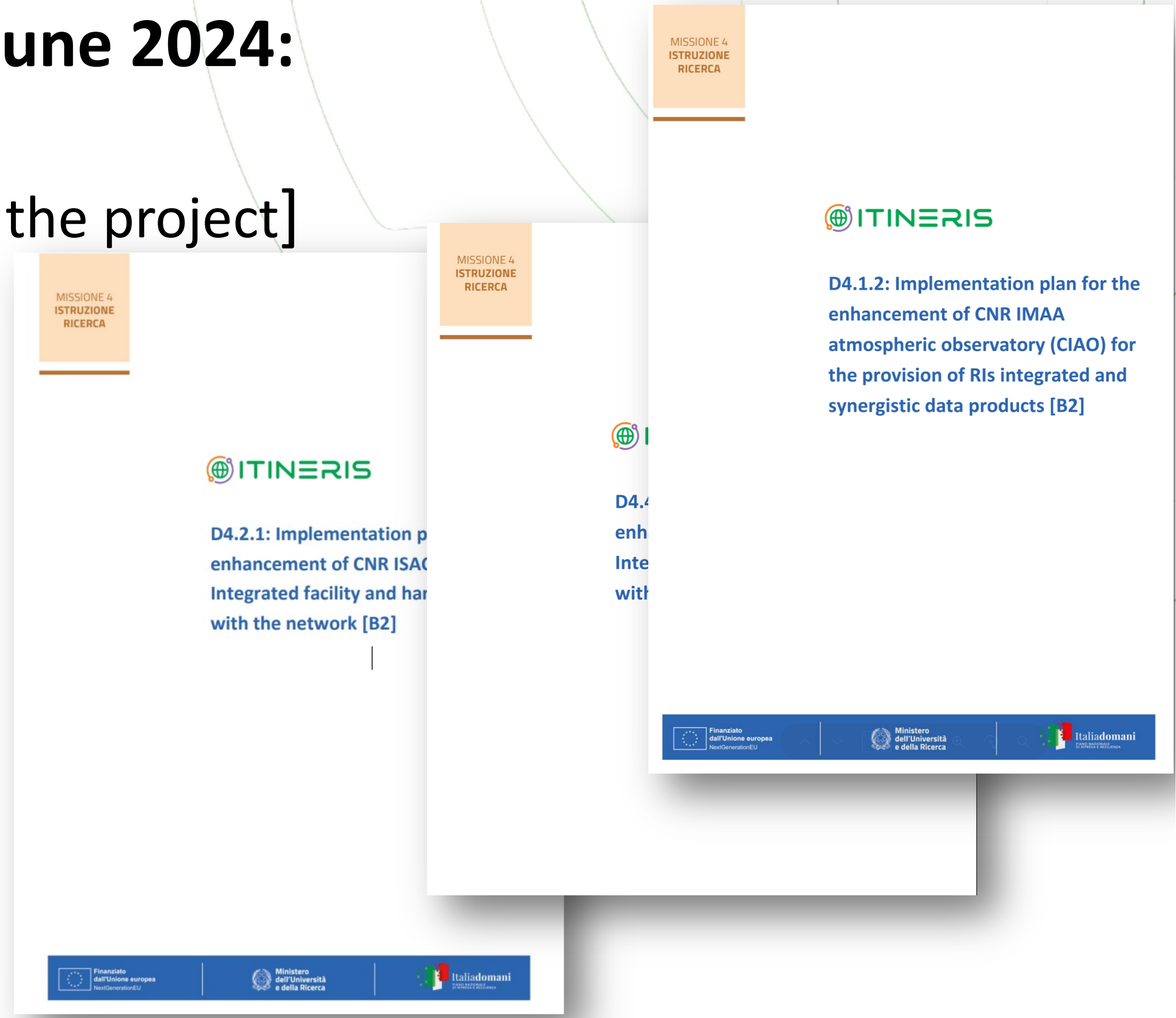
ACTRIS ICOS Integrated Carbon Observation System EUFAR SIOS CeTrA Centre for Trace Analysis

- **Objective 1** Integration and harmonization within the Italian Network of Environment RIs
- **Objective 2** Pilot service on Aerosol types and sources
- **Objective 3** Pilot service on Planetary Boundary Layer height and its impact on aerosol and trace gases concentration at ground
- **Objective4** Pilot service on impact of natural and anthropic fires on atmospheric composition

WP4 deliverables status at B10 (IO 4.5 - June 2024)

Deliverables released (PI4.4) - Status at June 2024:

OBJ 1: **18** deliverables [33 due at the end of the project]
OBJ 2: **4** deliverables [9]
OBJ 3: **4** deliverables [6]
OBJ 4: **2** deliverables [3]



Everything released on schedule

Performance indicators status at B10 (IO 4.5 - June 2024)

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Purchase procedures (PI 4.1; 4.2): Slighlty delayed

Delays occurred in starting procedures:

- 45% of procedures started (expected status at B10: 70%)
- 33% of contract signed (expected status at B10 : 60%)

Realignment expected in next months

Personnel selection (PI 4.1; 4.3): Completed!

12 Researchers, 4 Technicians and 12 Technologists

Datasets production (PI 4.5): 60 datasets at the project end

First survey: 30 datasets + SIOS and Cetra (rough estimate 15)

ISP Istituto di Scienze Polari – Consiglio Nazionale delle Ricerche

Università Ca'Foscari Venezia – Dipartimento di Scienze Ambientali, Informatica e Statistica

info missing from some units

Good!

OBJ1: Integration Harmonization – Main achievements

- Deploying trans–RI instruments at the different sites
- Reinforcing the observational capability at RI locations and beyond
- Building and empowering the digital resources collection & provision in atmospheric domain
- Building up a National community strengthening cooperation and collaboration
    - Mutual use of resources available in the National community for progressing on science
    - Mutual support based on specific expertise
    - Training activities (organized in WP3) saw the involvement of groups as lecturers and as attendees

OBJ1: Integration Harmonization – An example

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- Instruments for airborne measurements of aerosol

  - *Aethalometer for black carbon concentration, including biomass burning (BB) fraction*
  - *SMPS Scanning mobility particle Spectrometer 10 to 800 nm range (customized for airborne use)*
  - *APS - aerosol particle sizer 0.5 to 20 um (customized for airborne use)*
  - *Nephelometer for scattering and backscattering coefficient*
  - *Dust monitor 0.15-40 um (customized for airborne use)*
  - *CPC CEN (customized for airborne use)*
  - *Airborne Meteorological System (airborne use)*
  - *Airborne isokinetic Aerosol inlet (airborne use)*
  - *Other possible inlets*

Piper Seneca III owned by OGS

OGS
Istituto Nazionale di Oceanografia e di Geofisica Sperimentale

→ The perfect link between different sites

OBJ1: Integration Harmonization – *Extra Domain*

Development of Lidar observation capabilities at **AAOT** (WP4.6) and **Gaia Blu** (WP5.16) for regular monitoring of relevant and marine variables and for innovative air-sea interaction studies

Atmospheric Variables

Vertical profiles of:

- Particle backscatter coefficient and depolarization ratio from aerosols and clouds
- Particle exctinction coefficient from aerosols and clouds
- Aerosol fluorescence

Marine Variables

Vertical profiles of:

- Chlorophyll-a concentration
- Particulate backscattering coefficient
- Depolarization ratio of ocean waters
- Diffuse attenuation coefficients of downwelling irradiance
- Colored dissolved organic matter (CDOM) concentration

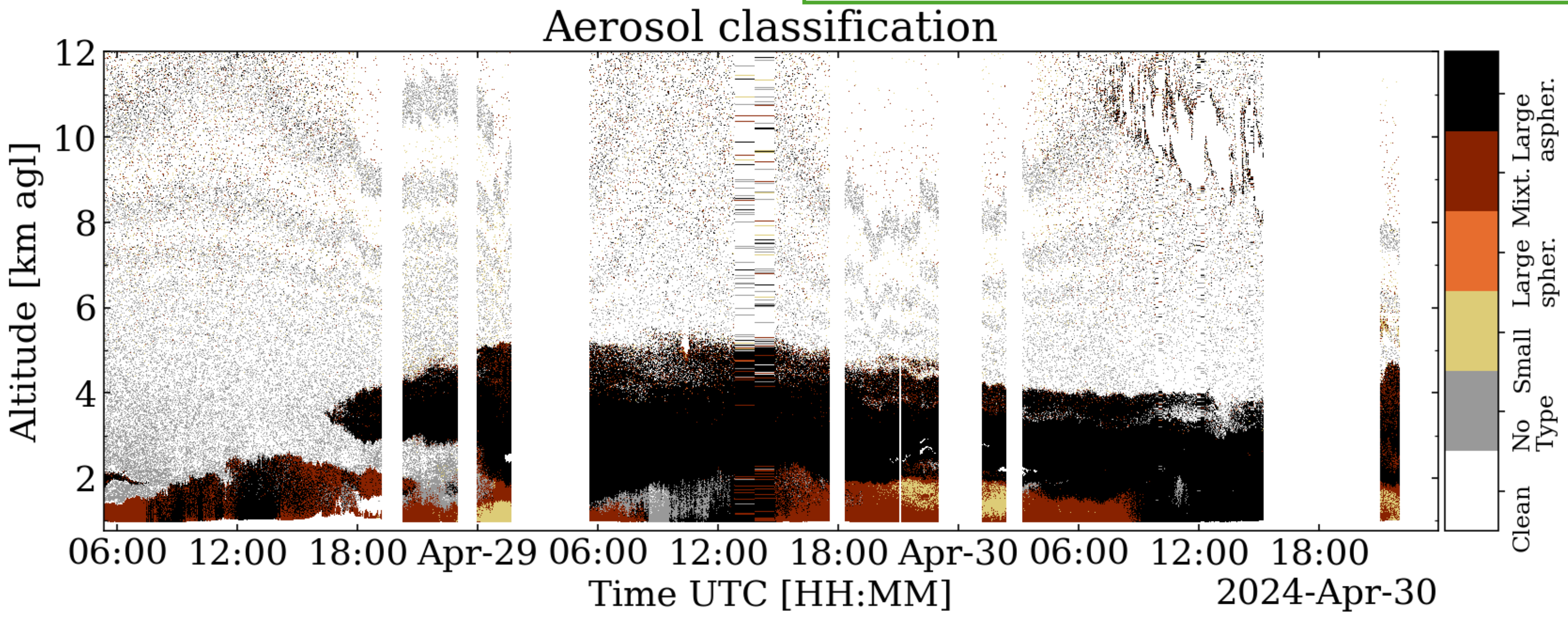
Interconnections between marine ecosystems, aerosols, and clouds

Task 4.11 – Aerosol typing

- **3 aerosol typing algorithms** have been translated into python and fine-tuned to accept ACTRIS-like lidar data
- **+ 1 high-temporal-resolution aerosol typing** methodology has been developed for ACTRIS lidar data

- A **dedicated server** hosts the abovementioned algorithms and their output with the goal to become the centerpiece of this task

- A dataset of **pure dust vertical profiles** has been created using aerosol lidar measurements provided by the ACTRIS lidar stations in Italy



contact: nikolaos.papagiannopoulos@cnr.it

Task 4.11 - Aerosol Typing over Italy from AERONET

Florin Unga[1,*], Barbara Bulgarelli[2], Giuseppe Zibordi[2], Stefano Corradini[3], Sergio Teggi[4], Lorenzo Guerrieri[5], Vincenzo Rizi[6], Marco Iarlori[6], Francesca Barnaba[7], Alessandro Bracci[7], Antonella Boselli[8,9], Salvatore Amoruso[9], Gelsomina Pappalardo[10], Lucia Mona[10], Fabio Madonna[10], Maria Rita Perrone[11], Angelo Palombo[12], Stefano Pignatti[12], Michele Furnari[13], Daniela Meloni[14], Alcide di Sarra[14], Damiano Massimiliano Sferlazzo[15], Daniela Cesari[1], Daniele Contini[1]

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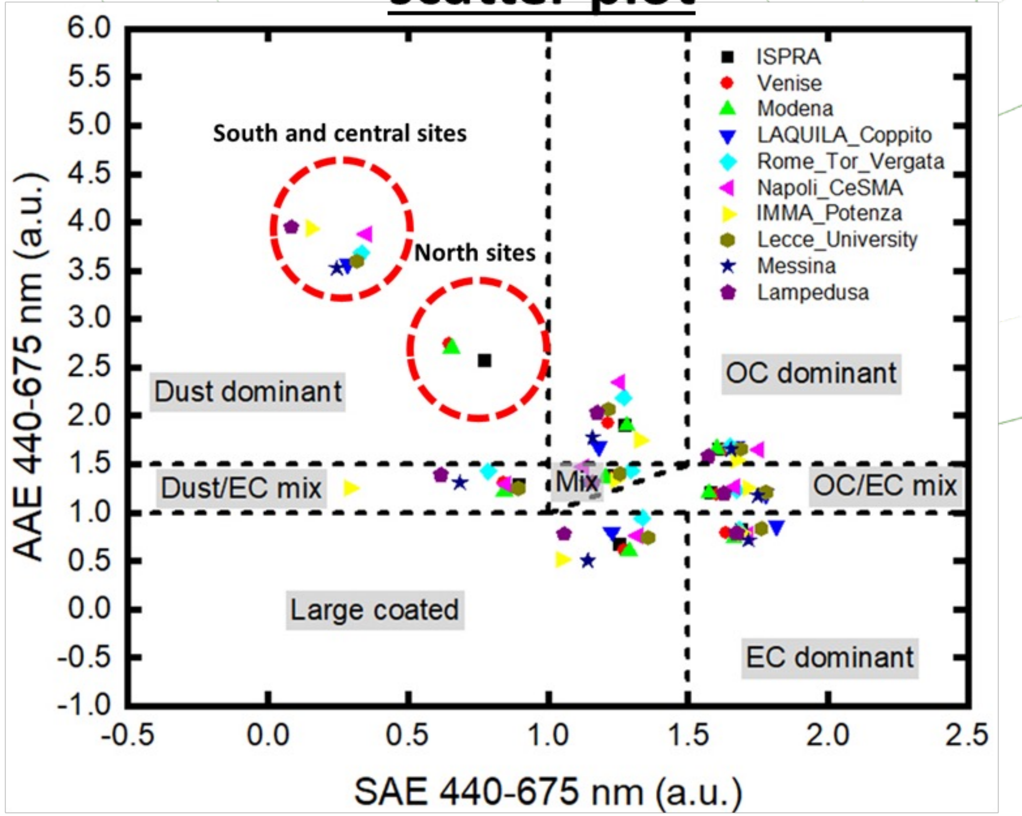
CIMEL CE318-T photometer at CNR-ISAC Lecce

Average AAE vs. SAE 440-675 nm scatter plot



Task 4.11 - Aerosol Typing over Italy from AERONET

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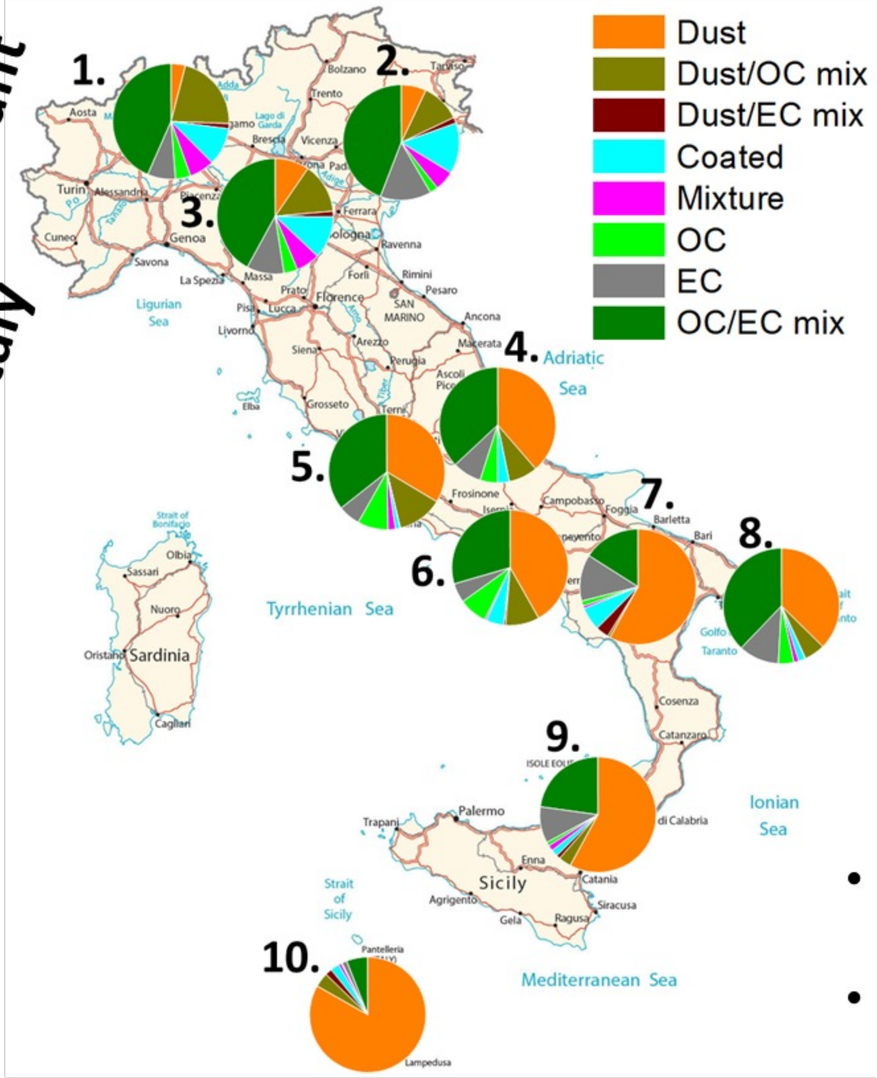
Relative proportion of dominant aerosol types over Italy



Site	Dust %	Dust/OC mix %	Dust/EC Mix %	Coated %	Mixture %	OC %	EC %	OC/EC mix %
1. Ispra	4.02	21.57	1.46	10.54	6.93	4.23	7.77	43.48
2. Venise	7.02	10.87	1.65	14.24	5.57	2.27	14.17	44.22
3. Modena	9.54	14.07	1.54	11.96	6.63	3.80	10.35	42.12
4. LAQUILA_Coppito	38.71	8.06	-	3.23	-	4.84	8.06	37.10
5. Rome_Tor_Vergata	33.63	12.61	0.18	1.23	2.10	8.41	6.13	35.73
6. Napoli_CeSMA	41.87	9.36	0.49	4.93	0.49	7.88	5.42	29.56
7. IMAA_Potenza	57.97	0.72	3.62	6.52	0.72	1.45	13.04	15.94
8. Lecce_University	37.40	5.76	0.13	1.88	1.34	4.29	11.26	37.94
9. Messina	57.91	3.49	1.07	1.88	1.61	1.07	10.19	22.79
10. Lampedusa	83.29	4.04	1.89	2.43	0.81	0.27	1.35	5.93

North

South

- Higher proportion of Dust dominant aerosol type in the south (closer to source, Saharan desert).
- Higher proportion of OC/EC mixture in north (continental pollution).

Task 4.11 - Aerosol Typing

ChAMBRe

Chamber for Aerosol Modelling and Bio-aerosol Research

Bioaerosol

Systematic studies on the effects of atmospheric conditions on bacteria viability

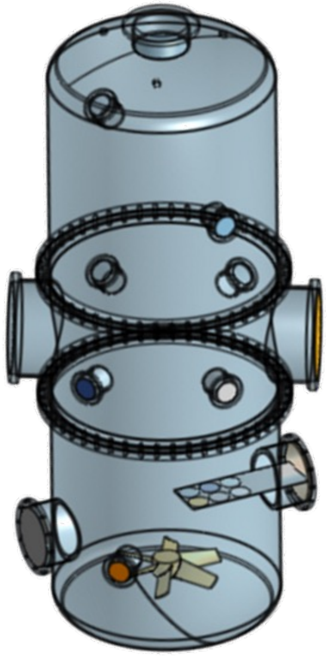
Vernocchi et al., (2023). Atmos. Meas. Tech., 16, 5479-5493

New experimental protocol

BACTERIA PREPARATION
- Bacteria growth
- Inoculum characterization

BACTERIA EXPOSURE
- Bacteria injection in ChAMBRe
- Setting of atmospheric conditions in ChAMBRe
- Bacteria sampling

DATA ANALASYS
- Determination of bacteria total concentration
- Determination of bacteria viable concentration



Optical properties

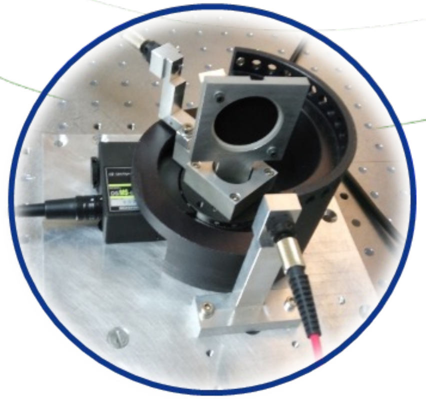
Online and offline determination of absorption/scattering/extinction coefficients

Isolabella et al., (2023). NCC-C, 46, 1-4

Production of "aerosol standards"

BLAnCA

A new instrument for full-spectrum light absorption measurements of aerosols collected on filters



Optical apportionment of carbonaceous aerosol

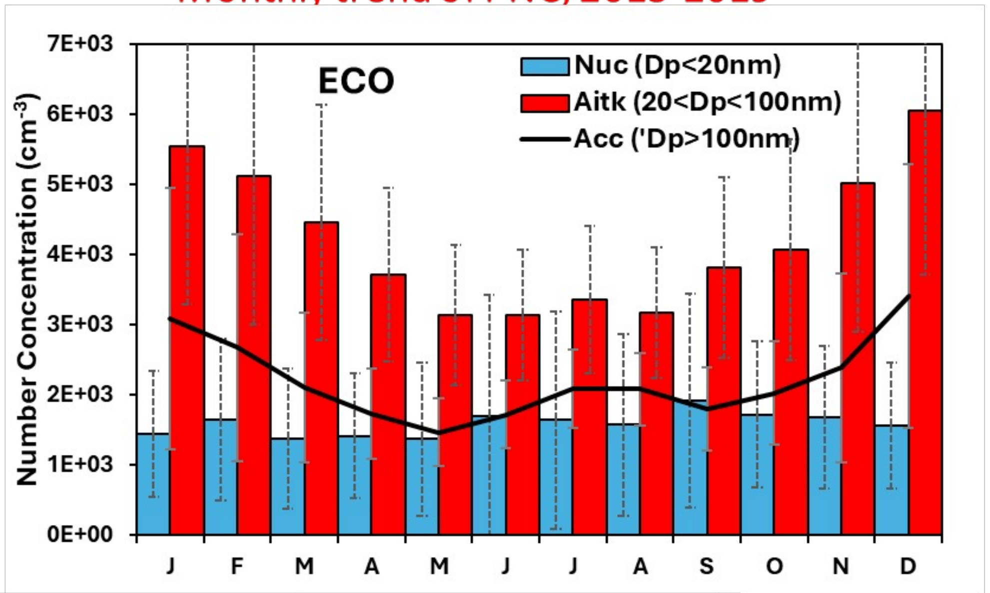
Isolabella et al., (2024). Atmos. Meas. Tech., 17, 1363-1373

Task 4.12 - Aerosol sources – NPF events

SITE: ECO Observatory (40°N;18°E) urban background, 5 km from Lecce. Regional stations of GAW/ACTRIS.

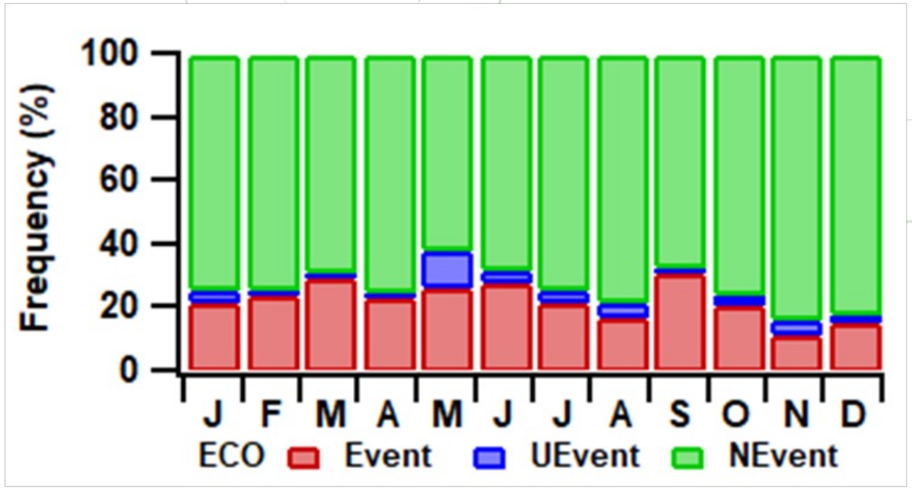
INSTRUMENTATION
PNC (10-800nm) by MPSS;
SO_2 (Thermo Instruments analyzers, TEI 43i); Meteo data (T, WS, WD, RH, rain, Solar Flux)

Monthly trend of PNC, 2015-2019



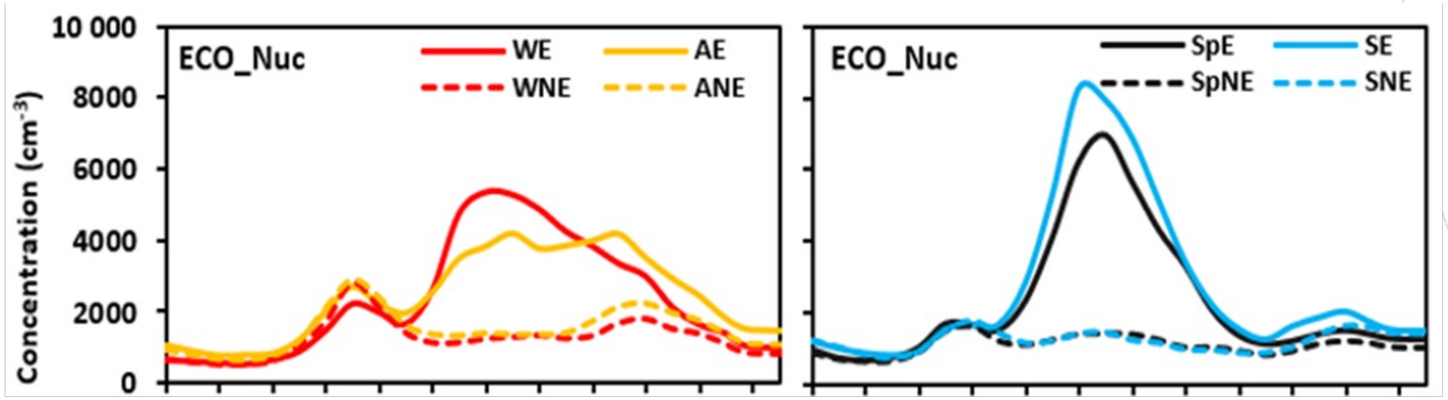
N_{NUC}<20nm (21%)	20nm<N_{AIT}<100nm (53%)	100nm<N_{ACC}<800nm (27%)

Classification of new particle formation events

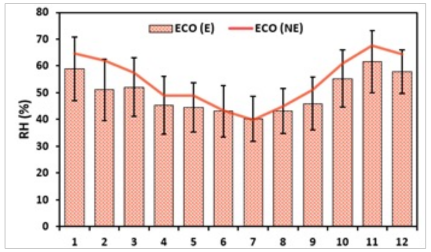


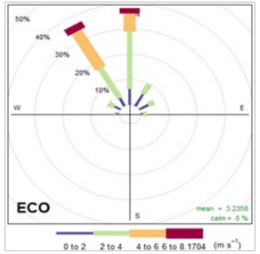
Frequency (%) > March and September (30%);
< November and December (12%-16%)

Task 4.12 - Aerosol sources – NPF events

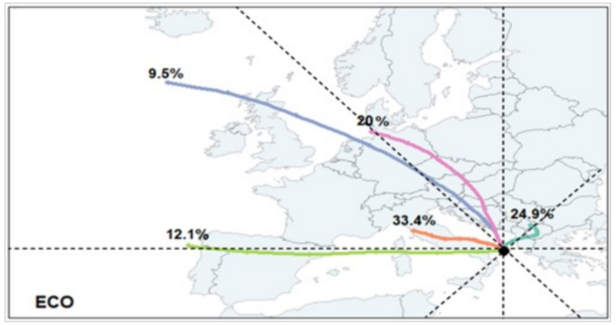


Factors associated with NPF events

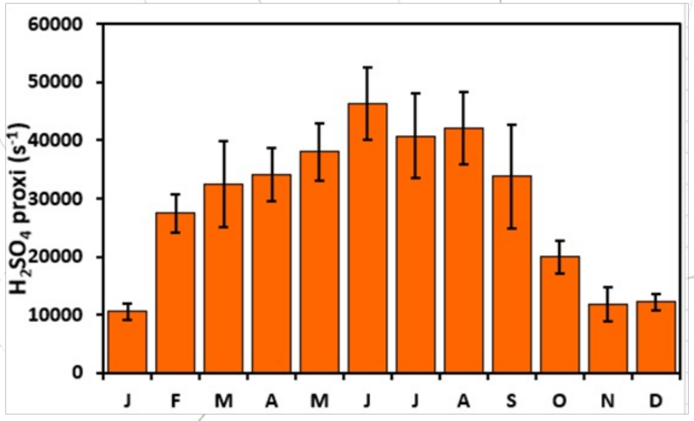




Local weather: clear skies, RH<52 % and moderate ws 3-4 m/s.



Cluster analysis of back trajectories (72 h, 500 m h) associated with NPF events, 6 centroids.



The monthly values of the H^2SO_4 proxy are larger in warm months with values ~ 35% higher during event days.

The air masses come from European continental areas, highly anthropized, and the marine environment before reaching the receptor point. The lack of air masses from the southern sector (dust can suppress photochemical activity by scavenging reactive gases and condensable vapours) emphasizes their role in terms of transport of precursors and synoptic atmospheric conditions to them associated (Dinoi et al., ACP 23(3)2167-2181, 2023).

Collaboration with ACTRIS/RI-URBAN to a paper on inter-annual trends of ultrafine particles in urban Europe (Environment international 185, 108510, 2024) and to a paper on source apportionment based on PNSD (in preparation).

Task 4.12 - Aerosol sources - source apportionment

- **24 sites in total**. 21 in the area of Lecce (South Italy) and 3 in small villages (< 25000 inhabitants in the province ~ 40 km from Lecce).
- One site was the **ECO ACTRIS observatory of Lecce**.
- **30 samplers** (22 for $PM_{2.5}$ and 8 for PM_{10}) at 9-19 m agl.

Classification of the sites

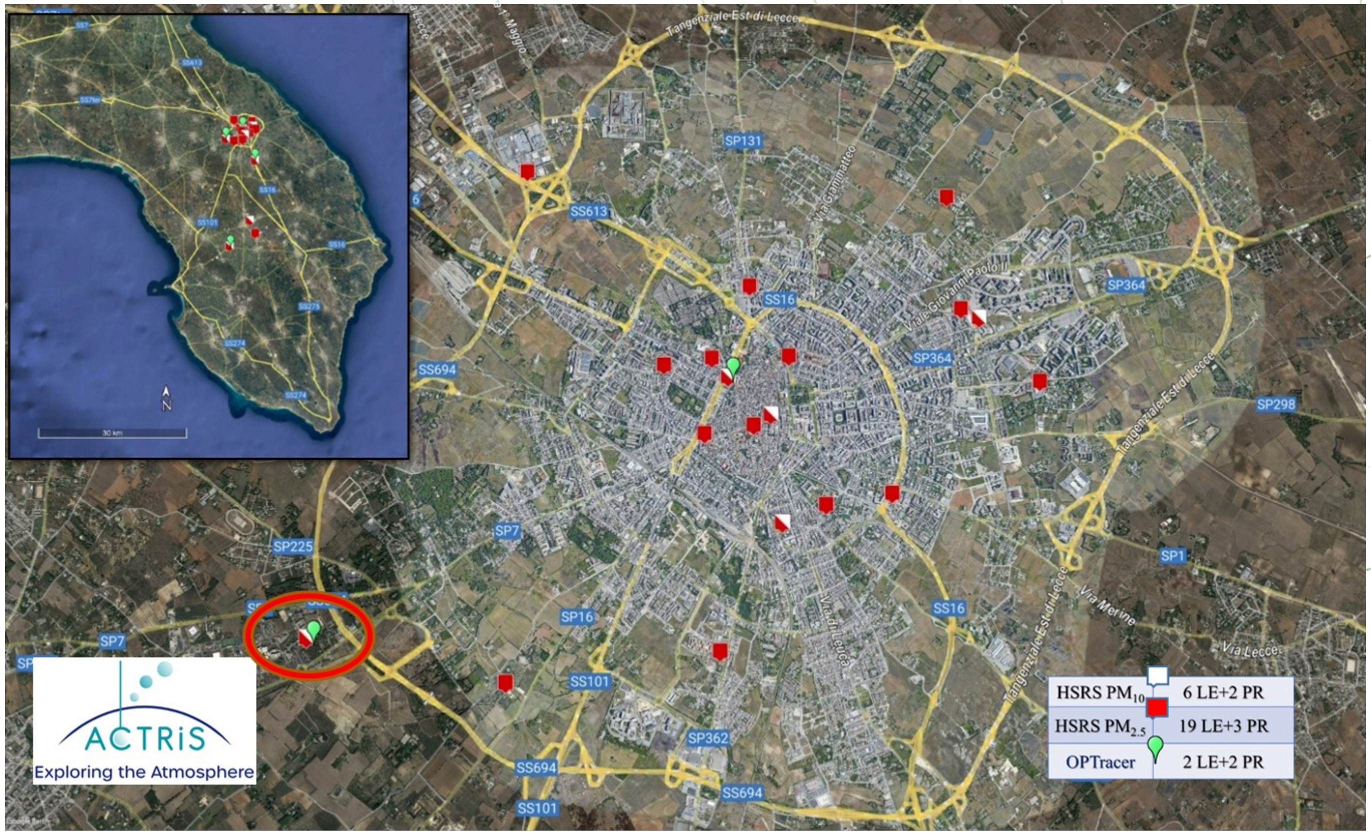
- **FU/S**: 11 sites of urban background/city background.
- **TU**: 8 sites urban traffic.
- **I/CS**: 2 sites at large commercial centers.
- **PR**: 3 sites in the province of Lecce.

Composition analysis and post-processing

- Chemical analysis for metals (ED-XRF); OC/EC (Sunset-EUSAARII) and water soluble carbon (TOC/TN); major ions (IC).
- Application of EPA-PMF5.0 for source apportionment separately for the two size fractions but pooling together the different sites.

Main results

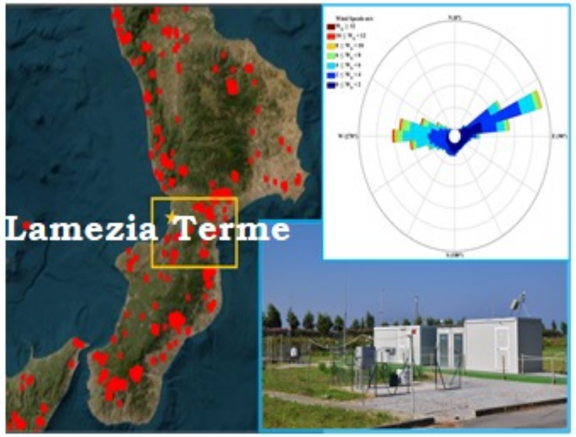
- Spatial variability was smaller than seasonal variability with the exclusion of biomass burning (BB) source.
- Industrial contribution limited and visible only on $PM_{2.5}$.
- Soluble and insoluble Ca allowed to separate crustal and carbonates contributions in both size fractions.



Samplers **installed at heights agl 9-19.5 m** at public buildings, schools and private houses

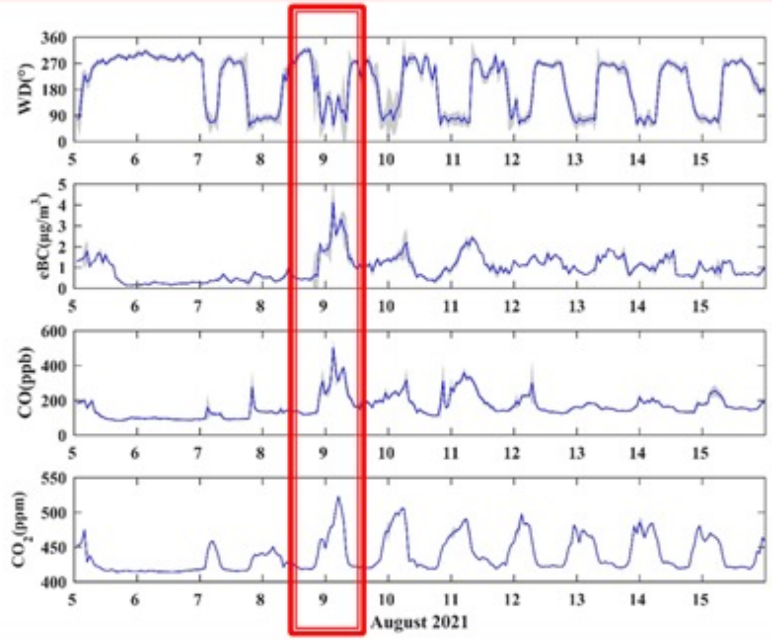
Sampling campaign: Dec 2021 – Dec 2022

Task 4.16 - Open Fire, case and tracers identification



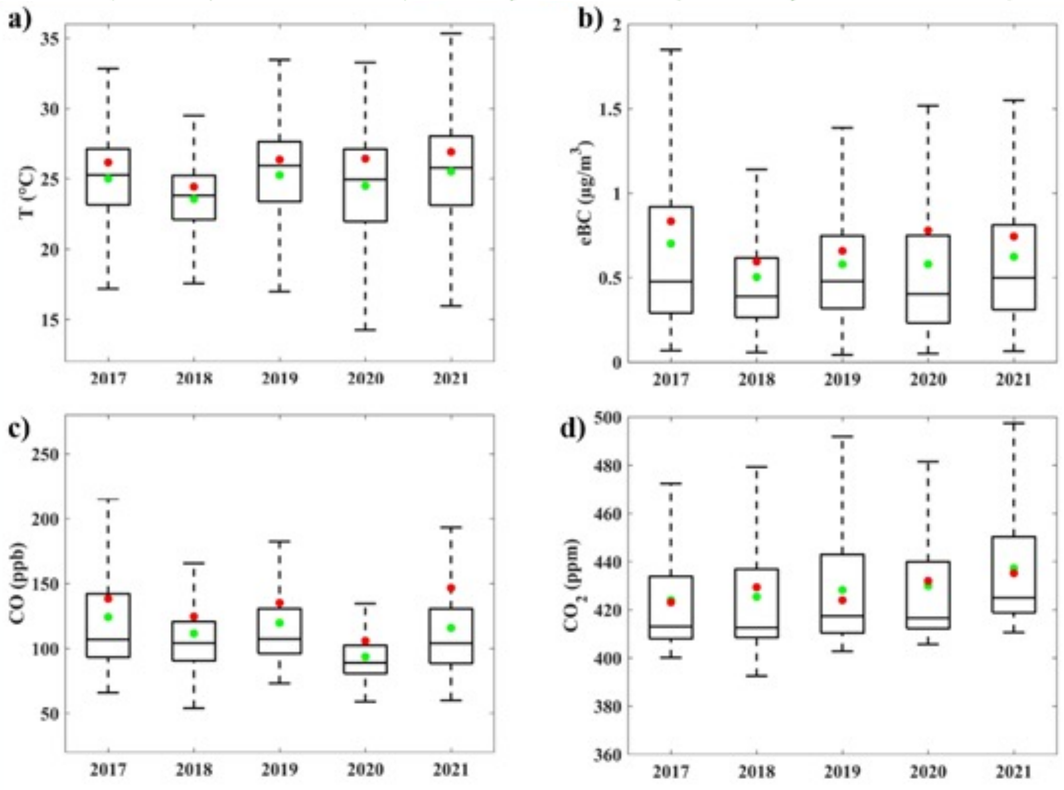
SITE: LMT Observatory (38.88 N 16.23 E; 6 m.a.s.l.) coastal semirural-background. 10km from Lamezia Terme in land NE.
Regional Station GAW/WMO.
Predominant circulation W-NE

Methods and data :
CO2, CO, CH4, H20 (PiCARRO)
eBC (MAAP Thermo)
Data (T, WS, WD, RH, rain) (Vaisala)
Active fires (GFED4- MODIS satellite)



RESULTS

First case study of the 8th-12th August 2021 - the directionality of atmospheric circulation and wind fields, using also WRF output, with respect to the location of the experimental site were able to provide sufficient information to corroborate the hypotheses of comparison between the sources of fire events (yellow box in map above) and the concentrations of the detected combustion products in situ time series



For each year 2017 – 2021 (years with biggest concentration of fires) for air-temperature (a), eBC (b), CO (c) and CO_2 (d).

- the average summer season values (green spots),
- the mean values for August months (red spots),
- the median (bold lines) and
- the 5th, 25th, 75th and 95th percentiles (box and whiskers)

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WP4 Atmosphere

4.14 Impact of atmospheric boundary layer height on aerosol and trace gases concentration at the ground	4.15 Atmospheric boundary layer height (ABLH)

Operative Unity

Consiglio Nazionale delle Ricerche - Istituto di Scienze dell'Atmosfera e del Clima(CNR-ISAC)

Operative Unity

Consiglio Nazionale delle Ricerche - Istituto di Metodologie per l'Analisi Ambientale (CNR-IMAA)

Atmospheric boundary layer relevance

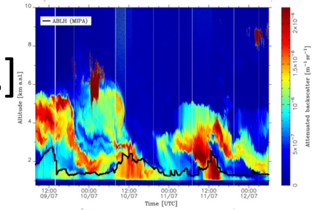
- The atmospheric boundary layer (ABL) is the part of the troposphere that is directly or indirectly influenced by the Earth's surface (land and sea). It usually responds to atmospheric changes in an hour or less.

- The characterization of ABL is of primary importance in a variety of fields as weather forecasting, climate change modelling and air quality prediction.

- The PBL height (ABLH) is a relevant meteorological variable with a strong effect on air pollution as it defines the atmospheric volume that can be used for pollutant dispersion.

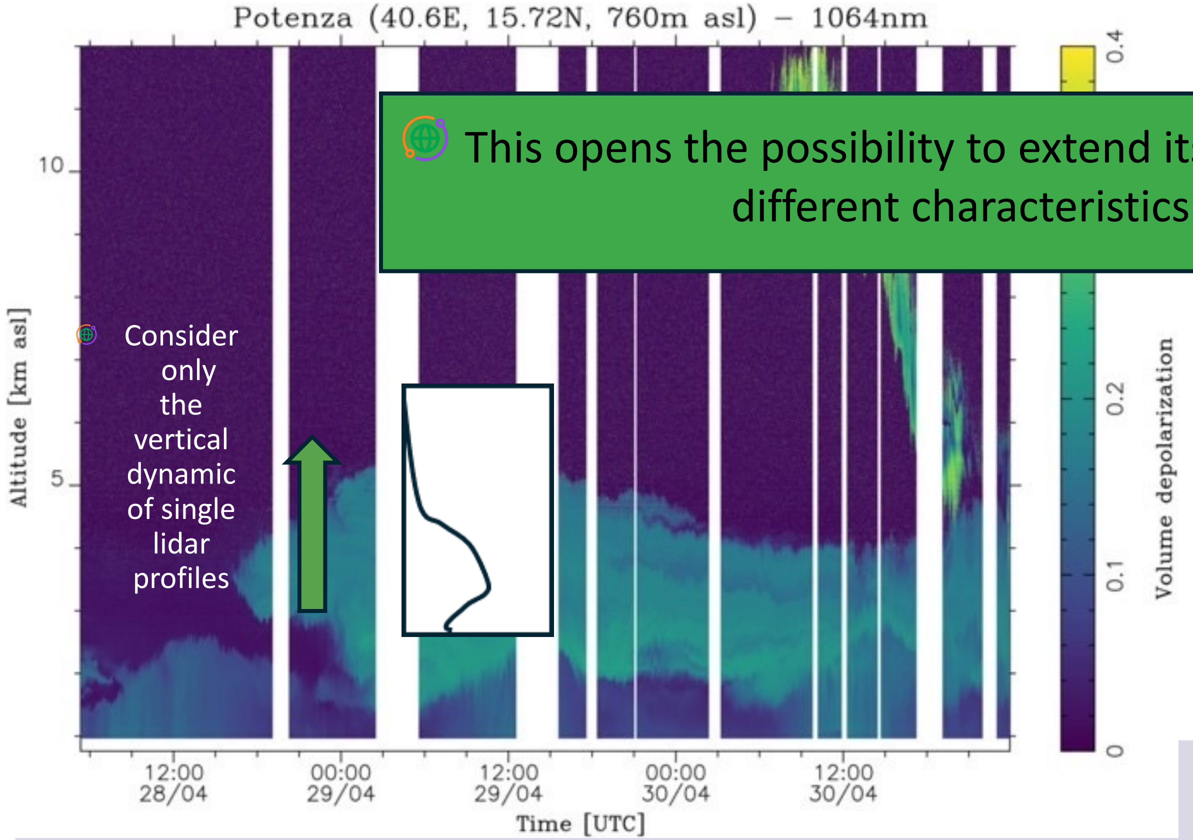
4.15 → CIAO ABLH campaign

The CIAO ABLH measurement campaign was aimed at the optimization/validation of MIPA (Morphological Image Processing Approach). The algorithm MIPA has been developed at CNR-IMAA [**Vivone et al. ACP 2021**] MIPA is based on artificial intelligence algorithms already used for satellite image processing.

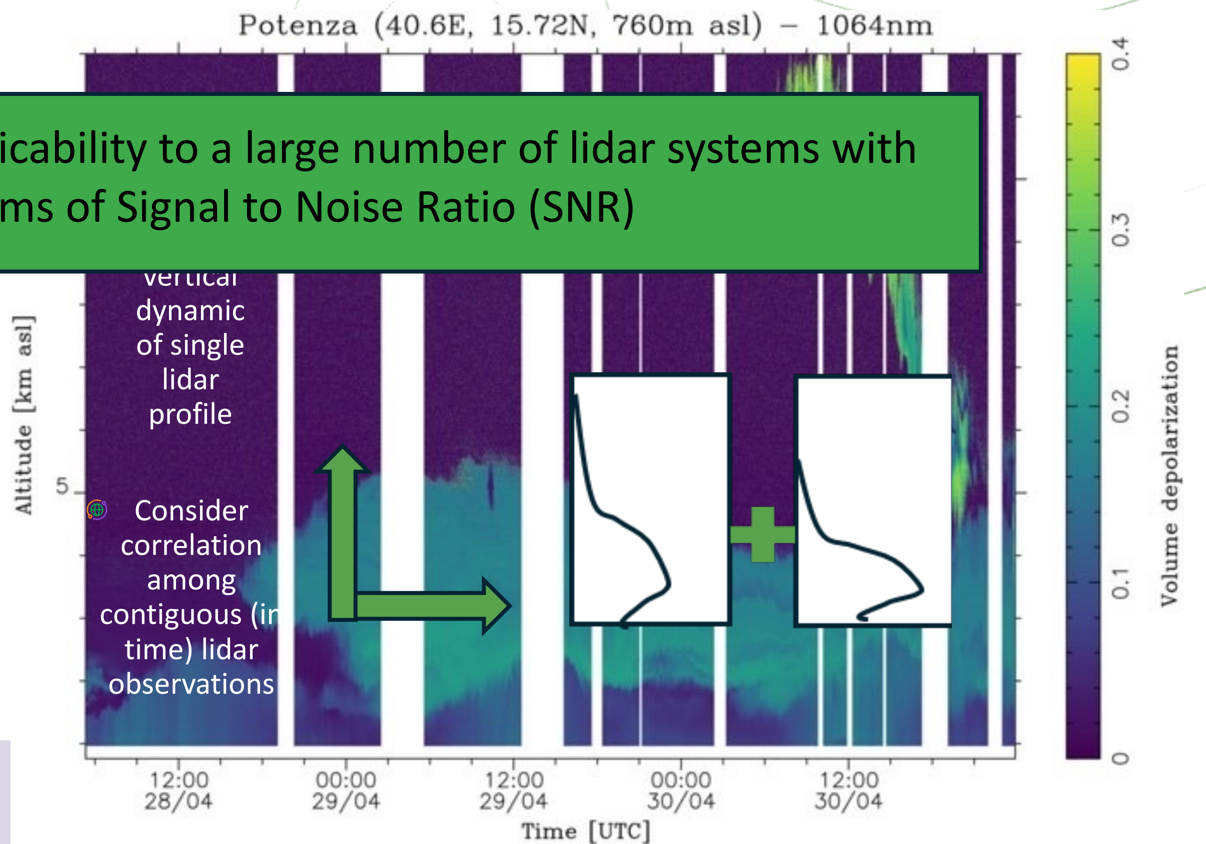


MIPA operates on timeseries of lidar profiles and not on single lidar profile

Traditional lidar ABLH retrieval techniques

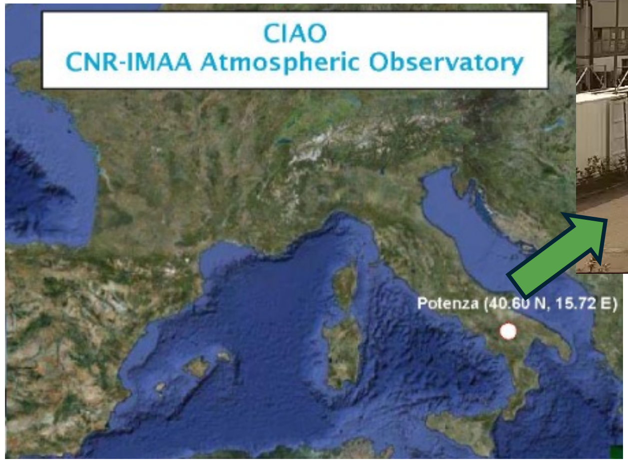


MIPA



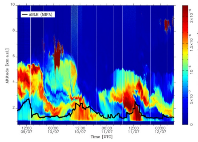
This opens the possibility to extend its applicability to a large number of lidar systems with different characteristics in terms of Signal to Noise Ratio (SNR)

CIAO ABLH campaign



Reference technique against which to compare the values obtained from MIPA.

The number of radio soundings carried out in short time periods represents the uniqueness of this study.



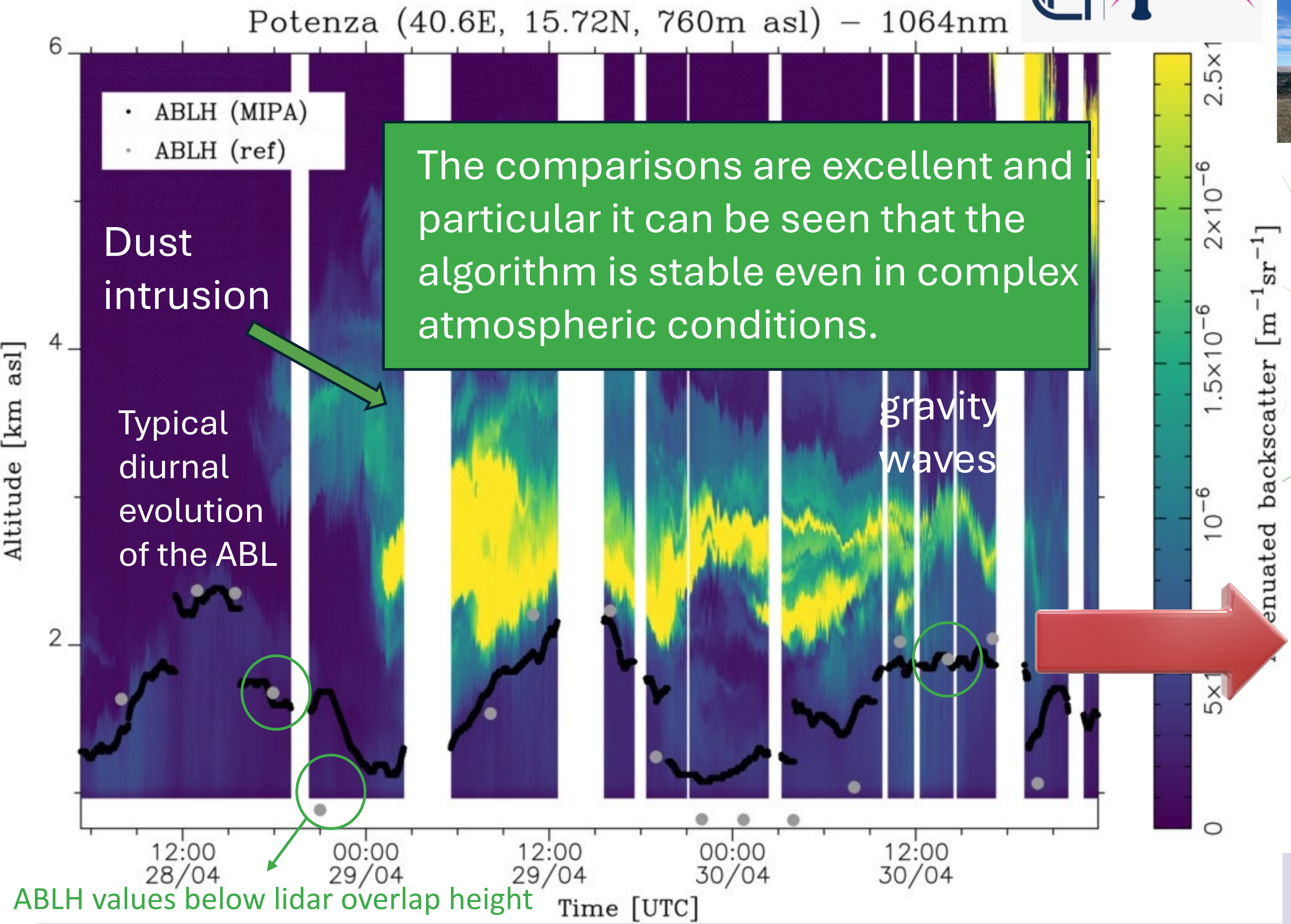
The CIAO ABLH measurement campaign was aimed at the optimization/validation of MIPA.

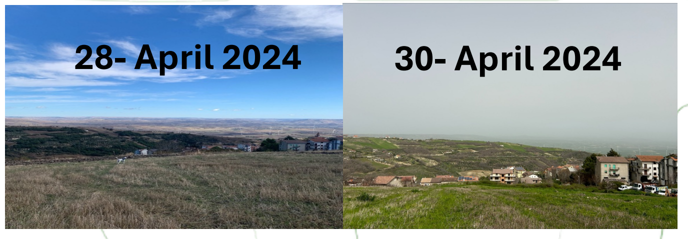
Started April 15, 2024

The main goal is to have different types of remote sensing instruments operating simultaneously and continuously 24/7 together with frequent radiosondes' launches to establish a reference dataset for the ABLH retrieval.

Two case studies were selected to test the algorithm in complex meteorological conditions.

Case study 1) 28-29-30 April 2024





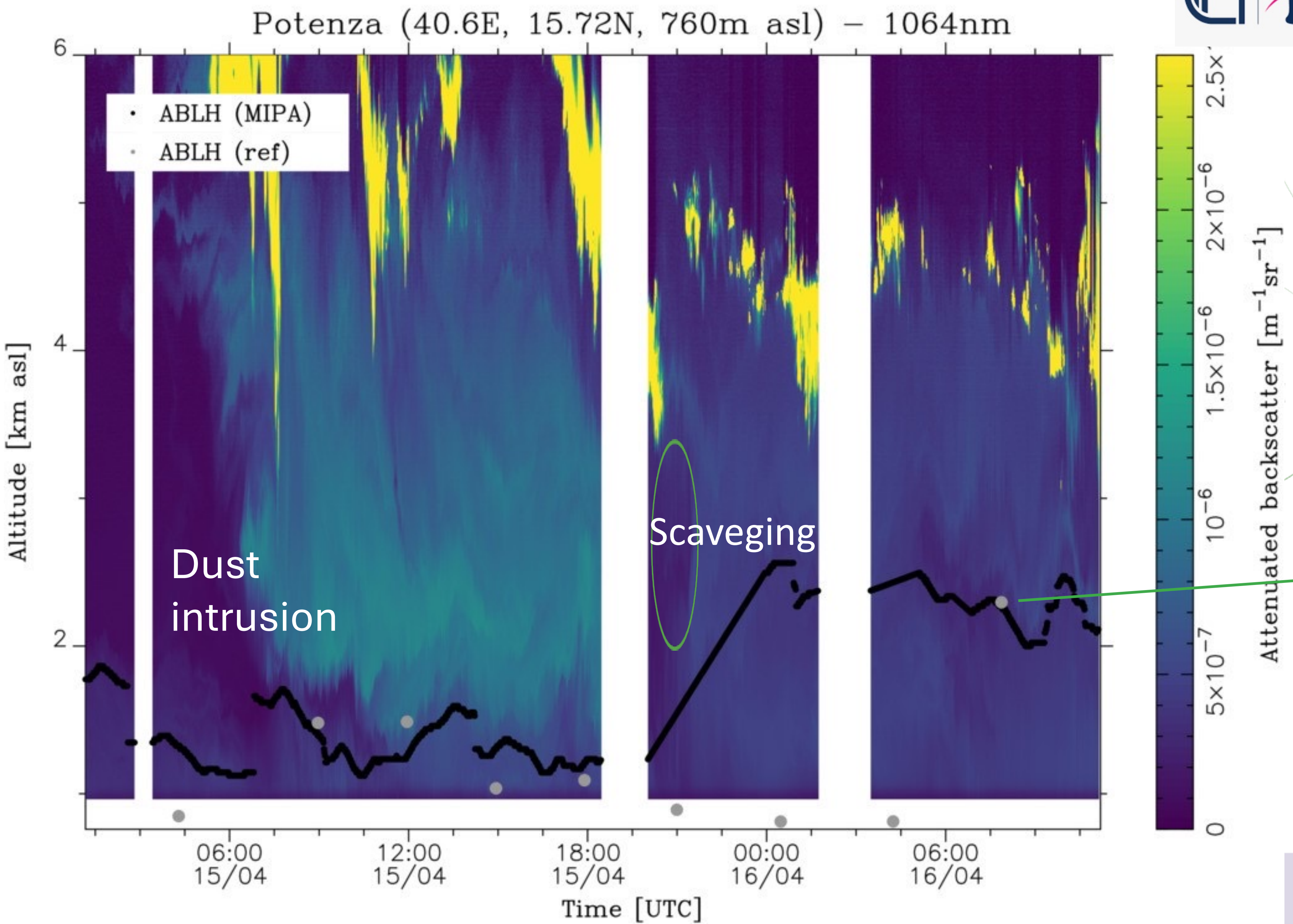
- **17 radiosoundings: high launch frequency is a crucial factor for the assessment of MIPA algorithm**
- **69 hours of almost continuous observations made by POLPO (Potenza lidar for Particle Observation).**

Downward dust deposition (Nikolaos Papagiannopoulos)

Lower ABLH

Upward convective pushing

Case study 2) 15-16 April 2024



- **9 Radiosoundings**
- **36 hours of almost continuous PL observations made by POLPO lidar.**

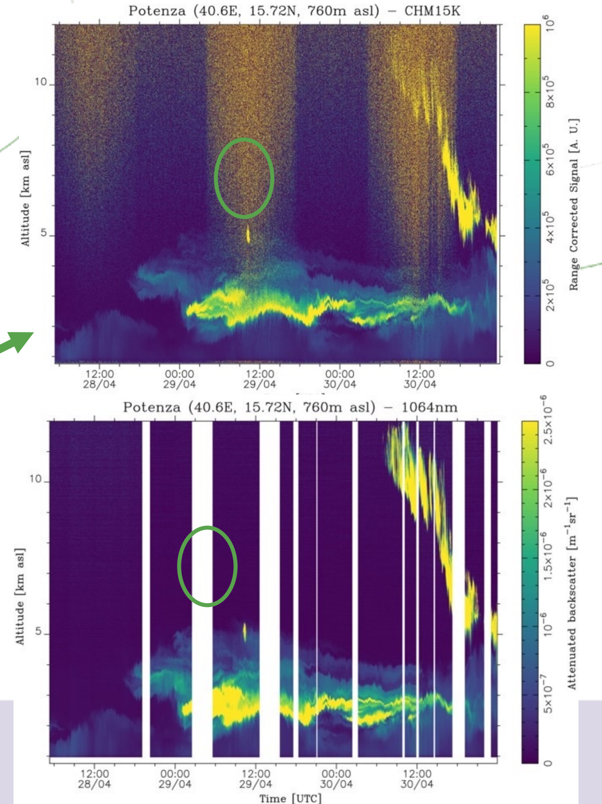
The dust layer is still present, but its concentration is reduced allowing the ABLH to growth more than on the previous day.

Conclusion

	All reference points	*Only reference points above lidar full overlap height*
Δ_{mean} [m]	365	151
Δ_{med} [m]	240	116
Δ_{SD} [m]	434	105
Δ_{SE} [m]	85	26
Δ_{min} [m]	16	16
Δ_{max} [m]	1750	373
N	26	16

- Algorithm (MIPA)
- Instrumental limitations (ABLH values below lidar overlap height)
- Different ABL definitions (thermodynamic one in case of reference dataset, based on aerosol as ABL tracers in case of lidar dataset)

Considering that the cases were selected for their complexity, the comparisons are excellent.



Next steps:

- **New case studies**
- **We will check how MIPA works when it is applied to timeseries of total attenuated backscatter at shorter wavelengths (355 nm, 532 nm).**
- Evaluation of the optimized MIPA configuration on ceilometer measurement campaign datasets.
- Since during the campaign all the instruments were in continuous operation it will be possible the evaluation of ABLH retrieval using a multi-sensor approach.

Vivone, G., D'amico, G., Summa, D., Lolli, S., Amodeo, A., Bortoli, D., & Pappalardo, G. (2021). Atmospheric boundary layer height estimation from aerosol lidar: a new approach based on morphological image processing techniques. Atmospheric Chemistry and Physics, 21(6), 4249-4265.

Aerosol in-situ instrumentations was operating continuously for the whole campaign period providing useful information for the aerosol full characterization at the ground (*short oral Laurita- July 10, 2024*).

Sensor type	Instrument	Main Products
In situ	Aethalometer AE33	Absorption coefficient and equiv alent Black Carbon (eBC) concentration
	Nephelometer Aurora 3000	Scattering and back scattering coefficient
	Aerodynamic Particle Size APS 33 21	Particle size distribution (0.5-20 μm)
	Condensation Particle Counter (CPC 3750)	Particle number concentration (> 10 nm)
	Scanning Mobility Particle Sizer (SMPS 3938)	Size distribution and concenbtrat ion (10-800 nm)
	ToF-ACSM	Chemical composition and mass co9ncentration of non-refractory aerosol (<1μm)
	PMx Samplers	PM10, PM2.5, PM1 concentration

Sampled filters sent to LABEC laboratory of the INFN in Florence for elemental composition analyses.

Vivone, G., D'amico, G., Summa, D., Lolli, S., Amodeo, A., Bortoli, D., & Pappalardo, G. (2021). Atmospheric boundary layer height estimation from aerosol lidar: a new approach based on morphological image processing techniques. Atmospheric Chemistry and Physics, 21(6), 4249-4265.

Development of methods in 4.14

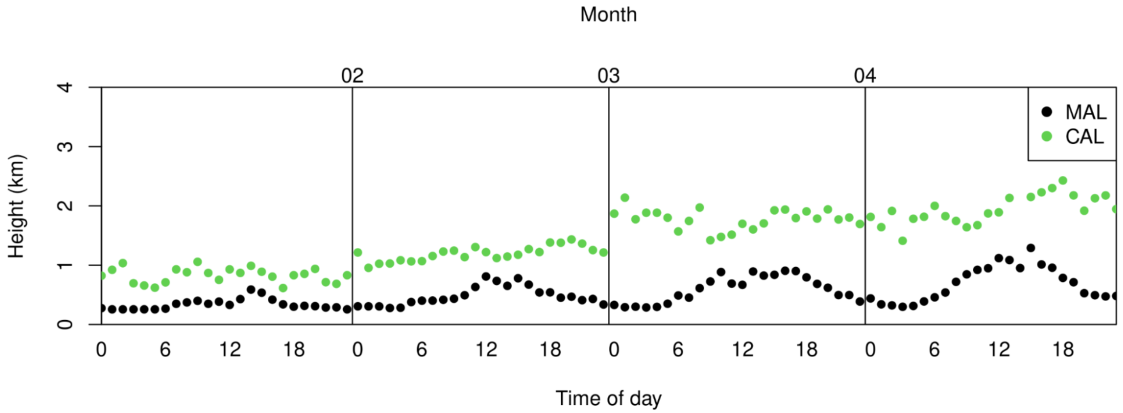
4.14 Impact of atmospheric boundary layer height on aerosol and trace gases concentration at the ground

- Compare in situ AQ data & vertical structure
- Identify Key variables influencing concentration of in situ species
- Quantify the capacity of vertical mixing to dilute pollutants concentrations

CAMPAIGN in Milan during 2023

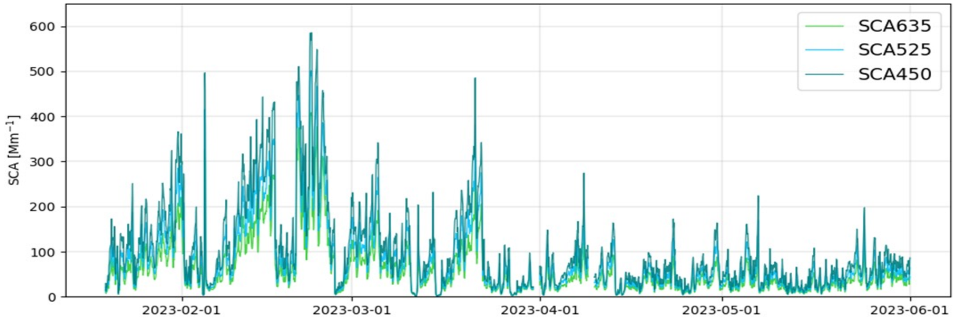
Mixed aerosol layer
Continuous aerosol layer

VERTICAL LAYERING



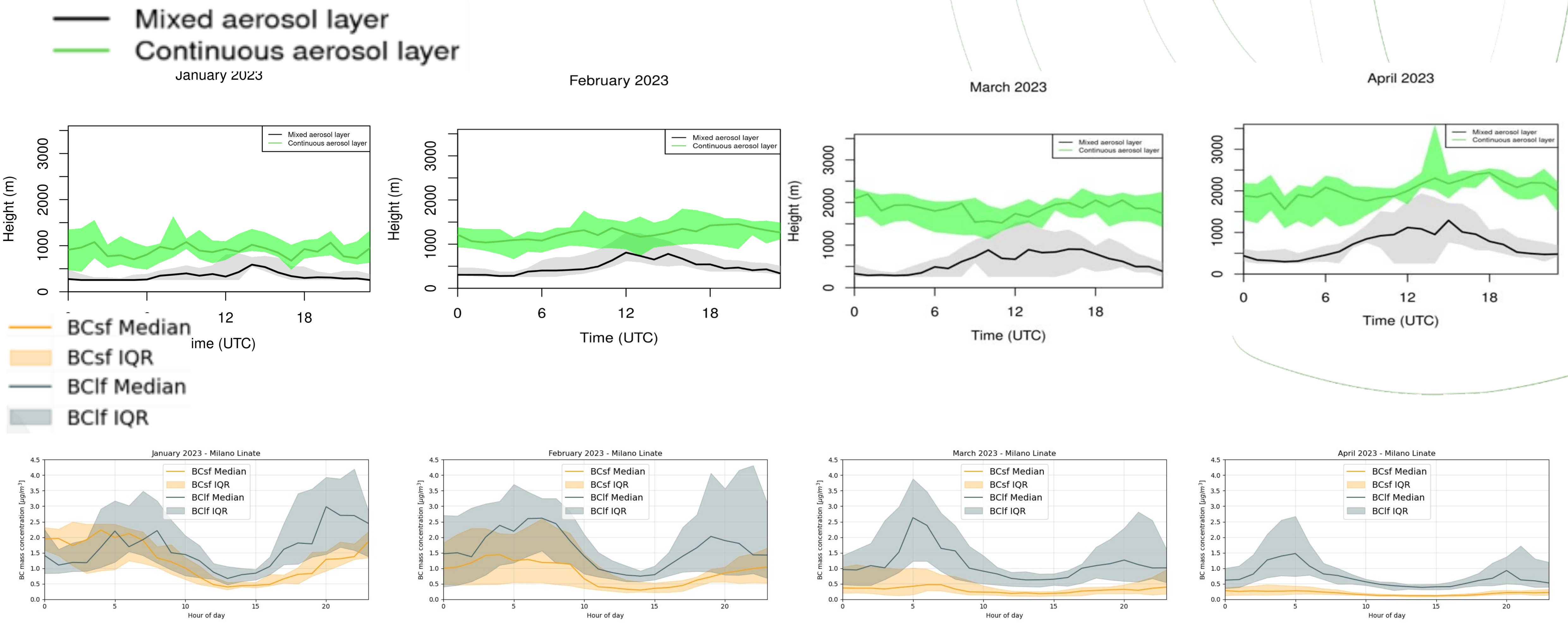
+

IN-SITU CONCENTRATIONS

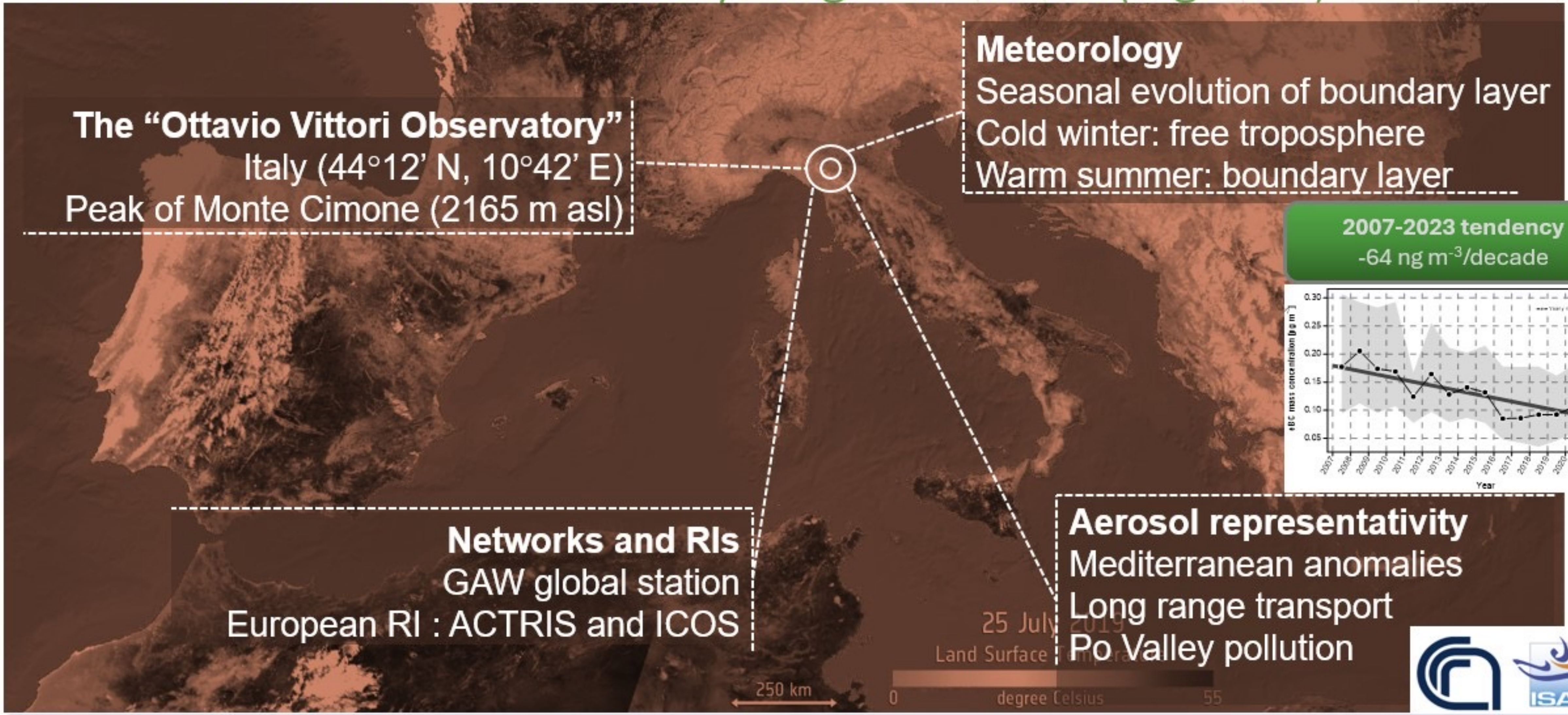


Milan monthly BC measurements

- winter spring PBL evolution and in-situ BC apportioned (solid vs liquid fuels).



Influence of PBL on mountain free troposhere, the Monte Cimone observatory long data series (e.g. eBC)



The "Ottavio Vittori Observatory"
Italy (44°12' N, 10°42' E)
Peak of Monte Cimone (2165 m asl)

Meteorology
Seasonal evolution of boundary layer
Cold winter: free troposphere
Warm summer: boundary layer

2007-2023 tendency
-64 ng m^{-3}/decade

Networks and RIs
GAW global station
European RI : ACTRIS and ICOS

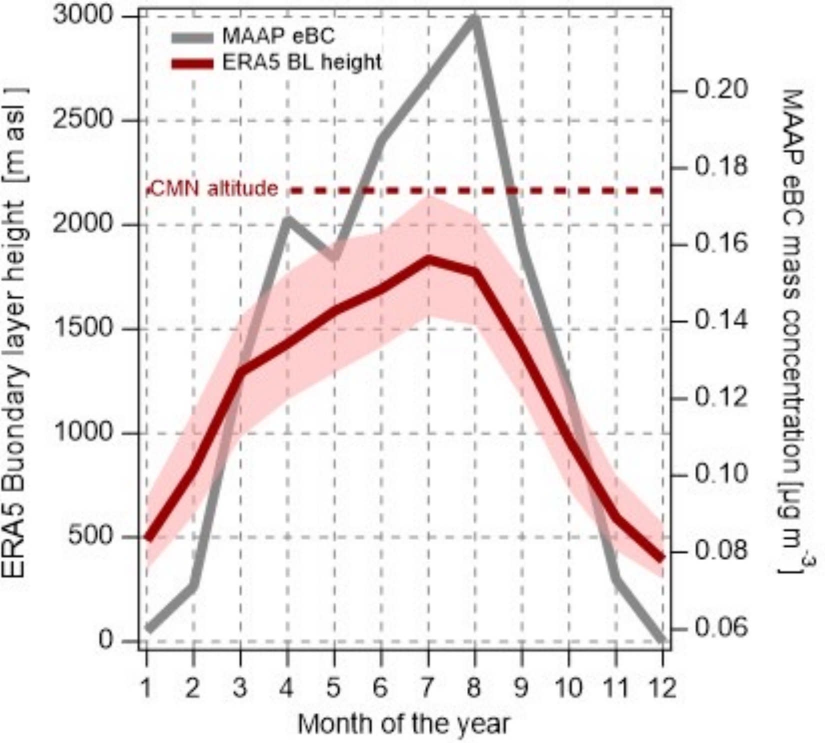
Aerosol representativity
Mediterranean anomalies
Long range transport
Po Valley pollution

Merging observations with reanalysis data

- ERA-5 boundary layer height

  h resolution

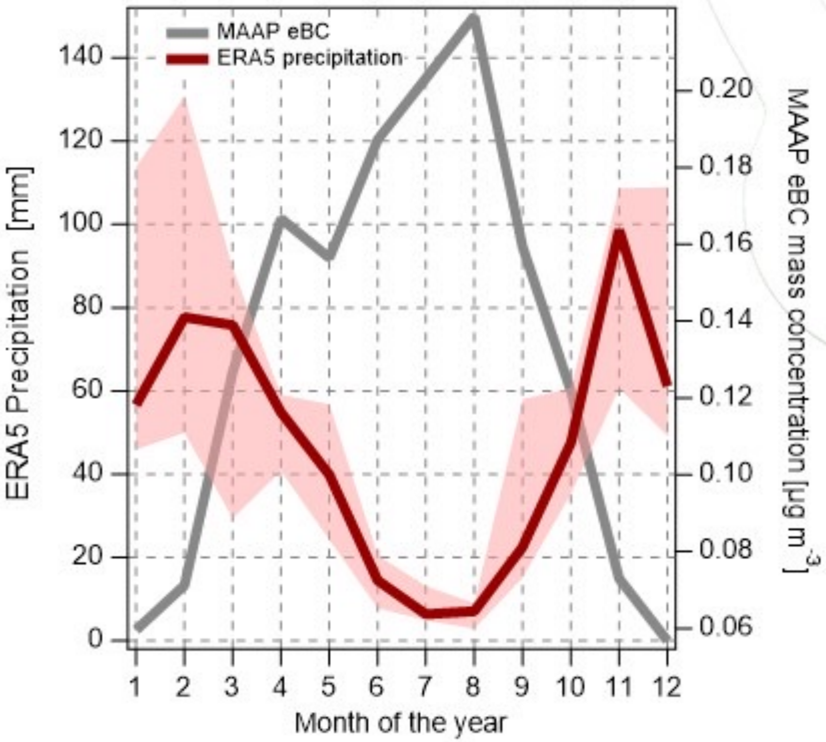
  CMN



- ERA-5 large scale precipitation

  h resolution

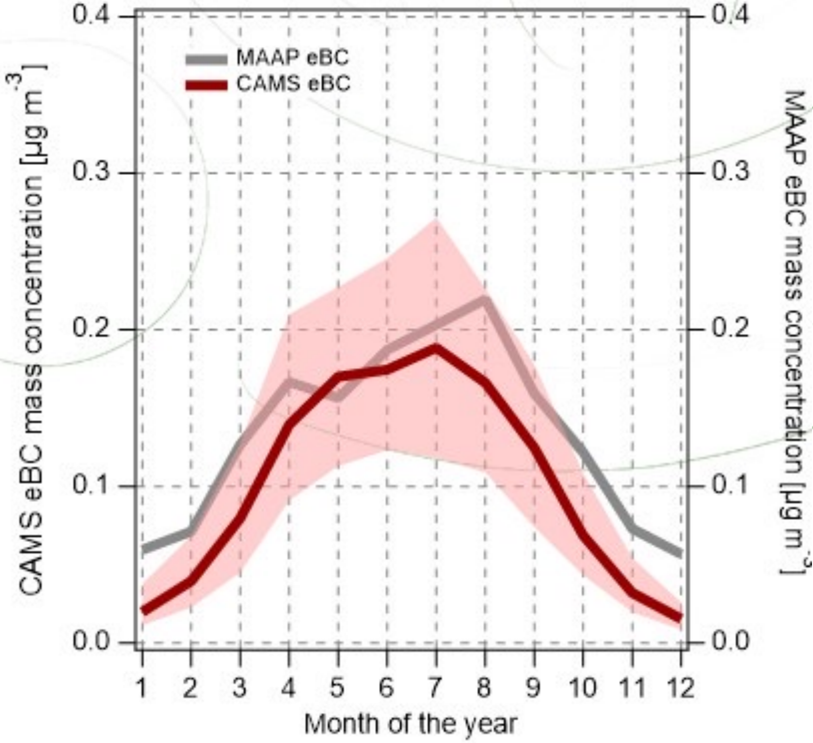
  CMN



- CAMS BC conc

  h resolution

  Po Valley



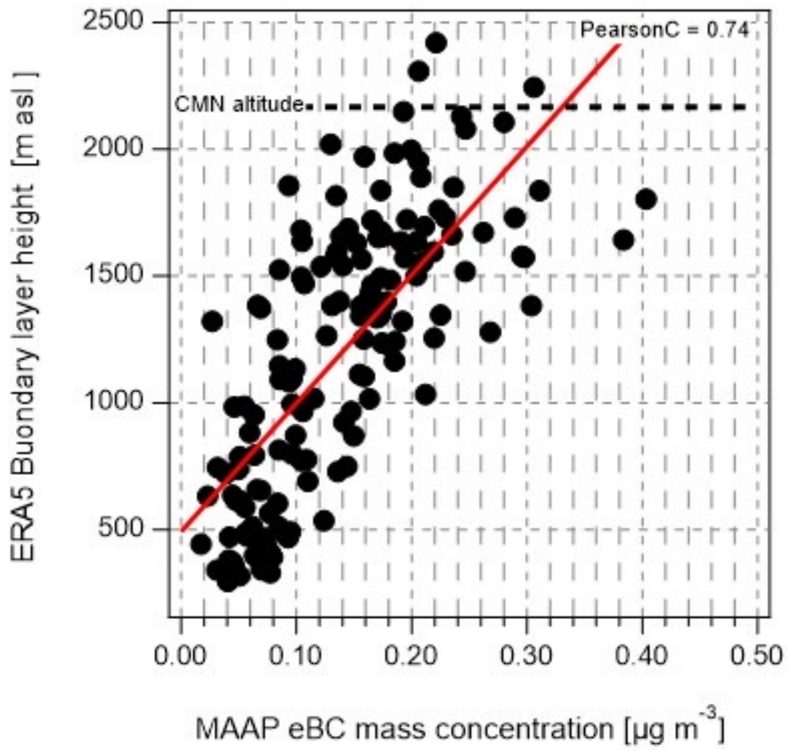
Multi Angle Absorption Photometer (MAAP)

Merging observations with reanalysis data

- ERA-5 boundary layer height

  h resolution

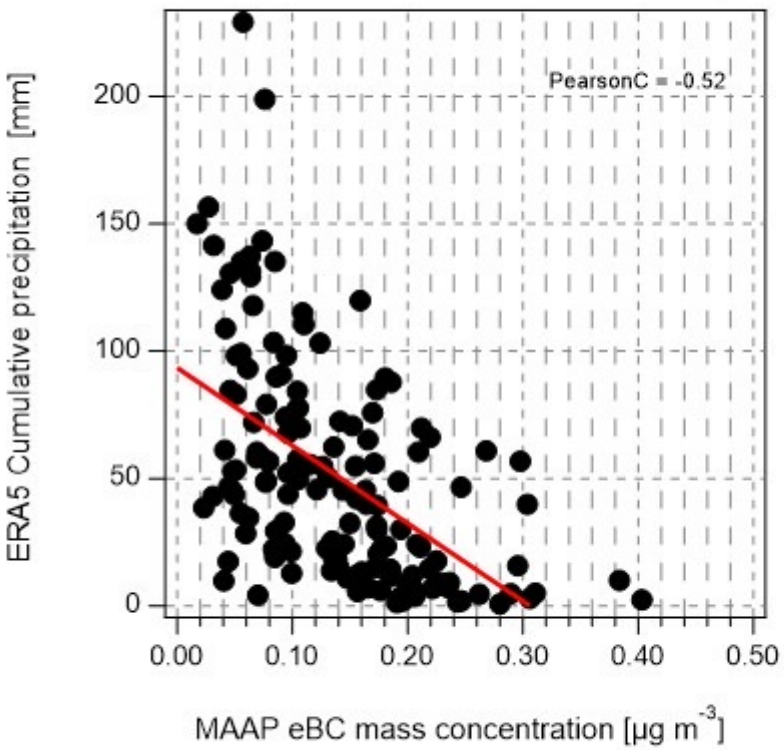
  CMN



- ERA-5 large scale precipitation

  h resolution

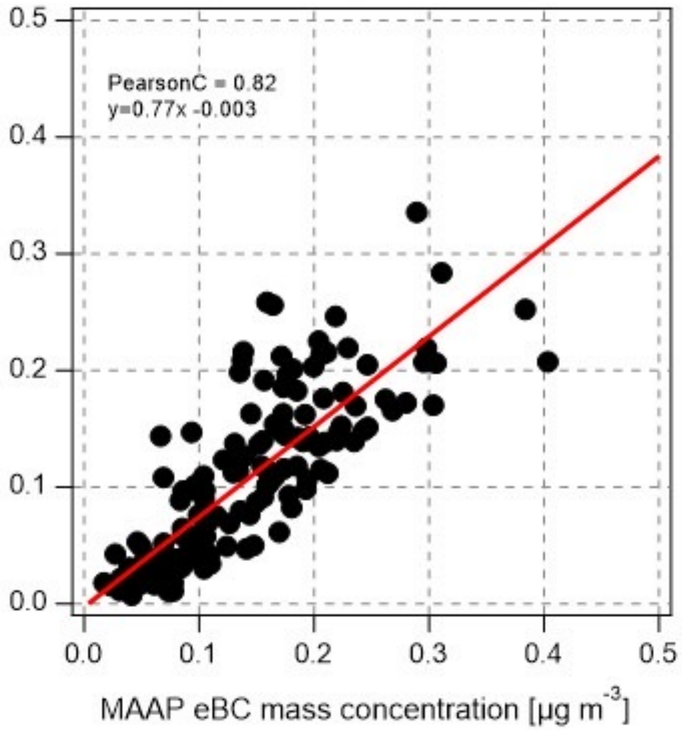
  CMN



- CAMS BC conc

  h resolution

  Po Valley



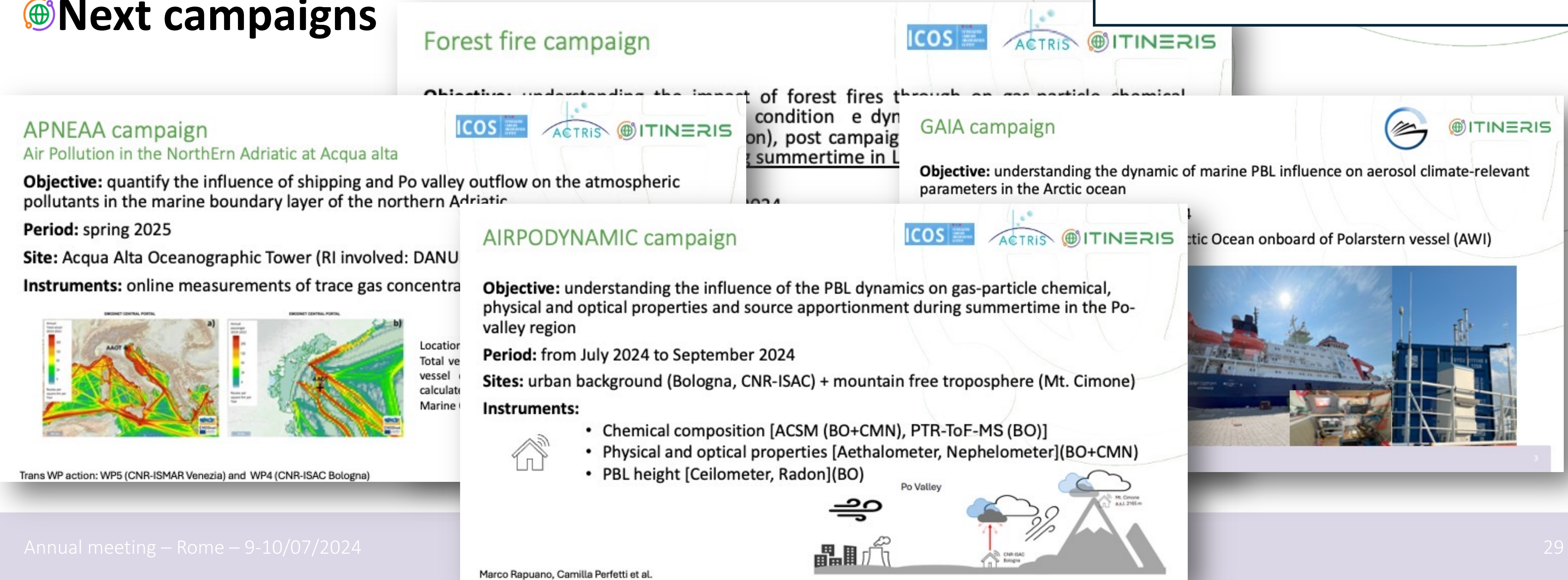
What next?

- **Start of measurements with ITINERIS instruments**
- **Progresses on research activities**
- **Next campaigns**

NATIONAL BIODIVERSITY FUTURE CENTER

TOX in air

- ITINERIS instruments + ACTRIS MAGA exploratory platform – Campaign in Rome
- 2 sites campaigns for pollution aims 20



What next?

Access provided to external (link to WP2 activities) and used in WP4 to support the objectives of WP4?

- **IMAA -> INFN BL campaign analysis**
- **Mobile platforms -> ISAC LT for fires campaign**
- **Mobile Platforms -> Italian RI sites for OBJ purposes**

……

WP4 scientific production (PI 4.6)

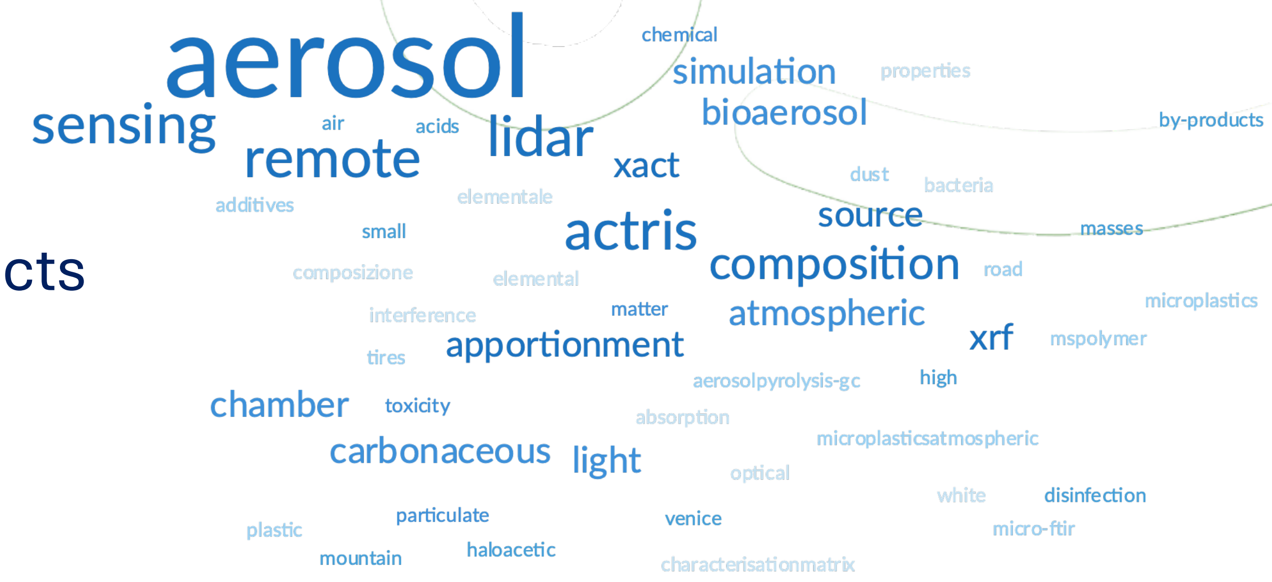
Current status <u>24 products:</u> 8 articles in scientific journals; 16 abstract in conferences

Target value at the end of the project: 30 Scientific products.

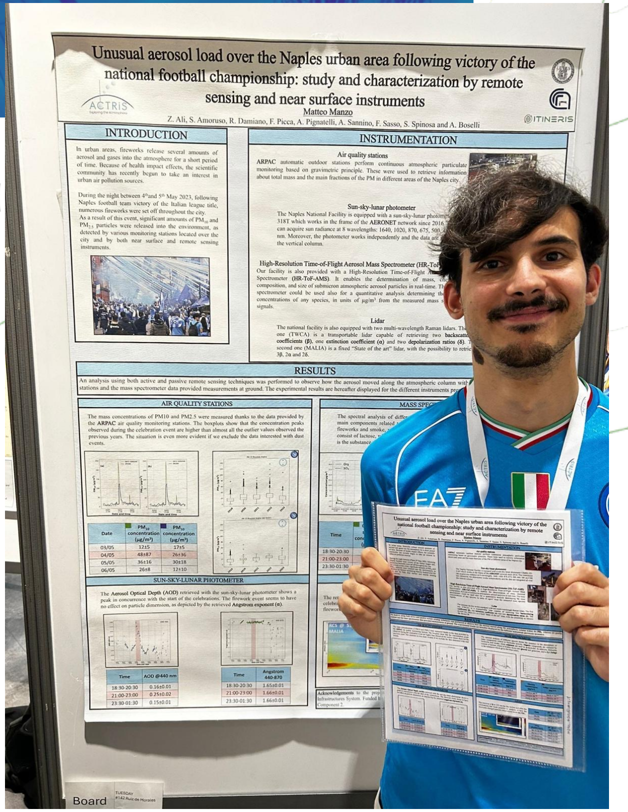
Main Topics

Scientific production per topic

- OBJ1: 12 scientific products
- OBJ2 (Typing): 8 scientific products
- OBJ3 (PBL): 4 scientific products
- OBJ4 (Forest fires): no scientific products yet



WP4 scientific awards!



Best Poster

Matteo Manzo. UniNa, CNR-IMAA

Unusual aerosol load over the Naples urban area following the victory of the national football championship: study and characterization by remote sensing and near-surface instruments

WP4 scientific awards!

Grant for joint research with Research Institute for Applied Mechanics, Kyushu University, Fukuoka, Japan

Bracci Alessandro. CNR-ISAC ITINERIS

Research Title: Long-term Statistics of Snowfall Microphysical Features for EarthCARE validation activities

WP4 linkages with European and National projects

CAMS21b C3S2_311

PRIN2022 - FEMTO

PRIN2022 - PBHLsat

INFN - CSN5 2024 - HardLife

THANKS!

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(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-Mission 4 "Education and Research" - Component 2: "From research to business" - Investment 3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"

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Ministero dell'Università e della Ricerca

Italiadomani