Response to comments from Anonymous Referee #1

We thank the reviewer for taking the time to read the manuscript and provide detailed and valuable feedback.

The above manuscript describes the set-up and characteristics of a combined aerosol in situ and remote sensing measurement side, operated by CNR in ACTRIS. At the beginning, I had my doubts if AMT is the right place for this. But there are, at least for me, two strong arguments, why the manuscript should become an AMT publication. Firstly, for each infrastructure, a reference paper is needed, where, hopefully, all the scientific papers to come can refer to. Secondly, as the authors claim, such a paper can act as "a practical guide for implementation", in particular for researchers in America or Asia, where ACTRIS is probably not so well known. However, to make these two arguments valid, some more detailed information must be provided that the paper can act as reference. And if it should be a practical guide for implementation, for me it is a must to give at least an overview about associated resources (time, man-power, maintenance costs, etc.), both concerning the implementation as well as for the operation later on. This would a with ACTRIS not familiar person allow to do a cost benefit analysis. It would be interesting to go further into that direction and give an estimation on how much of these stations would be needed across Europe or globally to cover the scientific needs. But this is only a nice-to-have remark, no request.

We thank the reviewer for this comment that helped us to improve the paper in order to better underline the importance of the paper for extra European /outside ACTRIS community. Indeed, the ACTRIS aerosol in-situ standards are in some way following the GAW ones, therefore the interest in technical solutions for an ACTRIS compliant in-situ instrumentations stays not only with stations potentially involved in ACTRIS. More relevant for European perspective, new air quality directive is under definition and this legislation is taking into account standards developed into ACTRIS for example for black carbon (BC) and ultrafine (UF) particles. The approach of such new EU air quality directive is to have BC and UF measurements in some more advanced stations of the National Air Quality management system. Solutions adopted for collecting such measurements with ACTRIS standard could be of interest for AQMN for guarantying the quality of collected data.

A short sentence about the potential wide interest of our paper outside ACTRIS at European and International level will be added in the revised paper.

About resources associated to the CIAO aerosol in-situ component, we estimated a total initial investment of about 1 M€, and 2 years were needed for building it up from scratch. For the operation, we estimate about 30k€ as maintenance and 70€ as consumables as annual operational costs. In addition, at least 2 researcher fulltime is needed for running this in-situ instrumentation with the support of a technicians (half time).

Such indications are shortly provided in the revised version of the paper.

How many of such stations are needed to cover the scientific needs: very important question to which is difficult if not impossible to reply to. The geographical density (and the location) of needed number of stations depends on the specific scientific question. Aerosols are highly variable in space and time and therefore measurements collected in different places can strongly differ. For air quality issues, aerosol in-situ measurements should be collected where more inhabitants are for investigating the impact on health, but for decoupling the background levels from extremely local source (e.g. the single car),

background stations are needed. If instead the scientific aim is understanding how much the EU policies allow the reduction of PM, few stations maybe just one in remote site could be sufficient.

GAW indeed makes a distinction between: **Local stations** for research and supporting services related to urban environments, and in other locations impacted by nearby emissions (e.g. from biomass burning); **regional stations** for which the station location is chosen such that, for the variables measured, it is regionally representative and is normally free of the influence of significant local pollution sources or at least frequently experiences advection of pollution-free air from specific wind directions; finally **global stations** primarily observe GAW variables under background conditions, i.e. without permanent significant influence from local pollution sources (https://wmoomm-my.sharepoint.com/:w:/g/personal/jbourdeu_wmo_int/EXLkdQpkP-RBi1ooPA3zXpkBHxUFFhX25aJTnj4L4b8k6Q?e=xdra6a). Even if with this classification, the GAW implementation plan is not currently providing a clear directive related to the number of stations and currently GAW accounts for 8 Global stations over Europe, while over Northern America only 2 (https://community.wmo.int/en/activity-areas/gaw/research-infrastructure/gaw-stations/gaw-global-stations) .

In ACTRIS an intermediate solution is adopted, trying to have enough stations in each participating country to cover different regional characteristics. In Italy for example we have aerosol in situ site in Po Valley (north and polluted area), Potenza as background site in the Apennine (south), Lecce Southern Italy a city on the seaside, and Rome as big metropolitan area in the central Italy.

Specific remarks:

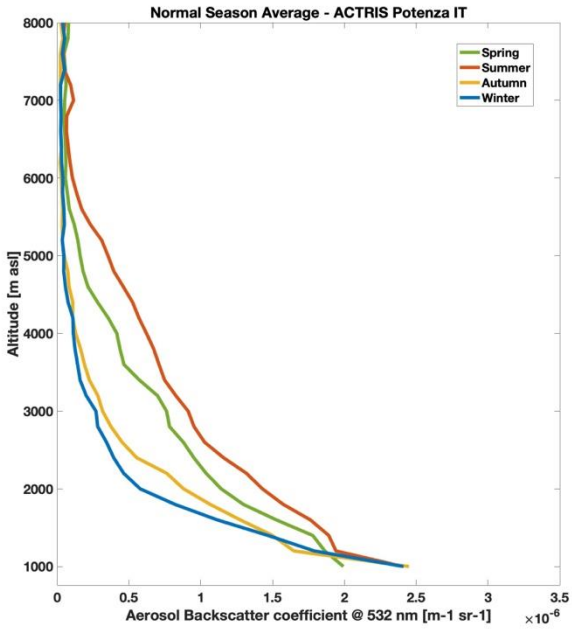
1. p. 1, l. 13: CNR, IMAA and all the other abbreviations in the manuscript. Please write the full name, when you us the acronym the first time. And as the manuscript has so many acronyms, please add a glossary.

   We will ensure that all abbreviations, including CNR-IMAA, are spelled out in full the first time they are mentioned in the manuscript. Additionally, we will include a glossary to help clarify all acronyms used throughout the text.

2. p. 1. l. 18: I´m not so sure if the provided examples are examples for a “synergistic approach”, both approaches, remote sensing and in situ, a complementary and hence help each other to get the full picture. My understanding of synergy would be that a combination of these two methods provide a totally new aspect, which cannot be obtained by one method alone. But please convince me that I´m wrong.

   When we talk about synergy, we refer to the ability to reveal new phenomena or insights that emerge only using together the 2 types of observations. Other researchers (e.g. Davulien et al., 2023 doi.org/10.1016/j.scitotenv.2023.167585) intended synergistic approach in a similar way. One example of this type of “synergistic approach” is related to the wintertime aerosol particle conditions. During winter, low clouds and fog often occur at CIAO and therefore lidar measurements are inhibited or no aerosol optical properties can be retrieved from lidar measurements.
   In small number of cases, aerosol particle properties profiles are obtained by lidar measurements in winter.

The climatological profile of aerosol backscatter at 532 nm for winter season 2000-2019 at CIAO (https://doi.org/10.57837/cnr-imaa/ares/actris-earlinet/level3/climatological/2000_2019/pot) shows very clean air respect to other seasons in the whole investigated atmospheric column.
Only the last point close to the surface is slightly higher, but the information content is too low for further investigation. These cases are typically considered as clean day from the aerosol remote sensing perspective.



But it should be considered that the lidar is blind in the lowest portion of the atmosphere and it is expected that due to the low BLH, most pollutant stays within the low BL area.
Aerosol in situ measurements instead do no see above the boundary layer height, but well capture what's happening close the surface. In wintertime the BC is higher at our site probably because of the increase in using heating system (typically fireplaces). Only such in-situ observations allow to understand that winter cases are not to be considered as background conditions below the boundary layer height.

On the other side, remote sensing excels at capturing large-scale, vertical, and temporal variations in aerosol distributions (e.g., the spread of wildfire smoke or desert dust layers), while in-situ instruments are able to offer a detailed chemical composition, size distribution, and ground-level concentrations. This synergy enables scientists to not only track dust but also assess its immediate and long-term impacts on ecosystems and human health, which would be unattainable with either method alone.
The unique value here comes from being able to validate and interpret remote sensing data using in-situ measurements, and vice versa, creating new insights that wouldn't be possible with only one method. For example:
While remote sensing and in-situ approaches are complementary in nature, the true synergy emerges when these methods work together to offer new insights and reduce uncertainties that cannot be achieved by one alone. This synergy is essential in environmental monitoring, as it helps create more accurate, multi-dimensional views of atmospheric processes, ultimately leading to better scientific understanding and policy decisions. Another aspect of synergy lies in reducing uncertainties in models. Aerosol-climate models, for instance, rely on accurate

ground truth data. Remote sensing gives a broader atmospheric overview, but it can suffer from calibration issues or may lack the fine details on chemical composition. In-situ data can calibrate and validate these remote measurements, ensuring that models predict both the spread and chemical impacts of aerosols more accurately. This is a completely new layer of certainty that one method alone cannot provide.

Some revisions will be done on the paper to tackle the reviewer's comment.
Firstly, based on reviewer's comments we decided to adopt combined instead of synergistic word in the text for what has been done up to now, but leaving the concept of synergistic approach for the further developments that we imagine and plan for the near future, but that are not yet achieved. The current paper is focusing on the implementation of the instruments in view of such synergistic approaches, which will be object of further paper(s).
Secondly the cases section will be reviewed (see reply to comment 23*)*.

3. p. 1 l. 28: Pöschl, 2005 reference is fine, but two decades old. Maybe add also a newer reference?

   We will add the following more recent references to the manuscript to complement the Pöschl (2005) reference:

   IPCC (2021). *Aerosols and their impact on climate and human health*. In *Climate Change 2021: The Physical Science Basis*. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press.

   Ren-Jian, Z., Kin-Fai, H., & Zhen-Xing, S. (2012). The Role of Aerosol in Climate Change, the Environment, and Human Health. *Atmospheric and Oceanic Science Letters*, *5*(2), 156–161. https://doi.org/10.1080/16742834.2012.11446983

4. p. 2 l. 34: I miss the refrence to the ACTRIS BAMS overvies paper here

   The reference to the ACTRIS BAMS overview paper has been added to the manuscript:

   "Laj et al Aerosol, Clouds and Trace Gases Infrastructure (ACTRIS); The European Research Infrastructure Supporting Atmospheric Science, BAMS, E1098-E1136, https://doi.org/10.1175/BAMS-D-23-0064.1, 2024."

5. p. 2 l. 56: the "labelling process" is well known for ACTRIS people. But already European users are unfamiliar with this, not to speak about people from other continents. As the labelling process is an important part of the data quality assurance in ACTRIS, it should be **shortly** described what it is for and how it works, and for the details reference should be given.

   I agree with your point, and we will add the following brief description along with a detailed reference:

   "The "labelling process" in ACTRIS is a key element of its data quality assurance system. This process ensures that instruments, data, and methodologies used across ACTRIS observational platforms meet specific quality criteria. The labelling process involves a series of evaluations and certifications to verify compliance with ACTRIS protocols."

Reference: Deliverable 5.1: ACTRIS NF Labelling Plan, https://www.actris.eu/sites/default/files/Documents/ACTRIS%20IMP/Deliverables/ACTRIS%20IMP_WP5_D5.1_ACTRIS%20NF%20Labelling%20Plan.pdf

6. p. 3 l. 67: “reference observatory for atmospheric research”? Who claims this? A reference for atmospheric dynamics and ozone hole chemistry? Probably not. I can imagine that it is “a reference station for short-live atmospheric constituents in Italy and the Mediterranean”.

   You are correct, and I appreciate your insight. The term “reference observatory for atmospheric research” may be too broad and misleading in this context. It would be more accurate to describe it as “could be a reference station for short-lived atmospheric constituents in Italy and the Mediterranean.”

   This change will clarify the specific focus of the station and better reflect its role in monitoring atmospheric dynamics and constituents relevant to our studies. Thank you for bringing this to my attention; the modification will help ensure that the description is precise and aligns with the station's actual contributions to atmospheric research.

7. p. 3 photo: a lot of infrastructure, all of this is in situ aerosol? Better to zoom in and show the in situ aerosol containers and the inlets.

   In the photo, we are showing the various infrastructures of the CIAO site, which provide a comprehensive view of the facilities. However, we agree that it would be beneficial to include a zoomed-in photo specifically highlighting the in-situ aerosol containers and the inlets. This will provide a clearer understanding of the aerosol sampling setup. We will make sure to add that zoomed-in image to enhance clarity and focus on the relevant components.

8. p. 5 l. 122: you state to list the “research lines” in the following rows here. But “development of”, “implementation of”, “harmonization of” etc. are no research lines, they are intended steps to allow your research later on. Hence the simplest way to make this consistent would be to replace “research lines” here with a more adequate wording.

   You make a valid point regarding the terminology used. Terms like “development of,” “implementation of,” and “harmonization of” are indeed steps or processes rather than distinct research lines. To improve clarity and consistency, we will replace "research lines" with "research themes" or "research objectives."

9. p. 6, table 1: the list of instruments is compelling, but, as an in situ person, I would rather like to know which parameters are provided by the remote sensing devices. This would be a good suggestion anyhow, make a table providing all the remote sensing and in situ parameters at the same spot, thus the potential synergy gets more visible.

   In the revised manuscript, we will update the table to include both the remote sensing and in situ instruments, along with the respective parameters they measure. This will help to better highlight the potential synergy between the different measurement techniques.

10. p. 6 l. 144: “Observational Platform” and “Exploratory Platform” are known to some of us, but not to the waste majority of the readers. Please explain shortly (in parentheses) what these terms stand for.

    We will add the following explanations in parentheses in the manuscript to clarify the terms:

Observational Platforms (fixed ground-based stations delivering long-term high-quality data and continuous atmospheric monitoring on a regular schedule and common operation standards by applying state-of-the-art remote-sensing and in situ measurement techniques.)

Exploratory Platform (atmospheric simulation chambers, laboratory platforms and mobile platforms that perform dedicated experiments and contribute data on atmospheric constituents, processes, events or regions.)

11. p. 6 l. 152: The description of the Central Facility part of CIAO is surely correct, but not needed for the purpose of the paper and rather confusing for the reader. Please omit this here, it is better described elsewhere.

    We will eliminate or condense the description of the Central Facility part of CIAO in this section, as it is not essential for the purpose of the paper and may cause confusion.

12. p. 9. L 211.: which heads do the PMx instruments have? Please give this information.

    This information is already provided in section 4.4, which details the instrument configuration. However, to clarify it here as well:

    "Additionally, two PMx samplers (SWAM 5a-Dual Channel Monitors, FAI Instruments) are installed with respective inlets: one equipped with two PM2.5 inlets, and the other with one PM10 and one PM1 inlet. Furthermore, a PMx monitor (EDM 180, Grimm) is placed as a standalone instrument with individual PM10 inlet line."

13. p. 9 l. 218: the isokinetic flow splitter: which one did you use? Or can you provide as drawing of it?

    The isokinetic flow splitters were custom-built to meet ACTRIS requirements by "4S SOLUZIONI E SVILUPPO PER LA STRUMENTAZIONE SCIENTIFICA," a company specialized in metrology, measurement physics, and the development of scientific instruments, with a particular focus on atmospheric observation tools. In the manuscript, we will include photos to provide a detailed view of the splitters.

14. p. 9 l. 219: I have some experience with sampling lines, but I only can guess the argument of the sharp tube ends, please be more specific.

    The ends of the tube in the isokinetic flow splitter must be sharp to ensure a homogeneous distribution of the air sample because sharp edges help minimize flow disturbances and turbulence at the entrance of the sampling tubes. A sharp edge promotes a smooth transition of the air flow, reducing the risk of vortices and irregular flow patterns that can lead to uneven sampling.

    When the air enters the tubes with a well-defined, sharp edge, it helps maintain the laminar flow conditions that are crucial for accurately capturing the aerosol particles. This ensures that the sampled air maintains a consistent velocity and composition, allowing for representative measurements and reducing the potential for aerosol losses due to inertial effects or diffusion. In essence, a sharp tube end facilitates better mixing and uniformity in the airflow, which is vital for the accuracy and reliability of aerosol measurements.

    The following revised sentence will be added to the revised version of the paper:

"Moreover, the tube ends in the isokinetic flow splitter must be sharp to minimize turbulence and promote smooth airflow, ensuring uniform sampling. This design helps maintain laminar flow, reduces aerosol losses, and enhances the accuracy and reliability of measurements."

15. p. 9 table 2: first of all, the two first Reynolds numbers are equal, even if the flow rate is different. The upper one is wrong in my opinion. Same for the speed there.

    To get a feeling about the sampling lines could you please add line length and number of bends?

    There was indeed a typo error in the table regarding the flow rate of the aethalometer, which is not 3 l/min but 5 l/min. As a result, both the aethalometer and the nephelometer, having the same internal diameter of the isokinetic splitter and flow rate, also have the same Reynolds number and flow speed. This will be corrected in the manuscript.

    We will include the information regarding the line length and number of bends in the revised version of the manuscript.

16. p. 10 l. 228: for me one of the most critical points. Knowing from the literature and also from own experience, conductive "plastic" tubes can be critical, both concerning particle losses as well as chemical composition. The chosen tube MIGHT be OK, but please either provide a reference for that or provide own measurement data e. g. on the size-resolved particle transmission. Otherwise all your data are always "conditionally" correct only.

    We sincerely thank the reviewer for highlighting this critical point. In the manuscript, there was an incorrect definition regarding the material of the tubes used. The tubes employed are actually TSI sampling black tubes. These TSI sampling tubes are made from conductive silicone, infused with carbon black to enhance conductivity. This design is essential for minimizing electrostatic losses, which can occur in non-conductive tubes, such as those made from standard silicone or Teflon, where particles may adhere to the tube walls due to static charges. The conductive nature of TSI tubes prevents the buildup of electrostatic fields, thereby improving particle penetration and reducing sampling biases caused by particle loss. These tubes are recommended and considered the best for particle sampling. Further details will be provided in the revised version of the manuscript.

17. p. 10 l. 232: the Nafion dryer, which one? Please provide reference or explain, what this is

    A **Nafion dryer** is a specialized device used in aerosol sampling to remove water vapor from a gas stream while preserving the integrity of the sample's chemical composition. Nafion membrane is a sulfonated tetrafluoroethylene-based polymer that selectively transfers water vapor from a gas sample to a surrounding purge gas, while retaining the sample's other gases and particles. This property makes it ideal for removing moisture from aerosol-laden air without affecting the aerosol particles themselves.

    We will include the following reference in the manuscript regarding the Nafion dryers we use: MD-700 Series Dryer for Aerosol Analysis.

18. p. 10 l. 240: why is the 2:1 flow ratio desired, please explain

    The 2:1 purge-to-sample flow ratio in a Nafion dryer operate in reflux mode is crucial for achieving efficient aerosol particulate sampling. This ratio ensures there is enough dry purge gas to continuously absorb moisture from the sample, which prevents the purge from becoming

saturated. By maintaining this higher purge flow, the system can keep moisture levels low, ensuring that the sample's integrity is preserved. This is particularly important for aerosol particulate sampling, where even small amounts of moisture can alter the particle characteristics and lead to inaccurate measurements. The 2:1 ratio helps maintain consistent drying efficiency over time, which is essential for reliable aerosol analysis.

Here is the revised version that we will include in the manuscript with the shortened explanation:

"The vacuum on the purge air should be at least 15 inches Hg, with a higher vacuum preferable. This vacuum level is required to provide the desired 2:1 purge-to-sample flow ratio based on the actual volumetric flow. The 2:1 ratio ensures enough dry purge gas to continuously absorb moisture, preventing saturation and preserving sample integrity. This is crucial in aerosol particulate sampling, where even small amounts of moisture can affect particle characteristics and compromise measurement accuracy."

19. p. 13 l. 317: “unattended measurements … on the timescale of years” is an overstatement, you have to check the instruments regularly, even if they might be OK for one or the other year (which I personally doubt). Please soften this statement.

    We agree that the statement could be softened. While the robustness of the instrument was the point being emphasized, it is indeed essential that the instruments are regularly checked and calibrated to ensure the accuracy and reliability of long-term measurements. We will adjust the wording to reflect this and avoid the implication that the instruments can operate indefinitely without maintenance.

20. p. 13 l. 338: the statement that Potenza is a rural site is a trivial statement, please remove or phrase differently, what you want to highlight

    We will remove the statement referring to Potenza as a rural site, as it might be too simplistic. Here's a rephrased version of the initial sentence:

    "As a general comment, we could say that the Potenza site exhibits low PM concentrations and a very high contribution of the organic substances, as observed in rural areas.”

    p. 15 l. 366: in the manuscript, I miss some more evaluation data, checking the consistence of the measurements e.g. here, how good the mass measurements of the different instruments agree with the size distribution derived mass etc.

    The reviewer is perfectly right. Several tests can be made for cross checking the instruments (between the aerosol in-situ instruments as well as versus the aerosol remote sensing ones). Anyhow the aim of the current paper is the description of the different steps and solution adopted for implementing such a large aerosol in-situ laboratory coupled to an existing remote sensing observatory. Part of the checks suggested by the reviewer are part of the quality assurance procedures working in ACTRIS and we are proceeding with those. Additional cross checks will be done taking the most from the plethora of CIAO instruments and expertise. However long record of data would be desirable for an assessment of the consistency and accuracy of the measurements. The results will be included and fully explained in subsequent manuscripts.
    A short sentence about this will be added in Final section of the revised paper.

21. p. 15 l. 370ff: The elemental analysis, what is given in ACTRIS there or is this just an add-on to the in situ aerosol particle properties?

The elemental analysis of aerosol particles is a recommended variable by ACTRIS, though it is not mandatory for a site to become an ACTRIS National Facility (NF) observatory. Despite not being compulsory, elemental analysis of in situ aerosol particles plays a crucial role in understanding the composition and sources of atmospheric aerosols, as well as their impact on air quality, health, and climate.

The elemental analysis provides important data on the concentration of potentially toxic elements and trace metals in particulate matter, helping to distinguish between natural and anthropogenic sources. This type of analysis is essential for more detailed studies on the environmental and health impacts of aerosols.

For this reason, we have equipped our site with ICP-OES (Inductively Coupled Plasma Optical Emission Spectroscopy) and an OC/EC analyzer (Organic Carbon/Elemental Carbon) to perform comprehensive elemental and carbon content analysis, which significantly enhances our capability to assess aerosol properties in detail.

In the revied paper we add a short sentence at beginning of section 4.1 about mandatory and recommended instruments for ACTRIS aerosol in situ facility.

22. p. 17 l. 433: the three cases: I believe I understood what the authors wanted to show here, but I have the feeling that most of the statements can be already given with only one of the two methods, in situ and remote. I do not see the real synergy. This would be the case, at least for me, if you would use in situ and remote sensing data to generate another data product. Please elaborate a little bit more on that section, otherwise you weaken your own argument that collocated measurements are valuable. At the same time please shorten the section, there is too much "text book" knowledge in.

    This comment is linked to the point 2 above, where we discussed the general framework. Here the comment is more specific to the three show cases. As reported in the paper, "we present three emblematic cases recurring at CIAO where the combined deployment of the in- situ and remote sensing observations is expected to be of added value". Here we describe the 3 topics on which we expect the most from the, combined first and synergistic then, use of remote sensing and in-situ data. The description of these topics allows also to report first 10 months record of black carbon measurements collected at CIAO and a show case of desert dust arrival over CIAO captured by the lidar and photometer measurements and the identification of its intrusion down to the ground by aerosol in-situ measurements.

    To address the reviewer comment, for the three cases we will shorten the section by reducing the textbook-like knowledge and focus more on the added value of combining these measurement techniques. In particular: 1) local wild fire subsection will be mentioned as potential case of investigation in the text; 2) winter pollution: paucity of aerosol remote sensing, low BLH and blind lidar region for this period and needs of independent and in-situ measurements for such period relevant for air quality (health) issue will be underlined; 3) desert dust: it will be better underlined how such case demonstrates firstly the agreement between the 2 observations in capturing a desert dust event, underlining how each one of the technique overcomes the limit of the other one and finally we will describe potential future synergistic products.

    Moreover, I believe modelling could strongly benefit from collocated in situ and remote sensing measurements, but this is not addressed in the manuscript.

This suggestion will be addressed in the revised version of the manuscript by highlighting the added value of the availability of in situ collocated measurements and remote sensing of aerosols in increasing the accuracy of model predictions, allowing the reduction of uncertainty of aerosol measurements in the atmosphere (e.g., Vratolis et al., 2020), as well as in the evaluation of aerosol models. Furthermore, in recent years, the use of collocated aerosol measurements has found application in training machine learning-based models (see, e.g., Redemann and Gao, 2024).

Redemann, J. and Gao, L.: A machine learning paradigm for observations needed to reduce uncertainties in aerosol climate forcing, Nature Communications, 15, 8343, 2024.

Vratolis, S., Fetfatzis, P., Argyrouli, A., Soupiona, O., Mylonaki, M., Maroufidis, J., Kalogridis, A.-C., Manousakas, M., Bezantakos, S., Binietoglou, I., Labzovskii, L.D., Solomos, S., Papayannis, A., Močnik, G., O'Connor, E., Müller, D., Tzanis, C.G., Eleftheriadis, K.: Comparison and complementary use of in situ and remote sensing aerosol measurements in the Athens metropolitan area, Atmos. Environment, 228, 117439, 2020.

A small paragraph about this aspect as well as about the relevance of aerosol insitu measurements for qualifying the microphysical properties retrievals based on remote sensing measurements will be explicitly reported in the revised version.

23. p. 24. l. 620: the conclusion is not a conclusion, it is mainly written as outlook. Outlook is fine in at the end of the conclusion, but should not cover the major part of the text. Hence please rephrase the conclusions. Therefore imagine, e.g. the three most important statements the reader should have learned reading your paper.

    The conclusions in the revised manuscript will be as follows, highlighting the most important statements the reader should have learned from reading the paper:

    "The recent upgrade of aerosol in-situ laboratory to the well-established remote sensing activities at the CIAO observatory significantly enhances its observational capacity. The integration of in-situ and remote sensing measurements offers a more complete understanding of aerosol behaviour, enabling detailed studies from ground level up to the stratosphere. This combination adds value by providing both vertical profiles by remote sensing measurements and precise ground-level chemical and physical properties through in-situ measurements, which is crucial for improving climate models and understanding aerosol impacts on human health.

    Establishing the aerosol in-situ facility has been a complex and labour-intensive endeavour. The process, which began in 2018, required careful planning, technical expertise, and collaboration with field specialists. The setup involved designing and implementing ACTRIS-compliant inlets, sampling lines, and advanced instruments to ensure accurate and reliable measurements. This development highlights the significant effort required to meet international standards and provide high-quality data for the scientific community.

    Given CIAO's strategic location in the Mediterranean, the case studies planned for future research are especially relevant. The site is frequently affected by Saharan dust intrusions, which impact air quality and ecosystems, and the observatory is strategically positioned to study these phenomena. Moreover, the Mediterranean is also prone to wildfires, which are projected to increase in intensity and frequency due to climate change. The CIAO observatory

can monitor both the short-range transport of smoke from local fires and long-range plumes from major events, providing insights into their effects on air quality and human health. Lastly, local winter pollution, which results from residential heating, can also be analysed in detail, particularly during temperature inversions that trap pollutants near the ground. The combination of in-situ and remote sensing measurements will help investigate these key environmental issues.

Furthermore, the next-to-come ICOS Atmospheric Class 1 site at CIAO (first step of labelled process already passed) will offer other possibilities of synergistic studies and integration among Ris in the environmental filed. In this direction, CIAO is deeply involved in the developments of ITINERIS (Italian Integrated Environmental Research Infrastructures System), an overarching National project for enhancing the interlinkages of all the Italian Ris in the environmental domain. The multi-platform and multi-disciplinary approach of the observatory coupled with the open data and open access philosophy is key for better addressing complex atmospheric and environmental questions posed by climate change and anthropization processes."

Technical corrections:

1. p. 1, title: isn´t it "building-up" with a hyphen?

   it will be done

2. p. 1 l. 21: not sure if "container organization" does fit in here, "container layout" sounds better. Also "optimization" should be deleted in l. 22 in order to make the list more homogeneous.

   it will be done

3. p. 1 l. 26: might sound nitpicking but I believe it is important to state "aerosol particle" or "particle" everywhere, where the particles are meant, and not "aerosol", which are the particles and the surrounding gas. Please check this in the whole manuscript.

   We will modify the term **aerosol** to **aerosol particle** or simply **particle** throughout the manuscript wherever particles are specifically meant, ensuring clarity and precision in the terminology used.

4. p. 2 l. 33: Please add "The" before "Aerosol Clouds and Tr...."

   it will be done

5. p. 2 l. 45: here CNR-IMAA has a hyphen, on page one not. Please be consistent.

   We will ensure consistency throughout the manuscript by using **CNR-IMAA** with a hyphen uniformly. This adjustment will be made to maintain coherence across the entire document.

6. p. 4 wind rose: you might have used all the wind speed classes shown in the legend, but in practical, only winds up to 10 m/ show up. Hence make the higher wind speed classes just one additional " and larger" bin. This also prevents that the same color shows up more than once in the legend.

   Thank you for your valuable suggestion. We fully agree with your observation, and the wind rose has been adjusted accordingly. The higher wind speed classes have been consolidated into one additional "and larger" bin to reflect the practical wind speeds observed, preventing the repetition of colors in the legend. The updated wind rose diagram is available in the supplemental PDF files under "New Wind Rose Diagram."

7. p. 5 l. 95: either “Small and Medium-sized Enterprises” or “small and medium-sized enterprises” but not a mixture of both small and capital letters.

   We will ensure that the term **small and medium-sized enterprises** will be written entirely in lowercase throughout the manuscript for consistency.

8. p. 5 l. 98: delete the “and”, because there still follows the “or” in the list

   it will be done

9. p. 5 l. 98: please make it either “to contribute instruments,” or “to contribute to the instrumentation,”

   it will be done

10. p. 5 l. 100: please exchange “revolve around” with “evolved within”

    it will be done

11. p. 5 l. 104: please exchange “measurements” with “data”, because you provide the quality-assured data for the satellite validation.

    it will be done

12. p. 5 l. 114: please exchange “smokes” with “smoke plumes”

    it will be done

13. p. 6 l. 128: please add an “and “ before “ i)”

    it will be done

14. p. 6, table 1.: “lidar and optical laboratories” are infrastructure, no “instrument” as stated in the table caption.

15. p. 6 l. 149: I learned that there should always be a space between the number and the unit, i. e. should be “20 km” here. (Only exception “10°C”). Please check the whole manuscript.

    We will review the entire manuscript and ensure that there is a space between the number and the unit (e.g., "20 km"), except for specific cases like "10°C." All instances will be corrected accordingly.

16. p. 7 l. 152: should be “Central Facilities” starting with capital letters. Please check the whole manuscript.

    We will ensure that **"Central Facilities"** is consistently written with capital letters throughout the manuscript. All instances will be corrected accordingly.

17. p. 8 l. 199: please make it either “particulate matter collected on filters.” or “aerosol particles collected on filters.”

    It will be done

18. p. 8 Fig. 4 caption: please add “aerosol” before “facility”

    It will be done

19. p. 9 l. 206/209: please exchange “under” with “downstream”, because that is meant

    It will be done

20. p. 9 l. 208: please move the comma after “3938” and remove the hyphen to be consistent

    It will be done

21. p. 9 Fig. 4: please add the information of the inlet heads also to the PMx instruments

    It will be done

22. p. 10 l. 244: please exchange “Instead” with “In contrast”

    It will be done

23. p. 10 l. 244: please move the “since …” half sentence to the end of the sentence, the subject and the verb should not be separated.

    It will be done

24. p. 11 l. 250: please exchange “input” with “inflow”

    It will be done

25. p. 11 l. 259: please add “matter” after “particulate”.

    It will be done

26. p. 12 l. 281: “human range of visibility” sounds strange for me, maybe “the visible part of the electromagnetic spectrum” is better

    It will be done

27. p. 13 l. 322: what is “ < ng m^{-3}”, please complete this equation or write it in words

    We will either write "< ng m^{-3}" in words (e.g., “less than nanograms per cubic meter”). This adjustment will be made in the manuscript.

28. p. 14 l. 340: please exchange “increasing” with “peaks”

    It will be done

29. p. 14 Fig. 7: please add “a)” and “b)” to the two rows of plots and change the figure caption accordingly

    It will be done

30. p. 16 l. 415: “aerosol load” is very unspecific, please use a more appropriated term for what is meant here

    We will replace the term **"aerosol load"** with a more specific term like **"aerosol concentration"**

31. p. 17 l. 446: please exchange “in short” with “over short”

    It will be done

32. p. 20 l. 530/532: please remove the “%” after “BB”, same in fig. 8 b

    It will be done

33. p. 21 l. 553: should be “coarse” not “carse”

    It will be done

34. p. 25 l. 649: why some words in the “authors contribution” section are written in capital letters and others not, is not clear to me.

    The words in the “Authors Contribution” section were capitalized to highlight the different contributions of the authors in line with the guidelines provided by the AMT journal. However, we can modify this and switch to lowercase for consistency if preferred. This will ensure uniformity in the manuscript's style.

35. p. 25 l. 662, acknowledgement: Most of the guidelines for setting-up an in situ aerosol side in ACTRIS are given by the in situ aerosol Topical Centre. Hence, here and also in the text this TC should be acknowledged, as many years of hard work are the basis for this.

    We fully agree with your suggestion and will include the acknowledgement. We will make sure to acknowledge the in-situ aerosol Topical Centre (TC) in the acknowledgements section, recognizing the many years of hard work that have provided the essential guidelines for setting up the in situ aerosol site within ACTRIS.