Response to comments from Anonymous Referee #2

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

The paper describes the CIAO laboratory that have been recently added an aerosol in-situ measurement component that is aimed to add to the ACTRIS RI in future.

Overall, I am a bit worried if the paper is publishable in it's current shape. On the one hand there is the title stating the in-situ upgrade. That is described but ther eis as well a large portion of general description of the station that have in part already described by some papers of some of the authors.

The processes that are linked to the compliance with ACTRIS and the procedures to achive that, like "labelling" are a very specific in frame of European research infrastructures and play a minor role outside these communities. Therefore, such terms are kind of a jargon and needed some explanation, at least.

We thank the reviewer for his/her comment that pushes us to improve our paper. We will shorten the description of the remote sensing components for highlighting the novel aspect developed at CIAO, We will also avoid the ACTRIS jargon throughout the paper for facilitating the reading for not ACTRIS readers. These 2 aspects are really valuable for improving the quality of our paper. Thanks for pointing this out.

The paper tries to fulfil AMT's requirements but that leads to a situation where the scientific strenght remains low and the bare description of a measurement station or system alone without innovation may not qualify for the journal. However, I can imagine that AMT may set rules to make descriptions of such large scale efforts and stations or systems and by that reduce the antagonistic problem these type of descriptions are causing.

The aim of our paper is **to benefit the aerosol community providing a comprehensive and detailed description of technical solutions for the implementation of such component** (aerosol in situ). The development of such laboratory for aerosol in situ measurements required designing implementing and optimizing technical solutions. This paper is the way in which we want to share our experience allowing others to do not repeat all the process but adopting and in case of needs tailoring our solutions to their needs. Examples of measurements and their combined use with aerosol remote sensing observations are reported as show cases of potentialities of CIAO extended observatory.

Such a topic perfectly fits in our opinion with AMT scope: *The main subject areas comprise the development, intercomparison, and validation of measurement instruments and techniques of data processing and information retrieval for gases, aerosols, and clouds. Papers submitted to AMT must contain atmospheric measurements, laboratory measurements relevant for atmospheric science, and/or theoretical calculations of measurements simulations with detailed error analysis including instrument simulations.*

The development of the CIAO laboratory can be seen as development of measurement instrument and observational techniques. Atmospheric measurements of interest are provided into the paper.

Among journals we selected AMT firstly because the CAIO observatory in its old configuration (only remote sensing part) is described in a previous AMT paper. Secondly, other observatory similar papers appeared on AMT (e.g. doi.org/10.5194/amt-16-6097-2023 and doi:10.5194/amt-8-3481-2015

Comments

page 1, line 26ff: You use the term aerosol here but actually that are the particles or the particulate matter that has these effects. It need to be changed in the whole manuscript.

We will adjust the terminology throughout the manuscript by replacing **aerosol** with **aerosol particle** or simply **particle**, wherever particles are specifically intended. This will ensure greater clarity and precision in conveying the effects attributed to particulate matter.

page 3/4, line 74 and Fig 2: Why to use the radiosonde ground level measurement for RH ant temperature to assess ground level dewpoint temperatures? This can be done with any meteorological equipment with higherdata resolution.

We agree with your point. In the revised version of the paper, Fig. 2 will show the dew point temperature measured by the VAISALA MILOS520 automatic weather station, with daily averages. This weather station was also used to generate the wind rose shown in Fig. 3, ensuring consistency in data sources.

page 4, fig 3: The color scheme in intervals to show also the percentage is a good idea but the color repetition and the polar plot that has its advantage in showing the wind direction makes the reading of low wind speed percentages rather complicated. Btw, the Vaisala MILOS is the data logger of the weather station if I remember well. What anemometer was used?

Thank you for your insightful feedback. We have revised the wind rose to avoid color repetition, ensuring that the plot is now clearer and easier to interpret, especially when reading the percentages for low wind speeds. The updated wind rose diagram is available in the supplemental PDF files under "New Wind Rose Diagram."

Regarding the anemometer installed, it is a mechanical sensor, specifically the Vaisala WA15 model. It consists of the Vaisala WAA151 wind speed sensor and the WAV151 wind direction sensor. These sensors are installed at approximately 10 meters above ground level. We have also included the specifications provided by Vaisala in the supplementary files for reference (wind sensor-wa15).

page 8, section 4: While the inlets are described in high detail, I didn't find the simple parameter of the inlets heights? You tell they are vertical, i.e. rooftop inlets and a height above the roof, but how heigh is that above the ground? Especially as you have a weather station there, mentioned in fig 3.

We will include the height of the inlets from the ground level in the manuscript, not just their height above the roof of the container, to provide a more complete description.

The Vaisala MILOS weather station mentioned in Figure 3, which is used to derive the wind rose diagram and provide an overview of the CIAO observatory, is not located on the in-situ shelter. Instead, it is positioned approximately 50 meters away and at a height of around 10 meters above the ground.

page 9, lines 212ff: You describe here the inlet lines diameters in great detail. In the part where you describe the isokinetic splitter it remains unclear if you have one splitter with several outputs or if you use several splitters one after another? From the description this can be only guessed.

We have two isokinetic splitters with multiple outputs for the various instruments: one is located under the PM10 line, and the other is under the PM2.5 line. This ensures that both aerosol fractions are sampled appropriately for the different instruments. We will clarify this in the manuscript to avoid any ambiguity.

page 9, line 219: Its not clear what you mean with sharp ends here? Their position to be right-angled (90°) in the air stream?

It doesn't need to be at a right angle (90°) in the air stream, but the end should be beveled, not flat. The reason for this is to minimize turbulence and particle loss as the airflow enters the inlet. A beveled edge ensures a smoother transition for the aerosol into the sampling system, which helps maintain the integrity of the sample by reducing potential particle deposition at the edges of the inlet. This also improves the efficiency of the sampling process.

The following revised sentence will be added to the updated 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."

page 9, line 220: The statement of the sampling from the laminar main stream is, at least in engineering, a trivial statement. Do you use an off-the-shelf splitter or was it self made?

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.

page 9/10, table 2: The table layout is a bit awkward which is most probably due to the split over two pages and may be solved by change in the place of the table.

We will adjust the table layout and change its position in the manuscript to ensure that it is not split over two pages, which should resolve the awkward formatting.

page 10/11: Paragraphs on the Nafion dryer system, you discuss the drying capacities, however, did you also determine the losses in the dryer and the whole inlet line in general? E.g. Zoller et al. (2000) report for a rather similar system up to 37% losses on 10nm particles where 20% is lost in the dryer section. Do you have strategies to compensate for inevitable losses in sample lines?

(Zoller, J., Gulden, J., Meyer, J. _et al._ Loss of Nanoparticles in a Particulate Matter Sampling System Applied for Environmental Ultrafine Particle Measurements. _Aerosol Sci Eng_ **4**, 50–63 (2020). https://doi.org/10.1007/s41810-020-00054-6)

In our study, we focused on the drying capacity of the Nafion dryer system but did not specifically measure the particle losses in the dryer or the overall inlet line.

Anyway, the general configuration of the system's inlet line is designed to ensure laminar flow within the sampling line, which is essential for minimizing turbulence and reducing particle loss. Additionally, the use of a conductive tube is kept to a minimum length to further decrease the potential for particle deposition.

Moreover, the system incorporates a Nafion®-based Perma Pure MD-700 air sampling dryer, featuring a large-diameter inlet and a 0.700" diameter flow path. According to test data from TROPOS-WCCAP, this large-diameter Perma Pure MD-700 dryer demonstrates very low particle losses during practical operation, making it an effective solution for maintaining the integrity of particle sampling.

Reference: https://www.permapure.com/wp-content/uploads/2014/06/MD-700-TROPOS-Presentation-10-2014.pdf

However, it is well recognized that losses, especially for small particles, can be significant in such systems. In the future, we will certainly assess the actual particle loss in the dryer and the entire inlet line. Additionally, we will work to identify the appropriate strategies to compensate for these losses and ensure accurate measurements.

page 16, section 5: Synergistic approach or synergy between measurement systems. The way these are described here is complementary, not synergistic. Two or more measurement systems give details on the same process and each could be used to explain the process. A synergy would create a new aspect that can not be reached by each of the methods alone.

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.

Anyhow, 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).

Technical remarks

page 13, line 316: TOF-ACSM; I think you already introduced the manufacturer before (page 8) no need for redundant mentioning, maybe check over the manuscipt and as well for other devices.

We will ensure that the manufacturer's name is only mentioned once, as it was already introduced on page 8. We will also check the rest of the manuscript for any other redundant mentions of device manufacturers and streamline the text accordingly.

page 25, line 641: filed = field

It will be done