ATMO ACCESS
Access to Atmospheric Research Facilities

Activity report of the TNA to ATMO-ACCESS research infrastructures

Name and First Name: Wisniewska Kinga

TNA title and acronym:
Pollen and Fine Particulate Monitoring, Forecasting, and Analysis (PEMFA)

Facility/ies accessed:
RADO-MARS - Romanian Atmosphere 3D research Observatory – Măgurele Centre for Atmosphere and Radiation Studies

This work has received funding from the European Union's Horizon 2020 research and innovation programme through the ATMO-ACCESS Integrating Activity under grant agreement No 101008004

Instructions

Please limit the report to max 3-5 pages, including tables and figures.
The report should be sent as pdf document and include the subheadings listed below. Please make sure to address any comments made by the reviewers (if applicable).

Is the information provided in the report confidential and should not be made available on the ACTRIS website?

☒ No, the information can be made public.

☐ Yes, the information should not be made public and access should be restricted to the TNA Team, the ATMO-ACCESS access providers, the reviewers concerned and the ATMO-ACCESS Strategic TNA Board.

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1. Short executive summary (can be made available to reviewers and EU experts)

Few lines to present the TNA project

The PEMFA (Pollen and Fine Particulate Monitoring, Forecasting, and Analysis) project aimed to enhance expertise in lidar-based atmospheric aerosol analysis by facilitating collaboration between researchers from the University of Wrocław (Poland) and the RADO-MARS research facility in Magurele (Romania). Participants engaged in hands-on training with advanced instruments, including bioaerosol analyzers and lidars, and conducted comparative studies on aerosol characteristics. The project emphasized the development of methods for lidar data processing and interpretation, leading to the creation of a Python-based analysis program. This collaboration significantly enhanced the operational capabilities of the new ACTRIS station in Wrocław and paved the way for continued bilateral studies.

2. User group

Complete the table with details of the user group members who actually accessed the Facility. Duplicate the table below for each member of the user group.

Information on the User group members	
Member # 1	
First and last name	Kinga Wiśniewska
Gender	☒ Female ☐ Male ☐ Prefer not to say
Nationality	Polish
Profile	☐ Undergraduate ☐ Postgraduate ☒ Expert scientist ☐ Engineer, Technician ☐ Other
Field of activity	☒ ENV-ATMO - Earth and environmental sciences/Atmospheric domain ☐ ENV-HYDRO - Earth and environmental sciences/Hydrosphere domain ☐ ENV-LITHO - Earth and environmental sciences/Lithosphere ☐ ENV-ECOBIO - Earth and environmental sciences/Eco-biosphere ☐ PHY - Physics astronomy, astrophysics and mathematics ☐ CHEM - Chemistry and material sciences ☐ BIO-MED - Biological, medical sciences and biotechnology ☐ ENG-TECH - Engineering and technology ☐ EGY - Energy ☐ ART - Humanities and arts

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	☐ ISC - Information science and communication ☐ SOC - Social sciences			
Are you a new user?	☒ Yes ☐ No			
Institution name (employer)	University of Wroclaw			
Institution legal status (employer)	☐ Public research (including international research organizations and private research organization controlled by a public authority) ☒ University and higher education ☐ Public authority ☐ Small Medium Enterprise (SME) ☐ Other industrial and/or profit private organization ☐ Other			
Address (employer)	Pl. Uniwersytecki 1, 50-137 Wroclaw	**Country**	Poland	
Email address	kinga.wisniewska@uwr.edu.pl			
Access start date	~~20~~10/~~05~~06/2024	**Access end date**	~~20~~10/12/2024	

Information on the User group members	
Member # 2	
First and last name	Aleksandra Walkowicz
Gender	☒ Female ☐ Male ☐ Prefer not to say
Nationality	Polish
Profile	☐ Undergraduate ☒ Postgraduate ☐ Expert scientist ☐ Engineer, Technician ☐ Other
Field of activity	☒ ENV-ATMO - Earth and environmental sciences/Atmospheric domain ☐ ENV-HYDRO - Earth and environmental sciences/Hydrosphere domain ☐ ENV-LITHO - Earth and environmental sciences/Lithosphere ☐ ENV-ECOBIO - Earth and environmental sciences/Eco-biosphere ☐ PHY - Physics astronomy, astrophysics and mathematics ☐ CHEM - Chemistry and material sciences ☐ BIO-MED - Biological, medical sciences and biotechnology

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	☐ ENG-TECH - Engineering and technology ☐ EGY - Energy ☐ ART - Humanities and arts ☐ ISC - Information science and communication ☐ SOC - Social sciences		
Are you a new user?	☒ Yes		
	☐ No		
Institution name (employer)	University of Wroclaw		
Institution legal status (employer)	☐ Public research (including international research organizations and private research organization controlled by a public authority) ☒ University and higher education ☐ Public authority ☐ Small Medium Enterprise (SME) ☐ Other industrial and/or profit private organization ☐ Other		
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Access start date	10~~20~~/0~~6~~5/2024	**Access end date**	~~20~~10/12/2024

3. Scientific objectives

This project initially assumed only measurements including? aerosol optical depth, fine particle concentration, and bioaerosol analysis, the purpose of which was to validate the model predicting pollutant concentrations. The polish researchers took part in these measurements, but due to both financial constraints and the parallel project TNA focused on bioaerosols, researchers from both stations decided to focus primarily on research using atmospheric lidar. Therefore, the aim of this project was to familiarize polish scientists with advanced methods of processing lidar data in order to improve the accuracy of the characterization of atmospheric aerosols, including their composition, size, and dynamics.

The University of Wrocław is one of the youngest members of ACTRIS. When joining the TNA project, this station was not able to fully utilize the resources of its new infrastructure, which is the atmospheric lidar. The experience gained at the research station in Romania will significantly accelerate research work using lidar in Poland. As part of the cooperation, researchers from Poland gained valuable knowledge regarding the requirements and recommendations of ACTRIS regarding conducting measurements using lidar. The researchers learned the best practices of lidar measurements, from the stage of conducting tests to obtaining results and their interpretation.

Importantly, thanks to the cooperation with RADO-MARS, a program written in Python was developed [1], which will significantly accelerate work on the interpretation of results obtained in the future. The goals regarding the development of a model predicting atmospheric pollutant concentrations will be achieved in the future through continued close scientific cooperation with a research center in Romania.

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4. Reasons for choosing the Facility/ies

The Romanian RADO facility was chosen as a partner for this project due to its extensive expertise and resources, which align closely with the project's objectives. RADO specializes in the calibration of LIDAR systems. Additionally, the facility conducts advanced research on fine particles and bioaerosols. The researchers at the Magurele station, who are authors or co-authors of several significant studies on atmospheric lidars [e.g. (Belegante et al., 2018; Chaikovsky et al., 2016; Papayannis et al., 2014; Wang et al., 2014], bring an invaluable depth of knowledge, particularly beneficial to researchers new to lidar technology.

The facility is equipped with state-of-the-art measurement instruments, facilitating detailed analyses of aerosol optical depth, fine particle concentrations, and bioaerosols. Its capability to conduct continuous measurements enables the investigation of diurnal variations in the vertical distribution of particles, thereby improving the accuracy of pollution forecasting. Moreover, the collaboration provides both methodological support and opportunities for knowledge exchange, significantly enhancing the research framework of the project.

5. Activities during the TNA (research, training, events, ...)

During the visit to the RADO MARS research facilities, Polish researchers gained hands-on experience with ACTRIS equipment for atmospheric measurements, with a particular focus on the RAPID-E bioaerosol analyzer and two lidar systems. The training emphasized both the theoretical and practical aspects of operating lidar systems for aerosol measurements. Participants were trained in equipment operation, including conducting Quality Assurance tests, performing measurements, and utilizing dedicated software for data analysis

The program also featured lectures by experts Dr. Doina Nicolae and Dr. Livio Belegante, who provided in-depth insights into lidar principles, data processing methodologies, and the operational framework of the ACTRIS network. Additionally, a course led by Dr. Jeni Vasilescu facilitated discussions on bioaerosol and fluorescence measurements, offering a deeper understanding of these phenomena in the context of atmospheric research. Comparisons were also conducted between the performance of the RAPID-E and SWISENS POLENO analyzers. A key component of the project involved simultaneous lidar measurements, which enabled comparisons between results obtained from different systems. These comparative measurements were initiated upon the researchers' return to Poland, and several parallel campaigns have already been conducted, with plans for continuation beyond the project's conclusion. The collaboration between the two research centers has extended beyond the Romanian visit, with the next phase focusing on a case study of pollution sources in Romania. Under the guidance of the Romanian team, the Polish researchers developed a Python program for analyzing lidar data. This program clearly defined the analytical steps required to interpret lidar data effectively, marking a significant step forward in methodological refinement.

6. Method and set-up of research

As part of this project, several remote meetings were conducted, regular correspondence was maintained, and a research visit to the RADO facility was undertaken, involving two participants from Poland. During their stay in Romania, the primary focus was on conducting measurements using two atmospheric lidars, RALI and ALPHA. The measurement protocols included calibration procedures such as the Rayleigh and Telecover tests, which ensured accurate signal evaluation. Additional measurements were performed to identify

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interference signals (dark signals). All experimental activities were preceded by comprehensive theoretical instruction.

One of the key objectives of this collaboration was to analyze data and assess the aerosol composition in the Romanian atmosphere. To support this effort, a Python-based program was developed and shared on a GitLab platform [1]. The program enabled the generation of "quick looks" for the range-corrected signal and the volume linear depolarization ratio, facilitating detailed interpretation of results processed by the SCC system. Moreover, lidar ratio and color index analyses were employed to characterize aerosol composition in the sampled layers. Backward trajectories of air masses were computed using the HYSPLIT model to trace the origins of these aerosols.

These analyses provided Polish researchers with a deeper understanding of SCC products and their application. To validate the conclusions drawn, the results were compared with data obtained from the NATALI (Neural network Aerosol Typing Algorithm based on Lidar data) algorithm available at the Romanian facility.

7. Preliminary project results and conclusions

Due to budgetary constraints, only two participants, rather than the nine originally planned, were able to take part in the project, which limited the scope of the tasks that could be undertaken. Consequently, the focus was narrowed to aerosol measurements using atmospheric lidar as a remote sensing method. The project significantly enhanced participants' expertise in operating and analyzing lidar data. Both theoretical lectures and hands-on training provided valuable insights into lidar data processing, particularly in the context of a case study on smoke and dust transport. This practical application reinforced the skills acquired during the project. The data analysis methods developed and refined during the training will be implemented at the measurement station in Wrocław. Currently, a campaign of parallel lidar measurements is ongoing between the Wrocław and Romanian research stations. This collaboration has already addressed several technical challenges associated with lidar operations at the Wrocław station, further strengthening its capabilities.

8. Outcomes and future studies

To deepen our understanding of LiDAR data and its analysis, we selected a short time period with existing measurements to visualize and characterize various atmospheric events. The period chosen was March 25–28, 2024. Among these days, March 28 stood out due to the presence of a notable event that provided valuable insights into the capability of LiDAR data to characterize atmospheric composition, particularly regarding aerosol loadings.

The case study revealed the presence of a layer at an altitude of 2 km [Fig. 1b], originating from the Bulgarian region and reaching the research station, as shown by the backward trajectories of air masses which were determined at different heights using the HYSPLIT model [Fig. 5] [6]. Parameters such as linear and volume particle depolarization ratio, lidar ratio, and color ratio, along with analyses conducted using the NATALI algorithm, were instrumental in determining the composition of the particles [Fig. 2-4]. The aerosol composition of the layer described the predominance of aged smoke and also particles of continental origin.

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Additionally, ice clouds were observed at higher altitudes [Fig. 1a]. .

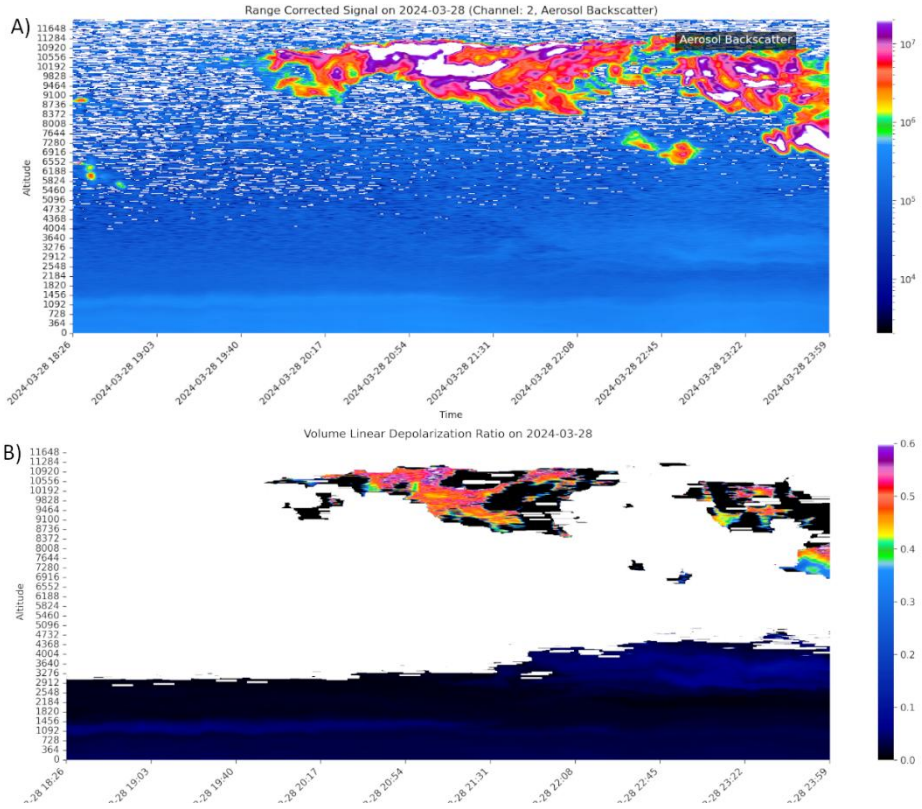

Fig. 1 Example quick looks from the analyzed case studies showing (a) the range-corrected signal and (b) the volume depolarization ratio.

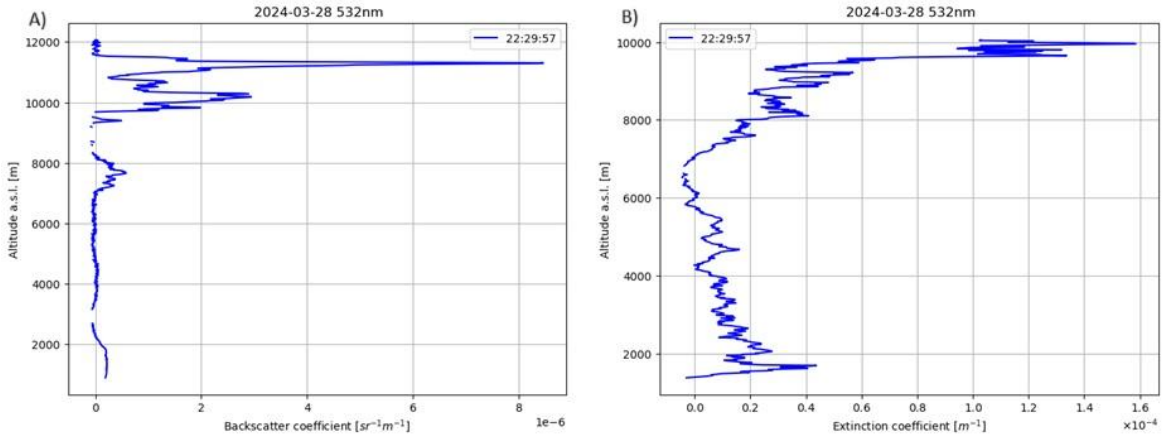

Fig. 2 A) (A) Backscatter coefficient and (B) extinction coefficient, used to calculate the lidar ratio for the Magurele station.

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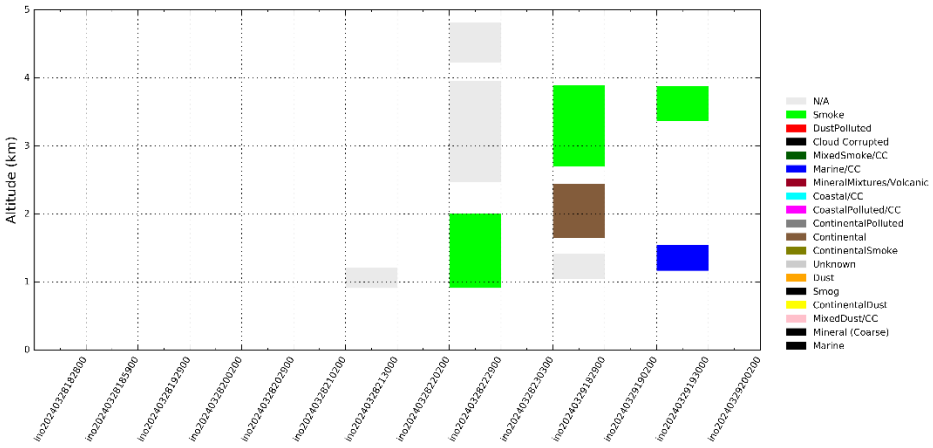

Fig. 3 Analysis of pollutant composition for a selected period above the Magurele station, calculated using the NATALI algorithm.

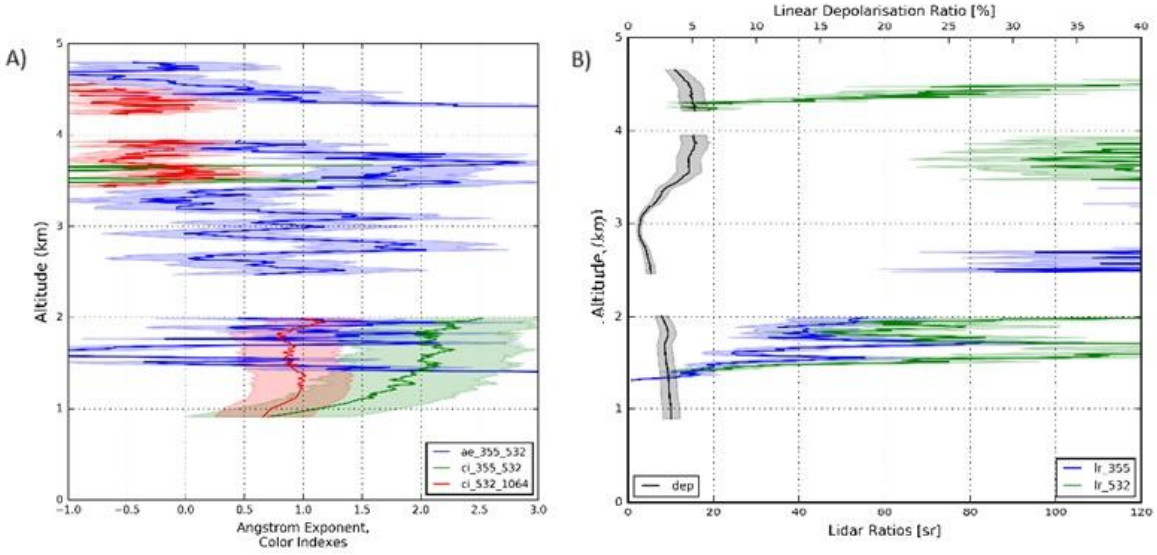

Fig. 4 Parameters supporting the determination of the origin of aerosol particles (A) color index (B) lidar ratio

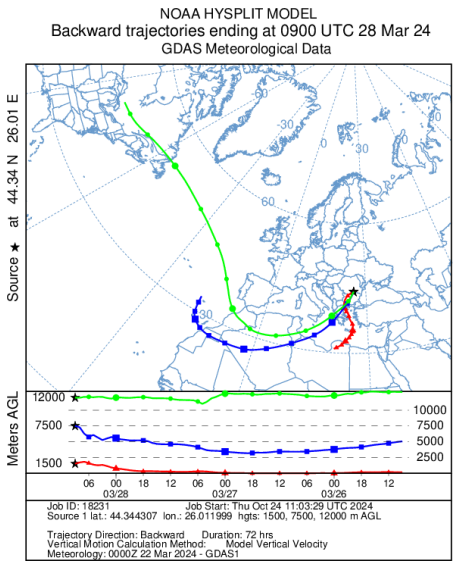

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Fig. 5 Backward air mass trajectory analysis over the Magurele station for the selected period in the case studies.

This analysis marked the first experience for researchers from the University of Wrocław in working with lidar data. Through this project, they developed familiarity with SCC products and created a dedicated program for processing these data.

Future plans include additional parallel lidar measurements between the research stations in Magurele and Wrocław. These measurements aim to enhance data quality at the Wrocław station and improve the interpretation of similar episodes. High-quality lidar data from Wrocław will serve as a foundation for validating future atmospheric forecasting models. Continued collaboration with the Romanian research station will enable more comprehensive model validations.

9. Plans for publications

(in peer-reviewed journals, conference proceedings, etc. acknowledging the support by ATMO-ACCESS). Details, including the DOI, need to be provided as soon as available.

Data from parallel lidar measurements between Wrocław and Magurele, once supplemented with further observations, will be utilized in upcoming conference presentations. The program developed during the case study analyses will be refined and serve as a foundational tool for future lidar research. These enriched datasets will also support the preparation of a scientific paper highlighting the capabilities of the new ACTRIS network station in Wrocław and the advanced measurement techniques applied in event analysis.

10. References

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