Preliminary results from the Lidar-based Atmospheric Measurement at Pianosa (LAMP) field campaign

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Abstract: The Lidar-based Atmospheric Measurement at Pianosa (LAMP) field campaign investigates marine-influenced atmospheric conditions in the Central Mediterranean using the MARCO Raman lidar system. MARCO provides high-resolution profiles of aerosol optical properties, clouds, temperature, and water vapour. The system was deployed at the CNR research base on Pianosa island (42.5849 N, 10.0971 E, 17 m a.s.l.), Italy, in December 2024, a site characterized by minimal local anthropogenic influence. Preliminary results include calibrated water vapour mixing ratio and aerosol backscattering profiles, showing good agreement with ERA5 reanalysis data, and demonstrating the reliability of the measurements for marine atmospheric studies. The dataset is here introduced, and preliminary results will be shown at the conference.

1. Introduction

Understanding the complex interactions between atmospheric processes and the Earth's surface requires precise, high-resolution observations. In marine and coastal regions, the ability to capture vertical and temporal variations in atmospheric constituents is essential for improving weather prediction models and climate projections. This work presents preliminary results from the Lidar-based Atmospheric Measurement at Pianosa (LAMP) field campaign, which focuses on the characterization of marine-influenced atmospheric conditions. Central to the campaign is the MARCO lidar system (Micro-pulse Atmospheric Optical Radar for Climate and Weather Observations), a compact and transportable Raman lidar developed by the University of Basilicata, Italy. MARCO's advanced capabilities in measuring backscatter, extinction, depolarization, temperature, and water vapour mixing ratio (WVMR) profiles enable detailed atmospheric profiling in coastal and marine environments.

2. MARCO

MARCO is a compact and easily transportable Raman lidar system based on a micro-pulse laser source, developed by the Lidar Group of the University of Basilicata in 2022 [1]. It is an advanced instrument that enables the acquisition of vertical profiles of the backscatter and extinction coefficients of atmospheric particulate matter and clouds, the aerosol depolarization ratio, temperature, and the mixing ratio of atmospheric water vapor. Housed in a sealed and rugged container with a fused-silica window, it is capable of operating in all weather conditions and can be remotely operated with 24/7 measurement capabilities. The technical characteristics are listed in Table 1.

Table 1. Technical specifications of the lidar system MARCO.

Reception channels	Elastic total, ∥ and ⊥ @ 354.7 nm Ro-vib. Raman N_2 @ 386.7 nm Ro-vib. Raman H_2O @ 407.5 nm Rotational Raman (Low J) @ 354.3 nm and (High J) @ 352.9 nm
Telescope diameter	406 mm (f/8)

Field of view	0.31 mrad (FWHM)
Full overlap	~ 500 m
Detector	Photomultiplier modules (Hamamatsu H10721P-210)
Filter bandwidths	0.2–0.5 nm
Vertical sampling	15 m
Vertical resolution	15 m - 150 m
Temporal resolution	3 s - 30 min
Acquisition system	16 Bit 40 MHz analog, 800 MHz photon counting

The overall small volume (< 3 m^3), weight (750 kg) and power consumption (~900 W) translates into the possibility of considerably simplifying the logistics and costs associated with the transportation and deployment of the system. After its development, the system was deployed in several field campaigns, including WaLiNeAs [2–4] and DECIPHER, part of the TEAMx project [5,6], and was subsequently relocated in Pianosa for the LAMP campaign. From its development until a laser failure in the midst of the campaign, MARCO collected approximately 18k hours (25 months) of measurements. A new laser was installed in November 2025, enabling the resumption of operations with improved performance. The characteristics of the old and the new laser are reported in Table 2.

Table 2. Technical specifications of the old and new laser sources

Laser	Nd:YAG @ 354.7 nm	Nd:YAG @ 354.7 nm
Power / Energy	250 µJ 5 W	1.14 mJ 5.7 W
Frequency	20 kHz	5 kHz
Beam divergence	< 0.3 mrad	~ 0.25 mrad

3. LAMP

On December 17th 2024, MARCO was installed at the BRP-CNR (Base Ricerca Pianosa – Italian National Research Council) in Pianosa, Tuscan Archipelago, Italy (Lat: 42.5849 N, Lon: 10.0971 E, Elev: 17 m a.s.l.) as part of the LAMP project. This project, organized by the Institute of Marine Sciences (ISMAR-CNR), aims to characterize marine aerosols and monitor atmospheric water vapour to better understand the interactions between marine aerosols and cloud formation [7], as well as to study extreme precipitation events in the Mediterranean [2].

The island of Pianosa was chosen as the ideal site for the installation of the lidar system due to its geographical characteristics: small size (10 km^2), limited human activity, and absence of complex topography (max. elev. of 29 m a.s.l.). These conditions allow for the acquisition of background measurements of marine aerosol and the study of its interaction with continental aerosols under different atmospheric circulation scenarios. Moreover, the CNR base in Pianosa is in a favourable position for monitoring atmospheric water vapour and studying intense precipitation in the Mediterranean. The collected measurements will contribute to the validation of models and satellite products (e.g., EarthCARE). The project also represents the first planned step toward the potential future permanent installation of a multispectral scanning lidar system, integrated into the international Earlinet/ACTRIS observation network.

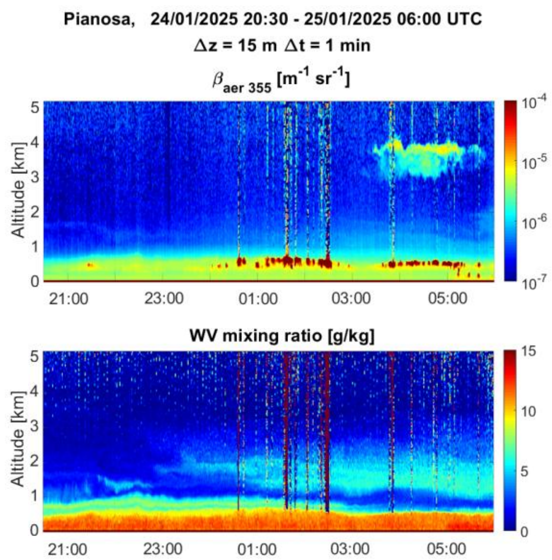

Figure 1: Test measurements carried out during the night between January 24th and 25th 2025 in the LAMP field campaign. The graph shows the temporal evolution of the backscattering coefficient of aerosols and clouds, as well as the mixing ratio of water vapor.

Activation, testing, and calibration of the lidar system took place from January 21st to 28th 2025 (Figure 1), with the objective to carry out continuous measurements for a full year. Problems with the laser forced the interruption of the measurements between August and November 2025, when the new laser was installed in the system and the measurement resumed. A timeline of the state of the system is shown in Figure 2.

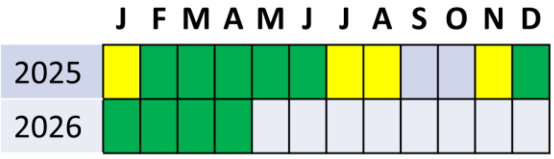

Figure 2. Timeline of the acquired measurements, showing partial (yellow), full (green), and absent or not yet acquired (gray) monthly coverage.

LAMP data is currently being analyzed in order to produce a dataset of WVMR and aerosol backscatter coefficient profiles with a temporal resolution of 30 min and a vertical resolution of 15 m. For the WVMR retrieval, periods characterized by a stable calibration factor were identified, and the system was calibrated through comparison with ERA5 reanalysis data. The resulting dataset shows good agreement, with A RMSE of 0.66 (see Figure 3).

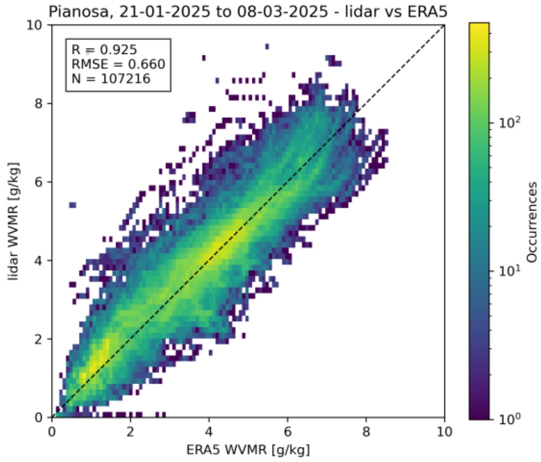

Figure 3: bi-dimensional histogram of matches between lidar measurements and ERA5 WVMR data used for the calibration of the first segment of data. Only values with a standard deviation of less than 1 g kg-1 were considered.

In Figure 4, the temporal evolution of WVMR is shown for the month of February 2025. For the aerosol backscatter, the coefficients are being retrieved with the Raman technique; Figure 5 shows their temporal evolution during the same month.

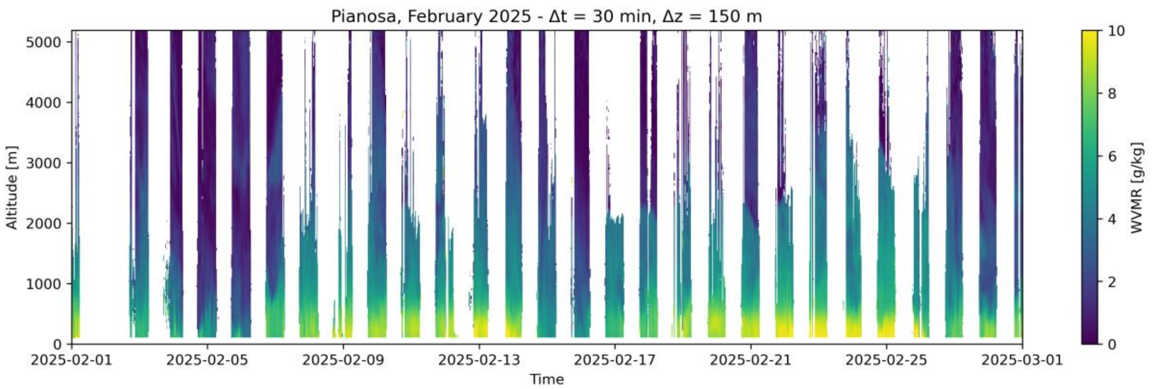

Figure 4: Temporal evolution of the water vapour mixing ratio during February 2025.

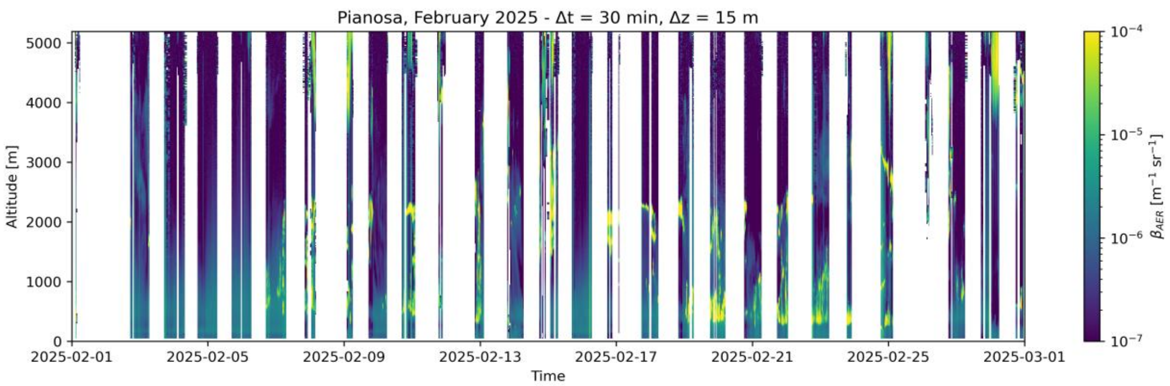

Figure 5: Temporal evolution of the aerosol backscattering coefficient at 355 nm during February 2025.

4. Conclusions and data availability

A dataset of calibrated and quality-controlled water vapour mixing ratio and aerosol backscattering coefficient profiles is currently being produced and will be freely available at 10.5281/zenodo.18480783 [8]. The dataset will be regularly updated to include newly acquired measurements. Preliminary results of the analysis will be presented at the conference. The analysis includes the determination of boundary layer height, aerosol and cloud occurrence and typing, and the investigation of daily and seasonal variability of aerosols and water vapour using probability density functions.

5. Acknowledgments

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6. References

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