

Integrating Remote Sensing and Ground-Based Measurements to Analyze PM Concentrations

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Atmospheric aerosols affect air quality (AQ) and human health. The aerosol mass concentration, or PM, measured at the surface, is a key metric for assessing AQ, and strict regulatory limits are therefore set for PM to protect human health (*Directive EU 2024/2881 EN EUR-Lex.*, 2024).

The vertical distribution of aerosols is also particularly important from both an AQ and a climate perspective, as it affects the thermal structure and stability of the atmosphere, leading to substantial impacts on local and regional climates (Fasano et al., 2021).

In the last decades, both ground-based and space-based lidar systems have been widely deployed and used for scientific research purposes, and they are expected to play an increasingly important role in climate and public health studies (Bellini et al., 2025, 2024; Remer et al., 2024). Their vertical profile observations effectively complement surface in situ measurements, such as those from optical particle counters providing accurate characterization of aerosol size distribution and PM concentrations.

This study analyzes the correlation between aerosol concentration and atmospheric thermodynamic properties by integrating data from multiple remote sensing and in-situ instruments located at the urban station of Turin. Turin, situated in the Po Valley, one of Europe's atmospheric pollution hotspots, is recognized as a critical area for air pollution due to its geographical and meteorological conditions. The aim of the study is therefore to correlate aerosol concentration variations with environmental parameters by comparing different measurement methodologies.

In particular, the ground air quality monitoring station includes an Optical Particle Counter (OPC Palas Fidas 200S) for PM and size distribution measurement, a CL61 polarization-sensitive Automated Lidar Ceilometer (P-ALC) for aerosol vertical profiles, an MTP5 temperature profiler, an OTT PARSIVEL 2 disdrometer for precipitation microphysical characterization and a Lidar Doppler

Wind Cube for wind profile measurements. The experimental setup also includes surface level analyzers of NO_x and ozone.

The complexity of the analysis lies in both the heterogeneous nature of the available datasets and the integration of remote sensing instruments with surface air quality monitoring stations. By combining these different datasets, this study provides a novel investigation into the relationships between aerosol vertical distribution, temperature profiles and precipitation patterns. There are no similar studies in Turin to this point, making this research a unique contribution to understanding the complex interactions that regulate air quality and atmospheric processes in this region.

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