CIVIL AND ENVIRONMENTAL ENGINEERING

ItaliaMeteo - Investigating the Aerosol–Cloud–Precipitation Link in a Mediterranean Context: Insights from Multi-Sensor Remote Sensing Data

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Context of the research activity	The research investigates the interactions among aerosols, wind, and precipitation in the Mediterranean atmosphere through the integrated use of lidar–ceilometer, Doppler wind lidar, and disdrometer observations, complemented by satellite data. The study aims to quantify how aerosol loading and wind dynamics influence precipitation characteristics, contributing to improved understanding of regional hydrometeorological processes.
Objectives	Aerosols play a fundamental role in shaping the Earth's energy budget, the water cycle, and the formation of precipitation. They can modify cloud microphysics and lifetime by acting as condensation and ice nuclei, influencing both the intensity and spatial distribution of rainfall. However, the magnitude and direction of these effects remain highly uncertain, due to the complex interplay between microphysical, radiative, and dynamical processes. This PhD research aims to improve the quantitative understanding of aerosol–wind–precipitation interactions at local and regional scales, with a particular focus on Italy and the Mediterranean basin—regions characterized by strong aerosol variability and complex topography. The study will integrate observations from national ground-based networks such as ALICENET (Automated Lidar–Ceilometer Network), which provides vertical profiles of aerosol backscatter and mass concentration, and GID (Gruppo Italiano Disdrometria), which delivers high-resolution measurements of precipitation particle size distributions. These datasets will be complemented by WindCube Doppler lidar profiles of wind speed and direction, enabling a comprehensive analysis of the dynamical processes driving aerosol transport, dispersion, and removal. A first research objective will be to characterize the spatial, vertical, and seasonal variability of aerosol, wind, and precipitation parameters over Italy. Co-located ALICENET–GID–WindCube sites, distributed from northern to southern Italy, will serve as reference observatories for integrated analysis. The second objective will focus on identifying and quantifying how aerosol concentration, composition, and layer altitude—together with wind dynamics

	—affect precipitation frequency, intensity, and microphysical properties. Satellite observations, particularly from the ESA/JAXA EarthCARE mission, will be employed to extend the analysis to broader spatial scales and to validate ground-based retrievals. Statistical and process-based approaches will be applied to derive empirical relationships between aerosol loading, wind shear, and rainfall characteristics, with special attention to conditions leading to rainfall suppression or enhancement. The final goal of the project is to provide insight into the physical mechanisms that regulate the coupling between aerosol and precipitation in the Mediterranean atmosphere. The outcomes are expected to contribute to the improvement of numerical weather prediction and climate models, particularly in the representation of aerosol–cloud–precipitation feedbacks relevant to extreme weather events.

Skills and competencies for the development of the activity	The candidate should have a strong background in physics, mathematics, or environmental engineering, with skills in data analysis, statistics, and programming (Python or MATLAB). Experience with atmospheric or remote-sensing data, lidar or radar systems, and familiarity with basic meteorological and fluid-dynamics concepts will be considered valuable. Curiosity, analytical thinking, and interdisciplinary collaboration are essential.