

**23rd International Conference on
Harmonisation within Atmospheric Dispersion Modelling
for Regulatory Purposes
15-19 September 2025, Hamburg, Germany**

EXTENDED ABSTRACT

Monitoring and dispersion modelling of traffic-related air pollution in urban environments: a case study from Southern Italy

Riccardo Buccolieri, University of Salento, Lecce, Italy

riccardo.buccolieri@unisalento.it

Chiara Metrangolo, University of Salento, Lecce, Italy; Antonio Esposito, University of Salento, Lecce, Italy; Adelaide Dinoi, National Research Council of Italy (CNR-ISAC), Lecce, Italy; Jose Luis Santiago, CIEMAT, Spain; Gianluca Pappaccogli, University of Salento, Lecce, Italy

Abstract

Urban air quality is critically influenced by traffic emissions, microclimate and urban morphology. This study integrates two approaches: (1) a multi-city ADMS-Roads modelling analysis across Lecce, Bari, Rome and Milan to assess the relationship between NO₂ and PM_{2.5} concentrations, dispersion and local morphology; and (2) a focused monitoring campaign at three sites in Lecce using comprehensive traffic, meteorological and air quality sensors. The combined framework provides insights for developing targeted air pollution mitigation strategies in vulnerable urban areas.

1. Introduction

Road traffic is a primary source of urban NO_x and particulate matter (PM), posing significant public health risks (<https://www.eea.europa.eu/highlights/emissions-from-road-traffic-and>). Pollutant dispersion is heavily influenced by microclimatic conditions and urban morphology, leading to localized hotspots (Li et al., 2021). High-resolution models like ADMS-Roads (<https://cerc.co.uk>) simulate these complex dynamics. This study combines extensive ADMS-Roads modelling across four Italian cities (Lecce, Bari, Rome, Milan) with targeted field measurements in Lecce to: (i) delineate dispersion patterns under varied conditions; (ii) quantify the role of building surface fraction (λ_p); and (iii) characterize real-world pollutant concentration profiles.

2. Methodology

2.1 Dispersion modelling

Four cities (Lecce, Bari, Rome and Milan) were selected, spanning a latitudinal gradient. In each city, six (eight in Lecce) 500×500 m areas were delineated to encompass λ_p values from 11% to 65%, multiple building heights and canyon aspect ratios. Hourly meteorological data (wind speed and direction, temperature, humidity, solar radiation) for 2019-2021 were processed to generate seasonal files. Street network and canyon

**23rd International Conference on
Harmonisation within Atmospheric Dispersion Modelling
for Regulatory Purposes
15-19 September 2025, Hamburg, Germany**

geometry were extracted from high-resolution GIS datasets via QGIS (qgis.org). Traffic emissions were prescribed as a constant aggregate flow of 23,250 veh/h at 30 km/h, redistributed among domains based on relative intensities from Google Traffic, and temporally modulated using the ADMS Roads ‘3DayDiurnal’ profile. Simulations yielded hourly NO₂ and daily PM₁₀ concentration outputs for each area. Background concentrations were not included, as the focus was on isolating the combined effect of traffic and urban morphology on pollutant dispersion. Details and preliminary results from these simulations are presented in Metrangolo et al. (2024).

To further quantify the influence of building canopy density on PM₁₀ concentrations, each area was subdivided into 25 equal-area grid cells. For every cell, the λ_p value and the corresponding modelled PM₁₀ concentration were recorded. A random forest regression was applied to evaluate the effects of λ_p on mean PM₁₀. To explore how λ_p modulates different parts of the PM₁₀ distribution, quantile regressions were also conducted.

2.2 Field campaign in Lecce

The experimental campaign was conducted to validate dispersion model predictions and to characterize real-world pollutant dynamics in representative urban environments. Data from all three Lecce sites refer to a common observation period from 1 May to 15 July 2025. The three monitoring locations, Cosimo De Giorgi High School, Grazia Deledda High School, and a peri-urban viaduct (Figure 1), were each equipped with an AIRQINO air quality station (measuring NO, NO₂, CO, CO₂, O₃, PM₁₀, PM_{2.5}, and VOC), an AIRQINO meteorological station (recording wind speed and direction, temperature, humidity, and solar radiation), and a FLOUD vehicle-counting camera (capturing the number, type, and speed of vehicles along the adjacent road). Instrument installation began in April 2025 and was carried out progressively across sites and devices. The date of 1 May marks the first day on which all instruments were simultaneously operational at all sites, thus defining the initial period of fully harmonized data collection. Figure 2 shows the complete instrumental setup at the measurement sites.

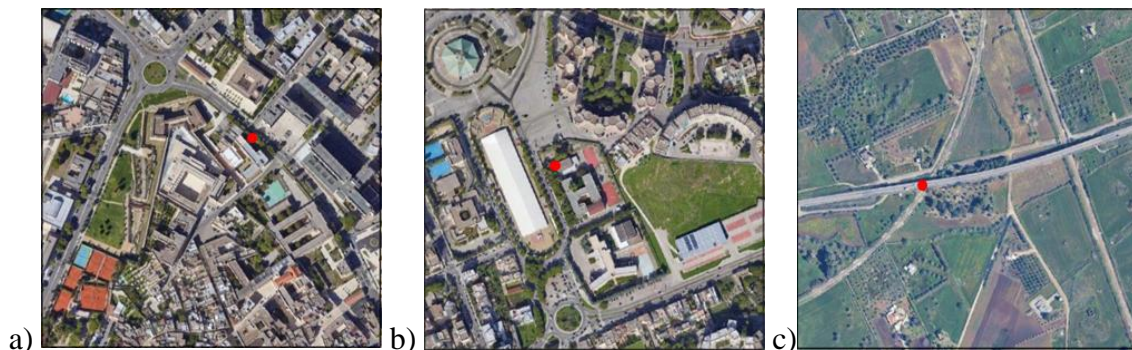


Figure 1. Study area of a) Cosimo De Giorgi ($\lambda_p = 30.3\%$), b) Grazia Deledda ($\lambda_p = 12.5\%$), c) Viaduct ($\lambda_p = 0\%$). Red points indicate the position of the instruments.

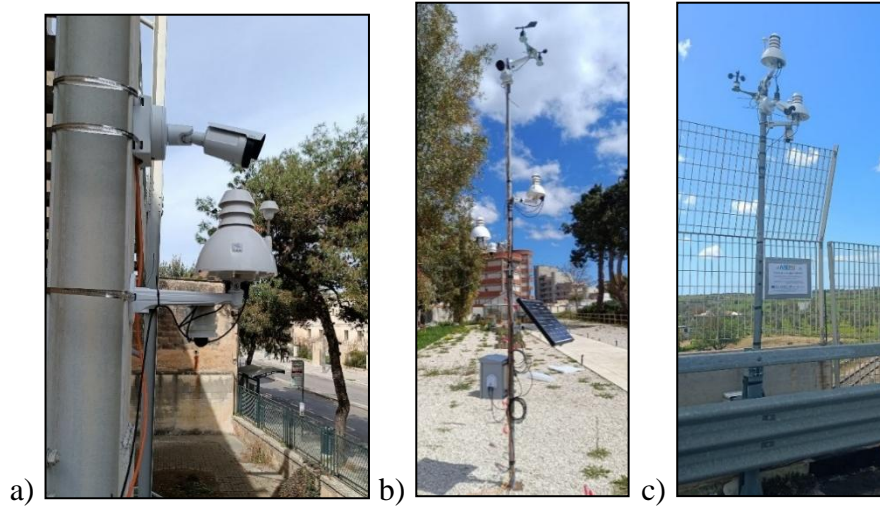


Figure 2. Instrumental setup for a) Cosimo De Giorgi, b) Grazia Deledda and c) Viaduct.

3. RESULTS

3.1 Modelled dispersion patterns

Figure 3 presents summer contour plots of PM_{10} concentrations for domains with medium density ($\lambda_p \approx 25\%$). The spatial fields reveal wind-driven plumes transporting pollutants downwind and canyon confinement producing localized maxima, with each city's unique layout imparting a distinct "fingerprint".

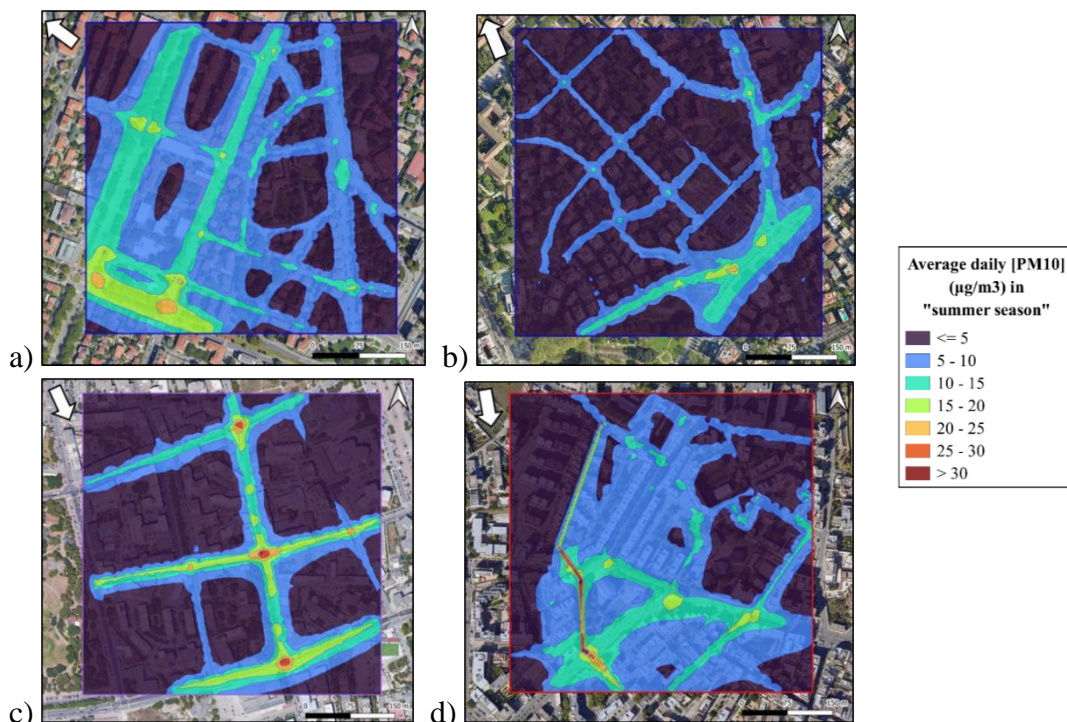


Figure 3. Summer contour plots of PM_{10} for a) Milan, b) Rome, c) Bari, d) Lecce.

3.2 Effects of λ_p on PM₁₀

Random forest analysis demonstrated that increasing λ_p produces a modest but consistent reduction in mean PM₁₀ (summer). Quantile regressions indicated negligible λ_p impact below the median but progressively steeper negative slopes at the 75th and 90th percentiles, confirming canopy density's pronounced mitigation of extreme pollutant levels (Figure 4). Similar results were obtained for primary NO₂, and across all seasons.

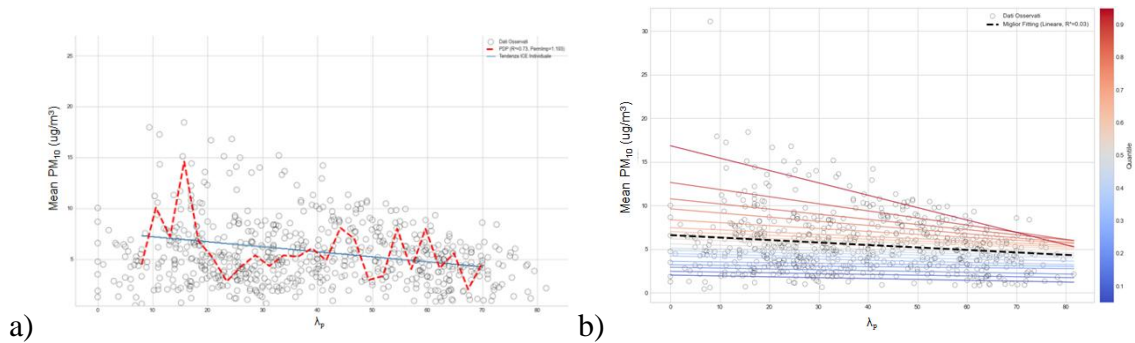


Figure 4. Graphs of a) random forest regression and b) quantile regression, showing the relationship between λ_p and concentration levels.

3.3 Field campaign observations

Hourly traffic profiles (Figure 5a) identified De Giorgi as the location with significantly higher traffic volume. NO concentrations (Figure 5b) largely mirrored these traffic patterns, with De Giorgi exhibiting higher peaks during morning and evening rush hours. The less trafficked locations like Deledda and Viadotto showed slightly lower NO values, consistent with their environments. PM_{2.5} concentrations (Figure 5c) followed a characteristic diurnal cycle, with nocturnal maxima attributed to a shallow planetary boundary layer trapping pollutants, and midday lows occurring when vertical mixing was enhanced. The Viadotto site exhibited the highest PM_{2.5} levels, especially during nocturnal accumulation, likely due to rural activities or the resuspension of PM from the surrounding soil. Deledda and De Giorgi, conversely, showed higher PM_{2.5} concentrations during the central hours of the day, possibly associated with secondary particulate matter formation. Please note that the stations at the three sites are undergoing a new calibration, thus the data are preliminary and may be subject to variations.

4. CONCLUSIONS

This integrated study highlights how urban morphology and traffic emissions impact air pollution. The ADMS-Roads model effectively simulates this with high-resolution inputs, showing promising results for pollutants patterns and statistical links to urban form. Field observations have been undertaken to reveal pollutant dynamics under varying conditions, providing an empirical basis for understanding air quality and traffic's

**23rd International Conference on
Harmonisation within Atmospheric Dispersion Modelling
for Regulatory Purposes
15-19 September 2025, Hamburg, Germany**

contribution. Subsequent research will utilise field measurements to validate ADMS-Roads predictions and develop future air quality scenarios. All instruments are currently still active, and data collection is ongoing, allowing for future analyses to explore seasonal patterns and strengthen the robustness of model validation over longer timeframes.

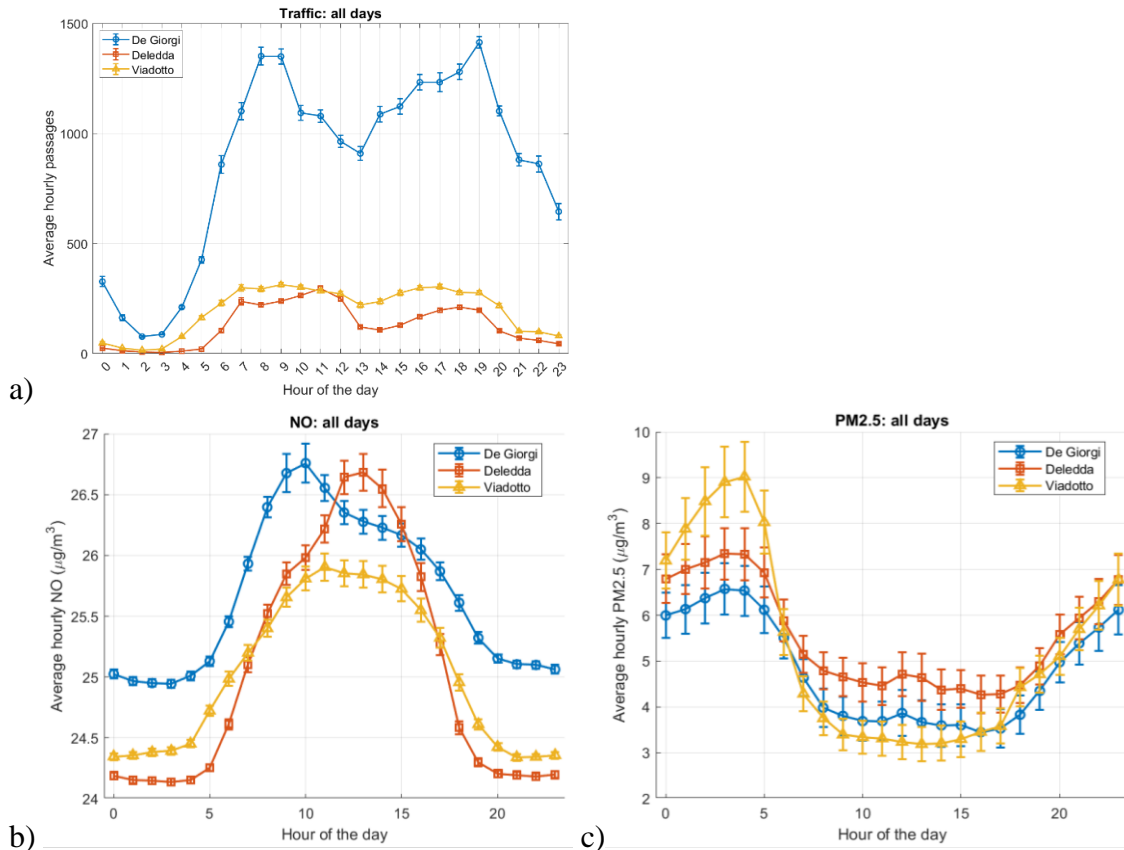


Figure 5. Hourly measured profiles of a) traffic, b) NO and c) PM_{2.5}.

Acknowledgements

The work has been funded by the European Union– Next Generation EU - PNRR– MISSIONE 4– COMPONENTE 2- INVESTIMENTO 1.4– Project Sustainable Mobility Center (Centro Nazionale per la Mobilità Sostenibile– CNMS) Spoke 7 - Code CN00000023, CUP: F83C22000720001. The ADMS-Roads software was made available by CERC - Cambridge Environmental Research Consultants.

References

- Li Z. et al. 2021. Review on pollutant dispersion in urban areas-part A: Effects of mechanical factors and urban morphology. *Build Environ.* 190, 107534.
- Metrangolo C., Dinoi A., Pappacogli G., Kumar P., Buccolieri R., 2024. Assessing urban air pollution dynamics: the impact of traffic emissions and urban morphology in Lecce and Bari, Italy. *Bull. of Atmos. Sci.& Technol.* 5, 13.