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Modeling NO_x and benzene emissions and exposure from road traffic and domestic heaters in street canyons: a case study in Verona, Italy

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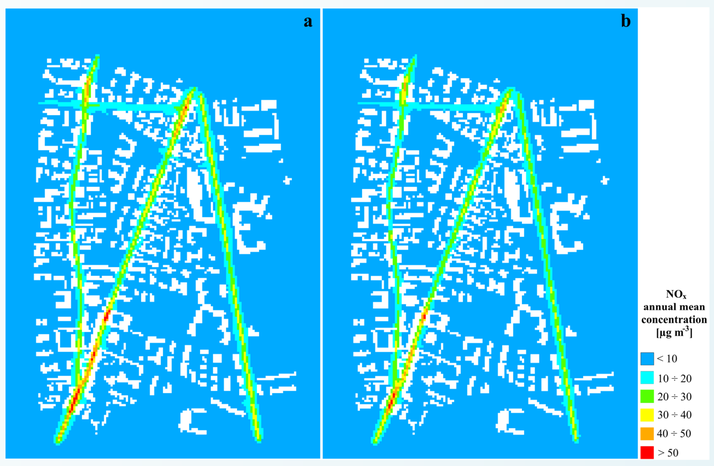
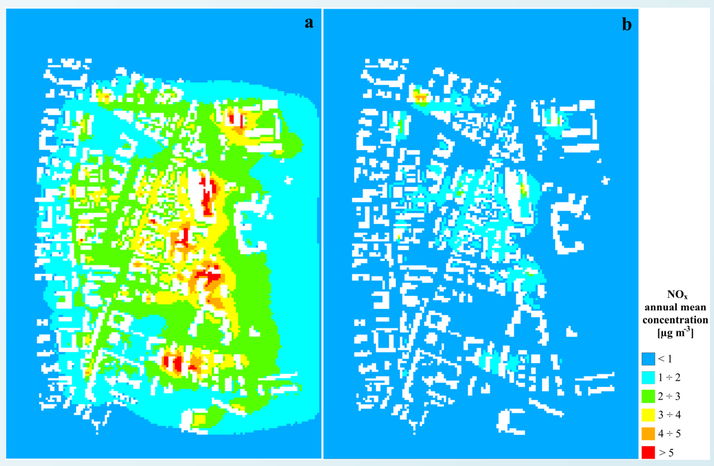
INTRODUCTION

Simulations of emission and dispersion of nitrogen oxides (NO_x) are performed in a dense central urban area of the city of Verona (Italy), characterized by street canyons and typical sources of urban pollutants. Two dominant source categories are considered: road traffic and domestic heaters. Also, to assess the impact of urban air pollution on human health and, in particular, the cancer risk, simulations of emission and dispersion of benzene are carried out. Emissions from road traffic are estimated by the COPERT 4 algorithm, whilst NO_x emission factors from domestic heaters are retrieved by means of criteria provided in the technical literature. Then maps of the annual mean concentrations of NO_x and benzene are calculated by the AUSTAL2000 dispersion model, considering both scenarios representing the current situation, and scenarios simulating the introduction of environmental strategies for air pollution mitigation. The simulations highlight potentially critical situations of human exposure that may not be detected by the conventional network of air quality monitoring stations. The adoption of mitigation strategies leads to overall improvements in the air quality, although high concentrations still occur within street canyons. The proposed methodology provides a support for air quality policies, such as planning targeted measurement campaigns, re-locating monitoring stations and adopting measures in favor of better air quality in urban planning.

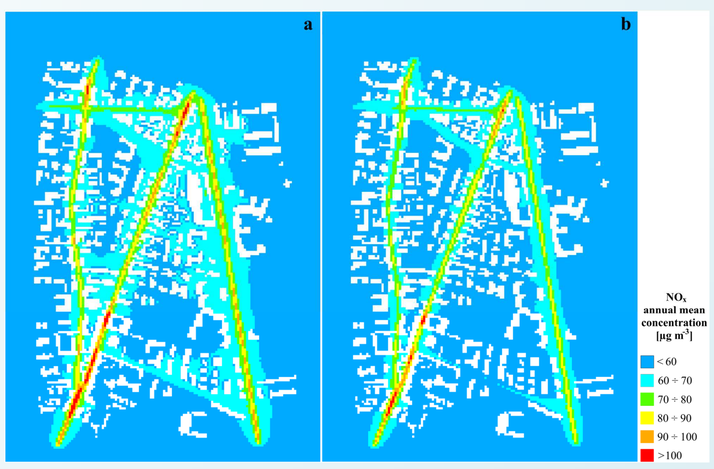
RESULTS



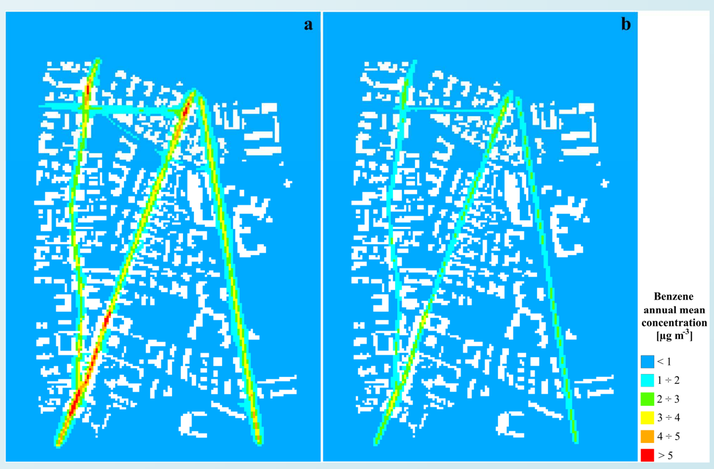
Maps of the NO_x annual mean concentrations induced *a)* by the whole vehicle fleet and *b)* only by the EURO 2 and latest vehicles.



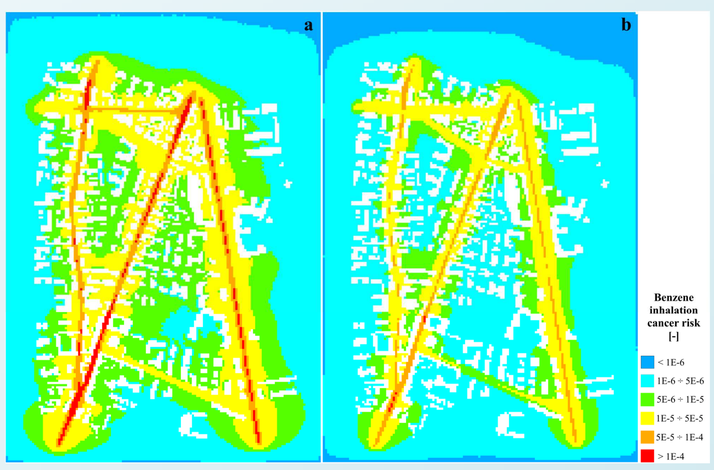
Maps of *a)* the NO_x annual mean concentrations induced by the current hot-water heaters and *b)* of the NO_x annual mean concentrations replacing the current hot-water heaters with condensing boilers.



Maps of *a)* the NO_x annual mean concentrations induced by the whole vehicle fleet together with the current hot-water heaters *b)* of the NO_x annual mean concentrations with only EURO 2 and newer vehicles and replacing the current hot-water heaters with condensing boilers.



Maps of the benzene annual mean concentrations induced *a)* by the whole vehicle fleet and *b)* only by the EURO 2 and latest vehicles.



Maps of the cancer risk related to lifelong exposure to benzene concentrations induced *a)* by the whole vehicle fleet and *b)* only by the EURO 2 and latest vehicles.

NO_x concentrations up to 58,9 µg/m^3 in Via Centro, close to a kindergarten (law's limit for NO_2: 40 µg/m^3). Heaters contribute for about **20%** of the annual mean concentrations. Restrictions to the most polluting vehicles and the adoption of enhanced hot-water heaters show significant reductions in NO_x concentrations.

The annual mean benzene concentrations induced from the whole vehicle fleet exceed the limit value (5 µg m^{-3}) in several points in the two street canyons.

Since the inhalation cancer risk is proportional to the concentration, the highest value (1.95E-04) occurs at the junction between the two street canyons, while a slightly lower risk value (1.85E-04) was calculated in proximity of the kindergarten of Via Centro.

MATERIALS AND METHODS

Study area

- analysis of the urban morphology by means of GIS techniques;
- information on the vehicle fleet of Verona retrieved from the most recent census;
- reconstruction of the vehicle fluxes along the road network from measurements.

- localization of the emission points;
- data on the heaters technologies;
- Consumption of natural gas in every building.

Two urban canyons in the study area

Via Scuderlando

Via Centro

Emissions

- Heaters: three temporal modulations (monthly, daily and hourly) for each building type (schools, shops, residential buildings). Literature emission factors for each type of heater.
- Traffic: *COPERT 4* model to estimate emissions from vehicles on the basis of the estimated traffic fluxes and vehicular fleet.

Result: hourly-mean emissions of NO_x from each chimney and hourly-mean NO_x and benzene emissions from the road traffic.

Dispersion model

AUSTAL 2000: lagrangian model to evaluate air pollutant dispersion at the local scale. Explicit treatment of obstacles (orography and buildings).

- input data: localization of pollutant sources, building morphology, hourly-mean emissions, hourly-mean meteorological data (Klug-Manier stability classes, wind speed and direction) measured at a nearby surface weather station;
- domain: 400 m x 990 m;
- resolution: 5 m x 5 m.

CONCLUSIONS

The methodology here applied provides a basis for air quality management policies:

- support for the localizations of sensitive buildings;
- support for planning measurement campaigns in areas without permanent air quality stations;
- support decisions on urban planning.

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