

Chapter 66

Analysis of the Differences Between Pollution Levels into a New and an Old District of a Big City Using Dispersion Simulations at Microscale

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Abstract The new residential district ‘CityLife’ is under construction inside the city of Milan, northern Italy, replacing the old structure of the trade fair. It consists of relatively insulated blocks, surrounded by many gardens and commercial buildings and no car traffic at the surface. The objective of this study is to simulate and compare the pollution level inside this new area with a more common residential district located not so far away. High resolution simulations have been performed inside two domains – having linear dimension of approximately 1 km – using a microscale modeling system, taking directly into account the effects of buildings and street canyons to the atmospheric mean flow and turbulence. Emissions coming from car traffic (around the new district and inside the old one), underground traffic (emerging from ground-level openings in the new district) and heating systems (during winter) have been taken into account. Background values have been estimated from local measurements using a box model and added to the simulated concentration fields in order to produce a complete view of the local pollution levels. Both average levels of pollution at district scale and local behaviours into sub-zones of the two domains where similar activities are supposed to take place are compared showing the potential benefits inside the new district both in absolute terms and in percentage, setting in evidence which portion of the pollution can be reduced by local interventions.

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D. Steyn and R. Mathur (eds.), *Air Pollution Modeling and its Application XXIII*,
Springer Proceedings in Complexity, DOI 10.1007/978-3-319-04379-1_66,
© Springer International Publishing Switzerland 2014

66.1 Introduction

In the city of Milan (Northern Italy) is under development the new residential district “CityLife”, characterized by innovative architectural and urban solutions in term of energy efficiency, local traffic and use of green spaces. This district represents the renovation of the old exhibition complex, located well inside the city of Milan. Within a zone of this type, potentially able to bring benefits to the local air quality, the air pollution due to the rest of the city must be added to the effects generated by local emissions. The aim of the work is to reproduce the levels of air quality in the new district through dispersion simulations at microscale, taking into account local effects at very high resolution. The results of these simulations are then compared with similar results obtained in a reference residential district with more traditional features, in order to verify the possible benefits for the population due to the new district design.

66.2 Modeling Setup

To perform the simulations, the MSS [1] modeling system, already tested in an urban context [1, 2], has been used. MSS is the combination of the meteorological Micro-Swift code and the Micro-Spray dispersion model [3], both able to directly take into account the effect of buildings. Micro-Swift is a mass consistent diagnostic 3D wind model, in which the aerodynamic effects due to the buildings are represented by analytical flow zones with a fast-response solution. Micro-Spray is a 3D Lagrangian Particle Dispersion Model taking into account of particle bouncings against obstacles, the effect of both a local and background turbulence and being able to consider different physical and geometrical emissions, such as those coming from traffic or domestic heating. Two urban areas are investigated representing the new CityLife district, (left side of Fig. 66.1) covering $900 \times 900 \text{ m}^2$, and a reference district, in the (right side of the same figure) with an extension of $1,100 \times 500 \text{ m}^2$.

Inside these areas, meteorological and dispersion simulations have been performed at 3 m horizontal resolution taking into account the complex structure of 3d obstacles. Two one-day periods representing typical and recurrent conditions in winter and summer have been simulated taking into account a complex set of local emissions (traffic, domestic heating). Ground level concentrations on hourly basis have been locally simulated for species NO_x , NO_2 , CO, PM_{10} , Benzene, PM_{10} , then background values have been estimated using a box-model and added to produce total concentration levels. Inside the new CityLife district, in the inner part of the first domain, heating systems are not considered as sources of pollutants, due to the presence of zero emission advanced heat pumps, while the only local traffic admitted here are the underground paths to parking spaces. Figure 66.2 shows an example of daily average NO_x concentrations generated by the contribution of different local sources inside the domain of the new district.



Fig. 66.1 Position of the two considered domains (black rectangles)

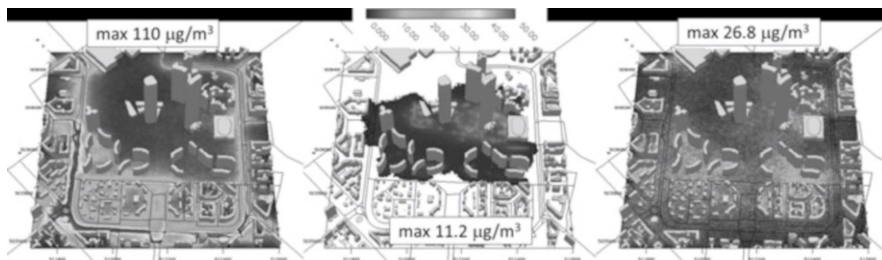


Fig. 66.2 Ground level daily averaged concentration maps of NO_x ($\mu\text{g}/\text{m}^3$) generated by the traffic around (*left*), internal to the new district (*center*) and domestic heating (*right*) in the winter case, CityLife district domain

66.3 Main Results

Total concentration fields inside the two domains for the various species considered have been used to compare a reference and existing situation to the one in the new district, in order to show the local potential benefits of the solutions adopted in this last case. This comparison shows systematic enhancements on the local levels of NO₂ at ground, up to 15 % on hourly concentrations during winter and about 40 % during summer. The situation for PM₁₀ shows to be less good due to the presence of higher levels of the background contribution for this specie, that prevents the possibility for a more drastic reduction of local concentration levels. In any case,

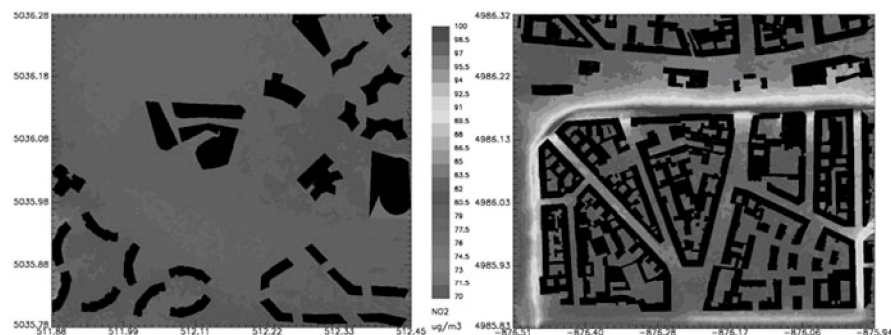


Fig. 66.3 Ground level concentration daily average fields of NO_2 in the winter case ($\mu\text{g}/\text{m}^3$), details of the CityLife district (*left*) and reference district (*right*)

also for PM_{10} a maximum reduction of the order of 5–6 % during winter and 25 % during summer is visible inside the CityLife district. The absence of traffic at surface level in the new CityLife district determines also local concentration levels lower for Benzene and CO. As an example, the Fig. 66.3 shows daily average concentrations fields for the NO_2 specie in the CityLife district and in the reference district. It is evident the impact of the main roads inside the reference district, generating local maximum present also into secondary roads and totally absent inside the CityLife district.

Inside the reference district the small distance among building blocks determines the presence of many urban canyons. This generates a more efficient vertical mixing of the emitted pollutants, leading to larger concentration values at vertical levels corresponding to the higher floors. Simulation results show that inside the new CityLife district, where the distance among building block is maintained larger, concentration levels up to 20 m in vertical remain smaller.

Acknowledgments The authors thanks CityLife S.p.A., for their support in supplying the data necessary for the realization of the work.

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