URBAN AIR QUALITY AND TRAFFIC IN FLEMISH CITIES

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Summary/Samenvatting

Op 26 juni 2005 stelde minister Peeters de modellen CAR en MOBILEE voor aan de pers en de Vlaamse steden en gemeenten. Met het CAR-model dat het Vlaams Gewest gratis aanbiedt kunnen steden en gemeenten voortaan zelf een eerste ruwe inschatting maken van de effecten van lokaal verkeer op de luchtkwaliteit in een straat. CAR werd ontwikkeld in het zog van het strategisch VITO-project MOBILEE (een samentrekking van mobiliteit en leefbaarheid). Tussen 2002 en 2005 heeft een multidisciplinair team onder leiding van VITO gewerkt aan de ontwikkeling van de methodologie en de opbouw van het MOBILEE model. Op een systematische en consistente manier worden alle milieu-effecten van een lokaal verkeers- of mobiliteitsplan onder de loep genomen: andere verkeersstromen, gewijzigde emissiepatronen en effecten op de blootstelling van de lokale bevolking. MOBILEE berekent concentraties van polluenten in de hele stad, zowel in tuinen en parken als binnenin zogenaamde stadscanyons (smalle straten omgeven door aaneengesloten bebouwing) met een superieure resolutie in ruimte en tijd.

In Vlaanderen geldt CAR nu als een eenvoudige screeningstool. Complexere problemen worden met de MOBILEE benadering van VITO bestudeerd. Enerzijds omdat lokale verkeersingrepen slechts een klein effect hebben op de concentraties en anderzijds omdat het risico bestaat dat problemen anders gewoon worden verschoven van de ene straat naar de andere. Het ter beschikking stellen van beide modellen heeft geleid tot een grotere bewustwording bij de lokale besturen en een grotere vraag naar MOBILEE-studies. Op dit ogenblik lopen er al studies in Antwerpen, Gent en Brugge.

1 Introduction

Road transport is known as one of the main sources of urban air pollution especially for NO_x and PM. In addition people are more exposed to air pollution in urban areas because emissions are released in the immediate vicinity of densely populated areas.

Some of the larger Flemish cities have implemented innovative transport and mobility policies in the past decade. Most cities focused policies on their (old) centres and on prevention of noise pollution. Private car use was discouraged in specific zones using measures on parking, speed reduction and provision of alternative travel modes.

Air quality never was the most important reason for local actions taken by cities. Moreover some of the actions taken to tackle noise problems or address traffic safety risks may well have had a negative effect on air quality (Int Panis et al., 2006).

Under pressure of the stringent European air quality standards more cities are now evaluating the air quality situation and looking for actions to take. It is expected that many cities and districts will fail to meet air quality standards when they take effect in 2010. Especially the daily average value for PM10 is often exceeded in numerous places while the number of exceedences allowed will decrease from 35 to only 7 each year. Knowledge of the health effects of PM10 has increased and many citizens are aware of them. This has lead to a growing concern at the local level and a greater willingness to cooperate with the regional authorities.

The Flemish environmental administration recent published a policy document "*Knelpunten luchtkwaliteit in 2010 als gevolg van verkeersemissies*" containing a long list of cities and communities where air quality is likely to be a problem in 2010 because of traffic emissions. The list is based on emissions from national & regional roads only. Exceedences caused by emissions from heavy traffic on local roads are not included. The Flemish government has decided to coach the cities and help them in the evaluation of hotspots and possible measures.

In this paper measurements and modelling are the two tools used to characterise the actual situation of the air quality of the city. Based on this information measures are defined and evaluated.

2 Methodologies available to cities

2.1 Questions to be addressed

Local policy makers have increasingly been turning to scientific institutes and consultants for support of their air quality policies. The questions asked in most cities are remarkably similar:

- What is the present air quality ?
- Has air quality improved due to local measures taken in the past ?
- Is traffic an important source of air pollution in our city ?
- Is it possible to take more measures ?
    - That have a relevant effect on air quality
    - That improve the situation in *all* streets
    - That are specific for each city
    - That allow us to meet air quality standards by 2010
- How do narrow street canyons affect local air quality ?

To answer the needs of cities, any methodology must address at least these questions. Necessary ingredients of useful methodologies must therefore include:

1. The identification of local hotspots
    a. Screening locally available information and experience
    b. Perform well targeted measurements
    c. Model emissions and concentrations
2. Evaluate measures
    a. Model sets of measures likely to significantly affect local air quality
    b. Evaluate specific measures within the local policy level (e.g. adaptation of the city council fleet)

2.2 The MOBILEE methodology

2.2.1 Introduction

On June 26th 2006 minister Peeters presented the computer models CAR and MOBILEE to the press and to the Flemish cities and communities. CAR was developed by TNO by order of the Flemish government. It can be used by local administrations to perform a quick-and-dirty evaluation of air quality and the effect of traffic in one street.

In parallel, a multidisciplinary team at the Flemish research institute VITO has developped its own MOBILEE methodology and MOBILEE model suite. Between 2002 and 2005 the Belgian federal science policy and VITO's strategic research fund joint forces and spent approximately 500000€ on the development of a tool for local policy makers. The result is a flexible model that can evaluate scenarios of air quality with a resolution in time and space that is superior to any other model.

In this way (and this was emphasized by minister Peeters) two complementary models are now simultaneously available. CAR is to be used as a preliminary screening tool. It has a low threshold for anyone wishing to find out if a specific situation could be problematic with respect to air quality. The order of magnitude of PM and NO_x concentrations predicted by CAR in one street will allow cities to assess if a more detailed study on a wider area is justified. The Flemish government recommends that more complex problems (in which the air quality of successive street canyons is interrelated should be studied with MOBILEE to avoid that problems are simply transferred from one street to another.

2.2.2 General approach

One of the outstanding features of MOBILEE is its integrated approach to the problem, where the whole city (or district) is analyzed as a whole. Both the local background and all local sources; traffic, heating and local industry are explicitly modeled.

The different phases of MOBILEE are described in the following paragraphs, but the actual content of any MOBILEE-project is always specifically tailored to meet the needs of each specific city.

2.2.3 The screening phase

Analyses at the Flemish level always risk to miss some of the local problems because of the generalizations they make. Likewise even a local approach may miss some potential problems if the area under study is not well defined. Each MOBILEE project therefore starts with a screening phase in which several actions are possible:

- interviews with key actors in the local administration
- preliminary modeling of emissions based on available traffic models
- semi-random measurements with passive samplers

2.2.4 The measurement campaigns

Existing air quality measurement networks measure air pollutants at different sites and give an 'average value' for the surrounding area. However, these measurement stations are (mostly) not located at hot spot locations (e.g. close to busy roads) identified in the screening phase. Actual urban values are mostly higher than expected due to traffic specific situations (e.g. congestion) or specific situations (street canyon effect).

PM_{10} daily average values are measured on at least 5 locations in the cities during 3-4 weeks representing different 'typical' traffic locations: e.g. ring road, access road, P route, local traffic, park. Most of the locations are kerbside sites. The measurements are performed according to the EU reference method (gravimetric) using a sequential high volume sampler. The measured values are compared to the EU limit value for PM_{10}. High volume samplers require sufficient space to be placed on the sidewalk and should be protected (Figure 1).

Figure 1: Sequential high volume sampler in a street canyon in Ghent

At most of these locations a mobile emission laboratory is used during one week to measure the weekly profile of NO_2 and PM_{10} (with TEOM-FDMS) on a ½ hours bases and to measure the size distribution of the aerosol using APS.

At about 15 other (mostly) traffic-related locations the PM concentration is measured for different PM fractions (**TSP, PM_{10}, $PM_{2.5}$ and PM_1**) during about 1 week. It is known that combustion-generated PM is more present in the finer fractions ($PM_{2.5}$, PM_1). The measurements are performed using a Grimm 1.108 laser spectrometer. A correction factor for the optical method is defined, making intercomparison of daily average PM_{10} values of the optical and gravimetrical method possible.

NO_2, which is also a traffic related pollutant is measured at all locations (weekly/(monthly) average) by diffusive samplers. In one of the cities also the monthly averages of other traffic-related pollutants are measured (BTX and aldehydes) by diffusive samplers. Diffusive sampler can be fitted into small housing that can conveniently be placed on existing traffic signs or lamp posts. Although they are out of easy reach, they are often vandalized, causing loss of material and data (Figure 2).

Figure 2: Housing using for optical PM device and diffusive samplers (see arrow)

Measured values are compared to the EU limit value for PM_{10} and NO_2. The values are also compared to data of nearby monitoring sites -which are used as 'background values'- in order to assess the 'traffic related increment'. Meteorological conditions are taken into account for data interpretation.

The main goals of the measurement campaign are:
- location of main hot spot sites (together with the modelling results) in the city
- on site measurement of the actual concentration of air pollutants in the city
- model validation

2.3 Modelling

2.3.1 Traffic flows and emissions

The starting point for any evaluation of traffic emissions and resulting air quality impacts is an existing traffic model. Almost all cities in Flanders have a working macroscopic traffic model describing the traffic flows. In some cases provincial sections of the Flemish TRIPS model have been used.

When MOBILEE was developed, a lot of effort was put in the development of methodologies based on microscopic traffic models. These have some clear advantages because the calculation of exhaust emissions can be based on the exact position and instantaneous speed and acceleration of every simulated vehicle. In the MOBILEE research project specific emission factors as a function of instantaneous speed and acceleration were derived (Int Panis et al., 2005). These emission functions were finally included in an emission module which was inserted in PARAMICS. In that way, traffic emissions are calculated simultaneously when carrying out the traffic flow simulations. This methodology offers the possibility to increase the resolution within street canyons and study the effect of e.g. speed humps.

In later projects this approach was abandoned because the disadvantages of using microscopic models outweighed the benefits. At present virtually no microscopic models are available for significant portions of cities or districts. Existing models usually describe only a single intersection. Building an extensive microscopic model is an effort that is too expensive and cannot be justified for air quality calculations only.

MOBILEE therefore uses the Flemish MIMOSA emission model which is based on the well known Copert / MEET (1999) functions that were designed for emission estimation at the macroscopic level. They correlate specific emissions of the pollutants CO, CO_2, NO_x, VOC and particles to the average trip speed and do not include the instantaneous acceleration as an explanatory variable. MIMOSA has been specifically tailored to the emissions of the Flemish fleet and local circumstances.

2.3.2 Air quality

Air quality in an urban region is determined by the emissions in the region upwind of the receptor and –if the receptor is located inside a street canyon-, by the emissions in that street canyon. The Danish model OSPM (Cosemans et al., 1992) is probably the best model available for estimating concentrations resulting from traffic emissions in a street canyon. The Belgian bi-Gaussian model IFDM (Cosemans, 2005) is a reliable tool for the impact assessment of time varying emissions from point sources (industry), area sources (residential heating) and line sources (traffic lanes).
OSPM and IFDM have been integrated into a the new MOBILEE software that allows for the computation of the impact of all emissions affecting a region, taking into account the street canyon effect for those receptors where this is required. The combined result is usually explained to local policy makers as the concentrations “above the roofs” and “within” a street canyon (Figures 3 and 4).

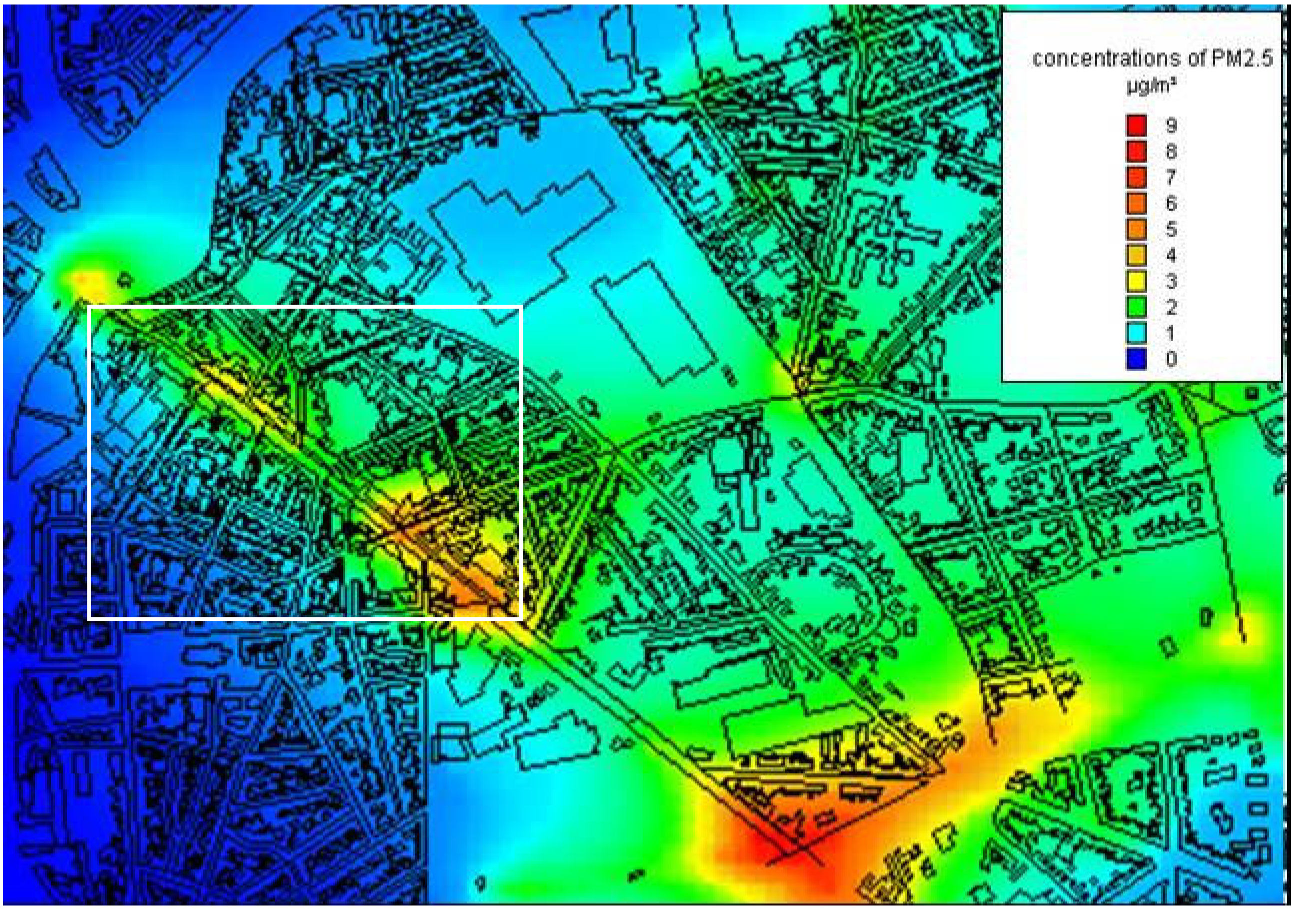

Figure 3: Contribution of local traffic to general PM levels in Ghent (district of Gentbrugge). The street canyons within the white rectangle where modeled in detail (Figure 4)

Standard output, such as percentiles of hourly or daily concentrations, yearly averages, average concentration for each hour of the day,... can be readily calculated. For the IFDM sub model, a network of line sources is derived from the hourly emission data for each line source. These emissions are used to compute the air pollution over the urban region, including the pollution that enters the street canyons due to upwind sources. Next, for a selected region of interest, OSPM receptors are created every 10 or 15 meter along the street axes of the street canyons in that region. For each receptor, a description of the street canyon geometry and of the emissions therein is generated, as well as a line source which is used to prevent double accounting of the emissions in the street.

The main advantage of this new approach is that the evaluation of air quality inside street canyons is nested inside the overall air quality model and takes it boundary conditions from it. In this way possible hotspots are identified as a group of street canyons; a continuous area of connected narrow streets and their side streets that are often street canyons as well.

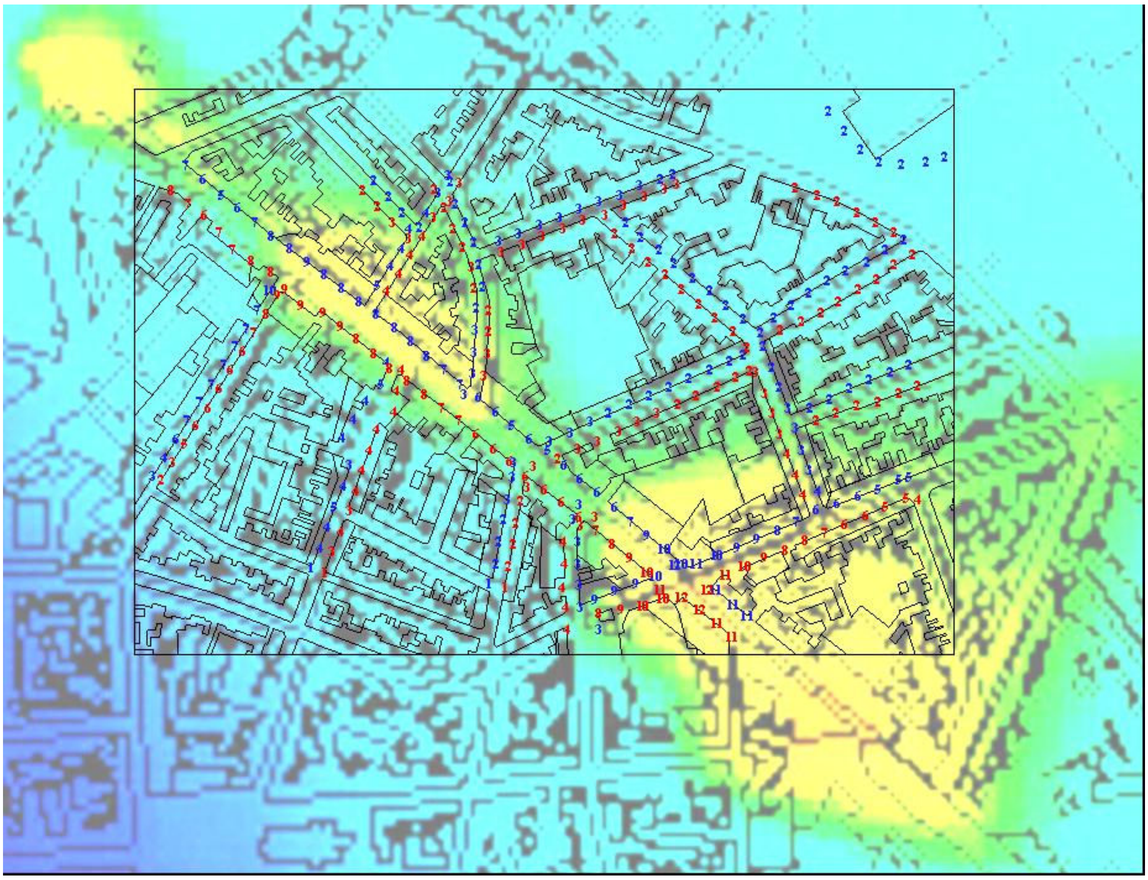

Figure 4: PM2.5 concentrations inside the canyons (red and blue numbers) are approximately twice as high as those resulting from the general modeling (Figure 3, and background)

3 Discussion

Since the launch of the MOBILEE approach their has been plenty of interest among local policy makers, resulting in a number of workshops and a large number of preliminary ideas. MOBILEE studies are now ongoing simultaneously in three Flemish cities: Bruges, Ghent and Antwerp. Both in Bruges and in Ghent, the city council ordered a study of the town centre, including the main roads leading in and out of the city. First results will be presented to the local authorities by the end of 2006. Final results will be available from the cities in 2007.

The combination of measurements and modeling in a complementary design ensures the usefulness of the results. Most local policy makers initially favor a study design based on measurements only because they distrust models.
Measurements do provide an accurate assessment of concentrations at a particular location and a given time, but it remains difficult to generalize the results to other locations or different meteorological conditions. In addition measurements cannot be used to assess the 2010 situation until its too late. Models can provide contiguous estimates of concentrations over wider areas and predict evolutions over time, allowing to evaluate measures and policies. The combination with measurements allows to calibrate the model and significantly increases the value of the modeling results.

In most cases we support the calculation of a single scenario for the future which includes all additional measures deemed feasible by the local actors. It was demonstrated during the research project that the calculation of the effect of individual measures is not very useful and usually negligible. Only the evaluation of the full set of measure displays a significant effect on local air quality and allows to make a street by street assessment of the improvements.

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