AIR POLLUTION LEVELS AT HOTSPOT AREAS OF SELECTED EUROPEAN CITIES

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INTRODUCTION

In the development of the EU air quality legislation prior to the Clean Air for Europe programme (CAFE), as well as in projections of air quality across Europe accounting for existing and new policies and measures (EEA and DGEnv work), Integrated Assessment modelling was carried out with the RAINS model and focused on the analysis of regional scale concentrations in Europe. However, ambient concentrations of certain air pollutants show strong variability at a much finer scale (e.g. urban and local scale). Measurements at traffic stations located in streets across Europe show that air quality close to areas with increased traffic is of particular concern. Moreover, evidence of the adverse health effects of fine particulate matter is continuously emerging and the fact that most of the traffic related emissions are in the fine particulates range (<$PM_{2.5}$), the problem is alarming. Studies of short and long-term exposure to air pollution suggest an increased mortality, increased risk of chronic respiratory illness and the development of various types of cancer (e.g. *Pope et al.*, 2002). For all the above reasons, the urban and local scales should also be accounted for in the design of air pollutant abatement strategies, in particular considering that human exposure to increased pollutant concentrations in densely populated urban areas is high.

METHODOLOGY

This paper presents the increased air pollution levels at traffic hotspot areas in 20 European cities, compared to the urban background concentrations. The current situation (reference year 2000) and two scenarios aimed at 2030 (Current Legislation, CLE, and Maximum Feasible Reductions, MFR) described in detail in *Cofala et al.* (2005) were considered in order to analyse and project air quality. In line with the nature of air quality assessment and air pollution abatement strategies, a multi-pollutant, multi scale approach has been adopted. The analysis was performed for NO_2, NO_x, PM_{10} and $PM_{2.5}$ using a complete regional-urban-local scale modelling sequence developed in the SEC project (*Moussiopoulos et al.*, 2005). The urban scale OFIS model (*Arvanitis and Moussiopoulos*, 2003) was applied, driven by results of the regional scale model EMEP (URL1). In turn, the local scale OSPM model (*Berkowicz et al.,* 1997) was applied using OFIS results to derive the urban background conditions required.

The urban emission inventories required as input to the OFIS model were developed in the frame of the MERLIN project for the 20 cities through the application of the European Emission model (*Friedrich and Reis*, 2004; *Schwarz*, 2002; *Wickert*, 2001). For local air quality analysis, specific street canyon characteristics were required in order to define particular case studies (types of streets) in each city. Due to the absence of such detailed data for street types across Europe, a generic approach was adopted. The hypothetical street canyons for which OSPM was applied were defined in the "Typology Methodology" representing a first attempt to categorise street types according to various parameters and parameter ranges (*van den Hout and Teeuwisse*, 2004). TREMOVE (*De Ceuster et al.*, 2005) and TRENDS (*Giannouli et al.*, 2005) models were used to calculate the vehicle fleet data and then local emissions were calculated with the COPERT 3 emission model (*Ntziachristos et al.*, 2000).

RESULTS AND DISCUSSION

The urban background concentrations obtained with OFIS and used for the street level model OSPM are presented in *EEA* (2005a) and were found to compare well with Airbase measurement data (URL2). The results also compared well with the $PM_{2.5}$ urban estimates obtained using the RAINS model and the City-Delta functional relationships approach (*Amann et al.*, 2005).

The street increments (i.e. the difference between the street and the urban background concentrations) presented in detail in *EEA* (2005a) were calculated for NO_2, NO_x, PM_{10} and $PM_{2.5}$ for three hypothetical street canyon configurations. Here the results for NO_2 and $PM_{2.5}$ are presented for the narrow canyon configuration (height=15m and width=10m) with average daily traffic 20,000 vehicles per day. The streets were assumed to be centrally located, i.e. the urban background concentrations were assumed to be adequately described by the OFIS results for the centre of the city. The street orientation was assumed to be East to West and wind speed and direction for each city were derived from EMEP data. Figures 1 and 2 show the model results for the reference year (2000) and the CLE and MFR scenarios. Airbase measurements for the year 2000 are also presented for comparison. Due to lack of data availability for certain cities and certain pollutants, the years 2001, 2002 and 2003 were also used, as they are undoubtedly good approximations for the level of the concentrations measured in 2000. Due to the lack of reliable vehicle fleet data for the cities located in non-EU15 countries, it was not possible to compute realistic attenuation factors for the projection year 2030, hence these were not considered in the scenario analysis.

The measured street increments were calculated using the maximum measured street and background concentrations in each city, considered to represent as far as possible the concentrations observed close to the centre of the city and so comparable to the modelled street increments. Inevitably, this introduces an uncertainty as the increment depends critically on the location of the respective urban background and traffic stations, which are often not close to each other. This can lead to either an overestimation or an underestimation of the measured street increments depending on whether the street station is located in the city centre and the urban background station far from the centre or vice-versa. Moreover, agreement or disagreement between measured and modelled street increments will be strongly affected by the question of how similar the actual street geometry, orientation, traffic characteristics, etc. are to the hypothetical streets studied. For these reasons, it should be noted that the aim of Figures 1 and 2 is not to show an ideal comparison with measurements, but rather to provide an order of magnitude of the street increments for the various pollutants across European cities for the current situation and two alternative scenarios.

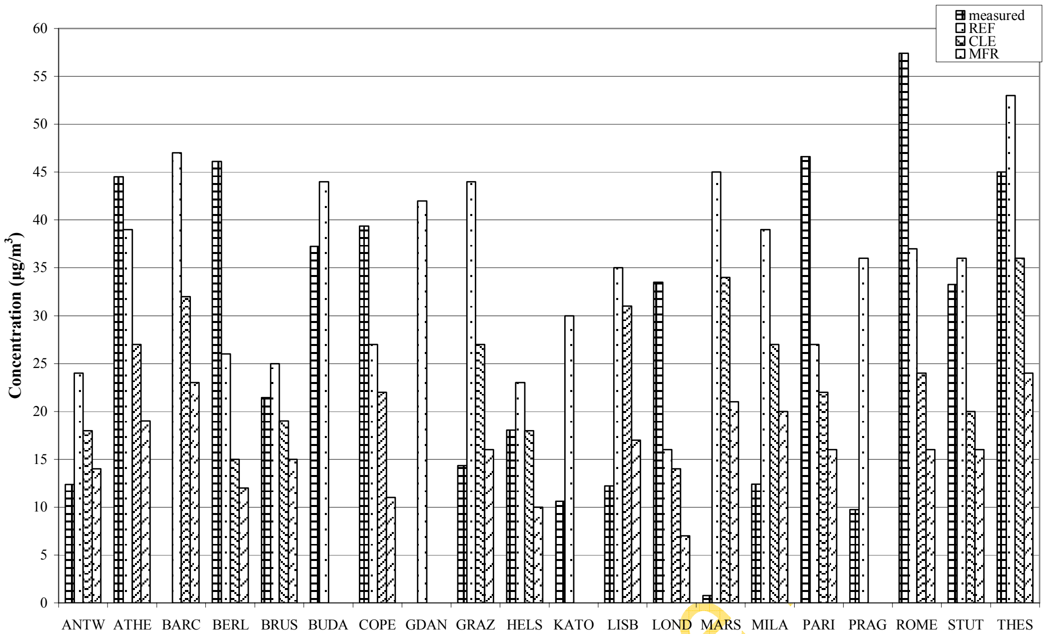

Fig. 1; Annual mean NO_2 calculated street increments for cities across Europe in 2000 compared against measurements and street increment projections in 2030 according to the CLE and MFR scenarios.

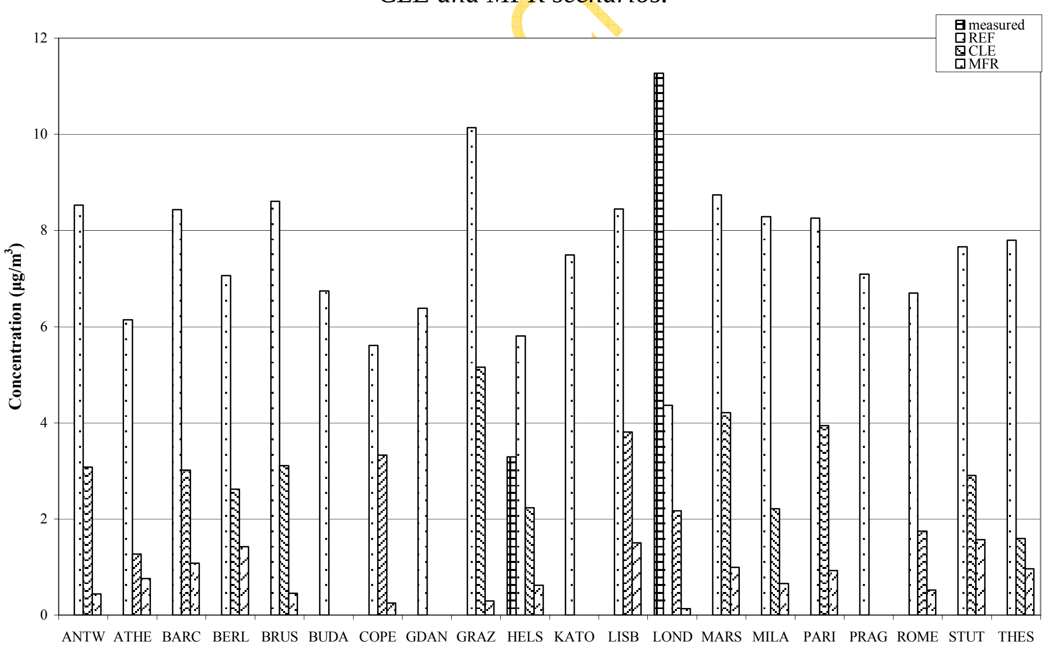

Fig. 2; Annual mean $PM_{2.5}$ calculated street increments for cities across Europe in 2000 compared against measurements and the street increment projections in 2030 according to the CLE and MFR scenarios.

In the case of NO_2, large but comparable variations are observed from city to city in both the measured and the modelled street increments (10-57 µg/m^3 and 16-53 µg/m^3 respectively). A reduced street increment is projected according to both scenarios and ranges from 14-36 μg/m^3 in the CLE and 7-24 μg/m^3 in the MFR scenario.

For $PM_{2.5}$ the range of the modelled street increments for the narrow canyon is 4-10μg/m^3. From the few data available, the measured increment is found to range between 3.3 μg/m^3 in Helsinki to 11.3 μg/m^3 in London. In the year 2030, a larger reduction is projected for $PM_{2.5}$ compared to NO_2. The range of values for cities across Europe is projected to be between 1.3-5.2 μg/m^3 and 0.1-1.6 μg/m^3 in the CLE and MFR scenarios, in line with the significant reductions in the urban scale emissions and hence the background concentrations as well as in the street scale PM emissions, attributed to the EURO 5 and EURO 6 technology vehicles. The difference between measured and modelled increments in the London case can be attributed to the dissimilarity of the actual street canyon characteristics compared to the hypothetical canyon and the distance of the urban background station location. The measured increment has been calculated using the Marylebone Rd. and Bloomsbury station data (located approximately 2km apart). Marylebone Rd. is a wide canyon with ~85,000 vehicles per day and ~10% Heavy Duty Vehicles (HDV), whereas the hypothetical street canyon assumes 20,000 vehicles per day and 7% HDV.

CONCLUSIONS

The application of the multi-scale model approach using the EMEP, OFIS and OSPM models, in conjunction with generic values assumed by the typology methodology, leads to reasonable results. Overall, the selection of the specific street configurations (fleet composition, traffic volume etc.) has led to a good approximation of the street increment. It is apparent that a measured increment exceeding the modelled one could be associated with the use of a much too low urban background value, whereas the opposite could well imply that there are hotspots in the city with air pollution levels higher than the measured street concentrations. The comparison of modelled and measured increments also reveals the restrictions of the hypothetical street canyon configurations since the worst street increments may have been missed (see Berlin, Paris, Rome and London NO_2 street increments and London $PM_{2.5}$ increments), as the worst street canyon configurations in terms of street geometry and traffic characteristics have not been explicitly considered. The precise HDV % and average vehicle speed per day were found to play the most important role in the emission calculations. Both quantities can vary significantly from street to street affecting strongly NO_x and PM emissions and thus the range in the modelled concentrations. A number of different street canyons with different assumptions concerning street orientation, prevailing wind, aspect ratio etc. need to be studied for an even larger number of cities prior to drawing final conclusions regarding the sensitivity to particular parameters and defining with confidence the appropriate ranges of parameter values which will allow for a generalised approach to estimate pollutant concentrations in streets.

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