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THE PERFORMANCE EVALUATION OF WinOSPM MODEL FOR URBAN STREET CANYONS OF NANTES IN FRANCE

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Abstract. Air quality modelling is primarily the quantative approach. It is more difficult as it demands input data accuracy, uncertainties and the efficient methodologies to judge the extent of models accuracy. As a result, model validation has to be regarded as an integral part of the modelling process. Furthermore, models are often validated on a limited number of testcases therefore, appropriate evaluation procedure must be implemented to ensure these models will be applicable for various conditions. The study presented here was carried out to evaluate the WinOSPM (Preliminary version of windows based Operational Street Pollution Model) for air pollutants viz. CO, NO, NO_2, NO_x and C_6H_6 for three street canyons of Nantes (France) and for the three base years 1999, 2000, and 2001. Each street canyon selected for this study has typical and unidentical features. The rue de Strasbourg and Boulevard Victor Hugo have many building exceptions whereas rue Crébillon has not any. Application of the model above to the three street canyons revealed that WinOSPM could be used in the case when measurements are not available. This was justified from the results at rue Crébillon. The special interest was in the benzene modelled values as its content in fuel has been targeted to reduce to 1% for the years 2000 and onwards (from its 5% until the year 1999). The 50 to 70% reduction in the benzene concentrations is found for both the years i.e. in 2000 and 2001. This has further justified that air quality models are useful and interesting tools in optimising emission reduction strategies. Moreover, it is also the new pollutant added to the measurement campaign of Air Pays de la Loire (APL) for the city of Nantes. For benzene weekly averages are estimated from the hourly-modelled values for all the streets and compared with that of measurements. They are found in excellent agreement with each other's. For other pollutants annual means and percentiles were compared. The statistical analysis was done to evaluate the models performance using index of agreement and correlation coefficient. The index of agreement (d) and correlation coefficient (r) for all the streets show that estimated concentration levels are in good agreement with that of measurements. From the index of agreements, it can be inferred that model has very less potential for errors. The model's sensitivity to building-exceptions was also tested for the rue de Strasbourg. Results did not reflect this feature very well. It is perceived that the influence of this feature might have been suppressed in averaging the annual hourly values. This influence is apparently seen in hourly average time series variations. Finally, WinOSPM model was found a simple but very useful model. It could very well represent the detailed flow and dispersion conditions in urban streets.

Keywords: benzene content, COPERT methodology, OSPM, street canyon modeling performance evaluation, traffic emissions

1. Introduction

Due to rapid growth of traffic volumes within urban areas, pollutant concentrations are still receiving a lot of attention in densely built-up areas where people are concentrated and where both buildings and the people are more affected. Dense settlement and high traffic density often lead to bad pollutant dispersion conditions and thereby increased exposure risks. To assess pedestrian exposure and the people living close to streets in urban environment demands to have efficient air quality models, the model development and micro-level validation studies. Efficient and validated models on varied conditions are the need of hour these days as they are the essential tools in understanding the pollutant dynamics in the urban atmosphere. There are not many air quality models which involve both chemical dispersion schemes and basic street-flow features in a simple way and which are yet reliable for regulatory purposes. Operational street pollution model (OSPM) is one of such parameterised model. It has been developed by the Department of Atmospheric Environment, National Environmental Research Institute, Denmark. The model calculates concentrations of exhaust gases combining a plume model for direct contributions and a box model for the recirculating part of the pollutants in streets. An important original feature of this model is that turbulence in the street is modelled taking into account both the effects of atmospheric turbulence due to wind speed and the effects induced by traffic. Traffic-induced turbulence dominates for low and calm wind conditions. Note that it is under such weather conditions that, from statistical point of view, extreme events occur. The model also takes into account the wind meandering effects by averaging the calculated concentrations over a wind speed dependent wind sectors. It is argued that the quality of input data, such as e.g. emissions, is often not sufficient to justify application of more complex numerical tools. However, although this model makes use of a priori assumptions about flow features and dispersion mechanisms, it requires to be validated for varied meteorology and street configurations so as to carefully document its performance and limitations (Berkowicz, 2000).

The main objectives of the study were i) to model the concentration levels of pollutants viz. Benzene, CO, NO, NO_2 and NO_x for three street canyons in the city centre of Nantes (France) using the WinOSPM model (Window version released in August 2002); ii) to evaluate the performance of the model by comparison of the base years 1999, 2000, and 2001 modelled concentration data with measured data; iii) to examine the influence of parameters such as the height to width ratio and presence or not of building exceptions.

The paper is organised as follows: the first section describes the street canyons selected for the study along with their relevant features. The second section presents the parameterised details of the model. The third section presents the experimental methods used for field data collection carried out in this work. While the fourth section focuses on the sensitivity analysis. Relevant results are discussed. The

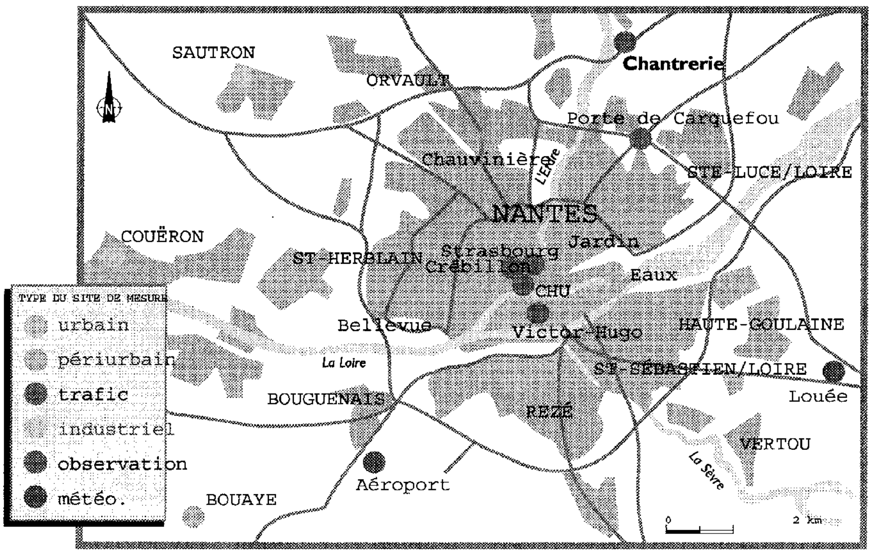

Figure 1. Map showing the monitoring locations in the city of Nantes, France.

fifth section describes the performance evaluation done on WinOSPM using some statistical indicators.

2. Selected Street Canyons

Three street canyons were chosen for the study viz. Rue de Strasbourg, Rue Crébillon and Boulevard Victor Hugo in the city centre of Nantes. The map in Figure 1 shows the locations of monitoring stations in and around the city. The selected street canyons are representative of the general road network in the city centre as shown in Figure 2. They have typical unidentical geometrical configurations. Of them, rue de Strasbourg is a 3-lane, one-way street with an average traffic of around 20000 vehicles a day. It is treated as a type 2 (broad urban) street. The street is flanked by dense high rised buildings of unequal heights. For modelling purpose a mean height of 21 m was considered. Although the width of the street varies near exceptions and average value of 15 m was taken. These mean parameters give a mean W/H ratio of 0.7. The street orientation is 150^{O} towards South with respect to North. This street has 9 building exceptions over 250 m.

The second street, rue Crébillon, is a single-lane street. An average of around 10000 vehicles ply on this street every day. It is treated as type 1 (narrow urban) street. The street is surrounded by dense high rised buildings having unequal heights. We considered a mean height of 23 m, and the width of the street was averaged to about 9.5 m. These mean parameters give a mean W/H ratio of 0.4, which is very small. Rue Crébillon is well representative of a street canyon with almost no

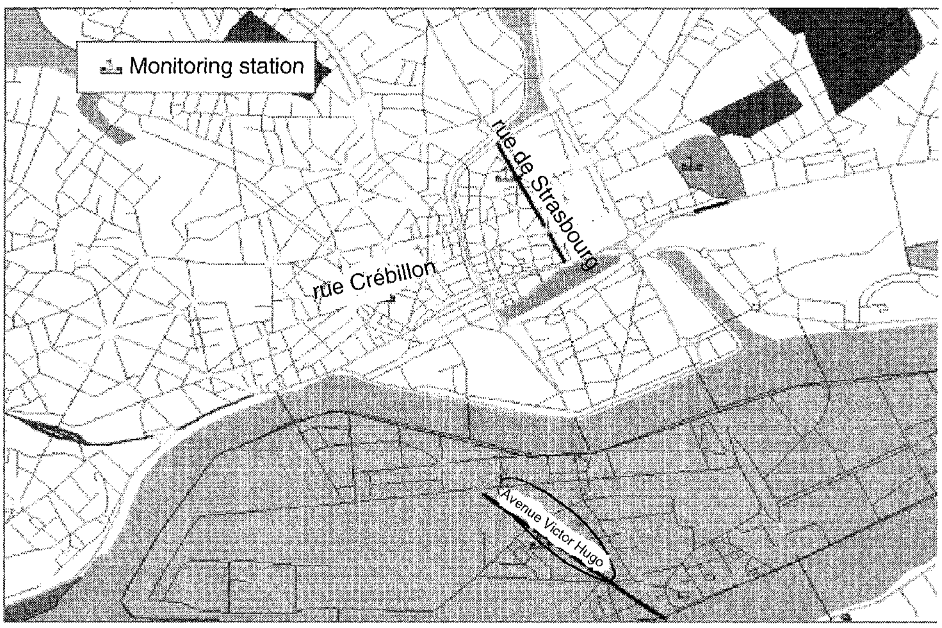

Figure 2. Locations of streets and monitoring stations for the selected streets canyons in city of Nantes.

building exceptions. The street orientation is 65^{o} towards South with respect to North.

The third street canyon, Boulevard Victor Hugo, is a 2-lane, two-way and highly trafficked street. An average of around 25000 vehicles ply on this street in a day. It is treated as a type 2 street. The street is surrounded by high rised buildings of many varied unequal heights. Hence, for the modelling purpose the height of the buildings was considered 0m (zero) and the varying buildings height around the street was configured by taking exceptions height. The width of the street varies near exceptions. It was averaged to about 14m. The street orientation is 127° towards South with respect to North. The configurations for all the streets are shown in Figures 3a,b,c. The street geometrical data such as street widths, mean heights of buildings surrounded by streets, orientations of streets with respect to north, etc were obtained from CERMA laboratory, Ecole d'Architecture, Nantes.

3. Model Parameterisation Details

The model requires hourly meteorological data inputs. Meteorological data include wind speed, wind direction, temperature and global radiation. Wind speed and directions are those above roof level in the city. Temperature and global radiation are used to compute chemical transformations between NO, NO_2, and O_3. Hourly

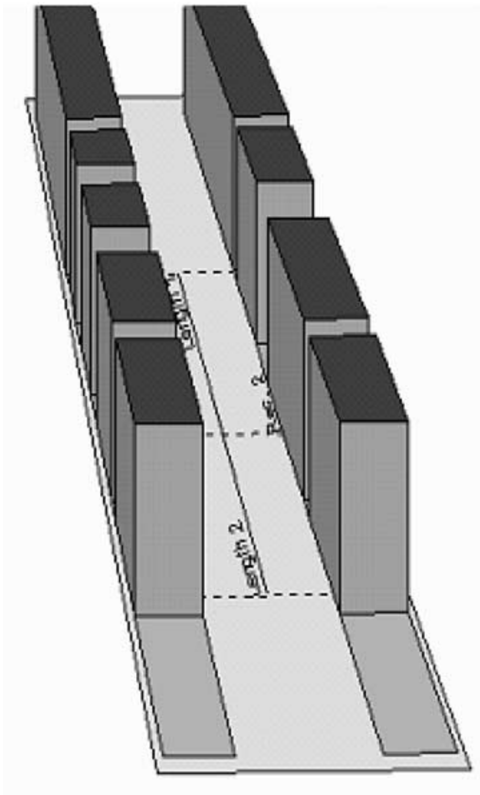

Figure 3. (a) Street configurations for Strasbourg with surrounded buildings.

urban background concentrations can be approximated by if regional data is available. However, it calculates the urban background from the predefined population data. Another information required to estimate emissions is the relative distribution of vehicle types (such as e.g. passenger cars, vans, trucks and buses) and the fraction of the daily total for each vehicle types. However to use such predefined data the average daily traffic and the average traffic speed for the street have to be specified. Pre-defined traffic data can be provided for typical street types with specific traffic conditions, such as e.g. main streets in the city centre, streets in residential areas, etc (type 1, type 2, etc). Traffic emissions are calculated knowing the traffic flow in the street (vehicles/hour) and emission factors (g/vehicle/km). Furthermore, each of these vehicle types comprises several different (vehicle) subcategories depending on fuel type, the technology and type of emission reduction equipments (such as catalytic converters) and also the age of the vehicle. Emission factors for these sub-categories can differ substantially. The methodology for calculations of speed related emission factors adopted in this model is based on the European Emission Model COPERT-III. The speed refers to the average traffic speed. These emission factors can be used throughout Europe. However, they should be correc-

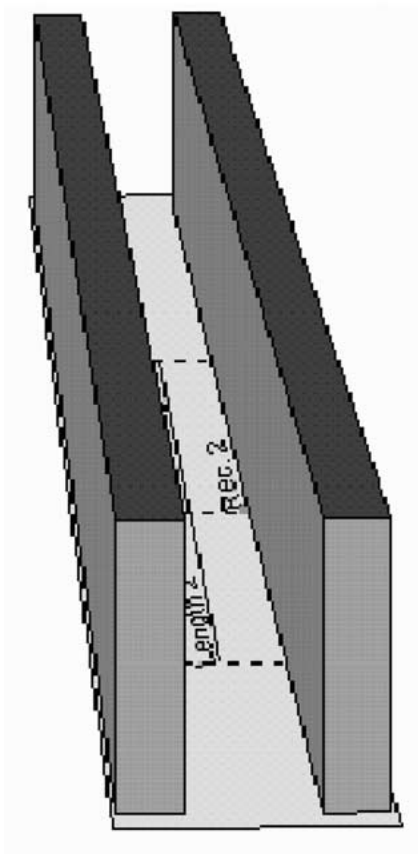

Figure 3. (b) Street configurations for Crébillon with surrounded buildings.

ted to account for cold starts and mileages as per applied local conditions. These corrections are the effect of cold start on the emissions and the mileage, which is to take into account the deterioration of emissions with the age of vehicles. However, for the pollutants namely benzene, the emission factor depend also on its content in the fuel. The COPERT methodology applies for present vehicle fleet as well as for the future vehicle types considering expected emission reduction norms. This may allow conducting calculations for the future expected air quality in streets. This requires, however, a forecast of future traffic compositions. The model also has a facility of calculations for different set of scenario years depending on the country settings. The data on the national fleet composition for the particular scenario year is also required to be provided.

The output of the model is very flexible in defining the parameters, which should be displayed. It models the concentrations for maximum 2 receptors on windward and leeward side of the street. The model also includes a special mode tool to analyse the dependence of air quality on wind speed and direction for a given street

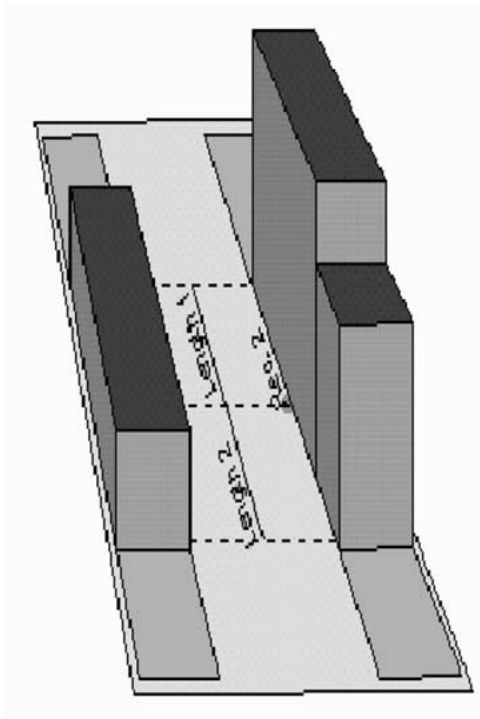

Figure 3. (c) Street configurations for B Victor Hugo with surrounded buildings.

geometry. The calculations are performed for a combination of wind directions and wind speeds and the results are presented in graphical form (Berkowicz, *et al.*, 2002).

4. Experimental Methods for Field Data Collection

4.1. CONCENTRATION DATA

The measured pollutants data were obtained from the monitoring stations maintained by APL in all the selected street canyons. Hourly averages were taken for three years 1999, 2000, and 2001. The receptor height was 3 m in rue de Strasbourg, and 2 m in rue Crébillon and rue Boulevard Victor Hugo. Urban background concentrations levels were obtained for all pollutants and for all the years. This data were measured at the monitoring station namely JAPL which is around a kilometre away from major streets in the city centre of Nantes and CHAU and used in modelling the pollution from all the street. The pollutant background concentrations measured at JAPL station are NO, NO_2, NO_x, O_3. Benzene and CO were obtained from the measurement at monitoring stations Verdun in La Rochelle and Michelet in Nantes respectively (see Figure 1).

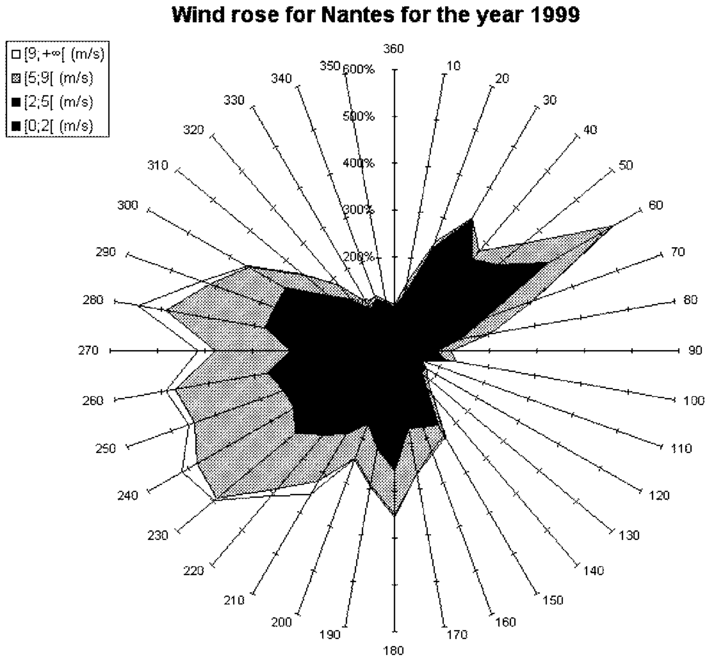

Figure 4. (a) Wind rose for the year 1999.

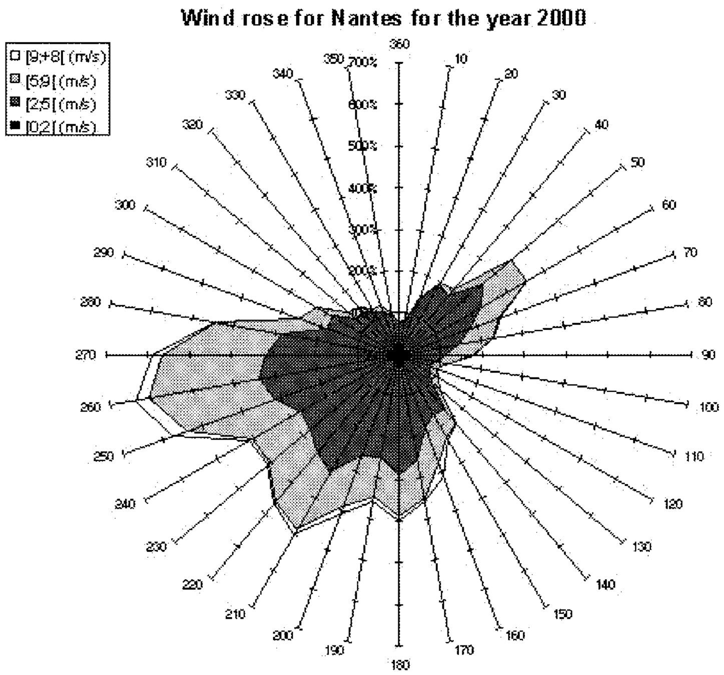

Figure 4. (b) Wind rose for the year 2000.

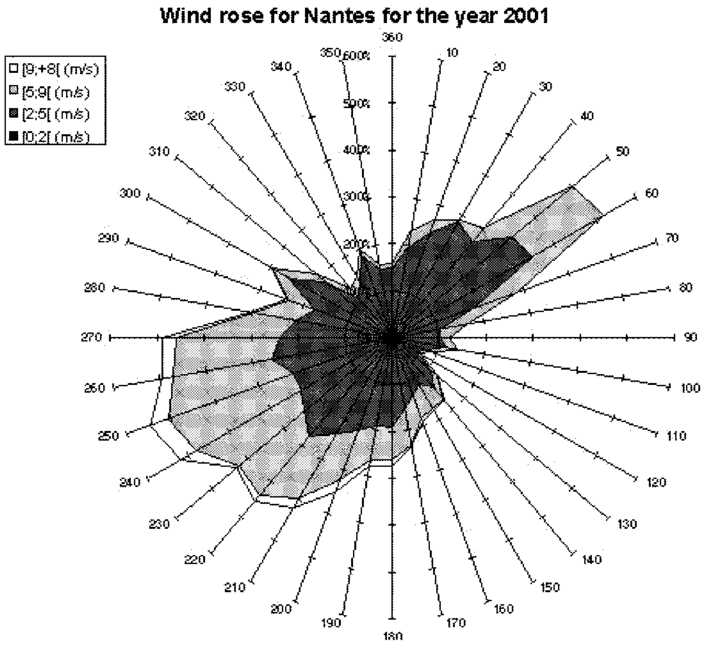

Figure 4. (c) Wind rose for the year 2001.

4.2. METEOROLOGY

Hourly averaged meteorological variables including wind speed, wind direction, temperature, global radiation have been obtained from the Meteo France for years 1999, 2000, and 2001 and supplied in the WinOSPM formats. Relevant wind roses are plotted in Figures 4a,b,c. The predominant wind direction is SW-NE for all the years with the average wind speed of 3.7 m sec^{-1}. The type of meteorological data used are sequential time series.

4.3. TRAFFIC AND VEHICLE SPEED FRACTIONS

Traffic count and vehicle speeds were obtained from the road technical centre of Nantes for all investigated years. The hourly traffic fractions were estimated for weekdays, weekends, public holidays and for vacations. These fractions are based on peak-hour traffic records at 17:00–18:00H on tuesdays taken as the 100% basis for both street types 1 and 2. Annual traffic was estimated from monthly fractions from the traffic report for Nantes (Traffic report, Nantes, January, 2000). The average diurnal total traffics for all vehicle fractions are shown in Figure 5. Corresponding average diurnal emissions for total and for all vehicle fractions and all observed pollutants are plotted in Figures 6. The hourly vehicle speeds were also estimated based on the same hourly fractions. These speed fractions were further distributed into long and short vehicle speeds. Long vehicle speed was reduced

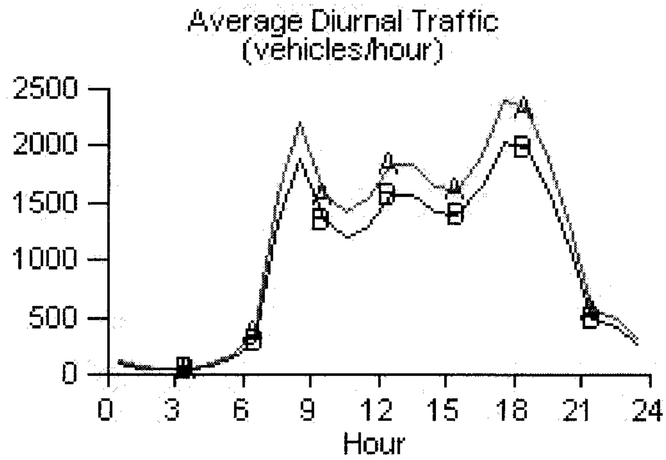

Figure 5. Diurnal variation total traffic and the compositions of the total traffic. A: Total traffic and B: Passanger cars.

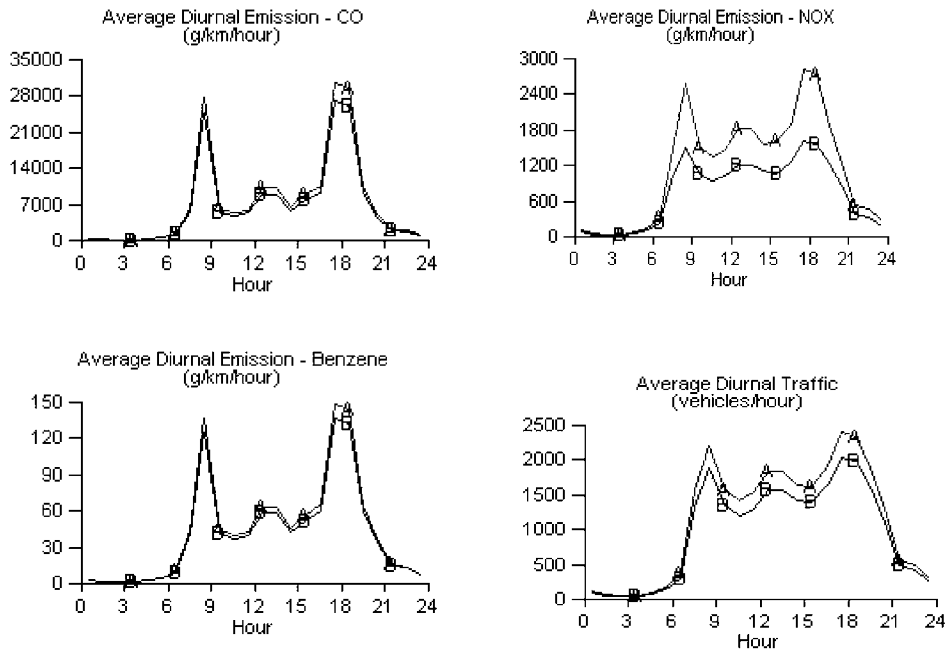

Figure 6. Diurnal variation of pollutants emissions and traffic for A: total traffic and B: Passanger cars.

by 20% compared with the short vehicle speed. The vehicle speed for type-1 street was considered an average value of 30 and 50 km h^{-1} for the street of type-2. Extra day cases were considered in addition to regular 7 days to cater for public holidays and vacations. The traffic emission is characterised by a substantial daily variation as well as a variation between different types of days.

4.4. Corrected emission factors

The speed related emission factors were corrected for cold correction factor based on French urban traffic conditions. The cold start correction factor was considered to be constant. The average trip length, which is required for estimating the cold start correction factor, was obtained from the road technical centre of Nantes. This factor was estimated using COPERT-III methodology. The methodology works out the beta parameter β, which is a fraction of mileage driven with cold engines or catalyst operated below the light-off temperature.

$$\beta = 0.6474 - 0.02545 * l_t - (0.00974 - 0.000385 * l_t) * t_a$$
$$l_t = trip\ length$$
$$t_a = ambient\ temperature$$

The average trip length was taken to be 7.7 km (based on DAVIS model for Nantes agglomeration) for urban streets. The annual mean ambient temperature was set to 12 °C (mean of three years 1999, 2000, and 2001). But due to the unavailability of the hourly fractions same factor (37%) was applied to each hour of the year. According to COPERT methodology, the increase of vehicle emissions is mainly due to a degradation of the functioning of emission reduction equipments (catalytic converters) with vehicle mileage. In order to estimate an average mileage correction for the national vehicle fleet, two parameters are required. The first is the average mileage of vehicles, considering separately vehicles mileage < 120000 km. The other parameter is the fraction of vehicles with mileage > 120000 km. Due to the unavailability of those data, mileage corrections were not applied to emission factors.

4.5. Fleet share calculations and fuel contents

The fleet composition was estimated from the MEET (Methodology for calculating Transport Emissions and Energy Consumption) programme for the year 2000 and was considered the same for year 1999 and year 2001. The sub-categorised traffic compositions were estimated from the same traffic programme for the year 2000. The traffic composition fractions estimated were 0.8537 for passenger cars, 0.1206 for Vans, 0.0229 and 0.0006 for truck1 and truck2 respectively and 0.0021 for buses. Fuel contents in benzene and sulphur for the year 1999 and year 2000 were taken from the recommendations by the European commission of petroleum industries in collaboration with automobile industries.

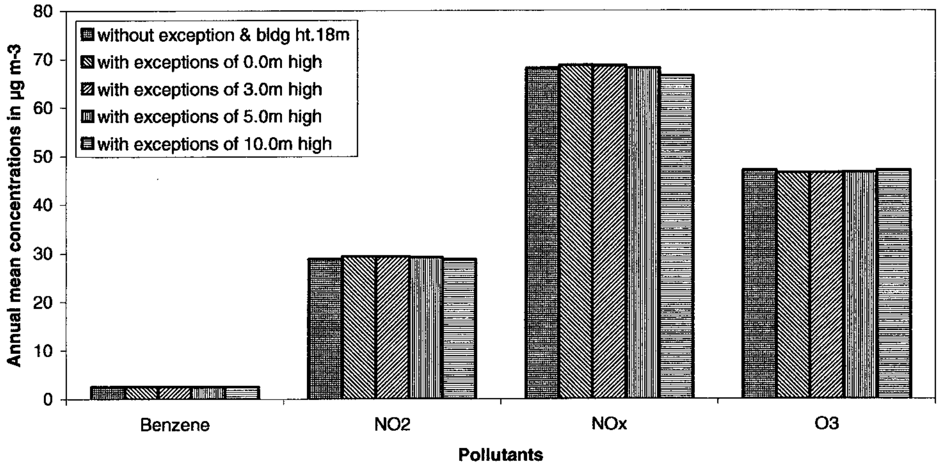

Figure 7. Comparison of pollution for with-and-without building exceptions.

5. Results and Discussions

Computed concentrations (for all the years) were compared with measured concentrations. Modelled and measured time series data have been subject to special considerations for some specific representative days. Statistical analysis were carried out to assist in the comparison of model predictions with measured data and to evaluate the performance of WinOSPM model. Statistical data include annual mean, correlation coefficient, and index of agreement. The statistical evaluation was done for the streets for which measured concentrations data were available viz. rue de Strasbourg and Bd. Victor Hugo. Percentile values have also been calculated as the European Commission (EC) now recommends 98 percentile values.

5.1. Sensitivity of model for canyon effects

A sensitivity analysis was performed to see the relative changes in the output with the changes in a few canyon parameters. The street rue de Strasbourg was selected for this analysis as it is a street with dense traffic and with many building exceptions at short intervals (see Figure 3a). The sensitivity of the model was carried out varying the number of building exceptions, the height of buildings, and the street width.

5.2. Influence of the presence of building exceptions on pollution levels

The comparison of the pollution with respect to the pollutants benzene, NO, NO_2, NO_x, and O_3 for with and without exceptions and with various exception heights are done. The results are compared in terms of annual means for all the pollutants

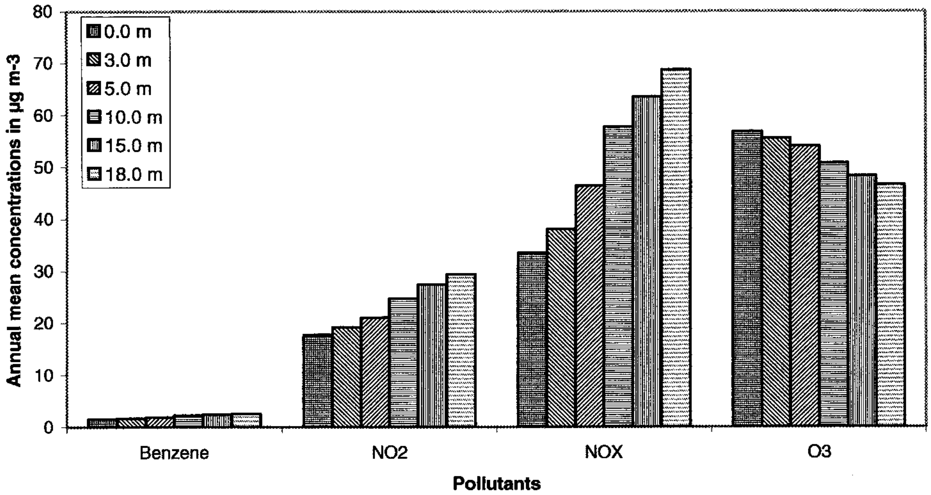

Figure 8. Comparison of pollution for without building exceptions for varying heights of the buildings.

(Figure 7). No effect was observed. To ascertain the results, the same study was carried out while additionally varying the street width. It is perceived that the results are attributed to street geometry with many wide exceptions. However, additional cases are required to ascertain the observed trends. In particular the receptor location should be varied to check whether the present results can be extended to any point in a street. We know that street intersections lead to non-uniform spatial distribution of pollutants.

5.3. Influence of Varying Building Heights on Pollution for No-Building-Exception Case

The comparison of the pollution with respect to benzene, NO, NO_2, NO_x, and O_3 for various building heights in the absence of building exceptions are presented in Figure 8. Again, results are compared on the basis of annual means. The height dependency of concentration levels is clearly reflected.

5.4. Influence of Varying Street Widths on Pollution for Yes-and-No-Building-Exceptions Case

Benzene, NO, NO_2, NO_x, and O_3 levels for various street widths, with and without building exceptions, are shown in Figures 9 and 10 respectively. The results are compared by taking annual means of all the pollutants and found very much sensitive to the width of the streets in both the cases. However, from both the figures it is confirmed that building exceptions have little influence on air quality.

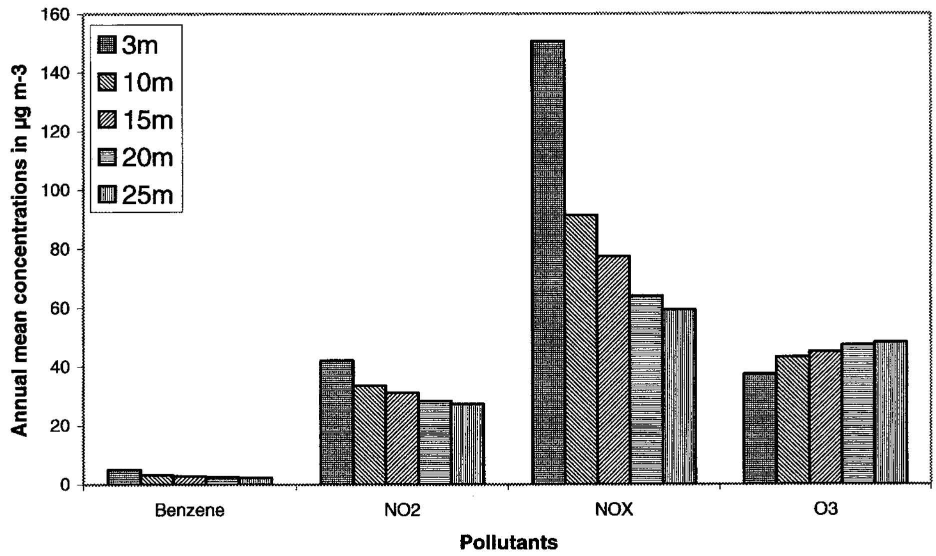

Figure 9. Comparison of pollution for with building exceptions for varying widths of the streets.

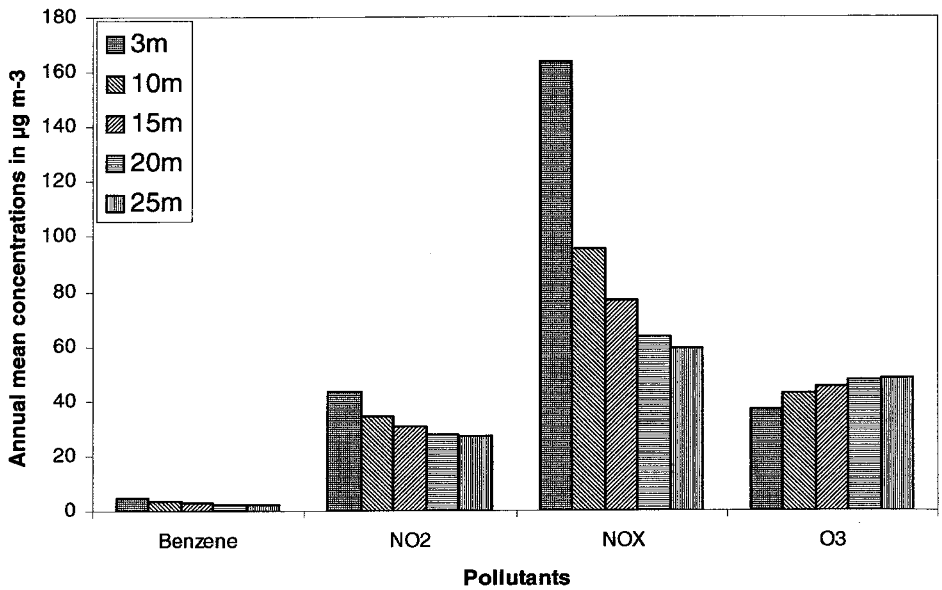

Figure 10. Comparison of pollution for without building exceptions for varying widths of streets.

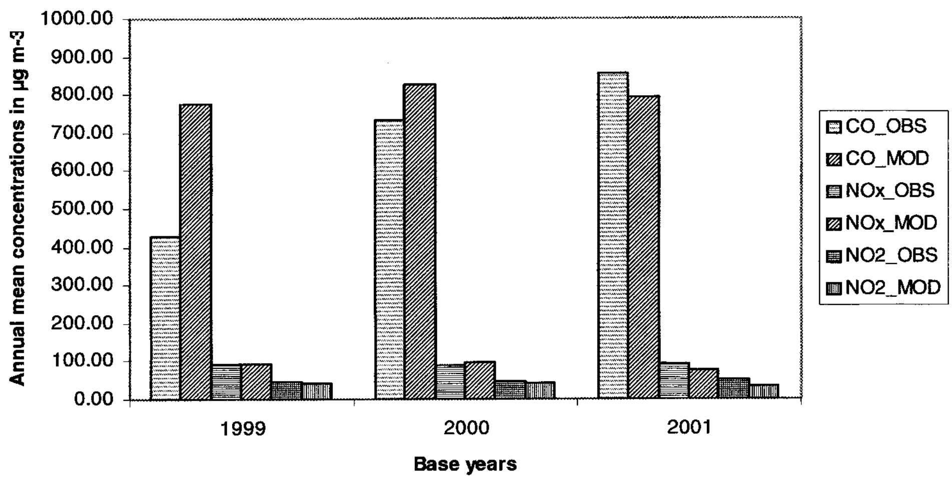

Figure 11. Comparison of pollution wrt their annual means at rue Strasbourg for the year 1999, 2000, and 2001.

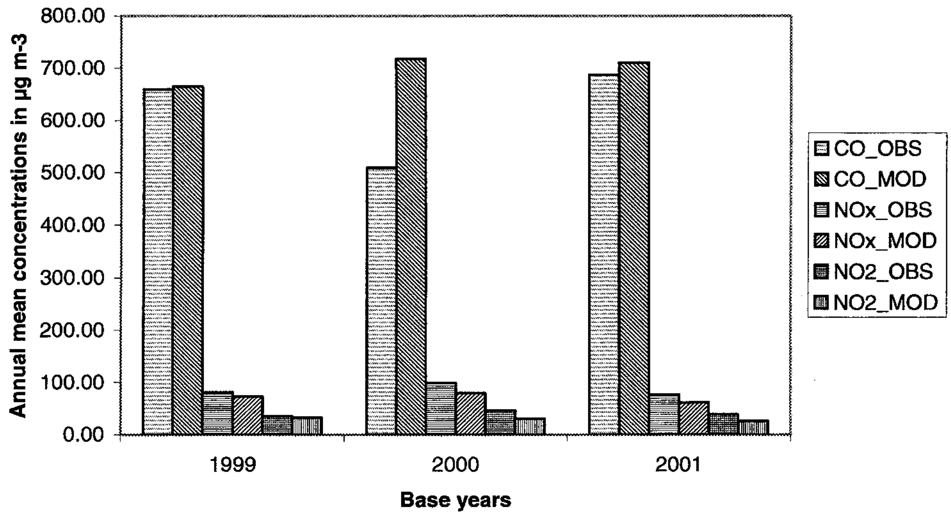

Figure 12. Comparison of pollution wrt their annual means at rue B Victor Hugo for the year 1999, 2000, and 2001.

6. Street modelling

The WinOSPM model containing the dispersion and the COPERT-III emission model and the data concerning meteorology, traffic and background concentrations were used to predict concentrations of Benzene, CO, NO, NO_2 and NO_x for base years 1999, 2000, and 2001. Model predictions show a reasonable agreement with measured data for all streets and pollutants although the model tends to overpredict

TABLE I

Modelled annual mean values at rue Crébillon

Year	C_6H_6	CO	NO_2	NO_x
1999	16.53	1020	46.40	102.21
2000	4.77	1026	42.95	101.05
2001	5.22	1112	39.11	93.60

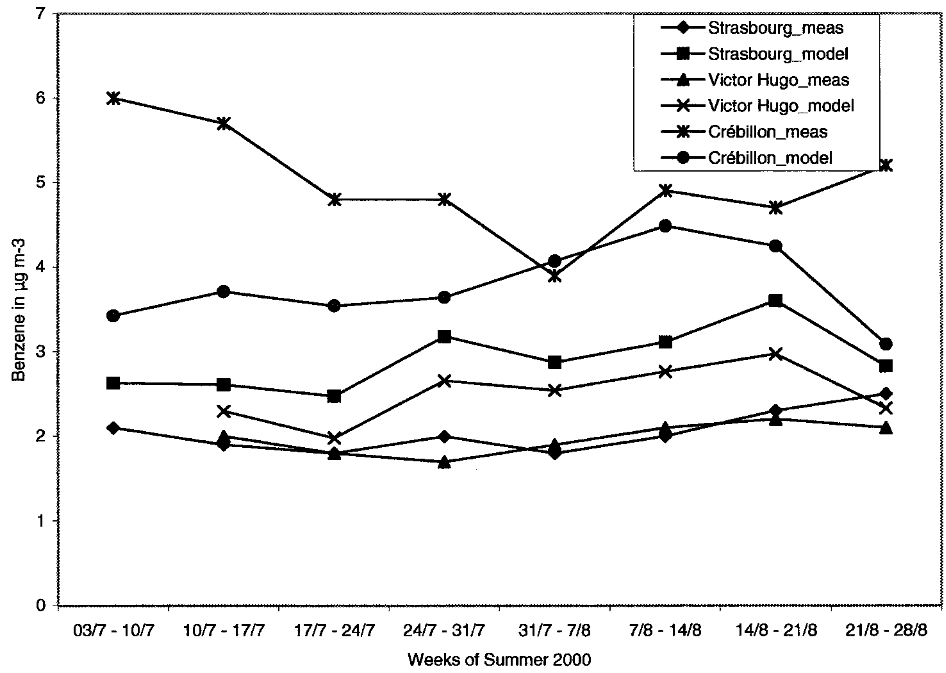

Figure 13. Comparison of weekly averages modelled and measured benzene for all streets for summer 2000.

CO concentration. The quality of the predictions of NO_2 concentrations depends highly on the availability of representative urban background concentrations for NO_2 as well as O_3. Good results are obtained for rue de Strasbourg and for Bd. Victor Hugo (Figures 11 and 12 respectively). Results for rue Crébillon are presented in Table I since no pollutant measurement data were available at this street location except hourly average benzene for two weeks.

A special interest was given to benzene (modelled) values as it is one of the new pollutants that has been recently included in measurement campaign and also the targeted change of its content in the fuel from the year 2000. It is seen that the

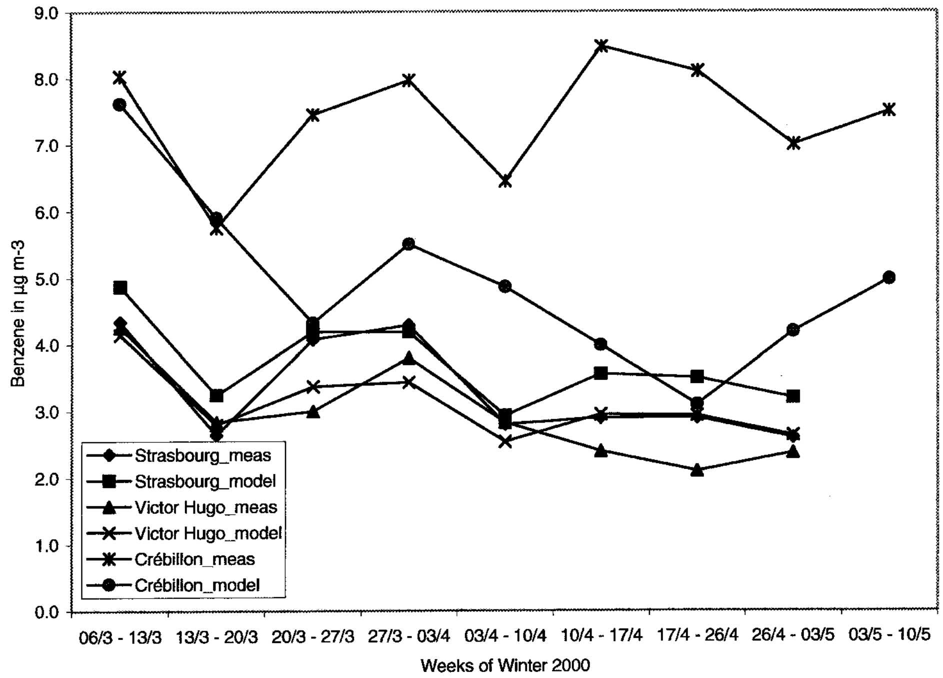

Figure 14. Comparison of weekly averages modelled and measured benzene for all streets for winter 2000.

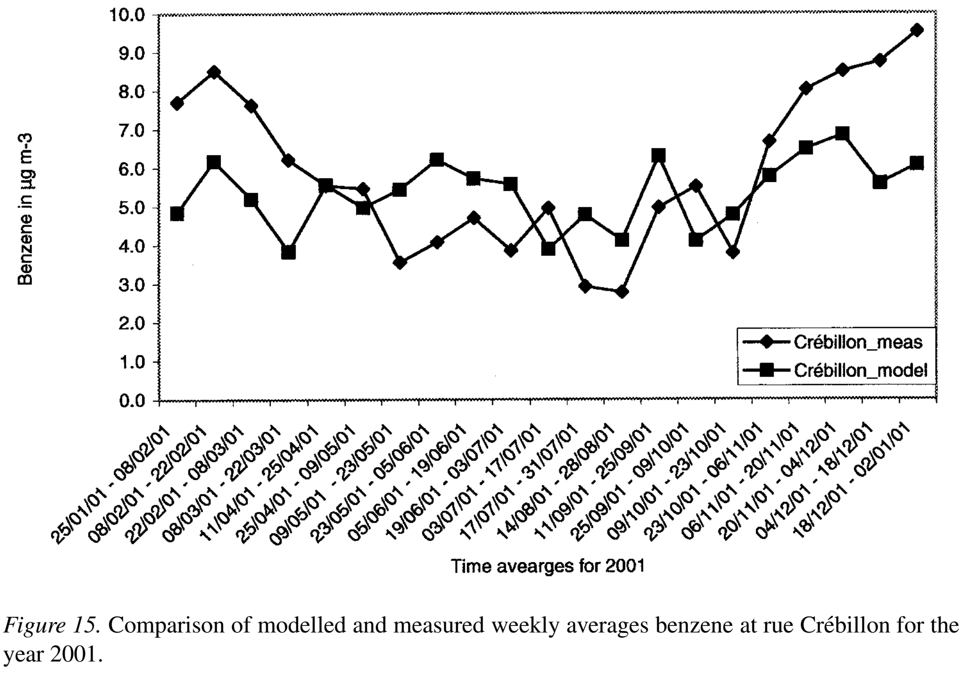

Figure 15. Comparison of modelled and measured weekly averages benzene at rue Crébillon for the year 2001.

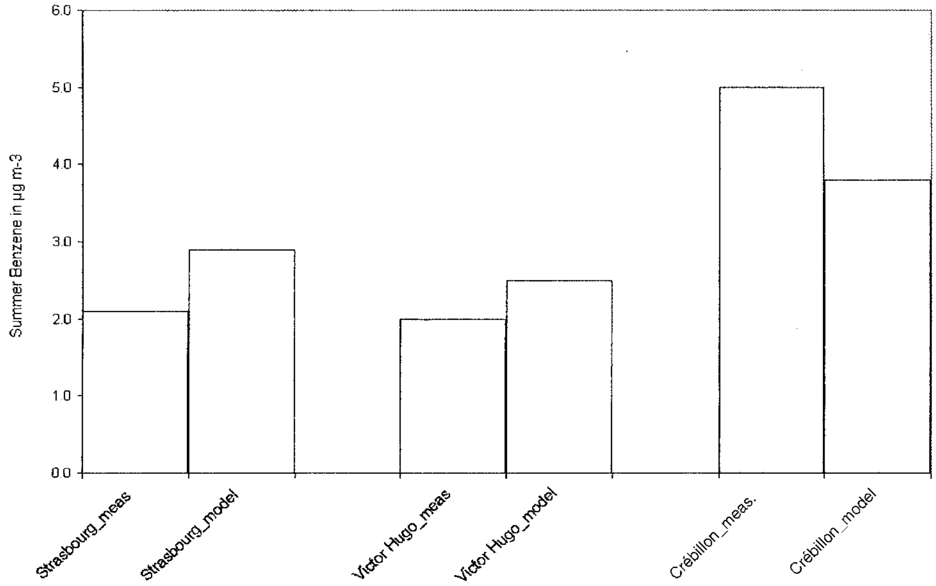

Figure 16. Comparison of modelled and measured seasonal means benzene for all streets for summer 2000.

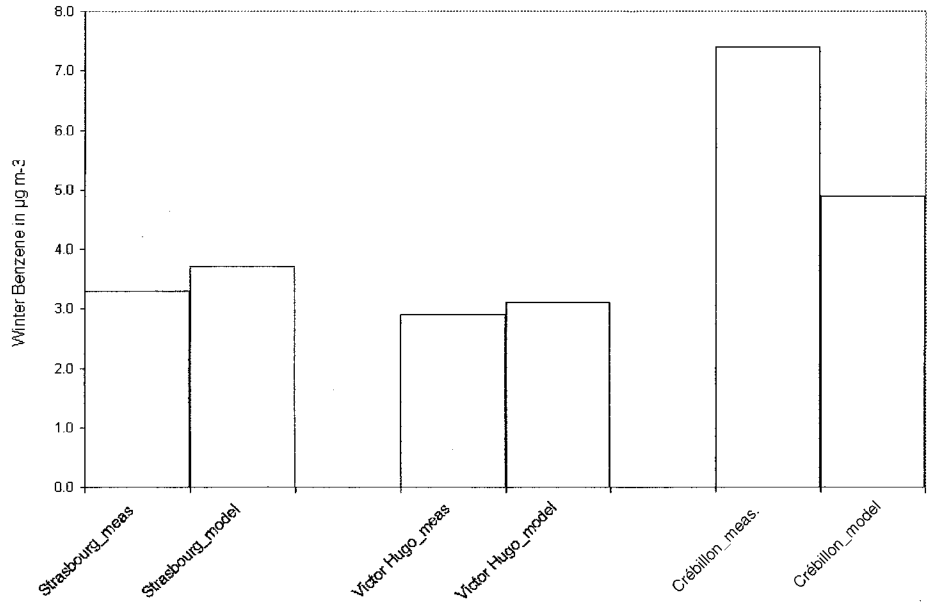

Figure 17. Comparison of modelled and measured seasonal means benzene for all streets for winter 2000.

TABLE II
98 percentile values for three pollutants for three years in two street canyons

Streets	Year	CO_MOD	CO_OBS	NOX_MOD	NOX_OBS	NO_2_MOD	NO_2_OBS
Rue de	1999	2615	1995	309	289	93	98
Strasbourg	2000	3089	2352	323	266	93	100
	2001	2695	2831	245	252	78	98
Bd.Victor	1999	2021	2455	253	302	85	90
Hugo	2000	2399	2093	260	229	85	118
	2001	2221	2143	205	236	69	87

targeted change in benzene content resulted into lower predicted values of benzene, as expected. Modelled Weekly averages are in excellent agreement with measurements. The weekly averages of benzene with their seasonal means for years 2000 and 2001 at all the streets are presented in Figures 13–17. The percentage changes in benzene modelled concentrations caused by the targeted change in benzene content for the year 2000 and 2001 with respect to the base year 1999 are estimated. The percentage change in the benzene concentrations was 65% for year 2000 and 67% for 2001 at rue Strasbourg. Its change for Crébillon was 71% for 2000 and 68% for 2001. But for Bd.Victor Hugo it was comparatively lower i.e. 58% for year 2000 and 59% for 2001. This could be attributed to the other influential parameters such as street configuration, which is quite different than other streets. Computed and measured benzene concentrations for year 2001 were also compared on the basis of annual means and found in good agreement with each other. The annual mean at rue Crébillon is measured 5.9 and modelled 5.3. The 98 percentile of hourly concentrations are derived from hourly average concentrations for all the pollutants for all the years and tabulated in Table II.

The scatter diagrams were also plotted between measured and modelled concentration values for the rue de Strasbourg and Bd. Victor Hugo for NO_x, and NO_2 for all the years. Plots are shown in Figures 18–20.

The ratios of measured annual mean concentrations to modelled concentrations were also estimated and tabulated in Table III.

For CO model overpredicted for all years except in 2001 at rue de Strasbourg. And, for NO2 and NOx, model underpredicted the annual mean values. This discrepancy could be due to the unavailability of annual hourly CO concentration data. The actual CO data used for this study was extrapolated from weekly data to annual hourly average for all years. This may have dissociated hourly meteorology.

The small difference between (O) observed concentration and (P) predicted concentration lead to low or sometimes negative values of the correlation coefficient (r) (Willmot, 1982a). Though r and r^2 describe the proportional changes with respect to the means of the two quantities, distinction between the types or magnitudes

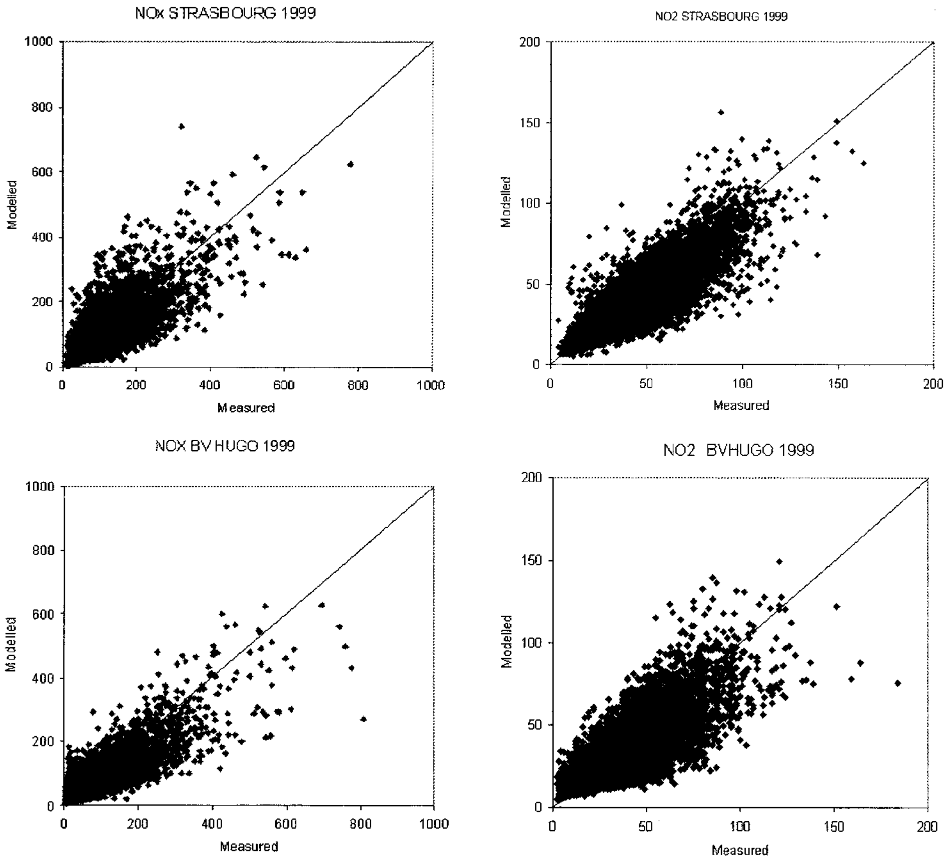

Figure 18. Scatter plots for modelled and measured hourly concentrations for NO_X and NO_2 for streets Strasbourg and BV Hugo for the year 1999.

TABLE III

Ratio of measured annual mean to modelled annual mean values

Street	Year	CO	NO_2	NO_X
Strasbourg	1999	0.55	1.12	1.01
	2000	0.89	1.15	0.89
	2001	1.1	1.42	0.86
BV Hugo	1999	0.99	1.08	1.10
	2000	0.71	1.51	1.08
	2001	0.97	1.51	1.25

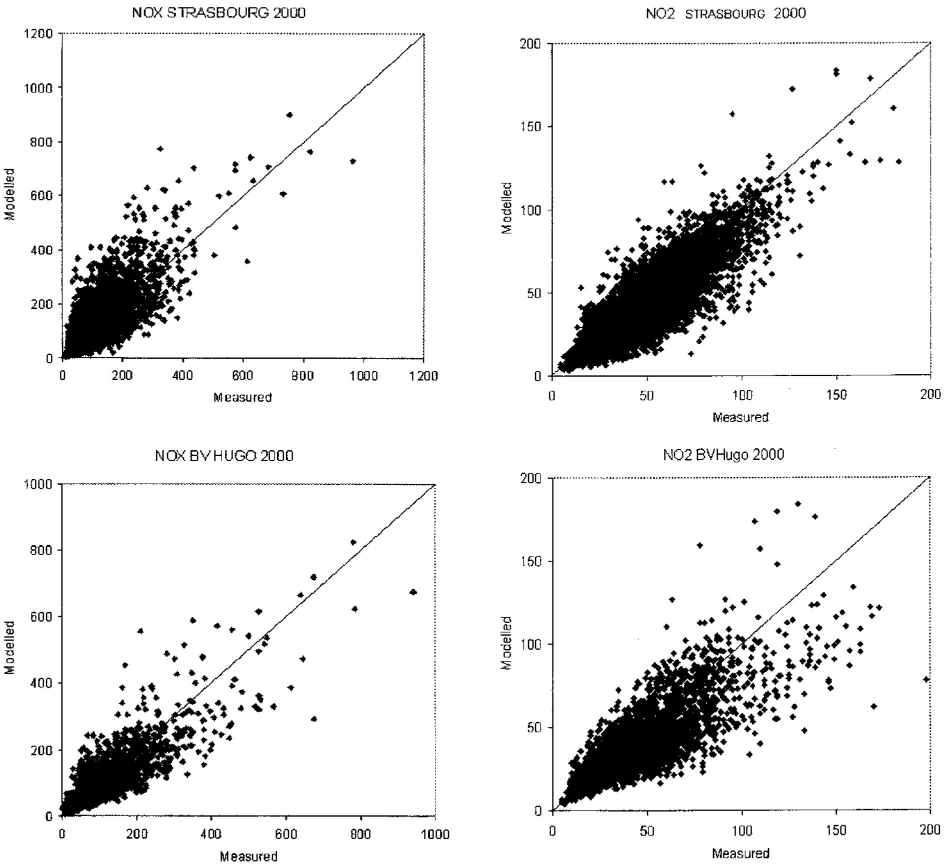

Figure 19. Scatter plots for modelled and measured hourly concentrations for NO_x and NO_2 for streets Strasbourg and BV Hugo for the year 2000.

of variables are not indicated by the value of r. It has also been observed that the use of r and r^2 can be misleading in interpreting model performance. It was suggested by Willmot (1981, 1982) and Willmot and Wicks (1980) to use an index of agreement (d). This index determines the extent to which magnitudes and signs of the observed values about observed mean are related to the predicted deviations about observed mean and allows for sensitivity toward differences in O and P as well as proportionality changes. However to ascertain it the correlation coefficients have also to be estimated.

The index of agreement (d) is one of the statistical indicators estimated for two streets locations for all the years. The equation for d is

$$d = 1 - \frac{\sum_{i=1}^{n} (Pi - Oi)^2}{\sum_{i=1}^{n} (|Pi - \bar{O}|) + (|Oi - \bar{O}|)^2} \qquad and \quad 0 \leq d \leq 1$$

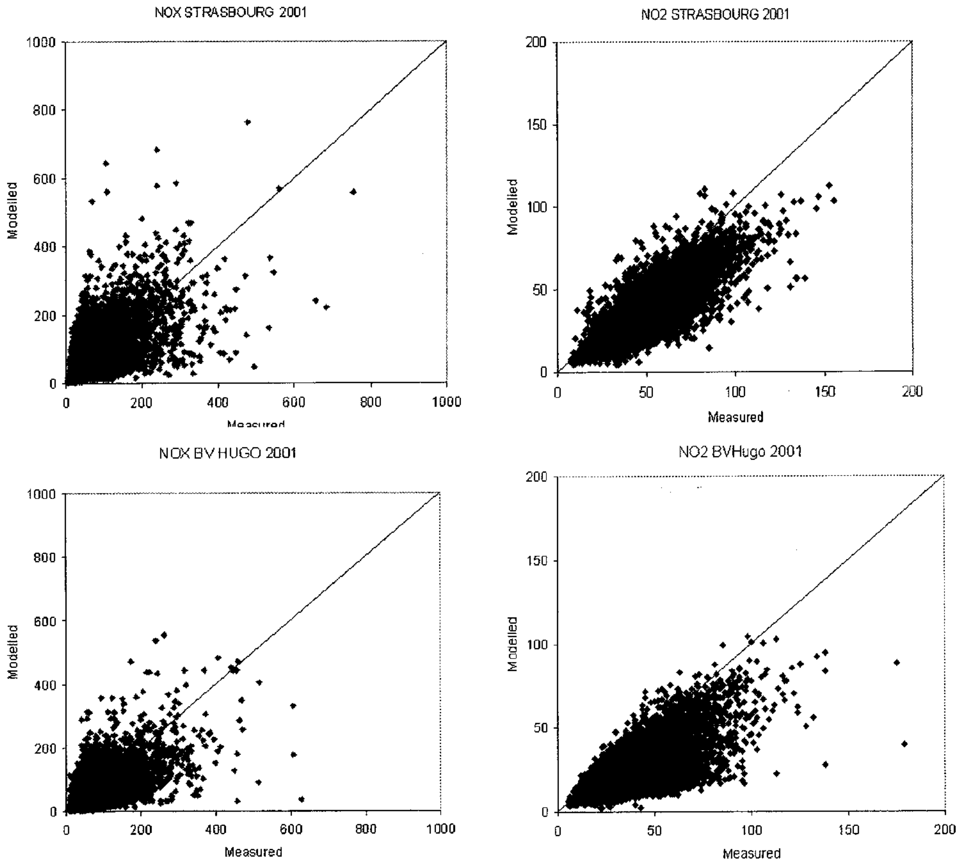

Figure 20. Scatter plots for modelled and measured hourly concentrations for NO_X and NO_2 for streets Strasbourg and BV Hugo for the year 2001.

Where, Pi is *i*th modelled value, Oi is *i*th observed value, and O the mean of observed values. Both the indicators were estimated and presented in Table IV.

TABLE IV

Coefficient of correlation (r) and index of agreement (d)

Streets	Parameters	1999			2000			2001		
		CO	NO_X	NO_2	CO	NO_X	NO_2	CO	NO_X	NO_2
Rue de Strasbourg	r	0.55	0.72	0.83	0.54	0.77	0.87	0.59	0.51	0.83
	d	0.83	0.88	0.96	0.89	0.91	0.97	0.92	0.77	0.90
Bd. Victor Hugo	r	0.55	0.7	0.79	0.66	0.73	0.88	0.53	0.43	0.75
	d	0.91	0.84	0.95	0.92	0.90	0.98	0.86	0.77	0.88

Results show that the index of agreement is good, thus indicating good model prediction ability with the measurements and showing very little percentage of the potential for error. The 'r' value for CO for year 1999 in both streets is found to be the same although there is a significant difference in their annual means whereas d is representing the difference very apparently. Measurement data were not available for rue Crébillon location except the benzene concentrations for two weeks. Hence corresponding weekly averages in rue Crébillon were compared with the weekly average modelled concentration value and gave good results.

7. Conclusions

In the recent past, there have been many workshops organised in Europe attempting to harmonise air quality models for regulatory purposes emphasizing the need for more and more evaluated models. The results of applications of WinOSPM model to three street canyons of Nantes let us believe that the model could be used in the case as a predictive tool. Statistical evaluators such as index of agreement and correlation coefficient for all the evaluation-streets show that modelled concentration levels are in good agreement with those from measurements. These indicators indicate that the model has a less potential for error. The model's sensitivity to the building exceptions feature for rue de Strasbourg revealed that the model is not so receptive to this new feature since very negligible differences have been recorded with respect to the annual means. It is perceived that the influence has been suppressed in averaging the annual hourly (8761) values and may have had it in hourly variations. WinOSPM model is found a highly simplified, parameterised model and more advanced and very well representing the detailed flow and dispersion conditions in street canyons. As models should be able to describe not only dispersion but also the chemical and photochemical transformation in order to account for secondary pollutants too, the WinOSPM model has just been found giving excellent predictions for NO_2. This model may be seen capable to meet the needs of regulatory bodies for assessing urban air quality.

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