A COMPARISON OF DISPERSION MODELS FOR TRAFFIC SITUATIONS

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INTRODUCTION

Since the strict implementation of the first and second EU daughter directives in 2001 air quality modelling has become increasingly important, considering that the legal limit values for air quality can not be met in a substantial part of the Netherlands. During the last two decades local air quality along roadways in the Netherlands has mainly been assessed using only two numerical dispersion models. Since 2003/2004 several companies have also started to perform air quality calculations. All individual models have to some extent been validated with experimental data. In specific cases the results obtained using different models were found to show considerable differences. Serious debates have taken place during legal procedures as a result of these differences.

The Dutch Ministry of Housing, Spatial Planning and the Environment (VROM) has asked the Dutch National Institute for Public Health and the Environment (RIVM) to determine the bandwidth introduced by using several different air quality models. An anonymous comparison of the models actually in use was organized for this purpose. The RIVM has defined a set of test cases, covering both 'urban street canyon' and 'single roadway' situations. Six relevant owners of air quality models were invited to run their models for these cases and report the results to the RIVM. Four of the models are of a Gaussian dispersion type; one represents a very simple empirical parameterization and one is of a Computational Fluid Dynamics (CFD) type. Of the Gaussian models, two use hourly information and the other two use yearly averaged wind fields with three classes for speed and twelve classes for direction.

TEST CASES

Test cases have been defined for both a roadway and a street canyon:

Roadway | Street canyon

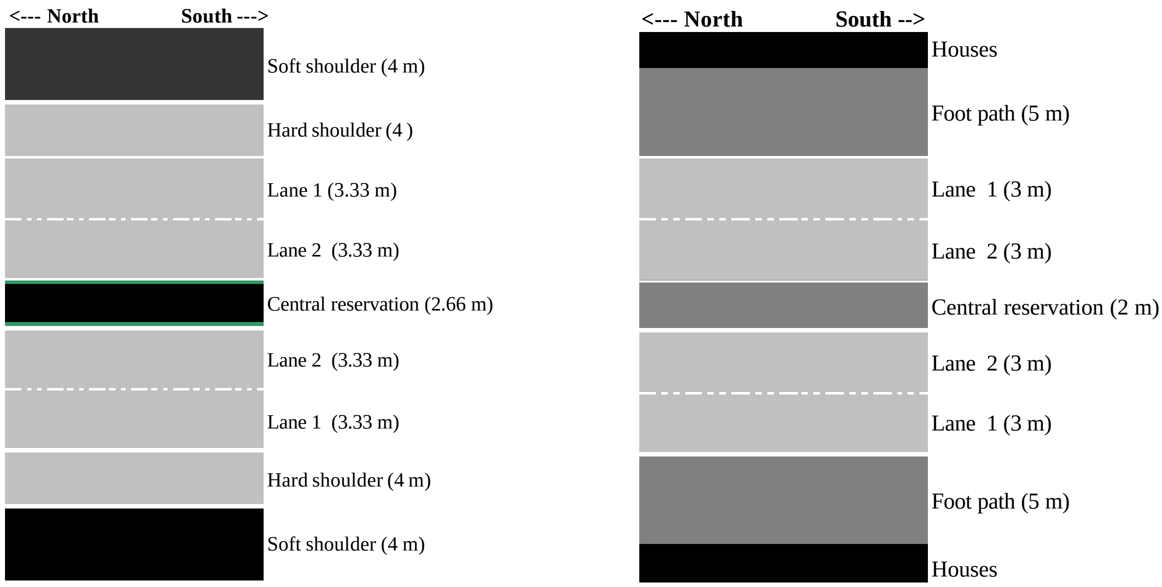

Figure 1: Layouts used in the tests.

Assumed traffic intensity on the roadway is 120,000 vehicles per day, with 4% medium heavy traffic and 6% heavy traffic. Assumed traffic intensity in the street canyon is 15,000 vehicles per day, with 3% medium heavy traffic and 5% heavy traffic. The emission factors to be used in the calculations were provided by the RIVM.

Table 1: Emission factors (g/km, year: 2004) with respect to traffic intensity

	Street canyon		Roadway	
	NO_X	PM_{10}	NO_X	PM_{10}
Light	0.62	0.065	0.76	0.055
Medium heavy	10.46	0.419	7.01	0.195
Heavy	15.25	0.515	9.64	0.266

A direct emission of 5% was prescribed for calculating NO_2 emissions, with hourly background concentrations for NO_2, O_3 and PM_{10} provided by RIVM. The hourly traffic intensity for the roadway base case was also provided; see Figure 2.

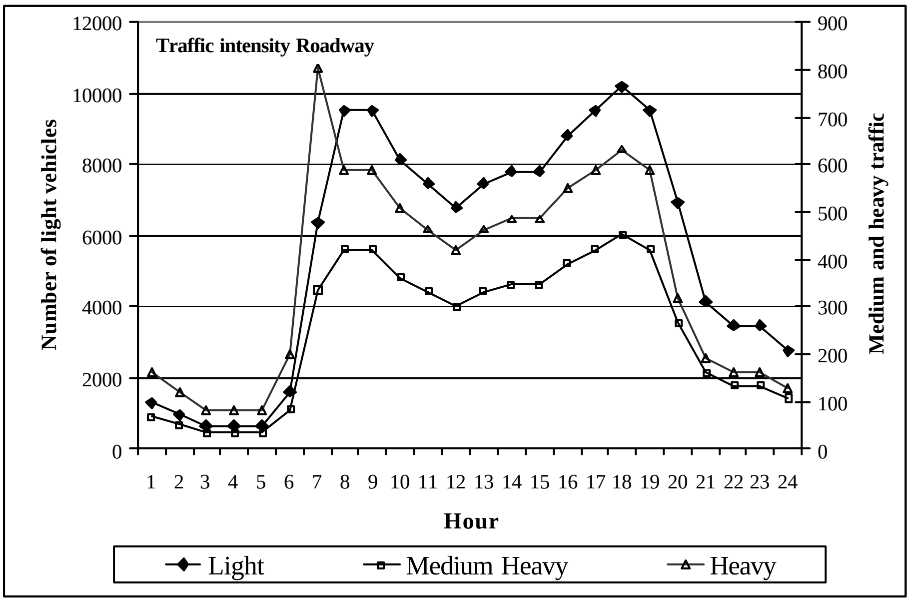

Figure 2: Number of vehicles per hour

A number of receptors were defined and all participating model owners were asked to calculate yearly average concentration levels for NO_2 and PM_{10}, as well as the number of days the PM_{10} levels exceed 50 $\mu g/m^3$. In total, some 14 situations were investigated using varying meteorological conditions and such factors as background levels, roughness and number of traffic lanes. Not all model owners have participated in all the tests.

RESULTS

The yearly average NO_2 and PM_{10} concentrations along the roadway calculated with four different models for the year 2004 are shown in Figures 3 and 4.

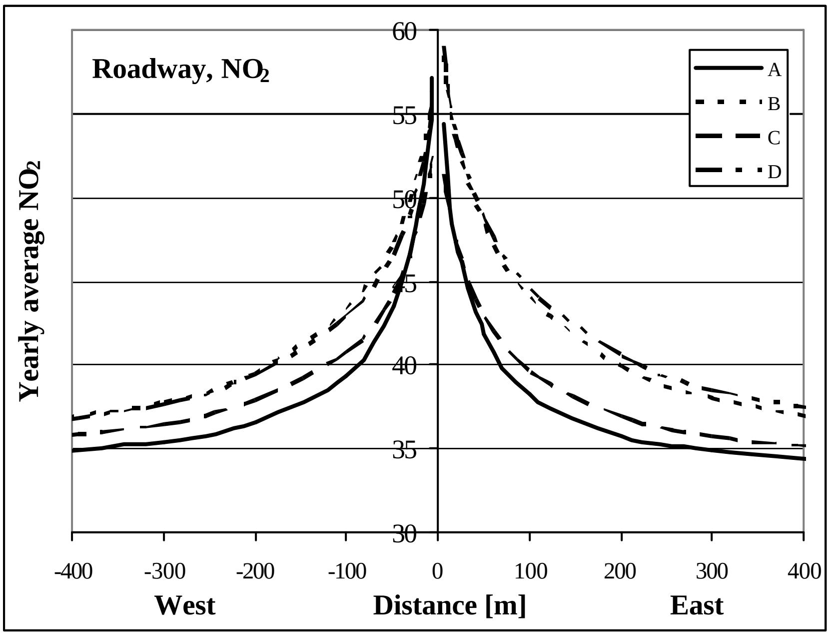

Figure 3: Yearly average NO_2 concentrations (mg/m^3).

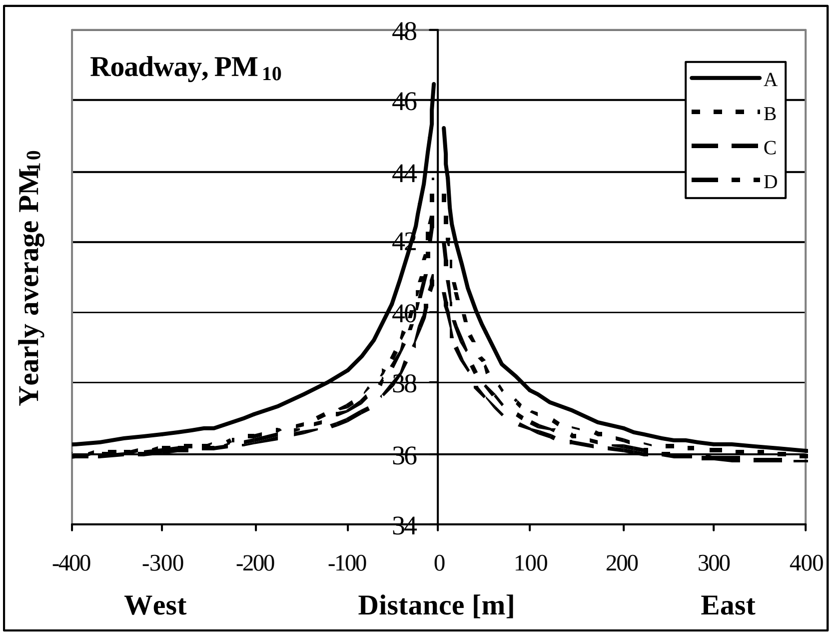

Figure 4: Yearly average PM_{10} concentrations (mg/m^3).

The results for the street canyon are listed in Table 2.

Table 2: Calculated concentration levels for the street canyon in mg/m^3

	NO_2	PM_{10}
Model I	39.9	28.9
Model II	46.0	32.0
Model III	37.4	28.3
Model IV	36.5	28.2

DISCUSSION

The range in results obtained with the models is quite substantial. Depending on the distance to the road, the results were shown to differ by more than 5 μg/m^3 for NO_2 and more than 2 μg/m^3 for PM_{10}. For NO_2 there is still a substantial difference between the model results registered at longer distances from the road, whereas for PM_{10} the model results converge for longer distances.

The resulting bandwidths of results collected have recently been used by the Dutch government to define a benchmark that is used to test new air quality models. New air quality models have to agree with the benchmark results within a certain limit in order for them to get a permit. These limits are 10% for both NO_2 and PM_{10} for a single roadway, and 15% (NO_2) and 10% (PM_{10}) for an urban street canyon. As an example the 'reference values' and bandwidth for NO_2 for a roadway are shown in Figure 5.

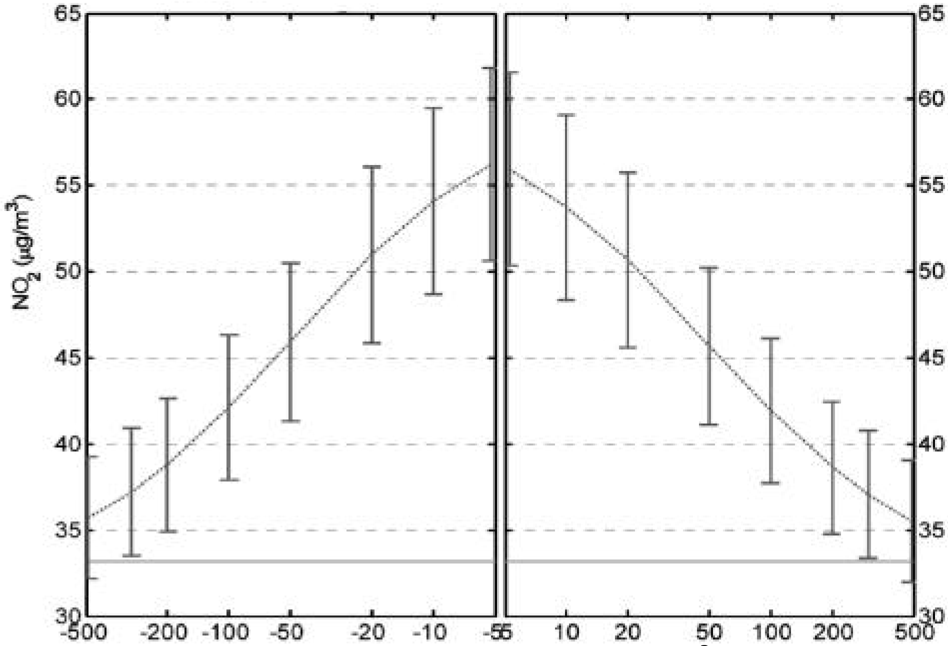

*Figure 5: Yearly average NO_2 concentrations (mg/m^3) for a roadway.
The distance scale is logarithmic.*

Several recommendations for future harmonization were made on the basis of the information obtained in the study. These are:

- to use the same or at least comparable values for traffic-induced turbulence;
- to employ comparable models for the $NO_x \rightarrow NO_2$ conversion;
- to use similar definitions for the speed and height of the plume;
- to use the same data sets for tuning and validation.

Hopefully more experimental data for testing the models will become available in the course of 2007.