5.39 AN EVALUATION OF THE URBAN DISPERSION MODELS SIRANE AND ADMS URBAN, USING FIELD DATA FROM LYON.

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INTRODUCTION

Although there has been much progress in reducing vehicle and industrial emissions, urban air quality remains a significant problem, and in many cities the regulatory thresholds are often exceeded. In order to develop strategies for reducing pollutant concentrations in urban areas, we need to establish detailed maps of pollution levels. Since the number of pollution monitors in a city is necessarily limited, the data that are available cannot provide a sufficiently detailed coverage, and we therefore need to be able to model the transport and dispersion of pollutants at the scale of city streets.

Most of the models for the transport and dispersion of pollutants in the urban canopy have dealt either with processes on the scale of the whole agglomeration, and have been concerned principally with modelling the chemical reactions that take place in the canopy, or else they have focussed on processes within a single street, usually in the form of a street-canyon type model. In order to map pollution levels in a city we need also to consider scales intermediate between these two extremes, where the dispersion of pollutants is dominated by complex interactions between several different physical processes – pollutants are emitted within the street, and are initially confined within it by the surrounding buildings; they escape either into the atmosphere through the top of the street, or they pass into adjoining streets at street intersections. Finally, pollutants in the canopy can also be entrained into the street. Very few models are currently available to compute these processes, and there are hardly any experimental data (either full scale or wind tunnel) that can be used to evaluate them.

The aim of the work presented here was therefore to generate some suitable field data, and to compare the measurements with the results from two dispersion models – SIRANE and ADMS Urban.

FIELD EXPERIMENTS WITHIN A QUARTIER OF LYON

A campaign of field measurements (LYON6) was conducted over a two week period in July 2001, in collaboration with the COPARLY – the organisation responsible for monitoring pollution levels in the Lyon agglomeration. (Full details are given in Soulhac et al. 2001a).

The area studied is a relatively flat district, 1.5 km x 1.5 km, consisting of relatively regular, and fairly uniform buildings, creating some 500 street canyons (see figure 1). Traffic flows, weather conditions and pollution levels were measured at different positions in the district, over a period of 15 days.

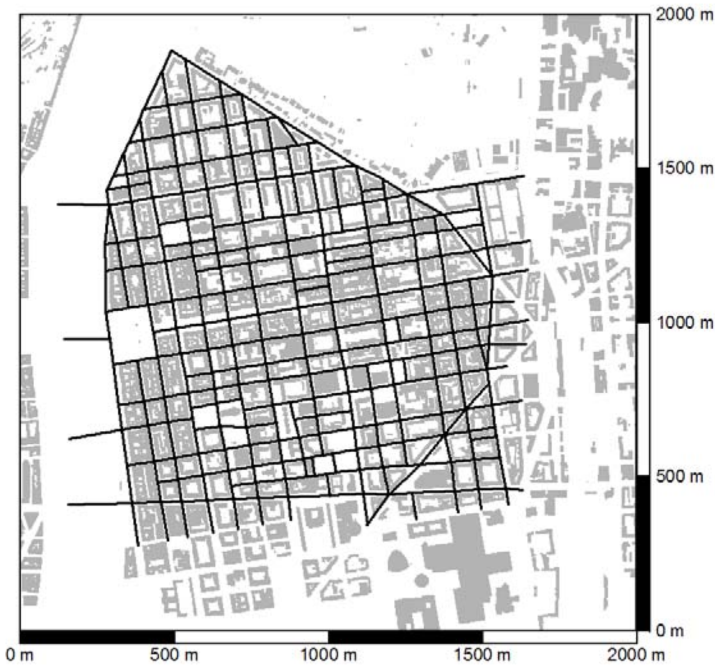

Figure 1. Quarter of Lyon studied. The buildings are in grey and the network of streets is in black.

- *Traffic flows* were measured by traffic counters in 10 streets in the district; these provided hourly vehicle counts. In addition, numerical simulations of traffic flows provide estimates of the rush hour flows throughout the domain.
- *Meteorological conditions* were measured with ground stations, an ultrasonic anemometer at roof level and a SODAR. These provided wind speed and direction, temperature, cloud cover, humidity and precipitation.
- *Background pollution levels* were measured using 3 NO_X analysers, placed on the outer boundaries of the district. These provided hourly estimates of the background concentrations.
- *Street level pollution* was measured at 33 sites in the district, using passive diffusion tubes, which provide the concentration of NO_2, integrated over the 15 days of the campaign. In addition, 3 NO_X analysers at different sites in the district provided a measure of the hourly variation in concentrations. (Some other passive tubes were used to measure the concentration of VOC aromatics – Benzene, Toluene and Xylene, but those results will not be presented here.)

The data sets are available for other researchers, and can be obtained by contacting the COPARLY (COPARLY@atmo-rhonealpes.org).

MODELLING AIR QUALITY WITH SIRANE AND ADMS URBAN

Sirane

Sirane is a model for transport and dispersion of pollutants in a street network (Soulhac 2000, Soulhac *et al* 2001b). The pollutant concentration in each street is calculated from a balance of pollutants entering and leaving; the physical processes currently represented in the model are vehicle emissions in the street, turbulent flux at the interface between the street and the atmosphere, entry and exit fluxes at each end of the street, dry and wet deposition. A specific model was developed to compute pollutant exchange within street intersections. Pollutant which leaves the street through the upper interface with the atmosphere is transported and dispersed by the external wind; this is modelled using a Gaussian plume type solution, with dispersion characteristics derived from similarity theory. The profiles of wind velocity and turbulence intensity can be calculated from meteorological data using a meteorological pre-processor. Simple chemical reactions are modelled using the Chapman cycle (NO-NO_2-NO_3), assuming photo-stationary.

ADMS Urban

ADMS Urban is a Gaussian plume type model, developed by CERC (McHugh *et al* 1997). Concentrations within a street are calculated using the OSPM street canyon model (Berkowicz *et al* 1977). The parameters for the wind field and the Gaussian plume model are calculated by a meteorological pre-processor. Chemical reactions are represented by the Chapman cycle, which is modelled using either the empirical parameterisation of Derwent and Middleton (1996) or the GRS scheme (Venkatram *et al* 1994).

Input data

Vehicle emissions of NO_x were calculated for each street in the *quarter*, over the 15 day period of the study, using the COPERT III method (Ntziachristos and Samaras, 2000). This required estimates of traffic flows, which were obtained from numerical simulations of rush hour traffic flows, adjusted on an hourly basis, using the traffic flows measured in 10 of the streets. The computed vehicle speeds were also adjusted in a similar fashion to take account of congestion. Background pollution levels and meteorological conditions were derived from data measured during the experimental campaign.

RESULTS

The measured and computed concentrations (averaged over the 15 day experimental period) are shown in figure 2, for the different measurement sites. The two models are generally in good agreement, although it appears that the GRS chemistry model in ADMS does not perform as well as the Derwent-Middleton correlation, or the simplified chemistry model in SIRANE. In fact, a more detailed sensitivity analysis of the results from ADMS Urban with the GRS model suggests that the variations are due more to the dispersion modelling than to the chemistry model. It is also interesting to note that in those streets with relatively high concentrations, ADMS has a tendency to underestimate the concentrations, whereas SIRANE shows much greater variability.

Temporal variations in pollutant concentrations were measured using 3 continuous samplers placed in 3 streets within the *quarter*; figure 3 shows a comparison of the results from one of those samplers with the corresponding concentrations calculated by the model SIRANE. On the whole, the model calculations and the data agree satisfactorily.

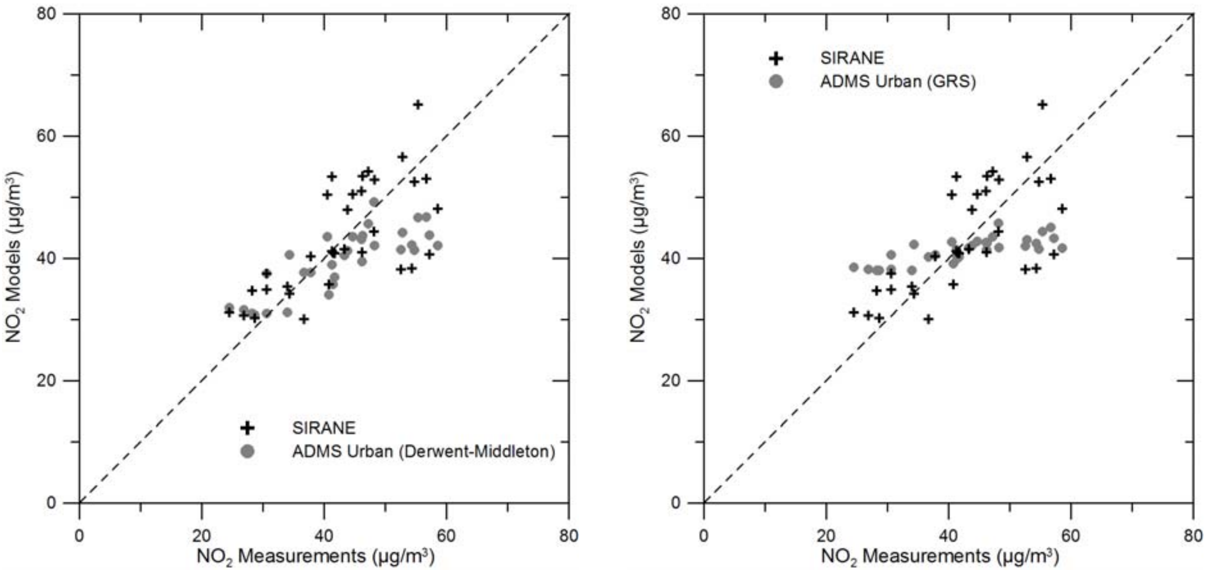

Figure 2. Comparison between SIRANE, ADMS Urban and field measurements performed with passive diffusion tubes.

CONCLUSIONS

A campaign of field measurements has been performed in a *quarter* of Lyon, to provide data for testing small scale urban dispersion models. The field experiments have been simulated using ADMS-Urban and SIRANE, with input data derived from in-situ measurements. A comparison between measured and computed concentrations shows that both models reproduce reasonably well the observed spatial variations in concentration.

These results represent a preliminary test case for the models; the comparisons have been based principally on concentrations averaged over 15 days, and whilst this corresponds reasonably well to many practical preoccupations, it does make it difficult to make detailed comparisons between models, and between models and data. In the future, therefore, it will be necessary to carry out more detailed studies, both at full scale and in the wind tunnel, in particular, to compare concentrations averaged over shorter timescales.

ACKNOWLEDGEMENTS

The field measurements were realised by COPARLY. The calculations with ADMS Urban were performed in collaboration with *Numtech* – the French distributors for the model.

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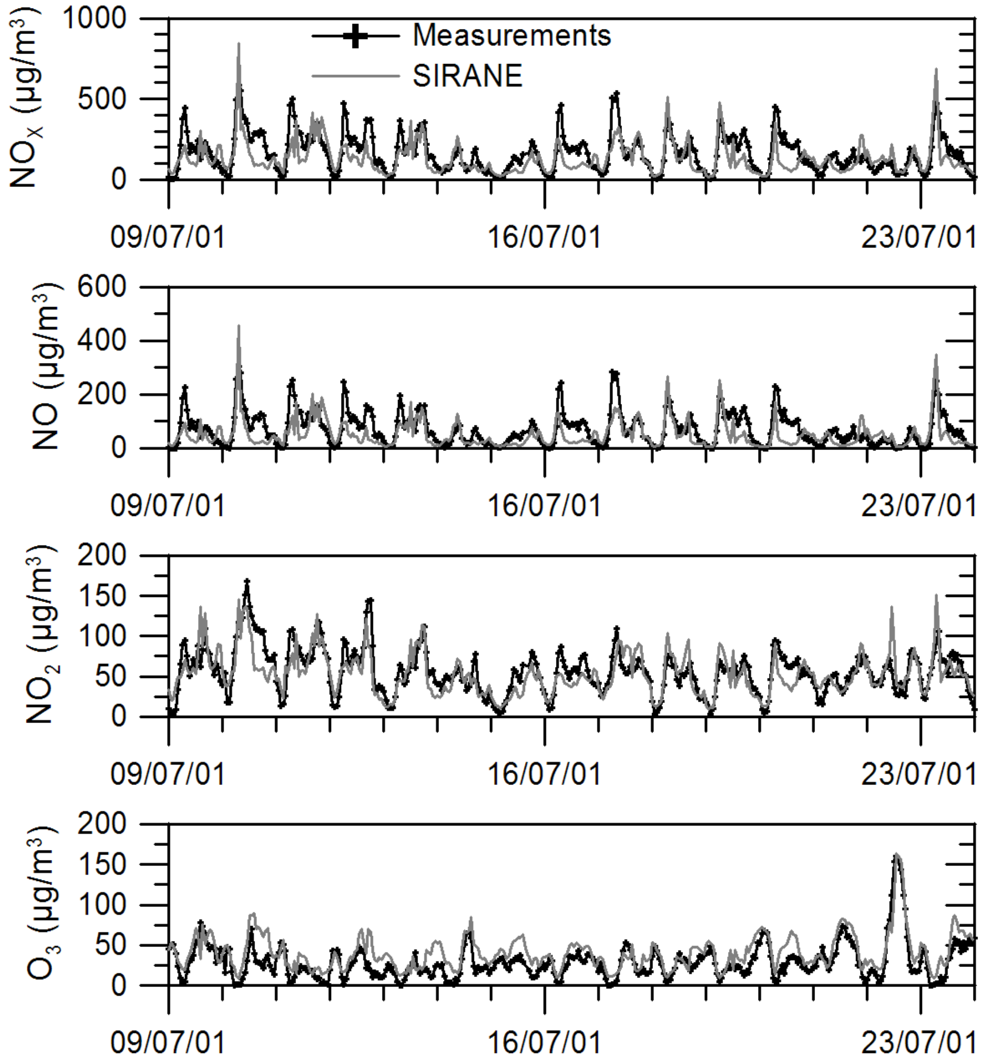

Figure 3. Comparison between SIRANE model and field measurements performed in Garibaldi Street. NO_X, NO, NO_2 and O_3 concentrations during the 15 days of the LYON6 campaign.