Development of an Integrated Air Quality Management System for Urban Areas

A contribution to subproject SATURN

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Summary

This work describes the contribution of GEMAC/University of Aveiro to the SATURN subproject during the last year of work. The main purpose of this contribution is the development of an air quality management system for urban areas. Principal results in 2001 include the development and testing of an integrated system of two models: (i) the Transport Emission Model for Line Sources (TREM), and (ii) the local air quality model VADIS. The TREM model is based on MEET/COST methodology and integrated in GIS environment. The model is specially adapted for estimation of road traffic emission with the temporal and spatial resolutions required by air quality model. The local scale VADIS model is based on the Lagrangian approach and is able to calculate instantaneous concentrations of gaseous pollutants. The model was improved in order to better describe urban real-world conditions (multi-obstacles, multi-source emission) and is particularly valuable under low-wind speed and varying wind conditions. The integrated system based on the TREM and VADIS models is planned to use as a decision support tool in air quality management at local scale for urban areas.

Introduction

Road traffic is one of the principal sources of air pollution in urban areas and an integrated urban air quality management system should include a precise quantification of pollutants emitted by vehicles to the atmosphere, as well as detailed dispersion estimation for the most critical areas. Modelling of road traffic emissions and local dispersion of air pollutants could be a consistent approach to analyse traffic-induced environmental pressure and to evaluate air pollution questions in hot spot areas.

Objectives

The main purpose of the contribution of the University of Aveiro to the SATURN subproject is the development of an air quality management system for urban areas. This research work combines several activities including the development and implementation of an emission model for road transport; the adaptation and improvement of the local scale model VADIS in order to be applied to urban areas; and, the validation and application of the models.

Activities

The local scale VADIS model is based on the Lagrangian approach and is able to calculate instantaneous concentrations of gaseous pollutants (Borrego *et al*., 1999). It was improved in order to better describe obstacles (multi-obstacle) and flow fields (any direction) as well as

emissions (multi-source, time varying). The validation with real scale data and with measurements performed at two wind tunnels, at the Department of Environment and Planning of the University of Aveiro, allowed to verify its good performance and to show its particular value under low-wind speed varying conditions.

A transport emission model specially adapted for line sources was also developed. It is based on MEET/COST methodology and integrated in GIS environment to improve and simplify the spatial data processing. The model distinguishes between different vehicle type, technology, engine capacity, and the average speed approach is used.

Aiming to contribute to the Lisbon air quality management, a downtown area was chosen, and the integrated system of models, TREM and VADIS, was applied for a typical summer weekday. Higher values of traffic are observed in the downtown during summer due to its tourist interest.

In addition to the contributions above mentioned, an important work has been done on the project level concerning Quality Assurance/Quality Control. The methodology and general requirements for the QA/QC implementation in SATURN were developed in order to ensure that the appropriate methods and data are used, that error in calculations and measurements are minimised and that documentation is adequate to meet the project objectives.

Results

The developed system was applied to an urban area in Lisbon during a typical summer day.

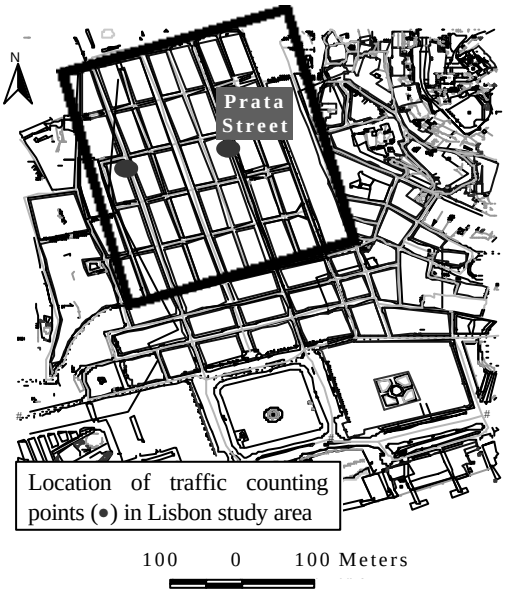

Figure 1: Domain simulation for VADIS model.

The study area covers 400 m x 400 m and local hot spot air pollutants levels are expected to occur there.

Hourly traffic emissions were estimated with TREM using local data sets including traffic counting (see figure 1). Emission factors based on average speed were considered as the best approach. Also, different technology (engine type, model year) and engine capacity are distinguished in TREM model to derive emission factors. The following pollutants were covered: CO, NO_x, SO_2, VOC, CO_2 and particulates (Borrego *et al*., 2000).

Figure 2 presents the hourly variation of CO emissions estimated by TREM for Prata and Ouro Streets for August 16th.

It is possible to notice a similar behaviour of CO emissions in both streets, which is quite related to the traffic flux, with smaller values during night, increasing with the sunrise, until a peak hour, around 9 a.m.

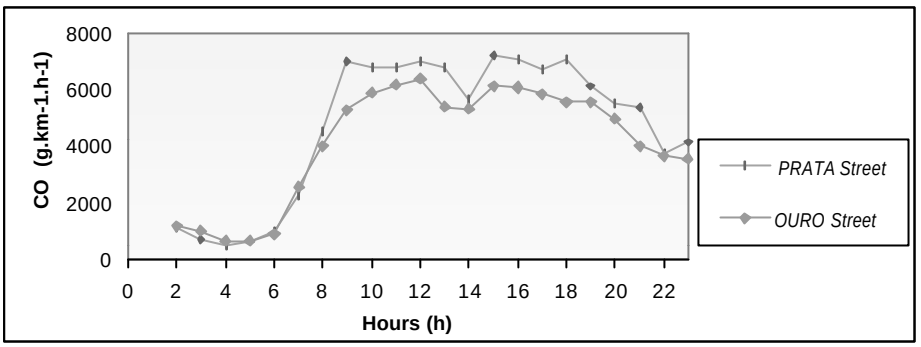

Figure 2: Hourly variation of CO emissions for Prata and Ouro Streets for August 16th estimated by TREM.

In order to obtain CO concentration levels in this area VADIS was applied. Wind direction during the simulation day was mainly from North and Northeast. Information on the buildings volumetry, CO emissions, and meteorology was given as input data to the model.

In Figure 3, a comparison between CO measurements from an air quality station located in Prata Street (see figure 4) and VADIS results is presented. CO concentration values, measured and estimated, are not very high, never exceeding the limit hourly value of the Portuguese legislation (40 000 $\mu g.m^{-3}$) or even the 8-hours average limit value (10 000 $\mu g.m^{-3}$). During night and the first morning hours, measurements and estimated values are quite similar. However, from midday till 9 p.m. measured values are higher than VADIS results. This behaviour can be related to the transport of CO from other sources (namely, other roads) outside the simulation domain. The model still needs some improvements in order to better integrate boundary and background concentration values.

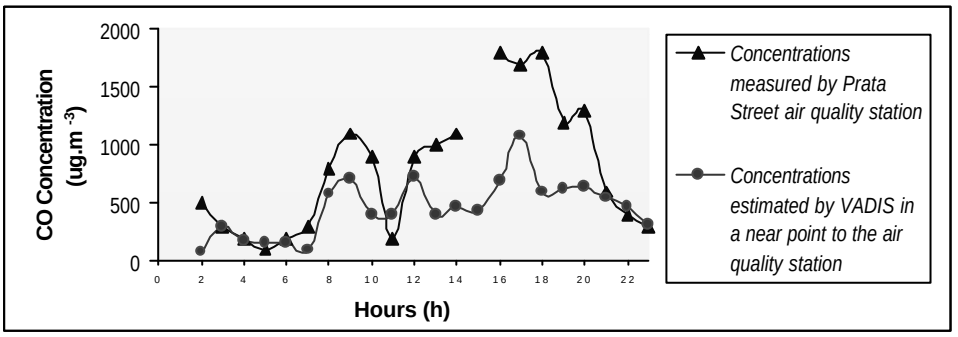

Figure 3: Comparison between CO concentrations measured by the air quality station located at Prata Street and the concentrations calculated by VADIS.

Figure 4 represents the wind and dispersion fields for 12 a.m., when the model has an output similar to the air quality data. It is possible to notice that the higher CO concentration values are located in Prata Street and in the adjacent pedestrian street, since the main winds blow from Northeast. Nevertheless, these values don't exceed the legislation.

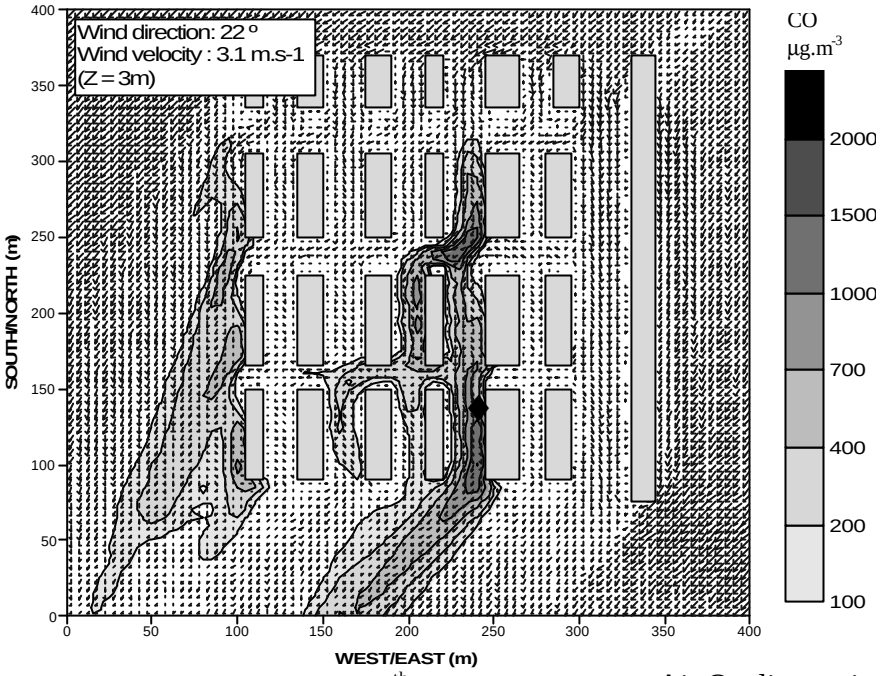

Figure 4: CO dispersion simulation for the 12 a.m. of 16th August (♦-Location of Air Quality station).

Conclusions

The developed system TREM / VADIS is a useful and friendly tool (because a graphical interface was developed) for air quality management in urban areas. Several traffic scenarios can be simulated and analysed aiming to support decision in order to improve the urban air quality. This system can also be used to determine local hot-spots values.

The capability of this numerical tool to calculate the flow and dispersion around obstacles under variable wind conditions opens a vast application field in areas like air quality assessment and policy support with regulatory purposes, or in emergency planning. The model results analysis allows obtaining air quality reference values at the simulated area, which can be used in traffic management as a way to improve citizens' life quality.

Acknowledgements

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References

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Borrego C., Tchepel O., Barros N., Miranda A.I. Impact of road traffic emissions on air quality of the Lisbon region, *In: Atm. Env. 34 (2000), pp. 4683-4690*

List of publication in 2001 and aims for next year

-BORREGO, C.; TCHEPEL, O.; MONTEIRO, A.; MIRANDA, A.I. and BARROS, N. (2001): Influence of traffic emissions estimation variability on urban air quality modelling. The Third International Conference on Urban Air Quality, 19-23 March, Loutraki, Greece (Proceedings in CD-Rom).

-BORREGO, C., MIRANDA, A.I.; COUTINHO, M.; COSTA, A.M.; GOMES, P. and RIBEIRO, C. - The Impact of Road Traffic on the Urban Air Quality: a Modelling and an Experimental Approach. In 7th Conference on Environmental Science and Technology, Ermoupolis, Syros, Greece. 3-6 September 2001 - *Proceedings of the 7th Conference on Environmental Science and Technology*. Greece, T.D. Lekkas, 2001, Vol A, p.90-97.

During the next year main work will be focused on application of VADIS and TREM to several European cities, including Genoa, Geneva, Gdansk and also to Tel-Aviv and Buenos-Aires. It is planned to analyse and validate the results by comparison with air quality measurements. Furthermore, an intercomparison of the results with other models is intended to perform during the coming year.