A refined modelling system for estimating the emissions, dispersion, chemical transformation and dry deposition of traffic-originated pollution from a road

Jari Härkönen, Jaakko Kukkonen, Juha Nikmo and Ari Karppinen
Finnish Meteorological Institute (FMI), Air Quality Research, Sahaajankatu 20 E, FIN – 00810, Helsinki, Finland, Fax +358 9 1929 5403 E-mail: jari.harkonen@fmi.fi

1 Introduction

We present here a new version of a mathematical model for predicting dispersion of pollution from a road, for use in regulatory context. The model includes an emission model, treatment of the meteorological time series, a dispersion model, statistical analysis of the computed time series of concentrations and a graphical Windows-based user interface (Härkönen et al., 1995 and 1996). The name of the model is CAR-FMI, i.e., Contaminants in the Air from a Road – Finnish Meteorological Institute. Recently, application and evaluation of the model have been described by Karppinen et al. (2000a,b).

The dispersion model is based on a partly analytic solution of the Gaussian diffusion equation for a finite line source. It allows for any wind direction with respect to the road (Luhar and Patil, 1989). Dispersion parameters are evaluated using stability data produced by a meteorological preprocessing model, based on a Monin-Obukhov -type boundary layer scaling. The chemical transformation is modelled by using the discrete parcel method. It contains the basic reactions of nitrogen oxides, oxygen and ozone. The validity of the presented analytic solution has been tested against a more detailed numerical model; the results show that it can be used with confidence (Härkönen et al., 1996).

The model performance has been evaluated against the data from two field measurement campaigns (Härkönen et al., 1997, Kukkonen et al, 2001 and Öttl et al., 2001).

2 Mathematical model

A new version (CAR-FMI 2.0) of the model has been completed. The new version includes the following improvements, compared with the previous model version:

1. The user can easily change the model input values and parameters, in particular the meteorological and background concentration time series, and the emission coefficients,
2. The vehicular emissions have been modelled to be dependent on vehicle travel velocity (ranging up to 120 km/h), for the main vehicle categories,
3. Particulate matter emissions ($PM_{2.5}$) are included, in addition to CO, NO and NO_2,
4. The model has been refined to include the dry deposition of particulate matter,
5. The user can select any particular concentration percentile to be computed and presented in the results,
6. A new graphical user interface has been written that utilises utilizes 3-D graphics and a Geographic Information System (GIS) system MapInfo.

An example screenshot has been shown in Figure 1.

The emission factors are estimated as a function of travel speed, for various vehicle categories (Keller et al, 1999). The size distribution of fine PM (aerodynamic diameter d_a <2.5 μm) in primary vehicular emissions is evaluated based on Lappi et al. (2000).

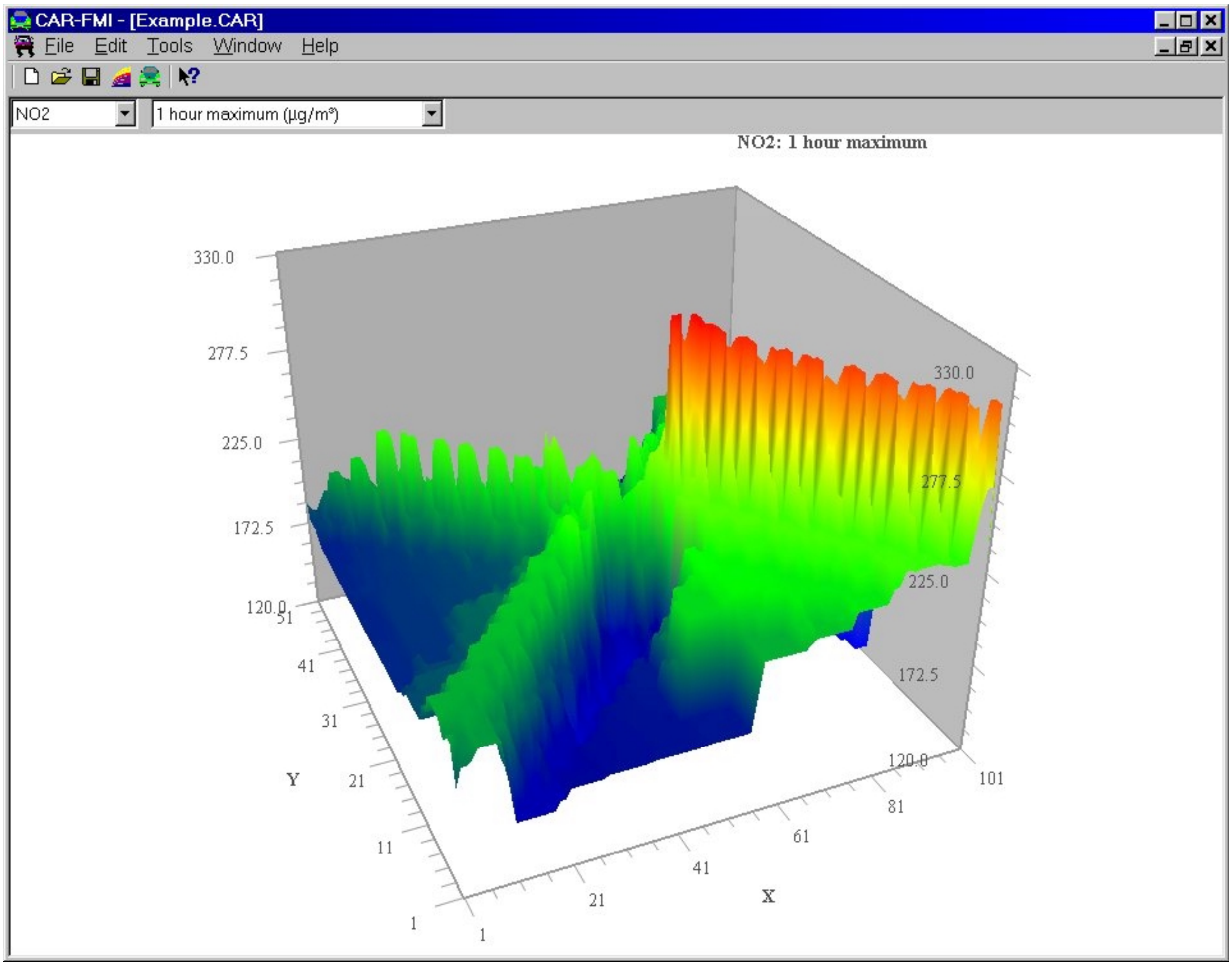

Figure 1 An example screenshot produced by the CAR-FMI model (version 2.0) that shows the three-dimensional presentation of a computed spatial concentration distribution (NO^2, hourly maximum concentration in a year, $\mu g/m^3$). The data presented also can easily be transferred to the GIS system MapInfo, to be presented and processed on user-selected digital maps.

The dispersion and dry deposition of PM is computed according to Lin and Hildemann (1997). The influence of relative humidity on the growth of particles is estimated by a semi-empirical equation based on Swietlicki et al. (2000).

The model can be executed on a personal computer, and it includes a Windows-based user interface. The interface includes also a three-dimensional presentation of the computed spatial concentration distributions.

The results also can be analyzed and presented utilizing the GIS (geographic information system) MapInfo. In addition to basic statistical parameters, the calculation of any percentile value from the computed time series of concentrations (optionally CO, NO, NO_x, O_3 and $PM_{2.5}$) is possible.

The model is transferable, and the user can easily change any set of input values: the meteorological time series, the background concentrations and the emission coefficients. The applications are limited by computational requirements; these are mainly determined by the number of line sources selected, the temporal extent of meteorological time-series and the computational domain.

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