TRAFFIC EMISSION USING FLOATING CAR AND TRAFFIC SENSOR DATA

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Abstract

Air pollution is an important aspect for transportation, particularly car emission in urban area. The objective of this paper is to evaluate the global emission of a transport network based on probe car and traffic sensor data. This paper used the microsimulator; AIMSUN to simulate vehicles on a network and also the pollutant emitted. Different penetration rate of probe vehicles were simulated and the accuracy of pollutant estimated from probe vehicles were compared against the emission from the all vehicles simulated i.e probe and normal vehicles. Two spatial resolutions i.e. at a network level and at a link level were studied. This paper shows that probe car can be used to give good estimate of pollutant emitted by vehicles traversing on a network. Depending of the network configuration, a penetration rate of 5-10 % of probe car is sufficient to obtain satisfactory results of the global emission data.

Keys-words*: Probe vehicles, environmental aspect, vehicle emission, global emission, Microsimulation.*

INTRODUCTION

Air pollution is becoming a more and more important aspect for transportation, particularly CO car emission in urban area. Using probe vehicles (vehicle equipped to provide vehicle's trajectory data during the trip [5]) would allow evaluation of the global urban emission by extrapolation [3]. In order to know the confidence of these extrapolated values, different analysis must be carried out by using a traffic simulator to reproduce the different traffic conditions observable in a network.
The microsimulator AIMSUN NG developed by the Polytechnical University of Catalunya in Spain allows evaluating different parameters such as pollutant emission ([1], [2]). By splitting vehicle in two categories (normal and probe vehicles), it allows extracting global (normal and probe vehicles) and sample (probe vehicles) emission values as output.

OBJECTIVES

The objective of this study is to determine the optimal penetration rate of probe vehicles in the network for a good representative sample for the estimation of global pollutant emission. Accordingly, the accuracy given by the sample for different penetrate rates against the global emission is determined.

NETWORK

The study area presented in this article is based on the Lausanne city centre's network (Switzerland). This is a 2 km x 2 km (4 km^2) area representing a dense urban network where all the roads have been considered (except dead ends). Congestion during evening rush hours can be considered as moderate even if, some arterials are over saturated (particularly in the city centre exits and entrances).
Figure 1 represents the modelled network in green. Junctions are represented by yellow circles and the perimeter's limits are in black.

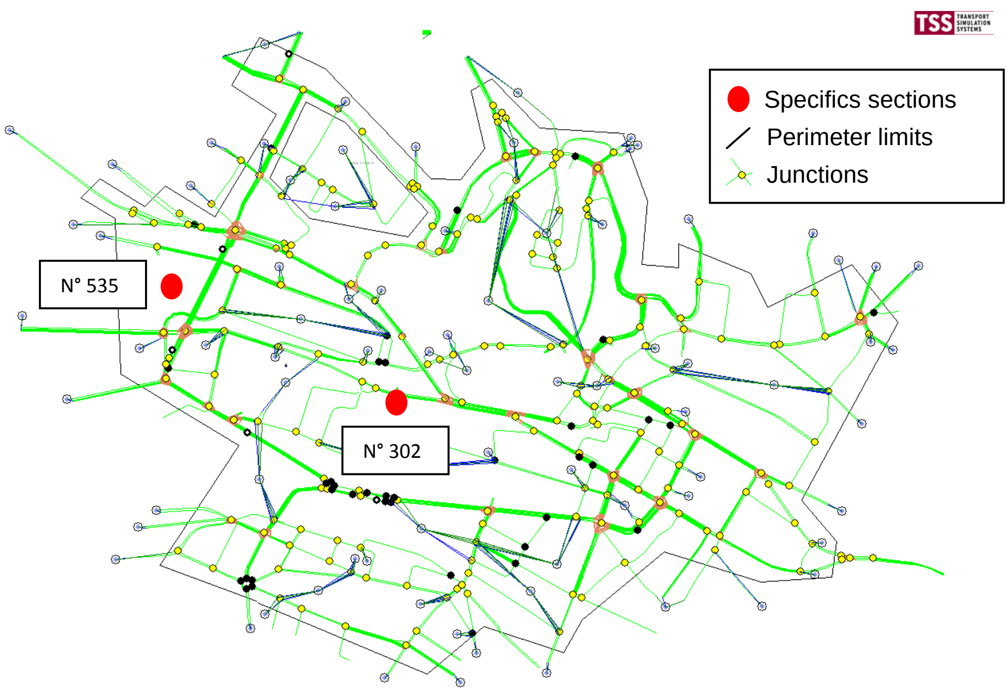

Figure 1: Study network.

The different characteristics of the network are summarised in the following table.

Table 1: Network characteristics.

Number of sections	1’351	Number of nodes	241
Number of polysection	524	Number of traffic light	49
OD Matrix size	80 * 80	Simulation time	19h00 – 20h00

In AIMSUN, there is a special distinction between a section and a polysection (combination of sections). In this network, polysections are formed by an average of four sections. This represents dense network with short distance between junctions. The network has been modelled with all the unsignalized controls and fixed time traffic signal.

DEMAND

The original matrix for the network has been provided from the Origin-Destination feature of the macroscopic EMME/2 software (INRO) using traffic counts and OD survey data. It is a static one hour matrix for the evening peak period. The network has 80 centroïdes (traffic origin and/or destination).
Two different demands (matrices) used in this study to represent different traffic conditions are derived from real data. The first matrix represents heavy traffic condition with 14’800 vehicles / hour and an average of 20 vehicles / km in the whole network.
Second traffic condition represents a lighter utilisation of the network with 11’500 vehicles / hour and 10 vehicles / km.

To represent probe vehicle, two categories of cars have been created by splitting the original demand in groups depending on the percentage of probe cars. Several proportions of probe vehicle have been tested (0.1 %, 0.5 %, 2 %, 5 %, 10 %, 20 %, 50 % and 75 %). The microsimulator provides information for the whole car fleet and for the probe vehicles. In this way, data from the probe vehicle can be compared to the global reference emission data (emission from all simulated vehicles, both probe and normal vehicles).
Percentage of probe vehicle is applied to the whole vehicle fleet (total demand). Hence, variation in the percentage of probe vehicles from link to link could be observed depending of the OD matrix and road types.

EMISSIONS

AIMSUN calculates the emission produce by the different vehicle types in the network using a Fuel Consumption Model. The vehicle state (accelerating, decelerating, idling or cruising) and the vehicle speed are used to calculate the emission from each vehicle for each simulation time step.

Depending on the behaviour of the car in the network, data used for this study for CO emission are ([4]):

Table 2: Emission rates for cars.

Emission rates for cars (g/s)	CO
Idling emission rate (g/s)	0.06
Accelerating emission rate (g/s)	0.377
Decelerating emission rate (g/s)	0.072
Cruising emission rate (g/s) :	
10 (km/h)	0.06
20	0.091
30	0.13
40	0.129
50	0.09
60	0.11

RESULTS FOR THE WHOLE NETWORK

The total amount of CO emitted (from all vehicles) is compared with CO emitted by the probe vehicle. Since the percentage of probe vehicle varies from 0.1 to 75 percent, probe vehicles' emission is scaled to 100 percents.

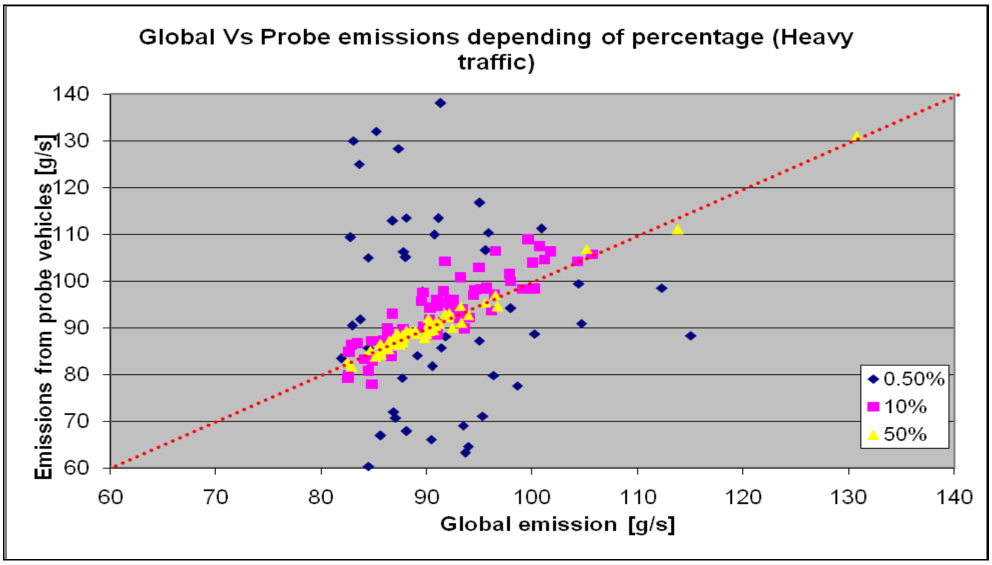

Figure 2: Global and probe emissions depending of percentage (heavy traffic).

Figure 2 shows the emission from all vehicles versus estimates from probe vehicles.
As expected, the lower the percentage of probe vehicle is; the less accurate of the sample data is when compared to the reference values (global emission).

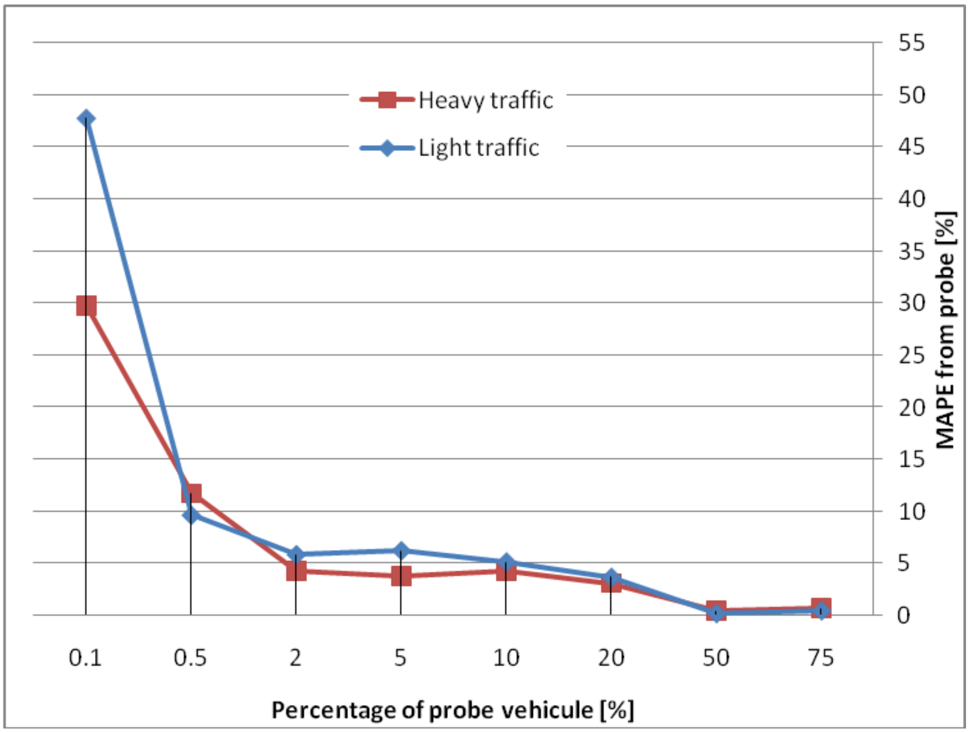

Figure 3: Error (MAPE) between probe data and reference data emission.

Figure 3 shows the mean absolute percentage error (MAPE) of using probe vehicle's emission. Based on the simulation network, for an accuracy of 95 % or higher, at least 2 % of probe vehicle is needed for heavy traffic conditions and 10 % for light conditions.
T tests showed that estimates from 2 or more percent of probe vehicles are significant at 95 % confidence interval.

RESULTS FOR SPECIFIC LINKS

While the total amount of pollutant emitted for a road network may be sufficient for some applications, however air quality modelling requires estimation of pollutant at finer spatial resolution. For this reason, two links have been selected for comparing the accuracy of probe estimates with global values.
The links chosen to be analysed (see red points in Figure 1) are different in term of utilisation. The first link (N° 535) is a heavy traffic link (density around 18 veh/km) and the other link (N° 302) is less used (density: 6 veh/km).
These two links have been tested in the two traffic condition presented in the section "Demand".

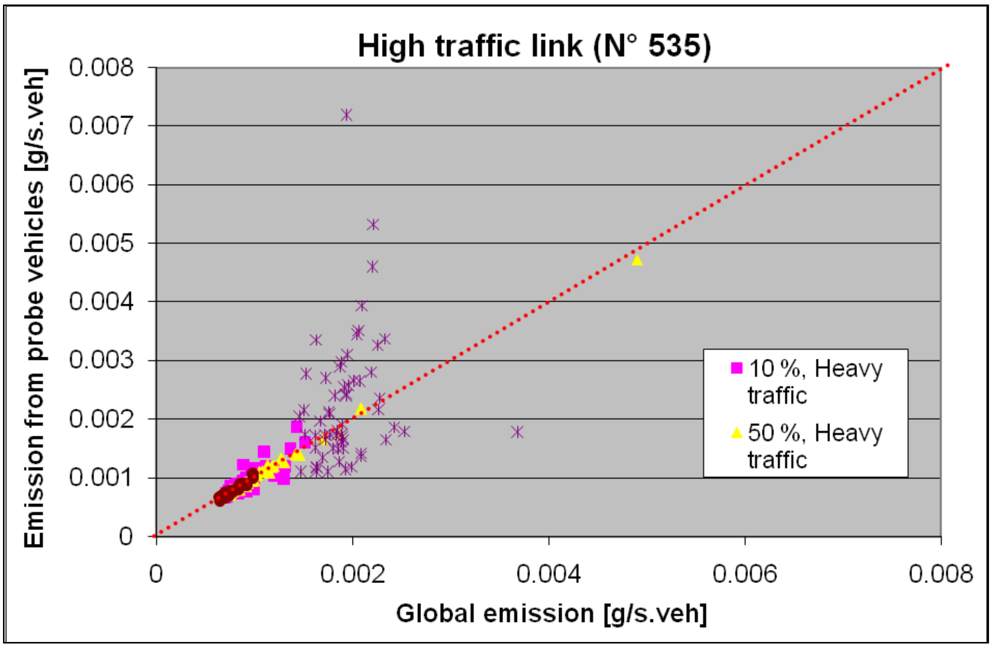

Figure 4: Emissions for high traffic link (N° 535).

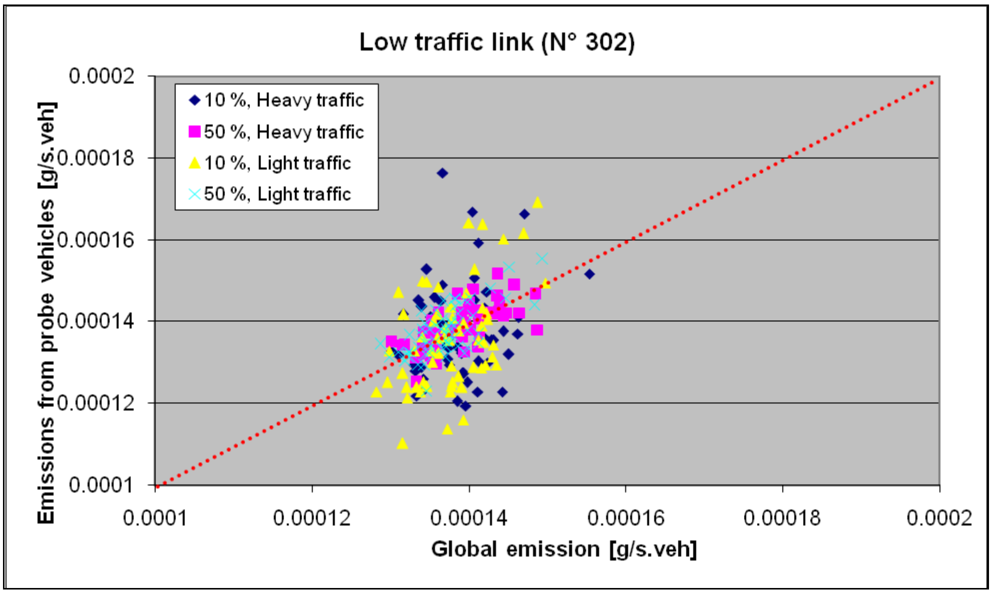

Figure 5: Emissions for low traffic link (N°302).

Table 3: Limits percentages for representative values

		Link traffic condition	
		High	Low
Global traffic condition	Heavy	15%	30%
	Light	30%	60%

Table 3 shows that the higher the link flow is, the smaller the number of overall percentage of probe vehicle is needed because chances of having sufficient probe sample are higher. On the other hand, for links which are not heavily trafficked, a low overall penetration rate could result in no probe or very few probe vehicles on the link.
The case of light traffic condition and low link flow could be considered as an extreme situation and of course the percentage of probe vehicle could be less if a lower accuracy is needed (Cf. the graph of the probe-global points, Figure 2)

CONCLUSION AND FURTHER RESEARCHES

This paper shows that probe car can be used to give good estimate of pollutant emitted by vehicles traversing on a network. Depending of the network configuration, a penetration rate of 5-10 % of probe car is sufficient to obtain satisfactory results of the global emission data. This study also analysed the emission from two links and conclude that for low flow link, an overall percentage of 30-60 % is required to achieve 95 % accuracy. Corresponding figure for high flow link is 15-30% penetration rate.

This study provides encouraging results. Nevertheless, more research has to be performed to better understand the proportion needed with respect to the demand, trip distribution and the size of the network.

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