



Session: Source apportionment and emission models/inventories

High resolution emission estimation in a heavily trafficked urban area in Madrid (Spain)

C. Quaassdorff, R. Borge, D. de la Paz, J. Pérez,
J.M. de Andrés, J. Lumbreras

*Laboratory of Environmental Modelling
Technical University of Madrid (UPM)*

christina.quaassdorff@etsii.upm.es

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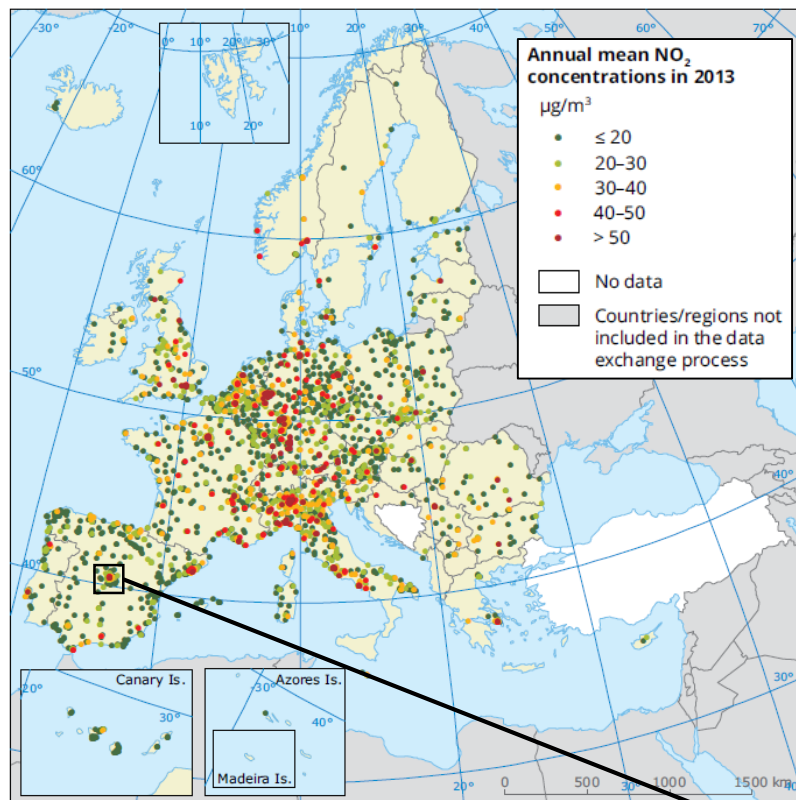
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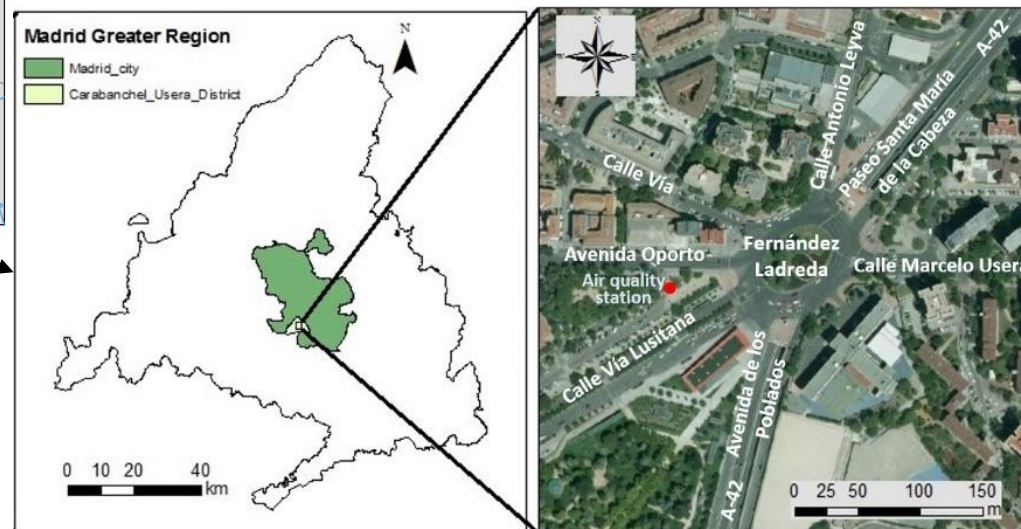
1. INTRODUCTION



EEA 2015

Many European cities are struggling to fulfill NO_2 limit values (Directive 2008/50/CE)

How to reduce emissions in certain urban hot-spots remains unsolved



1. INTRODUCTION

Traffic is the major source of NO_x **emissions** in Madrid city, with a contribution to total emissions of up to **55% (2013)**

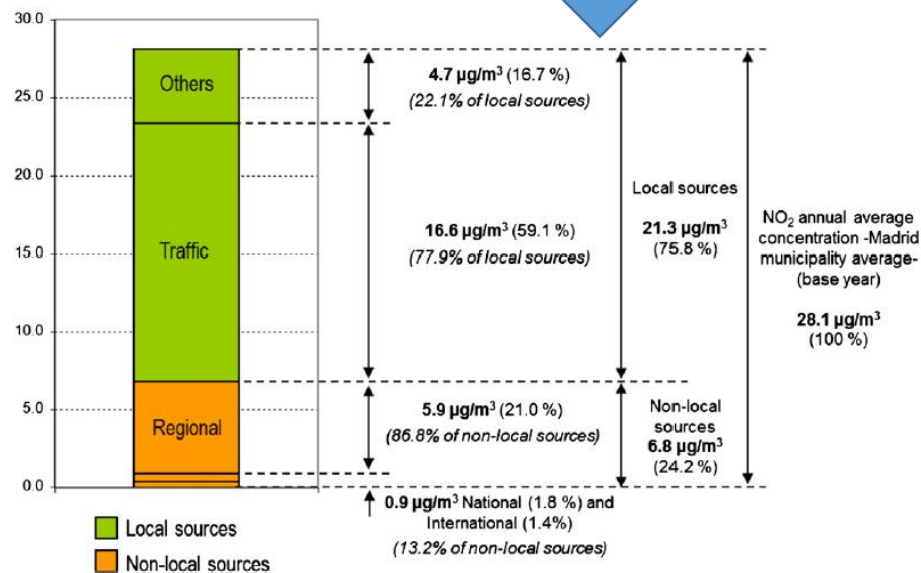
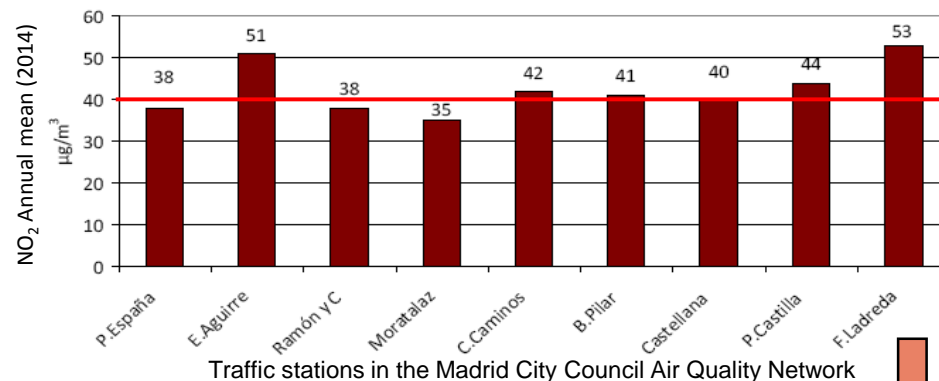


Figure from Borge et al., 2014 (STOTEN)



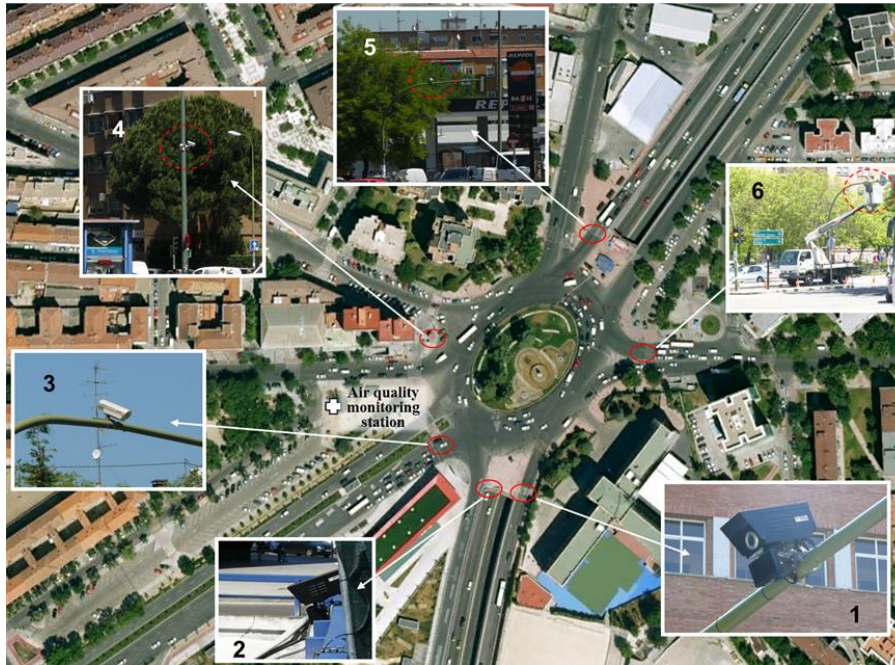
Traffic stations in the Madrid City Council Air Quality Network

Pollution levels **exceed legal limits** in specific traffic-related urban locations

Additional **emission reduction measures** on traffic hot-spots are needed

2. METHODOLOGY

2.1. Measurement campaign



Recompilation of traffic data was done with **2 fluxes** and **11 movements** cameras to define **fleet composition**, **traffic volume** and vehicle **routes**



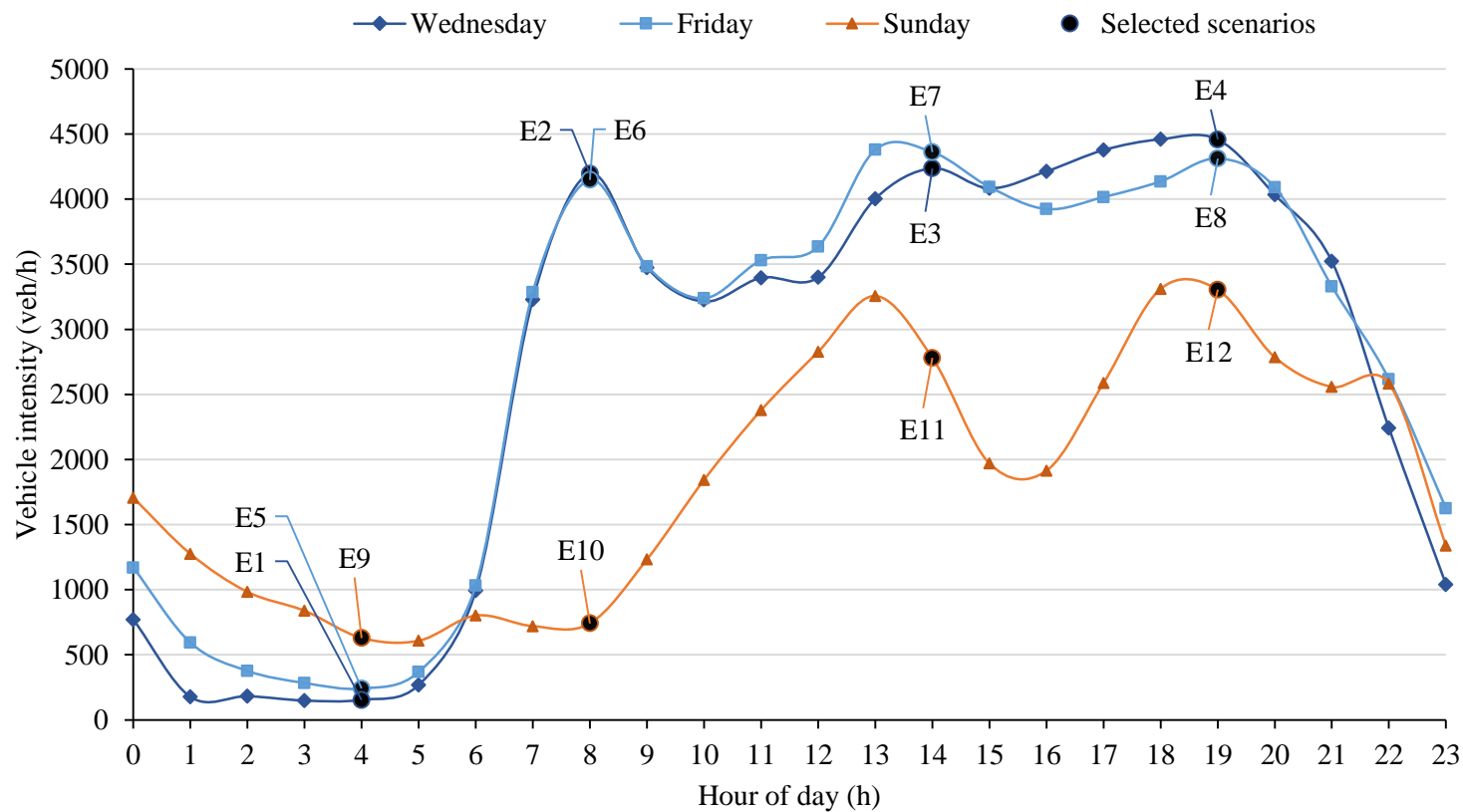
Between May, 23-27th 2013



2. METHODOLOGY

2.2. Scenarios

- 12 scenarios were selected to perform 1-h length simulations
- Representative of a weekly pattern

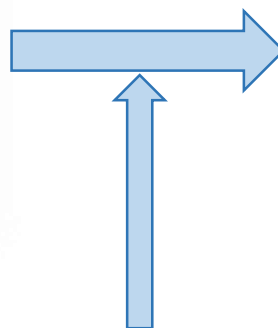


2. METHODOLOGY

2.3. Modelling system: Microscale Traffic simulation model PTV VISSIM



Real world



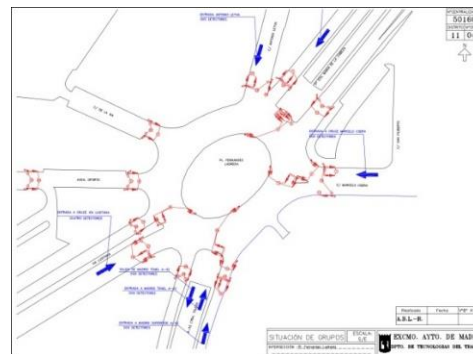
Scenario simulation



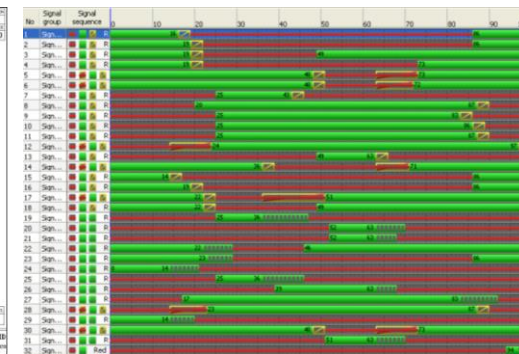
Traffic volume,
composition and routes



Bus lines and stops

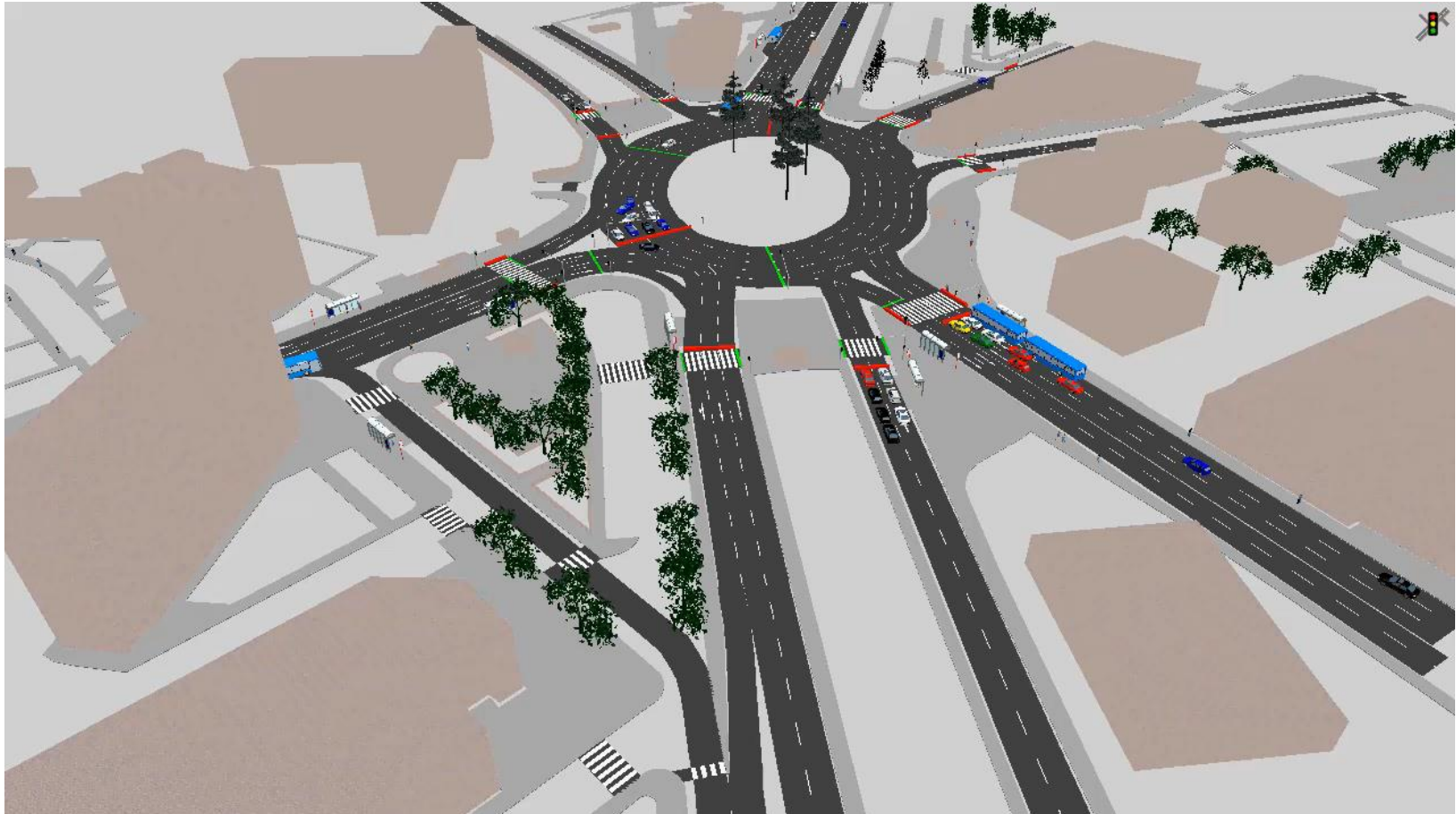


Position of traffic lights and phases



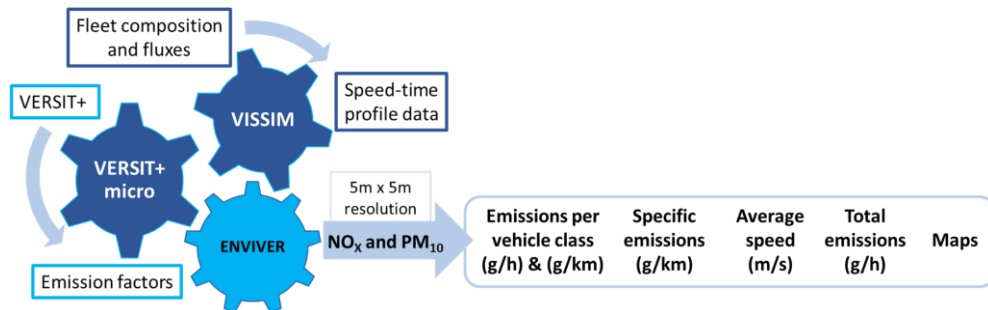
2. METHODOLOGY

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2. METHODOLOGY

2.3. Modelling system: Microscale emissions model VERSIT+_{micro}/ENVIVER

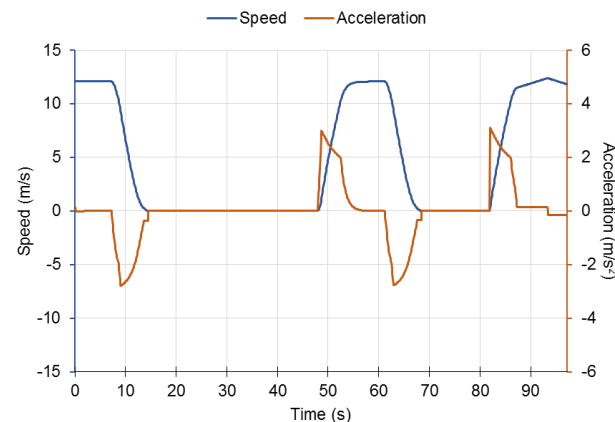


Emissions factor Traffic volume Section length

$$TE_j = \sum_{k,m} (E_{j,k,l}^F \cdot TV_{k,m} \cdot L_m)$$

pollutant Vehicle class Speed-time profile Road section

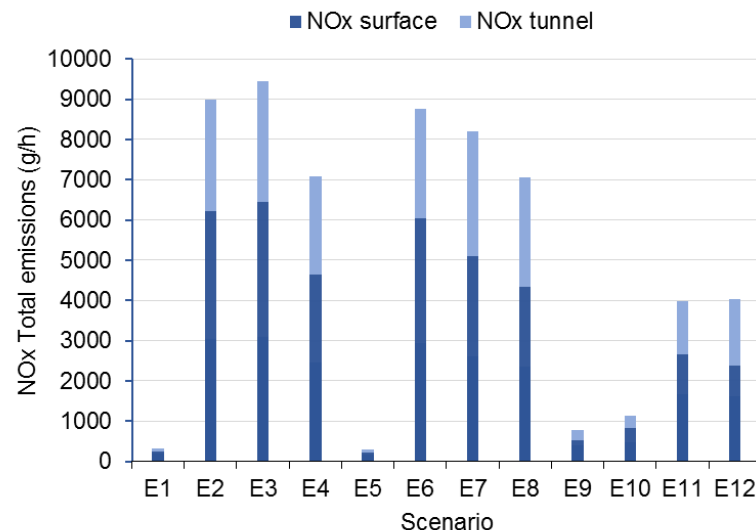
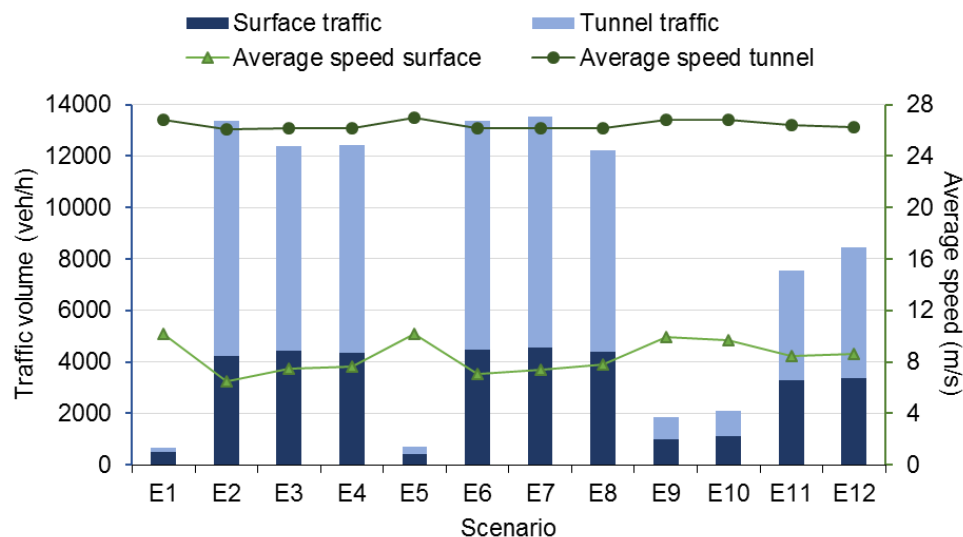
Area	Road type	VISSIM customized classes	VERSIT+ customized vehicle class name
Surface	Urban	Car	Urban_Car_2013_FL
		Taxi	Urban_Car_2013_FL
		Truck	Urban_HGV_2013_FL
		Bus	Urban_Bus_2013_FL
		Motorcycle	Not assigned
Tunnel	Highway	Car_tunnel	Highway_Car_2013_FL
		Truck_tunnel	Highway_HGV_2013_FL
		Bus_tunnel	Highway_Bus_2013_FL
		Motorcycle_tunnel	Not assigned



3. RESULTS AND DISCUSSION

3.1. Total emission results

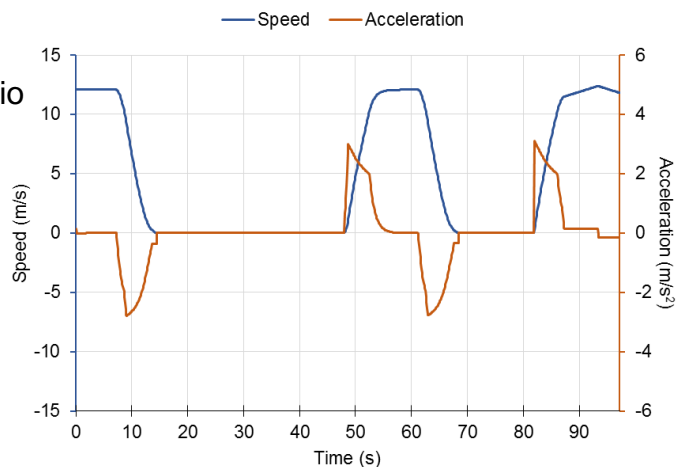
- NO_x hourly emissions in the square range from 100 to more than 9000 grams
- Maximum traffic intensity and emissions do not correspond because of congestion and total traveled distance



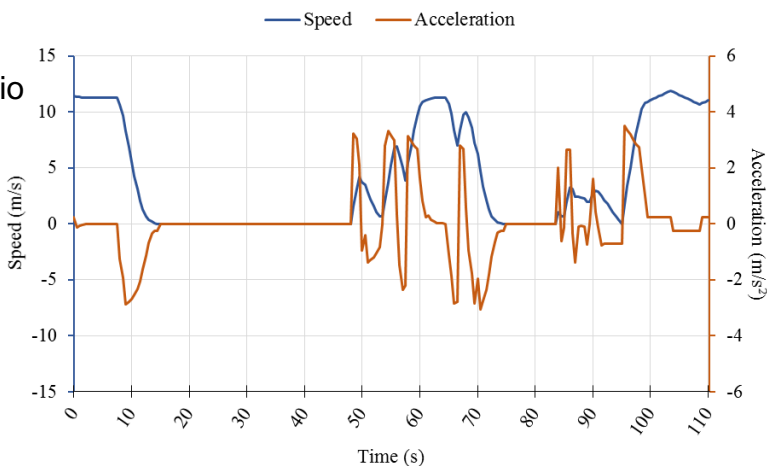
3. RESULTS AND DISCUSSION

3.2. Emission factors and congestion

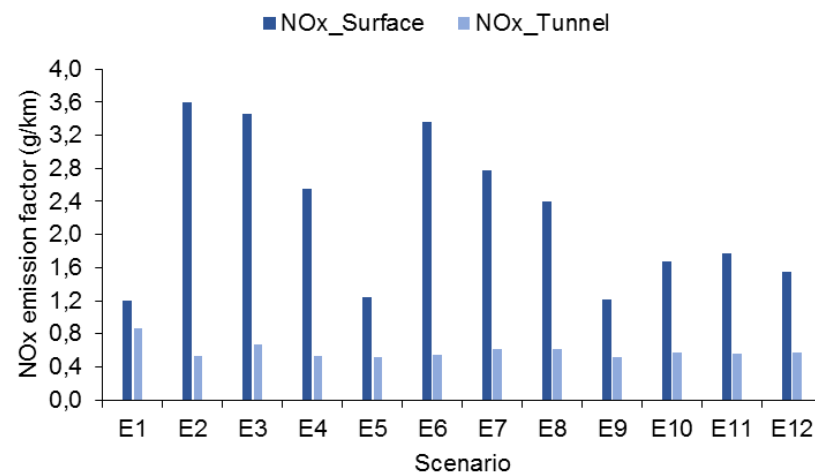
Free flow
conditions
E1 scenario



Saturated
conditions
E2 scenario



- Emission factors presents huge differences due to congestion, up to 65% for NO_x



3. RESULTS AND DISCUSSION

3.3. Spatial distribution of emissions

E1 scenario

Average speed surface: 5.58 m/s (20.1 km/h)

Average speed tunnel: 27.01 m/s (97.2 km/h)

NO_x : 248.50 g/h surface

84.45 g/h tunnel

1.20 g/km surface

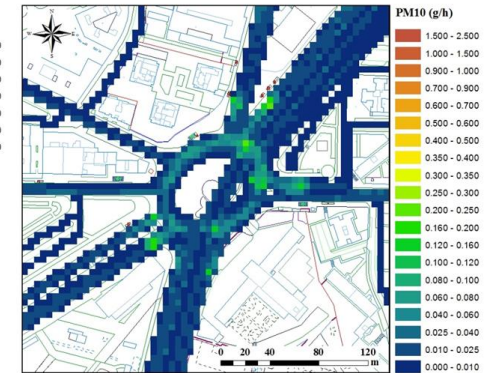
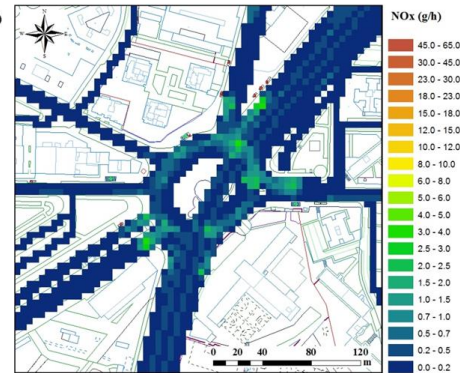
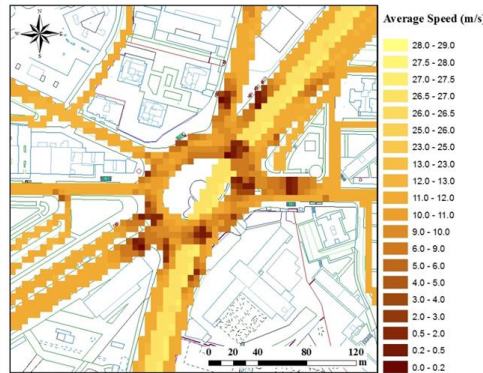
0.87 g/km tunnel

PM_{10} : 18.47 g/h surface

5.47 g/h tunnel

0.09 g/km surface

0.06 g/km tunnel



Free flow
conditions

E3 scenario

Average speed surface: 5.02 m/s (18.1 km/h)

Average speed tunnel: 26.17 m/s (94,2 km/h)

NO_x : 6444.00 g/h surface

3015.00 g/h tunnel

3.47 g/km surface

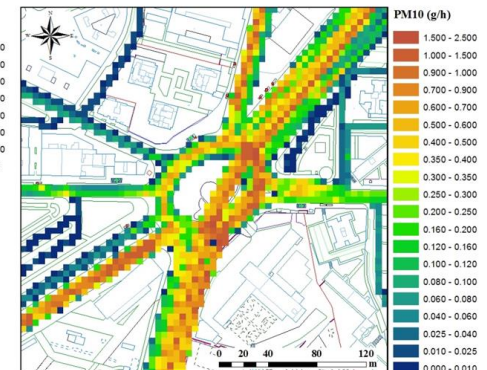
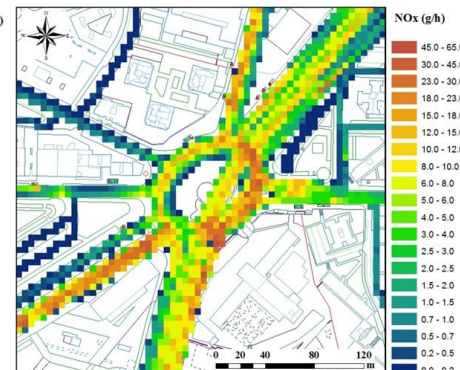
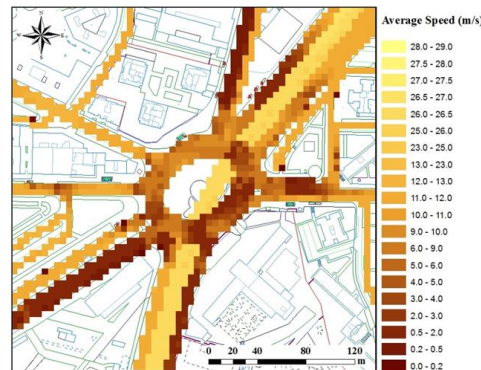
0.66 g/km tunnel

PM_{10} : 309.60 g/h surface

232.50 g/h tunnel

0.17 g/km surface

0.05 g/km tunnel

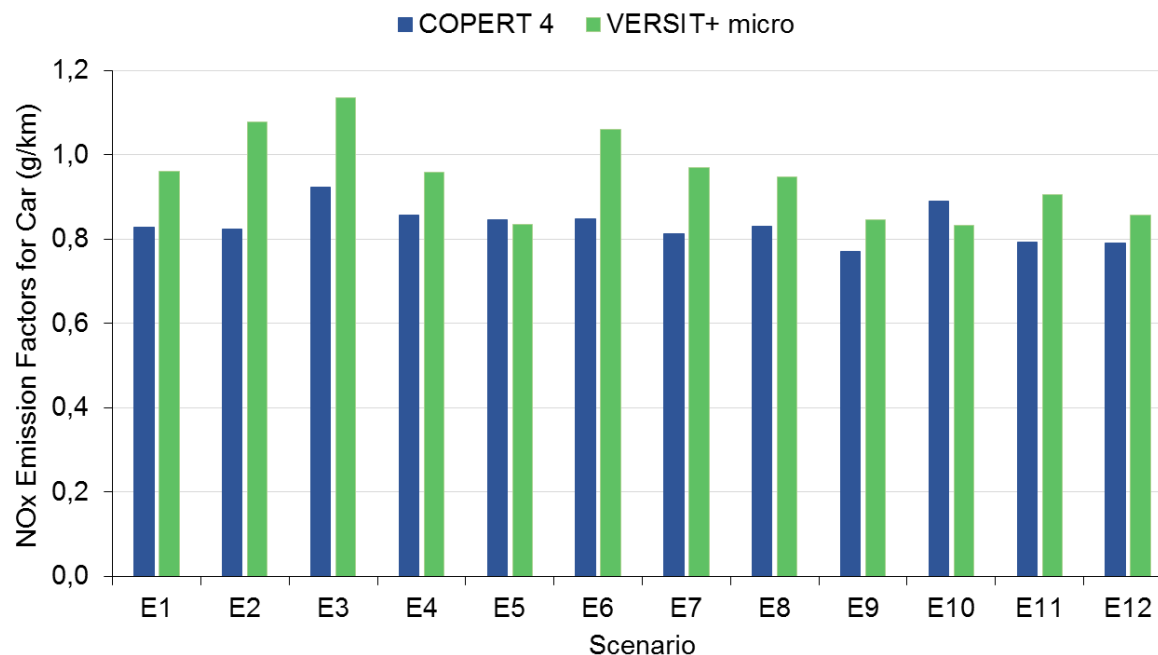


Saturated flow
conditions

3. RESULTS AND DISCUSSION

3.4. Comparison with COPERT 4

- Emission factors as a function of speed have been estimated



- Mean normalized bias error = 14% (taking COPERT as reference)
- Deviations of VERSIT+ at scenario level range between -6% and 31%



4. CONCLUSIONS

- Suitable combination of traffic and emission micro-simulation models is needed to estimate reliable, high resolution emissions in hot-spots
- NO_x and PM_{10} emissions can be up to 27 and 23 times larger during peak hours than in free flow conditions
- Differences in emission factors (g/km), up to 65% for NO_x , highlight the potential of local measures
- Aggregated results are in reasonable agreement with the ones of COPERT 4
- Promising as input for CFD models able to assess microscale abatement measures

NEXT STEPS

- Apply the methodology to other hot spot configurations (junctions, street canyons, etc.)
- Expand the vehicle type categories available in the emission model to make full use of the traffic data and refine it for Madrid
- Appropriate exportability of emission results to integrate it in CFD models for air quality modeling in hot-spot



ACKNOWLEDGEMENTS



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- VISSIM and VERSIT+_{micro} (ENVIVER) were licensed by PTV Group and TNO

Thank you for your attention!

christina.quaassdorff@etsii.upm.es