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

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OUTLINE

1. Introduction

2. Methodology
   2.1. Measurement campaign
   2.2. Scenarios
   2.3. Modelling system

3. Results and discussion
   3.1. Total emission results
   3.2. Emission factors and congestion
   3.3. Spatial distribution of emissions
   3.4. Specific emission comparison with COPERT 4

4. Conclusions
1. INTRODUCTION

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\textsubscript{X} emissions in Madrid city, with a contribution to total emissions of up to 55% (2013).

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

2.3. Modelling system: Microscale Traffic simulation model PTV VISSIM
2. METHODOLOGY

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

<table>
<thead>
<tr>
<th>Area</th>
<th>Road type</th>
<th>VISSIM customized classes</th>
<th>VERSIT+ customized vehicle class name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Urban</td>
<td>Car, Taxi, Truck, Bus, Motorcycle</td>
<td>Urban_Car_2013_FL, Urban_HGV_2013_FL, Urban_Bus_2013_FL, Not assigned</td>
</tr>
<tr>
<td>Tunnel</td>
<td>Highway</td>
<td>Car_tunnel, Truck_tunnel, Bus_tunnel, Motorcycle_tunnel</td>
<td>Highway_Car_2013_FL, Highway_HGV_2013_FL, Highway_Bus_2013_FL, Not assigned</td>
</tr>
</tbody>
</table>

\[
TE_j = \sum_{k,m} \left( E_{j,k,m}^P \cdot TV_{k,m} \cdot L_m \right)
\]

- Emissions factor
- Traffic volume
- Section length
- Pollutant
- Vehicle class
- Speed-time profile
- Road section
3. RESULTS AND DISCUSSION

3.1. Total emission results

- NO\textsubscript{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

- Emission factors presents huge differences due to congestion, up to 65% for NO\textsubscript{X}
### 3. RESULTS AND DISCUSSION

#### 3.3. Spatial distribution of emissions

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Average Speed Surface</th>
<th>NOₓ</th>
<th>PM₁₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>5.58 m/s (20.1 km/h)</td>
<td>248.50 g/h surface</td>
<td>18.47 g/h surface</td>
</tr>
<tr>
<td></td>
<td>27.01 m/s (97.2 km/h)</td>
<td>84.45 g/h tunnel</td>
<td>5.47 g/h tunnel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.20 g/km surface</td>
<td>0.09 g/km surface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.87 g/km tunnel</td>
<td>0.06 g/km tunnel</td>
</tr>
</tbody>
</table>

**Free flow conditions**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Average Speed Surface</th>
<th>NOₓ</th>
<th>PM₁₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>E3</td>
<td>5.02 m/s (18.1 km/h)</td>
<td>6444.00 g/h surface</td>
<td>309.60 g/h surface</td>
</tr>
<tr>
<td></td>
<td>26.17 m/s (94.2 km/h)</td>
<td>3015.00 g/h tunnel</td>
<td>232.50 g/h tunnel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.47 g/km surface</td>
<td>0.17 g/km surface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.66 g/km tunnel</td>
<td>0.05 g/km tunnel</td>
</tr>
</tbody>
</table>

**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\textsubscript{X} and PM\textsubscript{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\textsubscript{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!
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