COMPARISON OF MICROSCALE TRAFFIC EMISSION MODELS FOR URBAN NETWORKS

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Outline

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- Modelling domains
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- Power calculation

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- Emission maps

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Introduction

- Traffic is the major source of air pollution in many cities
- Non-compliance with ambient air quality standards is often linked to traffic-related hot-spots
- How to reduce emissions in this highly polluted microenvironments remains unsolved

Woolloongabba, Brisbane. *Courier Mail*

Air pollution from traffic. *Shutterstock*

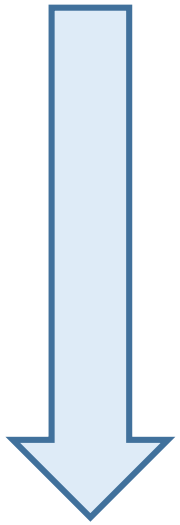
- The assessment of potential solutions for such locations requires high-resolution spatial/temporal models that can successfully capture the complexity of traffic emissions and provide accurate inputs for detailed micro-scale air quality models

Introduction

There are many emission models based on alternative approaches for emission computation

SCALE

MACRO



MICRO

‘**Average-speed**’ models (e.g. COPERT) – Emission Factors (EF) are function of mean speed

‘**Traffic-situation**’ models (e.g. HBEFA) – EF are determined by traffic situations

‘**Traffic-variable**’ models (e.g. TEE) – EF defined by traffic flow variables

‘**Cycle-variable**’ models (e.g. VERSIT+) – EF are function of specific driving pattern variables (instantaneous speed, acceleration and road grade) at high resolution

‘**Modal**’ models – (e.g. PΔP, PHEM) – EF as function of engine operation mode (engine power)

The choice of the modelling approach would depend on the purpose of the computation (detail needed, scale of interest, etc)

More information: Smit et al., 2009

Introduction

- Modal emission models are able to compute emission rates as a function of specific engine or vehicle operating modes with high temporal resolution (seconds)

- They are suitable for this kind of analysis on hot-spot locations

The aim of this work is to obtain and compare detailed traffic emission predictions from two modal emission models in different urban network configurations in Australia and Spain

Selected models to be compared:

Australian

PΔP
vehicle emission software

Smit, 2013

European

PHEM LIGHT
Passenger car and Heavy duty Emission Model

Hausberger & Krajzewicz, 2014

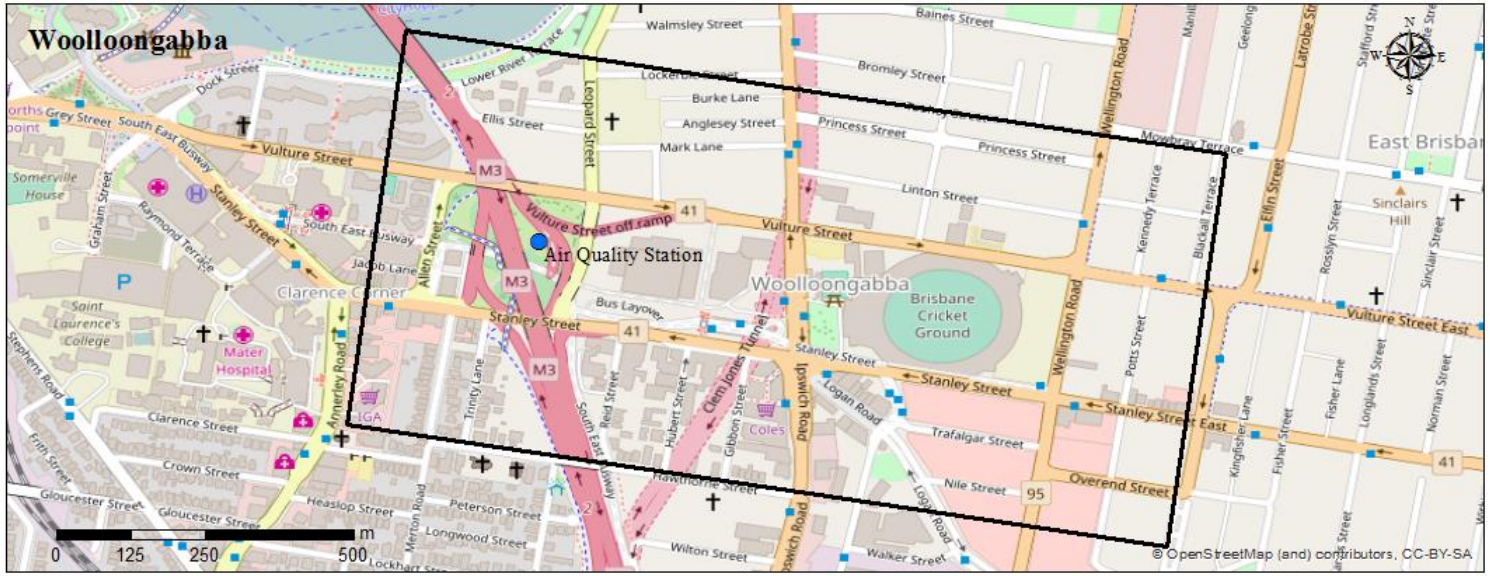
Methodology: modelling domains

- Fernández Ladreda is an urban signalized roundabout located south-west from Madrid city (Spain).

300 m x 300 m

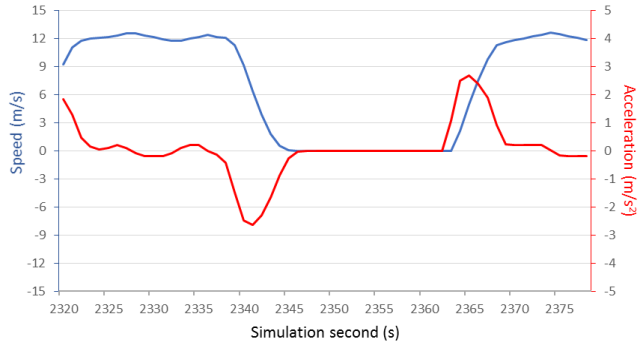
- Woolloongabba is an urban signalized network configuration connected with a highway located south from Brisbane city (Australia).

1250 m x 600 m



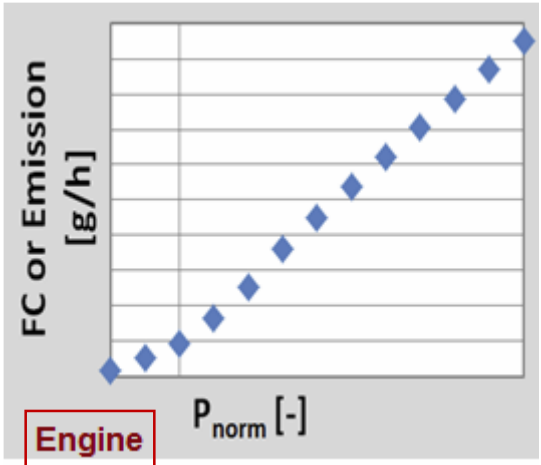
Methodology: modelling system

Driving cycle



Vehicle data

Emission-curve



Vehicle speed

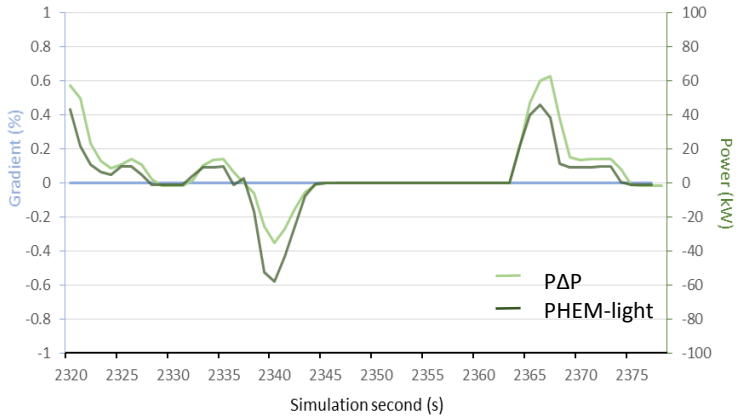
Road grade

Vehicle type

Loading

Vehicle mass

Use of air conditioning



Emissions and Fuel consumption

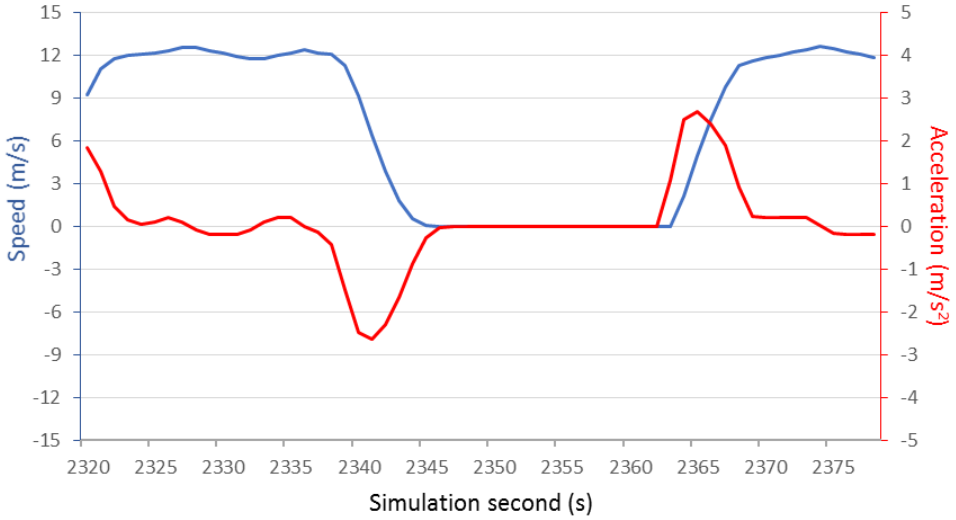
Adapted from Hausberger & Krajzewicz, 2014

Methodology: driving cycles

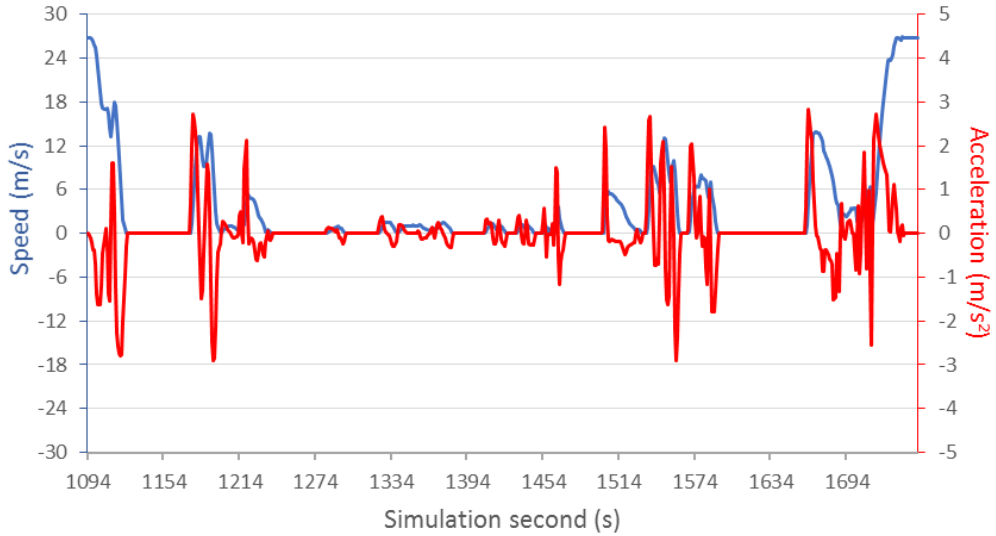
- These estimations are based on individual driving profiles, which are significantly influenced by traffic and road conditions

- Driving patterns for individual vehicles were generated with the traffic micro-simulation model PTV VISSIM providing speed-time profiles with 1 second resolution under different traffic congestion conditions

Example of free-flow conditions in Fernández Ladreda (Madrid, Spain)



Example of saturated conditions in Woolloongabba (Brisbane, Australia)

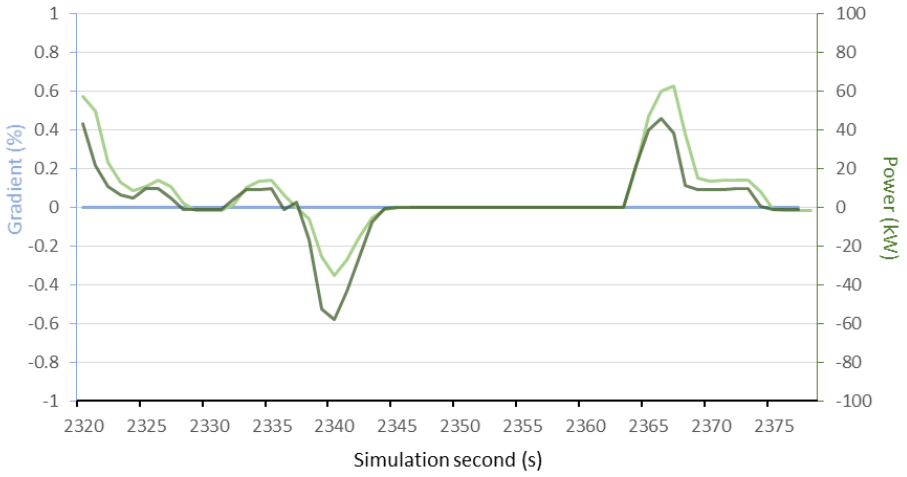


More information: Quaassdorff et al., 2016

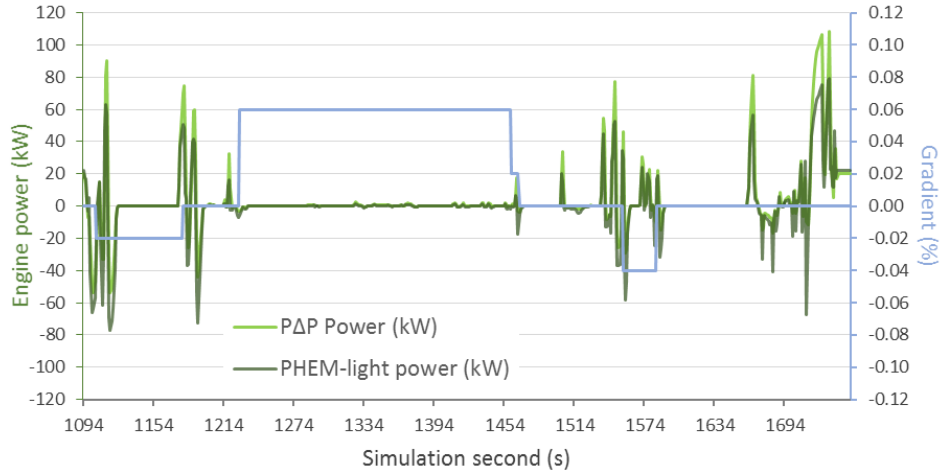
Methodology: power calculation

- To understand the response of these emission models, vehicle classes considered in both models were mapped to a common classification (using power-to-mass ratio) to ensure a consistent comparison.

- Power is one of the fundamental parameters in emission calculations, and this variable is significantly affected by acceleration-deceleration behaviour



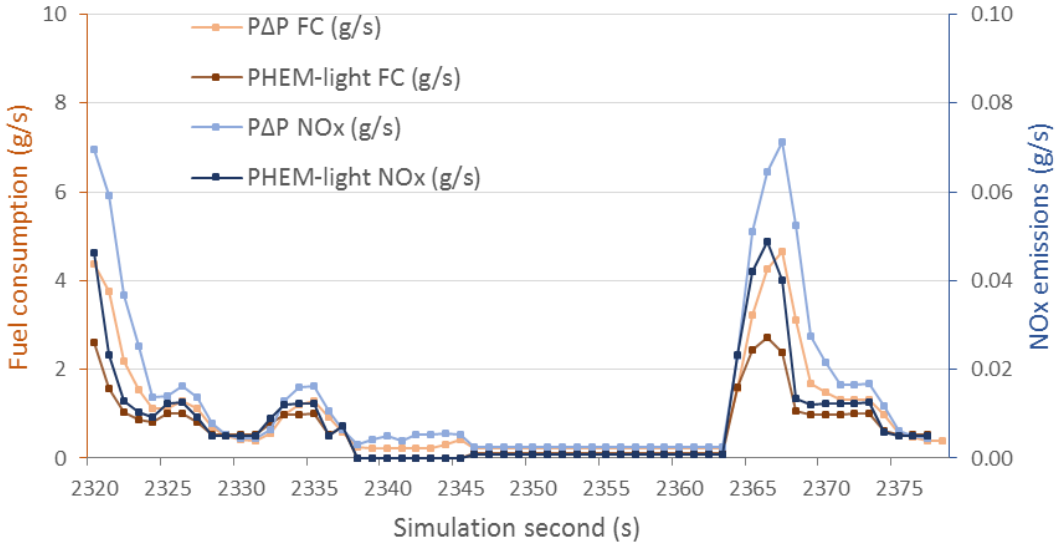
Free-flow in Madrid domain

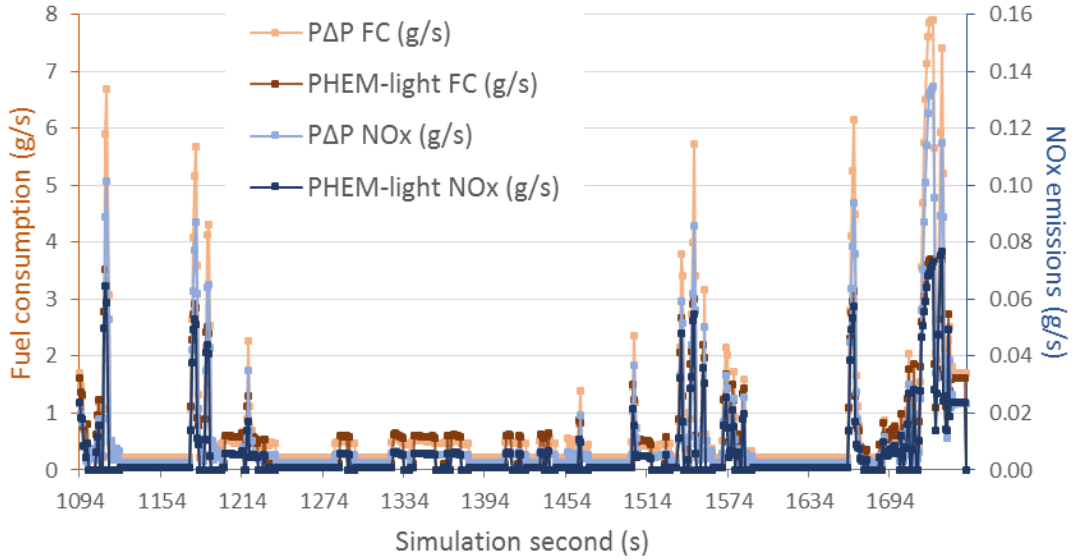


Saturated conditions in Brisbane domain

Results: individual trips

- Instantaneous emission profiles for individual driving patterns are very sensitive to speed-acceleration profiles, vehicle mass (+ loading) and road grade, which are essential variables for the emission calculation.



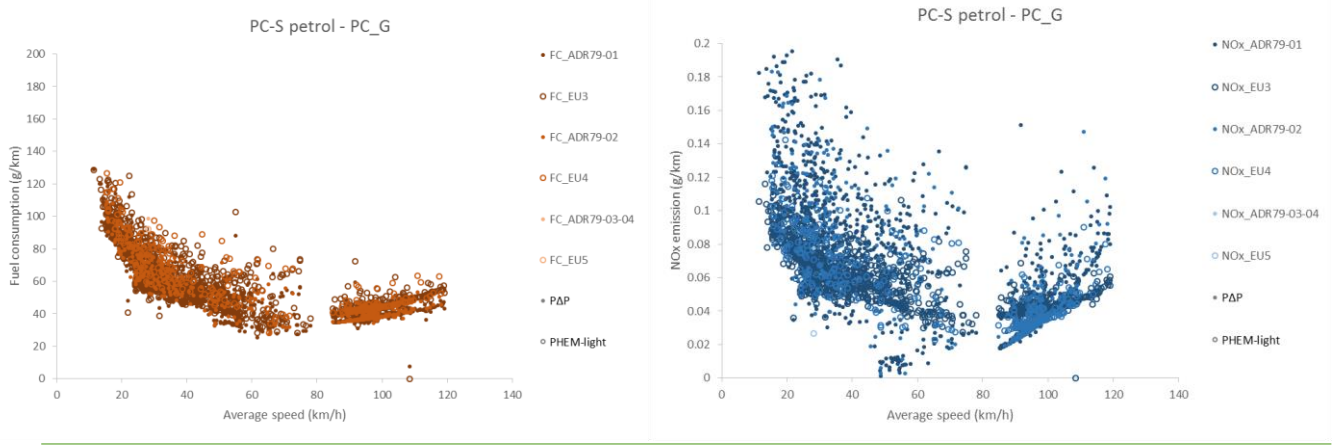


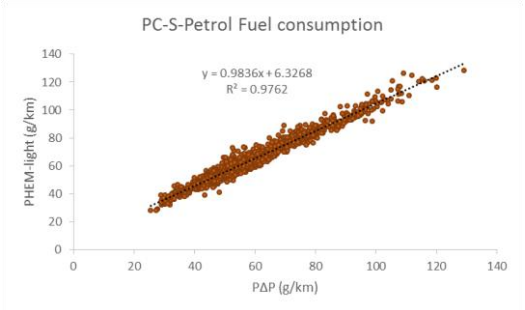
- Differences are due to the power calculation. PHEM-light tends to predict lower power values than PΔP and this is reflected in emission results. For the same Power-to-Mass ratio, Australian vehicles are larger and present higher engine power than EU ones.

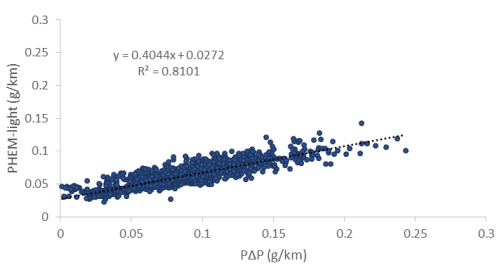
Results: individual trips

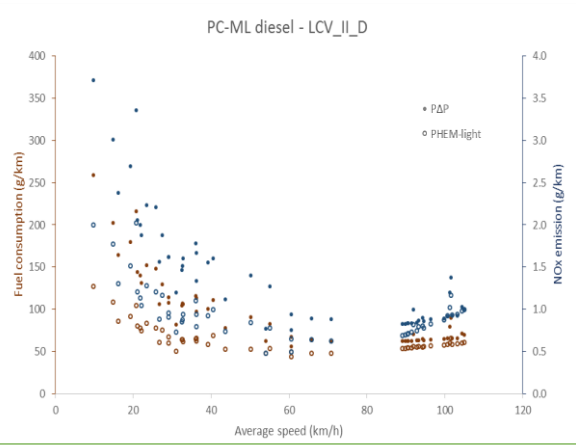
Aggregating all individual trips corresponding to one vehicle type:

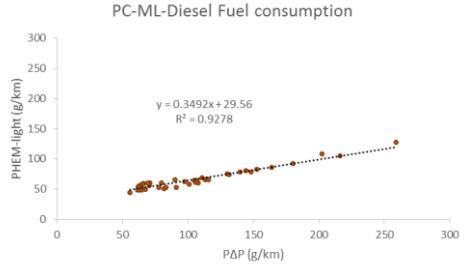
- Lower average speed → stop-go conditions → higher emission factors
- High correlation coefficients between models
- Satisfactory results can be achieved with any of the models, if reliable information on the vehicle fleet composition and vehicle characteristics is provided.

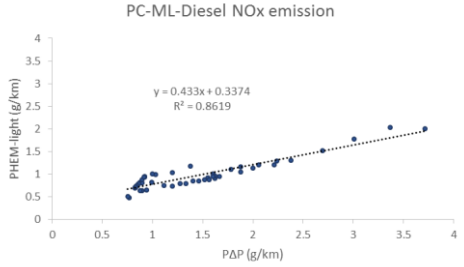






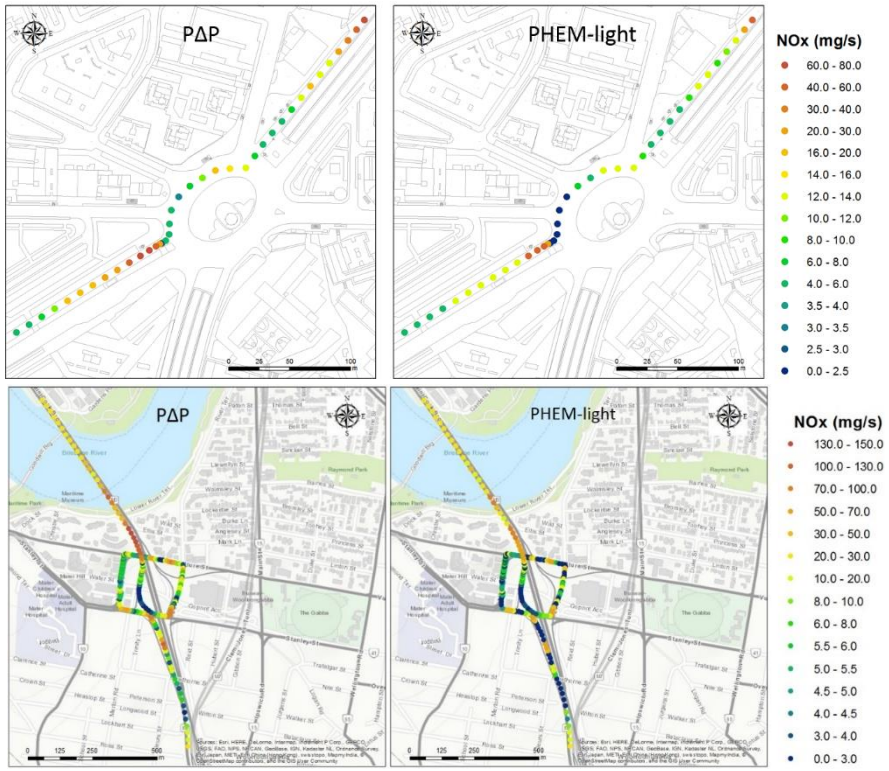


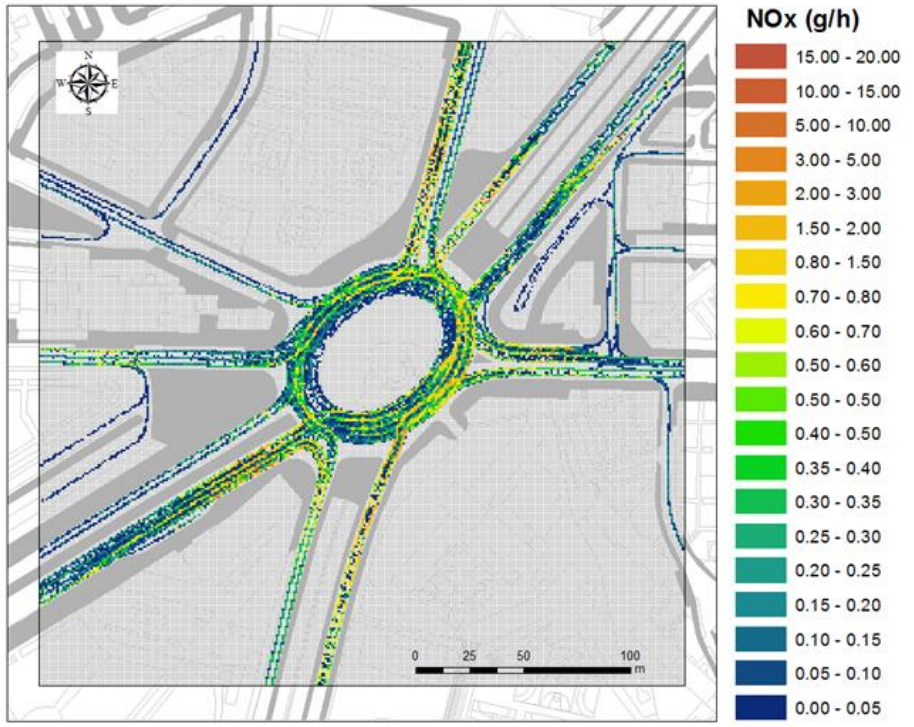




Results: emission maps

- Second-by-second emission results provided by both emission models coupled to the instantaneous position provided by the traffic simulation model can be used to produce emission maps with meters and seconds resolution:





- Suitable for high-resolution air quality modelling (Computational Fluid Dynamics – CFD – models)

Conclusions

- The analysis of emission estimations for driving patterns under different traffic conditions points out the importance of an **accurate definition of the model parameters** for a specific vehicle fleet.

- Large **differences** in the results are observed due to differences in **Power-to-Mass ratios** considered for each vehicle category.

- Larger number of **vehicle classes** included in a particular model implies a better chance to provide representative emissions estimates.

- It is essential to define **power** and **load** parameters as accurately as possible for each vehicle class to obtain accurate emissions regardless of the specific model being used.

- Modal models are a promising option to obtain **high resolution emission estimates** (meters and seconds) for different traffic scenarios for **CFD** air quality modelling in urban areas.

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- R. Smit made available the licence of PΔP

Thank you for your attention!

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