IRTEMS
H2020-MSCA-IF-2019,
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IRTEMS project closure workshop:
Modelling instantaneous road transport emissions
February 13, 2024

Measuring and modelling road transport emissions at microscale

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and

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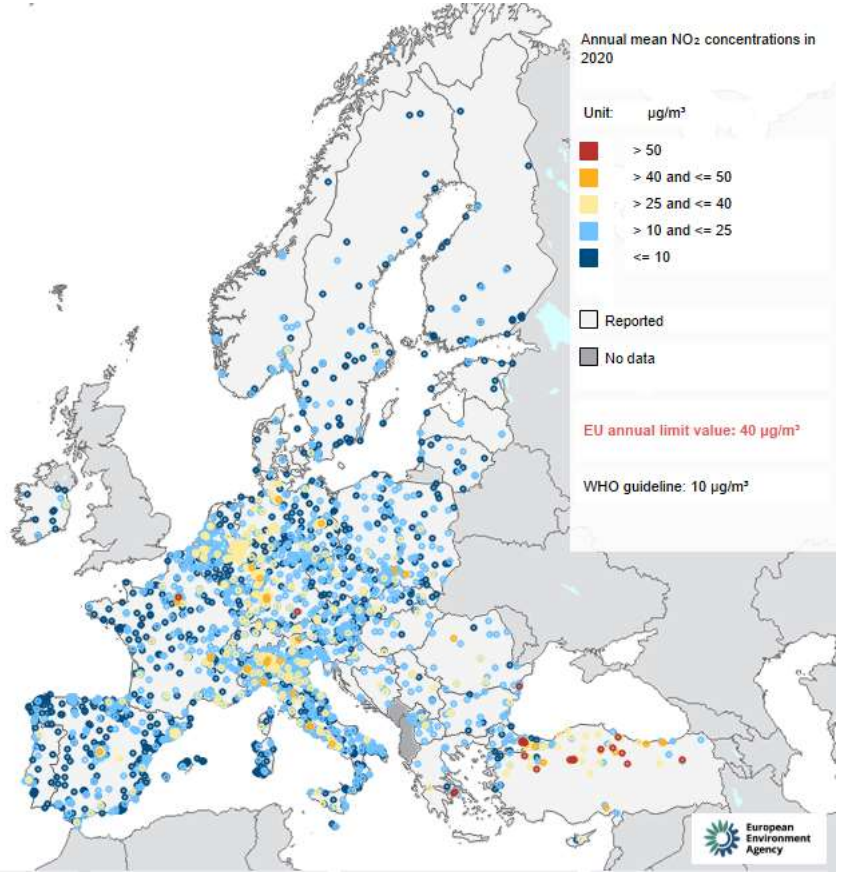
Background on road transport emissions



EEA 2022

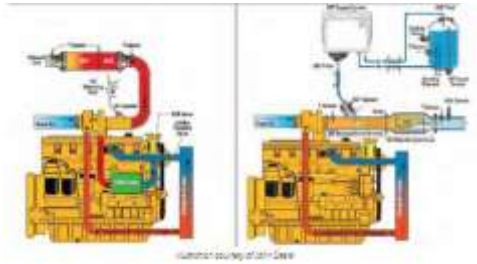
Despite strong improvements in recent years, many cities around the world are still struggling to fulfill air quality limit values and greenhouse gas emission regulations.

Background on road transport emissions

Road transport is often the main source of air pollution in urban areas worldwide and its emissions are often more harmful than those from other sources, as these happen at ground level and tend to occur in cities, close to people.

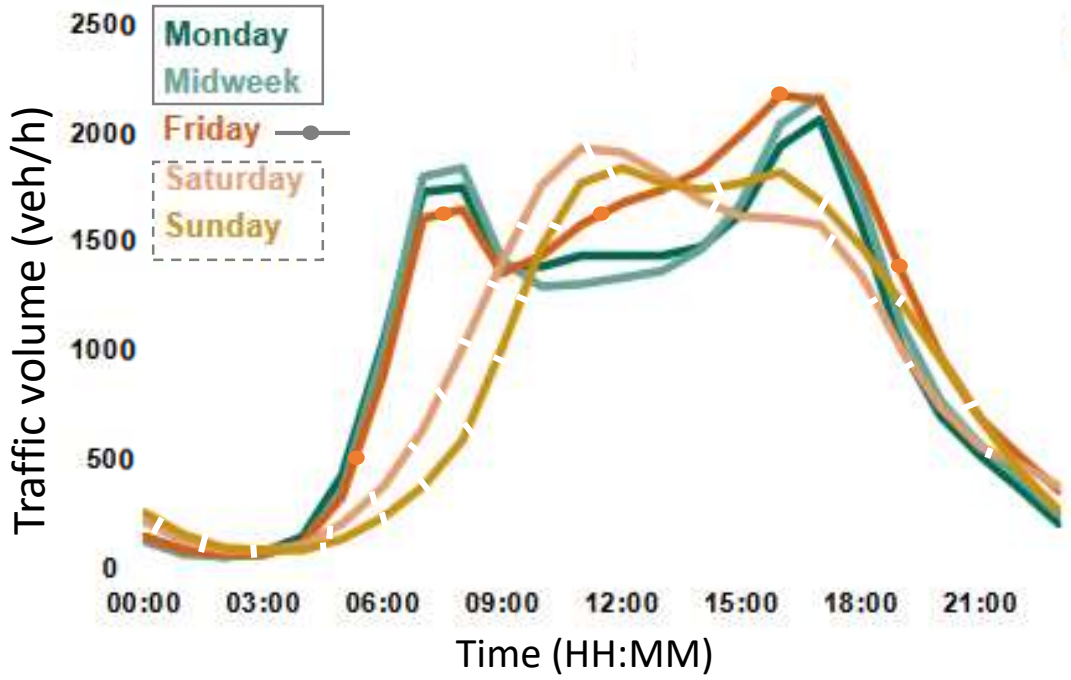
Road traffic activity and emissions

- Traffic activity varies with time of day, and there is typically variability in traffic volume, vehicle mix, and speed during a day.
- Emissions depend on multiple factors:
  - type of road and traffic conditions
  - vehicle type, age and maintenance conditions
  - driving patterns / driving type
  - Fuel used



Temporal distribution of traffic

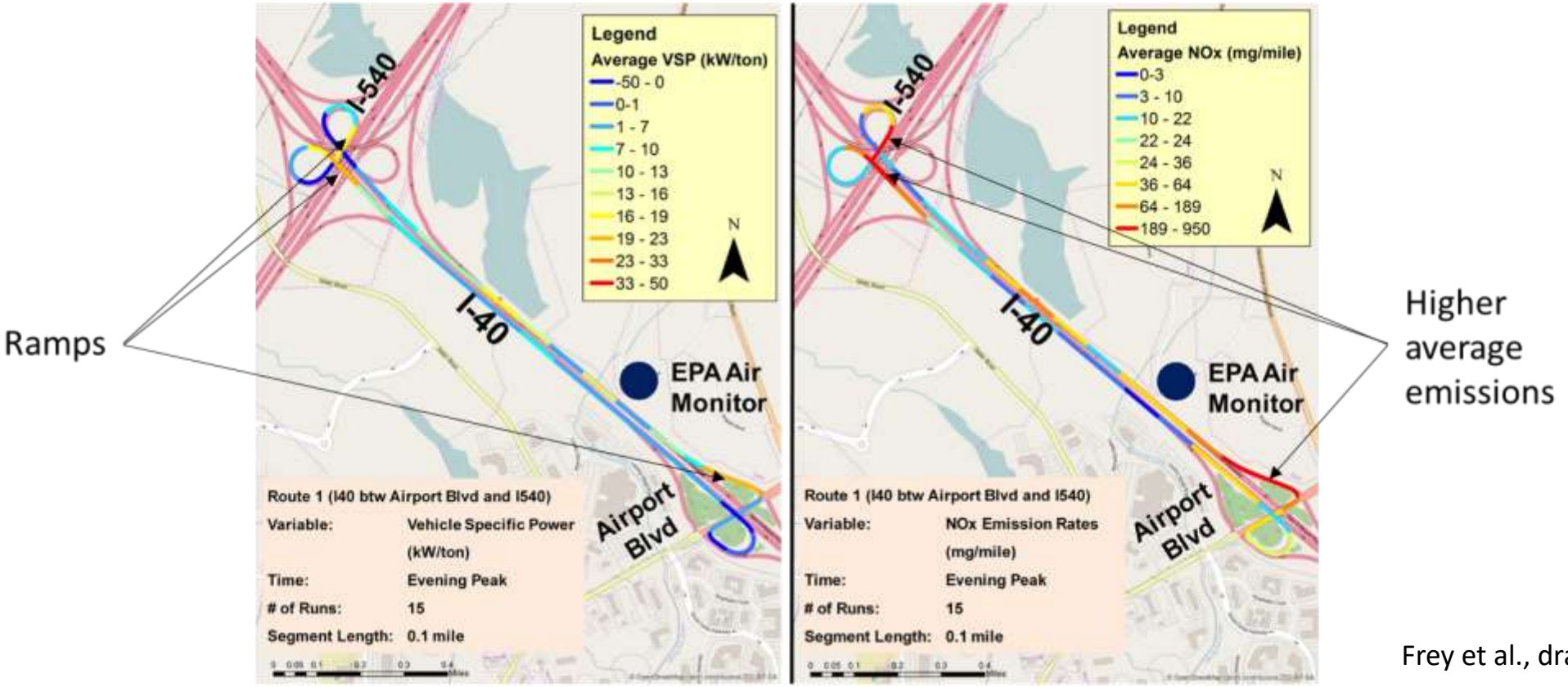
- Typical diurnal variation of traffic indices:
  - Week days: traffic volume has a distinctive bimodal pattern with peaks corresponding to the morning (7-9 a.m.) and afternoon (4-7 p.m.) rush hours → more emissions
  - Weekends: peak hour diluted and peak later in the morning.



Adapted from Storey, 2019

Spatial distribution of emissions

- Emissions increases with higher vehicle specific power (power demand) on ramps and associated with acceleration.



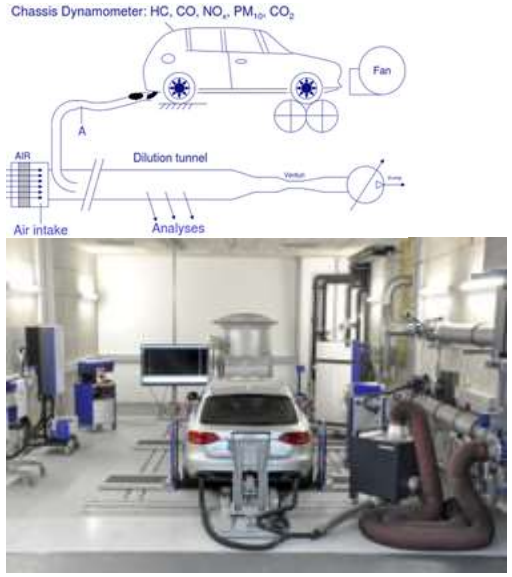
Frey et al., draft HEI report 2020

Types of measurements

Emission data collection can be done using various measurement techniques:

- Laboratory: Chassis-dynamometer and engine bench tests.
- PEMS: Portable Emissions Measurement System.
- Remote Sensing Measurement (RSD) - with roadside devices.
- Mobile laboratory: with instrumented vehicle.

Chassis-dynamometer

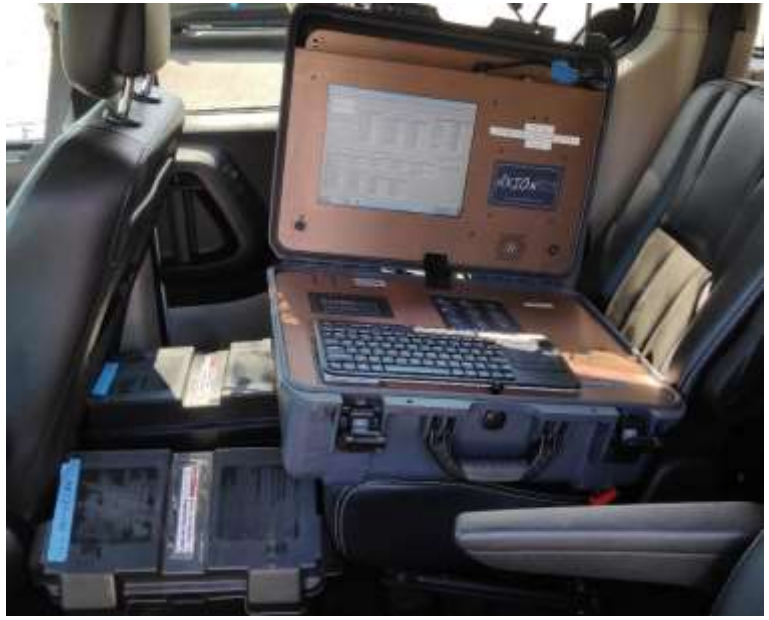


Mobile laboratory

PEMS

Remote sensing with RSD

Measurement of vehicle activity and emissions



Portable Emission Measurement System (PEMS): CO_2, NO_X, HC, CO

Global positioning system (GPS) with barometric altimeter.

On-Board Diagnostic scantool (OBD): 1Hz vehicle activity data (e.g. speed)

Images courtesy of MAPEL Lab (NCSU)

Measured vehicle set-up

NC STATE UNIVERSITY

Measuring vehicle activity and emissions at microscale

NC STATE UNIVERSITY

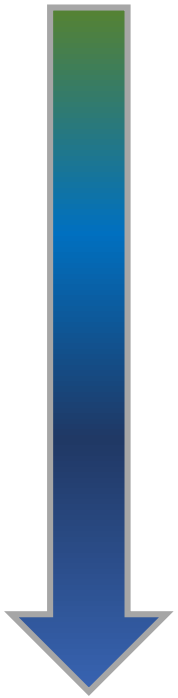
Traffic emissions estimation

- Traffic is an especially complex source. For this reason, several specific calculation models have been developed.
- The calculation of traffic emissions is based on emission factors (EF) that are derived from experimental data obtained during experimental campaigns. Usually dependent on vehicle type, technology, fuel and speed.
- Road traffic emission models are used to obtain emission estimates based on the main inputs that affect the generation of pollution.

Road traffic models: exhaust emissions

SCALE

MACRO



MICRO

There are many models based on different approaches for computing traffic emissions:

'**Average speed**' (i.e. COPERT, MOBILE/MOVES, EMFAC) – emission factors (EF) are a function of average trip speed.

'**Traffic situation**' (i.e. HBEFA, ARTEMIS) – EF defined by street level traffic situations (level of service: free flow, heavy traffic, saturated, stop-go).

'**Traffic-variable**' (i.e. TEE, Matzoros, etc) – EF defined by traffic flow variables (e.g., speed, congestion).

'**Cycle-variable**' (i.e. VERSIT+, MEASURE) – EF are a function of specific variables of the driving pattern (vehicle speed, acceleration, slope of the road) at high resolution (e.g., 1 Hz).

'**Modal**' (i.e. PHEM, MOVES, PΔP) – EF are a function of the engine operating mode (power) obtained from instantaneous data of the driving pattern.

The choice of approximation will depend on the purpose of the calculation (necessary detail, scale of interest, pollutants to be simulated, etc.)

Modal models

PHEM LIGHT
Passenger car and Heavy duty Emission Model
(Hausberger and Krajzewicz, 2014)

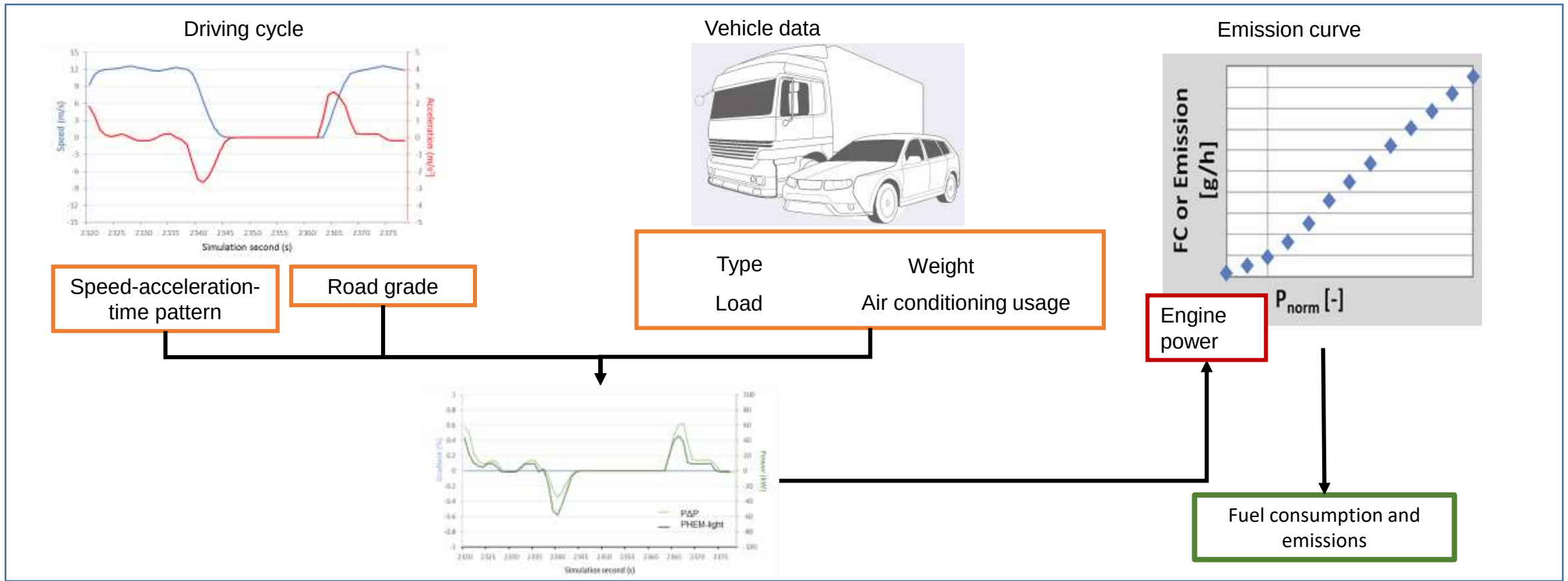
- Passenger car and Heavy duty Emission Model

P∆P
vehicle emission software
(Smit., 2013)

- Power delta power emission software

MOVES
Motor Vehicle Emission Simulator
(USA EPA, 2021)

- Motor Vehicle Emission Simulator



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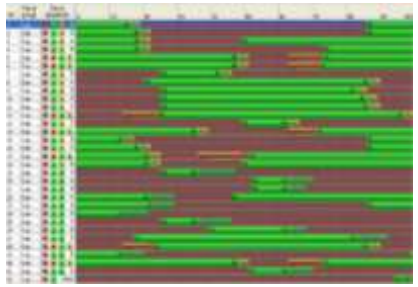
Microscale traffic activity from models

Real world

Traffic volume, composition and routes

Bus lines and stops



Position of traffic lights and phases

With microscale traffic models, instantaneous position, speed - time, and acceleration data are obtained for each vehicle in different congestion scenarios.

Scenario simulation

Quaassdorff et al. 2016

Previous experience: cycle-variable model

Microscale emissions

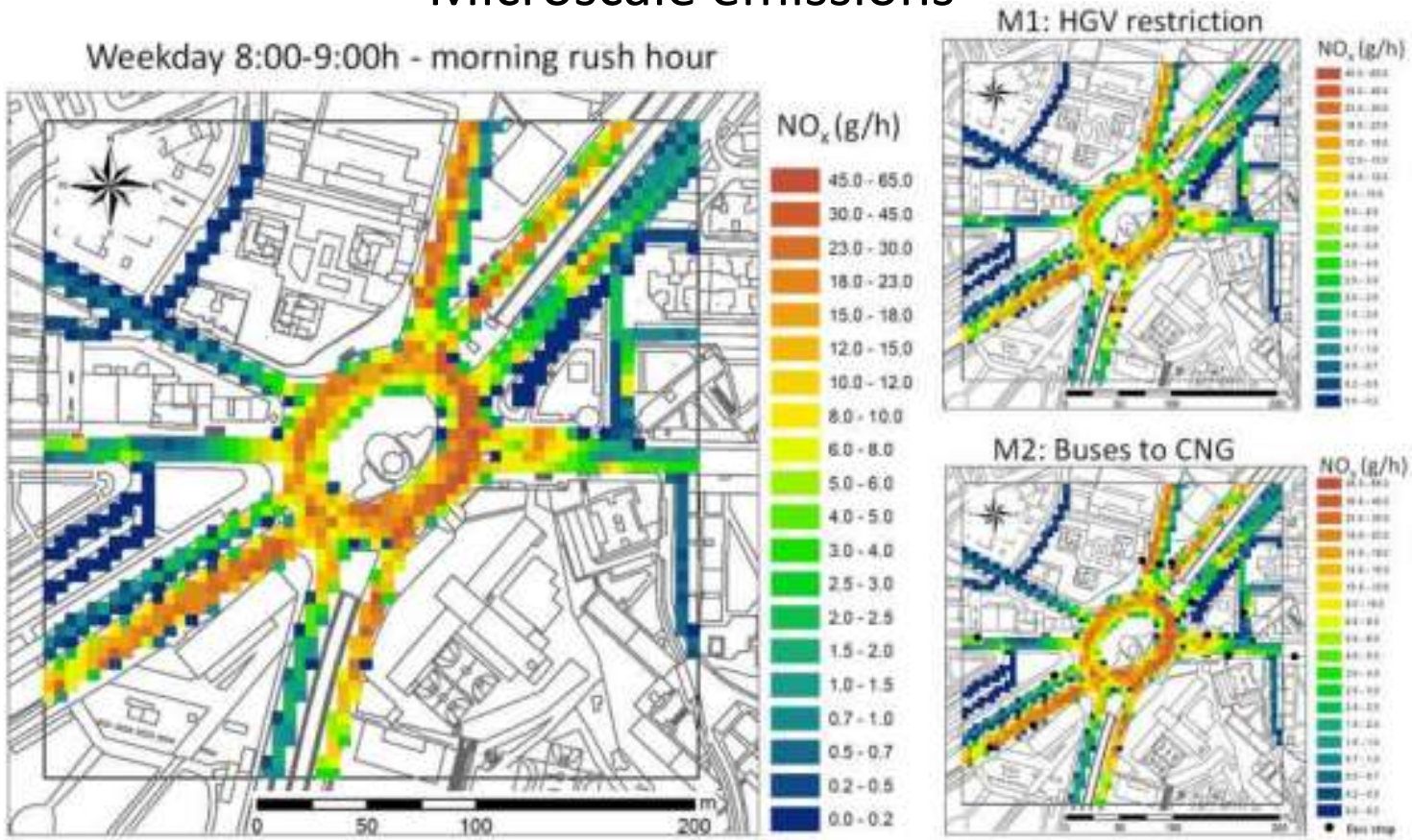


Figure 5.18. Base emission for weekday peak hour scenario in FL (left) and after application of measures 1 (right above) and measure 2 (right below).

Quaassdorff 2018