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SHERPA-City: a web-tool to assess the impact of traffic measures on NO_2 pollution in cities

Bart Degraeuwe, Enrico Pisoni, Philippe Thunis

Bratislava, 27 November 2019

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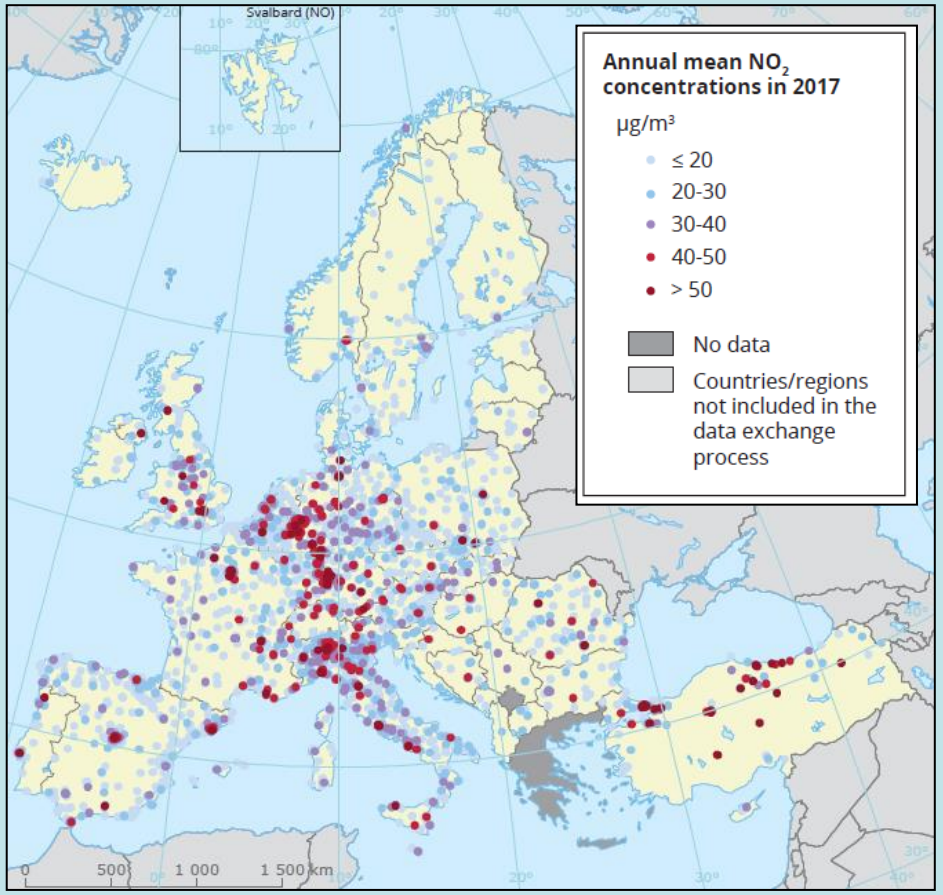
Content

- The NO_2 problem in cities
- Possible measure
- A web-tool to asses the impact of traffic measures
  - Methodology
  - Interface
  - Application
- Current status
  - Madrid workshop
  - Future improvements

The NO_2 problem in cities

- 86% of exceedances of the annual average NO_2 limit value ($40\ \mu g/m^3$) occur at traffic stations

- NO_2 is an urban traffic problem



Source: NO_2 annual average in 2017 from EEA, Air quality in Europe – 2019 report

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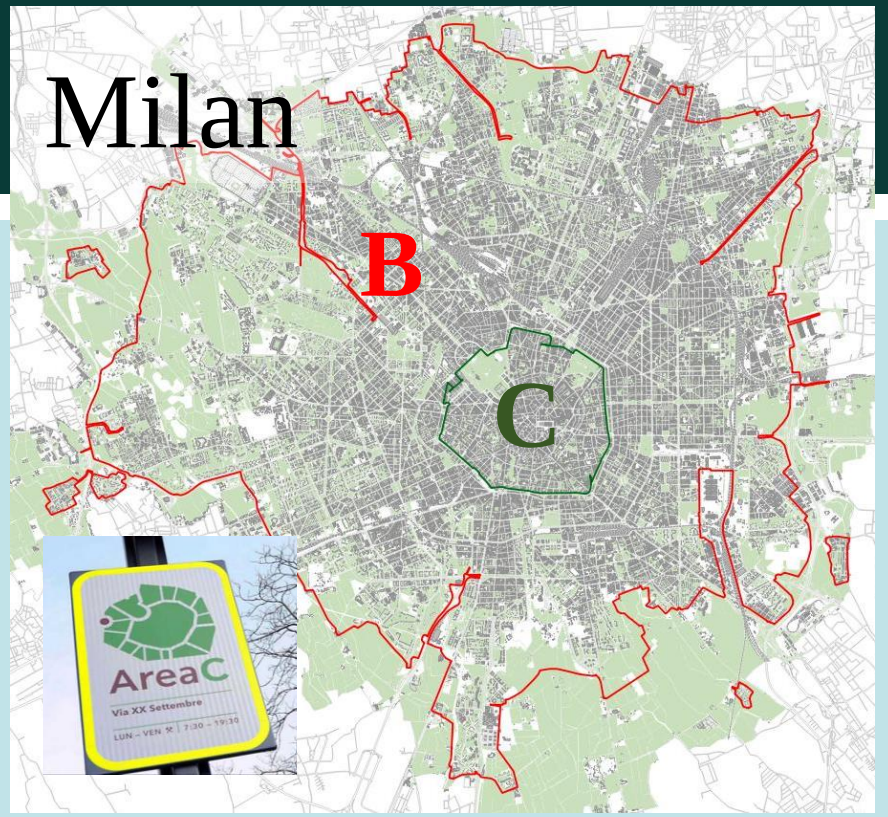
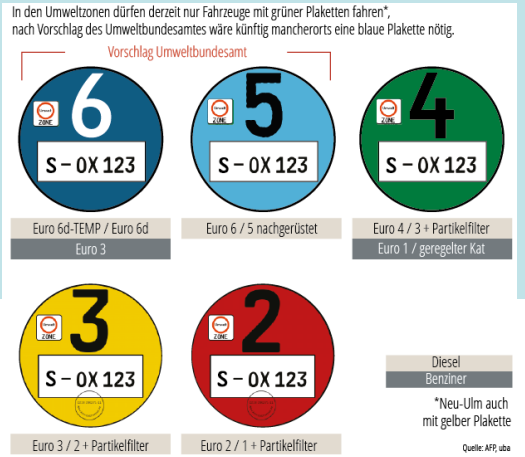
What can cities do?

- Access regulations:
  - Milan Area B and C: combination of **congestion charge** and low emission zone (bans of older vehicles).
  - German ‘Umweltplakette’
- Promote public transport, walking, biking…

How to evaluate the impact of measures?



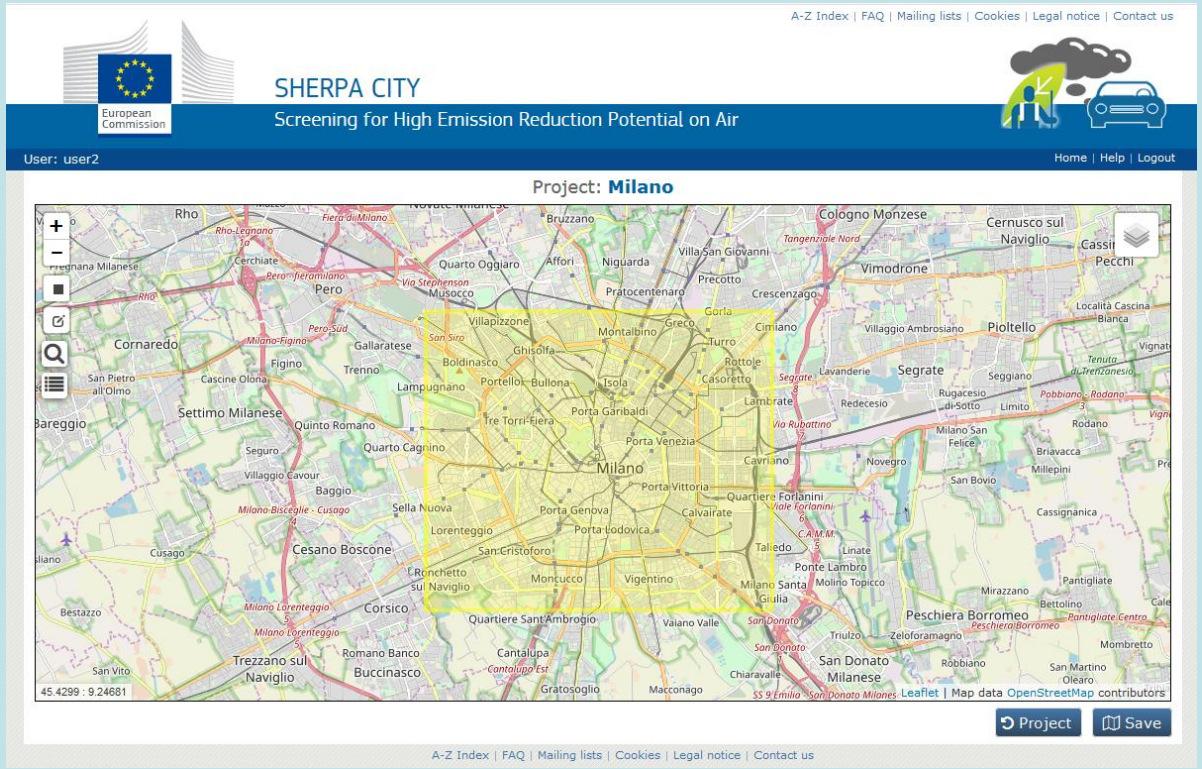


SHERPA-city web-tool: main features

- Available for free after registration at:
  - https://integrated-assessment.jrc.ec.europa.eu/sherpacity/
- Default road network with traffic flows available.
- Default emission factors of the national vehicle fleets available for historic years (until 2016) and projections (2020 and 2025).
- Dispersion kernels based on local meteorology for fast concentration calculations.
- Background NO_2 concentration due to other sources (industry, residential, shipping,…) from EMEP and CHIMERE.
- Possible to define fleet restrictions and traffic reductions in user defined areas.
- Visualization of the results.

SHERPA-city workflow (1)

- Select your domain



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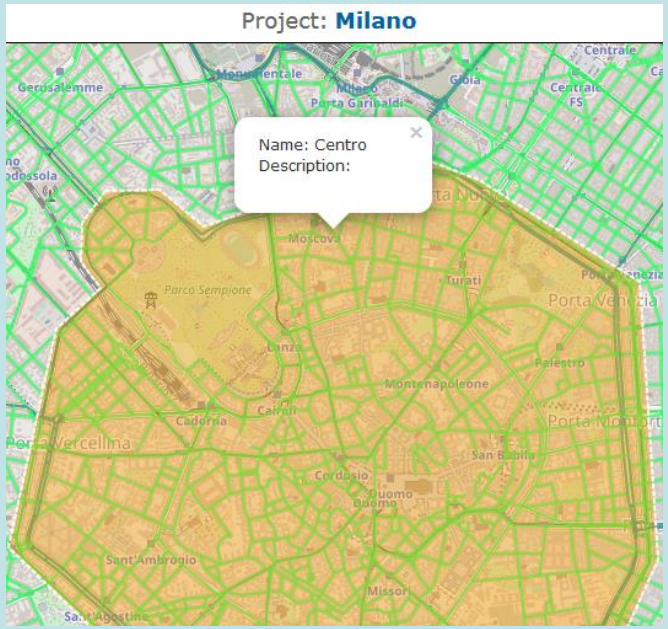
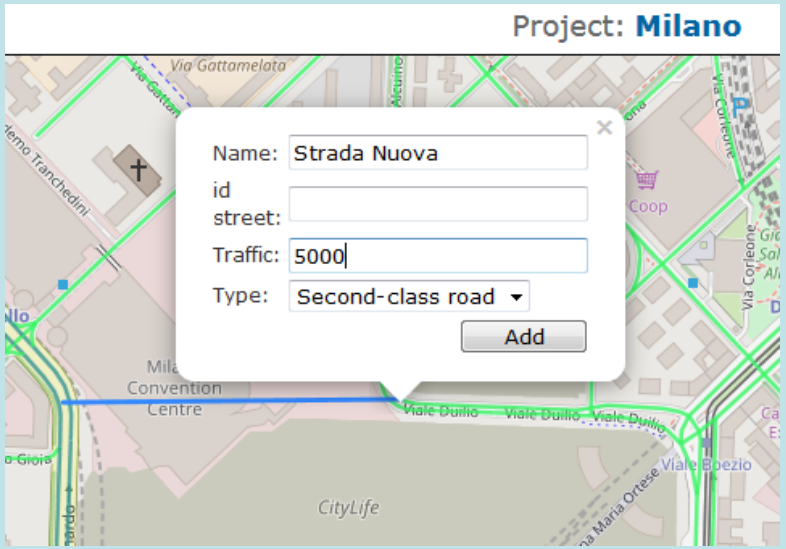
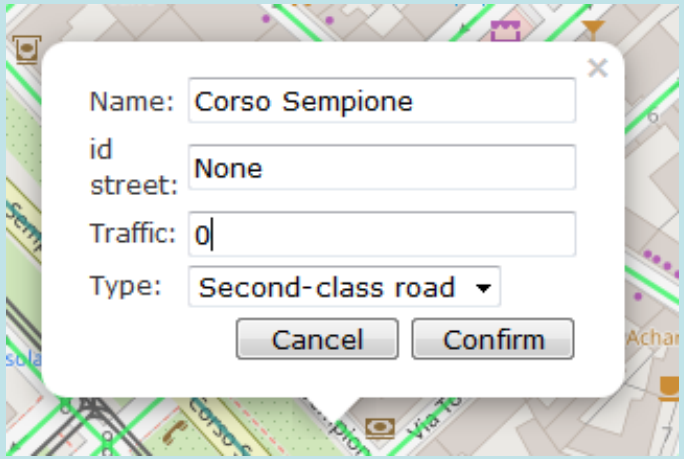
SHERPA-city workflow (2)

- Define Low Emission Zones
- Modify roads and traffic flows







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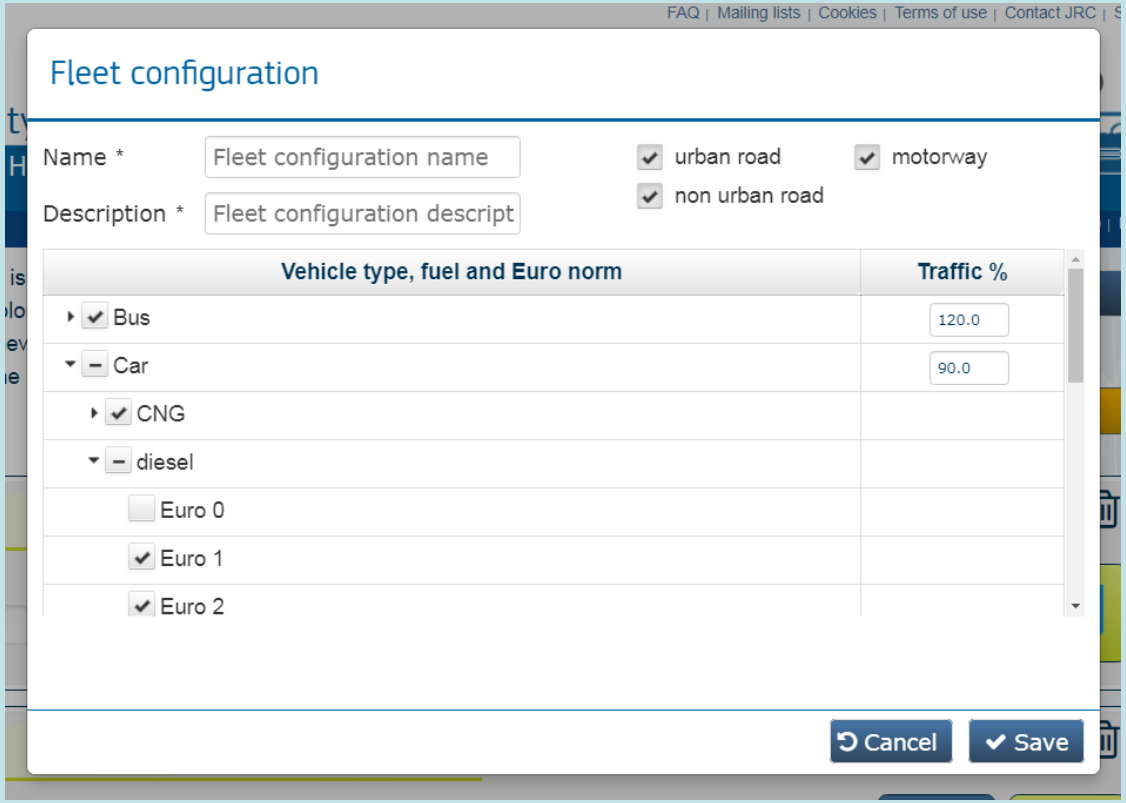
SHERPA-city workflow (3)

- Define fleet restrictions per:
  - Road type
  - Vehicle type
  - Fuel
  - Euro norm
- Define traffic flow reductions or increases.



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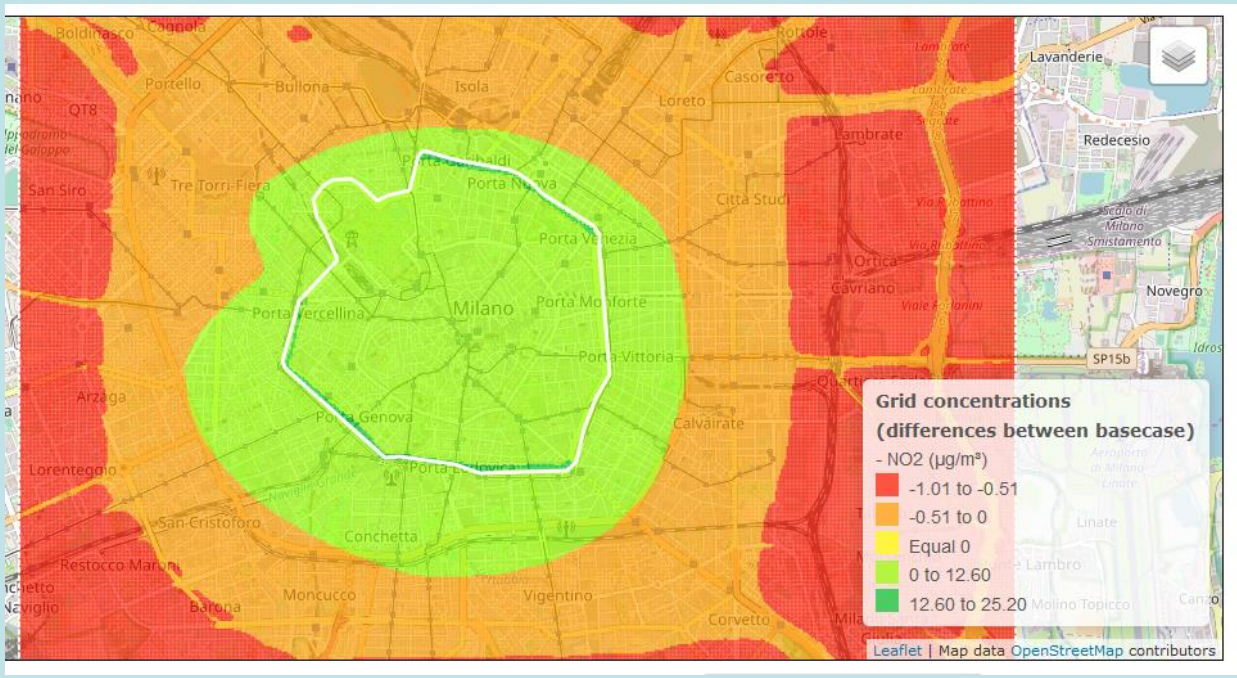
SHERPA-city workflow (4)

- Visualization of the results in absolute concentrations at as difference with the baseline.



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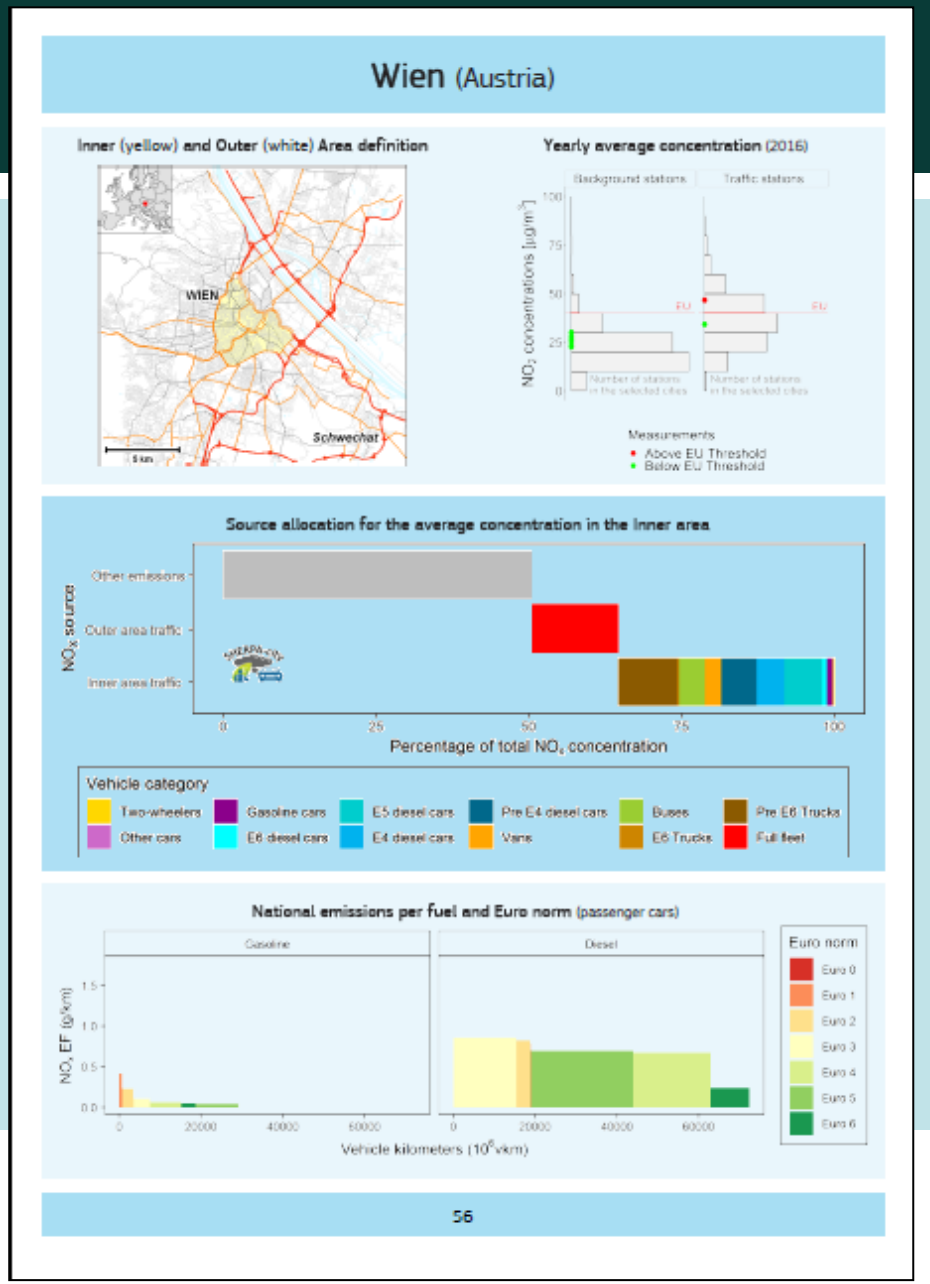
SHERPA-city: Warnings

- The default data have to be checked carefully against local information:
  - ⚠There can be big differences between the real traffic flows and the default flows in SHERPA-City.
  - ⚠Emission factors are national averages ➔ local characteristics (e.g. high EV share, only LNG busses) are not taken into account.
  - ⚠The default background concentration might differ significantly from the actual background and should be checked against local measurements.

Application: Urban NO_2 Atlas

- Fact sheet for 30 cities with:
  - City map with inner area
  - Local measurements
  - Source apportionment for the average NO_X concentration in the central area
  - NOx emissions of passenger cars per fuel (diesel or gasoline) and Euro norm
- Available here!



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SHERPA-City: details on the methodology

Bart Degraeuwe, Enrico Pisoni, Philippe Thunis

Bratislava, 6 December 2019

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Content

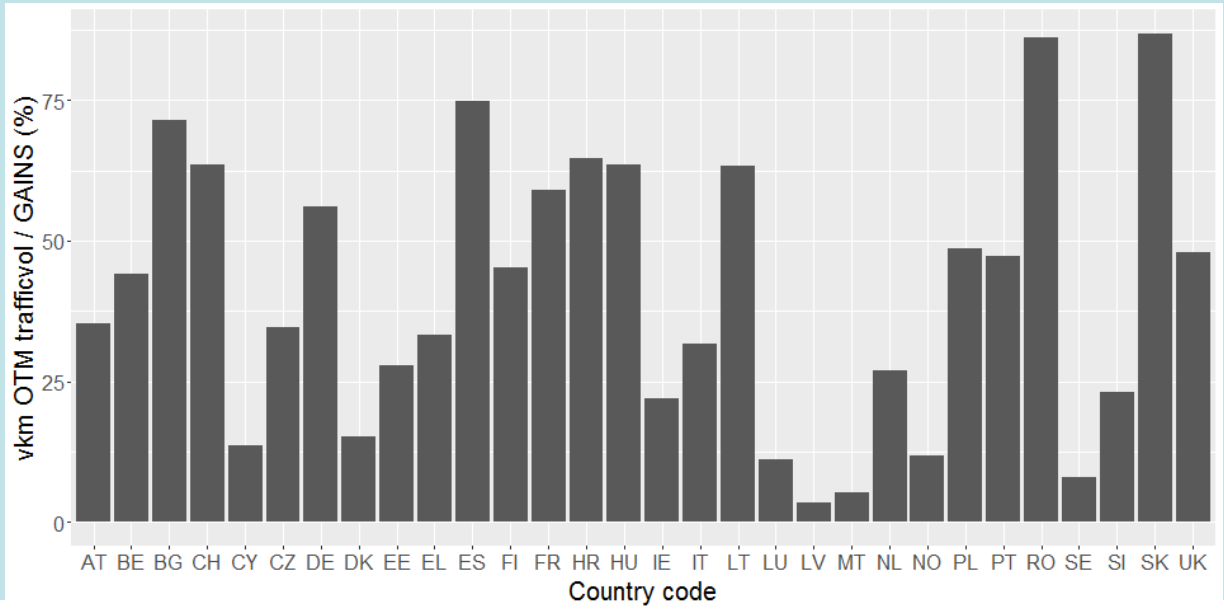
- The input data
  - The road network and traffic
  - The fleet composition and emissions
- From emissions to concentrations
  - Dispersion kernels
  - Including NO_X from other sources
  - From NO_X to NO_2

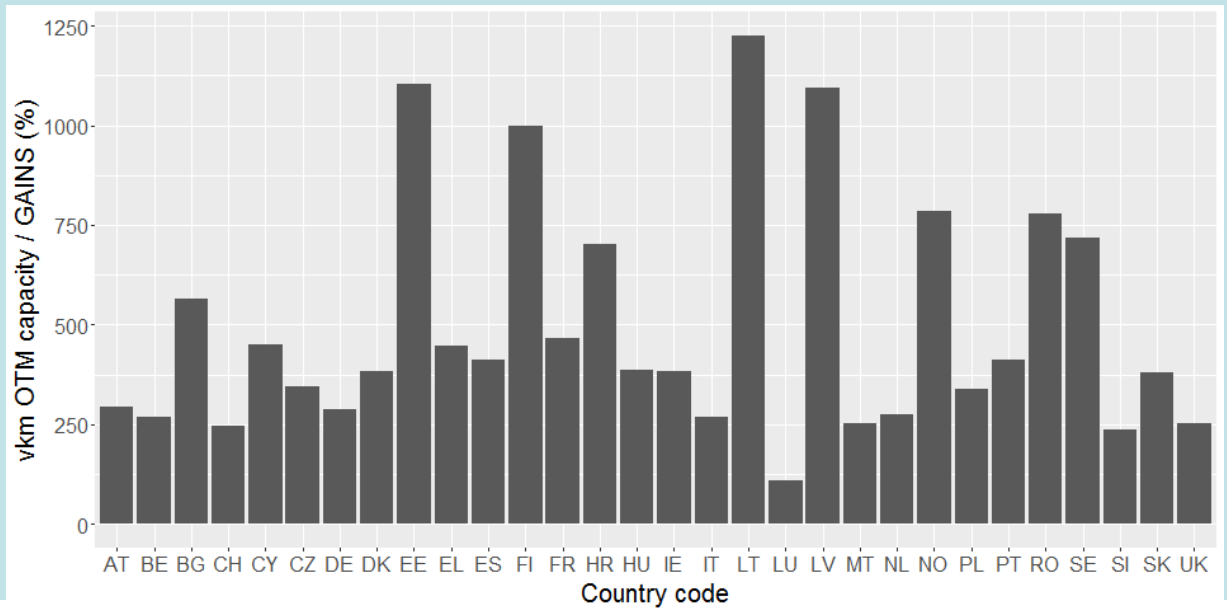
Traffic input: Road network and traffic

- The road network is the one from OpenStreetMap
- Traffic flows come from OpenTransportMap (http://www.opentransportmap.info/)
  - Traffic flow expressed in Annual Average Daily Traffic (AADT), estimated with Omnitrans (traffic model)
  - Road capacity provided.
- Problems:
  - Total vehicle kilometers based on AADT and capacity do not match the national totals.
  - Clearly unrealistic traffic allocation (e.g. traffic through center instead of ring road)

Traffic input: scaling OTM

- AADT underestimates traffic (~50%)
- The road capacity overestimates (~300%)
- Both are scaled to the GAINS national totals





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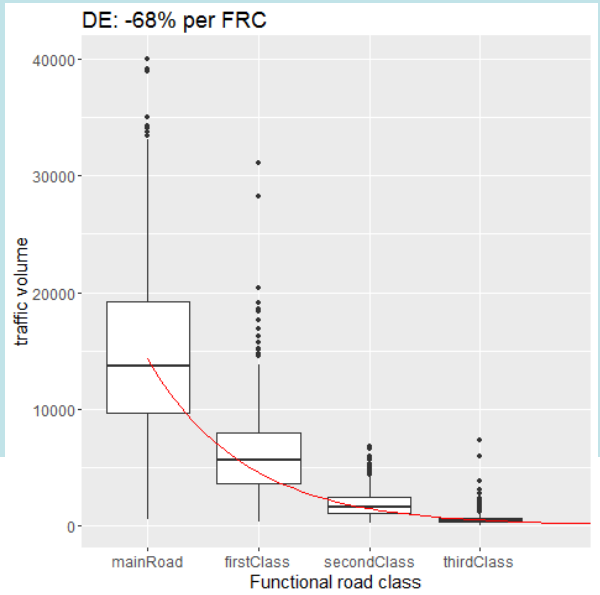
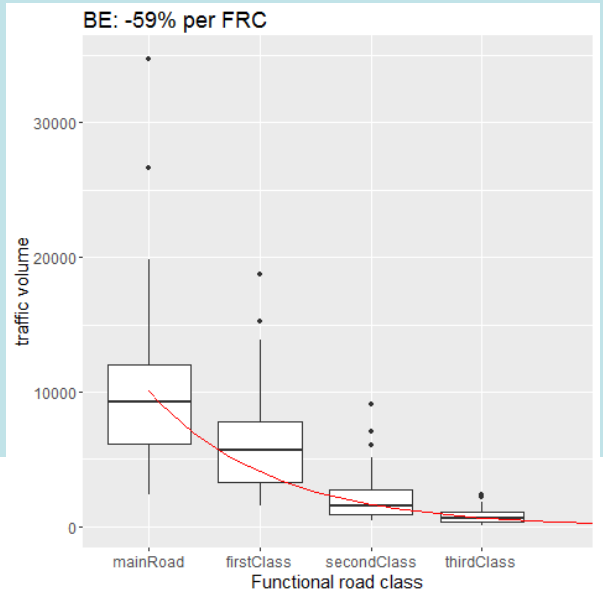
Traffic input: OTM gap filling

- OTM only gives traffic on function road classes ***main*** (highway), ***first*** and ***second*** (major roads) and ***third*** (urban) but not on ***fourth*** class (smaller urban)
- Correlation between road class and AADT. (A bit fuzzy, I admit.)
  - Fixed percentage decrease in traffic when increasing class





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Traffic input: other solutions

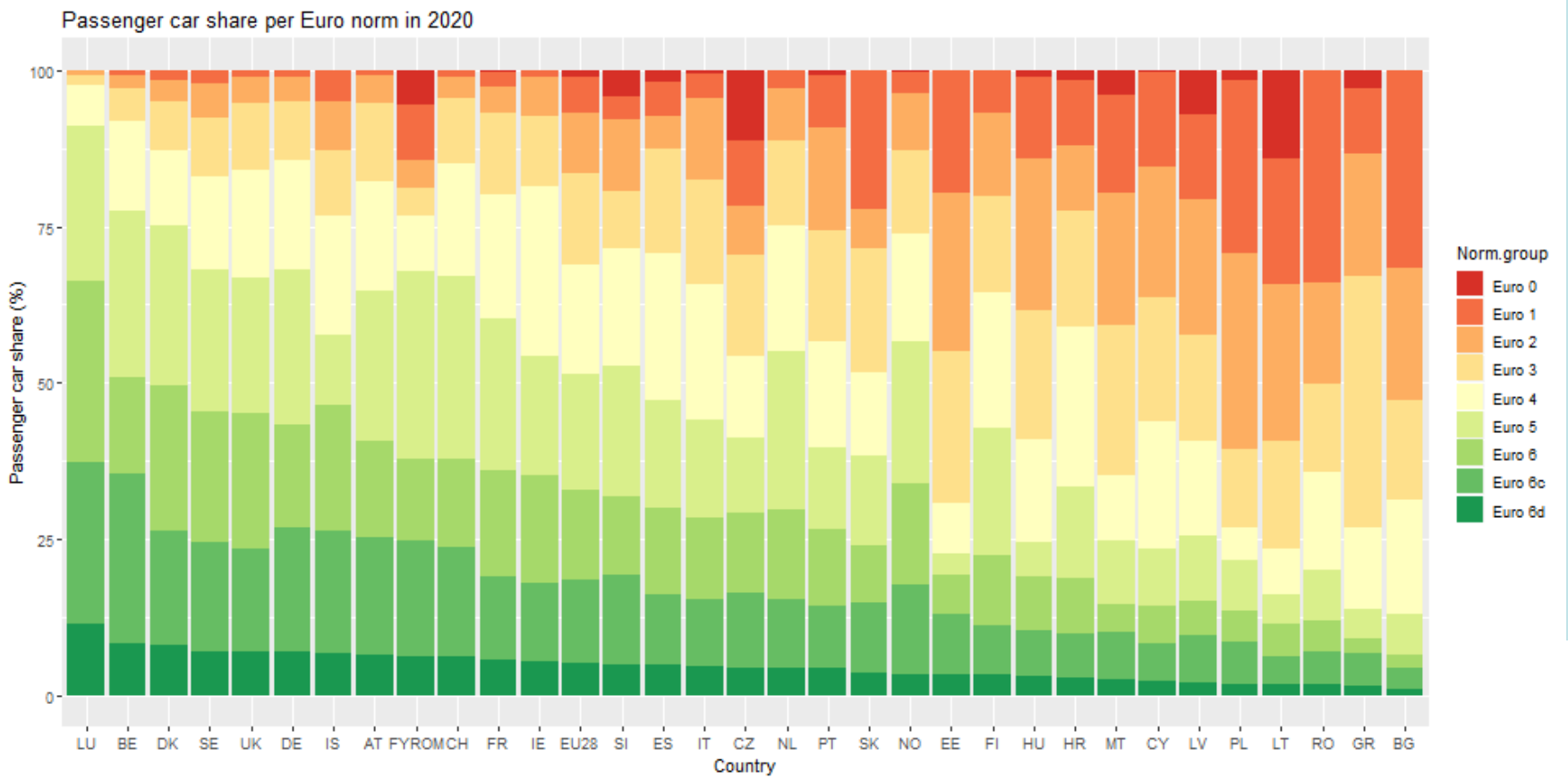
- Upload your own traffic data.
- Future collaboration with Google (?). Their data would be a good proxy to distribute national totals.
  - Status: first teleconference, maybe we get some data for a few cites participating in the Covenant of Mayors (CoM)

Fleet input: EMISIA data

- JRC bought data from EMISIA (developers of the COPERT software)
  - Coverage: EU30
  - Years: historical data until 2016.
  - Projections with Sybil for 2020 and 2025
  - Updates: historical data for 2017 (end 2019) and 2018 (end 2020)
- Remarks:
  - These data cannot be shared at the most disaggregated level (e.g. emissions or vehicle kilometers for medium Euro 6 diesel cars)

Fleet input: EMISIA data

- Share of passenger cars complying with each Euro norm per country in 2020



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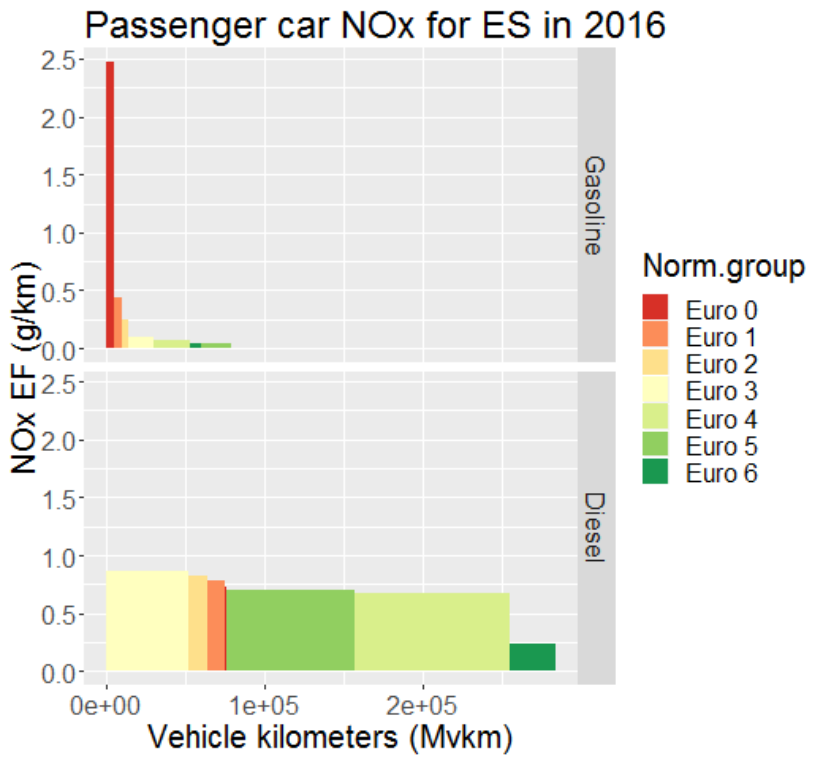
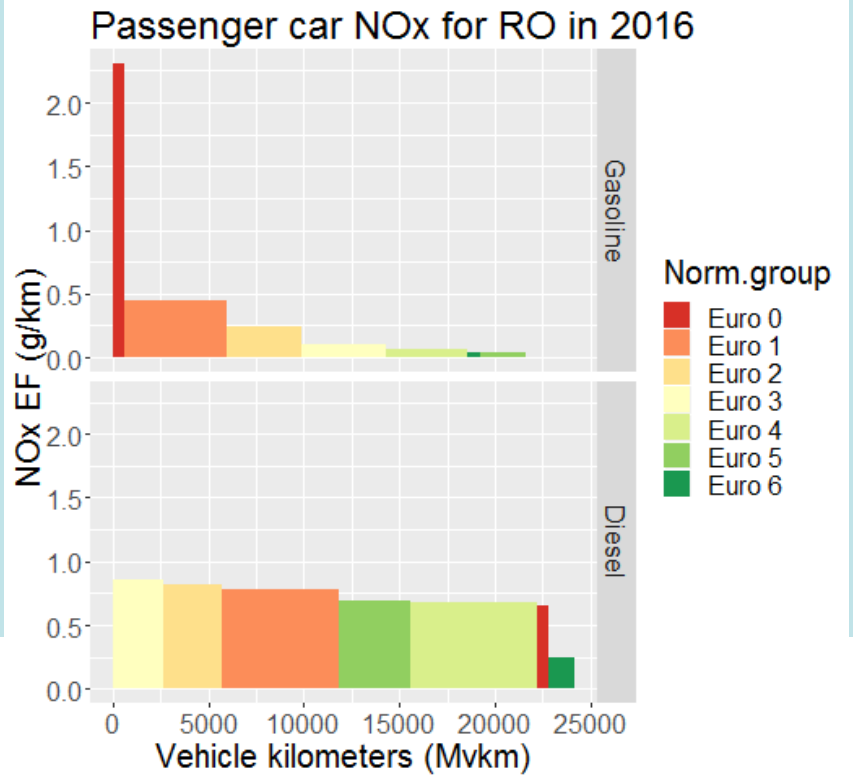
Fleet input: EMISIA data

- Vehicle kilometers and emission factor of diesel and gasoline passenger cars complying different Euro norms. The surfaces correspond to total emissions.





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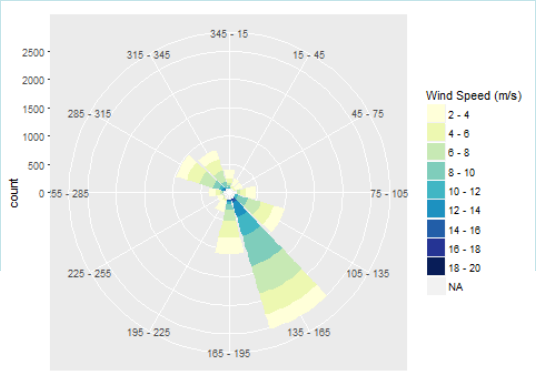
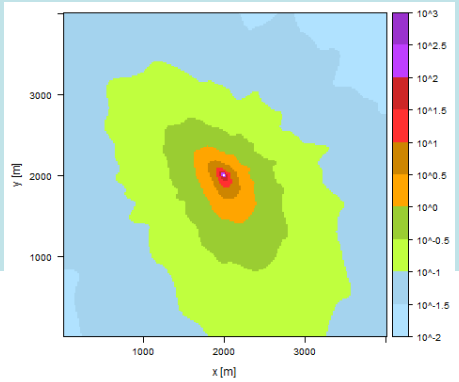
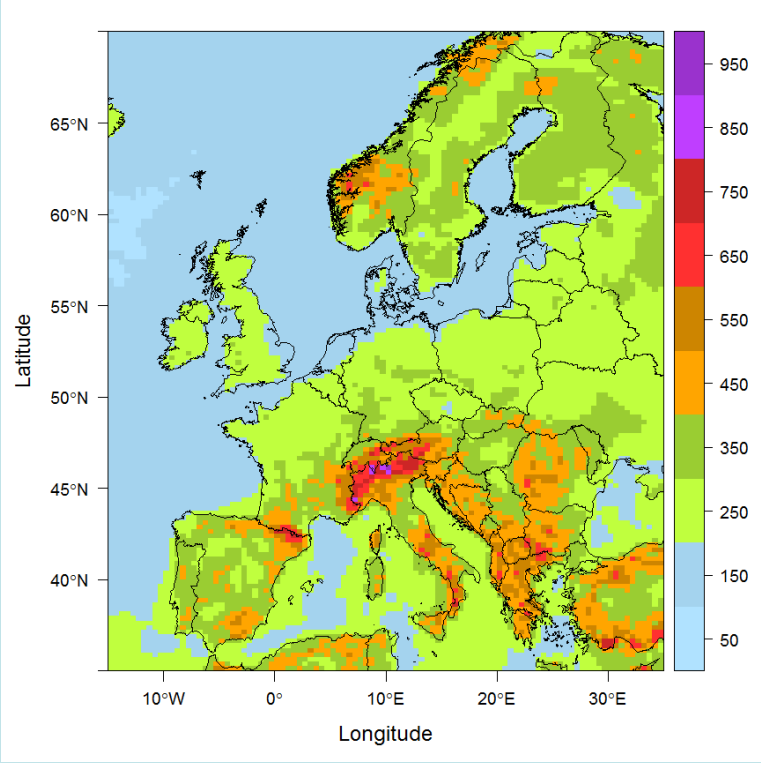
Emissions to Concentrations: Kernels

- Weather data ➔ dispersion kernel
  - Yearly average concentration of an inert (within the kernel extent) pollutant (NOx, PM2.5) around a unit point source.
  - 4 by 4 km, 20 by 20 meter resolution
  - Produced with the IFDM Gaussian dispersion model







Kernel maximum concentrations

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E2C: Including NO_X from other sources

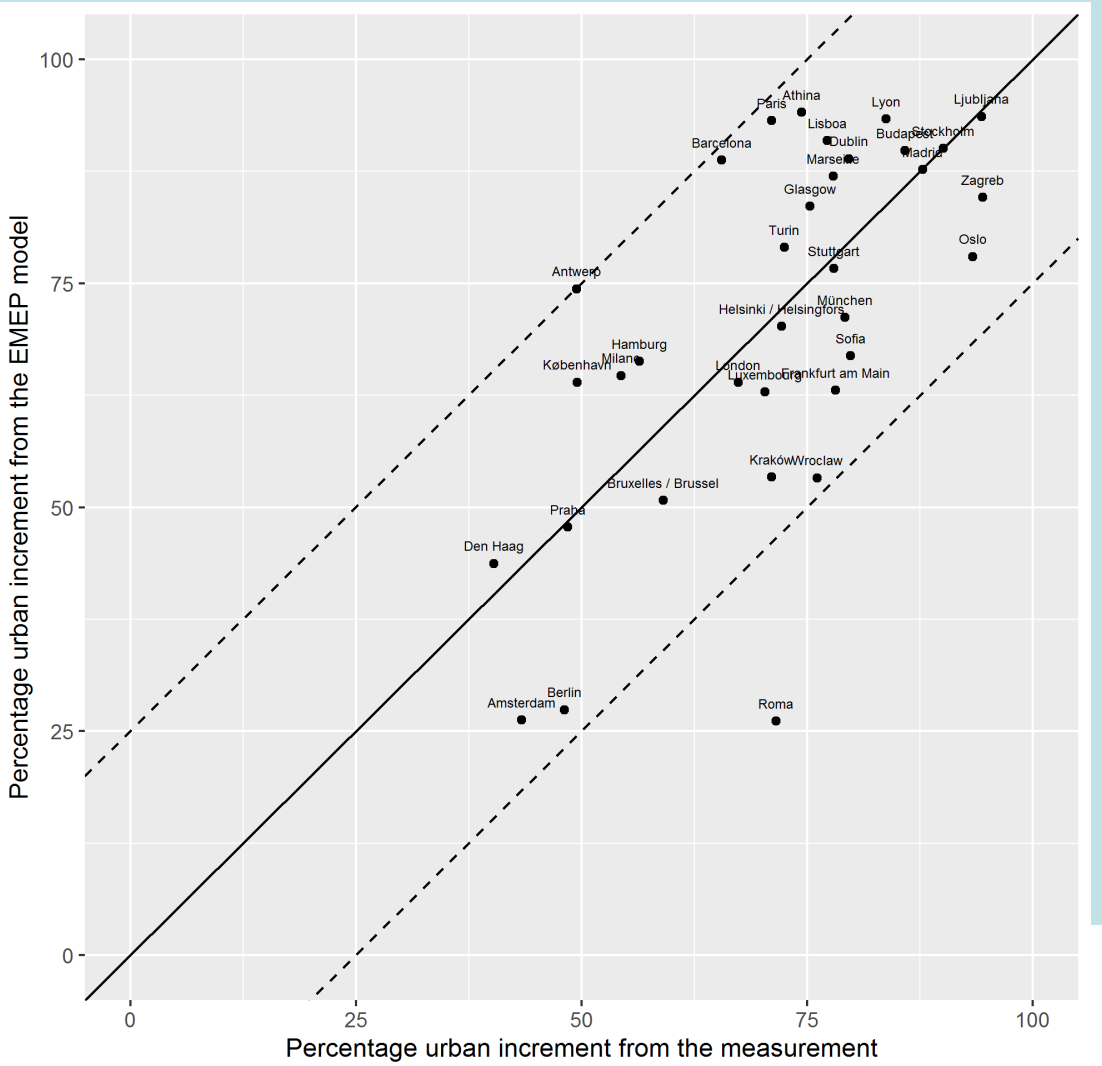
- The kernels give the traffic contribution to NOx only.
- Avoid double counting:
  - Total high resolution NOx = total low resolution NOx – low resolution local contribution + high resolution local contribution
- A background concentration is needed from:
  - A CTM basecase (EMEP or CHIMERE, both implemented)
  - A CTM run without traffic (EMEP, not implemented)
  - Measurement (not implemented)
  - User defined (not implemented)

E2C: problems with NO_X background

- CTM background
  - CTM might underestimate total NOx ➔ negative high resolution NOx concentrations
  - CTM might overestimate total NOx ➔ share of traffic is underestimated.
  - Both cases occur.
- CTM run without traffic
  - Can still under or overestimate the background
  - Slightly higher tendency for underestimation (also the traffic outside the domain is zero)

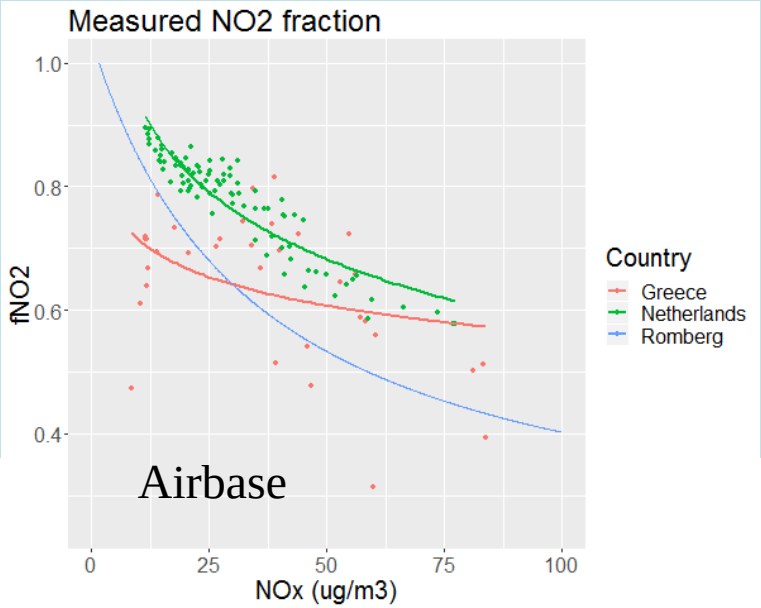
E2C: problems with NO_X background

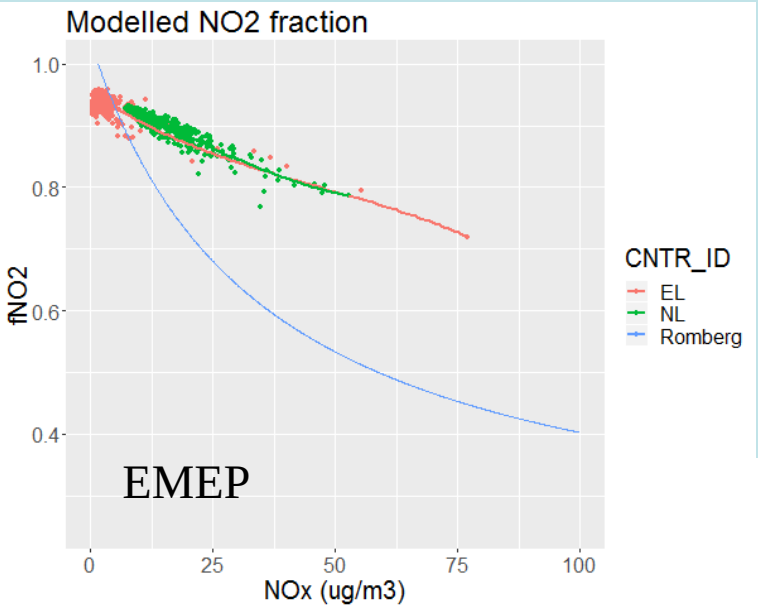
- From measurements: Rural-Near_city minus Urban background
  - Almost never available
  - Depending on the choice of stations

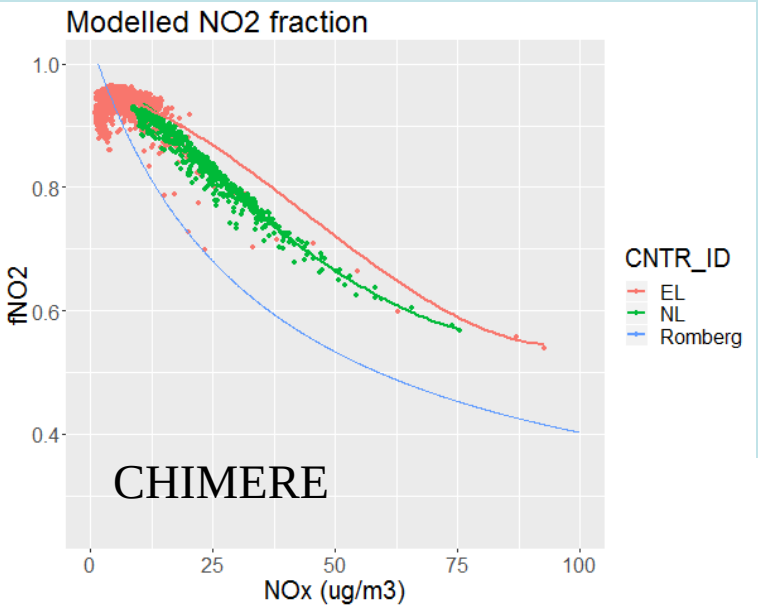


E2C: From annual average NO_X to NO_2

- Annual average NO_X has to be split up in NO and NO_2
- SHERPA-city uses a Romberg-like correlation fitted on the split predicted by the CTM (EMEP or CHIMERE)
- The NO_2 fraction decreases with increasing NO_X concentration but models underestimate this sensitivity.

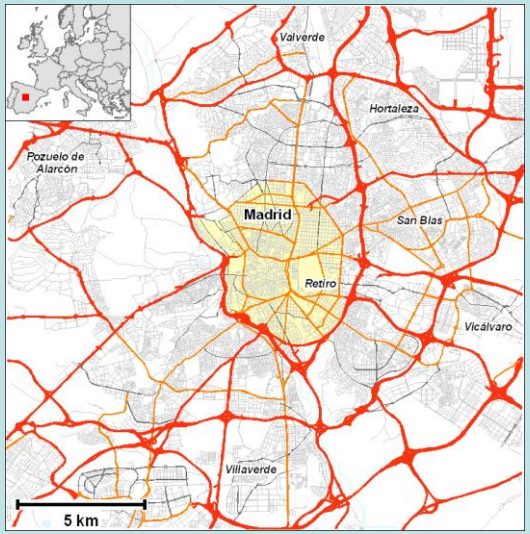


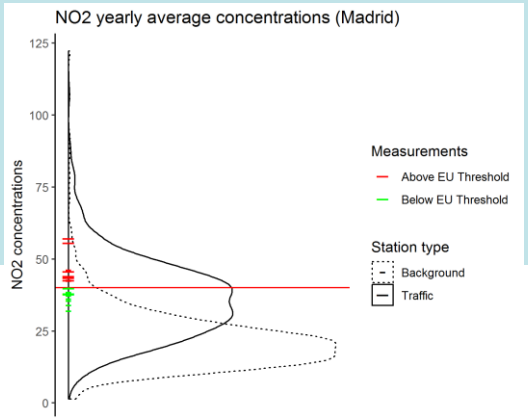


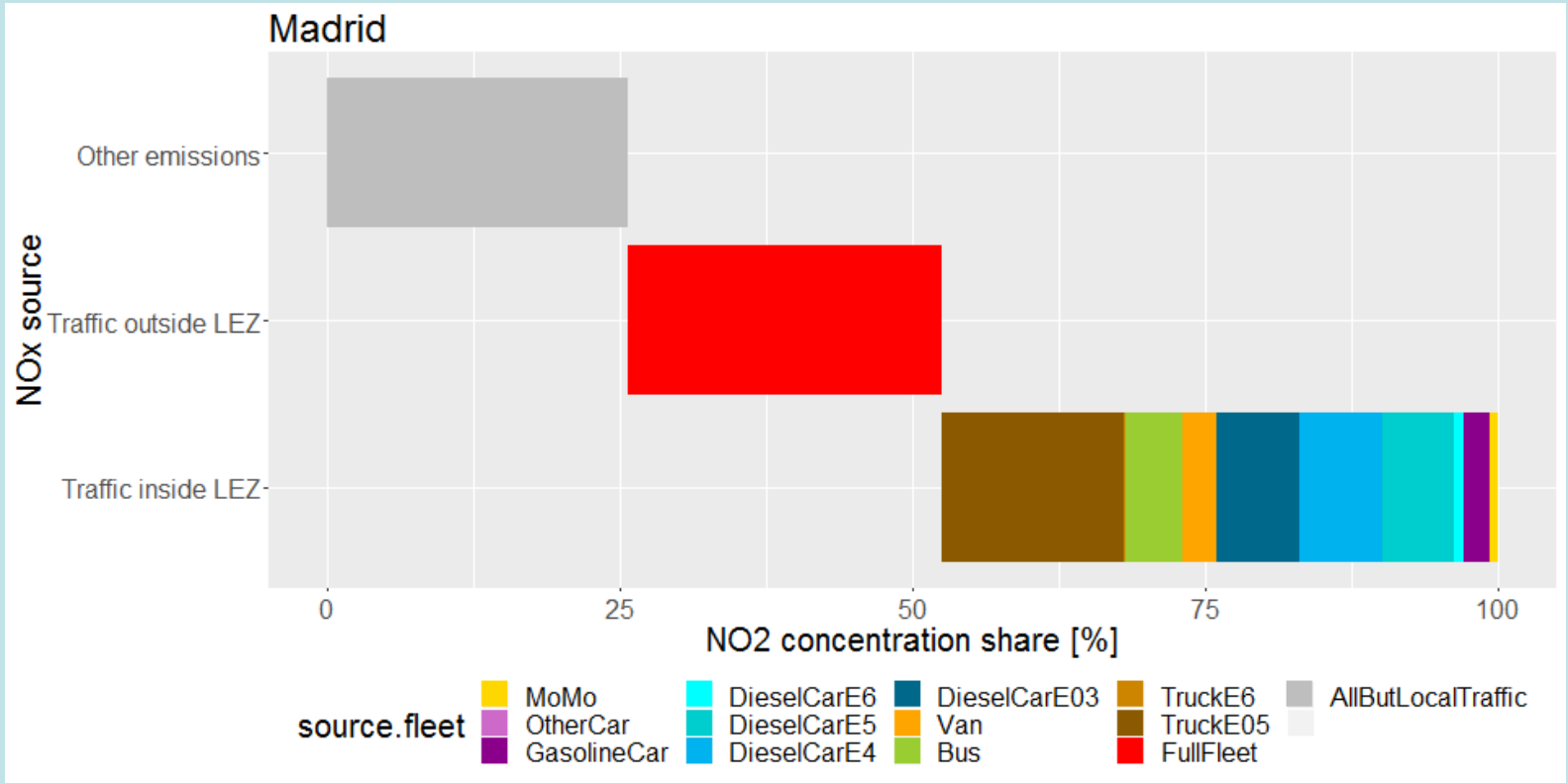


Application: NO_2 Atlas (Madrid)

- Source apportionment for the NO_2 concentration in a LEZ.







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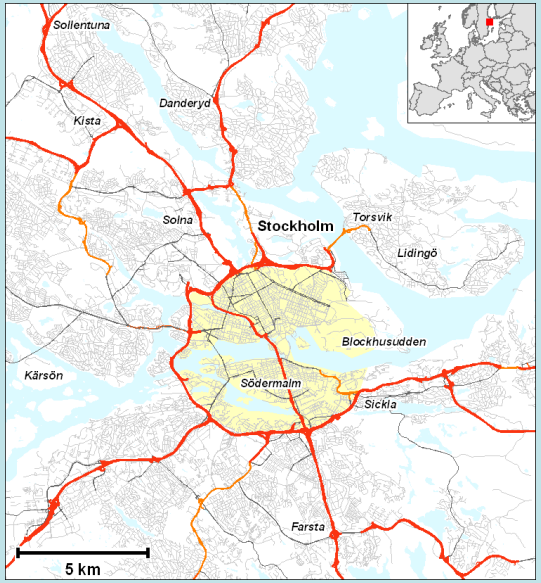
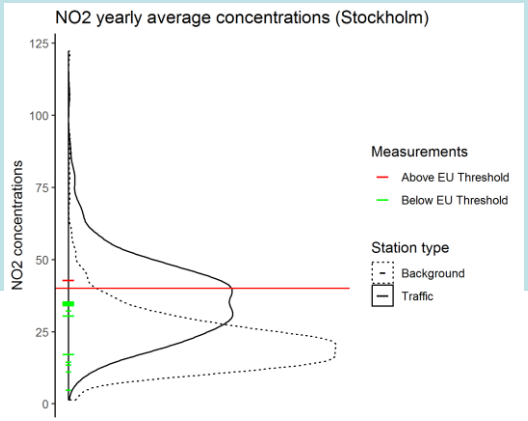
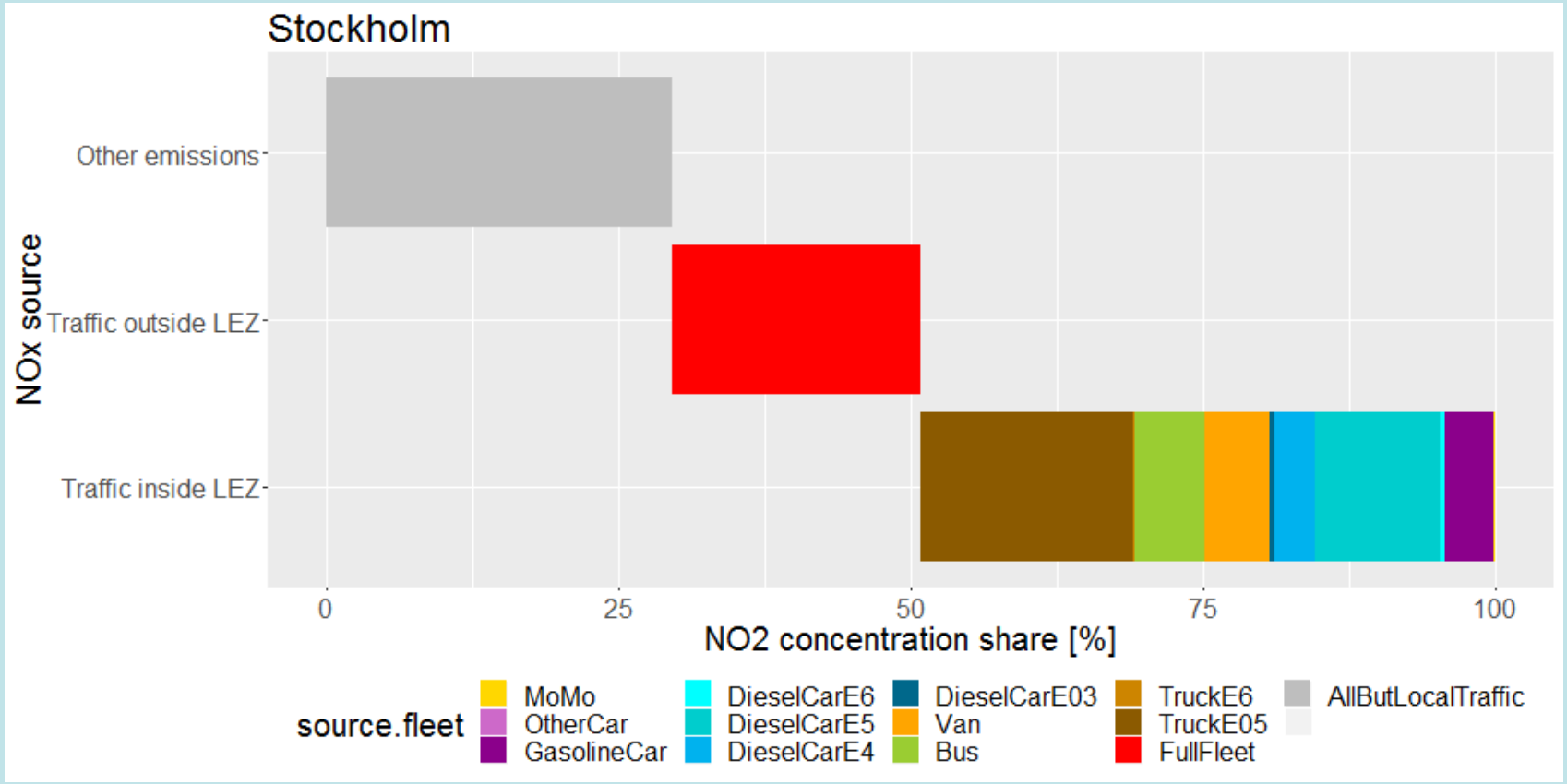
Application: NO_2 Atlas (Stockholm)







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