A detailed urban road traffic emissions inventory model using aerial photography and GPS surveys

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Overview

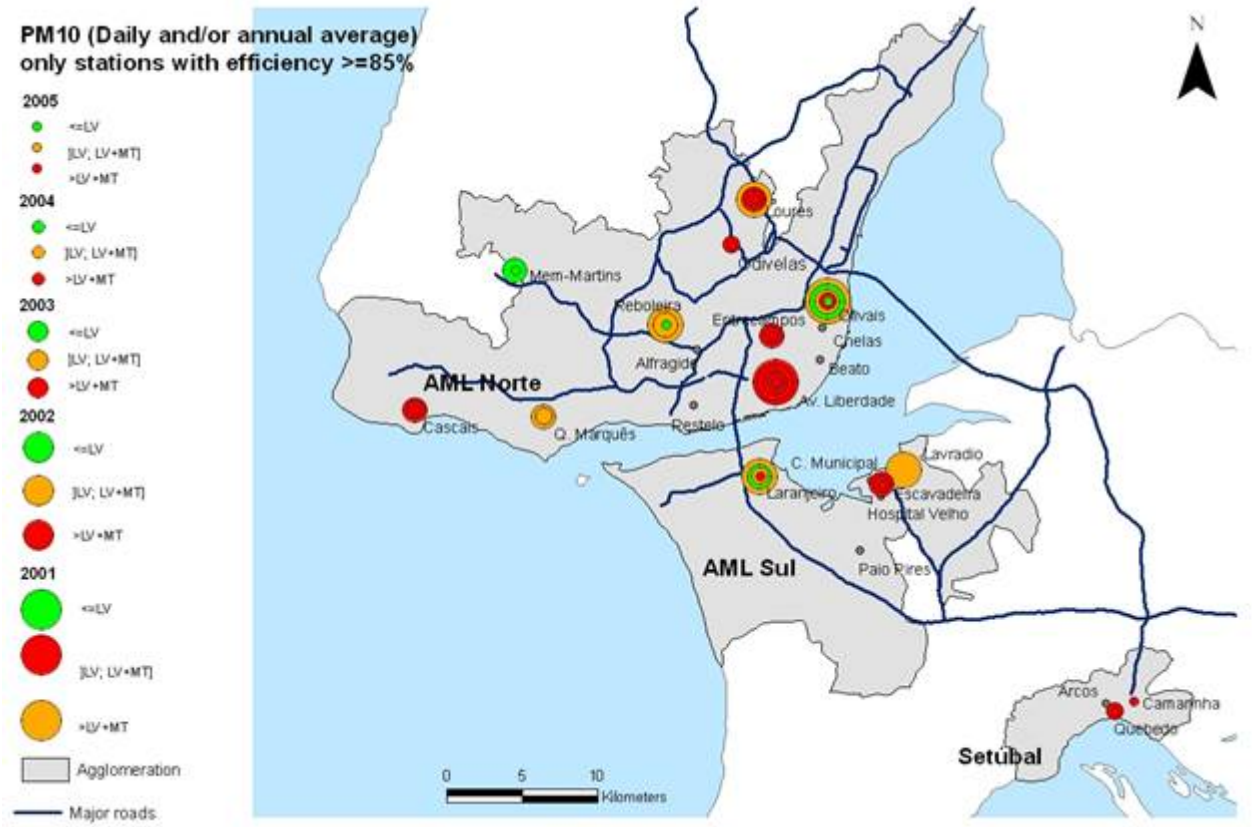
- Scope
- Case-study
- Problem Definition
- Principles
- Methodology
- Results and methodology validation

Scope

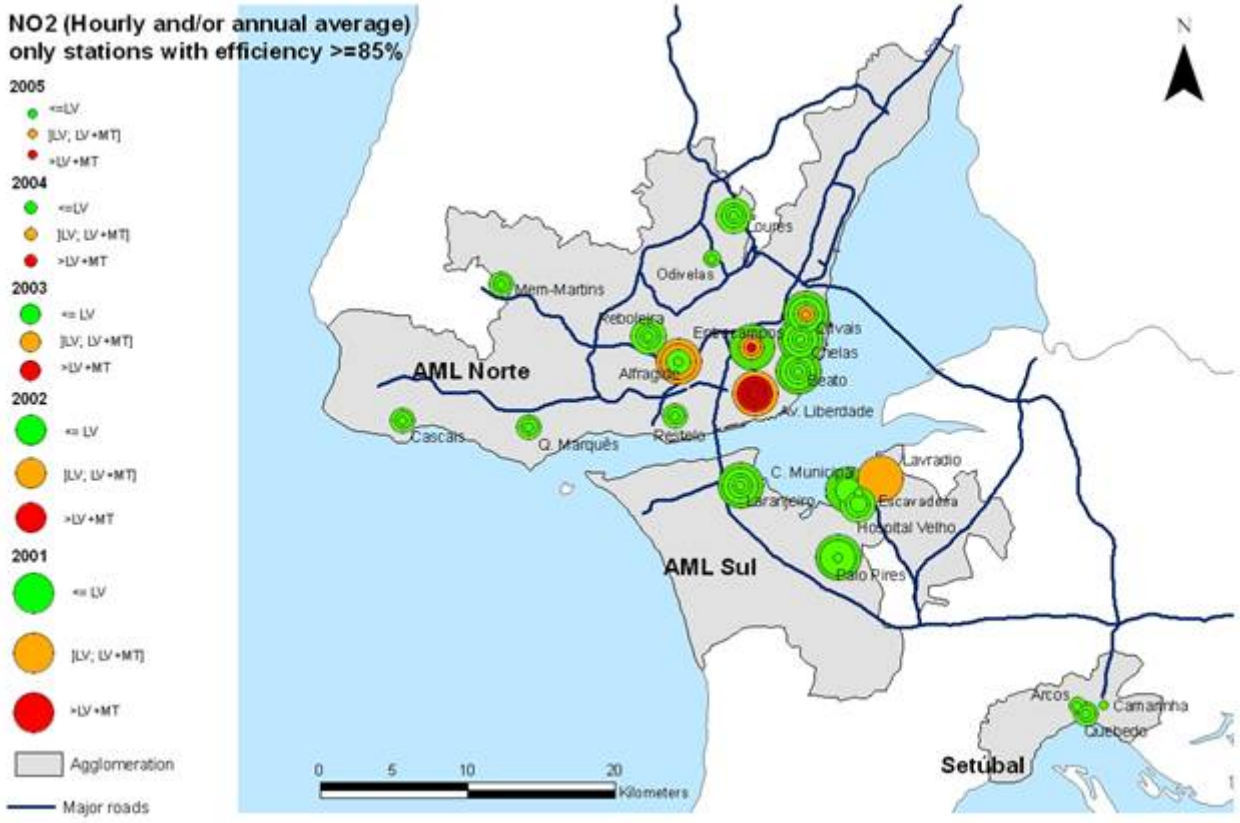
- EU law (Directive 96/62/CE) defines zones, where air quality must be assessed in detail, using:
  - Monitoring stations
  - Periodic campaigns (e.g. Passive sampling)
  - Modelling & Air emission inventories
- Air quality problems have been detected in Lisbon area in most recent years
  - Particulate matter (PM10): widespread
  - NO_2: confined to traffic hotspots
  - Ozone in summer
- Particulate levels (PM10) in Lisbon show the highest values in Europe as consequence of:
  - Importance of diesel vehicles
  - Specific meteorological conditions
  - Road re-suspension
  - Topographic conditions
  - Natural events (Saharan dust, forest fires)

Lisbon: Identification of “Zones” of Air Quality Management

Air Quality Problems in recent years
Lisbon area - PM10

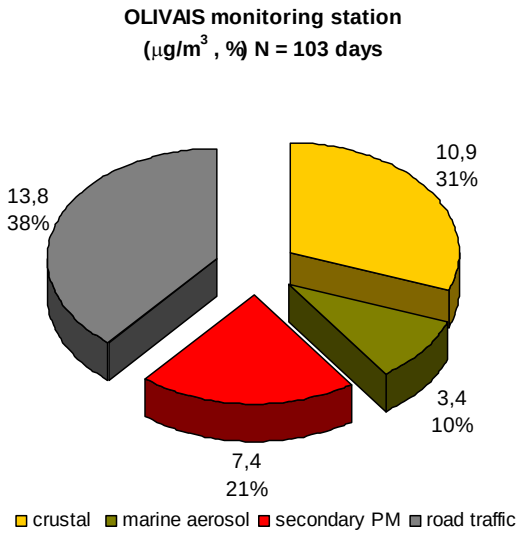


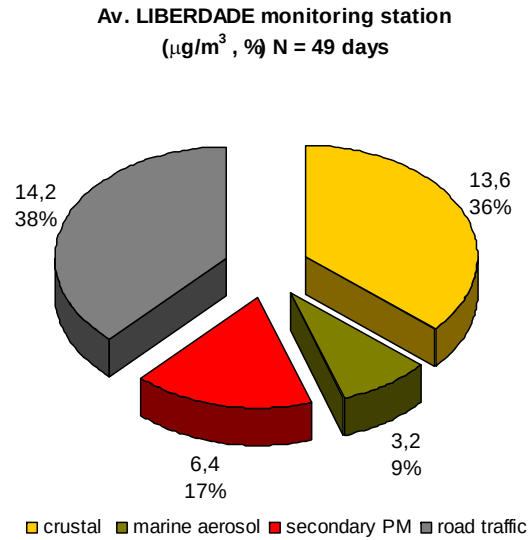
Air Quality Problems in recent years
Lisbon area - NO_2



Urban Transportation as major contributor to Air Quality

- Road Transport is the dominant factor of PM in Lisbon
  - Weekly variation, with maximum values at weekdays especially on Fridays when traffic levels tend to be the highest
  - Chemical analysis of particles collected in samplers (55 per cent of particulate matter are originated, directly or indirectly)
  - Natural events (Saharan dust outbreaks and forest fires)





Air Quality Management Tools under development in Lisbon Region

- Air Quality Management is under responsibility of the

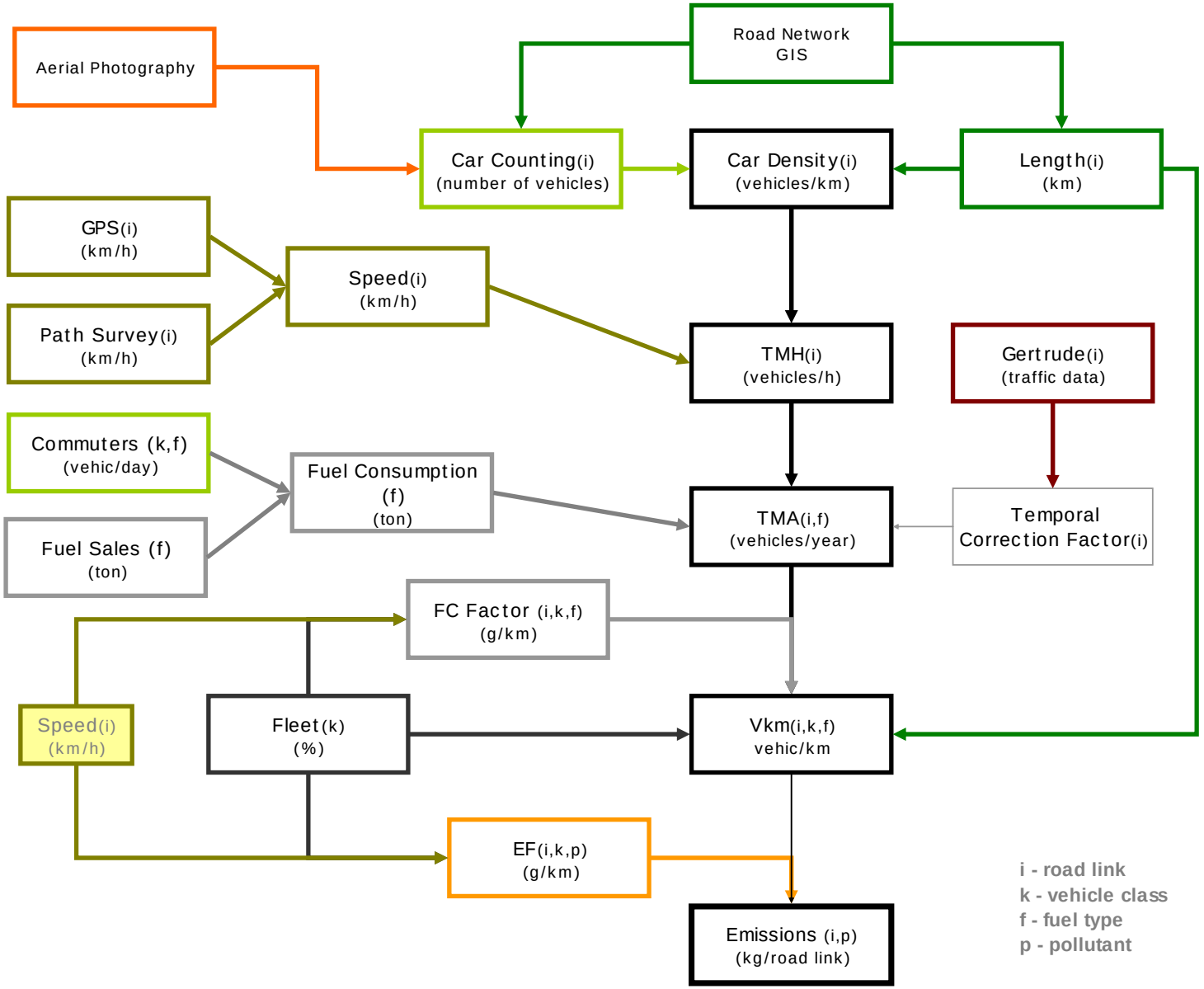
Commission for Coordination and Regional Development of Lisbon and Tagus Valley (CCDR-LVT)

- Policies
  - Improvement of the monitoring survey system:
    - Stationary stations
    - Extensive monitoring: period campaigns using Passive sampling (Diffusion tubes and portable PM samplers)
  - Plans and Programs (June, 2005)
    - Identification of measures and policies, mainly traffic related
  - Modelling tools
    - Regional level (TAPM from CSIRO)
    - European level (Chimere, CAMx, REM-3 under CAFE program)

Definition of the Inventory model

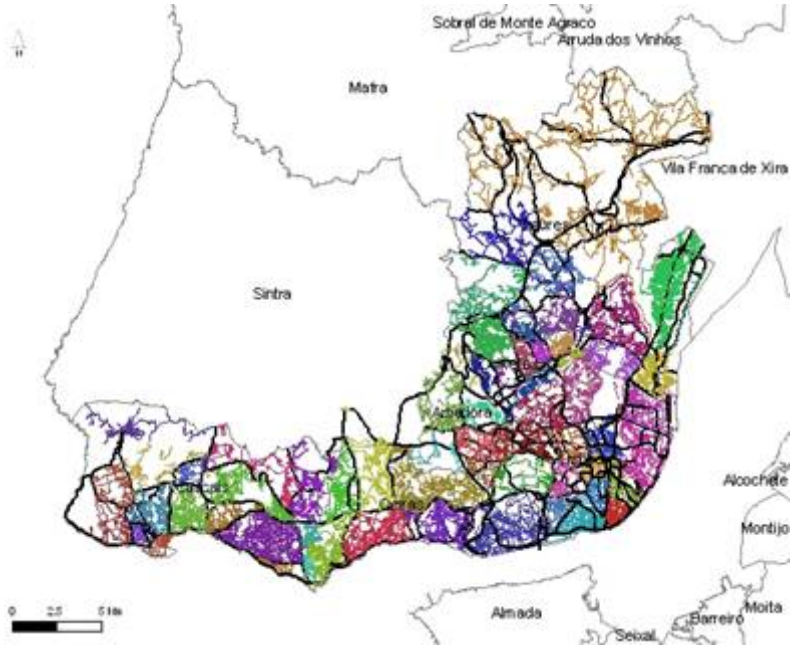
- The Air Emission Inventory Model has to consider that:
  - Urban road transport MUST be the major component
  - Air quality problems are very local
  - A high level of spatial detail is necessary
    - Suitable for the scale used in modelling
    - Considering the scale at which policies and measures are defined
  - Affordable costs and low investment
    - Relying in a small team
    - Using available data as much as possible
    - Unfeasible to extend the existing traffic monitoring system
- Main objectives were to gain knowledge:
  - How many vehicles are moving at a given place and time
  - What type of vehicles exist (in movement)
  - How fast are vehicles moving (time of travel)
  - How are they moving (topography)

Methodology: General Structure



Definition of the Urban Structure in the area under study

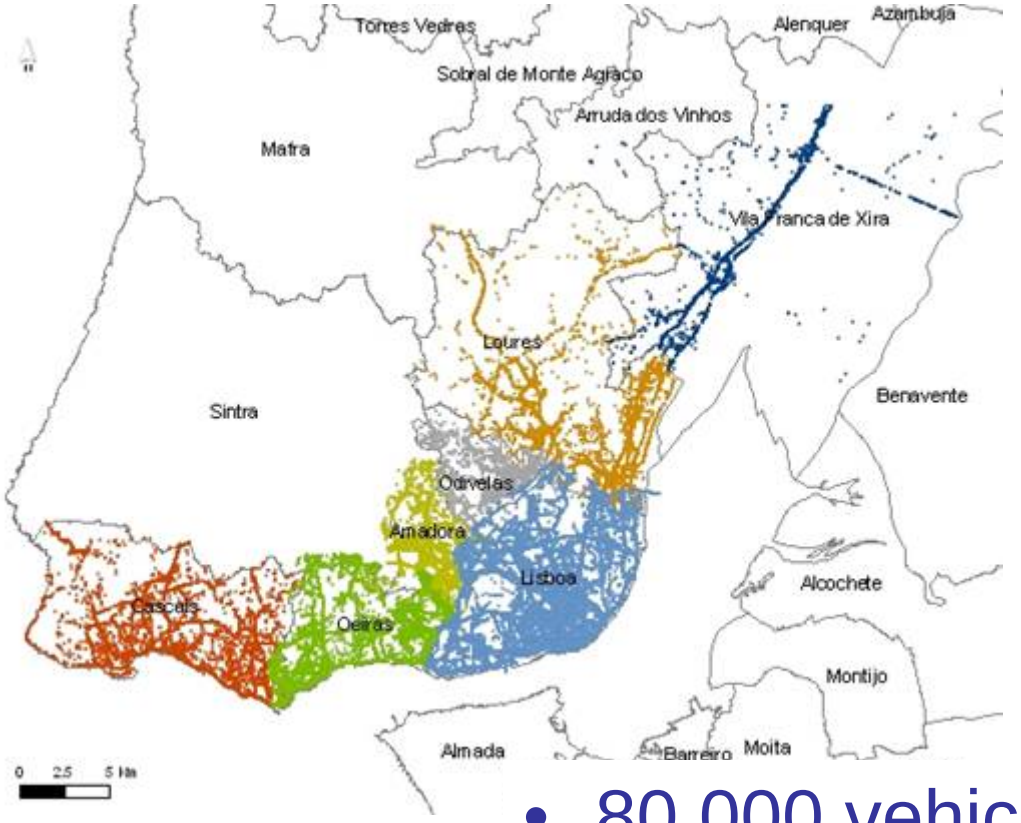
- Definition of main roads and neighbourhoods should be done prior to data collection considering
  - Major road boundaries;
  - Road structure (density, width, intersections nb, slope)
  - Economic Activity
    - Commerce - frequent stoping/parking 2nd line
    - Institutional
    - Residential
  - Distance to city centre
-



Identification of moving vehicles

Source: Lisbon Municipality

Density of moving vehicles

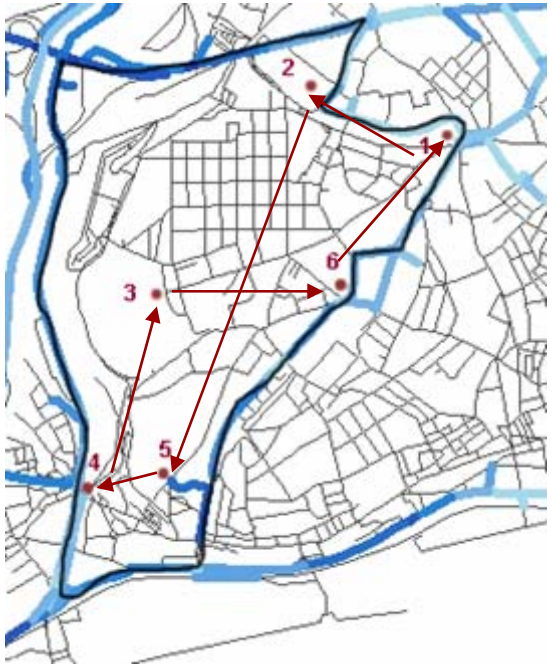


- 80 000 vehicles identified
  - 15 % total licenses (Insurance data) in the area

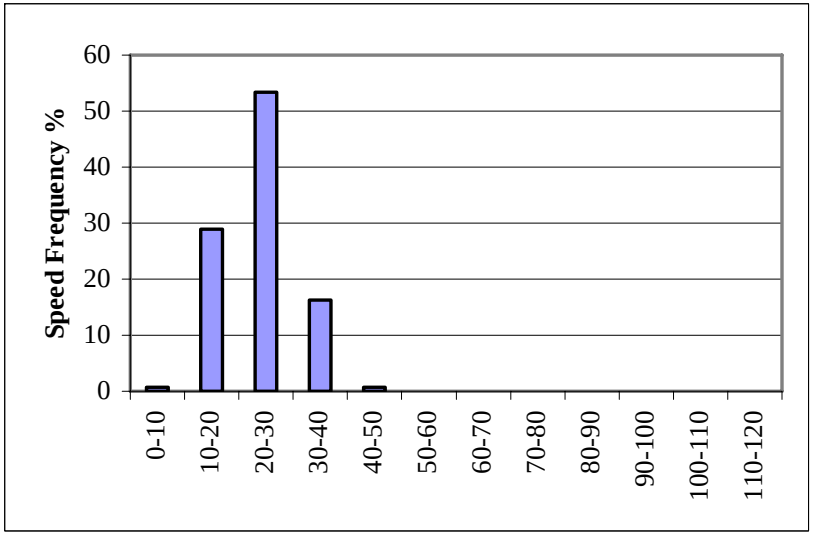
Speed:
Method 1 - Predefined paths

- **Path definition**
  - Pre-defined objective points
  - 3 random paths at 3 different periods
    - (Morning, noon, evening)
- Advantages
  - No special equipment needed
  - Possible to use in all conditions
  - Suitable for areas with low car density
- Problems
  - Low detail
  - Restricted knowledge of speed variations

Speed: Method 1



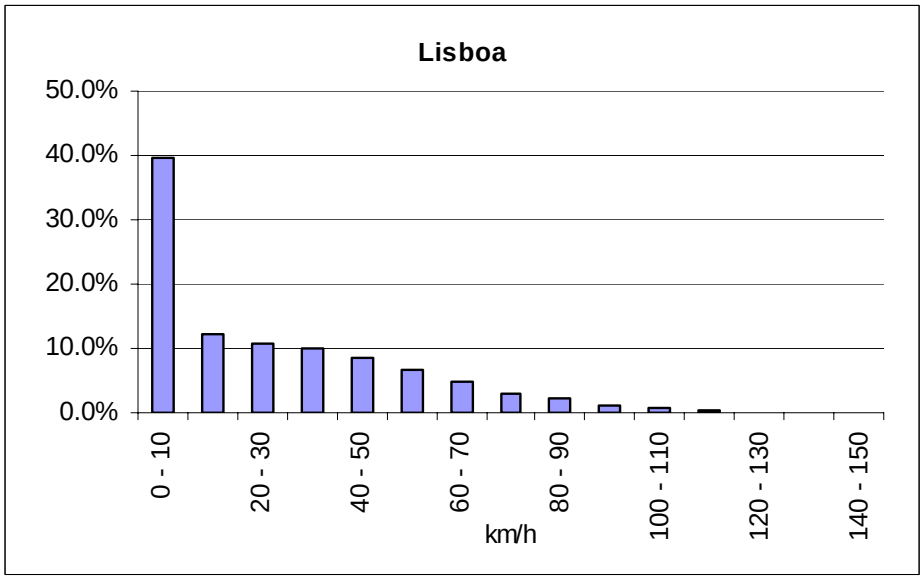
1 - Largo do Rato
2 - EPAL
3 - Cemitério dos Prazeres
4 - Cruzamento de Alcântara
5 - Palácio das Necessidades
6 - Basílica da Estrela

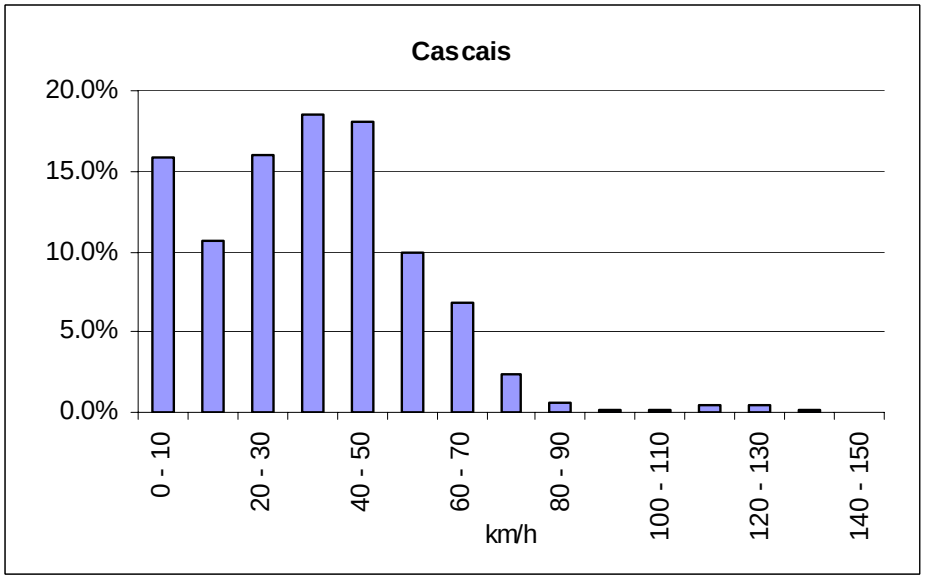


Speed:
Method 2 - GPS

- GPS in vehicle
- Rules for test driver
  - Keep with main flow
  - but copy driver behaviour -> objective oriented travel
    - E.g. Service Stations, Museums
- Data acquisition problems in narrow roads with tall buildings

Speed Histograms
Urban and Sub-urban areas





Municipality	Main roads	Secondary roads
Cascais	39.4	28.2
Oeiras	49.2	28.3
Lisboa	25.1	28.1
Amadora	48.6	24.4
Odivelas	33.9	27.5
Loures	52.7	39.8

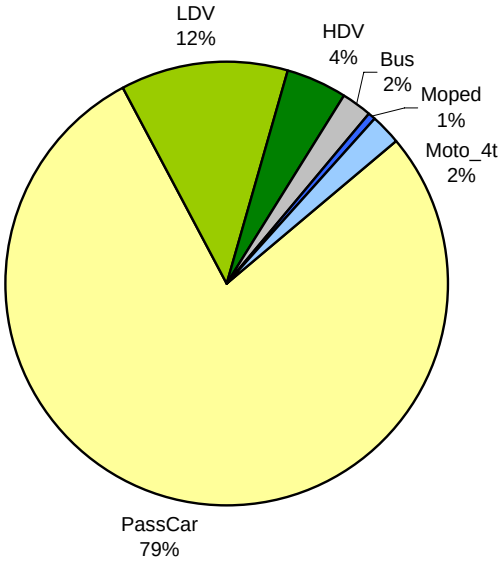
Emission Factors

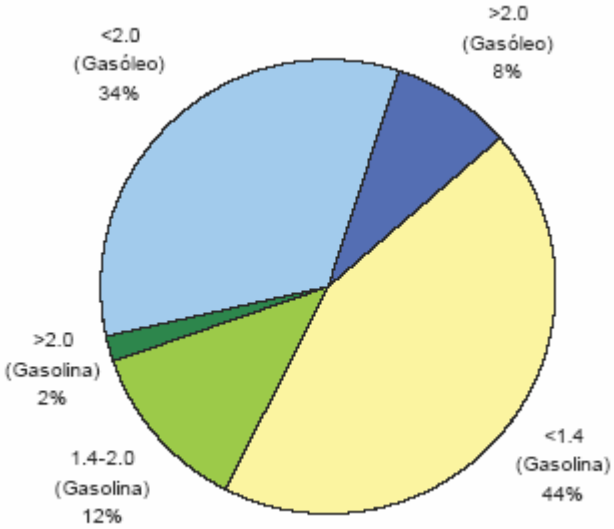
- Base - > EMEP/CORINAIR (EEA, 2002)
  - Based on extensive monitoring and database
  - Variables
    - Vehicle type, age, fuel, technology, engine size
    - Vehicle speed per link
    - Road gradient
    - Vehicle wear
    - Non-exhaust emissions

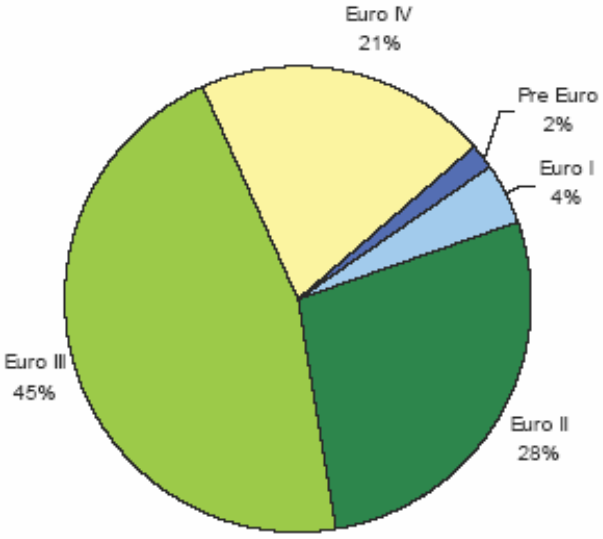
Characterization of the Fleet (Moving Vehicles)

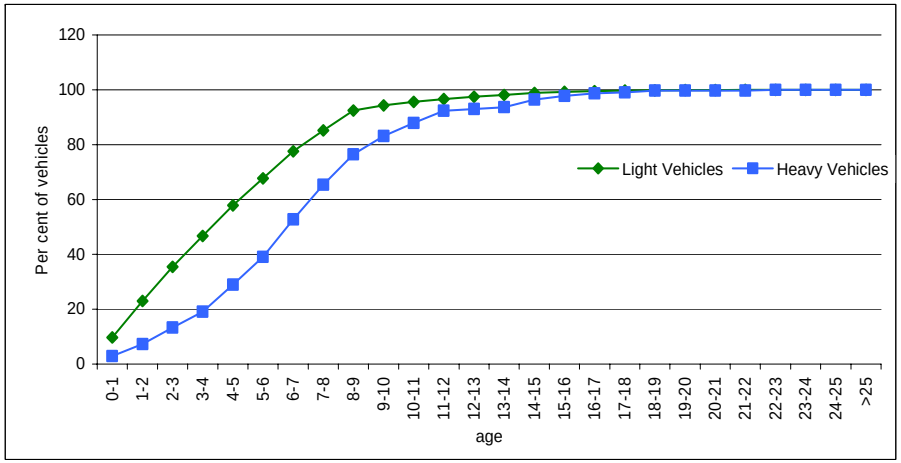
- Methodology (Torres et al, 2006)
  - Survey/questionnaire in
    - Traffic lights
    - Parking
  - Questions
    - Age (license date)
    - Vehicle type: PC, LDV, HDV, Bus, 2w, mopeds
    - Fuel type: gasoline, diesel, LPG, Natural Gas
    - Engine size (c.c.)
    - Mileage (km)
    - Mobile Air Conditioner
- 17 800 results (5.6% vehicles registered in insurance companies)

Fleet: Results

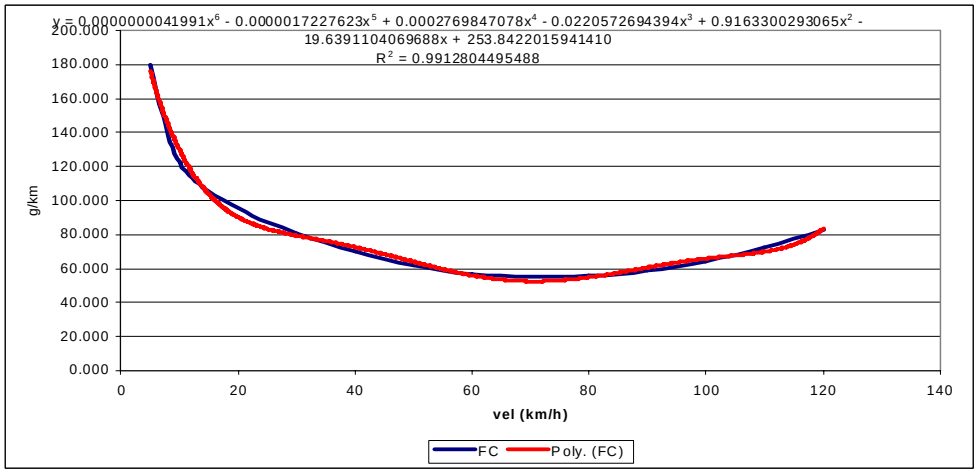


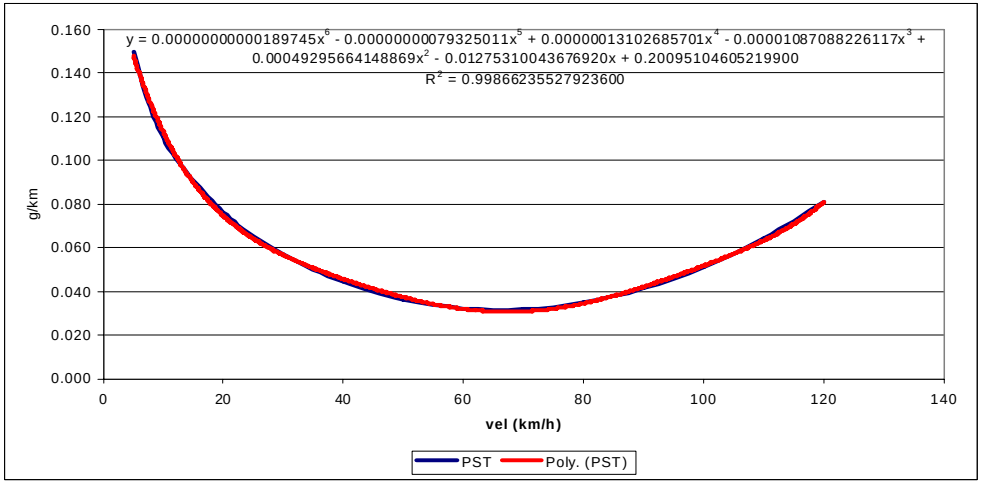






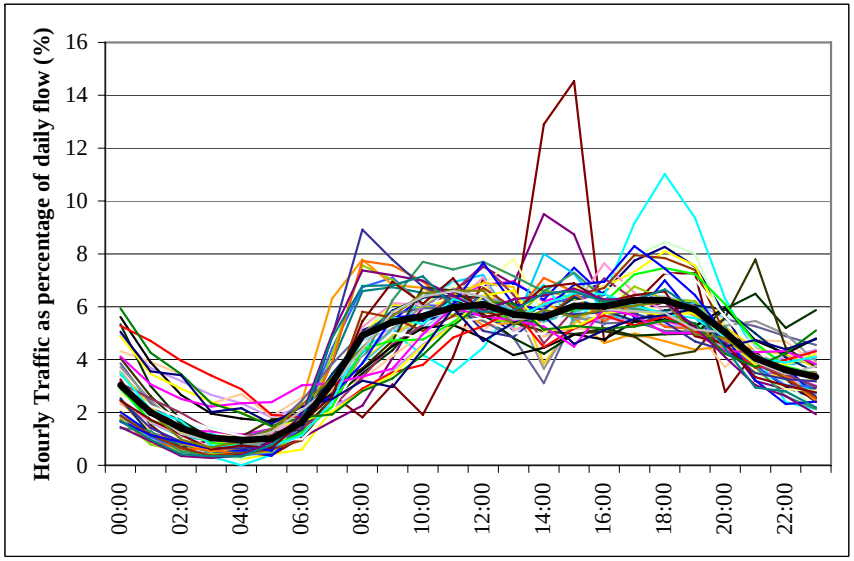
Emission Factors for a normalized vehicle





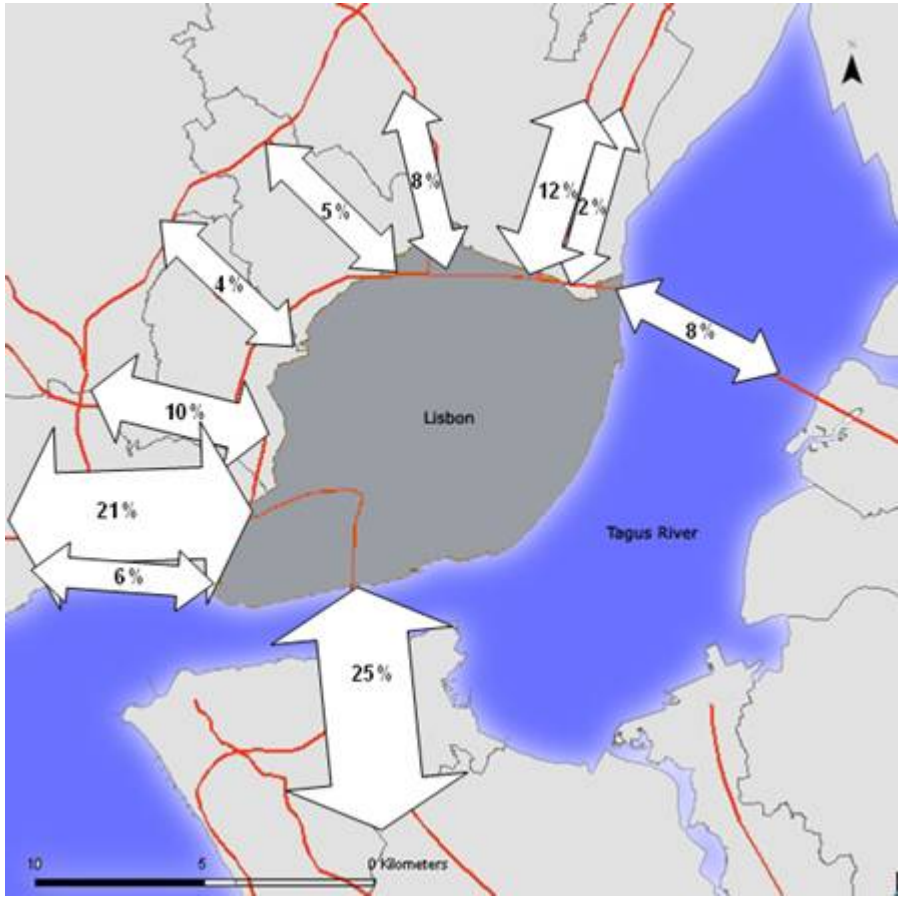
Time Variation

- t_{FAC} - Hourly to daily traffic volume
  - 11h-14 h -> Annual Daily Average
  - 10 representative GERTRUDE traffic monitoring stations
    - Working Days + Weekends
  - TFac = $TMDA/TMDA_w * TMDA_w/TMD_{11h-14h}$
  - TFac = 0.88 * 16 = 14.6

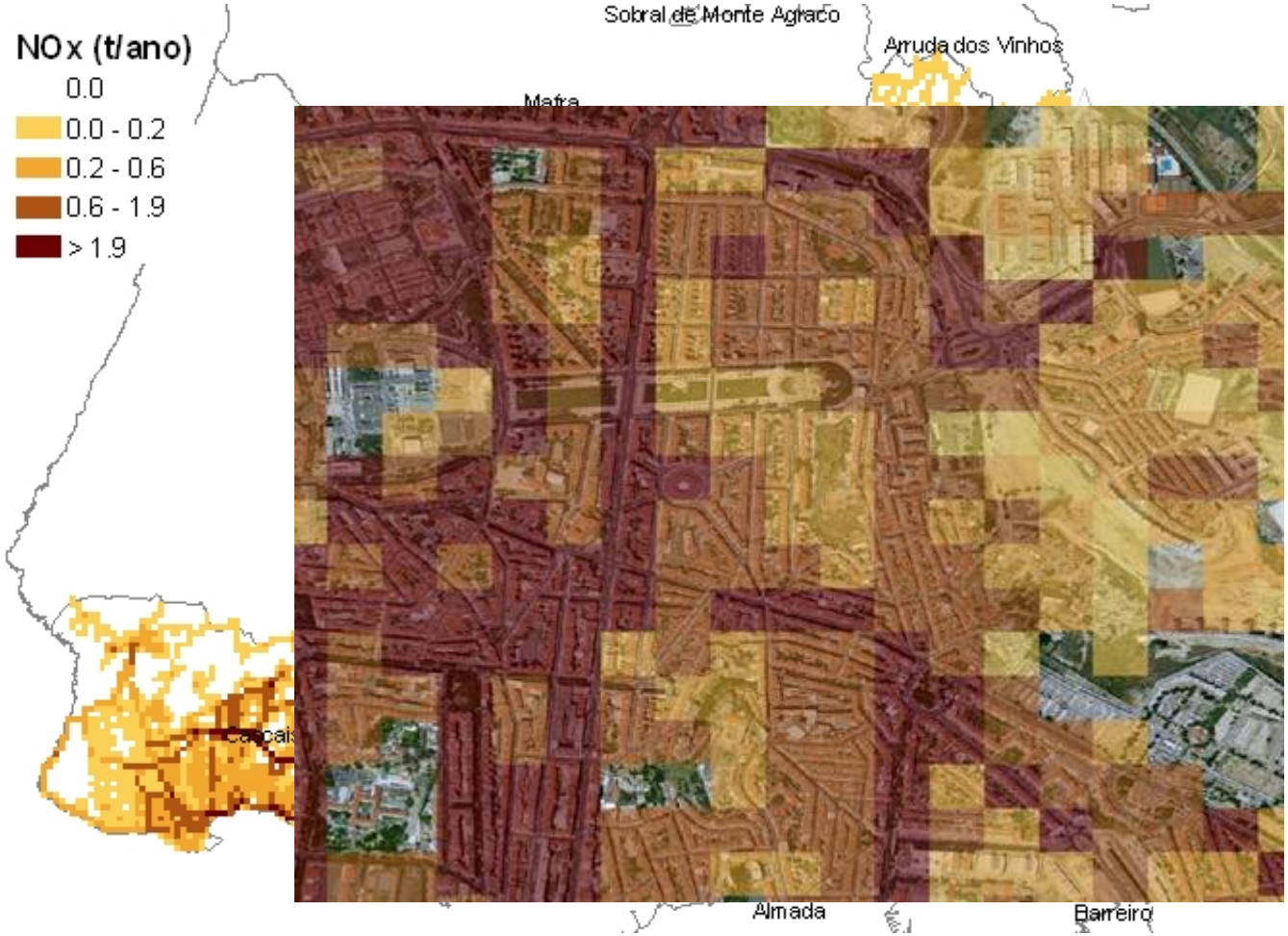


Top-down approach

Consumption = Sales + Import in commuters * FC * Length
Consumption = Sales + (Vehicle Inflow - Vehicle Outflow) * FC * Length



Results: NOx

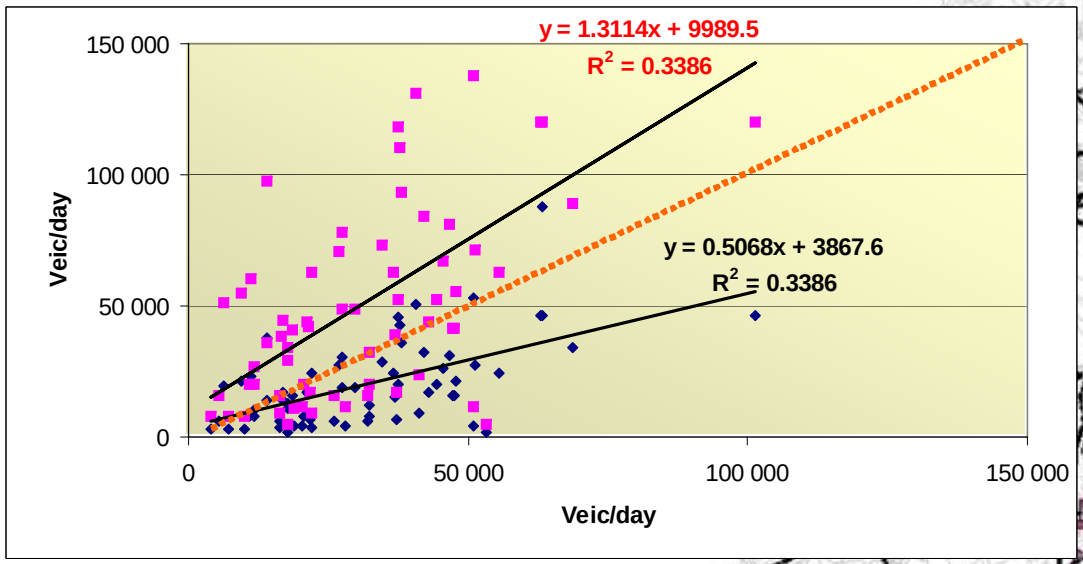

NOx (t/ano)
0.0
0.0 - 0.2
0.2 - 0.6
0.6 - 1.9
> 1.9
Sobral de Monte Agraco
Arruda dos Vinhos
Mafra
Almada
Barreiro

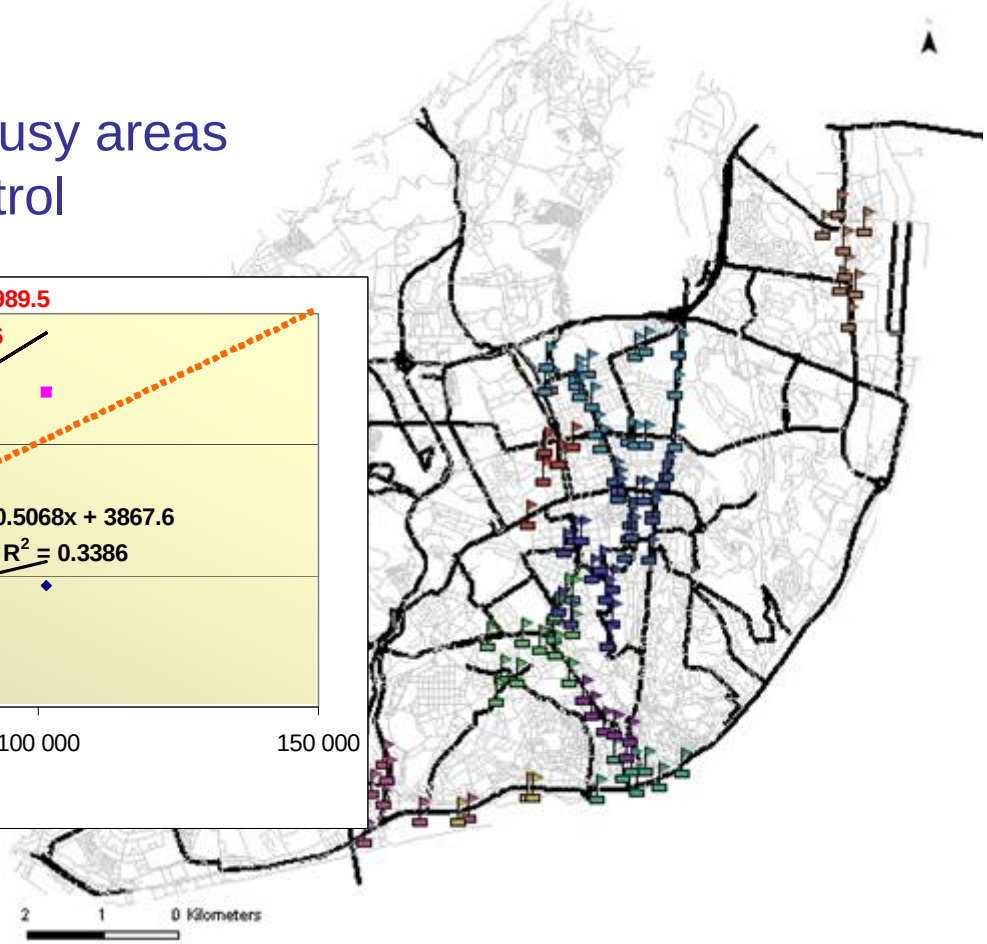
Evaluation: traffic

- GERTRUDE

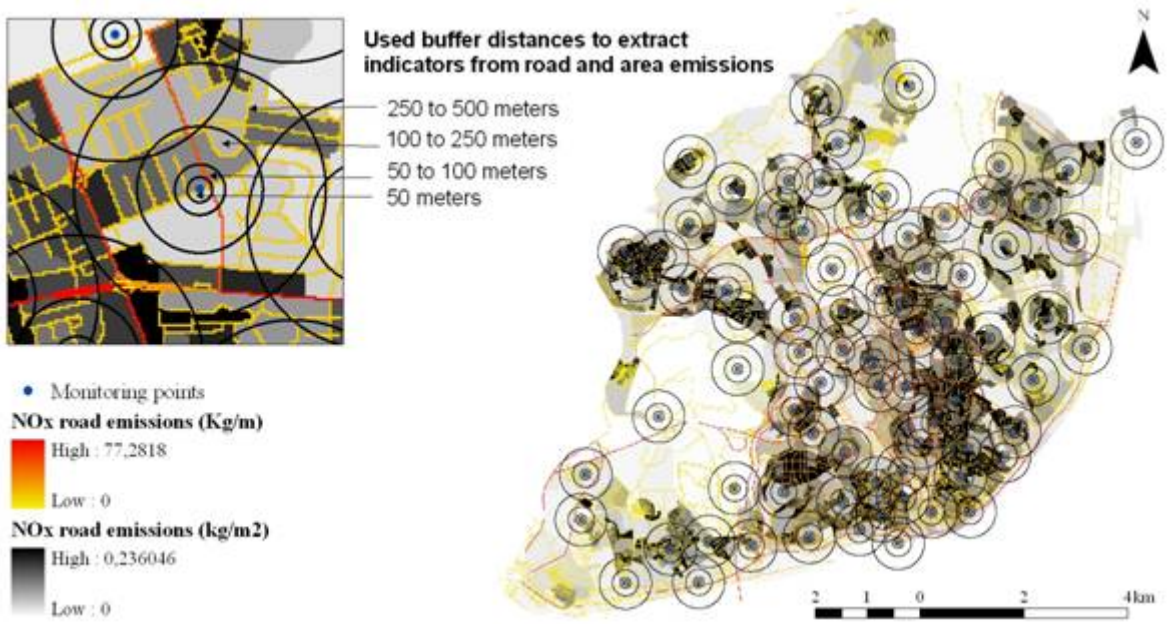
  (*Gestion Electronique de Règulation en Temps Réel pour L'Urbanisme, les Déplacements et l'Environnement*)

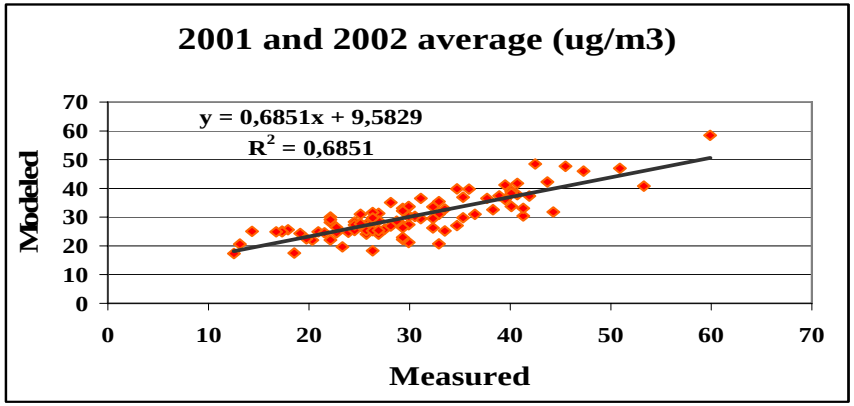
  - Lisbon Municipality
  - local groups: 10
  - 110 counters (2000)
  - Restricted to central/busy areas
  - Objective: Traffic Control



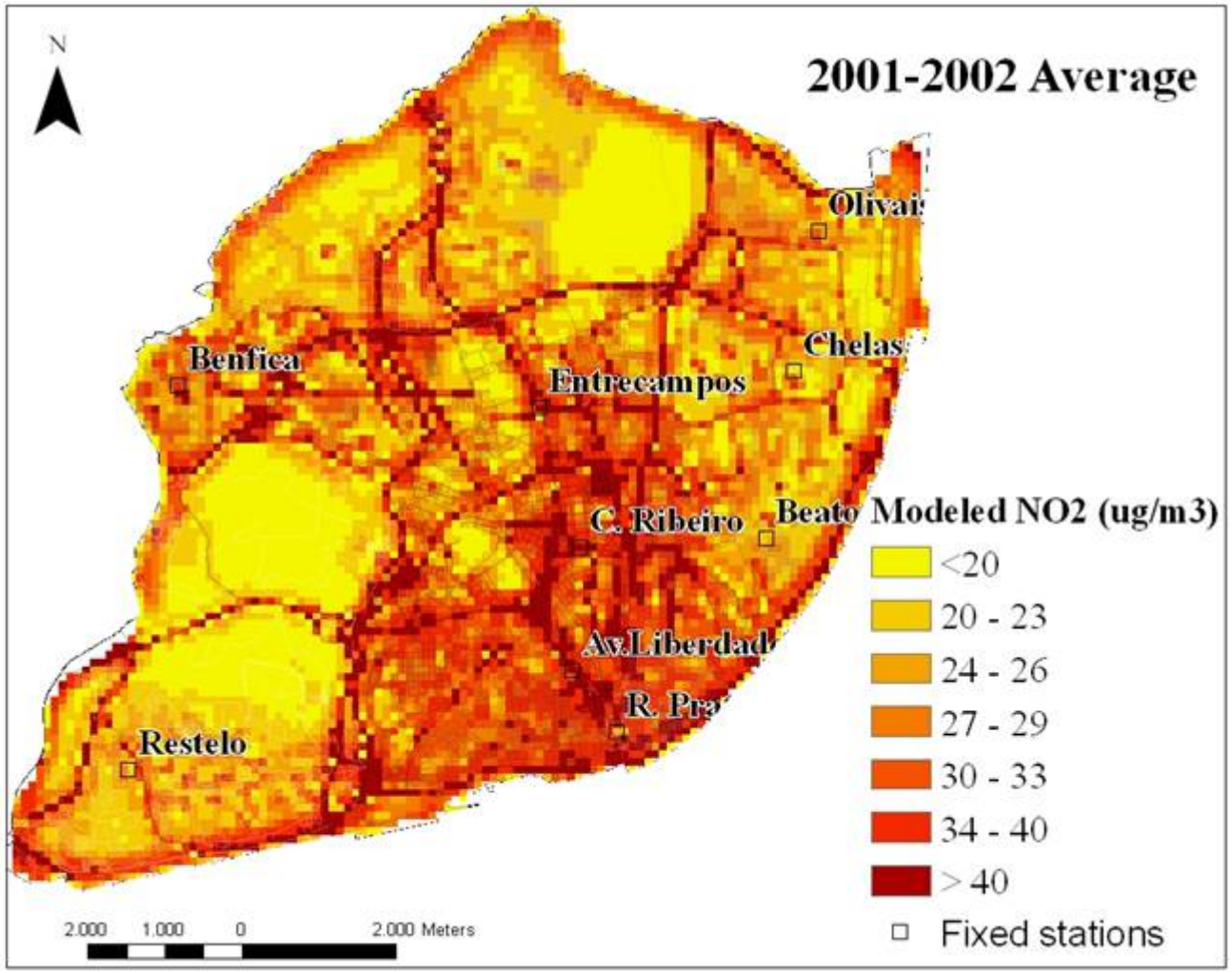


Model Validation
Comparison with air quality surveys





Final Results: Air Quality Mapping



Conclusions

- **Conclusions**
  - **Methodology is feasible**
  - **Comparison to air quality surveys shows good possibilities**
  - **Relatively inexpensive**
    - **Main costs are GPS survey and characterization of the fleet**
  - **Appropriate for diverse media**
    - **Central urban areas and sub-urban areas**
  - **Several potential uses beyond air emission inventories**

Thank you