Progress in IAM in Spain

M. Vedrenne, J. Lumbreras, R. Borge, J. Perez, D. de la Paz, J.M. de Andres, C. Quaassdorff & E. Rodriguez

Technical University of Madrid (UPM)

julio.lumbreras@upm.es

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OUTLINE

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3. Results for Spain (2000-2020)
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   b) Ambient concentration levels
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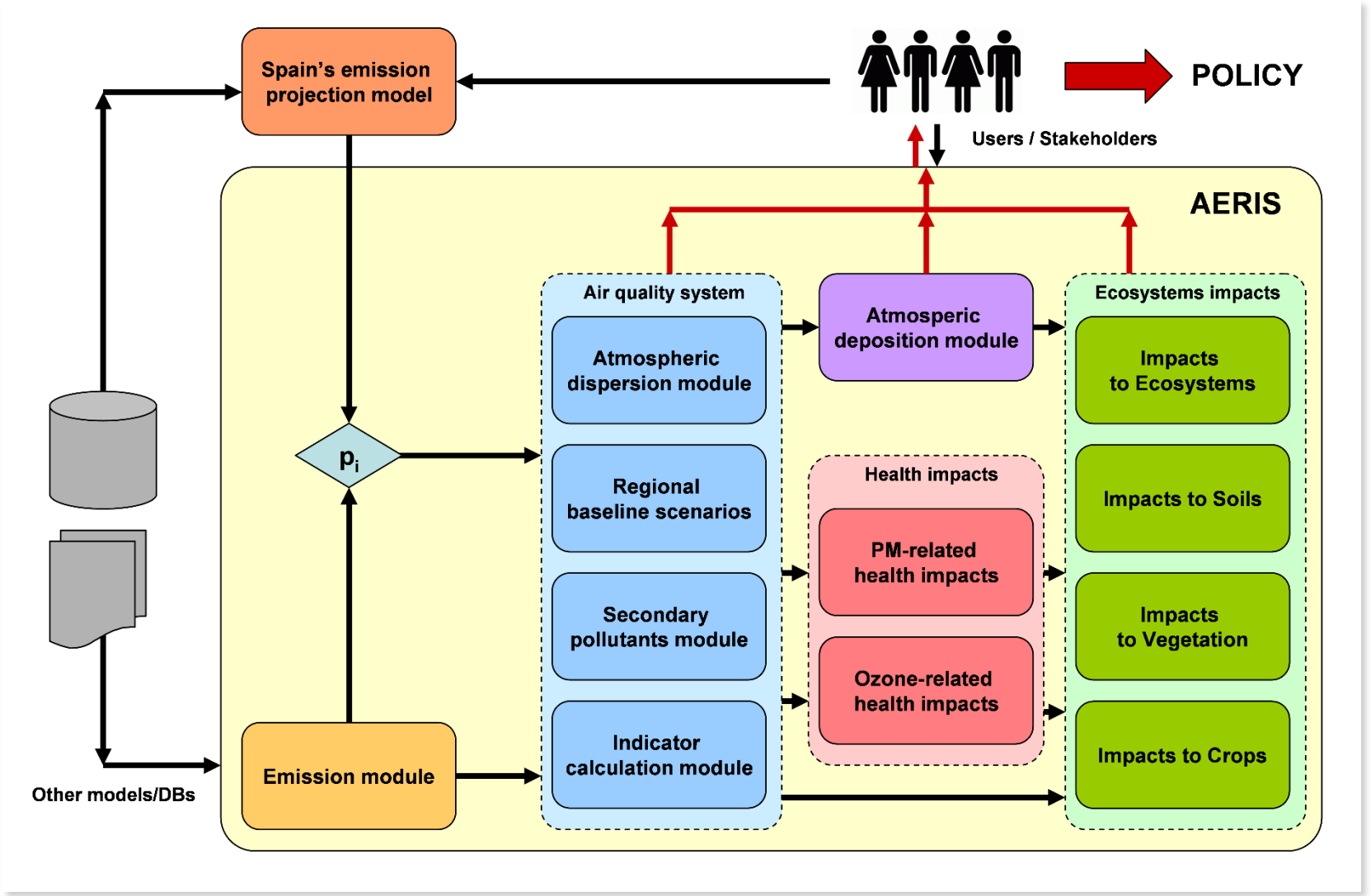
Introduction

- IAM Provides a holistic description of environmental problems under a policy-driven framework.
- Methodology for gaining insight about the complex interactions between “emissions-impacts” phenomena.
- Intended to satisfy the needs of a wide range of stakeholders. Quick response. No intensive computations involved.
- Broader scope – description of phenomena is simplified.

The AERIS model

- AERIS – Atmospheric Evaluation and Research Integrated system for Spain.
- Multi – pollutant approach: SO_2, NO_2, NH_3, PM_{10}, $PM_{2.5}$. Describes formation of O_3 and secondary PM. Deposition of nitrogen (N_{dep}) and sulphur (S_{dep}) species.
- Addresses air quality variations and impacts as a function of percentual variations in emissions against a reference scenario:
  - Impacts on forests and crops (O_3, SO_2, NO_2)
  - Impacts on human health ($PM_{2.5}$, O_3)
  - Impacts on ecosystems and soils (N_{dep}, S_{dep})
- Basic methodology described in Vedrenne et al., (2014) – Environmental Modelling & Software 57, 177-191.
- Main results for 2000-2020 presented in Vedrenne et al. (2015, In Press) – Science of the Total Environment.

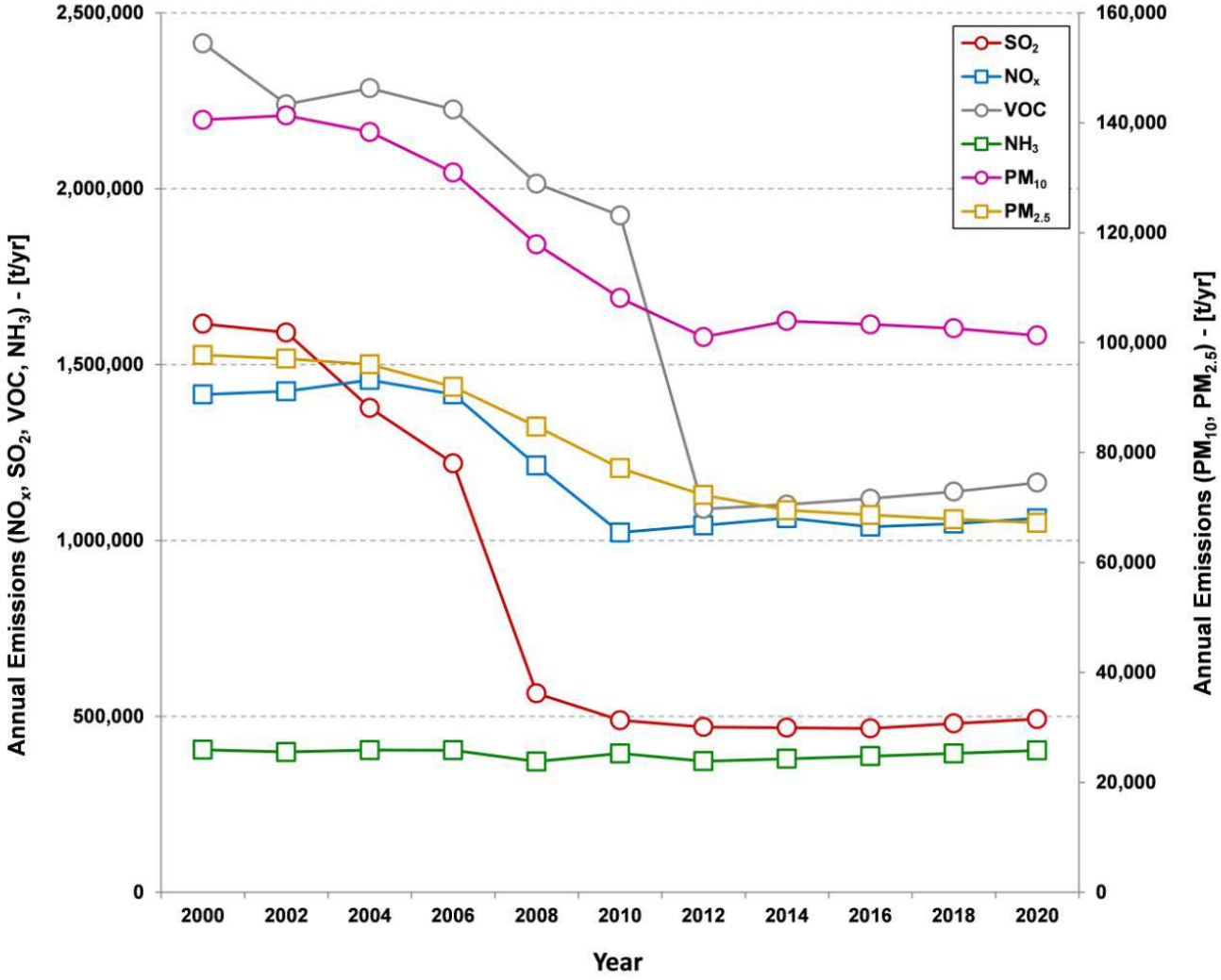
AERIS Structure



2000-2020 emissions

- Biannual emissions
- 2000-2012 based on official Spanish Emission Inventory
- 2012-2020 based on Spanish Emission Projection model (non-official Spanish projections)
- Projections:
    - Defined by the current legislation (CLE)
    - Including Technical and Non-Technical Measures
    - Differentiate by the administrative level

Evolution of Spanish emissions (2000-2020)



AQ control measures implemented (2000-2012)

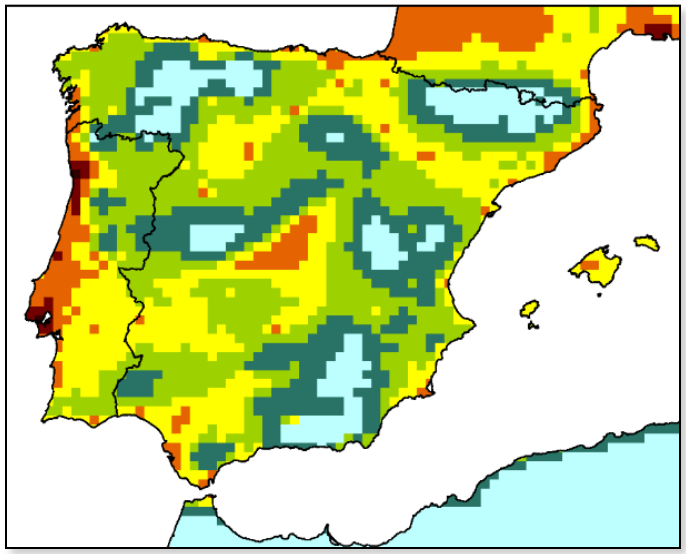
Sector	Measure	Type	AERIS	Admn. Level
Road Transport	Creation of protected atmosphere urban zones	NTM	070000	L
	Improving and promoting public transport	NTM	070100	N,R,L
	Limitation of maximum and variable circulation speed	NTM	070000	L
	Modification of the vehicle inspection procedures	NTM	070000	N
	Economic incentives for new and efficient vehicles	NTM	070000	N,R
	Renovate public fleets with efficient vehicles	NTM	070000	L
	Foster technological improvements in heavy duty vehicles	TM	0703, 0707*	N
	Incentivise the use of bicycles – bicycle paths	NTM	070100	R,L
	Increase road cleaning/washing activities	TM	070000	L
	Mobility and public transport plans	NTM	070100	N,R,L

TM= Technical Measures; NTM= Non Technical Measures
N=National; R= Regional; L= Local

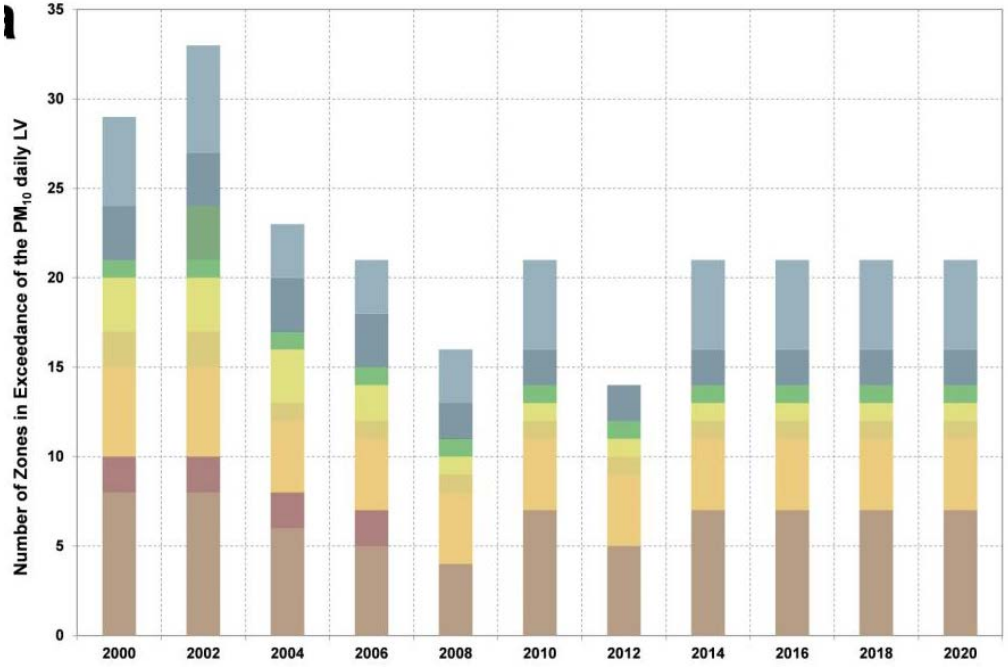
Industry	Implementation of best available techniques (BAT)	TM	03*, 04*	N,R
	Reviewing and updating industry emission limits	NTM	03*, 04*	N
	Promoting change to cleaner fuels – end of coal funding	NTM	03*, 04*	N,R
Domestic	Domestic installation retrofitting	TM	020202	R,L
	Promoting change to cleaner fuels – discourage solid fuels	NTM	020202	N,R,L
	Change from individual to district heating	TM	020202	R,L
Energy	Implementation of best available techniques (BAT)	TM	010000	N,R
	Promoting change to cleaner fuels – end of coal funding	TM	010000	N,R
	Economic incentives to renewable energy sources	TM	010000	N,R
Construction	Limiting dust emissions through technology improvements	TM	080800	N,R,L
	Implementation of best available techniques (BAT)	TM	080800	N,R
Airports	Fleet renewals	NTM	080500	N
	Operational measures (approach, towing, boarding)	TM	080500	N
Agriculture	Banning agricultural waste burning	NTM	100500	N,R,L
	Reduce emissions associated with fertilisers	TM	1001, 1002	N,R
	Reduce emissions from manure operations	TM	100500	N,R
	Reduce engine operation times for tractors	NTM	080600	N,R

2000-2020 ambient concentration levels

- NO_2, SO_2, NH_3, PM_{10}, $PM_{2.5}$ and O_3 concentrations (mean annual or the respective metrics to compare with the limit values, LVs)
- Through transfer matrices including a secondary pollutants module (parametrization of WRF-CMAQ)
- 4500 cells, 4x4 km^2



Example of 2007 $PM_{2.5}$ mean annual conc.



# of AQ management zones above the PM_{10} daily LVs

2000-2020 impacts (1)

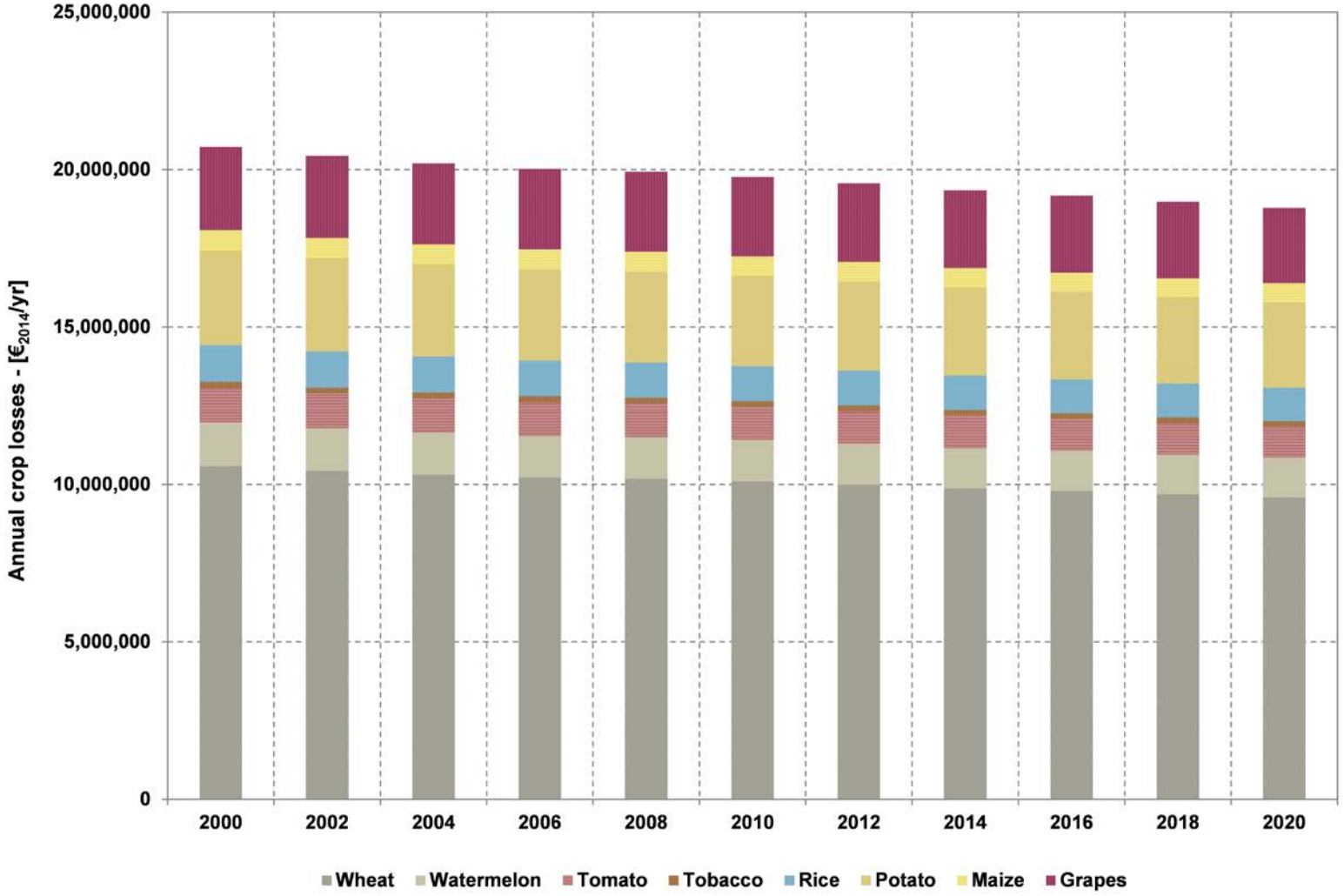
- Deposition and protection of ecosystems:
  - annual accumulated atmospheric deposition of oxidised and reduced N and S (in milligrams per hectare annum)
  - CMAQ parametrization (8 species of oxidised N, 3 of reduced N, and 5 of S)
  - Eutrophication: CL for nutrient nitrogen-$CL_{nut}(N)$
  - Acidification: acidity trapezoidal function of CL for sulphur and nitrogen ($CL_{max}(S)$, $CL_{min}(N)$ and $CL_{max}(N)$)
  - Accumulated Average Exceedance (AAE) in order to account for ecosystem area gap closures

Annual exceedance of CL for soils and forests

2000-2020 impacts (2)

- Impacts on crops and forests:
  - Damage to forests caused by the exceedance of CL of NO_2 and SO_2
  - Decrease in crop production caused by O_3 for a number of plant species

Temporal evolution of the annual crop losses due to exposure to O_3 (referred to Spanish € of 2014)



2000-2020 impacts (3)

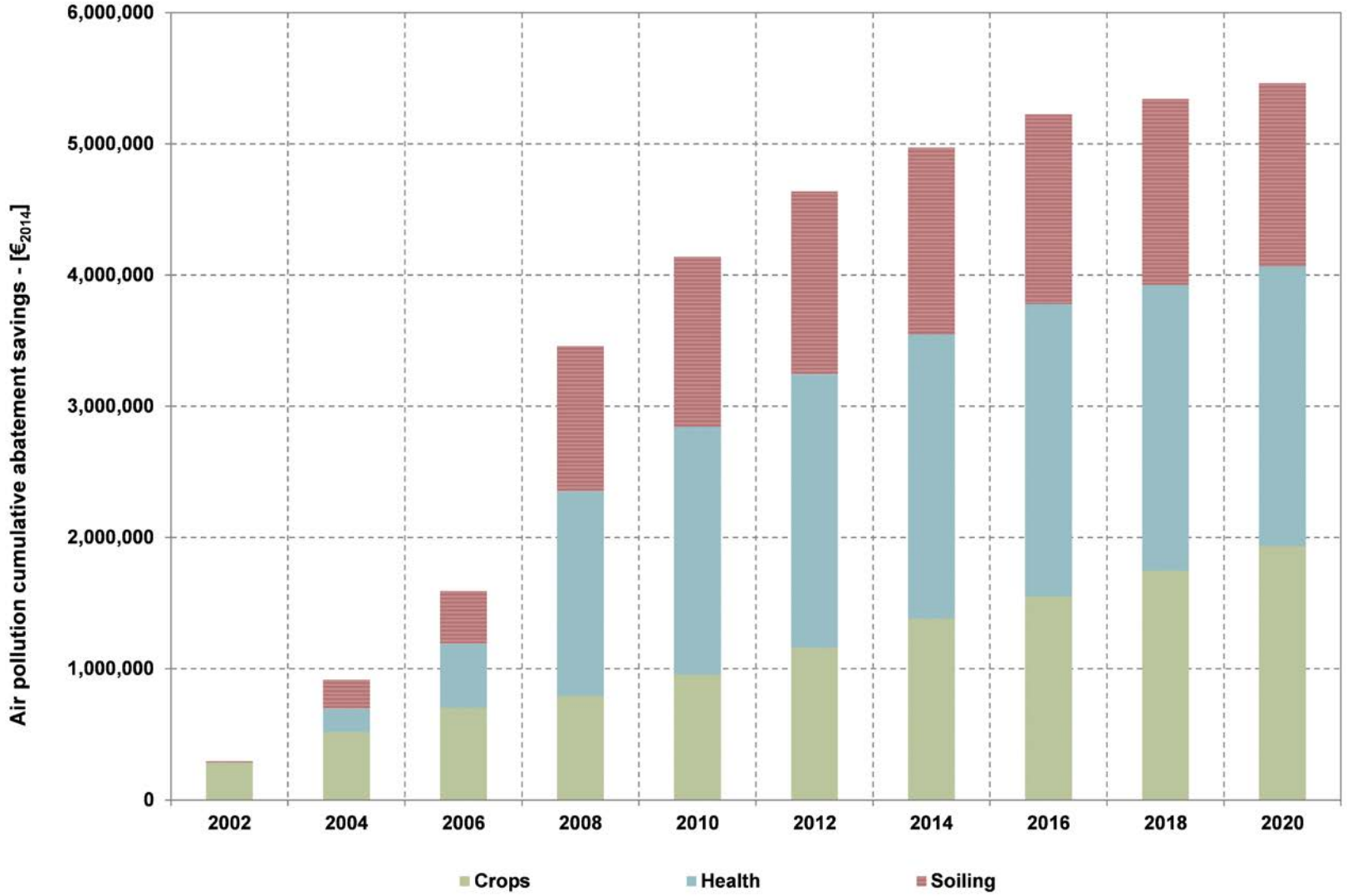
- Impacts on human health:
  - Limited to particulate matter ($PM_{2.5}$) and tropospheric ozone (O_3)
  - $PM_{2.5}$:
    - Change in statistical life expectancy per person (Δec),
    - Total amount of life years lost (YOLL) and
    - Disability adjusted life years (DALY)
  - O_3: cardiopulmonary impacts and the annual cases of premature mortality (Mort).

Biannual and total improvements $PM_{2,5}$ mortality (YOLL)

2000-2020 impacts (4)

- Cost and benefits:
  - Only for health damage, crop-losses and building soiling in M€/yr
  - The cost to individuals and health services was modelled for $PM_{2.5}$ under an impact pathway approach adapted to Spain
  - The valuation of non-health damage was carried out for crop-losses (O_3 related) and building soiling ($PM_{2.5}$)
  - Market prices for crops were taken from Spanish databases

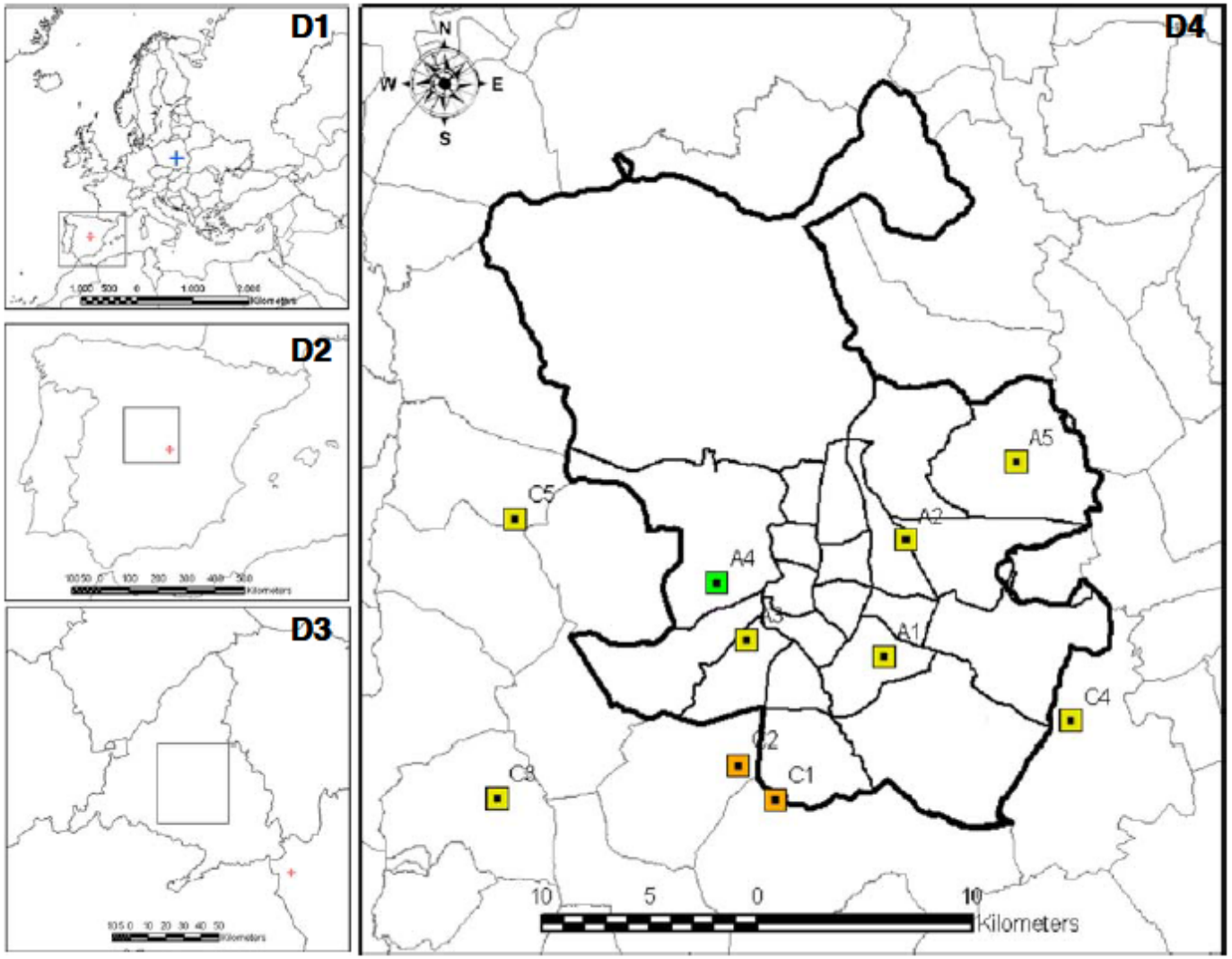
Cumulative abatement savings (referred to Spanish € of 2014)



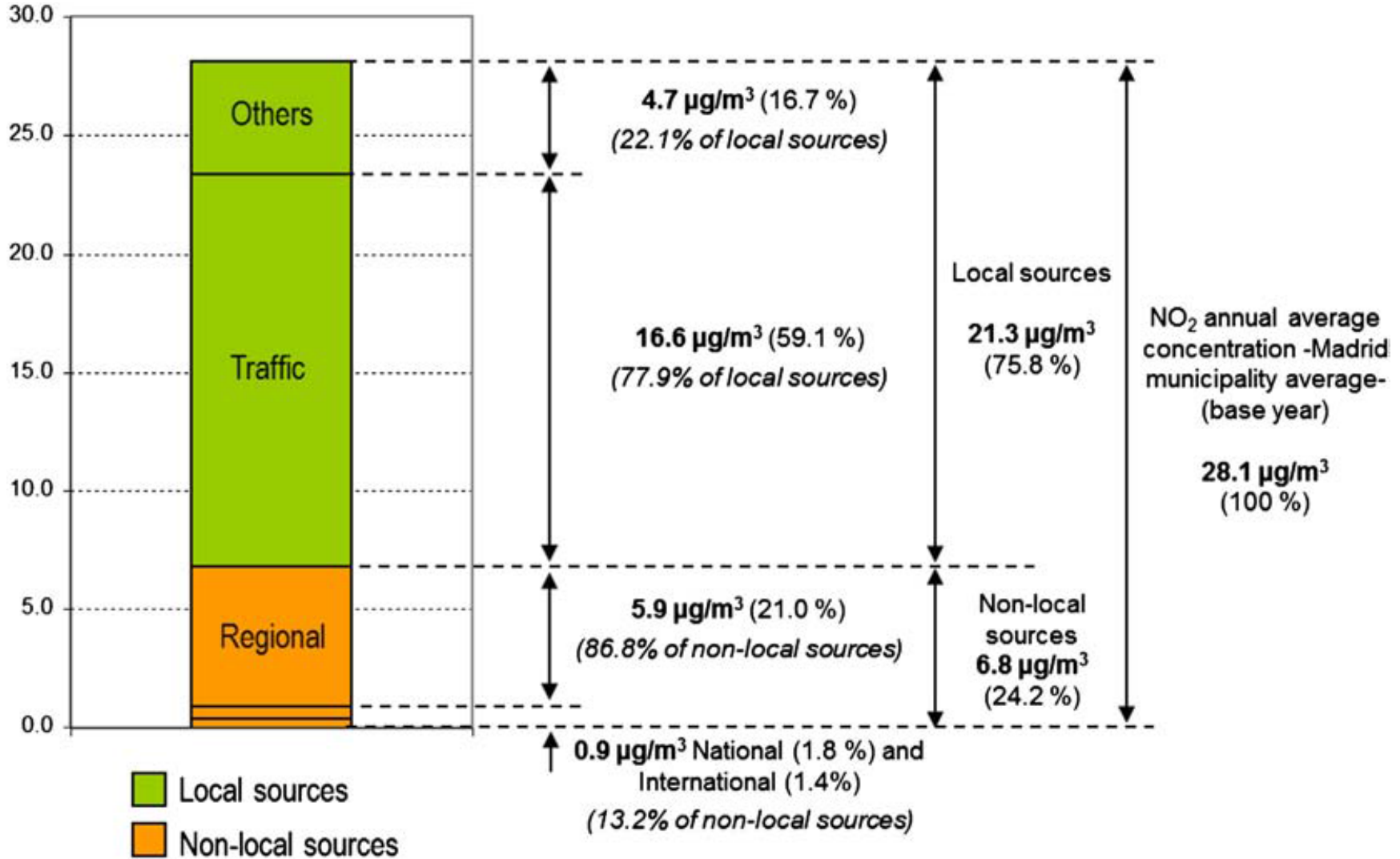
Conclusions

- Projected reduction of emissions (much lower for the 2012-2020 period)
- Substantial decrease of ambient concentration levels (and exceedances)
- A number of air quality management zones would still be in infringement of NO_2 and PM_{10} limit values (without natural discounts) by 2020
- Ecosystem damage due to S deposition has been widely mitigated
- The abatement of N-related deposition was more modest
- Decrease in the monetary losses due to O_3-induced crop damage (wheat, potato and grapes)
- O_3 impacts in mortality were not improved over the 20-year period
- $PM_{2.5}$ related health impacts were substantially decreased
- Undertaking air quality actions directed towards emission abatement brought about gross savings in the order of 5.5 $M€_{2014}$ (40% health)
- Starting point for identifying key issues for further abatement measures to deliver better air quality in Spain in the forthcoming years

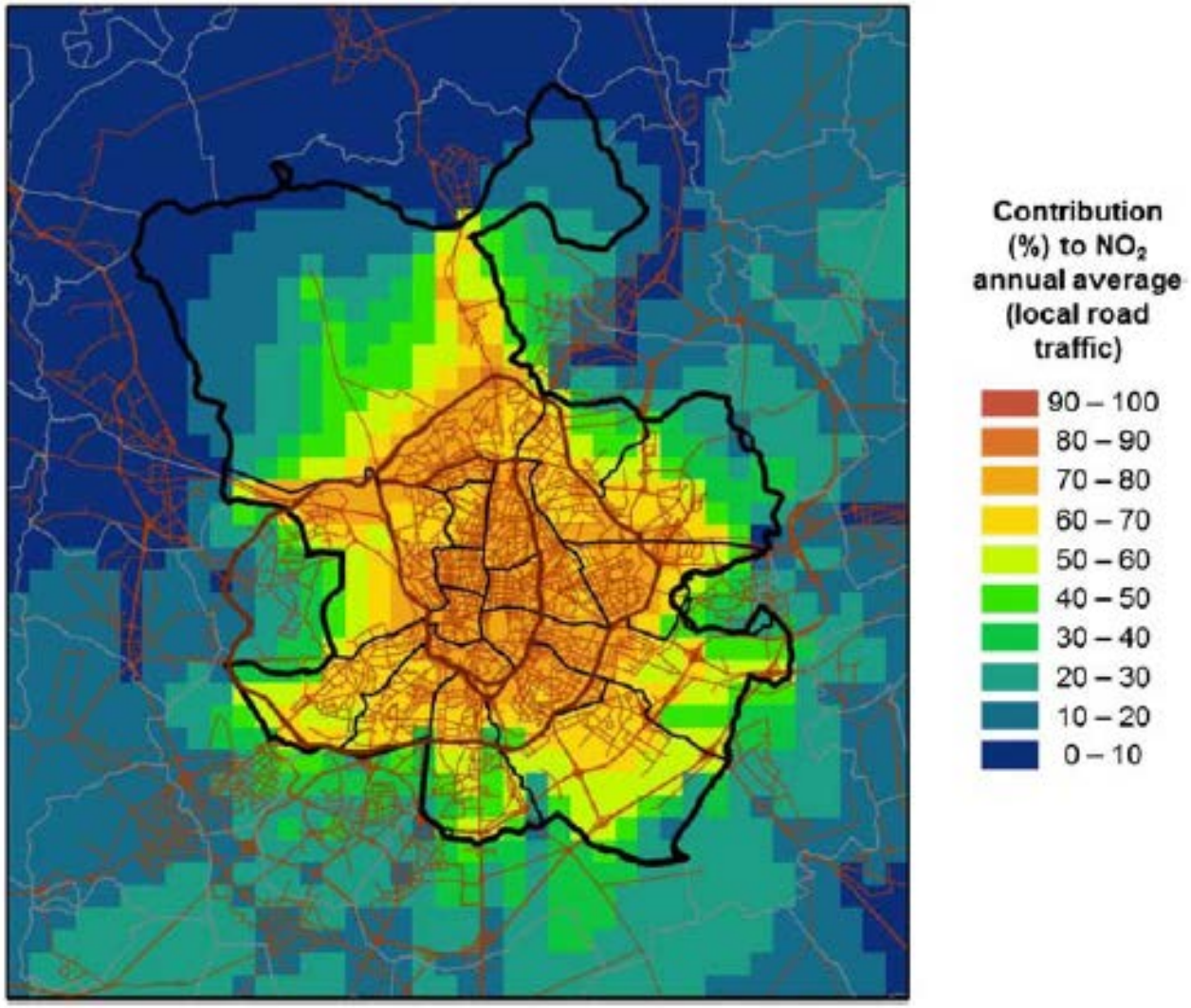
Other work (Madrid)



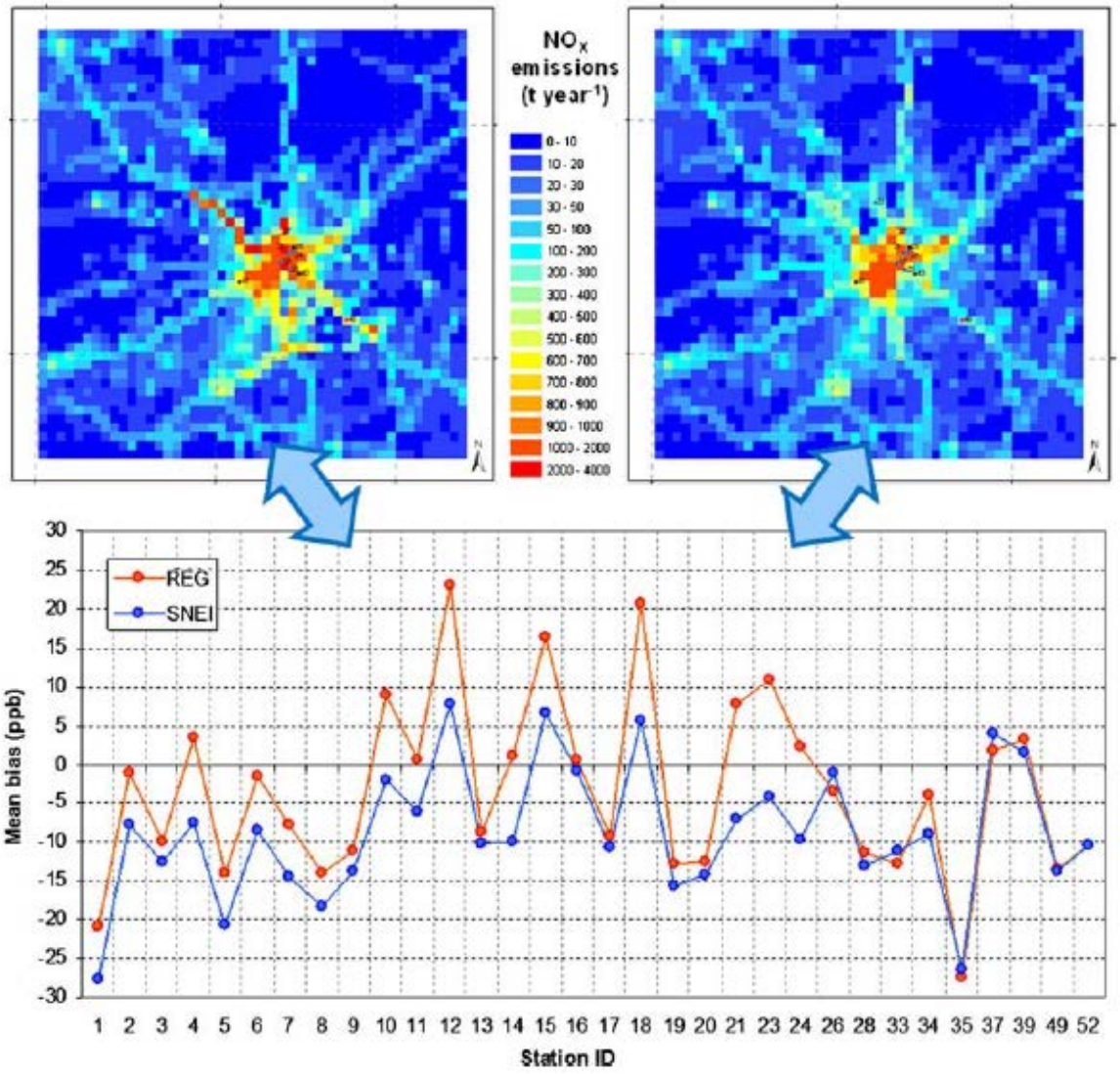
Source apportionment



Traffic contribution

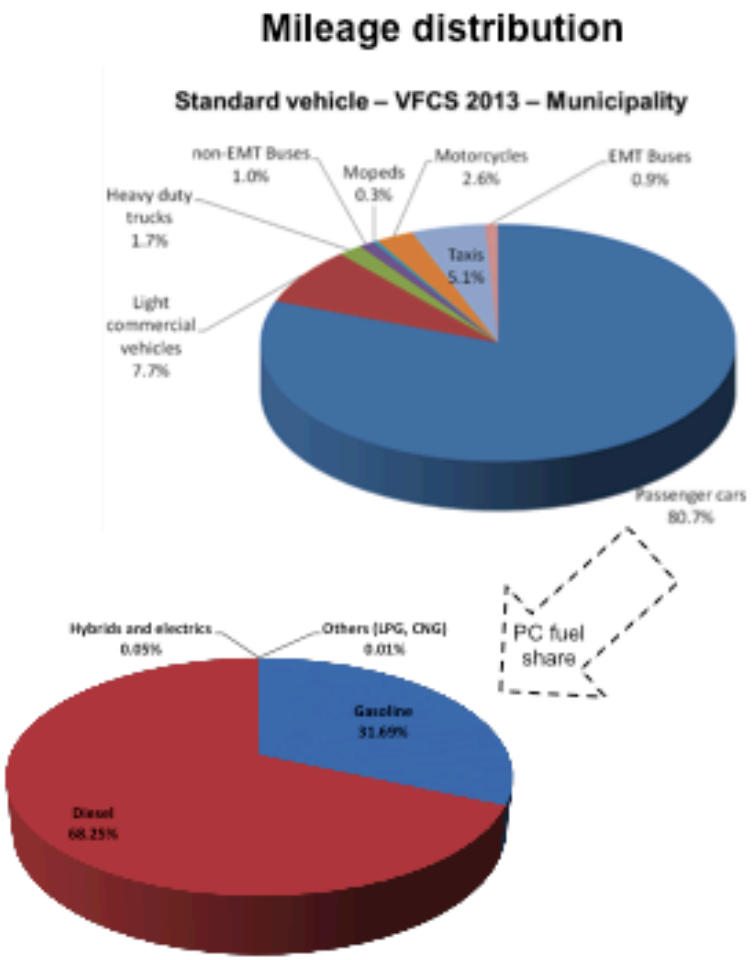


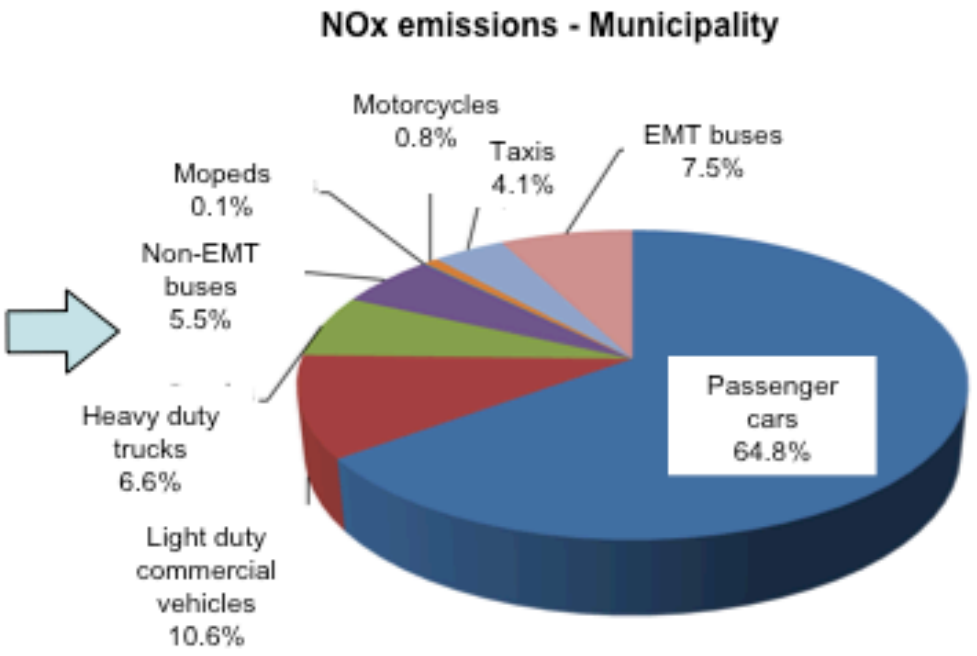
Inventory scale influence



Running fleet (campaign)

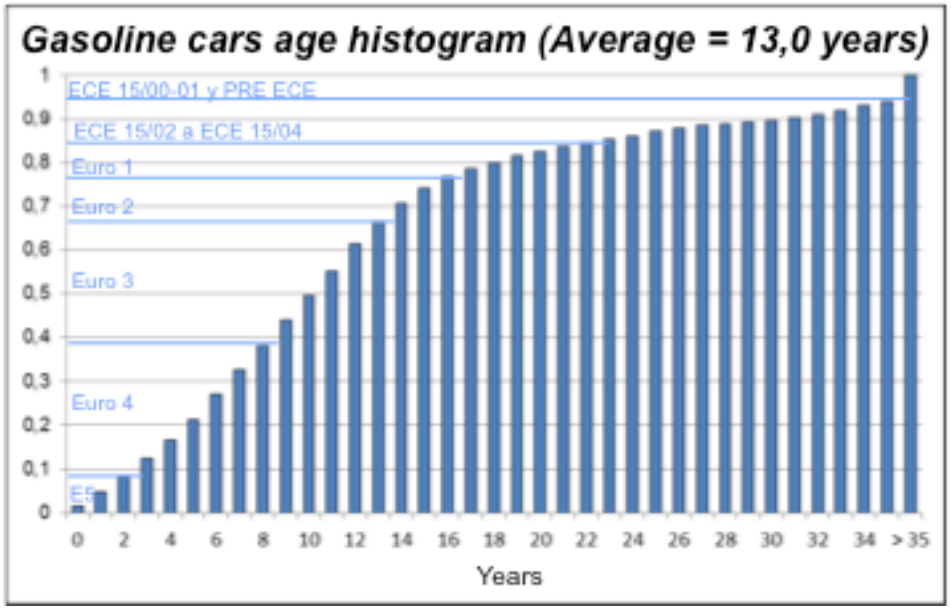
- 4,911,708 plate readings was made during the campaign
- Up to 1,304,112 different plates were identified (after data cleaning and duplicates removal)

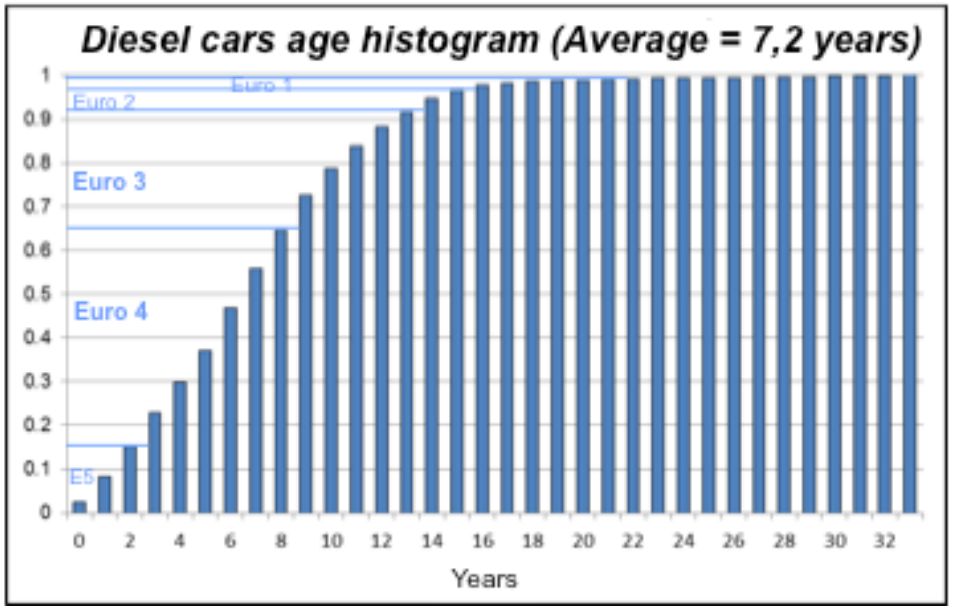




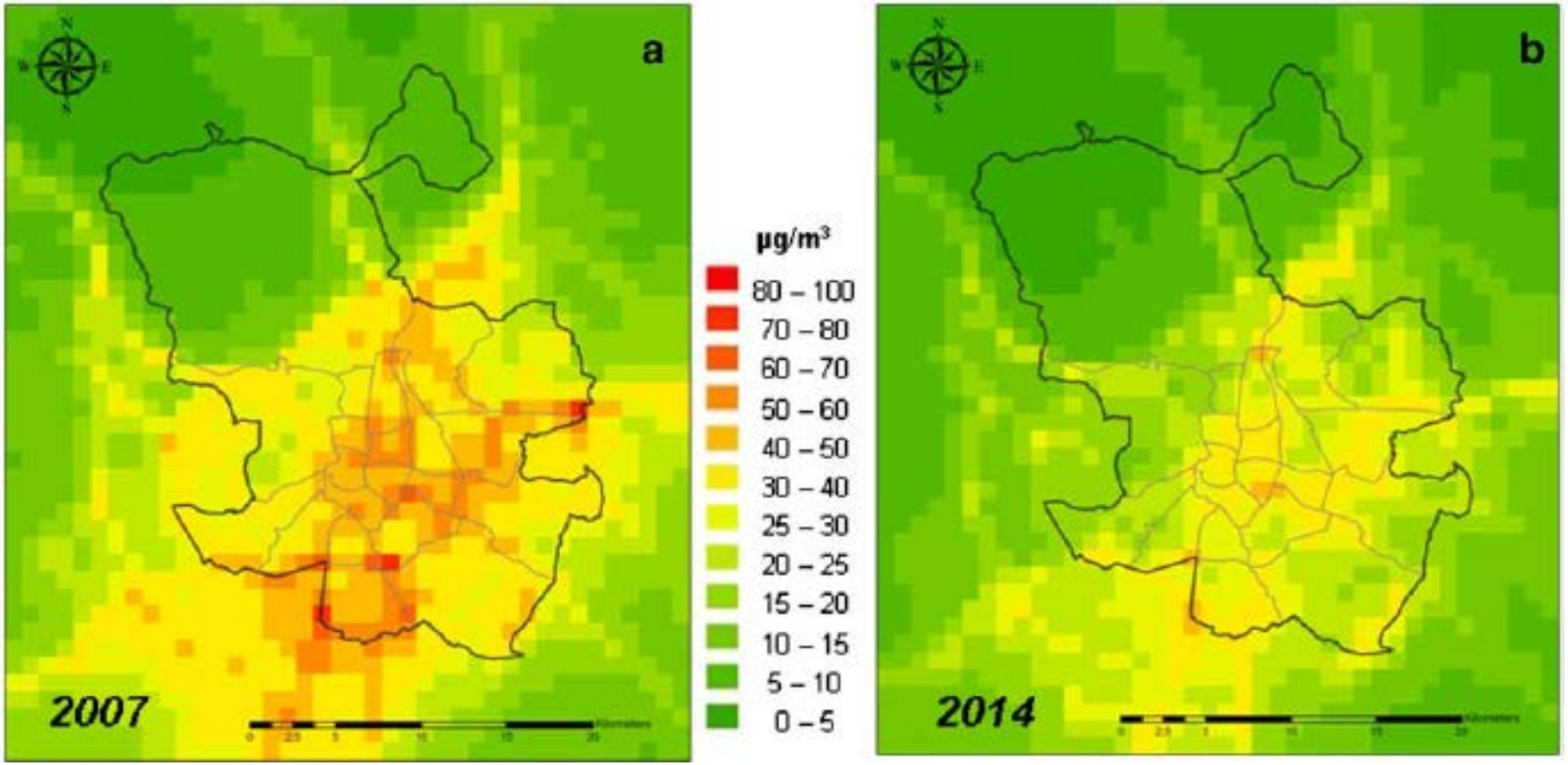
Running fleet

	Average age (years)	*Previous study (2009)*
Passenger cars	9.3	*5.7*
Light commercial vehicles	10.0	*5.1*
Heavy-duty trucks	10.8	*6.8*
Buses	8.1	*6.2*
Motorcycles	9.8	*3.1*
Taxis	4.4	-

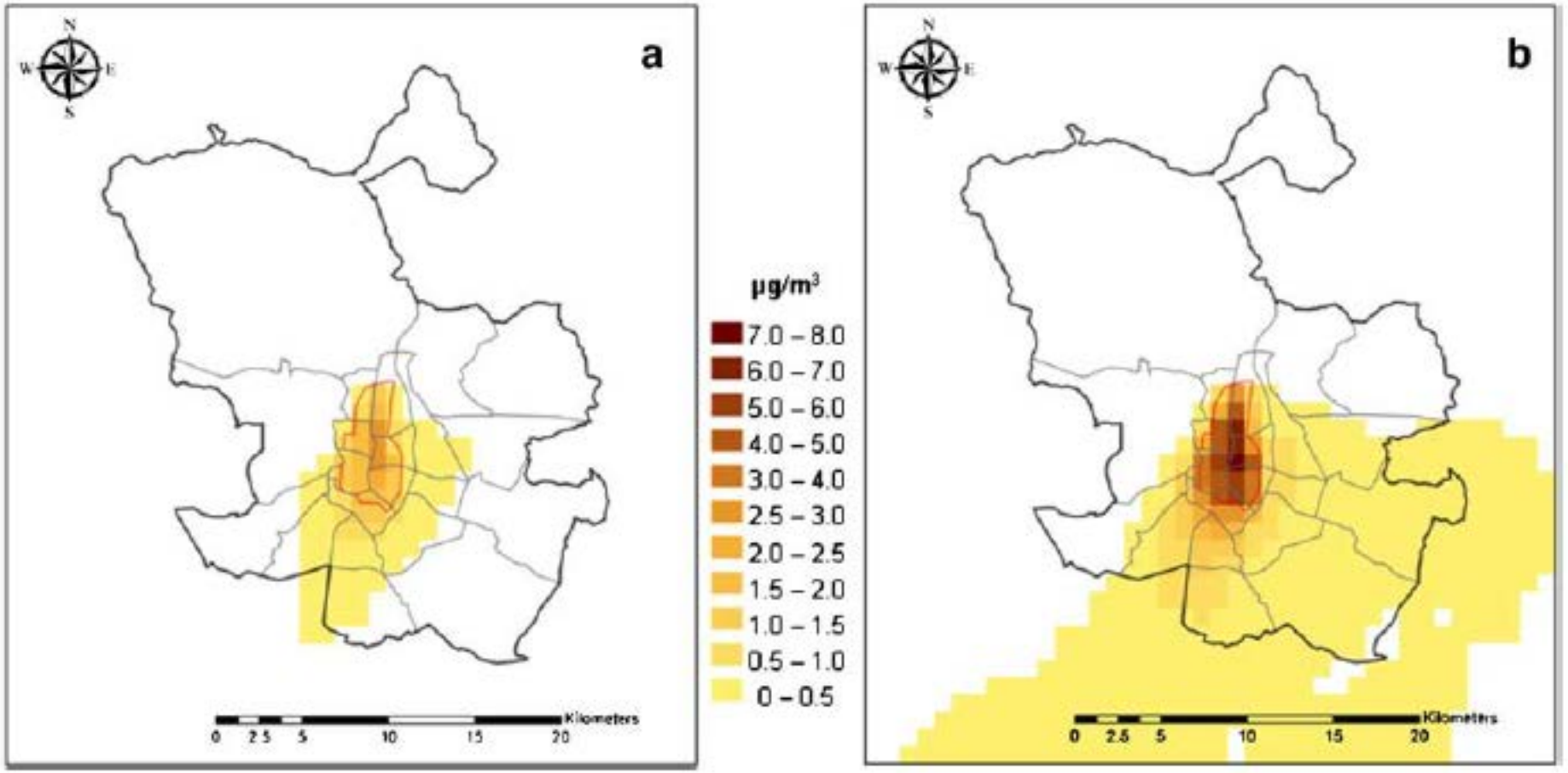




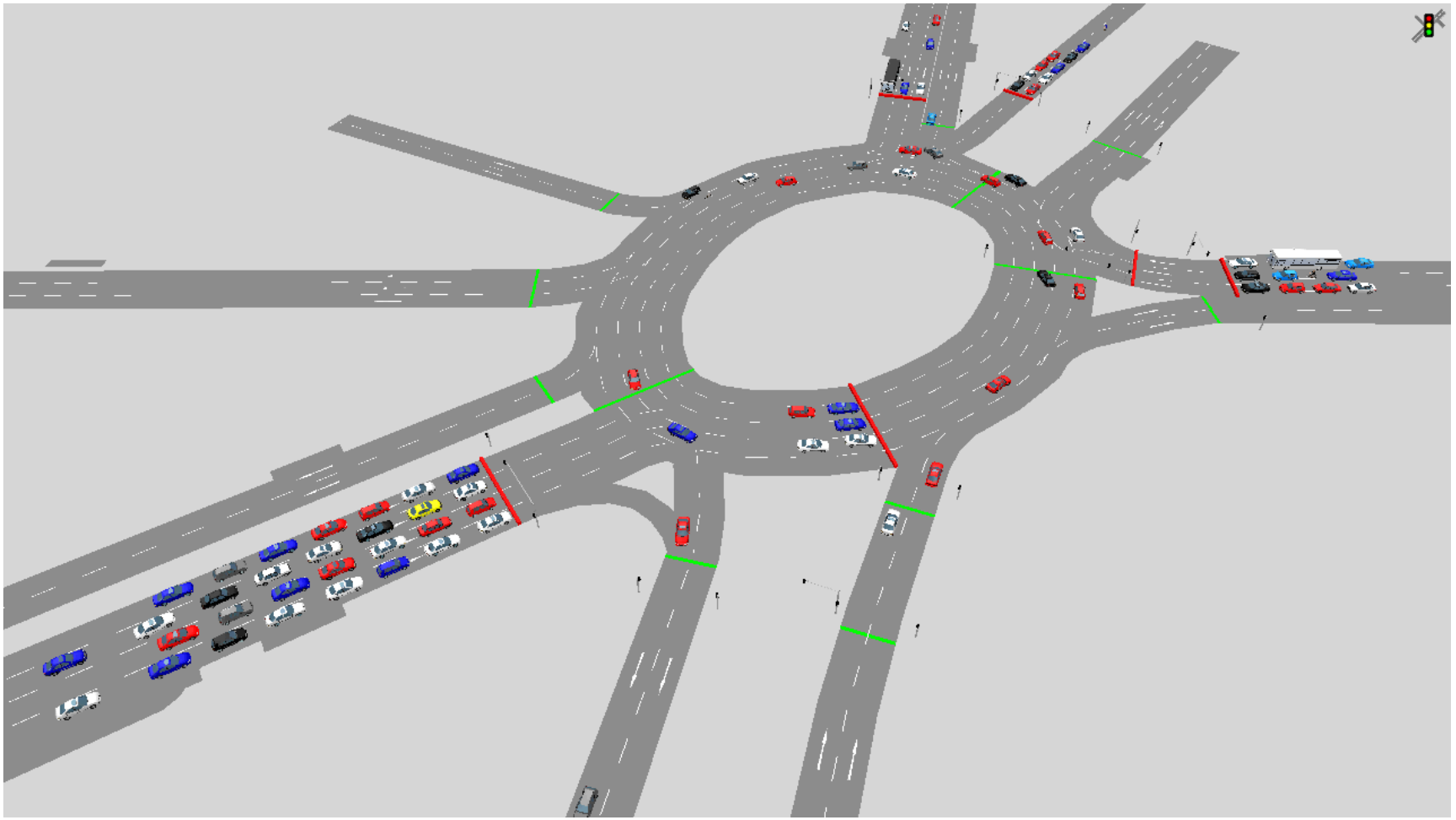
AQ Plans


a
2007
µg/m³
80 – 100
70 – 80
60 – 70
50 – 60
40 – 50
30 – 40
25 – 30
20 – 25
15 – 20
10 – 15
5 – 10
0 – 5
b
2014

Episodes restrictions



Microscale simulations



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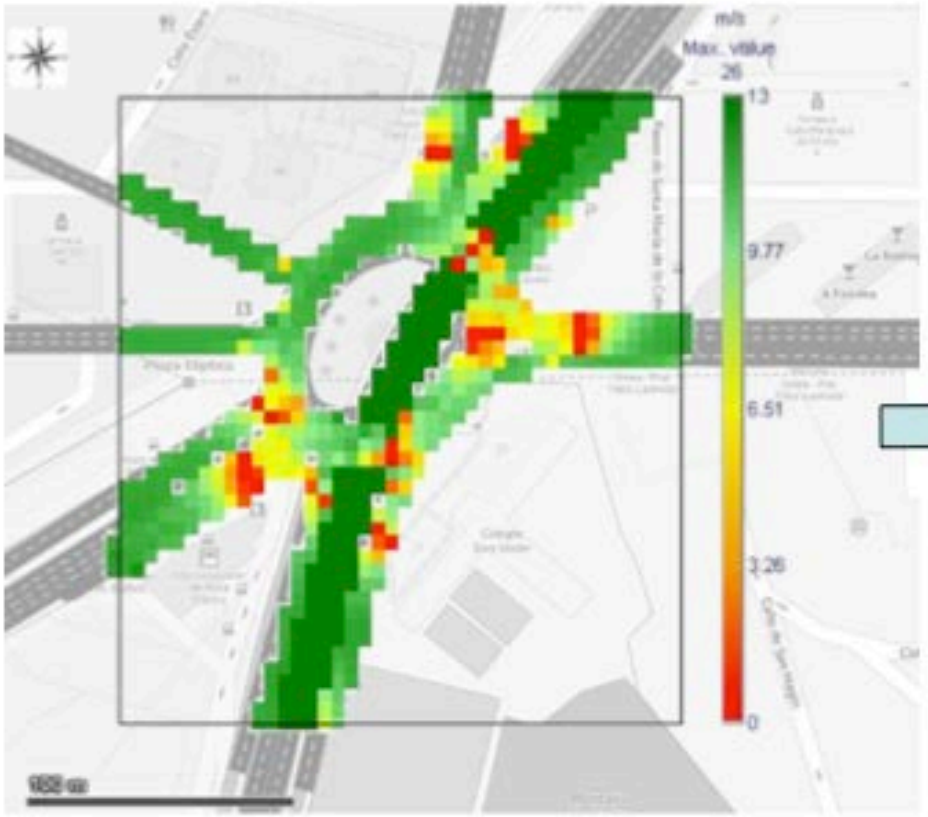

Average speed (E1): low traffic intensity, freeflow
(Wednesday 4:00-5:00 AM)

NO_x emissions (E1): 111 gr/h