LIFE REMY

LIFE20 PRE/IT/000004

LIFE_REMY (Reducing Emission Modelling uncertaintY)

FAIRMODE Technical meeting

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www.LifeREMY.eu

Overview

1. LIFE REMY project & Recommendations document
2. State of art: most relevant emission uncertainties
3. First emission uncertainties & lessons learnt found in REMY

LIFE REMY project

LIFE REMY (Reducing Emission Modelling uncertaintY) is a 3 years (2021-2024) EU LIFE Preparatory Project, which involves five partners:

TerrAria s.r.l. | AGENZIA MOBILITÀ AMBIENTE TERRITORIO | RSE Ricerca Sistema Energetico | IOŚ-PIB Institute of Environmental Protection National Research Institute | idaea Institute of Environmental Assessment and Water Research | CSIC

Objectives:

Provide updated, comprehensive and **harmonized recommendations** that can support modelling groups in **reducing emission uncertainties** and therefore contributing to **a better development, implementation and evaluation of air quality assessment, air quality plans** and source apportionment **in the framework of the AAQ Directives** through a modelling approach. They're firstly **based on REMY's emissions and modelling results**.

Timeline:

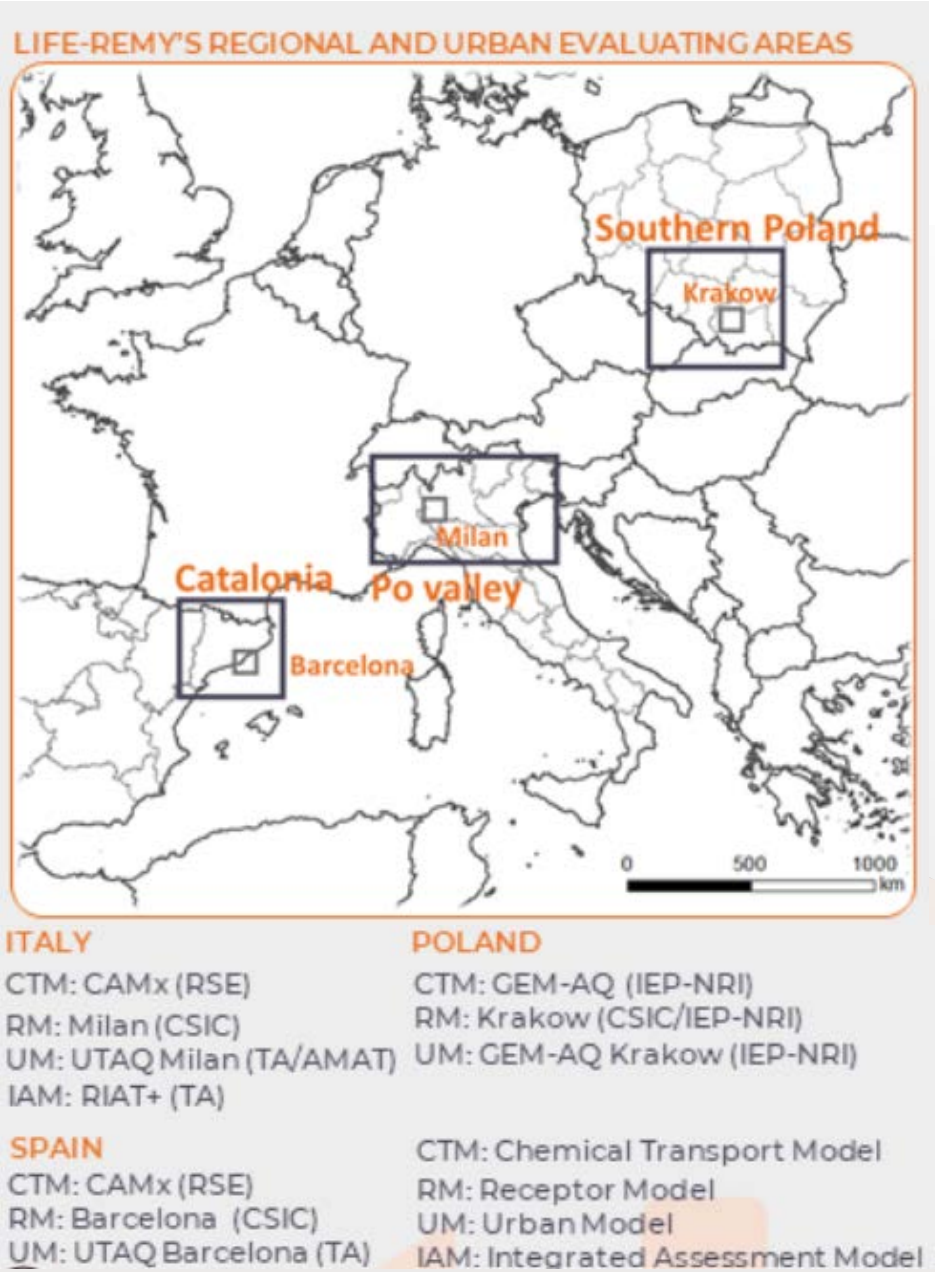
REMY's **Final Recommendation Document** will be available in **April 2024**

LIFE REMY project

Case studies:

The project is focused on the reduction of most relevant uncertainties associated to the emission processing and specific analysis and simulations of two scenarios (i.e., BASELINE and COVID19) both at regional and urban level in 3 EU areas:

- Po Valley/Milan in Italy
- Catalonia/Barcelona in Spain
- Southern Poland/Krakow in Poland.



Emission uncertainties: what?

EMEP/EEA Guidebook: "*Accuracy of the emission estimates should be assured where emission estimates are neither biased or too uncertain*". **Member states need to report uncertainty together with their emission values.**

Main causes of emission uncertainty analyzed in REMY are:

- Estimation of emissions (emission factor EF and activities AI)
- Emission spatialization, temporal modulation, chemical speciation

$$E(s, t, a, p) = AI(s, t, a, p) \times EF([s, t,] a, p)$$

- s = space
- t = time
- a = activity
- p = pollutant

Emission uncertainty: how?

Different methods to provide a first estimates of uncertainty:

- DIRECT: error propagation (emission factor uncertainty x activity uncertainty)
- UNDIRECT: inventories comparison (e.g. in REMY BU vs TD EMEP/EEA)
- UNDIRECT: EEA estimates in EMEP/ EEA guidebook

Rating	Definition	Typical error range
A	An estimate based on a large number of measurements made at a large number of facilities or individual sources across a comprehensive range of operating conditions that fully represent the sector	10 to 30 %
B	An estimate based on a large number of measurements made at a large number of facilities or individual sources across a range of operating conditions that represent a large part of the sector	20 to 60 %
C	An estimate based on a number of measurements made at a small number of representative facilities or individual sources across a smaller range of operating conditions, or an engineering judgement based on a number of relevant facts. An estimate based on a large number of measurements across a range of conditions for a source which is complex and/or variable.	50 to 200 %
D	An estimate based on single measurements, or an engineering calculation derived from a number of relevant facts An estimate based on a large number of measurements across a range of conditions for a source which is particularly complex and/or variable.	100 to 300 %
E	An estimate based on an engineering calculation derived from assumptions only An estimate based on a limited number of measurements for a source which is particularly complex and/or variable.	order of magnitude

Emission uncertainty for different pollutants/sectors

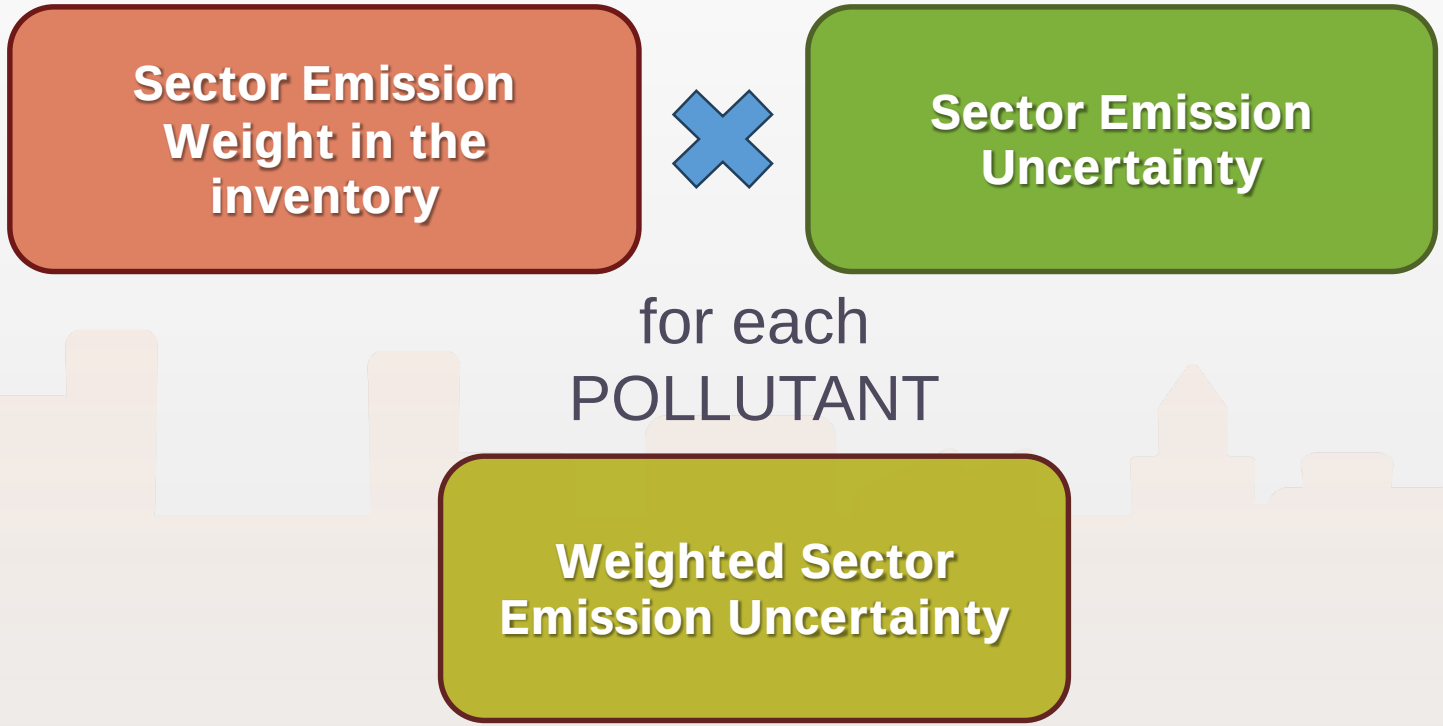
Main NFR source categories with applicable quality data ratings (EMEP/ EEA guidebook)

NFR	SOURCE CATEGORY	SO_2	NOx	VOC	CO	NH3	PM	HM/POP
1.A.1	Public power, cogeneration and district heating	A	B	C	B	E	C	D
1.A.2	Industrial combustion	A	B	C	B	E	C	D
1.A.3.b	Road transport	A	C	C	C	E	C	E
1.A.3.a,c,d,e	Other mobile sources and machinery	B	D	D	D	E	D	E
1.A.4	Commercial, institutional and residential combustion	A	C	C	C	E	D	E
1.B	Extraction and distribution of fossil fuels	C	C	C	C		D	E
2	Industrial processes	B	C	C	C	E	C	E
3	Solvent use			B			D	E
4	Agriculture activities		D	D	D	D	E	E
5.a , 5.b	Waste treatment	B	B	B	C		C	D
5.c	Waste disposal activities	C	C	C	C	E	C	E
11	Nature	D	D	D	E	E	E	E

- depends on pollutant: SO_2 < NOx < PM < NH_3
- depends on sector: industry < road transport, residential heating < agriculture, nature

Emission uncertainty: which?

The REMY project focuses its efforts on emission sources characterized by both significant emission weight (respect to the total inventory) and high uncertainty;



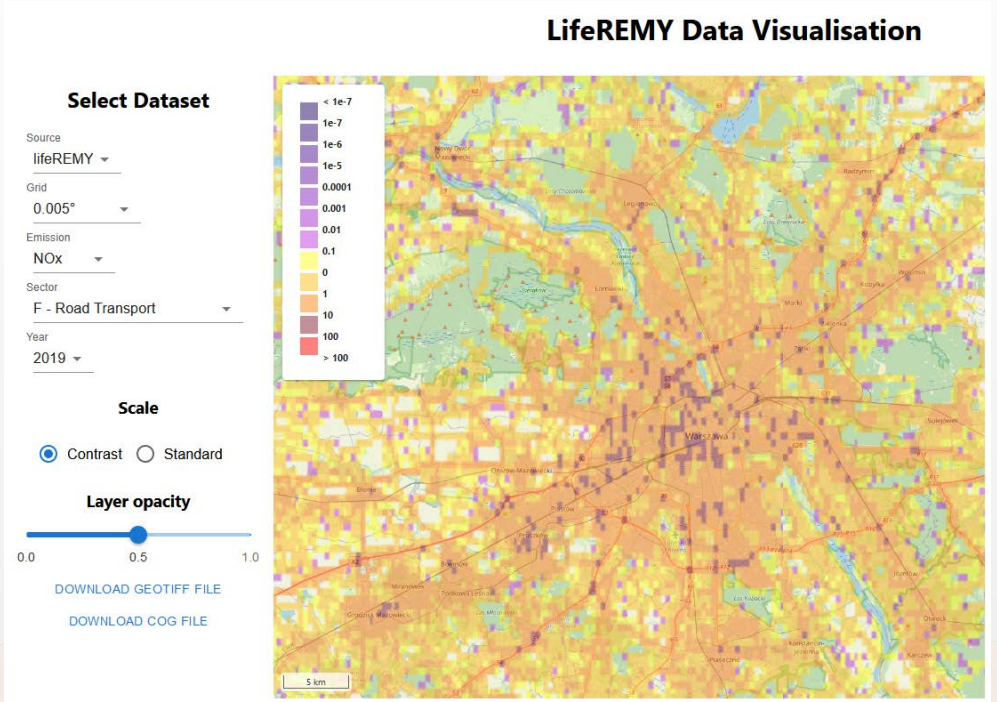
Emission uncertainty: which – Emission data tool (A2)

Relocation emission data tool on EU level at high resolution

- Relocation process is based on proxy data and EMEP inventory
- Total emission load per original low-resolution grid is conserved
- Output categories follows GNFR sectors

The tool could help

- countries with no local high resolute inventory
- benchmarking of local BU emission inventory



https://vis.liferemy.eu/

The 'real' emission value is unknown: **a indirect way to assess emission accuracy is to compare emission inventories**. It does not prove that one inventory is more correct than another but can reveal inconsistencies between inventories - Thunis et al. (GMD, 2022) (ppt M. Guevara and S. López-Aparicio)

LIFE REMY's emission tool: lesson learnt (A2)

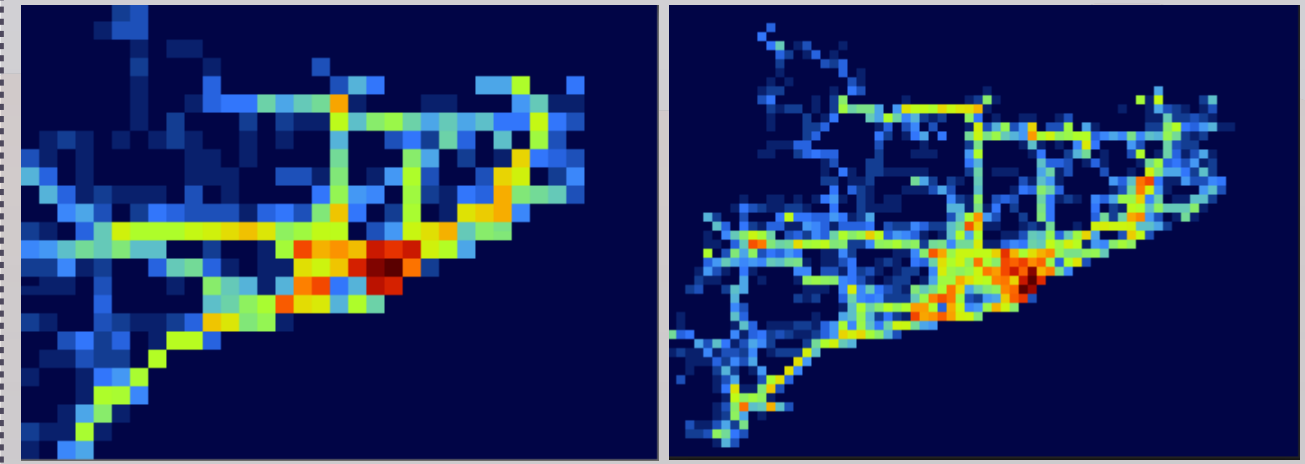
Main features of the tool:

- The tool will operate on data for the European region
- Following pollutants: BaP, PM10, PM2.5, NO_X, NVOC, SO_X, NH_3
- Three resolutions of relocated data are available: 0.025°x0.025°, 0.01°x0.01°, 0.005°x0.005°
- Data can be downloaded in standard geotiff and Cloud Optimized GeoTIFF format

REMY's lessons learnt:

- With TD inventories local hotspots cannot be properly reproduced (e.g. TD inventories spatial pattern of road network in the cities)
- Relocated top down inventories differs from bottom up inventories

EMEP relocation



Catalonia domain – Example of EMEP road transport emissions NO_2 201701115 h13

REMY's emission factors uncertainty (A1)

Resuspension emission from road traffic:

Road dust resuspension emissions are affected by a high uncertainty and typically it is usually not included in the emission inventories.

REMY's lessons learnt:

Resuspension should be counted in emission inventories: PM source apportionment studies demonstrates that **resuspension contributes significantly to PM levels** even excluding direct wear emissions.

A standardized method to calculate EF for resuspension does not exist. Four different methods available in literature at the same location were used to provide uncertainty of EF estimates and the comparison revealed that the EF uncertainty is 65%: EFs was found in Milan: 3-63 mg/VKT, in Barcelona: 3-10 mg/VKT due to impact of pavement and fleet characteristics.

REMY's emission factors & activity uncertainty (A2)

Open waste combustion

The quantification of the illegal burning of solid waste emissions (construction sites, vegetable garden and agricultural residue) is highly uncertain and in particular **activity indicators**. The total amount of PM10 emitted doesn't seem to be so relevant for a city like Milan. However, toxic or carcinogenic compounds could be emitted in considerable quantities that **could cause significant environmental impacts at local scale**.

Domestic heating

While for the conventional boilers (diesel and natural gas) the measured emission factors agree with the reference ones, for recent pellet boilers, the TSP (solid fraction) emissions seem to be lower in comparison to the EEA Emission Inventory Guidebook emission factor, especially if particulate abatement systems are installed. **Local emission factors better describe emission impact of the local sources.**

Wood oven "pizzerias"

Specific emission factors for non-industrial burning appliances different from heating systems (such as the wood burning ovens) are not known. The obtained results showed a **high variability among the collected data**, but it seems that the condensable fraction of the particulate emissions is not so relevant, contrary to other biomass appliances. **Local emission factors are sometimes needed.**

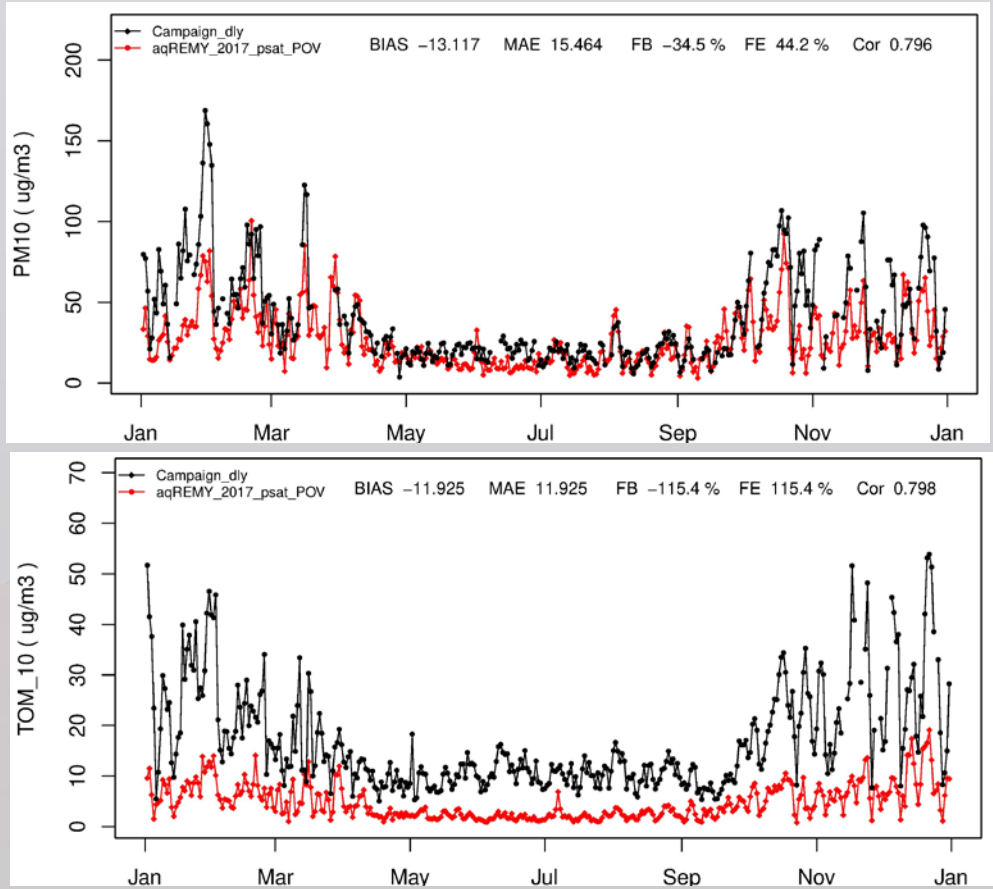
Uncertainty from Source Apportionment (A3/A4)

Receptor (PMF) and CTM (CAMx for Po Valley and Catalunya and GEM-AQ for Southern Poland) comparisons:

Model performance evaluation issues:

1. **Good agreement for PM10/PM2.5 does not indicate correct aerosol modelling** in terms of the origin and composition as the evaluation scores for organic matter are unsatisfactory
2. **SOA formation** should be further analysed in terms of Intermediate Volatile Organic Compounds (IVOC)
3. It is recommended to **use local aerosol chemical speciation profiles** rather that predefined ones if available

Underestimation of anthropogenic SOA



Po Valley domain – PM10 and Total Organic Matter concentration in Milano Pascal – BC2017

Uncertainty from Source Apportionment (A3/A4)

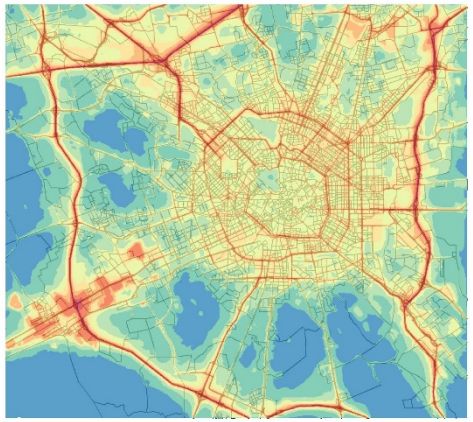
Lessons learnt from comparison of results PMF vs CTM:

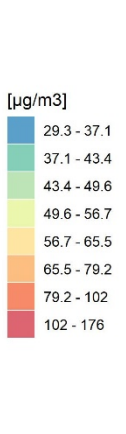
- Severe **underestimation of anthropogenic SOA** (mostly related to road traffic) at all sites (CAMx and GEM-AQ)
- **Road dust resuspension emissions should be included in emission inventories**.
- Improve **commercial heating/burning emission estimates**, including temporal profile (they cannot be the same as residential heating)
- **Residential heating emissions** need to be inventoried from a **bottom-up approach**, with a good time-profile (as in Poland, temperature based)
- **Industrial sectors seem to be very uncertain** in terms of emissions, mostly for the small-medium enterprises. In addition PMF not always separates single industrial processes

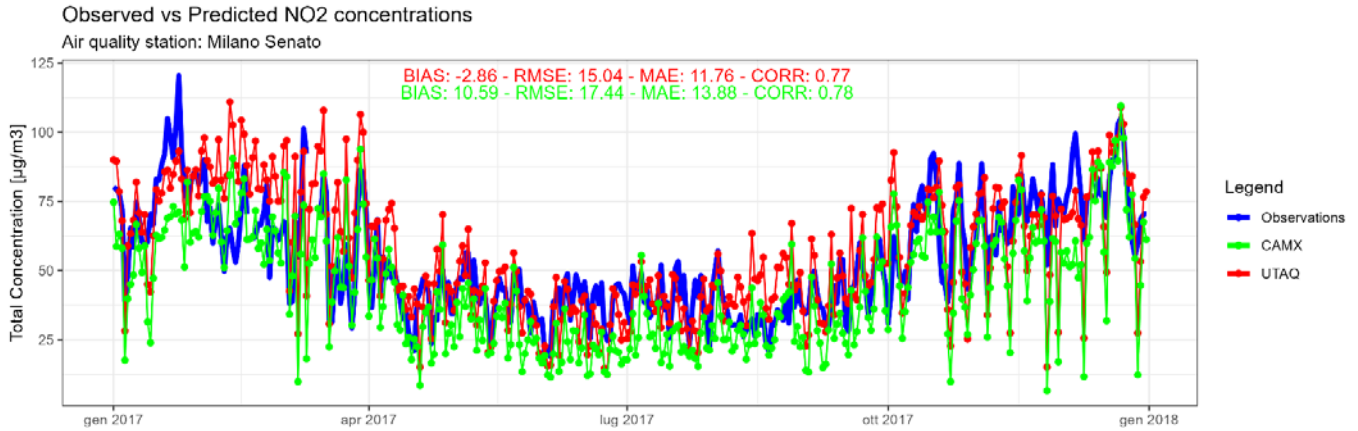
Urban vs regional concentrations (A4/A5)

Comparison between urban concentrations (obtained with UTAQ - Urban Tool for Air Quality, www.utaq.eu) and regional ones (estimated by CAMx) on Milan – Basecase scenario 2017

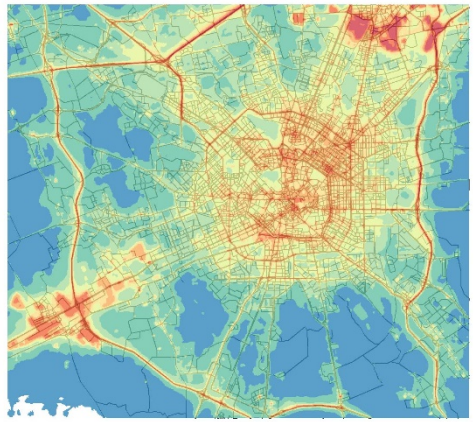
NO_2 total concentrations

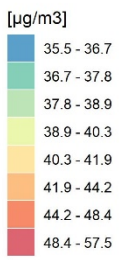


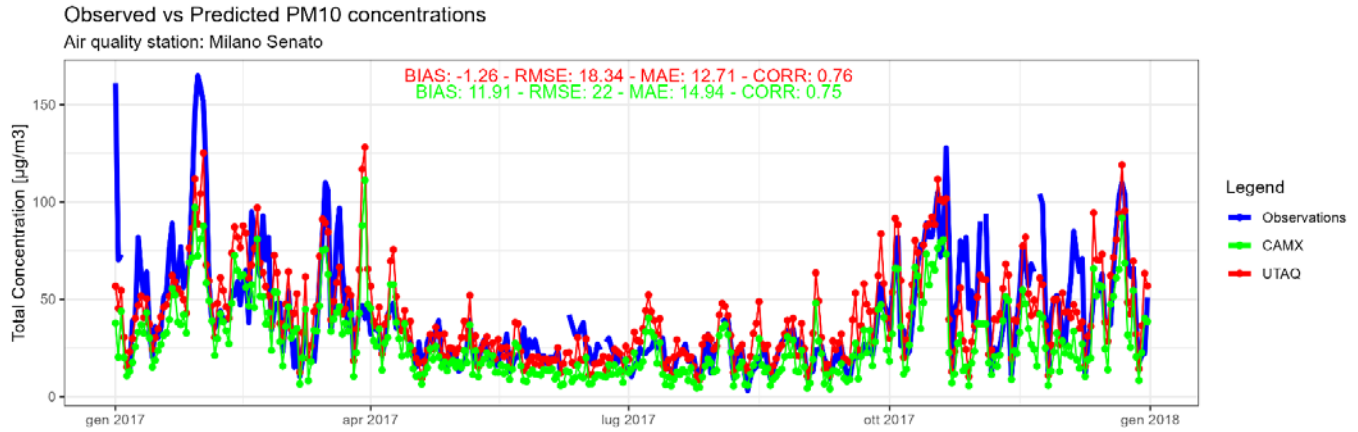




PM10 total concentrations







Reducing uncertainty: sensitivity scenarios

Sensitivity scenario	Description
Residential heating - **Wood oven pizzerias on Po Valley**	Study on the effects of local wood oven pizzerias EFs and the adoption of a new specific hourly modulation profile for this source
Domestic heating systems - natural gas fuel	Updating of NO_X and POA EFs and NO_2/NO_X emissions ratio of natural gas plants on the base of local EFs
Particle resuspension evaluation	Introduction of resuspension emissions, not considered in the base case. These emissions will be estimated from the EFs estimated in Action A1 and carried out on a detailed scale
SOA's new chemical scheme in CAMx	Evaluation of the introduction of the new SOA scheme in CAMx (in Lombardy and Catalonia's domains)
EMEP relocation	Relocation of EMEP emissions using REMY's tool (Action A2)
Temporal modulation of emissions (optional)	Temporal modulation in particular of residential heating and agriculture emissions
NOX and NH3 traffic emissions (optional)	Updating of emission factors of NO_X and NH_3 for traffic emissions from local EFs
Combination of previous scenarios – BAU	Combination of the previous scenarios in the baseline simulation
Combination of previous scenarios - COVID19	Combination of the previous scenarios in the COVID19 simulation

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THANK YOU!

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