APPLICATION OF AIR QUALITY MODELS IN THE PO VALLEY. RESULTS FROM THE PREPAIR PROJECT

LIFE 15 IPE IT 013

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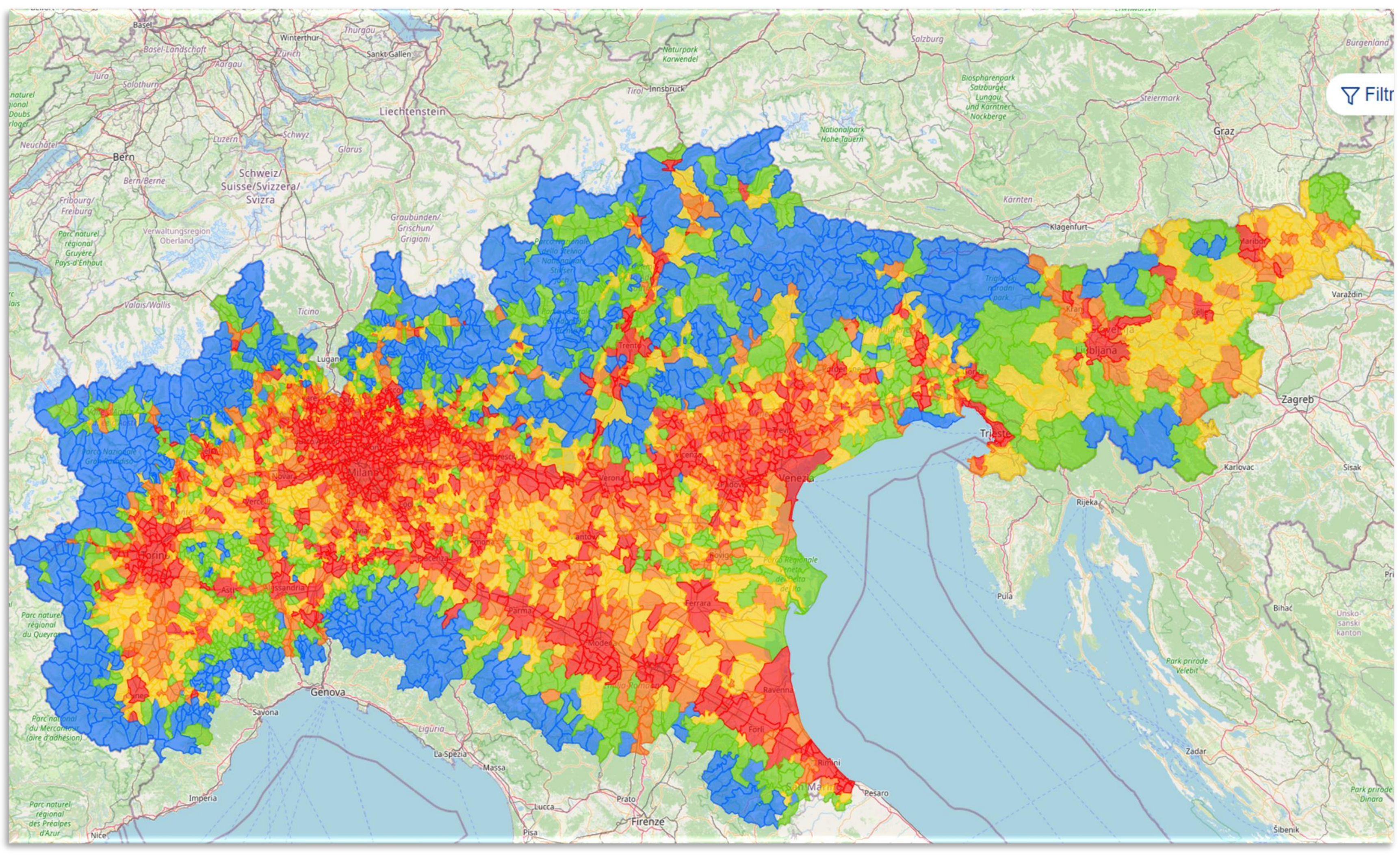
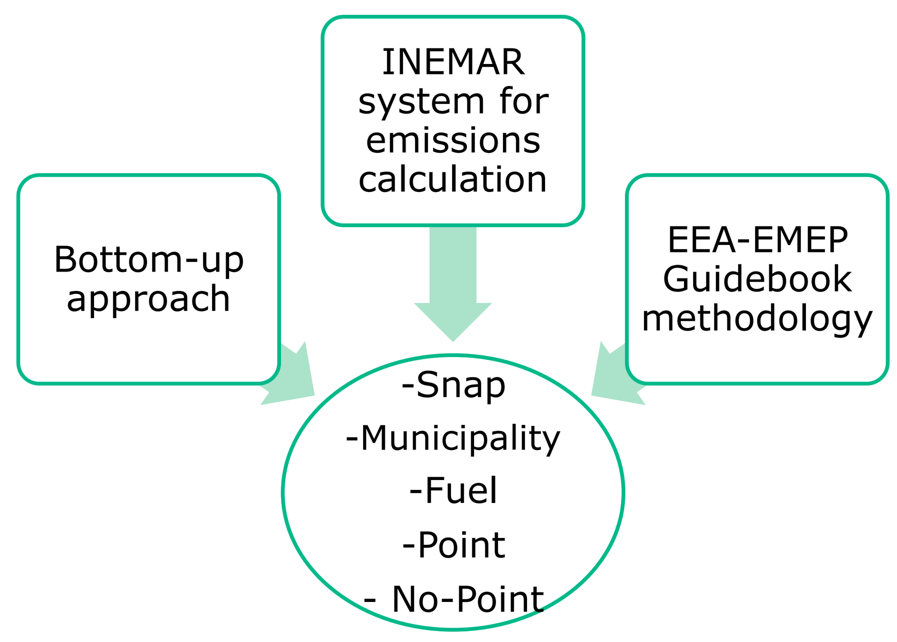
Emissions and domain



Emission share for Po-basin	2019						
	PM_{10}	$PM_{2.5}$	NH3	NOx	COV	CO	SO_2
1 - Combustion in energy and trasformation industries	0.7%	0.7%	0.0%	7.1%	1%	2%	17%
2 - Non-industrial combustion plants	58%	68%	2.2%	9.6%	3%	53%	8%
3 - Combustion in manufacturing industry	3.2%	3.2%	0.3%	14%	0%	4%	41%
4 - Production processes	2.5%	1.9%	0.1%	2.2%	0%	7%	21%
5 - Extraction and distribution of fossil fuels and geothermal energy	0.2%	0.0%	0.0%	0.0%	13%	0%	0%
6 - Solvent and other product use	2.3%	2.4%	0.0%	0.1%	4%	0%	0%
7 - Road transport	21%	13%	1.0%	49%	0%	25%	1%
8 - Other mobile sources and machinery	3.4%	4.0%	0.0%	13%	0%	3%	2%
9 - Waste treatment and disposal	0.8%	0.9%	0.4%	1.4%	20%	1%	3%
10 - Agriculture	4.7%	3.0%	96%	2.2%	57%	1%	0%
11 - Other sources and sinks	3.3%	3.1%	0.1%	0.3%	1%	4%	1%
Total emission	100%	100%	100%	100%	100%	100%	100%

LIFE PREPAIR INVENTORIES



The emissions from natural (biogenic) sources and fires were included in the PREPAIR database but not in this study. The emissions of biogenic VOCs were estimated with the MEGAN model in all systems, while fires were excluded.

The LIFE PREPAIR project enabled the creation of a unified database of air pollutant emissions in the Po basin and Slovenia. The emissions were calculated following the EEA-EMEP Guidebook methodology mainly with the INEMAR system and were compared among the various regions and autonomous provinces. Considering the reference year 2017, the analysis of the database showed that the main sources of primary emissions of PM10, CO and NOx are non-industrial plants (e.g. heating) and road traffic, while the agricultural sector (especially livestock and mineral fertilizers) is the major source of NH3. The emissions of SO2 are due to the sulfur content in the fuels used in the industries.

The emissions were divided into point and diffuse sources. For diffuse sources, the vertical allocation was different depending on the system used: SPIAR assigned the emissions to the first layer of the model (between the ground and 20 m), while NINFA-ER, SMAL-LO and PieAMS used specific vertical profiles for the SNAP emission sectors or activities. Also, the temporal and spatial models for distributing the annual emissions in hours were different for each AQ modelling system.

Modelling systems

In this research, an evaluation of the annual air quality for the years 2020, 2021, and 2022 was conducted using five distinct air quality (AQ) modelling systems. These systems, namely **NINFA-ER**, **PieAMS**, **SMAL-LO**, **CAMx-SLO** and **SPIAIR**, are employed by regional agencies involved in the PREPAIR project. They utilize three unique chemical transport models (CTMs)—CHIMERE, FARM, and CAMx—to analyse the dynamics of gases and particulates in the atmosphere. Despite sharing the same Prepair emissions inventory, these AQ modelling systems exhibit differences in gas-phase and aerosol chemical mechanisms, domain size and location, meteorological input, parameterization, as well as spatialization and emission speciation/disaggregation.

The specific differences for each CTM are detailed in table 1. The chemical transport models employ different gas-phase chemical mechanisms:

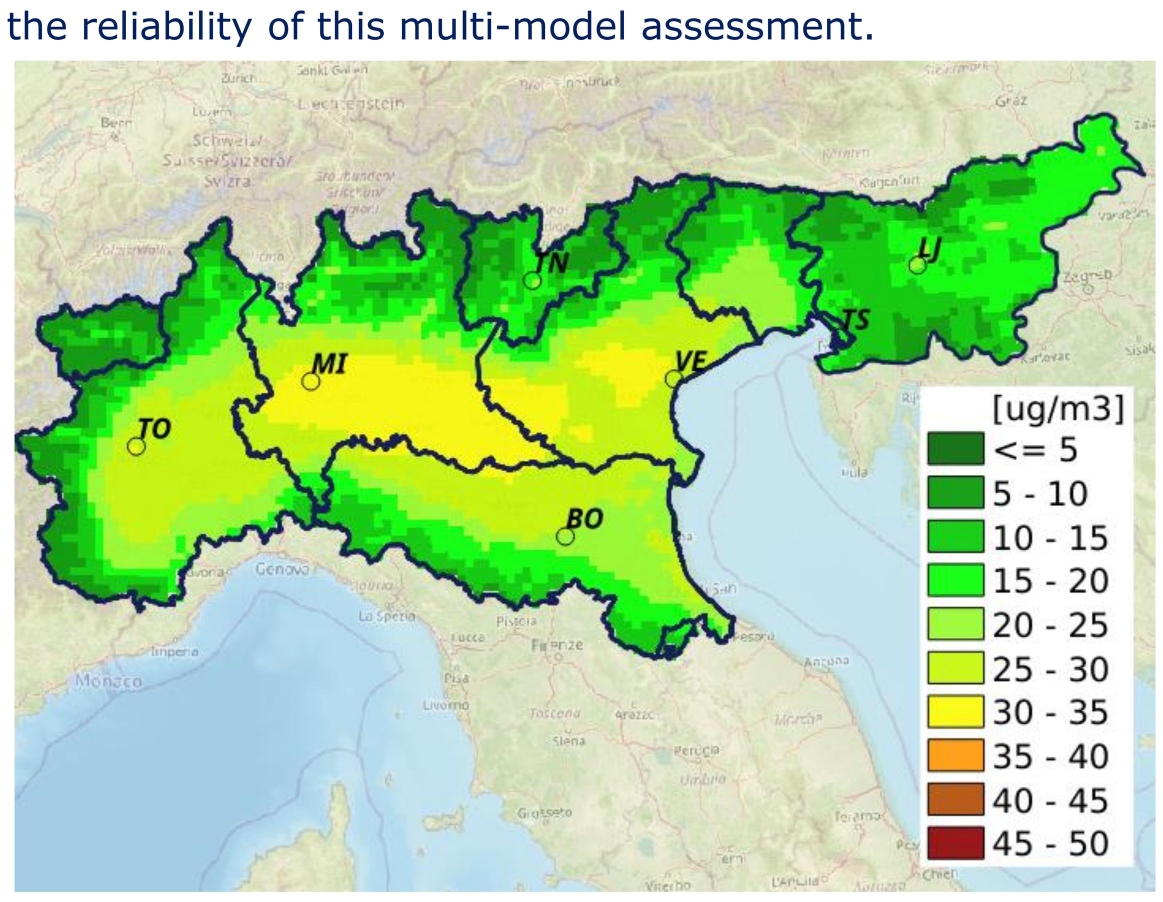
- MELCHIOR2 (CHIMERE): used for regional tropospheric chemistry modeling. It accurately simulates concentrations of ozone, carbon monoxide, nitrogen oxides, and other organic and inorganic compounds under various atmospheric conditions. It encompasses 120 chemical reactions involving over 40 gaseous species.
- SAPRC-99 (FARM): used for reactions of volatile organic compounds (VOCs) and nitrogen oxides (NOx). These reactions result in the formation of ozone and secondary organic aerosols in the lower troposphere. It includes 215 chemical reactions involving more than 140 species.
- CB05 Mechanism (CAMx): used for atmospheric chemistry modeling and pollutant formation. It describes 156 chemical reactions involving 51 species and explicitly incorporates the treatment of methyl peroxy radicals for simulating hydrogen peroxide under low NOx conditions.

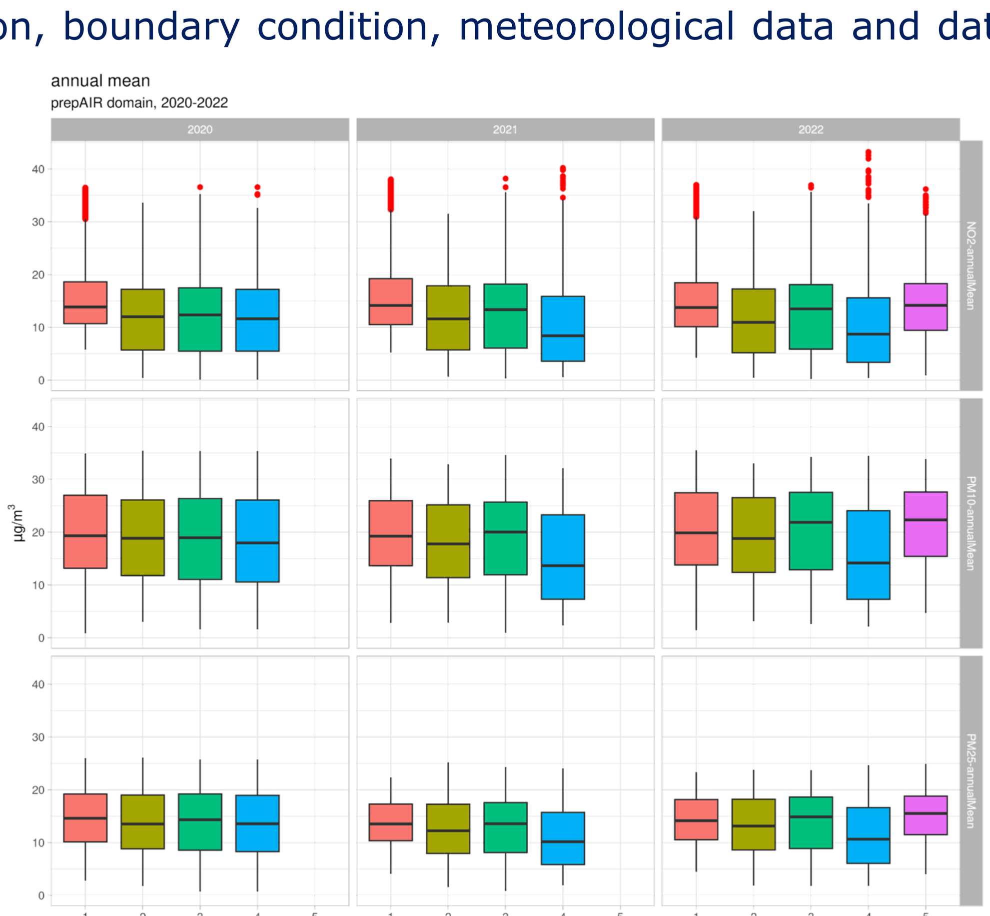
Name	CTM	meteorological driver	chemical boundary conditions	data fusion method	domain	available period
NINFA-ER (Arpa Emilia Romagna)	Chimere 2017 r4v1	COSMO-5M	kAIROS	kriging with external drift	Po Valley and Slovenia	2020-2023
SPIAIR (Arpa Veneto)	CAMx v6.5	COSMO-5M	kAIROS	multiple linear regression & interpolation of residuals	Po Valley	2022-2023
PieAMS (Arpa Piemonte)	FARM v4.13	COSMO-5M	Prev'Air / FORAIR	kriging with external drift	Po Valley	2020-2023
SMAL-LO (Arpa Lombardia)	FARM v4.13	WRF-ARW	QualeAria	SCM/optimal interpolation	Po Valley and Slovenia	2020-2023
CAMx-SLO (ARSO Slovenia)	CAMx v6.2	Aladin	MACC renalysis	kriging with external drift	Po Valley and Slovenia	2021-2023

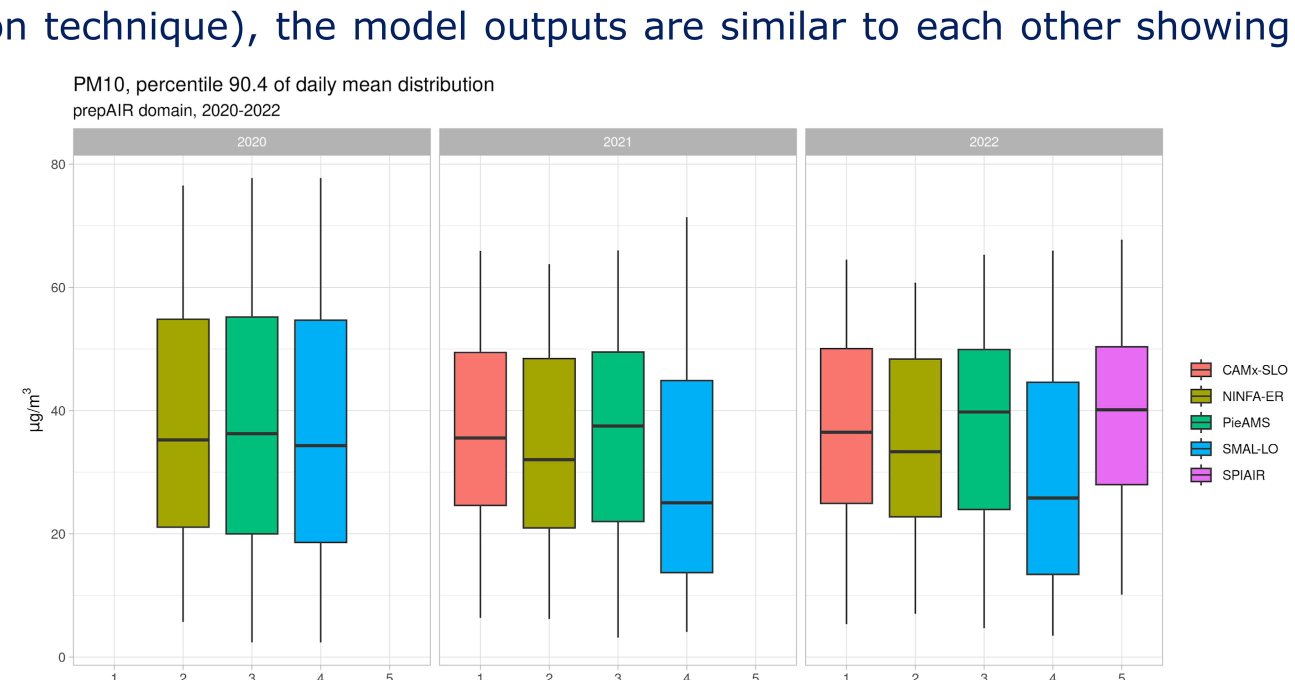
Data fusion is considered one of the techniques of data assimilation where we combine the results of numerical models and the point measurements. NINFA-ER, PieAMS and CAMx-SLO use Kriging with External Drift, with slight differences in the algorithm implementation. All three systems use CTM concentration fields and terrain height as external drift. SMAL-LO adopted the Optimal Interpolation approach for the data fusion process in the 2022 assessment and the Successive Correction Method in 2020 and 2021. Finally, SPIAIR uses a two-step procedure involving first a linear regression with observations as dependent variable and CTM output and terrain elevation as independent variables and then an IDW (inverse distance weight) algorithm interpolation of the regression residuals.

Results

The Air Quality Assessment reports offer a comprehensive overview of air quality conditions in the Po Valley and Slovenia. These reports focus on PM10, PM2.5, nitrogen dioxide and ozone, pollutants that in some cases exceed legal thresholds. The assessments have been carried out with a state-of-art approach that uses data fusion techniques to integrate information coming from air quality monitoring networks and CTM modelling systems. The results show that the most critical indicators are the 93.1 percentile of ozone and the 90.4 percentile of PM10. For the former there are not substantial differences over the three examined years and the exceedances are widespread the entire study area; for the latter higher levels are observed during 2022 and 2020, with the most critical areas concentrated in the main urban centers and in the plain central areas of the Po valley, between Piedmont, Lombardy, Veneto and Emilia. Annual average concentrations are everywhere below the legal limits for PM10 and NO2, and around this value or slightly below for PM2.5 in many areas). Finally, it must be underlined that although the five CTM systems have different setup (resolution, boundary condition, meteorological data and data fusion technique), the model outputs are similar to each other showing the reliability of this multi-model assessment.







ACKNWOLEDGMENTS
This research was funded by LIFE-IP PREPAIR (LIFE15 IPE/IT/000013)