Italian National Agency for New Technologies, Energy and Sustainable Economic Development

Modelling and measurements efforts to improve assessment of biogenic and biomass burning emissions on urban air quality

Mihaela Mircea

- Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)
- Department for Sustainability (SSPT)
- Division Models, Observations and Scenarios for Climate Change and Air Quality (CLIMAR)
- Models and Measures for Air Quality and Climate Observation Laboratory (AOC)

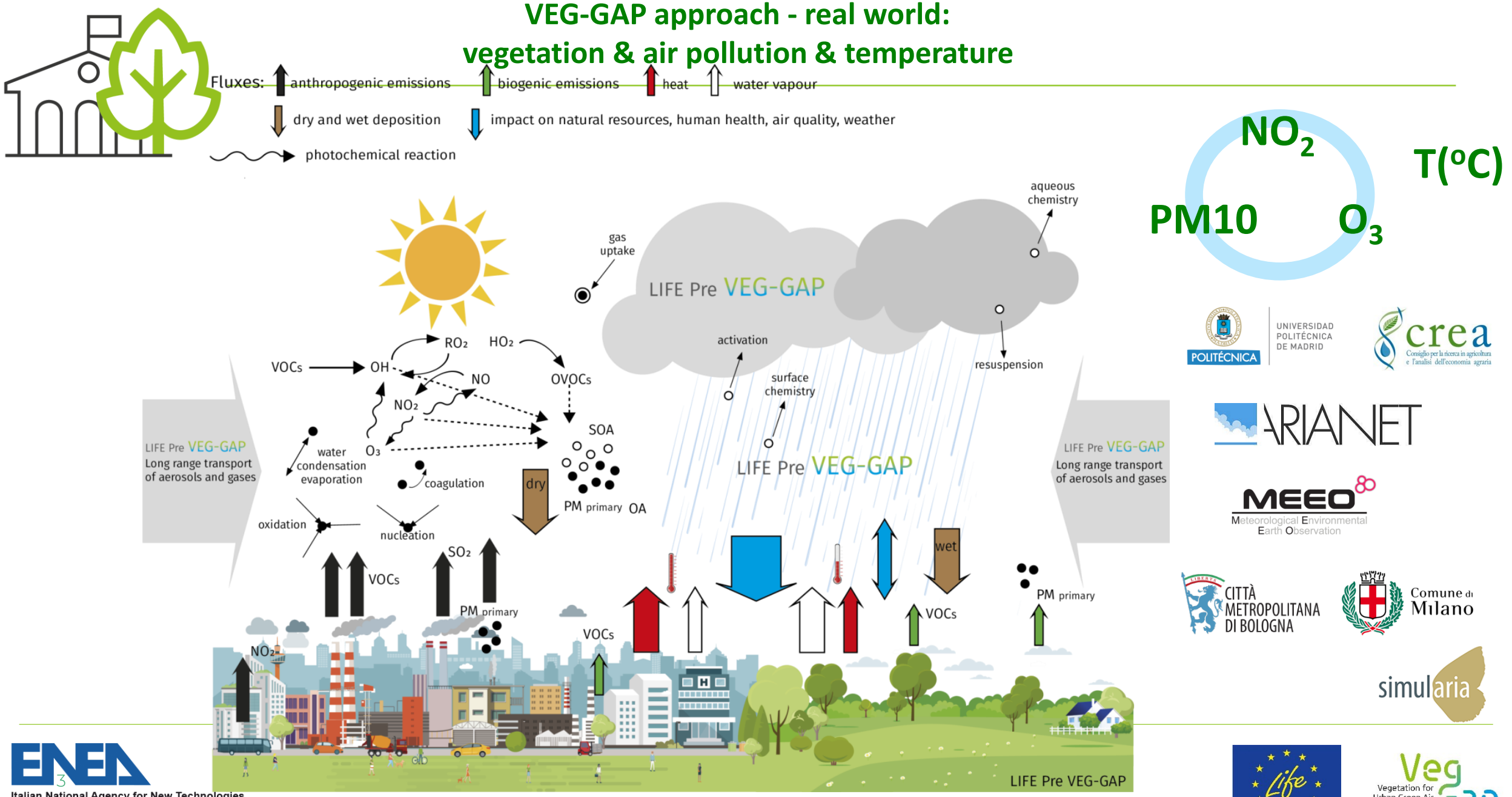
26th TFMM Meeting, 5-7 May 2025, Potsdam, Germany

Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

Presentation synopsis

- ❑ vegetation effects on urban air quality
- ❑ aging of biomass burning aerosol in day and night conditions
- ❑ emission factors for wood-fired pizza ovens

VEG-GAP approach - real world: vegetation & air pollution & temperature



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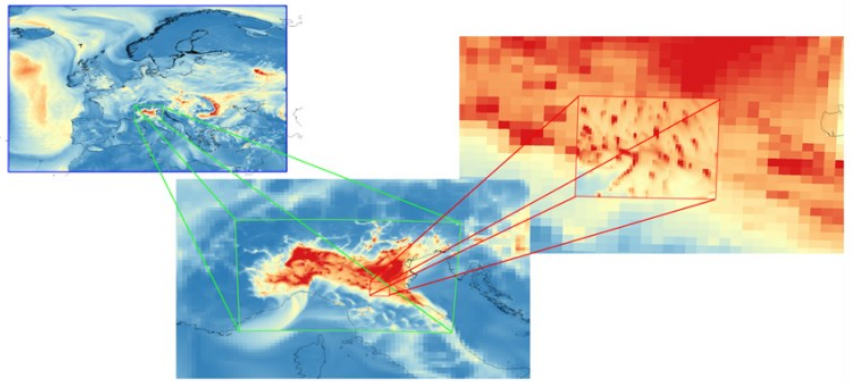
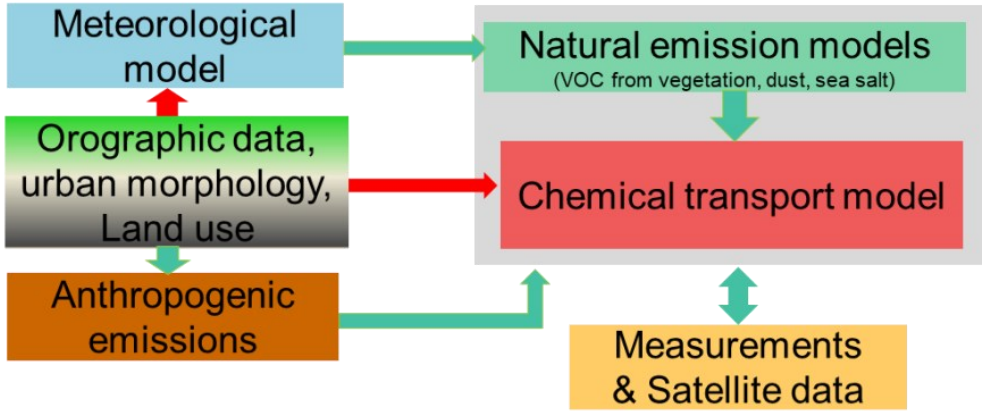
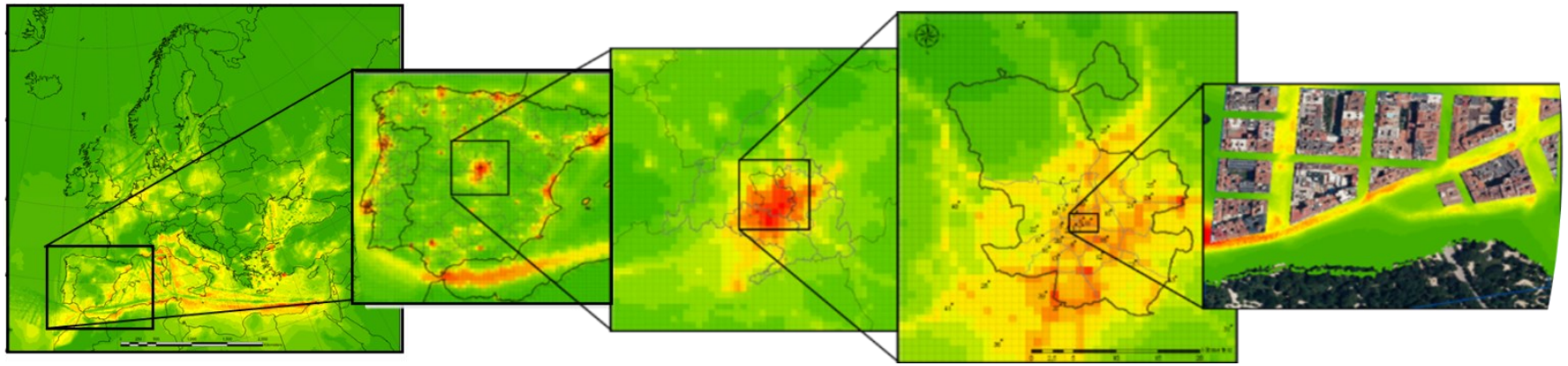
VEG-GAP modelling systems

ITALY: AMS-MINNI (ENEA)





SPAIN: WRF-CMAQ (UPM)



VEG-GAP modelling systems and simulations' setup

Simulation for the year 2015

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AMS	meteo	air quality	anthropogenic emissions	BVOC emissions
AMS-MINNI(ENEA)	WRFv3.9.1.1	FARMv4.14	EMMA	PSEM
WRF-CMAQ(UPM)	WRFv4.1.2	CMAQ v5.3.2	SMOKE v3.6.5	PSEM

Geographic area	Horizontal resolution	Model	Anthropogenic emissions
Europa	0.1° x 0.1°	IFS, AMS-MINNI	CAMS-REGAP_v2.2.1 (TNO)
North of Italy	4km x 4 km	AMS-MINNI	National Inventory (ISPRA)
Bologna Municipality	1 km x 1 km	AMS-MINNI	Regional Inventory ARPAE
Milan Municipality	1 km x 1 km	AMS-MINNI	Regional Inventory Lombardy
Europe	27 km x 27 km	WRF-CMAQ	CAMS-REGAP_v2.2.1
Iberian Peninsula	9 km x 9 km	WRF-CMAQ	National Inventories of Spain&Portugal andCAMS
Spain central area	3 km x 3 km	WRF-CMAQ	National Inventory

WRF with the Building Effect Parameterization (BEP) over the cities and Noah Land Surface

FARM	CMAQ
ISORROPIA	ISORROPIA
SORGAM	SOA
AERO3	AERO6
SAPRC99	CB6

Veg Gap Vegetation for Urban Green Air Quality Plans

VEG-GAP approach – same as for Air Quality Plans

VEG-GAP and Air Quality Plans

Air Quality Plans (AQPs) are instruments introduced by the Ambient Air Quality Directive 2008/50/EC (AQD50) in order to achieve EU standards.

AQPs is to set measures to reduce air pollution. The assessment of the effectiveness of possible measures in achieving compliance with AQD50 Limit or Target values is performed with AMS. The difference between an AMS simulation without measures and a simulation with measures shows the effectiveness of a measure.

VEG-GAP reveals the effectiveness of vegetation for air quality and temperature by showing the difference between an AMS simulation with actual vegetation and a simulation without vegetation. Thus, it is providing support to both City Air Quality and Climate Change Plans.

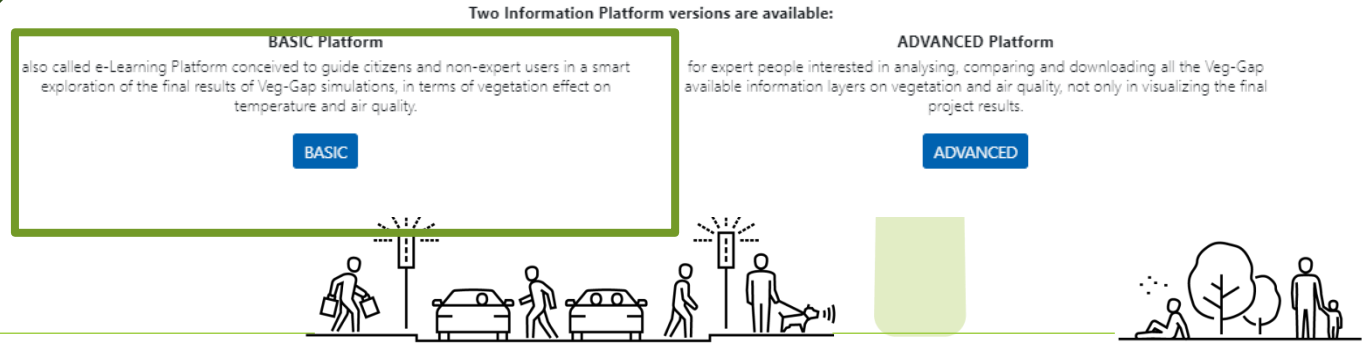
The effect of vegetation on air quality and temperature should be assessed by considering the multiple interactions between vegetation and atmosphere at city scale, for different years, in order to ensure a major positive effect of new interventions. https://veggaplatform.enea.it

AQPs approach in VEG-GAP

Simulation with vegetation: reconstruct the real atmosphere

Simulation without vegetation: hypothetical scenario

VEG-GAP results available through Information Platform



- **Present vegetation**
- **Future vegetation:** urban forests, green infrastructures, green roofs and walls, etc.

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Life

Veg Gap
Vegetation for Urban Green Air Quality Plans

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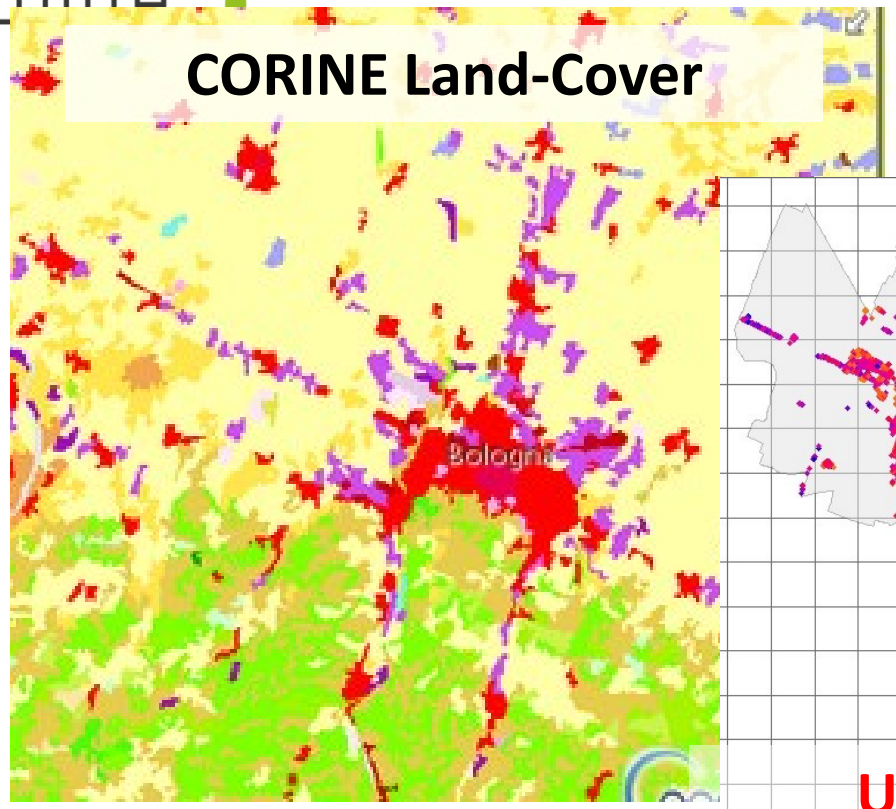
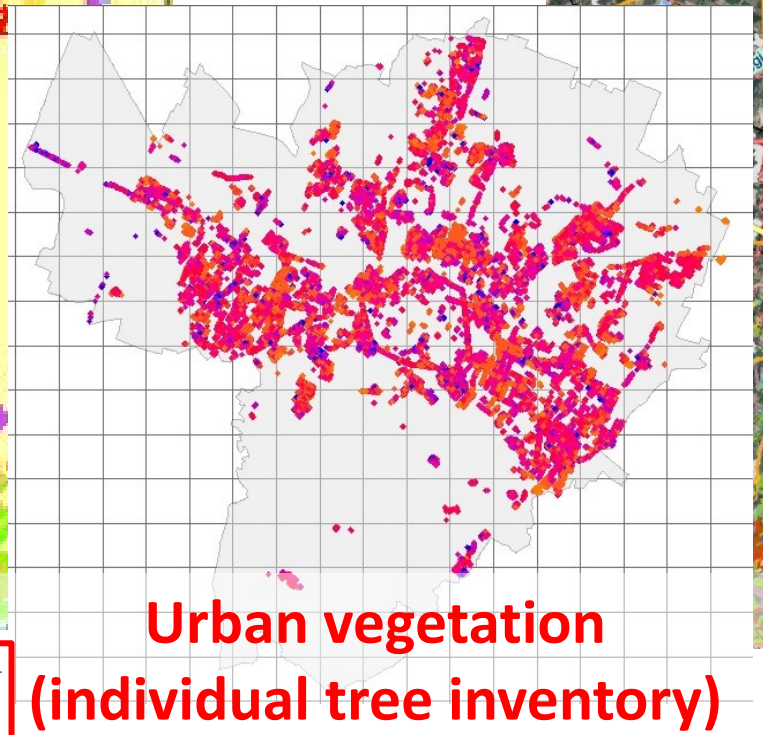
Integration of different data sources

Bologna example





Urban vegetation
(individual tree inventory)

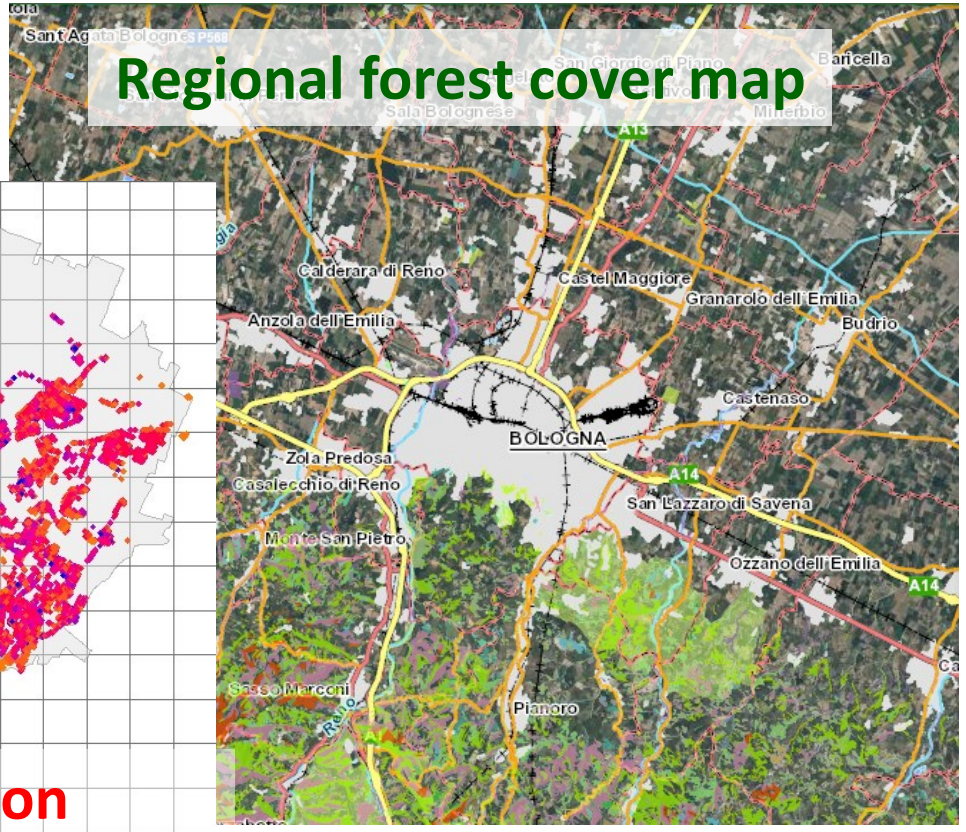


Table 1. Data available for each tree included in municipal urban vegetation inventories.

City	Geographic location	Species (genus, species, variety)	Height (m)	Trunk diameter (m)	Crown diameter (m)
Bologna	X	X	X	X	
Madrid	X	X	X	X	X
Milan	X	X	X	X	X

Courtesy of Sandro Finardi (ARIANET)

Life

Veg Gap
Vegetation for Urban Green Air Quality Plans

Effects of present vegetation on T, RH, WS and O_3, NO_2, PM10 concentrations -monthly average for July 2015-

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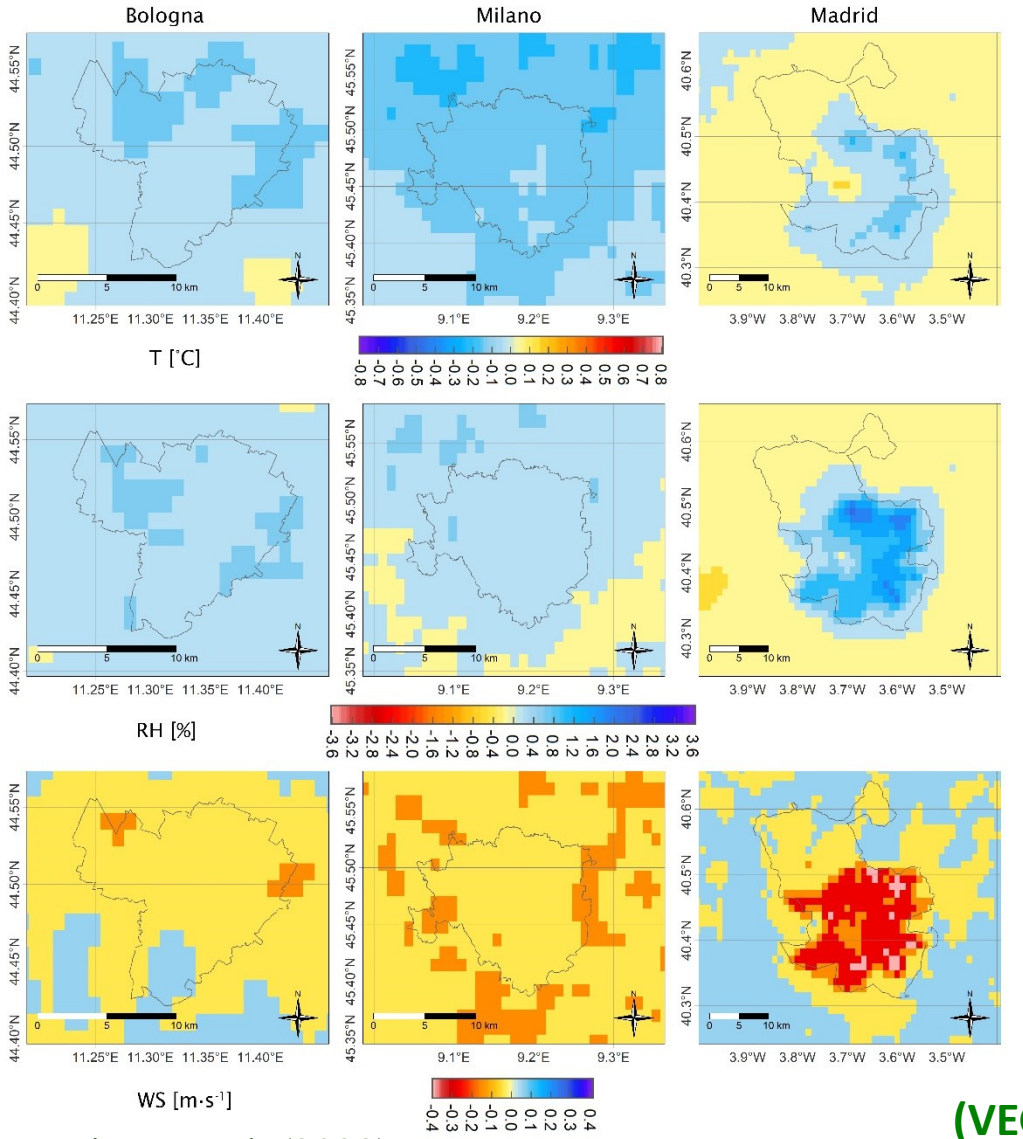

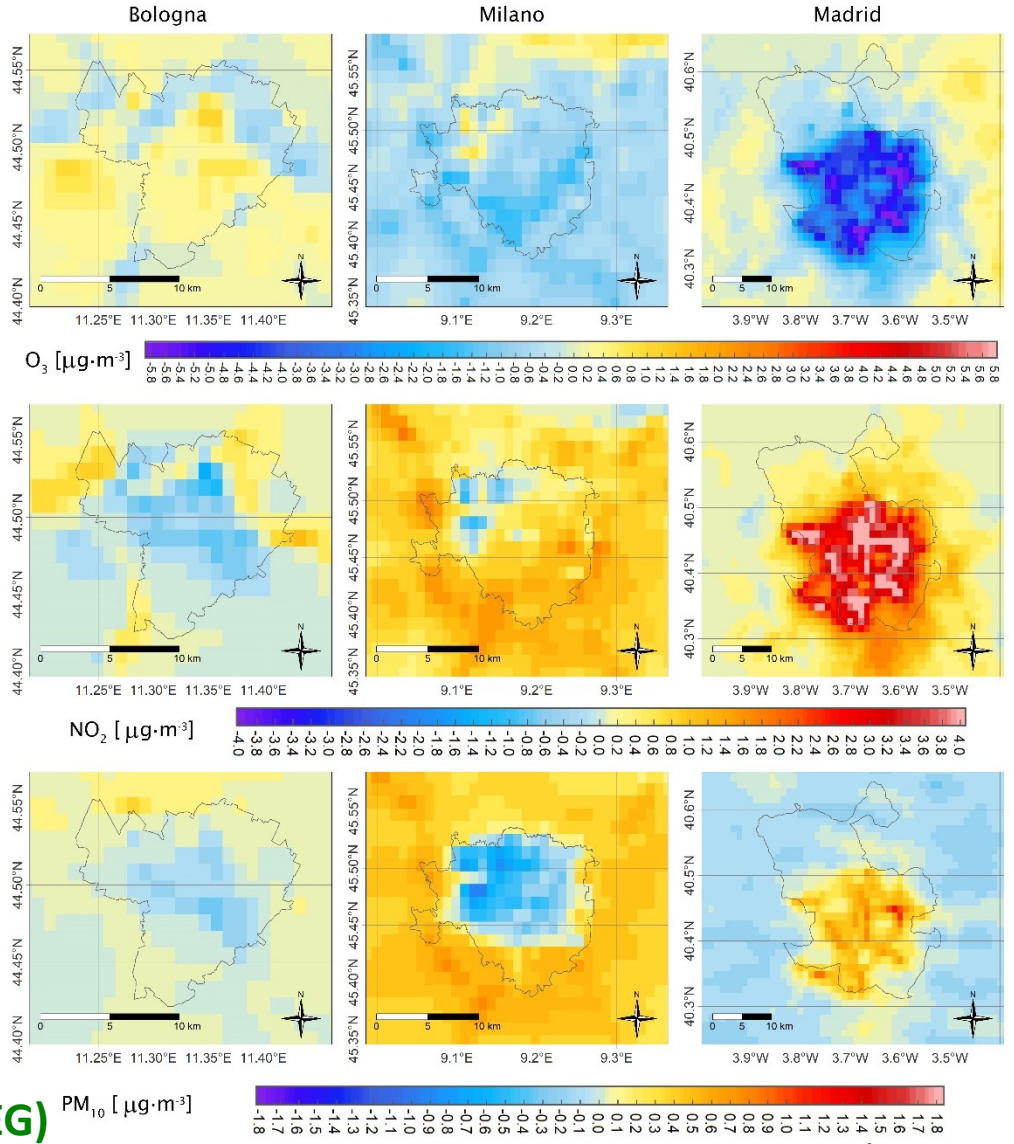

(VEG-NOVEG)

D'Isidoro&Mircea et al. (2023)

Mircea et al. (2023)

Effects of present vegetation on temperature

-variability of temperature differences (VEG-NOVEG) and of temperature (VEG) over the municipality area-

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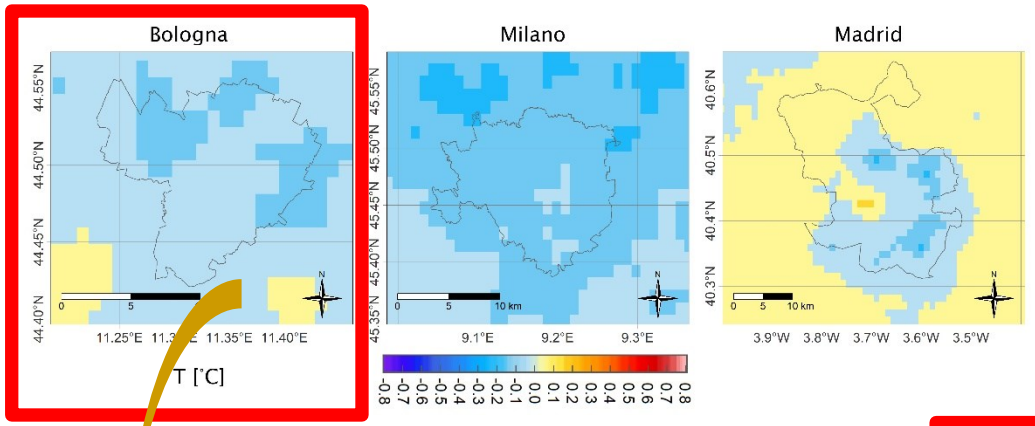
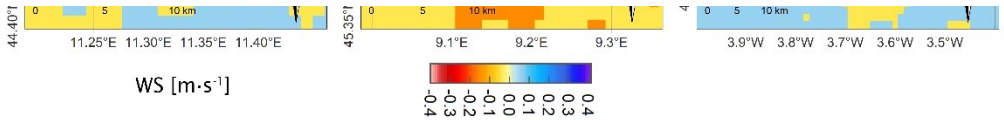
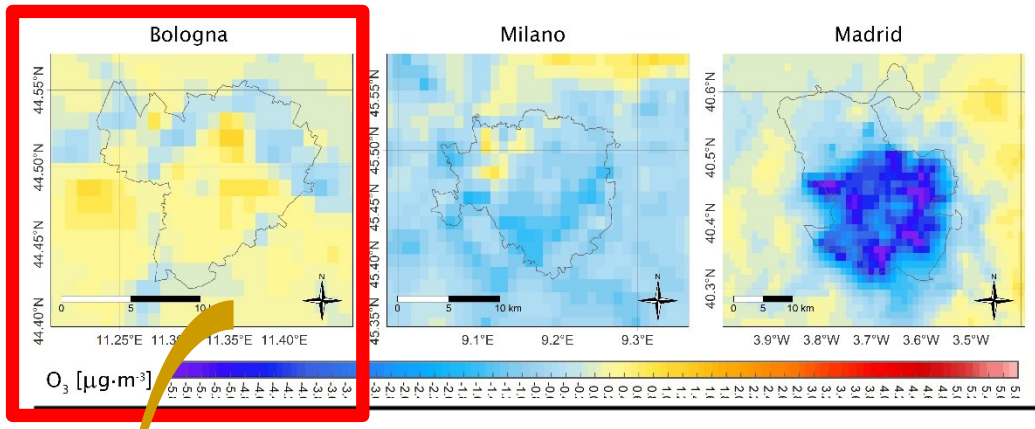


Temperature					VEG-NOVEG				VEG	
City	Average	Month	Minimum		Mean		Maximum		Mean	
			Min	Max	Min	Max	Min	Max	Min	Max
Bologna	hourly	January	−2.4	0.00	−0.46	0.40	−0.10	4.6	−3.2	14
		July	−5.6	0.00	−1.5	1.9	−0.13	4.5	18	33
	daily	January	−0.30	−0.10	−0.12	0.00	0.00	0.20	2.0	13
		July	−0.60	−0.20	−0.32	−0.10	0.00	0.28	23	32
	monthly	January	−0.15		−0.10		0.00		6.1	
		July	−0.35		−0.20		0.00		28	
	yearly		−0.25		−0.15		0.00		15.6	

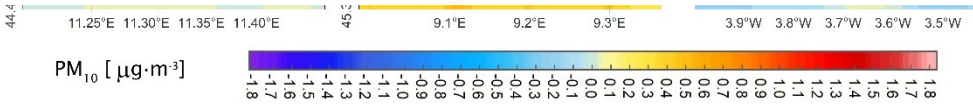


Effects of present vegetation on ozone (O_3)

-variability of O_3 concentrations differences (VEG-NOVEG) and of O_3 concentrations (VEG) over the municipality area-

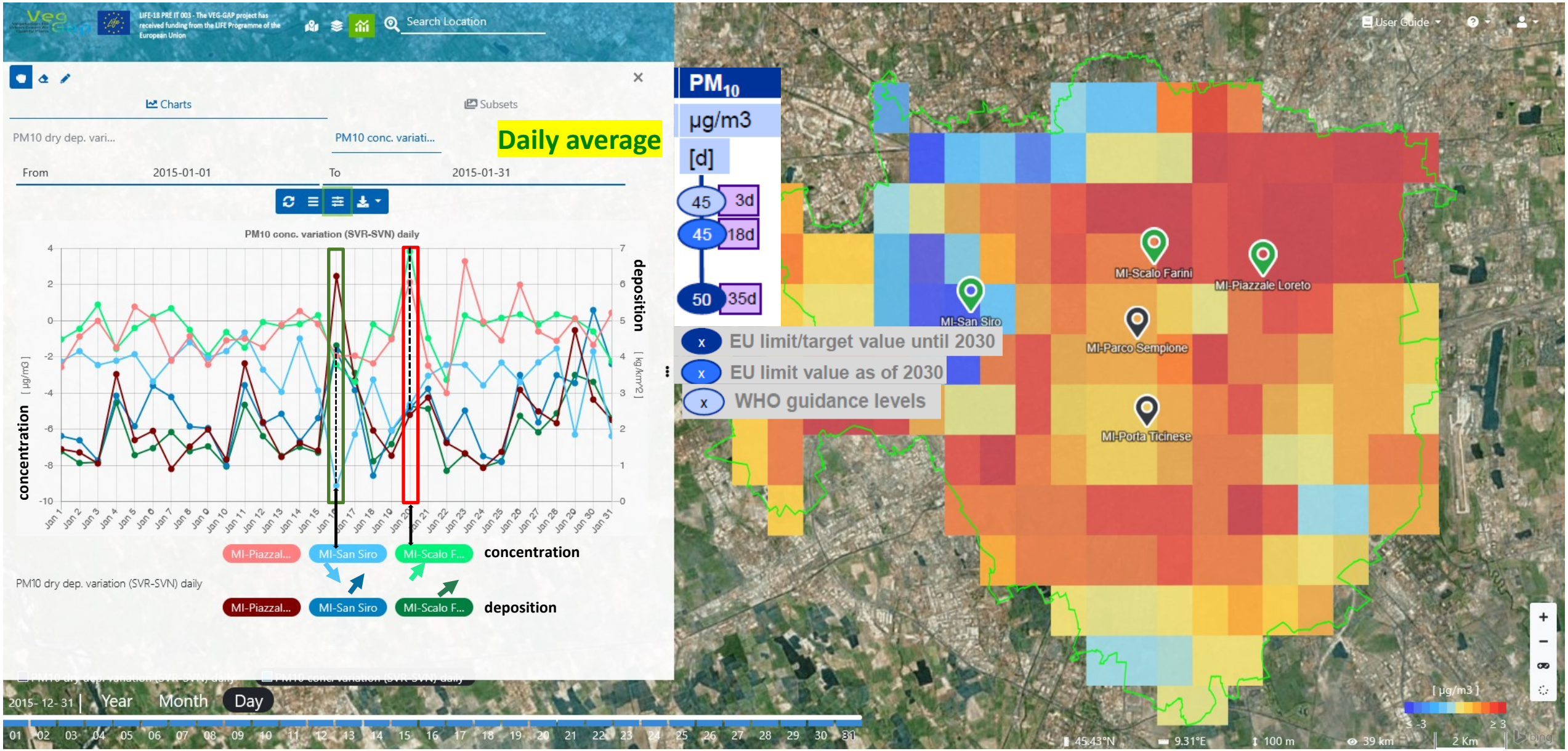


City	O_3 Average	Month	Minimum		VEG-NOVEG Mean		Maximum		VEG Mean	
			min	max	min	max	min	max	min	max
Bologna	hourly	Jan	−40.13	0.00	−2.94	6.78	0.00	45.27	0.00	58.62
		Jul	−55.81	−0.90	−9.35	8.39	0.31	84.25	12.80	143.02
	daily	Jan	−4.34	−0.07	−0.19	1.40	0.35	6.45	3.79	37.34
		Jul	−7.03	−1.19	−0.93	0.68	1.13	6.39	45.56	84.60
	monthly	Jan	−0.23		0.20		0.63		13.45	
		Jul	−1.36		0.00		1.45		73.88	
	yearly		−0.63		0.09		1.20		44.13	



Effect of present vegetation on PM10 concentration and deposition -Milan-

Italian National Agency for New Technologies, Energy and Sustainable Economic Development



ADVANCED: https://veggaplatform.enea.it/

Effects of future vegetation on T, RH, WS and O_3, NO_2, PM10 concentrations -monthly average for July 2015-

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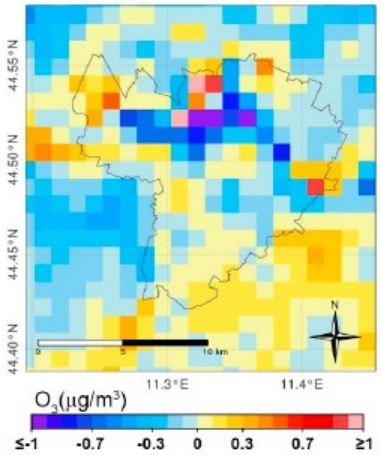
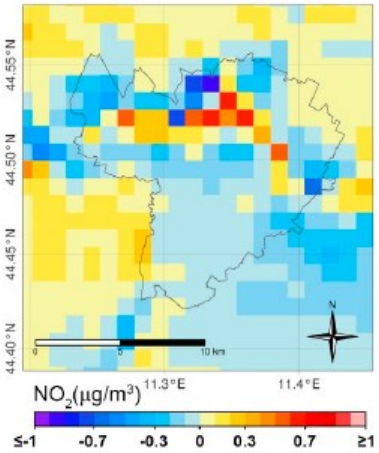
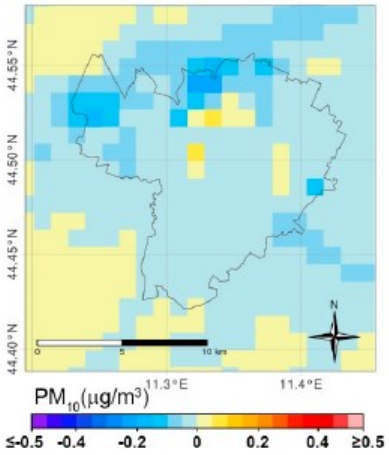
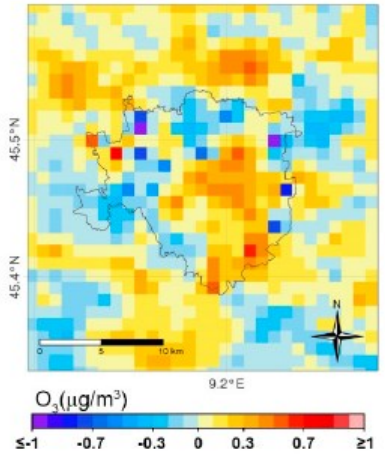
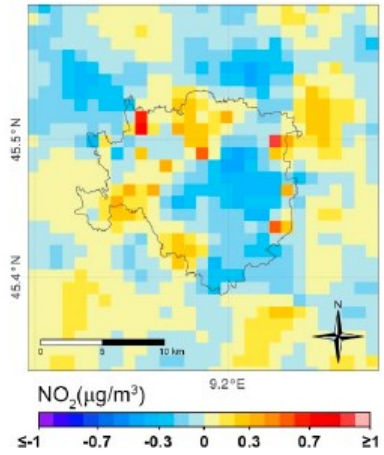
Bologna **Milan**

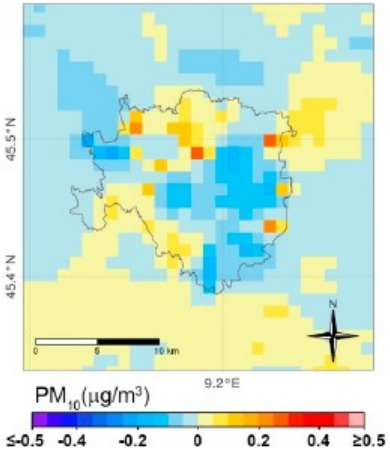


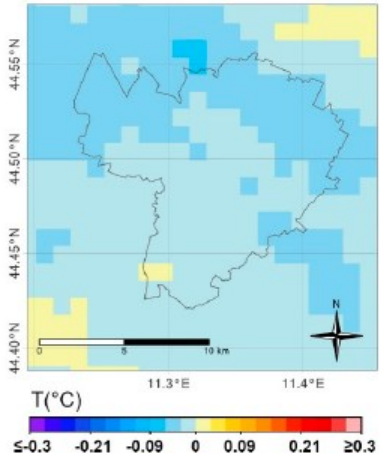


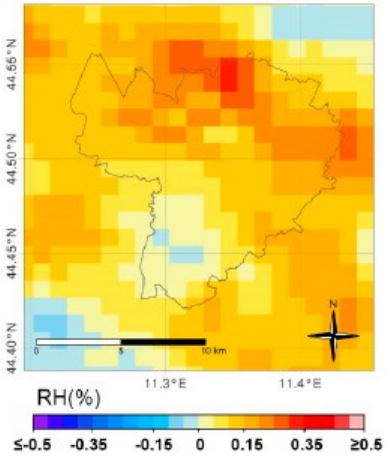


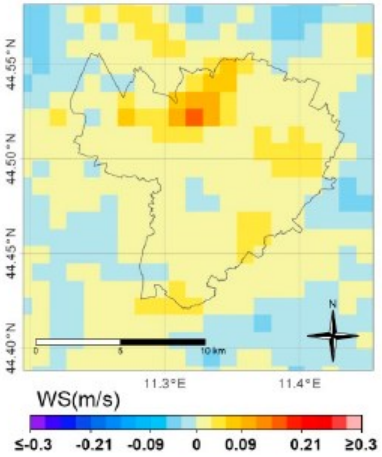


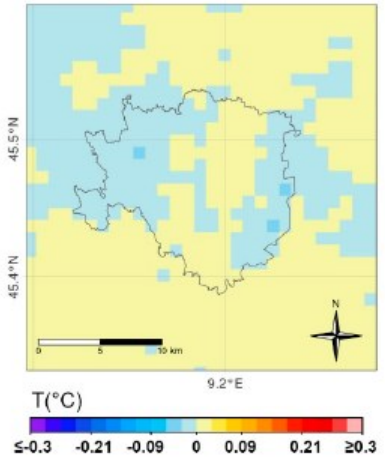


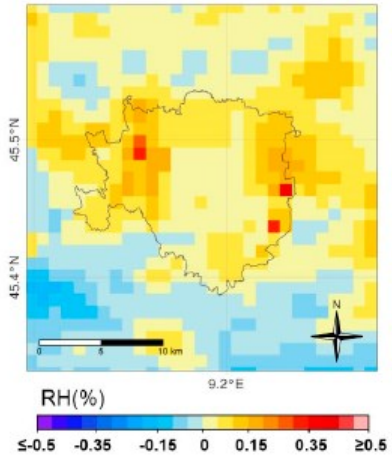


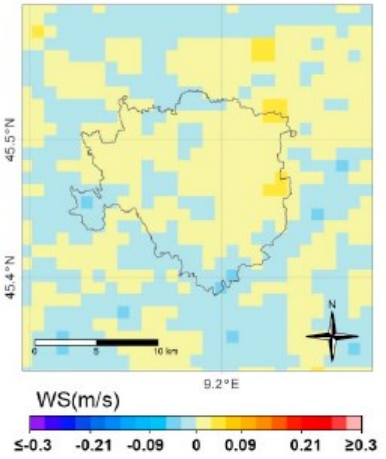




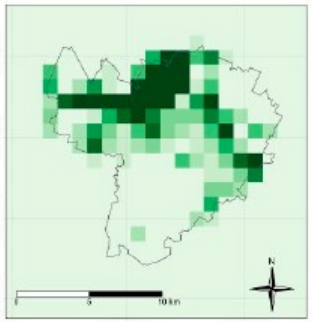


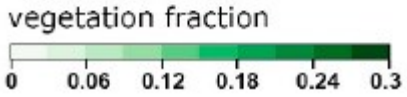


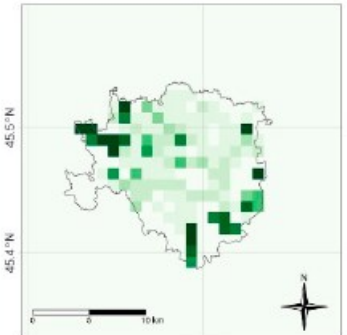




FUT (REF+NEW VEG)







[Mircea&Briganti et al. (2024)]

Vegetation effects on urban air quality - summary

Italian National Agency for New Technologies, Energy and Sustainable Economic Development

- vegetation effects are not homogeneously distributed in the city area and vary with city characteristics
- vegetation decreases temperature, increases relative humidity and most of the time decreases wind velocity
- vegetation removes pollutants, but the concentrations of O_3, NO_2, PM10 may increase or decrease, and this behaviour cannot be reproduced by simple static approaches. These approaches may give some answers for pollutants removal but not for air temperature and air pollutants concentrations
- assessment of vegetation effects should be done at city level, not for single intervention, to consider its effect on air properties in appropriate way
- -assessment of vegetation effects depend on city morphology, therefore, it should be done whenever it changes or at least every 5 years as it is now requested by AQD 50/2008/EC

Only "dynamical" assessment that considers the vegetation effects on meteorology and air quality on urban atmosphere may provide reliable science-based evidences for no-regret strategies in building equitable and sustainable urban development.

Life

Veg Gap
Vegetation for Urban Green Air Quality Plans

forests

MDPI

Article

Assessment of Air Quality and Meteorological Changes Induced by Future Vegetation in Madrid

David de la Paz [1], Juan Manuel de Andrés [1], Adolfo Narros [1], Camillo Silibello [2], Sandro Finardi [2], Silvano Fares [3,4], Luis Tejero [5], Rafael Borge [1,*] and Mihaela Mircea [6]

forests

MDPI

Article

The Role of Vegetation on Urban Atmosphere of Three European Cities—Part 1: Evaluation of Vegetation Impact on Meteorological Conditions

Massimo D'Isidoro [1,†], Mihaela Mircea [1,*,†], Rafael Borge [2], Sandro Finardi [3], David de la Paz [2], Gino Briganti [1], Felicita Russo [1], Giuseppe Cremona [1], Maria Gabriella Villani [1], Mario Adani [1], Gaia Righini [1], Lina Vitali [1], Milena Stracquadanio [1], Rossella Prandi [4] and Giuseppe Carlino [4]

atmosphere

MDPI

Article

Vegetation Effects on Air Pollution: A Comprehensive Assessment for Two Italian Cities

Mihaela Mircea [1,*,†], Gino Briganti [1,*,†], Felicita Russo [1,†], Sandro Finardi [2], Camillo Silibello [2], Rossella Prandi [3], Giuseppe Carlino [3], Massimo D'Isidoro [1], Andrea Cappelletti [1] and Giuseppe Cremona [1]

forests

MDPI

Article

The Role of Vegetation on Urban Atmosphere of Three European Cities. Part 2: Evaluation of Vegetation Impact on Air Pollutant Concentrations and Depositions

Mihaela Mircea [1,*], Rafael Borge [2], Sandro Finardi [3], Gino Briganti [1], Felicita Russo [1], David de la Paz [2], Massimo D'Isidoro [1], Giuseppe Cremona [1], Maria Gabriella Villani [1], Andrea Cappelletti [1], Mario Adani [1], Ilaria D'Elia [1], Antonio Piersanti [1], Beatrice Sorrentino [1], Ettore Petralia [1], Juan Manuel de Andrés [2], Adolfo Narros [2], Camillo Silibello [3], Nicola Pepe [3], Rossella Prandi [4] and Giuseppe Carlino [4]

The VEG-GAP project works on developing a strategy for providing new reliable information in support of designing urban Air Quality Plans (AQPs) considering the urban vegetation ecosystems characteristics such as plant type and state, green area extension, etc.

The multiple vegetation ecosystems services will be evaluated in an integrated way through multi-scale and multi pollutant approaches resembling the real-world as much as possible.

The vegetation ecosystems contributions both as a sources and sinks of air pollution, its effects on air temperature and further impact on air quality will be simultaneously investigated. This will contribute to a better understanding and evaluation of the possible risks and benefits for human health and ecosystems themselves associated with air pollution changes induced by vegetation/ecosystems changes which is another project objective.

Bologna, Madrid and Milan are the cities where the work will be implemented.

The main project aims are:

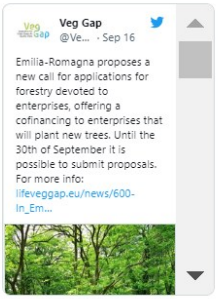
- to make available for the first time a framework of instruments (guidelines, support tools and information platform) that consistently consider the linkages between air pollution and vegetation characteristics in the development of effective control strategies
- to provide recommendations for improving the legislation aimed to maintain and improve air quality in European cities

VEG-GAP Information Platform Access

Download here the Layman's report

Download here the Vegetation for urban green air quality plans

Twitter



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ENEA

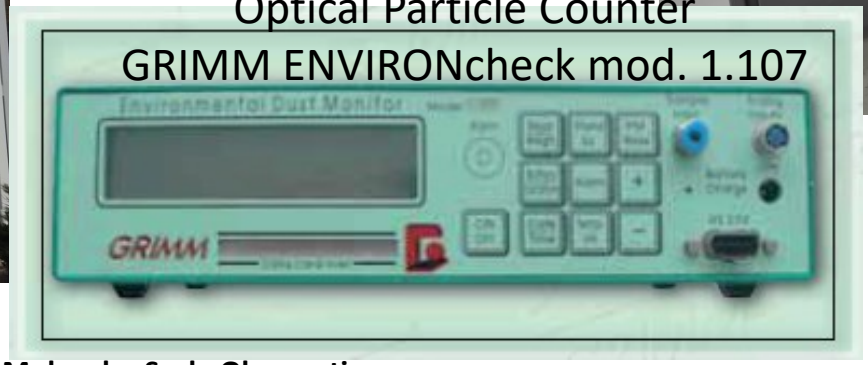
Italian National Agency for New Technologies, Energy and Sustainable Economic Development

Aging of biomass burning aerosol in day and night conditions

Italian National Agency for New Technologies, Energy and Sustainable Economic Development

The EuPhoRe Chamber facility

Optical Particle Counter
GRIMM ENVIRONcheck mod. 1.107



2 Maggio, 14:45–14:55 Room M1 – oral presentation
Session: AS3.37 Atmospheric Processes: Simulation Chambers, Laboratory Studies & Molecular Scale Observations
Title: "Air quality and health hazard of domestic Biomass Burning heating appliances: the experiment at the EUPHORE Chamber"
Authors: Ettore Petralia, Maurizio Gualtieri, Mila Ródenas, Ilaria D'Elia, Laura Caiazzo, Teresa M.G. La Torretta, Giandomenico Pace, Antonio Piersanti, Milena Stracquadanio, Rossella Bengalli, Sara Marchetti, Giulia Motta, Teresa Vera, Rubén Soler, Esther Borrás, Beatríz Domínguez, and Amalia Muñoz
EGU25-11081
This work is part of a project supported by the EC under the Horizon 2020–R&I FP through the ATMO-ACCESS Integrating Activity under GA N.101008004, and by the R+D project ATMOBE (PID2022-142366OB-I00), funded by MCIN/AEI/10.13039/501100011033/ and the "ERDF A way of making Europe" and EVER project CIPROM/20200/37

Experimental setup and preliminary results for PM_1 mass

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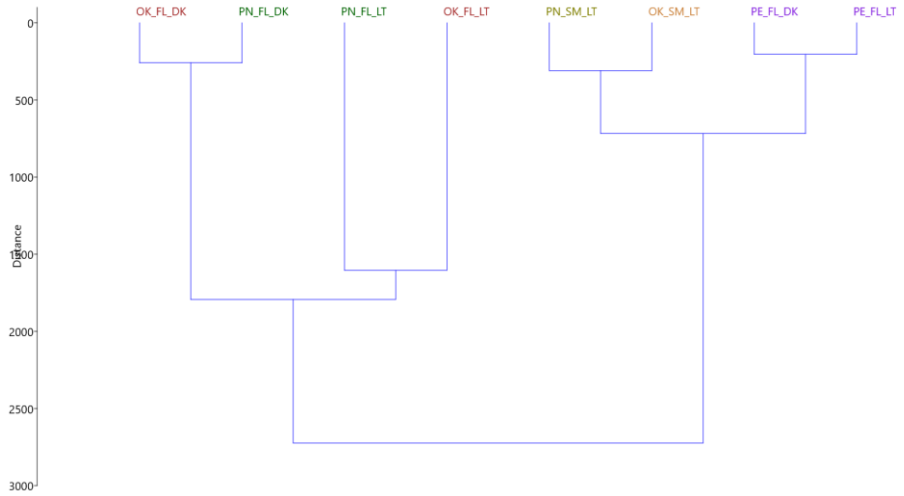
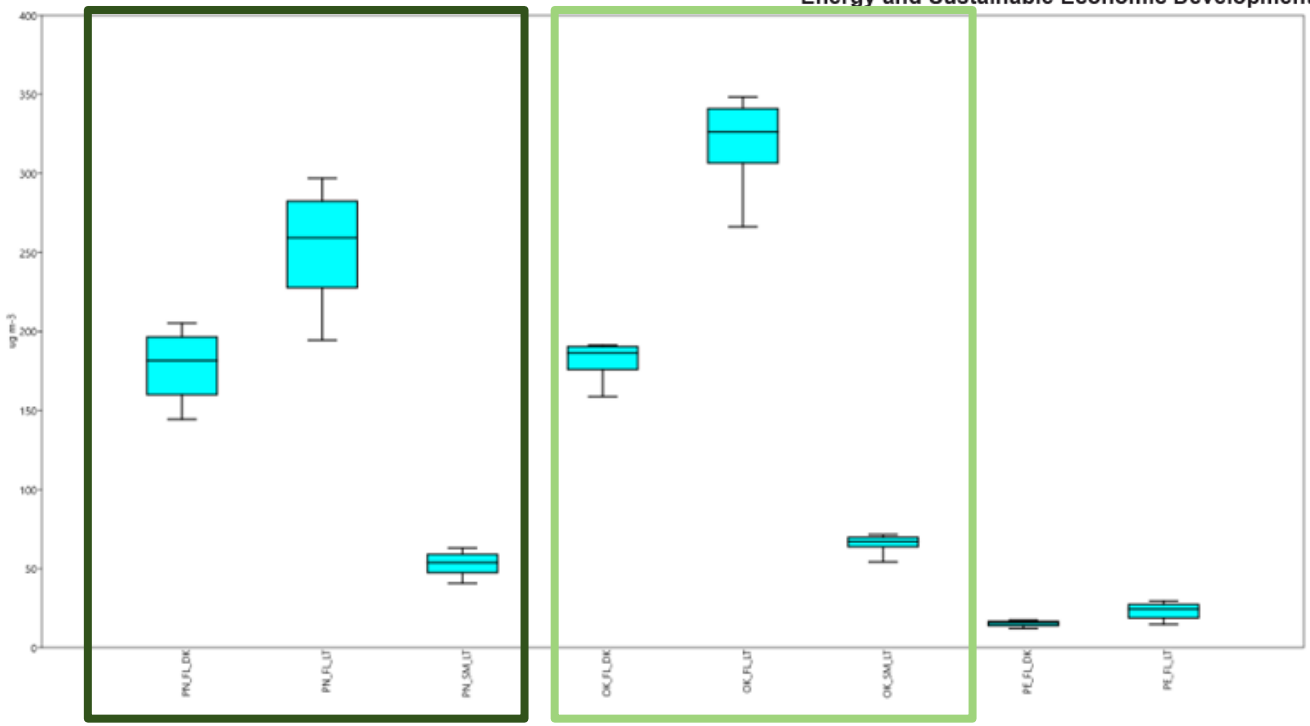
CODE	STOVE TYPOLOGY	FUEL	BURNING PHASE	OXIDATION CONDITiON	EMISSIONS
PN_FL_DK	Traditional	Pine	Flaming	Night-time	Primary & Aged
PN_FL_LT	Traditional	Pine	Flaming	Day-time	Primary & Aged
PE_FL_LT	Pellet	Pellet	Flaming	Day-time	Primary & Aged
OK_FL_LT	Traditional	Oak	Flaming	Day-time	Primary & Aged
OK_FL_DK	Traditional	Oak	Flaming	Night-time	Primary & Aged
PE_FL_DK	Pellet	Pellet	Flaming	Night-time	Primary & Aged
PN_SM_LT	Traditional	Pine	Smouldering	Day-time	Primary & Aged
PN_SM_DK	Traditional	Pine	Smouldering	Night-time	Primary & Aged
OK_SM_DK	Traditional	Oak	Smouldering	Night-time	Primary & Aged
OK_SM_LT	Traditional	Oak	Smouldering	Day-time	Primary & Aged





PERIOD	DURATION	EMISSION KIND	LOCAL TIME-FRAME (approximately)
1	2 hours	Primary emissions	10:30 – 12:30
2	4 hours	Aging process	12:30 – 16:30
3	4 hours	Aged/secondary compounds	17:00 – 21:00

Emission factors for wood-fired pizza ovens: experimental setup

Italian National Agency for New Technologies, Energy and Sustainable Economic Development

Three different ovens:

1. Traditional fixed-top wood-fired pizza oven (capacity: 5-6 pizzas). New device;
2. Hybrid model wood-fired/gas(CH_4) oven (capacity: 5-6 pizzas), New device;
3. Traditional fixed-top wood-fired pizza oven (capacity: 8-10 pizzas). Old device

Two different types of fuelwoods:

1. Beechwood logs.
2. Beechwood briquettes.

Operational phases:

1. Cold ignition
2. Hot re-ignition.
3. Cooking
4. No Cooking stationary phase

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Emission factors for wood-fired pizza ovens: sampling system

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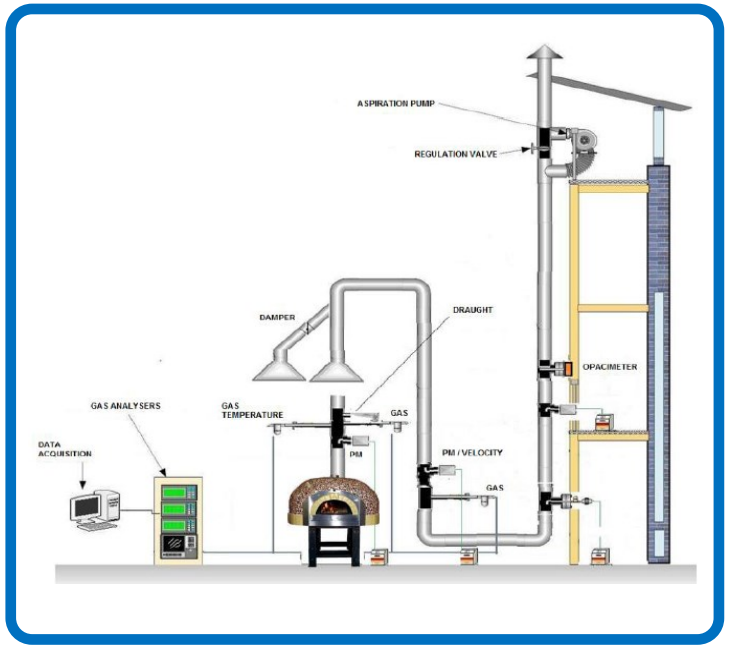

Dilution tunnel to study the impact of organic gaseous compounds condensation on particle emission.

Pollutants and tracers analysed:

- Total Suspended Particulate (**TSP**), **CO**, **NO_x**, Organic Gaseous Compounds (**OGC**) (UNI EN 16510-1:2019) sampled in the hot and diluted flue gas;

- **$PM_{2.5}$**, **PM_{10}**, Polycycle Aromatic Hydrocarbons (**PAH_s**) and Benzo(a)Pyrene (**BaP**); Elemental Carbon and Organic Carbon (**ECOC**), Water Soluble Inorganic Ions (**WSII**), **Levoglucosan** in diluted flue gas.

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Emission factors for wood-fired pizza ovens: assessement

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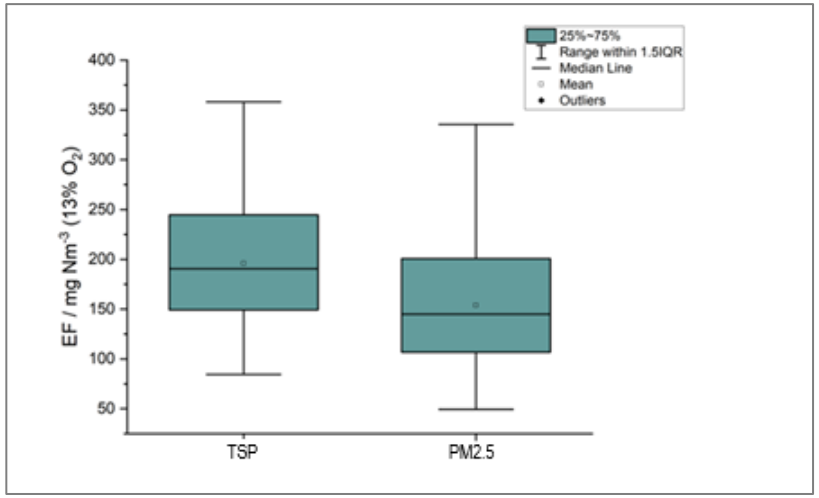
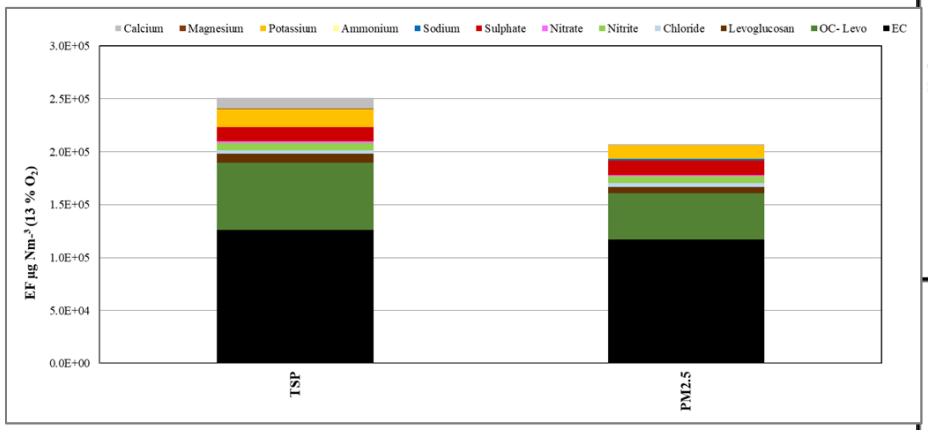
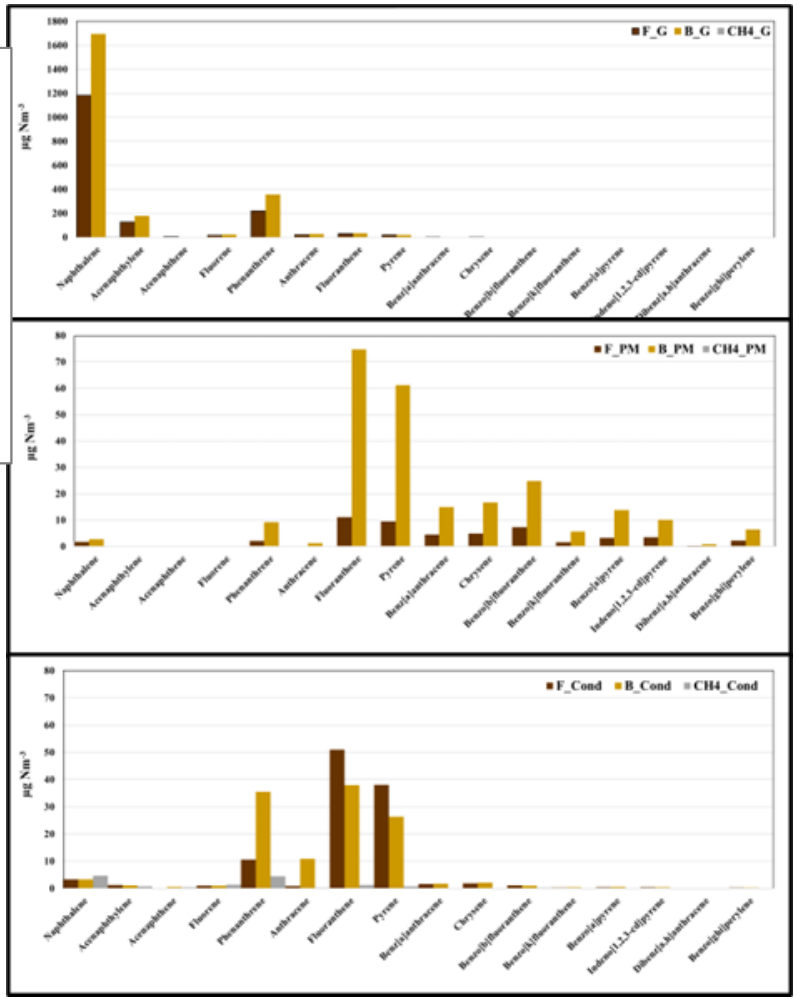
PM Emission



PM chemical characterization in the cooking phase



PAH in gas, particulate and condensate phase



Emission Factor

	TSP	PM_{10}	$PM_{2.5}$	NOx	CO	OGC	Total PAH	Benzo(a)Pyrene
	(g GJ^{-1})	(g GJ^{-1})	(g GJ^{-1})	(g GJ^{-1})	(g GJ^{-1})	(g GJ^{-1})	(mg GJ^{-1})	(mg GJ^{-1})
Emission Factor	233	162	157	85	1038	71	1482	12
Standard Error	21	16	16	3	59	10	883	5

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Conference:

EAC 2023: Poster presentation _ Preliminary Results

Stracquadanio *et al.* "Chemical characterization of particles emitted from wood-fired pizza ovens in Italy."

ICCE 2023: Oral presentation _ Preliminary Results

Bergomi *et al.* "Pollutant Emissions from Wood-Fired Pizza Ovens"

ABC 2023: Oral presentation

Bergomi *et al.* "Evaluation of pollutant emissions from a hybrid oven (wood-fired and gas-fired)"

PM 2024: Oral presentation + Poster presentation

Bergomi *et al.* Determinazione di Fattori di Emissione e caratterizzazione chimica del particolato emesso da forni a legna delle pizzerie attraverso misure sperimentali: Parte 1

Stracquadanio *et al.* Determinazione di Fattori di Emissione e caratterizzazione chimica del particolato emesso da forni a legna delle pizzerie attraverso misure sperimentali: Parte 2

Scientific Paper: One article submitted, One article in preparation

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INNOVHUB STAZIONI SPERIMENTALI PER L'INDUSTRIA

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Bertagna Silvia

UNIVERSITÀ DEGLI STUDI DI MILANO

Bergomi Andrea
Mattia Borelli
Valeria Comite
Fermo Paola

MASE –ENEA Agreements:

Collaboration agreement for air pollution emission assesment produced by wood-fired pizza ovens.

supported by Italian Ministry of the Environment and Energy Security [CUP (Unique Project Code) I34G20000010001].

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ENEA AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE

PROFILE Pizza, PaRticOlato da FornI a LEgna per PIZZA:

Evaluation of polluting emissions from wood-fired pizza ovens and related abatement systems

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ARPA LOMBARDIA Agenzia Regionale per la Protezione dell'Ambiente

Città metropolitana di Milano

AGENZIA MOBILITÀ AMBIENTE TERRITORIO

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26th TFMM Meeting, 5-7 May 2025, Potsdam, Germany

Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

Thank you!

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