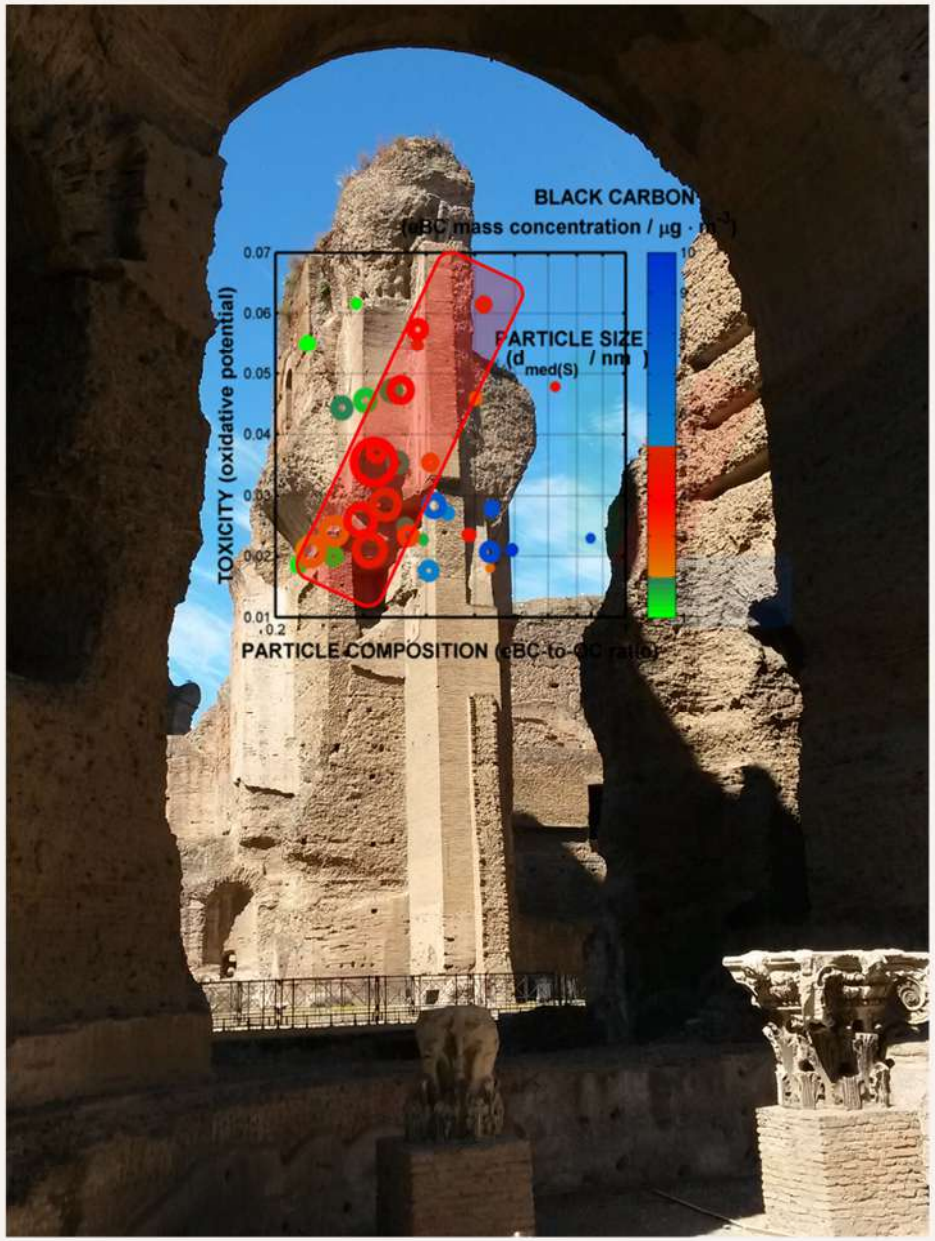
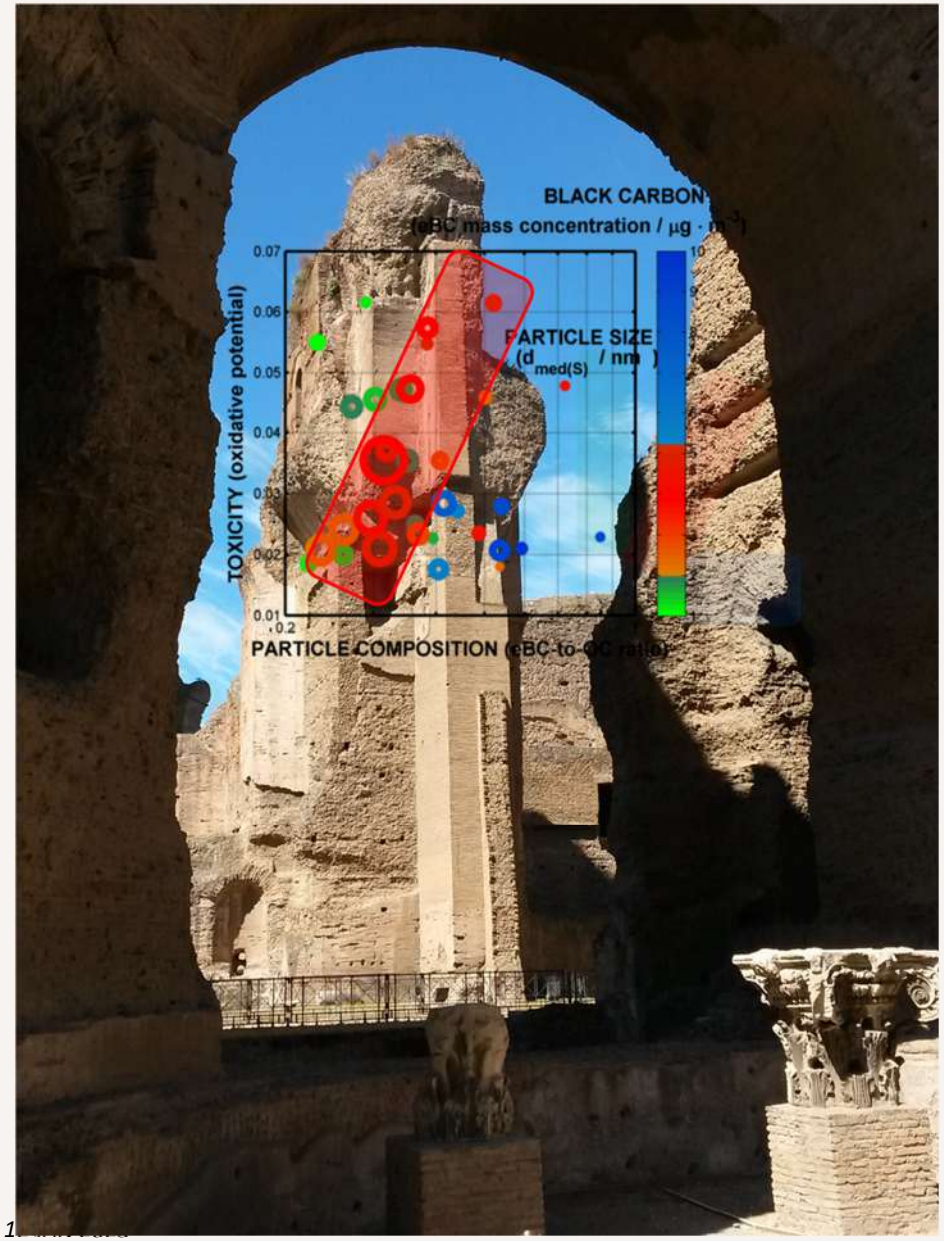


Nuove metriche per il materiale particolato: il Black Carbon a Roma

Costabile, F., Marinelli, L., Di Iulio, G.

12 JAN 2023



Contents

- L'aerosol in aria ambiente urbana ed il Black Carbon (BC): perché il BC (in chiave one-health/planetary-health)?
- Dati a lungo termine di BC a Roma
- Conclusioni: variabilità spaziotemporale, sorgenti principali, e metriche per il BC.

PLANETARY HEALTH

CNR-ISAC works on the development of new evidence-based methodologies exploring the impact on planetary health of the degradation of the atmosphere, with a one-health approach.

THE LANCET
Planetary Health

COMMENT | VOLUME 4, ISSUE 11, E503-E505, NOVEMBER 01, 2020

The Helsinki Declaration 2020: Europe that protects

Jaana I Halonen • Marina Erhola • Eeva Furman • Tari Haahtela • Pekka Jousilahti • Robert Barouki • Åke Bergman • Nils E Billo • Richard Fuller • Andrew Haines • Manolis Kogevinas • Marike Kolossa-Gehring • Kinga Krauze • Timo Lanki • Joana Lobo Vicente • Peter Messerli • Mark Nieuwenhuijsen • Riikka Paloniemi • Annette Peters • Karl-Heinz Posch • Pekka Timonen • Roel Vermeulen • Suvi M Virtanen • Jean Bousquet • Josep M Antó • Show less

Open Access • Published: November, 2020 • DOI: https://doi.org/10.1016/S2542-5196(20)30242-4 •

The challenge: To define, and navigate toward, a safe and just future for people and the planet.

AGU ADVANCING EARTH AND SPACE SCIENCE

Earth's Future

COMMENTARY

10.1029/2020EF001866

Identifying a Safe and Just Corridor for People and the Planet

Johan Rockström[1,2], Joyeeta Gupta[2,4], Timothy M. Lenton[5], Dahe Qin[6,7,8], Steven J. Lade[9,10,11], Jesse F. Abrams[5], Lisa Jacobson[9], Juan C. Rocha[9,10], Caroline Zimm[11], Xuemei Bai[12], Govindasamy Bala[13], Stefan Bringezu[14], Wendy Broadgate[9], Stuart E. Bunn[15], Fabrice DeClerck[16,17], Kristie L. Ebi[18], Peng Gong[19,20,21], Chris Gordon[22], Norichika Kanie[23], Diana M. Liverman[24], Nebojsa Nakicenovic[11], David Obura[25], Veerabhadran Ramanathan[26], Peter H. Verburg[27,28], Detlef P. van Vuuren[29,30], and Ricarda Winkelmann[1,31]

Key Points:

- An integrated people and planet perspective is required to guide human development and use of the global commons
- We outline an approach to defining a safe and just corridor for a stable and resilient planet supporting human development

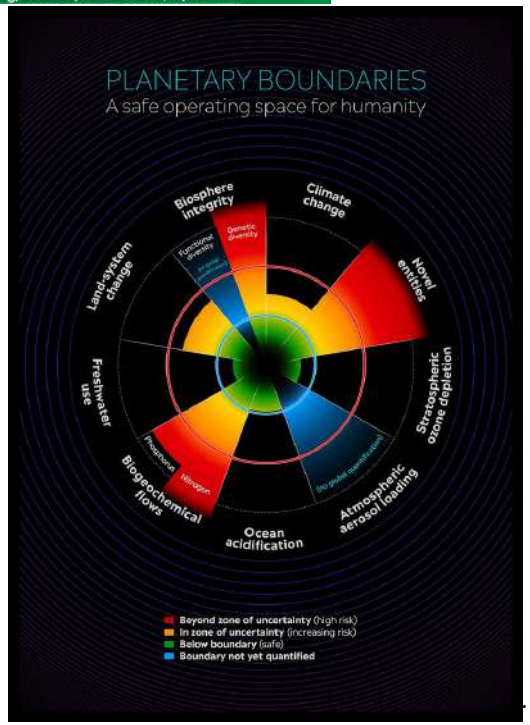
Planetary Boundaries: Exploring the Safe Operating Space for Humanity

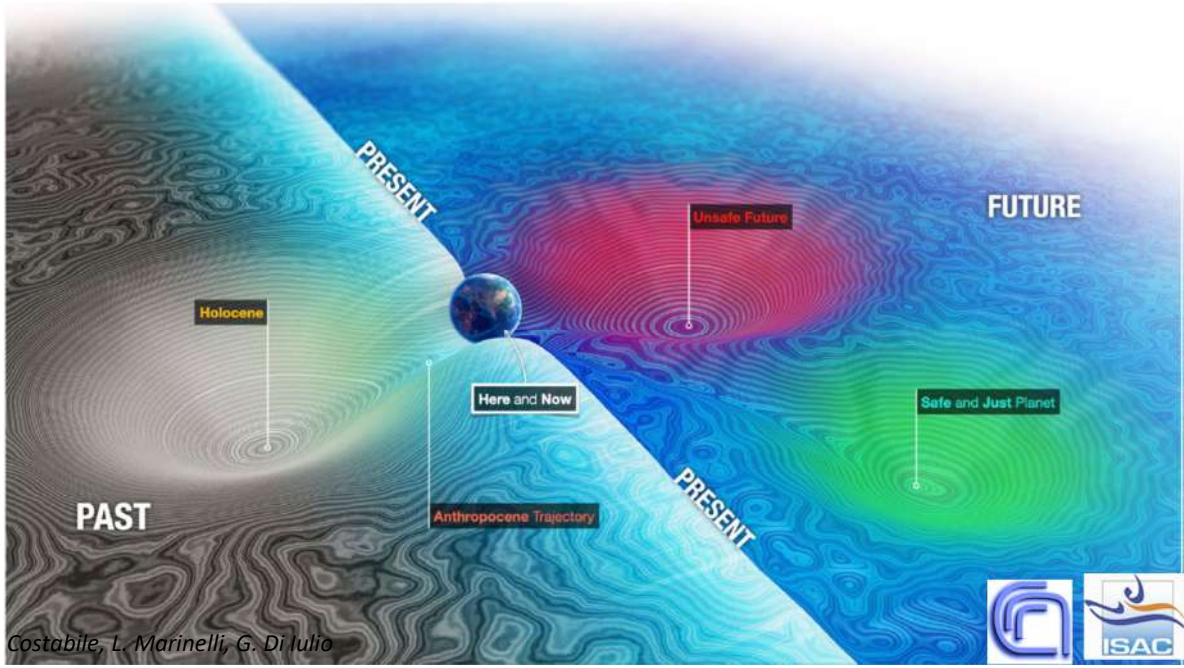
The first declaration is to raise awareness of the strong interlinkage between human and planetary health

ONE HEALTH

PLANETARY HEALTH

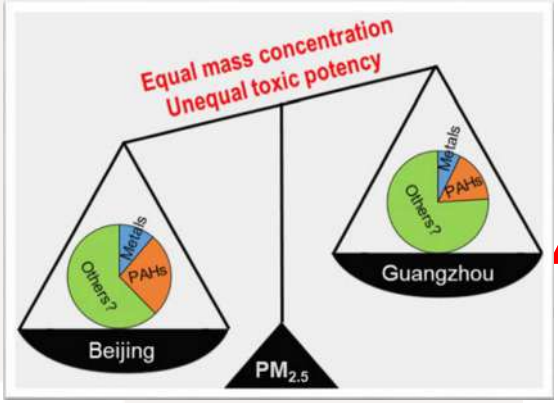
12 JAN 2023

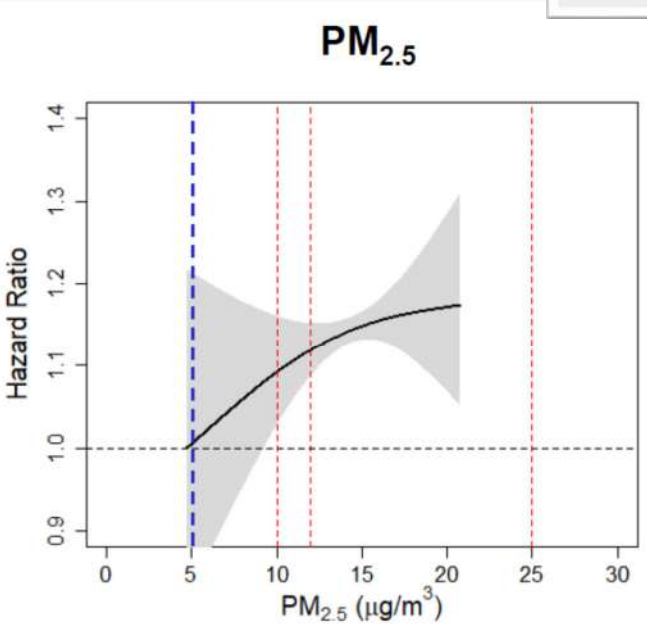




. Costabile, L. Marinelli, G. Di Iulio

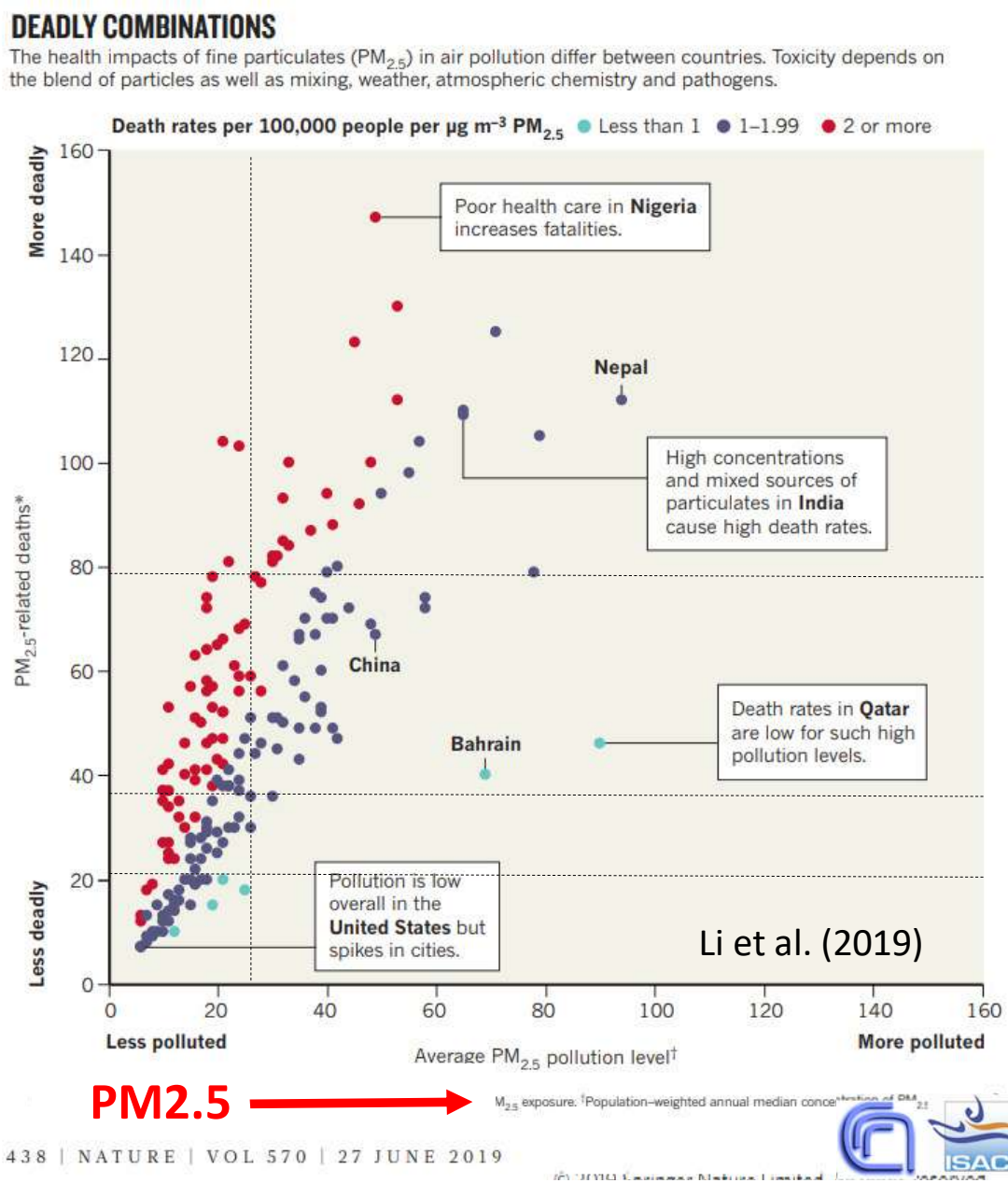
Our scientific question is related to the development of new control variables for air pollution- related human and planetary health studies: beyond $PM_{2,5}$





Stafoggia et al., 2022

DEATH



Revisione direttiva europea Air Quality

- *Introducing additional sampling points for unregulated air pollutants of emerging concern, such as **ultrafine particles (UFP), black carbon (BC)**, …, the **oxidative potential of particulate matter**, will support scientific understanding of their effects on health and the environment, where*
  - *"black carbon" (BC) means **equivalent black carbon (eBC) derived from optical methods.***
  - *"ultrafine particles" (UFP) means **particle number concentrations in cm³ f**or a size range with a lower limit of ≤ 10 nm and for a size range with no restriction on the upper limit.*
- *Measurements at all monitoring supersites at urban background locations shall include:*
  - *fixed measurements of black carbon (BC) and ultrafine particles (UFP),*
  - *fixed or indicative measurements of size distribution of ultrafine particles and particulate matter oxidative potential.*

EUROPEAN COMMISSION

Brussels, 26.10.2022
COM(2022) 542 final

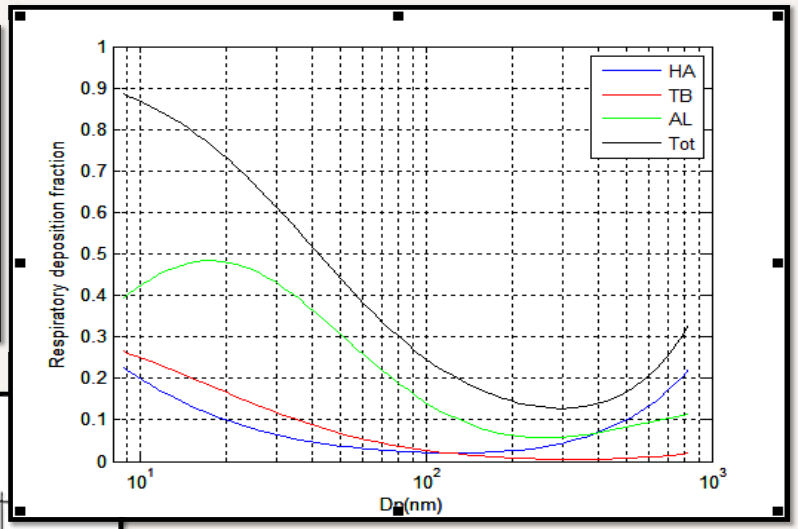
2022/0347 (COD)

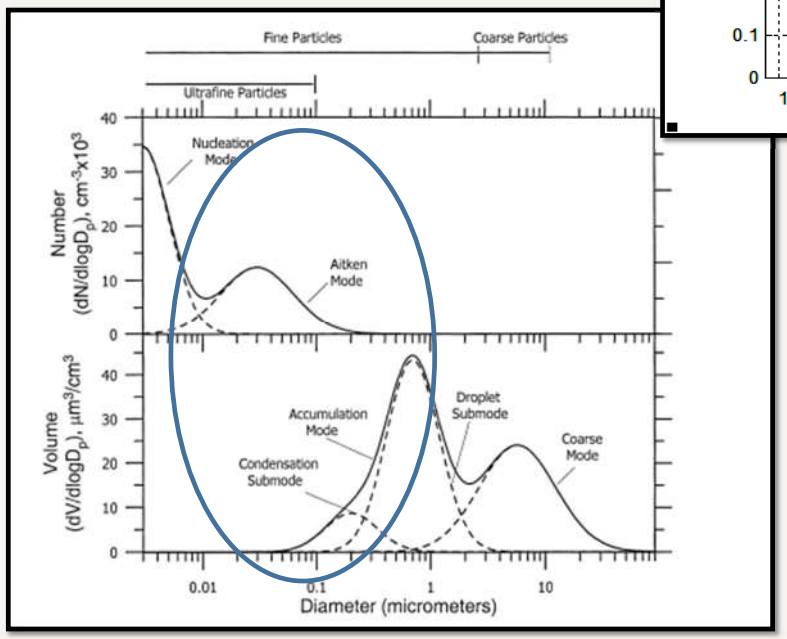
Proposal for a

DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

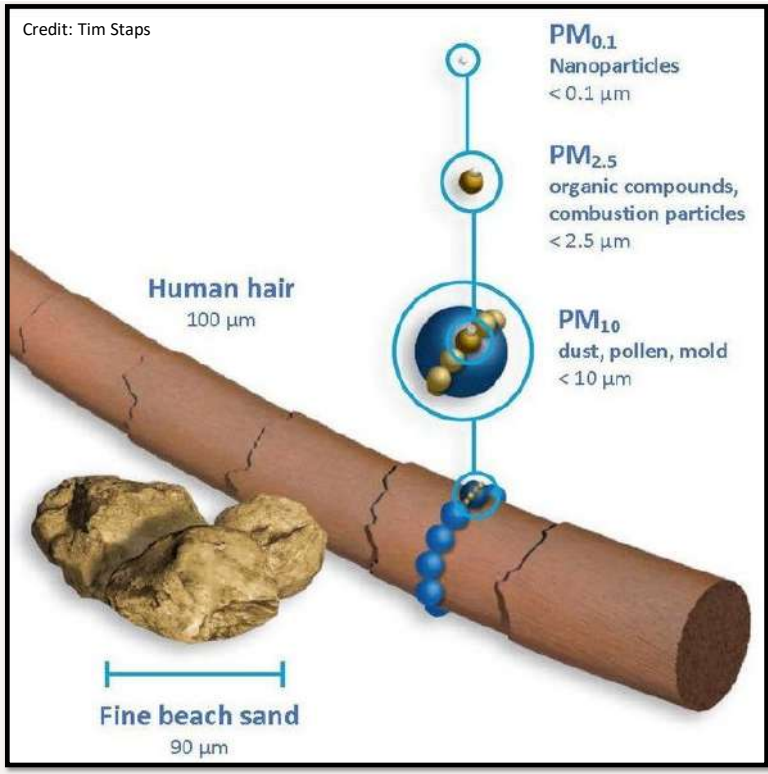
on ambient air quality and cleaner air for Europe

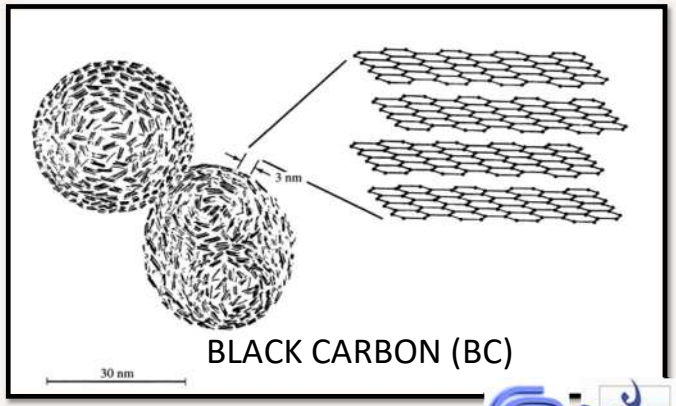
Aerosol atmosferici, il black carbon ultrafine e la deposizione nel tratto respiratorio





H, nose, larynx, pharynx and mouth; tracheobronchial (TB) and alveolar (Al) regions (ICRP, 1994; Manigrasso, Costabile et al., 2020; seinfield and Pandis, 2006)





F. Costabile, L. Marinelli, G. Di Iulio

Le tipologie di Black Carbon in area urbana

Prodotto dalla combustione incompleta di fossil fuels e da biomass burning, e dal successivo processamento in atmosfera.

BC_{ff} : fossil fuel → black, ultrafine BC, higher HOA, higher BC/OA and higher BC mass fraction in PM1

Higher Brown Carbon with the lowest BC/OA

BC_{bb} : biomass burning → fine BC, higher BBOA, lower BC/OA

BC/OA: Saleh et al., 2014 - Nature; Gilardoni, Costabile et al., 2016 – PNAS; Costabile et al., 2017 - ACP; Aethalometer model (Sandradewi et al., 2008; Drinovec et al., 2015)

What health-relevant metric for PM_1?

Oxidative and proinflammatory responses for the ultrafine black carbon

PM Parameter	Biological response	NRPM1 (µg/m³)	fNRPM1	Deposited Mass (µg/cm²)	Number (#/cm²)	Ntot (#/m³)	Dmed (nm)	BC (µg/m³)	fBC	PAHs (ng/m³)	fPAHs	OM (µg/m³)	fOM	NH_4^+ (µg/m3)	fNH_4^+	fSO_4^{2-}	NO_3 µg/m³)	fNO_3	Cl^- (µg/m3)	fCl^-
Infiammazione	IL-6 (FI)		−0.92*			*0.68***							0.79*		*−0.80***	*−0.84***				
proteins	IL-8 (FI)		−0.70*		*0.79***	*0.87***														
Genes	*IL-6 (FI)*	*−0.69**			*−0.74***	*−0.80***				*−0.77***		*−0.77**			*0.89**			*−0.69**		*0.97***
Stress ossidativo	*NQO1 (FI)*	*0.79***		*0.80***	*0.63***	*0.45***	**0.94^**	*0.46**	*−0.62***		*−0.72***	*0.66**		*0.98***			*0.77**	*0.65**	*0.87***	
	HO1 (FI)	*0.78***		*0.77***	*0.64***	*0.47***	**0.87^**	*0.48**				*0.66**		*0.93***			*0.78**	*0.68**	*0.86**	
Danno al DNA	*CYP1B1 (FI)*		*−0.96**			*0.41**	**−0.74^**		**0.96^**	*0.63***	**0.88^**		**0.71^**	*−0.64**	*−0.68**				**−0.93^**	*−0.56***
	AhR (FI)										*−0.40**									

Gualtieri, Costabile et al., 2018

Concentrazione in massa di PM1

Massa depositata di PM1

Concentrazione in numero depositata tot

Concentrazione in numero tot

Diametro delle particelle

Concentrazione in massa di BC

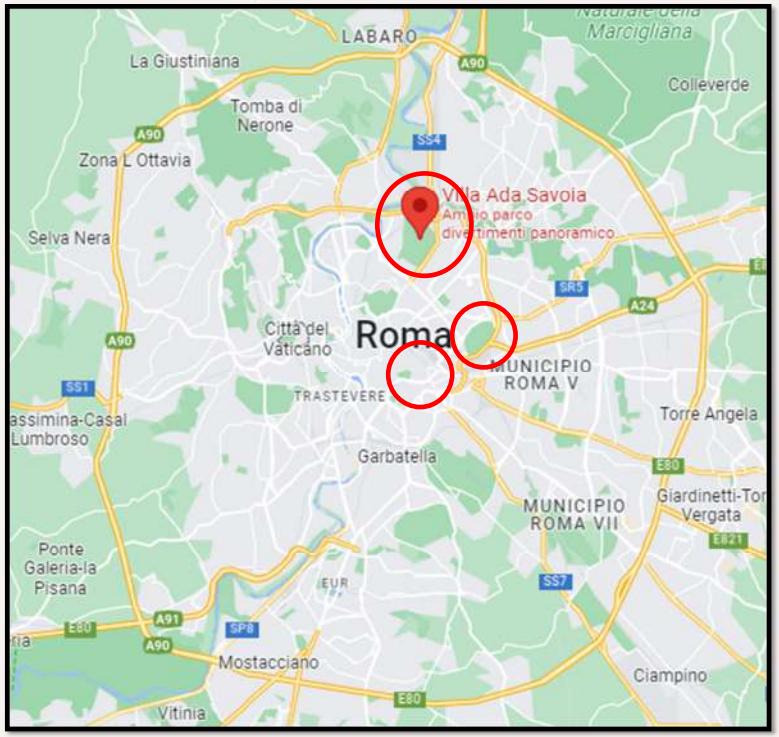
frazione in massa di BC sul PM1

Idrocarburi Policiclici Aromatici

Concentrazione in massa della frazione organica

Concentrazione in massa della frazione inorganica

Spatiotemporal variability – urban area of Rome

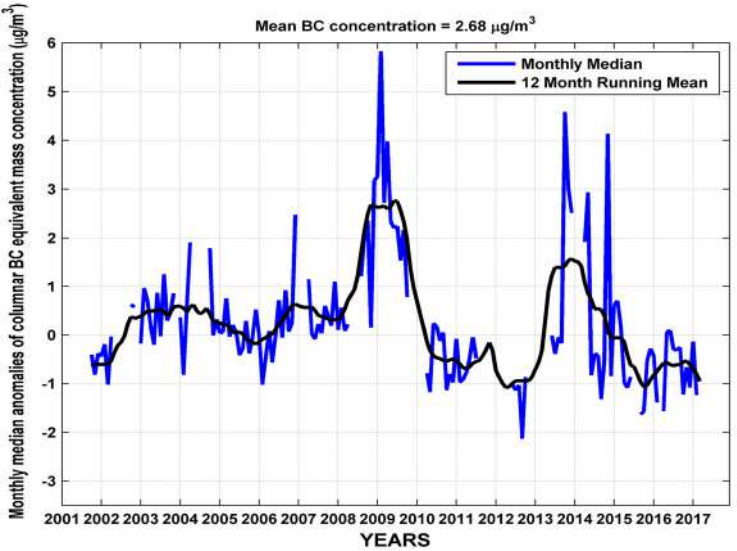


Sito	Tipo di stazione	Periodo	Progetto
Sapienza	UB	Marzo 2022	BRIC-INAIL-VIEPI
Villa Ada	UB Park	Luglio 2020 Novembre 2022	CareBC -ARPA Lazio
San Sisto	UB	Febbraio 2017	CARE
Tor Vergata	S-UB	2001-2017	AERONET

METRICHE

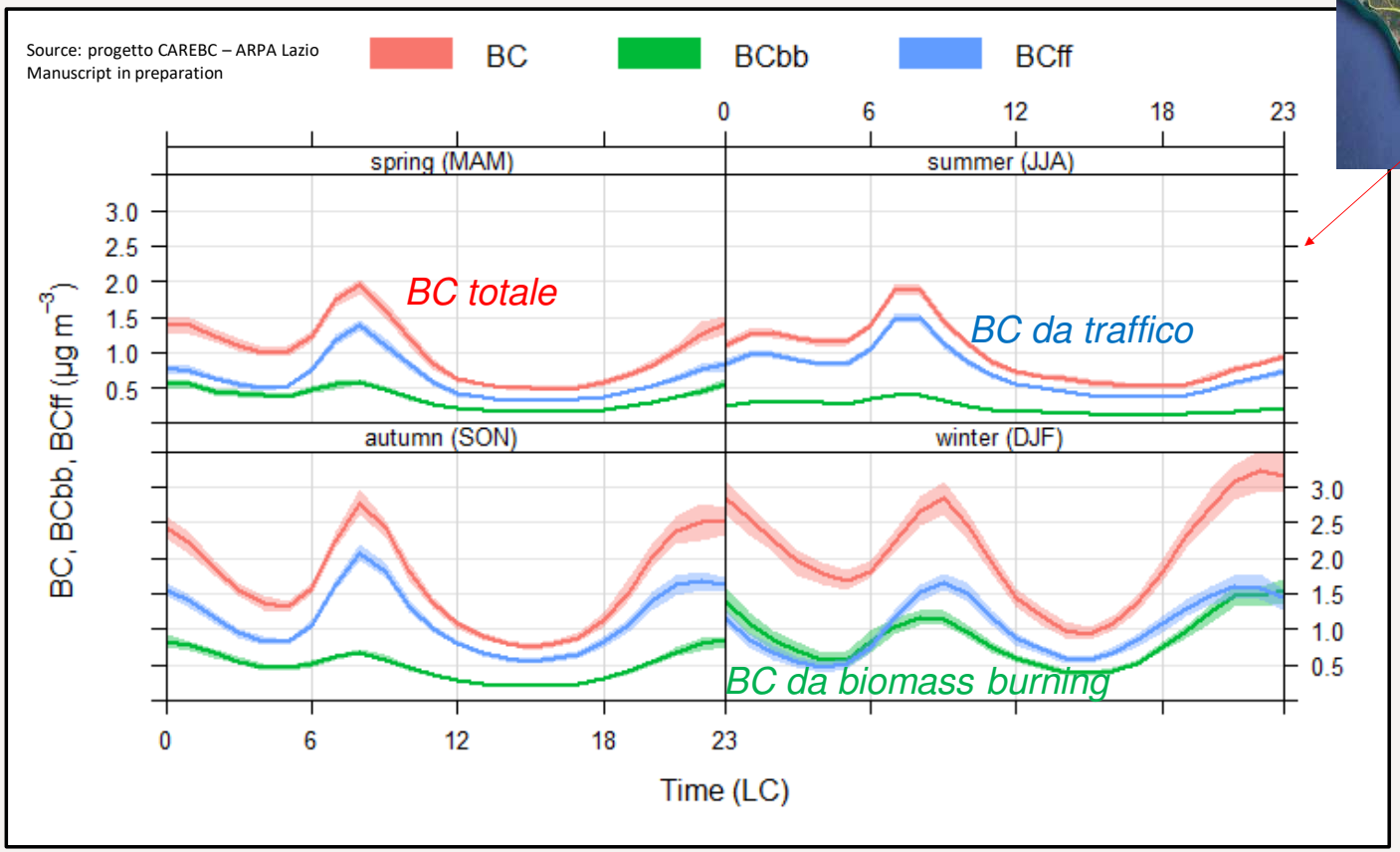
- Concentrazione in massa di Black Carbon
- Concentrazione in massa di Black Carbon ultrafine → proxy di traffico
- Concentrazione in massa di Black Carbon fine → proxy di biomass burning
- Concentrazione in massa di PM1
- Frazione in massa di Black Carbon sul PM1 → indicazione di secondario vs primario

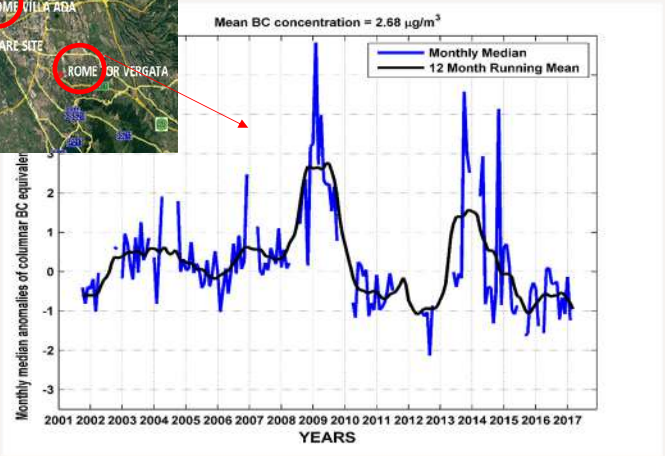
Spatiotemporal variability – suburban area of Rome



Di Ianni, A.; Costabile, F.; Barnaba, F.; Di Liberto, L.; Weinhold, K.; Wiedensohler, A.; Struckmeier, C.; Drewnick, F.; Gobbi, G.P. Black Carbon Aerosol in Rome (Italy): Inference of a Long-Term (2001–2017) Record and Related Trends from AERONET Sun-Photometry Data. *Atmosphere* **2018**, *9*, 81.

Variabilità temporale a Roma – Villa Ada



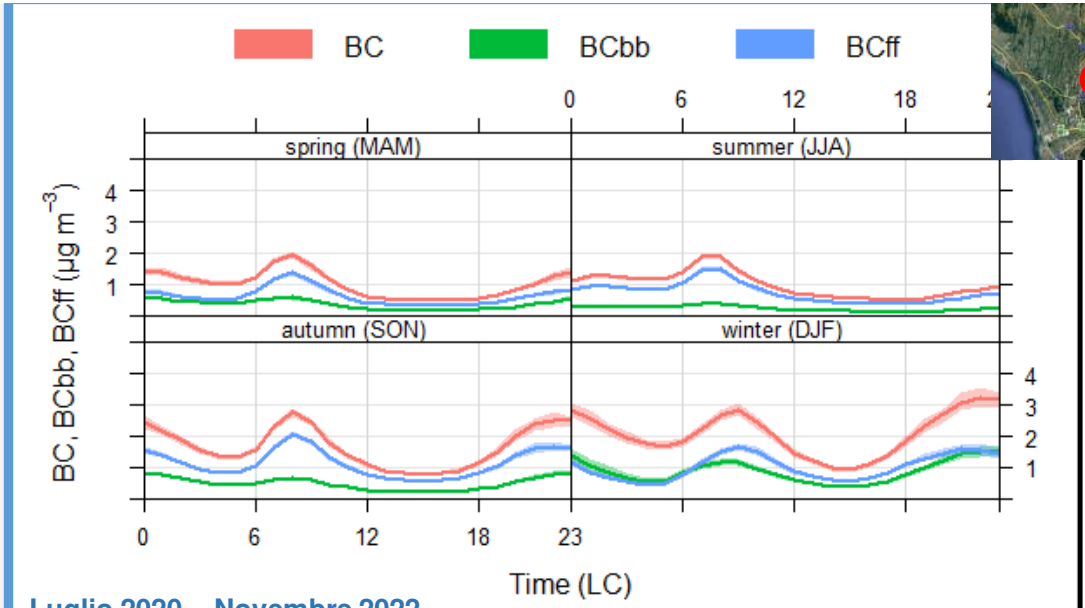


	Winter		Summer	
	mean	sd	mean	sd
BC [µg/m^3]	2.1↑	1.8	1.0↓	0.7
BCff [µg/m^3] *traffic*	1.1	1	0.7	0.5
BCbb [µg/m^3] *Biomass burning*	0.9↑	0.9	0.2↓	0.2

Luglio 2020 – Novembre 2022

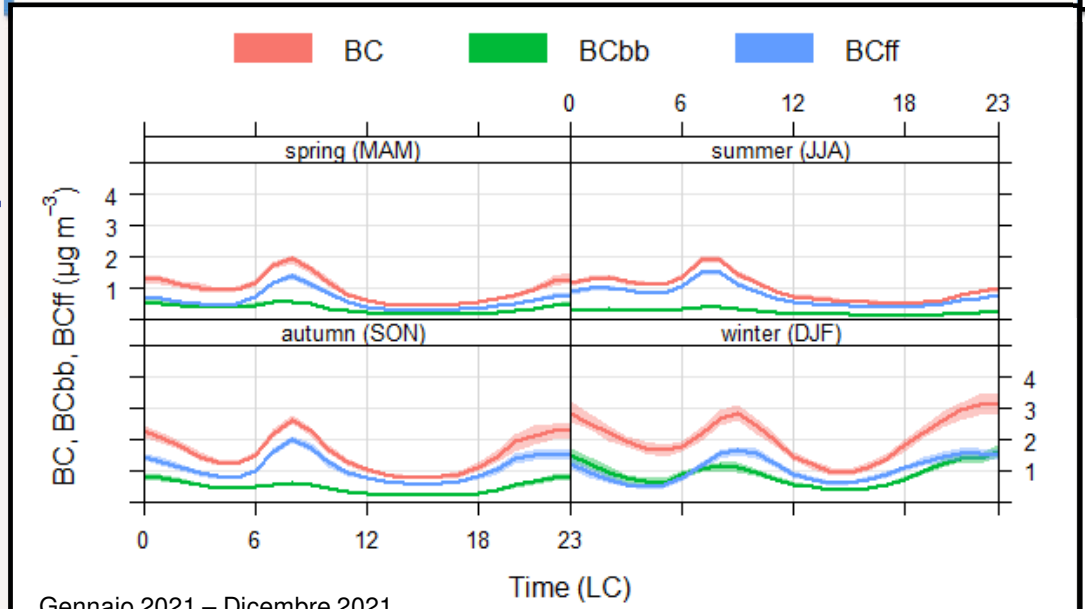
F. Costabile, L. Marinelli, G. Di Iulio

Variabilità temporale a Roma – Villa Ada

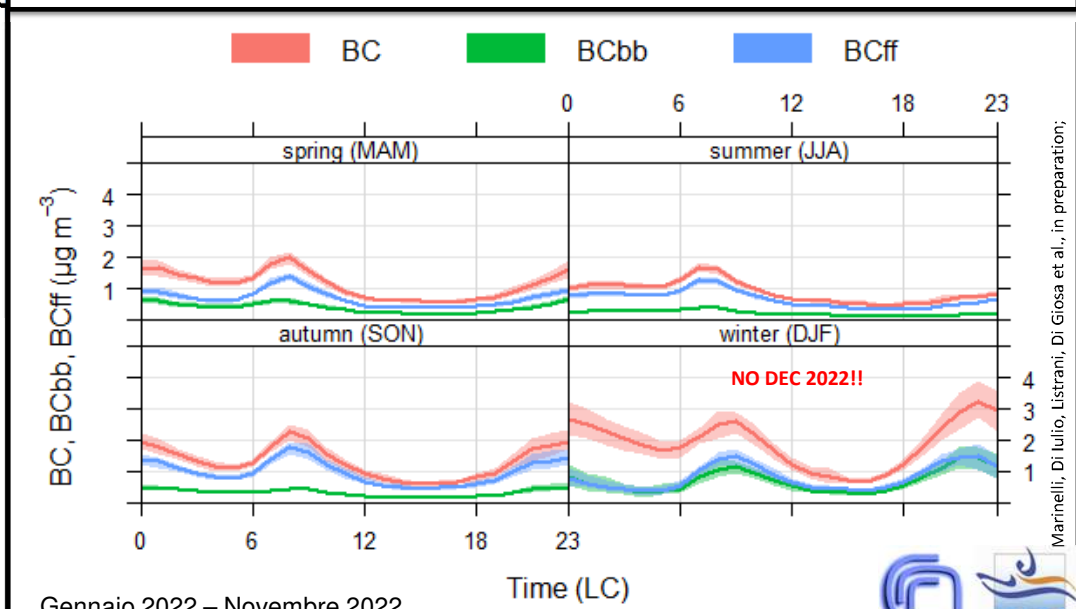


Luglio 2020 – Novembre 2022

Luglio 2020 – Dicembre 2020



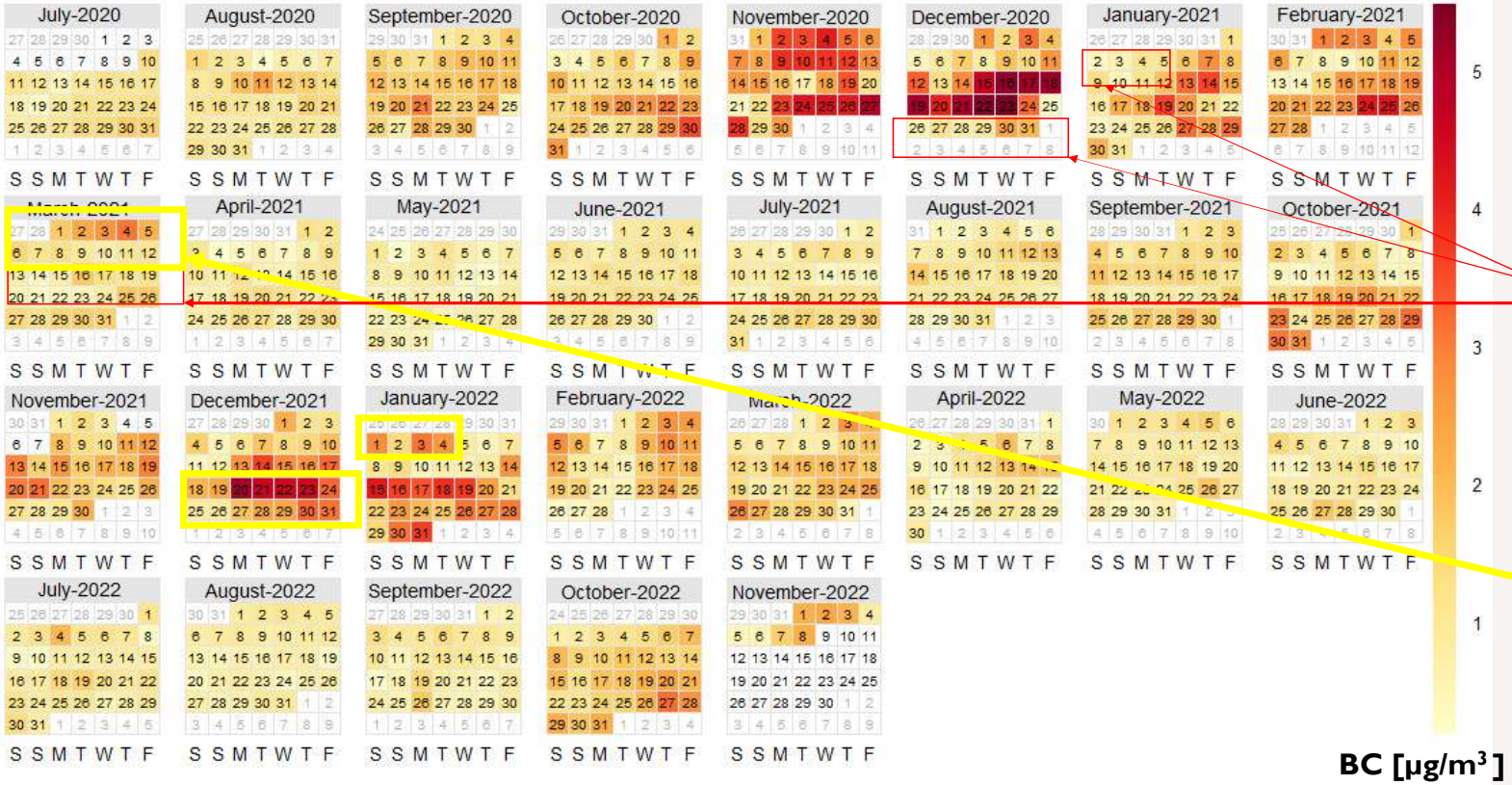
Gennaio 2021 – Dicembre 2021



Gennaio 2022 – Novembre 2022

Marinelli, Di Iulio, Listrani, Di Giosa et al., in preparation;

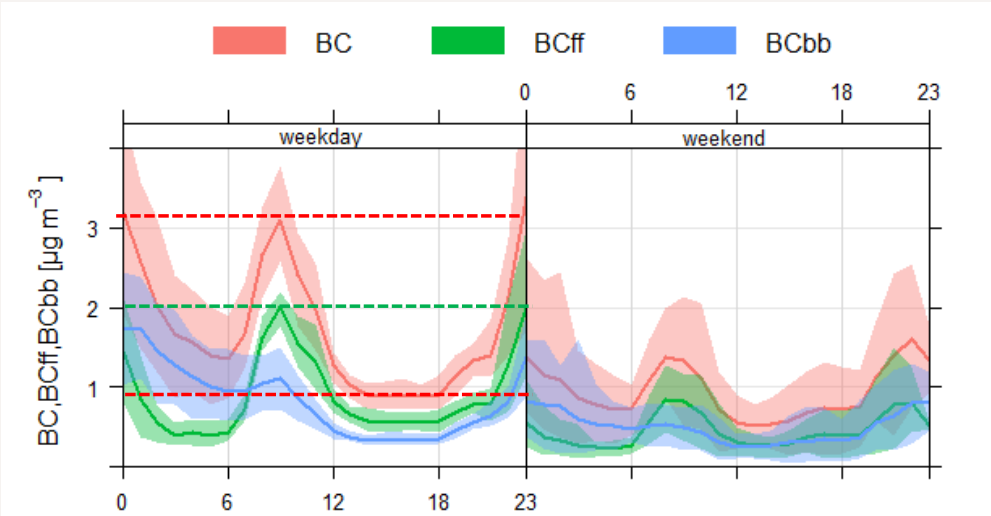
Calendar plot - Roma – Villa Ada



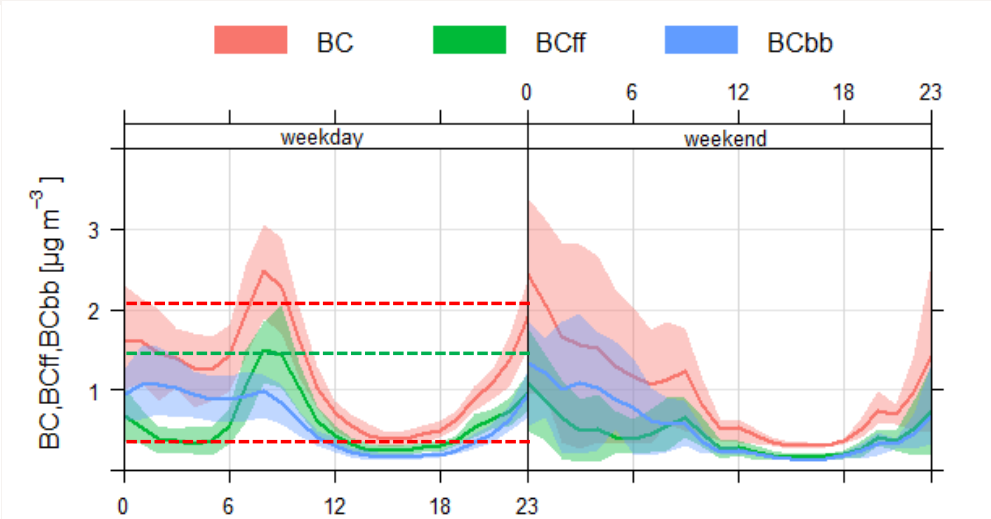
Zona	Data
Zona gialla	Dal 6/11/2020 al 24/12/2020
Zona rossa	25-26-27-31/12/2020 01-02-03/01/2021
Zona arancione	Dal 28/12/2020 al 30/12/2020, 04/01/2021
Zona arancione	Dal 17/01/2021 al 31/01/2021
Zona gialla	Dal 01/02/2021 al 14/03/2021
Zona rossa	Dal 15/03/2021 al 29/03/21

Costabile, Marinelli, Di Iulio, Listrani, Di Giosa et al., in preparation;

Blocco della circolazione COVID19 - Marzo 2021



ZONA GIALLA
Dal 01/03/2021 al 14/03/2021

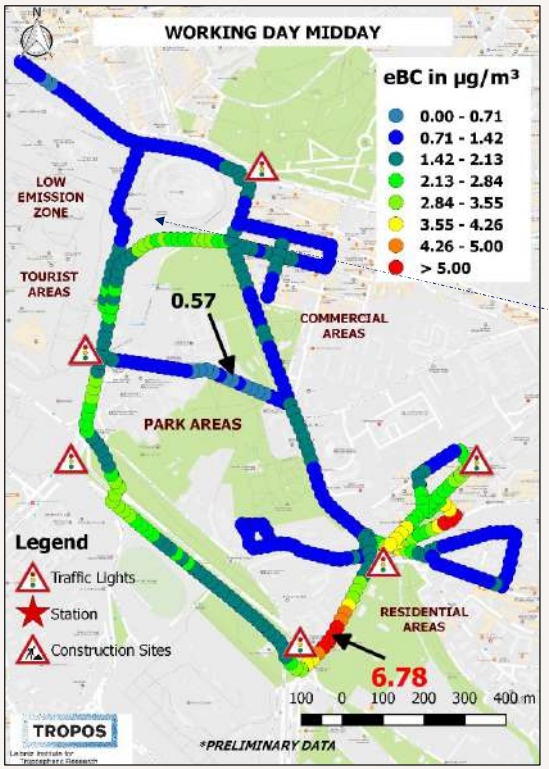


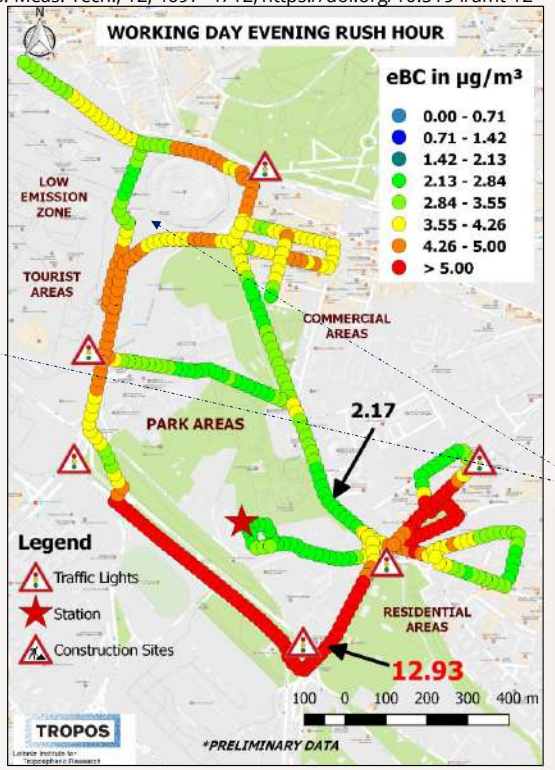
ZONA ROSSA
Dal 15/03/2021 al 29/03/21

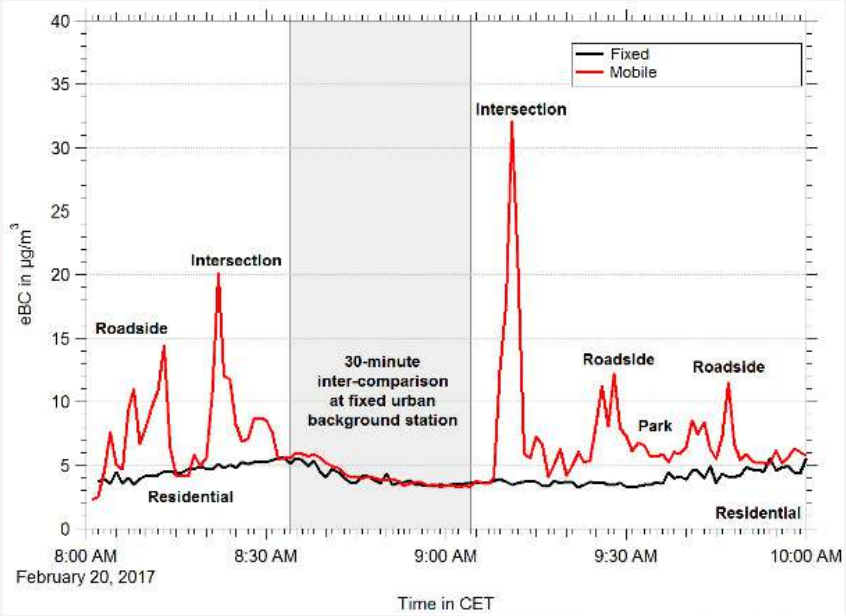
F. Costabile, L. Marinelli, G. Di Iulio

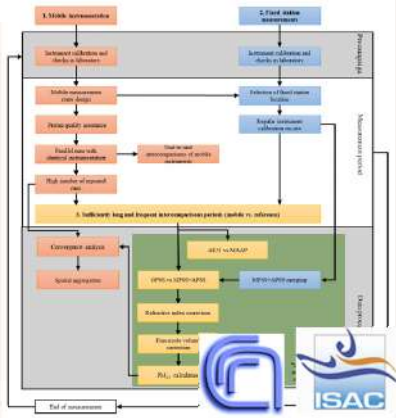
Variabilita’ spaziale – Roma downtown

Alas, H. D. C., Weinhold, K., Costabile, F., Di Ianni, A., Müller, T., Pfeifer, S., Di Liberto, L., Turner, J. R., and Wiedensohler, A.: Methodology for high-quality mobile measurement with focus on black carbon and particle mass concentrations, Atmos. Meas. Tech., 12, 4697–4712, https://doi.org/10.5194/amt-12-4697-2019, 2019.

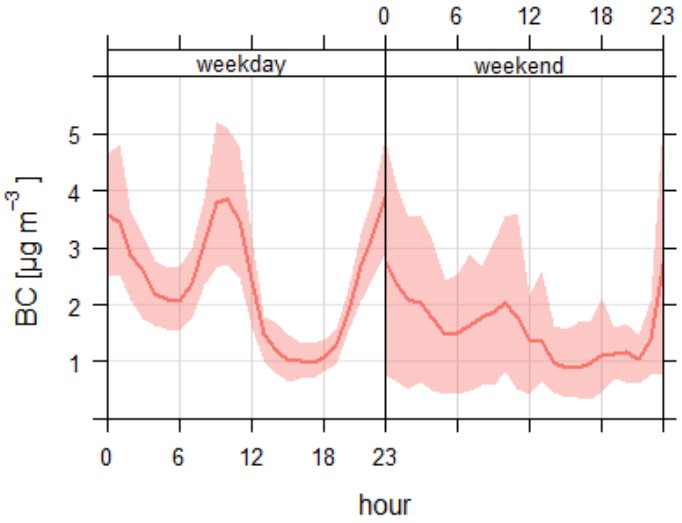




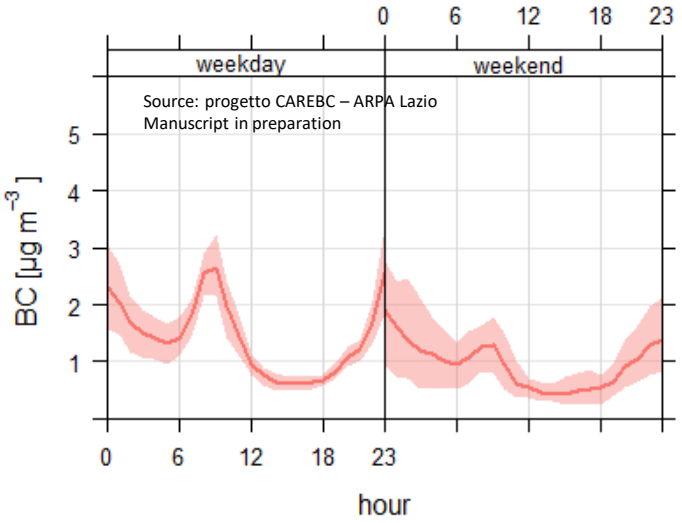




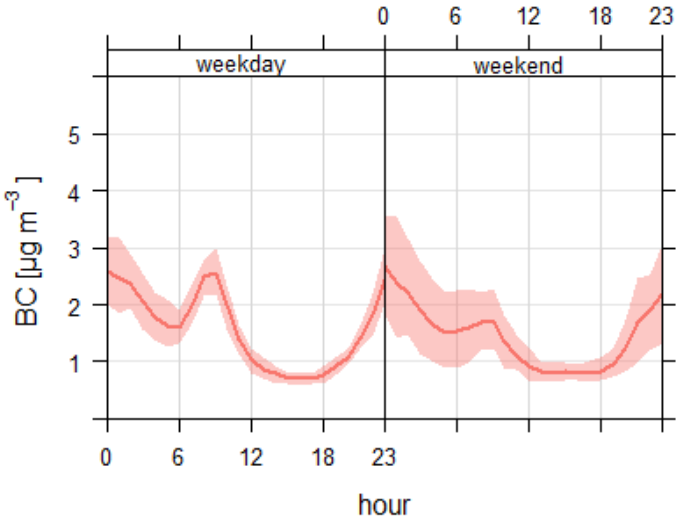
Febbraio 2021 Ada **UB park**



Marzo 2021 Villa Ada **UB park**

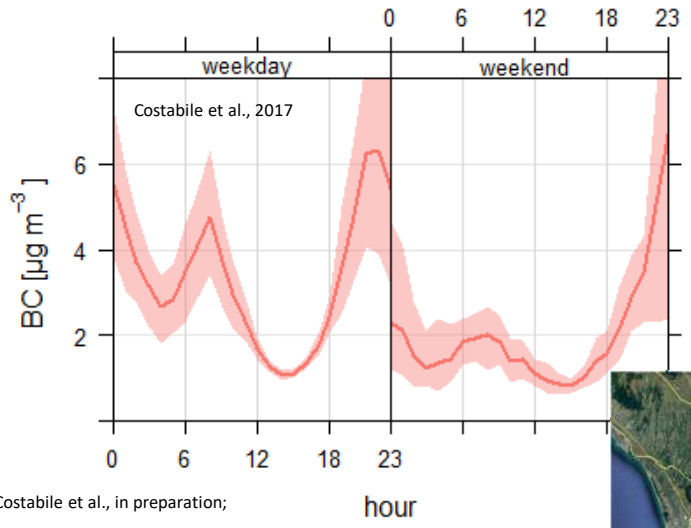


Marzo 2022 Villa Ada **UB park**



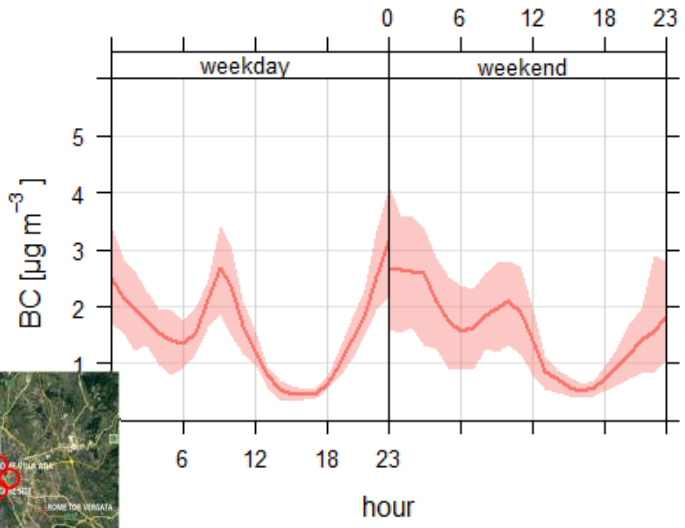
Concentrazione in massa di BC

Febbraio 2017 San Sisto **UB**



Costabile et al., in preparation;

Febbraio 2022 Villa Ada **UB park**



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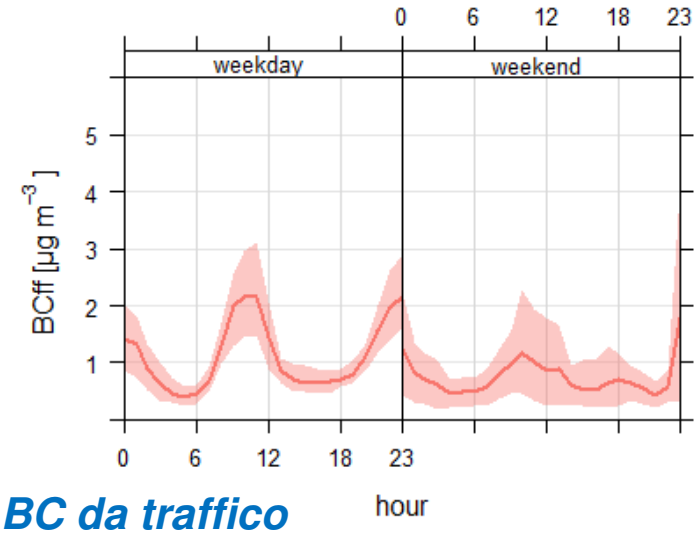
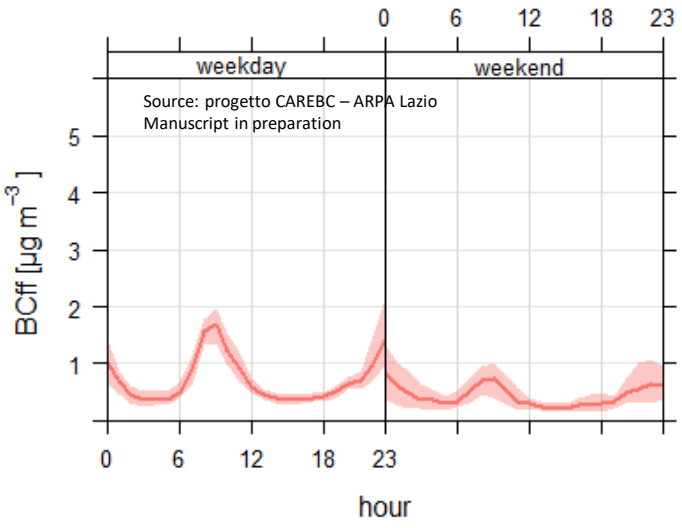
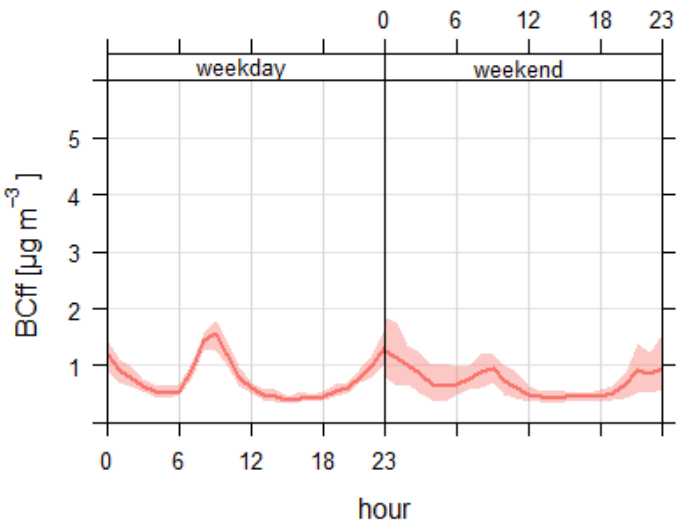
Febbraio 2021 Villa Ada



Marzo 2021 Villa Ada

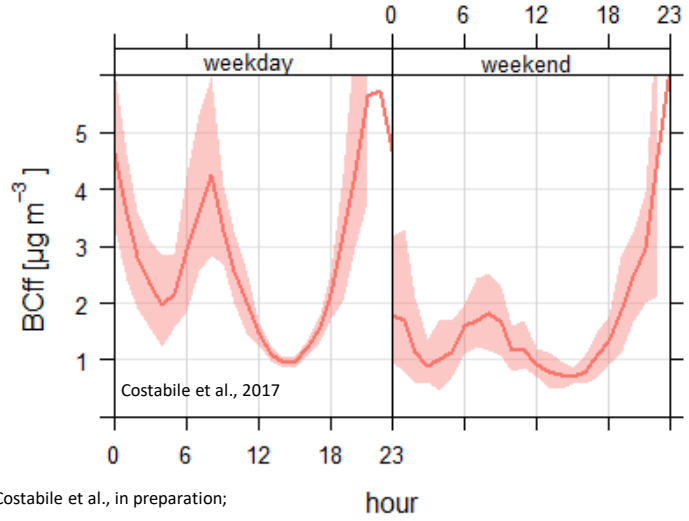


Marzo 2022 Villa Ada

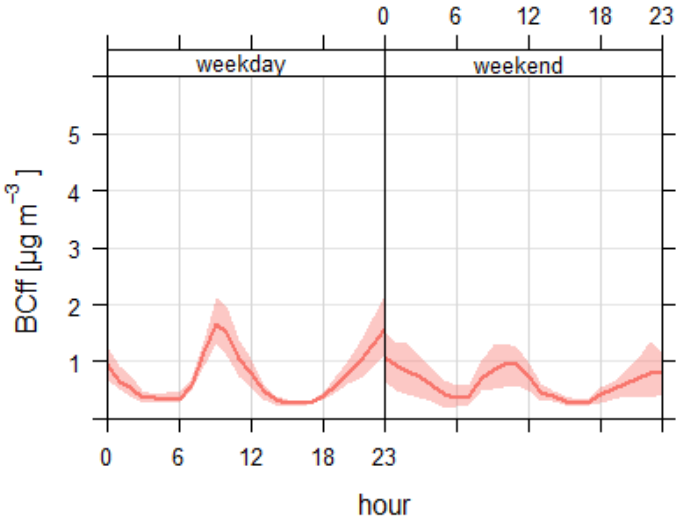


BC da traffico

Febbraio 2017 San Sisto



Febbraio 2022 Villa Ada



Costabile et al., in preparation;

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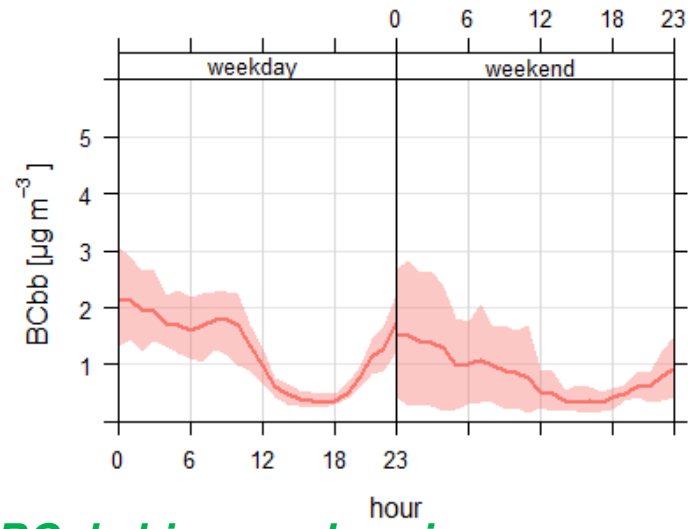
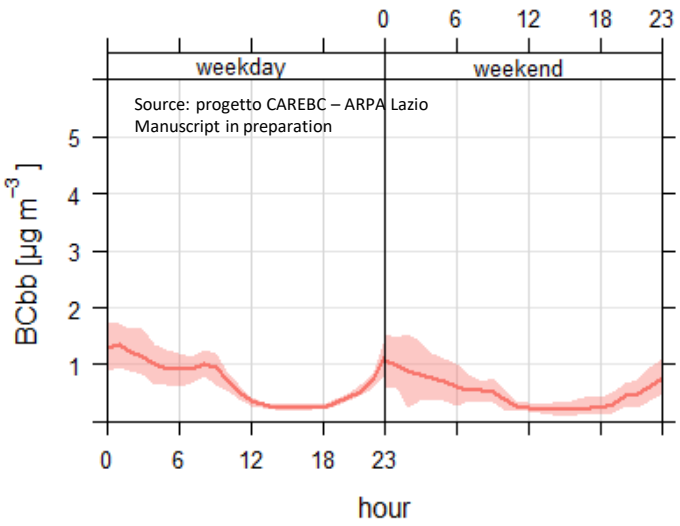
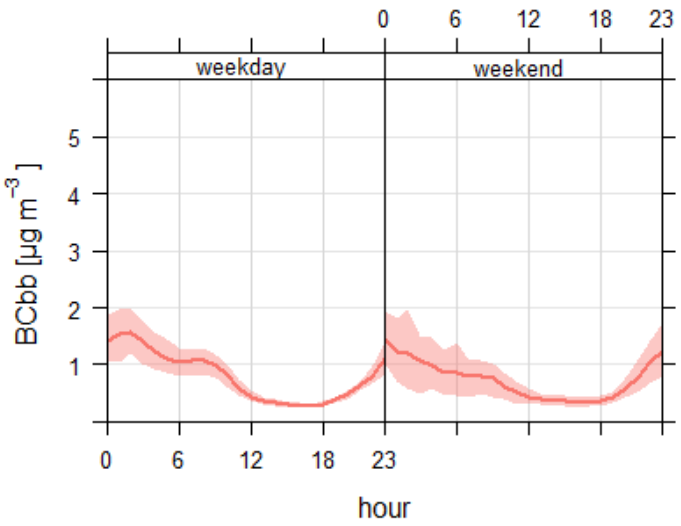
Febbraio 2021 Villa Ada



Marzo 2021 Villa Ada

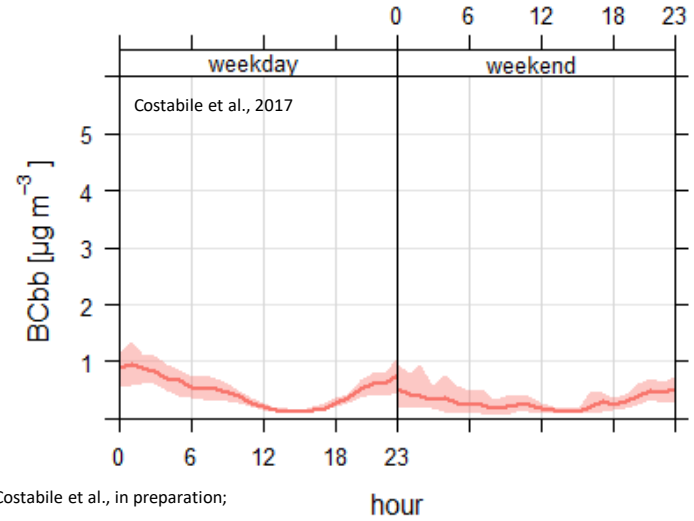


Marzo 2022 Villa Ada



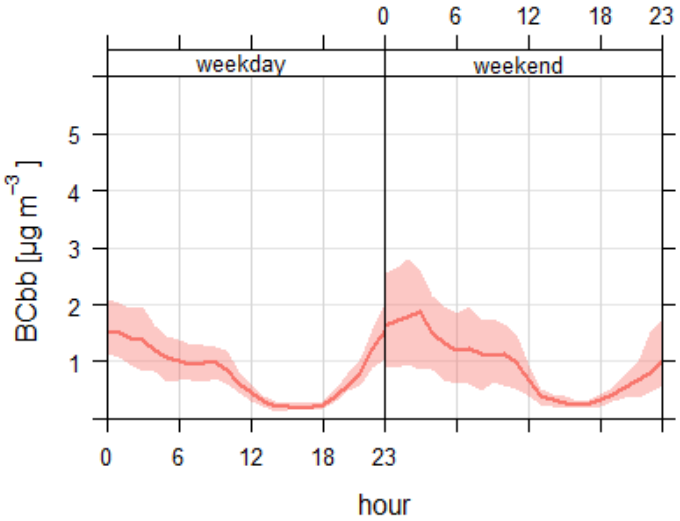
BC da biomass burning

Febbraio 2017 San Sisto



Costabile et al., in preparation;

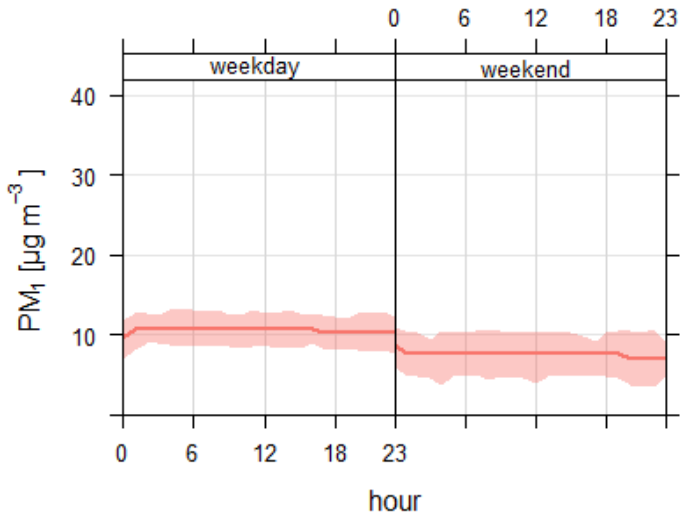
Febbraio 2022 Villa Ada



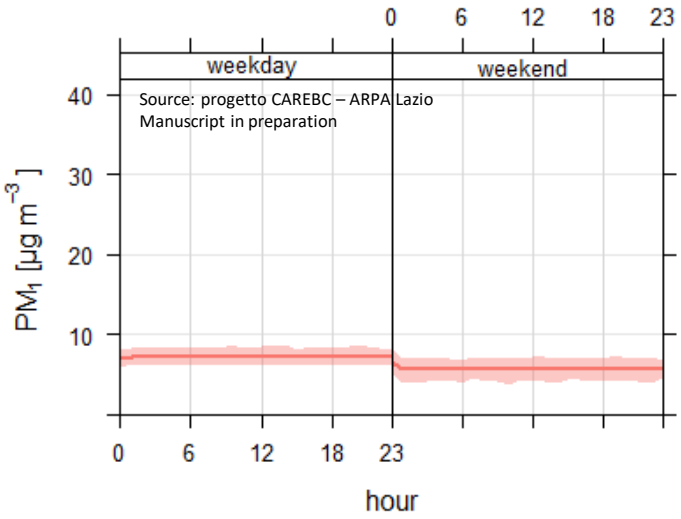
12 JAN 2023

F. Costabile, L. Marinelli, G. Di Iulio

Feb 2021 Ada



Marzo 2021 Ada



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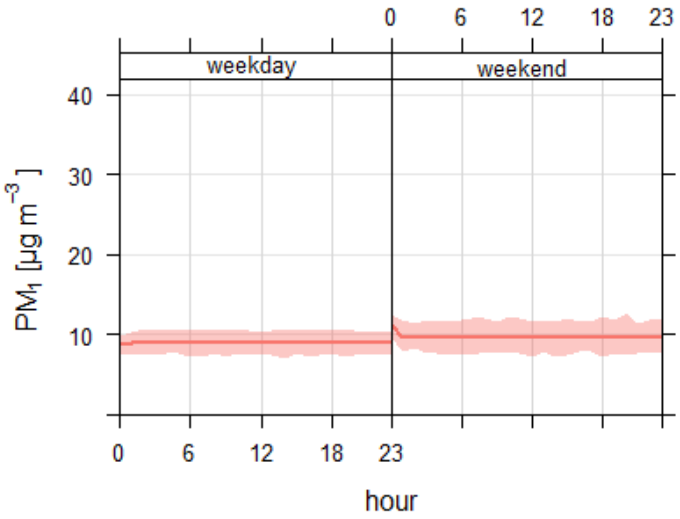
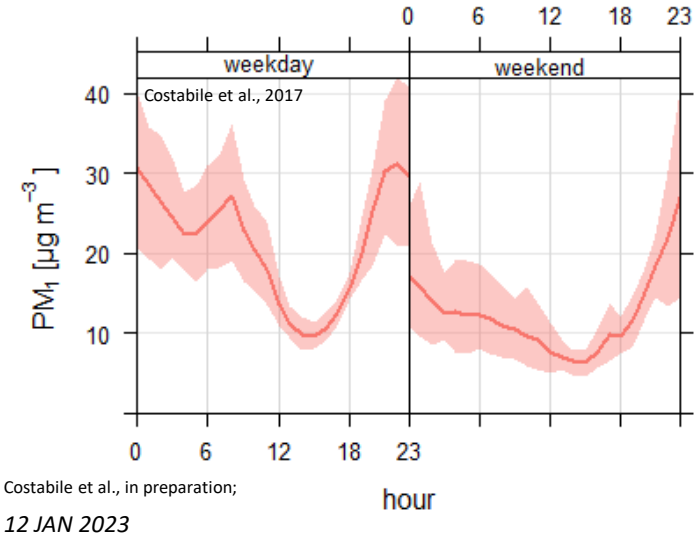


PM1

Feb 2017 San Sisto



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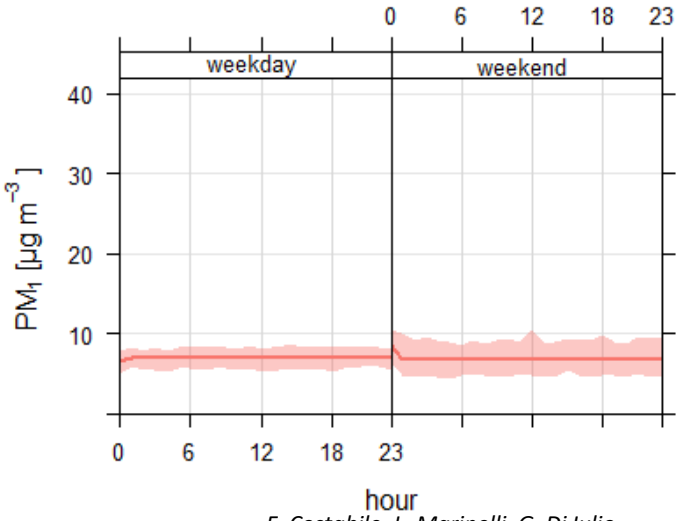

Costabile et al., in preparation;

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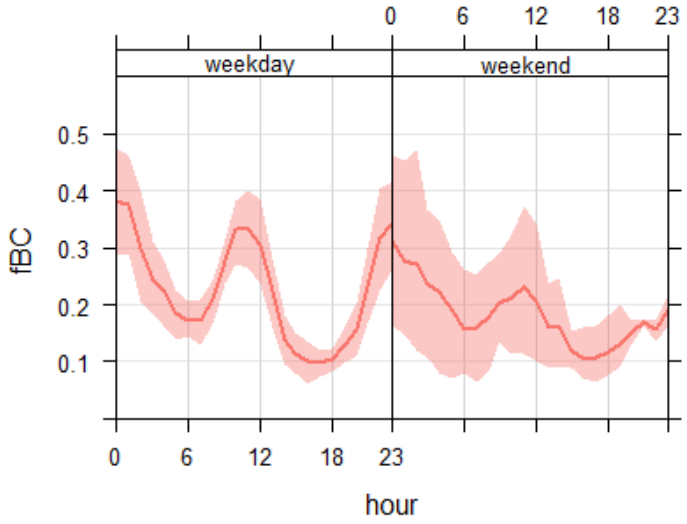
Feb 2021 Ada



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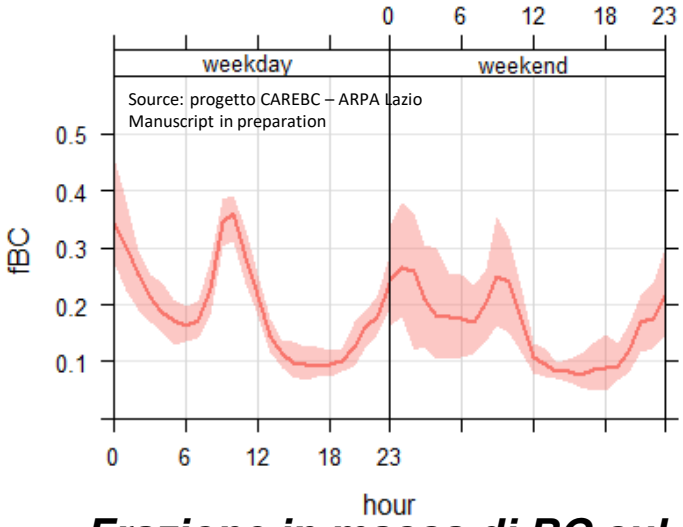

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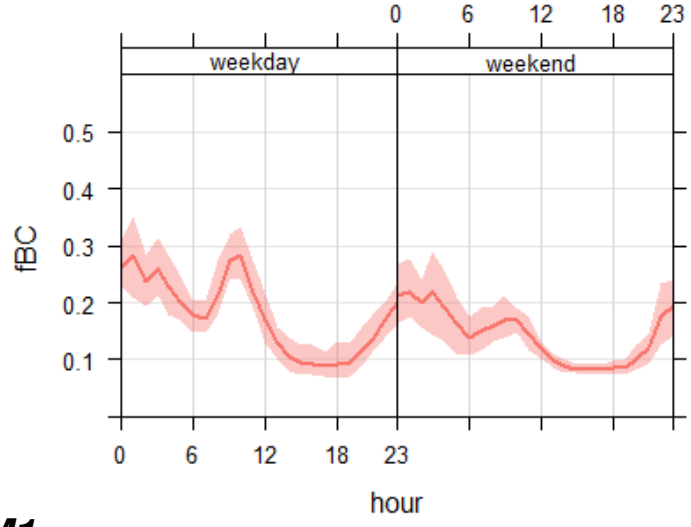
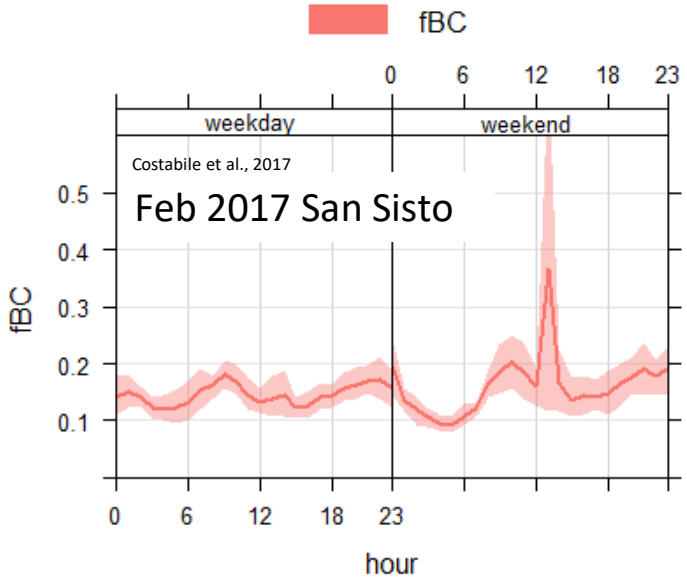


Frazione in massa di BC sul PM1



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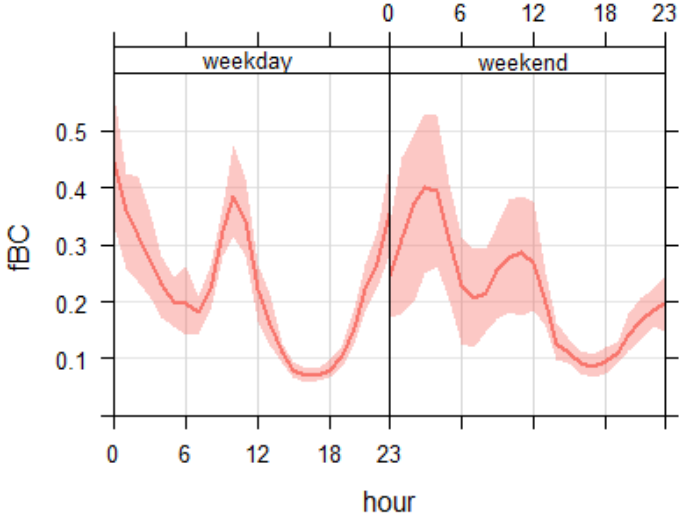

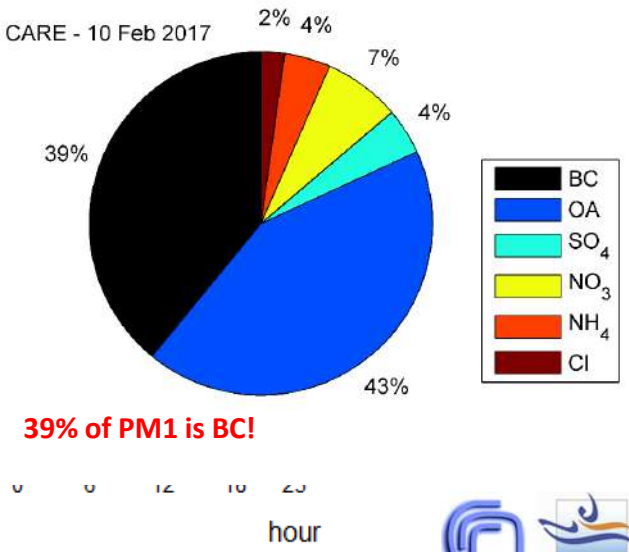

39% of PM1 is BC!

12 JAN 2023

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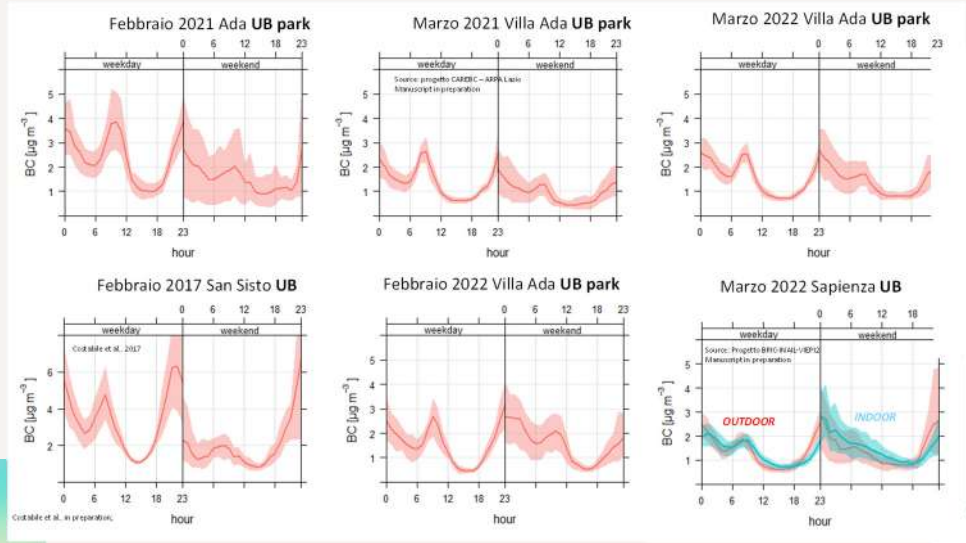
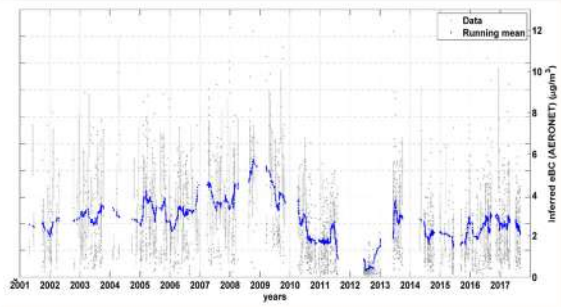
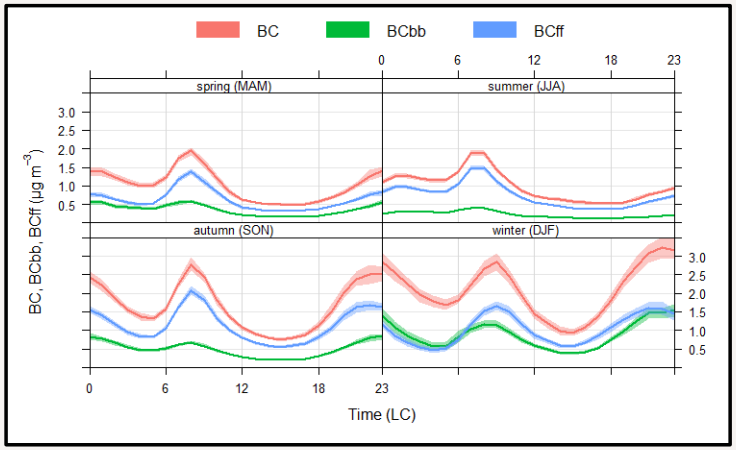
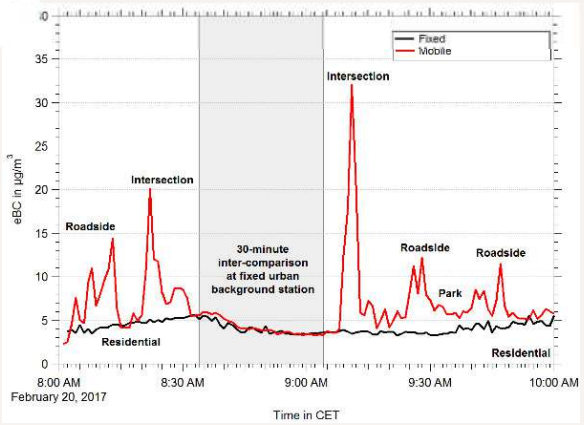
Conclusioni

Esiste un valore "diffuso" di concentrazione in massa di Black Carbon su tutta la citta' di Roma inferiore ad 1 $\mu g/m^3$ *, mentre i valori di "picco" possono variare di diversi ordini di grandezza.*







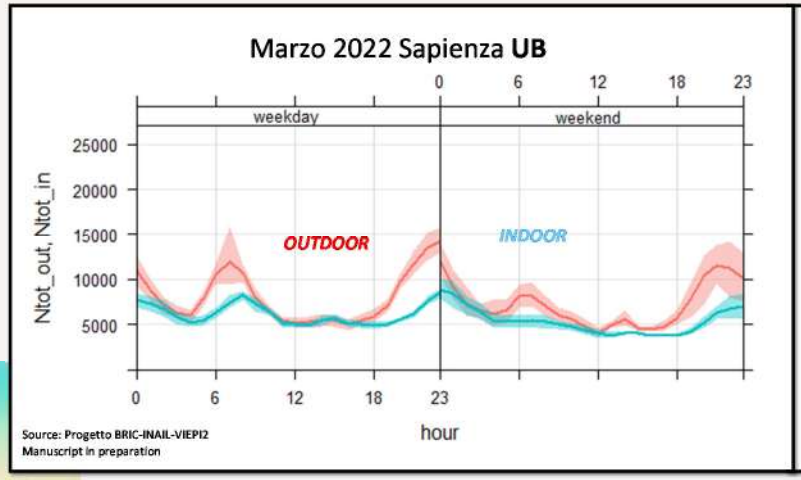


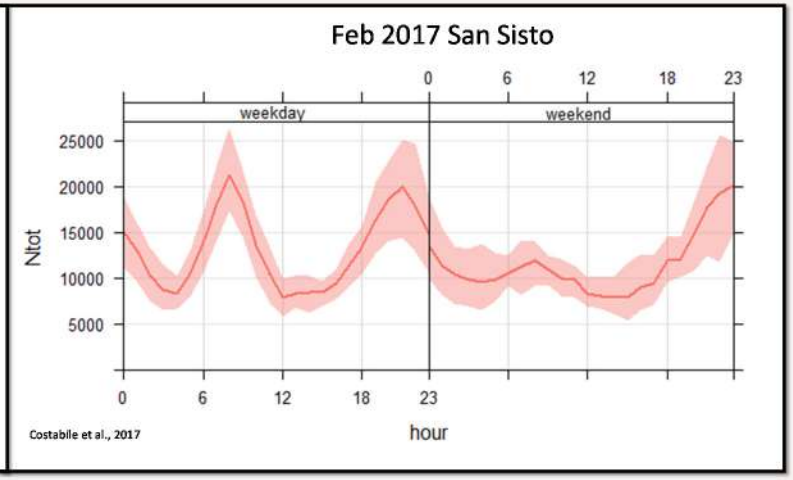
F. Costabile, L. Marinelli, G. Di Iulio

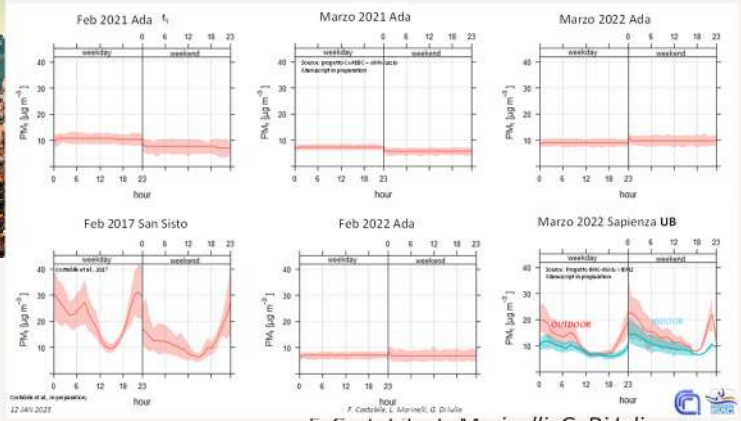
Conclusioni

Esiste un valore "diffuso" di concentrazione in massa di Black Carbon su tutta la citta' di Roma inferiore ad 1 $\mu g/m^3$, mentre i valori di "picco" possono variare di diversi ordini di grandezza.

Cio' non si applica ad altri inquinanti emergenti (e.g., UFPs) o convenzionali (e.g., PM1) nè ad altre metriche di BC



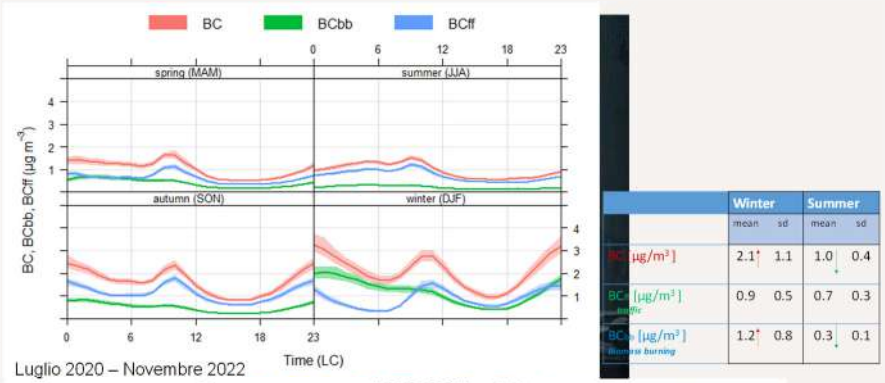




Villa Ada from 2023 ????

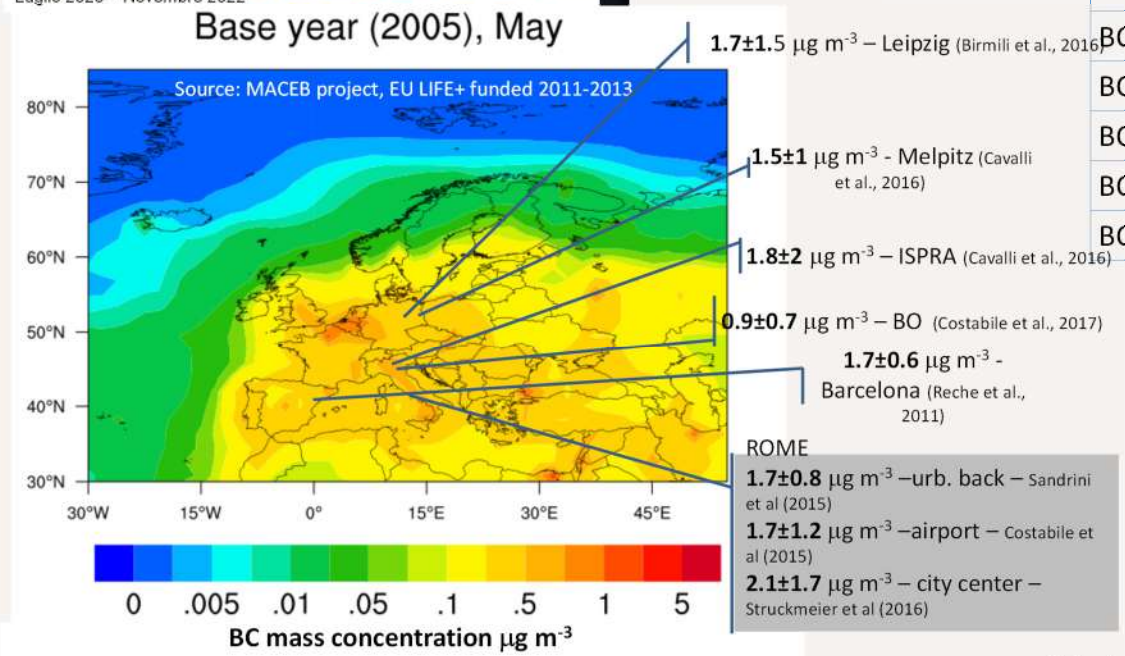
Conclusioni

Dal confronto con altre città, non appare che Roma abbia valori bassi di BC…



Luglio 2020 – Novembre 2022

	Winter		Summer	
	mean	sd	mean	sd
BC [µg/m³]	2.1	1.1	1.0	0.4
BCff [µg/m³]	0.9	0.5	0.7	0.3
BCbb [µg/m³]	1.2	0.8	0.3	0.1



1.7±1.5 µg m^{-3} – Leipzig (Birmili et al., 2016)

1.5±1 µg m^{-3} - Melpitz (Cavalli et al., 2016)

1.8±2 µg m^{-3} – ISPRA (Cavalli et al., 2016)

0.9±0.7 µg m^{-3} – BO (Costabile et al., 2017)

1.7±0.6 µg m^{-3} - Barcelona (Reche et al., 2011)

ROME

1.7±0.8 µg m^{-3} –urb. back – Sandrini et al (2015)

1.7±1.2 µg m^{-3} –airport – Costabile et al (2015)

2.1±1.7 µg m^{-3} – city center – Struckmeier et al (2016)

Variabile misurata [µg/m³]	Città	Periodo	Sito	Valor medio giornaliero µ [µg/m³]
BC	Rome	Feb 2017	UB	2.9
BC	Rome	Lug 2020 – Mag 2022	UB	1.5
BC	London	Anno 2009	UB	1.9
BC	Barcelona	Anno 2009	UB	1.7
BC	Kenitra	Lug 2020 – Feb 2021	U	0.9
BC	Lugano	Anno 2009	UB	1.8
BC	Huelva	Anno 2009	UB	0.7
BC	Shanghai	Giu 2016 – Giu 2017	SU	2.1
BC	North Kensington	Anno 2009	UB	1.9
BC	Xi'an	Nov 2019 – Dic 2019	U/R	6.0
BC	Addis Abeba	Nov 2015 – Nov 2016	U/R	13.7

Benchrif, Costabile et al., 2022; Costabile et al., 2017;

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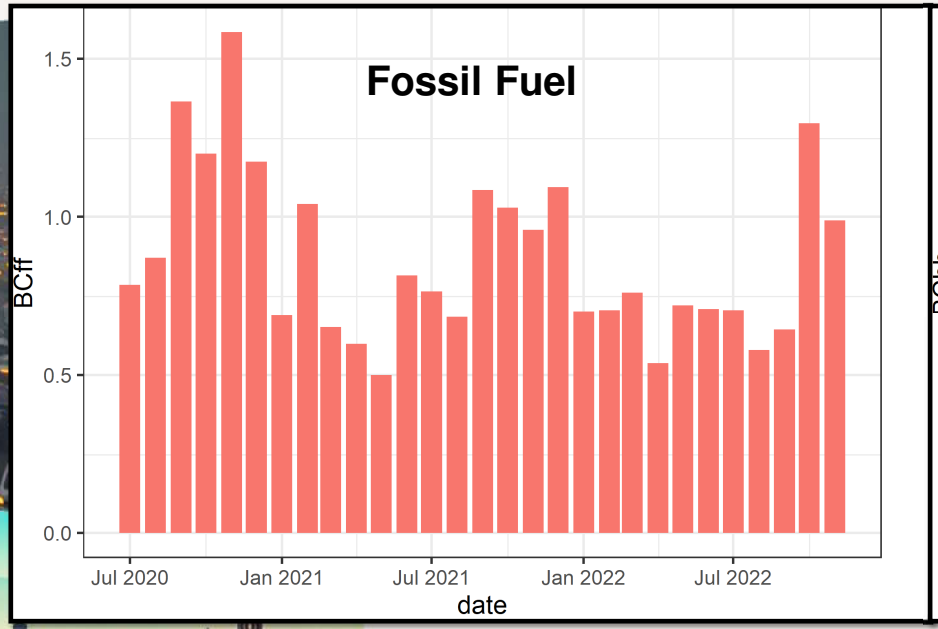
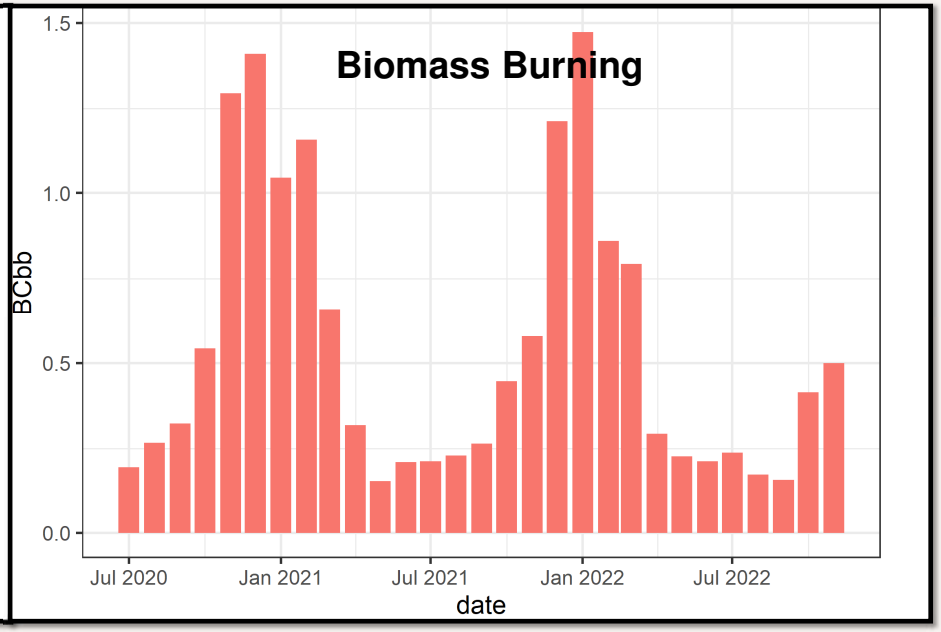
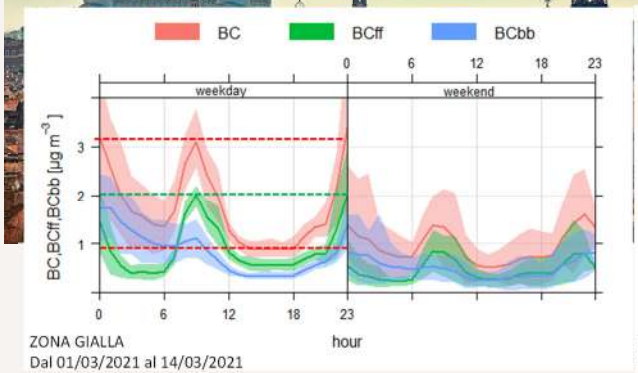
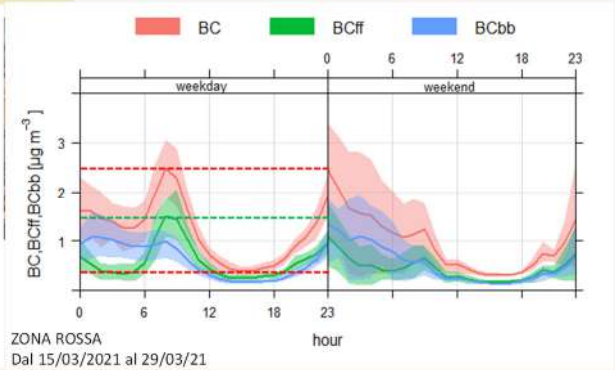
Conclusioni

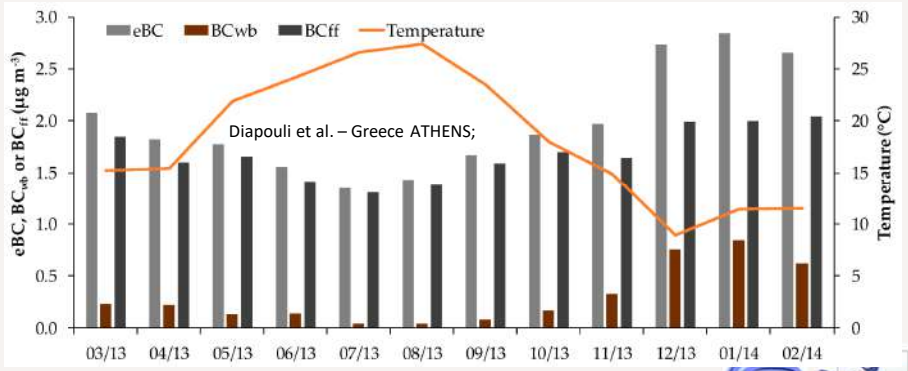
Contributi principali a Roma: traffic e biomass burning → marcato ciclo diurno, settimanale, stagionale





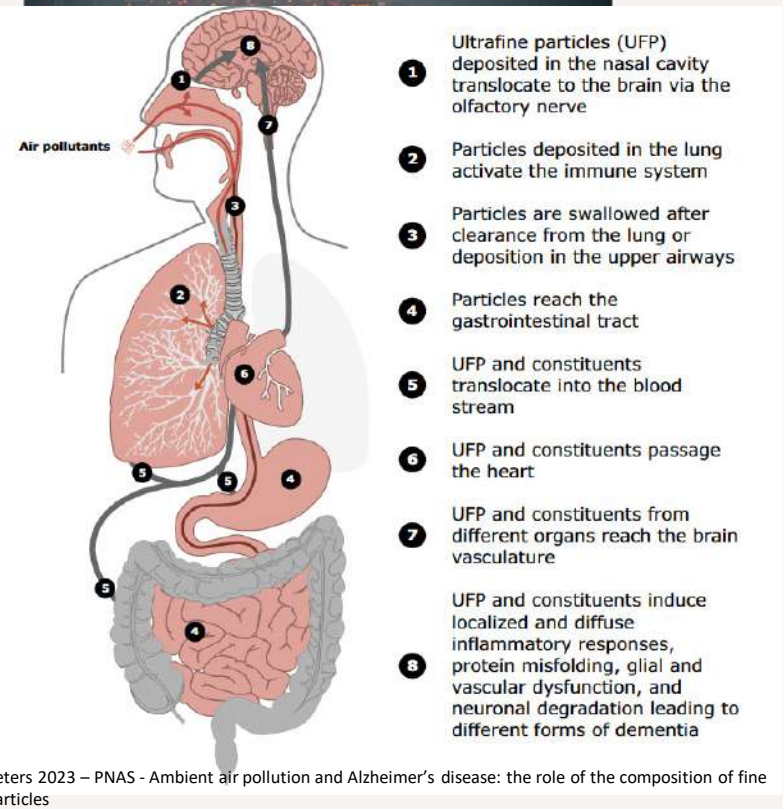






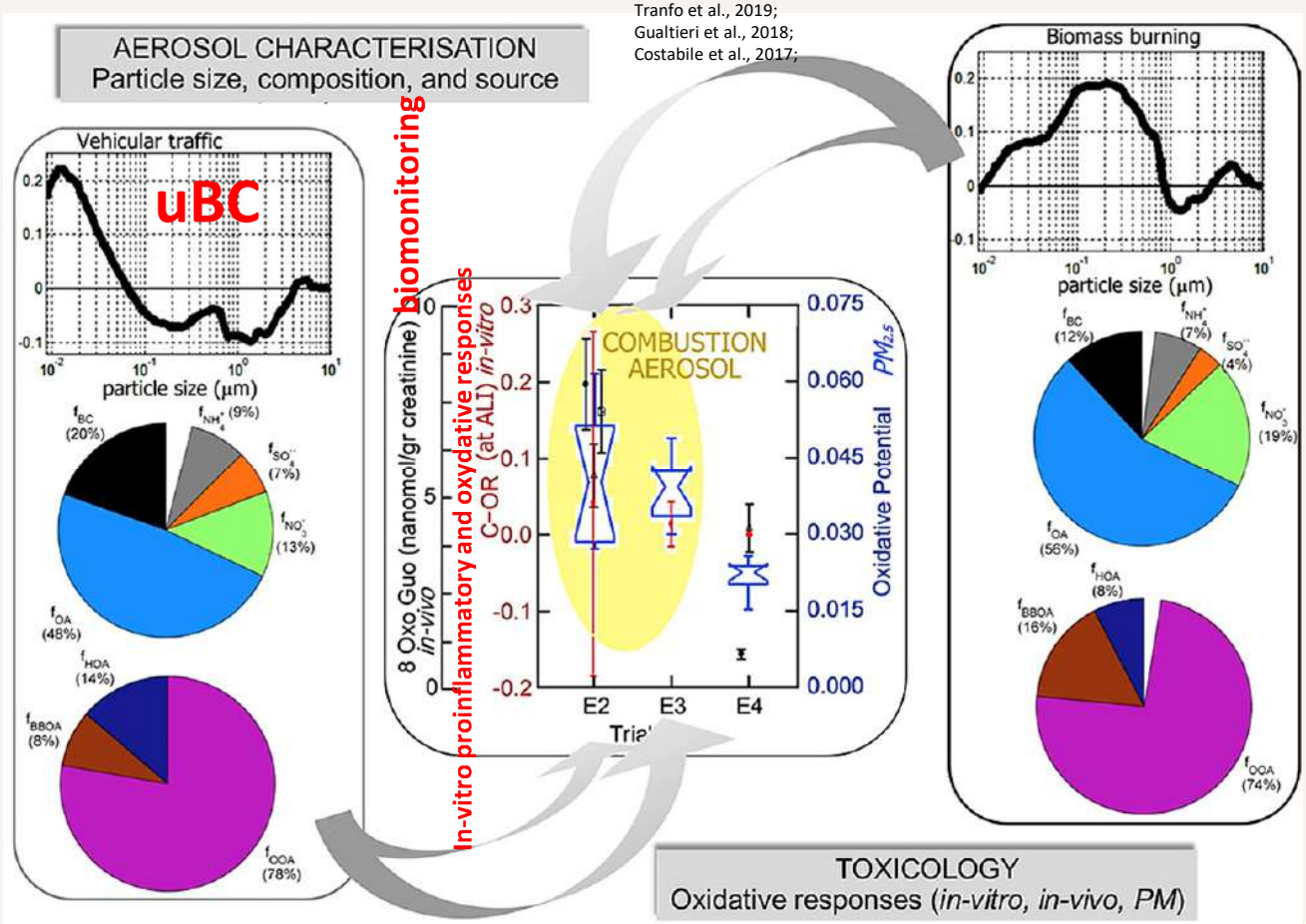
Conclusioni

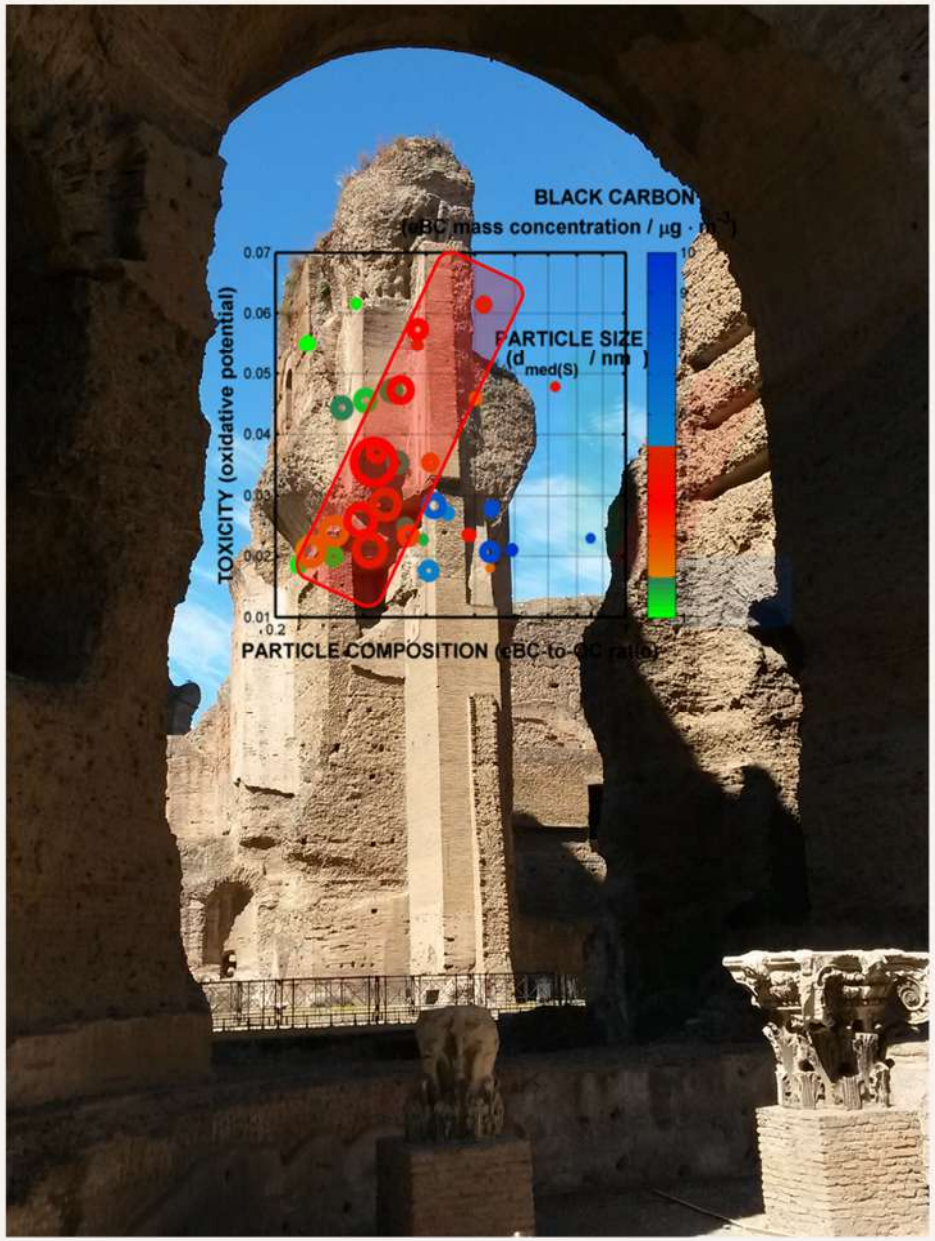
Non esiste una sola metrica (unica) per tutti gli effetti sulla salute



Peters 2023 – PNAS - Ambient air pollution and Alzheimer's disease: the role of the composition of fine particles

Costabile et al., 2020;
Manigrasso et al., 2020;
Costabile et al., 2019;
Tranfo et al., 2019;
Gualtieri et al., 2018;
Costabile et al., 2017;





Q&A

Grazie per l'attenzione

Costabile, F., Marinelli, L., Di Iulio, G.
f.costabile@isac.cnr.it

Acknowledgments

- Progetto CareBC - ARPA LAZIO - Unità aria e agenti fisici di Roma e l'Unità centro regionale della qualità dell'aria
- Progetto BRIC-INAIL-VIEPI2 per le misure indoor
- Progetto CARE

12 JAN 2023

Health effects of atmospheric aerosol

atmosphere — MDPI

Received: 9 April 2020; Accepted: 10 April 2020; Published: 13 April 2020

Editorial

Does Air Pollution Influence COVID-19 Outbreaks?

Daniele Contini [1,*] and Francesca Costabile [2]

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atmosphere

Open Access Article

First Results of the "Carbonaceous Aerosol in Rome and Environs (CARE)" Experiment: Beyond Current Standards for PM_{10}

by Francesca Costabile [1,*], Honey Alas [2], Michaela Aufderheide [3], Pasquale Avino [4,5], Fulvio Amato [6], Stefania Argentini [7], Francesca Barnaba [7], Massimo Berico [7], Vera Bernardoni [8], Riccardo Bionda [1], Gianpietro Casasanta [7], Spartaco Ciampichetti [1], Giulia Calzolai [9], Silvia Canepari [10], Alessandro Conidi [1], Eugenia Cordelli [11], Antonio Di Ianni [1,12], Luca Di Liberto [1], Maria Cristina Facchini [13], Andrea Facci [12] + Show full author list

Evidence of association between aerosol properties and in-vitro cellular oxidative response to PM_1, oxidative potential of $PM_{2.5}$, a biomarker of RNA oxidation, and its dependency on combustion sources

F. Costabile[a,*], M. Gualtieri[b], S. Canepari[c], G. Tranfo[d], C. Consales[c], M.G. Grollino[c], E. Paci[d], E. Petralia[e], D. Pigini[d], G. Simonetti[c]

Chemosphere 207 (2018) 552–564

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International Journal of *Environmental Research and Public Health*

MDPI

Article

Levels of Urinary Biomarkers of Oxidatively Generated Damage to DNA and RNA in Different Groups of Workers Compared to General Population

Giovanna Tranfo [1,*], Enrico Paci [1], Mariella Carrieri [2], Enrico Marchetti [1], Renata Sisto [1], Monica Gherardi [1], Francesca Costabile [3], Lisa Bauleo [4], Carla Ancona [4] and Daniela Pigini [1]

Is it the time to study air pollution effects under en conditions? A case study to support the shift of *in vitro* toxicology from the bench to the field.

Maurizio Gualtieri [a,*], Maria Giuseppa Grollino [b], Claudia Consales [b], Francesca Costabile [c], Maurizio Manigrasso [d], Pasquale Avino [d,g], Michaela Aufderheide [f], Eugenia Cordelli [b], Luca Di Liberto [c], Ettore Petralia [a], Giuseppe Raschellà [b], Milena Stracquadanio [a], Alfred Wiedensohler [e], Francesca Pacchierotti [b], Gabriele

atmosphere

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Article

Ultrafine Particle Features Associated with Pro-Inflammatory and Oxidative Responses: Implications for Health Studies

Environment International 141 (2020) 105714

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Size resolved aerosol respiratory doses in a Mediterranean urban area: From PM_{10} to ultrafine particles

Maurizio Manigrasso[b,*], Francesca Costabile[b], Luca Di Liberto[b], Gian Paolo Gobbi[b], Maurizio Gualtieri[c], Gabriele Zanini[c], Pasquale Avino[d]

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Article

On the Redox-Activity and Health-Effects of Atmospheric Primary and Secondary Aerosol: Phenomenology

Francesca Costabile [1,*], Stefano Decesari [2], Roberta Vecchi [3], Franco Lucarelli [4,5], Gabriele Curci [6,7], Dario Massabò [8], Matteo Rinaldi [2], Maurizio Gualtieri [9,†], Emanuela Corsini [10], Elena Menegola [11], Silvia Canepari [12], Lorenzo Massimi [12], Stefania Argentini [1], Maurizio Busetto [2], Gianluca Di Iulio [1], Luca Di Liberto [1], Marco Paglione [2], Igor Petenko [1], Mara Russo [2], Angela Marinoni [2], Gianpietro Casasanta [1], Sara Valentini [2], Vera Bernardoni [8], Federica Crova [2], Gianluigi Valli [3], Alice Corina Forello [4], Fabio Giardi [4], Silvia Nava [4,5], Giulia Pazzi [4], Paolo Prati [8], Virginia Vernocchi [8], Teresa La Torretta [8], Ettore Petralia [1], Milena Stracquadanio [9], Gabriele Zanini [4], Gloria Melzi [10], Emma Nozza [1,10], Martina Iulini [10], Donatella Caruso [10], Lucia Cioffi [10], Gabriele Imperato [10], Flavio Giavarini [10], Maria Battistoni [1,11], Francesca Di Renzo [11], Maria Agostina Frezzini [12], Cinzia Perrino [13] and Maria Cristina Facchini [2]

Ultrafine particles and black carbon

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www.atmos-chem-phys.net/9/3163/2009/
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Atmospheric Chemistry and Physics

Spatio-temporal variability and principal components of the particle number size distribution in an urban atmosphere

F. Costabile[1,2], W. Birmili[1], S. Klose[1], T. Tuch[1,3], B. Wehner[1], A. Wiedensohler[1], U. Franck[3], K. König[1], and A. Sonntag[1]

[1]Leibniz Institute for Tropospheric Research (IfT), Permoserstrasse 15, 04318 Leipzig, Germany
[2]National Research Council, Institute for Atmospheric Pollution (CNR), via Salaria km 29, 00016 Rome, Italy
[3]Helmholtz Center for Environmental Research (UFZ), Permoserstrasse 15, 04318 Le

Atmospheric Environment 44 (2010) 5298–5308

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ATMOSPHERIC ENVIRONMENT

Sub-μm particle size distributions in a suburban Mediterranean area. Aerosol populations and their possible relationship with HONO mixing ratios

F. Costabile[a,b,*], A. Amoroso[b], F. Wang[c]

[a]CNR-ISAC, via Fosso del Cavaliere, Rome, Italy

Atmos. Meas. Tech., 12, 4697–4712, 2019
https://doi.org/10.5194/amt-12-4697-2019
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Atmospheric Measurement Techniques

EGU

Atmospheric Chemistry and Physics Discussions

Methodology for high-quality mobile measurement with focus on black carbon and particle mass concentrations

Honey Dawn C. Alas[1], Kay Weinhold[1], Francesca Costabile[2], Antonio Di Ianni[2], Thomas Müller[1], Sascha Pfeifer[1], Luca Di Liberto[2], Jay R. Turner[3], and Alfred Wiedensohler[1]

Traffic and nucleation events as main sources of ultrafine particles in high-insolation developed world cities

M. Brines[1,2], M. Dall'Osto[3,4], D. C. S. Beddows[4], R. M. Harrison[4,5], F. Gómez-Moreno[6], L. Núñez[6], B. Artiñano[6], F. Costabile[7], G. P. Gobbi[7], F. Salimi[8], L. Morawska[8], C. Sioutas[9], and X. Querol[1]

PNAS

CrossMark

Direct observation of aqueous secondary organic aerosol from biomass-burning emissions

Stefania Gilardoni[a,1], Paola Massoli[b], Marco Paglione[a], Lara Giulianelli[a], Claudio Carbone[a,2], Matteo Rinaldi[a], Stefano Decesari[a], Silvia Sandrini[a], Francesca Costabile[c], Gian Paolo Gobbi[c], Maria Chiara Pietrogrande[d], Marco Visentin[d], Fabiana Scotto[c], Sandro Fuzzi[a], and Maria Cristina Facchini[a]

[a]Italian National Research Council–Institute of Atmospheric Sciences and Climate, 40129 Bologna, Italy; [b]Aerodyne Research Inc., Billerica, MA 01821; [c]Italian National Research Council–Institute of Atmospheric Sciences and Climate, 00133 Rome, Italy; [d]Department of Chemical and Pharmaceutical Sciences, University of Ferrara, 44121 Ferrara, Italy; and [e]Agenzia Regionale per la Prevenzione, l'Ambiente e l'Energia, 40139 Bologna, Italy

Air quality in megacities

Atmos. Chem. Phys., 12, 7737–7752, 2012
www.atmos-chem-phys.net/12/7737/2012/
doi:10.5194/acp-12-7737-2012
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Atmospheric Chemistry and Physics

Summertime photochemistry during CAREBeijing-2007: RO_x budgets and O_3 formation

Z. Liu[1,*], Y. Wang[1], D. Gu[1], C. Zhao[1,**], L. G. Huey[1], R. Stickel[1], J.Liao[1], M. Shao[2], T. Zhu[2], L. Zeng[2], A. Amoroso[3], F. Costabile[3], C.-C. Chang[4], and S.-C. Liu[5]

[1]School of Earth and Atmospheric Science, Georgia Institute of Technology, Atlanta, GA, USA
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Evidence of Reactive Aromatics As a Major Source of Peroxy Acetyl Nitrate over China

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ATMOSPHERIC ENVIRONMENT

A preliminary assessment of major air pollutants in the city of Suzhou, China

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