Work Package 2

Roy Harrison and Gerard Hoek
Work Package Leaders
with many other hard-working scientists

Work Package 2

T2.1. Improved evaluation of health effects in epidemiologic time series studies
T2.2. Evaluation of oxidative potential (OP)
T2.3. Mobile monitoring of nanoparticles and citizen observatories to improve evaluation of health effects of long-term exposure
T2.4. WP2 synergy to support WP3 and SPs 2-3 for exposure and health effects assessment

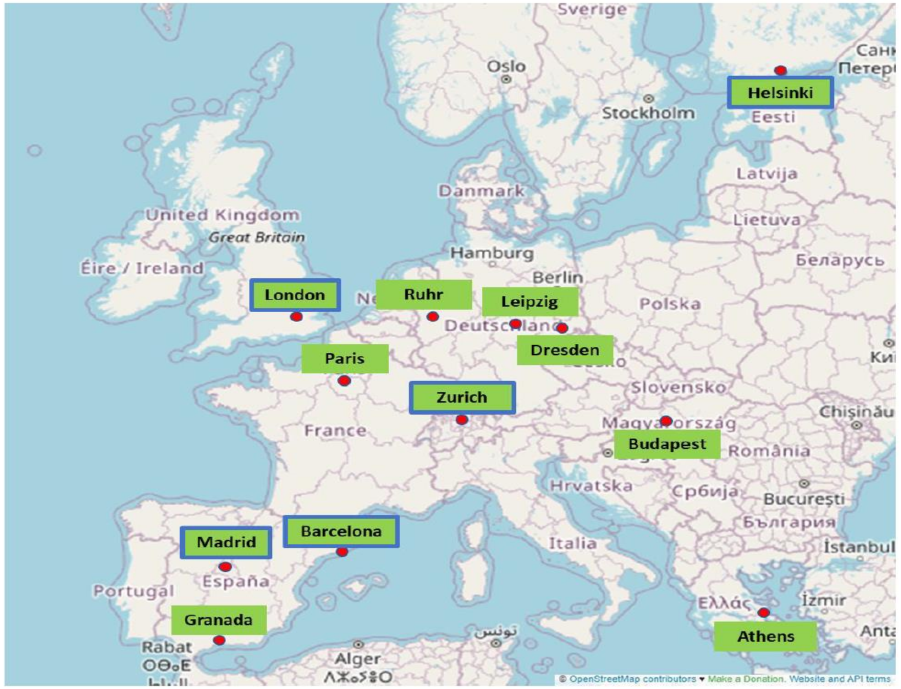
Task 2.1.
Short-term exposure to novel pollutants and health outcomes

Vanessa Nogueira, Ioar Rivas, Xavier Basagaña

RI-URBANS (101036245)

RiURBANS Science meeting, 08-09th September 2025

Task 2.1: Study the short-term associations between novel pollutants and mortality and hospital admissions



Based on long-term AQ measurements: [2009 – 2019]

Mortality + hospital admission data

Particle Number (#/cm^3)
- Nucleation [10-25 nm]
- Aitken [25-100 nm]
- UFP [10-100 nm]
- Accumulation [>100 nm]
- Ntotal [> 10 nm]

Particle Mass (µg/m^3)
- BC
- BC sources
- PM_1
- $PM_{2.5}$
- PM_{10}
- PMcoarse (PM_{10}-$PM_{2.5}$)

Oxidative Potential (OP) (nmol min^{-1}µg^{-1}, nmol min^{-1} m^{-3})
- From PM_1, $PM_{2.5}$ and PM_{10}
- DTT assay
- AA assay

Regulated gases (µg/m^3)
- NO_2
- SO_2
- O_3

+ many other pollutants
(e.g. sources of UFP, sources of BC, sources of OP)

Summary of results – task 2.1

Lags highlighted in green indicate associations that remained significant in at least one of the two-pollutant models. Red indicates a protective effect.

Associations with mortality

	Single pollutant			Two-pollutant [$PM_{2.5}$]			Two-pollutant [NO_2]			Two-pollutant [UFP]		
	Nat	CVD	Resp	Nat	CVD	Resp	Nat	CVD	Resp	Nat	CVD	Resp
PNSD modes												
Nucleation	6			0-2					7			
Aitken		5, 6, 4-7					7					
UFP		5, 6, 4-7		2, 2-3								
Accumulation		5										
Ntotal		5, 6, 4-7		2, 2-3								
PNSD sources												
Photonucleation	0, 0-1	0				4						
Traffic nucleation										6	5, 6	
Traffic gasoline		6										
Traffic diesel			4-7									
Mixed traffic		5		3, 2-3								
Total traffic		5, 4-7										
Urban background	0, 0-1		0, 7, 4-7				0, 1, 5, 0-1, 0-2, 4-7		0, 7, 4-7			
Regional nitrate						3, 4, 6, 4-7	6		7, 4-7		4-7	
Regional background	0	2										

Associations with hospitalisations

	Single pollutant		Two-pollutant [$PM_{2.5}$]		Two-pollutant [NO_2]		Two-pollutant [UFP]	
	CVD	Resp	CVD	Resp	CVD	Resp	CVD	Resp
PNSD modes								
Nucleation		5		5, 2-3				
Aitken		5, 6, 7, 4-7			3, 5, 2-3			
UFP		5, 6, 7, 4-7		6				
Accumulation		4, 5, 6, 4-7			0			
Ntotal		5, 6, 7, 4-7		6				
PNSD sources								
Photonucleation		2, 2-3	4-7				2, 2-3	0, 6
Traffic nucleation	5			5, 7, 2-3, 4-7	5			4, 6, 7, 4-7
Traffic gasoline		7	5, 7, 4-7	6, 7, 4-7	7	5, 6, 7, 4-7		0, 0-1
Traffic diesel		6, 4-7		3, 4, 5, 6, 0-2, 2-3, 4-7		5, 6, 0-2, 4-7	4	1, 0-1
Mixed traffic		6, 7, 0-1, 0-2	4-7			0-1, 0-2, 2-3		
Total traffic		6, 7, 4-7	5	3, 4, 5, 6, 0-2, 2-3, 4-7		5, 6, 7, 4-7		
Regional nitrate	0, 1, 7, 0-1, 0-2, 4-7	6, 7, 4-7	2, 2-3		0, 1, 0-1, 0-2		2	0, 2, 0-1, 0-2, 2-3
Regional background				6, 7, 4-7	0		0	0, 5, 6, 7, 0-1, 4-7

Several PNSD modes and sources were positively associated with adverse health effects, particularly on respiratory hospitalisations, remaining significant after adjusting for co-pollutants

Summary of results – task 2.1

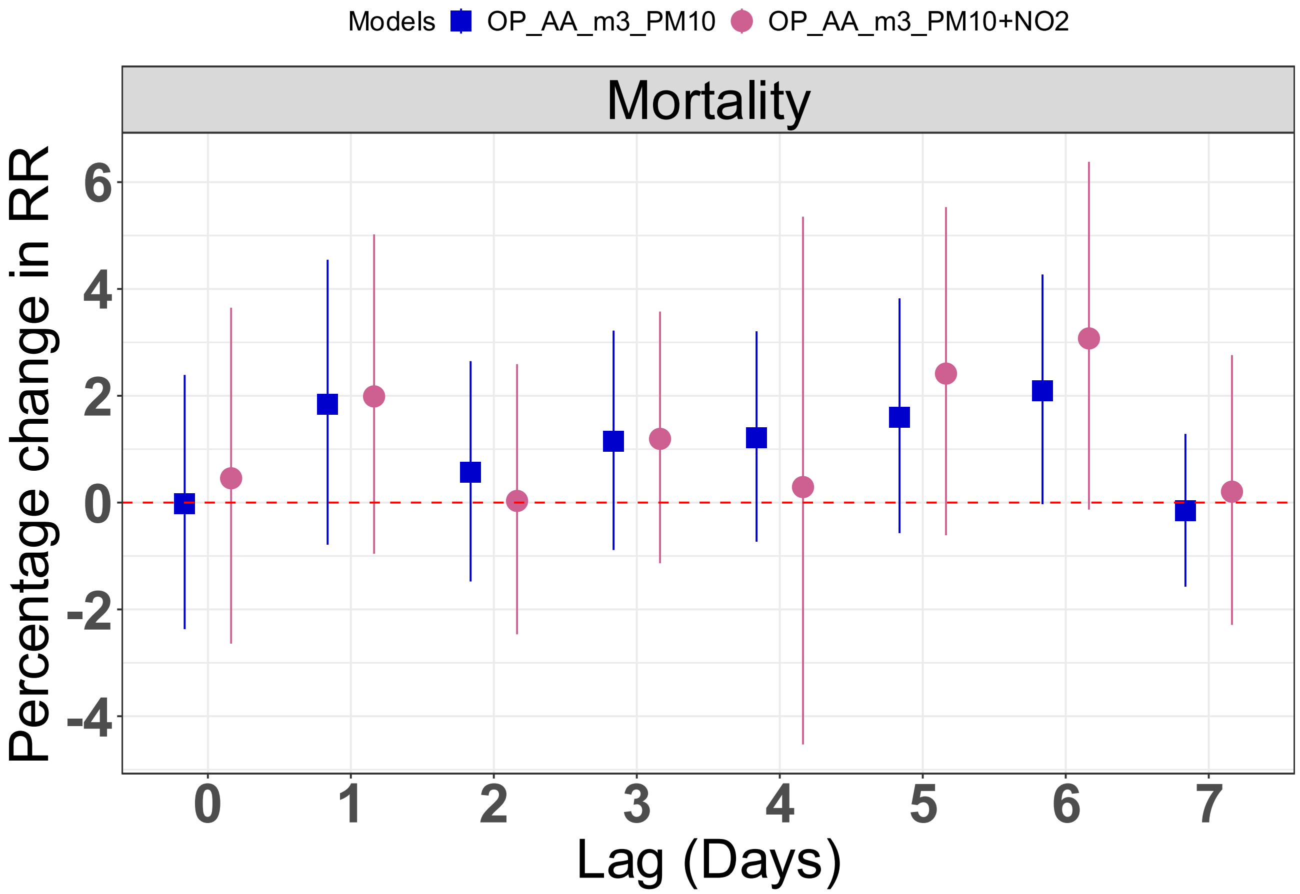
Associations with mortality												
	Single pollutant			Two-pollutant [$PM_{2.5}$]			Two-pollutant [NO_2]			Two-pollutant [UFP]		
	Nat	CVD	Resp	Nat	CVD	Resp	Nat	CVD	Resp	Nat	CVD	Resp
Total LDSA		5		2								
eBC			2, 2-3			4						
eBCRC	7	4, 5, 4-7			7		0, 0-1			0, 0-1		
eBCT												
$PM_{2.5}$	0		5, 4-7				0, 2, 0-1, 2-3		5			5
PM_{10}			0, 5	7, 4-7	2, 0-2				5			5
NO_2	4-7			0, 2, 0-1, 2-3		5						

Associations with hospitalisations								
	Single pollutant		Two-pollutant [$PM_{2.5}$]		Two-pollutant [NO_2]		Two-pollutant [UFP]	
	CVD	Resp	CVD	Resp	CVD	Resp	CVD	Resp
Total LDSA		4, 5, 6, 4-7						
eBC	2, 2-3	7	5	3, 4, 5, 6, 7, 4-7	1, 2, 0-2			
eBCRC			0-1		0, 0-1			
eBCT		5, 0-2	0	2, 5		2, 0-2, 2-3		
$PM_{2.5}$	0, 2, 3, 0-2, 2-3				1		0-2	
PM_{10}	2, 3, 4, 2-3		7	0	3, 2-3		0-2	
NO_2		5, 6, 7, 4-7		7				3, 4, 5, 4-7

- For mortality, most of the positive **associations were for CVD,** but many lost significance when adjusted for a second pollutant, except for **eBCRC (CVD) and Urban background (resp).** Regarding conventional pollutants, **$PM_{2.5}$ and PM_{10}** were positively associated with respiratory mortality, but protective effects were also found for $PM_{2.5}$ and natural mortality.

- For **hospital admissions, more consistent results were seen** with respiratory admissions. Nucleation, UFP, Ntotal, Total Traffic, traffic gasoline, traffic diesel, eBC, eBCT, NO_2 showed associations at late lags (5 to 7). Protective associations were found between $PM_{2.5}$ and PM_{10} and CVD hospitalisations.

Pooled effects of oxidative potential (OP) on mortality



- Suggestion for elevated risk of mortality associated with OP from PM_{10} (AA), with similar results in single and two-pollutant models.
- Less clear associations when using the DTT assay.

Units: Volume expressed OP variables: nmol $min^{-1}m^{-3}$

Summary

- Some consistent associations were found between several PNSD modes and sources, and eBC and sources on adverse health outcomes such as respiratory hospitalisations. Traffic was indicated as an important contributor.

- Given the large number of tests, many associations may be due to pure chance.

Limitations: The number of cities included in the meta-analysis varied depending on the pollutant. Some associations may be due to pure chance given the large number of analyses.

Task 2.2 – International comparison of protocols for measuring the oxidative potential (OP) of PM

G. Uzu, A. Marsal, P. Dominutti, I. Mudway, A. Nenes, K. Bougiatioti , N. Mihalopoulos, D. Green, T. Madhbi, G.Hoek, R. Harrison, F.Cavalli, JP. Puteaux & ALL the participating groups

University of Grenoble Alpes / IRD - France

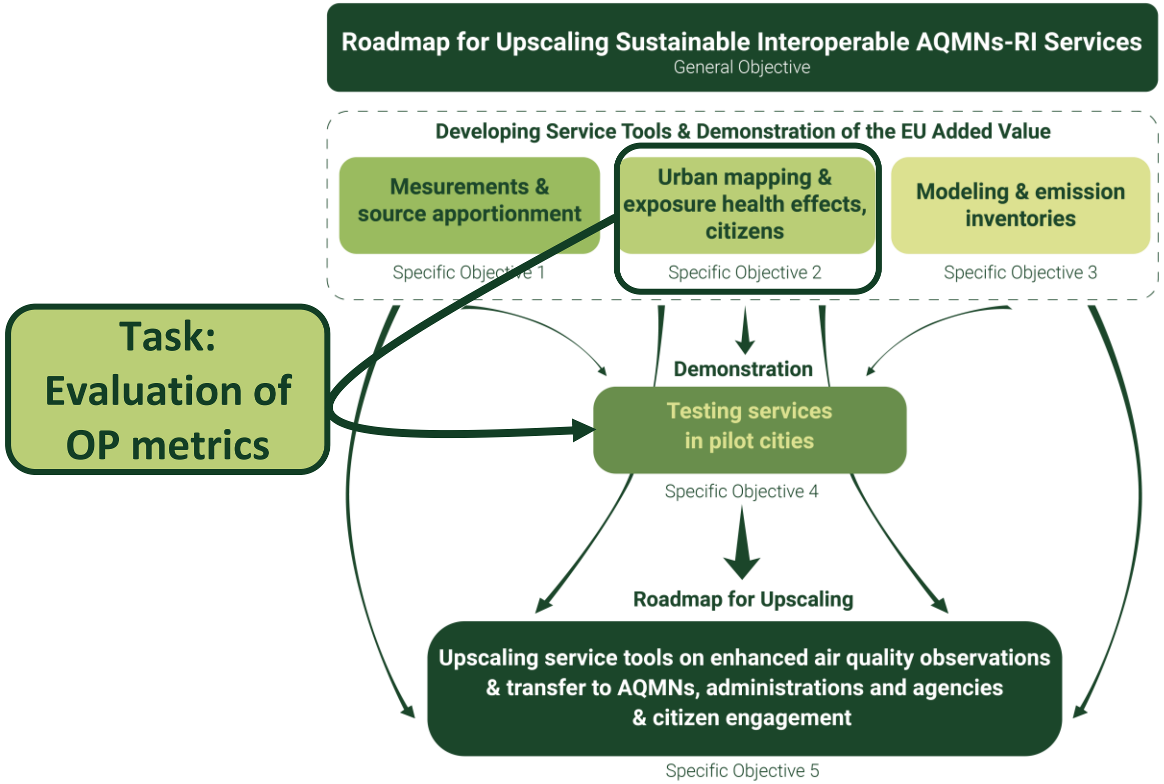
RI-URBANS (101036245)

Final Science Meeting, Barcelona September 8th, 2025

Context

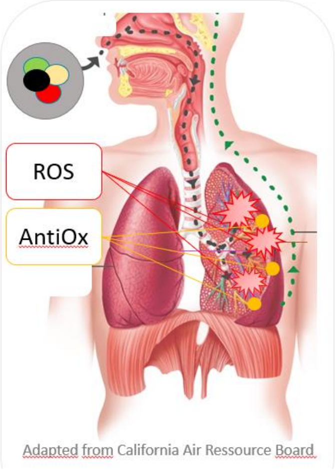
- The RI-URBANS' main objective is to demonstrate how **service tools** from atmospheric **research infrastructures** can be **adapted and enhanced in air quality monitoring networks** in an interoperable and sustainable way in EU.

- The European Directive 2024/2281 recommends additional monitoring of the oxidative potential of PM in supersites, which requires the use of harmonized measuring methods.



Context

OP measures the capacity of PM to generate ROS in vivo



- ✓Several offline methodologies
- ✓Several probes: AA, DTT, DCFH, GSH, FOX…
- ✓No standard test so far

Task 2.2. → 2 intercomparisons for the DTT (2023) and the AA (2025) tests

→ Evaluation of the extraction step for the 2nd intercomparison

Objectives

1) Develop common **simplified OP protocols** and evaluate the differences of OP results obtained by the RI-Urbans and OP home protocols.
2) Test results' **homogeneity** and investigate the potential **sources of discrepancies**

Results

https://doi.org/10.5194/amt-18-177-2025

	ILC1: DTT 2023	ILC2: AA 2025
Type of sample	Aqueous extracts 1,4-NQ, BB filter, traffic	Filter fragments (UB/BB, Winter UB, Traffic) + Powder: $CuSO_4$
Device	No restriction Plate-reader, cuvette, LWCC	SOP restricted to plate-readers and cuvette
Requirements	None → 18/20 SOP (9 cuvettes + 8 PR + 2 LWCC)	Mandatory to perform SOP → 26 SOP (10 cuvettes + 16 PR)

- ✓ ↓ uncertainties linked to **organising conditions** (homogeneity, stability, conservation)
- ✓ More participants → use of **all results** to evaluate participants' performance
- ✓ Evaluation of **extraction step**

- ✓ **Independent** data evaluation by the European Joint Research Centre (JRC)
- ✓ Very good repeatability between **extractions** in the ILC2 → 69% of participants with CV < 20% for filter samples
- ✓ **Less variability in the ILC2** than the ILC1 SOP protocol (77% vs. 33% with CV< 20% between replicates for all samples)
- ✓ Ranking of OP activity respected for 83% (3 samples) in the ILC1 and 73% (4 samples) in the ILC2

Results

ILC1

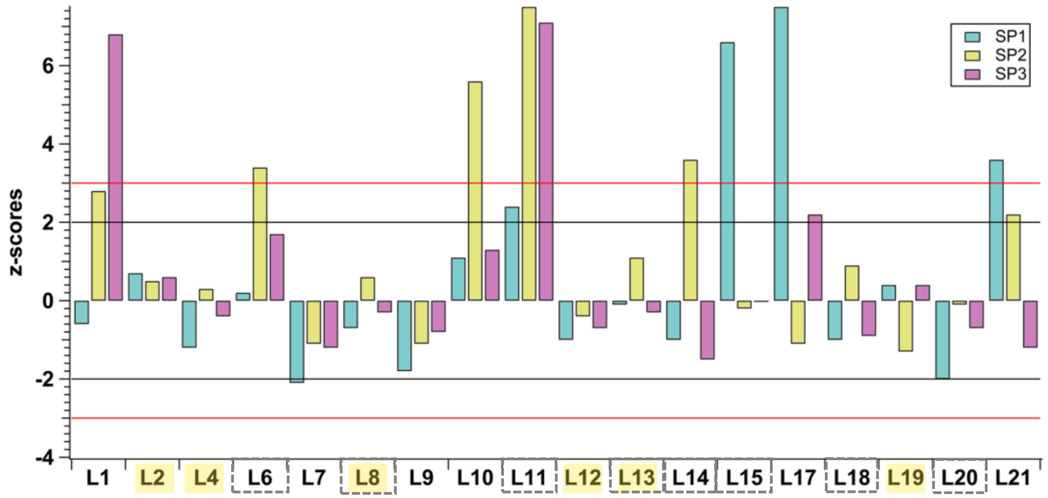
50% were in the satisfactory interval
No groups had an action signal for all 3 samples

ILC2

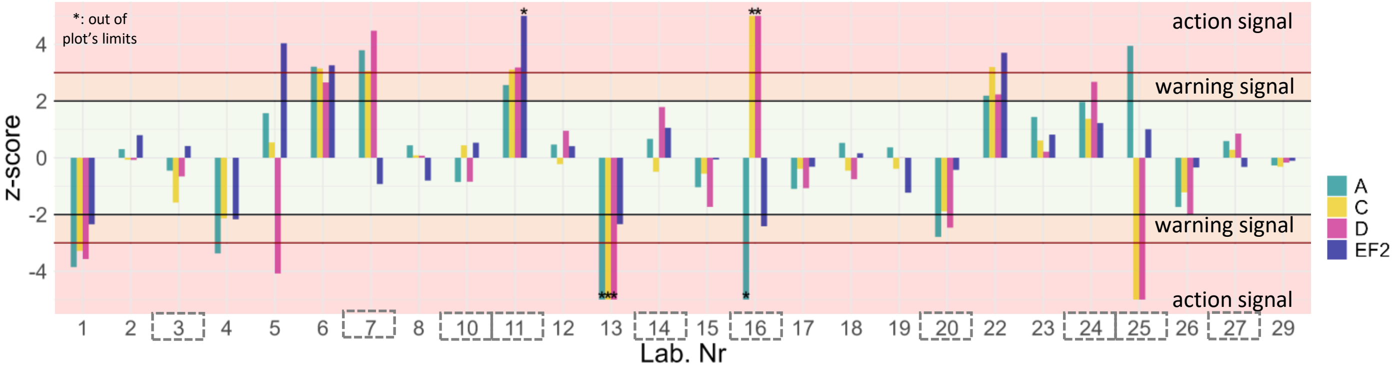
14 participants (54%) in the satisfactory interval
9 groups have an action signal for at least 2 samples

Modelling (multilinear regression models)

→ Only 1 sample/ILC tends to have greater OP values when measured with cuvettes compared to plate-readers
→ No clear effect of transit time and time before analysis in both ILCs



Satisfactory range: -2 ≤ z-score ≤ 2



cuvette

Conclusions

- Critical steps (extraction) added in the second intercomparison but **results are very promising**
- Results + community involvement = **encourages the standardisation of OP protocols**
- Some disparities in the results showing the measurement's sensitivity → **importance of training/expertise**
- Sample conservation and laboratory conditions (laminar hood, water quality…) are critical to ensure reproducible results

- The use of several OP tests in parallel remains recommended
- Future work should aim at defining OP of a reference material, along with a protocol of measurement

T2.3: Urban AQ mapping

Martine Van Poppel and Jelle Hofman

VITO

With contribution of T2.3 partners

RI-URBANS (101036245)

8 – 9 September 2025

T2.3 Urban AQ mapping

Mobile monitoring of nanoparticles and citizen observatories to improve evaluation of health effects

Summarize best practices
Selected methods to be tested

Collect feedback
on feasibility, added value
methodology

D2.5

Description of methodology for mobile monitoring and citizen involvement (M12)

Testing monitoring methods in
pilots

(T4.3 Urban fine scale mapping)

ROT, BIRM, BUCH

D2.6

Added value of mobile and citizens' observations for urban mapping and health (M36)

ST13: URBAN AQ MAPPING AND CITIZEN SCIENCE

European Commission
HORIZON 2020

PILOTS

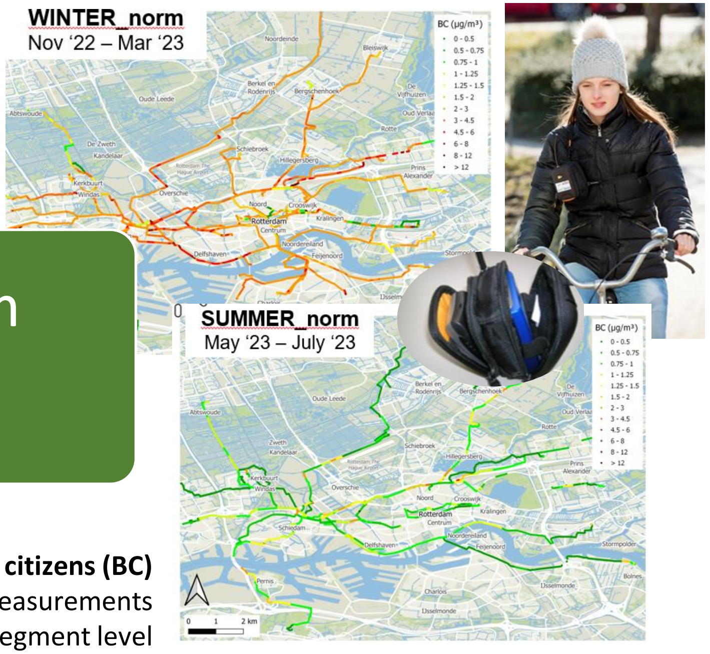
Birmingham (UK)

Fixed and mobile setups with citizens (UFP, BC, $PM_{2.5}$)
Involvement of local community (stationary), students (mobile)
ML used to predict $PM_{2.5}$ concentration
Case studies: neighborhood & street level AQ, prediction $PM_{2.5}$, indoor AQ

Mobile with citizens	Mobile without citizens
Fixed with citizens	Fixed without citizens

Rotterdam (NL)

Rotterdam (NL)



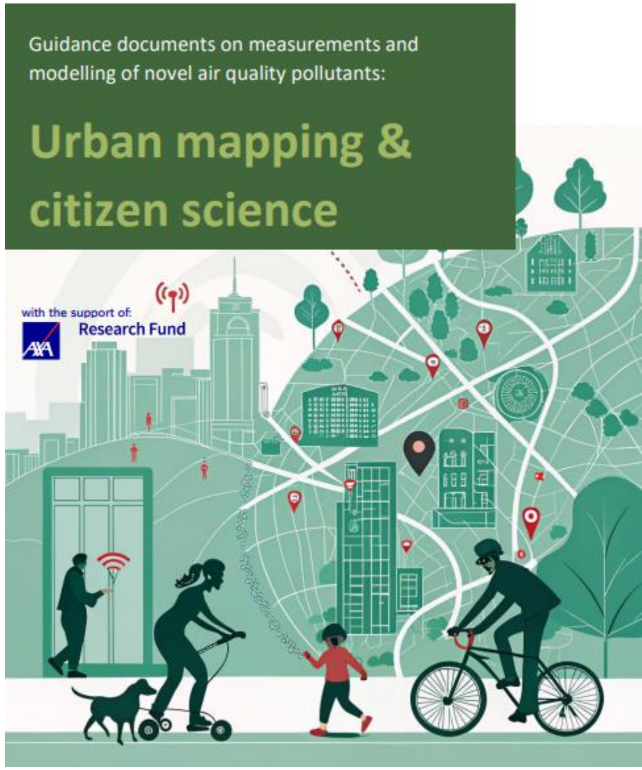
Mobile monitoring without citizens (UFP, BC, $PM_{2.5}$, NO_2)
Dedicated; two seasons, car with high-end equipment, repeated measurements aggregated over each 50 m street segment per day (~40000 segments)

Mobile monitoring with citizens (BC)
Opportunistic; two seasons, 38 participants, repeated measurements
n=4-21 individual route, up to n=65 at street segment level
Background normalization/winsorizing/Subsampling:
>15 repeats within season/>30 repeats cross-season

European Commission
HORIZON 2020
RI-URBANS (101036245)
RI URBANS

CONCLUSIONS and best practices

- Different approaches have been applied in pilot cities
    - Insights compiled in **ST13**
- Best practices:
    - With citizens
        - Valuable knowledge → domain experts
        - Single POC/communication is key/templates/on-site training
        - Provides a lot data!
    - Validation instruments
        - Co-location campaign
        - between instruments (BSU) + comparison against REF
        - ideally on-site/similar conditions
    - Data collection:
        - Dedicated vs opportunistic
        - Number of required repeats (>15 within season vs >30 multi-season)
    - Data analysis
        - Time/GPS synchronization
        - Data cleaning
        - Post-processing (Map matching/background normalization/winsorizing/…)
        - Number of required repeats (measurements only) vs model approach

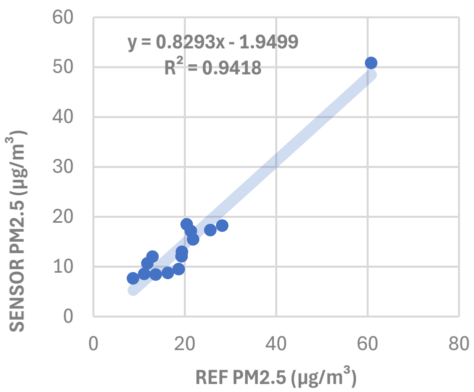


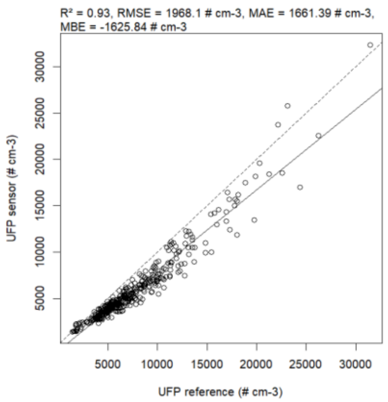
WARSAW

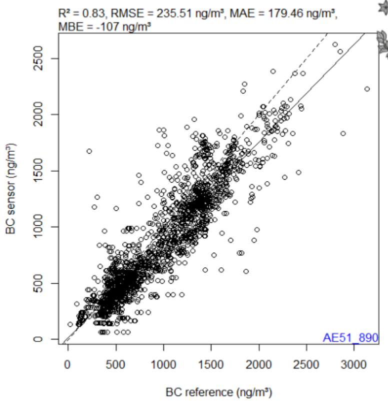
- Upscaling city → ST13
- Multi-pollutant: BC, UFP and PM
- Rush hours: 8-9h & 17-18h
- Co-location campaign
- Dedicated route (n=40)
    - Summer: 6/9 – 9/10
    - Winter: 22/1 – 5/3
- Pollutant maps + ratio’s
- Subsampling analysis

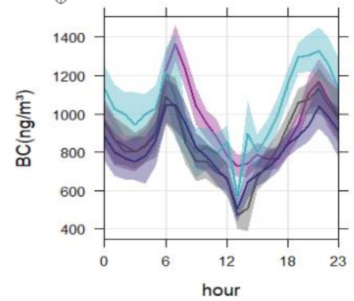
ATMO ACCESS
Access to Atmospheric Research Facilities

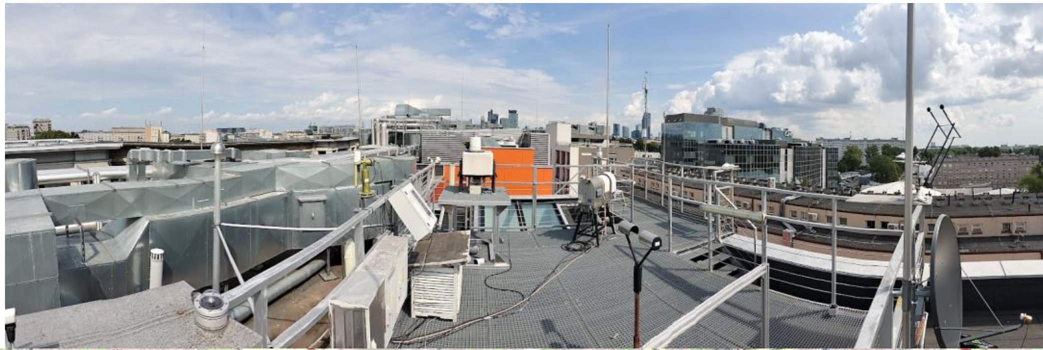
UNIVERSITY OF WARSAW

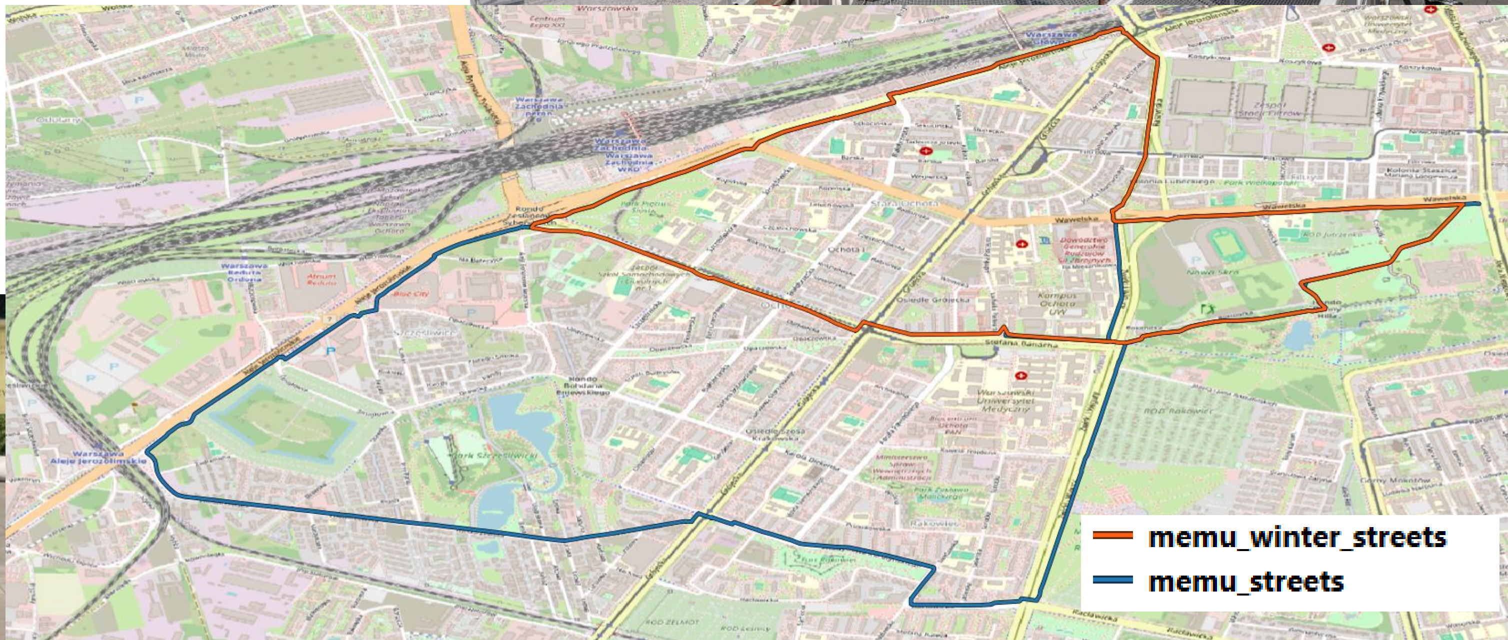




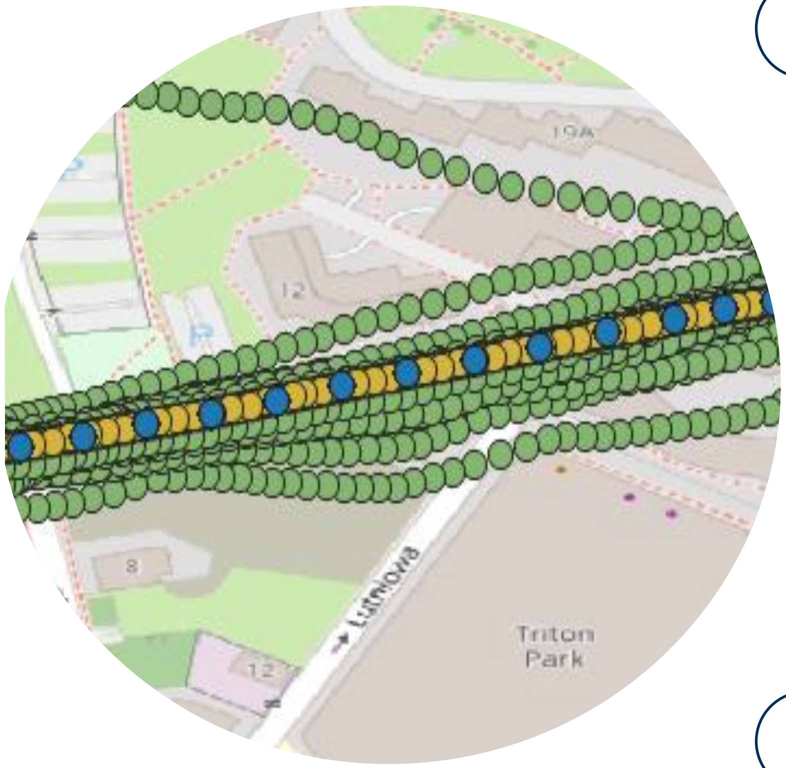








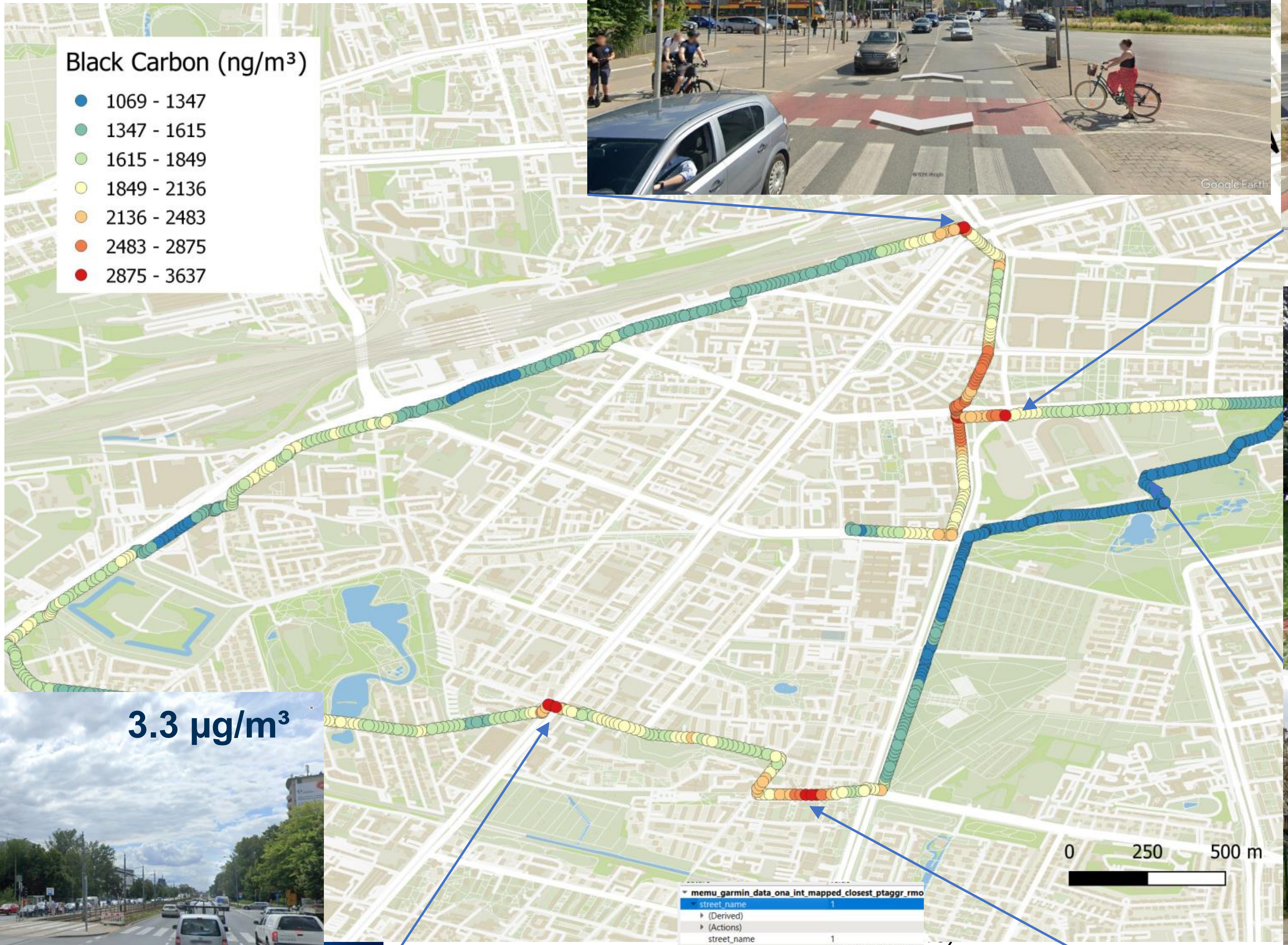
WARSAW



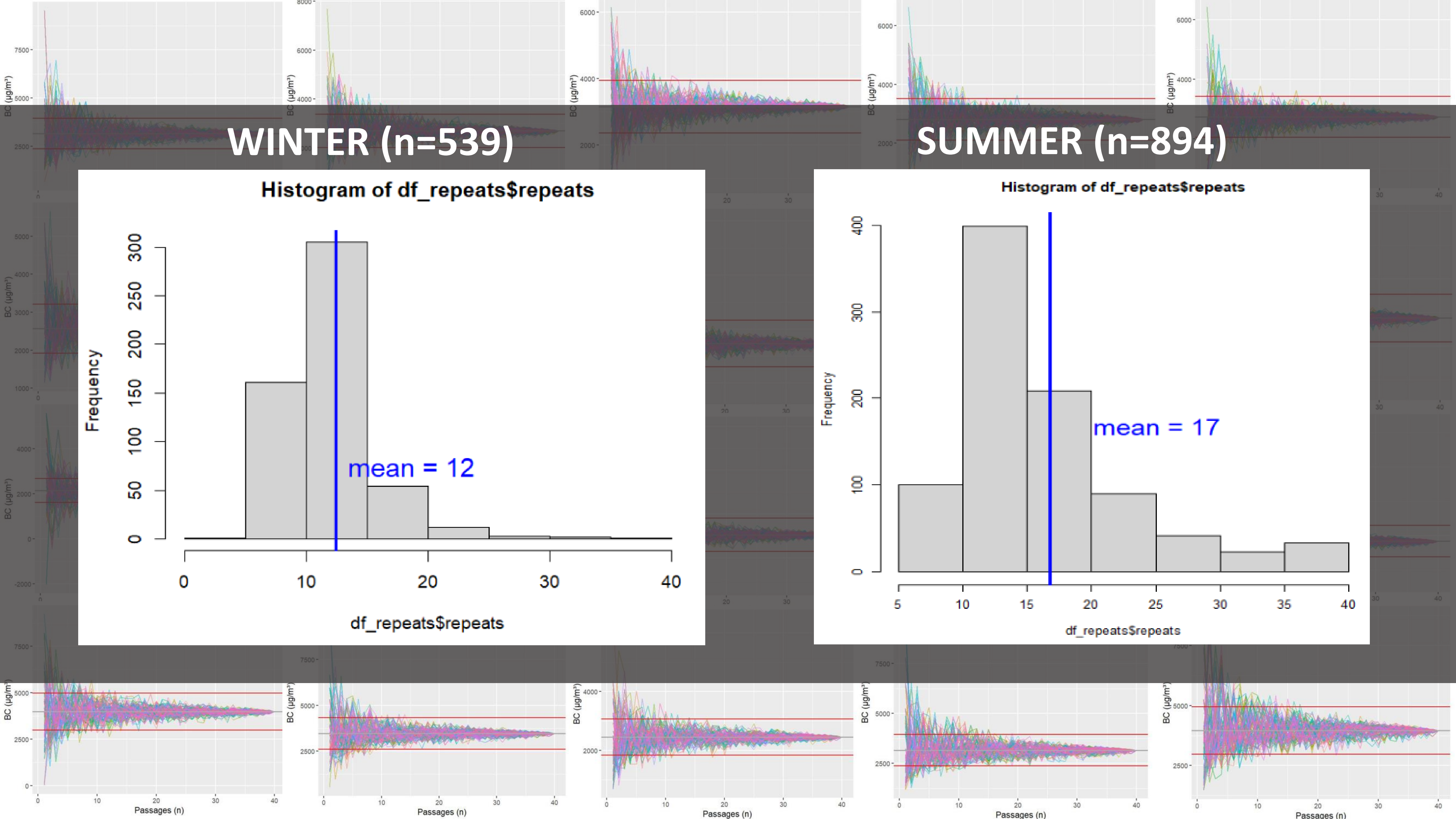
- SYNC GPS & MEASUREMENTS (1 SEC)
- NOISE CORRECTION BC (ONA)
- MATCH MEASUREMENTS TO SEGMENTS
- BACKGROUND NORMALISATION
- AGGREGATE MEASUREMENTS IN BUFFERS
- BUFFER AVERAGE FOR EVERY PASSAGE
- AVERAGE MULTIPLE PASSAGES

BC HOT/COLDSPOTS

AVG n=40



memu_garmin_data_ona_int_mapped_closest_ptaggr_rmo	
street_name	1
(Derived)	
(Actions)	
street_name	1
time_first	2024-09-06 08:23:43
time_last	2024-10-09 08:21:37
bc_aggr	3637
bc_aggr_min	635
bc_aggr_max	28143
bc_aggr_stddev	5243
number_of_passages	40
number_of_days_measured	23
mean_number_of_sec_meas	5
uncertainty_perc	0,52


WINTER (n=539)
SUMMER (n=894)
Histogram of df_repeats$repeats
Frequency
0 50 100 150 200 250 300
0 10 20 30 40
mean = 12
df_repeats$repeats
Histogram of df_repeats$repeats
Frequency
0 100 200 300 400
5 10 15 20 25 30 35 40
mean = 17
df_repeats$repeats
BC (µg/m³)
Passages (n)

WP2: Health effect assessment of PM, PM components, nanoparticles, and their source contributions

Planning of task 2.4 SYNERGY SUPPORT

Teresa Moreno

RI-URBANS (101036245)

WP2: Task 2.4 Synergy Support (M12-M40)

Teresa Moreno (IDAEA-CSIC)

***D2.7**: integration of results of WP2 to support the implementation of pilot demonstration tests and the definition of a roadmap for upscaling them to make them accessible for cities and AQMNs.*

- Main innovative strength of RI-URBANS multisite study lies in its application of a **standardised OP protocol** for samples from differing trans-national locations, with measurements made in same laboratory.
- Since results from the 2 normalisation methods led to similar conclusions, using **normalisation by PM mass** may provide advantages in epidemiologic studies (normally OP/m^3 is only taken into account).
- RI-URBANS multisite analysis **limitations and strengths:** Although amount of data is large, the number of cities included is small, and some sampling periods are short, reducing the statistical power of the methodology to detect true associations.
- The practical difficulties found reinforce the conclusion that **larger and more complete datasets**, in addition to standardisation of laboratory methodology, are needed to better establish the links between OP and human health.

WP2: Task 2.4 Synergy Support (M12-M40)

Recommendations for best practice regarding OP assay research on human health effects

- **Preparation of the samples before running assays, and the method chosen to run the assays**, can affect final OP result, so it is essential that correct and standardised protocols are agreed in multisite/interlaboratory studies:
  - with regard to filter extraction, we recommend using water and SML rather than methanol
  - if using offline acellular assays, at least 2 complementary approaches are recommended, one should be thiol-based (such as OPDTT or OPGSH) plus a choice between OPOH, OPAA or some other.
  - ideally, offline OP data value would be greatly enhanced if used in conjunction with real-time online OP measurement methods free from filter sampling and storage problems.
- The evidence for the impact of oxidative stress on human health is sufficient to recommend **routine monitoring of OP at official urban AQ monitoring stations** using standardised methodologies, an approach in line with the latest EU AQ Directive which calls for OP measurement in both rural and urban monitoring supersites (EU 2024).
- Time series observation of OP in urban air, combined with detailed exposure maps, will **facilitate health impact analyses** aimed at the identification of specific toxic emission sources in need of targeted mitigation.