ST for urban mapping and citizen science

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With contribution of T2.3 partners and DCMR

European Commission

HORIZON 2020

RI-URBANS (101036245)

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RI URBANS

ST13 Urban mapping and Citizen Science

WHAT?

- a methodology for mapping of UFP and other pollutants
- using mobile platforms and sensor networks (with involvement of citizens)
- for the generation of high spatial resolution exposure maps

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

PILOTS

Birmingham (UK)



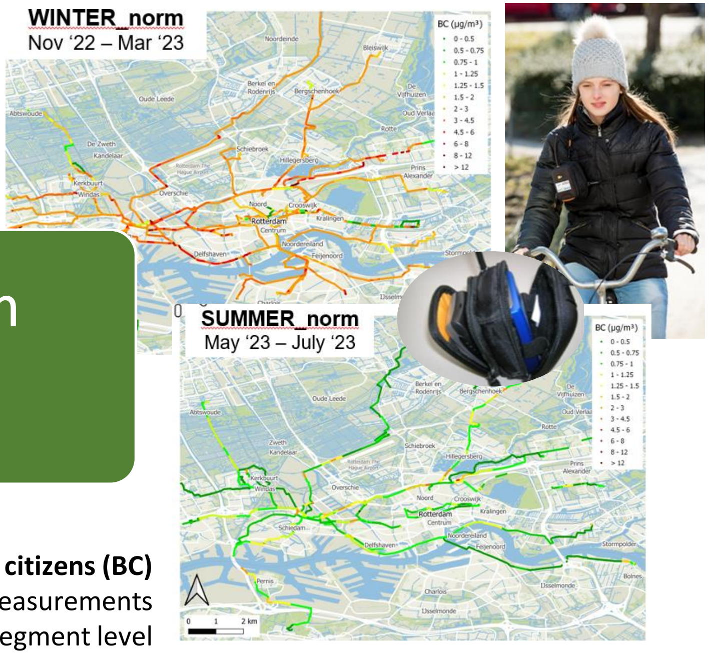
Fixed and mobile setups with citizens (UFP, BC, $PM_{2.5}$)
Involvement of local community (stationary), students (mobile)
ML used to predict $PM_{2.5}$ concentration
Case studies: neighborhood & street level AQ, prediction $PM_{2.5}$, indoor AQ

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

Rotterdam (NL)

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)

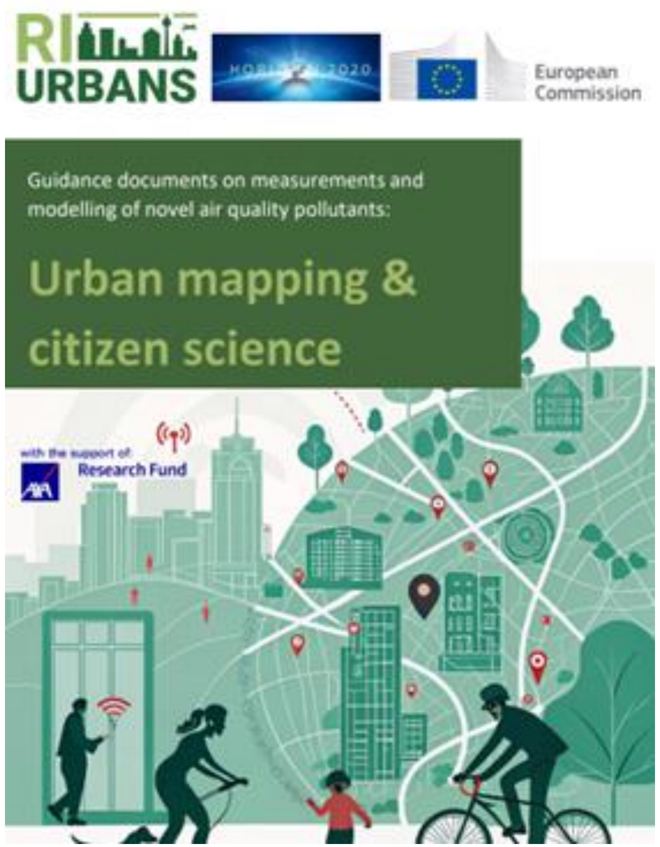
Rotterdam (NL)



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

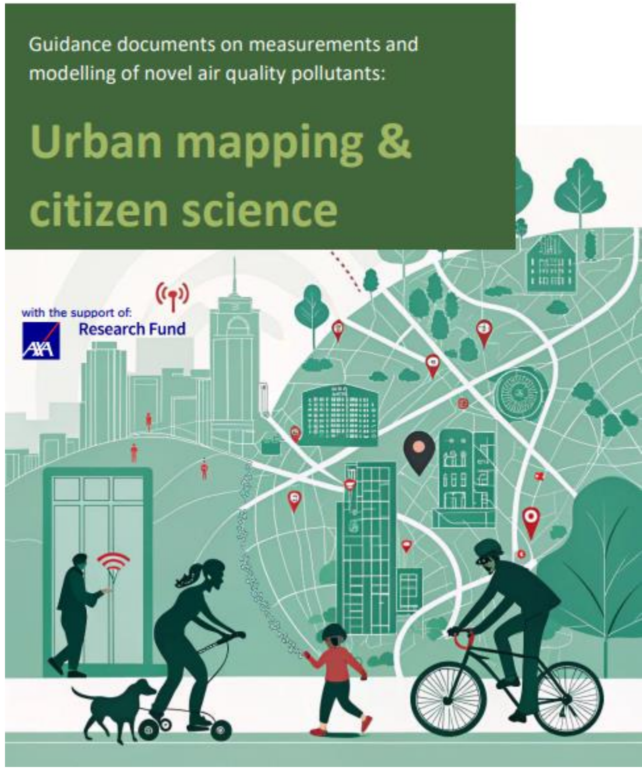
ST 13: Main findings

- Substantial new information can be learned by campaigns of mobile monitoring or low-cost sensor (LCS) fixed site monitoring
  - limited duration (weeks to months)
  - with a proper design
- These methods are useful as an addition to routine monitoring with reference grade instruments at a small number of fixed sites
  - Longer campaigns can result in more precise estimates of air pollution patterns
- Participatory approach is valuable tool to generate a lot of data



CONCLUSIONS and best practices

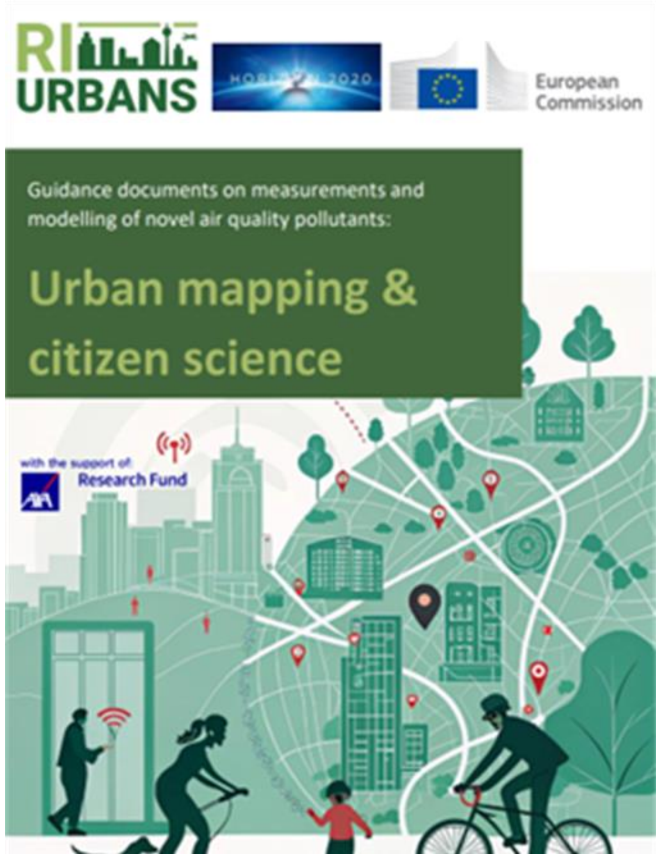
- Different approaches have been applied in pilot cities
  - Insights compiled in ST13
- Best practices:
  - With citizens
    - Valuable knowledge → domain experts
    - Single POC/communication is key/templates/on-site training
    - Provides a lot data!
  - Validation instruments
    - Co-location 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



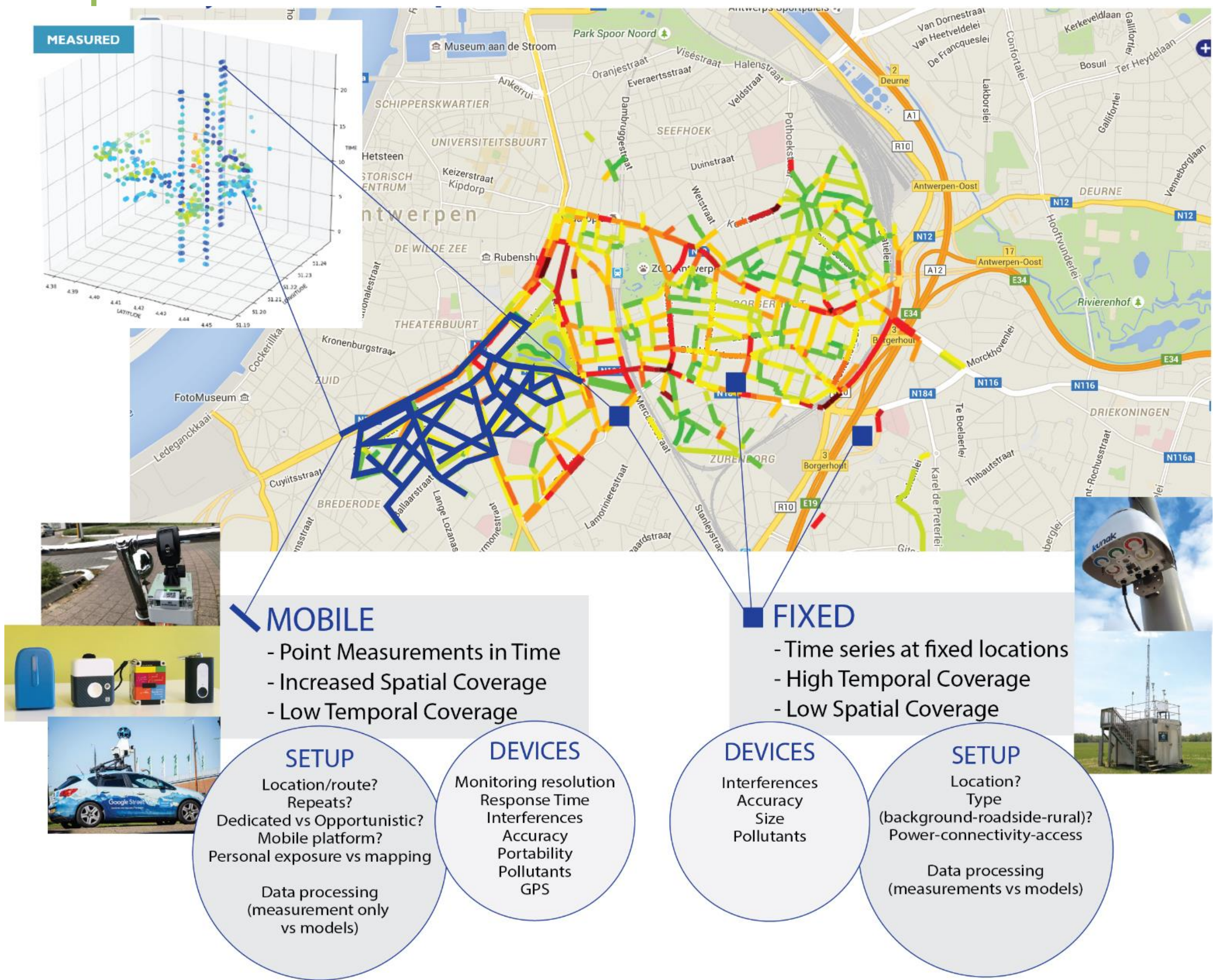
ST13: Recommendations

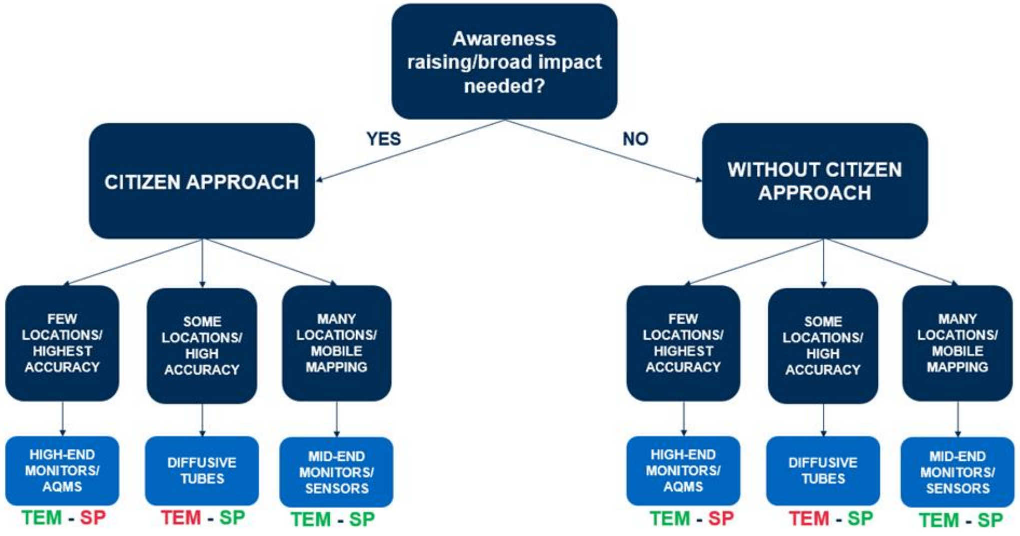
- Monitoring strategy and instrumentation
- Involvement of citizens
- Data processing
- Modelling strategy
- Results

→ For more details see:



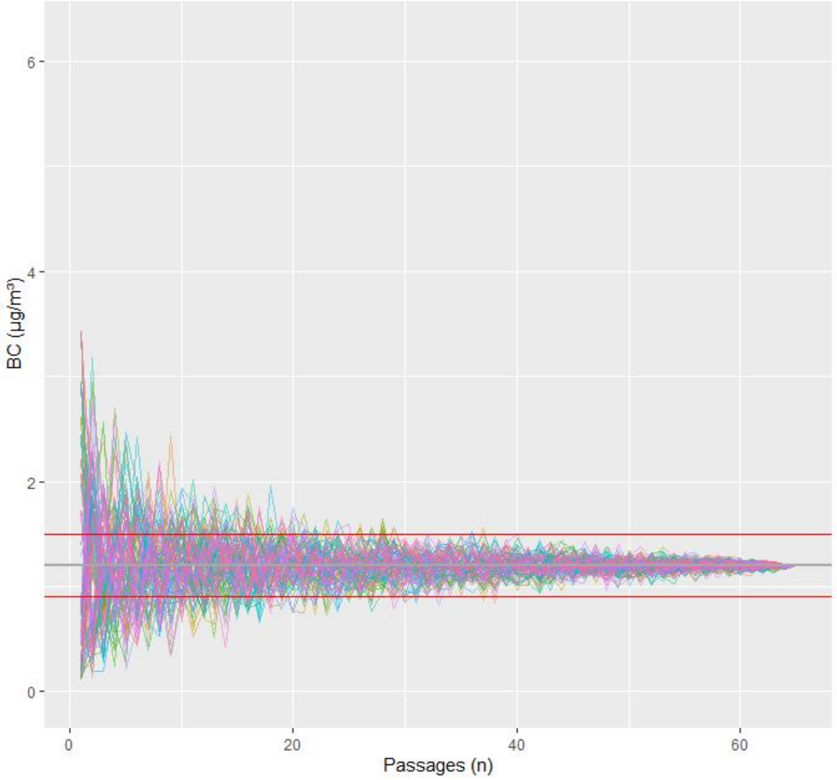
Monitoring strategy and instrumentation (1/2)





Monitoring strategy and instrumentation (2/2)

- Mobile approach:
  - **Dedicated** vs **opportunistic**
  - **Vehicle** vs **portable**
  - **Different seasons** to capture seasonal variability (sources, dispersion, meteo,…)
  - Minimum **number of repeats!**
  - Period of interest: peak hours, working days, annual average…



- Stationary approach: low-cost sensors
  - Quality control!

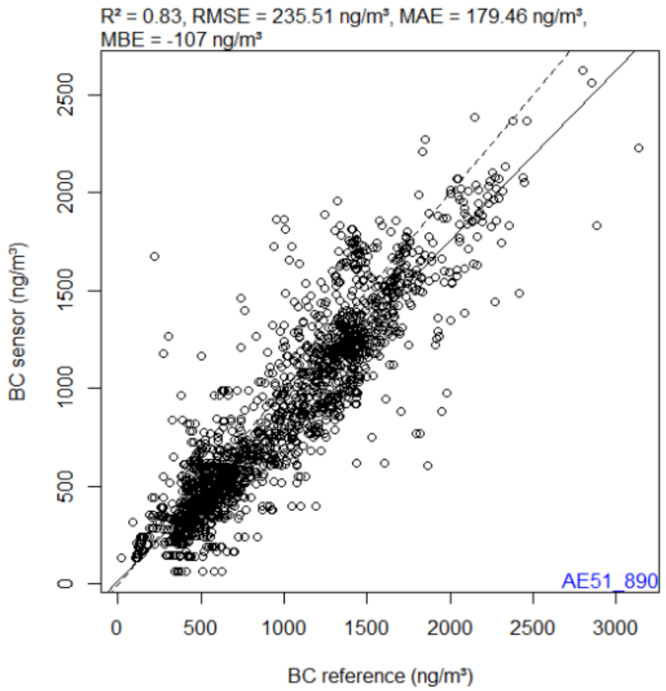
- Stationary approach: diffusive tubes
  - Low time resolution

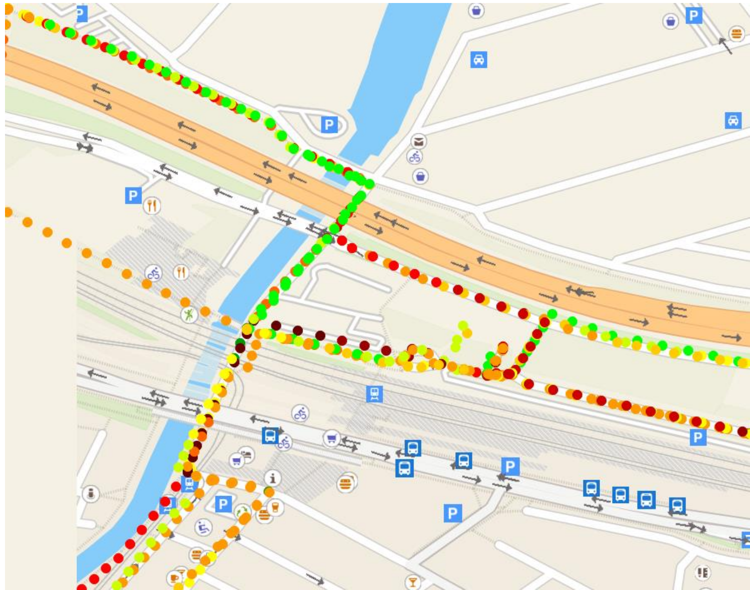
Involvement of citizens

- Instructions!
  - Operation of instruments
  - when and where to collect data
  - Central point of contact
  - Aim of the research
- Engagement and interactions with citizens
  - Building trust, anonymity (ethics)
  - Feedback of results (e.g. luchtalk at DCMR for participants)
  - Reward, interest in own environment
- Recruitment process
- Added value of including citizens:
  - Valuable knowledge → domain experts
  - Awareness raising, identification hotspots, representative exposure assessments

Data processing

- Quality control for sensors
  - Outlier detection (related to e.g. RH)
  - Calibration by co-location to reference (representative conditions)
    - Validation instrument
    - If needed: calibration model
- Mobile monitoring
  - Measurements at different locations & times
  - Rescaling is needed to:
    - 1) Extrapolate measured averages to long-term (annual) exposure
    - 2) Rescale data collected at another period in time (~opportunistic)
  - GPS accuracy & time synchronization





$$BC_{norm,i} = BC_i - BC_{bg,i} + \overline{BC}_{bg}$$

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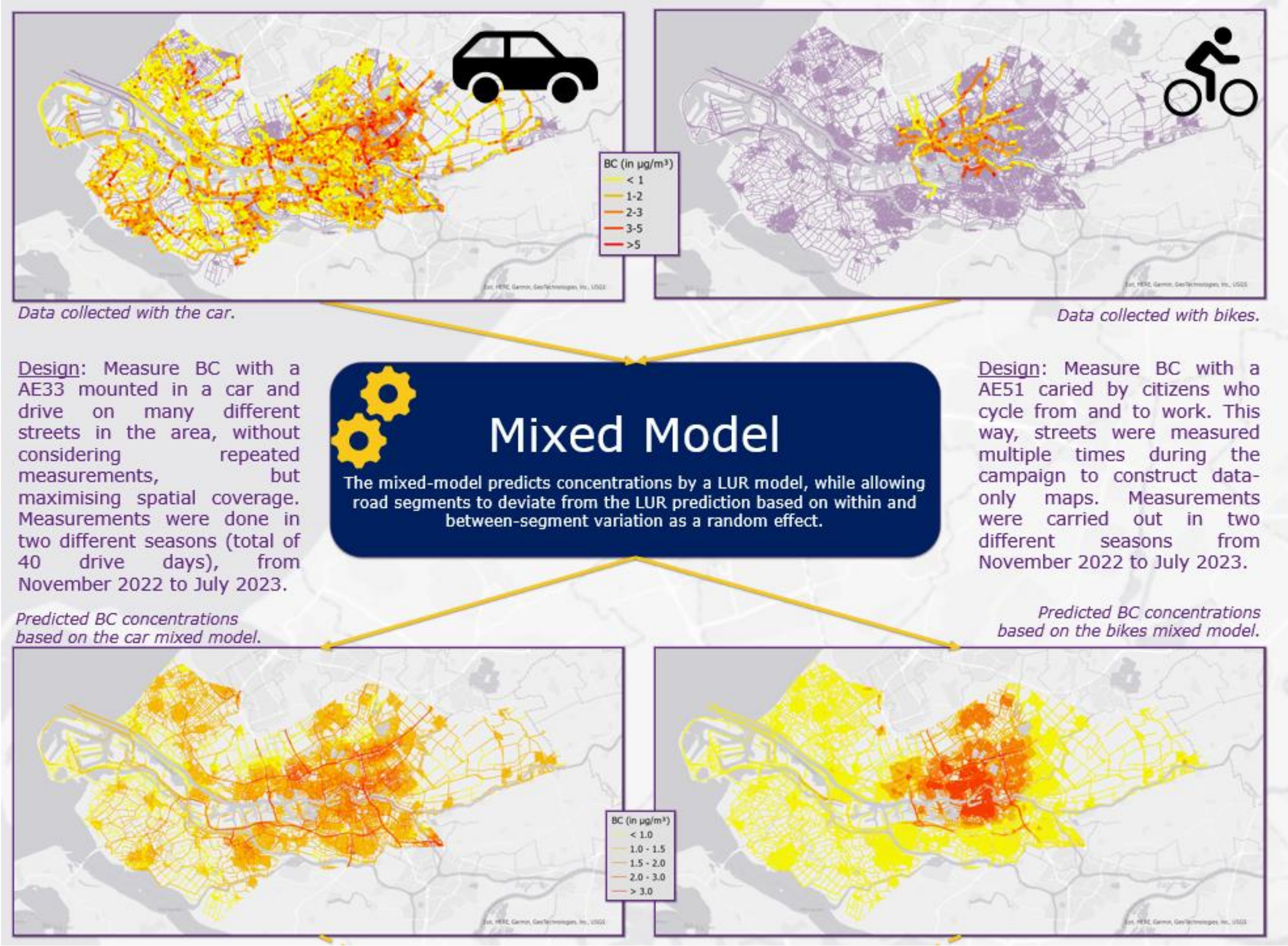
Data processing - modelling

- Data-only vs modelling strategy

- Modelling strategy
  - Mobile maps as input for LUR-based models e.g. Rotterdam
  - Measurements as validation for dispersion models:

  e.g. Rotterdam data showed discrepancies in model assumptions (e.g. urban ventilation)

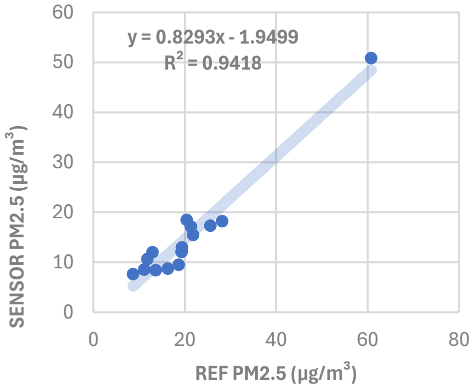


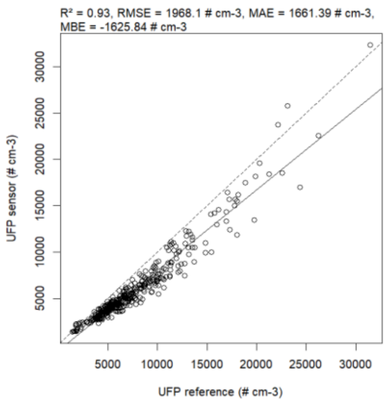
WARSAW

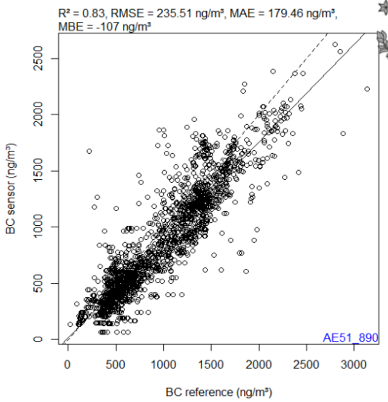
- Upscaling city → ST13
- Multi-pollutant: BC, UFP and PM
- Rush hours: 8-9h & 17-18h
- Co-location campaign
- Dedicated route (n=40)
  - Summer: 6/9 – 9/10
  - Winter: 22/1 – 5/3
- Pollutant maps + ratio’s
- Subsampling analysis

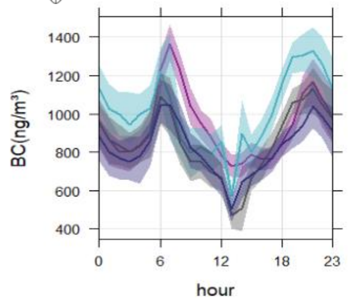
UNIVERSITY OF WARSAW

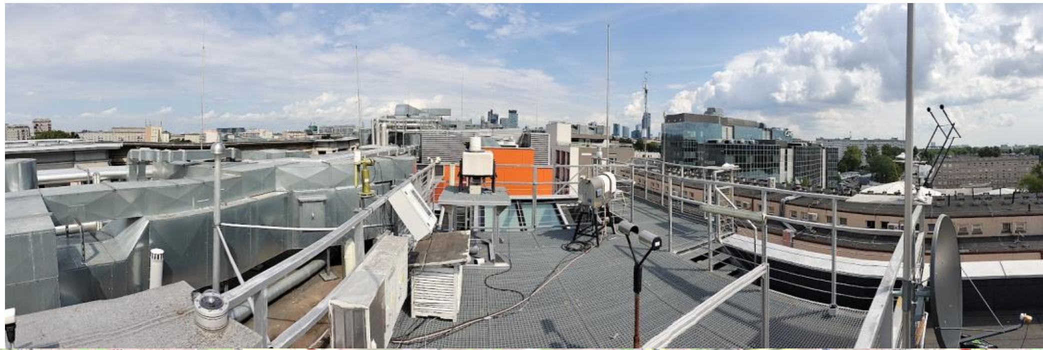
ATMO ACCESS
Access to Atmospheric Research Facilities

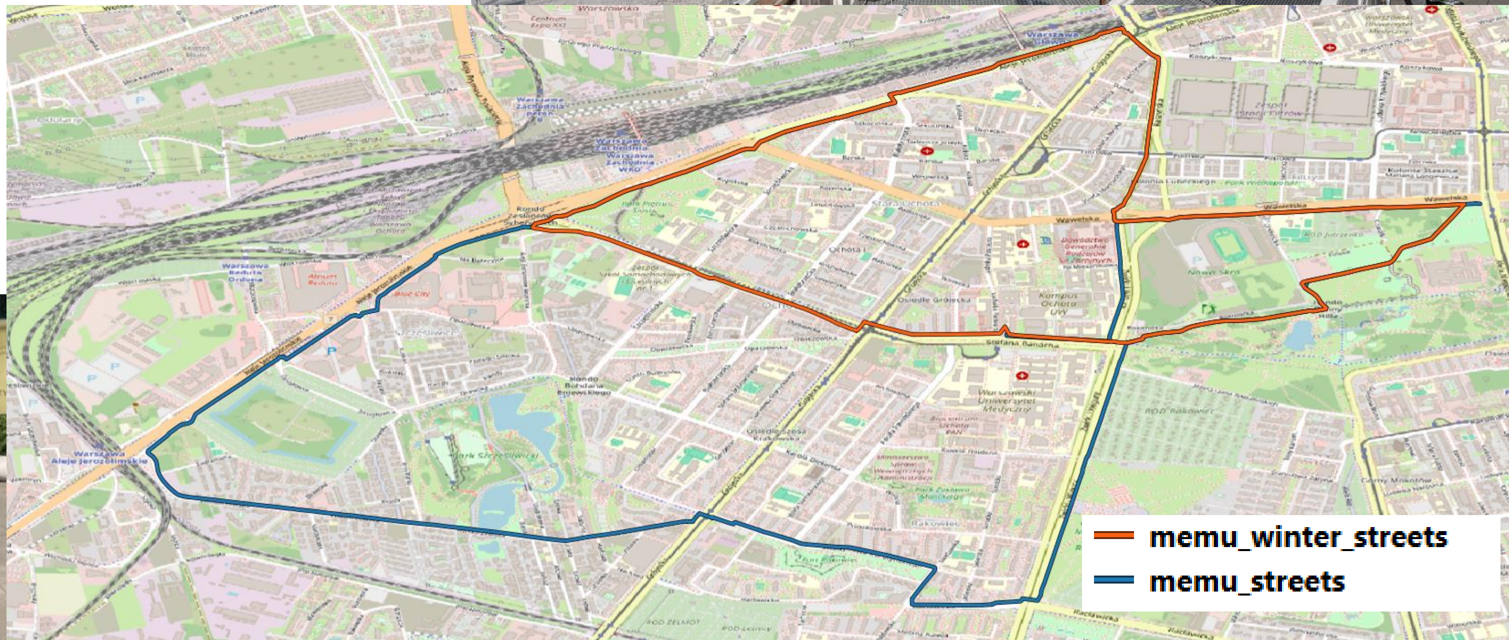




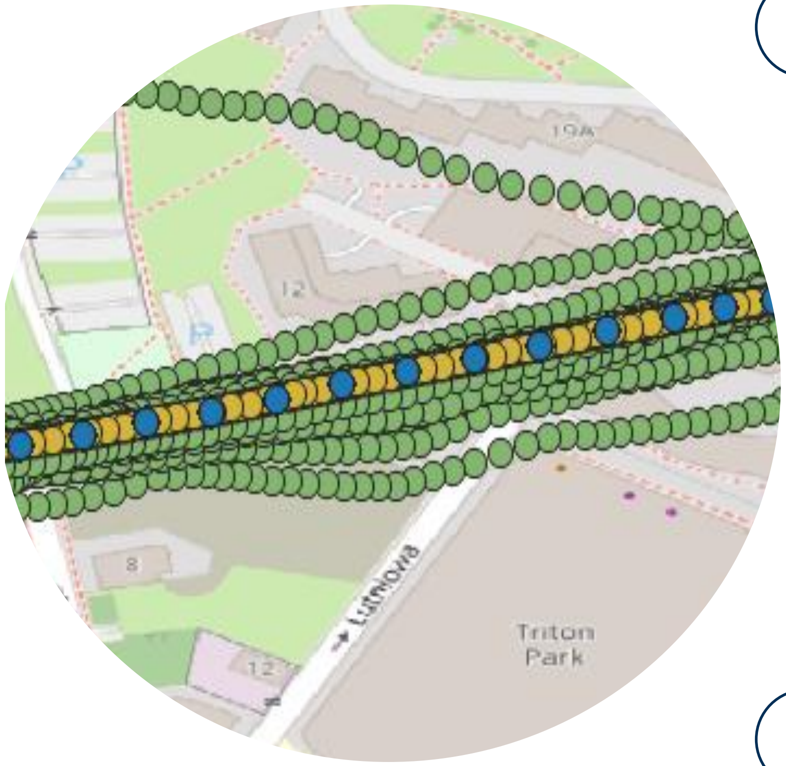








WARSAW



- 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

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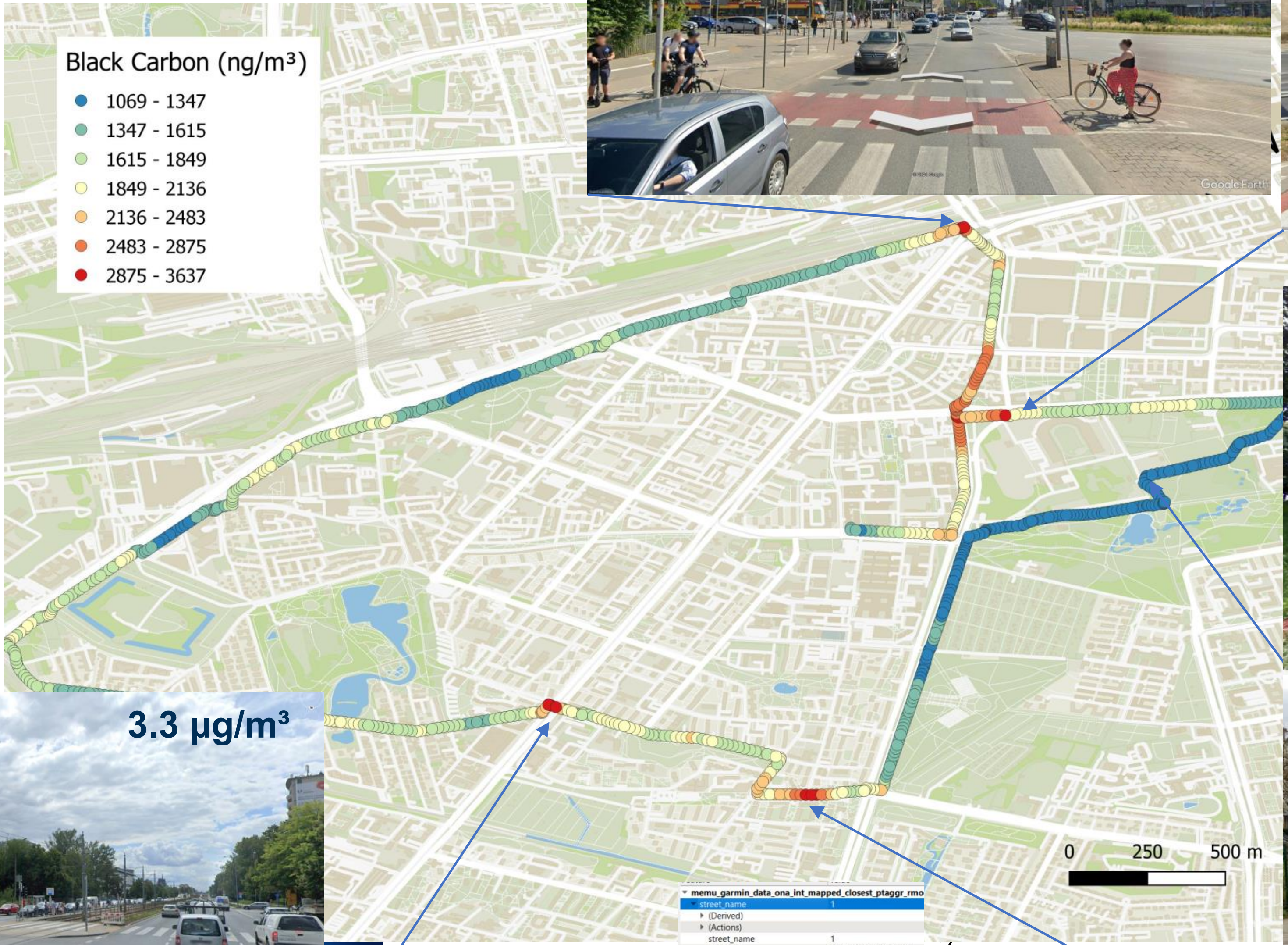
BC HOT/COLDSPOTS

AVG n=40



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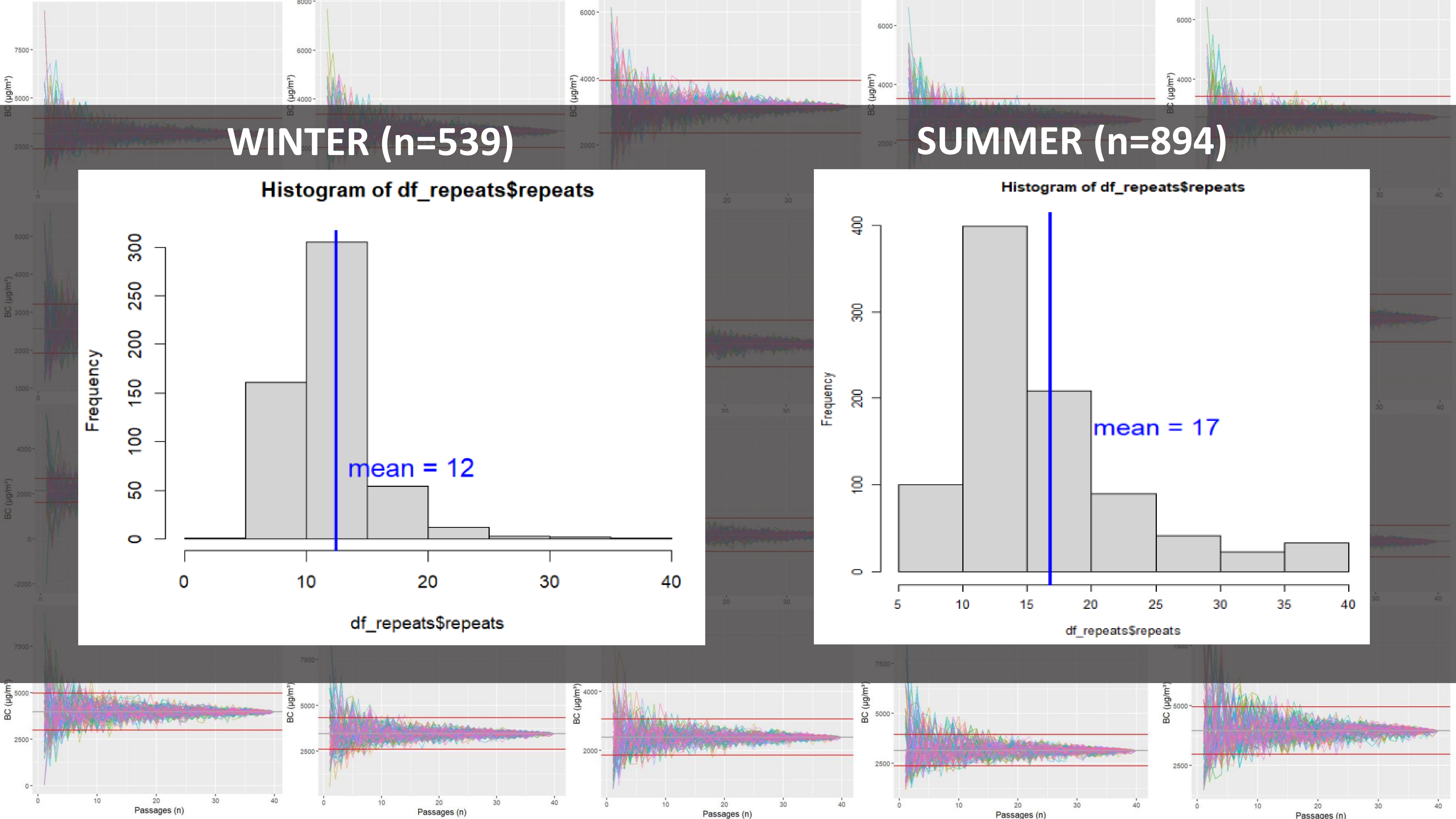
number_of_days_measured	23
mean_number_of_sec_meas	5
uncertainty_perc	0,52


WINTER (n=539)
SUMMER (n=894)
Histogram of df_repeats$repeats
Frequency
mean = 12
df_repeats$repeats
Histogram of df_repeats$repeats
Frequency
mean = 17
df_repeats$repeats
BC (µg/m³)
Passages (n)