Urban mapping of nanoparticles and other pollutants, coupled with regional modelling tools and citizen‘s science

RI-URBANS

Research Infrastructures Services Reinforcing Air Quality Monitoring Capacities in European Urban & Industrial AreaS (Project n. 101036245)

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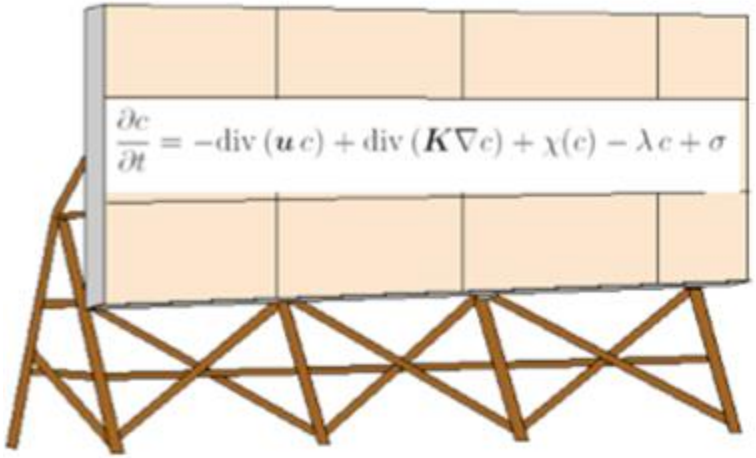
European Commission

HORIZON 2020

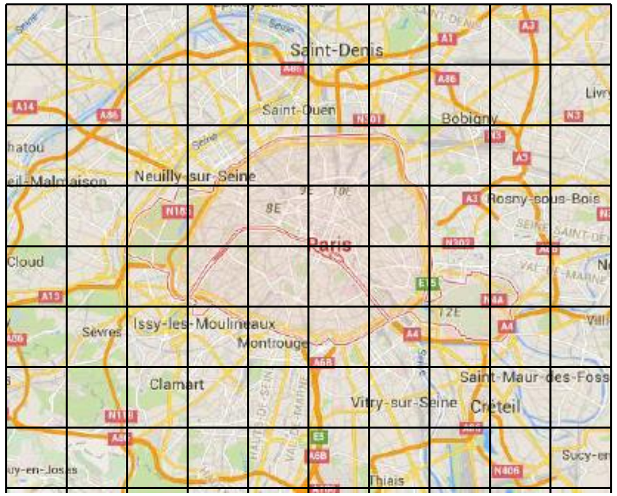
Regional modelling

Chemistry-transport models *[WP3]* solve the mass conservation equation on a 3D mesh.

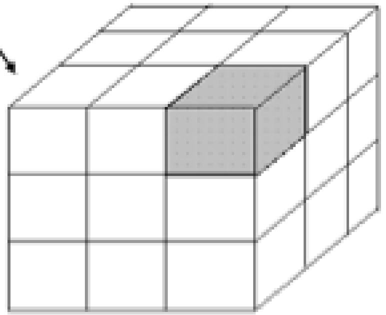
=> Background urban concentrations



2D view



3D

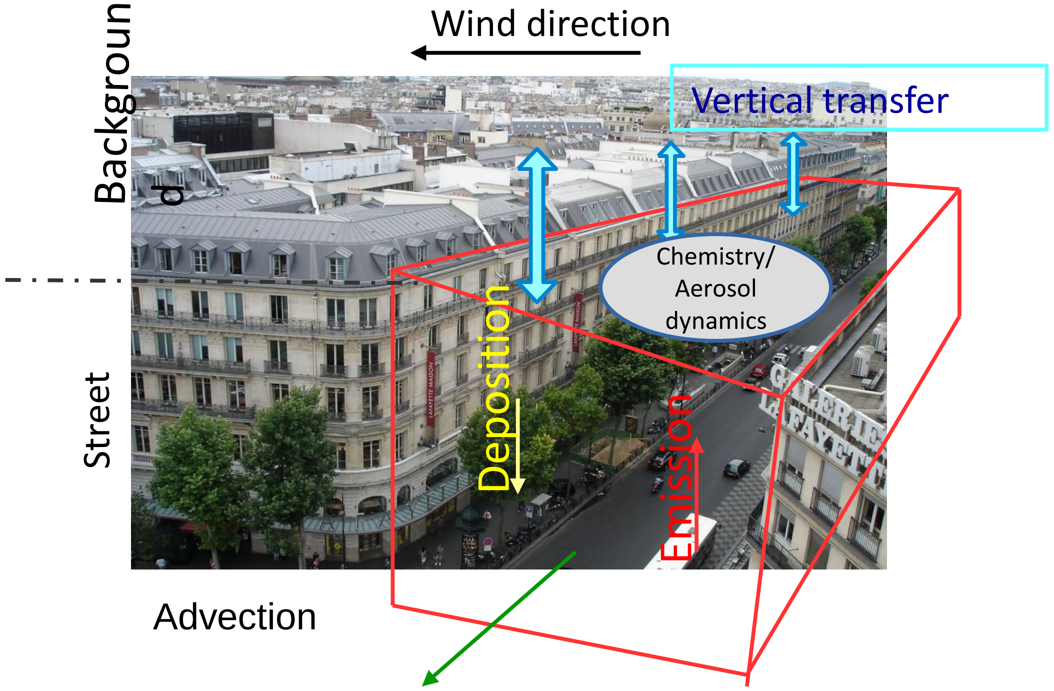


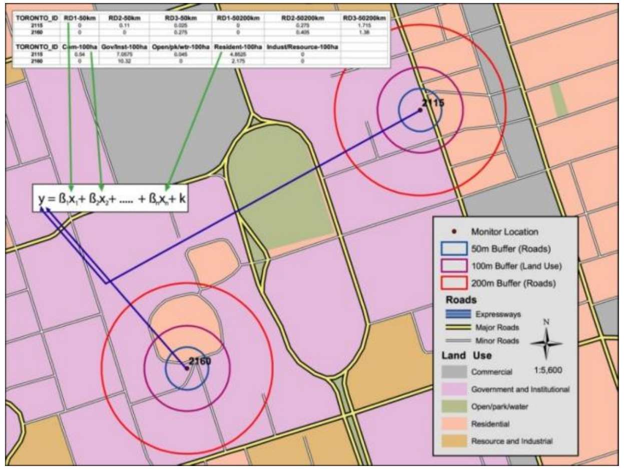
Spatial resolution: 1 km x 1 km

Local-scale modelling

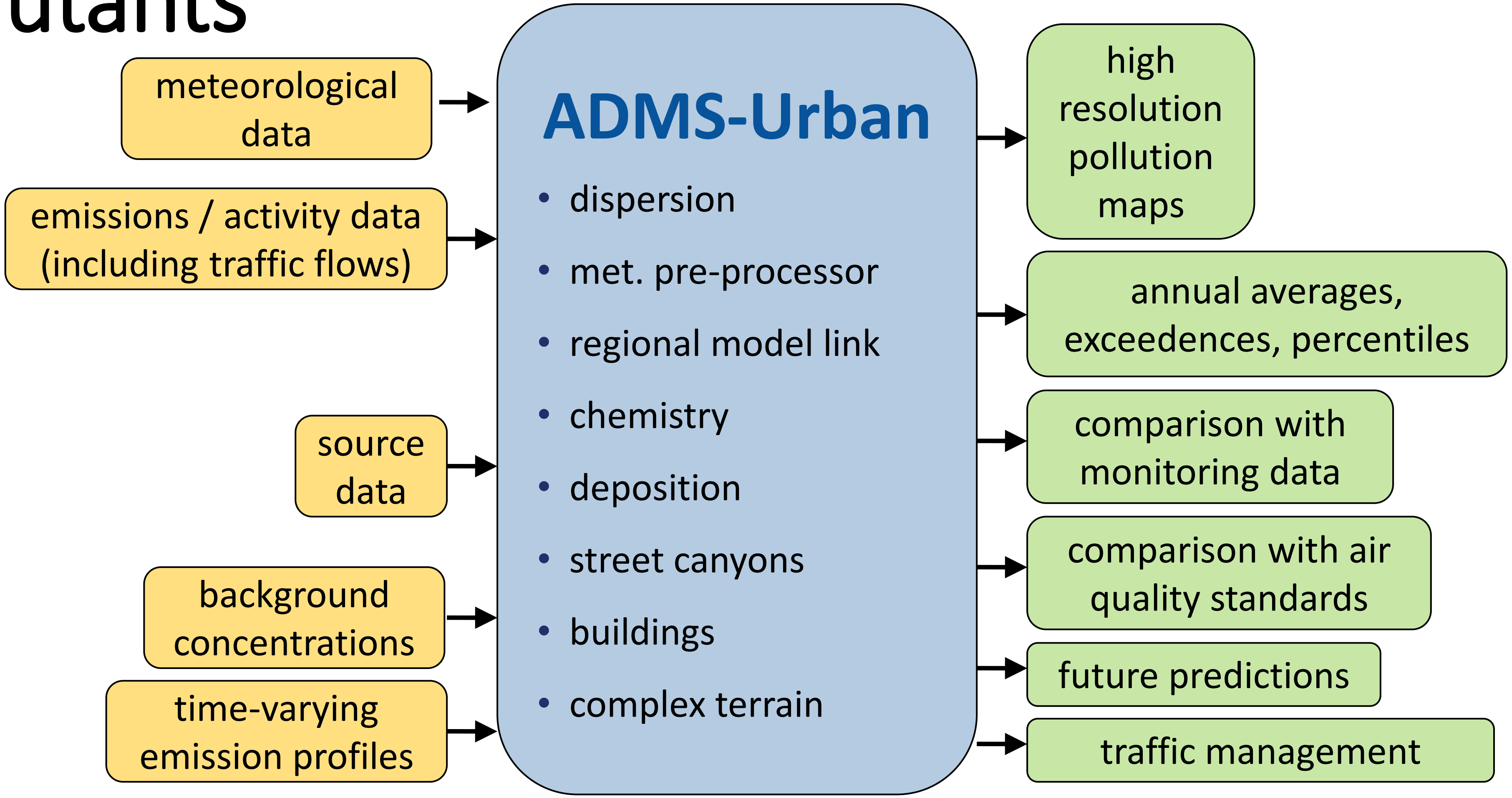
- Resolution of ten/hundred meters

- Mapping with **multi-scale modelling**
  - Parametric models:
    Gaussian *(ADMS)*,
    Street canyon *(MUNICH)*
- Mapping with **mobile measurements**
  - Statistical approach / Land Use Regression

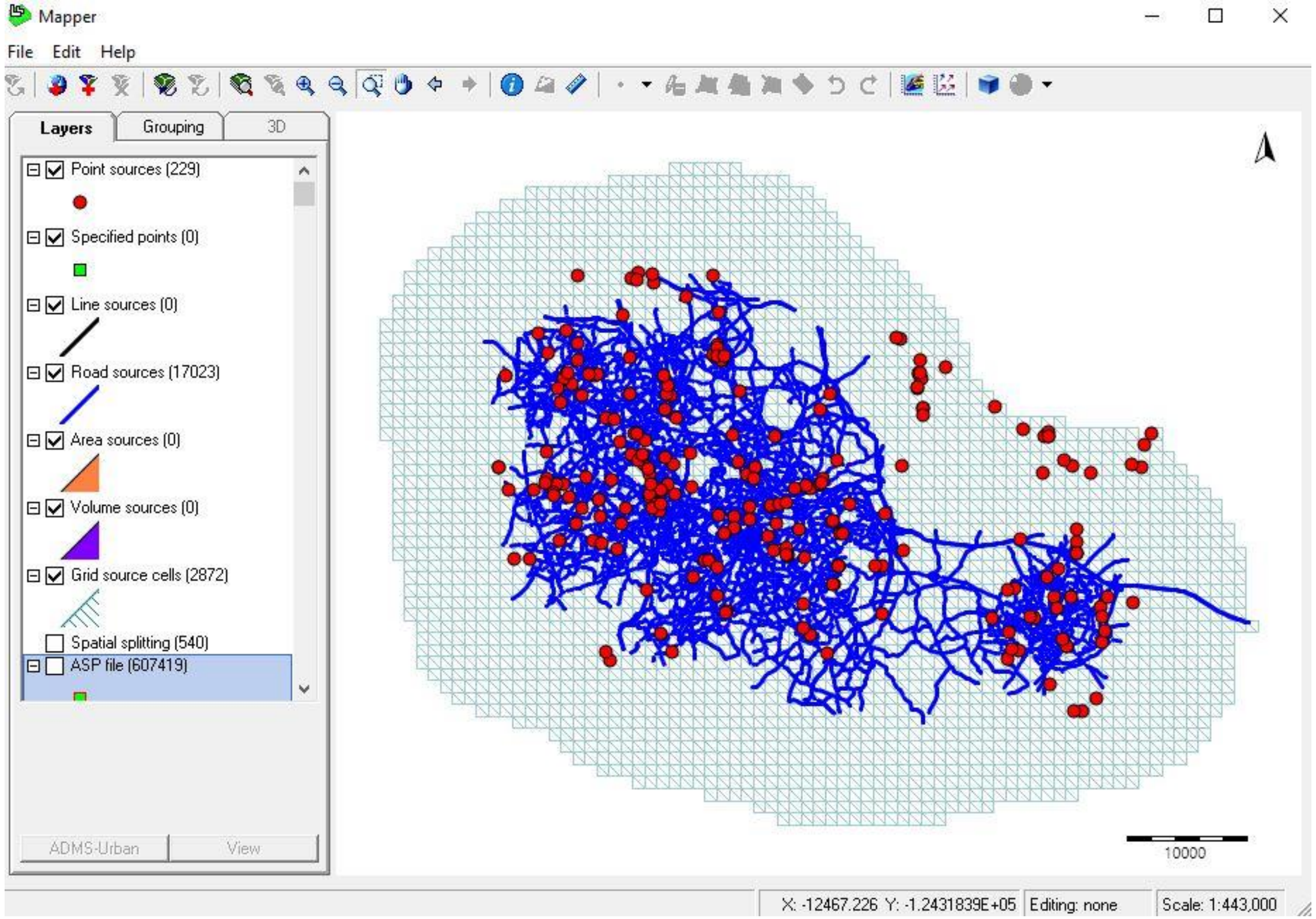




Birmingham: ADMS modelling of traditional air pollutants

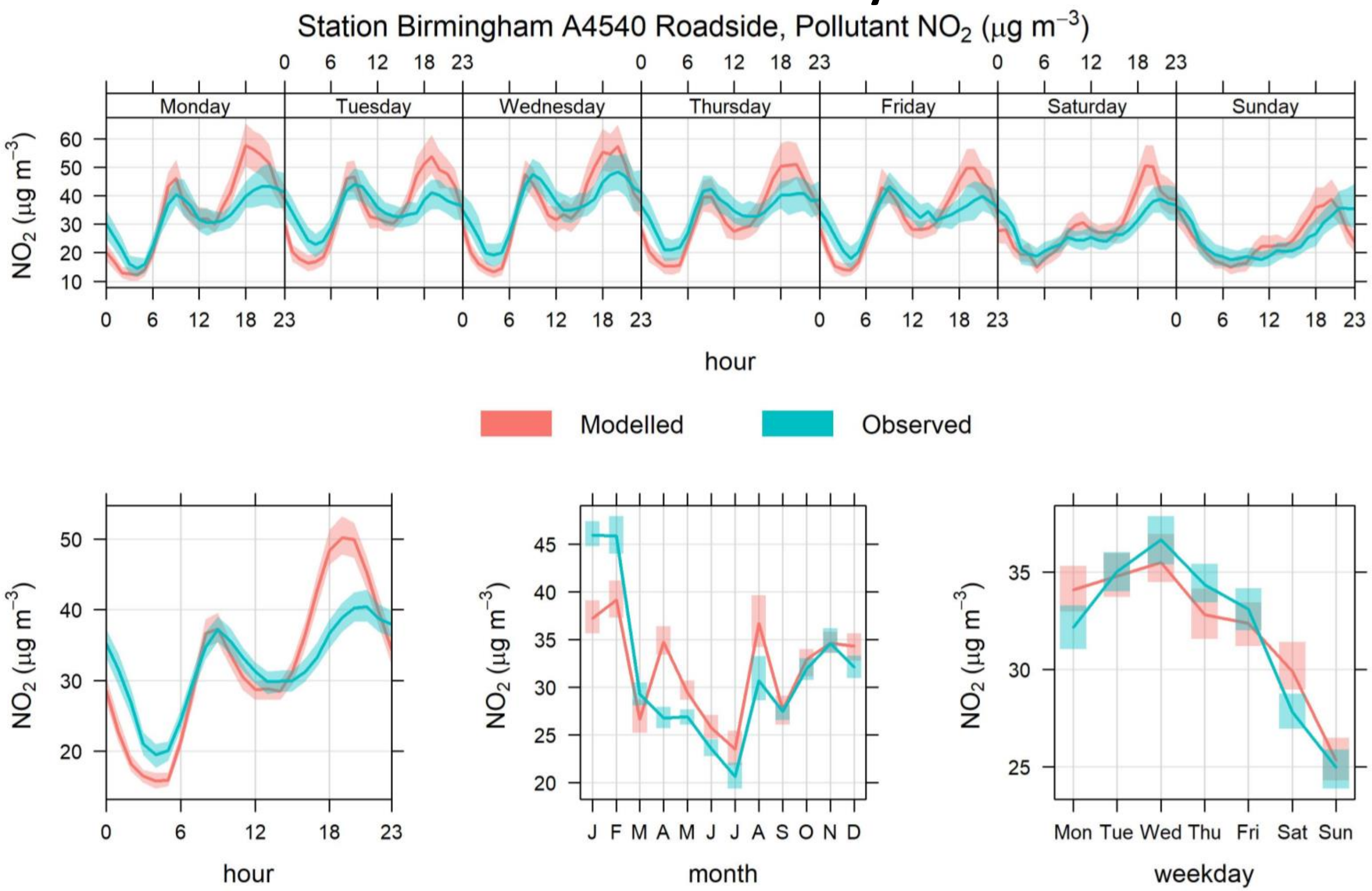


Model configuration - Birmingham

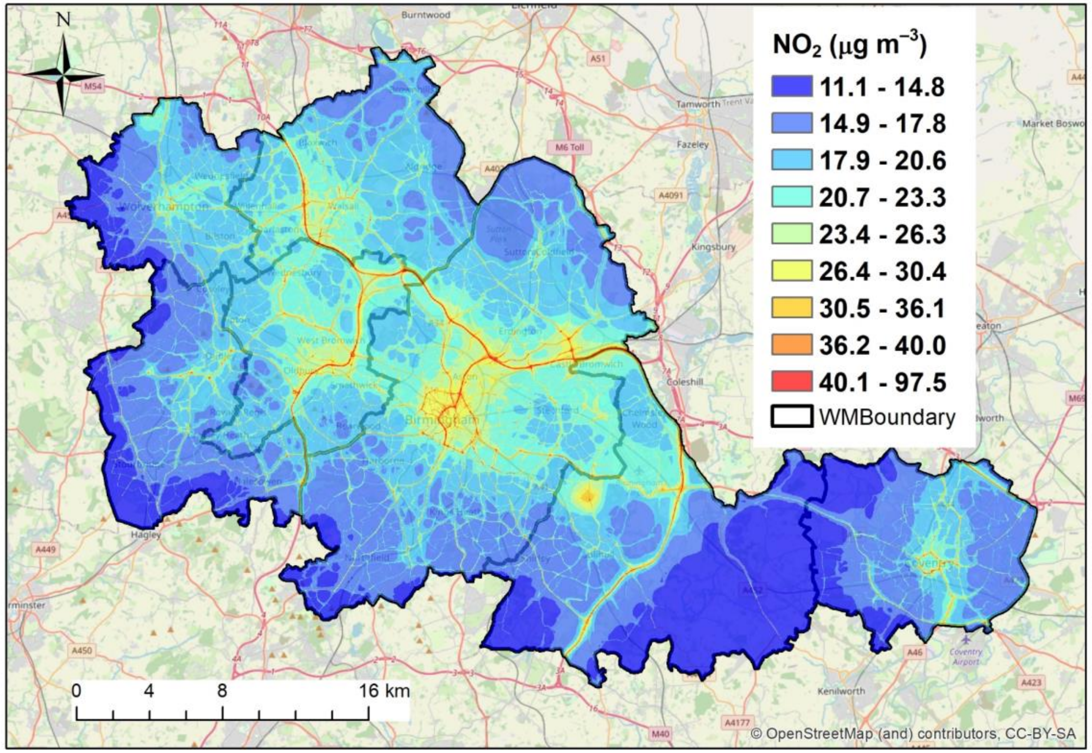


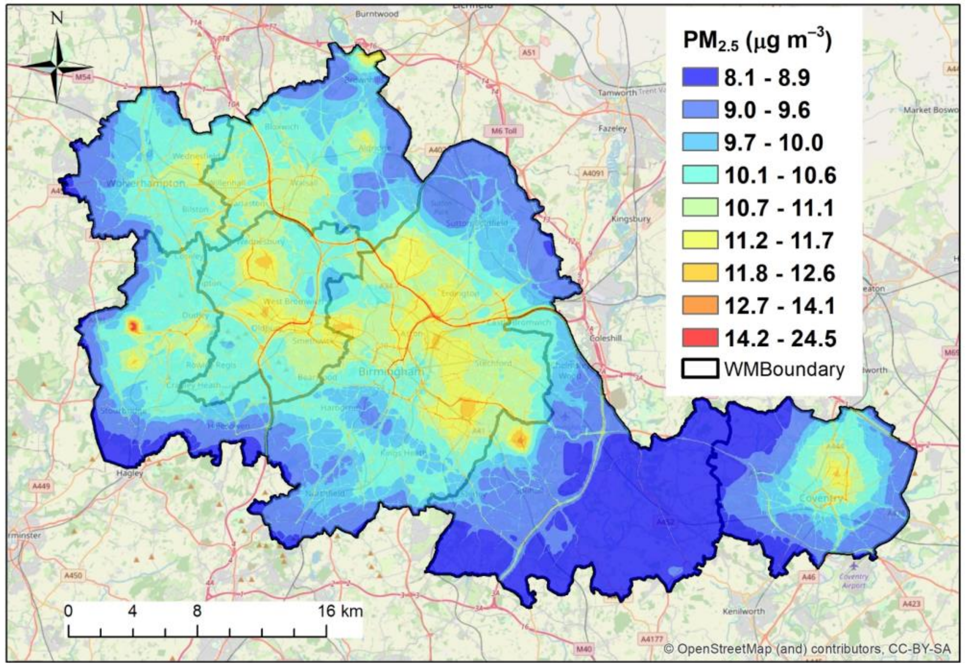
Model Evaluation - Birmingham

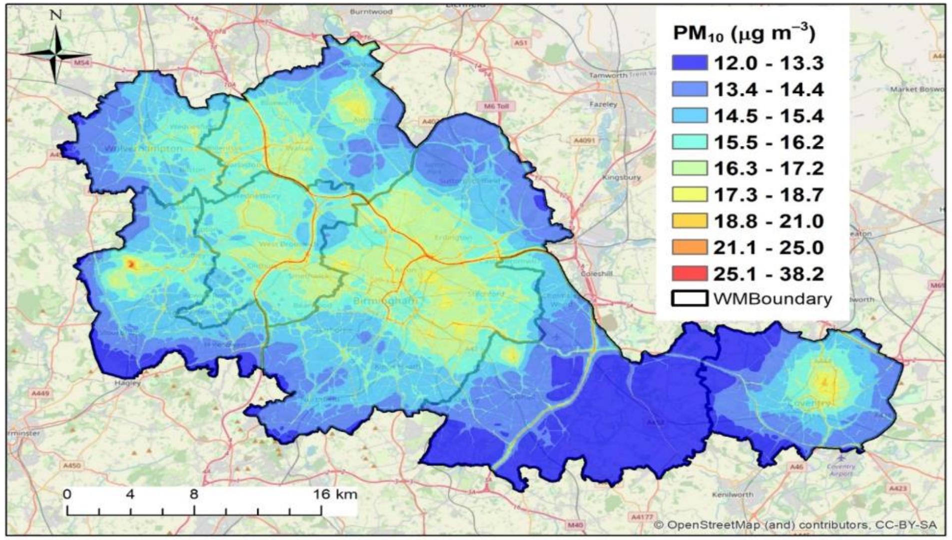
Time Variation Analysis



ADMS Annual air quality maps for 2019 baseline case





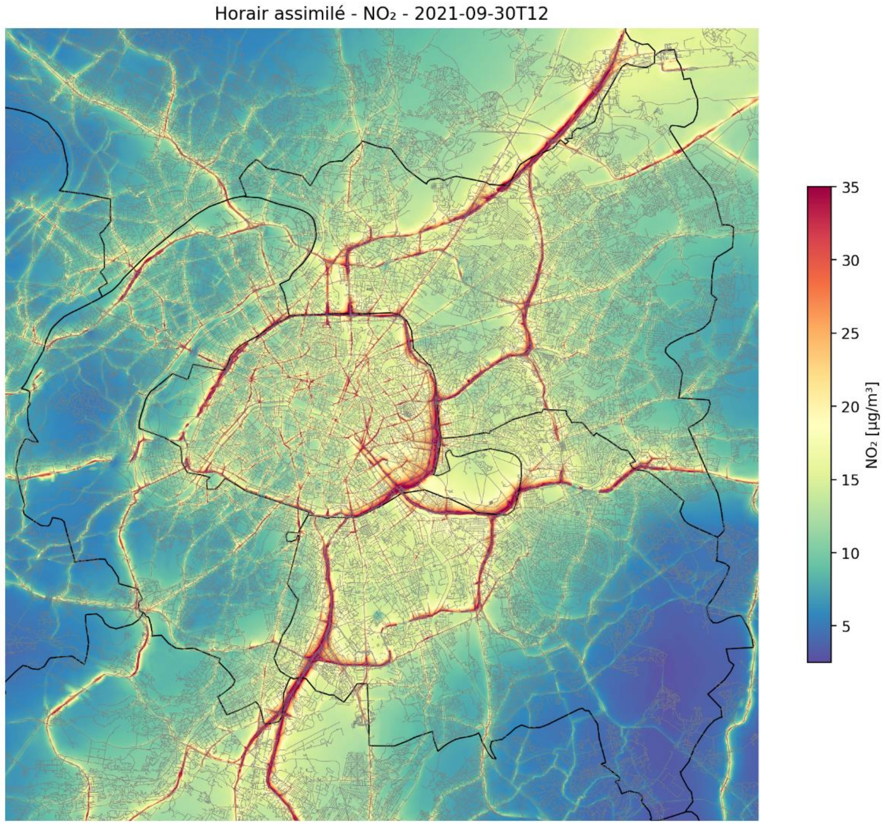


PARIS: multi-scale mapping

- Regional-scale background concentrations 1 km x 1 km (CHIMERE)
- Local-scale modelling with ADMS/data assimilation (Airparif)

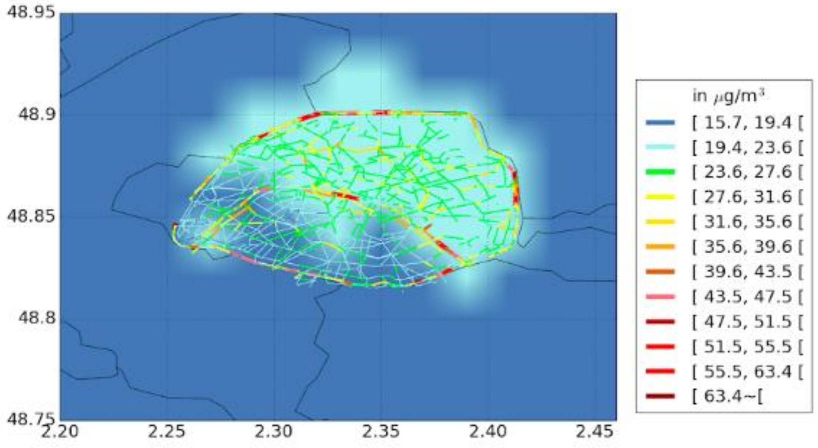
  daily forecast for

  - NO_2,
  - PM_{10},
  - $PM_{2.5}$,
  - *BC* (to be added)



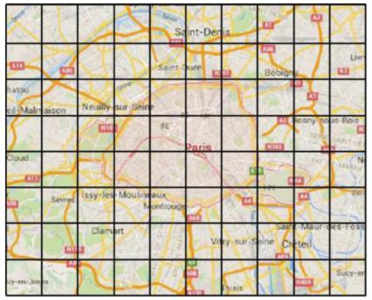
NO_2 concentrations with data assimilation for 2021-09-30 at 12h from Airparif forecast (courtesy of Fabrice Dugay)

PARIS: multi-scale mapping

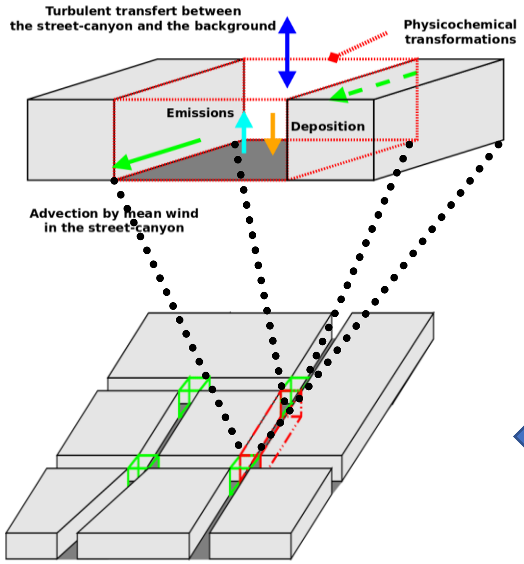


$PM_{2.5}$ concentrations in 2014 *(Lugon et al. 2022)*

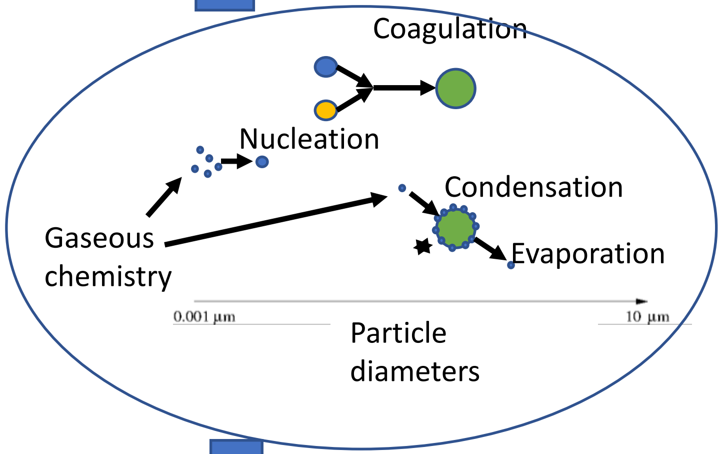
Regional scale
(Chimere WP3, Polair3D)



Street-in-Grid:
Multi-scale



SSH-aerosol
(Sartelet et al. 2020)



MUNICH: **street-network model** with comprehensive chemistry and aerosol dynamics => NO_2, PM_{10}, $PM_{2.5}$, BC, organics and inorganics, PN)

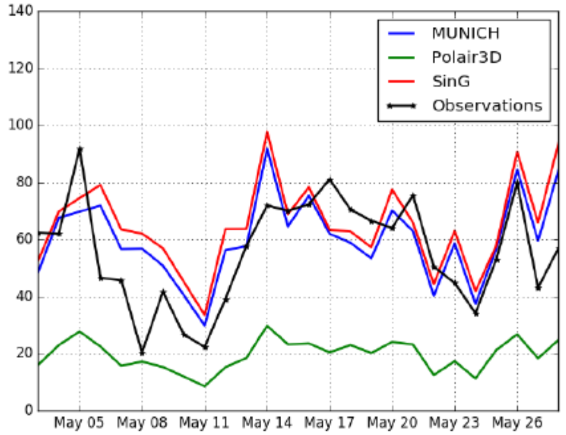
Kim et al, GMD, 2018, 2022; Lugon et al. ACP (2020)

PARIS: multi-scale mapping

- High concentrations observed in the streets, strong effect of traffic on local-scale concentrations
- Good agreements between model and measurements in streets and in the background

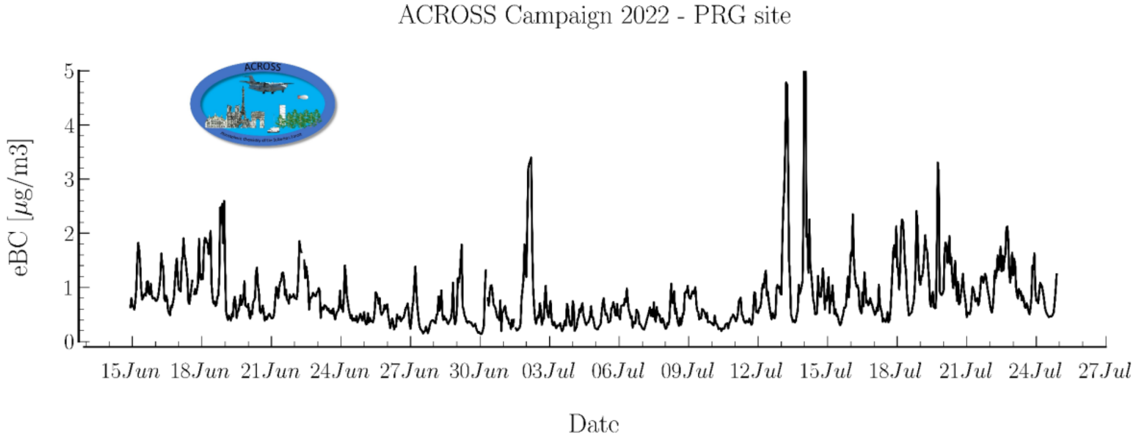
	Backgrd	Streets
PM_{10}	21.6	35.3
$PM_{2.5}$	18.3	23.7
$PM_{org,anth}$	2.8	7.0
$PM_{org,bio}$	2.4	2.4
PM_{inorg}	7.4	7.9
BC	2.1	5.9

Model	Pollutant	Conc. obs. ($\mu g.m^{-3}$)	Conc. sim. ($\mu g.m^{-3}$)	MG	NMSE
Polair3D (background)	PM_{10}	22.6	23.5	1.1	0.19
	$PM_{2.5}$	15.3	19.4	1.3	0.28
	NO_2	39.0	43.2	1.0	0.18
MUNICH (streets)	PM_{10}	33.1	35.6	1.1	0,20
	$PM_{2.5}$	20.7	25.0	1.2	0.22
	NO_2	67.6	73.0	1.1	0.30



NO_2 concentrations at the trafic station CELESTIN in Paris *(Lugon et al, ACP, 2020)*

PARIS: intensive campaigns for model improvements



- Intensive measurement campaigns to better characterise the variability and improve modelling (winter 2020 and summer 2022)

- In-situ measurements at traffic sites of BC and PN to **estimate consistency of emission factors**
- **ACSM and SMPS measurements** at traffic and background sites to evaluate PM composition and PN number
- **Summer 2022:** Doppler lidar, ceilometers, ballons

⇒**Characterise the spatial variability of boundary layer height** and vertical gradients

Courtesy of Claudia Di Biagio and Di Antonio Ludovico

Mapping with mobile measurements

. Mapping will be done using different monitoring approaches: mobile measurements with or without citizens, fixed sensor networks with or without citizens, in link with WP2.3.

- Extrapolate mobile collected data using Land Use Regression modelling
- Campaign plans for mobile measurements: Autumn 2022 (**Rotterdam, Birmingham**), Pre-campaign in April-August 2022 (**Bucharest**) and campaign in Autumn 2022

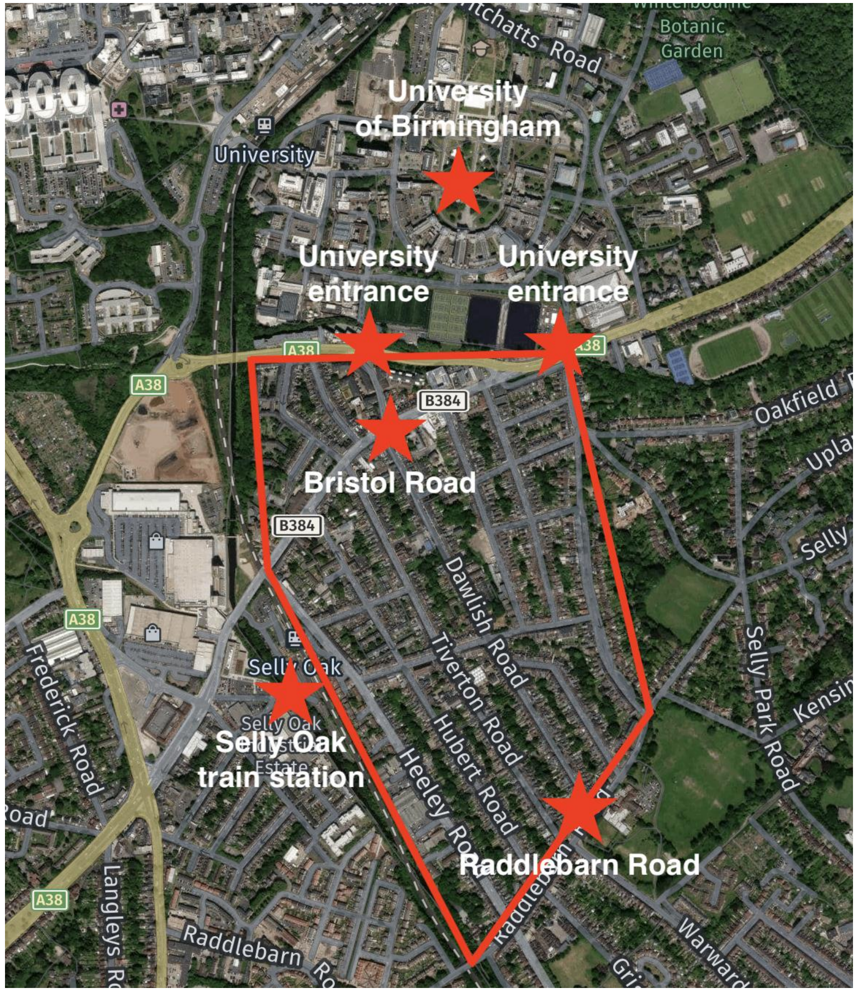
Birmingham Citizen Science

- A novel combined approach of stationary and mobile measurements using low-cost sensors.
- The campaign will take place in Selly Oak, a heavily populated area (about 10,000 students) next to the University of Birmingham.
- Multiple sites within a 1x1 km area along with multiple mobile measurements run by students at the University.
- This work will compliment the studies already done at the Birmingham Air Quality Supersite by adding several measuring points.

Setup to be used for mobile measurements, including the sensor, a GPS, a GSM and a BME module.

Mapping the area and quantifying the effect of pollution sources

- The data from the campaign will be used to map the area and find pollution hotspots.
- The effect of the pollution sources in the area will be quantified using source identification and apportionment methods.
- The evolution of pollution from the sources identified will be studied at a neighbourhood scale.
- The feasibility and shortcomings for similar future projects will be considered.



The area of the study in Selly Oak, Birmingham, UK.

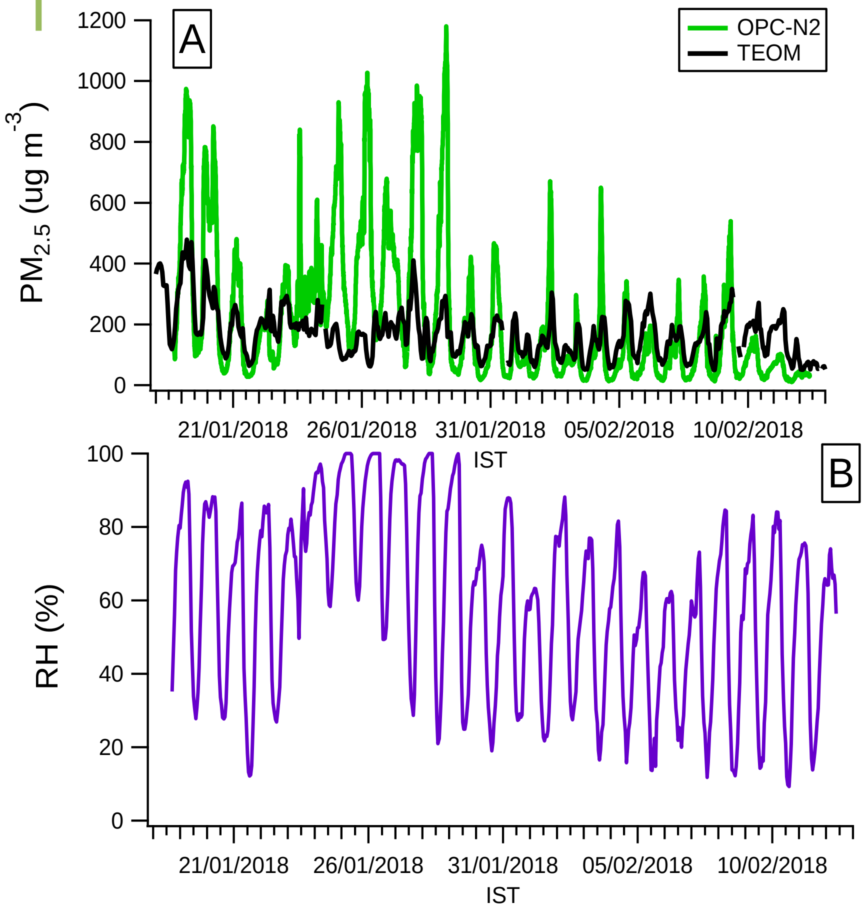
Sensors

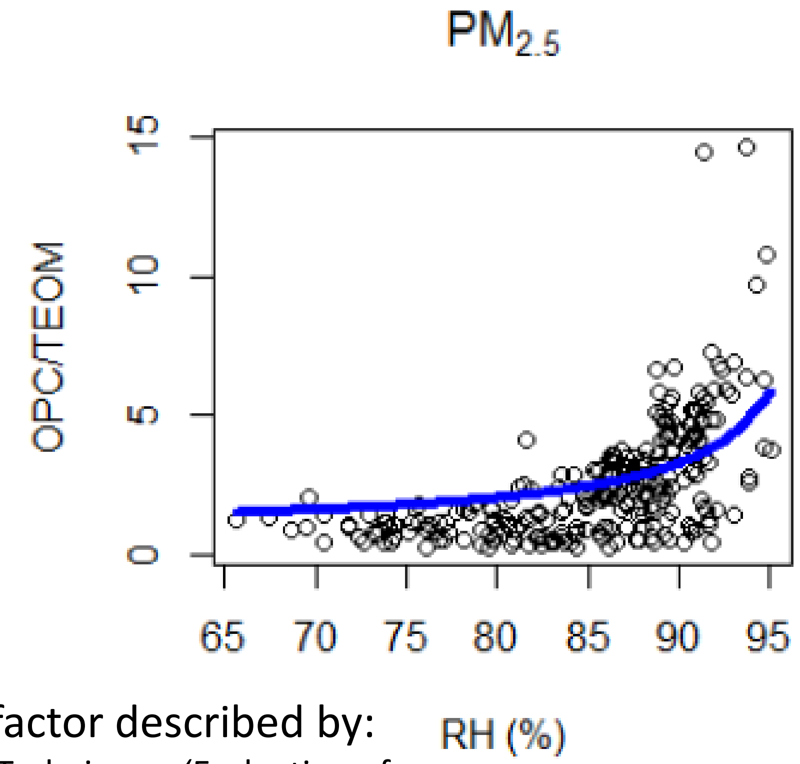
- Alphasense OPC-N3 sensors
  - Optical Particle Counters using light scattering
  - Measures: PM_1, $PM_{2.5}$, PM_{10}

- testo DiSCmini sensors
  - Diffusion size classifier
  - Measures nanoparticle number, mean particle diameter and LDSA (Lung Deposited Surface Area)

OPC Sensor Calibration

Optical particle sizing dependent upon environmental relative humidity due to particle hygroscopicity





RH dependent correction factor described by:

Crilley et al. (2018) Atmos. Meas. Techniques. ‘Evaluation of a low-cost optical particle counter for ambient air monitoring’

Crilley et al. (2020) Atmos. Meas. Techniques. ‘Effect of aerosol composition on the performance of low-cost optical particle counter correction factors’

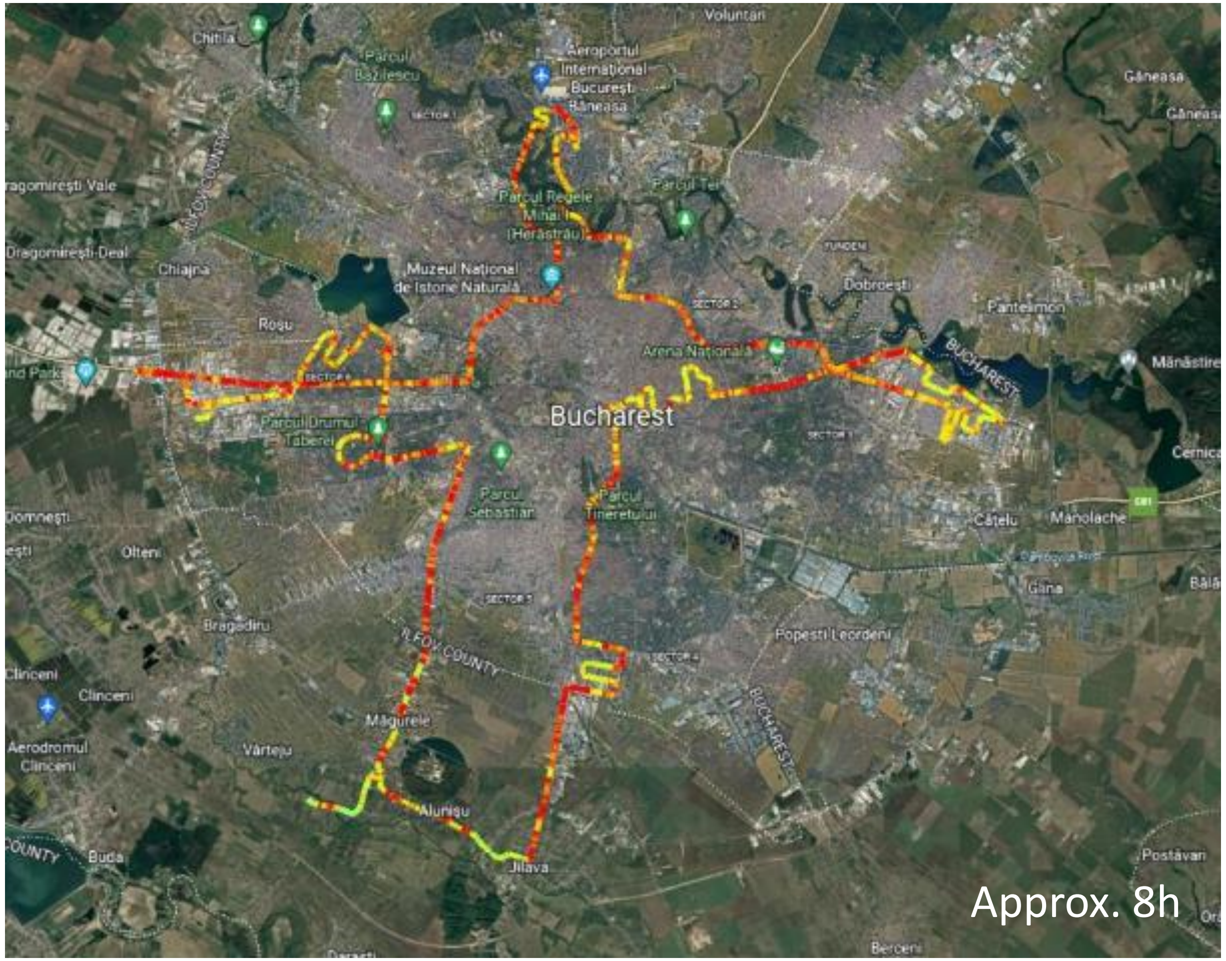
Bucharest mapping

- **Summer campaign**
  - **April 2022 –** tests & pre-campaign
  - **04 – 29 May + 16 June-13 July**
    - One day per week (Wednesday / Thursday)
  - **30 May – 10 June** ⟷ coincident with the Hotspot campaign
    - Higher frequency
- **Winter campaign**
  - 2022-2023
  - Based on results from first campaign
  - Similar timeframe (subject to updates)

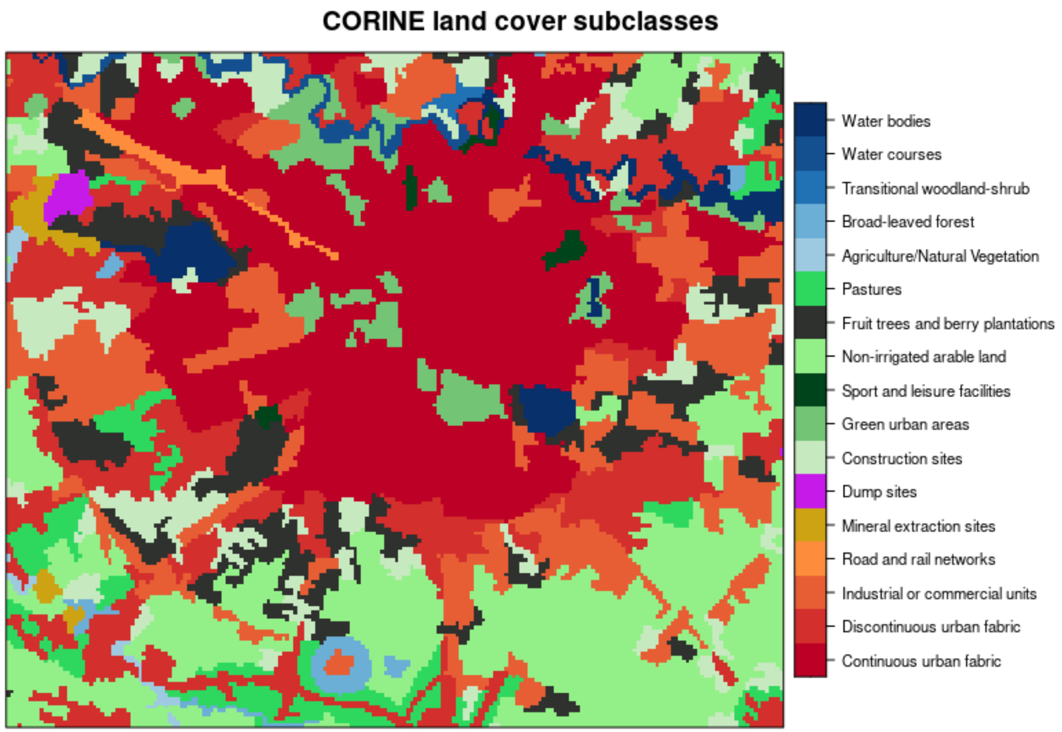
- Nano-particle counter
  - Number, Surface, Volume concentration, UFP mass range PM0.3
- Mobile PM counter
  - Mass concentration of PM10, PM2.5, PM1
- GPS unit

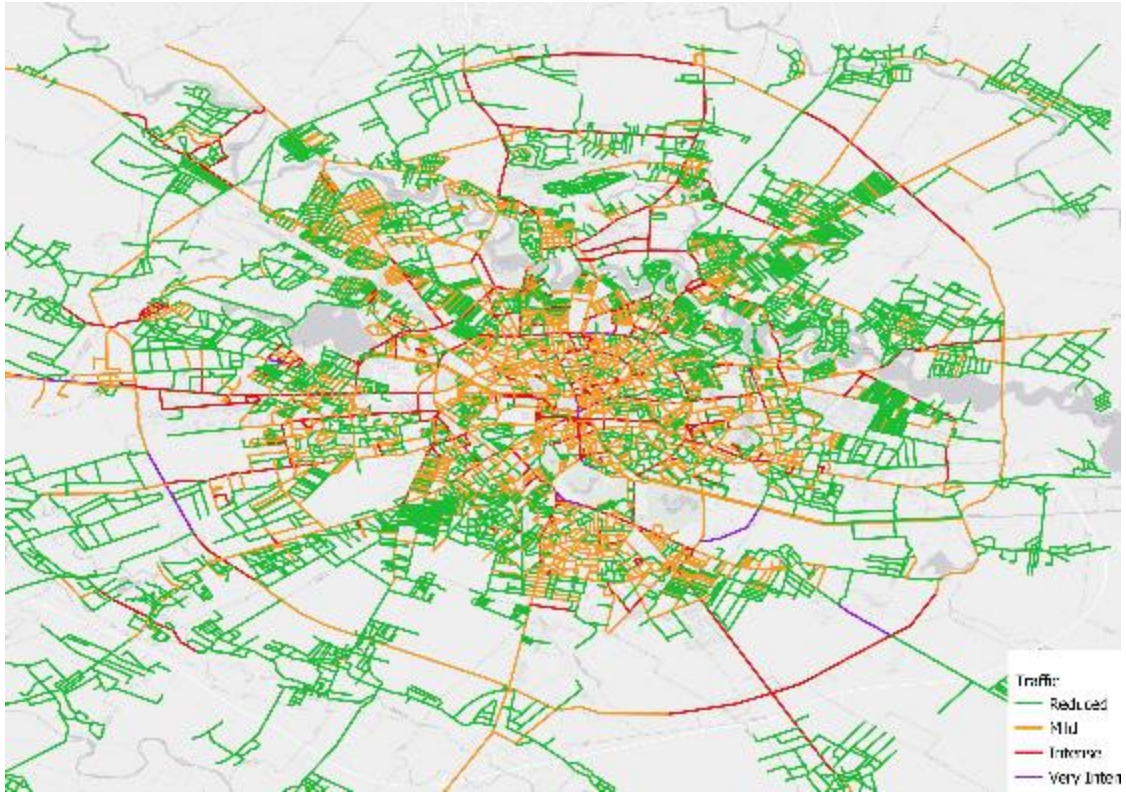
Bucharest mapping

- **Route**
  - Approx. 8h (8:30-17:00), including rush hours
  - Main traffic roads
  - Residential areas
  - Industrial and commercial areas
- **Model: ESCAPE Land Use Regression models + PyLUR tool + QGIS**
  - Road segments: ~250 m; midpoint coordinates
  - Dependent variables: average concentration of pollutant per road segment (UFP, PM10, PM2.5, PM1, NO2)
  - GIS predictors variables:
  - Corine CLC2018 Land use (industry, constructions, rezidential, green, agriculture, water bodies),
  - traffic (including traffic intensity and road lengths),
  - population density,
  - Meteorological data (temperature, relative humidity)



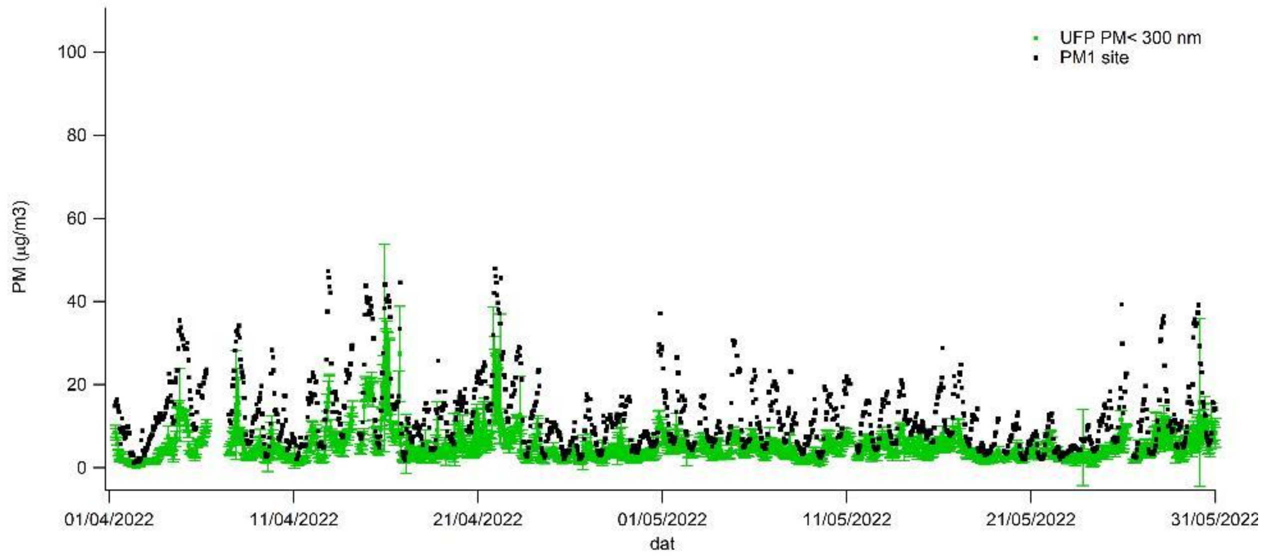
Land cover & high traffic

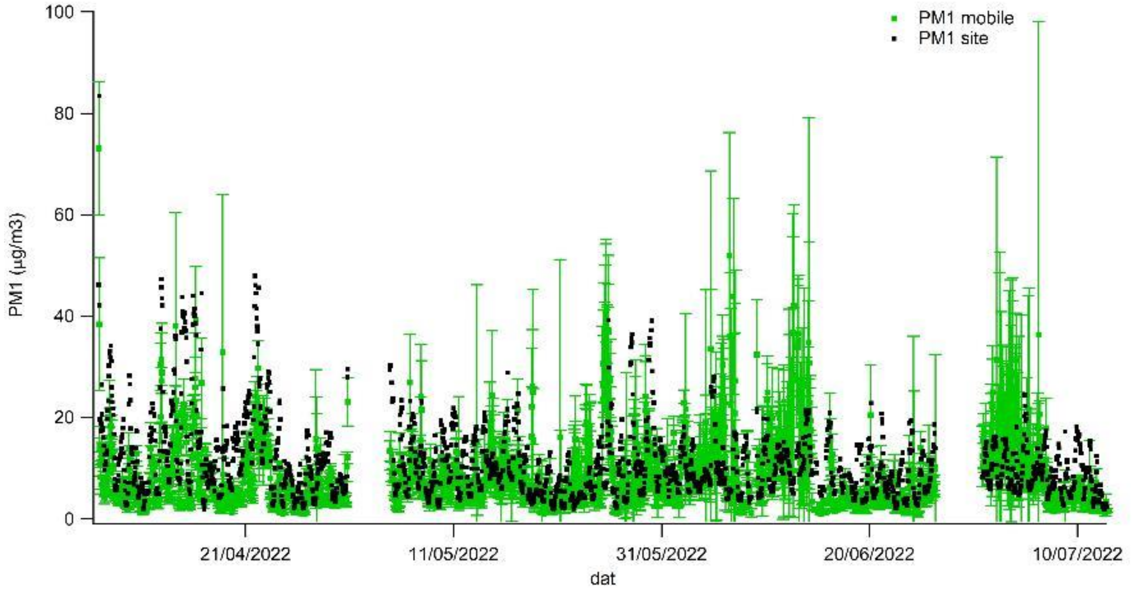




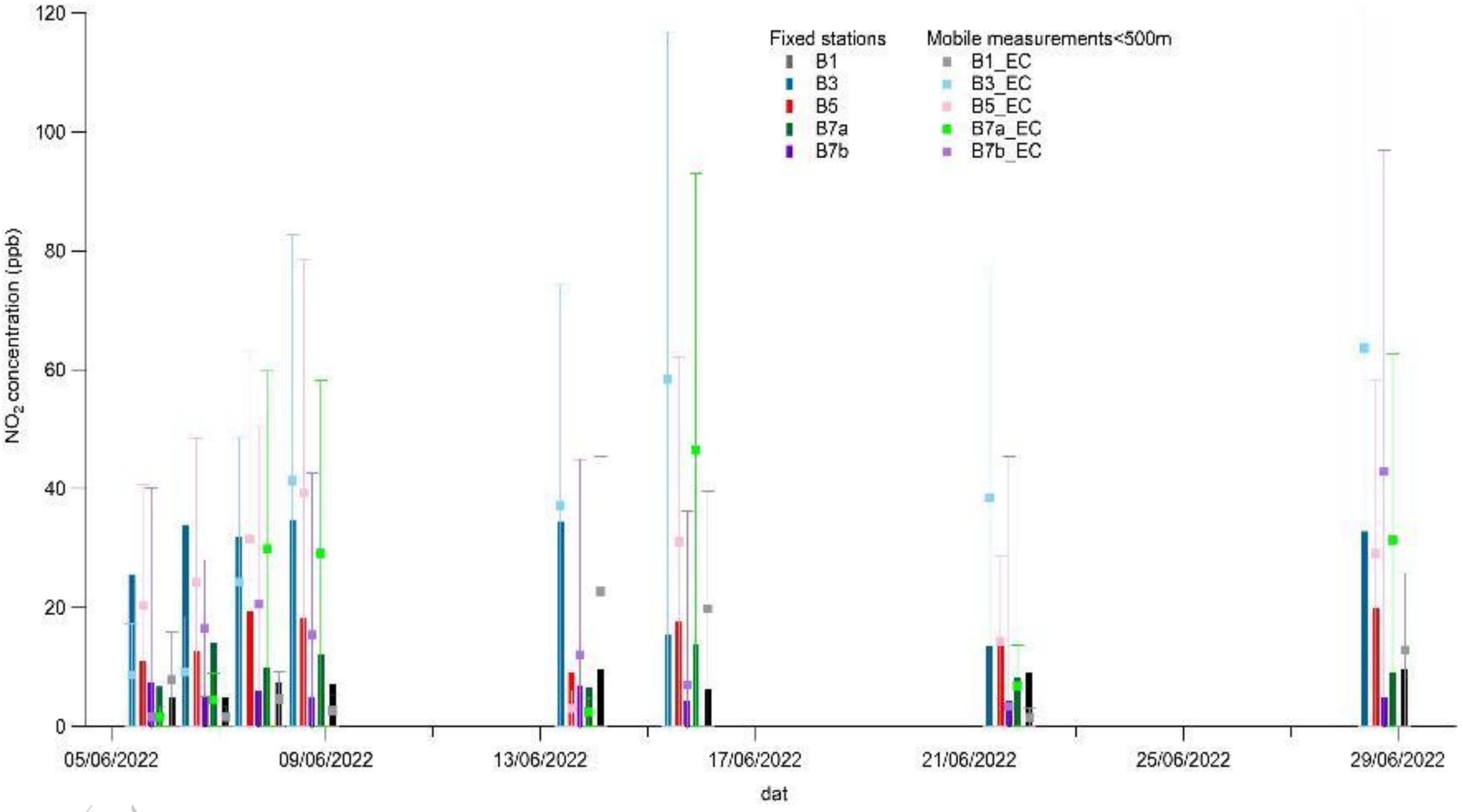
Tests & pre-campaign

Monthly comparison against a reference instrument at site or nearby: PMs & NO_2





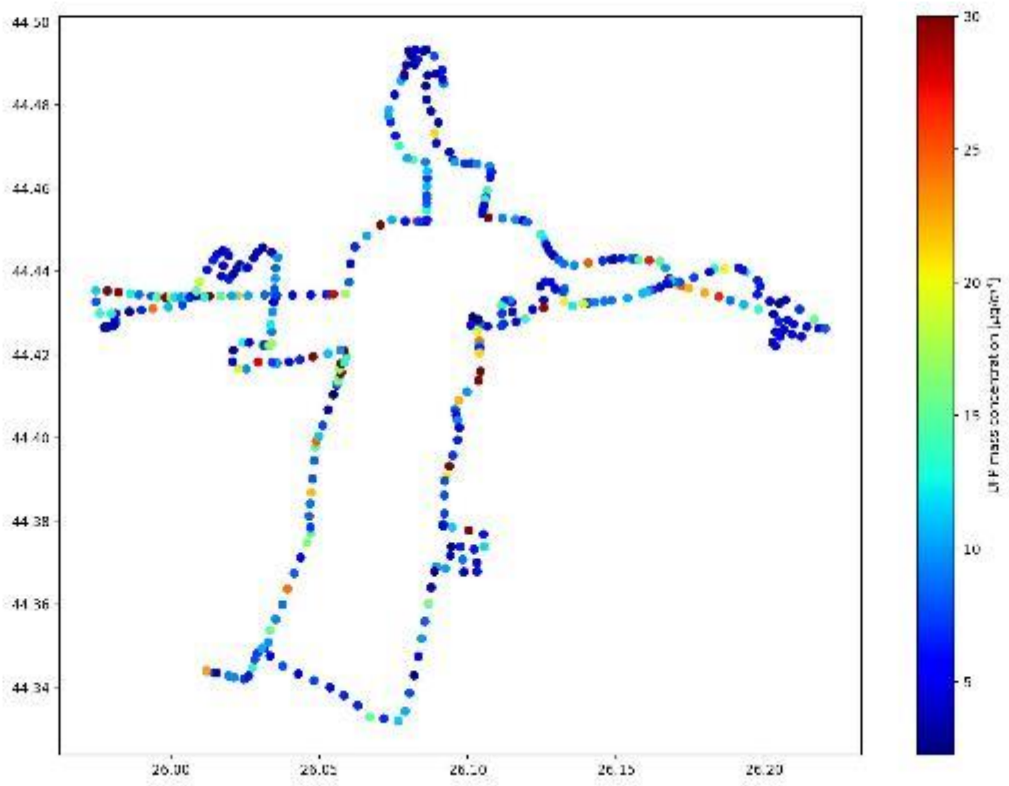
Tests & pre-campaign



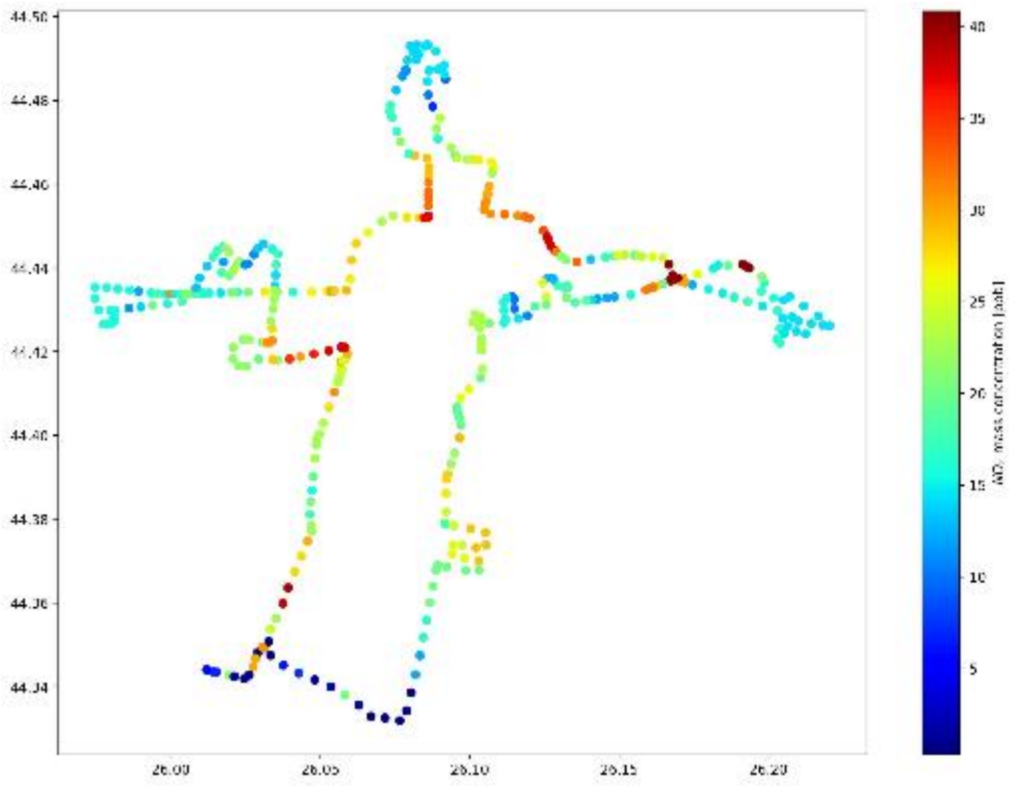
- Mean values comparison
  - mobile measurement (500m spatial distance from fixed stations)
  - hourly concentrations from fixed stations

Mean concentration - all measurements

UFP



NO_2



Rotterdam pilot

- Mobile monitoring using a dedicated car (Google airview)
- Mobile monitoring with citizens (with VITO)
- Existing low cost sensor measurements (with DCMR, RIVM: de Luchtclub Rotterdam focussed on PM2.5)
- Existing monitoring (DCMR, RIVM)

Device	Pollutants	Operating
GPS	Location	Google Ji-BOx
EPC	**Ultrafine Particles**	**Google Ji-BOx**
AE33	**Black Carbon**	**Google Ji-BOx**
DRX DustTrack	PM2,5	Manual
LiCOr	CO2	Google Ji-BOx
MiniDisc	Ultrafine Particles	Manual
2BTech	NOx	Google Ji-BOx
Aerodyne	NO2	Google Ji-BOx

Mobile monitoring car

- After WP2 protocol broadly completed (Jules Kerckhoffs, Univ. Utrecht)
- Multiple components
- Planned to start fall 2022
- Total about 6 weeks of driving
- Selected streets across the city to deliver a city-wide map
- Specific parts of city more repetitions e.g harbour area, refineries
- Input by DCMR: route selection and deterministic modelling

Mobile monitoring by bike with citizens

- Based on earlier work by VITO (Martine van Poppel, Jelle Hofman)
- BC only using portable aethalometer (AE51)
- Citizens from DCMR and city of Rotterdam will drive from home to work (preferably via the same route)

Deliverables & milestones

D4.6: Air pollution variability in the pilot studies (CNRS, R/PU, M30)
D4.7: Summary: mapping procedures, sustainability and applicability for upscaling (UU, R/PU, M40)

M4.5: Mapping pollutants related to health effects (maps available online, CNRS, M24)