



Milestone M20 (M4.4)

NRT data provision in operation



RI-URBANS

**Research Infrastructures Services Reinforcing Air
Quality Monitoring Capacities in European Urban &
Industrial Areas (GA n. 101036245)**

By

UoB, CSIC and UHEL



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Milestone M20 (M4.4): NRT data provision in operation

Authors: David Beddows (UoB), Katrianne Lehtipalo, Janne Lampilahti and Tuukka Petäjä (UHEL), Noemi Perez and Christina Reche (CSIC)

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Lead beneficiary	UoB
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1. About this document

This document reports the progress made towards the RI-URBANS Milestone M20 (M4.4) within Work Package 4, Task 4.2: Near-real time provision of nanoparticle-PNSD data / NRT data provision in operation.

This is a public document, available at the RI-URBANS website, <https://riurbans.eu/work-package-4/#milestones-wp4>, and distributed to all RI-URBANS partners for their use as well as submitted to European Commission as the RI-URBANS Milestone M20 (M4.4).

2. Aerosol number size distribution measurements

The aim of Pilot study 2 within RI-URBANS WP4 (Task 4.2) is to provide near-real time particle number size distribution (PNSD) data from different city environments in Europe. The measurements of aerosol number size distribution have started in each of the three pilot cities (Barcelona, Spain; Birmingham, UK and Helsinki, Finland) and work towards ensuring ACTRIS (Aerosol, Clouds and Trace Gases Research Infrastructure) compatibility and starting the NRT (near-real-time) data delivery is ongoing. The measurement sites and setups are described below.

2.1 BARCELONA

2.1.1 Site description

Barcelona has 1.6 million inhabitants (3.6 million in its metropolitan area). The city is located in a coastal area in the western Mediterranean (Figure 1). It is a densely populated area, also characterized by a high density of motor vehicles and by a compact architecture hampering dispersion of pollutants. The Barcelona Ring Roads Low Emission Zone (LEZ) was implemented in January 2020, so that the pilot will supply fundamental information for the evaluation of this plan.

Air quality (AQ) in the Barcelona city is affected by various industrial emissions in nearby areas. Moreover, the Barcelona harbour, one of the main harbours in the Mediterranean, is located in the city centre and the airport, the second largest airport in Spain, is 10 km away from the site. Barcelona is one of the most polluted cities in Europe, with NO₂ frequently exceeding the EU established limit values, and PM₁₀, PM_{2.5} and NO₂ concentrations above the WHO guidelines.

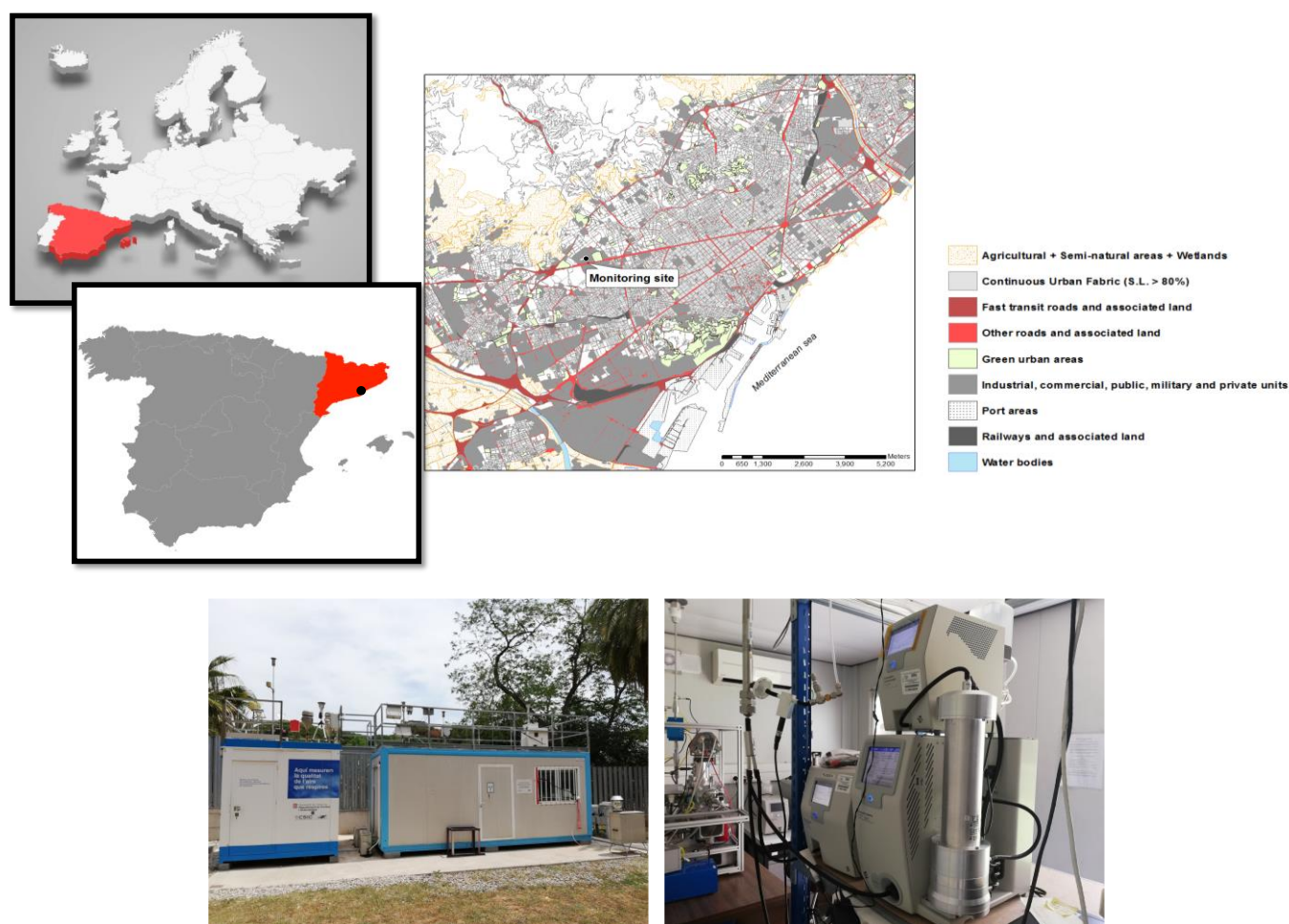


Figure 1. Barcelona monitoring station (BCN, urban background). Upper panel: Overview of the positioning of Barcelona and land use/cover of the area. Lower panel: monitoring station and instrumentation for UFP measurements.

2.1.2. Original Instrumental Setup and Description of Upgrade

The Barcelona supersite (BCN) is a reference site for AQ management authorities and AQ research in Spain. The site is operated in collaboration with the Government of Catalonia (GENCAT).

Since 2009, the BCN site is a complete state-of-the-art cutting-edge supersite integrated in AQ monitoring network, measuring a high number of variables and pollutants, comprising regulated pollutants (SO₂, NO_x, PM₁₀, PM_{2.5}), sub-micron aerosol number size distributions, absorption and aerosol chemical measurements, using offline (PM₁, PM_{2.5} and PM₁₀ sizes) and online Aerosol Chemical Speciation Monitor (ACSM) sub-micron) techniques. This approach has enabled studies on an extensive range of topics to be carried out, including time and spatial variation of ultrafine particles (UFP), sources of total number and PNSD modes resolved by cluster and receptor modelling, trends in primary and secondary particle number concentrations, PM_x chemistry and source apportionment, as well as quantification of African dust contributions using both offline and online multi-wavelengths particle absorption measurements. Online measurements of Volatile Organic Compounds (VOCs), combining different techniques (support from GENCAT), are currently being launched, while implementation of the Reactive Oxygen Species (ROS) measurements is also planned. It should be highlighted that BCN is a pilot in ACTRIS –CAMS (Copernicus Atmosphere Monitoring Service) system software, designed to report data in NRT.

On the other hand, intense collaboration CSIC - IS Global have allowed gathering understanding on effects of pollutants, including non-regulated variables, such as UFP and black carbon (BC), and sources on morbidity, mortality, hospitalizations and cognitive development. Citizen science has also been explored in our team (e.g., H2020 CAPTOR; H2020 CitieS-Health projects), based on a citizen network of low-cost sensors and passive dosimeters.

Average concentrations measured at the Barcelona supersite are in the range of those typically measured at an urban environment in southern Europe: O_3 70 $\mu\text{g}/\text{m}^3$; NO 2.5 $\mu\text{g}/\text{m}^3$; NO_2 18 $\mu\text{g}/\text{m}^3$; SO_2 2.1 $\mu\text{g}/\text{m}^3$; BC 925 ng/m^3 ; $\text{PM}_{2.5}$ 17 $\mu\text{g}/\text{m}^3$; PM_{10} 23 $\mu\text{g}/\text{m}^3$; N 11000 $\#/\text{cm}^3$

In the case of PNSD, the measurements started in 2013. The MPSS (Mobility Particle Size Spectrometer) system comprised of a TSI 3080 classifier, operated with a TSI 3081 DMA (Differential Mobility Analyzer) and a TSI 3772 CPC (Condensation Particle Counter). The MPSS was operated in conjunction with a stand-alone TSI 3785/3787 WCPC (Water-based Condensation Particle Counter). These instruments were connected to a sampling system consisting of a PM_{10} inlet, with a total flow rate of 38.3 l/min.

We have recently upgraded the MPSS system and stand-alone CPC to ACTRIS and CEN (European Committee for Standardization) standards. The Barcelona site is now running a TSI3938 SMPS (Scanning Mobility Particle Size) comprising of a TSI 3082 classifier, a wide range DMA TSI 3083 (10-800 nm) and a TSI 3750 CPC. Our classifier has been upgraded to be able to work with positive voltage. The stand-alone CPC has been replaced with a TSI 3750 CPC and this instrument has been upgraded to meet the ACTRIS standards. Therefore, the lower detection efficiency diameter (DP50) has been changed from 7 to 10 nm. All these instruments have recently been calibrated following the ACTRIS standards at the December 2022 Calibration Workshop held at TROPOS, Germany. We have recently added a UCPC (Ultrafine Condensation Particle Counter) TSI 3756 for parallel particle concentration measurements from 3nm.

We are using a BGI $\text{PM}_{2.5}$ inlet, exclusively dedicated to UFP measurements. The aerosol is dried before the splitter using a TROPOS Nafion dryer operated with a compressor and a membrane dryer, which dries aerosol to relative humidity $\text{RH}>40\%$.

The TSI software has been upgraded to the latest TSI AIM11 (monitoring version). In addition, we are exporting data continuously from our station using the CAMS system. NRT upgraded software was installed and set up on the logging computer at the December 2022 Calibration Workshop held at TROPOS, Germany.

2.2. BIRMINGHAM

2.2.1 Site description

With a population of 1.14 million inhabitants in 2019 (ONS, 2017), the UK city of Birmingham is the location (latitude = 52° 27' 19.872" N and longitude = 1° 55' 44.213" W, Figure 2) of Birmingham Air Quality Site (BAQS; urban background). The BAQS supersite is one of three NERC funded supersites in the UK, the other two being at Manchester Piccadilly and London Honor Oak Park sports ground. The Birmingham facility is located within a self-contained cabin within a small green space within the grounds of the University which itself is surrounded by green space residential and campus facilities. There is a trainline 84 m NW of the site and the nearest roads are: Farquhar Rd (177 m); Edgbaston Park Road (132 m); and Pritchatts Road (262 m). The next largest facility is the Queen Elizabeth Hospital (1.1 km) and the edge of the city centre (taken as the A4540 ring-road) is 2.1 km to the NE. According to the West Midlands Road traffic statistics, 4.21 billion vehicle miles were travelled on roads in Birmingham in 2019, 3.44 billion of which were cars and taxis. Edgbaston Park Road takes roughly 4,800 vehicle per day and Vincents Drive takes traffic from Pritchatts Road and Farquar Road to the Hospital takes roughly 6,814

vehicle per day (DfT Road Traffic Statistics for counting sites 945338 and 947763: <https://roadtraffic.dft.gov.uk/local-authorities/141>). The site experiences an average temperature of 11 E 5 °C; pressure of 995 E 12 mBar.

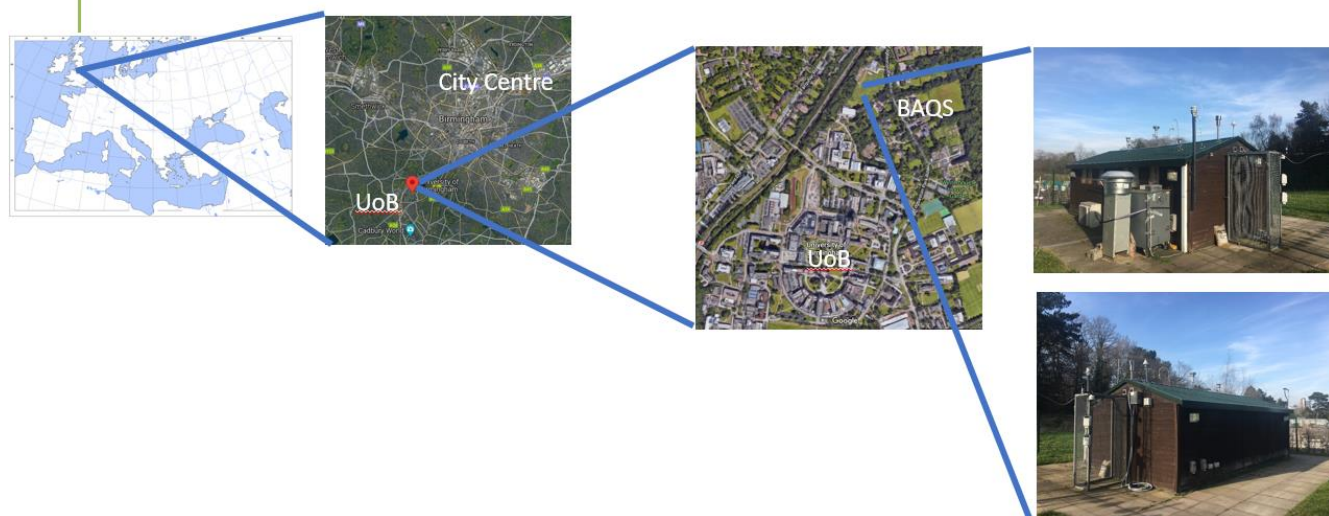


Figure 2. BAQS Birmingham Air Quality Site (urban background) in Birmingham, UK. Upper panel: Overview of the positioning of the site. Lower left panel: proximity of the sampling sites to the city centre (defined by the ring road shown in green). Lower right panel: location of BAQS within the University grounds

2.2.2. Original Instrumental Setup and Description of Upgrade

Since the start of its operation in 2019, BAQS has measured typical yearly mean values for both gas and aerosol measurements: O_3 48 $\mu\text{g}/\text{m}^3$; NO 3 $\mu\text{g}/\text{m}^3$; NO_2 18 $\mu\text{g}/\text{m}^3$; BC 777 ng/m^3 ; $PM_{2.5}$ 9.4 $\mu\text{g}/\text{m}^3$; PM_{10} 13 $\mu\text{g}/\text{m}^3$, and for particle number measurements the site has recently gone through an upgrade to ACTRIS standards.

Before the upgrade, the MPSS comprised of a TSI 3082 classifier, operated with a TSI 3081 DMA (Differential Mobility Analyzer) and a TSI 3750 CPC (Condensation Particle Counter). This was operated in conjunction with a stand alone TSI 3750 CEN-CPC. An average plot of the data measured using the MPSS is shown in Figure 3. Both the MPSS and CEN-CPC were connected to a Sampling System for Atmospheric Aerosol Model – TSI-3772200. This is described under the Technical Specification CEN*/TS 16976 which aimed at harmonizing the continuous measurement of particle number concentration in ambient air. It described a standardized method not only for the Condensation Particle Counter (CPC) for which we also added the MPSS via a T-piece.



Figure 3. Left panel: A photograph of the original MPSS system at BAQS. Right panel: A photograph of the upgraded MPSS and CEN system to ACTRIS standards, now scanning from 10-800 nm. More recently adapted to include a 4 ways aerosol splitter, not shown in photograph.

Also shown in the Figure 3 is the MPSS after its upgrade to the ACTRIS standards. The TSI-3082 classifier was upgraded to Dual Polarity; the DMA was upgraded to the 3083 which specializes on covering the size range from 10 nm to 800 nm in one single scan; and the sampling system was upgraded to the TSI-3750200, designed follows all requirements specified in the European standards CEN/TS 16976 and 17434. Aerosol entering through a PM₁₀ head, now passes through an optional PM_{2.5} cyclone, and is then dried to <40% relative humidity. An isokinetic flow splitter distributes particles to up to 4 instruments (currently just CEN-CPC and SMPS).

Further upgrades to the UoB system have focussed on the NRT Provision through the upgrading of the data acquisition from USB to Ethernet logging to improve stability and aid direct communication with the instruments over the network. Furthermore, by working with the University IT Service, were able to setup a secure data route through the University Firewall to Norwegian Institute for Air Research (NILU, Norway). At the 2022 December Calibration Workshop, the NRT software was installed and set up on the host computer. Through subsequent online meetings with Thomas Mulher, the various logging components of the NRT software were set up and the system is now sending hourly data to NILU.

2.3 HELSINKI

2.3.1 Site description

Helsinki is the capital of Finland, located on the coast of the Baltic Sea (LAT = 60° 10' 15" N; LONG = 24° 56' 15" E). The population is 660 000 inhabitants, with ca. 1.6M people living in the metropolitan area surrounding Helsinki. In Helsinki, we are conducting PNSD measurements within the H2020 RI-URBANS project at two nearby sites. Both are located ca. 4 km from the Helsinki city center (see Figure 4ab). Mäkelänkatu site is an urban traffic site operated by the Helsinki Regional Air Quality Authority (HSY), while SMEAR-III is an urban background site operated jointly by the University of Helsinki (UHEL) and the Finnish Meteorological Institute (FMI).

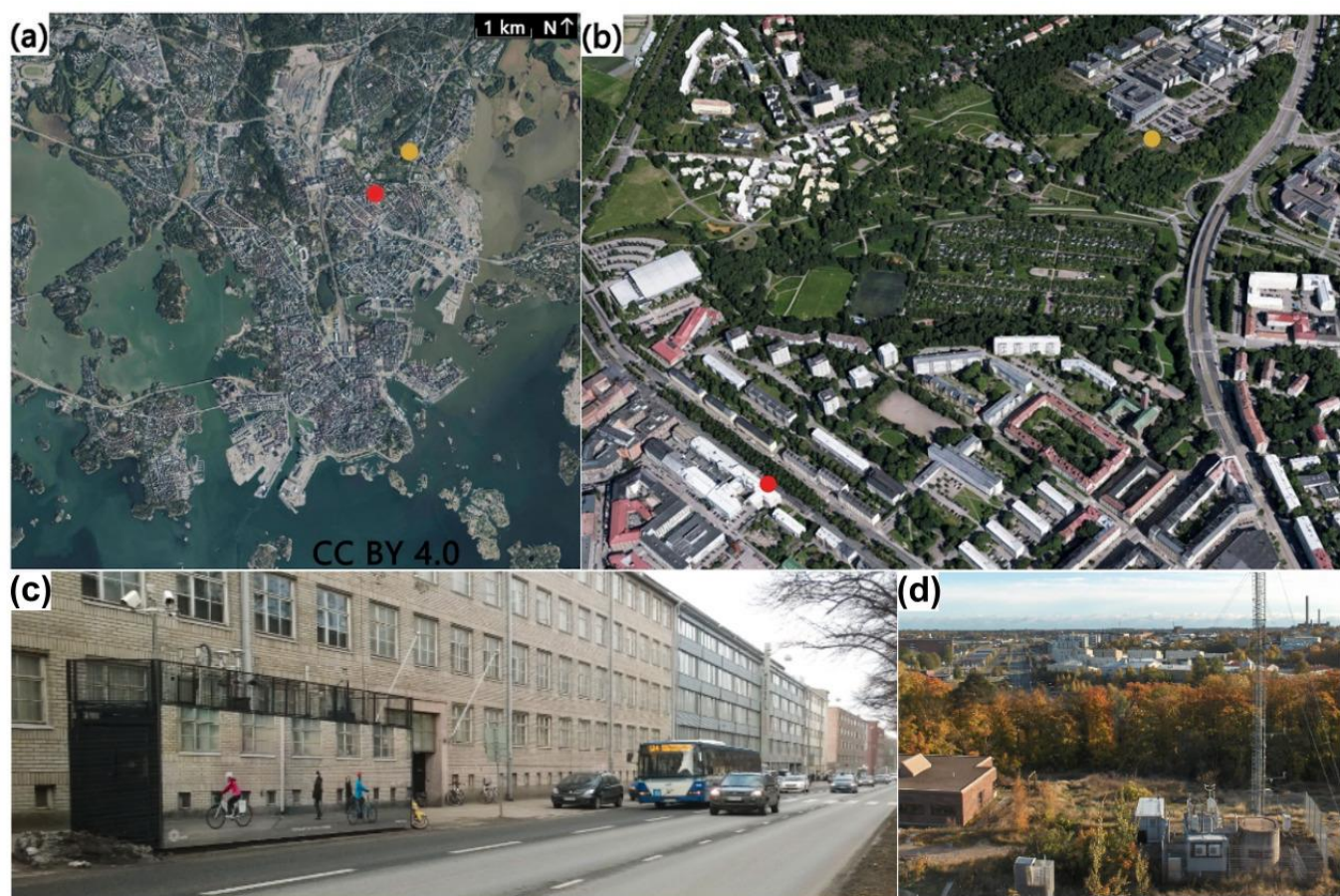


Figure 4. (ab) Locations of measurement sites in the Helsinki metropolitan area, Finland. Red dot is Mäkelänkatu road-side site, while the yellow dot is the SMEAR-III site located at the Kumpula University Campus area. (c) view of the Mäkelänkatu site and (d) a view towards South-East of the SMEAR-III site.

2.3.2 Original Instrumental Setup and Description of Upgrade

The SMEAR-III site was established in 2004 to provide long-term measurements of the chemical and physical properties of aerosol particles, trace gas concentrations, and meteorological parameters in an urban background environment. The instruments are located in a container or a 31 m tall tower that is next to the container (Figure 4d). SMEAR-III is an ACTRIS site and therefore follows the ACTRIS recommendations for sampling. The Mäkelänkatu site was established in 2015 and the set of measured variables is comparable to the SMEAR-III site. The instruments are in a container that is next to a busy road (Figure 4c).

The PNSD at the SMEAR-III station is measured by a Twin-DMPS system. The twin system consists of a Hauke-type DMA with a TSI Model 3756 CPC and a second Hauke-type DMA with a TSI Model 3772 CPC. The combined diameter range is 3-820 nm. The DMPS system at SMEAR-III first became operational in August 2004. Mäkelänkatu site also has a DMPS system but it uses a single Vienna type DMA with an Airmodus CPC model A20. The measured diameter range is 6-800 nm. The data availability starts from 2015.

Both the SMEAR-III and Mäkelänkatu sites are currently providing NRT data to the data center.

3. Calibration Workshop

All systems operating at the 3 pilot sites were calibrated at the December 2022 Calibration Workshop held at TROPOS, Germany. Attendance of the instruments completed the upgrade of the system. The Da50 values of the UoB MPSS CPC was changed from 7 to 10 nm and the NRT software was installed and set up on the logging computer. Furthermore, the necessary ACTRIS lab-based calibration procedures were carried out on the SMPS and CEN-CPC. Following the week of calibration, the systems were returned to their respective cities to continue normal operation. For the UoB, this completed the upgrade and setup of the MPSS system to collect ACTRIS compliant data in NRT although the CEN-CPC was found with issues requiring TSI maintenance.

4. Conclusions and next steps

NRT data provision is in operation at all pilot sites and the next step is to uphold this status until the next calibration workshop.