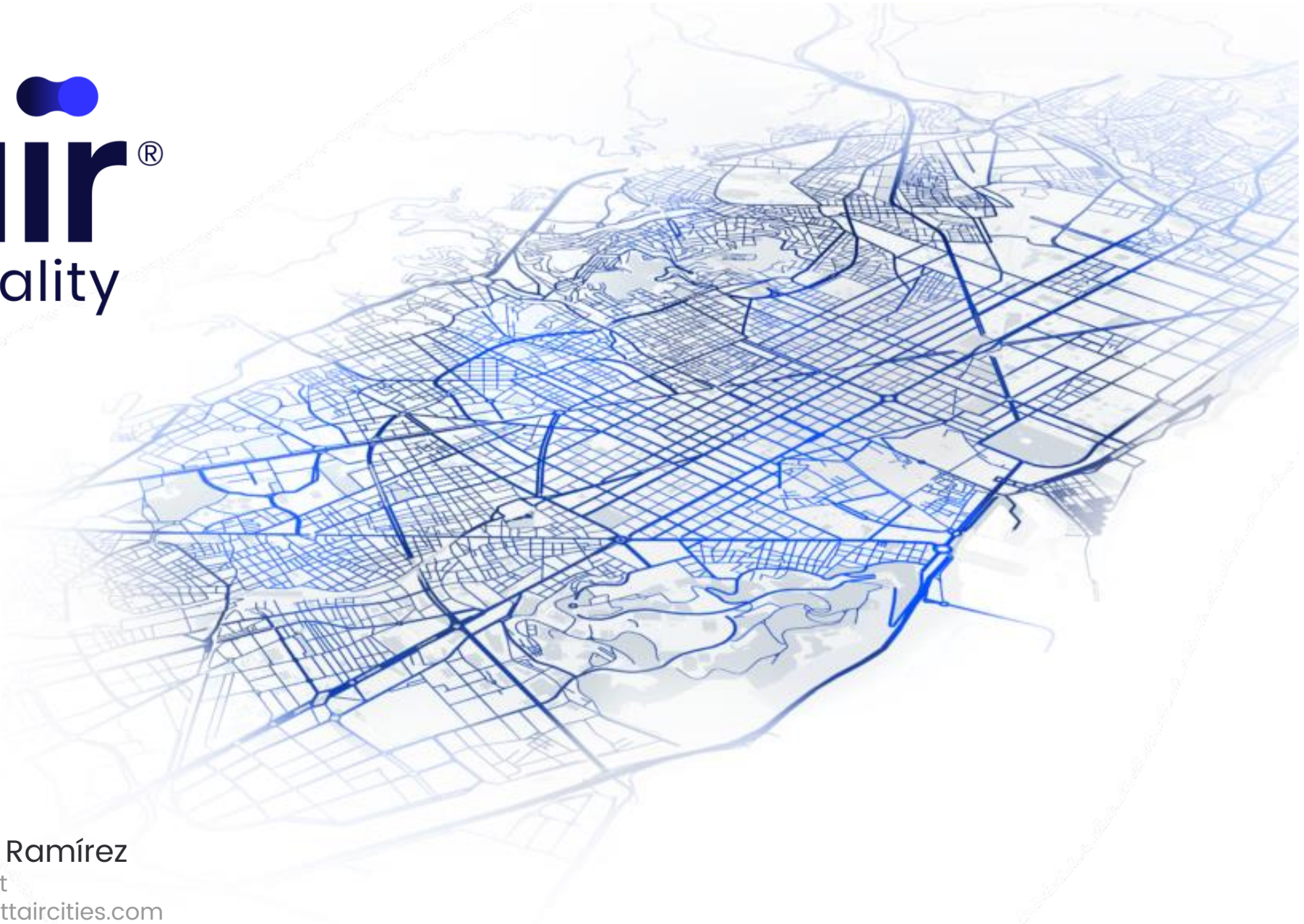
bettair®

Mapping Air Quality



3r Congrés Qualitat de l'aire

www.congresaire.cat

Josep Perello
CEO and Co-founder
jperello@bettaircities.com
+34 678478856

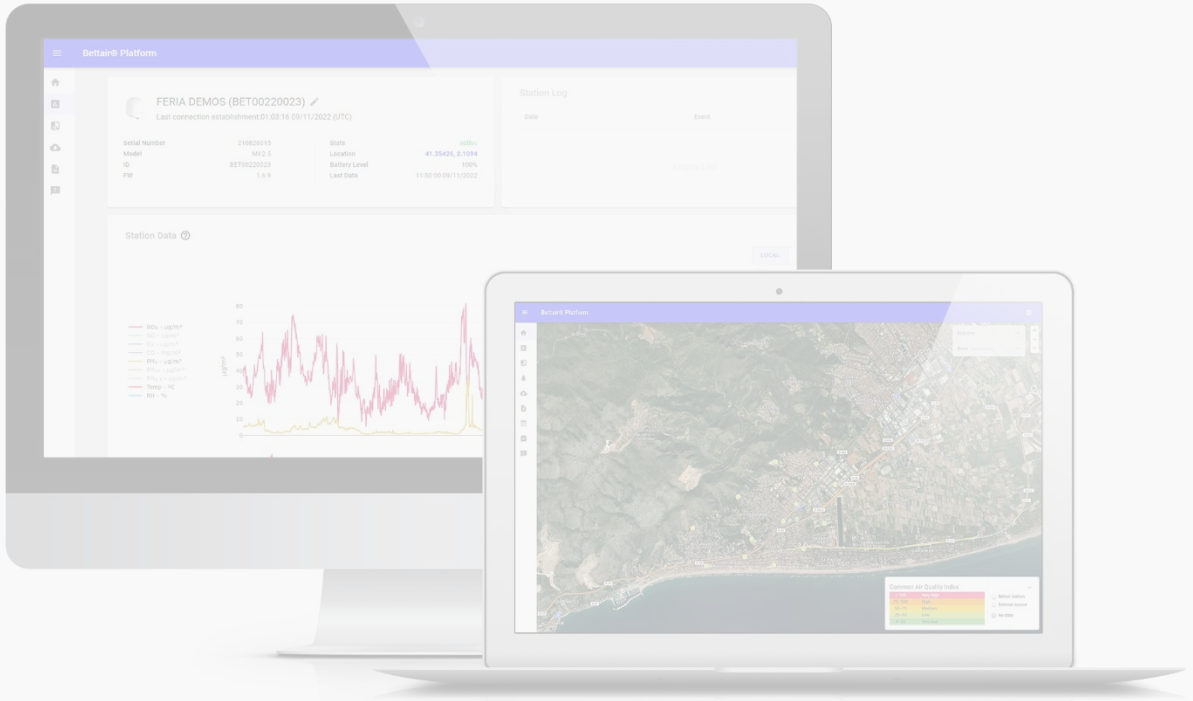
Francisco Ramírez
Lead Scientist
framirez@bettaircities.com
+34 685617817

https://bettaircities.com

Accurate air pollution mapping on a previously unimaginable scale

Our Story

bettair® technology



UNE-CEN/TS 17660-1

MappingAir

Mapping air quality with high accuracy and high special resolution

bettair® Mapping Air Quality

Omniflow

CISCO

TIM

ISGlobal Barcelona Institute for Global Health

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 878799

Outstanding accurate air pollution data

Artificial Intelligence algorithms trained during years in multiple cities for maximum accuracy.
+3M€ Intellectual property investment.

bettair®
Mapping Air Quality

Data gathering ➡ Auto calibrated AQM + Cartridge Design ➡ Artificial Intelligence ➡ SaaS

Raw Sensor Data

- Temperature
- Atmospheric Pressure
- Relative Humidity
- Air Pollutants…
  - NO_2, O_3, NO, CO, SO_2
  - H_2S, VOC, NH_3
- Particulate Matter
  - PM_1, $PM_{2.5}$, PM_{10}
- Greenhouse Gases
  - CO_2
- Ambient Noise

All sensors inside an easy to replace cartridge

Post processing Algorithm
2 years without calibration

Machine Learning Techniques

Accuracy according to CEN/TS 17660-1:2022 Class-1

Air quality - Performance evaluation of air quality sensor systems - Part 1: Gaseous pollutants in ambient air

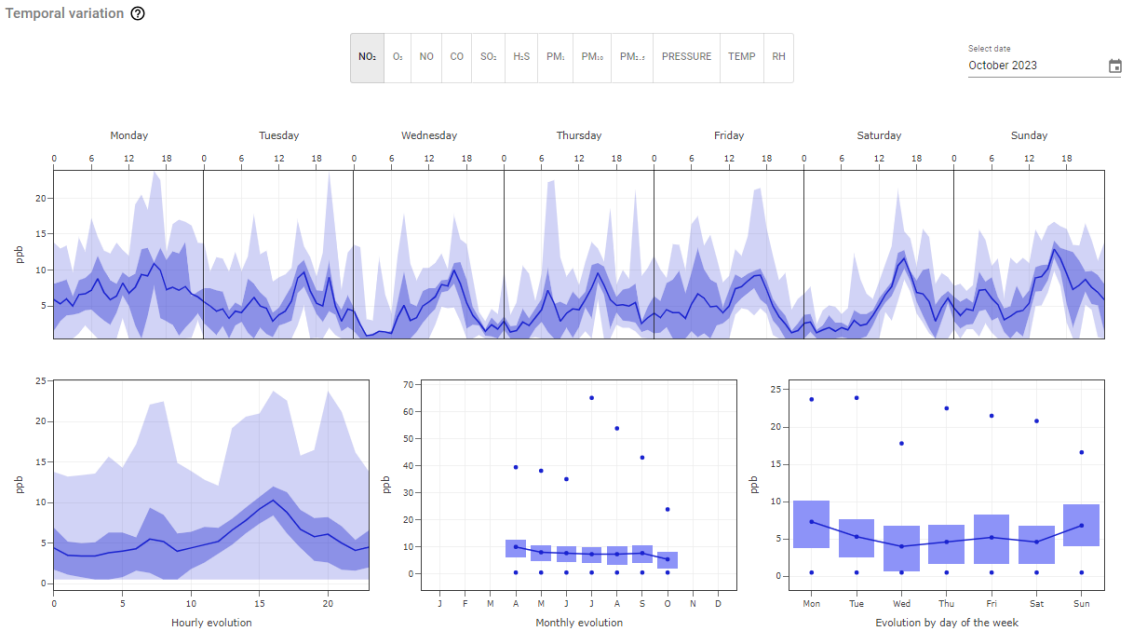
Low cost Air Quality Monitoring **Platform**

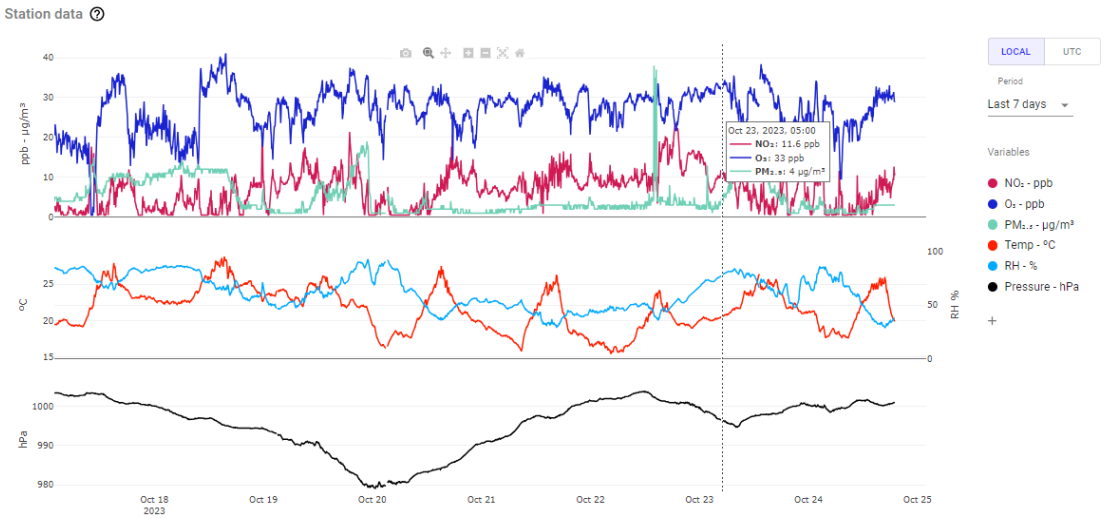
Data insights
Air quality maps
Air pollution forecast
Citizen Mobile apps

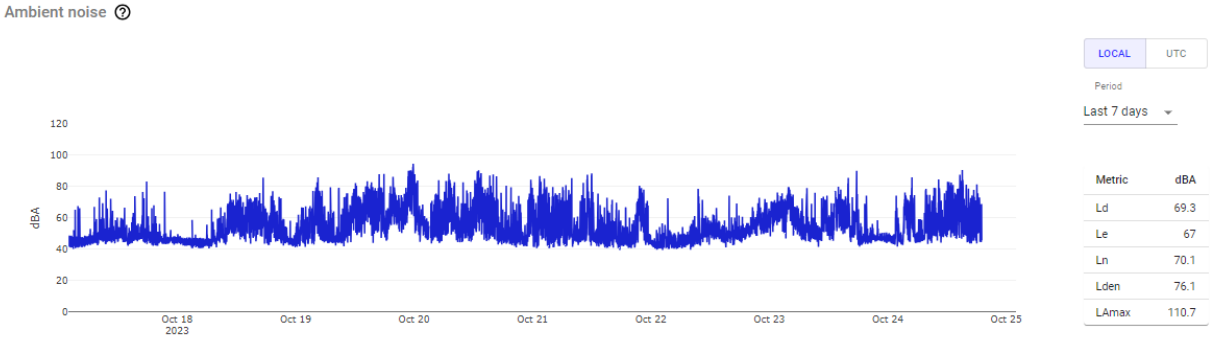
Easy-to-use SW Platform

Easy access to the air quality data by means of an online dashboard (or by API)

bettair®
Mapping Air Quality







Metric	dBA
Ld	69.3
Le	67
Ln	70.1
Lden	76.1
LAmax	110.7

Our first distributor – dnota medioambiente

dnota medioambiente is a National Accreditation entity that can homologate equipment

bettair® Mapping Air Quality

d·nota

ENAC Entidad Nacional de Acreditación

Distributors of **premium brands** of traditional equipment with offices in Barcelona and Madrid.

Thermo SCIENTIFIC · Synspec b.v. · DIGITEL enviro-sense

They **build up traditional Air Quality Monitoring** (AQM) stations in several regions in Spain and they are also **in charge of the maintenance** of these AQM stations.

The group also possess an **environmental lab in Canada.** H²Lab

Dnota medioambiente (Oscar Navarro – Managing Director):
"We had been testing different devices for years and we were impressed with the precision, accuracy and repeatability of the bettair® technology, which does not require any type of on-site calibration or maintenance during the lifetime of the sensing cartridge"

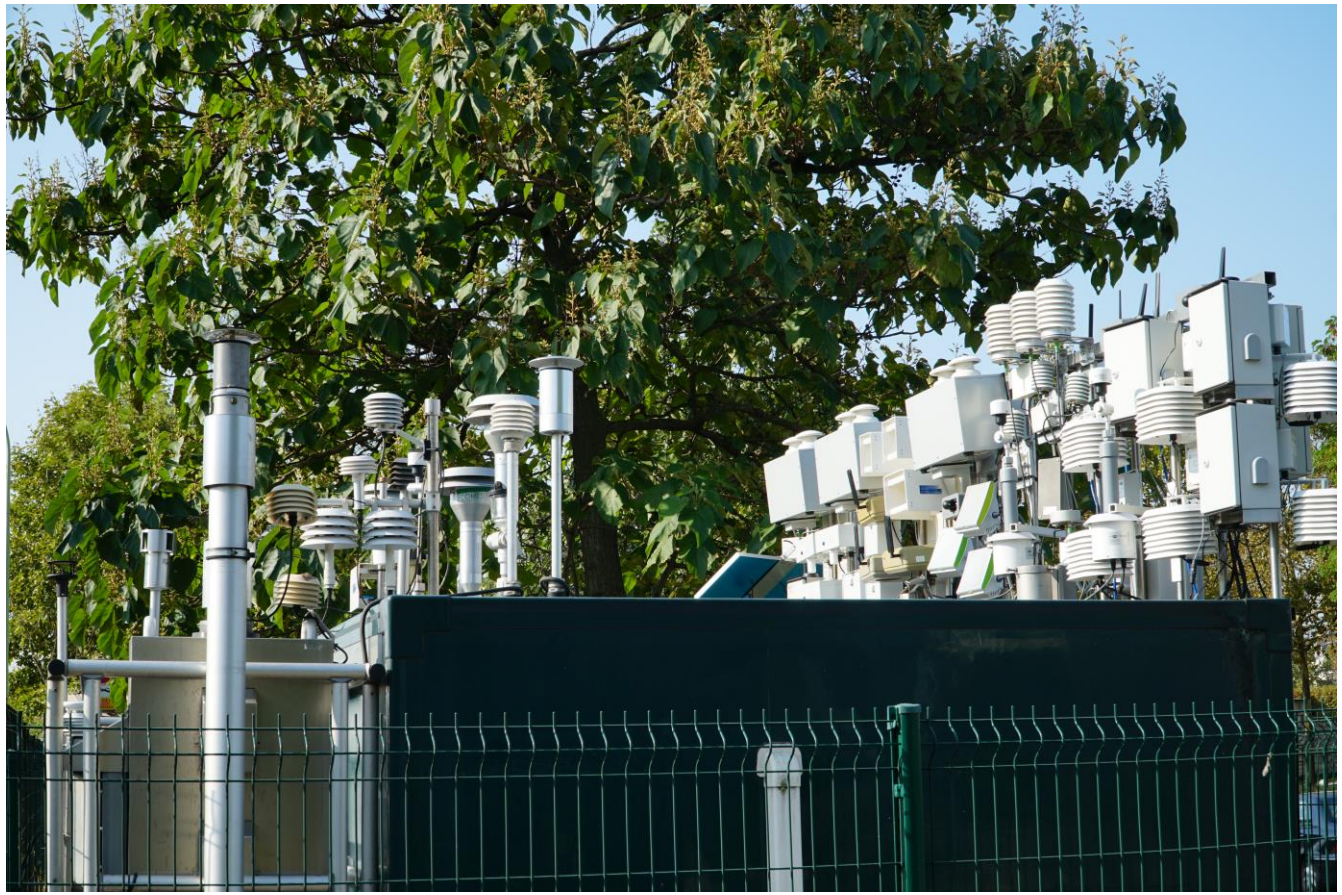
bettair® Accuracy

Co-location test leaded by recognised third parties

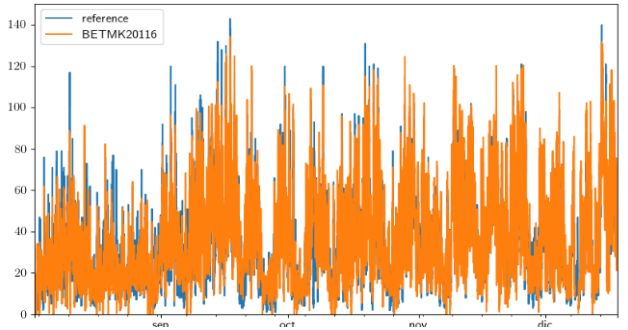
WINNER
AIRLAB
Microsensor
Best accuracy for Ozone
2021

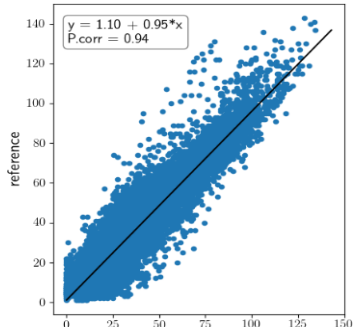
bettair®
Mapping Air Quality

UNIVERSITY OF CAMBRIDGE
Diputació Barcelona
AIRLAB SOLUTIONS POUR NOTRE AIR
d·nota
SGS

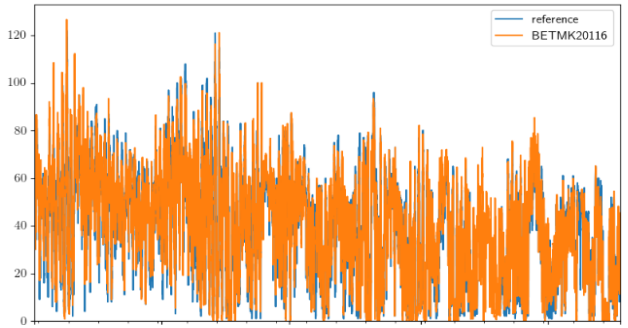


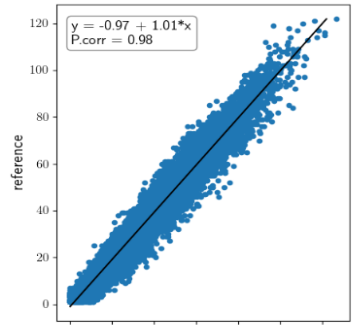
NO2



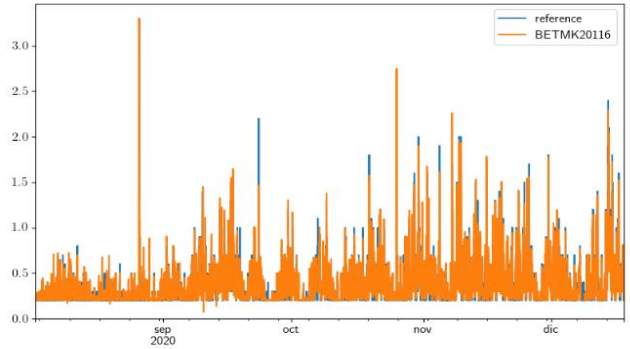


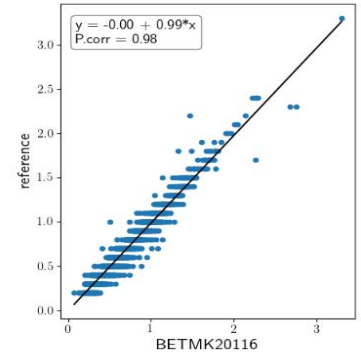
O3





CO





Who trust us

bettair®
Mapping Air Quality

Organismos

Ajuntament de Llinars del Vallès
Ayuntamiento de Málaga
SPQR ROMA CAPITALE
Ajuntament de Girona
Diputació Barcelona xarxa de municipis
Ajuntament de Palau-solità i Plegamans
Ajuntament de Montcada i Reixac
Ajuntament de Castelldefels
Ayuntamiento de BAENA
Ajuntament de L'Hospitalet
AJUNTAMENT DE SantCugat
Ajuntament de Dosrius
Port Tarragona
Viladecans
Ajuntament de Manlleu
Ajuntament de Mollet del Vallès
Ajuntament del Prat de Llobregat
Comune di Pordenone

Empresas

CONSTRUCCIONES RUBAU
d·nota
SGS
etra
Omniflow
ADTEL
ControlCat seguretat intel·ligent
nexusgeographics MAPPING YOUR WORLD
CospLaan CONSTRUIMOS GRANDES IDEAS
ROGASA
RACC
trafficnow

Directive 2008/50/EC

Ambient Air Quality Directive

- It establishes air quality objectives, including ambitious, cost-effective targets for improving human health and environmental quality.
- Sets for NO2,CO,NO,O3,SO2, Benzene, PM2.5, PM10 and Pb either:
  - **limit value:** legally binding levels from the date it enters into force subject to any exceedances permitted by the legislation.
  - **target values:** the obligation is to take all necessary measures not entailing disproportionate costs to ensure that it is attained, and so it is less strict than a limit value.
- Sensor system classification according Directive 2008/50/CE according to **Expanded Uncertainty** (EU), Data Capture (DC) and Time Coverage:
  - **Fixed Measurement** - EU less than 15% of limit value. DC more than 90%. Coverage
  - **Indicative Measurements** – EU less than 25% of limit value. DC more than 90%. Coverage.
  - **Objective Estimation** – EU less than 75%
  - **Modelling data** - EU less than 50%

Directive 2008/50/EC

Ambient Air Quality Directive

- It establishes air quality objectives, including ambitious, cost-effective targets for improving human health and environmental quality.
- Sets for NO2,CO,NO,O3,SO2, Benzene, PM2.5, PM10 and Pb either:
  - **limit value:** legally binding levels from the date it enters into force subject to any exceedances permitted by the legislation.
  - **target values:** the obligation is to take all necessary measures not entailing disproportionate costs to ensure that it is attained, and so it is less strict than a limit value.
- Sensor system classification according Directive 2008/50/CE according to **Expanded Uncertainty** (EU), Data Capture (DC) and Time Coverage:
  - **Fixed Measurement** - EU less than 15% of limit value. DC more than 90%. Coverage
  - **Indicative Measurements** – EU less than 25% of limit value. DC more than 90%. Coverage.
  - **Objective Estimation** – EU less than 75%
  - **Modelling data** - EU less than 50%

Directive 2008/50/EC

bettair®
Mapping Air Quality

Ambient Air Quality Directive

- It establishes air quality objectives, including ambitious, cost-effective targets for improving human health and environmental quality.
- Sets for NO2,CO,NO,O3,SO2, Benzene, PM2.5, PM10 and Pb either:
  - **limit value:** legally binding levels from the date it enters into force subject to any exceedances permitted by the legislation.
  - **target values:** the obligation is to take all necessary measures not entailing disproportionate costs to ensure that it is attained, and so it is less strict than a limit value.
- Sensor system classification according Directive 2008/50/CE according to **Expanded Uncertainty** (U), Data Capture (DC) and Time Coverage:
  - **Fixed Measurement** - U less than 15% of limit value. DC more than 90%. Coverage.
  - **Indicative Measurements** – U less than 25% of limit value. DC more than 90%. Coverage.
  - **Objective Estimation** – U less than 75% of limit value.
  - **Modelling data** - U less than 50% of limit value.

CEN/TS 17660-1:2022

Technical specifications to evaluate performance of **gas** sensor systems following the Directive 2008/50/CE.

- **NO2, NO, CO, SO2, O3**, Benzene, CO2.
- Different certifications according to climatology and site typology through.
    - Temperature and humidity / pluviometry.

CEN/TS 17660-1:2022

bettair®
Mapping Air Quality

Technical specifications to evaluate performance of **gas** sensor systems following the Directive 2008/50/CE.

- **NO2, NO, CO, SO2, O3**, Benzene, CO2.
- Different certifications according to climatology and site typology .
  - Temperature and humidity / pluviometry.

Temperature	Humidity/ precipitation	Classification		Season	
		Extreme	Mild	Extreme	Mild
Hot	Dry	Bwh	Bsk, Bsh	Summer	Summer
Hot	Wet	Cfa	Csa	Summer	Winter
Cold	Wet	Cfb	Dfb	Winter	Spring, Autumn
Changeable	Changeable	Cfa, Csa	Cfb, Dfb	Spring, Autumn	Spring, Autumn

Type of station	Hourly O_3 concentrations 2017					
	25 % µg/m³	Median µg/m³	75 % µg/m³	90 % µg/m³	98 % µg/m³	99,9 % µg/m³
Background rural	43	62	81	98	123	170
Background urban	28	50	70	89	118	169
Background suburban	30	53	74	94	122	173
Traffic rural	21	43	66	87	112	143
Traffic urban	22	45	66	84	109	146
Traffic suburban	24	50	72	92	116	147

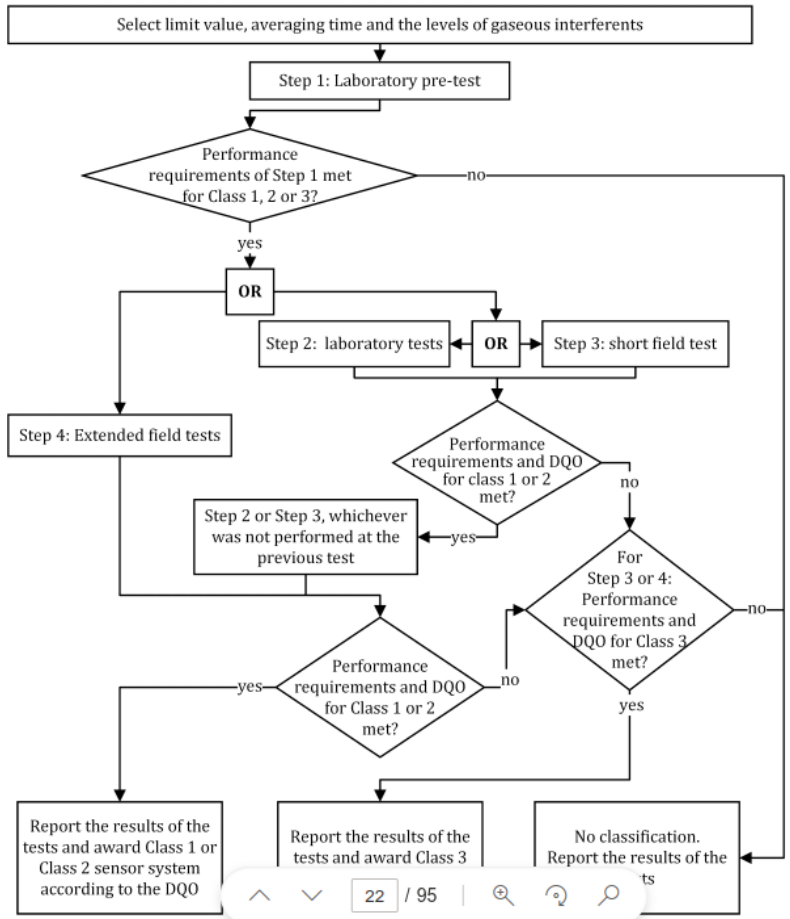
Classification	Conditions
Cfa Humid subtropical climate Extreme hot-wet	Coldest month average > 0 °C (or −3 °C). At least one month's average temperature > 22 °C. At least four months averaging > 10 °C. Similar precipitation in all seasons. Wet summer.
Cfb Temperate oceanic climate Extreme cold-wet	Coldest month averaging > 0 °C (or −3 °C). All months with average temperatures <22 °C. At least four months averaging >10 °C. Similar precipitation in all seasons.
Csa Hot-summer Mediterranean climate Mild hot-wet	Coldest month averaging > 0 °C (or −3 °C). At least one month's average temperature > 22 °C. At least four months averaging > 10 °C. Wettest winter month > 3 times driest summer month. Driest summer month < 30 mm.
Dfb Warm-summer humid continental climate Mild cold-wet	Coldest month averaging < −0 °C (or −3 °C). All months average temperatures < 22 °C. At least four months averaging > 10 °C. Similar precipitation in all seasons.

CEN/TS 17660-1:2022

Technical specifications to evaluate performance of **gas** sensor systems according the Directive 2008/50/CE.

- **NO2, NO, CO, SO2, O3**, Benzene, CO2.
- Different certifications according to climatology and site typology.
  - Temperature and humidity / pluviometry.

- Dual methodology (3 sensor systems):
  - Lab Pre-test
  - Then:
    - Extended field evaluation (40 days + 40 days)
      - In 2 Seasons: May-Sept, Nov-March,
      - Urban/Suburban, Rural
      - Different climate conditions should be covered
    - Lab. tests and short field evaluation (40 days)



CEN/TS 17660-1:2022

Technical specifications to evaluate performance of **gas** sensor systems according the Directive 2008/50/CE.

- **NO2, NO, CO, SO2, O3**, Benzene, CO2.
- Different certifications according to climatology and site typology.
  - Temperature and humidity / pluviometry.

- Dual methodology (3 sensor systems):
  - Lab Pre-test
  - Then:
    - Extended field evaluation (40 days + 40 days)
      - In 2 Seasons: May-Sept, Nov-March,
      - Urban/Suburban, Rural
      - Different climate conditions should be covered
      - Comparisons with AQMS
    - Lab. tests and short field evaluation (40 days)

Stage	Parameter
Field test	Between sensor system uncertainty
	Minimum data capture
	Slope of the regression line
	Intercept of the regression line
Pre-lab testing	Response time Lack of fit Limit of detection, repeatibility

CEN/TS 17660-1:2022

Technical specifications to evaluate performance of **gas** sensor systems according the Directive 2008/50/CE.

- **NO2, NO, CO, SO2, O3**, Benzene, CO2.
- Different certifications according to climatology and site typology.
  - Temperature and humidity / pluviometry.
- Dual methodology:
  - Long Laboratory Testing + Field evaluation
  - Pretest + Extended Field evaluation

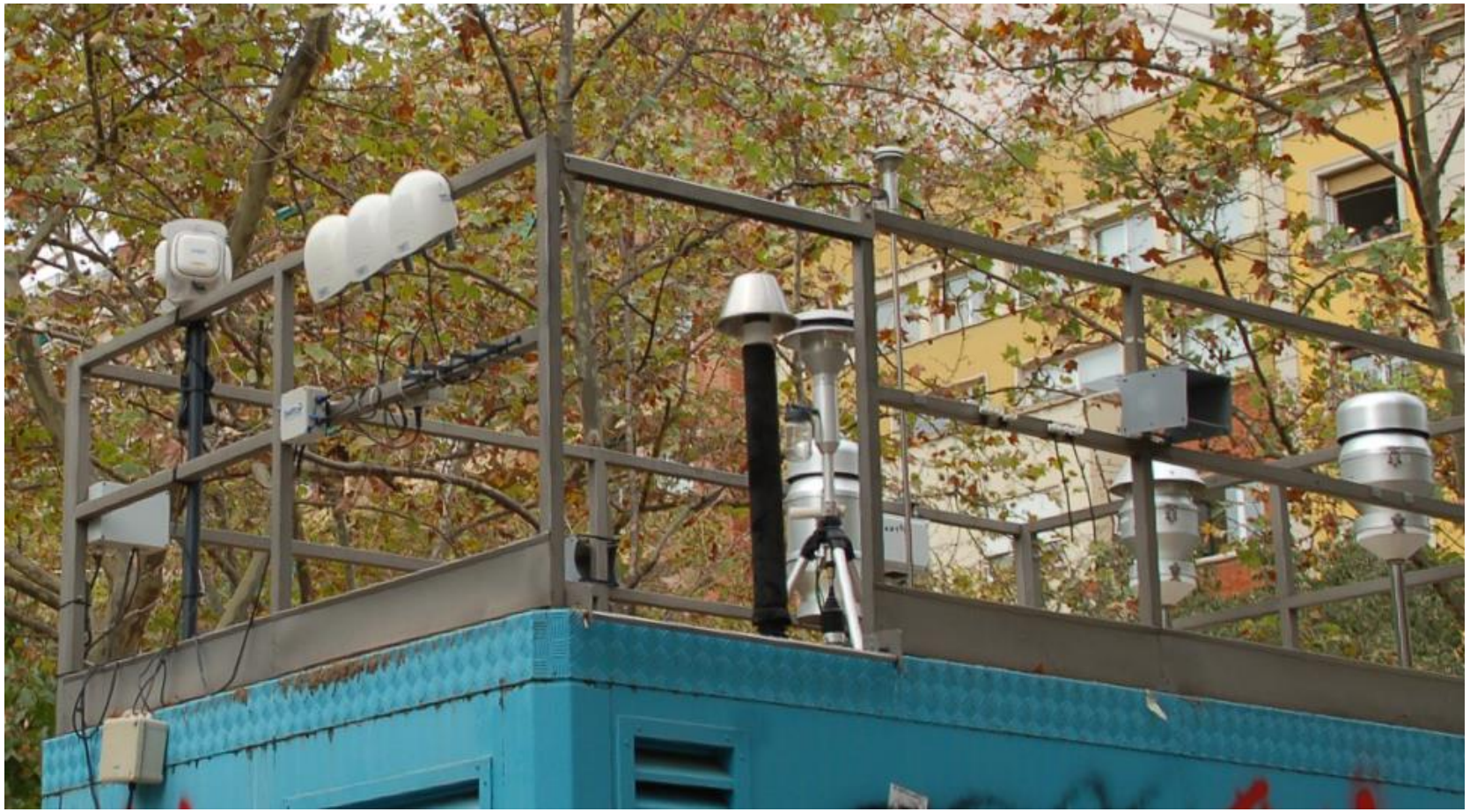
- Classification CEN/TS 17660-1:2022
  - Limitations:
    Data capture,
    Slope deviation and intercept
    Expanded uncertainty
    Between sensor uncertainty
  - Class 1 – (like **Indicative Measurement**)
  - Class 2 – (like **Objective Estimation**)
  - Class 3 - (**Not Directive 2008/50/EC**)
  - Other

Compound	Averaging period		LV	UAT	LAT	AT or CL	DQO of Class 1 sensor system	DQO of Class 2 sensor system	DQO of Class 3 sensor system
	h	year	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³ (% of LV)	µg/m³ (% of LV)	µg/m³ (% of LV)
SO_2	1	–	350	–	–	500	88 (25 %)	263 (75 %)	700 (200 %)
SO_2	24	–	125	75	50	20	–	–	–
NO_2	1	–	200	140	100	400	50 (25 %)	150 (75 %)	400 (200 %)
NO_2		1	40	32	26	–	–	–	–
O_3	8a	–	120	84	60	–	36 (30 %)	90 (75 %)	240 (200 %)
O_3	1	–	–	–	–	240	–	–	–
Benzene	–	1[b]	5	3,5	2	–	1,5 (30 %)	5 (100 %)	10 (200 %)
			mg/m³	mg/m³	mg/m³		mg/m³ (% of LV)	mg/m³ (% of LV)	mg/m³ (% of LV)
CO	8[c]	–	10	7	5	–	2,5 (25 %)	7,5 (75 %)	20 (200 %)

CEN/TS 17660-1:2022

Eixample (Barcelona), April 2022 to Now

January - February 2023 (59 days)



CEN/TS 17660-1:2022

Eixample (Barcelona), April 2022 to Now

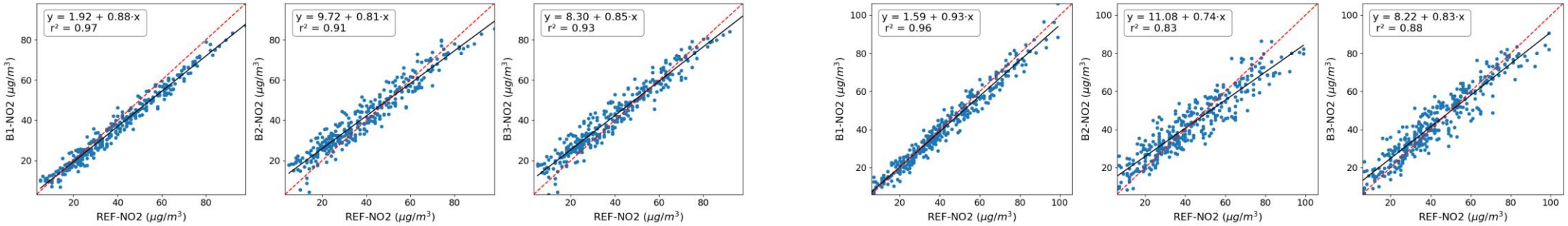
NO_2 January - February 2023 (59 days)

Parametros estadísticos	Unidades	Sensor 1	Sensor 2	Sensor 3	Clase 1	Clase 2	Clase 3
Datos capturados	%	95.2	90.9	96.1	90	50	-
Intercepcion eje linea regresion (a)	µg/m3	2.5	6.5	5.8	−9.8<=a<=9.8	−19<=a<=19	−33<a<33
Pendiente regresión lineal (b)		0.89	0.85	0.87	0.78<=b<=1.29	0.60<=b<=1.67	0.43<=b<=2.33
R2		0.96	0.87	0.87			
RMSE	µg/m3	3.5	5.1	6.0	-	-	-
Between sensor uncertainty	µg/m3	3.1			< 7.6	< 15	< 31
Expanded uncertainty at LV	µg/m3	38.0	48.4	41.9	50	150	400

CEN/TS 17660-1:2022

Eixample (Barcelona), April 2022 to Now

NO_2 January - February 2023 (59 days)



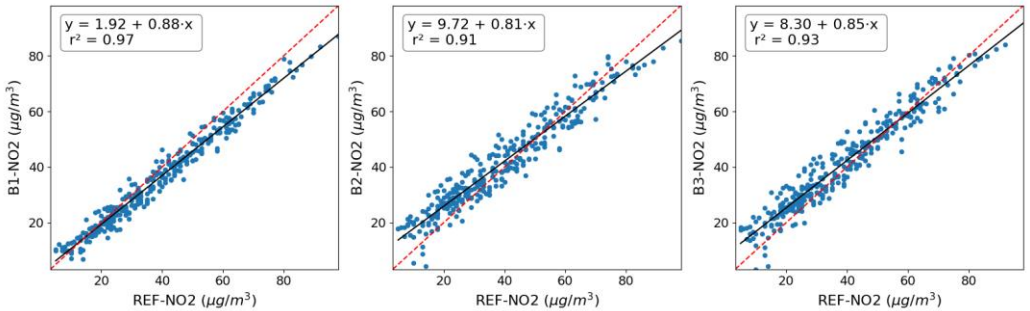
Parametros estadísticos	Unidades	Sensor 1	Sensor 2	Sensor 3	Clase 1	Clase 2	Clase 3
Datos capturados	%	95.2	90.9	96.1	90	50	-
Intercepcion eje linea regresion (a)	µg/m3	2.5	6.5	5.8	−9.8<=a<=9.8	−19<=a<=19	−33<a<33
Pendiente regresión lineal (b)		0.89	0.85	0.87	0.78<=b<=1.29	0.60<=b<=1.67	0.43<=b<=2.33
R2		0.96	0.87	0.87			
RMSE	µg/m3	3.5	5.1	6.0	-	-	-
Between sensor uncertainty	µg/m3	3.1			< 7.6	< 15	< 31
Expanded uncertainty at LV	µg/m3	38.0	48.4	41.9	50	150	400

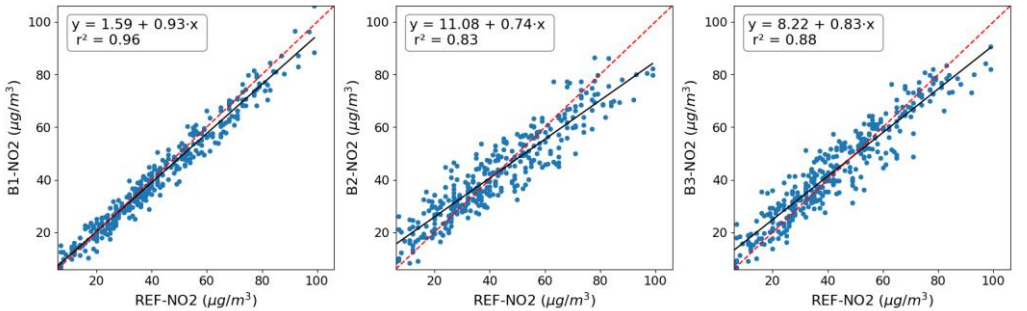
CEN/TS 17660-1:2022

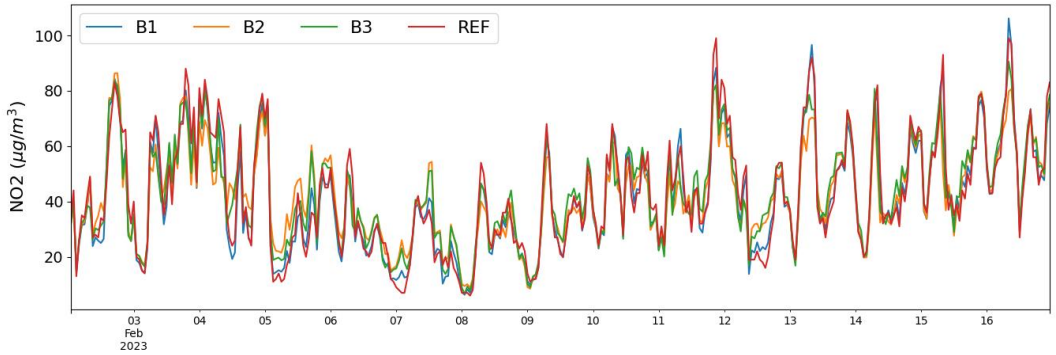
bettair® Mapping Air Quality

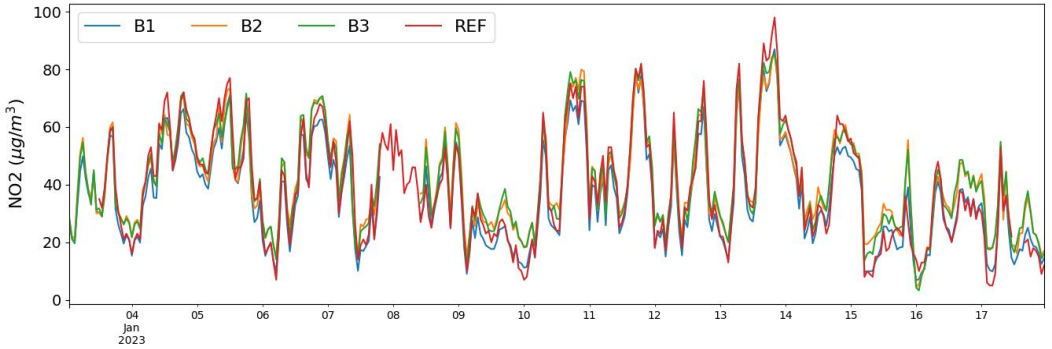
Eixample (Barcelona), April 2022 to Now

NO_2 January - February 2023 (59 days)









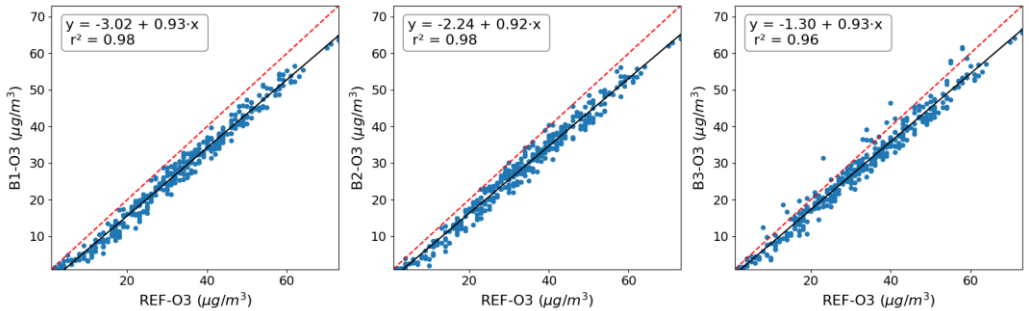
Parametros estadísticos	Unidades	Sensor 1	Sensor 2	Sensor 3	Clase 1	Clase 2	Clase 3
Datos capturados	%	95.2	90.9	96.1	90	50	-
Intercepcion eje linea regresion (a)	µg/m3	2.5	6.5	5.8	−9.8<=a<=9.8	−19<=a<=19	−33<a<33
Pendiente regresión lineal (b)		0.89	0.85	0.87	0.78<=b<=1.29	0.60<=b<=1.67	0.43<=b<=2.33
R2		0.96	0.87	0.87			
RMSE	µg/m3	3.5	5.1	6.0	-	-	-
Between sensor uncertainty	µg/m3	3.1			< 7.6	< 15	< 31
Expanded uncertainty at LV	µg/m3	38.0	48.4	41.9	50	150	400

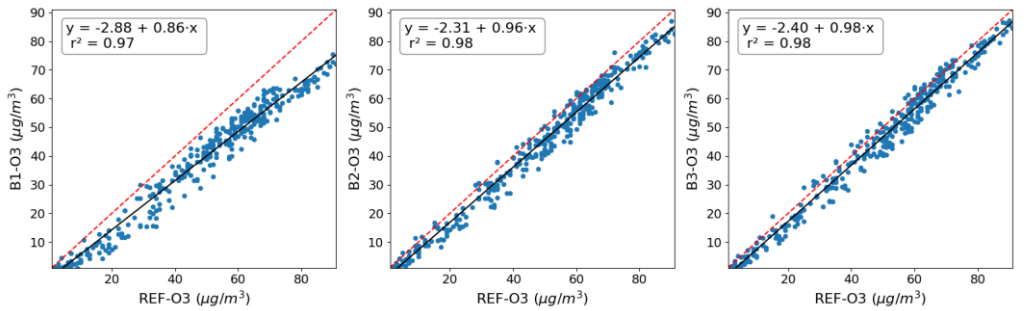
CEN/TS 17660-1:2022

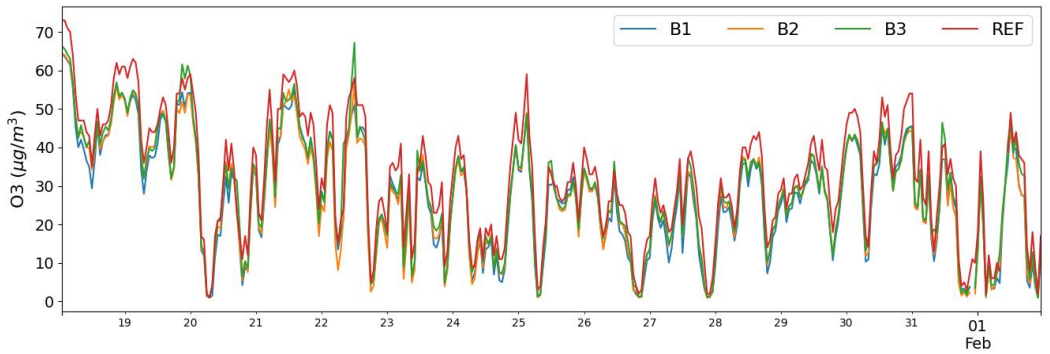
bettair®
Mapping Air Quality

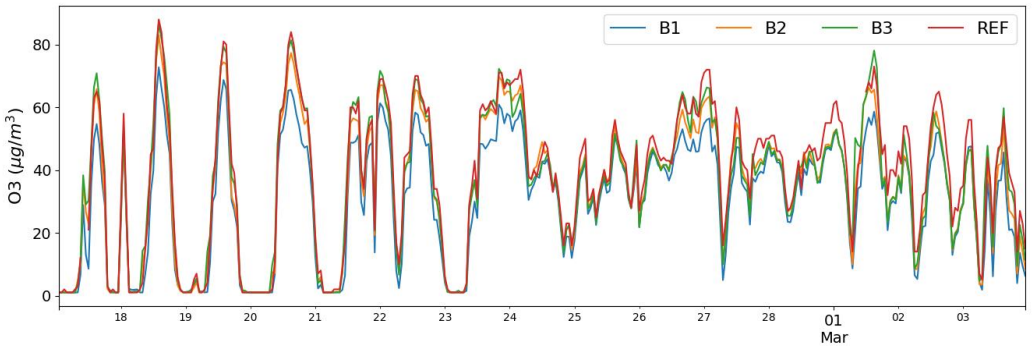
Eixample (Barcelona), April 2022 to Now

O_3 January - February 2023 (59 days)









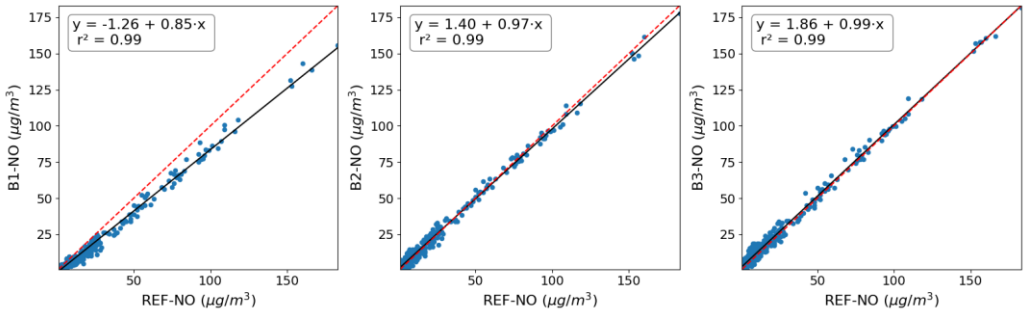
Parametros estadísticos	Unidades	Sensor 1	Sensor 2	Sensor 3	Clase 1	Clase 2	Clase 3
Datos capturados	%	95.2	90.9	96.1	90	50	-
Intercepcion eje linea regresion (a)	µg/m3	-1.2	-1.1	-0.6	−9,8<=a<= 9,8	−19<=a<=19	−33<=a<=33
Pendiente regresión lineal (b)		0.87	0.92	0.95	0.78<=b<=1.29	0.60<=b<=1.67	0.43<=b<=2.33
R2		0.89	0.98	0.96			
RMSE	µg/m3	3.9	3.1	4.0	-	-	-
Between sensor uncertainty	µg/m3	3.1			< 8	< 12	< 24
Expanded uncertainty at LV	µg/m3	35.3	21.8	16.1	36	90	240

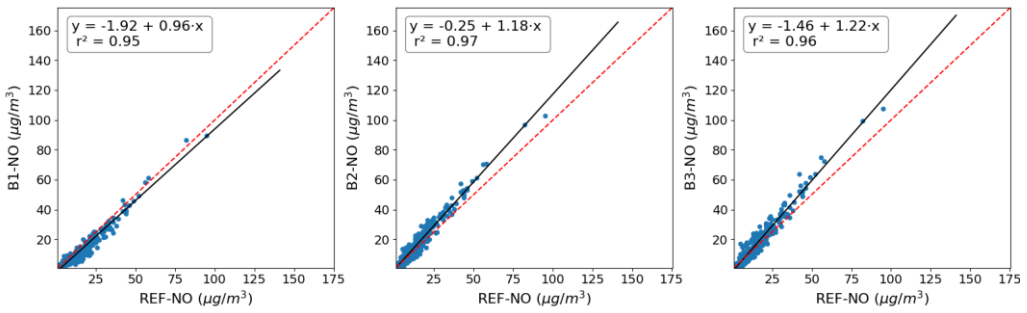
CEN/TS 17660-1:2022

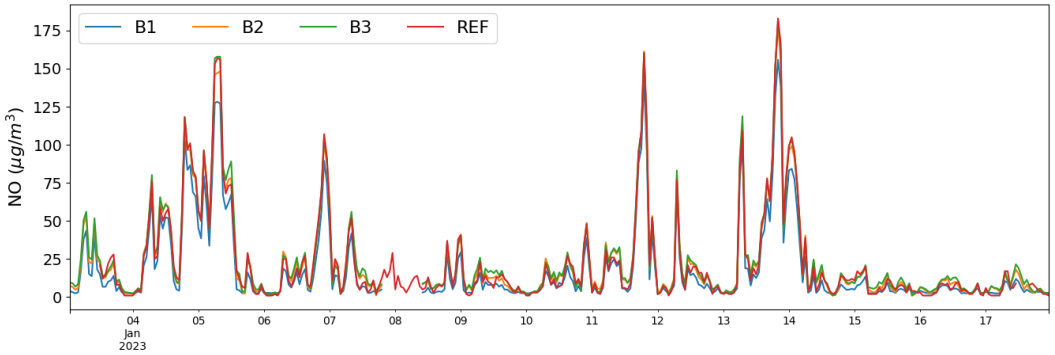
bettair® Mapping Air Quality

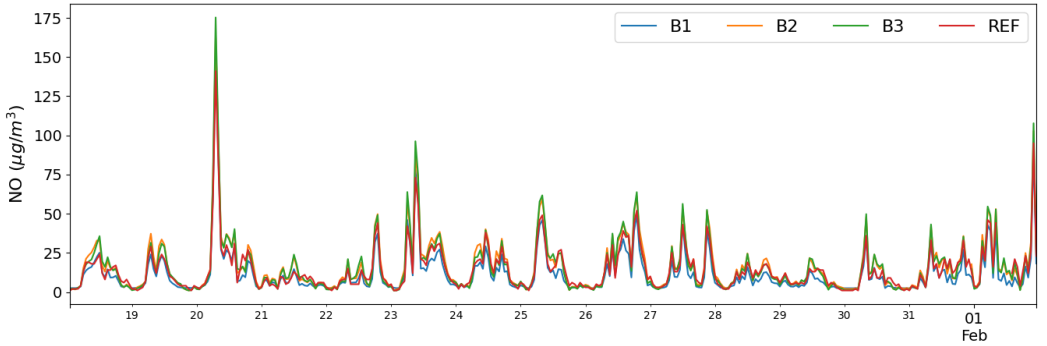
Eixample (Barcelona), April 2022 to Now

NO January - February 2023 (59 days)







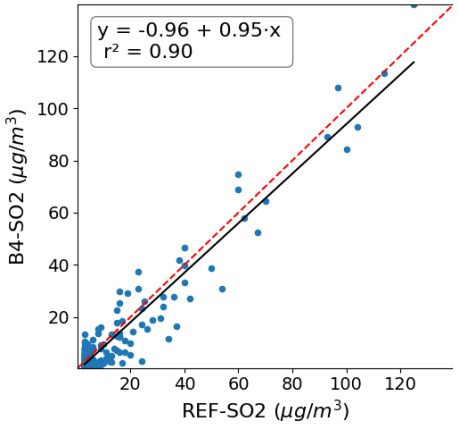


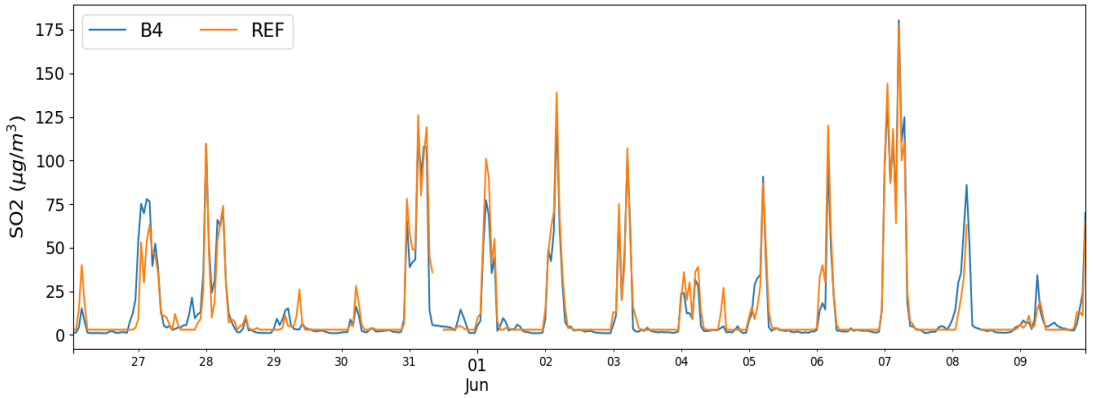
Parametros estadísticos	Unidades	Sensor 1	Sensor 2	Sensor 3	Clase 1	Clase 2	Clase 3
Datos capturados	%	95.2	90.9	96.1	90	50	-
Intercepcion eje linea regresion (a)	µg/m3	-1.8	0.6	0.3	−6,4<=a<=6,4	−12<= a<=12	−22<=a<=22
Pendiente regresión lineal (b)		0.89	1.01	1.07	0.78<=b<=1.29	0.60<=b<=1.67	0.43<=b<=2.33
R2		0.98	0.98	0.98			
RMSE	µg/m3	3.4	3.5	4.2	-	-	-
Between sensor uncertainty	µg/m3	3.9			<=5	<=10	<=20
Expanded uncertainty at LV	µg/m3	48.6	9.3	30.4	50	150	400

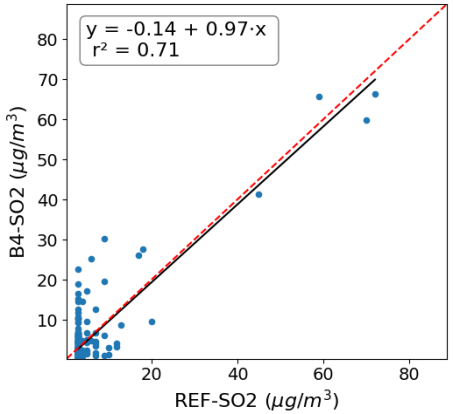
CEN/TS 17660-1:2022

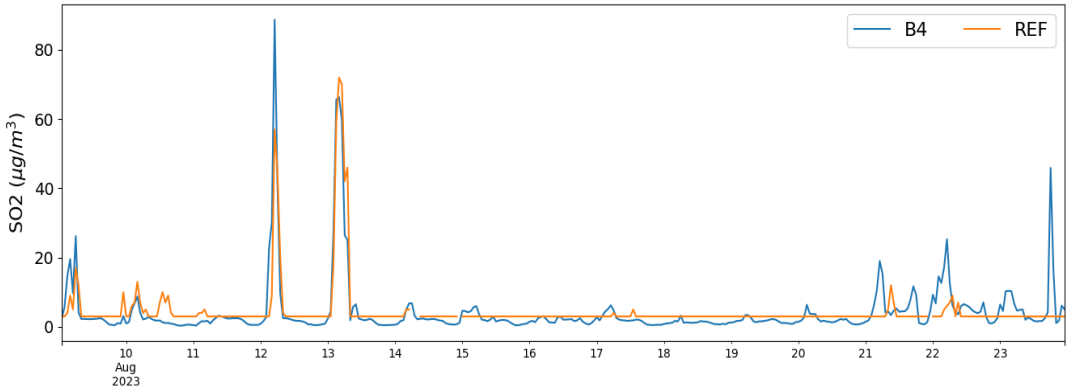
Almassora (Prov Castelló), January 2023 to Now

SO_2 June- September 2023 (> 100 days)









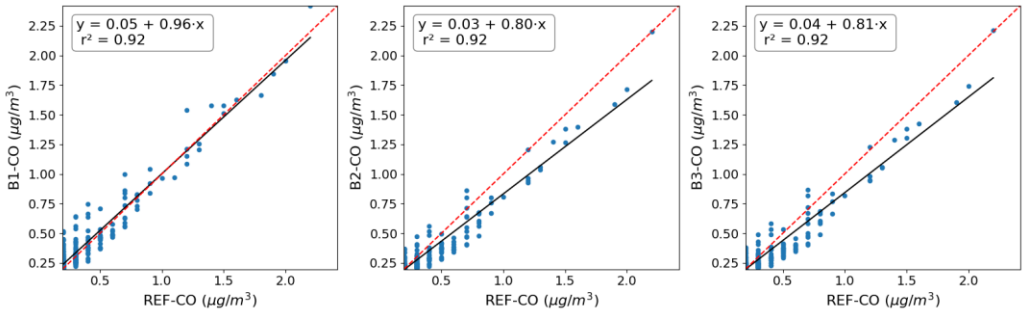
BETTAIR 4 / ES1877A	SO2
Intercept CEN (µg/m3)	-0,15
Slope CEN	0,93
Slope Class 1 in Field Test	*0,78-1,29*
Expanded Uncertainty (µg/m3)	48,99
Expanded Uncertainty / Limit Value (%)	14%
Class 1 Expanded Uncertainty limit (%)	*< 25%*

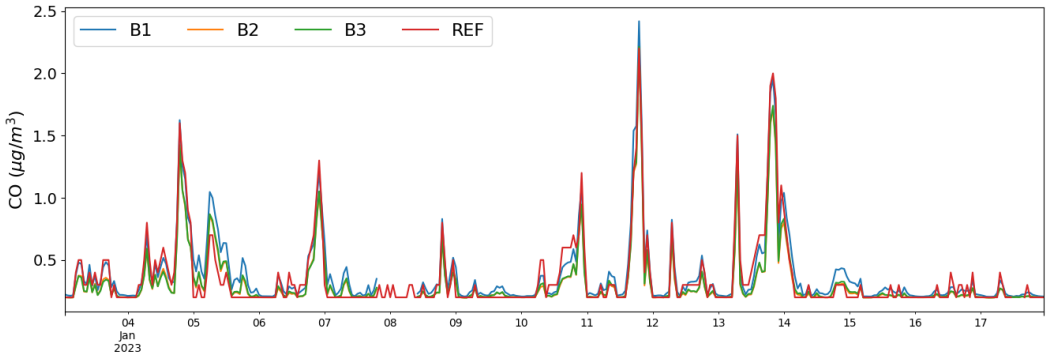
CEN/TS 17660-1:2022 Issues

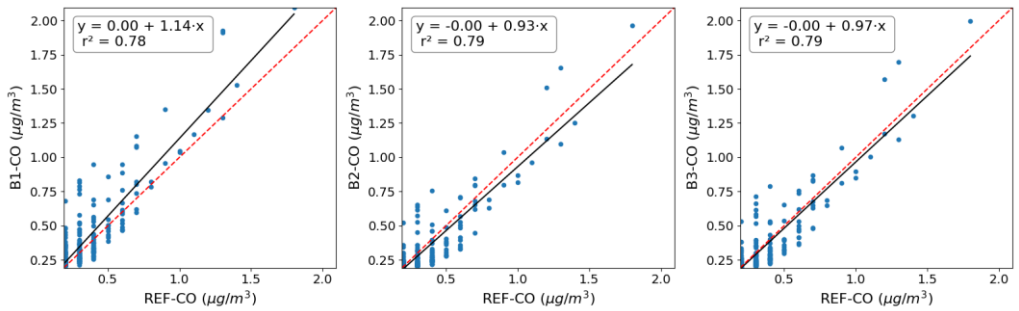
bettair® Mapping Air Quality

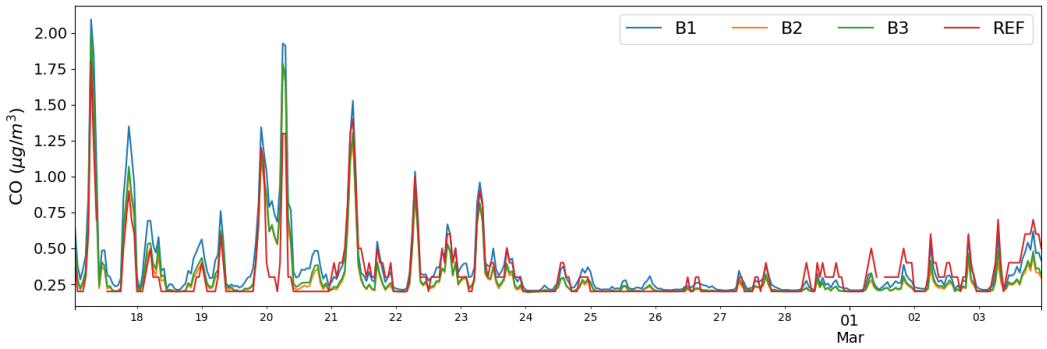
Eixample (Barcelona), April 2022 to Now

CO January - February 2023 (59 days)









system	period	R2	RMSE	Slope	Intercept	ExpU	CENClass
b1	2023-01-03	0.92	0.09	0.96	0.05	855.82	1
b2	2023-01-03	0.92	0.10	0.80	0.03	4059.12	2
b3	2023-01-03	0.92	0.10	0.81	0.04	3870.48	2
b1	2023-02-17	0.78	0.14	1.14	0.00	2708.89	2
b2	2023-02-17	0.79	0.11	0.93	0.00	1322.47	1
b3	2023-02-17	0.79	0.11	0.97	0.00	643.77	1

Ref. Instrument	Expanded U.
Thermo 48i	0.91

CEN/TS 17660-1:2022 Issues

Eixample (Barcelona), April 2022 to Now

CO January - February 2023
Issues to be considered with low concentration levels

system	period	R2	RMSE	Slope	Intercept	ExpU	CENClass
b1	2023-01-03	0.92	0.09	0.96	0.05	855.82	1
b2	2023-01-03	0.92	0.10	0.80	0.03	4059.12	2
b3	2023-01-03	0.92	0.10	0.81	0.04	3870.48	2
b1	2023-02-17	0.78	0.14	1.14	0.00	2708.89	2
b2	2023-02-17	0.79	0.11	0.93	0.00	1322.47	1
b3	2023-02-17	0.79	0.11	0.97	0.00	643.77	1

Type of station	Hourly CO concentrations 2017					
	25 % mg/m³	Median mg/m³	75 % mg/m³	90 % mg/m³	98 % mg/m³	99,9 % mg/m³
Background rural	0,140	0,180	0,241	0,400	0,700	1,500
Background urban	0,200	0,292	0,431	0,680	1,373	3,880
Background suburban	0,155	0,230	0,400	0,600	1,106	3,236
Traffic urban	0,209	0,324	0,537	0,831	1,598	6,690
Traffic suburban	0,200	0,243	0,400	0,600	1,000	2,130

Parametros estadísticos	Unidades	Sensor 1	Sensor 2	Sensor 3	Clase 1	Clase 2	Clase 3
Datos capturados	%	95.2	99.5	99.6	90	50	-
Intercepcion eje linea regresion (a)	mg/m3	-0.02	-0.05	-0.04	−0.18<=a<=0.18	−0.25<=a<=0.25	−0.4<=a<0.4
Pendiente regresión lineal (b)		1.03	0.89	0.91	0.78<=b<=1.29	0.60<=b<=1.67	0.43<=b<=2.33
R2		0.81	0.80	0.81			
RMSE	mg/m3	0.10	0.08	0.08			
Between sensor uncertainty	µg/m3	48.3			< 58	< 116	< 232
Expanded uncertainty at LV	mg/m3	0.6	2.4	2.0	2.5	7.5	20

Ref. Instrument	Expanded U.
Thermo 48i	0.91

bettair®
Mapping Air Quality

The **novelty** lies on:

- Electronics
- Mechanics
- Post-processing algorithm

AI accurate, small and cost-effective sensing devices allows to measure Air Quality in cities.

Josep Perello
CEO and Co-founder
jperello@bettaircities.com
+34 678478856

Francisco Ramírez
CSO Lead Scientist
framirez@bettaircities.com
+34 685617817