Overview and global evaluation of pilot tests

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Overview and global evaluation of pilot tests

- Part of GT6 “Field validation of the integrated electronic systems and cloud systems for air quality monitoring”

Pilot tests

A.6.1. Air Quality Monitoring campaigns

A.6.2. Evaluation of results of Air Quality Monitoring campaigns

A.6.3. Evaluation of sensor costs

A.6.4. Feasibility study of sensors usage in Air Quality Monitoring networks

A.6.5. Citizen awareness campaigns by panels

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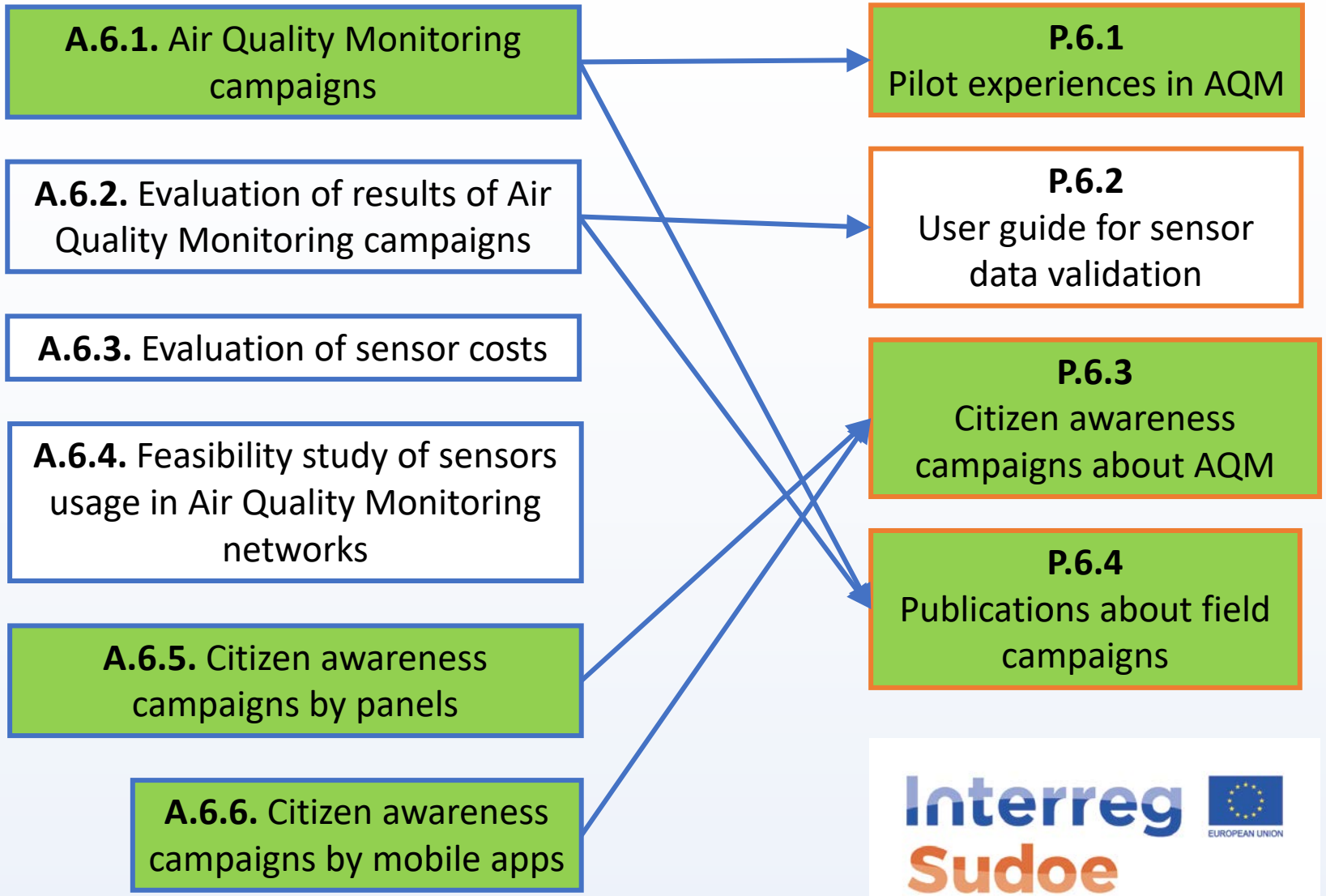
Publications about field campaigns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Pilot tests

Sensor type	Code	Number of units
Fixed sensors (commercial)	**FEC**	**8**
Fixed sensors (MOX developed by NanoSen)	**FMXCS, FMXCN, FMXCO**	**3**
Airborne (drone)	**DEC**	**1**
Bikes	**BEC**	**8**
Citizens	**CMX**	**10**

Pilot tests

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Year	2019	2020												2021					
Month	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
Project month	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Place	**Sensors**																		
Evora	FEC01-FEC02																		
Sines	FEC01-FEC02																		
Badajoz	FEC05-FEC06																		
Badajoz	DEC																		
Monfragüe	FEC05-FEC06																		
Badajoz	FMXCS, FMXCN, FMXCO																		
Ávila	FCE07-FEC08																		
Navarredonda de Gredos	FCE03-FEC04																		
El Barco (Gredos)	FCE03-FEC04																		
Sant Cugat	FEC03-FEC04																		
Hospitalet	FEC03-FEC04																		
Sant Adriá	FEC03-FEC04																		
Barcelona																			
Sant Cugat	BEC01 to BEC08																		
Hospitalet	BEC01 to BEC08																		
Sant Adriá	BEC01 to BEC08																		
Sant Cugat	CMX01 to CMX010																		
Hospitalet	CMX01 to CMX010																		
Sant Adriá	CMX01 to CMX010																		
Toulouse	CMX01 to CMX010																		
Évora	CMX01 to CMX010																		

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NanoSen-AQM
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Sensor Data Validation

Interreg Sudoe
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How to use this tool >>

Select parameter:

Insert Reference Analyzer Uncertainty:

Data read:

Validation results

Slope:

Confidence interval (95%): -

Intercept:

Confidence interval (95%): -

Expanded uncertainty (k=2): %

Regression chart

Insert data and validate

Show background data>>

Low-cost sensors

vs

Reference instruments

Field validation App

- Excel Macro
- Validate results of a low-cost sensor against a reference instrument, according to EU Guide for field validation of air quality sensors
- Accepts any type of paired data sets (10 min average, hourly, etc.)
- Gives advice about the overall performance of the sensor under validation

Sensor Data Validation

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How to use this tool >>

Select parameter:

Insert Reference Analyzer Uncertainty:

Data read:

Validation results

Slope:

Confidence interval (95%): -

Intercept:

Confidence interval (95%): -

Expanded uncertainty (k=2): %

Regression chart

Insert data and validate

Show background data>>

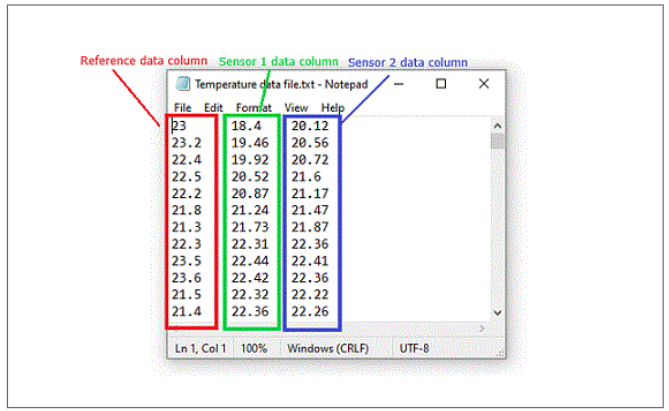
1) Select the parameter to validate (mandatory).

2) Insert the Refernce Analyzer Uncertainty (mandatory).

- This value depends on the parameter selected. If you do not know this value use the default sugested one.

3) Insert the data file.

- Data file format conist of a .xls file containing 2 or 3 columns. First column has the Reference Analyzer data values. Second and third columns has the Sensor data to validate. Number of data is limited to 500.



4) Stop the data load to analyze a lower number of data.

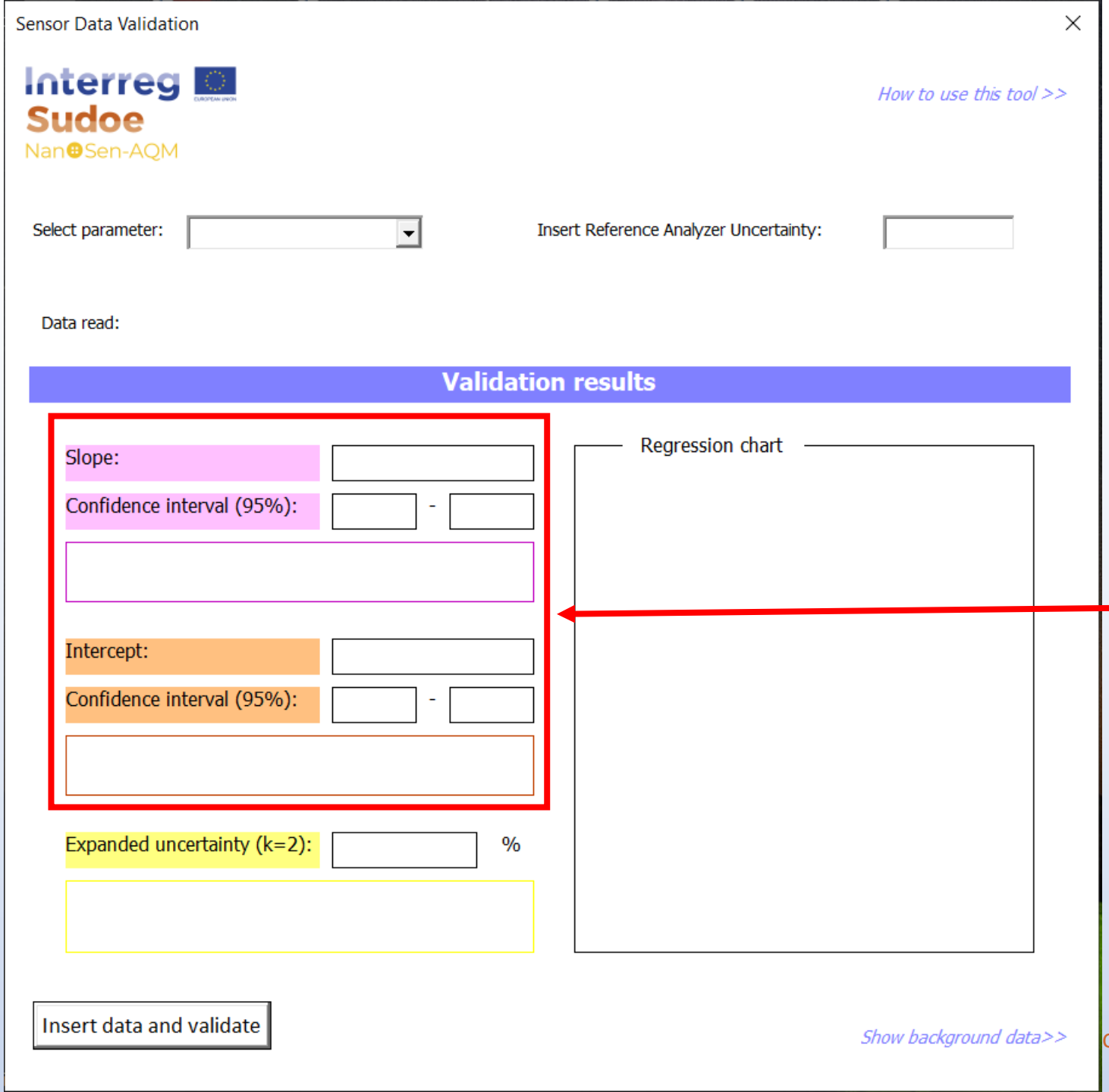
Default reference instrument uncertainty, or data given by user

Orthogonal regression and theoretical response

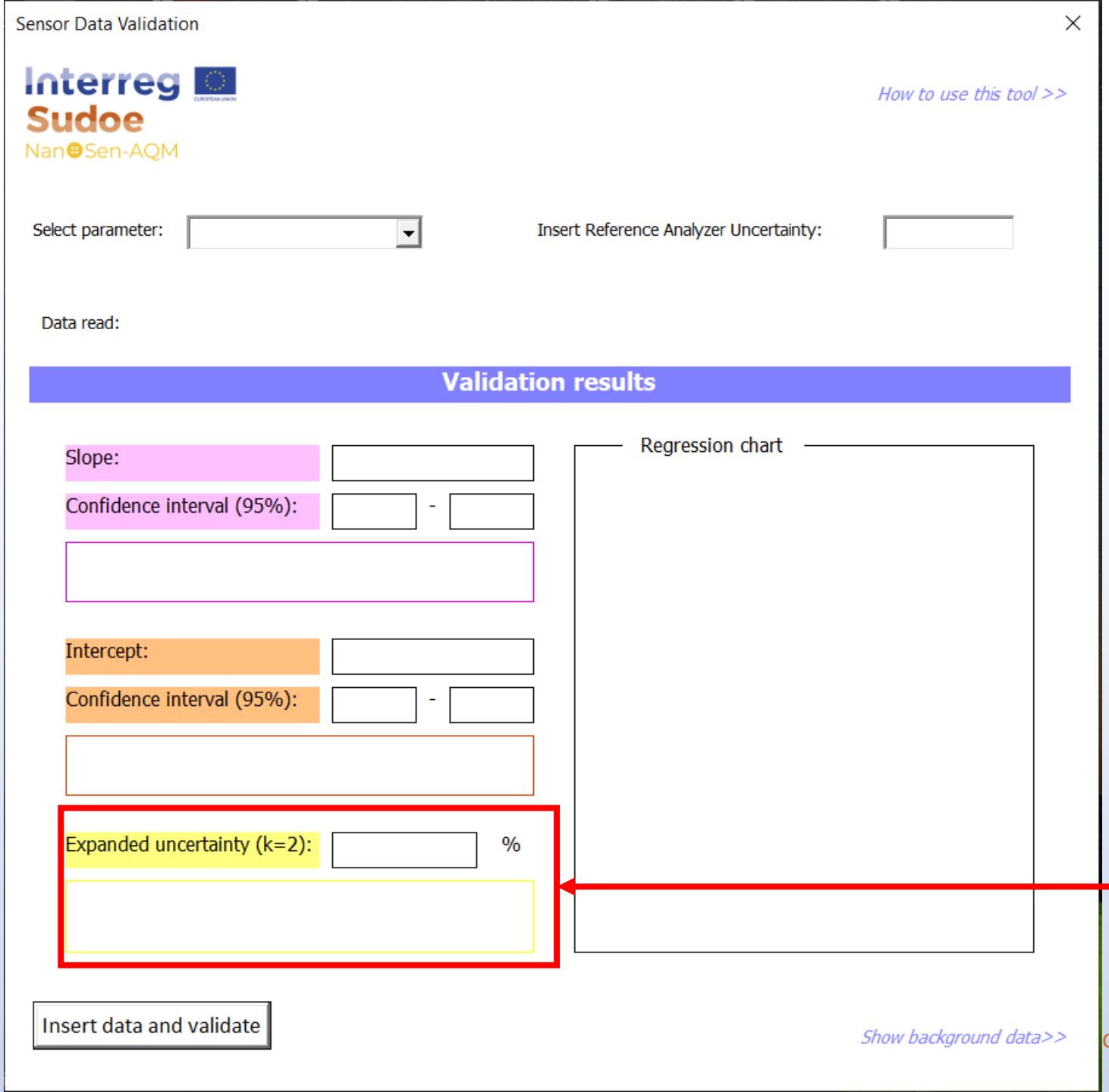
Uploads sensor and ref data file

Shows Excel document behind the macro

Field validation App



Parameter	Result	Message
Intercept	0 within confidence limits	There is no systematic error in the intercept (95% confidence level)
Intercept	0 out of confidence limits	There is a systematic error in the intercept (95% confidence level)
Slope	1 within confidence limits	There is no systematic error in the slope (95% confidence level)
Slope	1 out of confidence limits	There is a systematic error in the slope (95% confidence level)



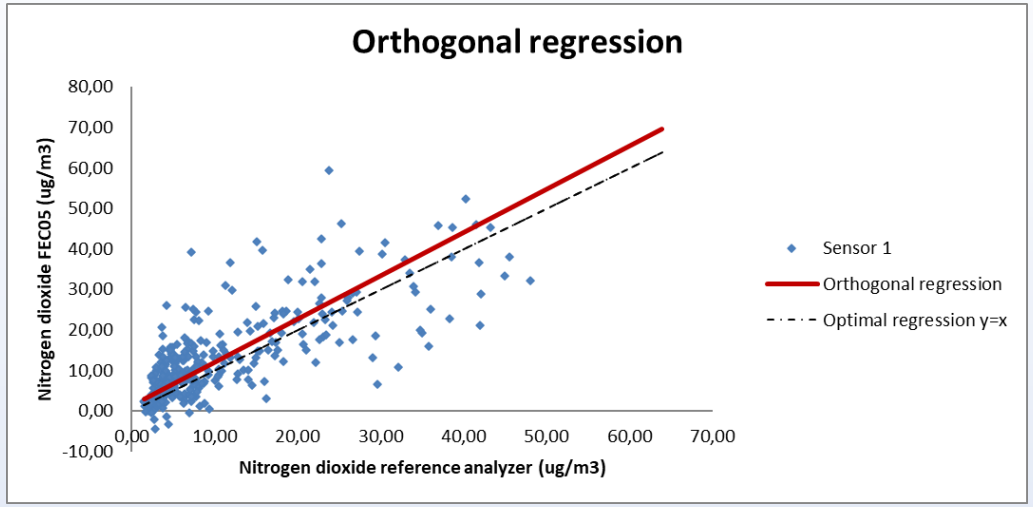
Field validation App

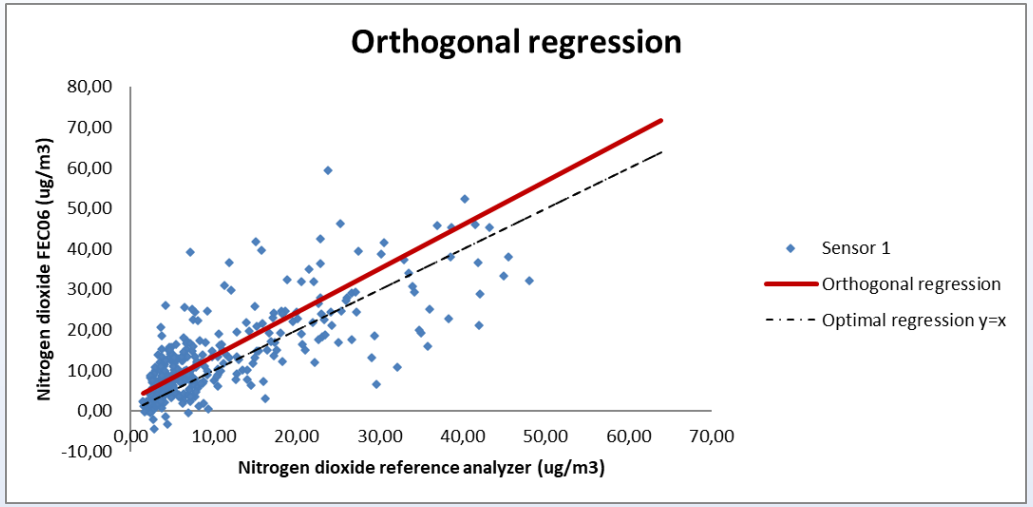
Expanded uncertainty	Value	Message
Equal to ref instrument	Equal to ref instrument	The performance of the sensor is equivalent to the performance of the reference instrument
Less than max value according to EU Directive 2008/50/CE	Numerical (%)	Good
Less than double of max value according to EU Directive 2008/50/CE	Numerical (%)	Questionable
Higher than double of max value according to EU Directive 2008/50/CE	Numerical (%)	Out of control

Field validation example (Badajoz 1-20 April, 2021)

Correlation between FEC05 AND FEC06 sensors and reference instrument. Multilinear regression.

NITROGEN DIOXIDE





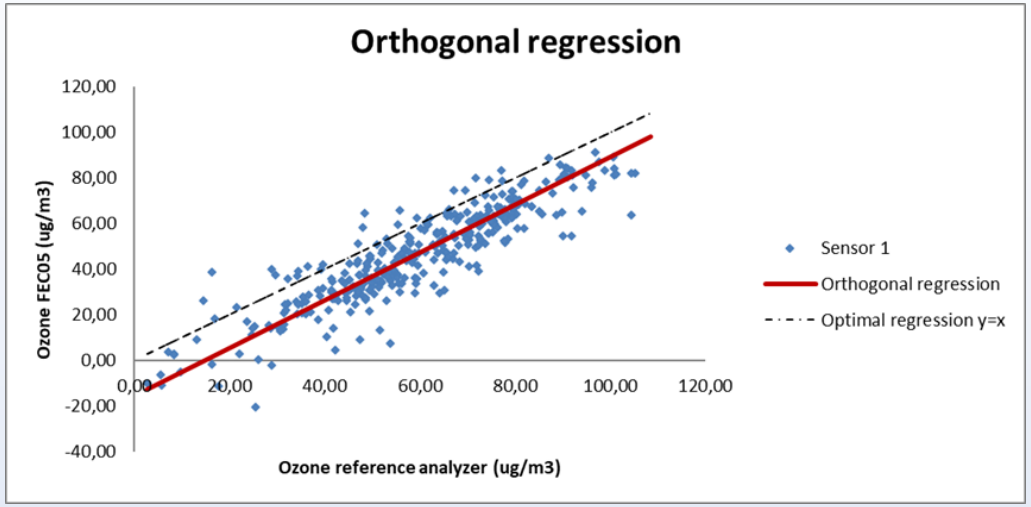
FEC05	Value	Standard error	Lower (95%)	Upper (95%)
Intercept	1,406	0,691	0,049	2,763
Slope	1,067	0,077	0,916	1,219
Rel. Exp. Uncertainty (%)	**57,7**			

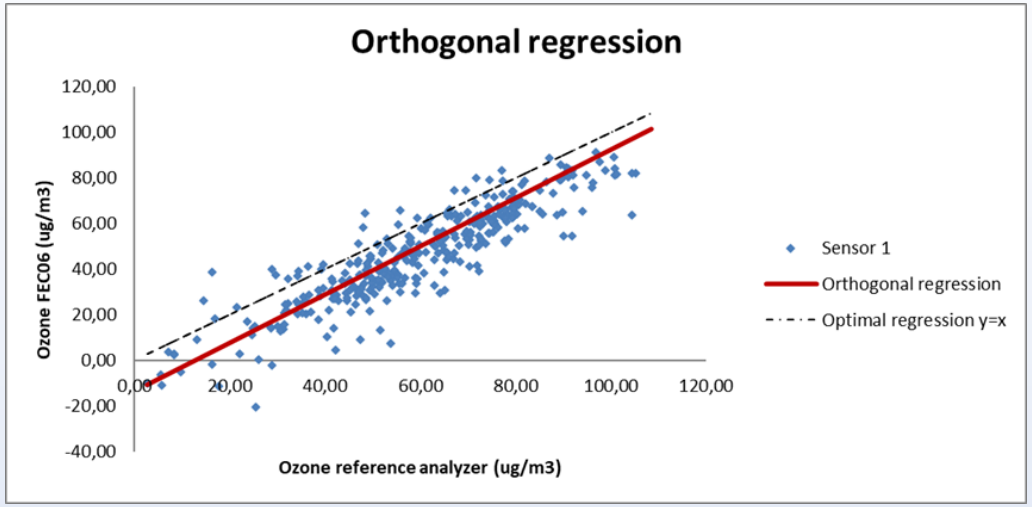
FEC06	Value	Standard error	Lower (95%)	Upper (95%)
Intercept	2,725	0,633	1,482	3,968
Slope	1,074	0,071	0,934	1,214
Rel. Exp. Uncertainty (%)	**65,9**			

Field validation example (Badajoz 1-20 April, 2021)

Correlation between FEC05 AND FEC06 sensors and reference instrument. Multilinear regression.

OZONE





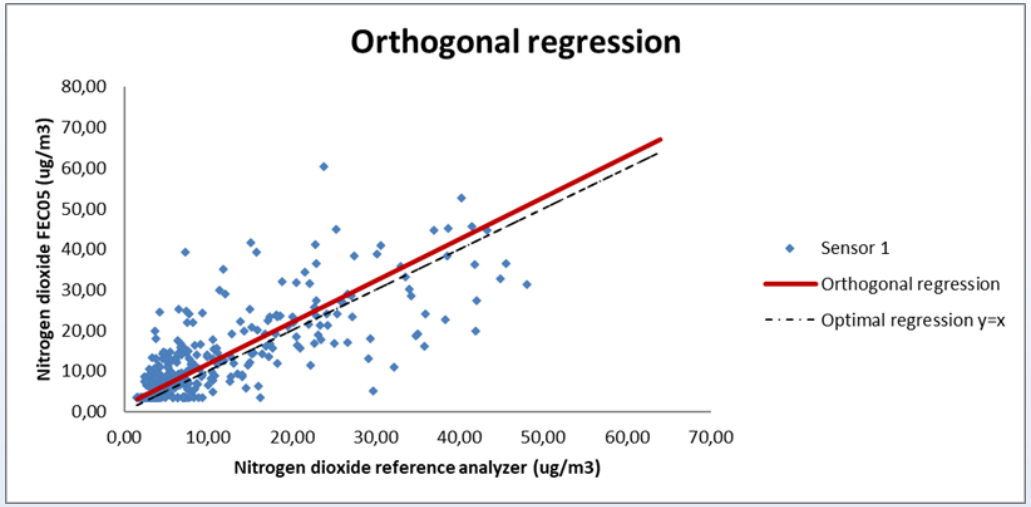
FEC05	Value	Standard error	Lower (95%)	Upper (95%)
Intercept	-15,756	1,676	-19,049	-12,463
Slope	1,052	0,025	1,003	1,101
Rel. Exp. Uncertainty (%)	**35,3**			

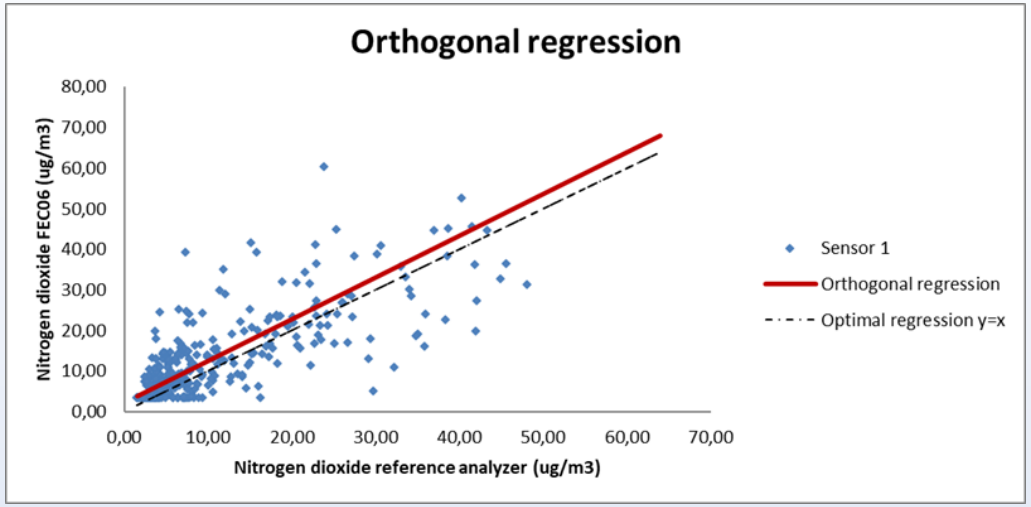
FEC06	Value	Standard error	Lower (95%)	Upper (95%)
Intercept	-15,964	1,711	-19,325	-12,603
Slope	1,101	0,025	1,052	1,150
Rel. Exp. Uncertainty (%)	**30,0**			

Field validation example (Badajoz 1-20 April, 2021)

Correlation between FEC05 AND FEC06 sensors and reference instrument. Neural Network.

NITROGEN DIOXIDE





FEC05	Value	Standard error	Lower (95%)	Upper (95%)
Intercept	1,673	0,662	0,371	2,974
Slope	1,022	0,075	0,875	1,170
Rel. Exp. Uncertainty (%)	**46,6**			

FEC06	Value	Standard error	Lower (95%)	Upper (95%)
Intercept	2,249	0,619	1,033	3,465
Slope	1,038	0,071	0,898	1,177
Rel. Exp. Uncertainty (%)	**50,3**			

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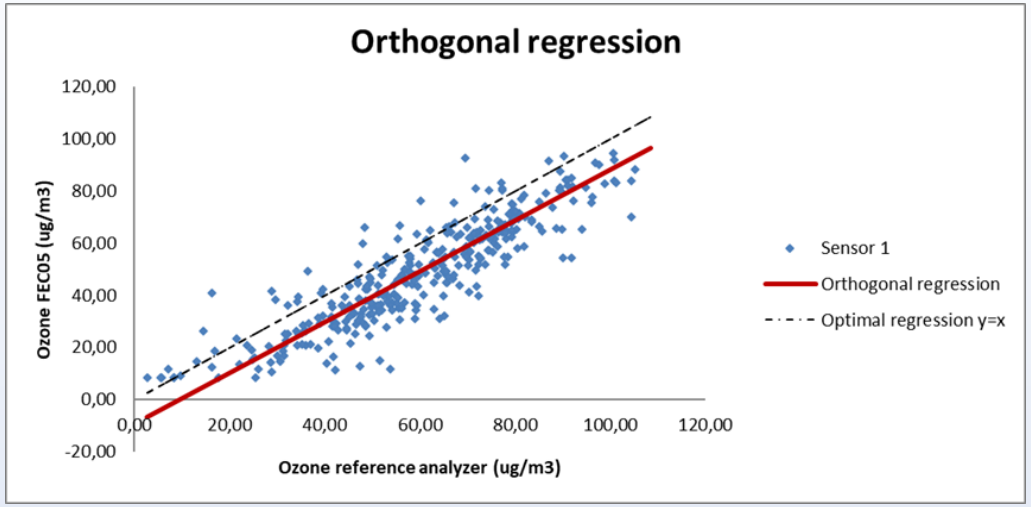
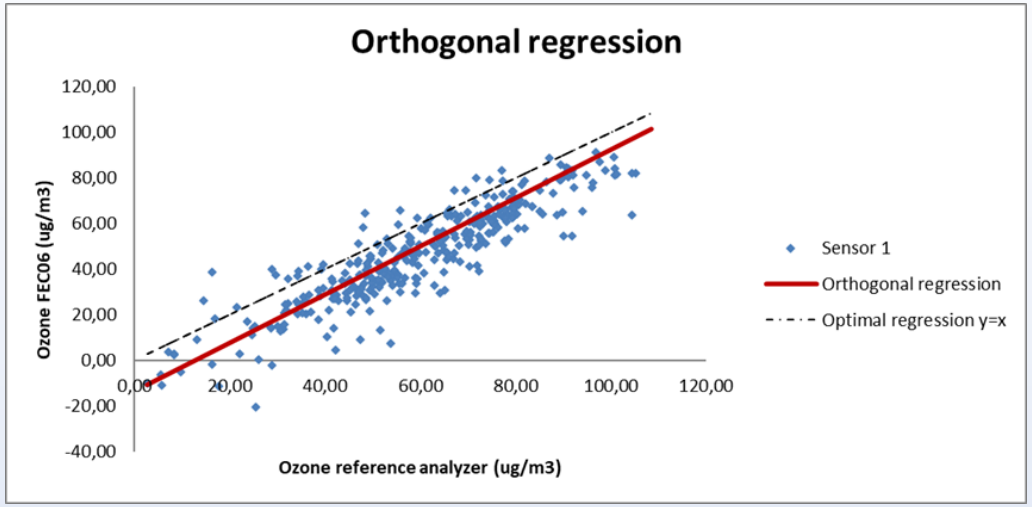
Correlation between FEC05 AND FEC06 sensors and reference instrument. Neural Network.

OZONE





FEC05	Value	Standard error	Lower (95%)	Upper (95%)
Intercept	-9,441	1,478	-12,344	-6,538
Slope	0,979	0,022	0,935	1,023
Rel. Exp. Uncertainty (%)	**36,9**			

FEC06	Value	Standard error	Lower (95%)	Upper (95%)
Intercept	-13,124	1,606	-16,279	-9,969
Slope	1,070	0,023	1,024	1,116
Rel. Exp. Uncertainty (%)	**32,0**			

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Deliverable E.6.3.1

Table 11: Estimated cost of a multisensor obtained by mass production with optimized processes.

	Cost (€)	Nºchip / wafer	Total/chip (€)
Wafer (Process in parallel of 3 Wafers)	20.000	200	
Packaging =30 €/unit			**130**
Packaging = 10€/unit)			**110**
Wafer (Process in parallel of 8 Wafers)	7.500	200	
Packaging =30 €/unit			≈ **68**
Packaging = 5 €/unit			≈ **43**

- The cost of the sensors developed in the project can be significantly reduced, reaching values similar to LCS available on the market.
- To achieve this, the preparation processes must be optimised, and a suitable equipment must be available for mass production, in order to process at least 8 wafers in parallel as shown in table 11.

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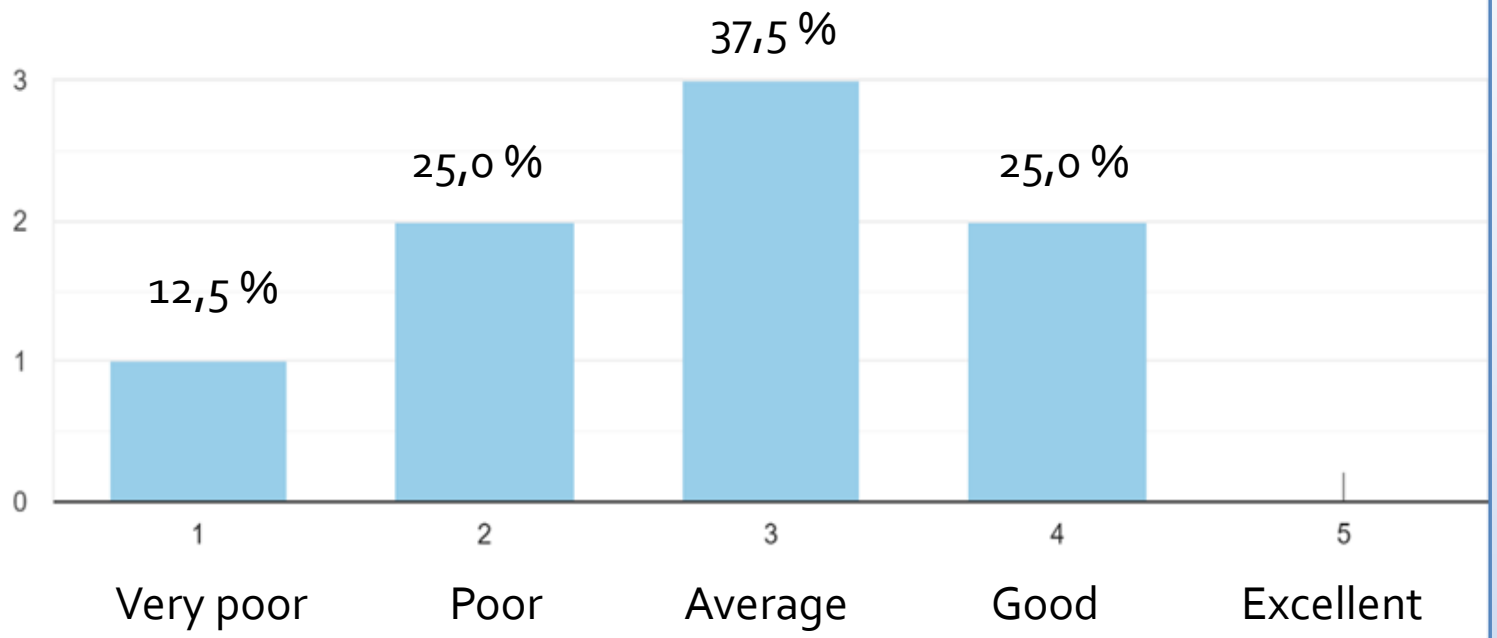
Deliverable E.6.4.1

Survey to official Air Quality Monitoring Network managers to test their opinion about low-cost sensors applicability in their networks

How do you value the functioning of low-cost sensors?



The managers consider low-cost sensors valuable for providing indicative values and collecting massive data.

They are sceptical about using the data as representative as the measurements made with standard fixed instruments.

The managers consider it essential to regulate the use of low-cost sensors making both calibrations and verifications mandatory.

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Thank you

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