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PROFICIENCY TESTING SCHEME

Measurement of inorganic gaseous pollutants (SO_2, CO, O_3, NO and NO_2) in filtered ambient air (04-07 April 2022, Ispra-Italy)

European Commission harmonisation programme for air quality measurements

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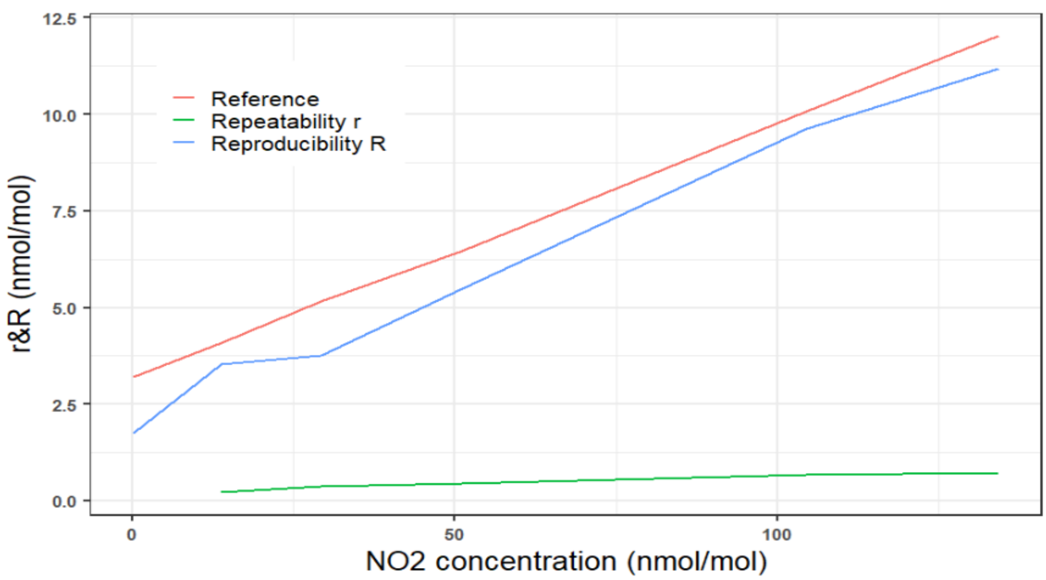
2022



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Contents

Abstract

Within the harmonisation programme of Air Quality monitoring in Europe the European Reference Laboratory of Air Pollution (ERLAP) organises Proficiency Tests (PT).
During the period **04-07 of April 2022**, ten Laboratories of AQUILA (Network of European Air Quality Reference Laboratories), including ERLAP, met for a laboratory comparison exercise in Ispra (IT) to evaluate their proficiency in the analysis of inorganic gaseous air pollutants (NO, NO2, SO2, CO and O3) covered by the European Air Quality Directive 2008/50 EC and its last amendments 2015/1480/EC.
Laboratory B didn't participate for CO measurement. Two laboratories (E and F) participated only for NO/NO2 and O3 analysis.
The proficiency evaluation, where each participant's bias was compared to two criteria (z/z'-score and En-score), provides information on the current situation and capabilities to the European Commission and can be used by participants in their quality control system.
On the basis of adopted criteria (z/z'-score and En-score), **5.3%** of the results were identified as outliers. Based only on the z/z'-score evaluation, between all the results reported, **91.5%** were satisfactory and **3.2%** of the values were found to be questionable and **5.3%** were unsatisfactory.
Considering the repeatability and reproducibility evaluation, the results among AQUILA participants at the highest generated concentration levels are generally in line with the previous similar PTs, only SO2 shows an underperforming result.

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1 Introduction

The Directive 2008/50/EC [1] and its last amendments 2015/1480/EC [42] on ambient air quality and cleaner air for Europe sets a framework for a harmonised air quality assessment in Europe.

One important objective of the Directive [1] is that the ambient air quality shall be assessed on the basis of common methods and criteria. It deals with the air pollutants sulphur dioxide (SO2), nitrogen dioxide (NO2) and nitrogen monoxide (NO), particulate matter, lead, benzene, carbon monoxide (CO) and ozone (O3). Among others it specifies the reference methods for measurements and Data Quality Objectives (DQOs) for the accuracy of measurements.

The European Commission (EC) has supported the development and publication of reference measurement methods for CO [2], SO2 [3], NO-NO2 [4] and O3 [5] as European standards. Appropriate calibration methods [6], [7] and [8] have been standardised by the International Organization for Standardization (ISO).

As foreseen in the Air Quality Directive [1, 42], the European Reference Laboratory of Air Pollution (ERLAP) of the Directorate for Energy, Transport and Climate at the Joint Research Centre (JRC) organises Proficiency Tests (PT) to assess and improve the status of comparability of measurements of National Reference Laboratories (NRL) of the Member States of the European Union.

The World Health Organization Collaborating Centre for Air Quality Management and Air Pollution Control, Berlin (WHO CC) is carrying out similar activities since 1994 [9] [10], [24], [31], [35], [38], [45] and [50], but with a view to obtaining harmonised air quality data for health related studies. Their programme integrates within the WHO EURO region, which includes public health institutes and other national institutes - especially from the Central Eastern Europe, Caucasus and countries from Central Asia.

Starting in 2004, it has been decided to bring together the efforts of both the JRC-ERLAP and WHO CC and to coordinate activities as far as possible, with a view to optimise resources and improve international harmonisation.

This report deals with the PT that took place in the period **04 - 07 of April 2022** in Ispra (IT).

Since 1990 ERLAP has organised PT in order to evaluate the comparability of measurements carried out by NRLs and promote information exchange among the expert laboratories. Recently, a more systematic approach has been adopted, in agreement with the Network of National Reference Laboratories for Air Quality (AQUILA) [11], aiming to both provide an alert mechanism for the purposes of the EC legislation and support the implementation of quality schemes by NRLs.

ERLAP is accredited to the latest version of the standard ISO 17025 and ISO 17043 for the pollutants and EN standard methods used during this proficiency test (EN 14211:2012-NO/NO2, EN 14212:2012-SO2, EN 14625:2012-O3, EN 14626:2012-CO) as proved by the certificates in Annex F.

The methodology for the organisation of PT was developed by ERLAP in collaboration with AQUILA and is described in a paper on the organisation of laboratory comparison exercises for gaseous air pollutants [12].

This evaluation scheme was adopted by AQUILA in December 2008 and is applied to all PT since then. It contains common criteria to alert the EC on possible performance failures, which do not rely solely on the uncertainty claimed by participants. The evaluation scheme implements the z-score and z'-score method [13] with the uncertainty requirements for calibration gases stated in the European standards [2], [3], [4] and [5], which are consistent with the DQOs of European Directives.

According to the above-mentioned Directive [1, 42], NRLs with an overall unsatisfactory performance in the z/z'-score evaluation **(one unsatisfactory or two questionable results per parameter)** is asked to repeat their participation in the following PT in order to demonstrate remediation measures [12]. All participants with an outlier measurement should investigate the analytical process and send to the PT provider the conclusion of this analysis.

In addition, considering that the evaluation scheme should be useful to participants for accreditation according to ISO 17025, they are requested to include their measurement uncertainty. Hence, participants' results (measurement values and uncertainties) are also compared to the assigned values applying the En–score method [13].

Beside the proficiency of participating laboratories, the repeatability and reproducibility of standardised measurement methods [14], [15] and [16] are evaluated as well. These group evaluations are useful indicators of trends in measurement quality over different proficiency tests.

2 Proficiency test organisation

The PT was announced in **September 2021** to the members of the AQUILA network and the WHO CC representative. Registration was opened in **February 2022** and closed the third week of **March 2022**.

Every participant, together with the registration confirmation, received a detailed protocol with all the necessary information about the PT. Each laboratory was required to bring their own measurement instruments, data acquisition equipment and travelling standards (to be used for calibrations or checks during the PT).

The participants were invited to arrive on **Monday, 04 of April 2022**, for the installation of their equipment. The calibration of NOx and O3 analysers was carried out the morning of the following day and the generation of NOx and O3 gas mixtures started at 11:00 on Tuesday.

The calibration of SO2 and CO analysers was carried out on Wednesday afternoon and the generation of CO and SO2 gas mixtures started at 20:00 of the same day.

The test gases generation and measurements finished on Thursday at 9:00. Due to a technical problem during the generation of NO/NO2 the sequence in table 3 has been modified compared to the one proposed in the protocol. All participants were informed during the PT and through an email the new sequence was confirmed.

3 Participants

All participants (Table 1) were organisations dealing with the routine ambient air monitoring or institutions involved in environmental or public health protection. The national representatives came from, Netherlands, Portugal, Poland, Sweden, Italy, Norway, Lithuania, Ireland.

Table 1: List of participating organizations.

Acronym	Laboratory	Country	Code
RIVM	National Institute for Public Health and the Environment	Netherlands	B
APA	Agencia Portuguesa Do Ambiente	Portugal	C
GIOS	Chief Inspectorate of Environmental Protection	Poland	D
ACES	Stockholm University ACES	Sweden	E
IVL	Swedish Environmental Research Institute	Sweden	F
ERLAP	European Reference Laboratory for Air Pollution	European Commission	G
NILU	Norwegian Institute for Air Research	Norway	H
ISPRA	The Institute for Environmental Protection and Research	Italy	I
AAA	Environmental Protection Agency	Lithuania	L
EPA	Environmental Protection Agency	Ireland	M

Source: JRC 2022

The following Table 2 reports the manufacturer and model of the instrumentations used by every participant during the Proficiency Test, including those used in the calculation of the assigned values. This information has been reported by the participants through a web interfaced questionnaire as described in the protocol.
The list contains technical information and cannot be considered as an implicit or explicit endorsement by the organisers of any specific instrumentation. This list is used to identify presence of cluster during the data evaluation.
Some laboratories didn't fill in the questionnaire about this PT so some information are missing in Table 2.

Table 2: List of instruments used by participants.

Code	Pollutant	Instruments
B	CO	none
C		Thermo Scientific 48i+
D		Horiba APMA-370
E		none
F		none
G		Horiba, APMA-370, 2021
H		Not reported
I		Thermo Scientific 48i
L		Not reported
M		Not reported
B	NO/NO2	Teledyne Tapi T200
C		Thermo Scientific 42i+
D		Thermo 42i
E		Environment, AC32M
F		Ecotech Serinus 40
G		Thermo, TE42iTL, 2015
H		Teledyne api T200
I		Thermo 42i
L		Not reported
M		Not reported
B	O3	Thermo Scientific 49i
C		Thermo Scientific 49i+
D		Teledyne API T400
E		Serinius 10
F		Envea O-342
G		Thermo, 49-iPS , 2015
H		Not reported
I		Thermo Scientific 49i
L		Not reported
M		Not reported
B	SO2	Thermo Scientific 43i TLE
C		Thermo Scientific 43i+
D		Thermo 43C
E		none
F		none
G		Thermo 43i TLE, 2009
H		Not reported
I		Thermo Scientific 43i
L		Not reported
M		Not reported

Source: JRC 2022

4 Preparation of test mixtures

The ERLAP PT facility has been described in several reports [17], [18]. During this PT, gas mixtures were prepared for SO2, CO, O3, NO and NO2 at concentration levels around limit values, critical levels and assessment thresholds set by the European Air Quality Directive [1].

Table 3: Sequence program of generated test gases with indicative pollutant concentrations

day	start time	duration	gas	installation	calibration	Zero Air	NO	NO2	O3	CO	SO2
		h				nmol/mol	nmol/mol	nmol/mol	nmol/mol	mmol/mol	nmol/mol
1st	09:00		/	X							
2nd	08:00	3	/		X						
2nd	11:00	1	NO-NO2-O3			X					
2nd	12:00	2	NO-NO2				120				
2nd	14:00	1	NO-NO2				NOT TO BE REPORTED				
2nd	15:00	2	NO-NO2				70	50			
2nd	17:00	2	O3						60		
2nd	19:00	2	NO-NO2				25				
2nd	21:00	2	NO-NO2				10	15			
2nd	23:00	2	O3						15		
3rd	01:00	2	NO-NO2				60				
3rd	03:00	2	NO-NO2				30	30			
3rd	05:00	2	O3						35		
3rd	07:00	2	NO-NO2				NOT TO BE REPORTED				
3rd	09:00	2	NO-NO2				160	100			
3rd	11:00	2	O3						110		
3rd	13:00	2	NO-NO2				150	130			
3rd	15:00	2	O3						130		
3rd	17:00	2	NO				480				
3rd	19:00	2	NO				300				
3rd	21:00	1	CO-SO2			X					
3rd	22:00	2	CO-SO2							3	125
4th	00:00	2	CO-SO2							8	50
4th	02:00	2	CO-SO2							5	35
4th	04:00	2	CO-SO2							1.5	19
4th	06:00	2	CO-SO2							0.9	8
4th	08:00	1	/								
4th	0:00	END									

Source: JRC 2022

The sequence programme of generated test gases is given in **Table 3**.
The test mixtures were prepared by the dilution of gases from cylinders containing high concentrations of NO, SO2 or CO using thermal mass flow controllers [8]. O3 was added using an ozone generator and NO2 was produced applying the gas phase titration method [19] in a condition of NO excess.
The participants were required to report three half-hour-mean measurements for each concentration level (run) in order to evaluate the repeatability of standardised measurement methods. Zero value concentration levels were generated for one hour and one half-hour-mean measurement was requested to be reported.

5 The evaluation of laboratory's measurement proficiency

To evaluate the participant's measurement proficiency, the methodology described in ISO 13528 [13] was applied and measurement results of ERLAP were used as the assigned/reference values for the whole PT [12].
The traceability of ERLAP's measurement results and the assigned values list are described in Annex A. In the following proficiency evaluations, the uncertainty of test gas homogeneity (Annex A) was added to the uncertainties of ERLAP's measurement results.
All data reported by participating laboratories are presented in Annex B.
As described in the AQUILA document 37 [12], the proficiency of the participants was assessed by calculating two performance indicators (z/z'-score and En-score).
The following performance indicators, z-score and z'-score (z/z'-score), verify if the difference between the participants measured value and the assigned/reference value remains within the limits of a common criterion. The choice between z/z'-score is consequence to the meeting of the criterion $u_{Xpt}<0.3\sigma_{pt}$ described in the standard ISO 13528 (par. 9.2) [13], where the uncertainty of the assigned value (u_{Xpt}) is compared to $0.3\sigma_{pt}$. When the criterion is met the z-score value is applied, in the other case z'-score is used. In Annex D a table is showing the values obtained during this evaluation and the selected indicator used for each measurement.
The second performance indicator (En-score) verifies if the difference between the participants measured values and assigned/reference value remains within the limits of a criterion, that is calculated individually for each participant, from the uncertainty of the participant's measurement result and the uncertainty of the assigned/reference value.

5.1 z-score – z'–score

The z/z'- score performance indicators are calculated according to ISO 13528 (par. 9.4 and 9.5) [13] as:

$$z = \frac{(x_i - X)}{\sqrt{\sigma_{pt}^2}} = \frac{(x_i - X)}{\sqrt{(a \cdot X + b)^2}} \qquad \text{Equation 1}$$

$$z' = \frac{(x_i - X)}{\sqrt{\sigma_{pt}^2 + u_X^2}} = \frac{(x_i - X)}{\sqrt{(a \cdot X + b)^2 + u_X^2}} \qquad \text{Equation 2}$$

z = z-score
z' = z'-score
x_i = participant average values
X = the assigned/reference value
u_X = uncertainty of the assigned/reference value
σ_{pt} = standard deviation for proficiency assessment
a = slope see table 4
b = intercept see table 4

In the European standards [2], [3], [4] and [5] the uncertainties for calibration gases used in ongoing quality control are described. In fact, it is stated that the maximum permitted expanded uncertainty for calibration gases is 5% and that 'zero gas' shall not give instrument reading higher than the detection limit.

As one of the tasks of NRLs is to supply calibration gas mixtures, the 'standard deviation for proficiency assessment' (σ_{pt}) [13] is calculated in fitness-for-purpose manner from requirements given in European standards.

Over the whole measurement range σ_{pt} is calculated by linear interpolation between 2.5% at the calibration point (75% of calibration range) and the limit of detection at zero concentration level. The limits of detection of studied measurement methods were evaluated from the data of previous PT. The linear function parameters of σ_{pt} are given in **Table 4**.

Table 4: Standard deviation for proficiency assessment (σ_{pt}).

Gas	a	b (nmol/mol)
SO2	0.022	1
CO	0.024	100
O3	0.020	1
NO	0.024	1
NO2	0.020	1

Source: JRC 2022

σ_{pt} is a linear function of concentration (c) with parameters: slope "**a**" and intercept "**b**".

$$\sigma_{pt} = (a \cdot X) + b$$ Equation 3

σ_{pt} = standard deviation for proficiency assessment
a = slope see table 4
X = reference value
b = intercept see table 4

The assessment of results in z/z'-score evaluation is made according to the following criteria:
$|z/z'| \leq 2$ are considered satisfactory.
$2 < |z/z'| < 3$ are considered questionable.
$|z/z'| \geq 3$ are considered unsatisfactory. Scores falling in this range are very unusual and are taken as evidence that an anomaly has occurred that should be investigated and corrected.

According to z/z'-score calculation, z/z'-score values between 2 and 3 are considered stragglers and they deserve a specific check. Nine values were identified as stragglers (see **Table 5**).

15 outlier values were found. Laboratory C had a serious poor performance in CO measurements. Laboratory H needs to investigate the NO/NO2 measurement process, because the majority of NO and NO2 values were unsatisfactory. Laboratory E had one O3 value identified as outlier and it needs an investigation to find the cause of this poor performance.

Table 5: z/z'-score evaluation.

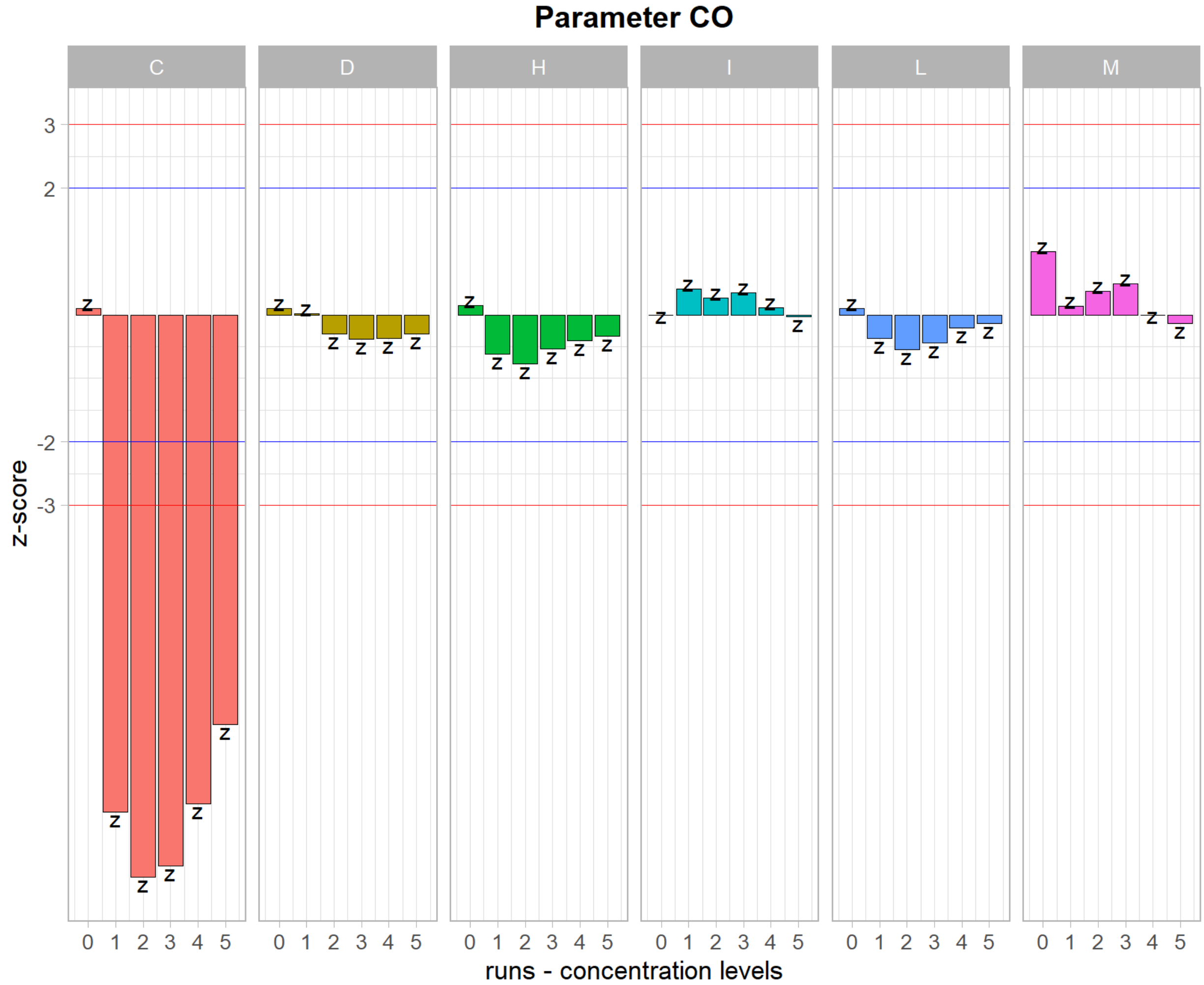
Code	Run	z/z'-score value	z/z'-score evaluation	z_type
C	CO _1	-7.839	unsatisfactory	z
C	CO _2	-8.863	unsatisfactory	z
C	CO _3	-8.690	unsatisfactory	z
C	CO _4	-7.707	unsatisfactory	z
C	CO _5	-6.463	unsatisfactory	z
C	SO2 _1	2.675	questionable	z'
C	SO2 _2	2.041	questionable	z'
H	NO _3	-2.82	questionable	z'
H	NO _5	-4.941	unsatisfactory	z'
H	NO _6	-3.523	unsatisfactory	z'
H	NO _7	-5.576	unsatisfactory	z
H	NO _8	-4.799	unsatisfactory	z
H	NO _9	-4.390	unsatisfactory	z
H	NO _10	-4.711	unsatisfactory	z
H	NO2 _4	-2.318	questionable	z'
H	NO2 _6	-3.658	unsatisfactory	z'
H	NO2 _7	-5.254	unsatisfactory	z'
H	NO2 _8	-4.972	unsatisfactory	z'
E	NO2 _2	-2.198	questionable	z'
E	NO2 _7	-2.212	questionable	z'
E	NO2 _8	-2.438	questionable	z'
E	O3 _1	-3.301	unsatisfactory	z
E	O3 _4	-2.370	questionable	z
I	SO2 _1	2.566	questionable	z'

Source: JRC 2022

In Annex C, **Table 14** is showing all z/z'-score values calculated for each participant, parameter and concentration level.

The results of z/z'-score evaluation are presented in bar plots (**Figure 1** to **Figure 5**) in which the z/z'-scores of each participant are grouped together. The assessment criteria are presented as z/z'=±2 (blue line) and z/z'=±3 (red line). They represent the limits for the questionable and unsatisfactory results.

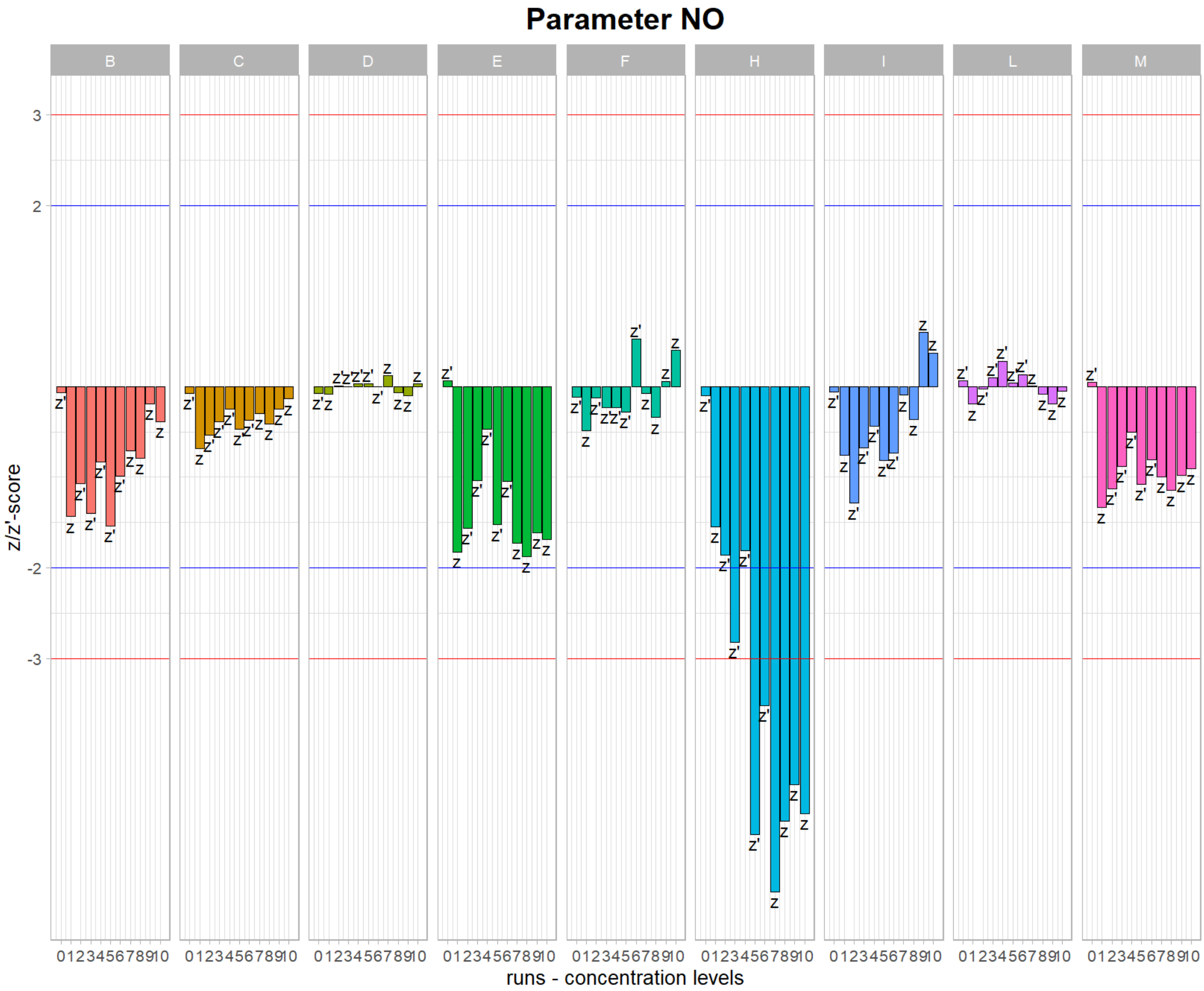
Figure 1: z-score evaluations of CO measurements in µmol/mol



Source: JRC 2022

Scores are given for each participant and each tested concentration level (run). Run number order (with nominal concentration) is: 0 (0 µmol/mol), 1 (3 µmol/mol), 2 (8 µmol/mol), 3 (5 µmol/mol), 4 (1.5 µmol/mol), 5 (0.9 µmol/mol).
The assessment criteria limits are presented as z=±2 (blue line) and z=±3 (red line).
In this PT, laboratories B, E and F didn't participate to the measurement of this parameter.

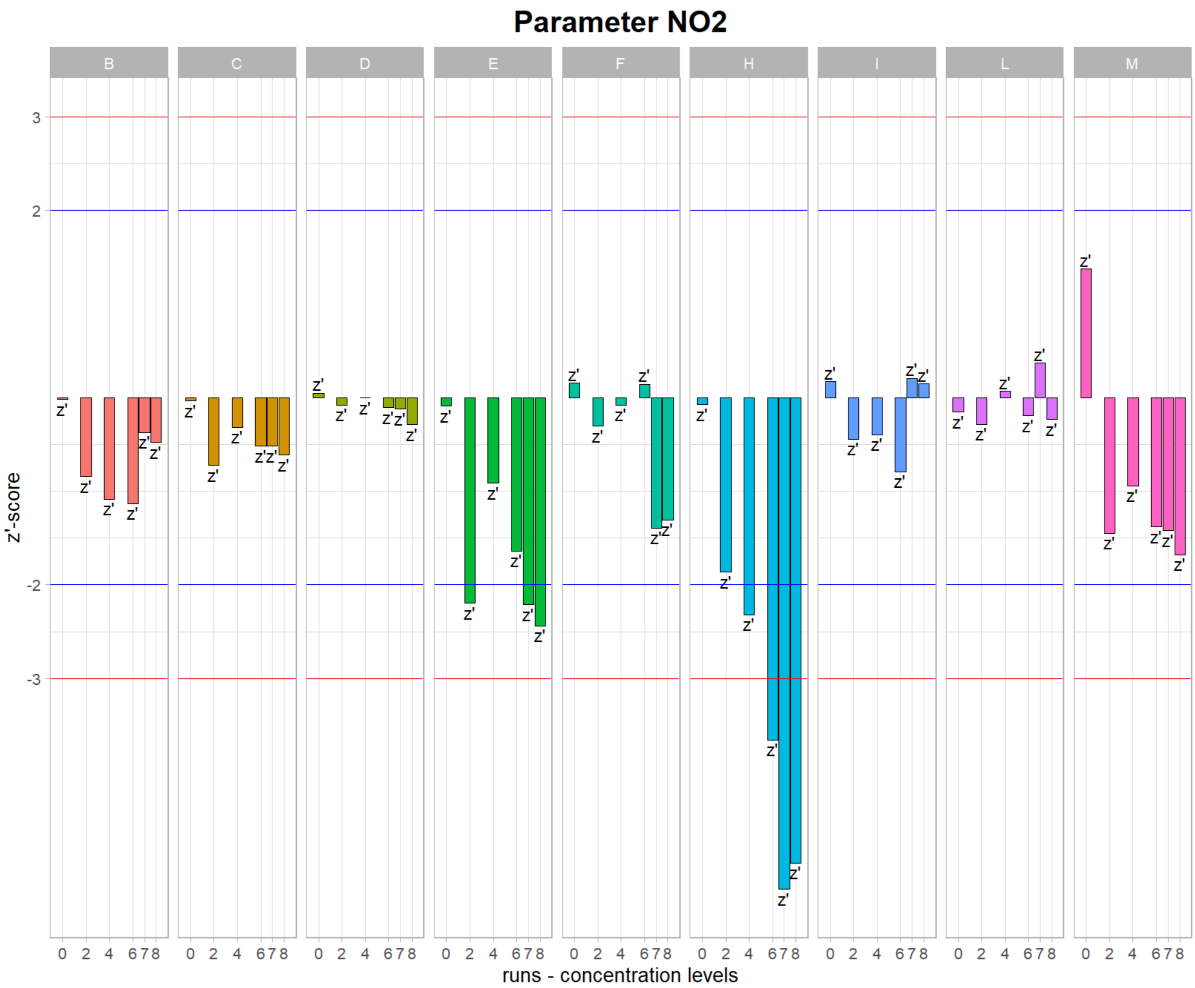
Figure 2: z/z'-score evaluations of NO measurements in nmol/mol



Source: JRC 2022

Scores are given for each participant and each tested concentration level (run). Run number order (with nominal concentration) is: 0 (0 nmol/mol), 1 (120 nmol/mol), 2 (70 nmol/mol), 3 (25 mol/mol), 4 (10 nmol/mol), 5 (60 nmol/mol), 6 (30 nmol/mol), 7 (160 nmol/mol), 8 (150 nmol/mol), 9 (480 nmol/mol), 10 (300 nmol/mol).
The assessment criteria limits are presented as z/z'=±2 (blue line) and z/z'=±3 (red line).

Figure 3: z'-score evaluations of NO2 measurements in nmol/mol

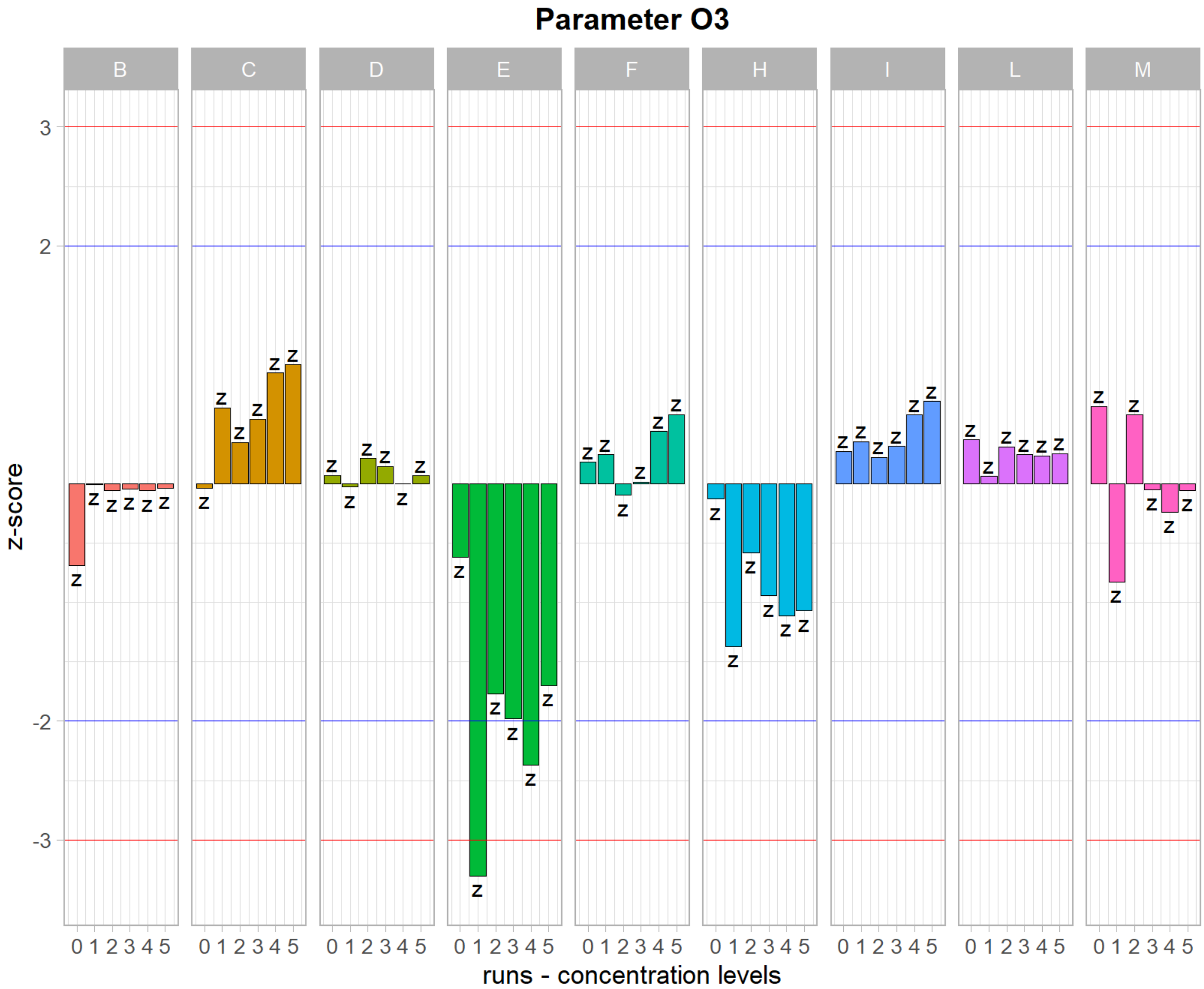


Source: JRC 2022

Scores are given for each participant and each concentration level (run). The order of run numbers when NO2 is generated (with nominal concentration) is: 0 (0 nmol/mol), 2 (50 nmol/mol), 4 (15 nmol/mol), 6 (30 nmol/mol), 8 (100 nmol/mol), 10 (130 nmol/mol). In the runs 1,3,5,9,10 there is no generation of NO2.

The assessment criteria limits are presented as z'=±2 (blue line) and z'=±3 (red line).

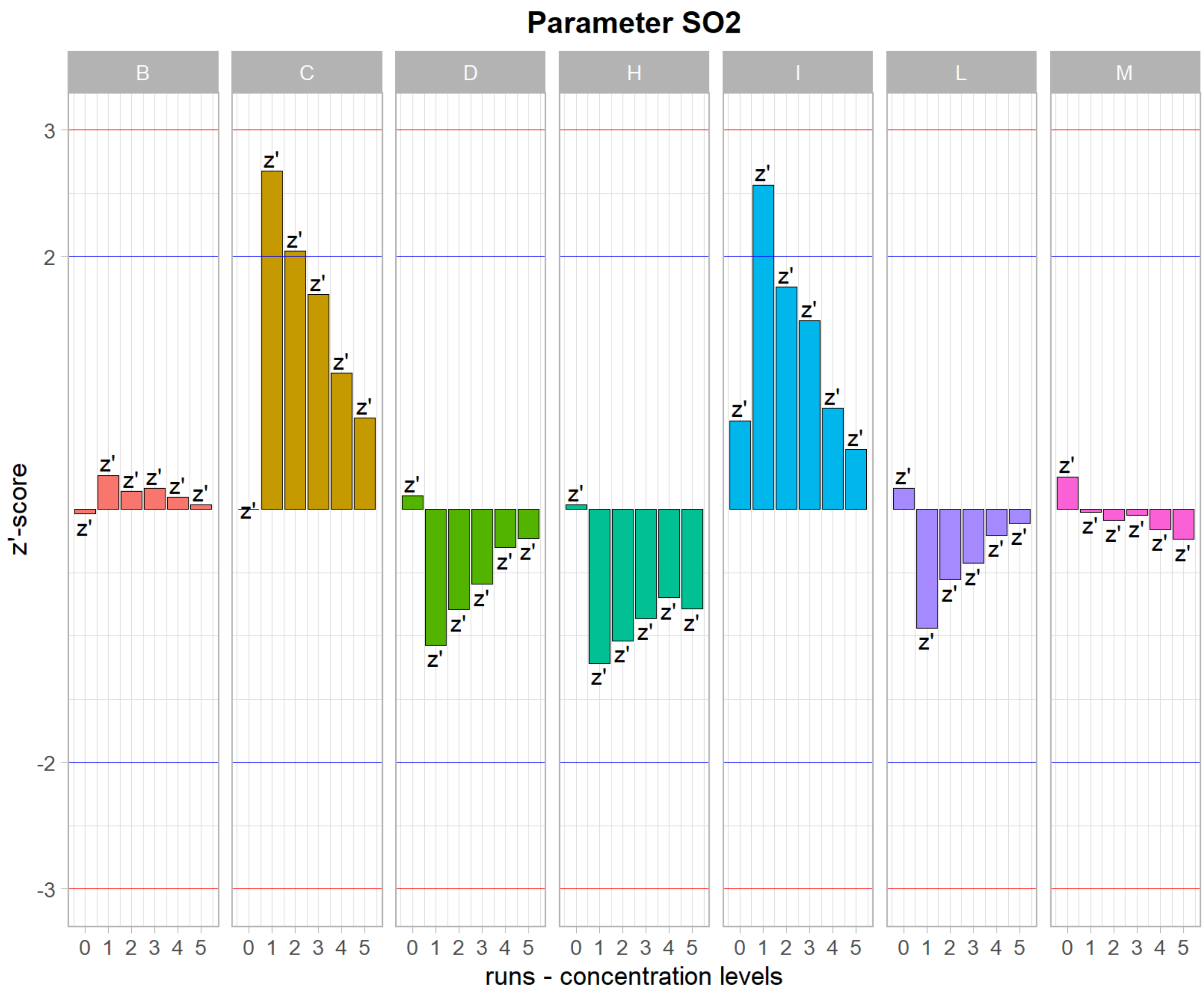
Figure 4: z-score evaluations of O3 measurements in nmol/mol



Source: JRC 2022

Scores are given for each participant and each concentration level (run). Run number order (with nominal concentration) is: 0 (0 nmol/mol), 1 (60 nmol/mol), 2 (15 nmol/mol), 3 (35 nmol/mol), 4 (110 nmol/mol), 5 (130 nmol/mol).
The assessment criteria limits are presented as z=±2 (blue line) and z=±3 (red line).

Figure 5: z'-score evaluations of SO2 measurements in nmol/mol



Source: JRC 2022

Scores are given for each participant and each tested concentration level (run). Run number order (with nominal concentration) is: 0 (0 nmol/mol), 1 (125 nmol/mol), 2 (50 nmol/mol), 3 (35 nmol/mol), 4 (19 nmol/mol), 5 (8 nmol/mol). The assessment criteria limits are presented as z'=±2 (blue line) and z'=±3 (red line).
In this PT, laboratories E and F didn't participate to the measurement of this parameter.

5.2 En-score

In order to evaluate the participant's ability to have results close to the reference values within their reported uncertainties, the En-score parameters (En) were calculated according to:

$$En = \frac{x_i - X}{\sqrt{U_{xi}^2 + U_x^2}} \qquad \text{Equation 4}$$

En = En-score
x_i = participant average values
X = assigned/reference value
U_{xi}= expanded uncertainty of the participants
U_X= expanded uncertainty of the assigned/reference value

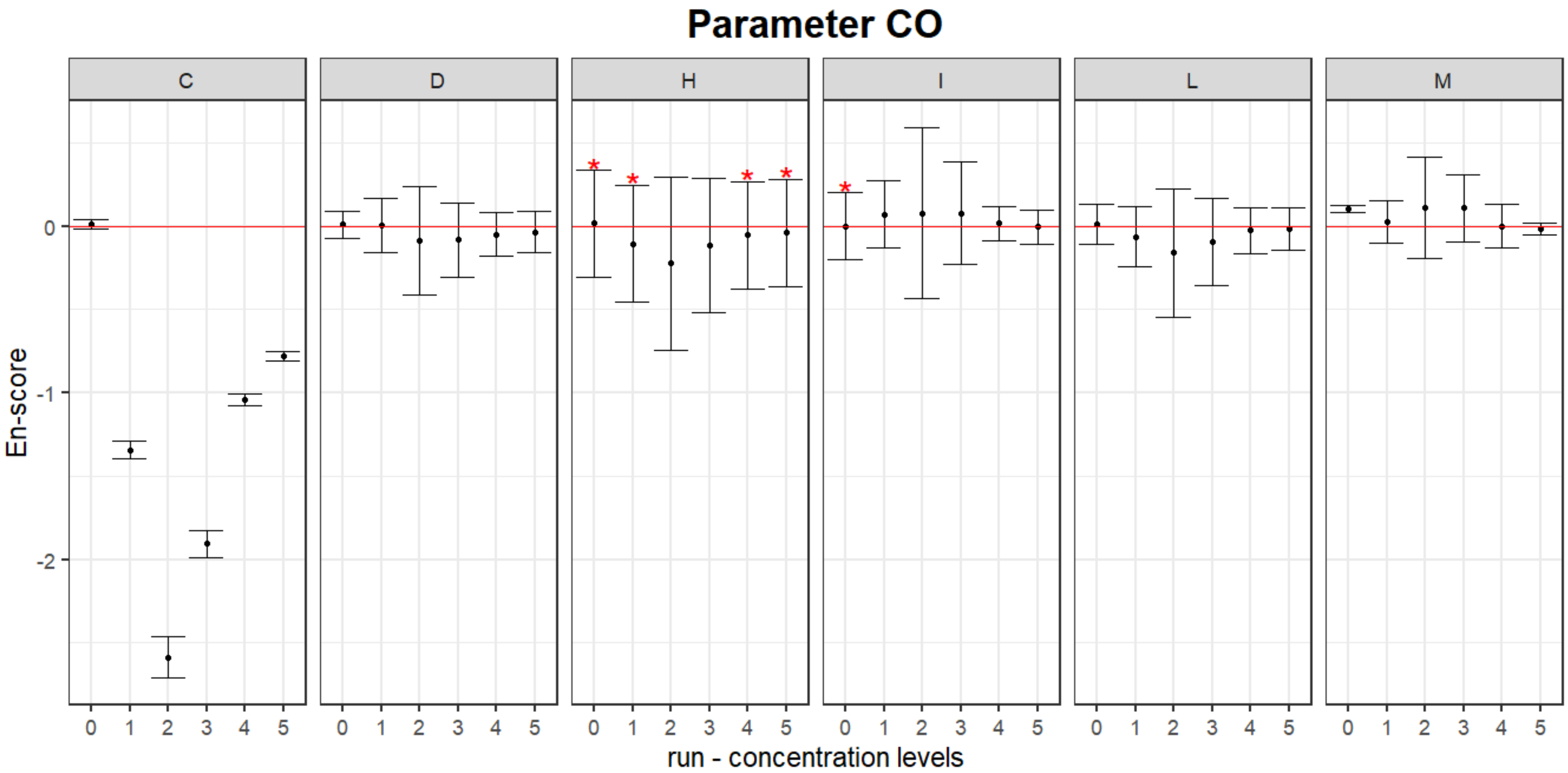
Satisfactory results are the ones for which |En-score|<1. In **Figure 6** to **Figure 10** the difference between participant's values and reference values (xi-X) and error bars are plotted.
These plots represent also the En-score evaluations where, considering the En criterion (|En-score|<1), all results are satisfactory if with the error bars are crossing the x-axis. Reported standard uncertainties (Annex A) that are larger than the "standard deviation for proficiency assessments" (σ_{pt}, **Table 4**) are considered not fit-for-purpose and are denoted with "*" in the x-axis of each figure.
The En evaluation showed in Figures 6-10 underline few unsatisfactory results for different parameters and concentrations, as reported in table 6.
In Annex D, **Table 15** is showing all En values calculated for each participant, parameter and concentration level.

Table 6: Unsatisfactory results according to En-score.

Code	Run	En-score	En evaluation
C	CO _1	-25.0	unsatisfactory
C	CO _2	-20.9	unsatisfactory
C	CO _3	-23.9	unsatisfactory
C	CO _4	-29.4	unsatisfactory
C	CO _5	-25.1	unsatisfactory
M	CO _0	4.9	unsatisfactory
B	NO _3	-1.4	unsatisfactory
B	NO _5	-1.3	unsatisfactory
H	NO _1	-1.1	unsatisfactory
H	NO _2	-1.6	unsatisfactory
H	NO _3	-2.8	unsatisfactory
H	NO _4	-1.5	unsatisfactory
H	NO _5	-4.9	unsatisfactory
H	NO _6	-3.7	unsatisfactory
H	NO _7	-4.4	unsatisfactory
H	NO _8	-3.7	unsatisfactory
H	NO _9	-2.9	unsatisfactory
H	NO _10	-3.3	unsatisfactory
E	NO2 _9	-1.4	unsatisfactory
E	NO2 _10	-1.3	unsatisfactory
I	NO2 _3	10.4	unsatisfactory
H	NO2 _2	-1.6	unsatisfactory
H	NO2 _4	-2.0	unsatisfactory
H	NO2 _6	-3.6	unsatisfactory
H	NO2 _7	-4.0	unsatisfactory
H	NO2 _8	-3.5	unsatisfactory
M	NO2 _0	1.2	unsatisfactory
M	NO2 _2	-1.4	unsatisfactory
M	NO2 _6	-1.4	unsatisfactory
M	NO2 _7	-1.2	unsatisfactory
M	NO2 _8	-1.4	unsatisfactory
C	O3 _4	1.4	unsatisfactory
E	O3 _0	-1.7	unsatisfactory
E	O3 _1	-1.2	unsatisfactory
E	O3 _2	-1.4	unsatisfactory
H	O3 _1	-1.2	unsatisfactory
H	O3 _3	-1.1	unsatisfactory
H	O3 _4	-1.8	unsatisfactory
M	O3 _0	1.5	unsatisfactory
C	SO2 _1	3.1	unsatisfactory
C	SO2 _2	2.7	unsatisfactory
C	SO2 _3	2.3	unsatisfactory
C	SO2 _4	1.4	unsatisfactory
H	SO2 _1	-1.4	unsatisfactory
H	SO2 _2	-1.4	unsatisfactory
H	SO2 _3	-1.1	unsatisfactory

Source: JRC 2022

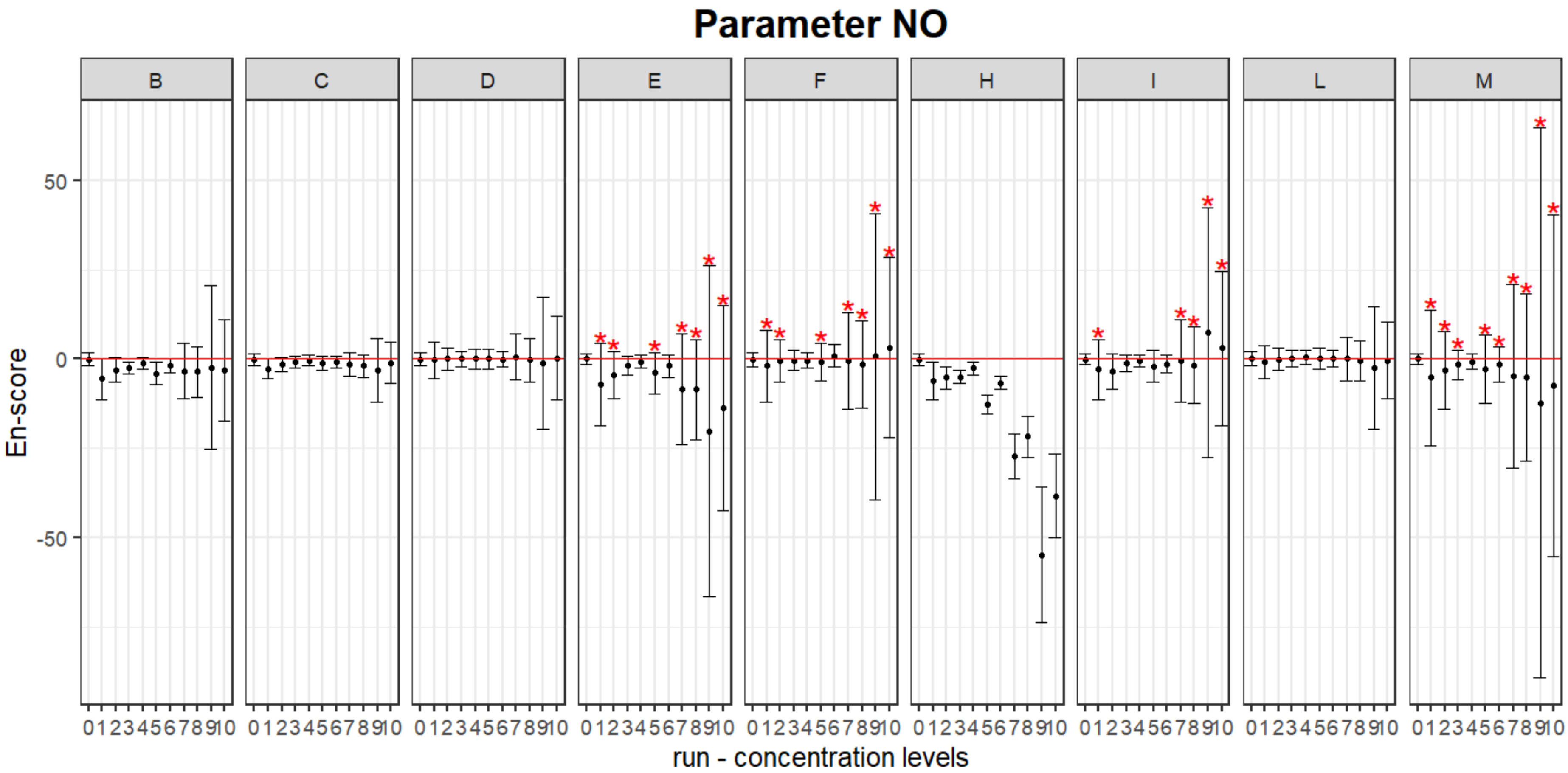
Figure 6: Bias of participant's CO measurement results in μmol/mol



Source: JRC 2022

Figure 6 is showing the expanded uncertainty of bias for each run presented as error bar. For each evaluation is given the run number (from 0 to 5) and the participants rounded run average (μmol/mol). The '*' mark indicates reported standard uncertainties bigger than σ_{pt}.
Laboratory B, E and F didn't participate to the measurement of the parameter.

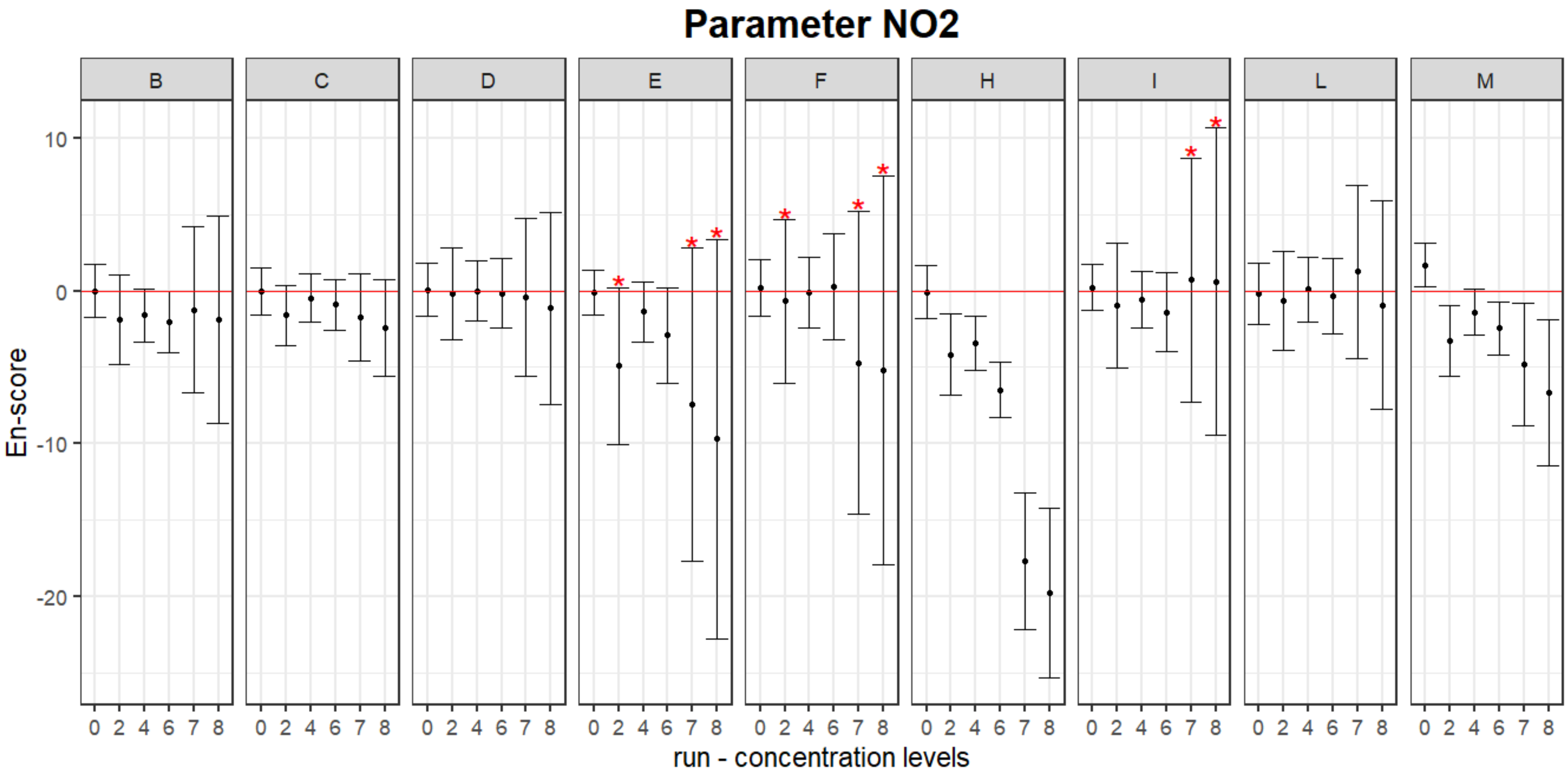
Figure 7: Bias of participant's NO measurement results in nmol/mol



Source: JRC 2022

Figure 7 is showing the expanded uncertainty of bias for each run presented as error bar. For each evaluation is given the run number (from 0 to 10) and the participants rounded run average (nmol/mol). The '*' mark indicates reported standard uncertainties bigger than σ_{pt}.

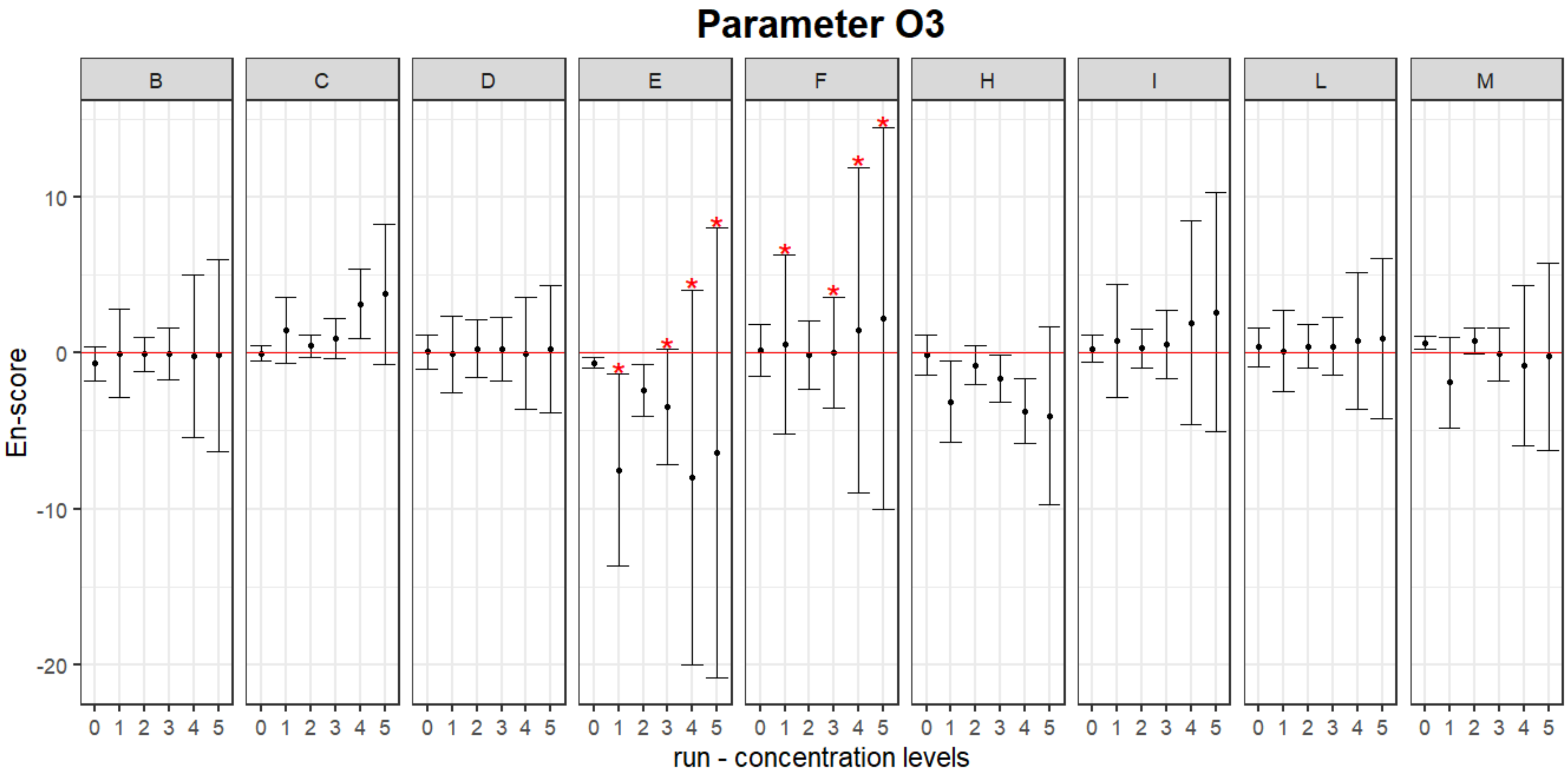
Figure 8: Bias of participant's NO2 measurement results in nmol/mol



Source: JRC 2022

Figure 8 is showing the expanded uncertainty of bias presented as error bar for NO2 run numbers 0, 2, 4, 6, 7 and 8 (see Table 3). For each evaluation is given the run number and the participants rounded run average (nmol/mol). The '*' mark indicates reported standard uncertainties bigger than σ_{pt}.

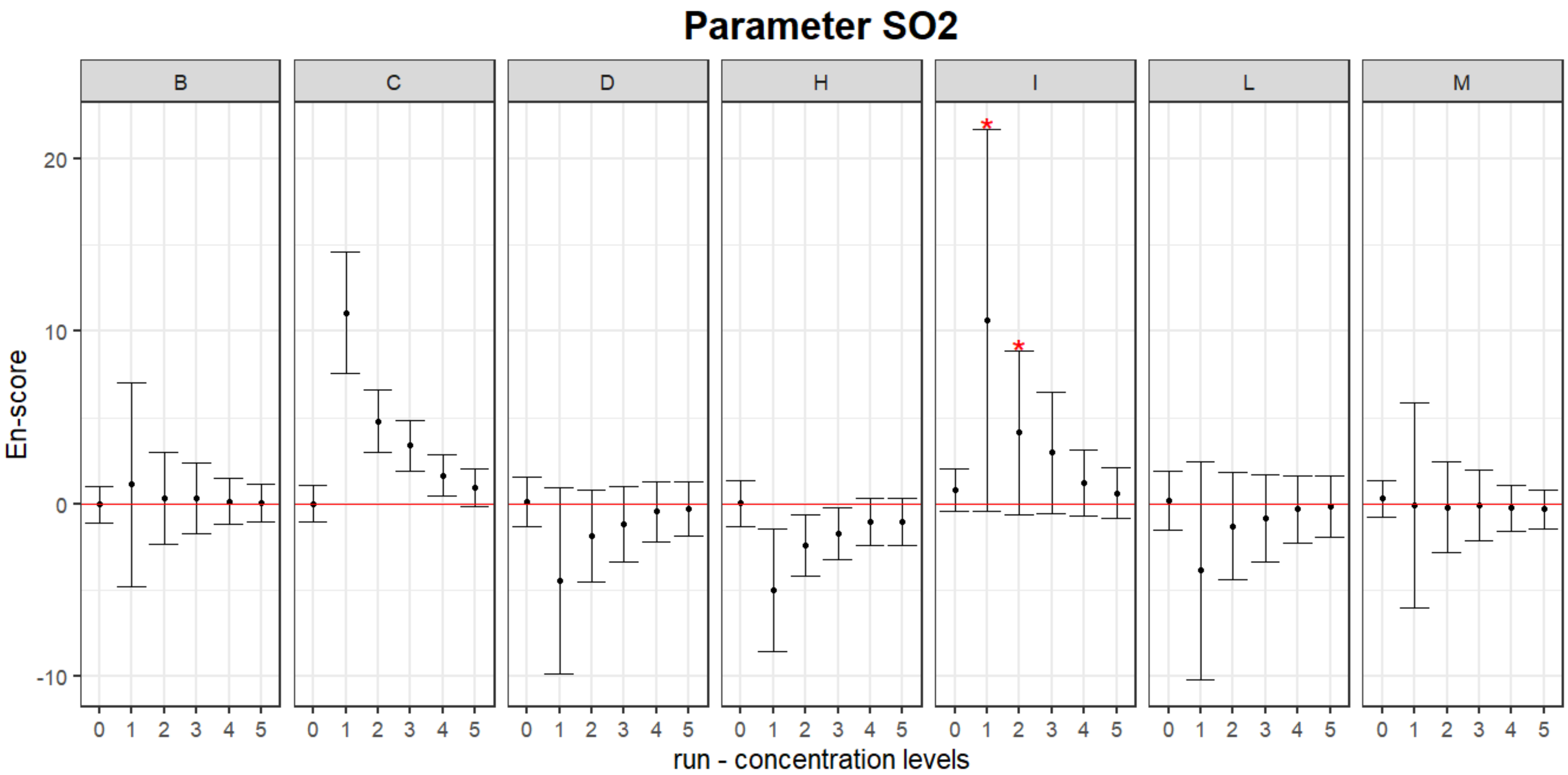
Figure 9: Bias of participant's O3 measurement results in nmol/mol



Source: JRC 2022

Figure 9 is showing the expanded uncertainty of bias for each run presented as error bar. For each evaluation is given the run number (from 0 to 5) and the participants rounded run average (nmol/mol). The '*' mark indicates reported standard uncertainties bigger than σ_{pt}.

Figure 10: Bias of participant's SO2 measurement results in nmol/mol



Source: JRC 2022

Figure 10 is showing the expanded uncertainty of bias for each run presented as error bar. For each evaluation is given the run number (from 0 to 5) and the participants rounded run average (nmol/mol). The '*' mark indicates reported standard uncertainties bigger than σ_{pt}.

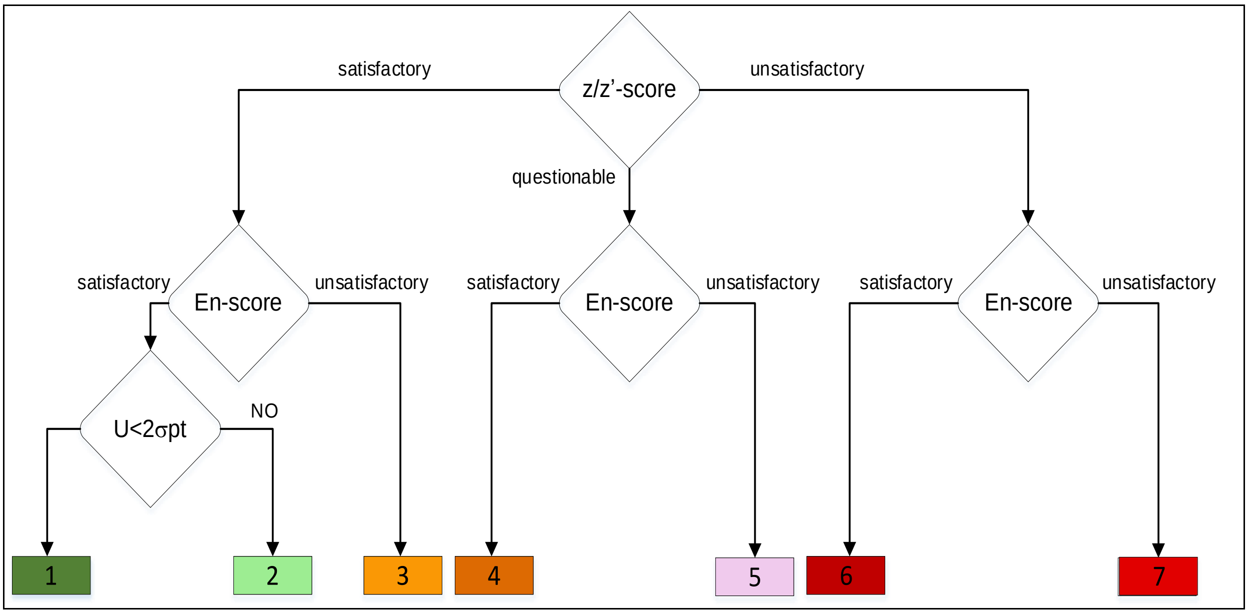
Laboratory E and F didn't participate to the measurement of the parameter.

6 Discussion

For a general assessment of the quality of each result, a decisional diagram was developed (**Figure 11**) that shows seven categories (1 to 7). The general description of each category is:

1. measurement result is completely satisfactory
2. measurement result is satisfactory for z/z'-score and En-score, but the reported uncertainty is too high according to the criteria $U<2\sigma_{pt}$
3. measured value is satisfactory for z/z'-score, but the reported uncertainty is underestimated (En-score unsatisfactory)
4. measurement result is questionable for z/z'-score, but due to a high reported uncertainty can be considered valid (En-score satisfactory).
5. measurement result is questionable for z/z'-score and unsatisfactory for En-score.
6. measurement result is unsatisfactory for z/z'-score, but due to a high reported uncertainty can be considered valid (En-score satisfactory)
7. measurement result is unsatisfactory for z/z'-score and En-score.

Figure 11: Decision diagram for general assessment of proficiency results.



Source: JRC 2022

The results of the PT were assigned to categories according to the diagram given in **Figure 11** and are presented in the following table (**Table 7**). All the results submitted are reported in Annex B.

Table 7: General assessment of proficiency results.

gas	Conc. level	Ref. values	B	C	D	E	F	H	I	L	M
CO	0	0.00	n.r.	1	1	n.r.	n.r.	2	2	1	3
	1	2.98	n.r.	7	1	n.r.	n.r.	2	1	1	1
	2	7.99	n.r.	7	1	n.r.	n.r.	1	1	1	1
	3	4.98	n.r.	7	1	n.r.	n.r.	1	1	1	1
	4	1.47	n.r.	7	1	n.r.	n.r.	2	1	1	1
	5	0.87	n.r.	7	1	n.r.	n.r.	2	1	1	1
NO	0	0.12	1	1	1	1	1	1	1	1	1
	1	119.75	1	1	1	2	2	3	2	1	2
	2	67.84	1	1	1	2	2	3	1	1	2
	3	24.77	3	1	1	1	1	5	1	1	2
	4	10.86	1	1	1	1	1	3	1	1	1
	5	59.50	3	1	1	2	2	7	1	1	2
	6	30.08	1	1	1	1	1	7	1	1	2
	7	161.08	1	1	1	2	2	7	2	1	2
	8	147.09	1	1	1	2	2	7	2	1	2
	9	478.87	1	1	1	2	2	7	2	1	2
	10	297.37	1	1	1	2	2	7	2	1	2
NO2	0	-0.01	1	1	1	1	1	1	1	1	3
	2	53.03	1	1	1	4	2	3	1	1	3
	4	14.67	1	1	1	1	1	5	1	1	1
	6	30.38	1	1	1	1	1	7	1	1	3
	7	106.63	1	1	1	4	2	7	2	1	3
	8	137.43	1	1	1	4	2	7	2	1	3
O3	0	0.03	1	1	1	3	1	1	1	1	3
	1	64.00	1	1	1	7	2	3	1	1	1
	2	17.38	1	1	1	3	1	1	1	1	1
	3	37.05	1	1	1	2	2	3	1	1	1
	4	118.32	1	3	1	4	2	3	1	1	1
	5	138.82	1	1	1	2	2	1	1	1	1
SO2	0	0.01	1	1	1	n.r.	n.r.	1	1	1	1
	1	134.24	1	5	1	n.r.	n.r.	3	4	1	1
	2	55.93	1	5	1	n.r.	n.r.	3	2	1	1
	3	40.11	1	3	1	n.r.	n.r.	3	1	1	1
	4	18.81	1	3	1	n.r.	n.r.	1	1	1	1
	5	9.94	1	1	1	n.r.	n.r.	1	1	1	1

"n.r." is referring to values not reported.

Source: JRC 2022

7 Conclusions

The proficiency evaluation scheme has provided an assessment of the participants measured values and their evaluated uncertainties.

In terms of the criteria imposed by the European Directive (σ_{pt}) **67.4%** of the results reported during this PT (see **Table 8**) by AQUILA laboratories fall into 'category 1' and are satisfactory both in terms of measured values and evaluated uncertainties. Among the remaining results, some of them presented satisfactory measured values, but the evaluated uncertainties were either too high, 'category 2' (**15.8%**), or too small, 'category 3' (**8.4%**). Four values were found for 'category 4' (**1.8%**) and 7 values were assigned to 'category 5' (**1.4%**). No values were falling under 'category 6' and 15 values were found totally unsatisfactory (**5.3%**) in 'category 7'.

A summary of the performances registered during the PT organised in Ispra from 2008 till 2022 is presented in Table 8. The table is showing how categories 1 and 2 are generally the majority as a sign of consistent satisfactory performances, even if the percentage of category 7 (outliers) is the highest since 2008 PT.

Table 8: Flags summary PT in Ispra from 2008 to 2022

PT_Ispra	Category 1	Category 2	Category 3	Category 4	Category 5	Category 6	Category 7
2008-04	68.4	18.1	7.3	1.0	1.0	2.6	1.6
2008-10_1	37.9	40.8	14.2	0.6	3.6	1.0	1.9
2008-10_2	34.3	38.9	23.7	1.0	2.0	0.0	0.0
2009-10	85.0	5.7	7.5	0.4	1.4	0.0	0.0
2010-06	84.6	8.1	4.4	0.7	2.3	0.0	0.0
2011-09	86.1	7.9	5.4	0.0	0.3	0.0	0.3
2011-10	78.6	12.5	7.6	0.0	1.3	0.0	0.0
2012-06	92.2	0.5	7.3	0.0	0.0	0.0	0.0
2013-09	89.4	7.3	3.3	0.0	0.0	0.0	0.0
2013-10	86.8	8.9	3.6	0.4	0.4	0.0	0.0
2014-05	81.8	15.2	1.1	0.0	0.7	0.0	1.1
2015-10_1	90.2	7.6	1.6	0.3	0.3	0.0	0.0
2015-10_2	75.6	10.8	7.3	0.6	3.5	0.0	2.2
2016-06	79.3	17.8	2.9	0.0	0.0	0.0	0.0
2017-06_1	92.8	4.3	1.8	0.0	0.7	0.0	0.4
2017-06_2	78.1	11.5	6.5	0.0	1.9	0.0	1.9
2018-06	95.6	1.3	3.1	0.0	0.0	0.0	0.0
2019-05_1	86.6	8.1	4.0	1.0	1.0	0.0	0.0
2019-05_2	82.8	10.7	3.5	3.0	0.0	0.0	0.0
2022-03_1	85.8	6.8	4.5	0.6	0.6	0.0	1.7
2022-03_2	91.7	6.0	1.7	0.0	0.7	0.0	0.0
2022-04	67.8	15.8	8.4	1.8	1.4	0.0	5.3

Source: JRC 2022

As in previous PT, the adopted criteria for high concentrations were the standard deviations for proficiency assessment, deriving from the European Standards' uncertainty requirements.

The reproducibility standard deviation obtained at this (Annex C) and previous PT [20], [21], [22], [23], [24], [25], [33], [34], [35], [36], [37], [38], [39], [40], [41], [43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53] and [54] is comparable to the mentioned criteria. On the other hand, the uncertainty criteria for zero levels were those set in AQUILA's position paper [12].

In this exercise **91.5%** of the results in the z/z'-score evaluations were satisfactory, **3.2%** questionable and **5.3%** of results were unsatisfactory. The results of this PT is in line with the performances of previous years as shown by the following **Table 9**.

Comparability of results among AQUILA participants at the highest concentration level is acceptable for all pollutant measurements beside for SO2 for which the reproducibility is beyond the reference curve from 40 nmol/mol onwards.

Table 9: z/z'-score summary PT in Ispra from 2005 to 2022

PT	Site	Satisfactory (%)	Questionable (%)	Unsatisfactory (%)
2005-06	Ispra (IT)	94.7	2.3	3.0
2007-06	Ispra (IT)	97.8	1.9	0.3
2008-04	Ispra (IT)	93.8	2.1	4.1
2008-10_1	Ispra (IT)	92.9	4.2	2.9
2008-10_2	Ispra (IT)	97.0	3.0	0.0
2009-10	Ispra (IT)	98.2	1.8	0.0
2010-06	Ispra (IT)	97.0	3.0	0.0
2011-09	Ispra (IT)	99.4	0.3	0.3
2011-10	Ispra (IT)	98.7	1.3	0.0
2012-06	Ispra (IT)	100.0	0.0	0.0
2013-09	Ispra (IT)	100.0	0.0	0.0
2013-10	Ispra (IT)	99.3	0.7	0.0
2014-05	Ispra (IT)	98.1	0.7	1.1
2015-10_1	Ispra (IT)	99.4	0.6	0.0
2015-10_2	Ispra (IT)	93.7	4.1	2.2
2016-06	Ispra (IT)	100	0.0	0.0
2017-06_1	Ispra (IT)	98.9	0.7	0.4
2017-06_2	Ispra (IT)	96.2	1.9	1.9
2018-06	Ispra (IT)	100	0.0	0.0
2019-05_1	Ispra (IT)	98.7	1.3	0.0
2019-05_2	Ispra (IT)	97.5	2.5	0.0
2022-03_1	Ispra (IT)	97.2	1.1	1.7
2022-03_2	Ispra (IT)	99.3	0.7	0.0
2022-04	Ispra (IT)	91.5	3.2	5.3

Source: JRC 2022

The relative reproducibility limits, at the highest studied concentration levels, are 15.8% for SO2, 6.1% for CO, 7.1% for O3, for NO 5.5% and for NO2 8.3% all within the objective derived from criteria imposed by the European Commission (σ_{pt} see **Table 4**).
During this PT the performance of all NRL was confirmed by the 91.5% of all values reported that were found satisfactory according to z/z'-score evaluation.
Fifteen values were identified as outliers (**Table 5**). This PT has shown a bad performance according to the number of outliers that is the highest ever since the PT organized by ERLAP in 2005 as shown in **Table 9**. In Annex D are reported all the details about the evaluation of this PT, the strugglers and outliers identified.
After the delivery of the draft report laboratory C and H replied:

Laboratory C: Our reported results for CO concentrations are below official values by about 30%. We realized that it is not a malfunction in the TEI 48i+ analyzer but a leak in the sampling line's internal pneumatic system. This is what we have to report as the cause of the deviation in our results.

Laboratory H: After a more thorough evaluation of the NO_x monitor that we used during this PT (Teledyne API T200 s/n 6964), it is clear that the unit shows performance issues. The instrument went through multiple linearity tests last week and an abnormal sensitivity variation was registered over a testing period of 3 days. These issues did not show up during the testing period at NILU, prior to the PT exercise. The controls against our travelling standard before and after the PT exercise did not indicate such variations. The instrument showed no warning and instrument parameters were all within tolerances during the exercise. This instrument is NILUs newest NO_x analyzer. It passed all the tests performed upon reception. Based on our post observations we conclude that the analyzer was probably malfunctioning during parts of the PT and that we should have discarded the reported results.

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List of abbreviations

AQUILA	Network of National Reference Laboratories for Air Quality
CEN	European Committee for Standardization
CO	Carbon monoxide
CRM	Certified Reference Material
DQO	Data Quality Objective
ERLAP	European Reference Laboratory for Air Pollution
EC	European Commission
GPT	Gas Phase Titration
ILC	Inter-Laboratory Comparison Exercise
ISO	International Organization for Standardization
JRC	Joint Research Centre
NO	Nitrogen monoxide
NO2	Nitrogen dioxide
NOX	The oxides of nitrogen, the sum of NO and NO2
NRL	National Reference Laboratory
O3	Ozone
PT	Proficiency Test
SO2	Sulphur dioxide
VDI	Verein Deutscher Ingenieure
WHO-CC	World Health Organization Collaborating Centre for Air Quality Management and Air Pollution

Mathematical Symbols

En	En–score statistic (ISO 13528)
r	repeatability limit (ISO 5725)
R	reproducibility limit (ISO 5725)
σ_{pt}	standard deviation for proficiency assessment (ISO 13528)
x*	robust average (Annex C ISO 13528)
s*	robust standard deviation (Annex C ISO 13528)
sr	estimate of repeatability variance (ISO 5725)
sR	estimate of reproducibility variance (ISO 5725)
UX	expanded uncertainty of the assigned/reference value (ISO 13528)
Uxi	expanded uncertainty of the participant's value (ISO 13528)
uX	standard uncertainty of the assigned/reference value (ISO 13528)
X	assigned/reference value (ISO 13528)
xi	average of 3 values reported by the participant i (for each parameter and concentration level)
xi,j	j-the reported value of participant i (for each parameter and concentration level)
z'	z'-score statistic (ISO 13528)
z	z-score statistic (ISO 13528)

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Annex A.
Assigned values

The assigned values of tested concentration levels (run) were derived from ERLAP's measurements which are calibrated against the certified reference values of CRMs and are traceable to international standards. In this perspective the assigned values are reference values as defined in the ISO 13528 [13]. To foster its reference function ERLAP is participating regularly to key comparisons of the Gas Analysis Working Group within the framework of BIPM's CCQM and it is yearly confirming the compliance to standard ISO 17025 for testing and to ISO 17043, both through an audit run by the competent Italian accreditation body (see Annex F).

During this PT ERLAP's SO2, CO and NO analysers were calibrated according to the methodology described in the ISO 6143 [6]. Reference gas mixtures were produced from the primary reference materials (produced and certified by NMi Van Swinden Laboratorium) by dynamic dilution method using mass flow controllers [8]. All flows were measured with a certified molbloc/molbox1 system. For O3 measurements, the analysers were calibrated using the JRC SRP42 primary standard (constructed by NIST), which has been compared to BIPM primary standard [26]. The photometer absorption cross section uncertainty (1.06%) was included in the uncertainty budget [27], [28].

The reference gas mixture and the calibration experiment evaluation were carried out using two computer applications, the "GUM WORKBENCH" [29] and "B-least" [30] respectively. For extending calibration from the NO to NO2 channel of NOX analyser the GPT test was performed to establish the efficiency of NO2-converter.

In **Table 10** the assigned values are reported together with their uncertainties.

Table 10: Assigned values (X)

Gas	Unit	X	u_ref	U_ref
CO _0	µmol/mol	0.000	0.009	0.018
CO _1	µmol/mol	2.977	0.020	0.040
CO _2	µmol/mol	7.990	0.050	0.099
CO _3	µmol/mol	4.976	0.032	0.063
CO _4	µmol/mol	1.467	0.012	0.024
CO _5	µmol/mol	0.867	0.010	0.021
NO _0	nmol/mol	0.12	0.720	1.43
NO _1	nmol/mol	119.75	1.100	2.200
NO _2	nmol/mol	67.84	0.860	1.720
NO _3	nmol/mol	24.76	0.740	1.480
NO _4	nmol/mol	10.86	0.720	1.440
NO _5	nmol/mol	59.49	0.830	1.660
NO _6	nmol/mol	30.08	0.740	1.490
NO _7	nmol/mol	161.08	1.340	2.670
NO _8	nmol/mol	147.09	1.250	2.500
NO _9	nmol/mol	478.86	3.400	6.800
NO _10	nmol/mol	297.37	2.180	4.360
NO2 _0	nmol/mol	-0.01	0.720	1.43
NO2 _1	nmol/mol	0.35	0.840	1.68
NO2 _2	nmol/mol	53.03	0.860	1.710
NO2 _3	nmol/mol	0.77	0.730	1.46
NO2 _4	nmol/mol	14.66	0.720	1.450
NO2 _5	nmol/mol	0.76	0.760	1.51
NO2 _6	nmol/mol	30.37	0.760	1.510
NO2 _7	nmol/mol	106.63	1.230	2.460
NO2 _8	nmol/mol	137.43	1.300	2.590
NO2 _9	nmol/mol	6.96	1.840	3.67
NO2 _10	nmol/mol	3.83	1.260	2.52
O3 _0	nmol/mol	0.03	0.180	0.37
O3 _1	nmol/mol	63.99	0.470	0.940
O3 _2	nmol/mol	17.38	0.200	0.410
O3 _3	nmol/mol	37.04	0.300	0.590
O3 _4	nmol/mol	118.31	0.850	1.700
O3 _5	nmol/mol	138.81	1.000	1.990
SO2 _0	nmol/mol	0.01	0.520	1.03
SO2 _1	nmol/mol	134.24	1.220	2.440
SO2 _2	nmol/mol	55.93	0.710	1.420
SO2 _3	nmol/mol	40.11	0.620	1.230
SO2 _4	nmol/mol	18.80	0.550	1.090
SO2 _5	nmol/mol	9.94	0.520	1.04

Source: JRC 2022

Homogeneity

The homogeneity of test gas was evaluated from measurements at the beginning and end of the distribution line. The relative differences between beginning and end measurements are calculated.

$$u_{fX} = \sqrt{u_X^2 + (X \cdot u_{homo})^2} \qquad \text{Equation 5}$$

u_{fX} = final reference value combined uncertainty
u_X = reference value uncertainty intermediate
X = reference value
u_{homo} = uncertainty contribution to u_X from homogeneity test

The upper and lower limits of bias due to homogeneity were evaluated to be smaller than 0.5%, which constitutes the relative standard uncertainty of 0.3% of each concentration level assuming a rectangular distribution of the bias. The standard uncertainties of assigned/reference values (u_{fX}) were calculated with Equation 5 and used in the proficiency evaluations of chapter 4.

This type of PT for inorganic gases foresee a generation of gas mixture that is analysed immediately. In this condition, the stability and homogeneity test is not fully applicable. In ERLAP as homogeneity test all sampling ports, used by participants during the PT, are compared with the last port (N20) with a running concentration of ozone and the measurement carried out with 2 different analysers. The test is considered acceptable when the difference of the two measurements is below 0.5%. This test is part of the equipment checks run before a PT organised by ERLAP in Ispra and its result is reported in **Table 11**.

Table 11: Homogeneity test.

Bench position	Sample Analyzer SN15	Ref Analyzer SN14	Diff. in nmol/mol	Diff<0.5% ?
20a/b	400.5	398.0	0.0	Yes
1a	400.0	398.0	-0.5	Yes
1b	400.5	397.5	0.5	Yes
2a	400.5	397.5	0.5	Yes
2b	400.5	397.5	0.5	Yes
3a	400.5	397.5	0.5	Yes
3b	400.5	397.5	0.5	Yes
4a	400.5	397.5	0.5	Yes
4b	400.5	397.5	0.5	Yes
5a	400.5	397.5	0.5	Yes
5b	400.5	397.5	0.5	Yes
6a	400.5	397.5	0.5	Yes
6b	400.5	397.5	0.5	Yes
7a	400.5	397.5	0.5	Yes
7b	399.0	396.0	0.5	Yes
8a	400.5	397.5	0.5	Yes
8b	400.5	397.5	0.5	Yes
9a	400.5	397.5	0.5	Yes
9b	400.5	397.5	0.5	Yes
10a	400.5	397.5	0.5	Yes
10b	400.5	397.5	0.5	Yes
11a	400.5	397.5	0.5	Yes
11b	400.5	397.5	0.5	Yes
12a	400.5	397.5	0.5	Yes
12b	400.5	397.5	0.5	Yes
13a	399.5	396.0	1.0	Yes
13b	399.0	397.0	-0.5	Yes
14a	399.0	396.0	0.5	Yes
14b	400.0	396.0	1.5	Yes
15a	399.0	397.0	-0.5	Yes
15b	399.5	396.0	1.0	Yes
16a	399.0	396.0	0.5	Yes
16b	399.0	396.0	0.5	Yes
17a	399.0	396.0	0.5	Yes
17b	399.0	396.0	0.5	Yes
18a	399.0	396.0	0.5	Yes
18b	399.0	396.0	0.5	Yes
19a	399.5	397.0	0.0	Yes
19b	399.5	397.0	0.0	Yes
21a	399.5	397.0	0.0	Yes
21b	399.5	397.0	0.0	Yes
22a	399.0	396.0	0.5	Yes
22b	399.5	397.0	0.0	Yes
22c	399.5	396.0	1.0	Yes
22d	399.5	397.0	0.0	Yes
23a	399.5	397.0	0.0	Yes
23b	399.5	397.0	0.0	Yes
23c	399.5	396.0	1.0	Yes
23d	399.5	396.0	1.0	Yes

Source: JRC 2022

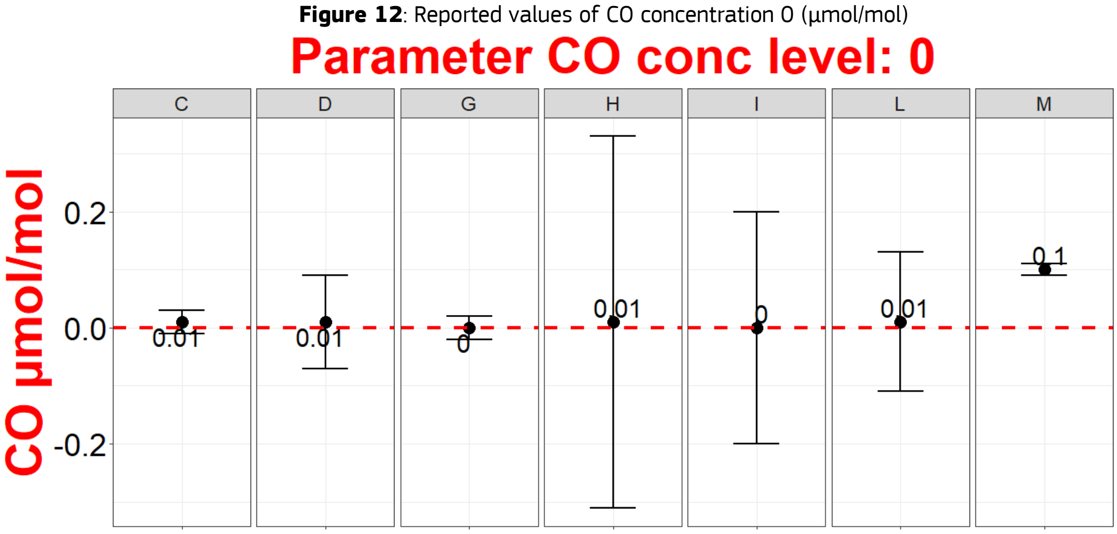
Annex B

Results reported by participants

In this annex participant's results are reported as tables and graphs. For all mixture concentration generated (run), participants were asked to report 3 results representing a measurement of 30 minutes each (xi).
In this annex are presented the reported data and their uncertainty u(xi) and U(xi) expressed in mol/mol units.
For all the runs except concentration levels 0, also average (x_mean) and standard deviation (sd) of each participant are presented.
The assigned value is indicated on the graphs with the red line and the individual laboratories expanded uncertainties (Uxi) are indicated with error bars.

Reported values for CO

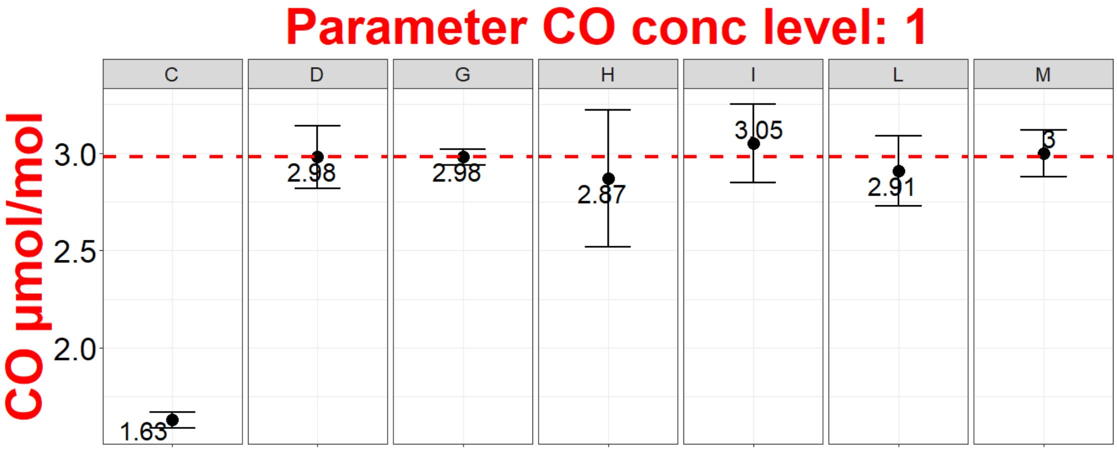
Figure 12: Reported values of CO concentration 0 (μmol/mol)



values	C	D	G	H	I	L	M
xi, 1	0.01	0.01	0	0.015	0	0.01	0.1
u(xi)	0.01	0.04	0.01	0.16	0.10	0.06	0.01
U(xi)	0.02	0.08	0.02	0.32	0.20	0.12	0.01

Source: JRC 2022

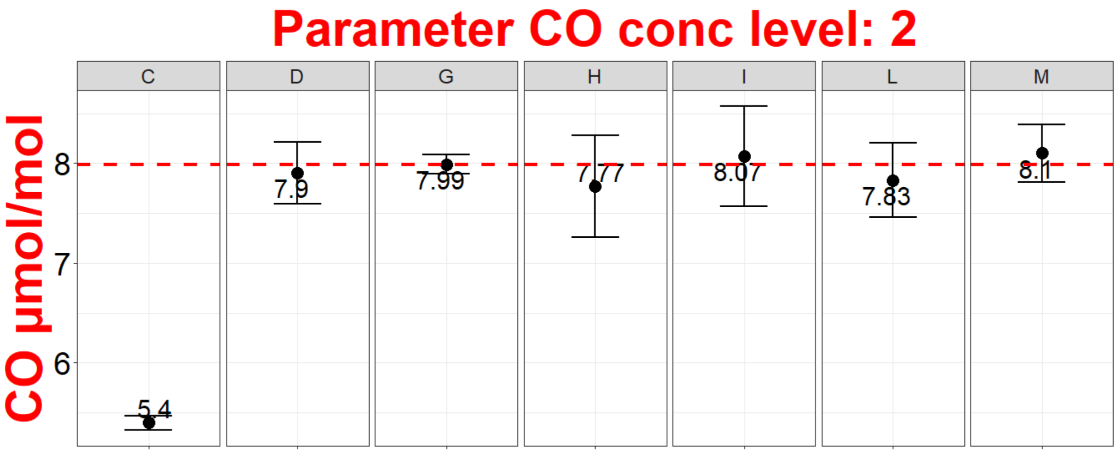
Figure 13: Reported values of CO concentration 1 (µmol/mol)



values	C	D	G	H	I	L	M
xi, 1	1.629	2.98	2.979	2.874	3.04	2.92	3
xi, 2	1.633	2.98	2.977	2.873	3.05	2.91	3
xi, 3	1.637	2.98	2.975	2.865	3.05	2.91	3
x_mean	1.63	2.98	2.98	2.87	3.05	2.91	3.00
sd	0.00	0.00	0.00	0.00	0.01	0.01	0.00
u(xi)	0.02	0.08	0.02	0.17	0.10	0.09	0.05
U(xi)	0.04	0.16	0.04	0.35	0.20	0.18	0.12

Source: JRC 2022

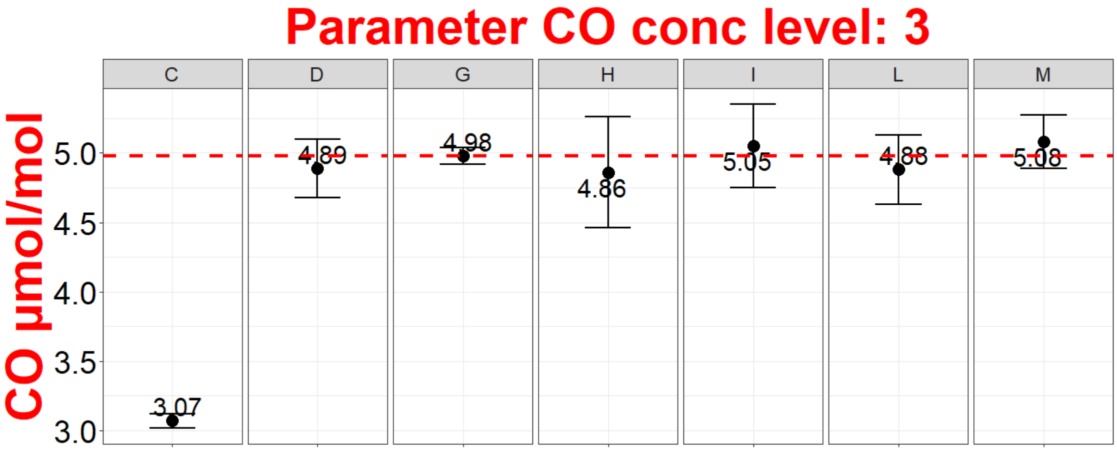
Figure 14: Reported values of CO concentration 2 (µmol/mol)



values	C	D	G	H	I	L	M
xi, 1	5.41	7.91	7.99	7.76	8.07	7.83	8.1
xi, 2	5.412	7.9	7.989	7.765	8.06	7.83	8.1
xi, 3	5.389	7.9	7.991	7.771	8.07	7.83	8.1
x_mean	5.40	7.90	7.99	7.77	8.07	7.83	8.10
sd	0.01	0.01	0.00	0.01	0.01	0.00	0.00
u(xi)	0.04	0.15	0.05	0.26	0.25	0.19	0.14
U(xi)	0.07	0.31	0.10	0.51	0.50	0.37	0.29

Source: JRC 2022

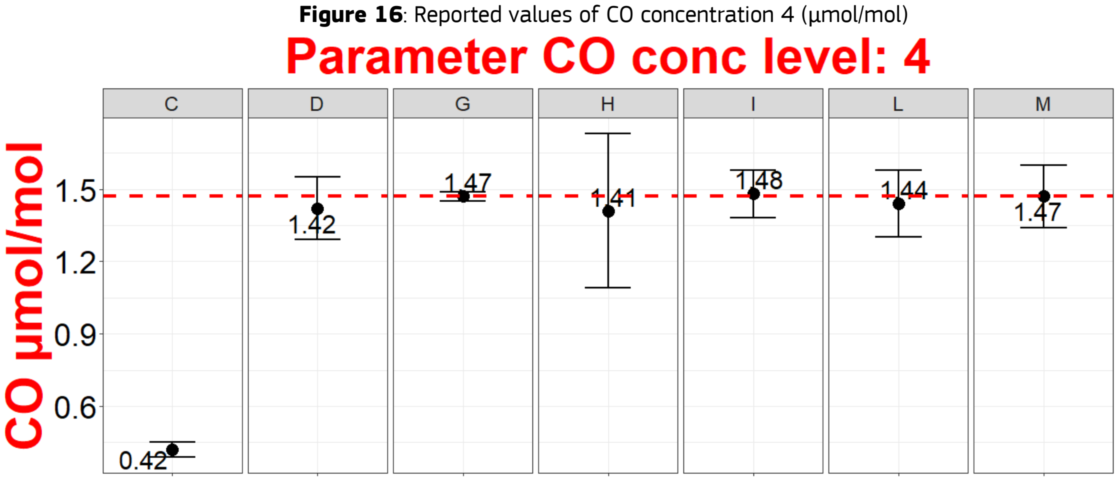
Figure 15: Reported values of CO concentration 3 (µmol/mol)



values	C	D	G	H	I	L	M
xi, 1	3.08	4.9	4.976	4.855	5.05	4.88	5.1
xi, 2	3.066	4.89	4.976	4.859	5.06	4.88	5.05
xi, 3	3.062	4.89	4.975	4.861	5.05	4.88	5.1
x_mean	3.07	4.89	4.98	4.86	5.05	4.88	5.08
sd	0.01	0.01	0.00	0.00	0.01	0.00	0.03
u(xi)	0.02	0.11	0.03	0.20	0.15	0.12	0.09
U(xi)	0.05	0.21	0.06	0.40	0.30	0.25	0.19

Source: JRC 2022

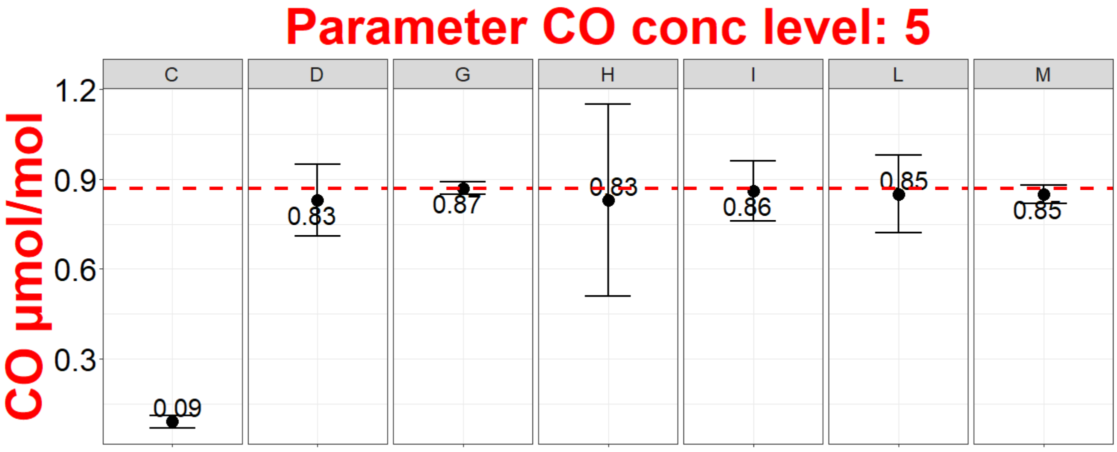
Figure 16: Reported values of CO concentration 4 (µmol/mol)



values	C	D	G	H	I	L	M
xi, 1	0.423	1.41	1.467	1.417	1.48	1.44	1.5
xi, 2	0.42	1.42	1.467	1.412	1.48	1.44	1.5
xi, 3	0.431	1.42	1.467	1.408	1.49	1.44	1.4
x_mean	0.42	1.42	1.47	1.41	1.48	1.44	1.47
sd	0.01	0.01	0.00	0.00	0.01	0.00	0.06
u(xi)	0.01	0.06	0.01	0.16	0.05	0.07	0.06
U(xi)	0.03	0.13	0.02	0.32	0.10	0.14	0.13

Source: JRC 2022

Figure 17: Reported values of CO concentration 5 (µmol/mol)

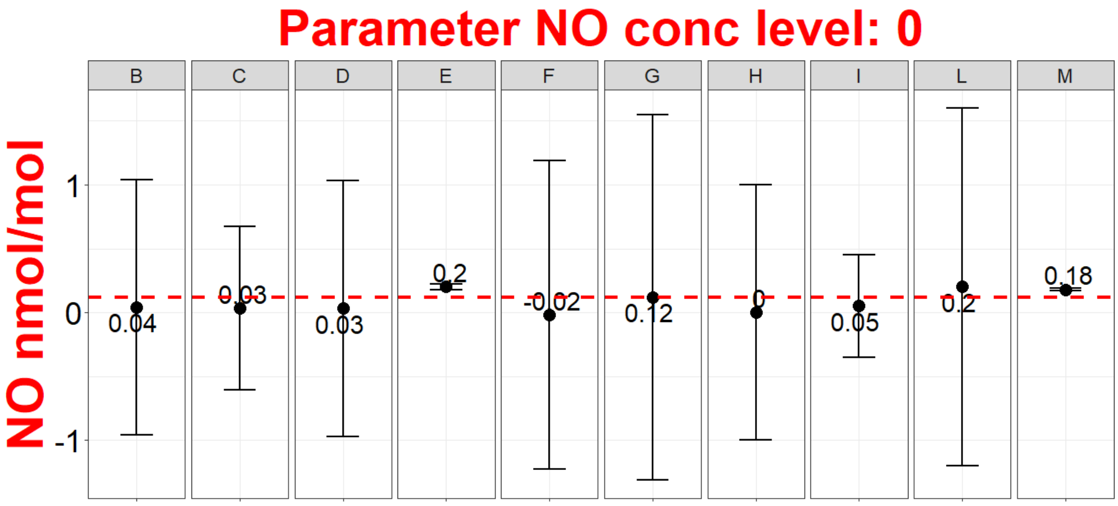


values	C	D	G	H	I	L	M
xi, 1	0.088	0.83	0.868	0.827	0.87	0.85	0.85
xi, 2	0.086	0.83	0.866	0.827	0.86	0.85	0.85
xi, 3	0.084	0.83	0.866	0.828	0.86	0.85	0.85
x_mean	0.09	0.83	0.87	0.83	0.86	0.85	0.85
sd	0.00	0.00	0.00	0.00	0.01	0.00	0.00
u(xi)	0.01	0.06	0.01	0.16	0.05	0.06	0.01
U(xi)	0.02	0.12	0.02	0.32	0.10	0.13	0.03

Source: JRC 2022

Reported values for NO

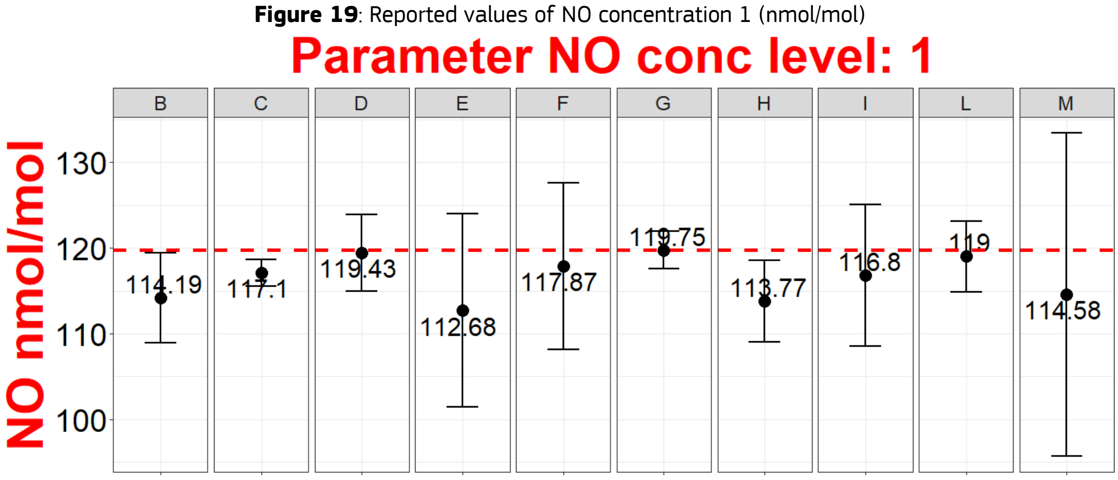
Figure 18: Reported values of NO concentration 0 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	0.04	0.03	0.03	0.2	-0.02	0.12	0	0.05	0.2	0.18
u(xi)	0.50	0.32	0.50	0.01	0.60	0.71	0.50	0.20	0.70	0.01
U(xi)	1.00	0.64	1.00	0.02	1.21	1.43	1.00	0.40	1.40	0.01

Source: JRC 2022

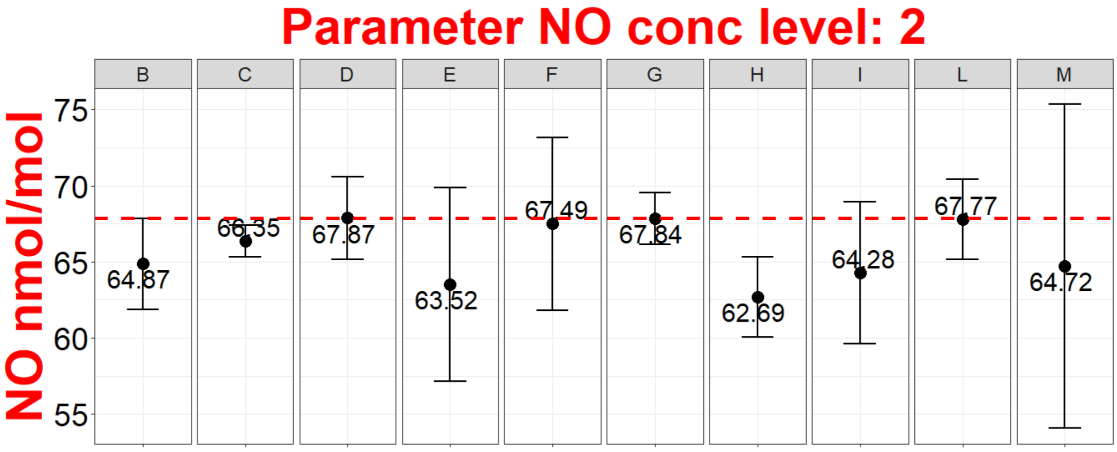
Figure 19: Reported values of NO concentration 1 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	114.18	117.26	119.66	112.96	117.69	120.03	114.6	116.83	119.2	114.9
xi, 2	114.23	116.95	119.36	112.76	117.99	119.66	113.8	116.65	118.9	114.4
xi, 3	114.15	117.1	119.27	112.33	117.93	119.57	112.91	116.91	118.9	114.45
x_mean	114.19	117.10	119.43	112.68	117.87	119.75	113.77	116.80	119.00	114.58
sd	0.04	0.16	0.20	0.32	0.16	0.24	0.85	0.13	0.17	0.28
u(xi)	2.63	0.79	2.23	5.63	4.87	1.10	2.38	4.12	2.07	9.41
U(xi)	5.26	1.58	4.46	11.27	9.74	2.20	4.75	8.23	4.14	18.82

Source: JRC 2022

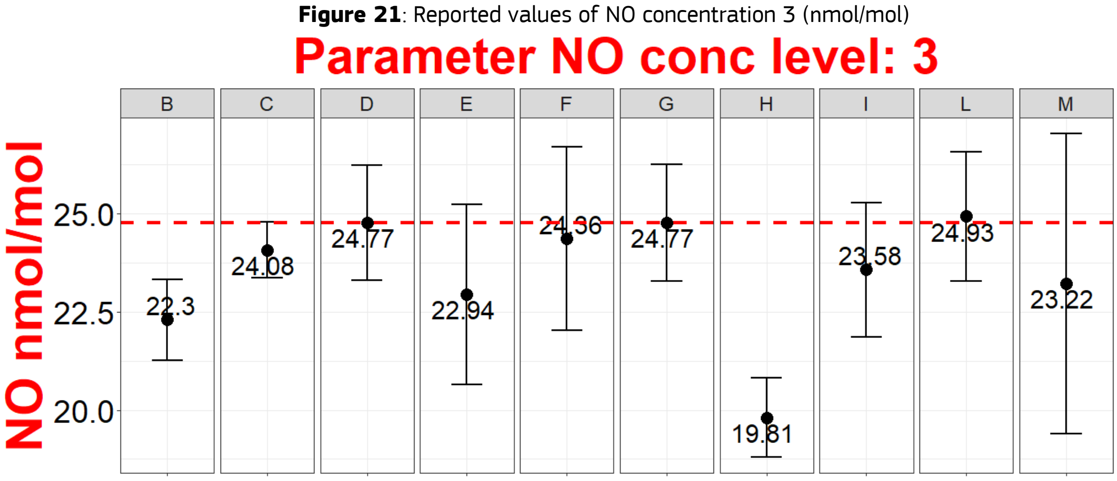
Figure 20: Reported values of NO concentration 2 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	64.83	66.38	67.94	63.47	67.33	67.87	63.22	61.16	67.8	64.8
xi, 2	64.87	66.32	67.81	63.67	67.45	67.85	62.63	65.99	67.8	64.7
xi, 3	64.91	66.34	67.85	63.42	67.68	67.81	62.23	65.7	67.7	64.65
x_mean	64.87	66.35	67.87	63.52	67.49	67.84	62.69	64.28	67.77	64.72
sd	0.04	0.03	0.07	0.13	0.18	0.03	0.50	2.71	0.06	0.08
u(xi)	1.49	0.52	1.35	3.18	2.83	0.86	1.31	2.32	1.31	5.31
U(xi)	2.98	1.04	2.70	6.35	5.66	1.72	2.62	4.64	2.62	10.62

Source: JRC 2022

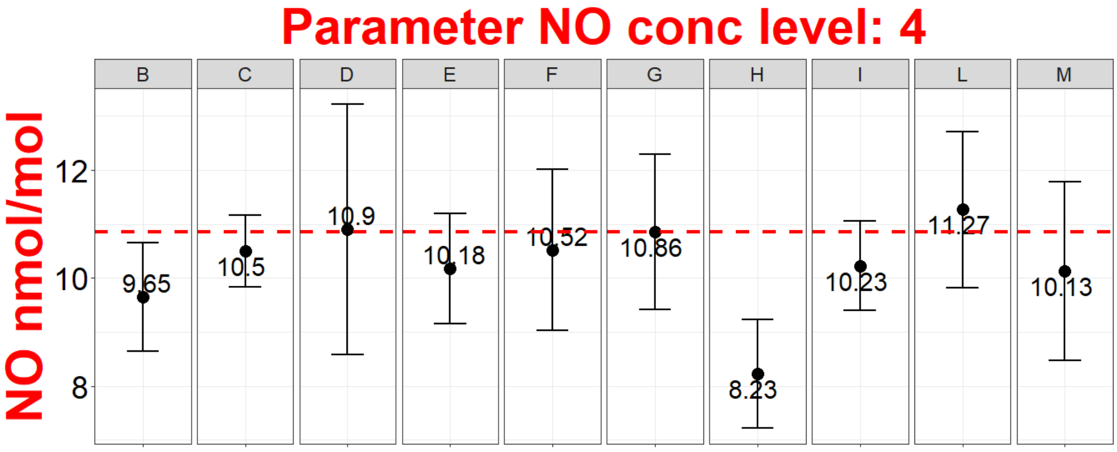
Figure 21: Reported values of NO concentration 3 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	22.11	24.05	24.7	22.43	24.16	24.66	19.91	23.54	24.7	23.05
xi, 2	22.27	24.06	24.8	23.05	24.47	24.81	19.91	23.6	25	23.3
xi, 3	22.53	24.14	24.82	23.34	24.45	24.83	19.61	23.59	25.1	23.3
x_mean	22.30	24.08	24.77	22.94	24.36	24.77	19.81	23.58	24.93	23.22
sd	0.21	0.05	0.06	0.46	0.17	0.09	0.17	0.03	0.21	0.14
u(xi)	0.51	0.35	0.73	1.15	1.17	0.74	0.50	0.85	0.81	1.91
U(xi)	1.03	0.71	1.46	2.29	2.34	1.48	1.00	1.71	1.65	3.82

Source: JRC 2022

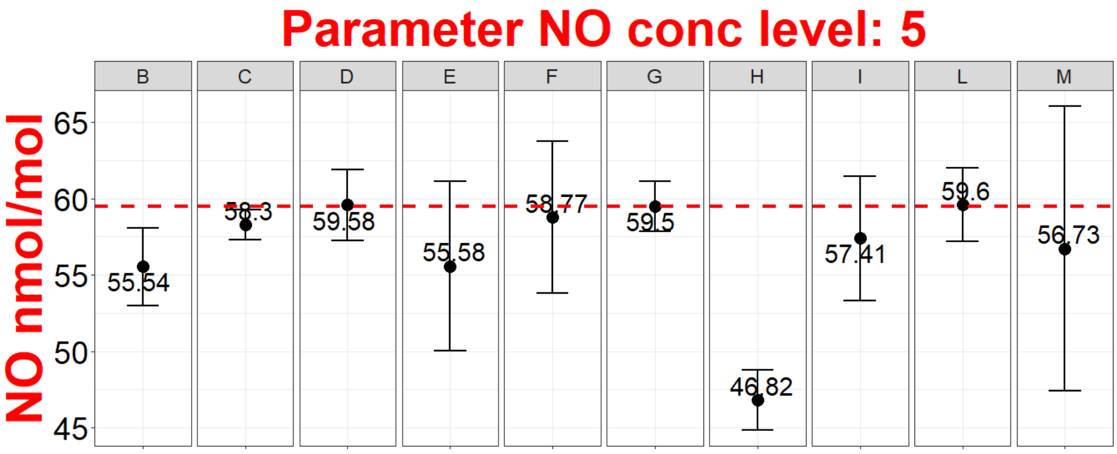
Figure 22: Reported values of NO concentration 4 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	9.71	10.48	10.88	10.11	10.63	10.85	8.26	10.19	11.3	10.1
xi, 2	9.61	10.49	10.91	10.22	10.36	10.87	8.26	10.23	11.3	10.15
xi, 3	9.63	10.52	10.91	10.21	10.56	10.86	8.16	10.26	11.2	10.15
x_mean	9.65	10.50	10.90	10.18	10.52	10.86	8.23	10.23	11.27	10.13
sd	0.05	0.02	0.02	0.06	0.14	0.01	0.06	0.04	0.06	0.03
u(xi)	0.50	0.33	1.16	0.51	0.74	0.72	0.50	0.41	0.72	0.83
U(xi)	1.00	0.66	2.32	1.02	1.49	1.44	1.00	0.83	1.45	1.66

Source: JRC 2022

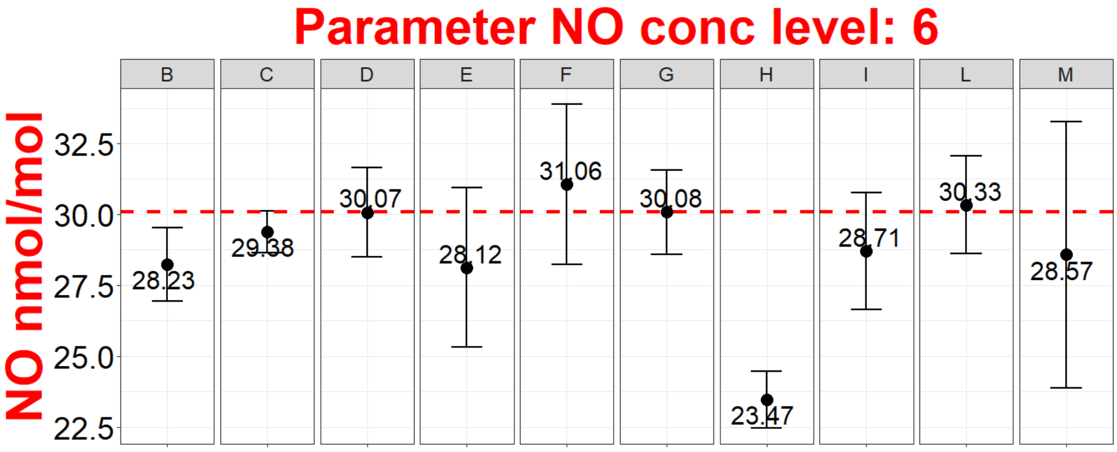
Figure 23: Reported values of NO concentration 5 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	55.24	58.25	59.55	55.33	58.56	59.4	46.89	57.38	59.6	56.55
xi, 2	55.42	58.31	59.59	55.75	58.91	59.46	46.79	57.47	59.6	56.85
xi, 3	55.95	58.33	59.61	55.66	58.84	59.63	46.79	57.38	59.6	56.8
x_mean	55.54	58.30	59.58	55.58	58.77	59.50	46.82	57.41	59.60	56.73
sd	0.37	0.04	0.03	0.22	0.19	0.12	0.06	0.05	0.00	0.16
u(xi)	1.28	0.48	1.16	2.78	2.49	0.83	0.98	2.03	1.20	4.66
U(xi)	2.55	0.97	2.32	5.56	4.97	1.66	1.96	4.07	2.40	9.32

Source: JRC 2022

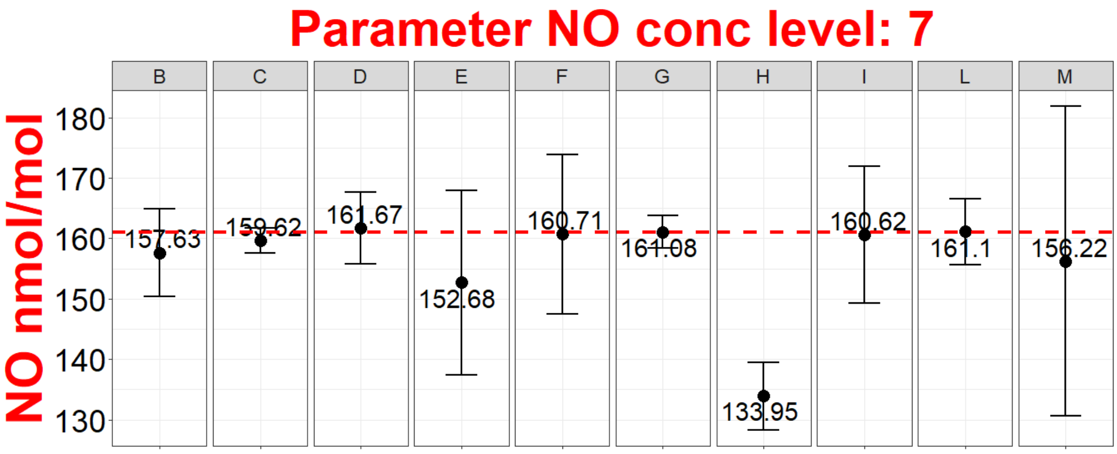
Figure 24: Reported values of NO concentration 6 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	28.01	29.35	30.03	28.26	30.83	30.03	23.5	28.75	30.3	28.5
xi, 2	28.18	29.37	30.01	28.04	31.35	30.06	23.4	28.7	30.3	28.55
xi, 3	28.49	29.42	30.17	28.06	31.01	30.15	23.5	28.67	30.4	28.65
x_mean	28.23	29.38	30.07	28.12	31.06	30.08	23.47	28.71	30.33	28.57
sd	0.24	0.04	0.09	0.12	0.26	0.06	0.06	0.04	0.06	0.08
u(xi)	0.65	0.37	0.79	1.41	1.41	0.75	0.50	1.03	0.86	2.35
U(xi)	1.30	0.74	1.58	2.81	2.82	1.49	1.00	2.06	1.72	4.69

Source: JRC 2022

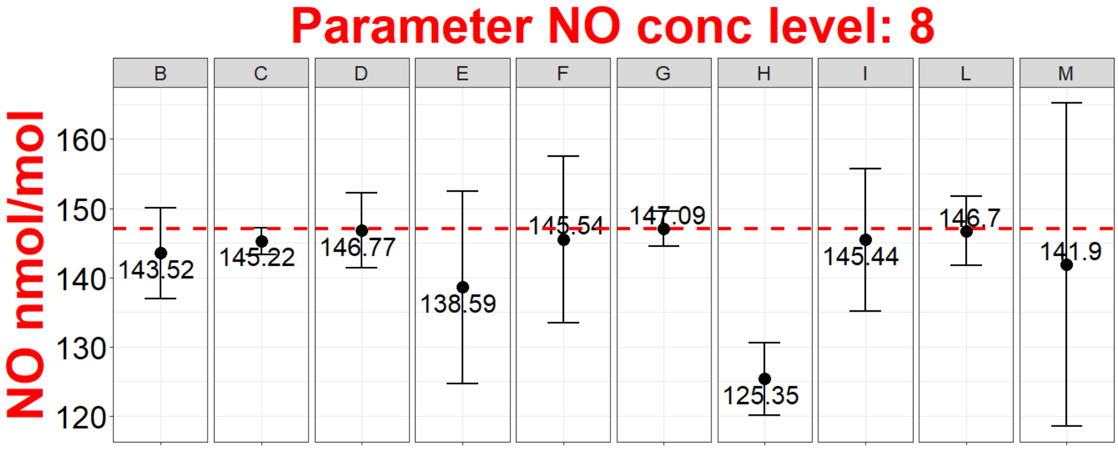
Figure 25: Reported values of NO concentration 7 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	157.69	159.6	161.71	152.97	161.06	161.06	133.52	160.72	161	156.2
xi, 2	157.94	159.65	161.59	152.48	160.49	161.05	133.92	160.67	161.2	156.3
xi, 3	157.26	159.61	161.7	152.59	160.57	161.13	134.41	160.46	161.1	156.15
x_mean	157.63	159.62	161.67	152.68	160.71	161.08	133.95	160.62	161.10	156.22
sd	0.34	0.03	0.07	0.26	0.31	0.04	0.45	0.14	0.10	0.08
u(xi)	3.63	1.04	2.97	7.63	6.62	1.33	2.80	5.66	2.72	12.82
U(xi)	7.27	2.07	5.94	15.27	13.23	2.67	5.60	11.32	5.45	25.64

Source: JRC 2022

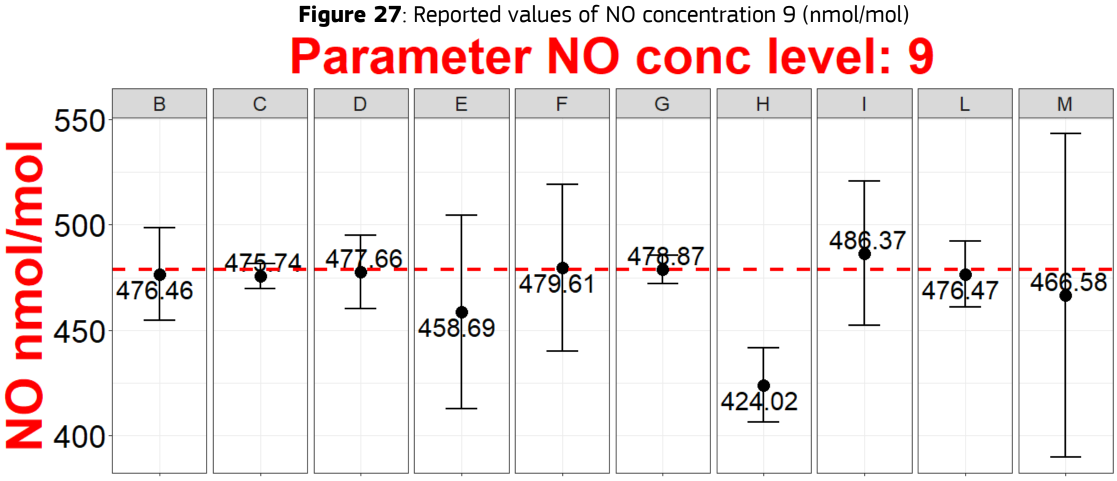
Figure 26: Reported values of NO concentration 8 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	142.74	145.2	146.65	138.24	145.22	147.09	124.46	145.32	146.7	141.6
xi, 2	143.79	145.23	146.85	138.82	145.57	147.07	125.65	145.49	146.7	141.9
xi, 3	144.03	145.24	146.81	138.71	145.84	147.11	125.95	145.5	146.7	142.2
x_mean	143.52	145.22	146.77	138.59	145.54	147.09	125.35	145.44	146.70	141.90
sd	0.69	0.02	0.11	0.31	0.31	0.02	0.79	0.10	0.00	0.30
u(xi)	3.30	0.95	2.71	6.93	6.01	1.25	2.62	5.12	2.50	11.65
U(xi)	6.60	1.91	5.42	13.86	12.02	2.50	5.24	10.25	4.99	23.30

Source: JRC 2022

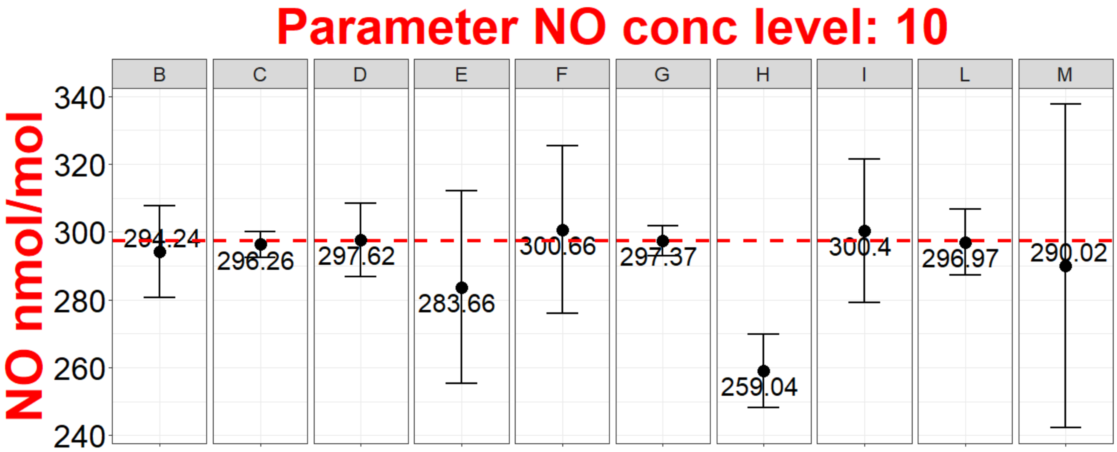
Figure 27: Reported values of NO concentration 9 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	475.12	475.26	477.25	456.73	476.22	478.48	423.35	486.1	476	465.95
xi, 2	476.82	475.92	477.85	459.28	480.26	479.14	424.25	486.6	476.7	466.8
xi, 3	477.43	476.05	477.89	460.07	482.35	478.98	424.45	486.4	476.7	467
x_mean	476.46	475.74	477.66	458.69	479.61	478.87	424.02	486.37	476.47	466.58
sd	1.20	0.42	0.36	1.75	3.12	0.34	0.59	0.25	0.40	0.56
u(xi)	10.96	2.96	8.64	22.93	19.70	3.40	8.86	17.13	7.81	38.30
U(xi)	21.92	5.92	17.28	45.87	39.39	6.80	17.72	34.25	15.64	76.60

Source: JRC 2022

Figure 28: Reported values of NO concentration 10 (nmol/mol)

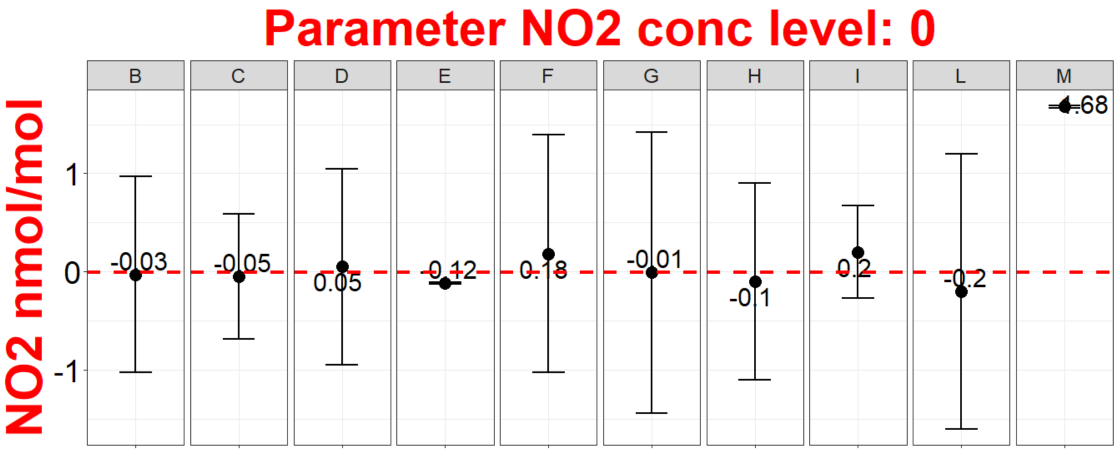


values	B	C	D	E	F	G	H	I	L	M
xi, 1	294.14	296.11	297.85	283.69	300.89	297.57	258.87	300.1	297	290.1
xi, 2	294.48	296.27	297.9	283.72	300.63	297.3	259.07	300.4	296.9	290.05
xi, 3	294.11	296.4	297.12	283.57	300.47	297.25	259.17	300.7	297	289.9
x_mean	294.24	296.26	297.62	283.66	300.66	297.37	259.04	300.40	296.97	290.02
sd	0.21	0.15	0.44	0.08	0.21	0.17	0.15	0.30	0.06	0.10
u(xi)	6.77	1.86	5.40	14.18	12.34	2.18	5.41	10.58	4.90	23.80
U(xi)	13.53	3.72	10.80	28.37	24.68	4.36	10.82	21.17	9.80	47.61

Source: JRC 2022

Reported values for NO2

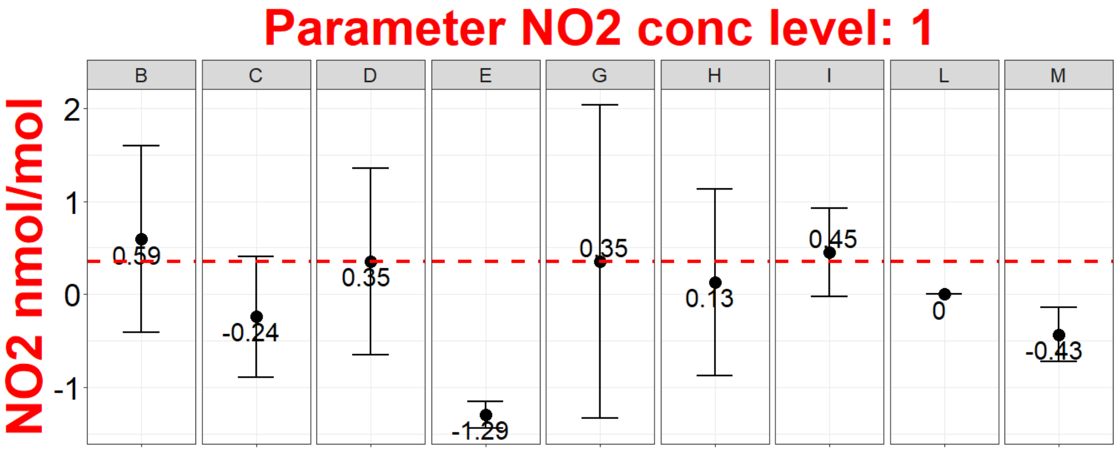
Figure 29: Reported values of NO2 concentration 0 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	-0.03	-0.05	0.05	-0.12	0.18	-0.01	-0.1	0.2	-0.2	1.68
u(xi)	0.50	0.32	0.50	-0.01	0.60	0.71	0.50	0.23	0.70	0.01
U(xi)	1.00	0.64	1.00	-0.01	1.21	1.43	1.00	0.47	1.40	0.01

Source: JRC 2022

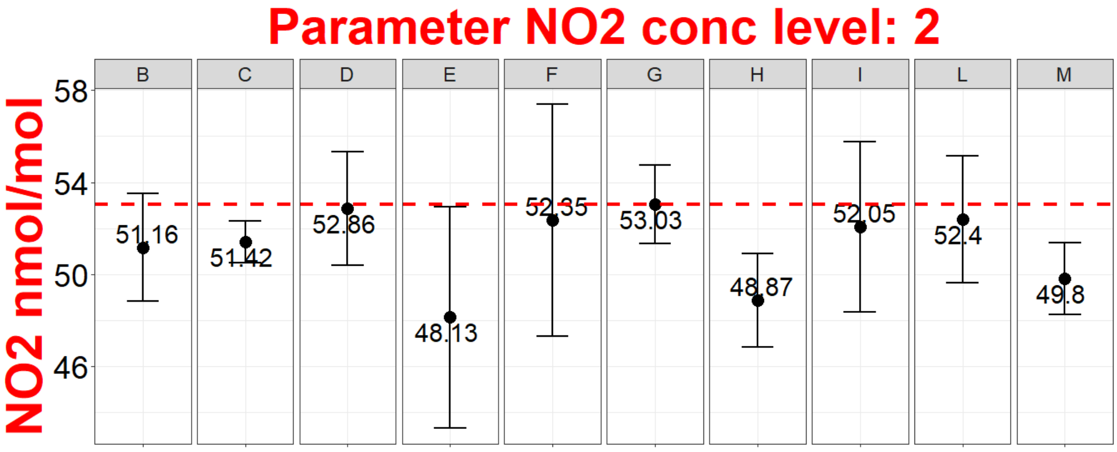
Figure 30: Reported values of NO2 concentration 1 (nmol/mol)



values	B	C	D	E	G	H	I	L	M
xi, 1	0.61	-0.28	0.39	-1.12	0.35	0	0.4	0	-0.35
xi, 2	0.5	-0.18	0.31	-1.4	0.35	0.1	0.43	0	-0.35
xi, 3	0.66	-0.26	0.34	-1.35	0.35	0.3	0.52	0	-0.6
x_mean	0.59	-0.24	0.35	-1.29	0.35	0.13	0.45	0.00	-0.43
sd	0.08	0.05	0.04	0.15	0.00	0.15	0.06	0.00	0.14
u(xi)	0.50	0.32	0.50	-0.07	0.84	0.50	0.23	0.00	-0.14
U(xi)	1.00	0.65	1.00	-0.14	1.68	1.00	0.47	0.00	-0.29

Source: JRC 2022

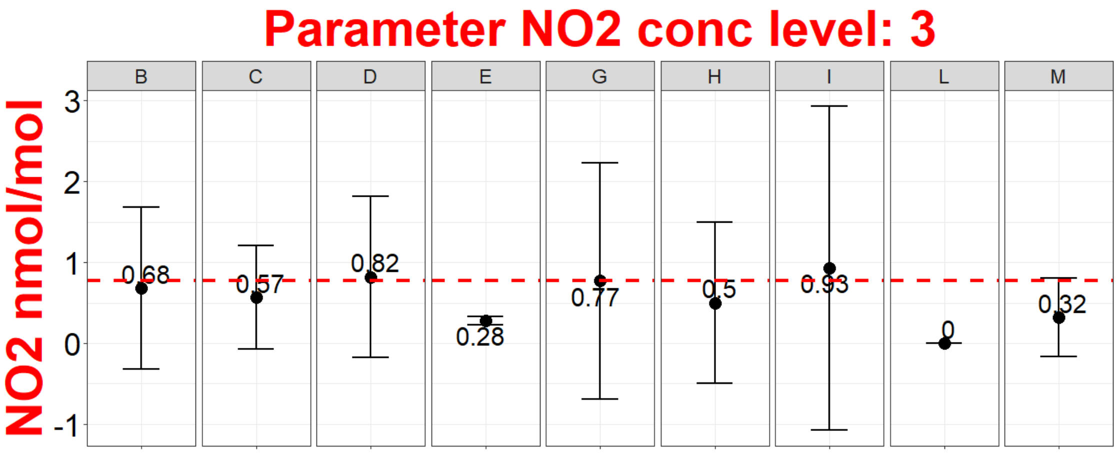
Figure 31: Reported values of NO2 concentration 2 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	51.3	51.38	52.64	48.12	52.34	52.97	49	51.98	52.2	49.7
xi, 2	51.03	51.17	52.93	47.98	52.42	53	48.8	52	52.4	49.8
xi, 3	51.15	51.7	53	48.29	52.29	53.13	48.8	52.16	52.6	49.9
x_mean	51.16	51.42	52.86	48.13	52.35	53.03	48.87	52.05	52.40	49.80
sd	0.14	0.27	0.19	0.16	0.07	0.09	0.12	0.10	0.20	0.10
u(xi)	1.18	0.45	1.23	2.41	2.52	0.85	1.02	1.85	1.37	0.77
U(xi)	2.35	0.91	2.46	4.81	5.04	1.71	2.04	3.70	2.76	1.55

Source: JRC 2022

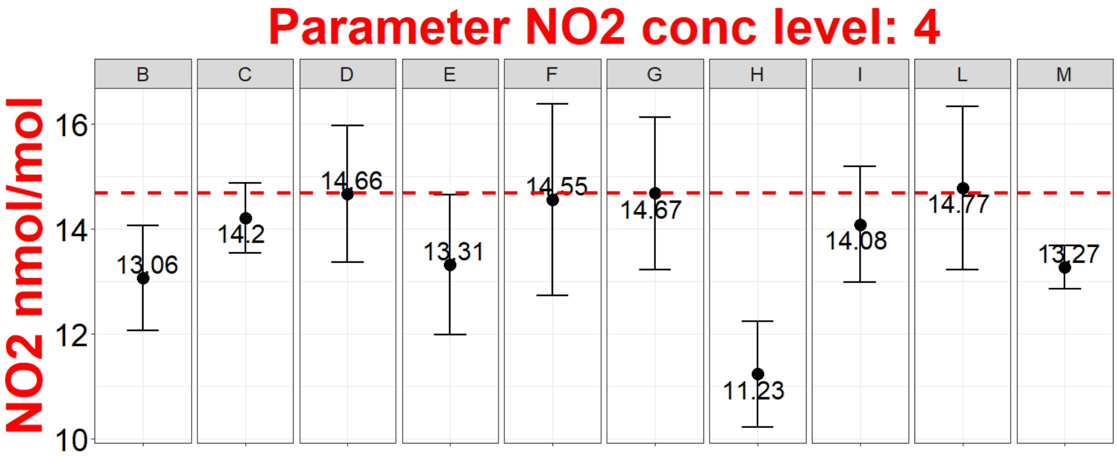
Figure 32: Reported values of NO2 concentration 3 (nmol/mol)



values	B	C	D	E	G	H	I	L	M
xi, 1	0.96	0.61	1.02	0.18	1.03	0.7	1.14	0	0.6
xi, 2	0.6	0.61	0.75	0.47	0.66	0.4	0.87	0	0.2
xi, 3	0.48	0.48	0.69	0.18	0.63	0.4	0.79	0	0.15
x_mean	0.68	0.57	0.82	0.28	0.77	0.50	0.93	0.00	0.32
sd	0.25	0.08	0.18	0.17	0.22	0.17	0.18	0.00	0.25
u(xi)	0.50	0.32	0.50	0.03	0.73	0.50	1.00	0.00	0.25
U(xi)	1.00	0.64	1.00	0.05	1.46	1.00	2.00	0.00	0.49

Source: JRC 2022

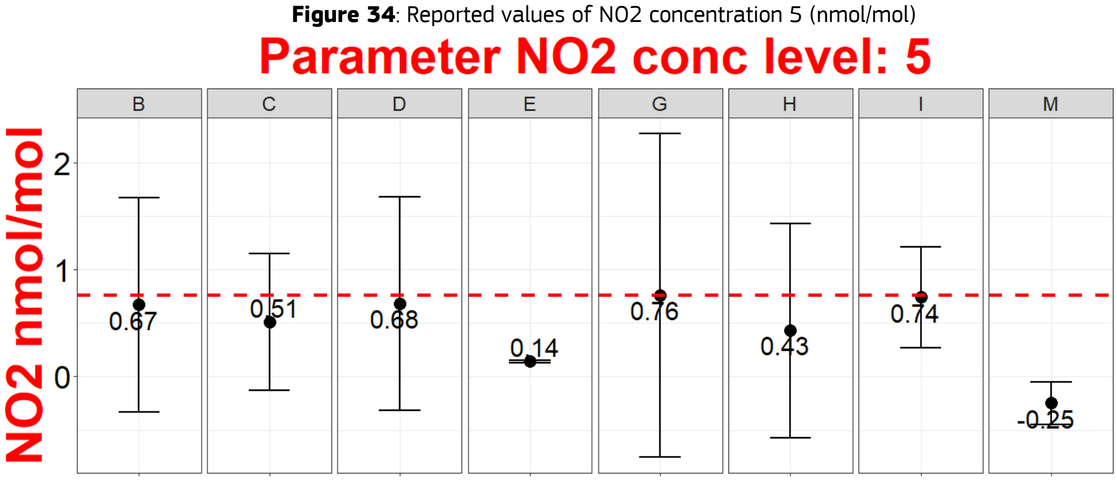
Figure 33: Reported values of NO2 concentration 4 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	13.13	14.2	14.69	13.22	14.4	14.7	11.33	14.08	14.8	13.25
xi, 2	13.09	14.22	14.62	13.32	14.72	14.67	11.23	14.09	14.7	13.25
xi, 3	12.96	14.17	14.68	13.38	14.52	14.63	11.13	14.07	14.8	13.3
x_mean	13.06	14.20	14.66	13.31	14.55	14.67	11.23	14.08	14.77	13.27
sd	0.09	0.03	0.04	0.08	0.16	0.04	0.10	0.01	0.06	0.03
u(xi)	0.50	0.33	0.65	0.67	0.91	0.72	0.50	0.55	0.76	0.21
U(xi)	1.00	0.67	1.30	1.33	1.82	1.45	1.00	1.10	1.55	0.41

Source: JRC 2022

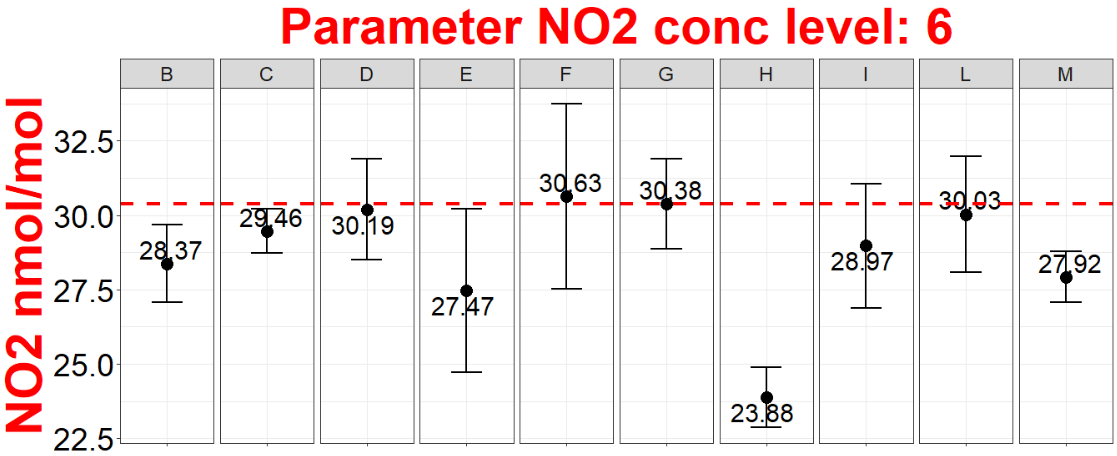
Figure 34: Reported values of NO2 concentration 5 (nmol/mol)



values	B	C	D	E	G	H	I	M
xi, 1	0.63	0.52	0.73	0.55	0.72	0.5	0.81	-0.25
xi, 2	0.79	0.5	0.66	-0.13	0.81	0.4	0.63	-0.35
xi, 3	0.58	0.51	0.64	0	0.75	0.4	0.77	-0.15
x_mean	0.67	0.51	0.68	0.14	0.76	0.43	0.74	-0.25
sd	0.11	0.01	0.05	0.36	0.05	0.06	0.09	0.10
u(xi)	0.50	0.32	0.50	0.01	0.75	0.50	0.24	-0.10
U(xi)	1.00	0.64	1.00	0.01	1.51	1.00	0.47	-0.20

Source: JRC 2022

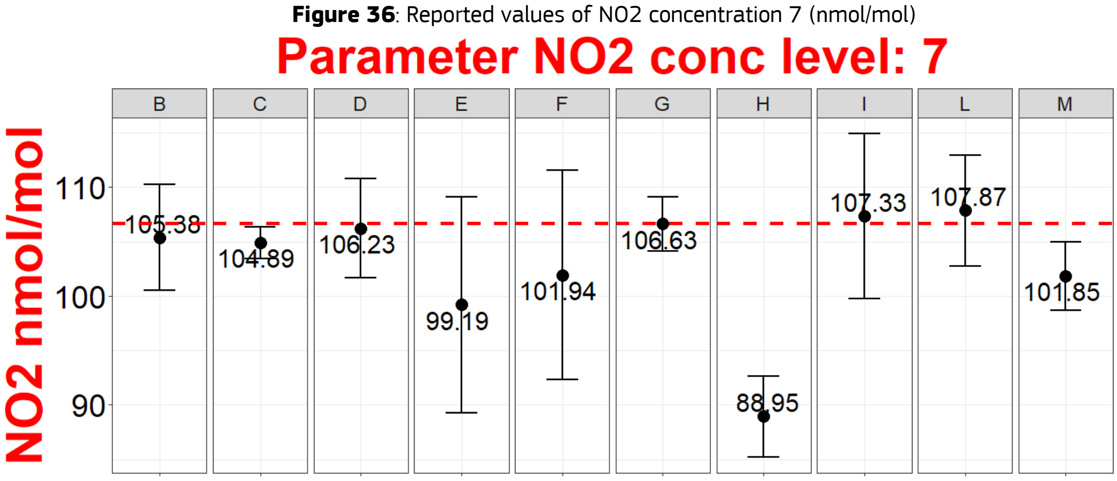
Figure 35: Reported values of NO2 concentration 6 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	28.3	29.55	30.28	27.39	30.41	30.48	23.95	28.92	30.1	27.95
xi, 2	28.3	29.45	30.21	27.49	30.94	30.4	23.85	29	30.1	27.9
xi, 3	28.5	29.39	30.07	27.54	30.54	30.25	23.85	29	29.9	27.9
x_mean	28.37	29.46	30.19	27.47	30.63	30.38	23.88	28.97	30.03	27.92
sd	0.12	0.08	0.11	0.08	0.28	0.12	0.06	0.05	0.12	0.03
u(xi)	0.65	0.37	0.85	1.37	1.55	0.76	0.50	1.05	0.98	0.43
U(xi)	1.31	0.74	1.70	2.75	3.11	1.51	1.00	2.09	1.96	0.86

Source: JRC 2022

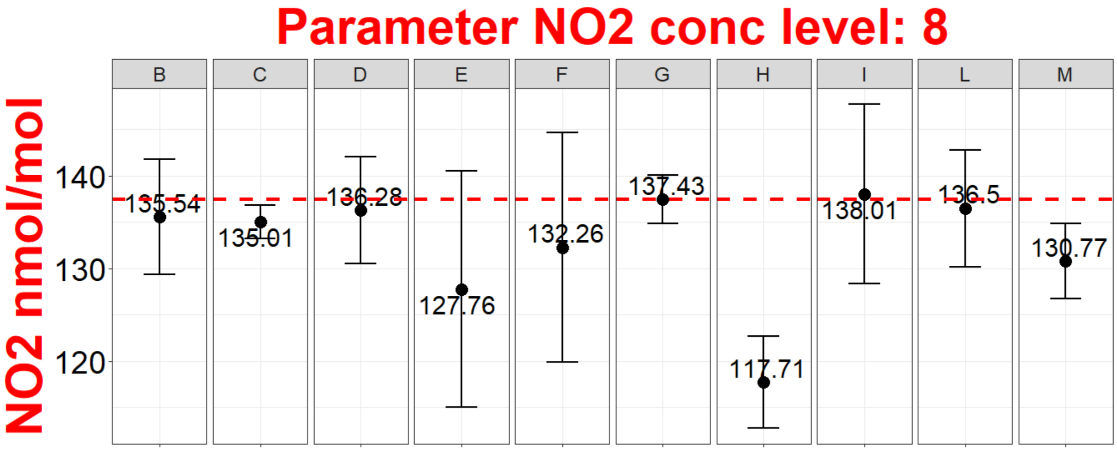
Figure 36: Reported values of NO2 concentration 7 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	105.62	105	106.4	99.24	101.72	106.74	88.65	107.67	108.2	101.9
xi, 2	105.18	104.84	106.3	99.38	102.18	106.58	89.05	107.41	107.9	101.85
xi, 3	105.34	104.84	105.99	98.96	101.93	106.58	89.15	106.92	107.5	101.8
x_mean	105.38	104.89	106.23	99.19	101.94	106.63	88.95	107.33	107.87	101.85
sd	0.22	0.09	0.21	0.21	0.23	0.09	0.26	0.38	0.35	0.05
u(xi)	2.42	0.72	2.27	4.96	4.80	1.23	1.86	3.80	2.54	1.57
U(xi)	4.85	1.45	4.54	9.92	9.60	2.46	3.72	7.60	5.09	3.14

Source: JRC 2022

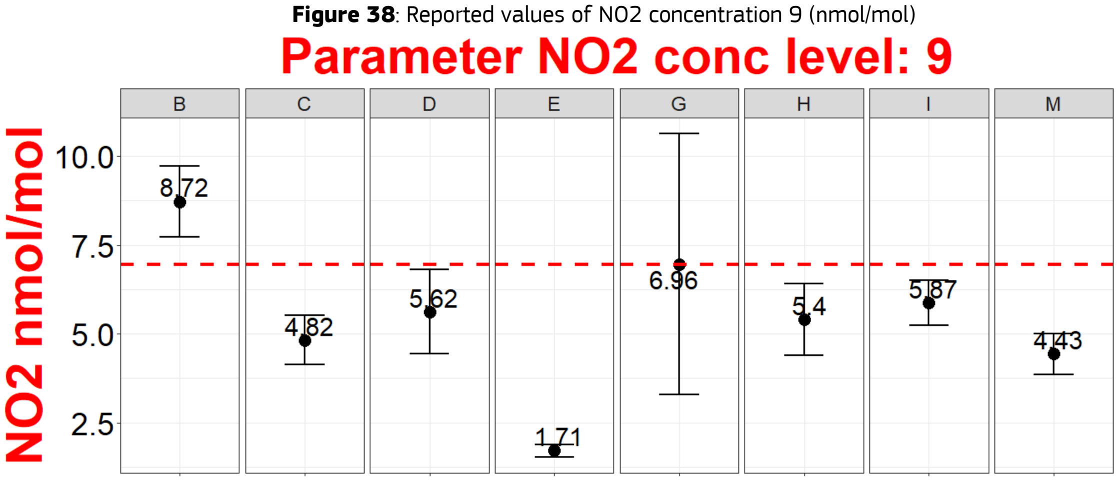
Figure 37: Reported values of NO2 concentration 8 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	135.26	135.06	136.34	128.16	132.85	137.47	117.18	138.21	136.4	130.85
xi, 2	135.54	134.95	136.26	127.53	132.07	137.43	117.67	138.03	136.5	130.8
xi, 3	135.81	135.03	136.25	127.59	131.86	137.39	118.27	137.8	136.6	130.65
x_mean	135.54	135.01	136.28	127.76	132.26	137.43	117.71	138.01	136.50	130.77
sd	0.28	0.06	0.05	0.35	0.52	0.04	0.55	0.21	0.10	0.10
u(xi)	3.12	0.89	2.87	6.39	6.21	1.30	2.46	4.80	3.16	2.02
U(xi)	6.23	1.79	5.74	12.78	12.42	2.59	4.92	9.70	6.31	4.03

Source: JRC 2022

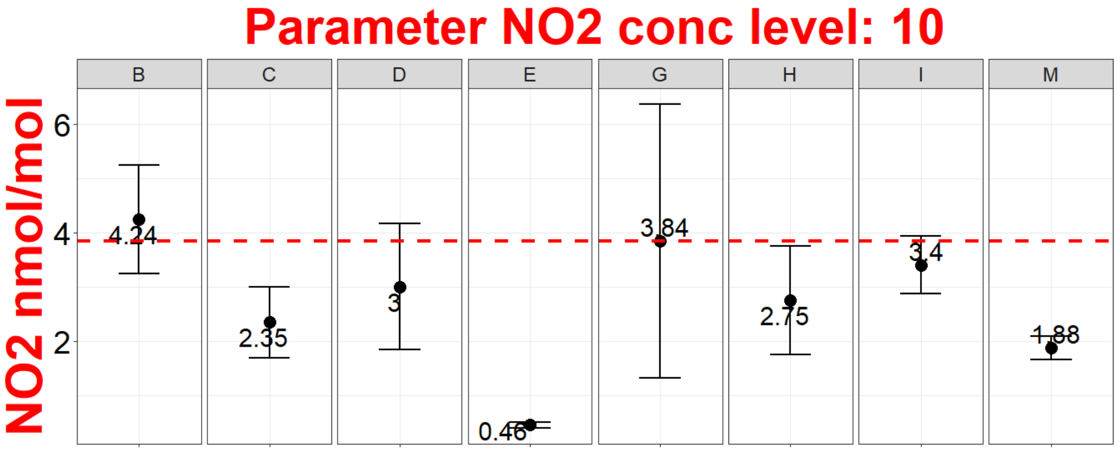
Figure 38: Reported values of NO2 concentration 9 (nmol/mol)



values	B	C	D	E	G	H	I	M
xi, 1	9.18	5.37	6.14	2.45	7.44	5.86	6.2	4.75
xi, 2	8.55	4.71	5.4	1.24	6.84	5.37	5.8	4.3
xi, 3	8.42	4.37	5.31	1.45	6.61	4.97	5.6	4.25
x_mean	8.72	4.82	5.62	1.71	6.96	5.40	5.87	4.43
sd	0.41	0.51	0.46	0.65	0.43	0.45	0.31	0.28
u(xi)	0.50	0.35	0.59	0.09	1.84	0.50	0.32	0.28
U(xi)	1.00	0.69	1.18	0.17	3.67	1.00	0.64	0.57

Source: JRC 2022

Figure 39: Reported values of NO2 concentration 10 (nmol/mol)

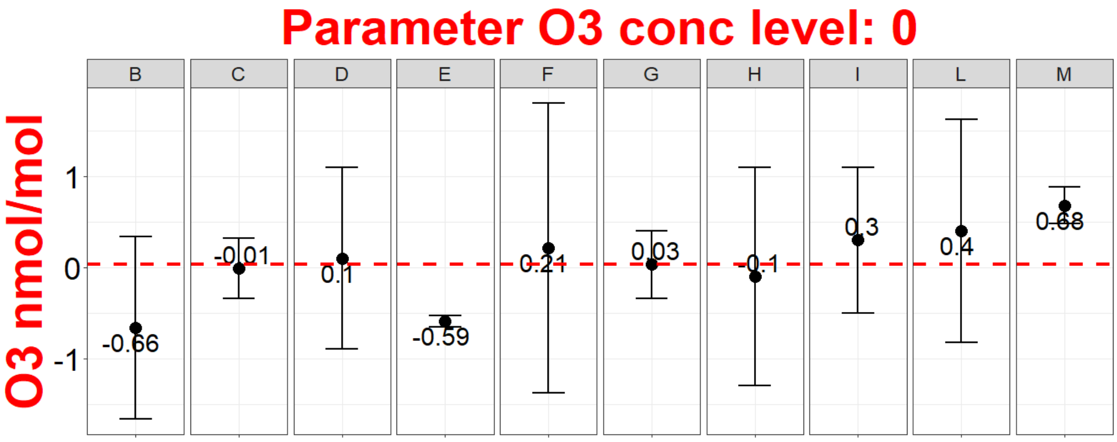


values	B	C	D	E	G	H	I	M
xi, 1	4.74	2.4	2.88	0.68	3.9	2.88	3.5	2
xi, 2	4.03	2.33	3.14	0.38	3.79	2.68	3.4	1.85
xi, 3	3.94	2.32	2.98	0.31	3.82	2.68	3.3	1.8
x_mean	4.24	2.35	3.00	0.46	3.84	2.75	3.40	1.88
sd	0.44	0.04	0.13	0.20	0.06	0.12	0.10	0.10
u(xi)	0.50	0.33	0.58	0.02	1.26	0.50	0.26	0.11
U(xi)	1.00	0.65	1.16	0.05	2.52	1.00	0.53	0.22

Source: JRC 2022

Reported values for O3

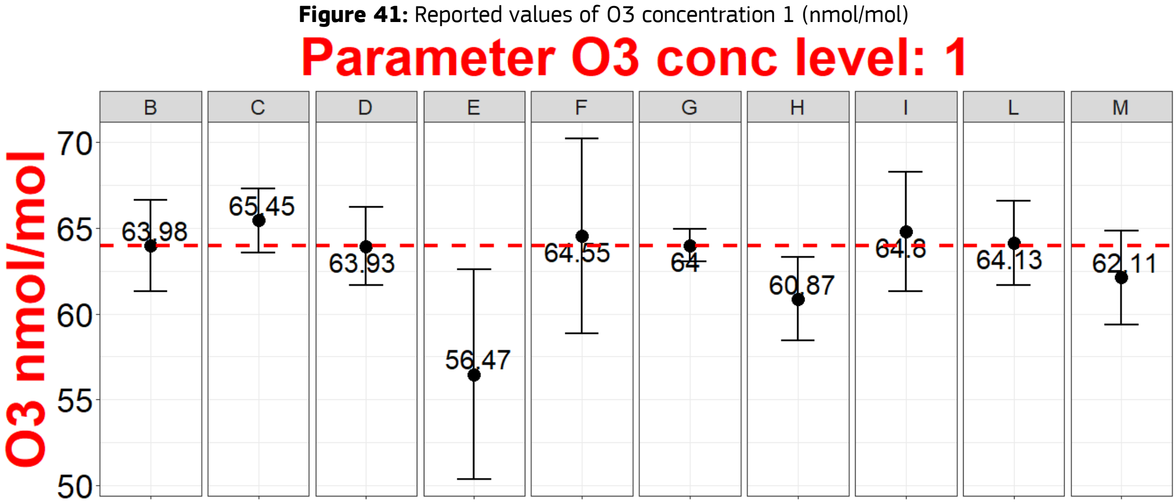
Figure 40: Reported values of O3 concentration 0 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	-0.66	-0.01	0.1	-0.59	0.21	0.03	-0.1	0.3	0.4	0.68
u(xi)	0.50	0.17	0.50	0.03	0.78	0.19	0.60	0.40	0.61	0.01
U(xi)	1.00	0.33	1.00	0.06	1.59	0.37	1.20	0.80	1.22	0.20

Source: JRC 2022

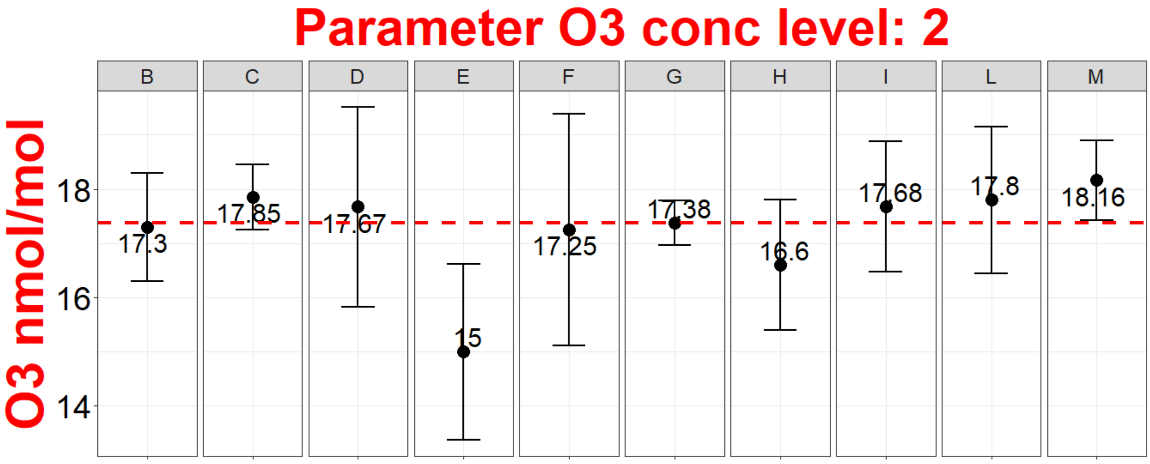
Figure 41: Reported values of O3 concentration 1 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	63.98	65.18	63.7	54.51	64.85	63.77	60.3	64.55	63.8	61.49
xi, 2	nr	65.49	64	56.83	64.31	64.08	61	64.84	64.2	62.22
xi, 3	nr	65.68	64.1	58.07	64.48	64.14	61.3	65	64.4	62.61
x_mean	63.98	65.45	63.93	56.47	64.55	64.00	60.87	64.80	64.13	62.11
sd	NA	0.25	0.21	1.81	0.28	0.20	0.51	0.23	0.31	0.57
u(xi)	1.34	0.94	1.14	3.05	2.84	0.47	1.21	1.70	1.21	1.38
U(xi)	2.68	1.88	2.28	6.10	5.67	0.94	2.42	3.50	2.46	2.76

Source: JRC 2022

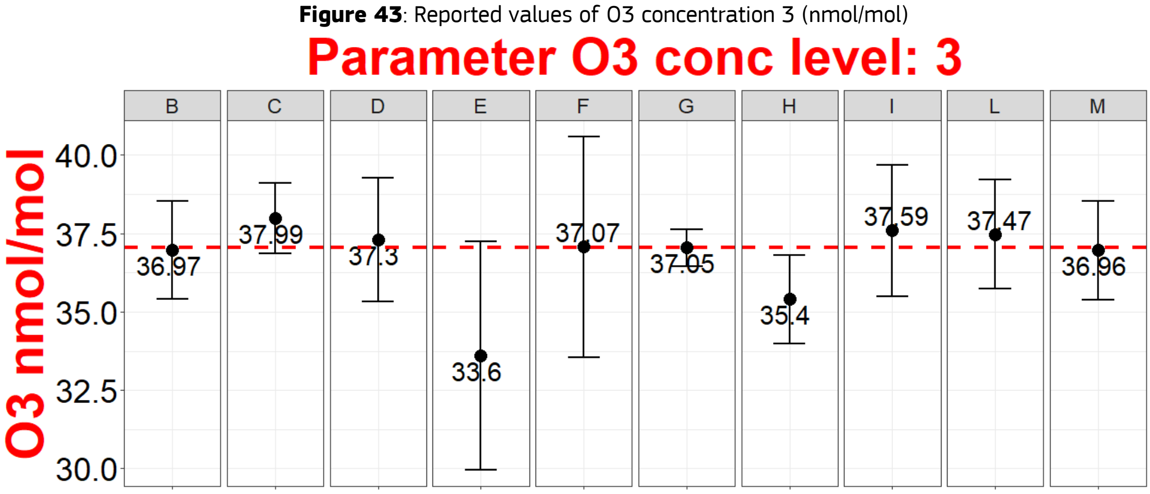
Figure 42: Reported values of O3 concentration 2 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	17.3	17.87	17.7	14.83	17.19	17.35	16.5	17.64	17.8	18.18
xi, 2	nr	17.82	17.6	15.01	17.31	17.38	16.6	17.68	17.8	18.18
xi, 3	nr	17.87	17.7	15.15	17.26	17.42	16.7	17.73	17.8	18.13
x_mean	17.30	17.85	17.67	15.00	17.25	17.38	16.60	17.68	17.80	18.16
sd	NA	0.03	0.06	0.16	0.06	0.04	0.10	0.05	0.00	0.03
u(xi)	0.50	0.30	0.92	0.81	1.07	0.21	0.60	0.60	0.68	0.37
U(xi)	1.00	0.60	1.84	1.62	2.13	0.41	1.20	1.20	1.35	0.74

Source: JRC 2022

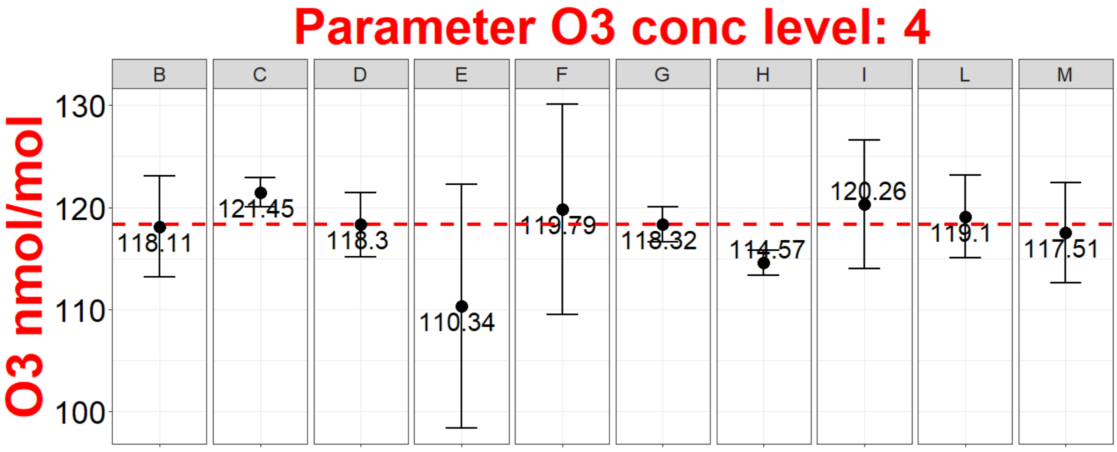
Figure 43: Reported values of O3 concentration 3 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	36.97	37.92	37.3	33.16	36.93	37.01	35.1	37.44	37.4	36.75
xi, 2	nr	38	37.3	33.62	37.08	37.04	35.5	37.61	37.4	36.9
xi, 3	nr	38.05	37.3	34.01	37.19	37.09	35.6	37.73	37.6	37.24
x_mean	36.97	37.99	37.30	33.60	37.07	37.05	35.40	37.59	37.47	36.96
sd	NA	0.07	0.00	0.43	0.13	0.04	0.26	0.15	0.12	0.25
u(xi)	0.78	0.56	0.99	1.81	1.75	0.30	0.70	1.10	0.86	0.79
U(xi)	1.56	1.12	1.98	3.63	3.51	0.59	1.41	2.10	1.74	1.58

Source: JRC 2022

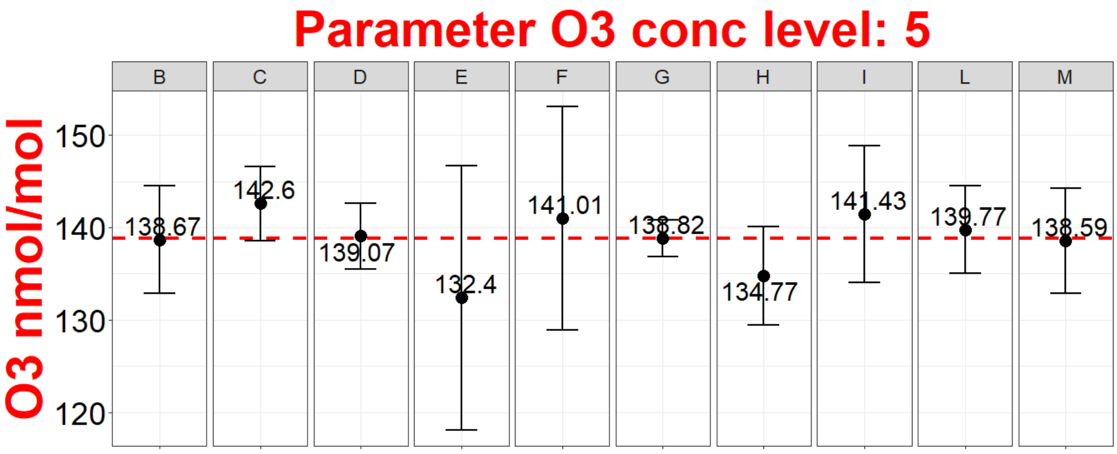
Figure 44: Reported values of O3 concentration 4 (nmol/mol)



values	B	C	D	E	F	G	H	I	L	M
xi, 1	118.02	121.33	118.3	108.96	119.64	118.23	114.2	120.09	119	116.86
xi, 2	118.13	121.42	118.2	110.65	119.84	118.32	114.6	120.28	119.1	117.74
xi, 3	118.17	121.61	118.4	111.4	119.89	118.4	114.9	120.42	119.2	117.94
x_mean	118.11	121.45	118.30	110.34	119.79	118.32	114.57	120.26	119.10	117.51
sd	0.08	0.14	0.10	1.25	0.13	0.09	0.35	0.17	0.10	0.57
u(xi)	2.48	1.72	1.58	5.96	5.15	0.85	0.60	3.20	2.04	2.44
U(xi)	4.96	1.44	3.16	11.92	10.29	1.70	1.20	6.30	4.08	4.89

Source: JRC 2022

Figure 45: Reported values of O3 concentration 5 (nmol/mol)

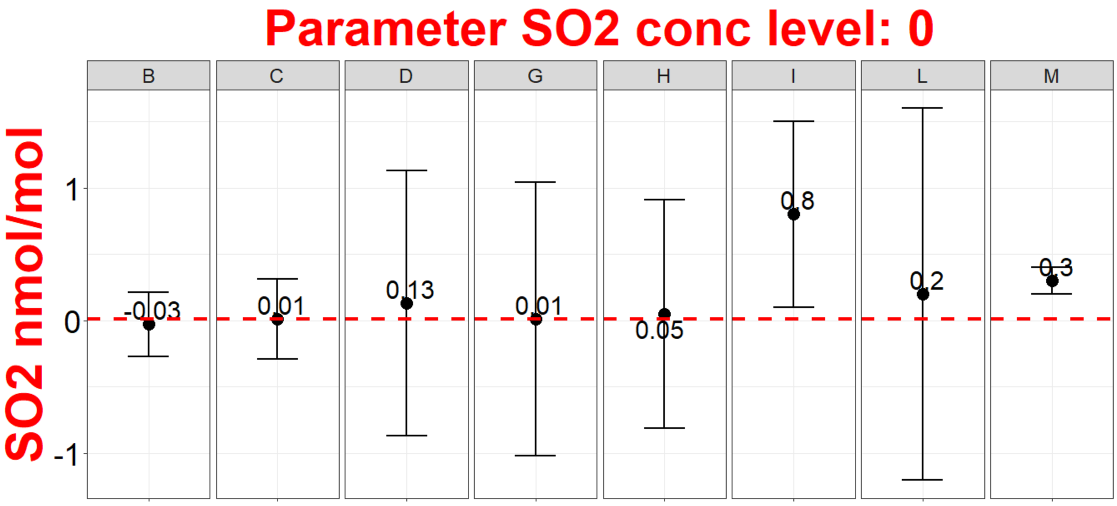


values	B	C	D	E	F	G	H	I	L	M
xi, 1	138.62	142.55	139	131.42	140.52	138.76	134.5	141.3	139.7	138.12
xi, 2	138.67	142.58	139	132.47	141.15	138.79	134.8	141.41	139.8	138.66
xi, 3	138.71	142.68	139.2	133.31	141.36	138.9	135	141.59	139.8	139
x_mean	138.67	142.60	139.07	132.40	141.01	138.82	134.77	141.43	139.77	138.59
sd	0.05	0.07	0.12	0.95	0.44	0.07	0.25	0.15	0.06	0.44
u(xi)	2.91	2.02	1.77	7.15	6.04	0.99	2.68	3.70	2.36	2.84
U(xi)	5.82	4.03	3.54	14.30	12.08	1.99	5.36	7.40	4.73	5.67

Source: JRC 2022

Reported values for SO2

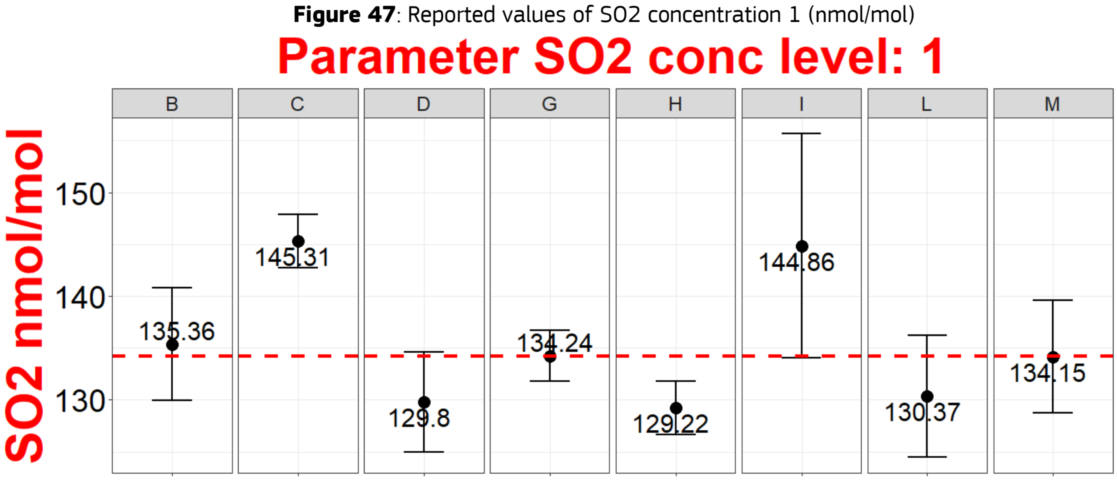
Figure 46: Reported values of SO2 concentration 0 (nmol/mol)



values	B	C	D	G	H	I	L	M
xi, 1	-0.03	0.01	0.13	0.01	0.05	0.8	0.2	0.3
u(xi)	0.12	0.15	0.50	0.51	0.43	0.30	0.70	-0.01
U(xi)	0.24	0.30	1.00	1.03	0.86	0.70	1.40	-0.10

Source: JRC 2022

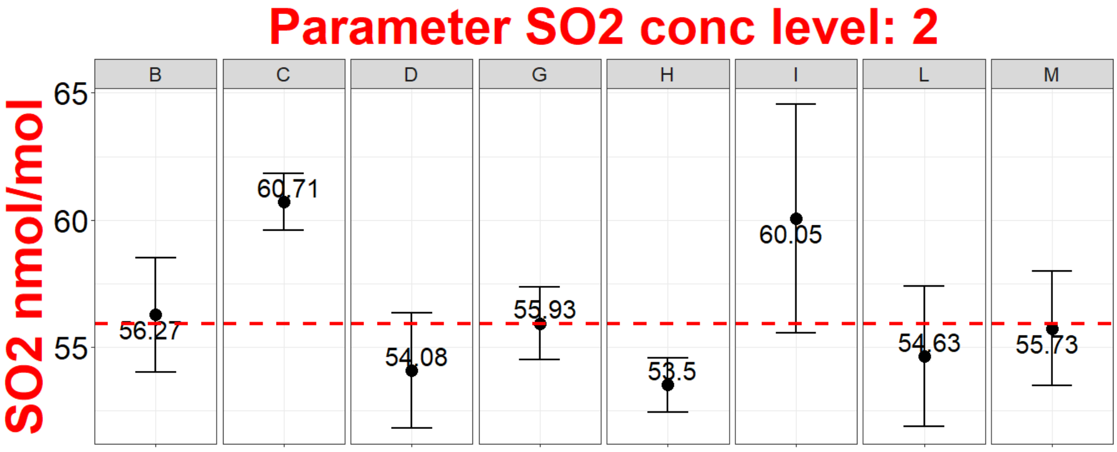
Figure 47: Reported values of SO2 concentration 1 (nmol/mol)



values	B	C	D	G	H	I	L	M
xi, 1	135.23	145.12	129.56	134.22	129.22	144.76	130.3	134.1
xi, 2	135.34	145.34	129.85	134.09	129.06	144.75	130.5	134.1
xi, 3	135.51	145.47	130	134.42	129.37	145.08	130.3	134.25
x_mean	135.36	145.31	129.80	134.24	129.22	144.86	130.37	134.15
sd	0.14	0.18	0.22	0.17	0.16	0.19	0.12	0.09
u(xi)	2.71	1.27	2.41	1.22	1.28	5.40	2.93	2.71
U(xi)	5.41	2.54	4.82	2.44	2.56	10.80	5.85	5.41

Source: JRC 2022

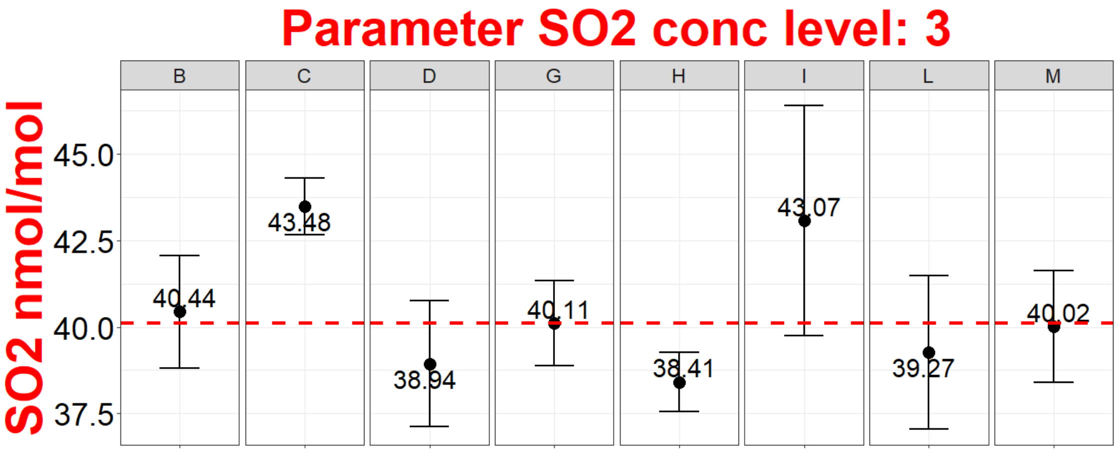
Figure 48: Reported values of SO2 concentration 2 (nmol/mol)



values	B	C	D	G	H	I	L	M
xi, 1	56.33	60.88	54.03	55.89	53.77	60	54.6	55.7
xi, 2	56.2	60.66	54.05	55.96	53.42	60.22	54.6	55.7
xi, 3	56.29	60.59	54.17	55.95	53.32	59.94	54.7	55.8
x_mean	56.27	60.71	54.08	55.93	53.50	60.05	54.63	55.73
sd	0.07	0.15	0.08	0.04	0.24	0.15	0.06	0.06
u(xi)	1.13	0.55	1.13	0.71	0.53	2.30	1.38	1.13
U(xi)	2.25	1.11	2.26	1.42	1.06	4.50	2.76	2.24

Source: JRC 2022

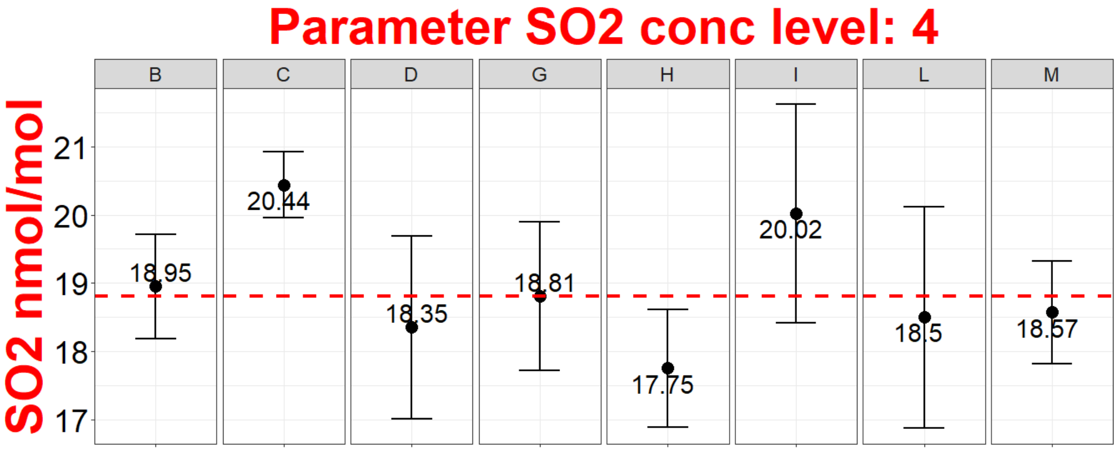
Figure 49: Reported values of SO2 concentration 3 (nmol/mol)



values	B	C	D	G	H	I	L	M
xi, 1	40.47	43.41	38.88	40.16	38.88	43.12	39.2	40.1
xi, 2	40.42	43.48	38.97	40.09	38.33	43.1	39.3	40
xi, 3	40.44	43.56	38.96	40.09	38.03	42.98	39.3	39.95
x_mean	40.44	43.48	38.94	40.11	38.41	43.07	39.27	40.02
sd	0.03	0.08	0.05	0.04	0.43	0.08	0.06	0.08
u(xi)	0.81	0.41	0.91	0.62	0.43	1.66	1.11	0.81
U(xi)	1.62	0.82	1.82	1.23	0.86	3.33	2.21	1.62

Source: JRC 2022

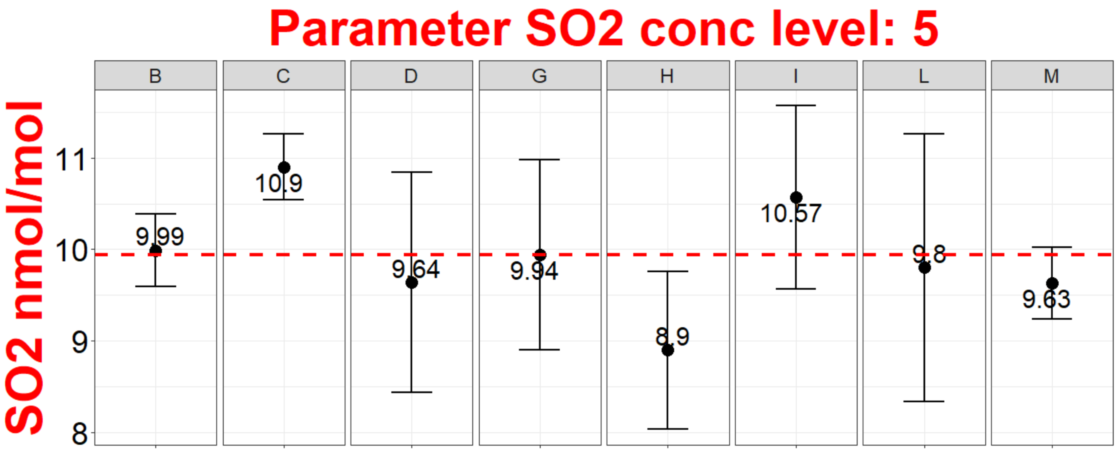
Figure 50: Reported values of SO2 concentration 4 (nmol/mol)



values	B	C	D	G	H	I	L	M
xi, 1	18.89	20.35	18.33	18.76	18.16	20.07	18.5	18.55
xi, 2	18.97	20.44	18.35	18.81	17.6	20.06	18.6	18.6
xi, 3	18.99	20.52	18.38	18.85	17.5	19.93	18.4	18.55
x_mean	18.95	20.44	18.35	18.81	17.75	20.02	18.50	18.57
sd	0.05	0.09	0.03	0.05	0.36	0.08	0.10	0.03
u(xi)	0.38	0.24	0.67	0.54	0.43	0.80	0.81	0.38
U(xi)	0.76	0.48	1.34	1.09	0.86	1.60	1.62	0.75

Source: JRC 2022

Figure 51: Reported values of SO2 concentration 5 (nmol/mol)



values	B	C	D	G	H	I	L	M
xi, 1	10.01	10.89	9.62	9.96	9.1	10.7	9.8	9.65
xi, 2	9.99	10.92	9.66	9.93	8.65	10.42	9.8	9.6
xi, 3	9.98	10.89	9.64	9.94	8.95	10.6	9.8	9.65
x_mean	9.99	10.90	9.64	9.94	8.90	10.57	9.80	9.63
sd	0.02	0.02	0.02	0.02	0.23	0.14	0.00	0.03
u(xi)	0.20	0.18	0.60	0.52	0.43	0.50	0.73	0.20
U(xi)	0.40	0.36	1.20	1.04	0.86	1.00	1.46	0.39

Source: JRC 2022

Annex C

Repeatability and reproducibility

For the main purpose of monitoring trends between different PT undertaken by ERLAP, the precision of standardized SO_2, CO, O_3 and NO_X measurement methods [2], [3], [4] and [5] as implemented by NRLs, was evaluated.

Applied methodology is described in ISO 5725-1, 5725-2 and 5725-6 [14], [15] and [16].

The precision experiment has involved a total of **10 laboratories** including ERLAP, the actual number of laboratories (***p_j***) is listed in **Table 12** according to the data reported.

Six concentration levels (for run 0 only one value is requested so repeatability cannot be evaluated) were tested for O_3, CO, SO_2 and NO_2, and eleven for NO. Outlier tests were performed and results are reported in Annex D.

In ISO 5725 repeatability (r) and reproducibility (R) limits are defined. These limits are the values less than or equal to which the absolute difference between two test results, obtained under either repeatability or reproducibility conditions, may be expected to be with (1 - α) probability level.

The repeatability standard deviation (***s_r***) was calculated as the square root of average within-laboratory variance at the 95% confidence level. The repeatability limit (***r***) is calculated using Equation 6 [16].

$$r = t_{\nu/\alpha} \cdot \sqrt{2} \cdot Sr \qquad \text{Equation 6}$$

r = repeatability limit

$t_{\nu/\alpha}$ = *t* Student distribution value

S_r = estimate of repeatability variance

The reproducibility standard deviation (*SR*) was calculated as the square root of sum of repeatability and between-laboratory variance at the 95% confidence level (α). The reproducibility limit (R) is calculated using Equation 7 [16].

$$R = t_{\nu/\alpha} \cdot \sqrt{2} \cdot SR \qquad \text{Equation 7}$$

R = reproducibility limit

$t_{\nu/\alpha}$ = *t* Student distribution value

SR = estimate of reproducibility variance

The repeatability standard deviation was evaluated with (pj *(3-1)) degrees of freedom (ν) and reproducibility standard deviation with (pj-1) degrees of freedom (ν).

The critical range Student factors, for r and R, corresponding to defined confidence level (α) and degree of freedom (ν) are reported in **Table 12**.

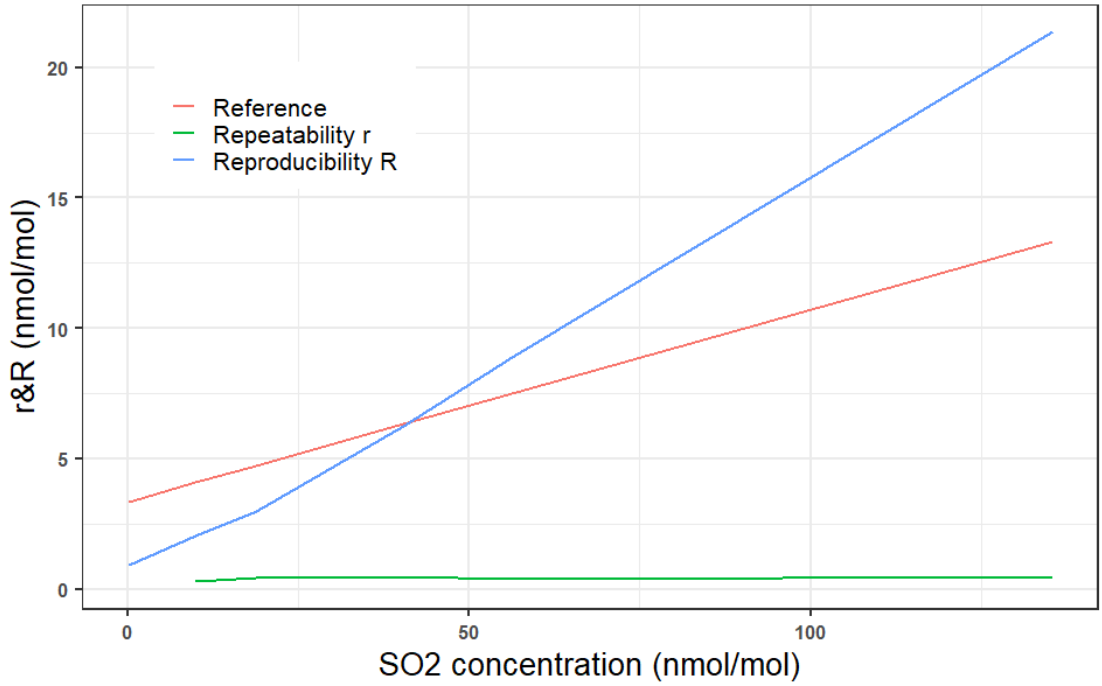
Table 12: Critical values of t used in the repeatability (r) and reproducibility (R) evaluation.

parameter	run	p_j	t critical value 95% for r	t critical value 95% for R
CO	1,2,3,4,5	6	2,179	2,571
NO	1,3,5,9	10	2,086	2,262
NO_2	2,4	10	2.086	2.262
NO_2	6,7,8	9	2.101	2.306
O_3	1	8	2.12	2.365
O_3	2,3	9	2.101	2.306
O_3	4,5	10	2,086	2,262
SO_2	1,2,3,4,5	8	2.12	2.365

Source: JRC 2022

The repeatability (r) and reproducibility (R) limits of measurement methods are presented from **Figure 52** to **Figure 56**. It is reported also the 'reproducibility from common criteria (Reference)' calculated by substituting *SR* in Equation 7 with a 'standard deviation for proficiency assessment' (see **Table 4**). Comparison between R and Reference serves to indicate that σ_{pt} is realistic [13] or from the other point of view, that the general methodology implemented by NRLs is appropriate for σ_{pt}.

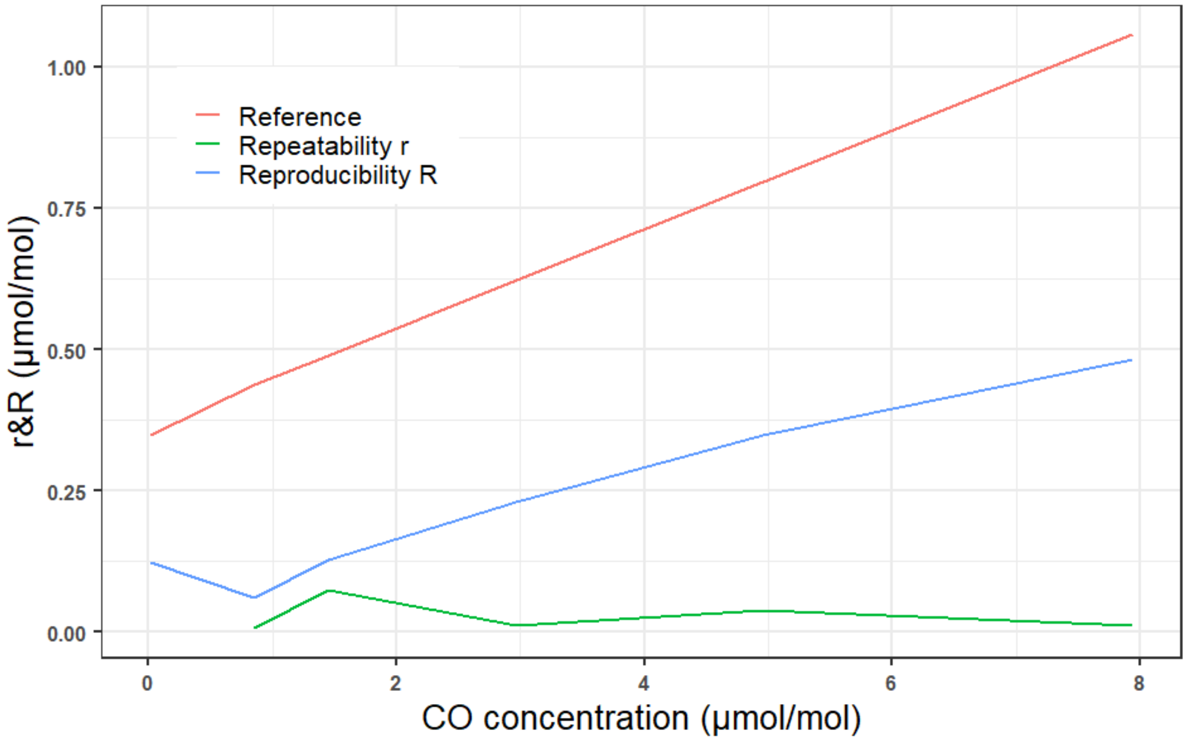
Figure 52: The R and r of SO_2 standard measurement method as a function of concentration.



Parameter	Conc.(nmol/mol)	r(nmol/mol)	R(nmol/mol)	R (%)	Reference
SO2	0.184		0.913		3.358
SO2	9.923	0.291	2.057		4.075
SO2	18.923	0.42	2.990		4.737
SO2	40.468	0.486	6.231		6.322
SO2	56.365	0.366	8.897		7.492
SO2	135.414	0.486	21.365	15.8	13.309

Source: JRC 2022

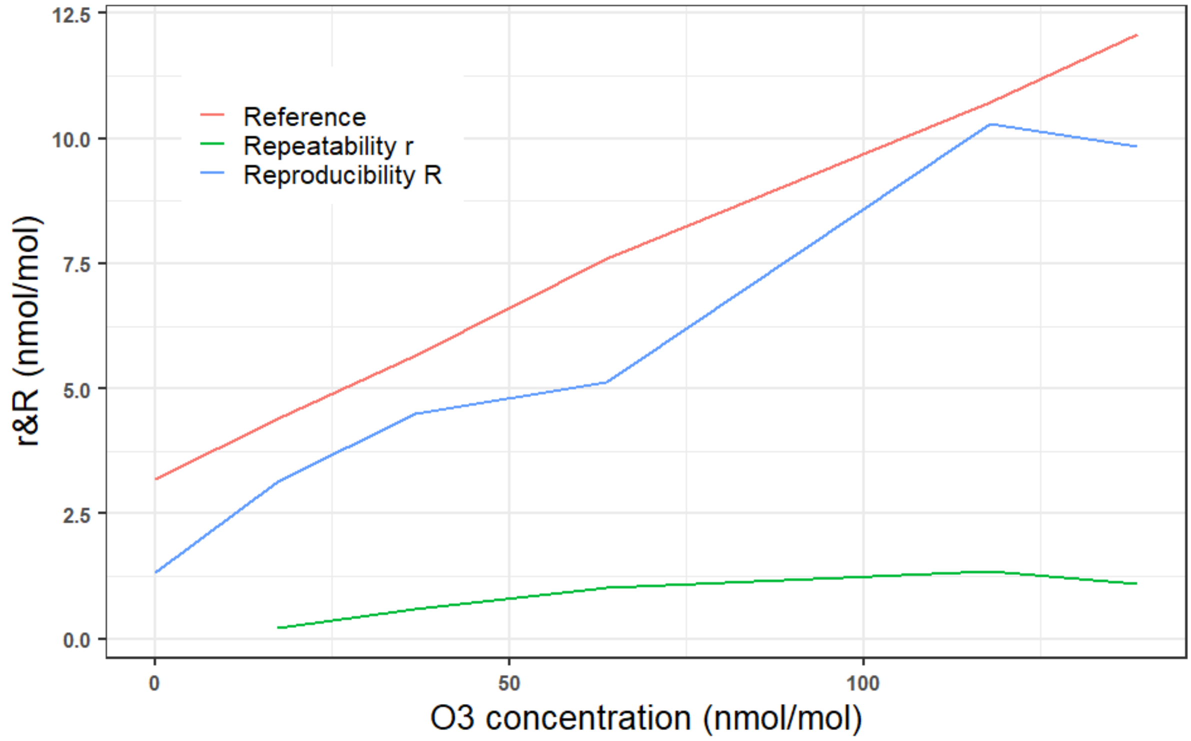
Figure 53: The R and r of CO standard measurement method as a function of concentration.



Parameter	Conc.(μmol/mol)	r(μmol/mol)	R(μmol/mol)	R (%)	Reference
CO	0.0207		0.1225		0.3478
CO	0.8479	0.0074	0.0600		0.4376
CO	1.4477	0.0736	0.1276		0.4899
CO	2.9646	0.0123	0.2294		0.6223
CO	4.9573	0.0379	0.3480		0.7962
CO	7.9426	0.0123	0.4829	6.1	1.0567

Source: JRC 2022

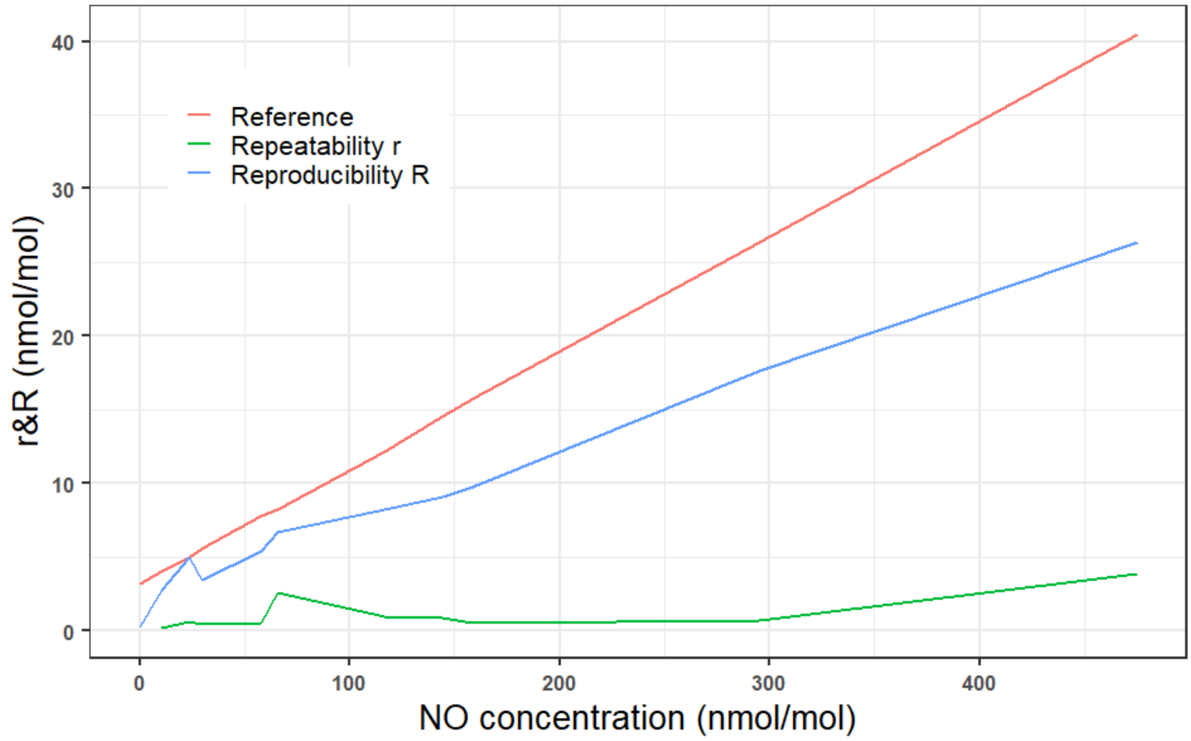
Figure 54: The R and r of O_3 standard measurement method as a function of concentration.



Parameter	Conc.(nmol/mol)	r(nmol/mol)	R(nmol/mol)	R (%)	Reference
O3	0.036		1.328		3.201
O3	17.267	0.217	3.137		4.387
O3	36.714	0.603	4.507		5.656
O3	63.729	1.034	5.124		7.608
O3	117.775	1.357	10.291		10.734
O3	138.712	1.103	9.850	7.1	12.074

Source: JRC 2022

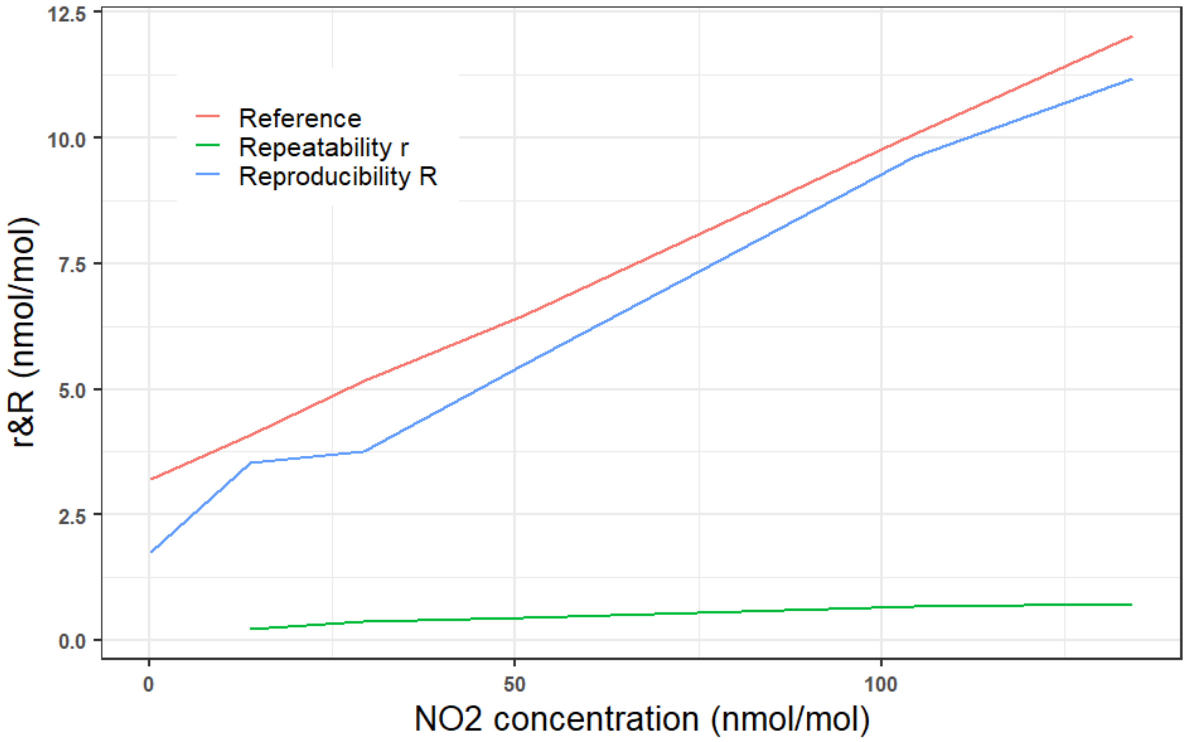
Figure 55: The R and r of NO standard measurement method as a function of concentration.



Parameter	Conc.(nmol/mol)	r(nmol/mol)	R(nmol/mol)	R (%)	Reference
NO	0.083		0.269		3.205
NO	10.246	0.177	2.710		3.986
NO	23.476	0.59	5.006		5.001
NO	29.394	0.404	3.427		5.562
NO	57.890	0.511	5.397		7.792
NO	65.739	2.581	6.676		8.246
NO	116.518	0.976	8.221		12.145
NO	144.530	0.871	9.099		14.573
NO	159.035	0.562	9.751		15.709
NO	295.245	0.657	17.597		26.369
NO	475.161	3.857	26.363	5.5	40.451

Source: JRC 2022

Figure 56: The R and r of NO_2 standard measurement method as a function of concentration.



Parameter	Conc.(nmol/mol)	r(nmol/mol)	R(nmol/mol)	R (%)	Reference
NO2	0.160		1.756		3.209
NO2	13.779	0.224	3.525		4.081
NO2	29.269	0.374	3.750		5.170
NO2	51.206	0.451	5.499		6.475
NO2	104.591	0.686	9.630		10.083
NO2	134.396	0.728	11.183	8.3	12.027

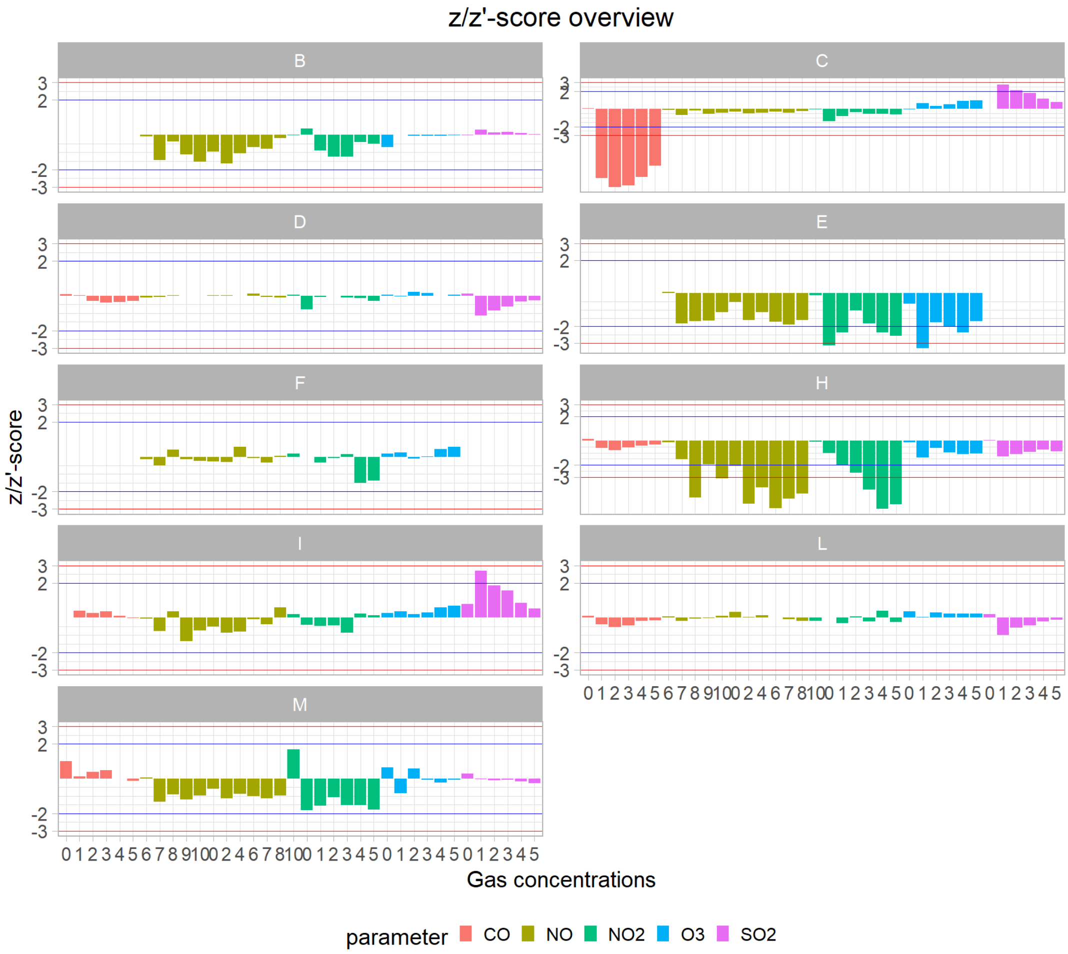
Source: JRC 2022

Annex D

Scrutiny of results for consistency and outlier test

The precision evaluation (Annex C) focuses on data that are as much as possible the reflection of every day work of NRLs and thus represents the comparability of participant's standard operating procedures.
For that reason, a procedure for the detection of exceptional errors (error during typing, slip in performing the measurement or the calculation, wrong averaging interval, malfunction of instrumentation, etc.) was applied. In this procedure were carried out tests for data consistency and statistical outliers as described in ISO 13528 [13].
Laboratories showing some form of statistical inconsistency were requested to investigate the cause of discrepancies before the release of the draft report. Laboratories were allowed to correct their results in case of identification of exceptional errors, few of the laboratories contacted has modified the values submitted.
Subsequently, data were considered definitive and z/z'-scores calculation was performed to estimate outliers. Statistical outliers obtained at this stage are not considered as extraordinary errors, but due to significant difference in participant's standard operating procedure.
The precision of standardised measurement methods reported in Annex D are calculated using the data pool without outliers. **Figure 57** is summarizing the z-score evaluation of each participant for all parameters where it is clear the poor performance of Laboratory C for CO, Laboratory H for NO and NO2 and laboratory E for O3.

Figure 57: Overview about z/z'-score final evaluation.



Source: JRC 2022

Table 13: z/z'-score selected according to the criteria uref<0.3 σ_{pt}.

Gas	Unit	Ref	u_ref	p	0.3*σpt	z/z'
CO _0	µmol/mol	0.000	0.009	6	0.030	z
CO _1	µmol/mol	2.977	0.020	6	0.051	z
CO _2	µmol/mol	7.990	0.050	6	0.088	z
CO _3	µmol/mol	4.976	0.032	6	0.066	z
CO _4	µmol/mol	1.467	0.012	6	0.041	z
CO _5	µmol/mol	0.867	0.010	6	0.036	z
NO _0	nmol/mol	0.12	0.72	9	0.301	z'
NO _1	nmol/mol	119.75	1.100	9	1.162	z
NO _2	nmol/mol	67.84	0.860	9	0.788	z'
NO _3	nmol/mol	24.76	0.740	9	0.478	z'
NO _4	nmol/mol	10.86	0.720	9	0.378	z'
NO _5	nmol/mol	59.49	0.830	9	0.728	z'
NO _6	nmol/mol	30.08	0.740	9	0.517	z'
NO _7	nmol/mol	161.08	1.340	9	1.460	z
NO _8	nmol/mol	147.09	1.250	9	1.359	z
NO _9	nmol/mol	478.86	3.400	9	3.748	z
NO _10	nmol/mol	297.37	2.180	9	2.441	z
NO2 _0	nmol/mol	-0.01	0.72	9	0.300	z'
NO2 _1	nmol/mol	0.35	0.84	8	0.302	z'
NO2 _2	nmol/mol	53.03	0.860	9	0.618	z'
NO2 _3	nmol/mol	0.77	0.73	8	0.305	z'
NO2 _4	nmol/mol	14.66	0.720	9	0.388	z'
NO2 _5	nmol/mol	0.76	0.76	7	0.305	z'
NO2 _6	nmol/mol	30.37	0.760	9	0.482	z'
NO2 _7	nmol/mol	106.63	1.230	9	0.940	z'
NO2 _8	nmol/mol	137.43	1.300	9	1.125	z'
NO2 _9	nmol/mol	6.96	1.84	7	0.342	z'
NO2 _10	nmol/mol	3.83	1.26	7	0.323	z'
O3 _0	nmol/mol	0.03	0.18	9	0.300	z
O3 _1	nmol/mol	63.99	0.470	9	0.684	z
O3 _2	nmol/mol	17.38	0.200	9	0.404	z
O3 _3	nmol/mol	37.04	0.300	9	0.522	z
O3 _4	nmol/mol	118.31	0.850	9	1.010	z
O3 _5	nmol/mol	138.81	1.000	9	1.133	z
SO2 _0	nmol/mol	0.01	0.52	7	0.300	z'
SO2 _1	nmol/mol	134.24	1.220	7	1.186	z'
SO2 _2	nmol/mol	55.93	0.710	7	0.669	z'
SO2 _3	nmol/mol	40.11	0.620	7	0.565	z'
SO2 _4	nmol/mol	18.80	0.550	7	0.424	z'
SO2 _5	nmol/mol	9.94	0.52	7	0.366	z'

Source: JRC 2022

Table 14: z/z'-score participants calculated values.

Gas	Code	Unit	Ref	u_ref	uref<0.3*σpt	z_value
NO _0	B	nmol/mol	0.12	0.72	z'	-0.065
NO _1	B	nmol/mol	119.75	1.10	z	-1.436
NO _2	B	nmol/mol	67.84	0.86	z'	-1.075
NO _3	B	nmol/mol	24.77	0.74	z'	-1.403
NO _4	B	nmol/mol	10.86	0.72	z'	-0.833
NO _5	B	nmol/mol	59.50	0.83	z'	-1.542
NO _6	B	nmol/mol	30.08	0.74	z'	-0.986
NO _7	B	nmol/mol	161.08	1.34	z	-0.709
NO _8	B	nmol/mol	147.09	1.25	z	-0.788
NO _9	B	nmol/mol	478.87	3.40	z	-0.193
NO _10	B	nmol/mol	297.37	2.18	z	-0.385
NO2 _0	B	nmol/mol	-0.01	0.72	z'	-0.016
NO2 _2	B	nmol/mol	53.03	0.86	z'	-0.840
NO2 _4	B	nmol/mol	14.67	0.72	z'	-1.084
NO2 _6	B	nmol/mol	30.38	0.76	z'	-1.130
NO2 _7	B	nmol/mol	106.63	1.23	z'	-0.372
NO2 _8	B	nmol/mol	137.43	1.30	z'	-0.477
NO2 _10	B	nmol/mol	3.84	1.26	z'	0.243
O3 _0	B	nmol/mol	0.03	0.18	z	-0.690
O3 _1	B	nmol/mol	64.00	0.47	z	-0.007
O3 _2	B	nmol/mol	17.38	0.20	z	-0.062
O3 _3	B	nmol/mol	37.05	0.30	z	-0.044
O3 _4	B	nmol/mol	118.32	0.85	z	-0.061
O3 _5	B	nmol/mol	138.82	1.00	z	-0.039
SO2 _0	B	nmol/mol	0.01	0.52	z'	-0.036
SO2 _1	B	nmol/mol	134.24	1.22	z'	0.270
SO2 _2	B	nmol/mol	55.93	0.71	z'	0.144
SO2 _3	B	nmol/mol	40.11	0.62	z'	0.165
SO2 _4	B	nmol/mol	18.81	0.55	z'	0.094
SO2 _5	B	nmol/mol	9.94	0.52	z'	0.035
CO _0	C	µmol/mol	0.00	0.01	z	0.100
CO _1	C	µmol/mol	2,977.00	0.02	z	-7.839
CO _2	C	µmol/mol	7,990.00	0.05	z	-8.863
CO _3	C	µmol/mol	4,975.70	0.03	z	-8.690
CO _4	C	µmol/mol	1,467.00	0.01	z	-7.707
CO _5	C	µmol/mol	866.70	0.01	z	-6.463
NO _0	C	nmol/mol	0.12	0.72	z'	-0.073
NO _1	C	nmol/mol	119.75	1.10	z	-0.685
NO _2	C	nmol/mol	67.84	0.86	z'	-0.540
NO _3	C	nmol/mol	24.77	0.74	z'	-0.391
NO _4	C	nmol/mol	10.86	0.72	z'	-0.248
NO _5	C	nmol/mol	59.50	0.83	z'	-0.467
NO _6	C	nmol/mol	30.08	0.74	z'	-0.373
NO _7	C	nmol/mol	161.08	1.34	z	-0.300
NO _8	C	nmol/mol	147.09	1.25	z	-0.413
NO _9	C	nmol/mol	478.87	3.40	z	-0.250
NO _10	C	nmol/mol	297.37	2.18	z	-0.137
NO2 _0	C	nmol/mol	-0.01	0.72	z'	-0.033
NO2 _2	C	nmol/mol	53.03	0.86	z'	-0.723
NO2 _4	C	nmol/mol	14.67	0.72	z'	-0.315
NO2 _6	C	nmol/mol	30.38	0.76	z'	-0.516
NO2 _7	C	nmol/mol	106.63	1.23	z'	-0.518
NO2 _8	C	nmol/mol	137.43	1.30	z'	-0.610
NO2 _10	C	nmol/mol	3.84	1.26	z'	-0.897
O3 _0	C	nmol/mol	0.03	0.18	z	-0.040
O3 _1	C	nmol/mol	64.00	0.47	z	0.637
O3 _2	C	nmol/mol	17.38	0.20	z	0.347
O3 _3	C	nmol/mol	37.05	0.30	z	0.542

Gas	Code	Unit	Ref	u_ref	uref<0.3*σpt	z_value
O3 _4	C	nmol/mol	118.32	0.85	z	0.931
O3 _5	C	nmol/mol	138.82	1.00	z	1.002
SO2 _0	C	nmol/mol	0.01	0.52	z'	0.000
SO2 _1	C	nmol/mol	134.24	1.22	z'	2.675
SO2 _2	C	nmol/mol	55.93	0.71	z'	2.041
SO2 _3	C	nmol/mol	40.11	0.62	z'	1.700
SO2 _4	C	nmol/mol	18.81	0.55	z'	1.078
SO2 _5	C	nmol/mol	9.94	0.52	z'	0.722
CO _0	D	µmol/mol	0.00	0.01	z	0.100
CO _1	D	µmol/mol	2,977.00	0.02	z	0.017
CO _2	D	µmol/mol	7,990.00	0.05	z	-0.298
CO _3	D	µmol/mol	4,975.70	0.03	z	-0.377
CO _4	D	µmol/mol	1,467.00	0.01	z	-0.370
CO _5	D	µmol/mol	866.70	0.01	z	-0.304
NO _0	D	nmol/mol	0.12	0.72	z'	-0.073
NO _1	D	nmol/mol	119.75	1.10	z	-0.083
NO _2	D	nmol/mol	67.84	0.86	z'	0.010
NO _3	D	nmol/mol	24.77	0.74	z'	0.002
NO _4	D	nmol/mol	10.86	0.72	z'	0.028
NO _5	D	nmol/mol	59.50	0.83	z'	0.032
NO _6	D	nmol/mol	30.08	0.74	z'	-0.005
NO _7	D	nmol/mol	161.08	1.34	z	0.121
NO _8	D	nmol/mol	147.09	1.25	z	-0.071
NO _9	D	nmol/mol	478.87	3.40	z	-0.097
NO _10	D	nmol/mol	297.37	2.18	z	0.030
NO2 _0	D	nmol/mol	-0.01	0.72	z'	0.049
NO2 _2	D	nmol/mol	53.03	0.86	z'	-0.078
NO2 _4	D	nmol/mol	14.67	0.72	z'	-0.005
NO2 _6	D	nmol/mol	30.38	0.76	z'	-0.105
NO2 _7	D	nmol/mol	106.63	1.23	z'	-0.120
NO2 _8	D	nmol/mol	137.43	1.30	z'	-0.290
NO2 _10	D	nmol/mol	3.84	1.26	z'	-0.505
O3 _0	D	nmol/mol	0.03	0.18	z	0.070
O3 _1	D	nmol/mol	64.00	0.47	z	-0.029
O3 _2	D	nmol/mol	17.38	0.20	z	0.213
O3 _3	D	nmol/mol	37.05	0.30	z	0.145
O3 _4	D	nmol/mol	118.32	0.85	z	-0.005
O3 _5	D	nmol/mol	138.82	1.00	z	0.067
SO2 _0	D	nmol/mol	0.01	0.52	z'	0.107
SO2 _1	D	nmol/mol	134.24	1.22	z'	-1.074
SO2 _2	D	nmol/mol	55.93	0.71	z'	-0.792
SO2 _3	D	nmol/mol	40.11	0.62	z'	-0.592
SO2 _4	D	nmol/mol	18.81	0.55	z'	-0.302
SO2 _5	D	nmol/mol	9.94	0.52	z'	-0.229
NO _0	E	nmol/mol	0.12	0.72	z'	0.065
NO _1	E	nmol/mol	119.75	1.10	z	-1.826
NO _2	E	nmol/mol	67.84	0.86	z'	-1.563
NO _3	E	nmol/mol	24.77	0.74	z'	-1.039
NO _4	E	nmol/mol	10.86	0.72	z'	-0.468
NO _5	E	nmol/mol	59.50	0.83	z'	-1.527
NO _6	E	nmol/mol	30.08	0.74	z'	-1.045
NO _7	E	nmol/mol	161.08	1.34	z	-1.726
NO _8	E	nmol/mol	147.09	1.25	z	-1.876
NO _9	E	nmol/mol	478.87	3.40	z	-1.615
NO _10	E	nmol/mol	297.37	2.18	z	-1.685
NO2 _0	E	nmol/mol	-0.01	0.72	z'	-0.089
NO2 _2	E	nmol/mol	53.03	0.86	z'	-2.198
NO2 _4	E	nmol/mol	14.67	0.72	z'	-0.915
NO2 _6	E	nmol/mol	30.38	0.76	z'	-1.637
NO2 _7	E	nmol/mol	106.63	1.23	z'	-2.212

Gas	Code	Unit	Ref	u_ref	uref<0.3*σpt	z_value
NO2 _8	E	nmol/mol	137.43	1.30	z'	-2.438
NO2 _10	E	nmol/mol	3.84	1.26	z'	-2.038
O3 _0	E	nmol/mol	0.03	0.18	z	-0.620
O3 _1	E	nmol/mol	64.00	0.47	z	-3.301
O3 _2	E	nmol/mol	17.38	0.20	z	-1.768
O3 _3	E	nmol/mol	37.05	0.30	z	-1.980
O3 _4	E	nmol/mol	118.32	0.85	z	-2.370
O3 _5	E	nmol/mol	138.82	1.00	z	-1.699
NO _0	F	nmol/mol	0.12	0.72	z'	-0.114
NO _1	F	nmol/mol	119.75	1.10	z	-0.486
NO _2	F	nmol/mol	67.84	0.86	z'	-0.128
NO _3	F	nmol/mol	24.77	0.74	z'	-0.232
NO _4	F	nmol/mol	10.86	0.72	z'	-0.234
NO _5	F	nmol/mol	59.50	0.83	z'	-0.283
NO _6	F	nmol/mol	30.08	0.74	z'	0.522
NO _7	F	nmol/mol	161.08	1.34	z	-0.076
NO _8	F	nmol/mol	147.09	1.25	z	-0.342
NO _9	F	nmol/mol	478.87	3.40	z	0.059
NO _10	F	nmol/mol	297.37	2.18	z	0.404
NO2 _0	F	nmol/mol	-0.01	0.72	z'	0.155
NO2 _2	F	nmol/mol	53.03	0.86	z'	-0.306
NO2 _4	F	nmol/mol	14.67	0.72	z'	-0.079
NO2 _6	F	nmol/mol	30.38	0.76	z'	0.142
NO2 _7	F	nmol/mol	106.63	1.23	z'	-1.394
NO2 _8	F	nmol/mol	137.43	1.30	z'	-1.304
O3 _0	F	nmol/mol	0.03	0.18	z	0.180
O3 _1	F	nmol/mol	64.00	0.47	z	0.243
O3 _2	F	nmol/mol	17.38	0.20	z	-0.099
O3 _3	F	nmol/mol	37.05	0.30	z	0.013
O3 _4	F	nmol/mol	118.32	0.85	z	0.438
O3 _5	F	nmol/mol	138.82	1.00	z	0.581
CO _0	H	µmol/mol	0.00	0.01	z	0.150
CO _1	H	µmol/mol	2,977.00	0.02	z	-0.618
CO _2	H	µmol/mol	7,990.00	0.05	z	-0.771
CO _3	H	µmol/mol	4,975.70	0.03	z	-0.536
CO _4	H	µmol/mol	1,467.00	0.01	z	-0.407
CO _5	H	µmol/mol	866.70	0.01	z	-0.329
NO _0	H	nmol/mol	0.12	0.72	z'	-0.097
NO _1	H	nmol/mol	119.75	1.10	z	-1.544
NO _2	H	nmol/mol	67.84	0.86	z'	-1.863
NO _3	H	nmol/mol	24.77	0.74	z'	-2.820
NO _4	H	nmol/mol	10.86	0.72	z'	-1.812
NO _5	H	nmol/mol	59.50	0.83	z'	-4.941
NO _6	H	nmol/mol	30.08	0.74	z'	-3.523
NO _7	H	nmol/mol	161.08	1.34	z	-5.576
NO _8	H	nmol/mol	147.09	1.25	z	-4.799
NO _9	H	nmol/mol	478.87	3.40	z	-4.390
NO _10	H	nmol/mol	297.37	2.18	z	-4.711
NO2 _0	H	nmol/mol	-0.01	0.72	z'	-0.073
NO2 _2	H	nmol/mol	53.03	0.86	z'	-1.866
NO2 _4	H	nmol/mol	14.67	0.72	z'	-2.318
NO2 _6	H	nmol/mol	30.38	0.76	z'	-3.658
NO2 _7	H	nmol/mol	106.63	1.23	z'	-5.254
NO2 _8	H	nmol/mol	137.43	1.30	z'	-4.972
NO2 _10	H	nmol/mol	3.84	1.26	z'	-0.656
O3 _0	H	nmol/mol	0.03	0.18	z	-0.130
O3 _1	H	nmol/mol	64.00	0.47	z	-1.372
O3 _2	H	nmol/mol	17.38	0.20	z	-0.581
O3 _3	H	nmol/mol	37.05	0.30	z	-0.946
O3 _4	H	nmol/mol	118.32	0.85	z	-1.113

Gas	Code	Unit	Ref	u_ref	uref<0.3*σpt	z_value
O3 _5	H	nmol/mol	138.82	1.00	z	-1.072
SO2 _0	H	nmol/mol	0.01	0.52	z'	0.036
SO2 _1	H	nmol/mol	134.24	1.22	z'	-1.214
SO2 _2	H	nmol/mol	55.93	0.71	z'	-1.039
SO2 _3	H	nmol/mol	40.11	0.62	z'	-0.860
SO2 _4	H	nmol/mol	18.81	0.55	z'	-0.698
SO2 _5	H	nmol/mol	9.94	0.52	z'	-0.787
CO _0	I	µmol/mol	0.00	0.01	z	0.000
CO _1	I	µmol/mol	2,977.00	0.02	z	0.408
CO _2	I	µmol/mol	7,990.00	0.05	z	0.264
CO _3	I	µmol/mol	4,975.70	0.03	z	0.352
CO _4	I	µmol/mol	1,467.00	0.01	z	0.118
CO _5	I	µmol/mol	866.70	0.01	z	-0.031
NO _0	I	nmol/mol	0.12	0.72	z'	-0.057
NO _1	I	nmol/mol	119.75	1.10	z	-0.762
NO _2	I	nmol/mol	67.84	0.86	z'	-1.288
NO _3	I	nmol/mol	24.77	0.74	z'	-0.675
NO _4	I	nmol/mol	10.86	0.72	z'	-0.434
NO _5	I	nmol/mol	59.50	0.83	z'	-0.813
NO _6	I	nmol/mol	30.08	0.74	z'	-0.730
NO _7	I	nmol/mol	161.08	1.34	z	-0.095
NO _8	I	nmol/mol	147.09	1.25	z	-0.364
NO _9	I	nmol/mol	478.87	3.40	z	0.601
NO _10	I	nmol/mol	297.37	2.18	z	0.372
NO2 _0	I	nmol/mol	-0.01	0.72	z'	0.171
NO2 _2	I	nmol/mol	53.03	0.86	z'	-0.441
NO2 _4	I	nmol/mol	14.67	0.72	z'	-0.396
NO2 _6	I	nmol/mol	30.38	0.76	z'	-0.792
NO2 _7	I	nmol/mol	106.63	1.23	z'	0.207
NO2 _8	I	nmol/mol	137.43	1.30	z'	0.146
NO2 _10	I	nmol/mol	3.84	1.26	z'	-0.264
O3 _0	I	nmol/mol	0.03	0.18	z	0.270
O3 _1	I	nmol/mol	64.00	0.47	z	0.352
O3 _2	I	nmol/mol	17.38	0.20	z	0.220
O3 _3	I	nmol/mol	37.05	0.30	z	0.312
O3 _4	I	nmol/mol	118.32	0.85	z	0.577
O3 _5	I	nmol/mol	138.82	1.00	z	0.692
SO2 _0	I	nmol/mol	0.01	0.52	z'	0.702
SO2 _1	I	nmol/mol	134.24	1.22	z'	2.566
SO2 _2	I	nmol/mol	55.93	0.71	z'	1.759
SO2 _3	I	nmol/mol	40.11	0.62	z'	1.493
SO2 _4	I	nmol/mol	18.81	0.55	z'	0.801
SO2 _5	I	nmol/mol	9.94	0.52	z'	0.473
CO _0	L	µmol/mol	0.00	0.01	z	0.100
CO _1	L	µmol/mol	2,977.00	0.02	z	-0.373
CO _2	L	µmol/mol	7,990.00	0.05	z	-0.548
CO _3	L	µmol/mol	4,975.70	0.03	z	-0.436
CO _4	L	µmol/mol	1,467.00	0.01	z	-0.200
CO _5	L	µmol/mol	866.70	0.01	z	-0.138
NO _0	L	nmol/mol	0.12	0.72	z'	0.065
NO _1	L	nmol/mol	119.75	1.10	z	-0.194
NO _2	L	nmol/mol	67.84	0.86	z'	-0.026
NO _3	L	nmol/mol	24.77	0.74	z'	0.093
NO _4	L	nmol/mol	10.86	0.72	z'	0.282
NO _5	L	nmol/mol	59.50	0.83	z'	0.040
NO _6	L	nmol/mol	30.08	0.74	z'	0.133
NO _7	L	nmol/mol	161.08	1.34	z	0.004
NO _8	L	nmol/mol	147.09	1.25	z	-0.086
NO _9	L	nmol/mol	478.87	3.40	z	-0.192
NO _10	L	nmol/mol	297.37	2.18	z	-0.050

Gas	Code	Unit	Ref	u_ref	uref<0.3*σpt	z_value
NO2 _0	L	nmol/mol	-0.01	0.72	z'	-0.155
NO2 _2	L	nmol/mol	53.03	0.86	z'	-0.284
NO2 _4	L	nmol/mol	14.67	0.72	z'	0.069
NO2 _6	L	nmol/mol	30.38	0.76	z'	-0.195
NO2 _7	L	nmol/mol	106.63	1.23	z'	0.368
NO2 _8	L	nmol/mol	137.43	1.30	z'	-0.234
O3 _0	L	nmol/mol	0.03	0.18	z	0.370
O3 _1	L	nmol/mol	64.00	0.47	z	0.058
O3 _2	L	nmol/mol	17.38	0.20	z	0.309
O3 _3	L	nmol/mol	37.05	0.30	z	0.243
O3 _4	L	nmol/mol	118.32	0.85	z	0.233
O3 _5	L	nmol/mol	138.82	1.00	z	0.252
SO2 _0	L	nmol/mol	0.01	0.52	z'	0.169
SO2 _1	L	nmol/mol	134.24	1.22	z'	-0.936
SO2 _2	L	nmol/mol	55.93	0.71	z'	-0.557
SO2 _3	L	nmol/mol	40.11	0.62	z'	-0.426
SO2 _4	L	nmol/mol	18.81	0.55	z'	-0.203
SO2 _5	L	nmol/mol	9.94	0.52	z'	-0.108
CO _0	M	µmol/mol	0.00	0.01	z	1.000
CO _1	M	µmol/mol	2,977.00	0.02	z	0.134
CO _2	M	µmol/mol	7,990.00	0.05	z	0.377
CO _3	M	µmol/mol	4,975.70	0.03	z	0.489
CO _4	M	µmol/mol	1,467.00	0.01	z	0.000
CO _5	M	µmol/mol	866.70	0.01	z	-0.138
NO _0	M	nmol/mol	0.12	0.72	z'	0.049
NO _1	M	nmol/mol	119.75	1.10	z	-1.335
NO _2	M	nmol/mol	67.84	0.86	z'	-1.129
NO _3	M	nmol/mol	24.77	0.74	z'	-0.880
NO _4	M	nmol/mol	10.86	0.72	z'	-0.503
NO _5	M	nmol/mol	59.50	0.83	z'	-1.078
NO _6	M	nmol/mol	30.08	0.74	z'	-0.805
NO _7	M	nmol/mol	161.08	1.34	z	-0.999
NO _8	M	nmol/mol	147.09	1.25	z	-1.146
NO _9	M	nmol/mol	478.87	3.40	z	-0.984
NO _10	M	nmol/mol	297.37	2.18	z	-0.904
NO2 _0	M	nmol/mol	-0.01	0.72	z'	1.375
NO2 _2	M	nmol/mol	53.03	0.86	z'	-1.449
NO2 _4	M	nmol/mol	14.67	0.72	z'	-0.942
NO2 _6	M	nmol/mol	30.38	0.76	z'	-1.383
NO2 _7	M	nmol/mol	106.63	1.23	z'	-1.421
NO2 _8	M	nmol/mol	137.43	1.30	z'	-1.679
NO2 _10	M	nmol/mol	3.84	1.26	z'	-1.181
O3 _0	M	nmol/mol	0.03	0.18	z	0.650
O3 _1	M	nmol/mol	64.00	0.47	z	-0.828
O3 _2	M	nmol/mol	17.38	0.20	z	0.577
O3 _3	M	nmol/mol	37.05	0.30	z	-0.050
O3 _4	M	nmol/mol	118.32	0.85	z	-0.240
O3 _5	M	nmol/mol	138.82	1.00	z	-0.060
SO2 _0	M	nmol/mol	0.01	0.52	z'	0.258
SO2 _1	M	nmol/mol	134.24	1.22	z'	-0.022
SO2 _2	M	nmol/mol	55.93	0.71	z'	-0.087
SO2 _3	M	nmol/mol	40.11	0.62	z'	-0.047
SO2 _4	M	nmol/mol	18.81	0.55	z'	-0.156
SO2 _5	M	nmol/mol	9.94	0.52	z'	-0.236

Source: JRC 2022

Table 15: En-score participants calculated values.

Code	Parameter	Concentrations	En
B	NO	0	0.0
B	NO	1	-1.0
B	NO	2	-0.9
B	NO	3	-1.4
B	NO	4	-0.7
B	NO	5	-1.3
B	NO	6	-0.9
B	NO	7	-0.4
B	NO	8	-0.5
B	NO	9	-0.1
B	NO	10	-0.2
B	NO2	0	0.0
B	NO2	1	0.1
B	NO2	2	-0.6
B	NO2	3	-0.1
B	NO2	4	-0.9
B	NO2	5	0.0
B	NO2	6	-1.0
B	NO2	7	-0.2
B	NO2	8	-0.3
B	NO2	9	0.5
B	NO2	10	0.1
B	O3	0	-0.6
B	O3	1	0.0
B	O3	2	-0.1
B	O3	3	0.0
B	O3	4	0.0
B	O3	5	0.0
B	SO2	0	0.0
B	SO2	1	0.2
B	SO2	2	0.1
B	SO2	3	0.2
B	SO2	4	0.1
B	SO2	5	0.0
C	CO	0	0.4
C	CO	1	-25.0
C	CO	2	-20.9
C	CO	3	-23.9
C	CO	4	-29.4
C	CO	5	-25.1
C	NO	0	-0.1
C	NO	1	-1.0
C	NO	2	-0.7
C	NO	3	-0.4
C	NO	4	-0.2
C	NO	5	-0.6
C	NO	6	-0.4
C	NO	7	-0.4
C	NO	8	-0.6
C	NO	9	-0.3
C	NO	10	-0.2
C	NO2	0	0.0
C	NO2	1	-0.3
C	NO2	2	-0.8

Code	Parameter	Concentrations	En
C	NO2	3	-0.1
C	NO2	4	-0.3
C	NO2	5	-0.2
C	NO2	6	-0.5
C	NO2	7	-0.6
C	NO2	8	-0.8
C	NO2	9	-0.6
C	NO2	10	-0.6
C	O3	0	-0.1
C	O3	1	0.7
C	O3	2	0.6
C	O3	3	0.7
C	O3	4	1.4
C	O3	5	0.8
C	SO2	0	0.0
C	SO2	1	3.1
C	SO2	2	2.7
C	SO2	3	2.3
C	SO2	4	1.4
C	SO2	5	0.9
D	CO	0	0.1
D	CO	1	0.0
D	CO	2	-0.3
D	CO	3	-0.4
D	CO	4	-0.4
D	CO	5	-0.3
D	NO	0	-0.1
D	NO	1	-0.1
D	NO	2	0.0
D	NO	3	0.0
D	NO	4	0.0
D	NO	5	0.0
D	NO	6	0.0
D	NO	7	0.1
D	NO	8	-0.1
D	NO	9	-0.1
D	NO	10	0.0
D	NO2	0	0.0
D	NO2	1	0.0
D	NO2	2	-0.1
D	NO2	3	0.0
D	NO2	4	0.0
D	NO2	5	0.0
D	NO2	6	-0.1
D	NO2	7	-0.1
D	NO2	8	-0.2
D	NO2	9	-0.3
D	NO2	10	-0.3
D	O3	0	0.1
D	O3	1	0.0
D	O3	2	0.2
D	O3	3	0.1
D	O3	4	0.0
D	O3	5	0.1
D	SO2	0	0.1
D	SO2	1	-0.8

Code	Parameter	Concentrations	En
D	SO2	2	-0.7
D	SO2	3	-0.5
D	SO2	4	-0.3
D	SO2	5	-0.2
E	NO	0	0.1
E	NO	1	-0.6
E	NO	2	-0.7
E	NO	3	-0.7
E	NO	4	-0.4
E	NO	5	-0.7
E	NO	6	-0.6
E	NO	7	-0.5
E	NO	8	-0.6
E	NO	9	-0.4
E	NO	10	-0.5
E	NO2	0	-0.1
E	NO2	1	-1.0
E	NO2	2	-1.0
E	NO2	3	-0.3
E	NO2	4	-0.7
E	NO2	5	-0.4
E	NO2	6	-0.9
E	NO2	7	-0.7
E	NO2	8	-0.7
E	NO2	9	-1.4
E	NO2	10	-1.3
E	O3	0	-1.7
E	O3	1	-1.2
E	O3	2	-1.4
E	O3	3	-0.9
E	O3	4	-0.7
E	O3	5	-0.4
F	NO	0	-0.1
F	NO	1	-0.2
F	NO	2	-0.1
F	NO	3	-0.1
F	NO	4	-0.2
F	NO	5	-0.1
F	NO	6	0.3
F	NO	7	0.0
F	NO	8	-0.1
F	NO	9	0.0
F	NO	10	0.1
F	NO2	0	0.1
F	NO2	2	-0.1
F	NO2	4	-0.1
F	NO2	6	0.1
F	NO2	7	-0.5
F	NO2	8	-0.4
F	O3	0	0.1
F	O3	1	0.1
F	O3	2	-0.1
F	O3	3	0.0
F	O3	4	0.1
F	O3	5	0.2
H	CO	0	0.0

Code	Parameter	Concentrations	En
H	CO	1	-0.3
H	CO	2	-0.4
H	CO	3	-0.3
H	CO	4	-0.2
H	CO	5	-0.1
H	NO	0	-0.1
H	NO	1	-1.1
H	NO	2	-1.6
H	NO	3	-2.8
H	NO	4	-1.5
H	NO	5	-4.9
H	NO	6	-3.7
H	NO	7	-4.4
H	NO	8	-3.7
H	NO	9	-2.9
H	NO	10	-3.3
H	NO2	0	-0.1
H	NO2	1	-0.1
H	NO2	2	-1.6
H	NO2	3	-0.2
H	NO2	4	-2.0
H	NO2	5	-0.2
H	NO2	6	-3.6
H	NO2	7	-4.0
H	NO2	8	-3.5
H	NO2	9	-0.4
H	NO2	10	-0.4
H	O3	0	-0.1
H	O3	1	-1.2
H	O3	2	-0.6
H	O3	3	-1.1
H	O3	4	-1.8
H	O3	5	-0.7
H	SO2	0	0.0
H	SO2	1	-1.4
H	SO2	2	-1.4
H	SO2	3	-1.1
H	SO2	4	-0.8
H	SO2	5	-0.8
I	CO	0	0.0
I	CO	1	0.3
I	CO	2	0.2
I	CO	3	0.3
I	CO	4	0.2
I	CO	5	0.0
I	NO	0	0.0
I	NO	1	-0.3
I	NO	2	-0.7
I	NO	3	-0.5
I	NO	4	-0.4
I	NO	5	-0.5
I	NO	6	-0.5
I	NO	7	0.0
I	NO	8	-0.2
I	NO	9	0.2
I	NO	10	0.1

Code	Parameter	Concentrations	En
I	NO2	0	0.1
I	NO2	1	0.1
I	NO2	2	-0.2
I	NO2	3	0.1
I	NO2	4	-0.3
I	NO2	5	0.0
I	NO2	6	-0.5
I	NO2	7	0.1
I	NO2	8	0.1
I	NO2	9	-0.3
I	NO2	10	-0.2
I	O3	0	0.3
I	O3	1	0.2
I	O3	2	0.2
I	O3	3	0.2
I	O3	4	0.3
I	O3	5	0.3
I	SO2	0	0.6
I	SO2	1	1.0
I	SO2	2	0.9
I	SO2	3	0.8
I	SO2	4	0.6
I	SO2	5	0.4
L	CO	0	0.1
L	CO	1	-0.4
L	CO	2	-0.4
L	CO	3	-0.4
L	CO	4	-0.2
L	CO	5	-0.1
L	NO	0	0.0
L	NO	1	-0.2
L	NO	2	0.0
L	NO	3	0.1
L	NO	4	0.2
L	NO	5	0.0
L	NO	6	0.1
L	NO	7	0.0
L	NO	8	-0.1
L	NO	9	-0.1
L	NO	10	0.0
L	NO2	0	-0.1
L	NO2	1	-0.2
L	NO2	2	-0.2
L	NO2	3	-0.5
L	NO2	4	0.0
L	NO2	6	-0.1
L	NO2	7	0.2
L	NO2	8	-0.1
L	O3	0	0.3
L	O3	1	0.1
L	O3	2	0.3
L	O3	3	0.2
L	O3	4	0.2
L	O3	5	0.2
L	SO2	0	0.1
L	SO2	1	-0.6

Code	Parameter	Concentrations	En
L	SO2	2	-0.4
L	SO2	3	-0.3
L	SO2	4	-0.2
L	SO2	5	-0.1
M	CO	0	4.9
M	CO	1	0.2
M	CO	2	0.4
M	CO	3	0.5
M	CO	4	0.0
M	CO	5	-0.5
M	NO	0	0.0
M	NO	1	-0.3
M	NO	2	-0.3
M	NO	3	-0.4
M	NO	4	-0.3
M	NO	5	-0.3
M	NO	6	-0.3
M	NO	7	-0.2
M	NO	8	-0.2
M	NO	9	-0.2
M	NO	10	-0.2
M	NO2	0	1.2
M	NO2	1	-0.5
M	NO2	2	-1.4
M	NO2	3	-0.3
M	NO2	4	-0.9
M	NO2	5	-0.7
M	NO2	6	-1.4
M	NO2	7	-1.2
M	NO2	8	-1.4
M	NO2	9	-0.7
M	NO2	10	-0.8
M	O3	0	1.5
M	O3	1	-0.6
M	O3	2	0.9
M	O3	3	-0.1
M	O3	4	-0.2
M	O3	5	0.0
M	SO2	0	0.3
M	SO2	1	0.0
M	SO2	2	-0.1
M	SO2	3	0.0
M	SO2	4	-0.2
M	SO2	5	-0.3

Source: JRC 2022

Annex E

Confidentiality

Results of the PT are published according to the agreements included in the document AQUILA-N37 [12] approved by all NRL of the AQUILA network.
In order to ensure confidentiality of the laboratories information, ERLAP guarantees the submitted data as follows:

- Any administrative information provided by the laboratory is confidential and cannot be communicated to a third party.
- Access to ERLAP facilities is allowed only to members of the Unit JRC-C5 and authorized persons (cleaning staff, maintenance staff, safety and security staff etc.)
- Confidential passwords to access the web application for data submission are sent once the registration to PT is completed. Confidential passwords allow access to the WEB interface and to on-line questionnaire. Passwords are valid until the PT is closed. Laboratories can change their password online.

The form LAB-REC-2000 (Confidentiality involvement form) is asked to be signed by the participants during their first participation to a PT organized by ERLAP.

Annex F

Accreditation certificates

ISO/IEC 17043:2010

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO

Membro degli Accordi di Mutuo Riconoscimento EA, IAF e ILAC
Signatory of EA, IAF and ILAC Mutual Recognition Agreements

CERTIFICATO DI ACCREDITAMENTO
Accreditation Certificate

ACCREDITAMENTO N. / *ACCREDITATION N.*: **0018P** REV. **00**

EMESSO DA / ISSUED BY: **DIPARTIMENTO LABORATORI DI PROVA**

SI DICHIARA CHE / *WE DECLARE THAT*: **European Reference Laboratory for air Pollution (ERLAP)**
Sede/Headquarters:
- Via E. Fermi 2749 - 21027 Ispra VA

È CONFORME AI REQUISITI DELLA NORMA: UNI CEI EN ISO/IEC 17043:2010

MEETS THE REQUIREMENTS OF THE STANDARD: *ISO/IEC 17043:2010*

MD-CA-01 rev. 03

QUALE: **Organizzatori di prove valutative interlaboratorio**

AS: ***Proficiency Testing Provider***

Data di 1ª emissione *1st issue date* **17-01-2019**	Data di modifica *Modification date* **17-01-2019**	Data di scadenza *Expiring date* **16-01-2023**
Dott.ssa Silvia Tramontin Il Direttore di Dipartimento *The Department Director*	Dott. Filippo Trifiletti Il Direttore Generale *The General Director*	Ing. Giuseppe Rossi Il Presidente *The President*

L'accreditamento attesta la competenza tecnica dell'Organizzazione relativamente al campo di accreditamento riportato nell'Elenco Schemi allegato al presente certificato di accreditamento.
Il presente certificato non è da ritenersi valido se non accompagnato dagli Elenchi Schemi, che possono variare nel tempo.
La vigenza dell'accreditamento può essere verificata sul sito web (www.accredia.it) o richiesta al Dipartimento di competenza.

The accreditation certifies the technical competence of the organisation limited to the scope detailed in the attached Enclosure.
The present certificate is valid only if associated to the annexed schedule, that may vary in the time.
Confirmation of the validity of accreditation can be verified on website www.accredia.it or by contacting the relevant Department.

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ACCREDIA

Sede operativa e legale: Via Guglielmo Saliceto, 7/9 | 00161 Roma - Italy | Tel. +39 06 8440991 | Fax +39 06 8841199
info@accredia.it | www.accredia.it | Partita IVA - Codice Fiscale 10566361001

ISO/IEC 17043:2010

Allegato al certificato di accreditamento n. **0018P** rev. **2** del **13/09/2022**

European Reference Laboratory for air Pollution (ERLAP) Via E. Fermi 2749 21027 Ispra VA	UNI CEI EN ISO/IEC 17043:2010	
	Revisione: **1**	Data: **13/09/2022**
	Sede **A**	pag. **1** di **1**

ELENCO SCHEMI ACCREDITATI - CON CAMPO FISSO IN CATEGORIA: 0

Codice identificativo	*Settore*	*Oggetto /Materiale/ Prodotto/Matrice*	*Misurando/ Proprietà misurata/ Grandezza*	*Tipologia*
	ambientale	Synthetic mixture gas	carbon monoxide	schema quantitativo
	ambientale	Synthetic mixture gas	nitrogen oxides	schema quantitativo
	ambientale	Synthetic mixture gas	ozone	schema quantitativo
	ambientale	Synthetic mixture gas	sulphur dioxide	schema quantitativo

Il QRcode consente di accedere direttamente al sito www.accredia.it per verificare la validità dell'elenco schemi e del certificato di accreditamento rilasciato al PTP.

L'eventuale simbolo (*) indica che è attiva una sospensione dell'accreditamento per la specifica attività riportata a fianco

ISO/IEC 17025:2017

L'ENTE ITALIANO DI ACCREDITAMENTO

Membro degli Accordi di Mutuo Riconoscimento EA, IAF e ILAC
Signatory of EA, IAF and ILAC Mutual Recognition Agreements

DL1362L/003

CERTIFICATO DI ACCREDITAMENTO
Accreditation Certificate

ACCREDITAMENTO N.
ACCREDITATION N. **1362L** REV. **03**

EMESSO DA
ISSUED BY **DIPARTIMENTO LABORATORI DI PROVA**

SI DICHIARA CHE
WE DECLARE THAT

European Reference Laboratory for Air Pollution (ERLAP) Air and Climate Unit Directorate C.Energy, Transport and Climate Joint Research Centre -European Commission

Sede/Headquarters:
- Via E. Fermi 2749 - 21027 Ispra VA

MD-CA-01 rev. 05

È CONFORME AI REQUISITI DELLA NORMA: UNI CEI EN ISO/IEC 17025:2018

MEETS THE REQUIREMENTS OF THE STANDARD: *ISO/IEC 17025:2017*

QUALE: **Laboratorio di Prova**

AS: ***Testing Laboratory***

Data di 1° emissione *1st issue date*	Data di revisione *Review date*	Data di scadenza *Expiring date*
19-06-2013	**22-06-2021**	**16-06-2025**

L'accreditamento attesta la competenza tecnica, l'imparzialità e il costante e coerente funzionamento del Laboratorio relativamente ai campo di accreditamento riportato nell'Elenco Prove allegato al presente certificato di accreditamento.
Il presente certificato non è da ritenersi valido se non accompagnato dagli Elenchi Prove, che possono variare nel tempo e può essere sospeso o revocato o ridotto in qualsiasi momento nel caso di inadempienza accertata da parte di ACCREDIA.
La vigenza dell'accreditamento può essere verificata sul sito web (www.accredia.it) o richiesta al Dipartimento di competenza.
I requisiti di sistema della ISO/IEC 17025 sono scritti in un linguaggio attinente alle attività di laboratorio e sono generalmente in accordo con i principi della norma ISO 9001 (si veda comunicato congiunto ISO-ILAC-IAF dell'Aprile 2017).
The accreditation attests competence, impartiality and consistent operation in performing laboratory activities, limited to the scope detailed in the attached Enclosure.
The present certificate is valid only if associated to the annexed Lists and can be suspended, withdrawn or reduced at any time in the event of non fulfilment as ascertained by ACCREDIA.
Confirmation of the validity of accreditation can be verified on the website (www.accredia.it) or by contacting the relevant Department.
The management system requirements in ISO/IEC 17025 are written in language relevant to laboratories operations and generally operate in accordance with the principles of ISO 9001 (refer joint ISO-ILAC-IAF Communiqué dated April 2017).

Il QRcode consente di accedere direttamente al sito www.accredia.it per verificare la validità del certificato di accreditamento rilasciato al CAB.
La data di revisione riportata sul certificato corrisponde alla data di aggiornamento / di delibera del pertinente Comitato Settoriale di Accreditamento. L'atto di delibera, firmato dal Presidente di ACCREDIA, è scaricabile dal sito www.accredia.it, sezione 'Documenti'
The QRcode links directly to the website www.accredia.it to check the validity of the accreditation certificate issued to the CAB.
The revision date shown on the certificate refers to the update / resolution date of the Sector Accreditation Committee. The Resolution, signed by the President of ACCREDIA, can be downloaded from the website www.accredia.it, 'Documents' section.

ACCREDIA è l'Ente Unico nazionale di accreditamento designato dal governo italiano, in applicazione del Regolamento Europeo 765/2008.
ACCREDIA is the sole national Accreditation Body, appointed by the Italian government in compliance with the application of REGULATION (EC) No 765/2008.

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ACCREDIA - Dipartimento Laboratori di prova

Sede operativa, legale e amministrativa: Via Guglielmo Saliceto, 7/9 | 00161 Roma - Italy
Tel. +39 06 8440991 | Fax +39 06 8841199
info@accredia.it | www.accredia.it | Partita IVA - Codice Fiscale 10566361001

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO

Allegato al certificato di accreditamento n. **1362L** rev. **3** del **22/06/2021**

European Reference Laboratory for Air Pollution (ERLAP) **Air and Climate Unit** **Directorate C.Energy, Transport and Climate** **Joint Research Centre -European Commission**	UNI CEI EN ISO/IEC 17025:2018
	Revisione: **5** — Data: **22/06/2021**
Via E. Fermi 2749	Sede **A** — pag. **1** di **1**

ELENCO PROVE ACCREDITATE - CON CAMPO FISSO IN CATEGORIA: 0

Aria ambiente/Ambient air

Denominazione della prova / Campi di prova	*Metodo di prova*	*Tecnica di prova*	*O&I*
Carbonio elementare/Elemental carbon, Carbonio organico/Organic carbon	EN 12341:2014 + EN 16909:2017	Thermal-optical analysis (TOA)	
Diossido di azoto/Nitrogen dioxide, Monossido di azoto/Nitrogen monoxide	UNI EN 14211:2012	Chemiluminescenza	
Diossido di zolfo/Sulfur dioxide	EN 14212:2012	Spettrofotometria UV fluorescenza	
Monossido di carbonio/Carbon monoxide	UNI EN 14626:2012	Spettrofotometria IR	
Ozono/Ozone	UNI EN 14625:2012	Spettrofotometria UV-VIS	
Particolato sospeso PM10/Suspended particulate matter PM10, Particolato sospeso PM2.5/Suspended particulate matter PM2.5	UNI EN 12341:2014	Gravimetria	

Legenda

L'eventuale simbolo (1) in corrispondenza della matrice indica:matrice non prevista dal metodo ma assimilabile/matrix not provided for by the method but acceptable

Il QRcode consente di accedere direttamente al sito www.accredia.it per verificare la validità dell'elenco prove e del certificato di accreditamento rilasciato al laboratorio.

L'eventuale simbolo "X" riportato nella colonna "O&I" indica che il laboratorio è accreditato anche per fornire opinioni e interpretazioni basate sui risultati delle specifiche prove contrassegnate.

L'eventuale simbolo (*) indica che è attiva una sospensione dell'accreditamento per la specifica attività riportata a fianco

End of report

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