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Evaluation of the Field Comparison Exercise for PM10 and PM2.5 Ispra, February 13th – April 9th, 2015

European Commission harmonization program for Air Quality Measurements

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List of abbreviations and definitions

DQO	Data Quality Objective of the European Directive 2008/50/EC
LV	Limit Value of the European Directive 2008/50/EC
AQUILA	Network of National Air Quality Reference Laboratories
WHO-CC	World Health Organization Collaboration Centre for Air Quality
PM10	Particulate Matter in the size fraction ≤ 10 µm aerodynamic diameter
PM2.5	Particulate Matter in the size fraction ≤ 2.5 µm aerodynamic diameter
ERLAP	European Reference Laboratory for Air Pollution
HVS	High Volume Sampler
LVS	Low Volume Sampler
PTFE	Polytetrafluoroethylene
JRC	Joint Research Centre of the European Commission
EC	European Commission
ISO	International Organization for Standardization
Avg	Average
U	Expanded Uncertainty (k=2)
R	Reproducibility
IE	Inter-laboratory comparison exercise
UTC	Coordinated Universal Time

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Abstract

An inter-laboratory comparison exercise (IE) for the determination of PM mass concentration with the reference gravimetric method (EN 12341:2014) was organised for the first time at European level in 2015. Such an IE comprises the comparison between the samplers used by the various participants. Samplers shall therefore be co-located for several days so that the number of test samples is large enough for statistical analyses. Thanks to the great interest for this type of IE and to the commitment from the AQUILA Network members, 22 Laboratories plus the European Reference Laboratory for Air Pollution deployed their instruments at a single place in the premises of the Joint Research Centre in Ispra (Italy) for the same period of time (13 Feb. – 9 Apr. 2015). For almost two months, 24 samplers for PM10 and 22 for PM2.5 collected ambient aerosol samples on the filter types used by each participant. Gravimetric analyses of the filters before and after sampling were performed by the participants in their own laboratories following their own conditioning and filter handling procedures.

The assigned daily values for PM10 and PM2.5 were calculated as the Consensus Value from all participant results following the standard ISO 13528:2015. They ranged from 3.5 to 106 µg/m³ for PM10, and from 2.1 to 96 µg/m³ for PM2.5.

The scope of this inter-laboratory comparison was to assess the robustness of the measurement process and to determine the performance of the participants' values. From the statistical analyses, conclusions could be drawn.

The reproducibility of the method was 14% for PM10 and 17% for PM2.5.

The Data Quality Objective of ±25% at the Daily Limit Value for PM10 (50µg/m³) was not reached for only 1.3% of all the participants' results over the whole IE concentration range.

For PM10, out of 1245 reported daily values, 17 (1.4%) were found to be unsatisfactory with respect to the z'-score criterion ($|z'|>3$). Close to half of these values were produced by one single laboratory. For PM2.5, out of 1193 daily averages, only 5 (0.4%) showed an unsatisfactory result. Questionable results ($3\geq|z'|>2$) amounted 4.7% and 3.8% of all PM10 and PM2.5 data, respectively.

The E_n-score, which takes into account also the uncertainties reported by the participants, exceeded the critical threshold ($|E_n|>1$) for 21.2% and 22.7% of the PM10 and PM2.5 reported data, respectively.

Between cooled and not-cooled samplers, the average relative differences (6% and 4% for PM10 and PM2.5, respectively) are significant at the 99.9% confidence level.

More than half of the samples were collected on quartz fibre filters for both aerosol size fractions. Compared to the assigned values, only PTFE filters led to significant biases (99.9% confidence level) of -4% and – 6% in PM10 and PM2.5, respectively.

1. Introduction

Particulate matter (PM) is considered as the most harmful air pollutant in outdoor air for human health. To protect human health the EU agreed on limit values for PM2.5 and PM10, as well as on an exposure reduction target for PM2.5, which are described in the Air Quality Directive [1]. The correct measurement of the two particulate fractions PM2.5 and PM10 is not only required by the Directive, but is also essential for a harmonized assessment of concentration levels, to detect the successful implementation of emission reductions and to identify changing emission patterns or sources at local, regional and global level.

The Air Quality Directive sets the legal basis for a harmonised assessment of air pollutants in Europe. The reference measurement methods for PM2.5 and PM10 are described in the European standard EN 12341:2014 [2]. Requirements on the data quality are set as minimum objectives for the uncertainty of the measurement itself, and as minimum data capture.

The accuracy of the PM measurements has to be assured and continuously controlled in line with the Air Quality Directive and requirements of international standards for accreditation. The EC's Joint Research Centre is the responsible body organising quality assurance at EU level, in collaboration with the AQUILA Network [3]. The Member States' National air quality reference laboratory in charge of the quality of air pollution measurements has to participate regularly to the quality assurance programmes organized by the European Commission's Joint Research Centre in Ispra. While for gaseous air pollutants inter-laboratory tests can be carried out in a special dynamic test gas generation facility [4] or by distribution of gas cylinders, these methods are not possible for aerosols.

Between 2006 and 2009 the JRC carried out a unique quality control programme in 18 Member States, where the JRC employed reference method measured in parallel to national reference sampling instruments and a monitoring station in the Member State. Detailed results of the campaign are described in a report [5].

In 2015 the JRC, in collaboration with the AQUILA Network of National Air Quality Reference Laboratories, organized for the first time an outdoor inter-comparison exercise (IE) in Ispra, Italy, for PM10 and PM2.5 measurement. A platform was identified inside the premises of the Joint Research Centre, which offered enough space for a larger number of sampling instruments, without being influenced by near-by local emission sources, which could impact on the homogeneity of the sampling platform.

The PM IE was announced at the 22nd AQUILA meeting in June 2014, where logistical and technical requirements and boundaries were discussed. The platform was presented to the AQUILA community at the occasion of the 23rd AQUILA meeting in November 2014. Static tests of the platform confirmed its suitability and subsequently electrical lines were installed to allow for proper and stable electricity supply to all instruments.

In order to catch a period with both low and high PM pollution levels, it was decided to start sampling in February 2015. During a period of 8 weeks, up to 56 filters per PM size fraction could be collected by the participants.

2. Organization of the field comparison

The comparison was announced in June 2014 to the members of the AQUILA network and the WHO-CC representatives. It took place on the premises of the EC's Joint Research Centre in Ispra, Italy. Participants were requested to bring their own PM10 and PM2.5 samplers, following the recommendations from the Reference Method for Particulate Matter as described in EN12341:2014, as well as the equipment necessary to check the samplers on site.

The installation of the samplers took place in the period February 9th - 12th, 2015, with a selected number of laboratories invited each day. Sampling started on February 13th, 2015, at 0:00 a.m. UTC and ended after eight weeks on April 9th, 2015, at 12:00 p.m. Participants were requested to pass by at least after 4 weeks to exchange the loaded filter cartridges with unloaded filter cartridges. In-between and in case of unavailability, filter cartridges were exchanged by JRC personal, storing unloaded and loaded filters inside the balance room of ERLAP at conditions as requested in EN12341:2014. Within the first week after the end of the campaign, participants passed by to dismantle their equipment.

Data were reported by the participants via a web application. Daily values (0:00 a.m. – 12:00 p.m.) and associated uncertainties were inserted by the participants together with a questionnaire regarding the used equipment and sampling details.

2.1 Participants

19 countries plus the European Commission were represented during the IE. 23 laboratories participated in the comparison of PM10 and 21 in the comparison of PM2.5. The European Reference Laboratory for Air Pollution (ERLAP) participated with two samplers for both PM10 and PM2.5, hence bringing the total number of datasets for PM10 to 24 and for PM2.5 to 22. Details and the code of each laboratory, used during the evaluation of the comparison, are given in table 1.

Table 1: Participating laboratories

COUNTRY	LABORATORY	ACRONYM	PM10	PM2.5	CODE
AUSTRIA	Environment Agency Austria	EEA	X	X	Y
AUSTRIA	Upper Austria Regional Government	OOE	X	X	A
BELGIUM	Institut Scientifique de Service Public	ISSeP	X	X	W
BELGIUM	Flemish Environmental Agency	VMM	X	X	D
CROATIA	Institute for Medical Research and Occupational Health	IMI	X	X	E
CZECH REPUBLIC	Czech Hydrometeorological Institute	CHMI	X	X	F
DENMARK	National Environmental Research Institute	NERI	X	X	H
EUROPEAN COMMISSION	European Reference Laboratory for Air Pollution	ERLAP	X	X	G
EUROPEAN COMMISSION	European Reference Laboratory for Air Pollution	ERLAP II	X	X	O
FINLAND	Finnish Metrological Institute	FMI	X		J
FRANCE	Institut National de l'Environnement Industriel et des Risques	INERIS	X	X	L
GERMANY	Landesamt fűr Natur, Umwelt und Verbraucherschutz	LANUV	X	X	U
GERMANY	TÜV Rheinland Energy GmbH	TUV	X	X	N
HUNGARY	Hungarian Meteorological Service	HMS	X	X	C
IRELAND	Environmental Protection Agency	EPA	X	X	P
ITALY	Istituto Speriore per la Protezione e Ricerca Ambientale	ISPRA	X	X	Q
LUXEMBOURG	Service Surveillance et Controle de la Qualite de Air	AEV	X	X	R
NORWAY	Norwegian Institute for Air Research	NILU	X	X	S
RUSSIA	State Environmental Institution 'Mosecommonitoring'	MOSECOM	X	X	T
SERBIA	Serbian Environmental Protection Agency	SEPA	X		M
SLOVENIA	Environmental Agency of the Republic of Slovenia	SEA	X	X	V
SPAIN	Instituto de Salud Carlos III	ISCIII	X	X	Z
SWITZERLAND	Swiss Federal Laboratories for Materials and Science Technology	EMPA	X	X	B
UNITED KINGDOM	Riccardo Energy and Environment - AEA	RICARDO-AEA	X	X	K

2.2 Equipment

Each participant provided information regarding the type of sampler used (including if a sheath air system was in place on the connecting pipe work to minimize effects of solar heating) and filter material.

In the PM10 comparison, 5 High Volume Samplers (HVS) and 19 Low Volume Samplers (LVS) were used, whereas in the PM2.5 comparison 4 HVS and 18 LVS were used.

Regarding the filter material, Quartz filters were used by 15, Glass filters by 4, Emfab by 2 and PTFE by 3 laboratories for PM10 sampling. For PM2.5, Quartz filters were used by 13, Glass filters by 5, Emfab by 2, and PTFE by 2 laboratories. Table 2 and 3, separated into PM10 and PM2.5, list in details the equipment used by each laboratory.

Table 2: Equipment used for PM10 measurements

PM10:				
ACRONYM	INSTRUMENT	FLOW RATE	FILTERMATERIAL	COOLING SYSTEM
EAA	Digitel LVS (Prototype)	2.3m^3/h	Munktell Glass Microfibre discs, grade 227/1/60	
OOE	Digitel DHA 80	30m^3/h	Munktell Glass Microfibre discs, grade 227/1/60	
ISSeP	Derenda PNS 16/6.1	2.3m^3/h	Pallflex Tisuqtz 2500 AQT-UP	X
VMM	Leckel SEQ 47/50	2.3m^3/h	Pallflex Tisuqtz 2500 AQT-UP	
IMI	Leckel SEQ 47/50-CD	2.3m^3/h	QMA Quartz Microfibre Filters, Whatman	X
CHMI	Leckel SEQ 47/50-CD	2.3m^3/h	Glass fiber Whatman GF/C	X
NERI	Leckel SEQ 47/50-CD	2.3m^3/h	QMA Quartz Microfibre Filters, Whatman	X
ERLAP	Leckel SEQ 47/50-CD	2.3m^3/h	Pallflex Tisuqtz 2500 AQT-UP	X
ERLAP II	Leckel SEQ 47/50	2.3m^3/h	Pallflex Tisuqtz 2500 AQT-UP	
FMI	Leckel SEQ 47/50	2.3m^3/h	Millipore Fluoropore Membrane (PTFE) 3.0 µm	
INERIS	Leckel SEQ 47/50-CD	2.3m^3/h	Pall PTFE with PMP support ring, 2.0 µm	X
LANUV	Digitel DHA 80	30m^3/h	Quartz fibre Machery & Nagel QF10	
TUV	Leckel SEQ 47/50	2.3m^3/h	Pall Emfab	
HMS	Digitel DHA 80	30m^3/h	Frisenette ApS, Quartz fibre filter grade QF	
EPA	Leckel SEQ 47/50	2.3m^3/h	Glass fiber Whatman	
ISPRA	TCR Tecora Skypost HV	2.3m^3/h	Quartz fibre Munktell Ahlstrom MK360	X
AEV	Leckel SEQ 47/50	2.3m^3/h	Quartz microfibre Type T293 Sartorius-Stedim	
NILU	Leckel SEQ 47/50	2.3m^3/h	Pall PTFE Zefluor, 2.0 µm	
MOSECOM	Comde Derenda, LVS/MVS mod. PNS15-3.1	2.3m^3/h	Whatman EPM2000, glass	X
SEPA	TCR Tecora Skypost HV	2.3m^3/h	Whatman tm grade QMA	X
SEA	Digitel DHA 80	30m^3/h	Quartz Pall Flex 2500 QAT-UP	
ISCIII	Derenda IND LVS3 sequential sampler	2.3m^3/h	Whatman QMA	X
EMPA	Digitel DHA 80 HTD	30m^3/h	Pallflex IP56, tissuquartz 2500 QAT-UP	
RICARDO-AEA	Leckel SEQ 47/50	2.3m^3/h	Emfab	

Table 3: Equipment used for PM2.5 measurements

PM2.5:				
ACRONYM	INSTRUMENT	FLOW RATE	FILTERMATERIAL	COOLING SYSTEM
EAA	Digitel DHA 80	30m^3/h	Munktell Glass Microfibre discs, grade 227/1/60	
OOE	Digitel DHA 80	30m^3/h	Munktell Glass Microfibre discs, grade 227/1/60	
ISSeP	Derenda PNS 16/6.1	2.3m^3/h	Pallflex Tisuqtz 2500 AQT-UP	X
VMM	Leckel SEQ 47/50	2.3m^3/h	Pallflex Tisuqtz 2500 AQT-UP	
IMI	Leckel SEQ 47/50-CD	2.3m^3/h	QMA Quartz Microfibre Filters, Whatman	X
CHMI	Leckel SEQ 47/50-CD	2.3m^3/h	Glass fiber Whatman GF/C	X
NERI	Leckel SEQ 47/50-CD	2.3m^3/h	QMA Quartz Microfibre Filters, Whatman	X
ERLAP	Leckel SEQ 47/50-CD	2.3m^3/h	Pallflex Tisuqtz 2500 AQT-UP	X
ERLAP II	Leckel SEQ 47/50	2.3m^3/h	Pallflex Tisuqtz 2500 AQT-UP	
INERIS	Leckel SEQ 47/50-CD	2.3m^3/h	Pall PTFE with PMP support ring, 2.0 µm	X
LANUV	Leckel SEQ 47/50	2.3m^3/h	Glass fiber Whatman GF10	
TUV	Leckel SEQ 47/50	2.3m^3/h	Pall Emfab	
HMS	Digitel DHA 80	30m^3/h	Frisenette ApS, Quartz fibre filter grade QF	
EPA	Leckel SEQ 47/50	2.3m^3/h	Glass fiber Whatman	
ISPRA	TCR Tecora Skypost HV	2.3m^3/h	Quartz fibre Munktell Ahlstrom MK360	X
AEV	Leckel SEQ 47/50	2.3m^3/h	Quartz microfibre Type T293 Sartorius-Stedim	
NILU	Leckel SEQ 47/50	2.3m^3/h	Pall PTFE Zefluor, 2.0 µm	
MOSECOM	Comde Derenda, LVS/MVS mod. PNS15-3.1	2.3m^3/h	Whatman GF/A, glass	X
SEA	Leckel SEQ 47/50	2.3m^3/h	Quartz filter Macherey Nagel, MN QF-10	
ISCIII	Derenda IND LVS3 sequential sampler	2.3m^3/h	Whatman QMA	X
EMPA	Digitel DHA 80 HTD	30m^3/h	Pallflex IP56, tissuquartz 2500 QAT-UP	
RICARDO-AEA	Leckel SEQ 47/50	2.3m^3/h	Emfab	

2.3 Measurement site

2.3.1 Location

As measurement site, the roof of a water reservoir (building 35a) on the premises of the Joint Research Centre of the European Commission in Ispra, Italy, has been chosen. The area is fenced with restricted access.

The site is situated in the pre-alpine area in northern Italy. Both high and low concentrations of particulate matter could be expected, as the site is on one hand influenced by the highly polluted Po-valley, on the other hand exposed to situations with strong foehn winds from the Alps transporting clean air.

The roof of building 35a is around 1-2 m above ground and free of obstacles in the surroundings. Roads around the building are frequented by JRC personal only, mainly in the morning, lunch-time and at the end of a working day. Figure 1 shows the area around the measurement site.

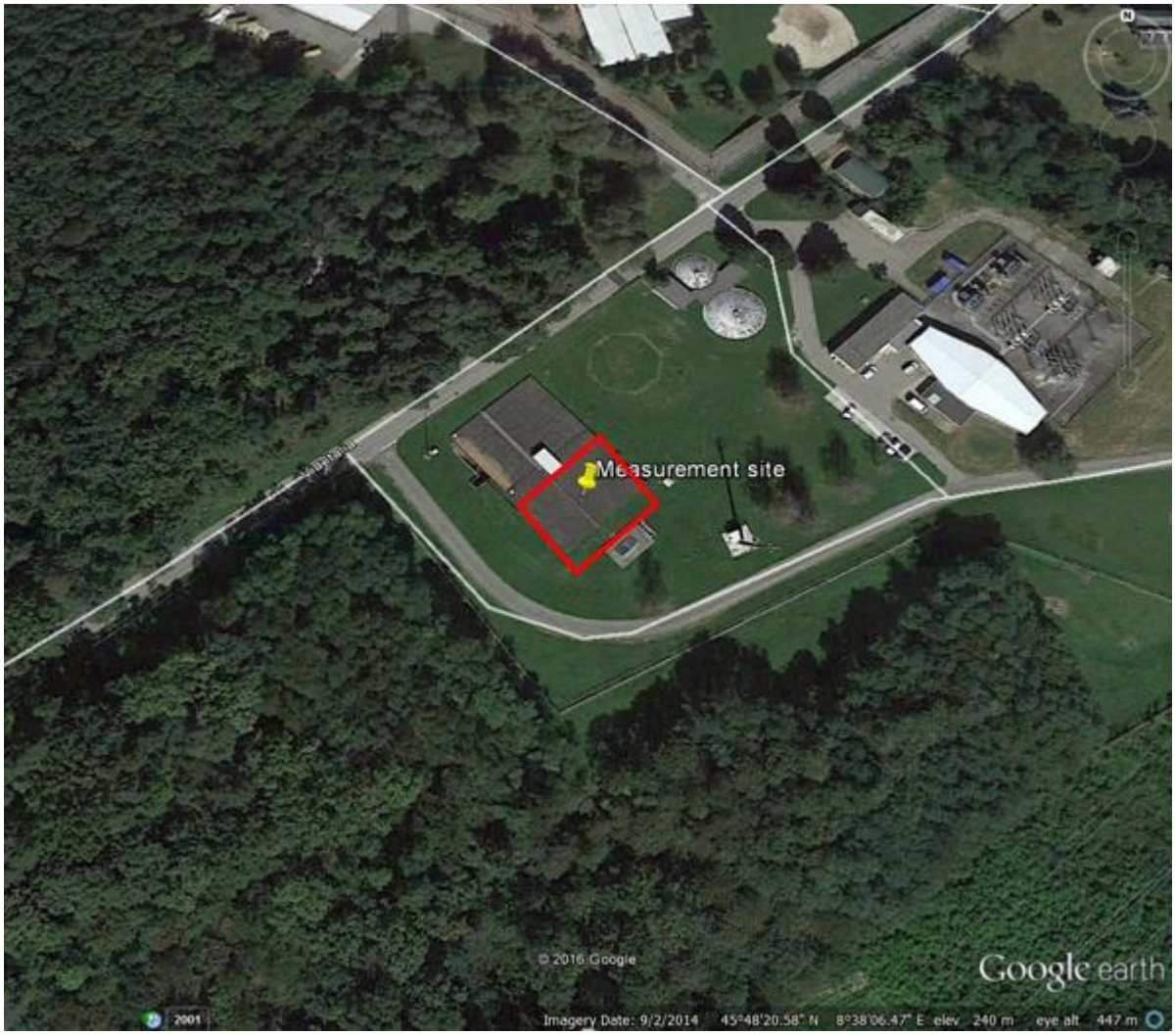


Figure 1: Measurement platform

2.3.2 Positions of samplers

Power supply and pathways for accessibility were installed by the JRC infrastructure service. All instruments were positioned in the south-eastern area of the platform. The following

drawing illustrates the position of each single sampler. Each box represents a sampler, identified by the Lab-code (see Table 1), a suffix "a" for PM10 and suffix "b" for PM2.5.

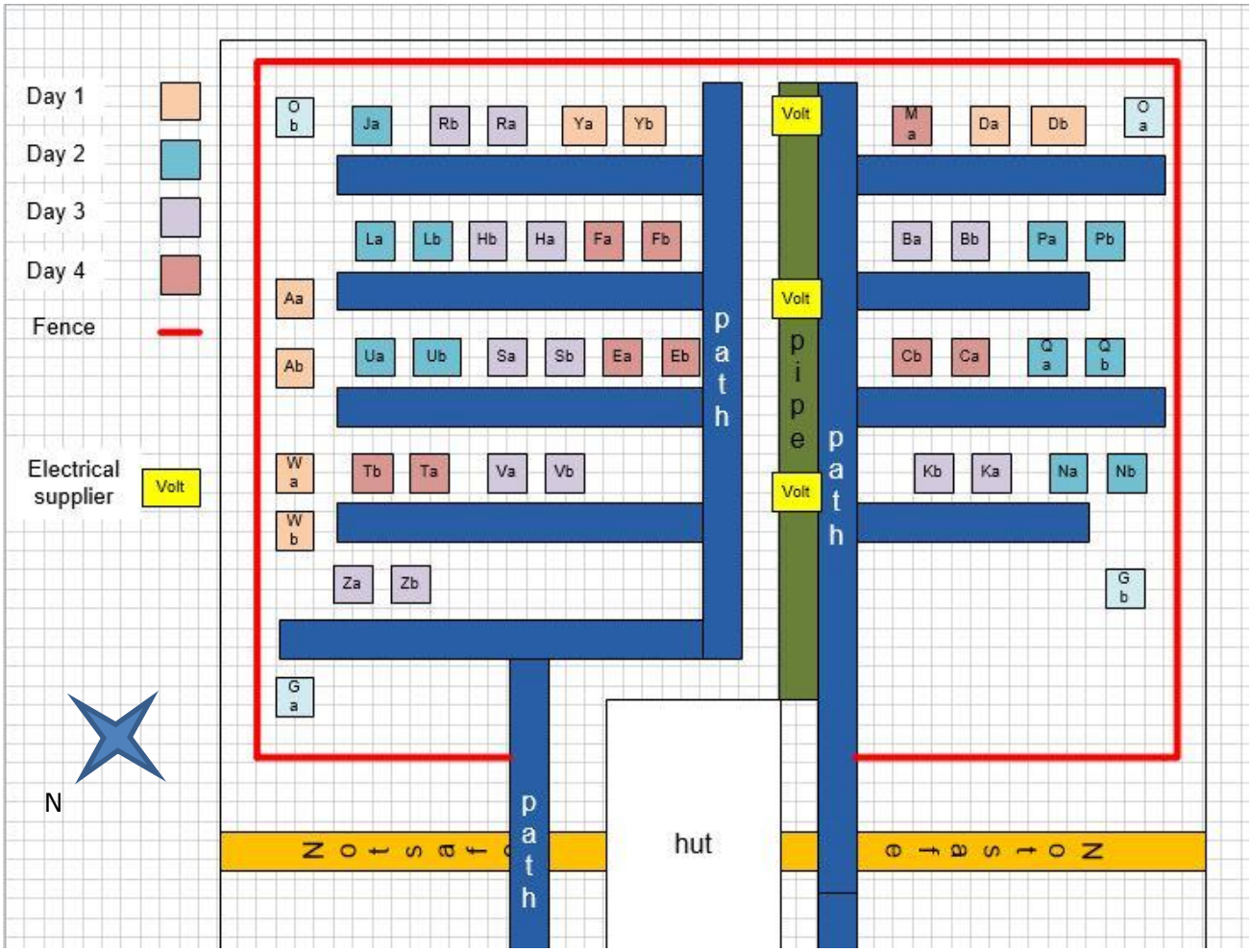


Figure 2: Sampler positions (with day of installation in different colours)

All instruments were labeled with details of the laboratory and checked daily by JRC personal according to a predefined check list. In case of malfunction, the concerned laboratory was informed and whenever possible, the problem was solved by JRC personal. A total of 25 repair works were registered over the entire sampling period. Figure 3 shows a picture of the eastern part of the measurement site with the samplers installed.

Figure 3: Samplers and measurement site

2.3.3 Homogeneity

The homogeneity of the measurement site was evaluated at the end of the campaign. Deviations of each sampler to the reference value were printed on daily maps according to the samplers' positions. A day by day check of all maps did not show any tendency of over- or underestimation in a certain limited area of the sampling site.

Furthermore, the between–sampler uncertainties (u_{field}) of the PM10 and PM2.5 samplers of ERLAP, positioned opposite each other on the measurement site, were calculated. An u_{field} of 1.14 µg/m^3 for PM10 and 0.80 µg/m^3 for PM2.5 underpin the homogenous distribution of PM across the measurement site during the measurement period.

2.3.4 Meteorological conditions

Meteorological conditions were measured at the EMEP site on the premises of the JRC and are reported as hourly averages in Figures 4 to 9.

Temperature ranged from -1.9 °C (February 19th) to 23.1 °C (March 31st), ambient pressure from 971 mbar (March 25th) to 1006.0 mbar (Feb 18th).

Lowest PM concentrations were measured during foehn events, periods characterized by low relative humidity (<20 %) and wind from the NW-sector with higher wind speed (max. 10 m/sec on April 1st).

Days with notable precipitation were February 21st, March 16th, 22nd and 24th.

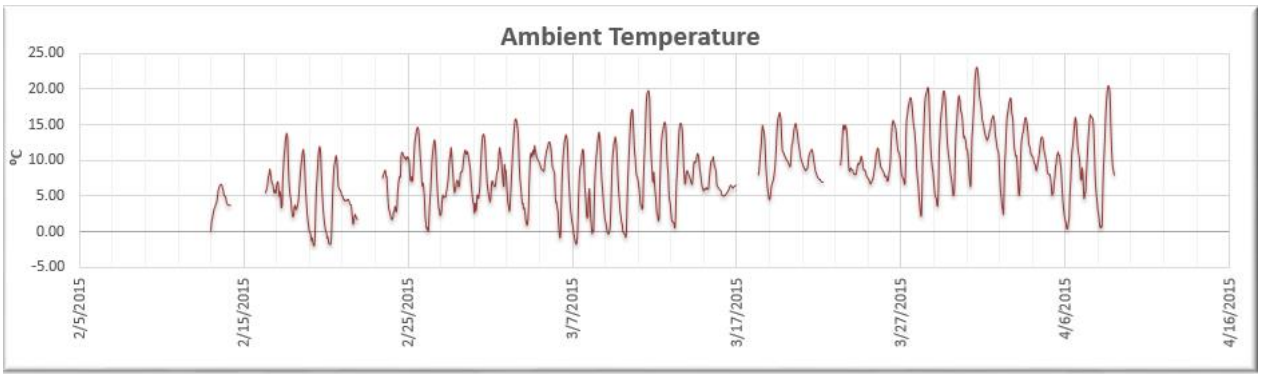


Figure 4: Ambient temperature (1h-avg.) at measurement site

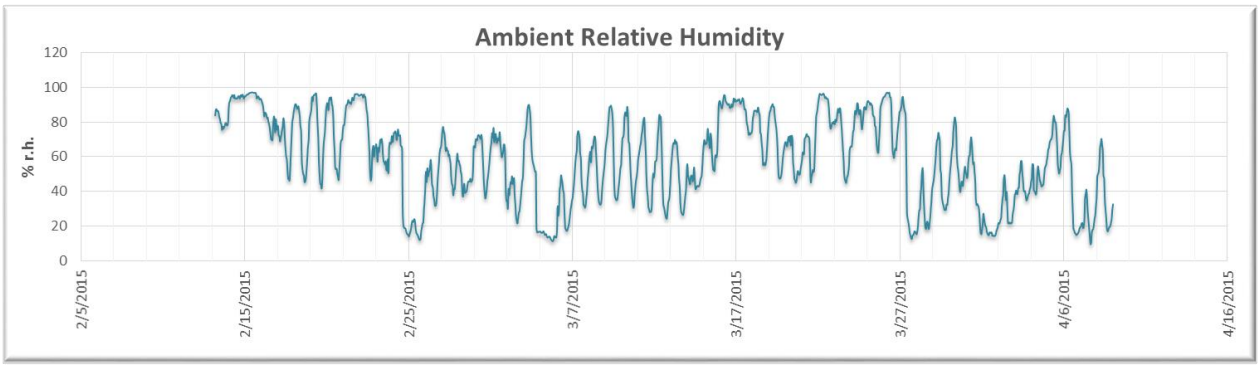


Figure 5: Ambient relative humidity (1h-avg.) at measurement site

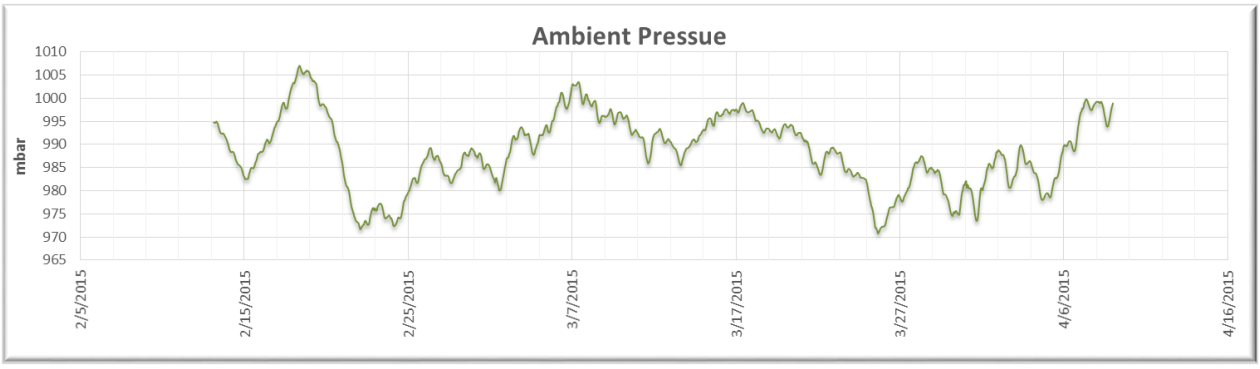


Figure 6: Ambient pressure (1h-avg.) at measurement site

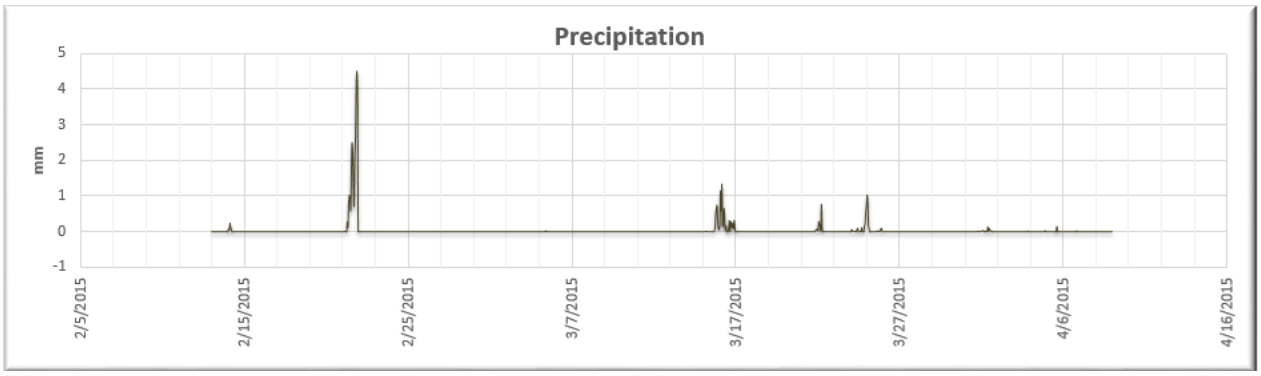


Figure 7: Precipitation (accumulation in 1h) at measurement site

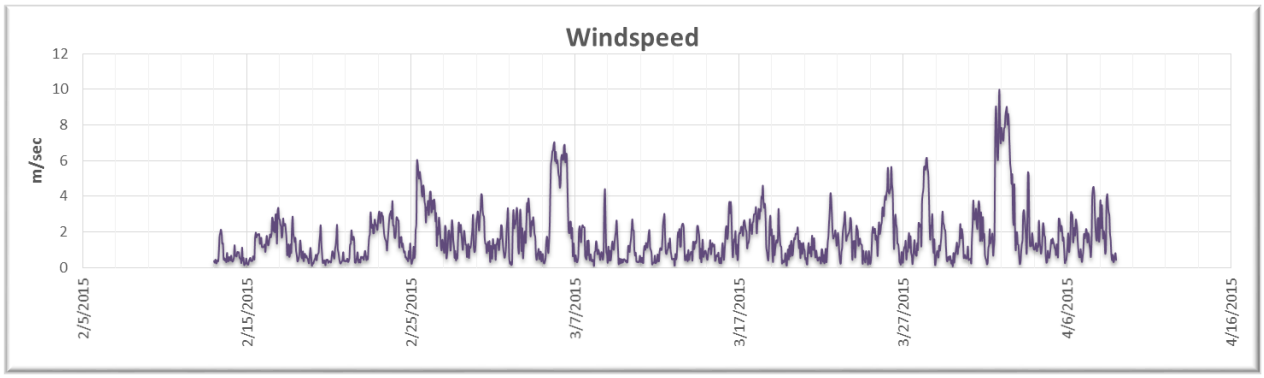


Figure 8: Wind-speed (1h-avg.) at measurement site

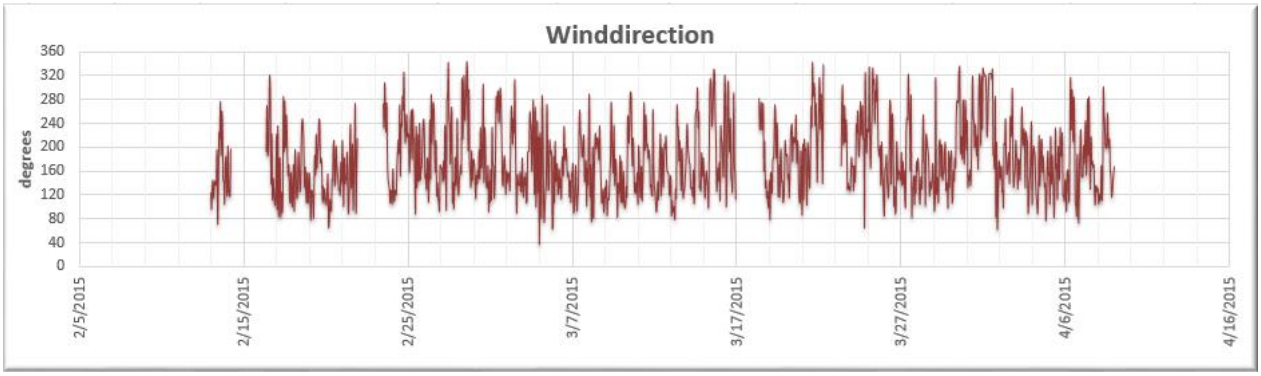


Figure 9: Wind-direction (1h-avg.) at measurement site

3. The Assigned Value

3.1 Selection of the Assigned Value

On two days for PM10 and on five days for PM2.5 the comparison of the ERLAP daily averages (2 values for each size fraction) with the Robust Average did not satisfy the criterion

$$|x_{pt} - x^*| \leq 2 * \sqrt{u^2_{(xpt)} + u^2_{(x*)}} \qquad \textbf{Equation 1}$$

given in ISO 13528:2015 [6].

As Assigned Value x_{pt}, it was decided to take the Robust Average x^* (Consensus Value from all participant results) calculated according to ISO 13528:2015 [6].

3.2 Calculation of the Robust Average and the Robust Standard Deviation

The Robust Average x^* and the Robust Standard Deviation s^* were calculated according to ISO 13528:2015 (part C.3.1) [6] as follows:

Calculation of initial values for x^* and s^*:

p items of data sorted into increasing order by: $x_{\{1\}}, x_{\{2\}},\ldots, x_{\{p\}}$

Note: p = Number of participants

x^* = median of x_i (i = 1,2,…,p)

s^* = 1.483 median of $|x_i - x^*|$ with (i=1,2,…,p)

Update the values of x^* and s^* as follows:

$\delta = 1.5 s^*$ **Equation 2**

For each x_i (i=1,2,…,p), calculate:

$$x_i^* = \begin{cases} x^* - \delta & \text{when } x_i < x^* - \delta \\ x^* + \delta & \text{when } x_i > x^* + \delta \\ x_i & \text{otherwise} \end{cases} \qquad \textbf{Equation 3}$$

Calculate the new values of $x^*$and s^* from:

$$x^* = \sum_{i=1}^{p} x_i^* / p \qquad \textbf{Equation 4}$$

$$s^* = 1.134 \sqrt{\sum_{i=1}^{p} (x_i^* - x^*)^2 / (p-1)} \qquad \textbf{Equation 5}$$

The robust estimates x^* and s^* were derived by iterative calculations, updating the values of x^* and s^* several times using the modified data in equations 2 to 5, until the process converged. Convergence was assumed when there was no change from one iteration to the next in the third significant digit of the Robust Mean and the Robust Standard Deviation (reached after 3 to 8 iterations).

3.3 Calculation of the Standard Uncertainty of the Assigned Value

The Standard Uncertainty of the Assigned Value $u(x_{pt})$ was calculated according to ISO 13528:2015 (part 7.7.3) [6] with equation 6:

$$u(x_{pt}) = 1.25 \times \frac{s^*}{\sqrt{p}}$$ **Equation 6**

4. Concentration range of the Assigned Value

The concentration range of the Assigned Value varied from 3.5 to 106 µg/m^3 for PM10, and from 2.1 to 96 µg/m^3 for PM2.5. Assigned values and uncertainties are listed in Annex A. Figure 10 shows the daily Assigned Value for PM10 and PM2.5 over the measurement period.

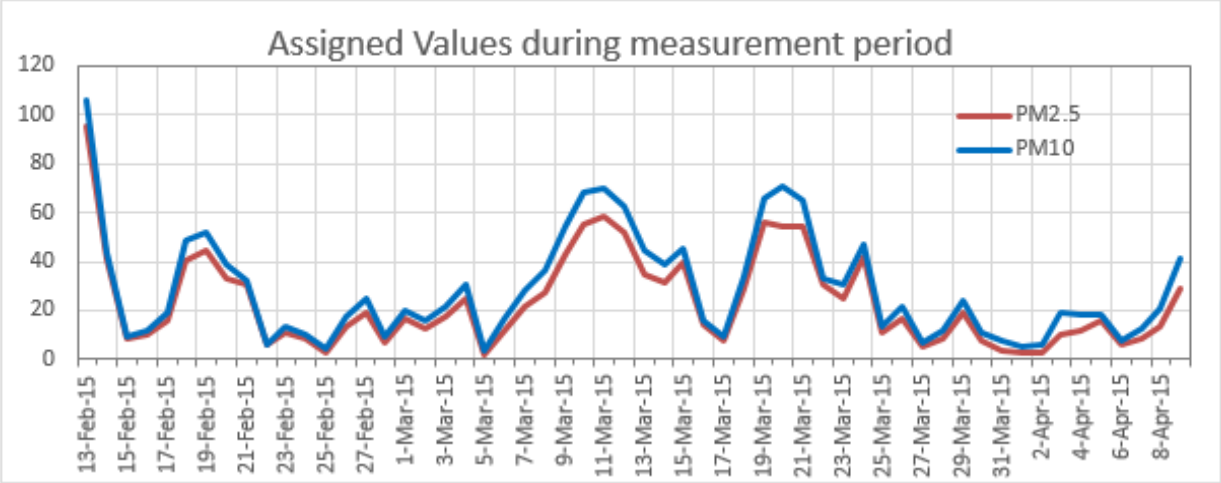


Figure 10: Assigned Values for PM10 and PM2.5 over the measurement period

Almost 50% of the Assigned Value for PM10 and more than 50% for PM2.5 are in a range <20 µg/m^3. Figures 11 and 12 show histograms with bins in steps of 10 µg/m^3. PM10's frequency distribution presents two modes, one between 10 and 20 µg/m^3 and another between 30 and 40 µg/m^3, while PM2.5's presents one distinct mode between 0 and 20 µg/m^3.

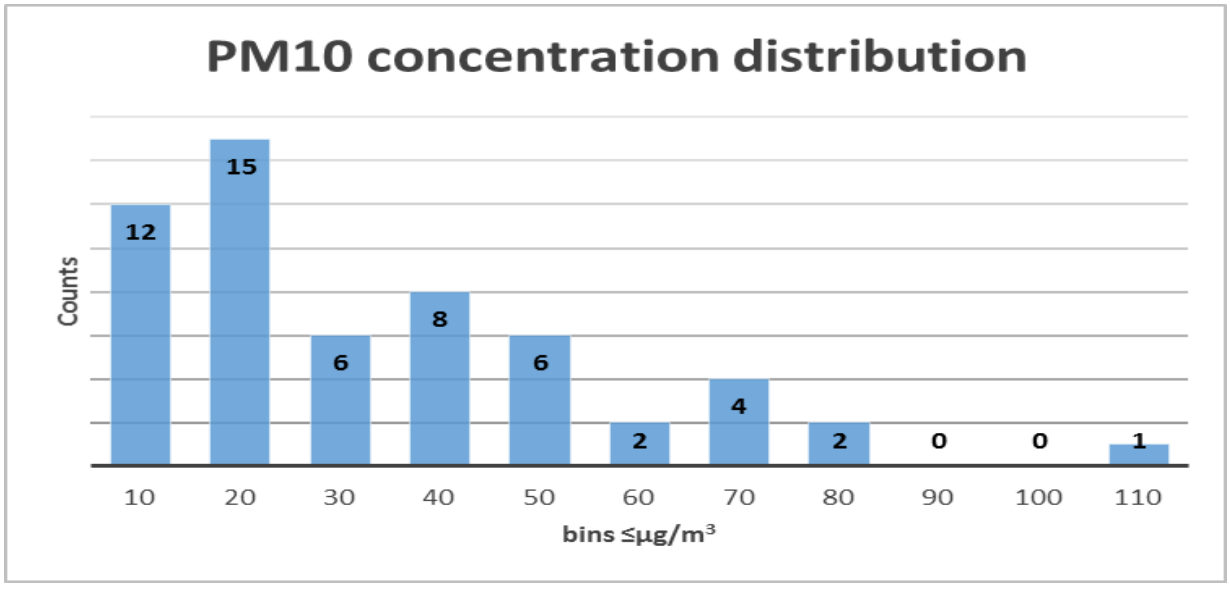


Figure 11: Histogram of the Assigned Values for PM10

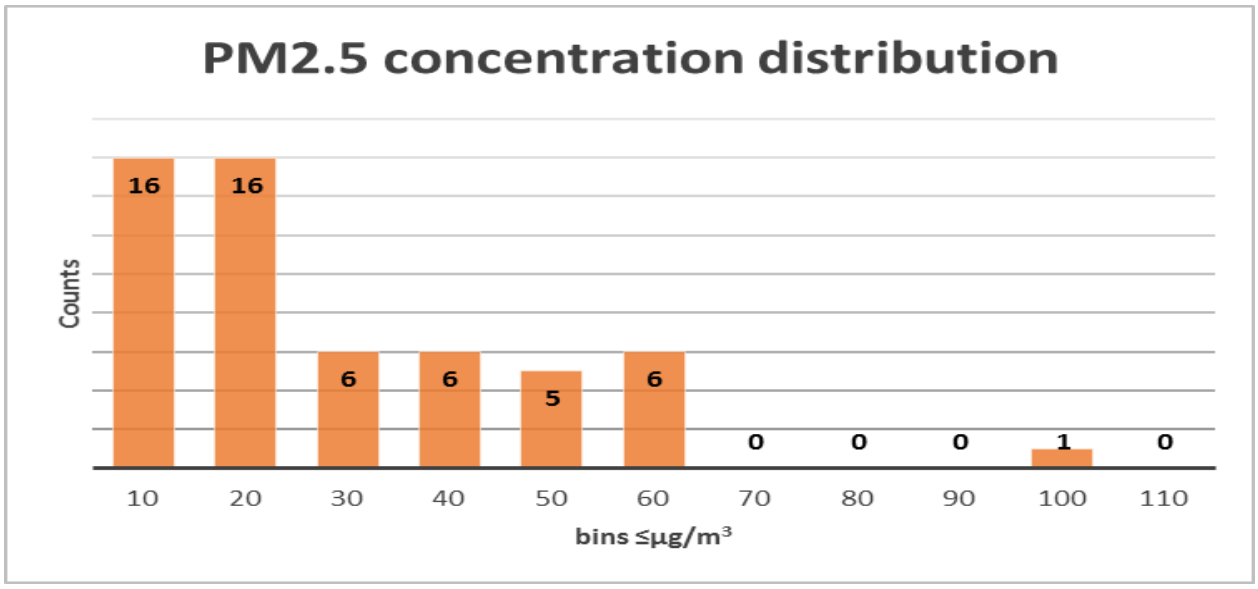


Figure 12: Histogram of the Assigned Values for PM2.5

The ratio PM2.5/PM10 of the Assigned Values is given in Figure 13.

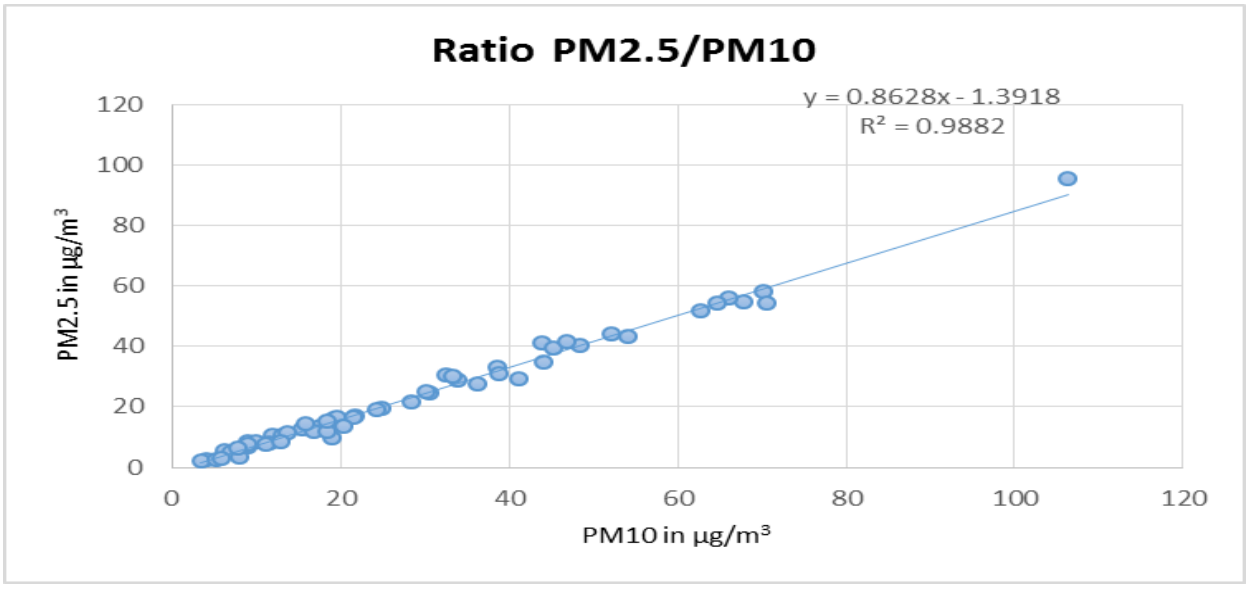


Figure 13: Ratio of PM2.5/PM10 Assigned Values

5. Evaluation of the Field Comparison Exercise

To evaluate the participant's measurement proficiency, the methodology described in ISO 13528:2015 [6] was applied. Derived from the data reported by all participants, the Robust Average x^* and its Standard Uncertainty $u(x_{pt})$ were taken as Assigned Value x_{pt} and Standard Deviation for proficiency assessment σ_{pt} for each daily value, details are listed in Annex A.

All data reported by all participating laboratories are also presented for each single day in Annex B.

The proficiency evaluation focuses on data that are as much as possible the reflection of every day work of the participating laboratories. For that reason, beforehand Grubb's outlier tests (5.1) were performed with the scope to detect exceptional errors.

The proficiency of the participants was assessed by calculation of two performance indicators, which both test if the difference between a participant's measured value and the Assigned Value remains within the limits of a criterion. They are calculated individually for each participant and each sample.

The first performance indicator (z'-score) compares the difference between the participant's measured value and the Assigned Value with the quadratic sum of the standard deviation for proficiency assessment and the standard uncertainty of the Assigned Value (5.2).

The second performance indicator (E_n-score) compares the difference between a participant's measured value and the Assigned Value with quadratic sum of the expanded uncertainties of the participant's measurement result and the Assigned Value (5.3).

Uncertainties of the participant's results were compared to each other and to the one of the Assigned Value (5.4).

In addition, the relative deviations of participant's results to the Assigned Value close to the level of and above the limit value (LV) of the European Directive were calculated and compared to the Data Quality Objective of the Directive (5.5).

To emphasize the overall uncertainty of both PM2.5 and PM10 measurements, the reproducibility of all participants was calculated both for all data and at the limit values of the European Directive 2008/50/EC [1], and compared to the corresponding concentration level (5.6).

5.1 Grubb's outlier test

The evaluation focuses on data, which are as much as possible reflecting participants performance levels and thus represents the comparability of their standard operating procedures for applying the standard EN12341:2014 [2]. For that reason a procedure for the detection of exceptional errors (error during typing, malfunction of instrumentation, etc.) was applied. Hence a "Grubb's test for one outlying observation" was performed according to ISO 5725, Part 2 [7].

The laboratories producing stragglers and/or outliers were first requested to investigate the cause of such discrepancies. They were allowed to correct their results in case of identification of exceptional errors. Subsequently, data were considered as definitive and "Grubb's test for one outlying observation" was repeated.

At this stage, data leading to the exceedance of the 1% critical value were considered outliers not due to exceptional errors. Data leading to the exceedance of the 5% critical value and not of the 1% critical value, were considered as stragglers.

5.1.1 PM10 Grubb's outlier test

In table 4 below are reported the outliers and stragglers identified during the field comparison exercise for PM10. The comment "min" or "max" indicate the side on which a critical value was exceeded.

Table 4: Outliers and stragglers for PM10

DAY	LAB	OUTLIER	STRAGGLER
1	J	min	
7	T	min	
11	R		min
13	N	max	
14	R	min	
17	L	max	
21	U	max	
29	M	max	
30	M		max
32	R		min
38	T	min	
41	S		min
42	T	min	
44	R		min
47	M	max	
50	M	max	
51	M	max	
53	M	max	
54	M	max	
55	R	min	
56	M	max	

5.1.2 PM2.5 Grubb's outlier test

In table 5 below are reported the outliers and stragglers identified during the field comparison exercise for PM2.5.

The comment "min" or "max" indicate the side on which a critical value was exceeded.

Table 5: Outliers and stragglers for PM2.5

DAY	LAB	OUTLIER	STRAGGLER
7	P	max	
8	P	min	
13	N	max	
14	T	max	
32	C	max	
33	Y		min

5.2 z'-scores

The z'-score statistic is calculated according to ISO 13528:2015 as:

$$z' = \frac{x_i - x_{pt}}{\sqrt{\sigma_{pt}^2 + u^2(x_{pt})}}$$ **Equation 7**

Where x_i is a participants value, x_{pt} is the Assigned Value, σ_{pt} is the standard deviation for proficiency assessment (in the case of this IE the standard deviation of the participants results was taken as σ_{pt}, detailed values are given in Tab. 15 and Tab. 18) and $u_{(xpt)}$ is the standard uncertainty of the Assigned Value.

The assessment of results in the z'-score evaluation is made according to the following criteria:

- $|z'| \leq 2$ are considered satisfactory
- $2 < |z'| \leq 3$ are considered questionable
- $|z'| > 3$ are considered unsatisfactory

The overall results of z'-score are presented in tables of exceedances and plots hereafter and in laboratory-specific bar plots in Annex C.

5.2.1 PM10 z'-scores

Figure 14 shows the z'-scores for PM10 measurements for each participant (vertical axis) and each day (horizontal axis) in colour chart from -4 (dark blue) to +4 (dark red). Entries for which no data were available have been assigned the value "0" in this figure. The data from two participants lead to z'-scores < -2 for more than 20% of the days, and the data from one participant lead to z'-scores > +2 for more than 20% of the days.

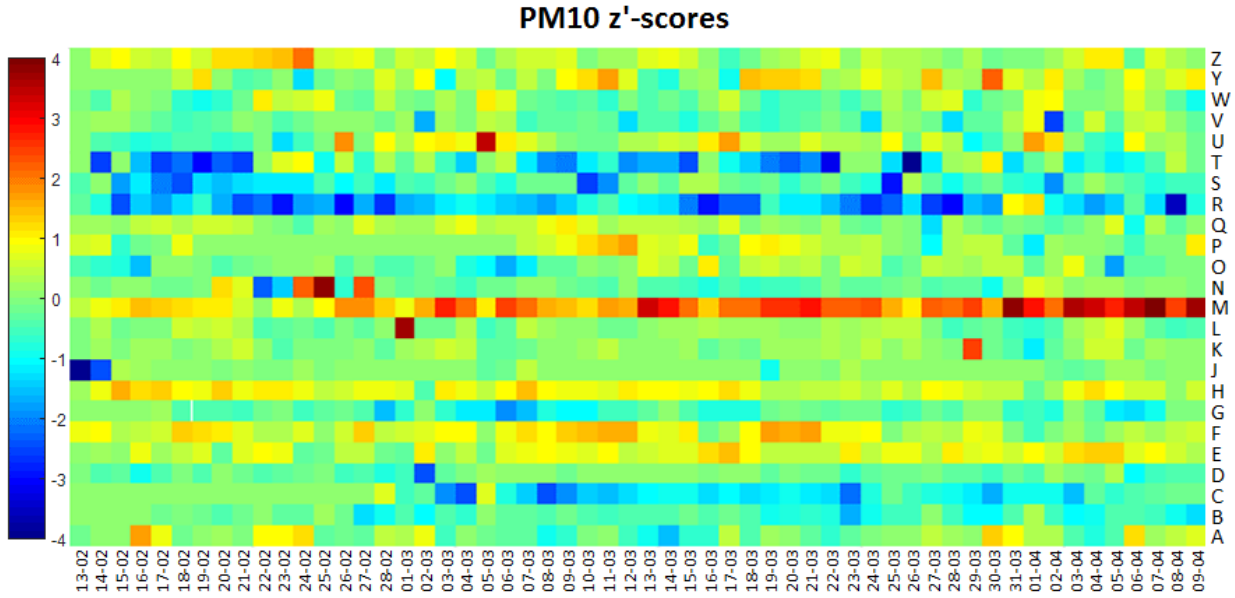


Figure 14: z'-scores for PM10 measurements in colour scale (left hand side) as a function of date (horizontal axis) and participant code (vertical axis).

Table 6 summarizes the z'-score for all PM10 results. 4.7% of the daily values were considered as "questionable" and 1.4 % as "unsatisfactory".

Table 6: Summary z'-score for PM10

Total daily averages	1245	
Daily averages in the range: $2 < \|z'\| \leq 3$	59	4.7 %
Daily averages in the range: $\|z'\| > 3$	17	1.4 %

5.2.2 PM2.5 z'-scores

Figure 15 shows the z'-scores for PM2.5 measurements similarly to Figure 14 above. The data from two participants lead to z'-scores < -2 for more than 20% of the days, and the data from one participant lead to z'-scores > +2 for more than 10% of the days.

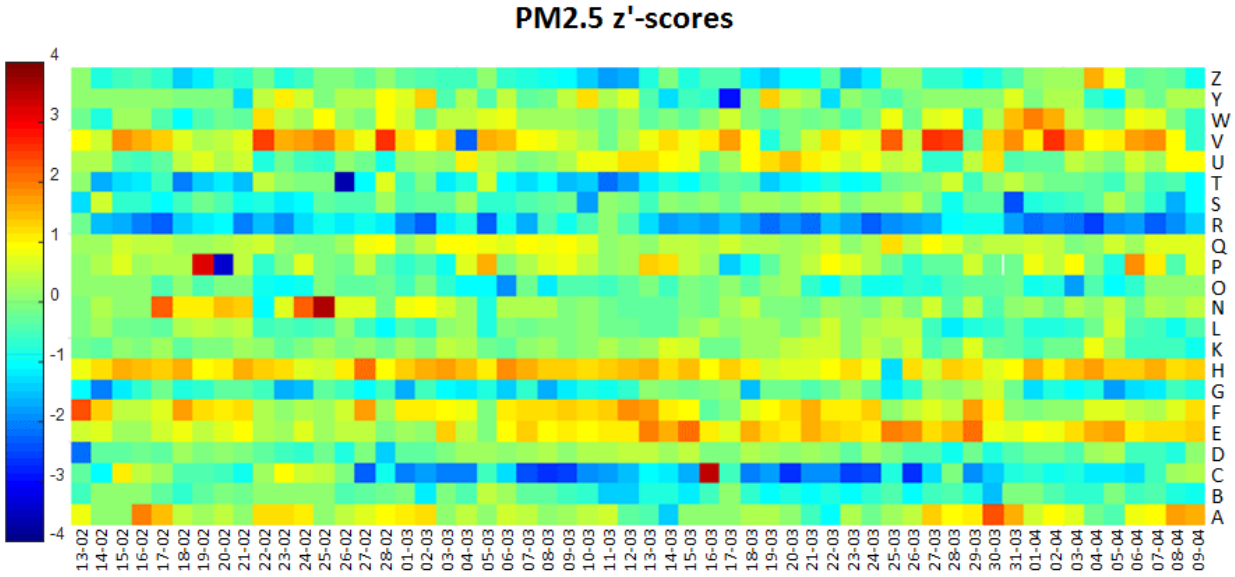


Figure 15: z'-scores for PM2.5 measurements in colour scale (left hand side) as a function of date (horizontal axis) and participant code (vertical axis).

Table 7 summarizes the z'-score for all PM2.5 results. 3.8 % of the daily averages were considered as "questionable" and 0.4 % as "unsatisfactory".

Table 7: Summary z'-score for PM2.5

Total daily averages	1193	
Daily averages in the range: $2 < \|z'\| \leq 3$	45	3.8 %
Daily averages in the range: $\|z'\| > 3$	5	0.4 %

5.3 E_n-scores

The E_n-scores are calculated according to ISO 13528:2015 as:

$$(E_n)_i = \frac{x_i - x_{pt}}{\sqrt{U^2(x_i) + U^2(x_{pt})}} \qquad \textbf{Equation 8}$$

Where x_i is a participant's value, x_{pt} is the Assigned Value, $U(x_i)$ is the participant's value expanded uncertainty and $U(x_{pt})$ is the expanded uncertainty of the Assigned Value. Participants' uncertainties were taken "as reported" (see chapter 5.4).

Successful performance is indicated by an $|E_n| \leq 1$, scores of $|E_n| > 1$ indicate either a need to review the uncertainty estimates or an erroneous measurement result. However, it shall be mentioned that the uncertainty (see Eq. 6) associated with the assigned value calculated as a Robust Average is lower than a typical uncertainty associated with a measurement result. This partly explains the rather high amount of data exceeding the E_n criterion.

The results of the E_n-scores are presented in figures and tables of exceedances hereafter. Further Annex D, in bar plots for each laboratory, presents the bias of each participant (x_i-x_{pt}) with error bars showing the denominator of the equation ($\sqrt{U^2(x_i) + U^2(x_{pt})}$). These plots represent also the E_n-scores where, considering the E_n criteria ($|E_n| \leq 1$), all results with error bars touching or crossing the x-axis are satisfactory.

5.3.1 PM10 E_n-scores

Figure 16 shows the E_n-scores for PM10 measurements for each participant (vertical axis) and each day (horizontal axis) in colour chart ranging from-5 (dark blue) to +5 (dark red), similarly to Figure 14. Entries for which no data were available have been assigned the value "0" in this figure. Very few are the participants for which both several E_n-scores <-1 and several E_n-scores >+1 are observed. This suggests that when significant with respect to the expanded uncertainties (|En|>1), the biases in the PM10 data reported by each participant are quite systematically positive or negative.

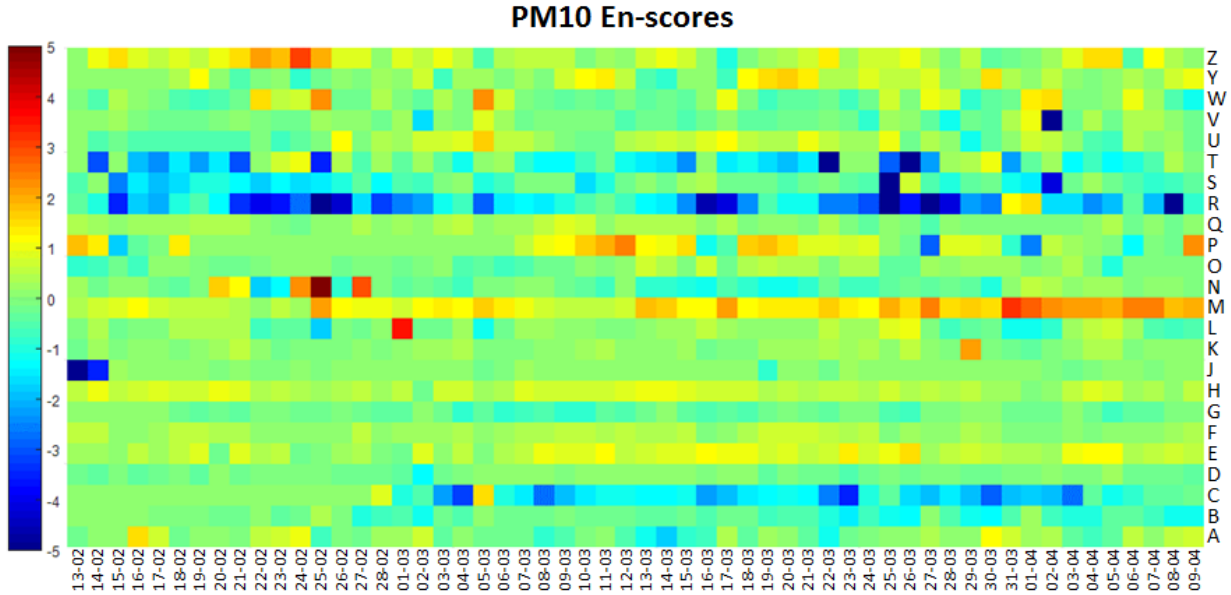


Figure 16: E_n-scores for PM10 measurements in colour scale (left hand side) as a function of date (horizontal axis) and participant code (vertical axis).

Table 8 summarizes the E_n-score for all PM10 results. 21.2 % of the daily averages exceeded the criterion of $|E_n| \leq 1$.

Table 8: Summary E_n-score for PM10

Total daily averages	1245	
Daily averages with $\|E_n\| \geq 1$	264	21.2 %

5.3.2 PM2.5 E_n-scores

Figure 17 shows the E_n-scores for PM2.5 measurements for each participant (vertical axis) and each day (horizontal axis) similarly to Figure 16. As for PM10, biases appear quite

systematically positive (orange-red) or negative (turquoise-blue) for participants data corresponding to |En|>1.

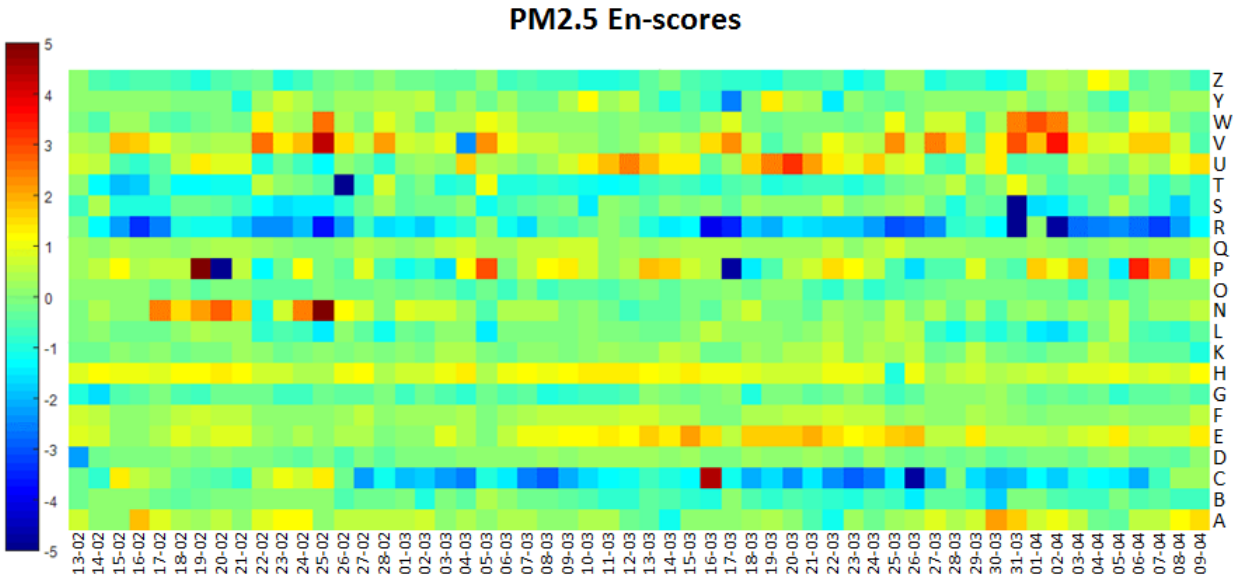


Figure 17: E_n-scores for PM2.5 measurements in colour scale (left hand side) as a function of date (horizontal axis) and participant code (vertical axis)

Table 9 summarizes the E_n-score for all PM2.5 results. 22.7 % of the daily averages exceeded the criterion of $|E_n| \leq 1$.

Table 9: Summary E_n-score for PM2.5

Total daily averages	1193	
Daily averages with $\|E_n\| \geq 1$	271	22.7 %

5.4 Uncertainties of participants results

To better understand the results of the E_n-scores, a closer look was given to the participants reported uncertainties and the uncertainty calculated for the Assigned Value. Most of the participants calculated their uncertainties with respect to the measured concentration, some gave a constant (or more or less constant) figure for the whole measurement period. This led to considerable differences between the participants, worst on the day with the highest measured PM concentration (Feb.13th, 2015), where expanded uncertainties between 1 and 15 µg/m^3 were reported. As this has a direct influence on the E_n-score (see equation 8), a review of the calculation of uncertainties (e.g. following EN 12341:2014) is advised for some participants. Figure 18 and 19 show the reported expanded uncertainties for PM10 and PM2.5 including the calculated uncertainty of the Assigned Value. The latter, being lower than a typical individual uncertainty, has a direct influence on the outcome of all E_n-scores as described in chapter 5.3.

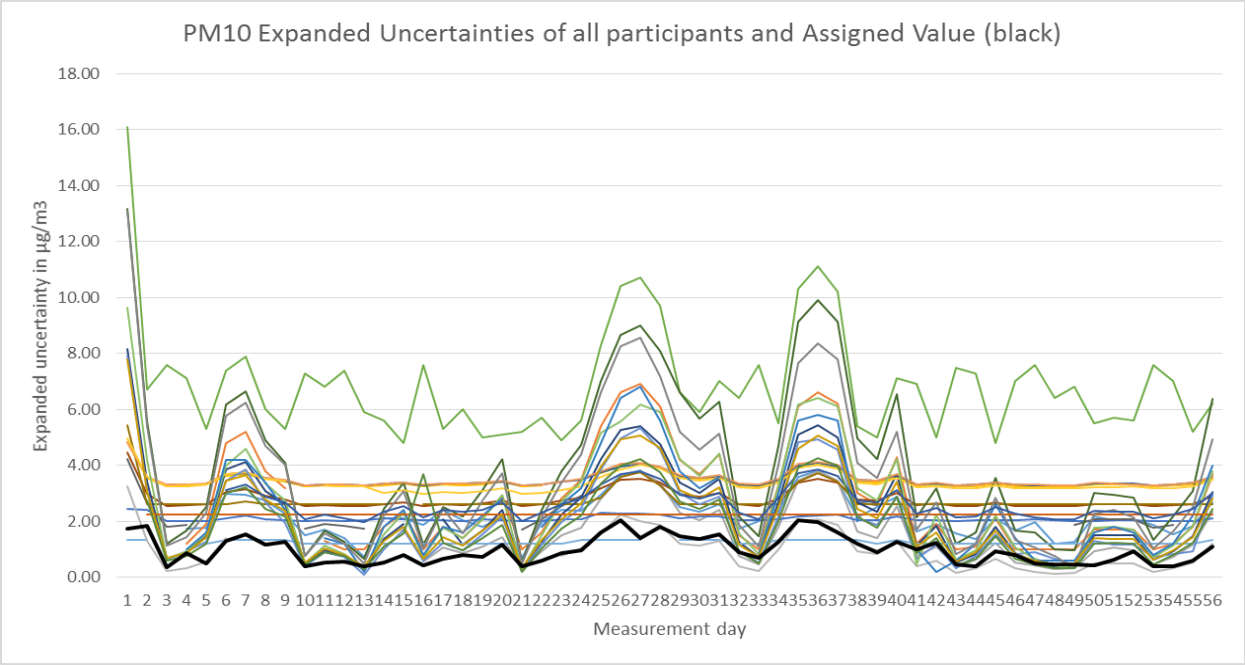


Figure 18: Expanded uncertainties of all participants' PM10 data and the Assigned Value

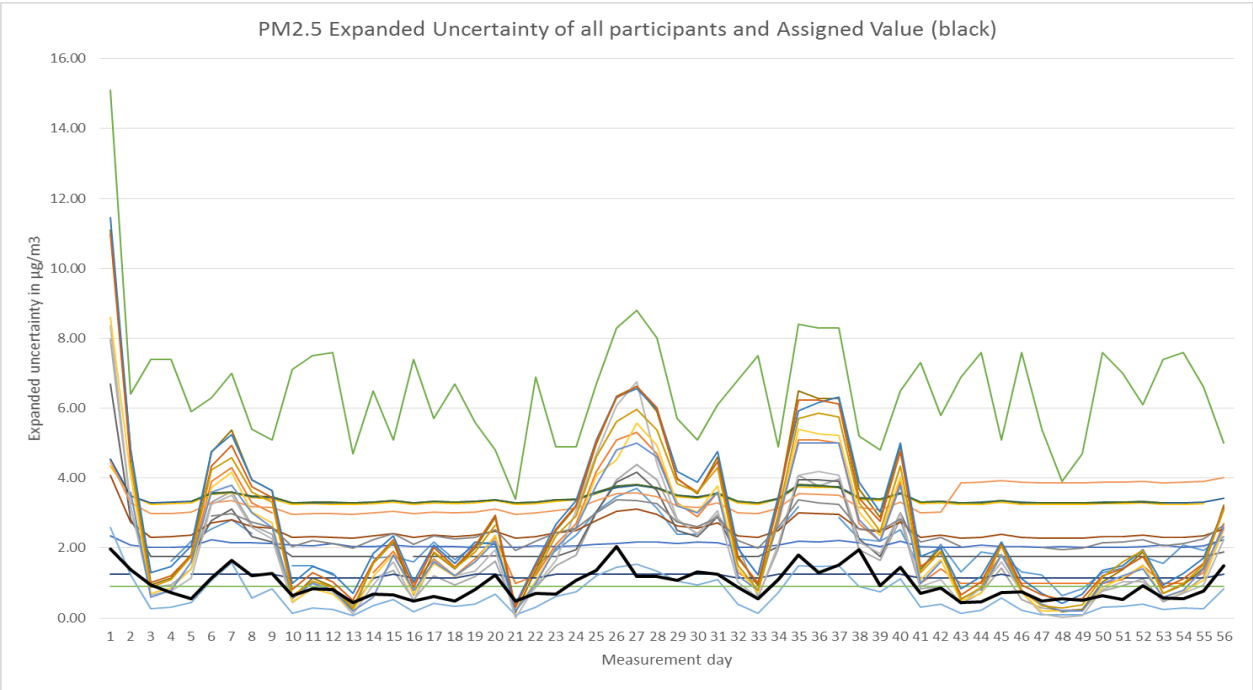


Figure 19: Expanded uncertainties of all participants' PM2.5 data and the Assigned Value

5.5 Compliance with the Data Quality Objective (DQO) of the European Directive

The participant's results in this field inter-comparison exercise were analysed to identify if they comply with the DQO for ambient air quality assessment given in Annex I of the European Directive 2008/50/EC [1].

The LV is 50 µg/m^3 for PM10 as a 24 h average and 25 µg/m^3 for PM2.5 as an annual average. The DQO for PM10 and PM2.5 is given as 25% at the Limit Value (LV), hence on both limit values a margin of 25% was applied. The fact, that relative deviations of participants' PM2.5

data are compared against the annual average, needs to be considered when PM2.5 data are interpreted.

5.5.1 PM10 relative deviations at the daily limit value

To compare data to the DQO close to the LV and above, the following procedure has been applied:
Only data measured when the Assigned Value was higher than 37.5 µg/m³ (= 0.75*LV) were compared to the DQO. The relative difference between each single daily value measured by a participant and the Assigned Value was calculated and shown in figure 20. For PM10, only 5 daily values exceeded the DQO, corresponding to 1.3% of all measured data in this concentration range.

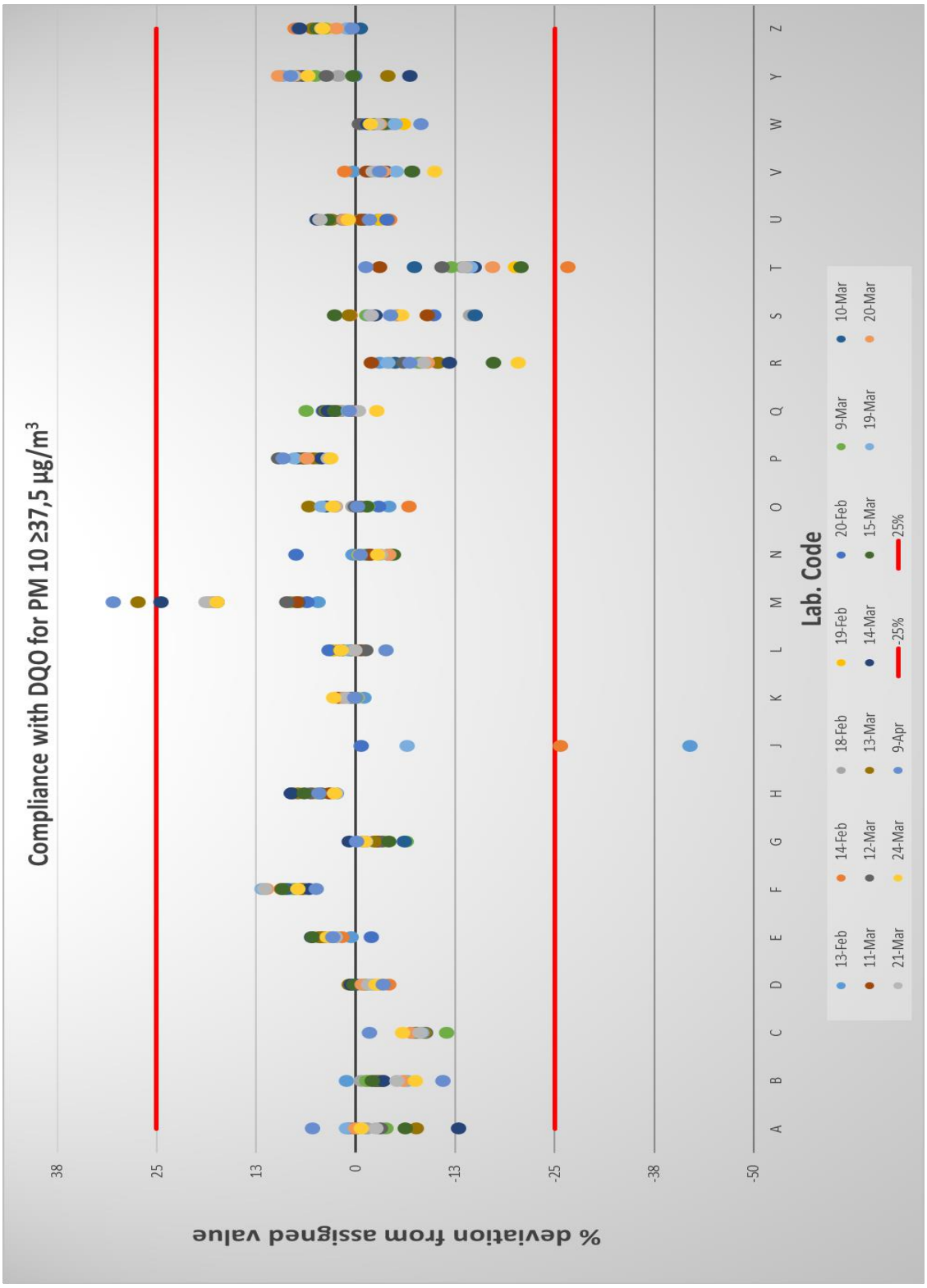


Figure 20: Relative deviations of participant's daily averages to the Assigned Value in the range of the daily LV for PM10

5.5.2 PM2.5 relative deviations at the annual limit value

To compare data to the DQO close to the LV and above, the following procedure has been applied:

As no daily LV for PM2.5 is available, the annual LV was considered. Only data measured when the Assigned Value was higher than 18.75 µg/m3 (= 0.75*LV) were compared to the DQO. The relative difference between each single daily value measured by a participant and the Assigned Value was calculated and shown in figure 21. For PM2.5, only 2 daily values exceeded the DQO, corresponding to 0.4% of all measured data in this concentration range.

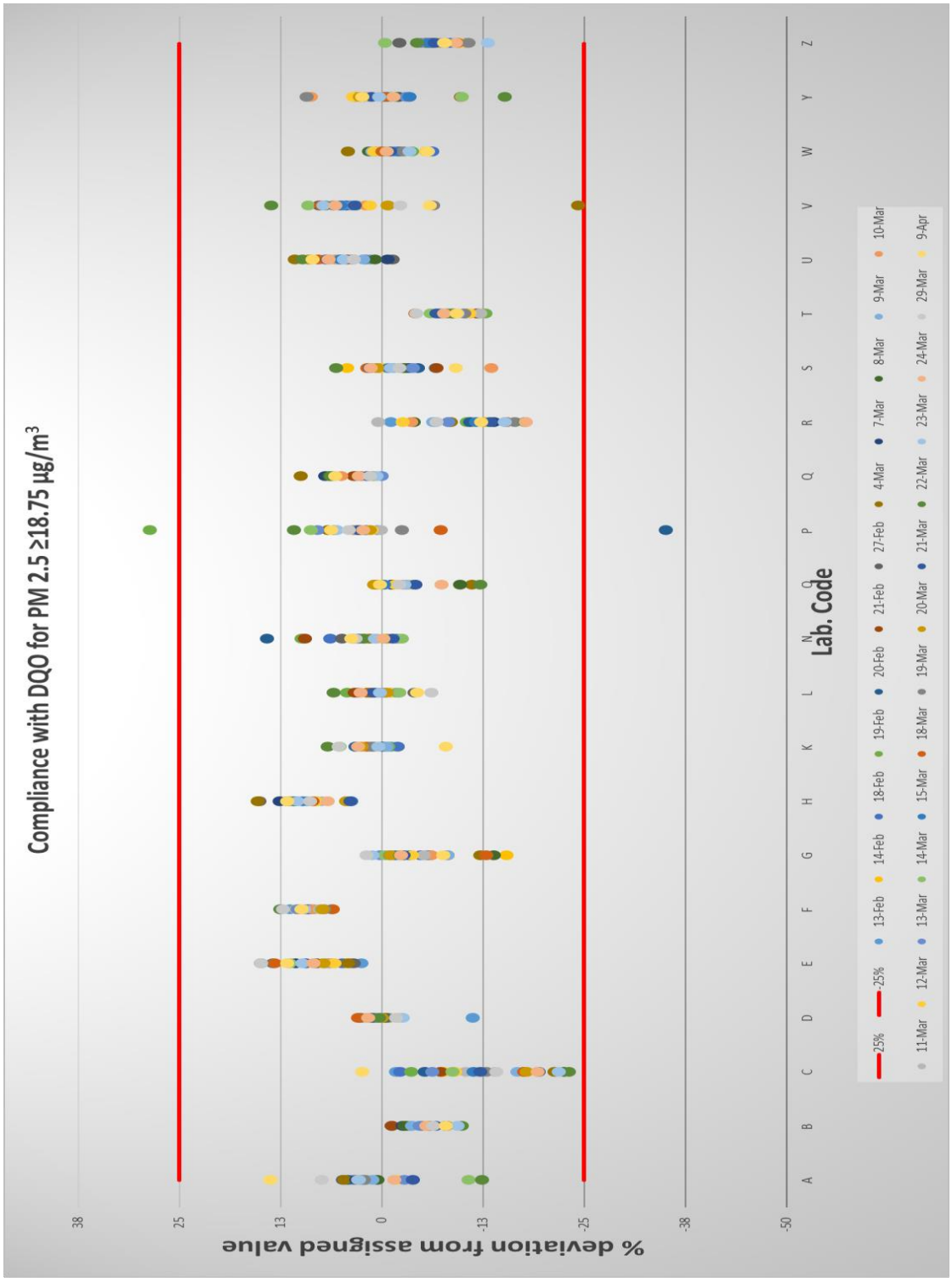


Figure 21: Relative deviations of participant's daily averages to the Assigned Value in the range of the annual LV

5.6 Reproducibility

The reproducibility of the method *R* [7] was calculated firstly of all daily values (including outliers and stragglers) and secondly of daily values exceeding 75% of the daily limit value (50 µg/m³) or the annual limit value (25 µg/m³) for PM10 and PM2.5, respectively. Table 10 lists the reproducibility of PM10 and PM2.5 measurements for the entire field comparison exercise.

Table 10: Reproducibility for PM10 and PM2.5 of the field comparison exercise

	PM10			PM2.5		
	R in %	participants	days	R in %	participants	days
all data	14	24	56	17	22	56
data ≥ 37.5 µg/m³	7	24	17			
data ≥ 18.75 µg/m³				7	22	26

Multiplying these figures with a coverage factor of 2 (95% probability) gives an indication on the overall uncertainty of PM10 and PM2.5 measurements. Hence, both the expanded uncertainty at the limit value of PM10 (14.4%) and PM2.5 (15%) would comply with the DQO of the European Directive 2008/50/EC (25%).

In a second stage, the reproducibility was calculated for each single day and compared to the corresponding concentration (Figures 22 and 23). As expected, the reproducibility depends on the measured concentration with a tendency to worsen at low concentration levels. Apart from a few cases, where outliers strongly affect the results (e.g. for PM10 at min and max concentration, for PM2.5 at min concentration), the reproducibility is quite homogenous at the various concentration levels. Multiplying all reproducibility-results with a coverage factor of 2, data above 22 µg/m³ (PM10) and 17 µg/m³ (PM2.5) comply with the requirement of the DQO of the European Directive 2008/50/EC.

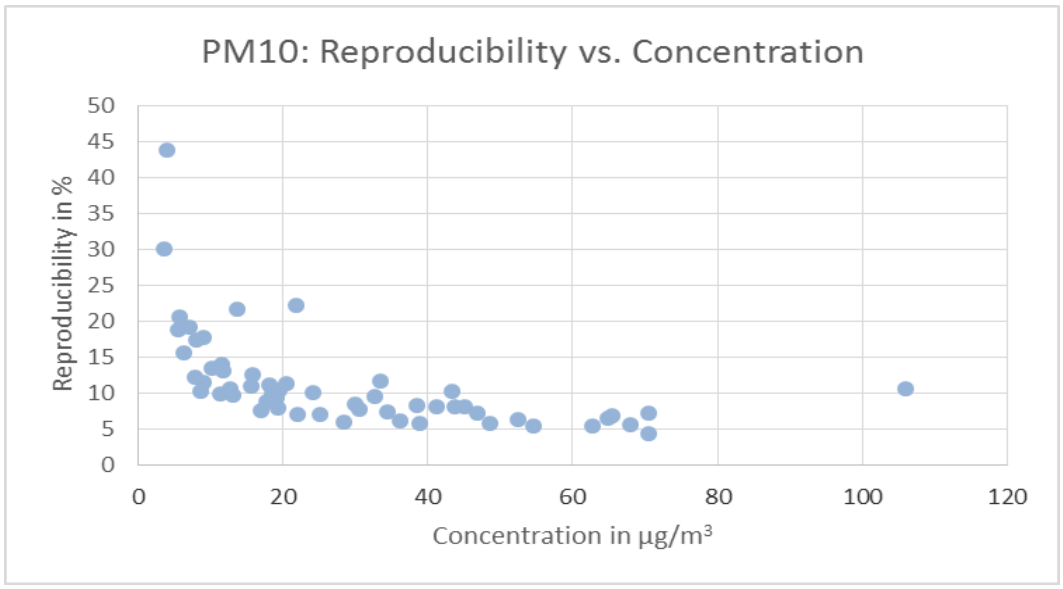


Figure 22: PM10 method reproducibility versus concentration

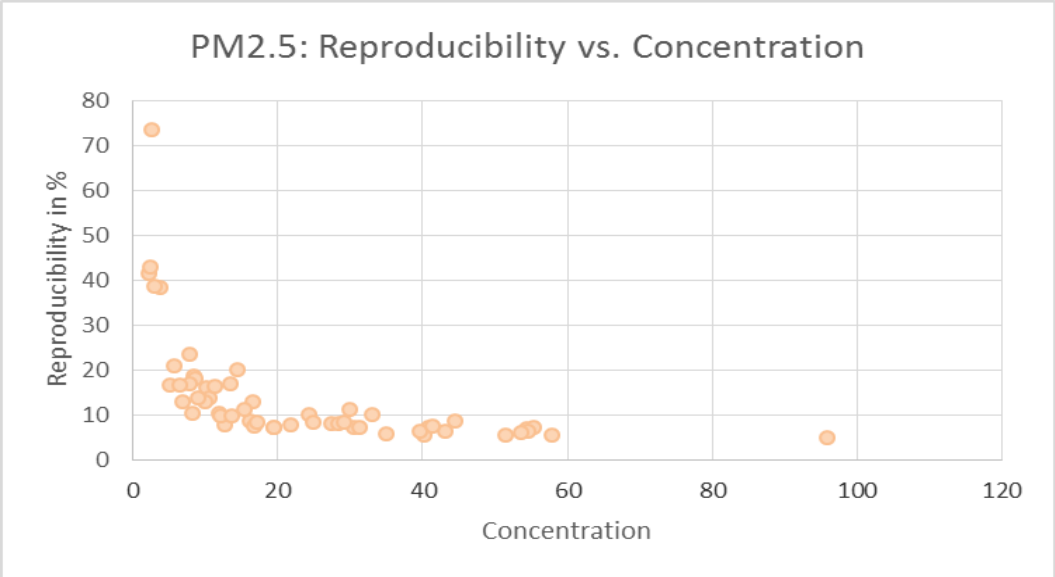


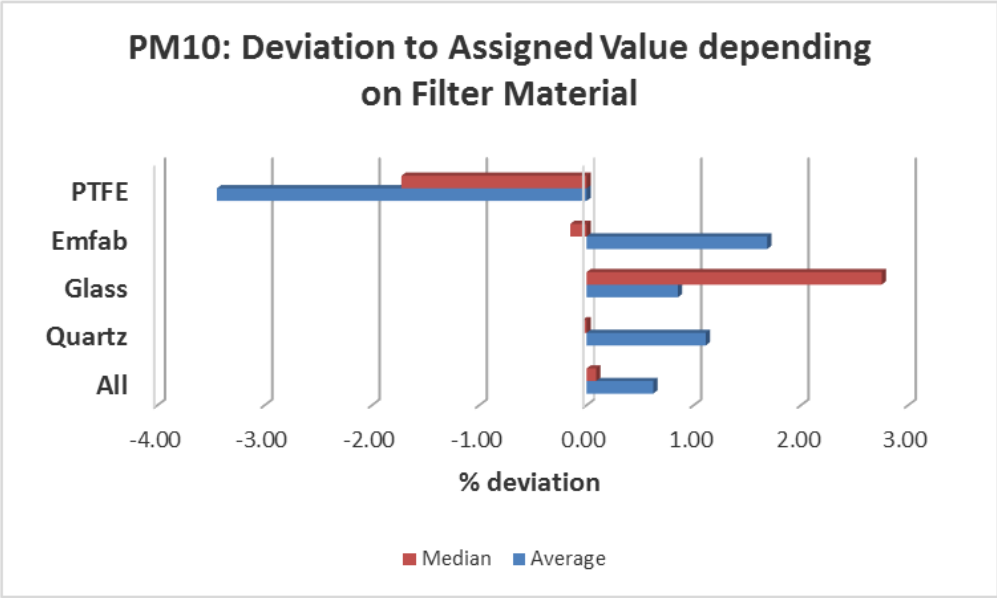
Figure 23: PM2.5 method reproducibility versus concentration

5.7 Differentiation between used filter materials and samplers with/without cooling system

5.7.1 Differentiation between used filter materials

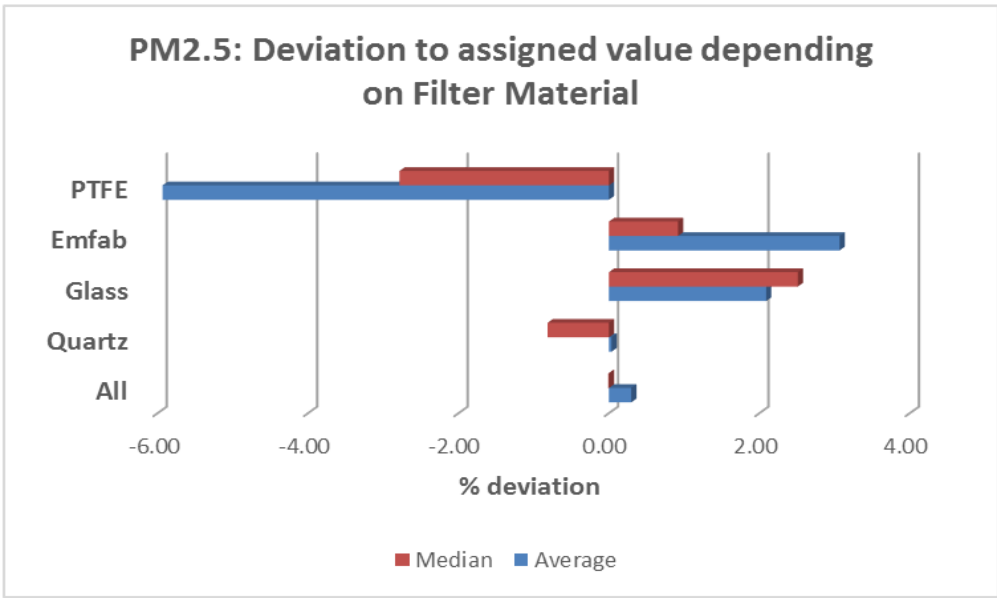
To identify a possible influence of the filter material used, data were split into the categories Quartz, Glass, PTFE and Emfab both for PM10 and PM2.5. Quartz filters were used by most of the participants (14 for PM10, 12 for PM2.5), followed by Glass filters (5 for PM10, 6 for PM2.5), PTFE filters (3 for PM10, 2 for PM2.5) and Emfab filters (2 for PM10, 2 for PM2.5).

The relative deviations to the Assigned Value were calculated for both the median and average of each "filter category". The results are presented in Figure 24 and 25. Due to the facts that Glass, PTFE and Emfab are represented by a small number of participants (p) only and outliers are included in this calculation, conclusions shall be considered very carefully. However, PTFE filters lead to significantly lower determination of PM10 (-4%) and PM2.5 (-6%) compared to the assigned values, dominated by the most commonly used filter material (quartz). In contrast, the reproducibility for each "filter category" is rather homogeneous compared to the others (apart from Emfab-PM2.5, see tables next to the figures).



	All	Quartz	Glass	Emfab	PTFE
R in %	14	14	13	18	12
p	24	14	5	2	3

Figure 24: PM10 deviation to Assigned Value depending on Filter Material



	All	Quartz	Glass	Emfab	PTFE
R in %	17	18	13	26	13
p	22	12	6	2	2

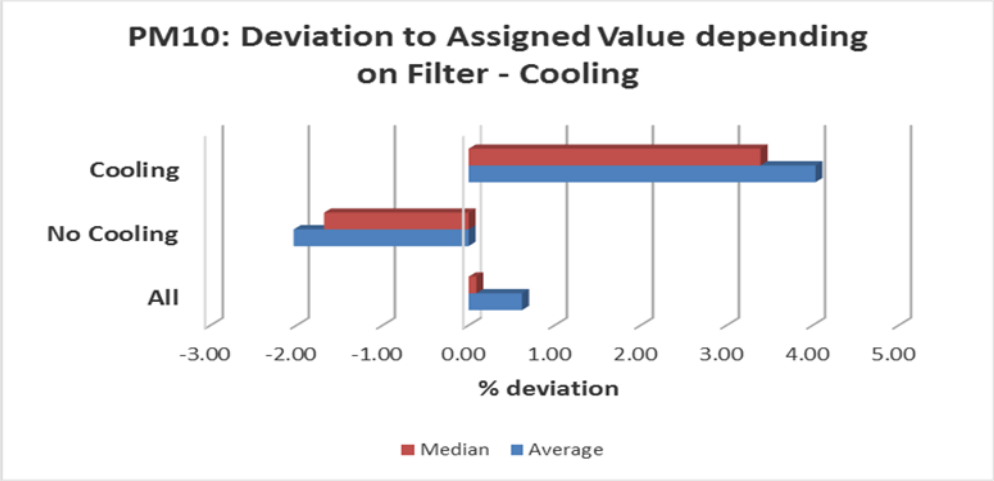
Figure 25: PM2.5 deviation to Assigned Value depending on Filter Material

5.7.2 Differentiation between samplers with/without filter-cooling

To identify a possible influence of the use of a filter-storage-cooling system, data were separated into the categories "Cooling" and "No Cooling" both for PM10 and PM2.5. "No

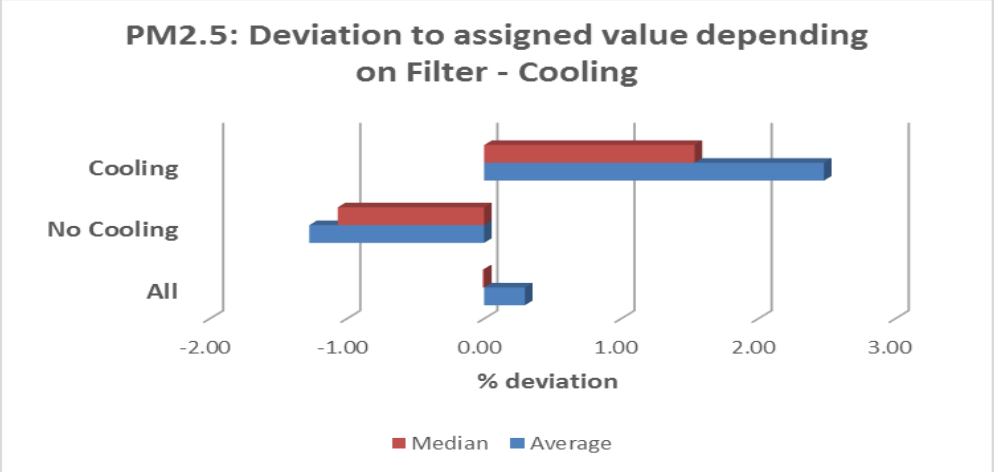
Cooling" samplers were used by more participants (14 for PM10, 13 for PM2.5) than "Cooling" samplers (10 for PM10, 9 for PM2.5).

The relative deviations to the Assigned Value were calculated for both the median and average of each "cooling-category". The results are presented in Figure 26 and 27. Cooled samplers lead to significantly higher (99.9% confidence level) PM10 (+6%) and PM2.5 (+4%) values than non-cooled samplers. In contrast, the reproducibility for each "cooling-category" is similar (see tables next to the figures).



	All	No Cooling	Cooling
R in %	14	14	13
p	24	14	10

Figure 26: PM10 deviation to Assigned Value depending on Filter Cooling (all labs)



	All	No Cooling	Cooling
R in %	17	20	14
p	22	13	9

Figure 27: PM2.5 deviation to Assigned Value depending on Filter Cooling (all labs)

Conclusion

For the present inter-laboratory comparison exercise, assigned daily values for PM10 and PM2.5 were computed as the robust average of the values determined by the participants. Comparisons with the data obtained by the European Reference Laboratory for Air Pollution (local participant) do not indicate any detectable loss of PM due to the filters' shipment. From statistical evaluations of the results some major conclusions have been drawn.

The performance of the participants was evaluated using Grubb's test, z'-scores, and En-scores:

- Through Grubb's test 16 values of PM10 (1.2% of the total results submitted) and 5 of PM2.5 (0.4% of the total results submitted) were found to be outliers. More than half of the outliers for PM10 come from 2 laboratories only.
- For z'-scores, only 1.4% of the results for PM10 and 0.4% for PM2.5 were found non satisfactory ($|z'|>3$). Close to half of the unsatisfactory entries for PM10 were produced by one single participant, who also produced most of the outliers in Grubb's test.
- For E_n-scores, 21.2% of the values of PM10 and 22.7% of the values of PM2.5 exceeded the test threshold ($|E_n|>1$). The large percentage of entries considered not valid for the E_n-score test is partly due to the small uncertainty of the assigned values, which were obtained by calculation (Robust Average) and not from measurements with a reference instrument. It also suggests that the expanded uncertainty of the measurements provided by some participants were underestimated. It is recommended to calculate the uncertainty according to EN 12341:2014 [2].
- Five laboratories produced outliers or stragglers for more than 10% of the days and are advised to examine their procedures.

The robustness of the measurement method was assessed by computing its reproducibility, and by comparing the deviation in PM concentrations to the Data Quality Objective (DQO) of ±25% at the limit value:

- The reproducibility of the method was 14% and 17% for PM10 and PM2.5, respectively, with a tendency to increase at lower concentration levels beyond the DQO.
- For PM10, only 5 measurements (1.4% of all the results) did not meet the DQO at the daily limit value (50 µg/m³). For PM2.5, the bias exceeded the DQO of ±25% at 25 µg/m³ for 2 measurements only (0.4% of all the data). The reference method for PM2.5 and PM10 measurement as defined in EN 12341:2014 therefore fulfils the DQO as defined in the Directive 2008/50/EC.

Cooled filter storage inside the used sequential samplers led to significantly higher (confidence level 99.9%) PM10 and PM2.5 values than non-cooled filter storage (+6% and +4% for PM10 and PM2.5, respectively), while PTFE membrane filters led to significantly lower (confidence level 99.9%) PM10 and PM2.5 values compared to the assigned values (-4% and -6% for PM10 and PM2.5, respectively).

References

[1] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe, L 152, 11.06.2008

[2] EN 12341:2014, Ambient air - Standard gravimetric measurement method for the determination of the PM10 or PM2.5 mass concentration of suspended particulate matter

[3] http//ies.jrc.ec.europa.eu/aquila-project/aquila-homepage.html

[4] E. de Saeger, M. Gerboles, H. Rau, M. Payrissat. European comparison of Nitrogen Dioxide calibration methods quality assurance programme n 1, QAP/1 of the European Directive for Nitrogen Dioxide. EUR 17661.

[5] F. Lagler, C. Belis, A. Borowiak. A quality Assurance and Control Program for PM 2.5 and PM10 measurements in European Air Quality Monitoring Networks. EUR 24851

[6] ISO 13528:2015, Statistical methods for use in proficiency testing by interlaboratory comparisons

[7] ISO 5725-2:1994, Accuracy (trueness and precision) of measurement methods and results – Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method

Annex A: Assigned Values and associated Expanded Standard Uncertainties (k=2)

Table 11: Assigned values for PM10 and PM2.5 from 13th of February till 11th of March

	PM10		PM2.5	
day	x(pt)	U(xpt)	x(pt)	U(xpt)
13-Feb-15	105.95	1.75	95.90	1.98
14-Feb-15	43.31	1.85	40.77	1.39
15-Feb-15	8.93	0.37	8.45	0.95
16-Feb-15	11.71	0.88	10.21	0.73
17-Feb-15	19.33	0.49	16.20	0.54
18-Feb-15	48.59	1.30	40.14	1.14
19-Feb-15	52.37	1.55	44.47	1.64
20-Feb-15	38.81	1.17	33.10	1.21
21-Feb-15	32.67	1.26	30.47	1.28
22-Feb-15	6.32	0.38	5.67	0.63
23-Feb-15	13.14	0.53	10.52	0.84
24-Feb-15	10.15	0.57	8.53	0.81
25-Feb-15	4.04	0.41	2.66	0.45
26-Feb-15	17.78	0.54	13.41	0.68
27-Feb-15	25.09	0.79	19.45	0.66
28-Feb-15	8.62	0.43	6.79	0.47
1-Mar-15	19.45	0.65	16.75	0.61
2-Mar-15	15.56	0.79	12.74	0.48
3-Mar-15	21.97	0.72	17.12	0.81
4-Mar-15	30.47	1.15	24.37	1.24
5-Mar-15	3.49	0.38	2.10	0.48
6-Mar-15	16.97	0.60	11.81	0.71
7-Mar-15	28.39	0.87	21.84	0.69
8-Mar-15	36.25	0.97	27.46	1.09
9-Mar-15	54.60	1.62	43.16	1.37
10-Mar-15	67.97	2.03	54.42	2.04
11-Mar-15	70.56	1.39	57.94	1.20

Table 12: Assigned values for PM10 and PM2.5 from 12th of March till 9th of April

	PM10		PM2.5	
day	$x_{(pt)}$	$U_{(xpt)}$	$x_{(pt)}$	$U_{(xpt)}$
12-Mar-15	62.73	1.80	51.53	1.18
13-Mar-15	43.75	1.46	35.02	1.08
14-Mar-15	38.52	1.36	31.26	1.33
15-Mar-15	45.00	1.54	39.62	1.26
16-Mar-15	15.80	0.91	14.47	0.88
17-Mar-15	9.01	0.71	7.76	0.55
18-Mar-15	34.34	1.27	28.36	1.11
19-Mar-15	65.38	2.03	55.41	1.79
20-Mar-15	70.45	1.96	54.46	1.29
21-Mar-15	64.84	1.60	53.50	1.51
22-Mar-15	33.44	1.19	29.93	1.96
23-Mar-15	29.89	0.89	24.81	0.92
24-Mar-15	46.86	1.26	41.46	1.44
25-Mar-15	13.59	0.99	11.22	0.69
26-Mar-15	21.77	1.24	16.44	0.86
27-Mar-15	6.99	0.48	5.17	0.44
28-Mar-15	11.28	0.41	8.26	0.46
29-Mar-15	24.08	0.93	19.42	0.73
30-Mar-15	11.53	0.79	7.90	0.75
31-Mar-15	8.09	0.49	3.67	0.49
1-Apr-15	5.43	0.47	2.43	0.54
2-Apr-15	5.62	0.47	2.97	0.51
3-Apr-15	19.04	0.44	9.87	0.64
4-Apr-15	18.56	0.62	12.10	0.53
5-Apr-15	18.20	0.94	15.33	0.93
6-Apr-15	7.93	0.39	6.50	0.57
7-Apr-15	12.75	0.41	8.88	0.56
8-Apr-15	20.38	0.61	13.60	0.78
9-Apr-15	41.21	1.11	29.09	1.50

Annex B: Participant's data

Table 13: Participant's value PM10 lab code from A to H

PM10	A		B		C		D		E		F		G		H	
day	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U
13-Feb-15	104.52	5.64	107.30	10.70			104.59	4.83	106.58	2.45	114.40	16.10			108.53	4.46
14-Feb-15							41.53	3.54	44.08	2.42	47.40	6.70			46.78	2.98
15-Feb-15							8.65	3.26	8.98	2.01	9.30	7.60			10.53	2.55
16-Feb-15	14.48	1.74	11.90	1.20			10.26	3.27	13.02	2.02	12.50	7.10			13.53	2.57
17-Feb-15	20.66	1.78	19.10	1.90			18.73	3.31	19.70	2.03	20.20	5.30	19.53	3.36	21.44	2.63
18-Feb-15	47.97	2.97	48.30	4.80			48.24	3.64	50.01	2.10	52.50	7.40	47.41	3.68	51.17	3.07
19-Feb-15	52.49	2.94	51.60	5.20			50.84	3.68	54.51	2.20	56.20	7.90	50.67	3.73	55.06	3.14
20-Feb-15	39.19	2.74	37.70	3.80			38.84	3.51	38.09	2.08	41.40	6.00	37.82	3.54	41.97	2.90
21-Feb-15	32.48	2.27	31.90	3.20			31.97	3.42	34.64	2.05	34.90	5.30	31.10	3.46	35.29	2.80
22-Feb-15	7.23	1.50					5.85	3.25	7.20	2.01	6.60	7.30	6.11	3.30	7.40	2.54
23-Feb-15	14.33	1.72	12.70	1.30			12.66	3.28	14.26	2.03	13.50	6.80	13.04	3.32	14.46	2.57
24-Feb-15	11.79	1.41	9.80	1.00			9.90	3.26	9.67	2.01	11.20	7.40	9.35	3.33	11.27	2.56
25-Feb-15	3.50	0.73	4.40	1.00			3.83	3.25	3.81	2.03	4.20	5.90	3.47	3.30	4.79	2.53
26-Feb-15	17.52	2.10	17.50	1.80			16.86	3.30	18.39	2.10	18.60	5.60	17.52	3.35	18.66	2.61
27-Feb-15	24.54	2.11	22.70	2.30			24.19	3.35	25.81	2.07	27.40	4.80	24.40	3.40	26.58	2.68
28-Feb-15	9.02	1.88	7.80	1.00	9.28	0.57	7.88	3.26	8.40	2.03	9.00	7.60	7.19	3.30	9.36	2.55
1-Mar-15	20.10	2.41	18.50	1.80	18.18	1.07	18.32	3.31	18.91	2.04	20.70	5.30	18.05	3.34	20.76	2.62
2-Mar-15	16.92	2.03	13.60	1.40	14.91	0.88	11.32	3.27	17.39	2.02	16.80	6.00	15.59	3.34	14.86	2.58
3-Mar-15	21.16	1.82	21.30	2.10	18.90	1.11	21.42	3.33	22.13	2.06	23.40	5.00	20.90	3.37	23.71	2.65
4-Mar-15	30.65	2.15	28.90	2.90	24.59	1.43	30.33	3.41	31.64	2.04	32.70	5.10	27.56	3.43	32.58	2.76
5-Mar-15	3.29	0.69	3.50	1.00	4.22	0.31	3.75	3.25	3.30	2.01	3.50	5.20	2.22	3.29	4.00	2.53
6-Mar-15	16.58	1.99	16.50	1.60	15.87	0.94	17.03	3.30	17.92	2.02	18.10	5.70	14.32	3.33	18.20	2.60
7-Mar-15	27.94	2.40	27.90	2.80	25.78	1.50			29.77	2.07	30.40	4.90	25.70	3.41	30.95	2.74
8-Mar-15	34.18	2.39	35.30	3.50	30.65	1.78			38.49	2.06	38.50	5.60	34.51	3.50	38.45	2.84
9-Mar-15	52.56	2.94	53.90	5.40	48.41	2.80	54.01	3.73	57.17	2.30	58.80	8.30	51.19	3.74	57.00	3.18
10-Mar-15	67.94	3.67	66.20	6.60	62.04	3.59	68.04	3.99	70.61	2.28	73.90	10.40	63.85	3.97	71.11	3.49
11-Mar-15	70.68	3.82	68.60	6.90	65.63	3.79			73.76	2.29	75.50	10.70	68.63	4.06	72.94	3.54
12-Mar-15	60.80	3.28	61.20	6.10	58.22	3.37			64.40	2.23	68.50	9.70	60.67	3.91	66.32	3.38
13-Mar-15	40.45	2.51	42.30	4.20	40.00	2.32	44.12	3.58	45.63	2.13	46.70	6.60	42.76	3.61	46.98	2.99
14-Mar-15	33.55	2.35	37.20	3.70	35.35	2.05	38.77	3.50	40.69	2.18	40.80	5.90	38.86	3.56	41.66	2.90
15-Mar-15	42.21	2.62	44.10	4.40	41.54	2.41	45.13	3.59	47.48	2.16	49.20	7.00	43.17	3.62	47.93	3.01
16-Mar-15	14.37	1.72	14.80	1.50	13.01	0.77	15.67	3.29	18.29	2.04	15.30	6.40	14.04	3.33	17.68	2.60
17-Mar-15	9.70	2.02	8.80	1.00	7.35	0.46	9.11	3.26	11.36	2.05	9.40	7.60	7.74	3.30	10.91	2.55
18-Mar-15	33.25	2.33	33.30	3.30	30.97	1.80	34.46	3.45	36.85	2.06	36.90	5.50	32.30	3.48	36.59	2.82
19-Mar-15	66.19	3.57	61.20	6.10	60.03	3.47	64.00	3.91	67.39	2.19	73.10	10.30	64.57	3.98	67.08	3.40
20-Mar-15	70.52	3.81	66.30	6.60	65.57	3.79	69.89	4.02	72.90	2.21	78.40	11.10	69.87	4.09	72.36	3.52
21-Mar-15	63.26	3.42	61.50	6.20	59.65	3.45	63.85	3.91	66.55	2.26	72.30	10.20	64.11	3.97	66.53	3.39
22-Mar-15	30.49	2.13	30.30	3.00	28.32	1.65	32.66	3.43	35.28	2.06	36.60	5.40	32.05	3.48	35.19	2.80
23-Mar-15	29.12	2.50	25.60	2.60	24.13	1.41	27.98	3.38	32.71	2.05	32.10	5.00	29.39	3.45	31.31	2.74
24-Mar-15	46.58	2.89	43.40	4.30	44.12	2.55	45.72	3.60	48.57	2.16	50.30	7.10	46.34	3.66	48.13	3.01
25-Mar-15	13.61	1.63	11.80	1.20	13.16	0.78	13.13	3.28	15.88	2.04	13.40	6.90	11.44	3.32	15.65	2.58
26-Mar-15	22.09	1.90	18.90	1.90	19.01	1.11	20.86	3.32	25.48	2.05	23.10	5.00	19.28	3.36	23.05	2.65
27-Mar-15	7.62	1.59	7.00	1.00	5.80	0.38	6.83	3.26	7.44	2.02	7.50	7.50	6.68	3.30	8.24	2.54
28-Mar-15	11.46	1.38	10.70	1.10	10.19	0.62	10.97	3.27	12.53	2.03	11.70	7.30	10.76	3.31	12.16	2.56
29-Mar-15	24.36	2.10	21.40	2.10	21.11	1.23	23.16	3.34	25.83	2.05	26.20	4.80	24.28	3.40	25.48	2.67
30-Mar-15	13.81	1.66	9.80	1.00	8.83	0.54	10.57	3.27	12.85	2.05	12.70	7.00	11.57	3.32	12.32	2.56
31-Mar-15	9.46	1.97	7.50	1.00	6.81	0.43	7.91	3.26	8.90	2.08	8.00	7.60	7.16	3.30	8.74	2.55
1-Apr-15	5.82	1.21	5.70	1.00	4.42	0.31	4.99	3.25	6.40	2.04	4.90	6.40	4.86	3.30	5.13	2.53
2-Apr-15	6.05	1.26	4.90	1.00	4.51	0.32	5.88	3.25	6.24	2.02	5.50	6.80	4.65	3.30	5.90	2.54
3-Apr-15	18.26	2.19	17.20	1.70	16.22	0.95	18.89	3.31	21.13	2.03	19.40	5.50	19.15	3.36	20.51	2.62
4-Apr-15	17.01	2.04	16.80	1.70	18.01	1.06	18.25	3.31	21.05	2.05	18.30	5.70	17.98	3.35	20.85	2.62
5-Apr-15	17.24	2.07	17.40	1.70	16.67	0.98	18.92	3.31	20.93	2.04	18.50	5.60	15.81	3.34	20.26	2.62
6-Apr-15	9.05	1.88	7.50	1.00	7.44	0.47	6.92	3.26	8.64	2.01	8.30	7.60	6.67	3.30	8.54	2.54
7-Apr-15	12.93	1.55	11.90	1.20	12.38	0.74	12.05	3.27	14.02	2.02	13.00	7.00	11.52	3.32	13.58	2.57
8-Apr-15	21.30	1.83	18.30	1.80	19.85	1.16	19.34	3.31	21.75	2.02	21.40	5.20	20.27	3.37	20.56	2.62
9-Apr-15	43.48	2.70	36.70	3.70	40.52	2.35	39.82	3.52	42.44	2.10	43.30	6.20	41.17	3.59	43.12	2.92

Table 14: Participant's value PM10 lab code from J to Q

PM10	J		K		L		M		N		O		P		Q	
day	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U
13-Feb-15	61.56	4.22	104.94	5.45	105.75	8.14	111.00	13.16	106.35	1.33	101.59	4.82	112.55	3.25	107.96	4.95
14-Feb-15	32.17	2.64	43.93	2.60	44.56	3.43	47.02	5.58	42.62	1.33	40.43	3.58	46.37	1.30	44.30	3.59
15-Feb-15	9.25	1.80	8.93	2.60	8.78	0.68	10.02	1.19			8.05	3.31	8.16	0.23	9.01	3.27
16-Feb-15	11.99	1.86	12.04	2.60	11.53	0.89	14.03	1.66			9.20	3.31	11.34	0.35	12.41	3.28
17-Feb-15			19.65	2.60	19.23	1.48	21.33	2.53	19.04	1.21	19.40	3.36	19.26	0.55	20.23	3.33
18-Feb-15			48.54	2.60	50.05	3.85	52.12	6.18	47.88	1.33	48.82	3.70	50.98	1.39	49.50	3.68
19-Feb-15			52.48	2.73	53.77	4.14	55.96	6.64	52.15	1.33	52.22	3.76			54.07	3.75
20-Feb-15	38.55	2.92	39.40	2.60	40.11	3.09	41.20	4.89	41.72	1.33	37.72	3.54			39.99	3.53
21-Feb-15			34.25	2.60	33.80	2.60	34.45	4.09	34.92	1.33	32.06	3.48			33.94	3.46
22-Feb-15	6.25	1.75	6.43	2.60	5.89	0.45	6.33	0.75	3.99	1.21	6.27	3.30				
23-Feb-15	13.07	1.92	12.61	2.60	12.69	0.98	14.22	1.69	11.34	1.21	13.16	3.32			13.11	3.28
24-Feb-15	10.37	1.83	10.09	2.60	9.82	0.76	10.57	1.25	13.24	1.21	10.32	3.31			9.55	3.27
25-Feb-15	4.00	1.72	3.86	2.60	3.21	0.25	5.65	0.67	10.81	1.21	4.34	3.30			4.45	3.26
26-Feb-15			17.66	2.60	17.61	1.36	20.59	2.44	16.69	1.21	17.07	3.36			17.81	3.03
27-Feb-15					24.57	1.89	28.44	3.37	29.30	1.21	24.88	3.40			26.26	3.10
28-Feb-15			8.39	2.60			9.84	1.17	8.52	1.21	8.19	3.31			8.96	2.98
1-Mar-15			19.78	2.60	27.07	2.09	21.14	2.51	18.86	1.21	18.66	3.36			19.97	3.05
2-Mar-15			16.15	2.60	15.23	1.17	18.23	2.16	15.14	1.21	15.31	3.34			15.99	3.02
3-Mar-15			22.79	2.60	21.64	1.67	26.25	3.11	21.40	1.21	22.00	3.38			22.97	3.07
4-Mar-15			31.60	2.60	31.23	2.41	35.56	4.22	29.21	1.21	28.52	3.44	32.31	3.17	28.08	2.16
5-Mar-15	3.16	1.72	3.15	2.60	2.95	0.23	4.56	0.54	3.35	1.21	2.33	3.29			3.85	2.97
6-Mar-15	16.74	2.07	16.60	2.60	16.63	1.28	20.24	2.40	16.77	1.21	14.72	3.33			17.63	3.03
7-Mar-15	29.14	2.53	27.97	2.60	29.07	2.24	32.08	3.81	28.40	1.21	26.24	3.42	29.10	0.78	29.21	3.13
8-Mar-15	36.31	2.93	36.43	2.60	36.78	2.83	39.74	4.71	36.28	1.33	35.38	3.51	37.65	1.03	38.10	3.25
9-Mar-15			54.67	2.84	54.95	4.23	59.07	7.01	53.97	1.33	53.80	3.78	57.15	1.57	58.05	3.58
10-Mar-15			68.89	3.58	68.32	5.26	72.92	8.65	66.85	1.33	68.03	4.05	72.93	2.24	70.74	3.85
11-Mar-15			72.13	3.75	70.12	5.40	75.84	9.00	69.29	1.33	70.18	4.09	75.21	2.02	70.98	4.01
12-Mar-15			62.97	3.27	62.00	4.77	68.18	8.09			62.79	3.95	68.85	1.87	64.37	3.88
13-Mar-15			44.14	2.60	44.15	3.40	55.73	6.61	41.92	1.33	46.33	3.66	46.08	1.22	45.38	3.54
14-Mar-15			38.91	2.60	39.23	3.02	47.95	5.69	36.92	1.33	39.97	3.57	40.19	1.14	39.86	3.46
15-Mar-15			45.55	2.60	45.85	3.53	52.87	6.27	42.92	1.33	44.42	3.64	47.90	1.29	46.22	3.55
16-Mar-15			15.25	2.60	16.55	1.27	18.41	2.18	14.09	1.21	18.04	3.35	14.70	0.41	16.27	3.22
17-Mar-15			8.99	2.60	9.29	0.72	12.40	1.47	8.20	1.21	8.44	3.31	8.62	0.24	10.15	3.19
18-Mar-15			33.89	2.60	34.78	2.68	39.74	4.71	32.69	1.33	35.65	3.52	36.92	1.01	34.30	3.39
19-Mar-15	61.17	4.16	66.14	3.44	66.03	5.08	77.10	9.14	62.69	1.33	68.19	4.05	70.48	2.02	66.00	3.91
20-Mar-15			71.56	3.72	70.60	5.44	83.51	9.91	67.55	1.33	72.30	4.14	74.84	2.07	70.98	4.01
21-Mar-15			65.60	3.41	65.00	5.01	77.12	9.15	62.89	1.33	66.60	4.02	67.13	1.86	64.67	3.88
22-Mar-15	32.95	2.70	34.73	2.60	34.91	2.69	41.93	4.97	32.95	1.33	33.44	3.49	34.65	0.94	34.76	3.39
23-Mar-15	30.67	2.60	30.51	2.60	30.46	2.35	35.72	4.24	28.94	1.21	31.23	3.47	30.66	0.83	29.49	3.33
24-Mar-15			48.17	2.60	47.78	3.68	55.05	6.53	45.57	1.33	48.25	3.69	48.35	1.31	45.63	3.54
25-Mar-15			13.67	2.60	14.83	1.14	18.05	2.14	13.08	1.21	12.22	3.32	13.61	0.38	13.78	3.21
26-Mar-15			23.47	2.60	24.07	1.85	26.80	3.18	21.24	1.21	20.64	3.37	21.50	0.59	21.43	3.26
27-Mar-15			7.01	2.60	6.90	0.53	10.03	1.19	6.47	1.21	7.52	3.30	5.53	0.15	5.20	3.17
28-Mar-15			11.21	2.60	10.66	0.82	13.67	1.62	10.91	1.21	11.67	3.32	11.70	0.31	11.70	3.19
29-Mar-15			30.04	2.60	23.32	1.80	30.09	3.57	23.44	1.21	24.68	3.40	25.13	0.65	23.93	3.27
30-Mar-15			11.12	2.60	11.19	0.86	14.22	1.69	9.99	1.21	12.28	3.32	12.16	0.33	11.02	3.19
31-Mar-15			7.54	2.60	7.28	0.56	13.49	1.60	8.16	1.21	8.65	3.31	7.62	0.20	7.93	3.18
1-Apr-15			4.24	2.60	4.70	0.36	8.39	1.00	6.17	1.21	5.16	3.30	4.17	0.12	5.19	3.17
2-Apr-15	5.38	1.89	5.24	2.60	5.05	0.39	8.02	0.95	6.17	1.21	5.87	3.30	5.90	0.15	5.14	3.17
3-Apr-15	18.57	2.08	19.07	2.60	19.43	1.50	25.34	3.01	19.14	1.21	20.39	3.37	19.23	0.50	18.67	3.23
4-Apr-15	18.31	2.07	19.70	2.60	19.36	1.49	24.79	2.94	18.87	1.21	18.37	3.35	18.60	0.50	18.71	3.23
5-Apr-15	18.47	2.07	19.30	2.60	19.56	1.51	23.88	2.83	18.59	1.21	14.54	3.33	18.15	0.50	19.58	3.24
6-Apr-15	8.10	1.79	7.74	2.60	8.08	0.62	11.30	1.34	7.89	1.21	7.68	3.30	7.35	0.19	7.05	3.17
7-Apr-15	12.73	1.89	12.92	2.60	12.26	0.94	18.23	2.16	12.88	1.21	12.30	3.32	12.70	0.34	13.16	3.20
8-Apr-15			20.44	2.60	19.19	1.48	26.07	3.09	20.50	1.21	20.23	3.37	20.23	0.53	19.67	3.24
9-Apr-15			41.31	2.60	39.66	3.05	53.78	6.38	40.99	1.33	41.16	3.59	44.99	1.21	41.57	3.48

Table 15: Participant's value PM10 lab code from R to Z and σ_{pt} of all participants

PM10	R		S		T		U		V		W		Y		Z		All
day	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	σ_{pt}
13-Feb-15	102.86	7.92	100.52	9.64					106.37	13.08	105.04	7.79					11.17
14-Feb-15	39.84	3.07	43.65	4.20	31.80	3.20	41.50	2.26	43.94	5.40	41.25	3.06			46.66	2.76	4.39
15-Feb-15	6.39	0.62	6.98	0.68			8.40	2.26	9.19	1.13	9.26	0.69			9.95	0.59	1.03
16-Feb-15	9.48	0.92	9.76	0.94	9.20	1.00	10.40	2.26	11.60	1.43	11.90	0.88			12.66	0.75	1.55
17-Feb-15	16.53	1.27	16.18	1.56	15.36	1.60	18.20	2.26	18.84	2.32	19.16	1.42			20.08	1.19	1.54
18-Feb-15	44.86	3.45	41.64	4.00	42.10	4.20	47.30	2.26	46.91	5.77	46.46	3.45	49.70	3.13	51.19	3.03	2.83
19-Feb-15	50.08	3.86	47.71	4.58	41.90	4.20	50.80	2.26	50.71	6.24	49.28	3.66	56.40	3.33	54.26	3.21	3.31
20-Feb-15	34.85	2.68	35.02	3.36	33.40	3.40	37.30	2.26	38.12	4.69	37.29	2.77	38.90	2.88	41.60	2.46	2.29
21-Feb-15	25.10	1.93	28.50	2.74	24.60	2.40	31.10	2.26	32.72	4.03	31.97	2.37	31.20	2.68	36.54	2.16	3.08
22-Feb-15	4.12	0.40	5.18	0.50			6.30	2.26	6.25	0.77	7.35	0.55	6.00	2.06	7.60	0.45	0.99
23-Feb-15	9.36	0.91	11.59	1.12	14.10	1.40	11.50	2.26	12.65	1.56	13.73	1.02	13.20	2.23	15.01	0.89	1.27
24-Feb-15	7.58	0.74	8.50	0.82	11.40	1.20	9.40	2.26	9.80	1.21	10.92	0.81	8.40	2.11	13.02	0.77	1.37
25-Feb-15	1.02	0.10	3.27	0.32	2.40	0.20	4.00	2.26	4.15	0.51	5.38	0.40	3.60	1.97	5.06	0.30	1.77
26-Feb-15	12.99	1.00	16.04	1.54	18.50	1.80	20.60	2.26	17.84	2.19	17.51	1.30	17.80	2.35	18.81	1.11	1.55
27-Feb-15	21.97	1.69	24.06	2.30	23.90	2.40	24.90	2.26	25.16	3.09	24.51	1.82	25.00	2.53	26.59	1.57	1.78
28-Feb-15	6.19	0.60	7.49	0.72	8.90	0.80	9.50	2.26	8.43	1.04	8.98	0.67	9.20	2.13		3.68	0.88
1-Mar-15	15.93	1.23	18.44	1.78	18.80	1.80	20.10	2.26	19.96	2.46	19.39	1.44	19.80	2.40	20.62	1.22	2.04
2-Mar-15	12.73	0.98	14.54	1.40	16.10	1.60	17.10	2.26	12.71	1.56	15.13	1.12	17.30	2.34	16.28	0.96	1.70
3-Mar-15	19.98	1.54	21.65	2.08	21.10	2.20	23.70	2.26	22.22	2.73	22.56	1.67	20.30	2.42	23.51	1.39	1.55
4-Mar-15	28.08	2.16	30.65	2.94	27.10	2.80	32.50	2.26	30.23	3.72	30.32	2.25	31.30	2.69	31.83	1.88	2.36
5-Mar-15	2.23	0.22	3.01	0.28			7.20	2.26	3.99	0.49	4.64	0.34	4.00	2.01	3.26	0.19	1.04
6-Mar-15	15.02	1.16	15.91	1.52	17.50	1.80	18.40	2.26	17.47	2.15	17.91	1.33	16.80	2.32	17.36	1.03	1.30
7-Mar-15	25.68	1.98	28.16	2.70	26.20	2.60	29.60	2.26	27.40	3.37	28.04	2.08	29.20	2.63	29.48	1.75	1.71
8-Mar-15	32.14	2.48	35.69	3.42	31.70	3.20	36.90	2.26	35.61	4.38	35.51	2.63	36.20	2.82	37.44	2.22	2.26
9-Mar-15	50.22	3.87	53.87	5.18	48.10	4.80	54.30	2.26	53.78	6.61	53.24	3.95	57.40	3.33	56.80	3.36	3.02
10-Mar-15	64.65	4.98	57.86	5.56	63.00	6.40	67.30	2.26	67.03	8.24	66.63	4.94	72.60	3.70	67.65	4.00	3.86
11-Mar-15	69.20	5.33	64.29	6.18	68.50	6.80	70.10	2.26	69.62	8.56	68.27	5.06	75.80	3.79	71.27	4.22	3.13
12-Mar-15	59.03	4.55	61.41	5.90	56.00	5.60	63.80	2.26	58.27	7.17	62.51	4.64	65.10	3.52	63.31	3.75	3.45
13-Mar-15	39.22	3.02	44.11	4.24	37.60	3.80	45.10	2.26	42.19	5.19	42.23	3.13	42.00	2.94	46.13	2.73	3.60
14-Mar-15	34.00	2.62	37.62	3.62	32.80	3.20	40.40	2.26	37.10	4.56	37.99	2.82	35.90	2.80	41.24	2.44	3.23
15-Mar-15	37.26	2.87	46.25	4.44	35.70	3.60	46.60	2.26	41.86	5.15	43.44	3.22	45.20	3.03	47.21	2.79	3.70
16-Mar-15	9.74	0.95	16.46	1.58			18.00	2.26	15.18	1.87	15.97	1.18	16.10	2.30	15.92	0.94	1.99
17-Mar-15	5.31	0.52	8.68	0.84	7.40	0.80	11.80	2.26	9.06	1.11	9.99	0.74	7.50	2.09	8.14	0.48	1.60
18-Mar-15	28.39	2.19	33.65	3.24	30.70	3.00	35.80	2.26	32.81	4.04	33.94	2.52	38.00	2.85	34.00	2.01	2.55
19-Mar-15	62.81	4.84	64.25	6.16	56.00	5.60	66.40	2.26	62.14	7.64	62.16	4.61	71.40	3.71	66.20	3.92	4.51
20-Mar-15	64.16	4.94	66.84	6.42	58.40	5.80	71.50	2.26	68.07	8.37	68.39	5.07	77.30	3.87	72.17	4.27	5.12
21-Mar-15	59.34	4.57	63.63	6.10	56.00	5.60	67.80	2.26	63.45	7.80	63.11	4.68	69.90	3.63	67.65	4.00	4.38
22-Mar-15	27.22	2.10	33.16	3.18	20.80	2.00	34.70	2.26	33.22	4.09	32.81	2.43	34.40	2.75	36.54	2.16	3.91
23-Mar-15	24.53	1.89	28.54	2.74			30.60	2.26	28.97	3.56	28.33	2.10	30.80	2.68	30.21	1.79	2.56
24-Mar-15	37.31	2.87	44.21	4.24			47.30	2.26	42.22	5.19	46.02	3.41	49.70	3.13	48.84	2.89	3.43
25-Mar-15	6.70	0.65	4.82	0.46	9.60	1.00	16.20	2.26	13.98	1.72	14.65	1.09	15.00	2.28	14.47	0.86	2.93
26-Mar-15	15.36	1.18	23.42	2.24	1.90	0.20	21.10	2.26	21.84	2.69	21.56	1.60	23.50	2.49	23.52	1.39	4.80
27-Mar-15	3.54	0.34	6.57	0.64	5.30	0.60	7.90	2.26	6.69	0.82	7.69	0.57	9.00	2.13	7.24	0.43	1.34
28-Mar-15	7.76	0.75	10.24	0.98	11.50	1.20	11.60	2.26	9.83	1.21	12.03	0.89	11.60	2.19	11.21	0.66	1.12
29-Mar-15	20.06	1.55	23.15	2.22	25.00	2.60	21.30	2.26	23.19	2.85	22.49	1.67	24.70	2.52	24.96	1.48	2.43
30-Mar-15	8.57	0.83	11.32	1.08	13.20	1.40	10.50	2.26	10.98	1.35	11.18	0.83	15.10	2.28	11.21	0.66	1.61
31-Mar-15	9.36	0.91	7.15	0.68	6.30	0.60	8.20	2.26	8.62	1.06	7.96	0.59	9.10	2.13	7.96	0.47	1.40
1-Apr-15	6.68	0.65	4.52	0.44	5.10	0.60	7.20	2.26	6.30	0.78	6.34	0.47	5.70	2.06	5.43	0.32	1.02
2-Apr-15	4.55	0.44	3.31	0.32	5.80	0.60	7.00	2.26	2.58	0.32	6.66	0.49	6.90	2.08	5.79	0.34	1.15
3-Apr-15	16.71	1.29	18.53	1.78	16.80	1.60	19.10	2.26	18.56	2.28	18.89	1.40	19.30	2.39	20.08	1.19	1.78
4-Apr-15	15.26	1.18	19.02	1.82	17.20	1.80	17.40	2.26	19.68	2.42	18.33	1.36	18.20	2.35	20.58	1.22	1.83
5-Apr-15	15.26	1.18	17.89	1.72	15.80	1.60	16.60	2.26	17.48	2.15	18.30	1.36	18.40	2.36	20.44	1.21	2.03
6-Apr-15	7.64	0.74	7.54	0.72	7.00	0.80	8.90	2.26	8.30	1.02	8.64	0.64	8.90	2.12	7.60	0.45	0.96
7-Apr-15	10.88	0.84	11.69	1.12	12.10	1.20	13.00	2.26	13.44	1.65	12.93	0.96	13.10	2.23	13.75	0.81	1.35
8-Apr-15	12.12	0.93	19.07	1.84	21.40	2.20	21.10	2.26	20.55	2.53	19.56	1.45	22.00	2.44	20.98	1.24	2.32
9-Apr-15	38.41	2.96	39.41	3.78	40.70	4.00	40.50	2.26	40.01	4.92	37.85	2.81	44.60	3.03	41.42	2.45	3.34

Table 16: Participant's value PM2.5 lab code from A to H

PM2.5	A		B		C		D		E		F		G		H	
day	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U
13-Feb-15	99.50	5.37	93.40	9.30	94.23	7.96	85.23	4.35	98.33	2.35	106.90	15.10	90.67	4.55	99.58	4.08
14-Feb-15					37.69	3.19	40.00	3.52	42.71	2.09	44.50	6.40	34.51	3.50	44.29	2.74
15-Feb-15					10.10	0.87	7.92	3.26	8.69	2.01	9.10	7.40	6.45	3.30	10.97	2.32
16-Feb-15	13.49	1.62			10.88	0.94	9.86	3.26	10.53	2.02	10.90	7.40	8.99	3.31	12.70	2.33
17-Feb-15	18.24	2.19	15.70	1.60	16.50	1.41	15.68	3.29	17.06	2.03	17.20	5.90	16.00	3.34	18.16	2.37
18-Feb-15	41.07	2.55	38.70	3.90	39.23	3.32	40.69	3.53	42.12	2.24	43.90	6.30	38.26	3.55	43.79	2.73
19-Feb-15	45.40	2.82	43.10	4.30	42.88	3.62	44.15	3.58	46.15	2.14	49.10	7.00	41.89	3.60	48.10	2.81
20-Feb-15	34.51	2.42	32.70	3.30	31.36	2.65	33.29	3.44	35.28	2.16	36.50	5.40	31.98	3.47	36.72	2.60
21-Feb-15			30.10	3.00	28.26	2.39	30.44	3.41	32.66	2.14	33.20	5.10	29.69	3.45	34.04	2.56
22-Feb-15	7.17	1.49			5.95	0.54	5.31	3.25	6.03	2.08	6.10	7.10	4.97	3.30	7.22	2.30
23-Feb-15	12.40	1.49			11.88	1.02	9.67	3.26	10.81	2.06	10.60	7.50	7.99	3.30	12.29	2.32
24-Feb-15	10.21	1.23			9.42	0.82	7.46	3.26	9.51	2.13	9.00	7.60	6.12	3.30	9.60	2.31
25-Feb-15					3.46	0.35	2.27	3.25	2.98	2.04	3.00	4.70	2.01	3.29	3.75	2.29
26-Feb-15	14.29	1.72	12.50	1.30	13.15	1.13	11.65	3.27	14.28	2.04	14.60	6.50	12.27	3.32	15.75	2.35
27-Feb-15	20.39	1.75	18.90	1.90	16.03	1.37	19.37	3.31	20.14	2.09	21.90	5.10	17.89	3.35	22.41	2.41
28-Feb-15	7.69	1.60	6.60	1.00	5.93	0.53	5.49	3.25	6.74	2.04	7.00	7.40	6.33	3.30	7.65	2.30
1-Mar-15	18.07	2.17	16.60	1.70	14.04	1.20	16.28	3.29	17.06	2.04	18.10	5.70	14.54	3.33	18.45	2.37
2-Mar-15	13.92	1.67	11.50	1.20	10.89	0.94	12.44	3.28	12.78	2.04	13.90	6.70	12.16	3.32	14.41	2.34
3-Mar-15	17.30	2.08	17.10	1.70	13.89	1.19	17.10	3.30	19.12	2.02	18.60	5.60	15.50	3.34	19.67	2.38
4-Mar-15	25.51	2.19	23.20	2.30	19.19	1.63	24.82	3.36	25.40	2.04	26.60	4.80	21.43	3.38	28.13	2.48
5-Mar-15			2.50	1.00	1.59	0.23	2.23	3.25	2.02	2.02	2.00	3.40	1.35	3.29	3.10	2.29
6-Mar-15	12.49	1.50	12.00	1.20	10.15	0.88	11.92	3.27	12.97	2.06	13.20	6.90	10.01	3.31	14.15	2.34
7-Mar-15	22.54	1.94	21.30	2.10	17.62	1.50	22.13	3.33	24.19	2.05	23.90	4.90	20.55	3.37	24.63	2.43
8-Mar-15	27.63	2.38	26.70	2.70	21.30	1.81	28.06	3.38	29.69	2.06	30.30	4.90	23.68	3.39	30.42	2.51
9-Mar-15	43.68	3.06	41.60	4.20	35.95	3.04	43.36	3.57	46.13	2.10	46.90	6.70	39.67	3.57	47.02	2.79
10-Mar-15	56.01	3.47	51.50	5.10	46.79	3.95	55.71	3.76	57.94	2.13	59.00	8.30	51.14	3.74	59.25	3.04
11-Mar-15	59.71	3.70	53.40	5.30	51.94	4.39	59.02	3.82	61.44	2.18	62.40	8.80	54.95	3.80	62.26	3.11
12-Mar-15	50.60	3.14	47.40	4.70	46.89	3.96	52.71	3.71	54.56	2.17	57.00	8.00	49.66	3.72	55.78	2.97
13-Mar-15	34.05	2.38	33.40	3.30	32.85	2.78	36.01	3.47	39.07	2.13	38.70	5.70	35.14	3.51	38.25	2.63
14-Mar-15	27.95	2.40	29.40	2.90	28.55	2.42	31.57	3.42	34.84	2.18	33.60	5.10	31.15	3.47	34.09	2.56
15-Mar-15			36.50	3.60	35.14	2.97	40.74	3.53	45.00	2.14	42.10	6.10	39.01	3.56	43.52	2.72
16-Mar-15			12.80	1.30	24.48	2.08	14.40	3.28	17.63	2.03	13.50	6.80	14.42	3.33	17.08	2.36
17-Mar-15			7.90	1.00	6.83	0.61	7.58	3.26	9.02	2.02	7.70	7.50	7.82	3.30	10.23	2.31
18-Mar-15	29.13	2.51	26.70	2.70	23.40	1.98	29.21	3.40	32.13	2.09	30.10	4.90	24.73	3.40	30.79	2.51
19-Mar-15	56.66	3.17	51.00	5.10	48.31	4.08	55.95	3.76	60.04	2.19	59.40	8.40	54.89	3.80	57.87	3.01
20-Mar-15			51.40	5.10	44.76	3.78	54.49	3.74	58.44	2.16	58.50	8.30	53.90	3.78	56.87	2.99
21-Mar-15	51.50	2.88	50.00	5.00	47.00	3.97	54.21	3.73	58.55	2.21	58.70	8.30	52.10	3.76	55.62	2.96
22-Mar-15	26.25	2.26	27.00	2.70	23.03	1.95	30.06	3.40	34.41	2.15	33.70	5.20	29.28	3.45	33.39	2.55
23-Mar-15	25.52	2.20	22.50	2.20	19.41	1.65	24.19	3.35	27.27	2.05	27.20	4.80	25.12	3.41	27.41	2.47
24-Mar-15	40.84	2.53	39.20	3.90	33.50	2.83	42.18	3.55	45.01	2.20	45.60	6.50	40.48	3.58	44.25	2.73
25-Mar-15	11.56	1.39	10.40	1.00	9.60	0.83	11.19	3.27	14.76	2.05	11.30	7.30	8.89	3.31	8.75	2.31
26-Mar-15	17.49	2.10	14.00	1.40	10.44	0.90	15.59	3.29	20.47	2.03	17.50	5.80	14.96	3.33	19.03	2.38
27-Mar-15	6.37	1.33	4.70	1.00	4.01	0.39	4.80	3.25	6.19	2.03	5.80	6.90	5.33	3.30	5.71	2.29
28-Mar-15	9.08	1.89	7.90	1.00	8.18	0.72	7.40	3.26	9.56	2.08	8.60	7.60	8.29	3.31	9.44	2.31
29-Mar-15	20.87	1.80	18.20	1.80	16.68	1.42	19.08	3.31	22.32	2.04	21.80	5.10	19.80	3.36	21.16	2.40
30-Mar-15	11.06	1.33	5.70	1.00	5.92	0.53	6.80	3.26	9.11	2.05	9.30	7.60	8.64	3.31	8.78	2.31
31-Mar-15	5.87	1.22	3.50	1.00	2.56	0.28	3.11	3.25	4.68	2.02	3.70	5.40	3.46	3.30	4.97	2.29
1-Apr-15	3.08	0.64	2.40	1.00	1.65	0.23	2.22	3.25	3.44	2.04	2.40	3.90	1.05	3.29	4.05	2.29
2-Apr-15	4.00	0.83	2.40	1.00	1.94	0.25	2.77	3.25	3.89	2.03	3.00	4.70	2.08	3.29	4.27	2.29
3-Apr-15	10.74	1.29	9.00	1.00	8.86	0.76	9.29	3.26	11.50	2.02	10.00	7.60	8.41	3.31	11.77	2.32
4-Apr-15	11.85	1.42	11.20	1.10	10.67	0.92	12.26	3.27	14.00	2.03	12.90	7.00	11.07	3.32	14.19	2.34
5-Apr-15	14.57	1.75	15.20	1.50	13.21	1.13	15.93	3.29	18.42	2.04	16.50	6.10	12.10	3.32	17.71	2.36
6-Apr-15	7.47	1.55	5.90	1.00	4.98	0.46	5.81	3.25	7.70	2.08	7.00	7.40	5.04	3.30	8.02	2.30
7-Apr-15	10.00	2.08	8.40	1.00	8.19	0.72	8.13	3.26	10.41	2.03	9.20	7.60	7.38	3.30	10.80	2.32
8-Apr-15	16.04	1.93	12.50	1.30	13.83	1.18	12.52	3.28	15.26	2.06	14.50	6.60	12.79	3.32	15.29	2.34
9-Apr-15	33.12	2.32	26.80	2.70	29.80	2.52			32.51	2.23	32.00	5.00	26.90	3.42	32.50	2.54

Table 17: Participant's value PM2.5 lab code from J to Q.
(Laboratory J and M did not install instruments for PM2.5 measurements)

PM2.5	J		K		L		M		N		O		P		Q	
day	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U	x_i	U
13-Feb-15			94.74	6.69	95.65	11.10			95.72	1.25			96.43	2.60	97.04	4.48
14-Feb-15			40.00	2.82	41.41	4.80			41.54	1.25			41.81	1.23	41.25	3.29
15-Feb-15			8.53	1.77	8.20	0.95							9.61	0.27	9.48	2.98
16-Feb-15			10.10	1.77	9.87	1.15							10.52	0.30	10.85	2.99
17-Feb-15			16.38	1.77	15.79	1.83			19.41	1.25	15.59	3.34	16.60	0.44	16.85	3.02
18-Feb-15			39.37	2.78	40.84	4.74			42.71	1.25	40.38	3.58	40.99	1.08	40.60	3.28
19-Feb-15			44.13	3.12	46.40	5.38			48.89	1.25	42.81	3.61	57.23	1.57	45.15	3.35
20-Feb-15			32.97	2.33	34.06	3.95			37.82	1.25	32.73	3.48	21.50	0.56	34.17	3.19
21-Feb-15			30.94	2.18	31.50	3.65			33.38	1.25	30.45	3.46	31.38	0.85	31.56	3.16
22-Feb-15			5.72	1.77	4.97	0.58			4.35	1.14	4.50	3.30	4.81	0.13	6.32	2.97
23-Feb-15			10.12	1.77	9.85	1.14			11.61	1.14	8.92	3.31	10.34	0.28	10.70	2.99
24-Feb-15			8.40	1.77	7.70	0.89			11.88	1.14	7.00	3.31	9.52	0.25	8.37	2.98
25-Feb-15			2.91	1.77	1.89	0.22			9.61	1.14	2.48	3.29	2.63	0.07	2.58	2.97
26-Feb-15			13.27	1.77	13.48	1.56			14.88	1.14	12.77	3.32	13.06	0.36	13.88	3.00
27-Feb-15					18.68	2.17			20.41	1.25	18.91	3.36	20.13	0.52	20.62	3.05
28-Feb-15			6.58	1.77	5.79	0.67			6.60	1.14	6.64	3.30	6.53	0.17	7.66	2.98
1-Mar-15			17.03	1.77	16.15	1.87			17.76	1.14	16.09	3.34	15.87	0.43	16.81	3.02
2-Mar-15			12.67	1.77	12.06	1.40			13.68	1.14	12.66	3.32	12.24	0.34	13.23	3.00
3-Mar-15			17.80	1.77	17.14	1.99			18.05	1.25	16.11	3.34	15.60	0.40	18.61	3.03
4-Mar-15			25.19	1.78	24.83	2.88			24.76	1.25	21.67	3.38	26.03	0.68	26.82	3.11
5-Mar-15			1.97	1.77	1.33	0.16			1.36	1.14	1.15	3.29	3.54	0.10	2.87	2.97
6-Mar-15			11.46	1.77	11.67	1.35			12.24	1.14	9.34	3.31	11.70	0.31	12.71	3.00
7-Mar-15			21.86	1.77	21.56	2.50			22.49	1.25	21.58	3.38	22.31	0.61	23.38	3.07
8-Mar-15			27.76	1.96	27.36	3.17			28.12	1.25	24.83	3.40	29.11	0.76	29.26	3.13
9-Mar-15			42.92	3.03	43.00	4.99			43.09	1.25	41.81	3.60	45.62	1.20	45.71	3.36
10-Mar-15			54.88	3.87	54.74	6.35			54.79	1.25	52.67	3.77	56.23	1.45	57.19	3.57
11-Mar-15			59.01	4.17	57.20	6.64			57.51	1.25	56.01	3.82	58.05	1.54	58.34	3.59
12-Mar-15			51.77	3.65	50.83	5.90			50.45	1.25	50.70	3.73	52.24	1.34	52.22	3.47
13-Mar-15			35.44	2.50	34.37	3.99			34.39	1.25	34.94	3.51	37.82	1.05	35.05	3.20
14-Mar-15			32.92	2.32	30.59	3.55			30.50	1.25	30.01	3.45	34.01	0.94	32.17	3.17
15-Mar-15			40.96	2.89	39.68	4.60			39.55	1.25	39.59	3.57	40.81	1.11	40.74	3.28
16-Mar-15			13.94	1.77	15.43	1.79			14.00	1.14	14.02	3.33	14.87	0.40	15.56	3.01
17-Mar-15			7.42	1.77	7.90	0.92			8.00	1.14	7.84	3.30	5.08	0.14	8.81	2.98
18-Mar-15			28.90	2.04	28.78	3.34			29.41	1.25	27.57	3.43	26.30	0.73	29.11	3.13
19-Mar-15			56.07	3.96	55.93	6.49			55.25	1.25	55.89	3.82	54.05	1.50	56.46	3.55
20-Mar-15			55.87	3.94	54.17	6.28			54.18	1.25	55.01	3.80	55.32	1.48	55.06	3.53
21-Mar-15			55.21	3.90	54.08	6.27			52.81	1.25	51.29	3.74	55.05	1.49	54.47	3.52
22-Mar-15			31.94	2.25	31.73	3.68			30.60	1.25	26.32	3.42	33.19	0.90	31.82	3.16
23-Mar-15			24.93	1.77	24.87	2.89			25.04	1.25	24.14	3.40	26.21	0.74	24.99	3.09
24-Mar-15			42.69	3.01	42.56	4.94			41.41	1.25	38.41	3.55	42.44	1.13	42.66	3.31
25-Mar-15			11.63	1.77	11.99	1.39			11.90	1.14	9.50	3.31	10.79	0.31	13.53	3.00
26-Mar-15			17.58	1.77	17.47	2.03			16.44	1.14	14.88	3.33	14.87	0.40	17.40	3.03
27-Mar-15			4.82	1.77	4.68	0.54			5.65	1.14	4.47	3.30	4.90	0.13	6.00	3.87
28-Mar-15			8.04	1.77	7.18	0.83			8.00	1.14	7.82	3.30	7.97	0.22	8.90	3.88
29-Mar-15			20.46	1.77	18.25	2.12			20.06	1.25	19.00	3.36	20.22	0.58	19.71	3.93
30-Mar-15			7.67	1.77	6.87	0.80			7.20	1.14	7.49	3.30	7.71	0.21	8.50	3.88
31-Mar-15			3.17	1.77	3.28	0.38			3.72	1.14	3.35	3.30	3.36	0.10	4.21	3.87
1-Apr-15			1.76	1.77	1.59	0.18			2.63	1.14	1.43	3.29	3.36	0.09	3.06	3.87
2-Apr-15			2.78	1.77	2.08	0.24			2.81	1.14	2.02	3.29	3.54	0.10	3.46	3.87
3-Apr-15			9.63	1.77	8.89	1.03			10.25	1.14	7.42	3.30	11.16	0.30	9.82	3.88
4-Apr-15			13.01	1.77	11.88	1.38			12.24	1.14	11.58	3.32	11.97	0.34	12.12	3.89
5-Apr-15			15.67	1.77	16.33	1.89			16.14	1.14	13.46	3.33	13.79	0.40	16.45	3.91
6-Apr-15			5.86	1.77	6.04	0.70			6.26	1.14	5.70	3.30	8.52	0.24	6.67	3.87
7-Apr-15			8.25	1.77	8.12	0.94			9.25	1.14			10.16	0.28	9.69	3.88
8-Apr-15			12.76	1.77	12.23	1.42			13.88	1.14			13.06	0.26	14.61	3.90
9-Apr-15			26.80	1.89	27.84	3.23			30.20	1.25	29.17	3.44	30.93	0.84	30.77	4.01

Table 18: Participant's value PM2.5 lab code from R to Z and σ_{pt} of all participants

PM2.5	R		S		T		U		V		W		Y		Z		All
day	Avg	U	Avg	U	Avg	U	Avg	U	Avg	U	Avg	U	Avg	U	Avg	U	σ_{pt}
13-Feb-15	94.89	8.35	89.56	8.60			97.40	0.90	100.46	11.45	95.22	10.99					4.67
14-Feb-15	36.30	3.19	42.53	4.08	35.70	3.60	41.60	0.90	42.31	4.82	38.55	4.45			38.42	4.43	2.87
15-Feb-15	5.77	0.67	7.32	0.70	6.20	0.60	7.80	0.90	11.42	1.30	8.74	1.01			7.61	0.88	1.58
16-Feb-15	6.70	0.78	9.03	0.87	8.30	0.80	9.20	0.90	12.92	1.47	10.49	1.21			9.42	1.09	1.66
17-Feb-15	12.90	1.14	14.59	1.40	15.40	1.60	15.80	0.90	18.07	2.06	15.60	1.80			15.22	1.75	1.43
18-Feb-15	36.84	3.24	38.96	3.74	35.30	3.60	41.00	0.90	41.68	4.75	37.65	4.34	39.90	2.91	36.79	4.24	2.22
19-Feb-15	39.83	3.51	43.48	4.18	38.80	3.80	47.00	0.90	45.91	5.23	42.85	4.94	44.00	2.99	39.87	4.59	3.92
20-Feb-15	29.52	2.60	31.66	3.04	29.20	3.00	34.30	0.90	34.56	3.94	32.55	3.76	33.00	2.74	31.17	3.59	3.32
21-Feb-15	25.79	2.27	28.42	2.72	26.90	2.60	31.80	0.90	32.01	3.65	29.83	3.44	27.50	2.59	28.82	3.32	2.20
22-Feb-15	3.76	0.44	4.68	0.46	6.20	0.60	4.60	0.90	8.69	0.99	7.12	0.82	6.20	2.05	5.44	0.63	1.18
23-Feb-15	7.65	0.89	8.65	0.84	10.60	1.00	10.30	0.90	12.85	1.47	11.15	1.29	12.20	2.21	9.24	1.06	1.45
24-Feb-15	6.41	0.74	6.97	0.68	8.40	0.80	7.70	0.90	11.24	1.28	8.87	1.02	9.40	2.13	7.61	0.88	1.50
25-Feb-15	0.93	0.11	1.96	0.20	2.50	0.20	1.40	0.90	6.28	0.72	4.40	0.51	2.50	2.00	2.54	0.29	1.90
26-Feb-15	10.72	0.94	12.32	1.18	5.10	0.60	13.50	0.90	16.21	1.85	13.96	1.61	14.00	2.25	13.41	1.55	2.19
27-Feb-15	18.17	1.60	18.87	1.82	17.90	1.80	19.20	0.90	20.62	2.35	19.44	2.24	19.90	2.41	19.03	2.19	1.42
28-Feb-15	5.70	0.50	7.00	0.68	7.40	0.80	5.90	0.90	9.13	1.04	7.69	0.89	7.60	2.10			0.88
1-Mar-15	14.21	1.65	16.17	1.56	16.10	1.60	16.90	0.90	18.28	2.08	17.49	2.02	17.70	2.35	16.31	1.88	1.25
2-Mar-15	10.37	1.20	12.36	1.18	12.70	1.20	13.00	0.90	13.73	1.57	12.49	1.44	14.10	2.26	12.32	1.42	1.02
3-Mar-15	15.24	1.34	16.62	1.60	15.40	1.60	17.30	0.90	19.16	2.18	17.82	2.06	16.50	2.31	16.31	1.88	1.46
4-Mar-15	22.32	1.96	24.78	2.38	22.20	2.20	27.00	0.90	18.46	2.11	25.41	2.93	25.20	2.52	23.02	2.65	2.48
5-Mar-15	0.00	0.01	1.49	0.20	2.60	0.20	2.50	0.90	3.54	0.40	2.70	0.31	1.70	1.94			0.87
6-Mar-15	10.53	0.93	10.96	1.06	10.50	1.00	12.00	0.90	13.69	1.56	12.94	1.49	12.30	2.20	10.87	1.25	1.24
7-Mar-15	18.83	1.66	21.12	2.02	19.60	2.00	21.70	0.90	23.55	2.69	22.06	2.55	21.40	2.44	20.48	2.36	1.70
8-Mar-15	26.40	3.06	26.75	2.56	25.10	2.60	27.70	0.90	29.41	3.35	27.90	3.22	27.00	2.57	25.37	2.92	2.22
9-Mar-15	40.43	4.69	42.57	4.08	38.80	3.80	44.20	0.90	44.71	5.10	43.71	5.04	44.30	3.01	40.06	4.61	2.76
10-Mar-15	52.47	6.09	47.10	4.52	48.50	4.80	57.50	0.90	55.51	6.33	54.52	6.29	59.20	3.37	48.76	5.62	3.84
11-Mar-15	58.21	6.75	58.13	5.58	50.90	5.00	60.70	0.90	57.48	6.55	57.35	6.62	59.00	3.36	51.84	5.97	3.22
12-Mar-15	50.25	4.42	51.48	4.94	46.00	4.60	55.10	0.90	52.34	5.97	52.05	6.01	53.40	3.26	46.58	5.37	2.91
13-Mar-15	32.15	2.83	33.70	3.24	32.50	3.20	37.50	0.90	36.75	4.19	34.46	3.98	34.00	2.75	33.35	3.84	2.04
14-Mar-15	27.15	2.39	31.50	3.02	29.40	3.00	33.30	0.90	34.14	3.89	31.24	3.61	28.20	2.62	31.17	3.59	2.23
15-Mar-15	35.02	3.08	39.33	3.78	36.90	3.60	41.70	0.90	41.68	4.75	38.79	4.48	38.30	2.87	37.33	4.30	2.56
16-Mar-15	8.97	1.04	14.53	1.40	12.90	1.20	13.90	0.90	17.56	2.00	14.82	1.71	12.60	2.21	13.23	1.52	2.91
17-Mar-15	5.00	0.58	7.47	0.72	7.20	0.80	8.00	0.90	10.79	1.23	8.83	1.02	2.30	2.00	6.89	0.79	1.81
18-Mar-15	24.05	2.12	28.89	2.78	27.20	2.80	30.60	0.90	30.50	3.48	28.36	3.27	28.30	2.60	25.73	2.96	2.27
19-Mar-15	46.35	4.08	56.20	5.40	49.80	5.00	60.40	0.90	51.94	5.92	53.97	6.23	60.60	3.39	49.48	5.70	3.95
20-Mar-15	47.65	4.19	54.77	5.26	50.30	5.00	59.40	0.90	54.08	6.17	54.08	6.24	56.00	3.30	50.75	5.85	3.51
21-Mar-15	46.35	4.08	54.34	5.22	49.90	5.00	57.10	0.90	55.35	6.31	52.98	6.11	54.20	3.25	50.03	5.76	3.25
22-Mar-15	24.65	2.17	31.65	3.04	27.30	2.80	32.90	0.90	34.05	3.88	29.77	3.44	25.40	2.54	28.64	3.30	3.36
23-Mar-15	21.06	1.85	24.55	2.36	22.50	2.20	26.00	0.90	26.61	3.03	23.98	2.77	24.90	2.51	21.57	2.48	2.07
24-Mar-15	34.10	3.00	42.07	4.04	38.30	3.80	44.20	0.90	43.88	5.00	41.23	4.76	40.90	2.84	37.70	4.34	3.17
25-Mar-15	7.69	0.89	11.46	1.10	10.90	1.00	12.00	0.90	15.36	1.75	12.80	1.48	10.50	2.17	11.31	1.30	1.83
26-Mar-15	12.41	1.09	17.27	1.66	16.20	1.60	17.60	0.90	17.48	1.99	16.15	1.86	16.30	2.31	16.49	1.90	2.15
27-Mar-15	3.69	0.43	5.01	0.48			4.60	0.90	7.42	0.85	5.79	0.67	5.20	2.04	4.53	0.52	0.87
28-Mar-15	7.37	0.86	7.38	0.70	8.80	0.80	7.60	0.90	10.41	1.19	8.98	1.04			7.61	0.88	0.85
29-Mar-15	18.11	1.59	19.01	1.82	18.60	1.80	20.10	0.90	18.98	2.16	18.32	2.11			17.94	2.07	1.39
30-Mar-15	6.51	0.76	7.46	0.72	8.00	0.80	9.50	0.90	9.77	1.11	8.28	0.96			6.71	0.77	1.35
31-Mar-15	0.98	0.11	0.18	0.20	4.30	0.40	3.10	0.90	6.22	0.71	5.67	0.65	4.60	2.03	3.08	0.35	1.41
1-Apr-15	0.00	0.02	1.49	0.20	2.50	0.20	2.10	0.90	3.63	0.41	4.57	0.53	2.30	1.96	2.54	0.29	1.05
2-Apr-15	0.52	0.06	2.14	0.20	2.70	0.20	2.60	0.90	5.98	0.68	4.77	0.55	3.40	2.00	3.26	0.38	1.15
3-Apr-15	7.07	0.82	9.19	0.88	9.60	1.00	10.50	0.90	12.04	1.37	10.38	1.20	10.20	2.16	10.15	1.17	1.27
4-Apr-15	9.00	1.04	11.78	1.14	11.70	1.20	12.40	0.90	13.18	1.50	12.12	1.40	11.20	2.18	13.96	1.61	1.18
5-Apr-15	11.85	1.04	15.92	1.52	14.30	1.40	15.30	0.90	17.15	1.96	15.26	1.76	13.40	2.24	16.85	1.94	1.75
6-Apr-15	4.43	0.51	6.22	0.60	6.50	0.60	7.10	0.90	8.39	0.96	7.47	0.86	6.70	2.06	6.16	0.71	1.09
7-Apr-15	6.02	0.70	8.05	0.78	8.10	0.80	9.10	0.90	11.17	1.27	9.67	1.12	8.70	2.13	8.70	1.00	1.22
8-Apr-15	10.78	0.95	11.29	1.08	13.00	1.40	14.90	0.90	14.97	1.71	13.60	1.57	14.10	2.26	13.23	1.52	1.36
9-Apr-15	25.53	2.25	26.45	2.54	26.40	2.60	31.60	0.90	27.38	3.12	27.48	3.17	29.80	2.65	26.83	3.09	2.42

Annex C: Daily z'-scores for each laboratory

PM2.5

LEGEND 

Figure 28 to 49 show for each laboratory the calculated z'-score daily value for PM2.5.

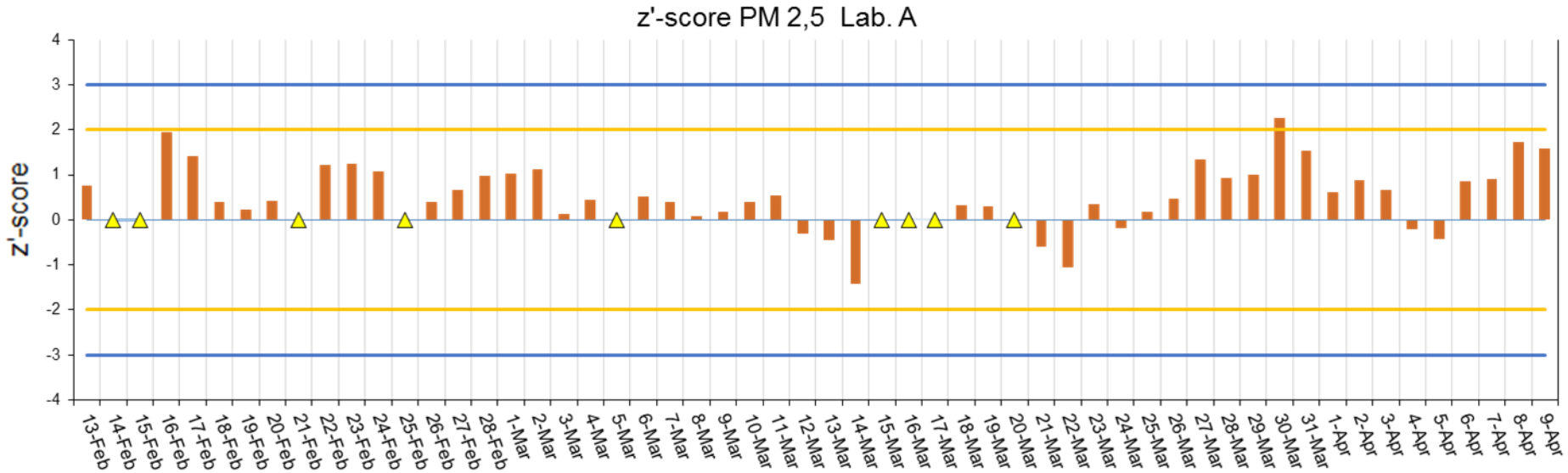


Figure 28: Chart of z'-score evaluation for PM2.5 related to Lab. A

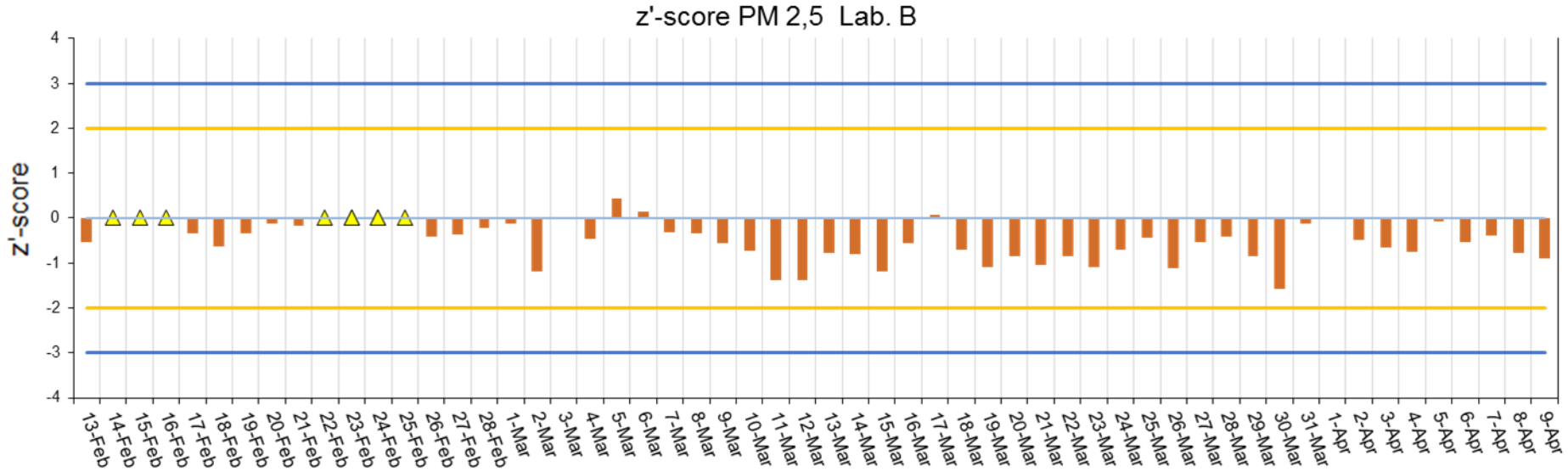


Figure 29: Chart of z'-score evaluation for PM2.5 related to Lab. B

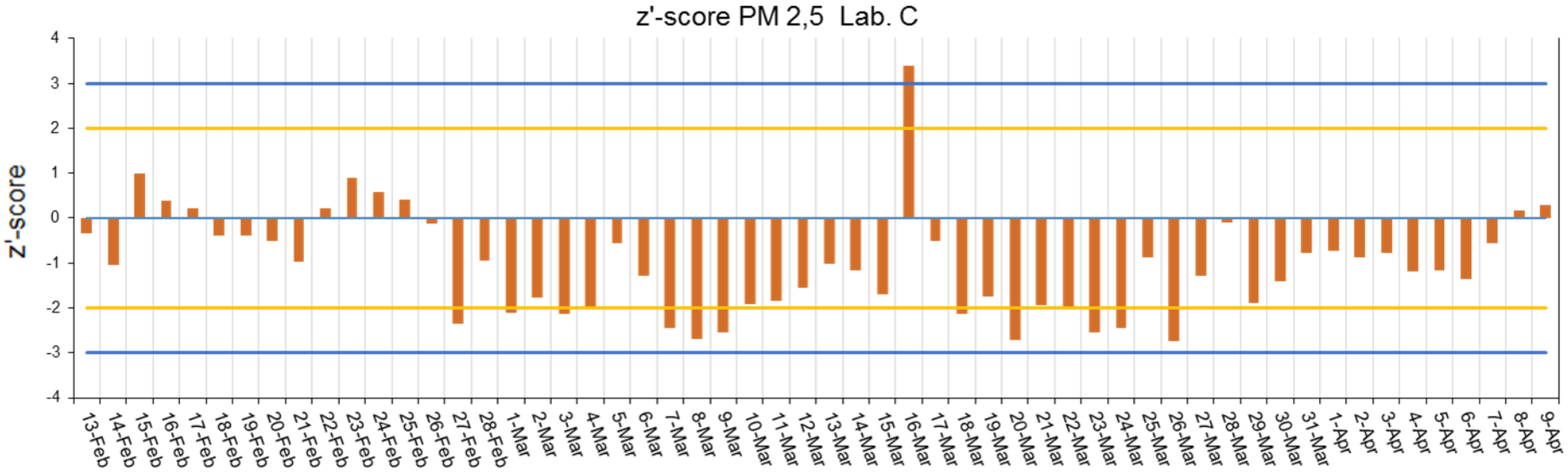


Figure 30: Chart of z'-score evaluation for PM2.5 related to Lab. C

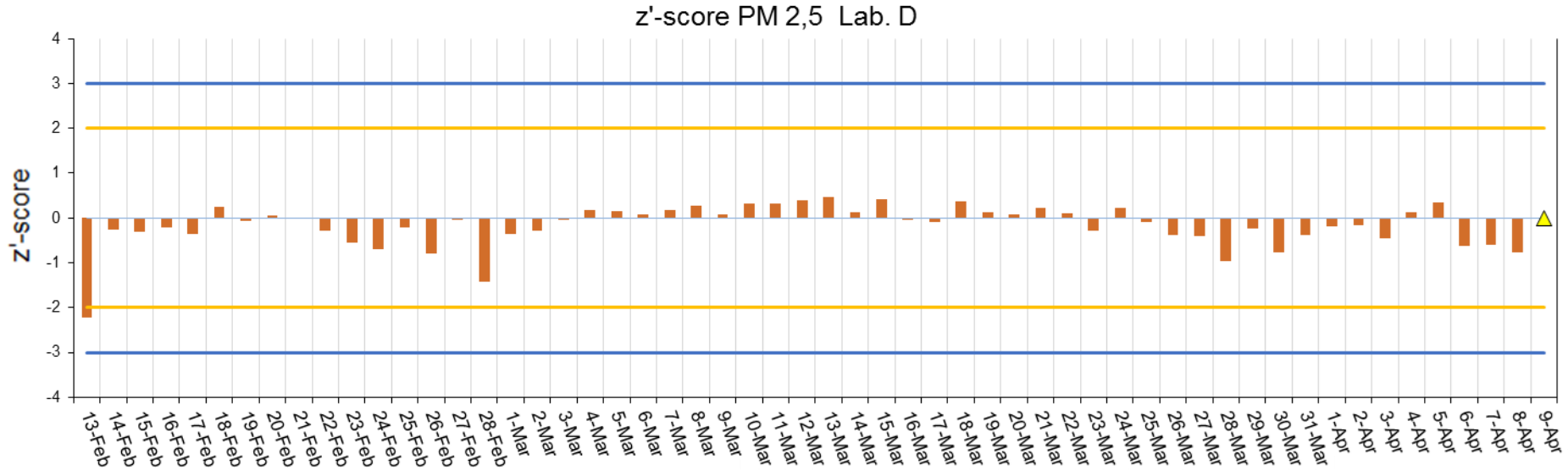


Figure 31: Chart of z'-score evaluation for PM2.5 related to Lab. D

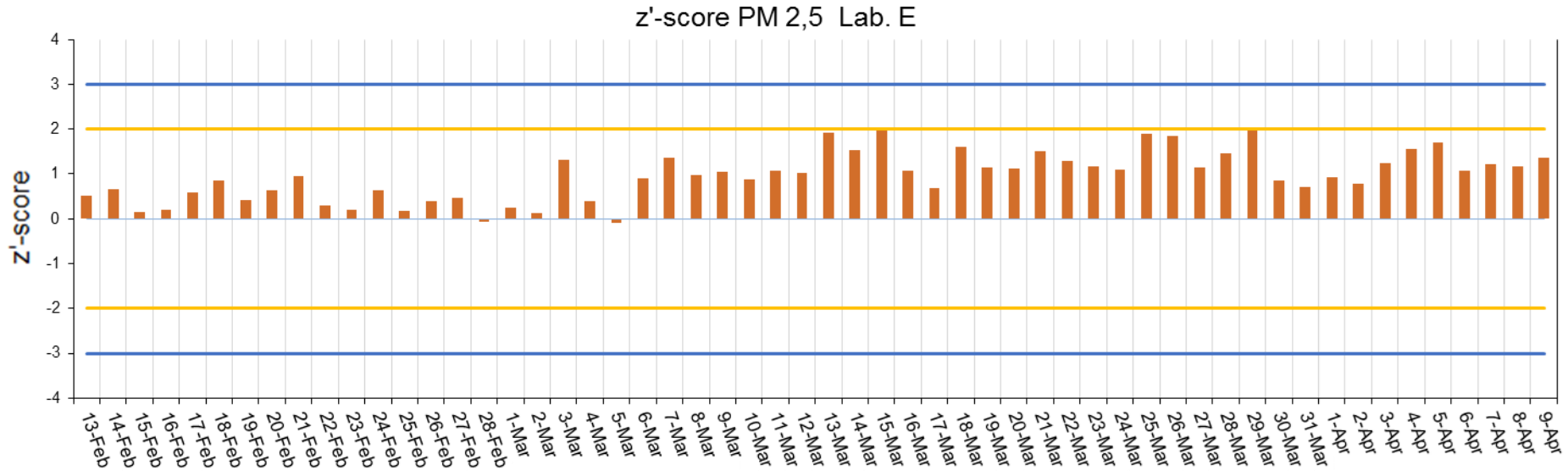


Figure 32: Chart of z'-score evaluation for PM2.5 related to Lab. E

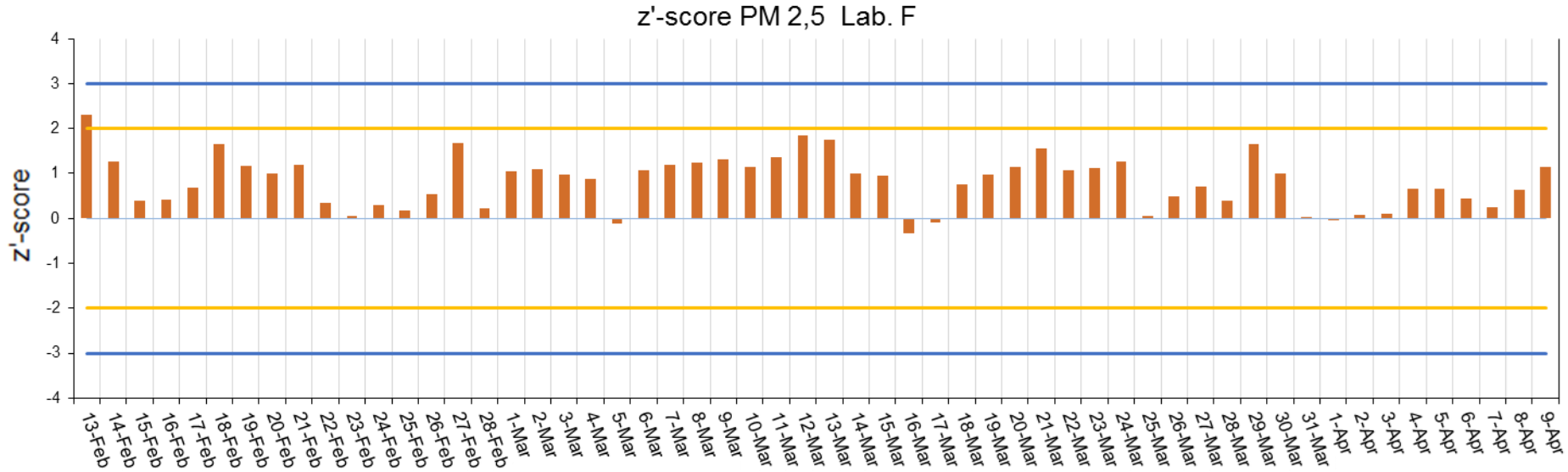


Figure 33: Chart of z'-score evaluation for PM2.5 related to Lab. F

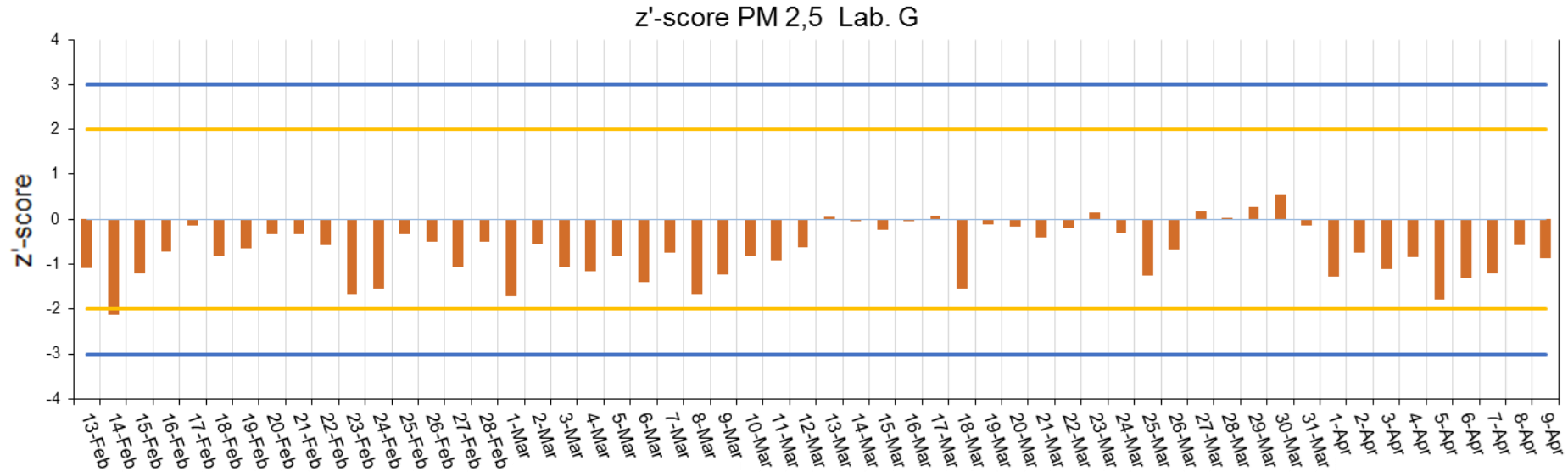


Figure 34: Chart of z'-score evaluation for PM2.5 related to Lab. G

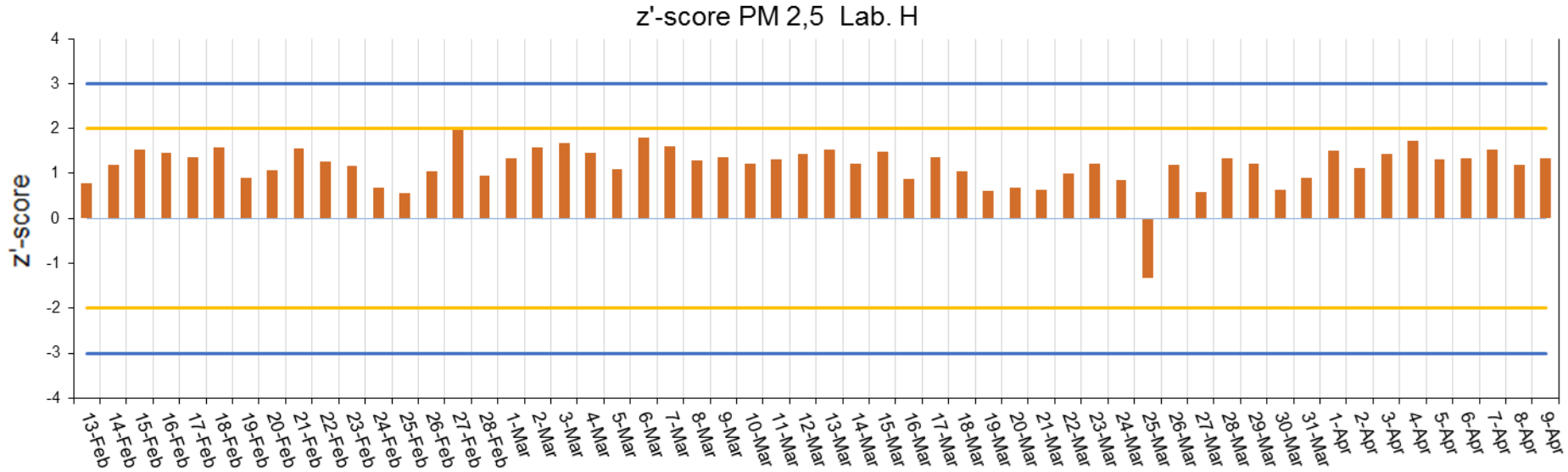


Figure 35: Chart of z'-score evaluation for PM2.5 related to Lab. H

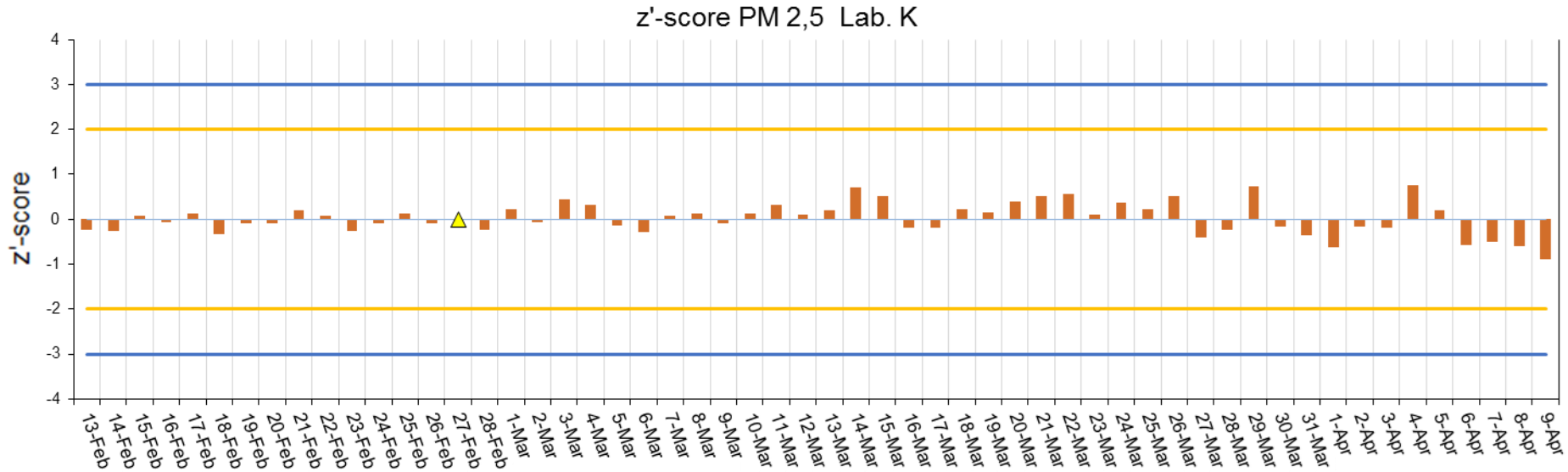


Figure 36: Chart of z'-score evaluation for PM2.5 related to Lab. K

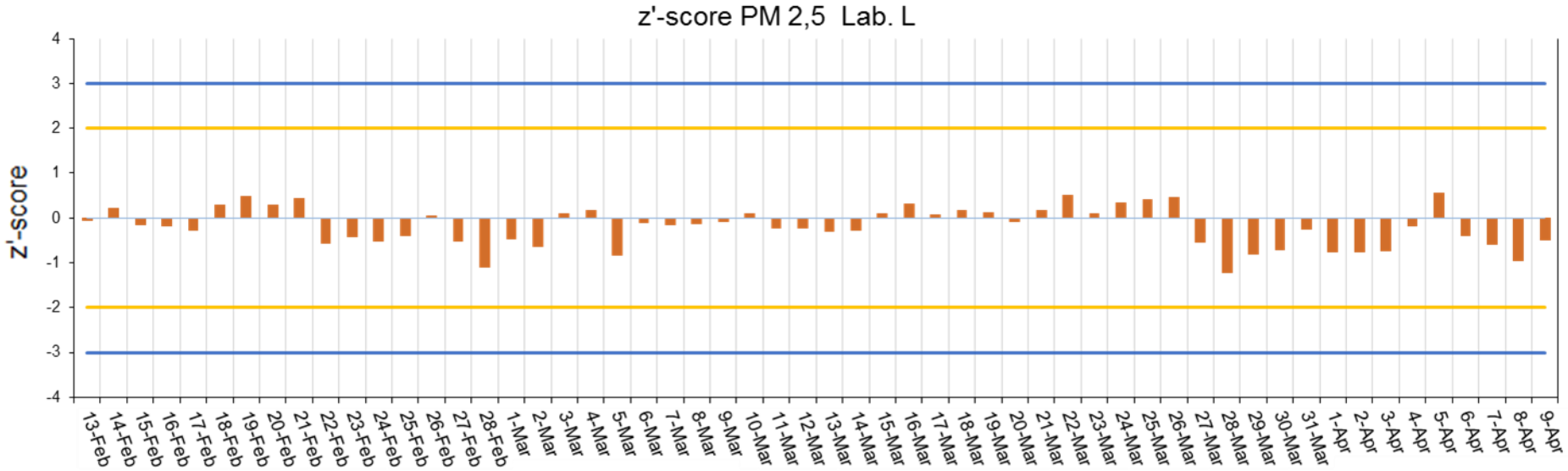


Figure 37: Chart of z'-score evaluation for PM2.5 related to Lab. L

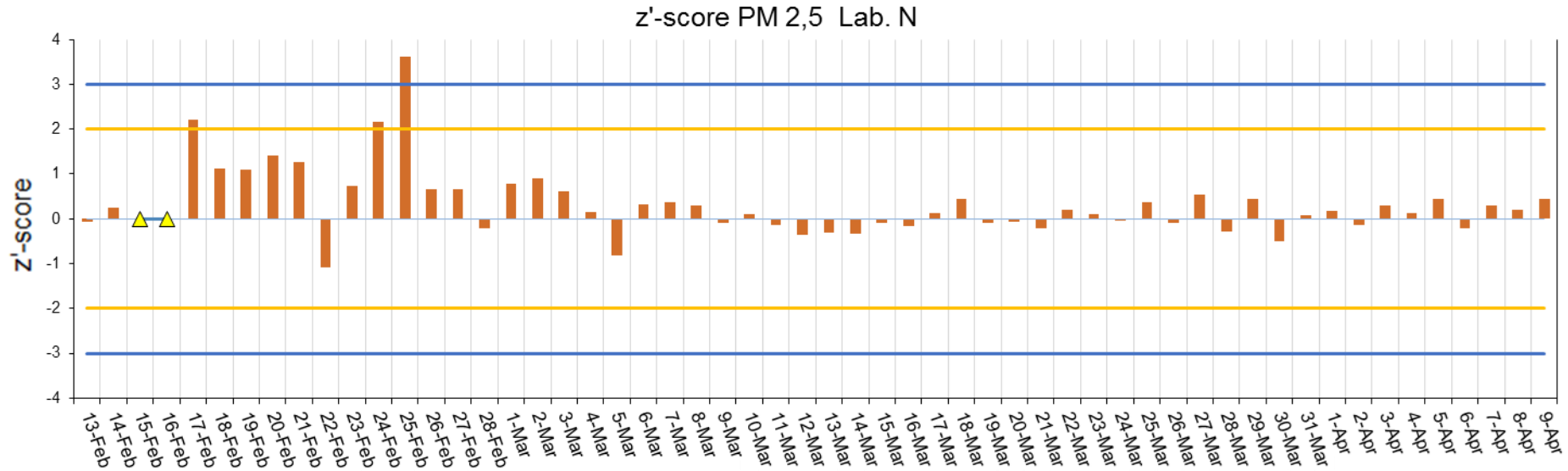


Figure 38: Chart of z'-score evaluation for PM2.5 related to Lab. N

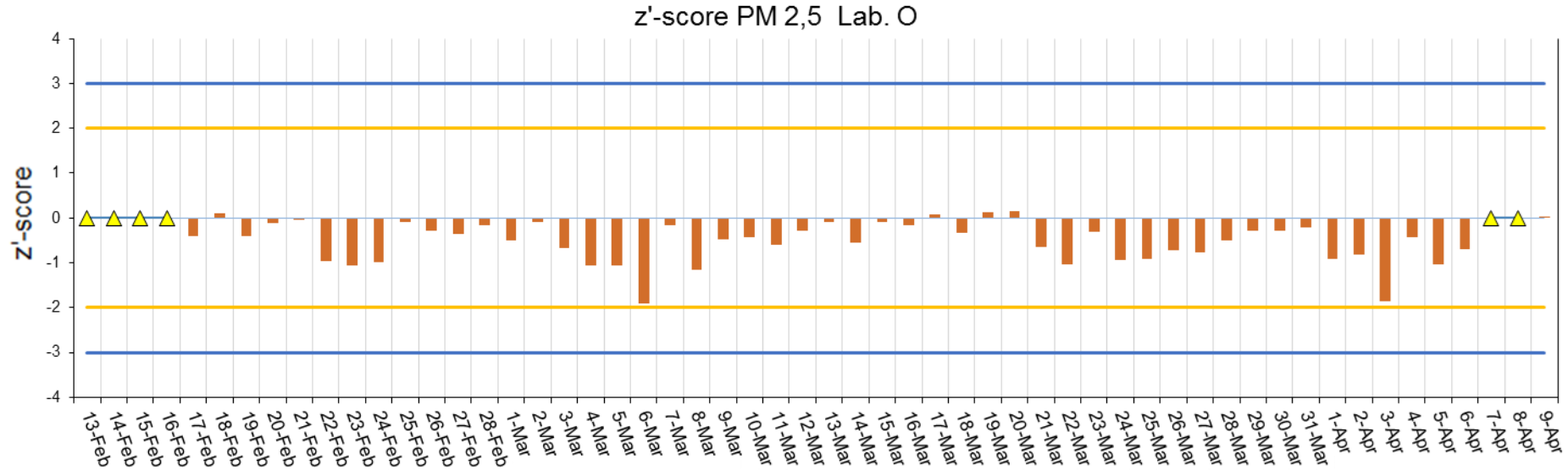


Figure 39: Chart of z'-score evaluation for PM2.5 related to Lab. O

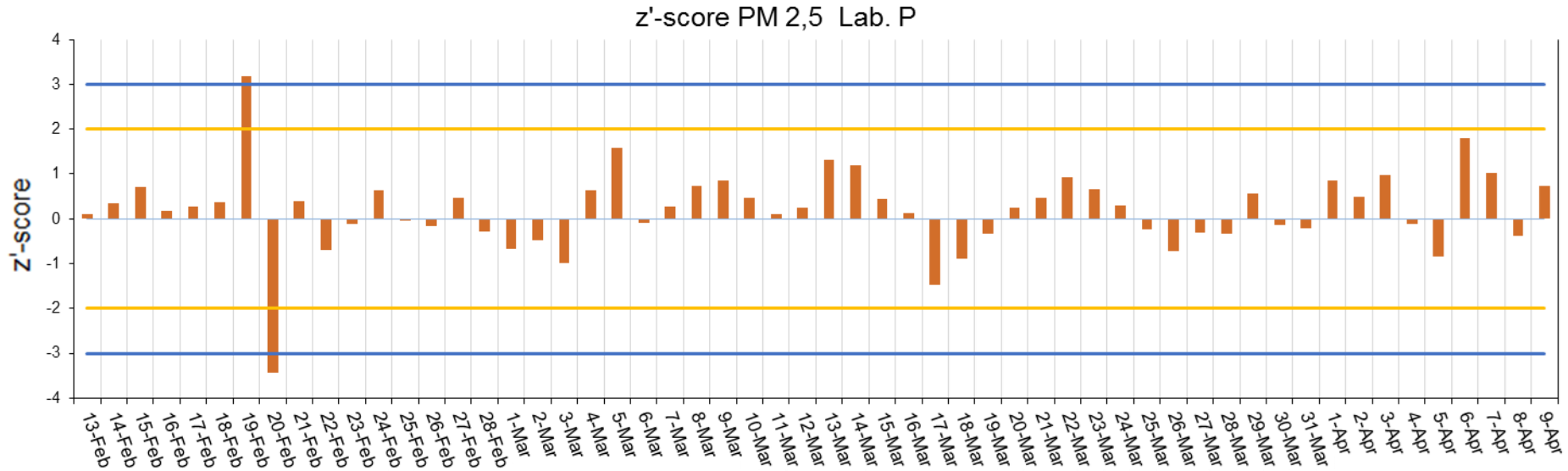


Figure 40: Chart of z'-score evaluation for PM2.5 related to Lab. P

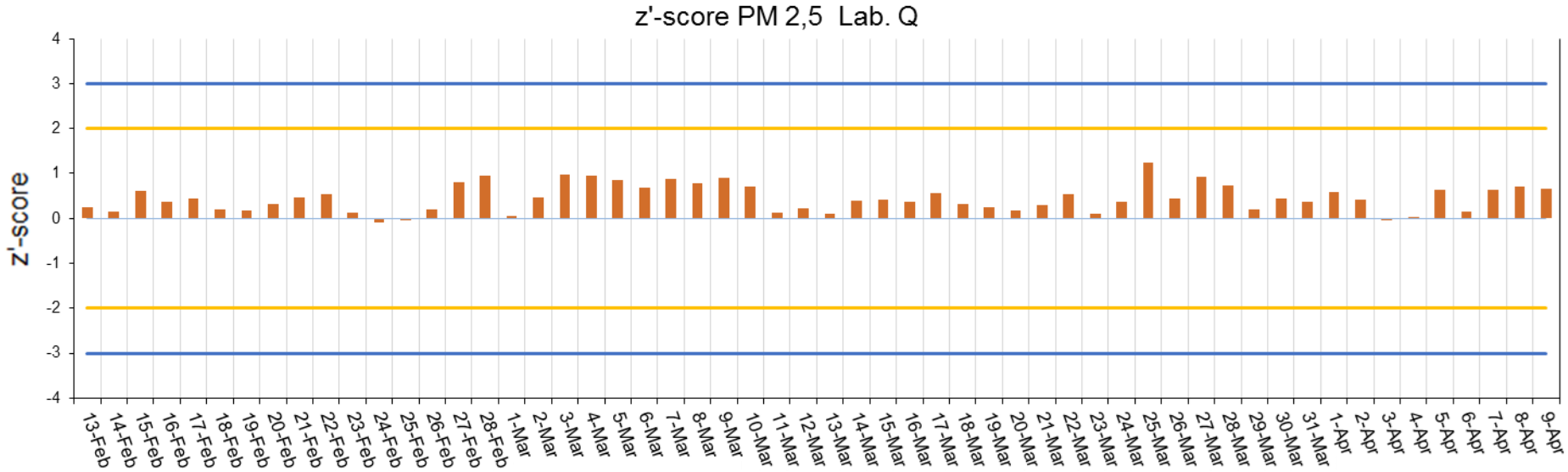


Figure 41: Chart of z'-score evaluation for PM2.5 related to Lab. Q

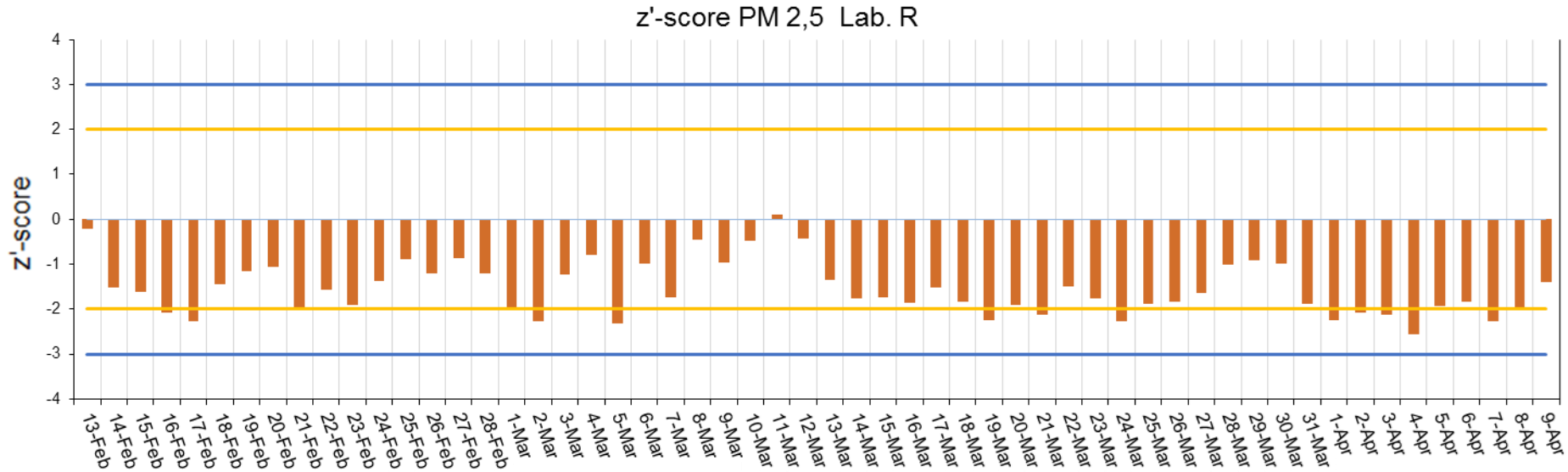


Figure 42: Chart of z'-score evaluation for PM2.5 related to Lab. R

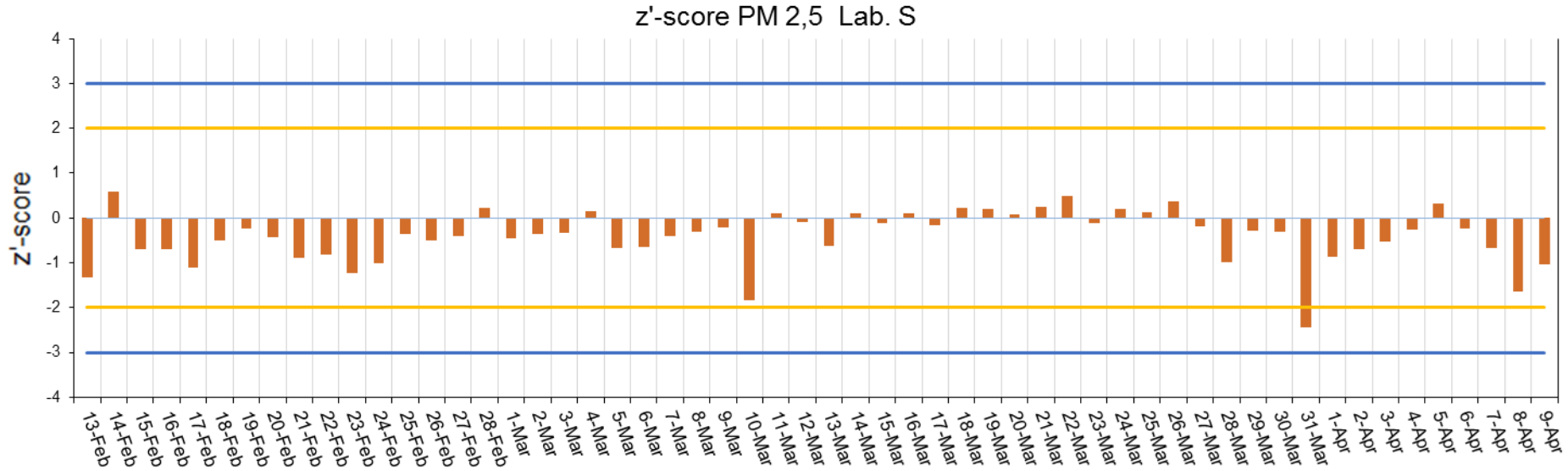


Figure 43: Chart of z'-score evaluation for PM2.5 related to Lab. S

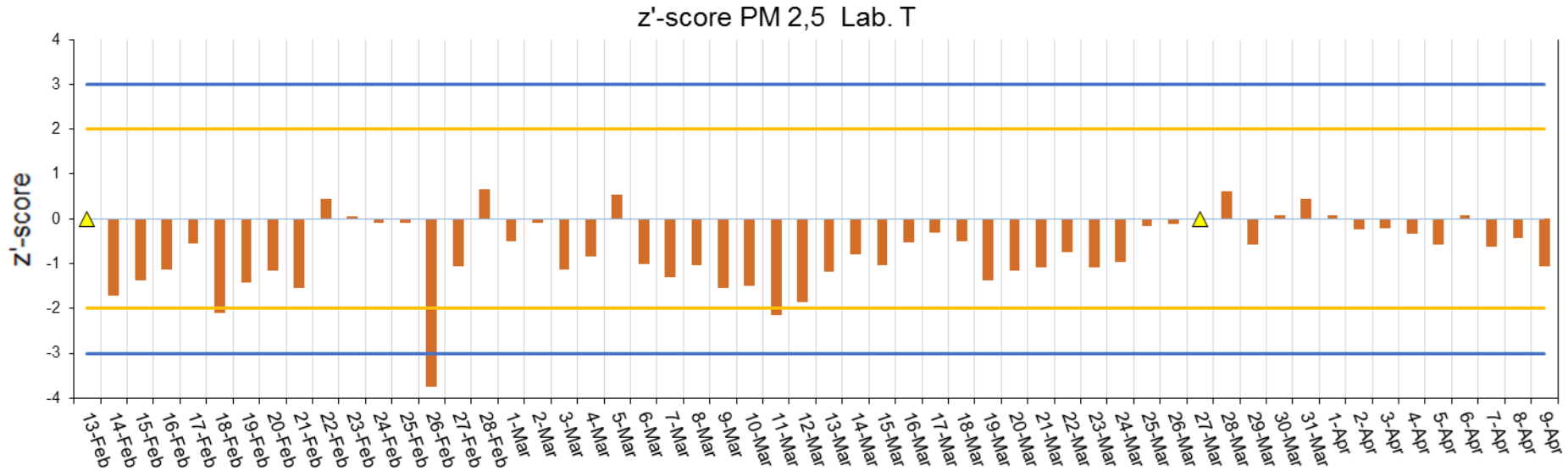


Figure 44: Chart of z'-score evaluation for PM2.5 related to Lab. T

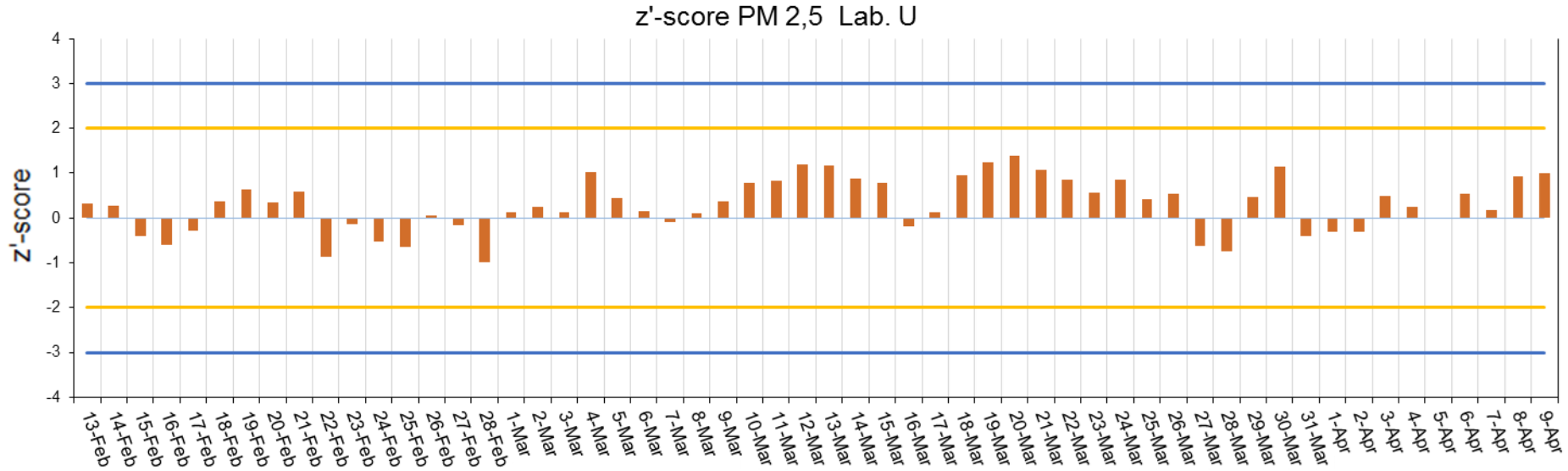


Figure 45: Chart of z'-score evaluation for PM2.5 related to Lab. U

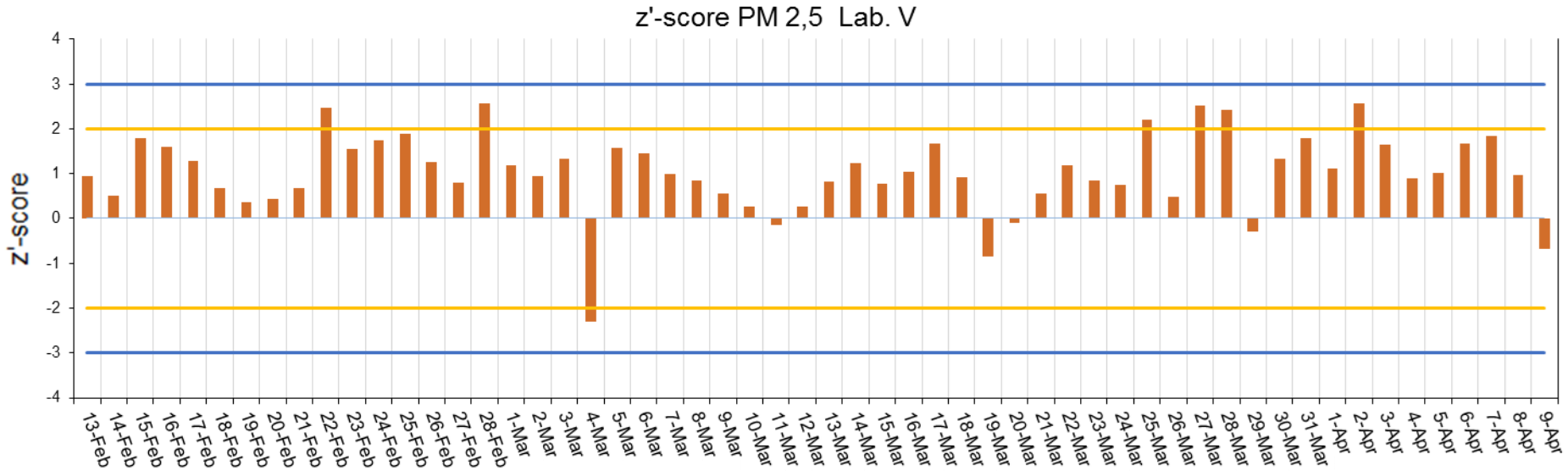


Figure 46: Chart of z'-score evaluation for PM2.5 related to Lab. V

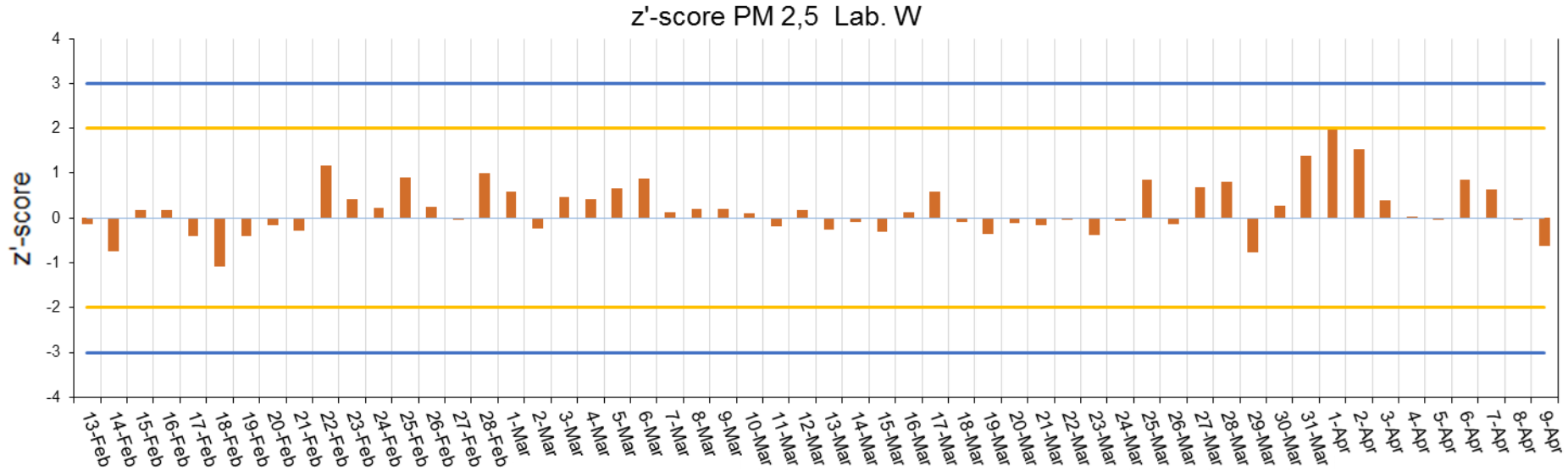


Figure 47: Chart of z'-score evaluation for PM2.5 related to Lab. W

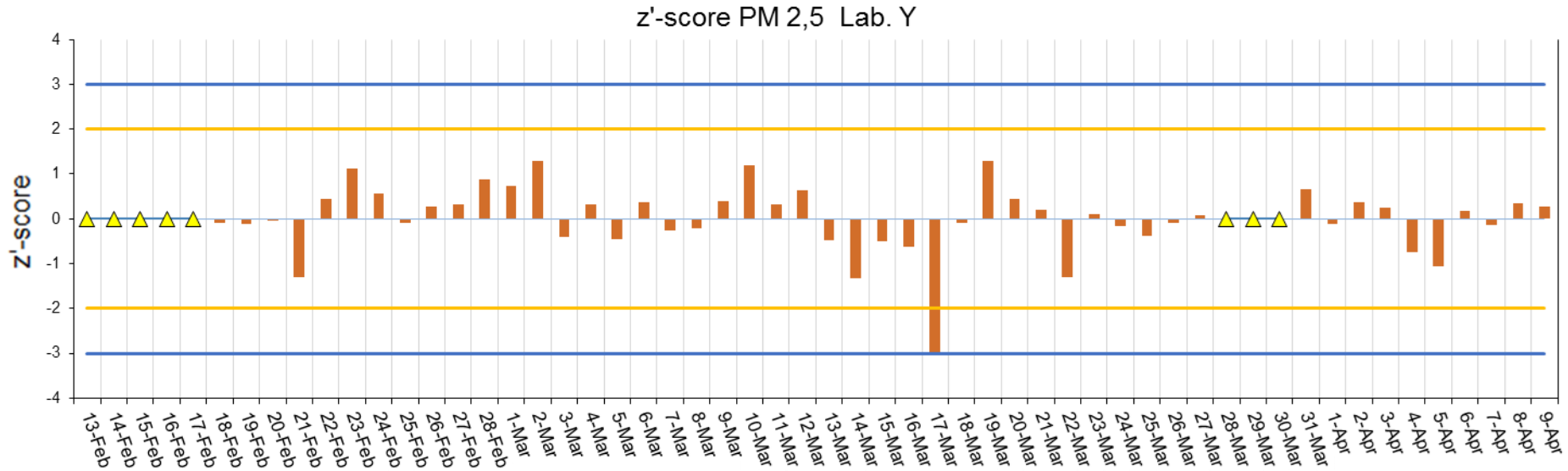


Figure 48: Chart of z'-score evaluation for PM2.5 related to Lab. Y

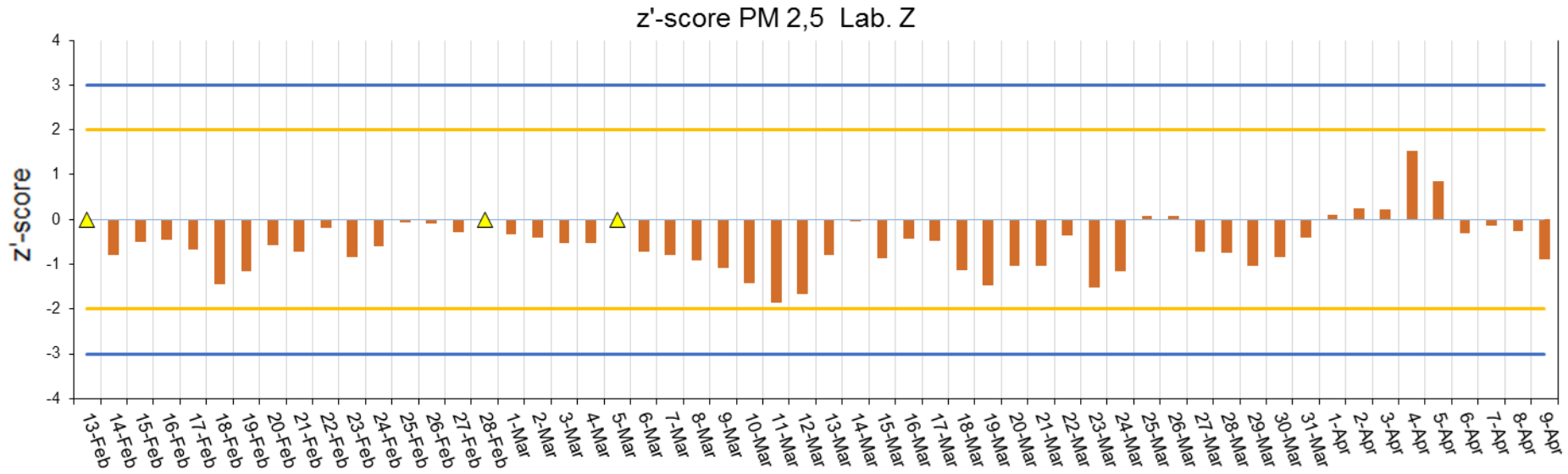


Figure 49: Chart of z'-score evaluation for PM2.5 related to Lab. Z

PM10

LEGEND z'-score 2 -2 3 -3 not reported

Figure 50 to 73 show for each laboratory the calculated z'-score daily value for PM10.

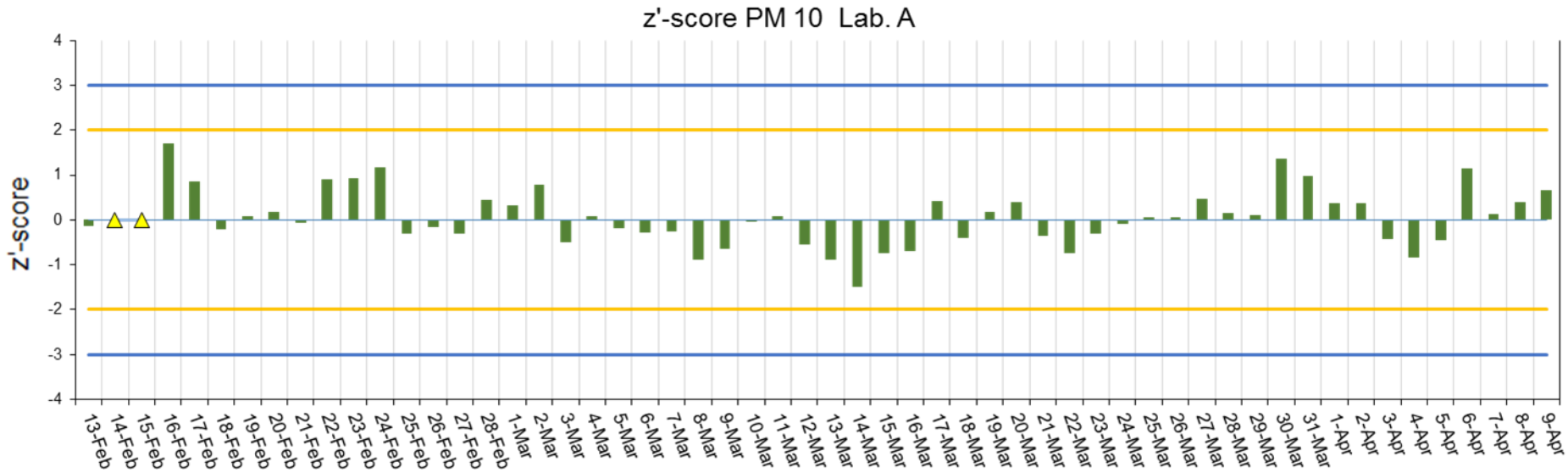


Figure 50: Chart of z'-score evaluation for PM10 related to Lab. A

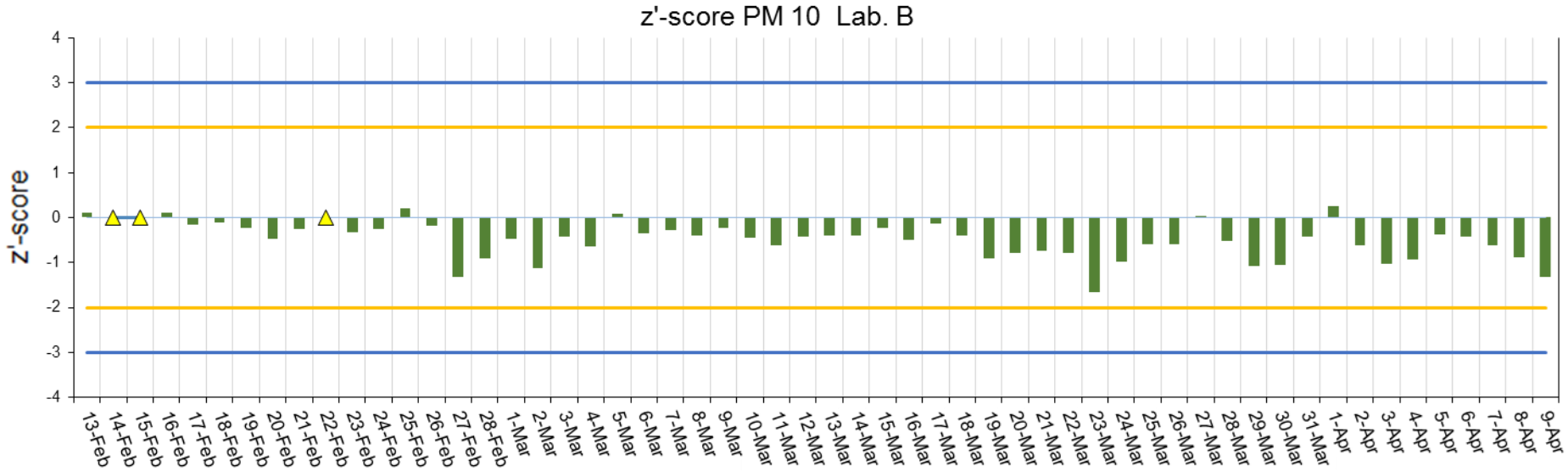


Figure 51: Chart of z'-score evaluation for PM10 related to Lab. B

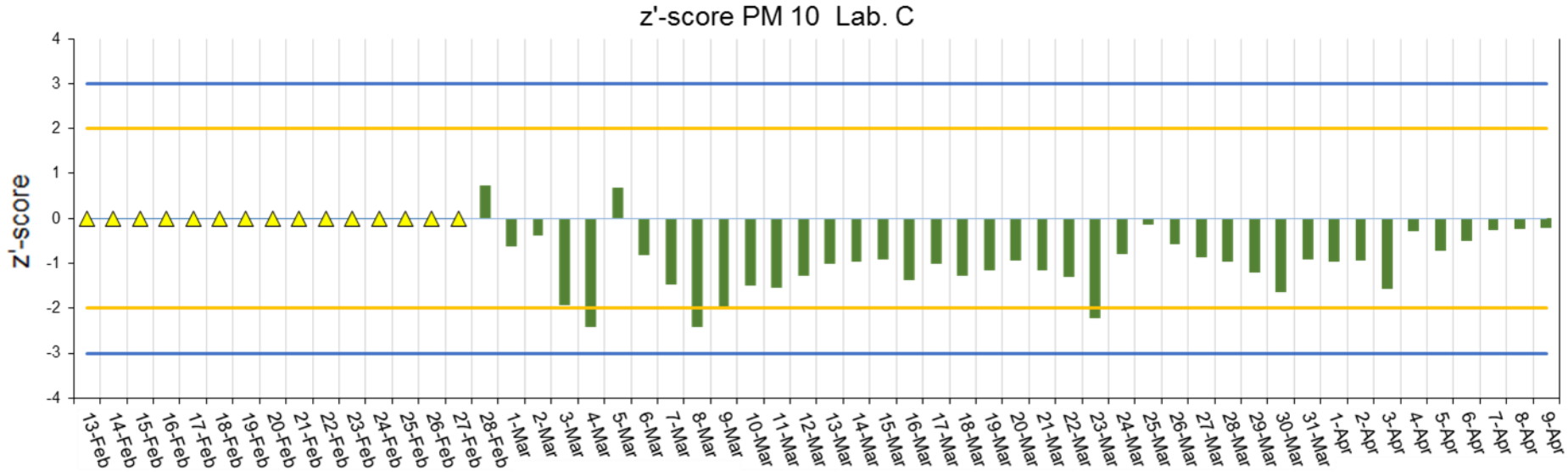


Figure 52: Chart of z'-score evaluation for PM10 related to Lab. C

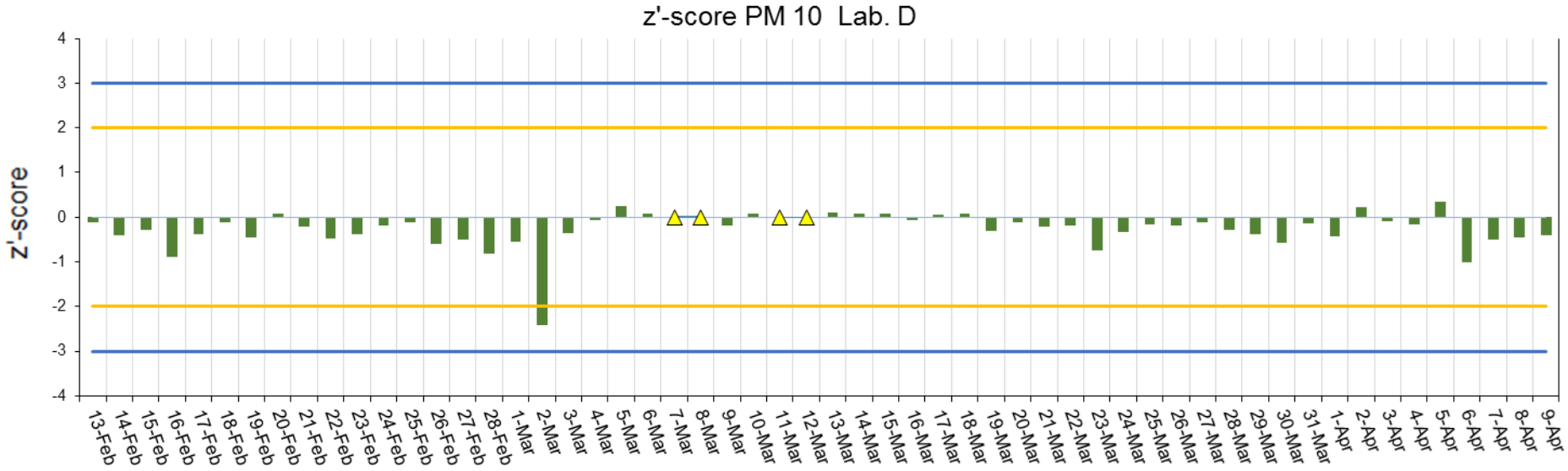


Figure 53: Chart of z'-score evaluation for PM10 related to Lab. D

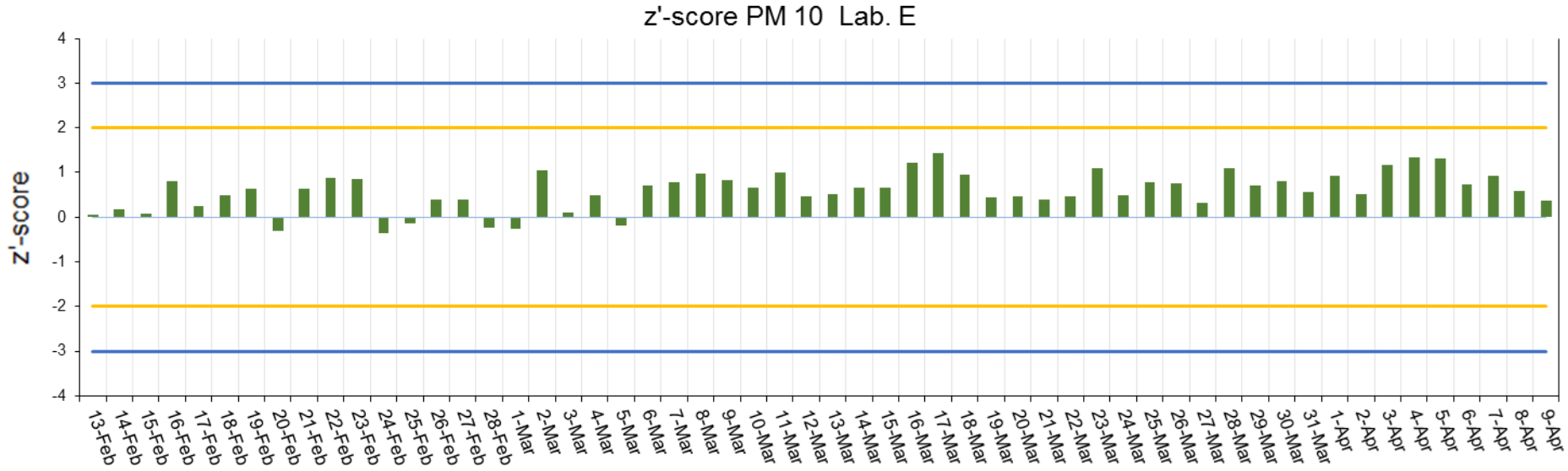


Figure 54: Chart of z'-score evaluation for PM10 related to Lab. E

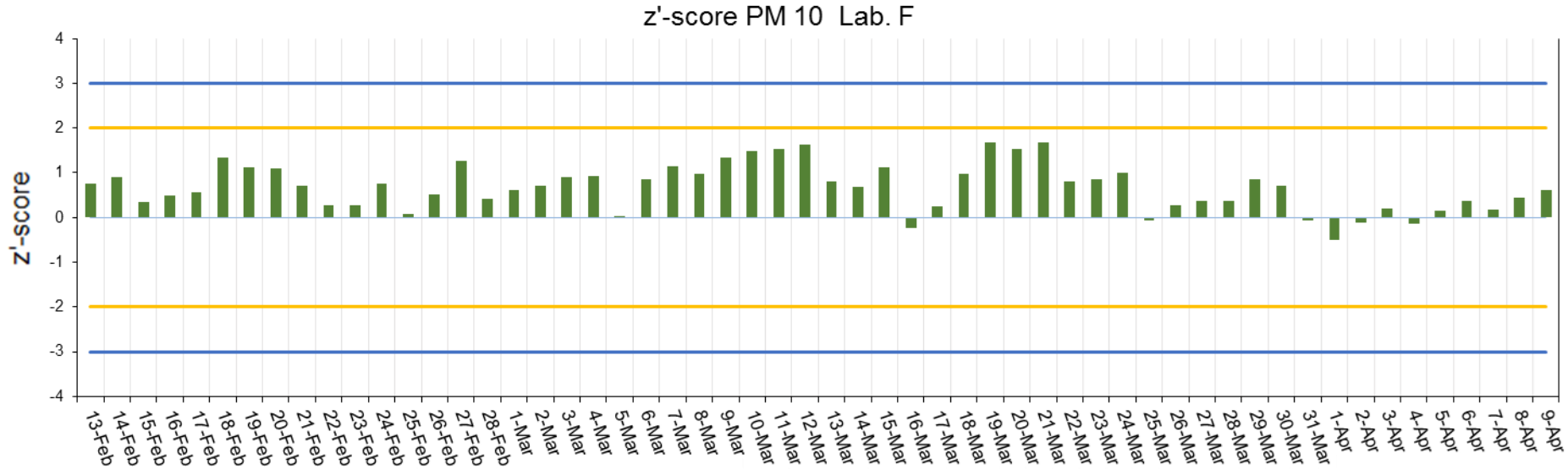


Figure 55: Chart of z'-score evaluation for PM10 related to Lab. F

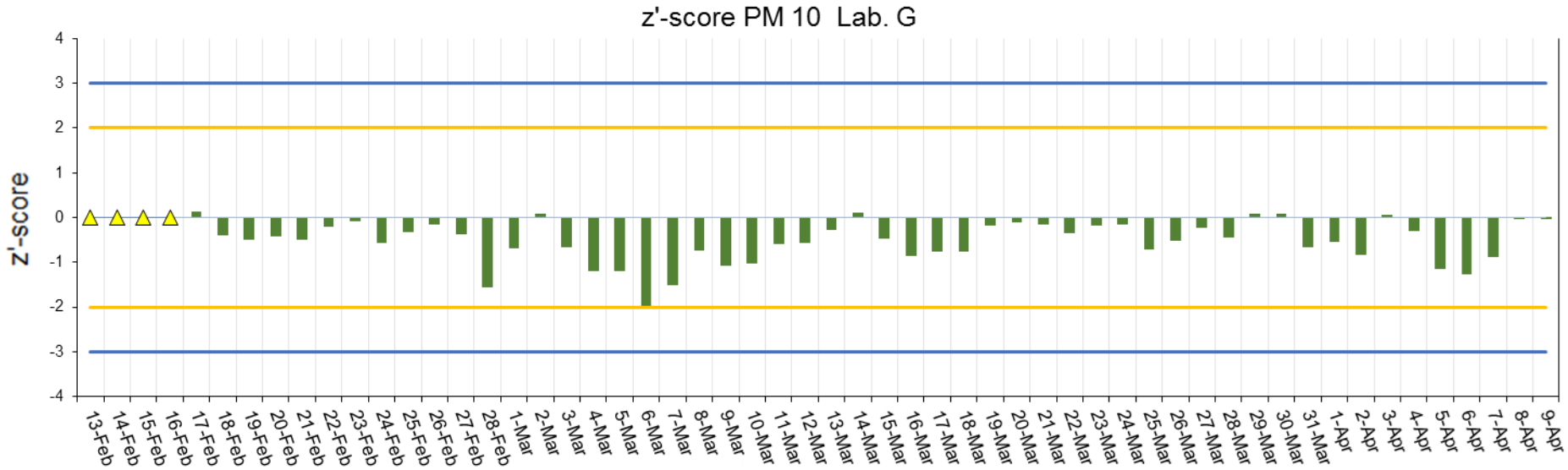


Figure 56: Chart of z'-score evaluation for PM10 related to Lab. G

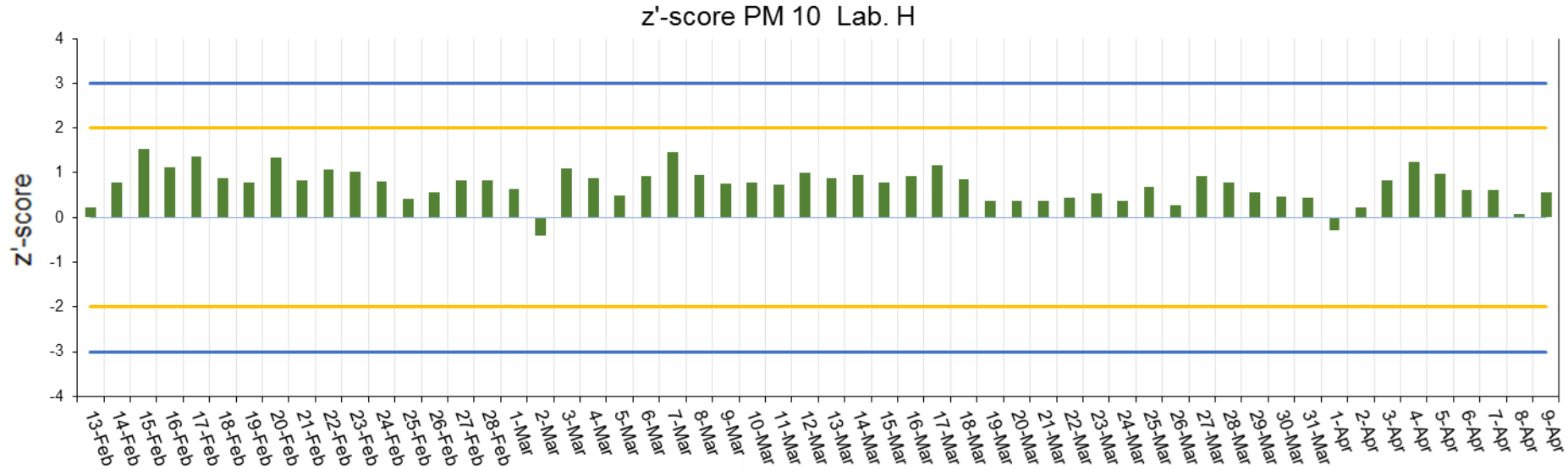


Figure 57: Chart of z'-score evaluation for PM10 related to Lab. H

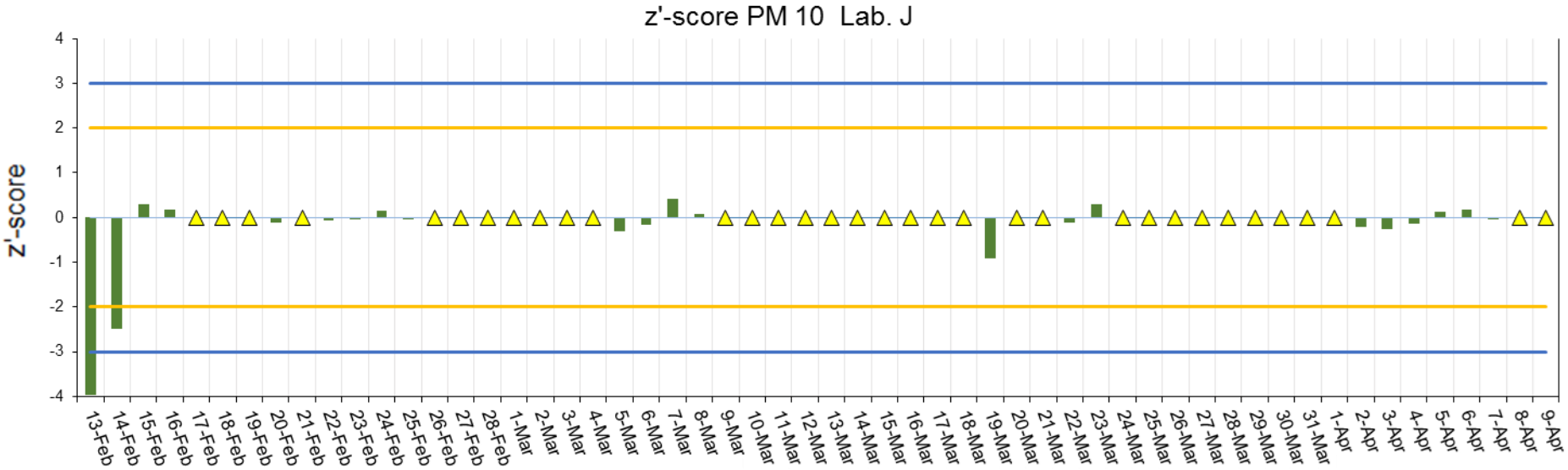


Figure 58: Chart of z'-score evaluation for PM10 related to Lab. J

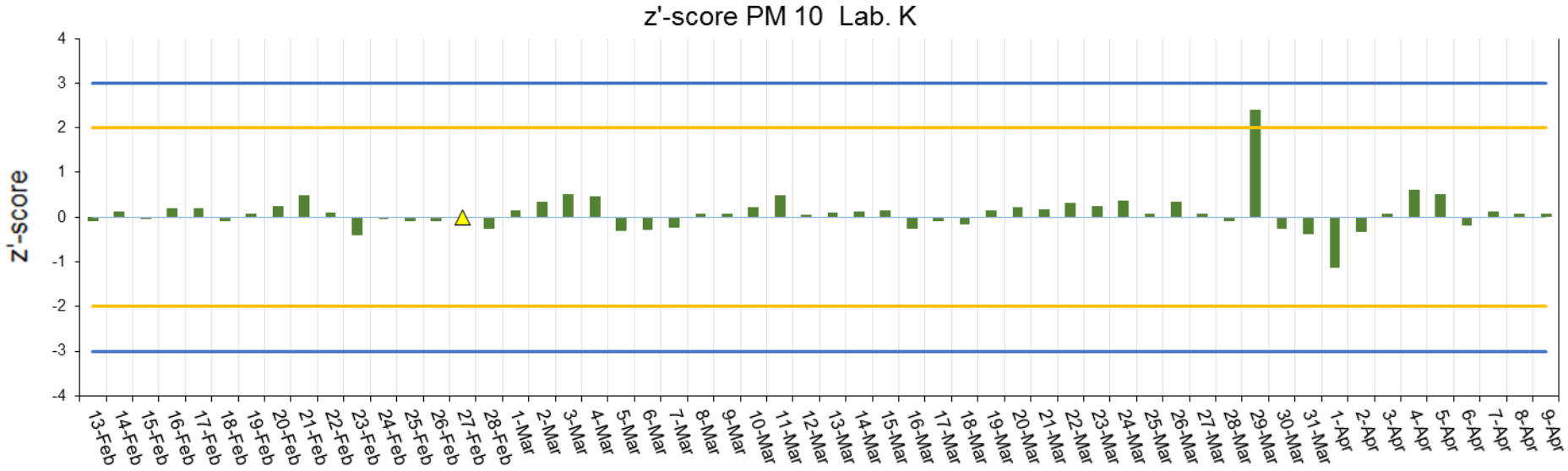


Figure 59: Chart of z'-score evaluation for PM10 related to Lab. K

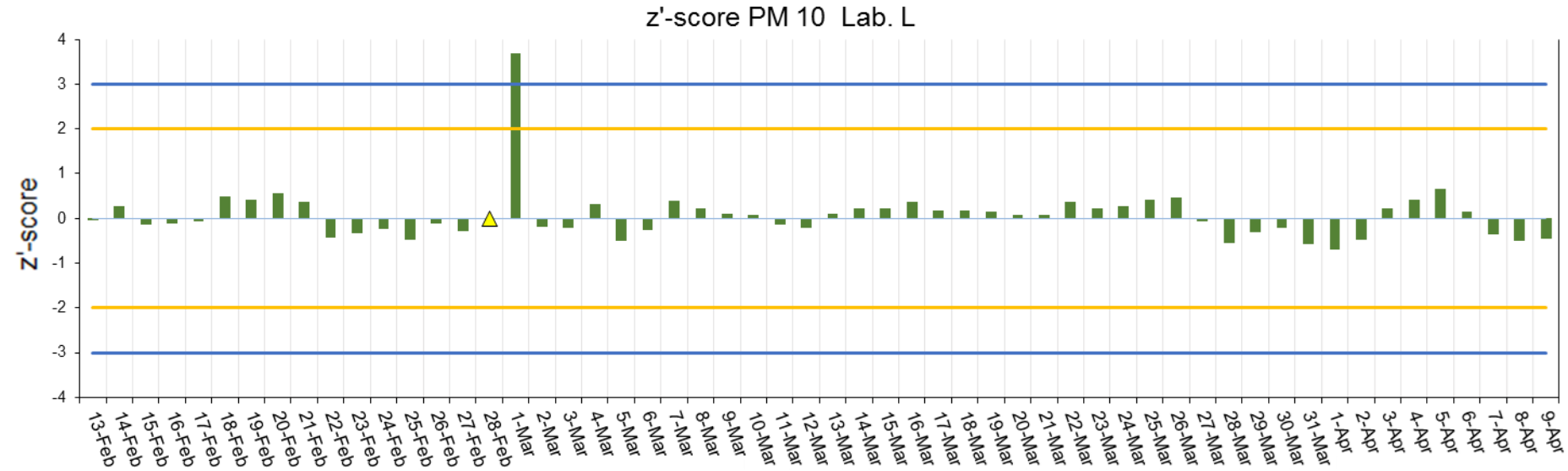


Figure 60: Chart of z'-score evaluation for PM10 related to Lab. L

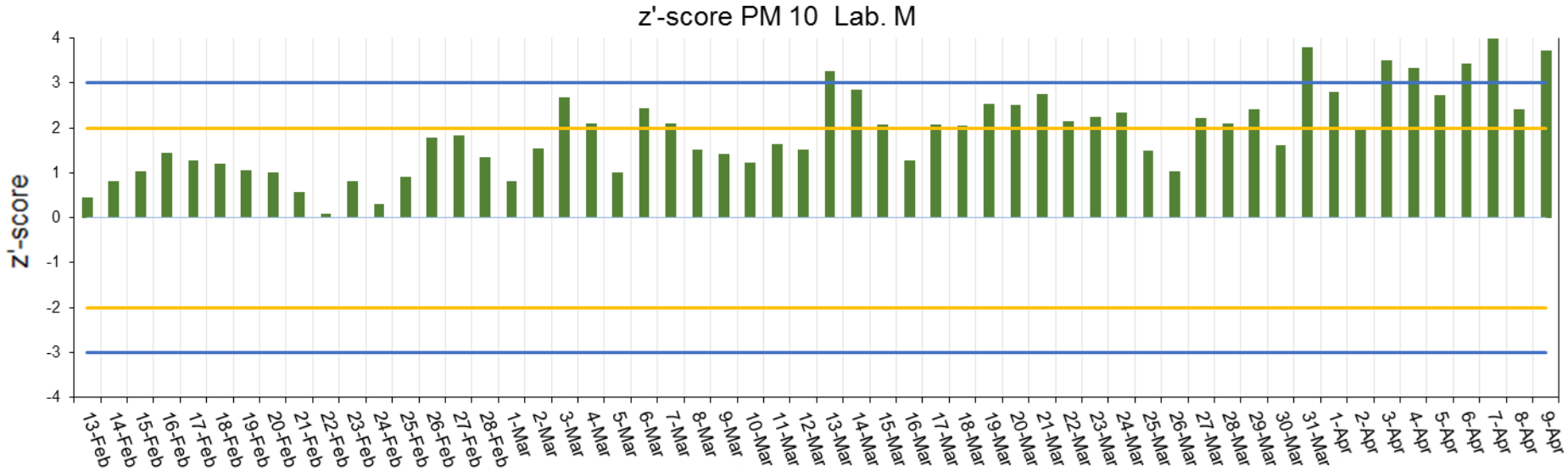


Figure 61: Chart of z'-score evaluation for PM10 related to Lab. M

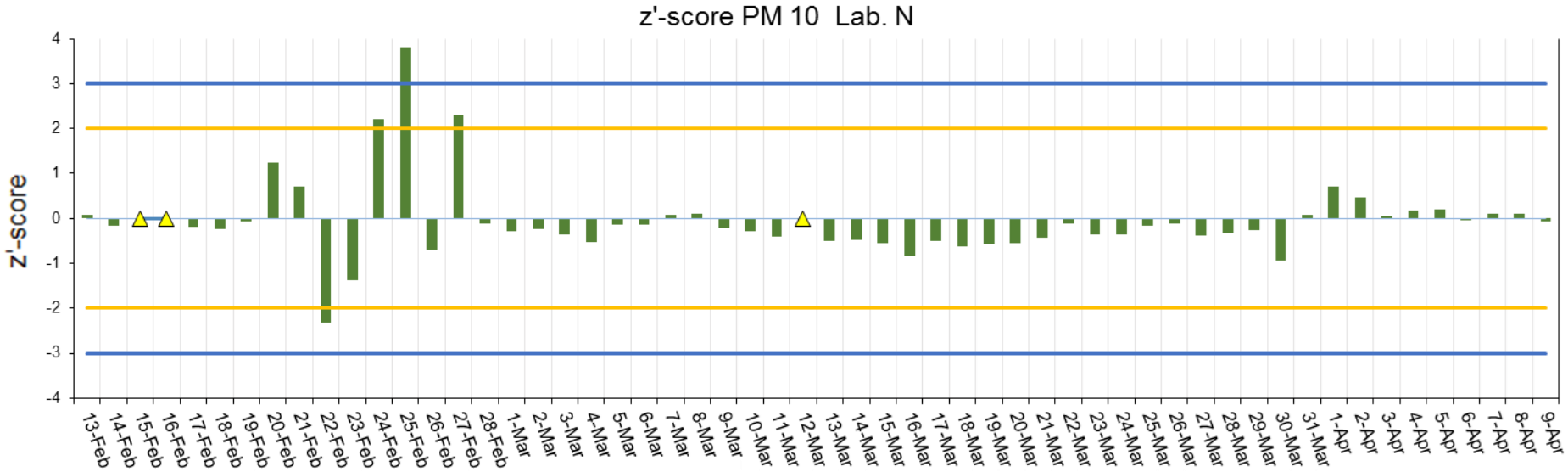


Figure 62: Chart of z'-score evaluation for PM10 related to Lab. N

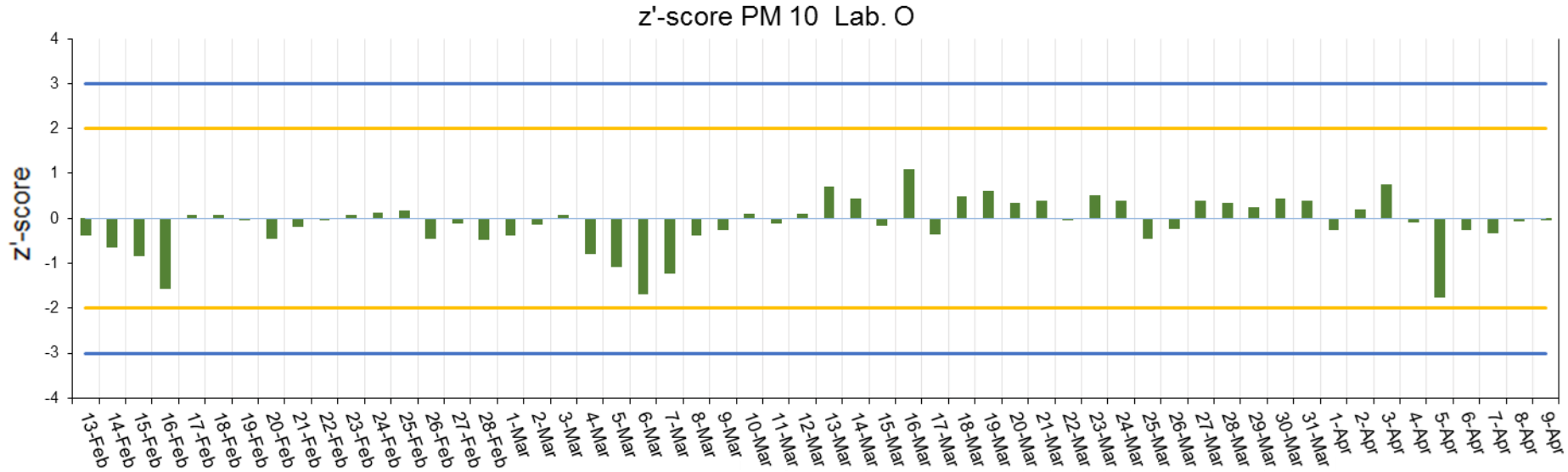


Figure 63: Chart of z'-score evaluation for PM10 related to Lab. O

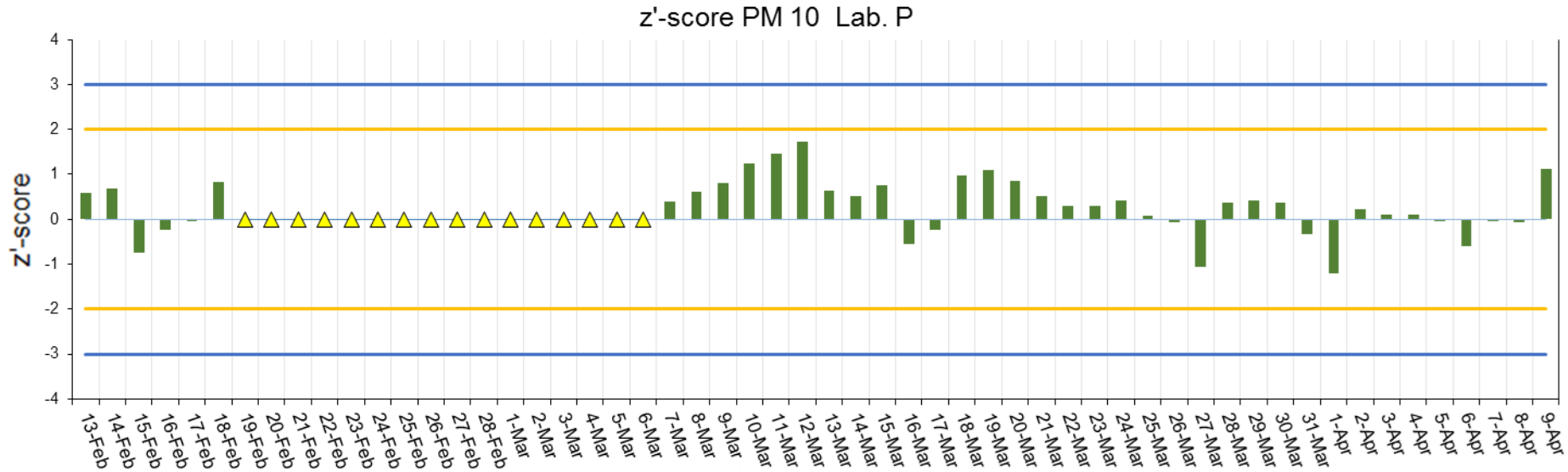


Figure 64: Chart of z'-score evaluation for PM10 related to Lab. P

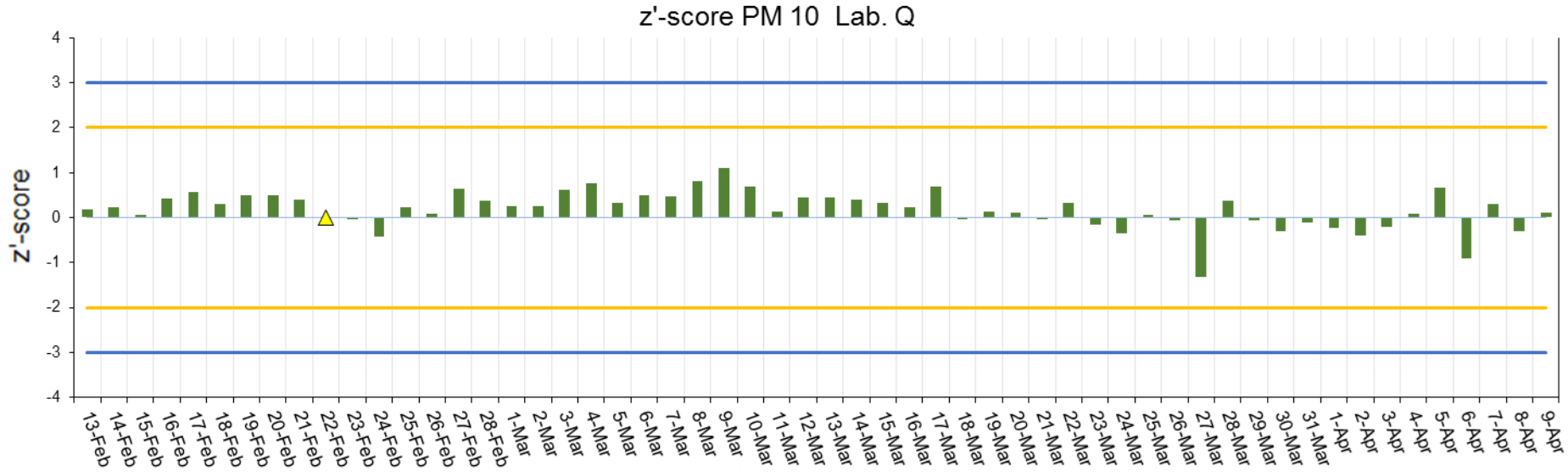


Figure 65: Chart of z'-score evaluation for PM10 related to Lab. Q

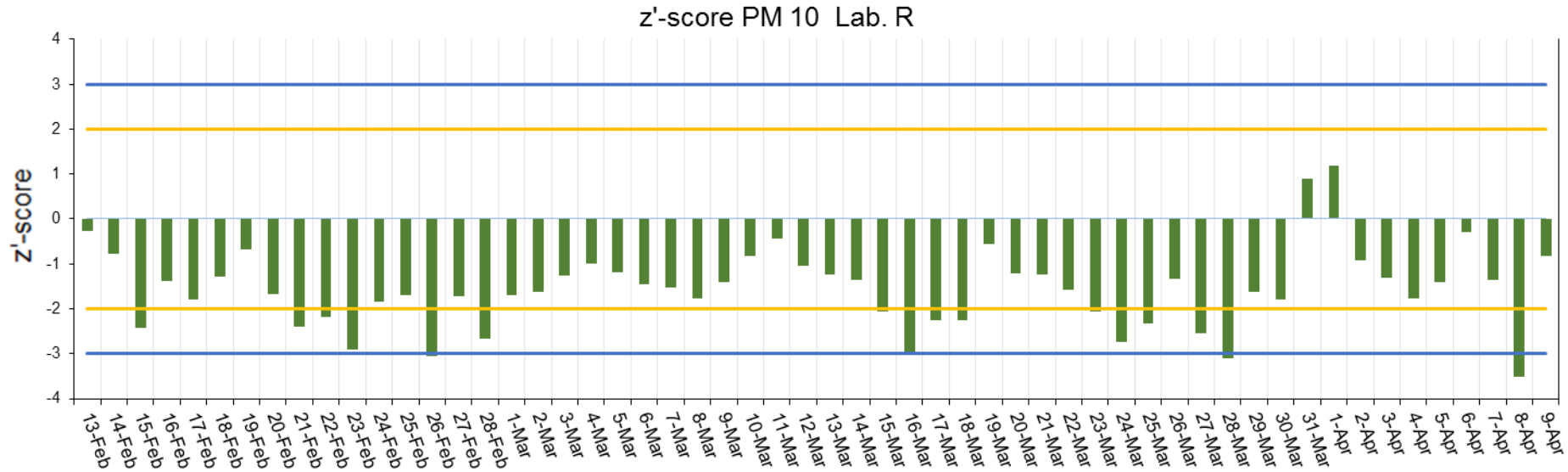


Figure 66: Chart of z'-score evaluation for PM10 related to Lab. R

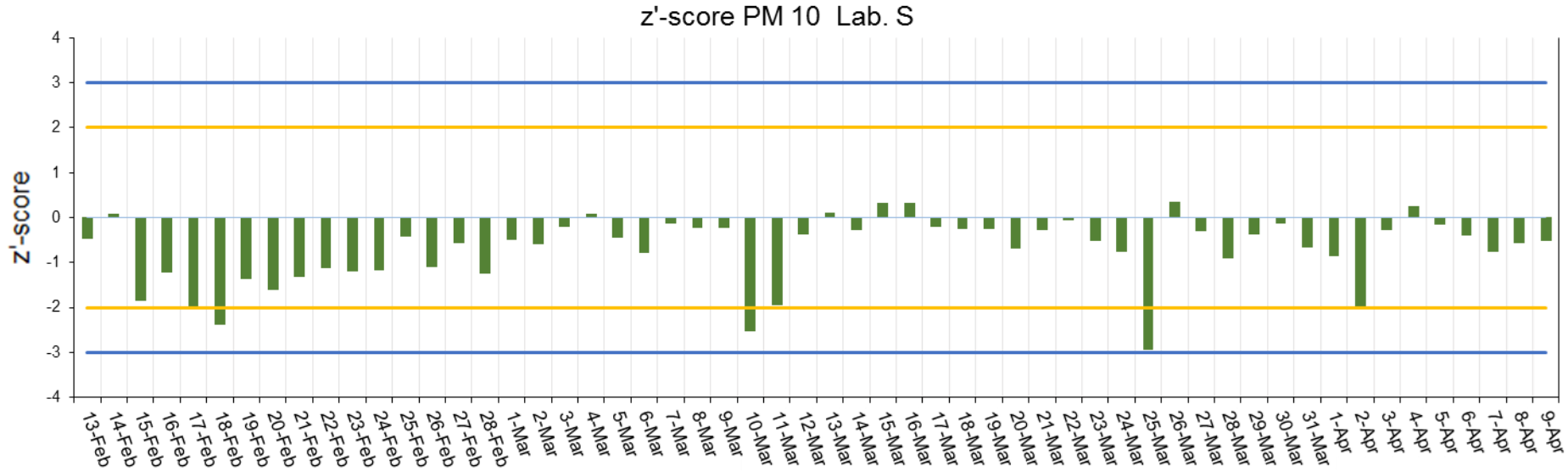


Figure 67: Chart of z'-score evaluation for PM10 related to Lab. S

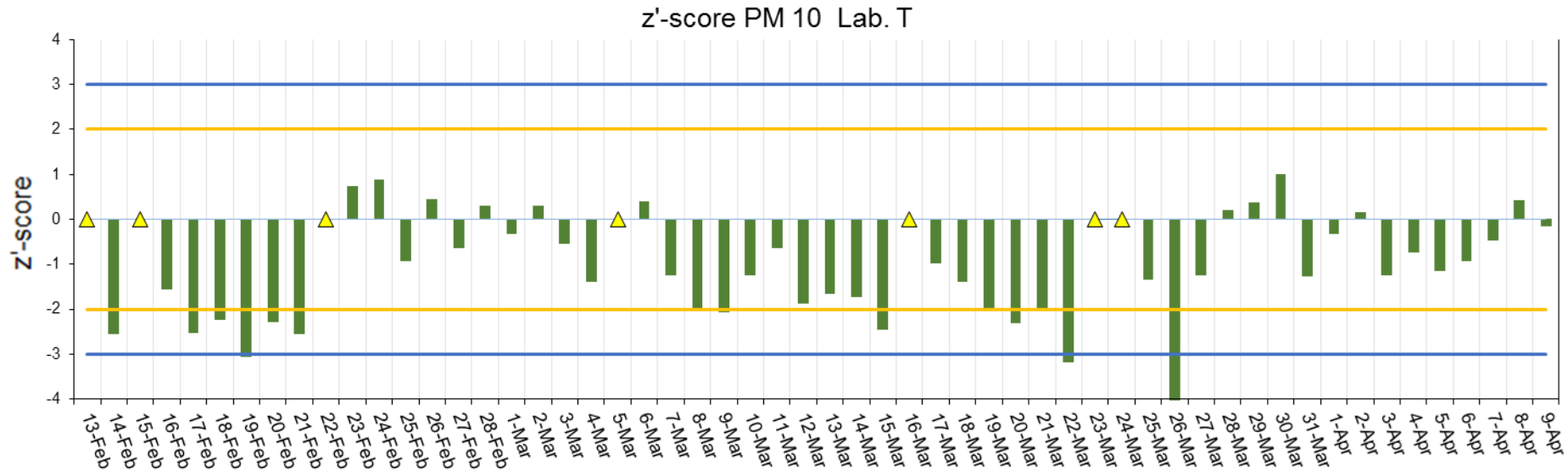


Figure 68: Chart of z'-score evaluation for PM10 related to Lab. T

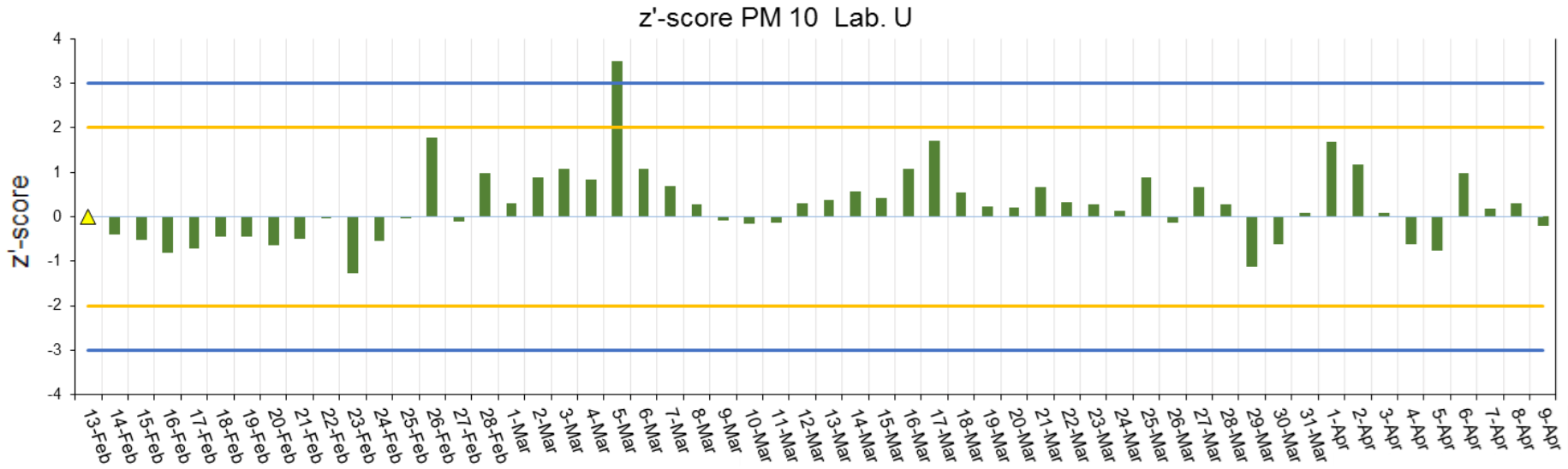


Figure 69: Chart of z'-score evaluation for PM10 related to Lab. U

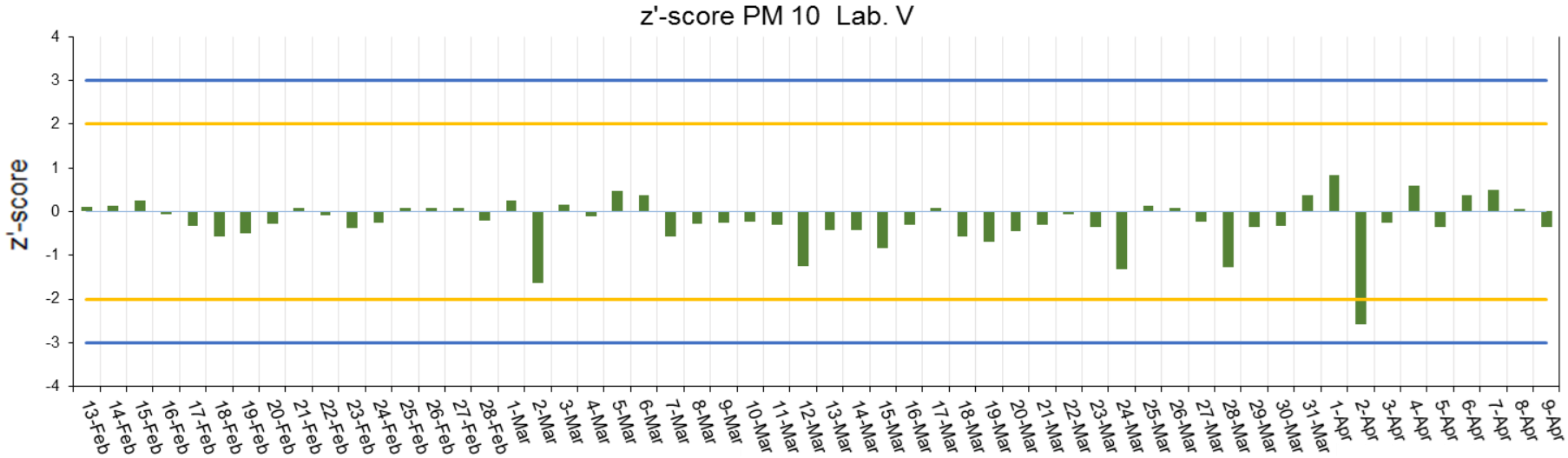


Figure 70: Chart of z'-score evaluation for PM10 related to Lab. V

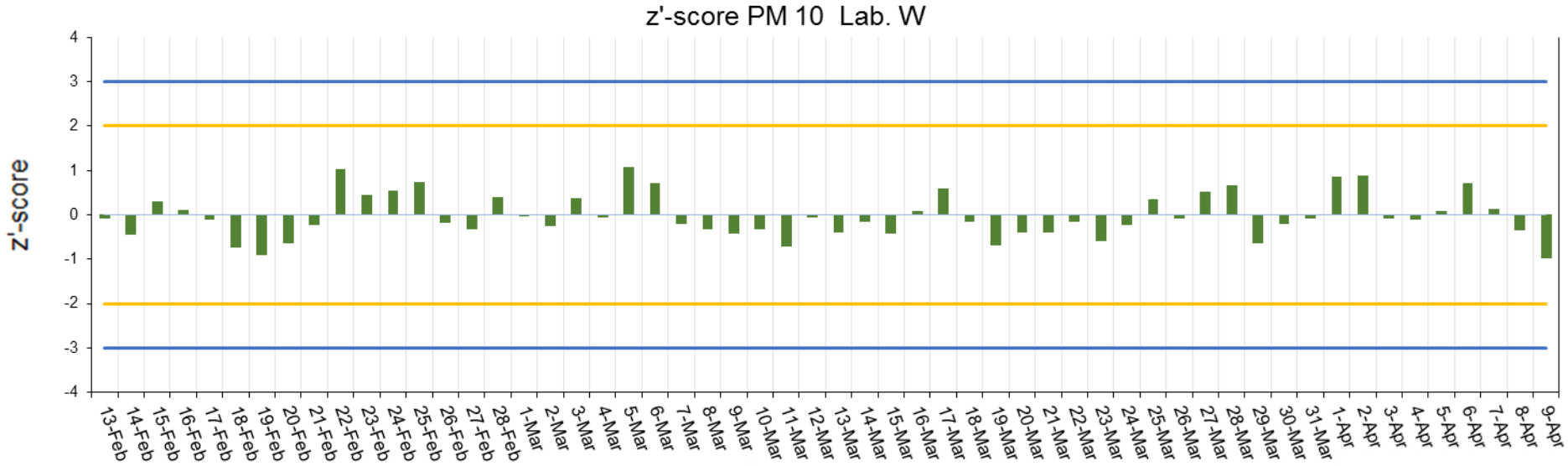


Figure 71: Chart of z'-score evaluation for PM10 related to Lab. W

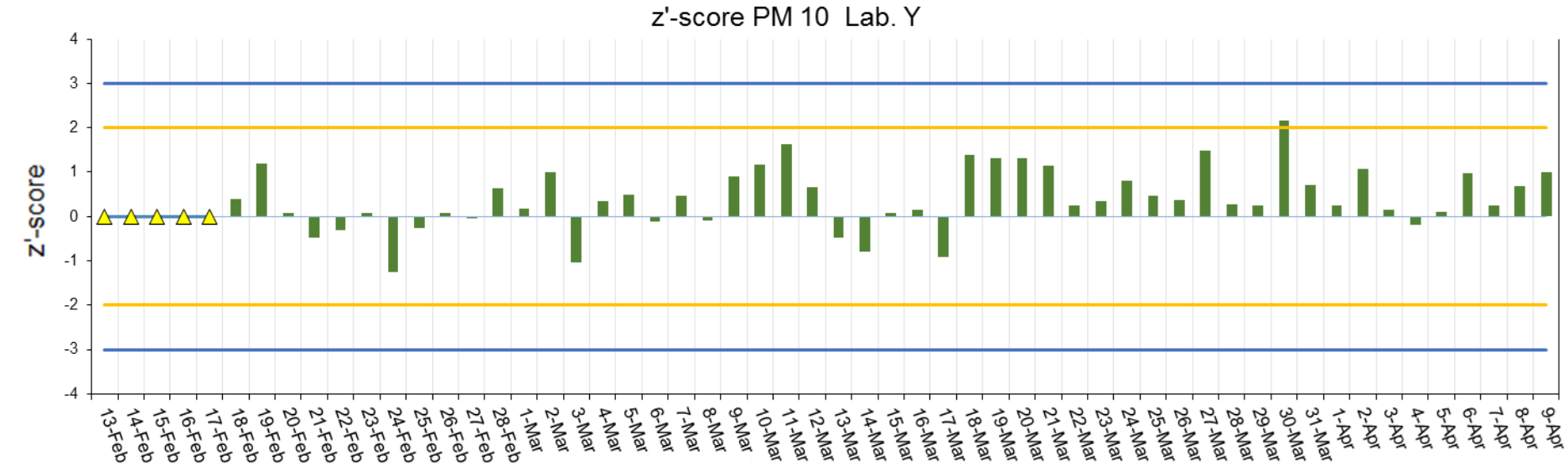


Figure 72: Chart of z'-score evaluation for PM10 related to Lab. Y

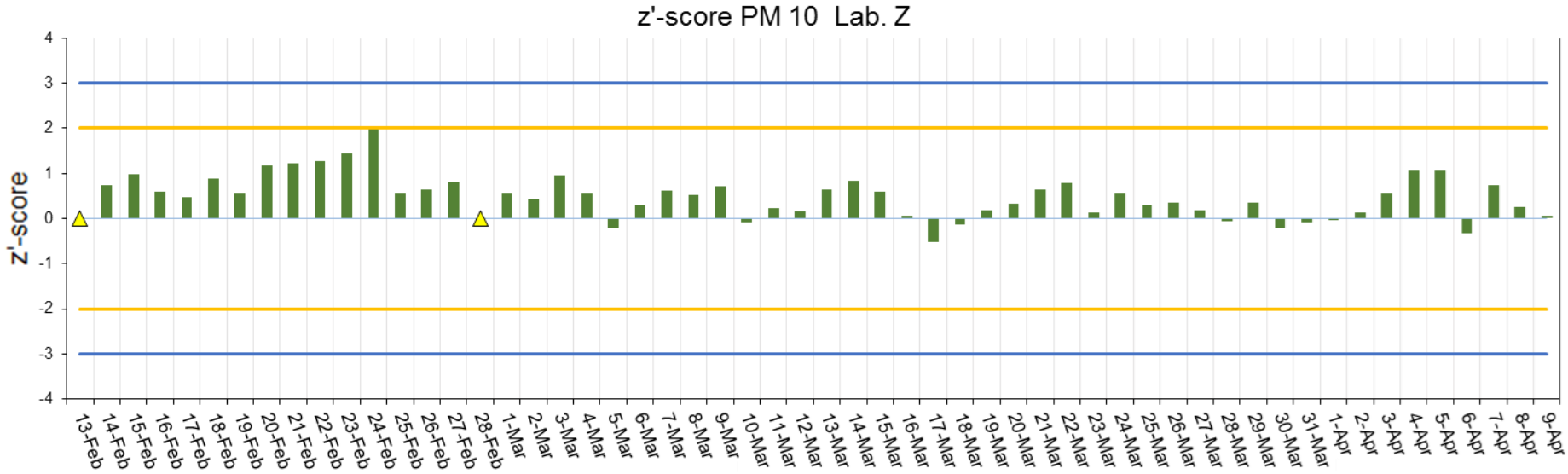


Figure 73: Chart of z'-score evaluation for PM10 related to Lab. Z

Annex D: Participants E_n-scores

PM2.5

LEGEND ▫ Bias △not reported

Figure 74 to 95 show for each laboratory the calculated E_n-score daily value for PM2.5.

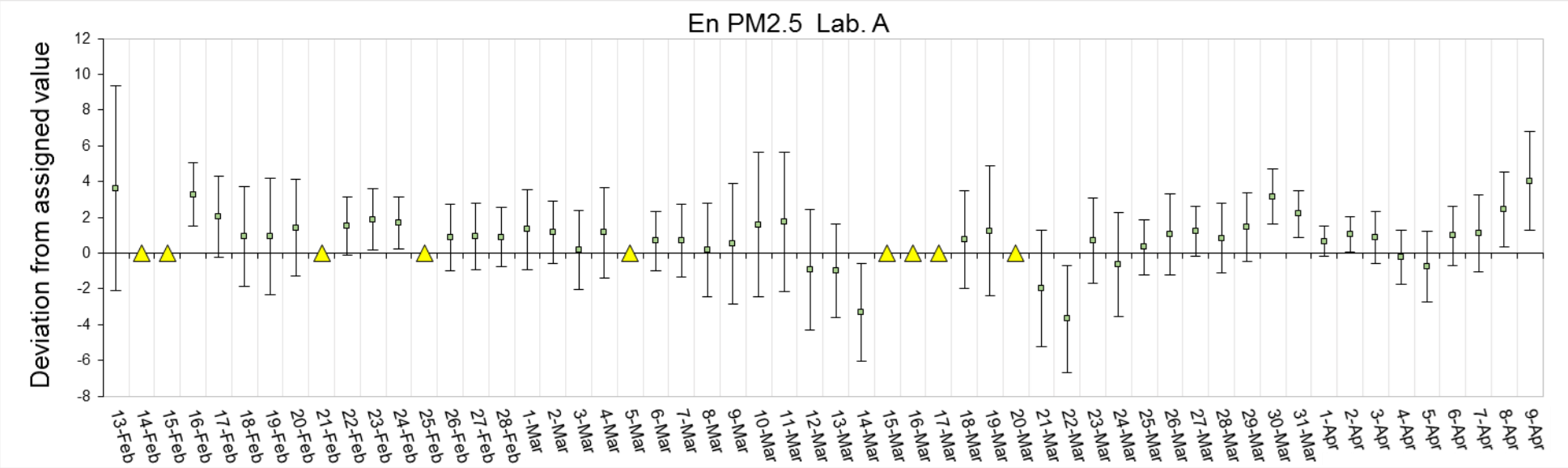


Figure 74: Chart of Bias evaluation for PM2.5 related to Lab. A

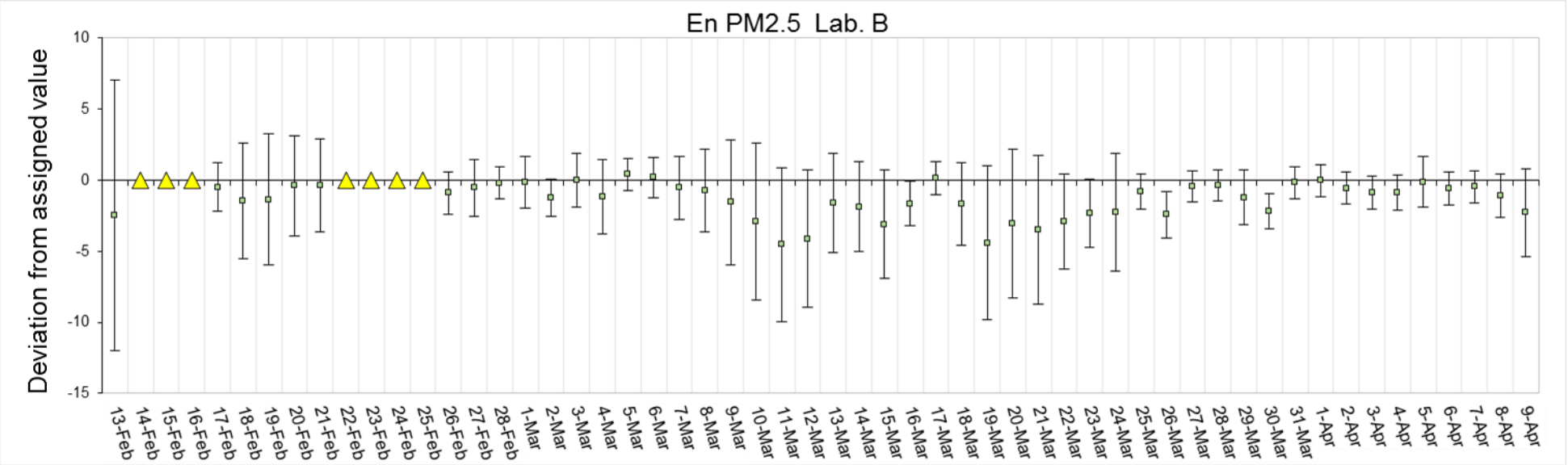


Figure 75: Chart of Bias evaluation for PM2.5 related to Lab. B

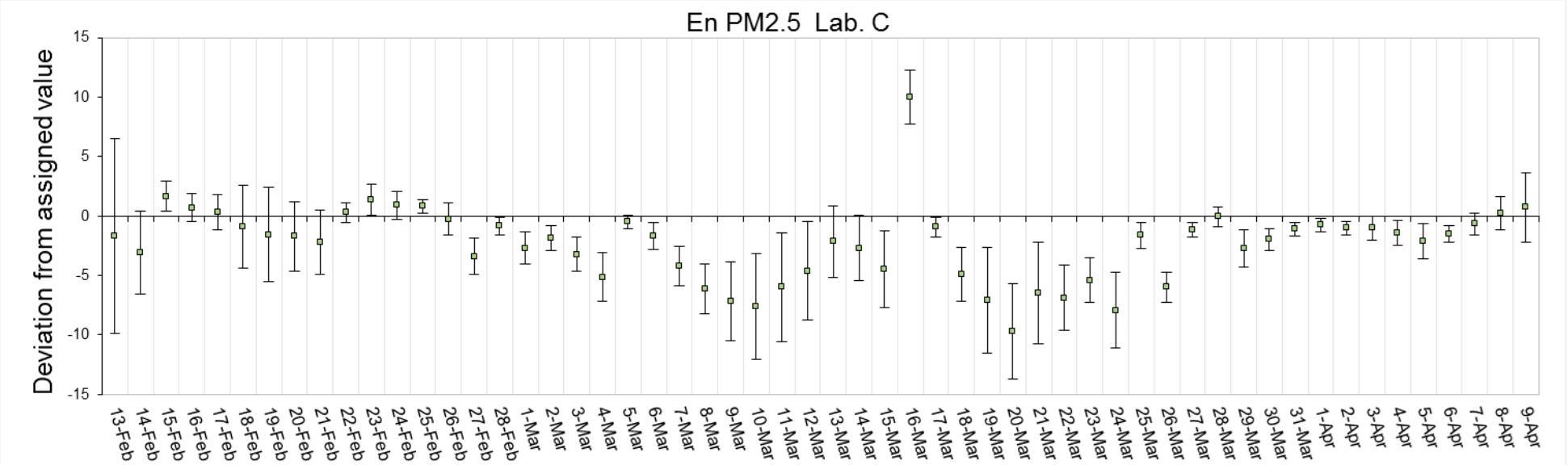


Figure 76: Chart of Bias evaluation for PM2.5 related to Lab. C

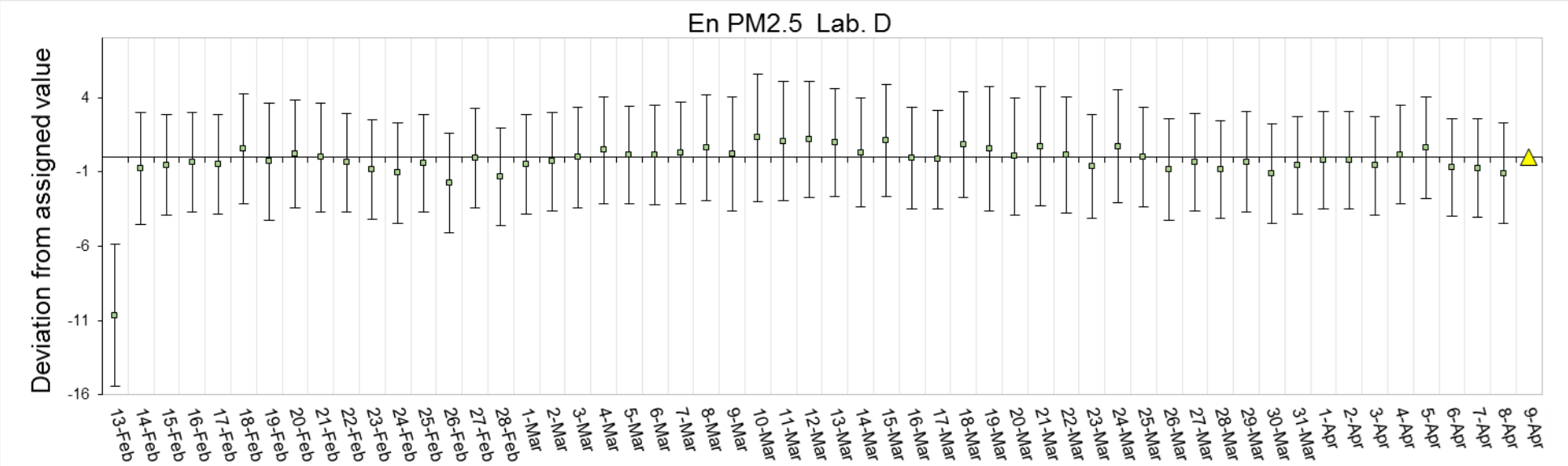


Figure 77: Chart of Bias evaluation for PM2.5 related to Lab. D

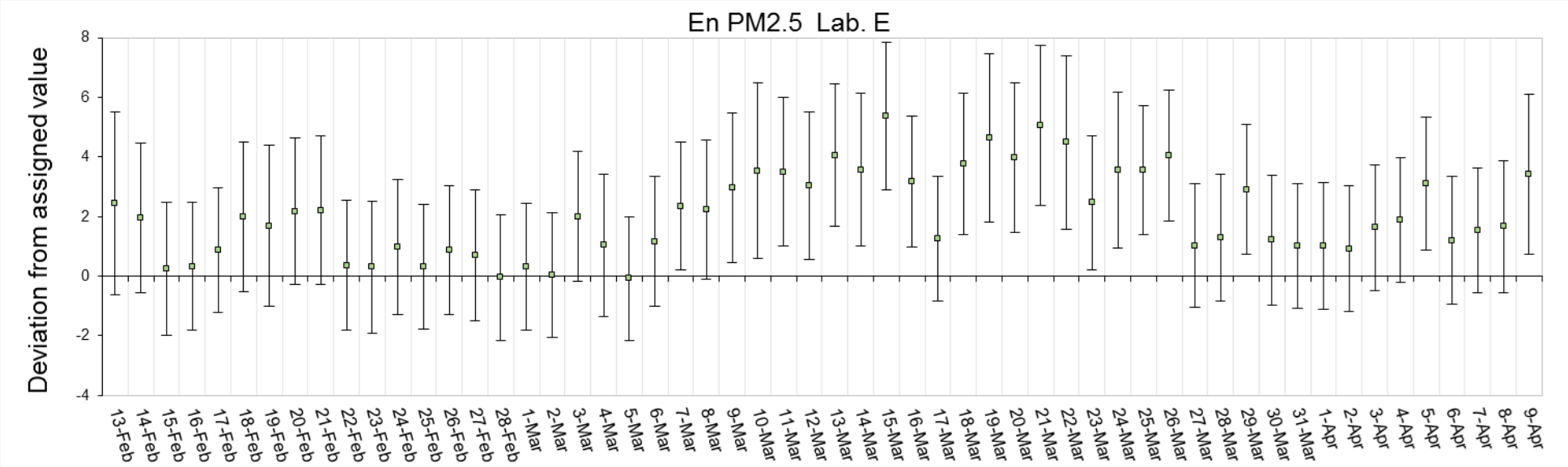


Figure 78: Chart of Bias evaluation for PM2.5 related to Lab. E

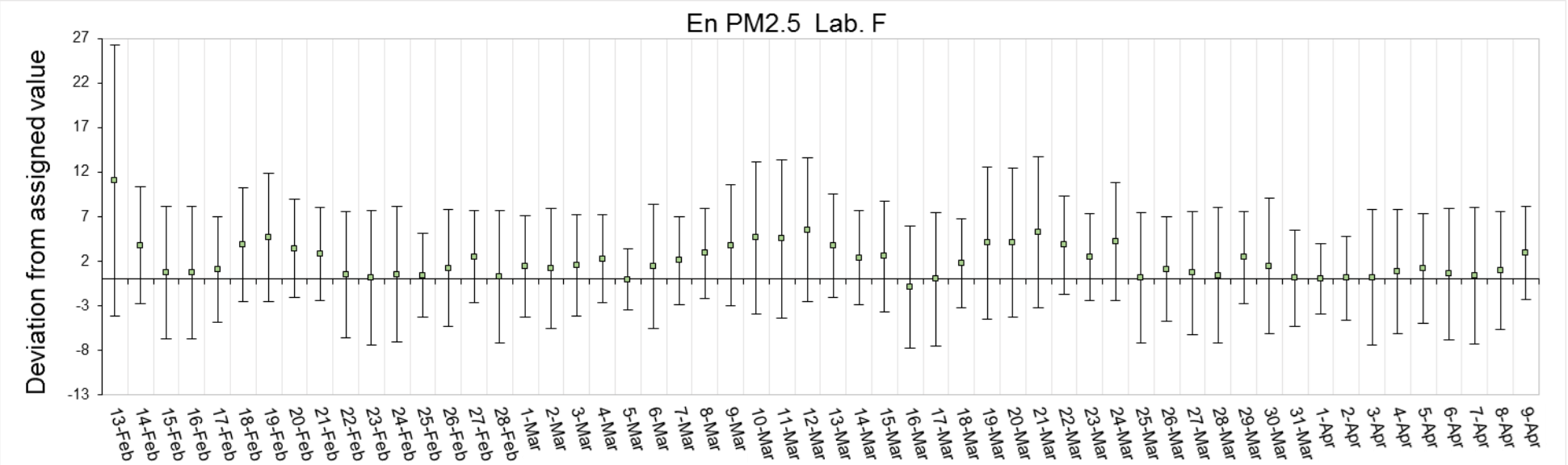


Figure 79: Chart of Bias evaluation for PM2.5 related to Lab. F

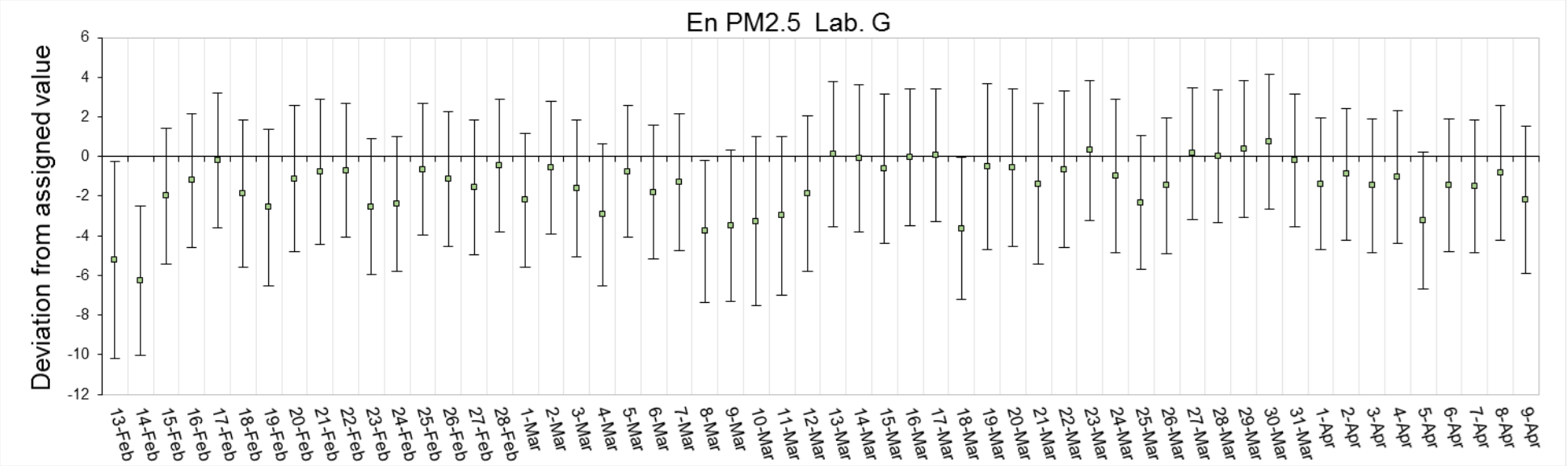


Figure 80: Chart of Bias evaluation for PM2.5 related to Lab. G

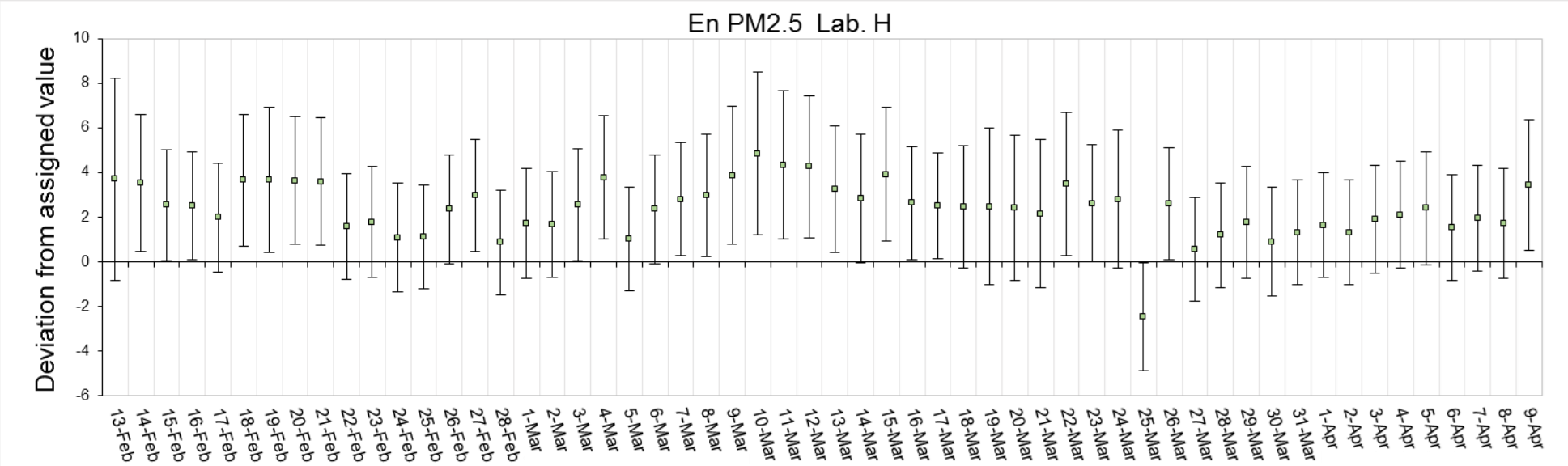


Figure 81: Chart of Bias evaluation for PM2.5 related to Lab. H

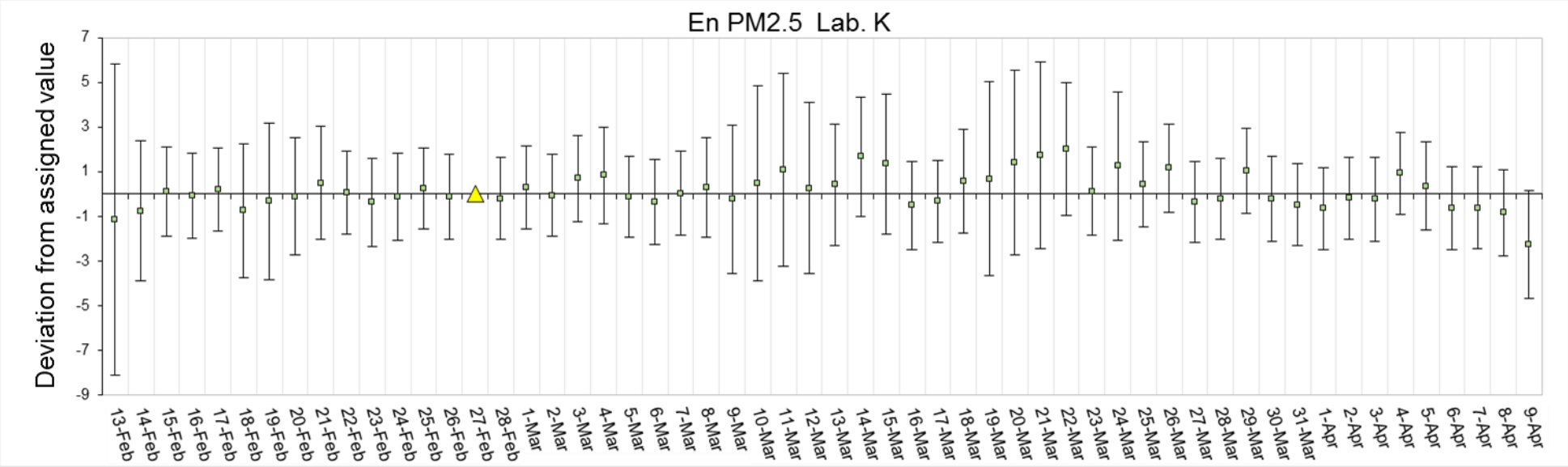


Figure 82: Chart of Bias evaluation for PM2.5 related to Lab. K

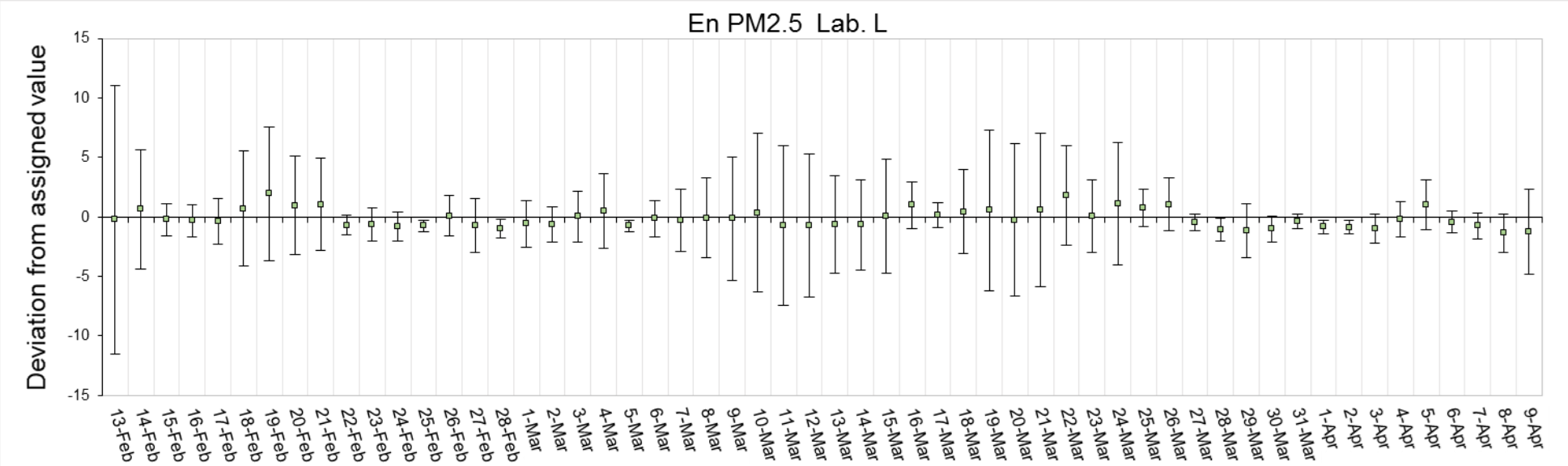


Figure 83: Chart of Bias evaluation for PM2.5 related to Lab. L

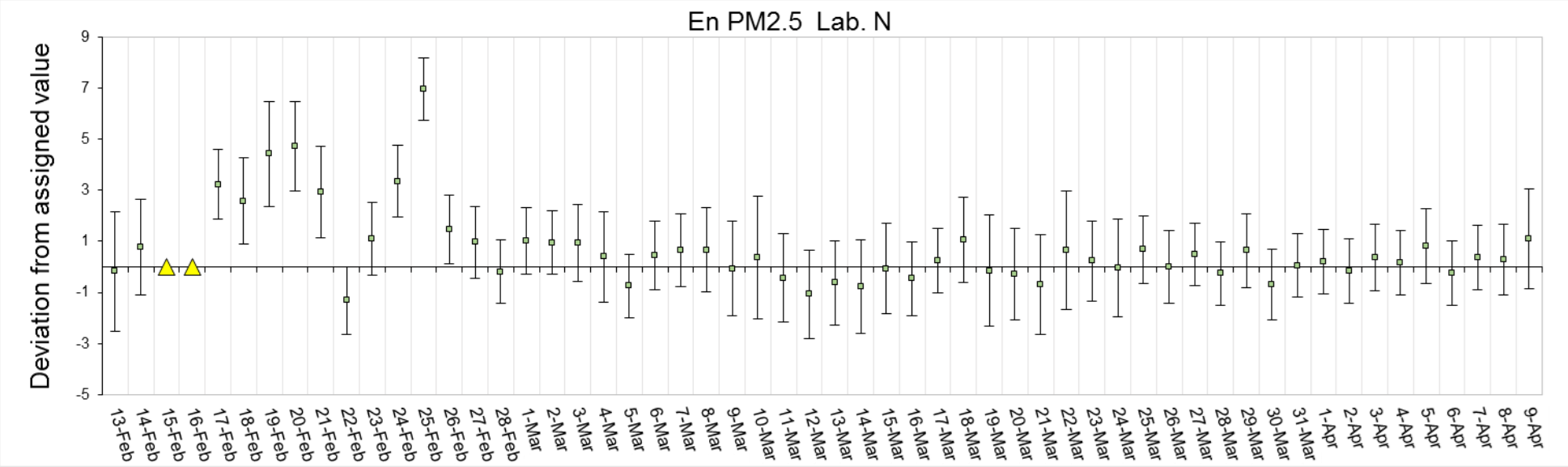


Figure 84: Chart of Bias evaluation for PM2.5 related to Lab. N

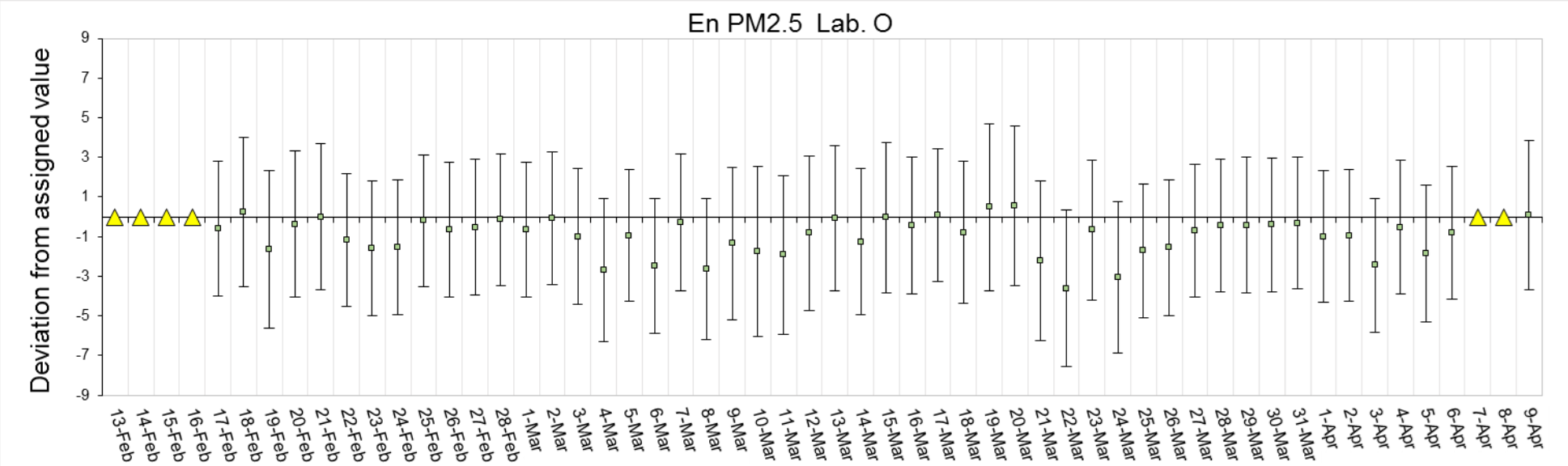


Figure 85: Chart of Bias evaluation for PM2.5 related to Lab. O

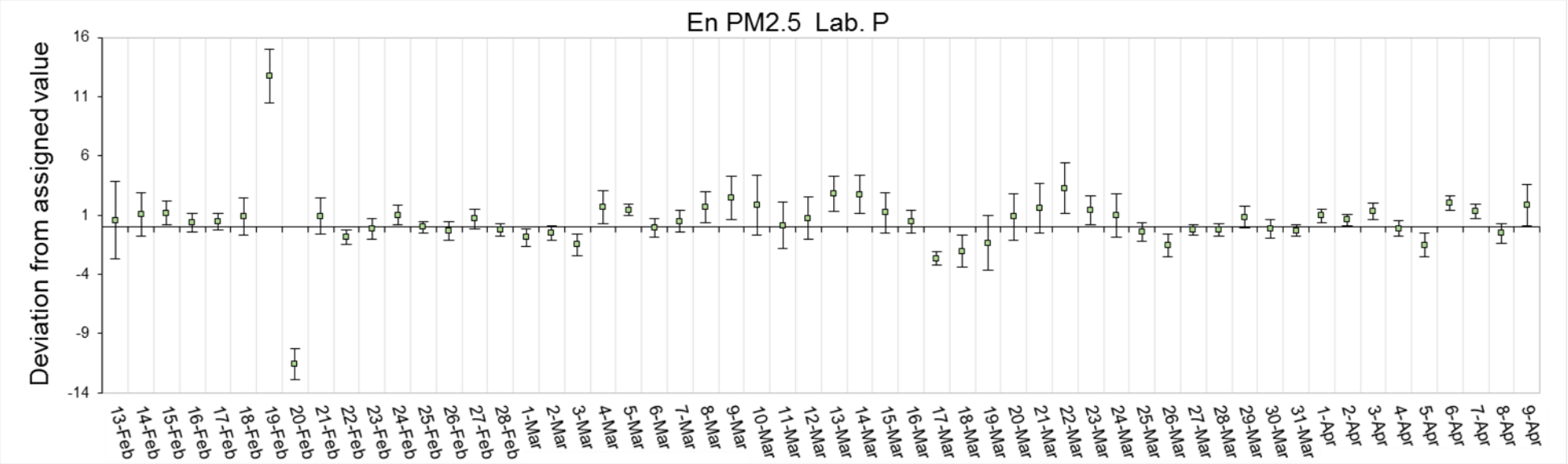


Figure 86: Chart of Bias evaluation for PM2.5 related to Lab. P

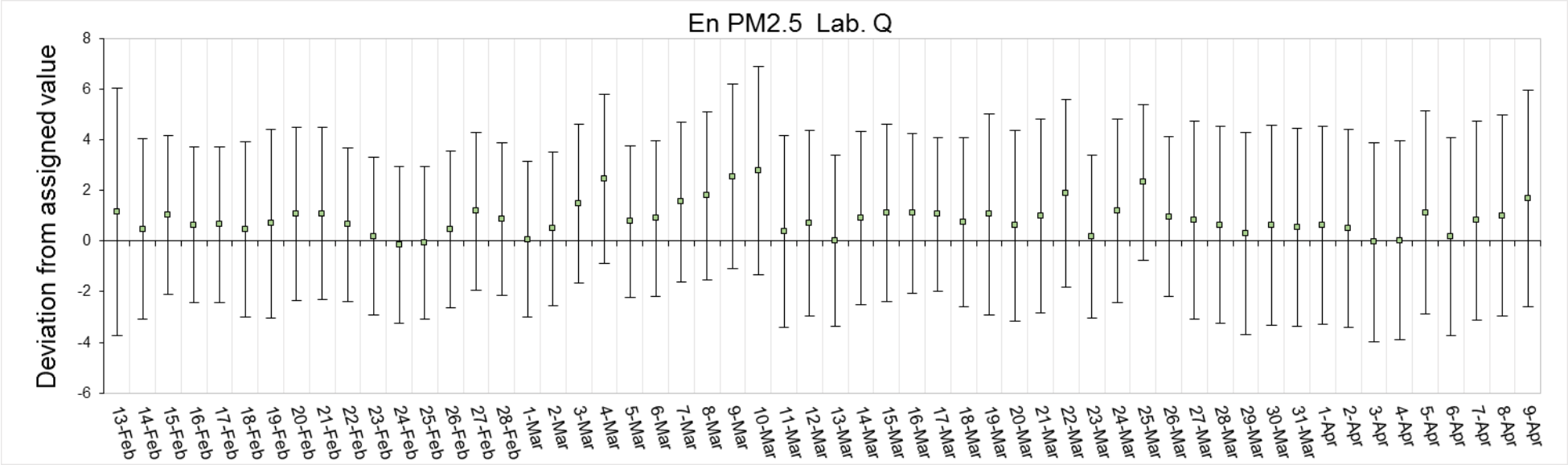


Figure 87: Chart of Bias evaluation for PM2.5 related to Lab. Q

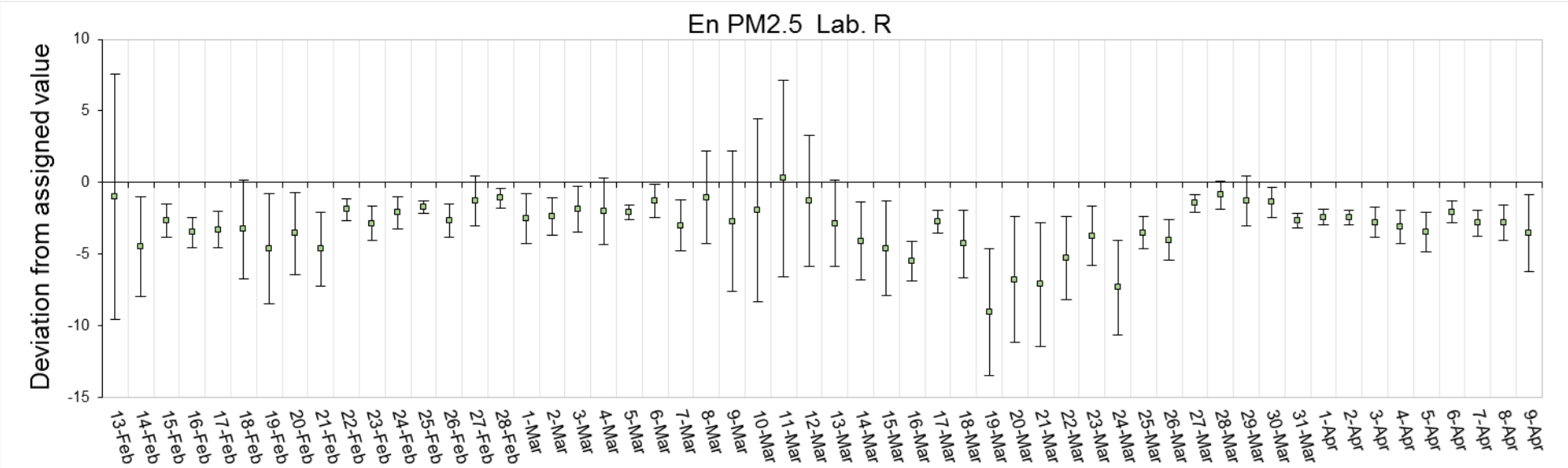


Figure 88: Chart of Bias evaluation for PM2.5 related to Lab. R

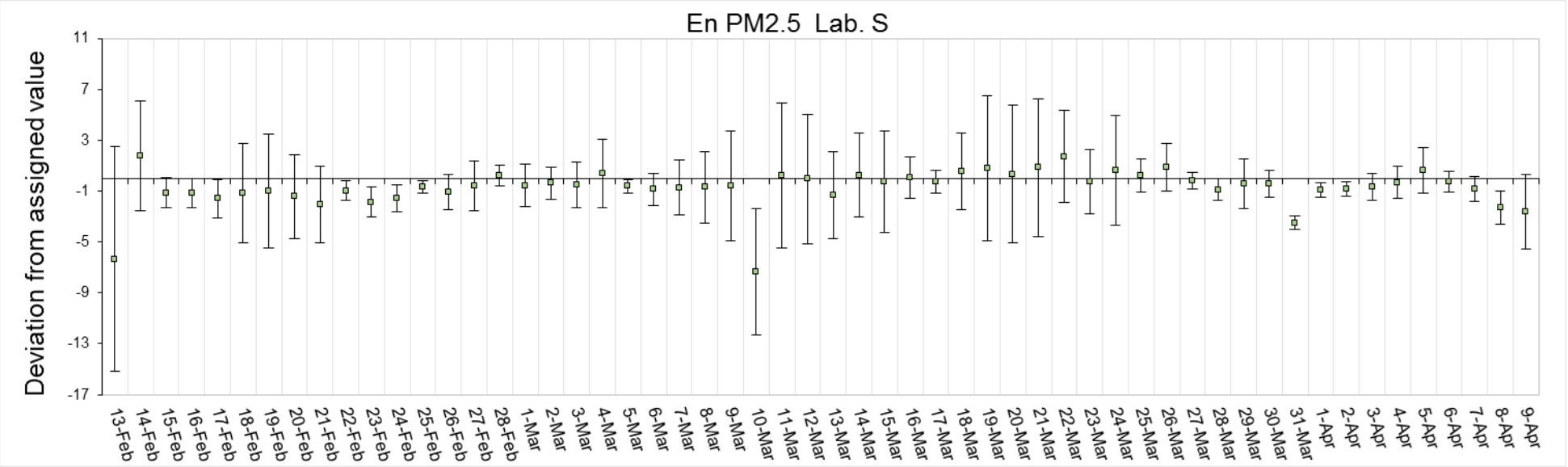


Figure 89: Chart of Bias evaluation for PM2.5 related to Lab. S

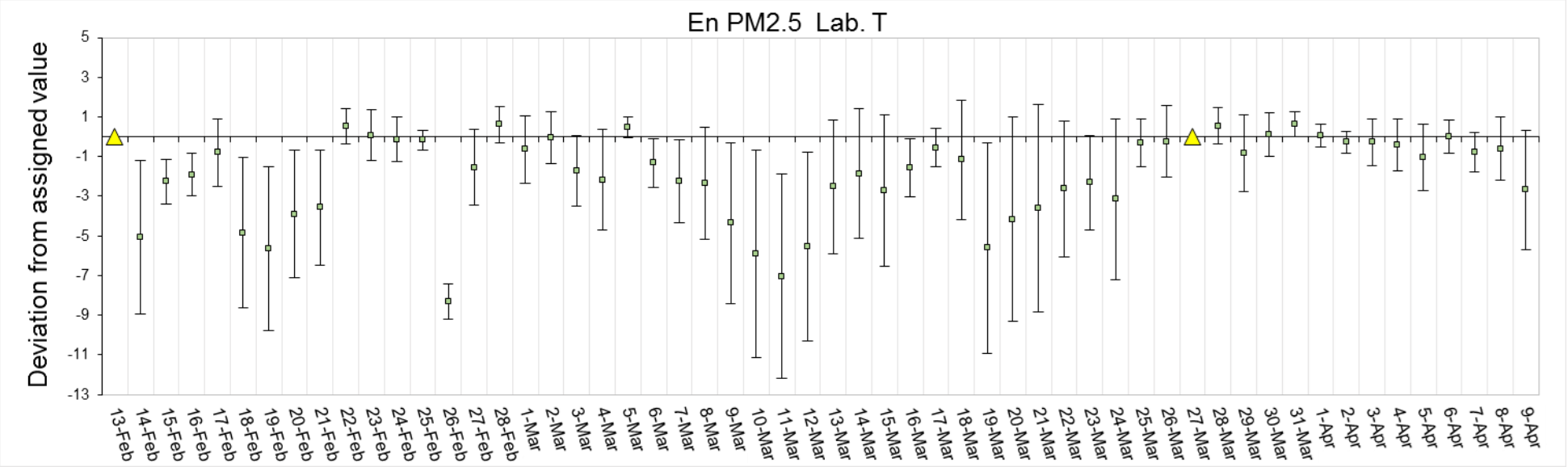


Figure 90: Chart of Bias evaluation for PM2.5 related to Lab. T

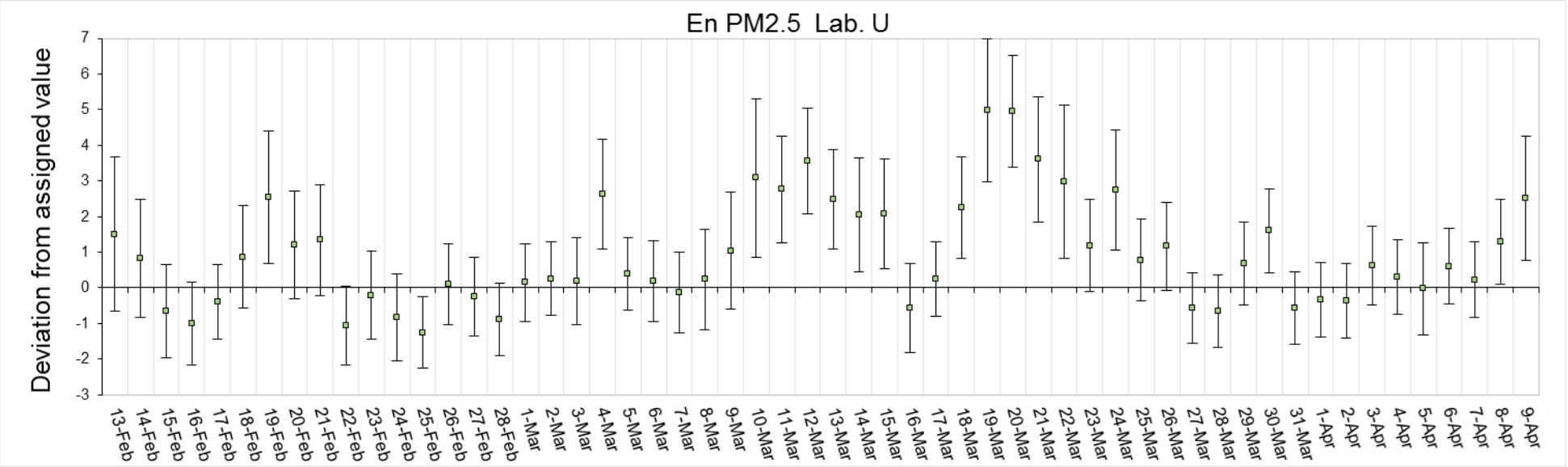


Figure 91: Chart of Bias evaluation for PM2.5 related to Lab. U

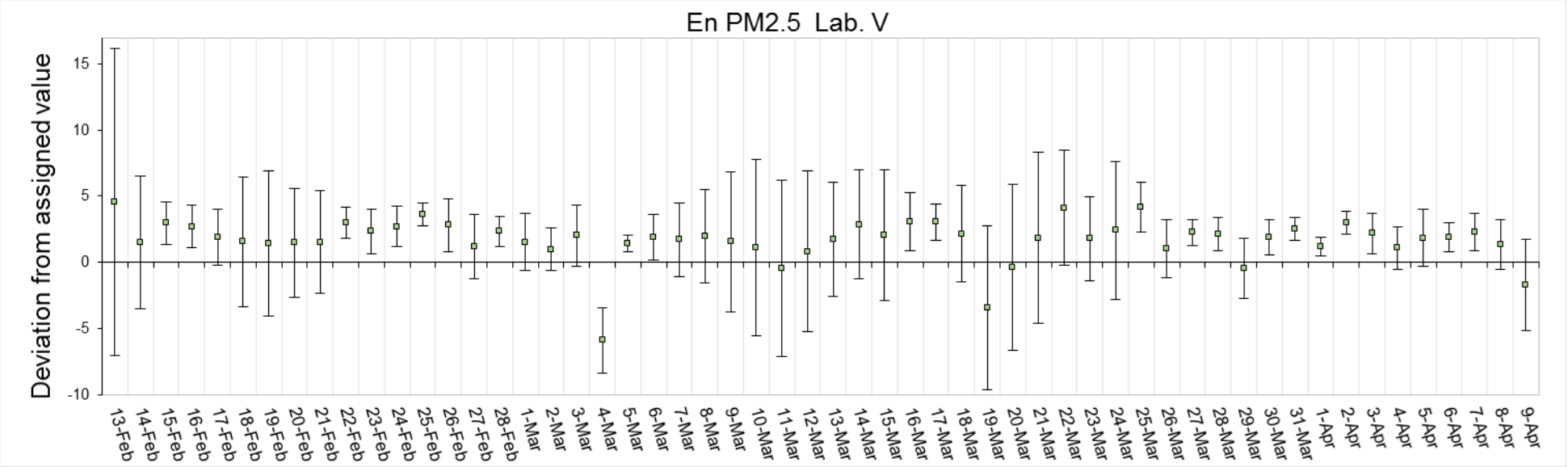


Figure 92: Chart of Bias evaluation for PM2.5 related to Lab. V

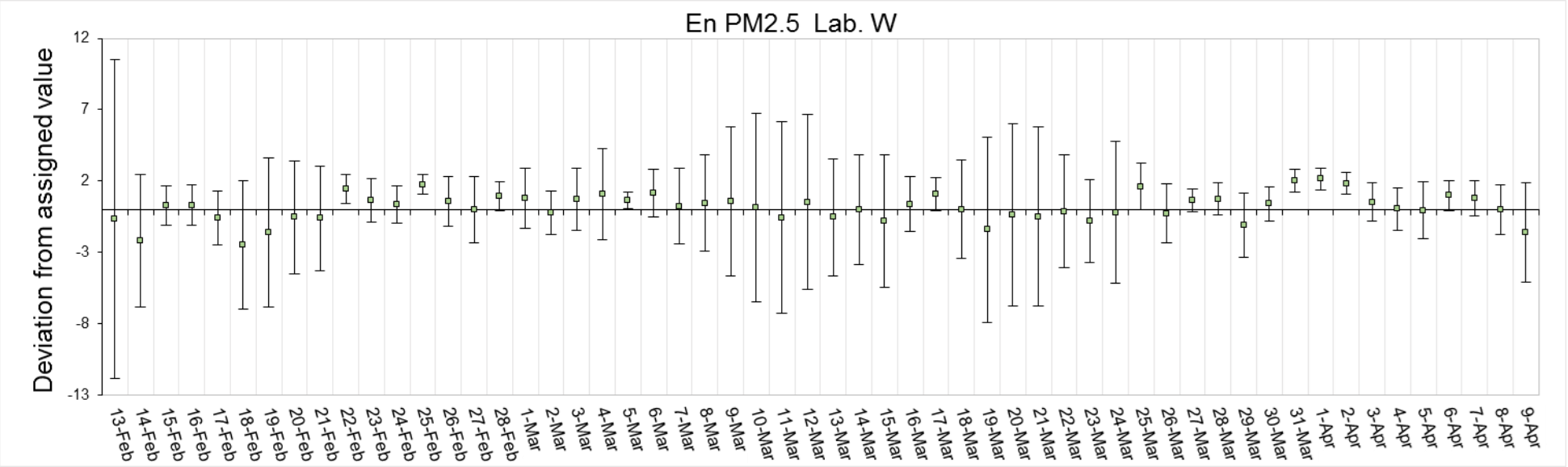


Figure 93: Chart of Bias evaluation for PM2.5 related to Lab. W

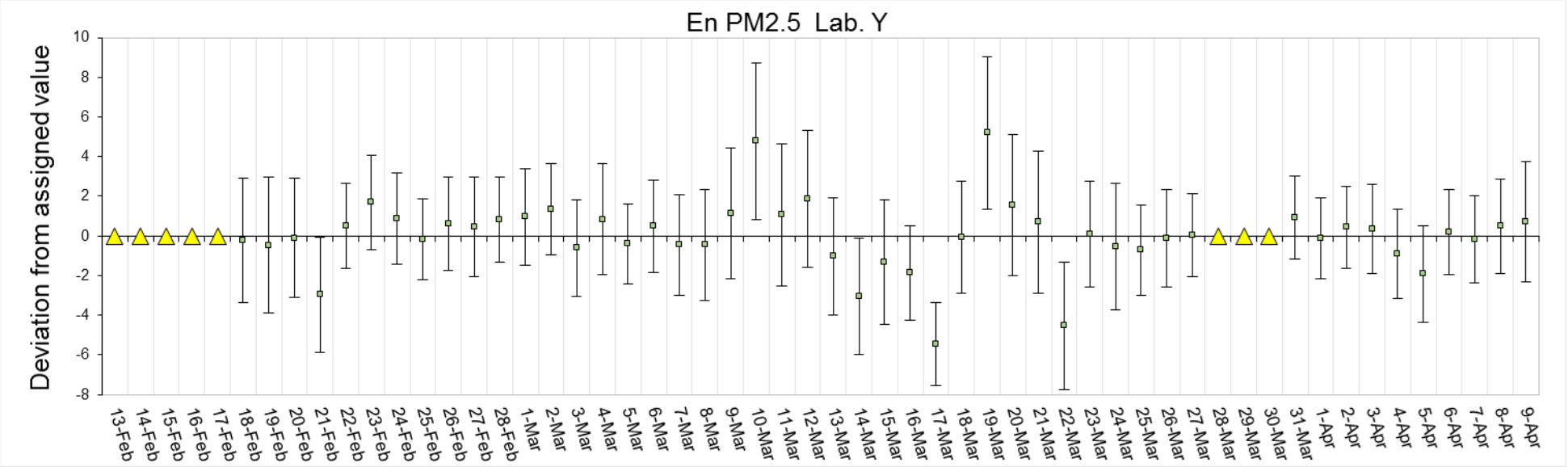


Figure 94: Chart of Bias evaluation for PM2.5 related to Lab. Y

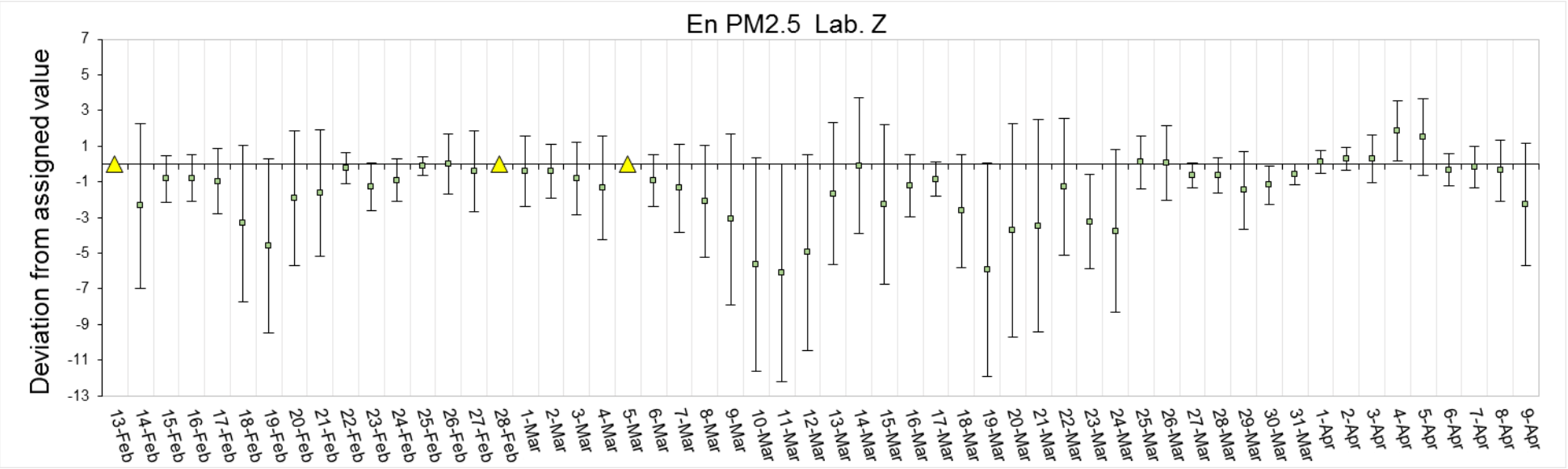


Figure 95: Chart of Bias evaluation for PM2.5 related to Lab. Z

PM10

LEGEND ▪ bias △ not reported

Figure 96 to 119 show for each laboratory the calculated E_n-score daily value for PM10.

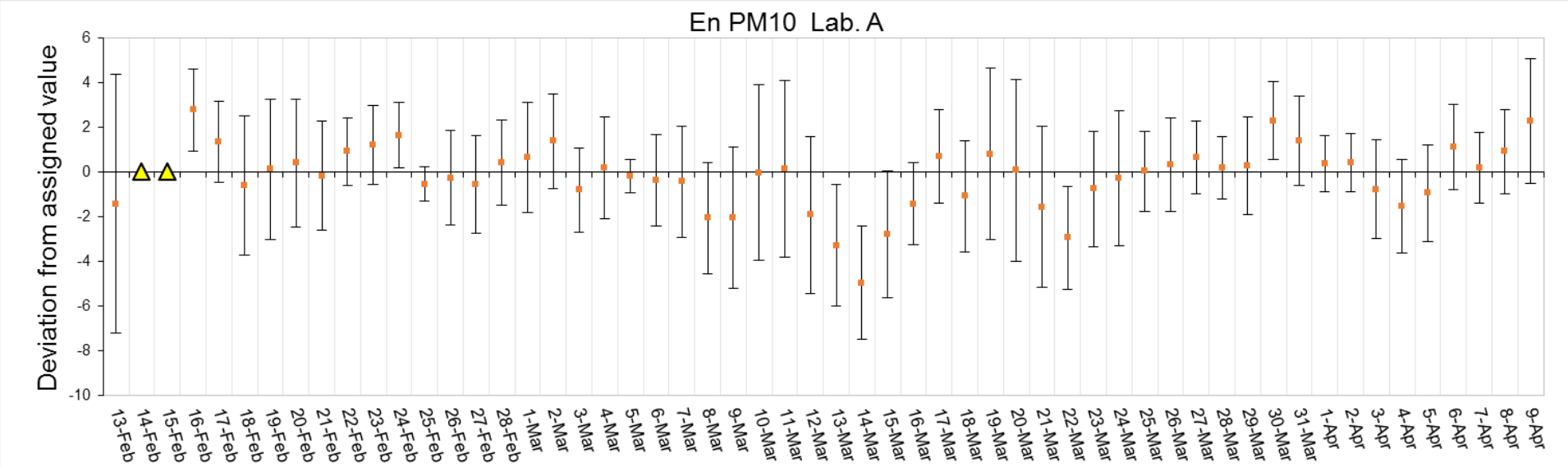


Figure 96: Chart of Bias evaluation for PM10 related to Lab. A

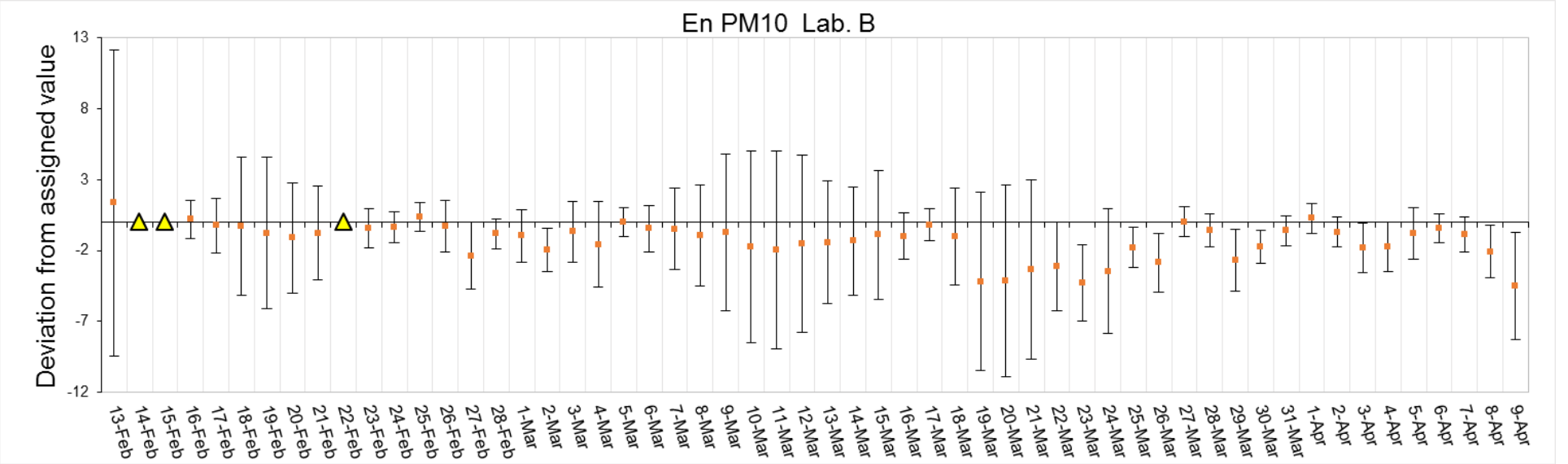


Figure 97: Chart of Bias evaluation for PM10 related to Lab. B

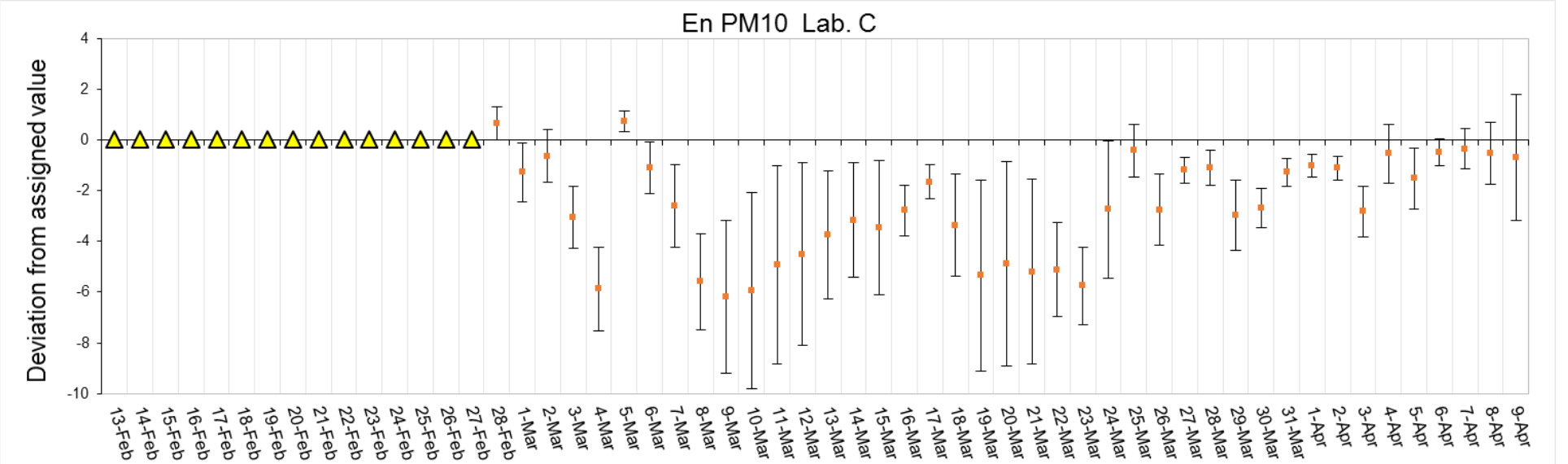


Figure 98: Chart of Bias evaluation for PM10 related to Lab. C

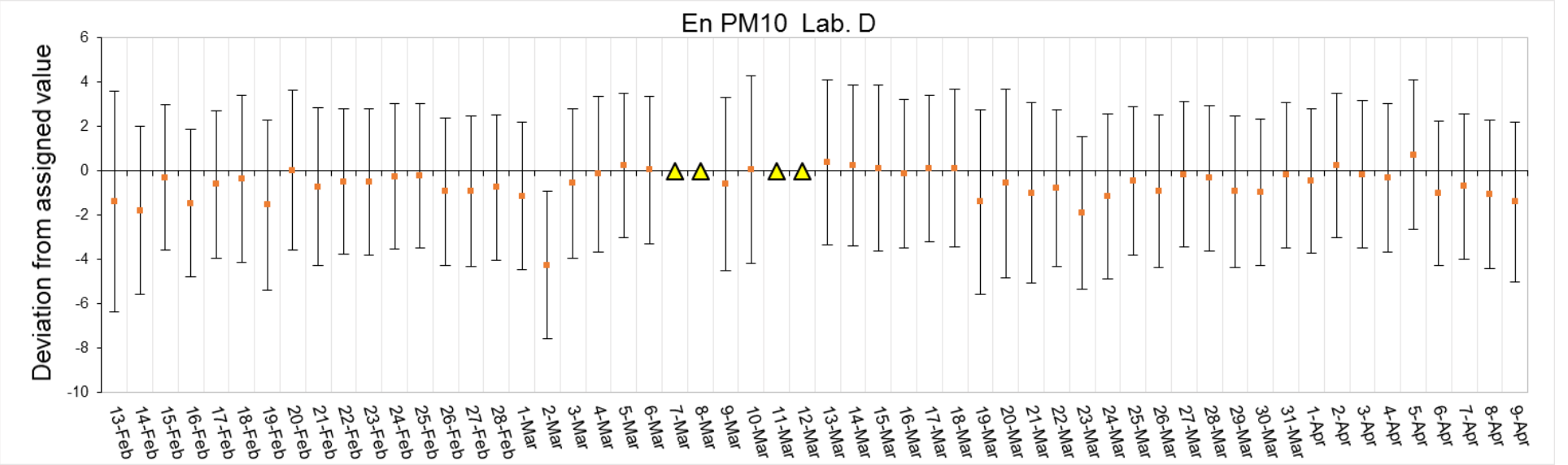


Figure 99: Chart of Bias evaluation for PM10 related to Lab. D

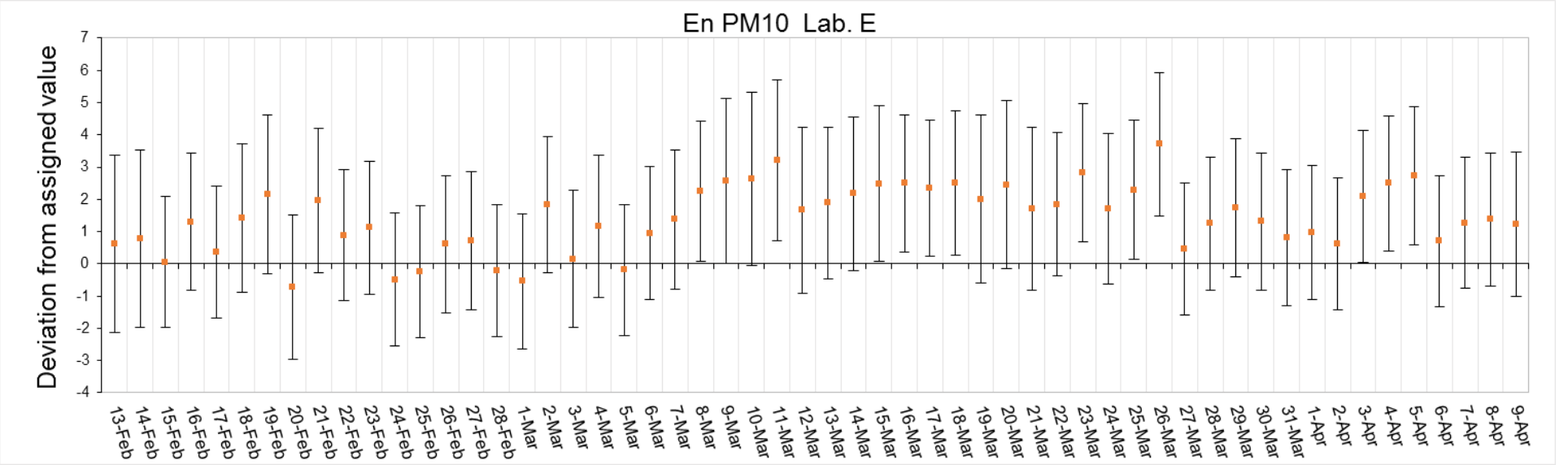


Figure 100: Chart of Bias evaluation for PM10 related to Lab. E

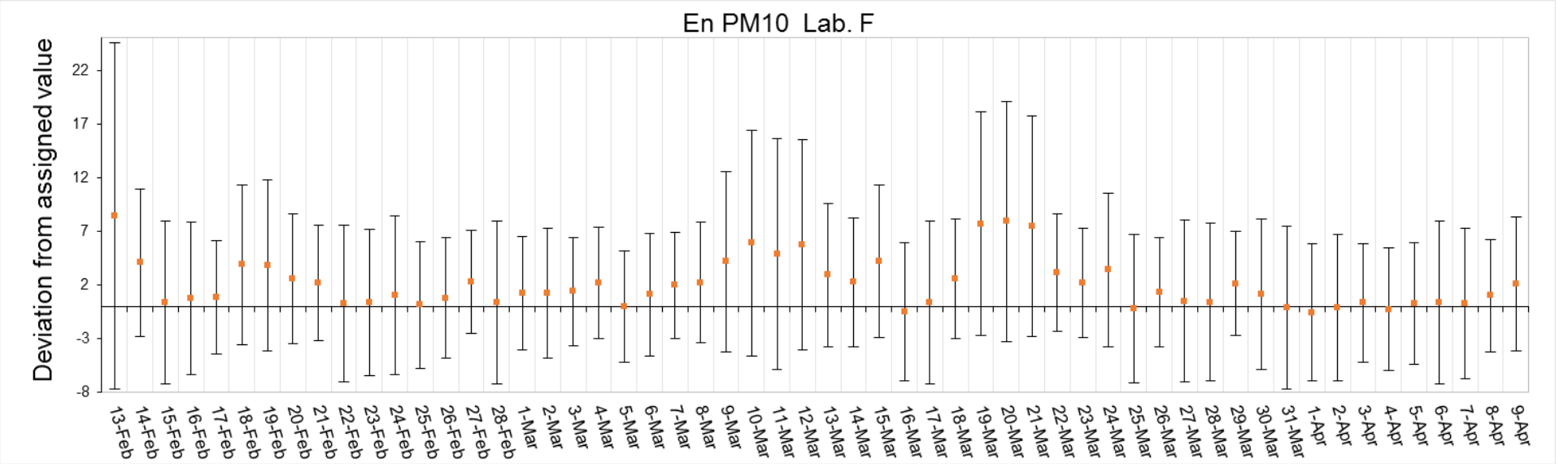


Figure 101: Chart of Bias evaluation for PM10 related to Lab. F

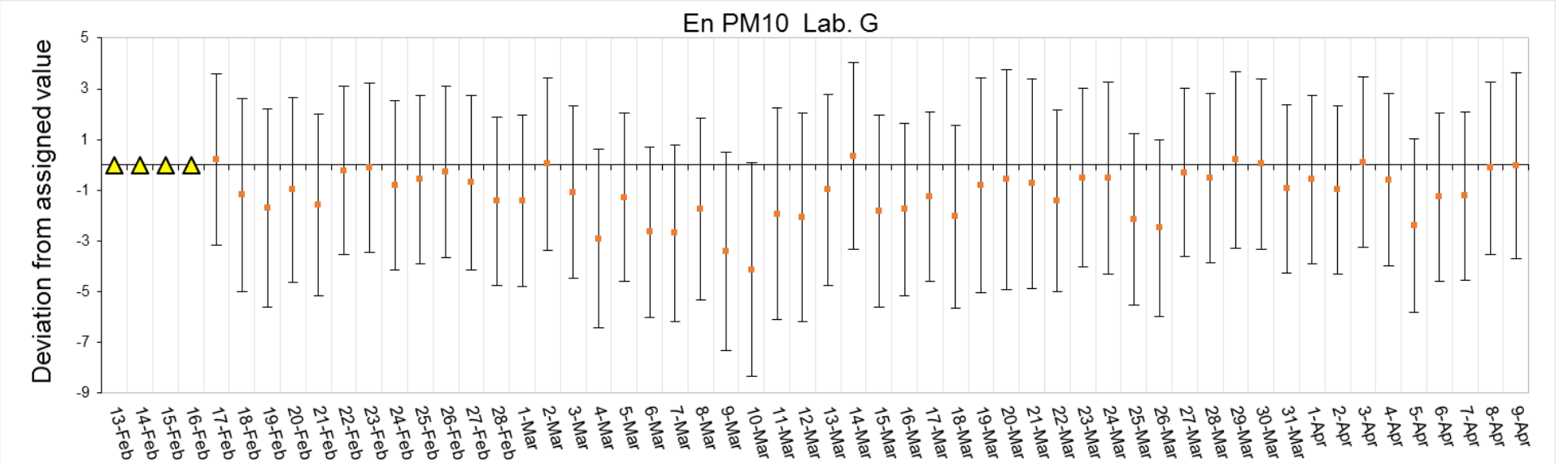


Figure 102: Chart of Bias evaluation for PM10 related to Lab. G

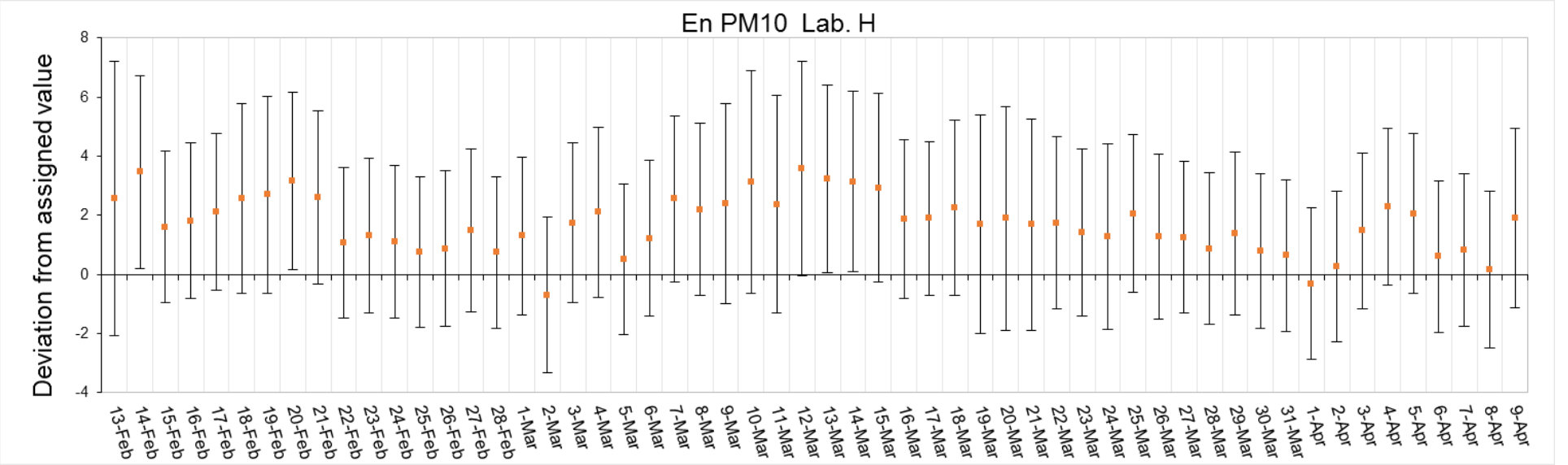


Figure 103: Chart of Bias evaluation for PM10 related to Lab. H

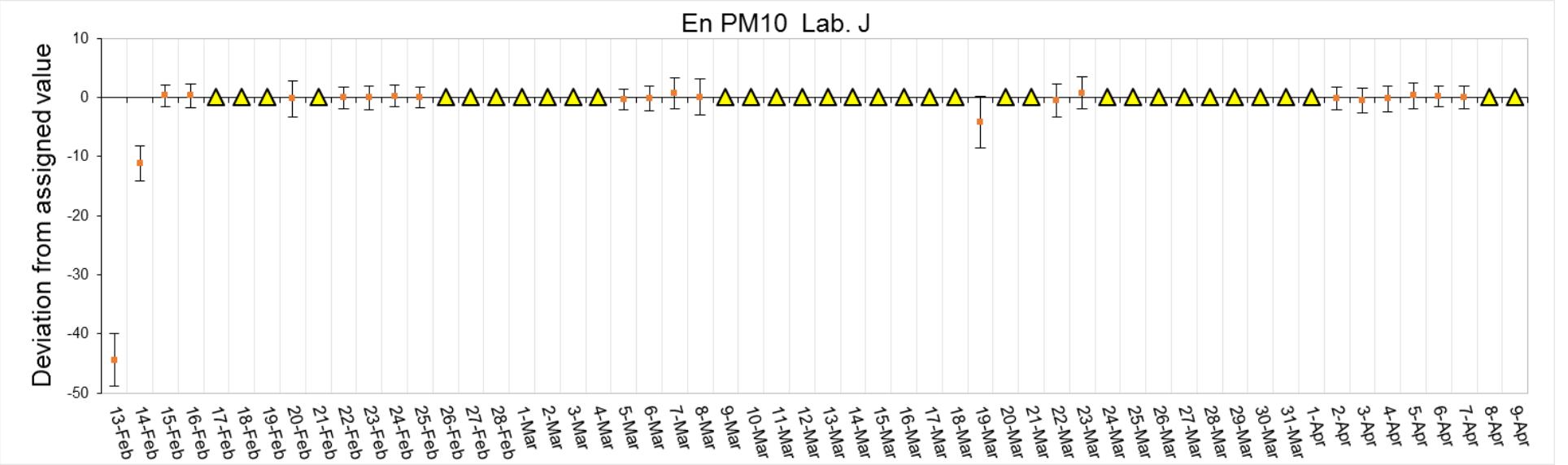


Figure 104: Chart of Bias evaluation for PM10 related to Lab. J

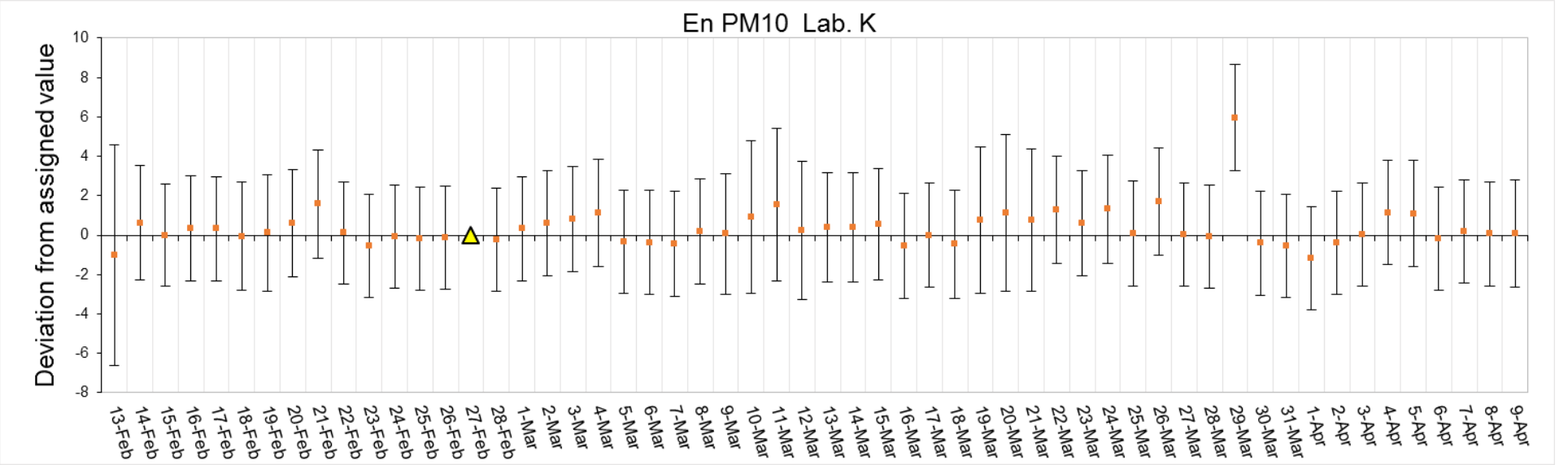


Figure 105: Chart of Bias evaluation for PM10 related to Lab. K

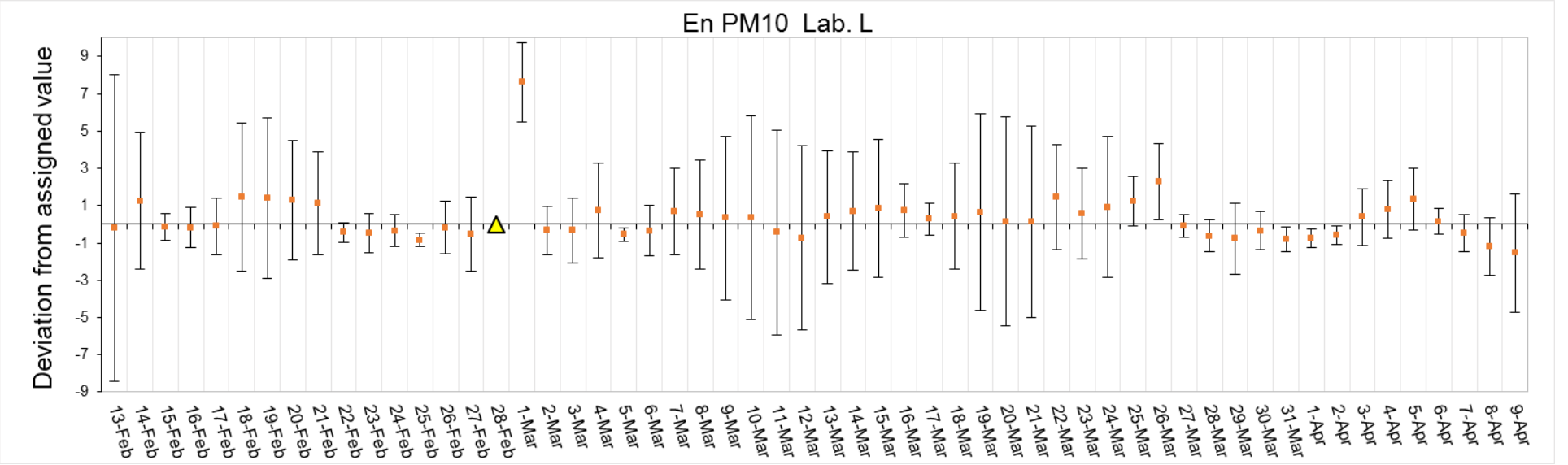


Figure 106: Chart of Bias evaluation for PM10 related to Lab. L

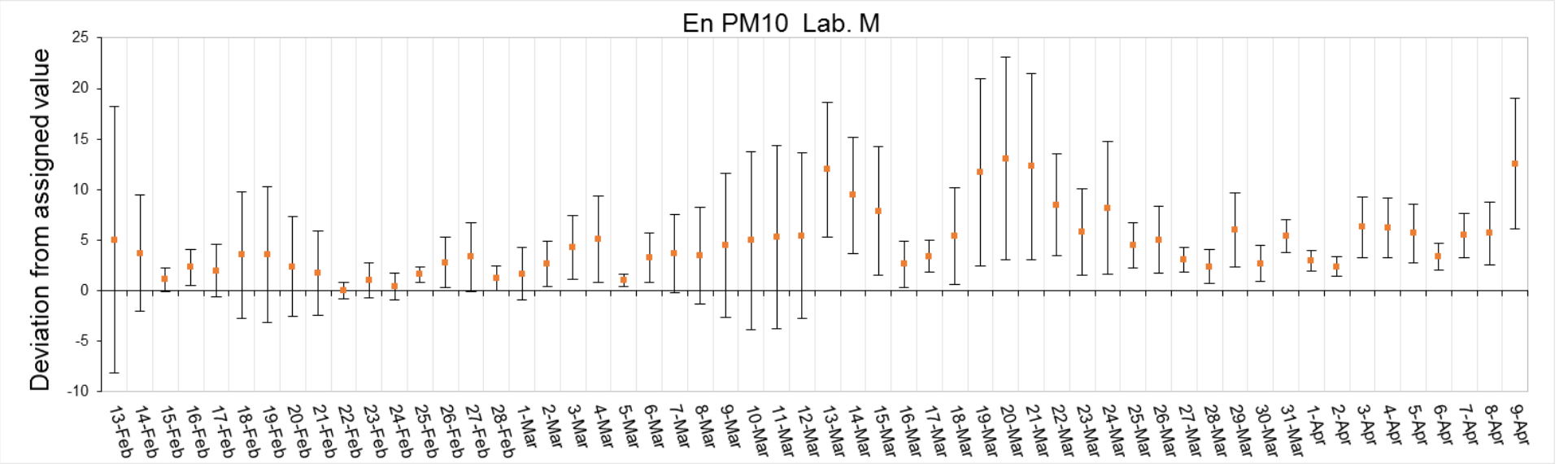


Figure 107: Chart of Bias evaluation for PM10 related to Lab. M

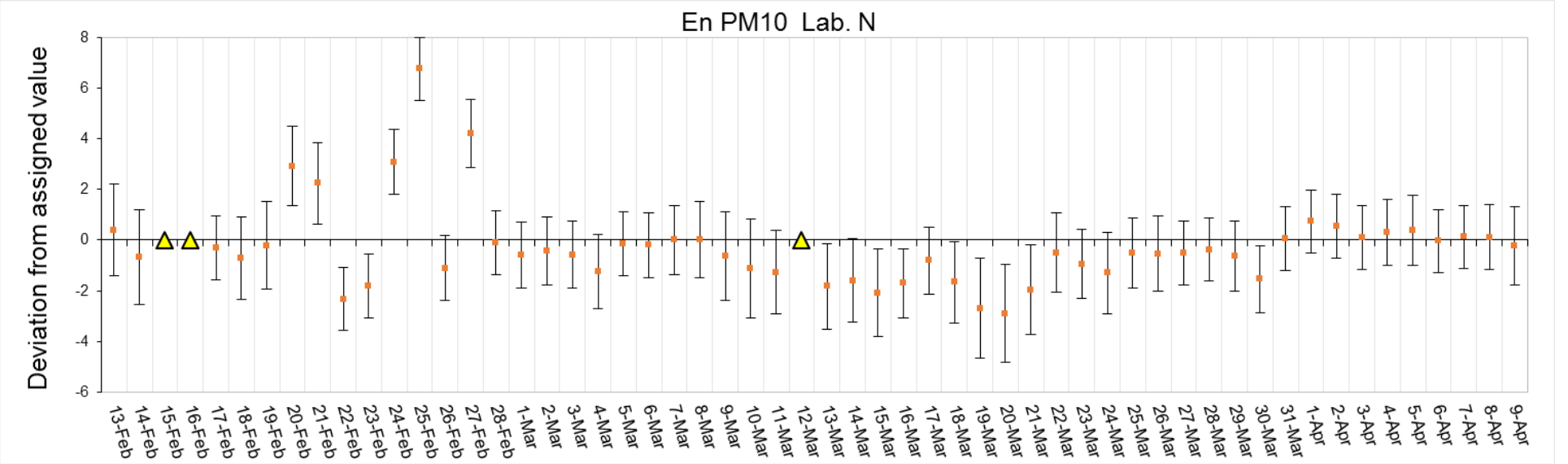


Figure 108: Chart of Bias evaluation for PM10 related to Lab. N

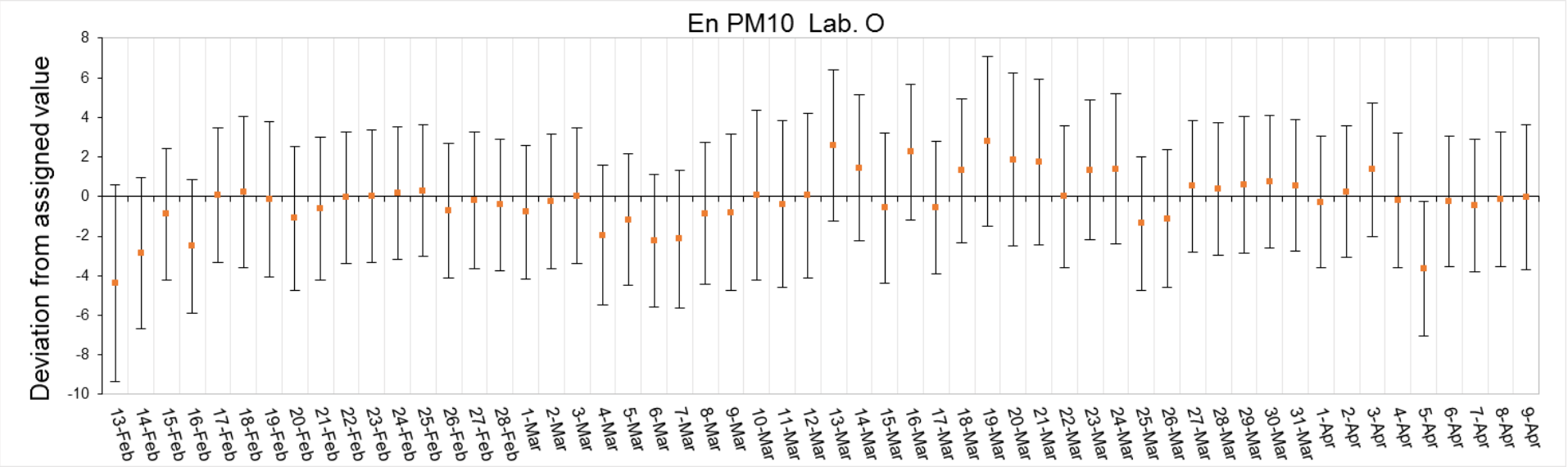


Figure 109: Chart of Bias evaluation for PM10 related to Lab. O

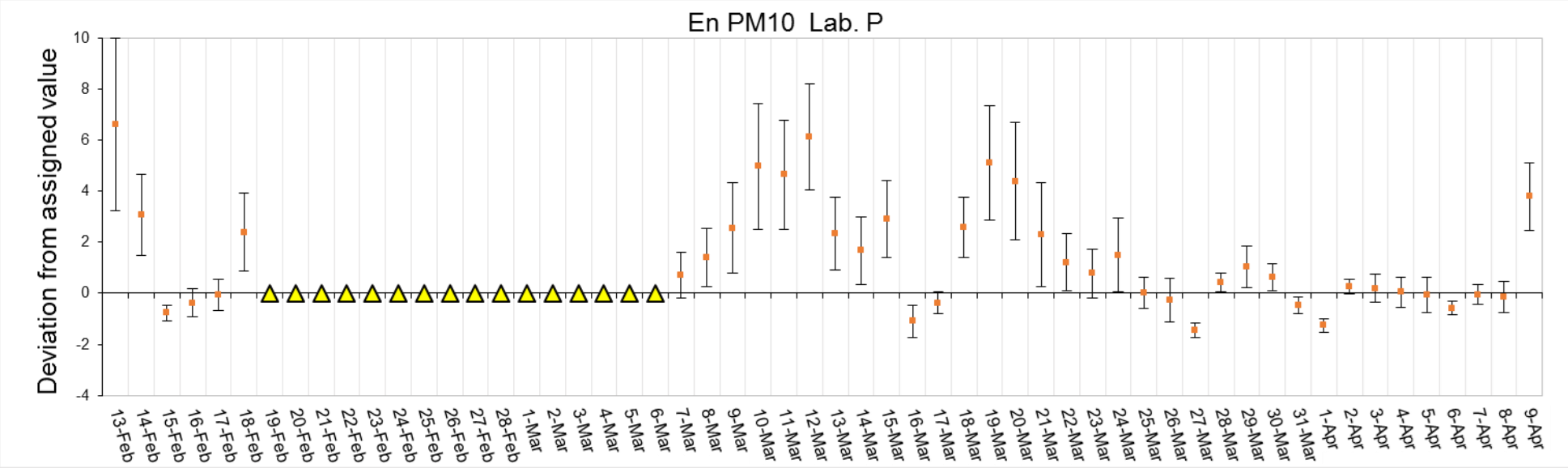


Figure 110: Chart of Bias evaluation for PM10 related to Lab. P

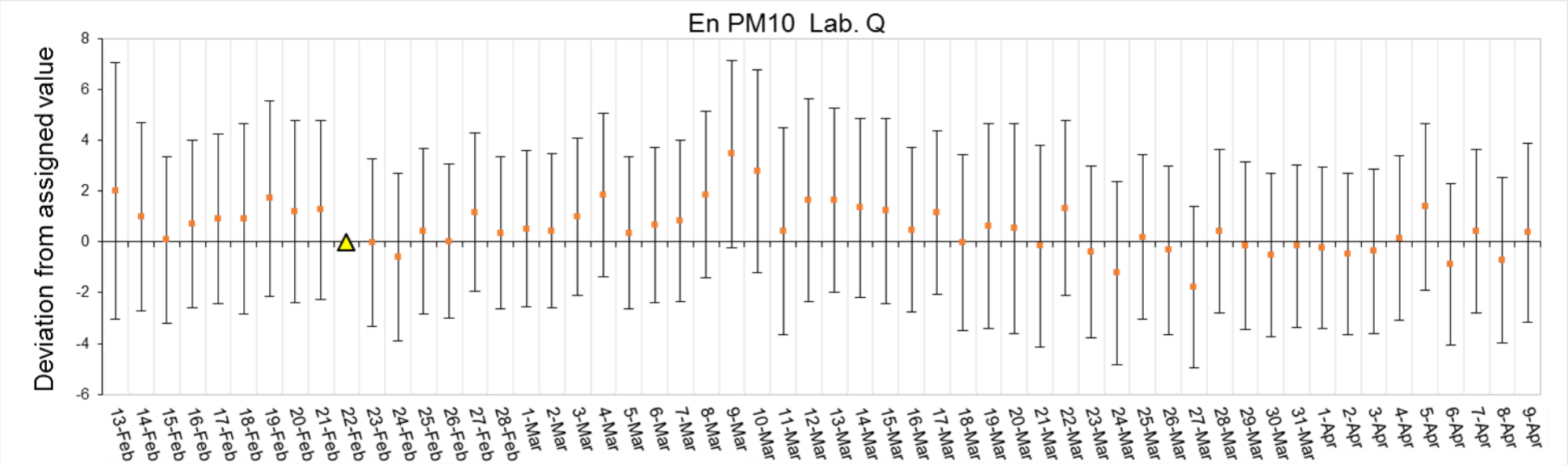


Figure 111: Chart of Bias evaluation for PM10 related to Lab. Q

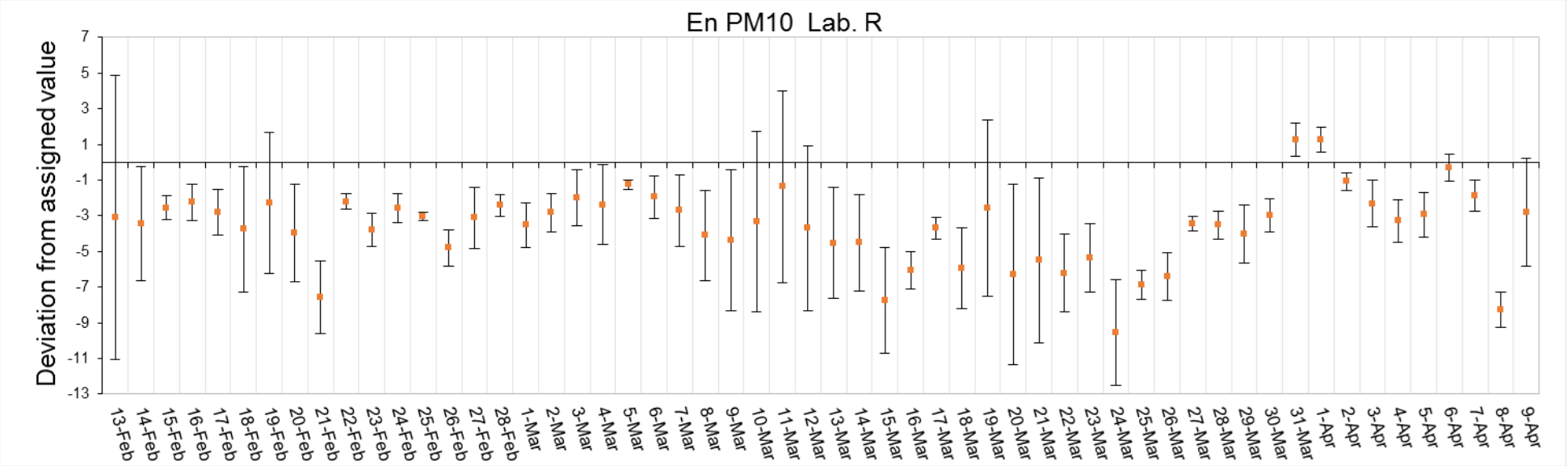


Figure 112: Chart of Bias evaluation for PM10 related to Lab. R

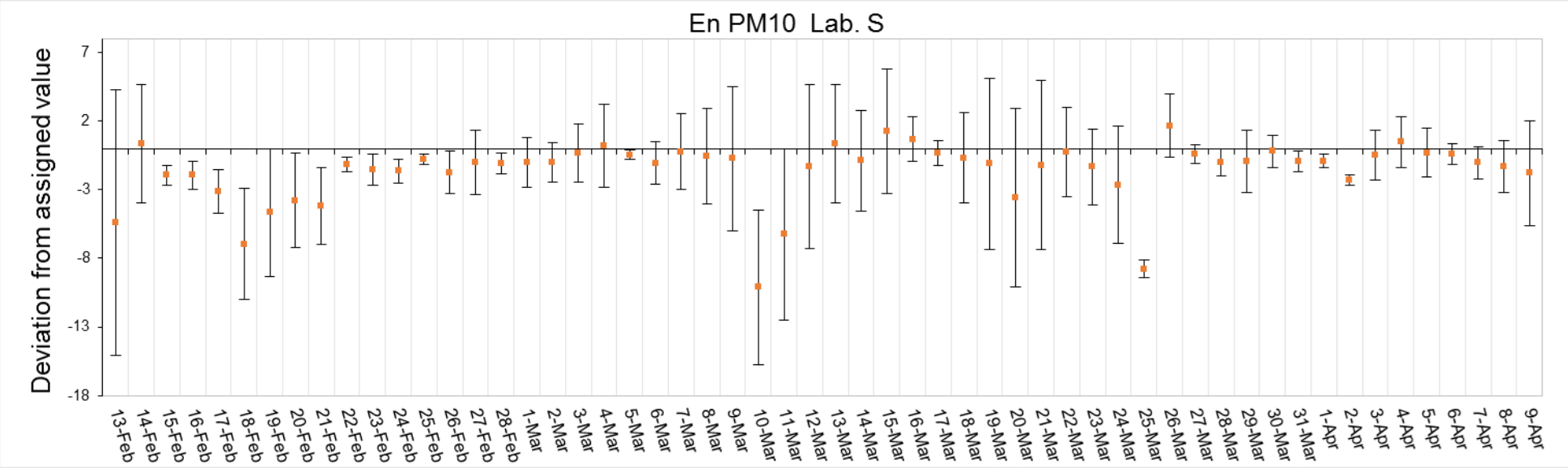


Figure 113: Chart of Bias evaluation for PM10 related to Lab. S

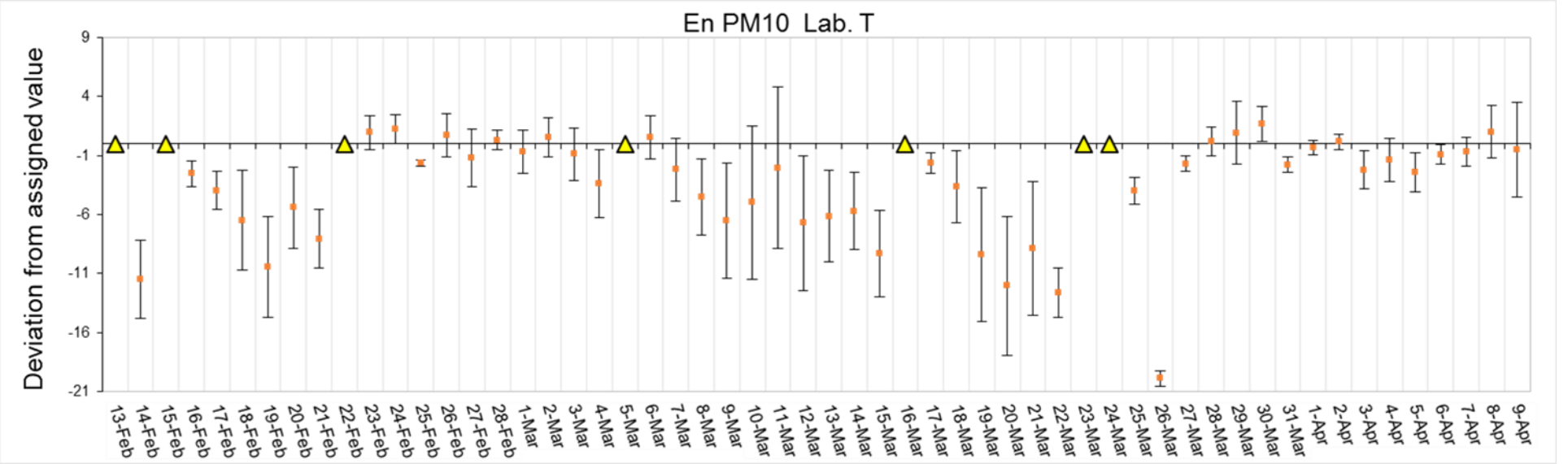


Figure 114: Chart of Bias evaluation for PM10 related to Lab. T

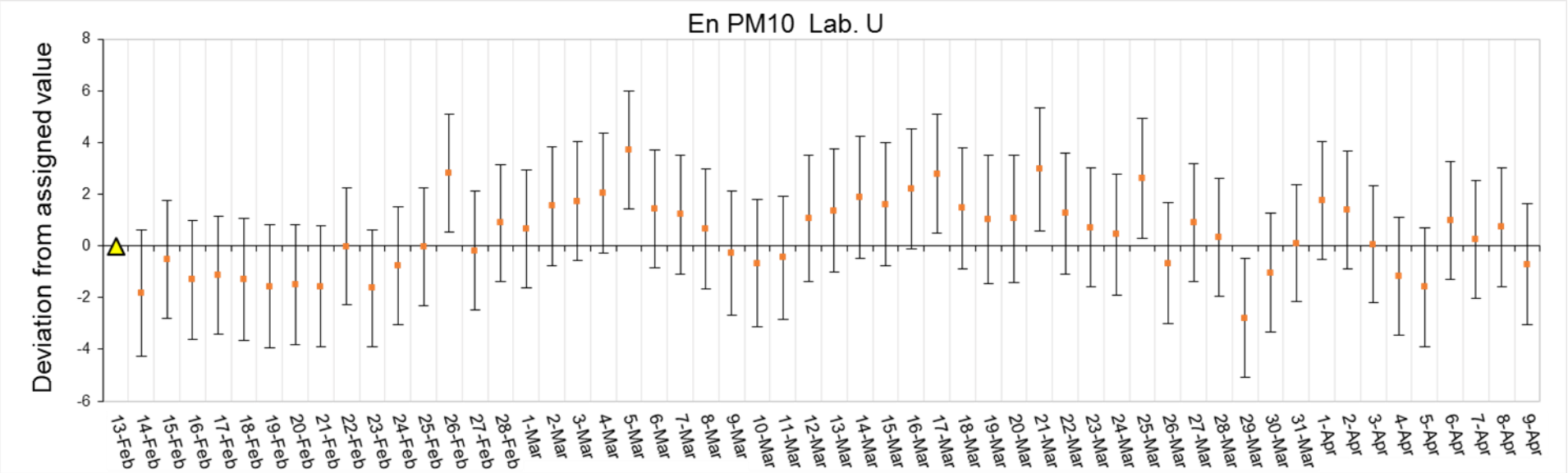


Figure 115: Chart of Bias evaluation for PM10 related to Lab. U

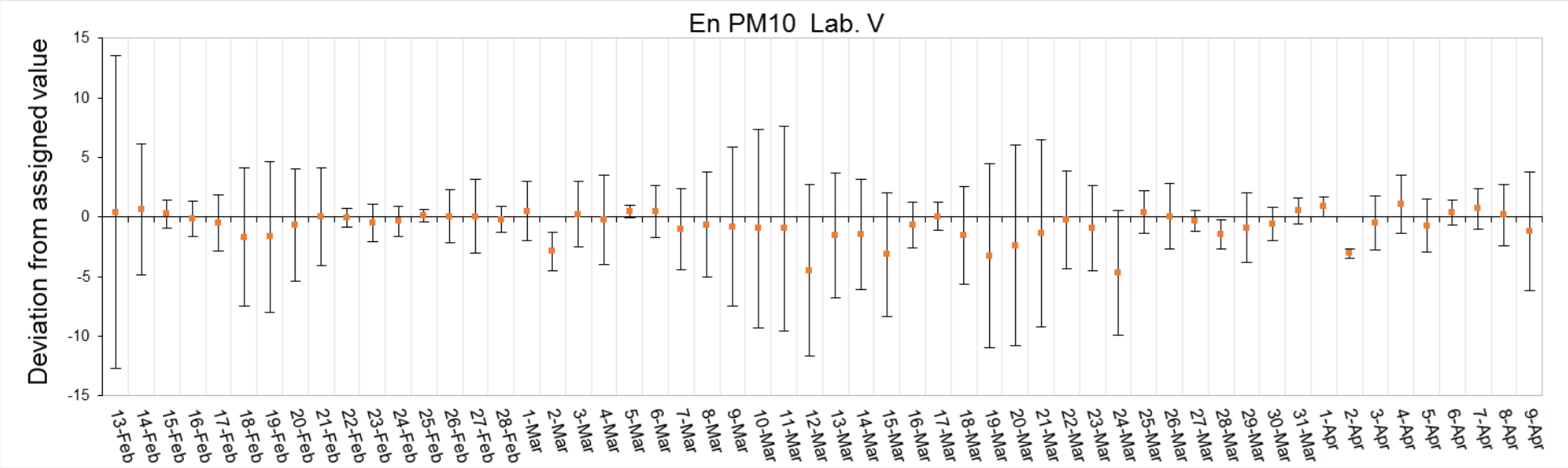


Figure 116: Chart of Bias evaluation for PM10 related to Lab. V

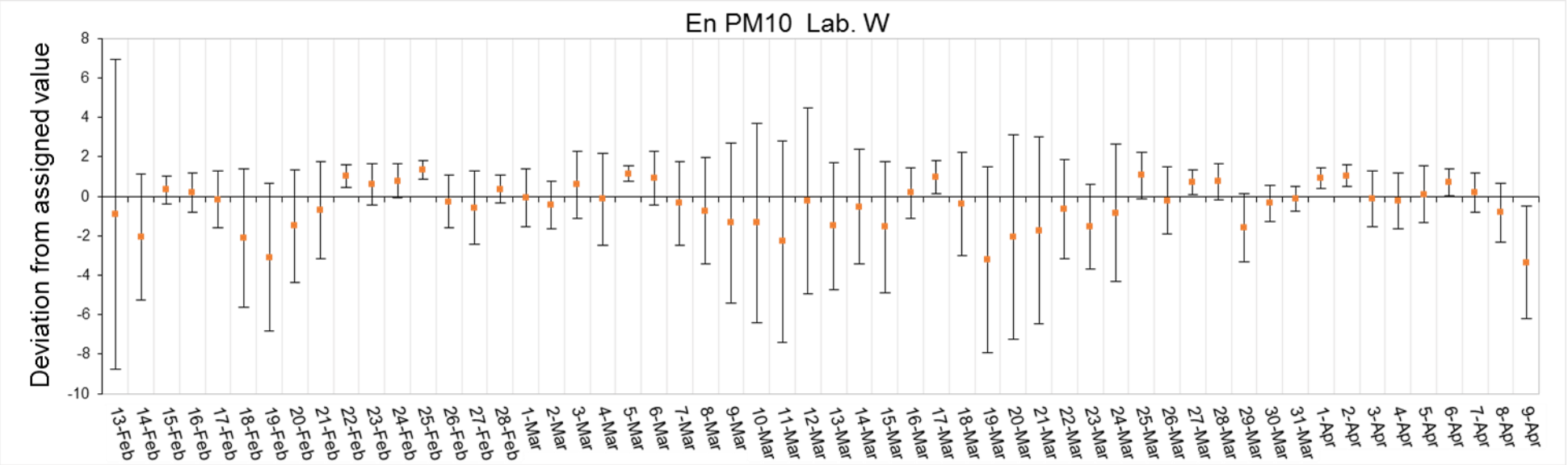


Figure 117: Chart of Bias evaluation for PM10 related to Lab. W

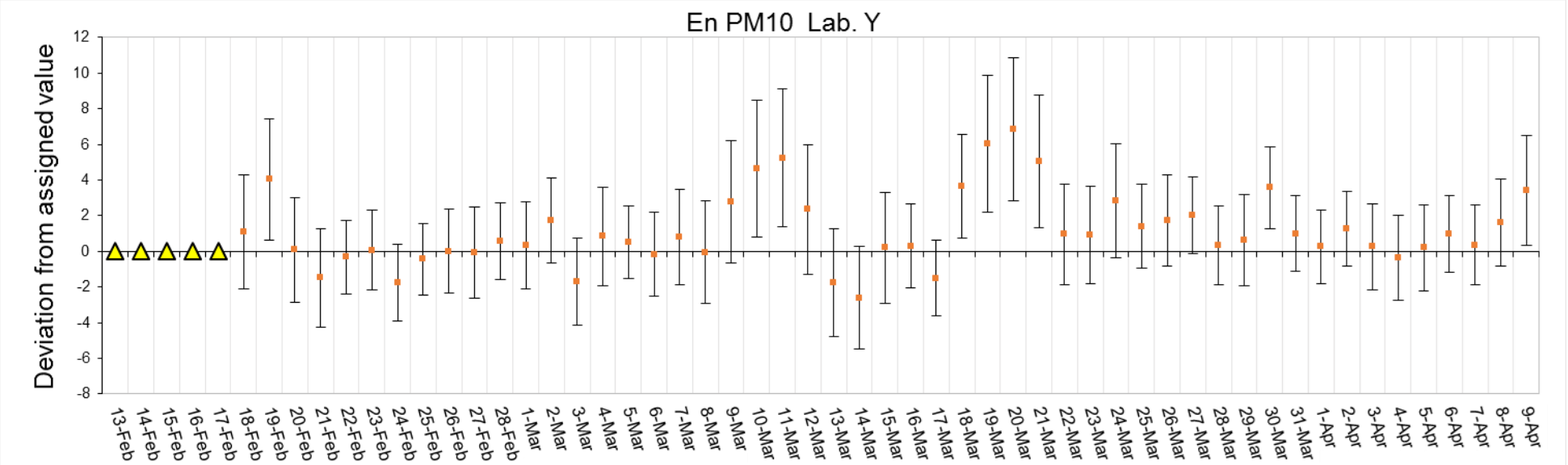


Figure 118: Chart of Bias evaluation for PM10 related to Lab. Y

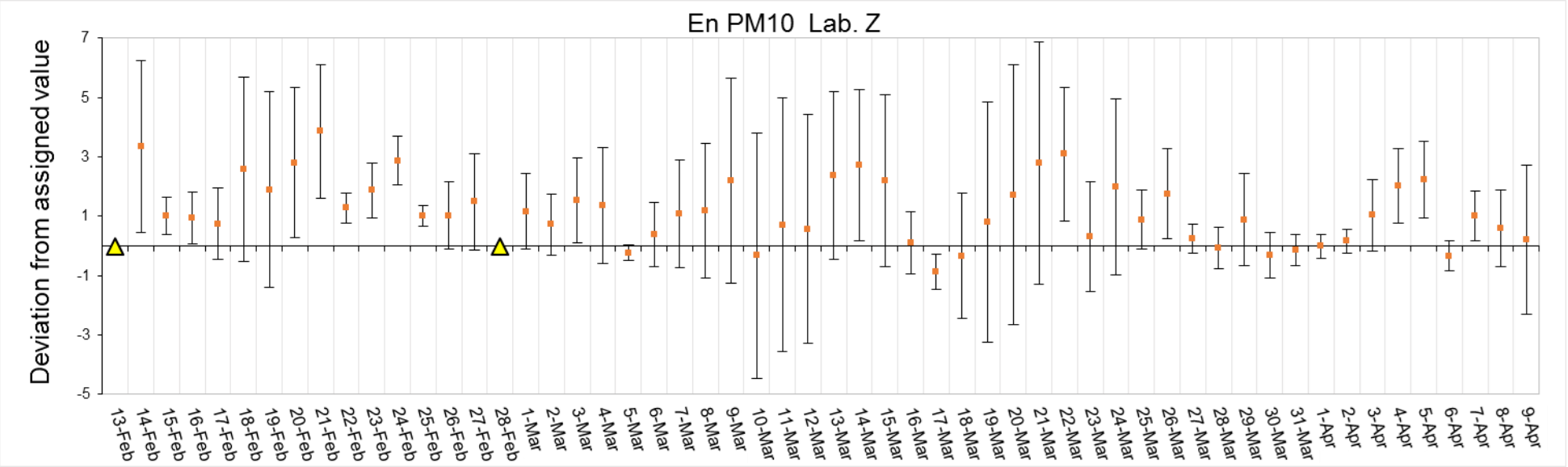


Figure 119: Chart of Bias evaluation for PM10 related to Lab. Z

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