



**Global Atmosphere Watch
World Calibration Centre for Surface Ozone
Carbon Monoxide and Methane**



**Swiss Federal Laboratories for Materials Testing
and Research (EMPA)**

WCC-EMPA REPORT 03/1

**Submitted to the
World Meteorological Organization**

SYSTEM AND PERFORMANCE AUDIT FOR SURFACE OZONE GLOBAL GAW STATION TAMANRASSET / ASSEKREM FEBRUARY 2003

4 August 2003

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Contents:

1. Abstract	3
2. Introduction	5
3. Global GAW Site Tamanrasset / Assekrem	7
3.1. Description of the Site	7
3.2. Description of the Station	8
3.3. Staff / Operators	10
4. System- and Performance Audit for Surface Ozone	11
4.1. Monitoring Set-up and Procedures.....	11
4.1.1. Air Inlet System	11
4.1.2. Instrumentation	11
4.1.3. Data Handling	12
4.1.4. Documentation.....	13
4.2. Inter-comparison of ozone analyzer at Assekrem.....	13
4.2.1. Experimental set-up	13
4.2.2. Results	15
4.3. Recommendation for the Ozone Measurements.....	18
5. General Recommendations	19
6. Conclusions	21
Appendix	23
I EMPA Transfer Standard TEI 49C-PS	23
II Stability of the Transfer Standard TEI 49C-PS.....	23
III System and Performance Audits Executive Summary.....	26

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1. Abstract

A system and performance audit was conducted at the Global Atmosphere Watch station Assekrem from 3. to 7. February 2003 by the World Calibration Center (WCC-EMPA) for Surface Ozone, Carbon Monoxide and Methane. The results can be summarized as follows:

System Audit of the Observatory

The Assekrem research station offers laboratory and office facilities in a remote location of the Saharan desert. The station is visited daily by an operator. The infrastructure supports the measurements of the atmospheric composition as well as measurements of physical and meteorological parameters.

Audit of the Surface Ozone Measurement

The subsequent inter-comparison, consisting of three multipoint runs between the WCC transfer standard and the ozone instrument of the station, demonstrated "good" agreement between the station analyzer and the transfer standard. However, the instrument was first found to be reading low by about 50 % due to an exhausted scrubber. After exchange of the scrubber, the instrument was still reading low by 6 %. Therefore, the calibration factors (i.e. SPAN) were changed from 485 to 515. The recorded differences fulfilled after maintenance the defined assessment criteria as "good" over the tested range up to 100 ppb (Figure 1).

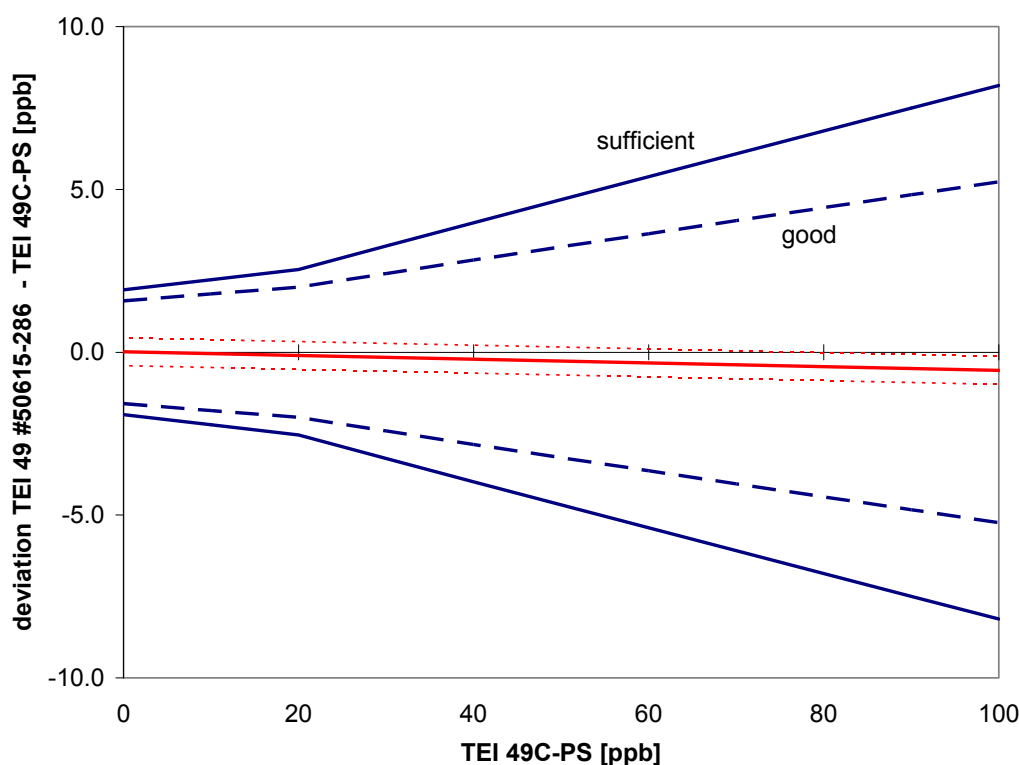


Figure 1: Intercomparison of the TEI 49-003 #50615-286 field instrument with the WCC transfer standard after maintenance

An executive summary of the audit results is shown in Appendix III.

Conclusions and Recommendations

The Assekrem station is an important one within the GAW program since ground based measurements of air pollutants from continental Africa are very limited. Furthermore, the station offers excellent infrastructure concerning laboratory facilities. To take advantage of this, national and international co-operation for both technical and scientific staff (workshops, exchange programs, scientific partnerships) is important and should be enhanced.

The station will require regular training for some years to come. All possibilities for twinning should be explored.

Several recommendations were made by WCC-EMPA mainly concerning ozone measurements but also the general operation of the station. The main recommendations are summarized below:

- The situation concerning power production / storage should improve, and the replacement of the batteries is of highest priority. Measures to that effect have already been taken by the local authorities.
- Persistent problems with any of the measurements at Assekrem should be communicated to external partners and WMO. Communication should be re-established where necessary and maintained to ensure continuing support of external partners.
- A budget, for example in accordance with the GAW measurement guide, should be available for the long-term operation and maintenance of the station. Part of the budget should be at the immediate disposal of the station manager.
- An extensive measurement program is important for a global GAW station. Any possibility to expand the measurement program should be explored.
- Regular inter-comparisons of the ozone analyzer with an ozone calibrator are encouraged. The inter-comparison with a TEI 165 ozone generator that was initially proposed is not sufficient. WCC-EMPA can provide regular calibrations every 2 to 4 years, however, at least half-yearly calibrations are suggested. It should be explored if an ozone calibrator can be made available to Assekrem. All the other WMO-GEF stations received an ozone calibrator through the GEF project. It should also be checked if the ozone calibrator (TEI 49PS) currently located at the Laboratoire Interuniversitaire des Systèmes Atmosphériques (LISA, Paris) can be used for calibrations at Assekrem.
- Yearly visits of the station by LISA, preferably with a calibration of the ozone analyzer at Assekrem, are encouraged. This was proposed by P. Perros from LISA during the conference held in Tamanrasset in February 2003.

Dübendorf, 11. August 2003

EMPA Dübendorf, WCC

Project scientist

Project manager

Dr. C. Zellweger

Dr. B. Buchmann

2. Introduction

The **Global GAW Station Tamanrasset / Assekrem** is part of Algeria's contribution to the World Meteorological Organization's (WMO) Global Atmosphere Watch (GAW) program. The observatory was established within the framework of UNDP's Global Environment Facility (GEF) and is designed for long-term measurements of atmospheric trace compounds and physical and meteorological parameters in the lower troposphere. The station has started its operation in September 1995. The leading office is the Office National de la Météorologie (ONM).

The air pollution and environmental technology section of the Swiss Federal Laboratories for Materials Testing and Research (EMPA) has been designated by WMO to operate the GAW **World Calibration Center (WCC)** for Surface Ozone, Carbon Monoxide and Methane, thereby establishing a coordinated quality assurance program for this part of GAW. The detailed goals and tasks of the WCC concerning surface ozone are described in the GAW report No. 104. System and performance audits at global GAW stations are conducted about every two years based on mutual agreement.

In agreement with the director general of the Office National de la Météorologie (ONM), Abdelmalek Kirouane, a **system and performance audit** for surface ozone was conducted at the station by WCC-EMPA from February 3-7, 2003.

The scope of the audit was the whole measurement system in general and surface ozone measurements in particular. The entire system from the inlet to the data processing and the quality assurance was reviewed during the audit procedure. The ozone audit was performed according to the "Standard Operating Procedure (SOP) for performance auditing ozone analyzers at global and regional WMO-GAW sites", WMO-GAW Report No. 97. The assessment criteria for the ozone inter-comparison were developed by EMPA based on WMO-GAW Report No. 97 (WCC-EMPA Report 98/5, "Traceability, Uncertainty and Assessment Criteria of ground based Ozone Measurements", July 2000, available on request from EMPA or downloadable from www.empa.ch/gaw).

The present audit report is distributed to the Office National de la Météorologie (ONM, Alger), the station manager, the Laboratoire Interuniversitaire des Systèmes Atmosphériques (LISA, Paris) and the World Meteorological Organization in Geneva.

Staff involved in the audit

ONM/ Station	Mr. Abdelmalek Kirouane	Director general of ONM; contacts, organization
	Mr. Mohamed Kadi	Vice director; contacts, organization
	Mr. Mohamed Mimouni	Station manager, data responsible
	Mr. Bouziane Ouchene	Engineer, technical assistance at station
	Mr. Salah Ferroudj	Engineer, technical assistance at station
WCC-EMPA	Dr. Christoph Zellweger	lead auditor
EMPA-QA/SAC	Dr. Jörg Klausen	assistant auditor

Previous audits at the GAW station Tamanrasset / Assekrem:

- none.

3. Global GAW Site Tamanrasset / Assekrem

3.1. Description of the Site

The global GAW station Assekrem (23°16' N – 05°38' E) is located on the summit (plateau) of the second highest point of the Hoggar mountain range in the Saharan desert at an altitude of 2710 m a.s.l. (Figure 2). The site is very remote at a distance of 50 km from Tamanrasset (approx. 70000 inhabitants). Tourist activities in the area are limited due to difficult access to a few dozen visitors per day. Vegetation is extremely sparse. Access to the site requires a four hour drive from Tamanrasset by a 4WD.

Facilities at the site include the main station building located on the plateau and housing for the operators and a small hotel (both at altitudes approx. 100 m below the station). Furthermore, a small monastery is nearby which is permanently inhabited by two monks at present. Meteorological observations were started by the monastery in 1955.



Figure 2: Map of Algeria with the location of Tamanrasset and Assekrem
(Source: U.S. Central Intelligence Agency, www.lib.utexas.edu/maps/algeria.html)

Ozone Level at Assekrem

Ozone measurements started in 1997, and a continuous time series is available since then. However, the data has not yet been quality checked and is regarded to be preliminary. The frequency distribution based on one hour averages of 1998 is shown in Figure 3.

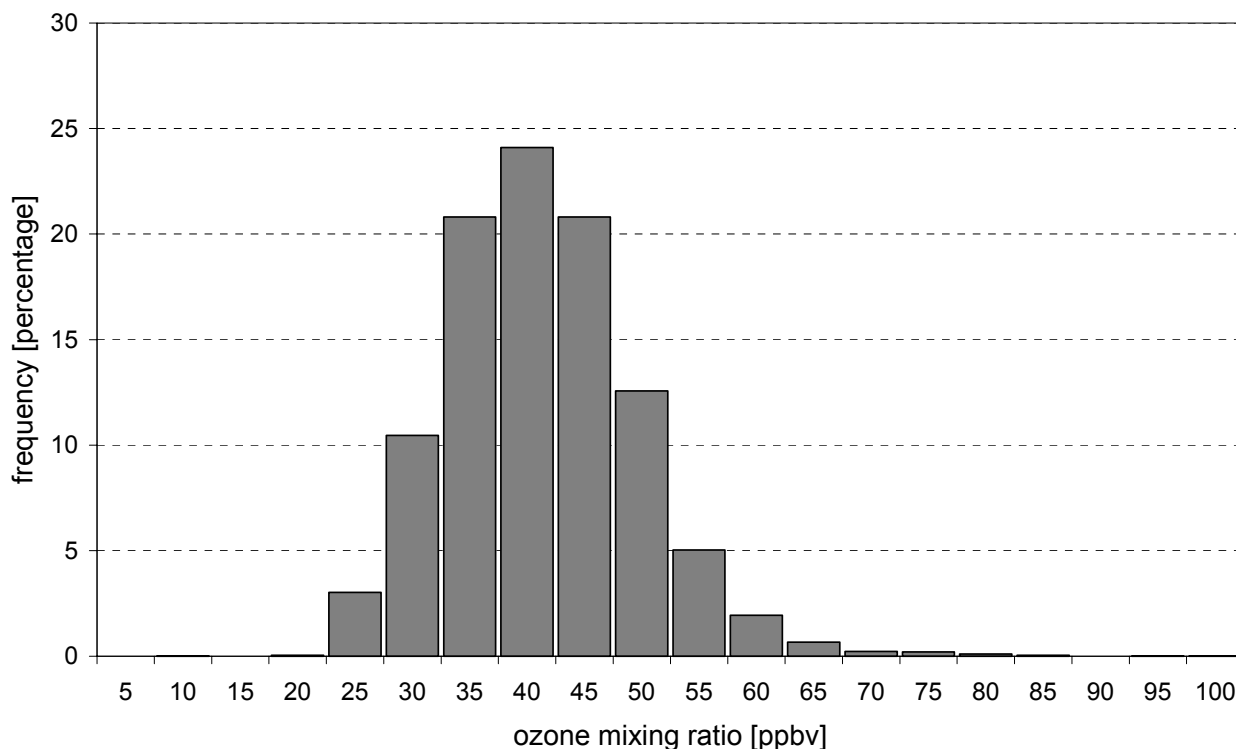


Figure 3: Frequency distribution of the ozone mixing ratio at Assekrem (one hour averages, 1998). Availability of data: 94.9%.

3.2. Description of the Station

The facilities at the site (Figure 4 and 5) consist of a laboratory building providing space for an office and measurement instruments. The air inlet and several radiation and meteorological instruments are mounted on the flat roof of the laboratory (walk on). Electricity is provided by solar panels, and lead accumulators are used for night time operation. Average electrical power capacity is 2.5 kW.

Comment

- The facilities at Assekrem support the measurements of atmospheric parameters.
- The batteries capacity has decreased below a level that would support 24 h operation of the instruments. Immediate replacement is a pre-requisite for sustained operation of the site.



Figure 4: View of Assekrem station



Figure 5: Ozone analyzer at Assekrem with support staff

3.3. Staff / Operators

The staff responsible for the Assekrem GAW station is listed in Table 1. One station operator is always at the station for a two week shift. All other station staff stays in Tamanrasset and visits the station only when needed.

Table 1: Staff responsible for the GAW site Tamanrasset / Assekrem (February 2003)

Name	Position and duty
Abdelmalek Kirouane	Director general of ONM, Algiers
Mohamed Kadi	Vice director of ONM, Algiers
Mohamed Mimouni	Engineer, station manager, data responsible
Bouziane Ouchene	Engineer, maintenance team, calibrations
Mohamed Salah Ferroudj	Engineer, maintenance team
Mohamed Zoukani	Technician, station operator
Abdelkrim Bouklia	Technician, station operator
Abdou Ali Omar	Technician, station operator
Abdessadek Saanoune	Technician, station operator

4. System- and Performance Audit for Surface Ozone

Ozone measurements started at Assekrem in 1996. The whole system was shipped to Algeria by the twinning partners from LISA, and the station staff was trained at LISA in Paris. However, due to the political situation in Algeria, a visit of foreign experts at the station was not possible until the date of the audit. All installations were made by ONM.

The ozone instrument at Assekrem was found to be running. However, a first check indicated a serious instrument problem because ozone readings were found to be approx. 50% of the conventional true value. As a consequence repair work was done before the final inter-comparison. The changes made by WCC-EMPA before the performance audit can be summarized as follows:

- The ozone scrubber of the field analyzer including tubing was replaced with a new scrubber (TEI Part. No. 14697). This was the cause of the low readings (insufficient ozone destruction of the scrubber in use) and represents a critical maintenance operation.
- The tubing of the inlet was replaced by new PFA tubing, and the inlet was mounted approx. one meter higher compared to the original installation to avoid potential ozone loss at the metal fence on top of the building. This is not considered to be a critical change.
- After the replacement of the ozone scrubber, low readings of approx. 6% were observed. This was confirmed by two preliminary calibration runs. The calibration factor (SPAN) of the instrument was changed from 485 (setting before the final inter-comparison) to 515 (final setting). No adjustments were made for the instrument offset (setting 49).

Recommendations concerning ozone measurements are summarized in section 4.3. General, parameter independent recommendations can be found in section 5.

4.1. Monitoring Set-up and Procedures

4.1.1. Air Inlet System

Sampling-location: The air inlet is mounted on top of the flat roof, approx. 1.0 m above the roof top and 4.6 m above the ground.

Sample inlet:

Rain protection: The Inlet is protected against rain and snow by an upside-down Teflon beaker.

Inlet-filter: Teflon inlet filter at the beginning of the sampling line.

Sampling-line:

Dimensions: length = ca. 4 m, i.d. = 4 mm

Flow rate: sample line: ca. 1.6 l/min

Residence time in the sampling line: approx. 2 s

Comment

The tubing was clean and free of dust, but was replaced to fit the new location of the inlet approx. 1 m above the roof top. The replacement was made to gain distance to a metal railing on top of the building. Materials as well as residence time of the inlet system are adequate for trace gas measurements in particular with regard to minimal loss of ozone.

4.1.2. Instrumentation

Ozone Analyzer

The monitoring system at the global GAW station Assekrem consists of an ozone analyzer with an internal ozone generator, plus an external zero air unit consisting of a pump and a charcoal cartridge. The ozone instrument is installed inside the laboratory on a table. The room has no air conditioning. Temperatures inside the laboratory building range from 4°C to 16°C. The instrument is not exposed to direct sunlight. Instrumental details for the ozone analyzer are summarized in Table 2.

Table 2: Ozone analyzer at the Assekrem Research Station

Type	TEI 49-003 #50615-286
Method	UV absorption at 254 nm
at Assekrem	since May 1996
Range	0-500 ppb
Analog output	0-10 V
Settings	Span: 485; Offset: 49 (prior to adjustment) Span: 515; Offset: 49 (after adjustment)
Instrument specials	Internal ozone generator, RS232

Ozone Calibrator

No ozone calibrator is available at the site. A calibrator model 49 PS from Thermo Environmental Instruments Inc. was used for the first calibration of the instrument at LISA, and frequent inter-comparisons were planned. However, no further inter-comparisons were made. An ozone generator TEI 165 was also available at the site, but had never been used. Inter-comparisons with an ozone generator are encouraged for quality assurance. However, an ozone generator can not be used to calibrate the instrument.

Operation and Maintenance

A daily check of general operation is performed by the operator in charge. Biweekly maintenance includes the exchange of inlet filters and the check of temperatures, pressures, pump function, ozone signal, intensities and instrument noise.

Manual zero and span checks are performed regularly (once per month) with the internal ozone generator and the zero air generator.

4.1.3. Data Handling

Data Acquisition and –transfer

Data is acquired on a custom made acquisition software (QuickBasic for DOS; LISA) via the RS-232 interface. The source code was not available to station staff. One minute averages of the ozone concentration, temperatures, pressures and O₃ A/B are stored.

Data Treatment

The raw data is inspected every other week by the station manager in Tamanrasset (time series plot, check with instrument log book). No further data treatment was done at Tamanrasset but data were forwarded to LISA. An improved scheme for data review and QA/QC is strongly recommended to provide more direct feed-back to the station operators and the manager.

Data Submission

Surface ozone data was submitted to the GAW World Data Centre for Greenhouse Gases (WDCGG) at JMA. The data is regarded as preliminary because quality control is still ongoing.

4.1.4. Documentation

Logbooks

A logbook is available for the ozone instrument. The notes are up to date and describe all important events. Furthermore, a log book for the general operation of the station is available.

Standard Operation Procedures (SOPs)

No manual for the instrument was available at the site. Documentation provided by LISA was available at the headquarter in Tamanrasset but not at the site.

Comment

The frequent instrument checks and the up-to-date logbook support the quality of the data. However, instrument manuals and further documentation should be available at the site.

4.2. Inter-comparison of ozone analyzer at Assekrem

4.2.1. Experimental set-up

The WCC transfer standard TEI 49C PS (details see Appendix I-II) was operated in stand-by mode for warming up for 5 hours. This rather short warm-up period was necessary because the inter-comparison had to be performed during day time (power-failure during the night because of insufficient capacity of the batteries). During the stabilization time the transfer standard and the PFA tubing connections to the instrument were conditioned with 800 ppb ozone for 120 minutes. Afterwards, three comparison runs between the field instrument and the WCC transfer standard were performed. Table 3 shows the experimental details and Figure 6 the experimental set up during the audit. No modifications of the ozone analyzer which could influence the measurements were made for the inter-comparisons.

The audit procedure included a direct inter-comparison of the TEI 49C-PS WCC transfer standard with the Standard Reference Photometer SRP#15 (NIST UV photometer) before and after the audit in the calibration laboratory at EMPA. The results are shown in Appendix II.

Table 3: Experimental details of the ozone inter-comparison

reference:	EMPA: TEI 49C-PS #54509-300 transfer standard
field instrument:	TEI 49-003 #50615-286
ozone source:	WCC: TEI 49C-PS, internal ozone generator
zero air supply:	EMPA: silica gel - inlet filter 5 μm - metal bellow pump - Purafil (potassium permanganate) - activated charcoal - outlet filter 5 μm
data acquisition system:	16-channel ADC with acquisition software
pressure transducer readings:	TEI 49C-PS (WCC): 739.1 hPa adjusted to ambient pressure 741.0 hPa TEI 49-003 (Assekrem): 737 hPa adjusted to ambient pressure 741 hPa
concentration range	0 - 100 ppb
number of concentrations:	5 + zero air at start and end
approx. concentration levels:	15 / 35 / 55 / 75 / 90 ppb
sequence of concentration:	random
averaging interval per concentration:	5 minutes
number of runs:	3 runs on 6. February 2003
connection between instruments:	approx. 1.5 meter of 1/4" PFA tubing

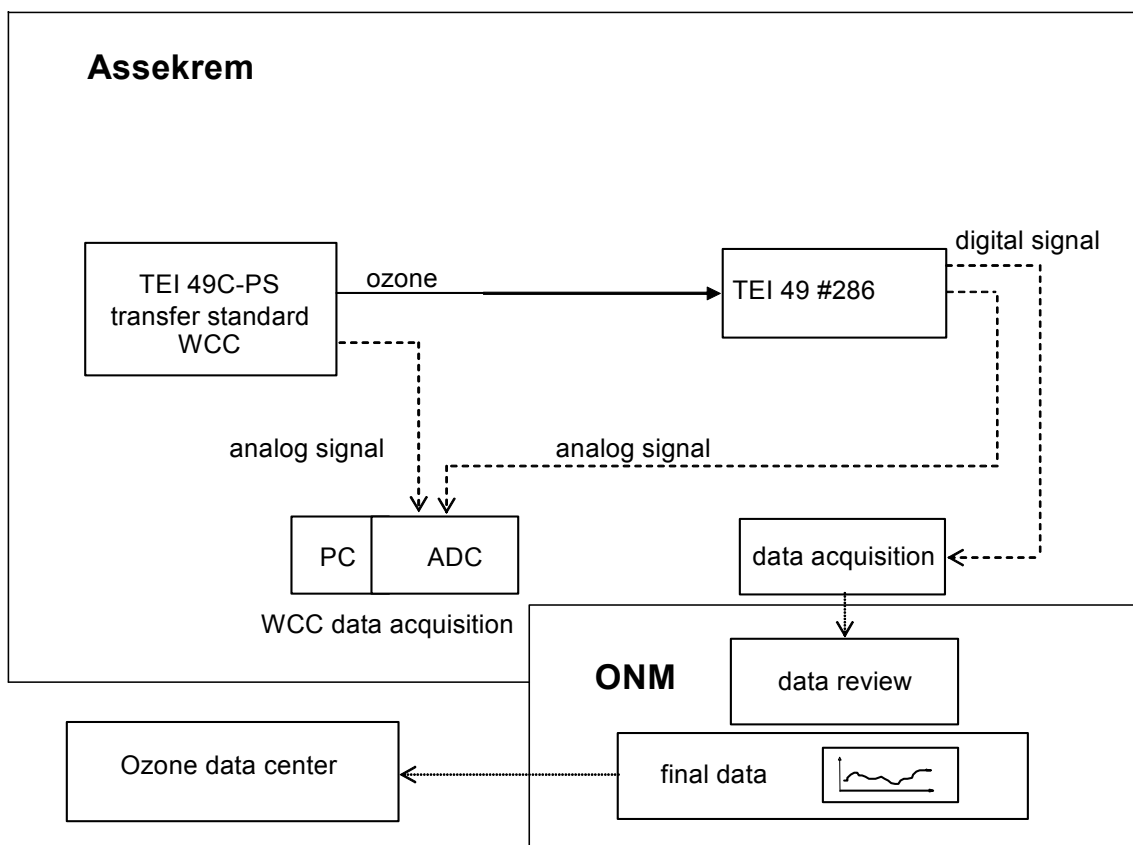


Figure 6: Experimental set up for the ozone inter-comparison

4.2.2. Results

The results comprise the inter-comparison between the TEI 49-003 field instrument and the WCC transfer standard TEI 49C-PS, carried out on 6 February 2003.

The resulting mean values of each ozone concentration and the standard deviations (s_d) of ten 30-second-means are presented in Table 4. For each mean value the differences between the tested instruments and the transfer standard are calculated in ppb and in %.

Figures 7 and 8 show the residuals of the linear regression analysis of the field instrument compared to the EMPA transfer standard. The residuals versus the run index are shown in Figure 7 (time dependence), and the residuals versus the concentration of the WCC transfer standard are shown in Figure 8 (concentration dependence). The result is presented in a graph with the assessment criteria for GAW field instruments (Figure 9).

Table 4: Inter-comparison of the ozone field instrument

run index	TEI 49C-PS		TEI 49-003 #50615-286			
	conc.	s_d	conc.	s_d	deviation from reference	
	ppb	ppb	ppb	ppb	ppb	%
1	0.2	0.1	0.6	0.4	0.4	
2	15.1	0.1	15.4	0.3	0.3	1.9%
3	55.1	0.1	55.1	0.4	0.0	-0.1%
4	35.1	0.1	35.2	0.3	0.1	0.2%
5	90.0	0.1	89.8	0.4	-0.2	-0.3%
6	75.1	0.1	74.7	0.3	-0.4	-0.6%
7	0.2	0.1	0.3	0.3	0.1	
8	0.3	0.1	0.4	0.4	0.1	
9	35.1	0.1	34.9	0.3	-0.2	-0.6%
10	90.0	0.1	89.7	0.3	-0.3	-0.4%
11	55.1	0.1	54.6	0.4	-0.5	-0.8%
12	75.1	0.1	74.5	0.3	-0.6	-0.7%
13	15.1	0.1	15.0	0.4	-0.1	-0.6%
14	0.2	0.1	0.1	0.2	-0.1	
15	0.2	0.1	0.0	0.3	-0.2	
16	15.1	0.1	14.9	0.3	-0.2	-1.7%
17	90.0	0.1	89.5	0.3	-0.5	-0.6%
18	35.1	0.1	34.7	0.3	-0.4	-1.3%
19	75.1	0.1	74.6	0.4	-0.5	-0.7%
20	55.2	0.1	54.5	0.4	-0.7	-1.1%
21	0.2	0.1	0.1	0.2	-0.1	

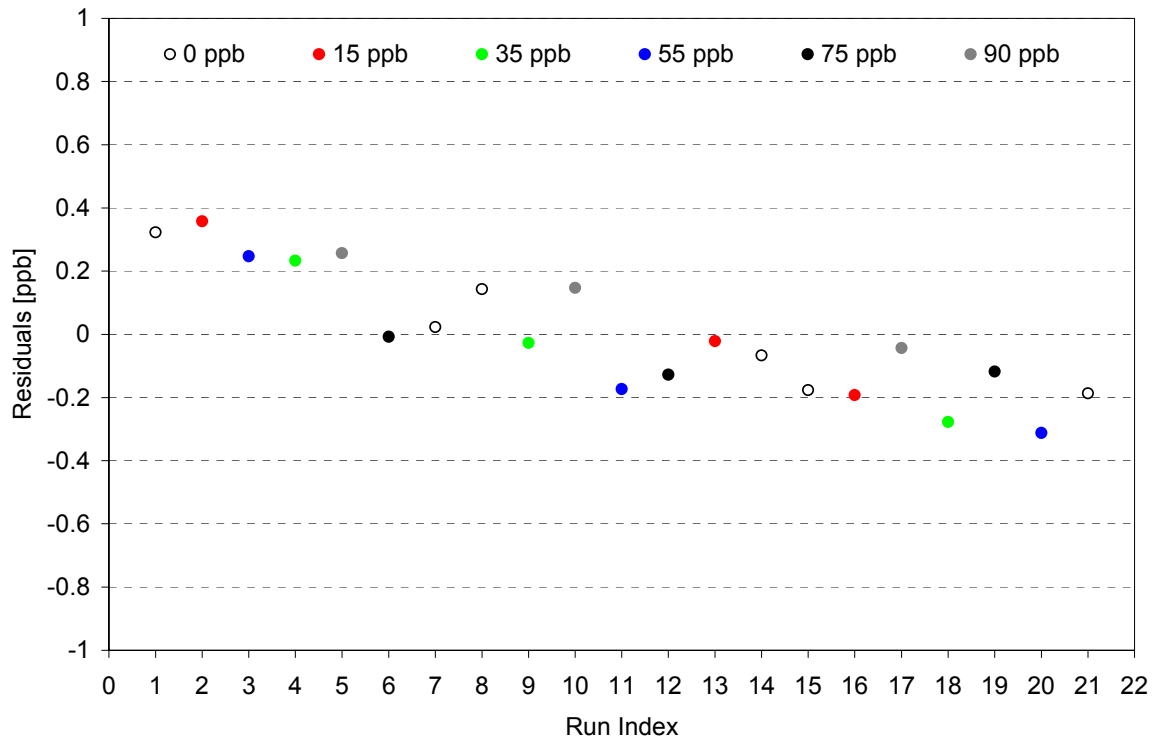


Figure 7: Residuals of the linear regression (TEI 49-003 #286) vs the run index (time dependence)

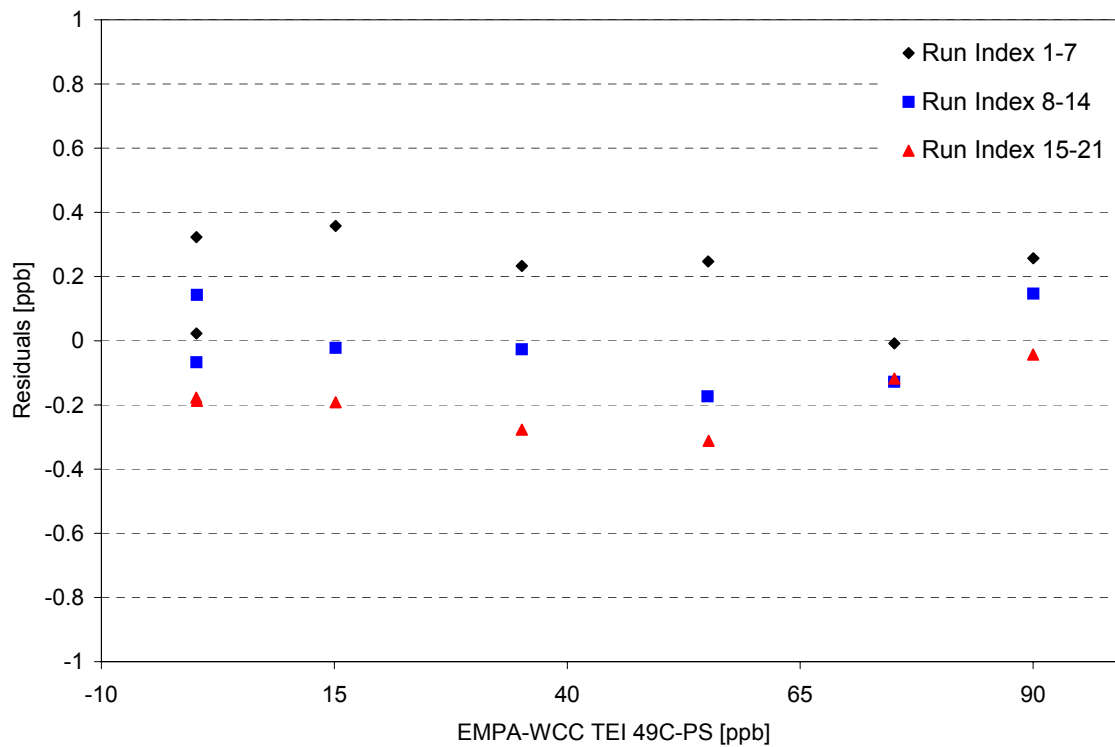


Figure 8: Residuals of the linear regression (TEI 49-003 #286) vs the concentration of the WCC transfer standard (concentration dependence)

From the inter-comparisons of the TEI 49-003 #286 field instrument with the TEI 49C-PS transfer standard from EMPA, the resulting linear regression (for the range of 0-100 ppb ozone) is:

TEI 49-003 #286:

$$\text{TEI 49-003} = 0.9943 \times \text{TEI 49C-PS} + 0.02 \text{ ppb}$$

TEI 49-003 = O₃ mixing ratio in ppb, determined with TEI 49-003 #50615-286

TEI 49C-PS = O₃ mixing ratio in ppb, determined with TEI 49C-PS #54509-300

Standard deviation of:	- slope s_m	0.001	(f = 19)	f = degree of freedom
	- offset S_b in ppb	0.07	(f = 19)	
	- residuals in ppb	0.14	(n = 21)	

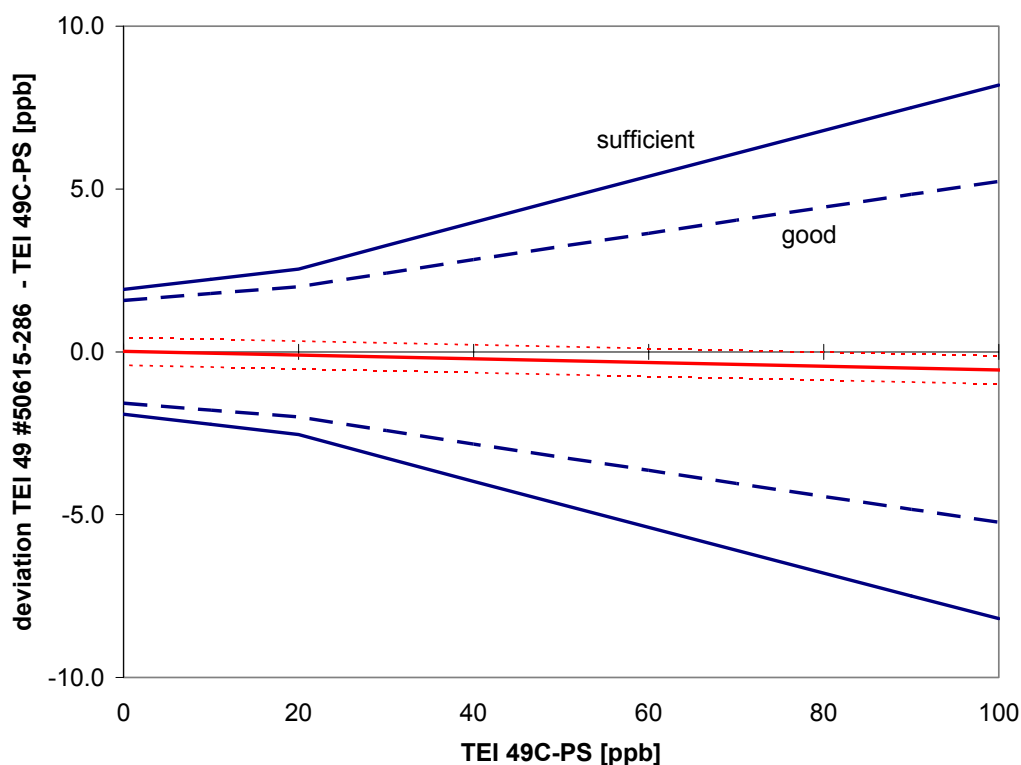


Figure 9: Inter-comparison of instrument TEI 49-003 #50615-286

Comment

The instrument fulfils the assessment criteria of “good” over the tested range between 0 and 100 ppb ozone. A small drift with time was observed, which may be explained by insufficient warm-up time. However, it is not expected to cause significant changes in the audit results.

4.3. Recommendation for the Ozone Measurements

The TEI 49-003 ozone instrument at the Assekrem station is now in a good condition and fulfilled the assessment criteria as "good" over the tested range of 0 to 100 ppb. However, some maintenance work had to be done to obtain these results.

The following recommendations are made by WCC-EMPA concerning the ozone measurements. Refer also to section 5 for general recommendations suggested by WCC-EMPA.

- The capacity of the batteries for overnight storage of electrical power was not sufficient at the time of the audit. This resulted in regular power failures during the night. New batteries were already ordered by ONM, and the installation is of highest priority.
- Data should be quality controlled in regular intervals, e.g. biweekly. A quality control procedure should be established in co-operation with LISA or QA/SAC.
- Instrument manuals and further documentation provided by LISA should be kept at the site.
- Regular back-ups of the measurement data are strongly encouraged.
- Regular inter-comparisons with an ozone calibrator are encouraged. The proposed inter-comparison with a TEI 165 ozone generator is not sufficient. WCC-EMPA can provide regular calibrations every 2 to 4 years, however, at least half-yearly calibrations are suggested. It should be explored if an ozone calibrator can be made available to Assekrem. The other WMO-GEF stations received an ozone calibrator through the GEF project. To provide an ozone standard was also proposed by LISA in the original agreement between WMO and LISA from 13. July 1994. It should be in particular checked if the ozone calibrator (TEI 49PS) of the Laboratoire Interuniversitaire des Systèmes Atmosphériques (LISA, Paris) can be used for calibrations at Assekrem, e.g. during yearly station visits.
- Yearly visits of the station by LISA, preferably with a calibration of the ozone analyzer at Assekrem, are encouraged. This was proposed by P. Perros from LISA during the conference held in Tamanrasset in February 2003.
- Submission of the data to the GAW World Data Center for Greenhouse Gases (WDCGG) at JMA is recommended as soon as the existing time series pass quality control. QA/SAC Switzerland is ready to offer assistance as needed.

5. General Recommendations

The following recommendations are made to ensure the long-term operation of the GAW station Assekrem.

- The situation concerning power production / storage must be improved, and the replacement of the batteries is of highest priority. Measures have already been taken by ONM.
- Persistent problems with any of the measurements at Assekrem should be communicated to external partners and WMO. Communication should be re-established where necessary and maintained to ensure continuing support of external partners.
- A budget, for example in accordance to the GAW measurement guide, should be available for the long-term operation and maintenance of the station. Part of the budget should be at the immediate disposal of the station manager.
- An extensive measurement program is important for a global GAW station. Any possibility to expand the measurement program should be explored.
- An ozone calibrator should be available either at Assekrem or Tamanrasset. This was also proposed in the original agreement between WMO and LISA from 13. July 1994. It should be in particular checked if the ozone calibrator (TEI 49PS) can be used for calibrations at Assekrem. This could be done e.g. during yearly station visits by LISA or by yearly shipping of the calibrator when traveling is not possible.

6. Conclusions

The global GAW station Assekrem was established in 1996 and time series for surface ozone along with other parameters are available since then. Due to the difficult political situation the station was for many years not accessible for foreign experts, and training of the station staff was limited to a few occasions. Despite of these unfortunate circumstances ONM managed to establish and run the station successfully.

To assure a high data quality for surface ozone, it is regarded as extremely important that an ozone calibrator (e.g. a TEI 49PS or TEI 49C-PS) is available for calibrations. To provide an ozone standard was also proposed by LISA in the original agreement between WMO and LISA from 13. July 1994. It should be in particular checked if the ozone calibrator (TEI 49PS) currently located at LISA can be used for calibrations at Assekrem.

The geographical position of the Assekrem station within the GAW program is regarded as important, since ground based measurements of air pollutants from continental Africa are very limited. Furthermore, the station offers excellent infrastructure concerning laboratory facilities. To take advantage of this, national and international co-operation for both technical and scientific staff (workshops, exchange programs, scientific partnerships) is regarded as important.

The station will require regular training for some years to come. All possibilities for twinning should be explored.

Appendix

I EMPA Transfer Standard TEI 49C-PS

The Model 49C-PS is based on the principle that ozone molecules absorb UV light at a wavelength of 254 nm. The UV absorption is proportional to the concentration as described by the Lambert-Beer Law.

Zero air is supplied to the Model 49C-PS through the zero air bulkhead and is split into two gas streams, as shown in Figure 10. One gas stream flows through a pressure regulator to the reference solenoid valve to become the zero reference gas. The second zero air stream flows through a pressure regulator, ozonator, manifold and the sample solenoid valve to become the sample gas. Ozone from the manifold is delivered to the ozone bulkhead. The solenoid valves alternate the reference and sample gas streams between cells A and B every 10 seconds. When cell A contains reference gas, cell B contains sample gas and vice versa.

The UV light intensities of each cell are measured by detectors A and B. After the solenoid valves switch the reference and sample gas streams to opposite cells, the light intensities are ignored for several seconds to allow the cells to be flushed. The Model 49C-PS then determines the ozone concentration for each cell and outputs the average concentration.

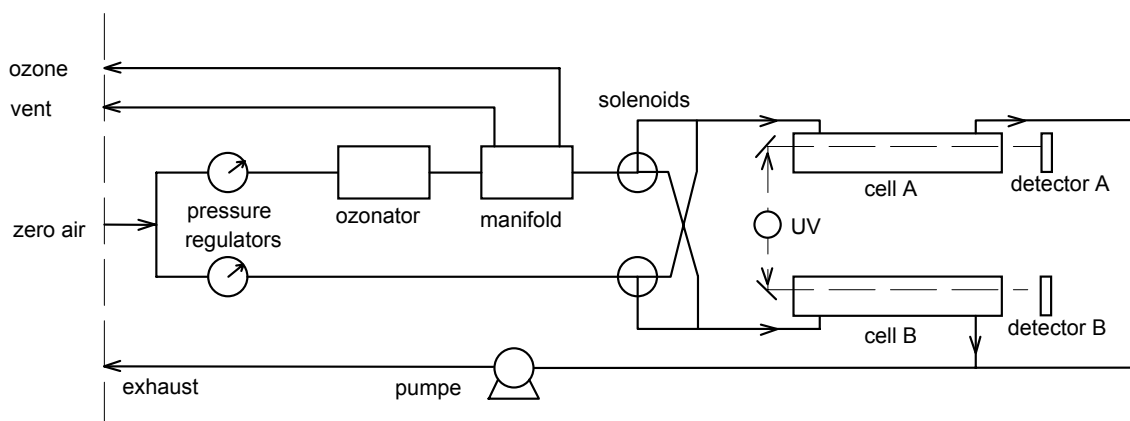


Figure 10: Flow schematic of TEI 49C-PS

II Stability of the Transfer Standard TEI 49C-PS

To exclude errors that might result from transportation of the transfer standard, the TEI 49C PS #54509-300 was compared with the SRP#15 before and after the field audit.

The procedure and instrumental details of this inter-comparison at the EMPA calibration laboratory are summarized in Table 5 and Figure 11.

Table 5: Intercomparison procedure SRP - TEI 49C-PS

pressure transducer:	zero and span check (calibrated barometer) at start and end of procedure
concentration range:	0 - 200 ppb
number of concentrations:	5 + zero air at start and end
approx. concentration levels:	30 / 60 / 90 / 140 / 190 ppb
sequence of concentration:	random
averaging interval per concentration:	5 minutes
number of runs:	3 before and 3 after audit
zero air supply:	Pressurized air - zero air generator (CO catalyst, Purafil, charcoal)
ozone generator:	internal generator of SRP
data acquisition system:	SRP ADC and acquisition

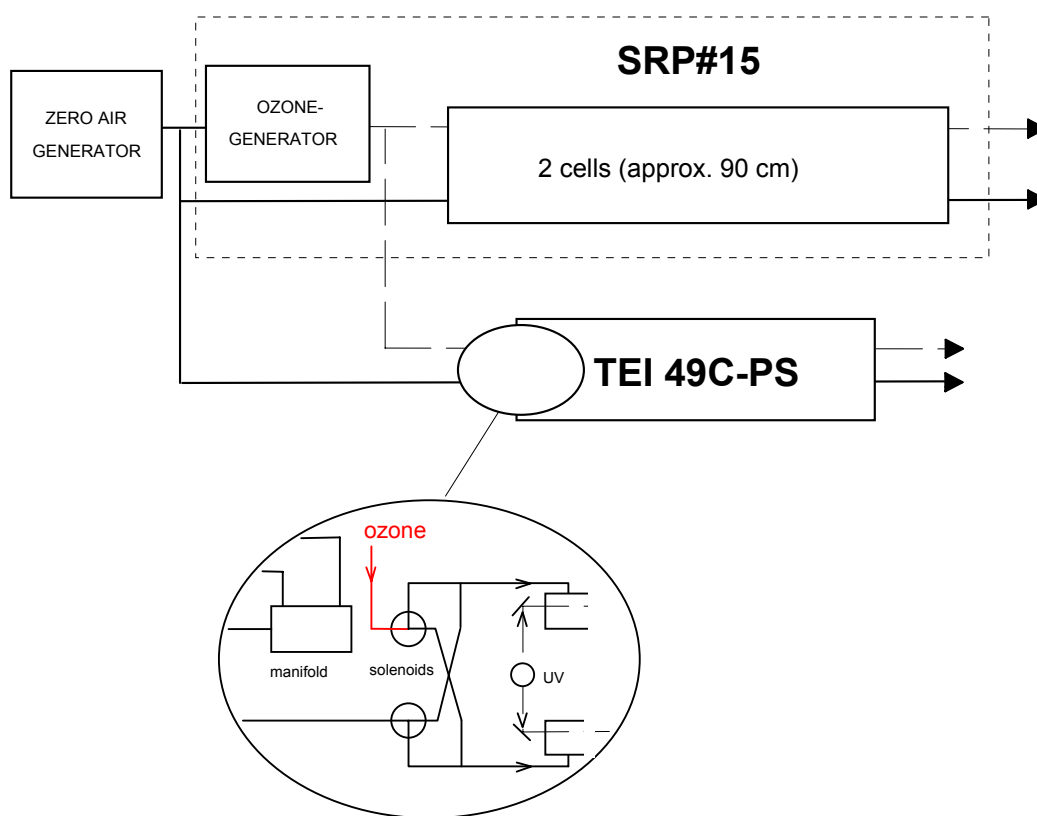


Figure 11: Instruments set up SRP -TEI 49C-PS

The stability of the transfer standard was thoroughly examined with respect to the uncertainties of the different components (systematic error and precision). For the GAW transfer standard of the WCC-O₃ (TEI 49C-PS) the assessment criteria, taking into account the uncertainty of the SRP, are defined to approximately $\pm(1 \text{ ppb} + 0.5\%)$.

Figures 12 and 13 show the resulting linear regression and the corresponding 95% precision interval for the comparisons of TEI 49C-PS vs. SRP#15. The results show that the EMPA transfer standard fulfilled the recommended criteria for the period of the audit, including transportation.

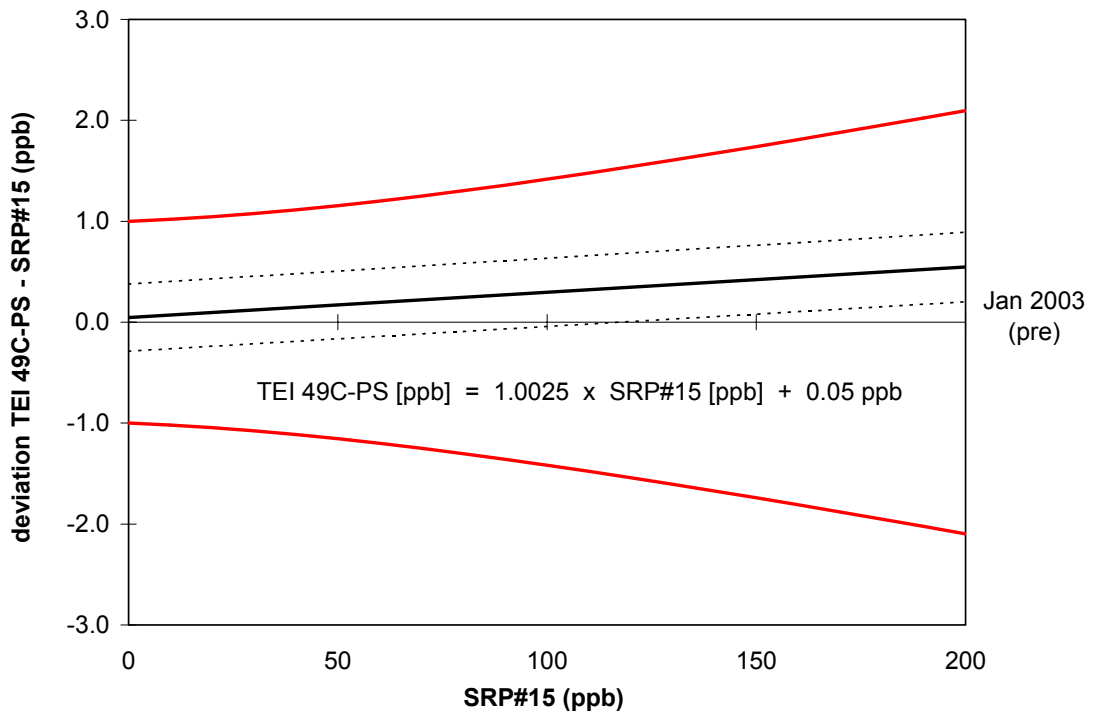


Figure 12: Transfer standard before audit

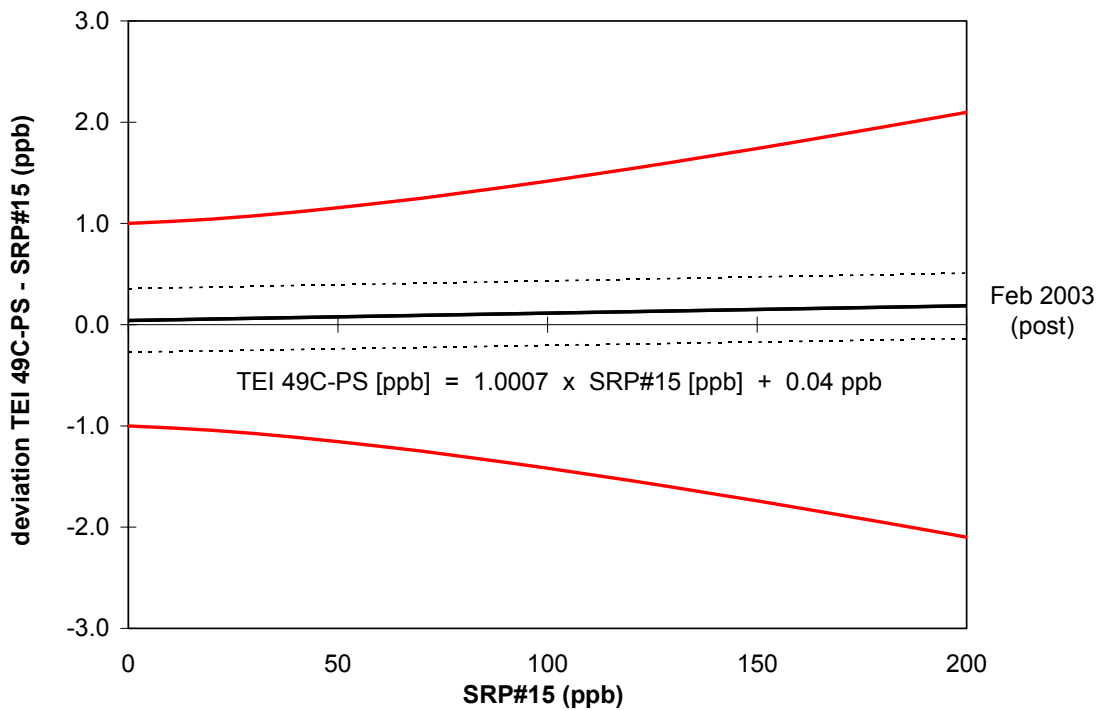


Figure 13: Transfer standard after audit

III System and Performance Audits Executive Summary

GAW World Calibration Centre for Surface Ozone
 GAW QA/SAC Switzerland
 Swiss Federal Laboratories for Materials Testing and Research (EMPA)
 EMPA Dübendorf, CH-8600 Dübendorf, Switzerland
<mailto:gaw@empa.ch>

System and Performance Audit Executive Summary

0.1 Station Name: Assekrem
 0.2 GAW ID:
 0.3 Coordinates/Elevation: 23°16' N 05°38' E / 2710 m a.s.l
 0.4 Parameter: Surface Ozone

- | | | |
|-------|--|---|
| 1.1 | Date of Audit: (03.02.2003 – 07.02.2003) | |
| 1.2 | Auditors: | Dr. C. Zellweger and Dr. J. Klausen |
| 1.3 | Station staff involved in audit: | Mr. Abdelmalek Kirouane, Director general of ONM
Mr. Mohamed Kadi, Vice director
Mr. Mohamed Mimouni, Station manager
Mr. Bouziane Ouchene, Engineer
Mr. Salah Ferroudj, Engineer |
| 1.4 | Ozone Reference [SRP]: | NIST SRP#15 |
| 1.5 | Ozone Transfer Standard [TS] | |
| 1.5.1 | Model: | TEI 49C PS S/N: 54509-300 |
| 1.5.2 | Range of calibration: | 0 – 200 ppb |
| 1.5.3 | Mean calibration (ppb): | $[TS] = (1.0014 \pm 0.0010) \times [SRP] + (0.05 \pm 0.13)$ |
| 1.6 | Ozone Analyzer [OA] | |
| 1.6.1 | Model: | TEI49-003 S/N: 50615-286 |
| 1.6.2 | Coefficients prior to audit | ZERO: 49 SPAN: 485 |
| 1.6.3 | Coefficients during and after audit | ZERO: 49 SPAN: 515 |
| 1.6.4 | Range of calibration: | 0 – 100 ppb |
| 1.6.5 | Calibration after audit (ppb): | $[OA] = (0.9943 \pm 0.0034) \times [TS] + (-0.01 \pm 0.17)$ |
| 1.6.6 | Unbiased ozone concentration (ppb): | $C = ([OA] - 0.0596) / 0.9957$ |
| 1.6.7 | Standard uncertainty remaining after compensation of calibration bias (ppb): | $u_C \approx \{0.67 \text{ ppb}\}^2 + (0.0062 \times C)^2\}^{1/2}$ |
| 1.7 | Comments | Ozone scrubber was exchanged prior to audit. |
| 1.8 | Reference: | EMPA-WCC Report 03/1 |