Report of the 6th African Dobson and 20th European Brewer Spectrophotometer Campaigns at El Arenosillo, Spain

1. Introduction

Africa (RA-I) is a continent located in the western hemisphere with most of its land mass in the northern hemisphere but including a large area in the tropics. It limits to the north with the European continent. It also includes a diverse geography including desert, jungle and grassland.

The tropical regions of Africa are of particular importance as it is well known that ozone recovery is weak in these regions. Observations of ozone distributions here not only serve to give trend analyses and provide data for satellite validation but can also contribute to studies of changes in tropopause height and atmospheric circulation.

Ozone measurements in RA-I have been made at several locations with Dobson spectrophotometers for three decades, and also with the more modern Brewer Ozone Spectrophotometer. For Dobson instruments, it is recommended they be calibrated every six years and for the instruments of RA-I the next calibration was scheduled for 2025, the last calibration for Dobson occurred back in 2019. In addition, there are issues with some stations due to retirements or personnel changes with lack of training which need to be addressed in order to continue these valuable records. These issues possibly caused the instruments from Botswana (Maun) and Seychelles did not participate although they have been contacted.

Brewer instruments require calibration every two years and an intercomparison was planned for 15th to 27th June 2025 at El Arenosillo near Huelva in Spain. This is a regular intercomparison hosted by the Regional Calibration Centre – Europe (RBCC-E) in collaboration with Instituto Nacional de Técnica Aeroespacial" (INTA).

WMO's GAW Secretariat suggested to combine the planned European campaign for Brewers with the African Dobson intercomparison, including also the African Brewers and inviting other instruments as the BTS, being candidates to replace traditional Brewers, which have recently ceased production.

More than 50 specialists from 16 countries participated with 10 Dobson spectrophotometers, 20 Brewer spectrophotometers, and 6 BTS spectrometers. Calibration traceability was provided by DWD (R-DCC Europe), CIAI-AEMET (RBCC-E), and PMOD-WRC (QASUME). During the second week (23–27 June), a hands-on WMO-certified operators' course on total-ozone instrumentation and UV measurements was delivered. Additionally, Dobson users received training on maintenance and best practices during all the campaign.

Instruments from the United Kingdom, Denmark, Spain, Italy, Greece, Kenya, Egypt, Algeria, Uganda, and South Africa were calibrated against references provided by the Regional Dobson Calibration Centre at Hohenpeissenberg (DWD, Germany), the Regional Brewer Calibration Centre (CIAI-AEMET, Spain), and the World Radiation Center (PMOD-WRC, Davos, Switzerland).

2. Objectives

The campaign strengthened the Global Atmosphere Watch (GAW/WMO) ozone-monitoring network by ensuring calibration consistency, harmonizing operational procedures, and fostering regional capacity building. Specific objectives included: (i) calibration of Dobson and Brewer spectrophotometers against regional references; (ii) cross-platform intercomparison, including BTS spectrometers as candidates for UV spectral measurements; (iii) operator training and certification; and (iv) targeted support to African services to improve data quality and continuity.

3. List of participants funded by the GTF

Instrument ID	Station	Country	Name
D011 B201	Tamanrasset	Algeria	Sida Lamine BAIKA
			Mebarek Kedida
D069	Aswan	Egypt	Ayman El Shahat Badawy
D059	Hurghada	Egypt	Ahmed Saad
B143	Matrouh	Egypt	Ahmed Azzam
D018 B071	Nairobi	Kenya	Syprose Nyadida
			Francis Mutuku
D089	Irene	S. Africa	Tshidi Machinini
D132	Springbok	S. Africa	Gerard Oppel
D056	Kampala	Uganda	Taddeo SSenyonga



Figure 1. Top left: Ahmed Saad (EMA), Francis Mutuku (KMD), Mebarek Kedida (ONM), Ahmed Azzam (EMA), Tshidi Machinini (SAWS), José Manuel Vilaplana Guerrero (INTA), Thumeka Mkololo (SAWS), Pieter Labuschagne (SAWS), Taddeo Ssenyonga (Makerere University), Syprose Nyadida (KMD), Gerard Oppel (SAWS). Bottom left: Sida Lamine Baika (ONM), Sergio Moreno Valero (WMO), Alberto Redondas Marrero (AEMET), Voltaire Velazco (DWD).

4. Highlights from the campaign

El Arenosillo offered not only clear skies and stable sunlight—ideal for calibration—but also a welcoming environment for collaboration. The site provided excellent conditions

for observing a wide range of solar zenith angles, enabling calibration across different atmospheric paths.
Among the highlights of the Dobson calibration campaign were the participation of several historical instruments, including #073 from the British Antarctic Survey—famous for its role in the discovery of the ozone hole (Farman et al., 1985)—and the maintenance of the African instruments, which had arrived in very poor condition.



Figure 2. Top left: On-site, hands-on instruction during intercomparison campaigns is essential for teaching key techniques and refreshing operational procedures. Top right: Ten Dobsons, including the European standard, participated in the Huelva campaign. Bottom left: Dobson #073, one of the British Antarctic Survey (BAS) instruments that contributed to the discovery of the ozone hole (Farman et al., 1985), was flown in from Antarctica for maintenance in Germany and calibration in Spain, operated here by S. Kucieba (BAS). Center: Instruments from Uganda (#056), Egypt (#069), and Algeria (#011) — one of the oldest Dobsons still operating, built around 1932 — also took part in the campaign.

Regarding the Brewer calibration, the intercomparison addressed ozone‑slant path characterization, slit‑function checks, and optical alignment, and compiled calibration histories for participating instruments. For UV spectral measurements, PMOD‑WRC's QASUME unit provided the reference irradiance scale, while INTA and the Universidad de Extremadura supported UV angular characterization. Experts from International Ozone

Services (IOS) also participated in the intercomparison enabling participants to request on-site technical service for their instruments during the campaign. In addition, six BTS spectrometers were evaluated as prospective operational complements to traditional Brewers, which have recently ceased production.
A good way to evaluate the performance of the Brewer network is shown in Figure 3, where the ratio to the reference Brewer #185 is presented for the blind days. During the blind days, the instruments remain unmodified, use their home calibration, and provide an indication of the current calibration status. For four instruments, the agreement is very good, with ratios below 0.5%. The number of instruments with good calibration (deviations less than 1%) is nine, representing 50% of all participating instruments.

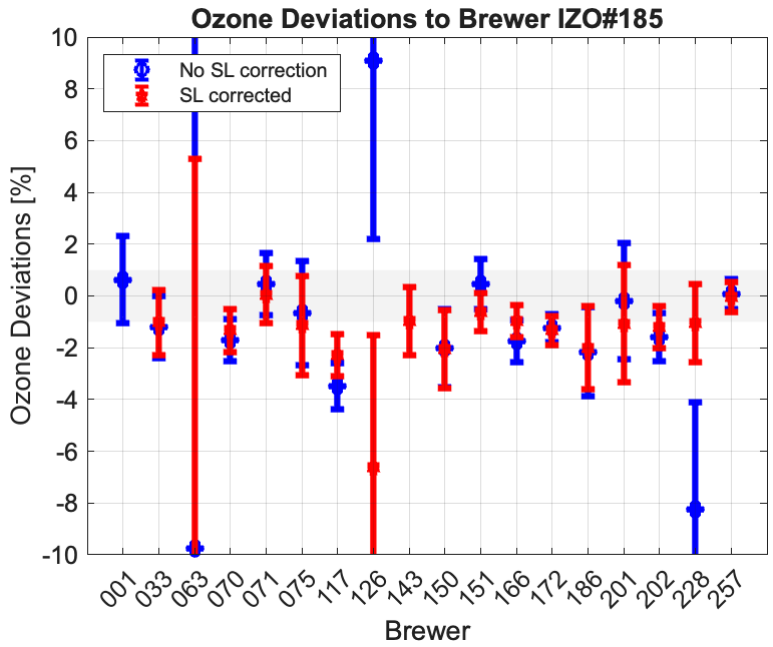


Figure 3: Mean ozone deviations (%, relative to Brewer IZO #185) during the blind-day period, showing instrument performance before any intervention. Instruments: 001, 033, 063, 070, 071, 117, 126, 143, 150, 151, 166, 172, 186, 201, 202, 228, 257. Blue: no stray-light correction; red: stray-light corrected; error bars: ±1σ.

The following activities were performed during the Brewer calibration campaing:

• Calibrations: Updated calibration constants and uncertainty budgets prepared for participating Dobson and Brewer instruments.
• UV Scale: QASUME reference irradiance applied to UV instruments; angular response characterized with INTA/UEx support where applicable.
• Documentation: Calibration histories updated; recommended maintenance and configuration changes recorded for each instrument.
• Data Quality: Harmonized processing settings and SOPs reinforced through the course and daily briefings.
• BTS Evaluation: Initial performance assessment completed to inform future operational deployments alongside or as complements to Brewers.
4. WMO Operators Course (23–27 June 2025)

A hands-on training course for Dobson and Brewer operators ran in parallel to the intercomparison during the second week. The curriculum covered field operations, preventive maintenance, baseline calibration concepts, data processing and evaluation, uncertainty assessment, UV spectral measurements, and data submission workflows. Successful participants received WMO certification. African operators were prioritized for mentoring and peer-to-peer exchanges to accelerate national capacity development.



Figure 4: Hands on training course, Virgilio Carreño (AEMET) showing the insides of the Brewer spectrometer.

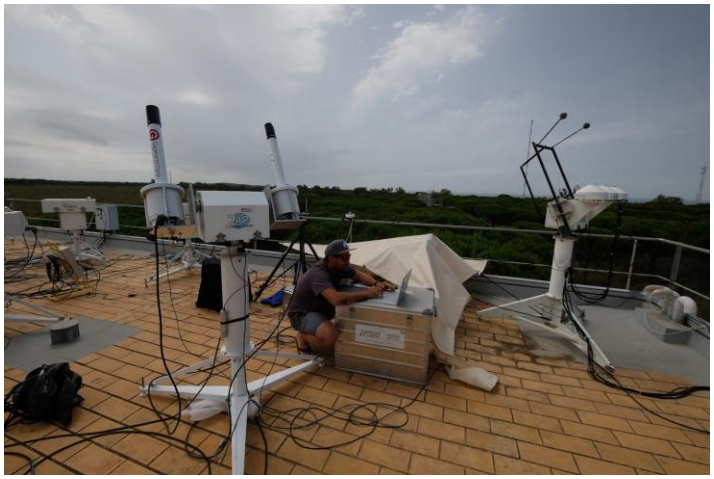


Figure 5: On first plane two BTS instruments and behind the QASUME unit operated by PMOD-WRC with provides the Ultraviolet Radiation reference. At the campaign 6 BTS instruments, a candidate replacement of the Brewer spectrometer, were tested.



Figure 6: Global UV cosine-response characterization was provided by INTA and the University of Extremadura. Cosine-response testing is essential for improving the quality of UV radiation observations. Experts from International Ozone Services (IOS) also participated in the intercomparison enabling participants to request on-site technical service for their instruments during the campaign.

5. Conclusions and next steps

The campaign was a success in bringing together experts and operators from very diverse environments. It fostered a strong sense of collaboration and unity between the Brewer and Dobson communities, both committed to the same goal: monitoring total column ozone. It was also an opportunity to see the BTS in action; in fact, the South African Weather Service is now planning to acquire several BTS instruments.
The campaign also revealed the significant challenges involved and the substantial amount of time and resources required to coordinate and manage such an exercise. The WMO coordinated the transport of instruments and participants, as well as their accommodation. Planning began in November 2024, yet some instruments arrived only three days before the end of the campaign (27 June 2025). This highlights the importance of starting preparations well in advance to avoid last-minute issues. Additionally, procedures related to transport, procurement, and travel have become increasingly cumbersome due to the high level of administrative scrutiny that public organizations must comply with.
For future campaigns, it is recommended that the local organizing institution manage the intercomparison—similar to how INPE successfully handled the South American Brewer Intercomparison in 2024—taking advantage of their regional expertise and logistical knowledge.
The continuation of combined intercomparison campaigns (Brewer, Dobson, BTS, Pandora) is strongly encouraged. These joint efforts are essential to improve our understanding of instrument performance under common conditions and to establish reliable cross-calibration links, thereby optimizing resources and reducing the need for extensive and costly field campaigns.
RDCC-E, RBCC-E and its partners will finalize and distribute individual calibration reports to participating institutions, provide remote support for implementation, and prepare a consolidated technical summary for WMO/GAW and UNEP. African teams will receive targeted follow-up—such as virtual clinics, SOP reviews, and data-submission checks—to ensure sustained improvements in data quality.

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