PART I

WMO/GAW International Comparison of Dobson Spectrophotometers

(Arosa, Switzerland, 19 - 31 July 1999)

1. PURPOSE OF THE INTERCOMPARISON

The Intercomparison (IC-99) was organized by WMO Secretariat in close cooperation with and financial assistance of the Swiss Meteorological Institute (SMI). It was a regular event in a campaign to maintain the network of the Dobson ozone spectrophotometers operated in RA VI (Europe), plus Egypt. The Dobson Intercomparison also served as an assurance of the quality of the total ozone data sets created at the GAW ozone stations operated by WMO Member countries. This action is an application of WMO/GAW/QC requirements for monitoring atmospheric total ozone.

The main tasks were:

- The technical inspection and adjustment of the instruments.
- Comparison of the Dobson spectrophotometers with the World Secondary Dobson Standard Instrument (WSSI) No. 65 from NOAA/CMDL, Boulder, CO, USA, to determine the existing calibration level.
- Determination of new calibration constants for each Dobson spectrophotometer, as needed.
- To provide a forum for instruction for operating the Dobson spectrophotometers at home stations, and sharing knowledge concerning the management of an ozone-observing programme.

2. ORGANIZATION

The Intercomparison was held at the Lichtklimatisches Observatorium (LKO) of the Swiss Meteorological Institute in Arosa during the period 19 to 31 July 1999. Its programme was arranged by the Scientific Director, Robert D. Evans (NOAA) and by Technical Director, Bruno Hoegger (SMI) in cooperation with an Executive Team comprising:

Ulf Koehler	DWD	MOHp	Scientific and technical assistance
Karel Vanicek	CHMI	SOO	Scientific and technical assistance
Martin Stanek	CHMI	SOO	Technical assistance

Matthias Lugauer	DWD	MOHp	Technical assistance
Bert Doemling	DWD	MOHp	Technical assistance

The following Swiss experts supported the infrastructure of the Intercomparison:

Kurt Aeschbacher	SMI-LKO
Herbert Schill	SMI-LKO
Reto Wetter	SMI-LKO
Franz Herzog	SMI/LKO

Twenty nine specialists from 13 countries and the WMO Secretariat participated at the Intercomparison – see Part I, Annex A. The following national Dobson spectrophotometers were inspected, adjusted and compared:

Dobson No.	Country	Station
D041	United Kingdom	Camborne
D048	Italy	Sestola
D049	France	Bordeaux
D056	Norway	Oslo
D062	Switzerland	LKO Arosa
D064	Germany	Hohenpeissenberg (Regional Reference Instr.)
D065	USA	Boulder - World Secondary Standard Instr. WSSI
D069	Egypt	Aswan
D074	Czech Republic	Hradec Kralove (Regional Reference Instr.)
D085	France	OHP, Haute Provence

D101	Switzerland	LKO Arosa
D107	Russia	CAO Moscow
D120	Spain	El Arenosillo
M-124 / filter Instr.	Russia	St. Petersburg - on request of WMO

The Intercomparison IC-99 was conducted and all activity arranged in daily schedules according to the weather conditions and with respect to the technical state of the individual instruments. The technical infrastructure of SMI and special facilities from NOAA, Boulder, CO, USA and from the Meteorological Observatory Hohenpeissenberg, DWD, Germany were utilized during IC-99.

The main steps specified below were applied to each Dobson spectrophotometer:

- Unpacking the instrument, an inspection and transport and installation on the roof of the LKO.
- Inspection of the technical condition of the Dobson spectrophotometer and its functioning by means of daily SL and Hg lamp tests.
- Initial comparison against the WSSI to determine the existing calibration level.
- Definition of the technical adjustments and special tests required (wedge calibrations, discharge lamp tests, cleaning and adjustment of the optics, etc.).
- Final comparison against the WSSI.
- Assessment of the results, determination of new calibration constants (Reference R-N tables, Q-table and Reference Standard Lamp Readings).
- Interview by the Scientific Director with the operator in charge on the results of his instrument intercomparison and other calibrations (meta data). At this point, copies of documentation related to the spectrophotometer calibration were given to the operators.
- Packing of the instrument and other technical facilities for transport to home station.
- Preparing the final report of IC-99.

All work done and the results obtained for individual instruments are summarized in Part I, Annex B. This information has been saved in detail by operators and by the Scientific Director of the IC.

The success of the IC was accomplished mainly through the instructions provided by the Scientific and Technical Directors at the regular daily meetings of all

participants. These instructions were determined at the daily meetings of the scientific and executive group.

With regard to the goal of sharing knowledge on the operation of the Dobson instruments and the management of an observing programme, the individual participants were required to perform the necessary calibration procedures under the supervision of the scientific staff. For example, almost all wedge calibrations were undertaken by the instrument's own operator.

3. OTHER ACTIVITIES

- At the request of WMO, a filter instrument for measurement of total ozone (M-124) from St. Petersburg took part in IC-99. The measurements. will be processed and a calibration constant will be developed by the specialists from the Voieykov Observatory, St. Petersburg, Russian Federation.

- The participants at IC-99 participated in the NDSC Dobson/Brewer Workshop held in Arosa 22 – 23 July 1999 and made several presentations relating to monitoring total ozone, and the functioning of the global ozone monitoring network.

- The updated version of the generalized software for processing Dobson total ozone observations, DOBSON 3.0, created by the CHMI at Hradec Kralove, was also presented. It was also made available to participants, upon request.

- Dr Mike Proffitt, scientific officer, WMO Secretariat, Geneva visited the IC-99 and discussed important issues related to the operation of the GAW total ozone monitoring programme and activities of the WMO/Dobson Ad-Hoc Committee.

- Special morning Umkehr observations on the zenith sky were made by all participating instruments on 26 July 1999 to create a reliable data set for verification of the technologies used for processing these observations in the WMO Global Atmosphere Watch Programme. Ozonesonde balloon flights were also made on this day from Payerne, Switzerland, and Hohenpeissenberg, Germany. Specialists from NASA interested in Umkehr ozone vertical profiles data were present during the observations at LKO.

- Mr David Melkonyan from Armenia, invited by WMO, was present at IC-99 during the period 24 - 31 July 1999 as a potential manager of a proposed Dobson observing programme in his country. He was provided with fundamental scientific literature on the operation of Dobson spectrophotometers and data processing, and took part in all activities of IC-99 thus acquiring basic knowledge on maintenance, operation and calibration of this instrument.

- Mr Archie Asbridge, scientific consultant, assisted in inspection and adjustments of the instruments at the Intercomparison. He also gave a talk on function and special technical tests of the Dobson spectrophotometers. His main task was to introduce a draft of his Dobson manual and to discuss it with

Dobson specialists and the WMO representative. Amendments, corrections and additional chapters were recommended and a special, adaptable and open form of publication by WMO was suggested.

4. CONCLUSIONS

All participating instruments left the intercomparison properly calibrated allowing a precision of the ADDS observations less than 1% limit with the WSSI spectrophotometer from the WSSI instrument.

A majority of the instruments that participated at IC-99 arrived with the calibration offset less than 1%. This situation with respect to the Dobson spectrophotometers operated in the WMO RA-VI Region is a result of previous regular intercomparisons organized by WMO. Nevertheless, continuous attention must be paid to the maintenance of the instruments at all stations.

The results of comparative measurements with the D065 WSSI spectrophotometer confirmed that instruments D064 and D074 fulfill all technical and calibration requirements of Reference Dobson Spectrophotometers of the RA-VI region. Annual calibrations are planned at MOHp in cooperation with SOO-HK and WMO beginning in the year 2000 according to schedules established by the head of the Regional Dobson Calibration Centre (RDCC). The regional standards were compared against the WSSI at both MOHp and LKO, with very similar results, demonstrating the usefulness of the MOHp site.

Because of good weather conditions and no significant technical problems with the Dobson instruments the IC-99 was completed on schedule.

5. FINDINGS AND RECOMMENDATIONS

- Long-term maintenance of the World Primary Standard Dobson Spectrophotometer (WPSS) D083 and the Secondary Standard D065 by NOAA, Boulder, CO, USA has established a well-defined calibration background for the Dobson spectrophotometers worldwide.

- Based on recommendations specified in the Report from the previous Dobson Intercomparison, Arosa 1995 (WMO GAW Report No. 108), a Regional Dobson Calibration Centre (RDCC) for RA-VI has been established to efficiently transfer the calibration scale into the network, and to assist the stations with operational problems. This RDCC will be maintained by the Meteorological Observatory of DWD at Hohenpeissenberg (Germany) in cooperation with the Solar and Ozone Observatory of CHMI at Hradec Kralove (Czech Republic). RDCC began its work in July 1999 with a joint calibration of the Dobson spectrophotometers D064 (MOHp) and D074 (SOO-HK) with the World Secondary Standard Instrument D065 (NOAA Boulder, CO, USA).

- Future intercomparisons of European Dobson spectrophotometers are expected to be held at MOHp using the instruments D064 and D074 maintained as the Regional Reference Dobson spectrophotometers. The specialists from MOHp and SOO-HK have created a suitable infrastructure

and have the necessary experience and scientific knowledge to carry out the responsibilities of a RDCC.

- The D064 and D074 instruments will represent new reference instruments that need to be defined by very precise calibration constants. Therefore, it was recommended that a simultaneous absolute calibration of both instruments with the WSSI D065 be conducted in the next 2 years. Both instruments should have all optical parameters, such as slit widths within the published specifications of Dobson instruments.

- The Dobson instruments still show a remarkable variety of electronic circuitry. Some of them are needlessly complicated, and have a problem with missing spare parts and documentation. The IC-99 recommended that WMO standardize the electronic circuits with a simple and effective design using easily available components. To ensure the use of this design, WMO should provide the resources for converting the various instruments to a standardized system.

- The use of personal computers and new communication technologies at the stations could provide a good basis for the development and implementation of unified software tools for processing measurements, data management and data exchange. This would require raising the qualification of the operators. It is expected that the RDCC can assist and in solving problems in individual regions by direct transfer of knowledge as well as by organizing relevant training as has been done at SOO-HK in recent years. WMO's assistance in this matter was considered essential, mainly under the umbrella of the GAW programme.

- To assess the results of the recent effort undertaken and to maintain the integrity of the global total ozone monitoring network through the RDCCs, it was recommended that a joint meeting of the members of the WMO/Dobson Ad-Hoc Committee be held during the Quadrennial Ozone Symposium in Sapporo, 2000. The Secretariat of WMO was urged to financially support the participation of members of the DAHC at the meeting, if at all possible.

- The Scientific Committee of the IC-99 acknowledged the excellent support and infrastructure provided to the intercomparison by SMI and by the Technical Committee headed by Mr Bruno Hoegger. It also urged WMO to continue organizing the four to five year schedule of RA VI Dobson Ozone Spectrophotometer Intercomparisons.

- An important part of an intercomparison with a large number of participants is the sharing of instrument operations and observing programme experiences. The Technical Committee and participants recommended that WMO organize biennial meetings of the data producers and data users.

- The Scientific Committee of IC-99 discussed the installation of Dobson spectrophotometer D044 in Armenia with Mr David Melkonyan and agreed on the following schedule of work to be completed by the end of 2000:

(a) Submission of the questionnaire and station description by Armenian Hydro-Meteorological Institute (Armhydromet) to Hohenpeissenberg DCC by the end of October 1999.

b. A visit to the proposed station by an expert and a WMO representative was recommended before the spring of 2000. The Scientific Committee suggested Arkadi Shalamijanski from the Voieykov Main Observatory, St. Petersburg for this purpose as he is familiar with the use of both Dobson instruments and the M-124 filter instruments used by Armhydromet in the past .
c. Recommendation to WMO and final decision on installation of D044 - before spring 2000.

PART I, ANNEX A

WMO/GAW International Comparison of Dobson Spectrophotometers

(Arosa, Switzerland, 19-31 July 1999)

List of Participants

Armenia

Mr David Melkonyan

Monitoring of Ozone and UV Radiation

Department of Heliographics

Armhydromet

62 Teryan Str. Apt. 24

Yerevan 375009

Phone: +3742-532001, 534472, 533575

Fax: +3742-151959, 533575

E-mail: david_melkonyan@hotmail.com

meteo@ mbox.amilink.net

Canada

Mr Isaac. A. Asbridge - scientific consultant

9 Lehar Crescent

Willowdale, Ontario, M2H 1J4

Phone: +001 416 494 2622

Fax: +001 416 496 9190

E-mail: archie@inforamp.net

Czech Republic

Mr Karel Vanicek

Mr Martin Stanek

Mr Jiri Pokorny

Solar and Ozone Observatory of CHMI,

Hvezdarna 456,

500 08 Hradec Kralove 8

Phone: +420-49-526 0352

Fax: +420-49-526 4127

E-mail: vanicek@chmi.cz

E-mail: stanek@chmi.cz

Egypt

Mr Ahmed Abdel Moneim Gahein

Egyptian Meteorological Authority

Regional Ozone Center

Kobry El Qubba

P.O. Box 11748

Cairo

Phone: +00202 2849 585

Fax: +00202 2849 857

E-mail: gahein@nwp.gov.eg

France

Mr Jerome de La Noe

Mr Francois Bosq

Universite Bordeaux 1

Observatoire de Bordeaux

BP 89

F -33270 Floirac

Phone: +33 5 57 77 61 56

Fax: +33 5 57 77 61 55

E-mail: delanoe@observ.u-bordeaux.fr

bosq@observ.u-bordeaux.fr

Mr Alain Barbe

Mr Didier Decatoire

Université de Reims

Faculté des Sciences

GSMA

BP 6089

F-51687 Reims cedex 2

Phone: +33 3 26 91 33 77

Fax: +33 3 26 91 31 47

E-mail: alain.barbe@univ-reims.fr

Didier.decatoire@univ-reims.fr

Germany

Mr Ulf Koehler

Mr Matthias Lugauer

Mr Bert Doemling

Deutscher Wetterdienst, DWD

Meteorologisches Observatorium Hohenpeissenberg

Albin-Schwaiger- Weg 10,

D-82383 Hohenpeissenberg

Phone: +49 8805 920021

Fax: +49 8805 920046

E-mail: ulf.koehler@dwd.de

mlugauer@mohp.dwd.d400.de

bert.doemling@dwd.de

Italy

Mr Tiziano Colombo

Aeronautica Militare

Centro A.M. di Montagna

Monte Cimone,

I-41029 Sestola

Phone: +39 0536 62446

Fax: +39 0536 62446

E-mail: tiziano@msw.it

cnv@ecmwf.int

Norway

Mr Sverre Norman Thon

Fysisk institutt

Universitetet i Oslo

Address of contact:

Dr F. Tonnessen

P.O. Box 1048 Blindern

N-0316 Oslo

Phone: +47 22 85 56 73

Fax: +47 22 85 56 71

E-mail: finn.tonnessen@fys.uio.no

snthon@online.no

Russian Federation

Mr Valery Dorokhov

Central Aerological Observatory, CAO

3, Pervomayskaya st.

Dolgoprudny

Moscow Region 141700

Phone: +7 095 408 6150

Fax: +7 095 576 3327

E-mail: vdor@ozone.mipt.ru

Spain

Mr Jose Manuel Vilaplana

Mr Federico Soubrier

Instituto National de Tecnica Aeroespacial (INTA)

El Arenosillo

Mazagon

E-21130 Huelva

Phone: +34 959 20 88 58

Fax: +34 959 20 88 57

E-mail: vilaplanagjm@inta.es

morenacb@inta.es

Switzerland

Dr Bruno Hoegger

Swiss Meteorological Institute

Aerological Station Payerne:

Phone: ++41 (0) 26 662 62 11

Fax: ++41 (0) 26 662 62 12

E-mail: hoe@sma.ch

Mr Kurt Aeschbacher

Mrs Maud Neininger, LKO

Mr Armin Urech, LKO

Mr Herbert Schill, GeoSol - scientific consultant

Mr Franz Herzog, SLF - technical staff

Mr Reto Wetter, SLF - technical staff

SMI, LKO Arosa

Phone.: +41 81 377 2616

Fax: +41 81 377 1901

E-mail: kar@sma.ch

United Kingdom

Mr David Moore

Rm X2, (OLA) 36

The UK Meteorological Office

Beaufort Park

Easthampstead

Wokingham, Berks, RG40 3DN

Phone: +44 1344 855 804

Fax: +44 1344 855 005

E-mail: dmoore@meto.gov.uk

USA

Mr Robert Evans

Mrs. Dorothy Quincy (CIRES)

NOAA/CMDL Laboratories

325 Broadway

Boulder CO.80303

Phone: +1 303 497 6679

Fax: +1 303 497 5590

E- mail: bevans@cmdl.noaa.gov

World Meteorological Organization

Dr Mike Proffitt

WMO Secretariat

GAW/Environment Division

7 bis, Avenue de la Paix

Case Postale 2300

CH-1211 Geneva 2, Switzerland

Phone: +41 22 730 82 35

FAX: +41 22 740 80 49

E-mail: proffitt@wmo.ch

WMO/GAW International Comparison of Dobson Spectrophotometers

(Arosa, Switzerland, 19-31 July 1999)

Individual Instrument Reports

INSTRUMENT D041

UK (Camborne)

Original Calibration Data:

N-tables from 30 July 1995, Arosa LKO intercomparison.

Reference Standard Lamp values for lamps 41Q3, 41Q4 and 41Q5

Lamp tests used regularly for data processing at home station.

Initial Calibration Results

Adjustments based with the results of Standard Lamp tests included.

27 July 1999

d_Na: -0.6 d_Nc:-0.2 d_Nd:-0.2 d_Nad:-0.4

The d_Nad value implies an average **+0.6% error** in calculated ozone value, Mu=1 to 3, Total Ozone = 300 Dobson Units.

Work Performed:

- Wedge Slides cleaned to remove black coating that was making the R-dial difficult to move.
- The shutter rods were cleaned to remove stiffness in operation.

- New drive belt was installed. This required the removal and replacement of the shutter motor assembly.
- Optical and general cleaning, apart from mirrors.
- Wedge calibration on A wave length to verify that the instrument was reassembled correctly.
- The light mask in front of wedge on right hand side was physically restrained by adding a screw to prevent the mask from being bent down into the light path.

Final intercomparison: Not applied, as the instrument is within calibration limits to D065

Highest Difference against the standard for ADDSGQP observations in Mu range 1.15 to 3.2 was 0.7% in total ozone.

The instrument was compared to D065 on the 21 July 1999, and repeated the results within 0.5% based on Nad differences. The average of the two intercomparisons still showed the instrument was within 1.0% of the Standard.

Comments

Whilst there were no obvious problems evident in the intercomparison between the instrument and the standard, these features of the instrument are noted for the record only.

- Left hand side mirror has fine vertical scratches.
- Symmetry test fails on S3Q2 vs. S3Q1 – this is repeatable, and has been evident for a number of years.

Recommendation: The apparent shift in R-dial position with change in the gain setting (EHT or High voltage) should be investigated further at the home station.

INSTRUMENT D048

Italy (Sestola)

Original Calibration Data:

N-tables from 25 July 1995, Arosa LKO intercomparison.

Reference Standard Lamp Values for lamps 48/1,48/3,48/5 and 48/6

Lamp tests results used in data processing at home station.

Initial Calibration Results

Adjustments based on the results of Standard Lamp tests included

25 July 1999

d_Na:-0.7 d_Nc:-0.4 d_Nd:-1.1 d_Na:+0.4

The d_Nad value implies an average **- 0.6% error** in calculated ozone value, Mu=1 to 3, Total Ozone = 300 Dobson Units.

Work Performed.

- Optical Symmetry checked: A small deviation from the expected values was found with respect to S2Q1 versus S2Q2. No change was made in the instrument, as the intercomparison results shown no problem.
- Standard Lamp Power Supply cable was repaired.
- Reference standard lamps UQ1 and UQ7 values were defined for this instrument.

Final intercomparison: Not applied, as the instrument is within calibration limits to D065

Highest Difference against the standard for ADDSGQP observations in Mu range 1.15 to 3.2 was –1.0% in total ozone, at low Mu.

The instrument was compared to D065 on three separate days, and repeated the results within 1.0%. The 25 July 1999 intercomparison was chosen, as it was the clearest conditions of three days.

The existing calibration will remain as is, but dated to the 25 July 1999 to document the intercomparison here.

INSTRUMENT D049

France (Bordeaux)

Original Calibration Data:

N-tables from 30 July 1995, Arosa LKO intercomparison

Reference Standard Lamp Values for lamps 49/2H1, 49/3H1 and 49/4H1

Lamp test results are not used for data processing at home station

Initial Calibration Results:

25 July 1999

d_Na: -1.2 d_Nc:-1.0 d_Nd:-1.0 d_Nad:-0.2

The d_Nad value implies an average **+0.3% error** in calculated ozone value, Mu=1 to 3, Total Ozone = 300 Dobson Units.

Work Performed.

- Discharge lamp test was performed – the results matched the existing Q-table
- Optical Symmetry checked and found to be in limits.
- Interior and Optics were inspected and found to be very clean.

Final intercomparison: Not applied, as the instrument is within calibration limits to D065

Highest Difference against the standard for ADDSGQP observations in Mu range 1.15 to 3.2 was +0.6% in total ozone, at low Mu.

The instrument was compared to D065 on three separate days, and repeated the results within 0.5% based on the differences in the Nad values. The 25 July 1999 intercomparison was chosen, as it was the clearest conditions of three days.

The instrument has an encoder mounted on the wedge to record the wedge position electronically. For a wedge calibration to be performed, this encoder will have to be removed. This procedure was beyond the facilities and time of this intercomparison. The operators are encouraged to have the wedge calibration checked at the Region VI DCC in Hohenpeissenberg, Germany within the next several years

INSTRUMENT D056

Norway (Oslo)

Original Calibration Data:

N-tables from 22 June 1994 Izana intercomparison

Reference Standard Lamp Values for lamps 56Q2, 56Q3, UQ1

SL tests are not used for data processing at home station.

Initial Calibration Results from 25 July 1999

d_Na: +0.62 d_Nc:-0.11 d_Nd:+0.07 d_Nad:+0.56

The d_Nad value implies an average **- 0.9% error** in calculated ozone value, Mu=1 to 3, Total Ozone = 300 Dobson Units.

Work Performed.

- Wedge Calibration performed on 20. July 1999 - New G-table created
- Home Q-setting table dated 06 December 1994 corrected for Arosa on 19 July 99 was used for IC-99
- Inspection of the Cobalt filter done on 25 July 1999 – no cleaning necessary
- Optical Symmetry was checked on 24 July 1999 – S3Q2 found out of limits

Final intercomparison: 25 July 1999.

New N-tables and Reference Standard Lamp values defined for 56Q2, 56Q3, UQ1

Highest Difference against the standard for ADDSGQP observations in Mu range 1.15 to 3.2 was +0.12% in total ozone.

Recommendations.

Though the results of intercomparisons were very good for the AD pair, a significant offset for CD pair and Mu values 2.5-5.0 is permanently persisting. This could not been improved even by the wedge calibration and development of new G-Tables

To perform CD observations at the home station located at 60 deg. N accurate as Much as possible, it is recommended to make systematic CDA sequence of observations for the Mu range from 2.5 and higher and investigate relation between AD and CD total ozone values. Based on these analyses a correction factor can be derived for correction of CD observations either for DS, FDS and Zenith measurements.

It is emphasized that Q-setting table Must be corrected when the results of regular Hg tests systematically come over the limit **0.3**.

The UV Cobalt filter was checked on 25 July 99 and found deteriorated in certain places. But the deterioration was not so significant to do any polishing.

INSTRUMENT D062

Switzerland (LKO Arosa)

Original Calibration Data:

N-tables from based on the 1995 LKO Arosa intercomparisons and the 1992 N-table. The ”extra-terrestrial constant” in the tables were chosen by station personnel to attempt to make the instrument’s ozone values be consistent with other total ozone measuring instruments, and remain at the 1.0% level to the Dobson calibration scale.

Reference Standard Lamp Values for lamps 62v and 62W

Lamp tests results used in data processing at home station.

Initial Calibration Results (Adjustments to the N-values were first made as normal at this station.)

21 July 1999

d_Na: -0.44 d_Nc:+0.31 d_Nd:+0.16 d_Nad:-0.6

The d_Nad value implies an average **0.9% error** in calculated ozone value, Mu=1 to 3, Total Ozone = 300 Dobson Units.

Work Performed.

- Wedge Calibration performed, but only for the record.
- Discharge lamp series was performed, results were not applied – existing table not changed.
- Symmetry test was performed, and fails – there is no indication of a problem in the intercomparison results.

No recommendations, as instrument is within one percent of the standard. Note that a recalculation of the 21 July 1999 intercomparison using the full results of the 1995 intercomparison with D065, gives a closer match between the instruments (D_Nad difference of approximately –0.3 or 0.4%)

Highest Difference against the standard for ADDSGQP observations in Mu range 1.15 to 3.2 was 1.0% in total ozone, at low Mu.

The station personnel responsible for the data analyses will have to evaluate these results, and decide what course of action to take, with respect to the calibration level.

INSTRUMENT D064

Germany (Hohenpeissenberg)

Regional reference instrument (Europe)

Original Calibration Data:

N-tables from 22 July 1997. Kalábryta intercomparison

Reference Standard Lamp Values for lamps 64-Q-I and 64-Q-II

Lamp tests results used in data processing at home station.

Initial Calibration Results:

(Adjustments based on the results of Standard Lamp tests included)

17 July 1999

d_Na:0.0 d_Nc:0.0 d_Nd:+0.3 d_Nad:-0.3

The d_Nad value implies an average **+0.4% error** in calculated ozone value, Mu=1 to 3, Total Ozone = 300 Dobson Units.

Work Performed.

- Wedge Calibration performed on 15 July 1999, but results not applied.
- Discharge lamp series was performed and new Q-tables produced. The new table is not significantly different from the older table.

Final intercomparison: 17July 1999.

New N-tables and Reference Standard Lamp values defined for 64Q1, 64Q2, UQ1 and UQ7.

Highest Difference against the standard for ADDSGQP observations in Mu range 1.15 to 3.2 was –0.5% in total ozone.

Recommendations and comments.

- The intercomparison held on 17 July 99 at LKO Arosa is in a very good agreement with the previous intercomparison at MOHp on 05. July 1999

- To keep the best fit with the reference D065 and D074 both for AD and CD observations and Mu= 1.15-3.2, it was decided to develop new reference N-Tables and SL Readings based on SL tests and IC from 17 July 99. The same decision was made also for D074.
- The instrument will be maintained as a Regional Reference Spectrophotometer for RA-VI, Therefore it is recommended to perform more frequent tests of its optical alignment and absolute calibration.

INSTRUMENT D069

Egypt (Aswan)

Original Calibration Data:

N-tables from 25 May 1993, Hradec Kralove Intercomparison

Reference Standard Lamp Values for lamps 69-Q-I and 69-Q-II

Lamp tests results used in data processing at home station.

Initial Calibration Results

Adjustments based on the results of Standard Lamp tests included.

25 July 1999

d_Na: -1.01 d_Nc: +0.39d_Nd: +0.69 d_Nad:-1.70

The d_Nad value implies an average **+2.5% error** in calculated ozone value, Mu=1 to 3, Total Ozone = 300 Dobson Units.

Work Performed.

- Wedge calibration performed.
- Optical cleaning
- Discharge lamp test performed and a new Q-setting table extended up to 50 C created, dated 23 July 1999.
- Symmetry test performed on 24 July 1999 – S2Q2 and S3Q2 were found out of limits
- Adjustment of position of M2
- New test of symmetry performed on 27. July 1999 – in good limits
- Q-levers removed and cleaned because of their difficult movement. New gaskets mounted and the Q-levers assembled.

Final intercomparison:

25 July 1999

New N-tables and Reference Standard Lamp values dated 25. July 1999 defined for the lamps 69-Q-I, 69-Q-II and UQ7 lamps

Highest Difference against the standard for ADDSGQP observations in Mu range 1.15 to 3.2 was -0.25% in total ozone.

Recommendations:

- Different corrections of the original 1993 N-Tables based on SL tests were found at LKO for A, C, D pairs comparing the results at the station. The operator has been instructed how to investigate the history of SL tests and correction of N-Tables to correct the ozone data sets at Aswan.
- The Q-levers mechanisms are worn, so that metal rubs on metal as the Q-levers are moved. The material of which the Q-lever mechanisms are made has a tendency for ”galling” – metal transfer that causes fusing together of the moving pieces. The Q-lever mechanisms were lubricated with Apezeon grease. If the problem of galling appears again, the mechanisms should be repaired by a facility capable of installing new bearing surface.
- To avoid overheating the instrument during the summer season an installation of a shading cover is recommended

INSTRUMENT D074

Czech Republic (Hradec Kralove)

Regional reference instrument (Europe)

Original Calibration Data:

N-tables from 22 July 1997, Kalábryta Intercomparison

Reference Standard Lamp Values for lamp Qj-74-I, Qj-74-II dated 22.July 97

Lamp tests results used in data processing at home station.

Initial Calibration Results:

17 July 1999

d_Na:+0.27 d_Nc:+0.42 d_Nd:+0.05 d_Nad:+0.22

The d_Nad value implies an average **- 0.3% error** in calculated ozone value, Mu=1 to 3, Total Ozone = 300 Dobson Units.

Work Performed.

- Wedge calibration performed on 14. July 99, New G tables not created.

Final intercomparison: 17 July 1999.

New N-tables and Reference Standard Lamp values defined for QJ/74-1, QJ/74-2, UQ7.

Highest Difference against the standard for ADDSGQP observations in Mu range 1.15 to 3.2 was -0.03% in total ozone.

Recommendations and comments.

- The intercomparison held on 17 July 99 at LKO Arosa is in a very good agreement with the previous intercomparison at MOHp on 05. July 1999
- To keep the best fit with the reference D065 and D064 both for AD and CD observations and Mu= 1.15-3.2, it was decided to develop new reference N-Tables and SL Readings based on SL tests and IC from 17 July 99. The same decision was made also for D064.
- The instrument will be maintained as a Regional Reference Spectrophotometer for RA-VI, Therefore it is recommended to perform more frequent tests of its optical alignment and absolute calibration.
- The instrument is fitted with an encoder/counter linked with a PC for automated reading and real-time data processing

INSTRUMENT D085

France (OHP)

Original Calibration Data:

N-tables from 10 July 1990, intercomparison with D065 at OHP.

Reference Standard Lamp Values for lamps 85Q1, 85Q3, 85Q4, UQ1, UQ2, and UQ8

Lamp tests results used in data processing at home station.

Initial Calibration Results (Adjustments based on the results of Standard Lamp tests included.)

25 July 1999

d_Na:-1.6 d_Nc:-0.7 d_Nd:-.5 d_Nad:-1.1

The d_Nad value implies an average **+1.5% error** in calculated ozone value, Mu=1 to 3, Total Ozone = 300 Dobson Units.

Work Performed.

- Discharge lamp test series performed – the result table was not used, as it appeared that the lamp series was performed with the instrument not temperature stable.
- Wedge calibration was performed (28 July 1999), but not applied. This instrument is used for automated Umkehr measurements, and the G-function should not be changed without a proper reason. The process of reducing an Umkehr measurement to a ozone profile is more sensitive to the wedge calibration than to the calibration for total ozone
- Interior and optics were inspected, and no problems were noted. Optics cleaned of dust.
- The symmetry test was performed and the S3Q1 values were out of specification. There was no evidence of a problem in the intercomparison results.

Final intercomparison: 25 July 1999.

New N-tables and Reference Standard Lamp values defined for 85Q1, 85Q3, 85Q4, UQ1, and UQ7.

Highest Difference against the standard for ADDSGQP observations in Mu range 1.15 to 3.2 was 0.6% in total ozone.

Recommendations.

- The existing data set will be reprocessed to account for the calibration drift of 1.5% in nine years. The drift was documented in the results of the 1995 Arosa LKO intercomparison, but was not at the 1% level at that time.
- The symmetry test should be performed at the home station after the instruments is re-installed, and is temperature stable.

INSTRUMENT D101

Switzerland (LKO)

Original Calibration Data:

N-tables from based on the 1995 LKO Arosa intercomparisons and the 1995 G-table from the same intercomparison meeting. The ”extra-terrestrial constant” in the tables were chosen by station personnel to

attempt to make the instrument's ozone values be consistent with other total ozone measuring instruments, and remain at the 1.0% level to the Dobson calibration scale.

Reference Standard Lamp Values for lamps 101A and 101B

Lamp tests results used in data processing at home station.

Initial Calibration Results (Adjustments to the N-values were first made as normal at this station.)

25 July 1999

d_Na:-2.08 d_Nc:-1.12 d_Nd:-1.19 d_Nad:-0.89

The d_Nad value implies an average **+1.3% error** in calculated ozone value, Mu=1 to 3, Total Ozone = 300 Dobson Units.

Work Performed.

- Wedge Calibration performed, but only for the record.
- Discharge lamp series was performed, results were not applied – existing table not changed.
- Symmetry test was performed, and fails – there is no indication of a problem in the intercomparison results.

The instrument is <u>not</u> within one percent of the standard. Note that an analyze of the 25 July 1999 intercomparison using the full results of the 1995 intercomparison with D065, gives a closer match between the instruments (d_Nad difference of approximately 0.0 or 0.0%). The instrument was also intercompared to D065 on 27 July 1999, with very similar results.

Highest Difference against the standard for ADDSGQP observations in Mu range 1.15 to 3.2 was 1.8% in total ozone, at low Mu.

The station personnel responsible for the data analyses will have to evaluate these results, and decide what course of action to take, with respect to the calibration level.

INSTRUMENT D107

Russia (CAO Moscow)

Original Calibration Data:

N-tables from 30 July 1995, Arosa LKO intercomparison

Reference Standard Lamp Values for lamps 107-Q-1, 107-Q-2 and 107-Q-4

Lamp tests results used in data processing at home station.

Initial Calibration Results (Adjustments based on the results of Standard Lamp tests included.)

25 July 1999

d_Na:-0.7 d_Nc:-1.0 d_Nd:-0.9 d_Nad:+0.2

The d_Nad value implies an average **- 0.3% error** in calculated ozone value, Mu=1 to 3, Total Ozone = 300 Dobson Units.

Work Performed.

- Wedge Calibration performed – but not used as existing N-table produced very good results with comparison with the standard instrument.
- Discharge lamp test series performed, which verified existing Q-setting table.
- Instrument was cleaned, both optically and in general – producing a pronounced shift in standard lamp readings.

Final intercomparison: Not applied, as the instrument is within calibration limits to D065

Highest Difference against the standard for ADDSGQP observations in Mu range 1.15 to 3.2 was –0.3% in total ozone.

The instrument was compared to D065 on three separate days, and repeated the results within 1.0%. The 25 July 1999 intercomparison was chosen, as it was the clearest conditions of three days.

The existing calibration will remain as is, but dated the 25 July 1999 to document the intercomparison here.

Comments

- Sun Director needs repair. The instrument is also missing the adjusting screws for the leveling of the sun director to the optics of the instrument.
- The R-dial post is dented, and perhaps slightly bent.

INSTRUMENT D120

Spain (El Arenosillo)

Original Calibration Data:

N-tables from 22 June 1994, Izana intercomparison with D065

Reference Standard Lamp Values for lamps 120Q2, 120Q4, 120Q5, UQ1, R51 and R52

Lamp tests results used in data processing at home station.

Initial Calibration Results (Adjustments based on the results of Standard Lamp tests included.)

21. July 1999

d_Na: -1.89 d_Nc:-1.22 d_Nd:-0.78 d_Nad:-1.11

The d_Nad value implies an average **+1.6% error** in calculated ozone value, Mu=1 to 3, Total Ozone = 300 Dobson Units. Application of new G-tables from wedge calibration improves results significantly.

Work Performed:

- Optics checked, and gaskets replaced, inlet window and ground quartz plate cleaned.
- Wedge calibration performed, new G-tables created and used for determination of new N-tables.
- Discharge lamp test series performed, new Q-table not used due to discrepancies with Hg-test after creation.
- Symmetry test was performed, one result (S2Q1 and S3Q1) out of limits. This was not evident in the intercomparison results.

Final intercomparison: 25 July 1999, new R-N-tables used, new calibration level established.

Highest Difference against the standard for ADDSGQP observations in Mu range 1.15 to 3.2 was +0.9% in total ozone, at low Mu.

Recommendations/Comments:

- New calibration defined with new R-G-tables.

- Initial calibration with original R-N-tables showed doubtful results, new R-G-tables from wedge calibration improve results significantly, application on the data record backwards has to be decided after reprocessing Izana-IC 1994 with new R-G-tables.
- Correction of original Q-tables from results of the Hg-Test immediately after return to station.
- Performance of regular Symmetry test each 3 months.