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WMO/GAW inter-comparison of Dobson Ozone Spectrophotometer in Tsukuba, Japan-2006 and inter-comparison of National standard 112 with Delhi Dobson 36

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सार – वायु विज्ञान वेधशाला, सुकुबा, जापान में 6 मार्च से 24 मार्च 2006 तक डॉबसन ओजोन स्पेक्ट्रों फोटो मीटर परस्पर तुलना करने के लिए एक डब्ल्यू.एम.ओ./जी.ए.डब्ल्यू. अभियान चलाया गया। इस परस्पर तुलनात्मक अभियान के दौरान भारतीय मानक डॉबसन ओज़ोन स्पेक्ट्रोफोटोमीटर संख्या 112 की तुलना क्षेत्रीय मानक डॉबसन ओजोन स्पेक्ट्रोफोटोमीटर संख्या 116 के साथ की गई। इन तुलनाओं से इस बात की पुष्टि हुई है कि भारतीय डॉबसन ओजोन स्पेक्ट्रोफोटोमीटर संख्या 112 अंशाकन की सही स्थिति में था और उपकरण से प्राप्त आँकड़ें सही थे। 36 के साथ 112 से प्रापत परिणाम भी एक दूसरे से सही मेल खा रहे हैं।

ABSTRACT. The WMO/GAW campaign for inter-comparison of Dobson Ozone Spectrophotometer was held from 6 to 24 March 2006 at the Aerological Observatory, Tsukuba, Japan. During the inter-comparison campaign, the Indian standard Dobson Ozone Spectrophotometer no.112 was compared with the regional standard Dobson Ozone Spectrophotometer no.116. The comparisons confirmed that the Indian standard Dobson Ozone Spectrophotometer no.112 was in good state of calibration and the data derived from the instrument was reliable. The results of 112 with 36 are also in good agreement with each other.

Key words – Ozone, Dobson Spectrophotometer, Standard instrument, Inter-comparison.

1. Introduction

Dobson ozone spectrophotometer serves as a standard for measurement of atmospheric total column ozone. International Dobson instrument comparisons in the past have revealed large calibration errors for many of the instruments (Dziewulska-Losiowa and Walshaw 1975: Gushchin (1972). However, the accuracy of the ozone measurements within the global Dobson station network improved markedly following an international Dobson spectrophotometer inter-comparison campaign (Komhyr *et al.*, 1981) held in Boulder 1977. At that time, eight spectrophotometers, designated by the World Meteorological Organization (WMO) as regional secondary standards, were calibrated relative to instrument no. 83 (World Primary Standard Dobson Instrument) with the intent that they may be used to calibrate field instruments within their respective regions. Dobson Spectrophotometer no.112 maintained by National Ozone Centre, India Meteorological Department, New Delhi had participated in the earlier international inter-comparison campaigns of Dobson Spectrophotometer held at Boulder in 1977, Melbourne (Australia) in 1984 and Tsukuba (Japan) in 1996 (Peshin *et al*., 1998). The Dobson instrument no. 112 was procured in 1969 and since then it is working.

The inter-comparison campaign of Dobson Ozone Spectrophotometer was held from 6 to 24 March 2006 at the Aerological Observatory, Tsukuba, Japan. During the inter-comparison campaign, the Indian standard Dobson Ozone Spectrophotometer no.112 was compared with the regional standard Dobson Ozone Spectrophotometer no.116. The results of Delhi Dobson Ozone Spectrophotometer no.36 has been compared with the national standard Dobson Ozone Spectrophotometer no.112 for the period 2010-2011.

1.1. *Operation*

The inter-comparison campaign (2006) of the Dobson spectrophotometer at Tsukuba, Japan was held on the roof platform of the Aerological Observatory at the Tsukuba. Technical works on instrument and processing of tests and observations were performed in the laboratory facility in the same building that was equipped with high tech infrastructure and the computer network.

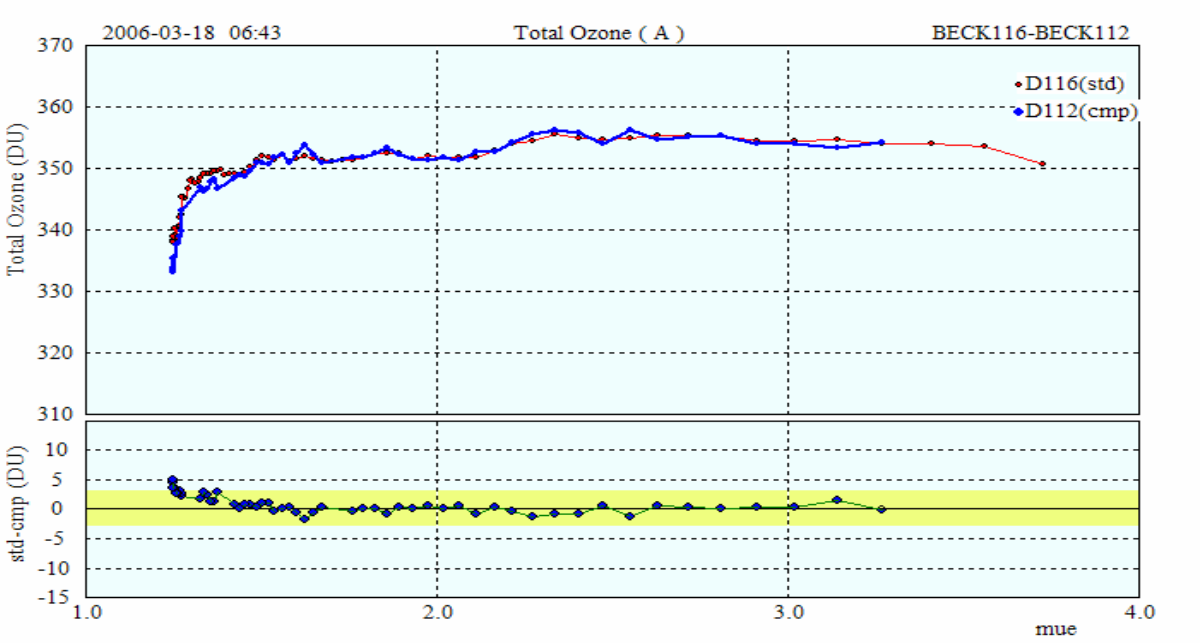

Fig. 1. Comparison of Dobson Ozone Spectrophotometer no. 112 with Dobson Ozone Spectrophotometer no. 116 showing the average difference for "A" wavelength

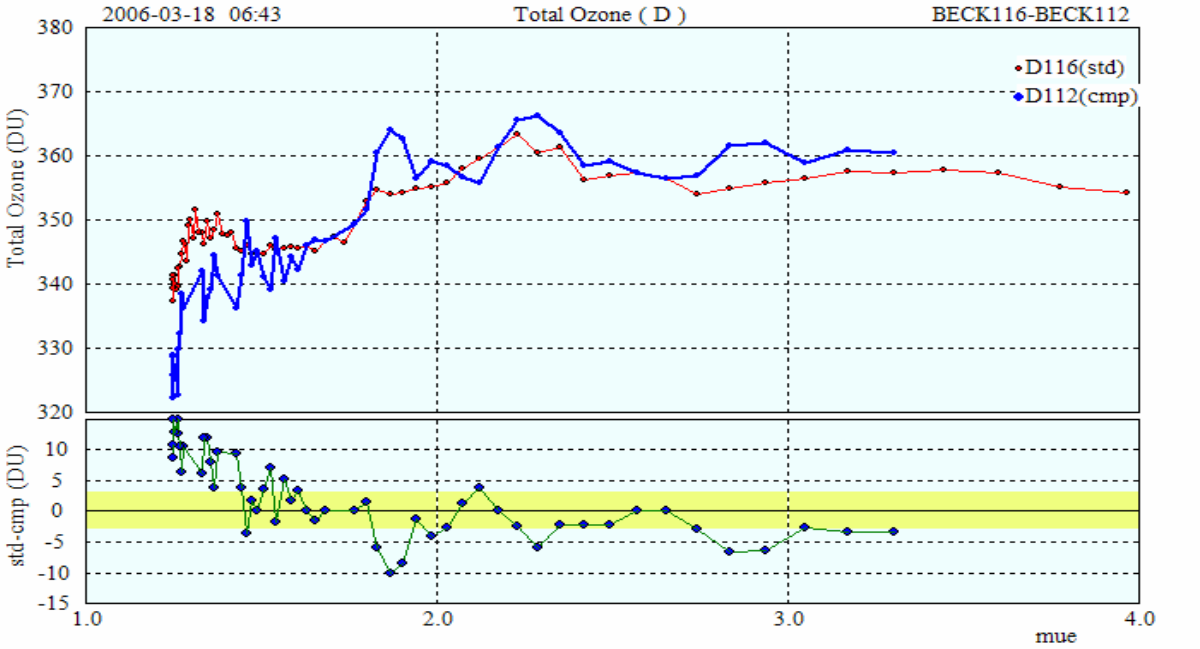

Fig. 2. Comparison of Dobson Ozone Spectrophotometer no. 112 with Dobson Ozone Spectrophotometer no. 116 showing the average difference for "D" wavelength

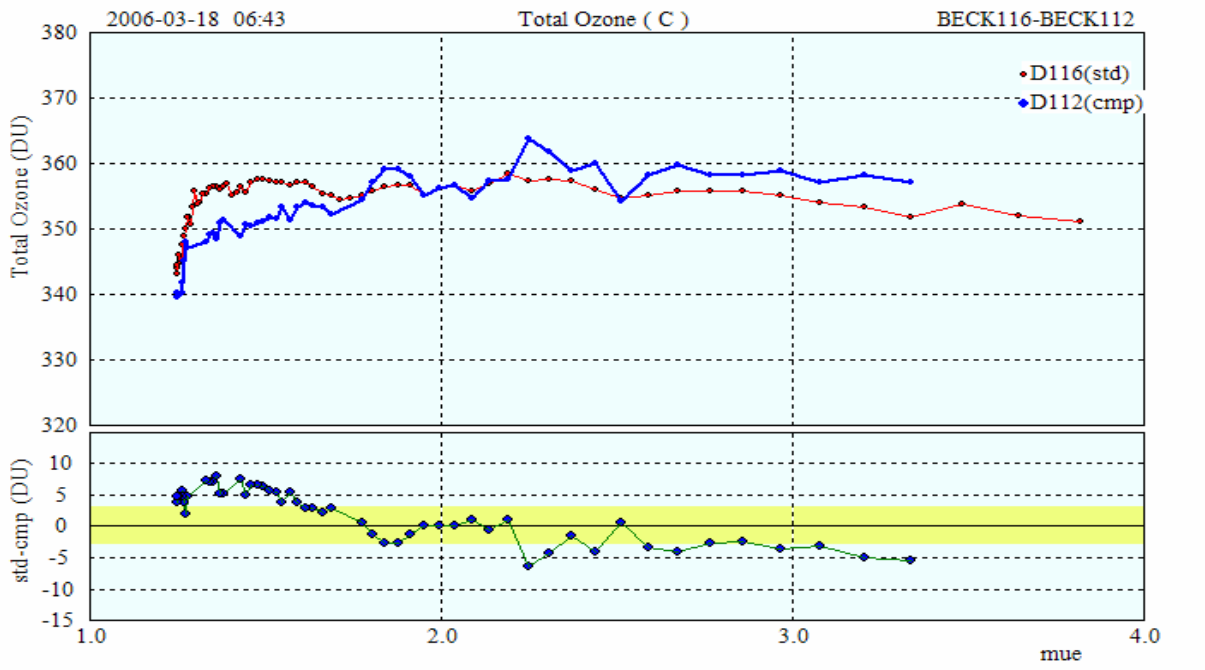

Fig. 3. Comparison of Dobson Ozone Spectrophotometer no. 112 with Dobson Ozone Spectrophotometer no. 116 showing the average difference for "C" wavelength

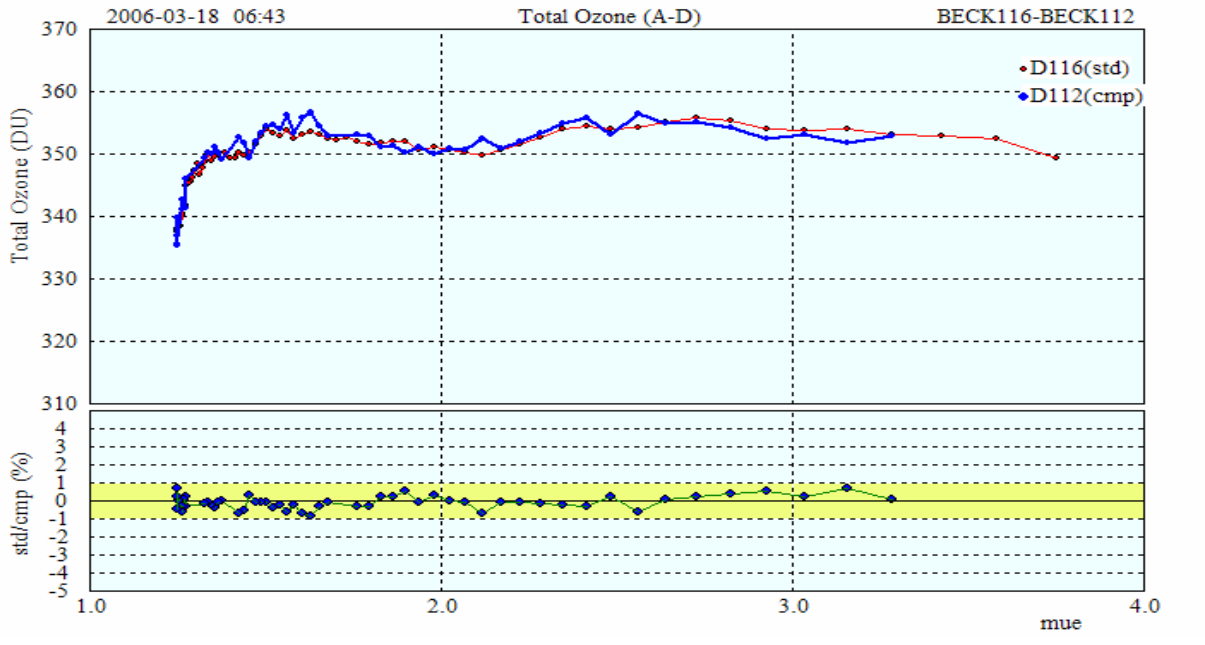

Fig. 4. Comparison of Dobson Ozone Spectrophotometer no. 112 with Dobson Ozone Spectrophotometer no. 116 showing the average difference for "A-D" wavelength

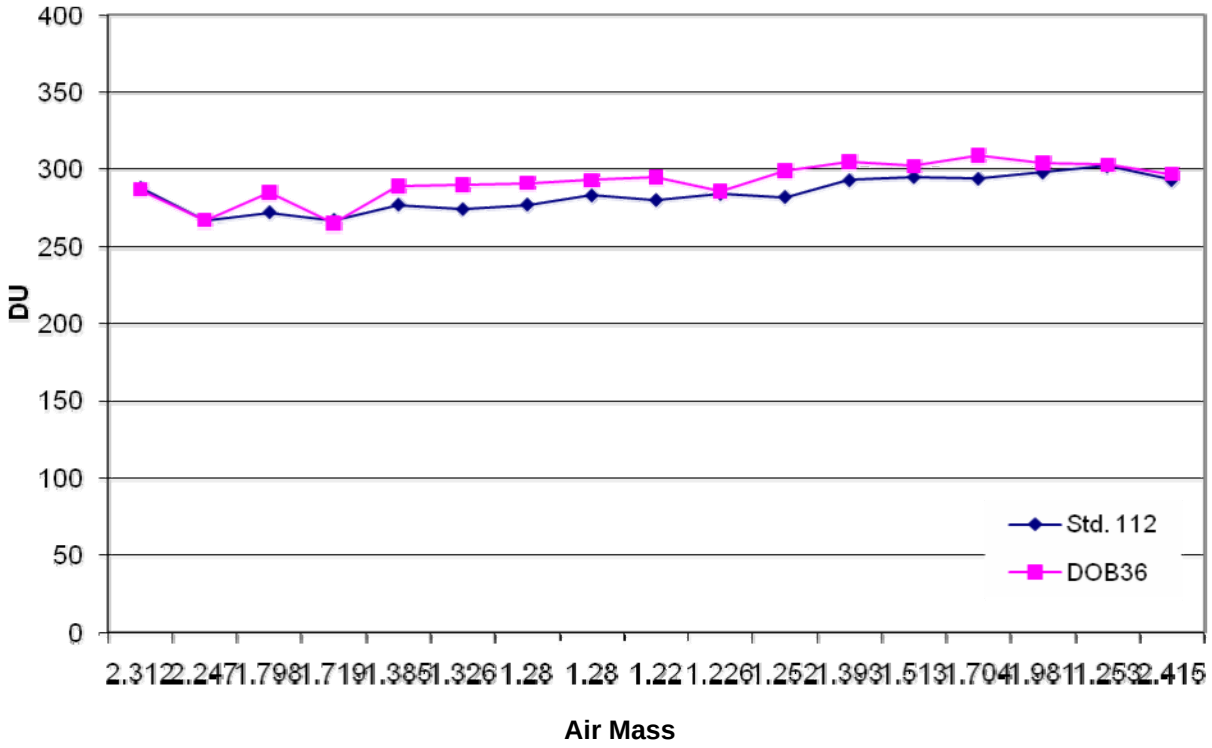

Fig. 5. Comparison of Dobson Ozone Spectrophotometer no. 112 with Dobson Ozone Spectrophotometer no. 36

The inter-comparison (IC) was performed and all works were done in daily schedules according to the weather conditions and with respect to the technical state of the individual instruments. The technical facilities of the Aerological Observatory of Japan Meteorological Agency, Tsukuba were used to conduct the inter-comparison.

1.2. *Instrument and calibration*

The Dobson instrument and the method of operation are well documented (Dobson and Normand 1957; Komhyre *et al*., 1989). Briefly, the instrument measures the intensity ratios of selected wavelength pairs in the ultraviolet band by attenuating the more intense wavelength to match the intensity of the other. If the atmospheric ozone absorption coefficients for these wavelengths are known, the total ozone amount can be calculated from the difference found in measurements on direct sun-light or light from the zenith sky. The calibration of the instrument consists of :

(a) The wavelength calibration of the instrument : The instrument should be optically aligned using the published parameters (Dobson and Normand, 1957) so that it is operating on the correct wavelengths and the correct bandpass.

(b) The optical attenuator (Wedge) calibration : This relates the attenuator position to the difference in intensity. The "two lamp" method performed by an expert is recommended.

(c) The extra terrestrial calibration (ETC) : The determination of ETC can be done either by the Langley plot method, *i.e*., making measurements on the rising or setting sun and then extrapolating the results to outside the atmosphere. The Langley plot method assumes that the total ozone amount in the atmosphere does not change during time of the calibration.

The following methods are recommended for calibration of Dobson Ozone Spectrophotometer :

(*i*) By direct comparison to a standard. The direct comparison method is recommended. This calibration is thus traceable to a primary standard, which improves the station-to-station consistency. The instrument performance with respect to the Sun's zenith angle is then also evaluated with respect to the standards.

(*ii*) Or by the use of "standard "lamps.

2. Calibration monitoring

Once the calibration has been done, the standard operating procedure is to verify the calibration on a regular schedule. The wavelength calibration can be verified with a simple mercury discharge lamp and changes in the instrument's ETC can be tracked with a simple quartz halogen lamp (a "standard" lamp).

Changes in the "wedge" calibration can be best tracked with repeated two lamp calibrations. The schedule depends on the age and history of the instrument but every four years is the most common schedule. Now or recently rebuilt instruments should have the calibration checked more often. The instrument should be compared to a standard instrument on a regular basis, normally four years. The comparison is also a time to review observation techniques and data handling procedures. If there are changes in the calibration, these must be accounted for in the existing data.

3. Results

The results of Dobson Spectrophotometer no.112 are enlisted below:

(*i*) Initial calibration results shows that the d-Nad value implies an average + 0.2 % error in calculated ozone value, mu = 1 to 3, Total ozone = 300 D.U.

(*ii*) Final inter-comparison shows average difference against the standard for ADDSGQP observations in mu range 1.15 to 3.2 was 0.1% in total ozone.

(*iii*) Figs. 1, 2, 3 and 4 shows the comparison of average difference for "A" , "C", "D" and "A-D" wavelengths.

(*iv*) Fig. 5 shows intercomparison of National Standard Dobson 112 with Delhi Dobson 36. The comparison results shows 2-3 % deviation from the standard Dobson which is within limit of ±3% value.

4. History of Dobson-36

The Dobson Spectrophotometer No.36 was purchased in 1955 and installed in National Ozone Centre, New Delhi. Total ozone measurements and processing of data was performed according to instructions and manuals prepared by Prof. G. M. B. Dobson (Dobson 1957a, Dobson and Normand 1957b & 1962) with calibration constants of Dobson 36 provided by the manufacturer R & J Beck, Ltd., London. Total Ozone is measured with Dobson 36 everyday if the weather conditions are suitable for observations (no rain or no cloud).

5. Conclusion

The inter-comparison data confirms that the existing ozone data derived from the instrument no.112 is accurate. This instrument is used to calibrate other Dobson instruments in the IMD network. Therefore, it confirms that the existing data at various IMD stations meet the international standard of reliability.

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