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Re-Evaluation of Total and Umkehr Ozone Data from NOAA-CMDL Dobson Spectrophotometer Observatories

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DISCLAIMER

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1. Introduction

This report describes work performed under U.S.A. Department of Energy (D.O.E.), Environmental Science Services Division, Interagency Agreement No. DE-A103-93ER61726, to improve the quality of total ozone and Umkehr data obtained in the past at the NOAA Climate Monitoring and Diagnostics Laboratory (and its predecessor laboratories') Dobson spectrophotometer ozone observatories. The research stemmed from D.O.E.'s solicitation published in the Federal Register, Volume 58, No. 6, Monday, January 11, 1993, for applications to support the DOE evaluation of atmospheric ozone trends and distributions. Rationale justifying the need for the data re-evaluation is amply described in D.O.E. Report DOE-ER-0575T entitled "Overview of DOE Atmospheric Chemistry Ozone Project".

We present results of total ozone data re-evaluations for ten stations: Byrd, Antarctica (80.0°S, 119.5°W); Fairbanks, Alaska (64.8°N, 147.9°W); Hallett, Antarctica (72.3°S, 170.2°E); Huancayo, Peru (12.1°S, 75.3°W); Haute Provence, France (43.9°N, 5.7°E); Lauder, New Zealand (45.1°S, 169.7°E); Perth, Australia (31.9°S, 116.0°E); Poker Flat, Alaska (65.1°N, 147.5°W); Puerto Montt, Chile (41.5°S, 72.8°W); and South Pole, Antarctica (90.0°S, 24.8°W). The improved data will be submitted in early 1996 to the World Meteorological Organization (WMO) World Ozone Data Center (WODC), Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario, Canada M3H5T4 for archiving. Considerable work has been accomplished, also, in re-evaluating Umkehr data from seven of the stations, viz., Huancayo, Haute Provence, Lauder, Perth, Poker Flat, Boulder, Colorado (40.0°N, 105.3°W); and Mauna Loa, Hawaii (19.5°N, 155.6°W).

Because of the convening of the 1994 WMO Ozone Trends Panel, a need arose early in 1994 for updating the re-evaluation of NOAA total ozone data from currently operating stations that have long-term records dating back to the 1960s and 1970s. The stations are Bismarck, North Dakota (46.8°N,100.8°W); Boulder, Colorado; Caribou, Maine (46.9°N, 68.0°W); Mauna Loa, Hawaii: Nashville, Tennessee (36.2°N, 86.6°W); Samoa, South Pacific (14.3°S, 170.6°W); and Wallops Island, Virginia (37.9°N, 75.5°W). As part of the overall data optimization effort, data re-evaluation for these stations was updated through December 31, 1994. Details concerning the re-evaluation of data from these stations are described in a report that is in preparation.

2. NOAA Dobson Spectrophotometer Ozone Observations Program

2.1 Total Ozone Observations

Ozone observations with Dobson spectrophotometers date back to the early 1930s. The program gained impetus during the International Geophysical Year (IGY, 1957-1959), with the number of stations around the globe increasing to the present day 80-90. Dobson instruments are manufactured in Oxford, England, and calibrated there under adverse meteorological and air pollution conditions. Because, also, Dobson instrument observing programs throughout the world have generally been relegated low priority, data quality in the past was often not high. For example, at International Dobson Instrument Comparisons held in Siofok, Hungary, in 1967, disagreement in measured ozone values among several instruments spanned the range of 15%. At similar instrument comparisons held in Belsk, Poland, in 1974, ozone values for six of ten instruments agreed in the mean to ±4%, but the mean errors for the four other instruments ranged from 6-16%.

The U.S.A. (originally U.S. Weather Bureau, then ESSA, now NOAA) Dobson instrument network grew from one-half dozen sites during the IGY to a total of 28 stations, 16 of which are currently operating. Several of these are foreign cooperatives. Milestones of the program since the early 1960s are the following:

(a) The U.S.A. Dobson ozone spectrophotometers were revamped optically and electronically in the early 1960s, and all instruments were calibrated at that time with a newly established U.S.A. Standard Dobson Spectrophotometer 83. Since then, all NOAA instruments have been periodically calibrated with instrument No. 83 (or with a Secondary Standard Spectrophotometer 65). The long-term ozone measurement precision of instrument 83 had been maintained at ±0.5% through 1987 [*Komhyr et al.*, 1989] and is now ±1%. In the early 1960s, also, detailed Dobson instrument operating instructions were prepared for use at the U.S.A. station network. These instructions [*Komhyr*, 1980] were subsequently adopted by the WMO for use in the global Dobson spectrophotometer network.

(b) With formation of the WMO Ozone Research and Monitoring Program in the mid 1970s, the WMO became actively involved in the global Dobson instrument measurements program. Under auspices of the WMO, an International Comparison of Dobson Spectrophotometers was conducted by NOAA in Boulder in 1977 [*Komhyr et al.*, 1981]. NOAA Dobson spectrophotometer 83 served as the primary standard instrument at the comparisons. (Subsequently, in 1980, instrument 83 was designated by the WMO as the World Primary Standard Dobson Spectrophotometer.) Participating foreign instruments were 41 (United Kingdom), 71 (former German Democratic Republic), 77 (Canada), 96 (Egypt), 105 (Australia), 108 (former USSR), 112 (India), and 116 (Japan). These foreign spectrophotometers were designated at that time by the WMO as secondary standard instruments, with the stipulation that they be used within their respective regions in future years for routine, periodic calibrations of field Dobson spectrophotometers.

(c) Since the mid-1970s, NOAA has not only periodically calibrated the secondary standard Dobson instruments named above, but has also been involved in a program to upgrade the quality of field Dobson instruments throughout the world. Numerous foreign instruments have been overhauled optically and electronically, and calibrated several times relative to Primary Standard Dobson Instrument 83. The work has been conducted in Boulder, Colorado, and at several WMO-sponsored Dobson instrument comparisons, e.g., in Aspendale, Australia, in 1980; in Arosa, Switzerland in 1990 and 1995; and in Tenerife, Canary Islands in 1994. All instruments in the global Dobson station network now have calibrations traceable either directly or indirectly to World Primary Standard Dobson Instrument 83. Since NOAA's involvement in the program, the quality of ozone data throughout the world has steadily improved. For example, at the Arosa Dobson Instrument Comparisons in 1990, of sixteen instruments calibrated relative to NOAA's standard instrument, twelve measured ozone amounts that agreed with the standard to ±1%. The other four instruments measured ozone values too low by 1.3- 3.2%.

(d) At the 1977 Boulder International Comparison of Dobson instruments [*Komhyr et al.*, 1981] it was shown that well optically adjusted Dobson spectrophotometers could be calibrated to ±1% with standard lamps calibrated with Dobson instrument 83. Conversely, the standard lamps could be used to identify field Dobson instruments that needed recalibration. To assess the status of instruments throughout the world, seven standard lamp units, each consisting of two calibrated lamps and a stable power supply, were built in 1981. The global Dobson instrument network was then divided into seven areas, each containing from 5-17 instruments, and a lamp unit was sent to each area to check on the calibration status of the instruments there. Results of calibration checks performed in 1981-1983 on 78 instruments [*Grass and Komhyr*, 1985] showed that 27 of these exhibited errors exceeding 2%, with a number of instruments having errors of 6-10%. During a repeat calibration check in 1985-1987 [*Grass and Komhyr*, 1989], of 81 instruments checked, errors larger than 2% were obtained only for 13 instruments, with the largest error being 4.6%.

(e) The extensive Dobson instrument work performed by NOAA throughout the years has been of significant benefit to satellite ozone observing programs. As early as November 1986, *Fleig et al.* [1986] noted that there was a long-term drift between the SBUV/TOMS total ozone and average total ozone measured from an ensemble of 42 Dobson instrument stations. It was not until 1988, however, when TOMS overpass total ozone data at Mauna Loa Observatory and Dobson instrument 83 calibration data for the years 1979, 1980, 1981, 1986, and 1987 were inter-compared that the TOMS and SBUV instrument calibrations were shown conclusively to have drifted due to degradation of a diffuser plate shared by both instruments [*McPeters and Komhyr*, 1991]. Comparison results showed that relative to Dobson instrument 83 ozone values the TOMS instrument calibration drifted non-linearly downward by 7% during 1979-1989. The calibration drift for the SBUV instrument was similar. TOMS satellite total ozone data that were presented in the 1988 WMO Ozone Trends Panel Report [1988] were normalized to data from the Dobson instrument network, and therefore to the calibration record of Dobson instrument 83. The integrity of the conclusions concerning any trends in total ozone drawn by the Ozone Trends Panel depended critically on the calibration and maintenance record of Dobson instrument 83. Currently satellite ozone observations rely heavily on ground truth from World Primary Standard Dobson Spectrophotometer 83 and the Dobson instrument network as a whole. The need for continued high quality Dobson instrument observations is now fully recognized.

The NOAA Dobson spectrophotometer total ozone data record is shown in Table 1. It is comprised of over 430 station-years of data from 28 stations, 16 of which (as indicated earlier) are currently in operation. All of the data have now been re-evaluated. Specific stations' data re-evaluated under D.O.E. Interagency Agreement No. DE-A103-93E1261726 are indicated in Table 1.

2.2 Umkehr Observations

NOAA Umkehr observations began in Boulder in 1978 with a manually operated Dobson spectrophotometer. In the early 1980s a project was undertaken to automate Dobson spectrophotometer 61 for Umkehr observations. The work was accomplished successfully, and automatic Umkehr observations began in Boulder with instrument 61 in 1982. On the basis of the success of the instrument automation effort, funding was then sought to automate 6 additional Dobson instruments for establishment of a 7-station Umkehr observations network at select locations on earth for the purpose of early detection of stratospheric change. Funding for the project was secured from the U.S.A. Environmental Protection Agency (EPA), with contributions from the Chemical Manufacturers Association, Incorporated, and from NOAA. The 6 additional instruments were automated [*Komhyr et al.*, 1984] and deployed in the mid 1980s to two U.S.A. field sites (Mauna Loa Observatory, Hawaii, and Poker Flat, Alaska), and four foreign locations (Haute Provence, France; Huancayo, Peru; Lauder, New Zealand; and Perth, Australia).

The NOAA Dobson spectrophotometer Umkehr observations record is shown in Table 2. Considerable work has been accomplished in re-evaluating the Umkehr data through 1992. First processing of the 1993 and later data is also underway.

Table 1. NOAA Dobson Spectrophotometer Total Ozone Data Record

Station	Period of Record
Albuquerque, NM	February 1965 - July 1966
American Samoa, South Pacific[2]	December 1975 - present
Bedford, MA	October 1963 - December, 1970
Bismarck, ND[2]	January 1963 - present
Boulder, CO[2]	September 1966 - present
Byrd, Antarctica[1]	September 1962 - October 1969
Canton Island, South Pacific	February 1965 - July 1966
Caribou, ME[2]	January 1963 - present
Fairbanks, AK[1]	December 1964 - June 1972 February 1993-present
Fresno, CA[2]	June 1983 - March 1995
Greenbay, WI	January 1963 - June 1975
Hallett, Antarctica[1]	January 1962 - October 1962
Hanford, CA	March 1995 - present
Haute Provence, France[1]	September 1983 - present
Huancayo, Peru[1]	February 1964 - December 1992
Lauder, New Zealand[1]	January 1987 - present
Mauna Loa, HI[2]	January 1964 - present
Midland, Texas	July 1962 - October 1963
Nashville, TN[2]	January 1963 - present
Perth, Australia[1]	July 1984 - present
Point Barrow, AK	August 1973 - December, 1982; June 1986 - present
Poker Flat, AK[1]	March 1984 - May 1992
Puerto Montt, Chile[1]	November 1964 - December 1965
South Pole, Antarctica[1]	November 1961 - present
Sterling, VA	January 1962 - June 1967
Tallahassee, FL	May 1964 - November 1989 April 1993 - present
Wallops Island, VA[2]	July 1967 - present
White Sands, NM	January 1972 - January 1982

[1]Stations for which total ozone data were re-evaluated under D.O.E. Interagency Agreement DE-A103-93E1261726.

[2]Stations for which data re-evaluation was updated through December 31, 1994.

Table 2. Umkehr Observations Data Record

Station	Period of Record	No. Obs.*
Boulder, CO	February 1978 - present	1675
Fairbanks, AK	February 1993 - present	-
Haute Provence, France	August 1983 - present	1908
Huancayo, Peru	April 1985 - December 1991	40
Lauder, New Zealand	February 1987 - present	653
Mauna Loa, HI	October 1983 - present	2557
Perth, Australia	June 1984 - present	1906
Poker Flat, AK	March 1984 - May 1992	607

*Number of Umkehr observations made through December 1991.

While few problems were experienced at the majority of the Umkehr stations throughout the years, the program at Huancayo was largely unsuccessful because the station infrastructure there was unable to adequately support operation of a fairly sophisticated automated Dobson instrument. Furthermore, station operations were at times adversely affected by subversive actions of the Peruvian Shining Path Guerrillas.

Due to a decrease in staffing at the Poker Flat facility in 1992, the Umkehr observations program was relocated to nearby Fairbanks, Alaska, in the winter of 1992-1993.

3. Total Ozone Data Re-evaluation

Provisional total ozone data from the NOAA Dobson spectrophotometer station network have been routinely archived throughout the years at the WMO World Ozone Data Center (WODC) in Downsview, Ontario, Canada, generally within 2-3 months after acquisition of the data. The provisional nature of the data stemmed from the need for final instrument calibrations that were performed several or more years after initial calibrations. Additionally, standard empirically-derived charts used for determining ozone values from observations on the zenith sky, or charts derived from sparse sets of comparison direct sun and zenith sky observations, did not always yield optimum quality data. Approximate corrections to the provisional data, determined from periodic re-calibrations of the field instruments, have been provided throughout the years to the WMO and to other users of the data upon request. These mean corrections, expressed as percent errors in measured ozone for an ozone amount of 300 Dobson units (DU) and an air mass of 2, have been applied linearly to back ozone data requiring correction.

Because of the need for "ground truth" validation of satellite instrument ozone data and the desirability of obtaining reliable information on ozone trends during past decades, the NOAA National Environmental Satellite, Data, and Information Service (NESDIS), in cooperation with the WMO, embarked in 1991 on an international project to promote optimization of the quality of total ozone data from the global Dobson spectrophotometer station network. Following several meetings of experts, a "Dobson Data Re-Evaluation Handbook" was prepared [*R.D. Hudson and W.G. Planet*, eds.,1993; also available as WMO Global Ozone Research and Monitoring Project Report No. 29] which provided detailed instructions concerning total ozone data re-evaluation procedures. Ozone researchers throughout the world were then encouraged to re-evaluate their total ozone data records in accordance with procedures outlined in the Handbook.

3.1 Total Ozone Data Re-evaluation Handbook

The Dobson Data Re-evaluation Handbook (hereafter referred to as the Handbook) provides detailed information for data re-evaluation in three sections. Section I, prepared by K. Vanicek, is entitled "Examination of Instrument Histories". It describes historical information and data to be archived for each instrument. These include information about instrument ownership, places and periods of operation, organizations and persons in charge, raw data bases, past data processing and archiving, instrument calibrations (e.g., by the Langley plot method, with calibrated standard lamps, or relative to calibrated standard spectrophotometers), instrument optical wedge calibration data, instrument wavelength setting calibration data, monthly standard lamp and mercury lamp test data, and empirical charts or polynomials used in processing zenith sky observations.

Section II of the Handbook, prepared by W.D. Komhyr and entitled "Evaluation of Instrument Constants", provides detailed instructions for re-evaluating total ozone data obtained with spectrophotometers that have calibrations traceable to World Primary Standard Dobson Instrument 83 (or to Secondary Standard Instrument 65). These include all NOAA Dobson spectrophotometers operating since the early 1960s as well as numerous other instruments of the global Dobson spectrophotometer network that have been periodically calibrated directly or indirectly relative to Dobson instrument 83 since the mid 1970s. Included in Section II, reproduced in Appendix A of this report, are updated calibration scales dating back to 1962 for primary and secondary standard Dobson spectrophotometers 83 and 65. Instructions provided in the section for data re-evaluation are based on analyses of periodic initial and final calibrations of field instruments with the standard spectrophotometers to determine field instrument calibration changes that may have occurred with time. Changes in calibration may arise from accumulation of dust on the instrument optics, aging of the optics (particularly the mirrors), corrosion of cobalt filters by water vapor within instruments that were not always kept dry at field stations, occasional shifts in the alignment of the instrument optical components due to accidental jarring of the instrument, inadvertent use of imprecise wavelength settings during observations, and changes in the spectral characteristics of the instrument's optical wedge due to deterioration with time of the Canada balsam cement used in the wedges as a binder. Resulting calibration errors may be categorized into three classes: 1) those for which needed corrections are constants to be applied to the instrument's calibration parameters (N Tables); 2) those for which needed corrections are air mass (μ) dependent and instrument optical wedge characteristics remained stable with time; and 3), those for which needed corrections are air mass dependent but instrument optical wedge characteristics changed with time. Methods for correcting total ozone data for the three classes of errors are described in detail with examples in subsections 2.3, 2.4, and 2.5, respectively, of Section II of the Handbook (see Appendix A). They will hereafter be referred to as data re-valuation methods 2.3 (standard), 2.4 (μ-dependent), and 2.5 (μ-wedge-dependent). Included in Section II, also, are instructions for deriving polynomial corrections to empirical charts that are used in deducing total ozone amounts from observation on clear and cloudy zenith sky.

Section III of the Handbook, prepared by R.D. Bojkov and A. Lapworth, describes procedures to be used in improving total ozone data obtained with instruments for which calibration data are unreliable or unavailable. Several methods may be used. First, the data should be examined for internal consistency (i.e., for obvious shifts in the data). Here, however, care must be taken to distinguish instrumentally induced data anomalies from those that may have been meteorologically induced. Second, because a high correlation exists between total ozone and 100 hPa stratospheric temperatures, particularly at latitudes greater than 30° away from the equator, useful information regarding ozone data quality can be obtained from correlation studies of the two variables. The correlation breaks down at high latitudes, particularly in Antarctica during the austral spring when considerable photochemical ozone destruction occurs. Finally, assessments of total ozone data quality can be made from comparisons of observations made at two nearby stations (e.g., in Europe where station density is relatively high), or in recent years from Dobson and satellite instrument data comparisons.

3.2 NOAA/CMDL Re-evaluated Total Ozone Data Archive

Because NOAA total ozone data have been obtained since the early 1960s with field Dobson spectrophotometers calibrated throughout the years relative to World Primary Standard Dobson Instrument 83, it has been possible to use instructions contained in Section II of the Dobson Data Re-evaluation Handbook exclusively in re-evaluating the data. There has been no need in the re-evaluations to resort to comparisons of the NOAA data with data from other sources (e.g., Brewer spectrometer data, or TOMS or SBUV/SBUV-2 satellite data). The re-evaluated data, therefore, constitute a completely independent data set. All data have been re-evaluated using *Bass and Paur* [1985] ozone absorption coefficients, modified for use with Dobson ozone spectrophotometers [*Komhyr et al.*, 1993].

Data re-evaluation for each of the 28 stations where observations have been made is fully documented in a set of hard copy volumes stored at the NOAA CMDL laboratory in Boulder, Colorado. (The same information is available also on computer hard disk.) Information contained in each set of volumes is the following:

<u>Basic Information:</u>

(a) Station name, latitude, longitude, elevation, Greenwich mean time minus local standard time, mean atmospheric pressure, mean height of the ozone layer at the station, and earth radius at the station.

(b) List of Dobson instruments used at the station and their periods of operation.

(c) Equations used in deducing ozone from direct sun and moon observations made on various wavelengths; including ozone absorption and scattering coefficients.

<u>Monthly Lamp Tests Data:</u>

(a) Summary of mercury lamp tests data obtained routinely throughout the years at monthly intervals to ensure that observations are made on correct wavelengths. Included are Dobson instrument Q (wavelength setting) tables used at the station. Sample data are shown in Appendix B.

(b) Summary of standard lamp tests data obtained at the station at monthly intervals to check on Dobson instrument calibration stability. Included are Reference Standard Lamp Readings established at times of instrument re-calibrations. Sample data are shown in Appendix B.

<u>Wedge Calibration Data</u>

(a) These are results of instrument optical wedge calibrations made every several years as a check on the stability of the optical wedge. The data can be used to correct initially-derived ozone values for time intervals when a significant change occurred in the spectral characteristics of the wedge. Sample archived optical wedge calibration data are shown in Appendix C.

Instrument Historical Information

(a) In conjunction with calibration data presented for the instrument applicable to the time of initiation of observations at a station, a brief past history of the instrument is given which includes information about instrument ownership, past operations (including past calibration data if available), and modifications made to the instrument which may include optical realignment and electronic modernization.

(b) In conjunction with subsequent presentations of instrument re-calibration data in the archive volumes, the documentation of the instrument histories is continued, summarizing problems that may have occurred with the instrument since its previous calibration, solutions to the problems, optical wedge and wavelength-setting re-calibrations, etc. More detailed such information is preserved in a separate archive at NOAA/CMDL in Boulder, Colorado.

Instrument Calibration Records

(a) NOAA field Dobson spectrophotometers have been calibrated with Primary Standard Dobson Instrument 83, or with Secondary Standard Instrument 65 since 1962. (On rare occasions calibrations were affected by means of standard lamps calibrated with instrument 83.) The calibrations are conducted by making simultaneous ozone observations on direct sunlight with the two instruments during one-half day (i.e., over a μ range of about 1-5), analyzing the observational data, then transferring the calibration constants of the standard instrument to the field instrument. The majority of the instrument calibrations have been conducted throughout the years in pairs, i.e., an 'initial' calibration followed several years later by a 'final' calibration performed on the instrument in an "as is" condition. It is from the 'final' calibration that calibration corrections are derived. The NOAA/CMDL data archive volumes contain all instrument calibration records. These include raw calibration data, data analyses, and final results. Sample 'initial' instrument calibration data are shown in Appendix D. Sample 'final' calibration records used in re-evaluating data by the standard, μ-dependent, and μ-wedge-dependent methods, also provided in the archive volumes, are shown in sections 2.3, 2.4, and 2.5 of Handbook Section II (Appendix A).

Corrections to Zenith Sky Observations

(a) Zenith sky observational total ozone data are reduced in the NOAA program using standard empirical charts derived in the past from quasi-simultaneous observations on direct sun and the clear and cloudy zenith [*Komhyr*, 1980]. Because the chart characteristics are ozone vertical distribution and instrument dependent, it is necessary to determine needed corrections to the charts for each station. This is accomplished through analyses of additional comparison direct sun and zenith observational data obtained at the station. All such analyses, as well as the deduced corrections (μ-dependent polynomials), are documented in the data archive volumes. Sample analyses and deduced corrections are shown in Appendix A.

(b) This section of the data archive volumes also contains edited standard lamp tests data. These edited data, together with corrected instrument calibrations, are used in processing the direct sun observations with which zenith sky observations are compared.

(c) Since direct sun observations on AD wavelengths are fundamental, analyses are performed also on quasi-simultaneously made AD and CD wavelength direct sun observations to determine correction factors that reduce the CD wavelength observations to the AD level. CD-wavelength direct sun observations are made in the μ-range 2.5-5.0.

Re-evaluated Total ozone Data

(a) Re-evaluated total ozone data are presented in the data archive volumes month-by-month. Included are the basic parameters that were used in processing the data (e.g., station latitude, longitude, time zone, mean height of the ozone layer, etc.) as well as the ozone absorption and scattering coefficients employed. These are followed by a listing of the instruments used and their periods of operation, calibration scales employed in the data processing, polynomial coefficients used in processing the data to optimize the quality of ozone values derived from zenith sky observations, and the CD direct sun observations' correction factors. A sample of such data is shown in Appendix E.

(b) Archived data for a month (a sample of which is also shown in Appendix E, consists of all observations made during the month. Information archived for each observation includes the date and time of the observation, the raw observational data, the kind of observation made (wavelengths employed; whether made on direct sun, moon, or zenith sky), coded sky condition information, mean airmass (μ) value for the observation, standard lamp corrections applied in processing the data, and finally the computed ozone value expressed in atmo-cm ozone. From the available data, up to five representative total ozone values obtained at different times of the day are selected to comprise the re-evaluated ozone data base. A single ozone value is then chosen for each day to be representative of the total ozone present over the station at local apparent noon. The ensemble of these values comprises the NOAA/CMDL archive of daily total ozone values, which are also archived at the WODC in Downsview, Ontario, Canada.

3.3 Brief Observing Program Histories

3.3.1 Amundsen-Scott, Antarctica

Total ozone observations began at Amundsen-Scott, Antarctica (90.0°S, 24.8°W), with Dobson spectrophotometer 65 on September 17, 1961, and continued with instrument 65 through November 28, 1963. The observing program at the site was implemented by the Polar Operations Project of the U.S. Weather Bureau prior to the time that W. Komhyr assumed responsibility for the U.S.A. Dobson instrument program operations in late 1961. The 1961 calibration of instrument 65 was based on an original calibration performed in the late 1950s or 1960-1961 at Oxford, England, by R and J Beck, Limited, the manufacturer of the instrument. Relevant calibration tables and constants have not been located.

In December 1962, Dobson spectrophotometer 82, which had been optically, electronically, and mechanically overhauled in Boulder earlier and calibrated with primary standard Dobson instrument 83 on September 14, 1962, was transported to Amundsen-Scott station where comparison ozone observations were made with instruments 65 and 82 during December 17-22, 1962. Instrument 82 was then shipped to Hallett, Antarctica, where it was in operation through October 1963 at which time the Hallett ozone observing program was discontinued. Instrument 82 was then returned to Amundsen-Scott station where ozone observations with it began December 5, 1963.

In subsequent years, total ozone observations at Amundsen-Scott station were made alternately with Dobson instruments 80 and 82. Instrument calibrations were conducted throughout the years according to the schedule shown in the table below. The column in the table named 'Initial' Calibrations lists the times of primary calibrations of instruments 80 and 82, while the 'Final' Calibrations column lists the calibrations from which needed data corrections are deduced. The designators R (and M or U, and W, not indicated in the above calibration scales but which occur for other instruments) denote the method

'Initial' Calibrations	Ref. Inst.	'Final' Calibrations	Ref. Inst.
#65 Unavailable, 1961	R/J Beck	#65 Dec. 17-22, 1962	#82/83
#82 Sept. 14, 1962 R1	#83	#82 Oct. 29, 1973	#83
#80 Aug. 7, 1972 R1	#83	#80 Nov., 1978	Lamp X
		#80 May 1, 1986	#83
#82 Aug. 6, 1985 R1	#83	#82 May 21, 1990	#83
#80 May 26, 1988 R1	#83	#80 April 30. 1993	#83
		#80 Oct. 11. 1994	#83
#82 Aug. 27, 1992 R1	#65		

employed in data re-evaluation, whether standard, μ-dependent, or μ-wedge-dependent. No significant instrument calibration changes occurred at Amundsen-Scott station. Changes in instrument optical wedge densities were minor. Thus, re-evaluation of the total ozone data was performed according to Handbook method 2.3 (i.e., the non-μ-wedge-dependent method).

Due to observer error, total ozone observations were made incorrectly at Amundsen-Scott station with Dobson instrument 80 during October and November of 1983. The problem stemmed from operation of the instrument with its wavelength selector rod in the 'long' rather than the 'short' position when direct sun observations were made on AD and CD wavelengths. This caused observations to be made on the long, but not the short, wavelength of each wavelength pair A, C, or D, as well as on other near-visible wavelengths. Fortuitously, computed ozone amounts fell within the range of values observed in past years at Amundsen-Scott station. Following recognition of the observing problem, corrections to the October 1993 Amundsen-Scott station total ozone data were deduced in Boulder from quasi-simultaneous observations made correctly and incorrectly (as at Amundsen-Scott) in Boulder with Dobson instrument 80. Corrected October 1983 ozone values for Amundsen-Scott were considerably lower than values originally deduced.

3.3.2 Byrd, Antarctica

Dobson instrument 80 was shipped to Byrd, Antarctica (80.0°S, 119.5°W), by the Polar Operations Project Group of the U.S.A. Weather Bureau for total ozone observations probably in 1961. At that time only a tentative calibration was assigned to the instrument. First observations were made at Byrd in August 1962.

W. Komhyr traveled to Byrd in November 1963. At that time the optics and electronics of instrument 80 were checked and corrected where necessary, the optical wedge was calibrated by the two lamp method, and wavelength settings were established by means of discharge lamp tests. The instrument was then calibrated on November 17, 1963, with traveling standard lamps X and Y that had been calibrated with primary standard Dobson instrument 83.

'Initial' Calibrations	Ref. Inst.	'Final' Calibrations	Ref. Inst.
#80 Nov. 17, 1963 $W1_i$	X, Y	#80 Nov. 30, 1968 $W1_f$ #80 Aug. 7, 1972**	X, Y* #83

* Initial calibration, with routine standard lamp test corrections applied.
** Approximate instrument 80 calibration check made after optical adjustment and repair of instrument.

Total ozone observations continued at Byrd uneventfully through about November 1968. In December 1968, (or early in 1969), something happened to the instrument causing its spectral characteristics to change drastically. Although observations continued to be made in 1969, the data could not be processed reliably.

Final processing of the Byrd total ozone data was based on the November 17, 1963 calibration of Dobson instrument 80, taking into account small instrument spectral characteristics changes as determined from monthly standard lamp tests made at the station, as well as a minor change in the instrument's optical wedge densities that occurred during 1963-1968. An inter-calibration of instrument 80 with primary standard Dobson spectrophotometer 83 in Boulder in 1972, made after optical realignment of the instrument and a cobalt filter change, suggested that monthly mean ozone measurement errors in the re-evaluated Byrd data most likely fell within the range of 0 to -1.5 percent.

3.3.3 Fairbanks, Alaska

NOAA (then the U.S. Weather Bureau) total ozone observations first began at Fairbanks, Alaska (64.8°N, 147.9°W), in February 1965, and continued through June 1972. Dobson spectrophotometer 76 used at the station was mechanically, optically, and electronically overhauled during August-September 1964, and calibrated relative to primary standard Dobson instrument 83 on

'Initial' Calibrations	Ref. Inst.	'Final' Calibrations	Ref. Inst.
#76 Oct. 16, 1964 R1	#83	#76 Aug. 9, 1972	#83
#63 May 29, 1992 R1	#83		

October 16, 1964. A visit was made to Fairbanks in 1969 to effect minor instrument repairs, perform calibration checks and clean the instrument optics. Following termination of operations at Fairbanks in 1972, the Dobson instrument was returned to Boulder. A recalibration of instrument 76 relative to Dobson instrument 83 was made on August 9, 1972, indicating a calibration change of 1.5% for ozone amounts of 300 DU and an air mass of 2. During final data re-evaluation performed according to standard Handbook method 2.3, this needed correction was applied linearly with time to the data for the period of observations. A small change occurred in the optical wedge densities of instrument 76 during 1964-1972. Had final data re-evaluation been performed using Handbook method 2.5 (i.e., the μ-wedge-dependent method), the derived total ozone amounts would have differed by no more than about ±1% from the values obtained.

Total ozone observations were resumed at Fairbanks in February of 1993 with Dobson ozone spectrophotometer 63. This occurred following re-location of instrument 63 from nearby Poker Flat, Alaska, where it had been in operation during March 1984-May 1992.

3.3.4 Hallett, Antarctica

Observations of total ozone began at Hallett, Antarctica (72.3°S, 170.2°E), with Dobson instrument 37 in January 1961. The instrument had been installed there by the Polar Operations Project Group of the Weather Bureau prior to the time that W. Komhyr assumed responsibility for the U.S.A. Dobson instrument program operations in late 1961. Calibration tables and constants used in processing the data were based on the original calibration of instrument 37 made at Oxford, England in 1960. Routine (monthly) instrument calibration checks (standard lamp and mercury lamp tests) were not made. Instrument 37 continued to be operated at Hallett through October, 1962. In November 1962, the instrument optical wedge bands broke, and the instrument was shipped to Boulder for repair. Because standard lamp tests had not been made at Hallett, it was impossible to reposition the optical wedge close to its original position upon repair. An intercalibration of instruments 37 and 83 was, therefore, not

'Initial' Calibrations	Ref. Inst.	'Final' Calibrations	Ref. Inst.
#37 Oct. 1, 1960 X0	R.J.Beck		
#82 Sept. 14, 1962 R1	#83		

performed in Boulder. The Hallett total ozone data, as archived, were therefore processed using the 1960 calibration of R.J. Beck, Ltd., and have no tie-in to the calibration scale of World Primary Standard Dobson Instrument 83.

In January 1963, Dobson instrument 82 was installed at Hallett. It had been calibrated in Boulder in September 1962 relative to Dobson instrument 83. Total ozone observations were made during February-October 1963. The observations were terminated at Hallett in November 1963 due to logistics considerations. Instrument 82 was then shipped to Amundsen-Scott, Antarctica, where it was put into operation on December 28, 1963.

3.3.5 Haute Provence, France

French Dobson instrument 85 was transported to Boulder in May 1983 to be automated for Umkehr observations. At that time new electronics and an "air-space" optical wedge were installed into the instrument, the optics were re-aligned, and wavelength-settings and optical wedge densities determined. An initial calibration of the instrument was performed on June 21, 1983, relative to World Primary Standard Dobson Instrument 83.

'Initial' Calibrations	Ref. Inst.	'Final' Calibrations	Ref. Inst.
#85 June 21, 1983 R1	#83	#85 Aug. 21, 1986	#83
		#85 Aug. 25, 1986	#83
		#85 July 7, 1990	#65
#85 July 10, 1990 R1	#65	#85 July 27, 1995	#65
		#85 July 31, 1995	#65

A calibration check made on the instrument August 21, 1986, showed the instrument to be in good calibration. No calibration change was detected several days later following cleaning of the instrument, so that the #85 June 21, 1983 R1 calibration scale of instrument 85 continued to be used. The calibration of instrument 85 was checked again on July 7, 1990. Only a small calibration change was detected (~0.7% O_3 error at $\mu = 2$ and $x = 300$ DU). After cleaning the instrument optics, a new calibration scale for the instrument was established on July 10, 1990.

Checks on the #85 July 10, 1990 R1 calibration scale of Dobson instrument 85 were made at Arosa, Switzerland, on July 27 and 31, 1995. These indicated needed corrections to instrument 85 ozone values of less than 1% (for 300 DU ozone and $\mu \sim 2$). A decision was made, therefore to continue use of the #85 July 10, 1990 R1 calibration scale at Haute Provence following July 1995.

3.3.6 Huancayo, Peru

Total ozone observations began at Huancayo, Peru (12.0°S, 75.3°W), with Dobson instrument 87 in February 1964. The instrument has not been used previously in an observing program. Prior to shipment to Peru, the optical alignment of the instrument was checked, the instrument's wavelength settings were established with discharge lamps, and its optical wedge was calibrated by the two lamp method. Instrument 87 was then calibrated with Primary Standard Dobson Instrument 83 on August 30, 1963.

Routine standard lamp tests performed at monthly intervals indicated stable instrument 87 performance during 1964 through about December 1, 1974 (i.e., lamp readings remained relatively constant), at which time the lamp readings began to decrease markedly with time. Re-calibration of the instrument with Dobson instrument 83 in February 1977 showed a large change in its calibration. An optical wedge calibration made February 19, 1977, revealed the main cause of the calibration change to have been a large change in the instrument's optical wedge densities.

A new calibration scale (#87 Feb. 22, 1977 R1) was then established for instrument 87. The instrument continued to be operated at Huancayo until early in 1983 when it was shipped to Boulder for automation for Umkehr observations. Recalibration of the instrument in Boulder on April 25, 1983, indicated a large calibration change again, accompanied by a substantial change in the optical wedge densities of instrument 87.

In the absence of Dobson instrument 87, the continuity of observations at Huancayo was maintained with Dobson instrument 91 which had been shipped there for temporary use. Instrument 91 had been calibrated with primary standard Dobson instrument 83 in May of 1982. A recalibration of the instrument in March 1986 showed the instrument to be in excellent calibration.

Following automation of Dobson instrument 87 for Umkehr observations, at which time an 'air-space' optical wedge was installed into the instrument for optical stability, the instrument was recalibrated on May 15, 1985, and returned to Huancayo. Operations at Huancayo continued until termination of the ozone observing program there on December 31, 1992. A final calibration of instrument 87 was made in June 1994, indicating a relatively small calibration change, minor optical wedge density changes, but some air mass dependency in the observations.

In re-evaluating the Huancayo total ozone data, it was assumed that the 1974-1983 approximately parabolic downward drift in Dobson instrument 87

'Initial' Calibrations	Ref. Inst.	'Final' Calibrations	Ref. Inst.
#87 Aug. 30, 1963 R1	#83	Std. Lamp Corr. Applied	#87
#87 Dec. 1, 1974 $W1_i$	#87	#87 Feb. 15, 1977 $W1_f$	#83
#87 Feb. 22, 1977 $W2_i$	#83	#87 April 25, 1983 $W2_f$	#83
#91 May 18, 1982 R1	#83	#91 Oct. 8, 1985	#87
		#91 March 27, 1986	#83
#87 May 15, 1985 $U1_i$	#83	#87 June 16, 1994 $U1_f$	#65

routine standard lamp test readings was a reflection of the change that occurred in the instrument's optical wedge densities. Calibration scales used in re-evaluating the data are shown in the table above. For the time intervals of high instrument stability, 1962-1974 and 1983-1985, the data were re-processed according to Handbook method 2.3. The assumed parabolic temporal change in optical wedge densities that occurred during 1974-1983 was approximated by two linear changes occurring during 1974-1977 and 1977-1983. Data re-evaluations for these two time periods were performed using the μ-wedge dependent Handbook method 2.5. Data obtained during 1985-1992 were re-processed using the μ-dependent Handbook method 2.4.

3.3.7 Lauder, New Zealand

The instrument in use at Lauder is U.S.A. instrument 72. (It had been operated at Wallops Island, Virginia, during 1967-1979.) In early 1983 instrument 72 was automated in Boulder for Umkehr observations. Prior to the automation, the instrument's electronics had been modernized, and its optical alignment checked. During the automation an "air-space" optical wedge was installed into the instrument to increase wedge stability.

The calibration record for Dobson spectrophotometer 72 is shown in the table below. The reference spectrophotometers used in calibrating instrument 72 are also listed in the table.

'Initial' Calibrations	Ref. Inst.	'Final' Calibrations	Ref. Inst.
#72 May 26, 1983 R1	#83	#72 June 28, 1985	#83
#72 May 1, 1986 R1	#83	#72 Dec. 13, 1988	#83
#72 Dec. 20, 1988 R1	#83	#72 July 14, 1992	#65
#72 Nov. 14, 1991 R2	#65		
#72 July 27, 1992 R2	#65		

On November 14, 1991, the calibration of the Lauder Dobson instrument abruptly changed following inadvertent exposure of the instrument to rain. In July 1992, the instrument was transported to Boulder for recalibration. Calibration of the instrument on July 14, 1992, with it in an "as is" condition revealed a large change in the spectral characteristics of the optical wedge, particularly at A wavelengths. The wedge was re-calibrated, and a new calibration scale, #72 July 14, 1992 R2, was established for re-evaluation of ozone data obtained during November 14, 1991 to July 14, 1992. Cleaning of the wedge caused its spectral characteristics to revert to original values. A final calibration of the cleaned instrument was made July 27, 1992. The next calibration check is tentatively scheduled for early 1997.

3.3.8 Perth, Australia

Early historical records for U.S.A. Dobson instrument 81 are sparse. The instrument was apparently at Wilkes, Antarctica, in the early 1960s, from where it was loaned to Australia and set up for observations at Port Morsby, New

Guinea in 1965. Later it was transferred to Darwin, Australia. During a 1976 hurricane at Darwin, the instrument was struck by a gas cylinder causing distortion of its R-dial shaft and damaging the optical wedge. The wedge was repaired by the Australians in 1977. In 1978 the instrument was relocated to Cairns, Australia. It was returned to Boulder in late 1983 at which time an "air space" optical wedge was installed into it (the wedge control R-dial shaft remained slightly bent); an old photomultiplier tube was replaced with a more sensitive new one, and the instrument optics were re-aligned. Following mechanical and electronic modification of the instrument for automatic Umkehr observations, the instrument's wavelength settings and optical wedge densities were established prior to calibrating the instrument and deploying it to Perth, Australia, for total ozone and Umkehr observations.

Times of calibration of Dobson instrument 81 are summarized in the table below. Following the 'initial' 1984 calibration, the instrument's steel band of the optical wedge broke in November, 1988. The wedge was repaired on site with

'Initial' Calibrations	Ref. Inst.	'Final' Calibrations	Ref. Inst.
#81 May 8, 1984 R1	#83	#81 Nov. 18, 1988	#83
#81 Nov. 25, 1988 R1	#83	#81 June 19, 1992	#65
#81 July 7, 1992 R2	#65		

care taken to reposition the wedge to its original configuration. That this was correctly done was verified by standard lamp tests and an instrument optical wedge calibration made November 22, 1988. The November 25, 1988, calibration of Dobson instrument 81 was performed after cleaning and re-calibrating the wedge on November 24. Prior to the instrument calibration of July 7, 1992, the wedge control R-dial shaft was straightened. The next calibration of instrument 81 is scheduled for early 1997.

3.3.9 Poker Flat, Alaska

Dobson instrument 63, which was in operation at Mauna Loa Observatory since the late 1950s, was brought to Boulder in 1983 for automation for Umkehr observations. The work included installation into the instrument of a new EMI photomultiplier tube and an "air-space" optical wedge, cleaning and re-alignment of the optics, and re-determination of instrument optical wedge densities and wavelength settings. Calibration of the instrument relative to World Primary Standard Dobson Instrument 83 was accomplished in May, 1983.

Ozone observations began at Poker Flat in March 1984. In March 1989, instrument 63 was returned to Boulder temporarily for a calibration check, and

'Initial' Calibrations	Ref. Inst.	'Final' Calibrations	Ref. Inst.
#63 May 26, 1983 R1	#83	#63 March 24, 1989	#83
#63 May 29, 1992 R!	#83		

found to be in excellent calibration. Observations at Poker Flat continued into May 1992 when one of the steel bands of the optical wedge broke. In effecting repair, the wedge was repositioned as closely as possible to its original position within the instrument with the aid of standard lamp test data, but a subsequent calibration of the wedge showed a small change in optical wedge densities from original values. Recalibration of instrument 63 relative to Dobson instrument 83 in May 15, 1992, indicated a calibration change of nearly 1% since 1989. Because the change most likely resulted from the small shift in optical wedge densities, the #63 May 26, 1983 R1 calibration scale of instrument 63 was used in final processing of the March 1989-May 1992 Poker Flat ozone data.

Following cleaning of Dobson instrument 63 optical components, a new calibration for the instrument relative to Dobson instrument 83 was obtained on May 27, 1992. Ozone observations at Poker Flat were, however, not resumed due to staffing problems at the site. Later in the year program operations were transferred to the Geophysical Institute of the University of Alaska in Fairbanks. Observations in Fairbanks began in February, 1993.

3.3.10 Puerto Montt, Chile

An 11-month total ozone measurements program was conducted at Puerto Montt, Chile (41.5°S, 72.9°W), during November 1964-December 1965 in cooperation with the Chilean Meteorological service. Dobson instrument employed was No. 93. It had been obtained from the U.S. Air force in trade for a U.S. Weather Bureau Dobson instrument installed for total ozone measurements in 1963 at Bedford, Massachusetts. Prior to shipment to Chile, instrument 93

'Initial' Calibrations	Ref. Inst.	'Final' Calibrations	Ref. Inst.
#93 Oct. 16, 1964 OO	#83		

was thoroughly overhauled optically and electronically in Boulder, and calibrated relative to primary standard Dobson instrument 83 on October 16, 1964.

In December 1965 the instrument became inoperative, and could not be repaired on site. It was then put into storage and lost. After many attempts made to locate the instrument, it was finally found and returned to Boulder in 1978.

3.3.11 U.S.A. Mainland Dobson Instrument Stations, Mauna Loa, Hawaii, and Samoa, South Pacific

Considerable work was accomplished under D.O.E. Interagency Agreement No. DE-A103-93E1261726, also, in updating re-evaluations of total ozone data through the end of 1994 from six U.S.A. mainland stations (Caribou, Bismarck, Boulder, Wallops Island, Nashville, and Fresno), Mauna Loa Hawaii, and Samoa, South Pacific. In the past, data for most of the stations had been re-evaluated through about mid 1991. At the time of some of the earlier data re-evaluations, computer programs for μ and μ-wedge dependent data reprocessing were not yet finalized; to improve data quality the data were tentatively re-processed using standard Handbook method 2.3. Relevant portions of the records have since been re-processed by Handbook methods 2.4 and 2.5. Furthermore, re-evaluated data exhibiting apparent anomalies, particularly for Mauna Loa, Hawaii, have been submitted to special analyses such as, the processing of single pair wavelength data, to ensure optimal data quality. Brief operations histories for these stations, including calibration scales used in final data processing, will be presented in a more comprehensive version of this report that is being prepared for formal publication at a later date.

4. Umkehr Data Re-evaluation

Umkehr ozone observations, made at the NOAA stations with automated Dobson spectrophotometers, are comprised of series of morning or afternoon observations made on A, C, and D Dobson instrument wavelengths and the clear or sporadically cloudy zenith sky. In processing the data the instrument dial readings, converted to N values (related to measured wavelength relative intensities and the instrument's extraterrestrial constants), are plotted vs solar zenith angle. N values extracted from the plots at solar zenith angles of 60, 65, 70, 74, 75, 77, 80, 83, 84, 85, 86.5, 88, 89, and 90 degrees then serve as input data to computer algorithms from which ozone vertical distributions are deduced. Ozone profiles can be obtained from observations on C wavelengths alone using the Standard Umkehr Evaluation Technique [*Mateer and Dütsch*, 1964], or a more current, improved version of the algorithm [*Mateer and DeLuisi*, 1991]. Ozone profiles can also be derived from "short" Umkehr observations made in the limited air mass range of 80-90 degrees [*Deluisi*, 1979], in which case observations on all three wavelengths (A, C, and D) are needed.

Figure 1a is a plot of raw Umkehr data obtained from clear zenith sky, C-wavelength observations made at Mauna Loa Observatory on the morning of

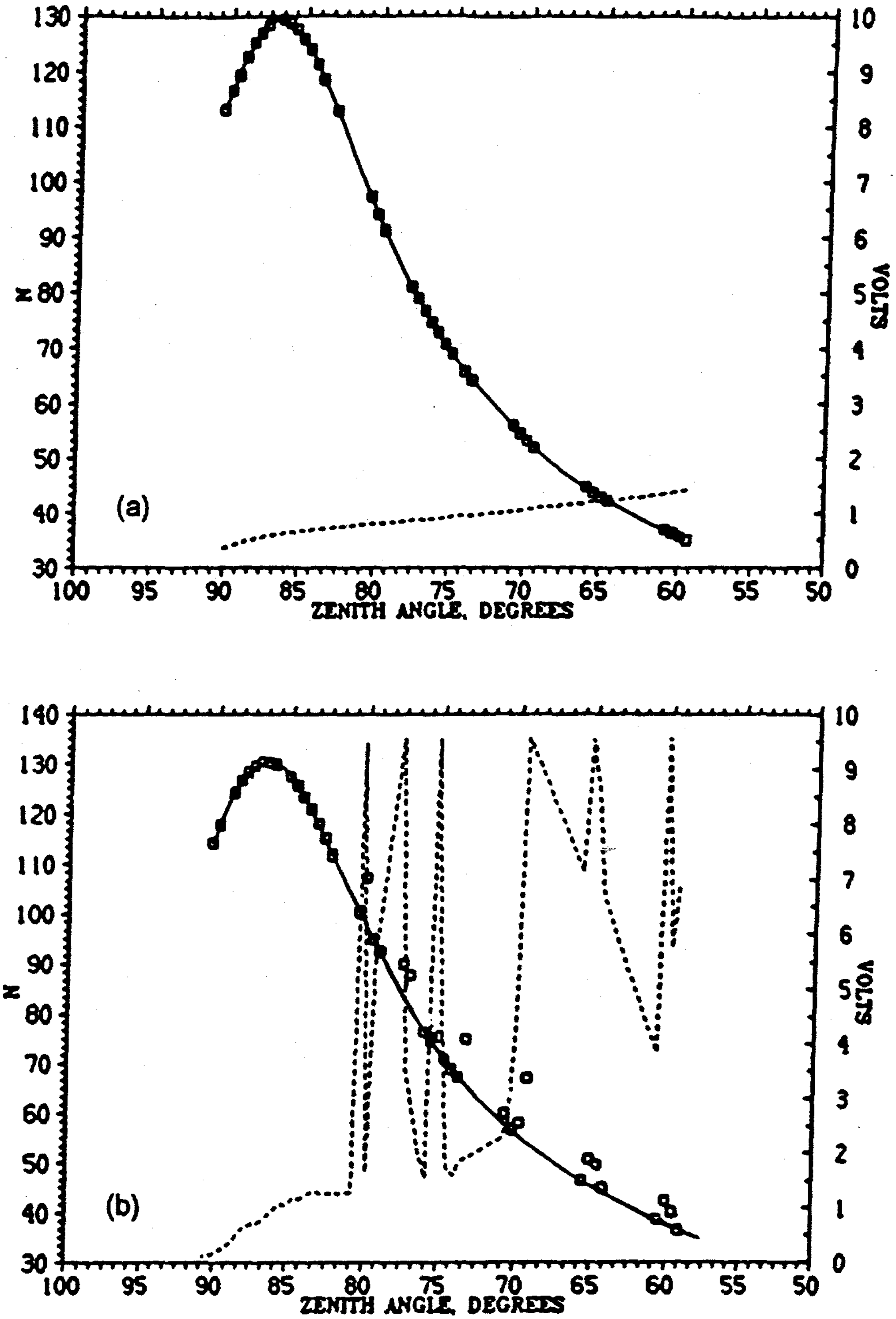

Figure 1. Umkehr observation N values vs solar zenith angles obtained at Mauna Loa Observatory from observations on C wavelengths and (a) clear and (b) cloudy zenith sky.

March 21, 1988. All data points lie on a smooth least squares curve (cubic spline with fixed knots) that has been fitted to the data. Considerable scatter in the raw data is evident, however, for the Umkehr observation made March 19, 1988, when the zenith sky was at times cloudy (Figure 1b). To help identify erroneous data resulting from cloud interference, the NOAA Umkehr observatories were provided in 1988-1989 with sensitive photometric zenith cloud detectors [*DeLuisi et al.*, 1988] that are operated whenever Umkehr observations are made. The dashed curves in the two figures are signals from such a detector. They are useful for assessing Umkehr data quality, and aid in the identification of erroneous observational data that are excluded from final Umkehr curve fitting routines.

A main cause underlying the need for re-evaluation of routinely processed Umkehr data stems from the requirement that the instrument optical wedges be highly accurately calibrated since errors in optical wedge densities adversely influence Umkehr curve shapes. Dobson spectrophotometers are manufactured with wedges that contain Canada balsam cement as a binder of wedge sections. Experience throughout the years has shown that the cement can deteriorate with time, causing large changes in the optical wedge characteristics. In automating the NOAA Dobson instruments for Umkehr observations, the Canada balsam cement was removed from all wedges. This has resulted in wedges whose spectral characteristics have remained virtually unchanged with time. Optical wedge characteristics can change, also, when contamination of the wedge occurs. This happened, for example at Lauder, New Zealand in 1991 when rain inadvertently entered the instrument. Although Umkehr observations were continued with the contaminated wedge for a one-half year thereafter, it was possible to re-evaluate the data following calibration of the contaminated wedge. Finally, optical wedge densities can change due to mechanical effects such as breaking of the wedge bands. Repair of the wedge on site generally restores it only approximately to its original configuration. Although Umkehr observations may continue to be made for many months, data obtained can be successfully re-evaluated following recalibration of the repaired wedge.

An important parameter of each Umkehr observation is the relevant total ozone, needed as input for the algorithm used in converting the raw data into ozone vertical distributions. The total ozone is measured during each one-half day when the solar elevation is near maximum for the day. Measurements at the NOAA automated Umkehr observatories are made by the station observers semi-automatically, generally on AD (or CD) wavelengths and on direct sun. With observers not present on site, as for example on weekends or holidays, total ozone is derived from the observational zenith sky Umkehr data. Incorporated into the re-evaluated Umkehr data are relevant re-evaluated total ozone data derived from the direct sun and zenith sky observations.

Calibration data (N-tables) used in final re-evaluation of Umkehr data for Huancayo, Haute Provence, Lauder, Perth, and Poker Flat are identified in section 3 of this report. In Boulder, sporadic, manual Umkehr observations began in 1978 with Dobson instrument 82. In 1981 Dobson instrument 61 was automated for Umkehr observations. An "air-space" optical wedge was installed into the instrument at the time, and the instrument was overhauled optically and electronically. Following calibration of the instrument in September 1981, a program of automated Umkehr observations began in Boulder in early 1982 that has continued into 1996. N-tables used in re-evaluation of the Boulder data are shown below. The optical wedge densities of the instrument have been highly

'Initial' Calibrations	Ref. Inst.	'Final' Calibrations	Ref. Inst.
#82 Aug. 31, 1977 R1	#83	#82 May 20, 1980	#83
#82 May 20, 1980 R1	#83	#82 Aug. 24, 1983	#83
#38 Sept. 21, 1978 R1	#83	#38 May 8, 1984	#83
#61 Sept. 8, 1981 R1	#83	#61 May 8, 1984	#83
#61 May 8, 1984 R1	#83	#61 April 11, 1985	#83
		#61 Sept. 1, 1987	#83
#61 Sept. 1, 1987 R1	#83	#61 Aug. 14, 1991	#65
#61 Aug. 14, 1991 R1	#65	#61 Aug. 27, 1992	#65
#61 Aug. 27, 1992 R1	#65	#61 May 11, 1994	#83
#61 Aug. 8, 1994 R1	#65		

stable throughout the years, with density changes between wedge calibrations generally corresponding to less than 0.01 N

Umkehr observations began at MLO with automated Dobson instrument 76 on March 12, 1984. Earlier, in 1983, the instrument had been optically and electronically overhauled, an "air-space" optical wedge was installed into it, and optical wedge and wavelength setting calibrations performed. Instrument 76 was then calibrated with Primary Standard Instrument 83 on August 17, 1983. This calibration, as well as those made subsequently having suffixes R1, R2, and X8, are listed in the table on the following page. Mu (μ) dependent N-tables derived from these calibrations with suffixes such as $U5_i$ and $M7_i$, used in final re-evaluation of the MLO total ozone and Umkehr data, are also shown in the table. (Handbook method 2.4 was resorted to in reprocessing of the MLO data because A-wavelength observations made with Dobson instrument 76 exhibited a μ dependency.)

When instrument 76 was first installed at MLO March 12, 1984, standard lamp readings were found to be in error by about 0.050 N unit. This was because a temperature sensor cable had accidentally become dislodged within

'Initial' Calibrations	Ref. Inst.	'Final' Calibrations	Ref. Inst.
#76 Aug. 17, 1983 R1	#83		#83
#76 Aug. 17, 1983 $U5_i$	#83	#76 Nov. 24, 1984 $U5_f$	#83
		#76 May 14, 1987 R2	#83
#76 Nov. 25, 1984 $U5_i$	#83	#76 May 14, 1987 $U5_f$	#83
#76 May 19, 1987 R1	#83		
#76 May 19, 1987 $U6_i$	#83	#76 June 8, 1991	#83
		#76 June 8, 1991 $U6_f$	#83
#76 June 9, 1991 R1	#83		
#76 June 9, 1991 $M7_i$	#83	(Used June 9-July 18, 1991, only)	
#76 Aug. 7, 1991 R1	#65		
#76 Aug. 7, 1991 $M8_i$	#65	(Used Aug. 7, 1991-June 28, 1992, only)	
#76 June 28, 1992X8	#65	(Used June 28, 1992-July 15, 1993, only)	
#76 June 16, 1993 R1	#83		
#76 June 16, 1993 $U9_i$	#83	(Used June 16, 1993-Feb. 22, 1994, only)	
#76 May 11, 1994 R1	#83		
#76 May 11, 1994 $M9_i$	#83		

the instrument, falling into the instrument's light beam to partially obstruct it. Operation of the instrument was, however, continued "as is" until November 24, 1984, when the problem was corrected and standard lamp readings reverted to normal values. On November 24, also, a smudge observed on the instrument's optical wedge was cleaned off the wedge. Re-evaluation of the March 12-November 24, 1984, MLO ozone data was based, therefore, on the August 17, 1983 R1 calibration of instrument 76, with standard lamp corrections applied.

When Dobson instrument 76 was next calibrated May 14, 1987, a change was noted in its optical wedge densities. This was assumed to have resulted from cleaning of the wedge in November 1984. The November 25, 1984-May 14, 1987 MLO ozone data re-processing was, therefore, based on the May 14, 1987 R2 calibration of Dobson instrument 76, with the processing performed backwards in time to 1994.

Calibration of Dobson instrument 76 on June 9, 1991, showed worsening of its A-wavelength μ dependency. A decision was therefore made in July to return the instrument to Boulder to correct the problem. While in Boulder during late July to early August, 1991, all quartz optical components were cleaned, sticky mirror M1 was repaired, scratched mirror M2 was replaced, and a corroded cobalt filter was re-polished. The instrument was then re-calibrated August 7, 1991, exhibiting considerably less A-wavelength μ dependency. Instrument 76 was then returned to MLO where observations began again on August 7, 1991.

Operation of the instrument 76 continued at MLO uneventfully until June 28, 1992 when suddenly a problem surfaced, causing AD-wavelength total ozone observations to be too high by about 3%. Subsequently, on June 16, 1993, the problem was traced to a faulty spring that adversely affected the instrument's automatic balancing of the optical wedge when observations were being made on D wavelengths. The wedge setting error was determined to be 0.010 N_D unit. The June 28, 1992-July 16, 1993 MLO ozone data were, therefore, re-processed using N-tables #76 June 28, 1992 X8, equivalent to the #76 August 7, 1991 N-tables, but with 0.010 unit added to N_D values. The corrected data, when compared with observations made with Dobson instrument 83 at MLO during part of the time interval under consideration, were found to be satisfactory.

Following correction of instrument 76's mechanical problem, the instrument was re-calibrated on June 16, 1993. Ozone observations were then continued at MLO through February 22, 1994, when a band broke on the instrument's optical wedge. Repair of the wedge was made in Boulder ,with re-calibration of the instrument on April 12, 1994. Shortly after return of instrument 76 to MLO the band on the optical wedge broke again. The instrument was once again returned to Boulder for repair, and re-calibration on May 11, 1994. (Because of problems with the optical wedge, ozone observations were not made at MLO during February 22-May 25, 1994.) Ozone observation at MLO have continued into 1996 without interruption since May 26, 1994.

5. WODC Re-evaluated Total Ozone Data Archive

As indicated earlier, total ozone data re-evaluated under D.O.E. Interagency Agreement DE-A103-93ER61726 included data not only from the 10 stations Amundsen Scott, Byrd, Fairbanks, Hallett, Huancayo, Haute Provence, Lauder, Perth, Poker Flat, and Puerto Montt, but also 1990s portions of records from Caribou, Bismarck, Boulder, Wallops Island, Nashville, Fresno, Mauna Loa Observatory and Samoa Observatory. These data from 18 stations, representing 327 station years of data and shown in Figures 2 and 3 as monthly means, will be submitted early in 1996 to the World Ozone Data Center (WODC) in Downsview, Ontario, Canada, for archiving.

Table 3 is a sample record of archived 1993 data from Boulder, Colorado. Listed in the extreme left hand column of the table are the station number, and the month and year of the observations. Total ozone data, together with auxiliary information, are recorded for each month in 8 columns of 4 lines each.

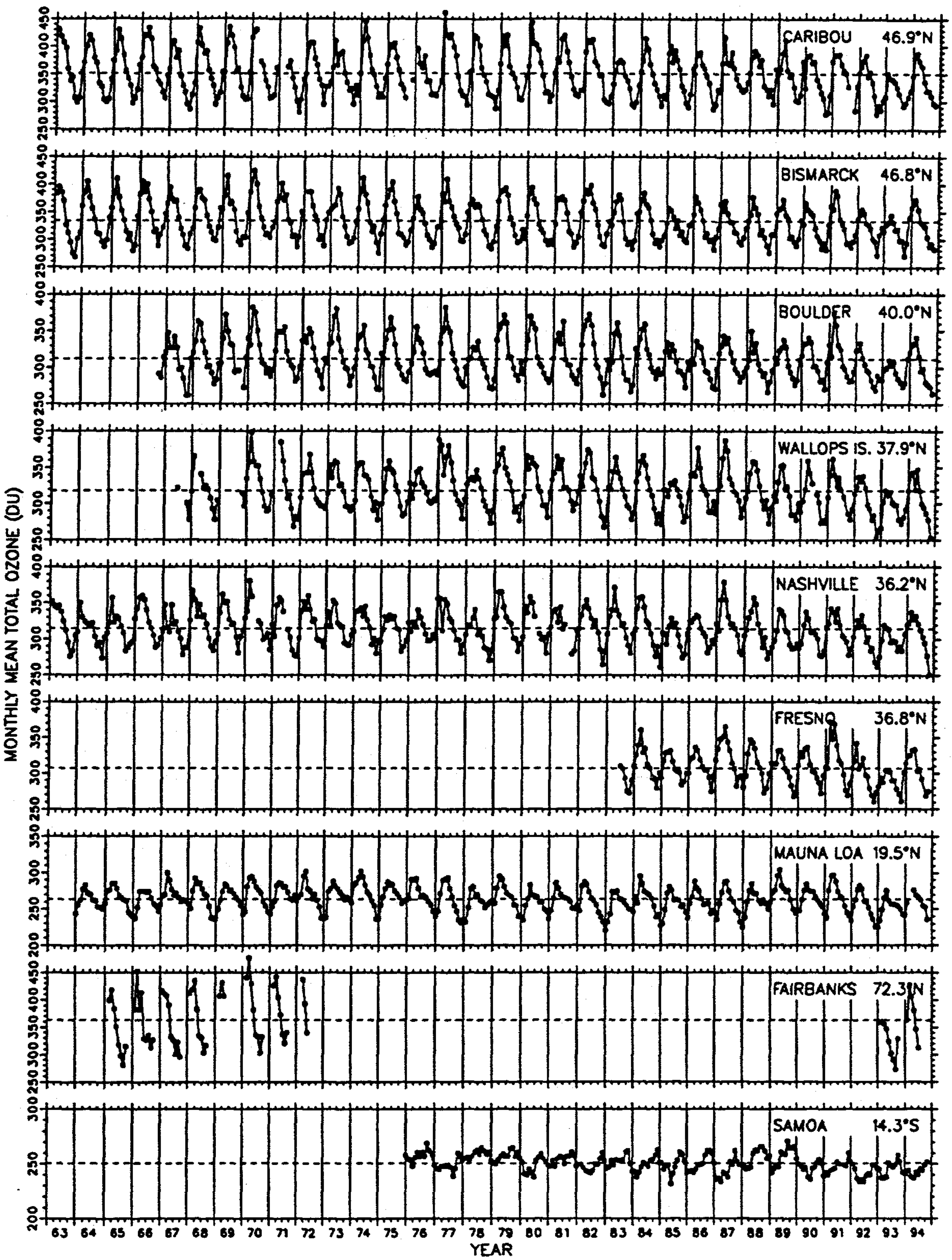

Figure 2. Total ozone monthly means from re-evaluated data, for stations indicated in the plots.

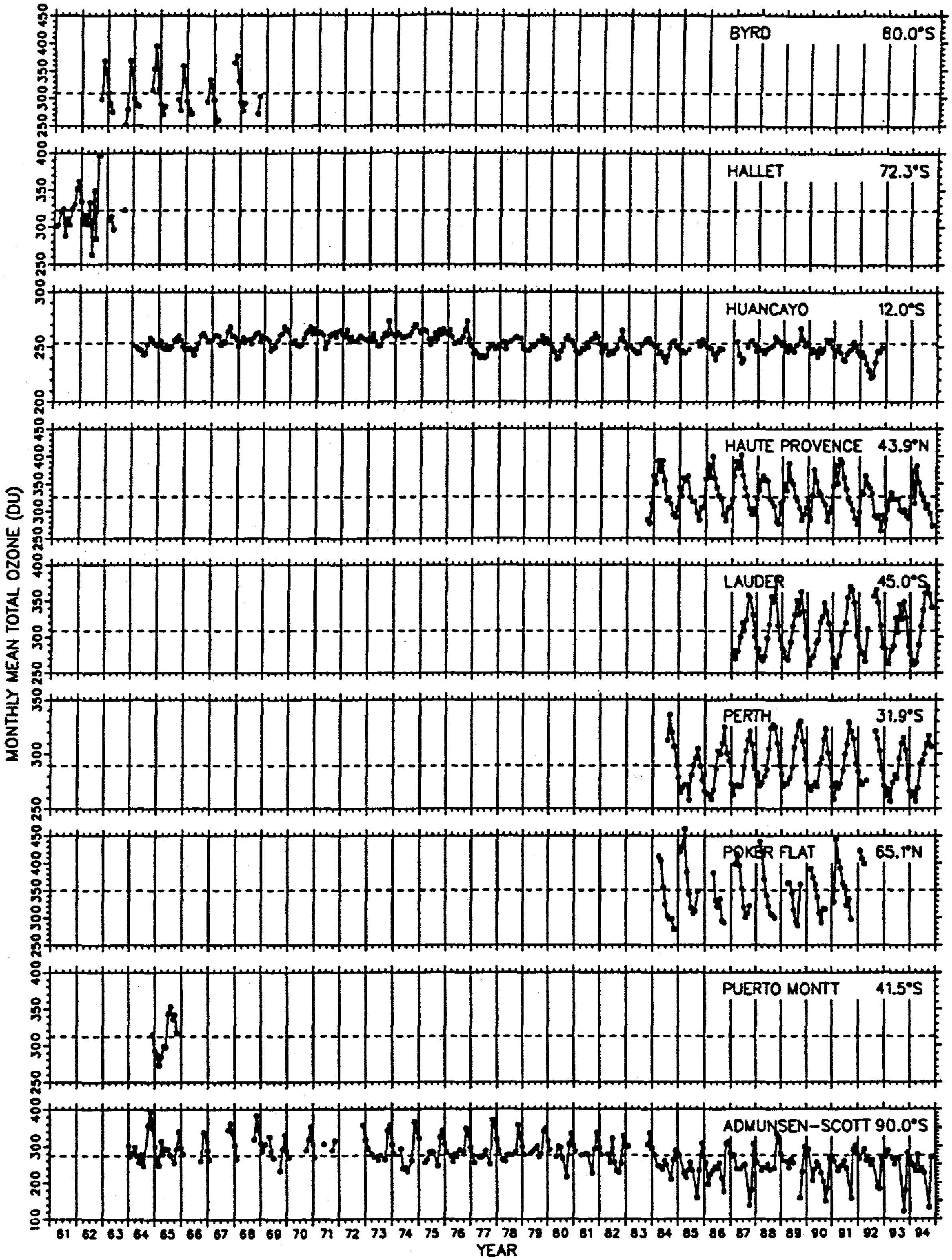

Figure 3. Total ozone monthly means from re-evaluated data for stations indicated in the plots.

Table 3. Sample Re-evaluated Total Ozone Data Archived at the WODC

6710193				1900308	1700326	2100285	1804258	2125285
6720193			1800266	1800275	1805266	1900277	2100280	
6730193			2125321	1900294	1800288	1800293		
6740193	2100295	1800267	1900262	1800258	1903276			283
6710293	1900257	2100280	1905318	2100283	1900276			2100255
6720293	2100259	1904297	1900275	2100305				2125378
6730293	1900301	1900278	1900279			2100317	1900330	1904319
6740293	1904311	2100319						297
6710393	2000330	1700303	1900293	1900305	1700314			1900293
6720393	1700287	1906309		1700318			1900326	1900312
6730393	1705284	1900287	2100306			2100318	1900271	1900262
6740393	1700275	1900275			1505326		1800306	300
6710493	1700295	1900308			1900313	1706332	1700330	1900303
6720493	2200307			1700304	2100312	1700313	1800325	2100332
6730493			1700340	1900314	1700295	1700288	1700306	
6740493		1900278	1900298	1900305	1900315	1800334		311
6710593			1900321	1900313	1900325	1900333	2300332	
6720593		1900287	1600290	1703293	2106280	2100283		
6730593	1705327	1800306	2100306	1700287	1900287			1704304
6740593	2106313	1700299	1700292	2106307				304
6710693	2200298	1900309	1700335	1704323			1900364	2100324
6720693	1700316	1900300	1900316			1900287	2205282	1900304
6730693		2406341			2200285	1700292	1900299	1900305

The reported total ozone value is chosen from the ensemble of observations made during each day to be representative of local apparent noon. Auxiliary information provided is the Universal Time (to the nearest hour) of the observation, the wavelengths on which measurements were made, and the viewing conditions (direct sun, clear zenith, cloudy zenith, etc.). The fourth data line in column 8 lists the mean total ozone for the month. The mean is computed from observations on all days of the month, and may not be representative of the true monthly mean if observations were made on fewer than 10 days. (For additional information about the coded data, see Guide Book No. 2, Ozone Data for the World, published by the Canadian Atmospheric Environment Service in cooperation with the World Meteorological Organization, Toronto, Canada).

Outliers in plotted, re-evaluated daily total ozone values were examined to identify erroneous data (e. g., due to observer error) as well as uncertain data whose reliability could not be definitively ascertained. Decisions regarding reliability of outliers were made following examination of raw and processed data for all the observations made during days when outliers occurred. The number of daily total ozone values identified as erroneous in the 327 station-years of data was surprisingly small, only 47, or approximately 0.05% of the total body of data. Similarly, only 172 daily total ozone values were flagged to be uncertain, or about 0.2% of the entire data set.

Erroneous data have not been included in the WODC archive. Uncertain data are identified in the archive with asterisks. These, generally, should not be excluded from the main body of data when performing data analyses.

Use of data from the Total Ozone Mapping Spectrometer (TOMS) instrument was not invoked in the data flagging process described above except as a check in the case of the MLO and the SMO data. For MLO during 1979-1993, the approximate life-time of the TOMS instrument, total ozone values on only 5 of 15 days, flagged as being uncertain, would have been rejected as erroneous had the TOMS data, also, been used as flagging criteria. For the same time interval, total ozone data on 12 of 21 days at SMO, flagged as uncertain on the basis of Dobson instrument data alone, would have been identified as erroneous considering, also, the TOMS measurements.

6. Re-Evaluation of Observational Umkehr Data

A sample record of Boulder, Colorado, Umkehr data prepared for archiving is shown in Table 4. Numbers in the first column of the table specify the days, months, and year of the observations. Those in column 2 indicate whether the observations were made in the morning (1) or afternoon (2); the wavelengths on which observations were made: (1), (3), and (4) being A, C, and D wavelengths, respectively; the kinds of total ozone observations made, e.g., (00) denotes AD-wavelength direct sun observations; and finally the measured

Table 4. Sample Coded Umkehr Data Archived at the WODC

010491	2100331	79	253	485	698	750	839	917	922	910	890	846	780	719	639	67
010491	2300331	457	544	670	811	853	946	97	236	273	300	316	301	274	233	67
010491	2400331	140	184	249	323	346	398	493	614	661	711	784	838	855	854	67
040491	1100339	75	251	487	699	752	841	925	935	916	888	829	734	650	579	67
040491	1300339	450	539	669	809	853	948	108	258	293	317	327	305	272	222	67
040491	1400339	131	178	243	321	344	398	502	633	683	732	800	850	867	863	67
080491	1100398	247	423	648	847	892	967	34	29	5	972	904	813	741	675	67
080491	1300398	542	634	762	908	951	43	194	330	362	383	388	359	320	270	67
080491	1400398	183	231	295	373	398	452	551	679	726	771	833	881	899	895	67
090491	1100362	165	360	601	810	855	935	7	993	970	936	869	776	701	633	67
090491	1300362	498	598	735	885	928	22	175	310	341	361	369	345	308	255	67
090491	1400362	157	208	280	361	385	441	544	673	720	767	832	880	894	888	67
100491	1100360	142	321	553	760	809	895	972	966	946	915	843	744	666	596	67
100491	1300360	489	581	711	854	895	987	137	278	314	339	344	315	277	224	67
100491	1400360	156	203	268	345	369	422	519	642	689	737	807	859	876	872	67
170491	2100341	-1	-1	-1	-1	-1	885	979	992	975	949	890	802	724	637	67
170491	2300341	-1	-1	-1	-1	-1	957	114	280	326	359	374	347	307	251	67
170491	2400341	-1	-1	-1	-1	-1	408	499	633	686	740	817	874	893	889	67
260491	1300392	-1	-1	770	914	952	40	186	314	346	367	374	349	311	252	67
270491	1300352	492	581	709	848	888	975	122	269	307	334	345	319	279	225	67

total ozone amount in DU. Columns 3 to 16 of the table then list the measured Umkehr observation N-values (Log I/I' + constant) to 3 decimal places for the solar zenith angles 60°, 65°, 70°, 74°, 75°, 77°, 80°, 83°, 85°, 86.5°, 88°, 89°, and 90°. (When Log I/I' + constant exceeds unity, the integer value is omitted.) The last column of Table 4 lists the WMO number of the station reporting the data. (For additional information about coded Umkehr data see Guide Book No. 2, Ozone Data for the World, published by the Canadian Atmospheric Environment Service, Downsview, Ontario, Canada, in cooperation with the WMO.)

While final N-tables have been established for re-evaluating Umkehr data from all stations through 1995, considerable work remains to be done [G.L. Koenig, NOAA/CMDL, Boulder, Colorado]. Re-evaluation of the MLO record is nearing completion. Umkehr data from Boulder, Haute Provence, Huancayo, Lauder, Perth , and Poker Flat, processed in the past through 1991, are currently undergoing re-evaluation. Data from these stations obtained since 1991, however, await first processing.

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Financial support for re-evaluation of portions of total ozone data records from the U.S.A. mainland stations, and from Hawaii and Samoa, was provided by the NOAA National Environmental Satellite, Data, and Information Service (NESDIS). G.L. Koenig of NOAA/CMDL is continuing re-evaluation of Umkehr data, with funding support from NESDIS.

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<u>Appendix A</u>

DOBSON DATA RE-EVALUATION HANDBOOK
Section II: Re-evaluation of instruments Constants

October 1993

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DOBSON DATA RE-EVALUATION HANDBOOK

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* <u>Note:</u> Only "Section 2: Re-evaluation of Instrument Constants" has been reproduced in Appendix I which describes in detail the methodology used in re-evaluating the NOAA total ozone data.

Introduction

Two international Workshops addressing the state of the total ozone data set obtained by the global network of Dobson spectrophotometer stations have recently been held.

The First International Dobson Ozone Data Workshop was held September 11-13, 1991 in the Washington, D.C., area. The Workshop participants discussed the shortcomings of the existing data set and the need for a revised, more accurate data set useable for climate trend analyses and also for satellite comparisons. The participants recommended a second Workshop where those who have already reanalyzed their data sets would present their procedures and results to those station operators who have not yet begun reanalysis of their own data sets or who have applied incorrect procedures

The Second International Workshop was held June 1-3, 1992, in conjunction with the Quadrennial Ozone Symposium at Charlottesville, Virginia. The major recommendation of the participants of this Second Workshop was to prepare a Handbook which will contain procedures, algorithms, etc, useful for re-evaluating historical Dobson data sets. Primary authors and contributors were solicited from the international Dobson community.

This Handbook follows the consensus of the participants of the Second Workshop. It has been reviewed by a significant segment of the Dobson community and thereby is considered a library reference alongside previous publications which have become standards over the years.

SECTION II: RE-EVALUATION OF INSTRUMENT CONSTANTS

WALTER D. KOMHYR

2. Final Dobson Spectrophotometer Data Processing Using Re-Evaluated Instrument Constants

This section describes procedures for determining and applying final corrections to raw observational Dobson spectrophotometer total ozone data obtained with instruments that have been periodically calibrated relative to World Standard Dobson Spectrophotometer 83 or relative to a secondary standard Dobson instrument with calibration traceable to instrument 83. The long-term ozone measurement precision of Dobson instrument 83 has been maintained to better than ±1% since 1962 [Komhyr et al., 1989]. The technique of calibrating all instruments of the global Dobson instrument network relative to instrument 83 standardizes total ozone measurements throughout the world, causing ozone data from all instruments to be directly comparable.

The correction methods described herein apply, furthermore, to Dobson instruments that have been operated according to procedures described by Dobson [1957] in the "Observers' Handbook for the Ozone Spectrophotometer" and by Komhyr [1980] in WMO Report No. 6 entitled "Operations Handbook--Ozone Observations with a Dobson Spectrophotometer." In addition to having "initial" and "final" calibrations relative to Dobson instrument 83, such instruments have had performed on them Hg lamp (wavelength-setting) tests and standard lamp tests at monthly intervals, and optical wedge re-calibrations every several years.

Data reprocessing procedures are described in the following sections for three cases. First, we consider the situation where a change occurred in the spectral characteristics of a Dobson instrument with time, but instrument optical wedge characteristics remained unchanged, and the observational data were not highly air mass (μ) dependent. Second, we treat the case where a Dobson instrument, with a well calibrated optical wedge, exhibits excessive μ dependency in observed ozone values relative to ozone values measured simultaneously with Dobson instrument 83 or with a secondary standard Dobson instrument. Finally, procedures are described for reprocessing and correcting Dobson instrument data obtained during observing time intervals when a change occurred in the instrument's optical wedge. In the case considered, corrections are also made for an additional change in instrument spectral characteristics and, for μ-dependency in the observations.

The re-evaluated Dobson instrument data must be kept independent of other ozone data sets. Thus, ozone data from satellite instrument ozone observations, for example, should not be used in correcting the Dobson instrument data.

2.1 Use of Vigroux Ozone Absorption Coefficient Scale for Data Reprocessing

Final data processing for observations made during 1 July 1957 through 31 December 1991 should be performed using the Vigroux [1953, 1967] ozone absorption coefficient scale, with the 1.388 cm^{-1} absorption coefficient for AD wavelengths adopted as standard. Final results are ultimately to be archived at the WODC in Toronto, Canada, where all ozone values will be converted to the Bass-Paur [1985] ozone absorption coefficient scale as adapted for use with Dobson instruments by Komhyr et al. [1993]. The Bass-Paur [1985] ozone absorption coefficients were adopted for use throughout the world for Dobson instrument data processing beginning January 1, 1992 [Hudson et al., 1991]. On January 1, 1992, also, new improved Rayleigh molecular scattering coefficients were adopted for use for total ozone data processing [Komhyr et al., 1993]. The combined effect of the use of the new ozone absorption and molecular scattering coefficients has been to decrease ozone values by 2.6% compared to values obtained in the past.

2.2 Dobson Instrument 83 and 65 Calibration Scales

Dobson instrument 83 calibration scales, relative to which Dobson instruments have been calibrated throughout the years, are the following:

#83 June 18, 1962
#83 June 26, 1972
#83 August 26, 1976
#83 July 10, 1987
#83 August 26, 1991

Detailed information regarding slightly improved (F1) versions of these scales is presented in Appendix 2.A in the form of N_A, N_C, and N_D tables with associated reference standard lamp readings. Except for the June 26, 1972, calibration scale, N_A, N_C, and N_D values in the updated F1 scales are 0.004, 0.002, and 0.001 units larger, respectively, than those in the original scales, causing computed ozone values to be about 0.3% larger (at air mass ~2 and total ozone 300 DU) than values obtained using the original scales. The small scale change arose from improved calculations of μ at Mauna Loa Observatory, the site of Dobson instrument 83 calibrations, as well as from correction of a small glitch in earlier computations of Julian calendar day.

Due to an inadvertent computational error, the #83 June 26, 1972, calibration scale was originally established inaccurately. It is especially important, therefore, to correct any calibration data obtained in the past using this scale with the corrected and updated #83 June 26, 1972 F1 scale given in Appendix 2A.

The instrument 83 calibration scales are basically interchangeable. Thus, either the #83 July 10, 1987 F1 scale or the #83 August 26, 1991 F1 scale can be used successfully in processing calibration data for a field Dobson spectrophotometer calibrated on, say, a day in 1989.

Because a number of Dobson spectrophotometers have been calibrated relative to NOAA/CMDL secondary standard Dobson instrument 65, we provide in Appendix 2.B the F1 calibration scales for instrument 65. The scales are designated as:

#65 April 10, 1981 F1
#65 May 21, 1990 F1
#65 August 30, 1991 F1.

Instrument 65 and 83 calibration scales were essentially identical through 1991 but began to diverge in 1992 causing instrument 65 ozone values to be larger than those of instrument 83 by 1%. The cause of the discrepant results is under investigation.

2.3 Data Reprocessing Procedures - Stable Dobson Instrument Optical Wedge and No μ-Dependency in the Observations

We describe here the application of final corrections to Dobson instrument observational N_A, N_C, $N_{C'}$, and N_D values obtained during a time interval when a significant change occurred in the spectral characteristics of the instrument as revealed by a "final" calibration of the instrument relative to a standard spectrophotometer, but when the instrument's optical wedge characteristics remained unchanged, and when μ-dependence was not present in the observations. (In the example to follow, some μ-dependency is present, but for purposes of illustration, we will assume it to be insignificant.). The data processing procedures described here are useful, also, for improving the quality of ozone data obtained during a time interval for which an "initial" instrument calibration relative to a standard may have lacked high precision.

Gradual changes in Dobson instrument spectral characteristics may occur, for example, due to corrosion of the instrument's cobalt filter[1], contamination of the instrument's optics, or an aging photomultiplier tube. While such changes in special characteristics are largely compensated for by the application of monthly standard lamp test corrections during data processing, residual errors may remain. Abrupt changes in Dobson instrument spectral characteristics may arise due to accidental instrument jarring which may disturb instrument optical alignment, sudden

[1]This occurs in humid atmospheres when the instrument silica gel air drier is not renewed often enough.

optical contamination, or when partial damage occurs to the instrument photomultiplier due to inadvertent exposure to excessive light.

As an illustrative example of such data reprocessing, Appendix 2.C shows "initial" and "final" calibration data for Dobson spectrophotometer 33 relative to standard instrument 83 obtained April 15, 1986, and May 11, 1988. The "initial" calibration data include newly established reference N tables and standard lamp readings dated April 15, 1986 R1. The "final" instrument 33 calibration, performed May 11, 1988, showed that mean corrections of -0.59, -0.72, and -1.79 were needed, respectively, to $100N_A$, $100N_C$, and $100N_D$ values[2] of the April 15, 1986 R1 N tables used for data processing. (These mean corrections were deduced from instrument 33 and 83 comparison ozone data obtained in the μ-range 1.15-2.5.). The correction needed to $100N_{AD}$ values was, therefore, 1.21, which is significant.

In final processing of April 15, 1986-May 11, 1988, observational ozone data, we begin by using the reference N tables and standard lamp readings dated April 15, 1986 R1 (Appendix 2.C). For an AD-DSGQP type observation, for example, correct N_A and N_D values are deduced from

$$N_A = N_A' + \Delta N_A + \Delta N_A(t) \qquad (1)$$

$$N_D = N_D' + \Delta N_D + \Delta N_D(t) \qquad (2)$$

Where N_A' and N_D' are obtained from the April 15, 1986 R1 N tables corresponding to the Dobson instrument observational dial readings R_A and R_D, respectively; the ΔN's are the standard lamp corrections to the N values, determined from differences in reference standard lamp N values dated April 15, 1986 R1 and N values determined by linear interpolation of routine monthly standard lamp test data; and the $\Delta N(t)$ are the time-dependent N-value drift corrections determined from the "final" calibration of instrument made May 11, 1988 (Appendix 2.C). The time dependent function to be used in applying the drift corrections may be linear, exponential, step, etc., or a combination of these. Standard lamp test history as well as other pertinent instrument information should be examined in establishing the time dependent function to use when applying the drift corrections.

The following numerical example illustrates the procedures described above for final data processing.

(a) We consider an AD-DSGQP observation made at Bismarck, North Dakota, April 3, 1987, at 18h 20m 00s UT (μ=1.339). The

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[2]A convention is employed in expressing N values in Appendices 2.C-2.E whereby true N values are multiplied by 100.

observation yielded mean $R_A = 122.4°$ and mean $R_D = 39.9°$. From the N tables dated April 15, 1986 R1 (Appendix 2.C), we obtain $100N'_A = 98.1$ and $100N'_D = 33.4$.

(b) Standard lamp corrections needed this day (not shown), determined by linear interpolation from lamp tests made March 29, 1987, and April 27, 1987, were $100\Delta N_A = -1.0$ and $100\Delta N_D = -0.7$.

(c) With regard to the $\Delta N(t)$ corrections, Appendix 2.C shows that during April 15, 1986 to May 11, 1988, Dobson instrument 33 standard lamp N value readings changed by about two 100N units. Examination of the monthly standard lamp test data for the instrument showed the change to have occurred approximately linearly with time. Therefore, using the N-value drift correction data shown on the last page of Appendix 2.C, and considering that April 3, 1987, occurred 0.467 of the way into the time interval April 15, 1986-May 11, 1988, we have that

$$100\Delta N_A(t) = 0.467(-0.59 -0.00) = -0.276$$

$$100\Delta N_D(t) = 0.467(-1.79 -0.00) = -0.836$$

(d) Evaluating relations (1) and (2), then we have

$$N_A = 0.981 -0.010 -0.003 = 0.968$$

$$N_D = 0.334 -0.007 -0.008 = 0.319$$

Finally, total ozone amount for the observation, computed using Vigroux ozone absorption coefficients, is

$$X_{AD} = 1000\left[\frac{0.968 -0.319}{1.388(1.339)} -0.008\right] = 341 \text{ DU}$$

Monthly standard lamp N-value corrections and the N-value calibration drift corrections should be applied not only to direct sun observational data, but also to data obtained from zenith-sky observations. Corrections to $N_{C'}$ values are determined from routine, monthly standard lamp tests. For standard lamp corrections to be reliable, it is important always to have operated the standard lamps at correct voltages.

2.4 Data Reprocessing Procedures - Stable Instrument Optical Wedge, but Data Exhibiting μ-Dependency

Here we consider the situation where calibration ozone data, obtained with a spectrophotometer having a well calibrated, stable optical wedge, exhibit significant μ-dependency relative to ozone measured coincidentally with a standard spectrophotometer. Cause of the μ-dependency may be use with the instrument of an erroneous wavelength setting table; some defect in instrument optical alignment; or one or more defective optical components, e.g., a quartz prism fabricated from inferior quality quartz that attenuates ultraviolet radiation excessively, a cobalt filter with insufficient opacity at near ultraviolet wavelengths, or a corroded cobalt filter that slightly alters the effective wavelengths passing through the Dobson instrument during observations. Because the exact cause of the μ-dependency is often difficult to determine, it is important not to over correct for it. If AD wavelength calibration ozone data for an instrument vary by less than about ±1% relative to the standard Dobson instrument ozone values for $1.15<\mu<2.5$, then μ-dependent corrections are most likely not worthwhile applying. Corrections may not be necessary, also, when single pair wavelength ozone observations exhibit significant μ-dependency, but double pair wavelength observations do not.

2.4.1 Observations Made on Non-Standard Wavelengths

This may occur when a Q-setting table is inadvertently established incorrectly for one or more of the Dobson instrument wavelength pairs. The standard ozone absorption coefficients, then, do not apply. However, by using more appropriate (effective) absorption coefficients, the μ-dependency in the ozone observations can be largely eliminated.

The procedure for establishing a double pair wavelength (e.g., AD wavelength) effective ozone absorption coefficient for a spectrophotometer (say, instrument 63) and calibrating it relative to a standard spectrophotometer (say, instrument 83) is as follows: Simultaneous AD-DSGQP observations are made with the two instruments during one-half day as μ varies between 1.15 and 2.5. For instrument 63 properly calibrated, we have for any observations pair

$$X_{AD}^{63} = X_{AD}^{83}$$

and

$$\frac{N_{AD}^{63} + \Delta N_{AD}^{63}}{\alpha_{AD}^{63}\mu} - \frac{\beta_{AD}mp}{\alpha_{AD}^{63}\mu p_0} = \frac{N_{AD}^{83}}{\alpha_{AD}^{83}\mu} - \frac{\beta_{AD}mp}{\alpha_{AD}^{83}\mu p_0}$$

where

ΔN_{AD}^{63} = Correction needed to Dobson instrument 63 N_{AD} values, and

α_{AD}^{63} = Effective AD wavelength ozone absorption coefficient for instrument 63.

In the above relation, the two terms containing the Rayleigh scattering coefficients, β_{AD}, are approximately equal and cancel for observations on double pair wavelengths. The relation may then be written as

$$N_{AD}^{63} = \alpha_{AD}^{63}\left[\frac{N_{AD}^{83}}{\alpha_{AD}^{83}}\right] - \Delta N_{AD}^{63}$$

A plot of N_{AD}^{63} vs. $N_{AD}^{83}/\alpha_{AD}^{83}$ observational data yields a straight line with slope α_{AD}^{63} and intercept $-\Delta N_{AD}^{63}$. Thus, the effective AD wavelength ozone absorption coefficient is determined for the instrument, together with the correction to the instrument's N-tables.

For single pair wavelength observations (e.g., the D wavelengths), the Rayleigh scattering terms referred to above become significantly different, so that the above method cannot be used e.g., to determine α_D^{63}. However, α_D^{63} and corrections to N_D^{63} values can be obtained by a successive approximation method. For an instrument measuring, e.g., ozone amounts too high at low μ, ozone amounts are computed using decreased α_D^{63} and N_D^{63} values. Final α_D^{63} and N_D^{63} values are chosen that yield measured ozone amounts closely similar to those obtained with the standard instrument 83 for all μ.

2.4.2 Correcting for μ-Dependency Due to Other Causes

This section describes more general but approximate procedures for correcting for μ-dependency in ozone observations arising, for example, from light scattering within the instrument or other causes, including wavelength setting errors. As shown in section 2.5, the method can be used, if necessary, when correcting ozone data obtained with a spectrophotometer whose optical wedge characteristics changed with time.

For illustration, Appendix 2.D shows "initial" and "final" calibration data for Dobson spectrophotometer 79, relative to standard Dobson instrument 83, obtained August 25, 1981, and June 19, 1985. Note that for the August 25, 1981 R1 calibration, significant μ-dependent N_A-, N_C-, and N_D-value differences exist for instrument 79 relative to corresponding N-values for instrument 83. These are defined by the linear relations:

$$100\Delta N_A(\mu)_i = -27.28 + 0.9992\mu + 25.51 \tag{3}$$

$$100\Delta N_C(\mu)_i = -26.38 + 0.5846\mu + 25.34 \tag{4}$$

$$100\Delta N_D(\mu)_i = -28.55 + 0.5106\mu + 27.65 \tag{5}$$

ΔN_{AD} and ΔN_{CD} differences for the two instruments on the other hand, are relatively μ-independent giving rise to μ-dependent ozone differences for instrument 79 versus instrument 83 of only $\pm 0.5\%$ for $1.15 \le \mu \le 3.2$.

The final calibration data for Dobson instrument 79, of June 19, 1985 (Appendix 2.D), not only show a highly significant μ-dependency in N_C values relative to Dobson instrument 83 N_C values but also slope reversals in the case of the instrument 79 μ-dependent N_C and N_D values compared to corresponding results obtained in 1981. Again, ΔN_{AD} differences for the two instruments are relatively independent of μ, but ΔN_{CD} differences are highly μ-dependent, causing instrument 79 X_{CD} values to be underestimated by 4.7% at $\mu = 1.33$ but overestimated at $\mu = 2.85$ by 1.9%. As shown in Appendix 2.D, the μ-dependency in the instrument 79 calibration data of June 19, 1985, is defined by

$$100\Delta N_A(\mu)_f = 0.7067 - 3.5786\mu + 1.1641\mu^2 - 0.0903\mu^3 \tag{6}$$

$$100\Delta N_C(\mu)_f = -0.1559 + 2.4719\mu - 2.5068\mu^2 + 0.4657\mu^3 \tag{7}$$

$$100\Delta N_D(\mu)_f = -5.3086 + 10.2567\mu - 5.1692\mu^2 + 0.7756\mu^3 \tag{8}$$

Final processing of ozone data obtained with Dobson instrument 79 during August 25, 1981-June 19, 1985, is performed using the August 25, 1981 R1 N tables and reference standard lamp data given in Appendix 2.D. To process an observation made, for example, on A and D wavelengths, first convert observed mean R_A and R_D (instrument dial reading) values to N'_A and N'_D values where the primes indicate (as in section 2.3) that additional N-value corrections are needed. Then apply standard lamp corrections ΔN_A and ΔN_D to these values based on monthly standard lamp tests as described in section 2.3. Corrected N_A and N_D values for the observation are then obtained from

$$N_A = N'_A + \Delta N_A + \Delta N_A(\mu,t) \tag{9}$$

$$N_D = N'_D + \Delta N_D + \Delta N_D(\mu,t) \tag{10}$$

where $\Delta N_A(\mu,t)$ and $\Delta N_D(\mu,t)$ are needed additional μ and time dependent N-value corrections.

Information on how the μ-dependent N-value correction changed with time must be gleaned from an examination of the instrument's standard lamp test history and other relevant instrument information. For the purpose of illustration, we assume here that the change occurred approximately linearly with time and independently of measured total ozone. We have then

$$\Delta N_A(\mu,t) = \Delta N_A(\mu)_i + r(\Delta N_A(\mu)_f - \Delta N_A(\mu)_i) \tag{11}$$

$$\Delta N_D(\mu,t) = \Delta N_D(\mu)_i + r(\Delta N_D(\mu)_f - \Delta N_D(\mu)_i) \tag{12}$$

when r is the fraction of time that elapsed on the day of the observation since August 25, 1981, within the observing time interval under consideration.

The following numerical example illustrates the procedures described above for final data processing.

(a) We consider an AD-DSGQP observation made at Nashville, Tennessee, June 29, 1983 at 18h, 19m, 00s UT (μ = 1.033). The observation yielded mean R_A = 96.9° and R_D = 51.3°. From the N tables dated August 25, 1981 R1 (Appendix 2.D) we obtain, corresponding to the instrument dial readings, $100N_A'$ = 67.9 and $100N_D'$ = 22.1.

(b) Corrections (not shown) needed on June 29, 1983 to N values, based on monthly standard lamp test data, were $100\Delta N_A$ = 3.0 and $100\Delta N_D$ = 2.4.

(c) Evaluating relations (3), (5), (6), and (8) above for μ = 1.033 to obtain the needed μ-dependent N-value corrections, we have

$$100\Delta N_A(\mu)_i = -27.28 + 1.032 + 25.51 = -0.738$$

$$100\Delta N_D(\mu)_i = -28.55 + 0.527 + 27.65 = -0.373$$

$$100\Delta N_A(\mu)_f = 0.7067 - 3.6967 + 1.2422 - 0.0995 = -1.847$$

$$100\Delta N_D(\mu)_f = -5.3086 + 10.5952 - 5.5160 + 0.8549 = 0.626$$

(d) For the observation made June 29, 1983, the fraction of time, r, that elapsed since August 25, 1981 within the time interval August 25, 1981-June 19, 1985, is 0.483. Evaluating relations (11)-(12) we then have

$$\Delta N_A(\mu,t) = -0.0074 + 0.483(-0.0185 + 0.0074) = -0.013$$

$$\Delta N_D(\mu,t) = -0.0037 + 0.483(0.0063 + 0.0037) = 0.0011$$

(e) Relations (9) and (10) are then evaluated to yield

$$N_A = 0.679 + 0.030 - 0.013 = 0.696$$

$$N_D = 0.221 + 0.024 + 0.001 = 0.246$$

Finally, total ozone amount for the observation, computed using Vigroux ozone absorption coefficients, is

$$X_{AD} = 1000\left[\frac{0.696-0.246}{1.388(1.033)} - 0.009\right] = 305 \text{ DU}$$

The method described above for final processing of μ-dependent observational ozone data involves N-value determinations from "initial" calibration mean N tables (derived from instrument 79 and 83 comparison calibration observations made at $1.15<\mu<2.5$) to which are added μ-dependent N-value corrections. An alternate procedure, yielding equivalent results, would be to use, instead, μ-dependent N tables comprised of G tables with associated μ-dependent ΔG values that convert the G tables to N tables. For the example considered, the μ-dependent ΔG values are defined by the three linear relations that appear on the top of the third page of Appendix 2.D.

2.5 Data Processing Procedures - Unstable Dobson Instrument Optical Wedge, Change in Instrument Spectral Characteristics, and μ-Dependency in the Observations

We finally consider the situation where, during a certain time interval, a change occurred in the Dobson instrument optical wedge characteristics. Here it is assumed that a reasonable estimate can be made of how the wedge changed with time, whether linearly, exponentially, or via a step function, etc.; and that optical wedge calibrations and instrument calibrations relative to a standard spectrophotometer were performed prior to and after the time interval of the wedge change. With such information, it is possible to improve reprocessed ozone data quality not only by largely accounting for the optical wedge change but also by substantially correcting for additional long-term instrument calibration drift that may have occurred due to causes described in sections 2.3 and 2.4 as well as for μ-dependency in the observations.

As an illustrative example, we consider total ozone data obtained at Nashville, Tennessee, with Dobson instrument 79 between September 10, 1975, and August 14, 1981. During this time interval the spectral characteristics of the optical wedge in instrument 79 changed significantly by up to about 0.035 unit, as indicated in Table 1.

Table 1. Optical Wedge Density Changes for Dobson Instrument 79 During September 9, 1975-August 24, 1981.

Inst. Dial Readings (°)	G_A 1981-G_A 1975	G_C 1981-G_C 1975	G_D 1981-G_D 1975
10	0.002	0.000	0.001
50	-0.005	-0.005	-0.006
100	-0.018	-0.017	-0.018
150	-0.021	-0.022	-0.021
200	-0.030	-0.033	-0.032
250	-0.033	-0.037	-0.032
290	-0.029	-0.035	-0.032

For final data processing, it is necessary to adopt some functional form for the temporal optical wedge density changes. As much available information as possible should be used in deciding on what functional form to adopt. We begin by examining standard lamp test data for Dobson instrument 79 (Figure 1). Here standard lamp 79C readings appear to be relatively constant during September 29, 1975-March 31, 1979, but then increase with time through August 14, 1981. Such data imply that the change in optical wedge densities may have begun about April 1, 1979, and proceeded in a linear fashion through 1981. But additional data suggest a different scenario. Examining all available calibration data (not shown) for instrument 79, we find that for the time interval defined by instrument 79 optical wedge calibration dates of July 23, 1962; July 7, 1971; October 17, 1973; September 9, 1975; August 24, 1981; and June 27, 1985, the optical wedge density rates of change were 0% yr^{-1}, 0.2% yr^{-1}, 0.6% yr^{-1}, 0.5% yr^{-1}, and 0.3% yr^{-1}, respectively. (These were determined from optical wedge density data for instrument 79 R-dial readings of 200°, and are assumed to be representative of density change rates throughout the wedge.) Thus the conclusion must be that instrument 79 optical wedge density characteristics changed approximately linearly throughout the entire observing interval under consideration, namely, September 10, 1975-August 14, 1981. What then caused the change in the character of the standard lamp readings beginning about April 1, 1979 (Figure 1)?

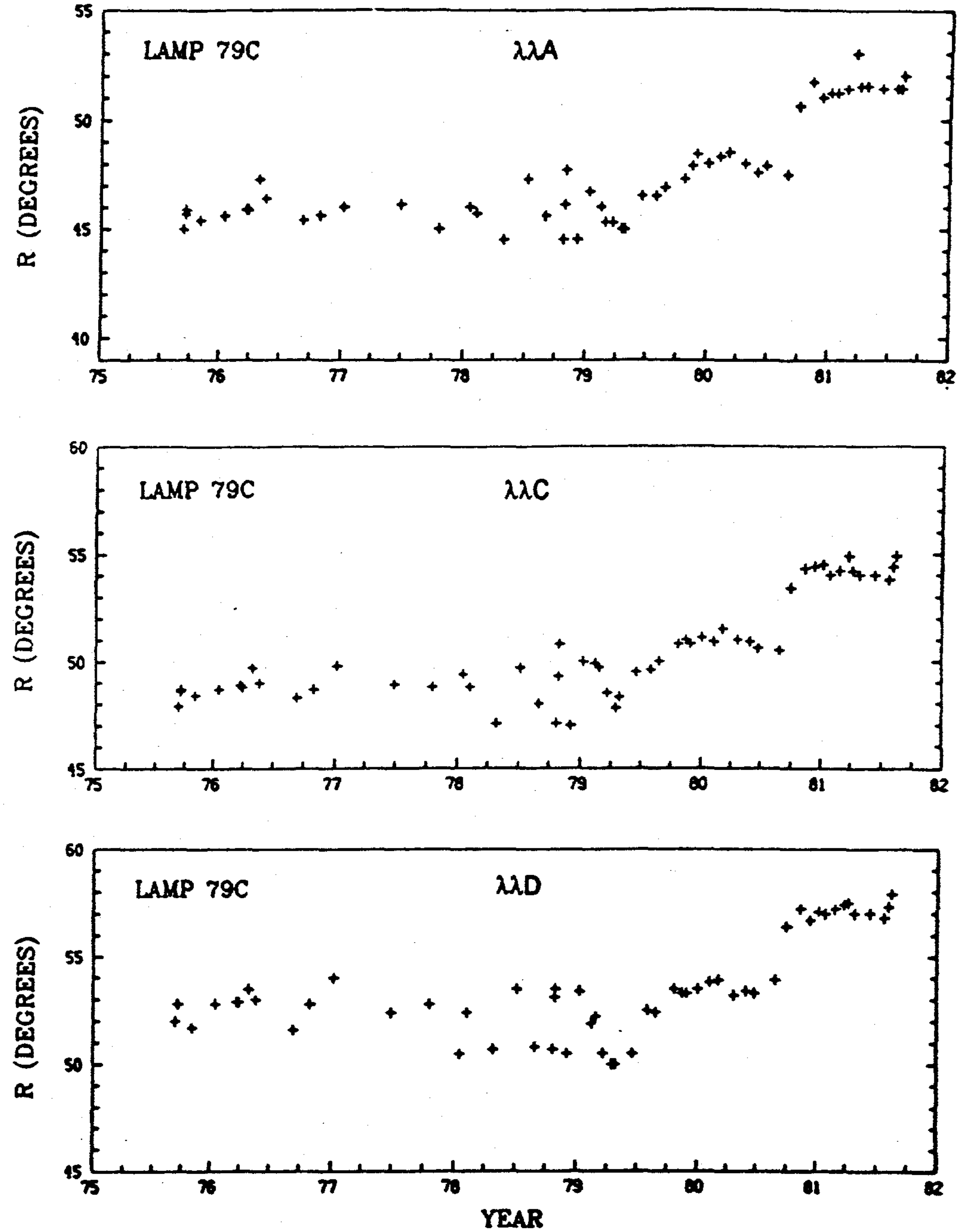

Figure 1. Standard Lamp 79C test data for Nashville Dobson instrument 79 obtained during September 1975-August 1991.

Our historical records show that in August 1981, when instrument 79 was received in Boulder, Colorado, the cobalt filter in front portions of the filter exhibiting a milky coloration. As indicated previously, filter corrosion occurs in humid air. (In 1975 the filter exhibited no sign of corrosion.) We surmise, therefore, that following about April 1, 1979, silica gel air drier within the instrument was not renewed often enough to keep the instrument dry. As a result, instrument 79 optical characteristics changed approximately linearly with time during April 1, 1979-August 24, 1981, due to cobalt filter deterioration.

In final processing of the total ozone data obtained at Nashville we, therefore, take the spectral characteristics of Dobson instrument 79 to have changed in part linearly with time during September 9, 1975-August 24, 1981, due to optical wedge density changes, and additionally linearly with time during April 1, 1979-August 24, 1981, due to cobalt filter deterioration. Final data processing should therefore, proceed as follows, where corrections are also made for μ-dependency in the instrument 79 observational data that were partly induced by the cobalt filter corrosion.

Appendix 2.E presents "initial" calibration data for Dobson instrument 79 relative to Dobson instrument 83 obtained September 10, 1975. Instrument 79 optical wedge density tables used in analyzing the calibration data were those determined September 9, 1975. Note (Appendix 2.E) that the calibration data for instrument 79 exhibit little μ dependency relative to instrument 83 data. The new calibration scale for Dobson instrument 79, dated September 10, 1975 R1, is presented in Appendix 2.E.

A "final" calibration of instrument 79 was conducted in Boulder on August 14, 1981. Appendix 2.E presents usual analysis data for the instrument comparison where standard lamp corrections to the data are applied and a change in instrument 79 calibration relative to its calibration of September 19, 1975 R1, is determined. (No account is taken here of instrument 79 optical wedge density changes.) Note (Appendix 2.E) the large instrument 79 calibration change (i.e., $\Delta N_{AD} = 0.0244$) that occurred during September 10, 1975-August 14, 1981, that was not corrected for by the application of standard lamp test data. This calibration change corresponds to AD-DSGQP ozone measurement errors on August 14, 1981, of 5.6% at $\mu = 1$, and 2% at $\mu = 3$. A large calibration change is evident, also, for CD wavelength observations made with instrument 79.

In Appendix 2.E the instrument 79 "final" calibration data of August 14, 1981, are processed using correct optical wedge density data, determined August 24, 1981. When processing the data, GA and GD values in the tables corresponding to instrument 79 observational R_A and R_D R-dial readings, respectively, are converted to N'_A and N'_D values[3] using the relations

$$N'_A = G_A + (N_{AS} - G_{AS}) \quad (13)$$

$$N'_D = G_D + (N_{DS} - G_{DS}) \quad (14)$$

where G_{AS} and G_{DS} are the G values obtained from the G tables dated August 24, 1981, corresponding to reference standard lamp readings R_{AS} and R_{DS} obtained August 14, 1981; and N_{AS} and N_{DS} are the reference lamps N values established September 10, 1975 (Appendix 2.E). In practice, mean results of tests with two or more reference standard lamps are used for the N-value determinations. For the example under consideration, mean $N_{AS} - G_{AS} = -0.292$ and mean $N_{DS} - G_{DS} = -0.304$ were computed from tests made August 14, 1981, with instrument 79 reference standard lamps 79C and 79D (Appendix 2.E).

Results of processing of the instrument 79 "final" calibration data of August 14, 1981, are summarized in Appendix 2.E. Note that use of correct optical wedge densities in the data processing has reduced former mean N_{AD} and N_{CD} calibration error of -0.0244 and -0.0099 (Appendix 2.E) to -0.0120 and -0.0035, respectively. We interpret the residual error to have resulted from Dobson instrument 79 spectral characteristics changes due to cobalt filter deterioration. Note that the errors exhibit a μ-dependency, part of which was an original spectral characteristic of Dobson instrument 79, but part of which was induced by the cobalt filter corrosion.

In reprocessing total ozone observational data (i.e., applying final corrections to the data) for example, for an AD-wavelength observation, it is first necessary to evaluate relations (13) and (14). Here the standard lamp N_{AS} and N_{DS} values are constants (Appendix 2.E), while the G_{AS} and G_{DS} values are derived for the day of the total ozone measurements from linear interpolation of monthly standard lamp test R_{AS} and R_{DS} values, as well as from the G-tables dated September 9, 1975, and August 24, 1981. The G_A and G_D terms in relations (13) and (14), corresponding to mean R_A and R_D values for the ozone observation, are also derived by linear interpolation from the September 9, 1975, and the August 24, 1981, G-tables. N'_A and N'_D values thus computed from (13) and (14) for the AD-wavelength observations are corrected for temporal drift of the optical wedge densities of Dobson instrument 79, but they are not corrected for the change in

[3]Primes associated with N_A and N_D values indicate that additional corrections to these values may be needed.

instrument 79 spectral characteristics that occurred during April 1, 1979-August 24, 1981, due to cobalt filter deterioration, including μ-dependency. Denoting these additional, time dependent corrections by $\Delta N_A(\mu,t)$ and $\Delta N_D(\mu,t)$, we have

$$N_A = N_A' + \Delta N_A(\mu,t) \tag{15}$$

$$N_D = N_D' + \Delta N_D(\mu,t) \tag{16}$$

where the N_A and N_D values are now corrected not only for the optical wedge calibration drift, but also for the cobalt filter deterioration effects as well as for observational time-dependent μ-dependency.

As indicated earlier, a small μ-dependency in instrument 79 ozone observations relative to instrument 83 ozone observations is evident in the "initial" calibration of instrument 79 on September 10, 1975 (Appendix 2.E). While a μ-dependency of this magnitude would not normally be considered for correction, we account for it here mainly to demonstrate the technique. As shown in Appendix 2.E, applicable μ-dependent corrections for Dobson instrument 79 September 10, 1975, were

$$\Delta N_A(\mu)_i = A + B\mu - \overline{G_A} \tag{17}$$

$$\Delta N_D(\mu)_i = C + D\mu - \overline{G_D} \tag{18}$$

where A, B, C, and D are constants, and the $\overline{G_A}$ and $\overline{G_D}$ are mean G-values deduced from the comparison observations made at $1.15<\mu<2.5$ that, when added to the G tables dated September 9, 1975, convert them to N-tables dated September 10, 1975. These linear relations[4] express N-value differences as a function of μ for Dobson instruments 79 and 83 on September 10, 1975. They are assumed to be independent of total ozone amount, and to remain unchanged during September 10, 1975-March 31, 1979, the time interval when standard lamp test data for instrument 79 remained relatively constant.

"Final" calibration data of August 14, 1981 (Appendix 2.E), with optical wedge density drift corrected, show a change in instrument 79 spectral characteristics, including a change in the μ-dependency of the comparison observations. Applicable μ-dependent N-value corrections on this day (Appendix 2.E) are shown to be

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[4]For other instrument calibrations, these relations may be parabolic or cubic.

$$\Delta N_A(\mu)_f = E + F\mu \tag{19}$$

$$\Delta N_A(\mu)_f = J + K\mu \tag{20}$$

where, again, E, F, H, and K are constants.

During final data processing, then, two time intervals must be considered in applying the above N-value corrections to observational data. For ozone observations made during September 10, 1975-March 31, 1979, when instrument spectral characteristics appear to have remained constant (except for the wedge density change that has been accounted for), correct observational N-values [relations (13) and (14)] are given by

$$N_A = N_A' + \Delta N_A(\mu)_i \tag{21}$$

$$N_D = N_D' + \Delta N_D(\mu)_i \tag{22}$$

For the time interval April 1 to August 14, 1979, on the other hand, the μ-dependent corrections are assumed to have changed linearly with time from those given by (17) and (18) to those given by (19) and (20). Thus for ozone observations made during this latter time interval, correct N-values for an ozone observation are given by

$$N_A = N_A' + \Delta N_A(\mu)_i + r[\Delta N_A(\mu)_f - \Delta N_A(\mu)_i] \tag{23}$$

$$N_D = N_D' + \Delta N_D(\mu)_i + r[\Delta N_D(\mu)_f - \Delta N_D(\mu)_i] \tag{24}$$

where r is the fraction of time that has elapsed for the particular ozone observation since April 1, 1979, within the time interval under consideration.

The following numerical example illustrates the procedures described above for final data processing:

(a) We consider an AD-DSGQP observation made at Nashville, Tennessee, June 15, 1980, at 20h 00m 00s UT (μ = 1.171). The observation yielded mean R_A = 112.0° and mean RD = 57.2°. From the wedge density tables dated September 9, 1975 (Apendix 2.E) we obtain, corresponding to these instrument dial readings, $100G_A$ = 110.5 and $100G_D$ = 56.0. But from the August 24, 1981, wedge density tables (Appendix 2.E) we obtain $100G_A$ = 108.7 and $100G_D$ = 55.3. Now the time interval September 9, 1975-June 15, 1980, comprises 0.799 of the overall time interval (September 9, 1975-August 24, 1981) under consideration. Therefore, by linear interpolation, G values corresponding to the AD-DSGQP observational R values are $100G_A$ = 109.1 and $100G_D$ = 55.4.

(b) Standard lamp tests were performed on instrument 79 at Nashville with lamps 79C on May 30, 1980, giving R_{AS} and R_{DS} values of 47.6° and 53.4°, respectively; and on June 25, 1980, giving R_{AS} and R_{DS} values of 47.9° and 53.5°, respectively. By linear interpolation, we take the standard lamp readings to be R_{AS} = 47.8° and R_{DS} = 53.5° on June 15, 1980. From the September 9, 1975-August 24, 1981, G tables, corresponding G-values are found by linear interpolation to be $100G_{AS}$ = 47.8 and $100G_{DS}$ = 51.9 on June 15, 1980. Standard lamp 79C N-values are $100N_{AS}$ = 22.3 and $100N_{DS}$ = 25.4 (Appendix 2.E).

(c) Using relations (13) and (14) we obtain for the AD-DSGQP observation of June 15, 1980

$$N_A' = 1.091 + (0.223 - 0.478) = 0.836$$

$$N_D' = 0.554 + (0.254 - 0.519) = 0.289$$

Incorporated into the N' values are corrections for instrument 79 optical wedge density drift, but not corrections for instrument 79 spectral characteristics change due to cobalt filter deterioration, including μ-dependent corrections.

(d) To correct the observational data for the additional instrument spectral characteristics changes, we begin by evaluating relations (17)-(20) above (see Appendix 2.E) for μ = 1.171

$$100\Delta N_A(\mu)_i = -24.5148 + 0.8356(1.171) + 23.03 = -0.506$$

$$100\Delta N_D(\mu)_i = -26.5822 + 0.5610(1.171) + 25.59 = -0.335$$

$$100\Delta N_A(\mu)_f = -3.4037 + 1.2064(1.171) = -1.991$$

$$100\Delta N_D(\mu)_f = -0.5166 + 0.2543(1.171) = -0.219$$

(Note that had the ozone observation been made prior to April 1, 1979, only relations (17) and (18) would have had to have been evaluated.)

For the observations made June 15, 1980, the fraction of time, r, elapsed since April 1, 1979, within the time interval April 1, 1979-August 14, 1981, is 0.509. Final, corrected N-values for this ozone observation are then computed from (23) and (24):

$$N_A = 0.836 - 0.005 + 0.509(-0.020 + 0.005) = 0.823$$

$$N_D = 0.289 - 0.003 + 0.509(-0.002 + 0.003) = 0.287$$

(e) Total ozone amount for the observation, using Vigroux ozone absorption coefficients, is then

$$X_{AD} = 1000\left[\frac{0.823-0.287}{1.388(1.171)}-0.009\right] = 321 \text{ DU}$$

As in section 2.4, a variation of the data reprocessing described above, yielding equivalent results, would involve direct use of μ-dependent G tables. Such a procedure may be more adaptable to use with existing Dobson instrument data processing software than that described.

The optical wedge of Dobson instrument 79 was manufactured by R. and J. Beck, Ltd., of Oxford, England. Canada balsam cement was used in gluing the wedge sections together. Over the years, experience has shown that the cement in such wedges ages with time, causing optical densities along the wedge to change. Many of the Dobson instruments in the global network have been retrofitted with "air-space" wedges from which the cement has been removed [Komhyr and Grass, 1972]. Such wedges are inherently more stable. Nevertheless, their optical characteristics may still change with time should they become contaminated; for example, with lubricant from the optical wedge track or from the instrument optical shutter bearing.

The example presented in this section of Dobson instrument performance degradation due to cobalt filter corrosion by humid air attests to the importance of keeping the Dobson instrument optics clean and dry at all times.

2.6 Air Mass Dependence of Ozone Measurements in Polluted Air

An important source of ozone measurement error is stray light interference, particularly at the shorter wavelength of the Dobson spectrophotometer A-wavelength pair. Stray light is radiation scattered by the atmosphere in the instrument's field of view, as well as unwanted radiation scattered within the instrument. The stray light effect varies among Dobson instruments [Olafson and Asbridge, 1981; Basher, 1982], significantly limiting the accuracy of AD wavelength direct sun observations at air mass (μ) values above 2.5 to 3. G.M.B. Dobson [Walshaw, 1975] examined both sources of stray light, describing a detailed investigation of errors in ozone measurements made at low sun. Basher (1982) modeled instrumental and atmospheric factors influencing stray light, including the effect of ozone amount variations. Degórska and Rajewska-Wiech

[1989] showed that the stray light is influenced by local pollution--a topic that is the focus of this section. One of the methods of testing a spectrophotometer for stray light is to take a series of observations on the rising or setting sun and compare results with the stray light model of Basher [1982]. A parameter of Basher's heterochromatic stray light model is R_0 which depends inversely on the quality of the instrument stray light rejection preoperties. Values of R_0 were estimated to range from 10^{-5} to 10^{-3}. Values of a second model parameter, **a**, representing the atmosphere relative attenuation of the stray light band, range from about 0.7 to 1.2 depending on ozone amount.

Figure 2 shows two sets of μ-dependent ozone data obtained with Dobson instrument 84: at Belsk, Poland in 1981 in polluted air, and at Arosa, Switzerland in 1986 in clean air. Note that in polluted air in Belsk, measured ozone decreased rapidly at μ values greater than 2.5. At Arosa, in clean air, significant decrease in ozone began at μ greater than 3.5.

The observational data in Figure 2 have been fitted with Basher model curves having the same R_0 values for both days, but different values of **a** (1.2 and 0.7). Differences in the shapes of the curves, stemming from use of the different parameters **a**, cannot be attributed to ozone amount differences, since ozone on both days was nearly the same (~305 DU). Thus the differences must stem from pollution effects.

In re-evaluating Dobson instrument total ozone data, it is important to know that atmospheric pollution (including turbidity) adversely affect ozone measurements at the higher μ values. Unless ozone data from series of observations at extended μ values exist for a particular station, correction for pollution effects will be difficult to make. New measurements can provide data that may be useful in assessing errors in observations made in the past. Where possible, data selected for archiving, as representative of local apparent noon, should be restricted to observations made at $1.3<\mu<2$, since stray light and other instrumental problems tend to degrade, also ozone measurements at low μ.

2.7 CD-Wavelength Observations on Direct Sun

AD-DSGQP observations are fundamental; data from all other kinds of observations must ultimately be reduced to their calibration level. But as noted in the previous section, stray light errors, due either to instrumental factors or to sky conditions, degrade the quality of the AD-DSGQP observations at μ values larger than 2.5 to 3.

Instrumental stray light effects are less severe for the longer wavelength and more intense CD-DSGQP observations. In relatively clean atmospheres, these observations can be extended to μ values

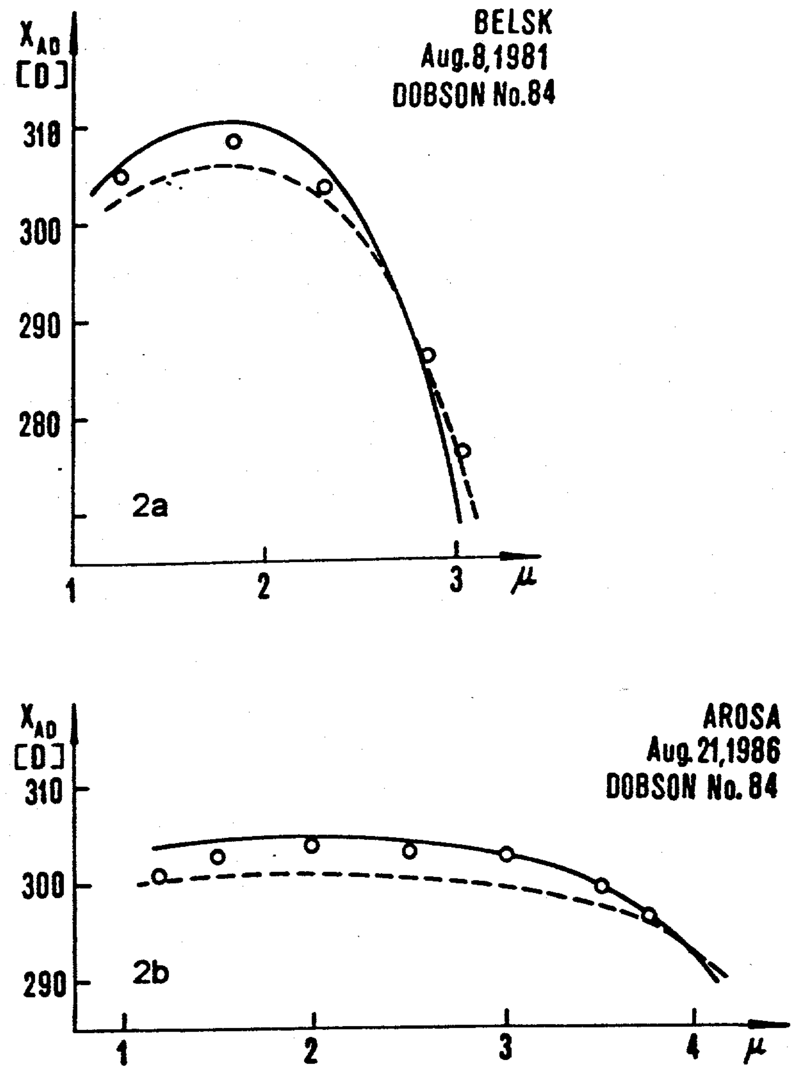

Figure 2. (a) Comparison of experimental data with stray light model: ——$R_o = 10^{-3.8}$, ----$R_o = 10^{-4.0}$, **a** = 1.2. (b) As in (a), but for **a** = 0.7.

of 3.5 to 4.0. Nevertheless, because relative intensity differences for C and D wavelengths are considerably smaller than for A and D wavelengths, it is more difficult to calibrate and maintain in calibration a Dobson instrument at CD wavelengths. For stations at latitudes that must resort to CD type direct sun observations during certain times of the year, then, it is necessary to maintain an ongoing program of comparison AD-DSGQP and CD-DSGQP observations. These should be made in the μ-range 1.5 to 2.5 or 3, depending on the optical condition of the instrument, sky turbidity, and total ozone amount. In final data processing, ratios of the comparison total ozone amounts, plotted as a function of μ, should be used in correcting the CD-DSGQP observations data.

AD-DSFI and CD-DSFI ozone measurements can be made in the μ intervals 2.5-4.0 and 2.5-6.0, respectively [Komhyr, 1980], extending the μ-range of Dobson spectrophotometer direct sun observations. This is possible because focused image observations reduce the amount of skylight entering the instrument and at the same time increase the intensity of the direct solar radiation entering the instrument. Correction procedures for both skylight and scattered light, when the focused image method is used, have been described by Hamilton [1964]. Focused image observations are, however, difficult to make requiring considerable skill by the observer. S.H.H. Larsen, University of Oslo, Norway, has adapted the methodology of Hamilton [1964] to C-DSGQP and CD-DSGQP observations which are considerably easier to make (see Appendix 2.F). Under good observing conditions, ozone measurements can be extended by this method to μ values as high as 8. Such observations are useful especially in late fall and early spring at high latitudes when solar elevation is low during the day.

2.8 Use of Empirically Established Charts for Processing Zenith Sky Observations

Zenith-sky observational data are reduced by means of empirically constructed charts that relate instrument N-values, μ, and total ozone, x. Such charts are drawn up using quasi-simultaneously obtained data from AD-DSGQP observations and observations on the clear or cloudy zenith. Nearly simultaneous direct sun and clear zenith sky observations are readily obtainable. However, when the sky is cloudy, it often becomes necessary to compare direct sun and cloudy zenith observations that have been made several hours apart.

Charts for reducing ozone measurement data from zenith sky observations, derived from observations made at Oxford, England [Dobson, 1957], were available in the past from the manufacturer of the Dobson instruments (R.J. Beck, Ltd.). Another set of charts has been published in WMO Report No. 6 [Komhyr, 1980]. They were devised in the late 1950s and early 1960s from observations made at Edmonton and Moosonee, Canada [Kinisky, 1961; Komhyr, 1961]. It is important to note that these charts cannot be used universally since the shapes of the chart curves are a function of the ozone vertical distribution, earth albedo, atmospheric clarity, and instrumental factors. Therefore, although the charts serve as useful starting tools for preliminary reduction of data, it is necessary at each station to obtain a sufficient number of comparison direct sun and zenith-sky observations to correct the charts so that they yield optimum quality data for that location.

An interesting variation of the standard method employed in constructing the zenith sky charts has been described by Hassan [1982] who used a multiple linear regression technique involving pair X_{AD}^{DS} and $N_{\lambda\lambda}^{ZB}$ observations to construct sky charts for Cairo, Egypt. More work is needed, however, to ascertain whether such charts can be used successfully at higher latitude stations.

Zenith sky charts can also be derived from theoretical calculations based on multiple scattering in a purely molecular atmosphere [Mateer et al., 1977]. Such calculations take into account standard or climatological ozone profiles, the effect of temperature on ozone absorption coefficients, and ground albedo. Stamnes et al. [1990] used a comprehensive radiative transfer algorithm to draw zenith sky charts. The method allows taking into consideration atmospheric optical depth and cloud height as well. Such theoretically derived charts, however, need on-site correcting to account for modelling uncertainties and instrumental factors.

Final processing of ozone observations made on zenith sky should be performed with corrected and re-drawn charts. An alternative procedure is to determine corrections; for example, to the charts provided in WMO Report No. 6, by plotting AD-DSGQP versus ADZB, ADZC, CC'ZB, CC'ZC, CDZB, CDZC observations as a function of μ. As an example, such corrections for ADZB type observations, determined at Bismarck from measurements made during 1962 to 1985, are shown in Figure 3. Ideally, such plots should be made for low, medium, and high values of ozone. Figure 4 shows similar comparison data for AD wavelength zenith cloud observations. Here the scatter in the data is considerably greater since the comparison observations were often made several hours apart during which time significant changes in ozone sometimes occurred. Cloud observations are, also, inherently less precise than are the clear zenith observations.

We have strong indication from Umkehr observations that stratospheric aerosols from occasional volcanic eruptions influence UV flux ratios emanating downward from the zenith sky at the A, C, and D Dobson instrument wavelength pairs. The extent to which these aerosols affect total ozone data derived from zenith sky observations requires further study.

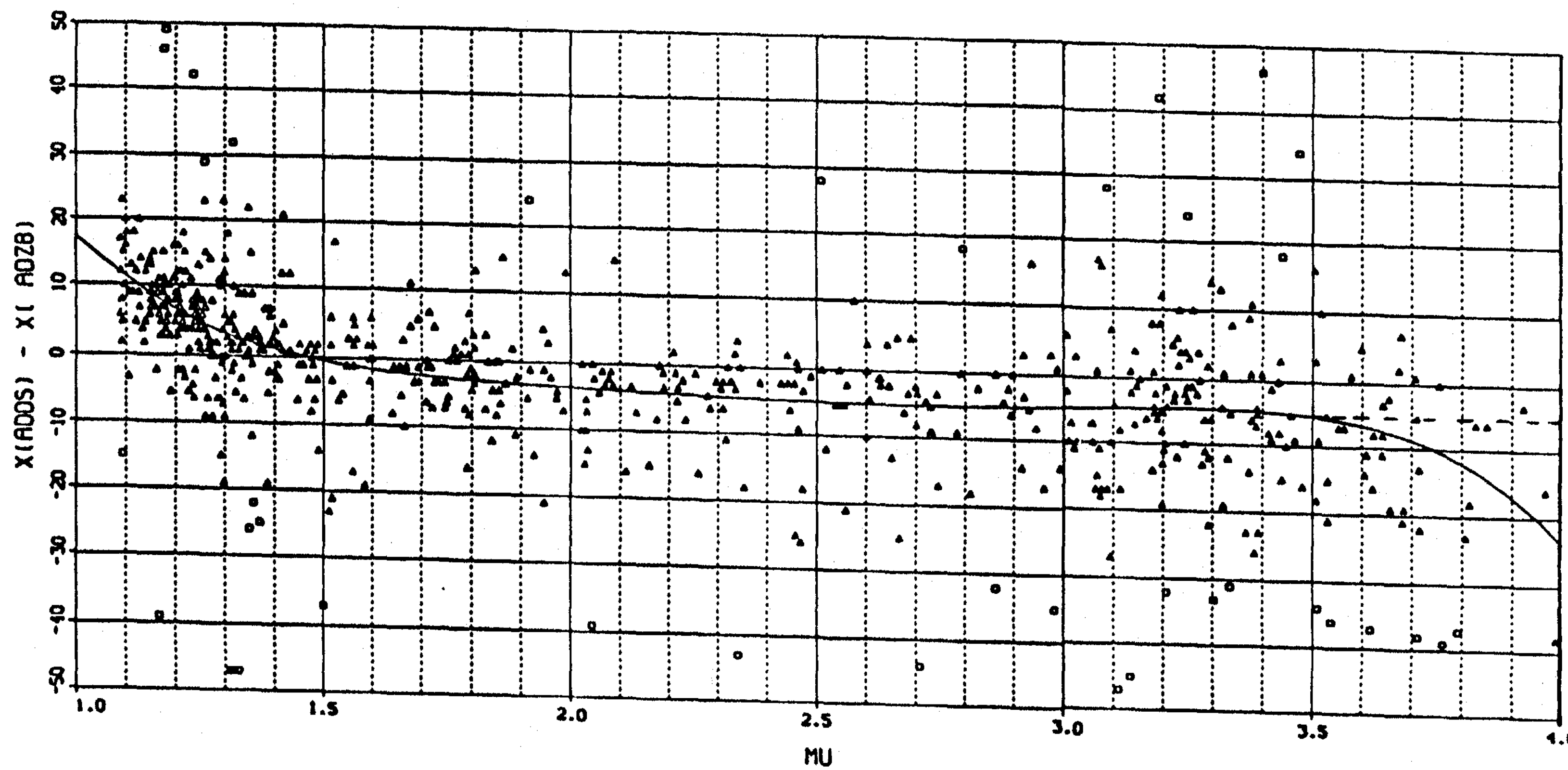

Figure 3. Corrections needed to Chart AD of WMO Report No. 6 when processing total ozone data obtained at Bismarck, North Dakota, from observations made on the clear zenith sky.

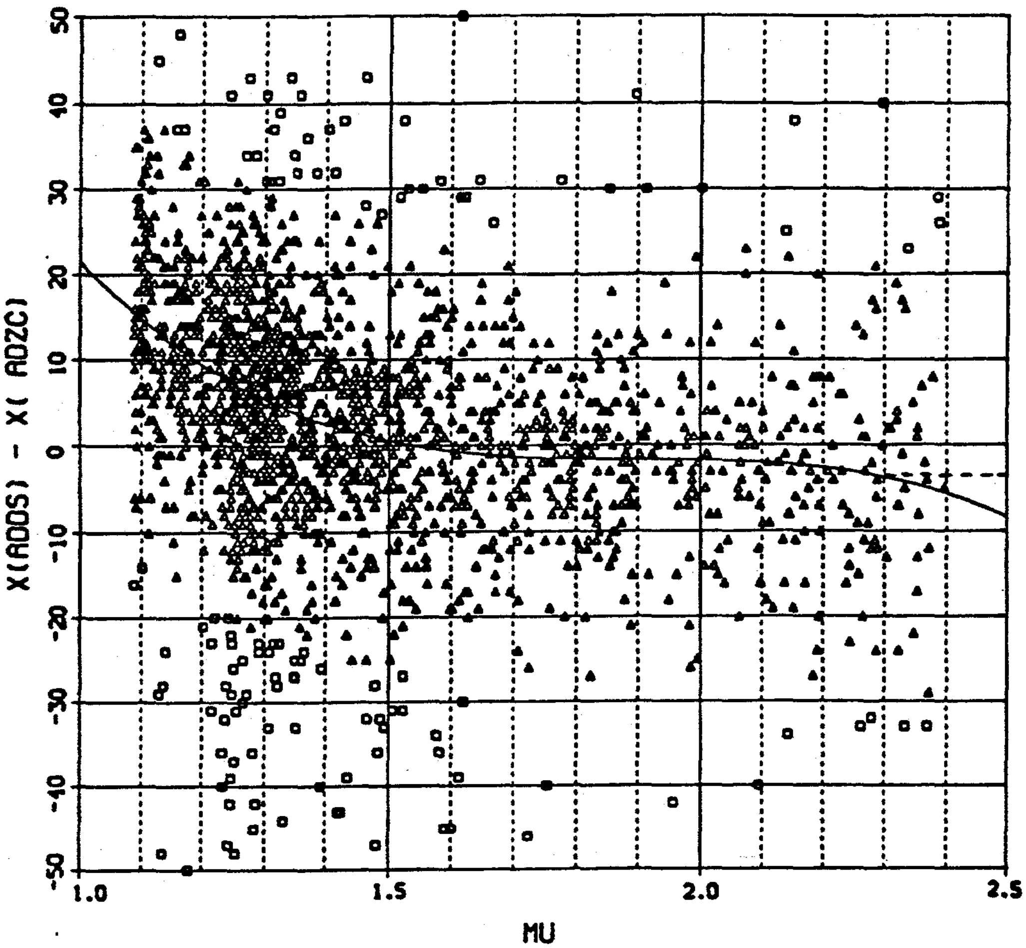

Figure 4. Corrections needed to Chart AD of WMO Report No. 6 for processing total ozone data at Bismarck, North Dakota, from observations made on the cloudy zenith sky.

Special attention is called to Chart $N_{C'}$ used in reducing CC'ZC observations. The abscissa values for this chart are fixed by setting the $\Delta N = 0$ correction curve at the extreme right of plotted $N_{C'}$ values derived from observations on the blue sky. This is shown, for example, in Figure 5, for observations made a Bismarck during June 2, 1976-May 28, 1980. Should similar observational data not be available for the following several-year observing interval beginning May 29, 1980, for which new reference N tables and standard lamp readings are established for routine total ozone data reduction, the $N_{C'}$ chart derived from the 1976-1980 observations can continue to be used beyond May 28,

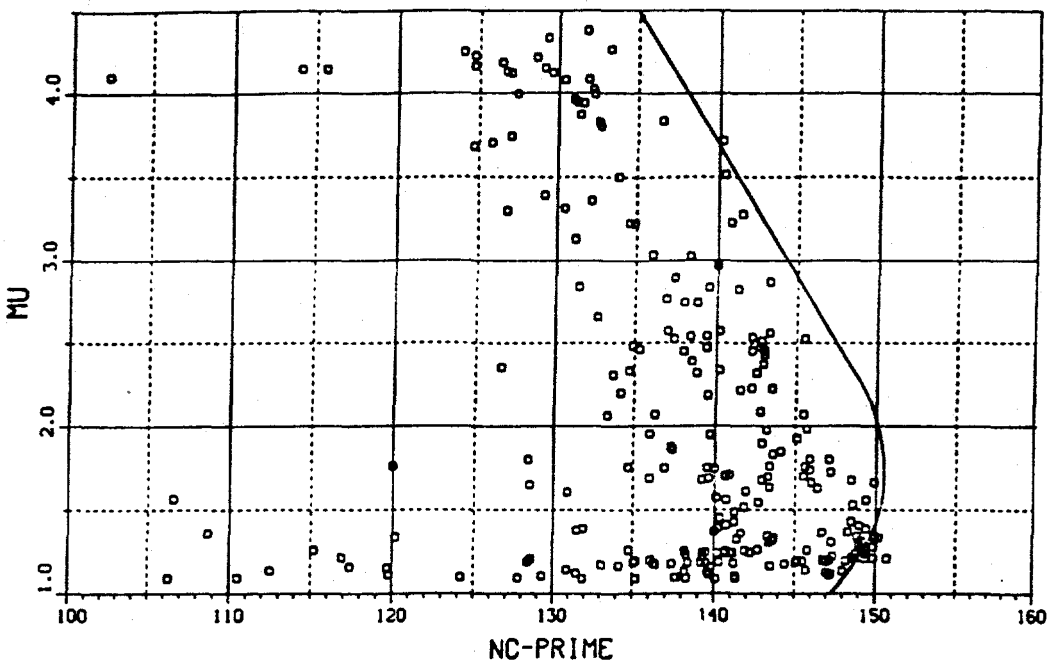

Figure 5. Illustration, from observations made at Bismarck during June 1976-May 1980, of the method of fixing the abscissa value of the $\Delta N = 0$ curve of the cloud correction Chart C' given in WMO Report No. 6.

1980. However, before using it, it is first necessary to shift the $\Delta N=0$ curve of Figure 4 horizontally by the difference in reference standard lamp $N_{C'}$ readings for the June 2, 1976, and May 29, 1980, instrument calibrations. For example, as shown in Figure 5, the abscissa value for the curve $\Delta N_C = 0$ at $\mu = 1$ is $100N_{C'} = 147$. If the reference standard lamp $N_{C'}$ values for the instrument in-the-mean are larger on May 29, 1980, by 6 100N units than they were June 2, 1976, the curve should be shifted to read $100N_{C'} = 147 + 6 = 153$ at $\mu=1$. The need for this shift arises because Dobson spectrophotometer calibrations relative to a standard are performed at A, C, and D wavelengths, but not C' wavelengths, and $N_{C'}$ values are obtained from N_C tables.

The above technique may be used also when a replacement spectrophotometer, for which an $N_{C'}$ chart has not been established observationally, is temporarily used at a station.

2.9 Total Ozone Measurement Interfering Absorbing Species

Komhyr and Evans [1980] identified a number of trace gas species that possess absorption spectra in the spectral region of the Dobson instrument wavelengths. Of these, SO_2 and NO_2 have the greatest potential for causing Dobson instrument total ozone measurement errors. De Backer and De Muer [1991] and De Muer and De Backer [1992] have shown that in certain regions of the globe SO_2 pollution may also have a significant effect on the determination of ozone trends.

Although SO_2 measurements are possible with a Dobson spectrophotometer, such observations are seldom made. Near ground-level SO_2 data are available in some locations from pollution monitoring networks; however, translating surface SO_2 concentrations to atmospheric total column SO_2 entails considerable research that is best reserved for special studies, with formal publication of results obtained in the open literature. Thus, re-evaluation of Dobson instrument data should, in general, not include correcting the data for SO_2 interference or other interfering absorbing species.

An exception exists where a Dobson instrument observatory is located fairly close to a coal- or oil-fired power plant. On occasion when the observatory is downwind from the plume, measured ozone values may be too high by 10% or more. Successive ozone observations made under such conditions generally yield erratic data with a large standard deviation associated with the mean. Such data, if included in the ozone daily means archive, should be flagged as most likely being unreliable.

(For reasons given above, the re-evaluated Dobson instrument data should, also, not be corrected for changes in effective Dobson instrument ozone absorption coefficients that vary seasonally or on a secular basis as stratospheric temperatures change.)

2.10 Calibration of Dobson Spectrophotometers With Calibrated Traveling Standard Lamps

At the 1977 International Comparison of Dobson Ozone Spectrophotometers held in Boulder, Colorado, a traveling standard lamp method was devised [Komhyr et al., 1981] for identifying Dobson instruments that have gross calibration errors. (Traveling standard lamps are calibrated with World Primary Standard Dobson Spectrophotometer 83). Tests on 14 instruments at that time, well calibrated on a relative scale (i.e., newly optically aligned, and with high quality wavelength-setting and optical wedge calibrations), showed that such instruments can be calibrated with lamps to yield ozone measurement uncertainties at the 95% interval confidence level of 2.2%, 1.1%, and 0.7% when measuring 300 DU ozone at air mass values of 1, 2, and 3, respectively. (These errors are about twice as large as those associated with direct spectrophotometer intercalibrations.) Subsequently, seven standard lamp units were built and calibrated, each consisting of two calibrated lamps and a stable power supply. The global Dobson instrument network was then divided into seven areas, each containing from 5 to 17 instruments, and a lamp unit was shipped to each area for use in checking the calibrations of the Dobson instruments in that area. Results of the first round robin of such calibrations, conducted in 1981-1983 [Grass and Komhyr, 1985], showed that 21 of the 78 instruments tested needed re-calibration, with 17 instruments having large calibration errors of 3-10%. A second series of tests in 1985-1987 involving 81 instruments [Grass and Komhyr, 1989] showed that 13 needed re-calibration, with 5 instruments having calibration errors as large as 3-5%. A third such Dobson instrument test series, initiated in 1990, is nearing completion.

The main purpose of the traveling standard lamp tests has not been to calibrate Dobson instruments, but to check on how well they are calibrated. Such calibrations, however, can be useful when performed on instruments that are well aligned optically and have high quality wavelength-setting and optical wedge calibrations. Large calibration errors can ensue, however, for instruments that have poor, not well known, optical characteristics. Total ozone data re-evaluations for such instruments should not be based on calibrations of the instruments with traveling standard lamps.

Acknowledgments

Appreciation is expressed to M. Degórska and B. Rajewska-Wiech of the Polish Academy of Sciences; D. DeMuer of the Royal Meteorological Institute of Belgium; and S.H.H. Larsen, University of Oslo in Norway for contributions to portions of the Handbook. Helpful comments and criticisms were provided also by J. Easson of the Australian Bureau of Meteorology; A. Frolov and A. Shalamiansky of the Main Geophysical Observatory in St. Petersburg, Russia; and G.K.Y Hassan of the Egyptian Meteorological Authority in Cairo.

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APPENDIX 2.A

CALIBRATION SCALES - WORLD PRIMARY STANDARD DOBSON SPECTROPHOTOMETER 83

#83 JUNE 18, 1962F1

N Tables

R	0°	50°	100°	150°	200°	250°	290°
N_A	-0.103	0.419	0.889	1.368	1.855	2.359	2.770
N_C	-0.072	0.446	0.913	1.386	1.869	2.367	2.774
N_D	-0.059	0.454	0.920	1.389	1.866	2.359	2.761

Q-Setting Table Applicable at Sterling, Virginia

At 15°C: $Q_A = 49.05°$ $Q_C = 76.30°$ $Q_D = 107.40°$
$Q_{Hg-312.9} = 84.05°$

Temp. Coeff. Hg-312.9 nm: 0.125°Q/°C

Reference Standard Lamp Readings

Lamp No.	R_A(°)	N_A	R_C(°)	N_C	R_D(°)	N_D
83A	28.0	0.198	28.5	0.231	28.1	0.238
83B	28.3	0.201	28.8	0.234	28.3	0.240
W	26.9	0.187	27.9	0.225	27.7	0.234
X	32.9	0.248	31.8	0.265	30.3	0.260
Y	30.7	0.226	30.1	0.247	29.0	0.247
Z	27.0	0.188	27.6	0.222	27.4	0.230

N Tables

R	0°	50°	100°	150°	200°	250°	290°
N_A	-0.092	0.424	0.893	1.369	1.861	2.366	2.775
N_C	-0.063	0.452	0.916	1.387	1.871	2.370	2.775
N_D	-0.047	0.468	0.929	1.395	1.874	2.368	2.767

Q-Setting Table Applicable at MLO

At 15°C: $Q_A = 47.30°$ $Q_C = 73.65°$ $Q_D = 104.85°$
$Q_{Hg-312.9} = 81.30°$

Temp. Coeff. Hg-312.9 nm: 0.125°Q/°C

Reference Standard Lamp Readings

Lamp No.	R_A(°)	N_A	R_C(°)	N_C	R_D(°)	N_D
83A	28.5	0.209	28.7	0.240	28.3	0.252
83B	28.8	0.212	29.0	0.243	28.5	0.254
W	27.5	0.199	28.1	0.234	27.8	0.247
X	33.4	0.260	32.1	0.275	30.6	0.276
Y	31.3	0.238	30.5	0.259	29.4	0.263
Z	27.7	0.201	28.1	0.234	27.8	0.247

#83 AUGUST 26, 1976F1

N Tables

R	0°	50°	100°	150°	200°	250°	290°
N_A	-0.091	0.423	0.891	1.366	1.855	2.360	2.769
N_C	-0.061	0.452	0.917	1.387	1.870	2.367	2.773
N_D	-0.048	0.465	0.926	1.391	1.867	2.358	2.758

Q-Setting Table Applicable at MLO

At 15°C: $Q_A = 47.30°$ $Q_C = 73.65°$ $Q_D = 104.85°$
$Q_{Hg-312.9} = 81.30°$

Temp. Coeff. Hg-312.9 nm: 0.125°Q/°C

Reference Standard Lamp Readings

Lamp No.	R_A(°)	N_A	R_C(°)	N_C	R_D(°)	N_D
83A	28.5	0.210	28.6	0.241	28.4	0.252
83B	28.9	0.214	29.0	0.245	28.6	0.254
W	27.9	0.204	28.3	0.238	28.0	0.248
X	33.9	0.265	32.3	0.279	30.8	0.277
Y	31.5	0.241	30.5	0.261	29.5	0.264
Z	28.1	0.206	28.3	0.238	27.9	0.247
83Q1	20.6	0.127	22.0	0.172	22.5	0.191
83Q2	20.3	0.124	21.7	0.169	22.3	0.188
83Q3	20.0	0.121	21.5	0.167	21.9	0.184
UQ1	21.4	0.135	22.8	0.180	23.4	0.200
UQ2	21.1	0.132	22.5	0.177	23.0	0.196
UQ4	20.3	0.124	21.5	0.167	22.2	0.187

#83 JULY 10, 1987 FI

N Tables

R	0°	50°	100°	150°	200°	250°	290°
N_A	-0.058	0.459	0.928	1.403	1.891	2.396	2.805
N_B	-0.132	0.383	0.851	1.321	1.805	2.307	2.713
N_C	-0.023	0.491	0.955	1.422	1.901	2.400	2.803
N_D	-0.005	0.506	0.968	1.431	1.906	2.400	2.800

Q-Setting Table Applicable at MLO

At 15°C: $Q_A = 47.85°$ $Q_B = 61.45$ $Q_C = 74.45°$
$Q_D = 105.40°$ $Q_{Hg-312.9} = 82.10°$

Temp. Coeff. Hg-312.9 nm: 0.125°Q/°C

Reference Standard Lamp Readings

Lamp No.	R_A(°)	N_A	R_B(°)	N_B	R_C(°)	N_C	R_D(°)	N_D
83QI	16.9	0.124	17.3	0.054	18.1	0.170	18.2	0.188
83Q2	16.8	0.123	17.1	0.052	17.9	0.168	18.1	0.187
83Q3	16.4	0.118	16.7	0.048	17.6	0.165	17.7	0.183
83Q4	16.6	0.121			17.6	0.165	17.8	0.184
83Q5	16.4	0.118			17.4	0.163	17.7	0.183
UQ1	17.9	0.134	18.2	0.063	19.0	0.179	19.2	0.198
UQ2	17.4	0.129	17.8	0.059	18.5	0.174	18.7	0.193
UQ4	16.7	0.122	16.9	0.050	17.8	0.167	17.9	0.185
UQ5	16.4	0.118			17.5	0.164	17.6	0.182
83B	25.4	0.212			25.4	0.246	24.5	0.254
W	24.0	0.198			24.4	0.235	23.5	0.243
X	30.4	0.264			28.6	0.279	26.5	0.274
Y	27.8	0.237			26.6	0.258	24.9	0.258
Z	24.0	0.198			24.3	0.234	23.1	0.239

N Tables

R	0°	50°	100°	150°	200°	250°	290°
N_A	-0.066	0.450	0.917	1.391	1.879	2.383	2.793
N_B	-0.140	0.375	0.840	1.310	1.793	2.294	2.701
N_C	-0.033	0.481	0.944	1.410	1.890	2.387	2.790
N_D	-0.015	0.498	0.959	1.421	1.897	2.389	2.790

Q-Setting Table Applicable at MLO

At 15°C: Q_A = 47.40° Q_B = 60.90° Q_C= 73.70°
Q_D = 104.85° $Q_{Hg-312.9}$ = 81.60°

Temp. Coeff. Hg-312.9 nm: 0.125°Q/°C

Reference Standard Lamp Readings

Lamp No.	R_A(°)	N_A	R_B(°)	N_B	R_C(°)	N_C	R_D(°)	N_D
83QI	18.2	0.129	18.5	0.058	19.3	0.173	19.4	0.192
83Q3	17.6	0.123	18.0	0.052	18.8	0.168	18.8	0.186
83Q4	17.8	0.125			18.8	0.168	18.9	0.187
83Q5	17.6	0.123			18.6	0.166	18.8	0.186
UQ1	19.1	0.138	19.5	0.068	20.2	0.182	20.2	0.200
UQ2	18.7	0.134	19.0	0.063	19.7	0.177	19.8	0.196
UQ5	17.6	0.123			18.7	0.167	18.7	0.185

APPENDIX 2.B

CALIBRATION SCALES - SECONDARY STANDARD DOBSON SPECTROPHOTOMETER 65

#65 APRIL 10, 1981F1

N Tables

R	0°	50°	100°	150°	200°	250°	290°
N_A	-0.172	0.364	0.855	1.363	1.904	2.438	2.884
N_C	-0.118	0.417	0.906	1.407	1.942	2.469	2.911
N_D	-0.101	0.433	0.920	1.418	1.948	2.472	2.911

Q-Setting Table Applicable in Boulder, Colorado

At 15°C: $Q_A = 48.50°$ $Q_C = 75.30°$ $Q_D = 106.45°$
$Q_{Hg-312.9} = 83.10°$

Temp. Coeff. Hg-312.9 nm: 0.125°Q/°C

Reference Standard Lamp Readings

Lamp No.	R_A(°)	N_A	R_C(°)	N_C	R_D(°)	N_D
65Q1	25.6	0.111	25.5	0.165	25.7	0.183
65Q2	26.5	0.121	26.6	0.177	26.7	0.194
65Q3	26.1	0.116	26.3	0.173	26.5	0.192
UQ1	27.3	0.129	27.3	0.188	27.7	0.205
UQ2	27.1	0.127	27.2	0.183	27.4	0.201
UQ3	26.0	0.115	26.3	0.173	26.4	0.190
65Q4	25.9	0.114	26.2	0.172	26.3	0.189
65Q5	26.0	0.115	26.2	0.172	26.4	0.190

#65 MAY 21, 1990F1

N Tables

R	0°	50°	100°	150°	200°	250°	290°
N_A	-0.168	0.362	0.850	1.353	1.892	2.428	2.868
N_C	-0.129	0.402	0.888	1.384	1.917	2.446	2.881
N_D	-0.110	0.422	0.906	1.400	1.930	2.456	2.888

Q-Setting Table Applicable in Boulder, Colorado

At 15°C: Q_A = 48.00° Q_C = 74.85° Q_D = 106.10°
$Q_{Hg-312.9}$ = 82.75°

Reference Standard Lamp Readings

Lamp No.	R_A(°)	N_A	R_C(°)	N_C	R_D(°)	N_D
65Q1	26.3	0.119	26.4	0.160	26.4	0.180
65Q2	27.1	0.128	27.3	0.170	27.3	0.190
65Q4	26.8	0.125	27.1	0.168	27.1	0.188
65Q5	26.7	0.124	27.0	0.167	27.0	0.187
UQ1	28.2	0.139	28.5	0.183	28.5	0.202
UQ2	27.8	0.135	28.0	0.177	28.2	0.199
UQ5	26.8	0.125	27.0	0.167	27.0	0.187

N Tables

R	0°	50°	100°	150°	200°	250°	290°
N_A	-0.172	0.358	0.849	1.353	1.893	2.428	2.870
N_C	-0.128	0.405	0.892	1.390	1.921	2.449	2.885
N_D	-0.117	0.417	0.902	1.397	1.925	2.450	2.882

Q-Setting Table Applicable in Boulder, Colorado

At 15°C: $Q_A = 47.95°$ $Q_C = 74.70°$ $Q_D = 105.95°$
$Q_{Hg-312.9} = 82.50°$

Reference Standard Lamp Readings

Lamp No.	R_A(°)	N_A	R_C(°)	N_C	R_D(°)	N_D
65Q1	26.5	0.117	26.7	0.165	26.7	0.178
65Q2	27.1	0.123	27.5	0.174	27.7	0.188
65Q4	27.0	0.122	27.2	0.170	27.2	0.183
65Q5	26.8	0.120	27.0	0.168	27.0	0.181
UQ1	28.2	0.135	28.7	0.186	28.8	0.199
UQ2	28.0	0.133	28.0	0.179	28.3	0.194
UQ3	26.8	0.120	27.2	0.170	27.3	0.184

APPENDIX 2.C

DOBSON INSTRUMENT 33 SAMPLE CALIBRATION DATA - APRIL 15, 1986 AND MAY 11, 1988

(a) Stable optical wedge.

(b) No μ-dependency for observations on A and D wavelengths.*

(c) A change occurred in the spectral characteristics of Dobson instrument 33 at A, C, and D wavelengths.

*C-wavelength observations show a μ-dependency. Procedures for correcting ozone data for μ-dependency are described in section 2.4.

DOBSON OZONE SPECTROPHOTOMETER CALIBRATION

Place: Boulder, Colorado

Date: April 15, 1986 A.M./P.M. A.M.

U.S.A. Inst. No. 33 VS U.S.A. Inst. No. 83
(Country) (Country)

For instrument No. 33 use G tables dated March 14, 1986

Apply the following corrections to the tables:

To GA or NA values add NA

To GC or NC values add NA

To GD or ND values add NA

For instrument No. 83 use N tables dated August 26, 1976 FI

Apply the following corrections to the tables:

To GA or NA values add +3.9

To GC or NC values add +4.2

To GD or ND values add +5.2

NOTES: "Initial" calibration.

Performed after new "air-space" optical wedge installed into the instrument, optical adjustments made, and Q-setting table re-determined.

Note: Results of AD observations good; poor for C-wavelength observations

Data summary using Inst. 33 G tables dated March 14, 1986: Calib Inst. 83 vs 33 April 15, 1986 AM

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD083*	.308 (.003)	.310 (.001)	.311 (.001)	.311 (.000)	.309 (.001)	.305 (.000)	.310 (.001)	ATMO-CM
XAD033*	.347 (.002)	.343 (.003)	.333 (.002)	.329 (.002)	.321 (.002)	.316 (.000)	.338 (.007)	ATMO-CM
DXAD033*	12.41	10.54	7.31	5.55	4.10	3.71	8.94	PERCENT
XCD083*	.290 (.005)	.295 (.002)	.294 (.002)	.294 (.002)	.293 (.002)	.296 (.000)	.293 (.002)	ATMO-CM
XCD033*	.332 (.003)	.333 (.004)	.325 (.003)	.323 (.004)	.311 (.003)	.306 (.000)	.328 (.004)	ATMO-CM
DXCD033*	14.73	13.01	10.63	9.90	6.03	3.31	12.06	PERCENT
XA 083*	.322 (.002)	.322 (.001)	.321 (.001)	.319 (.001)	.316 (.001)	.311 (.000)	.321 (.001)	ATMO-CM
XA 033*	.352 (.001)	.347 (.002)	.339 (.002)	.334 (.002)	.327 (.002)	.322 (.000)	.343 (.007)	ATMO-CM
DXA 033*	9.49	7.70	5.68	4.43	3.62	3.59	6.83	PERCENT
XC 083*	.325 (.002)	.324 (.001)	.321 (.001)	.317 (.002)	.312 (.001)	.310 (.000)	.322 (.003)	ATMO-CM
XC 033*	.348 (.002)	.343 (.002)	.338 (.002)	.334 (.002)	.325 (.003)	.320 (.000)	.341 (.005)	ATMO-CM
DXC 033*	7.27	5.75	5.49	5.30	4.05	3.23	5.96	PERCENT
XD 083*	.363 (.004)	.356 (.002)	.348 (.002)	.340 (.003)	.331 (.004)	.324 (.000)	.352 (.009)	ATMO-CM
XD 033*	.363 (.005)	.350 (.002)	.349 (.002)	.342 (.003)	.338 (.002)	.334 (.000)	.351 (.008)	ATMO-CM
DXD 033*	.05	-1.57	.16	.53	1.95	3.19	-.22	PERCENT

Corr. needed to Inst. 33 G values

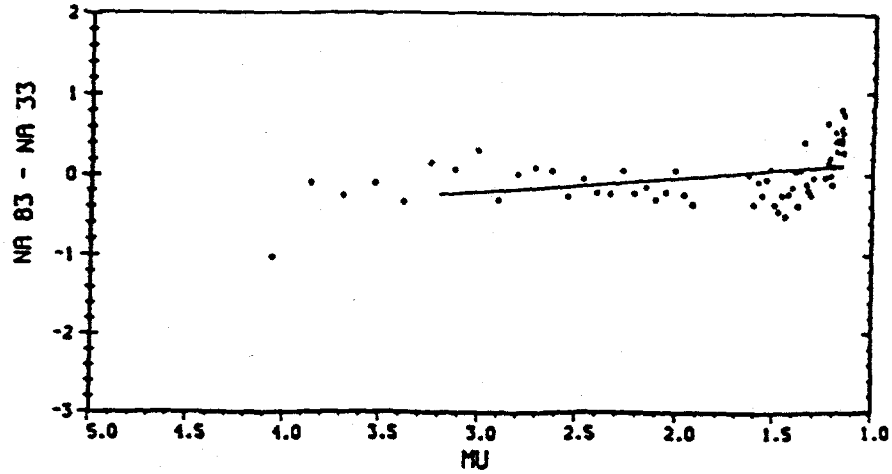
MU=	1.33	1.75	2.25	2.85	mean (1.15-2.5)	rsd
To GA ADD	-7.05	-7.13	-7.23	-7.34	-7.14	.305
To GC ADD	-2.50	-2.87	-3.31	-3.84	-2.89	.212
To GD ADD	.06	.02	-.03	-.08	.02	.253

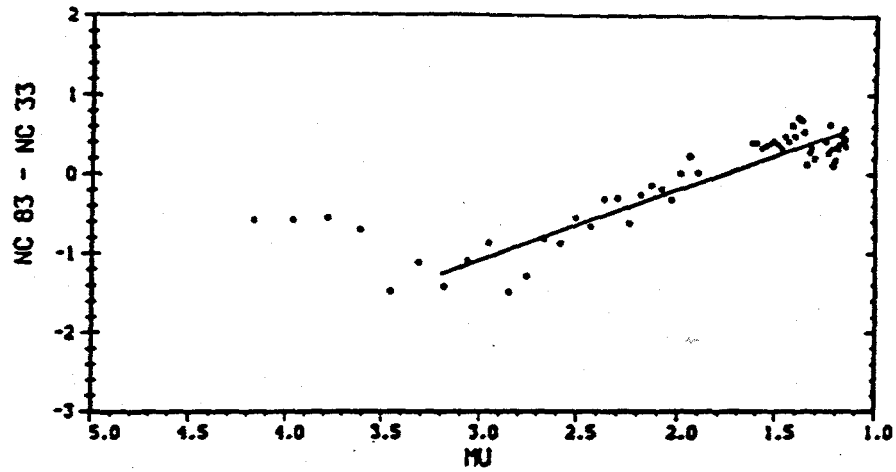
MU=	1.33	1.75	2.25	2.85	mean (1.15-2.5)
To GAD ADD	-7.11	-7.16	-7.20	-7.26	-7.16
To GCD ADD	-2.56	-2.89	-3.29	-3.76	-2.91

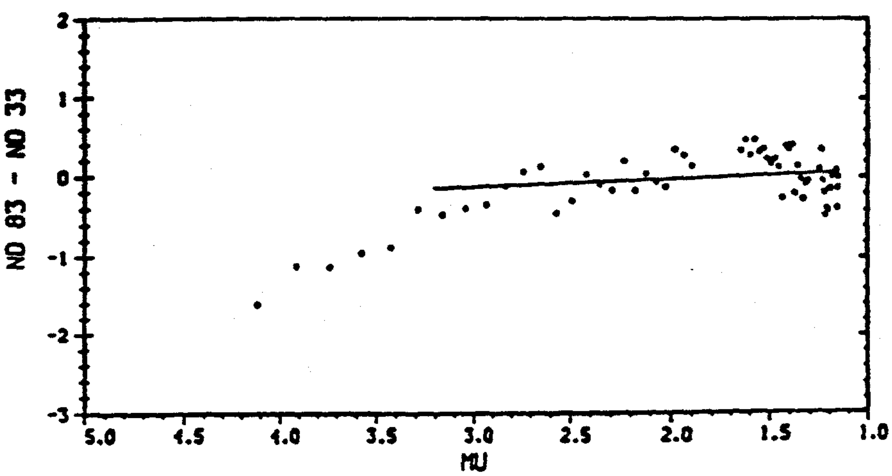
Data summary using corrected Inst. 33 N Tables: (using mean)

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD083	.308 (.003)	.310 (.001)	.311 (.001)	.311 (.000)	.309 (.001)	.305 (.000)	.310 (.001)	ATMO-CM
XAD033	.307 (.004)	.313 (.001)	.311 (.001)	.311 (.001)	.307 (.001)	.304 (.000)	.310 (.002)	ATMO-CM
DXAD033	-.33	.75	.08	-.15	-.46	-.31	.09	PERCENT
XCD083	.290 (.005)	.295 (.002)	.294 (.002)	.294 (.002)	.293 (.002)	.296 (.000)	.293 (.002)	ATMO-CM
XCD033	.282 (.006)	.295 (.002)	.297 (.002)	.301 (.004)	.293 (.002)	.290 (.000)	.294 (.007)	ATMO-CM
DXCD033	-2.53	.16	1.01	2.33	.03	-1.85	.25	PERCENT
XA 083	.322 (.002)	.322 (.001)	.321 (.001)	.319 (.001)	.316 (.001)	.311 (.000)	.321 (.001)	ATMO-CM
XA 033	.321 (.003)	.323 (.001)	.321 (.001)	.319 (.001)	.316 (.001)	.312 (.000)	.321 (.001)	ATMO-CM
DXA 033	-.22	.20	.11	.02	.07	.46	.03	PERCENT
XC 083	.325 (.002)	.324 (.001)	.321 (.001)	.317 (.002)	.312 (.001)	.310 (.000)	.322 (.003)	ATMO-CM
XC 033	.321 (.002)	.322 (.001)	.323 (.001)	.321 (.002)	.315 (.002)	.312 (.000)	.322 (.001)	ATMO-CM
DXC 033	-1.16	-.65	.59	1.39	.96	.54	.03	PERCENT
XD 083	.363 (.004)	.356 (.002)	.348 (.002)	.340 (.003)	.331 (.004)	.324 (.000)	.352 (.009)	ATMO-CM
XD 033	.364 (.005)	.351 (.002)	.349 (.002)	.342 (.003)	.338 (.002)	.334 (.000)	.351 (.008)	ATMO-CM
DXD 033	.17	-1.48	.23	.59	1.99	3.23	-.13	PERCENT

Values in brackets are standard deviations. NEW II BK O3 ABS. COEF. applied.


NA 83 - NA 33
MU
2
1
0
-1
-2
-3
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0


NC 83 - NC 33
MU
2
1
0
-1
-2
-3
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0


ND 83 - ND 33
MU
2
1
0
-1
-2
-3
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0

FROM:
G-TABLE
MAR 14, 1986

N-TABLE
INST. 33
APR 15, 1986
VERSION: R1

NA TABLE

R	0	1	2	3	4	5	6	7	8	9
0	-12.1	-11.1	-10.1	-9.1	-8.1	-7.1	-6.1	-5.2	-4.2	-3.2
10	-2.2	-1.2	-.2	.8	1.8	2.8	3.7	4.7	5.7	6.7
20	7.7	8.6	9.6	10.6	11.6	12.5	13.5	14.4	15.4	16.3
30	17.3	18.2	19.1	20.0	20.9	21.8	22.8	23.7	24.6	25.4
40	26.3	27.2	28.1	29.0	29.9	30.8	31.7	32.6	33.5	34.4
50	35.3	36.2	37.1	38.0	38.9	39.8	40.7	41.5	42.4	43.3
60	44.2	45.1	46.0	46.8	47.7	48.6	49.4	50.3	51.2	52.0
70	52.9	53.8	54.6	55.5	56.3	57.2	58.0	58.9	59.7	60.6
80	61.4	62.3	63.1	64.0	64.8	65.7	66.6	67.4	68.3	69.1
90	70.0	70.9	71.7	72.6	73.4	74.3	75.2	76.0	76.9	77.7
100	78.6	79.5	80.3	81.2	82.0	82.9	83.8	84.6	85.5	86.4
110	87.2	88.1	89.0	89.8	90.7	91.6	92.5	93.3	94.2	95.1
120	96.0	96.8	97.7	98.6	99.5	100.4	101.3	102.1	103.0	103.9
130	104.8	105.7	106.6	107.5	108.4	109.3	110.2	111.1	112.0	112.9
140	113.8	114.7	115.6	116.5	117.5	118.4	119.3	120.2	121.1	122.0
150	122.9	123.8	124.8	125.7	126.6	127.5	128.4	129.4	130.3	131.2
160	132.1	133.1	134.0	134.9	135.8	136.8	137.7	138.6	139.6	140.5
170	141.4	142.4	143.3	144.3	145.2	146.1	147.1	148.0	149.0	149.9
180	150.9	151.8	152.8	153.7	154.7	155.6	156.6	157.5	158.5	159.5
190	160.4	161.4	162.4	163.3	164.3	165.3	166.3	167.3	168.2	169.2
200	170.2	171.2	172.2	173.2	174.2	175.2	176.2	177.2	178.2	179.2
210	180.2	181.2	182.2	183.2	184.2	185.2	186.3	187.3	188.3	189.3
220	190.3	191.3	192.3	193.3	194.3	195.3	196.3	197.3	198.3	199.3
230	200.3	201.3	202.3	203.3	204.3	205.3	206.3	207.3	208.3	209.3
240	210.3	211.3	212.3	213.3	214.3	215.3	216.3	217.3	218.2	219.2
250	220.2	221.2	222.1	223.1	224.1	225.1	226.1	227.0	228.0	229.0
260	230.0	231.0	232.0	233.0	234.0	235.0	236.0	237.0	238.1	239.1
270	240.1	241.1	242.1	243.1	244.1	245.1	246.1	247.1	248.1	249.1
280	250.1	251.0	252.0	253.0	254.0	255.0	256.0	257.0	258.0	259.0
290	260.0	261.0	262.0	263.0	264.0	265.0	265.9	266.9	267.9	268.9
300	269.9									

TABLE GENERATED ON 92/09/15.

FROM:
G-TABLE
MAR 14, 1986

N-TABLE
INST. 33
APR 15, 1986
VERSION: R1

NC TABLE

R	0	1	2	3	4	5	6	7	8	9
0	-7.9	-6.9	-5.9	-4.9	-3.9	-2.9	-1.9	-.9	.1	1.1
10	2.1	3.1	4.1	5.0	6.0	7.0	8.0	9.0	10.0	10.9
20	11.9	12.9	13.9	14.8	15.8	16.7	17.7	18.6	19.6	20.5
30	21.5	22.4	23.3	24.2	25.2	26.1	27.0	27.9	28.8	29.7
40	30.6	31.5	32.4	33.3	34.2	35.1	36.0	36.9	37.8	38.7
50	39.6	40.4	41.3	42.2	43.1	44.0	44.9	45.8	46.6	47.5
60	48.4	49.3	50.2	51.0	51.9	52.8	53.7	54.5	55.4	56.3
70	57.1	58.0	58.8	59.7	60.6	61.4	62.3	63.1	64.0	64.8
80	65.7	66.5	67.4	68.2	69.1	69.9	70.8	71.6	72.5	73.3
90	74.2	75.0	75.9	76.7	77.6	78.4	79.3	80.1	81.0	81.8
100	82.7	83.5	84.4	85.2	86.1	87.0	87.8	88.7	89.5	90.4
110	91.3	92.1	93.0	93.8	94.7	95.6	96.4	97.3	98.2	99.1
120	99.9	100.8	101.7	102.5	103.4	104.3	105.2	106.0	106.9	107.8
130	108.7	109.5	110.4	111.3	112.2	113.1	114.0	114.8	115.7	116.6
140	117.5	118.4	119.3	120.2	121.1	122.0	122.9	123.8	124.7	125.6
150	126.5	127.4	128.3	129.2	130.1	131.0	132.0	132.9	133.8	134.7
160	135.6	136.5	137.4	138.3	139.2	140.2	141.1	142.0	142.9	143.8
170	144.8	145.7	146.6	147.5	148.4	149.4	150.3	151.2	152.2	153.1
180	154.0	155.0	155.9	156.8	157.8	158.7	159.7	160.6	161.6	162.5
190	163.5	164.4	165.4	166.3	167.3	168.2	169.2	170.2	171.1	172.1
200	173.1	174.0	175.0	176.0	177.0	177.9	178.9	179.9	180.9	181.9
210	182.9	183.9	184.8	185.8	186.8	187.8	188.8	189.8	190.8	191.8
220	192.8	193.8	194.8	195.8	196.7	197.7	198.7	199.7	200.7	201.7
230	202.7	203.7	204.6	205.6	206.6	207.6	208.6	209.6	210.6	211.5
240	212.5	213.5	214.5	215.5	216.4	217.4	218.4	219.4	220.3	221.3
250	222.3	223.3	224.2	225.2	226.2	227.2	228.2	229.1	230.1	231.1
260	232.1	233.0	234.0	235.0	236.0	237.0	238.0	239.0	240.0	241.0
270	241.9	242.9	243.9	244.9	245.9	246.9	247.9	248.9	249.9	250.8
280	251.8	252.8	253.8	254.8	255.8	256.7	257.7	258.7	259.7	260.6
290	261.6	262.6	263.5	264.5	265.5	266.5	267.5			

TABLE GENERATED ON 92/09/15.

FROM:
G-TABLE
MAR 14, 1986

N-TABLE
INST. 33
APR 15, 1986
VERSION: R1

ND TABLE

R	0	1	2	3	4	5	6	7	8	9
0	-4.9	-3.9	-3.0	-2.0	-1.0	.0	1.0	2.0	3.0	4.0
10	5.0	6.0	7.0	7.9	8.9	9.9	10.9	11.9	12.9	13.9
20	14.9	15.8	16.8	17.8	18.7	19.7	20.6	21.6	22.5	23.5
30	24.4	25.3	26.3	27.2	28.1	29.0	29.9	30.8	31.7	32.6
40	33.5	34.4	35.3	36.2	37.1	38.0	38.9	39.8	40.7	41.6
50	42.5	43.4	44.3	45.2	46.0	46.9	47.8	48.7	49.6	50.5
60	51.3	52.2	53.1	54.0	54.9	55.7	56.6	57.4	58.3	59.2
70	60.0	60.9	61.7	62.6	63.4	64.3	65.1	66.0	66.8	67.7
80	68.5	69.4	70.2	71.1	71.9	72.8	73.6	74.5	75.3	76.2
90	77.0	77.9	78.7	79.6	80.4	81.2	82.1	82.9	83.8	84.6
100	85.5	86.3	87.2	88.0	88.9	89.7	90.6	91.4	92.3	93.1
110	94.0	94.8	95.7	96.6	97.4	98.3	99.1	100.0	100.9	101.7
120	102.6	103.5	104.3	105.2	106.1	106.9	107.8	108.7	109.5	110.4
130	111.3	112.2	113.0	113.9	114.8	115.7	116.5	117.4	118.3	119.2
140	120.1	121.0	121.8	122.7	123.6	124.5	125.4	126.3	127.2	128.1
150	129.0	129.9	130.8	131.7	132.6	133.5	134.4	135.3	136.2	137.1
160	138.0	138.9	139.8	140.7	141.6	142.5	143.4	144.3	145.2	146.1
170	147.1	148.0	148.9	149.8	150.7	151.6	152.6	153.5	154.4	155.3
180	156.2	157.2	158.1	159.0	160.0	160.9	161.8	162.7	163.7	164.6
190	165.6	166.5	167.4	168.4	169.3	170.3	171.2	172.2	173.1	174.1
200	175.0	176.0	177.0	177.9	178.9	179.9	180.8	181.8	182.8	183.8
210	184.8	185.7	186.7	187.7	188.7	189.7	190.6	191.6	192.6	193.6
220	194.6	195.5	196.5	197.5	198.5	199.5	200.4	201.4	202.4	203.4
230	204.4	205.4	206.3	207.3	208.3	209.3	210.3	211.2	212.2	213.2
240	214.2	215.1	216.1	217.1	218.1	219.0	220.0	220.9	221.9	222.9
250	223.8	224.8	225.8	226.7	227.7	228.6	229.6	230.6	231.6	232.6
260	233.5	234.5	235.5	236.5	237.5	238.4	239.4	240.4	241.4	242.4
270	243.4	244.4	245.3	246.3	247.3	248.3	249.3	250.2	251.2	252.2
280	253.1	254.1	255.1	256.1	257.0	258.0	259.0	259.9	260.9	261.9
290	262.9	263.9	264.8	265.8	266.8	267.8	268.7	269.7	270.7	

TABLE GENERATED ON 92/09/15.

INST. NO: 33 DATE: April 15, 1986 R1

REFERENCE STANDARD LAMP DATA

Lamp No.	Voltage d.c.	Voltage a.c.	Current amps	R_A	R_C	$R_{C'}$	R_D
33Q1	24.0			13.0* 25.5	17.8 26.1	26.2 35.1	21.0 26.4
33Q3	24.0			13.0 25.5	17.5 25.8	25.4 34.2	20.8 26.2
33Q4	24.0			12.7 25.2	17.5 25.8	27.7 36.8	20.6 26.0
UQ1	24.0			14.0 26.5	18.6 27.0	25.0 33.8	21.9 27.3
UQ2	24.0			13.4 25.9	18.3 26.7	25.0 33.8	21.5 26.9

NOTES: * N-values

DOBSON OZONE SPECTROPHOTOMETER CALIBRATION

Place: Boulder, Colorado

Date: May 11, 1988 A.M./P.M. A.M.

U.S.A. Inst. No. 33 VS U.S.A. Inst. No. 83
(Country) (Country)

For instrument No. 33 use N tables dated April 15, 1986 R1

Apply the following corrections to the tables:

To GA or NA values add -2.0

To GC or NC values add -2.1

To GD or ND values add -2.0

For instrument No. 83 use N tables dated July 10, 1987 F1

Apply the following corrections to the tables:

To GA or NA values add -0.4

To GC or NC values add -0.3

To GD or ND values add -0.1

NOTES: "Final" calibration, with instrument as received from Bismarck

Data summary using Inst. 33 N tables dated April 15, 1986: Calib Inst. 83 vs 33 May 11, 1988 AM

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD083*	.333 (.001)	.332 (.001)	.329 (.001)	.328 (.000)	.330 (.001)		.331 (.002)	ATMO-CM
XAD033*	.325 (.001)	.327 (.001)	.326 (.001)	.327 (.001)	.329 (.001)		.326 (.001)	ATMO-CM
DXAD033*	-2.62	-1.36	-.98	-.28	-.08		-1.31	PERCENT
XCD083*	.325 (.003)	.326 (.002)	.323 (.001)	.320 (.001)	.321 (.002)		.324 (.002)	ATMO-CM
XCD033*	.302 (.006)	.312 (.003)	.314 (.002)	.317 (.002)	.317 (.001)		.311 (.005)	ATMO-CM
DXCD033*	-7.07	-4.16	-2.88	-1.17	-1.46		-3.83	PERCENT
XA 083*	.339 (.001)	.337 (.001)	.334 (.001)	.333 (.000)	.334 (.001)		.336 (.002)	ATMO-CM
XA 033*	.340 (.001)	.339 (.002)	.335 (.001)	.335 (.000)	.337 (.000)		.338 (.002)	ATMO-CM
DXA 033*	.42	.60	.49	.72	.93		.56	PERCENT
XC 083*	.338 (.001)	.336 (.001)	.332 (.001)	.331 (.001)	.331 (.001)		.334 (.003)	ATMO-CM
XC 033*	.344 (.002)	.341 (.002)	.337 (.001)	.336 (.000)	.336 (.001)		.339 (.003)	ATMO-CM
DXC 033*	1.63	1.40	1.26	1.38	1.53		1.42	PERCENT
XD 083*	.350 (.004)	.344 (.004)	.340 (.002)	.339 (.001)	.339 (.001)		.343 (.004)	ATMO-CM
XD 033*	.390 (.009)	.371 (.006)	.360 (.002)	.354 (.002)	.356 (.001)		.369 (.014)	ATMO-CM
DXD 033*	11.58	7.86	6.01	4.47	4.83		7.51	PERCENT

Corr. needed to Inst. 33 N values

MU=	1.33	1.75	2.25	2.85	mean (1.15-2.5)	rsd
To NA ADD	-.37	-.57	-.82	-1.11	-.59	.240
To NC ADD	-.58	-.71	-.86	-1.04	-.72	.166
To ND ADD	-1.89	-1.80	-1.68	-1.55	-1.79	.229

MU=	1.33	1.75	2.25	2.85	mean (1.15-2.5)
To NAD ADD	1.53	1.22	.87	.44	1.21
To NCD ADD	1.31	1.09	.83	.51	1.08

Data summary using corrected Inst. 33 N Tables: (using mean)

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD083	.333 (.001)	.332 (.001)	.329 (.001)	.328 (.000)	.330 (.001)		.331 (.002)	ATMO-CM
XAD033	.331 (.001)	.332 (.001)	.330 (.001)	.330 (.001)	.332 (.000)		.331 (.001)	ATMO-CM
DXAD033	-.67	.14	.16	.62	.65		.06	PERCENT
XCD083	.325 (.003)	.326 (.002)	.323 (.001)	.320 (.001)	.321 (.002)		.324 (.002)	ATMO-CM
XCD033	.321 (.004)	.326 (.003)	.324 (.003)	.325 (.002)	.323 (.001)		.324 (.002)	ATMO-CM
DXCD033	-1.47	.12	.40	1.44	.63		.12	PERCENT
XA 083	.339 (.001)	.337 (.001)	.334 (.001)	.333 (.000)	.334 (.001)		.336 (.002)	ATMO-CM
XA 033	.338 (.001)	.337 (.001)	.334 (.001)	.334 (.000)	.336 (.000)		.336 (.002)	ATMO-CM
DXA 033	-.32	.03	.05	.38	.65		.03	PERCENT
XC 083	.338 (.001)	.336 (.001)	.332 (.001)	.331 (.001)	.331 (.001)		.334 (.003)	ATMO-CM
XC 033	.337 (.001)	.336 (.002)	.333 (.001)	.333 (.000)	.334 (.000)		.335 (.002)	ATMO-CM
DXC 033	-.34	-.11	.09	.45	.80		.02	PERCENT
XD 083	.350 (.004)	.344 (.004)	.340 (.002)	.339 (.001)	.339 (.001)		.343 (.004)	ATMO-CM
XD 033	.353 (.006)	.343 (.004)	.339 (.001)	.337 (.002)	.342 (.001)		.343 (.006)	ATMO-CM
DXD 033	.95	-.37	-.33	-.54	.86		-.07	PERCENT

Values in brackets are standard deviations. NEW II BK O3 ABS. COEF. applied.

APPENDIX 2.D

DOBSON INSTRUMENT 79 SAMPLE CALIBRATION DATA - AUGUST 25, 1981 AND JUNE 19, 1985

(a) Stable optical wedge

(b) Observations exhibit a μ-dependency relative to Dobson instrument 83.

DOBSON OZONE SPECTROPHOTOMETER CALIBRATION

Place: Boulder, Colorado

Date: Aug. 25, 1981 A.M./P.M. A.M.

U.S.A. (Country) Inst. No. 79 VS U.S.A. (Country) Inst. No. 83

For instrument No. 79 use G tables dated Aug. 24, 1981

Apply the following corrections to the tables:

To GA or NA values add NA

To GC or NC values add NA

To GD or ND values add NA

For instrument No. 83 use N tables dated Aug. 26, 1976 FI

Apply the following corrections to the tables:

To GA or NA values add +3.4

To GC or NC values add +3.8

To GD or ND values add +4.4

NOTES: "Initial" instrument calibration, performed after cleaning optics and installing a new cobalt filter into the instrument.

Data summary using inst. 79 G tables dated August 24, 1981: Calib Inst. 83 vs 79 August 25, 1981 AM

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD083*	.286 (.001)	.286 (.001)	.284 (.000)	.284 (.000)	.283 (.002)	.275 (.003)	.285 (.001)	ATMO-CM
XAD079*	.275 (.001)	.278 (.001)	.278 (.001)	.278 (.000)	.275 (.002)	.263 (.004)	.277 (.001)	ATMO-CM
DXAD079*	-3.66	-2.78	-2.23	-2.22	-2.81	-4.40	-2.72	PERCENT
XCD083*	.285 (.005)	.288 (.003)	.286 (.001)	.286 (.002)	.285 (.001)	.281 (.001)	.286 (.001)	ATMO-CM
XCD079*	.245 (.006)	.256 (.002)	.261 (.002)	.265 (.002)	.266 (.002)	.264 (.002)	.257 (.007)	ATMO-CM
DXCD079*	-14.07	-10.97	-8.64	-7.26	-6.83	-6.27	-10.23	PERCENT
XA 083*	.297 (.001)	.296 (.001)	.293 (.000)	.293 (.000)	.291 (.001)	.284 (.002)	.295 (.002)	ATMO-CM
XA 079*	.412 (.010)	.383 (.004)	.356 (.004)	.341 (.005)	.325 (.005)	.308 (.005)	.373 (.027)	ATMO-CM
DXA 079*	38.76	29.11	21.41	16.46	11.78	8.18	26.49	PERCENT
XC 083*	.307 (.002)	.307 (.002)	.303 (.001)	.301 (.001)	.300 (.000)	.296 (.001)	.304 (.003)	ATMO-CM
XC 079*	.552 (.020)	.490 (.009)	.436 (.009)	.407 (.008)	.382 (.006)	.360 (.006)	.471 (.056)	ATMO-CM
DXC 079*	79.90	59.78	44.13	35.27	27.31	21.46	54.91	PERCENT
XD 083*	.330 (.007)	.326 (.003)	.319 (.002)	.315 (.001)	.313 (.001)	.310 (.002)	.322 (.006)	ATMO-CM
XD 079*	.925 (.052)	.773 (.020)	.646 (.021)	.577 (.019)	.520 (.015)	.474 (.012)	.730 (.133)	ATMO-CM
DXD 079*	180.79	137.20	102.89	83.10	65.82	52.61	126.65	PERCENT

Corr. needed to inst. 79 G values

MU=	1.33	1.75	2.25	2.85	mean (1.15-2.5)	rsd
To GA ADD	-25.96	-25.53	-25.03	-24.43	-25.51	.175
To GC ADD	-25.60	-25.35	-25.06	-24.71	-25.34	.160
To GD ADD	-27.88	-27.66	-27.40	-27.10	-27.65	.227

MU=	1.33	1.75	2.25	2.85	mean (1.15-2.5)
To GAD ADD	1.92	2.13	2.37	2.67	2.14
To GCD ADD	2.28	2.31	2.34	2.39	2.31

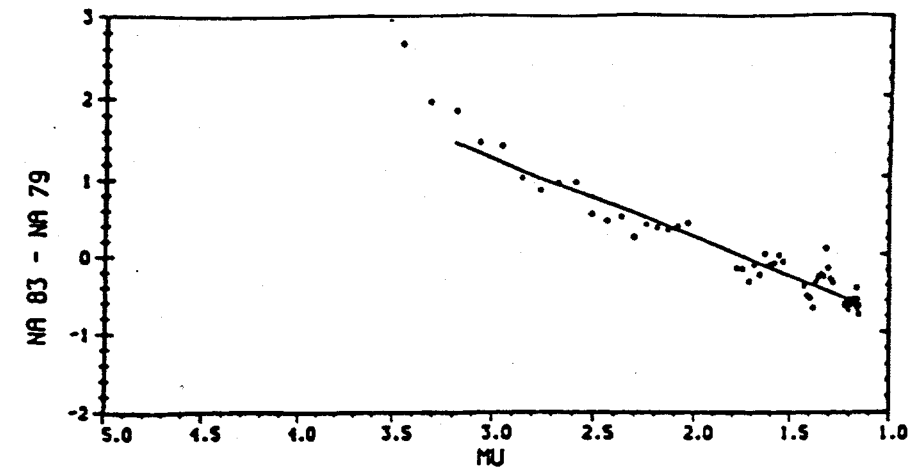
Data summary using corrected inst. 79 N Tables: (using mean)

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD083	.286 (.001)	.286 (.001)	.284 (.000)	.284 (.000)	.283 (.002)	.275 (.003)	.285 (.001)	ATMO-CM
XAD079	.287 (.001)	.287 (.001)	.284 (.000)	.283 (.000)	.278 (.003)	.266 (.004)	.285 (.002)	ATMO-CM
DXAD079	.42	.22	-.06	-.53	-1.53	-3.38	.01	PERCENT
XCD083	.285 (.005)	.288 (.003)	.286 (.001)	.286 (.002)	.285 (.001)	.281 (.001)	.286 (.001)	ATMO-CM
XCD079	.286 (.003)	.288 (.002)	.285 (.001)	.285 (.001)	.282 (.002)	.277 (.002)	.286 (.001)	ATMO-CM
DXCD079	.24	.10	-.19	-.35	-1.20	-1.55	-.05	PERCENT
XA 083	.297 (.001)	.296 (.001)	.293 (.000)	.293 (.000)	.291 (.001)	.284 (.002)	.295 (.002)	ATMO-CM
XA 079	.299 (.002)	.297 (.001)	.293 (.000)	.291 (.001)	.286 (.002)	.275 (.004)	.295 (.003)	ATMO-CM
DXA 079	.76	.16	-.31	-.72	-1.66	-3.13	-.03	PERCENT
XC 083	.307 (.002)	.307 (.002)	.303 (.001)	.301 (.001)	.300 (.000)	.296 (.001)	.304 (.003)	ATMO-CM
XC 079	.310 (.003)	.307 (.001)	.301 (.001)	.299 (.001)	.296 (.001)	.291 (.002)	.304 (.005)	ATMO-CM
DXC 079	1.04	.04	-.64	-.75	-1.37	-1.91	-.07	PERCENT
XD 083	.330 (.007)	.326 (.003)	.319 (.002)	.315 (.001)	.313 (.001)	.310 (.002)	.322 (.006)	ATMO-CM
XD 079	.336 (.009)	.326 (.002)	.315 (.003)	.311 (.001)	.309 (.002)	.303 (.002)	.322 (.010)	ATMO-CM
DXD 079	1.90	-.03	-1.15	-1.20	-1.58	-2.34	-.10	PERCENT

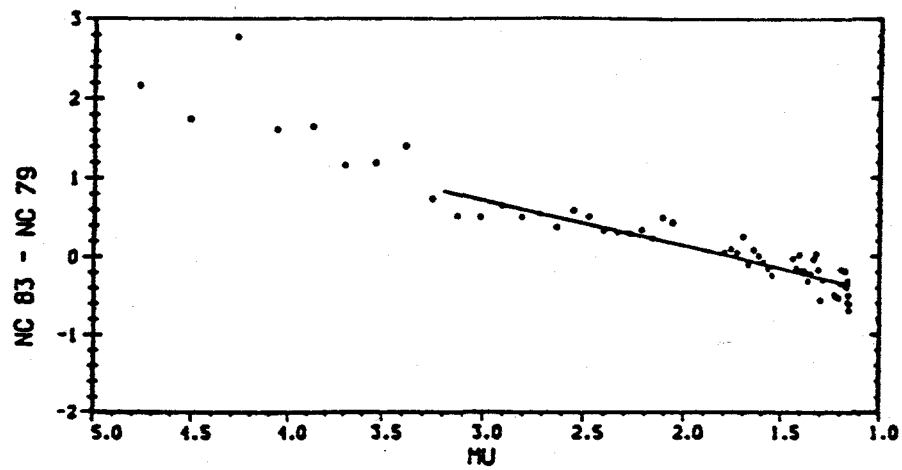
Values in brackets are standard deviations. NEW II BK 03 ABS. COEF. applied.

Cubic equations for N-function corrections to inst. 79 G-Tables

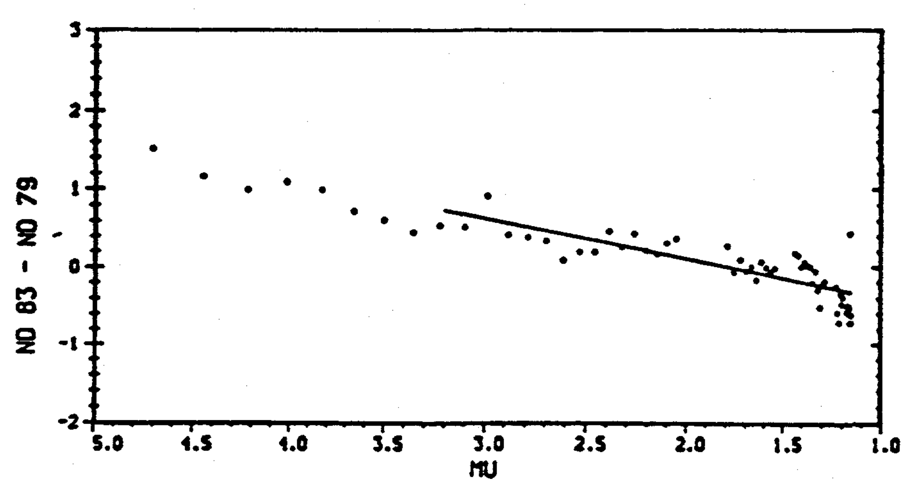
A	-.2728061294E+02	.9992239398E+00	.0000000000E+00	.0000000000E+00
C	-.2637512621E+02	.5846220291E+00	.0000000000E+00	.0000000000E+00
D	-.2855338277E+02	.5105867495E+00	.0000000000E+00	.0000000000E+00



NA 83 - NA 79
MU



NC 83 - NC 79
MU



ND 83 - ND 79
MU

FROM:
G-TABLE
AUG 24, 1981

N-TABLE
INST. 79
AUG 25, 1981
VERSION: R1

NA TABLE

R	0	1	2	3	4	5	6	7	8	9
0	-31.4	-30.2	-29.1	-27.9	-26.7	-25.5	-24.3	-23.1	-22.0	-20.8
10	-19.6	-18.4	-17.3	-16.2	-15.0	-13.9	-12.7	-11.6	-10.4	-9.2
20	-8.0	-6.8	-5.6	-4.4	-3.2	-2.1	-.9	.3	1.4	2.6
30	3.8	4.9	6.0	7.2	8.3	9.4	10.5	11.6	12.6	13.6
40	14.6	15.6	16.6	17.6	18.5	19.5	20.4	21.4	22.4	23.3
50	24.3	25.2	26.1	27.1	28.0	29.0	29.9	30.8	31.7	32.6
60	33.5	34.5	35.4	36.3	37.2	38.1	39.0	39.9	40.8	41.7
70	42.6	43.5	44.5	45.4	46.3	47.2	48.1	49.0	49.9	50.8
80	51.7	52.6	53.6	54.5	55.5	56.4	57.3	58.3	59.2	60.2
90	61.2	62.2	63.1	64.1	65.1	66.1	67.1	68.0	69.0	70.0
100	71.0	72.0	73.0	74.1	75.1	76.1	77.1	78.1	79.1	80.1
110	81.2	82.2	83.2	84.2	85.2	86.2	87.2	88.2	89.2	90.2
120	91.3	92.3	93.3	94.3	95.3	96.3	97.4	98.4	99.4	100.4
130	101.4	102.5	103.5	104.5	105.5	106.6	107.6	108.6	109.6	110.7
140	111.7	112.7	113.7	114.7	115.7	116.8	117.8	118.8	119.8	120.8
150	121.8	122.8	123.8	124.8	125.8	126.8	127.8	128.8	129.8	130.8
160	131.8	132.8	133.9	134.9	135.9	136.9	137.9	138.9	139.9	140.9
170	142.0	143.0	144.0	145.0	146.0	147.0	148.0	149.0	150.0	151.0
180	152.0	153.0	154.0	155.0	156.0	157.0	158.0	159.0	160.0	161.0
190	162.0	163.1	164.1	165.1	166.1	167.1	168.1	169.1	170.2	171.2
200	172.2	173.2	174.3	175.3	176.3	177.3	178.4	179.4	180.4	181.4
210	182.4	183.5	184.5	185.5	186.5	187.5	188.5	189.6	190.6	191.6
220	192.6	193.6	194.7	195.7	196.7	197.7	198.8	199.8	200.8	201.9
230	202.9	203.9	205.0	206.0	207.1	208.1	209.1	210.2	211.2	212.3
240	213.3	214.4	215.4	216.5	217.6	218.6	219.7	220.7	221.8	222.9
250	223.9	225.0	226.1	227.1	228.2	229.3	230.3	231.4	232.5	233.5
260	234.6	235.6	236.6	237.7	238.7	239.7	240.7	241.8	242.8	243.8
270	244.9	245.9	246.9	247.9	248.9	250.0	251.0	252.0	253.1	254.1
280	255.2	256.2	257.3	258.4	259.5	260.6	261.7	262.8	263.9	265.0
290	266.1	267.2	268.3	269.4						

TABLE GENERATED ON 92/05/26.

FROM:
G-TABLE
AUG 24, 1981

N-TABLE
INST. 79
AUG 25, 1981
VERSION: R1

NC TABLE

R	0	1	2	3	4	5	6	7	8	9
0	-31.1	-29.9	-28.8	-27.6	-26.5	-25.3	-24.2	-23.0	-21.9	-20.7
10	-19.6	-18.4	-17.2	-16.0	-14.9	-13.7	-12.5	-11.3	-10.1	-9.0
20	-7.8	-6.6	-5.5	-4.3	-3.2	-2.0	-.9	.2	1.3	2.4
30	3.5	4.6	5.7	6.8	7.9	8.9	10.0	11.1	12.1	13.1
40	14.1	15.1	16.1	17.1	18.1	19.1	20.1	21.0	22.0	23.0
50	23.9	24.9	25.8	26.7	27.7	28.6	29.6	30.5	31.4	32.3
60	33.2	34.1	35.0	35.9	36.8	37.7	38.7	39.6	40.5	41.4
70	42.3	43.2	44.2	45.1	46.0	46.9	47.8	48.8	49.7	50.6
80	51.6	52.5	53.4	54.4	55.3	56.3	57.2	58.2	59.1	60.1
90	61.0	62.0	63.0	63.9	64.9	65.9	66.9	67.9	68.9	69.8
100	70.8	71.8	72.8	73.8	74.8	75.8	76.8	77.8	78.8	79.8
110	80.8	81.8	82.8	83.8	84.9	85.9	86.9	87.9	88.9	89.9
120	90.9	91.9	92.9	93.9	94.9	95.9	96.9	98.0	99.0	100.0
130	101.0	102.0	103.0	104.0	105.0	106.0	107.0	108.0	109.0	110.0
140	111.0	112.0	113.0	114.0	115.0	116.0	117.0	117.9	118.9	119.9
150	120.9	121.9	122.9	123.9	124.9	125.9	126.9	127.9	128.9	129.9
160	130.9	131.9	132.9	133.8	134.8	135.8	136.8	137.8	138.8	139.7
170	140.7	141.7	142.7	143.7	144.7	145.7	146.6	147.6	148.6	149.6
180	150.6	151.6	152.6	153.6	154.6	155.6	156.6	157.6	158.6	159.6
190	160.6	161.6	162.6	163.6	164.6	165.6	166.6	167.6	168.6	169.6
200	170.6	171.6	172.6	173.6	174.6	175.6	176.6	177.6	178.6	179.6
210	180.6	181.6	182.7	183.7	184.7	185.7	186.7	187.7	188.7	189.7
220	190.7	191.7	192.7	193.7	194.7	195.7	196.7	197.7	198.7	199.7
230	200.7	201.8	202.8	203.8	204.8	205.8	206.9	207.9	208.9	210.0
240	211.0	212.0	213.1	214.1	215.2	216.2	217.3	218.3	219.4	220.4
250	221.4	222.5	223.5	224.6	225.6	226.7	227.7	228.7	229.7	230.8
260	231.8	232.8	233.9	234.9	235.9	236.9	237.9	239.0	240.0	241.0
270	242.0	243.0	244.0	245.1	246.1	247.1	248.1	249.1	250.2	251.2
280	252.2	253.3	254.3	255.4	256.4	257.5	258.6	259.7	260.8	261.9
290	262.9	264.0	265.2	266.3	267.4	268.5	269.6			

TABLE GENERATED ON 92/05/26.

FROM:
G-TABLE
AUG 24, 1981

N-TABLE
INST. 79
AUG 25, 1981
VERSION: R1

ND TABLE

R	0	1	2	3	4	5	6	7	8	9
0	-33.4	-32.2	-31.1	-29.9	-28.8	-27.6	-26.5	-25.4	-24.2	-23.1
10	-21.9	-20.8	-19.6	-18.5	-17.4	-16.2	-15.1	-14.0	-12.8	-11.7
20	-10.5	-9.4	-8.3	-7.2	-6.1	-5.0	-3.8	-2.7	-1.6	-.5
30	.6	1.6	2.7	3.8	4.9	5.9	7.0	8.1	9.1	10.1
40	11.1	12.1	13.1	14.1	15.1	16.0	17.0	18.0	18.9	19.9
50	20.9	21.8	22.7	23.7	24.6	25.6	26.5	27.4	28.4	29.3
60	30.2	31.2	32.1	33.0	33.9	34.9	35.8	36.7	37.6	38.6
70	39.5	40.4	41.3	42.3	43.2	44.1	45.1	46.0	46.9	47.9
80	48.8	49.7	50.7	51.6	52.6	53.5	54.5	55.4	56.4	57.3
90	58.3	59.3	60.2	61.2	62.2	63.1	64.1	65.1	66.1	67.1
100	68.1	69.1	70.1	71.0	72.0	73.0	74.0	75.0	76.0	77.0
110	78.0	79.0	80.0	81.0	82.0	83.0	84.0	85.0	86.0	87.0
120	88.0	89.0	90.0	91.0	92.0	93.0	94.0	95.0	96.0	97.0
130	98.0	99.0	100.0	101.0	102.0	103.0	104.0	105.0	106.0	107.0
140	107.9	108.9	109.9	110.9	111.9	112.9	113.9	114.8	115.8	116.8
150	117.8	118.8	119.8	120.7	121.7	122.7	123.7	124.6	125.6	126.6
160	127.6	128.6	129.5	130.5	131.5	132.4	133.4	134.4	135.4	136.3
170	137.3	138.3	139.3	140.2	141.2	142.2	143.2	144.1	145.1	146.1
180	147.1	148.0	149.0	150.0	151.0	152.0	153.0	154.0	154.9	155.9
190	156.9	157.9	158.9	159.8	160.8	161.8	162.8	163.8	164.8	165.8
200	166.8	167.8	168.8	169.8	170.8	171.8	172.8	173.8	174.8	175.8
210	176.8	177.8	178.8	179.8	180.8	181.8	182.8	183.8	184.8	185.8
220	186.7	187.7	188.7	189.7	190.7	191.7	192.7	193.7	194.7	195.7
230	196.7	197.7	198.7	199.7	200.7	201.7	202.7	203.8	204.8	205.8
240	206.8	207.8	208.8	209.8	210.9	211.9	212.9	213.9	214.9	216.0
250	217.0	218.0	219.0	220.1	221.1	222.1	223.2	224.2	225.2	226.2
260	227.3	228.3	229.3	230.3	231.3	232.4	233.4	234.4	235.4	236.4
270	237.4	238.4	239.4	240.4	241.4	242.4	243.4	244.4	245.4	246.4
280	247.4	248.4	249.4	250.5	251.6	252.6	253.7	254.8	255.9	257.0
290	258.1	259.2	260.3	261.5	262.6	263.7	264.8	265.9	267.1	

TABLE GENERATED ON 92/05/26.

INST. NO: 79 DATE: Aug. 25, 1981 R1

REFERENCE STANDARD LAMP DATA

Lamp No.	Voltage d.c.	Voltage a.c.	Current amps	R_A	R_C	$R_{C'}$	R_D
79 Q1	24.00			12.1 37.5	16.6 42.5	41.8 67.4	17.8 46.8
79 Q2	24.00			12.6 38.0	17.1 43.0	41.3 68.9	18.3 47.3
79 Q3	24.00			12.5 37.9	17.0 42.9	41.0 68.5	18.1 47.1
UQ1	24.00			13.9 39.3	18.2 44.1	39.0 66.3	19.5 48.6
UQ2	24.00			13.4 38.8	17.8 43.7	39.3 66.7	19.1 48.2
UQ3	24.00			12.6 38.0	16.8 42.7	40.8 68.3	18.2 47.2
R12	24.00			37.7	42.8	67.9	46.8
R13	24.00			38.0	42.8	67.9	47.3
79C*		100.0		22.2 47.8	25.4 51.5	31.0 57.5	25.7 55.1
79D*		100.0		22.0 48.6	25.6 51.7	—	25.8 55.2

NOTES:
* Inferred, not highly accurate

DOBSON OZONE SPECTROPHOTOMETER CALIBRATION

Place: Boulder, Colorado

Date: June 19, 1985 A.M./P.M. A.M.

U.S.A. Inst. No. 79 VS U.S.A. Inst. No. 83
(Country) (Country)

For instrument No. 79 use N tables dated Aug 25, 1981 R1

Apply the following corrections to the tables:

To GA or NA values add +1.0

To GC or NC values add +1.0

To GD or ND values add +0.7

For instrument No. 83 use N tables dated August 26, 1976 F1

Apply the following corrections to the tables:

To GA or NA values add +4.1

To GC or NC values add +4.5

To GD or ND values add +5.0

NOTES: "Final" calibration, with instrument as received from Nashville. Cobalt filter was found to be corroded.

Cubic equations for N-function corrections to inst. 79 N-Tables

A	.7066894194E+00	-.3578645285E+01	.1164079967E+01	-.9028646822E-01
C	-.1558734476E+00	.2471852090E+01	-.2506799330E+01	.4656886357E+00
D	-.5308585447E+01	.1025674035E+02	-.5169168193E+01	.7756341925E+00

Data summary using Inst. 79 N tables dated August 25, 1981: Calib Inst. 83 vs 79 June 19, 1985 AM

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD083*	.287 (.001)	.289 (.001)	.290 (.001)	.290 (.000)	.288 (.001)	.286 (.001)	.289 (.001)	ATMO-CM
XAD079*	.304 (.001)	.303 (.001)	.299 (.001)	.295 (.001)	.288 (.003)	.272 (.003)	.300 (.003)	ATMO-CM
DXAD079*	5.91	5.05	3.04	1.83	-.10	-4.98	3.95	PERCENT
XCD083*	.283 (.004)	.286 (.003)	.286 (.001)	.285 (.001)	.284 (.001)	.285 (.000)	.285 (.001)	ATMO-CM
XCD079*	.302 (.006)	.310 (.003)	.310 (.002)	.305 (.003)	.296 (.002)	.291 (.001)	.307 (.003)	ATMO-CM
DXCD079*	6.49	8.35	8.28	6.99	4.32	1.85	7.53	PERCENT
XA 083*	.295 (.001)	.297 (.001)	.297 (.001)	.296 (.000)	.294 (.001)	.291 (.001)	.296 (.001)	ATMO-CM
XA 079*	.305 (.001)	.305 (.001)	.303 (.001)	.300 (.001)	.295 (.003)	.281 (.003)	.303 (.002)	ATMO-CM
DXA 079*	3.20	2.69	2.03	1.45	.23	-3.36	2.34	PERCENT
XC 083*	.301 (.001)	.302 (.001)	.300 (.001)	.298 (.001)	.296 (.000)	.295 (.000)	.301 (.002)	ATMO-CM
XC 079*	.303 (.002)	.307 (.001)	.311 (.000)	.309 (.001)	.305 (.001)	.301 (.001)	.308 (.003)	ATMO-CM
DXC 079*	.45	1.61	3.49	3.69	3.02	2.12	2.30	PERCENT
XD 083*	.319 (.005)	.318 (.003)	.313 (.002)	.309 (.001)	.306 (.001)	.302 (.001)	.315 (.004)	ATMO-CM
XD 079*	.299 (.003)	.300 (.003)	.308 (.002)	.309 (.001)	.311 (.001)	.309 (.001)	.304 (.004)	ATMO-CM
DXD 079*	-6.14	-5.52	-1.65	.00	1.59	2.46	-3.36	PERCENT

Corr. needed to Inst. 79 N values

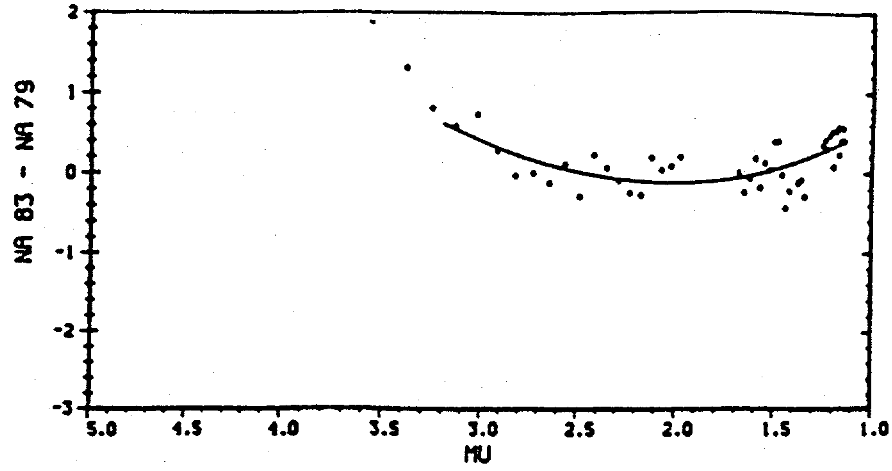
MU=	1.33	1.75	2.25	2.85	mean (1.15-2.5)	rsd
To NA ADD	-2.20	-2.47	-2.48	-2.13	-2.39	.230
To NC ADD	-.20	-1.01	-1.98	-2.69	-1.06	.152
To ND ADD	1.01	.97	.44	-.11	.80	.187

MU=	1.33	1.75	2.25	2.85	mean (1.15-2.5)
To NAD ADD	-3.21	-3.44	-2.92	-2.02	-3.19
To NCD ADD	-1.21	-1.98	-2.42	-2.58	-1.87

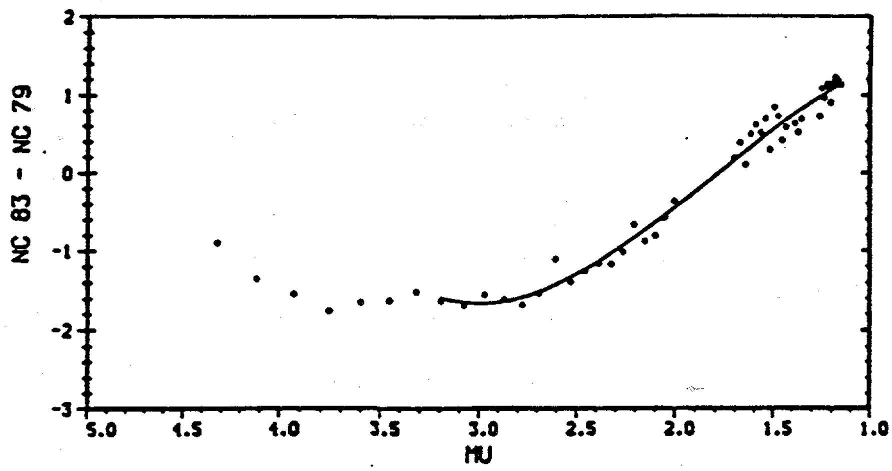
Data summary using corrected Inst. 79 N Tables: (using mean)

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD083	.287 (.001)	.289 (.001)	.290 (.001)	.290 (.000)	.288 (.001)	.286 (.001)	.289 (.001)	ATMO-CM
XAD079	.286 (.002)	.290 (.001)	.289 (.001)	.287 (.001)	.282 (.003)	.266 (.003)	.288 (.001)	ATMO-CM
DXAD079	-.17	.33	-.38	-.88	-2.32	-6.86	-.27	PERCENT
XCD083	.283 (.004)	.286 (.003)	.286 (.001)	.285 (.001)	.284 (.001)	.285 (.000)	.285 (.001)	ATMO-CM
XCD079	.270 (.008)	.285 (.004)	.292 (.001)	.291 (.002)	.285 (.002)	.281 (.001)	.284 (.009)	ATMO-CM
DXCD079	-4.74	-.35	1.89	1.92	.31	-1.55	-.31	PERCENT
XA 083	.295 (.001)	.297 (.001)	.297 (.001)	.296 (.000)	.294 (.001)	.291 (.001)	.296 (.001)	ATMO-CM
XA 079	.294 (.001)	.297 (.001)	.297 (.000)	.296 (.001)	.291 (.003)	.278 (.003)	.296 (.001)	ATMO-CM
DXA 079	-.32	-.05	.03	-.14	-1.07	-4.46	-.12	PERCENT
XC 083	.301 (.001)	.302 (.001)	.300 (.001)	.298 (.001)	.296 (.000)	.295 (.000)	.301 (.002)	ATMO-CM
XC 079	.293 (.003)	.299 (.001)	.305 (.001)	.304 (.001)	.301 (.001)	.298 (.001)	.300 (.005)	ATMO-CM
DXC 079	-2.86	-1.03	1.56	2.17	1.82	1.09	-.05	PERCENT
XD 083	.319 (.005)	.318 (.003)	.313 (.002)	.309 (.001)	.306 (.001)	.302 (.001)	.315 (.004)	ATMO-CM
XD 079	.316 (.004)	.314 (.002)	.318 (.001)	.317 (.001)	.317 (.001)	.315 (.001)	.316 (.002)	ATMO-CM
DXD 079	-.85	-1.37	1.45	2.49	3.57	4.17	.41	PERCENT

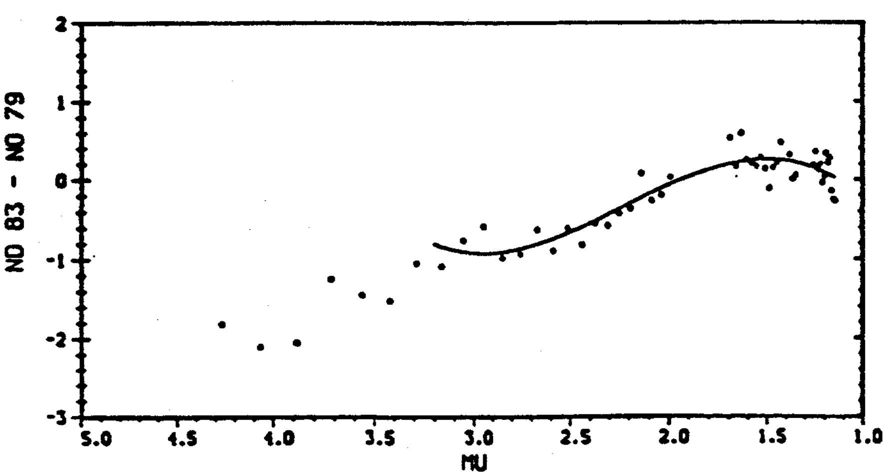
Values in brackets are standard deviations. NEW II BK 03 ABS. COEF. applied.



NA 83 - NA 79
2
1
0
-1
-2
-3
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
MU



NC 83 - NC 79
2
1
0
-1
-2
-3
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
MU



ND 83 - ND 79
2
1
0
-1
-2
-3
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
MU

APPENDIX 2.E

DOBSON INSTRUMENT 79 SAMPLE CALIBRATION DATA - SEPTEMBER 10, 1975 AND AUGUST 14, 1981

(a) Unstable optical wedge.

(b) Observations are μ-dependent.

(c) Change in instrument optical characteristics occurred also due to cobalt filter corrosion.

DOBSON OZONE SPECTROPHOTOMETER CALIBRATION

Place: Bolder, Colorado

Date: Sept. 10, 1975 A.M./P.M. A.M.

U.S.A. Inst. No. 79 VS U.S.A. Inst. No. 83
(Country) (Country)

For instrument No. 79 use G tables dated September 9, 1975

Apply the following corrections to the tables:

To GA or NA values add NA

To GC or NC values add NA

To GD or ND values add NA

For instrument No. 83 use N tables dated August 26, 1976 F1

Apply the following corrections to the tables:

To GA or NA values add -0.5

To GC or NC values add -0.4

To GD or ND values add -0.5

NOTES: "Initial" calibration.

GA TABLE

R	0	1	2	3	4	5	6	7	8	9
0						.0	1.1	2.3	3.4	4.5
10	5.7	6.9	8.0	9.2	10.4	11.6	12.8	14.0	15.2	16.4
20	17.7	18.9	20.1	21.3	22.5	23.7	24.9	26.0	27.1	28.2
30	29.4	30.5	31.6	32.7	33.8	34.9	36.0	37.0	38.1	39.1
40	40.2	41.2	42.3	43.3	44.3	45.3	46.3	47.3	48.4	49.3
50	50.3	51.3	52.3	53.3	54.2	55.2	56.1	57.0	57.9	58.9
60	59.8	60.7	61.6	62.5	63.4	64.3	65.2	66.1	67.1	68.0
70	68.9	69.9	70.8	71.7	72.6	73.6	74.5	75.5	76.4	77.4
80	78.3	79.3	80.3	81.2	82.2	83.2	84.2	85.2	86.2	87.2
90	88.2	89.2	90.2	91.2	92.2	93.2	94.2	95.3	96.3	97.3
100	98.3	99.3	100.3	101.4	102.4	103.4	104.4	105.4	106.4	107.5
110	108.5	109.5	110.5	111.5	112.6	113.6	114.6	115.6	116.7	117.7
120	118.7	119.8	120.8	121.8	122.9	123.9	124.9	126.0	127.0	128.0
130	129.0	130.1	131.1	132.1	133.1	134.1	135.1	136.2	137.2	138.2
140	139.2	140.2	141.2	142.2	143.2	144.3	145.3	146.3	147.3	148.3
150	149.4	150.4	151.4	152.4	153.5	154.5	155.5	156.5	157.5	158.6
160	159.6	160.6	161.6	162.6	163.6	164.6	165.7	166.7	167.7	168.7
170	169.7	170.7	171.7	172.7	173.8	174.8	175.8	176.8	177.9	178.9
180	179.9	181.0	182.0	183.1	184.1	185.1	186.2	187.2	188.2	189.3
190	190.3	191.4	192.4	193.4	194.5	195.5	196.6	197.6	198.6	199.7
200	200.7	201.7	202.8	203.8	204.8	205.9	206.9	208.0	209.1	210.1
210	211.2	212.2	213.3	214.3	215.4	216.4	217.5	218.5	219.5	220.6
220	221.6	222.7	223.7	224.7	225.8	226.8	227.8	228.9	229.9	230.9
230	231.9	233.0	234.0	235.0	236.1	237.1	238.2	239.2	240.2	241.3
240	242.3	243.4	244.4	245.5	246.5	247.5	248.6	249.6	250.7	251.7
250	252.8	253.8	254.9	255.9	256.9	258.0	259.0	260.0	261.0	262.1
260	263.1	264.1	265.1	266.2	267.2	268.2	269.3	270.3	271.3	272.3
270	273.4	274.4	275.4	276.5	277.5	278.6	279.6	280.6	281.7	282.7
280	283.8	284.8	285.9	287.0	288.0	289.1	290.2	291.3	292.4	293.4
290	294.5	295.6	296.8	297.9	299.1	300.2				

INPUT DATA:

25.82	25.65	25.83	26.40	27.41	28.53	29.68	30.75
31.52	32.00	32.24	32.17	31.70	31.18	30.69	30.28
29.96	29.72	29.56	29.44	29.38	29.37	29.38	29.43
29.48	29.53	29.57	29.59	29.60	29.59	29.54	29.47
29.38	29.27	29.14	29.03	28.94	28.88	28.84	28.84
28.88	28.93	28.98	29.01	29.00	28.98	28.97	29.01
29.09	29.14	29.15	29.05	28.81	28.42	27.81	

GC TABLE

R	0	1	2	3	4	5	6	7	8	9
0						.0	1.1	2.3	3.4	4.5
10	5.7	6.8	8.0	9.2	10.4	11.6	12.8	13.9	15.1	16.3
20	17.5	18.7	19.8	21.0	22.1	23.3	24.4	25.5	26.6	27.7
30	28.8	29.9	31.0	32.1	33.2	34.3	35.4	36.5	37.5	38.6
40	39.7	40.7	41.8	42.8	43.8	44.8	45.8	46.8	47.8	48.8
50	49.8	50.8	51.7	52.7	53.6	54.6	55.5	56.5	57.4	58.3
60	59.2	60.2	61.1	62.0	63.0	63.9	64.8	65.8	66.7	67.7
70	68.6	69.5	70.5	71.4	72.4	73.3	74.3	75.2	76.2	77.1
80	78.1	79.1	80.0	81.0	82.0	83.0	84.0	84.9	85.9	86.9
90	87.9	88.9	89.9	90.9	91.9	92.9	93.9	94.9	95.9	96.9
100	97.9	98.9	100.0	101.0	102.0	103.0	104.0	105.0	106.0	107.0
110	108.0	109.0	110.1	111.1	112.1	113.1	114.2	115.2	116.2	117.2
120	118.2	119.3	120.3	121.3	122.3	123.3	124.3	125.4	126.4	127.4
130	128.4	129.4	130.4	131.4	132.4	133.4	134.4	135.4	136.4	137.4
140	138.4	139.4	140.4	141.4	142.4	143.5	144.5	145.5	146.5	147.5
150	148.5	149.5	150.5	151.5	152.5	153.5	154.5	155.5	156.5	157.5
160	158.5	159.5	160.5	161.5	162.5	163.5	164.5	165.5	166.6	167.6
170	168.6	169.6	170.6	171.6	172.6	173.6	174.7	175.7	176.7	177.7
180	178.8	179.8	180.8	181.8	182.9	183.9	184.9	185.9	186.9	188.0
190	189.0	190.0	191.0	192.0	193.1	194.1	195.1	196.1	197.2	198.2
200	199.2	200.3	201.3	202.3	203.4	204.4	205.4	206.5	207.5	208.6
210	209.6	210.6	211.7	212.7	213.7	214.7	215.8	216.8	217.8	218.8
220	219.9	220.9	221.9	222.9	223.9	225.0	226.0	227.0	228.0	229.0
230	230.0	231.1	232.1	233.1	234.1	235.1	236.2	237.2	238.2	239.2
240	240.3	241.3	242.3	243.3	244.4	245.4	246.4	247.4	248.5	249.5
250	250.5	251.5	252.6	253.6	254.6	255.6	256.6	257.6	258.6	259.6
260	260.6	261.6	262.6	263.7	264.7	265.7	266.7	267.7	268.7	269.8
270	270.8	271.8	272.8	273.9	274.9	275.9	276.9	278.0	279.0	280.1
280	281.1	282.2	283.2	284.3	285.4	286.4	287.5	288.5	289.6	290.7
290	291.8	292.9	294.0	295.0						

INPUT DATA:

26.37	26.14	26.31	26.89	27.77	28.73	29.69	30.62
31.28	31.76	31.90	31.77	31.43	31.08	30.75	30.44
30.17	29.93	29.77	29.68	29.66	29.67	29.72	29.78
29.84	29.93	29.97	29.98	29.96	29.92	29.84	29.75
29.66	29.56	29.46	29.37	29.30	29.25	29.23	29.24
29.30	29.39	29.44	29.46	29.46	29.47	29.50	29.57
29.62	29.61	29.54	29.32	29.08	28.66	28.02	

GD TABLE

R	0	1	2	3	4	5	6	7	8	9
0						.0	1.1	2.3	3.4	4.5
10	5.6	6.8	8.0	9.1	10.3	11.5	12.6	13.8	14.9	16.1
20	17.2	18.4	19.5	20.6	21.7	22.8	23.9	25.0	26.1	27.1
30	28.2	29.3	30.4	31.4	32.5	33.6	34.7	35.7	36.8	37.8
40	38.9	39.9	41.0	42.1	43.1	44.1	45.1	46.1	47.1	48.1
50	49.1	50.0	51.0	52.0	52.9	53.9	54.8	55.8	56.7	57.6
60	58.6	59.5	60.5	61.4	62.4	63.3	64.3	65.2	66.2	67.1
70	68.1	69.0	70.0	70.9	71.9	72.9	73.8	74.8	75.8	76.7
80	77.7	78.6	79.6	80.6	81.6	82.6	83.6	84.5	85.5	86.5
90	87.5	88.5	89.5	90.5	91.5	92.5	93.5	94.5	95.5	96.5
100	97.5	98.5	99.5	100.5	101.5	102.5	103.5	104.5	105.5	106.5
110	107.5	108.5	109.6	110.6	111.6	112.6	113.6	114.6	115.6	116.6
120	117.6	118.6	119.6	120.6	121.6	122.6	123.6	124.6	125.6	126.6
130	127.6	128.6	129.6	130.6	131.6	132.6	133.6	134.6	135.6	136.5
140	137.5	138.5	139.5	140.5	141.5	142.5	143.5	144.5	145.5	146.5
150	147.5	148.5	149.5	150.5	151.5	152.5	153.5	154.5	155.5	156.4
160	157.4	158.4	159.4	160.4	161.4	162.4	163.4	164.4	165.4	166.4
170	167.4	168.4	169.4	170.4	171.4	172.4	173.4	174.4	175.4	176.4
180	177.5	178.5	179.5	180.5	181.5	182.5	183.5	184.5	185.5	186.5
190	187.5	188.6	189.6	190.6	191.6	192.6	193.6	194.6	195.6	196.6
200	197.6	198.7	199.7	200.7	201.7	202.7	203.8	204.8	205.8	206.8
210	207.9	208.9	209.9	210.9	211.9	213.0	214.0	215.0	216.0	217.0
220	218.0	219.0	220.0	221.1	222.1	223.1	224.1	225.1	226.1	227.1
230	228.1	229.1	230.1	231.1	232.1	233.1	234.1	235.1	236.1	237.2
240	238.2	239.2	240.2	241.2	242.2	243.2	244.2	245.2	246.2	247.2
250	248.2	249.2	250.2	251.2	252.2	253.2	254.2	255.2	256.2	257.2
260	258.2	259.2	260.2	261.2	262.2	263.2	264.2	265.2	266.2	267.3
270	268.3	269.3	270.3	271.3	272.3	273.3	274.3	275.4	276.4	277.4
280	278.4	279.5	280.5	281.5	282.6	283.6	284.7	285.8	286.9	287.9
290	289.0	290.1	291.3	292.4	293.5	294.6				

INPUT DATA:

26.97	26.75	26.98	27.52	28.21	28.98	29.73	30.42
31.03	31.42	31.60	31.43	31.16	30.90	30.66	30.43
30.23	30.08	30.00	29.98	30.01	30.05	30.11	30.16
30.22	30.25	30.27	30.29	30.27	30.22	30.17	30.08
30.00	29.92	29.84	29.76	29.70	29.64	29.62	29.62
29.65	29.73	29.81	29.86	29.91	29.95	29.97	29.99
30.02	30.01	29.92	29.72	29.38	28.88	28.22	

Cubic equations for N-function corrections to inst. 79 G-Tables

A	-.2451477739E+02	.8355565381E+00	.0000000000E+00	.0000000000E+00
C	-.2280700086E+02	.3147929774E+00	.0000000000E+00	.0000000000E+00
D	-.2658217543E+02	.5610387537E+00	.0000000000E+00	.0000000000E+00

Data summary using inst. 79 G tables dated September 9, 1975:

Calib inst. 83 vs 79 September 10, 1975 AM

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD083*	.285 (.001)	.286 (.001)	.286 (.000)	.285 (.001)			.285 (.001)	ATMO-CM
XAD079*	.273 (.000)	.276 (.001)	.278 (.000)	.278 (.001)			.276 (.002)	ATMO-CM
DXAD079*	-4.21	-3.55	-2.69	-2.43			-3.22	PERCENT
XCD083*	.292 (.001)	.291 (.001)	.288 (.001)	.284 (.001)			.289 (.003)	ATMO-CM
XCD079*	.242 (.001)	.246 (.006)	.258 (.001)	.259 (.002)			.251 (.007)	ATMO-CM
DXCD079*	-17.21	-15.36	-10.58	-8.49			-12.95	PERCENT
XA 083*	.287 (.001)	.290 (.001)	.289 (.000)	.289 (.001)			.289 (.001)	ATMO-CM
XA 079*	.376 (.001)	.364 (.006)	.344 (.004)	.333 (.003)			.354 (.017)	ATMO-CM
DXA 079*	30.78	25.78	18.91	15.01			22.61	PERCENT
XC 083*	.291 (.000)	.294 (.001)	.292 (.001)	.291 (.001)			.292 (.001)	ATMO-CM
XC 079*	.476 (.003)	.451 (.011)	.407 (.008)	.384 (.006)			.430 (.036)	ATMO-CM
DXC 079*	63.42	53.46	39.40	31.86			47.04	PERCENT
XD 083*	.286 (.001)	.292 (.002)	.293 (.001)	.296 (.002)			.292 (.004)	ATMO-CM
XD 079*	.760 (.006)	.692 (.032)	.587 (.017)	.533 (.013)			.643 (.089)	ATMO-CM
DXD 079*	165.40	136.63	100.30	79.71			120.12	PERCENT

Corr. needed to inst. 79 G values

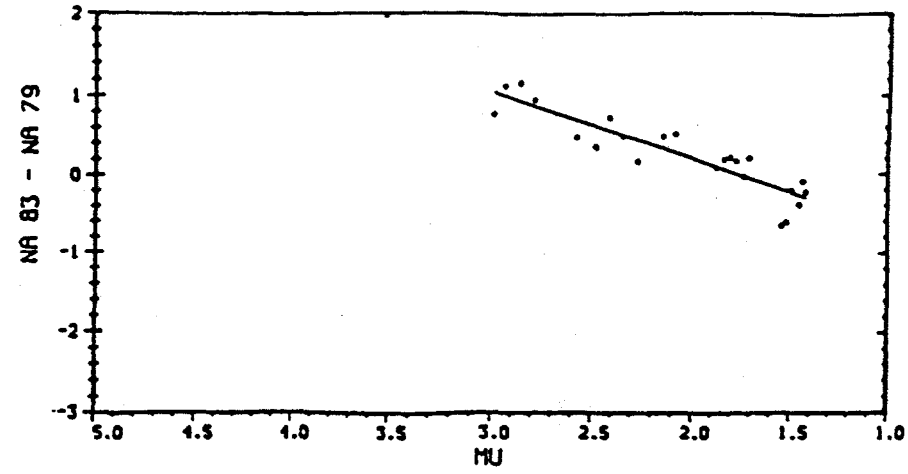
	MU= 1.33	1.75	2.25	2.85	mean (1.15-2.5)	rsd
To GA ADD	-23.41	-23.05	-22.63	-22.13	-23.03	.219
To GC ADD	-22.39	-22.26	-22.10	-21.91	-22.25	.139
To GD ADD	-25.84	-25.60	-25.32	-24.98	-25.59	.223

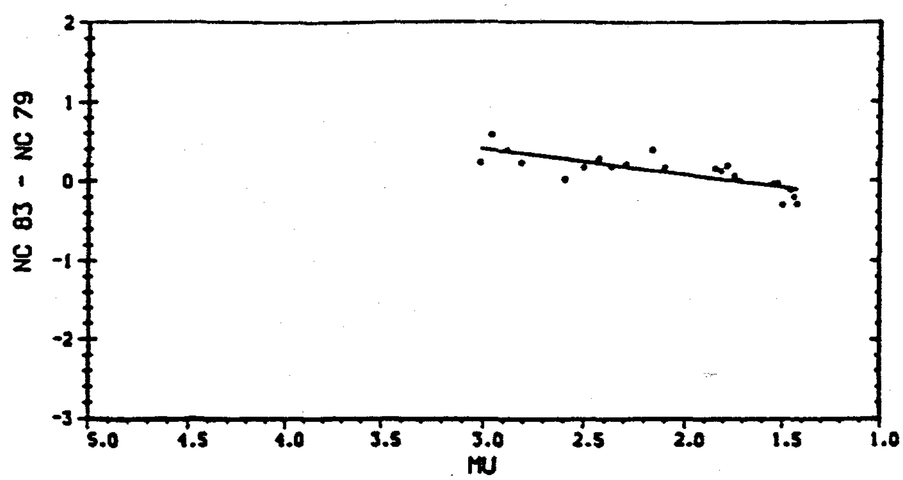
	MU= 1.33	1.75	2.25	2.85	mean (1.15-2.5)
To GAD ADD	2.43	2.55	2.69	2.85	2.55
To GCD ADD	3.45	3.34	3.22	3.07	3.34

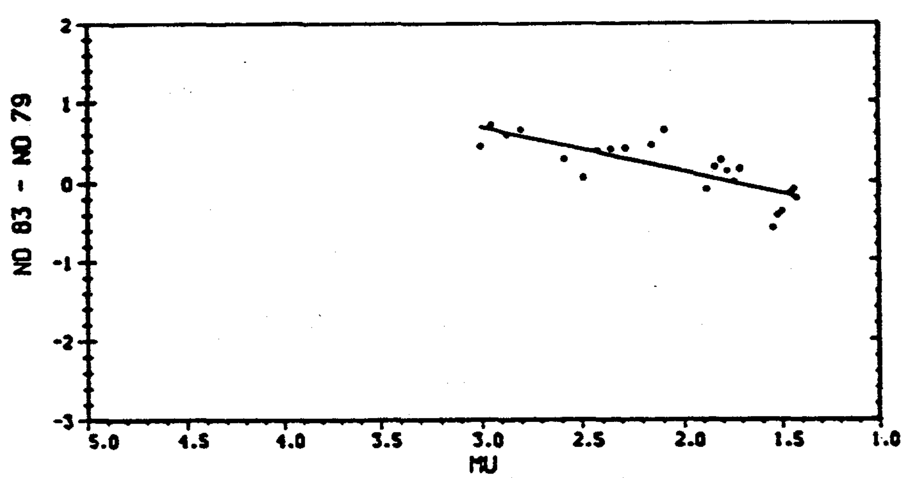
Data summary using corrected inst. 79 N Tables: (using mean)

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD083	.285 (.001)	.286 (.001)	.286 (.000)	.285 (.001)			.285 (.001)	ATMO-CM
XAD079	.285 (.000)	.286 (.001)	.286 (.001)	.284 (.001)			.285 (.001)	ATMO-CM
DXAD079	.02	.02	-.03	-.29			-.07	PERCENT
XCD083	.292 (.001)	.291 (.001)	.288 (.001)	.284 (.001)			.289 (.003)	ATMO-CM
XCD079	.292 (.002)	.290 (.003)	.290 (.002)	.286 (.002)			.289 (.002)	ATMO-CM
DXCD079	-.04	-.50	.60	.72			.19	PERCENT
XA 083	.287 (.001)	.290 (.001)	.289 (.000)	.289 (.001)			.289 (.001)	ATMO-CM
XA 079	.288 (.001)	.290 (.000)	.288 (.000)	.288 (.001)			.288 (.001)	ATMO-CM
DXA 079	.34	.09	-.36	-.59			-.13	PERCENT
XC 083	.291 (.000)	.294 (.001)	.292 (.001)	.291 (.001)			.292 (.001)	ATMO-CM
XC 079	.293 (.001)	.293 (.000)	.291 (.001)	.290 (.002)			.292 (.001)	ATMO-CM
DXC 079	.66	-.12	-.40	-.39			-.06	PERCENT
XD 083	.286 (.001)	.292 (.002)	.293 (.001)	.296 (.002)			.292 (.004)	ATMO-CM
XD 079	.291 (.002)	.293 (.003)	.288 (.002)	.291 (.002)			.291 (.002)	ATMO-CM
DXD 079	1.55	.36	-1.61	-1.70			-.36	PERCENT

Values in brackets are standard deviations. NEW II BK O3 ABS. COEF. applied.


NA 83 - NA 79
MU
2
1
0
-1
-2
-3
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0


NC 83 - NC 79
MU
2
1
0
-1
-2
-3
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0


ND 83 - ND 79
MU
2
1
0
-1
-2
-3
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0

FROM:
G-TABLE
SEP 9, 1975

N-TABLE
INST. 79
SEP 10, 1975
VERSION: R1

NA TABLE

R	0	1	2	3	4	5	6	7	8	9
0	-28.7	-27.6	-26.4	-25.3	-24.2	-23.0	-21.9	-20.8	-19.6	-18.5
10	-17.3	-16.2	-15.0	-13.8	-12.6	-11.5	-10.3	-9.0	-7.8	-6.6
20	-5.4	-4.2	-3.0	-1.8	-.5	.7	1.8	3.0	4.1	5.2
30	6.3	7.5	8.5	9.6	10.7	11.8	12.9	14.0	15.0	16.1
40	17.1	18.2	19.2	20.2	21.3	22.3	23.3	24.3	25.3	26.3
50	27.3	28.3	29.3	30.2	31.2	32.2	33.1	34.0	34.9	35.8
60	36.7	37.7	38.6	39.5	40.4	41.3	42.2	43.1	44.0	45.0
70	45.9	46.8	47.8	48.7	49.6	50.6	51.5	52.5	53.4	54.3
80	55.3	56.3	57.2	58.2	59.2	60.2	61.1	62.1	63.1	64.1
90	65.2	66.2	67.2	68.2	69.2	70.2	71.2	72.2	73.2	74.3
100	75.3	76.3	77.3	78.3	79.3	80.4	81.4	82.4	83.4	84.4
110	85.4	86.5	87.5	88.5	89.5	90.5	91.6	92.6	93.6	94.7
120	95.7	96.7	97.8	98.8	99.8	100.9	101.9	102.9	103.9	105.0
130	106.0	107.0	108.0	109.1	110.1	111.1	112.1	113.1	114.1	115.2
140	116.2	117.2	118.2	119.2	120.2	121.2	122.2	123.3	124.3	125.3
150	126.3	127.3	128.4	129.4	130.4	131.4	132.5	133.5	134.5	135.5
160	136.5	137.6	138.6	139.6	140.6	141.6	142.6	143.6	144.7	145.7
170	146.7	147.7	148.7	149.7	150.7	151.7	152.8	153.8	154.9	155.9
180	156.9	158.0	159.0	160.0	161.1	162.1	163.1	164.2	165.2	166.3
190	167.3	168.3	169.4	170.4	171.4	172.5	173.5	174.6	175.6	176.6
200	177.7	178.7	179.7	180.8	181.8	182.9	183.9	185.0	186.0	187.1
210	188.1	189.2	190.2	191.3	192.3	193.4	194.4	195.5	196.5	197.6
220	198.6	199.6	200.7	201.7	202.7	203.8	204.8	205.8	206.9	207.9
230	208.9	209.9	211.0	212.0	213.0	214.1	215.1	216.2	217.2	218.2
240	219.3	220.3	221.4	222.4	223.5	224.5	225.6	226.6	227.7	228.7
250	229.7	230.8	231.8	232.9	233.9	234.9	236.0	237.0	238.0	239.0
260	240.1	241.1	242.1	243.1	244.2	245.2	246.2	247.3	248.3	249.3
270	250.4	251.4	252.4	253.4	254.5	255.5	256.6	257.6	258.7	259.7
280	260.8	261.8	262.9	263.9	265.0	266.1	267.2	268.2	269.3	270.4
290	271.5	272.6	273.8	274.9	276.0	277.2				

FROM:
G-TABLE
SEP 9, 1975

N-TABLE
INST. 79
SEP 10, 1975
VERSION: R1

NC TABLE

R	0	1	2	3	4	5	6	7	8	9
0	-27.9	-26.8	-25.7	-24.5	-23.4	-22.3	-21.1	-20.0	-18.8	-17.7
10	-16.6	-15.4	-14.2	-13.0	-11.9	-10.7	-9.5	-8.3	-7.1	-5.9
20	-4.7	-3.6	-2.4	-1.3	-.1	1.0	2.2	3.3	4.4	5.5
30	6.6	7.7	8.8	9.9	11.0	12.1	13.2	14.3	15.3	16.4
40	17.4	18.5	19.5	20.5	21.5	22.6	23.6	24.6	25.6	26.6
50	27.5	28.5	29.5	30.4	31.4	32.3	33.3	34.2	35.1	36.1
60	37.0	37.9	38.9	39.8	40.7	41.7	42.6	43.5	44.5	45.4
70	46.4	47.3	48.2	49.2	50.1	51.1	52.0	53.0	53.9	54.9
80	55.9	56.8	57.8	58.8	59.7	60.7	61.7	62.7	63.7	64.7
90	65.7	66.7	67.7	68.7	69.7	70.7	71.7	72.7	73.7	74.7
100	75.7	76.7	77.7	78.7	79.7	80.7	81.7	82.8	83.8	84.8
110	85.8	86.8	87.8	88.8	89.9	90.9	91.9	92.9	93.9	95.0
120	96.0	97.0	98.0	99.0	100.1	101.1	102.1	103.1	104.1	105.1
130	106.1	107.1	108.1	109.2	110.2	111.2	112.2	113.2	114.2	115.2
140	116.2	117.2	118.2	119.2	120.2	121.2	122.2	123.2	124.2	125.2
150	126.2	127.3	128.3	129.3	130.3	131.3	132.3	133.3	134.3	135.3
160	136.3	137.3	138.3	139.3	140.3	141.3	142.3	143.3	144.3	145.3
170	146.3	147.3	148.3	149.4	150.4	151.4	152.4	153.4	154.5	155.5
180	156.5	157.5	158.6	159.6	160.6	161.6	162.6	163.7	164.7	165.7
190	166.7	167.7	168.8	169.8	170.8	171.8	172.9	173.9	174.9	175.9
200	177.0	178.0	179.0	180.1	181.1	182.2	183.2	184.2	185.3	186.3
210	187.3	188.4	189.4	190.4	191.5	192.5	193.5	194.5	195.6	196.6
220	197.6	198.6	199.6	200.7	201.7	202.7	203.7	204.7	205.8	206.8
230	207.8	208.8	209.8	210.8	211.9	212.9	213.9	214.9	216.0	217.0
240	218.0	219.1	220.1	221.1	222.1	223.1	224.2	225.2	226.2	227.2
250	228.3	229.3	230.3	231.3	232.3	233.3	234.4	235.4	236.4	237.4
260	238.4	239.4	240.4	241.4	242.4	243.4	244.4	245.5	246.5	247.5
270	248.5	249.6	250.6	251.6	252.6	253.7	254.7	255.7	256.8	257.8
280	258.9	259.9	261.0	262.0	263.1	264.2	265.2	266.3	267.3	268.4
290	269.5	270.6	271.7	272.8						

FROM:
G-TABLE
SEP 9, 1975

N-TABLE
INST. 79
SEP 10, 1975
VERSION: R1

ND TABLE

R	0	1	2	3	4	5	6	7	8	9
0	-31.2	-30.1	-29.0	-27.8	-26.7	-25.6	-24.5	-23.3	-22.2	-21.1
10	-20.0	-18.8	-17.6	-16.5	-15.3	-14.1	-13.0	-11.8	-10.7	-9.5
20	-8.4	-7.2	-6.1	-5.0	-3.9	-2.8	-1.7	-.6	.5	1.5
30	2.6	3.7	4.8	5.9	6.9	8.0	9.1	10.1	11.2	12.3
40	13.3	14.4	15.4	16.5	17.5	18.5	19.5	20.5	21.5	22.5
50	23.5	24.5	25.4	26.4	27.3	28.3	29.2	30.2	31.1	32.1
60	33.0	33.9	34.9	35.8	36.8	37.7	38.7	39.6	40.6	41.5
70	42.5	43.4	44.4	45.4	46.3	47.3	48.2	49.2	50.2	51.1
80	52.1	53.0	54.0	55.0	56.0	57.0	58.0	58.9	59.9	60.9
90	61.9	62.9	63.9	64.9	65.9	66.9	67.9	68.9	69.9	70.9
100	71.9	72.9	73.9	74.9	75.9	76.9	77.9	78.9	79.9	81.0
110	82.0	83.0	84.0	85.0	86.0	87.0	88.0	89.0	90.0	91.0
120	92.0	93.0	94.0	95.0	96.0	97.0	98.0	99.0	100.0	101.0
130	102.0	103.0	104.0	105.0	106.0	107.0	108.0	109.0	110.0	111.0
140	112.0	112.9	113.9	114.9	115.9	116.9	117.9	118.9	119.9	120.9
150	121.9	122.9	123.9	124.9	125.9	126.9	127.9	128.9	129.9	130.9
160	131.8	132.8	133.8	134.8	135.8	136.8	137.8	138.8	139.8	140.8
170	141.8	142.8	143.8	144.8	145.8	146.8	147.8	148.8	149.8	150.8
180	151.9	152.9	153.9	154.9	155.9	156.9	157.9	158.9	159.9	160.9
190	162.0	163.0	164.0	165.0	166.0	167.0	168.0	169.0	170.0	171.0
200	172.1	173.1	174.1	175.1	176.1	177.2	178.2	179.2	180.2	181.2
210	182.3	183.3	184.3	185.3	186.3	187.4	188.4	189.4	190.4	191.4
220	192.4	193.4	194.5	195.5	196.5	197.5	198.5	199.5	200.5	201.5
230	202.5	203.5	204.5	205.5	206.5	207.5	208.5	209.6	210.6	211.6
240	212.6	213.6	214.6	215.6	216.6	217.6	218.6	219.6	220.6	221.6
250	222.6	223.6	224.6	225.6	226.6	227.6	228.6	229.6	230.6	231.6
260	232.6	233.6	234.6	235.6	236.6	237.6	238.6	239.6	240.6	241.7
270	242.7	243.7	244.7	245.7	246.7	247.7	248.7	249.8	250.8	251.8
280	252.8	253.9	254.9	256.0	257.0	258.1	259.1	260.2	261.3	262.4
290	263.4	264.5	265.7	266.8	267.9	269.1				

INST. NO: 79　　　　DATE: Sept. 10, 1975

REFERENCE STANDARD LAMP DATA

Lamp No.	Voltage d.c.	Voltage a.c.	Current amps	R_A	R_C	$R_{C'}$	R_D
79C		100.0		22.3 45.0	25.5 47.9	41.8 65.1	25.4 52.0
79D		100.0		23.3 46.0	26.2 48.6	42.3 65.7	26.0 52.6
W		100.0		19.6 42.4	23.1 45.5	42.2 65.6	23.4 49.9
X		100.0					
Y		100.0					
Z		100.0		20.1 42.9	23.3 45.7	43.9 67.4	23.3 49.8

NOTES:

DOBSON OZONE SPECTROPHOTOMETER CALIBRATION

Place: Boulder, Colorado

Date: Aug. 14, 1981 A.M./P.M. A.M.

U.S.A. Inst. No. 79 VS U.S.A. Inst. No. 65
(Country) (Country)

For instrument No. 79 use N tables dated Sept. 10, 1975 R1

Apply the following corrections to the tables:

To GA or NA values add −6.8

To GC or NC values add −6.6

To GD or ND values add −5.5

For instrument No. 65 use N tables dated April 10, 1981 F1

Apply the following corrections to the tables:

To GA or NA values add −0.1

To GC or NC values add −0.2

To GD or ND values add −0.2

NOTES: "Final" calibration, with instrument just as received from Nashville. Comparison made with secondary standard instrument 65.

Data summary using inst. 79 N tables dated September 10, 1975:

Calib inst. 65 vs 79 August 14, 1981 AM

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD065*	.299 (.003)	.298 (.001)	.299 (.000)	.298 (.000)	.297 (.001)	.294 (.000)	.299 (.000)	ATMO-CM
XAD079*	.315 (.004)	.309 (.001)	.305 (.002)		.296 (.002)	.290 (.000)	.310 (.004)	ATMO-CM
DXAD079*	5.39	3.40	2.19		-.25	-1.25	3.70	PERCENT
XCD065*	.298 (.009)	.299 (.002)	.301 (.002)	.302 (.001)	.301 (.001)	.298 (.003)	.300 (.002)	ATMO-CM
XCD079*	.315 (.009)	.315 (.002)	.309 (.001)	.306 (.002)	.301 (.001)	.298 (.001)	.311 (.004)	ATMO-CM
DXCD079*	5.97	5.35	2.64	1.19	-.03	.10	3.78	PERCENT
XA 065*	.306 (.002)	.307 (.001)	.307 (.000)	.306 (.001)	.304 (.001)	.302 (.000)	.306 (.001)	ATMO-CM
XA 079*	.320 (.003)	.316 (.001)	.313 (.001)		.305 (.002)	.300 (.000)	.316 (.003)	ATMO-CM
DXA 079*	4.52	2.82	2.03		.26	-.71	3.19	PERCENT
XC 065*	.312 (.003)	.315 (.001)	.316 (.000)	.314 (.001)	.313 (.000)	.311 (.002)	.314 (.002)	ATMO-CM
XC 079*	.324 (.004)	.326 (.001)	.323 (.001)	.320 (.001)	.316 (.001)	.313 (.001)	.323 (.002)	ATMO-CM
DXC 079*	4.05	3.30	2.18	1.79	.96	.63	2.83	PERCENT
XD 065*	.326 (.011)	.331 (.001)	.330 (.002)	.325 (.001)	.323 (.001)	.324 (.000)	.328 (.003)	ATMO-CM
XD 079*	.332 (.011)	.335 (.002)	.336 (.001)	.333 (.001)	.330 (.001)	.328 (.000)	.334 (.001)	ATMO-CM
DXD 079*	1.87	1.01	1.70	2.49	2.10	1.24	1.76	PERCENT

Corr. needed to inst. 79 N values

	MU= 1.33	1.75	2.25	2.85	mean (1.15-2.5)	rsd
To NA ADD	-3.06	-2.83	-2.55		-2.82	.211
To NC ADD	-1.38	-1.37	-1.36	-1.34	-1.37	.152
To ND ADD	-.22	-.37	-.55	-.77	-.38	.202

	MU= 1.33	1.75	2.25	2.85	mean (1.15-2.5)
To NAD ADD	-2.85	-2.46	-2.00		-2.44
To NCD ADD	-1.17	-1.00	-.81	-.57	-.99

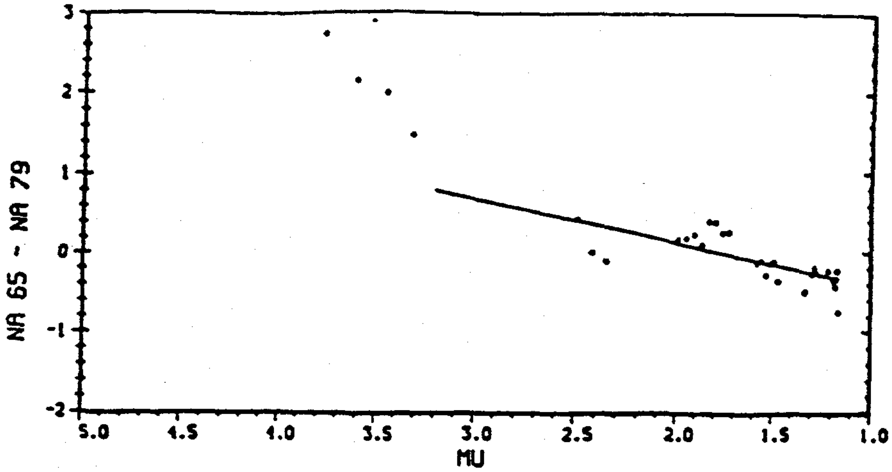
Data summary using corrected inst. 79 N Tables: (using mean)

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD065	.299 (.003)	.298 (.001)	.299 (.000)	.298 (.000)	.297 (.001)	.294 (.000)	.299 (.000)	ATMO-CM
XAD079	.302 (.004)	.299 (.001)	.298 (.001)		.291 (.002)	.286 (.000)	.299 (.002)	ATMO-CM
DXAD079	.83	.10	-.28		-1.83	-2.64	.25	PERCENT
XCD065	.298 (.009)	.299 (.002)	.301 (.002)	.302 (.001)	.301 (.001)	.298 (.003)	.300 (.002)	ATMO-CM
XCD079	.298 (.008)	.302 (.002)	.300 (.000)	.298 (.002)	.295 (.001)	.293 (.001)	.300 (.002)	ATMO-CM
DXCD079	.21	1.19	-.51	-1.36	-2.06	-1.63	-.12	PERCENT
XA 065	.306 (.002)	.307 (.001)	.307 (.000)	.306 (.001)	.304 (.001)	.302 (.000)	.306 (.001)	ATMO-CM
XA 079	.307 (.002)	.307 (.000)	.306 (.001)		.301 (.002)	.296 (.000)	.307 (.000)	ATMO-CM
DXA 079	.49	-.10	-.07		-1.17	-1.95	.17	PERCENT
XC 065	.312 (.003)	.315 (.001)	.316 (.000)	.314 (.001)	.313 (.000)	.311 (.002)	.314 (.002)	ATMO-CM
XC 079	.311 (.003)	.316 (.001)	.316 (.001)	.314 (.001)	.311 (.000)	.309 (.001)	.314 (.002)	ATMO-CM
DXC 079	-.18	.25	-.11	-.09	-.53	-.64	-.03	PERCENT
XD 065	.326 (.011)	.331 (.001)	.330 (.002)	.325 (.001)	.323 (.001)	.324 (.000)	.328 (.003)	ATMO-CM
XD 079	.324 (.011)	.329 (.002)	.331 (.001)	.330 (.001)	.327 (.001)	.325 (.000)	.328 (.003)	ATMO-CM
DXD 079	-.62	-.77	.33	1.36	1.20	.47	.07	PERCENT

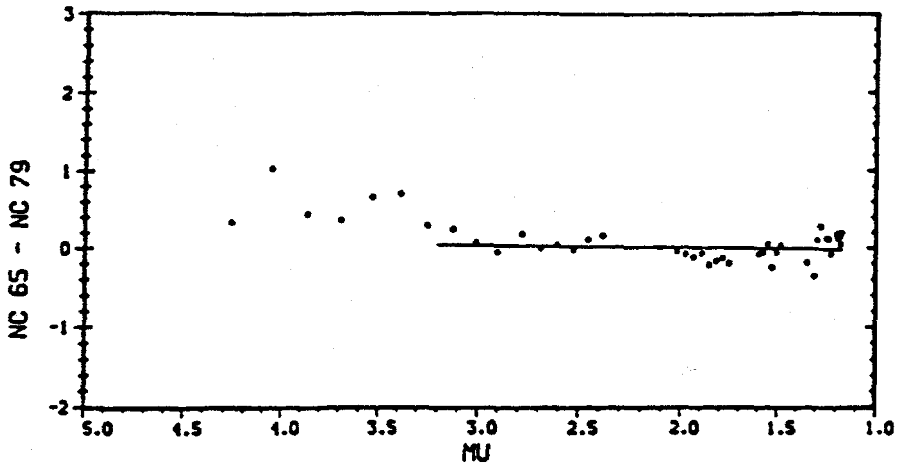
Values in brackets are standard deviations. NEW 11 BK O3 ABS. COEF. applied.

Cubic equations for N-function corrections to inst. 79 N-Tables

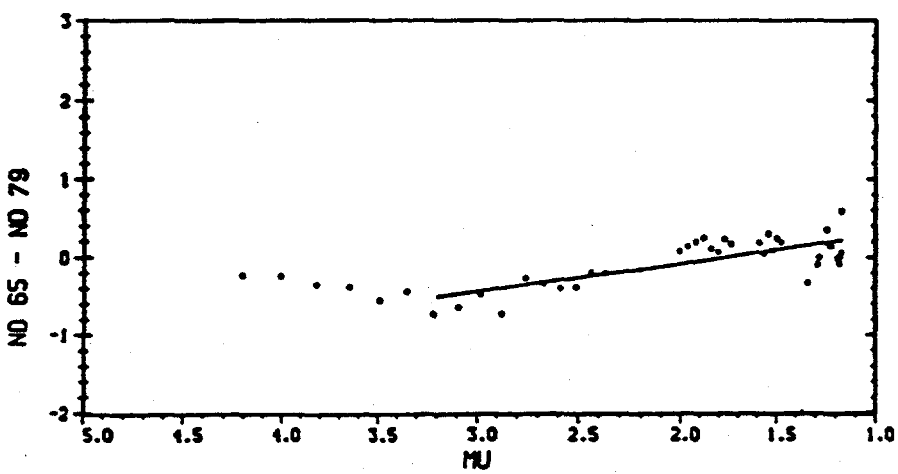
A	-.3795325355E+01	.5520981376E+00	.0000000000E+00	.0000000000E+00
C	-.1419450791E+01	.2694022590E-01	.0000000000E+00	.0000000000E+00
D	.2602520658E+00	-.3608938000E+00	.0000000000E+00	.0000000000E+00



NA 65 - NA 79
MU



NC 65 - NC 79
MU



ND 65 - ND 79
MU

DOBSON OZONE SPECTROPHOTOMETER CALIBRATION

Place: Boulder, Colorado

Date: August 14, 1981 A.M./P.M. A.M.

U.S.A. Inst. No. 79 VS U.S.A. Inst. No. 65
(Country) (Country)

For instrument No. 79 use G tables dated Aug. 24, 1981

Apply the following corrections to the tables:

To GA or NA values add −29.2 *

To GC or NC values add −28.3

To GD or ND values add −30.4

For instrument No. 65 use N tables dated April 10, 1981 F1

Apply the following corrections to the tables:

To GA or NA values add −0.1

To GC or NC values add −0.2

To GD or ND values add −0.2

NOTES: "Final" calibration, using new (Aug. 24, 1981) optical wedge density data.

* These ΔG values convert the G-tables to N-Tables based on reference standard lamp N values determined September 10, 1975 (see next page)

ΔG-Value Computations

Standard lamp readings: August 14, 1981

Reference standard lamp N-values: September 10, 1975 R1

Lamp		R_A	R_C	R_D
79C	Ref. N →	$52.0^{22.3}$	$54.9^{25.5}$	$57.9^{25.4}$
	G^* →	51.6	53.9	55.9
	ΔG	−29.3	−28.4	−30.5
79D	Ref. N →	$52.7^{23.3}$	$55.3^{26.2}$	$58.2^{26.0}$
	G^* →	52.3	54.3	56.2
	ΔG	−29.0	−28.1	−30.2
	$\overline{\Delta G}$	−29.2	−28.3	−30.4

* From G tables dated Aug. 24, 1981

$\Delta G = N_{AS} - G_{AS}$

GA TABLE

R	0	1	2	3	4	5	6	7	8	9
0						.0	1.2	2.4	3.6	4.7
10	5.9	7.1	8.2	9.3	10.5	11.6	12.8	13.9	15.1	16.3
20	17.5	18.7	19.9	21.1	22.3	23.5	24.6	25.8	27.0	28.1
30	29.3	30.4	31.5	32.7	33.8	34.9	36.0	37.1	38.1	39.1
40	40.1	41.1	42.1	43.1	44.0	45.0	46.0	46.9	47.9	48.8
50	49.8	50.7	51.6	52.6	53.5	54.5	55.4	56.3	57.2	58.1
60	59.0	60.0	60.9	61.8	62.7	63.6	64.5	65.4	66.3	67.2
70	68.1	69.1	70.0	70.9	71.8	72.7	73.6	74.5	75.4	76.3
80	77.2	78.2	79.1	80.0	81.0	81.9	82.9	83.8	84.7	85.7
90	86.7	87.7	88.6	89.6	90.6	91.6	92.6	93.6	94.5	95.5
100	96.5	97.5	98.6	99.6	100.6	101.6	102.6	103.6	104.6	105.6
110	106.7	107.7	108.7	109.7	110.7	111.7	112.7	113.7	114.7	115.8
120	116.8	117.8	118.8	119.8	120.8	121.8	122.9	123.9	124.9	125.9
130	127.0	128.0	129.0	130.0	131.1	132.1	133.1	134.1	135.2	136.2
140	137.2	138.2	139.2	140.2	141.3	142.3	143.3	144.3	145.3	146.3
150	147.3	148.3	149.3	150.3	151.3	152.3	153.3	154.3	155.3	156.3
160	157.3	158.4	159.4	160.4	161.4	162.4	163.4	164.4	165.4	166.5
170	167.5	168.5	169.5	170.5	171.5	172.5	173.5	174.5	175.5	176.5
180	177.5	178.5	179.5	180.5	181.5	182.5	183.5	184.5	185.5	186.5
190	187.6	188.6	189.6	190.6	191.6	192.6	193.6	194.7	195.7	196.7
200	197.7	198.8	199.8	200.8	201.8	202.8	203.9	204.9	205.9	206.9
210	207.9	209.0	210.0	211.0	212.0	213.0	214.0	215.1	216.1	217.1
220	218.1	219.1	220.2	221.2	222.2	223.2	224.3	225.3	226.3	227.4
230	228.4	229.5	230.5	231.5	232.6	233.6	234.6	235.7	236.8	237.8
240	238.9	239.9	241.0	242.0	243.1	244.1	245.2	246.3	247.3	248.4
250	249.5	250.5	251.6	252.7	253.7	254.8	255.8	256.9	258.0	259.0
260	260.1	261.1	262.1	263.2	264.2	265.2	266.2	267.3	268.3	269.3
270	270.4	271.4	272.4	273.4	274.5	275.5	276.5	277.5	278.6	279.6
280	280.7	281.7	282.8	283.9	285.0	286.1	287.2	288.3	289.4	290.5
290	291.6	292.7	293.8	294.9						

INPUT DATA:

25.82	25.71	25.98	26.53	27.70	29.04	30.38	31.67
32.36	32.69	32.88	32.83	32.55	32.18	31.71	31.20
30.65	30.26	30.00	29.82	29.69	29.62	29.57	29.55
29.56	29.62	29.71	29.78	29.84	29.88	29.89	29.91
29.90	29.89	29.85	29.77	29.67	29.59	29.55	29.50
29.44	29.37	29.25	29.06	28.84	28.64	28.50	28.52
28.62	28.80	28.96	28.96	28.76	28.34	27.88	

GC TABLE

R	0	1	2	3	4	5	6	7	8	9
0						.0	1.1	2.3	3.4	4.6
10	5.7	6.9	8.1	9.3	10.5	11.7	12.8	14.0	15.2	16.4
20	17.6	18.7	19.9	21.0	22.2	23.3	24.4	25.5	26.7	27.8
30	28.9	30.0	31.0	32.1	33.2	34.3	35.4	36.4	37.4	38.4
40	39.4	40.5	41.5	42.5	43.4	44.4	45.4	46.4	47.3	48.3
50	49.3	50.2	51.1	52.1	53.0	54.0	54.9	55.8	56.7	57.6
60	58.5	59.4	60.4	61.3	62.2	63.1	64.0	64.9	65.8	66.7
70	67.6	68.6	69.5	70.4	71.3	72.3	73.2	74.1	75.0	76.0
80	76.9	77.8	78.8	79.7	80.7	81.6	82.6	83.5	84.4	85.4
90	86.4	87.3	88.3	89.3	90.2	91.2	92.2	93.2	94.2	95.2
100	96.2	97.2	98.2	99.2	100.2	101.2	102.2	103.2	104.2	105.2
110	106.2	107.2	108.2	109.2	110.2	111.2	112.2	113.2	114.2	115.2
120	116.2	117.2	118.3	119.3	120.3	121.3	122.3	123.3	124.3	125.3
130	126.3	127.3	128.3	129.3	130.3	131.3	132.3	133.3	134.3	135.3
140	136.3	137.3	138.3	139.3	140.3	141.3	142.3	143.3	144.3	145.3
150	146.3	147.3	148.3	149.3	150.3	151.3	152.2	153.2	154.2	155.2
160	156.2	157.2	158.2	159.2	160.2	161.2	162.1	163.1	164.1	165.1
170	166.1	167.1	168.0	169.0	170.0	171.0	172.0	173.0	174.0	175.0
180	176.0	176.9	177.9	178.9	179.9	180.9	181.9	182.9	183.9	184.9
190	185.9	186.9	187.9	188.9	189.9	190.9	191.9	192.9	193.9	194.9
200	195.9	196.9	197.9	198.9	199.9	200.9	201.9	202.9	204.0	205.0
210	206.0	207.0	208.0	209.0	210.0	211.0	212.0	213.0	214.0	215.0
220	216.0	217.0	218.0	219.0	220.0	221.0	222.0	223.1	224.1	225.1
230	226.1	227.1	228.1	229.1	230.2	231.2	232.2	233.2	234.3	235.3
240	236.3	237.4	238.4	239.5	240.5	241.6	242.6	243.7	244.7	245.7
250	246.8	247.8	248.9	249.9	250.9	252.0	253.0	254.1	255.1	256.1
260	257.1	258.2	259.2	260.2	261.2	262.3	263.3	264.3	265.3	266.3
270	267.3	268.4	269.4	270.4	271.4	272.4	273.5	274.5	275.5	276.5
280	277.6	278.6	279.7	280.7	281.8	282.8	283.9	285.0	286.1	287.2
290	288.3	289.4	290.5	291.6	292.7	293.9	295.0			

INPUT DATA:

26.28	26.12	26.44	27.27	28.33	29.40	30.47	31.54
32.12	32.48	32.68	32.62	32.38	31.98	31.59	31.20
30.81	30.49	30.22	30.04	29.94	29.93	29.94	29.99
30.07	30.13	30.21	30.29	30.37	30.42	30.43	30.43
30.42	30.38	30.28	30.17	30.07	30.01	29.97	29.95
29.93	29.87	29.76	29.58	29.38	29.18	29.03	29.01
29.10	29.26	29.36	29.32	29.10	28.67	28.23	

GD TABLE

R	0	1	2	3	4	5	6	7	8	9
0						.0	1.1	2.3	3.4	4.6
10	5.7	6.9	8.0	9.1	10.3	11.4	12.6	13.7	14.8	16.0
20	17.1	18.2	19.4	20.5	21.6	22.7	23.8	24.9	26.0	27.1
30	28.2	29.3	30.4	31.5	32.5	33.6	34.7	35.7	36.8	37.8
40	38.8	39.8	40.8	41.8	42.7	43.7	44.7	45.6	46.6	47.6
50	48.5	49.5	50.4	51.3	52.3	53.2	54.2	55.1	56.0	56.9
60	57.9	58.8	59.7	60.7	61.6	62.5	63.4	64.4	65.3	66.2
70	67.1	68.1	69.0	69.9	70.8	71.8	72.7	73.6	74.6	75.5
80	76.4	77.4	78.3	79.3	80.2	81.2	82.1	83.1	84.0	85.0
90	85.9	86.9	87.9	88.8	89.8	90.8	91.8	92.8	93.8	94.7
100	95.7	96.7	97.7	98.7	99.7	100.7	101.7	102.7	103.7	104.7
110	105.7	106.6	107.6	108.6	109.6	110.6	111.6	112.6	113.6	114.6
120	115.6	116.6	117.7	118.7	119.7	120.7	121.7	122.7	123.7	124.7
130	125.7	126.7	127.7	128.7	129.7	130.7	131.6	132.6	133.6	134.6
140	135.6	136.6	137.6	138.5	139.5	140.5	141.5	142.5	143.5	144.5
150	145.4	146.4	147.4	148.4	149.4	150.3	151.3	152.3	153.3	154.3
160	155.2	156.2	157.2	158.2	159.1	160.1	161.1	162.0	163.0	164.0
170	165.0	165.9	166.9	167.9	168.8	169.8	170.8	171.8	172.8	173.7
180	174.7	175.7	176.7	177.7	178.6	179.6	180.6	181.6	182.6	183.6
190	184.5	185.5	186.5	187.5	188.5	189.5	190.5	191.5	192.4	193.4
200	194.4	195.4	196.4	197.4	198.4	199.4	200.4	201.4	202.4	203.4
210	204.4	205.4	206.4	207.4	208.4	209.4	210.4	211.4	212.4	213.4
220	214.4	215.4	216.4	217.4	218.4	219.4	220.4	221.4	222.4	223.4
230	224.4	225.4	226.4	227.4	228.4	229.4	230.4	231.4	232.4	233.4
240	234.4	235.5	236.5	237.5	238.5	239.5	240.5	241.6	242.6	243.6
250	244.6	245.7	246.7	247.7	248.7	249.8	250.8	251.8	252.9	253.9
260	254.9	255.9	257.0	258.0	259.0	260.0	261.0	262.0	263.0	264.1
270	265.1	266.1	267.0	268.0	269.0	270.0	271.0	272.0	273.0	274.0
280	275.0	276.1	277.1	278.1	279.2	280.3	281.4	282.4	283.5	284.6
290	285.8	286.9	288.0	289.1	290.2	291.3	292.5	293.6	294.7	

INPUT DATA:

26.79	26.73	27.07	27.75	28.64	29.56	30.47	31.37
31.97	32.20	32.33	32.29	32.15	31.85	31.52	31.20
30.89	30.61	30.38	30.22	30.13	30.12	30.16	30.22
30.31	30.43	30.58	30.68	30.77	30.82	30.85	30.83
30.82	30.74	30.63	30.50	30.38	30.30	30.24	30.21
30.18	30.15	30.10	30.02	29.88	29.71	29.55	29.47
29.46	29.62	29.77	29.68	29.38	28.90	28.42	

Data summary using Inst. 79 G tables dated August 24, 1981: Calib Inst. 65 vs 79 August 14, 1981 AM

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD065*	.299 (.003)	.298 (.001)	.299 (.000)	.298 (.000)	.297 (.001)	.294 (.000)	.299 (.000)	ATMO-CM
XAD079*	.308 (.004)	.304 (.001)	.301 (.002)		.293 (.002)	.288 (.000)	.304 (.003)	ATMO-CM
DXAD079*	3.10	1.78	.85		-1.13	-1.83	1.94	PERCENT
XCD065*	.298 (.009)	.299 (.002)	.301 (.002)	.302 (.001)	.301 (.001)	.298 (.003)	.300 (.002)	ATMO-CM
XCD079*	.306 (.008)	.305 (.002)	.302 (.000)	.301 (.001)	.298 (.001)	.293 (.002)	.304 (.002)	ATMO-CM
DXCD079*	2.88	1.93	.27	-.25	-1.13	-1.44	1.20	PERCENT
XA 065*	.306 (.002)	.307 (.001)	.307 (.000)	.306 (.001)	.304 (.001)	.302 (.000)	.306 (.001)	ATMO-CM
XA 079*	.314 (.003)	.311 (.001)	.308 (.001)		.301 (.001)	.297 (.000)	.311 (.002)	ATMO-CM
DXA 079*	2.73	1.30	.46		-1.03	-1.72	1.56	PERCENT
XC 065*	.312 (.003)	.315 (.001)	.316 (.000)	.314 (.001)	.313 (.000)	.311 (.002)	.314 (.002)	ATMO-CM
XC 079*	.319 (.004)	.318 (.001)	.316 (.001)	.314 (.001)	.310 (.001)	.307 (.001)	.317 (.002)	ATMO-CM
DXC 079*	2.41	.98	-.08	-.28	-.93	-1.39	.75	PERCENT
XD 065*	.326 (.011)	.331 (.001)	.330 (.002)	.325 (.001)	.323 (.001)	.324 (.000)	.328 (.003)	ATMO-CM
XD 079*	.331 (.011)	.331 (.002)	.328 (.002)	.324 (.001)	.321 (.001)	.320 (.000)	.329 (.003)	ATMO-CM
DXD 079*	1.76	-.16	-.48	-.33	-.71	-1.35	.19	PERCENT

Corr. needed to Inst. 79 G values

	MU= 1.33	1.75	2.25	2.85	mean (1.15-2.5)	rsd
To GA ADD	-1.81	-1.29	-.69		-1.26	.166
To GC ADD	-.71	-.43	-.10	.29	-.41	.129
To GD ADD	-.18	-.07	.06	.21	-.07	.190

	MU= 1.33	1.75	2.25	2.85	mean (1.15-2.5)
To GAD ADD	-1.63	-1.22	-.74		-1.20
To GCD ADD	-.53	-.36	-.16	.08	-.35

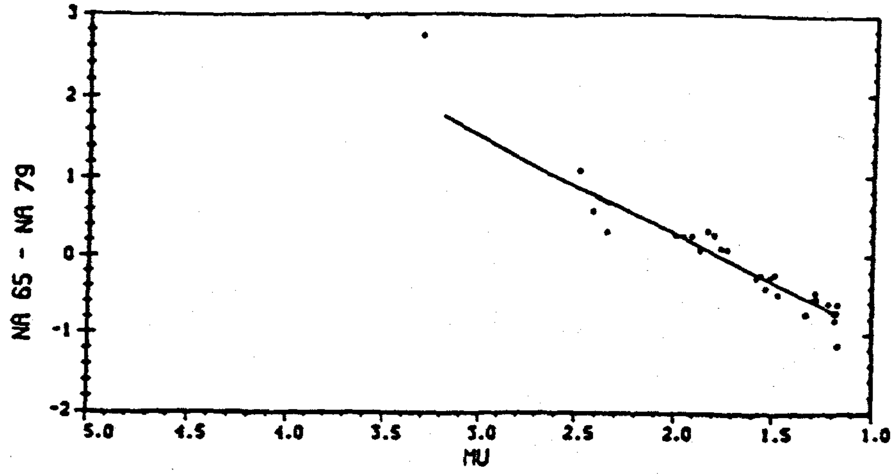
Data summary using corrected Inst. 79 N Tables: (using mean)

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD065	.299 (.003)	.298 (.001)	.299 (.000)	.298 (.000)	.297 (.001)	.294 (.000)	.299 (.000)	ATMO-CM
XAD079	.302 (.004)	.299 (.001)	.298 (.001)		.291 (.002)	.286 (.000)	.299 (.002)	ATMO-CM
DXAD079	.86	.15	-.36		-1.90	-2.52	.25	PERCENT
XCD065	.298 (.009)	.299 (.002)	.301 (.002)	.302 (.001)	.301 (.001)	.298 (.003)	.300 (.002)	ATMO-CM
XCD079	.300 (.008)	.300 (.002)	.299 (.000)	.299 (.001)	.296 (.001)	.292 (.002)	.299 (.001)	ATMO-CM
DXCD079	.85	.46	-.84	-1.15	-1.84	-2.05	-.17	PERCENT
XA 065	.306 (.002)	.307 (.001)	.307 (.000)	.306 (.001)	.304 (.001)	.302 (.000)	.306 (.001)	ATMO-CM
XA 079	.309 (.002)	.307 (.000)	.305 (.001)		.299 (.001)	.295 (.000)	.307 (.001)	ATMO-CM
DXA 079	.92	-.00	-.48		-1.67	-2.27	.21	PERCENT
XC 065	.312 (.003)	.315 (.001)	.316 (.000)	.314 (.001)	.313 (.000)	.311 (.002)	.314 (.002)	ATMO-CM
XC 079	.315 (.003)	.316 (.001)	.314 (.001)	.312 (.001)	.309 (.001)	.306 (.001)	.314 (.001)	ATMO-CM
DXC 079	1.13	.06	-.78	-.85	-1.38	-1.77	-.11	PERCENT
XD 065	.326 (.011)	.331 (.001)	.330 (.002)	.325 (.001)	.323 (.001)	.324 (.000)	.328 (.003)	ATMO-CM
XD 079	.330 (.011)	.330 (.002)	.328 (.002)	.324 (.001)	.320 (.001)	.319 (.000)	.328 (.003)	ATMO-CM
DXD 079	1.33	-.47	-.71	-.52	-.86	-1.48	-.09	PERCENT

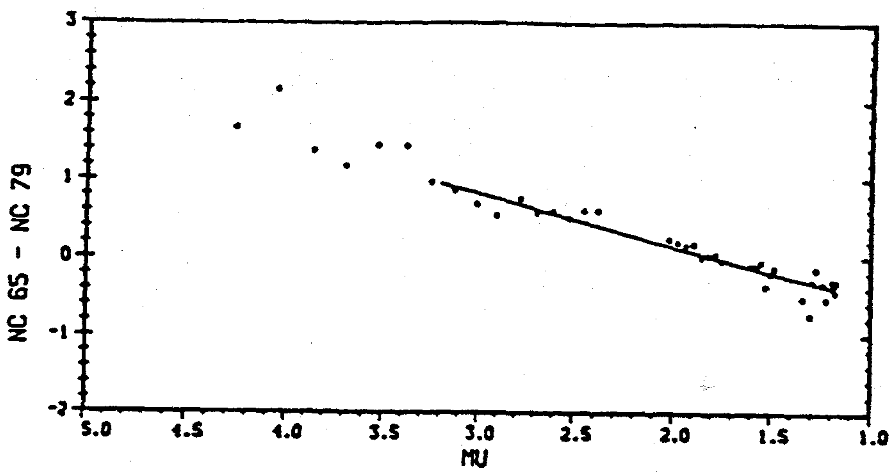
Values in brackets are standard deviations. NEW II BK O3 ABS. COEF. applied.

Cubic equations for N-function corrections to Inst. 79 G-Tables

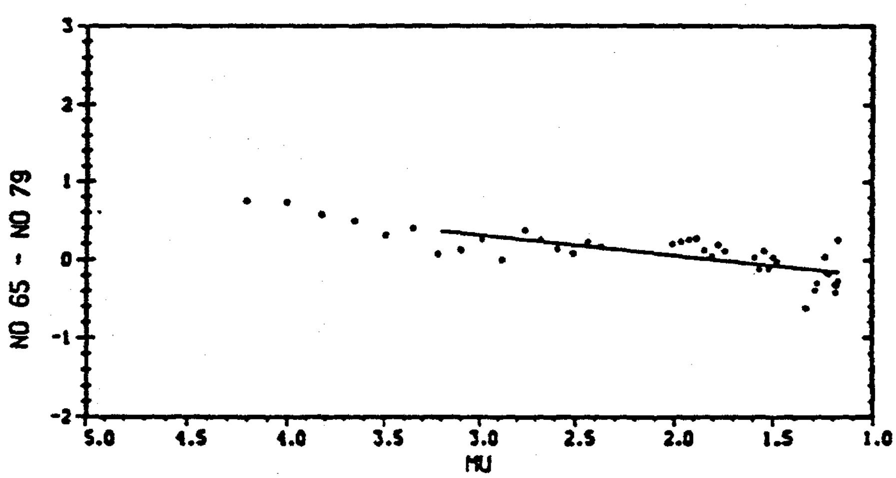
A	-.3403727558E+01	.1206449254E+01	.0000000000E+00	.0000000000E+00
C	-.1580171279E+01	.6565992229E+00	.0000000000E+00	.0000000000E+00
D	-.5165673688E+00	.2542950991E+00	.0000000000E+00	.0000000000E+00



NA 65 - NA 79
MU
3
2
1
0
-1
-2
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0



NC 65 - NC 79
MU
3
2
1
0
-1
-2
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0



NO 65 - NO 79
MU
3
2
1
0
-1
-2
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0

Appendix B

SAMPLE RECORD OF DOBSON SPECTROPHOTOMETER STANDARD AND MERCURY LAMP TESTS DATA

WALLOPS ISLAND, VA, 1966-1995

1. Reference Standard Lamp Readings.

Dobson Spectrophotometer No. 72

LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
Reference Standard Lamps																	
72B	06/16/66	29.6	31.9	62.3	33.5	REF		25.7	27.3	55.9	26.2						
72C	06/16/66	25.3	29.2	62.2	31.6	REF		21.5	24.7	55.8	24.4						
72Y	06/16/66	25.8	28.7	64.3	31.1	REF		22.0	24.2	57.7	24.0						
72Z	06/16/66	21.8	26.2	64.9	29.2	REF		18.0	21.7	58.2	22.1						
72D	05/27/69	19.7	23.8	63.5	27.7	REF		28.9	29.4	67.7	29.3						
72E	05/27/69	16.9	21.9	64.8	26.3	REF		26.0	27.4	68.8	27.9						
72W	05/27/69	11.4	17.8	66.0	23.4	REF		20.0	23.1	69.9	24.9						
72X	05/27/69	17.1	22.0	65.2	26.2	REF		26.2	27.5	69.2	27.8						
72Y	05/27/69	15.1	20.4	66.5	25.1	REF		24.0	25.8	70.4	26.7						
72Z	05/27/69	11.5	18.1	66.6	23.3	REF		20.1	23.4	70.5	24.8						
72D	10/02/72	23.2	27.4	63.6	31.2	REF		26.1	27.8	62.5	26.6						
72E	10/02/72	19.9	25.2	64.9	29.6	REF		22.7	25.5	63.7	25.1						
72Y	10/02/72	18.5	24.1	67.3	28.8	REF		21.2	24.4	65.8	24.3						
72Z	10/02/72	15.1	21.6	67.3	27.2	REF		17.6	21.8	65.8	22.7						
72D	05/19/76	18.1	23.3	72.7	27.7	REF		29.5	30.7	78.0	29.3						
72E	05/19/76	15.1	21.0	73.3	26.2	REF		26.2	28.2	78.6	27.7						
72Y	05/19/76	13.7	19.8	76.7	25.1	REF		24.6	26.9	81.7	26.6						
72Z	05/19/76	10.7	17.7	77.3	23.6	REF		21.2	24.7	82.2	25.0						
72Q1	05/19/76	4.6	12.2	89.6	18.9	REF		14.2	18.7	93.3	20.1						
72Q2	05/19/76	4.5	12.0	86.5	18.7	REF		14.1	18.4	90.5	19.9						

Dobson Spectrophotometer No. 38

LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
Reference Standard Lamps																	
38Q1	09/21/78	32.4	34.4	64.6	36.5	REF		10.9	16.1	46.6	18.0						
38Q2	09/21/78	32.7	34.7	64.1	36.7	REF		11.2	16.4	46.1	18.2						
38UQ1	09/21/78	33.7	35.8	63.5	37.8	REF		12.3	17.6	45.5	19.4						
38UQ2	09/21/78	33.5	35.3	62.8	37.5	REF		12.1	17.1	44.8	19.1						
38R12	09/21/78	32.5	34.6	M	36.5	REF		11.0	16.3	M	18.0						
38R13	09/21/78	32.4	34.4	M	36.5	REF		10.9	16.1	M	18.0						
38Q1	05/08/85	25.7	27.8	36.7	29.7	REF		12.0	16.8	26.7	18.3						
38Q2	05/08/85	26.0	28.2	35.7	30.2	REF		12.3	17.2	25.6	18.8						
38Q3	05/08/85	25.4	27.7	38.0	29.5	REF		11.7	16.7	28.1	18.0						
38UQ1	05/08/85	27.2	29.2	35.4	31.2	REF		13.7	18.3	25.3	20.0						
38UQ3	05/08/85	26.0	28.0	38.3	30.0	REF		12.3	17.0	28.5	18.6						
38Q1	09/16/91	26.5	28.5	42.7	30.3	REF		10.9	16.1	31.9	18.7						
38Q2	09/16/91	27.7	29.8	38.0	31.6	REF		12.2	17.6	26.7	20.2						
38Q3	09/16/91	26.2	28.1	44.3	30.0	REF		10.5	15.7	33.6	18.4						
38UQ1	09/16/91	27.8	29.8	41.2	31.7	REF		12.3	17.6	30.2	20.3						
38Q1	04/27/95	26.9	28.9	43.7	30.8	REF		10.2	15.6	32.0	17.9						
38Q2	04/27/95	27.5	29.4	42.0	31.4	REF		10.8	16.2	30.1	18.6						

Dobson Spectrophotometer No. 38

LAMP	DATE	Ra	Rc	Rc′	Rd	Hg	STN	Na	Nc	Nc′	Nd	dNa	dNc	dNc′	dNd	dNad	dNcd
Reference Standard Lamps																	
38Q3	04/27/95	26.7	28.6	44.9	30.6	REF		9.9	15.3	33.3	17.7						
38UQ1	04/27/95	28.3	30.3	41.3	32.3	REF		11.7	17.2	29.4	19.6						
38UQ2	04/27/95	27.9	29.8	41.4	31.8	REF		11.3	16.6	29.5	19.0						
38UQ7	04/27/95	27.2	28.8	44.1	30.9	REF		10.5	15.5	32.4	18.0						
38UQ8	04/27/95	27.0	28.8	44.2	30.8	REF		10.3	15.5	32.5	17.9						

Dobson Spectrophotometer No. 86

LAMP	DATE	Ra	Rc	Rc′	Rd	Hg	STN	Na	Nc	Nc′	Nd	dNa	dNc	dNc′	dNd	dNad	dNcd
Reference Standard Lamps																	
86Q1	05/26/83	42.6	40.4	67.1	38.7	REF		11.8	16.5	44.6	18.4						
86Q2	05/26/83	42.7	40.4	67.2	38.5	REF		11.9	16.5	44.7	18.2						
86Q3	05/26/83	42.8	40.6	66.4	38.6	REF		12.0	16.7	43.9	18.3						
86UQ1	05/26/83	44.2	41.8	65.2	40.2	REF		13.6	18.0	42.7	20.1						
86UQ2	05/26/83	43.7	41.3	64.8	39.7	REF		13.0	17.5	42.2	19.5						
86UQ3	05/26/83	42.8	40.7	66.4	38.8	REF		12.0	16.8	43.9	18.5						

2. Monthly Standard Lamp and Mercury Lamp Test Data.

Dobson Spectrophotometer No. 72

LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
72B	06/16/66	29.6	31.9	62.3	33.5			25.7	27.3	55.9	26.2	.0	.0	.0	.0	.0	.0
72C	06/16/66	25.3	29.2	62.2	31.6			21.5	24.7	55.8	24.4	.0	.0	.0	.0	.0	.0
72Y	06/16/66	25.8	28.7	64.3	31.1			22.0	24.2	57.7	24.0	.0	.0	.0	.0	.0	.0
72Z	06/16/66	21.8	26.2	64.9	29.2			18.0	21.7	58.2	22.1	.0	.0	.0	.0	.0	.0
72B	06/21/67	26.8	29.5	62.7	31.4	*	WAI	23.0	25.0	56.3	24.2	2.7	2.3	-.4	2.0	.7	.3
72C	06/21/67	23.5	27.6	60.3	30.7	+0.44*	WAI	19.7	23.1	54.1	23.6	1.8	1.6	1.7	.8	1.0	.8
72Y	06/21/67	24.0	27.1	64.2	29.7		WAI	20.2	22.6	57.6	22.6	1.8	1.6	.1	1.4	.4	.2
72Z	06/21/67	20.2	24.6	64.1	27.8		WAI	16.4	20.2	57.5	20.8	1.6	1.5	.7	1.3	.3	.2
72Z	06/21/67	20.2	24.6	64.2	27.9		WAI	16.4	20.2	57.6	20.9	1.6	1.5	.6	1.2	.4	.3
72Z	06/21/67	20.2	24.5	64.4	27.8		WAI	16.4	20.1	57.8	20.8	1.6	1.6	.4	1.3	.3	.3
72B	06/22/67	27.4	29.8	61.6	31.7	+0.50	WAI	23.6	25.3	55.3	24.5	2.1	2.0	.6	1.7	.4	.3
72B	06/23/67	27.4	29.8	61.4	31.7	+0.63	WAI	23.6	25.3	55.1	24.5	2.1	2.0	.8	1.7	.4	.3
72B	06/24/67	27.1	29.5	62.1	31.4		WAI	23.3	25.0	55.7	24.2	2.4	2.3	.2	2.0	.4	.3
72B	06/25/67	26.5	29.2	62.3	31.1	+0.52	WAI	22.7	24.7	55.9	24.0	3.0	2.6	.0	2.2	.8	.4
72B	06/30/67	27.0	29.8	60.8	31.7	+0.69	WAI	23.2	25.3	54.5	24.5	2.5	2.0	1.4	1.7	.8	.3
72B	08/05/67	25.2	27.8	79.7	29.8	+0.38	WAI	21.4	23.3	71.6	22.7	4.3	4.0	-15.7	3.5	.8	.5
72C	08/07/67	21.0	25.0	78.3	28.4	*	WAI	17.2	20.6	70.4	21.4	4.3	4.1	-14.6	3.0	1.3	1.1
72B	08/09/67	24.7	27.6	78.8	29.7	+0.27	WAI	20.9	23.1	70.8	22.6	4.8	4.2	-14.9	3.6	1.2	.6
72C	10/17/67	20.6	24.8	66.3	28.2	+0.52	WAI	16.8	20.4	59.5	21.2	4.7	4.3	-3.7	3.2	1.5	1.1
72C	10/17/67	21.5	25.8	62.6	29.3		WAI	17.7	21.3	56.2	22.2	3.8	3.4	-.4	2.2	1.6	1.2
72C	12/15/67					+0.32	WAI										
72C	01/04/68	20.0	24.6	61.8	28.6	+0.16	WAI	16.2	20.2	55.4	21.6	5.3	4.5	.4	2.8	2.5	1.7
72C	01/29/68	17.2	21.2	54.4	24.5	+0.33	WAI	13.4	16.8	48.6	17.6	8.1	7.9	7.2	6.8	1.3	1.1
72C	01/29/68	17.3	21.4	54.3	24.6		WAI	13.5	17.0	48.5	17.7	8.0	7.7	7.3	6.7	1.3	1.0
72C	05/08/68	17.6	22.2	57.4	26.0	+0.25	WAI	13.8	17.8	51.4	19.0	7.7	6.9	4.4	5.4	2.3	1.5
72C	05/08/68	16.5	22.0	57.4	26.0		WAI	12.7	17.6	51.4	19.0	8.8	7.1	4.4	5.4	3.4	1.7
72C	05/29/68	17.4	22.3	55.5	26.5	+0.07	WAI	13.6	17.9	49.6	19.5	7.9	6.8	6.2	4.9	3.0	1.9
72C	07/03/68	18.1	23.7	49.5	28.0	+0.19	WAI	14.3	19.3	44.0	21.0	7.2	5.4	11.8	3.4	3.8	2.0
72C	07/05/68	18.2	23.2	49.6	27.7		WAI	14.4	18.8	44.1	20.7	7.1	5.9	11.7	3.7	3.4	2.2
72C	08/15/68	17.8	23.2	50.6	27.8	+0.24	WAI	14.0	18.8	45.1	20.8	7.5	5.9	10.7	3.6	3.9	2.3
72C	08/17/68	17.9	23.6	48.7	28.3	+0.09	WAI	14.1	19.2	43.3	21.3	7.4	5.5	12.5	3.1	4.3	2.4
72D	08/17/68	14.6	20.5	53.8	25.6		WAI	10.7	16.1	48.1	18.6						
72Y	08/17/68	18.2	23.0	53.0	27.4		WAI	14.4	18.6	47.3	20.4	7.6	5.6	10.4	3.6	4.0	2.0
72Z	08/17/68	14.7	20.4	54.1	25.7		WAI	10.8	16.0	48.3	18.7	7.2	5.7	9.9	3.4	3.8	2.3
72C	08/18/68	17.8	23.7	49.4	28.4	+0.06	WAI	14.0	19.3	43.9	21.4	7.5	5.4	11.9	3.0	4.5	2.4
72D	08/18/68	14.5	20.6	53.1	25.6		WAI	10.6	16.2	47.4	18.6						
72Y	08/18/68	18.5	23.2	52.3	27.7		WAI	14.7	18.8	46.6	20.7	7.3	5.4	11.1	3.3	4.0	2.1
72Z	08/18/68	14.8	20.7	53.7	25.7		WAI	10.9	16.3	48.0	18.7	7.1	5.4	10.2	3.4	3.7	2.0
72C	08/29/68	18.3	23.9	48.0	28.6	+0.10	WAI	14.5	19.5	42.6	21.6	7.0	5.2	13.2	2.8	4.2	2.4
72C	10/02/68	17.0	22.7	45.7	27.6	-0.02	WAI	13.2	18.3	40.4	20.6	8.3	6.4	15.4	3.8	4.5	2.6
72C	10/30/68	17.3	22.6	43.0	26.1	+0.10	WAI	13.5	18.2	37.9	19.1	8.0	6.5	17.9	5.3	2.7	1.2
72C	12/02/68	17.4	22.9	40.7	27.4	+0.27	WAI	13.6	18.5	35.7	20.4	7.9	6.2	20.1	4.0	3.9	2.2
72D	02/04/69	14.2	21.2	40.6	26.7	-0.17	WAI	10.3	16.8	35.6	19.7						
72Y	04/23/69	15.3	20.8	69.4	25.4	-1.38	BDR	11.4	16.4	62.3	18.5	10.6	7.8	-4.6	5.5	5.1	2.3
72X	04/25/69	17.3	22.3	66.0	26.5	-1.57	BDR	13.5	17.9	59.2	19.5						
72Y	04/25/69	15.1	20.4	67.8	25.1	-1.59	BDR	11.2	16.0	60.9	18.2	10.8	8.2	-3.2	5.8	5.0	2.4

Dobson Spectrophotometer No. 72

LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
72Z	04/25/69	11.7	17.9	68.2	23.4		BDR	7.7	13.5	61.2	16.5	10.3	8.2	-3.0	5.6	4.7	2.6
72Z	04/28/69					-1.43	BDR										
72W	05/12/69	11.4	17.8	66.0	23.4	+0.25	BDR	7.4	13.4	59.2	16.5						
72X	05/12/69	17.1	22.0	64.9	26.2		BDR	13.3	17.6	58.2	19.2						
72Y	05/12/69	15.0	20.3	66.1	25.0		BDR	11.1	15.9	59.3	18.1	10.9	8.3	-1.6	5.9	5.0	2.4
72Z	05/12/69	11.5	18.1	66.6	23.3		BDR	7.5	13.7	59.8	16.4	10.5	8.0	-1.6	5.7	4.8	2.3
72D	05/27/69	19.7	23.8	63.5	27.7		BDR	28.9	29.4	67.7	29.3	.0	.0	.0	.0	.0	.0
72E	05/27/69	16.9	21.9	64.8	26.3		BDR	26.0	27.4	68.8	27.9	.0	.0	.0	.0	.0	.0
72W	05/27/69	11.4	17.8	66.0	23.4		BDR	20.0	23.1	69.9	24.9	.0	.0	.0	.0	.0	.0
72X	05/27/69	17.1	22.0	65.2	26.2		BDR	26.2	27.5	69.2	27.8	.0	.0	.0	.0	.0	.0
72Y	05/27/69	15.1	20.4	66.5	25.1		BDR	24.0	25.8	70.4	26.7	.0	.0	.0	.0	.0	.0
72Z	05/27/69	11.5	18.1	66.6	23.3		BDR	20.1	23.4	70.5	24.8	.0	.0	.0	.0	.0	.0
72D	05/27/69	18.8	22.9	65.2	26.9	+0.58	BDR	28.0	28.4	69.2	28.5	.9	1.0	-1.5	.8	.1	.2
72D	05/27/69	19.6	23.7	64.6	27.6		BDR	28.8	29.3	68.7	29.2	.1	.1	-1.0	.1	.0	.0
72D	05/27/69	19.7	23.7	63.7	27.6	+0.21	BDR	28.9	29.3	67.8	29.2	.0	.1	-.1	.1	-.1	.0
72D	05/27/69	19.7	23.8	63.4	27.7		BDR	28.9	29.4	67.6	29.3	.0	.0	.1	.0	.0	.0
72D	05/27/69	19.8	23.9	63.2	27.7		BDR	29.0	29.5	67.4	29.3	-.1	-.1	.3	.0	-.1	-.1
72E	05/27/69	16.8	21.8	65.2	26.3		BDR	25.9	27.3	69.2	27.9	.1	.1	-.4	.0	.1	.1
72E	05/27/69	16.9	22.0	64.3	26.3	+0.26	BDR	26.0	27.5	68.4	27.9	.0	-.1	.4	.0	.0	-.1
72X	05/27/69	17.0	21.7	65.8	26.0		BDR	26.1	27.2	69.8	27.6	.1	.3	-.6	.2	-.1	.1
72X	05/27/69	17.2	22.2	64.9	26.3		BDR	26.3	27.7	68.9	27.9	-.1	-.2	.3	-.1	.0	-.1
72Y	05/27/69	15.2	20.4	66.9	25.2		BDR	24.1	25.8	70.7	26.8	-.1	.0	-.3	-.1	.0	.1
72D	08/29/69	18.7	23.3	63.3	26.9	+0.18	BDR	27.9	28.8	67.5	28.5	1.0	.6	.2	.8	.2	-.2
72E	08/29/69	16.0	21.2	64.3	25.7		BDR	25.0	26.7	68.4	27.3	1.0	.7	.4	.6	.4	.1
72W	08/29/69	11.1	17.7	66.0	23.2		BDR	19.7	23.0	69.9	24.7	.3	.1	.0	.2	.1	-.1
72X	08/29/69	16.8	21.6	64.9	25.9		BDR	25.9	27.1	68.9	27.5	.3	.4	.3	.3	.0	.1
72Y	08/29/69	14.6	20.0	66.1	24.7		BDR	23.5	25.4	70.0	26.3	.5	.4	.4	.4	.1	.0
72Z	08/29/69	11.2	17.7	67.1	23.0		BDR	19.8	23.0	70.9	24.5	.3	.4	-.4	.3	.0	.1
72D	11/19/69	19.4	23.3	71.0	27.3	+0.20	WAI	28.6	28.8	74.4	28.9	.3	.6	-6.7	.4	-.1	.2
72D	12/16/69	19.6	23.9	71.6	27.6	-0.10	WAI	28.8	29.5	75.0	29.2	.1	-.1	-7.3	.1	.0	-.2
72E	12/16/69	16.9	21.6	72.4	26.2		WAI	26.0	27.1	75.7	27.8	.0	.3	-6.9	.1	-.1	.2
72D	02/25/70	18.8	23.0	69.5	27.6	-0.37	WAI	28.0	28.5	73.1	29.2	.9	.9	-5.4	.1	.8	.8
72D	06/06/70	17.8	21.4	70.4	25.4	+0.24	WAI	26.9	26.9	73.9	27.0	2.0	2.5	-6.2	2.3	-.3	.2
72D	09/01/70	18.5	23.3	68.6	27.2	+0.21	WAI	27.6	28.8	72.3	28.8	1.3	.6	-4.6	.5	.8	.1
72D	10/26/70	19.5	23.8	67.0	27.6	+0.21	WAI	28.7	29.4	70.8	29.2	.2	.0	-3.1	.1	.1	-.1
72D	04/14/71	20.8	25.3	60.9	29.2	-0.12	WAI	30.1	30.9	65.3	30.8	-1.2	-1.5	2.4	-1.5	.3	.0
72E	04/14/71	17.2	22.9	62.6	27.6		WAI	26.3	28.4	66.8	29.2	-.3	-1.0	2.0	-1.3	1.0	.3
72D	04/28/71	20.2	24.7	61.7	28.6	-0.08	WAI	29.4	30.3	66.0	30.2	-.5	-.9	1.7	-.9	.4	.0
72E	04/28/71	17.3	22.8	61.2	27.5		WAI	26.4	28.3	65.6	29.1	-.4	-.9	3.2	-1.2	.8	.3
72X	04/28/71	17.8	23.0	61.8	27.5		WAI	26.9	28.5	66.1	29.1	-.7	-1.0	3.1	-1.3	.6	.3
72W	04/28/71	12.5	19.4	62.3	25.1		WAI	21.2	24.8	66.6	26.7	-1.2	-1.7	3.3	-1.8	.6	.1
72D	05/26/71	21.1	25.1	58.4	28.6	+0.24	WAI	30.4	30.7	63.0	30.2	-1.5	-1.3	4.7	-.9	-.6	-.4
72D	06/30/71	20.4	25.0	57.0	29.0	+0.34	WAI	29.6	30.6	61.7	30.6	-.7	-1.2	6.0	-1.3	.6	.1
72D	07/30/71	21.0	25.0	54.9	29.4	+0.18	WAI	30.3	30.6	59.7	31.0	-1.4	-1.2	8.0	-1.7	.3	.5
72D	09/16/71	22.3	26.5	56.4	30.5	+0.09	WAI	31.6	32.1	61.1	32.0	-2.7	-2.7	6.6	-2.7	.0	.0
72E	09/16/71	19.6	24.9	57.8	29.4		WAI	28.8	30.5	62.4	31.0	-2.8	-3.1	6.4	-3.1	.3	.0
72D	12/13/71	23.7	28.3	58.1	31.4	+0.06	WAI	33.1	34.0	62.7	32.9	-4.2	-4.6	5.0	-3.6	-.6	-1.0

Dobson Spectrophotometer No. 72

LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
72D	03/22/72	23.2	27.3	60.7	30.2	+0.14*	WAI	32.6	32.9	65.1	31.7	-3.7	-3.5	2.6	-2.4	-1.3	-1.1
72E	03/22/72	19.6	24.8	61.7	29.4	*	WAI	28.8	30.4	66.0	31.0	-2.8	-3.0	2.8	-3.1	.3	.1
72Y	03/22/72	18.2	23.6	65.0	28.6		WAI	27.3	29.2	69.0	30.2	-3.3	-3.4	1.4	-3.5	.2	.1
72Z	03/22/72	15.0	21.4	64.4	27.1		WAI	23.9	26.9	68.5	28.7	-3.8	-3.5	2.0	-3.9	.1	.4
72D	03/27/72	22.7	27.4	58.8	31.3	+0.21	WAI	32.1	33.0	63.4	32.8	-3.2	-3.6	4.3	-3.5	.3	-.1
72E	03/27/72	19.6	24.8	60.7	29.8		WAI	28.8	30.4	65.1	31.4	-2.8	-3.0	3.7	-3.5	.7	.5
72D	03/28/72	23.3	27.3	66.3	30.9	+0.23	WAI	32.7	32.9	70.2	32.4	-3.8	-3.5	-2.5	-3.1	-.7	-.4
72E	03/28/72	19.9	25.0	67.6	29.2		WAI	29.1	30.6	71.4	30.8	-3.1	-3.2	-2.6	-2.9	-.2	-.3
72Y	03/28/72	18.5	23.8	70.1	28.1	+0.24	WAI	27.6	29.4	73.6	29.7	-3.6	-3.6	-3.2	-3.0	-.6	-.6
72Z	03/28/72	15.3	21.5	70.0	26.7		WAI	24.2	27.0	73.5	28.3	-4.1	-3.6	-3.0	-3.5	-.6	-.1
72D	03/28/72	23.5	27.5	66.2	30.9		WAI	32.9	33.1	70.1	32.4	-4.0	-3.7	-2.4	-3.1	-.9	-.6
72E	03/28/72	20.0	24.8	67.8	29.2		WAI	29.2	30.4	71.6	30.8	-3.2	-3.0	-2.8	-2.9	-.3	-.1
72D	03/28/72	22.7	27.2	58.7	31.2	+0.25	WAI	32.1	32.8	63.3	32.7	-3.2	-3.4	4.4	-3.4	.2	.0
72D	04/26/72	23.2	27.6	63.2	31.0	+0.30	WAI	32.6	33.2	67.4	32.5	-3.7	-3.8	.3	-3.2	-.5	-.6
72D	08/01/72	23.6	27.5	64.4	31.1	+0.13	WAI	33.0	33.1	68.5	32.6	-4.1	-3.7	-.8	-3.3	-.8	-.4
72D	09/11/72	19.4	23.4	59.6	26.8	+0.39*	WAI	28.6	28.9	64.1	28.4	.3	.5	3.6	.9	-.6	-.4
72E	09/11/72	16.4	21.3	60.0	25.5	*	WAI	25.4	26.8	64.5	27.1	.6	.6	4.3	.8	-.2	-.2
72D	10/02/72	23.2	27.4	63.6	31.2	+0.07	WAI	26.1	27.8	62.5	26.6	.0	.0	.0	.0	.0	.0
72E	10/02/72	19.9	25.2	64.9	29.6		WAI	22.7	25.5	63.7	25.1	.0	.0	.0	.0	.0	.0
72Y	10/02/72	18.5	24.1	67.3	28.8		WAI	21.2	24.4	65.8	24.3	.0	.0	.0	.0	.0	.0
72Z	10/02/72	15.1	21.6	67.3	27.2		WAI	17.6	21.8	65.8	22.7	.0	.0	.0	.0	.0	.0
72D	11/06/72	23.3	27.5	62.4	30.9	+0.06	WAI	26.2	27.9	61.4	26.4	-.1	-.1	1.1	.2	-.3	-.3
72D	12/06/72	22.9	27.3	64.1	30.9	-0.12	WAI	25.8	27.7	62.9	26.4	.3	.1	-.4	.2	.1	-.1
72D	01/19/73	22.8	27.1	65.5	30.6	+0.10	WAI	25.7	27.4	64.2	26.1	.4	.4	-1.7	.5	-.1	-.1
72D	02/22/73	23.0	27.5	64.4	31.0	-0.14	WAI	25.9	27.9	63.2	26.5	.2	-.1	-.7	.1	.1	-.2
72D	02/23/73	21.6	25.9	64.3	30.2	-0.08	WAI	24.5	26.2	63.1	25.7	1.6	1.6	-.6	.9	.7	.7
72D	04/14/73	23.7	27.6	64.3	31.7	+0.17	WAI	26.6	28.0	63.1	27.1	-.5	-.2	-.6	-.5	.0	.3
72D	05/22/73	21.9	26.5	69.2	30.4	-0.04	WAI	24.8	26.8	67.5	25.9	1.3	1.0	-5.0	.7	.6	.3
72E	05/25/73	18.5	24.5	66.5	28.7	+0.47	WAI	21.2	24.8	65.1	24.2	1.5	.7	-1.4	.9	.6	-.2
72D	05/29/73	22.2	26.9	64.0	30.5	+0.04	WAI	25.1	27.2	62.8	26.0	1.0	.6	-.3	.6	.4	.0
72D	06/28/73	22.1	26.9	63.4	30.9	-0.01	WAI	25.0	27.2	62.3	26.4	1.1	.6	.2	.2	.9	.4
72D	07/31/73	22.2	26.9	63.6	31.0	-0.20	WAI	25.1	27.2	62.5	26.5	1.0	.6	.0	.1	.9	.5
72D	08/29/73	22.6	26.9	63.6	30.7	-0.08	WAI	25.5	27.2	62.5	26.2	.6	.6	.0	.4	.2	.2
72D	09/28/73	21.8	25.9	63.6	29.4	-0.09	WAI	24.7	26.2	62.5	24.9	1.4	1.6	.0	1.7	-.3	-.1
72D	10/12/73	20.8	25.2	67.1	29.0	-0.02	WAI	23.6	25.5	65.6	24.5	2.5	2.3	-3.1	2.1	.4	.2
72D	10/12/73	20.8	25.0	67.0	28.6	-0.13	WAI	23.6	25.3	65.5	24.1	2.5	2.5	-3.0	2.5	.0	.0
72E	10/12/73	17.2	22.5	68.1	26.8		WAI	19.8	22.7	66.5	22.3	2.9	2.8	-2.8	2.8	.1	.0
72Y	10/12/73	16.0	21.3	71.0	25.9		WAI	18.5	21.5	69.1	21.4	2.7	2.9	-3.3	2.9	-.2	.0
72Z	10/12/73	12.8	19.0	71.4	24.5		WAI	15.1	19.1	69.5	20.0	2.5	2.7	-3.7	2.7	-.2	.0
72D	10/29/73	21.3	25.4	66.3	29.0	-0.33	WAI	24.1	25.7	64.9	24.5	2.0	2.1	-2.4	2.1	-.1	.0
72D	11/28/73	21.2	25.4	66.3	28.8	-0.25	WAI	24.0	25.7	64.9	24.3	2.1	2.1	-2.4	2.3	-.2	-.2
72D	01/03/74	21.0	25.2	66.5	28.7	-0.19	WAI	23.8	25.5	65.1	24.2	2.3	2.3	-2.6	2.4	-.1	-.1
72D	01/31/74	20.6	25.2	65.7	28.8	-0.34	WAI	23.4	25.5	64.4	24.3	2.7	2.3	-1.9	2.3	.4	.0
72D	02/28/74	20.9	25.0	65.3	28.5	-0.07	WAI	23.7	25.3	64.0	24.0	2.4	2.5	-1.5	2.6	-.2	-.1
72D	03/28/74	21.0	25.2	65.5	28.8	-0.21	WAI	23.8	25.5	64.2	24.3	2.3	2.3	-1.7	2.3	.0	.0
72D	04/24/74	21.1	25.1	65.6	28.7	-0.23	WAI	23.9	25.4	64.3	24.2	2.2	2.4	-1.8	2.4	-.2	.0
72D	05/28/74	21.0	25.2	64.2	29.0	-0.13	WAI	23.8	25.5	63.0	24.5	2.3	2.3	-.5	2.1	.2	.2

Dobson Spectrophotometer No. 72

LAMP	DATE	Ra	Rc	Rc′	Rd	Hg	STN	Na	Nc	Nc′	Nd	dNa	dNc	dNc′	dNd	dNad	dNcd
72D	06/25/74	20.3	24.8	64.5	28.6	-0.11	WAI	23.1	25.1	63.3	24.1	3.0	2.7	-.8	2.5	.5	.2
72D	08/02/74	20.4	24.8	65.7	28.7	-0.21	WAI	23.2	25.1	64.4	24.2	2.9	2.7	-1.9	2.4	.5	.3
72D	08/29/74	19.8	24.4	67.2	28.3	-0.07	WAI	22.6	24.7	65.7	23.8	3.5	3.1	-3.2	2.8	.7	.3
72D	09/27/74	19.6	24.2	68.7	28.3	-0.03	WAI	22.3	24.5	67.1	23.8	3.8	3.3	-4.6	2.8	1.0	.5
72D	10/30/74	19.7	24.5	67.5	28.3	-0.02	WAI	22.5	24.8	66.0	23.8	3.6	3.0	-3.5	2.8	.8	.2
72D	11/29/74	19.7	24.4	68.0	28.2	-0.34	WAI	22.5	24.7	66.4	23.7	3.6	3.1	-3.9	2.9	.7	.2
72D	12/30/74	19.3	24.2	67.5	28.1	-0.14	WAI	22.0	24.5	66.0	23.6	4.1	3.3	-3.5	3.0	1.1	.3
72D	01/27/75	19.5	24.1	67.2	28.1	+0.15	WAI	22.2	24.4	65.7	23.6	3.9	3.4	-3.2	3.0	.9	.4
72D	03/04/75	19.1	24.0	66.3	27.7	-0.13	WAI	21.8	24.3	64.9	23.2	4.3	3.5	-2.4	3.4	.9	.1
72D	03/31/75	19.7	24.6	67.4	28.5	+0.30	WAI	22.5	24.9	65.9	24.0	3.6	2.9	-3.4	2.6	1.0	.3
72D	04/28/75	19.4	24.4	66.7	28.1	-0.25	WAI	22.1	24.7	65.3	23.6	4.0	3.1	-2.8	3.0	1.0	.1
72D	05/28/75	18.5	23.5	67.5	27.4	-0.15	WAI	21.2	23.8	66.0	22.9	4.9	4.0	-3.5	3.7	1.2	.3
72D	07/02/75	18.5	23.6	66.3	27.7	-0.17	WAI	21.2	23.9	64.9	23.2	4.9	3.9	-2.4	3.4	1.5	.5
72D	07/30/75	18.7	23.6	67.1	28.0	-0.17	WAI	21.4	23.9	65.6	23.5	4.7	3.9	-3.1	3.1	1.6	.8
72D	08/04/75	19.1	24.2	68.1	28.0	-0.30	WAI	21.8	24.5	66.5	23.5	4.3	3.3	-4.0	3.1	1.2	.2
72D	09/03/75	18.7	23.4	68.4	27.5	-0.35	WAI	21.4	23.7	66.8	23.0	4.7	4.1	-4.3	3.6	1.1	.5
72D	09/30/75	18.4	23.9	66.7	27.7	-0.01	WAI	21.1	24.2	65.3	23.2	5.0	3.6	-2.8	3.4	1.6	.2
72D	10/30/75	18.2	23.0	66.7	27.4	-0.13	WAI	20.9	23.2	65.3	22.9	5.2	4.6	-2.8	3.7	1.5	.9
72D	12/03/75	18.5	23.6	67.3	27.6	-0.21	WAI	21.2	23.9	65.8	23.1	4.9	3.9	-3.3	3.5	1.4	.4
72D	01/06/76	18.2	23.0	65.4	26.7	+0.39	WAI	20.9	23.2	64.1	22.2	5.2	4.6	-1.6	4.4	.8	.2
72D	01/27/76	18.5	23.9	67.5	27.6	+0.32	WAI	21.2	24.2	66.0	23.1	4.9	3.6	-3.5	3.5	1.4	.1
72D	03/02/76	18.6	23.6	66.9	27.4	+0.17	WAI	21.3	23.9	65.5	22.9	4.8	3.9	-3.0	3.7	1.1	.2
72D	03/31/76	18.5	23.3	66.3	27.8	+0.21	WAI	21.2	23.6	64.9	23.3	4.9	4.2	-2.4	3.3	1.6	.9
72D	04/27/76	18.5	23.5	65.3	27.7	-0.21	WAI	21.2	23.8	64.0	23.2	4.9	4.0	-1.5	3.4	1.5	.6
72D	05/11/76	18.1	23.1	69.1	27.7	+0.05	WAI	20.8	23.3	67.4	23.2	5.3	4.5	-4.9	3.4	1.9	1.1
72E	05/11/76	15.1	20.9	70.1	26.1		WAI	17.6	21.1	68.3	21.6	5.1	4.4	-4.6	3.5	1.6	.9
72D	05/13/76	18.2	23.4	69.0	27.9	+0.05	WAI	20.9	23.7	67.3	23.4	5.2	4.1	-4.8	3.2	2.0	.9
72D	05/17/76	18.7	23.9	68.7	28.2	-0.11	WAI	21.4	24.2	67.1	23.7	4.7	3.6	-4.6	2.9	1.8	.7
72E	05/17/76	15.6	21.6	69.7	26.5		WAI	18.1	21.8	68.0	22.0	4.6	3.7	-4.3	3.1	1.5	.6
72Y	05/18/76	14.3	20.5	73.2	25.7	+0.05	WAI	16.7	20.6	71.1	21.2	4.5	3.8	-5.3	3.1	1.4	.7
72Z	05/18/76	11.3	18.4	73.8	24.2		WAI	13.5	18.4	71.7	19.7	4.1	3.4	-5.9	3.0	1.1	.4
72D	05/19/76	18.1	23.3	72.7	27.7		WAI	29.5	30.7	78.0	29.3	.0	.0	.0	.0	.0	.0
72E	05/19/76	15.1	21.0	73.3	26.2		WAI	26.2	28.2	78.6	27.7	.0	.0	.0	.0	.0	.0
72Y	05/19/76	13.7	19.8	76.7	25.1		WAI	24.6	26.9	81.7	26.6	.0	.0	.0	.0	.0	.0
72Z	05/19/76	10.7	17.7	77.3	23.6		WAI	21.2	24.7	82.2	25.0	.0	.0	.0	.0	.0	.0
72Q1	05/19/76	4.6	12.2	89.6	18.9		WAI	14.2	18.7	93.3	20.1	.0	.0	.0	.0	.0	.0
72Q2	05/19/76	4.5	12.0	86.5	18.7		WAI	14.1	18.4	90.5	19.9	.0	.0	.0	.0	.0	.0
72D	05/28/76	17.8	23.5	71.3	27.8	+0.00	WAI	29.2	30.9	76.8	29.4	.3	-.2	1.2	-.1	.4	-.1
72D	07/07/76	17.6	22.5	71.3	27.1	-0.03	WAI	28.9	29.8	76.8	28.6	.6	.9	1.2	.7	-.1	.2
72D	07/30/76	18.2	23.2	69.4	28.1	-0.15	WAI	29.6	30.5	75.1	29.7	-.1	.2	2.9	-.4	.3	.6
72D	08/30/76	18.5	23.7	67.5	28.0	-0.31	WAI	29.9	31.1	73.4	29.6	-.4	-.4	4.6	-.3	-.1	-.1
72D	09/29/76	18.2	23.6	67.8	27.9	-0.06	WAI	29.6	31.0	73.6	29.5	-.1	-.3	4.4	-.2	.1	-.1
72D	11/01/76	18.1	23.2	67.9	27.9	-0.24	WAI	29.5	30.5	73.7	29.5	.0	.2	4.3	-.2	.2	.4
72D	11/26/76	18.2	22.9	68.1	27.6	+0.08	WAI	29.6	30.2	73.9	29.2	-.1	.5	4.1	.1	-.2	.4
72D	01/07/77	17.6	23.1	67.9	27.5	-0.30	WAI	28.9	30.4	73.7	29.0	.6	.3	4.3	.3	.3	.0
72D	01/27/77	17.7	23.4	67.6	27.9	-0.07	WAI	29.0	30.8	73.4	29.5	.5	-.1	4.6	-.2	.7	.1
72D	03/01/77	17.8	23.3	67.6	27.7	-0.34	WAI	29.2	30.7	73.4	29.3	.3	.0	4.6	.0	.3	.0

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LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
72D	04/04/77	17.1	22.4	67.2	27.4	-0.29	WAI	28.4	29.7	73.1	28.9	1.1	1.0	4.9	.4	.7	.6
72D	04/29/77	17.5	22.3	67.1	27.2	-0.10	WAI	28.8	29.6	73.0	28.7	.7	1.1	5.0	.6	.1	.5
72D	05/31/77	17.6	23.1	67.4	27.4	+0.05	WAI	28.9	30.4	73.3	28.9	.6	.3	4.7	.4	.2	-.1
72D	07/01/77	17.6	23.2	96.2	27.4	-0.15	WAI	28.9	30.5	99.3	28.9	.6	.2	-21.3	.4	.2	-.2
72D	07/26/77	17.6	23.2	98.4	27.8	+0.13	WAI	28.9	30.5	101.3	29.4	.6	.2	-23.3	-.1	.7	.3
72D	08/29/77	17.6	22.9	98.4	27.4	+0.38	WAI	28.9	30.2	101.3	28.9	.6	.5	-23.3	.4	.2	.1
72D	09/30/77	17.3	22.6	98.3	27.2	-0.21	WAI	28.6	29.9	101.2	28.7	.9	.8	-23.2	.6	.3	.2
72D	10/28/77	17.7	23.5	98.7	27.9	+0.19	WAI	29.0	30.9	101.6	29.5	.5	-.2	-23.6	-.2	.7	.0
72D	11/30/77	18.0	23.6	99.5	27.4	-0.21	WAI	29.4	31.0	102.3	28.9	.1	-.3	-24.3	.4	-.3	-.7
72D	01/04/78	17.7	22.7	98.6	27.3	-0.10	WAI	29.0	30.0	101.5	28.8	.5	.7	-23.5	.5	.0	.2
72D	01/27/78	17.2	22.4	98.0	27.1	-0.08	WAI	28.5	29.7	100.9	28.6	1.0	1.0	-22.9	.7	.3	.3
72D	03/01/78	17.6	22.5	99.4	27.2	+0.10	WAI	28.9	29.8	102.2	28.7	.6	.9	-24.2	.6	.0	.3
72D	03/30/78	17.5	22.9	99.5	27.4	-0.27	WAI	28.8	30.2	102.3	28.9	.7	.5	-24.3	.4	.3	.1
72D	05/02/78	17.6	22.9	98.2	27.5	-0.13	WAI	28.9	30.2	101.1	29.0	.6	.5	-23.1	.3	.3	.2
72D	06/29/78	18.7	23.4	99.4	26.9	+0.34*	WAI	30.1	30.8	102.2	28.4	-.6	-.1	-24.2	.9	-1.5	-1.0
72D	07/28/78	18.3	22.9	98.4	27.5	-0.10	WAI	29.7	30.2	101.3	29.0	-.2	.5	-23.3	.3	-.5	.2
72D	09/01/78	18.0	22.9	98.4	27.5	-0.05	WAI	29.4	30.2	101.3	29.0	.1	.5	-23.3	.3	-.2	.2
72D	10/02/78	18.4	23.5	97.2	27.8	+0.09	WAI	29.8	30.9	100.2	29.4	-.3	-.2	-22.2	-.1	-.2	-.1
72D	10/20/78	17.7	22.8	96.3	27.4	+0.00	WAI	29.0	30.1	99.4	28.9	.5	.6	-21.4	.4	.1	.2
72D	10/23/78	18.2	23.0	96.6	27.7	+0.14	WAI	29.6	30.3	99.7	29.3	-.1	.4	-21.7	.0	-.1	.4
72D	10/23/78	18.7	23.5	97.2	27.8	-0.05	WAI	30.1	30.9	100.2	29.4	-.6	-.2	-22.2	-.1	-.5	-.1
72E	10/23/78	14.3	20.0	97.2	24.3		WAI	25.3	27.1	100.2	25.8	.9	1.1	-21.6	1.9	-1.0	-.8
72Y	10/23/78	13.0	19.2	99.5	23.9		WAI	23.8	26.3	102.3	25.3	.8	.6	-20.6	1.3	-.5	-.7
72Z	10/23/78	10.6	17.7	98.9	23.0		WAI	21.1	24.7	101.8	24.4	.1	.0	-19.6	.6	-.5	-.6
72UQ1	10/23/78	5.1	12.9	110.1	19.5		WAI	14.8	19.4	112.1	20.8						
72D	10/24/78	16.8	21.9	68.4	26.4	+0.05	WAI	28.1	29.2	74.2	27.9	1.4	1.5	3.8	1.4	.0	.1
72E	10/24/78	13.6	19.5	68.7	24.4		WAI	24.5	26.6	74.4	25.9	1.7	1.6	4.2	1.8	-.1	-.2
72Y	10/24/78	12.5	18.6	71.7	23.6		WAI	23.2	25.6	77.1	25.0	1.4	1.3	4.6	1.6	-.2	-.3
72Z	10/24/78	9.1	16.4	70.9	22.0		WAI	19.4	23.3	76.4	23.4	1.8	1.4	5.8	1.6	.2	-.2
72UQ1	10/24/78	3.7	11.3	83.4	17.8		WAI	13.1	17.7	87.7	19.0						
72Q1	10/26/78	2.7	10.0	83.9	16.7		WAI	12.0	16.2	88.2	17.8	2.2	2.5	5.1	2.3	-.1	.2
72Q2	10/26/78	2.5	10.0	84.8	16.5		WAI	11.7	16.2	89.0	17.6	2.4	2.2	1.5	2.3	.1	-.1
72Q1	10/28/78	4.0	10.5	84.8	16.7	+0.22*	WAI	13.5	16.8	89.0	17.8	.7	1.9	4.3	2.3	-1.6	-.4
72Q1	11/28/78	2.2	8.0	89.7	15.9	+0.20	WAI	11.4	14.0	93.4	17.0	2.8	4.7	-.1	3.1	-.3	1.6
72Q1	11/28/78	2.0	10.0	84.8	16.0	15.9	WAI	11.2	16.2	89.0	17.0	3.0	2.5	4.3	3.1	-.1	-.6
72Q1	12/28/78	1.5	9.0	84.9	14.9	+0.12	WAI	10.6	15.1	89.1	15.9	3.6	3.6	4.2	4.2	-.6	-.6
72Q1	12/28/78	1.7	8.7	85.3	15.6		WAI	10.8	14.8	89.4	16.6	3.4	3.9	3.9	3.5	-.1	.4
72Q1	01/16/79	1.9	9.3	85.5	15.7	+0.19	WAI	11.1	15.4	89.6	16.8	3.1	3.3	3.7	3.3	-.2	.0
72Q2	01/16/79	1.8	9.1	85.4	15.5		WAI	10.9	15.2	89.5	16.5	3.2	3.2	1.0	3.4	-.2	-.2
72D	01/16/79	15.3	20.1	67.4	24.4	+0.06	WAI	26.4	27.2	73.3	25.9	3.1	3.5	4.7	3.4	-.3	.1
72E	01/16/79	12.5	18.3	70.4	23.1		WAI	23.2	25.3	76.0	24.5	3.0	2.9	2.6	3.2	-.2	-.3
72Q1	01/31/79	2.1	9.6	86.0	15.2	-0.05*	WAI	11.3	15.8	90.1	16.2	2.9	2.9	3.2	3.9	-1.0	-1.0
72Q1	02/28/79	2.7	10.0	87.0	15.5	+0.18*	WAI	12.0	16.2	91.0	16.5	2.2	2.5	2.3	3.6	-1.4	-1.1
72Q1	04/03/79	1.8	9.5	85.5	15.8	+0.08	WAI	10.9	15.7	89.6	16.9	3.3	3.0	3.7	3.2	.1	-.2
72Q1	04/30/79	2.4	9.6	85.6	16.1	+0.12	WAI	11.6	15.8	89.7	17.2	2.6	2.9	3.6	2.9	-.3	.0
72Q1	05/29/79	2.0	9.5	86.3	15.6	+0.11	WAI	11.2	15.7	90.4	16.6	3.0	3.0	2.9	3.5	-.5	-.5
72Q1	06/28/79	2.0	9.7	86.2	15.9	+0.11	WAI	11.2	15.9	90.3	17.0	3.0	2.8	3.0	3.1	-.1	-.3

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LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
72Q1	07/29/79	2.1	9.2	86.8	15.6	+0.06	WAI	11.3	15.3	90.8	16.6	2.9	3.4	2.5	3.5	-.6	-.1
72Q1	08/28/79	2.8	9.9	84.9	16.1	+0.12	WAI	12.1	16.1	89.1	17.2	2.1	2.6	4.2	2.9	-.8	-.3
72Q1	09/28/79	2.6	10.0	84.0	16.1	+0.16	WAI	11.9	16.2	88.3	17.2	2.3	2.5	5.0	2.9	-.6	-.4
72Q1	10/29/79	2.6	9.9	84.7	16.4	+0.33	WAI	11.9	16.1	88.9	17.5	2.3	2.6	4.4	2.6	-.3	.0
72Q1	02/26/80					-1.47	BDR										
72Q1	02/26/80					-0.40	BDR										
72Q1	02/29/80	1.8	9.2	84.5	15.3	-0.08	BDR	10.9	15.3	88.7	16.3	3.3	3.4	4.6	3.8	-.5	-.4
72UQ1	02/29/80	2.8	10.2	83.2	16.5		BDR	12.1	16.5	87.5	17.6						

Dobson Spectrophotometer No. 38

LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
38Q1	09/21/78	32.4	34.4	64.6	36.5	+0.08	BDR	10.9	16.1	46.6	18.0	.0	.0	.0	.0	.0	.0
38Q2	09/21/78	32.7	34.7	64.1	36.7		BDR	11.2	16.4	46.1	18.2	.0	.0	.0	.0	.0	.0
38UQ1	09/21/78	33.7	35.8	63.5	37.8		BDR	12.3	17.6	45.5	19.4	.0	.0	.0	.0	.0	.0
38UQ2	09/21/78	33.5	35.3	62.8	37.5		BDR	12.1	17.1	44.8	19.1	.0	.0	.0	.0	.0	.0
38Q1	10/29/79	32.3	34.4	66.8	36.3	-0.10	WAI	10.8	16.1	48.8	17.8	.1	.0	-2.2	.2	-.1	-.2
38Q1	11/29/79	31.9	34.3	66.1	36.2	-0.11	WAI	10.4	16.0	48.1	17.7	.5	.1	-1.5	.3	.2	-.2
38Q1	01/02/80	32.1	34.4	66.0	36.6	-0.08	WAI	10.6	16.1	48.0	18.1	.3	.0	-1.4	-.1	.4	.1
38Q1	01/28/80	32.5	34.5	65.6	36.7	-0.05	WAI	11.0	16.2	47.6	18.2	-.1	-.1	-1.0	-.2	.1	.1
38Q1	02/29/80	32.2	34.6	65.6	36.4	+0.06	WAI	10.7	16.3	47.6	17.9	.2	-.2	-1.0	.1	.1	-.3
38Q1	03/28/80	32.5	34.6	65.7	36.7	-0.01	WAI	11.0	16.3	47.7	18.2	-.1	-.2	-1.1	-.2	.1	.0
38Q1	04/28/80	32.5	34.9	66.2	36.8	-0.26	WAI	11.0	16.7	48.2	18.3	-.1	-.6	-1.6	-.3	.2	-.3
38Q1	05/28/80	32.1	34.6	65.3	36.2	-0.23	WAI	10.6	16.3	47.3	17.7	.3	-.2	-.7	.3	.0	-.5
38Q1	06/27/80	32.6	34.9	66.4	37.1	-0.32	WAI	11.1	16.7	48.4	18.6	-.2	-.6	-1.8	-.6	.4	.0
38Q1	07/28/80	33.1	35.4	66.0	37.5	-0.29	WAI	11.7	17.2	48.0	19.1	-.8	-1.1	-1.4	-1.1	.3	.0
38Q1	08/28/80	32.8	35.1	66.1	37.4	-0.14	WAI	11.4	16.9	48.1	19.0	-.5	-.8	-1.5	-1.0	.5	.2
38Q1	09/29/80	33.2	35.4	65.9	37.5	-0.25	WAI	11.8	17.2	47.9	19.1	-.9	-1.1	-1.3	-1.1	.2	.0
38Q1	10/28/80	33.3	35.5	65.2	37.6	-0.33	WAI	11.9	17.3	47.2	19.2	-1.0	-1.2	-.6	-1.2	.2	.0
38Q1	11/28/80	33.4	35.7	64.8	38.0	-0.28	WAI	12.0	17.5	46.8	19.6	-1.1	-1.4	-.2	-1.6	.5	.2
38Q1	12/30/80	33.5	35.6	64.5	37.9	-0.24	WAI	12.1	17.4	46.5	19.5	-1.2	-1.3	.1	-1.5	.3	.2
38Q1	01/28/81	33.5	35.9	64.5	38.0	-0.18	WAI	12.1	17.7	46.5	19.6	-1.2	-1.6	.1	-1.6	.4	.0
38Q1	02/28/81	33.3	35.6	65.0	37.8	-0.13	WAI	11.9	17.4	47.0	19.4	-1.0	-1.3	-.4	-1.4	.4	.1
38Q1	03/28/81	33.4	35.7	64.2	37.8	-0.21	WAI	12.0	17.5	46.2	19.4	-1.1	-1.4	.4	-1.4	.3	.0
38Q1	04/29/81	31.3	33.9	68.0	35.9	-0.28	WAI	9.8	15.6	50.0	17.4	1.1	.5	-3.4	.6	.5	-.1
38Q2	04/29/81	31.4	33.8	67.5	35.9		WAI	9.9	15.5	49.5	17.4	1.3	.9	-3.4	.8	.5	.1
38Q1	04/30/81	31.4	33.7	67.4	35.9	-0.25	WAI	9.9	15.4	49.4	17.4	1.0	.7	-2.8	.6	.4	.1
38Q2	04/30/81	31.7	34.0	66.6	36.2		WAI	10.2	15.7	48.6	17.7	1.0	.7	-2.5	.5	.5	.2
38Q1	04/30/81	31.7	34.1	67.0	36.2		WAI	10.2	15.8	49.0	17.7	.7	.3	-2.4	.3	.4	.0
38Q1	05/01/81	30.1	32.3	63.3	34.6	-0.60	WAI	8.6	14.0	45.3	16.0	2.3	2.1	1.3	2.0	.3	.1
38Q1	05/04/81	30.0	32.4	64.9	34.7	-0.08	WAI	8.5	14.1	46.9	16.1	2.4	2.0	-.3	1.9	.5	.1
38Q1	05/04/81	31.1	33.5	63.9	35.6	-0.57	WAI	9.6	15.2	45.9	17.1	1.3	.9	.7	.9	.4	.0
38Q1	05/05/81	31.3	33.6	64.8	35.8	-0.58	WAI	9.8	15.3	46.8	17.3	1.1	.8	-.2	.7	.4	.1
38Q1	05/06/81	31.0	33.4	63.9	35.6	+0.06	WAI	9.5	15.1	45.9	17.1	1.4	1.0	.7	.9	.5	.1
38Q2	05/06/81	31.3	33.6	63.0	35.8		WAI	9.8	15.3	45.0	17.3	1.4	1.1	1.1	.9	.5	.2
38Q1	05/07/81	30.9	33.3	64.5	35.5	+0.15	WAI	9.4	15.0	46.5	17.0	1.5	1.1	.1	1.0	.5	.1

Dobson Spectrophotometer No. 38

LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
38Q1	07/28/83	31.8	34.3	72.5	36.7	+0.14	WAI	10.3	16.0	54.4	18.2	.6	.1	-7.8	-.2	.8	.3
38Q1	08/30/83	31.7	34.2	72.9	36.5	+0.11	WAI	10.2	15.9	54.8	18.0	.7	.2	-8.2	.0	.7	.2
38Q1	09/29/83	31.8	34.3	74.6	36.5	+0.02	WAI	10.3	16.0	56.5	18.0	.6	.1	-9.9	.0	.6	.1
38Q1	10/31/83	31.8	34.5	74.4	36.7	+0.11	WAI	10.3	16.2	56.3	18.2	.6	-.1	-9.7	-.2	.8	.1
38Q1	11/28/83	31.9	34.3	74.1	36.6	-0.05	WAI	10.4	16.0	56.0	18.1	.5	.1	-9.4	-.1	.6	.2
38Q1	12/30/83	32.0	34.5	63.3	36.9	+0.15	WAI	10.5	16.2	45.3	18.4	.4	-.1	1.3	-.4	.8	.3
38Q1	01/30/84	32.1	34.5	63.5	37.0	+0.00	WAI	10.6	16.2	45.5	18.5	.3	-.1	1.1	-.5	.8	.4
38Q1	02/28/84	31.8	34.4	63.3	36.6	-0.02	WAI	10.3	16.1	45.3	18.1	.6	.0	1.3	-.1	.7	.1
38Q1	03/28/84	31.8	34.5	63.3	36.7	-0.16	WAI	10.3	16.2	45.3	18.2	.6	-.1	1.3	-.2	.8	.1
38Q1	04/25/84	32.2	34.7	63.6	37.0	-0.03	WAI	10.7	16.4	45.6	18.5	.2	-.3	1.0	-.5	.7	.2
38Q1	05/07/84	31.7	34.3	59.0	36.7	-0.31	BDR	10.2	16.0	41.0	18.2	.7	.1	5.6	-.2	.9	.3
38Q2	05/07/84	32.2	34.7	57.0	37.3		BDR	10.7	16.4	39.0	18.8	.5	.0	7.1	-.6	1.1	.6
38Q1	04/15/85	25.8	28.0	37.2	29.8	-0.09	BDR	4.1	9.5	19.0	11.0	6.8	6.6	27.6	7.0	-.2	-.4
38Q2	04/15/85	26.2	28.2	36.6	30.3		BDR	4.5	9.7	18.4	11.6	6.7	6.7	27.7	6.6	.1	.1
38Q3	04/15/85	25.7	27.6	38.3	29.7		BDR	4.0	9.1	20.2	10.9						
38UQ1	04/15/85	26.9	29.2	35.4	31.0		BDR	5.2	10.7	17.2	12.3	7.1	6.9	28.3	7.1	.0	-.2
38UQ3	04/15/85	26.0	28.0	37.5	29.8		BDR	4.3	9.5	19.3	11.0						
38Q1	05/08/85	25.7	27.8	36.7	29.7	-0.14	BDR	12.0	16.8	26.7	18.3	.0	.0	.0	.0	.0	.0
38Q2	05/08/85	26.0	28.2	35.7	30.2		BDR	12.3	17.2	25.6	18.8	.0	.0	.0	.0	.0	.0
38Q3	05/08/85	25.4	27.7	38.0	29.5		BDR	11.7	16.7	28.1	18.0	.0	.0	.0	.0	.0	.0
38UQ1	05/08/85	27.2	29.2	35.4	31.2		BDR	13.7	18.3	25.3	20.0	.0	.0	.0	.0	.0	.0
38UQ3	05/08/85	26.0	28.0	38.3	30.0		BDR	12.3	17.0	28.5	18.6	.0	.0	.0	.0	.0	.0
38UQ3	05/28/85					+1.14	WAI										
38UQ3	05/28/85					+1.08	WAI										
38UQ3	05/28/85					+1.31	WAI										
38Q1	05/29/85	25.9	27.9	36.3	29.9	+0.09	WAI	12.2	16.9	26.2	18.5	-.2	-.1	.5	-.2	.0	.1
38Q2	05/29/85	26.2	28.2	34.4	30.1		WAI	12.6	17.2	24.1	18.7	-.3	.0	1.5	.1	-.4	-.1
38Q1	06/28/85	25.7	27.7	36.9	29.6	+0.31	WAI	12.0	16.7	26.9	18.1	.0	.1	-.2	.2	-.2	-.1
38Q1	07/29/85	26.0	28.0	37.4	30.0	+0.25	WAI	12.3	17.0	27.5	18.6	-.3	-.2	-.8	-.3	.0	.1
38Q1	08/28/85	25.8	27.9	37.6	29.9	+0.29	WAI	12.1	16.9	27.7	18.5	-.1	-.1	-1.0	-.2	.1	.1
38Q1	09/30/85	26.0	28.1	38.1	30.2	+0.10	WAI	12.3	17.1	28.2	18.8	-.3	-.3	-1.5	-.5	.2	.2
38Q1	10/29/85	26.1	28.1	38.1	30.0	+0.29	WAI	12.5	17.1	28.2	18.6	-.5	-.3	-1.5	-.3	-.2	.0
38Q1	12/02/85	26.0	28.1	38.5	30.2	+0.22	WAI	12.3	17.1	28.7	18.8	-.3	-.3	-2.0	-.5	.2	.2
38Q1	12/30/85	26.1	28.2	38.0	30.0	+0.37	WAI	12.5	17.2	28.1	18.6	-.5	-.4	-1.4	-.3	-.2	-.1
38Q1	01/27/86	26.0	28.0	37.9	30.0	+0.17	WAI	12.3	17.0	28.0	18.6	-.3	-.2	-1.3	-.3	.0	.1
38Q1	02/28/86	26.4	28.4	38.0	30.1	+0.35	WAI	12.8	17.4	28.1	18.7	-.8	-.6	-1.4	-.4	-.4	-.2
38Q1	03/28/86	26.1	28.2	37.8	30.1	+0.35	WAI	12.5	17.2	27.9	18.7	-.5	-.4	-1.2	-.4	-.1	.0
38Q1	04/28/86	26.6	28.6	38.4	30.5	+0.17	WAI	13.0	17.7	28.6	19.2	-1.0	-.9	-1.9	-.9	-.1	.0
38Q1	05/28/86	26.2	28.3	38.5	30.1	+0.03	WAI	12.6	17.3	28.7	18.7	-.6	-.5	-2.0	-.4	-.2	-.1
38Q1	06/27/86	26.3	28.2	38.1	30.4	+0.38	WAI	12.7	17.2	28.2	19.1	-.7	-.4	-1.5	-.8	.1	.4
38Q1	07/28/86	26.3	28.4	39.0	30.3	+0.10	WAI	12.7	17.4	29.2	18.9	-.7	-.6	-2.5	-.6	-.1	.0
38Q1	08/29/86	26.2	28.1	38.3	30.1	+0.34	WAI	12.6	17.1	28.5	18.7	-.6	-.3	-1.8	-.4	-.2	.1
38Q1	09/29/86	26.1	28.1	38.3	30.1	+0.19	WAI	12.5	17.1	28.5	18.7	-.5	-.3	-1.8	-.4	-.1	.1
38Q1	10/10/86	26.4	28.5	37.9	30.5	+0.37	WAI	12.8	17.6	28.0	19.2	-.8	-.8	-1.3	-.9	.1	.1
38Q2	10/10/86	26.6	28.9	35.9	30.9		WAI	13.0	18.0	25.8	19.6	-.7	-.8	-.2	-.8	.1	.0
38R22	10/10/86	26.8	28.8	36.3	30.8	+0.37*	WAI	13.2	17.9	26.2	19.5						
38R23	10/10/86	26.3	28.5	36.7	30.5	*	WAI	12.7	17.6	26.7	19.2						

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LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
38Q1	05/10/81	31.0	33.4	64.8	35.5	+0.05	WAI	9.5	15.1	46.8	17.0	1.4	1.0	-.2	1.0	.4	.0
38Q1	05/28/81	31.0	33.6	65.7	35.6	+0.01	WAI	9.5	15.3	47.7	17.1	1.4	.8	-1.1	.9	.5	-.1
38Q1	06/28/81	31.7	34.1	67.9	36.0	-0.03	WAI	10.2	15.8	49.9	17.5	.7	.3	-3.3	.5	.2	-.2
38Q1	07/28/81	33.5	35.7	66.4	37.7	+0.23	WAI	12.1	17.5	48.4	19.3	-1.2	-1.4	-1.8	-1.3	.1	-.1
38Q1	07/30/81	33.5	35.9	66.4	37.8	+0.15	WAI	12.1	17.7	48.4	19.4	-1.2	-1.6	-1.8	-1.4	.2	-.2
38Q1	08/28/81	33.9	36.1	63.4	37.7	+0.10	WAI	12.5	17.9	45.4	19.3	-1.6	-1.8	1.2	-1.3	-.3	-.5
38Q1	08/30/81	31.2	33.6	68.8	35.8		WAI	9.7	15.3	50.8	17.3	1.2	.8	-4.2	.7	.5	.1
38Q1	08/31/81	31.2	33.8	68.9	36.0		WAI	9.7	15.5	50.9	17.5	1.2	.6	-4.3	.5	.7	.1
38Q2	08/31/81	31.5	33.9	67.3	36.2		WAI	10.0	15.6	49.3	17.7	1.2	.8	-3.2	.5	.7	.3
38Q1	09/28/81	31.3	33.8	68.7	36.1	+0.09	WAI	9.8	15.5	50.7	17.6	1.1	.6	-4.1	.4	.7	.2
38Q1	10/28/81	31.5	33.8	69.2	36.2	+0.14	WAI	10.0	15.5	51.2	17.7	.9	.6	-4.6	.3	.6	.3
38Q1	11/30/81	31.9	34.3	68.4	36.6	+0.06	WAI	10.4	16.0	50.4	18.1	.5	.1	-3.8	-.1	.6	.2
38Q1	12/29/81	31.9	34.4	68.0	36.6	+0.15	WAI	10.4	16.1	50.0	18.1	.5	.0	-3.4	-.1	.6	.1
38Q1	01/29/82	31.8	34.2	67.6	36.7	+0.22	WAI	10.3	15.9	49.6	18.2	.6	.2	-3.0	-.2	.8	.4
38Q1	03/01/82	32.3	34.6	68.1	36.8	+0.01	WAI	10.8	16.3	50.1	18.3	.1	-.2	-3.5	-.3	.4	.1
38Q1	03/29/82	32.1	34.6	68.2	36.8	+0.23	WAI	10.6	16.3	50.2	18.3	.3	-.2	-3.6	-.3	.6	.1
38Q1	04/28/82	32.1	34.6	67.4	36.9	+0.08	WAI	10.6	16.3	49.4	18.4	.3	-.2	-2.8	-.4	.7	.2
38Q1	05/28/82	32.2	34.6	73.4	36.8	+0.02	WAI	10.7	16.3	55.3	18.3	.2	-.2	-8.7	-.3	.5	.1
38Q1	06/17/82	31.4	33.7	77.7	36.1	-0.16	WAI	9.9	15.4	59.5	17.6	1.0	.7	-12.9	.4	.6	.3
38Q2	06/17/82	31.9	34.2	76.1	36.5		WAI	10.4	15.9	57.9	18.0	.8	.5	-11.8	.2	.6	.3
38R12	06/17/82	31.6	34.0	77.6	36.2		WAI	10.1	15.7	59.4	17.7	.9	.6	M	.3	.6	.3
38Q1	06/27/82	31.1	33.7	81.5	35.9	-0.21	WAI	9.6	15.4	63.2	17.4	1.3	.7	-16.6	.6	.7	.1
38Q2	06/27/82	31.5	34.0	79.8	36.4		WAI	10.0	15.7	61.6	17.9	1.2	.7	-15.5	.3	.9	.4
38R13	06/27/82	31.1	33.7	81.0	36.0		WAI	9.6	15.4	62.7	17.5	1.3	.7	M	.5	.8	.2
38Q1	06/29/82	31.1	33.5	81.4	35.9	-0.30	WAI	9.6	15.2	63.1	17.4	1.3	.9	-16.5	.6	.7	.3
38Q1	07/27/82	31.1	33.6	75.9	35.8	-0.19	WAI	9.6	15.3	57.7	17.3	1.3	.8	-11.1	.7	.6	.1
38Q1	08/30/82	30.2	33.6	79.7	35.8	+0.00*	WAI	8.7	15.3	61.5	17.3	2.2	.8	-14.9	.7	1.5	.1
38Q1	09/15/82	31.3	33.7	76.0	35.8	-0.26	WAI	9.8	15.4	57.8	17.3	1.1	.7	-11.2	.7	.4	.0
38Q2	09/15/82	31.8	34.1	74.0	36.3		WAI	10.3	15.8	55.9	17.8	.9	.6	-9.8	.4	.5	.2
38Q1	09/15/82	31.3	33.8	68.7	35.9	-0.24	WAI	9.8	15.5	50.7	17.4	1.1	.6	-4.1	.6	.5	.0
38Q2	09/15/82	31.8	34.1	66.8	36.3		WAI	10.3	15.8	48.8	17.8	.9	.6	-2.7	.4	.5	.2
38Q1	09/15/82	31.3	33.8	68.0	35.8		WAI	9.8	15.5	50.0	17.3	1.1	.6	-3.4	.7	.4	-.1
38Q2	09/15/82	31.8	34.3	66.6	36.2		WAI	10.3	16.0	48.6	17.7	.9	.4	-2.5	.5	.4	-.1
38Q1	09/29/82	31.5	33.7	68.0	36.0	+0.09	WAI	10.0	15.4	50.0	17.5	.9	.7	-3.4	.5	.4	.2
38Q1	10/28/82	31.1	33.6	75.2	35.7	+0.04	WAI	9.6	15.3	57.0	17.2	1.3	.8	-10.4	.8	.5	.0
38Q1	11/29/82	31.3	33.6	75.4	36.0	+0.10	WAI	9.8	15.3	57.2	17.5	1.1	.8	-10.6	.5	.6	.3
38Q1	12/30/82	31.4	33.8	80.6	36.1	+0.17	WAI	9.9	15.5	62.3	17.6	1.0	.6	-15.7	.4	.6	.2
38Q1	01/03/83	30.9	33.4	79.7	35.5	+0.07	WAI	9.4	15.1	61.5	17.0	1.5	1.0	-14.9	1.0	.5	.0
38Q1	02/02/83	31.5	34.2	65.9	36.3	-0.06	WAI	10.0	15.9	47.9	17.8	.9	.2	-1.3	.2	.7	.0
38Q2	02/02/83	32.0	34.6	64.3	36.8		WAI	10.5	16.3	46.3	18.3	.7	.1	-.2	-.1	.8	.2
38Q1	02/03/83	31.7	34.3	66.7	36.6	-0.04	WAI	10.2	16.0	48.7	18.1	.7	.1	-2.1	-.1	.8	.2
38Q2	02/03/83	32.2	34.7	65.1	37.0		WAI	10.7	16.4	47.1	18.5	.5	.0	-1.0	-.3	.8	.3
38Q1	02/28/83	31.5	34.0	66.7	36.5	+0.14	WAI	10.0	15.7	48.7	18.0	.9	.4	-2.1	.0	.9	.4
38Q1	03/28/83	31.6	34.1	66.8	36.4	-0.01	WAI	10.1	15.8	48.8	17.9	.8	.3	-2.2	.1	.7	.2
38Q1	04/28/83	31.7	34.2	66.2	36.5	+0.07	WAI	10.2	15.9	48.2	18.0	.7	.2	-1.6	.0	.7	.2
38Q1	05/31/83	31.7	34.2	66.4	36.5	-0.05	WAI	10.2	15.9	48.4	18.0	.7	.2	-1.8	.0	.7	.2
38Q1	06/28/83	31.7	34.1	73.0	36.5	-0.03	WAI	10.2	15.8	54.9	18.0	.7	.3	-8.3	.0	.7	.3

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LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
38Q1	10/29/86	26.5	28.5	38.4	30.4	+0.15	WAI	12.9	17.6	28.6	19.1	-.9	-.8	-1.9	-.8	-.1	.0
38Q1	12/01/86	26.4	28.6	38.0	30.6	+0.35	WAI	12.8	17.7	28.1	19.3	-.8	-.9	-1.4	-1.0	.2	.1
38Q1	12/30/86	26.6	28.6	37.9	30.6	+0.20	WAI	13.0	17.7	28.0	19.3	-1.0	-.9	-1.3	-1.0	.0	.1
38Q1	01/29/87	27.0	29.0	37.9	31.0	+0.31	WAI	13.5	18.1	28.0	19.7	-1.5	-1.3	-1.3	-1.4	-.1	.1
38Q1	02/27/87	26.8	28.8	38.0	30.8	+0.35	WAI	13.2	17.9	28.1	19.5	-1.2	-1.1	-1.4	-1.2	.0	.1
38Q1	03/30/87	26.9	28.8	38.4	30.8	+0.30	WAI	13.3	17.9	28.6	19.5	-1.3	-1.1	-1.9	-1.2	-.1	.1
38Q1	04/28/87	26.9	29.0	38.2	30.9	+0.27	WAI	13.3	18.1	28.3	19.6	-1.3	-1.3	-1.6	-1.3	.0	.0
38Q1	05/28/87	26.8	28.8	38.1	30.8	+0.32	WAI	13.2	17.9	28.2	19.5	-1.2	-1.1	-1.5	-1.2	.0	.1
38Q1	06/02/87	26.8	28.9	38.5	30.7	+0.27	WAI	13.2	18.0	28.7	19.4	-1.2	-1.2	-2.0	-1.1	-.1	-.1
38Q1	06/29/87	26.8	28.9	38.5	30.7	+0.27	WAI	13.2	18.0	28.7	19.4	-1.2	-1.2	-2.0	-1.1	-.1	-.1
38Q1	07/28/87	26.9	29.0	39.3	31.0	+0.23	WAI	13.3	18.1	29.5	19.7	-1.3	-1.3	-2.8	-1.4	.1	.1
38Q1	08/28/87	26.7	28.8	39.6	30.9	+0.24	WAI	13.1	17.9	29.9	19.6	-1.1	-1.1	-3.2	-1.3	.2	.2
38Q1	09/28/87	26.9	29.0	39.7	31.0	+0.26	WAI	13.3	18.1	30.0	19.7	-1.3	-1.3	-3.3	-1.4	.1	.1
38Q1	10/28/87	26.8	28.9	38.7	30.8	+0.29	WAI	13.2	18.0	28.9	19.5	-1.2	-1.2	-2.2	-1.2	.0	.0
38Q1	12/01/87	27.1	29.0	37.9	31.1	+0.23	WAI	13.6	18.1	28.0	19.8	-1.6	-1.3	-1.3	-1.5	-.1	.2
38Q1	12/29/87	26.8	28.9	38.2	30.8	+0.21	WAI	13.2	18.0	28.3	19.5	-1.2	-1.2	-1.6	-1.2	.0	.0
38Q1	01/28/88	27.0	29.0	38.0	31.0	+0.38	WAI	13.5	18.1	28.1	19.7	-1.5	-1.3	-1.4	-1.4	-.1	.1
38Q1	02/29/88	27.1	29.1	38.2	31.1	+0.22	WAI	13.6	18.2	28.3	19.8	-1.6	-1.4	-1.6	-1.5	-.1	.1
38Q1	03/28/88	27.0	29.0	37.7	31.0	+0.35	WAI	13.5	18.1	27.8	19.7	-1.5	-1.3	-1.1	-1.4	-.1	.1
38Q1	04/28/88	27.1	29.1	37.6	31.0	+0.12	WAI	13.6	18.2	27.7	19.7	-1.6	-1.4	-1.0	-1.4	-.2	.0
38Q1	05/27/88	27.0	29.0	38.3	31.0	+0.25	WAI	13.5	18.1	28.5	19.7	-1.5	-1.3	-1.8	-1.4	-.1	.1
38Q1	06/28/88	27.0	29.0	38.3	31.0	+0.29	WAI	13.5	18.1	28.5	19.7	-1.5	-1.3	-1.8	-1.4	-.1	.1
38Q1	07/29/88	27.0	29.1	39.9	31.0	+0.30	WAI	13.5	18.2	30.2	19.7	-1.5	-1.4	-3.5	-1.4	-.1	.0
38Q1	08/29/88	26.9	29.0	41.7	31.0	+0.30	WAI	13.3	18.1	32.2	19.7	-1.3	-1.3	-5.5	-1.4	.1	.1
38Q1	09/28/88	27.0	29.0	40.3	31.0	+0.29	WAI	13.5	18.1	30.6	19.7	-1.5	-1.3	-3.9	-1.4	-.1	.1
38Q1	10/28/88	27.0	29.1	39.4	31.0	+0.32	WAI	13.5	18.2	29.7	19.7	-1.5	-1.4	-3.0	-1.4	-.1	.0
38Q1	11/29/88	27.4	29.2	38.5	31.1	+0.35	WAI	13.9	18.3	28.7	19.8	-1.9	-1.5	-2.0	-1.5	-.4	.0
38Q1	12/28/88	27.3	29.4	38.6	31.1	+0.29	WAI	13.8	18.6	28.8	19.8	-1.8	-1.8	-2.1	-1.5	-.3	-.3
38Q1	01/30/89	27.5	29.5	38.5	31.3	+0.16	WAI	14.0	18.7	28.7	20.1	-2.0	-1.9	-2.0	-1.8	-.2	-.1
38Q1	02/27/89	27.4	29.5	38.6	31.4	+0.19	WAI	13.9	18.7	28.8	20.2	-1.9	-1.9	-2.1	-1.9	.0	.0
38Q1	03/29/89	27.5	29.3	38.8	31.2	+0.10	WAI	14.0	18.5	29.0	20.0	-2.0	-1.7	-2.3	-1.7	-.3	.0
38Q1	04/28/89	27.3	29.3	38.0	31.1	+0.28	WAI	13.8	18.5	28.1	19.8	-1.8	-1.7	-1.4	-1.5	-.3	-.2
38Q1	05/30/89	27.8	29.6	38.1	31.5	+0.22	WAI	14.3	18.8	28.2	20.3	-2.3	-2.0	-1.5	-2.0	-.3	.0
38Q1	06/28/89	27.1	29.4	39.4	31.3	+0.18	WAI	13.6	18.6	29.7	20.1	-1.6	-1.8	-3.0	-1.8	.2	.0
38Q1	07/28/89	26.3	28.7	40.6	30.8	+0.15	WAI	12.7	17.8	31.0	19.5	-.7	-1.0	-4.3	-1.2	.5	.2
38Q1	08/28/89	27.5	29.5	38.7	31.5	+0.30	WAI	14.0	18.7	28.9	20.3	-2.0	-1.9	-2.2	-2.0	.0	.1
38Q1	08/29/89	27.1	29.2	39.6	31.1	+0.11	WAI	13.6	18.3	29.9	19.8	-1.6	-1.5	-3.2	-1.5	-.1	.0
38Q1	09/28/89	27.1	29.1	39.6	31.1	+0.22	WAI	13.6	18.2	29.9	19.8	-1.6	-1.4	-3.2	-1.5	-.1	.1
38Q1	10/30/89	27.4	29.4	40.1	31.4	+0.15	WAI	13.9	18.6	30.4	20.2	-1.9	-1.8	-3.7	-1.9	.0	.1
38Q1	11/28/89	27.0	29.2	39.6	31.1	+0.22	WAI	13.5	18.3	29.9	19.8	-1.5	-1.5	-3.2	-1.5	.0	.0
38Q1	12/29/89	27.4	29.4	38.9	31.5	+0.35	WAI	13.9	18.6	29.1	20.3	-1.9	-1.8	-2.4	-2.0	.1	.2
38Q1	01/29/90	27.3	29.3	39.1	31.3	+0.28	WAI	13.8	18.5	29.3	20.1	-1.8	-1.7	-2.6	-1.8	.0	.1
38Q1	02/28/90	27.4	29.5	39.0	31.4	+0.33	WAI	13.9	18.7	29.2	20.2	-1.9	-1.9	-2.5	-1.9	.0	.0
38Q1	03/28/90	27.3	29.4	38.9	31.3	+0.35	WAI	13.8	18.6	29.1	20.1	-1.8	-1.8	-2.4	-1.8	.0	.0
38Q1	04/30/90	27.2	29.3	39.3	31.3	+0.23	WAI	13.7	18.5	29.5	20.1	-1.7	-1.7	-2.8	-1.8	.1	.1
38Q1	05/30/90	27.1	29.2	39.0	31.1	+0.17	WAI	13.6	18.3	29.2	19.8	-1.6	-1.5	-2.5	-1.5	-.1	.0
38Q1	06/08/90	27.3	29.4	39.3	31.3	+0.09	WAI	13.8	18.6	29.5	20.1	-1.8	-1.8	-2.8	-1.8	.0	.0

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LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
38Q2	06/08/90	27.7	29.7	38.2	31.6		WAI	14.2	18.9	28.3	20.4	-1.9	-1.7	-2.7	-1.6	-.3	-.1
38Q1	06/26/90	27.5	29.4	39.6	31.7	-0.04	NAT	14.0	18.6	29.9	20.5	-2.0	-1.8	-3.2	-2.2	.2	.4
38Q1	06/27/90	27.6	29.5	39.5	31.5		NAT	14.1	18.7	29.8	20.3	-2.1	-1.9	-3.1	-2.0	-.1	.1
38Q1	06/29/90	27.6	29.4	41.0	31.5	+0.00	NAT	14.1	18.6	31.4	20.3	-2.1	-1.8	-4.7	-2.0	-.1	.2
38Q1	07/13/90	27.5	29.5	39.9	31.4	+0.05	NAT	14.0	18.7	30.2	20.2	-2.0	-1.9	-3.5	-1.9	-.1	.0
38Q2	07/13/90	27.9	29.9	38.5	31.8		NAT	14.4	19.1	28.7	20.6	-2.1	-1.9	-3.1	-1.8	-.3	-.1
38Q1	07/22/90	27.2	29.3	40.0	31.2	+0.12	NAT	13.7	18.5	30.3	20.0	-1.7	-1.7	-3.6	-1.7	.0	.0
38Q2	07/22/90	27.6	29.8	39.2	31.7		NAT	14.1	19.0	29.4	20.5	-1.8	-1.8	-3.8	-1.7	-.1	-.1
38Q1	08/28/90	27.3	29.3	40.6	31.4	+0.10	WAI	13.8	18.5	31.0	20.2	-1.8	-1.7	-4.3	-1.9	.1	.2
38Q1	09/28/90	27.4	29.4	40.5	31.4	+0.03	WAI	13.9	18.6	30.9	20.2	-1.9	-1.8	-4.2	-1.9	.0	.1
38Q1	10/29/90	27.4	29.4	40.4	31.3	+0.34	WAI	13.9	18.6	30.8	20.1	-1.9	-1.8	-4.1	-1.8	-.1	.0
38Q1	11/28/90	27.1	29.2	39.7	31.2	+0.35	WAI	13.6	18.3	30.0	20.0	-1.6	-1.5	-3.3	-1.7	.1	.2
38Q1	12/31/90	27.1	29.3	39.5	31.3	+0.26	WAI	13.6	18.5	29.8	20.1	-1.6	-1.7	-3.1	-1.8	.2	.1
38Q1	01/28/91	27.2	29.2	40.0	31.4	+0.15	WAI	13.7	18.3	30.3	20.2	-1.7	-1.5	-3.6	-1.9	.2	.4
38Q1	02/28/91	27.6	29.5	40.1	31.5	+0.27	WAI	14.1	18.7	30.4	20.3	-2.1	-1.9	-3.7	-2.0	-.1	.1
38Q1	03/28/91	28.0	29.9	40.5	31.6	+0.14	WAI	14.6	19.1	30.9	20.4	-2.6	-2.3	-4.2	-2.1	-.5	-.2
38Q1	04/29/91	27.9	29.7	40.4	31.6	+0.36	WAI	14.4	18.9	30.8	20.4	-2.4	-2.1	-4.1	-2.1	-.3	.0
38Q1	05/28/91	28.0	29.9	41.1	31.6	+0.17	WAI	14.6	19.1	31.5	20.4	-2.6	-2.3	-4.8	-2.1	-.5	-.2
38Q1	06/28/91	27.1	29.0	42.2	31.1	+0.00	WAI	13.6	18.1	32.7	19.8	-1.6	-1.3	-6.0	-1.5	-.1	.2
38Q1	07/29/91	27.3	29.3	43.1	31.2	+0.25	WAI	13.8	18.5	33.7	20.0	-1.8	-1.7	-7.0	-1.7	-.1	.0
38Q1	08/28/91	27.4	29.4	42.1	31.3	+0.20	WAI	13.9	18.6	32.6	20.1	-1.9	-1.8	-5.9	-1.8	-.1	.0
38Q1	09/16/91	26.5	28.5	42.7	30.3	+0.01	BDR	10.9	16.1	31.9	18.7	.0	.0	.0	.0	.0	.0
38Q2	09/16/91	27.7	29.8	38.0	31.6		BDR	12.2	17.6	26.7	20.2	.0	.0	.0	.0	.0	.0
38Q3	09/16/91	26.2	28.1	44.3	30.0		BDR	10.5	15.7	33.6	18.4	.0	.0	.0	.0	.0	.0
38UQ1	09/16/91	27.8	29.8	41.2	31.7		BDR	12.3	17.6	30.2	20.3	.0	.0	.0	.0	.0	.0
38UQ1	10/15/91					+1.65	WAI										
38UQ1	10/15/91					+1.55	WAI										
38UQ1	10/15/91					+1.65	WAI										
38Q1	10/28/91	26.8	28.8	42.1	30.7	+0.12	WAI	11.2	16.5	31.2	19.2	-.3	-.4	.7	-.5	.2	.1
38Q2	10/28/91	28.0	29.9	37.6	31.9		WAI	12.5	17.7	26.3	20.5	-.3	-.1	.4	-.3	.0	.2
38Q1	12/02/91	26.5	28.5	43.0	30.4	+0.10	WAI	10.9	16.1	32.2	18.8	.0	.0	-.3	-.1	.1	.1
38Q1	12/30/91	26.6	28.7	42.8	30.5	+0.02	WAI	11.0	16.4	32.0	18.9	-.1	-.3	-.1	-.2	.1	-.1
38Q1	01/28/92	26.9	28.9	43.0	30.8	+0.25	WAI	11.3	16.6	32.2	19.3	-.4	-.5	-.3	-.6	.2	.1
38Q1	02/28/92	26.9	28.8	43.3	30.6	+0.10	WAI	11.3	16.5	32.5	19.0	-.4	-.4	-.6	-.3	-.1	-.1
38Q2	02/28/92	28.2	29.8	38.1	31.8		WAI	12.7	17.6	26.8	20.4	-.5	.0	-.1	-.2	-.3	.2
38Q1	03/30/92	27.4	29.2	43.8	31.1		WAI	11.9	16.9	33.0	19.6	-1.0	-.8	-1.1	-.9	-.1	.1
38Q1	03/30/92	26.9	28.8	43.3	30.6	+0.15	WAI	11.3	16.5	32.5	19.0	-.4	-.4	-.6	-.3	-.1	-.1
38Q1	04/28/92	27.4	29.3	43.7	31.0	+0.10	WAI	11.9	17.0	32.9	19.5	-1.0	-.9	-1.0	-.8	-.2	-.1
38Q1	05/28/92	27.0	28.9	43.0	30.7	+0.10	WAI	11.4	16.6	32.2	19.2	-.5	-.5	-.3	-.5	.0	.0
38Q1	06/29/92	27.1	29.0	43.4	30.7	-0.03	WAI	11.5	16.7	32.6	19.2	-.6	-.6	-.7	-.5	-.1	-.1
38Q1	07/28/92	26.8	28.8	43.5	30.7	+0.00	WAI	11.2	16.5	32.7	19.2	-.3	-.4	-.8	-.5	.2	.1
38Q1	08/28/92	27.0	28.8	43.2	30.7	+0.04	WAI	11.4	16.5	32.4	19.2	-.5	-.4	-.5	-.5	.0	.1
38Q1	09/28/92	27.3	29.1	43.2	30.8	+0.20	WAI	11.8	16.8	32.4	19.3	-.9	-.7	-.5	-.6	-.3	-.1
38Q1	10/28/92	27.6	29.5	42.9	31.1	+0.01	WAI	12.1	17.3	32.1	19.6	-1.2	-1.2	-.2	-.9	-.3	-.3
38Q2	10/28/92	28.3	30.1	38.5	32.0		WAI	12.9	17.9	27.3	20.6	-.7	-.3	-.6	-.4	-.3	.1
38Q1	12/02/92	27.5	29.4	42.9	31.2	-0.04	WAI	12.0	17.1	32.1	19.7	-1.1	-1.0	-.2	-1.0	-.1	.0
38Q1	12/29/92	27.5	29.1	42.4	31.1	+0.25	WAI	12.0	16.8	31.5	19.6	-1.1	-.7	.4	-.9	-.2	.2

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LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
38Q1	01/28/93	27.8	29.6	42.7	31.4	+0.30	WAI	12.3	17.4	31.9	20.0	-1.4	-1.3	.0	-1.3	-.1	.0
38Q1	03/01/93	27.8	29.7	42.9	31.5	+0.20	WAI	12.3	17.5	32.1	20.1	-1.4	-1.4	-.2	-1.4	.0	.0
38Q2	03/01/93	28.9	30.9	38.7	32.6		WAI	13.5	18.8	27.5	21.3	-1.3	-1.2	-.8	-1.1	-.2	-.1
38Q1	03/29/93	27.6	29.6	42.3	31.3	-0.17	WAI	12.1	17.4	31.4	19.8	-1.2	-1.3	.5	-1.1	-.1	-.2
38Q1	04/28/93	27.7	29.9	42.9	31.5	+0.25	WAI	12.2	17.7	32.1	20.1	-1.3	-1.6	-.2	-1.4	.1	-.2
38Q1	05/28/93	28.2	30.0	43.5	31.5	-0.10	WAI	12.7	17.8	32.7	20.1	-1.8	-1.7	-.8	-1.4	-.4	-.3
38Q1	06/28/93	27.9	29.8	43.4	31.6	+0.05	WAI	12.4	17.6	32.6	20.2	-1.5	-1.5	-.7	-1.5	.0	.0
38Q1	07/29/93	28.0	29.9	43.0	31.6	-0.03	WAI	12.5	17.7	32.2	20.2	-1.6	-1.6	-.3	-1.5	-.1	-.1
38Q2	07/29/93	29.0	31.0	38.9	32.6		WAI	13.6	18.9	27.7	21.3	-1.4	-1.3	-1.0	-1.1	-.3	-.2
38Q1	08/30/93	28.1	30.1	42.0	31.9	+0.14	WAI	12.6	17.9	31.1	20.5	-1.7	-1.8	.8	-1.8	.1	.0
38Q1	09/30/93	28.5	30.4	42.5	32.0	+0.10	WAI	13.1	18.3	31.6	20.6	-2.2	-2.2	.3	-1.9	-.3	-.3
38Q1	10/19/93	28.4	30.4	41.2	32.0	+0.22	WAI	13.0	18.3	30.2	20.6	-2.1	-2.2	1.7	-1.9	-.2	-.3
38Q1	10/19/93	28.0	30.3	40.6	31.9		WAI	12.5	18.2	29.6	20.5	-1.6	-2.1	2.3	-1.8	.2	-.3
38Q1	10/29/93	27.9	30.0	40.5	31.7	-0.02	WAI	12.4	17.8	29.4	20.3	-1.5	-1.7	2.5	-1.6	.1	-.1
38Q1	11/30/93	28.4	30.5	41.0	32.3	-0.07	WAI	13.0	18.4	30.0	21.0	-2.1	-2.3	1.9	-2.3	.2	.0
38Q1	12/30/93	28.1	30.3	41.4	32.1	+0.57	WAI	12.6	18.2	30.4	20.7	-1.7	-2.1	1.5	-2.0	.3	-.1
38Q1	12/30/93	28.2	30.3	41.4	32.2		WAI	12.7	18.2	30.4	20.8	-1.8	-2.1	1.5	-2.1	.3	.0
38Q1	01/03/94					+0.06	WAI										
38Q1	01/03/94					+0.07	WAI										
38Q1	01/04/94					-0.02	WAI										
38Q1	01/05/94					-0.04	WAI										
38Q1	01/06/94					+0.08	WAI										
38Q1	01/31/94	28.1	30.3	41.5	32.0	+0.11	WAI	12.6	18.2	30.5	20.6	-1.7	-2.1	1.4	-1.9	.2	-.2
38Q2	01/31/94	29.0	31.1	37.3	33.0		WAI	13.6	19.0	25.9	21.7	-1.4	-1.4	.8	-1.5	.1	.1
38Q1	02/02/94	28.3	30.4	41.1	32.2		WAI	12.9	18.3	30.1	20.8	-2.0	-2.2	1.8	-2.1	.1	-.1
38Q1	02/28/94	27.0	29.2	43.1	31.2	+0.23	WAI	11.4	16.9	32.3	19.7	-.5	-.8	-.4	-1.0	.5	.2
38Q1	03/31/94	26.9	29.0	43.4	30.9	+0.25	WAI	11.3	16.7	32.6	19.4	-.4	-.6	-.7	-.7	.3	.1
38Q1	04/05/94	26.8	28.8	43.7	30.7		WAI	11.2	16.5	32.9	19.2	-.3	-.4	-1.0	-.5	.2	.1
38Q2	04/05/94	27.7	29.8	40.0	31.7		WAI	12.2	17.6	28.9	20.3	.0	.0	-2.2	-.1	.1	.1
38R51	04/05/94	26.7	28.8	43.8	30.6		WAI	11.1	16.5	33.0	19.0						
38R52	04/05/94	26.7	28.8	44.3	30.7		WAI	11.1	16.5	33.6	19.2						
38Q1	04/06/94	26.9	29.0	42.8	30.9		WAI	11.3	16.7	32.0	19.4	-.4	-.6	-.1	-.7	.3	.1
38Q2	04/06/94	27.5	29.7	39.9	31.6		WAI	12.0	17.5	28.8	20.2	.2	.1	-2.1	.0	.2	.1
38R51	04/06/94	26.6	28.7	43.6	30.6		WAI	11.0	16.4	32.8	19.0						
38R52	04/06/94	26.6	28.7	44.1	30.6		WAI	11.0	16.4	33.4	19.0						
38Q1	04/07/94	26.8	28.9	41.7	30.8	*	WAI	11.2	16.6	30.8	19.3	-.3	-.5	1.1	-.6	.3	.1
38Q1	04/07/94	26.8	28.9	43.2	30.8		WAI	11.2	16.6	32.4	19.3	-.3	-.5	-.5	-.6	.3	.1
38Q1	04/07/94	26.8	28.9	43.2	30.8		WAI	11.2	16.6	32.4	19.3	-.3	-.5	-.5	-.6	.3	.1
38Q1	04/11/94	26.8	28.9	43.1	30.7		WAI	11.2	16.6	32.3	19.2	-.3	-.5	-.4	-.5	.2	.0
38Q1	04/29/94	26.6	28.7	44.0	30.6	+0.07	WAI	11.0	16.4	33.3	19.0	-.1	-.3	-1.4	-.3	.2	.0
38Q1	05/31/94	26.7	28.7	44.1	30.6	+0.18	WAI	11.1	16.4	33.4	19.0	-.2	-.3	-1.5	-.3	.1	.0
38Q1	07/05/94	26.6	28.7	44.0	30.6	+0.11	WAI	11.0	16.4	33.3	19.0	-.1	-.3	-1.4	-.3	.2	.0
38Q2	07/05/94	27.4	29.4	41.2	31.4	+0.17	WAI	11.9	17.1	30.2	20.0	.3	.5	-3.5	.2	.1	.3
38Q1	07/15/94	26.8	28.8	44.5	30.6	+0.06	WAI	11.2	16.5	33.8	19.0	-.3	-.4	-1.9	-.3	.0	-.1
38Q1	08/01/94	26.6	28.7	44.2	30.6	+0.16	WAI	11.0	16.4	33.5	19.0	-.1	-.3	-1.6	-.3	.2	.0
38Q1	09/01/94	26.7	28.7	43.8	30.6	-0.04	WAI	11.1	16.4	33.0	19.0	-.2	-.3	-1.1	-.3	.1	.0
38Q1	10/03/94	27.0	28.9	42.3	30.9	+0.27	WAI	11.4	16.6	31.4	19.4	-.5	-.5	.5	-.7	.2	.2

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LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
38Q1	11/01/94	26.9	28.9	43.9	30.9	-0.02	WAI	11.3	16.6	33.2	19.4	-.4	-.5	-1.3	-.7	.3	.2
38Q1	12/01/94	27.1	29.1	43.7	31.0	+0.21	WAI	11.5	16.8	32.9	19.5	-.6	-.7	-1.0	-.8	.2	.1
38Q2	12/01/94	27.8	29.8	41.0	31.7		WAI	12.3	17.6	30.0	20.3	-.1	.0	-3.3	-.1	.0	.1
38Q1	01/03/95	27.1	29.3	43.7	31.2	+0.22	WAI	11.5	17.0	32.9	19.7	-.6	-.9	-1.0	-1.0	.4	.1
38Q1	02/01/95	27.0	29.1	43.5	31.0	+0.04	WAI	11.4	16.8	32.7	19.5	-.5	-.7	-.8	-.8	.3	.1
38Q1	02/17/95	27.0	29.2	43.0	31.1		WAI	11.4	16.9	32.2	19.6	-.5	-.8	-.3	-.9	.4	.1
38Q1	03/01/95	26.9	29.0	42.9	30.9	+0.13	WAI	11.3	16.7	32.1	19.4	-.4	-.6	-.2	-.7	.3	.1
38Q2	03/01/95	27.5	29.8	40.0	31.6		WAI	12.0	17.6	28.9	20.2	.2	.0	-2.2	.0	.2	.0
38Q1	03/07/95	27.0	29.0	42.9	30.9	+0.05	WAI	11.4	16.7	32.1	19.4	-.5	-.6	-.2	-.7	.2	.1
38Q1	04/03/95	27.2	29.3	43.0	31.2	+0.19	WAI	11.6	17.0	32.2	19.7	-.7	-.9	-.3	-1.0	.3	.1
38Q1	04/04/95	27.2	29.3	43.2	31.2		WAI	11.6	17.0	32.4	19.7	-.7	-.9	-.5	-1.0	.3	.1
38Q1	04/24/95	27.2	29.3	43.5	31.2	-1.61	BDR	11.6	17.0	32.7	19.7	-.7	-.9	-.8	-1.0	.3	.1
38Q2	04/24/95	27.7	29.8	42.2	31.6		BDR	12.2	17.6	31.3	20.2	.0	.0	-4.6	.0	.0	.0
38Q2	04/25/95					+0.06	BDR										
38Q1	04/27/95	26.9	28.9	43.7	30.8	+0.04	BDR	10.2	15.6	32.0	17.9	.0	.0	.0	.0	.0	.0
38Q2	04/27/95	27.5	29.4	42.0	31.4		BDR	10.8	16.2	30.1	18.6	.0	.0	.0	.0	.0	.0
38Q3	04/27/95	26.7	28.6	44.9	30.6		BDR	9.9	15.3	33.3	17.7	.0	.0	.0	.0	.0	.0
38UQ1	04/27/95	28.3	30.3	41.3	32.3		BDR	11.7	17.2	29.4	19.6	.0	.0	.0	.0	.0	.0
38UQ2	04/27/95	27.9	29.8	41.4	31.8		BDR	11.3	16.6	29.5	19.0	.0	.0	.0	.0	.0	.0
38UQ7	04/27/95	27.2	28.8	44.1	30.9		BDR	10.5	15.5	32.4	18.0	.0	.0	.0	.0	.0	.0
38UQ8	04/27/95	27.0	28.8	44.2	30.8		BDR	10.3	15.5	32.5	17.9	.0	.0	.0	.0	.0	.0
38Q1	05/16/95	26.6	28.7	43.2	30.6		WAI	9.8	15.4	31.4	17.7	.4	.2	.6	.2	.2	.0
38Q1	05/22/95	26.7	28.8	44.1	30.5	-0.04	WAI	9.9	15.5	32.4	17.5	.3	.1	-.4	.4	-.1	-.3
38Q2	05/22/95	27.1	29.1	42.3	30.9		WAI	10.4	15.8	30.4	18.0	.4	.4	-.3	.6	-.2	-.2
38Q1	05/30/95	26.3	28.4	43.4	30.3	+0.00	WAI	9.5	15.1	31.6	17.3	.7	.5	.4	.6	.1	-.1
38Q1	06/01/95	26.4	28.5	43.8	30.5	+0.00	WAI	9.6	15.2	32.1	17.5	.6	.4	-.1	.4	.2	.0
38Q2	06/01/95	26.9	29.0	42.0	30.9		WAI	10.2	15.7	30.1	18.0	.6	.5	.0	.6	.0	-.1
38Q1	06/23/95	26.6	28.7	42.8	30.6	+0.05	WAI	9.8	15.4	31.0	17.7	.4	.2	1.0	.2	.2	.0
38Q1	06/30/95	26.6	28.7	43.1	30.5	+0.00	WAI	9.8	15.4	31.3	17.5	.4	.2	.7	.4	.0	-.2
38Q1	07/12/95	26.6	28.7	42.5	30.6	+0.01	WAI	9.8	15.4	30.7	17.7	.4	.2	1.3	.2	.2	.0
38Q1	07/31/95	26.9	28.8	42.5	30.6	-0.13	WAI	10.2	15.5	30.7	17.7	.0	.1	1.3	.2	-.2	-.1
38Q1	08/01/95	26.5	28.6	42.4	30.5	-0.11	WAI	9.7	15.3	30.6	17.5	.5	.3	1.4	.4	.1	-.1
38Q1	08/31/95	26.9	29.0	42.4	30.9	+0.12	WAI	10.2	15.7	30.6	18.0	.0	-.1	1.4	-.1	.1	.0

Dobson Spectrophotometer No. 86

LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
86Q1	05/26/83	42.6	40.4	67.1	38.7	-0.07	BDR	11.8	16.5	44.6	18.4	.0	.0	.0	.0	.0	.0
86Q2	05/26/83	42.7	40.4	67.2	38.5		BDR	11.9	16.5	44.7	18.2	.0	.0	.0	.0	.0	.0
86Q3	05/26/83	42.8	40.6	66.4	38.6		BDR	12.0	16.7	43.9	18.3	.0	.0	.0	.0	.0	.0
86UQ1	05/26/83	44.2	41.8	65.2	40.2		BDR	13.6	18.0	42.7	20.1	.0	.0	.0	.0	.0	.0
86UQ1	05/26/83	43.7	41.3	64.8	39.7		BDR	13.0	17.5	42.2	19.5						
86UQ3	05/26/83	42.8	40.7	66.4	38.8		BDR	12.0	16.8	43.9	18.5	.0	.0	.0	.0	.0	.0
86Q1	04/27/84	43.7	41.6	63.6	39.6	+1.50	WAI	13.0	17.8	41.0	19.4	-1.2	-1.3	3.6	-1.0	-.2	-.3
86Q1	04/27/84					+1.30	WAI										
86Q1	04/27/84					+1.20	WAI										

Dobson Spectrophotometer No. 86

LAMP	DATE	Ra	Rc	Rc'	Rd	Hg	STN	Na	Nc	Nc'	Nd	dNa	dNc	dNc'	dNd	dNad	dNcd
86Q1	04/27/84					+1.50	WAI										
86Q2	04/27/84	43.8	41.5	63.3	39.6		WAI	13.1	17.7	40.7	19.4	-1.2	-1.2	4.0	-1.2	.0	.0
86Q2	04/30/84					+1.45	WAI										
86Q1	05/29/84	44.5	42.0	62.4	40.4	+0.04	WAI	13.9	18.2	39.8	20.3	-2.1	-1.7	4.8	-1.9	-.2	.2
86Q1	06/28/84	44.4	41.8	63.5	40.2	-0.09	WAI	13.8	18.0	40.9	20.1	-2.0	-1.5	3.7	-1.7	-.3	.2
86Q1	07/30/84	43.9	41.6	63.9	39.7	-0.08	WAI	13.2	17.8	41.3	19.5	-1.4	-1.3	3.3	-1.1	-.3	-.2
86Q1	08/28/84	44.1	41.6	64.6	39.6	-0.10	WAI	13.4	17.8	42.0	19.4	-1.6	-1.3	2.6	-1.0	-.6	-.3
86Q1	09/28/84	43.7	41.3	64.5	39.1	-0.03	WAI	13.0	17.5	41.9	18.8	-1.2	-1.0	2.7	-.4	-.8	-.6
86Q1	10/30/84	43.2	41.0	64.4	39.1	+0.10	WAI	12.5	17.1	41.8	18.8	-.7	-.6	2.8	-.4	-.3	-.2
86Q1	11/29/84	43.8	41.2	65.2	39.5	+0.07	WAI	13.1	17.4	42.7	19.3	-1.3	-.9	1.9	-.9	-.4	.0
86Q1	12/31/84	43.6	41.2	66.0	39.4	+0.03	WAI	12.9	17.4	43.5	19.2	-1.1	-.9	1.1	-.8	-.3	-.1
86Q1	01/28/85	43.5	41.0	67.0	39.4	-0.24	WAI	12.8	17.1	44.5	19.2	-1.0	-.6	.1	-.8	-.2	.2
86Q1	02/28/85	43.8	41.4	66.3	39.5	+0.01	WAI	13.1	17.6	43.8	19.3	-1.3	-1.1	.8	-.9	-.4	-.2
86Q1	03/28/85	44.1	41.6	66.5	39.8	-0.15	WAI	13.4	17.8	44.0	19.6	-1.6	-1.3	.6	-1.2	-.4	-.1
86Q1	04/29/85	43.8	41.2	66.1	39.4	-0.03	WAI	13.1	17.4	43.6	19.2	-1.3	-.9	1.0	-.8	-.5	-.1
86Q1	05/22/85	43.9	41.5	66.5	39.5	-0.05	WAI	13.2	17.7	44.0	19.3	-1.4	-1.2	.6	-.9	-.5	-.3
86Q1	06/10/85	42.9	40.6	71.0	38.5	-0.05	BNA	12.1	16.7	48.6	18.2	-.3	-.2	-4.0	.2	-.5	-.4

3. N-Tables Used for Final Data Processing.

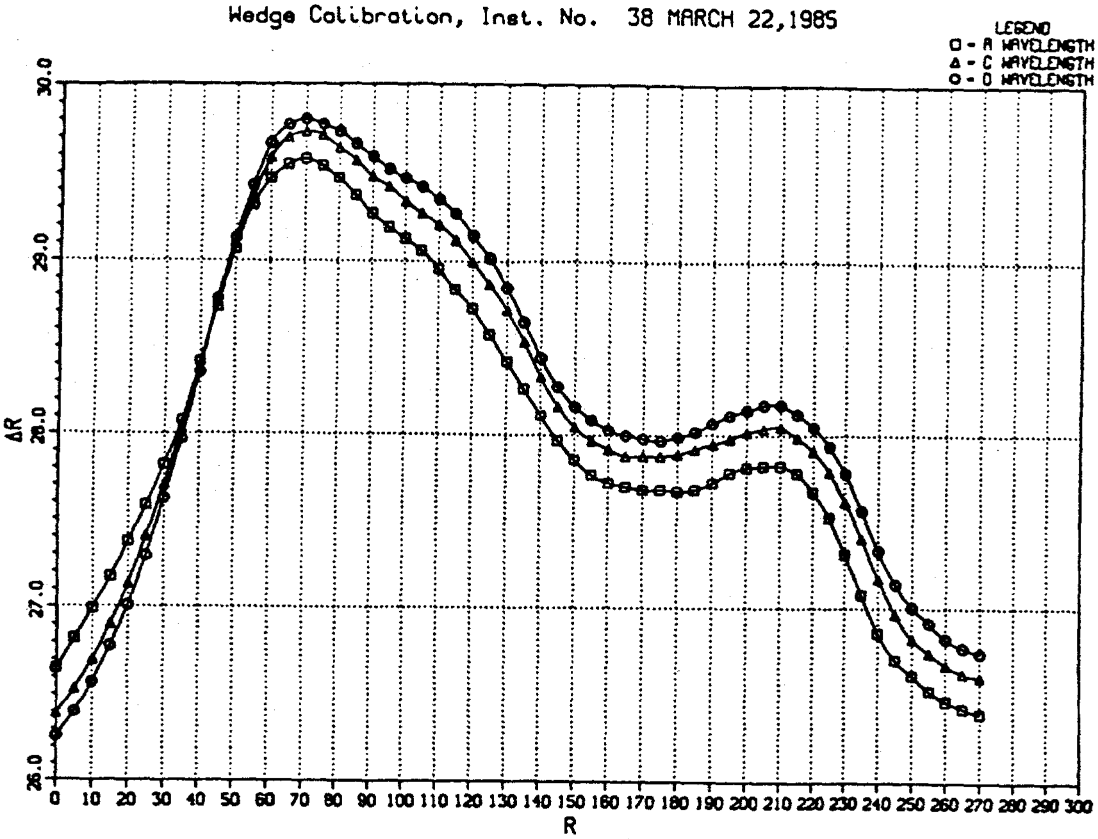
N-table control

Inst	N-table	From	To	Na	Nc	Nd
72	19660616R2	19660616	19690526	.69	.31	-1.93
72	19690527R1	19690527	19721001	12.98	9.38	5.70
72	19721002R1	19721002	19760518	6.52	4.09	-.37
72	19760519R1	19760519	99999999	14.64	10.60	5.16
38	19780921R1	19780921	19850507	-17.63	-14.67	-15.10
38	19850508M7	19850508	19910915	-11.35	-9.15	-9.92
38	19910916M8	19910916	19950426	-13.38	-10.57	-10.15
38	19950427M9	19950427	99999999	-14.54	-11.54	-11.54
86	19830526R1	19830526	99999999	-30.78	-23.54	-19.69

Appendix C

SAMPLE ARCHIVED DOBSON SPECTROPHOTOMETER OPTICAL WEDGE CALIBRATION DATA

Wedge Calibration, Inst. No. 38 MARCH 22,1985



GA TABLE

R	0	1	2	3	4	5	6	7	8	9
0						.0	1.1	2.3	3.4	4.5
10	5.7	6.8	7.9	9.1	10.2	11.3	12.5	13.6	14.7	15.9
20	17.0	18.1	19.2	20.4	21.5	22.6	23.7	24.8	25.9	27.0
30	28.1	29.2	30.3	31.4	32.5	33.6	34.7	35.8	36.9	38.0
40	39.1	40.2	41.3	42.3	43.4	44.5	45.6	46.7	47.8	48.9
50	49.9	51.0	52.1	53.1	54.2	55.2	56.3	57.3	58.4	59.4
60	60.5	61.5	62.5	63.6	64.6	65.7	66.7	67.7	68.7	69.8
70	70.8	71.8	72.9	73.9	74.9	75.9	76.9	77.9	79.0	80.0
80	81.0	82.0	83.0	84.0	85.0	86.1	87.1	88.1	89.1	90.1
90	91.1	92.1	93.2	94.2	95.2	96.2	97.2	98.3	99.3	100.3
100	101.3	102.4	103.4	104.4	105.5	106.5	107.5	108.6	109.6	110.6
110	111.6	112.7	113.7	114.7	115.8	116.8	117.8	118.9	119.9	120.9
120	122.0	123.0	124.1	125.1	126.1	127.2	128.2	129.2	130.3	131.3
130	132.4	133.4	134.5	135.5	136.5	137.6	138.6	139.7	140.7	141.8
140	142.9	143.9	145.0	146.0	147.1	148.1	149.2	150.3	151.3	152.4
150	153.4	154.5	155.6	156.6	157.7	158.8	159.9	160.9	162.0	163.1
160	164.2	165.2	166.3	167.4	168.5	169.6	170.7	171.7	172.8	173.9
170	175.0	176.1	177.2	178.3	179.3	180.4	181.5	182.6	183.7	184.8
180	185.9	187.0	188.0	189.1	190.2	191.3	192.4	193.5	194.6	195.6
190	196.7	197.8	198.9	200.0	201.1	202.2	203.3	204.4	205.5	206.5
200	207.6	208.7	209.8	210.9	212.0	213.1	214.2	215.2	216.3	217.4
210	218.5	219.6	220.7	221.7	222.8	223.9	225.0	226.1	227.1	228.2
220	229.3	230.4	231.4	232.5	233.6	234.7	235.8	236.9	237.9	239.0
230	240.1	241.2	242.3	243.4	244.5	245.5	246.6	247.7	248.8	249.9
240	251.0	252.1	253.2	254.3	255.4	256.5	257.6	258.7	259.8	260.9
250	262.0	263.1	264.2	265.3	266.5	267.6	268.7	269.9	271.0	272.1
260	273.3	274.4	275.6	276.7	277.8	279.0	280.1	281.2	282.4	283.5
270	284.6	285.7	286.9	288.0	289.1	290.3	291.4	292.5	293.7	294.8
280	295.9	297.1	298.2	299.4	300.5	301.7	302.8	304.0	305.1	306.3
290	307.4	308.6	309.7	310.8	312.0	313.1				

GC TABLE

R	0	1	2	3	4	5	6	7	8	9
0						.0	1.1	2.3	3.4	4.6
10	5.7	6.9	8.0	9.2	10.3	11.5	12.6	13.7	14.9	16.0
20	17.1	18.3	19.4	20.5	21.7	22.8	23.9	25.0	26.2	27.3
30	28.4	29.5	30.6	31.7	32.8	34.0	35.1	36.2	37.3	38.4
40	39.5	40.6	41.7	42.8	43.8	44.9	46.0	47.1	48.2	49.2
50	50.3	51.4	52.5	53.5	54.6	55.6	56.7	57.7	58.8	59.9
60	60.9	61.9	63.0	64.0	65.1	66.1	67.1	68.2	69.2	70.2
70	71.2	72.2	73.3	74.3	75.3	76.3	77.3	78.3	79.3	80.3
80	81.3	82.4	83.4	84.4	85.4	86.4	87.4	88.4	89.4	90.4
90	91.4	92.5	93.5	94.5	95.5	96.5	97.5	98.6	99.6	100.6
100	101.6	102.6	103.6	104.7	105.7	106.7	107.7	108.7	109.8	110.8
110	111.8	112.8	113.9	114.9	115.9	116.9	118.0	119.0	120.0	121.0
120	122.1	123.1	124.1	125.2	126.2	127.2	128.3	129.3	130.3	131.4
130	132.4	133.4	134.5	135.5	136.5	137.6	138.6	139.6	140.7	141.7
140	142.7	143.8	144.8	145.9	146.9	148.0	149.0	150.1	151.1	152.2
150	153.2	154.3	155.3	156.4	157.5	158.5	159.6	160.7	161.7	162.8
160	163.9	164.9	166.0	167.1	168.2	169.2	170.3	171.4	172.5	173.6
170	174.6	175.7	176.8	177.9	179.0	180.0	181.1	182.2	183.3	184.3
180	185.4	186.5	187.6	188.7	189.7	190.8	191.9	193.0	194.1	195.1
190	196.2	197.3	198.4	199.5	200.5	201.6	202.7	203.8	204.9	205.9
200	207.0	208.1	209.2	210.3	211.3	212.4	213.5	214.6	215.6	216.7
210	217.8	218.9	219.9	221.0	222.1	223.1	224.2	225.3	226.4	227.4
220	228.5	229.6	230.7	231.7	232.8	233.9	235.0	236.0	237.1	238.2
230	239.3	240.3	241.4	242.5	243.6	244.6	245.7	246.8	247.8	248.9
240	250.0	251.1	252.2	253.3	254.4	255.4	256.5	257.6	258.7	259.8
250	260.9	262.0	263.1	264.2	265.3	266.5	267.6	268.7	269.8	270.9
260	272.0	273.2	274.3	275.4	276.5	277.7	278.8	279.9	281.0	282.2
270	283.3	284.4	285.6	286.7	287.8	289.0	290.1	291.2	292.3	293.5
280	294.6	295.7	296.8	298.0	299.1	300.2	301.4	302.5	303.6	304.8
290	305.9	307.0	308.2	309.3	310.4	311.6	312.7			

GD TABLE

R	0	1	2	3	4	5	6	7	8	9
0						.0	1.2	2.3	3.5	4.6
10	5.8	6.9	8.1	9.2	10.3	11.5	12.6	13.8	14.9	16.1
20	17.2	18.3	19.5	20.6	21.7	22.9	24.0	25.1	26.3	27.4
30	28.5	29.7	30.8	31.9	33.0	34.1	35.2	36.3	37.4	38.5
40	39.6	40.7	41.8	42.9	44.0	45.1	46.2	47.3	48.4	49.4
50	50.5	51.6	52.7	53.7	54.8	55.9	56.9	58.0	59.0	60.1
60	61.1	62.2	63.2	64.2	65.3	66.3	67.3	68.3	69.4	70.4
70	71.4	72.4	73.4	74.4	75.5	76.5	77.5	78.5	79.5	80.5
80	81.5	82.5	83.5	84.5	85.5	86.5	87.5	88.6	89.6	90.6
90	91.6	92.6	93.6	94.6	95.6	96.6	97.7	98.7	99.7	100.7
100	101.7	102.7	103.8	104.8	105.8	106.8	107.8	108.8	109.9	110.9
110	111.9	112.9	113.9	114.9	116.0	117.0	118.0	119.0	120.1	121.1
120	122.1	123.1	124.2	125.2	126.2	127.2	128.3	129.3	130.3	131.3
130	132.4	133.4	134.4	135.5	136.5	137.5	138.5	139.6	140.6	141.6
140	142.7	143.7	144.7	145.8	146.8	147.9	148.9	149.9	151.0	152.1
150	153.1	154.2	155.2	156.3	157.3	158.4	159.4	160.5	161.6	162.6
160	163.7	164.8	165.8	166.9	168.0	169.1	170.1	171.2	172.3	173.4
170	174.4	175.5	176.6	177.7	178.7	179.8	180.9	181.9	183.0	184.1
180	185.2	186.2	187.3	188.4	189.5	190.5	191.6	192.7	193.8	194.8
190	195.9	197.0	198.1	199.2	200.2	201.3	202.4	203.5	204.6	205.6
200	206.7	207.8	208.9	209.9	211.0	212.1	213.1	214.2	215.3	216.3
210	217.4	218.5	219.5	220.6	221.7	222.7	223.8	224.9	226.0	227.0
220	228.1	229.2	230.2	231.3	232.4	233.4	234.5	235.6	236.6	237.7
230	238.8	239.9	240.9	242.0	243.1	244.1	245.2	246.3	247.3	248.4
240	249.5	250.6	251.6	252.7	253.8	254.9	256.0	257.1	258.1	259.2
250	260.3	261.4	262.5	263.6	264.7	265.8	266.9	268.0	269.1	270.3
260	271.4	272.5	273.6	274.7	275.8	277.0	278.1	279.2	280.3	281.4
270	282.6	283.7	284.8	285.9	287.1	288.2	289.3	290.4	291.5	292.7
280	293.8	294.9	296.0	297.1	298.3	299.4	300.5	301.7	302.8	303.9
290	305.0	306.2								

Appendix D

SAMPLE ARCHIVED DOBSON SPECTROPHOTOMETER CALIBRATION DATA

Dobson Ozone Spectrophotometer Calibration Observations

Place: Boulder, Colorado

Date: Sept. 16, 1991 A.M./P.M. A.M.

U.S.A. (Wallops Is) Inst. No. 38 vs U.S.A. Inst. No. 83
(Country) (Country)

For instrument No. 38 use G tables dated March 22, 1985

Apply the following corrections to the tables:

To GA or NA values add NA

To GC or NC values add NA

To GD or ND values add NA

For instrument No. 83 use N tables dated Aug. 26, 1991 FI

Apply the following corrections to the tables:

To GA or NA values add +0.3

To GC or NC values add +0.2

To GD or ND values add +0.3

Degree 3

Notes: 'Initial calibration'.

95/11/03. 16.21.47.

Instruments 83 and 38 Compared

at BOULDER, COLORADO U.S.A.
September 16, 1991 AM

New II BK O3 ABS. COEFFICIENTS applied.

Ozone at 23000. meters.

Station Elevation 1634.0 meters.

Mean Station Pressure 834.00 millibars.

Station Earth Radius 6369553.0 meters.

Absorption Coefficients:	A	B	C	D
Alpha:	1.806	1.192	.833	.374
Beta:	.114	.111	.109	.104

Mu fit min: 1.1500 Mu fit max: 3.6000

Instrument 38 G Tables dated March 22, 1985 N

Corrections to G Tables:

NOT AVAILABLE

Instrument 83 N Tables dated August 26, 1991 F1

Corrections to N Tables:

To NA values ADD .30
To NC values ADD .20
To ND values ADD .30

From:
G-table
May 31, 1990

N-table
Inst. 83
Aug 26, 1991
Version: F1

NA table

R	0	1	2	3	4	5	6	7	8	9
0	-6.6	-5.5	-4.4	-3.3	-2.3	-1.2	-.1	1.0	2.1	3.2
10	4.2	5.3	6.4	7.4	8.5	9.5	10.6	11.6	12.7	13.7
20	14.8	15.8	16.9	17.9	19.0	20.0	21.0	22.1	23.1	24.1
30	25.2	26.2	27.2	28.2	29.3	30.3	31.3	32.3	33.3	34.3
40	35.3	36.3	37.3	38.2	39.2	40.2	41.2	42.1	43.1	44.1
50	45.0	46.0	46.9	47.9	48.8	49.8	50.7	51.6	52.6	53.5
60	54.4	55.4	56.3	57.2	58.2	59.1	60.0	60.9	61.8	62.8
70	63.7	64.6	65.5	66.4	67.4	68.3	69.2	70.2	71.1	72.0
80	73.0	73.9	74.8	75.8	76.7	77.7	78.6	79.5	80.5	81.4
90	82.4	83.3	84.2	85.2	86.1	87.1	88.0	88.9	89.9	90.8
100	91.7	92.7	93.6	94.5	95.5	96.4	97.3	98.3	99.2	100.2
110	101.1	102.0	103.0	103.9	104.9	105.8	106.7	107.7	108.6	109.6
120	110.5	111.4	112.4	113.3	114.3	115.2	116.1	117.1	118.0	118.9
130	119.9	120.8	121.8	122.7	123.7	124.6	125.6	126.5	127.5	128.4
140	129.4	130.4	131.3	132.3	133.2	134.2	135.2	136.2	137.1	138.1
150	139.1	140.0	141.0	142.0	142.9	143.9	144.9	145.8	146.8	147.8
160	148.7	149.7	150.7	151.7	152.7	153.6	154.6	155.6	156.6	157.6
170	158.6	159.5	160.5	161.5	162.5	163.5	164.4	165.4	166.4	167.4
180	168.4	169.4	170.3	171.3	172.3	173.3	174.2	175.2	176.2	177.2
190	178.1	179.1	180.1	181.1	182.1	183.0	184.0	185.0	186.0	186.9
200	187.9	188.9	189.9	190.9	191.8	192.8	193.8	194.8	195.8	196.7
210	197.7	198.7	199.7	200.7	201.7	202.7	203.6	204.6	205.6	206.6
220	207.6	208.6	209.6	210.6	211.7	212.7	213.7	214.7	215.7	216.7
230	217.7	218.8	219.8	220.8	221.8	222.8	223.9	224.9	225.9	227.0
240	228.0	229.0	230.1	231.1	232.1	233.2	234.2	235.2	236.3	237.3
250	238.3	239.4	240.4	241.4	242.5	243.5	244.5	245.6	246.6	247.6
260	248.6	249.6	250.6	251.6	252.6	253.6	254.6	255.7	256.7	257.7
270	258.7	259.7	260.7	261.7	262.7	263.8	264.8	265.8	266.9	267.9
280	268.9	270.0	271.0	272.0	273.1	274.1	275.1	276.2	277.2	278.2
290	279.3	280.3	281.4	282.4	283.4	284.5	285.5	286.5	287.5	

From:
G-table
May 31, 1990

N-table
Inst. 83
Aug 26, 1991
Version: F1

NC table

R	0	1	2	3	4	5	6	7	8	9
0	-3.3	-2.2	-1.1	-.0	1.0	2.1	3.2	4.3	5.4	6.5
10	7.5	8.6	9.7	10.7	11.8	12.8	13.9	14.9	16.0	17.0
20	18.0	19.1	20.1	21.1	22.2	23.2	24.2	25.2	26.3	27.3
30	28.3	29.3	30.4	31.4	32.4	33.4	34.4	35.4	36.4	37.5
40	38.5	39.4	40.4	41.4	42.4	43.3	44.3	45.3	46.2	47.1
50	48.1	49.0	50.0	50.9	51.9	52.8	53.7	54.7	55.6	56.5
60	57.4	58.4	59.3	60.2	61.1	62.1	63.0	63.9	64.8	65.7
70	66.7	67.6	68.5	69.4	70.3	71.2	72.2	73.1	74.0	74.9
80	75.8	76.8	77.7	78.6	79.5	80.5	81.4	82.3	83.2	84.2
90	85.1	86.0	86.9	87.9	88.8	89.7	90.7	91.6	92.5	93.4
100	94.4	95.3	96.2	97.2	98.1	99.0	100.0	100.9	101.8	102.8
110	103.7	104.6	105.5	106.5	107.4	108.3	109.3	110.2	111.1	112.0
120	112.9	113.9	114.8	115.7	116.6	117.6	118.5	119.4	120.3	121.2
130	122.2	123.1	124.0	125.0	125.9	126.8	127.8	128.7	129.6	130.6
140	131.5	132.5	133.4	134.3	135.3	136.2	137.2	138.1	139.1	140.1
150	141.0	142.0	142.9	143.9	144.8	145.8	146.7	147.7	148.6	149.6
160	150.5	151.5	152.4	153.4	154.4	155.3	156.3	157.2	158.2	159.2
170	160.1	161.1	162.1	163.0	164.0	165.0	165.9	166.9	167.9	168.9
180	169.8	170.8	171.8	172.7	173.7	174.6	175.6	176.6	177.5	178.5
190	179.4	180.4	181.3	182.3	183.2	184.2	185.1	186.1	187.1	188.0
200	189.0	189.9	190.9	191.9	192.8	193.8	194.8	195.7	196.7	197.7
210	198.6	199.6	200.6	201.6	202.5	203.5	204.5	205.5	206.4	207.4
220	208.4	209.4	210.4	211.4	212.4	213.3	214.3	215.3	216.3	217.3
230	218.3	219.3	220.3	221.3	222.4	223.4	224.4	225.4	226.4	227.4
240	228.4	229.5	230.5	231.5	232.5	233.5	234.6	235.6	236.6	237.6
250	238.7	239.7	240.7	241.7	242.7	243.7	244.8	245.8	246.8	247.8
260	248.8	249.8	250.8	251.8	252.8	253.8	254.8	255.7	256.7	257.7
270	258.7	259.7	260.7	261.7	262.8	263.8	264.8	265.8	266.8	267.8
280	268.8	269.9	270.9	271.9	272.9	273.9	275.0	276.0	277.0	278.0
290	279.0	280.0	281.0	282.1	283.1	284.1	285.1			

G-table
Inst. 38
Mar 22, 1985
Version: N

GC table

R	0	1	2	3	4	5	6	7	8	9
0	-5.7	-4.6	-3.4	-2.3	-1.1	.0	1.1	2.3	3.4	4.6
10	5.7	6.9	8.0	9.2	10.3	11.5	12.6	13.7	14.9	16.0
20	17.1	18.3	19.4	20.5	21.7	22.8	23.9	25.0	26.2	27.3
30	28.4	29.5	30.6	31.7	32.8	34.0	35.1	36.2	37.3	38.4
40	39.5	40.6	41.7	42.7	43.8	44.9	46.0	47.1	48.2	49.2
50	50.3	51.4	52.5	53.5	54.6	55.6	56.7	57.8	58.8	59.9
60	60.9	61.9	63.0	64.0	65.1	66.1	67.1	68.2	69.2	70.2
70	71.2	72.2	73.3	74.3	75.3	76.3	77.3	78.3	79.3	80.3
80	81.3	82.3	83.4	84.4	85.4	86.4	87.4	88.4	89.4	90.4
90	91.4	92.5	93.5	94.5	95.5	96.5	97.5	98.6	99.6	100.6
100	101.6	102.6	103.6	104.7	105.7	106.7	107.7	108.7	109.8	110.8
110	111.8	112.8	113.9	114.9	115.9	116.9	118.0	119.0	120.0	121.0
120	122.1	123.1	124.1	125.2	126.2	127.2	128.3	129.3	130.3	131.4
130	132.4	133.4	134.5	135.5	136.5	137.6	138.6	139.6	140.7	141.7
140	142.7	143.8	144.8	145.9	146.9	148.0	149.0	150.1	151.1	152.2
150	153.2	154.3	155.3	156.4	157.5	158.5	159.6	160.7	161.7	162.8
160	163.9	164.9	166.0	167.1	168.2	169.2	170.3	171.4	172.5	173.6
170	174.6	175.7	176.8	177.9	179.0	180.0	181.1	182.2	183.3	184.3
180	185.4	186.5	187.6	188.7	189.7	190.8	191.9	193.0	194.1	195.1
190	196.2	197.3	198.4	199.5	200.5	201.6	202.7	203.8	204.9	205.9
200	207.0	208.1	209.2	210.3	211.3	212.4	213.5	214.6	215.6	216.7
210	217.8	218.9	219.9	221.0	222.1	223.1	224.2	225.3	226.4	227.4
220	228.5	229.6	230.7	231.7	232.8	233.9	235.0	236.0	237.1	238.2
230	239.3	240.3	241.4	242.5	243.5	244.6	245.7	246.8	247.8	248.9
240	250.0	251.1	252.2	253.3	254.3	255.4	256.5	257.6	258.7	259.8
250	260.9	262.0	263.1	264.2	265.3	266.5	267.6	268.7	269.8	270.9
260	272.0	273.2	274.3	275.4	276.5	277.6	278.8	279.9	281.0	282.2
270	283.3	284.4	285.6	286.7	287.8	289.0	290.1	291.2	292.3	293.5
280	294.6	295.7	296.8	298.0	299.1	300.2	301.4	302.5	303.6	304.8
290	305.9	307.0	308.2	309.3	310.4	311.6	312.7			

G-table
Inst. 38
Mar 22, 1985
Version: N

GD table

R	0	1	2	3	4	5	6	7	8	9
0	-5.8	-4.6	-3.5	-2.3	-1.2	.0	1.2	2.3	3.5	4.6
10	5.8	6.9	8.1	9.2	10.3	11.5	12.6	13.8	14.9	16.1
20	17.2	18.3	19.5	20.6	21.7	22.9	24.0	25.1	26.3	27.4
30	28.5	29.6	30.8	31.9	33.0	34.1	35.2	36.3	37.4	38.5
40	39.6	40.7	41.8	42.9	44.0	45.1	46.2	47.3	48.4	49.4
50	50.5	51.6	52.7	53.7	54.8	55.9	56.9	58.0	59.0	60.1
60	61.1	62.2	63.2	64.2	65.3	66.3	67.3	68.3	69.4	70.4
70	71.4	72.4	73.4	74.5	75.5	76.5	77.5	78.5	79.5	80.5
80	81.5	82.5	83.5	84.5	85.5	86.5	87.5	88.6	89.6	90.6
90	91.6	92.6	93.6	94.6	95.6	96.6	97.7	98.7	99.7	100.7
100	101.7	102.7	103.8	104.8	105.8	106.8	107.8	108.8	109.9	110.9
110	111.9	112.9	113.9	115.0	116.0	117.0	118.0	119.0	120.1	121.1
120	122.1	123.1	124.2	125.2	126.2	127.2	128.3	129.3	130.3	131.3
130	132.4	133.4	134.4	135.5	136.5	137.5	138.5	139.6	140.6	141.6
140	142.7	143.7	144.7	145.8	146.8	147.9	148.9	149.9	151.0	152.0
150	153.1	154.2	155.2	156.3	157.3	158.4	159.4	160.5	161.6	162.6
160	163.7	164.8	165.8	166.9	168.0	169.1	170.1	171.2	172.3	173.4
170	174.4	175.5	176.6	177.7	178.7	179.8	180.9	181.9	183.0	184.1
180	185.2	186.2	187.3	188.4	189.5	190.5	191.6	192.7	193.8	194.8
190	195.9	197.0	198.1	199.2	200.2	201.3	202.4	203.5	204.6	205.6
200	206.7	207.8	208.9	209.9	211.0	212.1	213.1	214.2	215.3	216.4
210	217.4	218.5	219.5	220.6	221.7	222.7	223.8	224.9	226.0	227.0
220	228.1	229.2	230.2	231.3	232.4	233.4	234.5	235.6	236.7	237.7
230	238.8	239.8	240.9	242.0	243.1	244.1	245.2	246.3	247.3	248.4
240	249.5	250.6	251.6	252.7	253.8	254.9	256.0	257.1	258.1	259.2
250	260.3	261.4	262.5	263.6	264.7	265.8	266.9	268.0	269.1	270.3
260	271.4	272.5	273.6	274.7	275.8	277.0	278.1	279.2	280.3	281.5
270	282.6	283.7	284.8	285.9	287.1	288.2	289.3	290.4	291.5	292.7
280	293.8	294.9	296.0	297.1	298.3	299.4	300.5	301.7	302.8	303.9
290	305.0	306.2								

NEW OZONE ABSORPTION COEFFICIENTS applied

TIME LST	MU	M	LL	R083	R038	N083	N038*	NA(083 -038*)	NC(083 -038*)	ND(083 -038*)	X083	X038*	XAD (083-038*)	XCD (083-038*)	N038	X038	XAD (083-038)	XCD (083-038)	XA (083-038)	XC (083-038)	XD (083-038)
07:01:00	3.892	4.026	C	138.70	139.00	130.5	141.7		-11.2		.291	.326			131.1	.293				-.002	
07:01:30	3.870	4.001	CD								.282	.285		-.003		.284		-.002			
07:02:00	3.847	3.976	D	79.80	86.50	77.6	88.1			-10.5	.303	.375			77.9	.305					-.002
07:02:30	3.825	3.951	AD								.288	.294	-.006			.288	.000				
07:03:00	3.803	3.926	A	248.20	239.30	236.8	250.2	-13.4			.291	.311			236.8	.291			.000		
07:05:00	3.717	3.832	C	132.60	133.40	124.8	135.9		-11.1		.292	.328			125.3	.294				-.002	
07:05:30	3.697	3.809	CD								.284	.286		-.002		.284		.000			
07:06:00	3.676	3.786	D	75.80	83.10	73.9	84.6			-10.7	.302	.380			74.5	.306					-.004
07:06:30	3.656	3.764	AD								.288	.295	-.007			.289	-.001				
07:07:00	3.636	3.742	A	238.00	230.30	226.2	240.4	-14.2			.291	.313			227.0	.292			-.001		
07:09:00	3.557	3.656	C	126.50	127.80	119.1	130.1		-11.0		.291	.328			119.5	.293				-.001	
07:09:30	3.538	3.636	CD								.282	.284		-.003		.282		-.001			
07:10:00	3.520	3.615	D	72.50	79.80	70.9	81.3			-10.4	.303	.383			71.2	.305					-.002
07:10:30	3.501	3.595	AD								.288	.295	-.007			.289	-.000				
07:11:00	3.483	3.575	A	228.80	221.30	216.8	230.7	-13.9			.291	.313			217.3	.292			-.001		
07:13:00	3.411	3.497	C	121.00		114.1					.291										
07:13:30	3.394	3.478	CD								.281										
07:14:00	3.376	3.459	D	69.30	76.70	67.9	78.2			-10.2	.304	.385			68.0	.304					-.001
07:14:30	3.359	3.441	AD								.288	.296	-.009			.289	-.002				
07:15:00	3.342	3.423	A	219.90	213.30	207.8	222.1	-14.2			.291	.315			208.7	.293			-.001		
07:17:00	3.276	3.352	C	116.50	118.50	109.9	120.5		-10.6		.293	.331			109.9	.293				.000	
07:17:30	3.260	3.334	CD								.284	.286		-.002		.283		.001			
07:18:00	3.244	3.317	D	66.30	74.00	65.2	75.5			-10.3	.303	.388			65.3	.304					-.001
07:18:30	3.229	3.300	AD								.288										
07:19:00	3.213	3.284	A	211.70		199.7					.291										
07:21:00	3.152	3.219	C	111.50	114.30	105.3	116.2		-10.9		.291	.333			105.6	.292				-.001	
07:21:30	3.138	3.203	CD								.279	.283		-.004		.281		-.002			
07:22:00	3.123	3.187	D	63.90	71.80	63.0	73.2			-10.2	.306	.393			63.1	.306					-.001
07:22:30	3.109	3.172	AD								.288	.296	-.008			.288	-.001				
07:23:00	3.094	3.156	A	204.30	198.70	192.4	206.2	-13.8			.291	.316			192.8	.292			-.001		
07:25:00	3.038	3.096	C	107.40	110.30	101.5	112.1		-10.7		.291	.333			101.5	.291				-.000	
07:25:30	3.024	3.082	CD								.282	.281		.001		.279		.003			
07:26:00	3.011	3.067	D	61.00	69.60	60.3	71.0			-10.7	.302	.397			60.8	.307					-.005
07:26:30	2.997	3.053	AD								.287	.294	-.007			.286	.001				
07:27:00	2.984	3.039	A	196.80	191.70	185.1	198.6	-13.5			.291	.316			185.2	.291			-.000		
07:29:00	2.932	2.984	C	103.40		97.7					.291										
07:29:30	2.919	2.970	CD								.279										
07:30:00	2.907	2.957	D	59.00	67.40	58.5	68.8			-10.3	.305	.399			58.6	.306					-.001
07:30:30	2.894	2.944	AD								.287	.295	-.008			.287	-.000				
07:31:00	2.882	2.931	A	190.30	186.00	178.7	192.4	-13.6			.291	.317			179.0	.291			-.000		
07:33:00	2.834	2.880	C	99.90	103.60	94.5	105.3		-10.8		.291	.337			94.7	.292				-.001	
07:33:30	2.822	2.867	CD								.282										
07:34:00	2.810	2.855	D	56.50		56.2					.302										
07:34:30	2.799	2.843	AD								.287										
07:35:00	2.787	2.831	A	184.20	181.00	172.8	186.9	-14.2			.290	.319			173.6	.292			-.002		
07:37:00	2.742	2.784	C	96.40	100.70	91.2	102.3		-11.1		.290	.339			91.7	.292				-.002	
07:37:30	2.731	2.772	CD								.281	.284		-.003		.281		-.000			
07:38:00	2.721	2.761	D	54.50	63.70	54.3	64.9			-10.6	.302	.406			54.8	.306					-.005
07:38:30	2.710	2.749	AD								.288	.296	-.008			.288	.000				
07:39:00	2.699	2.738	A	178.80	175.70	167.5	181.2	-13.7			.291	.319			167.8	.292			-.001		
07:41:00	2.657	2.694	C	93.30	97.70	88.3	99.3		-10.9		.290	.339			88.7	.291				-.002	
07:41:30	2.647	2.683	CD								.279	.282		-.003		.279		-.000			
07:42:00	2.637	2.673	D	52.90	62.10	52.8	63.3			-10.5	.304	.410			53.1	.307					-.003
07:42:30	2.627	2.662	AD								.287	.297	-.010			.288	-.001				
07:43:00	2.617	2.652	A	173.30	171.10	162.1	176.2	-14.1			.290	.320			162.8	.292			-.001		

From:
G-table
May 31, 1990

N-table
Inst. 83
Aug 26, 1991
Version: F1

G-table
Inst. 38
Mar 22, 1985
Version: N

ND table

R	0	1	2	3	4	5	6	7	8	9
0	-1.5	-.4	.7	1.8	2.8	3.9	5.0	6.1	7.1	8.2
10	9.3	10.4	11.4	12.5	13.5	14.6	15.7	16.7	17.7	18.8
20	19.8	20.9	21.9	22.9	23.9	25.0	26.0	27.0	28.0	29.0
30	30.1	31.1	32.1	33.1	34.2	35.2	36.2	37.1	38.1	39.1
40	40.1	41.1	42.1	43.1	44.1	45.0	46.0	47.0	47.9	48.9
50	49.8	50.7	51.7	52.6	53.6	54.5	55.4	56.3	57.3	58.2
60	59.1	60.0	60.9	61.9	62.8	63.7	64.6	65.5	66.5	67.4
70	68.3	69.2	70.1	71.0	72.0	72.9	73.8	74.7	75.6	76.6
80	77.5	78.4	79.3	80.2	81.1	82.0	83.0	83.9	84.8	85.7
90	86.6	87.6	88.5	89.4	90.3	91.3	92.2	93.1	94.0	95.0
100	95.9	96.8	97.7	98.7	99.6	100.5	101.4	102.4	103.3	104.2
110	105.1	106.1	107.0	107.9	108.8	109.7	110.6	111.6	112.5	113.4
120	114.3	115.2	116.1	117.0	118.0	118.9	119.8	120.7	121.6	122.5
130	123.4	124.4	125.3	126.2	127.1	128.1	129.0	129.9	130.8	131.8
140	132.7	133.6	134.6	135.5	136.4	137.4	138.3	139.3	140.2	141.2
150	142.1	143.0	144.0	144.9	145.9	146.8	147.8	148.7	149.7	150.6
160	151.6	152.5	153.5	154.4	155.4	156.3	157.3	158.2	159.2	160.1
170	161.1	162.0	163.0	164.0	164.9	165.9	166.8	167.8	168.7	169.7
180	170.7	171.6	172.6	173.5	174.5	175.4	176.4	177.3	178.3	179.2
190	180.2	181.1	182.1	183.0	184.0	184.9	185.9	186.8	187.8	188.7
200	189.7	190.6	191.6	192.5	193.5	194.4	195.4	196.3	197.3	198.3
210	199.2	200.2	201.1	202.1	203.1	204.0	205.0	206.0	206.9	207.9
220	208.9	209.9	210.8	211.8	212.8	213.8	214.7	215.7	216.7	217.7
230	218.7	219.7	220.7	221.7	222.7	223.7	224.7	225.7	226.7	227.7
240	228.8	229.8	230.8	231.8	232.8	233.8	234.9	235.9	236.9	237.9
250	238.9	239.9	241.0	242.0	243.0	244.0	245.0	246.0	247.0	248.0
260	248.9	249.9	250.9	251.9	252.9	253.9	254.9	255.8	256.8	257.8
270	258.8	259.8	260.8	261.8	262.8	263.9	264.9	265.9	266.9	267.9
280	268.9	269.9	270.9	272.0	273.0	274.0	275.0	276.0	277.0	278.0
290	279.0	280.0	281.0	282.0	283.0	284.0	285.0	286.0	287.0	

GA table

R	0	1	2	3	4	5	6	7	8	9
0	-5.7	-4.5	-3.4	-2.3	-1.1	.0	1.1	2.3	3.4	4.5
10	5.7	6.8	7.9	9.1	10.2	11.3	12.5	13.6	14.7	15.9
20	17.0	18.1	19.2	20.4	21.5	22.6	23.7	24.8	25.9	27.0
30	28.1	29.2	30.3	31.4	32.5	33.6	34.7	35.8	36.9	38.0
40	39.1	40.2	41.3	42.3	43.4	44.5	45.6	46.7	47.8	48.9
50	49.9	51.0	52.1	53.1	54.2	55.2	56.3	57.3	58.4	59.4
60	60.5	61.5	62.6	63.6	64.6	65.7	66.7	67.7	68.7	69.8
70	70.8	71.8	72.8	73.9	74.9	75.9	76.9	78.0	79.0	80.0
80	81.0	82.0	83.0	84.0	85.0	86.1	87.1	88.1	89.1	90.1
90	91.1	92.1	93.2	94.2	95.2	96.2	97.2	98.3	99.3	100.3
100	101.4	102.4	103.4	104.4	105.5	106.5	107.5	108.6	109.6	110.6
110	111.7	112.7	113.7	114.7	115.8	116.8	117.8	118.9	119.9	120.9
120	122.0	123.0	124.1	125.1	126.1	127.2	128.2	129.2	130.3	131.3
130	132.4	133.4	134.5	135.5	136.5	137.6	138.6	139.7	140.7	141.8
140	142.9	143.9	145.0	146.0	147.1	148.1	149.2	150.2	151.3	152.4
150	153.4	154.5	155.6	156.6	157.7	158.8	159.9	160.9	162.0	163.1
160	164.2	165.2	166.3	167.4	168.5	169.6	170.7	171.7	172.8	173.9
170	175.0	176.1	177.2	178.3	179.3	180.4	181.5	182.6	183.7	184.8
180	185.9	187.0	188.0	189.1	190.2	191.3	192.4	193.5	194.6	195.6
190	196.7	197.8	198.9	200.0	201.1	202.2	203.3	204.4	205.4	206.5
200	207.6	208.7	209.8	210.9	212.0	213.1	214.1	215.2	216.3	217.4
210	218.5	219.6	220.7	221.7	222.8	223.9	225.0	226.1	227.1	228.2
220	229.3	230.4	231.4	232.5	233.6	234.7	235.8	236.9	237.9	239.0
230	240.1	241.2	242.3	243.4	244.5	245.5	246.6	247.7	248.8	249.9
240	251.0	252.1	253.2	254.3	255.4	256.4	257.5	258.6	259.8	260.9
250	262.0	263.1	264.2	265.3	266.5	267.6	268.7	269.9	271.0	272.1
260	273.3	274.4	275.6	276.7	277.8	279.0	280.1	281.2	282.4	283.5
270	284.6	285.7	286.9	288.0	289.1	290.3	291.4	292.5	293.7	294.8
280	295.9	297.1	298.2	299.4	300.5	301.7	302.8	304.0	305.1	306.3
290	307.4	308.6	309.7	310.8	312.0	313.1				

TIME LST	MU	M	LL	R083	R038	N083	N038*	NA(083 -038*)	NC(083 -038*)	ND(083 -038*)	X083	X038*	XAD (083-038*)	XCD (083-038*)	N038	X038	XAD (083-038)	XCD (083-038)	XA (083-038)	XC (083-038)	XD (083-038)
NEW OZONE ABSORPTION COEFFICIENTS applied																					
07:45:00	2.578	2.611	C	90.50	95.20	85.8	96.7		-11.0		.290	.341			86.2	.292				-.002	
07:45:30	2.568	2.601	CD								.279	.284		-.004		.281		-.001			
07:46:00	2.559	2.591	D	51.20	60.50	51.2	61.6			-10.4	.304	.412			51.5	.306					-.003
07:46:30	2.549	2.581	AD								.287	.297	-.010			.288	-.001				
07:47:00	2.540	2.572	A	168.40	166.70	157.3	171.4	-14.1			.290	.321			158.0	.292			-.002		
07:49:00	2.504	2.533	C	87.80	92.80	83.3	94.3		-11.0		.290	.343			83.7	.292				-.002	
07:49:30	2.495	2.524	CD								.280	.286		-.006		.283		-.003			
07:50:00	2.486	2.515	D	49.60	58.90	49.7	60.0			-10.3	.303	.414			49.8	.304					-.001
07:50:30	2.477	2.506	AD								.287	.298	-.011			.289	-.002				
07:51:00	2.468	2.497	A	163.90	162.60	152.9	167.0	-14.1			.290	.322			153.6	.292			-.002		
07:53:00	2.434	2.461	C	85.30	90.30	80.9	91.7		-10.8		.290	.344			81.2	.291				-.001	
07:53:30	2.426	2.452	CD								.278	.287		-.008		.284		-.005			
07:54:00	2.417	2.444	D	48.30	57.30	48.5	58.3			-9.8	.305	.413			48.1	.301					.004
07:54:30	2.409	2.435	AD								.285	.298	-.013			.288	-.003				
07:55:00	2.401	2.427	A	159.20	158.30	148.3	162.3	-14.1			.289	.322			148.9	.291			-.002		
07:57:00	2.369	2.393	C	83.00	88.00	78.8	89.4		-10.6		.291	.344			78.8	.291				.000	
07:57:30	2.361	2.385	CD								.281	.284		-.004		.281		-.000			
07:58:00	2.353	2.377	D	46.70	56.20	47.0	57.1			-10.1	.303	.418			47.0	.302					.000
07:58:30	2.345	2.369	AD								.286										
07:59:00	2.338	2.361	A	155.10		144.3					.289										
08:15:00	2.120	2.136	C	73.70	79.70	70.3	81.0		-10.8		.289	.350			70.5	.291				-.001	
08:15:30	2.114	2.130	CD								.282	.285		-.003		.281		.000			
08:16:00	2.108	2.124	D	41.30	51.50	41.7	52.1			-10.4	.299	.431			42.0	.302					-.003
08:16:30	2.102	2.118	AD								.285	.298	-.013			.287	-.002				
08:17:00	2.096	2.111	A	138.90	140.10	128.6	143.0	-14.3			.288	.325			129.6	.290			-.002		
08:19:00	2.073	2.088	C	72.10	78.00	68.8	79.3		-10.5		.290	.351			68.7	.290				.000	
08:19:30	2.067	2.082	CD								.281	.283		-.002		.279		.002			
08:20:00	2.061	2.076	D	40.50	50.70	40.9	51.3			-10.3	.300	.434			41.1	.303					-.002
08:20:30	2.056	2.070	AD								.285	.297	-.013			.286	-.001				
08:21:00	2.050	2.064	A	136.20	137.30	126.1	140.0	-13.9			.288	.326			126.6	.290			-.002		
08:23:00	2.028	2.042	C	70.30	76.60	67.1	77.9		-10.8		.289	.353			67.3	.290				-.001	
08:23:30	2.023	2.036	CD								.277	.282		-.005		.278		-.001			
08:24:00	2.018	2.031	D	39.80	50.00	40.3	50.5			-10.3	.303	.439			40.4	.304					-.001
08:24:30	2.012	2.026	AD								.285	.297	-.013			.286	-.001				
08:25:00	2.007	2.020	A	133.50	134.80	123.5	137.4	-13.9			.288	.327			124.0	.290			-.001		
08:27:00	1.986	1.999	C	68.70	75.20	65.7	76.5		-10.8		.288	.354			65.9	.290				-.002	
08:27:30	1.981	1.994	CD								.278	.282		-.004		.278		.000			
08:28:00	1.976	1.988	D	38.80	49.20	39.3	49.7			-10.4	.301	.442			39.5	.304					-.003
08:28:30	1.971	1.983	AD								.286	.297	-.011			.285	.000				
08:29:00	1.966	1.978	A	131.00	132.20	121.1	134.7	-13.5			.289	.327			121.3	.289			-.000		
08:31:00	1.946	1.958	C	67.30	73.90	64.4	75.2		-10.8		.289	.355			64.6	.290				-.001	
08:31:30	1.942	1.953	CD								.277	.285		-.008		.281		-.004			
08:32:00	1.937	1.948	D	38.20	48.30	38.7	48.7			-10.0	.303	.442			38.5	.302					.002
08:32:30	1.932	1.943	AD								.284	.297	-.013			.286	-.001				
08:33:00	1.927	1.938	A	128.20	129.80	118.5	132.1	-13.6			.288	.327			118.8	.289			-.001		
08:35:00	1.909	1.919	C	66.20	72.50	63.4	73.8		-10.4		.290	.356			63.2	.289				.001	
08:35:30	1.904	1.915	CD								.281	.279		.002		.275		.006			
08:36:00	1.899	1.910	D	37.30	47.90	37.8	48.3			-10.5	.301	.449			38.1	.306					-.005
08:36:30	1.895	1.905	AD								.285	.297	-.012			.285	.000				
08:37:00	1.890	1.901	A	125.90	127.70	116.3	130.0	-13.6			.289	.328			116.6	.289			-.001		
08:39:00	1.873	1.883	C	64.90	71.50	62.2	72.8		-10.6		.290	.358			62.2	.290				-.000	
08:39:30	1.868	1.878	CD								.273	.282		-.009		.278		-.005			
08:40:00	1.864	1.874	D	37.30	47.20	37.8	47.5			-9.8	.311	.451			37.3	.306					.006
08:40:30	1.860	1.869	AD								.284	.298	-.014			.286	-.002				
08:41:00	1.856	1.865	A	124.00	125.80	114.6	128.0	-13.4			.290	.330			114.6	.290			-.000		

NEW OZONE ABSORPTION COEFFICIENTS applied

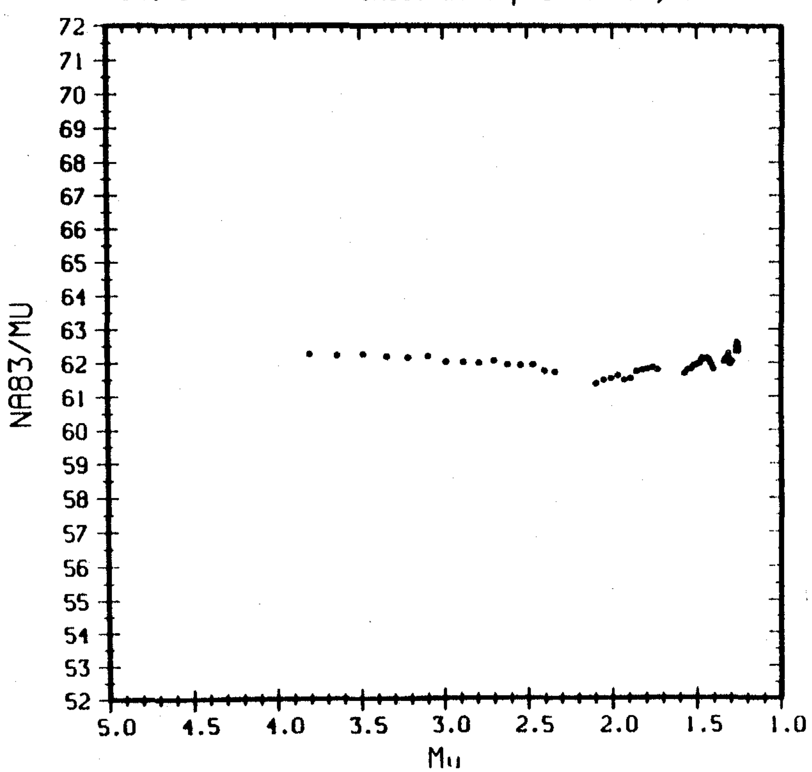
TIME LST	MU	M	LL	R083	R038	N083	N038*	NA(083 -038*)	NC(083 -038*)	ND(083 -038*)	X083	X038*	XAD (083-038*)	XCD (083-038*)	N038	X038	XAD (083-038)	XCD (083-038)	XA (083-038)	XC (083-038)	XD (083-038)
08:43:00	1.839	1.848	C	63.70	70.30	61.1	71.5		-10.5		.290	.359			61.0	.290				.001	
08:43:30	1.835	1.844	CD								.276	.282		-.006		.278		-.002			
08:44:00	1.831	1.840	D	36.40	46.50	36.8	46.7			-9.9	.308	.453			36.6	.304					.004
08:44:30	1.826	1.835	AD								.285	.298	-.013			.286	-.001				
08:45:00	1.822	1.831	A	121.90	123.80	112.6	125.9	-13.3			.290	.330			112.5	.290			.000		
08:47:00	1.806	1.815	C	62.50	69.50	60.0	70.7		-10.8		.290	.362			60.1	.291				-.001	
08:47:30	1.803	1.811	CD								.276	.288		-.012		.284		-.008			
08:48:00	1.799	1.807	D	35.70	45.70	36.2	45.9			-9.7	.307	.452			35.7	.301					.006
08:48:30	1.795	1.803	AD								.286	.299	-.013			.286	-.001				
08:49:00	1.791	1.799	A	119.90	121.80	110.7	123.8	-13.1			.290	.331			110.5	.289			.001		
08:51:00	1.776	1.784	C	61.50	68.50	59.0	69.7		-10.7		.291	.363			59.1	.291				-.001	
08:51:30	1.772	1.780	CD								.276	.288		-.012		.283		-.007			
08:52:00	1.768	1.776	D	35.20	45.20	35.7	45.3			-9.7	.309	.455			35.2	.302					.007
08:52:30	1.765	1.772	AD								.285	.299	-.014			.286	-.001				
08:53:00	1.761	1.769	A	118.00	120.10	108.9	122.1	-13.2			.290	.332			108.7	.290			.001		
08:55:00	1.746	1.754	C	60.40	67.40	58.0	68.6		-10.5		.291	.363			58.0	.290				.000	
08:55:30	1.743	1.750	CD								.274	.281		-.007		.277		-.002			
08:56:00	1.739	1.747	D	34.70	45.00	35.2	45.1			-10.0	.310	.464			35.0	.307					.003
08:56:30	1.736	1.743	AD								.285	.298	-.014			.285	-.000				
08:57:00	1.732	1.740	A	116.00	118.40	107.1	120.3	-13.3			.290	.332			106.9	.290			.000		
09:22:00	1.583	1.587	C	54.50	62.10	52.5	63.1		-10.6		.290	.371			52.5	.290				.000	
09:22:30	1.580	1.585	CD								.276	.283		-.007		.278		-.002			
09:23:00	1.577	1.582	D	31.30	41.90	31.7	41.7			-10.0	.308	.478			31.6	.306					.002
09:23:30	1.575	1.579	AD								.285	.298	-.013			.283	.001				
09:24:00	1.572	1.577	A	105.30	108.30	97.0	109.9	-12.9			.289	.335			96.5	.288			.002		
09:26:00	1.563	1.567	C	53.70	61.30	51.8	62.3		-10.5		.290	.370			51.7	.289				.001	
09:26:30	1.560	1.564	CD								.277										
09:27:00	1.558	1.562	D	30.80		31.2					.306										
09:27:30	1.555	1.560	AD								.286										
09:28:00	1.553	1.557	A	104.20	107.30	95.9	108.9	-12.9			.290	.336			95.5	.288			.002		
09:30:00	1.543	1.547	C	53.30	60.90	51.4	61.8		-10.4		.292	.373			51.3	.291				.001	
09:30:30	1.541	1.545	CD								.278	.284		-.006		.279		-.000			
09:31:00	1.539	1.543	D	30.60	41.20	31.0	41.0			-10.0	.309	.482			30.8	.306					.003
09:31:30	1.536	1.540	AD								.285	.299	-.013			.284	.001				
09:32:00	1.534	1.538	A	103.00	106.20	94.8	107.7	-12.9			.290	.337			94.4	.288			.002		
09:34:00	1.525	1.529	C	52.50	60.20	50.7	61.1		-10.5		.291	.373			50.5	.290				.001	
09:34:30	1.523	1.527	CD								.277	.282		-.005		.276		.000			
09:35:00	1.521	1.525	D	30.20	40.90	30.6	40.6			-10.1	.308	.485			30.5	.306					.002
09:35:30	1.519	1.522	AD								.286	.299	-.013			.284	.002				
09:36:00	1.516	1.520	A	102.00	105.20	93.9	106.7	-12.8			.291	.338			93.3	.289			.002		
09:38:00	1.508	1.511	C	52.00	59.70	50.2	60.6		-10.4		.292	.374			50.0	.290				.001	
09:38:30	1.506	1.509	CD								.276	.281		-.005		.275		.001			
09:39:00	1.504	1.507	D	30.00	40.70	30.4	40.4			-10.0	.311	.489			30.3	.309					.002
09:39:30	1.501	1.505	AD								.286	.299	-.013			.284	.002				
09:40:00	1.499	1.503	A	100.90	104.30	92.9	105.8	-12.9			.291	.339			92.4	.289			.002		
09:42:00	1.491	1.495	C		59.20		60.1					.376			49.5	.290					
09:42:30	1.489	1.493	CD									.283				.277					
09:43:00	1.487	1.491	D	29.30	40.30	29.6	40.0			-10.3	.304	.489			29.8	.307					-.003
09:43:30	1.485	1.489	AD								.288	.301	-.013			.286	.002				
09:44:00	1.483	1.486	A	99.90	103.60	91.9	105.1	-13.1			.291	.340			91.7	.290			.001		
09:46:00	1.475	1.479	C	50.80	58.80	49.0	59.7		-10.6		.291	.377			49.1	.291				-.000	
09:46:30	1.473	1.477	CD								.276	.283		-.007		.278		-.001			
09:47:00	1.472	1.475	D	29.30	40.10	29.6	39.8			-10.1	.309	.493			29.6	.308					.001
09:47:30	1.470	1.473	AD								.287	.301	-.013			.285	.002				
09:48:00	1.468	1.471	A	99.10	102.60	91.2	104.0	-12.8			.292	.340			90.6	.290			.002		

NEW OZONE ABSORPTION COEFFICIENTS applied

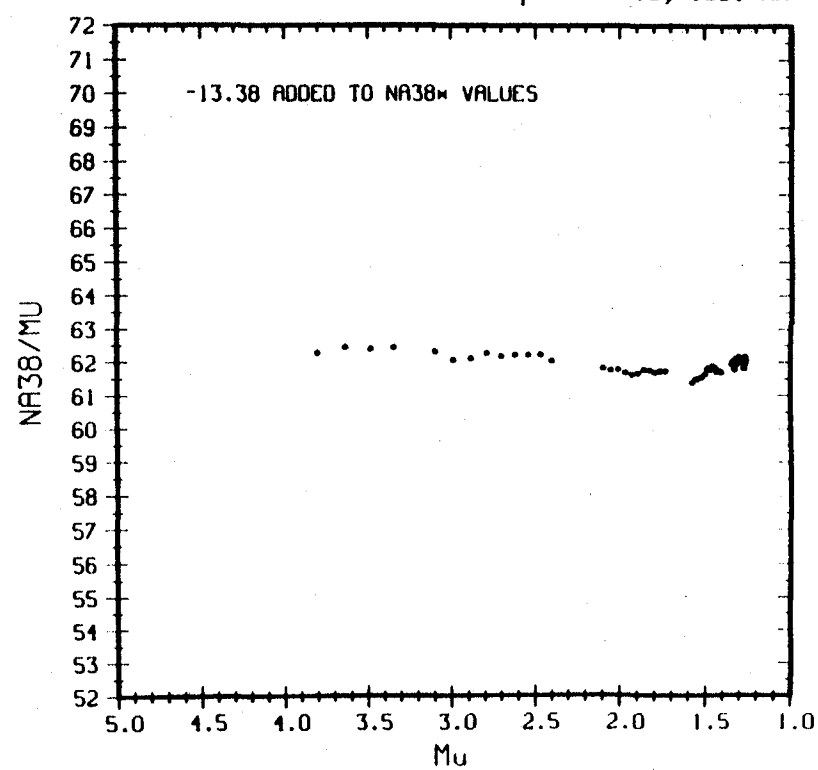
TIME LST	MU	M	LL	R083	R038	N083	N038*	NA(083 -038*)	NC(083 -038*)	ND(083 -038*)	X083	X038*	XAD (083-038*)	XCD (083-038*)	N038	X038	XAD (083-038)	XCD (083-038)	XA (083-038)	XC (083-038)	XD (083-038)
09:50:00	1.460	1.463	C	50.40	58.30	48.7	59.1		-10.5		.292	.378			48.5	.291				.001	
09:50:30	1.459	1.461	CD								.278	.280		-.002		.274		.004			
09:51:00	1.457	1.460	D	29.00	40.00	29.4	39.6			-10.3	.309	.498			29.5	.312					-.002
09:51:30	1.455	1.458	AD								.287	.301	-.013			.285	.002				
09:52:00	1.453	1.456	A	98.10	101.90	90.3	103.3	-13.1			.292	.342			89.9	.291			.001		
09:54:00	1.446	1.449	C	50.00	58.00	48.3	58.8		-10.5		.293	.380			48.2	.293				.000	
09:54:30	1.444	1.447	CD								.283	.283		-.000		.277		.006			
09:55:00	1.443	1.445	D	28.50	39.70	28.8	39.3			-10.5	.305	.499			29.2	.311					-.006
09:55:30	1.441	1.444	AD								.288	.301	-.012			.285	.004				
09:56:00	1.439	1.442	A	97.20	101.00	89.4	102.4	-13.0			.292	.342			89.0	.290			.002		
09:58:00	1.432	1.435	C	49.70	57.50	48.0	58.3		-10.3		.294	.381			47.7	.292				.003	
09:58:30	1.431	1.433	CD								.283	.285		-.002		.279		.004			
09:59:00	1.429	1.432	D	28.40	39.30	28.7	38.9			-10.1	.308	.498			28.7	.308					.000
09:59:30	1.427	1.430	AD								.287	.301	-.014			.285	.002				
10:00:00	1.426	1.428	A	96.20	100.00	88.5	101.3	-12.9			.292	.342			88.0	.290			.002		
10:02:00	1.419	1.422	C	49.10	56.80	47.4	57.5		-10.1		.293	.379			47.0	.289				.004	
10:02:30	1.418	1.420	CD								.280	.278		.002		.272		.008			
10:03:00	1.416	1.419	D	28.20	39.20	28.5	38.8			-10.2	.309	.502			28.6	.311					-.001
10:03:30	1.415	1.417	AD								.286	.300	-.014			.284	.002				
10:04:00	1.413	1.416	A	95.20	99.30	87.5	100.6	-13.1			.291	.342			87.2	.290			.001		
10:06:00	1.407	1.409	C	48.50	56.60	46.9	57.3		-10.5		.292	.381			46.8	.291				.001	
10:06:30	1.405	1.408	CD								.279	.279		-.000		.273		.006			
10:07:00	1.404	1.406	D	27.90	39.10	28.2	38.7			-10.4	.308	.507			28.5	.313					-.005
10:07:30	1.403	1.405	AD								.285	.299	-.014			.283	.002				
10:08:00	1.401	1.403	A	94.20	98.50	86.6	99.8	-13.2			.290	.342			86.4	.290			.001		
10:30:00	1.345	1.347	C	46.30	54.60	44.8	55.2		-10.4		.292	.385			44.6	.291				.001	
10:30:30	1.344	1.346	CD								.273	.276		-.003		.270		.004			
10:31:00	1.343	1.344	D	27.00	38.10	27.3	37.5			-10.2	.315	.519			27.4	.316					-.002
10:31:30	1.342	1.343	AD								.285	.301	-.016			.284	.001				
10:32:00	1.341	1.342	A	90.50	95.20	83.1	96.4	-13.3			.291	.346			83.0	.291			.000		
10:35:00	1.334	1.336	C	45.90	54.30	44.4	54.9		-10.5		.292	.386			44.3	.291				.001	
10:35:30	1.333	1.335	CD								.273	.275		-.002		.269		.004			
10:36:00	1.332	1.334	D	26.80	38.00	27.1	37.4			-10.3	.315	.522			27.3	.318					-.004
10:36:30	1.331	1.333	AD								.286	.301	-.015			.284	.002				
10:37:00	1.330	1.332	A	90.00	94.70	82.7	95.9	-13.3			.292	.347			82.5	.291			.001		
10:40:00	1.325	1.326	C	45.80	54.00	44.3	54.6		-10.3		.294	.387			44.0	.291				.003	
10:40:30	1.324	1.325	CD								.277	.278		-.001		.271		.006			
10:41:00	1.323	1.324	D	26.60	37.70	26.9	37.1			-10.2	.315	.521			27.0	.316					-.001
10:41:30	1.322	1.323	AD								.286	.301	-.014			.283	.003				
10:42:00	1.321	1.322	A	89.40	93.80	82.1	95.0	-12.9			.292	.346			81.6	.290			.002		
10:45:00	1.316	1.317	C	45.50	53.70	44.0	54.3		-10.3		.294	.387			43.7	.291				.003	
10:45:30	1.315	1.316	CD								.272	.273		-.000		.266		.006			
10:46:00	1.314	1.315	D	26.70	37.80	27.0	37.2			-10.2	.320	.528			27.1	.322					-.001
10:46:30	1.313	1.314	AD								.286	.301	-.016			.284	.001				
10:47:00	1.312	1.314	A	89.00	93.70	81.7	94.9	-13.2			.293	.348			81.5	.292			.001		
10:50:00	1.307	1.309	C	45.00	53.60	43.5	54.2		-10.6		.292	.390			43.6	.292				-.001	
10:50:30	1.306	1.308	CD								.274	.278		-.004		.271		.003			
10:51:00	1.306	1.307	D	26.20	37.50	26.5	36.9			-10.4	.313	.526			26.7	.318					-.005
10:51:30	1.305	1.306	AD								.285	.301	-.016			.284	.001				
10:52:00	1.304	1.305	A	88.00	93.00	80.8	94.2	-13.4			.291	.348			80.8	.291			.000		
10:55:00	1.300	1.301	C	44.80	53.30	43.3	53.8		-10.5		.292	.390			43.3	.292				.001	
10:55:30	1.299	1.300	CD								.278	.280		-.002		.273		.005			
10:56:00	1.298	1.299	D	25.90	37.20	26.2	36.5			-10.4	.310	.524			26.4	.315					-.004
10:56:30	1.297	1.299	AD								.287	.304	-.017			.286	.001				
10:57:00	1.297	1.298	A	87.70	92.80	80.5	94.0	-13.5			.292	.349			80.6	.292			-.000		

TIME LST	MU	M	LL	R083	R038	N083	N038*	NA(083 -038*)	NC(083 -038*)	ND(083 -038*)	X083	X038*	XAD (083-038*)	XCD (083-038*)	N038	X038	XAD (083-038)	XCD (083-038)	XA (083-038)	XC (083-038)	XD (083-038)
NEW OZONE ABSORPTION COEFFICIENTS applied																					
11:00:00	1.293	1.294	C	44.70	53.10	43.2	53.6		-10.4		.294	.390			43.1	.292				.002	
11:00:30	1.292	1.293	CD								.278	.282		-.004		.275		.003			
11:01:00	1.291	1.292	D	25.90	37.00	26.2	36.3			-10.2	.313	.523			26.2	.313					.000
11:01:30	1.291	1.292	AD								.286	.303	-.017			.286	.000				
11:02:00	1.290	1.291	A	87.20	92.20	80.0	93.4	-13.3			.292	.349			80.0	.291			.000		
11:25:00	1.267	1.268	C	43.80	52.30	42.4	52.8		-10.4		.293	.392			42.2	.292				.002	
11:25:30	1.267	1.268	CD								.271	.279		-.008		.272		-.001			
11:26:00	1.266	1.267	D	25.80	36.70	26.1	36.0			-9.9	.321	.531			25.8	.317					.005
11:26:30	1.266	1.267	AD								.286	.301	-.016			.283	.002				
11:27:00	1.266	1.267	A	86.00	90.50	78.9	91.6	-12.7			.293	.349			78.2	.290			.003		
11:30:00	1.264	1.265	C	43.90	52.10	42.5	52.6		-10.1		.295	.391			42.0	.291				.004	
11:30:30	1.264	1.265	CD								.275	.276		-.001		.269		.006			
11:31:00	1.263	1.264	D	25.70	36.70	26.0	36.0			-10.0	.321	.533			25.8	.318					.003
11:31:30	1.263	1.264	AD								.287	.302	-.015			.284	.003				
11:32:00	1.263	1.264	A	86.00	90.50	78.9	91.6	-12.7			.294	.350			78.2	.291			.003		
11:35:00	1.261	1.262	C	43.70	52.10	42.3	52.6		-10.3		.294	.392			42.0	.292				.003	
11:35:30	1.261	1.262	CD								.270	.275		-.005		.268		.003			
11:36:00	1.261	1.262	D	25.80	36.80	26.1	36.1			-10.0	.324	.537			26.0	.321					.003
11:36:30	1.261	1.262	AD								.287	.303	-.016			.285	.002				
11:37:00	1.260	1.261	A	86.00	90.60	78.9	91.7	-12.8			.295	.351			78.4	.292			.002		
11:40:00	1.259	1.260	C	43.80	52.00	42.4	52.5		-10.1		.296	.392			41.9	.291				.005	
11:40:30	1.259	1.260	CD								.273	.274		-.001		.266		.006			
11:41:00	1.259	1.260	D	25.80	36.80	26.1	36.1			-10.0	.325	.538			26.0	.322					.003
11:41:30	1.259	1.260	AD								.286	.301	-.015			.283	.003				
11:42:00	1.258	1.259	A	85.80	90.30	78.7	91.4	-12.7			.294	.350			78.0	.291			.003		
11:45:00	1.258	1.259	C	43.60	52.00	42.2	52.5		-10.3		.295	.393			41.9	.292				.003	
11:45:30	1.258	1.258	CD								.273	.276		-.003		.269		.004			
11:46:00	1.257	1.258	D	25.60	36.70	25.9	36.0			-10.1	.321	.536			25.8	.320					.001
11:46:30	1.257	1.258	AD								.287	.302	-.015			.284	.003				
11:47:00	1.257	1.258	A	85.70	90.30	78.6	91.4	-12.8			.294	.351			78.0	.292			.003		
11:50:00	1.257	1.258	C	43.60	52.00	42.2	52.5		-10.3		.295	.393			41.9	.292				.003	
11:50:30	1.257	1.258	CD								.277	.278		-.001		.271		.006			
11:51:00	1.257	1.258	D	25.40	36.60	25.7	35.9			-10.2	.317	.535			25.7	.319					-.001
11:51:30	1.257	1.257	AD								.287	.303	-.015			.285	.002				
11:52:00	1.256	1.257	A	85.50	90.30	78.4	91.4	-13.0			.294	.351			78.0	.292			.002		
11:55:00	1.256	1.257	C	43.60	52.10	42.2	52.6		-10.4		.295	.394			42.0	.293				.002	
11:55:30	1.256	1.257	CD								.275	.278		-.003		.271		.004			
11:56:00	1.256	1.257	D	25.50	36.70	25.8	36.0			-10.2	.319	.537			25.8	.321					-.002
11:56:30	1.256	1.257	AD								.286	.302	-.015			.284	.003				
11:57:00	1.256	1.257	A	85.40	90.20	78.3	91.3	-13.0			.293	.351			77.9	.292			.002		

PLOT OF NA/MU FOR INST. 83 September 16, 1991 AM



PLOT OF NA/MU FOR INST. 38 September 16, 1991 AM



Data summary using Inst. 38 G tables dated March 22, 1985; Calib Inst. 83 vs 38 September 16, 1991 AM

	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD083*	.287 (.001)	.285 (.001)	.285 (.001)	.287 (.000)	.288 (.000)		.286 (.001)	ATMO-CM
XAD038*	.301 (.001)	.298 (.001)	.298 (.000)	.296 (.001)	.295 (.001)		.298 (.002)	ATMO-CM
DXAD038*	5.19	4.58	4.34	3.00	2.48		4.27	PERCENT
XCD083*	.276 (.004)	.277 (.002)	.280 (.002)	.280 (.001)	.282 (.001)		.278 (.002)	ATMO-CM
XCD038*	.279 (.003)	.283 (.002)	.285 (.002)	.283 (.001)	.285 (.001)		.282 (.002)	ATMO-CM
DXCD038*	.95	2.38	1.66	.92	.97		1.48	PERCENT
XA 083*	.292 (.001)	.290 (.001)	.289 (.001)	.291 (.000)	.291 (.000)		.290 (.001)	ATMO-CM
XA 038*	.346 (.004)	.332 (.004)	.324 (.002)	.318 (.002)	.313 (.001)		.330 (.010)	ATMO-CM
DXA 038*	18.42	14.59	12.29	9.48	7.47		13.70	PERCENT
XC 083*	.293 (.001)	.290 (.001)	.290 (.001)	.290 (.000)	.292 (.001)		.291 (.001)	ATMO-CM
XC 038*	.386 (.006)	.364 (.007)	.348 (.004)	.338 (.004)	.328 (.002)		.359 (.018)	ATMO-CM
DXC 038*	31.69	25.35	20.21	16.29	12.60		23.41	PERCENT
XD 083*	.314 (.006)	.307 (.003)	.302 (.002)	.303 (.001)	.303 (.001)		.307 (.005)	ATMO-CM
XD 038*	.519 (.016)	.462 (.016)	.425 (.010)	.403 (.007)	.382 (.004)		.452 (.044)	ATMO-CM
DXD 038*	65.03	50.36	40.60	32.84	26.11		47.38	PERCENT

Corr. needed to Inst. 38 G values

	MU= 1.33	1.75	2.25	2.85	mean (1.15-2.5)	rsd
To GA ADD	-12.99	-13.38	-13.78	-14.03	-13.38	.268
To GC ADD	-10.36	-10.59	-10.77	-10.87	-10.57	.148
To GD ADD	-10.18	-10.09	-10.20	-10.39	-10.15	.210

	MU= 1.33	1.75	2.25	2.85	mean (1.15-2.5)
To GAD ADD	-2.81	-3.29	-3.58	-3.64	-3.23
To GCD ADD	-.18	-.50	-.57	-.48	-.42

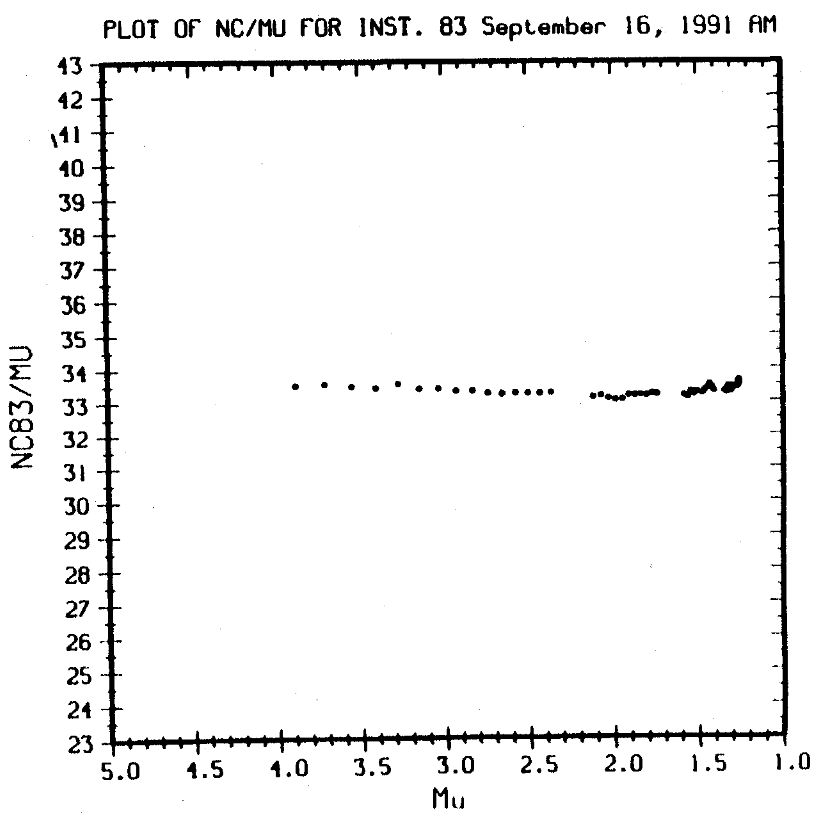
Data summary using corrected Inst. 38 N Tables: (using mean)

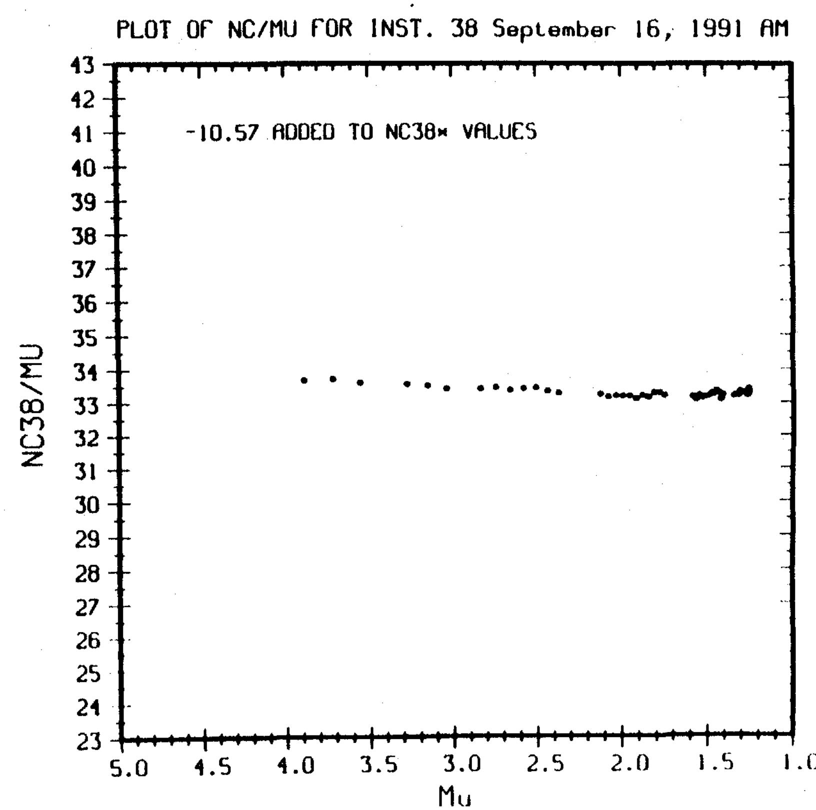
	1.15<MU<1.5	1.5<MU<2.0	2.0<MU<2.5	2.5<MU<3.2	3.2<MU<4.0	4.0<MU<5.0	1.15<MU<3.2	
XAD083	.287 (.001)	.285 (.001)	.285 (.001)	.287 (.000)	.288 (.000)		.286 (.001)	ATMO-CM
XAD038	.284 (.001)	.285 (.001)	.287 (.001)	.288 (.001)	.289 (.001)		.286 (.001)	ATMO-CM
DXAD038	-.73	-.06	.66	.11	.20		-.00	PERCENT
XCD083	.276 (.004)	.277 (.002)	.280 (.002)	.280 (.001)	.282 (.001)		.278 (.002)	ATMO-CM
XCD038	.272 (.004)	.278 (.003)	.281 (.002)	.280 (.001)	.283 (.001)		.278 (.004)	ATMO-CM
DXCD038	-1.44	.66	.42	-.00	.31		-.09	PERCENT
XA 083	.292 (.001)	.290 (.001)	.289 (.001)	.291 (.000)	.291 (.000)		.290 (.001)	ATMO-CM
XA 038	.291 (.001)	.289 (.001)	.290 (.001)	.292 (.000)	.292 (.000)		.290 (.001)	ATMO-CM
DXA 038	-.49	-.20	.57	.33	.31		.05	PERCENT
XC 083	.293 (.001)	.290 (.001)	.290 (.001)	.290 (.000)	.292 (.001)		.291 (.001)	ATMO-CM
XC 038	.292 (.001)	.290 (.001)	.290 (.001)	.292 (.000)	.293 (.000)		.291 (.001)	ATMO-CM
DXC 038	-.66	-.03	.24	.51	.49		.01	PERCENT
XD 083	.314 (.006)	.307 (.003)	.302 (.002)	.303 (.001)	.303 (.001)		.307 (.005)	ATMO-CM
XD 038	.315 (.005)	.305 (.002)	.303 (.001)	.306 (.000)	.305 (.001)		.307 (.005)	ATMO-CM
DXD 038	.35	-.73	.21	1.01	.65		.21	PERCENT

*Values in brackets are standard deviations. New II BK O3 ABS. COEF. applied.

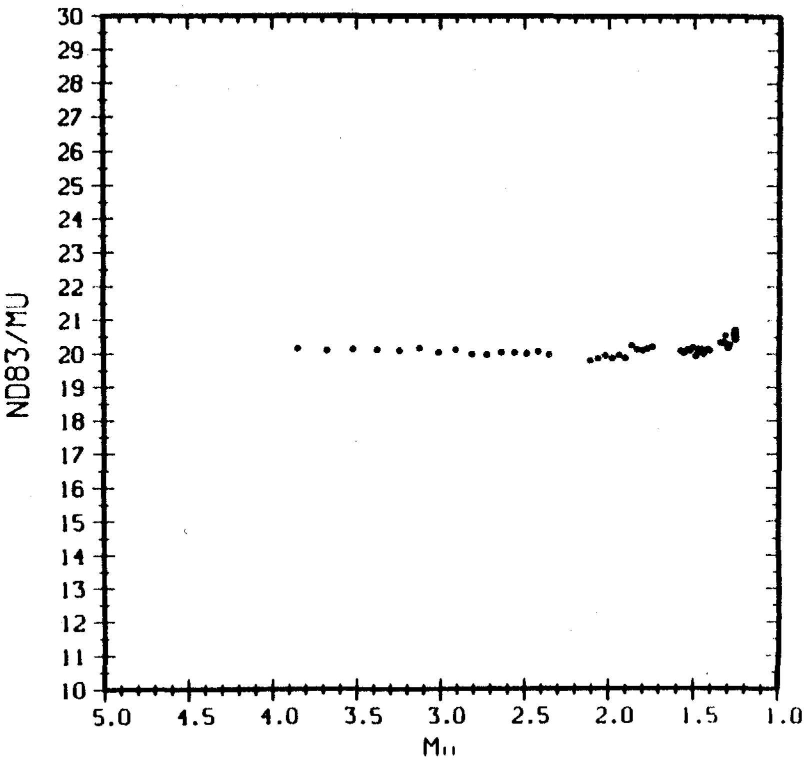
Cubic equations for N-function corrections to inst. 38 G-Tables

A	-.12380497980E+02	.27618654210E+00	-.77391923390E+00	.16639497710E+00
C	-.90696379240E+01	-.13150390510E+01	.27751527750E+00	-.13066565050E-01
D	-.12910697380E+02	.40640598240E+01	-.18529883200E+01	.25870086590E+00

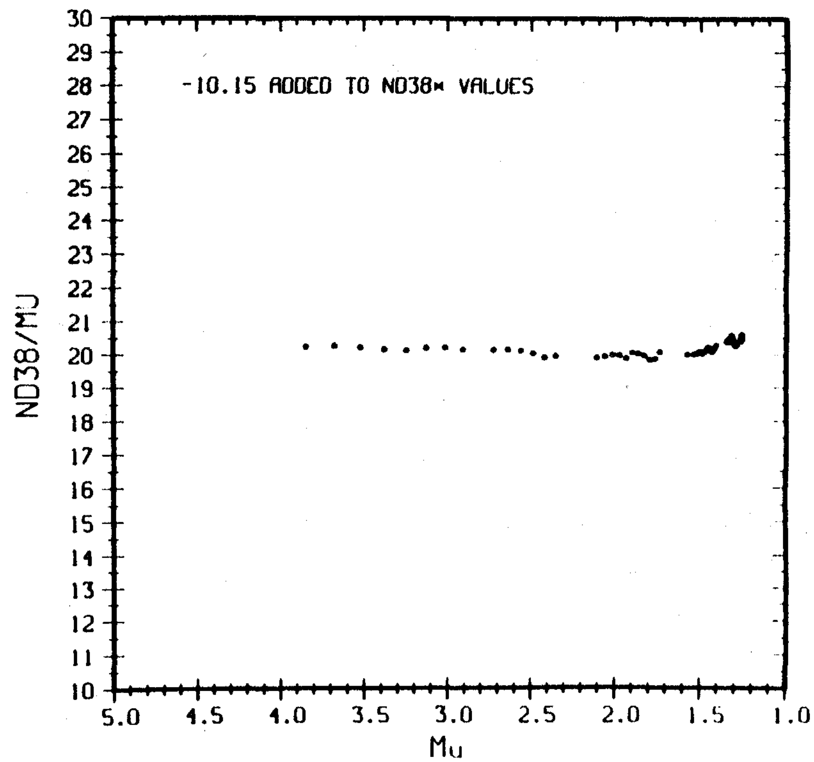

PLOT OF NC/MU FOR INST. 83 September 16, 1991 AM
NC83/MU
Mu


PLOT OF NC/MU FOR INST. 38 September 16, 1991 AM
-10.57 ADDED TO NC38* VALUES
NC38/MU
Mu

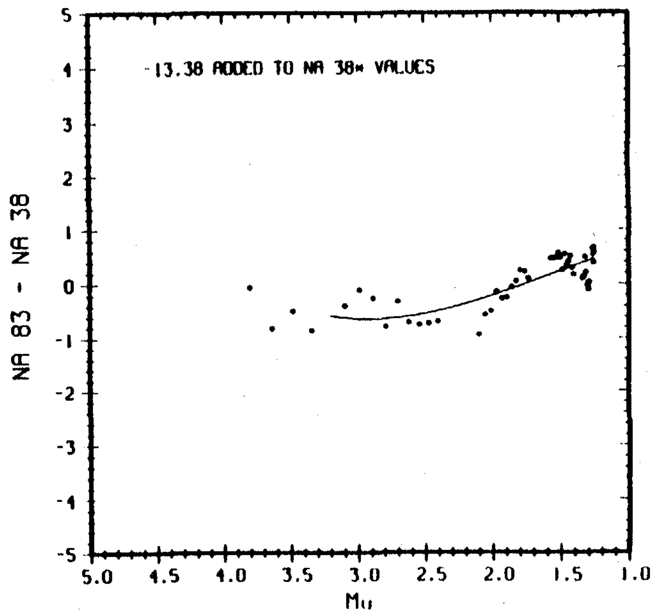
PLOT OF ND/MU FOR INST. 83 September 16, 1991 AM



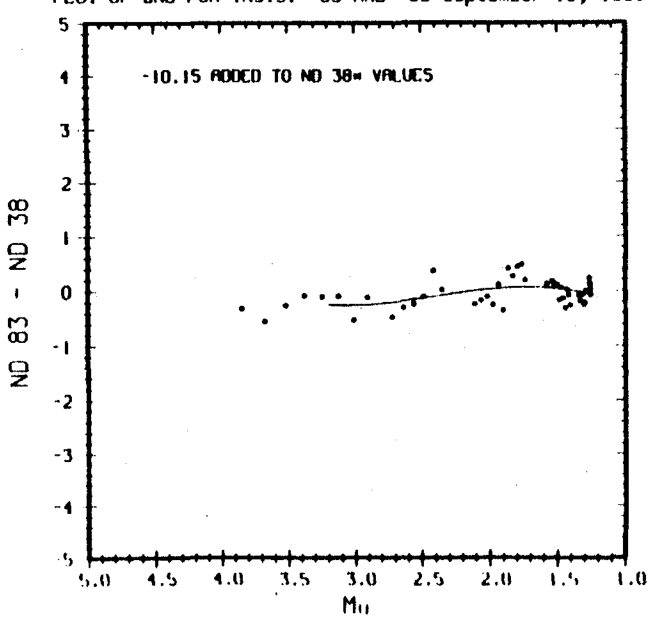
PLOT OF ND/MU FOR INST. 38 September 16, 1991 AM



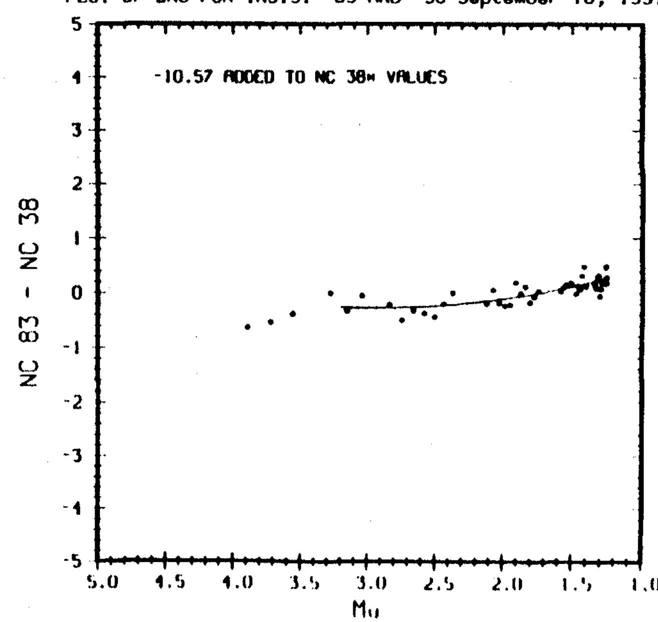
PLOT OF ΔNA FOR INSTS. 83 AND 38 September 16, 1991

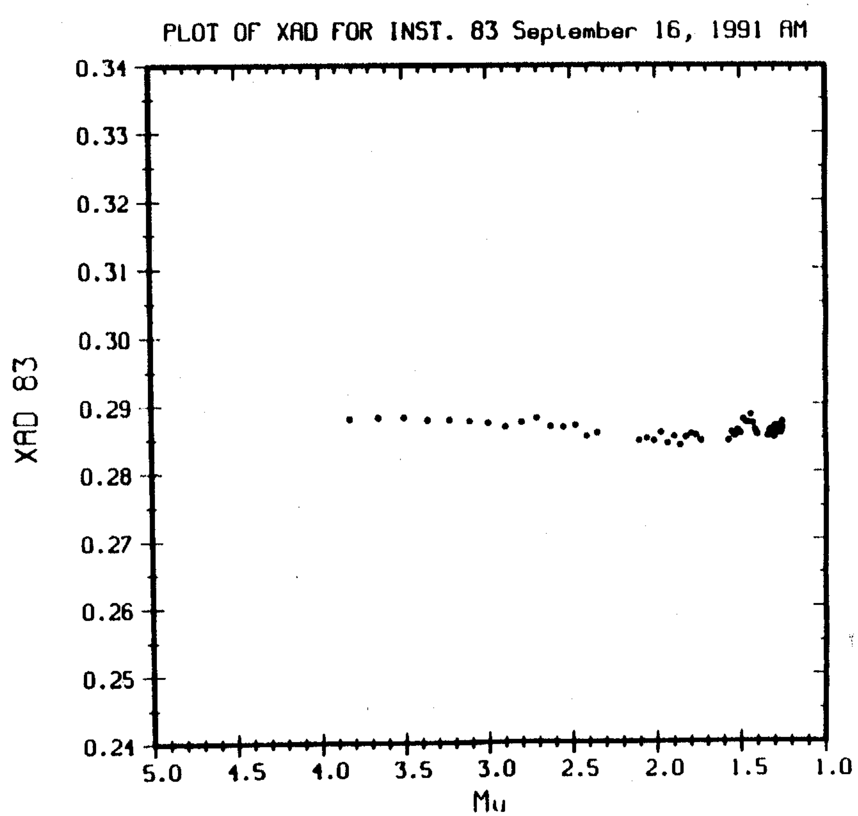


PLOT OF ΔND FOR INSTS. 83 AND 38 September 16, 1991



PLOT OF ΔNC FOR INSTS. 83 AND 38 September 16, 1991




PLOT OF XAD FOR INST. 83 September 16, 1991 AM
XAD 83
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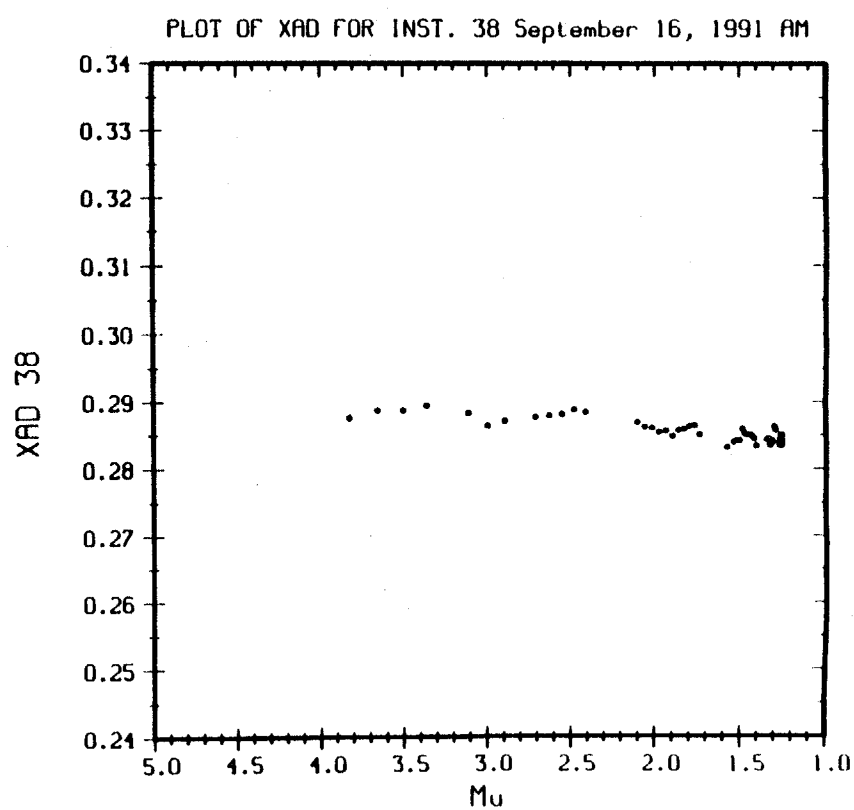
0.32
0.31
0.30
0.29
0.28
0.27
0.26
0.25
0.24
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Mu


PLOT OF XAD FOR INST. 38 September 16, 1991 AM
XAD 38
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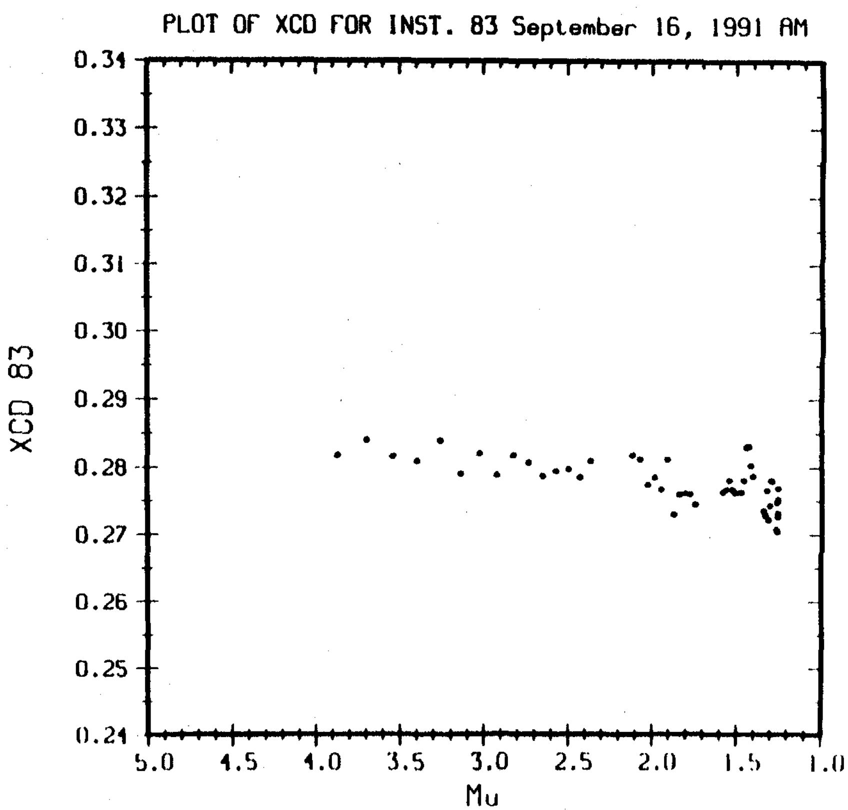
0.32
0.31
0.30
0.29
0.28
0.27
0.26
0.25
0.24
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Mu


PLOT OF XCD FOR INST. 83 September 16, 1991 AM
XCD 83
Mu
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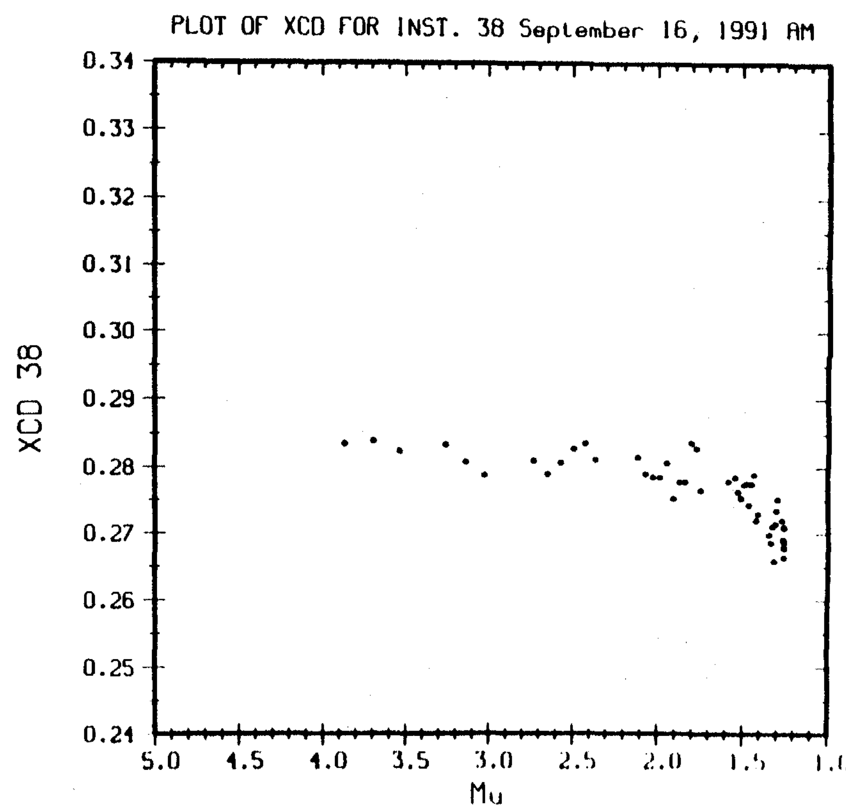
0.32
0.31
0.30
0.29
0.28
0.27
0.26
0.25
0.24
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0


PLOT OF XCD FOR INST. 38 September 16, 1991 AM
XCD 38
Mu
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0.33
0.32
0.31
0.30
0.29
0.28
0.27
0.26
0.25
0.24
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0

Appendix E

SAMPLE ARCHIVED
RE-EVALUATED TOTAL OZONE DATA

Single spaced output
Create/Overwrite archive file from beginning.

ABSORPTION/SCATTERING COEFFICIENTS USED -NEW II BK

WAVELENGTH	ABSORPTION	SCATTERING
A	1.806	.114
B	1.192	.111
C	.833	.109
D	.374	.104

ALL ZENITH OBSERVATIONS ARE MULTIPLIED BY .9743

STATION PARAMETERS USED:

STATION NAME	EARTH RAD METERS	LONGITUDE DEG MIN SEC	LATITUDE DEG MIN SEC	TIME ZONE	MEAN PRESSURE	ELEVATION METERS	HGT O3 METERS	STATION CODE	NUMBER
WALLOPS ISLAND, VIRGINIA U.S.A.	6370342.0	W 75 30 38	N 37 51 34	5.0	1014.	7.0	23000.	WAI	107

N-Table control

Inst	From	To	N-table	G-table	Na(5)	Nc(5)	Nd(5)	Nb(5)		Spectral Change From	To	
72	19660616	19690526	19660616R2		.69	.31	-1.93		Non Mu-Dependent			
72	19690527	19721001	19690527R1		12.98	9.38	5.70		Non Mu-Dependent			
72	19721002	19760518	19721002R1		6.52	4.09	-.37		Non Mu-Dependent			
72	19760519	99999999	19760519R1		14.64	10.60	5.16		Non Mu-Dependent			
38	19780921	19850507	19780921R1		-17.63	-14.67	-15.10		Non Mu-Dependent			
38	19850508	19910915	19850508M7		-11.35	-9.15	-9.92		1st Mu-Dependent N-table	00000000	00000000	Stable Wedge
			19910915M7		-12.15	-9.95	-10.52		2nd Mu-Dependent N-table			
38	19910916	19950426	19910916M8		-13.38	-10.57	-10.15		1st Mu-Dependent N-table	00000000	00000000	Stable Wedge
			19950426M8		-13.88	-11.07	-10.75		2nd Mu-Dependent N-table			
38	19950427	99999999	19950427M9		-14.54	-11.54	-11.54		Mu-Dependent			
86	19830526	99999999	19830526R1		-30.78	-23.54	-19.69		Non Mu-Dependent			

LAMP DATA A C C' D B AD

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FINAL CORRECTION DATA                      ADZB    CCZB    ADZC    CCZC    CDZB    CDZC

107038    3.20 3.00 2.30 3.00 4.00 3.00    -.004    .000  -.004  -.001    .010    .015      850508 999999
      .500000000E+01    .300000000E+01    .400000000E+01    .500000000E+01    .100000000E+01    .100000000E+01
     -.128104000E+02    .216373600E+01    .622366900E+02    .218707100E+01   -.240310900E+01    .438201800E+00
      .149614500E+03   -.154505700E+02   -.454926100E+03   -.251828800E+02    .198888500E+02    .132093200E+02
     -.682546700E+03    .387086100E+02    .122904500E+04    .110001300E+03    .000000000E+00    .000000000E+00
      .151861300E+04   -.353299900E+02   -.145351600E+04   -.231785300E+03    .000000000E+00    .000000000E+00
     -.164959100E+04    .000000000E+00    .630647400E+03    .252302500E+03    .000000000E+00    .000000000E+00
      .699691800E+03    .000000000E+00    .000000000E+00   -.133099000E+03    .000000000E+00    .000000000E+00
107072    3.20 4.40 2.20 4.40 3.00 3.00    -.010    .001  -.005    .000    .005    .008      620618 791031
      .400000000E+01    .200000000E+01    .300000000E+01    .200000000E+01    .200000000E+01    .200000000E+01
      .590649900E+01   -.548532200E+00   -.284600800E+02   -.231972600E+01    .286382800E+01    .450996000E+01
     -.610116700E+02    .553062200E+01    .156543000E+03    .171531500E+02   -.226187800E+02   -.212774100E+02
      .227965000E+03   -.125450800E+02   -.285238700E+03   -.300993400E+02    .468775200E+02    .310679200E+02
     -.369381900E+03    .000000000E+00    .167996900E+03    .000000000E+00    .000000000E+00    .000000000E+00
      .217393200E+03    .000000000E+00    .000000000E+00    .000000000E+00    .000000000E+00    .000000000E+00
      .000000000E+00    .000000000E+00    .000000000E+00    .000000000E+00    .000000000E+00    .000000000E+00
107038    2.30 2.00 2.20 2.00 1.00 1.00    -.007   -.007  -.002  -.009    .000    .000      791101 840427
      .400000000E+01    .300000000E+01    .300000000E+01    .200000000E+01    .000000000E+00    .000000000E+00
      .374873000E+02    .492773700E+02   -.209209200E+02   -.221973200E+02    .000000000E+00    .000000000E+00
     -.302157300E+03   -.245378400E+03    .118175700E+03    .832207100E+02    .000000000E+00    .000000000E+00
      .907730800E+03    .396876700E+03   -.218672400E+03   -.868658200E+02    .000000000E+00    .000000000E+00
     -.120370700E+04   -.212976800E+03    .129851900E+03    .000000000E+00    .000000000E+00    .000000000E+00
      .586796900E+03    .000000000E+00    .000000000E+00    .000000000E+00    .000000000E+00    .000000000E+00
      .000000000E+00    .000000000E+00    .000000000E+00    .000000000E+00    .000000000E+00    .000000000E+00
107086    2.60 4.40 2.00 2.00 1.00 1.00     .000   -.001  -.008  -.004    .000    .000      840430 850531
      .100000000E+01    .100000000E+01    .300000000E+01    .100000000E+01    .000000000E+00    .000000000E+00
     -.867591800E+01   -.656158100E+00   -.270019400E+02    .801869500E+01    .000000000E+00    .000000000E+00
      .224114700E+02    .219451500E+01    .141438400E+03   -.201280500E+02    .000000000E+00    .000000000E+00
      .000000000E+00    .000000000E+00   -.248100000E+03    .000000000E+00    .000000000E+00    .000000000E+00
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.000000000E+00	.000000000E+00	.138600100E+03	.000000000E+00	.000000000E+00	.000000000E+00
.000000000E+00	.000000000E+00	.000000000E+00	.000000000E+00	.000000000E+00	.000000000E+00
.000000000E+00	.000000000E+00	.000000000E+00	.000000000E+00	.000000000E+00	.000000000E+00

CD MF AND DELTA NC SF DATA

107072	1.000	117.0	670623	690526
107072	1.000	128.0	690527	721001
107072	1.000	123.0	721002	760518
107072	1.000	139.0	760519	780920
107038	1.000	88.0	780921	840427
107086	1.000	100.0	840430	850531
107038	1.010	74.0	850603	910915
107038	1.020	76.0	911016	950426

Interpolation coefficients

DATE: 95/11/03.   TIME: 15.11.17.

				INPUT RECORDS										MU	N1		N2		D1	D2	X
139.9	139.8	139.3	53.6	53.7ADDSGQP	01	100200	03	91	H		1	38	WAI	1.730	1.312	1.279	.445	.428			.336
79.6	79.1	79.0	53.1	52.9CDDSGQP	01	100700	03	91	H		2	38	WAI	1.703	.714	.690	.438	.422			*MU*.335
117.0	116.7	116.8	46.8	46.8ADDSGQP	01	120000	03	91	H		3	38	WAI	1.423	1.074	1.044	.371	.355			.331
67.9	67.7	67.5	46.9	46.7CDDSGQP	01	120300	03	91	H		4	38	WAI	1.422	.597	.574	.371	.355			*MU*.328
132.6	132.8	133.1	51.6	51.6ADDSGQP	01	141400	03	91	H		5	38	WAI	1.662	1.240	1.208	.423	.407			.330
76.9	77.0	77.1	51.6	51.9CDDSGQP	01	141700	03	91	H		6	38	WAI	1.676	.692	.667	.425	.408			*MU*.329
117.1	117.0	116.2	34.5	34.6ADZC	04	100600	03	91		L M V	1	38	WAI	1.666	1.073	1.040	.237	.220			.323
98.8	98.8	97.8	30.5	31.0ADZC	04	120000	03	91		L M V	2	38	WAI	1.395	.884	.854	.194	.178			.308
120.9	121.5	122.1	48.2	48.6ADDSGQP	04	140900	03	91	H		3	38	WAI	1.606	1.122	1.090	.389	.372			.305
71.9	71.6	71.7	49.1	49.2CDDSGQP	04	141200	03	91	H		4	38	WAI	1.619	.638	.614	.397	.380			*MU*.306
133.9	133.5	133.3	51.1	51.0ADDSGQP	05	100000	03	91	C		1	38	WAI	1.683	1.247	1.214	.417	.400			.331
76.4	75.9	75.7	50.9	50.6CDDSGQP	05	100300	03	91	C		2	38	WAI	1.667	.681	.656	.414	.397			*MU*.331
115.0	115.2	115.5	45.5	45.6ADDSGQP	05	120000	03	91	C		3	38	WAI	1.386	1.057	1.027	.358	.341			.338
66.4	66.5	66.9	45.4	45.8CDDSGQP	05	120300	03	91	C		4	38	WAI	1.385	.586	.562	.358	.342			*MU*.339
131.4	131.6	131.8	50.2	50.5ADDSGQP	05	140800	03	91	C		5	38	WAI	1.591	1.227	1.195	.410	.393			.345
76.2	76.5	76.8	50.9	51.2CDDSGQP	05	141200	03	91	C		6	38	WAI	1.608	.687	.662	.417	.400			*MU*.346
113.7	113.2	112.8	33.0	32.6ADZC	06	100000	03	91		H TN V	1	38	WAI	1.669	1.036	1.003	.217	.201			.318
98.5	98.9	98.9	29.7	30.0ADZC	06	120000	03	91		H TN V	2	38	WAI	1.377	.887	.857	.184	.167			.320
110.8	110.7	111.1	33.0	33.1ADZC	06	140000	03	91		M M V	3	38	WAI	1.550	1.012	.980	.220	.203			.324
129.5	129.0	128.6	50.4	50.2ADDSGQP	07	100000	03	91	C		1	38	WAI	1.655	1.200	1.167	.409	.392			.320
74.5	74.4	74.5	50.4	50.5CDDSGQP	07	100300	03	91	C		2	38	WAI	1.640	.666	.641	.411	.394			*MU*.320
109.2	109.1	109.2	44.6	44.6ADDSGQP	07	120900	03	91	C		3	38	WAI	1.366	.994	.964	.348	.331			.317
63.5	63.6	63.6	44.4	44.4CDDSGQP	07	121200	03	91	C		4	38	WAI	1.366	.555	.531	.345	.328			*MU*.315
122.7	123.1	123.8	48.4	48.5ADDSGQP	07	140100	03	91	C		5	38	WAI	1.544	1.139	1.107	.389	.372			.325
72.4	71.5	71.4	48.6	48.6CDDSGQP	07	140400	03	91	C		6	38	WAI	1.555	.639	.614	.391	.374			*MU*.328
151.0	151.0	151.1	54.7	55.0ADDSGQP	11	100000	03	91	C		1	38	WAI	1.603	1.432	1.399	.458	.441			.410
84.5	84.6	84.7	54.7	55.0CDDSGQP	11	100300	03	91	C		2	38	WAI	1.589	.768	.743	.458	.441			*MU*.407
128.1	128.0	128.0	48.0	48.0ADDSGQP	11	120000	03	91	C		3	38	WAI	1.335	1.190	1.159	.384	.367			.407
72.0	72.5	72.6	48.0	48.1CDDSGQP	11	120300	03	91	C		4	38	WAI	1.334	.645	.620	.385	.368			*MU*.405
143.5	143.7	144.0	52.0	52.1ADDSGQP	11	140000	03	91	C		5	38	WAI	1.502	1.354	1.322	.428	.411			.417
80.8	81.0	81.1	52.4	52.5CDDSGQP	11	140300	03	91	C		6	38	WAI	1.513	.732	.706	.432	.415			*MU*.412
141.3	141.0	140.8	52.4	52.3ADDSGQP	12	100000	03	91	H		1	38	WAI	1.591	1.326	1.293	.431	.414			.379
79.4	79.1	79.0	52.1	52.1CDDSGQP	12	100300	03	91	H		2	38	WAI	1.577	.713	.688	.428	.411			*MU*.374
121.1	121.2	121.5	46.5	46.5ADDSGQP	12	120000	03	91	H		3	38	WAI	1.327	1.119	1.089	.368	.351			.381
69.0	68.9	68.9	46.5	46.5CDDSGQP	12	120300	03	91	H		4	38	WAI	1.326	.610	.585	.368	.351			*MU*.378
135.8	136.1	136.5	50.0	50.1ADDSGQP	12	140700	03	91	H		5	38	WAI	1.518	1.274	1.242	.406	.389			.385
77.3	77.5	77.9	51.0	51.0CDDSGQP	12	141000	03	91	H		6	38	WAI	1.530	.697	.672	.417	.400			*MU*.380
136.2	135.7	135.7	38.4	38.2ADZC	13	100000	03	91		M M V	1	38	WAI	1.578	1.272	1.238	.278	.261			.402
128.2	128.0	127.9	37.4	37.4ADZC	13	120600	03	91		M M V	2	38	WAI	1.318	1.190	1.159	.269	.251			.439
141.9	142.1	141.9	40.1	40.1ADZC	13	140000	03	91		L M V RAIN	3	38	WAI	1.484	1.336	1.303	.298	.281			.444
138.1	135.5	136.5	38.5	37.8ADZC	15	100200	03	91		L M V	1	38	WAI	1.545	1.280	1.247	.277	.260			.414
121.5	122.0	120.7	34.8	34.4ADZC	15	120000	03	91		L M V	2	38	WAI	1.304	1.121	1.090	.237	.220			.424
112.4	112.6	112.8	32.0	32.5ADZC	18	130200	03	91		L TN V L FOG	1	38	WAI	1.314	1.030	.998	.211	.194			.392
131.9	131.7	132.0	48.7	48.7ADDSGQP	18	140000	03	91	H		2	38	WAI	1.442	1.230	1.197	.392	.375			.391
142.9	141.6	141.0	39.6	39.8ADZC	19	100000	03	91		L TK V	1	38	WAI	1.509	1.334	1.301	.294	.277			.439
135.0	134.9	134.8	50.1	50.0ADDSGQP	19	120000	03	91	H		2	38	WAI	1.275	1.261	1.230	.406	.389			.454
76.5	76.5	76.5	50.1	50.1CDDSGQP	19	120300	03	91	H		3	38	WAI	1.274	.687	.661	.407	.390			*MU*.458
151.3	151.5	151.9	55.0	55.1ADDSGQP	19	140000	03	91	H		4	38	WAI	1.435	1.438	1.405	.460	.443			.461
86.0	85.8	85.9	56.0	55.3CDDSGQP	19	140300	03	91	H		5	38	WAI	1.444	.781	.755	.466	.449			*MU*.455
137.0	136.9	136.2	51.1	51.0ADDSGQP	20	100000	03	91	H		1	38	WAI	1.498	1.280	1.246	.417	.400			.388
77.1	76.7	76.6	50.7	50.5CDDSGQP	20	100300	03	91	H		2	38	WAI	1.486	.690	.663	.412	.395			*MU*.386
116.1	116.2	116.1	45.5	45.5ADDSGQP	20	120000	03	91	H		3	38	WAI	1.268	1.066	1.035	.357	.340			.376
66.7	66.6	66.5	45.6	45.4CDDSGQP	20	120300	03	91	H		4	38	WAI	1.267	.586	.560	.357	.340			*MU*.372
127.1	127.4	128.3	48.9	49.0ADDSGQP	20	140000	03	91	H		5	38	WAI	1.427	1.185	1.152	.395	.377			.372
74.2	74.5	73.5	50.0	49.8CDDSGQP	20	140300	03	91	H		6	38	WAI	1.437	.662	.635	.405	.387			*MU*.369

DATE: 95/11/03.   TIME: 15.11.17.

INPUT RECORDS

														MU	N1		N2		D1	D2	X
111.1	111.0	110.6	33.5	33.4ADZC	21	100700	03	91		L TN V	1	38	WAI	1.461	1.012	.979	.225	.207			.342
105.1	104.6	104.6	31.6	31.9ADZC	21	120000	03	91		L M V	2	38	WAI	1.261	.949	.918	.206	.188			.366
109.2	109.2	109.4	32.7	32.9ADZC	21	140000	03	91		M TN V	3	38	WAI	1.419	.995	.962	.217	.200			.346
107.8	107.7	108.0	32.7	32.6ADZC	22	101200	03	91		M TN V	1	38	WAI	1.433	.981	.947	.216	.198			.337
108.5	108.0	107.7	32.6	33.0ADZC	22	120000	03	91		L M V	2	38	WAI	1.254	.983	.952	.217	.200			.379
117.1	117.9	118.7	33.8	34.3ADZC	22	140000	03	91		M M V	3	38	WAI	1.412	1.085	1.051	.231	.214			.379
117.6	117.5	116.0	34.9	34.5ADZC	25	100000	03	91		M TN V	1	38	WAI	1.448	1.076	1.042	.239	.221			.367
127.6	127.4	127.1	49.0	48.6ADDSGQP	25	100500	03	91	H		2	38	WAI	1.429	1.183	1.149	.393	.375			.371
103.9	103.6	103.6	32.5	32.5ADZC	25	120200	03	91		M TN V	3	38	WAI	1.235	.938	.906	.214	.196			.365
126.5	126.5	126.6	48.5	48.4ADDSGQP	25	140600	03	91	H		4	38	WAI	1.410	1.174	1.140	.389	.372			.374
72.6	72.8	72.5	48.6	48.4CDDSGQP	25	140900	03	91	H		5	38	WAI	1.420	.647	.620	.390	.372			*MU*.373
124.7	124.0	123.9	48.1	48.0ADDSGQP	26	100300	03	91	H		1	38	WAI	1.427	1.150	1.116	.385	.367			.359
71.2	70.9	70.9	48.4	48.0CDDSGQP	26	100600	03	91	H		2	38	WAI	1.417	.631	.604	.387	.369			*MU*.353
109.0	108.9	109.0	43.9	43.8ADDSGQP	26	120200	03	91	H		3	38	WAI	1.229	.992	.960	.339	.322			.356
120.9	121.0	121.3	47.6	47.6ADDSGQP	26	140000	03	91	H		4	38	WAI	1.384	1.117	1.084	.380	.362			.357
70.0	70.1	70.1	48.0	47.8CDDSGQP	26	140300	03	91	H		5	38	WAI	1.393	.621	.594	.383	.366			*MU*.350
63.5	63.2	63.1	44.1	44.6CDDSGQP	26	120500	03	91	H		6	38	WAI	1.229	.552	.525	.345	.327			*MU*.344
112.1	112.1	112.0	46.5	46.5ADDSGQP	27	102100	03	91	H		1	38	WAI	1.361	1.024	.991	.368	.350			.322
65.9	65.7	65.8	46.0	46.1CDDSGQP	27	102600	03	91	H		2	38	WAI	1.347	.578	.551	.363	.346			*MU*.324
102.1	102.0	102.0	43.6	43.6ADDSGQP	27	120000	03	91	H		3	38	WAI	1.223	.921	.889	.337	.319			.318
111.5	111.8	111.6	46.4	46.5ADDSGQP	27	140000	03	91	H		4	38	WAI	1.377	1.020	.986	.368	.350			.316
66.0	66.1	66.6	46.5	46.6CDDSGQP	27	140300	03	91	H		5	38	WAI	1.387	.582	.555	.369	.351			*MU*.312
61.0	61.0	61.1	43.5	43.5CDDSGQP	27	120600	03	91	H		6	38	WAI	1.223	.528	.502	.336	.318			*MU*.320
92.3	91.5	91.5	27.9	27.4ADZC	28	100000	03	91		H TN V	1	38	WAI	1.420	.816	.781	.159	.142			.287
87.5	87.2	87.0	28.2	28.2ADZC	28	120600	03	91		H TN V	2	38	WAI	1.217	.770	.738	.166	.148			.303
105.5	105.7	105.6	43.9	43.7ADDSGQP	28	140000	03	91	H		3	38	WAI	1.371	.958	.924	.339	.321			.300
62.9	62.4	62.5	44.1	43.6CDDSGQP	28	140300	03	91	H		4	38	WAI	1.380	.545	.517	.339	.322			*MU*.301
102.8	101.6	100.5	31.9	31.5ADZC	29	100800	03	91		L M V FOG	1	38	WAI	1.384	.917	.883	.205	.187			.319
101.1	100.9	101.1	31.4	31.4ADZC	29	120000	03	91		L M V	2	38	WAI	1.212	.911	.879	.202	.184			.361
101.9	101.9	101.9	31.6	31.7ADZC	29	140000	03	91		L M V	3	38	WAI	1.365	.920	.886	.205	.187			.325

TOTAL AMOUNT OF OZONE MAR 1991 WALLOPS ISLAND, VIRGINIA U.S.A.

YY	GGMMM	LSOOO	YY	GGMMM	LSOOO	YY	GGMMM	LSOOO	YY	GGMMM	LSOOO	YY	GGMMM	LSOOO
01	15173	00336	08	MSG		15	15155	05414	22	15143	05337	29	15138	07319
01	15170	20335*	08			-15	17130	05424	-22	17125	05379	29	17121	05361
-01	17142	00331	08			15			22	19141	05379	-29	19136	05325
01	17142	20328*	08			15			22			29		
01	19166	00330	08			15			22			29		
02	MSG		09	MSG		16	MSG		23	MSG		30	MSG	
02			09			16			23			30		
02			09			16			23			30		
02			09			16			23			30		
02			09			16			23			30		
03	MSG		10	MSG		17	MSG		24	MSG		31	MSG	
03			10			17			24			31		
03			10			17			24			31		
03			10			17			24			31		
03			10			17			24			31		
04	15167	05323	-11	15160	00410	18	18131	05392	25	15145	05367			
04	17140	05308	11	15159	20407*	-18	19144	00391	-25	15143	00371			
-04	19161	00305	11	17133	00407	18			25	17123	05365			
04	19162	20306*	11	17133	20405*	18			25	19141	00374			
04			11	19150	00417	18			25	19142	20373*			
05	15168	00331	12	15159	00379	19	15151	05439	26	15143	00359			
05	15167	20331*	12	15158	20374*	-19	17127	00454	26	15142	20353*			
-05	17139	00338	-12	17133	00381	19	17127	20458*	26	17123	00356			
05	17139	20339*	12	17133	20378*	19	19143	00461	-26	19138	00357			
05	19159	00345	12	19152	00385	19	19144	20455*	26	19139	20350*			
06	15167	05318	13	15158	05402	20	15150	00388	27	15136	00322			
-06	17138	05320	-13	17132	05439	20	15149	20386*	27	15135	20324*			
06	19155	05324	13	19148	06444	-20	17127	00376	-27	17122	00318			
06			13			20	17127	20372*	27	19138	00316			
06			13			20	19143	00372	27	19139	20312*			
-07	15166	00320	14	MSG		21	15146	05342	28	15142	05287			
07	15164	20320*	14			21	17126	05366	28	17122	05303			
07	17137	00317	14			-21	19142	05346	-28	19137	00300			
07	17137	20315*	14			21			28	19138	20301*			
07	19154	00325	14			21			28					

DATE: 95/11/03. TIME: 15.11.17.

DATE: 95/11/03.   TIME: 15.11.27.

INPUT RECORDS

														MU	N1		N2		D1	D2	X
91.5	91.3	91.1	29.4	29.5ADZC	01	100000	08	91		M TN V	1	38	WAI	1.209	.811	.786	.180	.167			.322
87.0	87.1	87.1	29.0	29.1ADZC	01	120000	08	91		M TN V	2	38	WAI	1.063	.768	.745	.175	.162			*MU*.347
90.0	90.4	90.7	28.9	29.0ADZC	01	140100	08	91		M TN V	3	38	WAI	1.173	.801	.777	.174	.161			.331
97.1	97.0	96.7	42.5	42.5ADDSGQP	02	101300	08	91	VH		1	38	WAI	1.180	.869	.844	.325	.311			.308
88.4	88.6	88.8	39.1	39.2ADDSGQP	02	125300	08	91	H		2	38	WAI	1.081	.784	.760	.288	.274			.307
93.3	93.4	93.7	40.4	40.4ADDSGQP	02	140000	08	91	H		3	38	WAI	1.173	.833	.809	.302	.288			.303
97.0	96.6	96.5	41.0	41.0ADDSGQP	05	100800	08	91	H		1	38	WAI	1.198	.866	.841	.308	.295			.312
88.9	88.7	88.7	38.8	38.6ADDSGQP	05	120000	08	91	H		2	38	WAI	1.070	.785	.762	.283	.269			.315
96.0	96.0	96.1	40.4	40.5ADDSGQP	05	140000	08	91	H		3	38	WAI	1.181	.859	.835	.302	.289			.316
98.4	98.0	97.8	41.2	41.2ADDSGQP	06	100600	08	91	H		1	38	WAI	1.205	.880	.855	.310	.297			.316
89.5	89.3	89.1	38.8	38.7ADDSGQP	06	120000	08	91	H		2	38	WAI	1.072	.791	.768	.283	.270			.317
97.1	97.3	97.4	41.2	41.5ADDSGQP	06	140000	08	91	H		3	38	WAI	1.183	.872	.847	.312	.299			.317
91.5	91.3	90.7	29.6	29.0ADZC	07	100000	08	91		M M V	1	38	WAI	1.223	.810	.785	.178	.165			.317
84.3	84.1	84.5	27.2	27.2ADZC	07	120000	08	91		L M V	2	38	WAI	1.074	.740	.717	.154	.141			*MU*.337
90.0	90.8	91.0	28.4	28.0ADZC	07	140000	08	91		L M V	3	38	WAI	1.186	.804	.779	.166	.152			.331
90.4	90.5	90.4	29.5	29.7ADZC	08	100000	08	91		H TN V	1	38	WAI	1.226	.802	.777	.181	.168			.312
90.6	90.9	90.1	40.3	40.7ADDSGQP	08	120000	08	91	H		2	38	WAI	1.076	.803	.780	.303	.289			.311
97.6	98.5	99.5	41.9	42.2ADDSGQP	08	140000	08	91	H		3	38	WAI	1.189	.885	.860	.320	.306			.318
92.4	92.9	92.9	30.6	30.9ADZC	09	100000	08	91		M TN V	1	38	WAI	1.228	.826	.800	.194	.181			.317
88.6	88.4	85.0	28.9	28.5ADZC	12	100000	08	91		M M V	1	38	WAI	1.237	.771	.745	.171	.158			.296
89.1	88.7	89.0	38.5	38.7ADDSGQP	12	120000	08	91	H		2	38	WAI	1.085	.787	.763	.282	.268			.312
92.9	92.2	92.4	30.0	30.1ADZC	12	140000	08	91		M M V	3	38	WAI	1.202	.823	.798	.187	.173			.326
101.1	100.7	100.5	42.9	42.9ADDSGQP	13	100000	08	91	H		1	38	WAI	1.239	.908	.882	.329	.315			.312
90.4	90.4	90.2	39.2	39.0ADDSGQP	13	120000	08	91	H		2	38	WAI	1.088	.801	.778	.287	.274			.317
97.4	98.1	99.0	40.9	41.5ADDSGQP	13	135700	08	91	H		3	38	WAI	1.199	.881	.856	.310	.297			.319
98.1	97.7	97.4	41.0	41.2ADDSGQP	14	100000	08	91	H		1	38	WAI	1.242	.877	.851	.309	.296			.305
86.7	86.6	86.6	37.5	36.9ADDSGQP	14	120000	08	91	H		2	38	WAI	1.090	.764	.740	.266	.253			.305
95.3	95.5	95.7	40.5	40.5ADDSGQP	14	140000	08	91	H		3	38	WAI	1.210	.854	.829	.303	.289			.305
94.6	94.8	94.8	29.5	29.6ADZC	15	101900	08	91		L M V	1	38	WAI	1.200	.846	.821	.181	.167			.342
83.2	83.9	82.9	26.6	26.6ADZC	15	120000	08	91		L M V	2	38	WAI	1.093	.730	.707	.148	.134			*MU*.328
87.0	85.5	85.7	29.4	28.5ADZC	15	140000	08	91		M TN V	3	38	WAI	1.213	.758	.733	.174	.160			.294
104.8	104.8	104.7	44.6	44.7ADDSGQP	16	100000	08	91	VH		1	38	WAI	1.249	.949	.923	.348	.334			.322
94.0	94.0	94.1	40.8	40.9ADDSGQP	16	120000	08	91	VH		2	38	WAI	1.095	.839	.815	.307	.293			.326
102.6	102.7	103.0	44.0	44.0ADDSGQP	16	140000	08	91	VH		3	38	WAI	1.217	.928	.903	.341	.327			.323
98.9	98.2	98.0	40.9	40.7ADDSGQP	19	100000	08	91	H		1	38	WAI	1.258	.883	.857	.306	.292			.307
88.7	88.7	88.6	38.0	38.0ADDSGQP	19	120000	08	91	H		2	38	WAI	1.104	.784	.760	.275	.261			.309
97.5	97.9	97.9	40.5	40.7ADDSGQP	19	135900	08	91	H		3	38	WAI	1.227	.877	.851	.304	.290			.312
99.4	98.2	97.4	30.5	30.9ADZC	20	100000	08	91		L M V	1	38	WAI	1.262	.883	.857	.194	.180			.338
84.1	85.0	85.1	27.9	27.9ADZC	20	120000	08	91		L TN V	2	38	WAI	1.106	.744	.720	.162	.148			*MU*.324
97.1	97.3	97.6	40.7	40.6ADDSGQP	20	140000	08	91	H		3	38	WAI	1.234	.873	.847	.304	.290			.308
103.1	102.6	102.2	42.6	43.0ADDSGQP	21	100000	08	91	H		1	38	WAI	1.265	.927	.901	.328	.314			.317
92.5	92.2	92.1	39.6	39.5ADDSGQP	21	120000	08	91	H		2	38	WAI	1.109	.821	.797	.292	.278			.319
101.9	101.9	102.0	43.1	43.1ADDSGQP	21	140000	08	91	H		3	38	WAI	1.239	.920	.894	.331	.317			.318
101.6	101.5	101.4	42.5	42.6ADDSGQP	22	100400	08	91	VH		1	38	WAI	1.258	.915	.889	.325	.311			.314
91.5	91.7	92.1	39.8	40.0ADDSGQP	22	120000	08	91	H		2	38	WAI	1.113	.816	.792	.296	.282			.313
100.5	100.5	100.6	42.8	42.9ADDSGQP	22	140000	08	91	H		3	38	WAI	1.243	.905	.880	.329	.315			.310
101.4	101.1	100.9	43.0	43.1ADDSGQP	23	100000	08	91	H		1	38	WAI	1.273	.912	.885	.331	.317			.305
90.9	90.7	90.7	39.7	39.7ADDSGQP	23	120000	08	91	H		2	38	WAI	1.116	.806	.781	.294	.280			.307
89.9	90.1	90.3	30.0	30.1ADZC	23	140000	08	91		M TN V	3	38	WAI	1.248	.799	.773	.187	.173			.302
90.7	89.0	91.1	28.6	28.4ADZC	26	100000	08	91		L TN V	1	38	WAI	1.284	.800	.774	.169	.155			.303
81.8	82.2	81.9	28.1	28.6ADZC	26	120000	08	91		L TN V	2	38	WAI	1.126	.716	.692	.167	.153			*MU*.298
92.4	92.5	91.2	29.9	29.7ADZC	26	140000	08	91		L TN V	3	38	WAI	1.264	.818	.792	.184	.170			.310
91.1	90.9	90.9	29.4	29.2ADZC	27	100000	08	91		M TN V	1	38	WAI	1.288	.808	.781	.178	.164			.301
89.5	89.5	89.5	38.4	38.4ADDSGQP	27	120000	08	91	H		2	38	WAI	1.129	.793	.768	.280	.265			.304
99.3	99.5	99.5	41.2	41.2ADDSGQP	27	140000	08	91	H		3	38	WAI	1.269	.894	.868	.310	.296			.307

DATE: 95/11/03. TIME: 15.11.27.

INPUT RECORDS

													MU	N1		N2		D1	D2	X
98.1	98.6	98.8	41.0	41.7ADDSGQP	28	101400	08	91	H	1	38	WAI	1.255	.885	.858	.312	.298			.305
90.1	90.1	90.2	38.2	38.2ADDSGQP	28	120000	08	91	H	2	38	WAI	1.133	.799	.774	.277	.263			.308
98.9	99.1	99.6	41.4	41.5ADDSGQP	28	135700	08	91	H	3	38	WAI	1.267	.892	.865	.313	.299			.305
100.6	100.5	100.3	41.9	41.9ADDSGQP	29	100000	08	91	H	1	38	WAI	1.296	.905	.878	.318	.304			.302
90.7	90.7	90.7	39.0	39.0ADDSGQP	29	120000	08	91	H	2	38	WAI	1.137	.805	.780	.286	.272			.305
100.0	100.2	100.3	42.0	42.0ADDSGQP	29	140000	08	91	H	3	38	WAI	1.280	.902	.875	.319	.305			.304
101.7	101.5	101.4	43.4	43.4ADDSGQP	30	100000	08	91	VH	1	38	WAI	1.301	.916	.889	.334	.320			.298
94.0	93.8	93.7	40.7	40.6ADDSGQP	30	110100	08	91	VH	2	38	WAI	1.178	.837	.811	.304	.290			.302

TOTAL AMOUNT OF OZONE AUG 1991 WALLOPS ISLAND, VIRGINIA U.S.A.

YY	GGMMM	LSOOO	YY	GGMMM	LSOOO	YY	GGMMM	LSOOO	YY	GGMMM	LSOOO	YY	GGMMM	LSOOO
01	15121	05322	08	15123	05312	15	15120	05342	22	15126	00314	29	15130	00302
01	17106	05347*	-08	17108	00311	-15	17109	05328*	-22	17111	00313	29	17114	00305
-01	19117	05331	08	19119	00318	15	19121	05294	22	19124	00310	-29	19128	00304
01			08			15			22			29		
01			08			15			22			29		
02	15118	00308	-09	15123	05317	16	15125	00322	-23	15127	00305	30	15130	00298
-02	18108	00307	09			16	17110	00326	23	17112	00307	-30	16118	00302
02	19117	00303	09			-16	19122	00323	23	19125	05302	30		
02			09			16			23			30		
02			09			16			23			30		
03	MSG		10	MSG		17	MSG		24	MSG		31	MSG	
03			10			17			24			31		
03			10			17			24			31		
03			10			17			24			31		
03			10			17			24			31		
04	MSG		11	MSG		18	MSG		25	MSG				
04			11			18			25					
04			11			18			25					
04			11			18			25					
04			11			18			25					
05	15120	00312	12	15124	05296	19	15126	00307	-26	15128	05303			
-05	17107	00315	-12	17109	00312	-19	17110	00309	26	17113	05298*			
05	19118	00316	12	19120	05326	19	19123	00312	26	19126	05310			
05			12			19			26					
05			12			19			26					
06	15121	00316	13	15124	00312	20	15126	05338	27	15129	05301			
-06	17107	00317	-13	17109	00317	20	17111	05324*	-27	17113	00304			
06	19118	00317	13	19120	00319	-20	19123	00308	27	19127	00307			
06			13			20			27					
06			13			20			27					
07	15122	05317	14	15124	00305	21	15127	00317	28	15126	00305			
-07	17107	05337*	-14	17109	00305	21	17111	00319	28	17113	00308			
07	19119	05331	14	19121	00305	-21	19124	00318	-28	19127	00305			
07			14			21			28					
07			14			21			28					

DATE: 95/11/03. TIME: 15.11.27.