Report to the Commission on Instruments and Methods of Observation
OPAG on Surface Observation Technology (OPAG-Surface)
Expert Team on Meteorological Radiation and
Atmospheric Composition Measurements
On Ultra-Violet Radiation Measurements

Introduction

The report to the Expert Team on Meteorological Radiation and Atmospheric Composition Measurements concerns sub-tasks (e) and (f) that are affiliated with Task 4 of the OPAG – Surface on the mandate, *Facilitate further activities related to meteorological radiation measurements*. These tasks are described in the Surface OPAG terms of reference as (with the expectations of the individual reporting member provided in the sub-text):

e) Review operational practice associated with UV and, aerosol optical depth measurements
   - Report to Members on operational practice
   - Recommendation on update as necessary

f) Monitor the efforts of the CAS Scientific Steering Committee on UV Measurements
   - Updated Ch 7, "Measurement of radiation", of the CIMO Guide

The importance of monitoring UV radiation by National Meteorological and Hydrological Services (NMHS's) cannot be underestimated. Within the Executive Summary of the Report of the Integrated Global Atmospheric Chemistry Observation (IGACO) Theme Team (GAW No. 159) the need for global observing networks, including UV, is recognized,

> *Networks of ground-based instrumentation, including balloon sondes, millimetre wave radiometers, lidars, UV-Visible and FTIR spectrometers, to measure ground concentrations, column densities and vertical profiles of the principal chemical species, aerosols and ancillary parameters,* ***together with UV radiation****, on a regular basis; the implication is that the current network needs to be maintained and expanded to fill critical gaps in coverage.*

And within the text of the document UV radiation is recognized as contributing to the four major issues facing atmospheric chemistry today; air-quality, oxidizing efficiency, stratospheric ozone and climate-chemistry interaction:

> *Ultraviolet Radiation: UV-A, j(NO2) and UV-B, j(O1D) Ultraviolet radiation is an important parameter throughout atmospheric chemistry and thus plays a role in all four issues.*

The recent meeting of Ozone Managers (WMO Global Ozone Research and Monitoring Project, No. 48) reiterates the ongoing need for high-quality network observations of UV

radiation, emphasizing the quality of the observations, the quantity of the observations (including their geographic distribution) and the duration of such observations:

> *While a number of regional UV observational networks have been put in place in recent years, there remains a need for a stable, long-term observational capability that is geographically balanced. Without such a capability, the necessary high-quality UV data record cannot be obtained. Various atmospheric effects of climate change (e.g., cloud cover, aerosol abundance, albedo, temperature) on ground-level UV may actually be larger than ozone-induced effects. This recognition places increased demands on improving the observational capabilities for tracking such UV changes, and thereby providing necessary data for effects research.*

The report of the Rapporteur on Ultra-Violet Radiation Measurements given at the 2002 13th Commission meeting indicated that the Commission on Atmospheric Sciences, through the Global Atmosphere Watch Programme had *de facto* taken the lead in the development of observational practices for the network observation of UV irradiances and that CIMO should not duplicate the effort of the UV Science Advisory Group (SAG) (Annex 1 provides the present members of the UV-SAG), but monitor their progress, anticipating that the documents that were produced could be used in the re-writing of Chapter 7 of the CIMO Guide. The UV-SAG had been mandated to provide documentation in the following two areas:

1) The quality control and quality assurance of UV observations
2) The technical specifications of the following three categories of UV radiometers
    - Spectral-resolving instruments (spectroradiometers)
    - Broadband UV-A, UV-B and erythemally weighted instruments
    - Filter radiometers for wide-spectral range instruments

The first publications from the UV-SAG were available to the community before the 13th Commission meeting. The rapporteur indicated that the document on quality assurance, *Guidelines for Site Quality Control of UV Monitoring* (WMO GAW No. 126) was not deemed adequate to be included as part of the CIMO Guide. Further, the document prepared by the UV-SAG on technical specifications and methods of operation of spectroradiometers (high resolution instruments for the measurement of spectral UV irradiances) *Instruments to Measure Solar Ultraviolet Radiation, Part 1: Spectral Instruments* (WMO GAW No. 125), was primarily concerned with 'laboratory' quality observations. While this report does provide useful information on a range of technical details and specifications that would be useful to include in the CIMO Guide, the amount of information on the extra demands associated with network observations of UV spectral irradiance is severely limited. In 2002 the UV-SAG claimed that a second document in this series, the one on broadband UV measurements was close to completion. Based on the output of the UV-SAG and the anticipated output of this expert body, the rapporteur recommended that the efforts of the UV-SAG be closed followed and their results used as a basis for the next edition of the CIMO Guide wherever applicable. This interim report indicates the progress to date on the efforts of

the UV-SAG and other associated activities associated with the measurement of UV radiation on a global basis.

Technical Documentation

Although being close to completing the documentation for the use of broadband instruments in 2002, it was not until 2005 that the report, still in final draft version was published as, *Instruments to Measure Solar Ultraviolet Radiation, Part 2: Broadband Instruments Measuring Erythemally Weighted Solar Irradiance* (WMO GAW No. 164). Although significantly later than anticipated, this report is far more useful to the NMHS's than the first report on spectral instruments. There are two main chapters, one on recommended specifications and the other on calibration and characterization. The report also contains a number of annexes that may be helpful to NMHS's in quality assuring any data obtained from these instruments. The introduction and objectives to the report carefully lay out the various possible uses of these instruments and the potential uncertainties associated with these uses. Reproduced below is the table of specifications recommended by the UV-SAG for these types of broadband instruments. The document details each of the aspects of these specifications and notes measurement issues associated with the various specifications.

	Quantity	Quality
1	Spectral response	a) Radiation amplification factor (RAF) for SZA=30° and 300 DU Desired: 1.21 ± 0.05 Recommended: 1.21 ± 0.2 Currently in use: 1.21 ± 0.4 b) Ratio (CF 75 / CF 30) at 300 DU Desired: 1.0 ± 0.02 Recommended: 1.0 ± 0.15 Currently in use: 1.0 ± 0.3
2	Stability in time (on timescales up to a year)	Currently in use: Better than 5% desired: 2%
3	Temperature stability	To within ±1°, and temperature preferably recorded
4	Cosine error	(a) < 10% for incidence angles <60° (b) < 10% to integrated isotropic radiance (c) < 3% azimuthal error at 60° incidence angle
5	Accuracy of time	Better than ±10s
6	Response time	< 5 seconds, and preferably < 1 second
7	Sensitivity to visible and IR solar radiation	< 1%, or below the detection limit
8	Detection threshold	<0.5 mW m-2 (CIE weighted)
9	Leveling	<0.2 °
10	Sampling Frequency	<= 1 minute

This document also provides information on the importance of each of these various specifications based on the primary use of the observations. For example, for observations that are to be primarily used in providing health warnings, the spectral response is extremely important. However, spectral specification is of low importance when considering the broadband sensor as a quality control and supplementary measurement for high resolution spectral instruments.

While there is no official information concerning the fate of the final report on the specification and measurement practices using UV-filter radiometers, a personal communication with one of the UV-SAG members (Seckmeyer, personal communication, 2005) indicated that the UV-SAG would probably not produce a document on this type of instrumentation. The primary reason given for this decision was the effort involved in the production of such a manual, with the secondary reason being a lack of interest by the experts on the committee to use such instruments. The largest single user of filter instruments of this type is the United States Department of Agriculture, which has been successfully operating this network since 1992 (http://uvb.nrel.colostate.edu/UVB/home_page.html). This network has a proven that such instruments can be successfully used to monitor UV radiation over long periods of time if the instruments are carefully characterized, maintained and calibrated.

The GAW implementation strategy, *Strategy for the Implementation of the Global Atmosphere Watch Programme (2001 – 2007)* (WMO GAW 142) indicated that a general guide for all GAW measurements and a further quality assurance strategy for stations measuring UV irradiance would be published during the CIMO intercessional period. However, the *Global Atmosphere Watch Measurements Guide* (WMO GAW 143) provides only limited information on the actual operation of each of the three types of instruments mentioned above, but does provide some useful data on the costs and manpower associated with the setting up of a single UV monitoring site. It also very carefully documents the need for such measurements and the requirement that this type of observation is of limited value without proper ancillary observations.

The second quality assurance report produced by the UV-SAG entitled, *Quality Assurance in Monitoring Solar Ultraviolet Radiation: The state of the art* (WMO GAW 146), published in 2003 provides an overview of the theory behind quality control and quality assurance techniques and the difficulties associated with determining robust uncertainty calculations for the various types of instruments used in the observation of UV radiation at the surface. The document also provides important information on the types of facilities that had been, or were being developed at the time, for the calibration and quality assurance of instruments and observations. These include facilities in North America, Europe and the Southern Hemisphere. While probably somewhat out-of-date now, the effort and direction of this document is commendable in many ways and could be used as a quality foundation for a portion of a chapter on UV instruments and methods of observation in an updated Guide.

Three significant European efforts on the observation of UV radiation have overlapped the present intercessional period. The first of these is European Database for UV Climatology and Evaluation (EDUCE) that was funded through the European Union through November 2003. This program was a follow-up to the successful Scientific UV DAta Management (SUVDAMA) project. According to GAW No. 146 two of the prime objectives of this project were the development of a QA audit that could be performed at the various measurement sites and the production of a set of recommendations for QA procedures to be performed at measuring sites. The GAW document directs readers to the EDUCE website to obtain information on these documents. A search of the website provided only limited information on these activities. It would appear that this documentation either does not exist or is not available through normal means.

The second project of interest is COST 726 entitled, *Long term changes and climatology of UV radiation over Europe*, which commenced in 2004 and will operate for 5 years. Although primarily designed to obtain an historical record of UV radiation through proxy observations and modeling, one area of interest within this project is sub-project C8 of the Scientific Programme, *Common Q/A and Q/C procedures for European broadband radiometers* that is described by:

> *To get high quality broadband UV measurements over the whole of Europe, common QA/QC procedures will be drafted, based on the results from previous projects (COST-713) and WMO documents. The participating institutions will implement these procedures at their measuring sites, to provide a common assessment methodology of the quality of their measurements.*
>
> *The main radiometer characteristics to be determined are :*
> - *Calibration*
> - *Spectral responsivity*
> - *Directional response of the entrance optic*
>
> *For the determination of the broadband UV radiometer calibration and the correction functions, the spectral response function and the cosine response function of the broadband UV radiometers will have to be determined accurately.*
>
> *A broadband UV radiometer reference group will be established, which will maintain an accurate UV irradiance scale for instruments used in Europe. To maintain the UV irradiance scale at the highest possible level, very accurate and stable reference spectrophotometers are needed, which are available at some places in Europe.*
>
> *During scheduled intercomparison campaigns, the instruments of the reference group will be installed at European UV radiation sites as a Quality Assurance exercise. These intercomparisons will allow to monitor and assess the homogeneity of the national broadband radiometer networks, based on a very short traceability chain.*

The results of this project should significantly aid in our understanding of the behaviour of broadband UV radiometers and whether or not a disparate group of radiometers can be maintained over a multi-year period based on a well-characterized group of radiometers. This type of approach closely mirrors the very successful approach of the World Radiation Reference that is based upon the World Standard Group of Radiometers located at the World Radiation Centre.

The third European project that is of significant interest to the operation of network UV instruments is *Quality Assurance of Spectral Ultraviolet Measurements in Europe* (QASUME) through the development of a transportable spectroradiometer unit. Details concerning the development of this project can be found at http://lap.physics.auth.gr/qasume/default.asp. The results of intercomparisons using this instrument in assessing the absolute calibrations of 10 different spectrometers throughout Europe shows that there is a variance of between +21% and -5% in the UV-B region of the spectra and between +16% and -11% in the UV-A. This method of a traveling standard instrument with associated calibration lamps is similar in nature to the calibration method used in the Canadian Brewer Spectroradiometer Network, although standard calibration systems are permanently located at many Canadian stations.

In the early to mid-1990s a number of UV radiometer comparisons were undertaken. Since about 1999, there has been no funding for such comparisons. With the development of the QASUME spectrometer system and the European Reference Centre for ultraviolet radiation measurements (ECUV), the continuing operation of the United States NOAA Central UV Calibration Facility, the Canadian calibration facility within the Meteorological Service of Canada, the development of the European Brewer Calibration Facility at Izaña, Spain (along with a successful Brewer Ozone comparison held in autumn 2005) suggests that a major comparison of regional calibration laboratories be considered over the next 2 – 5 years. By comparing instruments calibrated by these and other regional laboratories an estimation of the global uncertainty of spectral UV observations could be determined.

Data Archiving

The report of the Rapporteur to the 13th Plenary Session of the Commission also indicated that there was a significant need within WMO to encourage NMHS's to submit data to the WMO UV Data Centre. At the time of the last session there was a significant gap between the number of nations submitting data to the WUDC and those actually obtaining UV observations. There are two major reasons for this problem at present.

1) Many NMHS's are not responsible for the measurement of UV irradiance. Examples of this are the United States Department of Agriculture being responsible for the observation of UV irradiance in the rural areas of the United States (although they do provide data to the WUDC), the Health Protection Agency in the United Kingdom and the Australian Radiation Protection and

Nuclear Safety Agency (ARPANSA). Various universities also monitor global ultraviolet radiation.

2) Nations within European Union scientific investigations (i.e., SUVDAMA, EDUCE) have complicated the process of submitting observational data to the WOUDC through the need to submit data to European data centres, which do not forward the data to the WUDC. In WMO GAW No. 146, the European Union Database for UV Climatology and Evaluation indicated that data collected by the 17 contractors and 9 sub-contractors would be provided to the WUDC. However, this did not occur, even though at least 3 of the 26 participants in the project were NMHS's. While there is little that CIMO can do to entice agencies other than NMHS's to contribute data to the World UV Data Centre, it is apparent that CIMO should be encouraging NMHI's to provide data to the WMO along with providing data to privately funded scientific data centres. Annex 2 lists the countries presently submitting data to the WUDC (part of the World Ozone and UV Data Centre). While this has increased marginally since 2002 there remains a significant problem in obtaining UV and ozone data from various national agencies. This problem was also recognized at the most recent Ozone Manager's meeting, September 2006 and reported in the recommendation section as follows:

> ***Data Archiving***
> *The archiving and accessibility of ozone and UV data are as important as the measurements themselves. WMO's World Ozone and Ultraviolet Data Centre (WOUDC), operated by the Meteorological Service of Canada in Toronto, is the primary repository of the world's ozone data. However, additional ozone and UV measurement data are held at individual stations and often are archived at other data centre facilities. It must be recognized that data archiving is a resource-intensive activity; hence, it is important that funding provided for research and observations be adequate to include data archiving activities. Further, it is important that efforts be undertaken to transfer all ozone and UV data to the WOUDC, as well as to conduct re-evaluations of historical data.*
>
> *· Encourage the submission of near-real-time data for column ozone, ozone profiles, ancillary ozone- and climate-related data, UV radiation, and campaign data to the appropriate local and world data centres. Funding for such data archiving activities should be included in the resources provided for research and observations.*
> *· Urge all data centres to develop procedures for the prompt submission of their ozone, UV, and ancillary ozone- and climate-related data to the World Ozone and Ultraviolet Data Centre (WOUDC). Data archiving must include detailed metadata that describe the quality of the measurement and the instrument history.*
>
> *Report Of The Sixth Meeting Of The Ozone Research Managers Of The Parties To The Vienna Convention For The Protection Of The Ozone Layer (Vienna, Austria, 19–21 September 2005)*

Over the last 12 months, the WOUDC has archived ozone observations from 70 different agencies. In that same period however, only 9 agencies have submitted UV

data of any type (ANNEX 2). Of these 9 agencies, none have been involved with European Union funded projects. While some of the observations obtained within EU funded projects are made by agencies other than NMHS's or at academic institutions, at least 4 NMHS's participated in the study, but have not submitted data to the WOUDC.

Annex 3 and Annex 4 give information on the various countries that are observing UV radiation. Annex 3 is based on information provided at the recent Ozone Research Managers meeting, while Annex 4 is historical data obtained from the *Open Encyloepeadia*. Once again, it should be noted that it is not the responsibility of NMHS's to collect UV data. However, where HMHS's do collect data, they should again be reminded of their responsibility to submit this data to the WOUDC. In countries where they do not collect UV data, but have a working relationship with those agencies that do collect UV data (e.g., Australia and the UK) partnerships should be formed such that the NMHS could have access to the data for the expressed purpose of submitting the data to the WOUDC.

Recommendations to the Working Group

1) That the committee recognize the valuable contribution that the UV-SAG has made in attempting to define QA and QC techniques for UV instruments, the technical specifications and the techniques for measuring spectrally resolved UV radiation, and the technical specifications and methodologies associated with the operation and calibration of broadband UV instruments.
2) That the committee endorses the use of the above publications as a basis for the writing of the appropriate sections of the Guide on UV radiation observations.
3) That the committee recognize the operational efforts of the USDA UV monitoring network and request the use of this network's operating guidelines to serve as a basis for operational guidelines to be included in the CIMO Guide.
4) That the committee, once again, request that the president of CIMO request to CAS that a member of this working group be given status on the CAS GAW UV-SAG for the purpose of maintaining the appropriate ties between scientific research observations and network observations of UV radiation.
5) That the committee recognize the need for the archiving of UV radiation data in the WMO archive, the WOUDC, and request that a reminder be sent out to all WMO permanent representatives under the signature of the President of WMO of the requirement of WMO members to submit data to the WMO archive.
6) That this committee recognize that the observation of UV radiation is often part of the mandate of NMHS's and that efforts must be made to encourage the linkage between NMHS's and those organizations that are mandated to observe UV radiation in WMO member countries
7) That this committee devise a plan, to be forwarded to the Surface OPAG, that recognizes the efforts of the EU on the observation of UV radiation, but expresses a strong desire that the information generated from various EU projects be (a) more widely distributed than participating EU countries and (b) that the distribution of these results be done in a timely and efficient manner.

References

Instruments to Measure Solar Ultraviolet Radiation, Part 1: Spectral Instruments (lead author G. Seckmeyer) (GAW No. 125, WMO TD No. 1066),

Guidelines for Site Quality Control of UV Monitoring (lead author A.R. Webb) (GAW No. 126, WMO TD No.884).

Strategy for the Implementation of the Global Atmosphere Watch Programme (2001-2007),
A Contribution to the Implementation of the Long-Term Plan (GAW No. 142, WMO TD No.1077).

Global Atmosphere Watch Measurements Guide (GAW No. 143, WMO TD No. 1073).

Quality Assurance in monitoring solar ultraviolet radiation: the state of the art. (GAW No. 146, WMO TD No.1180).

IGOS-IGACO Report - September 2004 (GAW No. 159, WMO TD No. 1235)

Instruments to Measure Solar Ultraviolet Radiation Part 2: Broadband Instruments Measuring Erythemally Weighted Solar Irradiance (lead author: G. Seckmeyer) (GAW No. 164, WMO TD 1289)

Report Of The Sixth Meeting Of The Ozone Research Managers Of The Parties To The Vienna Convention For The Protection Of The Ozone Layer (Vienna, Austria, 19–21 September 2005) (WMO Global Ozone Research and Monitoring Project Report No. 48)

Long term changes and climatology of UV radiation over Europe, Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST 726

Open Encyclopedia Project, http://open-site.org/

ANNEX 1

UV SAG Membership (as of 2004)

DR ANN R. WEBB (CHAIR) DEPARTMENT OF PHYSICS UMIST P.O. BOX 88 MANCHESTER, M60 1QD UNITED KINGDOM TEL.: (+44-0161) 200 3917 FAX: (+44-0161) 200 3941 E-MAIL: ann.webb@umist.ac.uk	Ms Susana B. Diaz CADIC/CONICET CC92 H. Yfrigoyen s/n 9410 USHUAIA Tierra del Fuego Argentina Tel.: (+54-2901) 422754 Fax: (+54-2901) 430644 e-mail: rqdiaz@criba.edu.ar or uvgroup@speedy.com.ar
Dr Vitali Fioletov Experimental Studies Division Air Quality Research Meteorological Service of Canada 4905 Dufferin Street DOWNSVIEW Ontario Canada M3H 5T4 Tel.: (+1-416) 739 4915 Fax: (+1-416) 739 4281 e-mail: vitali.fioletov@ec.gc.ca	Dr Jay Herman NASA/Goddard Space Flight Centre Code 916 GREENBELT, MD 20771 USA Tel.: (+1-301) 614 6039 Fax: (+1-301) 614 5903 e-mail: jay.r.herman@nasa.gov
Dr Serm Janjai Department of Physics Faculty of Science Silpakorn University 73000 NAKHON PATHOM Thailand Tel.: (+66-34) 270761 Fax: (+66-34) 271189 e-mail: serm@su.ac.th	Prof. Berit Kjeldstad Department of Physics Norwegian University of Science and Technology N-7491 TRONDHEIM Norway Tel.: (+47) 735 919 95 Fax : (+47) 735 97710 e-mail: berit.kjeldstad@phys.ntnu.no
Dr Anne Kricker School of Public Health Medical Foundation Building K25 University of Sydney SYDNEY, NSW 2006 Australia Tel.: (+612 9) 036 3082 Fax: (+612 9) 036 3168 e-mail: annek@health.usyd.edu.au	Mr Toru Sasaki Japan Meteorological Agency 1-3-4 Ote-machi, Chiyoda-Ku TOKYO 100 100-8122 Japan Tel.: (+81-3) 32 12 83 41 Fax: (+81-3) 32 11 46 40 e-mail: tsasaki@met.kishou.go.jp
Dr Gunther Seckmeyer Institute for Meteorology and Climatology University of Hannover Herrenhuser Str. 2 30419 HANNOVER Germany Tel.: (+49-511) 762 4022 Fax: (+49-511) 762 4418 e-mail: seckmeyer@muk.uni-hannover.de	Dr Paul C. Simon Institut d'Aéronomie Spatiale de Belgique 3 Avenue Circulaire B-1180 BRUSSELS Belgium Tel.: (+32-2) 373 0471 Fax: (+32-2) 374 8423 e-mail: polymnia@oma.be
Dr Betsy Weatherhead NOAA/ERL/R/E/ARX1 325 Broadway BOULDER, CO 80305 USA Tel.: (+1-303) 497 6653 Fax: (+1-303) 497 6546 e-mail: betsy.weatherhead@cires.colorado.edu	

Annex 2
World Ozone and Ultraviolet Data Centre
Current Contributors

The following Agencies/Institutions have contributed data to the WOUDC archive in the past 12 months. The WOUDC acknowledges the commitment and dedication of those individuals who provide these data, on an ongoing basis, to this global data archive.

From 2005-01-21 through 2006-01-21, 70 Agencies have contributed WOUDC data.

Agency Acronym	Agency Name	Last Updated
CNR	Italian National Centre for Research	2006-01-17
PIMWM	Polish Institute of Meteorology and Water Management	2006-01-16
MeteoSwiss	MeteoSwiss (formerly Swiss Meteorological Institute)	2006-01-16
MLCD-LU	Meteo Lycee Classique Diekirch of Luxembourg	2006-01-16
AAS-AAAC	Argentine Antarctic Survey and the Argentine Antarctic Army Command	2006-01-16
CHMI-HK	Czech HydroMeteorological Institute - Hradec-Kralove	2006-01-16
CAS-IAP	Chinese Academy of Sciences - Institute of Atmospheric Physics	2006-01-16
SAWS	South African Weather Service	2006-01-16
SHMI	Slovak HydroMeteorological Institute	2006-01-16
INME-MU	National Institute of Meteorology of Spain - Murcia	2006-01-16
AWI-NM	Alfred Wegener Institute - Neumayer	2006-01-16
PMD	Pakistan Meteorologcal Department	2006-01-11
MDI	Meteorological Department of Iran	2006-01-11
AHMS	Armenian State Hydrometeorological and Monitoring Service (formerly DHRA)	2006-01-11
ASM-ARG	Academy of Sciences of Moldova-Atmospheric Research Group	2006-01-11
RMDA	Regional Meteorological Directorate of Algeria	2006-01-11
RMIB	Royal Meteorological Institute of Belgium	2006-01-11
SMHI	Swedish Meteorological and Hydrological Institute	2006-01-11
DWD-MOL	German Weather Service - Meteorological Observatory at Lindenberg	2006-01-11
EMA	Egyptian Meteorological Authority	2006-01-03
NASA-TOMS	NASA Goddard Space Flight Center	2006-01-03
LHMS	Lithuanian Hydrometeorological Service	2006-01-03
MSC	Meteorological Service of Canada (Atmospheric Environment Service)	2005-12-21
KSNU	Kyrgyz State National University	2005-12-19
DNMUY	National Meteorological Directorate of Uruguay	2005-12-19
MSS	Meteorological Service Singapore	2005-12-19
IMD	India Meteorological Department	2005-12-19

SMNA	National Meteorological Service of Argentina	2005-12-19
HMS	Hungarian Meteorological Service	2005-12-19
DWD-MOHp	German Weather Service - Meteorological Observatory at Hohenpeissenberg	2005-12-12
UK-NETCEN	UK National Environmental Technology Centre	2005-12-12
KMD	Kenyan Meteorological Department	2005-12-12
DMI	Danish Meteorological Institute	2005-12-12
JMA	Japan Meteorological Agency	2005-12-05
USDA_CSU	US Department of Agriculture - Colorado State University	2005-11-28
HSSRV	Hydrometeorological Service of S.R. Vietnam	2005-11-21
NMS	Nigerian Meteorological Agency (NIMET)	2005-11-21
CAMS-IAC	Chinese Academy of Meteorological Sciences - Institute of Atmospheric Chemistry	2005-10-31
U_Oslo	University of Oslo	2005-10-31
ABM	Australian Bureau of Meteorology	2005-10-31
NIWA	National Institute of Water and Atmospheric Research of New Zealand	2005-10-31
FMI	Finnish Meteorological Institute	2005-10-17
AWI-NA	Alfred Wegener Institute - Ny Alesund	2005-10-17
KNMI	National Meteorological Institute of the Netherlands	2005-10-17
IGTU	Institute of Geophysics - Tehran University	2005-10-17
NOAA-CMDL	NOAA - Climate Monitoring and Diagnostics Laboratory	2005-09-28
MMS	Malaysian Meteorological Service	2005-09-27
BSU-NOMREC	Belarus State University - Nat. Ozone Monitoring Research and Education Centre	2005-09-27
EPA_UGA	US Environmental Protection Agency and the University of Georgia at Athens	2005-09-15
HKPU	Hong Kong Polytechnic University	2005-08-03
HKO	Hong Kong Observatory	2005-07-25
INTA	National Institute of Aerospace Technology of Spain	2005-07-25
TMD	Thailand Meteorological Department	2005-07-19
AUTH	Aristole University of Thessaloniki	2005-06-28
INPE	National Institute of Aerospace Science of Brazil	2005-05-25
U_LaReunion	Université de La Réunion	2005-05-24
U_Nairobi	University of Nairobi	2005-05-14
CHMI-PR	Czech HydroMeteorological Institute - Prague	2005-05-09
BAS	British Antarctic Survey	2005-04-20
UKMO	UK Meteorological Office	2005-04-20
PIM	Portuguese Institute of Meteorology	2005-04-20
CNRS	National Centre for Scientific Research - France	2005-04-20
MSP	Meteorological Service of the Philippines	2005-04-20

Yonsei_U	Yonsei University	2005-04-20
DWD-MOP	German Weather Service - Meteorological Observatory at Potsdam	2005-04-20
NIWA-LAU	National Institute of Water and Atmospheric Research of New Zealand at Lauder	2005-03-07
NASDA	National Space Development Agency of Japan	2005-03-02
U_Rome	University of Rome	2005-02-28
RNIMH	Romanian National Institute of Meteorology and Hydrology	2005-02-08
JRC_EU	Joint Research Centre of the European Union	2005-01-26

Formats : [Print]

Created : 2003-05-05
Modified : 2003-05-07
Url of this page : http://www.woudc.org/currentcontributors_e.html

Annex 3
National Networks Measuring UV Radiation
(excerpted from the Sixth Meeting of the Ozone Research Managers of the Parties to The Vienna Convention For The Protection Of The Ozone Layer)

ARGENTINA

The Argentine Republic is one of the very few countries whose southern territories come, each spring under the direct influence of the Antarctic Ozone Hole. Furthermore its northwestern territories, at the edge of the Andes Altiplano, register some of the highest levels of UV radiation in the world. Thus ozone and UV monitoring as well as scientific research in the field are very relevant to its society, despite budget limitations. In recent years the developing evidence demonstrating the existence of ozone-climate interactions has become a growing concern. The present report is an update of the previous one and spans the period 2002-2005.

UV Measurements

Broadband Instruments

The main broadband network is operated by the S.M.N.: Solar Light at Buenos.Aires, Uhuaia, Marambio and for some years at Pilar. YANKEE at Pilar and La Quiaca.

All these instruments operate since the setup of the National UV Monitoring Network in 1995.

Regular measurements made are with a YES Biometer (erythemal irradiance meter), also belonging to the network, located and operated by the Observatorio Astronómico and Solar Radiation and Atmospheric Physics Group, Institute of Physics of Rosario - IFIR (Universidad Nacional de Rosario/CONICET, approx. 400km north of Buenos Aires). Furthermore IFIR also has an EKO Biometer and an EKO UVA solarmeter, presently located in Southern Patagonia, to study the influence of the near vortex (and ozone hole) edge on solar UV irradiances and related biological actions over the Argentine continental territory.

Narrowband filter instruments

The IAA operates the following instruments at the Argentine Antarctic Stations:
UV NILU instruments, at Marambio and Belgrano II, since 1993.

At CEILAP (Buenos Aires) measurements are made with the following instrument array:

UVB – MS-210D, EKO Radiometer (190 nm to 290 nm) with erithemic doses.
UVA – MS-210A, EKO Radiometer (290 nm to 400 nm).
GUV-541 Biospherical Inst. Inc.
CIMEL sun photometer measuring at 1200, 940, 870, 670, 500, 440, 380, 340nm

Spectroradiometers

The IAA operates the following instruments at the Argentine Antarctic Stations:

Brewer instruments, at Belgrano II, since 1993, and San Martin, since 2002. Periodic measurements are made with a Monospec 27 UV-Vis spectroradiometer with UV CCD detector at specific periods during the year. At present this instrument operates at CEILAP, Buenos Aires.

Calibration Activities

The Solar Radiation and Atmospheric Physics Group at IFIR (CONICET – National University of Rosario) is responsible for the scientific advice and calibration of the Argentina UV Monitoring Network together with the SMN.

BELARUS

A number of significant amendments to the Law of the Belarus Republic for Ozone Layer Protection, adopted in 2001, were introduced by the National Assembly of Belarus in October 2004. Ozone monitoring was determined as a part of National Environmental Monitoring System (NEMS). A plan for the development of the atmosphere Ozone Monitoring subsystem up to 2010 has been prepared. Decision of Belarus Government N 949 dated the July, 14 2003 pronounced the Ministry of Education responsible for ozone monitoring in Belarus.

In accordance with decisions of the Sixth Meeting of the Conference of the Parties to the Vienna Convention, Belarus has continued to construct instruments and develop monitoring, calibration and archiving of stratospheric and tropospheric ozone, aerosols, and surface UV radiation data.

UV measurements

Regular measurements of irradiance in the spectral range 285-450 nm are carried out at the Ozonometric station (NOMREC, Minsk) with the portable UV spectroradiometer PION-UV since September 2001. The automated instrument PION-UV registers more then a hundred global/diffuse UV spectra per day. Simultaneously controlling programme calculates UV-index and daily doses of biological effects.

Calibration activities

Calibration testing of the Spectrometer-ozonometer PION’s parameters is performed in NOMREC using special calibration bench with band-lamp certified by Russian National Standard Agency in spectral range 285 – 1200 nm.

BELGIUM

The main research institutes that are currently involved in ozone/UV and ozone related observations include: the Royal Meteorological Institute (KMI-IRM), the Belgian Institute for Space Aeronomy (BIRA-IASB) and the Université de Liège (ULg) - Institute of

Astrophysics and Geophysics. The Université Libre de Bruxelles (ULB, Laboratoire de Chimie Physique Moléculaire) is providing the laboratory support for analysing spectra.

UV measurements

Spectroradiometers

The Royal Meteorological Institute (KMI-IRM) -The Belgian Institute for Space Aeronomy (BIRA-IASB)

- UV spectral irradiance measurements at Uccle: both Brewer spectrophotometers are also used to monitor the UV-B radiation intensities. They perform several scans per day (number depending on the time the sun is above the horizon)

Calibration activities

The Royal Meteorological Institute (KMI-IRM)

- The Brewer UV-B calibration level was checked with 1000W lamps in 2003 during the calibration visit. In 2004 the special comparative observations were performed with a travelling reference UV instrument of the Joint Research Centre (JRC in Ispra) in the frame of the Qasume project (Gröbner et al, 2004). This showed that the calibration based on the monthly tests with 50W lamps was within the expected errors.

BOLIVIA

UV measurements

Broadband measurements

From December 1995, when the laboratory started measurements, until May 1997, we were using a Solar Light 501 Biometer. Since July 1998, there are two YES broadband radiometers. One of the YES is kept fixed at the LAF, and the second is used for the field campaigns.

Spectroradiometers

The LFA has a special agreement with the Brazilian National Institute for Space Research (INPE) which allows the LFA to run the Brewer #110 at La Paz since 1996. There is a nearly continuous data series of the ozone layer depth from July 1996 to July 2004, when the equipment breakdown and was shipped back to Brazil for repair. It is schedule to be returned next September.

Calibration activities

One of the YES broadband radiometers was recalibrated at Innsbruck, Austria in 2002. Two intercomparison campaigns were held at the LFA. The first as an extension of the Argentinean calibration of the National network in year 2000, and the second during the Second Latin American Congress on Ultraviolet Radiation, with equipments from several countries.

CANADA

OBSERVATIONAL ACTIVITIES

The Meteorological Service of Canada (MSC), part of Environment Canada, is the Canadian government department responsible for atmospheric ozone research. Its column ozone and UV monitoring programme is based on Brewer spectrophotometer measurements made at nine sites.

UV Measurements

Broadband measurements
Narrowband filter instruments

Environment Canada does not support these measurement types.

Spectroradiometers

The Brewer Spectrophotometers at all Canadian column ozone stations also make spectral scans of the horizontal UV irradiance. The data are reported in the WOUDC data base. Some stations are now equipped with double monochromator versions of the Brewer (Mark III). The instruments are re-calibrated on a two-year refurbishment and re-calibration cycle and an active life cycle management programme is underway to replace the present network instruments with MK III Brewers at the rate of one per year.

CHILE

Chile is located on the extreme southwestern coast of South America. Several different scientific groups and institutions are engaged in the investigation of ozone depletion and ultraviolet radiation. The majority are studying changes in incident UV using several types of instruments, mostly broad band.

UV measurements
Broadband measurements

Instruments of the groups of research.

Instruments	Institution	Station	LAT. LONG.	Period of observations
Solar Light 501	University of Atacama	Arica	18S;70W	1998 - today
Solar Light 501	University of Santiago	Antofagasta	23S;70W	2000 - today
Solar Light 501	University of Santiago	Santiago	33S;70W	1999 - today

Solar Light 501	University Federico Santa María	Valparaíso	33S;70l.9	
Solar Light 501	University of Magallanes	Puerto Natales	51S;72W	1997 - today
Solar Light 501	University of Magallanes	Punta Arenas	53S;71W	1997 - today
Solar Light 501	University of Magallanes	Puerto Porvenir	53S;70W	1997- 2002
Solar Light 501	University of Magallanes	Puerto Williams	55S;68 W	1997 - 2004
Solar Light 501	University of Magallanes	Bernardo O´Higgins	63S; 57W	2005 -

Network of DMC.

Instruments	Institution	Station	LAT. LONG.	Period of observations
Pyranometer UVA-B	DMC	Iquique	20S;70W	1998 - today
Pyranometer UVA-B	DMC	La Serena	29S;71W	2003 - today
Pyranometer UVA-B	DMC	El Tololo	30S;70W	1997 - today
Solar Light 501	DMC	Valparaíso	32S;71W	2002 - today
Pyranometer UVA-B	DMC	Pudahel	33S;70W	1992 -today
Pyranometer UVA-B	DMC	Concepción	36S;73W	2002 – today
SUV 100	DMC	Valdivia	39S;73W	1998 - today
Pyranometer UVA-B	DMC	Puerto Montt	41S;73W	2001 - today
Pyranometer UVA-B	DMC	Coyhaique	45S;72W	2001 - today
Pyranometer UVA-B	DMC	Punta Arenas	53S;70l.9	2001 - today
Pyranometer UVA-B	DMC	Base Presidente Eduardo Frei	62S;58W	1992 - today

Narrowband filter instruments

Instruments	Institution	Station	LAT. LONG.	Period of observations
GUV 511	University of Chile	Santiago	33S; 70W	1995 - today

GUV 511	University Austral	Valdivia	39S;73W	1995 - today
GUV 511	University Magallanes	Punta Arenas	53S;70l.9	1993 - today
NILU UV	University Magallanes	Base Prof. Julio Escudero	62S;58W	2005 -

Spectroradiometers

Instruments	Institution	Station	LAT. LONG.	Period of observations
SUV 100	University Austral	Valdivia	39S;73W	1997 - today
Brewer MKIII 180	University of Magallanes	Punta Arenas	53S;70.9W	2002 - today

Calibration activities

The instruments of the DMC are compared and calibrated at least every two years in Valdivia. GUV 511 instruments are calibrated annually with a standard instrument sent from the factory and are part of the project Latin American, “Enhanced ultraviolet-B radiation in natural ecosystems as an added perturbation due to ozone depletion”. This project is directed by Maria Vernet (Scripps Institution of Oceanography, La Jolla, California) and financed by the Inter American Institute for Global Research, (IAI), this project concluded in 2004, is possible that a new project will be approved during 2005 and starting in 2006.

Both the Brewer and the SUV spectroradiometers possess self calibration mechanisms which are constantly checked and updated by the respective scientific group. Additionally, the Brewer is calibrated monthly with an external lamps to verify the stability of the measurements. The last calibration of the Brewer No.180 from the factory was in December, 2004. The instruments Solar Light of the group of the University of Magallanes are calibrated once per year with the instrument Brewer.

CZECH REPUBLIC

In the Czech Republic (CR) monitoring and research of ozone and UV-B solar radiation are mostly carried out in the Czech Hydrometeorological Institute (CHMI). Scientific activities are performed also by the Institute of Atmospheric Physics of the Czech Academy of Science and by the Department of Meteorology of the Charles University in Prague. While the monitoring is fully funded by the CHMI the research projects are supported also by grant agencies or by EC programmes. In recent years the extensive assistance has been provided by CHMI experts to the ozone part of the Global Atmosphere Watch Programme (GAW) of WMO.

UV measurements

Broadband measurements
The broad-band UV Solar Light-Biometers are operated at three CHMI stations (Hradec Kralove, Kosetice and Labska Bouda) that are located in typical climate and geographical regions of CR (lowlands, rural land and mountains). The observations are used for the UV public information system and for research activities - see next parts of this Report.

Narrowband filter instruments
No narrowband UV radiometers are currently operated in CR.

Spectroradiometers
Spectral measurements of UV-B solar radiation (298-325 nm) and calculation of erythemal DUV irradiances have been performed with the single (MKIV) and double (MKIII) Brewer spectrophotometers at SOO-HK since 1994 and 2004, respectively. The observations are accompanied by measurements of other auxiliary radiation fluxes (global, diffuse, reflected).

Calibration activities
The above mentioned instruments are regularly calibrated towardsr egional or world standards of the GAW calibration centres (RDCC-E, Hohenpeissenberg, MSC/IOS Brewer Triad) and they are operated according to SOPs defined in GAW manuals. Therefore the data sets are consistent with observations from other GAW stations and they are given in relevant world calibration scales.

DENMARK

Ultraviolet radiation

Daily measurements of the surface UV-B radiation are performed by DMI at Thule, using a high resolution spectroradiometer, since summer 1994. The instrument has been intercompared to a NIWA instrument to become NDSC classified.

EGYPT

UV measurements

Broadband measurements
EMA take the measurements of broadband UV solar radiation using Eppley Ultraviolet Radiometer at Cairo and Aswan since 1989. Also EMA in cooperation with SVU have been measured the broadband UV radiation at Qena since 2000.

Narrowband filter instruments

EMA measured the biologically effective solar UV-B radiation by UVB-1 Pyranometer at Cairo, Aswan since 1998 and at Rafaah (31.22ºN, 34.20ºE) since 2000. The measurements of the global UV-B are performed with the Brewer single monochromator for different solar zenith angles at Matrouh. Also EMA in cooperation with SVU have been measured the UV-B radiation at Qena since 2000. The present network of measurements of UV radiation at Egypt are shown in the table below.

Type of observation	Location	Org.	Instrument	Start
UV Radiation	Cairo	EMA	Eppley Radiometer	1989
	Aswan	EMA	Eppley Radiometer	1989
	Qena	SVU	Eppley Radiometer	2000
UV-B Radiation	Cairo	EMA	UVB-1 Pyranometer	1996
	Aswan	EMA	UVB-1 Pyranometer	1998
	Matrouh	**EMA**	Brewer No. 143	1998
	Rafaah	EMA	UVB-1 Pyranometer	2000
	Qena	SVU	UVB-1 Pyranometer	2000

ESTONIA

In Estonia, atmospheric total ozone and UV radiation monitoring began in 1994. The monitoring is carried out at the Tartu-Tõravere Meteorological Station (58˚.16'N, 26˚.28'E, 70 m a.s.l.) and the research work by the Department of Atmospheric Physics of the Tartu Observatory, located at the same site. The studies of atmospheric aerosols and atmospheric transmittance are also performed at the Institute of Environmental Physics of the University of Tartu. The Tartu Observatory has participated in the European Community EDUCE research project and is also taking part in the COST 726 activities.

INSTRUMENTS AND MONITORING

The Tartu-Tõravere Meteorological Station is the successor of the Meteorological Observatory of the University of Tartu, operating regularly since 1865. The first attempts to measure solar radiation at this station were made in the 1930s. Since January 1950, regular measurements have been performed outside the town and from 1965 the station has been at the present site. In 1999, the station was included in the Baseline Surface Radiation Network (BSRN).

At present the operating UV sensors are:
• Erythemally weighted: Scintec UV-SET (since 1998)
• YES UVB-1 (since 2005)
• PMA2200 used for calibration transforms (since 2003)
• UV-B narrowband (306 nm) Kipp&Zonen CUVB1 (since 2002)
• UV-A broadband UVSB2 (since 2002)

At two other stations - Tallinn-Harku (59˚24'N, 24˚36'E, 39 m a.s.l.) and Tiirikoja, (58˚51'N, 26˚57'E, 32 m a.s.l.) the narrowband UV-B sensors are installed and the Pärnu station (58˚23'N, 24˚30'E, 5 m a. s. l.) has a broadband UV-A sensor. Taking into account the previous experience of the exploitation the minispectrometers a minispectrometer AvaSpec-256 produced by *Avantes* company was obtained by the Tartu Observatory and is suited for the field measurements by adding necessary auxiliary equipment. Additionally, a teflon diffuser was made and studied for cosine response. A quartz fiber of 4 m length and 100 μm diameter connects the diffuser to the spectrometer. An UFS-5 glass optical filter was installed between the diffuser and fiber to reduce the scattered light inside the spectrometer and to guarantee the reliable recording of signal in the whole measured spectral region. For reliable recording of noise signals, the optical interface is automatically covered by a shutter before and after each measurement cycle.

The control of the sensitivity for the uniform recording of spectra is realized through the change of integrating time at the interval 1 to 60 s. In this way a maximum value of the signal approximately 16,000 arbitrary units is realized in each spectrum. For reducing the noise level the spectrometer is installed in a refrigerator and kept at the temperature of + 7˚C. Radiometric response of the system was established using the NIST (National Institute of Standards and Technology) traceable quartz FEL lamp.

The measurement process is fully computer-aided through a Linux programme. The control computer of the spectrometer is connected to the observatory web. Using the server it is possible to access any spectrum in a user-friendly form. It is also possible to track the measurements using any computer of the local web (http://sputnik.aai.ee) and also to have access to the archive of spectra.

FINLAND

UV measurements

Broadband measurements

FMI operates SL501 broadband instruments at six sites in Finland. These instruments provide on-line information on the erythemal irradiance that is published thru the internet along with the UV-Index forecast.

Narrowband filter instruments

FMI cooperates with Argentina and Spain on Antarctic ozone and UV. In 1999 the collaboration was extended to include UV radiation research. The established UV monitoring network consists of NILU-UV instruments in Marambio, Belgrano and Ushuaia. In Sodankylä a NILU-UV radiometer has been used to measure UV radiation of a reference field within a large field experiment of FUVIRC (Finnish Ultraviolet International Research Center).

Spectroradiometers

FMI has measured spectral UV irradiance with Brewer instruments in Jokioinen (Mark III since 1995) and Sodankylä (Mark II since 1990). Additionally, a new Bentham DM150 was recently acquired for campaign use.

Calibration activities

FMI has a dark room UV calibration facility both in Jokioinen and Sodankylä. FMI has participated several UV measurement comparison campaigns, there it has been established that the quality of Finnish Brewer measurements is excellent and steady. The Brewer instrument of Jokioinen served as one of the core instruments of the QUASUME project (Quality Assurance of Spectral Ultraviolet Measurements in Europe). FMI is also responsible for calibration of the Antarctic NILU-UV instruments and data quality assurance.

FRANCE

UV measurements

Broadband measurements at Dumont d'Urville (Antarctica)
Spectroradiometers at Villeneuve d'Asq and Briançon (France)

Calibration activities

NDSC intercomparison campaign of UV-Vis instruments in Norway, and ozone lidar intercomparison at OHP.

GERMANY

In accordance with Decision VCV/3: Recommendations of the fifth meeting of the Ozone Research Managers to the Parties of the Vienna Convention at Geneva in 2002, the following significant research and monitoring activities have been carried out since 2002 in Germany. Ozone-monitoring and related research in Germany is distributed over numerous institutions. Usually, there is no distinct separation between research and development, monitoring and quality control. In general, research is carried out at university institutes or at research centers (MPI, DLR, FZ-Karlsruhe, FZ-Jülich). Regular long-term monitoring of ozone outside the planetary boundary layer is provided by DWD and AWI, UV-monitoring by BfS, UBA and DWD.

Table 1: Overview of institutes involved in ozone/UV research (R), development (D), modeling (MD), monitoring (MT), quality assessment /quality control (QA/QC).

Institute	Location	Field	Keywords
Deutscher Wetterdienst, www.dwd.de/en/FundE	Hohenpeissenberg, Lindenberg	MT, R, QA/QC	Regional Ozone Center, DCC, NDSC, GAW
Alfred Wegener Institut für Polar u. Meeresforschung, www.awi-potsdam.de/ www.awi-bremerhaven.de/	Potsdam, Bremerhaven	R, MT, D	Neumayer, NyÅlesund, MATCH
Forschungszentrum Jülich,	Jülich	R, QA/QC, MD	Calibration O3-

www.fz-juelich.de/			Sonde, JOSIE, ClaMS
MPI f. Meteorologie (DKRZ), www.dkrz.de/	Hamburg	R, MD	ECHAM
DLR, DLR/DFD, www.dlr.de/ www.wdc.dlr.de/index.html	Oberpfaffenhofen	R, MD, MT, QA/QC	GOME, ECHAM, Air-Traffic
IAP Kühlungsborn, www.iap-kborn.de/	Kühlungsborn	R, D, MT	Middle Atmosphere, Alomar,
Bundesamt f. Strahlenschutz (BfS) www.bfs.de/	Salzgitter	MT	UV
Umweltbundesamt, www.umweltbundesamt.de/	Berlin	MT,	Air quality
Uni Bremen, IUP, IFE, www-iup.physik.uni-bremen.de/index.html	Bremen	R, D	GOME, SCIAMACHY, MICROWAVE
Uni Köln, Inst. f. Meteorologie, www.uni-koeln.de/math-nat-fak/geomet/	Köln	R, MD	EURAD,
FU Berlin, Inst. f. Meteorologie , strat-www.met.fu-berlin.de/	Berlin	R, MT	Stratosphere
Uni Frankfurt, Inst. f. Meteorologie, www.rz.uni-frankfurt.de/IMGF/meteor/klima/	Frankfurt	R, MT	CFC's
Uni Mainz, MPI f. Chemie , www.atmosphere.mpg.de/enid/2_html	Mainz	R, MD	ECHAM/CHEM
Uni Heidelberg, www.uphys.uni-heidelberg.de/	Heidelberg	R, QA/QC	DOAS
IMK, Forschungszentrum und Universität Karlsruhe www-imk.physik.uni-karlsruhe.de/	Karlsruhe, Garmisch-Partenkirchen (IfU)	R, D, MD, MT, QA/QC	FTIR, MIPAS, ENVISAT,
Uni München (LMU)	München	R, MD	UV, STAR
Uni Hannover, Inst. f. Meteorologie www.muk.uni-hannover.de	Hannover	R	UV

UV MONITORING

Germany's Meteorological Service (DWD) is running a very intense measurement programme at the Observatories Hohenpeissenberg and Lindenberg. In addition to the observational UV-network of the BfS (Table 2), DWD continues to measure UV-B radiation for research and development purposes. Both institutes provide the public with UV-information including daily forecasts of the UV-index (see below).

Table 2: Operational network for long-term measurements of UV.

Type of observation	Location	Org.	Instrument	Type	Start
UV	Garmisch	FZK	Bentham DTM 300		1994
	Hohenpeissenberg	DWD	Brewer MK II	No. 010	1991
	Lindenberg	DWD	Brewer MK IV	No. 078	1991
	Potsdam	DWD	Brewer MK II	No. 030	1993

	Potsdam	DWD	Brewer MK III	No. 118	1996
	Potsdam	DWD	Bentham DM 150		2000
	Potsdam	DWD	Spectro 320D		2002
	Dortmund	BAuA	Bentham DM150		
	Kulmbach	LfU	Bentham DM150		
	München	BfS	Bentham DM150		1993
	Langen	BfS	Bentham DM150		1993
	Schauinsland	BfS	Bentham DM150		1993
	Sylt	CAU	Bentham DM 300		1995
	Zingst	BfS	Bentham DM150		1993
	Zugspitze	FZK	Bentham DTM 300		1995

INDIA

UV measurements

Broadband measurements

Regular measurement of UV-B radiation by filter photometer were started in 1979 at National Physical Laboratory, New Delhi. At present under Indian Middle Atmospheric Programme (IMAP) a chain of 7 stations have been established for routine measurement of global UV-B radiation at 280, 290, 300 and 310nm using narrow band interference filters at Shillong (IMD), Jodhpur (IMD), Pune University (Pune), Andhra University (Waltair), Mysore University (Mysore) and Trivandrum (Center for Earth Science Studies). *UV-Biometer :* The measurement of Minimum Erythermal dose in the UV-B range started at Delhi in 1995 January and is continuing.

Narrowband filter instruments

India started using Narrowband filter instruments for measurement of radiation from July 1957 at 21 principal and 22 ordinary stations where continuous recording of global and defused solar radiances and bright hours of sunshine are measured. UV-A, UV-B and UV-Total measurement has also been introduced at all the stations to study the impact of climate on human health, agriculture productivity, ozone depletion etc.

Spectoradiaometers

The spectral measurements in the UV-B range at ½ nm interval started in 1989 and is continuing. The UV network is likely to expand and coordinate with international programme.

Calibration activities

UV measuring instruments have been calibrated by using monochromators and wherever possible by using brewer spectrophotometer.

IRAN

The meteorological organization and geophysics institute of the University of Tehran are conducting UV-B and ozone monitoring and research activities in Iran.

Generally, there is continuous cooperation and exchange of information between these centers and other research groups, such as the universities and related research institutes.

UV-B Measurement
UV-B is being measured at Esphahan station. UV is measured at spectral of 320 - 330 nm including UV-B.

ITALY

Italy is active in many areas of stratospheric research, including atmospheric processes, monitoring of ozone and UV levels, modeling of ozone and related species. Most of the research is performed by Universities and Italian Research Council's (CNR) groups, but also by other institutions (i.e., ISPRA, ENEA, Air Force Meteorological Service). In the last years, these research activities have been supported by the Italian Government, Italian Space Agency (ASI), European Space Agency (ESA) and European Union.

UV and ozone column measurements
Currently, there are more than 10 UV/total ozone monitoring instruments (Brewers, pyranometers, spectrophotometers, see Table 1). The operating agencies are ISPRA, ENEA, Italian Meteorogical Service, CNR, and several universities.

Table 1: Some of the Italian UV/total ozone monitoring instruments (Brewers, pyranometers, spectrophotometers).

INSTRUMENT	LOCATION
17 Brewer Mark IV	Modena
21 RB-501	Bolzano
22 Brewer Mark IV	Ispra
24 Bentham DM 150	Ispra
78 Brewer Mark IV	Rome
304 Brewer Mark IV	Vigna di Valle
305 Brewer Mark IV	Brindisi
306 Brewer Mark IV	Messina
Brewer Mark III	Lampedusa
UVB/UVA Pyranometer (YES)	Ispra
UVB/UVA Pyranometer (YES) UVB	L'Aquila
Pyranometer (YES)	Rome

JAPAN

In Japan, the Ministry of the Environment (MOE) and the Japan Meteorological Agency (JMA) play principal roles in monitoring atmospheric ozone, atmospheric constituents related to the depletion of the ozone layer, and surface UV-A and UV-B ultraviolet radiation. The MOE has been promoting coordination and cooperation among national institutes and universities through the Global Environment Research Fund (GERF) since 1990. The MOE also supports a programme to monitor global environmental changes on a long-term basis at the Center for Global Environmental Research (CGER) of the National Institute for Environmental Studies (NIES). The Ozone Layer Monitoring Office of the JMA coordinates observations, monitoring, and data processing of atmospheric ozone and surface UV-B radiation.

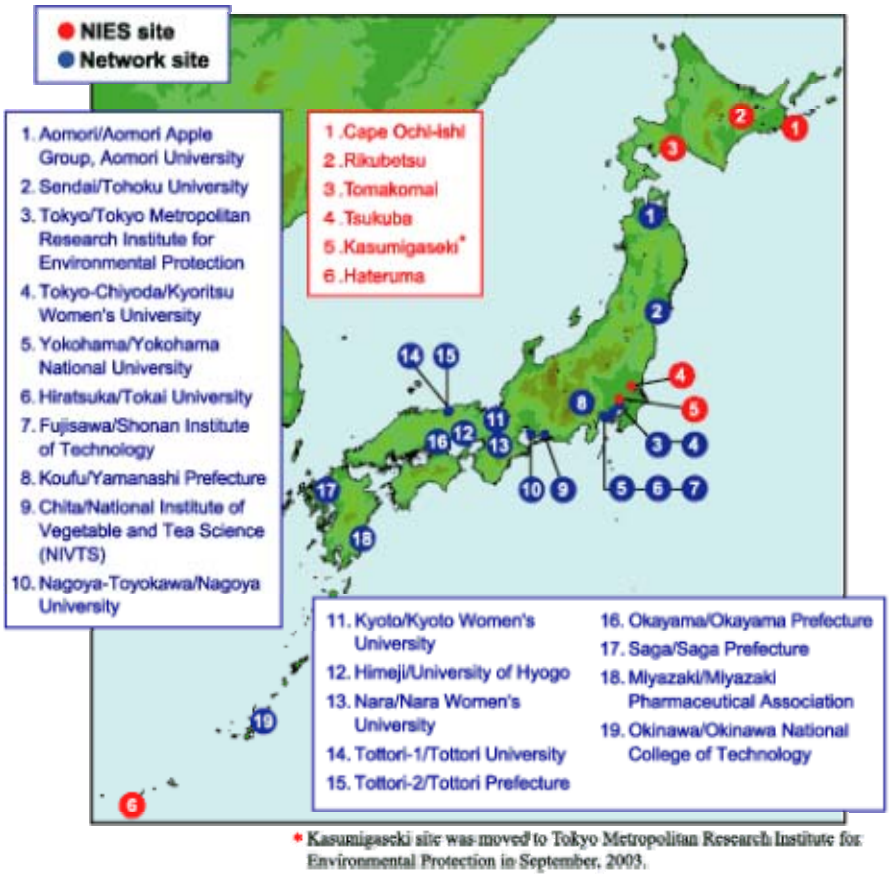
UV measurements

Broadband measurements

The CGER has been monitoring surface UV-A and UV-B radiation using broadband radiometers at 21 observation sites in Japan since 2000.

Spectroradiometers

The JMA observes surface UV-B radiation with Brewer spectrophotometers at Sapporo, Tsukuba, and Naha in Japan and at Syowa Station in Antarctica. The observations were started in 1990–1.



LITHUANIA

Observation Network

Lithuanian Hydrometeorological Service under the Ministry of Environment (LHMS) follows the standard programme of observations of the World Meteorological Organization recommendable for hydrometeorological services.

Ultraviolet solar radiation measurements have been carried out at Kaunas and Palanga (by the Baltic Sea) since 2000. Mean and maximum daily radiation is monitored using the UVBiometers type 501 A, version 3 (in Kaunas – UV-A and UV-B, in Palanga – UV-B).

Instrument calibration

The UV-Biometers have been calibrated by the LHMS Metrological Laboratory in 2005. Local standard meters were re-calibrated with a higher-class standard instrument in 2002 and should be re-calibrated again in 2006.

MALAYSIA

Observational Activities

The International Conference on Tropical Ozone and Atmospheric Change held in Penang, Malaysia in February 1991 underscore the lack of atmospheric ozone measurements and research in the equatorial region. Realizing the importance of developing countries in the tropics to play a more important role in the global initiatives to achieve a better understanding of the atmospheric changes and the effects on the environment linked to ozone changes, Malaysia has initiated its active involvement in the World Meteorological Organization (WMO) Global Ozone Observing System (GO3OS) with the launching of its ozone monitoring programme in October 1992. The ozone monitoring programme involves monitoring of ozone concentrations at the surface, the vertical distribution of ozone up to the stratosphere and total column ozone in the atmosphere.

Column Measurement of Ozone/UV

Total column ozone and UV spectral measurements in Malaysia began in 1992 using the Sci Tec Inc. Brewer Ozone Spectrophotometer Mark II, instrument number 090 at the Petaling Jaya Station, Petaling Jaya Meteorological Station (Lat. 03 deg.06' N, Long. 101 deg. 39' E, elevation 45.7m above MSL). This is the only regular long term total column ozone monitoring site in Malaysia.

Calibration Activities

The Brewer Spectrophotometer is calibrated by International Ozone Services of Canada. The calibration is performed every two years. Quality assurance and quality control procedures are strictly adhere to during ozone sounding and surface ozone measurements.

MOROCCO

Introduction

Casablanca is the biggest city in Morocco. It's located at 7,7° West and 33,6° North. Its climate is soft. Casablanca is a city which has evolved very quickly, its automobile park represents almost 50% of the national park and its industry represents 60% of the whole national industrial activity. The number of inhabitants in Casablanca is now about 4 millions. But each day, there is many cars and trucks which enter to Casablanca and many individuals who come to the city, from other small cities, for their work. This situation, with others, made of Casablanca a locality very polluted. Obviously, this pollution can affect the measurement accuracy. Casablanca is also a coastal city and breeze is a mechanism which attenuate the pollution concentration in the city.

In Casablanca, the Ozone measurement began on 1969. Until now, three instruments

have been used for that purpose: Dobson (1969-1989); Brewer MKII (1989-1993); Brewer MKIII (2000-…). Unfortunately, all over this period, no calibration test has been done.

MEASUREMENTS

Brewer MKIII period (2001-…);
This period began on late 2000. The instrument measures the SO2 concentration and the UV radiation also. The measurements are continuous and it's an easy to use instrument. Obviously it keeps the same limitations as its ancestor.

NETHERLANDS

Observations at KNMI in De Bilt, Netherlands, (52.10N, 5.18E)
Brewer MKIII Spectrophotometer:
• Total ozone, continuous observations since 1994.
• Data deposited at WO3UDC.
• Near-real-time data "WMO Ozone Mapping Centre" and WO3UDC
• UV scans, about once per hour since 1994.
• Data deposited at EDUCE database
• Aerosol optical depth (experimental product)
Research and applications
• Validation of ozonesonde and satellite observations
• Radiative transfer model studies
• UV exposure estimations by RIVM
• Calibration of UV-index forecasts
• Algorithm development for global UV index forecast

Observations at the Suriname Meteorological Service (MDS) in Parmaribo, Suriname, (5.81N, 55.21W).
Brewer MKIII Spectrophotometer:
• Continuous total ozone and UV scans, plus Umkehr at dusk and dawn: since April 1999.
• Data deposited at NDSC, WO3UDC databases
• Near-real-time data "WMO Ozone Mapping Centre" and WO3UDC
Research and applications
• Validation of ozonesonde and satellite observations
• Radiative transfer model studies
• Calibration of UV-index forecasts
• Algorithm development for global UV index forecast

NEW ZEALAND

Observational Activities

In New Zealand, most ozone and UV related research is undertaken by the National Institute of Water and Atmospheric Research (NIWA), a Crown Research Institute (CRI), at research centres at Lauder and Wellington. The site at Lauder is the southern hemisphere midlatitude charter site in the Network for Detection of Stratospheric Change (NDSC). Several other CRIs have programmes to monitor changes in biologically damaging UV radiation (e.g., Industrial Research, LandCare, AgResearch), some of which are conducted in collaboration with NIWA. The Physics and Astronomy Department at the University of Canterbury also contributes to ozone related research while the Department of Preventive and Social Medicine at the University of Otago researches epidemiological aspects of excess UV radiation exposure. This research is funded primarily through the Foundation for Research Science and Technology (FRST), but with considerable funding coming from international contracts and also from commercial activities such as providing research products and instrument development.

UV-visible spectrometers

UV-visible spectrometers at Arrival Heights, Macquarie Island (54.5oS, 159.0oE), Lauder, Mauna Loa (19.5oN, 155.6oW), Tarawa (1.5oN, 173oE), and Kiruna (67.8oN, 21.1oE) measure total column ozone. These spectrometers are also used to measure slant column NO2 over Kiruna, Japan, Hawaii, Tarawa, Lauder, Macquarie Island and Arrival Heights, BrO over Kiruna, Lauder and Arrival Heights, and OClO over Kiruna and Arrival Heights.

UV measurements

Spectroradiometers

Since late 1990, surface spectral UV irradiance has been measured routinely at Lauder. Scans are made at 5 degree steps in solar zenith angle, and at 15 minute intervals over the midday period. The spectral resolution is 0.6-0.8 nm, and data cover the range 285 to 450 nm in 0.2 nm steps. Similar spectral measurements have been undertaken in collaboration with NOAA/CMDL at two sites in the USA (Mauna Loa Observatory, Hawaii, and Boulder, Colorado); with the Australian Bureau of Meteorology at three sites in Australia (Melbourne, Alice Springs and Darwin); and with the University of Tokyo at one site in Japan using weatherproof, temperaturecontrolled spectrometers. In addition to the measurements of spectral irradiance, measurements of actinic fluxes, more relevant for atmospheric chemistry, are now available from Lauder and Tokyo.

Broadband measurements

The spectral measurements are complemented by a wide range of broadband measurements and by all-sky images taken at 1 minute intervals to quantify the effect of cloud distribution and type on UV radiation. Broadband instruments which measure integrated UV with a response close to the erythemal action spectrum, are operated by NIWA at several sites in New Zealand (Invercargill, Lauder, Leigh, Paraparaumu, Christchurch) and in the Pacific (Cook Islands – Rarotonga and, Fiji). Because of mismatch between instrument sensitivity and erythemal response, corrections which depend on solar elevation and ozone are applied to these broadband instruments.

Dosimeter badges for measuring personal exposures of UV have been developed in collaboration with the University of Canterbury. Similar sensors have been used in UV displays which have been deployed in public places and outdoor sporting events.

Narrowband filter instruments Since late 2002, the US Department of Agriculture have been undertaking complementary measurements of UV radiation at Lauder using multi-filter rotating shadow band radiometers. This pro-vides a direct linkage between the UV climatologies of New Zealand and the USA.

Calibration activities
The NIWA UV spectrometers represent the state-of-the-art, and have participated with distinction at an international intercomparison campaign in the USA, and have been used to certify instruments for acceptance by the Network for Detection of Stratospheric Change. During a measurement campaign at Lauder, the NIWA spectrometers were cross calibrated against a European reference instrument that measured spectral radiances as well as irradiances.

NIGERIA

Environmental problems emanating from ozone depletion and other sources have always been of great concern to the government and people of Nigeria. As the regional and global atmospheric pollution problems continue to assume a wider dimension, putting a high population at risk and seriously threatening the ecosystems, various programmes have been embarked upon in Nigeria to address these problems. Succeeding governments have implemented existing policies on environmental issues and formulated new ones in line with global programmes designed for the achievement of a friendly and sustainable environment. This commitment to environmental issues by the government led to the signing and ratification of the Montreal Protocol on substances that deplete the ozone layer by Nigeria on the 31st of October, 1988. Monitoring and research on ozone, UV radiation and related atmospheric constituents are carried out by different institutions in Nigeria. The aim is to support government policies on environment and thereby contribute positively to the implementation of the Vienna Convention for the protection of the ozone layer and its Montreal Protocol, as well as the United Nations Conference on Environment and Development in 1992 which emphasized the need for global understanding and proposed corrective actions in several areas of global environmental change, among them the effects from changes in the ozone layer. The increasing involvement of these institutions has greatly enhanced the development of the national programme on ozone monitoring and research in Nigeria.

UV Measurements
Apart from the GAW stations in Lagos and Oshogbo, NIMET has commenced measurements of surface UVB and Solar radiation at several locations in Nigeria.

The automatic weather stations that measure these parameters and some meteorological variables were set up as part of the implementation of the Agency's programme on studies relating to the effects of UV-B on human health and the ecosystems. The UV is measured with silicon photodiode sensor.

NORWAY

Ozone monitoring and related research in Norway involves several institutions and there is no distinct separation between research and development, monitoring and quality control. The following significant research and monitoring activities have been carried out in Norway since 2002.

Observational Activities

The Norwegian Pollution Control Authority established the programme *"Monitoring of theatmospheric ozone layer"* in 1990, which at that time only included measurements of total ozone. The Norwegian UV network was established in 1994/95 and consists of eight 5-channel GUV instruments located at sites between 58°N and 79°N. In addition the observational activities include ozone lidar and ozonesonde measurements. Table 1 gives an overview of the location of the various stations, the type of measurements, and the institutions responsible for the daily operation of the instruments at the different sites.

UV measurements

Narrowband filter instruments

The instruments in the Norwegian UV network are designed to measure UV irradiances in 4 channels. Using a technique developed by *Dahlback (1996)*1, we are able to derive from the raw data total ozone abundance, cloud cover information, complete spectra

Table 1: Overview of the locations and institutes involved in ozone and UV monitoring activities in Norway

Station	UV	Total ozone	Ozone profiles	Lidar	Sondes	Institute
Landvik, Grimstad, 8°N	x					Norwegian Radiation Protection Authority
Blindern, Oslo , 60°N	x	x				University of Oslo Norwegian Institute for Air Research
Østerås, Bærum, 60°N	x					Norwegian Radiation Protection Authority
Bergen, 60°N Kise,	x					Norwegian Radiation Protection Authority
Mjøsa, 60°N	x					Norwegian Radiation Protection Authority
Trondheim, 63°N	x					Norwegian Radiation Protection Authority
Ørlandet, 63°N					x	Norwegian Institute for Air Research
Andøya, 69°N	x	x	x			Norwegian Institute for Air Research /Andøya Rocket Range/FFI*
Ny-Ålesund, 79°N	x	x				Norwegian Institute for Air Research

* Norwegian Defence Research Establishment

from 290 to 400 nm, and biologically weighted UV doses for any action spectrum in the UV. In November 2004, NILU installed a NILU-UV radiometer at the new Norwegian research station, Troll, in Antarctica. The instrument was brought back to Norway in March 2005 to participate in the intercomparison of multiband filter radiometers (MBFR) at NILU (the FARIN campaign described in section 5). The NILU-UV instrument will be reinstalled at the Troll station in November 2005 and will be calibrated every year against a travelling standard. The NILU-UV measurements at the Troll station will be traceable to the Norwegian UV network through yearly calibration of the reference instrument at the Norwegian Radiation Protection Authority.

Spectroradiometers
Spectral UV irradiances (both direct and global scans) are measured daily with Brewer instruments at Department of Physics, University of Oslo and at ALOMAR. There have also been campaigns with global spectral measurements in the wavelength range from 290-450 and collection of data from periods in 2001, 2002, and 2003. In 2005 there were campaigns with direct and diffuse spectral measurements.

Calibration activities

The Brewer instruments
The Brewer instrument at the University of Oslo has been in operation since summer 1990, while Brewer operations in North Norway started in 1994. The International Ozone Services, Canada, calibrates the Brewer instruments in Oslo and Andøya on a yearly basis, and the instrument are regularly calibrated against standard lamps in order to check their stability. The calibrations show that the Brewer instruments have been stable during the 11 years of observations. The total ozone measurements from the Oslo Brewer instrument agree well with the Dobson measurements.
The GUV instruments
The Norwegian FARIN project, described in section 5, included a major international UV instrument intercomparison. All in all 51 UV radiometers from various nations articipated, among them 39 multiband filter radiometers (MBFR's). The instruments were also characterized on site. Beside measurements of spectral responses, measurements against QTH lamps and of the cosine responses were done for a selection of instruments. The data are available on the ftp serverzardoz.nilu.no at NILU. The directories are /nadir/projects/other/farin/rawdata
and nadir/projects/other/farin/processed.

PANAMA

UV measurements
At the three sites of the National Radiometric and Meteorological Network, Ultraviolet B radiation is measured in a continuous way, by means of broad band UV-B meters, model 501 UVBiometers, manufactured by Solar Light Co. At sites 1 (Panama City) and 2 (David City), global solar radiation and other atmospheric parameters are being measured. Global solar radiation is measured by means of Pyranometers Eppley**,**

model PSP and Pyranometers Kipp and Zonen. For the monitoring of the rest of atmospheric parameters, Campbell meteorological stations has been installed at sites 1 and 2. At site N° 3 (Santiago City), only UV-B radiation is measured up to now. We are planning to install another Campbell meteorological station at site N°3 on October 2005. The three monitoring sites with their respective coordinates are as follows:

National Radiometric Network				
Site	Location	Latitude	Longitude	Elevation
1	Main Campus of the	8° 59' N	79° 32' W	50 msnmm
	University of			
	Panama			
2	David City	8° 24' N	82° 25' W	27 msnmm
3	Santiago City	8° 6' N	80° 25' W	140 msnmm

At site N° 1, the monitoring process was initiated on July 1997. At site N° 2, the monitoring process was initiated on December 2001. At site N° 3, the monitoring process was initiated on March 2002. Radiometers and other sensors store data every five minutes, in a continuous way. Data from the three monitoring sites are downloaded from the Laboratory of Atmospheric Physics (Main Campus) through INTERNET by means of a software called PC ANYWHERE. Raw data is then processed, using statistical and graphical software.

Actually, the Radiometric Network administered by the Laboratory of Atmospheric Physics covers one site at the central part (Santiago City) of the Republic of Panama and two sites at the Pacific coastline (Panama City and David City). Up to now, the Laboratory of Atmospheric Physics has no monitoring site at the Caribbean coastline.

Calibration activities

All radiometers and other sensors are calibrated each year. Calibrations have been performed by Solar Light Co and by the Solar Radiation Observatory, at the UNAM, Mexico.

PARAGUAY

UV Observations

Broadband UV observations are made at the Faculty of Exact and Natural Sciences in the University Campus ofSan Lorenzo. The maximum value is of the order of 1800 mW/m2, and is had around the 12:00 hs local. The instrument is a Piranómetro UV, YES Model UV-B 1, which also measures the biological effectiveness of solar radiation UVB. First calibration was made in the Meteorological Service of Canada (1996). One second calibration in situ was made by investigators of the Meteorological Service of Spain in 1997.

PHILIPPINES

Observational Activities

On-going Monitoring Activities

In the Philippines, regular monitoring of total ozone and UV-B is conducted by the PAGASA using the Brewer Ozone Spectrophotometer and Dobson Spectrophotometer. Ozone monitoring activities are located at the PAGASA Science Garden Complex in Quezon City (14.6500 ºN, 121.0500 ºE).

Daily measurements of total ozone in the Philippines are being carried out at the local ozone-observing network since late 1970's. Monitoring of atmospheric ozone and related parameters (e.g. UV solar radiation) are performed as a contribution of PAGASA to the Global Atmosphere Watch Programme (GAW) of the World Meteorological Organization (WMO). An automated Brewer spectrophotometer (# 127) measures both direct sun and zenith sky measurements several times per day. The Brewer instrument is calibrated with respect to the travelling standard #017 of the Atmospheric Environment of Canada (AES). The Brewer instruments are programmed to make total ozone measurements on the sun and/ on the zenith sky. The Brewers also make Umkehr measurements of the ozone vertical profile and spectral scans of the horizontal UV irradiance. Measurements using Brewer Spectrophotometer started in late 90's.

UV Measurements

At the moment we do not have broadband measurements or narrowband filter measurements for UV-radiation monitoring. Such kind of regular measurements are very essential to be developed in our country, but again there is a shortage of funds. What we have right now is a Brewer spectrophotometer which measures UV radiation on a daily basis.

Calibration Reports

Brewer #127

Int'l Ozone Services (IOS) completed the calibration and service of Philippines Brewer #127 during period March 16-20, 2005. This project was to be supported by the World Meteorological Organization (WMO). The instrument has been out of service for the past 5 years due to azimuth tracker power supply failure. The standard lamp (SL) ratios had increased from values of 2160/4420 to 2340/4835 and sensitivity had dropped by ~40%. This large change normally means the PMT filter is deteriorating and probably will need to be replaced soon to stabilize the instrument. The ETC constants were adjusted to values 3580 / 4415 to get best agreement to #017. In the table and graph below are the direct sun daily means and results of #127 and #017 using final constants. Two Sun Scan (SC) test results showed that cal step of 295 was still proper.

UV Calibration:

The UV calibration was checked and the final response file (uvr07705.127) is recommended for future use. The initial UV calibration (uvr07605x.127) showed that the sensitivity had decreased ~40% and due to low counting rates.

POLAND

The ozone and UV-B monitoring and research activities, carried on in two INSTITUTES, are supported by: CHIEF INSPECTORATE FOR ENVIRONMENTAL PROTECTION; NATIONAL FUND FOR ENVIRONMENTAL PROTECTION AND WATER MANAGEMENT; MINISTRY OF THE ENVIRONMENT.

INSTITUTE OF METEOROLOGY AND WATER MANAGEMENT

UV Monitoring

• In July 1993 broadband UV Biometers model SL 501 vers. 3, have been installed at three stations in Poland: Leba (54.75N, 17.53E), *Baltic Coast,* Legionowo (52.40N, 20.97E), *Centre of Poland,* and in *Tatra Mountains:* Kasprowy Wierch 1989m (49.32N, 19.98E), operated until 1996, in 1995 a Biometer was installed at Zakopane 857m (49.30N, 19,97E).
• The reference UV Biometer model SL 501 for the IMWM network takes part in the intercomparison campaigns (Helsinki in 1995, Thessaloniki in 1999, Ispra in 2004).
• In 2000 two NILU-UV spectral filter instruments were installed at Legionowo, measuring the UV-B, UV-A, total ozone and optical depth.
• Since 2001 the NILU-UV spectral filter instrument has been regularly (yearly), calibrated at NRPA, Norway.

POLISH ACADEMY OF SCIENCES - INSTITUTE OF GEOPHYSICS

UV Monitoring

- Measurements are carried out at the Belsk Observatory (51° 50' N. 20° 47'E).
- The Brewer spectrophotometer is regularly calibrated. The recent calibration of Brewer instrument was calibrated against Brewer#17 maintained by International Ozone Corporation in 2005 at Hradec Kralove.
- Systematic measurements of ground level ultraviolet solar radiation (UV-B) with the Robertson-Berger meter have been carried out since 1975. In 1992 UV Biometer SL501A was installed. Spectral distribution of UV radiation has also been monitored with the collocated Brewer spectrophotometer.

RUSSIAN FEDERATION

UV measurements

The Lomonosov Moscow state University made monitoring of the surface UV radiation using the UVB-1 radiometer since 1999. The Brewer instruments located at the Yakutsk station and Obninsk were calibrated to measure the spectral distribution of the surface UV radiation. NPO “Typhoon” (Obninsk) uses Brewer instrument for regular monitoring of UV radiation.

Calibration Activities

The three Brewer instrument were calibrated by IOS Canada in 2003 and there is a grant from Ministry of education, science and technology of Russian Federation to realize calibration of four instruments on August 2005.

SLOVAKIA

Atmospheric ozone and UV-B monitoring is mainly conducted by the Slovak Hydrometeorological Institute (SHMI). Research is mostly carried out by the Geophysical Institute of the Slovak Academy of Sciences (GISAS).

UV measurements

Broadband measurements

At present the Slovak UV-B network consists of five stations. Four of them are equipped with SOLAR Light 501 UV Biometers. Three stations belong to SHMI (Kosice, 48.70N, 21.27E, 230 m altitude, in operation since 1997, Bratislava 48.17N, 17.12E, 287 m altitude, since 1998, Poprad-Ganovce, since 1999) and one station situated in mountains belongs to GISAS (Skalnate Pleso, 49.20N, 20.23E, 1778 m altitude, since 2001). GISAS also measures the global ultraviolet radiation with Eppley UV-radiometer model TUVR for the wavelength range 290-385 nm located at Stara Lesna (49.15N, 20.29E, 808 m altitude, in operation since 2002).

Narrowband filter instruments

No UV narrowband instruments are installed at SHMI and GISAS stations.

Spectroradiometers

Spectral measurements of the solar UV-B radiation (in the region 290-325 nm at 0.5 nm increments) have been performed with the Brewer spectrophotometer at Poprad-Ganovce since August 1993. Observations are scheduled at regular time intervals. Poprad-Ganovce is GAW regional station for spectral UV-B monitoring.

Calibration activities

The Brewer No.097 is regularly calibrated against World Travelling Standard Brewer No.017 every two years. Since the last Meeting of the Ozone Research Managers the instrument has taken part in two international comparisons and calibrations (Warsaw 2003, Hradec Kralove 2005).

The CAOM maintains the SL 501 UV Biometer designated as the national reference instrument. The instrument was compared with the Czech reference UV Biometer during the Brewer calibration campaign in Hradec Kralove in May 2005. In June all network UV Biometers in Slovakia were calibrated with the reference instrument.

UV-B data series from Bratislava (1997-2004) and Poprad-Ganovce (1999-2004) have been recalculated according to calibration results.

SOUTH AFRICA

Introduction And Observational Activities

The South African Weather Service (SAWS), an agency of the Government Department of Environmental Affairs and Tourism, is the national focal point of ozone monitoring and research activities in South Africa. These activities are greatly enhanced by collaboration with a few centers involved but mainly the Universities. The ozone monitoring and research activities are conducted within the context of the World Meteorological Organizations (WMO) Global Atmosphere Watch (GAW) programme. The Global Atmosphere Watch component of the South African Weather Service (SAWS), as part of its Public Good Service, are conducting certain specialized atmosphere monitoring and research services for the Department of Environmental and Tourism Affairs (DEAT), in order for the Department to fulfill its national, regional and international obligations. The Department has the responsibility for implementing the Montreal Protocol and facilitates the coordination role with industry. South Africa is dealing effectively with its commitments under the Protocol.

Ultraviolet-B measurements

Since January 1994 the Weather Service has maintained a routine programme for monitoring erythemally weighted UV-B radiation at Cape Town (34.0S, 18.6E), Durban (30.0S, 31.0E) and Pretoria (25.7S, 28.2E), De Aar (30.7S, 24.0E) and Port Elizabeth (33.9S, 25.5E). The equipment used in this network is the Solar Light Model 501 Robertson-Berger UV-Biometer. The programme was motivated by and in collaboration with the School of Pharmacy at the Medical University of Southern Africa (MEDUNSA), near Pretoria.

Since December 2001, the UV-Biometers are directly linked on the Services wide area network, and available in real-time on the SAWS WWW-site. UV-B forecasts are also issued for the Cape Town, Durban and Pretoria-Johannesburg metropolitan areas since 1 December 1997.

The main purpose of the UV-Biometer network is to make the public aware of the hazards of excessive exposure to biologically active UV-B radiation, and it contributes to the schools awareness programmes for education. Regular enquiries from scholars are dealt with to satisfy their need to acquire more ozone and ultraviolet radiation knowledge. Two UV-B narrow-band (~306nm) Kipp & Zonen sensors are located at the two Dobson sites to investigate possible trend correlation between ultraviolet radiation and total ozone. Great strides have been made to develop our own numerical weather predictions outputs for UV indices.

SPAIN

Observational Activities

Continuous ozone, UV radiation and related atmospheric compounds monitoring and research is mainly conducted by the Instituto Nacional de Meteorología (INM) and the Instituto Nacional de Técnica Aeroespacial (INTA). The Departments of Physics and Meteorology of several Spanish universities do research on ozone and UV. Most of the

national actions are financed by the National R+D Plan of the Ministry of Education and Science

Brewer spectrophotometer national network

INM operates a national Brewer spectrophotometer network (Figure 1 and Table 1), partially financed by the National R+D Plan of the former Ministry of Science and Technology. The Brewer at the "El Arenosillo" station, financed by the Andalusian Regional Government, is managed by INTA. This network provides total ozone and spectral UV that is real-time monitored through the INM's intranet. Since November 1999 the Brewer network has performed a common measurement schedule (ozone and spectral UV) on a daily basis. This information is stored and validated in the centralized INM database.

The Antarctic UV-VIS network

In the framework of several projects financed in previous convocations of the National R+D Plan of the Ministry of Science and Technology, three UV-VIS spectrometers (EVA) designed and developed at INTA to measure column NO2 and O3 were installed at the permanent Argentinean bases of Belgrano (77º 52' S 34º37' W), Marambio (64º 14' S 56º37' W) and Ushuaia (54º 48' S 68º19' W), respectively, in 1994. The selected stations are scientifically interesting for the study of polar atmosphere as the southernmost, which is Belgrano, is mostly located inside the vortex, Marambio on the edge, and Ushuaia right outside the vortex. A new UV photodiode array 240 spectrograph from INTA has been installed in October 2002 in Marambio (Antarctica) to retrieve zenith column amounts of BrO, OClO.

The main objective of this network is to provide both long term and near real-time observations of column O3 and NO2, in order to characterize the polar vortex. A description of the network, including instruments and stations, as well as the results of this network can be found at http://www.inm.es/mar

UV measurements

Broadband measurements

A national UVB broadband network of 17 Yes-pyranometers (Figure 1), managed by INM, has been fully operational since July 1999. This network has been partially financed by the National R+D Plan. The group of photobiology and algae biotechnology of the Ecology Department at Malaga University manages the "UVIFAN" UV network, based on broadband Eldonet (European Light Dosimeter Network) radiometers, in the Andalusia region. This network has been financed by the 241 EC FEDER 1FD97-0824 Project. Detailed information of this network can be found at http://uvifan.scai.uma.es/ INTA is collaborating with the Institute of Aerospace Medicine from DLR on solar UV dosimetry by biological sensors (biofilms @). The collaboration covers the measurement campaigns at different locations in Spanish and German territory and the improvement of data analysis (image treatments, unattended exposure devices, etc).

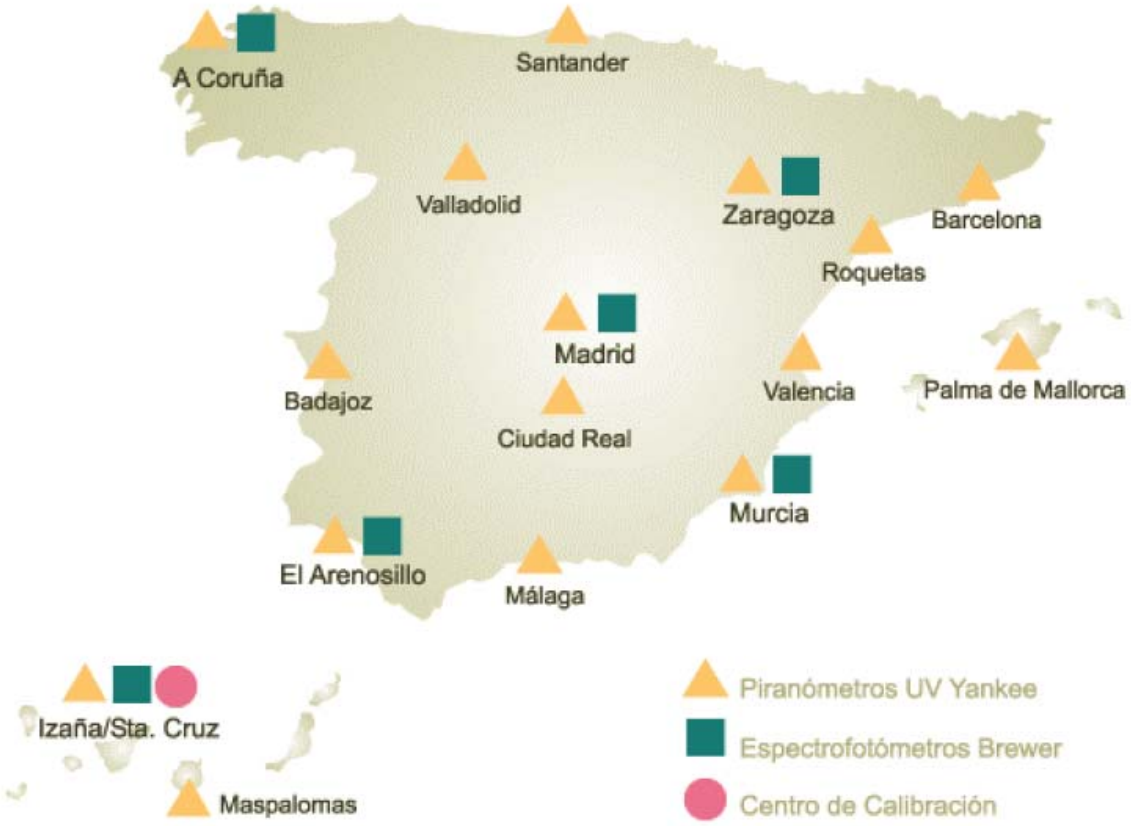


Figure 1: National UV broadband radiometer and spectrophotometer network.

Narrowband filter instruments

Three multi-channel narrow-band radiometers (NILU-UV6) were installed by INM in the UV-VIS Antarctic stations (see section 1.1.3) in 1999, thanks to the existent agreements of scientific collaboration between INTA, INM, Dirección Nacional del Antártico (DNA/IAA) and Centro Austral de Investigaciones Científicas (CADIC, Argentina). A fourth NILUT-UV-6 runs on a continuous basis at the GAW Izaña Observatory. The NILU-UV6 instruments measure global radiation at five UV channels and PAR. A radiative transfer model is used to calculate the total ozone content, cloud transmittance and the biologically effective UV doses. These instruments are part of the Spanish Antarctic network that has been coordinated in the framework of the joint INTAINM's "MAR" (Measurement of Antarctic Radiance for monitoring the ozone layer; REN2000-0245-C02-01) and on-going EGEO ("Estudio de la GEnesis del agujero de Ozono y sus implicaciones sobre la radiación UV"; Reference CGL2004-05419-C02-02ANT, financed both by the R+D National Programme.

The Finnish Meteorological Institute (FMI) is in charge of the NILU radiometers' quality assurance system performing intercomparisons twice a year with a travelling reference NILU.

The main objective of this network is to provide both long term and near real-time observations of column O3 and UV radiation in order to characterize the polar vortex.

Spectroradiometers

UV scans every 20 minutes have been obtained at the Izaña GAW Observatory from the Brewer spectrophotometers since May 1991. A double spectroradiometer Bentham DM-150, installed in March 1999 at the GAW Izaña Observatory, provides global and diffused UV radiation scans every 15 minutes. This is one of the national UV reference instrument. Since June 2005 is also obtained direct sun UV scans. The Department of the Fundamental Physics of La Laguna University, in collaboration with INM, operates a double Bentham DM-150 spectroradiometer at the Izaña Observatory headquarters (SCO; sea level) in Tenerife. A comparison of the UV and visible spectra obtained from this spectroradiometer with those obtained at the Izaña Observatory (2400 m a.s.l.) have been used to study the connection between UV radiation and radiative properties of the atmospheric aerosols and clouds.

Episodic UV spectra are obtained by the Universities of Barcelona (Bentham DM-300), Valencia (Optronics and LICOR), Valladolid (LICOR) and la Laguna (Bentham and Optronics). Most of the measurements are used in investigations concerning the relationship between aerosol optical depth and spectral UV radiation.

Calibration activities

The WMO/GAW Regional Brewer Calibration Centre for RA-VI region (RBCC-E)

In November 2003 the WMO/GAW Regional Brewer Calibration Centre for RA-VI region (RBCC-E) was established at Izaña Observatory (IZO) at Tenerife (Canary Islands). The project is also intended to contribute to the GAW Programme in the RA-VI Region as a part of the closer co242 operation between WMO and the European Commission being stated in the Memorandum of Understanding signed by WMO and EC in December 2003. IZO is located in subtropical region (28ºN) on the top of Izaña Mountain (2370 m.a.s.l.) with pristine skies and low ozone variability. This location allows routine absolute calibrations of the references in similar conditions to the Mauna Loa Observatory (MLO) site. The RBCC-E reference is based on three double Mark-III Brewer spectroradiometers (the IZO triad): a Regional Primary Reference (B157), a Regional Secondary Reference (B185) and a Regional Travelling Reference (B183). The IZO triad is regularly sun calibrated by means of Langley method and by external lamps. The travelling reference ensures reference transference to the WMO-Region VI Brewer network. Though B157, B183 and B185 are routinely calibrated by Langley plots method, these absolute calibrations are not used for definition of a new calibration scale. The MSC triad is respected as the official reference of the GAW Brewer international scale. The establishment of the IZO triad allows the implementation of a self-sufficient European Brewer calibration system that respects the world scale but works as independent GAW infrastructure. The IZO triad is linked to the world reference MSC triad with yearly calibrations towards the Canadian travelling reference B017. Systematic extraterrestrial constants (ETC) have been obtained by Langley method with B157 from 1998 to 2002. A comparison against ETCs transferred by travelling B017 shows an agreement within 1% in this period. This excellent result means, first of all,

that IZO is an excellent site to assure independent absolute sun calibration for the Brewer network, and secondly that the process based on ETC transfer from MSC triad to the world Brewer network through the traveling reference B017, is very accurate. The function of RBCC-E also allows development and testing of new measurement techniques for the ground Brewer network like zenith, polarimetric, UV or aerosol optical depth measurements at IZO. A dark room and an electronic workshop are available at IZO for accurate fittings and indoors calibration and maintenance of the triad instruments.

Total ozone calibrations

The Brewers (#033 and #157) at the Izaña Observatory have been intercompared with the international travelling reference Brewer#17 every year since 1991. The Brewer#17 is routinely calibrated against the World triad (Meteorological Service of Canada). Other Brewers of the network are intercompared and calibrated every two years. Last three intercomparisons were held at the El Arenosillo station in September 1999, September 2001 and September 2003.

Spectral UV calibrations

Spectral UV Quality Control (QC) consists of 50W lamp tests at each station performed every 2 weeks. Spectral UV Quality Assurance (QA) is carried out every year using a portable 1000W lamp calibration system designed by Int'l Ozone Services Inc. (IOS, Canada). Primary standard lamps (NIST traceable) are located at the optical lab of the Izaña Observatory. Before and after the national calibration trip 1000W secondary standard lamps are calibrated against the primary ones.

UV Broadband instrument calibrations

A primary reference UV pyranometer, located at the Izaña Observatory, and a secondary portable reference UV pyranometer are kept just for the broadband UV network tests. The primary reference instrument participated in a broadband UV detector intercomparison organised by the LAP (Laboratory of Atmospheric Physics) of the Aristotle University of Thessaloniki (Greece) in September 1999. This intercomparison, carried out within the scope of the COST 713 action on "UV-B forecasting", hosted a total of 33 UV broadband detectors from 14 countries.

Comparisons of these pyranometers with double Brewer and Bentham spectroradiometers have been performed at the Izaña Observatory and at the El Arenosillo station. Three national UV and visible spectroradiometer intercomparisons were held at the El Arenosillo station (INTA) in September 1999, September 2001 and September 2003, respectively. Solar measurements and lamp calibrations were performed.

SWITZERLAND

UV measurements

The **Swiss Atmospheric Radiation Monitoring** programme (CHARM) consisting of 4

stations covering the altitude range of 366 to 3587 m.a.s.l was build up between 1995 and 2000.

The measurements programme consists of :
- *Broadband measurements:* the direct, diffuse and global components of the broad-band erythemal UV-ERY radiation (Solar Light UV-Biometers) are measured,
- *Narrowband filter instruments:* spectral direct irradiances are measured with Precision Filter Radiometers (PFR) at 16 wavelengths in the range 305 nm to 1024 nm.
Besides the direct measurements, the UV index, the AOD at various wavelengths as well as the Integrated Water Vapor (IW) are calculated from those data.

Spectral Brewer UV measurements
At Arosa, since 1994 spectral global UVB measurements are recorded with the Brewer instruments 072 on the range 290 nm – 325 nm. Since 1998, the Brewer Mark III 156 is in operation and it measures the range 286.5 - 363 nm.

Calibration activities
Regular calibration and maintenance are organised for the Arosa Brewers (every year) and Dobsons (every 4 years) traceable to the world standards for each instrument types.

The CHARM instruments are compared to reference instruments traceable to the world standards.

TURKEY

UV-B Observations
The B band of the ultraviolet radiation has been measured with an UV-B recorder named Model 501 in two one location, Ankara and Antalya (located on southern coast of Turkey and at 54 m. Altitude, 30° 44’ (E) Longitude and 36° 42’ (N) Latitude).

The UV-B observations were started on 3 January 1997 at Ankara, and on 21 May 1997 at Antalya. There is any problem on the UV-B time series of Ankara. However, time series of Antalya has some gaps and missing data. Uv-B recorder hasn’t work in Antalya from August 2003. But this year we are planning to establish new instrument.

UV-B data have never been evaluated climatologically and statistically because of the very short time series.

UNITED STATES OF AMERICA

UV Irradiance Measurements (SURFACE)

Broadband Measurements
SURFRAD Network

Seven Surface Radiation Budget Network (SURFRAD) sites operate Yankee Environmental Systems, Inc. (YES) UVB-1 broadband radiometers. The ISIS network of solar measurements includes broadband Solar Light 501 UVB biometers at each of nine sites. Other instrumentation (located at the Table Mountain test facility near Boulder, Colorado) includes a triad of calibration-reference YES UVB-1 broadband radiometers, and two calibration reference Solar Light 501 UVB biometers. Several other broadband UV radiometers also are operated at the Table Mountain site. These include a Scintec UV radiometer, two types of Kipp & Zonen broadband UV radiometers, an EKO UV radiometer, and a Solar Light 501 UVA biometer. (NOAA/SRRB) *CMDL Network* Supplemental measurements of UV-B using YES UVB-1 instruments continue at Boulder, Colorado and Mauna Loa, Hawaii, where high-resolution UV spectroradiometers also are operated and can be used to interpret accurately the broadband measurements. (NOAA/CMDL) *USDA UVB Monitoring and Research Programme (UVMRP).* Thirty-four YES UVB-1 radiometers are fielded under this programme (USDA)

Narrowband Filter Measurements

SURFRAD Network

Currently operating at the Table Mountain test facility in Colorado are a Biospherical Instruments GUV-511 UV radiometer, a Smithsonian 18-channel UV narrow-band radiometer, and two YES UV-MFRSRs. A YES UV-MFRSR soon will be deployed at the Central Ultraviolet Calibration Facility's High-Altitude Observatory at Niwot Ridge, Colorado. (NOAA/SRRB) *CMDL Network*

Narrowband radiometers (Biospherical Instruments, GUV, 305 nm, 313 nm, 320 nm, and 380 nm) are used at three sites in Alaska. These sites were established in 1998 and operated for about two years with initial funding, but have been operated in a minimal-maintenance mode since. One site was discontinued in 2003 when it was determined that the combination of on-site support and data communications problems were prohibitive. Initial and subsequent calibrations of the instruments have been performed by the manufacturer. Due to reductions in personnel and funding, since 2001 the instrument calibration schedules have been reduced and adequate quality control has not yet been applied to the data. (NOAA/CMDL)

USDA UVB Monitoring and Research Programme (UVMRP)

UV-MFRSRs deployed within this network measure total and diffuse horizontal and direct normal irradiance at 300, 305, 311, 317, 325, 332, and 368 nm with a 2.0-nm bandpass. (USDA)

NSF UV Monitoring Network

Biospherical Instruments (BSI) GUV-511 moderate bandwidth multi-channel radiometers are deployed at five of the seven network sites (McMurdo and Palmer Station in Antarctica, San Diego California, Barrow Alaska, and Summit Greenland). A BSI GUV-514 radiometer is deployed at the South Pole. (NSF)

Spectroradiometer Measurements

SURFRAD Network

A high-precision UV spectroradiometer and a UV spectrograph are located at the Table Mountain Test Facility in Colorado under the auspices of this programme. (NOAA/SRRB)

Network for the Detection of Stratospheric Change (NDSC)
State-of-the-art, high-resolution spectroradiometric UV observations are conducted as a part of the NDSC at several primary and complementary sites. In particular, U.S. collaboration with NIWA (New Zealand) enables such measurements at Mauna Loa, HI and Boulder, CO. The measurements at Mauna Loa were started in 1995, those in Boulder began in 1998, and they continue to the present. (NOAA/CMDL)

NSF UV Monitoring Network
BSI SUV-100 high-resolution scanning spectroradiometers are deployed at all seven network sites (McMurdo Station, Palmer Station, and South Pole Station in Antarctica; San Diego California; Barrow, Alaska; Summit, Greenland; and Ushuaia, Argentina). A BSI SUV-150B spectroradiometer is also deployed at Summit, Greenland. (NSF)

UV-Net Programme
Brewer Mark IV spectrometers that measure the spectrum between 290 and 325 nm are deployed at all 21 network sites located in 14 U.S. national parks and 7 urban areas around the U.S. (EPA)

Calibration Activities (Surface-based instruments)

SURFRAD Network
The Central Ultraviolet Calibration Facility (CUCF) is located in NOAA's David Skaggs Research Center in Boulder, Colorado. The CUCF calibrates more than 80 UV instruments per year for several U.S. Government agencies and other UV research concerns, both national and international. In addition to laboratory calibrations, the CUCF has developed a portable UV field calibration system that allows laboratory-grade calibrations to be made at spectroradiometer field sites. The CUCF also produces secondary standards of spectral irradiance that are directly traceable to NIST primary standards. The secondary standards can be calibrated for operation in either the vertical or horizontal orientation. (NOAA/SRRB)

USDA UVB Monitoring and Research Programme (UVMRP)
NOAA CUCF lamp calibrations performed in horizontal and vertical position using NIST traceable 1000-W halogen lamps are used to calibrate 48 USDA UV-MFRSRs and 46 UVB-1 broadbands. A U-1000 1.0-m double Jobin Yvon with 0.1-nm resolution and 10-10 out-of-band rejection is used as a reference spectroradiometer to transfer lamp calibration to a broadband triad. The UV-MFRSR radiometer spectral response and its angular response (critical for direct beam retrieval) are measured. The Langley calibration method is employed to provide additional absolute calibration of UV-MFRSRs and to track radiometric stability *in situ*. (USDA)

UV-Net Programme
Collocating ultraviolet radiation (UVR) monitors of different types (e.g., multifilter and

broadband instruments) is important for determining changing surface levels and their cause. This supports instrument calibration and data comparison among networks, and allows continuous data collection should an instrument temporarily fail. Currently, only three network Brewers are collocated with other UVR monitors. The Table Mountain Test Facility in Colorado is host to numerous UVR instruments for data intercomparison and calibration. While some instruments remain there for years, others are transported there annually for intercomparison and calibration. The EPA Brewer in Big Bend National Park is 47 kilometres from USDA's climatological station. The instruments at Big Bend have been compared since February 1997. Other UVR monitor collocations operate at Bondville, Illinois and Fort Peck, Montana with SURFRAD and USDA monitors. (EPA)

VIETNAM

Introduction

National Hydro – Meteorological Service of S.R. Vietnam (NHMS) have 3 ozone and UV-B observing stations. The observation is carried out since May1992 in Hanoi station (21001'N, 105051'E). From 1994, Sapa station (22o21'N, 103o49'E) and Tan Son Hoa station (10o47'N, 106o42'E in Ho Chi Minh City) also start observing regularly. All the management for the ozone and UV-B observation in NHMS is operated by the Aero – Meteorological Observatory (AMO).

Observational Activities

The Total amount of atmospheric ozone (TO3) and UV-B are measured by M124 filter instrument, manufactured in Russia. The TO3 is measured 7 times per day with the sun height is in between 20^{o} and 70^{o} . The UV-B is measured 11 times per days from 7h to 17h LT (within period of 1st May to 31st October), and 9 times per day from 8h to 16h LT (within period of 1st November to 30th April).

From 2002 to 2005, AMO have sent all M124 for calibration in GGO (Petersburg, Russia) 2 times, in July 2002 and in September 2004. Since the new filters of M124 were not available, so after the calibration few months, our M124 instruments could not give the data with high quality. Even though, all the 3 stations have to absorb TO3 and UV-B, following the National Guide for observation. AMO have sent 03 more instruments M124 for calibration but only coming September AMO would receive the calibrated one.

ANNEX 4
Historical UV Regional / National Networks for Nations
Not Represented in the 6th Ozone Managers Meeting
(Based on information from the Open Encyclopaedia)

Australia:

Overview
The Australian Radiation Laboratory has been measuring spectral UV radiation sporadically since 1984. The first radiometer started monitoring in Melbourne in 1986. Short term detection of ozone holes passing over southern Australian is readily seen in the data. The purpose of Antarctic monitoring is to understand the UV levels reaching researchers working in Antarctica.
The primary interest in these levels concerns human health effects. The measurements are used to support the cancer council's education program. The data are also released daily on news and weather reports to inform the public.
In conjunction with the UV monitoring efforts, Australia has developed a standard for rating the UV protective ability of clothing. All sunglasses sold in Australia must meet the Australian standards.

As of mid-1995, 10 Solar Light 501 biometers were being intercompared and calibrated. They were slated to be installed in the field around Nov. 1995. Capital cities were to be first to be fitted with these meters. 6 more Solar Light 501 biometers were planned for implementation at the beginning of 1996.
Paltridge and Ian Barton at CSIRO had a network of RB meters running in the 1970's.
Instruments

Melbourne instruments, with installation dates:
Eppley PSP Mar 86
Eppley TUV Mar 86
International Light UVB Mar 86
International Light Actinic NS270 (ACGIH) Mar 89
Spex 1680B (double monochromator) with labsphere integrated sphere takes measurements on clear days and identical Spex 1680B is portable to go to instrument intercomparisons and acts as a traveling standard. Mar 86
Solar Light 501 Dec 92

Brisbane instruments, with installation dates:
Eppley PSP 1989
Eppley TUV 1989
International Light UVB 1989
International Light Actinic NS270 (ACGIH) 1989

Mackay instruments, with installation dates:
Eppley PSP 1989

Eppley TUV 1989
International Light UVB 1989
International Light Actinic NS270 (ACGIH) 1989

Toowoomba instruments, with installation dates:
International Light UVB 1989 (no longer active?
Solar Light Erythemal UV Biometer
Solar Light UVA Biometer

Sydney instruments, with installation dates:
International Light UVB 1990
International Light Actinic NS270 (ACGIH) 1990

Perth instruments, with installation dates:
Eppley TUV 1990
International Light UVB 1990
International Light Actinic NS270 (ACGIH) 1990

Darwin instruments, with installation dates:
Eppley PSP 1990
Eppley TUV 1990
International Light UVB 1990
International Light Actinic NS270 (ACGIH) 1990

Alice Springs instruments, with installation dates:
Eppley PSP 1990?
Eppley TUV 1990?
International Light UVB 1990?
International Light Actinic NS270 (ACGIH) 1990?

Geraldton instruments, with installation dates:
International Light UVB 1989-92
International Light Actinic NS270 (ACGIH) 1989-92

Adelaide instruments, with installation dates:
Eppley TUV 1993
International Light UVB 1993
International Light Actinic NS270 (ACGIH) 1993

Canberra instruments, with installation dates:
Eppley TUV 1993
International Light UVB 1993
International Light Actinic NS270 (ACGIH) 1993

Hobart instruments, with installation dates:

International Light UVB 1990

Townsville instruments, with installation dates:
Eppley TUV 1993
International Light UVB 1993
International Light Actinic NS270 (ACGIH) 1993

Mawson instruments, with installation dates:
Eppley TUV 1989
International Light UVB 1989
International Light Actinic NS270 (ACGIH) 1989

Casey instruments, with installation dates:
Eppley TUV 1989
International Light UVB 1989
International Light Actinic NS270 (ACGIH) 1989

Davis instruments, with installation dates:
Eppley TUV 1989
International Light UVB 1989
International Light Actinic NS270 (ACGIH) 1989
Spex 1680B (double monochromator 1989

Macquarie Island instruments, with installation dates:
Eppley TUV 1989
International Light UVB 1989
International Light Actinic NS270 (ACGIH) 1989

Contact Information

Dr. Peter Gies
Australian Radiation Laboratory
Lower Plenty Road
Yallambie, Victoria 3085
AUSTRALIA

Dr. Colin Roy
Australian Radiation Laboratory
Lower Plenty Road
Yallambie, Victoria 3085
AUSTRALIA
(Colin Roy is in charge of all of the meters. They are run in cooperation with the individual organizations which maintain the instruments. Ten minute averages are collected throughout the daylight hours (5 AM to 9 PM) except in the antarctic where collection runs throughout the day.)

Dr. Alfio Parisi
Centre for Astronomy and Atmospheric Research

University of Southern Queensland
Toowoomba 4350 Australia

Austria:

Instruments

Spectral Monitoring with location, installation date and observation periods:

Bentham DM-150 Spectral Double-Monochromator Hoher Sonnblick 47.05N, 12.95E, 3106 m Jul 1995 Every 30 min
Brewer Hoher Sonnblick Aug 1993 Every 30 min

Contacts

Stana Simic
Institut fur Meteorologie und Physik
University of Agriculture, Forestry, and Renewable Natural Resources
Tuerkenschanztrasse 18
A-1180 Wien

Mario Blumthaler
Institute for Medical Physics of the University of Innsbruck
Muellerstr. 44
A-6020 Innsbruck

Bahrain:

Overview

Bahrain has a YES UVB-1 pyranometer operating at the Bahrain International Airport (26.12N, 50.39E) since July 1994. It is under the supervision of A. Majeed H. Isa., Chief of Meteorology at the State of Bahrain Ministry of Development & Industry. Data from the instrument are saved on an hourly basis. Recorded are the hourly maximum, minimum, and mean values of irradiance. These data are based on a polling frequency of five seconds.

UV monitoring is a new field for this organization. Although not required to monitor, they believe that UV monitoring is an important aspect of environmental monitoring and could prove useful in the long run to their agricultural and fishery industries. At present they have no plans to increase UV monitoring with the addition of more instruments.

Contact Information

A. Majeed H. Isa.
Chief of Meteorology
Bahrain International Airport

P.O. Box 586
Bahrain
Instruments

Instrument; Location; Date Installed; Contact Name

29 YES UVB-1 Bahrain Int. Airport July 1994 A. Majeed

Greece:

Overview
Monitoring in Greece is being conducted by two organizations in Greece: Aristotle University of Thessaloniki and the University of Athens. The scientists of the University of Thessaloniki in Greece have pioneered instrument intercomparisons of UV instruments. In addition to extensive monitoring in Greece, Aristotle University operates both a Brewer and a Yankee in Reykjavik. They have also established close collaboration and issue annual UV-B bulletins with Iceland, Poland and Hungarian UV-B networks. Aristotle University also participated in an instrument intercomparison in the Ispra, Italy in May 1995.

All measurements are global irradiance, with additional measurements of direct irradiance taken 5-9 times per day in Thessaloniki. There is also a LIDAR system for tropospheric aerosol measurements and an ozone soundings program at Thessaloniki. Turbidity measurements and cloud cover observations are available. A dark room with lamp calibration facilities is installed at LAP AUTH since 1994. Albedo measurements include columnar total ozone and SO2 amounts, long-path Differential Optical Absorption Spectrometers (DOAS), and a Canterbury Filter Photometer. Air pollution monitoring station and automatic two meteorological station (with speed, direction, temperature, and humidity). Other ancillary measurements of total global irradiance are made with the use of Kipp & Zonnen AC21 pyranometers at the stations of Thessaloniki, Kos, and Aktion.
Instruments
Aristotle University of Thessaloniki:
8 Brewer Single Mono. Thessaloniki Sep. 1989 every 5 deg.
9 Brewer Single Mono.
Instrument hosted by Met Service Reykjavik Nov. 1991 every 5 deg.
10a Brewer Double Mono. Thessaloniki May 1993 every 5 deg.
10b Brewer Single Mono. Pertouli April 1996 every 5 deg.
11 YES Global, Diffuse Thessaloniki Jun. 1991 1 min. ave.
12 YES Global Athens Apr. 1993 1 min. ave.
13 YES Global Kos Island Apr. 1993 1 min. ave.
14 YES Global Atkion Airport Jul. 1993 1 min. ave.
15 YES Global Reykjavik Aug. 1993 1 min. ave.
16 YES Global (Note: This instrument ceased operation as of Jan. 1996) Mount

Vermion Oct. 1993 1 min. ave.
218 YES Global Reference Inst. 1994 1 min. ave.
219 YES Global Crete 1996 1 min. ave.
Eppley TUVR UVA Global Thessaloniki 1981 1-10 min. ave.
Eppley TUVR UVA Global Reference Inst. 1989 Irr egular

University of Athens
220 Eppley UV pyranometer Athens 1984 1/2 hourly
221 Eppley UV pyranometer Inside Lab for intercalibrations 1984 1/2 hourly
222 Eppley UV pyranometer Top of Mountain (Athens) 1990 1/2 hourly
223 CECIL-1000 Spect. (Polysulfone films) Athens 1990 Daily for 18 hrs./day
224 Vilber Lourmat
VLX-3W Athens Dept. of Biology 1991 Daily at local noon
225 Vilber Lourmat
VLX-3W Athens Dept. of Applied Physics 1991 Daily at local noon
226 AFO3-UV Athens 1995 1 min. average 227 Irradiation Photo-test
Monochromator Athens 1979 1 min. average
228 Robertson-Berger Athen Medical Dept. 1988 Occasionally
229 Eppley UV pyranometer Argolida,Greece 1992 1/2 hourly
230 YES UV-B pyranometer Argolida, Greece 1992 Every min.
231 Eppley UV pyranometer Argolida, Greece 1992 1/2 hourly
232 CECIL-1000 Spect.
(Polysulfone films) Naxos Island, Apiranthos 1993 Daily for 18 hrs./day
233 CECIL-1000 Spect. (Polysulfone films) Crete, Heraklion 1994 Daily for 18 hrs./day
234 CECIL-1000 Spect. (Polysulfone films) Rhodes Island 1994 Daily for 18 hrs./day
235 CECIL-1000 Spect. (Polysulfone films) Corfu, Kerkira 1994 Daily for 18 hrs./day
236 CECIL-1000 Spect. (Polysulfone films) Thessaloniki 1994 Daily for 18 hrs./day
237 CECIL-1000 Spect. (Polysulfone films) Mytilene, Greece 1994 Daily for 18 hrs./day

International monitoring
AFO3-UV Spect. Hamburg, Germany 1995 1 min. ave.
AFO3-UV Spect. Dundee, Scotland 1995 1 min. ave.
AFO3-UV Spect. St. Petersburg, Russia 1995 1 min. ave

Contact Information

Prof. Christos S. Zerefos
Aristotle University of Thessaloniki
School of Science-Physics
Department Laboratory of Atmoshpheric Physics
Campus Box 149
Thessaloniki 54006
Greece

Ass. Prof. Alkiviadis F. Bais
Aristotle University of Thessaloniki
School of Science-Physics
Department Laboratory of Atmoshpheric Physics

Campus Box 149
Thessaloniki 54006
Greece

Asst. Prof. Costas Varotsos
University of Athens
Dept. of Applied Physics
Laboratory of Meteorology
33 Ippokratons Str.
10680 Athens
Greece

Hungary:

Overview

The Hungarian UV-B monitoring network is operated by the Hungarian Meteorological Service and includes four stations. The Budapest station is situated at the Budapest/Lorinc meteorological observatory where Dobson ozone measurements are also carried out. The K-Puszta station is located in a plain area at the Global Atmospheric Watch WMO station. The Kekesteto station is on the highest peak of Hungary. The Keszthely station is situated at the side of lake Belaton. This lake is a great summer-time tourism center, so the measurements at this location are of special importance. All stations use SL501s. An additional sensor is available which is assigned as a secondary standard.

Quality assurance and control of the network sensors is carried out by traveling of the national standard. To collect data a general purpose data acquisition system is used at each station recording 10 minute averages.

This monitoring network is part of the Joint Research Network of UV-B along with the following institutions:

Laboratory of Atmospheric Physics
Aristotle University of Thessaloniki, Greece

Centre of Aerology
Institute of Meteorology and Water Management, Poland

Icelandic Meteorological Office, Iceland

Instruments

322 Solar Light 501 Budapest, Lat.=47.43N, Lon.=19.18E Mar. 1994
323 Solar Light 501 K-Puszta, Lat.=46.97N, Lon.=19.55E Mar. 1994
324 Solar Light 501 Kekesteto, Lat.=47.84N, Lon.=20.17E Mar. 1994
325 Solar Light 501 Keszthely, Lat.=46.75N, Lon.=17.23E Mar. 1994

Contact Information

Dr. Zoltan Nagy
Institute for Atmospheric Physics
P.O. Box 89
H-1675 Budapest
Hungary

Dr. P. Nemeth
Institute for Atmospheric Physics
P.O. Box 89
H-1675 Budapest
Hungary

Zoltan Toth
Hungarian Meteorological Service
Division for Upper-Air Observations
P.O. Box 39
H-1675 Budapest
Hungary

Prof. Christos S. Zerefos
Aristotle University of Thessaloniki
School of Science-Physics
Department Laboratory of Atmospheric Physics
Campus Box 149
Thessaloniki 54006
Greece
Iceland:

Overview
UV monitoring has been performed by the Engineering Research Institute at the University of Iceland since June of 1991. The measurements cover 250-800 nm with one nm increment. They are performed automatically during at least April to October with a longest time interval of one hour. Iceland is a member of the Nordic Ozone Group (NOG) which coordinates research activities on ozone and ultra- violet radiation in the Scandinavian countries. The Meteorological Office in Iceland operates all of the instruments and cooperates actively with other international groups including the Aristotle University of Thessaloniki in Greece and INTA in Madrid, Spain

There is also a Dobson instrument (#50) operating in Reykjavik since 1957. Surface ozone has also been measured by the Met. Office since 1991.

Contact Information

Bardi Thorkelsson
Icelandic Meteorological Office (IMO)
Bustadavegur 9
IS-150 Reykjavik
ICELAND

Gisli Jonsson
University of Iceland
Engineering Research Institute
Hjardarhagi 2-6
IS-107 Reykjavik
Iceland

Instruments in Iceland

Instruments	Location	Installed	Contact
Optronics 752	University of Iceland	June, 1991	Jonsson
9 Brewer	Reykjavik	Nov. 1991	A. Bias
41 Brewer 85-027	Reykjavik	1992	Thorkelsson
280 UVB-1 Pyran.	Reykjavik	1993	Thorkelsson
281 RASAS Spect.*	Keflavik Airport	1994	Thorkelsson

* (in 1993 this instrument was in Reykjavik)

International

The Icelandic Meteorological Office collaborates with the Aristotle University of Thessaloniki, Greece in ozone and UV monitoring. The Met Office also collaborates with INTA in Madrid, Spain in ozone monitoring (RASAS spectrometer and ozone sondes) during the wintertime.

Ireland, Republic of

Overview

There are four instruments in Ireland, three of which are under the charge of Dr. Tom O'Connor at University College in Galway. They are a Robertson-Berger meter, a broadband photopic detector, and a UV-A detector. These three instruments, developed by The National Radiological Protection Board (NRPB), constitute the Solar Monitoring System (SMS). There are a number of SMSs already deployed by NRPB in the UK. Calibration for the SMS in Mace Head, Ireland is carried out by the NRPB. The fourth instrument is a spectral Brewer Mark IV run by the Chief Scientist at Valentia Observatory.

Instruments

103 Brewer MarkIV, (Spectral) Caherciveen April 1993 Chief Scientist
144 Erythemally Weighted, RB Meter Mace Head Nov. 1993 O'Connor
145 Broadband, 3 Sensors, photopic detector Mace Head Nov. 1993 O'Connor
146 UV-A detector Mace Head Nov. 1993 O'Connor

The Brewer at Caherciveen takes measurements about two to three times every hour. The SMS (consisting of the three instruments listed above) located at Mace Head takes measurements hourly. The planned SMS is to also take measurements every hour.

Contact Information

Liam Burke
The Meteorological Service
Glasnevin Hill
Dublin 9
Ireland

Dr. Tom O'Connor
Physics Department
University College
Galway
Ireland

Chief Scientist
Valentia Observatory
Irish Meteorological Service
Caherciveen, Co. Kerry
Ireland

Luxembourg:

Overview

The Meteorological Station of the Lycee Classique de Diekirch (Meteo _LCD) is the only UV measuring station in Luxembourg and specializes in UV radiation related problems.

The data of Meteo_LCD are used to compute the UV-Index, published by several Luxembourg periodicals. A research project done in collaboration with the Radioprotection Office of Luxembourg studies the general UV pattern and the relationship between UVB irradiance and tropospheric ozone concentrations.

In addition to UV data, the station also collects a variety of meteorological data.

Contact Information

Francis Massen
Physics Laboratory
Lycee Classique de Diekirch
L-9233 DIEKIRCH
Luxembourg

Instruments

Instrument Location Elevation Installed Contact
Solar Light UVA/UVB Diekirch
50N 6E 225m May, 1995 Francis Massan

Mexico

Overview

Mr. Acosta works with Dr. Wayne Evans of Trent University in Ontario, Canada monitoring UV radiation as part of their public awareness campaign in Mexico. They have in operation Vital instruments which measure in both the UVA and UVB separately located in and near Mexico City.

Contact Information

Mr. L. R. Acosta
Apto. Post 71-70
06900 Mexico, D. F.
Ciudad de Mexico
MEXICO

Dr. Wayne Evans
Trent University
Ontario
Canada**Instruments**

236 BW100 Estado del Mexico Nov. 1992 Acosta
237 BW100 Estado del Mexico Nov. 1992 Acosta
238 BW100 Estado del Mexico Nov. 1992 Acosta

Sweden:

Overview

Sweden is an active member of NOG (Nordic Ozone Group), established to coordinate research activities on ozone and ultraviolet radiation in the Scandinavian countries. The Swedish Meteorological and Hydrological Institute (SMHI) produces a Swedish UV-index and information of stratospheric ozone. The prognoses are developed in cooperation with the Swedish Radiation Protection Institute (SSI) and the Swedish Environmental Protection Agency and are distributed to media and the public.

Instruments

Instrument Location Installed Contact

51 SL 501 Abisko 1993 Dept. of plant physics

54a UVB-306nm channel Lulea 1983-1993 SMHI

54a UVA-360nm channel Lulea 1983-1993 SMHI

55 UVA-360 nm Lulea 1983-1993 SMHI

59a UVB-306 UVB nm channel Stockholm 1989 SSI

59b UVA-360 UVA nm channel Stockholm 1989 SSI

61a EG&G 580/585 Stockholm 1980-1982 SSI

61 Optronics 742 Stockholm 1982-? SSI

62 R-B meter Norrkoping 1983 SMHI

63a UVB-306 nm channel Norrkoping 1983 SMHI

63b UVA-360 nm channel Norrkoping 1983 SMHI

65 SL 500 (MED glob.) Norrkoping 1990 SMHI

67 SL 500 UVA Norrkoping 1990 SMHI

68 SL 501 (global) Norrkoping 1991 SMHI

69 Brewer Norrkoping 1983 SMHI

70 SL-501 Isl. of Koster (Stromstad) 1994 Interdisciplinary Studies of the Human Condition; Univ. of Gothenb urg

72 SL 500 Lund 1990-94 SMHI

73 SL 500 UVA Lund 1990-94 SMHI

Brewer Vindeln 1991 SMHI

ELDONET dosimeter Kristineberg 1998 Dept. of Plant Physiology, Lund

ELDONET dosimeter Lund 1998 Dept. of Plant Physiology, Lund

ELDONET dosimeter Abisko 1998 Dept. of Plant Physiology, Lund

UVB 306 nm channel (previously #54a) Stockholm 1997 SSI

UVA 360 nm channel (previously #54b) Stockholm 1997 SSI

Middleton UVR1-B UV pyranometer (Carter-Scott) Stockholm 1997 SSI

Scintec UV-S-AE-T Stockholm 1997 SSI

GUV541 (Biospherical) Stockholm 1998 SSI

SL501 Stockholm 1999 SSI
SL500 (previously #58) Stockholm 2000 SSI

International

Sweden participated in the instrument intercomparisons in the Canary Islands in 1993 and in 1996, and the WMO-STUK intercomparison of broad-band meters in 1995.

Tiawan:

Overview

There are four UV monitoring instruments currently operating in Taiwan. The instruments consist of two EPLAB Ultraviolet Radiometers (295-385 nm) and two Brewer MKIV Spectrophotometers. All four are operated by the Central Weather Bureau under the charge of Dr. Hsiu-Wu Chang, Chief of the Atmospheric Physics Branch, Observation Division.

Instruments

Instruments in Taiwan with name, location and installation date.

85 Eplab Ultraviolet Radiometer Taipei, Taiwan Feb. 1991
86 Brewer MKIV Taipei, Taiwan Feb. 1991
87 Eplab Ultraviolet Radiometer Chengkung, Taiwan Jan. 1992
88 Brewer MKIV Chengkung, Taiwan Feb. 1991

Contact Information

Hsiu-Wu Chang
64 Kung Yuan Road
Taipei
Taiwan
Republic of China

United Kingdom:

Overview

There are currently ten UV monitoring instruments operating in the UK, one spectral, one multifilter and eight broadband.

Seven of the broadband sites belong to a network run by NRPB. These last seven instruments are divided into pairs, each pair making up a Solar Monitoring System (SMS). Six pairs of instruments consist of a modified RB-500 meter (290-400nm) and a UV-A detector (315-400nm). Measurements are recorded every 5 minutes. One pair consists of a modified RB-501 and a UV-A detector. Three of the sites have been in operation since 1988, and three since 1993. The seventh site began operation this year, but only operates from May to October. There are also three SMS's being monitored internationally by NRPB. One of them is located in Greenland. The others are operated in Ireland.

A single RB-501 is being independently operated by Dr. Grainger at Oxford University. The RB-501 run by Dr. Grainger was taking measurements every 30 minutes. As of September 1, 1993, measurements have been taken every 10 minutes.

Spectral measurements are made at Reading by Dr. Webb for the Department of the Environment, Food, and Rural Affairs. Scans from 290 to 500 nm with 1 nm steps were made hourly with and Optronic 742 spectroradiometer. Rountine data are available from December 1992. Sporadic (clear sky) spectral data are available from the same site from August 1989. Since 2000, the sampling has been increased to 0.5 nm steps at half hourly intervals and the instrument was changed over a period of time to a Bentham DM150.

A Biospherical Instruments GUV-541 multifilter radiometer has been monitoring at Manchester since 1997, run by Dr. Webb. It records 5 minute averages during daylight hours. Ozone measurements began at the same site in Manchester in 2000 with a Brewer Mk III spectroradiometer and the same instrument measures spectral UV from 290-365 nm.

Instruments

Instrument Location Installed Contact
Optronics 742/Bentham DM150 Reading 51.5 N Dec. 1992 Webb
Biospherical GUV-541 Manchester 53.5 N Webb
Robertson-Berger-501 Oxford 51.46 N May 1993 Grainger
Robertson-Berger w/ UVA Detector Chilton 51.35 N May 1988 Pearson
Robertson-Berger w/ UVA Detector Leeds 53.51 N May 1988 Pearson
Robertson-Berger w/UVA Detector Glasgow 55.52 N May 1988 Pearson
Robertson-Berger w/UVA Detector Lerwick 60.08 N Sept 1993 Pearson
Robertson-Berger w/UVA Detector Camborne 50.13 N Sept 1993 Pearson
Robertson-Berger w/ UVA Detector Kinloss 57.39 N 1993 Pearson
Robertson-Berger w/ UVA Detector Snowdon 53.04 N Pearson

International Instruments
Instrument Location Installed Contact
Robertson-Berger w/UVA Detector Thule Air Base,Greenland 76.34 N 1993 Pearson

Contact Information

Dr. A. R. Webb
Department of Physics
UMIST
PO Box 88
Manchester M60 IQD
United Kingdom

Dr. R. G. Grainger

Atmospheric Physics
Clarendon Lab
Parks Road
Oxford OX1 3PU
United Kingdom

Mr. A. Pearson
National Radiological Protection Board
Chilton
Didcot
Oxon OX11 0RQ
United Kingdom