NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230

OFFICE OF THE
ASSISTANT DIRECTOR
FOR GEOSCIENCES

September 6, 1994

Dr. D. James Baker
Under Secretary for Oceans and Atmosphere
Department of Commerce
14th and Constitution Ave., N.W.
Washington, D.C. 20230

Dear Dr. Baker:

I am pleased to forward "The U.S. Interagency UV-Monitoring Plan," a report prepared by the Subcommittee on Global Change Research (SGCR) for publication by the Committee on Environment and Natural Resources (CENR).

This plan was developed by the SGCR's Ultraviolet (UV) Panel for two purposes. First, the plan establishes guidelines for the U.S. Federal UV-monitoring community to ensure that data collected are accurate, intercalibrated and easily available to UV-data users through the use of common data archival and retrieval mechanisms. Additionally, as the first comprehensive inventory of U.S. Federal UV-related activities, the plan serves as an excellent resource of the capabilities and plans of the agencies active in this field for decision makers, scientists, and other persons with an interest in UV-radiation monitoring and research.

Prior to finalizing this plan, the UV Panel conducted an extensive needs analysis of the Federal UV-data user community and distributed a draft for public comment to over one hundred decision makers, researchers, instrument manufacturers, and environmental groups to ensure that the needs of these communities were also addressed.

As the plan has completed final SGCR review and does not include budget information, I recommend that you forward the plan to the CENR member agencies for final concurrence prior to its publication as a U.S. Global Change Research Program document.

Sincerely,

Robert W. Corell
Chair, CENR Subcommittee on
Global Change Research

Enclosure

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September XX, 1994

DRAFT

Dear Reader:

Ozone depletion and surface ultraviolet (UV) radiation flux have been priority research areas of the U.S. Global Change Research Program (USGCRP) since the Program was established in 1989. As concern regarding increased biologically damaging UV radiation at the Earth's surface has grown over the past few years, so has the need for an increased ability to monitor and understand the causes and effects of higher UV levels. Better understanding of UV-related issues is essential if the science community is to provide accurate information on the potential risks to humans and the Earth system of increased UV exposure to decision makers and the public at large.

Several U.S. Federal agencies that participate in the USGCRP through the Committee on Environment and Natural Resources' (CENR) Subcommittee on Global Change Research are conducting research activities to gain a better understanding of a wide variety of UV-related issues. These research activities include investigations on causes of UV-radiation and how it affects humans, other animal and plant life, agricultural productivity, and entire ecosystems. There also are efforts underway to develop operational products, such as UV health indices for public consumption. In order to conduct these activities, researchers and other data users must have access to long-term, scientifically valid and intercalibrated data sets. To ensure that UV-radiation measurements taken by U.S. Federal agencies are acquired, formatted, archived, and distributed to UV data users in a coordinated and cost-effective manner, the USGCRP has developed the U.S. Interagency UV-Monitoring Plan.

This plan was written by the USGCRP's UV Panel, which is comprised of Federal experts in UV monitoring and research. Input to this plan was also sought and obtained from a large number of decision makers, scientists, instrument manufacturers, and other persons concerned with UV radiation monitoring and research. This input was sought to ensure that, as resources permit, the needs of these communities are met. This is the first such integrated national plan for UV-monitoring. This plan is the starting point for the development of a national UV-monitoring network, and will be reviewed and periodically updated by the USGCRP UV Panel as U.S. Federal UV-monitoring activities mature.

I hope that you find this plan insightful and informative. For additional information on USGCRP UV monitoring and research activities, please contact either the agency points of contact listed in Appendix D of the plan or the Coordination Office of the USGCRP at the address listed in the Executive Summary.

Sincerely,

Robert W. Corell, Chair
CENR Subcommittee on
Global Change Research

U.S. INTERAGENCY UV-MONITORING PLAN
DRAFT FOR CENR APPROVAL 9/6/94

developed by

The Ultraviolet Radiation Panel
Observations Working Group
Subcommittee on Global Change Research
Committee on Environment and Natural Resources Research

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Executive Summary

There is growing concern in the scientific community and the public at large regarding reports of increasing solar ultraviolet (UV) radiation reaching the Earth's surface. Of particular concern is the increase in biologically damaging ultraviolet-B (UV-B) as a consequence of stratospheric ozone depletion.

In response to these concerns, several U.S. Federal agencies that participate in the U.S. Global Change Research Program (USGCRP) are conducting UV-monitoring and research activities to better understand trends and effects of UV radiation. To ensure that these efforts are coordinated in a scientifically valid and cost-effective manner, the USGCRP has developed the U.S. Interagency UV-Monitoring Plan. The purposes of this document are:

1) To establish guidelines for the U.S. Federal government UV-monitoring community to ensure that the data collected at each site are accurate, intercalibrated and easily available to UV-data users through the use of common data archival and retrieval mechanisms.

2) To inform decision makers, scientists, and other persons with an interest in U.S. Federal UV-radiation monitoring and research activities of the capabilities and plans of the agencies active in this field.

This plan discusses the needs of the U.S. Federal UV-research community and details the plans that the agencies of the USGCRP have developed to fulfill these needs using a "nested-network" approach. This approach will utilize a number of specialized instruments to collect accurate and intercalibrated data sets that will be used to examine specific aspects of UV radiation that are necessary to address the research requirements of the agencies involved in this national effort. The plan also proposes to increase coordination between USGCRP agencies through network-wide activities, such as common use of a UV Central Calibration Facility and the establishment of a UV Network Quality Assurance Panel. UV-radiation monitoring site selection criteria, instrumentation, data format, management, and delivery are also discussed. An overview of agency-specific UV data requirements is included as Appendix A and a brief description of UV-monitoring capabilities by agency is included as Appendix B.

In developing this plan, the USGCRP UV Panel has sought to build upon the experience gained by previous U.S. UV-monitoring activities, as well as the experience and knowledge gained by international organizations such as the World Meteorological Organization (WMO), and by other nations, such as Canada and New Zealand, where UV-monitoring networks are currently being operated. Input was also sought and obtained from a large number of decision makers, scientists, instrument manufacturers, and environmental groups to ensure that the needs of these communities were addressed.

The U.S. Interagency UV-Monitoring Plan is a starting point in the development of an integrated U.S. Federal UV-monitoring network. The plan will be updated periodically by the USGCRP UV Panel to reflect the increase in experience and knowledge gained by the component agencies in their operation of UV-monitoring networks and to reflect the changing needs of the UV data user community.

While this plan addresses many of the issues associated with UV-monitoring activities, the USGCRP UV Panel is aware that there are numerous other UV research-related issues, including biomass monitoring and technical training and education, not discussed in this plan. The Panel recommends that

as a follow-on to this plan, a comprehensive inventory of U.S. Federal UV trends and effects research and UV-education infrastructure be conducted, leading to a strategic plan to guide future activities.

This plan is available electronically via Mosaic at http://earth.usgcrp.gov. Additional copies of this plan can be obtained from the Global Change Research Information Office (GCRIO) at the following address:

GCRIO User Services
2250 Pierce Street
University Center, MI 48710
Voice #: (517) 797-2730
Fax #: (517) 797-2622
Internet Address: help@gcrio.org

For more information on this document or the activities of the USGCRP UV Panel, please contact:

The Coordination Office of the USGCRP
300 D Street, SW
Suite 840
Washington, DC 20024
ATTN: UV Panel
Voice #: (202) 554-6470
Fax #: (202) 554-7830
Internet Address: office@usgcrp.gov

1.0 Introduction

The discovery of the Antarctic ozone hole in 1985 drastically changed the way we view the Earth's atmosphere. We no longer take for granted the protection the planet's ozone layer provides all living organisms from the harmful effects of solar ultraviolet-B (UV-B) radiation. Analysis of the data from satellite, airborne, and ground-based monitoring sites has confirmed that stratospheric ozone levels are currently in a state of flux and there is evidence that ozone levels over the northern hemisphere are decreasing at a rate of 3.4 to 4.7% per decade[1]. What is not yet fully documented or understood is how changes in ozone levels affect the amount of solar UV that reaches the Earth's surface, or what the long-term trends or effects of this flux will be. In addition to fluxes in ozone, other variables such as solar output of UV, cloud cover, and presence of particles and other UV-absorbing gases such as sulphur dioxide may also affect surface UV levels. It is believed, however, that changes in UV levels may have significant impacts on agricultural productivity, fish populations, human health and most of the Earth's ecosystems.

What is Ultraviolet Radiation?

Ultraviolet (UV) radiation is part of the spectrum of energy emitted by the Sun. This spectrum also includes visible light, infrared radiation, and radio waves. The UV portion of the spectrum is broken

[1]S. Madronich And F. R. De Gruijl, "Skin Cancer and UV Radiation," *Nature* 366, November 4,1993 : 23.

down into three wavebands: UV-A, UV-B, and UV-C, based on physical properties and biological effects of each waveband.

UV-A (400-315 nanometers (nm)) [2] wavelengths freely penetrate the atmosphere and are unaffected by the ozone layer. UV-A is detected by numerous organisms and used in feeding, migration, and plant pollination. UV-A also induces vitamin D synthesis and may play a role in photorepair of sun-damaged tissue. Excessive exposure to UV-A, however, can be biologically damaging and is associated with the formation of cataracts, skin aging, skin cancer and inhibition of photosynthesis in plants.

UV-B (315-280 nm) exposure causes a range of biological injuries to humans and other terrestrial and aquatic organisms. These injuries can include immune system suppression, sunburn, eye cataracts, lesions, reduced vitamin D synthesis, and cancers which can result in reduced fitness and death. In plants, UV-B can inhibit the photosynthetic process and can also result in the death of the organism.

In general, the biological hazard of UV-B increases with decreasing wavelength and the extent to which UV-B is blocked by the ozone layer is also wavelength dependent. The longest wavelengths freely penetrate the ozone layer whereas atmospheric penetration by the more biologically harmful shorter wavelength UV-B is dependent on ozone layer thickness, and thus the basis of concern for ozone depletion.

UV-C (280-100 nm) wavelengths are highly damaging, but are entirely blocked by the atmosphere and are not present at the Earth's surface and UV-C levels at the Earth's surface are not expected to be increased by ozone depletion. In general, UV-C radiation, is highly effective in damaging critical biological molecules found in cell nuclei, but in most animals, including humans, this energy is absorbed prior to reaching critical cell nuclei in the skin, and is not damaging. As UV-C is not detectable at the Earth's surface, the U.S. Interagency UV-Monitoring Plan focuses on UV-A and UV-B monitoring activities.

There are three general types of measuring devices used to monitor surface UV radiation; two types that resolve UV energy into many narrow wavelength bands, and those capable of integrating the energy over broader wavelength bands. All three types of instruments have their respective roles in the U.S. Interagency UV-monitoring network. Additional information regarding categories and roles of these instruments is presented in Section 4.2 of this plan.

USGCRP Involvement in ~~UV~~ Monitoring and Research Coordination And Methodology Used in Developing this Document

In February, 1993, the Observations and Data Management Working Group (WG-1) of the U.S. Global Change Research Program (USGCRP) assembled a status report of ongoing Ultraviolet-B (UV-B) radiation monitoring and research activities being conducted within the agencies of the USGCRP. This report showed that a substantial effort is being made throughout the Federal research community to

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[2] A nanometer is one billionth of a meter. The 315 nm dividing point between UV-A and UV-B indicated in the text is per the International Lighting Vocabulary of the Commision Internationale de L'Eclairage (CIE). Many researchers in the photobiology and photodermatology community use 320 nm as the dividing point between the two portions of the spectra.

better understand the trends and effects of UV-B radiation. As the various Federal agencies that are conducting UV research are concerned with different aspects of UV-B radiation and its effects (e.g., EPA and NIH's concern with human health issues and USDA's concerns regarding effects on agriculture), these projects have different foci and require different types of data and research. These efforts have resulted in the significant advancement of our knowledge of UV-B radiation and its effects on the Earth system as well as our nation's economy.

Since the beginning of U.S. Federally-sponsored UV research, the agencies involved have worked cooperatively among themselves and with other local, regional, national and international organizations involved in UV research and monitoring. Numerous interagency and international agreements currently exist in this field, but the February 1993 USGCRP UV status report identified a need to increase the amount of cooperation within the Federal UV monitoring and research communities to ensure that these efforts are conducted in the most efficient and cost-effective manner possible.

On the recommendation of WG-1, a UV-B Research Panel was created in March 1993 to establish comprehensive UV-B research goals for the USGCRP and develop an interagency UV-B monitoring and research strategy. Because the surface monitoring and research activities of the agencies represented in the panel include collecting and examining data from both the UV-A and UV-B spectral regions, the scope of this panel has been expanded to include all UV radiation (as previously noted, UV-C radiation is not detectable at the Earth's surface). After lengthy deliberation, the Panel concluded that the first step in developing and implementing a national UV strategy was to develop a coordinated monitoring plan.

To this end, the USGCRP UV Panel has developed the U.S. Interagency UV-Monitoring Plan. The plan was developed by first polling the agencies involved in UV research and conducting an analysis of what types of data are needed to further their research goals. The UV-data requirements of these agencies are included as Appendix A. An extensive inventory of current and planned Federal UV-monitoring activities was then conducted. The capabilities of the individual agencies are included as Appendix B and maps of current and planned Federally-sponsored UV-monitoring sites are included as Appendix C. Great lengths were taken by the USGCRP UV panel to ensure that all federal UV-monitoring activities are listed in this plan. If any relevant U.S. Federal programs are not included in Appendix B, please contact the Coordination Office of the USGCRP.

Upon identifying the needs of the Federal UV data user community and the monitoring capabilities of the agencies, the USGCRP UV Panel then conducted an analysis of how these monitoring capabilities could be best utilized to address the needs of the UV data user community.

In order to address the concerns of interested parties outside the U.S. Government, the plan was released for a sixty-day period for public comment in May, 1994. During this sixty-day period, copies of the plan were forwarded to over one hundred decision-makers, UV trends and effects scientists, instrument manufacturers, international organizations and environmental groups. A substantial amount of comments were received during this comment period, and this invaluable feedback was used in developing the final plan.

The plan is structured to address the issues identified by the USGCRP UV Panel as priority areas during this effort. Section 2.0 presents an explanation and justification of the strategy selected in establishing a national UV-monitoring network. Section 3.0 provides a mission statement for the network. Section 4.0 outlines how the network will be implemented and addresses five areas that were

seen as the critical elements in successfully integrating the monitoring efforts of the individual agencies: site selection; instrumentation; data format; data management; and data delivery.

It is the goal of this plan to establish a U.S. Interagency framework to provide UV researchers worldwide with accurate, long-term data on surface UV levels. Armed with these data sets, researchers will then be able to improve the understanding of the potential changes in UV levels and provide UV trends and effects researchers and decision makers with science-based measurements, predictions, and strategy options.

International Linkages

Where the majority of UV-monitoring operations sponsored by U.S. Federal agencies are located in the United States, the identification of trends in UV-radiation flux requires local, regional, and global observations. To support their research missions, NBS and NSF currently operate surface UV-monitoring sites outside the U.S. and NOAA is pursuing gathering global UV observations via satellite. Other U.S. agencies are also investigating the development of international UV-monitoring capabilities.

As UV radiation has become an issue of global concern, several countries have initiated national UV-monitoring, research, and public outreach activities. Australia and New Zealand were the first two countries to launch national UV index programs in the late 1980's. These programs use models and UV measurements to develop daily UV-level measurements that are produced for public consumption. Many countries, including Canada, Germany, Greece, Great Britain, Japan, and the nations of Scandinavia have also implemented a variety of UV-monitoring, index and public awareness programs. Members of the U.S. Federal UV community regularly interact with their counterparts in these and other UV-related programs throughout the world. These relationships are, for the most part, informal, but they are an important step in incorporating the U.S. Interagency UV-Monitoring Network into a comprehensive global UV-monitoring effort.

Multilateral coordination occurs largely under the auspices of the World Meteorological Organization (WMO). The various U.S. agencies involved in measurements of UV at the Earth's surface interact with WMO programs individually, but with coordination among them formally facilitated by NOAA. The WMO oversees the operation of national atmospheric observing networks, concentrating on air quality but recently also extending to UV-B radiation, through its Global Atmosphere Watch (GAW). One of the main purposes of the GAW is to provide a uniform level of data quality assurance for the global array of observing stations. This quality assurance function is provided through a small number of Quality Assurance/Science Activity Centres, each with jurisdiction over a specific region. The first of these centers is based in Germany, and has oversight responsibility for Europe and Africa. The second center, with responsibility for the Americas, is now being set up in the United States with initial collaborative sponsorship by DOE, EPA, and NOAA. The functions of this center are planned to include a component related to UV radiation.

Under another WMO program, the World Climate Research Program, a Baseline Surface Radiation Network (BSRN) has been set up to monitor surface radiative fluxes, including UV. Several U.S. BSRN sites are presently measuring UV-B radiation.

Global data generated by the GAW and BSRN programs are collated and archived in a number of formally recognized WMO data centers. The WMO Ozone Data Center, located in Toronto, Canada,

has indicated that it will serve as an international center for spectral UV information. Details on the expansion of the WMO Ozone Data Center to include UV data are not yet finalized, and there is a need for additional coordination of global UV-monitoring and data archiving and distribution activities.

As a further step to ensure compatibility of U.S. and other national UV data sets, present plans are to establish additional international linkages through a program of instrumentation intercomparison led by the U.S. UV Central Calibration Facility discussed in Section 4.2.

2.0 Rationale for the Establishment of the U.S. Interagency UV Monitoring Network

There is significant evidence that changing levels of UV radiation at the Earth's surface present a potential risk to the Earth's living systems. Numerous data sets and study results have started to indicate trends in UV levels that may increase the risk of human skin cancer, eye cataracts, immune system suppression, jeopardize agricultural productivity, and cause a wide range of ecological effects.

It is important to note that the parties to the Montreal Protocol have continued their commitment to the provisions of the Protocol. Further need for UV monitoring is created by international decisions to be made on controls of methyl bromide and the rate of HCFC phaseout. This may require more precise information showing the relationship between ozone depletion and changes in UV intensity. Information, including that developed in this UV monitoring network, may be required to help parties determine appropriate controls in view of additional costs associated with these other phaseouts.

The importance of the issue has been underlined recently in a series of expert meetings. The U.S. Department of Agriculture (USDA) has identified the need for UV monitoring as a major issue because of the potential threat to plants, animals, and agricultural productivity. The U.S. Department of Energy (DOE) raised the level of concern by pointing to the need to consider, with increasing urgency, the long-term consequences of increased exposure levels on human health and aquatic ecosystems. At the same time, public concern generated by observations of decreasing stratospheric ozone concentrations, especially at high latitudes, has resulted in a number of public-awareness campaigns in several countries throughout the world.

UV-monitoring in the U.S. began in earnest in the 1970's in support of a Federal Aviation Administration (FAA) research effort associated with determining the effects of potential effects on the ozone layer by supersonic aircraft. A national network to monitor UV exposure qualitatively in regions of major population concentrations was cooperatively established by the National Oceanic and Atmospheric Administration (NOAA) and Temple University. This long-running program's activities were reduced upon the completion of this FAA initiative and is only now being revitalized and refurbished as UV has now become a high-priority issue. UV-monitoring sites were also established in the 1970's by the Smithsonian Institution.

Every agency addressing the UV issue has needs for data and understanding that are in accordance with the agency's mission. Likewise, each scientific group and every specialist panel that has addressed UV-related issues has generated its own set of priorities in accordance with the disciplinary views of the specialists involved. The different goals of the various groups that have been involved have dictated that a number of substantially different requirements for monitoring be generated. At this time, there is a need to consider each of these as a valid requirement, and to address the question of how national monitoring activities can best be consolidated, coordinated, and, if possible, integrated.

Common to all discussion has been the call for more and better data, so as to more accurately document levels of UV-radiation reaching the Earth's surface. There is particular interest in monitoring any changes that may be the consequence of human activities. At the same time, there is an awareness that latitude has a predictable effect and that some changes occur as a consequence of natural variability in climate, over which we have no influence. There is need, therefore, to monitor UV and those factors that influence UV so that objective guidance can be delivered to decision makers and regulators about the steps that can be taken to protect this planet from further adverse changes in UV radiation.

Further, there is scientific need to monitor UV in sufficient detail to deduce changes in those atmospheric quantities that affect it -- ozone in particular. An existing international array of sites coordinated by the World Meteorological Organization has made detailed observations of UV that are being used, in part, to study ozone levels in the upper atmosphere. There is need for more observations of this kind, so as to derive a better picture of ozone concentrations at the latitudes where ozone depletion has been observed, and so that the flux of ozone levels can be monitored through future decades. In this regard, there is an obvious and direct linkage with satellite systems, which have the capability for monitoring the spatial characteristics of ozone depletion with detail not possible using ground-based UV data. The information that is desired by researchers, modelers and decision-makers requires both kinds of data, as it is the ground-based observations that provide the "ground truth" against which the satellite systems are validated. In essence, satellite observing systems are good at documenting spatial patterns at specific times; ground-based systems are best at quantifying time trends at specific locations. To obtain the global picture that is needed, integration of both types of observations is required.

Many environmental and human health questions can be addressed by acquiring relatively simple measurements made by standardized instruments operated at many locations. Other more complex questions can only be addressed by using a series of more complex sensors, that generate not only the basic spatial patterns and temporal trends, but also additional ancillary data necessary to interpret these observations correctly.

As a single network of standardized instruments is unlikely to provide satisfactory answers to all questions regarding time trends and spatial changes of UV, this plan describes a multi-agency, nested-network approach. In this approach, UV climatology can be explored using a widespread array of relatively simple instruments, whereas detailed spectral analyses can be explored using more advanced instruments at a subset of fewer "core" stations. In this way, the cost of instrumenting every station to answer every need is avoided as the needs of the UV research community are best addressed using different technological approaches. In this regard, an integrated network involving a number of task-specific instruments rather than an array of standardized sensors is both more cost effective and scientifically sound.

This monitoring plan takes into account that UV monitoring and research are areas that require inter-disciplinary, multi-agency, and international attention. By integrating several tiers of measurements with coupled research activities, it is expected that the agencies involved in the U.S. Interagency UV Monitoring Network will be able to accomplish their missions in the most effective manner possible.

3.0 Mission of the U.S. Interagency UV Monitoring Network

The mission of the U.S. Interagency UV Monitoring Network (henceforth referred to as The Network) is to provide measurements of atmospheric Ultraviolet (UV) radiation to U.S. Government agencies with

operational and research data requirements and to facilitate the wide distribution of that data for interdisciplinary analysis to the UV research and data users community at large, both nationally and internationally. By closely coordinating the data collection activities of the individual agencies involved in The Network, the ability to ensure that the data collected by all nodes are intercomparable, complementary, and non-redundant will be enhanced.

The Network will have three main objectives:

1) Collection of UV radiation levels for research to understand factors affecting the transmission of UV through the atmosphere, research on the effect of UV radiation on plants, humans and other animals, and materials, and operational measurements such as in support of public UV advisories.
2) Detection of trends of Earth surface UV radiation levels.
3) Provide data for evaluation of radiative transfer models and other global change research activities.

4.0 Network Implementation Plan

The goal of this implementation plan is to provide guidelines to the U.S. Federal agencies that conduct UV-monitoring to ensure that the measurements and data that they collect are accurate, intercalibrated, intercomparable, archived and distributed effectively, and fulfill the requirements of the national and international data user communities.

The Network Quality Assurance (QA) Panel

The Federal agencies involved in acquiring UV data within The Network believe that measurement accuracy must be of paramount concern to ascertain UV trends, with several of these agencies concerned with these trends over time frames of five, ten, or more years. To accomplish these needs and to maintain databases whose accuracies are well defined, the Federal UV-monitoring community has agreed to develop an oversight panel that will review the various UV-monitoring programs, conduct systems and performance audits of specific monitors, and recommend specific practices to ensure data accuracies.

Each member agency of The Network will be represented on the UV Network Quality Assurance (QA) Panel by an individual familiar with their agency's monitoring program at the operational level. The individual should be aware of the operational functions of the instruments used by the program and must be familiar with the final data product generated by that program. Voting representation on this panel would be limited to one representative per monitoring agency and one representative each from the UV Central Calibration Facility in Boulder, Colorado (discussed in Section 4.2) and The National Institute of Standards and Technology (NIST). The Panel will then appoint an outside individual familiar with quality assurance and quality control (QA/QC) practices that can advise the Panel and provide an additional source of objective expertise to help address the QA/QC needs of the UV-monitoring community.

The primary mission of the UV Network QA Panel will be to see that the data generated, archived and distributed by network member agencies meet a commonly agreed upon set of standards and protocols. Specific activities of the panel are indicated in Sections 4.0-4.5 of this plan. Secondary missions will be realized as the community gathers more data and gains more experience with the

myriad of problems that may be encountered in comparing results from differing instrumentation. The UV Network QA Panel will not be responsible for defining any monitoring programs nor the monitoring criteria of the agencies involved.

The preliminary membership of the UV Network QA Panel will consist of representatives from the:

Department of Agriculture (USDA)
Environmental Protection Agency (EPA)
National Biological Survey (NBS)
National Institute for Standards and Technology (NIST)
National Oceanic and Atmospheric Administration (NOAA)
National Science Foundation (NSF)
Smithsonian Institution (SI)
UV Central Calibration Facility

A Quality Assurance/Quality Control (QA/QC) Specialist, to be selected by the Panel will also serve as a non-voting member. The members of the UV Network QA Panel will select a Chair that will be responsible for facilitating the Panel's activities. The agencies have already selected their representatives and the Panel will begin its activities in the fall of 1994.

During FY 1995, the UV Network QA Panel will produce two status reports. These report will be submitted to the USGCRP UV Panel in November and May. The USGCRP UV Panel's membership includes those U.S. Government agencies that use UV data but do not necessarily produce UV data sets. This reporting requirement will be reviewed in the summer of 1995 to determine future reporting requirements.

The USGCRP UV Panel will , in turn, submit an annual report to the Subcommittee on Global Change Research (SGCR) of the Committee on Environment and Natural Resources Research (CENR). This report will be filed in or around July of each year, and will be publicly released beginning in 1995.

4.1 Site Selection Criteria

It is necessary that The Network being developed have tiers with characteristics as required to address the different UV-related issues of the involved agencies. Each tier of The Network will be made up of a number of sites, with instrumentation specifically selected to provide the data that are required. Different sensors require different levels of technical capability on the part of the site operator and impose different constraints concerning instrument exposure, data collection, etc. Hence, there is no standardized sampling protocol that is feasible. Instead, it is a goal of this plan to assure that as many sites as possible are collocated, and that as many specific requirements as possible are answered at as large a number of sites as can be arranged.

As emphasized in Section 2.0, there are many different reasons why UV data are required. These can be categorized as follows (Agencies involved in these specific areas of research are listed in parentheses):

> Studies of trends - UV radiation is known to have strong effects on living organisms. For example, UV is one of the greatest sources of contemporary concern related to human health due to association of UV radiation with cancer, eye cataracts, immune system suppression, etc. Changes in UV radiation are expected as a consequence of changes in global ozone patterns and

in cloud cover, both of which accompany climate change but which also vary chaotically from year to year. Models are presently being developed to help predict future trends, but these models do not obviate the need for data. Instead, the models impose new demands for data so that they may be better evaluated. Moreover, such models are presently concentrating on those factors that influence long-term trends. The wide swings that occur from year to year due to unpredictable fluctuations in the circulation of the atmosphere are not addressed by these models and so data are required to show actual exposures and to quantify actual risk.

Human health -- Data are needed to assess possible impacts on human health (EPA, NIH, NCI, NOAA), and to educate the public about the potential risk (EPA, NOAA). The requirement in this case is for data indicative of the wavelengths that influence people at locations representative of where population is centered.

Effects on plants and animals -- Almost all terrestrial and aquatic living organisms are somehow affected by UV radiation, and hence changes in UV exposure must be taken into account in considerations of such current concerns as changing species biodiversity (USDA, EPA, NBS, NOAA, NSF, SI) and plant and animal productivity (USDA). In this case, the sensitivities of many species that are potentially at risk are not yet well enough known, and hence there is need for data not only to assess the risk but first to help researchers understand the cause and effect relationships that are involved. Data are needed to evaluate effects on agricultural productivity, forests and on ecosystems in general. Because of the different sensitivities and responses of different kinds of vegetation, detailed spectral data are required, obtained at locations representative of the system being studied (crop, forest, ocean, etc.).

Materials effects -- UV radiation affects such materials as plastics and rubber, and consequences of changes in exposure regimes are of some concern (DOI, EPA, NIST). The data requirements are likely to be similar to those generated by other parts of The Network operation.

Effects of chemicals in the atmospheric column - Trends in atmospheric ozone, SO_2, NO_x, and other atmospheric chemicals and aerosols have generated concern about potential effects on UV reaching the surface (USDA, EPA, NASA, NOAA, NSF). In addition, there is continuing awareness that the present knowledge of atmospheric chemistry is incomplete, and that other chemicals may be aggravating the situation even more.

Studies of UV as an indicator of other trends - Detailed high-resolution UV spectral measurements have provided some of the most detailed information available on global ozone distributions and trends in stratospheric ozone. The methods and instrumentation involved are well developed, and there is an existing global array of sites to measure ozone using these methods. There are few stations in the United States, however, and expansion of the array is needed (USDA, DOE, EPA, NASA, NOAA , NSF). Satellite measurements of ozone concentrations in the atmosphere provide the only mechanism that can paint a detailed global picture; in contrast, surface observations yield detailed records for specific locations. However the sensors carried by satellites decay with time, at rates that are not entirely predictable, and hence a "ground truth" capability is required. Detailed measurements of UV at the surface provide one of the benchmark data sets against which satellite systems can be validated (NASA, NOAA).

Each of the above issues carries with it a specific requirement for data, and a particular preference for some measurement locations. Without the active coordination of the agencies involved, we risk setting up many networks, each operating sensors that are finely attuned to specific agency needs at sites that are selected with great care to satisfy those needs. If measurement technology were well advanced and if high-quality data were always assured, then the data derived from these various independent networks could (in concept) be collated and integrated into a national data archive that would then have greater potential utility than any of the self-standing subnetworks alone. Unfortunately, measurement of UV radiation is demanding, and the instrumentation involved is still not perfected. Consequently, specific and conscious efforts must be made to share information among the scientists involved, to cooperate on calibration procedures and facilities, and finally to collocate as many field sites as possible.

It is not economically or logistically feasible to contemplate an array of sites such that every agency's needs are satisfied everywhere. Integrated broadband monitoring at numerous sites using relatively simple instrumentation has been proposed to provide data required for an assessment of human health effects. To meet this requirements, two conditions should be met: 1) The action spectrum for an effect based on detailed wavelength resolution must be known, and 2) broadband instrumentation must have a response function similar to the action spectrum of interest. However, the needs of researchers addressing ozone trends are for a comparatively small number of more advanced observatories where much more complicated and expensive equipment are operated.

There are several different methods used to design subnetworks for specific purposes like those outlined above. There are two divergent ways of approaching the problem. First, studies related to specific effects need to be made where the data are actually desired; hence, there is an imposed constraint to locate stations in areas near population centers (for reasons of human health), near major agricultural areas (crop productivity), etc. Second, studies related to the use of UV observations as an indicator of broader characteristics of the atmosphere require a uniform spatial coverage rather than an emphasis on particular locations. Both considerations need to be tempered by allowance for the complexity of the measurements: In general, it is better to locate a measurement site where appropriate skills already reside than to specify a location on some other basis and then to generate the appropriate skills.

The USDA UV-Site Selection and Measurements Committee

In order to develop instrument and site selection criteria for its UV-monitoring network, the USDA created a UV-Site Selection and Measurements Committee in 1992. This committee consists of scientists and network managers from several U.S. Federal agencies involved in UV monitoring and research, universities, and the Canadian Atmospheric Environmental Service, who currently operate an operational UV-monitoring network. While this committee's primary function is to advise the USDA's UV network, it has served as a forum within the U.S. Government for site selection criteria development, and its findings have been used by other agencies, including EPA, when establishing monitoring sites.

Several models can be used to help distribute stations in optimal arrays. The needs of the agricultural community were addressed by the USDA Committee by considering the following different models:

-- A Clustering Model, in which a network has groups ("clusters", each involving about five measurement locations) of sites arranged in several specified regions of the country. This design maximizes information about precision and short distance variability, and is intended to provide important input to models.

-- An Engineering Model, in which sites are located in areas that represent our current understanding of factors controlling UV irradiance. Sites are then chosen to explore, improve, and eventually verify current hypotheses specific to that region.

-- A Grid Model, in which sites are distributed across a gridded domain, as would be required to detect (with statistical certainty) differences between areas and trends with time, without knowledge of the processes being studied.

In the agricultural example presented here, criteria for research sites where high-resolution spectral radiometers would be operated were generated and an engineering model was used to develop an overall network design. Nine general regions within the U.S. with specific issues of major importance were identified. Identification of these regions was based on consideration of air pollution regimes (high/low O_3, SO_x, NO_x, and aerosols), along with meteorology, cloud patterns/frequency, and ground albedo. Collocation of sites with operations of other studies was considered as a desired goal: one of the first sites to be initiated will be located at the current Oklahoma ARM site operated by the Department of Energy.

The specific regions within the U.S. that this process identified are as follows:

1) Southeastern United States below latitudes of 30°. This area presents special meteorological-cloud characteristic considerations when studying tropospheric ozone.
2) Northeastern United States. This area is generally dominated by O_3, NO_x, and SO_x.
3) Midwestern United States. This is an area of extensive agriculture.
4) Northern Forests. The northern Great Lakes and Montana were considered as areas where there would be fewer aerosol, O_3, NO_x, and SO_x sources.
5) The Desert Southwest. Considered to be an area where aerosol concentrations are low.
6) Alaska. A high latitude region.
7) High Elevation areas in the west.
8) Northwestern United States. These would be low elevation clean-air sites.
9) Mid Ohio Valley. The region with the "dirtiest" air in the United States.

The network design was such that within each region consideration was given to research sites such as State Agricultural Experiment Stations, NSF Long-Term Ecological Research (LTER) sites, U.S. Forest Service Experiment Stations, other radiation monitoring sites, etc. In each case, the "ideal" site was considered to be a small island of a few kilometers located within an approximate 20 kilometer lake or ocean that would not freeze in the winter. This type of site should present the best opportunity to gather accurate, long-term trends data.

The same process produced a modified set of criteria for the operation of climatology sites which will require medium resolution fixed multi-wavelength spectral instruments (see Section 4.2 - Instrumentation). In this case, the network design was based on the decision to develop an improved grid model, and hence most sites were constrained to lie within the area to be addressed by this model. Some sites were to be collocated with the research sites mentioned above, where spectral radiometers

could then be used to evaluate the performance and/or limitations of the multi-wavelength instruments (initially broadband meters) of the climatology sites and to assist in the verification and quality assurance of previously collected data. Some collocation with other networks operating broad-band instruments was also foreseen, especially with the currently operating Dobson (ozone) network, with the NOAA Integrated Surface Irradiance Study (ISIS) network, with the DOE Atmospheric Radiation Measurement (ARM) program, and with active research sites (e.g. NSF LTER, USDA Agricultural Research Service, National Park Service IMPROVE, and NOAA Air Monitoring Program (AIRMoN) network sites).

4.2 Instrumentation

One of the most critical and time consuming issues that has confronted the agencies that are developing ground-based UV-monitoring networks is instrumentation. Accurate measurements in the UV wavelength regime of the irradiance at the Earth's surface pose technically difficult problems of instrument design. Due to low historic interest in, and support for these measurements, suitable research-grade instrumentation remains a development problem.

To date, the limited measurements of UV radiation at the Earth's surface have yielded conflicting results for mid-latitude northern hemisphere trends. However the most recent measurements support the conclusion that UV irradiances are increasing due to ozone depletion. Critics have raised objections concerning the interpretation of these data, and broad consensus has not yet been reached.

Historical data available in the U.S. consists primarily of measurements designed specifically to support research on the effect of UV radiation on human skin. The ability of so called "broadband," or erythemal, meters that have been employed to support research on the potential effects on biological systems including humans, other animals, agricultural crops and other plants is still an area of debate. These types of instruments cannot readily provide the spectral information needed to analyze the relationship of surface UV radiation to fluctuations in stratospheric ozone or other factors regulating the transmission through the Earth's atmosphere. In order to meet the UV trends research and forecasting needs of the Network's end-users spectrally resolved UV-monitoring data which is acquired by the research-grade instruments discussed above is required.

In order to acquire these required data sets, The Network will contain three categories of instrumentation based upon their capabilities to provide spectrally-resolved data:

1) High Resolution Scanning Spectroradiometers

> Acquisition of scanning spectroradiometers that provide spectrally resolved data (1 nanometer or better resolution) and 5% radiometric accuracy is currently underway by several agencies such as USDA and EPA and are currently being operated by NSF. The spectral coverage of these instruments is instrument dependent, and ranges from 300-330 nm to 280-400 nm. These are research grade instruments with high initial costs and require trained personnel for operation. Only a limited number will be required to meet network monitoring needs. This class of high resolution, high accuracy instrumentation is required for research on understanding factors effecting surface UV-B radiation and will provide the most reliable data for assessing trends.

2) Medium Resolution Fixed Multi-Wavelength Spectral Instruments

Many of the monitoring and trend data requirements could eventually be met with less costly multichannel instruments designed to provide spectrally resolved data at selected wavelengths in the region from approximately 290-340 nm (this range varies depending on design objectives). This would also lower the cost of operation and permit a larger number of instruments to deployed in networks and provide the effects research community with much greater access to spectral data. Such instruments, using interference filters, are currently under development by several manufacturers and scientists and multi-wavelength instruments with a 10 nm bandpass are available today.

Efforts to develop multi-wavelength instruments based on these technologies to monitor UV below 300 nm have not yet proven successful due to problems with stray light. However, it is believed that spectral irradiance can be modeled below 300 nm using multiple wavelength measurements in the 290-340 nm region. Further, interference filter based instruments have exhibited poor long-term stability, and this problem must be surmounted if such instruments are to be reliable for trend determination.

3) Low Resolution Broadband Meters

Broadband radiometers are instruments with a broad spectral response from approximately 300-340 nm resulting in a bandpass of 30-40 nm and with 10% radiometric accuracy. Historically these instruments were designed with a spectral response chosen to approximate a particular biological action spectrum. The most widely used broadband UV radiometer's spectral response mimics the human erythema (reddening or sunburn) action spectra. The problem in the general use of this type of instrumentation is that not all biological responses in the UV have the same action spectra and little atmospheric information can be inferred from their data. The prime function of this type of instrument will be to provide data for epidermal studies and public sunburn hazard information. Additionally, instruments in both the medium and low resolution categories can be used to broaden the spatial scale over which UV information is available when these instruments are intercompared and intercalibrated with high resolution instruments.

In order to ensure the highest possible accuracy and intercomparability of collected data, The Network will establish instrumentation protocols to be adhered to by all participating agencies. These protocols will be established by the UV Network QA Panel and the National Institute for Standards and Technology (NIST) will serve as the coordinator of these protocols. These protocols will include:

Characterization: Initial static physical characterization tests of all Network instruments must be conducted and be traceable to NIST prior to deployment. In the case of previously deployed instruments, an examination of previous characterization tests will be required. Tests will include a cosine response test, a linearity test over the dynamic range of the instrument, and the quantification of slit functions for spectral instruments and quantification of filter functions of broadband instruments performed. Because of the highly wavelength-dependent biological action spectrum in the UV-B spectral region, special emphasis must be made to test the wavelength accuracy and precision, as well as the stray light, and out-of-band contribution to readings of both spectral radiometers and broadband instruments that may result from high UV-A and visible radiation contributions in sunlight.

Intercomparison: As the various agency elements of The Network have different data needs and thus, different instrumentation, there is a need for field instrument intercomparisons in order to ensure continuous instrument calibration. To facilitate this need, intercomparison sites must be established to detect long-term spatial and temporal trends between disparate measurements from different instruments.

Mobile Field Standards: Where periodic instrument intercomparisons are necessary, the removal of instruments from their monitoring sites to attend such intercomparisons is not always possible or practical. Therefore, mobile field calibration standards are needed to conduct ongoing on-site instrument calibration.

An active campaign of instrument intercomparisons will be carried out with participation from each agency's network. These intercomparisons will be well instrumented with pertinent ancillary measurements and be initially undertaken on an annual basis. The purpose of these intercomparisons is to develop models of instrument performance based upon instrument characterizations and eventually to develop algorithms for the removal of instrument dependence from solar UV data. An additional goal of the intercomparison is to develop a standard UV data set for the testing of radiative transfer models and to intercompare different radiative transfer models with each other and the measured irradiances.

The Establishment of the UV Central Calibration Facility

In order to expedite the implementation of these instrumentation protocols, a UV Central Calibration Facility is being cooperatively established at the NOAA Laboratories in Boulder, Colorado by USDA, EPA, NOAA, NIST, AND NSF. This facility is an essential component of The Network as it will provide participating agencies with the technical assistance and instrumentation testing necessary to ensure that the data collected at their UV-monitoring sites is calibrated and accurate. Participation of all Federal agencies conducting UV-monitoring activities is sought and encouraged.

Preliminary instrumentation milestones, including UV Central Calibration Facility activities are currently being developed by the agencies involved in UV-monitoring.

4.3 Data Format

A pragmatic minimum set of quality controls should be implemented for each monitoring site to permit valid and interpretable analysis of the data. Additional information may be necessary in the future to improve on this construct. In particular, it may be useful to quantify the biases and uncertainties associated with different practices to ensure that a valid analysis of the data are feasible. Thus, this basic data management paradigm will be subject to revision in the light of assessments made during the course of the various UV-monitoring programs. The following items should be considered when developing the format of collected UV data:

Missing data - Most UV data are collected on a time scale shorter than a day. At many monitoring sites, the collected data is then used to compute daily and monthly totals. Any reasonable method for estimating missing data of two or three hours in any one particular day is acceptable as long as such missing hours do not comprise more than 20% of the total

monitoring hours or represent more than half of the expected UV radiation in a single day. A concise report of the amount of missing data, and any estimation methods used for missing data, should be included.

Time of day - If single daily scans are made, care should be taken concerning time of recording. Small changes in local times of recording can result in spurious trends. Times of daily recordings should be listed as either local time or local solar time for clarity.

Units of measurement - The data reported and archived by each program in the network should be the basic data captured. Basic data acquired by the network may be short term averages (3-5 minute) throughout the day for multi-wavelength or broadband meters and 3-5 minute scans for high resolution spectroradiometers. From this data it is possible to calculate daily doses (weighted or unweighted), daily or weekly means, study the effect of clouds or aerosols, determine trends, etc. All other needs can be derived from the basic data. Summarized data formats such as daily doses, weighted and unweighted, are particularly useful to both the effects and atmospheric community. Such data should be provided to make the data maximally accessible and useful to the broad scientific community.

Quality of measurements - Perhaps the single most important information about the UV data are the quality or reliability of the data. Unfortunately, this is the most difficult characteristic to assess or describe. Quality of measurements is determined by the limitations of the instrument, the characterization and calibration of the instrument, and perhaps most importantly, the personal care and attention given the instrument.

Instrument limitations - All instruments are subject to limitations, both known and unknown. Some of the identified limitations of instruments included cosine response aberrations, stray light noise, temperature response sensitivity, filter drifts, and diffuser material ageing. These can introduce errors in the resolution, accuracy and sensitivity of the instrument. Unfortunately most of these limitations cannot be post-operatively corrected, but with a documented detailed characterization of the aforementioned limitations for each instrument type put into the metadata data base some corrections may be possible.

Metadata and ancillary data - The coupling of the meta- and ancillary data to the physical data can provide a powerful pre-analysis tool that would be a very cumbersome process if conventional programming techniques were used. In addition, the coupling of the meta- and ancillary data to the physical data will lessen the misuse and erroneous interpretation of the data. The UV Network QA Panel will coordinate the development of meta- and ancillary data formats among the agencies that acquire UV data, as well as with other relevant interagency organizations such as the Federal Geographic Data Committee.

Metadata should include, at a minimum, the following:

- type of instrument;
- frequency of measurements;
- location of instrument (latitude, longitude, altitude);
- period of record;
- description of site (urban, desert, oceanic, etc.);
- action spectra used (broadband instruments only);

- instrument contact person information;
- quality assurance procedures;
- calibration procedures;
- instrument maintenance procedures; and
- operational procedures.

Ancillary data should include:

- basic meteorological data (wind speed, direction, temperature, etc.);
- Surface albedo;
- aerosols and particulates present;
- known levels of UV-absorbing gases (e.g., O_3, SO_3, NO_2);
- other radiative qualities; and
- cloud cover.

4.4 Data Management

To ensure optimal utility of data collected, standard procedures for data transferral to UV databases are required. Guidelines and checks on the validity of data abstracted from different facilities are also necessary.

Primary quality assurance (QA) and quality control (QC) will be handled at the agency level. Details regarding data acquisition, archiving procedures, cross comparisons, and verification will be discussed in detail by the UV Network QA Panel. Agencies collecting and managing UV data will participate in appropriate interagency efforts such as the National Geospatial Data Clearinghouse and will apply appropriate Federal standards to UV data-related activities. UV data management activities will also be consistent with planning for the interagency Global Change Data and Information System. Lead agencies will be identified by the UV Network QA Panel to develop standardized data products using data from the various agency UV-monitoring networks.

Issues to be considered in the development of these procedures should include:

1) Incorporation of calibration information, problems of calibration lamps such as variations of greater than a few percent between individual lamps, and degradation over time, differences in calibration problems associated with spectral and broad band instruments;
2) Accommodation of missing data;
3) Adjustment for discrete changes in instrumentation sensitivity;
4) Organization of the data file to facilitate the analysis would need to take into account:

   - quality control of the data;
   - analyses of UV changes;
   - other variables;
   - comparisons of different UV monitoring sites; and
   - adjustments for errors.

As instruments and data management procedures are improved and/or revised, there is an essential need that data continuity be a controlling consideration. Without such considerations, trends of UV radiation levels over time cannot be expected to be detected.

4.5 Data Delivery

The establishment of data delivery mechanisms to ensure that data acquired are available to UV end-users is an essential component of The Network. It is the goal of the agencies that acquire UV data to disseminate this data to all parties interested in using such data.

Upon appropriate evaluation, cross comparisons, validations, and verifications of acquired data, the component agencies of The Network will make the data available to the global end-user community in accordance with relevant U.S. Federal data policies. The agencies will work toward the establishment of a coordinated national UV data delivery system using a number of appropriate mediums, including CD-ROMS and the internet. Although specific details regarding the structure of these mechanisms have not yet been developed, the UV Network QA Panel will work in consultation with organizers of the Global Change Data and Information System (GCDIS), the National Spatial Data Infrastructure (NSDI) and other relevant data delivery networks such as the network currently operated by the NOAA National Climatic Data Center (NCDC) to develop these capabilities. The UV Network QA Panel will also consult with international organizations such as the WMO to ensure international interconnectivity.

4.6 Currently Available and Planned Data Products

There are several data products that are either now available or are planned for release by the fall of 1995 from individual USGCRP agencies. These include:

Department of Agriculture (USDA)

Data Set Name:	USDA UV-B Monitoring Network
Data Set Description:	UV-B measurements both spectral and/or broadband. Eventually this will include selected derived action spectra weighted products and summaries. Supporting data includes multiple wavelength measurements in the visible and infrared for determination of cloud cover and aerosol optical depth. These include total, diffuse and direct normal irradiance at 940, 862, 665, 610, 500, and 415 nanometers with a 10 nanometer bandpass. Albedo measured with a downward looking photometer to determine the presence or absence of snow and temperature and relative humidity. The data set will eventually include column ozone. Quality assurance and quality control information will be available.
Data Set Availability:	Some sites have data beginning in 1993.

Point of Contact:

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Environmental Protection Agency (EPA)

Data Set Name: EPA/Univ. of Georgia (UGA) UV Monitoring Station Measurements

Data Set Description: Data sets will include high resolution spectral scans from Brewer spectrophotometers, total column ozone and nitrogen dioxide, meteorological data (eg. wind speed, relative humidity, temperature) at selected sites, nephelometer data, and other types of measurements relating specific pollutants to possible UV attenuation (ground concentrations of ozone and NO2). There will also be a large set of metadata available to describe the site and other features that may have impact on the UV fluxes at that location.

Data Set Availability: EPA has set up a cooperative agreement with UGA to establish a UV Monitoring Center in Athens, Georgia. Data for the EPA program will be telemetered from the sites to UGA and distributed by the University after thorough quality assurance and quality controls (QA/QC) have been applied. Measurements from the Research Triangle Park, North Carolina site which began operations in October, 1992 should be available by January, 1995. Three additional sites began operation in the summer of 1994 and data from these sites will be available within six to eight months after its acquisition date once data distribution begins in early 1995.

Point of Contact:

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National Biological Survey (NBS)

Data Set Name:	Intermountain Wilderness Area Ecosystem (IWAES)/Paired Ecosystem (PE) Aerometric Station Measurements
Data Set Description:	Meteorology, air quality, and bulk deposition measurements made at remote wilderness-type locations in the western U.S. and 4 sites in Russia/Uzbekistan. The measurements at each station include total solar radiation and total UV-B from a Yankee Environmental Systems broadband radiometer.
Data Set Availability:	Measurements from some of these stations have been collected since 9/91 although the first UV instruments were not installed until 7/92. Quality checked data are expected to be available in 9/94 on a direct inquiry only basis.
Point of Contact:	Dr. Michael Sestak ESTC 2401 Research Blvd, Suite 205 Fort Collins, CO 80526 Phone: 303-221-4873 FAX: 303-491-2207 Email Address: mikese@storm.cfnr.colostate.edu

National Aeronautics and Space Administration (NASA)

Data Set Name:	Ultraviolet Radiation at the Top of the Atmosphere
Data Set Description:	Ultraviolet Radiation is measured at the top of the atmosphere using instruments flying aboard the Upper Atmosphere Research Satellite (UARS), launched in September, 1991. Two instruments on UARS measure this quantity - the Solar Ultraviolet Spectral Irradiance Monitor (SUSIM), and the Solar Stellar Irradiance Comparison Experiment (SOLSTICE). The wavelength range covered by these instruments is 115-420 nm.
Data Set Availability:	Data are available from the beginning of UARS operations. There may be a several month period before data are publicly available due to the need to correct for instrument degradation. Data may be obtained from the Distributed Active Archive Center (DAAC) of the Earth Observing System Data and Information System (EOSDIS) at the Goddard Space Flight Center.

Points of Contact:

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Data Set Name: Ultraviolet Radiation at the Ground

Data Set Description: Ultraviolet Radiation is measured at the ground using ultraviolet spectrometers which are affilitated with the Network for Detection of Stratospheric Change (NDSC). UV spectrometers are being included in NDSC in a "research mode" at primary and complementary NDSC sites. To date, measurements are being made at a European mid-latitude site as well as in New Zealand, and others may be added in the future.

Data Set Availability: Data will be available from NDSC consistent with their data policy.

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National Science Foundation (NSF)

Data Set Name: NSF UV Radiation Monitoring Network/primarily high-latitude sites

Data Set Description: High resolution spectral scans plus a variety of extracted products representing biologically or meteorologically significant measures (e.g., spectral integrals, weighed dose measures, wavelength pairs useful in

calculating total column ozone). Supporting data includes weather observations, data on total column ozone from TOMS sensors, intercomparisons data, etc.

Data Set Availability: Data available from 1988 to present.

Point of Contact:

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Smithsonian Institution (SI)

Data Set Name: UV-B global irradiance

Data Set Description: Archived data from the Smithsonian Environmental Research Center (SERC) medium resolution spectral radiometer (see instrument description, Appendix B). Data in seven spectral bands are available with center wavelengths of 295, 300, 305, 310, 315, 320 and 325 nm. Data are archived as 12 min averages. Procedures for instrument calibration and data treatment are covered in Correll, et al. (1992).

Data Set Availability: Data are currently available for the period of 1976 to 1992 for the Washington, DC area (Rockville or Edgewater, MD). The data are furnished in archived format on 10, 3.5 inch floppy discs. A fee of $100.00 is charged to obtain the data in order to cover the costs of duplication.

Point of Contact:

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Appendix A: Agency Missions and Data Requirements

Below are the mission objectives and data requirements of the USGCRP agencies that have UV data requirements.

The Department of Agriculture (USDA)

Operational/Research Requirements:

Surface UV-B radiation measurements are necessary to enhance the ability of the USDA to meet its responsibilities to sustain and strengthen U.S. agriculture by providing information on the climatology and long-term trends in UV-B radiation in order to assess the potential for damage to agricultural crops, animals and forests. In the broader sense, the establishment of the UV-B climatology and long-term trends is necessary to support programs related to assessment of UV-B effects on human health, ecosystems, and materials, as well as supporting atmospheric science research and model development and providing ground truth for satellite measurements. USDA is concerned not only with documenting UV-B climatology and trends, primarily in non-urban areas, but also is committed to providing data which will support research which will enhance our understanding of factors affecting UV-B irradiance.

Specific Data Sets Required

In order to meet the USDA program objectives, the following data sets are required:

- Research network-scanned spectral data (1 nm band width) from 290-400 nm at 1 nm intervals and ancillary data required for the interpretation of factors controlling UV-B transmission including UV-A, visible, and infrared spectral measurements (aerosol optical depth calculations) and ground level concentrations of UV absorbing gasses.

- Climatology network - 6-8 wavelengths (2 nm bandwidth) from 300-360 nm taken at 15 sec. intervals to provide one or three minute averages. Ancillary data requirements will include UV-A, visible, and infrared spectral measurements.

Department of Commerce (DOC)

The National Oceanic and Atmospheric Administration (NOAA)

Operational/Research Requirements:

NOAA's mission calls for prediction of events in the atmosphere and the oceans and the monitoring of the oceanic and atmospheric environments. There are several time scales involved in the prediction activity, which correspond to different aspects of the overall monitoring operation. On the short term, there is the desire to improve weather forecasts as they apply to society, agriculture, fisheries, etc. On the decadal time scale, there is need to produce long-term outlooks related to global issues and climate. On intermediate time scales, a variety of products are tailored to meet specific purposes.

Surface UV data are needed to meet several practical requirements associated with the NOAA mission: to help advise the public about potential health risks (NOAA will soon issue experimental

forecasts of UV), to provide guidance to agricultural, fisheries and ecosystem interests (i.e. predictions of radiation much like seasonal weather outlooks), and to detect atmospheric trends in trace constituents that might either influence UV or be affected by it. In many of these contexts, data are needed both to help test and improve forecast models and in research studies of effects of UV such as effects on marine plankton and larval fish. These data also provide a modicum of ground-truth for satellite systems that acquire UV data.

Specific Data Sets Required:

NOAA's mission imposes requirements at each end of the spectrum of measurement complexity. Information on the spatial distribution of UV and on time changes in this pattern are obtained using an array of broadband sensors, distributed as part of the NOAA Integrated Surface Irradiance Study (ISIS). In addition, NOAA operates a number of research grade atmospheric observatories, where spectrally detailed UV irradiance data are obtained, largely as a step towards the monitoring of atmospheric ozone and the calibration of satellite sensor systems.

The Department of Defense (DoD)

Operational/Research Requirements:

Defense requirements for UV data products are largely met through the efforts and products from other Federal agencies. These data are used to assess the impact of UV radiation on exposed military personnel and equipment. An example is the U.S. Army Environmental Hygiene Agency (USAEHA) which requires general trend UV-B data to assess the necessary protective measures for Army personnel. This is especially important in rural/high altitude training areas where the impact of stratospheric ozone has the greatest affect.

Specific Data Sets Required:

Summary data sets, preferably global, to support military operations is desired. These data sets are largely satisfied by current networks.

The Department of the Interior (DOI)

National Biological Survey (NBS)

Operational/Research Requirements:

The NBS is concerned with the impact of ozone depletion on terrestrial and aquatic ecosystems of the northern latitudes, particularly within temperate North America. There is a paucity of data on the UV sensitivity of natural fauna and flora, and available information is insufficient for interpreting the consequences of increased UV irradiance. The NBS seeks to relate UV climatology and trends to biological impact. This requires an understanding of biological mechanisms of UV sensitivity relative to present and projected UV irradiance, the identification of sensitive species, and the development of biomarker techniques for monitoring natural populations. The NBS also seeks to assess the vulnerability of habitats to increased UV relative to tropospheric interference, water column clarity, and presence of sensitive life stages and species within specific habitats. Information on the optical

characteristics of the habitat would be included in regional GIS models and linked to distributions of populations at risk.

Specific Data Sets Required:

The UV research program in NBS will likely occur in areas that have limited available instrumentation. Therefore, NBS would use Network data as a reference for on-site measurements. At a minimum, weekly information from locations representing a range of northern latitudes will be required on a routine basis. Data in the form of intensity by wavelength over the range of 290 to 800 nm would be most useful. The data should also include information on atmospheric clarity relative to cloud cover, dust, smoke, and pollutants that may reflect, scatter, or absorb UV radiation. A measure of haze or a smog index would be a reasonable first step. As a follow up, it is suggested that the Network develop specific measures of 'smog' pollutants. NBS suggests that the network use electronic data delivery systems to assist in data distribution. It will be beneficial for NBS to have access to radiometric calibration facilities, and to conduct comparative radiometric observations at NBS study sites using the Network's proposed mobile UV monitoring station in order to ensure the accuracy of the broadband and portable scanning radiometers in use by NBS.

The Environmental Protection Agency (EPA)

Operational/Research Requirements:

EPA is currently developing a program to implement and disseminate a UV Index of potential exposure to ultraviolet radiation and to support UV research activities with a 15-site UV monitoring network across the US. The UV Index is being developed in conjunction with the National Weather Service and the Canadian AES to enhance public awareness of the problems of UV exposure. The monitoring network is intended, primarily, to verify the predictions of potential human UV exposure of the UV Index; to assess and improve the algorithms for predicting the UV flux, accounting for pollutants and other factors in populated areas; and to provide high-quality, spectrally resolved UV radiation measurements that can be convolved with a variety of human health or biological action curves, either known now or to be developed in the future. A network of spectroradiometers will be deployed to measure the UV flux (see Appendix B), and to identify the impacts of clouds, particles, ozone, and other pollutants on the UV intensities.

Along with the research that focuses on the human health aspects of increases in UV radiation, EPA also has a research element which focuses on the effects of UV radiation on marine/estuarine phytoplankton and oceanic primary productivity. This program assesses the direct and indirect trophic effects of UV radiation on the egg and larval stages of marine fishes. The effects on phyto- and zooplankton are determined through controlled exposures either in the laboratory or from shipboard experiments using natural populations. Historic growth rates of long-lived Antarctic bivalves will be used to assess whether the onset of the ozone hole has had an effect on the food chain. A new study area is examining the potential UV radiation induced alterations in marine ecosystems which can affect the rate and extent of global warming. Modeling work will assess the potential effects of UV radiation induced reductions in primary production on the oceanic carbon cycle, and hence on global warming. UV radiation effects on the production of dimethylsulfide (DMS), a precursor for cloud formation, will be assessed in shipboard experiments and in long-term chemostat experiments.

Specific Data Sets Required:

Requirements will meet the needs of the research community and those doing long-term trend analysis.

National Institutes of Health (NIH)

National Cancer Institute (NCI)

Operational/Research Requirements:

The National Cancer Institute monitors cancer incidence and mortality rates in the general population through the Surveillance, Epidemiology, and End Results Program (SEER). There are 9 current SEER registries located in the San Francisco Bay area; Connecticut; Detroit, MI; Hawaii; Iowa; New Mexico; Seattle, WA; Utah; and Atlanta, GA. UV monitoring data in all of these areas would be extremely helpful in monitoring the rates of melanoma, the most serious skin cancer. Melanoma is currently an epidemic cancer. Although the mortality rates are not increasing as quickly as the incidence rates, deaths from melanoma are still rising. The reasons for this rise are not completely understood, but are thought to be due to increased (intermittent intense) UV exposure. Having the UV data would also help in the revisions of our sun protection guidelines for the prevention of melanoma. Non-melanoma skin cancers are the most common cancers, and cause substantial morbidity, especially in the older population. The rates of non-melanoma skin cancers are also rising rapidly, and are probably related to cumulative dose of UV over many years.

In addition to the population-based monitoring, NCI conducts large epidemiologic studies of melanoma and non-melanoma skin cancers in other areas of the U.S. (usually large population centers). UV data from these areas (e.g. Portland, OR; Philadelphia, PA) would add important etiologic information which is currently not readily available. Having UV measurements over a large part of the U.S. would also help target high-risk areas for education and possible intervention.

Other health problems that may be related to UV exposure include cataracts, intraocular melanoma, and possibly some types of immune suppression. These are all under active investigation at the NIH and other medical centers.

Specific Data Sets Required:

NCI requires consistent, daily UV data with coverage of as broad a range of latitudes and altitudes as possible.

National Eye Institute (NEI)

Operational/Research Requirements:

UV-B radiation from sunlight has been implicated in the production of singlet Oxygen or other active species of Oxygen by photodynamic action of the photosensitizers present in the normal eye. One of the long-term goals of NEI-sponsored research is to define a molecular mechanism for the changes in the vitreous fluid and lens components (such as hyaluronic acid, collagen, and the crystallin proteins) and determine whether there is a link between photooxidation and certain eye diseases. Several types of in vitro systems have been developed to correlate the effect of specific species of Oxygen with changes

in the conformation of these macromolecules. Biochemical and hydrodynamic techniques are being used for aggregation and crosslinking studies, while spectroscopic methods (absorption, fluorescence, and circular dichroism) are being employed for conformal studies. Inhibitors or scavengers specific for each species of molecular Oxygen will be used to determine the physiological significance of the changes observed.

A major NEI initiative is underway to determine how and why eye cataract develops, and to search for ways to prevent or slow the progression of cataract, an age-related eye disease that effects 17-20 million people globally. As UV-B radiation has been implicated as a specific risk factor in cataract, this project, The Age-Related Eye Disease Study (AREDS), is investigating the role of this radiation in cataract.

Another important area of NEI-funded research is the understanding of certain enzymatic and non-enzymatic detoxification systems in the eye and how they combat damage of UV-B radiation. The goal of this effort is to identify drugs that might have therapeutic or prophylactic applications.

Specific Data Sets Required:

NEI has not yet identified specific data sets needed to support its UV research.

National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS)

Operational/Research Requirements:

The NIAMS supports research on the effects of UV radiation on the skin, both in terms of mutagenesis and carcinogenicity, and on the immunologic effects. In addition, NIAMS helped plan and implement two NIH-consensus development conferences. Both conferences devoted a major portion of their agendas to a discussion of the effect of UV radiation on development of skin cancer.

More information regarding the mechanism of interaction of UV exposure in generation of melanomas is necessary. Current epidemiologic information about the incidence and prevalence of melanoma is good, but does not provide sufficient information about the role of UV radiation in the development of melanoma.

Specific Data Sets Required:

NIAMS has not yet identified specific data sets needed to support its UV research.

The National Institute of Environmental Health Sciences (NIEHS)

Operational/Research Requirements:

NIEHS currently supports a large number of grants and intramural projects related to UV radiation research. These studies include investigations of the effects of UV exposure on the immune system, aging process, sensitive tissues such as the retina and skin, and methods to reduce these harmful effects. Other projects involve the comparison of mutagenic potential in bacteria of UV and near-UV radiation at levels found in natural sunlight and at levels anticipated with a 15% depletion of stratospheric ozone.

Several projects supported by NIEHS are investigating molecular changes in DNA that lead to aberrations and mutations. These studies are conducted in many different models including human tissue, rodents, fruit flies, and bacteria. In addition, these studies are investigating the variety of ways these organisms repair damage to DNA resulting from UV exposure.

NIEHS is also supporting studies investigating cutaneous chemical phototoxicity -- the response of the skin to the combined effects of a chemical and sunlight. These studies are trying to determine the physiological and metabolic responses which may cause and result from toxicities. Long-term goals of this project include improved treatments for this condition.

Specific Data Sets Required:

NIEHS has not yet identified specific data sets needed to support its UV research.

National Aeronautics and Space Administration (NASA)

Operational/Research Requirements:

As part of the U.S. Global Change Research Program, NASA is responsible for conducting observations of global ozone levels and related atmospheric parameters and for performing research and analysis activities to explain why changes in ozone concentrations occur and the extent to which human activities are responsible for them. Supported by NASA's Upper Atmosphere Research Program and Atmospheric Chemistry Modeling and Analysis Program, U.S. investigators collaborate with atmospheric scientists from around the world to perform laboratory experiments; conduct atmospheric measurements from satellites, research aircraft, balloons, rockets, and the ground; and analyze the complex data sets thus obtained to better understand the causes of and likely trends in ozone depletion. NASA's research on ozone over the last two decades has been critical in formulating, and later amending, the Montreal Protocol, an international agreement to phase out the production of chlorofluorocarbons. NASA's research and analysis programs continue to play an important role in providing the scientific basis for the periodic international assessments that are mandated under the provisions of this global environmental accord.

Ultraviolet radiation plays a key role in controlling the chemistry and meteorology of the Earth's atmosphere, and NASA has a strong interest in understanding the flux of ultraviolet radiation into the atmosphere and its attenuation in the atmosphere by trace gases and particles, as well as its physical and chemical effects in the atmosphere. NASA makes measurements of ultraviolet radiation at the top of the atmosphere and uses models to calculate radiation fields in the atmosphere and then determine their effects on atmospheric chemistry and heating.

Specific Data Sets Required:

NASA requires regular measurements of spectrally resolved ultraviolet radiation at the top of the atmosphere. These measurements need to be made with sufficient accuracy and precision that both long and short term variability can be accurately characterized.

The National Science Foundation (NSF)

Operational/Research Requirements:

The National Science Foundation's (NSF) requirements for ultraviolet radiation monitoring were first identified in 1987. Data collected during the 1986 and 1987 National Ozone Expeditions indicated a depletion of stratospheric ozone over Antarctica. The predictions of increased UV-B radiation resulting from ozone depletion during the austral spring prompted the US Antarctic Program to establish a network of high-resolution wavelength specific instruments. By 1988, the network included sites at the three U.S. year-round Antarctic Stations: Palmer Station, McMurdo Station, and Amundsen-Scott South Pole Station. A site at Ushuaia, Argentina is operated through an agreement between the NSF and Consejo Nacional de Investigaciones Cientificas (CONICET) in Argentina. Barrow, Alaska was added as a network site in 1990, and in 1992 a training instrument became operational in San Diego, California.

The objective of the NSF UV Radiation Monitoring Network is to provide ground-based measurements of UV radiation reaching the earth's surface in high latitudes. These data will be critical in determining long-term trends in UV radiation over the next several decades. The network produces hourly, high-resolution measurements of the spectral distribution of irradiance whenever the sun is above the horizon. Data products resulting from this network include analyses of various measures of ultraviolet radiation, including UV-B, unweighted spectral integrals, and a variety of biological weighted dosages. Weekly summaries are provided upon request; researchers are able to obtain near real-time measurements needed in conjunction with their experimental programs. Calibrated and corrected data are available on CD-ROM. A report summarizing data and trends at each site is produced annually.

Data collected in the network support activities in many areas of basic research. The construction of a high-latitude UV radiation climatology, based on data from the monitoring network, satellite observations and radiative transfer modelling is one goal of research supported by the NSF. Research on the biological consequences of increased UV-B radiation observed during ozone depletion events has been a major activity. Included are projects to identify UV-B effects on the physiology of terrestrial, freshwater and marine organisms. Additionally, the effects of UV-B on species survival, particularly during vulnerable life history stages, and on species distribution are topics of interest. An understanding of the interactions among UV-B radiation, biogeochemical cycles and physical factors in structuring high-latitude ecosystems is a major goal of the program. The network sites at both Palmer and McMurdo Stations, Antarctica are in close proximity to designated LTER sites. UV radiation measurements from Ushuaia are available to assess potential health effects. Data from the NSF network have provided the first direct measurements of elevated levels of potentially harmful UV-B occurring in a region impacted by the Antarctic ozone hole, validation of atmospheric radiative transfer models dealing with the role of clouds, ozone, and incident UV-B spectral irradiance and analyses of UV-B spectral irradiance over a populated region in Argentina which showed a significant impact of ozone depletion in a populated region.

The Smithsonian Institution (SI)

Operational/Research Requirements:

The Smithsonian Institution's UV monitoring program is conducted by the Smithsonian Environmental Research Center (SERC). The program is designed to address basic research questions about short- and

long-term variation in spectral UV, variation of UV-B over latitudinal gradients, and the effects of clouds and other factors such as aerosols on UV-B. The program also supports the SERC program of UV-B effects research. Studies are underway in terrestrial and aquatic ecosystems. A current goal of the program is to determine action spectra for UV inhibition of phytoplankton photosynthesis and growth. Laboratory and field populations from estuarine, marine and Antarctic environments are being studied. The SERC UV-B monitoring program Instruments are currently installed in a temperate (Maryland) and a high-altitude, subtropical (Hawaii) site. The long-term goal of the program is to install instruments at other sites from the North to the South Pole.

Specific Data Sets Required:

Global UV-B spectral irradiance 290 to 324 nm with at least 2 nm bandwidth. Measurements are to be made continuously with sample times at least once per 5 sec to compute averages by minute. Measurements at other bandwidths and time intervals as necessary to support specific research projects.

Tennessee Valley Authority (TVA)

Operational/Research Requirements:

The TVA will require UV radiation data to interpret related field data and for photochemical modeling.

Specific Data Sets Required:

TVA will require hourly spectral distribution data during the summer months over the major metropolitan areas in the Tennessee Valley (e.g., Memphis, Nashville, and Knoxville Tennessee) and the Great Smoky Mountains.

Appendix B: Description of Network Components by Agency

The following are overviews of the current and planned UV-monitoring programs of the USGCRP by agency:

Department of Agriculture (USDA)

To meet the research objectives outlined in Appendix A of this plan, USDA determined that two networks, one for research and one for climatology, would be necessary.

USDA Research Network (high resolution spectral radiometers): An engineering model will be used with sites placed in areas that represent our current understanding of factors controlling UV-B irradiance. Sites will be chosen to explore/validate current hypotheses specific to that region. Nine general regions have been identified. Considered as major discriminators of regions were high/low O_3, SO_x, NO_x, and aerosols, along with meteorology, cloud patterns/frequency, and ground albedo.

The research network will be instrumented with a small number (10-14) of high-resolution spectral radiometers designed to:

- Provide an understanding of the factors controlling surface UV-B irradiance (tropospheric O_3, SO_2, NO_x, aerosols etc.).
- Provide highest possible precision for detecting long-term trends - to validate trend predictions based on changes in stratospheric ozone or other UV-absorbing chemicals.
- Provide ground truth measurements for satellite-based calculations of UV-B irradiance to aid in model related regional interpolations.
- Provide comparison and calibration for other instruments (example - broadband, multi-band spectral, etc.).

USDA Climatological Network: Sites will be distributed along over an even grid to provide UV-B climatological data across the continental U.S. including Alaska, Puerto Rico, and Hawaii. This grid model favors statistical approaches for estimating the spatial distribution of UV-B irradiance and generally assumes no knowledge of the process being studied. Approximately 30 grid "regions" have been initially proposed.

To provide an adequate density of measurement sites to establish the climatology of UV-B irradiance, a larger network of sites (30+) will be necessary. The climatology network will be instrumented with lower cost multi-band spectral (initially broadband at some sites) instruments and designed to:

- Provide information to Agriculture and others about the climatological and geographical distribution of UV-B irradiance.
- Provide ground truth for satellite model interpolations of UV-B irradiance.
- Provide information on trends in UV-B irradiance.

Network Status

The first of the spectral radiometer research sites will be installed in Oklahoma (see below). Since multi-band spectral instruments necessary to meet the objectives of the USDA climatological network are not currently available, ten sites (see site map in Appendix C) have been selected which are

initially being instrumented with broadband meters. All ten sites in the climatological network are operational. Three of these sites are collocated at DOE ARM program sites (Ohio, Maine, and Illinois). A number of these first ten sites are expected to become research sites when the first six spectroradiometers become available later this year. The broadband meters will be replaced with multi-band spectral instruments when available. At that time, the additional climatology sites will be added. USDA UV Sites include (Note - Broadband meters will initially installed at these sites except the Oklahoma site):

CALIFORNIA - University of California, Davis, Agricultural Experimental Station
COLORADO - Colorado State University, USDA ARS Central Plains Experimental, NSF LTER Site
GEORGIA - University of Georgia Bledsoe Farm, Griffin GA Agricultural Experiment Station
ILLINOIS* - University of Illinois, Illinois State Water Survey, Bondville Atmospheric Research Station
MAINE* - University of Maine, Howland Experimental Forest
MICHIGAN - University of Michigan, Douglas Lake Biological Station
NEW MEXICO - USDA ARS Jornada Experimental Range, NSF LTER Site
NEW YORK - Cornell University, Geneva Agricultural Experiment Station
OHIO* - Miami University Oxford, OH, Ecological Research Site
OKLAHOMA** - Department of Energy Atmospheric Radiation Measurement (ARM) Program, Great Plains Cloud and Radiation Testbed (CART) Site
WASHINGTON - Washington State University, Agricultural Experiment Station

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* DOE ARM Quantitative Links Program sites.
** First USDA research site with high resolution spectral radiometer.

Department of Commerce

National Oceanic and Atmospheric Administration

Reorganization of NOAA's solar and UV radiation monitoring programs is now in progress. The new Integrated Surface Irradiance Study (ISIS) network will have two components or sub-networks. The goal is to generate a single, coherent network, with common data recording, transfer, and archiving characteristics, and with as much continuity as possible, addressing operational and research needs for surface irradiance data.

This new network will be created from components of older NOAA radiation networks with the addition of a new research-grade sub-network to be known as SURFRAD. Its primary purpose is support for climate and global change research. The secondary mission is to improve our understanding of the radiative effects of clouds, aerosols, and water vapor on the earth's surface radiation budget.

The SURFRAD network will monitor broadband direct and global solar irradiance and broadband global IR irradiance. Some sites in the network may include sunphotometry in a few selected wavelength bands. This new set of measurements will provide valuable data for assessments of the full (all wavelength) surface radiation budget for scientific use in the areas of weather and climate, hydrology, energy, and agriculture. Discussions are being conducted between NOAA and USDA regarding the collocation of SURFRAD stations with the USDA UV monitoring stations. The WMO/WCRP Baseline Surface Radiation Network (BSRN) sites in the contiguous U.S. will be in the SURFRAD network.

The remaining parts of ISIS will consist of sites with less equipment measuring fewer variables. Sites in the older networks where past records can be continued and improved have been selected for continuation and the others closed. The selected sites are receiving new data acquisition systems and re-calibrated sensors. All sensors are to be coupled to the data acquisition system which can be interrogated regularly and automatically by telephone modem from a central location but which also permits continued local real-time data examination. Quality assurance will be a top priority.

For UV, those sites where there is an existing UV operation will continue. It is planned to collocate the existing broadband UV sensors with other irradiance instrumentation, and couple it with the same data acquisition system. New UV sensors will be installed and operated in parallel with the historic instrumentation during a transitional comparison period. These current UV-monitoring sites are at the following locations:

Minneapolis, Minnesota
El Paso, Texas
Detroit, Michigan
Seattle, Washington
Concord, New Hampshire
Burlington, Vermont
Salt Lake City, Utah

As the network operation expands with second-generation broadband sensors, seven new UV-B broadband sites are anticipated. The first of scheduled to be installed in Bondville, Illinois and Albuquerque, New Mexico.

The National Institute for Standards and Technology (NIST)

The Radiometric Physics Division is the primary unit within NIST for carrying out the basic mission of promoting accurate and useful optical radiation measurements in the ultraviolet, visible and infrared spectral region. It develops and maintains the national standards in optical radiation measurements and provides measurement services for customers requiring calibrations of the highest achievable accuracy. Since NOAA is the DOC agency charged with environmental stewardship with expertise in atmospheric sciences, and NOAA and NIST are sister agencies within the U.S. Department of Commerce, NIST and NOAA have joined forces to uniquely address the calibration needs of the U.S. agencies embarking on UV-monitoring programs. It should be noted that both NOAA and NIST have long-term historic commitments to environmental UV measurement programs.

The Department of Defense (DOD)

The U.S. Army Environmental Hygiene Agency (USAEHA)

The U.S. Army Environmental Hygiene Agency (USAEHA) maintains an optical radiation measurement and calibration capability and special expertise in evaluation of ocular and skin hazards from UV radiation exposure. Special capabilities exist from the use of a wide assortment of portable spectroradiometers and broadband radiometers, including instrumentation to measure UV-A, UV-B, and UV-C. This capability supports the USAEHA mission responsibility to evaluate adverse health effects to army personnel from manmade and solar UV sources encountered worldwide.

The USAEHA is also planning to install a Robertson-Berger broadband meter at Aberdeen Proving Ground, Maryland in the fall of 1994. This instrument will have two sensors; one global sensor, and one horizon-sky sensor for ocular exposure assessments.

The U.S. Air Force (USAF)

The United States Air Force's (USAF) Phillips Laboratory maintains a substantial instrumentation capability including an absolute calibration facility, which could be applied to ground-based observation systems and space-based backscattered UV sensors. In the past, USAF has not assigned priority to the collection of UV data, but has both the instrumentation capability and a world-wide network of bases that could readily be used in the production of UV data sets if resources were provided to do so.

The U.S. Navy (USN)

The U.S. Naval Research Laboratory (NRL) constructed and currently operates the Solar Ultraviolet Spectral Monitor (SUSIM) on the NASA Upper Atmosphere Research Satellite (UARS). The SUSIM monitors the solar spectrum incident on the atmosphere in the 115-410 nm wavelength range with the absolute accuracy of 2-5%. Theoretical modeling capabilities to support these measurements are available at NRL. The design goals for the UV-B spectrograph are currently under study.

The Department of Energy (DOE)

A joint project between DOE's Office of Health and Environmental Research (OHER) and USDA is investigating UV flux measurements using two high-accuracy ultraviolet spectroradiometers to acquire extended autonomous field data at the DOE Atmospheric Radiation Measurements (ARM) Program sites. The USDA spectroradiometers, which are currently being calibrated by NIST, will provide data on UV fluxes and the DOE instruments will provide the ancillary atmospheric data needed to interpret patterns and changes in UV fluxes. The spectroradiometers will consist of a dual 14-meter Ebert grating monochromator, a photon counting regime, and an on-board control and data telemetry computer. The instrument will also measure total horizontal irradiance and direct beam irradiance. Concurrent characterization of the state of the atmosphere and the consequent fluxes and their associated moments will be taken over both space and time at each site under clear sky, general overcast, and broken cloud conditions to provide ancillary information to assist in interpreting trends and variation of UV radiation fluxes. Other measurements to be taken at ARM sites will include basic meteorological parameters, cloud distribution, aerosols, water vapor, broad-band radiometry, spectral measurements, and flux divergence.

Department of the Interior (DOI)

National Biological Survey (NBS)

Two projects in the NBS currently include UV-B measurement. The Intermountain Wilderness Area Ecosystem Study (IWAES) involves the establishment of a network of 15 ecosystem monitoring sites at Bureau of Land Management (BLM) wilderness areas or wilderness study areas. The Paired Ecosystem Project will establish the same type of monitoring sites, with four sites in North America and four sites in the former Soviet Union, established at ecosystem boundaries likely to be particularly sensitive to

the effects of global atmospheric and climatic change.

These two networks will measure four ecosystem components: air quality and climate (aerometric); vegetation; surface water chemistry; and aquatic biology. UV radiation is one of the aerometric parameters that was chosen for monitoring:

- To provide long-term data for establishing a baseline for spatial and temporal trends of UV radiation in the remote areas of the western United States; and
- to assess, where possible, potential impacts of UV radiation on natural ecosystems, on a local, regional, and global basis.

Selection of UV radiometers for the networks was carried out by the Environmental Science and Technology Center (ESTC), a NBS/Colorado State University cooperative research unit in Fort Collins, Colorado. The power requirements, spectral response, sensitivity, temperature regulation, and operating specifications of several off-the-shelf radiometers were compared. An intercomparison test between UV broadband sensors and the UV spectroradiometer (SUV-100) designed by Biospherical Instruments Inc was also performed. The UV-B-1 broadband pyranometer made by Yankee Environmental Systems, Inc. was the sensor selected.

In the two networks eleven sites are currently acquiring aerometric data; eight in North America, three in Russia. At these sites the UV sensors are scanned every 15 seconds and hourly averages of output signal are recorded. After quality assurance the measurements are converted to daily and monthly total Watts/square meter. The hourly and long term values are then archived. The remaining monitoring sites will be established by the end of 1995.

Sites: Currently operating UV-monitoring locations:

Pereslaval Russia*	El Malpais, NM*
Trappeer Creek, WY	Snowy Range, WY*
Bear Trap Canyon, MT	Fairbanks, AK*
Little Wood River, ID	Terry Badlands, MT
Nalchik, Russia	North King Range, CA
Yakutsk, Russia	

NBS Planned UV-B monitoring sites:

Tashkent, Uzbekistan	Superior National Forest,MN*
Desatoya Mountains, NV	Goshute Canyon, NV
Jacamba Mountains, CA	Jordan Craters, OR
North Deep Creek, UT	Paiute WSA, AZ
Sewemup Mesa WAS, CO	Table Rocky WA, OR
Trigo Mountains, AZ	West Portrillo, NM

*Paired Ecosystem Sites

The Environmental Protection Agency (EPA)

EPA is developing a UV exposure index and monitoring network. The focus of the program is to inform

the public of the potential for UV exposure on the basis of daily predictions of an exposure "Index." The Index, being developed in conjunction with the climate analysis center of the National Weather Service, is similar to the one that was developed and published in Canada in 1992. The monitoring network is intended, primarily, to verify the Index; to assess and improve the algorithms for predicting the Index or UV flux, accounting for pollutants, clouds, and other factors in populated areas; and to provide high-quality, spectrally-resolved UV radiation measurements that can be convolved with a variety of human health action curves currently under development, either known now or to be developed in the future.

The monitoring program calls for a network of 15 research grade sites employing spectroradiometers, augmented by additional broadband measurements by EPA or other agencies. Aerosols, meteorological parameters, and gaseous pollutants will be measured at specific sites to account for potential factors that may effect the UV flux at the surface. Eleven of the research grade sites will be located in urban areas that cover more than 25% of the U.S. population. At least three of the urban sites will be placed in National Cancer Institute Cancer Registry cities; Atlanta, GA, Seattle, WA and San Francisco, CA. EPA's Atmospheric Research and Exposure Assessment Laboratory in Research Triangle Park, NC is cooperating with the International Agency for Research on Cancer in Lyon, France by placing sites in or near Intersun Project registry cities as well. The other four sites will be located in various background areas. EPA's needs for background sites are consistent with the requirements specified by a recent USDA site selection committee meeting. EPA is coordinating the background sites with USDA, so that both agencies can complement each other's monitoring effort and provide a means to ensure specific facets of a government-wide quality assurance program are addressed. The background sites will primarily cover high latitude, high altitude, low latitude, and pristine low altitude conditions.

Spectrally resolved data will be gathered in the 290-360 nanometer range to provide researchers with the means to convolve them with either biological or human action spectra under development or to determine long term trends in possible UV radiation increases expected from the stratospheric ozone depletion of the next few decades.

National Aeronautics and Space Administration (NASA)

NASA (through its Upper Atmosphere Research Program and Atmospheric Chemistry Modeling and Analysis Program), together with NOAA and several international scientific funding agencies, co-sponsors the Network for the Detection of Stratospheric Change (NDSC), an international set of high-quality research stations for monitoring the physical and chemical state of the global stratosphere with particular emphasis on ozone and ozone-related parameters. Currently, the NDSC Steering Committee is encouraging the inclusion of UV instruments in a "research mode" (spectrally resolved, high resolution) at NDSC primary and complementary sites. Two instruments have been accepted for operation at a European and a New Zealand site, and additional proposals are being solicited. Eventually, a UV instrument subgroup of the NDSC will define and monitor the quality of the measurements to ensure that the data from various stations are comparable and can be used for a meaningful trend analysis.

NASA is also beginning to systematically explore the possibility of using space-based data to assist in the retrospective inference of solar ultraviolet radiation reaching the ground. These studies have been initiated in a "research" mode and utilize (i) global total ozone data from the Total Ozone Mapping Spectrometer (TOMS) instruments, (ii) information about cloud distributions and properties obtained from a variety of sensors and data bases, and (iii) ultraviolet radiative transfer algorithms for the

calculation of UV reaching the surface. Comparisons between such calculated values and those obtained from ground-based measurements will be made. It is hoped that these inferred surface UV radiation levels may ultimately help to enhance our knowledge of surface UV radiation in areas for which there have been no accurate measurements.

National Science Foundation (NSF)

The development of a high-latitude monitoring network for ultraviolet radiation (UV) in Antarctica was established in 1988 through the United States Antarctic Program, National Science Foundation. This network presently consists of six monitoring stations:

Amundsen-Scott South Pole, Antarctica	Ushuaia, Argentina
McMurdo Station, Antarctica	Barrow, Alaska
Palmer Station, Antarctica	San Diego, California

The instruments are scanning double monochromator based spectroradiometers covering the spectral range of 280-620 nm with 0.7 nm bandwidth. The instruments are synchronized by the Global Positioning System (GPS) and conduct hourly scans at several spectral resolutions. They are designed as all-weather, permanent, year-round installations operated under automatic computer control. Auxiliary sensors are also used for quality control and diagnostics, and to identify scans conducted under stable sky conditions. A four-level program has been established to ensure data quality. The first level consists of totally automated, twice daily internal calibrations of wavelength position and system responsivity. A second level of calibrations occurs at two to four week intervals when technicians mount NIST-traceable standards of spectral irradiance on the irradiance collector and measure the complete system responsivity. The third level of calibrations occurs every year when a single master standard is brought to each site and intercomparisons are made both before and after a complete system servicing and refurbishment. The fourth level occurs in intercomparisons of standards and instruments that is typically done in San Diego.

Data are transmitted to San Diego where quality control, archiving, and dissemination occurs. Data dissemination occurs in three modes: 1) on-site preliminary data are provided to NSF-sponsored researchers conducting investigations where the individual instruments are located; 2) NSF-sponsored researchers are provided with preliminary data being acquired at the sites as is needed for individual research programs; and 3) CD-ROMs are issued yearly and made generally available at no charge to the scientific community. The CD-ROMs contain both high-resolution spectral scans, and a variety of extracted products representing biologically or meteorologically significant measures including spectral integrals such as UV-B, UV-A, several different biologically weighted dose measures, and wavelength pairs useful in calculating total column ozone.

Supporting data on the CD-ROMs include stability measures of the internal standards, weather observations, and data on total column ozone as determined independently by NASA's satellite borne TOMS sensors. A program of intercomparisons, both with radiative transfer models, and with other instruments has been established and is expected to continue.

Smithsonian Institution (SI)

The Smithsonian Institution has been building, calibrating and operating scanning spectral radiometers including UV-B models since 1975. The program is centered at the Smithsonian Environmental Research

Center (SERC), which has operated a limited UV monitoring network at the South Pole; Panama; Mauna Loa, Hawaii; Gainesville, Florida; the Washington, DC vicinity; and Point Barrow, Alaska. The longest data set (continuous from 1975 to present) is for the DC vicinity sites. The Mauna Loa record extends from 1984 to present.

The SERC instruments presently have 8 interference filters with nominal 5 nm bandwidths and nominal center wavelengths of 290,295,300,305,310,315,320 and 324 nm. The interference filters are mounted in a rotating filter wheel which positions the filters above a solar-blind photomultiplier (PMT) detector. The wheel rotates at 72 RPM so that spectral data can be obtained at high frequency.

An updated version of the instrument has been designed for future use in the SERC network, and will also be used in other agency networks (e.g. USDA network). It has 18 interference filters that cover the 290-324 nm range at 2 nm spectral resolution, the filters have nominal 2 nm bandwidths. The filter wheel rotates at 15 RPM, so that each wavelength is sampled about once every 4 seconds. The instrument is currently at a prototype stage and will replace the 8-band instruments as soon as it becomes field operational.

Tennessee Valley Authority (TVA)

TVA has purchased a portable Optronic Laboratories OL 752-PMT spectroradiometer having an operating range of 200 to 800 nanometers (nm). This instrument has a capability to measure the spectral distribution in the UV range (280 to 320 nm). It has a stray light level of 10^{-8} at 285 nm, wavelength precision of plus or minus 0.05 nm, scan resolution of 0.05 nm, and spectroradiometric accuracy of plus or minus 1 to 3 percent (relative to NIST Standard). Initially, its primary application will be to determine photolysis rates at wavelengths greater that 280 nm in chamber studies of photochemical pollutant formation and transformation. In addition, as part of the Southern Oxidant Study, its use is being planned to measure natural solar radiation photolysis rates in middle Tennessee.

U.S. INTERAGENCY UV-MONITORING PLAN
DRAFT FOR CENR APPROVAL 9/6/94

Appendix C: Maps of Current and Planned U.S. Federally-Sponsored UV-Monitoring Sites

These UV-monitoring site maps are currently included as Appendix C of the U.S. Interagency UV-Monitoring Plan. At publication, they will be inserted in the inside of the front and back covers.

PLEASE NOTE: THESE MAPS ARE IN COLOR. IF THIS COPY'S MAPS ARE IN BLACK AND WHITE AND YOU REQUIRE A SET OF COLOR MAPS, PLEASE CONTACT RICK KELLY AT THE COORDINATION OFFICE OF THE USGCRP (202-554-7836).

- CAPTIONS FOR SITE MAPS:

"U.S. Ultraviolet Radiation Monitoring Sites." - To be inserted into inside front cover.

CAPTION TEXT: This map indicates the current and planned locations of U.S. Federally-sponsored surface ultraviolet (UV) radiation monitoring sites within the U.S. as of August 1, 1994. "Broadband" instruments refer to Low Resolution Broadband Meters. "Spectral" instruments refer to High Resolution Scanning Spectroradiometers and Medium Resolution Fixed Multi-Wavelength Spectral Instruments. Please refer to Section 4.2 - Instrumentation, for detailed information on instrument characteristics and Appendix B - Description of Network Components by Agency, for the status of specific agency monitoring networks. For U.S. Federally-sponsored sites outside the United States, please see the Global Ultraviolet Radiation Monitoring Site Map on the insude back cover.

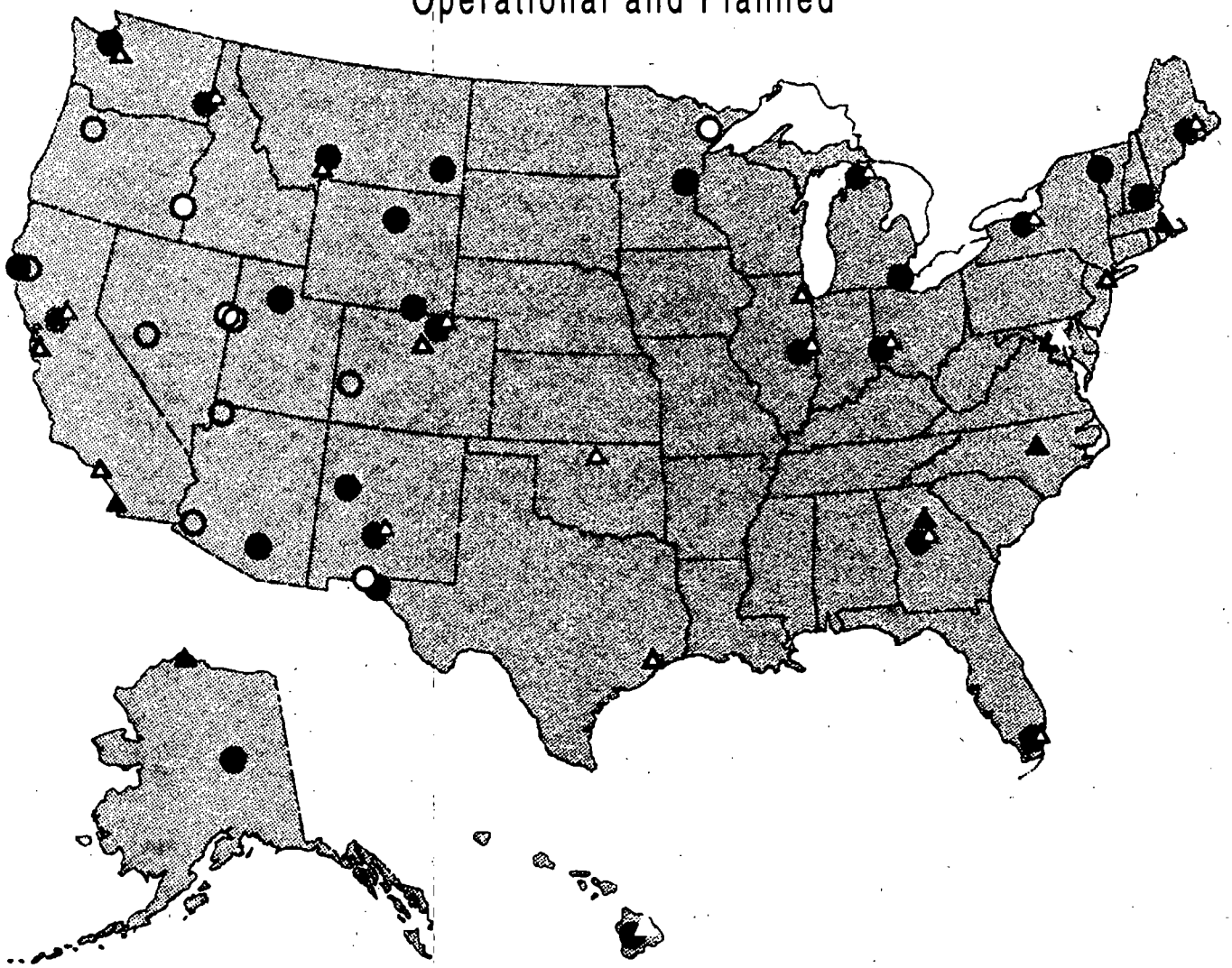
"Global Ultraviolet Radiation Monitoring Sites" - To be inserted in the inside back cover.

This map indicates the current and planned locations of U.S. Federally-sponsored surface ultraviolet (UV) radiation monitoring sites outside the U.S. as of August 1, 1994. "Broadband" instruments refer to Low Resolution Broadband Meters. "Spectral" instruments refer to High Resolution Scanning Spectroradiometers and Medium Resolution Fixed Multi-Wavelength Spectral Instruments. Please refer to Section 4.2 - Instrumentation, for detailed information on instrument characteristics and Appendix B - Description of Network Components by Agency, for the status of specific agency monitoring networks. For U.S. Federally-sponsored sites within the United States, please see the inside front cover.

DRAFT

U.S. ULTRAVIOLET RADIATION MONITORING SITES

Operational and Planned



Operational Instrument Sites

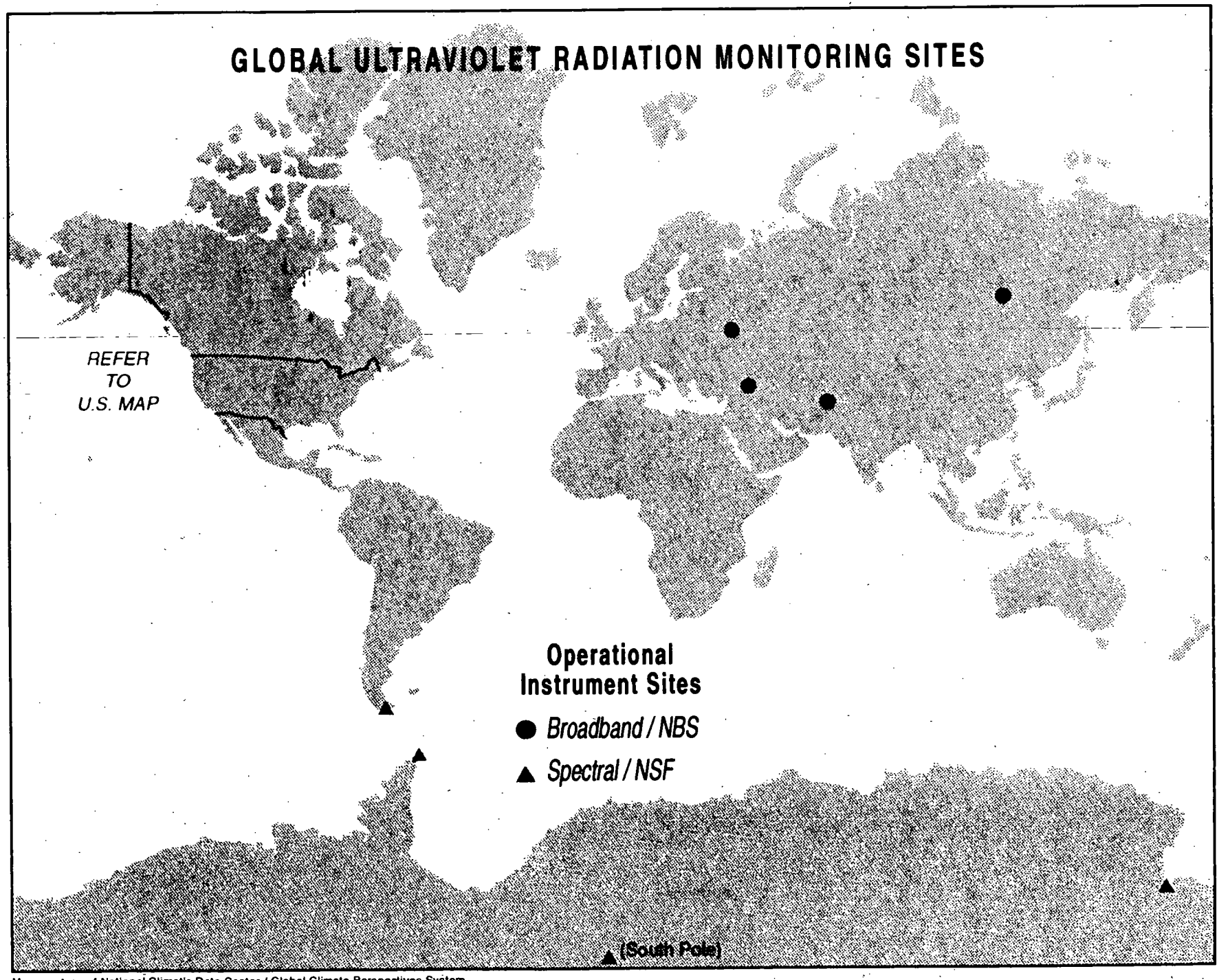
- ● *Broadband / NOAA*
- ● *Broadband / NBS*
- ● *Broadband / USDA*
- ▲ *Spectral / USDA*
- ▲ *Spectral / EPA*
- *Spectral / Smithsonian*
- ▲ *Spectral / NSF*

Planned Instrument Sites

- ○ *Broadband / NOAA*
- ○ *Broadband / NBS*
- △ *Spectral / USDA*
- △ *Spectral / EPA*
- *Spectral / Smithsonian*

Map courtesy of National Climatic Data Center / Global Climate Perspectives System

DRAFT



Map courtesy of National Climatic Data Center / Global Climate Perspectives System

Appendix D: Agency UV Points of Contact

The following is a listing of UV-related activity points of contact within the agencies of the USGCRP. For information on the activities of the USGCRP UV Panel, please contact:

Mr. Rick Kelly
Program Associate
Observations Working Group
Coordination Office of the USGCRP
300 D Street, SW, Suite 840
Washington, DC 20024
Voice #: (202) 554-7836/6470
Fax #: (202) 554-7830
Email Address: rkelly@usgcrp.gov

Please feel free to contact the individuals listed below on any agency-specific UV-related matter:

U.S. Department of Agriculture (USDA)

Dr. Boyd W. Post
Cooperative State Research Service
U.S. Department of Agriculture
Ag Box 2210
Washington, DC 20250-2210
Voice #: 202-401-5016
Fax#: 202-401-1706
Email Address: post@csrs.esusda.gov
Area of Responsibility: General information on the UV program

Dr. Daniel R. Tompkins
Cooperative State Research Service
U.S. Department of Agriculture
Ag Box 2220
Washington, DC 20250-2220
Voice#: 202-401-4603
Fax#: 202-401-4888
Area of Responsibility: UV monitoring

Dr. Anne H. Datko
Cooperative State Research Service
U.S. Department of Agriculture
Ag Box 2241
Washington, DC 20250-2241
Voice#: 202-401-4871
Fax#: 202-401-6488
Area of Responsibility: UV effects research

Department of Commerce (DOC)

National Institute of Standards and Technology (NIST)

Dr. Ambler Thompson
Radiometric Physics Division
National Institute of Standards and Technology
Bldg. 220/A317
Gaithersburg, MD 20899
Voice#: 301-975-2333
Fax#: 301-840-8551
Email Address: ambler@enh.nist
Area of Responsibility: UV instrument characterization and calibration

National Oceanic and Atmospheric Administration (NOAA)

Mr. Bruce Hicks
NOAA Air Resources Laboratory
1315 East West Highway
Bldg. 3, Rm. 3252
Silver Spring, MD 20910
Voice#: 301-713-0684
Fax#: 301-713-0119
Email Address: b.hicks@omnet.com
Area of Responsibility: UV monitoring and effects research

Dr. Craig S. Long
NOAA/NWS/NMC/Climate Analysis Center
W/NMC53
5200 Auth Road
Camp Springs, Maryland 20746
Voice#: (301) 763-8071
Fax: #: (301) 763-8125
Email Address: long@upair.wwb.noaa.gov
Area of Responsibility: UV Index

Department of Defence (DoD)

Capt. Bradley P. Smith
ODDR&E
Room 3D129
3080 Defense, Pentagon
Washington, DC 20301-3080
Voice #: (703) 695-9604
Fax #: (703) 693-7042
Email Address: smithbp&amomega.acq.osd.mil
Area of Responsibility: Central DoD UV contact

Department of the Air Force

Dr. Herbert Carlson
PL/CAG
Geophysics Directorate
Phillips Laboratory
Hanscomb AFB, MA 07131-5000
Voice #: (617) 377-3604
Fax #: (617) 377-5688
Email Address: carlsonh@afgl.usaf.mil
Area of Responsibility: UV Monitoring and effects research

Department of the Army (DA)

Dr. David H. Sliney
Chief, Laser Branch
US Army Environmental Hygiene Agency
Aberdeen Proving Ground, MD 21010-5422
Voice#: 410-671-3932
Fax#: 410-671-5411
Email Address: dsliney@aeha1.apgea.army.mil
Area of Responsibility: UV effects research

Department of the Navy

Dr. Kenneth P. Dere
Code 7663
Naval Research Laboratory
Washington, DC 20735-5352
Voice #: (202) 767-2161
Fax #: (202) 767-5636
Email Address: dere@halcyon.nrl.navy.mil
Area of Responsibility: UV monitoring and effects research

Department of Energy (DOE)

Dr. Jerry Elwood
Ecologist
Environmental Science Division
ER-74
Department of Energy
Washington, DC 20585
Voice#: 301-903-4583
Fax#: 301-903-8519
Email Address: j.elwood@omnet.com
Area of Responsibility: UV effects research

Department of the Interior (DOI)

National Biological Survey (NBS)

Mr. Stanley G. Coloff
National Biological Survey
Division of Research (725 ARLSQ)
1849 C Street, NW
Washington, DC 20240
Voice #: 703-358-1710
Fax #: 703-358-2228
Area of Responsibility: Coordination of NBS Global Change Research Program UV monitoring and effects research.

Dr. Edward Little
National Biological Survey
National Fisheries Contaminants Research Center
4200 New Haven Road
Columbia, MO 65201
Voice#: 314-875-5399
Fax#: 314-876-1896
Email Address: littlee@mail.fws.gov
Area of Responsibility: UV biological effects

Dr. Michael Sestak
National Biological Survey
National Ecology Research Center (ESTC)
2401 Research Blvd., Suite 205
Ft. Collins, CO 80256
Voice#: 303-491-2335
Fax#: 303-491-2207
Email Address: alr@storm.cfnr.colostate.edu
Area of Responsibility: UV monitoring

Environmental Protection Agency (EPA)

Mr. William Barnard
Research Physicist
Atmospheric Research and Exposure Assessment Laboratory
AREAL/MRDD
MD 44
Environmental Protection Agency
Research Triangle Park, NC 27711
Voice#: 919-541-2205
Fax#: 919-541-0239
Email Address: barnard.william@epamail.epa.gov
Area of Responsibility: UV monitoring

National Aeronautics and Space Administration (NASA)

Dr. Jack A. Kaye
Code YSM
NASA Headquarters
Washington, DC 20546
Voice#: 202-358-0757
Fax#: 202-358-2770
Email Address: jkaye@mtpe.hq.nasa.gov
Area of Responsibility: Atmospheric chemistry research

National Institutes of Health (NIH)

Ms. Mary Martin Gant
Assistant to the Director for Legislation
National Institute of Environmental Health Sciences
Building 31, Room B1-CO2
Bethesda, MD 20892
Voice#: 301-496-2919
Fax#: 301-496-0563
Email Address: m.gant@omnet.com
Area of Responsibility: UV effects research

National Science Foundation (NSF)

Dr. Polly A. Penhale
Office of Polar Programs
National Science Foundation
4210 Wilson Blvd.
Arlington, VA 22230
Voice#: 703-306-1033
Fax#: 703-306-0139
Email Address: ppenhale@nsf.gov
Area of Responsibility: UV monitoring, UV optics, physics and biological effects research

Smithsonian Institution (SI)

Dr. Patrick J. Neale
Smithsonian Environmental Research Center
P.O. Box 28
Edgewater MD 21037
Voice #: 410-798-4424 (From Washington, DC: 301-261-4190)
Fax #: 301-261-7954
Email Address: neale@serc.si.edu
Area of Responsibility: UV monitoring and effects research

Tennessee Valley Authority (TVA)

Dr. James F. Meagher
Manager, Atmospheric Processes Center
2A CEB
Tennessee Valley Authority
Muscle Shoals, AL 35660
Voice#: 205-386-2342
Fax#: 205-386-2499
Area of Responsibility: UV monitoring and research

Appendix E: Members of the USGCRP UV Panel

NAME	ORGANIZATION
Dr. Boyd Post	U.S. Department of Agriculture
Dr. Daniel Tompkins	U.S. Department of Agriculture
Dr. James Gibson	Colorado State University
Mr. Tom Nelson	Department of Defense
Dr. David Sliney	Department of Defense
Dr. Jerry Elwood	Department of Energy
Mr. William Barnard	Environmental Protection Agency
Ms. Drusilla Hufford	Environmental Protection Agency
Dr. Michael Kurylo	National Aeronautics and Space Administration
Dr. Jack Kaye	National Aeronautics and Space Administration
Mr. Stanley Coloff	National Biological Survey
Dr. Ed Little	National Biological Survey
Dr. Allen Riebau	National Biological Survey
Dr. Margaret Tucker	National Institutes of Health
Dr. Ambler Thompson	National Institute of Standards and Technology
Dr. John DeLuisi	National Oceanic and Atmospheric Administration
Mr. Bruce Hicks	National Oceanic and Atmospheric Administration
Mr. William Murray	National Oceanic and Atmospheric Administration
Dr. Bruce Baker	National Oceanic and Atmospheric Administration
Dr. Craig Long	National Oceanic and Atmospheric Administration
Dr. Hai-Tien Lee	National Oceanic and Atmospheric Administration
Dr. Betsy Weatherhead	National Oceanic and Atmospheric Administration
Dr. Roger Hanson	National Science Foundation
Dr. Polly Penhale	National Science Foundation
Dr. Patrick Neale	Smithsonian Institution
Mr. Rick Kelly	Office of the U.S. Global Change Research Program

Appendix F: Selected Reading List on UV Radiation Activities and Issues

The reference list includes a number of UV-related articles, papers, reports, workshop proceedings and other publications that have been assembled by members of the USGCRP UV Panel for those interested in additional information on UV monitoring and research issues.

Additionally, a significantly more comprehensive bibliography of UV-B related articles is maintained by Dr. William B. Grant of Yorktown, Virginia as a public service to the UV community. His bibliography of articles contains over 2400 references to literature related to UV-B radiation. It covers topics such as solar UV radiation including atmospheric effects on UV radiation reaching the Earth's surface and its effects on humans, other animals, and plants. The references are arranged by year and author, with over 400 entries for 1993. An attempt has been made to incorporate the historical references as well as the recent references. The bibliography also includes articles on ozone depletion, atmospheric effects, CFCs, and a partial list of UV researcher addresses. The list is updated weekly, and is available on 3.5"floppy disk in either WordPerfect 5.1 or ASCII format and via e-mail. Updates will be sent on request, and if a floppy disk is provided, please return it for the updated version. The USGCRP UV Panel would like to thank and applaud Dr. Grant for his efforts on the UV-B bibliography on behalf of the UV community. For more information, please contact:

Dr. William B. Grant
803 Marlbank Drive
Yorktown, VA 23692-4353

Selected Reading List on UV Radiation Activities and Issues

Acevedo J., C. Nolan, eds., 1993: *Environmental UV Radiation, Causes - Effects - Consequences,* Commission of the European Communities, Directorate-General XII for Science, Research, and Development, Rue de la Loi 200, B-1049 Bruxelles, Belgium, Fax: +32-2-296-30-24.

Alternate Fluorocarbons Environmental Acceptability Study, 1992: *UV-B Monitoring Workshop: A Review of the Science and Status of Measuring and Monitoring Programs*, Science and Policy Associates, Inc., 1333 H St., NW, Washington, DC.

Blough, N.V. and R.G. Zepp, eds., 1990: *Technical Report, Workshop on the Effects of Solar Ultraviolet Radiation on Biogeochemical Dynamics in Aquatic Environments.* Proceedings from a workshop held October 23-26, 1989, Woods Hole, Massachusetts, Woods Hole Oceanogr. Inst. Tech. Rept., WHOI-90-09.

Blumthaler, M., W. Ambach, R. Silbernagl, and J. Staehelin, 1994: Erythemal UV-B irradiance (Robertson-Berger meter sunburn data) under ozone deficiencies in Winter/Spring 1993. *Photochemistry and Photobiology*, 59, pp. 657 - 659.

Correll, D.L., C.O. Clark, B. Goldberg, V.R. Goodrich, D.R. Hayes, W.H. Klein, and W.D. Schecher, 1992: Spectral Ultraviolet-B Radiation Fluxes at the Earth's Surface: Long Term Variations at 39°N, 77°W. *Journal of Geophysical Research*, 97, pp. 7579-7591.

Cullen, J. J., and P. J. Neale, 1994. Ultraviolet radiation, ozone depletion, and marine photosynthesis. *Photosynthesis Research*, 39, pp. 303 - 320.

Farrell, M. P., Coord., 1993: *UV-B Critical Issues,* Proceedings from a workshop held February 24-26, 1993, Cocoa Beach, Florida, Oak Ridge National Laboratory (ORNL) Report, available from ORNL Division of Environmental Sciences.

Frederick, J. E., 1992: An assessment of the Robertson-Berger ultraviolet meter and measurements: Introductory comments. *Photochemistry and Photobiology,* 46, pp. 113 - 122.

Frederick, J. E., and E. C. Weatherhead, 1992: Temporal changes in surface ultraviolet radiation: A study of the Robertson-Berger meter and Dobson data records. *Photochemistry and Photobiology,* 46, pp. 123 - 131.

Frederick, J. E., A. E. Koob, A. D. Alberts, and E. C. Weatherhead, 1993: Empirical studies of tropospheric transmission in the ultraviolet: Broadband measurements. *Journal of Applied Meteorology,* 32, pp. 1883 - 1892.

Gibson, J. H., Coord., 1991: *Justification and Criteria for the Monitoring of Ultraviolet (UV) Radiation.* Colorado State University Report, 21 pp., available from the CSU National Resource Ecology Laboratory, published under sponsorship of the U.S. Department of Agriculture.

Gibson, J. H. , Coord., 1992: *Criteria for Status and Trends Monitoring of Ultraviolet (UV) Radiation,* Colorado State University Report, 6 pp., available from the CSU National Resource Ecology Laboratory, published under sponsorship of the Department of Agriculture.

Jokela. K., K. Lesczczynski, and R. Visuri, 1993: Effects of Arctic ozone depletion and snow on UV exposure in Finland. *Photochemistry and Photobiology,* 58, pp. 559 - 566.

Kennedy, B. C., and W. E. Sharp, 1992. A validation study of the Robertson-Berger meter. *Photochemistry and Photobiology,* 46, pp. 132 - 141.

Polar Research Program, Scripps Institution of Oceanography, 1990: *Response of Marine Phytoplankton to Natural Variations in UV-B Flux,* Proceedings of a workshop held April 5, 1990, La Jolla, California.

Rovinsky, F. Ya., and G. B. Wiersma, 1987: *Procedures and Methods for Integrated Global Background Monitoring of Environmental Pollution.* World Meteorological Organization Technical Document No. 178, GEMS Information Series No. 5.

Scientific Committee on Problems of the Environment, 1992: *Effects of Increased Ultraviolet Radiation on Biological System,* Proceedings of a Workshop held February, 1992, Budapest, Hungary.

Scientific Committee on Problems of the Environment, 1993: *Effects of Increased Ultraviolet Radiation on Global Ecosystems,* Proceedings of a Workshop held October, 1992, Tragmariglio, Sardinia.

Smith, R.C., B.B. Prézelin, K.S. Baker, R.R. Bidigare, N.P. Boucher, T. Coley, D. Karentz, S. MacIntyre, H.A. Matlick, D. Menzies, M. Ondrusek, Z. Wan and K.J. Waters, 1992: Ozone depletion: Ultraviolet radiation and phytoplankton biology in Antarctic waters. *Science* 255: pp. 952-959.

Song, P.-S., 1989: The biological effects of increased ultraviolet radiation: An update. *Photochemistry and Photobiology*, 50(4), pp. 439-524.

Teramura, A. H., and J. H. Sullivan, 1994: Effect of UV-B radiation on photosynthesis and growth of terrestrial plants. *Photosynthesis Research*, 39, pp. 463 - 473.

U.S. Environmental Protection Agency, 1989: *Workshop on Monitoring the Effects of UV-B Radiation*, Proceedings of a meeting held 21-23 June, 1989, Washington, D.C., 12 pp. plus 3 appendices.

van der Leun, J. C. , M. Tevini, and R. C. Worrest, eds., 1989: *Environmental Effects Panel Report*, United Nations Environment Programme, Nairobi, Kenya.

van der Leun, J. C. , M. Tevini, and R. C. Worrest, eds., 1991: *Environmental Effects of Ozone Depletion: 1991 Update*, United Nations Environment Programme, Nairobi, Kenya.

Weiler, C.S., ed., 1988: *Workshop on Ultraviolet Radiation and Biological Research in Antarctica*, Proceedings of a workshop held June 7-8, Washington, D.C., NSF 88-108, 28 pp.

Weiler, C.S. And P.A. Penhale, eds., 1994: Ultraviolet radiation in Antarctica: Measurements and biological effects. *American Geophysical Union Antarctic Research Series*, Vol. 62., 256 pp.

Williamson, C.E. & Zagarese, H.E., Eds., 1994: *Impact of UV-B Radiation on Pelagic Freshwater Ecosystems*. Archiv fur Hydrobiol., Bieh. Ergebn. Limnol. XX: 00-00.

WMO, 1990: *Scientific Assessment of Stratospheric Ozone: 1989*, Volume I, Chapter 3, World Meteorological Organization Report No. 20.

WMO, 1992: *Scientific Assessment of Ozone Depletion: 1991*, Chapter 11, World Meteorological Organization Report No. 25.

WMO, 1995: *Scientific Assessment of Ozone Depletion: 1994*, Chapter 9, World Meteorological Organization Report No. 37. In press.

Young, A. R., L. O. Bjorn, J. Moan, and W. Nultsch, eds., 1993: *Environmental UV Photobiology*. Plenum Press, New York.

COORDINATION OFFICE OF THE
US GLOBAL CHANGE RESEARCH
PROGRAM

MEMORANDUM

TO: Donna Wieting, CENR Secretariat

FROM: Rick Kelly, Program Associate, USGCRP Observations Working Group RK

RE: CENR Approval of the U.S. Interagency UV-Monitoring Plan

DATE: 09 September 1994

Donna,

Per our phone conversation earlier this morning, eighteen (18) copies of the draft USGCRP document "The U.S. Interagency UV-Monitoring Plan" are enclosed for distribution to the CENR agency representatives for final approval. Also enclosed is Bob Corell's letter of transmittal to Dr. Baker.

I will be informing the members of the USGCRP UV Panel that the Plan is being sent out for CENR approval so that they can alert the appropriate people within their agencies. This step should (hopefully) speed up the CENR agency approval. As one of the drivers in the development of this Plan was a series of letters sent from the Senate Committee on the Environment and Public Works to several CENR agencies late last year, we believe that the rapid CENR approval and publication of the UV Plan is crucial.

If there is any actions that I can take to assist the CENR Secretariat in obtaining feedback from the agencies on the UV Plan, please do not hesitate to contact me at (202) 554-7836 or via Email at rkelly@usgcrp.gov.

Washington Design Center
300 D Street, S.W., Suite 840
Washington, D.C. 20024

(202) 554-6470
(202) 554-7830 FAX
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To: bbaker@ncdc.noaa.gov,barnard.william@epamail.epa.gov
deluisi@srrb.erl.gov,J.Elwood@omnet.com
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mkurylo@mtpe.hq.nasa.gov,haitien@oahu.wwb.noaa.gov
littlee@mail.fws.gov,long@upair.wwb.noaa.gov
tlyon@aeha1.apgea.army.mil,nmaynard@mtpe.hq.nasa.gov
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r8nerc.estc@mail.fws.gov,dsliney@aeha1.apgea.army.mil
ambler@enh.nist.gov,betsy@srrb.erl.gov
Cc: DWieting@hq.noaa.gov,staff@usgcrp.gov
Bcc:
From: rkelly@usgcrp.gov (Rick Kelly)
Subject: UV Plan is now at CENR
Date: Friday, September 9, 1994 at 4:05:58 pm EDT
Attach: Headers.822
Certify: N
Forwarded by:

Dear USGCRP UV Panel Members:

Approximately two hours ago, I hand-carried the U.S. Interagency UV-Monitoring Plan to the CENR Secretariat for final CENR agency approval. The Secretariat will be distributing the Plan to your agency CENR Principals for agency sign-off.

You can assist in the completion of CENR approval and the amount of time it takes to get the Plan published by alerting your agency's CENR Principal that it is on the way and that you support your agency's approval of the document.

These are the CENR Principals for several of your agencies. You may wish to discuss the best plan of action with your agency's SGCR Principal prior to going to the CENR level.

USDA: Mr. Jim Lyons
DOC/NOAA: Dr. D. James Baker
DOD: Dr. Joseph Osterman
DOE: Ms. Susan Tierney
DOI: Dr. Debra Knopman
EPA: Mr. Robert Sussman
HHS: Dr. Kenneth Olden
NASA: Dr. Charles Kennel
NSF: Dr. Anne Petersen
SI: Dr. Thomas Lovejoy

As soon as CENR approval is onbtained, we can go to press. Please feel free to contact me if I can provide you with any additional information on the UV Plan.

Sincerely,

Rick Kelly

****
Rick Kelly
Program Associate
Observations Working Group
Coordination Office of the USGCRP
300 D Street, SW, Suite 840
Washington, DC 20024
Voice #: (202) 554-7836
Fax #: (202) 554-7830
Email: rkelly@usgcrp.gov
****