# 1. Introduction and Executive Summary

In the fall of 1987, responding to the serious ozone depletion reported in Antarctica, the Division of Polar Programs of the National Science Foundation called for the establishment of an Ultraviolet (UV) Monitoring System in Antarctica. Now in its 20th year, NSF's "Ultraviolet Spectral Irradiance Monitoring Network" is the longest operating, high-resolution UV scanning spectroradiometer network in the world. It has been operationally successful in the harshest environments of Antarctica and the Arctic and is continuously returning data to researchers studying the effects of UV radiation on terrestrial and marine biological systems. In addition, data are used by atmospheric scientists investigating the influence of atmospheric constituents such as ozone and clouds on UV levels at the ground. These studies helped to quantify the impact of ozone depletion, to analyze the variability of UV radiation on time-scales from hours to years, and to develop and verify models describing the transfer of solar radiation through the atmosphere.

Spectroradiometers of type SUV-100 and SUV-150B, manufactured by Biospherical Instruments Inc., are at the heart of the network. Systems were installed at four locations between February and November 1988; a fifth instrument was established at Barrow, Alaska, in December 1990. The San Diego system was installed in November 1992 and is also used for training of system operators and testing of upgrades to the instruments. The last addition was the installation of a SUV-150B spectroradiometer at Summit, Greenland in August 2004. Table 1.1 lists the locations of network sites.

**Table 1.1. NSF UV Monitoring Network Sites.**

| ID # | Site | Longitude | Latitude | Established | Normal Season |
|---|---|---|---|---|---|
| 1 | McMurdo, Antarctica* | 166º40'E | 77º50'S | March 1988 | August – April |
| 2 | Palmer, Antarctica | 64º03'W | 64º46'S | May 1988 | Year-round |
| 3 | South Pole, Antarctica | - | 90º00'S | February 1988 | September – March |
| 4 | Ushuaia, Argentina** | 68º19'W | 54º49'S | November 1988 | Year-round |
| 5 | San Diego, California*** | 117º12'W | 32º46'N | November 1992 | Year-round |
| 6 | Barrow, Alaska**** | 156º41'W | 71º19'N | December 1990 | January – November |
| 7 | Summit, Greenland***** | 38°27'W | 72 34'N | August 2004 | January – November |

* Located at Arrival Heights, approximately 3 km north of McMurdo
** Located at the Centro Austral de Investigaciones Cientificas (CADIC), Argentina
*** Collocated with Biospherical Instruments Inc.
**** Located at the Ukpeaġvik Iñupiat Corporation (formerly) Naval Arctic Research Laboratory (UIC/NARL)
***** Located in the "Green House"

SUV spectroradiometers are based on a temperature-stabilized, scanning double monochromator coupled to a photomultiplier tube (PMT) detector. Measurements of global spectral irradiance between 280 and 605 nm are conducted quarter-hourly when the sun is above the horizon. The instruments have internal wavelength and irradiance calibration lamps for daily automatic calibrations at programmed intervals.

Between 2001 and 2005, moderate-bandwidth, multi-channel filter radiometers (models GUV-511 and GUV-541, manufactured by Biospherical Instruments Inc.) were added to all network sites. These instruments provide measurements at four approximately 10 nm wide UV bands centered at 305, 320, 340, and 380 nm. A fifth channel either measures radiation at 313 nm (GUV-541) or Photosynthetically Active Radiation (GUV-511). Data from the GUV radiometers are made available in near real time-via the "Updates" link at the project's website at www.biospherical.com/nsf/. All network sites are also equipped with pyranometers (model PSP from Eppley Laboratory Inc.) and broadband UV-A detectors (model TUVR from Eppley Laboratory Inc.). For additional information on network hardware see Chapter 2.

Data from the SUV instruments are processed on a weekly basis and a subset of data in numeral and graphical form can also be accessed at the website www.biospherical.com/nsf/. These data have to be regarded preliminary and are subject to revision. Investigators are encouraged to contact Biospherical Instruments before drawing any final conclusions from these data or using them in a publication. Final data are made available on an annual basis and are distributed via the "Data/Report" link on the project's website, and on CD-ROM. Final data are also known as "Version 0." To produce Version 0 data, all available calibration information is used. This includes data collected during annual visits to the network

locations. During these visits, on-site standards of spectral irradiance are compared with traveling standards traceable to the U.S. National Institute for Standards and Technology (NIST). Version 0 data have further been screened for instrument drifts, instrumental malfunctions, and other events that may affect the accuracy. A detailed report on quality control can be found in Chapter 5.

Version 0 data have not been corrected for the cosine error of the SUV spectroradiometers. A new cosine-corrected data set is currently being prepared and is named "Version 2." As of September 2008, Version 2 data of all sites but San Diego are available. Version 2 data also include additional data products such as total ozone column, effective albedo, and cloud optical depth calculated from SUV measurements. Every measured spectrum is complemented with two model spectra calculated with the radiative transfer model UVSPEC/libRadtran. One spectrum is calculated assuming clear sky conditions while the second spectrum also takes attenuation by clouds into account. Version 2 data are not discussed in this report. For further information, see the Version 2 website at www.biospherical.com/NSF/Version2. Since Version 2 data have higher accuracy than Version 0 data, we encourage researches to use this new data set.

This report complements Volume 16.0 Version 0 data from the NSF Polar Programs UV Radiation Monitoring Network, encompassing the years 2006 and 2007. The published data set includes:

- Solar global irradiance spectra in full spectral resolution between 280 and 605 nm measured by SUV spectroradiometers. Each spectrum is stored in a separate file in ASCII comma separated value (CSV) format.
- Databases in ASCII format providing measurements of global spectral irradiance at selected wavelengths extracted from the full-resolution irradiance spectra from SUV spectra. These databases provide an easy way to analyze time series over extended periods of time.
- Databases with spectral integrals (e.g., UV-B and UV-A) and weighted spectral irradiances ("dose rates") calculated from SUV spectra. Six biological action spectra have been implemented, including the CIE action spectrum for erythema (McKinlay and Diffey, 1987) and the action spectrum for DNA damage (Setlow, 1974).
- Databases with daily doses that have been calculated by integrating spectral integrals and dose-rates over 24 hour time periods.
- Databases with measurements of GUV radiometers including spectral irradiance at selected wavelengths, integrals, and dose rates for a large number of action spectra.
- Ancillary measurements from Eppley PSP and TUVR radiometers.
- Databases with system parameters, which are helpful for quality control.

As of September 2008, this network of instruments has provided data for the support of 172 publications, of which 101 are peer-reviewed. These publications include work in atmospheric sciences (45%); effects research (30%); and validation of satellite, model, and instrument data (25%). A complete list of references is available in Appendix A2. Network data have also been featured in WMO/UNEP Scientific Assessments of Ozone Depletion (WMO, 1995; 1999; 2003; 2007), UNEP Assessment reports on the Environmental Effects of Ozone Depletion and its Interactions with Climate Change (UNEP, 2006), and in WMO ozone bulletins (www.wmo.ch/pages/prog/arep/gaw/ozone/), published during the austral spring.

This report is structured as follows: Section 2 provides a description of instrumentation used in the network. In Section 3, the network sites are described, including prevailing atmospheric conditions. Section 4 discusses raw data as well as calibration and data processing methods. Section 5 discusses the calibration standards used to process Volume 16 data and gives results of the quality control procedures applied. Section 6 describes the contents and format of the published data, including database structure. Section 7 provides examples of network data for each of the sites. In this section, Volume 16 data are contrasted with UV measurements of previous years.