5. Quality Control Summary

The successful operation of a network of complex instruments, such as scanning spectroradiometers, depends on having a well-defined approach to quality assurance and quality control (QA/QC). Many elements of this program have been discussed in previous sections. In the NSF UV Spectroradiometer Network, the following elements are part of our QA/QC program:

- Standardization of instruments in the network
- Standardized data processing procedures including calibration review and implementation of correction methods
- Standardized procedures, parts, and supplies
- Centralized operator training
- Scheduled instrument maintenance
- Careful review of recorded data
- Publication of instrument operating history
- Participation in instrument intercomparison
- Data analysis and publication by independent scientists
- Publication in refereed journals

In addition to the quality control procedures at each site, we have made additional quality assurances by standardizing operation protocols, data processing, and instrument configurations. All site operators are trained at our San Diego facility, and documented operating procedures are used. We schedule instrument maintenance to coincide with the annual site visits. A more detailed temporal view of the QA/QC activities is presented in the following table.

Table 5.1. Schedule of data acquisition, quality control/ assurance, and publication.

5 minute	***Bi-weekly***
Temperatures and power checks	External system calibration
Monochromator position check	***Monthly***
Peripheral UV sensors check	Analysis of calibration and standards stability
Detection of system anomalies by software	***Yearly***
Daily	Operator training at San Diego
Responsivity characterization	Site visits including:
Wavelength alignment check	Scheduled maintenance
Site-operator checks	Operation audit (testing)
On-site preliminary UV-B calculations	Standards comparison
1-2 days	Reprocessing of all calibrations and data
Data transfers	Final data check
Weekly	Report and CD-ROM generation
Data archive checks	***Additionally***
System performance reviews	Intercomparisons
Preliminary database updates	Comparisons with radiative transfer models
System parameter time series and irradiance value checks	Re-evaluation and testing of methods
Website updates	

Annual reports are published by Biospherical Instruments to detail the operating history of each instrument and present quality control data that can aid researchers in using data from the network. BSI also participates in both North American and international intercomparisons of spectroradiometers and standards. Many researchers have had access to these data, conducted their own independent analyses, and published their results.

In the post-seasonal analysis of the instrument performance, both the wavelength stability of the monochromator and drive system and the stability of the system responsivity are carefully analyzed (See Section 3 of this report for details on calibration and data processing protocols). System responsivity is tracked by analysis of the response scans. For example, there are several events that can occur and will introduce a change into the system sensitivity:

- Intentional change of the system responsivity (PMT high voltage change) to accommodate changing radiation levels throughout a day;
- Change of the response lamp to compensate for aging, casualty, or replacement;
- Change in instrument temperature;
- Any alteration to the system including engineering upgrades and routine or unanticipated maintenance; and
- Unknown causes.

The final quality of Level 3 data from the NSF UV Spectroradiometer is improved continuously and checked by several methods:

- Based on data from the internal irradiance and wavelength standards, and from measurements of other built-in or ancillary sensors (e.g., TSI, temperature, ground, wavelength-position sensor, PSP, and TUVR) system drifts and “outliers” can be detected forcing remedial action to be taken.

- Data of the current season are compared with data from previous seasons. This helps to detect system changes.

- Careful examination of all irradiance calibrations with 200-Watt standards. This also includes intercomparisons of on-site standards and traveling standards as well as standards with a new calibration applied by standards laboratories.

- With the Fraunhofer-correlation method, which was introduced in the current season (see Section 3), deviations in the wavelength registration can be detected and diminished.

- Comparisons of measured spectra with calculations of radiative transfer models.

- Beginning in 1994, SUV spectroradiometers participated in several intercomparisons with other research-quality instruments and standards. These activities have been, and will continue to be, reported elsewhere.

In the remainder of this section, ongoing advancements in network instrumentation, which will further improve the quality of network data, are introduced and the results of quality control and calibration monitoring of the current season are described in detail.

5.1. Advancements

Portable instruments were developed for the purpose of research as well as quality control. The portable SUV-100 and the new SUV-150 UV spectroradiometers, which has been developed as a successor to the SUV-100, have been active participants in both North American and international intercomparison activities.

The portable version of the SUV-100 participated at the Fraunhofer Institute for Atmospheric Environmental Research (IFU) Intercomparison, Garmisch-Partenkirchen, located in southern Germany, during August 1994 (Seckmeyer, et al., 1995). It also took part in three annual NOAA/NIST North American Intercomparisons of Ultraviolet Monitoring Spectroradiometers in 1994 through 1996 (Thompson et al., 1996, 1997).

Figure 5.1.1. *Test platform at Biospherical Instruments. SUV-100 installation (not shown) is in the roof seen to the left. Instruments shown here include the SUV-150 (top) and the portable SUV-100 (right foreground). On the edge of the roof in the foreground are two GPS receivers used for timekeeping, and at the left are several GUV and PUV radiometers also used in UV monitoring programs.*

Figure 5.1.2. *Portable SUV-100 and other instruments shown at the Fraunhofer Institute for Atmospheric Environmental Research (IFU), Garmisch-Partenkirchen, located in southern Germany, during an international intercomparison in August 1994.*

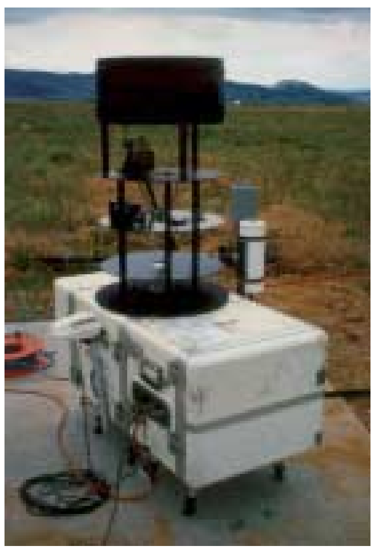

Figure 5.1.3.

NOAA/NIST North American Intercomparison at Boulder, Colorado, June 1996. Portable SUV-100 shown with NOAA/NIST Field Calibrator installed.

In 1997, a new instrument, the SUV-150, was developed to take advantage of 10 years of advancements in optical, electronic, data acquisition, and computer technologies, with the end goal of deployment at one of the sites. This technological showcase was first employed at the European Union (EU) SUSPEN Campaign, an international instrumentation and standards intercomparison in Thessaloniki, Greece (July 1997). After several engineering improvements following the experience at SUSPEN, the SUV-150 was then deployed at the NOAA/NIST North American Intercomparison at Boulder, Colorado (September 1997). The fourth in a series of annual NOAA/NIST North American Intercomparisons of Ultraviolet Monitoring Spectroradiometers in 1997, culminated in reductions of uncertainties in measurements and standards, and has also led to the development of standards and apparatus for the purpose of "field" characterizations of this type of instrumentation. A report on the results of this intercomparison campaign is currently being prepared by NOAA.

The SUV-150 spectroradiometer was operating in 1998 next to the SUV-100 network instrument on the roof platform of Biospherical Instrument Inc. Data from the period August 1998 to end of 1998 were evaluated and have been presented at the XXIV General Assembly of the European Geophysical Society that took place in The Hague, The Netherlands in April 1999. Compared to the SUV-100, it was shown that the SUV-150 has superior characteristics with respect to angular response, wavelength resolution, and detection limit. In addition, it has a smaller bandwidth and features a compact design, which facilitates installation, maintenance, and calibration. Instrument measurements were compared with model calculation. The agreement was in the range of ±5%, even for wavelength below 300 nm (at high sun) and solar zenith angles as high as 88°. As of this writing, the SUV-150 is under long term evaluation at San Diego to further the understanding and definition of its performance envelope, stability, and reliability.

Figure 5.1.4. *SUV-150 spectroradiometer at the SUSPEN Campaign Intercomprison held in Nea Michaniona, Greece, in July 1997.*