1. McMurdo Station (08/15/14 – 04/29/15)

Solar data of the SUV-100 spectroradiometer discussed in this quality control report were measured between 08/15/14 and 04/29/15 and were assigned to Volume 24. With few exceptions, the system performed normal during this period and its sensitivity was stable to within ±5%. Of note, the system's monochromator lost its wavelength position more frequently than usual. This led to some minor data loss (Section 1.4).

CUCF personnel visited McMurdo Station between 1/26/15 and 1/31/15, serviced the system, and compared on-site standards of spectral irradiance with traveling standards. During this visit, also the system's PSP radiometer (S/N 32760F3, calibration factor 7.73 x10^{-6} V/(W m^{-2})) was replaced with a similar unit that had been recalibrated in July 2013 by NOAA (S/N 12257F3, calibration factor 8.62 x10^{-6} V/(W m^{-2})).

The sensitivity of the system tends to depend somewhat on the azimuth position of the Sun. This dependency is reduced by the "cosine error" correction that is applied when "Version 0" data are converted to "Version 2" data. The phase of the azimuthal dependency was different before and after the site visit. This change in the system's angular response was addressed by applying different sets of cosine error correction coefficients to solar data collected before and after the site visit.

The GUV-511 multi-channel radiometer that is installed next to the SUV-100 spectroradiometer was not able to maintain its target temperature of 40 °C on 4/4/2015. It could not be determined whether this was due to an instrumental problem or to the exceptionally cold outside temperature (30 knot wind, wind chill was about -40 °C). As a precautionary measure, the instrument was removed from the roof and not reinstalled. There are therefore no GUV-511 data after 4/4/2015.

1.1. Irradiance Calibration

The on-site irradiance standards used during the reporting period were the lamps M-543, 200W011, 200W019, 200WN007, and 200WN008. Lamp 200WN004 was used as a traveling standard during the site visit in January 2015.

On-site standards
Lamps M-543, 200W011, and 200W019 have been in service for a long time. Lamps 200WN007 and 200WN008 were left at McMurdo in January 2014. Both lamps are considered long-term standard and will only be used during site visits. They were calibrated by CUCF in August 2013 with the same method as that applied to the traveling standards 200WN003 and 200WN004 (see below).

Lamps M-543, 200W011, and 200W019 were recalibrated in 2013 against lamp 200WN003 using absolute scans performed at McMurdo during the January 2013 site visit. Lamp 200WN003 was the traveling standard at this time. The traceability chain of this lamp is also described below. Calibrations established at this time for lamps 200W011 and 200W019 were also used for processing solar data of the reporting period. Lamp M-543 burned unstable during most of the Volume 22 and 23 periods (September 2012 – April 2014), but was reasonably stable during the reporting period. The lamp was recalibrated against the site standards 200WN007 and 200WN008 using absolute scans performed on 1/30/15, and this calibration was used for processing solar data of the reporting period.

Traveling standards 200WN003 and 200WN004
The traveling standards 200WN003 and 200WN004 were calibrated at NOAA against lamps 200WN001 and 200WN002 on 3/21/13. Lamps 200WN001 and 200WN002 had in turn been calibrated at BSI in November 2012 against the NIST primary standard F-616 using a multi-filter transfer radiometer. NIST standard F-616 is traceable to the detector-based scale of irradiance established by NIST in 2000. At the time 200WN001 and 200WN002 were calibrated, they were also compared with the long-term traveling

standard 200W017 of the NSF UV monitoring network. The irradiance scales of NIST standard F-616 and lamp 200W017 agreed to within 0.3%. It can therefore be assumed that the change from 200W017 to F-616 as the primary reference for calibrating on-site standards did not result in a significant step-change.

The five on-site standards and the traveling standard were compared with each other at the beginning and end of the January 2015 site visit. Figure 1 shows results of the comparison performed on 1/30/15. At this time, the scales of spectral irradiance of the on-site standards agreed on average to within ±0.5%. The scale of the traveling standard differed systematically from that of the on-site standards by about 1.5% in the UV-B and 0.5-1% in the UV-A and visible range. Deviations of this magnitude are still within the uncertainty of the irradiance scale and no correction was therefore attempted.

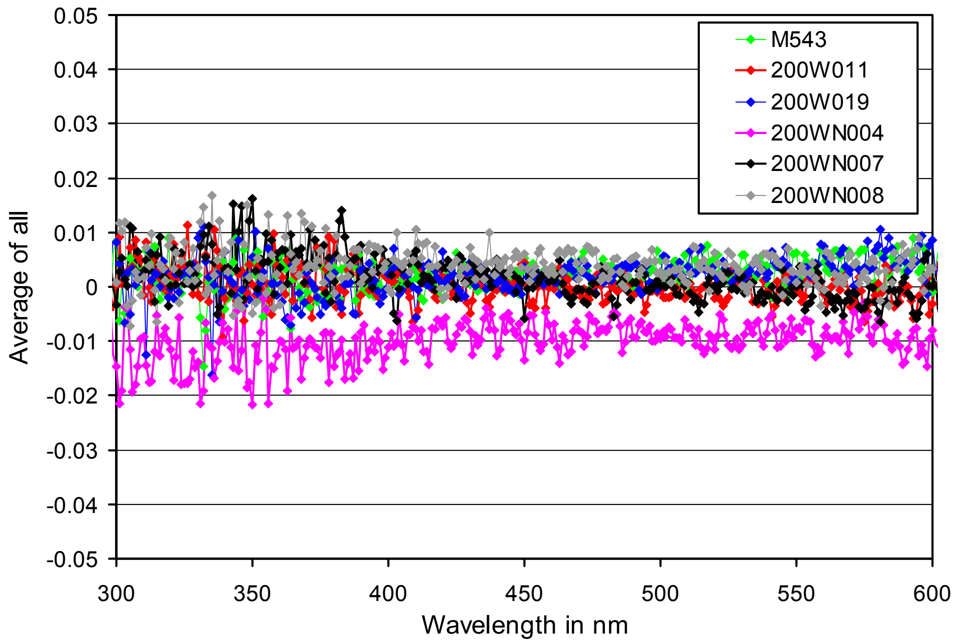

Figure 1. *Comparison of McMurdo on-site standards M543, 200W011, 200W019, 200WN007, and 200WN008 with the traveling standard 200W004 using absolute scans performed on 1/30/15.*

1.2. Instrument Stability

The temporal stability of the SUV-100 spectroradiometer was assessed by (1) analyzing measurements of the internal reference lamp, (2) analyzing absolute scans using the on-site standards, (3) comparing SUV-100 measurements with data of the collocated GUV-511 radiometer, and (4) comparing with results of a radiative transfer model. Results from the four methods are reviewed below.

Figure 2 shows results from measurements of the internal lamp. Specifically, readings of the instrument's TSI sensor are compared with measurements of the SUV-100's PMT at 300 and 400 nm. TSI readings decrease by about 3% between August 2014 and the time of the site visit (vertical line in Figure 2), indicating that the internal lamp was getting dimmer. The lamp was replaced during the site visit and the new lamp increased in brightness by about 3% during the post site visit period. For a perfectly stable system, TSI and PMT measurements would track each other in response to a change in the lamp's output. While this is not completely the case, the variations of both sensors are rather small, indicating that the internal elements of the system (monochromator, PMT) were stable to within about ±2%.

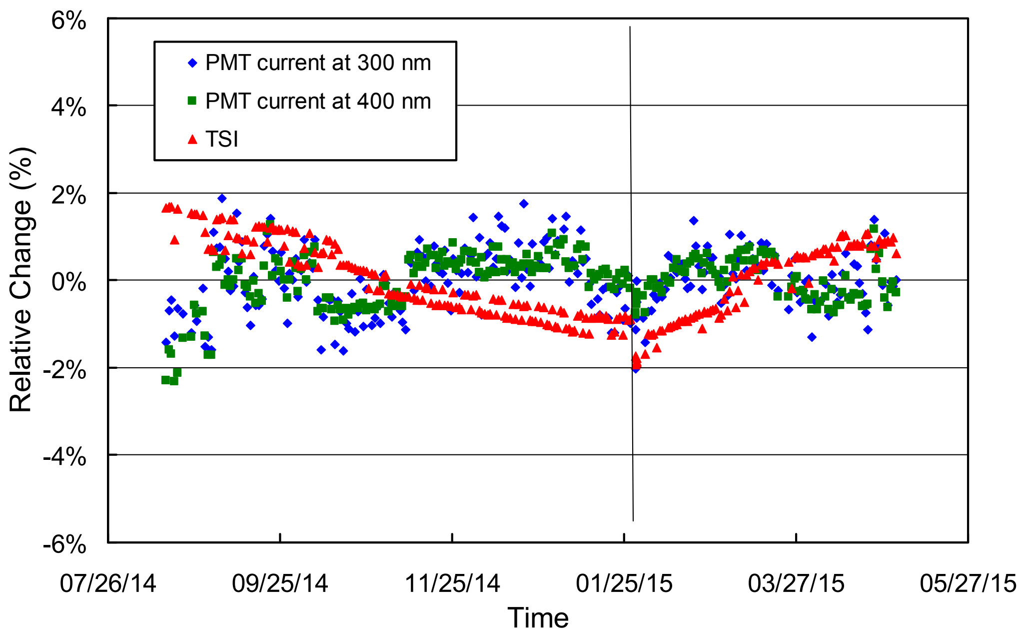

Figure 2. *Measurements of the SUV-100's TSI sensor and PMT currents at 300 and 400 nm. Data are shown as relative change. Data measured before and after the time of the site visit (vertical line) are normalized separately.*

Examination of scans of the on-site standards confirmed that the system was quite stable during the reporting period. Data of the bi-weekly calibration events varied by about ±3% in the UV and visible range, both before and after the site visit. Normal calibration procedures were applied, resulting in seven calibration periods, labeled P1 - P7 (Table 1). Figure 3 shows the ratios of irradiance spectra assigned to the internal reference lamp during these periods, relative to Period P1. A 10-15% change in the ratio can be observed between Periods P5 and P6, the periods bracketing the January 2015 site visit. A change in calibrations functions of this magnitude is normal and is caused by the system service performed during the site visit, including the replacement of the internal lamp.

Figure 3 shows the ratio of measurements of the 340 nm channel of the GUV-511 radiometer, which is installed next to the SUV-100 system, and final SUV-100 measurements. The latter were weighted with the spectral response function of the GUV's channel. The ratio is normalized and should ideally be one. The graph indicates that GUV and SUV measurements are consistent to within about ±5%; the standard deviation of the ratio is 2.0%. Times when the calibration changed are indicated by vertical lines.

Table 1: Calibration periods for McMurdo Volume 24 SUV-100 data.

Period name	Period range
P1	08/01/14 – 08/22/14
P2	08/23/14 – 09/15/14
P3	09/16/14 – 11/26/14
P4	11/27/14 – 12/10/14
P5	12/11/14 – 01/28/15
P6	01/29/15 – 02/04/15
P7	02/05/15 – 06/01/15

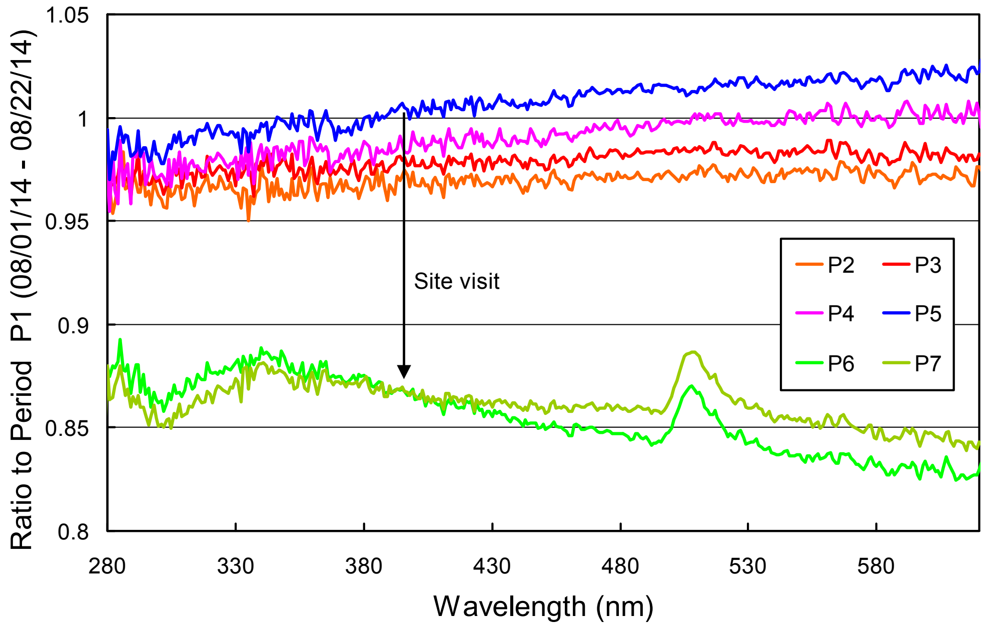

Figure 2. *Ratios of spectral irradiance assigned to the internal reference lamp during Periods P2 through P7, relative to Period P1. The large change in the ratio between Periods P5 and P6 is caused by service performed during the January 2015 site visit when the instrument was disassembled, cleaned, and reassembled.*

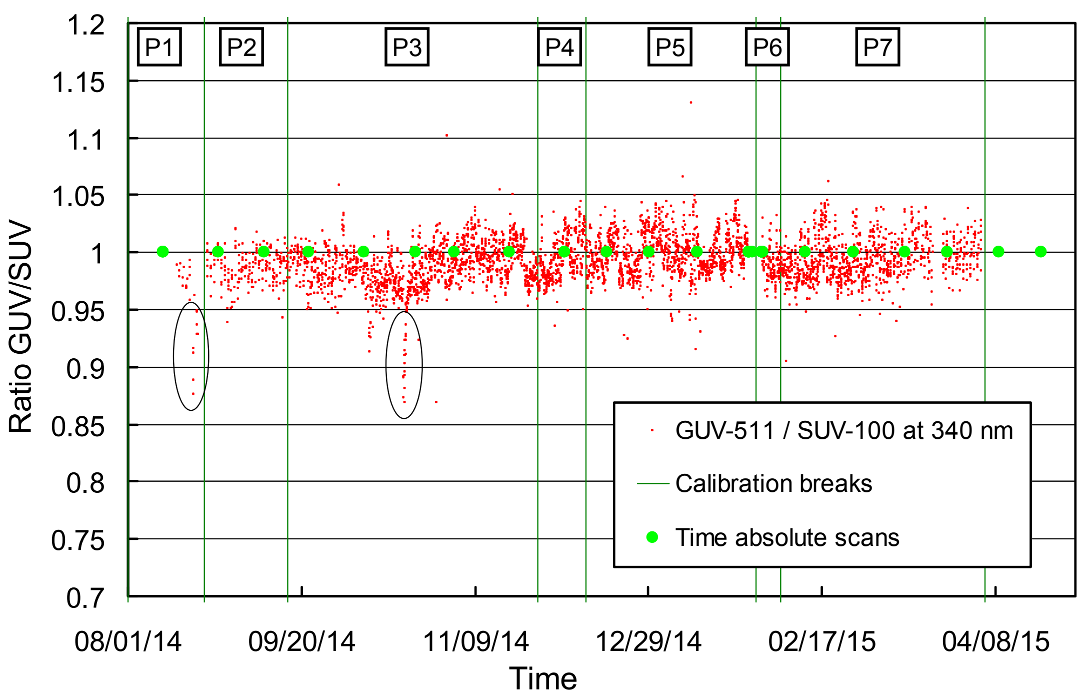

Figure 3. *Ratio of GUV-511 (340 nm channel) and SUV-100 measurements. Green vertical lines indicate times when the SUV-100 calibration was changed. Circles indicate times when the ratio of GUV and SUV measurements was abnormally small. The reason for these outlines could not be identified, but are likely caused by contamination of the GUV collector (e.g., from snow).*

As part of Version 2 processing, clear-sky measurements are routinely compared against results of a radiative transfer model (e.g., Bernhard et al., 2004). The median of measurement/model ratios, calculated from all clear-sky data of a given volume, is typically constant to within ±2% from volume to volume. Figure 4 show these "median ratios" for Volumes 17 – 24. It can be seen that the ratio of Volume 24 data is consistent with those of the earlier Volumes.

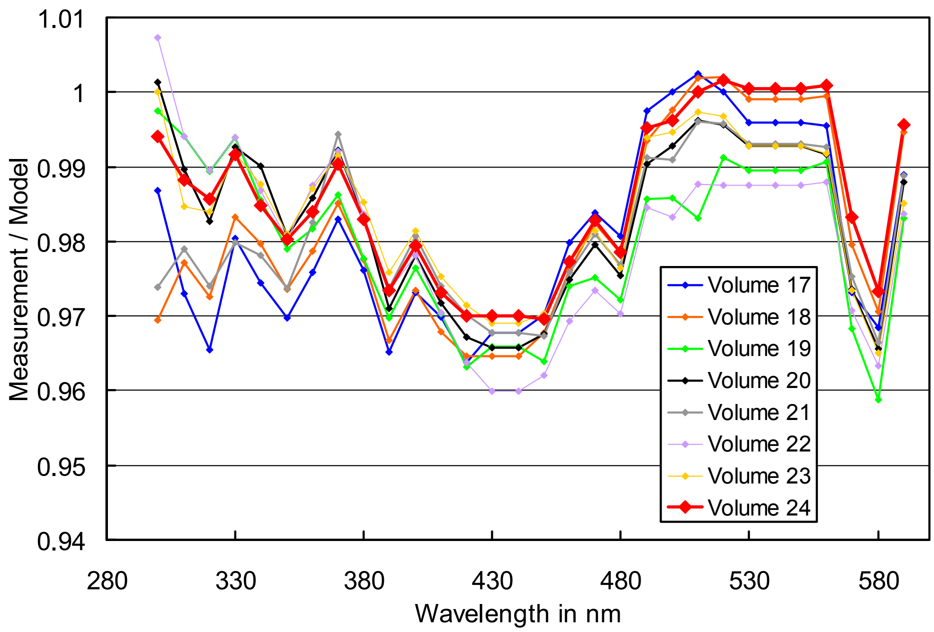

Figure 4. *Median measurement/model ratios calculated from clear-sky solar measurements for data of Volumes 17 – 24. Ratios were averaged over 10 nm intervals (305-315, 315-325, … 585-595 nm) before the median was calculated. There is a systematic, wavelength-dependent bias between measurement and model, however, this bias varies to within ±2% for the eight volumes, confirming that the irradiance scale used for processing of Volume 24 data is consistent with that used for earlier volumes.*

1.3. Wavelength Calibration

Wavelength stability of the system was monitored with the internal mercury lamp. Information from the daily wavelength scans was used to homogenize the data set by correcting day-to-day fluctuations in the wavelength offset. The wavelength-dependent bias of this homogenized dataset and the correct wavelength scale was determined with the Version 2 Fraunhofer-line correlation method (Bernhard et al., 2004). Figure 5 shows the correction functions calculated with this algorithm. Instrument service performed during the January 2015 site visit had only a small effect on the wavelength mapping of the monochromator. Hence, a single correction function for processing Version 0 data was applied to all solar data of the reporting period.

Figure 6 indicates the wavelength accuracy of final Version 0 data for six wavelengths in the UV and visible that was established by running the Version 2 Fraunhofer-line correlation method a second time. Shifts are typically smaller than ±0.05 nm. The wavelength correction was further modified when processing Version 2 data, which consequently have a somewhat better wavelength accuracy than Version 0 data.

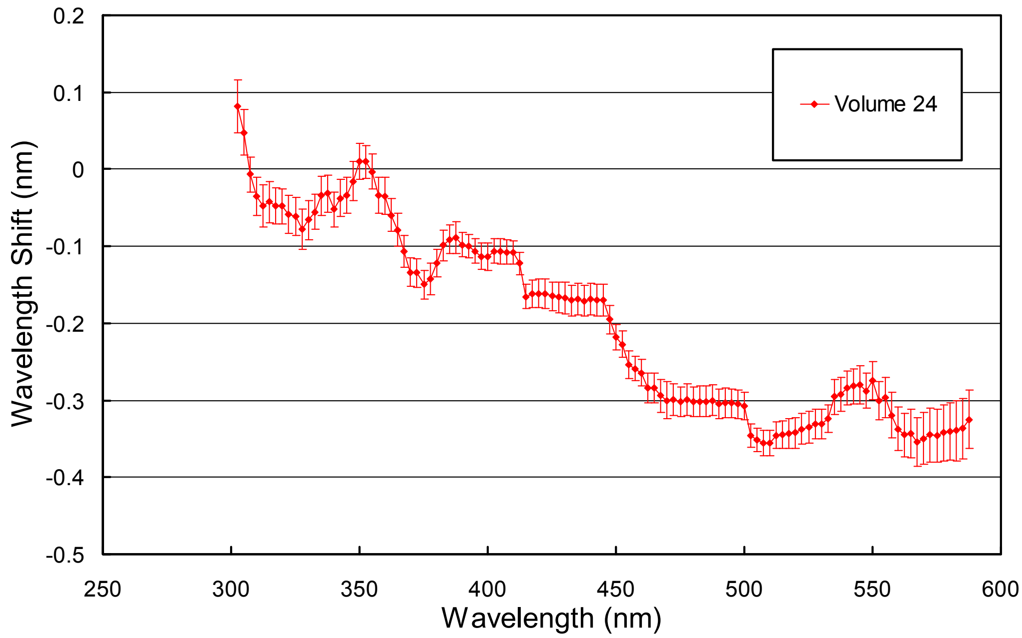

Figure 5. Monochromator non-linearity correction function for the Volume 24 period. Error bars indicate the 1σ-variation.

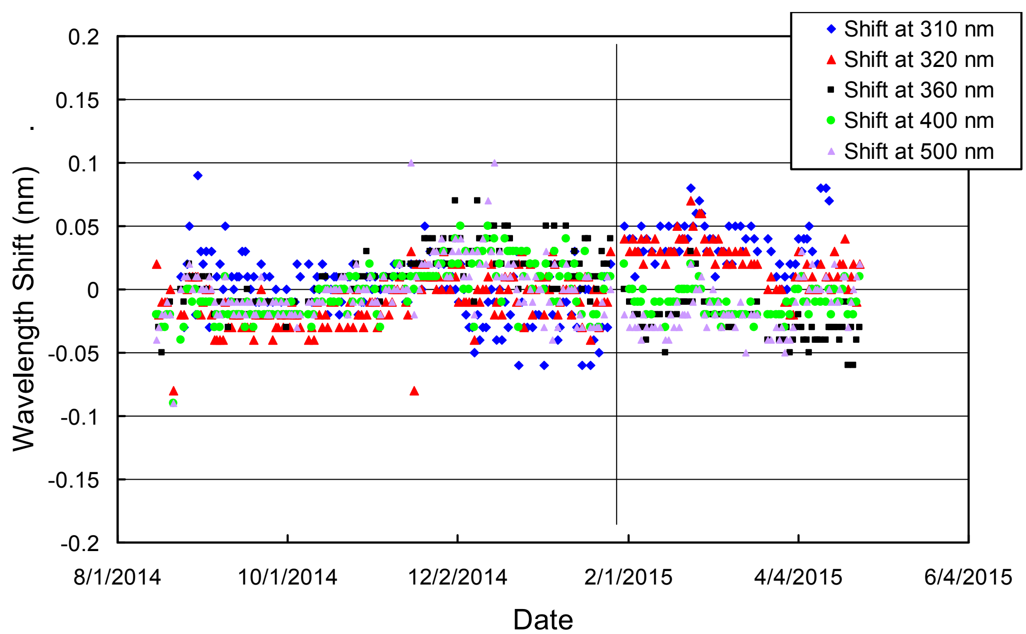

Figure 6. *Check of the wavelength accuracy of final Version 0 data at six wavelengths by means of Fraunhofer-line correlation. The plot is based on daily measurements at noon. The vertical line indicates the time of the site visit.*

1.4. Missing data

Table 2 provides a list of days that have substantial data gaps, plus indications of their causes.

Table 2 Days with substantial data gaps.

Date	Reason
08/22/14 - 08/23/14	Power outage, change of hard drive system control computer
08/27/14	Monochromator wavelength shifted by several nanometers
01/27/15 - 01/30/15	Annual site visit and instrument service
03/17/15	Monochromator wavelength shifted by several nanometers
03/21/15 - 03/23/15	System control computer reboots every hour; monochromator wavelength shifted by several nanometers

References

Bernhard, G., C. R. Booth, and J. C. Ehramjian. (2004). Version 2 data of the National Science Foundation's Ultraviolet Radiation Monitoring Network: South Pole, *J. Geophys. Res., 109,* D21207, doi:10.1029/2004JD004937.