1. McMurdo Station (08/15/21 – 04/30/22)

Solar data of the SUV-100 spectroradiometer discussed in this quality control (QC) report were measured between 08/15/21 and 04/30/22, and were assigned to Volume 31. There was no site visit during the reporting period due to the COVID-19 pandemic. The system was very stable and performed normally, with the exception of the following issues:

- Instead of performing four scans per hour as in the past, the system only measured three scans per hour (indexed at the hour, and 20 and 40 minutes past the hour.) The reduced schedule was the consequence of a "major" upgrade of the Windows 10 Operating System on 12/31/20 as described in the Volume 30 QC report. As of this writing, there is still no fix available for this issue.
- Like during the previous few seasons, the wavelength stability was degraded, requiring frequent adjustment of the system's wavelength registration during post-processing.
- The system's GPS receiver, which has been used to automatically update the computer time, failed on 1/14/20 (during the Volume 29 reporting period). From that time onward, the computer's clock has been checked and adjusted manually. The clock of the system PC is fortunately very stable. Hence, time errors in published data remain negligible. A replacement of the GPS receiver that is compatible with the system is not available.

The datasets consists of 13,094 solar spectra, which are fewer than typical due to the reduce duty cycle. The system's PSP radiometer was unit 32760F3 and has a calibration factor of 7.501 x10^{-6} V/(W m^{-2}). Data of the collocated TUVR radiometer were erratic and were not published.

On 12/4/21, a solar eclipse was visible from Antarctica. At McMurdo, the eclipse started on 7:21:26 and ended on 9:07:15 UT. The eclipse maximum (magnitude of 0.851) occurred on 8:14:51 UT when approximately 83% of the solar disk was covered by the Moon. Figure 1 shows measurements of the UV Index by the SUV-100 and GUV-511 radiometers during the eclipse. The two datasets are in good agreement. Note that GUV-511 data have a time resolution of 1 minute while SUV-100 spectra are measured every 20 minutes.

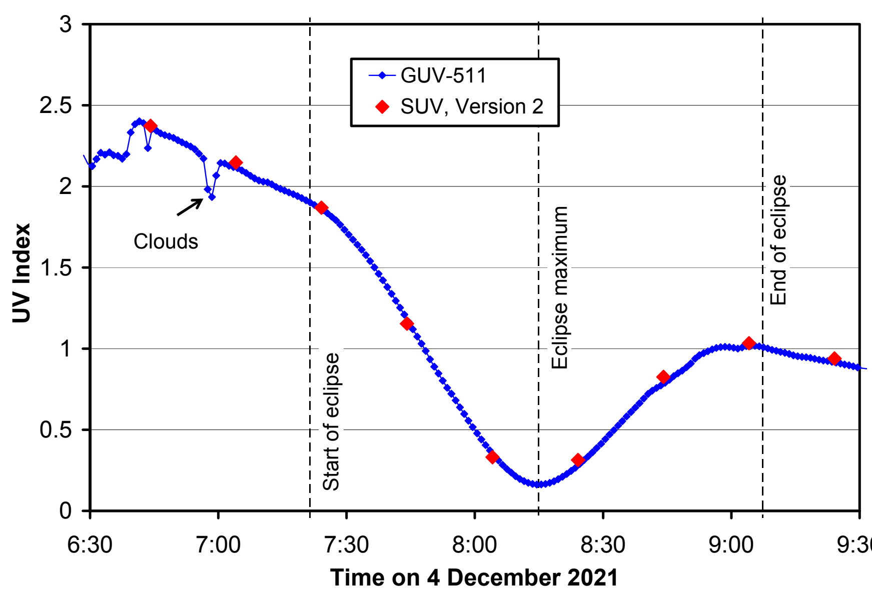

Figure 1. *UV Index at the McMurdo during the solar eclipse of 12/4/21. Measurements by the SUV-100 spectroradiometer (Version 2 data) and GUV-511 radiometer are in good agreement. During the eclipse maximum, the UV Index is about 13% of the value expected from the unobstructed Sun. Measurements were slightly affected by clouds.*

1.1. Irradiance Calibration

On-site irradiance standards available during the reporting period were the lamps M-543, 200W011, 200W019, 200WN007, and 200WN008. Lamps M-543, 200W011, and 200W019 are "working standards" and are used on a regular basis. Lamps 200WN007 and 200WN008 were left at McMurdo in January 2014. Both lamps are designated "long-term" standards and are typically only used during site visits. Only lamp 200WN007 was used during the reporting period.

The scales of spectral irradiance assigned to the three working and long-term standards were the same as those applied during the previous four season (Volumes 27–30), specifically:

- Lamps 200W011 and 200W019 had been recalibrated on 6/11/18 against the scale of the two long-term standards 200WN007 and 200WN008.
- Lamp M543 had been recalibrated on 8/8/16 against the working standard 200W011.

Traceability of long-term standards 200WN007 and 200WN008
Lamps 200WN007 and 200WN008 were calibrated by CUCF in August 2013 against lamps 200WN001 and 200WN002. The latter two lamps had in turn been calibrated by Biospherical Instruments in November 2012 against the NIST 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 when lamps 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%.

In early 2020, the chain of calibrations applied between 1996 and 2019 to solar data of the NSF and NOAA monitoring networks was re-evaluated (Bernhard and Stierle, 2020). This analysis suggested that the scale of spectral irradiance of NIST standard F-616 is low compared to the scale of primary standards used before 2013. This bias is –2% at 300 nm, –1% at 375 nm, and less than ±0.5% between 420 and 600 nm. **Version 2 solar data of Volume 31 were scaled upward accordingly, however, Version 0 remain traceable to the original scale of the primary standard F-616.**

Figure 2 shows a comparison of working standards 200W011 and 200W019 with the long-term standard 200WN007 based on absolute scans taken on 8/16/2021. The scales of spectral irradiance of the three standards agreed to better than ±0.5% on average in the UV-A and visible range, and to within ±1% in the UV-B range. A similar comparison of the working standards M543, 200W011, 200W019 was performed on 4/28/2022. At this time, the three standard agreed to within ±0.7%, confirming that calibrations of the reporting period are very consistent.

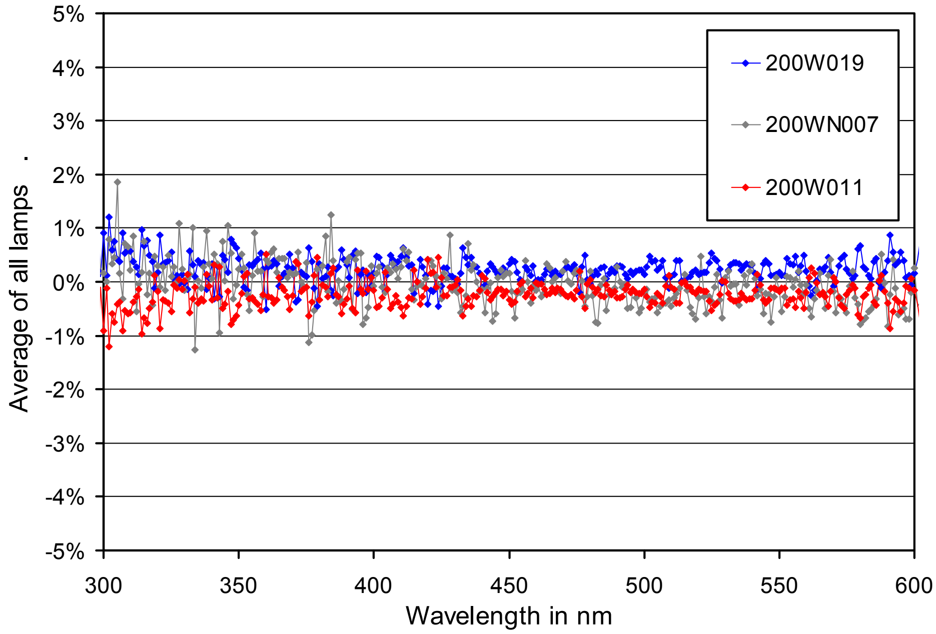

Figure 2. Comparison of McMurdo standards 200W011, 200W019, and 200WN007 using absolute scans performed on 8/16/2021

The scale of irradiance maintained by the five on-site standards was further checked by comparing SUV-100 measurements with data of the collocated GUV-511 radiometer. Like in the last years, the GUV radiometer was vicariously calibrated against the SUV's measurements. Calibration factors established for the GUV's 305, 340, 380 and PAR channels for the 2020/21 period agreed to within 0.5% with those calculated for the reporting period, confirming that the scales of irradiance applied to solar data of the SUV-100 spectroradiometer in 2020/21 and 2021/22 are consistent.

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 solar measurements with results of a radiative transfer model. Results of the four methods are reviewed below.

Figure 3 shows results from measurements of the internal lamp. Specifically, readings of the instrument's TSI sensor (a filtered photo diode with sensitivity mostly in the UV-A) are compared with measurements of the SUV-100's PMT at 300 and 400 nm. TSI readings increased by about 1% over the reporting period, indicating excellent stability of the internal lamp. For a perfectly stable system, TSI and PMT measurements would track each other in response to a change in the lamp's output. In actuality, PMT measurements at both wavelengths increased by about 4% between the start of the reporting period and 11/1/21, and remained stable to within ±1% for the remainder of the reporting period. By "pairing" solar scans with scans of the internal lamp that were performed on the same day as the solar measurements, day-to-day changes of the system's sensitivity (as indicated by changes in PMT current and/or monochromator throughput) are corrected.

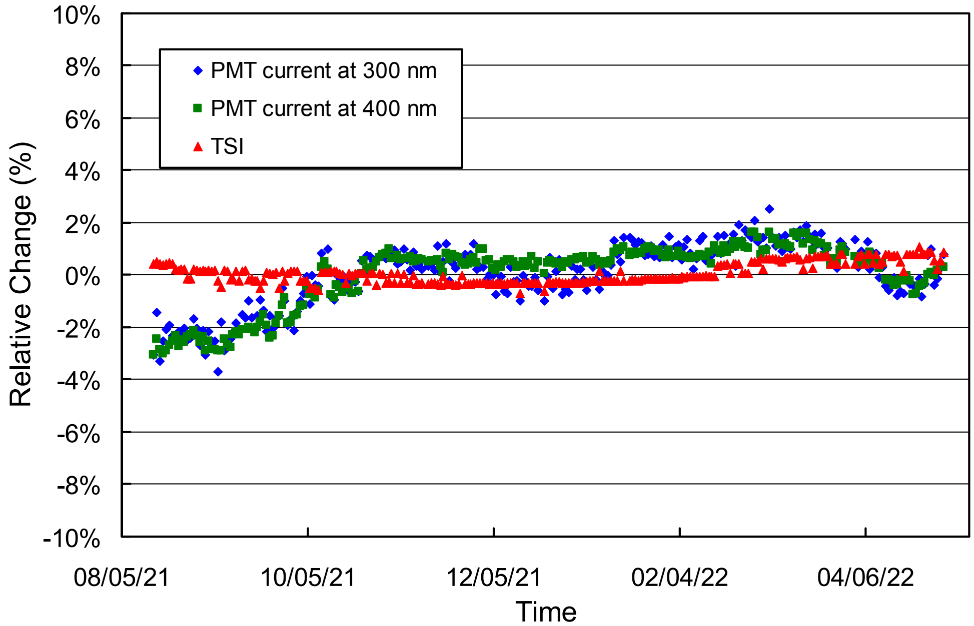

Figure 3. *Measurements of the SUV-100's TSI sensor and PMT currents at 300 and 400 nm. Data are shown as relative change and normalized to the average of the entire period.*

Examination of scans of the on-site standards confirmed that the system was extraordinarily stable during the reporting period, and only one calibration function was needed for the entire period. This function was the average of 20 calibration scans performed with the three working standards throughput the reporting period, plus standard 200WN007 on 8/16/21.

Figure 4 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 measurements 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% except for one period on 9/18/21 when snow was potentially covering the collector of the SUV-100 but not the GUV.
Several other outliers can be attributed by shading from obstacles that are in the field of view of the instruments. Because GUV and SUV radiometers are not positioned at exactly the same location, shadows from these obstacles fall on the collectors of the two instruments at slightly different times. Scans affected by shadowing were flagged in the SUV-100 Version 2 dataset, removed from the GUV dataset, but remain part of the SUV-100 Version 0 dataset.

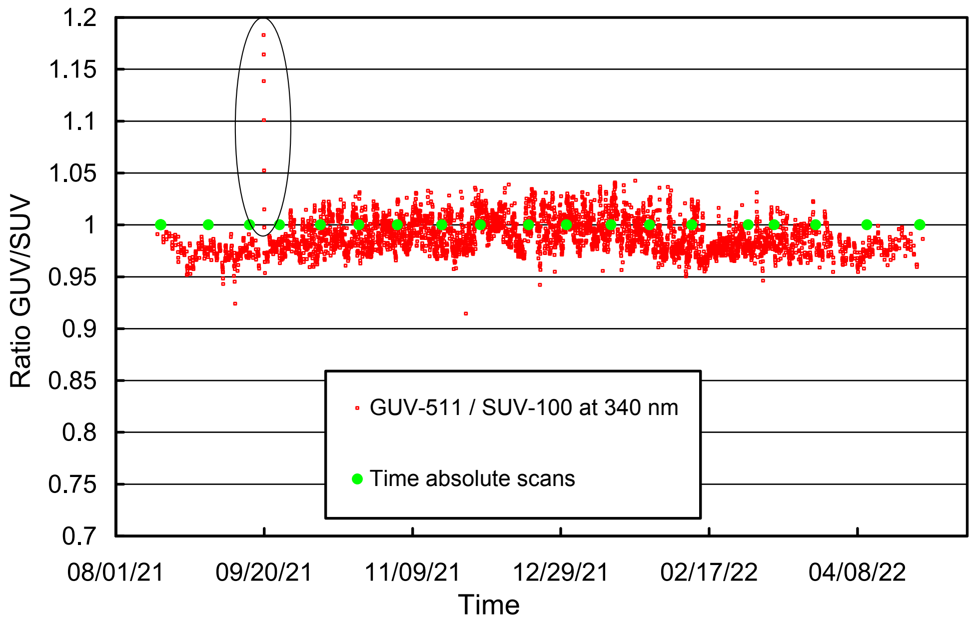

Figure 4. *Ratio of GUV-511 (340 nm channel) and SUV-100 measurements. The times when "absolute" calibration scans of the SUV-100 were performed are indicated by green symbols. The ellipse marks outliers which were likely caused by snow covering the collector of the SUV-100 but not the GUV-511.*

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 function calculated with this algorithm.

Figure 6 indicates the wavelength accuracy of Version 0 data for six wavelengths in the UV and visible range, which was established by running the Fraunhofer-line correlation method for a second time. Shifts are typically smaller than ±0.1 nm, but these residuals are not uniformly distributed over the reporting period. Instead, shifts vary between +0.1 nm and –0.1 nm and have a periodicity of about 14 days. The reason of this periodicity could not be unambiguously identified. For some periods, there is some correlation with the timing of absolute scans, but not for all periods. (During absolute scans, the system scans up to 700 nm while the terminal wavelength during solar scans is 605 nm. It is possible that scanning over the longer range affects the wavelength mapping of the monochromator.)

The wavelength correction was further improved when processing Version 2 data by breaking the dataset into 41 sub-periods with a different correction function applied in each sub-period. Figure 7 shows the residuals of the wavelength offsets for the Version 2 dataset. The improvement of the wavelength accuracy compared to the Version 0 dataset (Figure 6) is obvious.

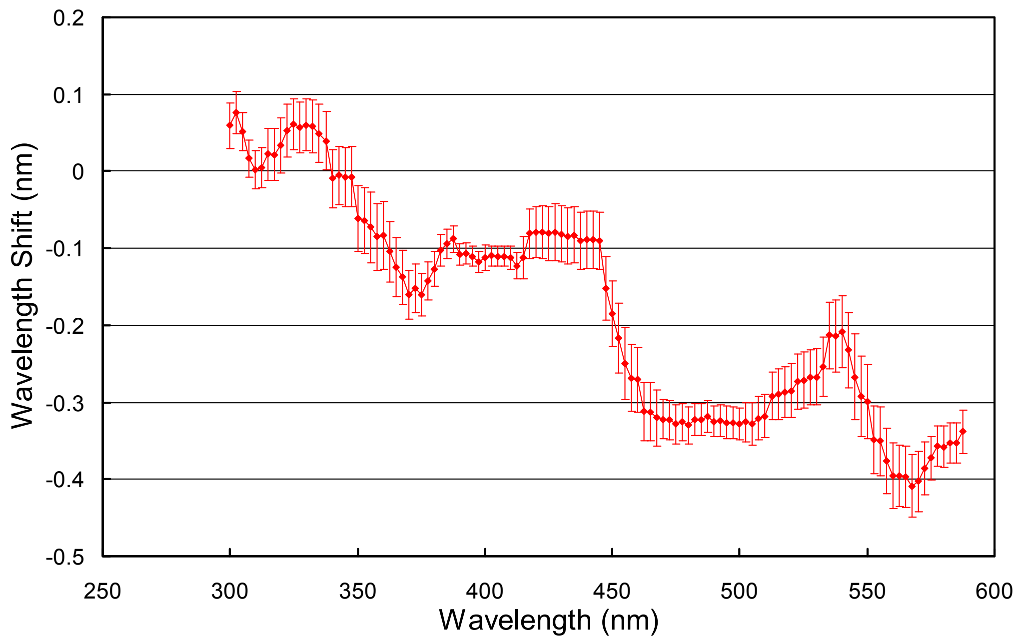

Figure 5. *Monochromator non-linearity correction function for the Volume 31 period. Error bars indicate the 1σ-variation.*

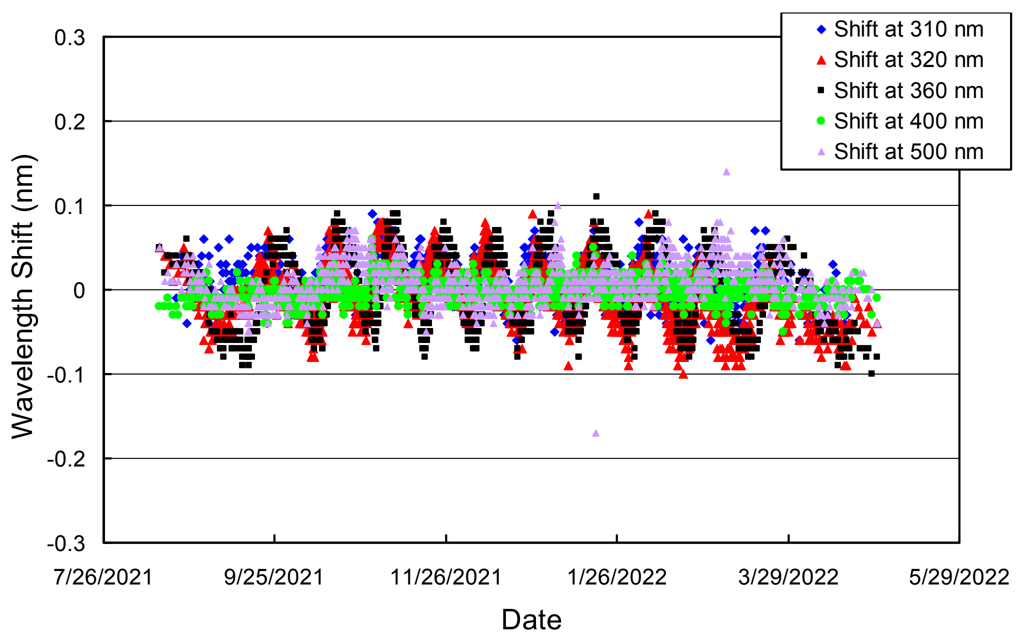

Figure 6. *Check of the wavelength accuracy of* <u>*Version 0*</u> *data at six wavelengths by means of Fraunhofer-line correlation. The plot is based on measurements that are three hours apart.*

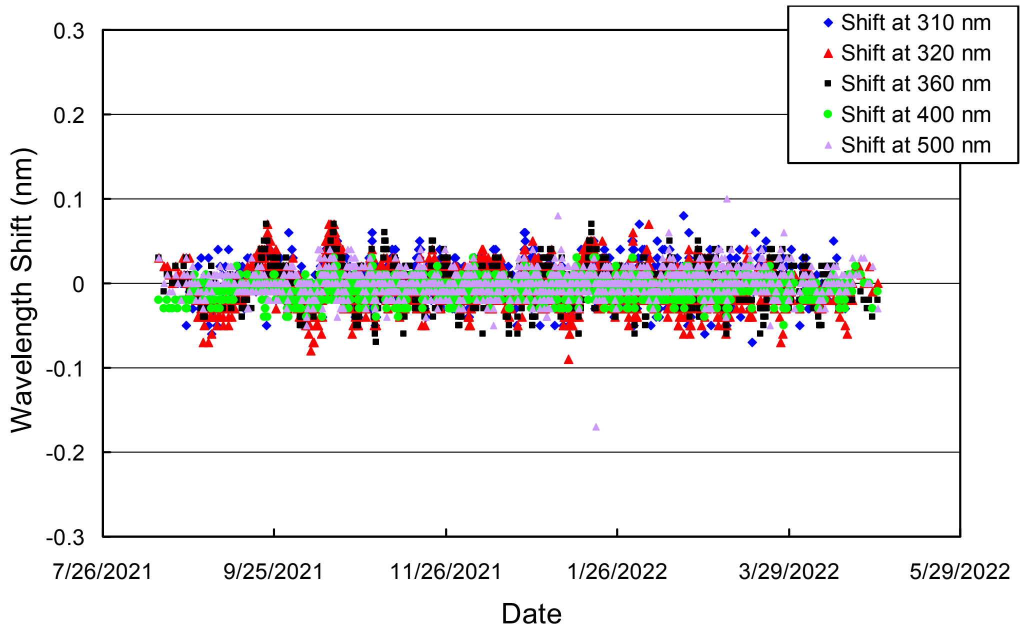

Figure 7. *Check of the wavelength accuracy of* *Version 2* *data at six wavelengths by means of Fraunhofer-line correlation.*

1.4. Missing data

The only day missing from the dataset is 03/31/22. The data loss resulted from an unforced computer reboot, which was potentially due to an automated operating system update.

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.

Bernhard G. and S. Stierle (2020). Trends of UV Radiation in Antarctica, Atmosphere, 11(8), 795, doi: https://doi.org/10.3390/atmos11080795.