

1. McMurdo Station (08/14/20 – 04/30/21)

Solar data of the SUV-100 spectroradiometer discussed in this quality control report were measured between 08/14/20 and 04/30/21 and were assigned to Volume 30. There was no site visit during the reporting period due to the COVID-19 pandemic. The system performed normally, with the exception of the following issues:

- After a “major” upgrade of the Windows 10 Operating System on 12/31/20, communication between the system control computer and peripheral electronic slowed-down considerably. As a consequence, spectral scans lasted longer than 15 minutes and the standard schedule of four scans per hour could no longer be maintained. Between 1/1/21 and 1/7/21, only two scans per hour were executed. Between 1/8/21 and 1/10/21, the schedule was changed to three scans per hour, starting at the top of the hour, and 20 and 40 minutes past the top of the hour. The schedule was reverted to two scans per hour on 1/10/21 because it was not clear at this time whether the post-processing software could handle this revised schedule. After it was confirmed that a 3-scan-per-hour schedule does not pose a problem, this schedule was implemented between 1/23/21 and the end of the reporting period. As of this writing, there is still no fix available for the issue resulting from the operating system upgrade.
- As 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 is used to automatically update the computer time, failed on 1/14/20 (during the previous 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 replace of the GPS that is compatible with the system is not available.

The datasets consists of 14,879 solar spectra, which is less than typical due to the reduce duty cycle. The system’s PSP radiometer was unit 32760F3 and has a calibration factor of $7.501 \times 10^{-6} \text{ V}/(\text{W m}^2)$. Data of the collocated TUVB radiometer were erratic and were not published.

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 only used during site visits. Only lamp 200WN008 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 three season (Volumes 27–29), 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 ranges between -2% at 300 nm, -1% at 375 nm, and less than $\pm 0.5\%$ between 420 and 600 nm. **Version 2 solar data of Volume 30 were scaled upward accordingly, however, Version 0 remain traceable to the original scale of the primary standard F-616.**

Figure 1 shows a comparison of the three working standard on lamp 200WN008 based on absolute scans taken between 4 and 10 May 2021. The scales of spectral irradiance of the three working and the two long-term standards agree to better than $\pm 0.5\%$ on average.

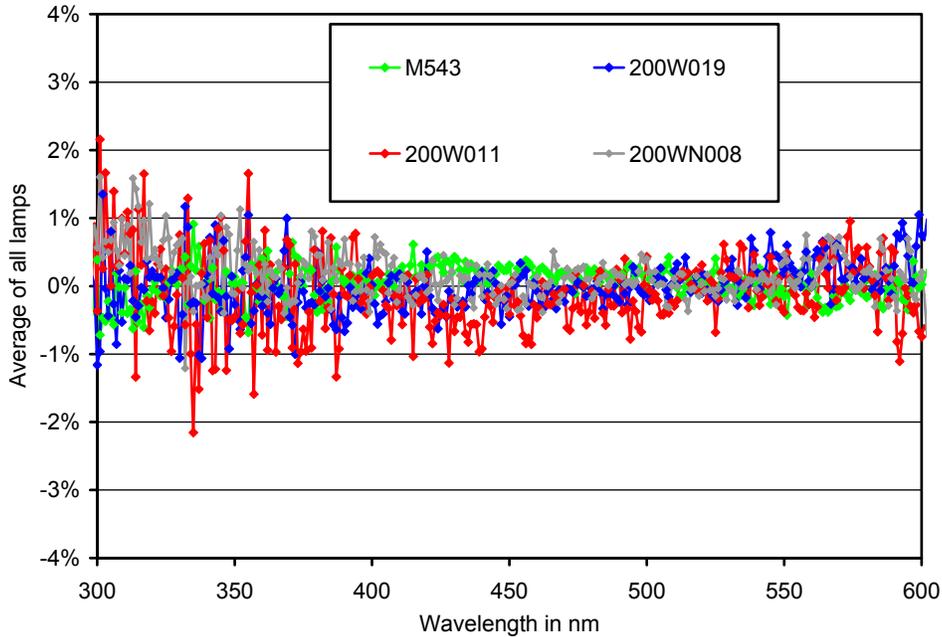


Figure 1. Comparison of McMurdo standards M-543, 200W011, 200W019, and 200WN008 using absolute scans performed on 5/4/21 and 5/10/21.

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 2019/20 period agreed to within 1.8% with those calculated for the reporting period, confirming that the scales of irradiance applied to solar data of the SUV-100 in 2019/20 and 2020/21 are consistent within acceptable limits.

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 2 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 3% between the start of the reporting period and 11/1/20. There was sudden increase by 2% in both PMT currents during the following day for no obvious reason. Between 11/2/20 and the end of the reporting period, PMT readings decreased by about 3%. There are no measurements between 12/31/20 and 1/7/21, and between 01/10/21 and 10/21/21 because of the excessive length of solar scans (see introduction), which overlapped with the time of scans of the internal lamp. By “pairing” solar scans with scans of the internal lamp that were performed on the same day as the solar measurements, changes of the system’s sensitivity (as indicated by changes in PMT current and/or monochromator throughput) are corrected. Because of the good stability of the system in January 2021, the missing scans of the internal lamp (and need to pair solar scans with lamp scans outside the affected time period) had little effect on the accuracy of published solar data.

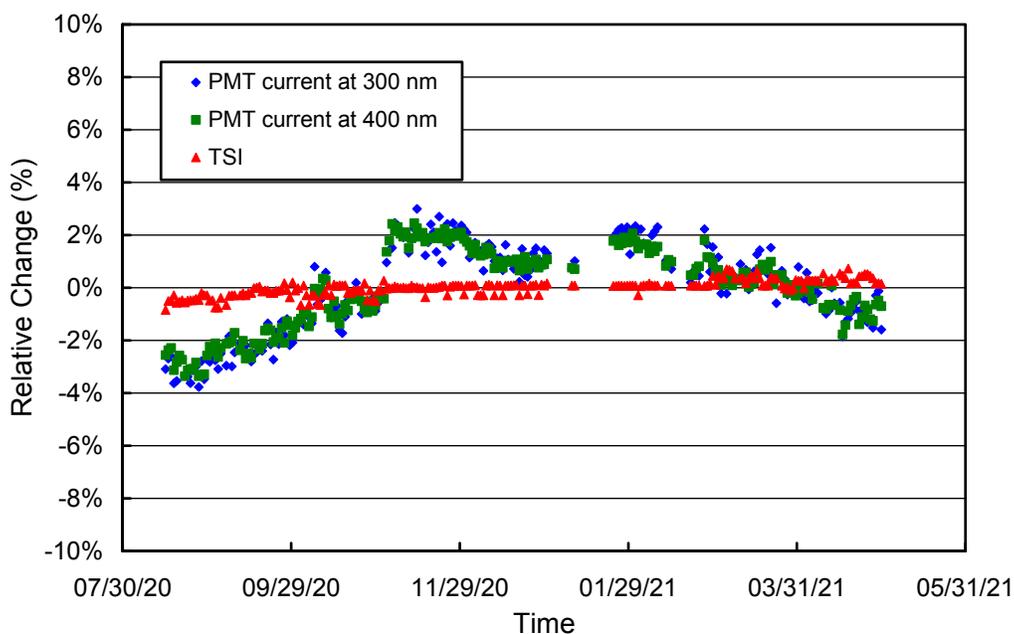


Figure 2. Measurements of the SUV-100’s TSI sensor and PMT currents at 300 and 400 nm. Data are shown as relative change and normalized to the average of the entire period.

Examination of scans of the on-site standards confirmed that the system was quite stable during the reporting period. Normal calibration procedures were applied, resulting in three calibration periods, labeled P1 – P3 (Table 1). Figure 3 shows ratios of irradiance spectra assigned to the internal reference lamp during these periods relative to the spectrum of Period P1. Changes in responsivity between periods are generally smaller than 1%.

Table 1: Calibration periods for McMurdo Volume 30 SUV-100 data.

Period	Period range	Number of absolute scans
P1	08/14/20 – 10/14/20	6
P2	10/15/20 – 04/23/21	9
P3	04/24/21 – 04/30/21	5

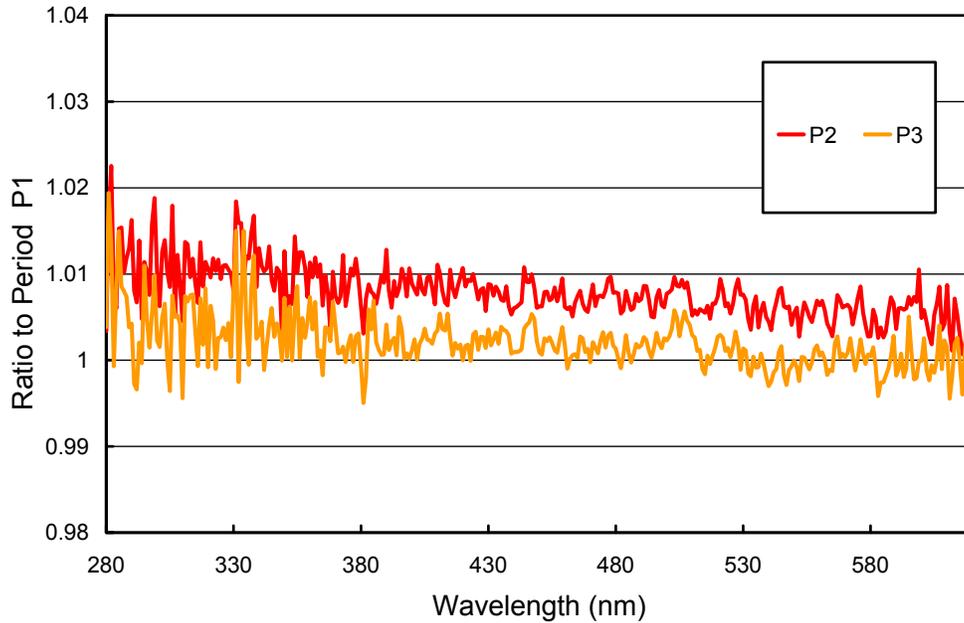


Figure 3. Ratios of spectral irradiance assigned to the internal reference lamp during Periods P2 and P3, relative to Period P1.

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 $\pm 5\%$ except for two periods (09/01/20–09/02/20 and 03/16/21–03/17/21) when snow was potentially covering the collector of the GUV but not the SUV-100.

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 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.

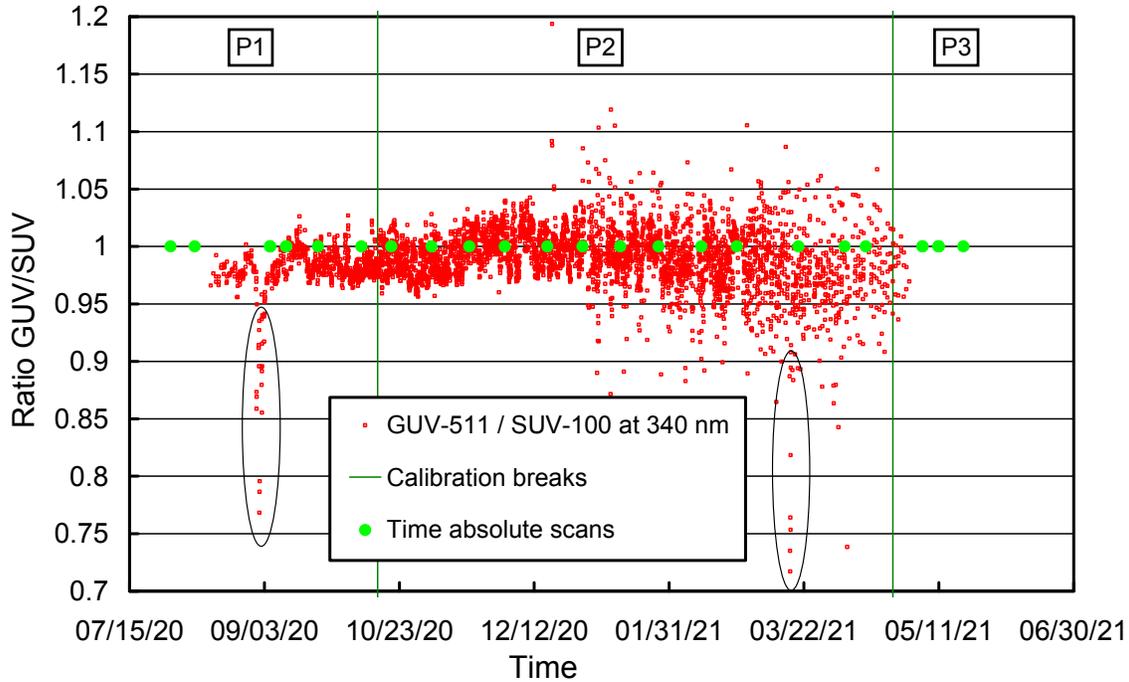


Figure 4. Ratio of GUV-511 (340 nm channel) and SUV-100 measurements. Green vertical lines indicate times when the SUV-100 calibration changed. The times when “absolute” calibration scans of the SUV-100 were performed are also indicated. Periods with outliers are marked with ellipses and could be caused by snow cover the collector of the GUV but not the SUV-100.

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.

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 Version 2 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 65 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. A few scans on 1/15/21 and 1/16/21 have a elevated wavelength error of -0.1 to -0.15 nm, and these scans were flagged in the Version 2 dataset.

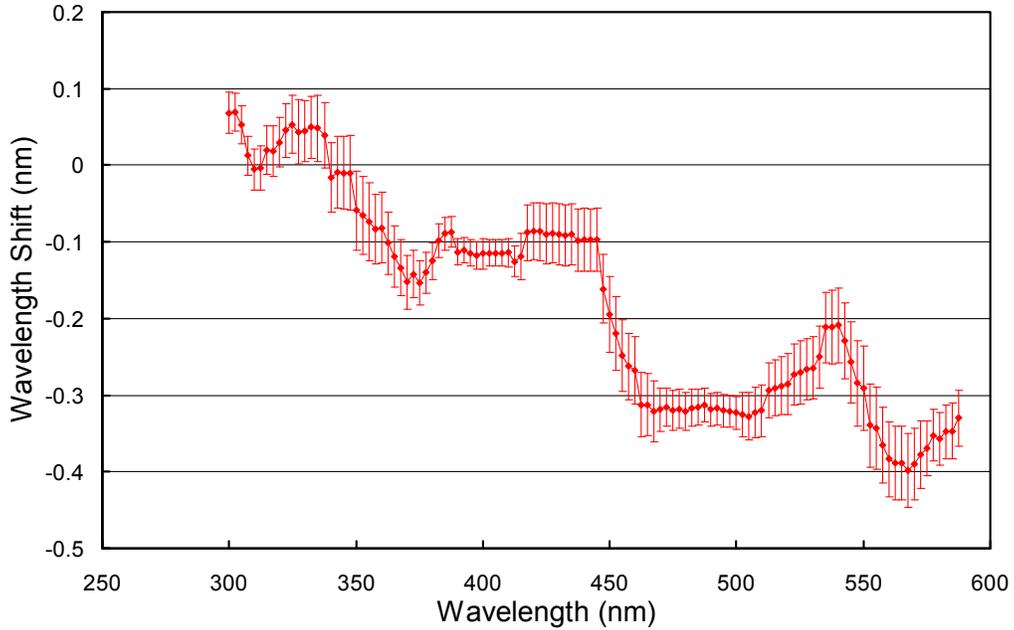


Figure 5. Monochromator non-linearity correction function for the Volume 30 period. Error bars indicate the 1σ -variation.

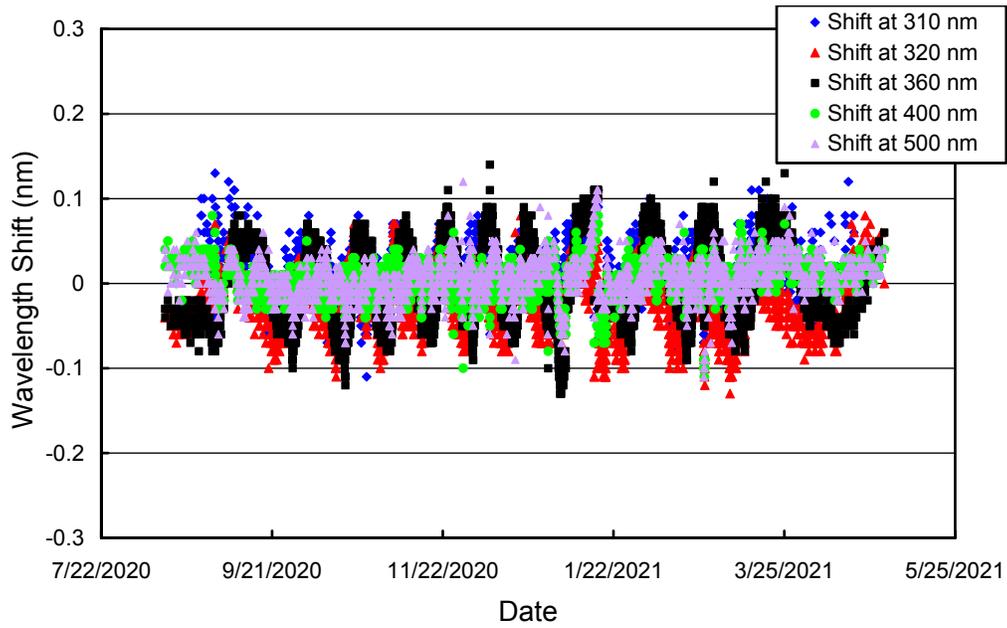


Figure 6. Check of the wavelength accuracy of *Version 0* data at six wavelengths by means of Fraunhofer-line correlation. The plot is based on hourly measurements.

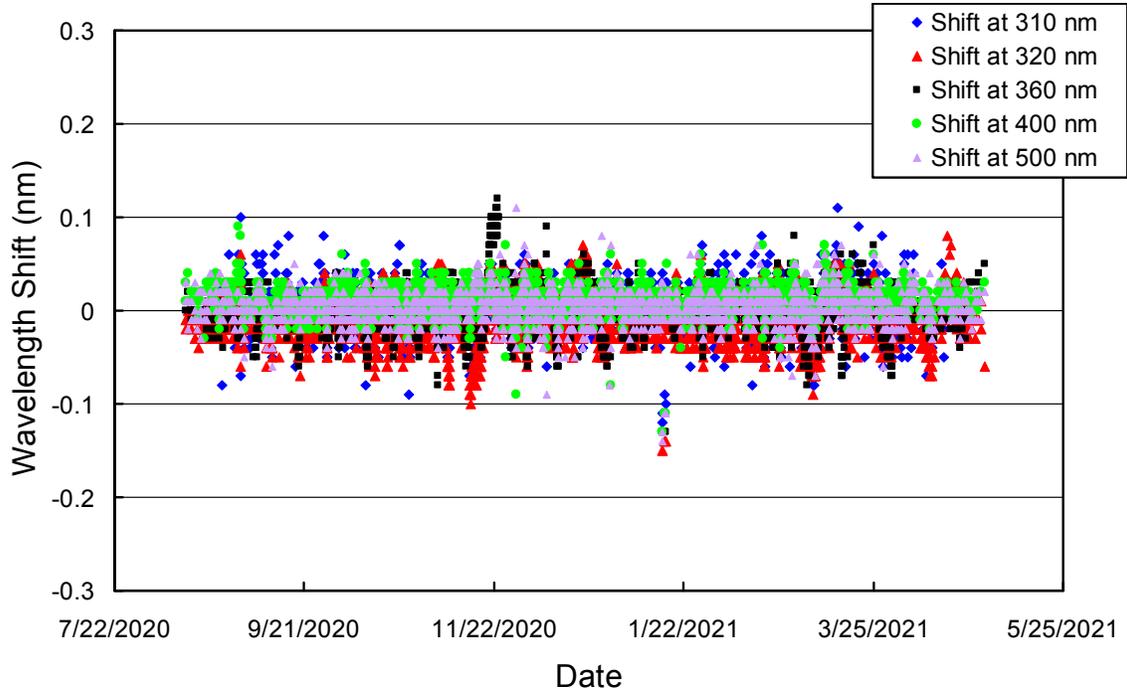


Figure 7. Check of the wavelength accuracy of *Version 2* data at six wavelengths by means of Fraunhofer-line correlation.

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
12/31/20	Operating system update
02/09/21	Unforced computer reboot
04/08/21	Unforced computer reboot
04/14/21	Unforced computer reboot

References

Bernhard, G., C. R. Booth, and J. C. Ebrahimian. (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>.