1. McMurdo Station (08/15/17 – 04/30/18)

Solar data of the SUV-100 spectroradiometer discussed in this quality control report were measured between 08/15/17 and 04/30/18 and were assigned to Volume 27. A site visit was performed between 1/29/18 and 2/4/18. The system performed normally during the reporting period, however, no data are available between 11/17/17 and 11/19/17 because of frequent reboots of the system control computer. These reboots were caused by pending Windows updates that have not been applied yet. The datasets consists of 16,843 solar spectra.

The system's PSP radiometer (S/N 32760F3, calibration factor 7.575 x10^{-6} V/(W m^{-2})) was replaced during the site visit with a similar unit (S/N 12257F3, calibration factor 8.714 x10^{-6} V/(W m^{-2})).

Of note, a magnitude 0.366 partial solar eclipse occurred on 2/15/2018, which started at 19:07:20 UT and lasted until 20:54:24 UT. The maximum eclipse was observed on 20:00:15 UT. At this time, 24.6% of the Sun were obscured by the moon and the resulting change of the solar irradiance at the surface can clearly be seen in the measurements.

1.1. Irradiance Calibration

On-site irradiance standards used during the reporting period were the lamps M-543, 200W011, 200W019, 200WN007, and 200WN008. Lamps M-543, 200W011 and 200W019, are "working standards" that 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. Both lamps were calibrated by CUCF in August 2013 with the same method as that applied to the former traveling standard 200WN004 (see below). During site visits in January 2015 and February 2016, the calibration of the three working standards agreed to within ±0.5% with that of the long-term standards.

The traveling standard was lamp 200WN014 and was used during the site visit in January 2018.

Comparisons of calibrations with the various lamps during the site visit in January/February 2018 suggested that the scale of spectral irradiance of the two working standards 200W011 and 200W019 has drifted by 1.0 to 2.5% relative to the scale of the two long-term standards. Lamps 200W011 and 200W019 were therefore recalibrated against the average of the scale of the two long-term standards and the new scale was used for calibrating solar measurements of the reporting period. The scale of lamp M-543, which was established in August 2016, remained in almost ideal agreement with that of the long-term standards, and this scale was therefore used for processing of solar data.

<u>History of working standards</u>
Lamps M-543, 200W011, and 200W019 have been in service for a long time. They 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. Lamp M-543 burned unstable during most of the Volume 22 and 23 periods (September 2012 – April 2014) but was reasonably stable thereafter. The lamp was recalibrated against site standards 200WN007 and 200WN008 using absolute scans performed on 1/30/15. It was again recalibrated against site standard 200W011 using absolute scans performed on 2/1/16.

The five on-site standards were compared with the traveling standard 200WN014 during the last site visit in February 2016 (see previous Quality Control report). At this time, the scales of spectral irradiance of the five on-site standards agreed on average to within ±0.5% with the scale of the traveling standard.

Lamps M-543, 200W011, 200W019, 200WN007 and 200WN008 were compared with traveling standard 200WN014 using absolute scans performed between 1/31/2018 and 2/4/2018. The new scale of irradiance of lamps 200W011 and 200W019 was used for this comparison. Figure 1 shows the percentage difference of the lamps' calibration relative to that of the traveling standard. The scales of irradiance of the five on-site standards agree with each other almost ideally, but there is a ~1% difference of this scale relative to the scale of the traveling standard. This suggests that the calibration of the traveling standard 200WN014 has drifted by this amount. The alternative explanation that the traveling standard remained stable and that the two long-term standards have drifted seems less likely.

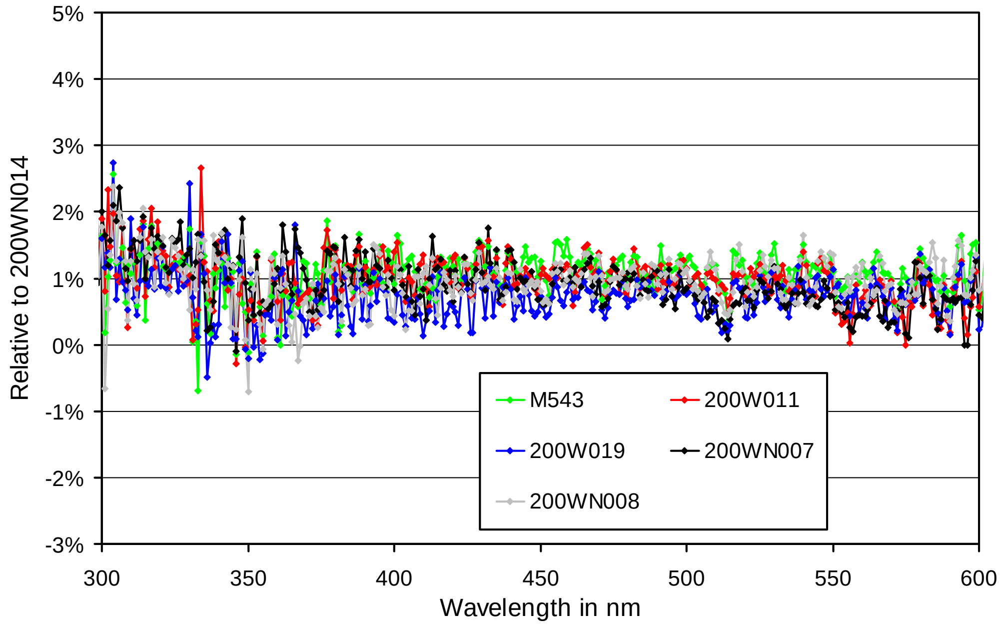

Figure 1. *Comparison of McMurdo on-site standards M-543, 200W011, 200W019, 200WN007 and 200WN008 with traveling standard 200WN014 using absolute scans performed between 1/31/2018 and 2/4/2018.*

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 2016/17 period agreed to within ±0.4% with those calculated for the reporting period, confirming that the scales of irradiance applied to solar data of the SUV-100 in 2016/17 and 2017/18 are consistent within the expected degree of uncertainty.

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 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 decreased by about 2.5% between the start of the reporting period and the site visit when the internal lamp was replaced. TSI readings with the new lamp were virtually constant. 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 remained stable to within ±1% before the site visit and decreased by about 2.5% after the site visit when the new internal lamp was installed. By pairing solar scans with scans of the internal response scan 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.

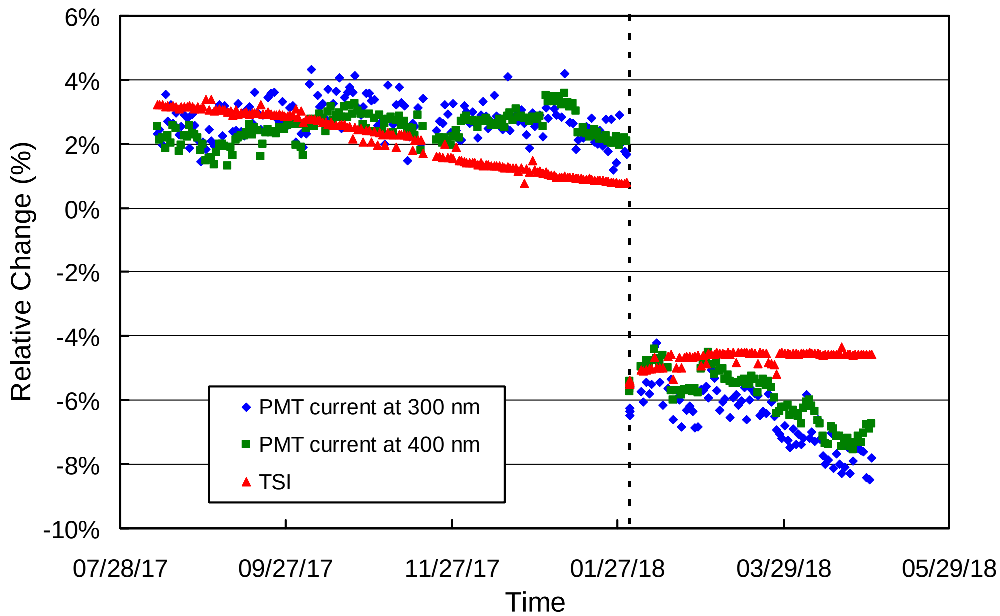

Figure 2. *Measurements of the SUV-100's TSI sensor and PMT currents at 300 and 400 nm. Data are shown as relative change and normalized to the average of the entire period. The broken vertical line indicates the time when the internal lamp was changed.*

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). Irradiance spectra assigned to the internal reference lamp during the two periods before the site visit differed by less than 2% in the UV-B and less than 1% in the visible range.

Table 1: Calibration periods for McMurdo Volume 27 SUV-100 data.

Period name	Period range	Number of absolute scans	Remark
P1	06/21/17 – 12/24/17	9	Before site visit
P2	12/25/17 – 01/27/18	3	Before site visit
P3	01/28/18 – 06/01/18	16	After site visit

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 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 2.4%. Times when the calibration changed are indicated by vertical lines.

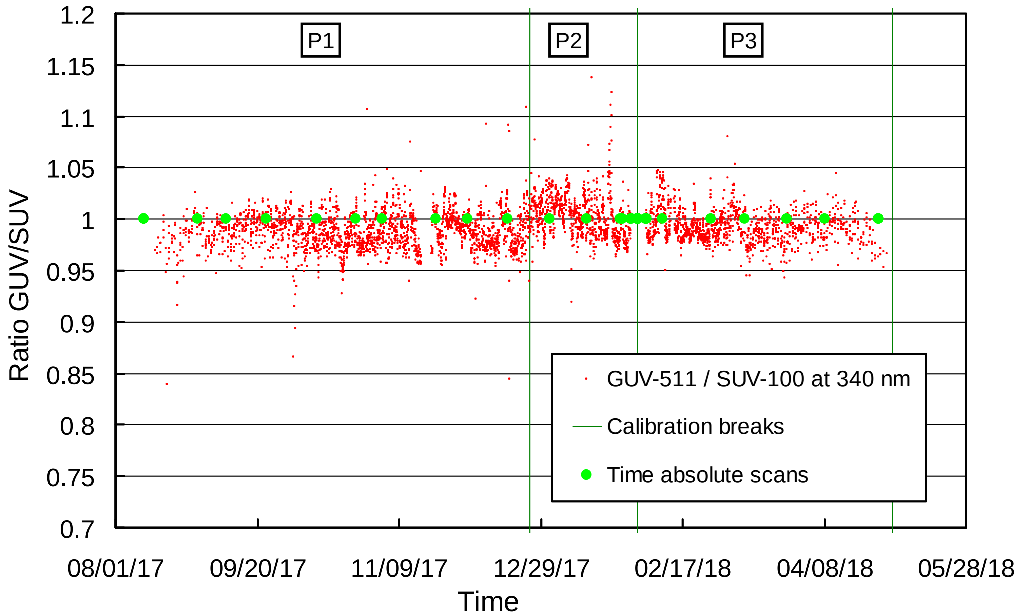

Figure 3. *Ratio of GUV-511 (340 nm channel) and SUV-100 measurements. Green vertical lines indicate times when the SUV-100 calibration was changed. The times when "absolute" calibration scans of the SUV were performed are also indicated.*

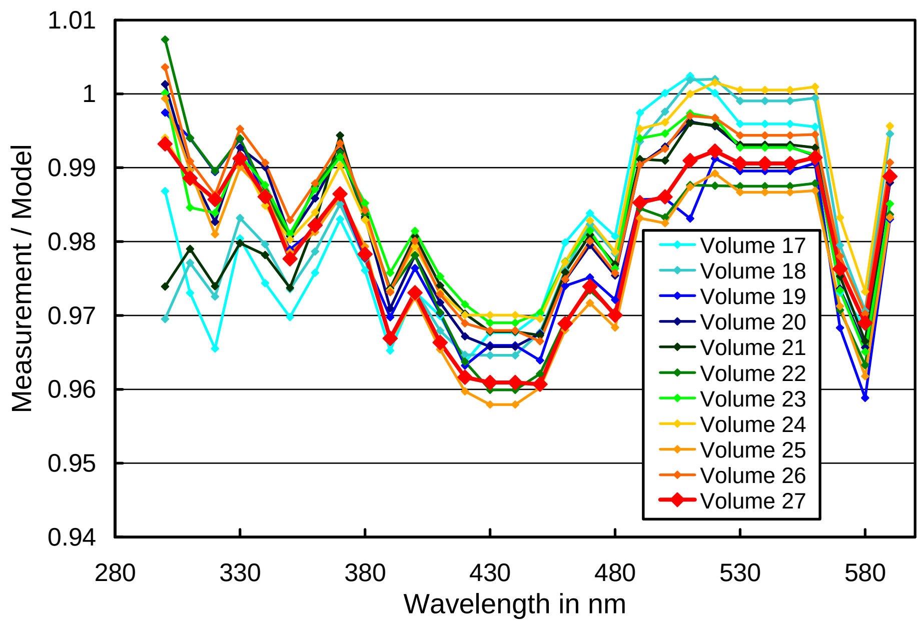

Figure 4. *Median measurement/model ratios calculated from clear-sky solar measurements for data of Volumes 17 – 27. Ratios were averaged over 10 nm intervals (305-315, 315-325, ... 585-595 nm) before the median was calculated. There is a systematic, wavelength-dependent bias between measurement and model, partly because of systematic errors of the extraterrestrial spectrum used in the model calculations. However, this bias varies to within ±2% for the eleven volumes shown, confirming that the irradiance scale used for processing of Volume 27 data is consistent within this range with that used for earlier volumes.*

As a 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 – 27. It can be seen that the ratio of Version 2 data of Volume 27 (red) is by and large consistent with those of the 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.

Figure 6 indicates the wavelength accuracy of final 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 standard 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 64 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.

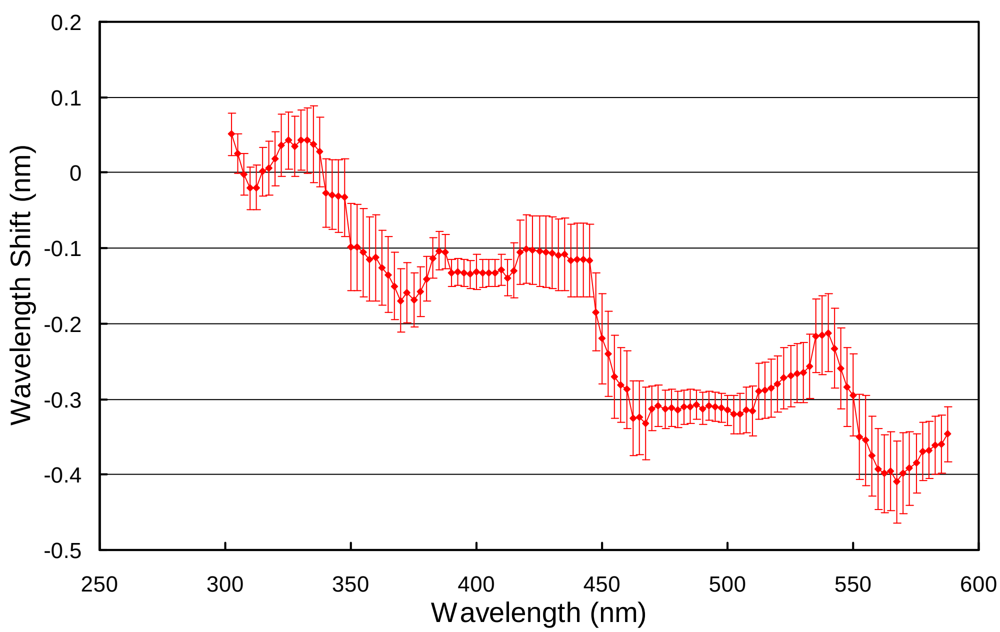

Figure 5. *Monochromator non-linearity correction function for the Volume 27 period. Error bars indicate the 1σ-variation.*

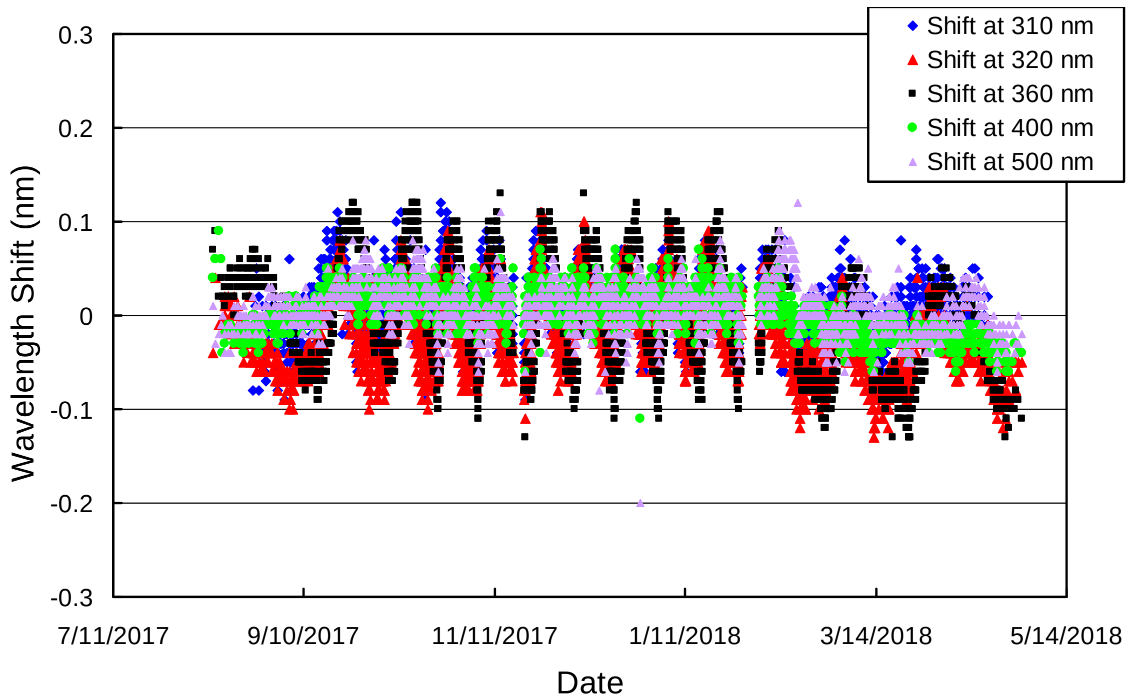

Figure 6. *Check of the wavelength accuracy of Version 0 data at six wavelengths by means of Fraunhofer-line correlation. The plot is based on hourly measurements.*

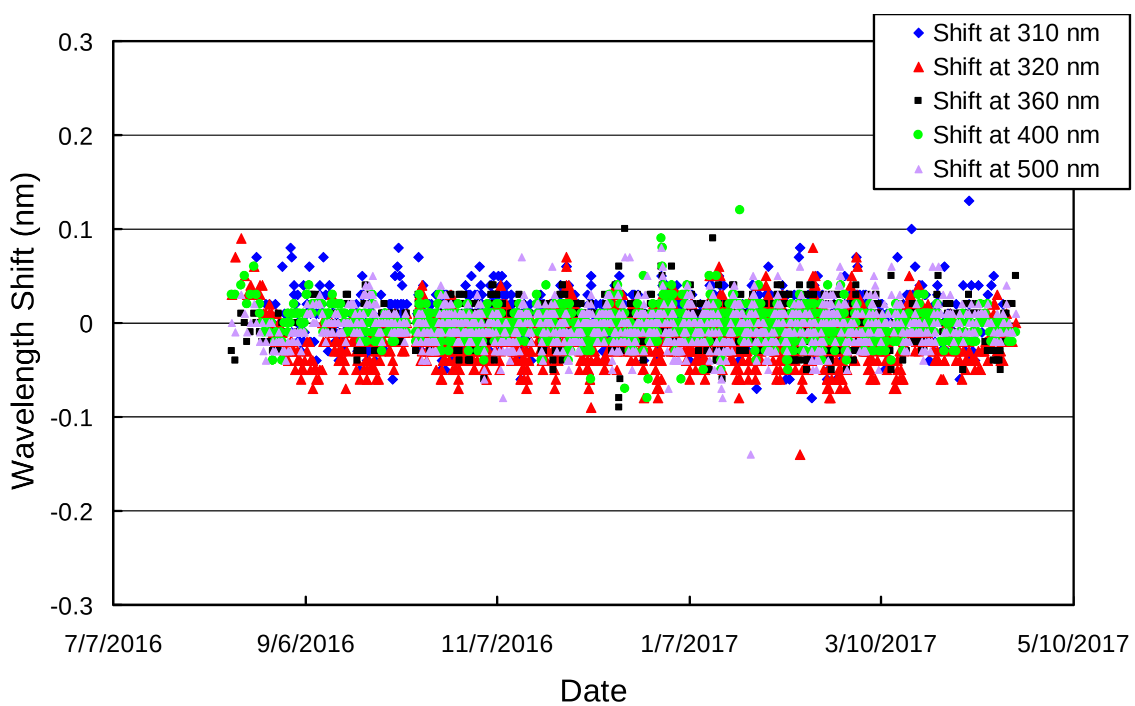

Figure 7. *Check of the wavelength accuracy of Version 2 data at six wavelengths by means of Fraunhofer-line correlation. The plot is based on measurements at 01:00 UT (approximate local solar noon at McMurdo).*

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
11/17/17 – 11/19/17	Computer reboots due to pending Windows updates.
01/30/18 – 02/03/18	Annual site visit
02/13/18	Unknown

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.