1. McMurdo Station (08/15/15 – 04/30/16)

Solar data of the SUV-100 spectroradiometer discussed in this quality control report were measured between 08/15/15 and 04/30/16 and were assigned to Volume 25. With few exceptions, the system performed normal during this period and its sensitivity was stable to within ±5%. The datasets consists of 16,895 solar spectra.

CUCF personnel visited McMurdo Station between 2/2/16 and 2/8/16, serviced the system, and compared on-site standards of spectral irradiance with traveling standards. The system's leaf shutter was replaced with a Uniblitz shutter from Vincent Associates (model CS4553T0, S/N 2203). The electronic driver of the shutter was added to the system's electronics. The new shutter is expected to improve the reliability and stability of the system. For example, abrasion of paint from the blades of the old shutter frequently accumulated on the optical components in the past and led to a gradual change in system responsivity. The blades of the new Uniblitz shutter are resistant to abrasion.

Furthermore, the "Oldham" coupler, which connects the system's stepper motor with the monochromator, was replace by a helical cross-slot coupler (model XCA20-8-6mm, BSI part number 0003996). As part of the routine maintenance, the system's wavelength potentiometer, response lamp, and wavelength counter were replaced with identical components. Finally, the system's PSP radiometer (S/N 12257F3, calibration factor 8.62 x10^{-6} V/(W m^{-2})) was replaced with a similar unit (S/N 32760F3, calibration factor 7.575 x10^{-6} V/(W m^{-2})).

No data of the GUV-511 multi-channel radiometer, which is installed next to the SUV-100 spectro-radiometer, are available until 8/27/15.

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 200WN014 was used as a traveling standard during the site visit in January 2016. (The previous traveling standard 200WN004 was removed from service due to damage it incurred during or after the Palmer station site visit in March-April 2015.)

<u>On-site standards</u>
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. The latter two lamps are considered long-term standard and are only be used during site visits.

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 2013 calibrations of lamps 200W011 and 200W019 that were 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 thereafter. The lamp was recalibrated against the site standards 200WN007 and 200WN008 using absolute scans performed on 1/30/15. It was again recalibrated against the site standards 200W011 using absolute scans performed on 2/1/16. This last calibration was used for processing of solar data of the reporting period.

<u>Traveling standard 200WN014</u>
The traveling standard 200WN014 was calibrated on three occasions by NOAA/CUCF. The first event was on April 16, 2016 during NOAA/CUCF lamp calibration transfer #96. The second calibration was during transfer #102 on January 13, 2016 just prior to use for the 2016 South Pole and McMurdo site visits. The third calibration, which was the bracketing calibration performed just after the site visits was performed on February 29, 2016, during transfer #103. The transfer standard 200WN014 was compared to laboratory lamps 200WN002 and 200WN011, which were previously calibrated by BSI. The scale of spectral

irradiance of lamp 200WN014 agreed with the scales of lamps 200WN002 and 200WN011 to within ±0.3%. (Lamp 200WN002 was 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.)

The five on-site standards were compared with the traveling standard 200WN014 at the beginning and end of the February 2016 McMurdo site visit. Figure 1 shows results of the comparison performed at the start of the visit. 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.

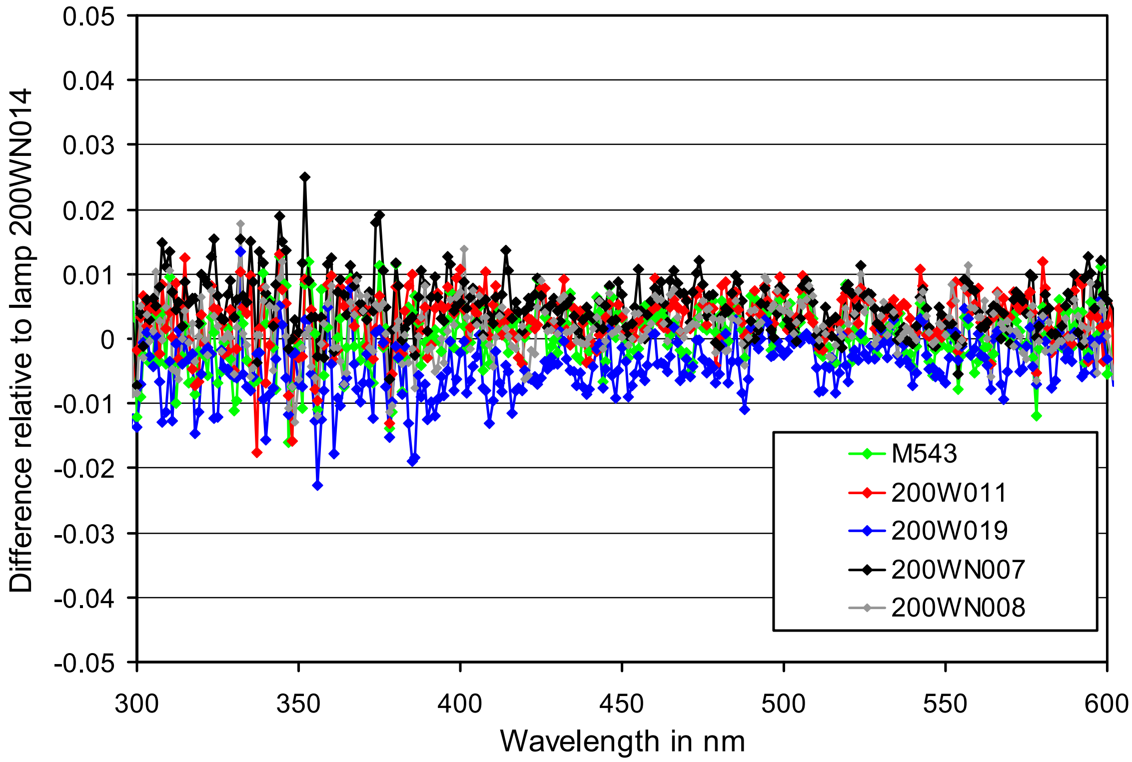

Figure 1. *Comparison of McMurdo on-site standards M543, 200W011, 200W019, 200WN007, and 200WN008 with the traveling standard 200W014 using absolute scans performed at the start of the February 2016 site visit.*

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 (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 decrease by about 2% between August 2015 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 1.5% during the period after the site visit. 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 6.5% between 15 August and 20 December, and decreased thereafter and until the start of the site visit. These changes don't match the decrease of the TSI sensor reading observed during this period and indicate changes of either the PMT sensitivity or the monochromator throughput. PMT measurements changed by less than ±1% after the site visit. By pairing solar scans with scans of the internal response scan performed at the same as the solar measurements, changes of the system's sensitivity (as indicated by changes in PMT current and/or monochromator throughput) are corrected.

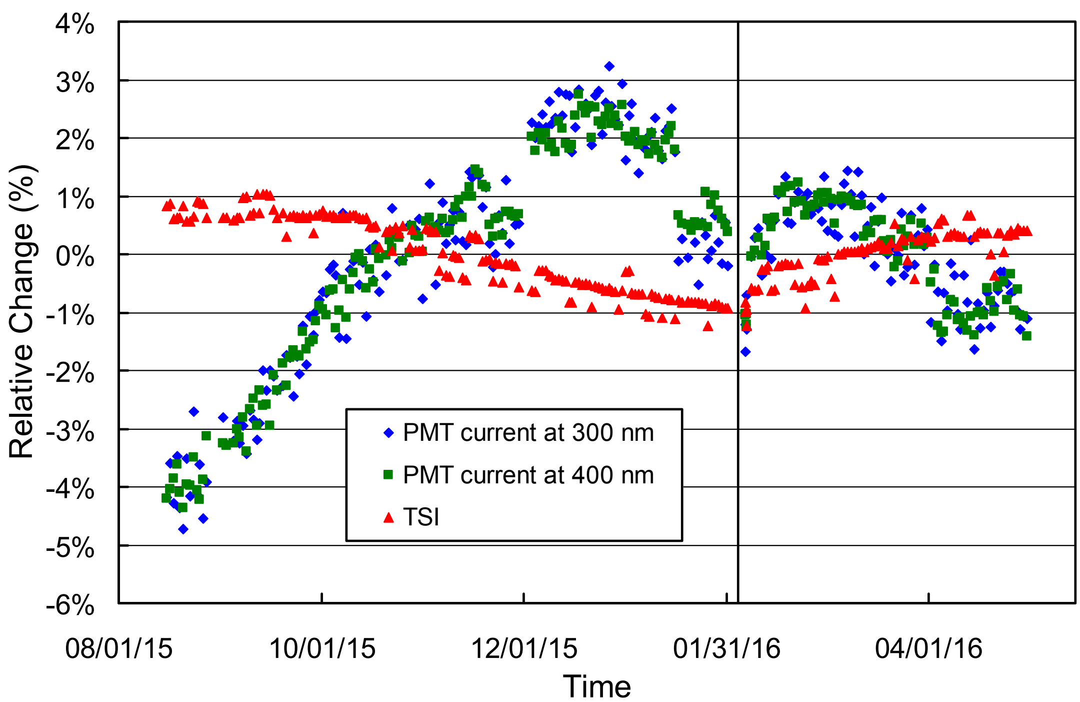

Figure 2. *Measurements of the SUV-100's TSI sensor and PMT currents at 300 and 400 nm. Data are shown as relative change. Data measured before and after the time of the site visit (vertical line) are normalized separately.*

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 ±5% in the UV and visible range, both before and after the site visit. Normal calibration procedures were applied, resulting in eight 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 7% change in the ratio can be observed between Periods P5 and P6, the periods bracketing the February 2016 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 25 SUV-100 data.

Period name	Period range
P1	08/15/15 – 09/30/15
P2	10/01/15 – 11/12/15
P3	11/13/15 – 12/09/15
P4	12/10/15 – 01/24/16
P5	01/25/16 – 02/05/16
P6	02/06/16 – 02/07/16
P6B	02/08/16 – 02/11/16
P7	02/12/16 – 04/30/16

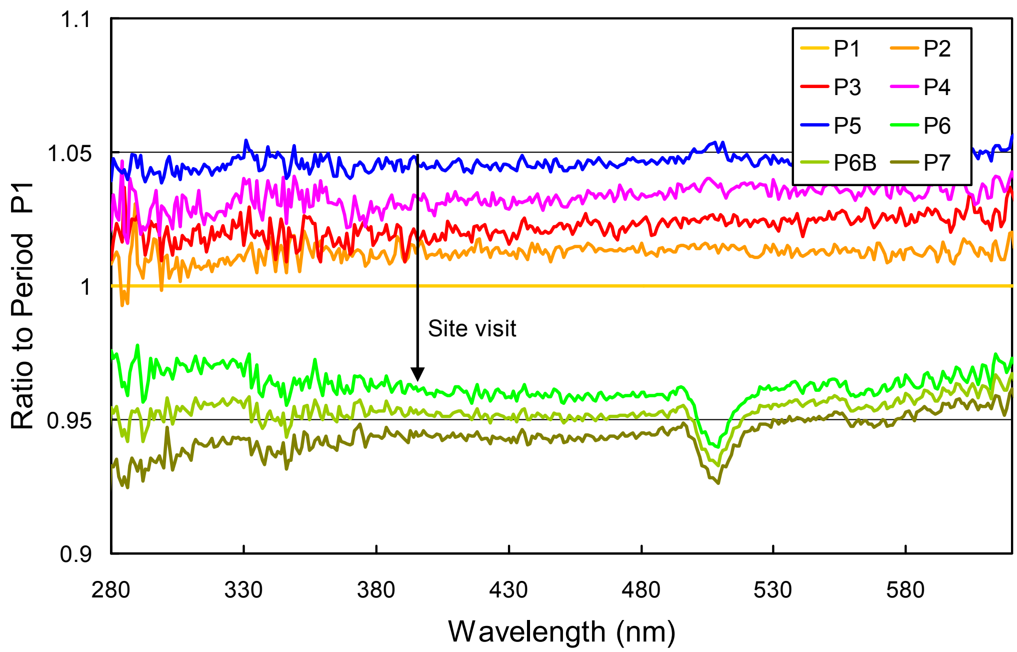

Figure 2. *Ratios of spectral irradiance assigned to the internal reference lamp during Periods P2 through P7, relative to Period P1. The large change in the ratio between Periods P5 and P6 is caused by service performed during the February 2016 site visit when the instrument was disassembled, cleaned, and reassembled.*

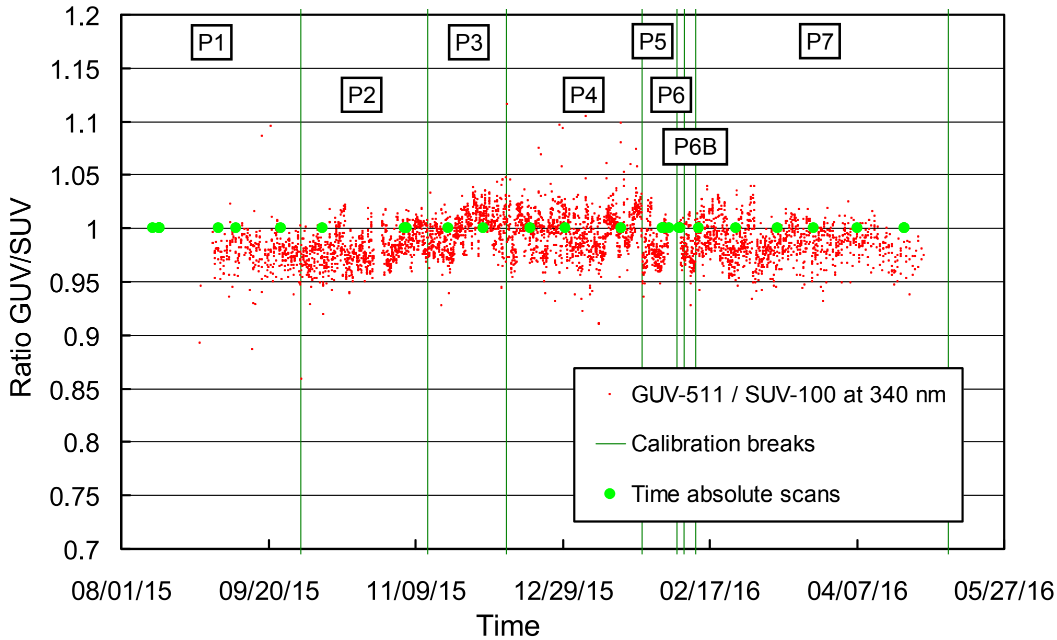

Figure 3. *Ratio of GUV-511 (340 nm channel) and SUV-100 measurements. Green vertical lines indicate times when the SUV-100 calibration was changed. The times when "absolute" calibration scans of the SUV were performed are also indicated.*

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 – 25. It can be seen that the ratio of Volume 25 data 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. Instrument service performed during the February 2016 site visit had some effect on the wavelength mapping of the monochromator. Hence, two correction functions were applied for processing of Version 0 data.

Figure 6 indicates the wavelength accuracy of final Version 0 data for six wavelengths in the UV and visible, which was established by running the Version 2 Fraunhofer-line correlation method a second time. Shifts are typically smaller than ±0.05 nm, but there are outliers as large as 0.10 nm. The residuals are not uniformly distributed over the reporting period. The wavelength correction was therefore further improved when processing Version 2 data by breaking the dataset into 21 sub-periods with different correction functions. 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 is (Figure 6) is obvious.

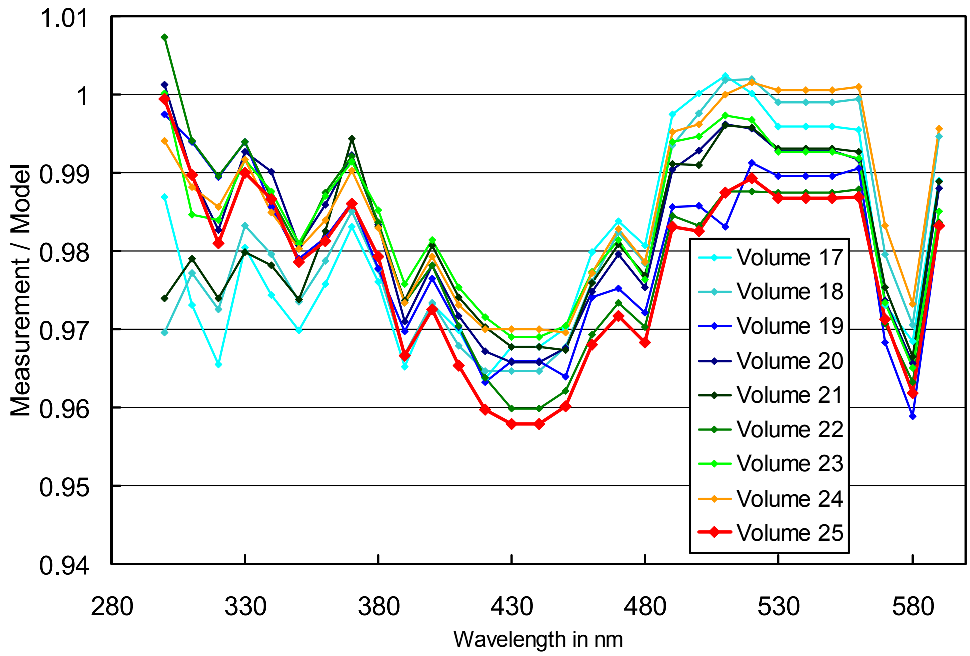

Figure 4. *Median measurement/model ratios calculated from clear-sky solar measurements for data of Volumes 17 – 25. Ratios were averaged over 10 nm intervals (305-315, 315-325, … 585-595 nm) before the median was calculated. There is a systematic, wavelength-dependent bias between measurement and model, however, this bias varies to within ±2% for the nine volumes, confirming that the irradiance scale used for processing of Volume 25 data is consistent with that used for earlier volumes.*

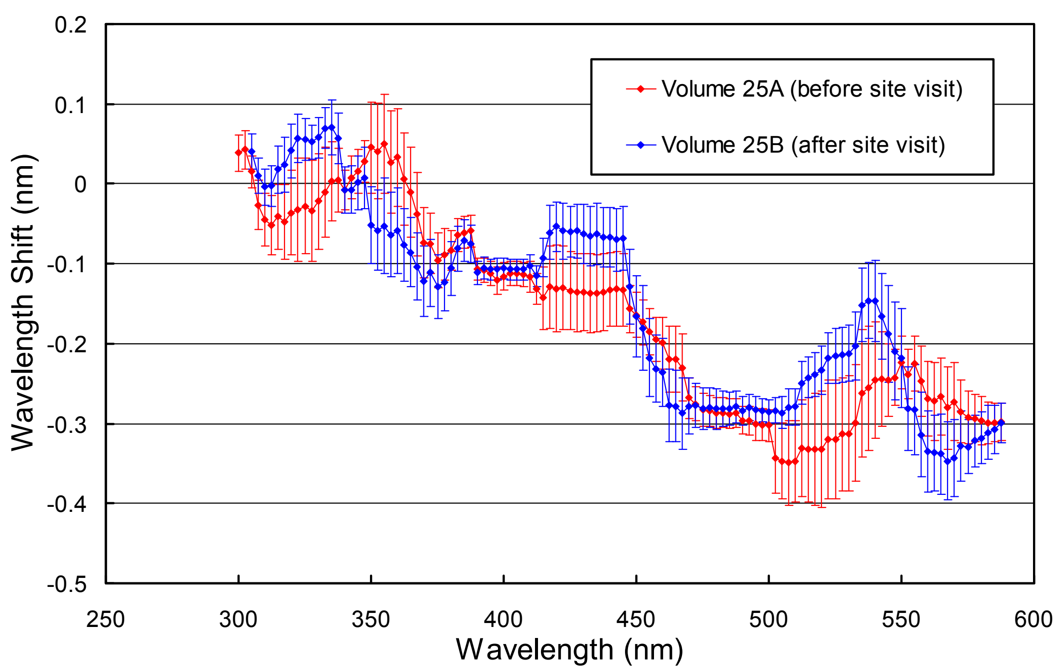

Figure 5. Monochromator non-linearity correction functions for the Volume 25 period. Error bars indicate the 1σ-variation.

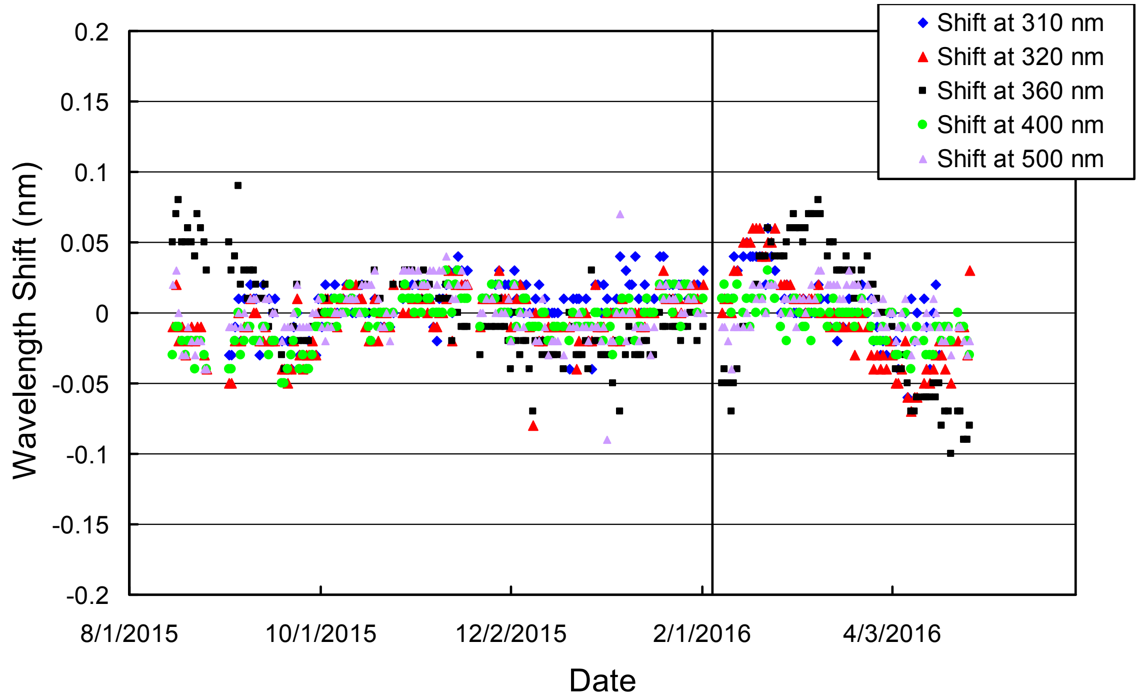

Figure 6. *Check of the wavelength accuracy of final Version 0 data at six wavelengths by means of Fraunhofer-line correlation. The plot is based on daily measurements at noon. The vertical line indicates the time of the site visit.*

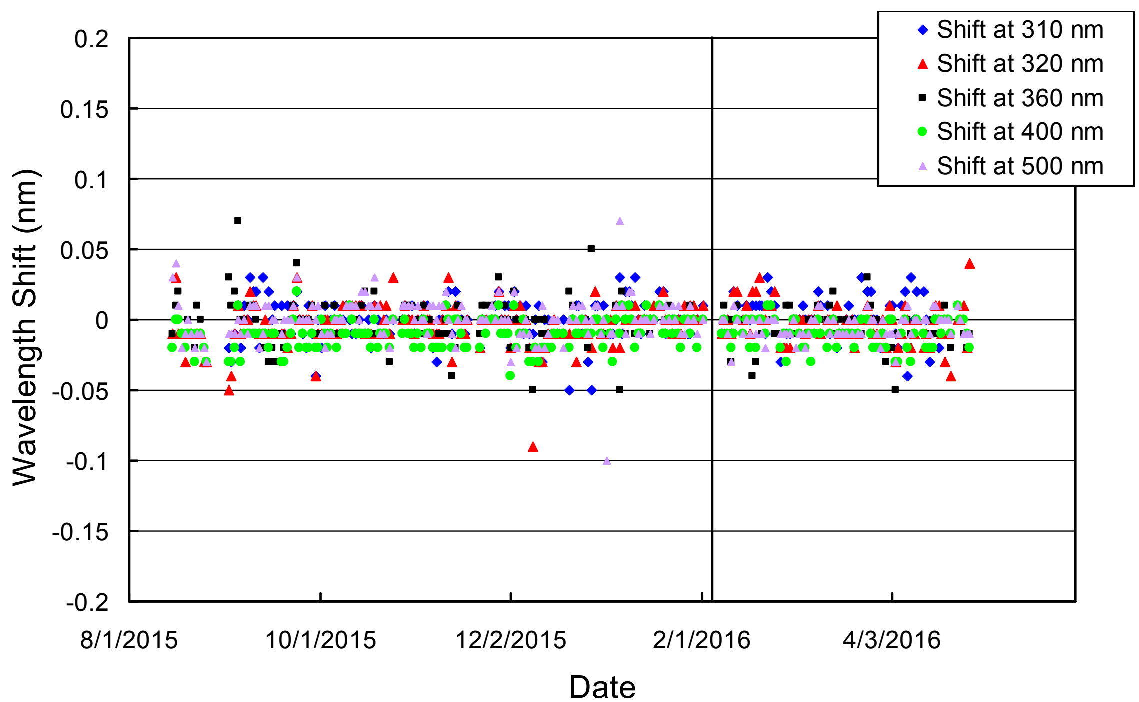

Figure 7. *Check of the wavelength accuracy of final Version 2 data at six wavelengths by means of Fraunhofer-line correlation. The plot is based on daily measurements at noon. The vertical line indicates the time of the site visit.*

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
08/28/15 - 08/31/15	Computer rebooted several times for no obvious reason.
09/18/15	Monochromator wavelength shifted by several nanometers. Data unrecoverable.
10/19/15	Monochromator wavelength shifted by several nanometers. Data unrecoverable.
10/26/15	No data for unknown reasons
02/03/16 - 02/05/16	Annual site visit

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.