2. Palmer Station (03/29/15 – 07/31/16)

This sections describes quality control of solar data recorded at Palmer Station between 03/29/15 and 07/31/16. This period resulted in a total of 20,431 solar scans. The system was inspected and serviced in March 2015 before the reporting period. On-site standards of spectral irradiance were compared with traveling standards during this visit. The system's performance was affected by several issues:

- On several days, the system's shutter did not open completely, leading to a large reduction in responsivity. Affected solar scans were determined by comparing measurements of the SUV-100 spectroradiometer with measurements of the collocated GUV-511 multi-filter radiometer. Approximately 1,300 solar scans (6% of all scans) had to be removed from the dataset due to this problem. Periods that are affected are listed in Section 2.4.
- Apart from the shutter problem, the system exhibited some instabilities (Section 2.2), but these could be corrected during data processing.
- In October 2015, the system rebooted without user intervention. The problem could be traced to the system's Uninterruptible Power Supply (UPS).
- At the end of January 2016, the power supply that is powering the system's external and internal lamps failed and was replaced with the on-site spare.

2.1. Irradiance Calibration

<u>On-site standards</u>

The on-site irradiance standards for the reporting period were the lamps 200W007, M700, M765, 200WN009, and 200WN010. The last two lamps were left at Palmer Station during the March 2014 site visit. It is the intent to run lamp 200WN009 once per year to compare with the other on-site standards. 200WN010 will be run every other year during site visits when all of the station lamps and the traveling standard are compared.

The calibration of lamp 200W007 was established against the former traveling standards 200W017 and 200W038 using absolute scans performed on 5/10/08 ("closing scans" of the Volume 17 period). Lamp M700 was calibrated against lamp 200W007 using scans performed on 9/22/08. Lamp M765 was rotated in its holder sometime between 6/6/11 and 7/4/11 (see Volume 20 report). Lamp M765 was recalibrated twice against measurements of the site standards 200W007 and M700, namely on 12/17/11 and 9/27/15. The calibration on 9/27/15 was used for processing of solar data of the reporting period.

The "long-term" standards 200WN009, and 200WN010 were calibrated on 12/20/2013 against lamps 200WN001 and 200WN002 using the same procedure as applied to the traveling standard 200WN004 described below. Both lamps also served as de facto traveling standards during the site visit in March 2014 (see Volume 24 report).

<u>Traveling standard traceability</u>

The traveling standard used during the site visit in March 2015 was lamp 200WN004. It had been calibrated at NOAA on 3/21/13 against lamps 200WN001 and 200WN002. Lamps 200WN001 and 200WN002 had in turn been calibrated at BSI 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. 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%. 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 traveling standard 200WN004 was damaged during or after the March 2015 site visit and removed from service.

The five on-site standard and the traveling standard were compared during the March 2015 site visit. Figure 1 shows results for data collected at the end of the visit ("season opening scans"). Results are referenced against the average of measurements of on-site standards M700 and 200W007. The calibrated output of the five on-site standard agreed to within ±1.0% with this reference. Results for the traveling standard 200WN004 are biased high by approximately 1%. This bias may be caused by the damage the lamp sustained during the visit. The excellent agreement between results for the "regular" on-site standards 200W007, M700 and M765 and the long-term standards 200WN009 and 200WN010 gives confidence in the scale of irradiance applied to solar data of the reporting period.

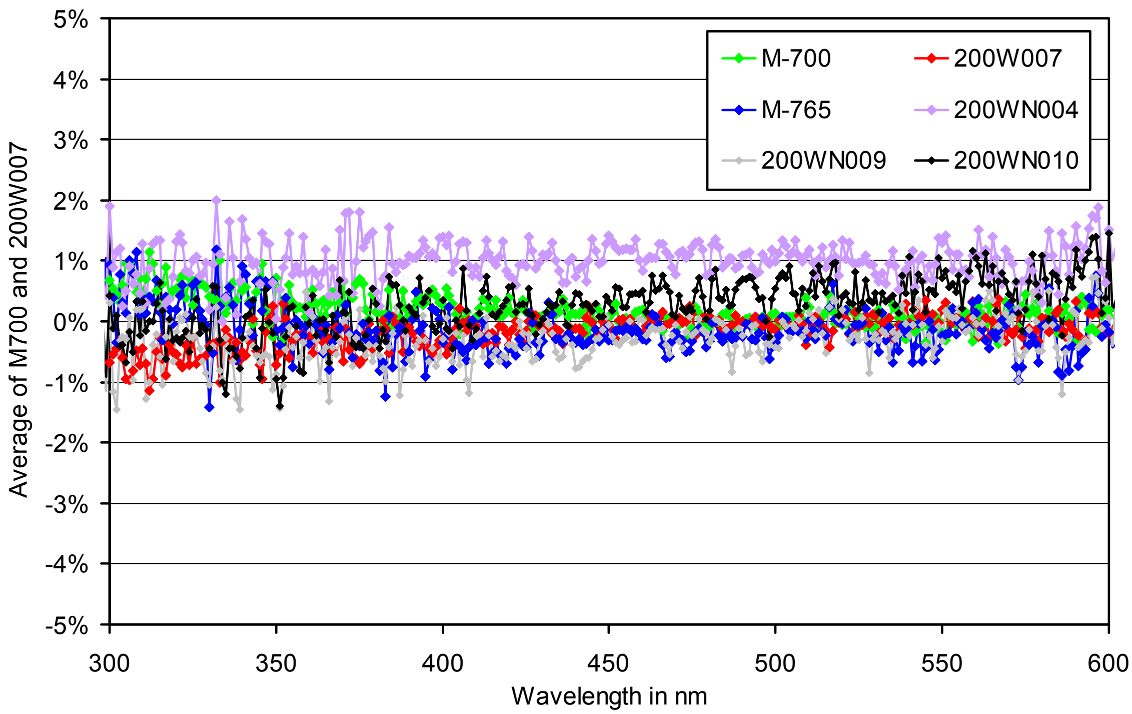

Figure 1. *Comparison of the calibration of on-site standards M700, 200W007, M765, 200WN009, and 200WN010; and the traveling standard 200WN004 on 3/28/2015. Data are reference to the average of the measurements of lamps M700 and 200W007.*

Lamps M700, 200W007, and M765 were also compared five times with each other during the reporting period, namely on 7/7/15, 9/27/15, 12/29/15, 3/29/16, and 7/12/16. Results of the three lamps agreed to within ±1.0% on all occasions.

To confirm the irradiance scale of solar measurements of the SUV-100 spectroradiometer chosen for the reporting period, the GUV-511 radiometer that is collocated with the SUV was vicariously calibrated against SUV measurements. Calibration factors calculated with this method were compared with similar factors established during previous years. The analysis showed that calibration factors for the GUV 305, 340, 380, and PAR channels that were calculated for the period 2013 – 2016 are in agreement to within ±1.1%. (The change for the GUV channel at 320 nm is larger because of a known drift of this channel.) This result confirms the excellent consistency of SUV calibrations.

2.2. Instrument Stability

The radiometric stability of the SUV-100 spectroradiometer was monitored with calibrations utilizing the on-site irradiance standards, with daily "response" scans of the internal lamp, by comparison with measurements of the collocated GUV-511 multifilter radiometer, and by comparisons with results of a radiative transfer model (part of "Version 2" data).

Figure 2 shows changes in TSI readings and PMT currents at 300 and 400 nm, derived from response scans performed between 3/27/15 and 7/31/16. During this time, the output of the internal lamp decreased monotonically by 7% as indicated by the TSI sensor. (A new internal "response" lamp was installed during the site visit. A drift of this magnitude is not unusual for a new lamp). The PMT currents decreased by a similar amount, reflecting the change of the lamp. There are two discontinuities. The first one was on 1/29/16 and coincides with the installation of the back-up lamp power supply. The second discontinuity occurred on 7/6/16 and its cause is unknown. The calibration of the system was changed at the times of these discontinuities (vertical lines in Figure 2).

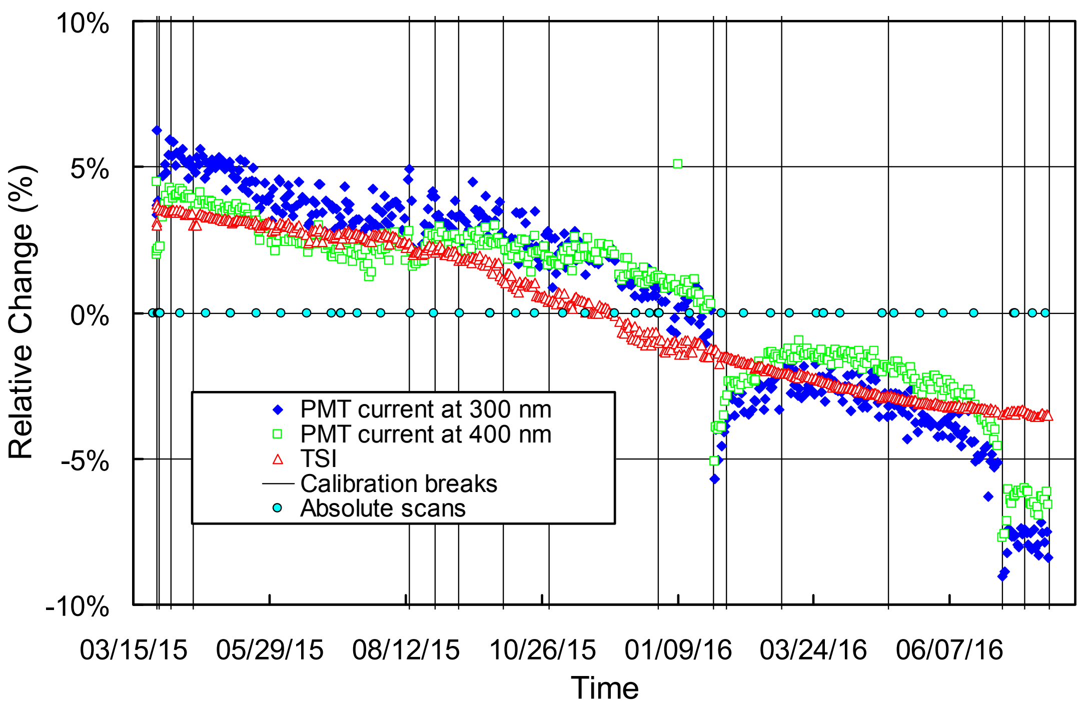

Figure 2. *Time-series of PMT current at 300 and 400 nm, and TSI signal. All data were extracted from measurements of the internal irradiance standard and are normalized to their average. Calibration break points (Table 1) and times of absolute scans are also indicated.*

Changes in the system's sensitivity were corrected by adjusting calibration break points accordingly. The reporting period was divided into sixteen calibration periods, labeled P1 – P15 (Table 1). Figure 3 shows ratios of the calibration functions applied during Periods P2 through P12 relative to the function of Period P1.

Table 1. Calibration periods for Palmer Volumes 25.

Period name	Period range	Number of absolute scans
P1	03/28/15	5
P2	03/29/15 – 04/04/15	3
P2B	04/05/15 – 04/16/15	0 (average of P2 and P3)
P3	04/17/15 – 08/13/15	9
P5	08/14/15 – 08/27/15	2
P5B	08/28/15 – 09/09/15	0 (average of P5 and P6)
P6	09/10/15 – 10/04/15	5
P7	10/05/15 – 10/29/15	2
P8	10/30/15 – 12/28/15	5
P10	12/29/15 – 01/28/16	2
P11A	01/29/16 – 02/04/16	1
P11B	02/05/16 – 03/05/16	2
P12	03/06/16 – 05/03/16	6
P13	05/04/16 – 07/05/16	3
P14	07/06/16 – 07/17/16	3
P15	07/18/16 – 07/31/16	2

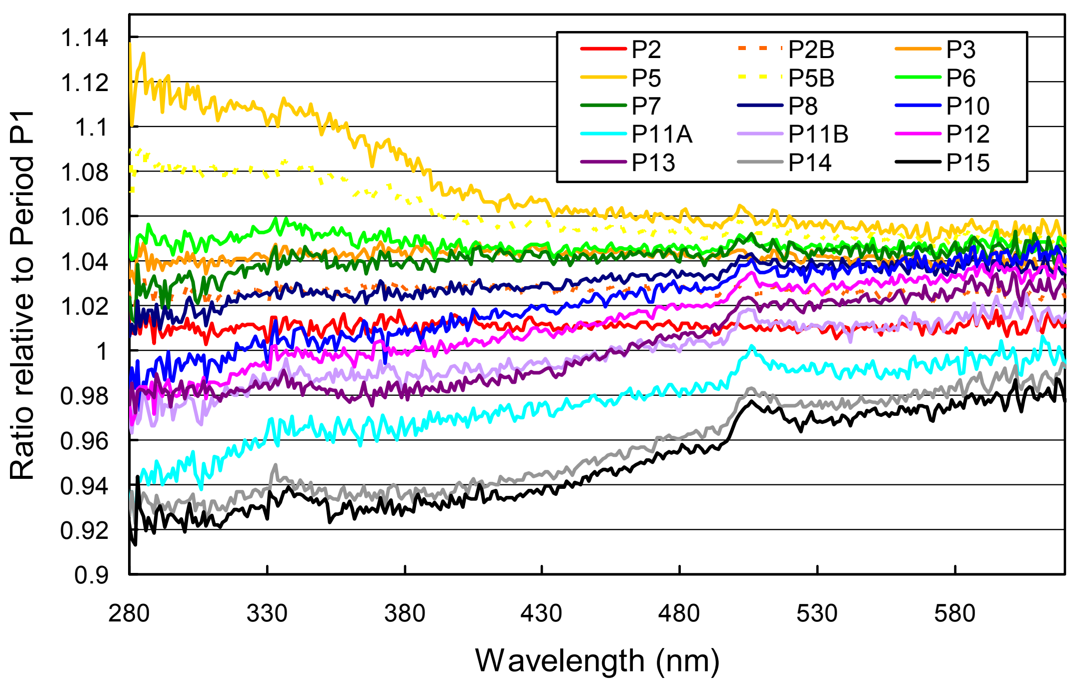

Figure 3. *Ratios of spectral irradiance assigned to the internal reference lamp for periods P2 – P15 relative to Period P1. Broken lines indicate interpolated data.*

The suitability of the selected calibration break points was checked by comparing calibrated SUV-100 measurements with GUV data. Figure 4 shows the ratio of GUV-511 data (340 nm channel) and final SUV-100 measurements, which were weighted with the spectral response function of this channel. The ratio is normalized and should ideally be one. The graph indicates that GUV and SUV measurements are consistent to within ±2.7% (±1σ). There are no step changes exceeding 1.0% between calibration periods.

These results indicate that solar data of the SUV-100 have been appropriately corrected. Remaining uncertainty caused by step changes in sensitivity are below 1% for all periods. The figure also indicates that all data affected by the malfunctioning shutter have been removed.

Figure 5 shows a few short periods when the ratio is abnormally high (e.g., on 5/7/15, 10/16/15, 1/11/16, and 3/9/16) when snow was presumably covering the diffuser of the SUV-100 spectroradiometer for short periods. GUV measurements are less affected by snow because the instrument is heated to a higher temperature.

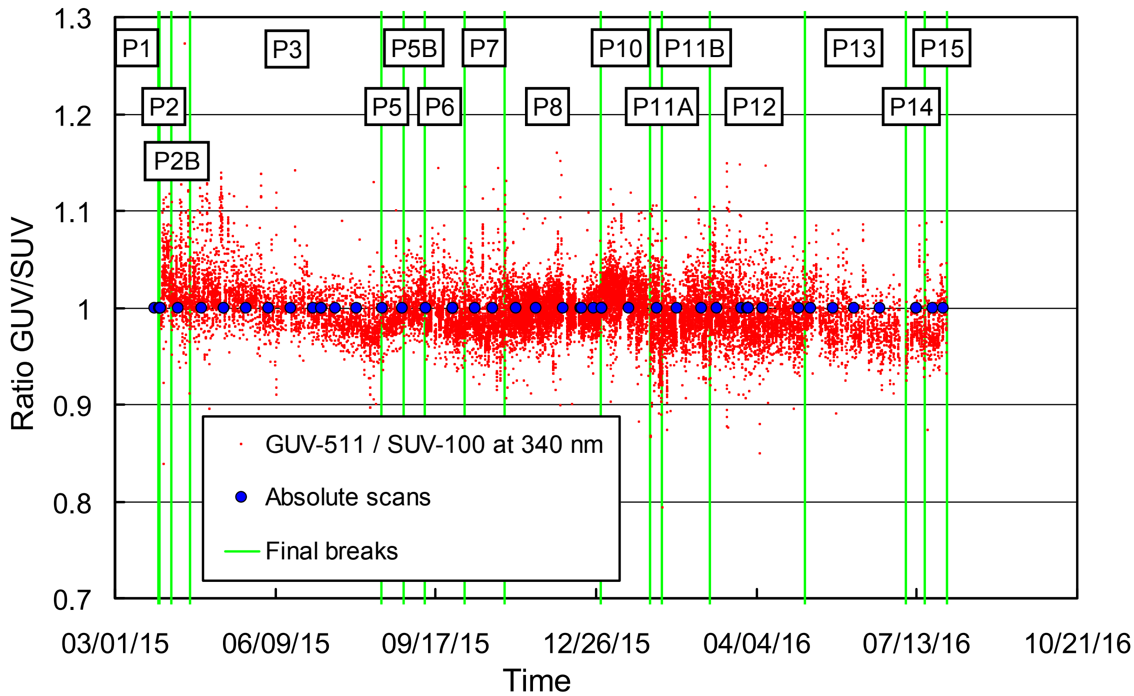

Figure 4. *Ratio of GUV-511 measurements at 340 nm with final SUV-100 measurements. The latter were weighted with the spectral response function of the GUV-511 340 nm channel.*

2.3. 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 final Version 0 data for five wavelengths in the UV and visible by running the Version 2 Fraunhofer-line correlation method a second time. Shifts are typically smaller than ±0.1 nm. (The standard deviations for wavelengths between 305 and 400 nm are 0.029 nm on average). The wavelength accuracy was further improved as part of the production of Version 2 data. Figure 7 shows the wavelength accuracy of Version 2 data. The standard deviations for wavelengths between 305 and 400 nm decreased to 0.024 nm.

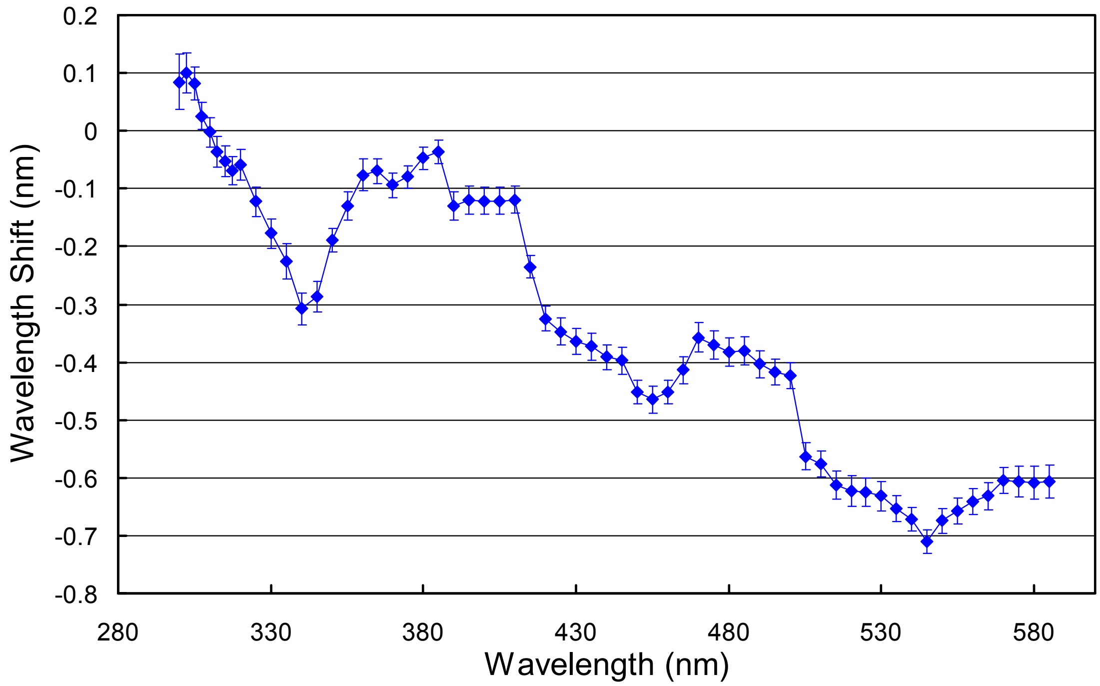

Figure 5. *Monochromator mapping function.*

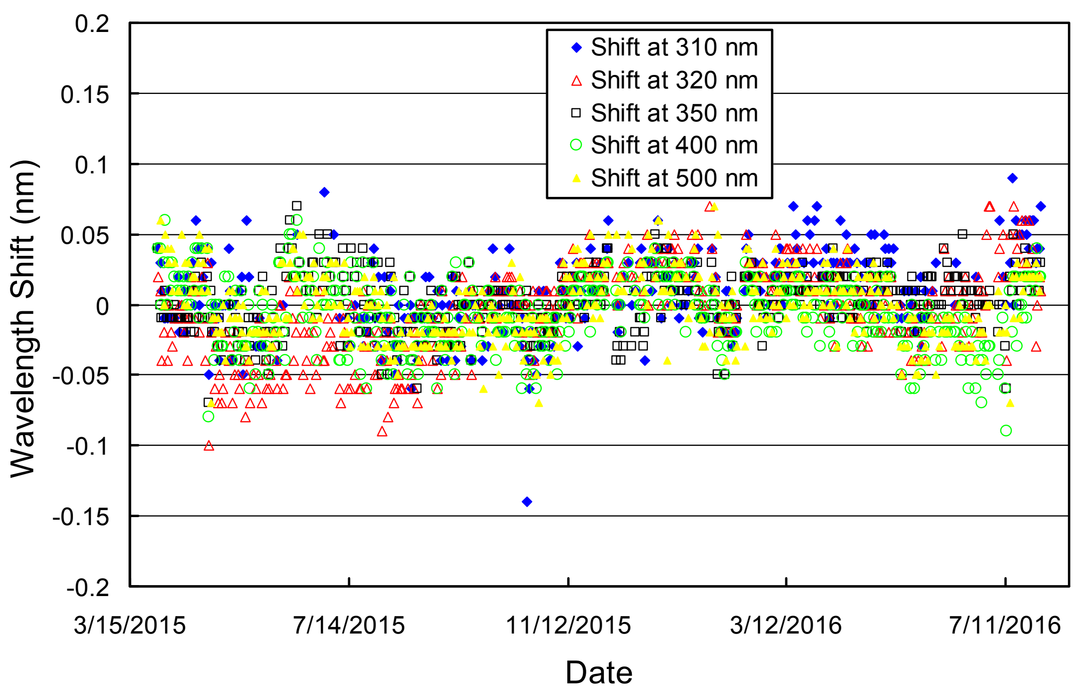

Figure 6. *Wavelength accuracy check of the final Version 0 data at five wavelengths by means of Fraunhofer-line correlation. Noontime measurements from every day of the year have been evaluated.*

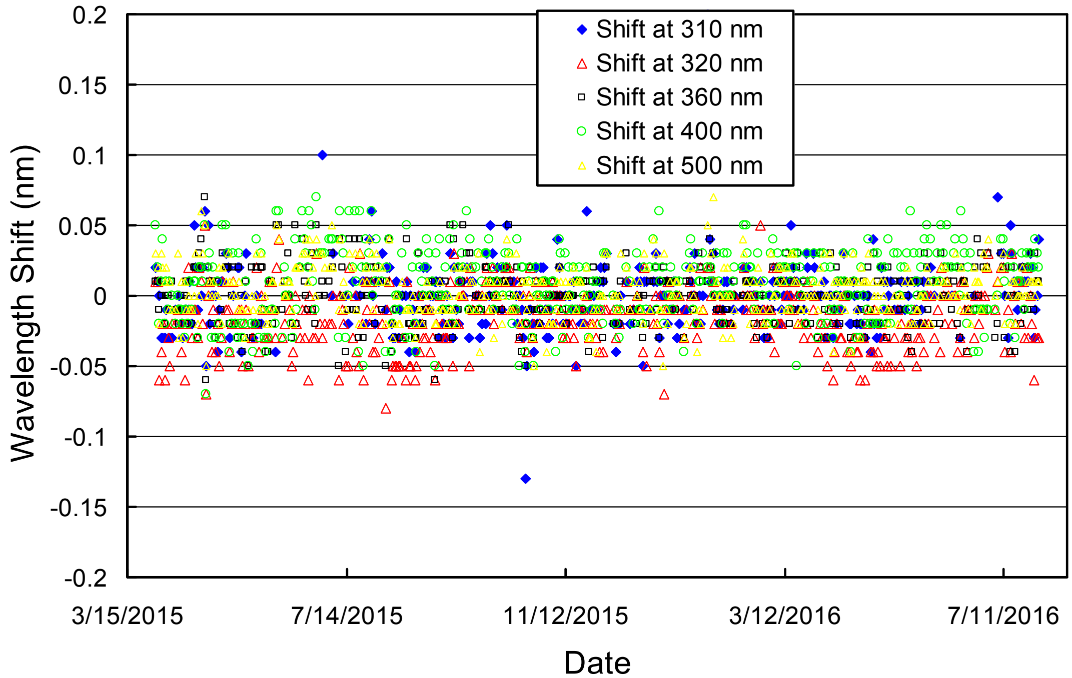

Figure 7. *Same as Figure 6 but for Version 2 data.*

2.4. Missing data

Table 2 provides a list of days that have substantial data gaps, and indicates their causes. About 1,300 (6%) solar scans were lost due to the malfunctioning shutter before it was repaired on 5/11/2016.

Table 2. Days with substantial data gaps.

Date	Reason
04/09/15 – 04/10/15	Shutter malfunction
04/17/15	Shutter malfunction
04/23/15 – 04/24/15	Wavelength position of monochromator lost
05/22/15	Shutter malfunction
06/17/15 – 06/18/15	GPS receiver assigns incorrect time
06/28/15	Shutter malfunction
07/02/15	Unknown
07/07/15	Lamp comparison
08/13/15 – 08/14/15	Shutter malfunction
08/27/15	Unknown
09/15/15	Shutter malfunction
09/16/15 – 09/18/15	Shutter malfunction
10/06/15	Shutter malfunction
11/23/15 – 11/27/15	Shutter malfunction
12/05/15 – 12/07/15	Wavelength position of monochromator lost
12/13/15 – 12/16/15	Shutter malfunction
12/20/15	Shutter malfunction
12/27/15	Shutter malfunction
12/29/15 – 12/30/15	Shutter malfunction

01/14/16 – 01/15/16	Shutter malfunction
01/18/16 – 01/20/16	Shutter malfunction
01/24/16 – 01/28/16	Shutter malfunction
02/14/16 – 02/16/16	Wavelength position of monochromator lost
03/29/16	Lamp comparison
05/10/16	Snow on irradiance collector of SUV-100
05/12/16	Snow on irradiance collector of SUV-100
05/16/16	Snow on irradiance collector of SUV-100
06/01/16	Snow on irradiance collector of SUV-100
06/11/16	Snow on irradiance collector of SUV-100
07/03/16	Snow on irradiance collector of SUV-100
07/04/16 – 07/05/16	Wavelength position of monochromator lost
07/08/16	Snow on irradiance collector of SUV-100
07/12/16	Lamp comparison
07/29/16	Lamp comparison
07/31/16	Scheduled power outage

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.