2. Palmer Station (01/01/14 – 03/25/15)

This sections describes quality control of solar data recorded at Palmer Station between 01/01/14 and 03/25/15. The system was inspected and serviced in March 2014 and March 2015. During these visits, on-site standards of spectral irradiance were compared with traveling standards. System components performed by and large normal during the reporting period. The system exhibited some instabilities (Section 2.2), but these could be corrected during data processing. The period resulted in a total of 24615 solar scans.

The operating system of the system control computer was upgraded from Windows XP to Windows 7 on 3/12/2014.

2.1. Irradiance Calibration

On-site standards
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 the site visit when all of the station lamps and the traveling standard are compared.

The calibration of lamp 200W007 had been 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 had been 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 using measurements of the other two site standards on 12/17/11.

Lamps 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.

Traveling standard traceability
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. At the time 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 five on-site standard and the traveling standard were compared during both site visits. Figure 1 shows results for data collected during the March 2014 visit. Results are referenced against the average of measurements of on-site standards M700 and 200W007. This reference was chosen because solar data of the Volume 24 period were calibrated against these two lamps as discussed in more detail below. The calibrated output of the five lamps agreed to within ±1.5% with this reference. Results for lamps 200W007 and 200WN010 are virtually identical, while results for lamp M700 are 0-0.5% larger than the reference and results for lamps M765 and 200WN009 are 0.5 - 1.5% lower. These difference are within the uncertainty of the scale of spectral irradiance realized by these lamps.

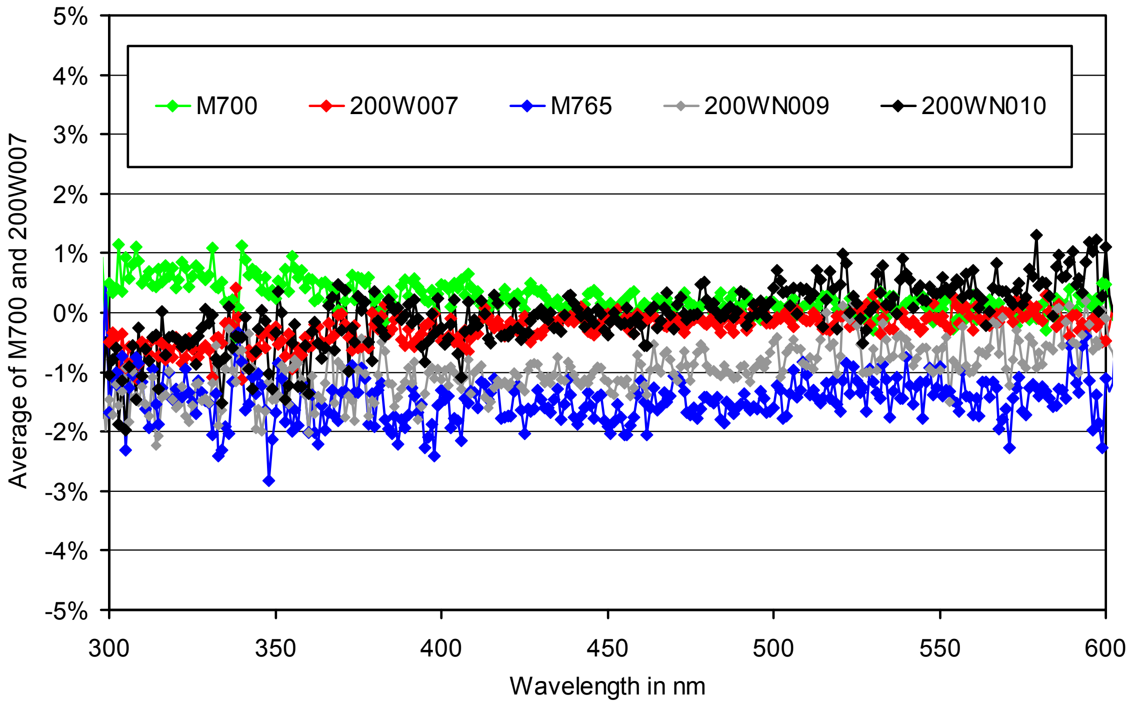

Figure 1. *Comparison of the calibration of on-site standards M700, 200W007, M765, 200WN009, and 200WN010 on 3/21/2014. Data are reference to the average of the measurements of lamps M700 and 200W007.*

The scan of the travelling standard 200WN004 executed at the beginning of the March 2015 site visit was affected by a measurement of the external wavelength standard that was executed immediately before measuring the travelling standard. This resulted in a strong wavelength dependence of the measured spectrum of the travelling standard relative to all on-site standards. Such a wavelength dependence was absent in other comparisons involving lamp 200WN004. Results of the Volume 24 “season closing” lamp comparison are therefore not discussed here.

Figure 2 show the comparison for data collected at the end of the March 2015 site visit (“opening” calibrations of Volume 25), referenced again against the average of the measurements of on-site standards M700 and 200W007. Results indicate that the calibrations of lamps M700 and 200W007 agree ideally with each other for wavelengths in the visible. In the UV-A, the calibration of both lamps agree to within 1%. The level of agreement in the UV-B is only slightly worse. Results of the two newly introduced on-site standards, lamps 200WN009 and 200WN010, also agree to within ±1% with the reference, thereby giving credence to the choice of the reference. Results for the traveling standard 200WN004 are higher by 1% compared to the reference, independent of wavelength, while results of lamp M765 are low by 2%. A similar bias was also observed in March 2014 (Figure 1).

Lamps M700, 200W007, and M765 were also compared four times with each other during the reporting period. The relative differences between the calibrations of the lamps were very consistent: lamps M700 and 200W007 always agreed to within ±1.5% while the calibration of lamp M765 was systematically lower. The onset of the drift of M765 was already hinted in data of the previous reporting period (Volume 22).

Based on the results discussed above, it was decided to base the calibration of solar data of the Volume 24 period on absolute scans of lamps M700 and 200W007 only. Lamp M765 is in need for recalibration.

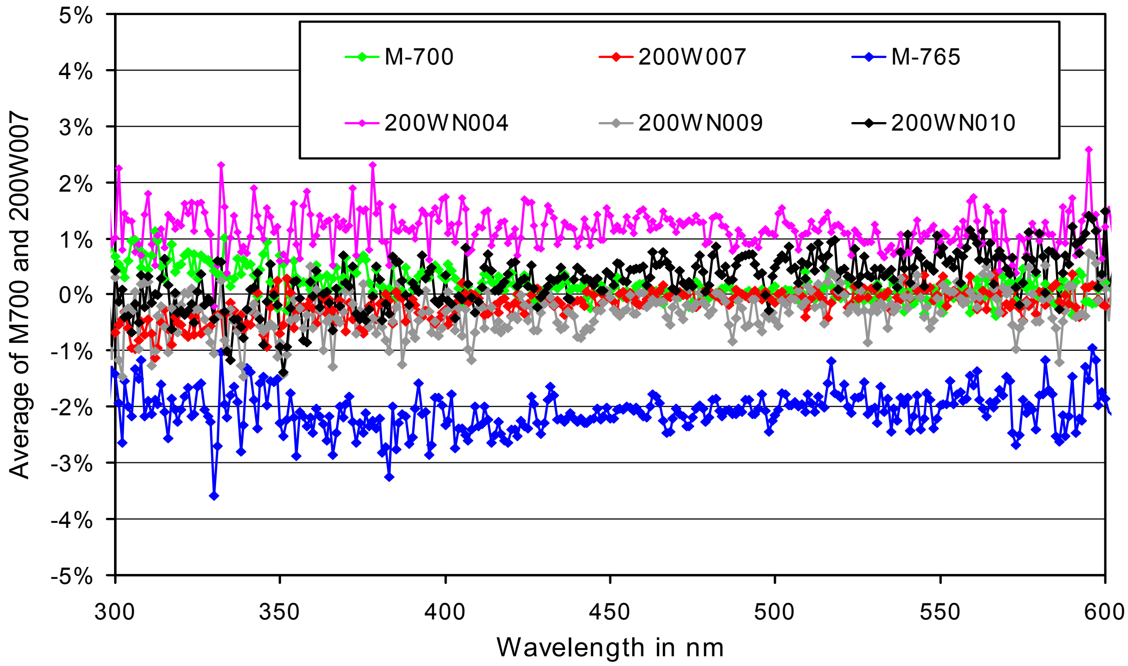

Figure 2. *Comparison the calibration of on-site standards M700, 200W007, and M765, 200WN009, and 200W010, and the traveling standard 200WN004. The five on-site standards were measured on 3/28/15 while the traveling standards was measured on 3/29/15.*

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 of years 2006 - 2015 are in agreement at the ±1% level. This result confirms the excellent consistency of SUV calibrations, the excellent stability of the GUV radiometer, and supports the decision of basing the calibration of solar data of the Volume 24 period on the average of the calibration scales of lamps M700 and 200W007.

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 3 shows changes in TSI readings and PMT currents at 300 and 400 nm, derived from response scans performed between 1/1/14 and 3/25/15. During this time, the output of the internal lamp remained constant to within ±1% as indicated by the TSI sensor. The PMT currents on the other hand showed frequent abrupt upward changes in the order of 2-3%. These changes typically occurred after an absolute scan (times indicated by blue circles in Figure 3) was executed. The cause of these instabilities could not be unambiguously indentified, but it is suspected that they are caused by changes in monochromator throughput. (For performing absolute scans, the monochromator scans up to 700 nm while the terminal wavelength of other scans is 605 nm.).

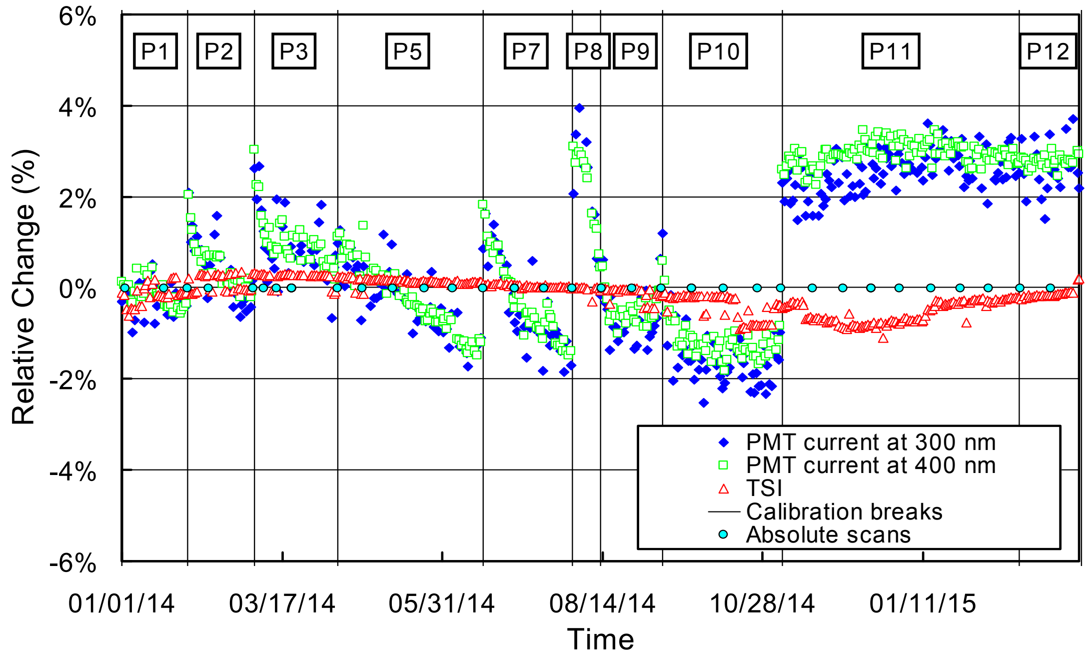

Figure 3. *Time-series of PMT current at 300 and 400 nm, and TSI signal. All data were extracted from measurements of the internal irradiance standard and are normalized to their average. Calibration break points (Table 1) and times of absolute scans are also indicated.*

Changes in the system's sensitivity were corrected by adjusting calibration break points accordingly. The reporting period was divided into ten calibration periods, labeled P1 – P12 (Table 1 and lines in Figure 3). Figure 4 shows ratios of the calibration functions applied during Periods P2 through P12 relative to the function of Period P1. Some of the changes between these functions correlate with the step changes shown in Figure 3.

Table 1. Calibration periods for Palmer Volumes 24.

Period name	Period range	Number of absolute scans
P1	01/01/14 – 01/31/14	2
P2	02/01/14 – 03/03/14	2
P3	03/04/14 – 04/11/14	3
P5	04/12/14 – 06/18/14	2
P7	06/19/14 – 07/30/14	2
P8	07/31/14 – 08/12/14	1
P9	08/13/14 – 09/10/14	2
P10	09/11/14 – 11/05/14	4
P11	11/06/14 – 02/24/15	7
P12	02/25/15 – 03/26/15	3

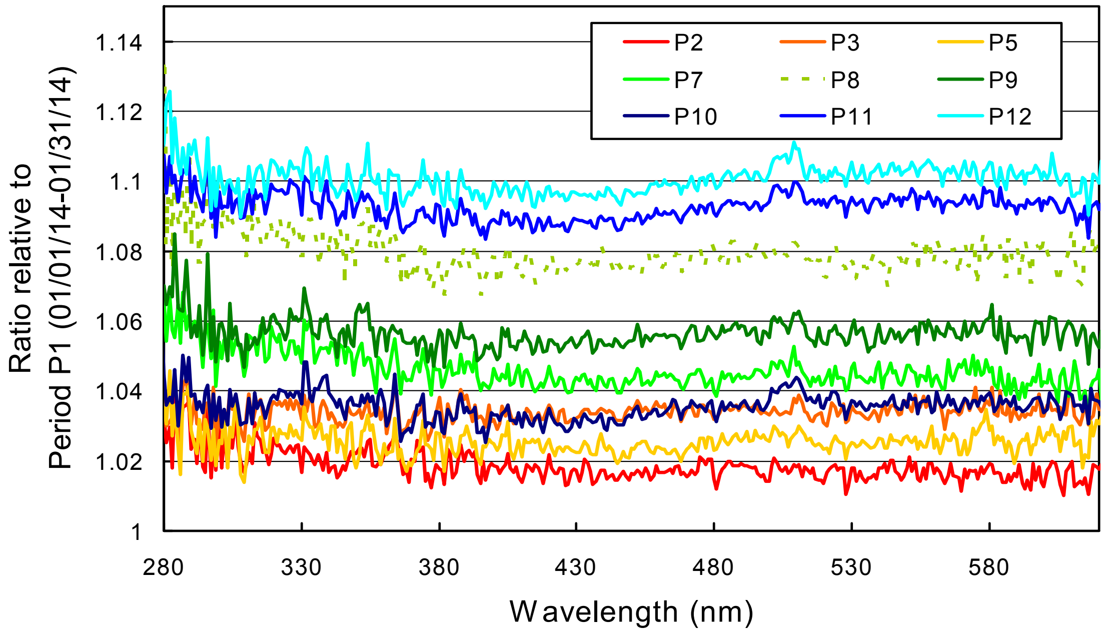

Figure 4. *Ratios of spectral irradiance assigned to the internal reference lamp for periods P2 – P12 relative to Period P1.*

The suitability of the selected calibration break points was checked by comparing calibrated SUV-100 measurements with GUV data. Figure 5 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 ±3.5% (±1σ). There are no obvious step changes between calibration periods P1/P2, P2/P3, P5/P7, and P10/P11, where large steps were indicated in Figure 3. Only the step between periods P7 and P8 could not be completely removed. These results indicate that solar data of the SUV-100 have been appropriately corrected and that the remaining uncertainty caused by step changes in sensitivity are below 1% for all periods with the exception of the transition between periods P7 and P8 where it is 3%.

Figure 5 also shows a few short periods when the ratio is abnormally high. These high values occurred mostly in winter when snow was presumably covering the diffuser of the SUV-100 spectroradiometer for short times. GUV measurements are less affected by snow because the instrument is heated to a higher temperature. Table 2 provides a listing of the affected periods. Associated scans were flagged in the Version 2 data edition.

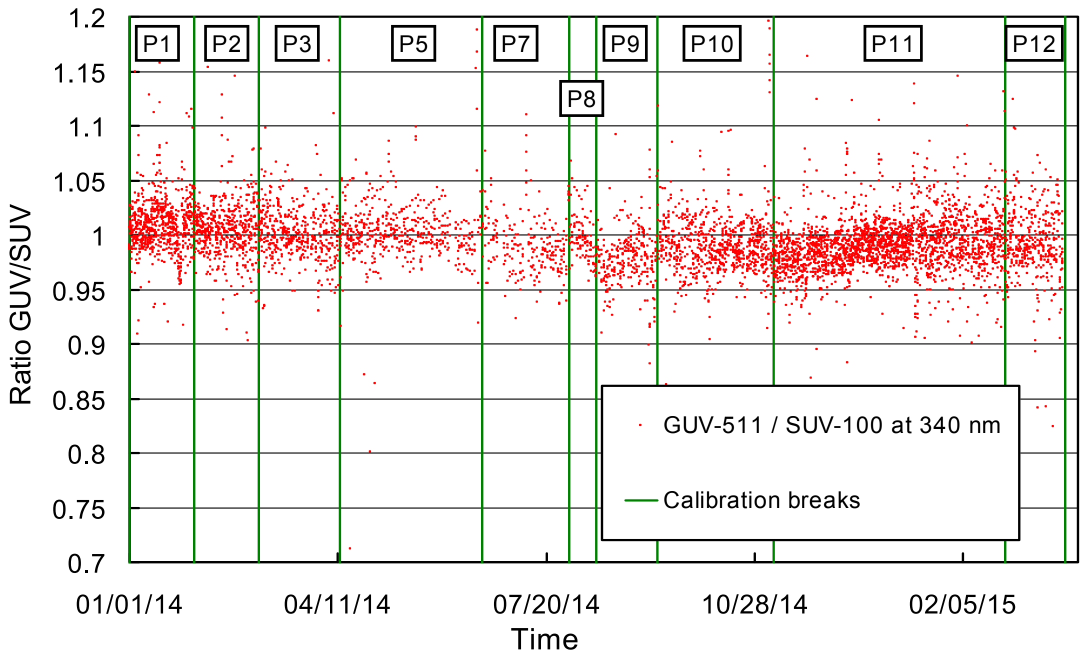

Figure 5. *Ratio of GUV-511 measurements at 340 nm with final SUV-100 measurements. The latter were weighted with the spectral response function of the GUV-511 340 nm channel. Outliers with ratios larger than one are typically caused by measurements were the SUV-100 collector was covered by snow. Associated data have been flagged in the SUV-100 Version 2 data edition.*

Table 2. Periods with abnormally high ratios of GUV/SUV, indicating snow on the SUV collector.

Period	Ratio GUV / SUV
06/16/14 14:00 - 18:00	1.11 - 1.16
07/09/14 15:00 - 19:00	1.28
07/10/14 14:00 - 19:00	1.07
08/22/14 12:00 - 17:00	1.10 - 1.55
09/11/14 12:00 - 19/12/14 15:00	1.10 - ~ 3.0
09/17/14 22:00 - 09/18/14 13:00	1.10 - 1.30
10/17/14 08:15 - 11:00	1.16 - 1.21
11/03/14 20:00 - 11/04/14 13:00	1.13 - 1.31

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 6 shows the correction function calculated with this algorithm. Figure 7 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 0.027 nm on average). The wavelength accuracy was further improved as part of the production of Version 2 data. For example, the tendency for negative shifts in April 2014 was reduced.

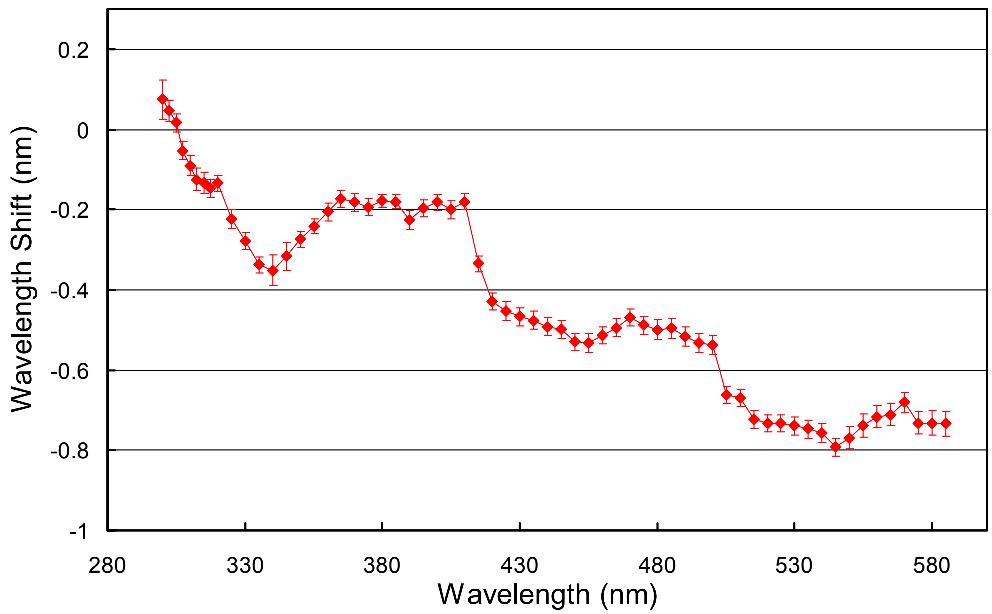

Figure 6. *Monochromator mapping function.*

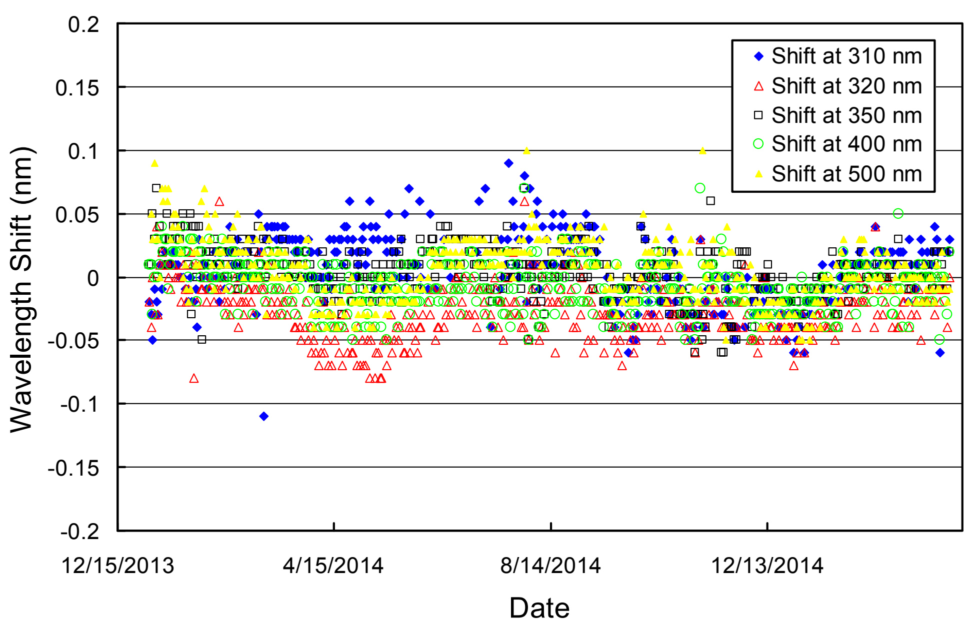

Figure 7. *Wavelength accuracy check of the final data at five wavelengths by means of Fraunhofer-line correlation. Noontime measurements from every day of the year have been evaluated.*

2.4. Missing data

Table 3 provides a list of days that have substantial data gaps, and indicates their causes.

Table 3. Days with missing data

Date	Reason
03/21/14	Quadruple absolute scans
03/28/14	Data file missing for unknown reasons
03/29/14	Manual start up of software
06/04/14	Monochromator wavelength registration too far off
06/05/14	Monochromator wavelength registration too far off
06/27/14	No GUV data
06/28/14	No SUV data for no obvious reason
09/11/14	Monochromator wavelength registration too far off
10/23/14	Erratic computer rebooting caused by a Microsoft Security Essential update.
11/16/14	System reboot for no obvious reasons
12/02/14	Monochromator wavelength registration too far off
12/03/14	Monochromator wavelength registration too far off
01/19/15	Scheduled power outage
01/19/15	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.