3. Amundsen-Scott South Pole Station (9/15/18–3/29/19)

The 2018–2019 data season at Amundsen-Scott South Pole Station is from 9/15/18 to 3/29/19. No site visit took place during this period. The system performed without significant problems. However, data at wavelengths shorter than about 310 nm were noisier than usual up to 9/29/19 because of ice build up underneath the instrument's collector. The collector was cleaned on 9/29/19 and noise levels returned to their normal range.

A total of 17,333 SUV-100 spectra were assigned to Volume 28.

Like for the previous three seasons, measurements of the 320 nm channel of the GUV-541 radiometer (S/N 29239) that is installed next to the SUV-100 spectroradiometer drifted greatly. GUV data products had to be produced without utilizing measurements of this channel. A comparison of calibrated GUV and SUV data performed during the Volume 26 season indicated that the quality of GUV data products is only marginally affected by the omission of the 320 nm channel. Solar data of the GUV are therefore part of the published datasets.

The PSP radiometer installed next to the system had the serial number S/N 30451F3 and a calibration factor of 8.34 $x10^{-6}$ V/(W m^{-2}).

3.1. Irradiance Calibration

The on-site irradiance standards used for calibrating the SUV-100 spectroradiometer during the reporting period were the lamps M-666, 200W021, 200W013, 200WN005 and 200WN006. Lamps M-666, 200W021, and 200W013 are "working standards" that are used on a regular basis. Please see previous Operations Reports on the history of these lamps. Lamps 200WN005 and 200WN006 were left at the South Pole in March 2014. Both lamps are designated "long-term" standards and are typically only used during site visits. Both lamps were calibrated by CUCF in August 2013 (see below).

Comparisons of calibrations with the various lamps suggested that the three working standards were in need for recalibration. The three lamps were therefore recalibrated against the two long-term standards 200WN005 and 200WN006 using absolute scans performed on 9/11/18 and 9/12/18. Solar data of the reporting period are based on these new calibrations.

<u>Calibration history of long-term standards</u>
The long-term standards 200WN005 and 200WN006 were calibrated against lamps 200WN001 and 200WN002 on 8/20/13. Lamps 200WN001 and 200WN002 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 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 the SUV-100 instrument at the South Pole did not result in a significant step-change.

Figure 3.1. shows a comparison of lamps M-666, 200W021, and 200W013, relative to the average of lamps 200WN005 and 200WN006, based on absolute scans performed on 11 and 12 September 2018. The scales of spectral irradiance of all lamps agree to better than ±0.5% on average. The good agreement is expected because the three working standards were recalibrated against the long-term standards. Note that the scales of the two long-term standards also agree within this limit, suggesting that both standards have not drifted since their calibration in August 2013.

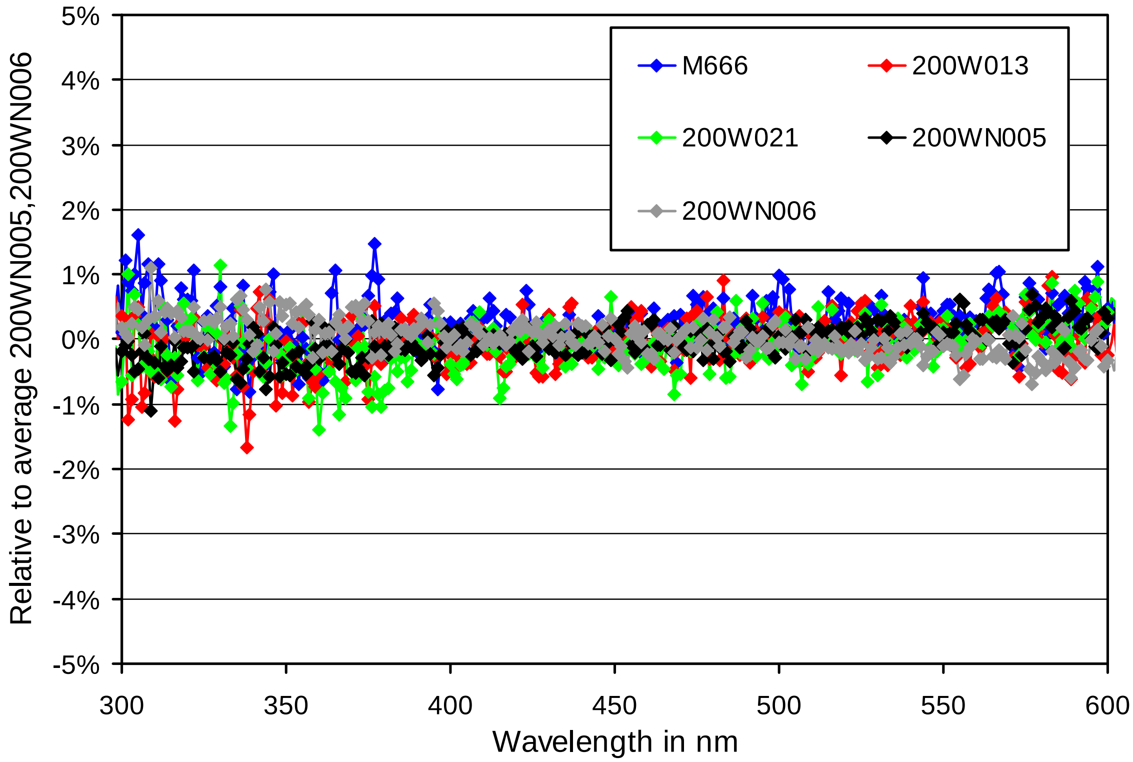

Figure 3.1. *Comparison of South Pole lamps M-666, 200W021, 200W013, 200WN005 and 200WN006 on 11 and 12 September 2018.*

The GUV-541 radiometers was calibrated vicariously against SUV-100 data. Calibration factors were established in the same way when data of previous volumes were processed. Calibration factors of the last six years (Volumes 23 –28) agree to within ±1.5% (±1σ) for all GUV channels, with exception of the drifting 320 nm channel. This result confirms the good consistency of calibrations over time.

3.2. Instrument Stability

The temporal stability of the spectroradiometer's sensitivity was assessed with (1) bi-weekly calibrations utilizing the on-site standards, (2) daily "response" scans of the internal irradiance reference lamp, (3) comparison with data of the collocated GUV-541 radiometer, and (iv) model calculations, which are part of "Version 2" data edition.

The internal reference lamp is monitored with a filtered photodiode with sensitivity in the UV-A, called "TSI". This photodiode has proven to be very stable over time and its measurements therefore allow to decouple temporal drifts of the internal lamp from changes in the SUV-100's responsivity. These changes may be caused by variations in monochromator throughput or PMT sensitivity. Figure 3.2 shows changes in TSI readings and PMT currents at 300 and 400 nm, which were derived from the daily scans of the internal lamp during the reporting period. The TSI measurements indicate that the internal lamp became dimmer by about 2% over this period. This amount of drift is typical. The PMT currents at 300 and 400 nm also showed a downward trend in response to the change in the lamp's output, but also exhibited some variability of about ±3%. The magnitude of these variations is within the normal range observed in previous years. The resulting changes in the instrument's sensitivity were corrected by adjusting the system's calibration as described below.

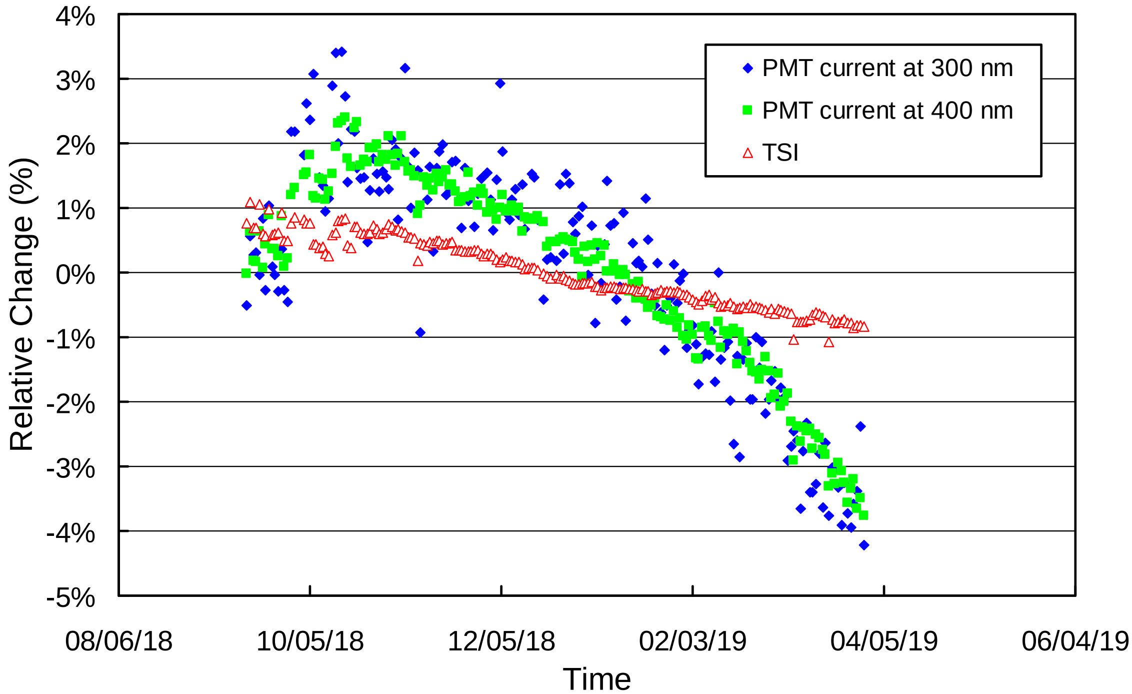

Figure 3.2. *Time-series of PMT current at 300 and 400 nm, plus the TSI signal, derived from daily measurements of the SUV-100's the internal irradiance standard. Data are normalized to the average of the whole period.*

A comparison of GUV-541 and SUV-100 measurements allows to detect anomalies in SUV-100 data. Accordingly, Figure 3.3 shows the ratio of GUV-541 (340 nm channel) and SUV-100 measurements. The latter were weighted with the spectral response function of the GUV's 340 nm channel. The ratio was normalized to its average and should ideally be equal to one at all times. The graphs indicates that GUV and SUV measurements are generally consistent to within ±5%. The few outliers can be explained by shading from obstacles (e.g. air sampling masts) that are in the field of view of the instruments. Because GUV and SUV radiometers are not positioned at exactly the same location, the shadows from these obstacles fall on the collectors of the two instruments at different times. Scans affected by shadowing from stacks were flagged in the SUV-100 Version 2 dataset, removed from the GUV dataset, but remain part of the SUV-100 Version 0 dataset.

Six calibration functions were applied to SUV-100 data of the reporting period. Times when the calibration changed are indicated by vertical lines in Figure 3.3. More information on these calibrations is provided in Table 3.1. Figures 3.4 shows ratios of these calibration functions. The ratio for Period P1 to Period P2 is not plotted on the chart because the system's responsivity was lower by approximately a factor 3 up to 9/29/18 compared to later periods. The small responsivity in period P1 can be attributed to ice build up underneath the instrument's collector. Comparisons with data from the GUV radiometer (Fig. 3.3) indicate that the small responsivity was fairly constant during the affected period, and the uncertainty of solar data from the SUV-100 is therefore not significantly increased over this period.

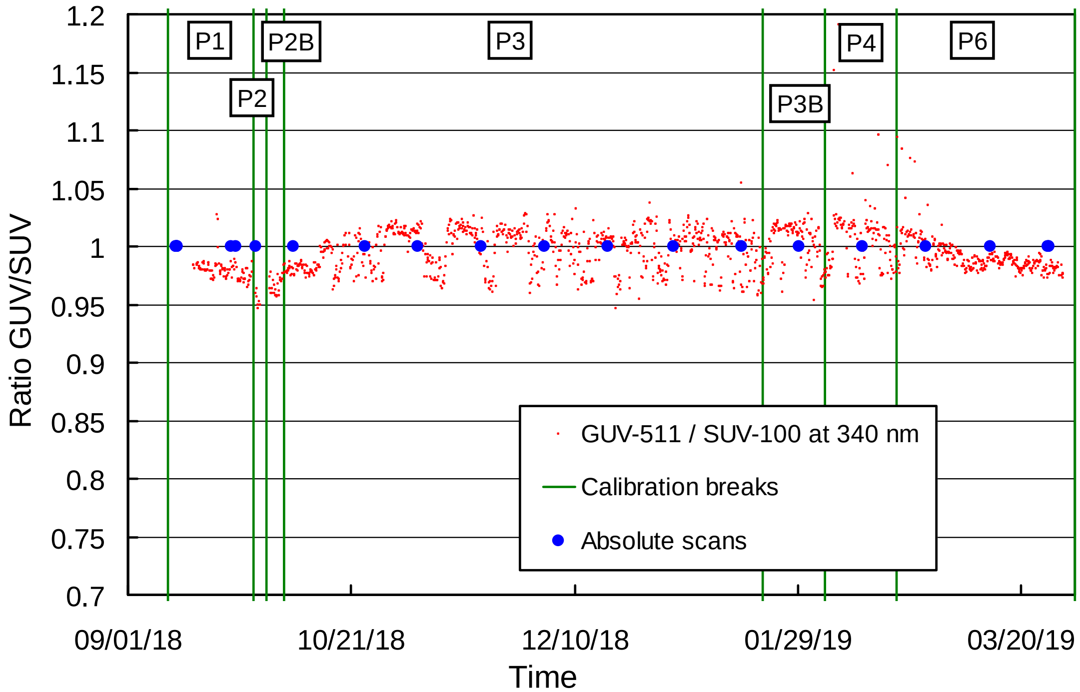

Figure 3.3. *Ratio of GUV-541 (S/N 29239) measurements (340 nm channel) with SUV-100 measurements. SUV-100 data were weighted with the spectral response function of this GUV channel. The vertical green lines indicate times when the calibration applied to SUV-100 data was changed (see also Table 3.1).*

Table 3.1 Calibration periods for South Pole data of Volume 28.

Period	Period range	Number of absolute scans	Remarks
P1	09/10/18 – 09/28/18	2	
P2	09/29/18 – 10/01/18	1	
P2B	10/02/18 – 10/05/18	0	Average P2 and P3
P3	10/06/18 – 01/20/19	6	
P3B	01/21/19 – 02/03/19	0	Average P3 and P4
P4	02/04/19 – 02/19/19	1	
P5	02/20/19 – 03/29/19	4	

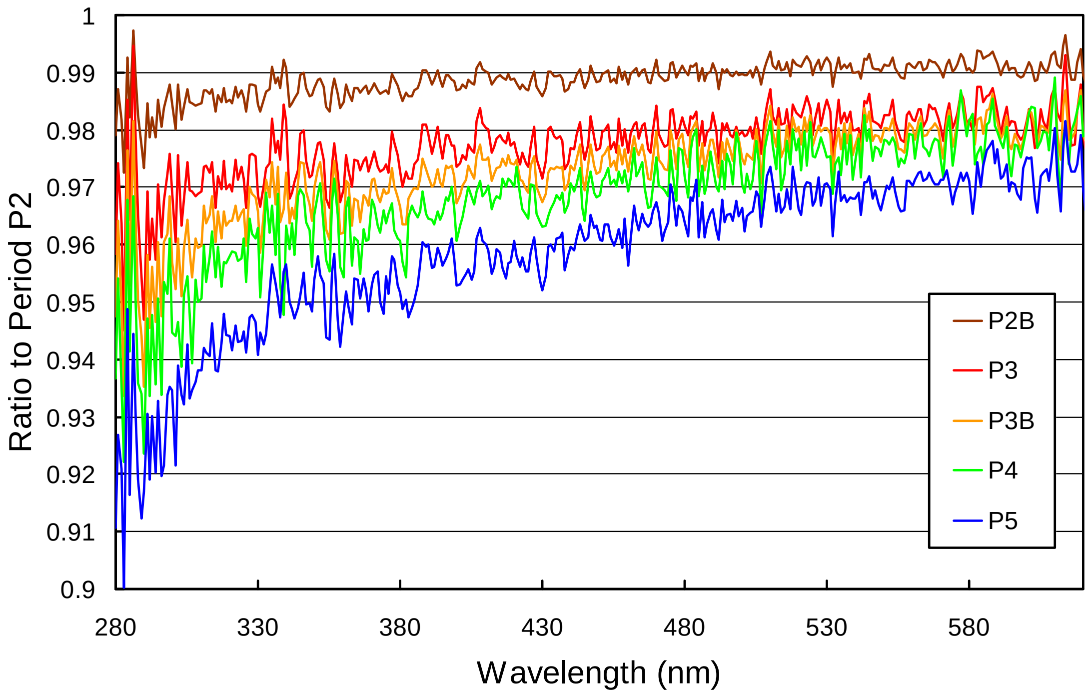

Figure 3.4. *Ratios of spectral irradiance assigned to the internal lamp relative to the spectral irradiance of Period P2.*

3.3. Wavelength Calibration

The 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. The wavelength registration of the system changed appreciably when the collector was cleaned on 9/29/18. Two correction functions were therefore calculated and are shown in Figure 3.5.

Figure 3.6 indicates the wavelength accuracy of final “Version 0” data for five wavelengths in the UV and visible range. The plot was generated by applying the Version 2 Fraunhofer-line correlation method to the corrected data. Residual wavelength shifts are typically smaller than ±0.15 nm, but there is still a considerable day-to-day variability. The wavelength accuracy was further improved when processing Version 2 data by breaking the dataset into 75 periods and calculating separate correction functions for each period. Figure 3.7 indicates the wavelength accuracy of final “Version 2” data. A significant improvement in the wavelength uncertainty can be observed when comparing Figs. 3.6 and 3.7.

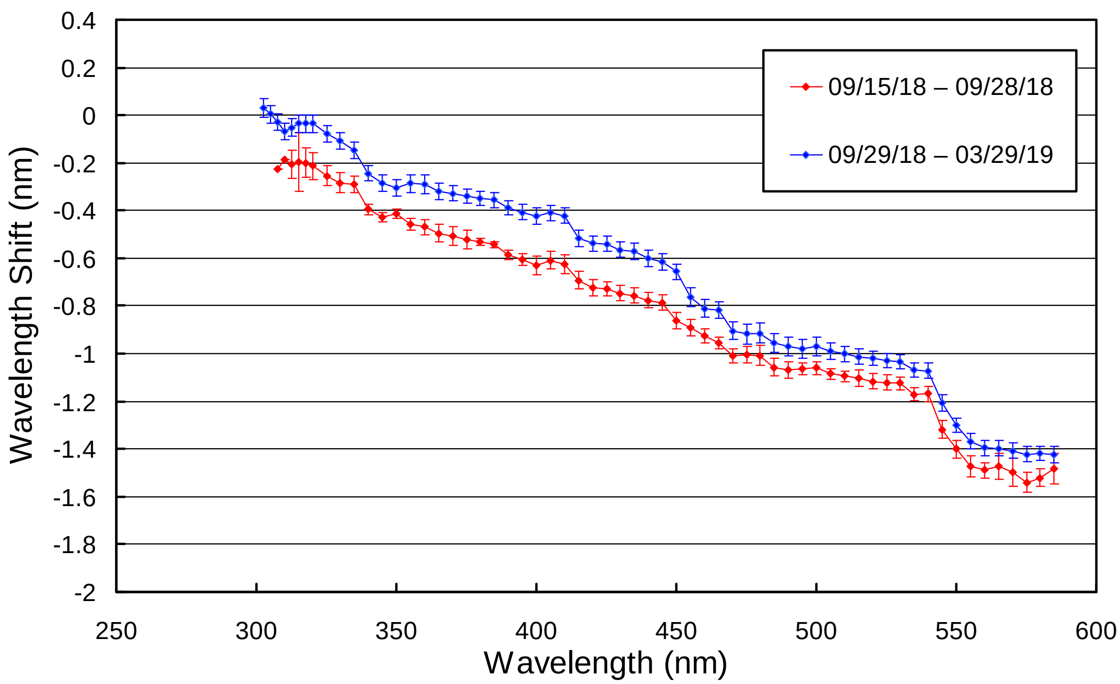

Figure 3.5. *Monochromator non-linearity correction functions.*

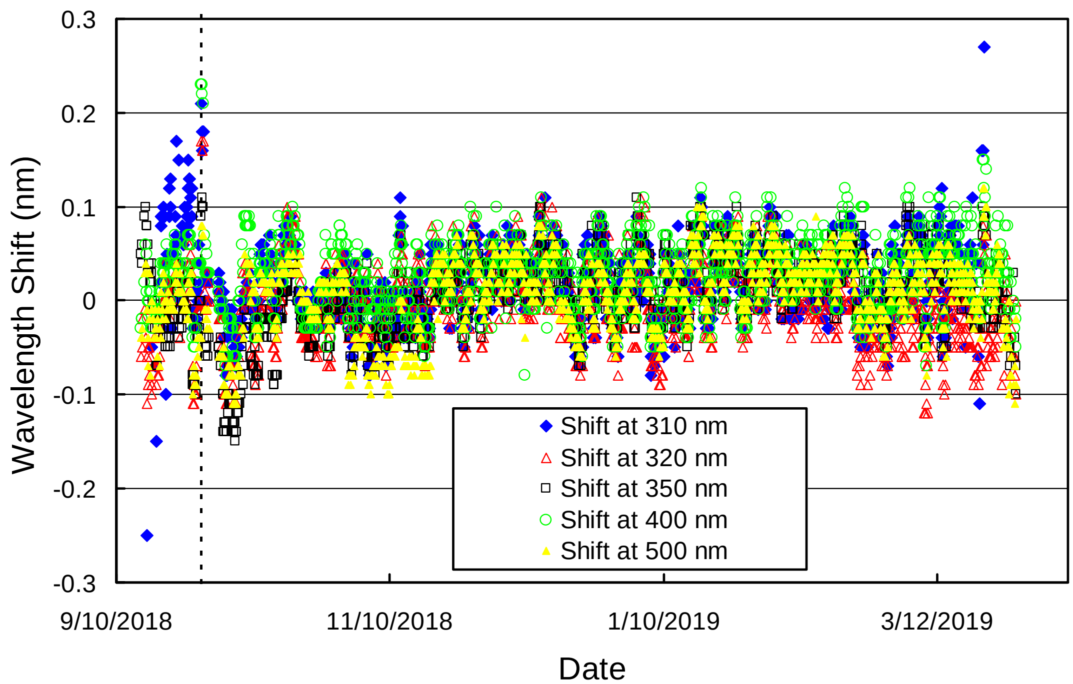

Figure 3.6. *Wavelength accuracy check of* <u>*Version 0*</u> *data at five wavelengths by means of Fraunhofer-line correlation. The vertical broken line indicates the time when the collector was cleaned.*

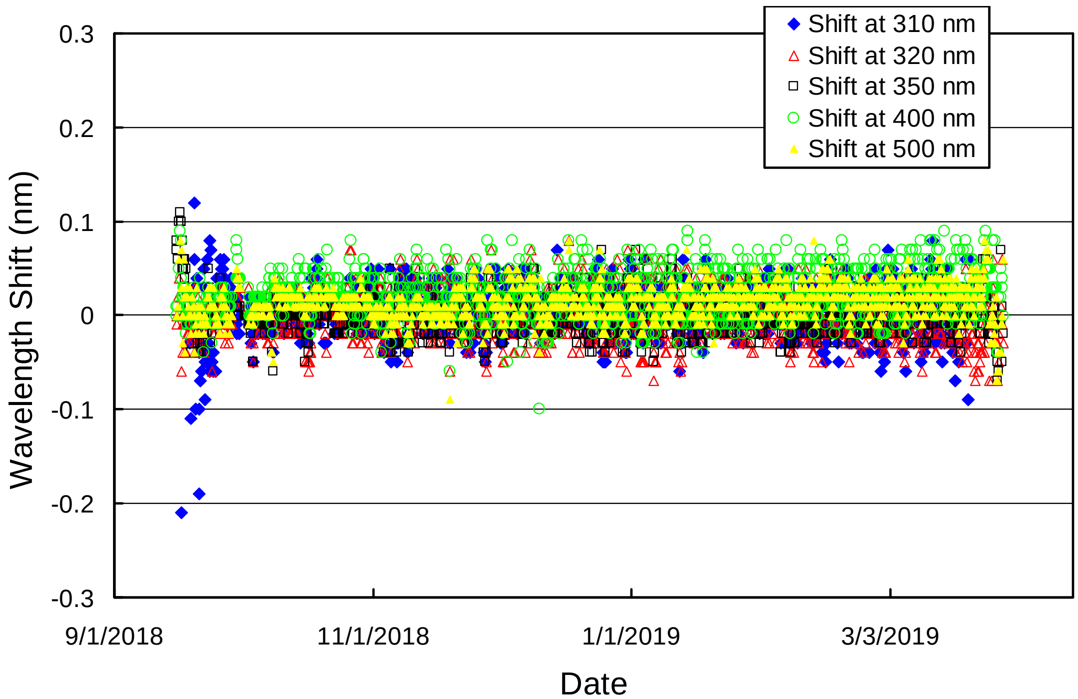

Figure 3.7. *Wavelength accuracy check of Version 2 data at five wavelengths by means of Fraunhofer-line correlation.*

3.4. Missing data

The dataset is almost complete, however, no data are available for 9/29/18 between 00:00 and 15:00 due to the collector service, and between 9/30/18 17:30 and 10/2/18 17:00 when the communication between the spectroradiometer's control module and the system's computer was interrupted for unknown reasons.