3. Amundsen-Scott South Pole Station (9/15/15–3/28/16)

The 2015–2016 data season at Amundsen-Scott South Pole Station is from 9/15/15–3/28/16. The system was serviced at the end of January 2016 by NOAA personnel. At this time, also on-site standards were compared with a travelling standard. The SUV-100 spectroradiometer worked well during the reporting period. However the angular response of the system was somewhat compromised between the start of the season and the beginning of the site visit on 1/28/16 because an aperture stop installed in the instrument's irradiance collector was not in the correct position. Published data were corrected for this problem by applying a non-standard "cosine-error correction." A total of 16,604 SUV-100 spectra were measured and assigned to Volume 25.

The 320 nm channel of the GUV-541 radiometer that is installed next to the SUV-100 spectroradiometer drifted by 30% between September 2014 and February 2015 (Volume 24 period). These larger drifts continued during the reporting period (Volume 25). Because of these excessive drifts, data of the 320 nm channel could not be used. Final GUV data products were therefore produced without utilizing measurements of this channel. A comparison of calibrated GUV and SUV data indicates 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.

Up to 1/28/16, Eppley PSP pyranometer #30451F3 was installed adjacent to the SUV and GUV radiometers. The calibration constant of this instrument is 8.21 10^{-6} V/(W/m^2) and was established by Don Nelson of NOAA on 8/15/13. The instrument was replaced during the site visit with PSP pyranometer #27228F3. The calibration constant of this instrument is 8.377 10^{-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. The tables of spectral irradiance assigned to these lamps during the 2015–2016 season were identical to those applied during the previous (2014–2015) season. Lamp 200WN014 was used as a traveling standard during the site visit in January 2016.

<u>On-site standards</u>
Lamps M-666 and 200W021 have been in service for a long time. Lamp M-666 was originally calibrated against lamps 200W006 and 200W021 using season closing scans of the Volume 9 and opening scans of the Volume 10 periods. Comparisons of lamp M-666 with lamps 200W021, 200W013, 200WN003 and 200WN004 performed during the site visit in January 2013 indicated a systematic bias of lamp M-666 with respect to the four other lamps of about 2% in the UV-B, decreasing to 0% at 600 nm. Lamp M-666 was recalibrated against lamp 200W021 using scans performed during the January 2013 site visit, and this calibration was also used for this reporting period.

The original calibration of lamp 200W021 was established by Optronic Laboratories in September 1998. Lamp 200W013 was introduced in January 2008 and had been calibrated against the former traveling standard M-763 using closing scans of the Volume 17 period. Comparisons with lamps 200WN003, 200WN004, 200WN005, and M-666 during the January 2015 site visit indicated that the calibrations of lamps 200W021 and 200W013 have drifted. Both lamps were recalibrated against the scale of irradiance of the traveling standard 200WN004 using data collected at the start of the site visit in January 2015.

Lamps 200WN004 and 200WN005 were left at the South Pole in March 2014. They are considered long-term standard and are typically 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).

Traveling standard

The traveling standard 200WN014 has been calibrated by NOAA/CUCF against lamps 200WN001 and 200WN002 on 1/13/16. 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 all lamps discussed above. The plot is based on scans performed at the beginning of the site visit in January 2016. The calibrations of all on-site lamps agree with the calibration of the traveling standard 200WN014 to within ±1.5%. This difference is within the uncertainty of the scale of irradiance represented by these lamps. The relative differences between the various lamp agree to within ±0.5% with similar differences observed during the previous lamp comparison in January 2015.

Lamps M-666, 200W013, and 200W021 were also compared with each other on 9/12/15 and 3/27/16. Results agreed to within ±1% on both occasions, confirming that the scale of irradiance applied to solar data of the reporting period did not change over this period.

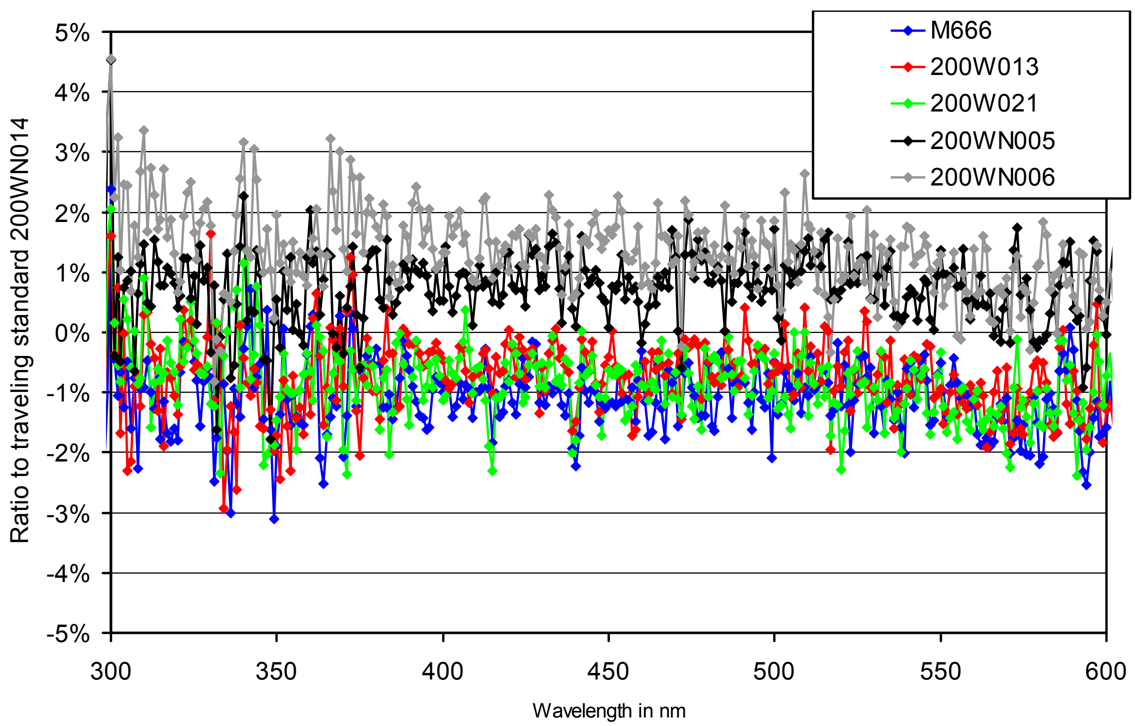

Figure 3.1. *Comparison of South Pole lamps M-666, 200W021, 200W013, 200WN005, and 200WN006 with traveling standard 200W014 at the beginning of the January 2016 site visit.*

3.2. Instrument Stability

The stability of the SUV-100 spectroradiometer over time was assessed by comparison with data of the collocated GUV-541 radiometer and model calculations that are part of "Version 2" data processing.

Figures 3.2 shows the ratio of GUV-541 (340 nm channel) and final SUV-100 measurements. The latter were weighted with the spectral response function of the GUV's 340 nm channel. The ratios were normalized and should ideally be equal to one. The graphs indicates that GUV and SUV measurements are generally consistent to within ±5%. Most 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 shadow from these obstacles falls 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.

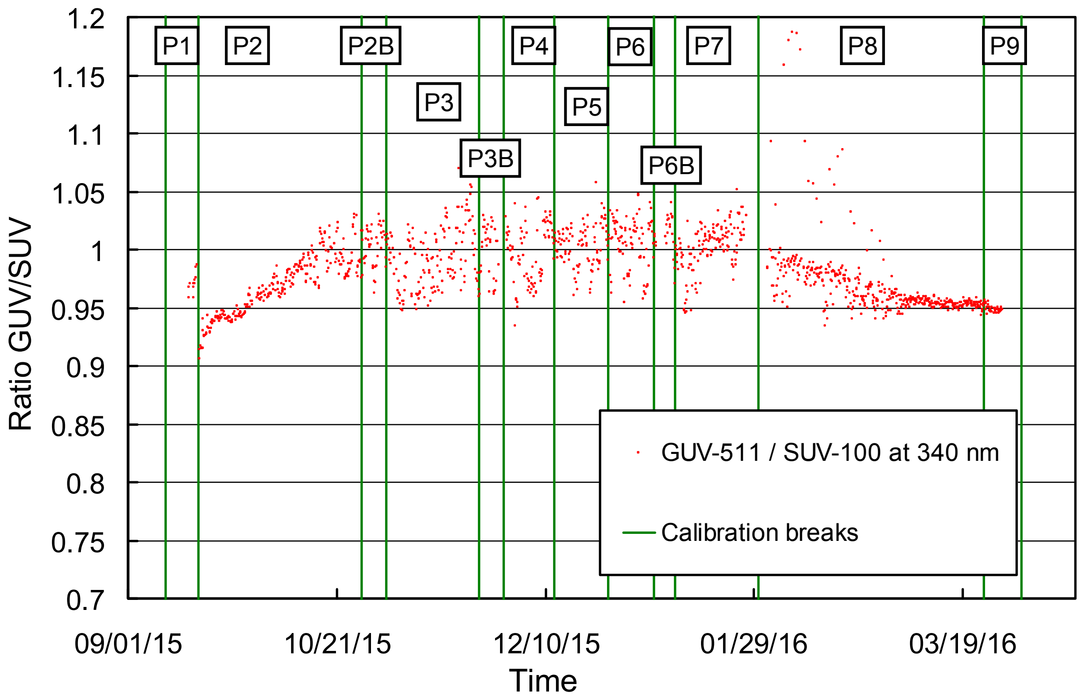

Figure 3.2. *Ratio of GUV-541 #29239 measurements (340 nm channel) with SUV-100 measurements. SUV-100 data were weighted with the spectral response function of this GUV channel. The vertical lines indicate times when the calibration applied to SUV-100 data was changed (see also Table 3.1).*

Twelve calibration functions were applied to SUV-100 data of the reporting period. Times when the calibration changed are indicated by vertical lines in Figure 3.2. More information on these calibrations is provided in Table 3.1. Figures 3.3 shows ratios of the calibration functions applied prior to the site visit relative to the function of the second period (Period P2). Figure 3.4. shows a similar ratio for the post-visit calibrations. There was a large changes in the instrument's responsivity between periods P1 and P2. These can be attributed to the change in the position of the aperture stop discussed earlier. This is of minor importance because period P1 includes only three days at a time when the Sun was still below the horizon. Between 9/18/15 and the site visit in January 2016, the responsivity of the system gradually changed by approximately 15% with somewhat larger changes below 305 nm. The effect of these changes on final solar data is small (< 2%), because the system is calibrated frequently and the responsivity adjusted accordingly. After the site visit, the system's responsivity changed by less than 1% (Figure 3.4).

Table 3.1 Calibration periods for South Pole data of Volume 25.

Period name	Period range	Number of Absolute Scans	Remarks
P1	09/10/15 – 09/17/15	4	
P2	09/18/15 – 10/26/15	3	
P2B	10/27/15 – 11/01/15	0	Average of Period P1 and P2
P3	11/02/15 – 11/23/15	2	
P3B	11/24/15 – 11/29/15	0	Average of Period P3 and P4
P4	11/30/15 – 12/11/15	1	
P5	12/12/15 – 12/24/15	1	
P6	12/25/15 – 01/04/16	1	
P6B	01/05/16 – 01/09/16	0	Average of Period P6 and P7
P7	01/10/16 – 01/29/16	7	
P8	01/30/16 – 03/23/16	6	
P9	03/24/16 – 04/01/16	3	

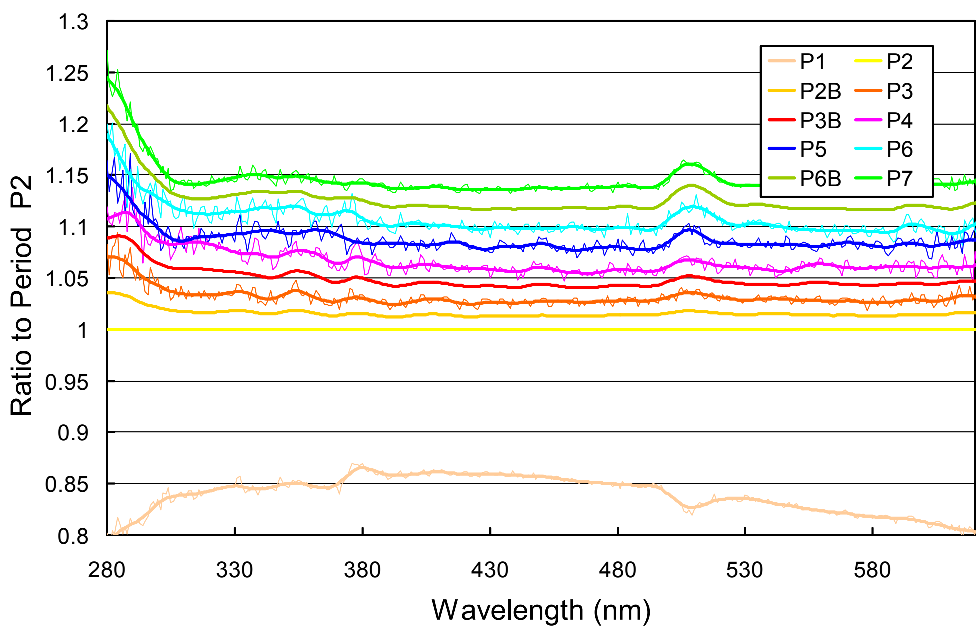

Figure 3.3. *Ratios of spectral irradiance assigned to the internal lamp prior to the site visit in January 2016 relative to Period P2 (09/18/15–10/26/15).*

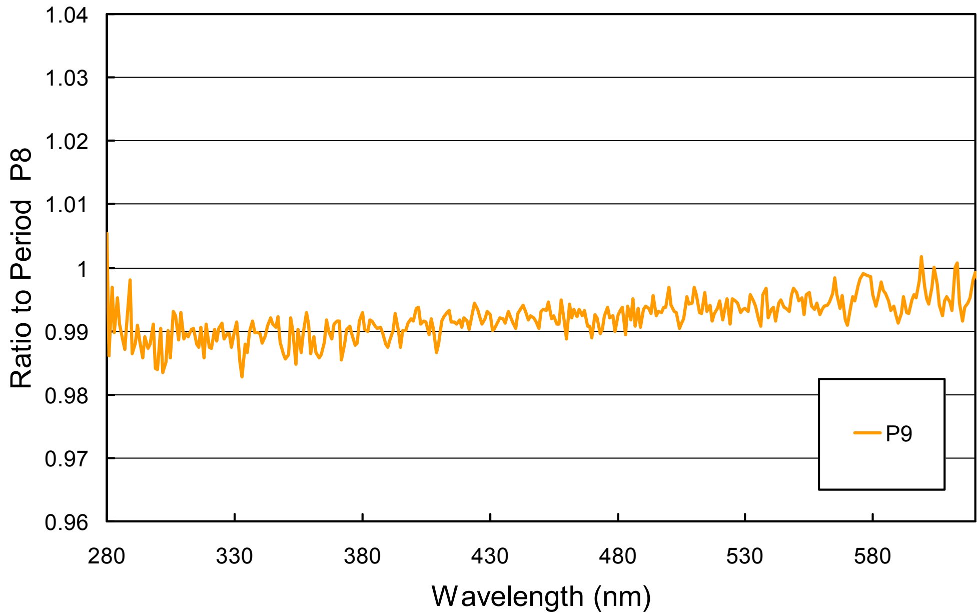

Figure 3.4. *Ratio of spectral irradiance assigned to the internal lamp after the site visit in January 2016 relative to Period P8 (01/30/16 – 03/23/16).*

3.3. 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. Figure 3.5 shows two correction functions calculated with this algorithm from data of the periods 9/15/15 - 1/29/16 (period before site visit) and 01/30/16 - 03/31/16 (period after site visit).

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 for a second time. Residual wavelength shifts are typically smaller than ±0.1 nm, however, in certain periods shift as large as 0.2 nm are observed. To correct for these relative larger shifts, the wavelength mapping was further refined as part of Version 2 data processing. Specifically, the dataset was broken into 25 subsets with different correction functions applied in each subset. The maximum wavelength shift of Version 2 data is smaller than ±0.1 nm with very few exceptions (Figure 3.7).

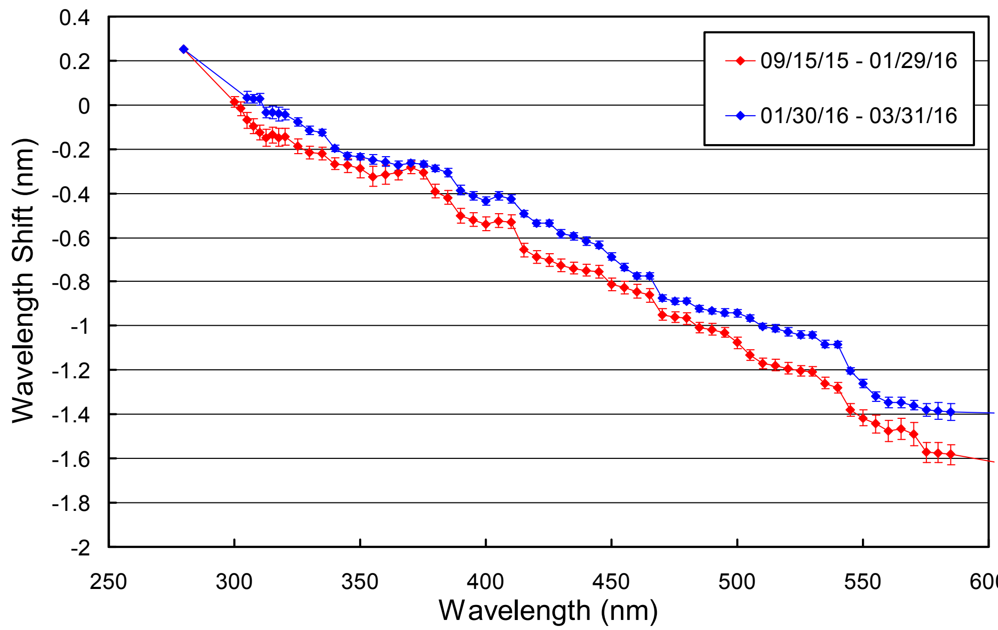

Figure 3.5. *Monochromator non-linearity correction functions for South Pole data of the period 9/15/15 - 3/31/16.*

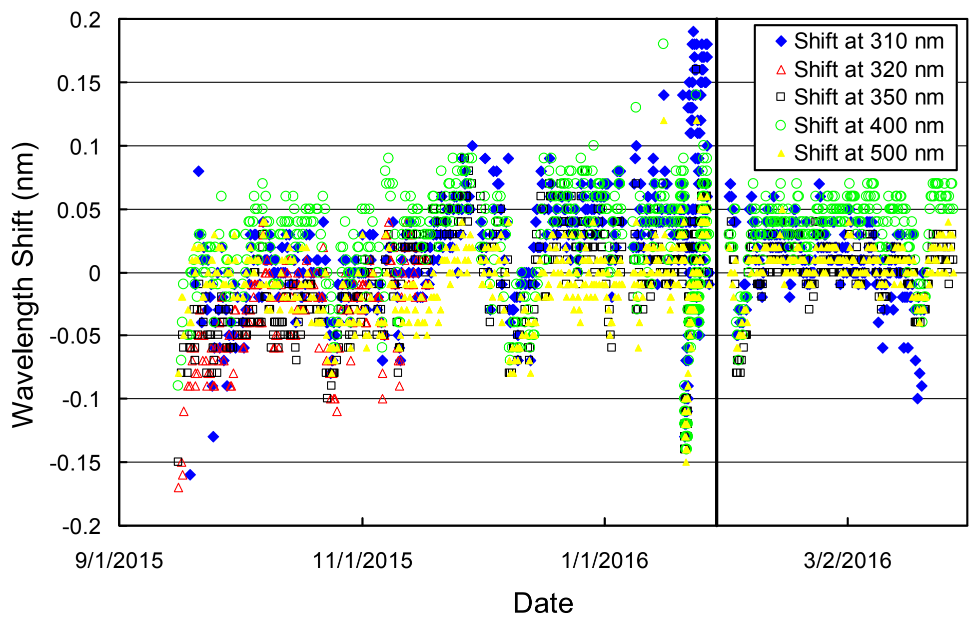

Figure 3.6. *Wavelength accuracy check of Version 0 data at five wavelengths by means of Fraunhofer-line correlation. The vertical line indicates the time of the site visit.*

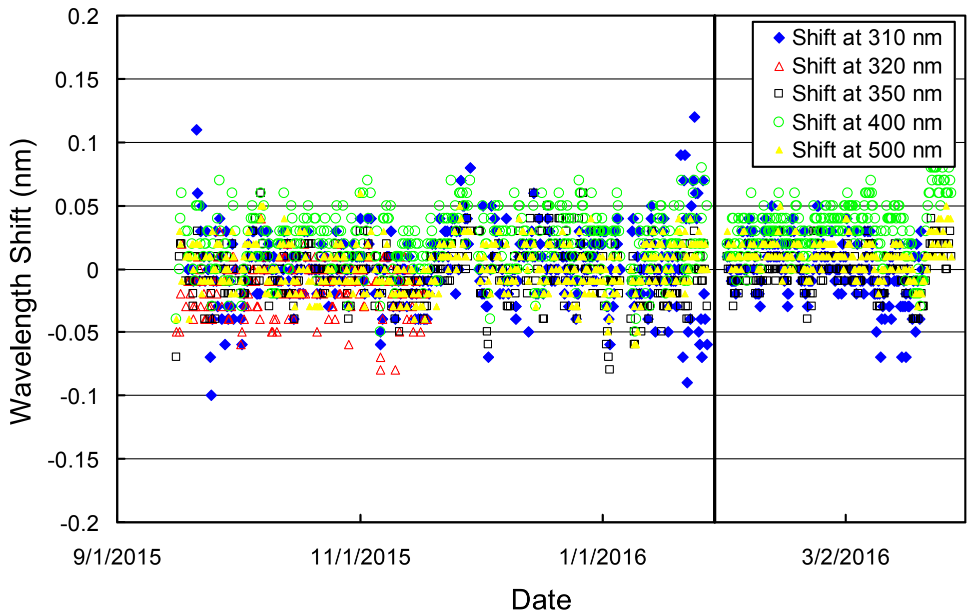

Figure 3.7. *Same as Figure 3.6 but for Version 2 data.*

3.4. Missing data

Table 3.2 provides a list of days that have substantial data gaps and indicates their causes.

Table 3.2 Days with substantial data gaps.

Date	Reason
10/1/15	Communication error between system control computer and monochromator control unit (Spectralink)
11/29/15	Wavelength position of monochromator lost
01/06/16	Wavelength position of monochromator lost
01/27/16 - 01/31/16	Site visit