5.3. Amundsen-Scott South Pole Station (9/15/11–3/31/14)

This report discusses calibration and quality control of UV data measured at Amundsen-Scott South Pole Station with SUV, GUV and PSP radiometers between 9/15/11 and 3/31/14. Calibrated solar data were assigned to three volumes as indicated in Table 5.3.1.

Table 5.3.1: Volume assignment.

Volume	Period	Number of SUV-100 spectra
21	09/15/11–03/29/12	17543
22	09/14/12–03/29/13	17081
23	09/15/13–03/31/14	17253

The systems were serviced in January 2013 by NOAA personnel. On-site calibration standards were compared with two travelling standards also at this time. The SUV-100 spectroradiometer worked without problems during the reporting period and the data records are almost complete.

The 313 nm channel of the GUV-541 radiometer (serial number #29239) installed next to the SUV-100 instrument failed sometime between April and September 2010. The instrument was removed for repair on 01/31/12 and replaced with a similar instrument (serial number #29202). After repair, the original instrument was reinstalled on 8/28/13. Despite the problem with the 313 nm channel, measurements of instrument #29239 performed between September 2011 and January 2012 were useful to check the stability of the SUV-100 spectroradiometer. However, for the low solar elevations prevailing that the South Pole, the 313 nm channel is important to calculate data products with a strong contribution from the UV-B. GUV data products for the period 09/15/11–01/30/12 are therefore not available. Data of GUV #29202 were calibrated and are available for the period 01/31/12–03/29/13. Data of the refurbished GUV #29239 are available for the period 09/15/13–03/31/14.

Up to 01/13/12, the Eppley PSP pyranometer with serial number 27228F3 was installed next to the SUV and GUV radiometers. Its calibration constant was established by NOAA and is 8.47 10^{-6} V/(W/m^2). Between 01/13/12 and 01/26/13, PSP #30451F3 was installed. Its calibration constant was also established by NOAA and is 8.12 10^{-6} V/(W/m^2). Instrument #27228F3 was reinstalled on 01/26/13 and continues to be in operation, using the calibration constant of 8.47 10^{-6} V/(W/m^2).

5.3.1. Irradiance Calibration

The on-site irradiance standards that were used during the reporting period for calibrating the SUV-100 spectroradiometer were the lamps M-666, 200W021, and 200W013. Lamps 200WN003 and 200WN004 were used as traveling standard during the site visit in January 2013.

On-site standards

Lamps 200W021 and M-666 have been in service for a long time. The original calibration of lamp 200W021 was established by Optronic Laboratories in September 1998. Lamp M-666 was originally calibrated with lamps 200W006 and 200W021, using season closing scans of Volume 9 and opening scans of Volume 10. Based on comparisons performed during the site visit in January 2006, it was determined that lamps 200W021 and M-666 had drifted by about 2%. New calibration were transferred to the two lamps using the former traveling standard 200W017 as reference. For lamp 200W021, this calibration is still valid and was used to process solar data of the reporting period. Comparisons of lamp M-666 with lamps 200W021, 200W013, 200WN003 and 200WN004 performed during the reporting period 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.

Lamp 200W013 was introduced in January 2008. It was calibrated against the former traveling standard M-763 using closing scans of the Volume 17 season. Comparisons with the other two on-site standards and the traveling standard in February 2010 suggested that the calibration of this lamp had drifted by about 2%. The lamp was recalibrated against lamp 200W017 using scans performed on 2/4/2010. This calibration was also used to process solar data of the reporting period.

Traveling standards

The traveling standards 200WN003 and 200WN004 have been calibrated by NOAA/CUCF against lamps 200WN001 and 200WN002 on 3/21/13. Lamps 200WN001 and 200WN002 had in turn been calibrated at 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 did not result in a significant step-change.

Figure 5.3.1 shows a comparison of all lamps discussed above. The plot is based on scans performed at the beginning of the site visit in January 2013. The calibrations of all lamps agree to within ±1.0%. A similar good result was obtained when the comparison was repeated at the end of the site visit. The three on-site standards were also compared relative with each other throughout the reporting period. The agreement was always to within ±1.0%.

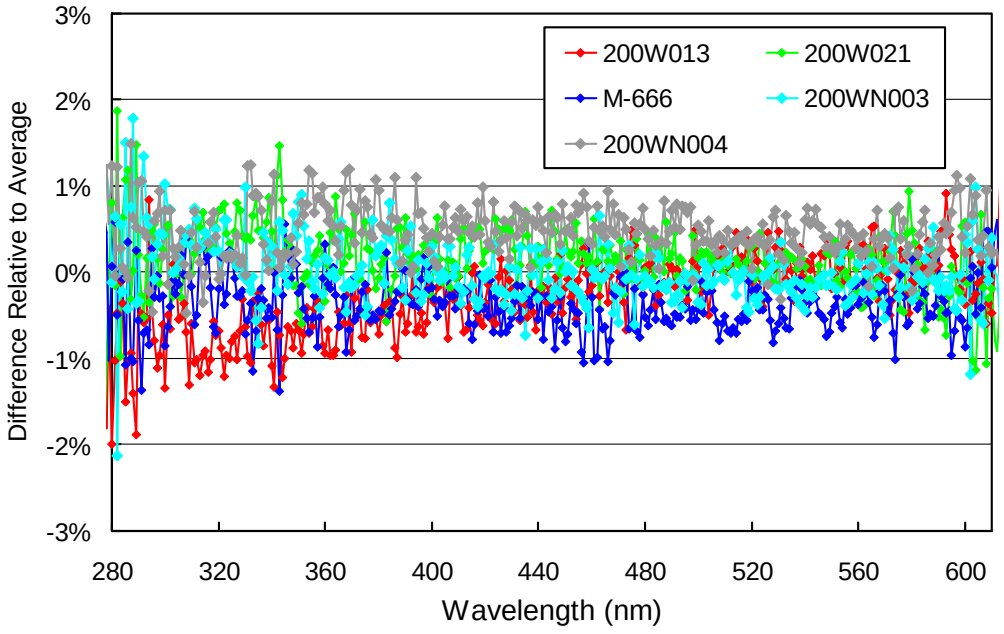

Figure 5.3.1. *Comparison of South Pole lamps M-666, 200W021, and 200W013, and traveling standard 200WN003 and 200W004 at the beginning of the January 2013 site visit.*

5.3.2. Instrument Stability

The stability of the 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 5.3.2a – 5.3.2c show the ratio of GUV-541 (340 nm channel) and final SUV-100 measurements, which were weighted with the spectral response function of this channel. The ratios were normalized and should ideally be one. The graphs indicates that GUV and SUV measurements are generally consistent to within ±4%. Most outliers can be explained by shading from obstacles (e.g. air sampling masts) in the field of view of

the instruments. Because GUV and SUV radiometers are not positioned at exactly the same location, the shadow of these obstacles falls at the collectors of the two instruments at different times.

Sixteen calibrations were applied to data of the reporting period. Times when the calibration changed are indicated by vertical lines in Figures 5.3.2a –5.3.2c. More information on these calibrations is provided in Table 5.3.2. Figure 5.3.3 shows ratios of these calibration functions applied relative to the function of Period "2011-12, P1". There is a large change in instrument responsivity between Periods P2 and P3 of the 2012/13 season. These are the periods before and after the site visit. The change is caused by the system service during which the instrument was dismantled, cleaned, and reassembled. Relative changes between other periods are typically smaller than 2%.

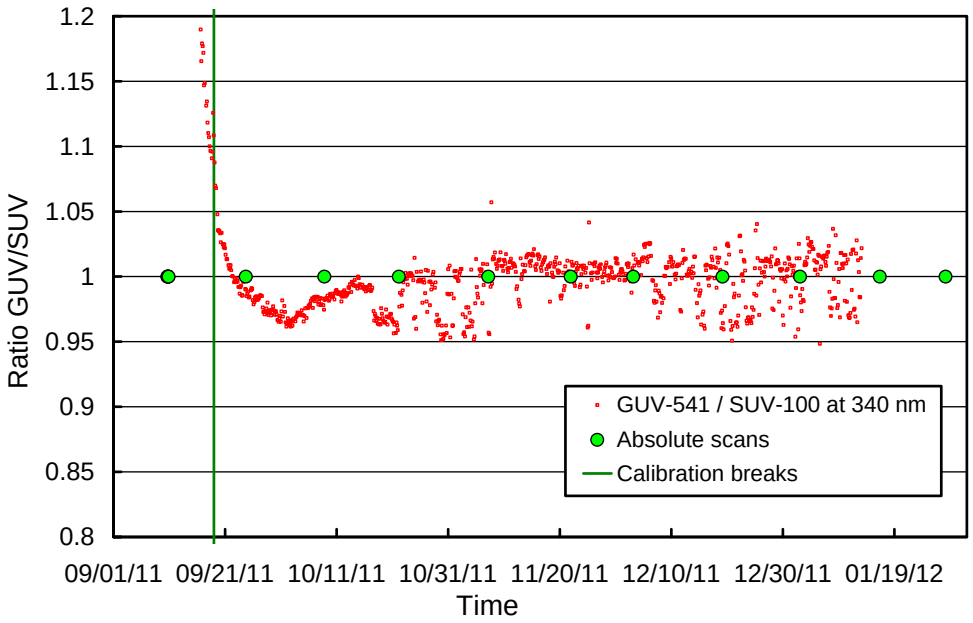

Figure 5.3.2a. *Ratio of GUV-541 #29239 measurements (340 nm channel) with SUV-100 measurements that were weighted with the spectral response function of this channel. The plot includes the period when GUV-541 #29239 was installed before it was returned for repair. Data of the 340 nm channel are not affected by the problem of the 313 nm channel. The vertical line indicates a change in the SUV-100 calibration applied to solar data (see Table 5.3.2). Times when absolute scans with standard lamps were executed are indicated by green circles.*

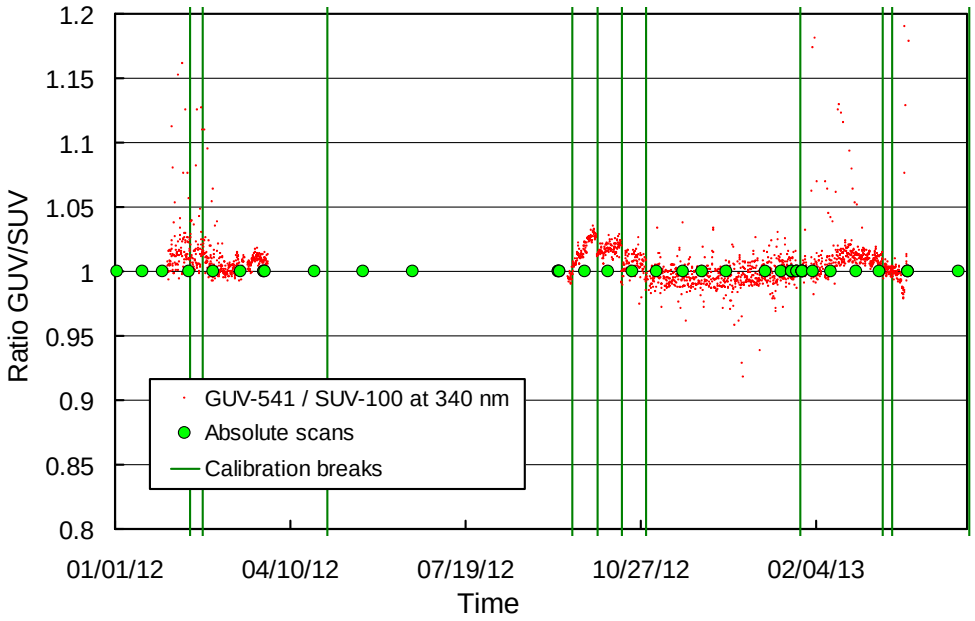

Figure 5.3.3b. *Ratio of GUV-541 #29202 measurements (340 nm channel) with SUV-100 measurements that were weighted with the spectral response function of this channel. The plot includes the period when GUV-541 #29202 was installed. There are no data for the period of the polar night, between 4/1/12 and 9/15/12. The vertical lines indicate a change in the SUV-100 calibration applied to solar data (see Table 5.3.2). Times when absolute scans with standard lamps were executed are indicated by green circles.*

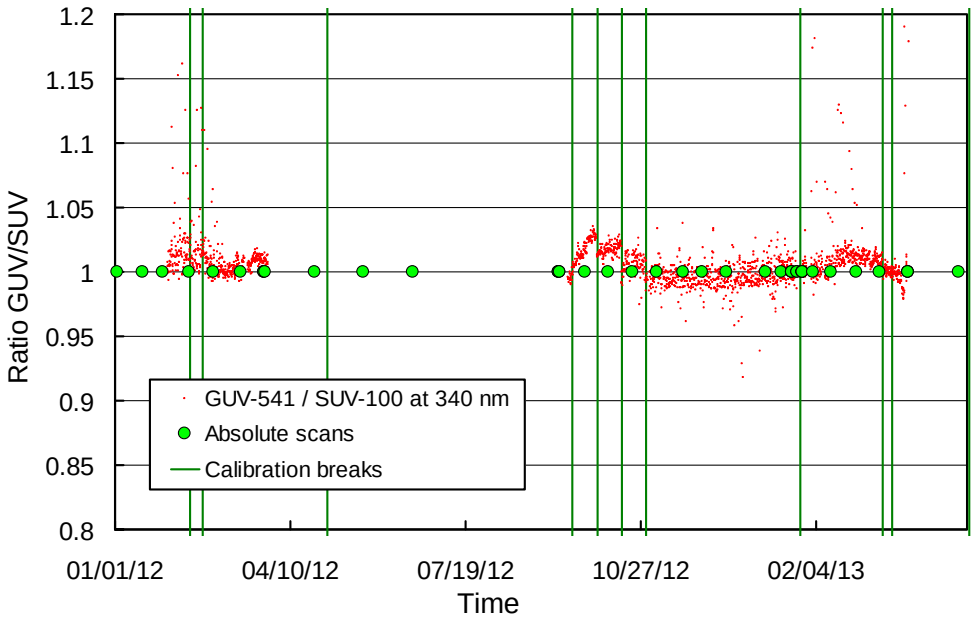

Figure 5.3.4c. *Ratio of GUV-541 #29239 measurements (340 nm channel) with SUV-100 measurements that were weighted with the spectral response function of this channel. The plot includes the period when the refurbished GUV-541 #29239 was installed. The vertical lines indicate a change in the SUV-100 calibration applied to solar data(see Table 5.3.2). Times when absolute scans with standard lamps were executed are indicated by green circles.*

Table 5.3.2: Calibration periods for South Pole data of Volumes 21–23.

Period name	Period range	Number of Absolute Scans	Remarks
2011-12, P1	04/02/11 – 09/18/11	3	
2011-12, P2	09/19/11 – 02/13/12	10	
2011-12, P2B	02/14/12 – 02/24/12	0	Average of Period P2 and P3
2011-12, P3	02/25/12 – 04/30/12	5	
2012-13, P1	05/01/12 – 09/17/12	2	
2012-13, P1B	09/18/12 – 10/01/12	1	
2012-13, P1C	10/02/12 – 10/15/12	1	
2012-13, P1D	10/16/12 – 10/29/12	1	
2012-13, P2	10/30/12 – 01/25/13	9	Scans at beginning of site visit
2012-13, P3	01/26/13 – 03/13/13	9	Scans at end of site visit
2012-13, P3B	03/14/13 – 03/24/13	0	Average of Period P3 and P4
2012-13, P4	03/25/13 – 05/01/13	3	
2013-14, P1	05/02/13 – 10/21/13	5	
2013-14, P1B	10/22/13 – 11/12/13	1	
2013-14, P2	11/13/13 – 03/19/14	5	
2013-14, P3	03/20/14 – 04/30/14	2	

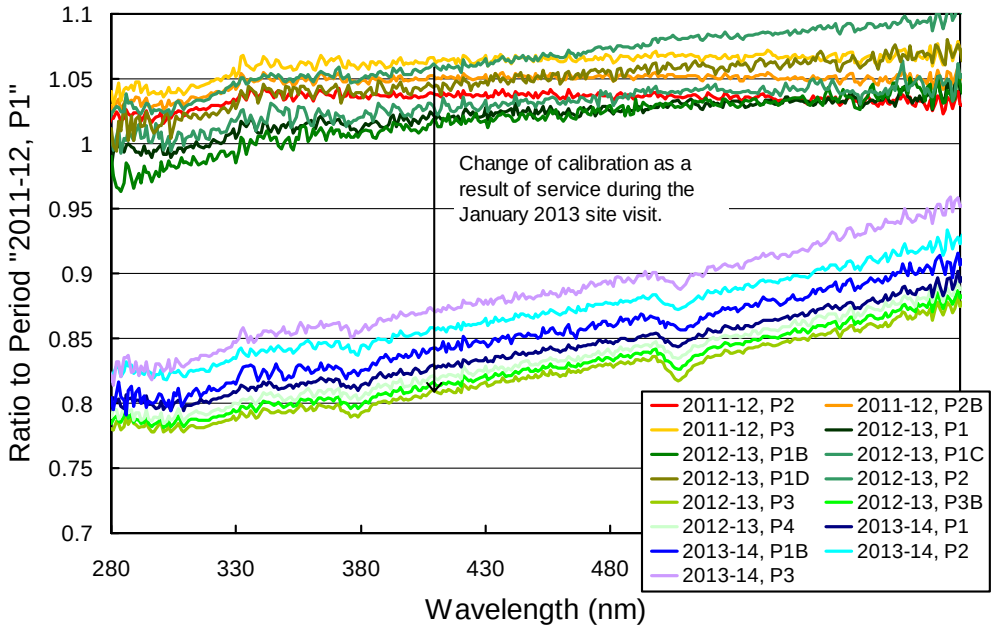

Figure 5.3.3. *Ratios of spectral irradiance assigned to the internal lamp relative to Period "2011-12, P1".*

5.3.3. 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 5.3.4 shows five correction functions calculated with this algorithm from data of the periods 9/01/11 - 06/21/12 (Period 1), 06/22/12 - 01/25/13 (Period 2), 01/26/2011 - 06/21/13 (Period 3), 06/22/13 - 11/07/13 (Period 4), 11/08/2013 - 06/21/14 (Period 5). Note that the instrument was serviced between Periods 2 and 3.

Figure 5.3.5 indicates the wavelength accuracy of final data for five wavelengths in the UV and visible by running the Version 2 Fraunhofer-line correlation method a second time. Residual wavelength shifts are typically smaller than ±0.05 nm, with few exceptions.

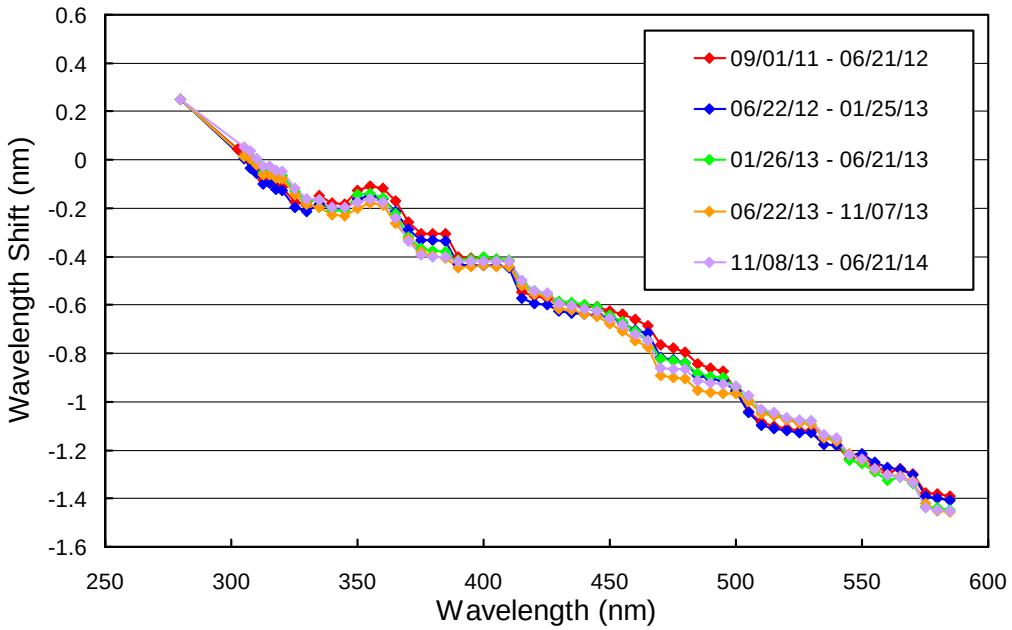

Figure 5.3.4. *Monochromator non-linearity correction functions for South Pole data of the period 9/1/11 - 6/21/14.*

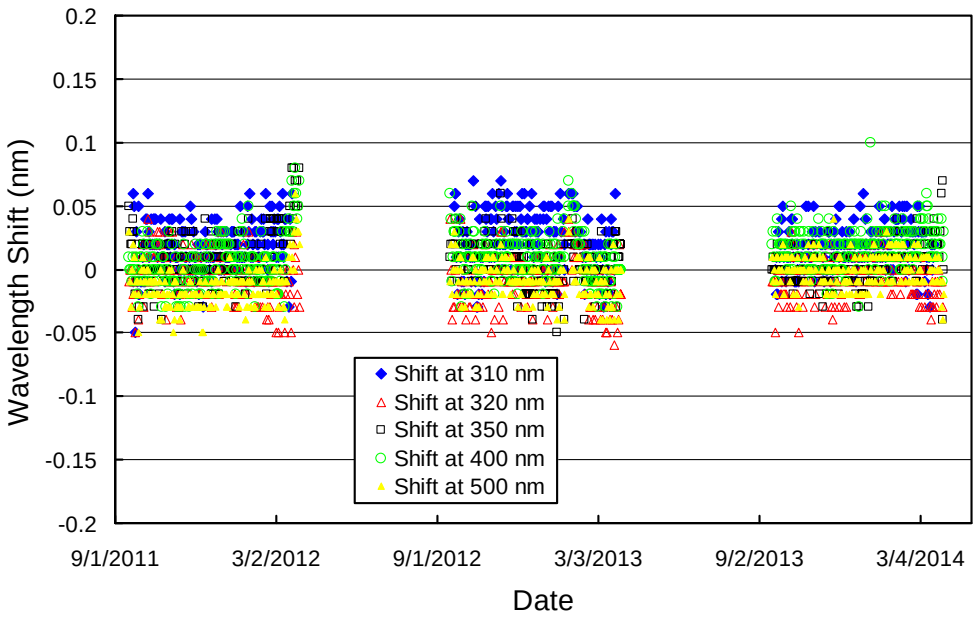

Figure 5.3.5. *Wavelength accuracy check of final data at five wavelengths by means of Fraunhofer-line correlation. Measurement performed at 00:00 UT were evaluated for each day of the reporting period. No data exist during Polar Night.*