5.3. Amundsen-Scott South Pole Station (1/25/08–3/29/09)

The 2008–2009 season at Amundsen-Scott South Pole Station is defined as the period between the site visit performed between 1/17/08 and 1/25/08, and the end of March 2009. Season opening calibrations were performed on 1/23/08–1/24/08. There was no site visit in 2009, however, the site standards were compared with traveling standards on 2/8/09. Volume 18 solar data of the SUV-100 spectroradiometer comprise the period 1/25/08–3/29/09 (total number of scans is 22671).

Data from the GUV-541 radiometer are available for the period 1/18/08–3/30/09. The 305, 313, and 320 nm channels of the instrument suffered from an unusually large change in sensitivity by 5%, 4%, and 13%, respectively. These drifts were corrected by adjusting the channel's calibration factors accordingly. The uncertainty of the measurements is increased by about ±2%.

5.3.1. Irradiance Calibration

The site irradiance standards used during the 2008/09 season were the lamps M-666, 200W021, and 200W013. Lamp M-763 was the traveling standard in 2008; lamp 200W017 was used as traveling standard in 2009.

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 lamp using the traveling standard 200W017 as reference, and these calibrations were also used to process solar data from the 2008/09 season.

Lamp 200W013 is a new standard, which was introduced in January 2008. It was calibrated against the traveling standard M-763 using closing scans of the Volume 17 season.

Traveling standards
Lamp 200W017 has been originally calibrated by Optronic Laboratories in March 2001. It has been recalibrated in June 2007 at BSI against a set of four 1000-W FEL lamps, which in turn had been calibrated by the U.S. Central UV Calibration Facility (CUCF) in Boulder, Colo. This calibration procedure was complicated by the fact that the irradiance scale of the four FEL lamps refers to the detector-based scale of the National Institute of Standards and Technology established in 2000 (NIST2000; Yoon et al., 2002), whereas all solar data of the NSF UVSIMN refer to the source-based NIST scale from 1990 (NIST1990, Walker et al., 1987). The NIST2000 scale is about 1.3% larger than the NIST1990 scale. Data of certificates issued by the CUCF were converted to the NIST1990 scale before the calibration was transferred to 200W017.

Lamp M-763 has been in service for many years and was also calibrated in June 2007 against the four CUCF FEL lamps. Unfortunately, the bulb of lamp M-763 was slightly rotated in its holder sometime in October 2007. Comparisons with other lamps performed before and after the misalignment indicated that the rotation changed the irradiance of lamp M-763 by about 2% in the UV and 1-2% in the visible. The effect of the misalignment was adjusted by applying a correction function to the calibration values of the lamp. See the Volume 17 Operations Report for more details.

Figure 5.3.1 shows a comparison of all lamps at the start of the season (1/23/08-1/24/08). The calibrations of the site standards agree with the calibration of the traveling standard to within ±0.5%. Figure 5.3.2 shows a similar comparison performed on 2/8/09 against the traveling standard 200W017. Measurements of lamps M-666 and 200W021 agree with the traveling standard to within ±1%, however, measurements of lamp 200W013 are different by 2-3%. The three site standards were also compared with each other on 3/25/08 and 9/16/08. Lamps M-666 and 200W021 agreed during these events to within ±1%; data of lamp 200W013 were systematically off by 1-2%.

These comparisons confirmed that the calibrations of the traveling standards M-763 and 200W017 were consistent. This also confirms the correction factor applied to M-763 to account for its misalignment. Lamp 200W013 seems to be drifting, and absolute scans of this lamp were therefore not use for processing solar data of the Volume 18 period.

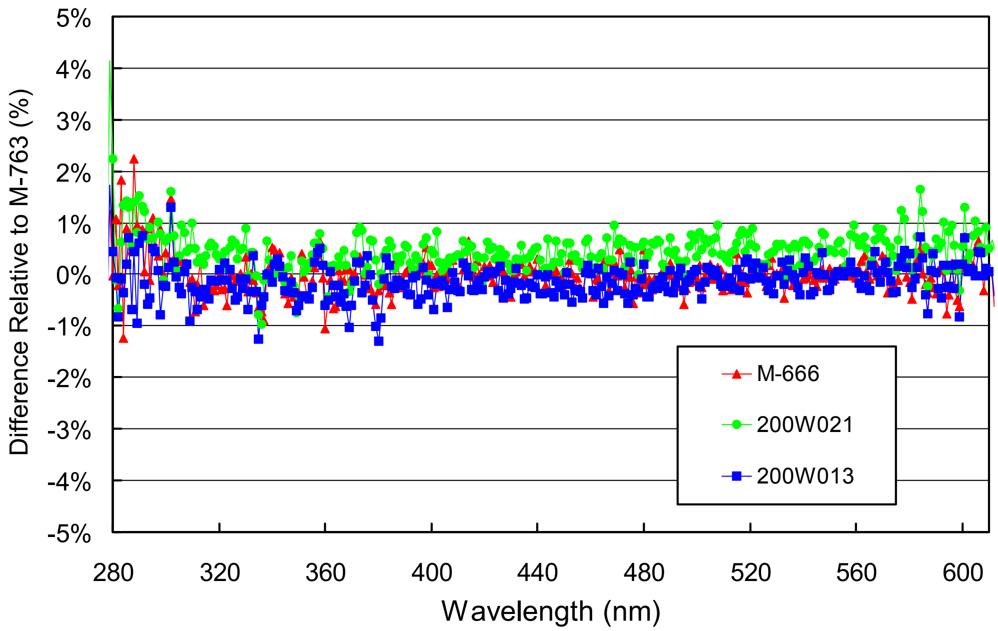

Figure 5.3.1. *Comparison of South Pole lamps M-666, 200W021, and 200W013 with BSI traveling standard M-763 at the beginning of the season (1/23/08-1/24/08).*

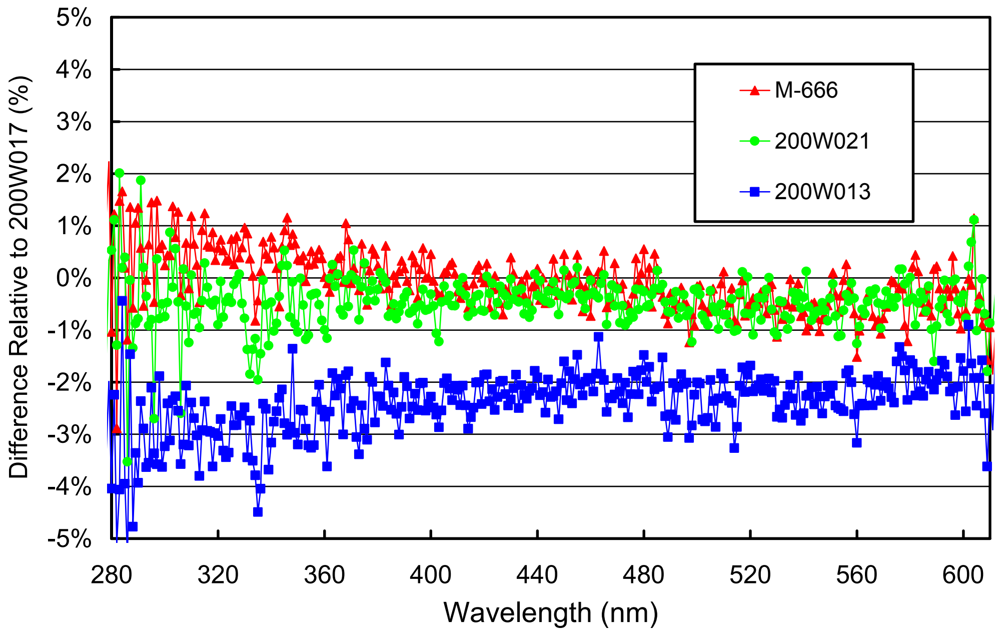

Figure 5.3.2. *Comparison of South Pole lamps M-666, 200W021, and 200W013 with BSI traveling standard 200W017 in February 2009.*

5.3.2. Instrument Stability

The stability of the spectroradiometer' sensitivity over time is primarily monitored with bi-weekly calibrations utilizing the on-site standards and daily response scans of the internal irradiance reference lamp. The stability of the internal lamp is monitored with the TSI sensor, which is independent from possible monochromator and PMT drifts.

Figure 5.3.3 shows changes in TSI readings and PMT currents at 300 and 400 nm, derived from the daily scans of the internal lamp during the South Pole 2008/09 season. The TSI measurements indicate that the internal lamp became dimmer by about 3% during this period. This amount of drift is typical. The PMT currents at 300 and 400 nm varied by about ±4%, indicating reasonable stability of the instrument.

Absolute calibrations indicated some variation of the system responsivity, which were mostly related to transmission changes of the irradiance collector due to ice-buildup underneath the cosine diffuser. To correct for these changes, five different calibration functions were applied to solar measurements of Volume 18. An overview of calibration periods is provided in Table 5.3.1. Figure 5.3.4 shows ratios of all calibration functions relative to the function applied during Period P1. Note that this period covers the period up to the onset of winter darkness.

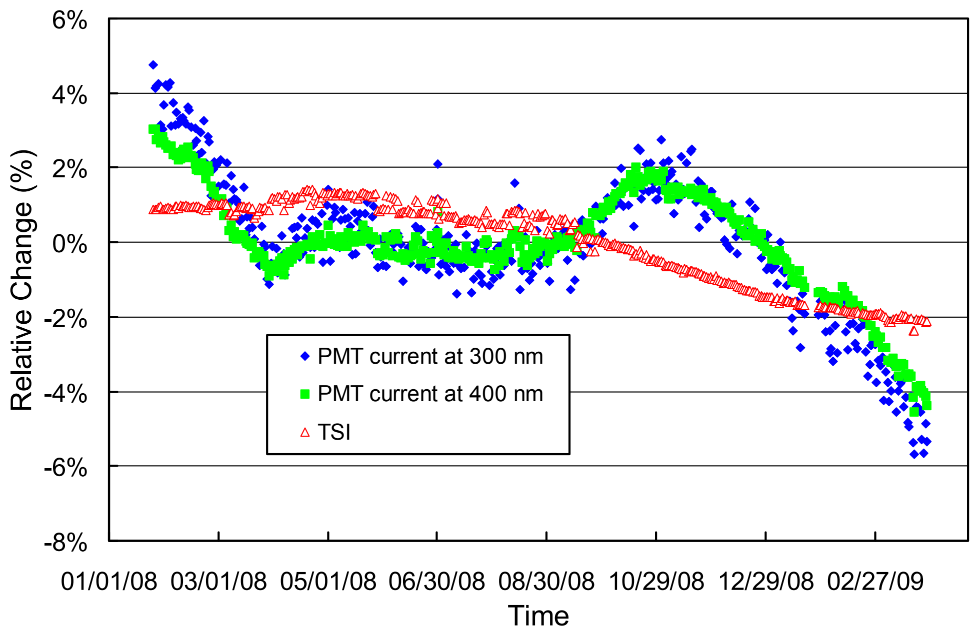

Figure 5.3.3. *Time-series of PMT current at 300 and 400 nm, and TSI signal for measurements of the internal irradiance standard performed during the South Pole 2008/09 season. Data are normalized to the average of the whole period.*

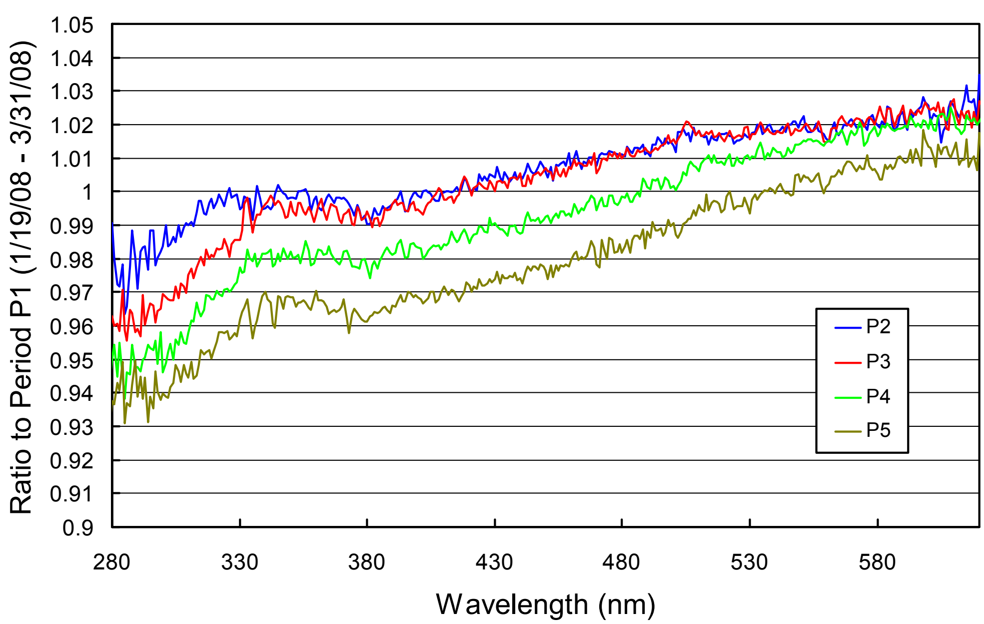

Figure 5.3.4. *Ratios of irradiance assigned to the internal lamp relative to Period P1.*

Figure 5.3.5 presents the relative standard deviation calculated from the individual calibration scans of each period. These data are useful for estimating the variability of calibrations in each period. The variability is typically less than 1.0% for wavelengths above 330 nm, indicating very good consistency for all periods.

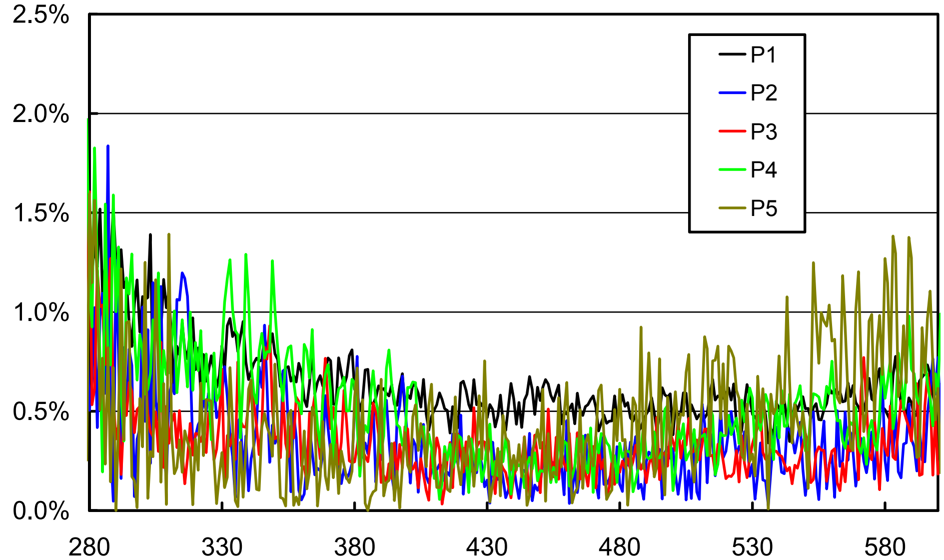

Figure 5.3.5. *Relative standard deviation calculated from absolute calibration scans measured during the South Pole 2008/09 season.*

Table 5.3.1: Calibration periods for South Pole Volume 18 data.

Period name	Period range	Number of Absolute Scans	Remarks
P1	01/25/2008 – 04/01/2008	10	Before Polar Night
P2	09/15/2008 – 11/04/2008	3	After Polar Night
P3	11/05/2008 – 01/24/2009	4	
P4	01/25/2009 – 02/22/2009	4	
P5	02/23/2009 – 03/31/2009	2	

To test the consistency of final SUV-100 data, measurements at 340 nm were compared with measurements of the 340 nm channel of the collocated GUV-541 radiometer (see also Section 5.3.5). For this comparison, SUV-100 spectra were weighted with the response function of the GUV-541 instrument according to the procedure described in Section 4.3.1. The same calibration factor was applied to GUV measurements of the entire period. The resulting ratio is shown in Figure 5.3.6. The standard deviation of the ratio GUV/SUV is 0.022. The ratio tends to show steps in the order of 2% at times when the calibration was changed. This difference is within the uncertainty of SUV and GUV measurements.

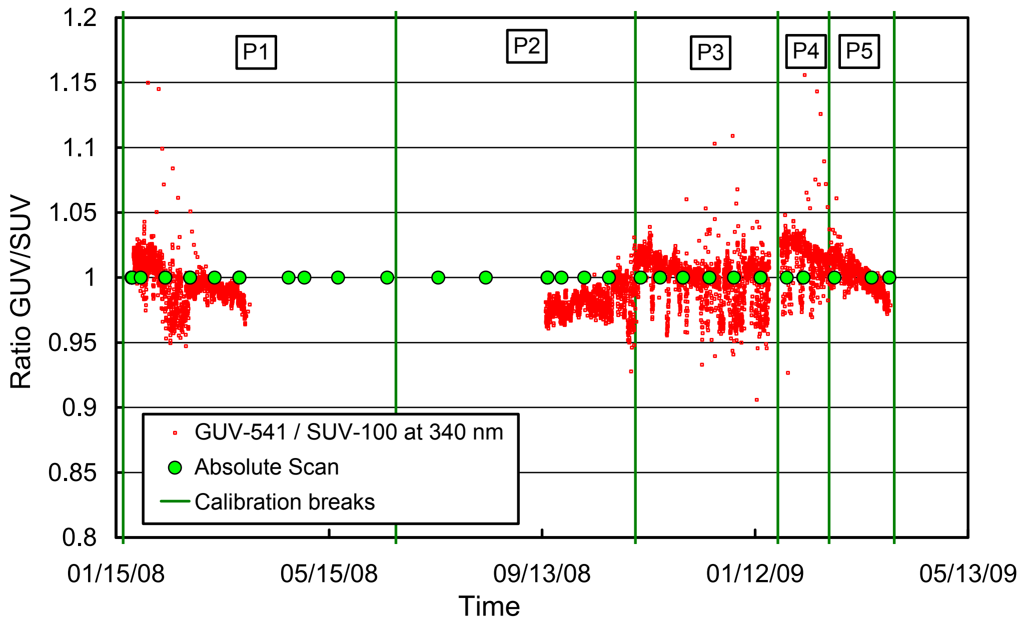

Figure 5.3.6. *Ratio of GUV-541 and SUV-100 measurements. Green lines indicate limits of calibration periods.*

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. Figure 5.3.7 shows the difference of the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. A total of 455 pairs of scans were evaluated. The change in offset was less than ±0.025 nm for 96% of the scans and smaller than ±0.055 nm for 99% of the scans. Only the shift of two scan-pairs was larger than ±0.1 nm, which was caused by operator intervention. The wavelength calibration was adjusted accordingly.

After data were corrected for day-to-day wavelength fluctuations, the wavelength-dependent bias between this homogenized data set and the correct wavelength scale was determined with the Version 2 Fraunhofer-line correlation method (*Bernhard et al*., 2004). The resulting correction function is shown in Figure 5.3.8. The function exceeds 1 nm for wavelengths larger than 500 nm. The magnitude of the correction is considerably larger than for other sites and caused by the properties of the monochromator installed. The accuracy of solar data is not compromised since the correction is well defined.

After data had been wavelength-corrected using the shift-functions described above, the wavelength accuracy was tested again with the Version 2 Fraunhofer-line correlation method. The results are shown in Figure 5.3.9 for four UV wavelengths. Remaining shifts are generally smaller than ±0.1 nm, with the exception of a few outliers. Data for the period 1/28/09 - 3/30/09 are biased high by about 0.03 to 0.06 nm, indicating that the monochromator's wavelength mapping has slightly changed at the end of January 2009. Version 2 data have been corrected for this wavelength shift.

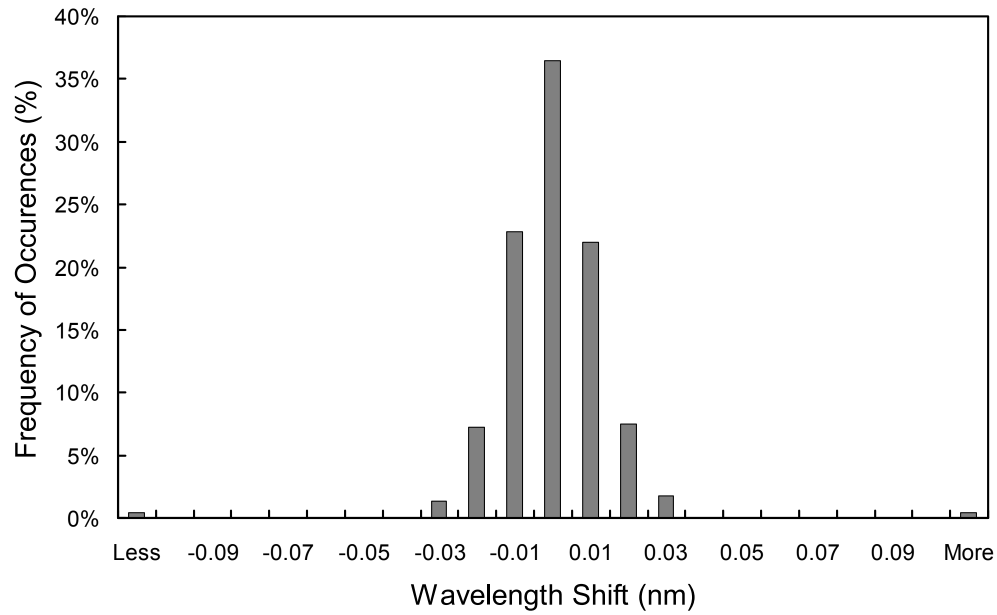

Figure 5.3.7. F*requency distribution of the difference of the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts beyond –0.105 nm; "more" means shifts beyond +0.105 nm.*

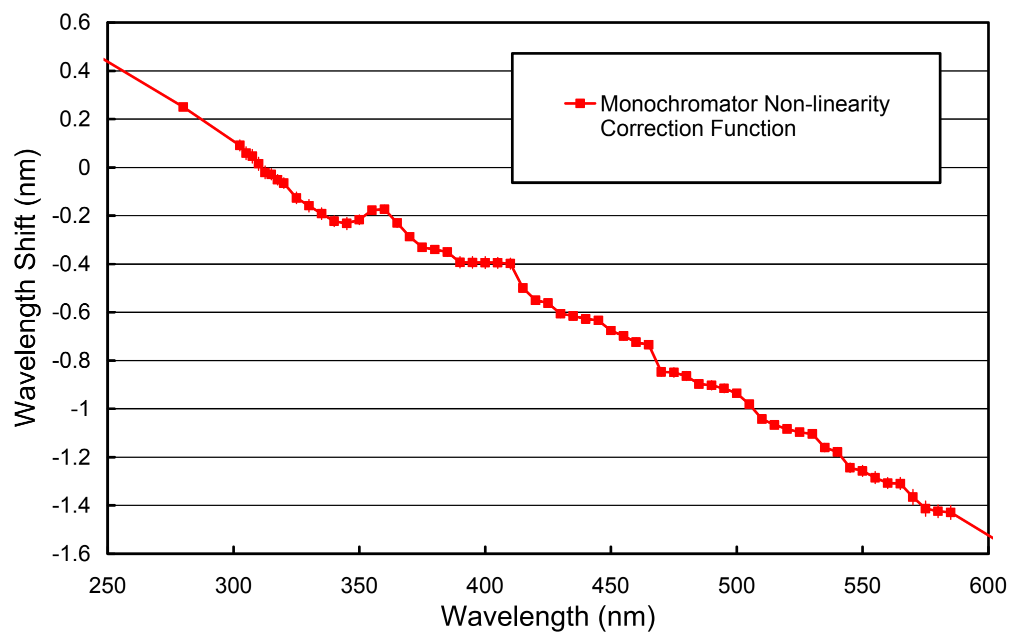

Figure 5.3.8. *Monochromator non-linearity correction function for the South Pole 2008/09 season.*

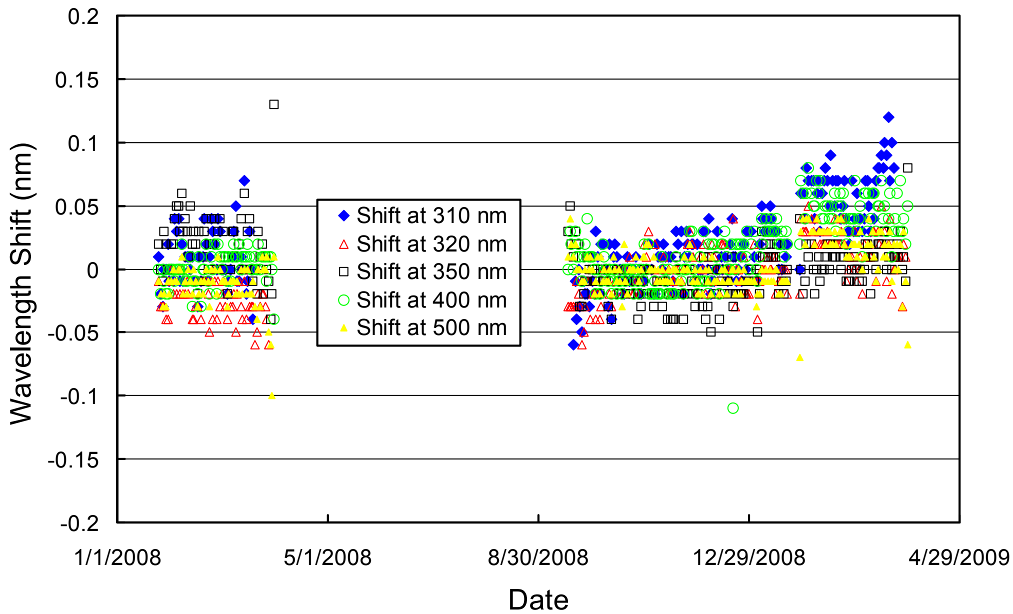

Figure 5.3.9. *Wavelength accuracy check of final data at four wavelengths by means of Fraunhofer-line correlation. Measurement performed at 00:00 UT were evaluated for each day of the season. No data exist during Polar Night.*

5.3.4. Missing Data

A total of 22671 scans are part of the South Pole Volume 18 dataset. These are 91.6% of the maximum possible number of data scans. 1226 solar scans were superseded by calibration scans. Since South Pole Station has 24 hours of sunlight per day during the summer season, a loss of solar data cannot be avoided. 3.4% of all scans were lost due to technical problems. A break-down of missing data is provided in Table 5.3.2.

Table 5.3.2. Missing solar scans in the South Pole Volume 18 data set.

Period	Number of scans	Reason
		Calibration scans
Throughout season	512	Response scans
Throughout season	577	Wavelength scans
Throughout season	137	Absolute scans
		Technical problems
03/09/08	7	Incorrect time stamp
09/14/08 - 09/15/08	18	Removal of ice build-up from irradiance collector
01/20/09 - 01/26/09	650	Monochromator wavelength position off by 10 nm - not correctable
02/01/09 - 02/02/09	105	Communication problem with Digital Multimeter
02/19/09	43	Communication problem with monochromator control electronics
02/22/09 - 02/23/09	41	Unprocessed
		Other
02/12/08	8	Scheduled replacement of system control computer
11/13/08	5	Anti-virus software update
02/03/09	3	Anti-virus software update

5.3.5. GUV Data

The GUV-541 radiometer, which is installed next to the SUV-100, was calibrated against final SUV-100 measurements following the procedure outlined in Section 4.3.1. The calibration of the instrument's 305, 313, and 320 nm channels drifted by 5%, 4%, and 13%, respectively, over the course of the year. Drifts of the 340 and 380 nm channels were smaller than 2%. To corrected for these changes, the GUV time-series was broken into three periods and different calibration factors were applied for these periods. Drifts in published GUV data are smaller than 3%.

Data products were calculated from the calibrated measurements (Section 4.3.2). Figure 5.3.10. shows a comparison of GUV-541 and SUV-100 erythemal irradiance based on final Volume 18 data. For solar zenith angles smaller than 85°, measurements of the two instruments agree to within ±2% (±1σ), except for times when an air sampling stack installed at the ARO building casts a shadow on the GUV-541 radiometer but not on the SUV-100.[+] We advise data users to use SUV-100 rather than GUV-511 data whenever possible, in particular when the solar zenith angle is smaller than 85°.

Figure 5.3.11 shows a comparison of total ozone measured by the GUV-541 radiometer, the SUV-100 (Version 2 data set; see www.biospherical.com/NSF/Version2), and the Ozone Monitoring Instrument (OMI) installed on NASA's AURA satellite. GUV-541 ozone values were calculated as described in Section 4.3.3. Between January and March 2008, SUV-100 measurements are on average 3% larger than OMI observations while GUV data are 4 % lower. Between October 2008 and March 2009, SUV-100 measurements are on average 2% larger. GUV measurements agree very well with SUV-100 data for October - January, but tend to be low in February and March 2009. A similar pattern has been observed also in previous years. The reason of this systematic change is caused by the choice of the ozone profile used in by the inversion method, which is optimized for the austral spring. GUV-541 ozone data become unreliable for SZA larger than 80° and should not be used.

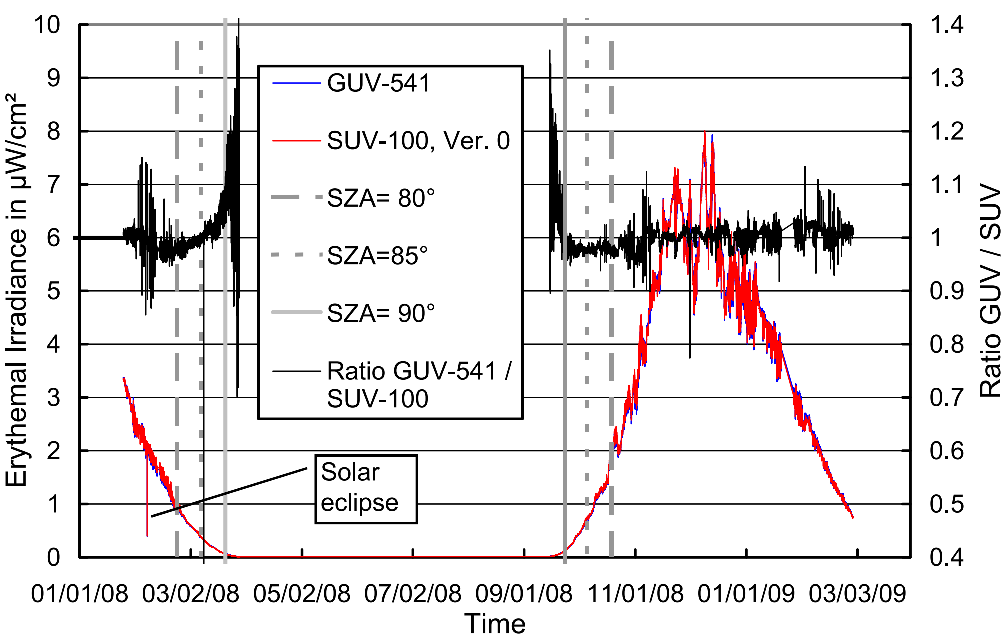

Figure 5.3.10. *Comparison of erythemal irradiance measured by the SUV-100 spectroradiometer and the GUV-541 radiometer. SUV-100 measurements are based on "Version 0" (cosine-error uncorrected) data.*

[+] Since the SUV-100 collector is located approximately 2 meters away from the GUV-541 radiometer, both instruments are not shaded during exactly the same .

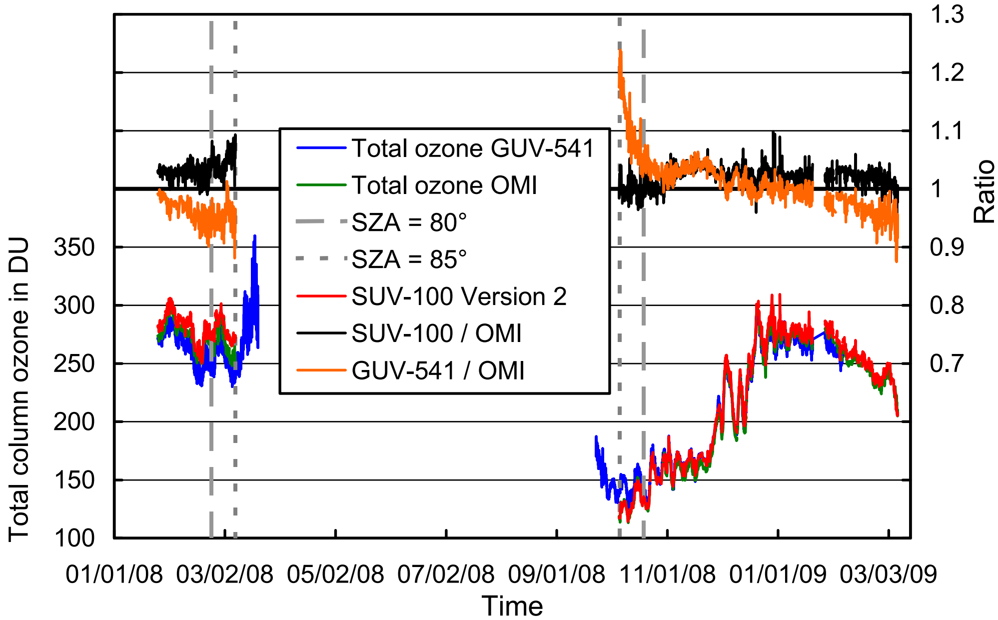

Figure 5.3.11. *Comparison of total column ozone measurements from GUV-541, SUV-100 (Version 2 data), and OMI. GUV-541 and SUV-100 measurements are plotted in 15 minute intervals. For calculating ratios of data sets, only GUV-541 and SUV-100 measurements concurrent with OMI overpass data were evaluated.*