5.2. Palmer Station (5/18/08 – 2/28/09)

This sections describes quality control of solar data recorded at Palmer Station between 5/18/08 and 2/28/09. There were no site visit in 2008 and 2009. Opening calibrations were performed by the site operator between 5/17/08 and 5/20/08. There were no closing calibrations. The system performed normally during the reporting period, however, two site standards had to be re-calibrated mid-season using the third site standard. The calibration uncertainty of data collected after 9/22/08 is increased by about ±2% due to the drift of the two standards and the uncertainty of the recalibration.

The Volume 18 period resulted in a total of 15641 solar scans. Only 1.2% of all possible scans were lost due to technical problems.

5.2.1. Irradiance Calibration

Traveling standards
Lamps 200W017 and 200W038 were used as traveling standards at the beginning of the reporting period. Lamp 200W017 was originally calibrated by Optronic Laboratories in March 2001. It was recalibrated in May 2007 against a set of four 1000-W FEL lamps with serial numbers H-011, H-013, H-023, and H035. These FEL lamps have been calibrated by NOAA's Central UV Calibration Facility (CUCF) at Boulder, Colo, and their irradiance scale refers to the detector-based NIST scale from 2000 (NIST2000) (*Yoon et al.*, 2002). Since all NSF network data refer to the source based NIST scale from 1990 (NIST1990) (*Walker et al.*, 1987), the irradiance values of the four FEL lamps were first converted to the NIST1990 scale before their calibration was applied to the two traveling standards.

Lamp 200W038 was originally calibrated against the same set of four 1000-W FEL lamps. It was recalibrated in April 2008 against lamps 200W028 and 200W022. Lamp 200W028 was also calibrated in May 2007 against the set of four 1000-W FEL lamps. Lamp 200W022 is one of the project’s long-term standards and was calibrated by Optronic Laboratories in March 2001.

Site standards
The site irradiance standards for 2008-2009 were the lamps 200W007, M-765, and M-700. Lamp M-765 was (re-)calibrated by comparison with lamp 200W017 using absolutes scans performed on 4/14/06 (“closing scans” Volume 15) and 4/28/06 (“opening scans” Volume 16). Lamps M-700 and 200W007 were (re-)calibrated against the traveling standards 200W017 and 200W038 using absolute scans performed on 5/10/08 (“closing scans” of the Volume 17 period). Figure 5.2.1 shows a comparison of absolute scans run with the three site standards and similar scans of the two traveling standards. Scans of the five lamps are consistent to within ±1% in the UV and ±2% in the visible.

The three site standards were also compared with each other on 6/30/08, 9/22/08, 10/1/08, and 12/22/08. On 6/30/08, the calibration of the three lamps agreed to within ±1%. Data from the three other cross-comparison events are consistent, but different from data collected on 6/30/08, indicating a change in the lamps’ brightness of up to 4%. Other data suggested that lamp 200W007 was stable over the entire reporting period and that the observed differences were due to abrupt changes in the outputs of lamps M-700 (-2%) and M-765 (-4%). We hypothesize that the two lamps were physically moved in their holders by the research associate immediately before the cross-comparison exercise on 9/22/08. As a consequence, we recalibrated lamps M-700 and M-765 against lamp 200W007 using data collected on 9/22/08, 10/1/08, and 12/22/08. Recalibrated data of the three lamps for the three days are consistent to within ±0.5%. The new calibrations were implemented from 9/22/08 onwards.

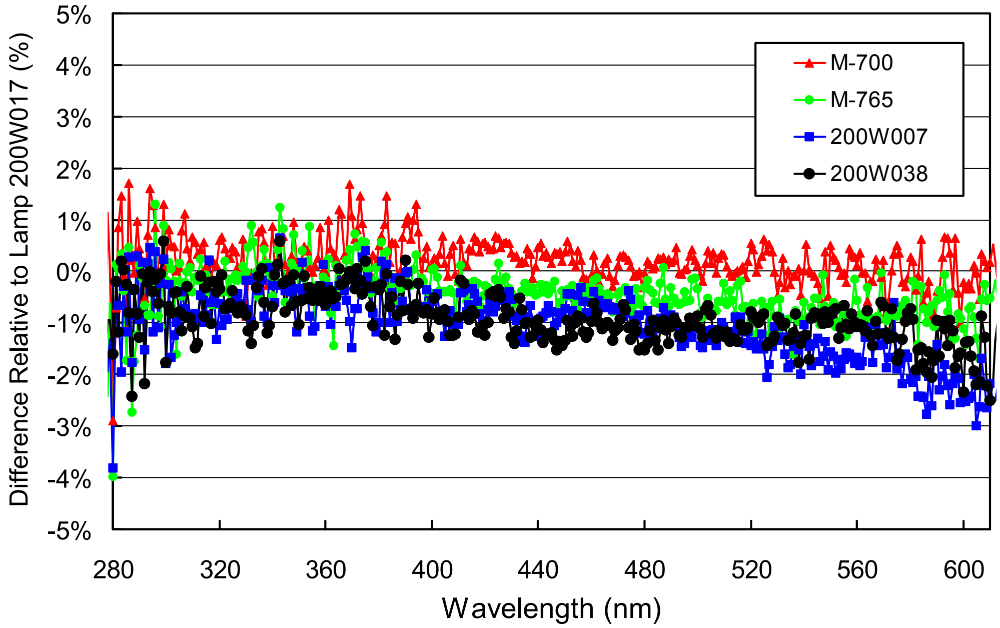

Figure 5.2.1. *Comparison of lamps M-700, M-765, 200W007, and 200W038 with BSI traveling standard 200W017at the beginning of the Volume 18 period. The calibration of lamp 200W017 was established by comparison with a set of four 1000-W FEL lamps that had been calibrated by NOAA's Central UV Calibration Facility (CUCF).*

5.2.2. Instrument Stability

Stability of the spectroradiometer over time is primarily monitored with bi-weekly calibrations utilizing the site irradiance standards, and daily response scans of the internal irradiance reference. The stability of the internal lamp is monitored with the TSI sensor, which is independent from possible monochromator and PMT drifts. By logging the PMT currents at several wavelengths during response scans, changes in the instrument responsivity can be detected.

Figure 5.2.2 shows TSI measurements and PMT currents at 300 and 400 nm recorded during response scans. TSI and PMT data were normalized to their average values of the reporting period. Measurements of the TSI decreased by about 3% over the reporting period. PMT currents generally follow this pattern, except for a decline by 4% at the very beginning.

The responsivity of the system as monitored with absolute scans changed by 7% during the reporting period. The season was broken into five periods to adjust for these changes. Table 5.2.1 gives an overview of these calibrations and Figure 5.2.3 shows the ratio of the different irradiance spectra to that applied in the first period (Period P1).

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-511 radiometer (see also Section 5.2.5). For this comparison, SUV-100 spectra were weighted with the response function of the GUV-511 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 5.2.4. There is no systematic change as a function of time, indicating that data of both independent radiometers are consistent. However, the ratio of GUV/SUV is high by 10-30% for several short period, which are listed in Table 5.2.2. The most likely reason for these outliers is snow covering the collector of the SUV but not the GUV, which is heated to a higher temperature.

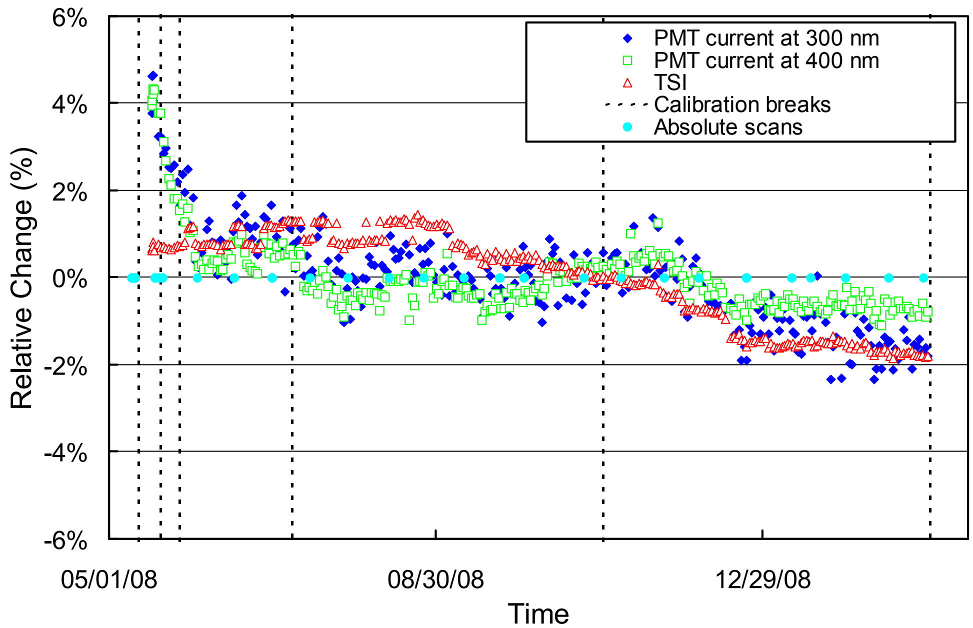

Figure 5.2.2. *Time-series of PMT current at 300 and 400 nm, and TSI signal calculated from measurements of the internal irradiance reference . All data sets are normalized to their average values. Calibration breaks are indicated by vertical broken lines. Times of absolute scans are indicated by cyan circles.*

Table 5.2.1. Calibration periods for Palmer Volume 18 data.

Period name	Period range	Number of absolute scans
P1	05/12/08-05/19/08	6
P2	05/20/08-05/26/08	1
P3	05/27/08-07/07/08	2
P4	07/08/08-10/30/08	12
P5	10/31/08-02/28/09	9

Table 5.2.2. Periods when the ratio of GUV/SUV is high.

Time
07/03/08 15:15-17:15
07/04/08 14:15-15:30
08/07/08 14:30-15:00
08/07/08 15:15-20:15
08/25/08 19:45-21:15
09/21/08 10:00-13:45
11/16/08 06:00-06:30
12/05/08 01:15-06:00
12/21/08 05:15-09:00
01/25/09 09:00-13:00
01/27/09 00:15-14:30

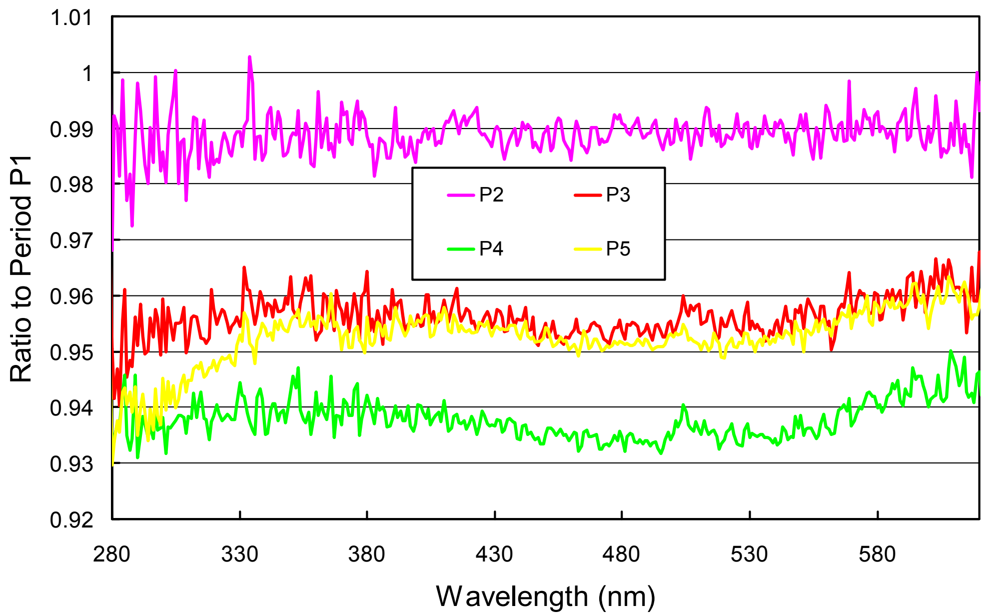

Figure 5.2.3. *Ratios of spectral irradiance assigned to the internal reference lamp for periods P2 – P5, relative to Period P1.*

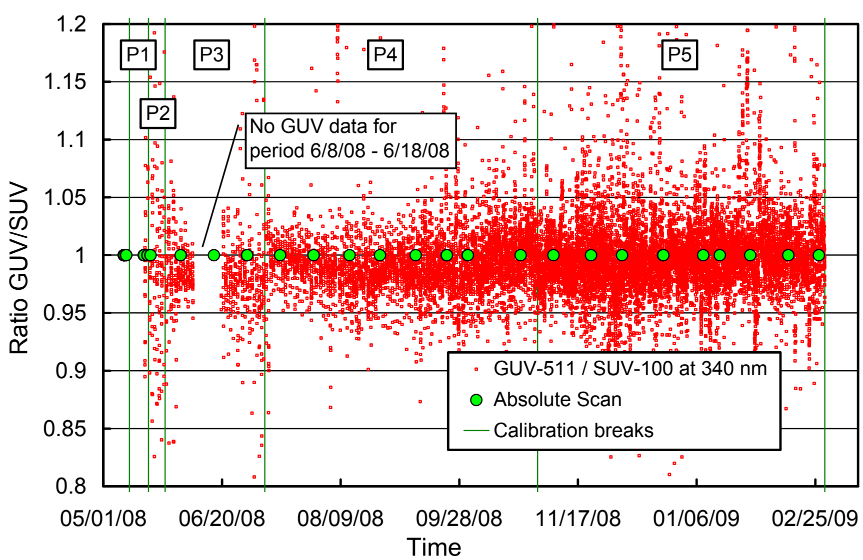

Figure 5.2.4. *Ratio of GUV-511 and SUV-100 measurements. Green lines indicate limits of calibration periods.*

The calibration of Period 2 is based on one absolute scan only. Calibration functions for other periods are based on up to 12 absolute scans, which were averaged according to the procedure described in Section 4.2.1.2. The standard deviations of individual spectra contributing to the average spectrum of a given period were also determined. Ratios of the “standard deviation spectrum” and the “average spectrum” were calculated for each period and are plotted in the Figure 5.2.5. These “relative standard deviation spectra” are a useful tool to assess the variability of calibrations within a given calibration period. The relative standard deviation is usually less than 1.2% for wavelengths larger than 300 nm, indicating good consistency of absolute scans performed within each period.

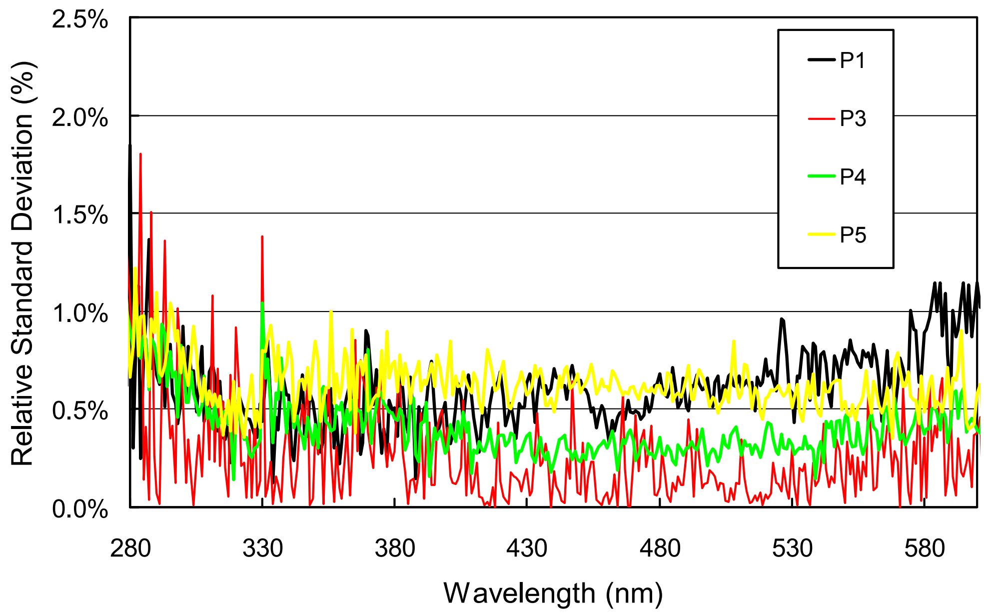

Figure 5.2.5. *Relative standard deviation spectra for periods with more than two absolute scan.*

5.2.3. 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. After this step, there may be still a deviation from the correct wavelength scale, but this bias should ideally be the same for all days. Figure 5.2.6 shows differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 310 scans were evaluated. The change in offset between consecutive scans was smaller than ±0.025 nm in 88% and smaller than ±0.055 nm in 99% of all cases.

After the data was 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 5.2.7.

After data had been wavelength corrected using the shift-function described above, the wavelength accuracy was tested again with the Version 2 Fraunhofer-line correlation method. The results for noontime scans are shown in Figure 5.2.8 for four wavelengths in the UV. The standard deviation of the residual shifts at 320 nm is 0.021 nm. The actual wavelength uncertainty of the instrument may be slightly larger due to wavelength fluctuations during a given day and possible systematic errors of the Fraunhofer-correlation method (*Bernhard et al*., 2004).

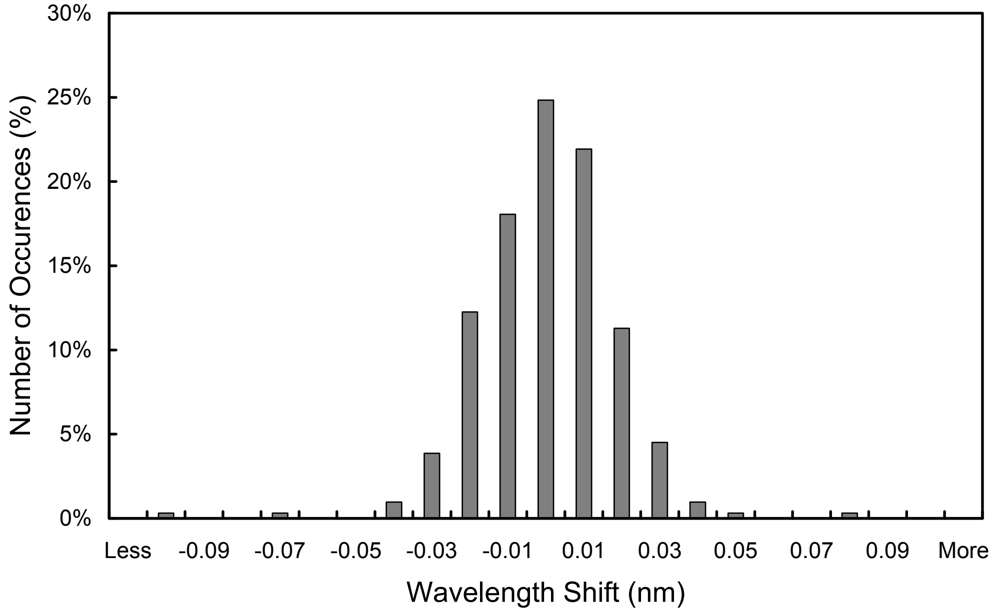

Figure 5.2.6. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. Thus the 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

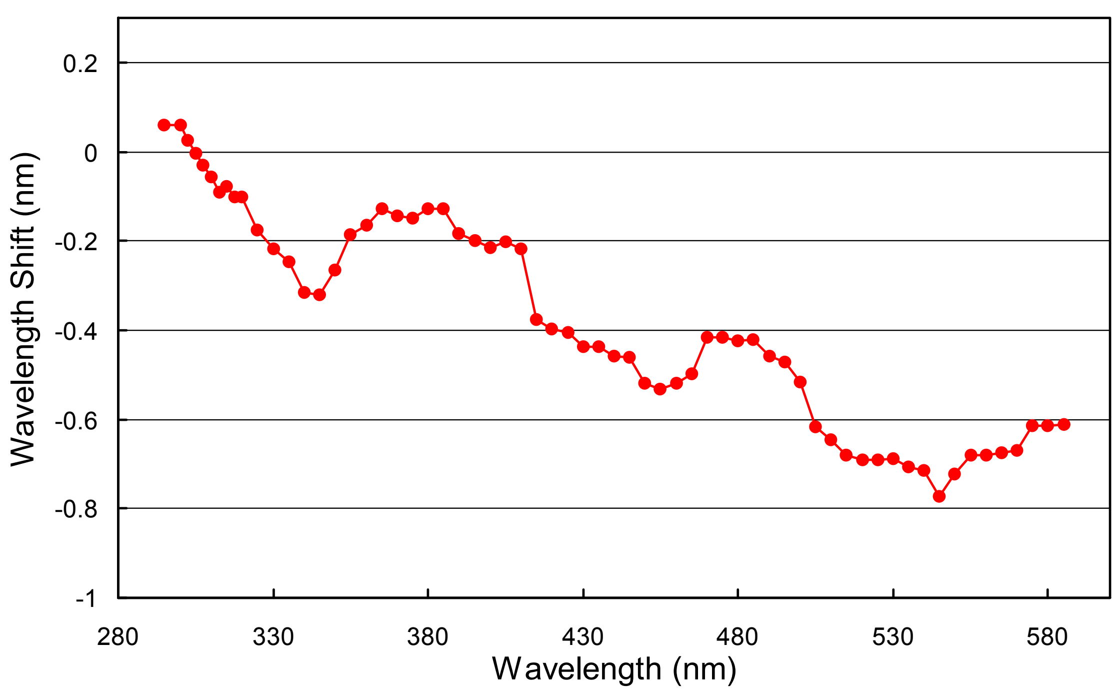

Figure 5.2.7. *Monochromator mapping function.*

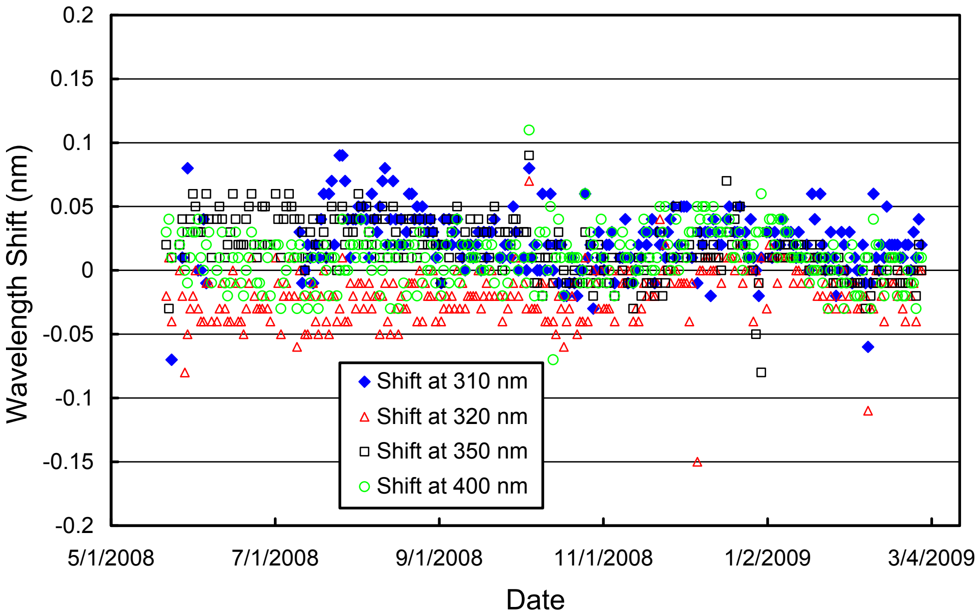

Figure 5.2.8. *Wavelength accuracy check of the final data at four wavelengths by means of Fraunhofer-line correlation. Noontime measurements from every day of have been evaluated.*

5.2.4. Missing Data

The Palmer Volume 18 dataset includes 15641 solar scans. These are 97% of all solar scans possible. Only 1.2% of all scans were lost because of technical problems. See Table 5.2.2 for a tally of missing scans. GUV-511 data of the period 6/8/08 - 6/18/08 are missing because the program for data collection had been inadvertently switched off.

Table 5.2.2 Missing scans of Palmer Volume 18.

Time Period	Scans missing	Reason
Throughout period	400	Calibration absolute, wavelength and response scans
05/21/08-05/28/08	39	Scans lasting longer than 15 minutes prevent consecutive scans to be executed / optimization of hardware settings
06/08/08	21	Computer not running for unknown reasons
09/12/08	17	Snow on collector
12/16/08	81	Troubleshooting of Power Distribution Unit
12/22/08	15	Computer reboot for unknown reasons
12/23/08	27	Missing for unknown reasons

5.2.4. GUV Data

The GUV-511 radiometer was installed next to the SUV-100 and calibrated against final SUV-100 measurements following the procedure outlined in Section 4.3.1. The sensitivity of all channels did not appreciably change over the course of the reporting period.

Data products were calculated from the calibrated measurements (Section 4.3.2). Figure 5.2.9. shows a comparison of GUV-511 and SUV-100 erythemal irradiance based on final Volume 18 data. For solar zenith angles smaller than 80°, measurements of the two instruments agree to within ±3.7% (±1σ) with the exception of several outliers, which may partly be caused by sporadic snow and ice accumulation on the either of the two collectors. We advise data users to use SUV-100 rather than GUV-511 data whenever possible, in particular for low-Sun conditions.

Figure 5.2.10 shows a comparison of total ozone measurements from the GUV-511 radiometer, the Ozone Monitoring Instrument (OMI) installed on NASA's AURA satellite, and SUV-100 Version 2 data. GUV-511 ozone values were calculated as described in Section 4.3.3. There is typically good agreement between the three data sets. For SZA larger than 80°, GUV-511 ozone data become unreliable and should not be used.

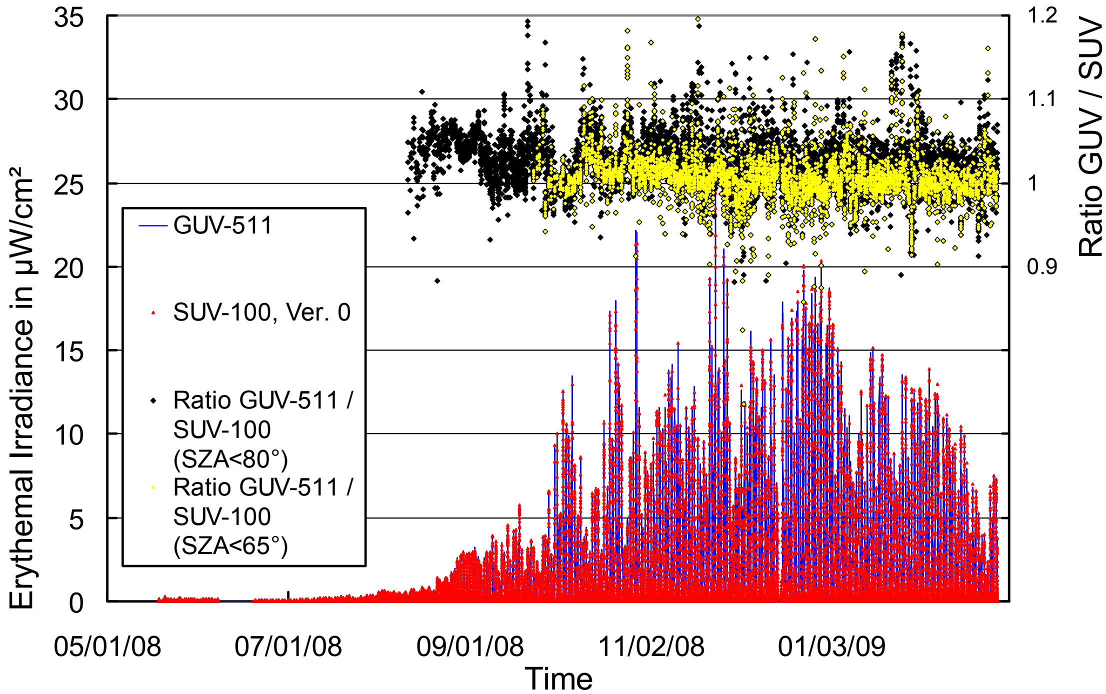

Figure 5.2.9. *Comparison of erythemal irradiance measured by the SUV-100 spectroradiometer and the GUV-511 radiometer of the Volume 18 period. The ratio was filtered for measurements performed at solar zenith angles smaller than 80° (black markers) and 65° (yellow markers).*

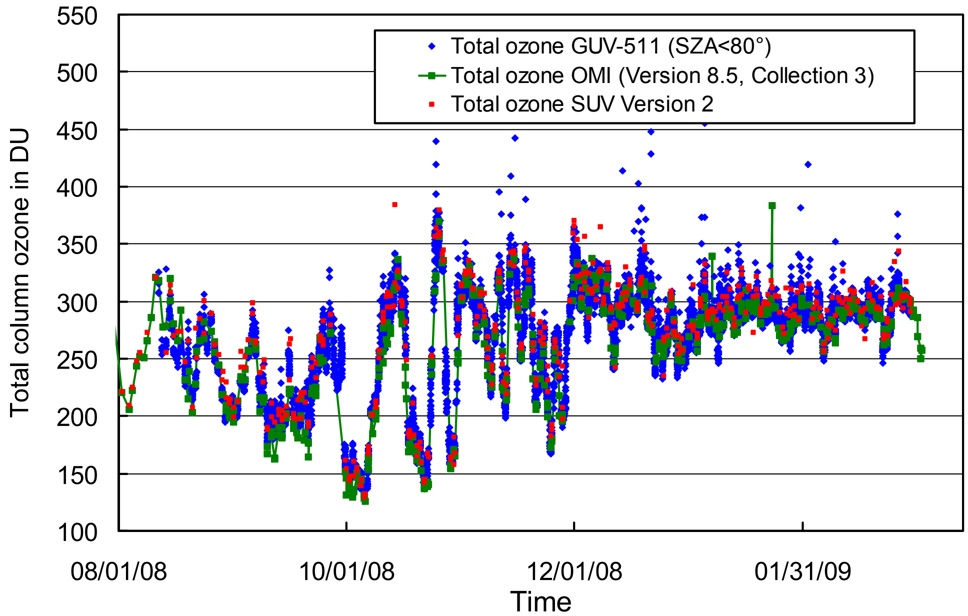

Figure 5.2.10. *Comparison of total column ozone measurements from GUV-511, OMI, and SUV-100. GUV total ozone data are provided in 15 minute increments for solar zenith angles smaller than 80°. OMI data are from the "Version 8.5 Collection 3" data edition, which is approximately 2% smaller than the original OMI data release. SUV-100 data are from the "Version 2" data edition.*