5.1. McMurdo Station (01/31/08 – 3/31/09)

The 2008/09 season at McMurdo Station is defined as the period between the site visit on 1/25/08 – 2/1/08 and the arbitrarily set end-point of 3/31/09. Season opening calibrations were performed on 1/29/08 and 1/30/08. Site standards were further compared with traveling standards on 2/11/09. Volume 18 solar data of the SUV-100 spectroradiometer and the GUV-511 radiometer comprise the period 01/31/08 – 3/31/09. A total of 20928 scans of the SUV-100 are part of the McMurdo Volume 18 dataset. 6% of scans are missing due to technical problems, mostly communication error between computer and peripheral electronics.

5.1.1. Irradiance Calibration

The site irradiance standards for the McMurdo 2007/08 season were the lamps M-543, 200W005, 200W011, and 200W019. Lamp M-763 was the traveling standard in 2008; lamp 200W017 was used as traveling standard in 2009.

<u>On-site standards</u>
Lamps M-543, 200W005, and 200W019 have been in service for a long time and have been recalibrated several times since their first use. The three lamps were last re-calibrated against the traveling standard M-763 using "closing" scans from the 2008 site visit. This calibration was used for processing solar data of Volume 17 and 18. More details of the lamps' history and the latest recalibration procedure can be found in the Volume 17 Operations Report. Lamp 200W011 was put into service in January 2008 and also calibrated against the traveling standard M-763. It was not used during the reporting period and rather serves as a long-term standard for McMurdo.

<u>Traveling standards</u>
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 5.1.1 shows a comparison of the four site standards against traveling standard M-763. Data were collected at the beginning of the Volume 18 period. All datasets are consistent to within ±1%. This good agreement can be expected as the four lamps were recalibrated against M-763 using the closing scans of the Volume 17 period.

Figure 5.1.2 shows a similar plot against traveling standard 200W017 based on data collected on 2/11/09. There is excellent agreement between the data sets of lamps M-543 and 200W019, but both datasets are about 1.5% low compared to that of the traveling standard 200W017. A difference of 1.5% is well within the uncertainty of the traveling standard's calibration. The large difference of 3.5% between lamps 200W005 and 200W017, and the offset of 2% to the other site standards is surprising. Lamps

M-543, 200W005, and 200W019 have also be compared with each other on 4/23/08, 8/27/08, and 11/20/08. The difference between measurements of the three lamps was smaller than 1% on all three occasions. It therefore appears that the output of lamp 200W005 has abruptly changed between 11/20/08 and 2/11/09.

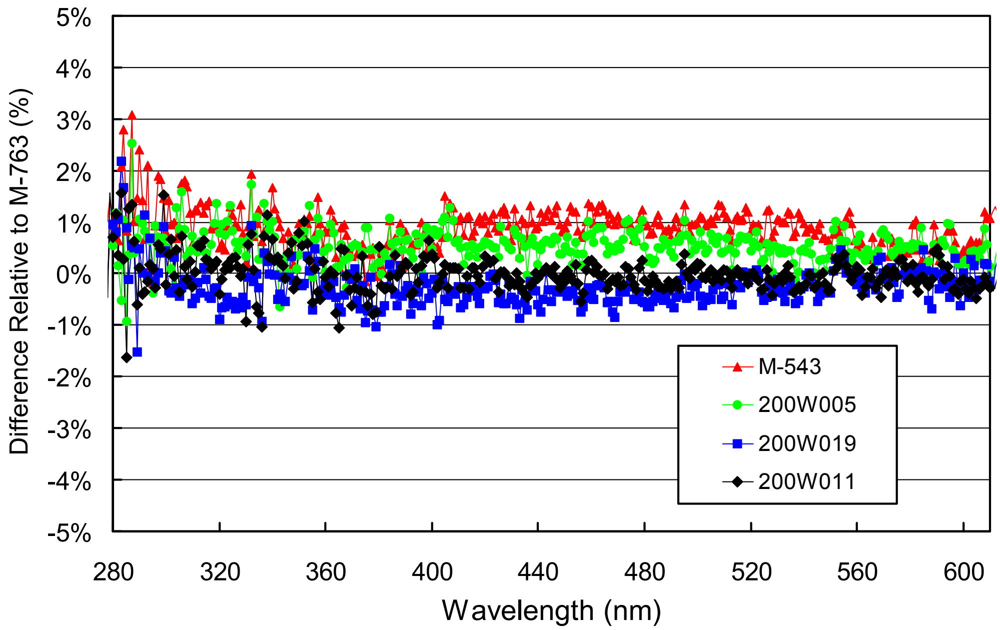

Figure 5.1.1. *Comparison of McMurdo lamps M-543, 200W005, 200W011, and 200W019 with the BSI traveling standard M-763 on 1/29/08. Lamp M-763 had been calibrated in June 2007 against four 1000-Watt FEL standards provided by CUCF and corrected for the misalignment in its holder.*

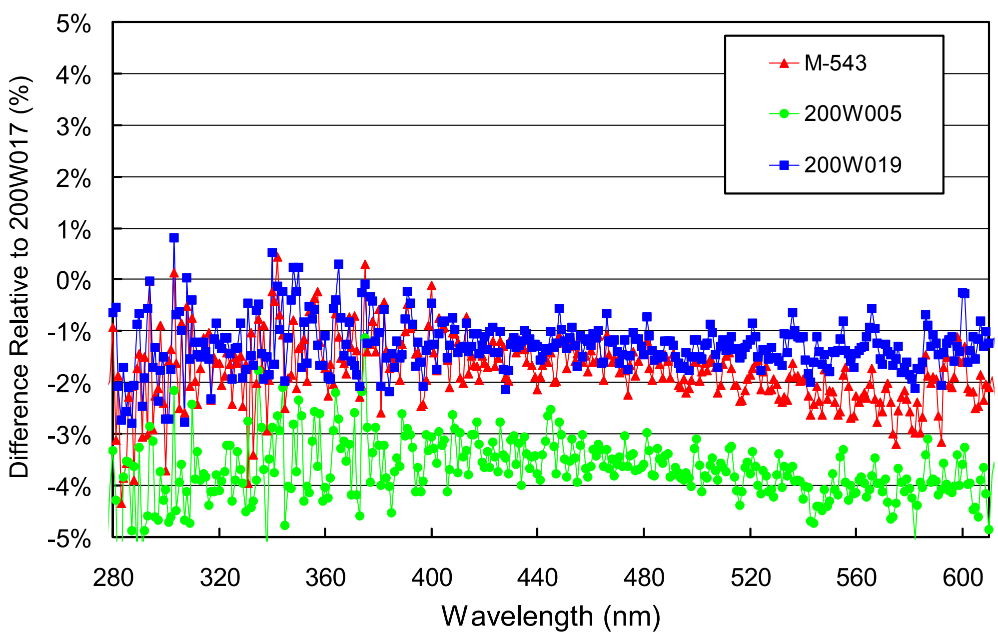

Figure 5.1.2. *Comparison of McMurdo lamps M-543, 200W005, and 200W019 with the BSI traveling standard 200W017 on 2/11/09.*

5.1.2. Instrument Stability

The stability of the spectroradiometer over time is monitored with bi-weekly calibrations utilizing the site irradiance standards, daily response scans of the internal irradiance reference lamp, and by comparison with the collocated GUV-511 radiometer. 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 monochromator throughput and PMT sensitivity can be detected.

Figure 5.1.3 shows changes in TSI readings and PMT currents at 300 and 400 nm, derived from the daily response scans. TSI measurements indicate that the internal lamp was stable to within ±1.5%. The PMT currents at 300 and 400 nm varied by ±2.5%, with lowest values in winter. This temporal pattern has been observed also in previous seasons. Changes in system response indicated in Figure 5.1.3 are automatically corrected during processing of solar data.

Nine calibration functions were applied to the solar measurements of Volume 18 to correct for changes in through-the-collector throughput. More details on calibration periods are provided in Table 5.1.1. Figure 5.1.4 shows ratios of the calibration functions applied during Periods P2 – P6, relative to the function of Period P1. There is a change of about 20% over the course of the season, which is likely related to dust collecting on the instrument's relay lens.

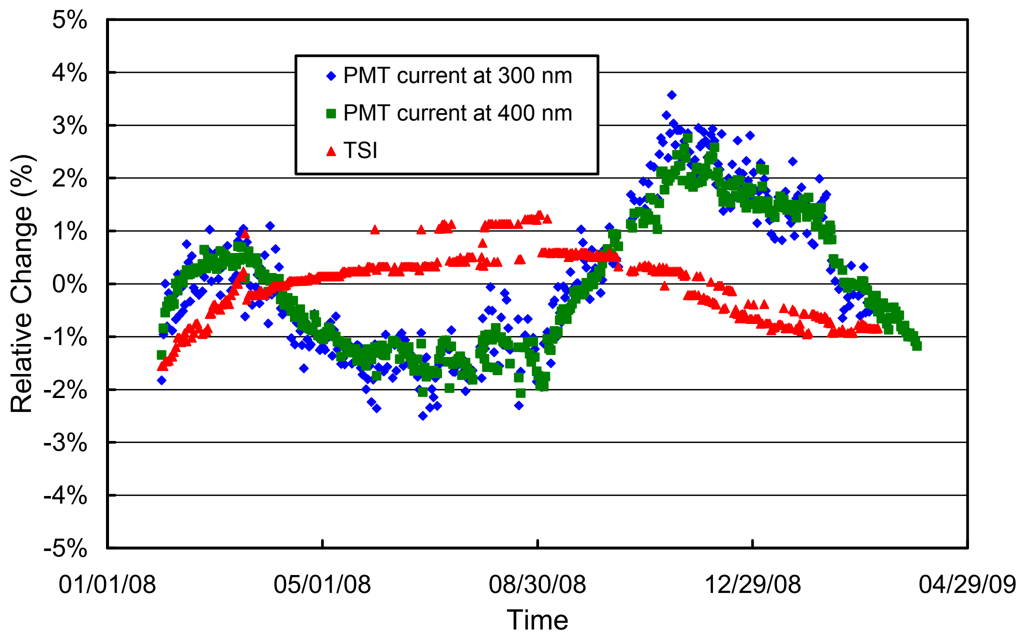

Figure 5.1.3. *Time-series of PMT current at 300 and 400 nm, and TSI signal derived from measurements of the internal irradiance reference lamp during the McMurdo 2007/08 season. Data are normalized to the average value of the whole season.*

Figure 5.1.5 presents the relative standard deviation calculated from the individual absolute scans for periods with more than one absolute scan. These data are useful for estimating the variability of calibrations. The variability is typically less than 1.5% for wavelengths above 300 nm, indicating good consistency of individual absolute scans. Data of period P5 are noisy because the standard deviation was calculated from two absolute scans only.

Table 5.1.1: Calibration periods for McMurdo Volume 18 data.

Period name	Period range	Number of Absolute Scans	Remarks
P1	01/27/08 - 03/10/08	13	
P2	03/11/08 - 06/21/08	6	Last period before Polar Night
P3	06/22/08 - 09/25/08	5	
P3B	09/26/08 - 10/12/08	2	
P3C	10/13/08 - 10/25/08	0	Interpolated from Periods P3B and P3D
P3D	10/26/08 - 11/03/08	1	
P4	11/04/08 - 12/05/08	5	
P5	12/06/08 - 01/31/09	2	
P6	12/01/09 - 03/31/09	4	

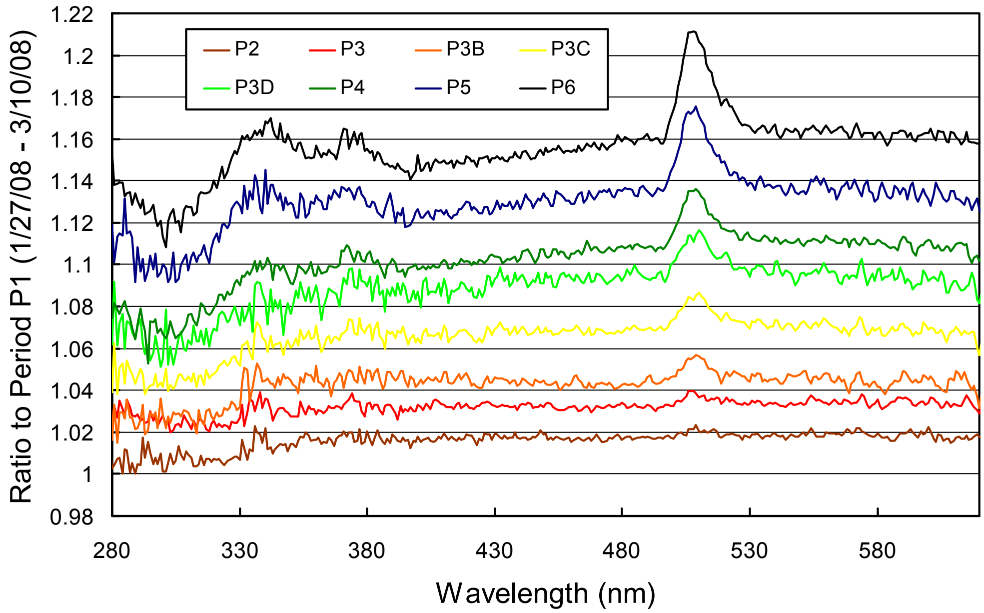

Figure 5.1.4 *Ratios of irradiance assigned to the internal reference lamp during periods P2 – P6, relative to Period P1.*

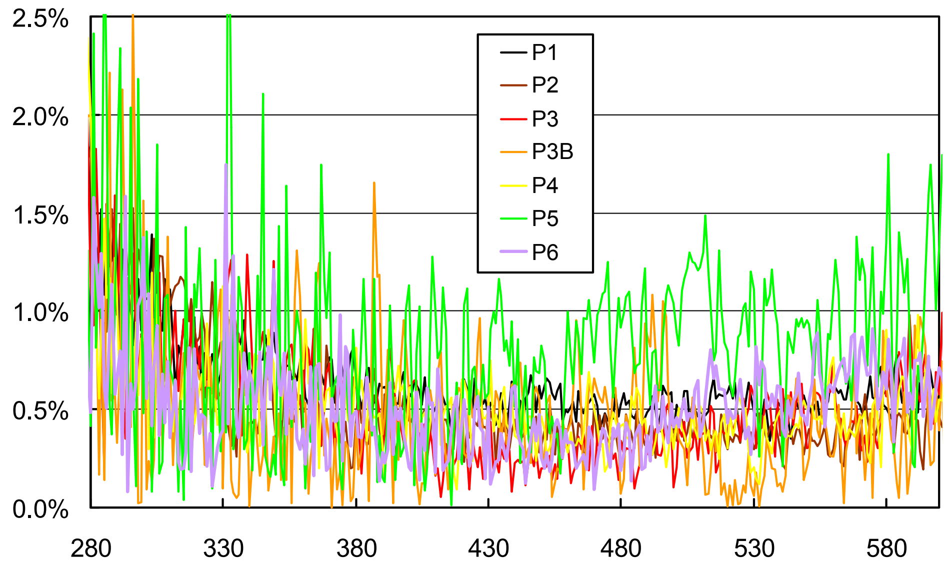

Figure 5.1.5. *Ratio of standard deviation and average calculated from absolute calibration scans.*

5.1.3. 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 5.1.6 shows the difference of the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. A total of 490 pairs of scans were evaluated. The change in offset was less than ±0.025 nm for 87% of the scans and smaller than ±0.055 nm for 91% of the scans. Larger shifts were only observed in three periods: (1) between 8/13/08 and 8/24/08, (2) between 10/14/08 and 11/6/08, and (3) between 2/13/09 and 2/22/09. Shifts were corrected during data processing.

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). Figure 5.1.7 shows the correction function calculated with this algorithm. Figure 5.1.8 indicates the wavelength accuracy of final Version 0 data for five wavelengths in the UV and visible by running the Version 2 Fraunhofer-line correlation method a second time. Shifts are typically smaller than ±0.05 nm.

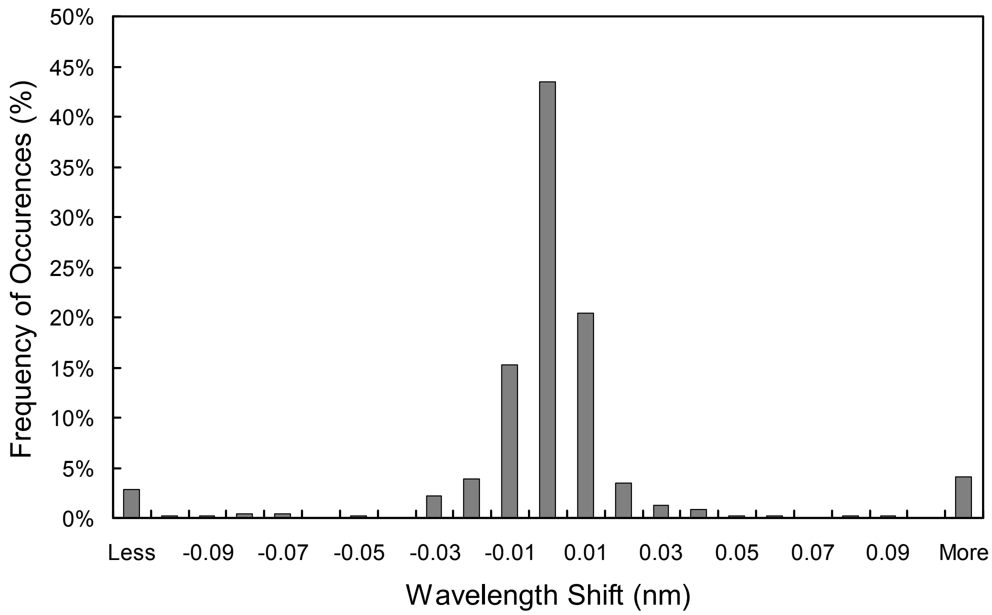

Figure 5.1.6. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

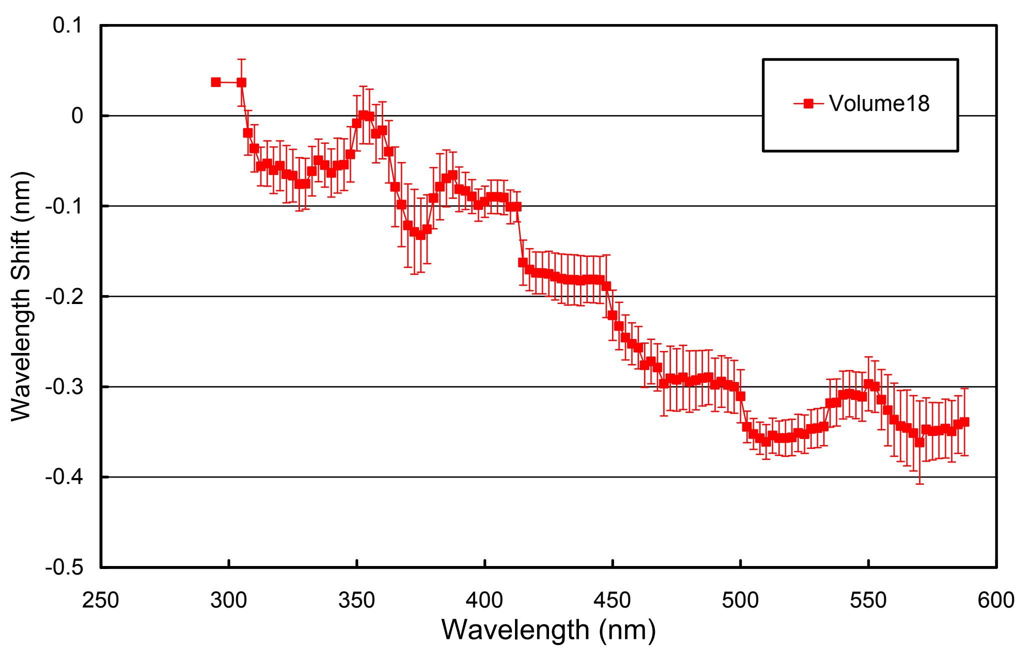

Figure 5.1.7. *Monochromator non-linearity correction function. Error bars indicate the 1σ-variation.*

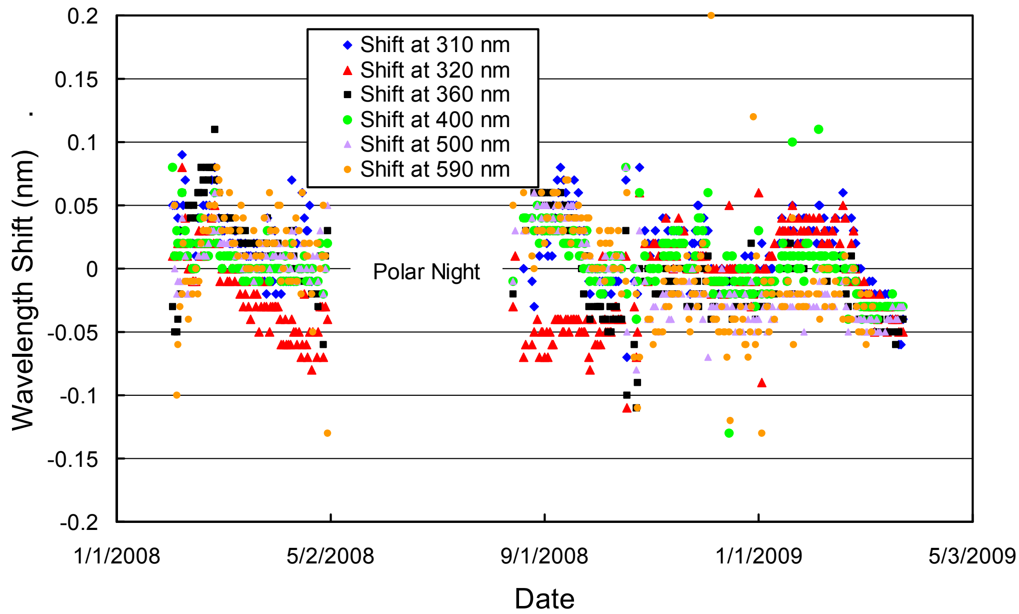

Figure 5.1.8. *Check of the wavelength accuracy of final data at four wavelengths by means of Fraunhofer-line correlation. The noontime measurement has been evaluated for each day of the season. No correlation data is available during Polar Night.*

5.1.4. Missing Data

A total of 20928 scans are part of the McMurdo Volume 18 dataset. These are 89.0% of the maximum possible number of data scans. 1157 (4.9%) solar scans were superseded by calibration scans. Since McMurdo Station has 24 hours of sunlight per day during summer, a loss of solar data cannot be avoided. Of the remaining missing scans 1406 (6.0%) were lost due to technical problems, mostly related to communication problems between the computer and electronics that control the monochromator and amplify the PMT current. The root-cause of the problem is still unknown, but it seems to correlate with temperature in the laboratory. A break-down of missing data is provided in Table 5.1.2.

Table 5.1.2. Missing solar scans in the McMurdo Volume 18 data set.

Period	Number of scans	Reason
		Calibration scans
Throughout season	553	Response scans
Throughout season	423	Wavelength scans
Throughout season	181	Absolute scans
		Technical problems
Throughout season at 10:30	93	Scan superseded by reading of GPS receiver
08/13/08	3	Communication problem computer-monochromator control
08/14/08	6	Communication problem computer-monochromator control
08/15/08 – 08/19/08	74	Communication problem computer-monochromator control
08/21/08 – 08/24/08	45	Communication problem computer-monochromator control
08/21/08 – 08/24/08	653	Wavelength setting of monochromator off - not correctable

10/29/08	10	Operator intervention for unknown reasons
11/03/08 – 11/04/08	29	Communication problem computer-monochromator control
11/05/08 – 11/06/08	18	Communication problem computer-monochromator control
01/10/09 – 01/12/09	108	Communication problem computer-monochromator control
01/30/09 – 01/31/09	95	Communication problem computer-monochromator control
02/10/09	4	Test of System Digital Multimeter
02/14/09 – 02/15/09	84	Communication problem computer-monochromator control
02/16/09 – 02/17/09	46	Communication problem computer-monochromator control
02/19/09	40	Communication problem computer-monochromator control
02/21/09 – 02/22/09	9	Communication problem computer-monochromator control
02/24/09 – 02/25/09	40	Communication problem computer-monochromator control
03/12/09	7	Unprocessed for unknown reasons
03/25/09	6	Unprocessed for unknown reasons
		Other
02/01/08	8	Cloning of hard drive
02/01/09 – 02/02/09	10	Update Operating System

5.1.5. GUV Data

The GUV-511 radiometer, which is installed next to the SUV-100, was calibrated against final SUV-100 measurements following the method outlined in Section 4.3.1.

Data products were calculated from the calibrated measurements according to the procedure outlined in Section 4.3.2. Figure 5.1.9. 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 GUV are on average smaller by 2%; the standard deviation of the ratio is ±2.6% (±1σ). Agreement is best at large irradiance levels. We advise data users to use SUV-100 rather than GUV-511 data when the Sun is low.

Figure 5.1.10 shows a comparison of total ozone measurements from the GUV-511 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-511 ozone values were calculated as described in Section 4.3.3 and are plotted for SZAs smaller than 80°. On average, GUV-511 ozone values are larger by 0.9% than OMI data. SUV-100 measurements are on average 2.0% larger than OMI observations. These offset are partly caused by the different treatment of the atmospheric ozone and temperature profiles in the inversion algorithms for the three data sets. GUV-541 ozone data become unreliable for SZA larger than 80° and should not be used.

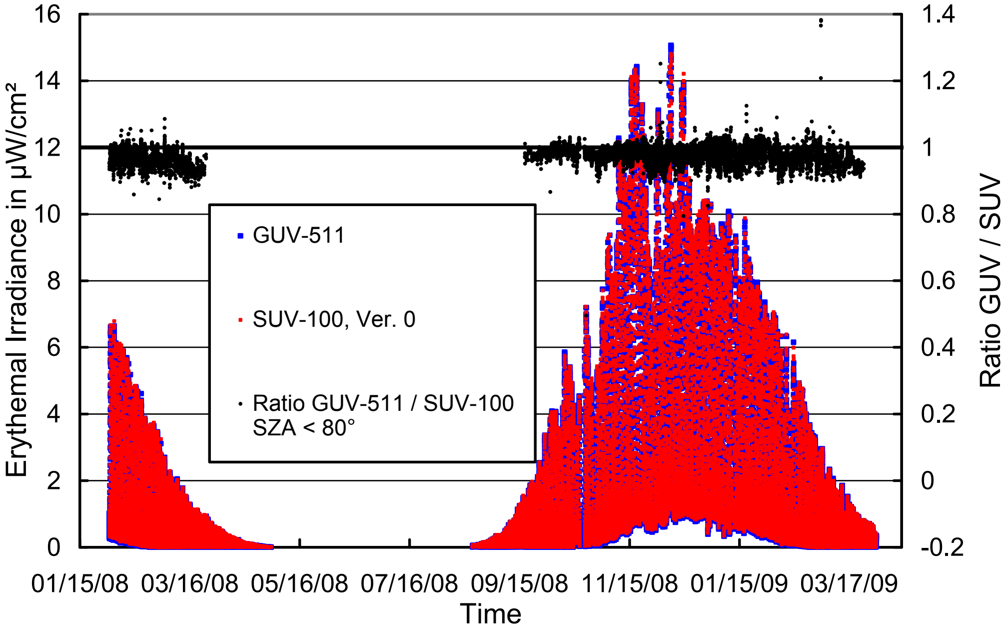

Figure 5.1.9. *Comparison of erythemal irradiance measured by the SUV-100 spectroradiometer and the GUV-511 radiometer. All data are based on "Version 0" (cosine-error uncorrected) data.*

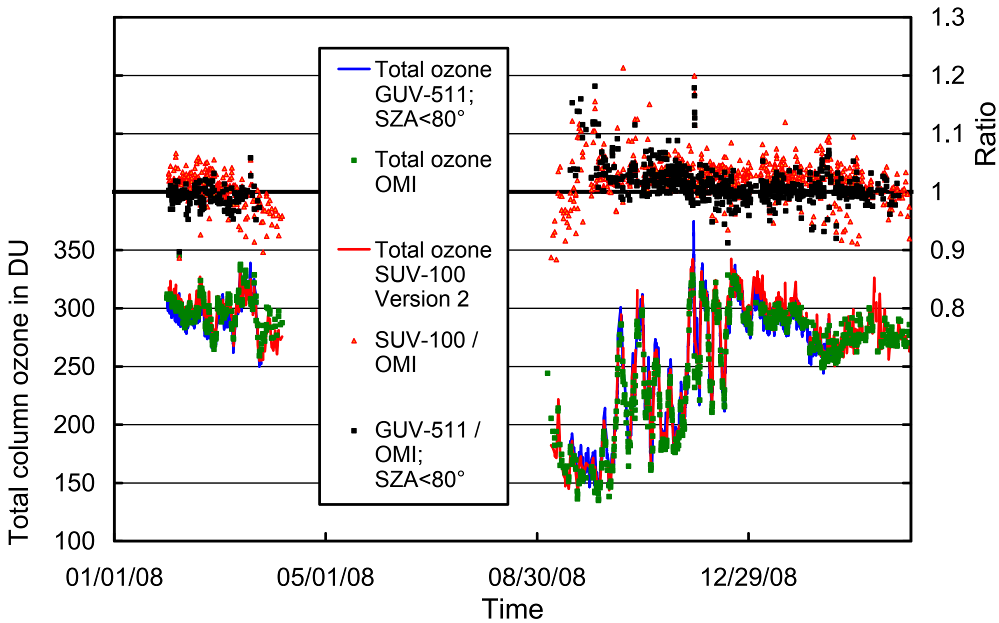

Figure 5.1.10. *Comparison of total column ozone measurements from GUV-511, SUV-100 (Version 2 data), and OMI (v8.5, Collection 3). GUV-511 and SUV-100 measurements are plotted in 15 minute intervals. For calculating the ratio of both data sets, only GUV-511 measurements concurrent with OMI overpass data were evaluated. OMI measurements from 2009 are affected by an obstruction in the instruments field-of-view and have been removed from the dataset plotted.*