5.5. San Diego (8/25/05 – 8/28/06)

The 2005-2006 season at San Diego includes the period 8/25/05 – 8/28/06. In contrast to other network sites, San Diego also serves as a facility for operator training, test of new system components, and comparison of calibration standards. Instrument maintenance is performed year-round and during operator training. Measurement of solar spectra are more frequently interrupted than at other sites. The list below gives an overview of activities during the San Diego Volume 15 season.

- **08/25/05:** Start of the season
- **08/25/05 – 8/26/05:** Operator training (in support of McMurdo and Palmer Stations)
- **09/02/05:** External wavelength scans
- **09/22/05:** Power outage; shutdown of system
- **10/4/05 – 10/5/05:** Operator training (in support of South Pole Station)
- **10/11/05:** Repair of temperature regulation
- **11/17/05:** Replacement of voltmeter and shunt used for measuring lamp current
- **11/23/05:** Replacement of Eppley Laboratory pyranometer S/N 27228F3 with S/N 27224F3
- **12/13/05 – 12/14/05:** Operator training (in support of Barrow)
- **01/05/06 – 01/06/06:** Operator training (in support of Summit)
- **03/07/06 – 03/08/06:** Test of linearity high resolution analog-to-digital converter (HRAD) in support of troubleshooting at Barrow; check signal when measuring the 254-nm mercury line in second-order
- **03/23/06:** Operator training (in support of Palmer Station)
- **03/29/06 – 03/30/06:** Operator training (in support of Summit)
- **04/25/06 – 05/11/06:** Test of new software (migration from Windows® NT to Windows® XP)
- **05/15/06 – 05/19/06:** Test of new software
- **05/17/06:** Test temperature regulator and thermo-electric cooler for Barrow
- **05/25/06 – 05/26/06:** Test of new software
- **05/31/06 – 06/02/06:** Test of new software
- **06/09/06:** Test of new software
- **06/27/06 – 06/28/06:** Replacement of shutter, inspection of collector
- **07/27/06:** Test of software
- **08/03/06:** Test of software
- **08/28/06 – 8/31/06:** Operator training (in support of South Pole and Palmer Stations)
- **08/29/06:** End of season

The system operated normally during the Volume 15 period with the exception of some problems with the temperature stabilization and the failure of the instrument's shutter. Operation was interrupted more frequently than usual due to testing of new software, which eventually will allow the system to run under the Windows® XP operating system.

Approximately 95% of all scheduled data scans are part of the published dataset. Of all solar scans, only 0.5% were lost due to technical problems. The majority of the missing scans were superseded by operator training, tests of hardware and software, upgrades, instrument calibration, and maintenance.

Volume 15 also includes data from a GUV-511 moderate-bandwidth filter radiometer (Section 2). These data complement SUV-100 measurements and were also used for quality control. A comparison of GUV-511 and SUV-100 data is provided in Section 5.5.5. The instrument was very stable during the reporting period, except of the 320-nm channel, which was affected by an abrupt sensitivity change by 10% on 8/8/06 for unknown reasons. The calibration of GUV data was adjusted accordingly and published solar data are not affected.

5.5.1. Irradiance Calibration

The calibration of Volume 15 solar data was mostly based on lamp 200W028. The lamp was originally calibrated by Optronic Laboratories in March 2001 but has drifted between 2004 and 2005. It was recalibrated by comparison with lamps M-763 and 200W017 using measurements from 4/26/05 (see also previous operations report). Lamp M-763 is a long-term standard which has been used sparingly since its latest calibration by Optronic Laboratories in March 2001. Lamp 200W017 is a traveling standard. It has also an Optronic Laboratories calibration from March 2001.

Figure 5.5.1 shows a comparison of lamps 200W028, 200W022, M-763, and 200W017, performed on 10/4/05. Lamp 200W022 is another long term standard and also has an Optronic Laboratories calibration from March 2001. The calibrations of all lamps agreed to within ±1.0%.

Figures 5.5.2 and 5.5.3 show similar comparisons of the four lamps performed on 1/5/06 and 6/1/06. On 1/5/06, all lamps agreed to within ±0.5%. On 6/1/06, the agreement is somewhat worse, but still within the uncertainty of the comparison procedure of about ±1%.

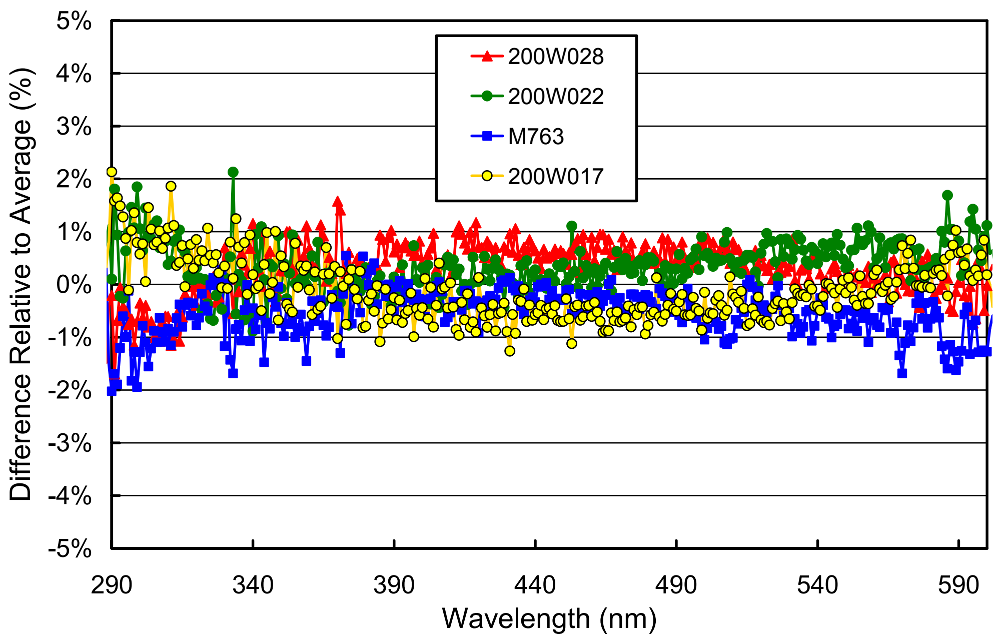

Figure 5.5.1. *Comparison of lamps 200W028, 200W022, M-763, and 200W017 on 10/4/05.*

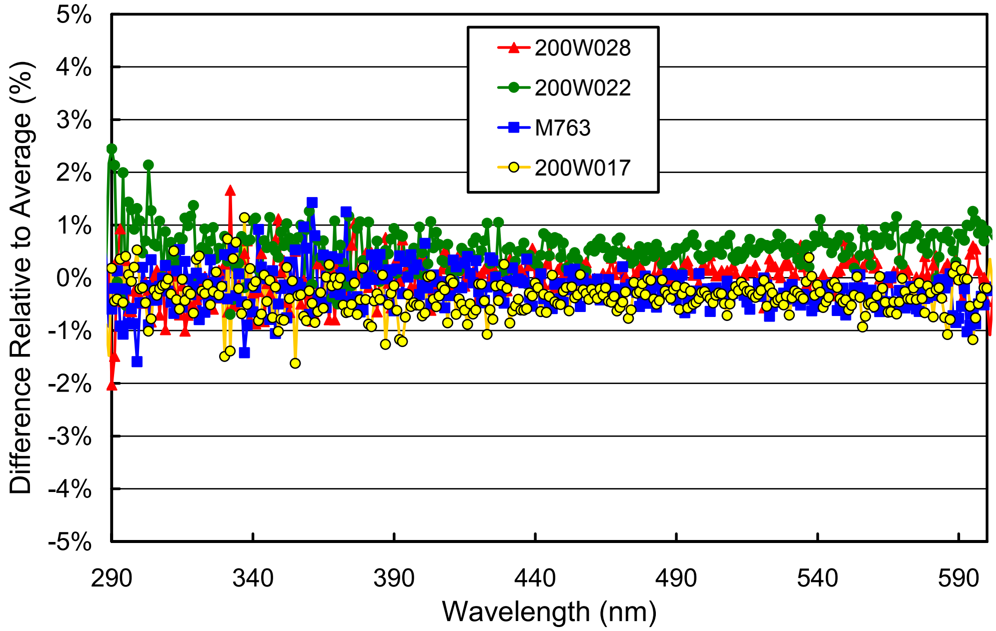

Figure 5.5.2. *Comparison of lamps 200W028, 200W022, M-763, and 200W017, on 1/5/06.*

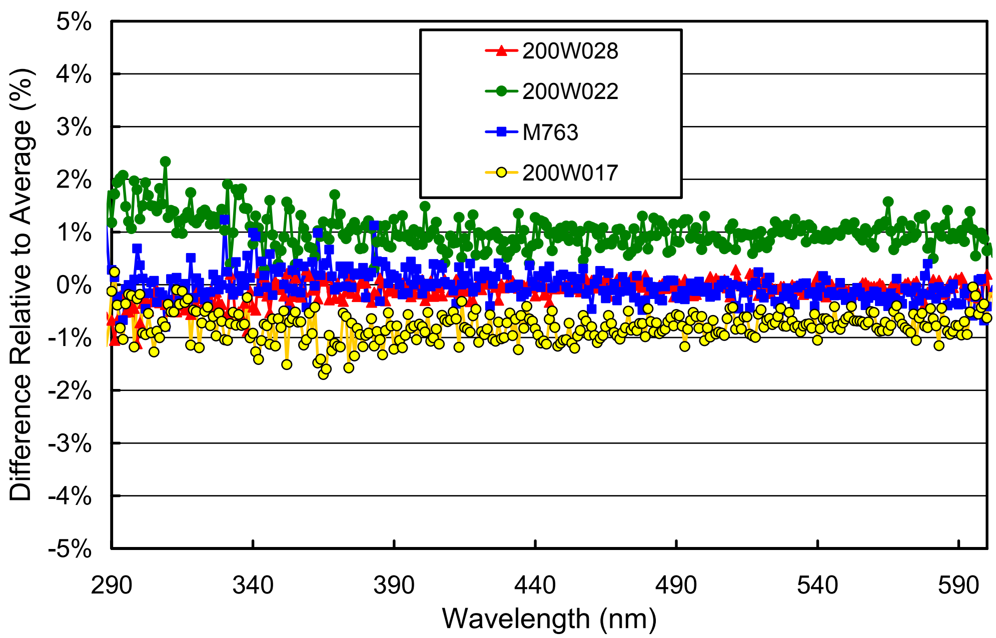

Figure 5.5.3. *Comparison of lamps 200W028, 200W022, M-763, and 200W017, on 6/1/06.*

5.5.2. Instrument Stability

The 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 lamp. The stability of the internal lamp is monitored with the TSI sensor, which is independent from possible monochromator and PMT drifts. A new irradiance is usually assigned to the internal lamp when TSI measurements indicate that the lamp has drifted by more than 2%.

Figure 5.5.4 shows TSI measurements and PMT currents at 300 and 400 nm during response scans. TSI and PMT data were normalized to their average values of the reporting period. Measurements of the TSI were stable to within ±1%, indicating very good stability of the reference lamp. PMT currents show distinct changes at times when instrument service was performed. Solar data were corrected for these discontinuities.

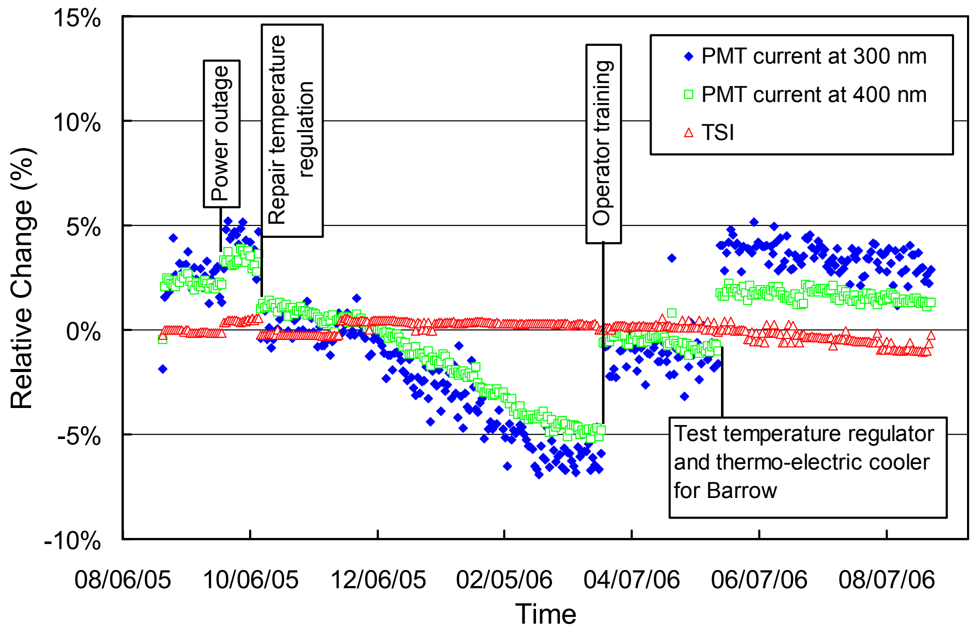

Figure 5.5.4. *Time-series of PMT current at 300 and 400 nm, and TSI signal calculated from measurements of the internal irradiance reference lamp during the San Diego 2005-2006 season. All data sets are normalized to their average values.*

The season was divided into eight calibration periods (Table 5.5.1). Figure 5.5.5 shows ratios of the spectral irradiance assigned to the internal reference lamp during each calibration period to the irradiance of the first period (8/24/05-9/3/05). At the end of period P1B was a power outage, which exceeded the buffer-time of the UPS. Although the system could be gracefully powered down, the responsivity changed by about 1-2%. The 3-5% change in responsivity between Periods P4 and P5 was caused by the test of a temperature regulator and a thermo-electric cooler in support of the system at Barrow. At the end of Period P5 the instrument shutter was replaced. The change in responsivity by 2-3% between Periods P6 and P7 remains unexplained.

Table 5.5.1 Calibration periods for San Diego Volume 15.

Period name	Period range	Number of Absolute scans	Remarks
P 1	08/24/05 - 09/03/05	3	
P 1B	09/04/05 - 09/22/05	1	System shutdown at end of period
P 2	09/23/05 - 10/10/05	4	
P 3	10/11/05 - 03/20/06	15	
P 4	09/10/04 - 09/13/04	7	Test thermo-electric cooler at end of period
P 5	05/19/06 - 06/28/06	12	Replacement of shutter at end of period
P 6	06/29/06 - 07/27/06	1	
P 7	07/28/06 - 08/31/06	6	

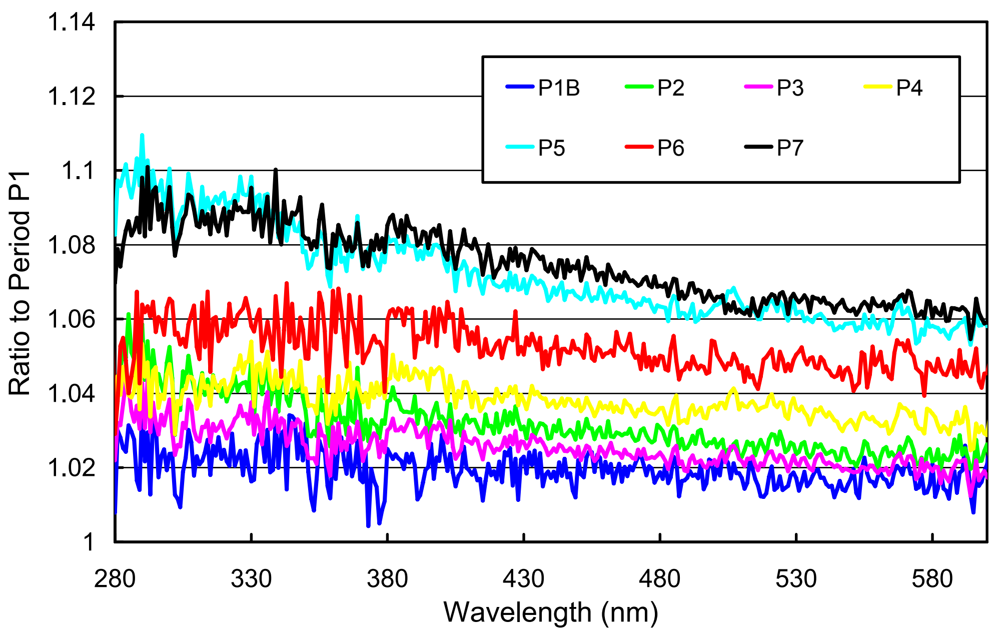

Figure 5.5.5. *Ratios of the spectral irradiance assigned to the internal reference lamp during the Volume 15 calibration periods to the irradiance applied in the first period.*

Figure 5.5.6 shows the relative standard deviation of all spectra contributing to the average-spectrum of each calibration period. (Only periods with at least two scans were considered). The plot is useful for estimating the variability of calibrations in a given period. Calibrations were generally consistent to within 1.5% (1σ). At very short wavelengths, the calibrations are affected by noise resulting in a somewhat larger variability.

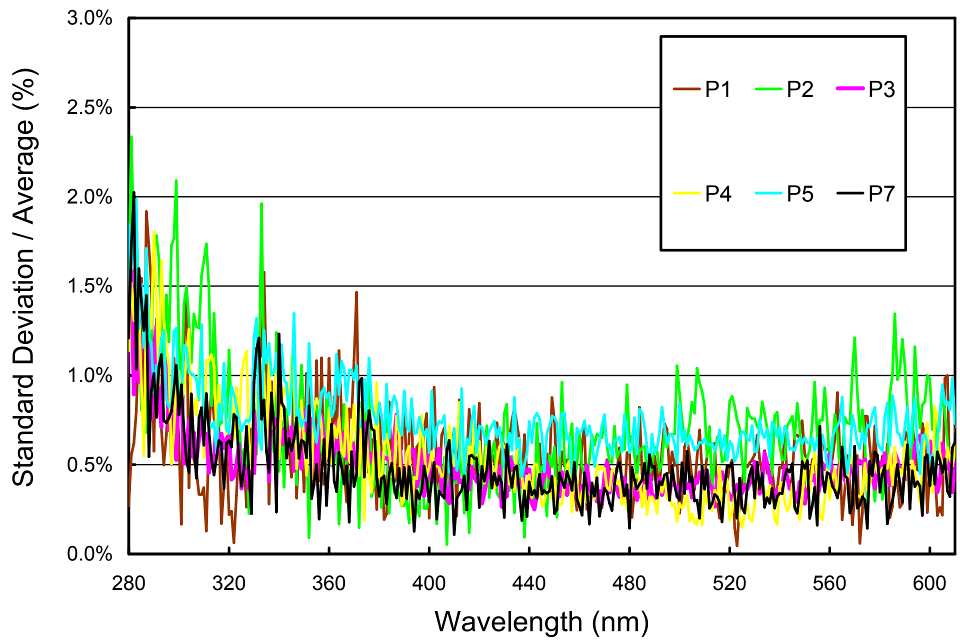

Figure 5.5.6. *Ratio of standard deviation and average calculated from calibration scans of the Volume 15 period.*

5.5.3. 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 still be a deviation from the correct wavelength scale, but this bias should ideally be the same for all days. Figure 5.5.7 shows the differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 467 scans were evaluated. For 84% of the days, the change in offset was smaller than ±0.025 nm; for 89% of all days shifts were below 0.055 nm. 48 pairs of scans (10%) showed a change greater than ±0.1 nm. This number is relatively large and mostly caused by operator training and testing of a new version of the system control software. The wavelength calibration was adjusted accordingly.

After 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 new Fraunhofer correlation method developed for Version 2 NSF network data (Section 4.2.2.2). The calculated correction function is shown in Figure 5.5.8.

After all data was wavelength corrected using the shift function described above, the wavelength accuracy was confirmed with the "Version 2" Fraunhofer line correlation method. The results are shown in Figure 5.5.9 for four UV wavelengths, evaluated for all noontime scans measured during the reporting period. The residual shifts are typically smaller than ±0.05 nm. When clouds move in front of the Sun spectra will get distorted, which may confuse the algorithm. This, and not real wavelength shifts, are the likely reason for the few outliers seen in Figure 5.5.9. The actual wavelength uncertainty may be somewhat larger due to wavelength fluctuations of about ±0.02 nm during the day.

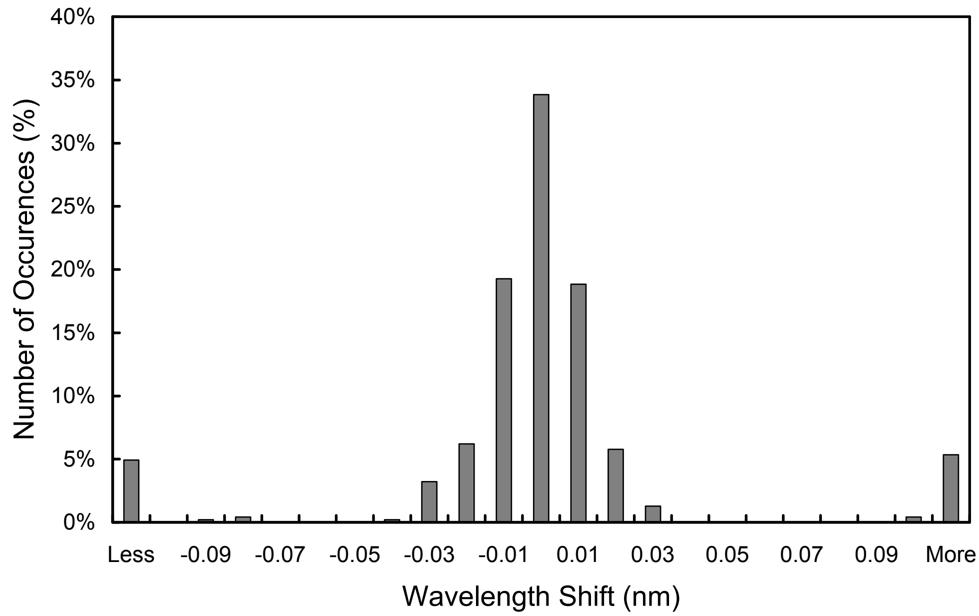

Figure 5.5.7. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

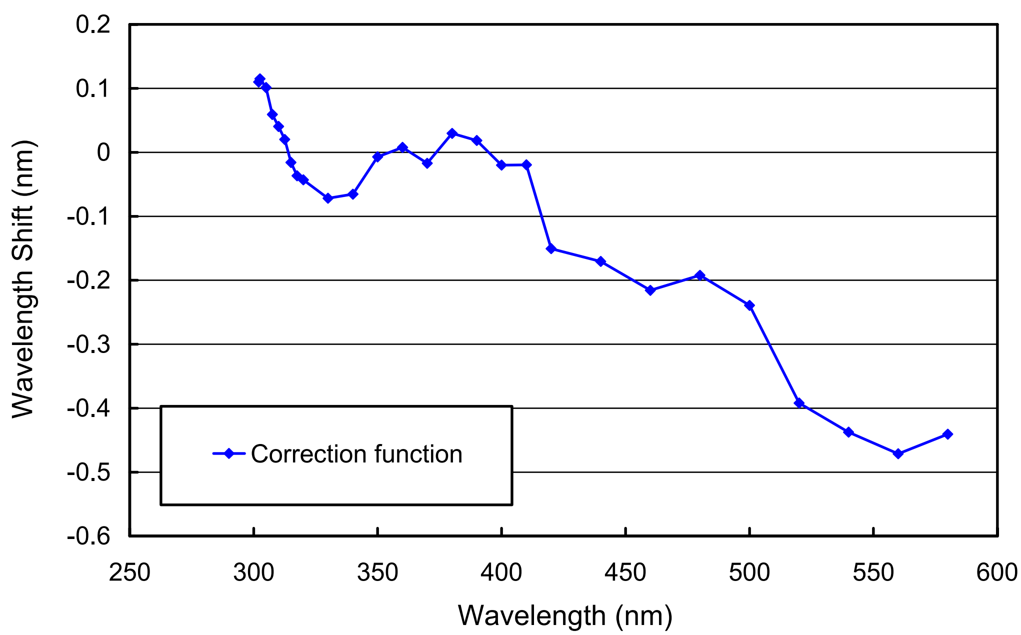

Figure 5.5.8. *Monochromator non-linearity correction function for the San Diego 2005-2006 season.*

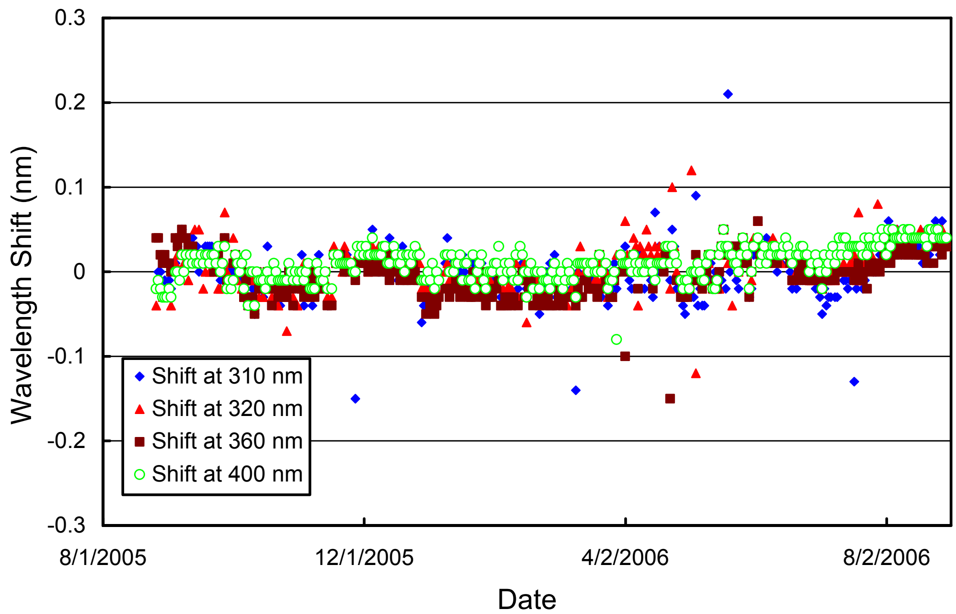

Figure 5.5.9. *Check of the wavelength accuracy of final data at four wavelengths by means of Fraunhofer-line correlation. The noontime measurements have been evaluated for each day of the season.*

Data from external mercury scans do not have a direct influence on the data products but are an important part of instrument characterization. Figure 5.5.10 shows internal and external mercury scans measured on three occasions during the Volume 15 period. Measurements at the three times were very consistent. External scans have a bandwidth of about 1.04 nm FWHM; the bandwidth of the internal scan is 0.89 nm. External scans have the same light path as solar measurements and represent the actual monochromator bandpass at 296.73 nm. The center positions of internal and external scans are shifted by about 0.15 nm. This shift is caused by the different light paths for both scan types; see Section 4.1.4 for details.

5.5.4. Missing Data

A total of 17557 scans are part of the published San Diego Volume 15 dataset. These are 95% of all solar scans scheduled between 8/25/05 and 8/28/06. Approximately 2.2% of solar scans were superseded by calibrations performed throughout the season. Additional reasons for missing solar data are technical problems (0.5%); and hardware and software tests, mid-season operator training, and system upgrades (2.6%). Table 5.5.2 describes gaps in published solar data in more detail.

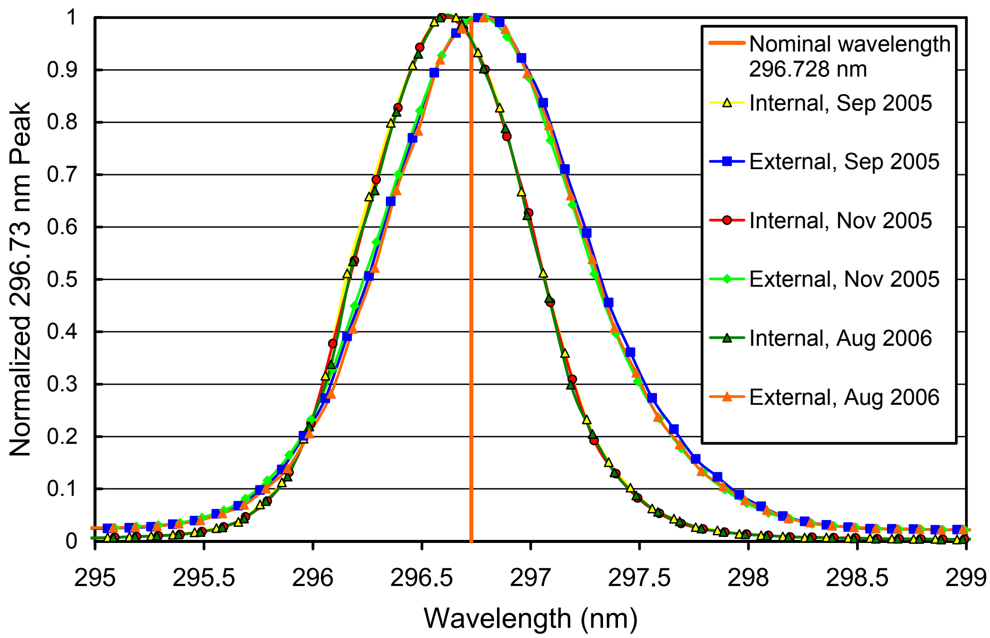

Figure 5.5.10. *The 296.73 mercury line as registered by the PMT from external and internal sources.*

Table 5.5.2 Missing scans San Diego Volume 15 (gaps due to calibration activities are not included).

Time Period	Scans missing	Reason
09/02/05 - 09/03/05	25	External wavelength scans
09/22/05	19	Regional power outage
10/04/05 - 10/05/05	12	Operator training
11/15/05 - 11/16/05	5	External wavelength scans
11/17/05	3	Replacement of voltmeter and shunt for measuring lamp current
12/13/05 - 12/14/05	31	Operator training
01/05/06 - 01/07/06	55	Operator training
02/03/06	9	Erroneous temperature alarm triggering automatic system shutdown
03/07/06	3	Measurement of second order of 254-nm mercury line
03/07/06 - 03/08/06	19	Linearity check of high-resolution analog-to-digital converter
03/23/06 - 03/24/06	17	Operator training
03/29/06 - 04/01/06	40	Operator training
04/25/06 - 04/28/06, 05/02/06 - 05/05/06, 05/08/06 - 05/12/06	188	Test of new system control software
05/16/06 - 05/19/06	67	Test of new system control software, temperature regulator, thermo-electric cooler
05/25/06 - 05/26/06, 05/31/06, 06/02/06, 06/09/06	69	Test of new system control software
06/19/06 - 06/28/06	55	Scans affected by defective shutter; replacement of shutter
07/27/06, 08/03/06	7	Test of new system control software
08/28/06	10	Operator training

5.5.5. GUV Data

Data from the GUV-511 radiometer installed next to the SUV-100 were calibrated against final SUV-100 measurements following the procedure outlined in Section 4.3.1. Data products were calculated from the calibrated measurements as described in Section 4.3.2. Figure 5.5.11. shows a comparison of GUV-511 and SUV-100 erythemal irradiance based on final Volume 15 data. For solar zenith angles smaller than 80°, measurements of the two instruments agree to within ±3% (±1σ). For data measured between 11/26/05 and 12/1/05, the ratio GUV/SUV is high by 3% for unknown reasons. Between 7/28/06 and 8/3/06, the ratio tends to be low by 2%. The measurement uncertainty during the two periods is increased.

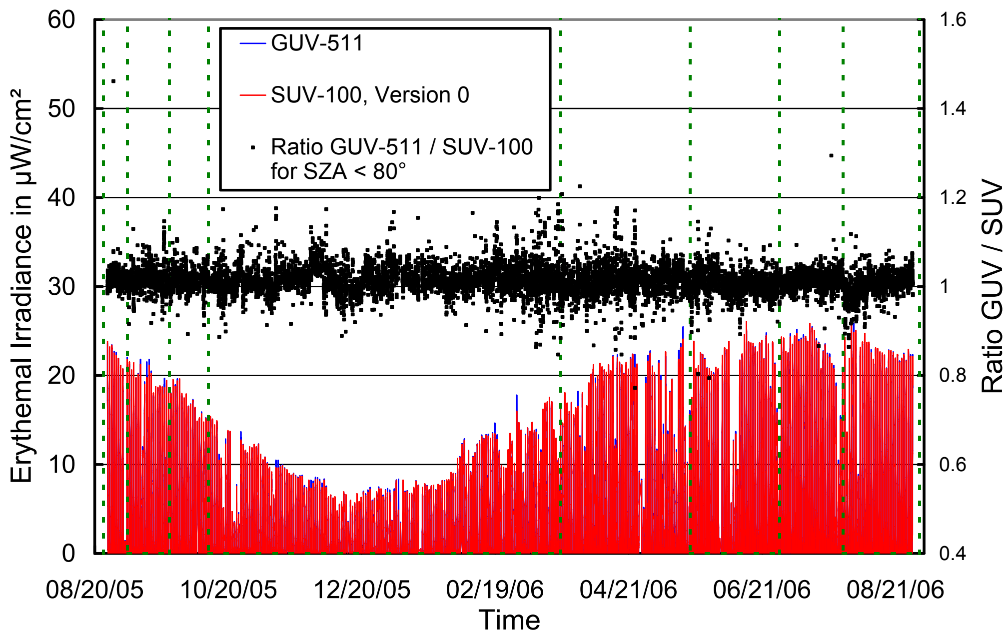

Figure 5.5.11. *Comparison of erythemal irradiance measured by the SUV-100 spectroradiometer and the GUV-511 radiometer. SUV-100 measurements are based on "Version 0" (cosine-error uncorrected) data. The broken green line indicates the time when the calibration of the SUV-100 was adjusted.*

Figure 5.5.12 shows a comparison of total ozone measurements from the GUV-511 and observations from OMI on NASA's AURA satellite. GUV-511 ozone values were calculated as described in Section 4.3.3. GUV-511 total ozone measurements exceed OMI data by 1.7±3.1% (±1σ) on average. The median difference is 1.3%. GUV measurements overestimate the actual ozone column during periods with heavy cloud cover. This effect is mostly caused by multiple scattering of photons inside the cloud. Scattering leads to an enhanced photon path length, resulting in an amplification of absorption by ozone molecules that are located inside the cloud. Affected data have not been filtered. For SZA larger than 75°, GUV-511 ozone data become unreliable and should not be used.

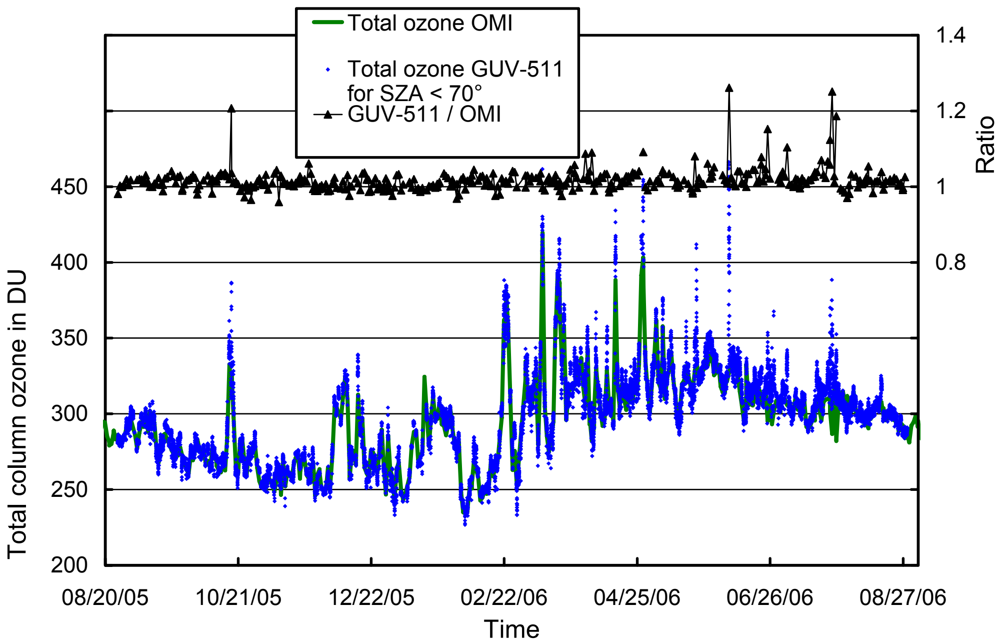

Figure 5.7.12. *Comparison of total column ozone measurements from GUV-511 and OMI. GUV-511 measurements are plotted in 15 minute intervals. For calculating the ratio of both data sets, only GUV-511 measurements concurrent with the OMI overpass were evaluated.*