## 5.5. San Diego (10/8/04 – 8/23/05)

The 2004-2005 season at San Diego includes the period 10/8/04 – 8/23/05. 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 14 season.

- **10/08/04:** Start of the season following operator training
- **10/14/04:** External wavelength scans, replacement of voltmeter and shunt used for measuring lamp current
- **10/15/04:** Replacement of controller for monochromator temperature to correct monochromator temperature instabilities
- **10/18/04:** Test of amplifier for Eppley PSP pyranometer
- **10/27/04:** Long power outage during winter storm
- **11/01/04:** Test temperature stabilization of instrument to correct discrepancies between temperature readings of different sensors
- **11/24/04:** Continuation of testing temperature sensors roofbox; evaluation of an integrating sphere (the purpose of this evaluation is to test a new material for the integrating sphere used in the collector of the of SUV-150B spectroradiometer at Summit, Greenland)
- **11/25/04:** Evaluation of integrating sphere for instrument at Summit
- **11/29/04:** Adjustment of parameters of temperature controller for instrument enclosure
- **11/30/94:** Measurement of fluorescence of integrating sphere for instrument at Summit
- **12/23/04:** Replacement of Eppley PSP pyranometer with a different unit
- **01/04/05:** Cloning of hard drive of system control computer
- **01/06/05:** Troubleshooting in response to defective scans of the internal lamp on 01/05/05 and 01/06/05
- **02/22/05:** Repair of intermitted temperature sensor of instrument enclosure
- **04/01/05:** Replacement of voltmeter and shunt for measuring lamp current
- **04/04/05:** System “hung” for unknown reasons
- **07/13/05 – 07/15/05:** Training of research associate for instrument at Summit
- **07/15/05 – 7/29/05:** Troubleshooting of “logger” application controlling the GUV-511 radiometer
- **07/29/05, 08/03/05:** Switch to second hard drive
- **08/22/05:** End of season and start of operator training

With the exception of some problems with the temperature stabilization of the instrument, the system operated normally during the Volume 14 period. The monochromator temperature was too high before the temperature controller was replaced on 10/15/04. The temperature of the instrument enclosure was too low by 5-10 °C in November 2004. Both problems did not significantly affect solar data.

Approximately 96% of all scheduled data scans are part of the published dataset. A total of 1.3% of all solar scans was lost due to technical problems. The majority of the missing scans were superceded by operator training, upgrades, tests, instrument calibration, and maintenance.

Volume 14 also includes data from a GUV-511 moderate-bandwidth filter radiometer (Section 2). These data complement SUV-100 measurements and are also used for quality control. A comparison of GUV-511 and SUV-100 data is provided in Section 5.5.5.

### 5.5.1. Irradiance Calibration

The calibration of Volume 14 solar data was mostly based on lamp 200W028. The lamp was originally calibrated by Optronic Laboratories in March 2001. The lamp's calibration changed by 3.5% in the UV and 1.5 - 2.5% in the visible between October 2004 and April 2005. The lamp's original calibration was used before 4/14/05. The lamp was recalibrated by comparison with lamps M-763 and 200W017 using measurements from 4/26/05 and the new calibration was used from 4/15/05 onward. Scans with lamp 200W028 performed after 4/26/05 did not indicate any additional change of the lamp. 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, which also has an Optronic Laboratory calibration from March 2001. Lamps M-763 and 200W017 agreed to within ±1% on 4/26/05.

Lamp 200W028 was further compared with the traveling standard M-764. Scans of lamp M-764 at McMurdo, South Pole, Ushuaia and San Diego suggest that this lamp has changed by 1.5-3% during the first half of 2005, possibly during transport from Ushuaia to San Diego. Due to this change, absolute scans of lamp M-764 performed in 2005 were not used for the calibration of solar data.

Figure 5.5.1 shows a comparison of lamps 200W028 and M-764 performed at the start of the Volume 14 season. The calibrations of both lamps agreed to within ±1.5%. Lamp M-764 was still a reliable calibration standard at that time.

Figure 5.5.2 shows a comparison of lamps 200W028, 200W022, M-763, 200W017, and M-764 performed on 10/5/05 and 10/6/05 shortly after the Volume 14 period had ended. Lamp 200W022 is a long-term standard like M-763, which has a Optronic Laboratory calibration from March 2001. For 200W028, the transfer calibration from 4/26/05 was used. All lamps agreed to within ±1.5%, with the exception of M-764, confirming that this lamp has drifted.

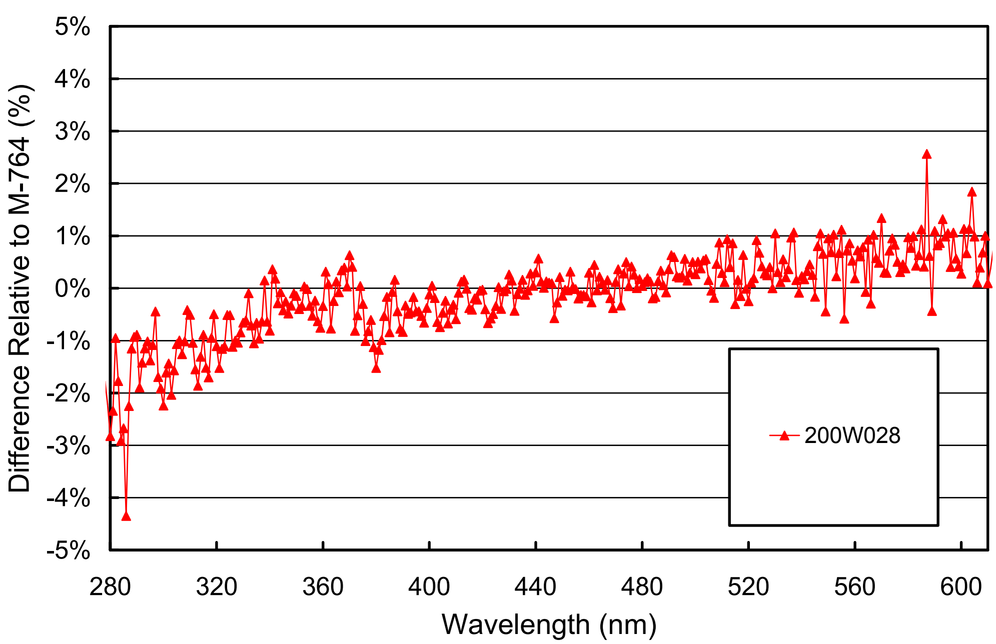


**Figure 5.5.1.** *Comparison of lamps 200W028 and M-764 on 10/8/05.*

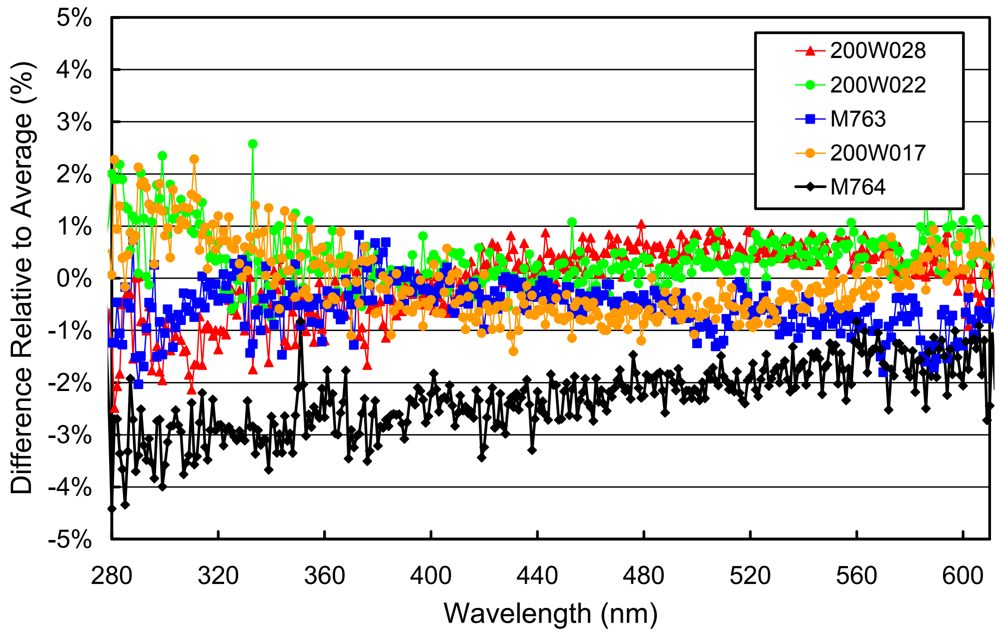


**Figure 5.5.2.** *Comparison of lamps 200W028, 200W022, M-763, 200W017, and M-764 on 10/5/05 and 10/6/05.*

## 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. Usually a new irradiance is assigned to the internal lamp when TSI measurements indicate that the lamp has drifted by more than 2%.

Figure 5.5.3 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 entire season. Measurements of the TSI were stable to within ±1.5%, indicating good stability of the reference lamp. PMT currents show a general downward trend and a change of 3-5% between 4/14/05 and 4/15/05. The reason for this change is unknown but likely not related to the monochromator. Scans of the internal lamp are not only used to monitor stability but also to correct solar data for changes in responsivity. Despite this correction, the ratio of GUV measurements and final SUV data exhibits a step change of 1-4% on 4/14/05, depending on wavelength, indicating that the change in responsivity has not been completely removed. A part of this change can also be attributed to the change of the calibration of lamp 200W028, which occurred at around the same time. Variations in the order of ±2% are still within the uncertainty of the measurement.

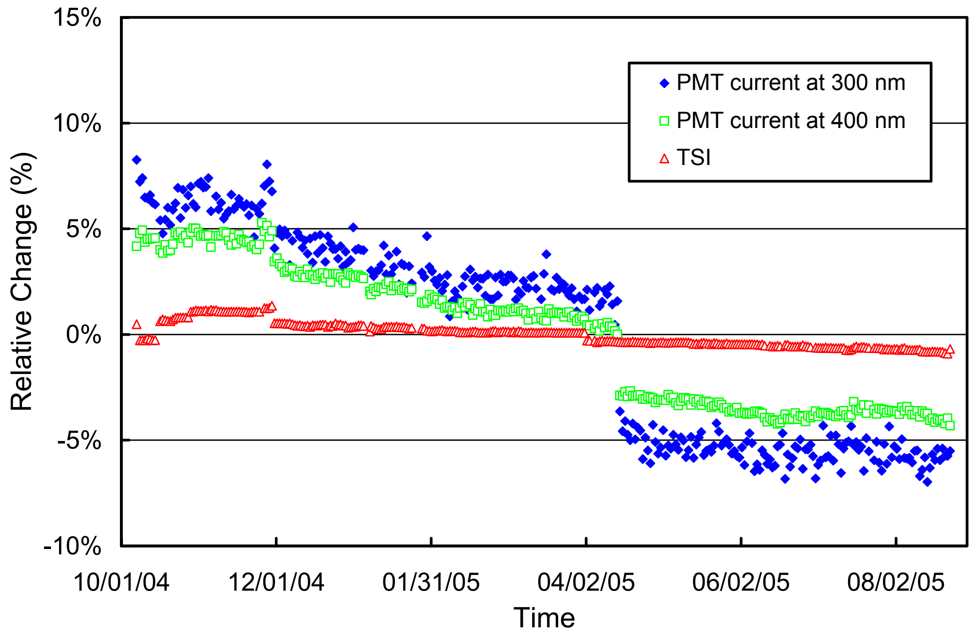


**Figure 5.5.3.** *Time-series of PMT current at 300 and 400 nm, and TSI signal calculated from measurements of the internal irradiance reference lamp during the San Diego 2004-2005 season. All data sets are normalized to their average values.*

The season was divided into two calibration periods. Figure 5.5.4 shows the ratio of the spectral irradiance assigned to the internal reference lamp during the second period (11/25/04-8/23/05) referenced to the irradiance assigned in the first period (10/07/04-11/24/04). The change of the two calibration functions is about 1.5%.

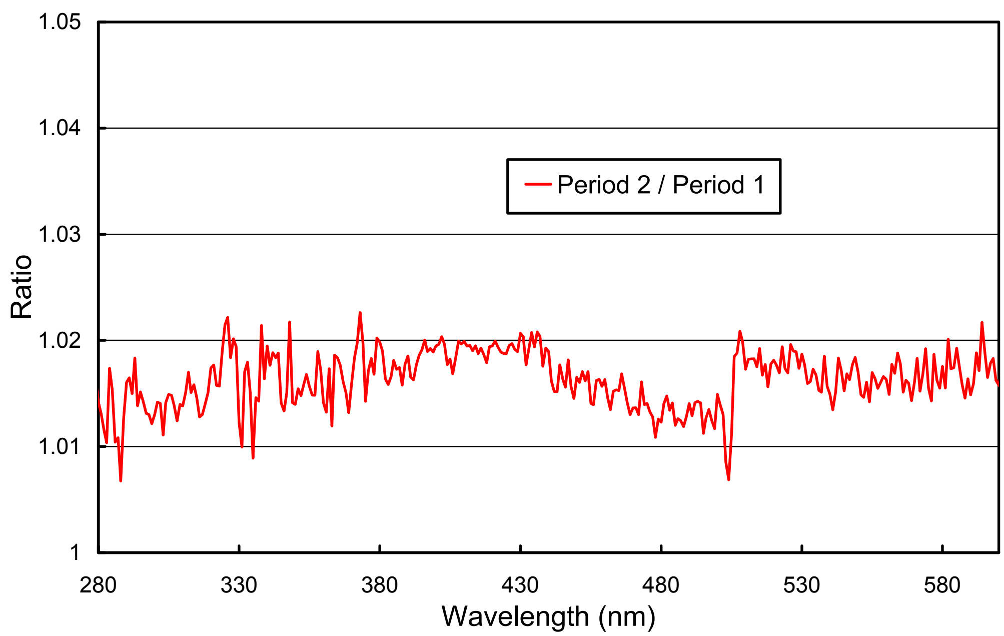


**Figure 5.5.4.** *Ratios of irradiance assigned to the internal reference lamp in Period 2 referenced to Period 1.*

Figure 5.5.5 shows the relative standard deviation of all spectra that contribute to the irradiance spectra assigned to the internal lamp in Period 1 and 2. The plot is useful for estimating the variability of calibrations in a given period. Calibrations were generally consistent to within 1.5% (1σ). At shorter wavelengths, the calibrations are affected by noise resulting in a somewhat larger variability.

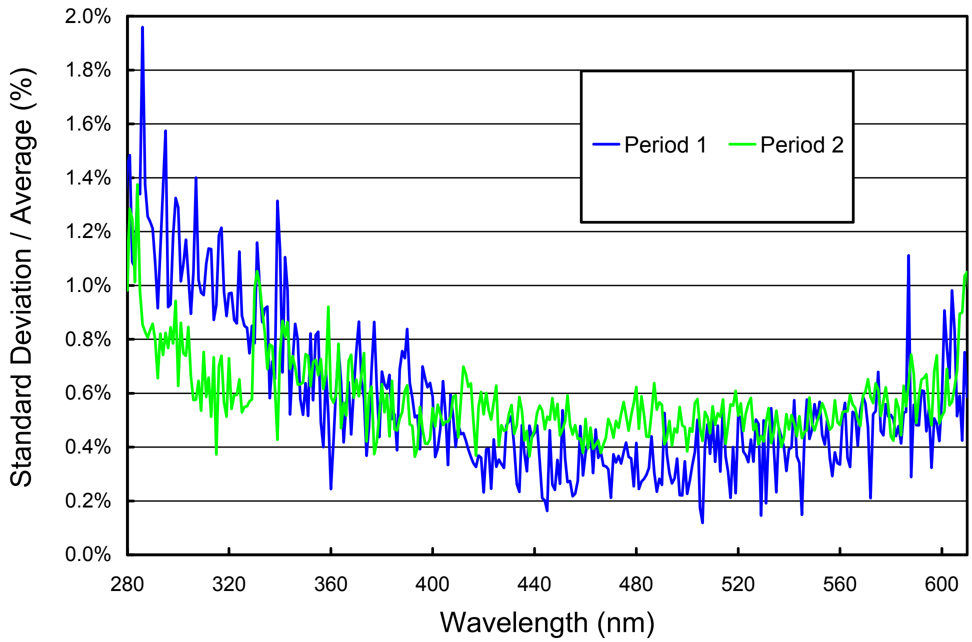


**Figure 5.5.5.** *Ratio of standard deviation and average calculated from the absolute calibration scans that were used to establish the calibration of the San Diego spectroradiometer for the 2004-2005 season.*

### 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 5.5.6 shows the differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 366 scans were evaluated. For 95% of the days, the change in offset was smaller than ±0.025 nm; for 97% of all days shifts were below 0.055 nm. Ten scans showed a change larger than ±0.1 nm. These changes are mostly caused by system maintenance. 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). The calculated correction function is shown in Figure 5.5.7.

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 5.5.8 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 5.5.8. The actual wavelength uncertainty may be somewhat larger due to wavelength fluctuations of about ±0.02 nm during the day.

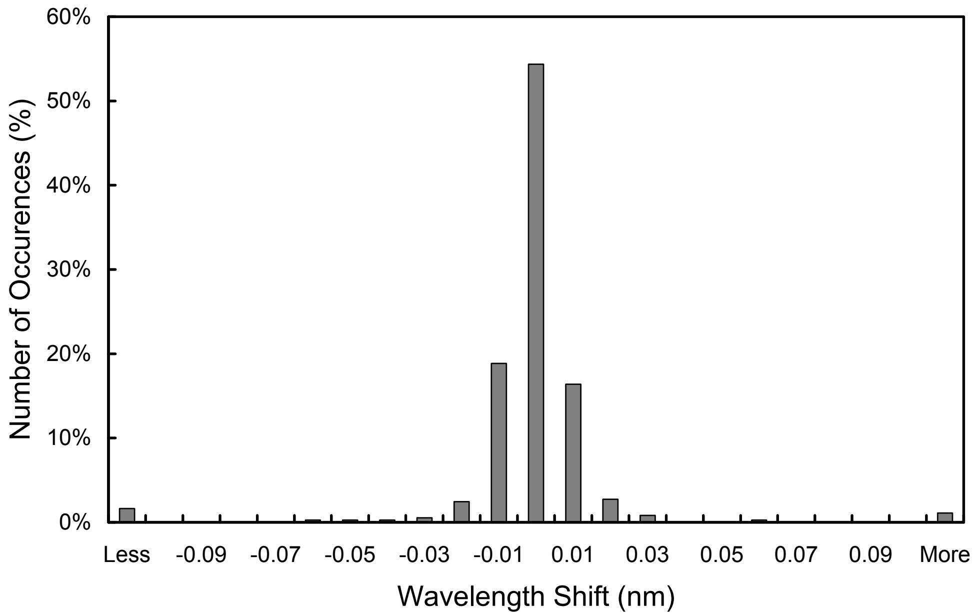


**Figure 5.5.6.** *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

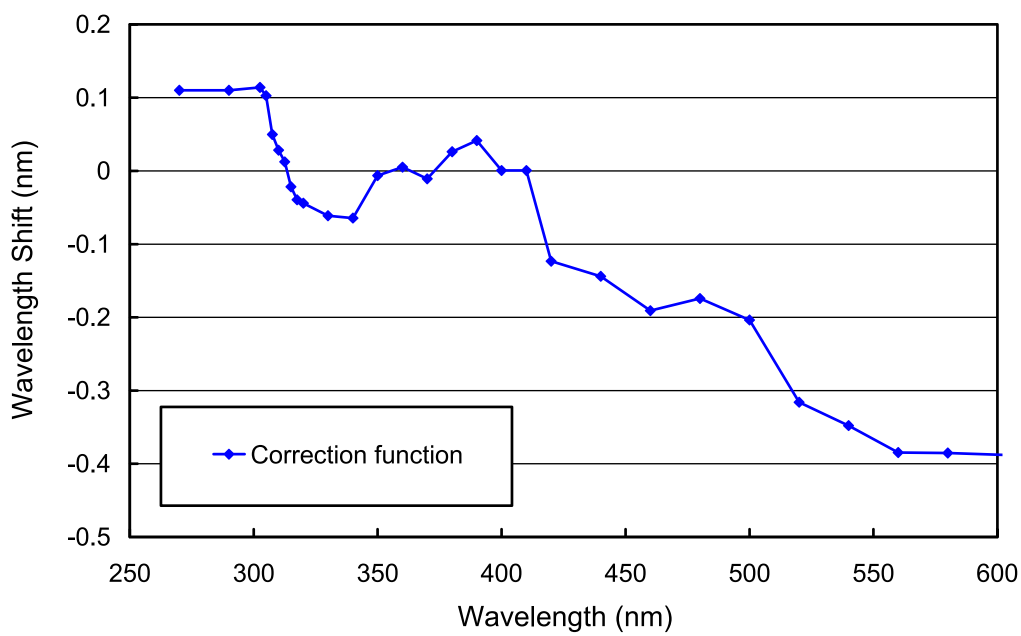


**Figure 5.5.7.** *Monochromator non-linearity correction function for the San Diego 2004-2005 season.*

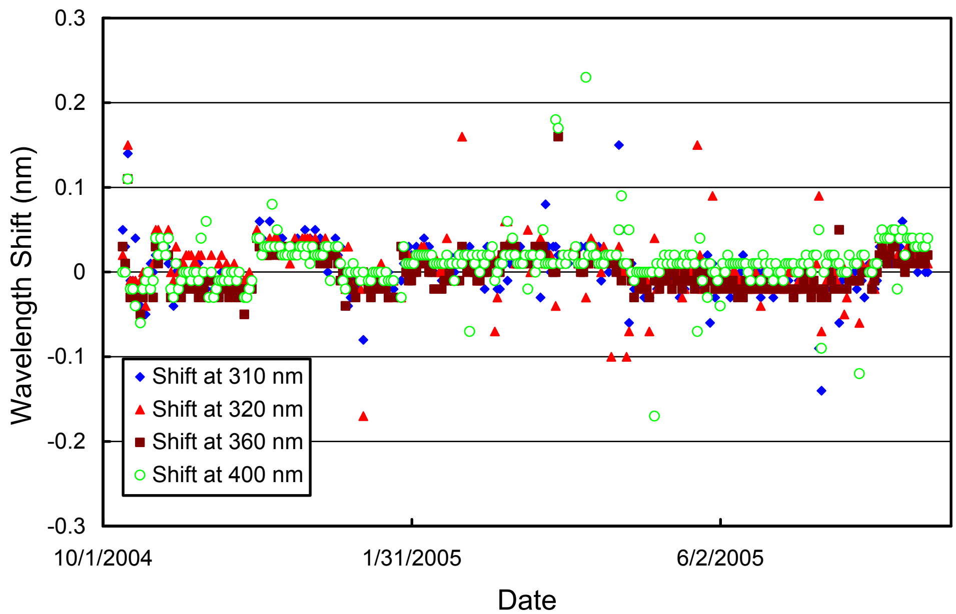


**Figure 5.5.8.** *Check of the wavelength accuracy of final data at four wavelengths by means of Fraunhofer-line correlation. The noontime measurements have been evaluated for each day of the season.*

Although data from external mercury scans do not have a direct influence on the data products, they are an important part of instrument characterization. Figure 5.5.9 shows internal and external mercury scans measured in October 2004. The bandwidth of the external scan is 1.05 nm; that of the internal scan is 0.93 nm. The external scan has the same light path as solar measurements. The center wavelength of the external scan is approximately at the nominal wavelength of 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 15326 scans are part of the published San Diego Volume 14 dataset. These are 96% of all solar scans scheduled between 10/8/04 and 8/23/05. Approximately 1.6% of solar scans were superceded by calibrations performed throughout the season. Additional reasons for missing solar data are technical problems (1.3 %) and system tests and upgrades (0.9%). Table 5.5.2 describes gaps in published solar data in more detail.

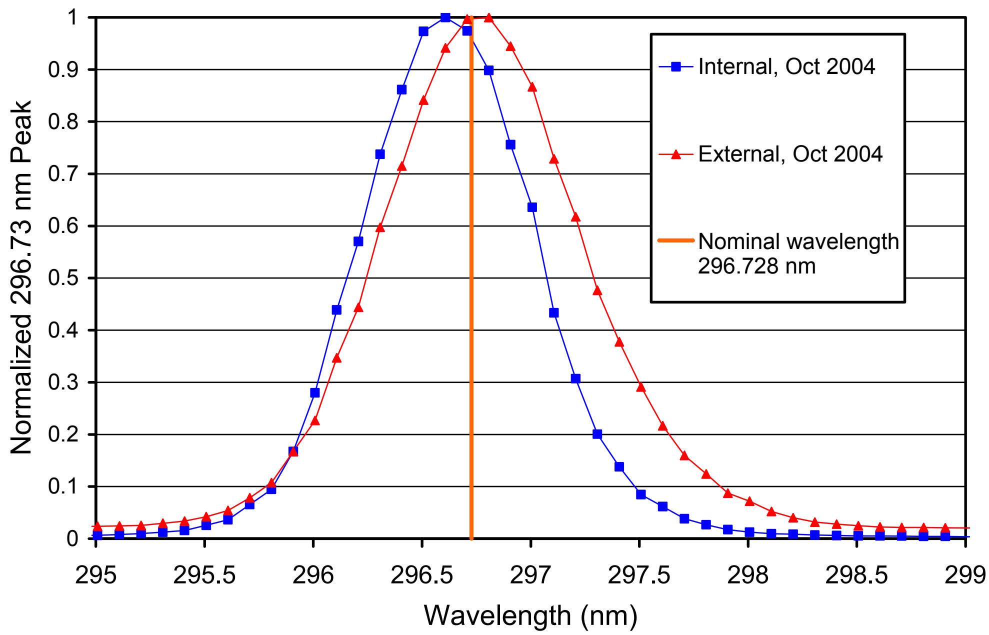


**Figure 5.5.9.** *The 296.73 mercury line as registered by the PMT from external and internal sources.*

**Table 5.5.2 Missing scans San Diego Volume 14 (gaps due to calibration activities are not included).**

| Time Period | Scans missing | Reason |
|---|---|---|
| 10/14/04 | 33 | Series of absolute scans, external mercury lamp scans, replacement of voltmeter and shut used for measuring lamp current |
| 10/15/04, 10/16/04 | 36 | Series of absolute scans, replacement controller monochromator temperature |
| 10/18/04 | 5 | Test amplifier Eppley PSP pyranometer |
| 10/21/04 | 7 | Software “hung” |
| 10/27/04, 10/28/04 | 20 | Power outage |
| 11/24/04, 11/25/04 | 12 | Testing temperature sensors roofbox; evaluation of an integrating sphere for the instrument at Summit, Greenland |
| 11/29/04,11/30/04 | 5 | Measurement of fluorescence of integrating sphere for Summit |
| 12/23/04 | 1 | Replacement of Eppley pyranometer |
| 1/4/05 | 6 | Cloning of hard drive of system control computer |
| 1/6/05 | 5 | Troubleshooting in response to defective scans of the internal lamp |
| 1/24/05 – 1/26/05 | 106 | Power outage |
| 2/22/05 | 1 | Repair of intermitted temperature sensor of roof box |
| 4/1/05 | 2 | Replacement of voltmeter and shunt for measuring lamp current |
| 4/4/05 | 49 | Monochromator control electronics (spectralink) “hung” |
| 6/15/05 | 5 | Scans not recorded for unknown reasons |
| 7/13/05 | 5 | Operator training |
| 7/18/05, 7/22/05, 7/23/05,7/24/05 | 78 | Troubleshooting of “logger” application, which is controlling the GUV-511 radiometer |
| 7/29/05, 8/3/05 | 30 | Switch between hard drives |

### 5.7.5. 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 with the procedure outlined in Section 4.3.2. Figure 5.5.10. shows a comparison of GUV-511 and SUV-100 erythemal irradiance based on final Volume 14 data. For solar zenith angles smaller than 80°, measurements of the two instruments agree to within ±4.4% (±1σ). However, there is a step change in the ratio GUV/SUV of about 4% on 4/14/05. This change is caused by the adjustment of the calibration of lamp 200W028 (Section 5.5.1) and a change of system responsivity (Section 5.5.2). A change of 4% is still within the combined uncertainties of lamp calibration and instrument drifts. Some of the differences between the two instruments seen between October 2004 and April 2005 may also be due to changes in the sensitivity of the GUV instrument as well as low light levels and small solar elevations during winter.

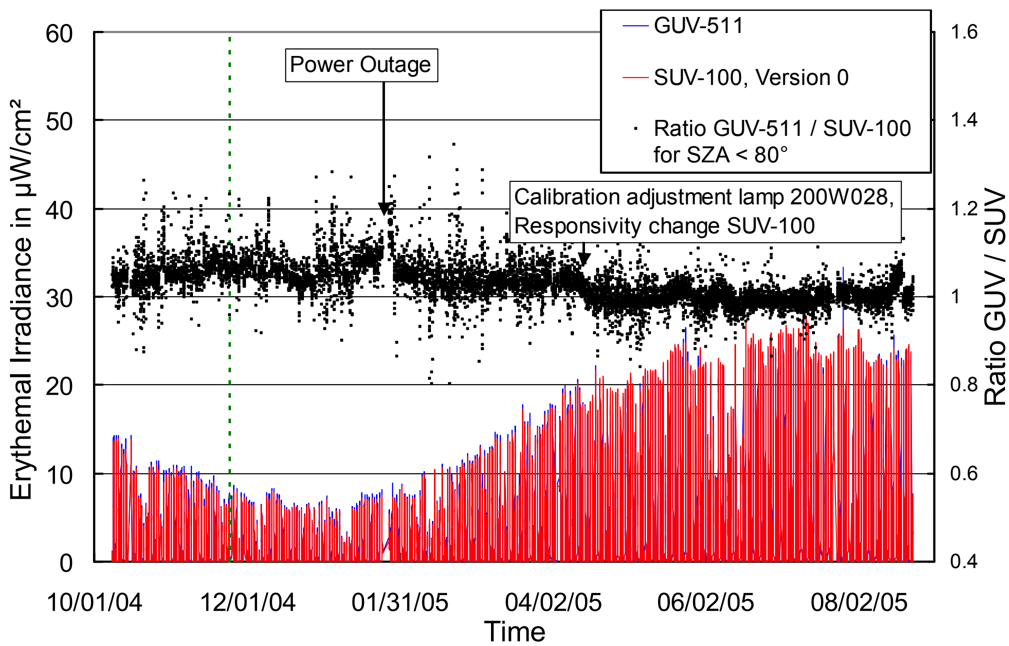


**Figure 5.5.10.** *Comparison of erythemal irradiance measured by the SUV-100 spectroradiometer and the GUV-511 radiometer. SUV-100 measurements are based on "Version 0" (cosine-error uncorrected) data. The broken green line indicates the time when the calibration of the SUV-100 was adjusted.*

Figure 5.5.11 shows a comparison of total ozone measurements from the GUV-511 and NASA/TOMS Earth Probe satellite (Version 8). GUV-511 ozone values were calculated as described in Section 4.3.3. Both data sets agree on average to within 4%. Some of the bias may be related to the recent degradation of the TOMS instrument (personal communication R. McPeters, NASA). For SZA larger than 80°, GUV-511 data become unreliable and should not be used.

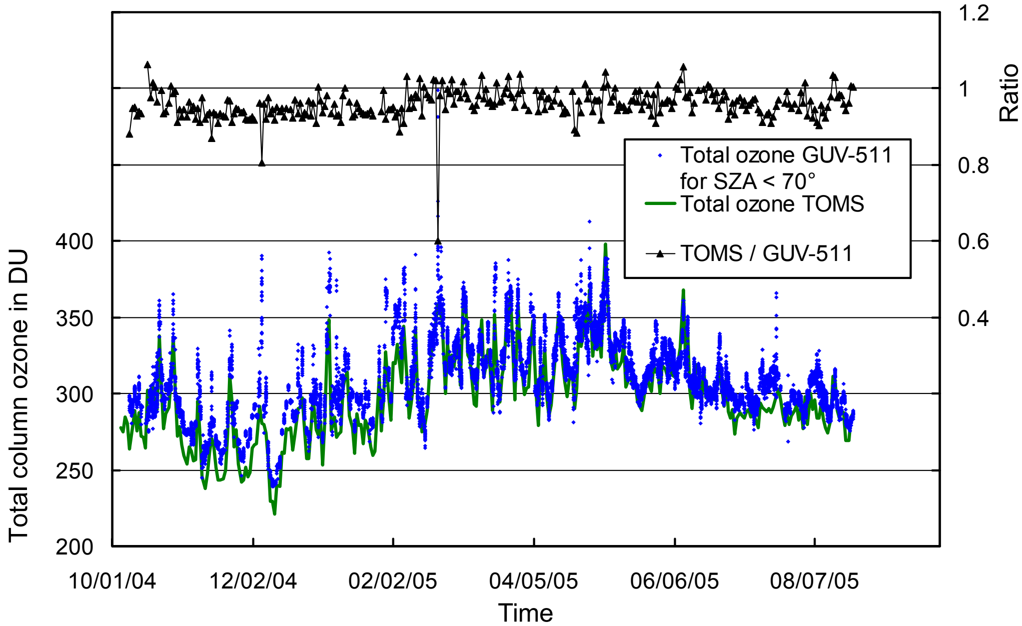


**Figure 5.5.11.** Comparison of total column ozone measurements from GUV-511 and NASA/TOMS Earth Probe satellite. GUV-511 measurements are plotted in 15 minute intervals. For calculating the ratio of both data sets, only GUV-511 measurements concurrent with TOMS overpass data were evaluated.