5.5. San Diego (9/9/00 – 8/14/01)

The 2000-2001 season at San Diego includes the period 9/9/00 – 8/14/01. In contrast to other network sites, San Diego serves also as a facility for operator training, test of new system components, and comparison of calibration standards. Scheduled maintenance is performed year-round and during operator training. The measurement of solar spectra is therefore more frequently interrupted than at other sites. The list below gives an overview of the most important non-standard activities during the San Diego Volume 10 season:

- **9/15/00:** Test of a new light source for angular response characterization
- **10/10/00 – 10/14/00:** Comparison of BSI calibration standards with standards from the Central UV Calibration Facility (CUCF). Results from this comparison were already published in Chapter 5 of the previous Network Operations Report.
- **11/17/00:** Exchange of system control computer
- **10/25/00, 12/05/00, 12/15/00, 01/08/01:** Test of new PMT cooler power supply and characterization of PMT temperature sensitivity in order to resolve PMT cooler power supply related problems at Palmer Station and Ushuaia
- **01/10/01 – 01/11/01:** Adjusting offset of analog digital converter (IFCNT module)
- **02/14/01 – 02/16/01:** Screening of new calibration standards
- **03/13/01 – 03/14/01:** Angular response characterization of system
- **03/20/01 – 03/23/01:** Site operator training for Palmer Station
- **03/30/01:** External wavelength scans
- **04/02/01 – 04/06/01:** Comparison of new calibration standards after their calibration at Optronic Laboratories
- **04/17/01 – 04/20/01:** Systematic evaluation of possible systematic errors related to calibration equipment. Results are published in Chapter 5 of the previous Network Operations Report.
- **05/31/01:** UPS modification
- **06/12/01:** Replacement of air conditioning unit
- **06/15/01:** Installation of new instrument rack
- **06/25/01 – 06/27/01:** Site operator training for Summit, Greenland (future network site)
- **07/12/01:** Characterization of irradiation apparatus from Scripps Institute of Oceanography
- **07/20/01 – 07/21/01:** Characterization of instrument slit function with HeCd Laser

The collector of the instrument was modified during the operator training in September 2000, immediately before the start of Volume 10. This upgrade resulted in substantially decreased azimuth errors, which affected solar data of previous volumes (see the introduction to Chapter 5). In addition, the relay lens of the optics block (see Figure 2.1 of Chapter 2) was replaced with a lens of larger focal length, leading to a higher system sensitivity. This gain in sensitivity compensates for the reduction in sensitivity due to the collector upgrade. Data analysis does not indicate a significant step-change in time-series of noon-time solar irradiance measurements or daily dose data introduced by the upgrade. Small systematic changes at low solar elevations cannot be excluded, though. A investigation on the effect of the cosine error on network data is in preparation.

The system operated normally during the Volume 10 period. Approximately 91% of the scheduled data scans are part of the published dataset. Only a small fraction of all solar scans was lost due to technical problems. The majority of the missing scans were superceded by the activities compiled above, and scheduled instrument calibration and maintenance.

5.5.1. Irradiance Calibration

The calibration of the spectroradiometer in San Diego was based on 15 different calibration standards that were calibrated by Optronic Laboratories in March 2001. Some of these standards had been in use before and were re-calibrated. Some standards were new and were calibrated for the first time. Table 5.1.1 lists all the lamps, their history, and assigned use for the future. After the lamps had been returned from Optronic Laboratories , they were compared with each other to check the consistency of their calibration. The result is shown in Figure 5.5.1. All lamps agree to within ±1% in the visible and ±1.5% in the UV, which is within the calibration uncertainty by Optronic Laboratories. From 05/05/01 onward, San Diego calibrations are based on the lamps 200W028 and 200W029 exclusively.

Table 5.5.1. Lamps used at San Diego during the Volume 10 season.

Serial Number	Previous Use	Future Use
200W009	Site standard Barrow	Site standard Barrow
200W017	N/A	undecided
200W022	Long-term reference	Long-term reference
200W023	N/A	Site standard Valdivia
200W025	N/A	Site standard Valdivia
200W026	N/A	Site standard Ushuaia
200W027	N/A	Site standard Summit
200W028	N/A	Site standard San Diego
200W029	N/A	Site standard San Diego
200W030	N/A	Site standard Summit
M-699	Site standard Barrow	Site standard Barrow
M-762	Site standard Barrow	Site standard Barrow
M-763	Site standard South Pole	Long-term reference
M-764	Site standard McMurdo / Traveling standard	Traveling standard
M-874	Traveling standard	Retired

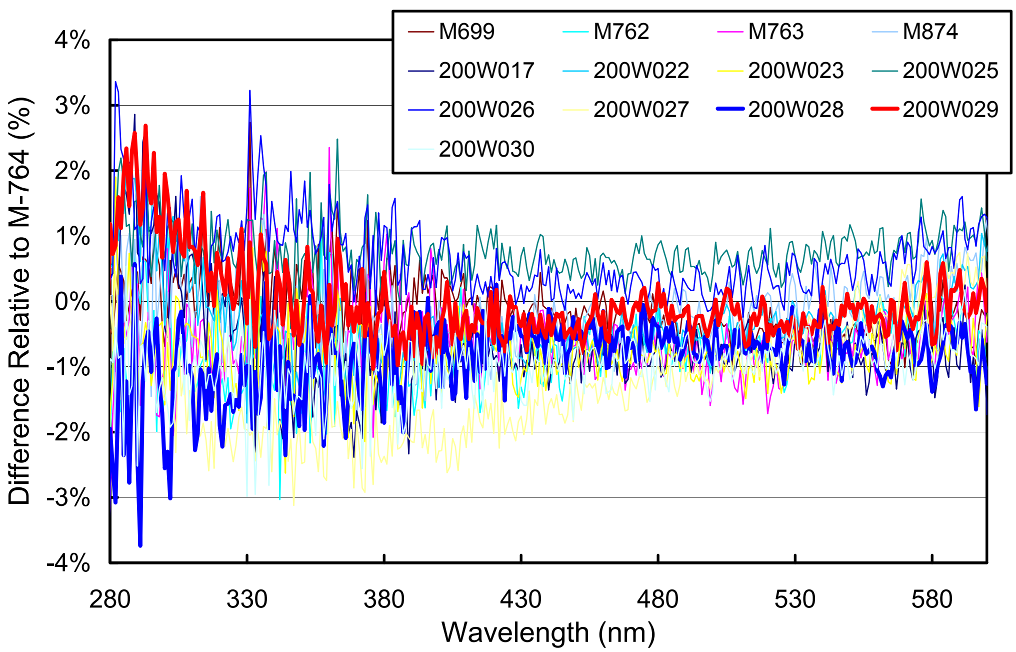

Figure 5.5.1. *Comparison of 13 lamps with lamp M-764 after return from their calibration by Optronic Laboratories in March 2001. The data for lamps 200W028 and 200W029 are printed bold, as both lamps served as site standards for San Diego for the period 5/5/01 – 8/15/01.*

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. 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 this lamp has drifted by more than 2%.

Figure 5.5.2 shows TSI measurements and PMT currents at 300 and 400 nm during response scans. TSI measurements agree to within ±2.5% and PMT currents to within ±10%. There are abrupt changes in all three parameters at certain times, which can be explained as follows:

- Change of all parameters by +2.5% on 10/11/00:
  This change is attributable to two causes, the exchange of the shunt that is used to set the lamp current and the resolution of the lamp power supply.
  - It was discovered during the CUCF 2000 lamp comparison campaign that the resistance of the shunt used to set the lamp current was too high by 0.1%. The lamp current before 10/11/00 was therefore too low by 0.1%. A deviation of the current of this amount leads approximately to a 1% reduction of the lamp's radiative power in the UV.
  - The accuracy of the lamp current is principally limited to approximately ±0.07% by the resolution of the digitally controlled power supply. (The small fluctuation of the TSI signal that can be seen in Figure 5.5.2 before 10/11/00 is mostly attributable to this effect). Before this date, the current tended to be too low by 0.07%, after that date it was generally too high by approximately the same amount.

  Because of both effects, the lamp's radiative power in the UV was too low by 1.7% before 10/11/00 and too high by 0.7% afterwards. Solar data was not corrected.

- Adjustment of the instrument's analog to digital converter (ADC) on 01/10/01:
  The change in PMT current at 300 nm on 01/10/01 is attributable to the adjustment of the offset of the ADC. (All data depicted in Figure 5.5.2 show signal levels without the offset subtracted As the absolute signal at 300 nm is much smaller than the signal at 400 nm, the data at 300 nm is more affected by the offset adjustment). Solar data are not affected as the offset is measured before each scan and subtracted from the signal.

- Site operator training on 3/22/01:
  The system was removed for site operator training on 3/21/01 and redeployed on 3/22/01. As the internal irradiance standard was not replaced, TSI readings before and after system removal agree to within 1%. Due to the system services performed, PMT currents after installation are higher by several percent. Solar data are not affected as a new irradiance was assigned to the internal lamp in Period 2.

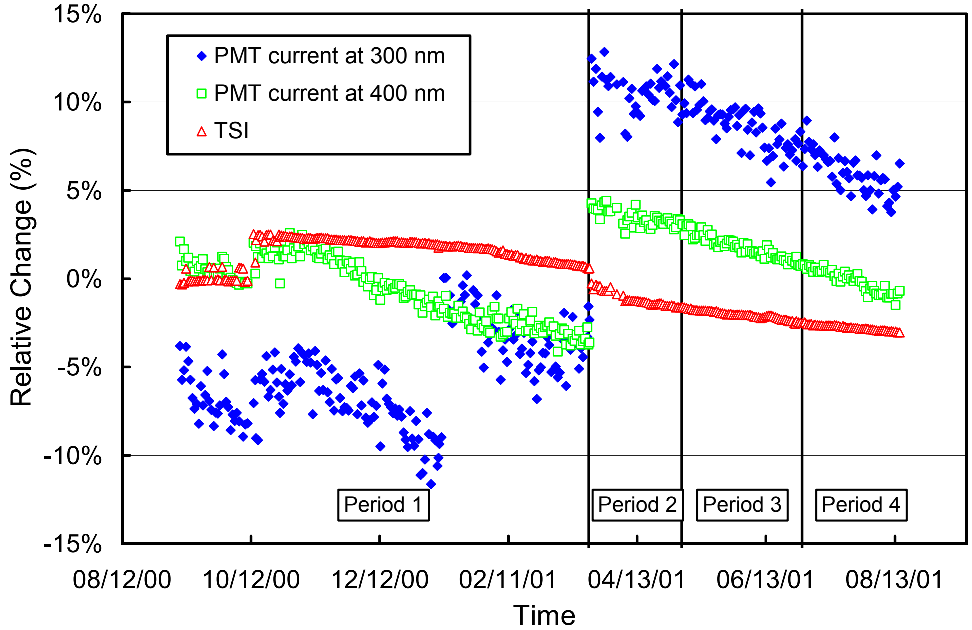

Figure 5.5.2. *Time-series of PMT current at 300 and 400 nm, and TSI signal during measurements of the internal irradiance reference lamp during the San Diego 2000-2001 season. The data is normalized to the average value of the whole season.*

The San Diego Volume 10 season was split in four different periods (named Period 1 – 4). Different irradiance spectra were assigned to the internal lamp in each period (see Section 4.2.1.2 for details). As mentioned before, a break in the calibration between Period 1 and 2 was required due to system service during operator training. Figure 5.5.3 shows the ratios of irradiances assigned to the internal reference lamp, referenced to Period 2. The change between Period 3 and Period 2 is below 2%. There is virtually no change between Period 3 and Period 4. The only reason why two separated calibration files were used is due to the fact that solar data based on the calibration of Period 3 have been used for SUV-GUV comparisons before the final calibrations for San Diego were established. The preliminary calibration for Period 3 was not changed to avoid reprocessing the comparison data. For all four periods, the standard deviation of the individual spectra contributing to the average spectrum in a given period were calculated. Figure 5.5.4 shows the ratio of the standard deviation and average spectra. The ratios are useful for estimating the variability of the calibrations in each period. Figure 5.5.4 shows that the calibrations performed in each of the four periods are consistent to within 1.5% (1σ).

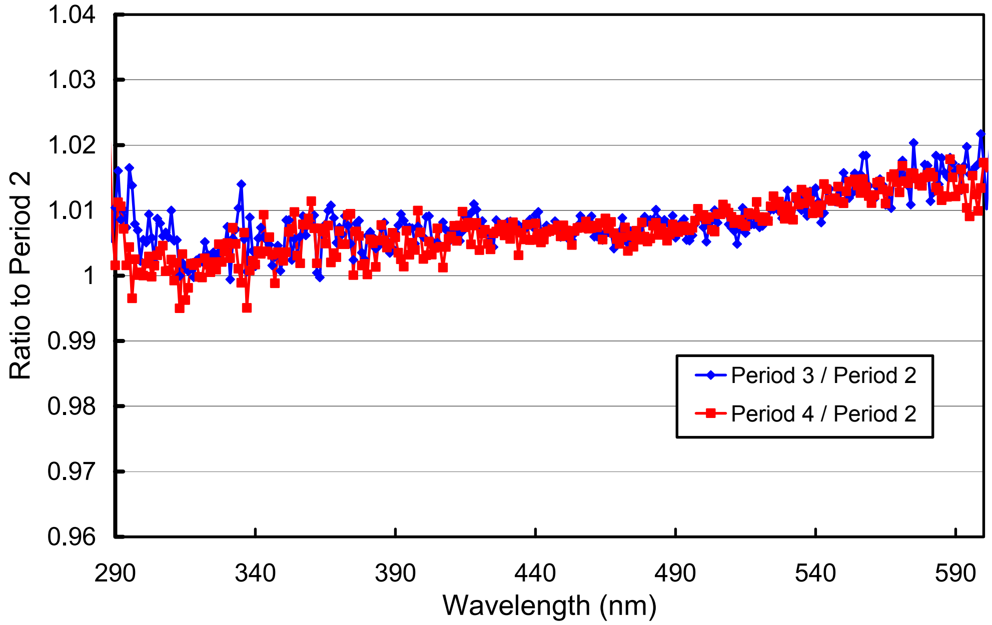

Figure 5.5.3. *Ratios of irradiance assigned to the internal reference lamp, referenced to Period 2.*

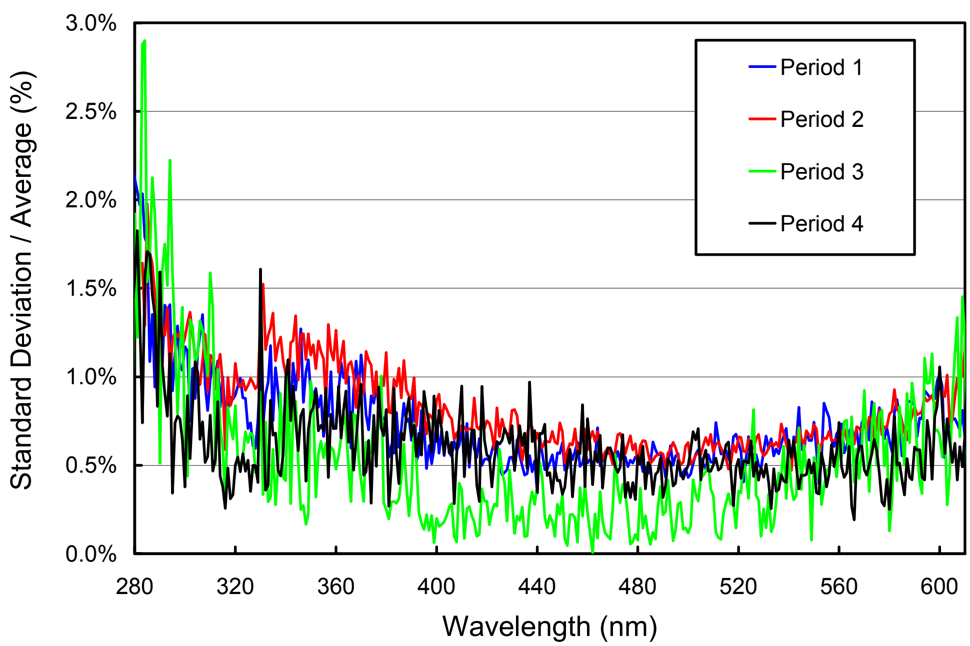

Figure 5.5.4. *Ratio of standard deviation and average calculated from the absolute calibration scans used to establish the calibration of the San Diego spectroradiometer for the 2000-2001 season.*

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 5.5.5 shows the differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 381 scans were evaluated. For 74% of the days, the change in offset was smaller than ±0.025 nm; for 94% of all days shifts were below 0.055 nm. Seven scans showed a change larger than ±0.1 nm caused by system maintenance. The wavelength calibration was adjusted accordingly.

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 Fraunhofer-correlation method, as described in Section 4.2.2.2. Figure 5.5.6 shows the resulting correction functions that were applied to the Volume 10 San Diego data. Three different functions were used for three different periods, labeled Period A – C. Site operator training took place between Periods A and B.

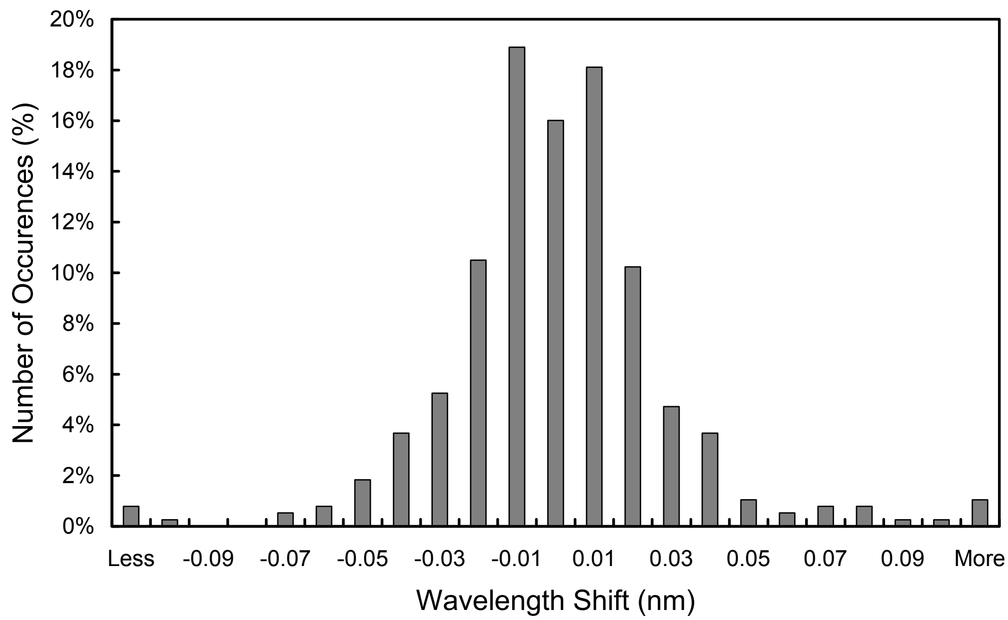

Figure 5.5.5. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

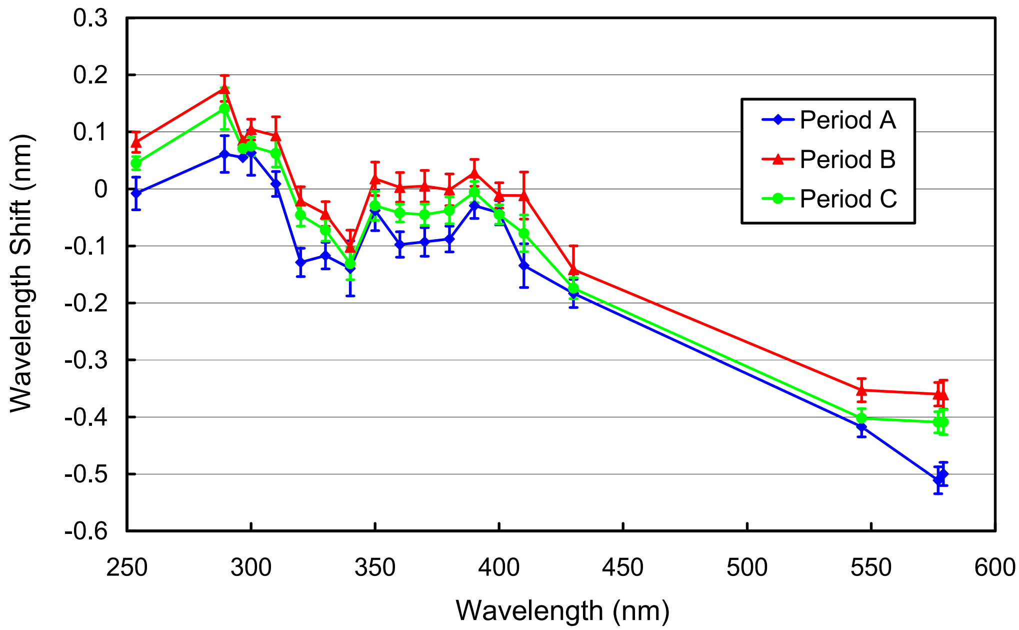

Figure 5.5.6. *Monochromator non-linearity for the San Diego 2000-2001 season for Periods A (9/8/00 – 3/21/01), Period B (3/22/01 – 6/8/01), and Period C (6/9/01 – 8/15/01).*

After the data was wavelength corrected using the shift function described above, the wavelength accuracy was confirmed again with the Fraunhofer method. The results are shown in Figure 5.5.7 for four UV wavelengths, evaluated for all noontime scans measured during the season. The residual shifts are generally smaller than ±0.05 nm. The actual wavelength uncertainty may be larger due to wavelength fluctuations of about ±0.02 nm during the day, and possible systematic errors of the Fraunhofer-correlation method (see Chapter 4).

Although data from the external mercury scans do not have a direct influence on the data products, they are an important part of instrument characterization. Figure 5.5.8 illustrates the difference between internal and external mercury scans measured in March 2001. The peak of the external scans, agrees approximately with the nominal wavelength of 296.73 nm, whereas the peak of the internal scans is shifted about 0.12 nm to shorter wavelengths. External scans have a bandwidth of about 1.03 nm FWHM, whereas the bandwidth of the internal scan is only 0.75 nm. Since external scans have the same light path as solar measurements, they more realistically represent the monochromator bandpass relevant to solar scans.

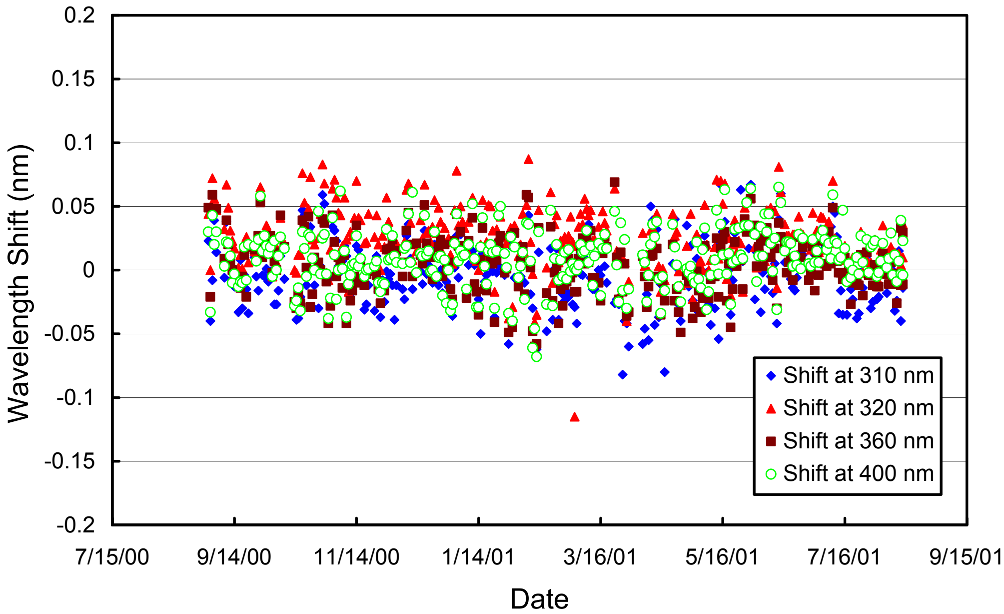

Figure 5.5.7. *Check of the wavelength accuracy of the final data at four wavelengths by means of Fraunhofer correlation. The noontime measurements have been evaluated for each day of the season.*

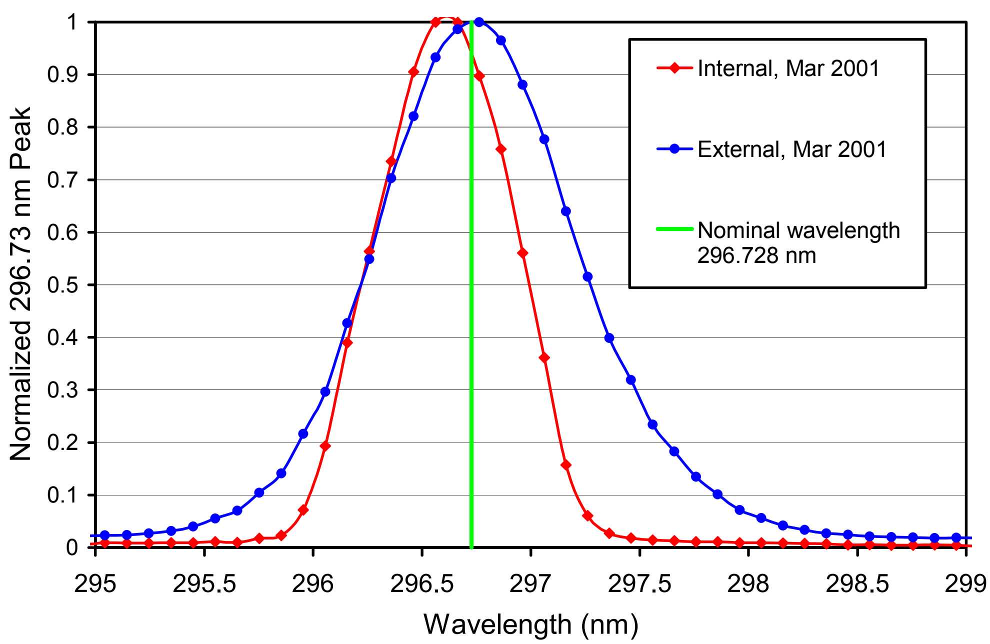

Figure 5.5.8. *The 296.73 mercury line as registered by the PMT from external and internal sources.*

5.5.4. Missing Data

A total of 15426 scans are part of the published San Diego Volume 10 dataset. These are 91% of all scans scheduled between 9/9/00 and 8/14/01. Approximately 1.2% of all scans were superceded by scheduled calibrations performed throughout the season. The rest of the missing scans were lost due to system service (0.9%); support of other sites, including operator training (1.9%); system characterization (0.5%); calibration standard comparison and lamp screening (3.2%); support of other researchers (0.1%); and operation errors (1.2%). Table 5.5.2 describes the gaps in the published solar data in more detail:

Table 5.5.2 Missing scans San Diego Volume 10.

Time Period	Scans missing	Reason
9/15/00	10	Test light source for angular response measurements
10/10/00 – 10/14/00	163	Calibration standard comparison / CUCF audit
10/25/00	21	Adjustment PMT cooler
11/17/00	25	Exchange system control computer
11/27/00	4	Test GPS module
12/05/00 – 12/06/00	19	Test temperature sensitivity PMT
12/15/00	23	Test PMT cooler and dark measurements
01/08/01 – 01/09/01	20	Test temperature sensitivity PMT
01/10/01 – 01/11/01	23	Adjusting electronics (IFCNT module)
02/14/01-02/16/01	80	Screening of new calibration standards
03/13/01 – 03/14/01	12	Angular response characterization of system
03/20/01 – 03/23/01	161	Site operator training for Palmer Station
03/30/01	14	External wavelength scans
03/30/01 – 04/01/01	121	Shutter closed
04/02/01 – 04/06/01	193	Comparison of new calibration standards
04/11/01	6	Exchange multimeter of calibration equipment
04/17/01 – 04/20/01	117	Evaluation calibration equipment (power supply, shunt, stand, etc.)
04/23/01	8	Software installation
04/25/01 – 04/27/01	89	Shutter closed
05/24/01 – 05/25/01	11	Network configuration
5/31/01	7	UPS modification
06/12/01	14	Installation of air conditioning unit
06/15/01	14	Installation new instrument rack
06/25/01-06/27/01	73	Site operator training for Summit, Greenland
07/12/01	14	Characterization of irradiation apparatus Scripps
07/20/01 – 07/21/01	43	Characterization of instrument slit function with HeCd Laser