5.7. San Diego, California, USA

The spectroradiometer system at San Diego is located in the roof of Biospherical Instruments Inc., approximately three miles from the Pacific Ocean. Since its installation on October 28, 1992, the system has been operating normally. In addition to collecting data for the NSF UV network, this SUV is used for testing software and hardware, long-term engineering change evaluation, and training of site operators. This means that system operation is more frequently interrupted by these activities than at other network sites.

Figure 5.7.1. *SUV-100 mounted through the roof of a specially constructed room at Biospherical Instruments in San Diego, California. This rooftop facility is used for calibration and intercomparison of UV and visible radiometers.*

The city of San Diego is situated on San Diego Bay in the southwestern most corner of California (32°45'N, 117°11'W). The Pacific Ocean tempers prevailing winds and weather, creating an environment different from other locations along this latitude. Temperatures typically range from 16 to 27°C throughout the year. Temperatures of freezing or below freezing are rare, while hot (32°C+) weather is slightly more frequent. Considerable fog occurs on the coast (where the instrument is located), particularly during fall and winter months. The following figures illustrate the day length and typical zenith angles during noon for San Diego, CA. Typical cloud cover data are summarized in Table 5.7.1.

Table 5.7.1. Typical cloud-cover data for San Diego.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Sky Cover	3.9	5.9	7.0	5.7	8.1	4.7	5.1	3.4	3.0	5.0	3.7	4.5
% Possible Sunshine	83	68	54	77	40	62	64	82	84	68	90	71
Number of Clear Days	18	8	6	9	3	15	11	17	21	12	17	13
Number of Cloudy Days	10	12	19	11	22	7	7	3	4	10	8	10
Number of Part/Cloudy Days	3	9	6	10	6	8	13	11	5	9	5	8

Note: Data supplied by the National Weather Service.

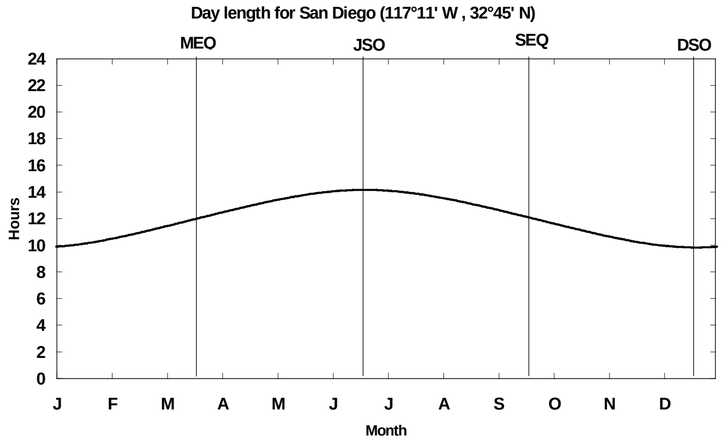

Figure 5.7.2.
Day length for San Diego. (MEQ=March equinox, JSO=June solstice, SEQ=September equinox, DSO=December solstice)

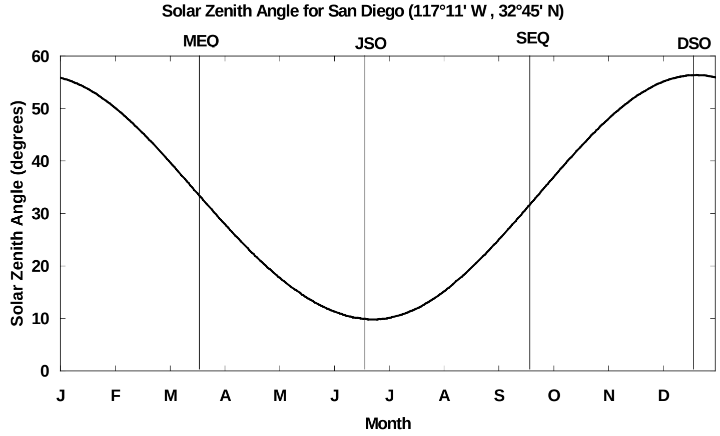

Figure 5.7.3.
Noontime solar zenith angle during the year at San Diego.

5.7.1. Weather Observations

Weather observations for San Diego, California (WMO station number 72290) were obtained from the National Climatic Data Center (NCDC). The data are in a format described in Appendix A7 of this report. The file SAN DIEGO.CSV, can be found in the \WEATHER directory on the CD-ROM 7.0.b.

5.7.2. Ozone Observations

Table 5.7.2 TOMS ozone averages and minima for San Diego.

	TOMS												TOVS		
	Nimbus 7			Meteor 3			Adeos			Earth Probe					
Year	**Avg**	**Min**	**Date**	**Avg**	**Min**	**Date**	**Avg**	**Min**	**Date**	**Avg**	**Min**	**Date**	**Avg**	**Min**	**Date**
1988	302.1	224	1/26/88												
1989	306.3	251	11/22/89												
1990	308.5	248	11/30/90												
1991	315.6	235	12/4/91	286.6	243	12/4/91									
1992	299.3	225	12/25/92	298.1	224	12/25/92									
1993				286.8	235	11/20/93									
1994				305.1	218	11/24/94							293.8	227	3/20/94
1995													291.1	239	12/12/95
1996							276.6	225	11/23/96, 11/24/96	281.6	221	11/24/96	299.3	257	2/19/96
1997							304.0	244	1/1/97	294.6	245	1/30/97			
1998										307.4	242	1/31/98			

Note: Shaded areas represent partial year data.

Table 5.7.3. TOMS ozone data availability description for San Diego.

	T O M S				**TOVS**
Year	**Nimbus 7**	**Meteor 3**	**Adeos**	**Earth Probe**	
1988	full year				
1989	full year				
1990	full year				
1991	full year	8/28/91 – 12/31/91			
1992	full year	full year			
1993		full year			
1994		1/1/94 – 12/1/94			3/1/94 – 10/31/94
1995					full year
1996			9/11/96 – 12/31/96	7/16/96 – 12/31/96	1/1/96 – 9/8/96
1997			1/1/97 – 6/29/97	full year	
1998				1/1/98-12/12/98	

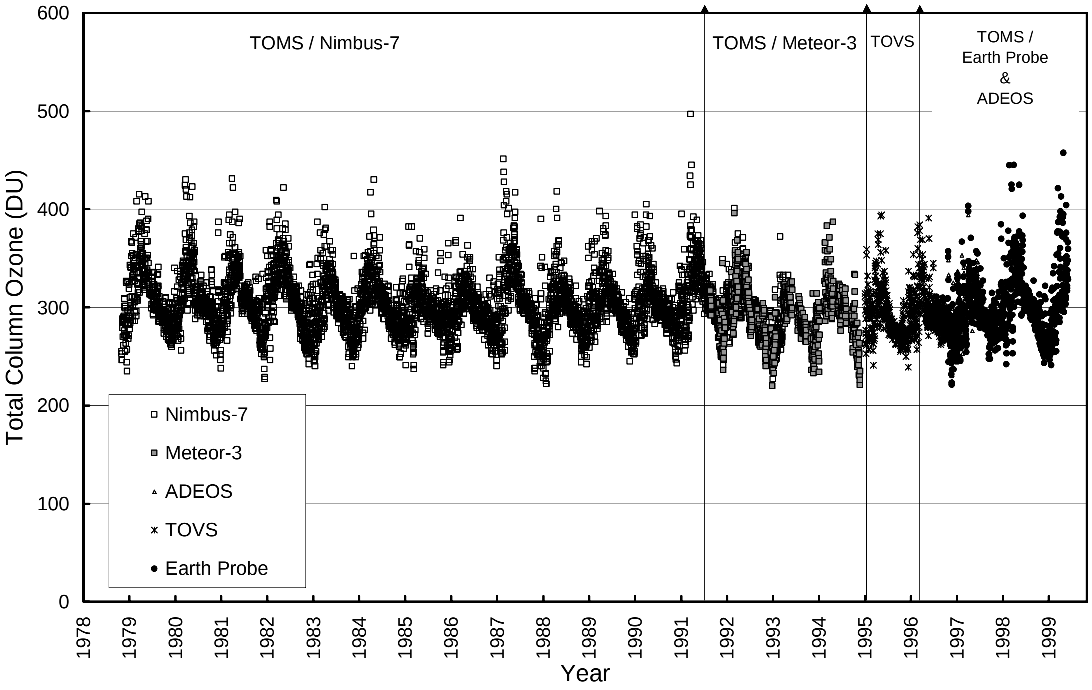

Figure 5.7.4. *Total column ozone at San Diego as reported by TOMS and TOVS.*

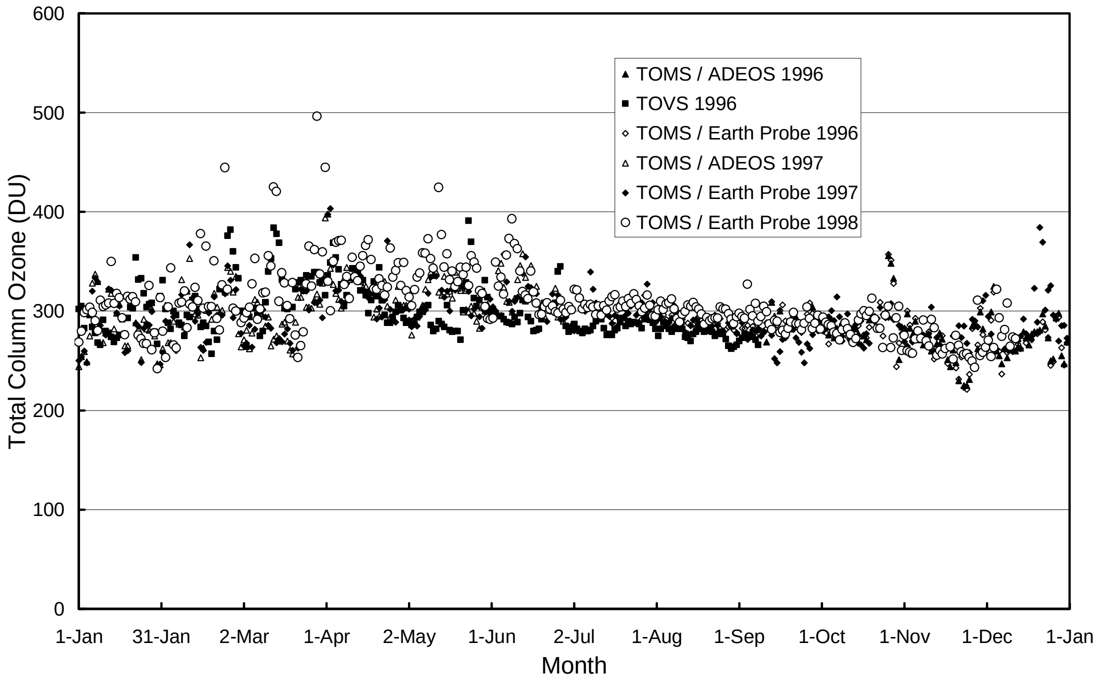

Figure 5.7.5. *Seasonal variation of ozone as seen at San Diego.*

5.7.3. San Diego 9/2/97 – 10/2/98

The Volume 7 San Diego season lasts between 9/2/97 and 10/2/98 but is interrupted by a mid-season maintenance between 3/11/98 and 3/13/98, when site operator training was also conducted. The season opening “site visit” was scheduled between 9/2/97 and 9/8/97; the closing visit was between 9/21/98 and 10/2/98. Solar data are available for the period 9/9/97-9/20/98. In contrast to other sites, where lamp comparisons are mainly carried out during the site visits, such activities were performed in San Diego throughout the year. During most of the season, the system operated normally. Between 11/8/97 and 12/3/97, the PMT cooler did not work, leading to a reduction in system responsivity. For a short period in January 1998, a faulty temperature-control circuit led to a 2.5°C increase in monochromator temperature. Both problems did not significantly affect solar data. All calibration standards showed some drift during the season. With a careful analysis of the calibration record, however, these changes could be corrected so that the impact on solar data is also negligible. The overall stability of the instrument was very good during the entire period.

5.7.3.1. Stability in the Wavelength Domain

As described in Section 3, a new method to determine and correct systematic errors of the wavelength setting was implemented for the Volume 7 data. System wavelength *stability*, however, was monitored with the internal Mercury lamp, as in previous seasons. Information from the daily wavelength scans was used to homogenize the data set by correcting day-to-day fluctuations of 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 5.7.6 shows the differences in the wavelength offset of the 296.73-nm mercury line between two consecutive wavelength scans. In total, 425 scans have been evaluated. For 72.9% of the days, the change in offset is smaller than ±0.025 nm; for 89.6% of the days the shift is smaller than ±0.055 nm. Twenty scans (4.7%) have an offset-difference larger than ± 0.09 nm. The reasons for these deviations were carefully examined, see Table 5.7.4. Whenever a change in the wavelength alignment of the monochromator occurred, great care was taken that no data scan was incorrectly adjusted with a wavelength scan taken before or after the change of the wavelength scale.

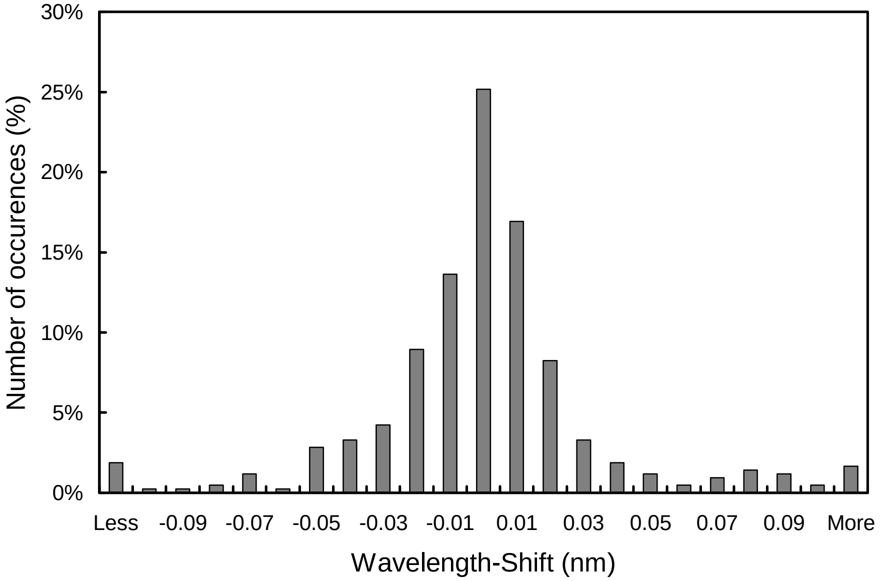

Figure 5.7.6. *Differences in the measured position of the 296.73-nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. Thus the 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

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 3. In contrast to all other sites, two correction functions were established for San Diego, one for the period 9/9/97-3/12/98 and one for 3/14/98-9/20/98. In between the two periods was the mid-season site visit, during which the monochromator non-linearity function changed slightly.

The thick lines in Figure 5.7.7 shows the resulting correction functions that were applied to the Volume 7 San Diego data. In order to demonstrate the difference between the results of the new Fraunhofer-correlation method and the method that had been applied historically, Figure 5.7.7 also includes correction functions that were calculated with the old method, i.e., the function is based on internal wavelength scans only. The average differences between both approaches are 0.109 and 0.089 nm for periods 9/9/97-3/12/98 and 3/14/98-9/20/98, respectively. As explained in Section 3, the different light paths for internal wavelength scans and solar measurements cause this bias.

Table 5.7. 4 Worst-case wavelength differences between consecutive scans at San Diego.

First Wavelength File	Second Wavelength File	First Date	Second Date	Wavelength shift Second-First (nm)	Cause
EM972209.255	EM970645.256	9/12/97	9/13/97	0.166	Wavelength position manually adjusted
EM972129.262	EM970645.263	9/19/97	9/20/97	-0.164	System reboot
EM972134.304	EM970630.305	10/31/97	11/1/97	0.183	Wavelength position manually adjusted
EM970630.308	EM970630.309	11/4/97	11/5/97	-0.149	System maintenance and reboot
EM970630.311	EM972046.311	11/7/97	11/7/97	1.181	System reboot with new software version
EM972131.317	EM970630.318	11/13/97	11/14/97	-1.104	Wavelength position manually adjusted
EM970630.322	EM970630.323	11/18/97	11/19/97	-0.096	Unknown
EM970645.340	EM970645.343	12/6/97	12/9/97	-0.094	Three day data gap
EM972336.353	EM970645.354	12/19/97	12/20/97	0.121	Wavelength position manually adjusted
EM980700.013	EM980700.015	01/13/98	01/15/98	-0.136	Monochromator temperature out of range
EM980700.026	EM980700.027	01/26/98	01/27/98	-0.111	Wavelength position manually adjusted
EM982307.030	EM980700.031	01/30/98	01/31/98	0.121	System maintenance, wavel. adjustment
EM980700.061	EM981937.061	03/02/98	03/02/98	0.986	Wavelength position manually adjusted
EM981840.064	EM980700.065	03/05/98	03/06/98	-0.889	Wavelength position manually adjusted
EM982148.070	EM980109.l07	03/11/98	03/12/98	1.171	Site visit and operator training
EM980109.l07	EM980700.072	03/12/98	03/13/98	-1.142	Site visit and operator training
EM982125.149	EM980645.150	03/29/98	03/30/98	0.098	Wavelength position manually adjusted
EM981621.198	EM980700.199	07/17/98	07/18/98	-0.108	Wavelength position manually adjusted
EM982237.205	EM980700.206	07/24/98	07/25/98	0.103	Wavelength position manually adjusted
EM980700.215	EM980700.216	08/03/98	08/04/98	0.092	System maintenance, wavel. adjustment

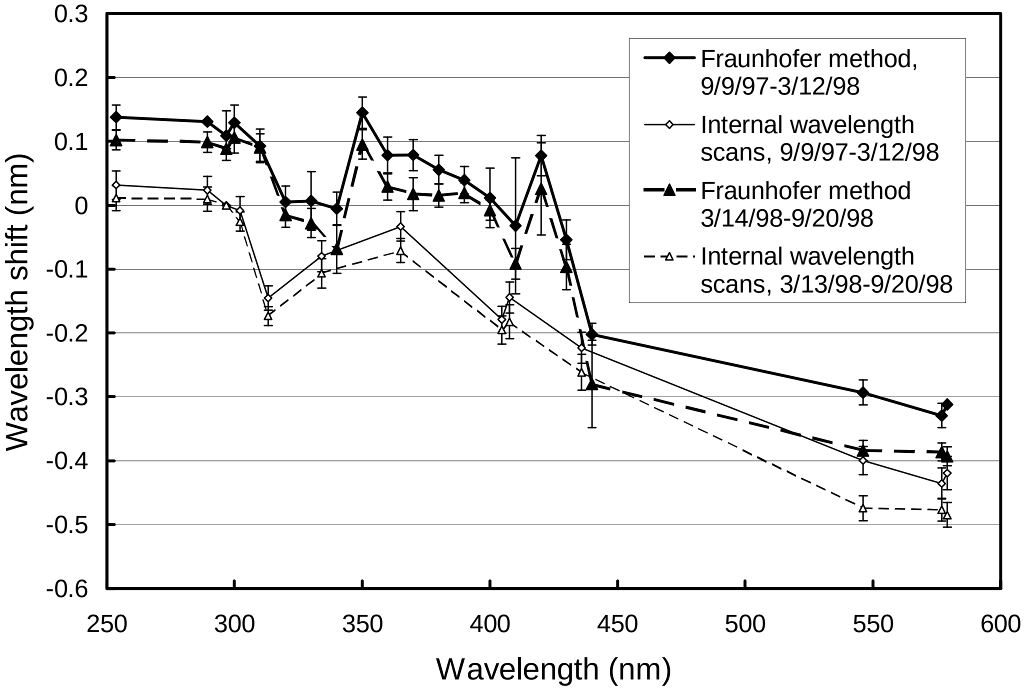

Figure 5.7.7. *Functions expressing the monochromator non-linearity for San Diego. The season was split in two periods (see the legend). Thick lines: Functions calculated with the Fraunhofer-correlation method. These functions were applied to correct the San Diego Volume 7 data. Thin lines: Function calculated with the method that was historically applied. The offsets between both methods are 0.109 and 0.089 nm for periods 9/9/97-3/12/98 and 3/14/98-9/20/98, respectively. The error bars give the 1σ standard deviation variation of the wavelength shifts.*

After the data was wavelength corrected using the shift-functions described above, the wavelength accuracy was tested again with the Fraunhofer method. The result is shown in Figure 5.7.8. Except for a few outliers, the wavelength shift for noontime measurements is smaller than ±0.05 nm at both 310 nm and 320 nm. The actual wavelength uncertainty may be a little larger because of wavelength fluctuations of about ±0.02 nm during a day and possible systematic errors of the Fraunhofer correlation method (see Section 3). The shifts for other wavelengths in the UV have a very similar pattern.

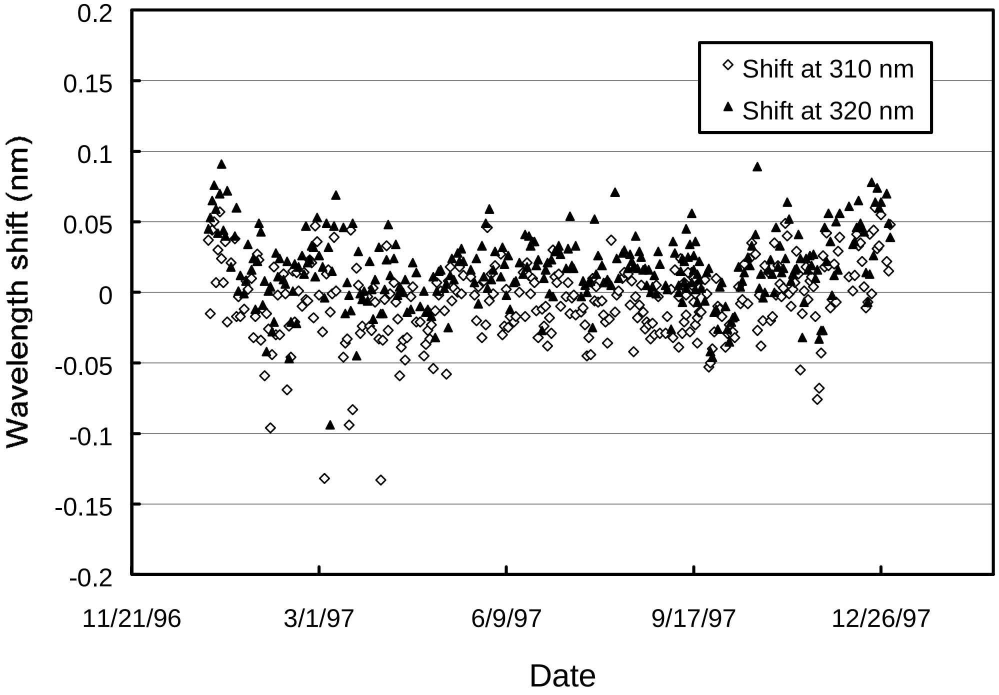

Figure 5.7.8. *Check of the wavelength accuracy of the final data by means of Fraunhofer correlation. For each day of the season the noontime measurement at 310 and 320 nm are shown.*

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 5.7.9 illustrates the difference between internal and external Mercury scans collected during both site visits. External scans have a bandwidth of about 1.04 nm FWHM, whereas the bandwidth of the internal scan is only 0.8 nm. In addition, the peak of external scans is shifted by about 0.1 nm towards longer wavelengths, compared to the internal peak. This is very consistent with the mean difference of the results of both wavelength correction methods depicted in Figure 5.7.7. Since external scans have the same light path as solar measurements they more realistically represent the bandpass of the monochromator. San Diego is the only site where mid-season maintenance was performed. For this reason, internal and external wavelength scans are compared for three periods. The scans at the start, middle and end of the season are very consistent, as can be seen from Figure 5.7.9.

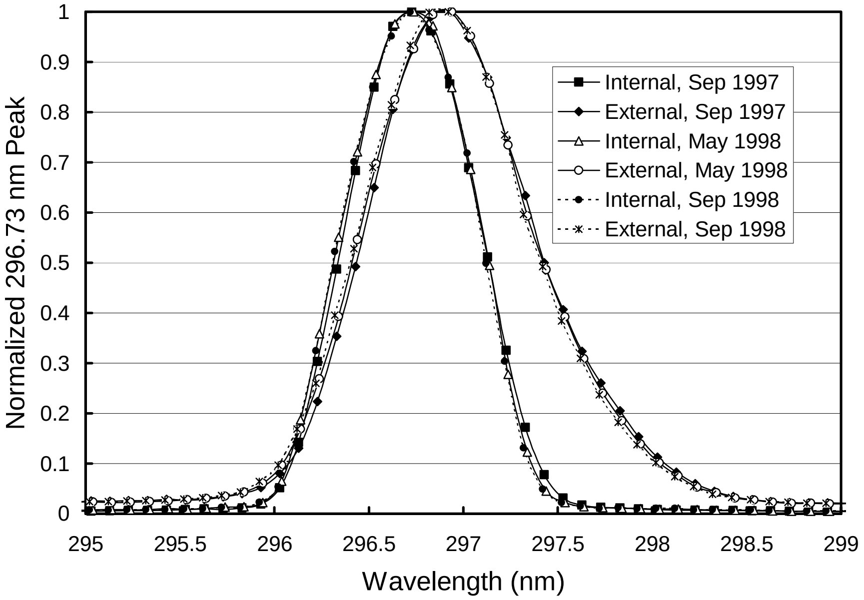

Figure 5.7.9. *The 296.73 mercury line as registered by the PMT from external and internal sources. For this plot, the wavelength calibration is based on the internal scans and it was assumed that the wavelength registration of the monochromator did not shift between internal and external scans, which were close in time.*

5.7.3.2. Responsivity Stability

The stability of the spectroradiometer's responsivity over time was monitored with the following parameters:

- Measurements of the TSI filtered-photodiode sensor during response lamp scans
- PMT current at several wavelengths during response lamp scans
- Bi-weekly calibrations with 200-Watt irradiance standards

Note that the TSI sensor is completely independent from possible monochromator and PMT drifts, whereas the PMT current is affected by all system parts, including response lamp, monochromator, and PMT, and is also sensitive to temperature changes and high voltage applied. PMT current therefore also provides valuable insight into possible drifts of these components.

Figure 5.7.10 shows the PMT current at 300 and 400 nm and the TSI behavior during the whole 1997/98 San Diego season. The season is broken into seven periods. All data are normalized to the averages of the individual system parameters from the whole season. There is a distinct change in all parameters at the end of Period 4 before the mid-season site visit. Between Period 4 and 5, the instrument was dismantled and the polarity of the internal response lamp was changed. This explains the change of all parameters between both periods.

In the first half of the season (Periods 1 – 4), the TSI response lamp measurements show an upward trend of about 2.5%. This means that the response lamp was quite stable. The PMT current measurements show somewhat more scatter. There is also a drop in the current of about 5-8% between days 11/8/97 and 12/3/97. During this period, the PMT cooler did not work, leading to lower system sensitivity. Since this does not affect the response lamp it was not necessary to break Period 2 into two parts on 11/8/97, the day when the problem first occurred.

In the second half of the season (Periods 5-7), the TSI response lamp measurements show a downward drift of about 2.5%. The downward drift of the PMT current at 300 and 400 nm is a little larger suggesting that the instrument responsivity also drifted slightly, in addition to the lamp drift. There is also a small 1% step on 7/7/98, between Periods 6 and 7. On this day, the air conditioner of the instrument was repaired.

In Periods 1, 2, 3, and 7, the monochromator temperature was set to 33 °C. In Periods 4-6, it was set to 31 °C. In Period 3, there is a slight increase in the actual temperature to 35.5 °C, i.e. 2.5 °C above the set point. This was caused by a faulty temperature control circuit, which was replaced on 1/13/98. The somewhat too high temperature did not affect the accuracy of the solar data however. Since the data scans of a given day are paired with a response lamp scan of this day possible changes in the responsivity cancel out.

Figure 5.7.11 through Figure 5.7.17 show the behavior of PMT currents and TSI separately for each period. Here, the data has been ratioed against the average of all measurements in the given period.

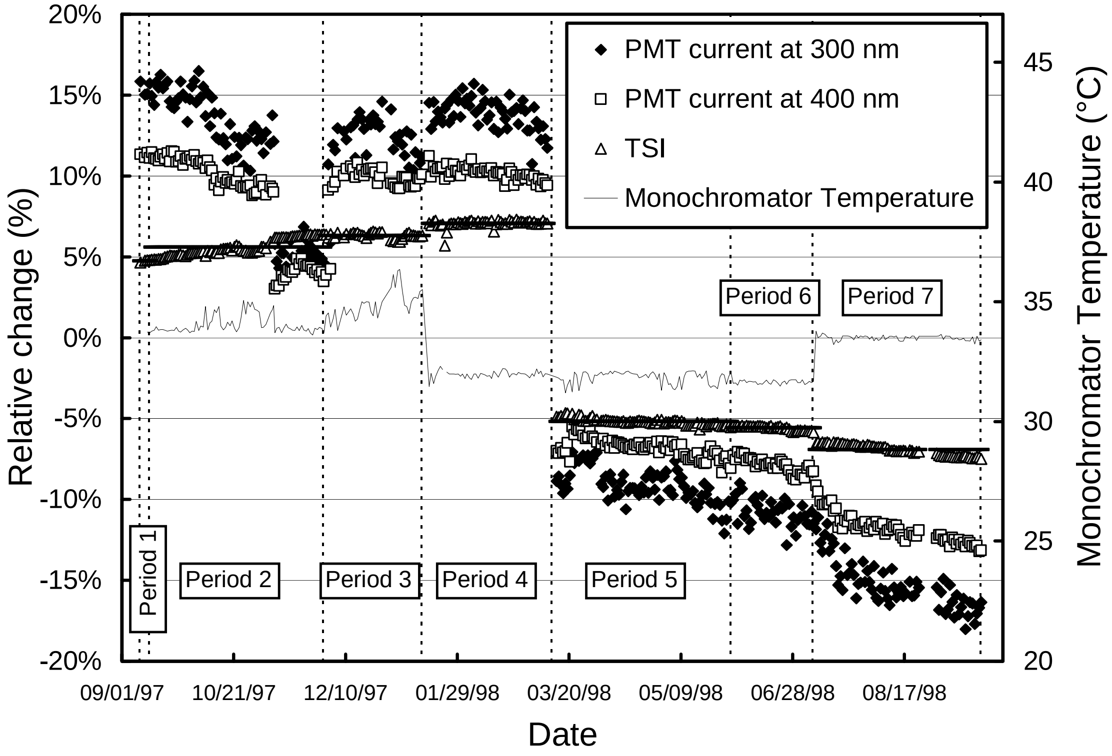

Figure 5.7.10. *Time-series of PMT current at 300 and 400 nm and TSI signal during measurements of the response lamp during the San Diego 1997/98 season. The data is normalized to the average of all data points. Between Periods 4 and 5 the mid-season site visit took place; the instrument was dismantled and the polarity of the internal response lamp was replaced. This explains the change of all parameters between both periods. The average of all TSI measurements in a given period is indicated by a thick line.*

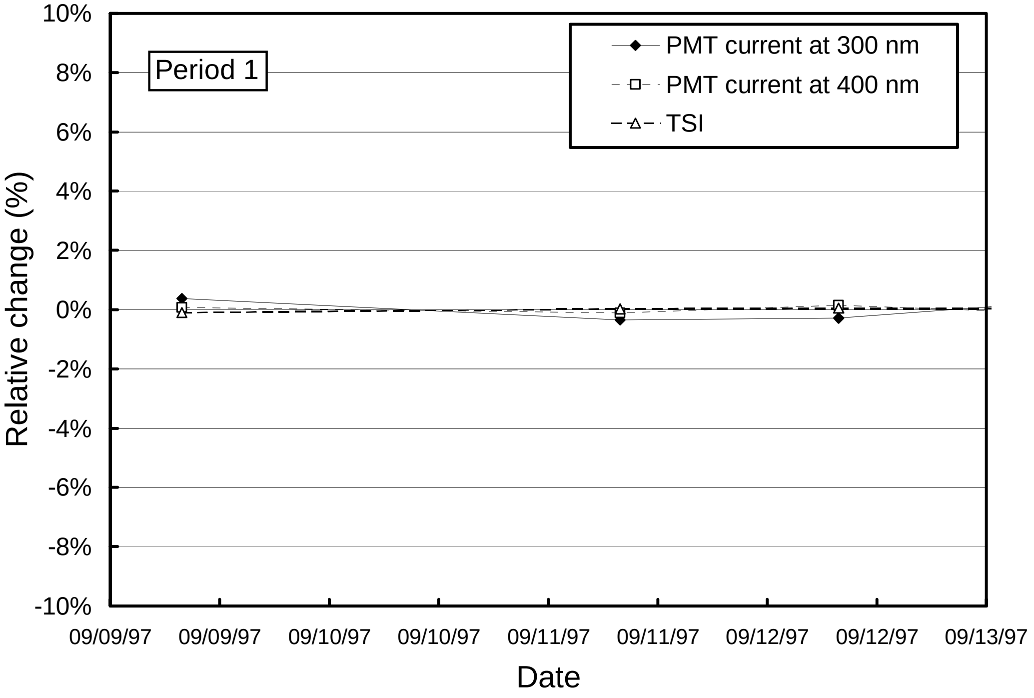

Figure 5.7.11. *Period 1 (9/9/97-9/13/97): Only three response scans exist in this very short period and these are completely stable.*

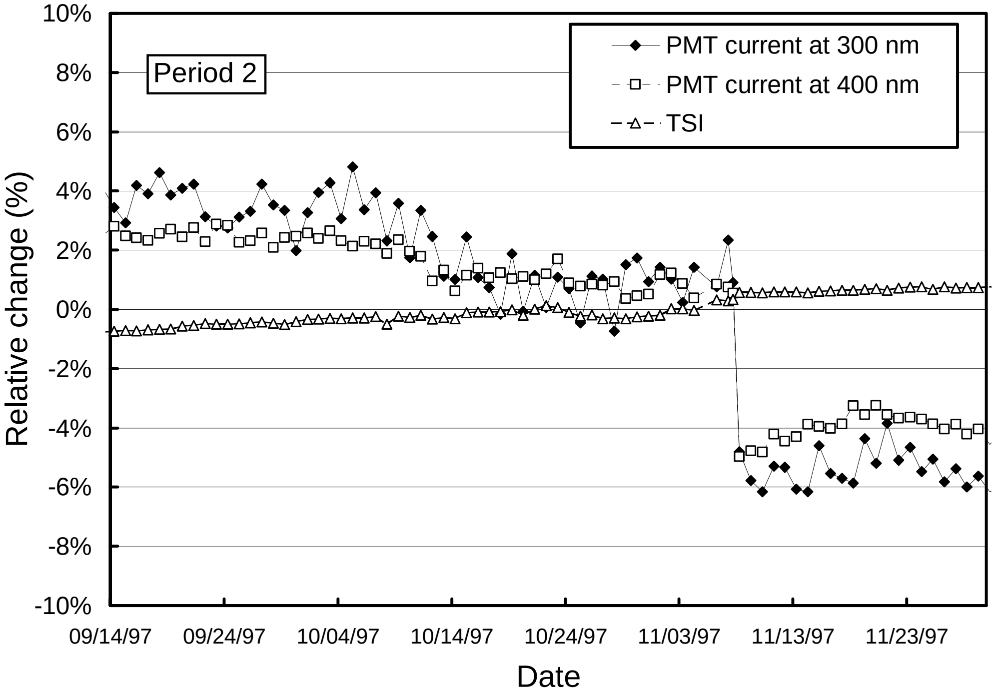

Figure 5.7.12. *Period 2 (9/14/97-11/30/97): The TSI response lamp measurements are stable to within ±0.8%. The PMT currents show a step of 6% on 11/8/97. On this day the PMT cooler became defective, leading to reduced instrument responsitivity.*

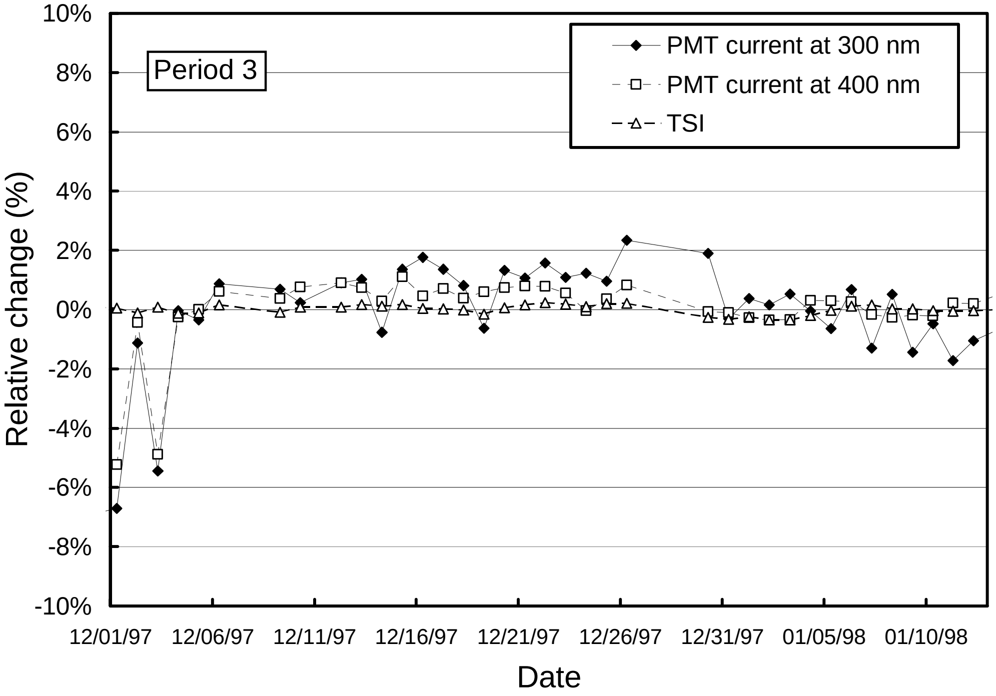

Figure 5.7. 13. *Period 3 (12/1/97-1/13/98): The TSI measurement is completely stable suggesting that the response lamp did not change during this period. Except for the first three days, the PMT currents are stable to within ±2%. On 12/01/97 and 12/03/97, the fuse of the PMT cooler burned out, leading to a drop in the responsivity of about 5%, similar to Period 2. Solar data from this day have an additional ±5% uncertainty.*

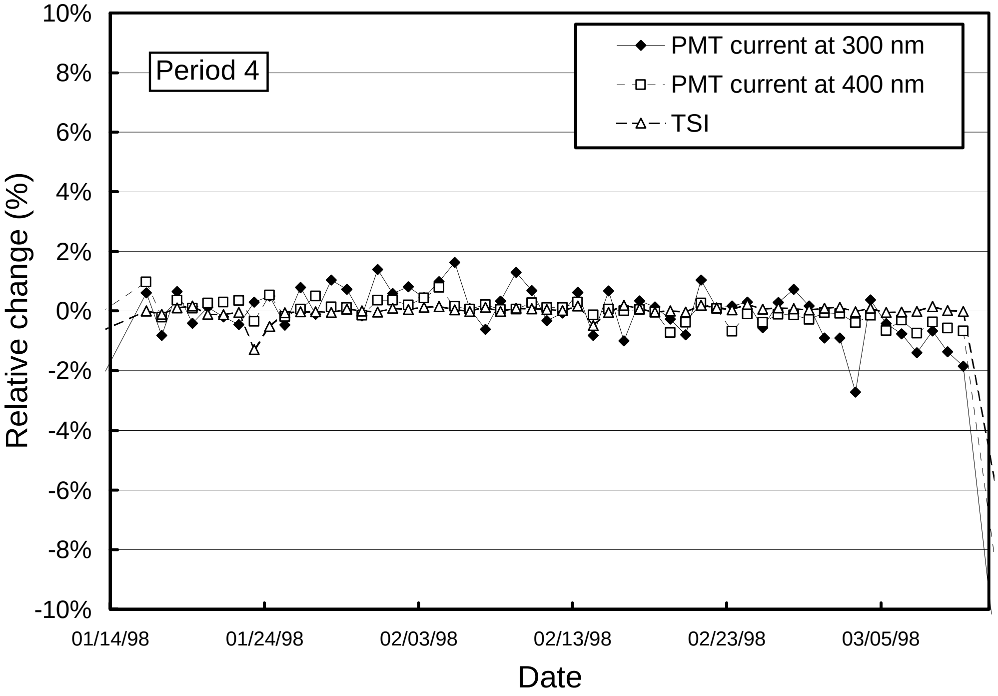

Figure 5.7.14. *Period 4 (1/14/98-3/12/98): All parameters are stable.*

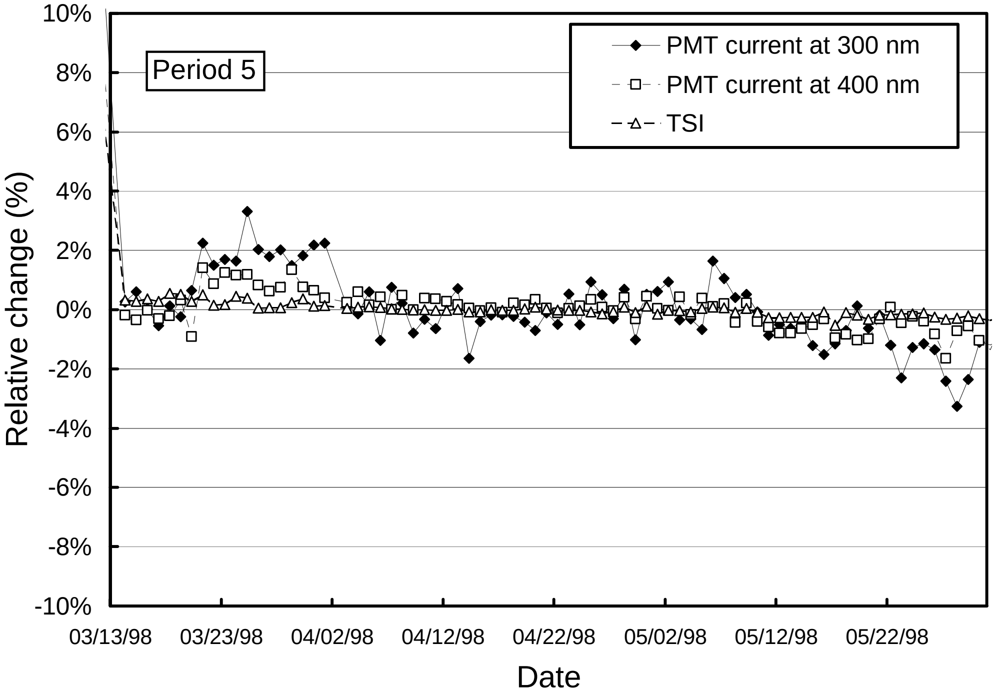

Figure 5.7.15. *Period 5 (3/13/98-5/31/98): All parameters are stable in this period, which succeeds the mid-season site visit.*

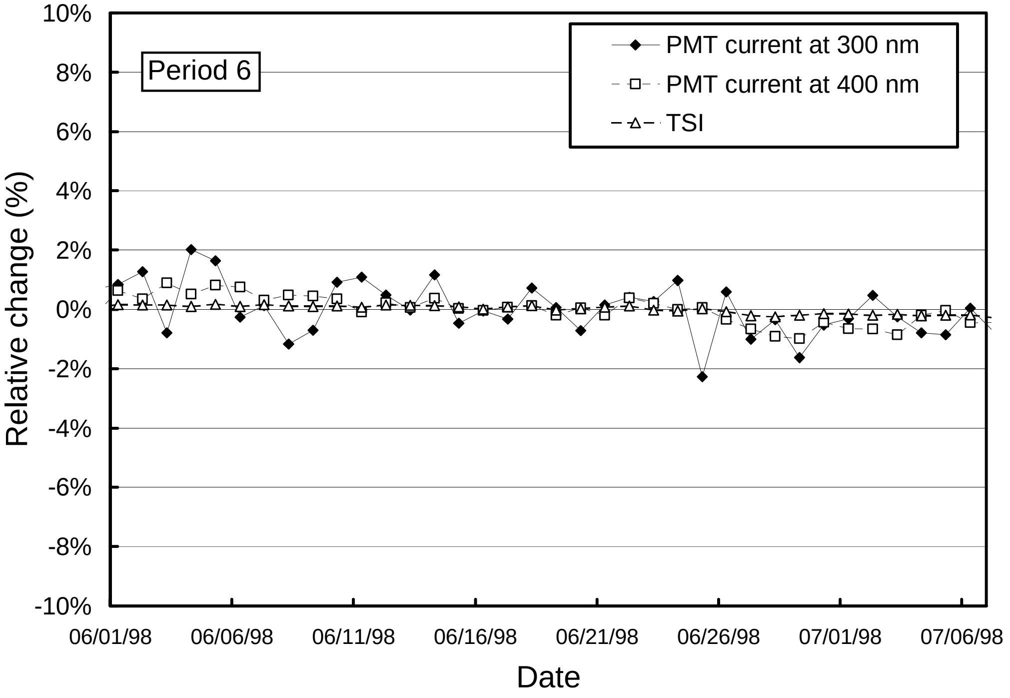

Figure 5.7.16. *Period 6 (6/1/98-7/7/98): All parameters are stable.*

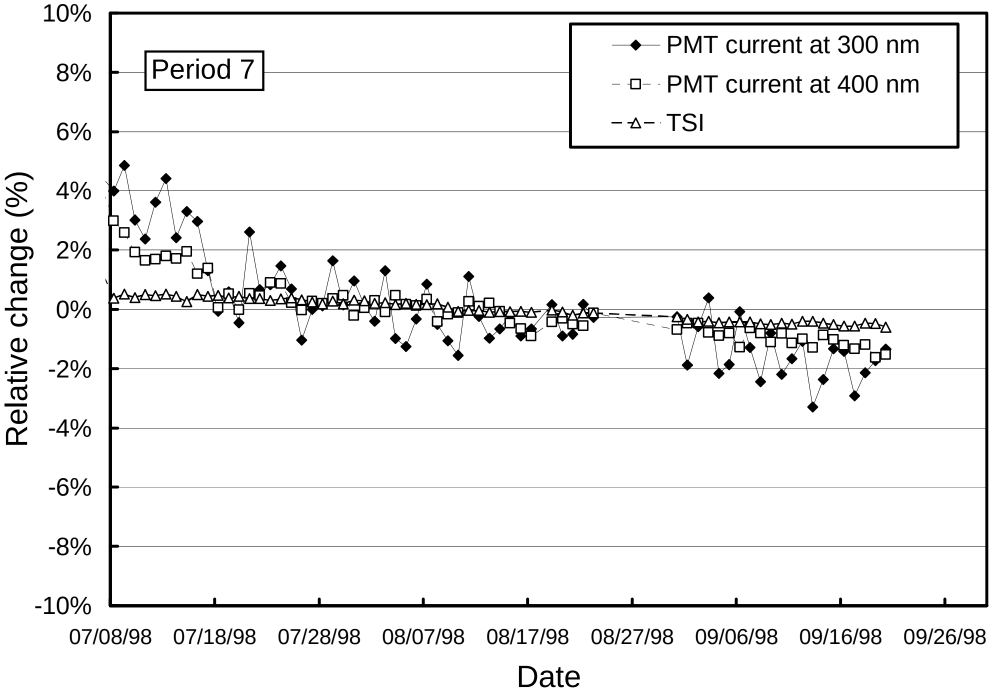

Figure 5.7.17. *Period 7 (7/8/98-9/20/98): The TSI response lamp measurement shows a downward drift of 0.5%. The PMT currents at 300 and 400 nm drift by 3%.*

For all periods, the system was calibrated in the usual fashion, i.e., a mean-irradiance of the response lamp was determined based on all calibrations with the 200-Watt standards, which were carried out in a given period. From each of these calibrations, irradiance values for the response lamp were calculated and finally, the mean-irradiance of that period was derived by averaging over the individual functions. In addition to the average, the standard deviation of these functions was also calculated (see in Figure 5.7.20 below).

By the method outlined above, the irradiance of the response lamp is described by a step function rather than by a smooth variation. This approach has been chosen for practical reason and has been applied at all sites. The magnitude of these steps is indicated in Figure 5.7.10. Thick black lines indicate for each period the average TSI reading when measuring the response lamp. The maximum step height is 1.5%, occurring between Periods 6 and 7 (except for the change between Periods 4 and 5 when the mid-season site visit took place). Because of this step, the calibration of solar measurements at the last day of Period 6 will be about 1.6% lower than measurements on the first day of Period 7. From the daily response lamp scans and these mean-irradiances, the responsivity of the system for each day was then calculated (see Section 3 for details).

Figure 5.7.18 shows the mean-irradiance applied in Period 1, 3, and 4 divided by the respective irradiance of Period 2. These ratios express the change of the response lamp in the first part of the season, between 9/9/97 and 3/12/98. The difference between Periods 2 and 3 is less than ±1%. Periods 3 and 4 are very consistent for wavelengths above 400 nm; the difference in the UV is on the order of 2%. The upward drift of the irradiance between Periods 2 and 4 is consistent with the change of the TSI response lamp measurements as indicated in Figure 5.7.10. The ratio Period 1 / Period 2 is low by 3-4%. This is a larger difference as suggested by the TSI measurements. However, Period 1 includes only 5 days after the season opening and is mainly based on calibrations on the first day after system maintenance was performed (9/3/97). The system was probably not completely stable on this day. Solar measurements in Period 1 therefore have an additional uncertainty of about ±3%.

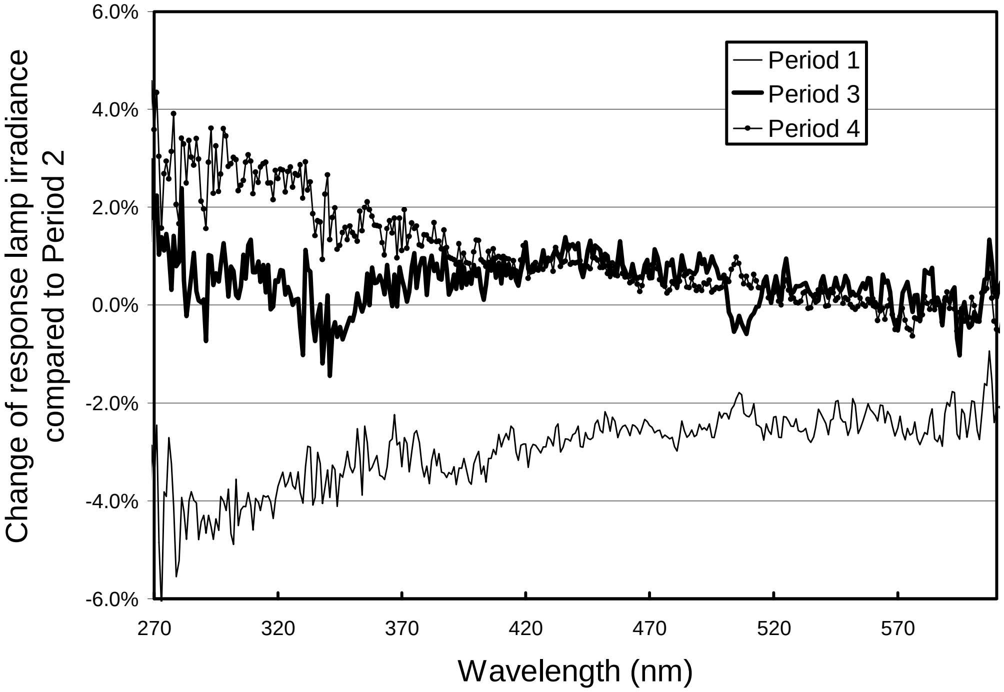

__Figure 5.7.18.__ Comparison of the response lamp's mean irradiances applied in the first part of the San Diego Volume 7 season, between 9/9/97 and 3/12/98. The irradiances applied in Period 1,3, and 4 are ratioed against the irradiance of Period 2.

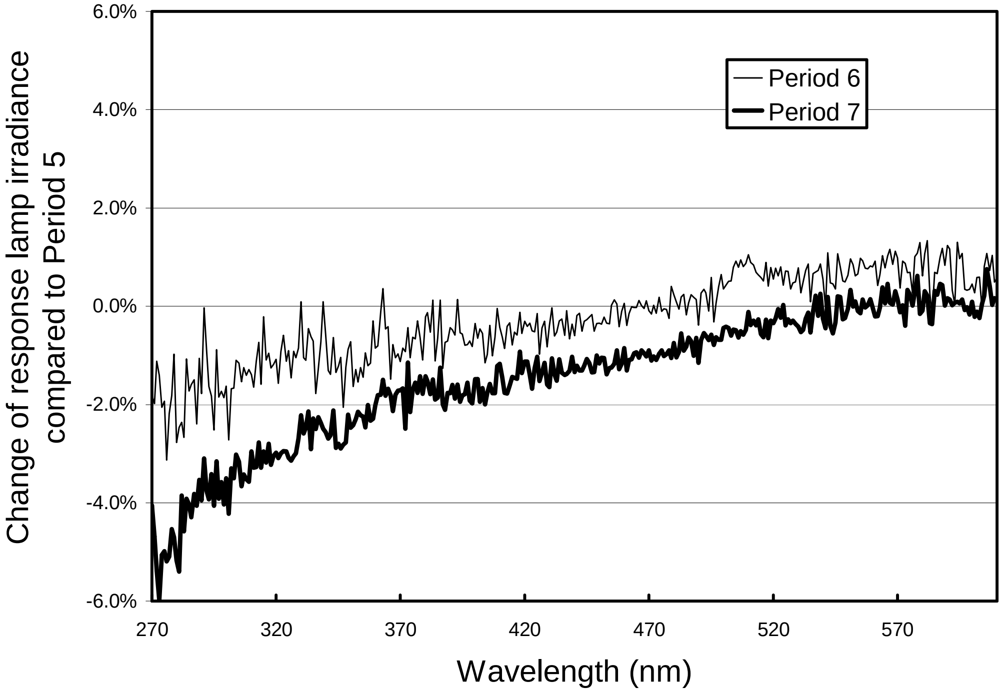

__Figure 5.7.19.__ Comparison of response lamp's mean-irradiances applied in the second part of the San Diego Volume 7 season, between 3/13/97 and 9/30/98. The irradiances applied in Periods 6 and 7 are ratioed against the irradiance of Period 5.

Figure 5.7.19 is similar to Figure 5.7.18 but compares the mean-irradiance applied in Periods 5-7 rather than Period 1-4. There is a gradual decrease; the UV-A irradiance in Period 7 is about 1 % lower than in Period 6, which in turn is 1% lower than Period 5. This downward trend is very consistent with the change in the TSI response lamp measurements as indicated in Figure 5.7.10.

The ratio of standard deviation and average mean-irradiance, calculated separately for each period, is a useful tool to estimate the variability of the calibrations in a given period. As shown in Figure 5.7.20, the standard deviation is usually about 1% of the average and increases slightly towards shorter wavelengths (2% at 270 nm). Only Period 4 exhibits a somewhat larger standard deviation below 330 nm. This, and the wavelength-dependent difference of the irradiance files for Periods 3 and 4 (Figure 5.7.18), indicates that the calibration in Period 3 was somewhat problematic. The reason is a drift of the calibration standard 200W010, which is further explained below. Solar measurements in this period will have an additional uncertainty in the order of ±1.5% in the UV-B.

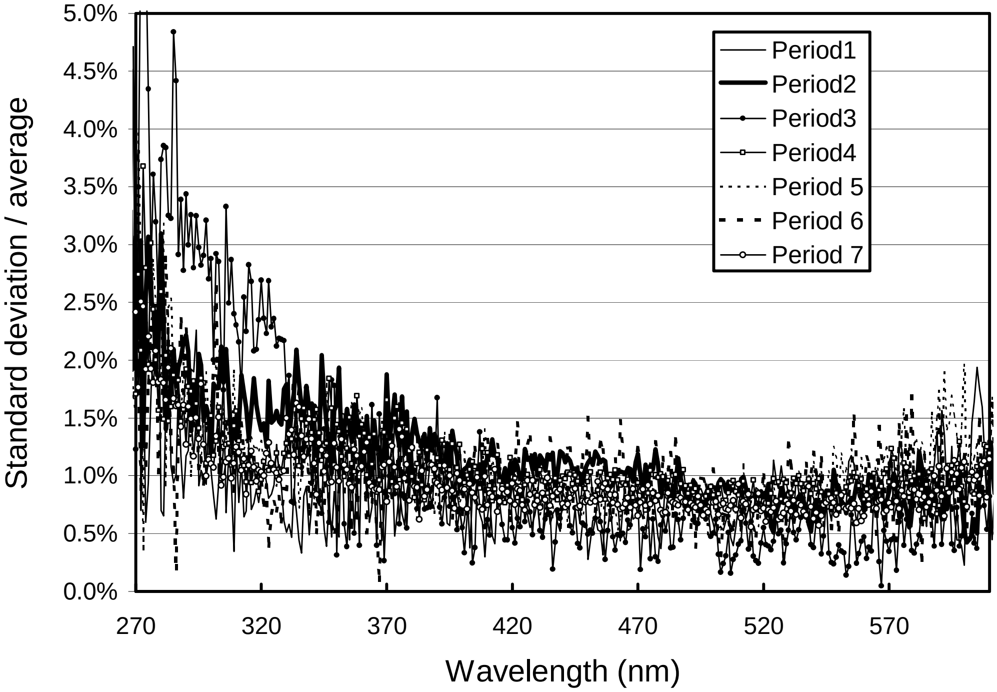

Figure 5.7.20. *Ratio of standard deviation and average calculated from the absolute calibration scans in Period 1- 7 for San Diego.*

5.7.3.3. Lamp Intercomparison

The site standards for the Volume 7 San Diego season were primarily the lamps M-881 and 200W010. In the addition, regular calibrations with the traveling standard M-874 were performed when it was not being used for visits at other sites.

All lamps have two sets of calibration values, see Table 5.7.5. For lamps 200W010 and M-881, the calibration values established by Optronics Laboratories in 1998 deviate significantly from their prior values, suggesting that the lamps have drifted during both calibration events. Careful analysis of calibrations during the Volume 7 San Diego season with lamp 200W010 shows that this lamp's irradiance changed abruptly by 4-6% between the calibrations performed on 1/31/98 and 2/20/98. The reason for this change is unknown. Lamp M-881 showed a lesser change of about 2-3%, also in early 1998. Finally, the traveling standard M-874 also showed a drift over the years as confirmed by Optronics Laboratories calibrations in 1995 and 1998. The values determined in 1998 exceed the 1995 values by 2%, independent of wavelength. For some sites, the 1995 values of M-874 were used, for others the 1998 values, dependent upon whether the season of a given site is closer to 1998 or 1996. For San Diego, a third set of calibration values was created for M-874 for the first part of the season. This set of values was established by BSI in December 1996 by transferring the calibration of lamp 200W010 to M-874 (see Section 3 for more details on how such a transfer is performed). This calibration agrees with the 1998 Optronics Laboratories calibration to within ±1%. Moreover, a comparison of the lamps M-874 (BSI 1996), M-881 (Optronic Laboratories 1995), and 200W010 (Optronic Laboratories, 1996), which was carried out in the beginning of the season, shows agreement of all lamps within ±1% (see below). Because of this good agreement, it was decided to use the BSI 1996 calibration rather than the Optronics Laboratories 1995 calibration of M-874 for the first part of the season.

Table 5.7.5. Calibration information of standards used for Volume 7 San Diego

Lamp	Calibration information	Period when calibration was used
M-874	Optronic Laboratories, 8/18/95	Never
M-881	Optronic Laboratories, 8/18/95	Start Volume 7 – 1/16/98
200W010	Optronic Laboratories, 11/19/96	Start Volume 7 – 1/31/98
M-874	BSI, 12/96, transfer lamp 200W010	Start Volume 7 – 2/9/98
M-881	Optronic Laboratories, 9/17/98	2/9/98 – End Volume 7
200W010	Optronic Laboratories, 9/27/98	2/20/98 – End Volume 7
M-874	Optronic Laboratories, 9/17/98	5/19/98 – End Volume 7
200W009	Optronic Laboratories, 9/17/98	8/31/98 – End Volume 7

Although all lamps that were used in San Diego have drifted. Solar data were only slightly affected for the following reasons:

- The time of the event causing the drift could be identified, thus the appropriate calibration values could be applied in each period.
- The ratios standard deviation / average of the response lamp's mean-irradiances, which were shown for each period in Figure 5.7.20, are very similar. The pattern for Period 4, in which both sets of calibration values have been used for all lamps, is very similar to the pattern for Period 7, in which the 1998 lamp certificates were applied.
- The change of the response lamp's mean-irradiance from one period to another (Figure 5.7.18 and Figure 5.7.19) is very consistent with the change of the TSI response lamp measurements, as shown in Figure 5.7.10. Since the calibration values of the 200-Watt lamps have a direct influence on the calculation of the mean-irradiances, the application of an incorrect calibration would readily lead to discrepancies, which is not the case here.

The information given above is illustrated in the following figures showing comparisons of all lamps used for Volume 7 San Diego. Figure 5.7.21 depicts a comparison of lamps 200W010, 200W009, and M-881 with the traveling standard M-874 close to the end of the season (9/1/98). The calibration values of all lamps are from Optronic Laboratories 1998 certificates. All lamps agree to within ±1%, thereby giving confidence in the absolute calibration of the solar data at the end of the Volume 7 season. Figure 5.7.22 shows a similar comparison performed in the second part of Period 4. Lamps 200W010 and M-881 are very consistent, as in Figure 5.7.21, but are about 1% lower than the reference lamp M-874. This change is within the uncertainty of lamp intercomparisons. Combining the results of Figure 5.7.21 and Figure 5.7.22 suggests that the lamps have been stable between February 1998 and the end of the season.

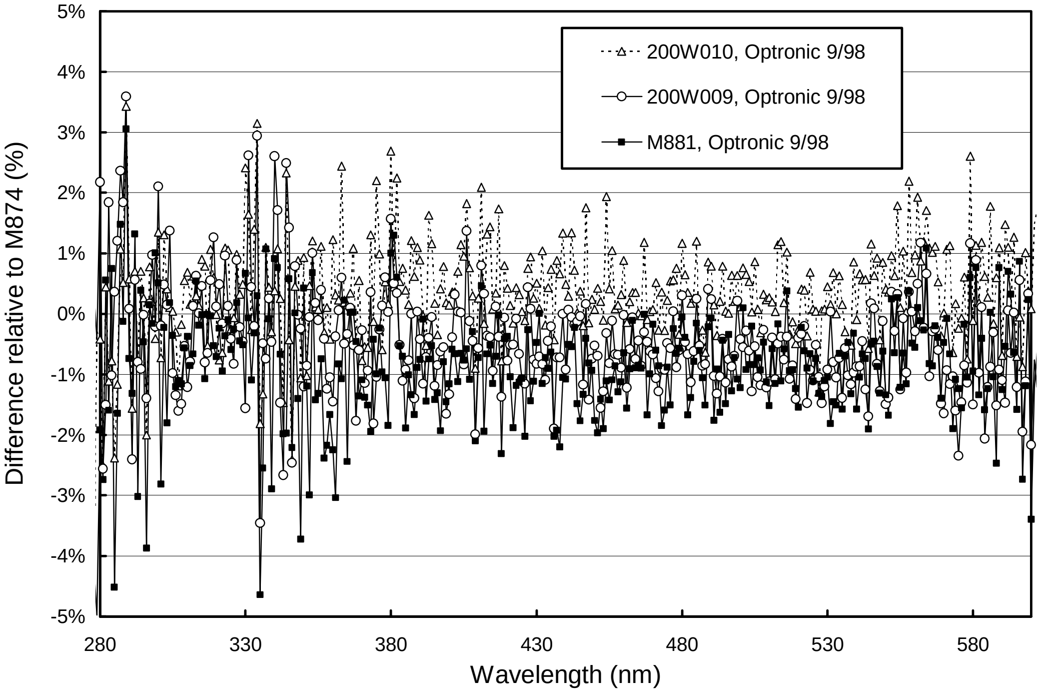

Figure 5.7.21. *Comparison of lamps 200W010, 200W00,9 and M-881 with the traveling standardM-874 close to the end of the season (9/1/98). The calibration values for all lamps were established by Optronic Laboratories in September 1998.*

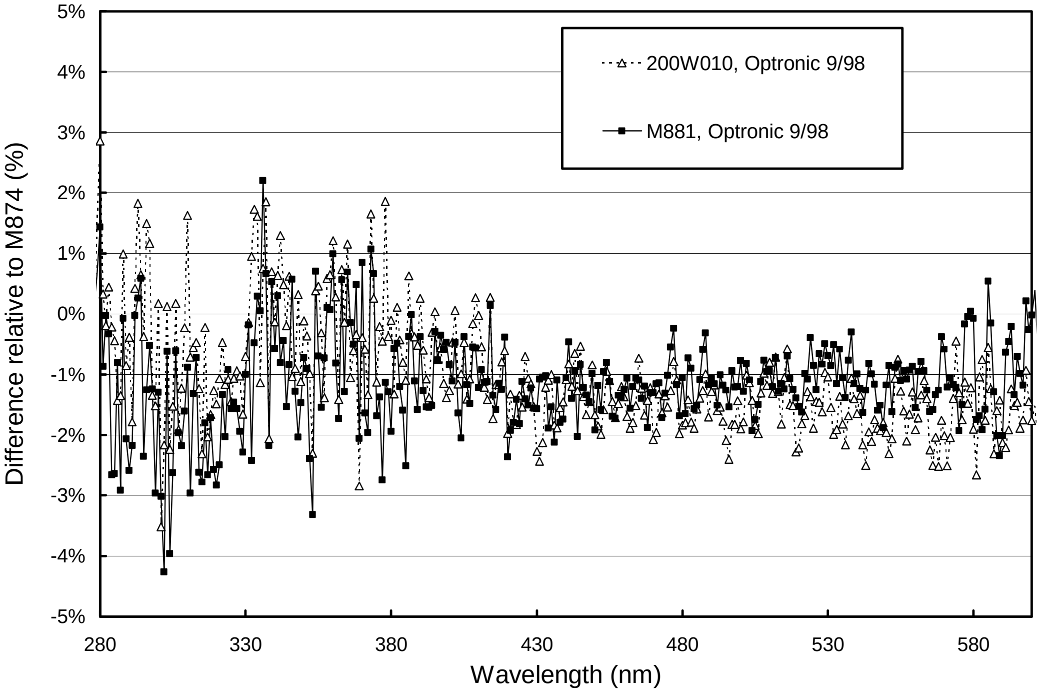

Figure 5.7.22. *Comparison of lamps 200W010 and M-881 with the traveling standard M-874 in the middle of Period 4 (2/9/98-2/20/98). Optronic Laboratories calibration values from September 1998 have been used for all lamps.*

Figure 5.7.23 shows another intercomparison of lamps 200W010 and M-881 with M-874 at the very beginning of the season. In order to allow a direct comparison with Figure 5.7.21 and Figure 5.7.22 above, the Optronic Laboratories calibration values from 1998 have also been used. As can be seen, the curve for lamp 200W010 is now 2-6% higher, whereas M-881 is lower by about 2% (A high curve means that the lamp was actually darker, see Section 3.3.2.4.). This is an indication that the lamps have drifted.

Figure 5.7.24 shows the same season-opening calibration event as Figure 5.7.23, but uses the old calibrations. For lamps 200W010 and M-881, the Optronic Laboratories calibrations from November 1996 and August 1995 were applied, respectively. The reference lamp M-874 uses the BSI calibration from 1996. The lamps now agree on the ±1% level. This suggests that the calibration values from 1995 and 1996 were still valid at the start of the San Diego Volume 7 season in September 1997 and the lamps changed afterwards.

For lamp 200W010, the date of the drift could clearly be identified. Figure 5.7.25 shows a comparison of all calibrations carried out with this lamp between 12/20/97 and 3/12/98, relative to their average. The results are clearly grouped. The calibrations between 12/20/97 and 1/31/98 are higher by 4-6% than the calibrations between 02/20/98 and 3/12/98, suggesting that lamp 200W010 was darker during the first three calibrations. Of course, Figure 5.7.25 could also be explained by a change in the spectroradiometer's responsivity. Figure 5.7.10 demonstrates, however, that the instrument and the response lamp were very stable in this period. The TSI measurements of the response lamp drifted by less than 1%, proving the lamp's stability. Similarly, the variability of the PMT current at 400 nm is also smaller than ±1%, proving the instrument's stability. The only possible conclusion is, therefore, that lamp 200W010 indeed got brighter by about 4-6% between 1/31/98 and 02/20/98. The reason for this change is unknown but is consistent with the change of the values in the lamp's Optronics Laboratories calibration certificates from 1996 and 1998.

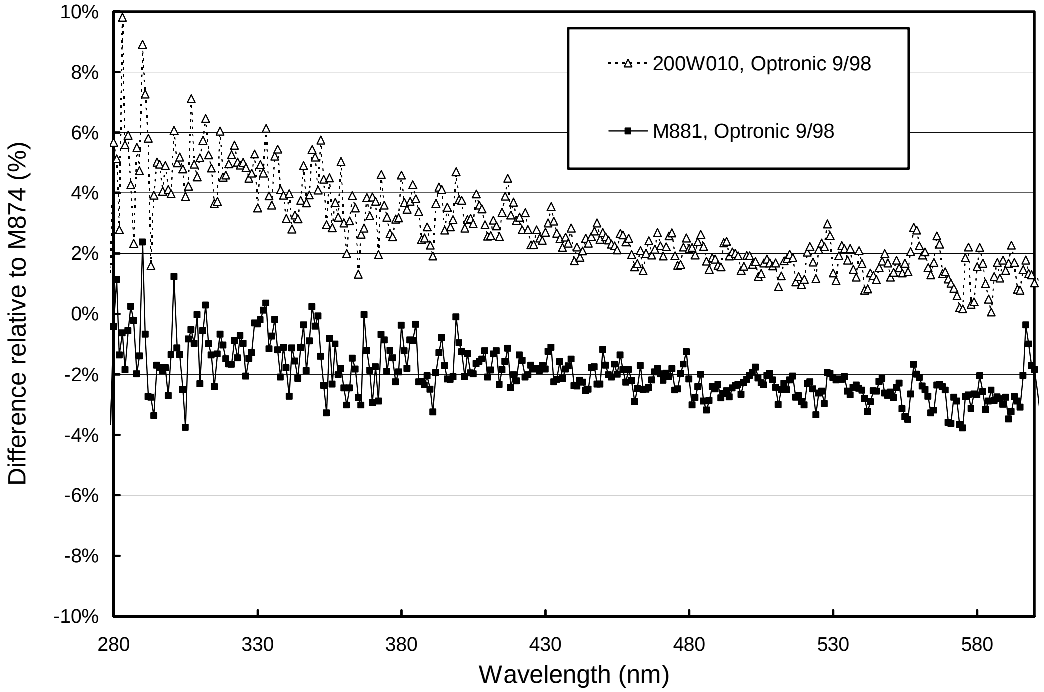

Figure 5.7.23. *Comparison of lamps 200W010 and M-881 with the traveling standard M-874 at the beginning of the season (9/3/97). Optronic Laboratories calibration values from September 1998 have been used for all lamps.*

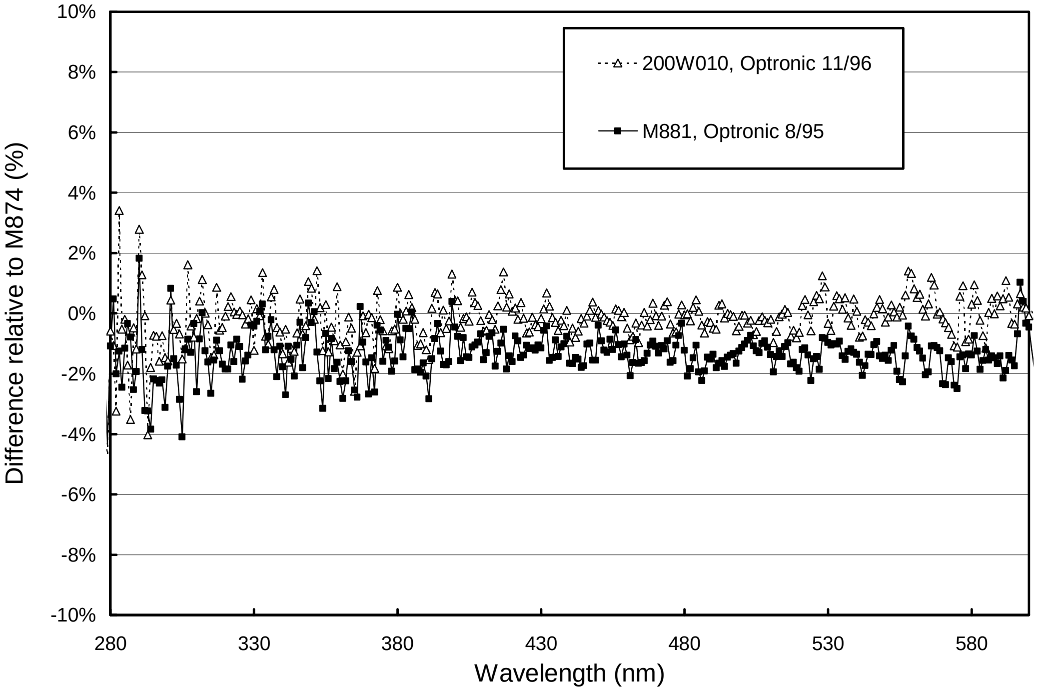

Figure 5.7.24. *Comparison of lamps 200W010 and M-881 with the traveling standard M-874 at the beginning of the season (9/3/97). In contrast to Figure 5.7.23, "old" calibration values for the lamps have been used. For lamps 200W010 and M-881, the Optronic Laboratories calibrations from November 1996 and August 1995 were applied, respectively. The reference lamp M-874 has the BSI calibration from 1996.*

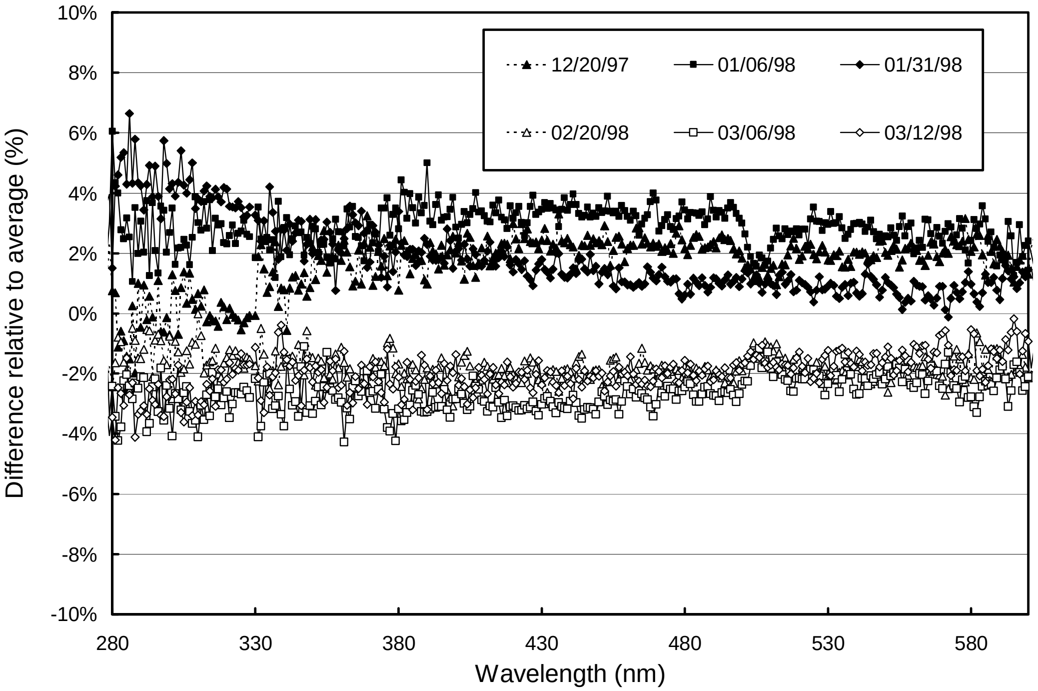

Figure 5.7.25. *Comparison of all calibrations carried out with lamp 200W010 between 12/20/97 and 3/12/98, relative to their average.*

5.7.3.4. Missing Data

A total of 18758 scans with SZA smaller than 92° were scheduled to be measured in the San Diego Volume 7 season, which includes the two periods 9/9/97-3/10/98 and 3/14/98-9/20/98. No scans were scheduled during the mid-season site visit (3/11/98-3/13/98). The scan rate was four scans per hour throughout the year. This caused a substantial increase in the total number of scans compared to previous seasons. A total of 17657 scans, 94.1% of the scans scheduled, were actually measured and 17394 scans (92.7%) were included in Volume 7. The discrepancy of 1101 scans between scheduled and measured data scans has several reasons:

- Approximately 550 data scans were superceded by absolute scans or external wavelength scans. This is a higher number than at the high latitude sites.
- 112 data scans were lost between 12/6/97 and 12/9/97 because of a full hard disk.
- 97 scans were lost on days 1/13/98 and 1/23/98 due to repair of defective temperature controllers.
- 8 scans were lost on 3/2/98 due to maintenance on the AXSS A/D converter.
- 15 scans were lost on 3/20/98 because the stand for absolute calibrations was not removed during data scans.
- 17 scans were lost on 7/9/98 due to repair of the PMT cooler.
- 15 scans were lost on 8/3/98 when a JAZ hard-drive was installed.
- On days 09/10/97, 12/27/97, 2/19/98, and 8/25/98 164 scans were lost for unknown reasons.
- 123 additional scans, which were scheduled for Volume 7 were not measured for various reasons.

A total of 301 data scans, which were meausured were found to be defective and were therefore not included in Volume 7:

- 35 scans on the days 9/2/97, 9/20/97, 11/4/97, 11/7/97, and 11/13/97 had a wrong wavelength assignment.
- 44 scans on 10/13/97 were affected by the PMT cooler not functioning.
- 85 scans on 12/9/97 were lost because of hard-disk problems.
- 15 scans on 1/15/98 were affected by a defective temperature controller.
- Several scans throughout the season (e.g., 7 scans on 5/19/98) did not cover the whole wavelength range and were therefore excluded from Volume 7.
- 22 scans on 7/9/98 were affected by general system maintenance.
- About 60 additional scans were found to be outliers and were therefore excluded from Volume 7.