5.1. McMurdo Station (1/19/98 – 1/19/99)

The 1998-99 season at McMurdo Station is defined as the time between the site visits 1/14/98 – 1/18/98 and 1/20/99-1/26/99. The season opening and closing calibrations were performed on 1/17/98 and 1/20/99, respectively. Volume 8 solar data comprises the period 1/19/98 – 1/19/99. During this time, the system operated normally, with only a few minor technical problems. The GPS receiver failed to update the computer time between March 1998 and January 1999. The time was therefore adjusted manually at regular intervals by the site operator. On 3/5/98 and 10/25/98, the time was set incorrectly by the GPS unit and affected data scans were either discarded or time-corrected during data analysis. All scans between 10/25/98 07:15 and 11/04/98 04:30 had to be shifted by one hour and the time-stamp in the composite scans and the databases now correctly match the irradiance values. The filenames of the composite scans and the field “DataScan” in the published databases, however, were not adjusted, since the filename is also the key field of our internal data structure and changing the name would have led to inconsistencies. Therefore, the data scan 1AD980615.298 (i.e. the first scan that is affected) includes the measurement at 07:15 rather than 06:15.

Approximately 94% of the scheduled data scans are part of the published dataset; only 2% of all scans were lost because of technical problems. The reponsivity remained stable to within ±3% during the whole season and small drifts were further reduced during data analysis.

5.1.1. Irradiance Calibration

The site irradiance standards for the 1998-99 McMurdo season were the lamps 200W005, M-764, and M-543. As with all other sites, lamp M-874 was the traveling standard, which was used during season opening and closing calibrations. The lamp has two calibrations from Optronic Laboratories, one from August 1995 and one from September 1998. As mentioned few pages before, there are strong indications that the lamp drifted by 2% between the beginning and middle of 1998. The analysis showed that the 1995 Optronic Laboratories calibration had to be applied for the McMurdo Volume 8 opening calibrations. For the closing calibrations in 1999, the Optronic Laboratories calibration from 1998 was used, because M-874 appears to have been very stable from the second calibration date onward.

Lamp 200W005 was first introduced in the 1997-98 season and has an irradiance calibration from Optronic Laboratories from November 1996. Lamp M-764 has an Optronic Laboratories calibration from 1992 and has been in use at McMurdo Station since 1992. Comparisons with other lamps indicate that the somewhat older calibration of M-764 is still valid (see also below). Lamp M-543 does not have a calibration from an independent standards laboratory. For use in the 1998-99 season, the lamp was calibrated by comparison with M-874 using data centered around the 1999 site visit. The procedure applied is explained in Section 4.2.1.5.

Figure 5.1.1 shows a comparison of all lamps at the beginning of the season (day 1/17/98). All lamps agree generally on the ±1% level, with slightly larger deviations below 300 nm. The validity of the Optronic Laboratories 1995 calibration of M-874 for the season opening scans is confirmed with the good agreement to lamps 200W007 and M-764, which have independent calibrations.

Figure 5.1.2 shows a similar comparison of all lamps at the end of the season. The plot also includes calibration with lamp 200W019, which was used in the Volume 8 season during the closing calibrations only. The lamp has an independent calibration from Optronic Laboratories, performed in September 1998, and it is therefore valuable to further validate the calibrations of all other irradiance standards. Figure 5.1.2 demonstrates that all lamps agree with M-874 to within ±1%, independent of wavelength. The good agreement of all lamps both during season opening and closing calibrations gives confidence in the solar data of McMurdo in the 1998-99 season.

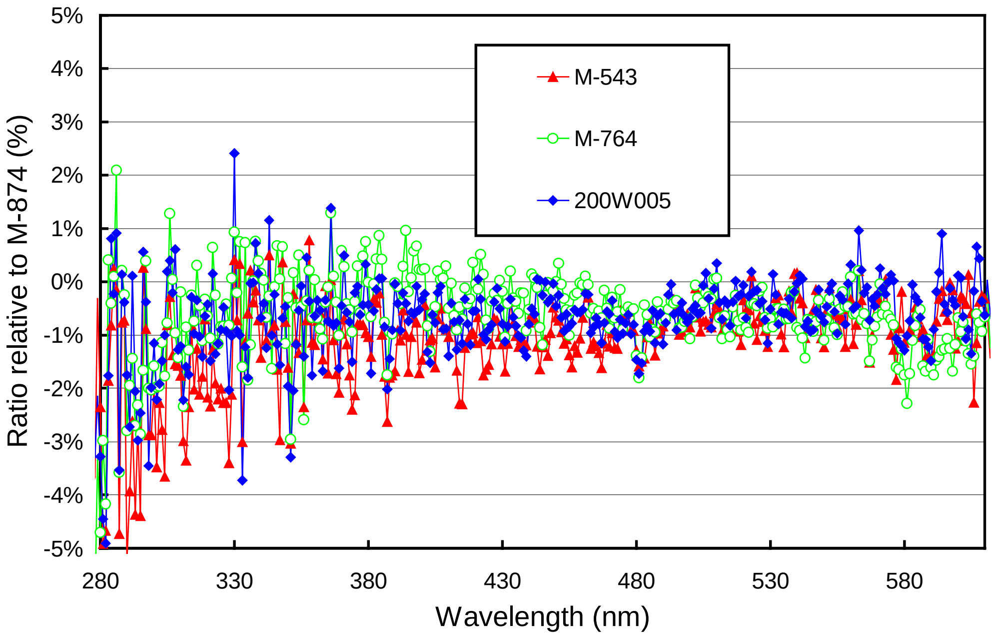

Figure 5.1.1. *Comparison of McMurdo lamps M-543, M-764, and 200W005 with the BSI traveling standard M-874 at the beginning of the season (1/17/98).*

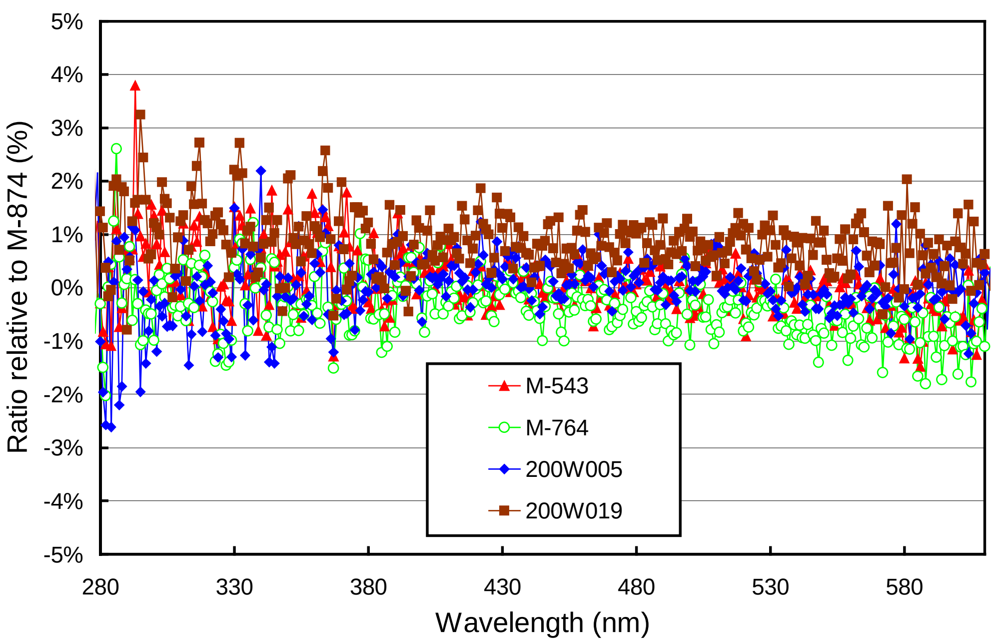

Figure 5.1.2. *Comparison of McMurdo lamps M-543, M-764, 200W005, and 200W019 with the BSI traveling standard M-874 at the end of the season (days 1/20/99 and 1/21/99).*

5.1.2. 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 itself is monitored with the TSI sensor, which is independent from monochromator and PMT drifts. When TSI measurements indicate that the internal lamp has drifted by more than 2%, a new irradiance is assigned to this lamp, based on the bi-weekly calibrations with the site standards (see Section 4.2.1.2). By logging the PMT currents at several wavelengths during response scans, changes in the instrument responsivity can be detected.

Figure 5.1.3 shows the changes in TSI readings and PMT currents at 300 and 400 nm, derived from the daily response scans of the McMurdo 1998-99 season. The TSI measurements indicate that the internal lamp became brighter by 1.5% between the start of the season and the middle of March. From then on, the lamp's radiation output did not change until 10/13/98 when the lamp became slightly dimmer. The brightness of the lamp at the end of the season agrees well with the brightness at the beginning. Because of this good stability, only one calibration of the internal irradiance reference was established for the whole season.

The PMT currents at 300 and 400 nm indicate that the instrument was stable to within ±3% throughout the entire season. The instrument responsivity at both wavelengths gradually decreased by 6% between the start of the season and the middle of September 1998 before the responsivity increased again, reaching the initial value at the end of the season. This annual cycle has also been observed during the 1997-98 season and could be attributable to variations in instrument temperature. The actual reason is unknown (see also Section 5.1.3 for South Pole). Note that the change in instrument responsivity does not affect solar data because the daily response scans are not performed exclusively for monitoring drifts, but also for correcting these drifts. Day-to-day changes, which would affect solar data, are below 0.5%.

The irradiance assigned to the internal lamp was calculated by analyzing 24 calibrations with the site irradiance standards M-764, 200W005, and the traveling standard M-874, carried out during the season. Calibrations with lamp M-543 were not included because these appeared to have a higher scatter than scans of the other lamps. From each of these calibrations, irradiance values for the internal lamp were calculated. The mean irradiance for this period was derived by averaging over the individual calibration functions, according to the procedure outlined in Section 4.2.1.2. The ratio of the standard deviation and average mean irradiance, both calculated from the 24 calibrations, is a useful tool for estimating the variability of the calibrations for this period. As shown in Figure 5.1.4, the standard deviation is about 1% of the average, almost independent of wavelength, showing that the calibrations applied to solar measurements during the entire season are consistent to the ±1% (±1σ) level.

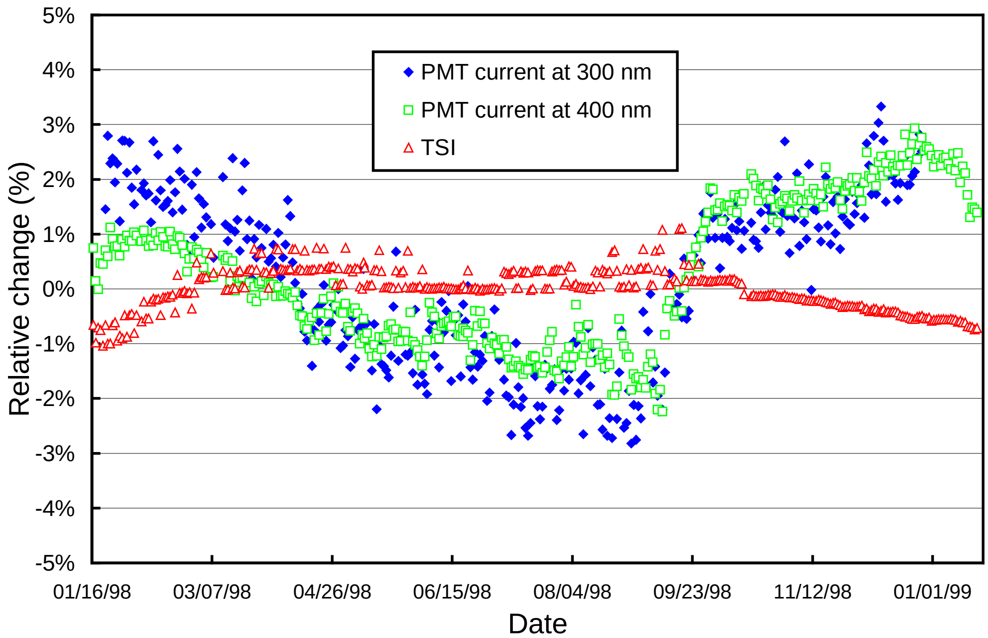

Figure 5.1.3. *Time-series of PMT current at 300 and 400 nm, and TSI signal during measurements of the internal irradiance reference lamp during the McMurdo 1998-99 season. The data is normalized to the average value of the whole season.*

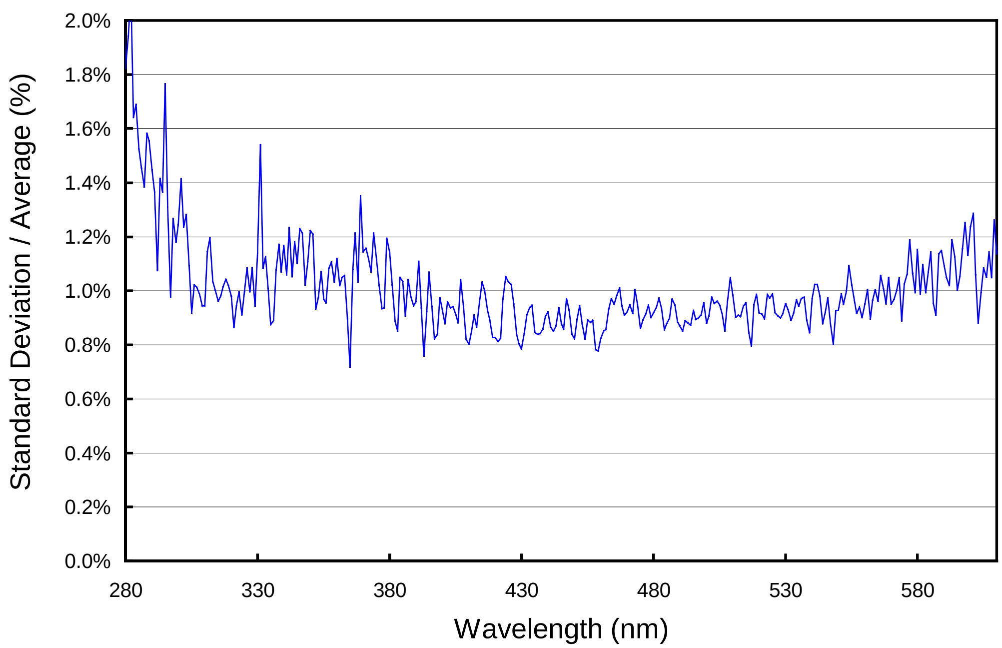

Figure 5.1.4. *Ratio of standard deviation and average calculated from the absolute calibration scans measured during the McMurdo 1998-99 season.*

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. 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 5.1.5 shows the differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 345 scans have been evaluated. For 72% of the days, the change in offset is smaller than ±0.025 nm; for 97% of the days the shift is smaller than ±0.075 nm. The offset-difference is larger than ± 0.1 nm for nine scans (2.6%), performed either in the period 3/7/98-3/23/98 or on the days 9/13/98 and 9/14/98. The wavelength shifts were caused by communication problems with the stepper motor drive control unit and subsequent manual adjustments of the wavelength offset. All break-points in the wavelength offset were carefully inspected and, when dubious, further checked with the Fraunhofer correlation method. Thus solar data was not affected by changes in the wavelength offset.

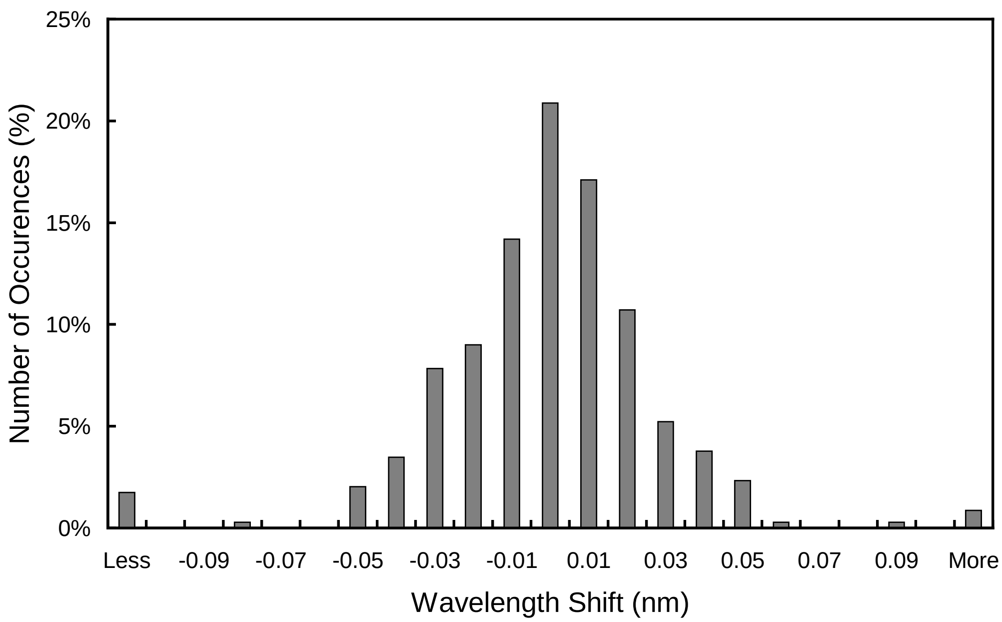

Figure 5.1.5. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

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. The thick line in Figure 5.1.6 shows the resulting correction function that was applied to the Volume 8 McMurdo data. The function clearly depends on wavelength, which is caused by inherent non-linearities in the monochromator drive. In order to demonstrate the difference between the result of the Fraunhofer-correlation method and the method that was historically applied, Figure 5.1.6 also includes a correction function that was calculated with the "old" method, i.e., the function is based on internal wavelength scans only. The average difference between both approaches is 0.14 nm. As explained in Section 4.2.2, this bias is caused by the different light paths for internal wavelength scans and solar measurements.

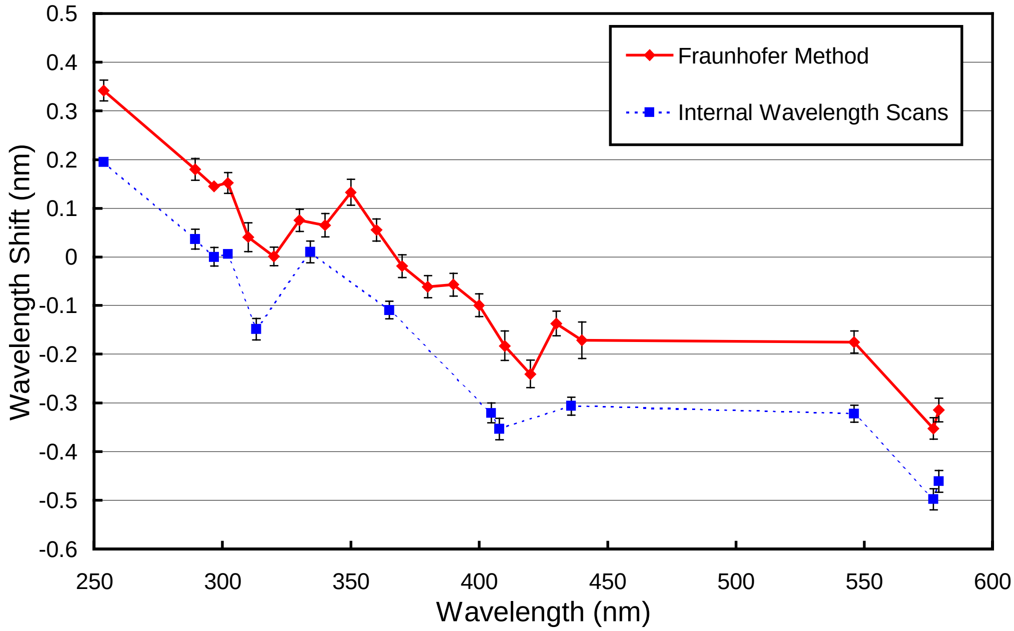

Figure 5.1.6. *Monochromator non-linearity for the McMurdo 1998-99 season. Line: Correction function calculated with the Fraunhofer-correlation method, applied to correct the McMurdo Volume 8 data. Broken line: Correction function calculated with the method that was historically applied. The offset difference between both methods is 0.14 nm. The error bars show the 1σ standard deviation of the wavelength shift for the season.*

After the data was wavelength corrected using the shift-function described above, the wavelength accuracy was tested again with the Fraunhofer method. The results are shown in Figure 5.1.7 for four UV wavelengths. The residual shifts are generally smaller than ±0.1 nm. There is more scatter at 310 nm shortly before and after polar night, because of the small solar irradiance levels that prevail during this part of the year. The wavelength stability is not worse during this time; yet the correction algorithm is less precise. The actual wavelength uncertainty may be a little larger due to wavelength fluctuations of about ±0.02 nm during the day, and possible systematic errors of the Fraunhofer-correlation method (see Section 4.2.2.2).

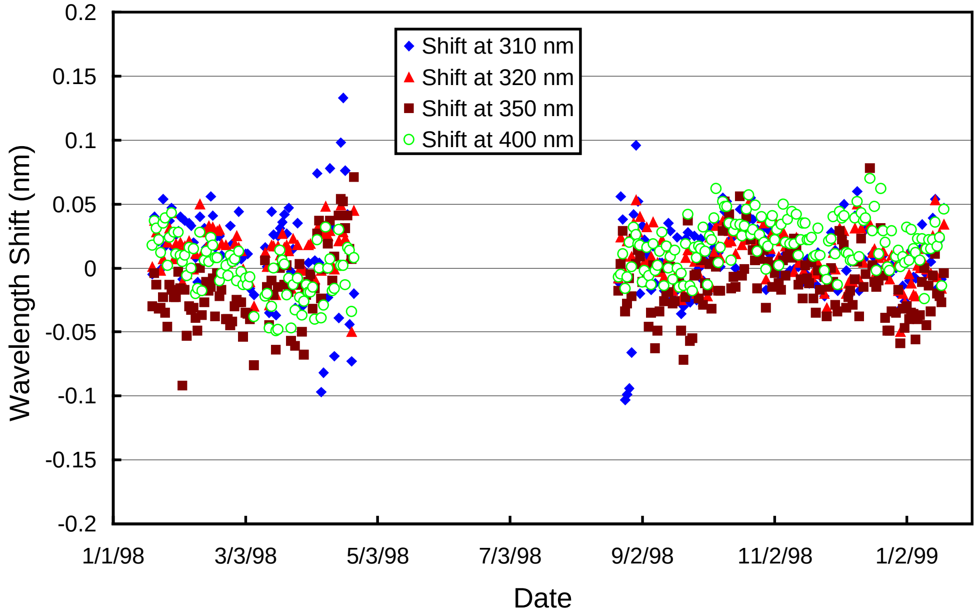

Figure 5.1.7. *Check of the wavelength accuracy of the final data at four wavelengths by means of Fraunhofer correlation. The noontime measurement has been evaluated for each day of the season. No correlation data is available during the polar night.*

Data from the external mercury scans do not have a direct influence on the data products, they are, however, an important part of instrument characterization. Figure 5.1.8 illustrates the difference between internal and external mercury scans collected during both site visits. The wavelength scale of the figure is the same as applied during solar measurements; the scale is based on a combination of the Fraunhofer- correlation technique and wavelength-offset determination with internal mercury scans. The peak of the external scans, which have the same light path as solar measurements, agrees well with the nominal wavelength of 296.73 nm, whereas the peak of the internal scans is shifted about 0.15 nm to shorter wavelengths. External scans have a bandwidth of about 1.0 nm FWHM, whereas the bandwidth of the internal scan is only 0.71 nm. Since external scans have the same light path as solar measurements, they more realistically represent the monochromator bandpass relevant for solar scans. The scans at the start and end of the season are very consistent.

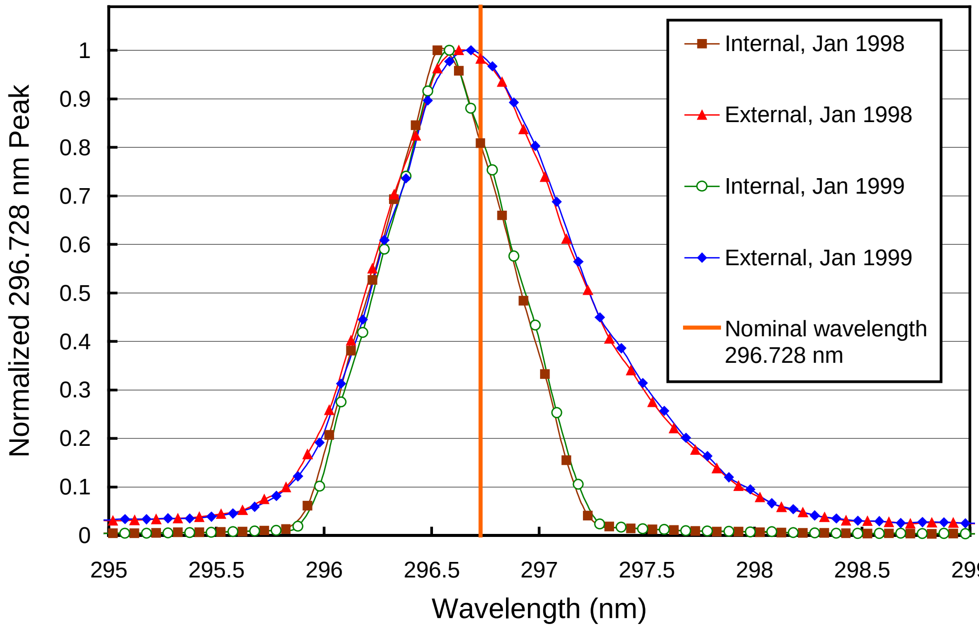

Figure 5.1.8 *The 296.73 mercury line as registered by the PMT from external and internal sources. The wavelength scale is the same as applied for solar measurements, i.e., it is based on a combination of internal scans and the Fraunhofer-correlation method. It is assumed that the wavelength registration of the monochromator did not shift between internal and external scans, which were close in time.*

5.1.4. Missing Data

A total of 18334 scans with SZA smaller than 92° were scheduled to be measured in the McMurdo Volume 8 season. Of these scans, 17251 (94.1%) were found to be of good quality and are therefore part of the published dataset. Of the missing scans, 87, 153, and 257 were superseded by absolute, wavelength and response scans, respectively. Since McMurdo has 24 hours of sunlight during summer, a loss of data scans cannot be avoided. A total of 377 scans was lost because of technical problems. The GPS module did not work correctly between March 1998 and January 1999 and the computer time was therefore not adjusted automatically. This did not lead to a loss of data *per se* because the time was adjusted by the site operator. On two days, however, the GPS unit adjusted the time incorrectly and data were collected with an incorrect time stamp on day 3/5/98 and and during the period 10/25/98-11/4/98. The correct time could be restored for most scans during data processing, a total of 133 scans, however, was either lost or never measured. On 3/10/98, 139 scans were lost because of a hard drive failure and 134 scans were not recorded on days 3/8/98 and 10/15/98 because of a full data media. In addition, 46 scans were lost during ftp configuration (days 1/19/98 and 9/14/98); 88 scans, which had been scheduled, were not started by the computer for unknown reasons (11/24/98); and a total of 24 scans were interrupted by the site operator throughout the year for unknown reasons. Finally, 21 scans had to be marked defective during data analyses and were excluded from the published dataset. A total of 17698 scas are listed in the published databases, including 447 scans with solar zenith angles between 92° and 95°.