5.1. McMurdo Station (1/27/01 – 1/22/02)

The 2001/02 season at McMurdo Station is defined as the period between the site visits 1/22/01 – 1/27/01 and 1/22/02-1/29/02. The season opening and closing calibrations were performed on 1/26/01 and 1/22/02, respectively. Volume 11 solar data comprises the period 1/27/01 – 1/22/02. The performance during this period was affected by the following problems:

- **Change in responsivity**
  The system responsivity decreased steadily by 14%. It was discovered during the site visit in 2002 that the coating of the shutter, which is located between the instrument's cosine diffuser and relay lens, had partially worn off during the season. Abrasion collected as fine dust on the relay lens. The problem was unexpected as the responsivity was very stable during the previous season and no sign of wear of the shutter was observed during the site visit in 2001. The shutter was replaced during the site visit in 2002. Due to the responsivity drift, the calibration of the instrument required frequent adjustments. The drift-related uncertainty in published data is typically smaller than 1.4%, except for one period where it is 2.3% in the UV-B (see Section 5.1.2). Uncertainties in published solar data therefore remain within reasonable limits despite of the observed drifts.
- **Computer problems**
  During the site visit in 2001, a new system control computer was set up. As there was no time to thoroughly test this computer with the system, it was decided to leave the old computer in place and swap computers during polar night when data loss is not critical if problems should occur. The old computer could not be re-installed without modifications, however, as its hard drive was very noisy, suggesting that it might fail in the middle of the season. A new hard drive was therefore "cloned", and installed into the old computer. The system operated normally with the new drive until 2/19/01. From this date onward, the computer frequently locked up, which lead to a loss of 385 data scans. After the new computer was installed on 5/29/01 the problems disappeared.
- **System time errors**
  The computer clock is adjusted once per day by a GPS receiver. On 3/26/01 and 11/24/01, the time was erroneously reset by one day by the receiver. The affected scans were time-corrected during final data processing and re-labeled to reflect the correct date. However, 21 scans recorded on 3/25/01 and 30 scans recorded on 11/23/01 were overwritten and could not be salvaged.
- **Failure of temperature controller**
  The controller of the monochromator temperature failed on 1/16/02 and the temperature rose from the target value of 33°C to 38°C. Despite the high temperature, the analysis of the data did not indicate problems with the monochromator's wavelength alignment. The controller was replaced on 1/17/02.
- **Step change caused by collector upgrade**
  As already pointed out in the previous Operations Report, the collector modification during the site visit in January 2000 lead to a step change in published solar data. Data from 2001 are very consistent with data from 2000, but are lower by several percent than data measured prior to January 2000 (see the 2000/2001 Operations Report for details). We believe that current data are more accurate, however, the step change should be taken into consideration when analyzing time-series spanning data before and after the collector modification. See Section 7.1. for more details.

The PSP and TUVR instruments installed at McMurdo were replaced by identical instruments during the site visit in January 2002. The PSP that was installed during the Volume 11 period was calibrated by Eppley Laboratory Inc. in August 2000 and February 2002. The two calibrations were in agreement to within 1.6%. Published data are based on the calibration from August 2000. The TUVR was calibrated by Eppley Laboratory Inc. in August 2000 and February 2002 and the calibrations were different by 16%. As solar data did not indicate a drift of the instrument we conclude that at least one of the calibrations by Eppley Laboratory Inc. may have been erroneous. When we calibrated solar TUVR data with either calibrations we found that the results are not consistent with data of previous years. We therefore decided to scale the TUVR measurements such that the published radiation levels agree with measurements of previous years. Note that this scaling is arbitrary as it is not clear whether historic TUVR calibrations are correct. We therefore advise data users to treat TUVR data as "uncalibrated" and use them only for referential purposes.

5.1.1. Irradiance Calibration

The site irradiance standards for the 2001/02 McMurdo season were the lamps 200W005, 200W019, and M-543. Lamp M-764 was used as traveling standard. Its calibration was established by Optronics Laboratories in March 2001. Lamps 200W005 and M-543 were recalibrated by comparison with M-764 using scans performed during the site visits in 2001 and 2002 (see Section 4.2.1.5 for details of the procedure). Compared to the irradiance values listed in their old certificates[1], the new values are higher by 1-3%. The smallest difference (1%) compared to the old scale is observed at 450 nm; differences at 300 and 600 nm are approximately 2%. Lamp 200W019 has an Optronics Laboratories certificate from September 1998, and was not recalibrated.

Figure 5.1.1 shows the Volume 11 season opening calibrations performed on 1/26/01. All site standards agree at the ±1% level. The good agreement between the lamps 200W005, M-543, and M-764 can be expected because of the recalibration. The calibration of 200W019 is independent and also agrees well with the other three lamps.

Figure 5.1.2 shows a similar comparison of all standards at the end of the season. All lamps agree at the 0.5% level.

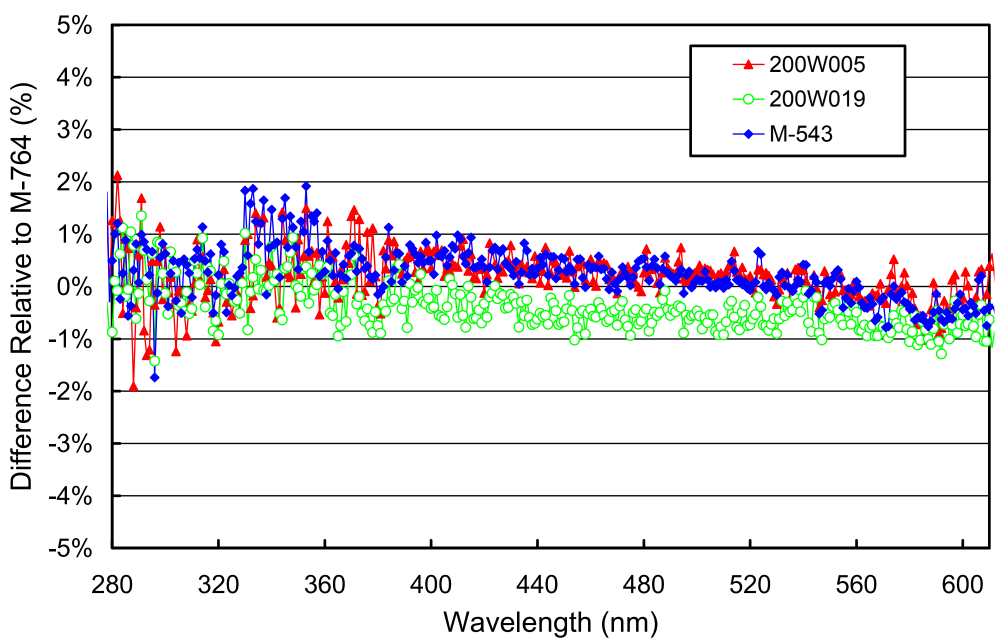

Figure 5.1.1. *Comparison of McMurdo lamps 200W005, 200W019, and M-543 with the BSI traveling standard M-764 at the beginning of the season (1/26/01).*

[1] The previous calibration of 200W005 was established by Optronics Laboratories on 11/19/96. The previous calibration of M-543 was established by comparison with the former traveling standard M-874 using scans from 1998 and 1999.

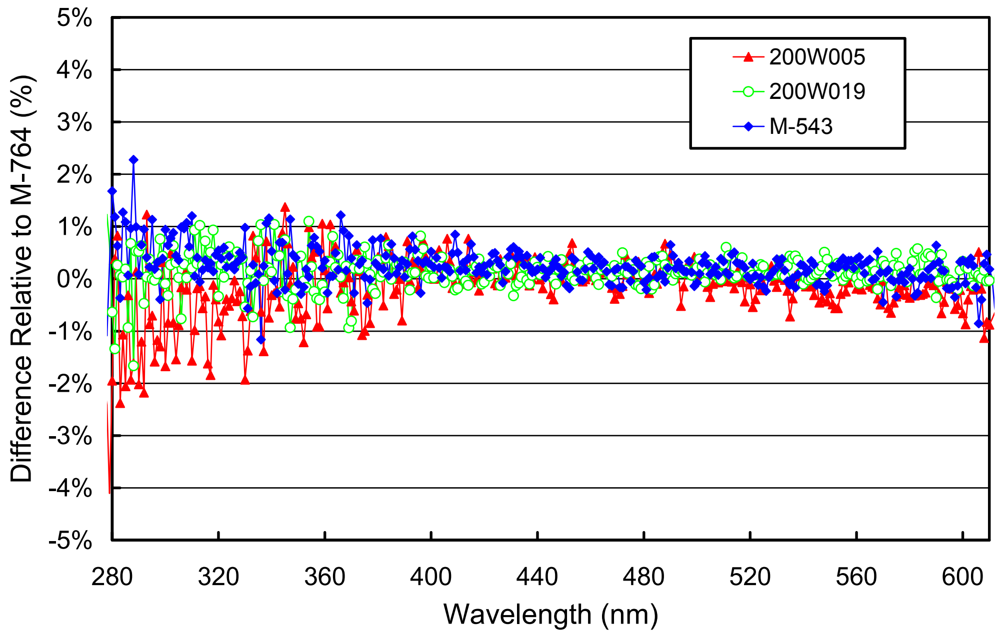

Figure 5.1.2 *Comparison of McMurdo lamps 200W005, 200W019, and M-543 with the BSI traveling standard M-764 at the end of the season (1/22/02).*

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 is monitored with the TSI sensor, which is independent from possible monochromator and PMT drifts. By logging the PMT currents at several wavelengths during response scans, changes in monochromator throughput and PMT sensitivity can be detected. However, changes in the instrument's fore-optics cannot be detected with response scans. As mentioned in the introduction, the worn coating of the shutter collected on the relay lens, which lead to a significant overall responsivity change during the 2001/2002 season.

Figure 5.1.3 shows the changes in TSI readings and PMT currents at 300 and 400 nm, derived from the daily response scans. TSI measurements fluctuated by less than ±1% during the entire season, indicating stability of the internal lamp. PMT currents decreased by 4% during the first several months, and increased thereafter to reach about the same level at the end of the season than at the beginning. Note that this annual cycle has also been observed during previous seasons. Its actual reason is unknown. The change in instrument responsivity does not affect solar data as the daily response scans are used for correcting these drifts. Day-to-day changes, which would affect solar data, are below 0.5%.

Because of the shutter abrasion, the overall responsivity of the system decreased by about 14%. The season was broken in 17 periods in order to account for this change. In each of these periods, a different irradiance function was assigned to the internal lamp following the procedure described in Section 4.2.1.2. Figure 5.1.4 shows the ratios of those functions relative to the function applied in the first period (1/25/01 - 2/6/01). During some periods, the change in responsivity as registered with the bi-weekly absolute scans was larger than the target value of 2%. The functions were therefore interpolated such that the relative change between consecutive calibration functions became smaller than 2%.

Table 5.1.1 gives for each period the 1-σ calibration uncertainty that is caused by the instrument drift. Note that this uncertainty is only a measure of the variability of calibrations in a given period. It is not the total calibration uncertainty, which would also include uncertainties in the calibration values of standard lamps. In periods when the system was stable the calibration file was derived by averaging the results of all absolute scans performed in this period. These periods include Periods P1, P2, P3, P4, P6, P7 and P16. The uncertainty for each of these periods is the ratio of standard deviation and average irradiance calculated from all calibration files performed in that period. These ratios are plotted in Figure 5.1.5. The 1-σ uncertainty is typically ±1.5% in the UV and ±1% in the visible. The uncertainty for periods when the calibration file was derived by interpolation was calculated from the uncertainty of the two calibration functions on which the interpolation is based, and the difference of those two functions. The uncertainty is typically smaller than 1.4%, except for Period 12, where it is 2.3% in the UV-B. This somewhat higher uncertainty is due to inspection of the collector by the system operator on 12/6/01, which might have changed the system's responsivity. In spite of the observed drifts, uncertainties in published solar data remain within reasonable limits.

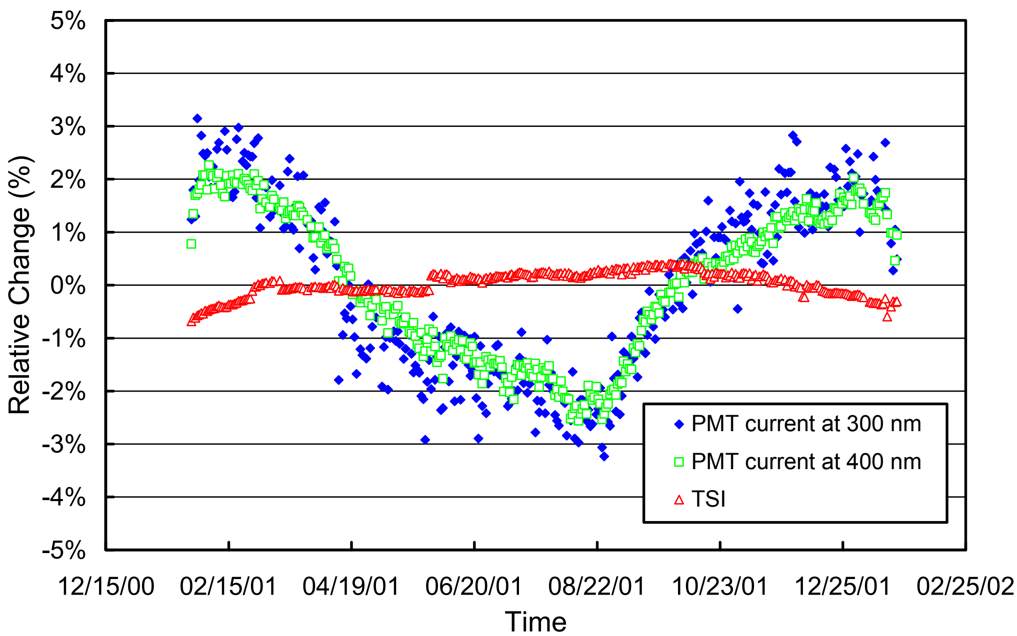

Figure 5.1.3. *Time-series of PMT current at 300 and 400 nm, and TSI signal during measurements of the internal irradiance reference lamp during the McMurdo 2001/02 season. The data is normalized to the average value of the whole season.*

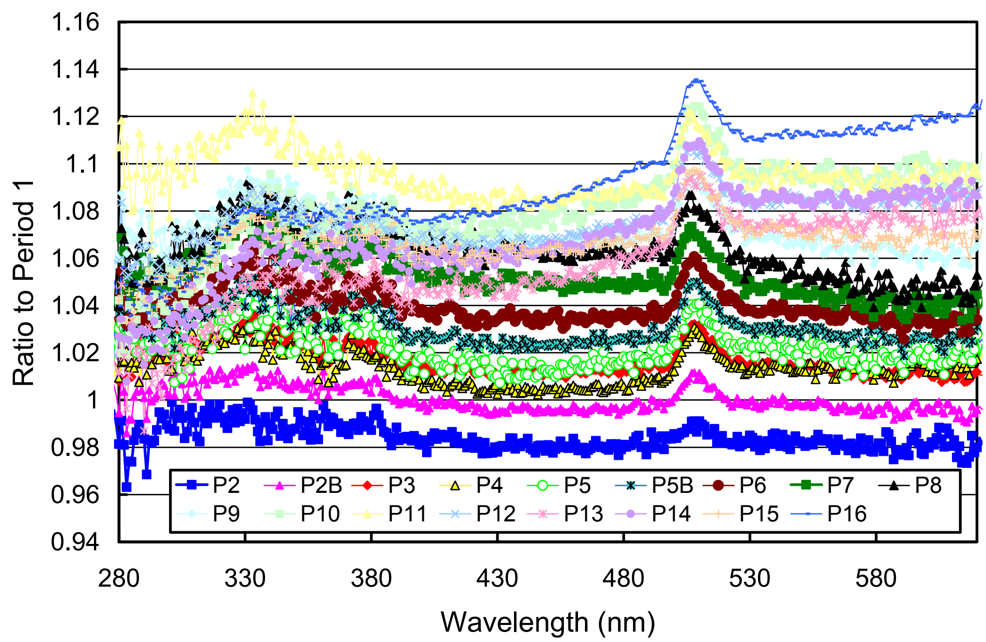

Figure 5.1.4 *Ratio of irradiance assigned to the internal reference lamp to the period 1/25/01 – 2/6/01.*

Table 5.1.1. 1-σ standard uncertainty of system calibration caused by responsivity drifts.

Period		Number of absolute scans	Standard uncertainty in %			Remarks
Label	Range of dates		UV-B	UV-A	VIS	
P1	01/25/01 - 02/06/01	8	0.6	0.6	0.5	Standard calibration
P2	02/07/01 - 02/23/01	2	0.5	0.7	0.5	Standard calibration
P2B	02/24/01 - 03/11/01	0	1.3	1.4	1.2	Interpolation
P3	03/12/01 - 06/20/01	6	0.7	0.7	0.5	Standard calibration
P4	06/21/01 - 09/07/01	4	0.6	0.5	0.4	Standard calibration
P5	09/08/01 - 09/20/01	1	0.7	0.7	0.5	Single scan
P5B	09/21/01 - 09/24/01	0	1.5	1.3	1.2	Interpolation
P6	09/25/01 - 10/27/01	3	1.1	0.8	0.7	Standard calibration
P7	10/28/01 - 11/01/01	2	0.7	0.7	0.5	Standard calibration
P8	11/02/01 - 11/10/01	1	1.0	1.0	0.8	Single scan
P9	11/11/01 - 11/16/01	2	1.1	1.0	1.1	Interpolation
P10	11/17/01 - 11/26/01	1	1.0	1.0	0.8	Single scan
P11	11/27/01 - 12/05/01	1	1.0	1.0	0.8	Single scan
P12	12/06/01 - 12/12/01	0	2.3	1.8	1.0	Interpolation
P13	12/13/01 - 12/22/01	1	1.0	1.0	0.8	Single scan
P14	12/23/01 - 12/31/01	0	1.3	1.2	0.8	Interpolation
P15	01/01/02 - 01/10/02	0	1.1	1.1	1.0	Interpolation
P16	01/11/02 - 01/23/02	11	0.8	0.7	0.4	Standard calibration

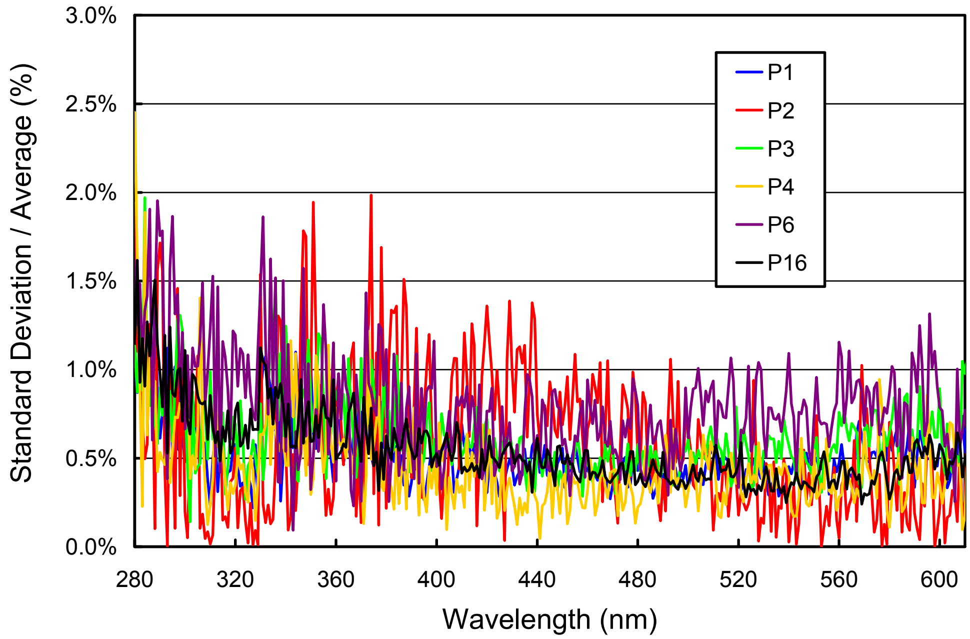

Figure 5.1.5. *Ratio of standard deviation and average calculated from the absolute calibration scans.*

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 5.1.6 shows the differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 378 pairs of scans have been evaluated. For 90% of the days, the offset change is smaller than ±0.025 nm; for 99% of the days it is smaller than ±0.055 nm. The offset-difference is only larger than ± 0.1 nm for 3 scans when the wavelength was manually adjusted. The wavelength calibration of the final data was corrected 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. The correction function is shown in Figure 5.1.7. In order to demonstrate the difference between the result of the Fraunhofer-correlation method and the method that was historically applied, Figure 5.1.7 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 about 0.1 nm. As explained in Section 4.2.2, this bias is caused by the different light paths for internal wavelength scans and solar measurements.

After the data was wavelength corrected using the shift-function described above, the wavelength accuracy was again tested with the Fraunhofer method. The results are shown in Figure 5.1.8 for four UV wavelengths. The residual shifts are typically smaller than ±0.05 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.

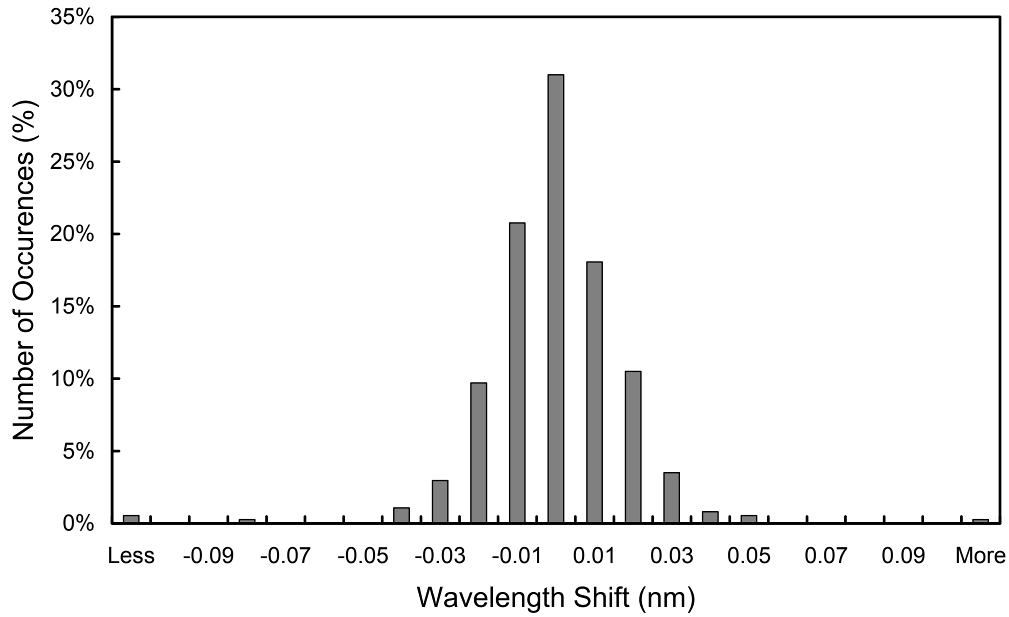

Figure 5.1.6. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. The 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

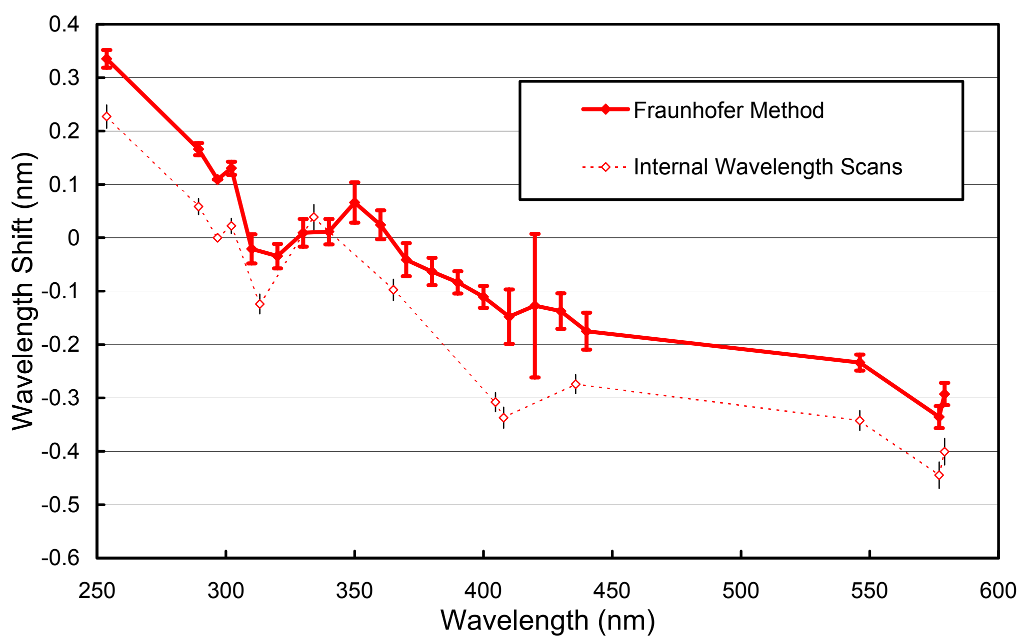

Figure 5.1.7. *Monochromator non-linearity for the McMurdo 2001/02 season. Line: Correction functions calculated with the Fraunhofer-correlation method. Broken line: Correction function calculated with the method that was historically applied. The offset difference between both methods is approximately 0.1 nm. The error bars show the 1σ standard deviation of the wavelength shift.*

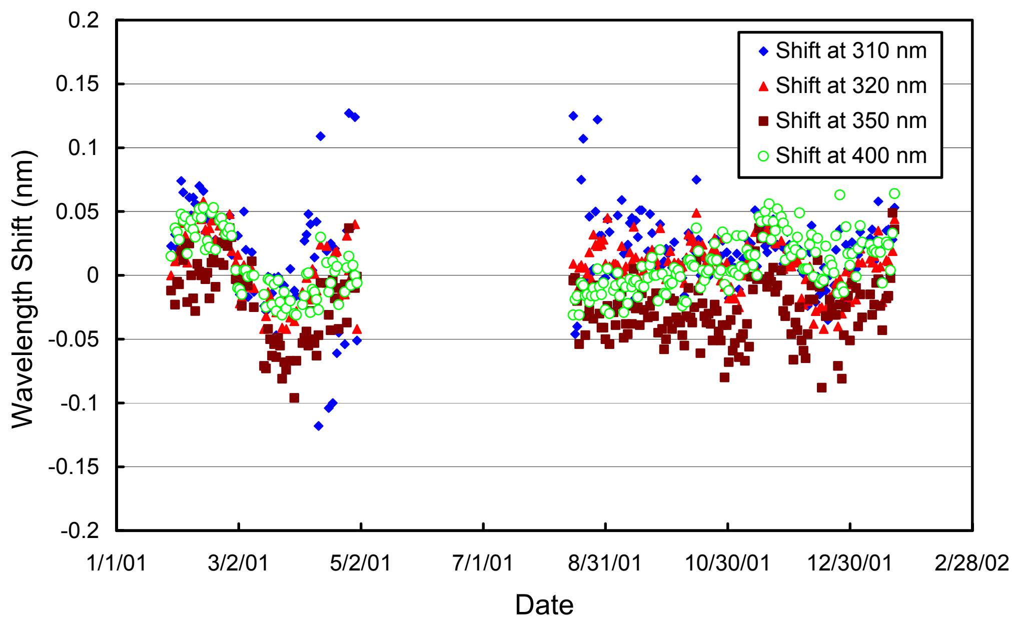

Figure 5.1.8. *Check of the wavelength accuracy of the final data at four wavelengths by means of Fraunhofer correlation. The noontime measurement has been evaluated for each day of the season. No correlation data is available during the polar night.*

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 5.1.9 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 peak of the external scans agrees well with the nominal wavelength of 296.73 nm, whereas the peak of the internal scans is shifted about 0.1 nm to shorter wavelengths. External scans have a bandwidth of about 1.02 nm FWHM. The bandwidth of the internal scan is 0.74 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.

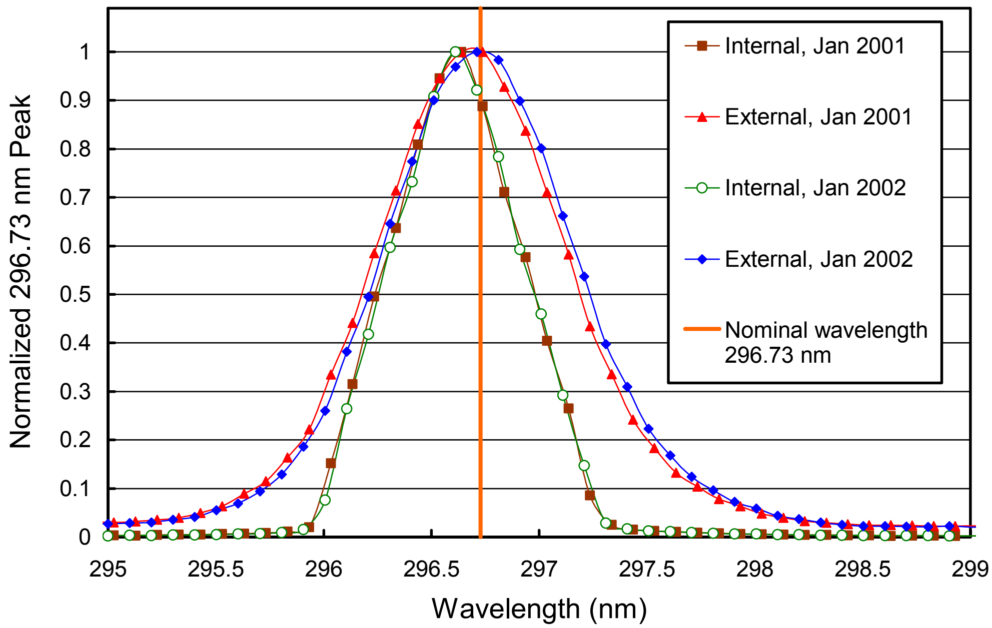

Figure 5.1.9 *The 296.73 mercury line as registered by the PMT from external and internal sources. The wavelength scale is the same as applied for solar measurements, i.e., it is based on a combination of internal scans and the Fraunhofer-correlation method. It is assumed that the wavelength registration of the monochromator did not shift between internal and external scans, which were close in time.*

5.1.4. Missing Data

A total of 16690 scans are part of the published McMurdo Volume 11 dataset. These are 91% of the scans scheduled. About 4.5% of all scans were missed due to technical problems. Between the site visit and polar night the computer malfunctioned frequently (see the introduction to this section), and a total of 385 scans were lost. The following days were affected; numbers in parenthesis give number of missing scans: 2/19/01 (20); 2/20/01 (15); 2/28/01 (11); 3/1/02 (4); 3/7/01 (30); 3/8/01 (8); 3/10/01 (11); 3/11/01 (65); 3/12/01 (42); 3/13/01 (5); 3/14/01 (3); 3/28/01 (24); 3/29/01 (11); 3/31/01 (18); 4/1/01 (26); 4/2/01 (10); 4/13/01 (32); 4/14/01 (10); 4/20/01 (13); 4/22/01 (21); 4/23/01 (9); 5/4/01 (0); 5/10/01 (0); 5/18/01 (0); and 5/29/01 (0).

Of all missing data scans, 137, 334, and 334 were superseded by absolute, wavelength, and response scans, respectively. On 3/26/01 and 11/24/01, the computer time was reset by one day by the system's GPS receiver. The affected scans were time-corrected, however, 21 scans recorded on 3/25/01 and 30 scans recorded on 11/23/01 were overwritten and could not be salvaged. Because of a full data storage medium, 188 scans recorded on 1/5/02 – 1/7/02 were lost. Checking or replacement of storage media lead to 8 missing scans on 1/28/01 and to 9 missing scans on 1/9/02. On 1/17/02, a regulator for the monochromator temperature stabilization became defective and had to be replaced. This caused a loss of 91 scans on 1/17/02 and 1/18/02.