5.6. Barrow, Alaska (10/24/01 – 3/2/04)

This sections describes quality control of solar data recorded between 10/24/01 – 3/2/04. There were no site visits in 2002 and 2003. Solar data recorded between 10/24/01 and 12/31/2002 were assigned to Volume 11; data covering the period 1/1/03 – 3/2/04 are part of Volume 13. No data were assigned to Volume 12. Opening and closing calibrations of the 2.5-year period described in this section were performed on 10/22/01–10/23/01 and 3/3/04, respectively.

The system performed well during the reporting period with the exception of the following problems:

- **GPS failure**
  The GPS unit became defective on 6/2/03, which caused several system lock-ups and data losses during the weeks following the failure. The GPS was disconnected on 7/19/03.
- **Time errors**
  Several periods are affected by time errors: the computer time was not adjusted by the GPS between 4/29/02 and 5/17/02. At the latter day, the time was found to be incorrect by 50 seconds. Time was also not adjusted between 6/1/03 and 6/11/03 (25 seconds error), and between 6/24/03 and 7/16/03 (42 seconds error). After 7/19/03, when the GPS unit was defective, time was manually adjusted by the site operator every 1-2 weeks. Uncertainty of time during this period is approximately ±30 seconds. The maximum time error was 45 seconds on 1/29/04. No corrections for time errors were applied.
- **UPS failure**
  The system's uninterruptible power supply (UPS) became defective on 9/19/03 and had to be disabled. This lead to some data loss during the following months when power outages occurred.
- **TUVR failure**
  Data from the TUVR showed unreasonable large day-to-day variations. Measurements at some days were close to zero while SUV-100 and PSP data appeared to be normal. No TUVR data were published.

During the site visit in October 2001, the PSP instruments was replaced by an identical unit, which had been calibrated by Eppley Laboratories on 2/21/01. This calibration was applied to Volume 11 and 13 data. Note that the PSP at Barrow is not ventilated. Since the instrument is cleaned only about twice per week, snow may accumulate leading to a reduction in signal. A ventilator was installed during the site visit in March 2004 in response to the problem.

About 96.5% of the scheduled data scans are part of the published Volume 11 dataset. The yield for Volume 13 is 89.5%. About 6% of Volume 13 scans were lost due to GPS failures and subsequent system lock-ups.

5.6.1. Irradiance Calibration

The site irradiance standards for the reporting period were the lamps 200W009, M-762, and M-699. Lamps M-764 and 200W017 were used as traveling standards. All lamps had been re-calibrated by Optronic Laboratories in March 2001. These calibrations were applied throughout the reporting period.

Figure 5.6.1 shows a comparison of all lamps at the beginning of the period (10/22/01–10/23/01). The site standard agreed with M-764 to within ±1.0% (±2.0% for M-699 at wavelengths below 330 nm). These differences are still within the uncertainties of the calibration standards. Figure 5.6.2 shows a similar comparison of the three site standards against 200W017, performed at the end of the reporting period. All lamps agreed to within ±1% for wavelengths larger than 330 nm. Below 330 nm, the three site standards differ by 2-4% from the traveling standard 200W017. This suggests that the discrepancy is caused by the traveling standard. We did not adjust the calibration of any lamp based on these results. In addition to scans conducted during site visits, the site standard were compared against each other seven times between October and 2001 and March 2004. The lamps agreed to within ±1.5% on all occasions.

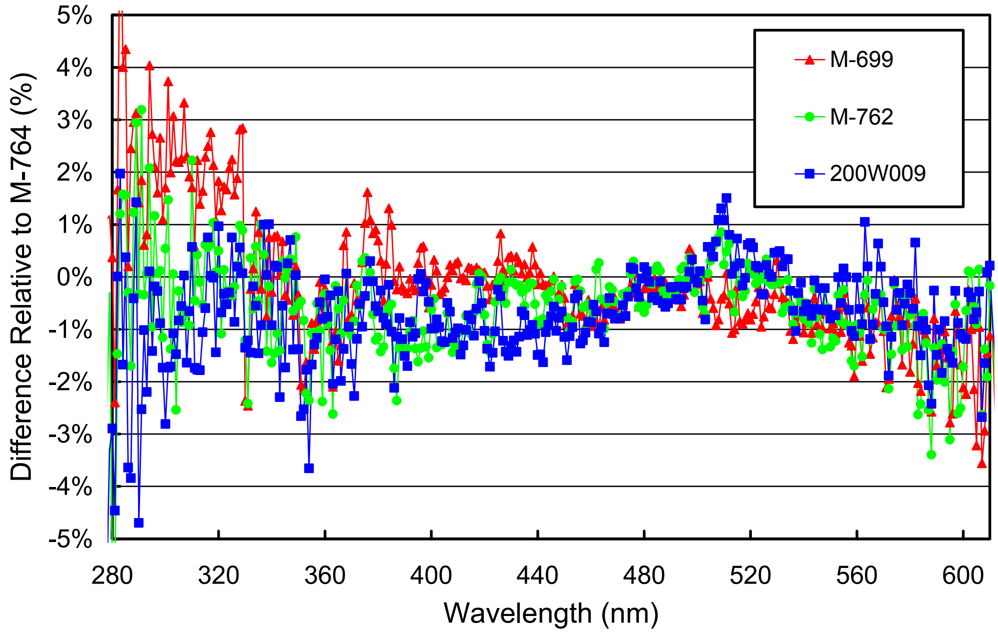

Figure 5.6.1. *Comparison of Barrow lamps 200W009, M-762, and M-699 with the BSI traveling standard M-764 at the beginning of the reporting period.*

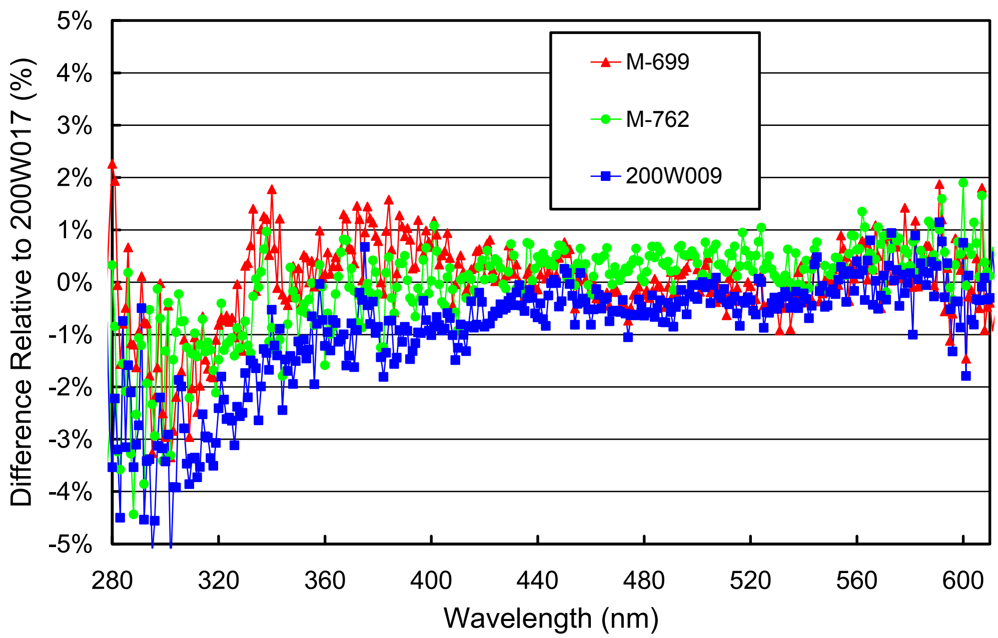

Figure 5.6.2. *Comparison of Barrow lamps 200W009, M-762, and M-699 with the BSI traveling standard 200W017 at the end of the reporting period.*

5.6.2. 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 this 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.

The internal lamp failed on 3/18/02 and was replaced on 4/4/02. Figure 5.6.3 shows changes in TSI readings and PMT currents at 300 and 400 nm, derived from the daily response scans of the period 10/28/01 – 3/16/02. TSI measurements indicate that the internal lamp became brighter by 4% during this period. The rate of change started to increase several days before the lamp failure. Changes in PMT currents tracked the TSI change well, suggesting that monochromator throughput and PMT sensitivity were stable.

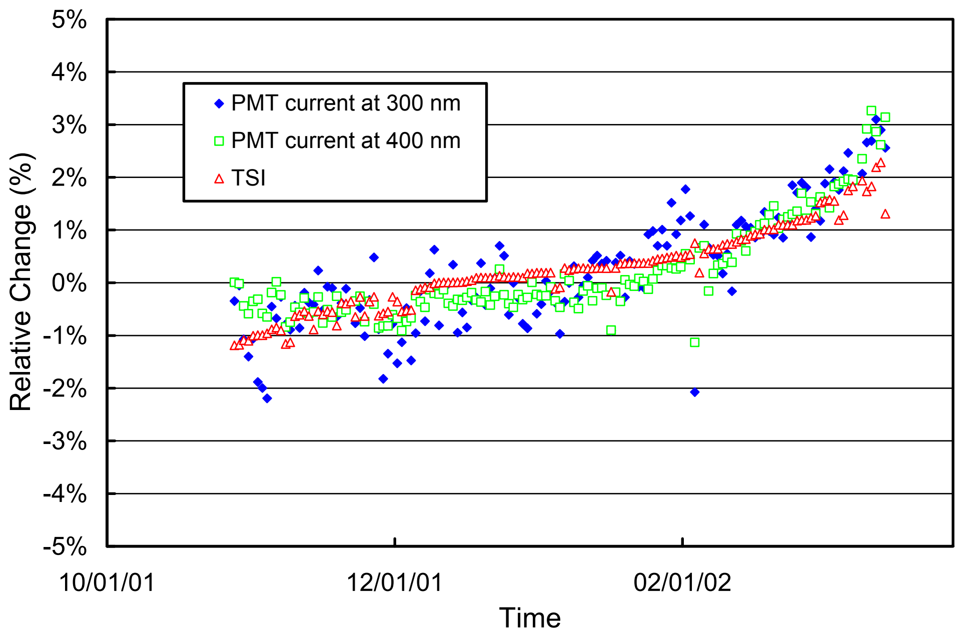

Figure 5.6.3. *Time-series of PMT current at 300 and 400 nm, and TSI signal extracted from measurements of the internal irradiance standard at Barrow between 10/28/01 – 3/16/02. All data sets are normalized to the average.*

Figure 5.6.4 shows TSI readings and PMT current for the period 4/5/02 – 3/1/04. TSI measurements indicate that the internal lamp became brighter by 4% between April and December 2002. Thereafter, the brightness gradually decreased and reached the original level at the end of the reporting period. This is a typical cycle for internal lamps. PMT currents tracked TSI measurements well, again indicating good stability of monochromator and PMT. Between 3/18/02 and 4/4/02, when no internal lamp scans were available, solar data were calibrated with the internal scan from 3/17/02. Thus, the system was "made to believe" that the lamp is still functional. Uncertainties of solar data for the affected period are increased as changes in throughput may have occurred.

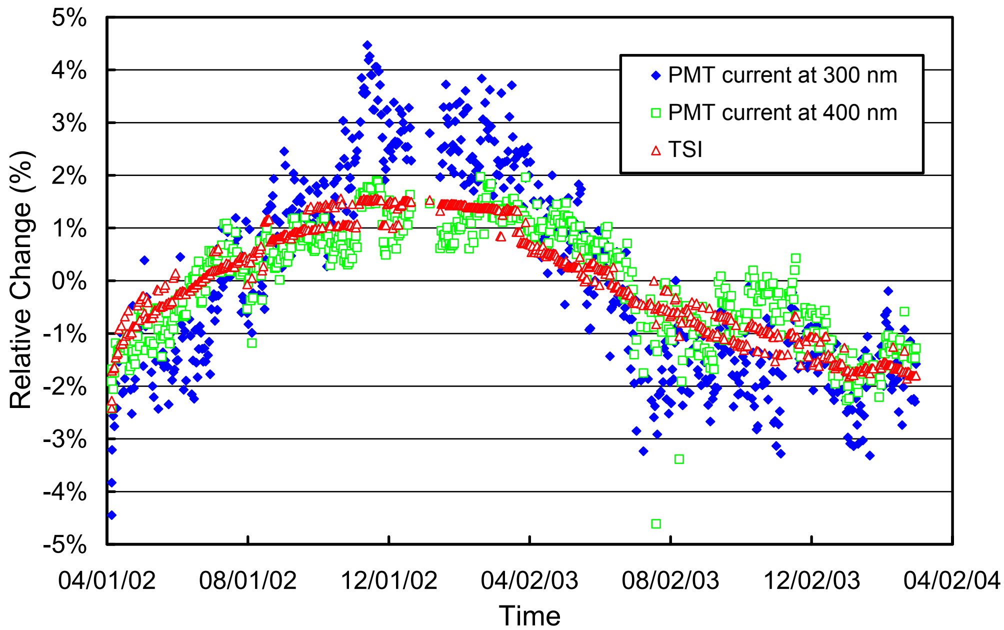

Figure 5.6.4. *Time-series of PMT current at 300 and 400 nm, and TSI signal extracted from measurements of the internal irradiance standard at Barrow between 4/5/02 and 3/1/04. All data sets are normalized to the average.*

Due to the good stability of the system in the reporting period, comparatively few changes to the irradiance values assigned to the two internal lamps were necessary. Figure 5.6.5 shows the ratio of the irradiance assigned to the first lamp. There is a difference of about 2-4% between the two periods 10/24/01 – 12/31/01 and 01/01/02 – 04/04/02. This change is consistent with the increase of brightness of the internal lamp as documented in Figure 5.6.3.

Figure 5.6.6 shows ratios of spectral irradiance values assigned to the second internal reference lamp during different periods, relative to the period 4/5/02 – 5/30/02. There is little variation between Periods 5, 6, 8, and 9 (see Figure 5.6.6 for Period assignment). Values for Period 7 (6/27/03 – 8/9/03) are 3% higher. This period was affected by increased system temperatures, which may have contributed to the difference. The difference was not seen by the TSI sensor, suggesting that it was caused by changes in the fore optics. Uncertainties in solar data for Period 7 are larger by approximately 2%.

Figure 5.6.7 presents the ratios of the standard deviation and average spectra, calculated from the individual absolute scans of each period. These ratios are useful for estimating the variability of the calibrations in each period. The variability is typically less than 1.5% for wavelengths in the UV-A and visible, and is 2.5% below 300 nm, indicating good consistency of the calibrations in all periods.

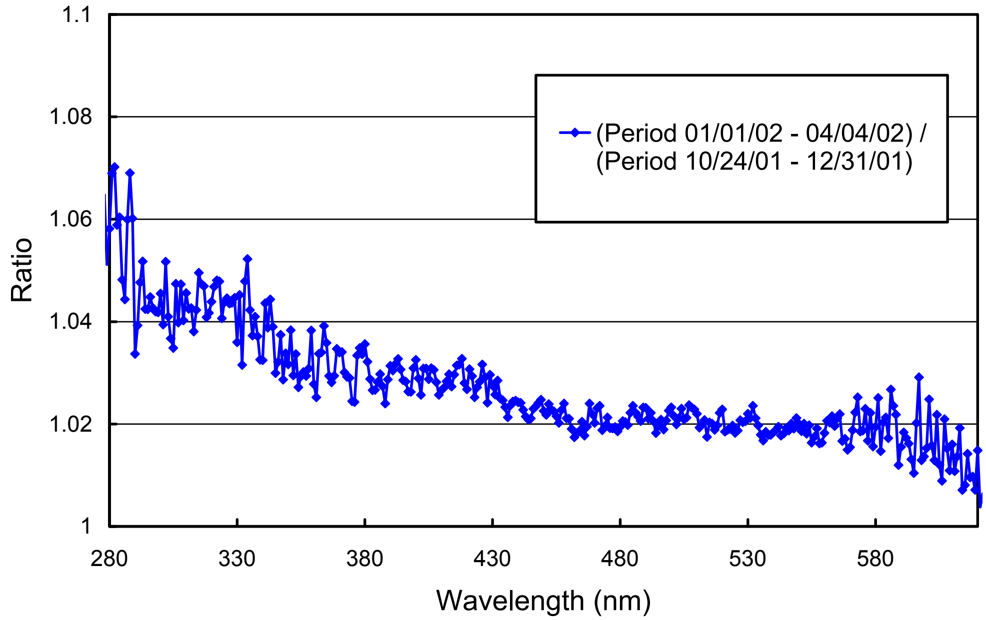

Figure 5.6.5. *Ratios of spectral irradiance values assigned to the internal reference lamp during the Periods 10/24/01 – 12/31/01 and 01/01/02 – 04/04/02. The two intervals cover the period when the first internal reference lamp was installed.*

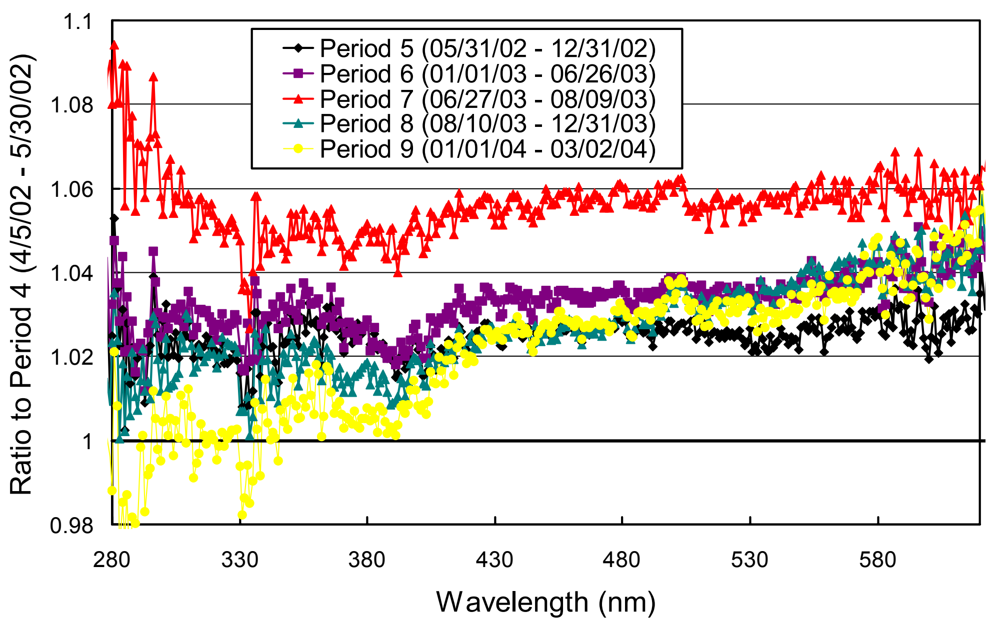

Figure 5.6.6. *Ratios of spectral irradiance values assigned to the second internal reference lamp during different periods, relative to the period 4/5/02 – 5/30/02*

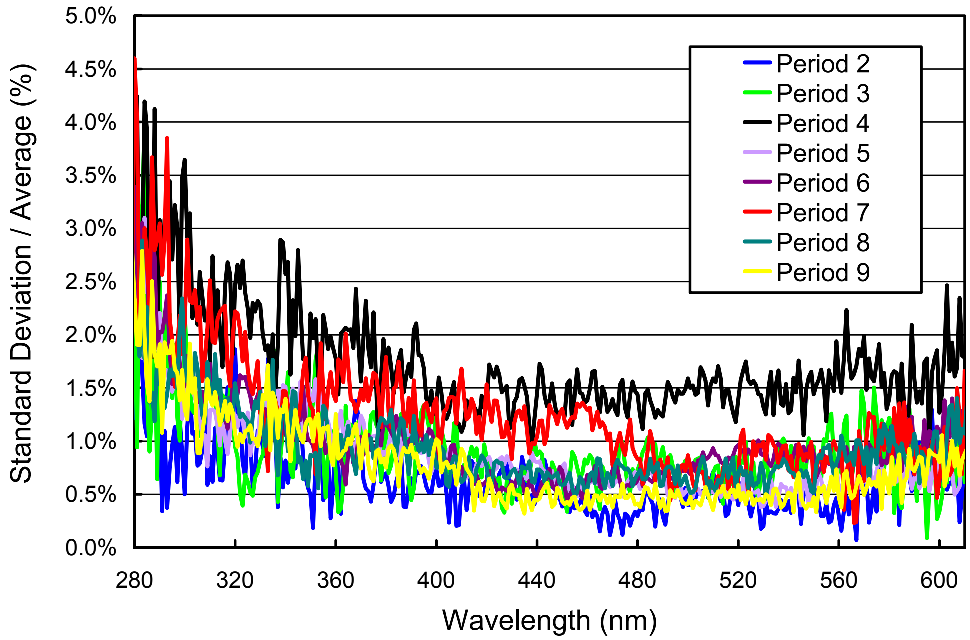

Figure 5.6.7. *Ratio of standard deviation and average spectra calculated from absolute calibration scans.*

5.6.3. 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 5.6.8 shows the differences in the wavelength offset of the 296.73 nm mercury line between two consecutive wavelength scans. In total, 858 scans were evaluated. For 97.0% (98.5%) of the days, the change in offset was smaller than ±0.025 nm (±0.055 nm). Differences for 8 pairs were larger than ±0.1 nm, and were related to system service and power outages. The 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. Figure 5.6.9 shows the resulting correction functions. There are two separate functions for the Volume 11 and Volume 13 data periods. The two functions are vary similar, indicating that the monochromator wavelength mapping was stable during the reporting period.

After the data was corrected using the two shift functions, the wavelength accuracy was again confirmed with the Fraunhofer method. The results are shown in Figure 5.6.10 for four UV wavelengths, evaluated for all noontime scans measured during the season.

Residual shifts are typically smaller than ±0.1 nm, except for the period 9/2/01 – 9/6/01, when shifts larger than ±0.2 nm occurred. Shift show comparatively large diurnal variations on these days for unknown reasons. There is more scatter at 310 nm shortly before and after the periods of winter darkness in all years because of the small solar irradiance levels prevailing during these periods. The wavelength stability is not worse during this time; yet the validation is less precise.

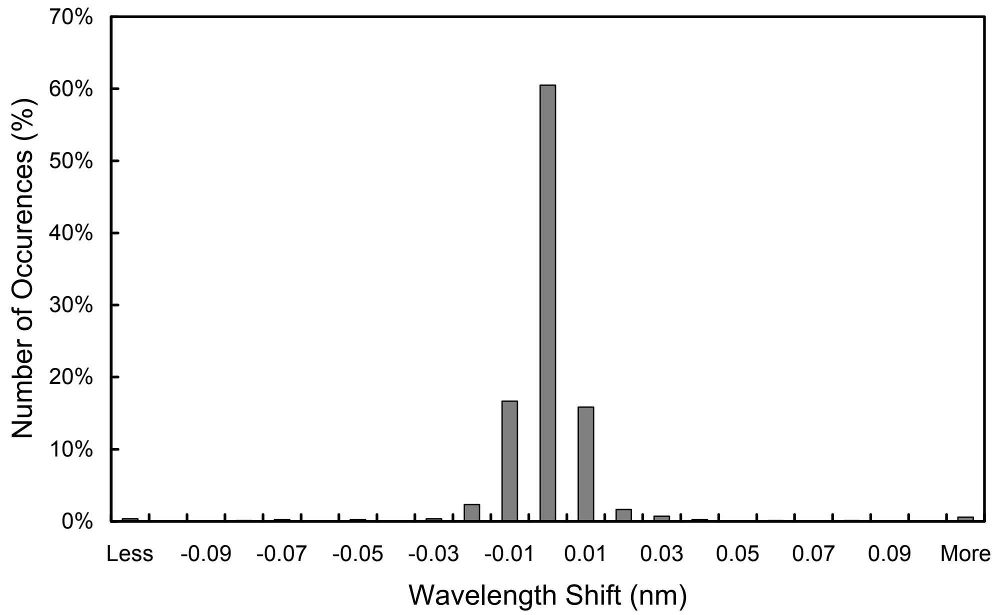

Figure 5.6.8. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans. The x-labels give the center wavelength shift for each column. Thus the 0-nm histogram column covers the range -0.005 to +0.005 nm. "Less" means shifts smaller than –0.105 nm; "more" means shifts larger than 0.105 nm.*

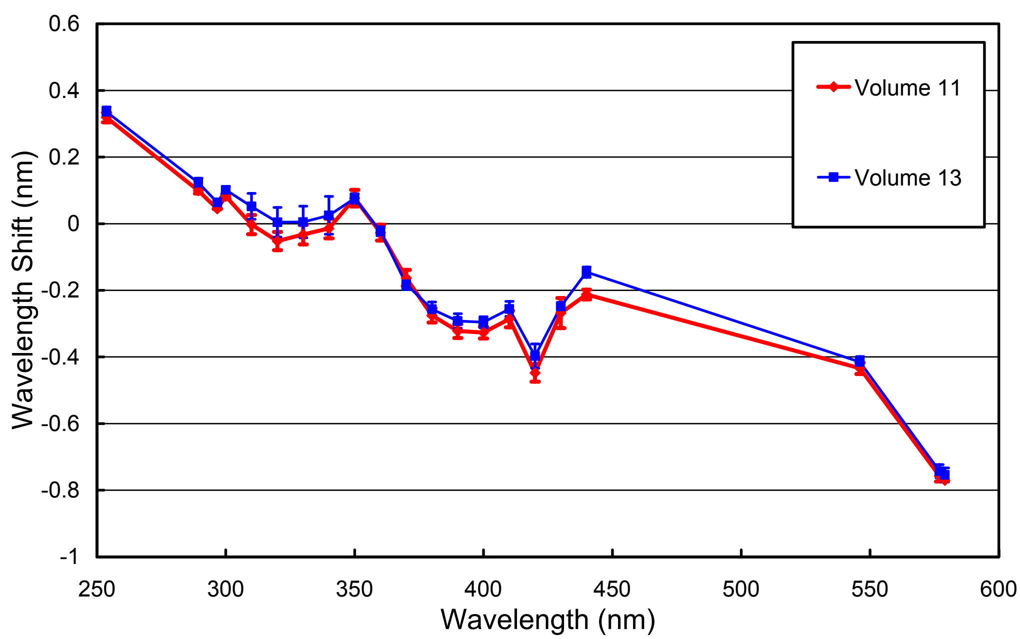

Figure 5.6.9. *Monochromator non-linearity correction functions used to correct Volume 11 and 13 Barrow data.*

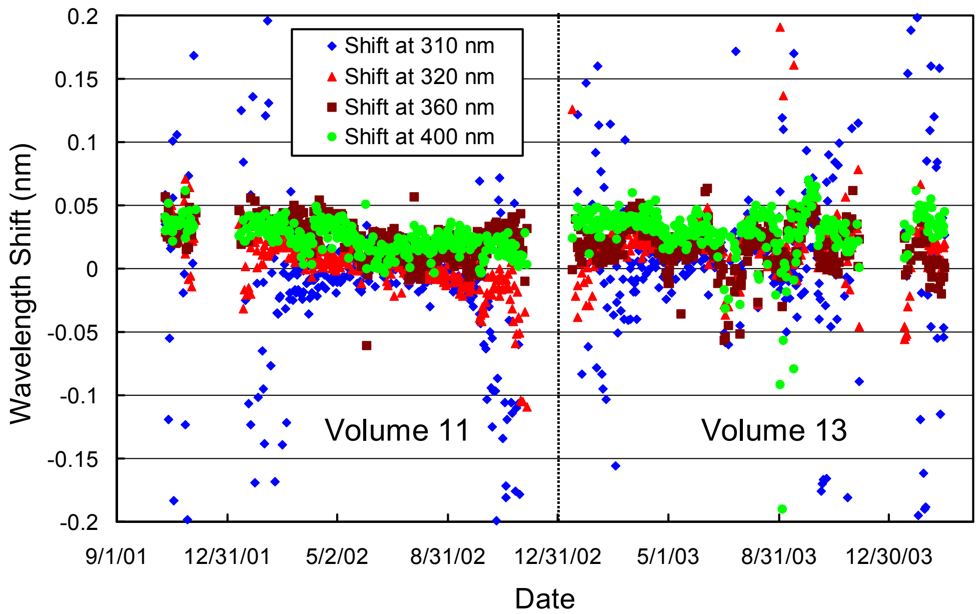

Figure 5.6.10. *Wavelength accuracy check of the final data at four wavelengths in the UV by means of Fraunhofer-line correlation. The noontime measurement has been evaluated for each day of the reporting period when the Sun was above the horizon.*

Although data from the external mercury scans do not have a direct influence on data products, they are an important part of instrument characterization. Figure 5.6.11 illustrates measurements of the 296.73 nm mercury line of internal and external mercury scans collected during both site visits. Results from October 2001 and March 2004 are consistent. Internal scan have a bandwidth of about 0.75 nm FWHM; the bandwidth of external scans is 0.98 nm FWHM. External scans better represent the monochromator bandpass relevant for solar scans, as they have the same light path.

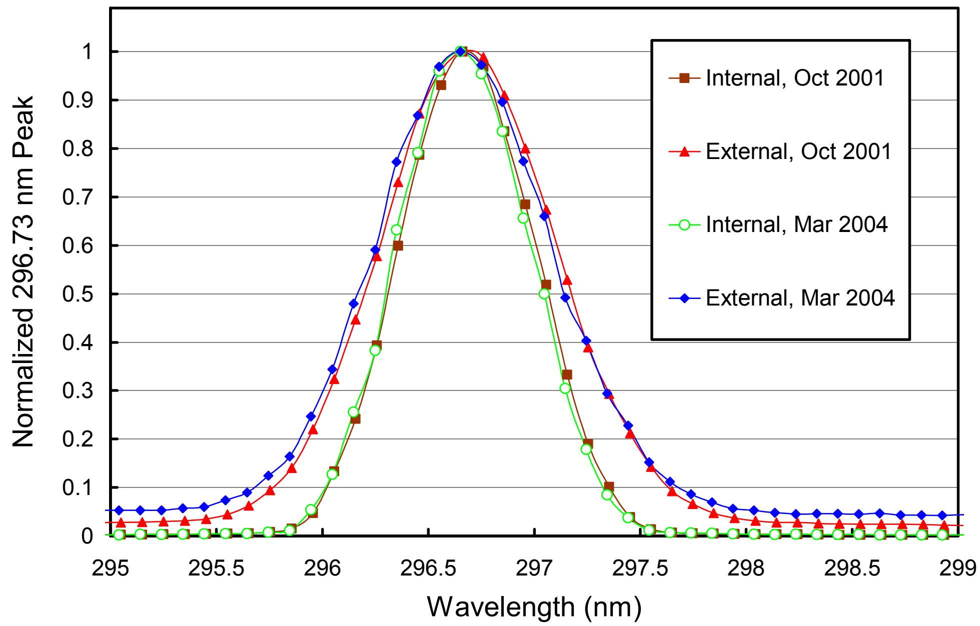

Figure 5.6.11. *The 296.73 mercury line as registered by the PMT from external and internal sources at start and end of the reporting period. The wavelength scale is the same as applied for solar measurements.*

5.6.4. Missing Data

Volume 11:
A total of 19609 scans are part of the published Barrow Volume 11 dataset. These are 96.5% of all scans scheduled. Only 1% of all scans were missed due to technical problems: 168 scans were not recorded on 6/9/02 and 6/10/02 due to full storage media and 18 scans were lost between 4/3/02 and 4/5/02 when the internal irradiance reference lamp was replaced. The remaining missing solar scans were superceded by absolute, wavelength, and response scans, respectively.

Volume 13:
A total of 18712 scans are part of the published Barrow Volume 13 dataset. These are 89.5% of all scans scheduled. 7.5% of all scans were missed due to technical problems. The majority of this loss is attributable to GSP failures and subsequent system lock-ups as described earlier. Table 5.6.1 gives a more detailed overview of scans lost due to technical problems. In addition, 179, 267, and 292 solar scans were superceded by absolute, wavelength, and response scans, respectively.

Table 5.6.1. Missing solar scans in Volume 13 due to technical problems.

Reason	Period	Number of scans
GPS failure with subsequent system lock-ups	06/05/03 – 07/19/03 and 10/09/03 – 10/10/03	1068
GPS testing	10/28/03 and 11/22/03-11/24/03	64
Power outage	07/08/03 and 01/24/04-01/28/04	186
Automatic scanning erroneously disabled	08/12/03 – 8/14/04	153
System time set incorrectly	11/07/03 – 11/10/03	73
Various	Throughout Volume 13	29