5.7. Summit, Greenland (1/20/07 – 7/11/07)

This section describes quality control of solar data recorded by the SUV-150B spectroradiometer at Summit Camp, Greenland, between 1/20/07 and 7/11/07. The start of the data series is indicated by the end of the Polar Night, defined here as the date when the solar zenith angle at noon is smaller than 93°. The site visit on 7/10/07-7/12/07 marks the end of the reporting period.

The instrument's performance was somewhat affected by larger-than-desirable changes in responsivity. However, these drifts could be corrected during data processing and the impact on published data is small. This was confirmed by comparing final SUV-150B data with measurements of the co-located GUV-511 multi-filter radiometer as well as radiative transfer calculations.

Measurements of the TSI sensor were not always correctly recorded and data from several days are missing in published databases. The Eppley PSP pyranometer (S/N 32760F3) installed next to the SUV-150B was calibrated by Eppley Laboratory on 4/8/2004.

A total of 10493 scans are part of the Summit Volume 16 dataset. Only 1.6% of all possible scans were lost due to technical problems.

5.7.1. Irradiance Calibration

The irradiance standards used during the reporting period were the lamps 200W027 and 200W030. Both lamps were originally calibrated by Optronic Laboratories on 3/28/01. The calibration of lamp 200W027 had changed by about 1-2% in the UV and 0-1% in the visible between 2004 and 2006. The lamp had been recalibrated in 2006 against lamp 200W030 using all scans of the two lamps executed at Summit during the 2005/2006 season (see Volume 15 Operations Report).

Lamps 200W017 and 200W038 were used as traveling standard during the site visit in July 2007. The original calibration of lamps 200W017 was established by Optronic Laboratories in March 2001. Lamp 200W038 did not have a calibration prior to July 2007.

The two traveling standards were (re-)calibrated in July 2007 at BSI with four 1000-Watt FEL lamps provided by the Central UV Calibration Facility (CUCF) at Boulder. This calibration procedure was complicated by the fact that the irradiance scale of the four FEL lamps refers to the detector-based scale of the National Institute of Standards and Technology established in 2000 (NIST2000; *Yoon et al*., 2002), whereas all solar data of the NSF UVSIMN refer to the source-based NIST scale from 1990 (NIST1990, *Walker et al*., 1987). The NIST2000 scale is about 1.3% larger than the NIST1990 scale. Data of certificates issued by the CUCF were converted to the NIST1990 scale before the calibration was transferred to the two traveling standards 200W017 and 200W038.

Comparisons of measurements between the site standards (200W027 and 200W030) and the traveling standards (lamps 200W017 and 200W038) performed during the site visit revealed a bias between the two groups of 2.8% in the UV-B and 2.4% in the UV-A and visible. Some of the difference is likely caused by drifts in the calibration of the on-site standards. For example, the change in brightness of lamp 200W027 observed during the previous years has likely continued in 2007. Lamps 200W027 and 200W030 were recalibrated against lamp 200W017 using all scans performed during the site visit. Figure 5.7.1 compares measurements of the (re-calibrated) on-site lamps 200W027 and 200W030 and the traveling standard 200W038 with measurements of lamp 200W017. Data from lamps 200W027, 200W030, and 200W017 agree at the ±0.5% level on average, as expected. Measurements of lamps 200W038 and 200W017 differ by about 1% in he UV, indicating a small discrepancy in the calibration of the two traveling standards.

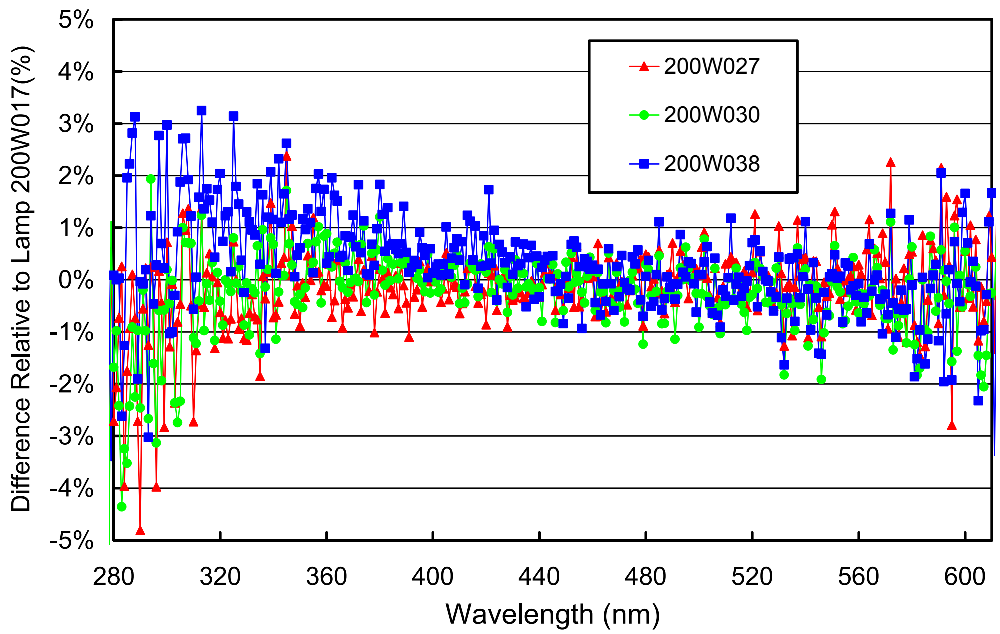

Figure 5.7.1. *Comparison of lamps 200W027, 200W030, 200W038 with lamp 200W017. Data was collected during the site visit in July 2007.*

5.7.2. Instrument Stability

The temporal stability of the spectroradiometer is monitored with bi-weekly calibrations utilizing site irradiance standards; daily response scans of the internal irradiance reference lamp; measurements of filtered photodiodes integral to the instrument's integrating sphere; and by comparison with the co-located GUV-511 radiometer. Daily response scans help to uncover instabilities related to monochromator and PMT but cannot be used to track changes in the instrument's cosine collector (integrating sphere + PTFE diffuser). In contrast, the sphere's photodetectors are only sensitive to changes in the cosine collector and are not affected by possible drifts of other system components such as the optical fiber or the monochromator.

The stability of the cosine collector was determined by analyzing the signal of the sphere's photodetectors when executing absolute scans. Signals should ideally be constant from one calibration event to the next, assuming that the irradiance from the external lamps do not change over time. Figure 5.7.2 shows signals of the four detectors as a function of time. Data were normalized to signals recorded on 1/15/07. Results indicate that the throughput of the collector increased by up to 12% during the course of the reporting period. The change is largest at short wavelengths (320 and 340 nm), but less than 3% at 490 nm. Changes of similar magnitude but with the opposite sign have been observed in 2006 (see Volume 15 Operations Report). We attribute these drifts to changes in the reflectivity of the integrating sphere's wall, but the detailed mechanism (e.g., contamination or condensation of water) is still unknown. Results are consistent with the analysis of absolute scans (Figure 5.7.4), excluding the possibility that drifts are caused by changes in the sensitivity of the photodetectors. Changes of the sphere's throughput are generally well predictable and could be corrected.

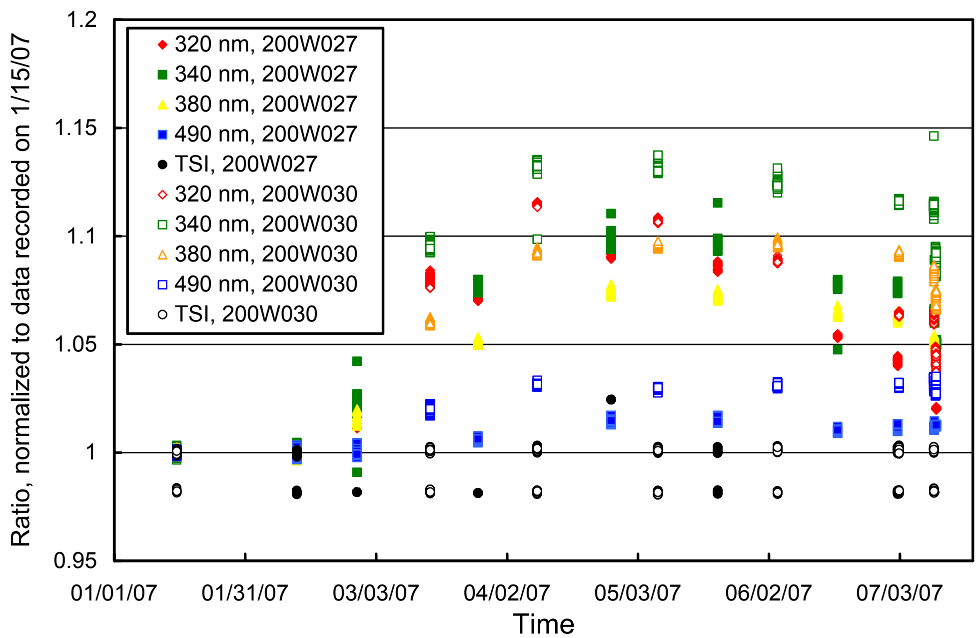

Figure 5.7.2. *Analysis of change in throughput of the instrument's integrating sphere. Change was assessed by analyzing data of photodetectors that are mounted around the sphere's exit port. Signals of the detectors were recorded during absolute scans when 200-Watt calibration standards were illuminating the sphere. Measurements are normalized to data recorded on 1/15/07 when lamps 200W027 and 200W030 were scanned. Data associated with the two calibration standards were analyzed separately. Measurements of the TSI sensor are also shown.*

Figure 5.7.3 shows changes in TSI readings and PMT currents at 320 and 400 nm, derived from response scans performed between 1/1/07 and 7/11/07. TSI measurements changed by less than 1%, indicating very good stability of the internal lamp. PMT currents varied by ±5% in a predictable manner. The cause of this variation could not be identified.

To account for changes of the system's responsivity, the reporting period was broken into nine sub-periods and a different irradiance spectrum was applied to the internal lamp in each period. A summary of the calibration periods is provided in Table 5.7.1. The ratio of these irradiance spectra relative to the spectrum applied in the first period (1/1/07 – 2/16/07) are shown in Figure 5.7.4. The responsivity changed by 10% between January and July.

Table 5.7.1. Calibration periods for Summit Volume 16.

Period name	Period range	Number of absolute scans	Remarks
P1	01/01/07 – 02/16/07	1	
P1B	02/17/07 – 02/22/07	0	Interpolated from Period P1, P2
P2	02/23/07 – 03/03/07	1	
P2B	03/04/07 – 03/10/07	0	Interpolated from Period P2, P3
P3	03/11/07 – 03/20/07	1	
P4	03/21/07 – 04/02/07	1	
P5	04/03/07 – 06/18/07	6	
P5B	06/19/07 – 06/29/07	0	Interpolated from Period P5, P6
P6	06/30/07 – 07/11/07	10	

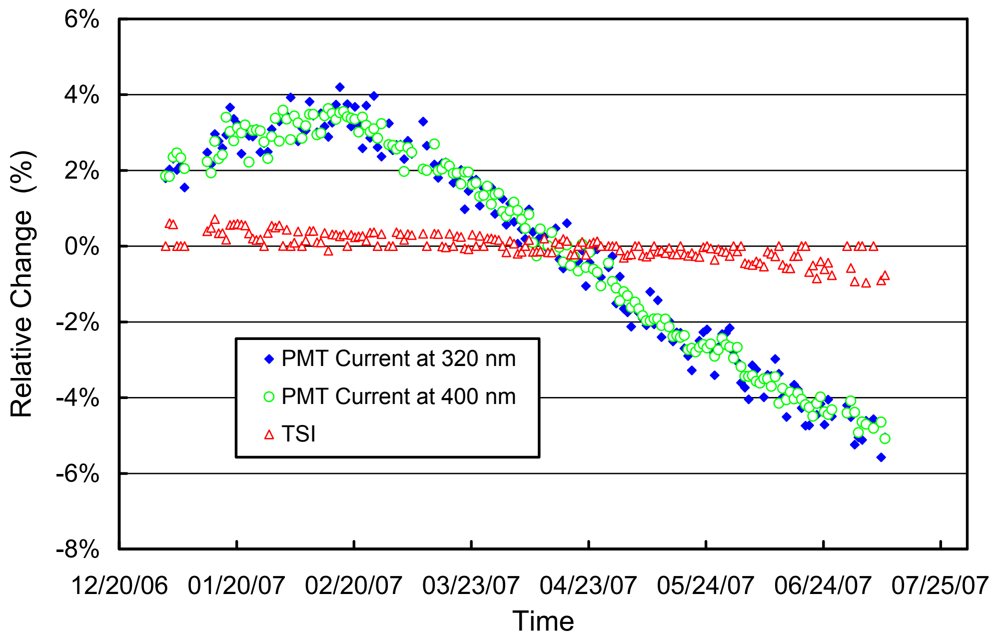

Figure 5.7.3. *Time-series of TSI signal and PMT currents at 320 and 400 nm during measurements of the internal reference lamp performed at Summit between 1/1/07 and 7/10/07.*

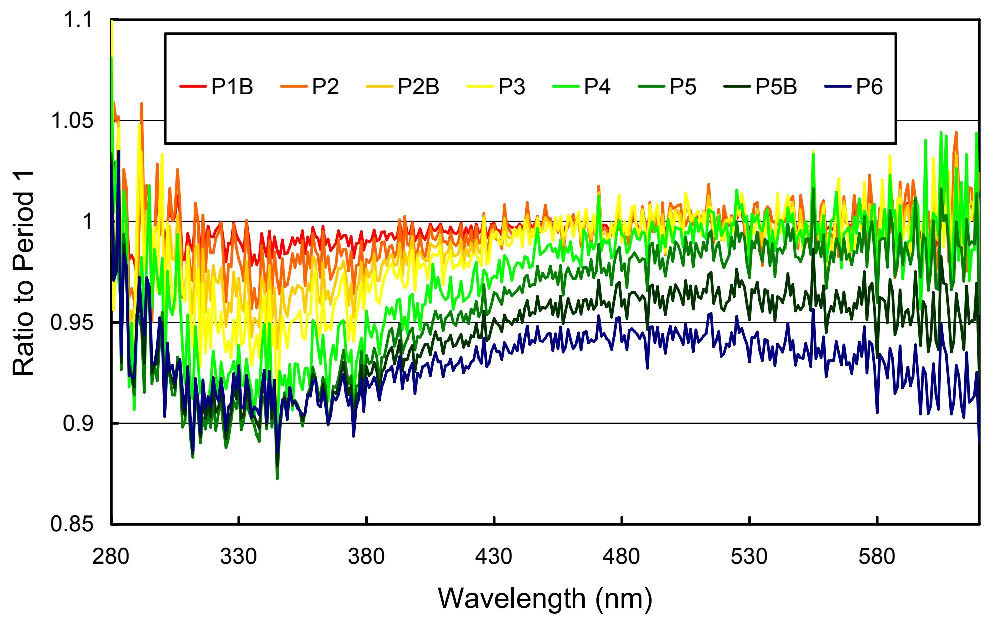

Figure 5.7.4. *Ratios of irradiance assigned to the internal reference lamp in Periods P1B – P6, referenced to the irradiance of Period P1. Data cover the period 1/1/07 - 7/11/07.*

The quality of calibrated solar measurements of the SUV-150B was further assessed by comparison with the GUV-511 radiometer. Figure 5.7.5 shows the ratio of measurements of the GUV's 340 nm channel with measurements of the SUV-150B. the latter have been weighted with the spectral response function of the GUV's channel prior to forming the average. Data of the two instruments agree to within ±2.5% on average. Step-changes at times when the SUV's calibration was changed are also smaller than 2.5%.

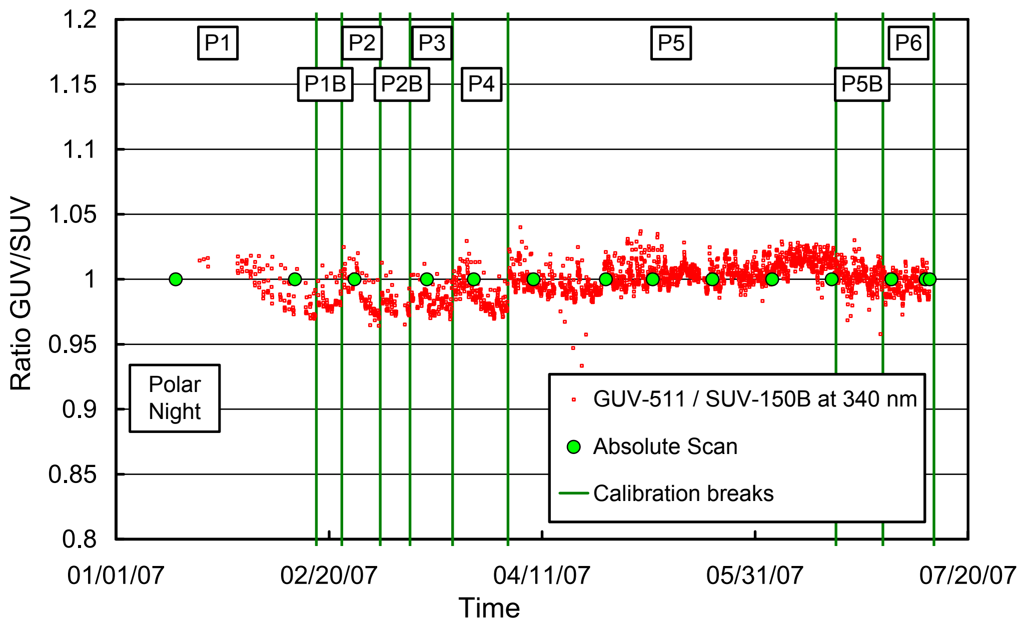

Figure 5.7.5. *Ratios of GUV-511 and SUV-150B measurements at 340 nm.*

5.7.3. Wavelength Calibration

Wavelength stability of the system was monitored with the internal mercury lamp. Figure 5.7.6 shows the differences in the wavelength offset of the 296.73 nm mercury line between pairs of consecutive wavelength scans for the period 1/1/07 – 7/11/07. In total,184 scans were evaluated. For 98.4% of the scans is the difference in the wavelength offset to neighboring scans less than ±0.0055 nm. Note that this stability is a factor of 10 better than the wavelength stability of SUV-100 spectroradiometers. The SUV-150B has a superior wavelength stability due to the use of high-resolution optical encoders that are used in a closed feedback loop with the stepper-motor controllers. Changes larger than ±0.01 nm were caused by intervention during the site visit.

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-line correlation method used for Version 2 processing (*Bernhard et al., 2004*; see also Section 4.2.2.2). Due to the good wavelength stability of the system, only one correction function had to be applied for the entire reporting period. This function is shown in Figure 5.7.7. Since the positions of the monochromator's gratings are determined by optical encoders, irregularities in the monochromator drive are inconsequential. This explains the smoothness of the function. Most of the variations observed are artifacts of the correlation algorithm, which has an uncertainty of about 0.015 nm.

After the data was corrected using this function, the wavelength accuracy of all noontime scans was verified with the "Version 2" Fraunhofer-line correlation algorithm. The results are shown for four UV wavelengths and one wavelength in the visible in Figure 5.7.8. Residual shifts are typically smaller than ±0.03 nm. A more detailed analysis reveals that wavelength shifts at 320 nm are smaller than ±0.02 nm for 99% of all scans. A few outliers occur when spectra are affected by changing cloud cover. The wavelength stability is not worse during cloudy conditions, but the validation is subject to larger uncertainties.

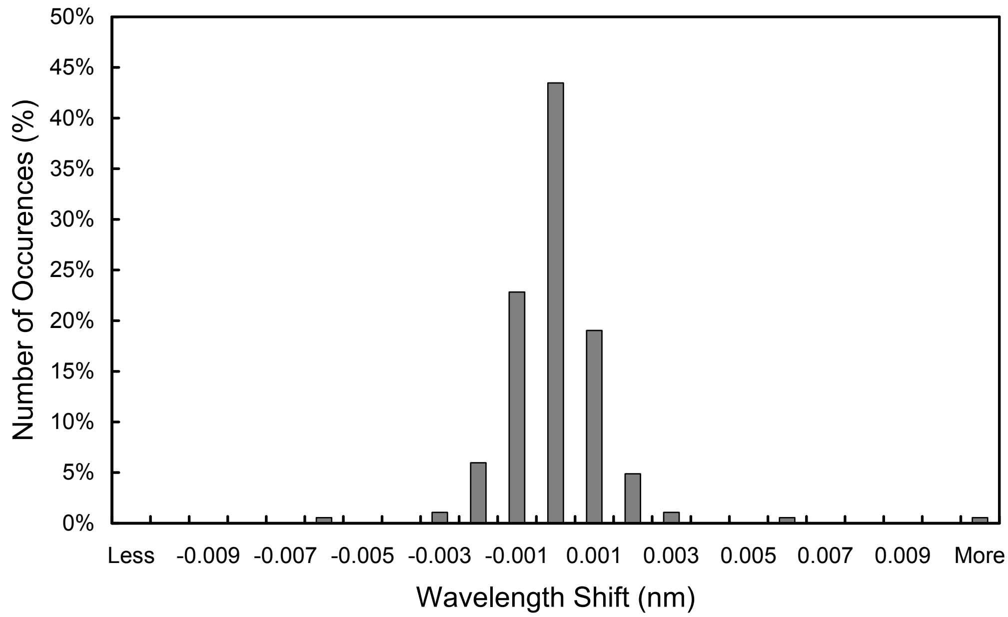

Figure 5.7.6. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength scans for the period 1/1/07 – 7/11/07. The labels of the horizontal axis give the center wavelength shift for each column. The 0-nm histogram column covers the range from -0.0005 to +0.0005 nm. "Less" means shifts smaller than -0.0105 nm; "more" means shifts larger than 0.0105 nm.*

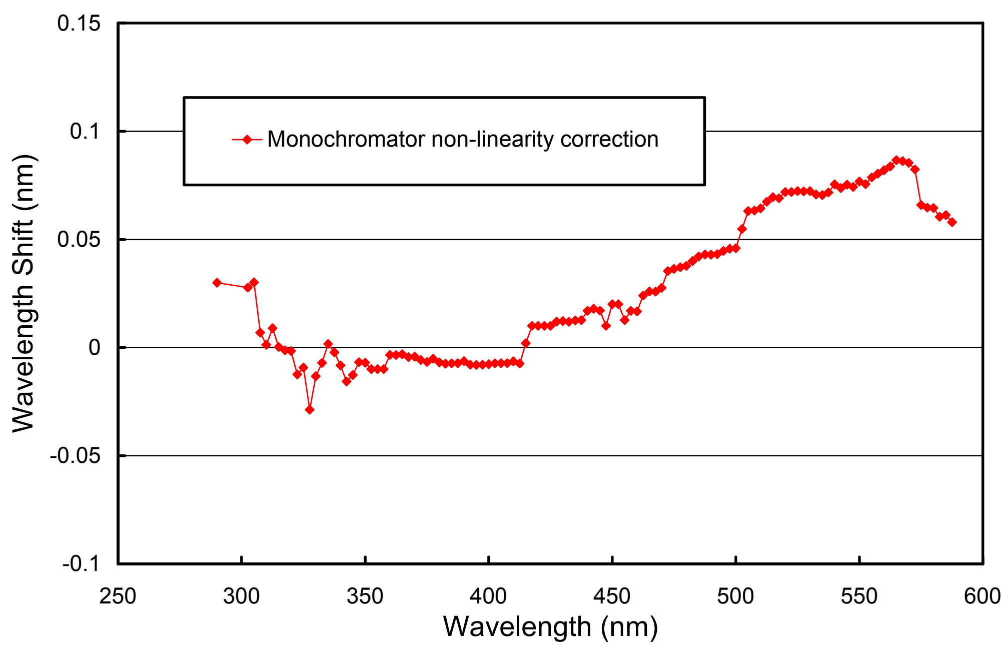

Figure 5.7.7. *Monochromator non-linearity correction functions for the Volume 16 period at Summit.*

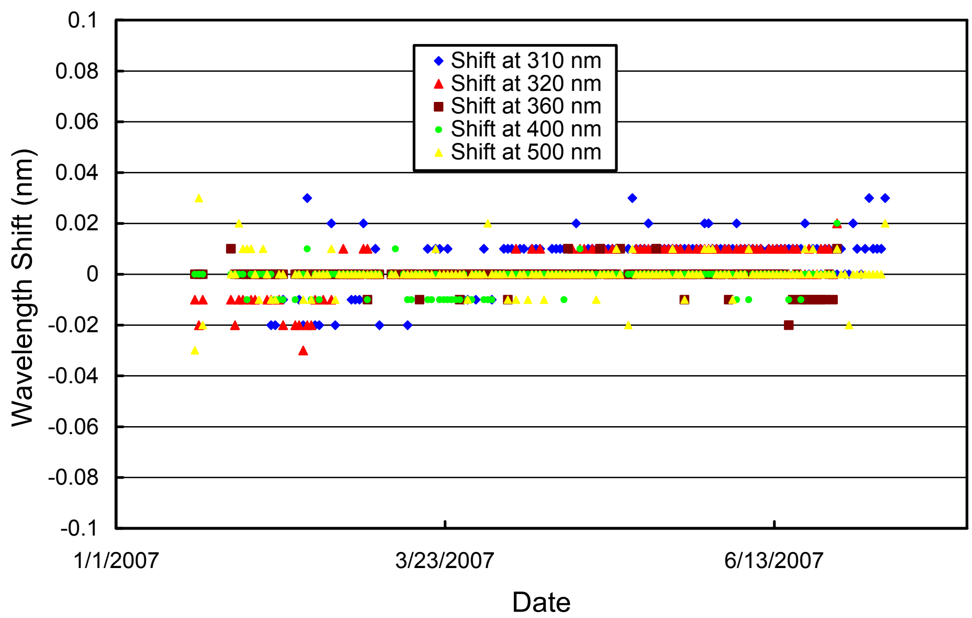

Figure 5.7.8. *Wavelength accuracy check of final data at five wavelengths in the UV and visible by means of Fraunhofer-line correlation. All noontime measurement have been evaluated.*

5.7.4. Missing Data

A total of 10493 scans are part of the Summit Volume 16 dataset. Only 1.6% of all possible scans were lost due to technical problems. Missing periods are summarized in Table 5.7.2.

Table 5.7.2. Missing solar scans in the Summit Volume 16 dataset.

Period	Number of scans	Reason
		Calibration scans
Throughout season	377	Response scans
Throughout season	251	Wavelength scans
Throughout season	81	Absolute scans
		Operational support
04/12/07	7	Operator training
06/27/07	2	Operator training
07/06/07	3	Preparation site visit
		Technical problems
Throughout season	11	Scans found defective
02/12/07 – 02/13/07	50	No data written to database
02/17/07	4	Unknown
03/08/07 – 03/09/07	77	No data written to database
03/12/07	27	No data written to database
07/09/07	12	Failure network switch

5.7.5. GUV Data

The GUV-511 radiometer, which is installed next to the SUV-150B, was calibrated against final SUV-150B measurements following the procedure outlined in Section 4.3.1. From the calibrated measurements, data products were calculated (Section 4.3.2). Figure 5.7.9 shows a comparison of GUV-511 and SUV-150B erythemal irradiance based on final Volume 16 data. For solar zenith angles smaller than 80°, measurements of the two instruments agree to within ±1.7% (±1σ). This good agreement confirms that drifts in SUV-150B data discussed in Section 5.7.2 have been satisfactorily removed by adjusting the instrument's calibrations. We advise data users to use SUV-150B rather than GUV-511 data whenever possible, in particular for low-Sun conditions.

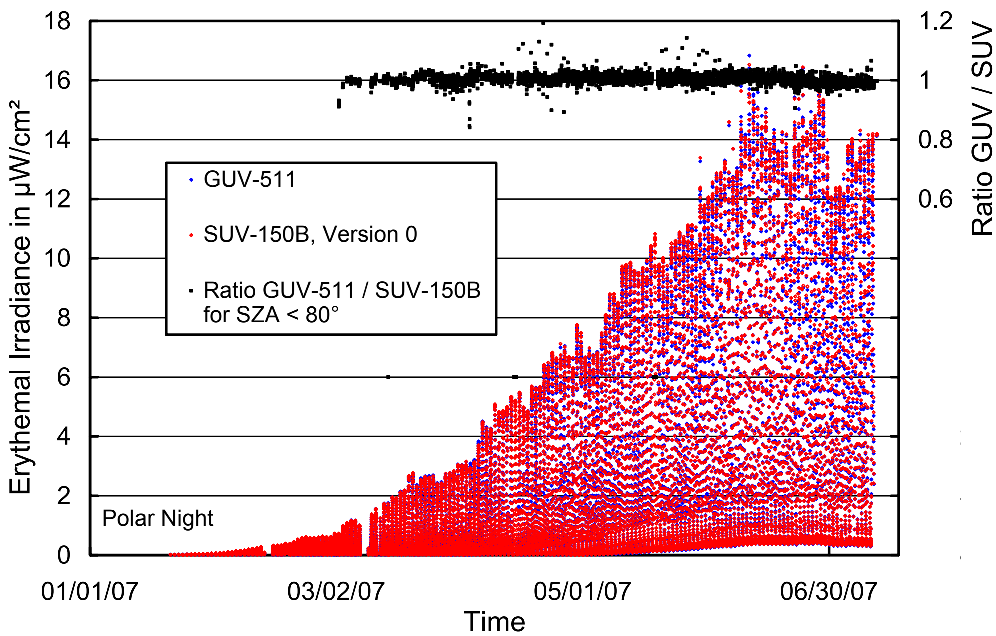

Figure 5.7.9. *Comparison of erythemal irradiance measured by the SUV-150B spectroradiometer and the GUV-511 radiometer. SUV-150B measurements are based on "Version 0" (cosine-error uncorrected) data.*

Figure 5.7.10 shows a comparison of total ozone measurements from the GUV-511, the SUV-150B (Version 2 data, available at www.biospherical.com/nsf/Version2/), and the Ozone Monitoring Instrument (OMI). GUV-511 ozone values were calculated as described in Section 4.3.3. Between May and July, GUV-511 ozone data agree well with SUV-150B and OMI measurements. GUV data are low in March and April when the solar elevations are small. The reason for this bias is the effect of the ozone profile on ozone retrievals. For SZA larger than 80°, measurements of the GUV's 305 nm channel are close to the detection limit. GUV ozone data at large SZAs become unreliable and should not be used. There is generally good agreement between SUV-150B and OMI data. The good agreement—even at large SZAs—is achieved by using ozone profiles in the inversion algorithm, which were measured at Summit approximately every week by NOAA/ESRL.

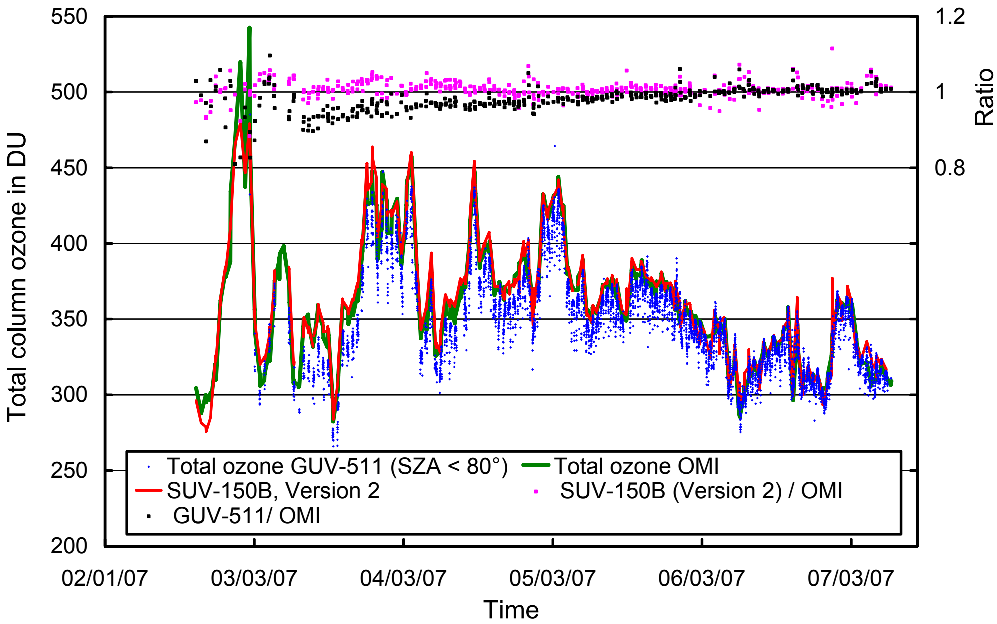

Figure 5.7.10. *Comparison of total column ozone measurements from GUV-511, SUV-150B (Version 2 data), and OMI. GUV-511 measurements are plotted in 15 minute intervals. For calculating the ratio of data sets, only measurements concurrent with the OMI overpass were evaluated.*