5.4. Ushuaia, Argentina (6/17/08 – 11/14/08)

This sections describes quality control of solar data recorded between 6/17/08 and 11/14/08. There were no site visits in 2008. Opening calibrations were performed by the site operator on 6/16/08. There were no closing calibrations, however, the site standards were compared with each other on 7/3/08 and 9/23/08. No Version 0 SUV-100 data are available after 11/14/08 due to a failure of the instrument's power converter, which transforms the line voltage of 220 V to the voltage of 110 V required by the system. The failure was caused by changes of the building's power distribution system.

After 9/25/08, the SUV-100 monochromator frequently lost its wavelength position due to power failures. The number of internal wavelength scans was not sufficient (particularly in October and November) to correct for changes of the system's wavelength setting. Many solar scans had to be excluded from the published data set. However, most of these scans could be corrected as part of Version 2 data processing using the Version 2 Fraunhofer-line correlation algorithm.

A total of 5177 spectral scans are part of the Ushuaia Volume 18 **Version 0** dataset. The number of scans in the **Version 2** dataset is 5506 and this dataset also includes measurements for the period 11/15/08 - 11/19/08. **We advise researchers to use the Version 2 dataset due to its better overall accuracy and completeness.**

The site's GUV-511 radiometer can also run on 220 V. It was switched from 110 V to 220 V on 11/26/08. There are some data gaps at times before the switch. Measurements between 11/27/08 and 2/28/09 are rather complete. **GUV data are available for the period 6/11/08 - 2/28/09.**

5.4.1. Irradiance Calibration

Traveling standards
Lamps 200W017 and 200W038 were used as traveling standards at the beginning of the reporting period. Lamp 200W017 was originally calibrated by Optronic Laboratories in March 2001. It was recalibrated in May 2007 against a set of four 1000-W FEL lamps with serial numbers H-011, H-013, H-023, and H035. These FEL lamps have been calibrated by NOAA's Central UV Calibration Facility (CUCF) at Boulder, Colo, and their irradiance scale refers to the detector-based NIST scale from 2000 (NIST2000) (*Yoon et al.*, 2002). Since all NSF network data refer to the source based NIST scale from 1990 (NIST1990) (*Walker et al.*, 1987), the irradiance values of the four FEL lamps were first converted to the NIST1990 scale before their calibration was applied to the two traveling standards.

Lamp 200W038 was originally calibrated against the same set of four 1000-W FEL lamps. It was recalibrated in April 2008 against lamps 200W028 and 200W022. Lamp 200W028 was also calibrated in May 2007 against the set of four 1000-W FEL lamps. Lamp 200W022 is one of the project's long-term standards and was calibrated by Optronic Laboratories in March 2001.

Site standards
The site standards used during the reporting period were the lamps M-698, M-766, 200W008, and 200W026. Lamps M-698, M-766, 200W008 have been in service for many years. They were recalibrated on 7/16/08 against the traveling standards 200W017 and 200W038 using scans from the June 2008 site visit (see Volume 17 Operations Report). Lamp 200W026 was calibrated by Optronic Laboratories (OL) on 11/19/96 and 3/28/01, respectively. It was used less than 30 times (total burn time of less than 20 hours) since its calibration in 2001. The lamp can be considered a long-term standard based on its rare use.

Figure 5.4.1 shows a comparison of site standards M-698, M-766, 200W008 (with their 7/16/08 calibration scales applied), site standard 200W026, and the traveling standards 200W017 and 200W038. Calibrations of all lamps agree to within ±1.5%. We note that this is a good result considering that the irradiance scales of all lamps but 200W026 are traceable to the CUCF irradiance scale, whereas lamp 200W026 is traceable to the OL irradiance scale from March 2001. This results confirms the consistency of the scales provided by CUCF and OL and also underlines our ability to preserve these scales over a long time.

Lamps M-698, M-766, and 200W008 were also compared with each other on 7/3/08 and 9/23/08. On 7/3/08, data of the three lamps agreed to within ±1%. On 9/23/08, measurements of lamps M-766, and 200W008 agreed ideally; the measurement of lamp M-698 was systematically different by 1.5%.

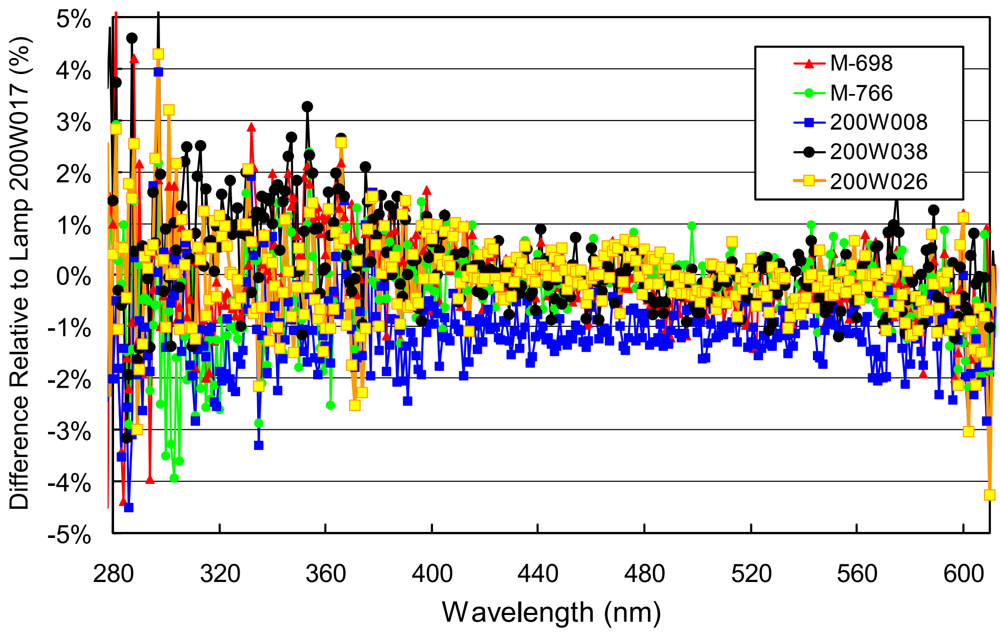

Figure 5.4.1. *Comparison of traveling standards 200W017, 200W038 and Ushuaia lamps M-698, M-766, 200W008, and 200W026 at the beginning of the reporting period (6/16/08). The irradiance scales of all lamps but 200W026 are traceable to the CUCF irradiance scale, adjusted for the difference between the NIST2000 and NIST1990 scales. The irradiance scale of lamp 200W026 is traceable to the OL irradiance from March 2001, which at this time was also traceable to the NIST1990 irradiance scale.*

5.4.2. Instrument Stability

The stability of the spectroradiometer over time was primarily monitored with bi-weekly calibrations utilizing the on-site standards M-698, M-766 and 200W008, and daily response scans of the internal irradiance reference. The stability of the internal lamp is monitored with the TSI sensor, which is independent of possible monochromator and PMT drifts.

By logging the PMT currents at several wavelengths during response scans, drifts in monochromator throughput and PMT sensitivity can be detected. Figure 5.4.2 shows the changes in TSI readings and PMT currents at 300 and 400 nm, derived from response scans. The system was very stable over this period: TSI measurements changed by less than 0.5% and PMT currents were stable to within ±2%.

Measurements of the internal lamp cannot detect changes in the throughput of the instrument's fore optics. Analysis of absolute scans indicated somewhat larger changes in responsivity than results from the response scans. To correct for these changes, the instrument's calibration was broken into three periods, which are summarized in Table 5.4.1.

Figure 5.4.3 presents ratios of irradiance spectra applied to the internal lamp during periods P3 and P4, referenced to the spectrum for Period P2. The difference between the spectra for Periods P2 and P3 is less than 2%, but there is a 3-5% change between the spectra for Periods P3 and P4. The reason for this change is unknown, however, comparisons of calibration solar measurements of the SUV-100 and GUV-511 radiometers confirmed that the change in the SUV-100's responsivity was successfully corrected by the change in the calibration.

Figure 5.4.4 presents ratios of standard deviation to average calculated from the individual absolute scans in the three periods. These "relative standard deviation spectra" are useful for estimating the variability of calibrations within a given period. The variability is typically less than 1.5% for wavelengths above 320 nm, indicating good consistency of individual absolute scans. Data for Periods P3 and P4 are noisier than for Period P2 because of the lesser number of absolute scans.

Table 5.4.1 Calibration periods for Ushuaia Volumes 18.

Period name	Period range	Number of Absolute scans
P2	06/17/08-09/17/08	8
P3	09/18/08-10/05/08	2
P4	10/06/08-02/28/09	3

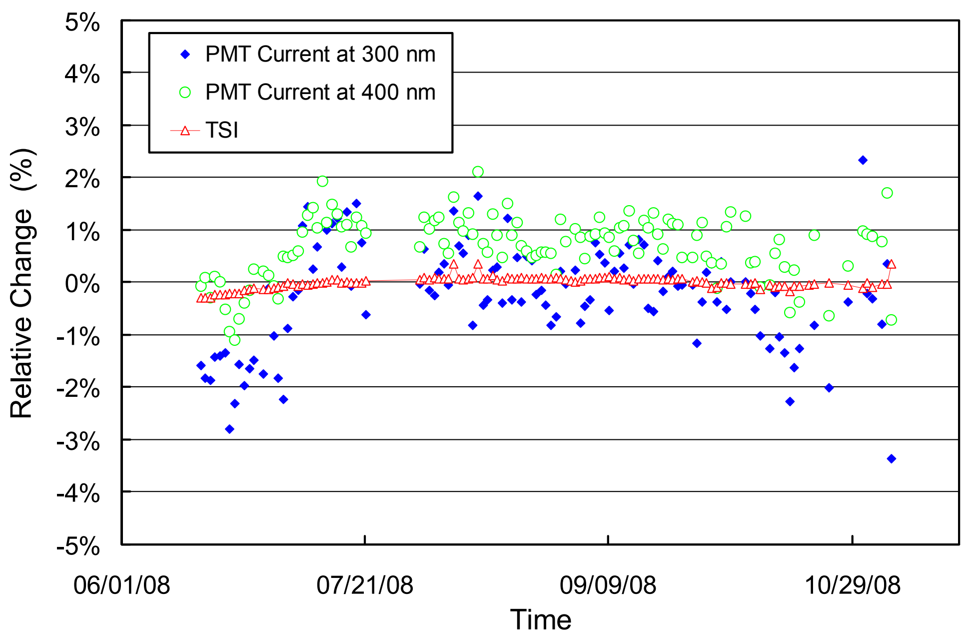

Figure 5.4.2. *Time-series of TSI signal and PMT currents at 300 and 400 nm during measurements of the internal reference lamp.*

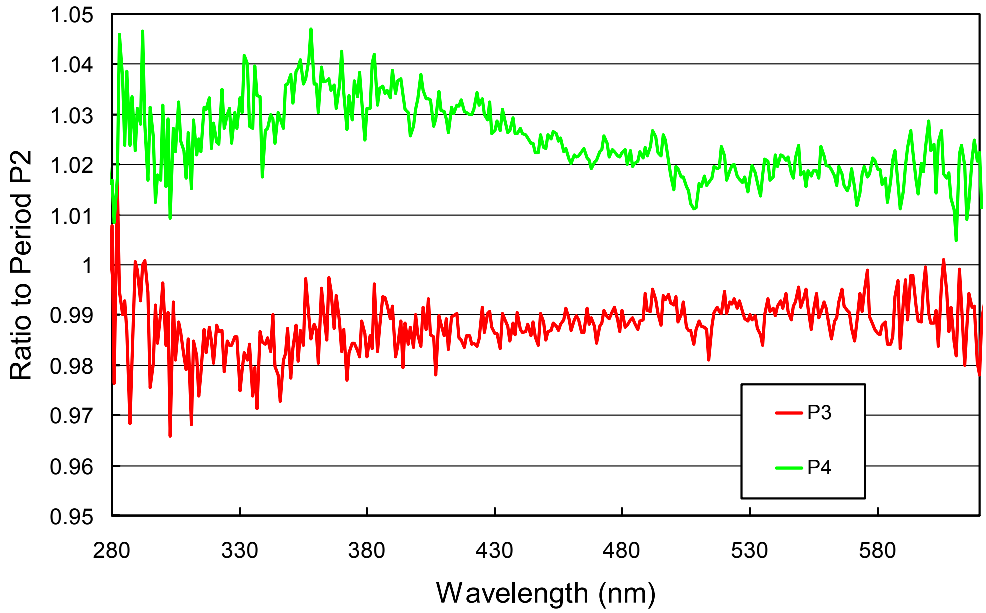

Figure 5.4.3 *Ratios of irradiance assigned to the internal reference lamp in Periods P3 and P4, referenced to the irradiance of Period P2.*

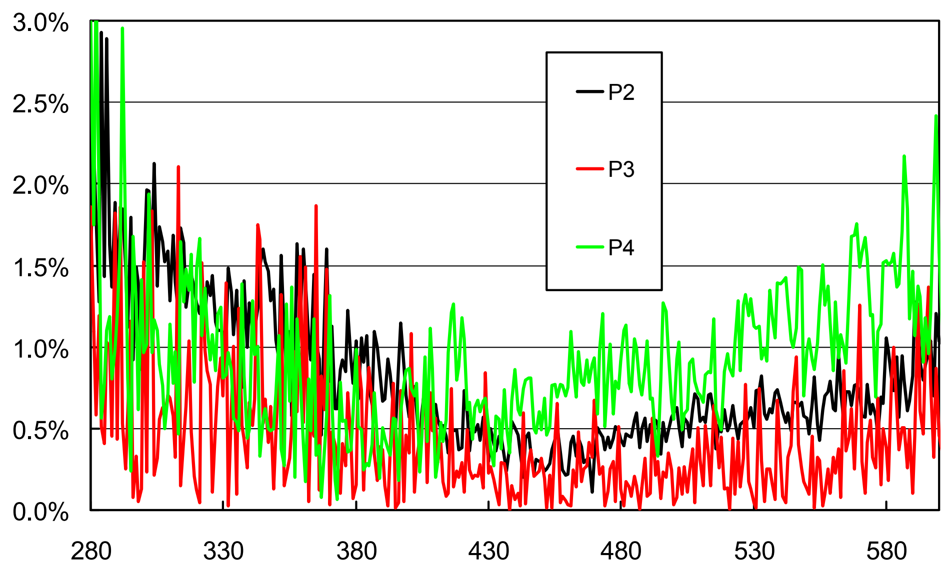

Figure 5.4.4. *Ratio of standard deviation and average calculated from the absolute calibration scans measured at Ushuaia.*

To test the consistency of final SUV-100 data, measurements at 340 nm were compared with measurements of the 340 nm channel of the collocated GUV-511 radiometer (see also Section 5.4.5). For this comparison, SUV-100 spectra were weighted with the response function of the GUV-511 instrument according to the procedure described in Section 4.3.1. The same calibration factor was applied to GUV measurements of the entire period. The resulting ratio is shown in Figure 5.4.5. The standard deviation of the ratio GUV/SUV is 0.034. There is no clear systematic change as a function of time, although ratios for Period P3 tend to be higher by about 2% than ratios for the other periods. This difference is within the uncertainty of SUV and GUV measurements. Ratios for 10/11/08 and part of 10/12/08 are high by 10%. Inspection of data did not reveal a clear cause for this outlier. The most likely reason is contamination of the SUV-100 collector.

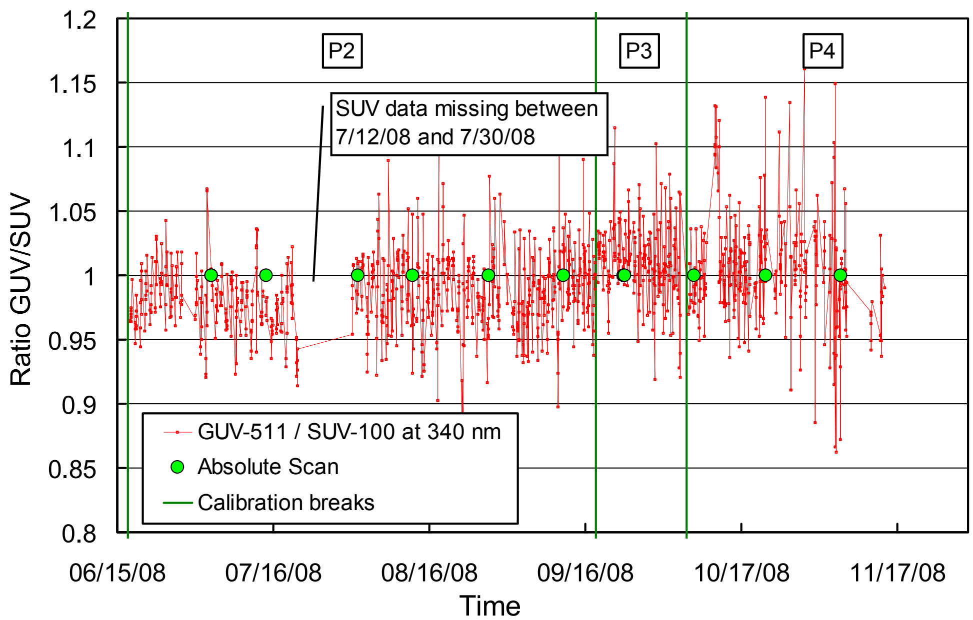

Figure 5.4.5. *Ratio of GUV-511 and SUV-100 measurements. Green lines indicate limits of calibration periods.*

5.4.3. Wavelength Calibration

Wavelength stability of the system was monitored with the internal mercury lamp. Figure 5.4.6 shows the differences in the wavelength offset of the 296.73 nm mercury line between pairs of consecutive wavelength scans for the reporting period. In total, 141 scans were evaluated. There is comparatively large amount of pairs with shifts larger than ±0.1 nm caused by frequent power outages. Not all affected solar data could be corrected with the tools available for Version 0 processing and are therefore not part of the Version 0 data set. However, most scans were corrected as part of Version 2 processing and are available at the Version 2 website at http://www.biospherical.com/nsf/Version2/.

After data were 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 Version 2 Fraunhofer-line correlation method (*Bernhard et al*., 2004). The resulting monochromator non-linearity correction function is shown in Figure 5.4.7.

After data had been wavelength corrected using the shift-function described above, the wavelength accuracy was tested again with the Version 2 Fraunhofer-line correlation method. Results for noontime scans are shown in Figure 5.4.8 for four wavelengths in the UV and one in the visible. Wavelength shifts are typically smaller than ±0.07 nm; the standard deviation of the residual shifts at 320 nm is 0.027 nm. In particular in October and November, there is some temporal variation of the wavelength-shift pattern, but this has been removed during Version 2 data processing reported elsewhere. Outliers may also occur when spectra are distorted due to changing cloud cover. The wavelength stability is not worse during cloudy conditions but the validation is subject to larger uncertainties.

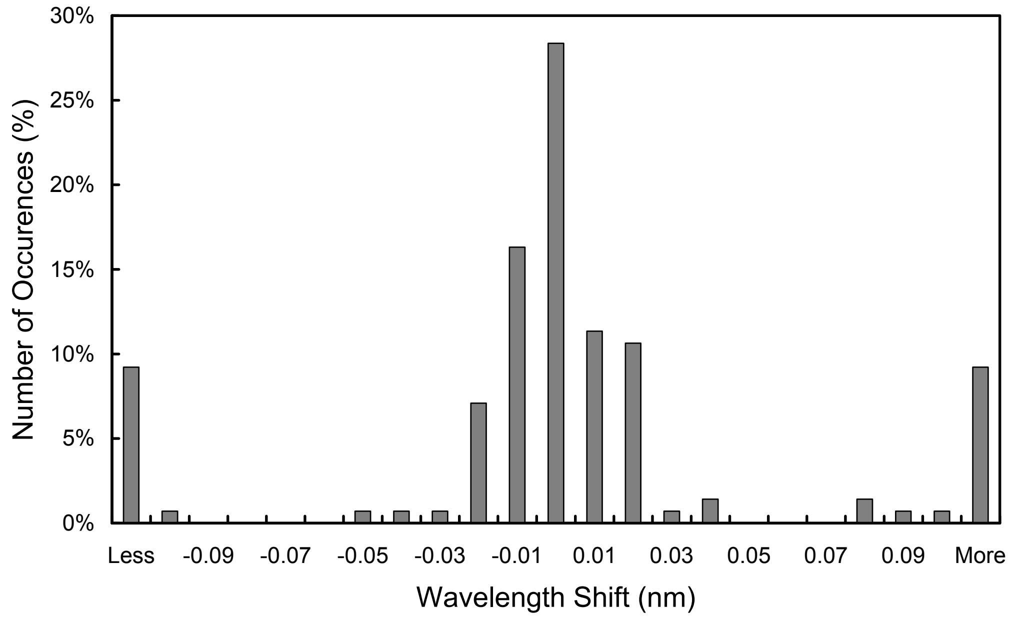

Figure 5.4.6. *Differences in the measured position of the 296.73 nm mercury line between consecutive wavelength The labels of the horizontal axis give the center wavelength shift for each column. The 0-nm histogram column covers the range from -0.005 to +0.005 nm. "Less" means shifts smaller than -0.105 nm; "more" means shifts larger than 0.105 nm.*

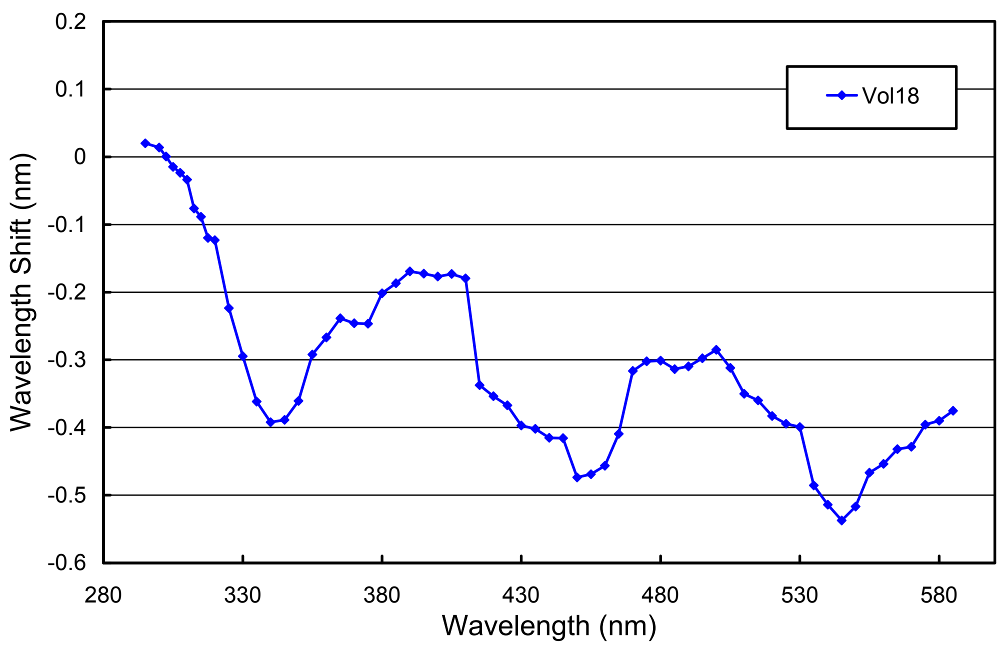

Figure 5.4.7. *Monochromator non-linearity correction function.*

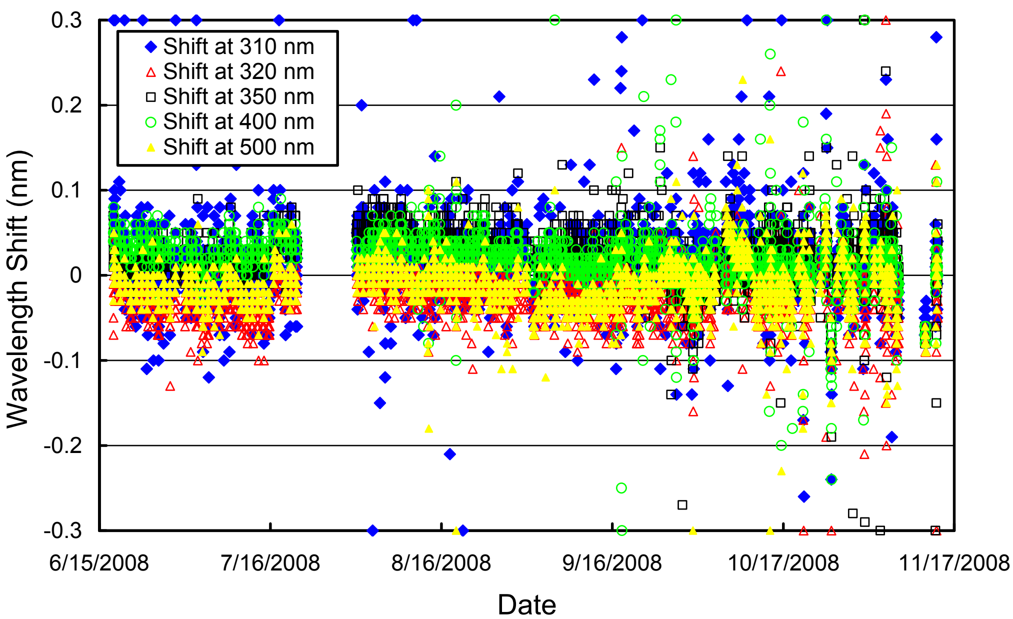

Figure 5.4.8. *Wavelength accuracy check of final data at four wavelengths in the UV and one in the visible by means of Fraunhofer-line correlation. All spectra of the Volume 18 period have been evaluated.*

5.4.4. Missing Data

A total of 5177 solar scans are part of the Ushuaia Volume 18 dataset. For the period of 6/17/08 – 11/14/08, about 28% of all possible scans are missing due to technical problems, of which 27% were related to power outages or resets of the system's power converter. The problem worsened after 11/19/08, and the system was switched off to prevent further damage. No SUV-100 data are available after 11/19/08, but GUV-511 data up to 2/28/09 were published.

Table 5.4.2 gives more details on missing scans. Some scans affected by large wavelength offsets could be salvaged and are part of the Version 2 data set - see last column of Table 5.4.2.

Table 5.4.2 Missing scans of Ushuaia Volumes 18.

Time Period	Scans missing	Reason	Part of Version 2?
Throughout period	141	Calibration absolute, wavelength and response scans	
06/27/08-06/28/08	27	GPS date reset; spectra overwritten	
06/29/08	32	No SUV raw data for unknown reasons	
07/14/08	9	Wavelength off by more than 10 nm - not correctable	
07/21/08-07/31/08	357	Wavelength off by more than 10 nm - not correctable	
08/30/08-09/01/08	76	Power failure	
09/05/08	5	Power failure	
9/25/08	15	Power failure	
10/04/08-10/06/08	77	Power failure	
10/11/08	23	Power failure	
10/18/08-10/30/08	327	Intermittent power failures	

10/30/08	46	Large wavelength offset after power failure	Yes
10/31/08-11/01/08	103	Power failure	
11/01/08		Power failure	
11/01/08	21	Large wavelength offset after power failure	Yes
11/02/08-11/03/08	59	Power failure	
11/03/08	18	Power failure	
11/03/08-11/07/08	34	Power failure	
11/07/08	35	Large wavelength offset after power failure	Yes
11/07/08-11/08/08	38	Power failure	
11/08/08	17	Large wavelength offset after power failure	Yes
11/08/08-11/09/08	33	Power failure	
11/09/08	23	Large wavelength offset after power failure	Yes
11/09/08-11/10/08	47	Power failure	
11/10/08	35	Large wavelength offset after power failure	Yes
11/10/08-11/11/08	31	Power failure	
11/11/08	11	Large wavelength offset after power failure	Yes
11/11/08-11/12/08	38	Power failure	
11/12/08	24	Large wavelength offset after power failure	Yes
11/12/08-11/14/08	61	Power failure	
11/14/08	37	Large wavelength offset after power failure	Yes
11/14/08-11/16/08	113	Power failure	
11/16/08	11	Large wavelength offset after power failure	Yes
11/16/08-11/18/08	115	Power failure	
11/18/08	18	Large wavelength offset after power failure	Yes

5.4.5. GUV Data

The GUV-511 radiometer, which is installed next to the SUV-100, was calibrated against final SUV-100 measurements following the procedure outlined in Section 4.3.1. Data products were calculated from the calibrated measurements (Section 4.3.2). Figure 5.4.9. shows a comparison of GUV-511 and SUV-100 erythemal irradiance. For solar zenith angles smaller than 80°, measurements of the two instruments agree to within ±5.3% (±1σ). The GUV tends to underestimate erythemal irradiance at large solar zenith angles. We advise data users to use SUV-100 rather than GUV-511 data whenever possible, in particular for low-Sun conditions.

Figure 5.4.10 shows a comparison of total ozone measured by the GUV-511 radiometer, the SUV-100 (Version 2 data set; see www.biospherical.com/NSF/Version2), and the Ozone Monitoring Instrument (OMI) installed on NASA's AURA satellite (data version 8.5, Collection 3). GUV-511 ozone values were calculated as described in Section 4.3.3. There is generally good agreement between the three data sets. SUV-100 measurements are on average 3% larger than OMI observations. The reason of these systematic differences is partly caused by the way the atmospheric ozone and temperature profiles are used by the three inversion methods. We also note that OMI version 8.5 ozone columns are slightly lower than the original OMI data release.

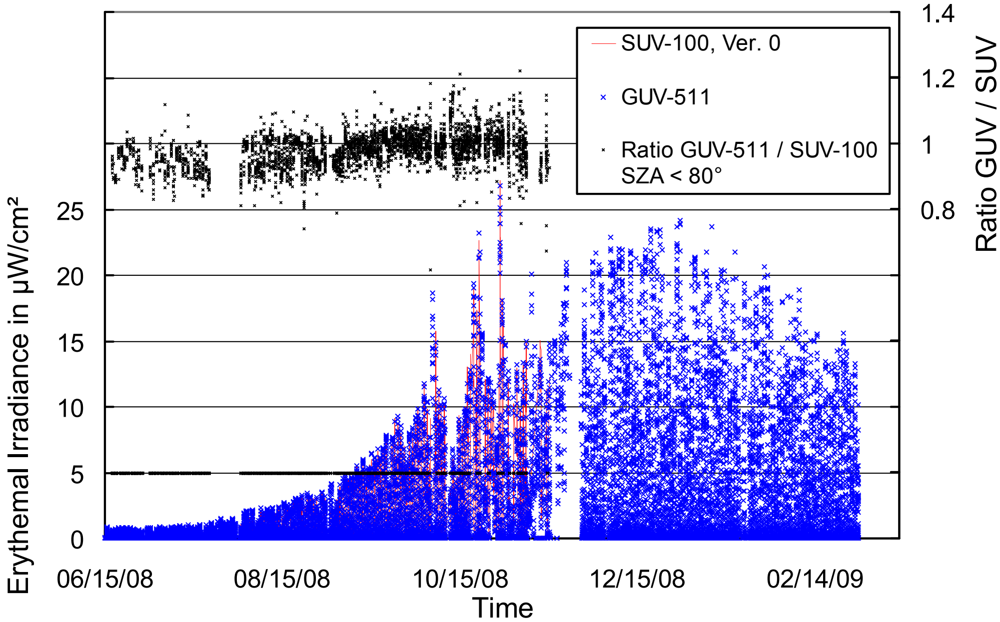

Figure 5.4.9. *Comparison of erythemal irradiance measured by the SUV-100 spectroradiometer and the GUV-511 radiometer. SUV-100 measurements are based on "Version 0" (cosine-error uncorrected) data.*

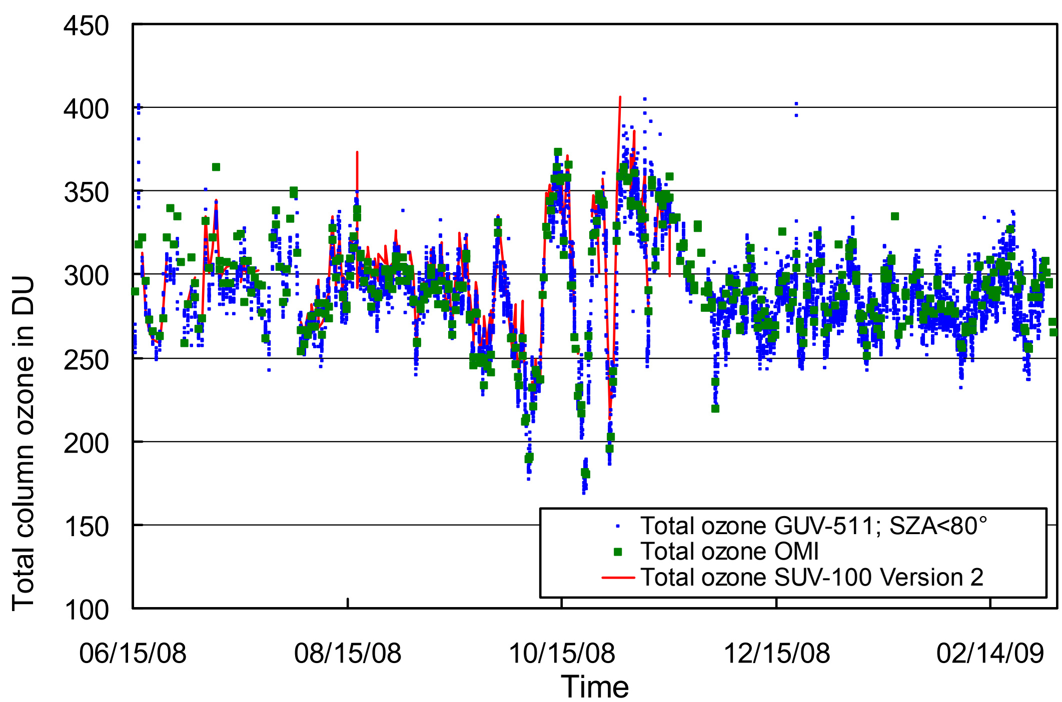

Figure 5.4.10. *Comparison of total column ozone measurements from GUV-511, SUV-100 (Version 2 data), and OMI. GUV-511 and SUV-100 measurements are plotted in 15 minute intervals.*