USDA UV-B Monitoring and Research Program

MAJOR IMPROVEMENT IN CALIBRATED DATA

Implementation date: 1 July 2007

In a nutshell, what is this change?

Lamp-calibrated irradiance values for the 311, 317, 325, 332 and 368 channels have increased, on average, 8.8%, 22.1%, 12.1%, 11.2%, and 4.0% respectively. The 300 and 305 channels are essentially unchanged.

Does this change affect the entire database?

No – only data collected by UV-MFRSR instruments with silicon photodiodes is affected, and only if that data is downloaded as lamp-calibrated. The start date for this data at each site will be different, though generally it begins in January 2001. See Appendix A of this document for the list of sites and the start date.

How do I get the revised data?

After Sunday 1 July, visit our web site <http://uvb.nrel.colostate.edu/> and download your data. Data is calibrated 'on-the-fly' when requested, and is not stored by us – only the raw voltage and cosine-corrected voltage are stored in the database. If you received your data via the ftp directory, and wish to receive revised data, send an e-mail to <beckyo@uvb.nrel.colostate.edu> describing the data you need replaced.

What is the detailed story behind this change?

The primary instrument used by the USDA UV-B Monitoring and Research Program (UVMRP) is the Ultra-Violet Multi-Filter Rotating Shadowband Radiometer (UV-MFRSR) which uses 2 nm nominal FWHM bandwidth filters to measure total-horizontal and diffuse-horizontal irradiances at nominal center wavelengths of 300, 305, 311, 317, 325, 332 and 368. The original instruments, built in 1995-1996 by Yankee Environmental Services (YES), used silicon-carbide (SiC) photodiodes in the 300 and 305 channels, and gallium-phosphide (GaP) photodiodes in the remaining five channels. By the end of 1997, UV-MFRSR instruments had been deployed at the 22 sites that then constituted the climatologic network. In December of 1997 we saw the first failure of a GaP photodiode, which would ultimately blossom to 59 by December of 2001 (with a 60th failure in a test instrument in March 2003). This was an unacceptable failure rate, so the UVMRP and YES developed the solution to replace the GaP photodiodes with silicon (Si) versions. However, we later learned there was an unanticipated problem with this choice – the Si photodiodes are sensitive to longer wavelengths (into the red region, called 'red light leakage') and the optical filters allow out-of-band (OOB) radiation through, as there are no blocking filters in conjunction with the band pass filters. Thus, an excess amount of this out of band light from the calibration lamp 'leaks' through. The Central UV Calibration Facility (CUCF), at the NOAA facility in Boulder, Colorado, has developed a procedure to measure this OOB contribution, and has sent us corrected calibration files that remove this influence for all of the affected instruments. These are now the calibration files that are dynamically accessed when you download lamp-calibrated data from our database.

state	*station name*	*town*	*site code*	*start date and time UTC*	*UV-MFRSR*
Alaska	University of Alaska Fairbanks \ Poker Flat Research Range	Fairbanks	AK02	2000-08-26 04:45	465
Arizona	Abyss Site at Grand Canyon National Park	Flagstaff	AZ02	2001-12-20 21:24	289
California	University of California Davis Climate Station	Davis	CA02	2002-03-20 17:09	283
California	University of California Desert Research and Extension Center	Holtville	CA22	2002-03-19 16:00	299
Colorado	CSU \ USDA ARS \ Central Plains Experimental Range \ Short-Grass Steppe LTER	Nunn	CO02	2002-08-15 23:00	295
Colorado	Desert Research Institute Storm Peak Laboratory	Steamboat Springs	CO12	2002-05-30 21:00	288
Colorado	Lamar Community College \ Ultra-High Energy Cosmic Rays research [Auger Project]	Lamar	CO42	2003-12-17 23:09	303
Florida	Beard Research Center at Everglades National Park	Homestead	FL02	2001-07-02 17:15	396
Georgia	University of Georgia Bledsoe Research Farm	Griffin	GA02	2001-11-01 16:48	391
Hawaii	NOAA Mauna Loa Observatory	Waimea	HI02	2001-01-22 22:24	387
Illinois	Bondville Environmental and Atmospheric Research Site (BEARS)	Bondville	IL02	2002-05-13 19:03	291
Indiana	Purdue University Agronomy Center for Research and Education (ACRE)	West Lafayette	IN02	2002-05-07 20:24	394
Louisiana	Louisiana State University Central Research Station at Ben Hur Farm	Baton Rouge	LA02	2001-10-10 15:24	284
Maryland	University of Maryland \ Wye Research and Education Center	Queenstown	MD02	2002-01-25 16:00	281
Maryland	USDA Beltsville Agricultural Research Center - South Farm	Beltsville	MD12	2002-01-28 16:03	395
Maryland	NASA Goddard Space Flight Center \ Atmospheric Chemistry and Dynamics Branch	Greenbelt	MD22	2002-09-30 19:06	271
Maine	Department of Environmental Protection Northern Maine Regional Office	Presque Isle	ME12	2001-04-20 16:03	304
Michigan	University of Michigan Biological Station at Douglas Lake	Pellston	MI02	2002-05-10 17:30	308
Minnesota	University of Minnesota North Central Research and Outreach Center	Grand Rapids	MN02	2001-09-20 21:24	293
Mississippi	Mississippi State University Agricultural and Forestry Experiment Station	Starkville	MS02	2001-11-05 18:30	294
Montana	Fort Peck Assiniboine and Sioux Tribes	Poplar	MT02	2002-11-26 21:36	300
North Carolina	North Carolina State University Air Quality Educational Unit	Raleigh	NC02	2002-10-03 22:39	396
North Dakota	North Dakota State University Microclimatic Research Station	Fargo	ND02	2004-10-29 18:03	285
Nebraska	University of Nebraska Lincoln High Plains Regional Climate Center	Mead	NE02	2001-08-30 20:39	306
New Mexico	USDA Agricultural Research Station \ Jornada Experimental Range	Las Cruces	NM02	2002-02-11 15:18	390
New York	Cornell University \ New York State Agricultural Experiment Station at Geneva	Geneva	NY02	2002-03-25 15:12	287
New Zealand	National Institute of Water and Atmospheric Research at Lauder	Alexandra	NZ02	2003-03-10 21:18	388
Oklahoma	US Department of Energy ARM / SGP / CART site	Billings	OK02	2001-10-30 22:00	303
Ontario	Environment Canada headquarters building	Toronto	ON02	2002-05-03 15:42	231
Saskatchewan	Environment Canada Bratt's Lake Observatory	Regina	SK02	2001-02-26 17:12	285
Texas	Castolon Site at Big Bend National Park	Panther Junction	TX02	2002-02-13 15:57	232
Texas	Texas Lutheran University Science Center	Seguin	TX22	2004-03-16 19:18	386
Texas	University of Houston - north Moody Tower	Houston	TX42	2006-08-04 02:57	528
Utah	Utah State University Utah Climate Center	Logan	UT02	2001-11-02 20:21	392
Vermont	University of Vermont Proctor Maple Research Center	Burlington	VT02	2001-01-10 19:57	307
Washington	Washington State University Albion Field Station	Pullman	WA02	2002-02-04 21:45	297
Wisconsin	Wisconsin Department of Natural Resources Lake Dubay site	Dancy	WI02	2002-04-11 15:51	302
Colorado	NOAA Earth System Research Laboratory Table Mountain Field Test Facility	Longmont	CO9x	various dates - contact us	
Ohio	Miami University Ecology Research Center	Oxford	OH02	had no Rev.Q instruments	
Texas	University of Texas El Paso \ Sunbowl Hill	El Paso	TX51	this is not a UV sensor	

TECHNICAL REPORT

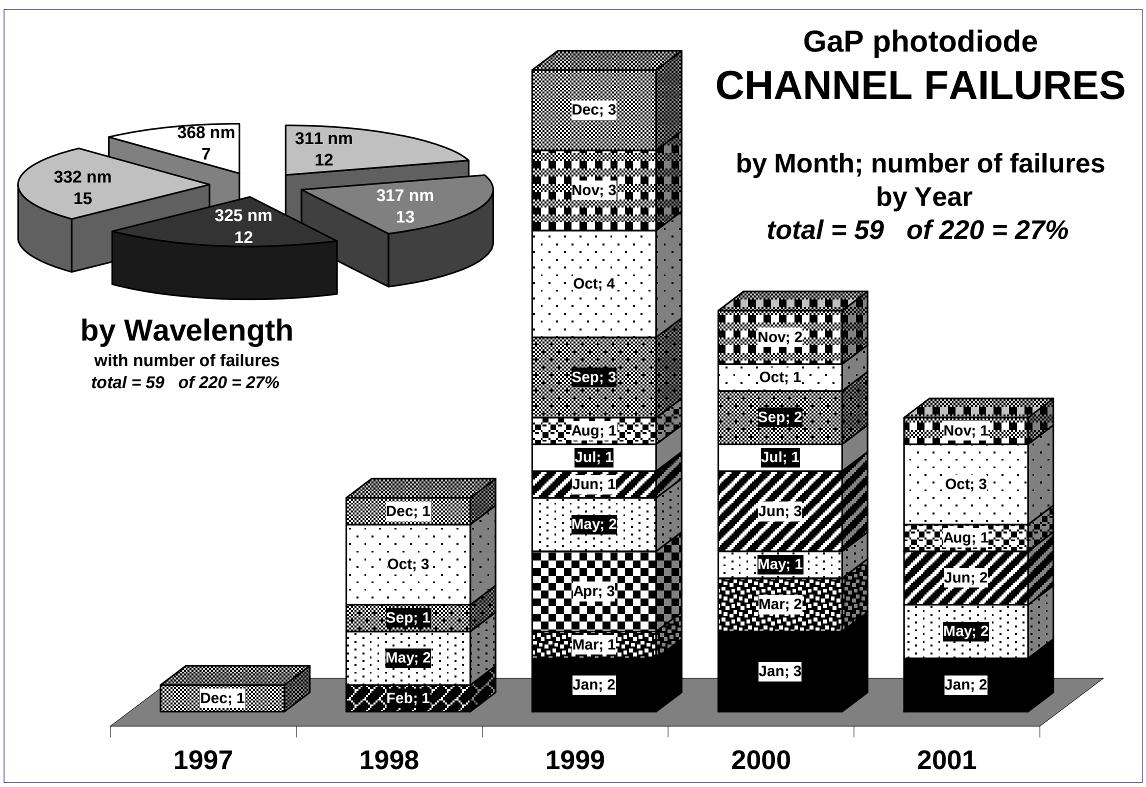
Date: July 1, 2007

1. Summary.

The UV-MFRSR instrument uses 2 nm nominal FWHM bandwidth filters to measure total-horizontal and diffuse-horizontal irradiances at nominal center wavelengths of 300, 305, 311, 317, 325, 332 and 368. The Central UV Calibration Facility is responsible for annually calibrating and characterizing 47 UV-MFRSR instruments from the USDA UVMRP. In addition, stability of the radiometers between calibrations is also monitored using the Langley Method [Bigelow et al., 2000; Slusser et al., 2000; Janson et al., 2004].

In 2003, a comparison of lamp calibrated UV-MFRSR instrument with filter-weighted irradiance from a reference spectroradiometer indicated that the UV-MFRSR channels 3 through 7 were in poor agreement with the U111 reference spectroradiometer. The UV-MFRSR instruments were measuring low with respect to the reference spectroradiometer. During previous intercomparisons, the UV-MFRSR instruments had agreed well with filter-weighted solar irradiance from participating spectoradiometers [Lantz et al., 2001]. The UV-MFRSR channels in poor agreement with the reference spectroradiometer were the channels that were changed from (gallium-phosphide GaP) detectors to silicon (Si) photodetectors. The change in photodetectors was to mitigate the high failure rate (see Figure 1) of the GaP detectors in the field.

Figure 1. History of failure of the GaP photodiodes.



Ideally, a radiometer should be designed to detect no signal outside the designated wavelength region, i.e. in the 2-nm wide wavelength band of each of the seven channels. Studies by the CUCF and USDA UVMRP indicated that the problem was primarily because the new silicon photodetectors were allowing out-of-band light from the NIST traceable tungsten-halogen lamps during the calibration procedure to contribute to the calibration signal resulting in an inaccurate calibration. A summary of the laboratory results is given in Table 1. Studies of the contribution of out-of-band light to the total signal with the sun as a source indicated an insignificant contribution to the total signal. A summary of the field results are given in Table 2. Further studies by the CUCF found the out-of-band light to be due to light mainly from wavelengths longer than 850-nm. Figure 2 gives the spectral range of the GaP and silicon photodetectors, typical spectral profile of solar irradiance and the calibration lamp. The calibration files for the 47 UV-MFRSR's of the USDA UV Network have been updated dating back to start of the change to Si detectors in June, 2000.

Table 1. Average percent contribution of Out-of-Band light to laboratory calibration files.

	300-nm	***305-nm***	***311-nm***	***317-nm***	***325-nm***	***332-nm***	***368-nm***
Average	*0.0%*	*0.0%*	*8.8%*	*22.1%*	*12.1%*	*11.2%*	*4.0%*
Maximum	*0.1%*	*0.1%*	*28.4%*	*35.7%*	*28.5%*	*23.1%*	*10.5%*
Minimum	*0.0%*	*0.0%*	*4.2%*	*6.6%*	*3.9%*	*4.9%*	*1.1%*

Table 2. Average percent contribution of Out-of-Band light to instrument in field.

	300-nm	***305-nm***	***311-nm***	***317-nm***	***325-nm***	***332-nm***	***368-nm***
Average	*0.1%*	*0.0%*	*0.2%*	*0.4%*	*0.1%*	*0.1%*	*0.1%*
Maximum	*0.0%*	*0.3%*	*0.5%*	*1.3%*	*0.3%*	*0.4%*	*0.5%*
Minimum	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*

2. Effective dates.

The up-dated calibration files were incorporated into the USDA data-base on July 1, 2007. The instruments were upgraded from GaP photodetectors to silicon photodetectors starting in 2000 and ending in late 2002. A list of the affected instrument calibration files, lamp name, and the out-of-band correction files used is shown in Appendix 1: OOB Correction List. The original date of the calibration is indicated in the filename (e.g. 00sssjjjyyC.ABS, where sss is the serial number of the instrument, jjj is the Julian day, yy is the year.)

3. Brief History.

The first prototype instruments were deployed in 1995, with final production instruments first reaching the field in late 1996. In the original design, the 300 and 305 channels use silicon-carbide (SiC) photodiodes and the remaining five channels used gallium-phosphide (GaP) photodiodes. Throughout the years there have been several modifications to the instruments. The prototype instruments used the same Spectralon diffuser as in the vis-MFRSR instrument, but proved to be a problem at northern latitudes during the winter because of insufficient irradiance reaching the photodiodes. Beginning in early 1997, all instruments were upgraded to a Teflon diffuser with a frosted quartz window underneath the diffuser and appropriate changes to the electronic gain circuits. This version is known as pre-Rev.M instruments. Over the next year minor changes were made to the electronics, primarily to optimize the signal to noise ratio, and to bring all instruments up to a common level of optical and electronic configuration, which is designated as Rev.M by the manufacturer, Yankee Environmental Services (YES). The pre-Rev.M and Rev.M versions have GaP photodiodes in channels 3 through 7.

The channels with GaP photodiodes began to experience failure beginning in December, 1997. The number and rate of failures increased throughout 1998 and subsequent years. Because of the unacceptable level of failure (59 of 220) of the GaP photodiodes, a change was necessary. The UVMRP and YES jointly developed a solution which involved replacing the GaP photodiodes with silicon versions, with the necessary electronic changes to the amplification circuits. The GaP photodiodes were replaced by silicon (Si) photodiodes beginning in June 2000 and all instruments were converted by the end of 2002 [Janson et al., 2004]. The revised instruments with normal gains using Si photodiodes are designated Rev.Q, and these comprise 43 of the 47 instruments. In 1999, the UVMRP needed an enhanced gain version to use at very high latitudes (Fairbanks, AK). This version was designated Rev.N or Rev.P by YES, using Si photodiodes in channels 3 through 7. The Rev.Q and Rev.N/P UV-MFRSR instruments were subsequently studied for out-of-band leakage and the results were published in Lantz et al. [2005].

4. Laboratory and Field Measurements.

4.1 Out-of-band rejection measurements in the field with the sun as source: Each of the 47 filter radiometers were measured for out-of band rejection in the field during regular site visits. The field sites are across North America and extend from Mauna Loa, HI to Fairbanks, AK, with one site in Lauder, New Zealand. The measurements cover solar zenith angles from 18 to 64.3 degrees. The filter used in the field is an OG 570-nm long-pass filter. Ideally, the measurement with the filter is zero indicating a 0% contribution of out-of-band light from wavelengths longer than 570 nm to the measured signal.

4.2 Out-of-band rejection measurements in the laboratory with a lamp as source: The instruments are calibrated and characterized annually at the CUCF for their absolute response, spectral response and angular response. The angular response of the instrument is measured in two planes, N-S and E-W, and the data in the field is corrected for the angular response error of the instrument. The spectral response of the instrument is measured to determine the effective bandwidth and centroid of the channel. The instruments are then calibrated using a 1000W quartz-tungsten-halogen lamp traceable to NIST. The 47 instruments are measured for out-of-band light using a Schott GG 400-nm long-pass filter. The measured signal with the filter in place is corrected for the reduction in signal that results from the internal transmittance of the filter as measured with a Cary spectrophotometer.

5. Data Analysis

3.1. Laboratory Calibrations. The out-of-band corrections on average for the 47 UV-MFRSR radiometers are given in Table 2. CUCF studies showed that the contribution of out-of-band light to the signal depended on several factors.

1) The channel
2) The individual instrument
3) Lamp used for the laboratory calibration.

First, the magnitude of the out-of-band signal depended on the channel with the 317-nm channel typically being the most affected, i.e. average of 22.1% for the 47 filter radiometers. Secondly, in a given channel the magnitude of the out-of-band signal depended on the instrument, where each instrument was different but grouped in about 4 different spectral patterns, i.e. for the 317-nm channel the out-of-band light ranged from 37.7% to 6.6%. Lastly, the signal depended on the lamp that was used and is likely due to the different color temperatures of the lamps, i.e. approximately 0-2% difference between lamps at 317-nm.

3.4. Source of out-of-band light. The theory is that higher order modal ringing of the transmittance filters is contributing to the out-of-band signal and that this light was detected because of the change from GaP to Si photodetectors. In the wavelength region of the Si photodiodes, higher orders of the transmittance filters could potentially contribute to the signal from 622 – 716 nm or from 933 to 1084 nm. It is believed that the filters also leak a low level of photons across a wide spectral range. The following steps were undertaken to determine the source of the out-of-band light.

What is desirable is to have measurements of the spectral responsivity of each of the seven wavelength channels, the irradiance of the calibration source, and the spectral responsivity of the GaP and Si photodiodes across the wavelength region of 290 to 1200 nm. The CUCF spectral response bench has a limited wavelength region in the ultraviolet and can not measure the spectral responsivity of the UV-MFRSR channels across the full wavelength range of the Si photodetector. However, the CUCF has a Cary spectrophotometer that can be used to measure the transmittance of the interference filters. From the CARY spectrophotometer measurements there is no indication of higher order modal ringing of the filters in the results. An additional series of measurements are performed using a series of long-pass filters with the FEL calibration lamp as a source to determine what wavelength region is producing OOB signal for the seven channels. The long-pass filters used to test this were GG-400, R-60, RG-645, R-70, IR-76, IR-80, RG-850 and a combination of KG-5 and GG-400.

There are several features of interest during of the out-of-band light investigations. First, there is negligible out-of-band light contributing to the signal with the sun as a source, but significant contributions when the lamp is used as a source. Secondly, there was no appreciable contribution of out-of-band light when the photodiode was GaP and occurred after the change to Si photodetectors. Thirdly, the contribution of out-of-band light to the total signal with the lamp as a source is typically largest in channel 317-nm and smallest in channels 332 and 368-nm. Lastly, there are four distinct spectral patterns of the percentage of out-of-band signal to the total signal among the instruments.

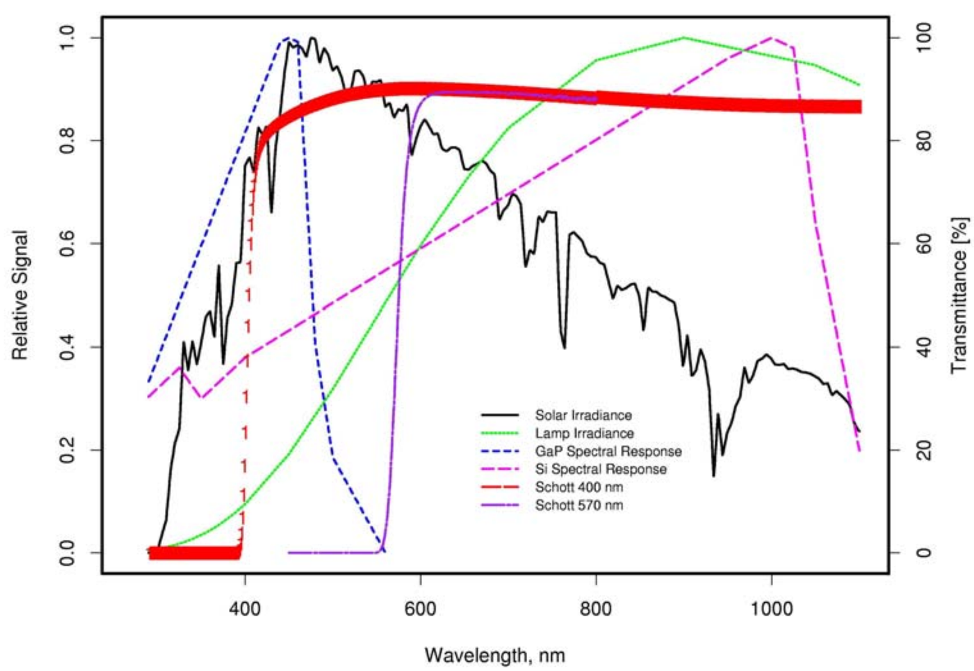
The first item of interest is explainable in part because of the decrease in the solar signal (blackbody profile) as the wavelength increases where the lamp signal increases as the wavelength increases as seen in Figure 2. In addition, there is a water absorption feature in the wavelength region around 900-1000 nm of the solar spectrum where the response function of silicon is peaking and the possibility of higher mode ringing of the transmittance filters. The second item can be explained by the spectral responsivity of the photodetector where Silicon photodiodes can detect out to approximately 1100 nm as seen in Figure 2 in comparison to GaP which is unresponsive after 550 nm.

The last item of interest was investigated by using a series of cut-off filters to determine the wavelength region of the light contributing to the signal in the channels. The results indicate that the majority of the measured OOB signal is coming from wavelengths longer than 850-nm. This indicates that the transmittance filters may be designed to block the region from 622 – 716 nm, but is still transmitting the region from 933 to 1084 nm. Also, silicon's responsivity is much lower under 850 nm and increases rapidly after 850 and peaks around 1000 nm. Additionally, the signal from the FEL lamp is also peaking in that wavelength region. The peak of the Si photodetector and the FEL lamp explains in part why the 317-nm channel has the most out-of-band light contribution to the total signal. It is believed that the filters also leak a low level of photons across a wide spectral range.

However, the above explains the general pattern for 317 nm channel measuring more out-of-band light but does not explain why there are 4 different spectral patterns of out-of-band light among the 47 instruments. Further measurements of the Si photodetector responsivity and the transmission of each of the transmittance filters over a larger dynamic range and more details on the proprietary manufacturing process of the transmittance filters would be helpful to fully understand why the contribution of out-of-band light is not the same from instrument to instrument.

3.4. Additional corrections to lamp calibration files: At this same time, the UV-MFRSR calibration files were also corrected for the 1-2% NIST adjustment to the lamp irradiance scale that occurred in June 2001 (see Appendix 2), and the 4-5% adjustment to the CUCF irradiance scale (see Appendix 3). The NIST correction occurred with the change from a source based to a detector based spectral irradiance scale. The new scale reduced uncertainties in the UV portion of the spectrum. The NIST correction occurs from the first CUCF calibration files until June 2001, the date the new scale was adopted. The CUCF correction to the irradiance scale occurred in March 1999 due to a bias that was introduced to the lamp calibration system during the move to the new DSRC building. The CUCF correction data affected the calibration on instruments from April 1999 – May 2002. The cause of the bias in the system was determined, and system modifications were implemented to remove this bias. All CUCF standard lamp calibration files have been reprocessed using these corrections. The lamp calibration files are now consistent with the current NIST spectral irradiance scale.

Figure 2. Spectral characteristics of Silicon and Gallium Phosphide photodetectors. Spectral envelope of 1000 W Tungsten Halogen Lamp and a typical solar irradiance spectrum at high sun.



Appendix 1: OOB Correction List

ABS_file_name	*lamp*	*OOB_file_name*	*revision*
0023100204C.ABS	hh026	0023104905A.OOB	Q
0023104905C.ABS	hh026	0023104905A.OOB	Q
0023216406C.ABS	hh026	0023216406A.OOB	Q
0023220204C.ABS	hh024	0023220204D.OOB	Q
0023235105C.ABS	hh032	0023235005H.OOB	Q
0027011505C.ABS	hh026	0027016406A.OOB	Q
0027016406C.ABS	hh026	0027016406A.OOB	Q
0027019806C.ABS	hh026	0027016406A.OOB	Q
0027035205C.ABS	hh032	0027035005H.OOB	Q
0027111605C.ABS	hh026	0027111605A.OOB	Q
0028123805C.ABS	hh026	0028123805A.OOB	Q
0028135905C.ABS	hh032	0028135805H.OOB	Q
0028208005C.ABS	hh026	0028218506A.OOB	Q
0028218406C.ABS	hh026	0028218506A.OOB	Q
0028302606C.ABS	hh032	0028302606H.OOB	Q
0028328204C.ABS	hh026	0028328204A.OOB	Q
0028425705C.ABS	hh026	0028425905A.OOB	Q
0028533605C.ABS	hh032	0028533505H.OOB	N
0028608005C.ABS	hh026	0028619205A.OOB	Q
0028616406C.ABS	hh026	0028616406A.OOB	Q
0028619205C.ABS	hh026	0028619205A.OOB	Q
0028706906C.ABS	hh032	0028706806H.OOB	N
0028800305C.ABS	hh026	0028800305A.OOB	Q
0028806006C.ABS	hh032	0028805906H.OOB	Q
0028925304C.ABS	hh025	0028925304F.OOB	Q
0028930505C.ABS	hh026	0028930505A.OOB	Q
0029011605C.ABS	hh031	0029011605B.OOB	Q
0029104805C.ABS	hh031	0029104805B.OOB	Q
0029112506C.ABS	hh032	0029112406H.OOB	Q
0029208205C.ABS	hh031	0029208105B.OOB	Q
0029219205C.ABS	hh026	0029219205A.OOB	Q
0029315904C.ABS	vv011	0029315904E.OOB	Q
0029318406C.ABS	hh026	0029318506A.OOB	Q
0029319205C.ABS	hh026	0029319205A.OOB	Q
0029410906C.ABS	hh032	0029410806H.OOB	Q
0029706906C.ABS	hh032	0029706806H.OOB	Q
0029731104C.ABS	hh026	0029731604A.OOB	Q
0029904805C.ABS	hh031	0029904805B.OOB	Q
0030017006C.ABS	hh026	0030017106A.OOB	Q
0030123804C.ABS	hh025	0030123804F.OOB	Q
0030124305C.ABS	hh026	0030124305A.OOB	Q
0030209506C.ABS	hh032	0030209406H.OOB	Q
0030228304C.ABS	hh030	0030228204C.OOB	Q
0030408105C.ABS	hh026	0030408105A.OOB	P
0030419306C.ABS	hh026	0030419306A.OOB	P
0030517604C.ABS	hh028	0030517604G.OOB	Q
0030523005C.ABS	hh026	0030523005A.OOB	Q
0030524306C.ABS	hh026	0030524306A.OOB	Q
0030620204C.ABS	hh024	0030620204D.OOB	Q
0030635905C.ABS	hh032	0030635805H.OOB	Q
0030720204C.ABS	hh024	0030720204D.OOB	N
0030727505C.ABS	hh026	0030727505A.OOB	N
0030827404C.ABS	hh024	0030827404D.OOB	Q

0030833305C.ABS	hh032	0030833305H.OOB	Q
0038611605C.ABS	hh026	0038611605A.OOB	Q
0038717604C.ABS	hh028	0038717604G.OOB	N
0038727505C.ABS	hh026	0038727505A.OOB	Q
0038817405C.ABS	hh026	0038817405A.OOB	Q
0038911605C.ABS	hh026	0038911605A.OOB	Q
0039007806C.ABS	hh032	0039007806H.OOB	Q
0039008105C.ABS	hh026	0039008105A.OOB	Q
0039115406C.ABS	hh032	0039115306H.OOB	Q
0039217504C.ABS	hh024	0039217504D.OOB	Q
0039308005C.ABS	hh026	0039308005A.OOB	Q
0039317006C.ABS	hh026	0039317106A.OOB	Q
0039402706C.ABS	hh032	0039402606H.OOB	Q
0039431204C.ABS	hh030	0039431104C.OOB	Q
0039517604C.ABS	hh028	0039517604G.OOB	Q
0039527505C.ABS	hh026	0039527505A.OOB	Q
0039600305C.ABS	hh026	0039600405A.OOB	Q
0039602806C.ABS	hh032	0039602706H.OOB	Q
0039713104C.ABS	vv011	0039713104E.OOB	Q
0039723005C.ABS	hh026	0039723005A.OOB	Q
0039726306C.ABS	hh026	0039726306A.OOB	Q
0039828204C.ABS	hh026	0039828204A.OOB	Q
0046500305C.ABS	hh026	0046500405A.OOB	Q
0046524306C.ABS	hh026	0046524306A.OOB	Q
0050717405C.ABS	hh026	0050722506A.OOB	Q
0050722506C.ABS	hh026	0050722506A.OOB	Q
0050802806C.ABS	hh032	0050802706H.OOB	Q
0050813104C.ABS	vv011	0050813104E.OOB	Q
0050819706C.ABS	hh026	0050819306A.OOB	Q
0050831504C.ABS	hh026	0050831504A.OOB	Q
0052816406C.ABS	hh026	0052816406A.OOB	Q
0052819806C.ABS	hh026	0052816406A.OOB	Q
0052833405C.ABS	hh032	0052833305H.OOB	Q
0023110902C.ABS	96600	0023104905A.OOB	Q
0023203002C.ABS	96600	0023235005H.OOB	Q
0023215503C.ABS	hh027	0023235005H.OOB	Q
0023217803C.ABS	hh025	0023235005H.OOB	Q
0023217903C.ABS	hh027	0023235005H.OOB	Q
0023218003C.ABS	hh030	0023235005H.OOB	Q
0027011303C.ABS	hh027	0027035005H.OOB	Q
0027023401C.ABS	96600	0027035005H.OOB	Q
0027035600D.ABS	hh028	0027035005H.OOB	Q
0027036503C.ABS	hh028	0027035005H.OOB	Q
0027110704C.ABS	hh024	0027111605A.OOB	Q
0027124602C.ABS	hh015	0027111605A.OOB	Q
0027124801C.ABS	96600	0027111605A.OOB	Q
0028100702C.ABS	96600	0028135805H.OOB	Q
0028108303C.ABS	hh015	0028135805H.OOB	Q
0028113104C.ABS	hh011	0028135805H.OOB	Q
0028225502C.ABS	96601	0028218506A.OOB	Q
0028230103C.ABS	hh028	0028218506A.OOB	Q
0028306402C.ABS	96600	0028328204A.OOB	Q
0028314303C.ABS	hh027	0028328204A.OOB	Q
0028411303C.ABS	hh027	0028425905A.OOB	Q
0028415504C.ABS	hh011	0028425905A.OOB	Q
0028423401C.ABS	96600	0028425905A.OOB	Q

0028522703C.ABS	hh027	0028533505H.OOB	N
0028527504C.ABS	hh030	0028533505H.OOB	N
0028535600C.ABS	96600	0028533505H.OOB	N
0028614102C.ABS	96601	0028621704D.OOB	Q
0028615503C.ABS	hh027	0028621704D.OOB	Q
0028617803C.ABS	hh025	0028621704D.OOB	Q
0028617903C.ABS	hh027	0028621704D.OOB	Q
0028618003C.ABS	hh030	0028621704D.OOB	Q
0028706402C.ABS	96600	0028706806H.OOB	N
0028710101C.ABS	96600	0028706806H.OOB	P
0028736503C.ABS	hh028	0028706806H.OOB	Q
0028814102C.ABS	96601	0028805906H.OOB	Q
0028914303C.ABS	hh027	0028930505A.OOB	Q
0028933701C.ABS	96600	0028930505A.OOB	Q
0029004304C.ABS	hh028	0029011605B.OOB	Q
0029014102C.ABS	96601	0029011605B.OOB	Q
0029106402C.ABS	96600	0029112406H.OOB	N
0029110902C.ABS	96600	0029112406H.OOB	Q
0029111303C.ABS	hh025	0029112406H.OOB	Q
0029135600C.ABS	96600	0029112406H.OOB	N
0029202904C.ABS	hh024	0029219205B.OOB	Q
0029225502C.ABS	96601	0029219205B.OOB	Q
0029324801C.ABS	96600	0029319205B.OOB	Q
0029331002C.ABS	hh015	0029319205B.OOB	Q
0029418304C.ABS	hh028	0029410806H.OOB	Q
0029423401C.ABS	96600	0029410806H.OOB	Q
0029434602C.ABS	hh015	0029410806H.OOB	Q
0029700702C.ABS	96600	0029731604A.OOB	Q
0029722703C.ABS	hh027	0029731604A.OOB	Q
0029906402C.ABS	96600	0029904805B.OOB	Q
0029908504C.ABS	hh024	0029904805B.OOB	Q
0030004905C.ABS	hh031	0030017106A.OOB	Q
0030025203C.ABS	hh028	0030017106A.OOB	Q
0030025502C.ABS	96601	0030017106A.OOB	Q
0030103603C.ABS	hh015	0030124305A.OOB	Q
0030209802C.ABS	96600	0030228204C.OOB	Q
0030410101C.ABS	96600	0030419306A.OOB	P
0030430203C.ABS	hh028	0030419306A.OOB	P
0030503603C.ABS	hh015	0030523005A.OOB	Q
0030614303C.ABS	hh027	0030635805H.OOB	Q
0030621101C.ABS	96600	0030635805H.OOB	Q
0030730203C.ABS	hh028	0030727505A.OOB	N
0030735600C.ABS	96600	0030727505A.OOB	N
0030810902C.ABS	96600	0030833305H.OOB	Q
0030822703C.ABS	hh027	0030833305H.OOB	Q
0038604404C.ABS	hh028	0038611605B.OOB	Q
0038625502C.ABS	96601	0038611605B.OOB	Q
0038714303C.ABS	hh027	0038727505A.OOB	N
0038735600C.ABS	96600	0038727505A.OOB	N
0038810704C.ABS	hh024	0038817405B.OOB	Q
0038831002C.ABS	hh015	0038817405B.OOB	Q
0038903603C.ABS	hh015	0038911605A.OOB	Q
0038908504C.ABS	hh024	0038911605A.OOB	Q
0039003002C.ABS	96600	0039008105A.OOB	Q
0039008303C.ABS	hh015	0039008105A.OOB	Q
0039010704C.ABS	hh024	0039008105A.OOB	Q

0039100204C.ABS	hh024	0039115306H.OOB	Q
0039102905C.ABS	hh031	0039115306H.OOB	Q
0039123401C.ABS	96600	0039115306H.OOB	Q
0039130902C.ABS	96601	0039115306H.OOB	Q
0039211303C.ABS	hh027	0039217504D.OOB	Q
0039223401C.ABS	96600	0039217504D.OOB	Q
0039224106C.ABS	hh026	0039221406A.OOB	Q
0039308504C.ABS	hh024	0039317106A.OOB	Q
0039331002C.ABS	hh015	0039317106A.OOB	Q
0039410902C.ABS	96600	0039431104C.OOB	Q
0039414303C.ABS	hh027	0039431104C.OOB	Q
0039500702C.ABS	96600	0039527505A.OOB	Q
0039508303C.ABS	hh015	0039527505A.OOB	Q
0039616901C.ABS	96600	0039602706H.OOB	Q
0039624602C.ABS	hh015	0039602706H.OOB	Q
0039630103C.ABS	hh028	0039602706H.OOB	Q
0039721101C.ABS	96600	0039723005A.OOB	Q
0039734602C.ABS	hh015	0039723005A.OOB	Q
0039803603C.ABS	hh015	0039828204A.OOB	Q
0046500901C.ABS	96600	0046500405A.OOB	N
0046511303C.ABS	hh027	0046500405A.OOB	Q
0046520700C.ABS	97510	0046500405A.OOB	N
0046521101C.ABS	96600	0046500405A.OOB	Q
0046532200C.ABS	96600	0046500405A.OOB	Q
0050702904C.ABS	hh024	0050722506A.OOB	Q

Appendix 2: NIST adjustment to the lamp irradiance scale

Header:	
Measurement type:	NIST irradiance scale correction
Comments:	from source-based scale to detector-based scale
Date:	1 June 2001
Lamps:	F-435, F-443, F-444
Labels:	

Wavelength [nm]	Average [multiplicative_factor]
270	1.0189764144043192
280	1.0171903010509238
290	1.0154520451684623
300	1.0139565053860158
310	1.0127940646246510
320	1.0120593005534921
330	1.0116193130087989
340	1.0113557665846172
350	1.0114123635171847
360	1.0117679154692419
370	1.0120736422917655
380	1.0124076585599067
390	1.0128965070726726
400	1.0132455790174483
410	1.0134410684588248
420	1.0135241990206618
430	1.0135231151295477
440	1.0134659612120707
450	1.0133808816948191

Appendix 3: CUCF correction to the irradiance scale

Header:
Measurment type: CUCF irradiance scale correction to horizontal scale
Date: 1 February 2002
Comments: To be applied from April 1999 to February 1, 2002 for U111 and May 1, 2002 for UV-MFRSR's or after Rev.Q
Lamps: H-011, H-012, H-013, H-019, H-020, H-022, E-012, E-013, E-014, E-015
Labels:

Wavelength [nm]	Average correction factor [multiplicative_factor]
270	0.956019081192939
280	0.957526532095908
290	0.959055326377029
300	0.960694368736824
310	0.962453447946962
320	0.964138713427788
330	0.965304930768137
340	0.965877993957521
350	0.966401880759124
360	0.967124392492985
370	0.96785797136186
380	0.968327570331634
390	0.968525054209662
400	0.968442389442638
410	0.96811351171304
420	0.967587925296727
430	0.966914916410141
440	0.966143771269726
450	0.965323776091923

Data: (above)