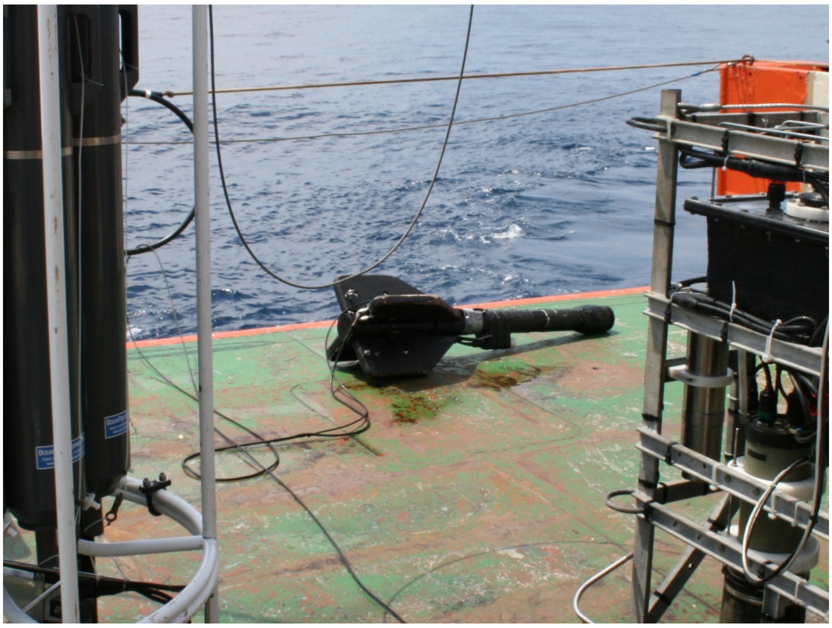
The BOUSSOLE project technical reports

Satlantic' SeaWiFS Profiling Multichannel Radiometer (SPMR s/n006) and Multichannel Surface reference (SMSR s/n 006)

Calibration history report (2001-2011)

Emilie Diamond, David Antoine, Vincenzo Vellucci, Bernard Gentili, Guislain Bécu[1]*, and Alec Scott*[2]

Laboratoire d'Océanographique de Villefranche (LOV)
06238 Villefranche sur mer cedex, FRANCE



The SPMR s/n 006 on the deck of the *Téthys II* R/V during the May 2009 BOUSSOLE cruise

BOUSSOLE project *19 February 2013*

[1] Now at: Unité Mixte Internationale Takuvik, CNRS & Univ. Laval, Université Laval, Québec, Canada
[2] Now at: Fugro GEOS Inc., tbc

Foreword

This report is part of the technical report series that is being established by the BOUSSOLE project.

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1 Introduction

Validation of the "geophysical products" derived from observations of satellite ocean colour sensors requires the collection of the same parameters from *in situ* instrumentation. In particular, the irradiance reflectance or the remote sensing reflectance have to be determined from field measurements of radiometric quantities such as the upward and downward plane irradiances at various depths in the water column. This task has been performed in the frame of the *BOUée pour l'acquiSition d'une Série à Long termE* (BOUSSOLE) project by using a commercial radiometer system specifically designed for that purpose. This system is built by the Satlantic company (Halifax, Nova Scotia, Canada). It is composed on an in-water profiling radiometer called the "*SeaWiFS Profiling Multichannel Radiometer*" (SPMR) and a deck reference called the "*SeaWiFS Multichannel Surface reference*" (SMSR). Deployment procedures and data processing are succinctly presented hereafter.

The Satlantic' SPMR was specifically designed to collect data for validation of the *National Aeronautics and Space Administration* (NASA) *Sea-viewing Wide Field-of-view Sensor* (SeaWiFS) ocean color instrument. The SPMR/SMSR system that was built for the remote sensing group of the *Laboratoire d'Océanographie de Villefranche* (LOV) measures both downward and upward underwater irradiance in 13 spectral channels ($E_d(\lambda)$ and $E_u(\lambda)$, respectively), and the above-water downward irradiance in the same 13 channels ($E_s(\lambda)$). These 13 channels were adapted to the band set of the *European Space Agency* (ESA) *Medium Resolution Imaging Spectrometer* (MERIS). The LOV SPMR/SMSR is serial number 006.

This system was bought in 1994 and has been used since then, until it was lost at sea during BOUSSOLE cruise 110 in April 2011. It was deployed during a number of oceanographic cruises before being used for BOUSSOLE, and still on a few occasion during the course of the project, from 1996 to 2009 (MINOS in 1996 in the Mediterranean, COASTLOOC in 1996-1997 in European coastal waters, PROSOPE in 1999 in the Mediterranean, POMME in 2000 in the Northeastern Atlantic, BIOSOPE in 2004 in the Southeast Pacific, BATS in 2009 in the Bermuda area, and Plumes & Blooms in 2009 in the Santa Barbara channel). From July 2001 to April 2011, the SPMR/SMSR 006 was essentially used during the monthly BOUSSOLE cruises, during which more than 800 profiles were collected.

This report summarizes the calibration history of these instruments. It does not include the description of the data processing that allows derivation of apparent optical properties from the profiles of radiometric quantities.

2 The SPMR/SMSR system description

2.1 In-water radiometer: the Satlantic's SPMR

Part of the following description simply quotes Satlantic own description of the instrument (see Satlantic Inc. SPMR/SMSR user manual, and Satlantic Inc. SPMR Repair Manual 1-C, Issue/Rev. 1/C draft. Date: 11/06/96).

The SPMR system uses the *Ocean Color Radiometer-1000* (OCR-1000) 13-channel radiometer, each channel of which is capable of detecting light over a 7 decade range. The system uses a proprietary filter/photodiode system to provide improved signal performance, ruggedness and sensor stability necessary for oceanographic use.

The "LOV version" of this profiling instrument is equipped with 2 "irradiance heads", collecting the upward (E_u s/n 18) and downward (E_d s/n 19) plane irradiances at the following wavelengths λ: 412, 443, 456, 490, 510, 532, 560, 620, 665, 683, 705, 779 and 865 nm. From August 2003, the 13th channel (865 nm) was replaced by a 381 nm cosine collector.

The SPMR Profiler is made of a long pressure case (1.2 m, 9 cm diameter) that contains the majority of system electronics, while the optical sensors are located and separately housed at either end of the case – looking up and down. The top end of the instrument has buoyant fins to stabilize the instrument's under-water free fall deployment and the bottom end has a small annular lead ballast to further stabilize the orientation and provide for fine tuning of the free fall velocity (Figure 1a).

Heads used for measuring irradiance, in $mW.cm^{-2}.nm^{-1}$, have a black Delrin plate on the end. The plate contains 13 specially-designed, diffuser-based, cosine collectors (Figure 1b). Tilt and pressure are recorded at the same frequency than the irradiance measurements, *i.e.*, at 6 Hz.

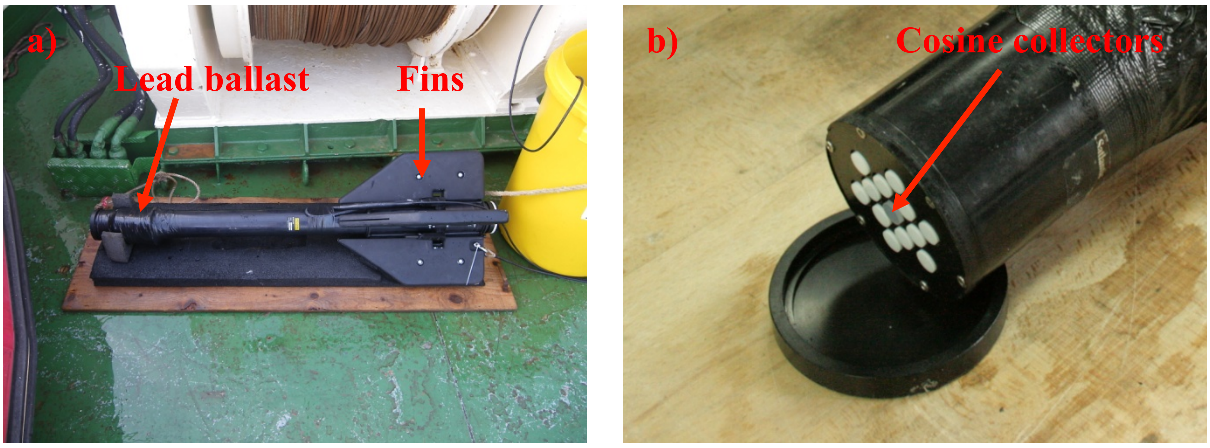

Figure 1. a) The SPMR on the ship deck. b) The SPMR head, with the 13 cosine collectors.

2.2 The SMSR deck reference

The SPMR is accompanied by a deck reference sensor, called the SMSR (Figure 2a). This sensor is equipped with the same 13 wavelengths sensor (E_S s/n 20) and is based on the same electronics than the SPMR. Data acquisition is simultaneous between the SPMR and the SMSR and it is performed again at the same 6 Hz frequency (Figure 2b).

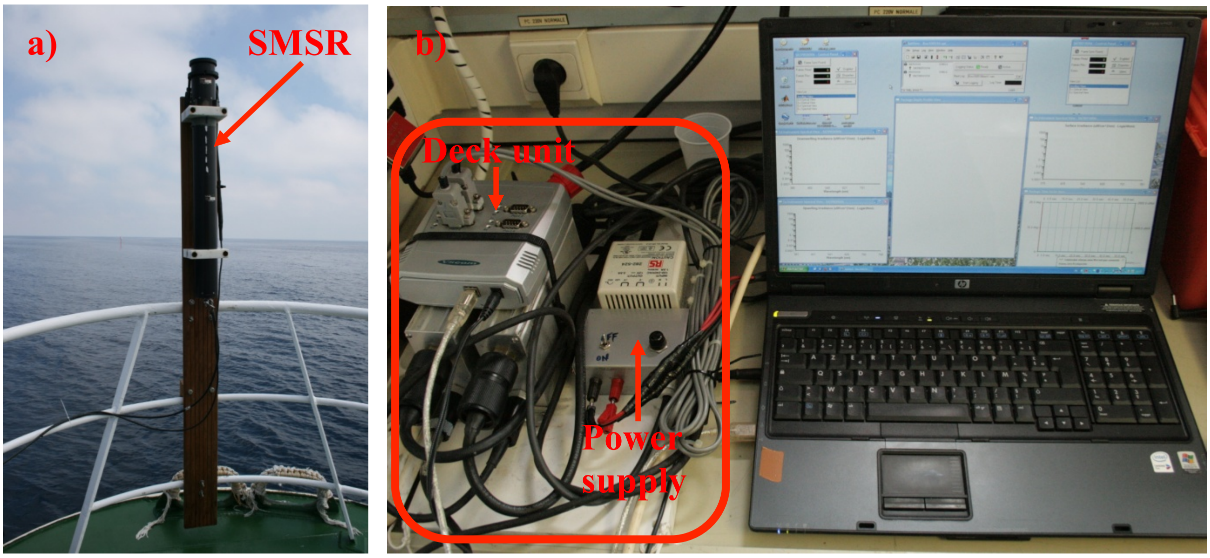

Figure 2. a) The deck reference SMSR at the bow of the ship. b) SPMR/SMSR deck unit and the acquisition laptop.

3 The SPMR/SMSR deployment techniques

A SPMR profile starts when the instrument has reached a distance of about 50 m off the ship stern (the Tethys-II R/V is 25 m long and a mark on the cable indicates the 50 m distance). The instrument is then released and falls at approximately 0.5 $m.s^{-1}$ in the water column, collecting data at a 6 Hz frequency. The descent is generally stopped when the pressure sensor indicates a depth of about 150 m, except in extremely clear waters where the profile is performed down to about 200 m (these depths ensure that the 0.1% light level is reached on the BOUSSOLE site). This technique allows to steer clear of the ship shadow and induced disturbances, and to get measurements with tilt angles less than 2 degrees. The sun is usually on the back or on port side of the ship, which is anyway not so important precisely because the ship shadow is not affecting the measurements (see Figure 3).

The reference SMSR is fixed vertically at the bow of the ship (no gimbal), and collects data at a 6 Hz frequency simultaneously with the SPMR. It is always ensured that the SMSR (the deck reference) is correctly exposed to the sun.

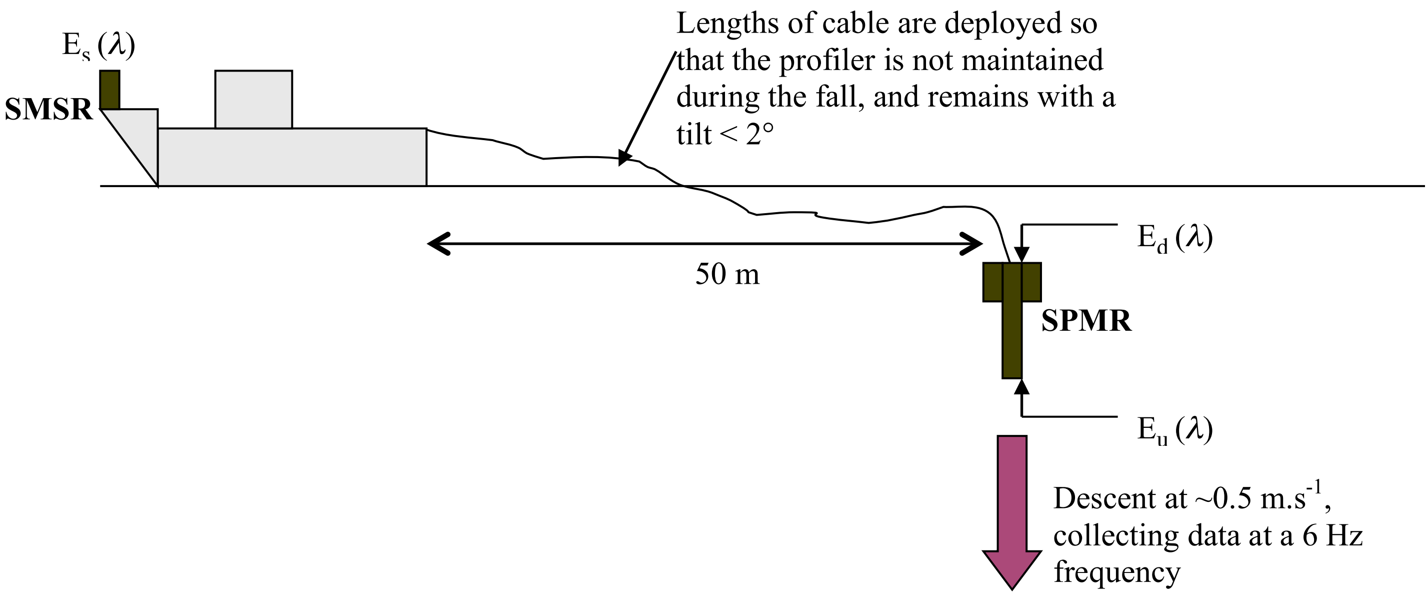

Figure. 3. Scheme of the SPMR deployment organization (nominal procedure; see text)

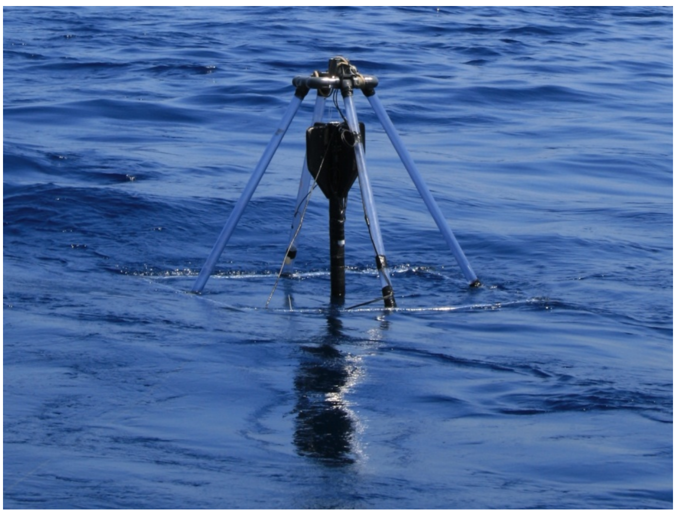

Figure 4. The SPMR hanging under the floating structure (occasional procedure; see text)

When sea state is very calm, a pyramidal floating platform (Figure 4) is used to support the SPMR E_u sensor approximately 20 cm below the surface for up to 3 minutes of stable light field before a release mechanism triggers the release of the profiler to start a descent as normal. Multiple descents are ideally started in this way and the data are used to assess near-surface E_u extrapolation model calculations.

4 SPMR gain modes during BOUSSOLE cruises

The SPMR has two "gain modes". One is called "auto gain" and automatically switches from low to high gain when irradiance falls below a certain threshold. The other one is the "fixed gain" mode, where the instrument is forced either to low or to high gain (actually to the high gain in our case). This second option was assumed to be selected most of the time. It is preferred because the "auto-gain" mode may introduce noise or faulty data after the switch has occurred. Careful examination of the data revealed that both modes were actually equally used over the 10 years concerned here (Figure 5). The reset to the "auto-gain" mode was actually performed during calibration of the instrument, and was not systematically reported to the BOUSSOLE staff, and therefore not changed back to the fixed mode.

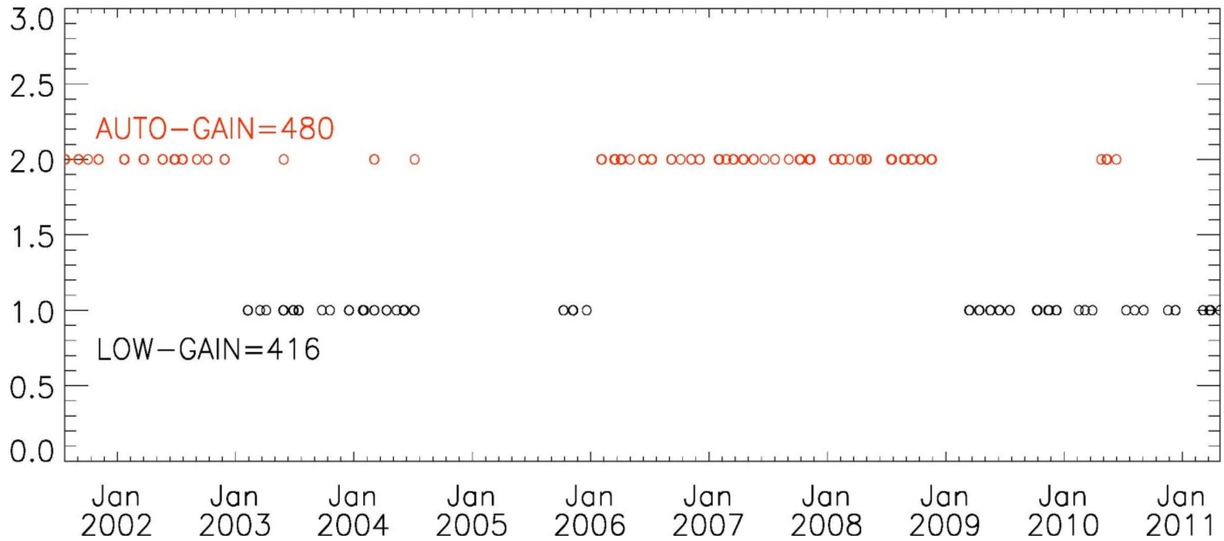

Figure 5. Gain mode used for data acquisition during BOUSSOLE cruises (arbitrary scale). Each symbol represents one cruise.

5 The SPMR/SMSR calibration procedures

5.1 Absolute radiometric calibration (profiler and reference irradiance)

Absolute calibration of the SPMR and SMSR with respect to NIST-traceable standards has been performed about every 6 months in the Satlantic optics calibration laboratory (Table 1), using a calibrated 1000W FEL lamp (ANSI designation for a tungsten coiled filament lamp) on a 5m optical bar using direct radiation from the lamp. The lamp is powered by an Optronics 83 A current source. The flux from the lamp is normally incident on the irradiance sensor cosine collector at a distance of D cm. The calibration irradiances are determined using the equation below:

$$E(\lambda, D\ \text{cm}) = E(\lambda, 50\text{cm}) * (50.0\ \text{cm} / D\ \text{cm})^2$$

where:

E(λ, D cm) is the calibration irradiance
E(λ, 50cm) is the lamp irradiance at 50cm
(50.0 cm/ D cm)² is the one over squared distance correction

The sensor output is sampled using its assigned A/D. The A/D output is sampled 10 times at 10Hz and averaged. This is repeated 10 times and logged to a file, once viewing the calibration source and once completely dark. The noise-equivalent irradainces (NEI) values are computed as the RMS noise level of the dark signal (mean removed).

During the SPMR s/n 006 calibrations, the distance D is set to 50 cm for the low gain calibration and to 140 cm for the high gain calibration.

During the SPMR s/n 006 calibrations, the distance D is set to 50 cm for the low gain calibration and to 70 cm for the high gain calibration.

SPMR			SMSR		
Day	**Month**	**Year**	**Day**	**Month**	**Year**
11	7	2001	13	7	2001
2	8	2002	2	8	2002
21	1	2003	21	1	2003
25	7	2003	25	7	2003
19	8	2003	18	8	2003
12	1	2004	12	1	2004
21	1	2004	-	-	-
10	9	2004	10	9	2004
-	-	-	20	9	2004
25	8	2005	25	8	2005
4	1	2006	4	1	2006
13	1	2006	13	1	2006
25	7	2006	25	7	2006
31	7	2006	-	-	-
20	12	2006	20	12	2006
3	8	2007	3	8	2007
20	8	2007	-	-	-
3	1	2008	3	1	2008
21	5	2008	21	5	2008
13	6	2008	-	-	-
7	1	2009	7	1	2009
25	8	2009	25	8	2009
8	9	2009	9	9	2009
23	2	2010	23	2	2010
9	4	2010	-	-	-
5	1	2011	5	1	2011

Table 1. Dates of the SPMR and SMSR absolute calibrations performed by Satlantic

5.2 Relative changes in calibration from the SQM-II

During the first years of BOUSSOLE, the calibration was tracked between each of the absolute calibrations using an ultra-stable portable light source developed for that purpose by Stalantic, *i.e.*, the "SeaWiFS Quality Monitor", SQM-II (Hooker and Aiken, 1998; also: Satlantic Inc. SQM-II manual R1.0A.doc, Version: 1.0A, Date: 04/27/99). Combining these two elements allows in principle a 3% maximum uncertainty to be maintained on the calibration of the SPMR and SMSR.

The use of the SQM-II was stopped in 2003, after it was observed that changes of calibration between the 6-months absolute calibrations were below the 3% level (see Tables 2, 3, 4), and also because the quite time-consuming protocol for using the SQM-II was not well adapted to a routine operation like BOUSSOLE (monthly cruises).

The results reported here nevertheless provide an illustration of the stability of the instrument.

	411	442.7	455.7	490.5	509.5	531.7	559.3	619.4	664.5	683.3	705.5	779.4
2002 / 01 / 15	0.291	**3.226**	0.718	0.593	-0.504	1.161	0.790	-0.188	0.575	-0.621	-0.124	1.446
2002 / 03 / 08	1.706	**3.581**	1.118	**2.810**	1.281	**2.331**	1.606	0.945	1.534	0.497	1.189	**2.766**
2002 / 03 / 10	**3.171**	**4.722**	**2.532**	**2.029**	1.321	**2.277**	1.516	0.366	1.066	-0.126	0.278	1.886
2002 / 04 / 01	**2.410**	**4.152**	**2.404**	**2.057**	1.265	**2.226**	1.776	0.930	1.812	0.460	0.990	**2.641**
2002 / 05 / 29	**2.854**	**4.624**	**3.562**	**3.902**	**2.206**	**3.112**	**2.037**	1.752	1.963	1.582	**2.254**	**3.627**
2002 / 10 / 23	0.455	0.787	1.272	**2.252**	1.408	1.268	0.571	0.640	0.391	1.111	1.080	1.413
2003 / 03 / 20	0.828	0.649	1.081	0.928	0.463	0.317	-0.074	0.099	0.261	0.101	0.177	0.413
2003 / 04 / 08	-0.434	-0.220	0.419	0.742	0.300	-0.182	-0.113	-0.489	-0.172	-0.338	-0.267	-0.087
2003 / 06 / 03	-1.914	-0.301	1.631	**2.888**	1.291	0.083	-0.608	-0.709	-0.434	-0.530	1.282	-0.169
Average percent diff.	1.041	2.358	1.637	2.022	1.003	1.399	0.833	0.372	0.777	0.237	0.762	1.548
Standard deviation	1.658	2.100	1.008	1.109	0.790	1.158	0.953	0.784	0.863	0.750	0.810	1.325

Table 2. Relative changes of the E_u sensor response derived from using the SQM-II, for the wavelengths and dates indicated (year/month/day). Numbers are percent differences between the sensor output at time of the SQM-II session and the sensor output from a SQM-II session performed just after absolute calibration (dates in Table 1). Bold values are values > 2%.

	411.2	443.2	455.8	490.9	509.6	531.9	560.1	619.2	664.3	683.4	704.5	780.2
2002 / 01 / 15	-1.947	-1.822	**-8.315**	**-5.184**	**-5.600**	**-2.672**	**-2.436**	-1.978	-1.681	-1.893	**-2.177**	**-2.396**
2002 / 03 / 08	-1.301	-0.019	**-2.040**	-1.364	-1.240	-0.016	-0.429	-0.400	-0.459	-0.635	-1.342	-1.109
2002 / 03 / 10	-0.794	-0.236	**-2.928**	**-2.439**	**-4.388**	-1.882	-1.298	**-2.284**	-1.174	-1.285	-1.783	-1.984
2002 / 04 / 01	-1.006	-0.537	**-2.582**	**-2.324**	**-2.111**	-0.632	-1.044	-0.260	-0.469	-0.408	-1.229	-1.012
2002 / 05 / 29	-0.417	-0.440	**-2.260**	-1.433	-0.911	-0.167	-0.349	-0.023	-0.044	-0.261	-0.665	-0.614
2002 / 10 / 23	1.126	1.045	**2.117**	1.315	1.398	0.522	**2.840**	0.649	1.364	1.817	1.229	1.351
2003 / 03 / 20	**2.471**	1.107	1.492	0.967	0.665	0.385	0.231	0.802	**2.539**	0.017	0.533	1.738
2003 / 04 / 08	-1.763	-1.068	-0.319	0.391	-0.747	-0.758	-0.545	-0.365	-0.971	-0.964	-0.516	-0.862
2003 / 06 / 03	-0.143	0.346	2.176	0.591	1.000	0.034	-0.316	0.183	0.002	0.007	0.608	1.268
Average percent diff.	-0.419	-0.180	-1.407	-1.053	-1.326	-0.576	-0.372	-0.408	-0.099	-0.401	-0.594	-0.402
Standard deviation	1.424	0.945	3.305	2.101	2.387	1.068	1.427	1.066	1.313	1.040	1.169	1.502

Table 3. As in Table 2, but for the E_d sensor

	411.1	443.7	455.8	490.8	510.7	531.9	560.2	619.7	664.8	682.5	705.1	780.7
2002 / 01 / 15	-0.931	-0.711	**-6.410**	-1.226	-0.659	-1.494	-0.787	-1.204	-1.159	**-5.171**	-1.188	-1.583
2002 / 03 / 10	0.320	0.015	**-4.394**	-0.400	0.129	-0.664	-0.598	-0.806	-1.104	**-4.381**	-1.633	**-2.179**
2002 / 04 / 01	-0.248	0.045	**-3.561**	-0.098	-0.109	-0.477	-0.148	-0.408	0.238	**-3.014**	-0.803	-0.930
2002 / 05 / 29	0.016	0.100	-1.971	0.031	0.095	-0.180	-0.246	-0.327	0.292	-1.861	-0.883	-0.709
2002 / 10 / 23	0.041	0.202	1.806	0.038	0.130	0.104	1.025	0.643	0.707	**2.511**	0.992	0.604
2003 / 03 / 20	0.559	0.483	1.034	0.855	0.557	0.495	0.055	0.114	-0.135	1.172	0.865	0.446
2003 / 04 / 08	0.223	0.222	1.921	0.605	0.368	0.217	-0.412	0.157	0.192	**3.889**	-0.828	0.748
2003 / 06 / 03	-0.567	0.013	**2.062**	0.603	0.037	0.216	-0.251	-0.389	0.035	**4.315**	**-3.561**	0.446
Average percent diff.	-0.073	0.046	-1.189	0.051	0.068	-0.223	-0.170	-0.278	-0.117	-0.318	-0.880	-0.395
Standard deviation	0.489	0.343	3.336	0.667	0.358	0.642	0.550	0.581	0.671	3.763	1.435	1.115

Table 4. As in Table 2, but for the E_s sensor

5.3 Immersion coefficients

Due to the difference in indices of refraction between air (where the instrument is calibrated) and water (where it is operated) a correction factor must be applied to obtain the effective in water irradiances. This correction factor is referred to as the immersion factor. For diffusing irradiance collectors, this effect has been attributed to the improved coupling between the water and the diffuser. This causes more light to scatter back out into the water than there would be in air, reducing the flux at the detector. The experimental setup for this test is described in the SeaWiFS Report Series Vol. 5 (section 4.1.6) (Zibordi et al., 2003).

The immersion corrections applied to the different wavelengths of the SPMR s/n 006 are provided in the Table 5. They are class-based values determined by Satlantic.

SPMR s/n 006				
E_u Channel	wavelength	E_d Channel	wavelength	Immersion coefficient
Eu18_1	509.5	Ed19_1	509.6	1.354
Eu18_2	411	Ed19_2	411.2	1.368
Eu18_3	559.3	Ed19_3	560.1	1.366
Eu18_4	442.7	Ed19_4	443.2	1.393
Eu18_5	455.7	Ed19_5	455.8	1.392
Eu18_6	490.5	Ed19_6	490.9	1.365
Eu18_7	779.4	Ed19_7	780.2	1.303
Eu18_8	531.7	Ed19_8	531.9	1.378
Eu18_9	381	Ed19_9	380.8	1.161
Eu18_10	619.4	Ed19_10	619.2	1.372
Eu18_11	664.5	Ed19_11	664.3	1.373
Eu18_12	683.3	Ed19_12	683.4	1.385
Eu18_13	705.5	Ed19_13	704.5	1.350
Eu18_14	865.3	Ed19_14	864.3	1.285

Table 5. Immersion coefficients of the SPMR 006, as revised in July 2002 and used across all our data

5.4 Cosine responses

The cosine responses are determined by Satlantic on production of radiometers, following accepted protocols (Zibordi et al., 2002).

These responses have not been reevaluated for the BOUSSOLE SPMR/SMSR instruments.

6 Maintenance operations on the SPMR/SMSR

6.1 Routine field/lab maintenance

After a set of casts the SPMR is rinsed with fresh water. At the end of a cruise the SPMR and the SMSR are properly rinsed with fresh water, the cosine collectors are rinsed with deionized water and the instruments are dried before being stored away.

6.2 Specific bi-yearly operations/repairs

Every 6 months Satlantic performed SPMR/SMSR inspection and maintenance while the instruments were there for calibration.

From 2001, the main repairs performed on the in-water profiler or the deck reference s/n 006 consisted in replacing some filters and/or collectors after a post calibration check and/or in replacing or repairing some damaged or faulty parts like screws, connectors or couplers.

In August 2003, the irradiance cosine collectors and detectors/filters for the band at 865nm were replaced on the 3 instruments (E_d s/n 019, E_u s/n 018 and E_s s/n 020) with a band at 380 nm.

These servicing and maintenance operations are summarized in Table 6.

Date	Work performed	Calibration files	
Aug. 2003	Work was done to both E_d s/n 019 and E_u s/n 018: - Replaced detectors 456, 490, and 510 nm. - Removed 865 nm detector and cosine collector and replaced with 380 nm detector and cosine collector, recalculate gains to specified saturation. - Performed solar intercomparison test and reality check.	pro006v.cal	pro006x.cal
Aug. 2003	Work done to E_s s/n 020: - Replaced detectors 456 and 683 nm. - Removed 865 nm detector and cosine collector and replaced with 380 nm detector and cosine collector, recalculate gains to specified saturations. - Performed solar intercomparison test and reality check.	ref006q.cal	ref006r.cal
Jan. 2006	- Replaced 443 and 456 nm detectors in E_d sensor. - Replaced 456 nm detector in E_u sensor. - Reset saturations. - Instrument intercompared - reality-checked - PASSED.	pro006ac.cal	pro006ad.cal
Jan. 2006	- Replaced 442 and 456 nm detectors. - Reset saturations. - Instrument reality-checked.	ref006w.cal	ref006x.cal
Jan. 2009	- Replaced filter/detector 532 nm on E_d sensor. - Visual inspection of OCI-1000 internal electronics	pro006am.cal	pro006an.cal

	- Purged with nitrogen and recalibrate		
Sept. 2009	- Repair E_u gain switching issue and E_s sensor noise problem	**xx ??**	**xx ??**
Nov. 2009	- SPMR E_u coupler replacement	**xx ??**	**xx ??**
Jan. 2010	- Replace SPMR and SMSR 4 pin Low Profile P/T Connector	**xx ??**	**xx ??**

Table 6. Satlantic SPMR and SMSR s/n 006 service history records.

7 Time series of calibration coefficients

Figures 6 to 17 show the time series of the SPMR and SMSR s/n 006 calibration coefficients from 2001 to 2011. For each OCI-1000 (E_u s/n 18, E_d s/n 19 and E_s s/n 20), the dark measurements and calibration slopes are given for the high-gain (low light) and low-gain (high light) calibrations.

7.1 SPMR E_u

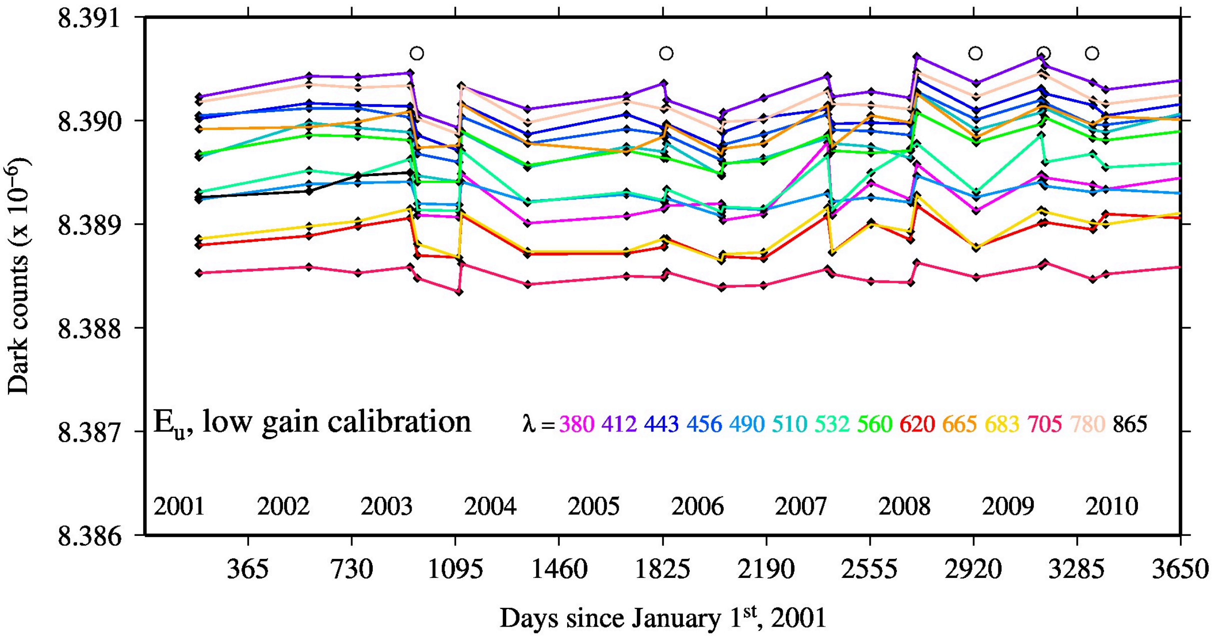

Figure 6. Time series (July 2001 to January 2011) of dark measurements for the SPMR E_u sensor in the low gain configuration, for the 14 wavelengths indicated (black diamonds and colored curves). The empty circles indicate major instrument servicing (see Table 5).

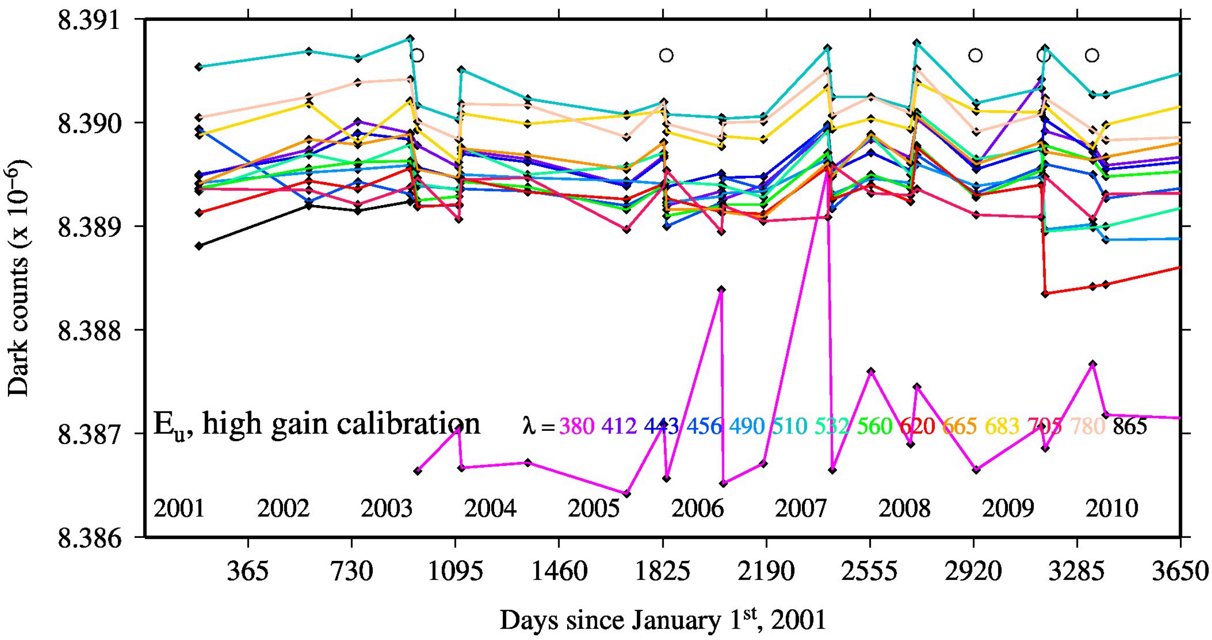

Figure 7. As in Fig. 6 but for the high gain configuration.

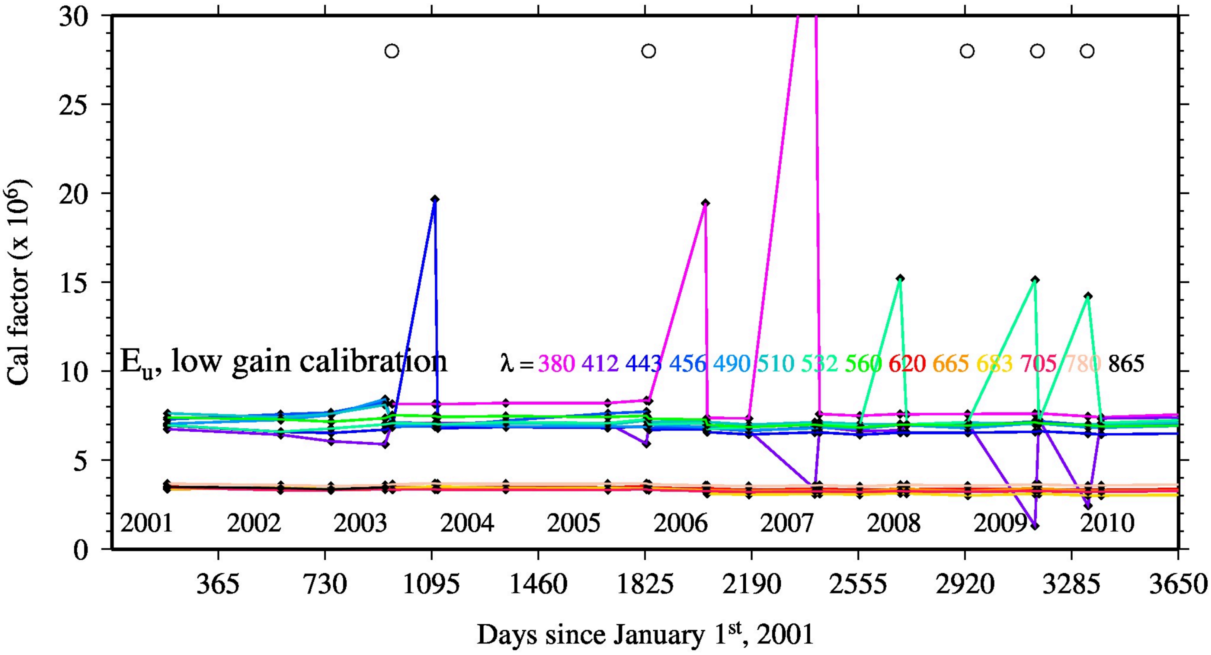

Figure 8. Time series (July 2001 to January 2011) of calibration slopes for the SPMR E_u sensor in the low gain configuration, for the 14 wavelengths indicated (black diamonds and colored curves). The empty circles indicate major instrument servicing (see Table 5).

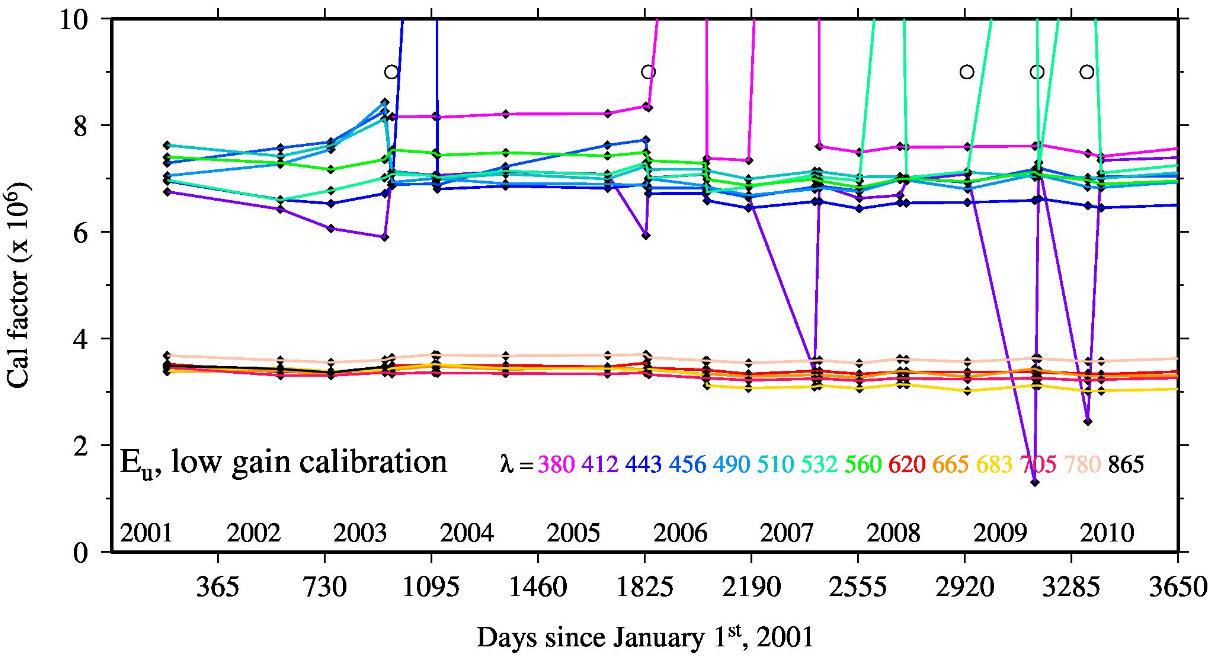

Figure 8bis. As in Fig. 8 but with a different scale for the vertical axis.

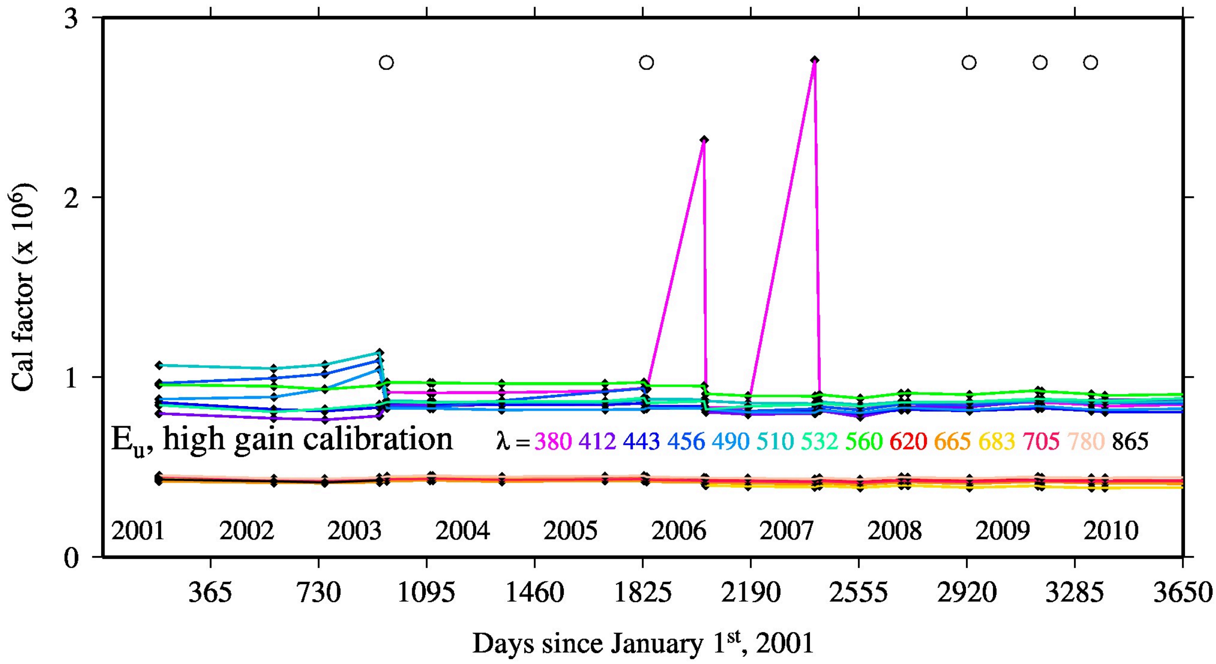

Figure 9. As in Fig. 8 but for the high gain configuration.

7.2 SPMR E_d

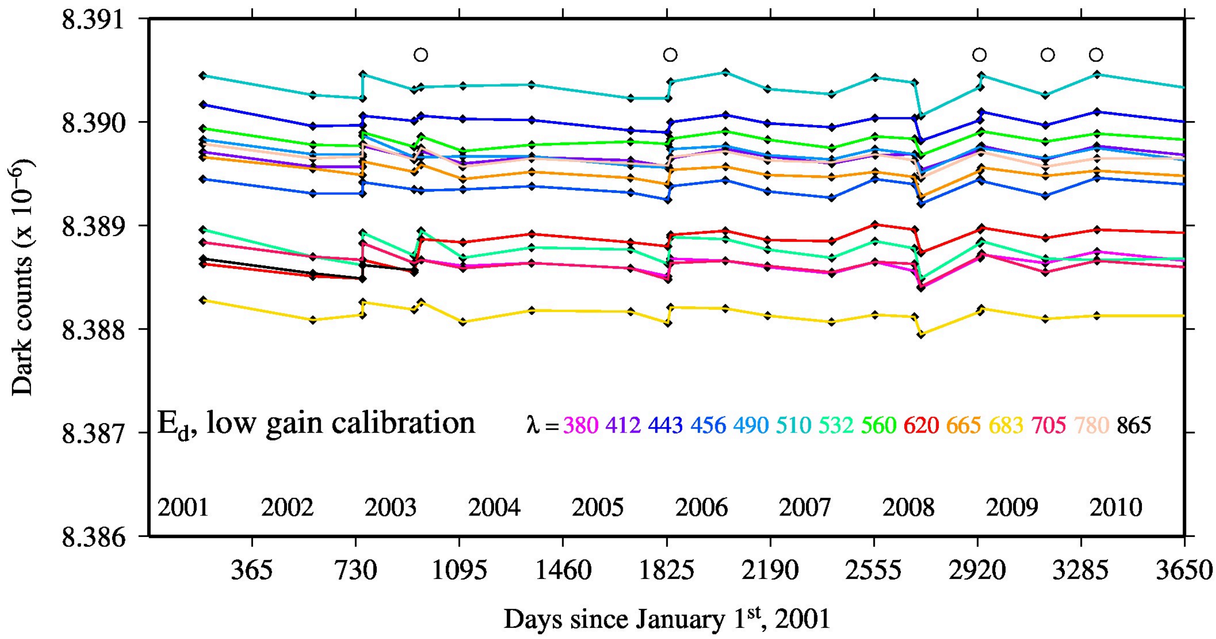

Figure 10. Time series (July 2001 to January 2011) of dark measurements for the SPMR E_d sensor in the low gain configuration, for the 14 wavelengths indicated (black diamonds and colored curves). The empty circles indicate major instrument servicing (see Table 5).

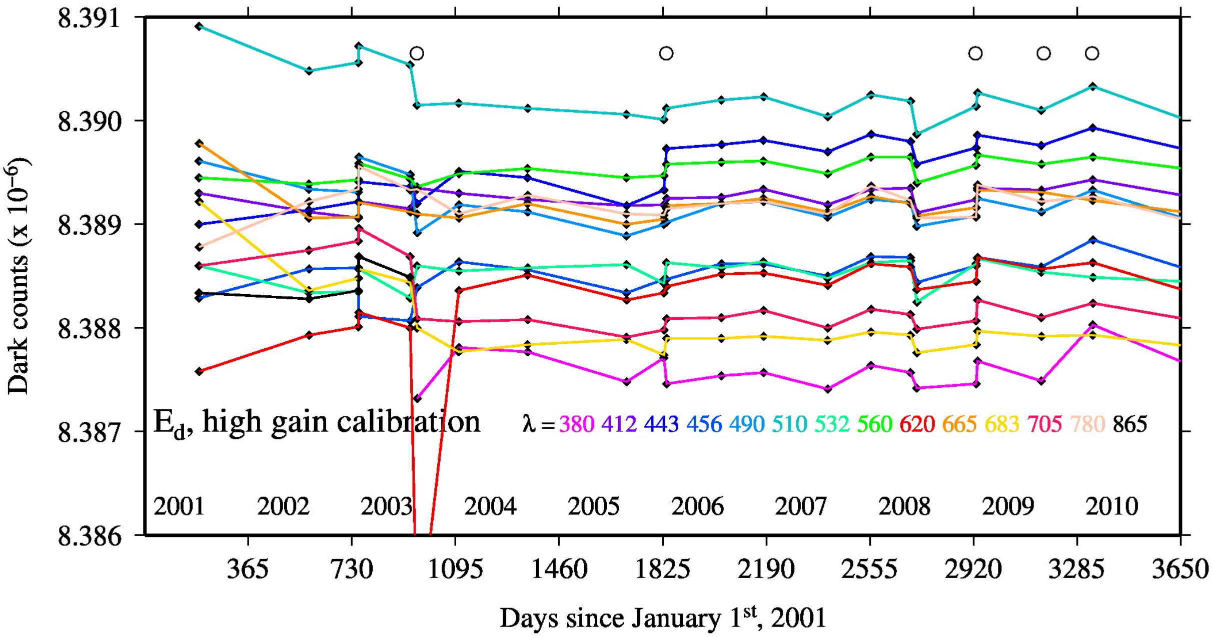

Figure 11. As in Fig. 10 but for the high gain configuration.

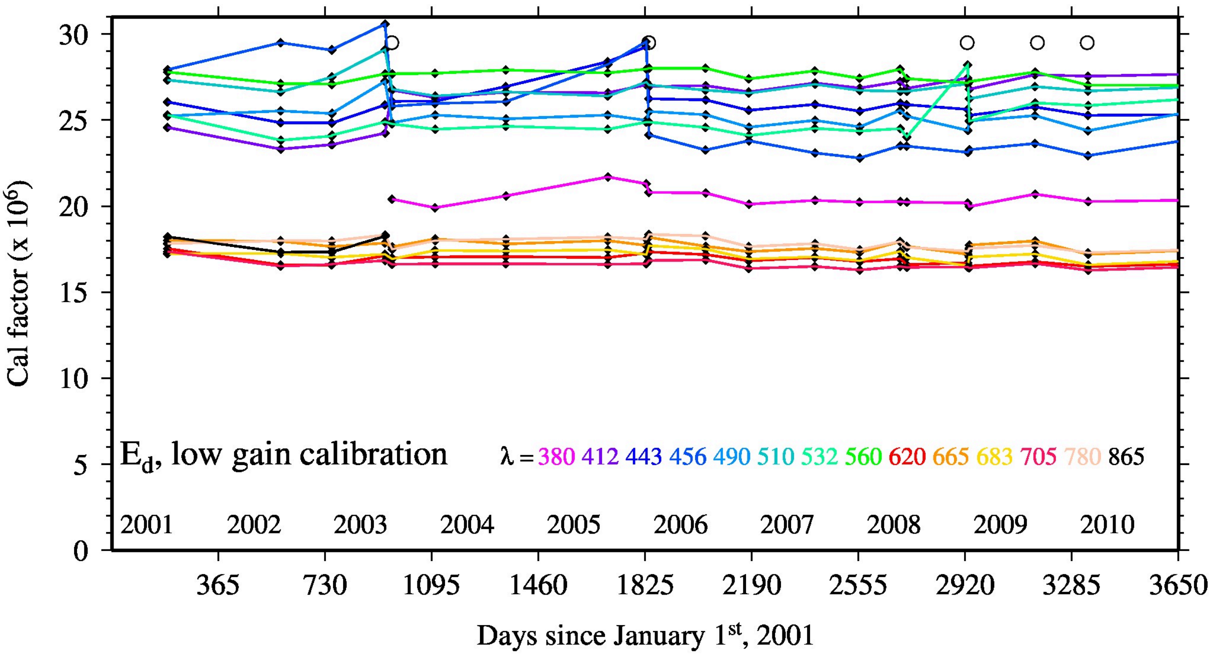

Figure 12. Time series (July 2001 to January 2011) of calibration slopes for the SPMR E_d sensor in the low gain configuration, for the 14 wavelengths indicated (black diamonds and colored curves). The empty circles indicate major instrument servicing (see Table 5).

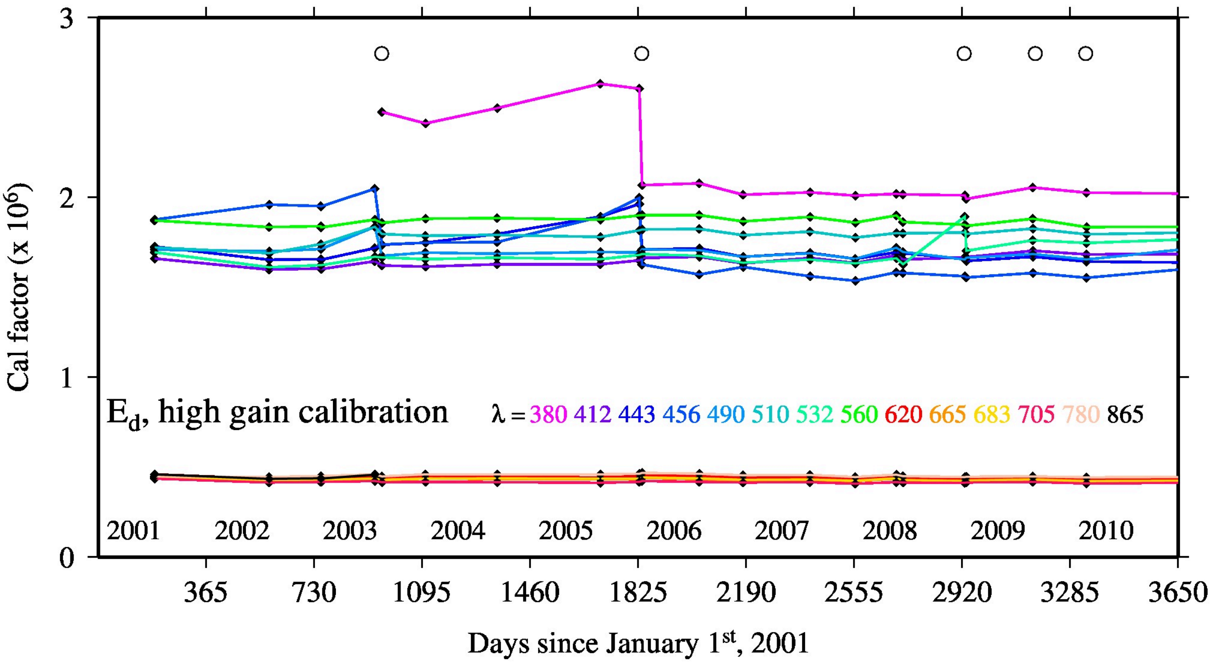

Figure 13. As in Fig. 12 but for the high gain configuration.

7.3 SMSR E_s

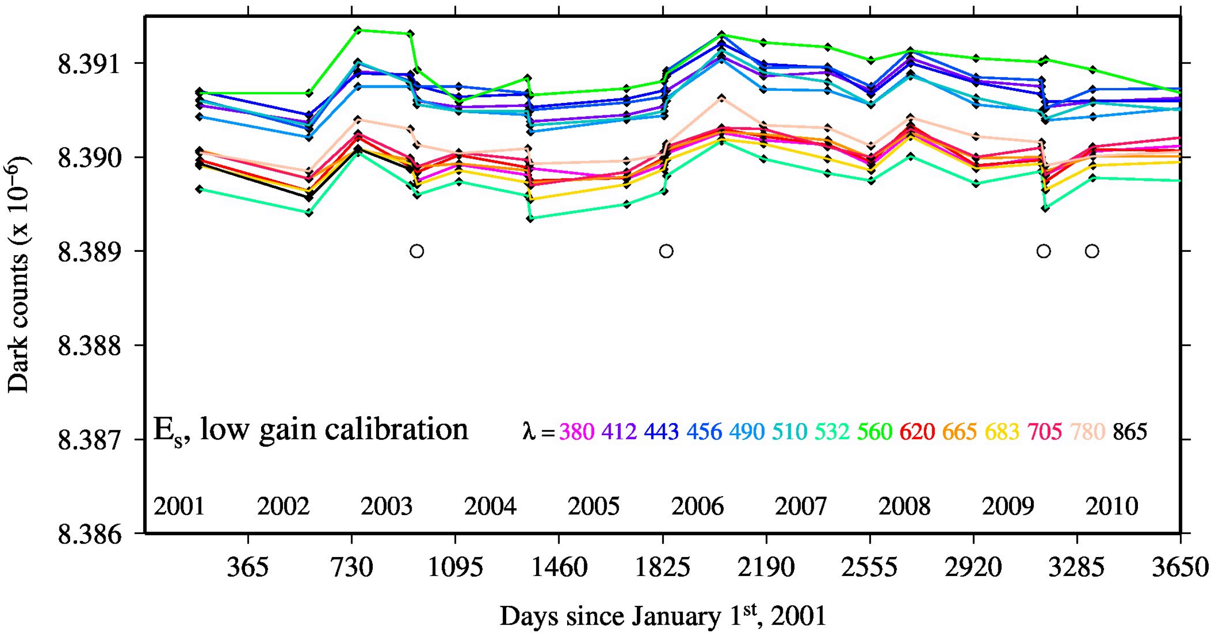

Figure 14. Time series (July 2001 to January 2011) of dark measurements for the SMSR E_S sensor in the low gain configuration, for the 14 wavelengths indicated (black diamonds and colored curves). The empty circles indicate major instrument servicing (see Table 5).

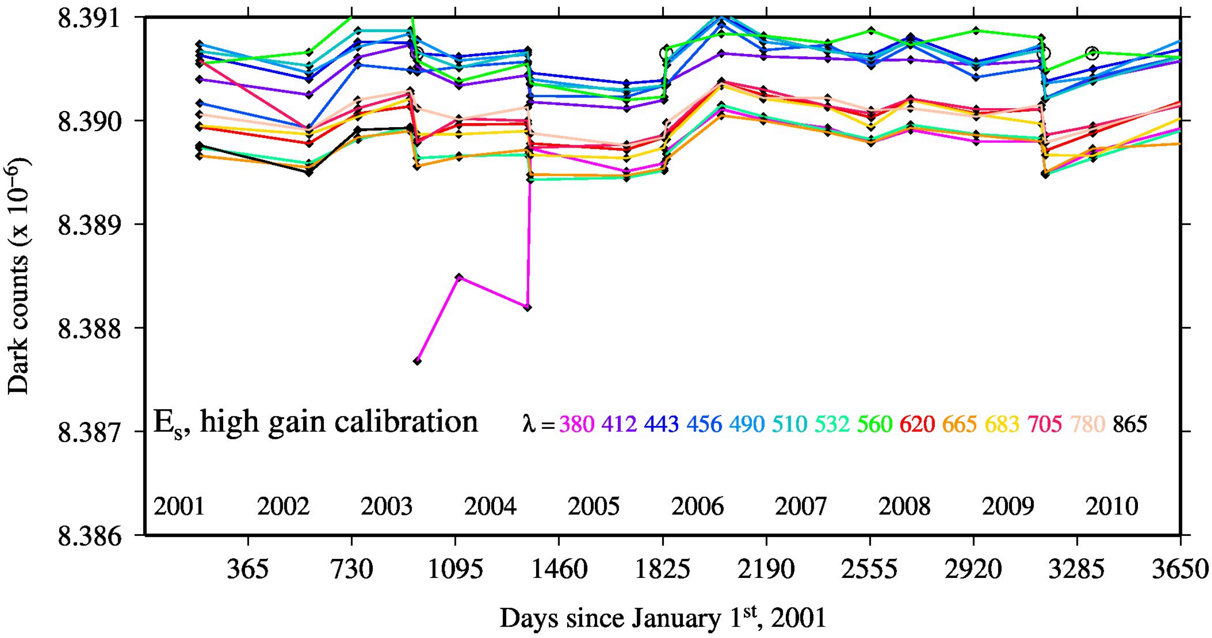

Figure 15. As in Fig. 14 but for the high gain configuration.

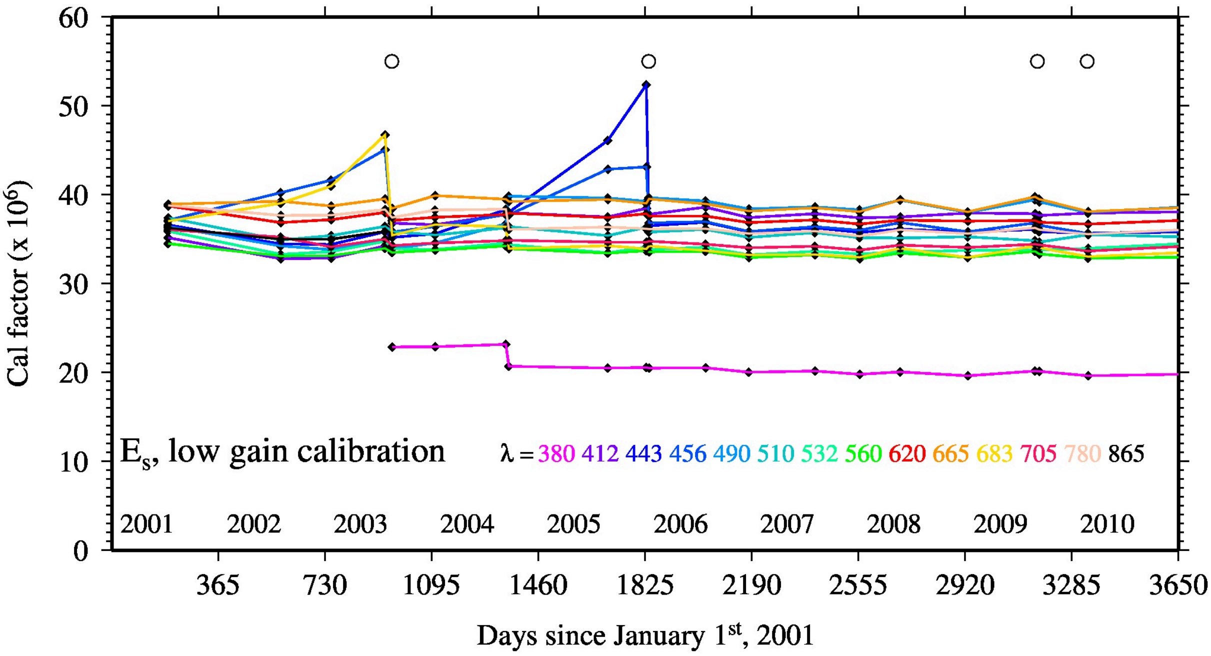

Figure 16. Time series (July 2001 to January 2011) of calibration slopes for the SMSR E_s sensor in the low gain configuration, for the 14 wavelengths indicated (black diamonds and colored curves). The empty circles indicate major instrument servicing (see Table 5).

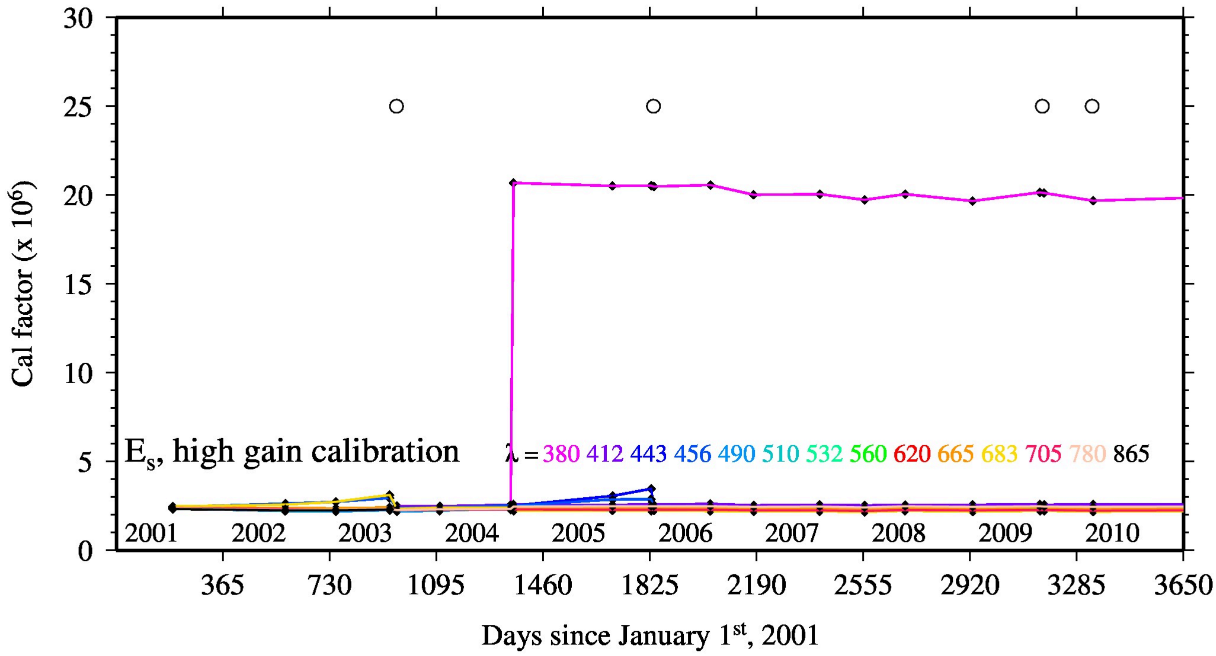

Figure 17. As in Fig. 16 but for the high gain configuration.

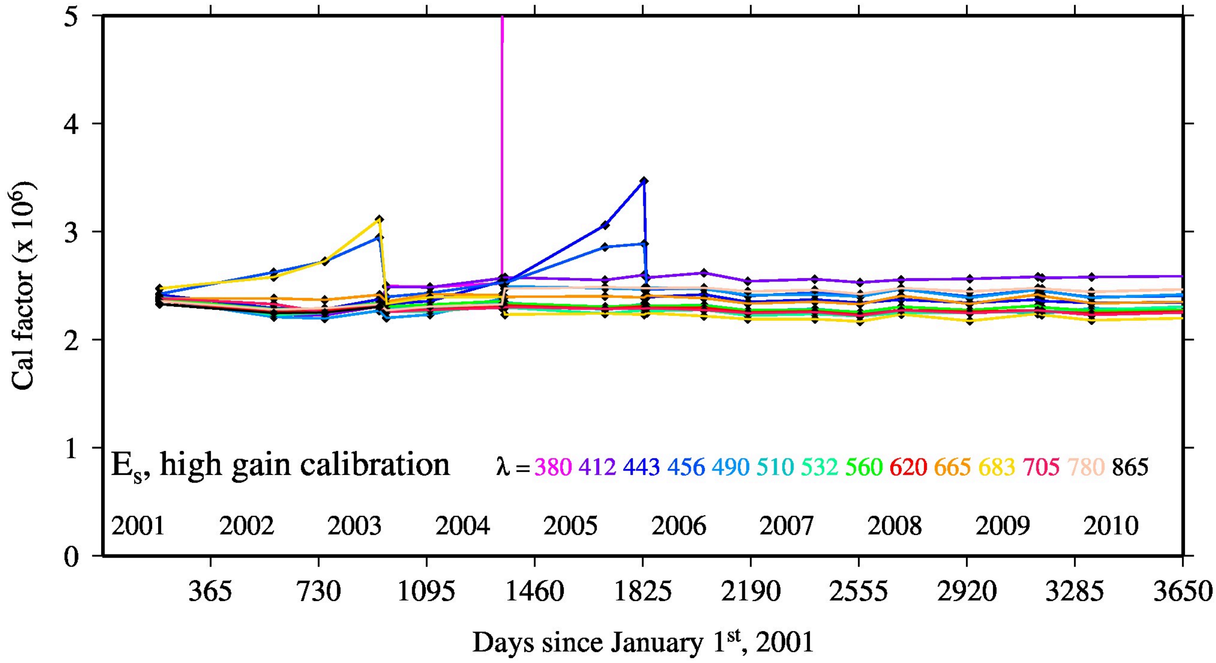

Figure 17bis. As in Fig. 17 but with a different scale for the vertical axis.

8 Average darks and calibration slopes over 2001 to 2011

Figures 18 to 29 and Tables 7 to 9 show the average and standard deviation of the dark records and calibration slopes across the 14 SPMR and SMSR bands, in both low and high gain configurations.

8.1 E_u sensor

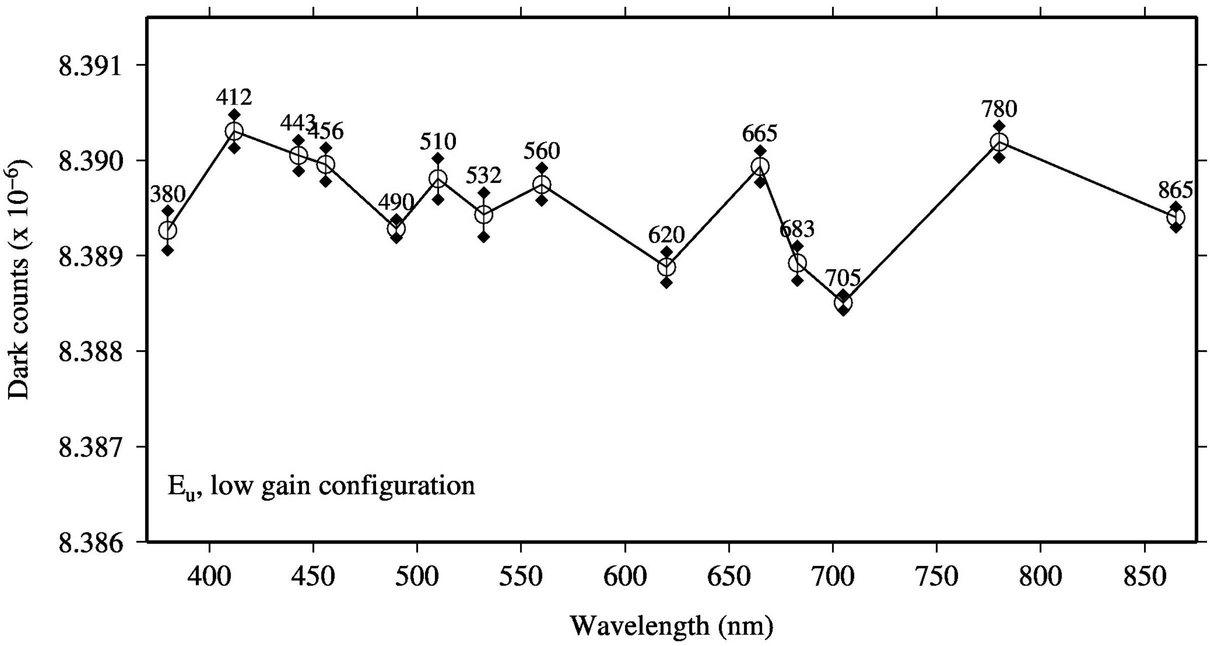

Figure 18. Average dark records for the E_u sensor in low gain configuration over the 2001-2011 time period and the 14 wavelengths indicated (open circles). The vertical bars and the black diamonds show one standard deviation.

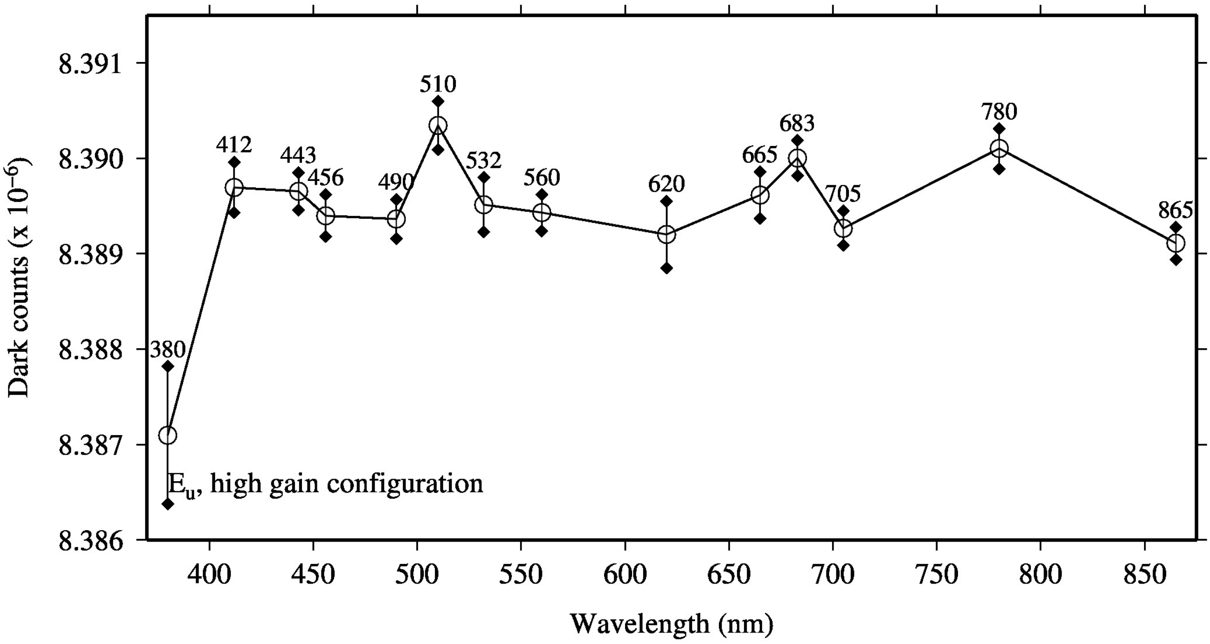

Figure 19. As in Fig. 18 but for the high gain configuration.

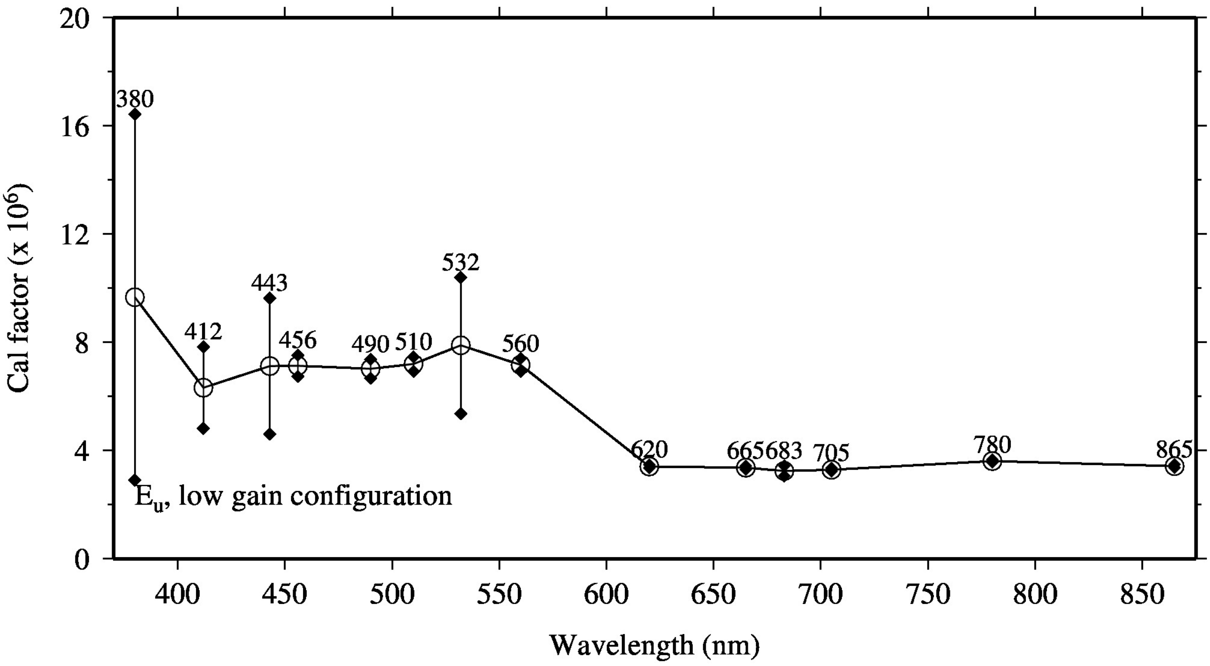

Figure 20. Average calibration slopes for the E_u sensor in low gain configuration over the 2001-2011 time period and the 14 wavelengths indicated (open circles). The vertical bars and the black diamonds show one standard deviation.

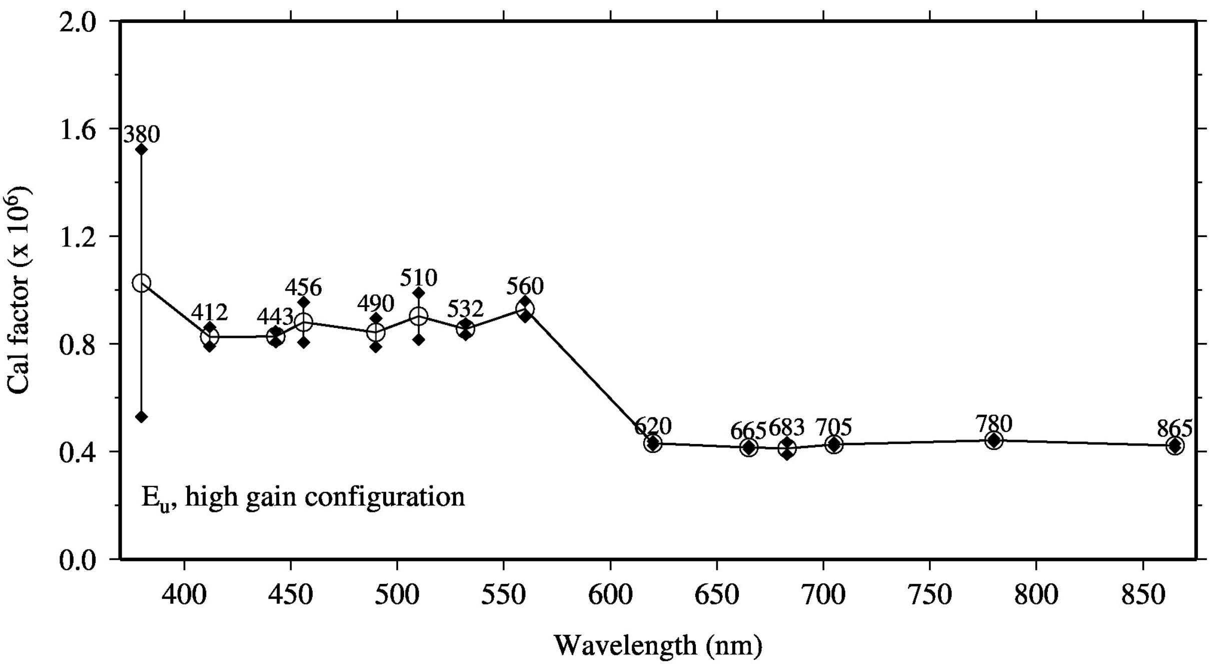

Figure 21. As in Fig. 20 but for the high gain configuration.

8.2 E_d sensor

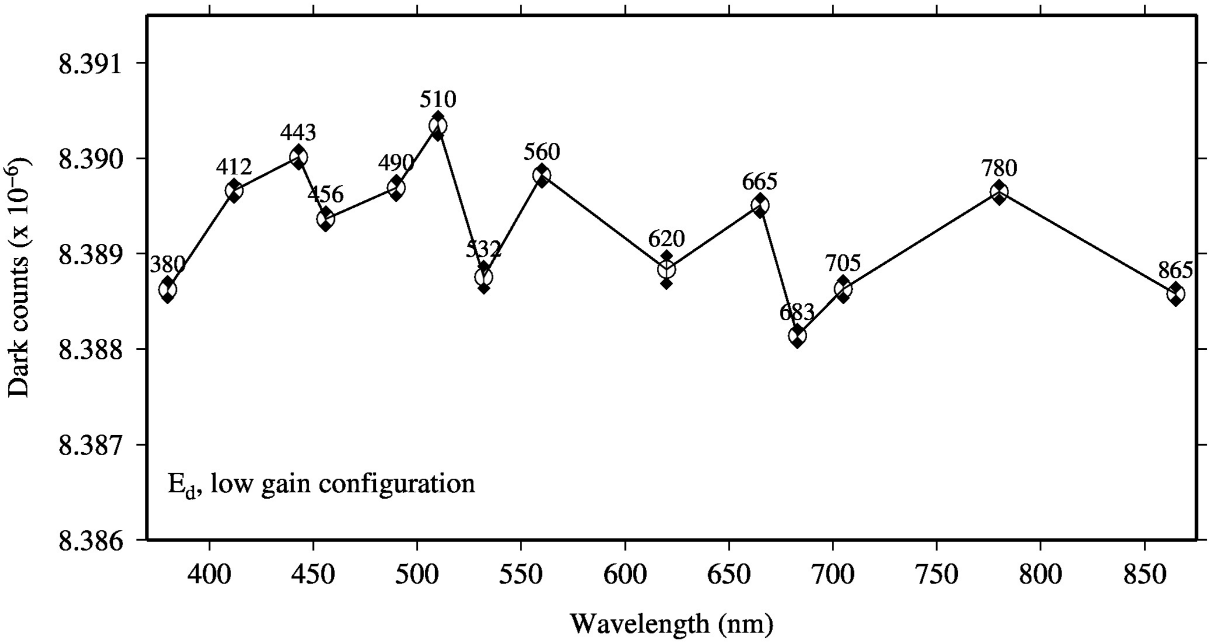

Figure 22. Average dark records for the E_d sensor in low gain configuration over the 2001-2011 time period and the 14 wavelengths indicated (open circles). The vertical bars and the black diamonds show one standard deviation.

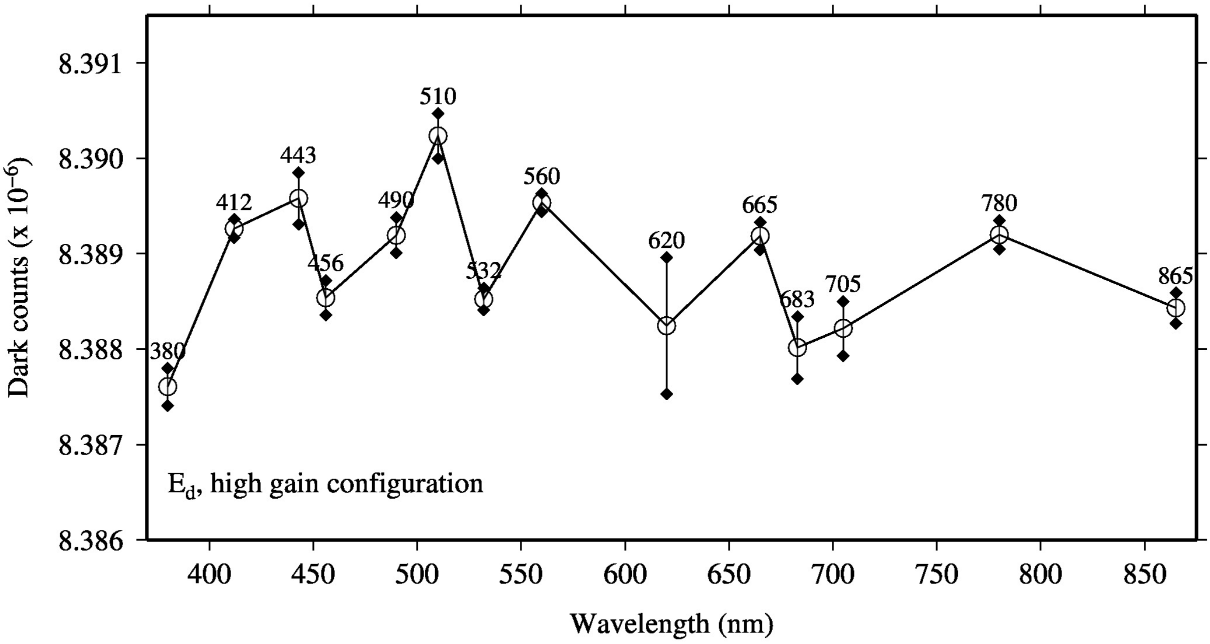

Figure 23. As in Fig. 22 but for the high gain configuration.

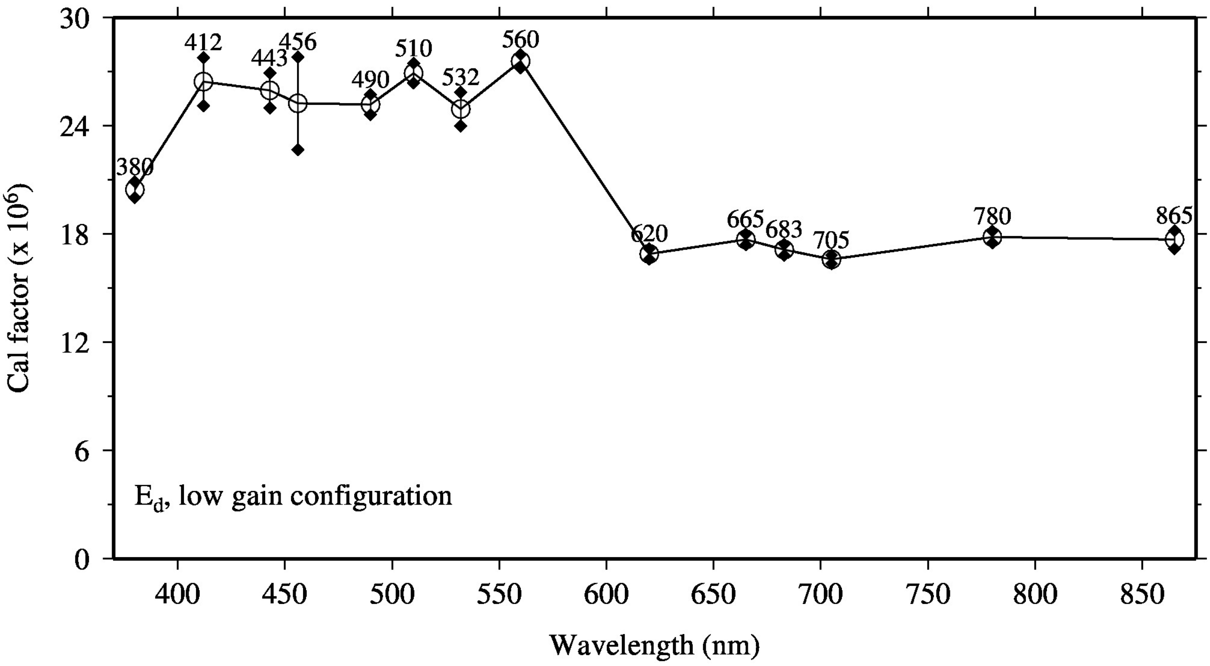

Figure 24. Average calibration slopes for the E_d sensor in low gain configuration over the 2001-2011 time period and the 14 wavelengths indicated (open circles). The vertical bars and the black diamonds show one standard deviation.

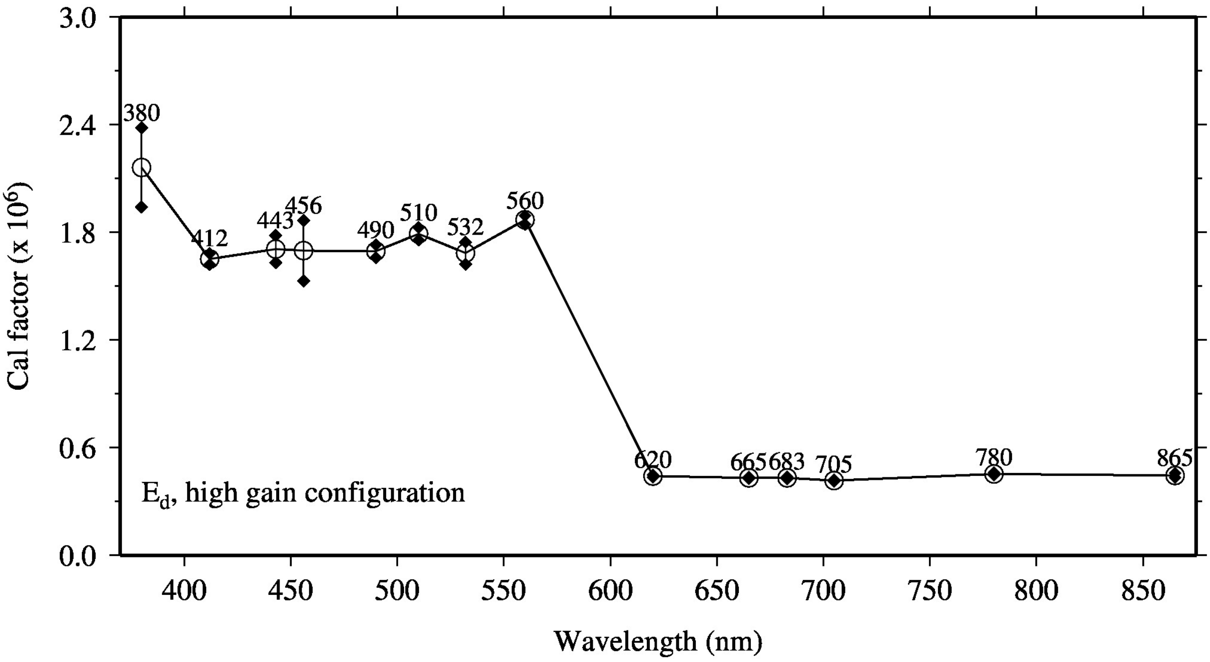

Figure 25. As in Fig. 24 but for the high gain configuration.

8.3 E_s sensor

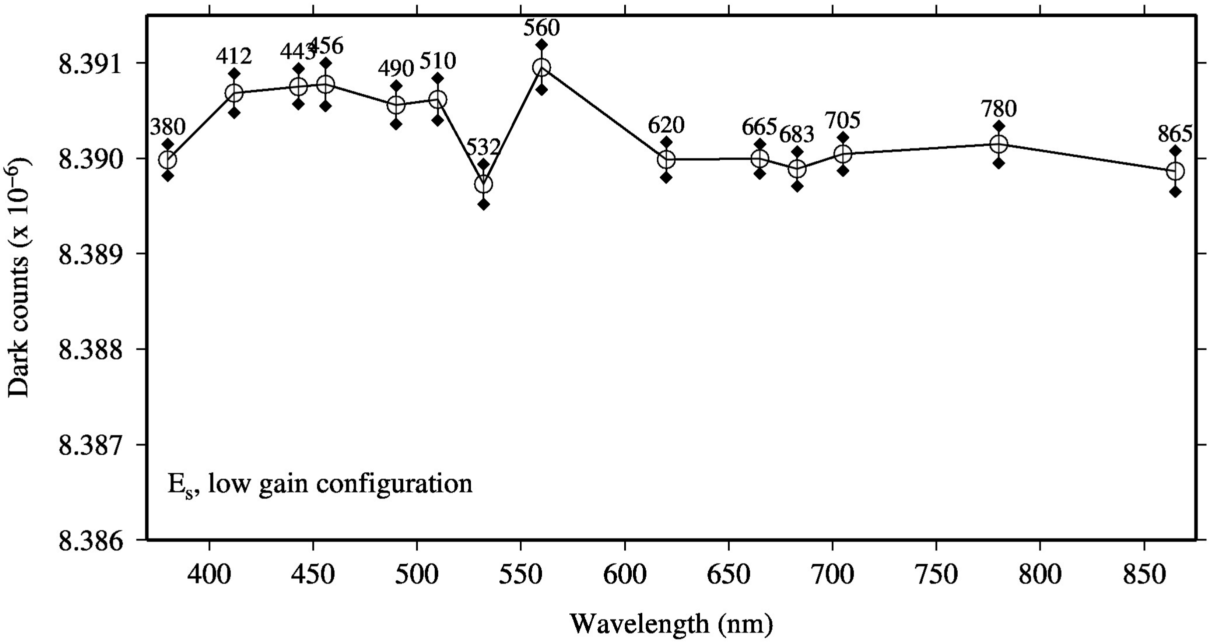

Figure 26. Average dark records for the E_S sensor in low gain configuration over the 2001-2011 time period and the 14 wavelengths indicated (open circles). The vertical bars and the black diamonds show one standard deviation.

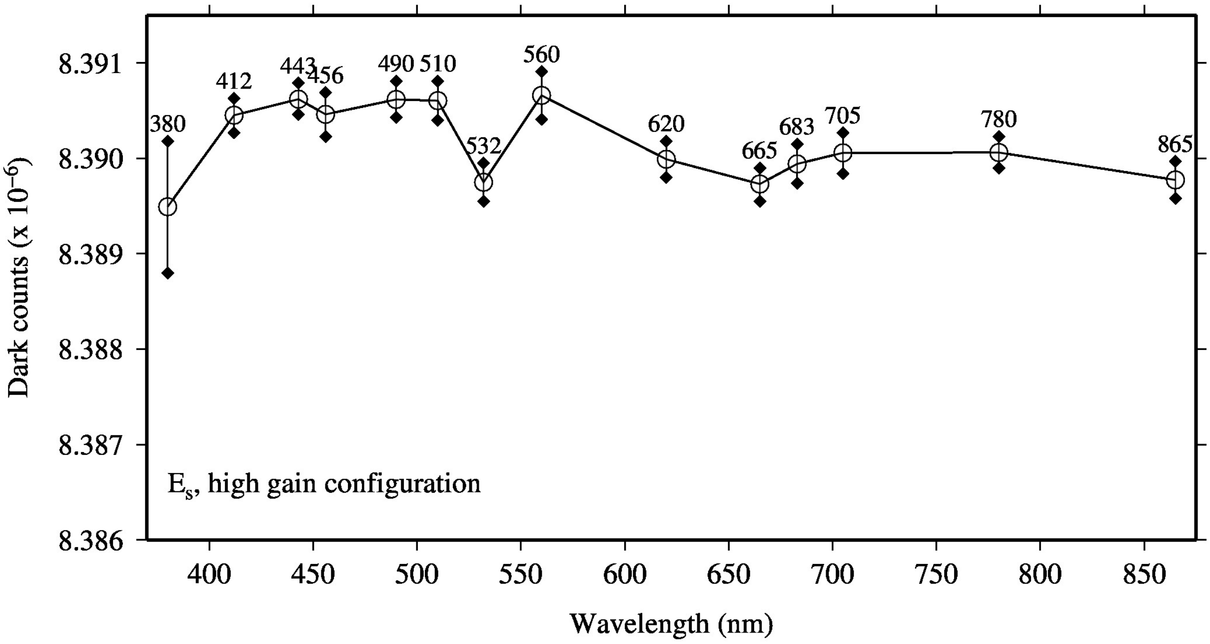

Figure 27. As in Fig. 26 but for the high gain configuration.

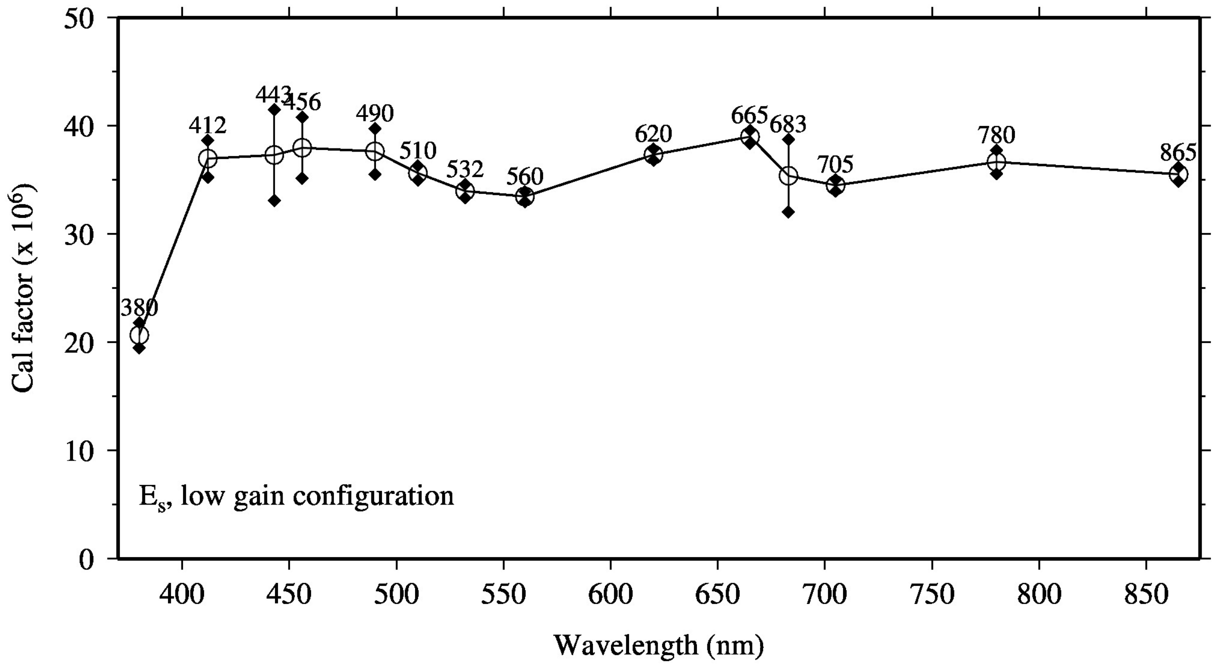

Figure 28. Average calibration slopes for the E_S sensor in low gain configuration over the 2001-2011 time period and the 14 wavelengths indicated (open circles). The vertical bars and the black diamonds show one standard deviation.

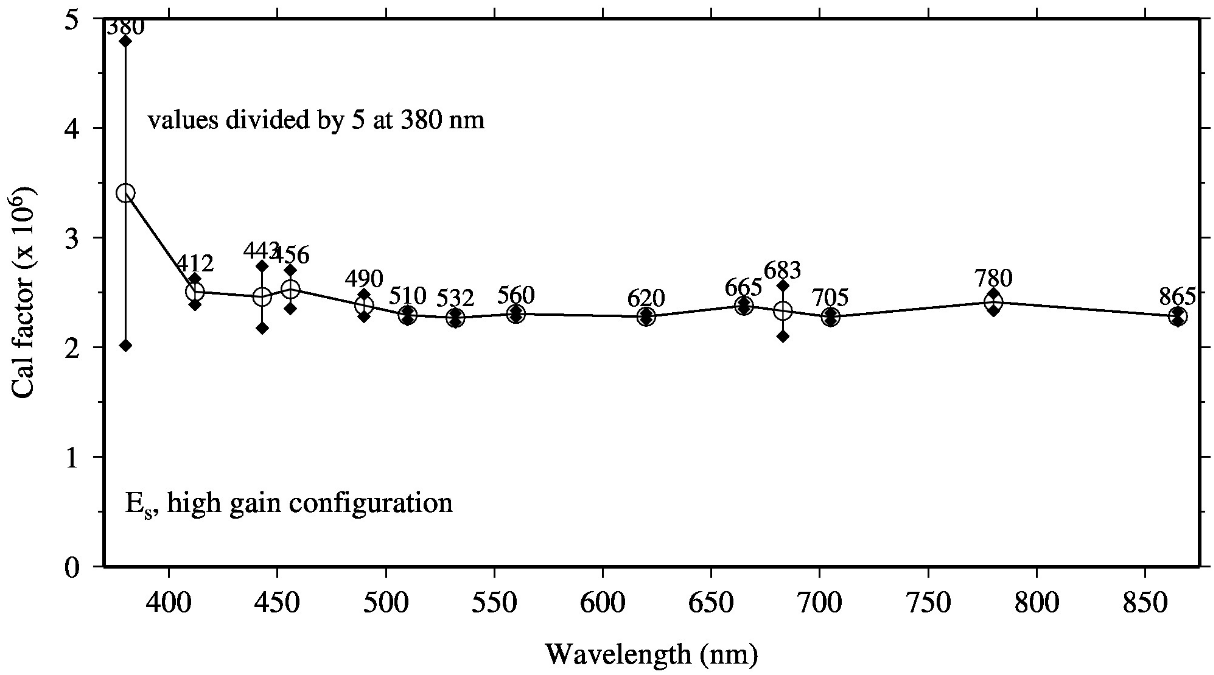

Figure 29. As in Fig. 28 but for the high gain configuration.

		Dark counts				Calibration slope			
		Low gain		High gain		Low gain		High gain	
Channel	Wavelength (nm)	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.
Eu18_09	381	8389266.38	209.17	8387097.96	718.00	9.6702×10^{-6}	6.7583×10^{-6}	1.0264×10^{-6}	4.9664×10^{-7}
Eu18_02	411	8390304.74	171.75	8389693.49	269.23	6.3253×10^{-6}	1.5085×10^{-6}	8.2711×10^{-7}	3.4960×10^{-8}
Eu18_04	442.7	8390052.73	159.38	8389653.93	190.39	7.1196×10^{-6}	2.5124×10^{-6}	8.2729×10^{-7}	1.9011×10^{-8}
Eu18_05	455.9	8389954.82	170.54	8389398.10	218.21	7.1360×10^{-6}	3.8703×10^{-7}	8.8133×10^{-7}	7.4271×10^{-8}
Eu18_06	490.8	8389286.16	98.59	8389364.54	208.94	7.0220×10^{-6}	3.4940×10^{-7}	8.4293×10^{-7}	5.2995×10^{-8}
Eu18_01	509.7	8389806.84	212.87	8390344.93	257.74	7.1945×10^{-6}	2.6614×10^{-7}	9.0325×10^{-7}	8.6399×10^{-8}
Eu18_08	531.7	8389430.93	228.83	8389515.27	282.72	7.8862×10^{-6}	2.5186×10^{-6}	8.5551×10^{-7}	1.9506×10^{-8}
Eu18_03	559.3	8389747.02	170.33	8389429.96	195.13	7.1662×10^{-6}	2.2961×10^{-7}	9.3031×10^{-7}	2.8931×10^{-8}
Eu18_10	619.4	8388881.09	163.31	8389200.07	349.81	3.4124×10^{-6}	6.2056×10^{-8}	4.3091×10^{-7}	7.7972×10^{-9}
Eu18_11	664.5	8389934.31	163.47	8389614.61	248.94	3.3665×10^{-6}	6.4925×10^{-8}	4.1557×10^{-7}	6.4968×10^{-9}
Eu18_12	683.3	8388923.53	178.35	8390003.94	182.90	3.2491×10^{-6}	1.8314×10^{-7}	4.1186×10^{-7}	2.2224×10^{-8}
Eu18_13	705.5	8388509.43	77.86	8389266.06	178.66	3.2930×10^{-6}	6.0170×10^{-8}	4.2678×10^{-7}	7.5939×10^{-9}
Eu18_07	779.4	8390191.82	161.86	8390102.43	210.98	3.6150×10^{-6}	5.0265×10^{-8}	4.4224×10^{-7}	6.2335×10^{-9}
Eu18_14	865.3	8389404.54	104.68	8389109.18	171.31	3.4263×10^{-6}	5.7927×10^{-8}	4.2236×10^{-7}	7.3641×10^{-9}

Table 7. Average of dark counts and calibration slopes computed over all calibrations performed from 2001 to 2011 on the SPMR E_u sensor

		Dark counts				Calibration slope			
		Low gain		High gain		Low gain		High gain	
Channel	Wavelength (nm)	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.
Ed19_09	380.8	8388625.52	81.51	8387604.43	192.72	2.0462×10^{-5}	4.3644×10^{-7}	2.1620×10^{-6}	2.2083×10^{-7}
Ed19_02	411.2	8389666.71	69.94	8389262.11	94.01	2.6451×10^{-5}	1.3285×10^{-6}	1.6515×10^{-6}	3.0095×10^{-8}
Ed19_04	443.2	8390010.93	72.24	8389583.15	268.45	2.5969×10^{-5}	9.6365×10^{-7}	1.7074×10^{-6}	7.5484×10^{-8}
Ed19_05	455.9	8389362.77	72.69	8388537.98	181.78	2.5246×10^{-5}	2.5705×10^{-6}	1.6980×10^{-6}	1.6879×10^{-7}
Ed19_06	490.9	8389692.00	78.38	8389192.41	185.80	2.5179×10^{-5}	5.4694×10^{-7}	1.6952×10^{-6}	3.4474×10^{-8}
Ed19_01	510.3	8390341.16	100.91	8390233.92	232.26	2.6921×10^{-5}	5.4474×10^{-7}	1.7924×10^{-6}	3.3984×10^{-8}
Ed19_08	531.9	8388755.90	113.51	8388525.99	111.89	2.4931×10^{-5}	9.2781×10^{-7}	1.6848×10^{-6}	6.0984×10^{-8}
Ed19_03	560.1	8389823.98	69.86	8389533.34	90.75	2.7582×10^{-5}	3.5989×10^{-7}	1.8697×10^{-6}	2.4147×10^{-8}
Ed19_10	619.2	8388836.14	146.45	8388248.12	711.62	1.6895×10^{-5}	2.8107×10^{-7}	4.4170×10^{-7}	7.4210×10^{-9}
Ed19_11	664.3	8389506.56	72.20	8389185.64	147.10	1.7708×10^{-5}	2.9072×10^{-7}	4.3169×10^{-7}	5.4122×10^{-9}
Ed19_12	683.4	8388141.36	72.60	8388015.34	327.37	1.7133×10^{-5}	3.0163×10^{-7}	4.3145×10^{-7}	6.1642×10^{-9}
Ed19_13	704.5	8388631.62	90.38	8388218.49	284.17	1.6603×10^{-5}	2.2942×10^{-7}	4.1704×10^{-7}	5.0668×10^{-9}
Ed19_07	780.2	8389648.75	73.00	8389197.99	147.40	1.7838×10^{-5}	3.2238×10^{-7}	4.5347×10^{-7}	7.4687×10^{-9}
Ed19_14	864.3	8388577.76	73.77	8388431.68	162.58	1.7696×10^{-5}	4.9366×10^{-7}	4.4576×10^{-7}	1.2641×10^{-8}

Table 8. As in Table 7 but for the E_d sensor

		Dark counts				Calibration slope			
		Low gain		High gain		Low gain		High gain	
Channel	Wavelength (nm)	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.
Es20_9	379.7	8389983.92	163.46	8389493.32	689.51	2.0657×10^{-5}	1.1506×10^{-6}	1.7036×10^{-5}	6.9421×10^{-6}
Es20_2	411.1	8390684.54	203.55	8390453.67	177.28	3.6963×10^{-5}	1.7114×10^{-6}	2.5092×10^{-6}	1.1799×10^{-7}
Es20_4	443.7	8390751.34	185.00	8390620.12	165.01	3.7312×10^{-5}	4.1914×10^{-6}	2.4603×10^{-6}	2.8219×10^{-7}
Es20_5	455.8	8390774.19	225.40	8390460.09	226.72	3.7978×10^{-5}	2.8199×10^{-6}	2.5303×10^{-6}	1.7426×10^{-7}
Es20_6	490.8	8390558.62	201.45	8390615.28	189.73	3.7635×10^{-5}	2.1129×10^{-6}	2.3847×10^{-6}	1.0004×10^{-7}
Es20_1	510.7	8390618.25	220.43	8390605.16	209.95	3.5649×10^{-5}	6.6158×10^{-7}	2.2935×10^{-6}	4.0277×10^{-8}
Es20_8	531.9	8389730.16	211.83	8389750.32	198.57	3.3968×10^{-5}	6.0722×10^{-7}	2.2706×10^{-6}	3.9764×10^{-8}
Es20_3	560.2	8390953.93	234.12	8390659.43	247.47	3.3460×10^{-5}	4.6144×10^{-7}	2.3059×10^{-6}	3.0382×10^{-8}
Es20_10	619.7	8389987.88	186.52	8389990.68	185.75	3.7344×10^{-5}	5.1009×10^{-7}	2.2819×10^{-6}	3.0238×10^{-8}
Es20_11	664.8	8389998.26	155.12	8389729.99	174.95	3.8988×10^{-5}	5.9079×10^{-7}	2.3810×10^{-6}	3.1399×10^{-8}
Es20_12	682.5	8389888.86	180.00	8389941.65	202.90	3.5400×10^{-5}	3.3425×10^{-6}	2.3344×10^{-6}	2.3049×10^{-7}
Es20_13	705.1	8390045.52	174.98	8390057.69	215.69	3.4501×10^{-5}	5.3568×10^{-7}	2.2771×10^{-6}	3.5751×10^{-8}
Es20_7	780.7	8390148.59	195.61	8390060.27	164.80	3.6663×10^{-5}	1.0894×10^{-6}	2.4135×10^{-6}	7.8133×10^{-8}
Es20_14	864.8	8389863.80	219.64	8389775.60	200.08	3.5527×10^{-5}	6.4741×10^{-7}	2.2842×10^{-6}	4.1664×10^{-8}

Table 9. As in Table 7 but for the E_S sensor

9 Acknowledgements

The BOUSSOLE project was established thanks to the work of numerous individuals, as well as the support and funding of several agencies and institutions. The latter are listed in the foreword of this report. Specifically, the following contracts are acknowledged: The *Centre National d'Etudes Spatiales* (CNES) provides funds through the *Terre Océan Surfaces Continentales et Atmosphère* (TOSCA) scientific committee, the *European Space Agency* (ESA) through the *European Space Research and Technology Center* (ESTEC) contract 14393/00/NL/DC, including contract change notices #1, #2, and #3, *European Space Research Institute* (ESRIN) through contracts 17286/03/I-OL, 21770/08/I-OL, and 13226/10/I-NB, and the *National Aeronautics and Space Administration* (NASA) through a Letter of Agreement with the *Université Pierre et Marie Curie* (UPMC). The *Institut National des Sciences de l'Univers* (INSU) provided ship time for the monthly cruises (R/V Tethys-II).

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10 References

Zibordi G., D. D'Alimonte, D. VanDerLinde, S.B. Hooker, and J.W. Brown, New Laboratory methods for characterizing the immersion factors of irradiance sensors. S.B. Hooker and E.R. Firestone, Eds. NASA/TM-2003-206892, vol. 26, NASA GSFC, Greenbelt, MD, USA.

Zibordi G., D. D'Alimonte, D. VanDerLinde, J.-F. Berthon, S.B. Hooker, J. Mueller, S. McClean, and G. Lazin, Cosine response measurements. In vol 21, "The Eighth SeaWiFS Intercalibration Round-Robin Experiment (SIRREX-8), September-December 2001". S.B. Hooker and E.R. Firestone, Eds. NASA/TM-2002-206892, vol. 21, SeaWiFS postlaunch technical report series, NASA GSFC, Greenbelt, MD, USA.

11 Appendix 1: an example profiler calibration file

The SPMR calibration file is produced in Satlantic standard file format which is designed to handle all of their instruments. This is an example of the calibration file pro006aa.cal.

```
#SATPRO0006
# SPMR s/n 006 calibrated with OCI-1000 s/n 018 (EU) and 019
# Annick Bricaud / Laboratoire de Physique et Chimie Marines / 9420
# Post Calibration file valid 13 September, 2004

INSTRUMENT SATPRO '' 6 AS 0 NONE
SN 0006 '' 4 AI 0 COUNT
RATE 6 'Hz' 0 BU 0 NONE

# Optical data updated by Jennifer

#EU sensor OCI-1000 S/N 018 calibrated for LO GAIN in IN SEAWATER
# by JENN on 09/10/04 at 13:40:51
# LO GAIN calibration LAMP: F760 at DIST: 50.0cm
#EU sensor OCI-1000 S/N 018 calibrated for HI GAIN in IN SEAWATER
# by JENN on 09/10/04 at 13:44:22
# HI GAIN calibration LAMP: F760 at DIST: 140.0cm
```

*** Irradiance Immersion Coefficients Updated - July 2002 ***
*** Irradiance Immersion Coefficients in this file are Class Based ***
EU 509.7 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389553.5 7.0908e-006 1.354
8390228.3 8.6249e-007 1.354
EU 411.0 'uW/cm^2/nm' 3 BU 2 OPTIC1
8390107.2 7.1400e-006 1.368
8389653.7 8.4664e-007 1.368
EU 559.3 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389568.0 7.4906e-006 1.366
8389378.3 9.6479e-007 1.366
EU 442.7 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389869.8 6.8608e-006 1.393
8389616.6 8.4695e-007 1.393
EU 455.9 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389778.2 7.2288e-006 1.392
8389336.0 8.6983e-007 1.392
EU 490.8 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389224.3 6.9040e-006 1.365
8389472.3 8.1790e-007 1.365
EU 779.4 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389984.3 3.6776e-006 1.303
8390166.4 4.4585e-007 1.303
EU 531.7 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389205.0 7.1432e-006 1.378
8389505.4 8.6603e-007 1.378
EU 381.0 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389010.6 8.2099e-006 1.161
8386724.1 9.1556e-007 1.161
EU 619.4 'uW/cm^2/nm' 3 BU 2 OPTIC1
8388706.0 3.5022e-006 1.372
8389328.9 4.3982e-007 1.372
EU 664.5 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389778.6 3.4219e-006 1.373
8389691.2 4.2063e-007 1.373
EU 683.3 'uW/cm^2/nm' 3 BU 2 OPTIC1
8388739.2 3.4450e-006 1.385
8389993.8 4.3429e-007 1.385
EU 705.5 'uW/cm^2/nm' 3 BU 2 OPTIC1
8388417.4 3.3487e-006 1.350
8389471.4 4.3029e-007 1.350
EU DARK 'COUNTS' 3 BU 0 COUNT

#ED sensor OCI-1000 S/N 019 calibrated for LO GAIN in IN SEAWATER
by JENN on 09/10/04 at 13:27:16
LO GAIN calibration LAMP: F760 at DIST: 50.0cm
#ED sensor OCI-1000 S/N 019 calibrated for HI GAIN in IN SEAWATER
by JENN on 09/10/04 at 13:30:21
HI GAIN calibration LAMP: F760 at DIST: 140.0cm
*** Irradiance Immersion Coefficients Updated - July 2002 ***
*** Irradiance Immersion Coefficients in this file are Class Based ***
ED 510.3 'uW/cm^2/nm' 3 BU 2 OPTIC1

8390363.6 2.6635e-005 1.354
8390122.6 1.7922e-006 1.354
ED 411.2 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389660.0 2.6626e-005 1.368
8389241.6 1.6290e-006 1.368
ED 560.1 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389781.3 2.7924e-005 1.366
8389541.7 1.8856e-006 1.366
ED 443.2 'uW/cm^2/nm' 3 BU 2 OPTIC1
8390019.8 2.6960e-005 1.393
8389450.3 1.7968e-006 1.393
ED 455.9 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389380.9 2.6069e-005 1.392
8388561.2 1.7518e-006 1.392
ED 490.9 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389670.6 2.5068e-005 1.365
8389117.4 1.6865e-006 1.365
ED 780.2 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389646.3 1.8089e-005 1.303
8389277.1 4.5975e-007 1.303
ED 531.9 'uW/cm^2/nm' 3 BU 2 OPTIC1
8388791.3 2.4643e-005 1.378
8388580.3 1.6657e-006 1.378
ED 380.8 'uW/cm^2/nm' 3 BU 2 OPTIC1
8388636.1 2.0597e-005 1.161
8387771.8 2.4967e-006 1.161
ED 619.2 'uW/cm^2/nm' 3 BU 2 OPTIC1
8388918.9 1.7061e-005 1.372
8388507.1 4.4533e-007 1.372
ED 664.3 'uW/cm^2/nm' 3 BU 2 OPTIC1
8389522.3 1.7816e-005 1.373
8389197.4 4.3355e-007 1.373
ED 683.4 'uW/cm^2/nm' 3 BU 2 OPTIC1
8388178.4 1.7386e-005 1.385
8387840.3 4.3761e-007 1.385
ED 704.5 'uW/cm^2/nm' 3 BU 2 OPTIC1
8388636.2 1.6649e-005 1.350
8388077.8 4.1729e-007 1.350
ED DARK 'COUNTS' 3 BU 0 COUNT

Ancillary Sensors

#Tilts calibrated July 13, 2001 by James Foesenek and Todd Hatt
Tilt X 'deg' 2 BU 1 POLYU
-8.2586360e+1 2.5465788e-3 -1.0295808e-9
Tilt Y 'deg' 2 BU 1 POLYU
7.9078567e+1 -2.3561670e-3 -1.1819617e-9

Aux1 none '' 2 BU 0 NONE
Aux2 none '' 2 BU 0 NONE
Aux3 none '' 2 BU 0 NONE

Datasonics Sonar Altimeter
Model: PSA^{-9}16
S/N: 526
#
1997^{-0}1^{-2}7, JS:
Uncalibrated. Coefficients are based on full range output
of 0^{-5} Volts for 0^{-1}00 metres range.
ALTIM none 'm' 2 BU 1 POLYF
0.00306 32768

Aux4 none '' 2 BU 0 NONE
Aux5 none '' 2 BU 0 NONE

FRAME COUNTER '' 1 BU 0 COUNT

PAD none '' 4 AS 0 NONE
Paroscientific Digiquartz pressure sensor
Model: 8WD270^{-I}
P/N: 1320^{-0}15^{-0}
S/N: 62248
Range: 0^{-2}70 metres
#
1997^{-0}1^{-2}7, JS, configured for:
BR=9600 (baud rate)
UN=1 (Units PSI)
PR=8 (20 ppm resolution, 22.4 ms integration period)
Note: These coefficients in calibration file convert the PSI
output from the pressure sensor into meters of "standard"
sea water assuming a density of 1028 kg/m^3
2000^{-0}7^{-1}8, Repair and Recalibration
#
PRES none 'm' 13 AF 1 POLYF
0.68391982 14.9
CRLF TERMINATOR '' 2 AS 0 NONE

12 Appendix 2: an example reference calibration file

The SPMR calibration file is produced in Satlantic standard file format which is designed to handle all of their instruments. This is an example of the calibration file ref006aa.cal.

#SATREF0006
SMSR s/n 006 calibrated with OCI^{-1}000 s/n 020
Annick Bricaud / Laboratoire de Physique et Chimie Marines / 9420
Post Calibration file valid 03 August, 2007

INSTRUMENT SATREF '' 6 AS 0 NONE
SN 0006 '' 4 AI 0 COUNT
RATE 6 'Hz' 0 AS 0 NONE

Optical data updated by Jennifer

#

Ls sensor option
#
Pad none '' 42 AS 0 NONE

#ES sensor OCI-1000 S/N 020 calibrated for LO GAIN in IN AIR
by JENN on 08/03/07 at 13:37:40
LO GAIN calibration LAMP: F887 at DIST: 50.0cm
#ES sensor OCI-1000 S/N 020 calibrated for HI GAIN in IN AIR
by JENN on 08/03/07 at 13:41:37
HI GAIN calibration LAMP: F887 at DIST: 70.0cm
ES 510.7 'uW/cm^2/nm' 3 BU 2 OPTIC1
 8390804.4 3.5748e-005 1.000
 8390665.8 2.2858e-006 1.000
ES 411.1 'uW/cm^2/nm' 3 BU 2 OPTIC1
 8390900.8 3.7869e-005 1.000
 8390601.5 2.5611e-006 1.000
ES 560.2 'uW/cm^2/nm' 3 BU 2 OPTIC1
 8391168.9 3.3242e-005 1.000
 8390746.5 2.2811e-006 1.000
ES 442.5 'uW/cm^2/nm' 3 BU 2 OPTIC1
 8390945.9 3.6265e-005 1.000
 8390672.1 2.3714e-006 1.000
ES 455.6 'uW/cm^2/nm' 3 BU 2 OPTIC1
 8390958.5 3.6397e-005 1.000
 8390734.4 2.4360e-006 1.000
ES 490.8 'uW/cm^2/nm' 3 BU 2 OPTIC1
 8390708.3 3.8637e-005 1.000
 8390687.6 2.4182e-006 1.000
ES 780.7 'uW/cm^2/nm' 3 BU 2 OPTIC1
 8390308.8 3.5888e-005 1.000
 8390216.4 2.4609e-006 1.000
ES 531.9 'uW/cm^2/nm' 3 BU 2 OPTIC1
 8389832.6 3.3634e-005 1.000
 8389906.7 2.2388e-006 1.000
ES 379.7 'uW/cm^2/nm' 3 BU 2 OPTIC1
 8390129.4 2.0164e-005 1.000
 8389934.7 2.0053e-005 1.000
ES 619.7 'uW/cm^2/nm' 3 BU 2 OPTIC1
 8390129.6 3.7170e-005 1.000
 8390140.9 2.2636e-006 1.000
ES 664.8 'uW/cm^2/nm' 3 BU 2 OPTIC1
 8390183.8 3.8525e-005 1.000
 8389890.4 2.3528e-006 1.000
ES 683.4 'uW/cm^2/nm' 3 BU 2 OPTIC1
 8389985.1 3.3281e-005 1.000
 8390125.6 2.1929e-006 1.000
ES 705.1 'uW/cm^2/nm' 3 BU 2 OPTIC1
 8390108.9 3.4193e-005 1.000
 8390142.5 2.2556e-006 1.000
ES DARK 'COUNTS' 3 BU 0 COUNT

#
Ancillary sensors
#
Tilts calibrated September 12, 2000 by James Foesenek
processed by Darrell Adams
#
Tilt X 'deg' 2 BU 1 POLYU
$^{-8}$.3547628e+1 2.5452226e^{-3} 1.9218928e^{-1}1

Tilt Y 'deg' 2 BU 1 POLYU
$^{-8}$.4976847e+001 2.5993480e^{-0}03 $^{-3}$.2845515e^{-0}10

#
#Irradiance calibrated Nov. 22, 1994 by Bryan
#
T i 'C' 2 BU 1 POLYU
$^{-7}$.0483881229e+00 1.1226747800e^{-0}3 $^{-2}$.8774331540e^{-0}8 1.2412188302e^{-1}2 $^{-3}$.2772134889e^{-1}7 4.5477101484e^{-2}2 $^{-2}$.5194676572e^{-2}7

Aux1 none '' 2 BU 0 NONE
Aux2 none '' 2 BU 0 NONE
Aux3 none '' 2 BU 0 NONE
Aux4 none '' 2 BU 0 NONE
Aux5 none '' 2 BU 0 NONE

FRAME COUNTER '' 1 BU 0 COUNT
reserved for Paroscientific pressure sensor
Pad none '' 17 AS 0 NONE

CRLF TERMINATOR '' 2 AS 0 NONE

13 Appendix 3: glossary

A/D	Analog to digital converter
ANSI	American National Standard Institute
BOUSSOLE	BOUée pour l'acquiSition d'une Série Optique à Long termE
CNES	Centre National d'Etudes Spatiales (French Space Agency)
CNRS	Centre National de la Recherche Scientifique (France)
ESA	European Space Agency
ESRIN	European Space Research Institute (part of ESA)
ESTEC	European Space Research and Technology Center (part of ESA)
FEL	ANSI designation for a tungsten coiled filament lamp
INSU	Institut National des Sciences de l'Univers (part of CNRS)
LOV	Laboratoire d'Océanographie de Villefranche.
MERIS	Medium Resolution Imaging Spectrometer
NASA	National Aeronautics and Space Administration of the USA
NIST	National Institute of Standards and Technology of the USA
OCR	Ocean Color Radiometer
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SMSR	SeaWiFS Mutlchannel Surface Reference
SPMR	SeaWiFS Profiling Mutichannel Radiometer
SQM-II	SeaWiFS Quality Monitor-II
TAOB	CNES scientific committee for Terre Atmosphère Océan & Biosphère
UPMC	Université Pierre et Marie Curie