Data Reduction algorithms for the Marine Optical Buoy and Marine Optical System

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Abstract

This report outlines the NOAA spectroradiometer data reduction system implemented by the Matlab MLML DBASE and MOBY programs. This is done by presenting the algorithms and graphs showing the effects of the algorithms.

Overview

The purpose of this report is to present in a simple format the sequence of data processing steps used to reduce raw spectroradiometer data into calibrated useful results. This is done primarily by showing graphs resulting from each stage from data acquisition to final results. The spectroradiometer data come from the Marine Optical Buoy (MOBY), all examples and graphs presented will be from the thirty sixth MOBY deployment, 9 Dec 2006 - 02 Mar 2007. MOBY measures surface-incident downwelled irradiance (E_s) in air, upwelled radiance (L_u) at four depths and downwelled irradiance (E_d) at three depths. E_s is measured before and after each L_u and E_d scan set (Appendix A). Data processing adjusts, averages and converts the raw analog digital units (ADU) from a 512X512 pixel charged couple detector (CCD). These data are then organized into a single processed file. Final processing steps include calculating the water-leaving radiance, attenuation coefficients, and the SeaWiFS and MODIS weighted radiances.

Data Acquisition

MOBY data acquisition occurs up to 3 times a day and takes about 1 hour. MOBY data acquisition programs obtain data in scan-sets containing a standard number of dark, and radiance, irradiance , or internal calibration scans. Each scan results in 2 partially overlapping spectra, the blue from 340 to 640 nm and the red from 550 to 900 nm. With a 25 µm entrance slit width the effective spectral resolution is about 0.6 nm in the blue and 0.8 nm in the red spectra.

A MOBY scan set consists (typically) of 1 dark scan, 3 to 6 radiance or irradiance scans, followed by 1 dark scan, Fig. 1. A raw MOBY file contains fifteen radiance and irradiance scan sets and three internal calibration scan sets (not included in routine processing). Internal calibration sources (red LED, blue LED and incandescent lamp) are used to detect large changes in system response and are monitored throughout the deployment. Some data sets may contain single noisy or invalid (caused by fluctuating wave and sky conditions) spectral scans which are marked as bad scans and not used in processing, Fig. 1. Spikes are also removed from scans.

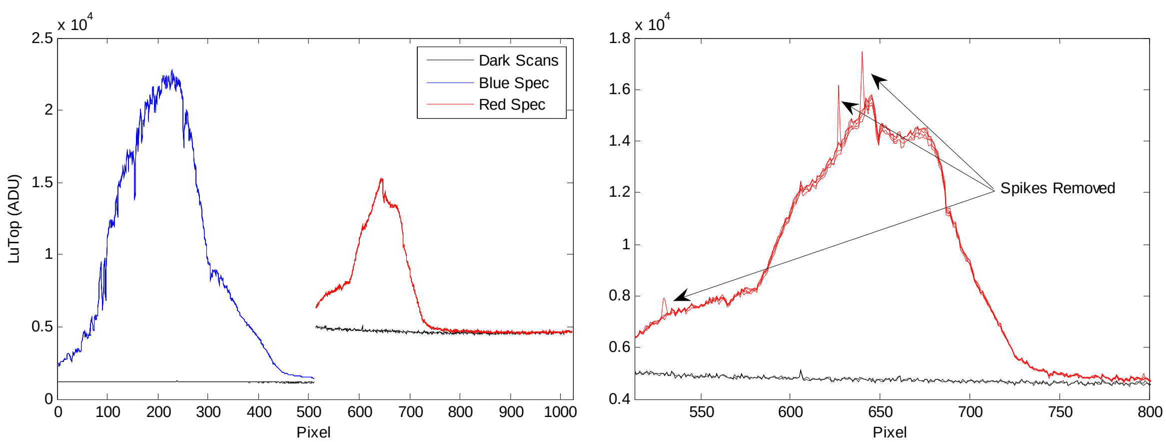

Figure 1. MOBY scan set (left). Example of spikes removed from the LuTop data (right).

Adjust

Three steps are involved in adjusting the data before averaging and conversion to radiance units: 1) dividing by integration time and CCD binning factor; 2) averaging light and dark scans; 3) calculating net radiance or irradiance. In the first step raw radiance, irradiance and dark ADU, are divided by the bin factor, Δb, and the integration time, Δt, which results in units of ADU/pix/sec, A (Eq. 1) .

$$A(\lambda) = \frac{ADU(\lambda)}{\Delta b \Delta t} \quad \textbf{(1)}$$

The bin factor is the number of CCD pixels combined during readout, the total number of pixels read for each wavelengths is 384. For example if the bin factor is 4 for the blue spectrum. Then 96 binned readouts are averaged in the blue and the raw scans will be per 4 pixels which is why we divide by ADU by 4. Step two averages the 5 radiance scans and two dark scans producing one dark and one radiance or irradiance scan per scan set. Also the integration times are interpolated to Mike's calibrated integration times.

Much of the skill in obtaining good in-water spectra is to reduce the effects of wave noise, clouds and varying sun altitude. The first effect produces random variations especially in downwelled irradiance. The second effect may be partially controlled by removing highly variable scans. The third effect can be corrected by normalization to surface irradiance. This process is subjective, and in the future we may establish rules based upon variation between scans at a few wavelengths to automate this procedure. At the moment all scans in a scan set are displayed and only those that agree "closely" are averaged. Step three; net irradiance or radiance, Net, are calculated by subtracting the average dark, $avgA_D$, values from the average radiances or irradiances, $avgA_L$.

$$\mathrm{Net}(\lambda) = \mathrm{avgA}_L(\lambda) - \mathrm{avgA}_D(\lambda) \quad \textbf{(2)}$$

At the same time the percent standard deviation PSTD , (Eq.3) are computed for the corrected spectra.

$$\begin{aligned} A_L(N,\lambda) &= \frac{ADU_L(N,\lambda)}{\Delta b \Delta t} - A_D(\lambda) \\ avgA_L(\lambda) &= \frac{\sum_{N=1}^{N=5} A_L(N,\lambda)}{N} \\ stdA_L(\lambda) &= std(A_L(N,\lambda)) \\ PSTD &= 100 \times \frac{stdA_L(\lambda)}{avgA_L(\lambda)} \end{aligned} \quad \textbf{(3)}$$

where ADU_L represents the radiance light scans, N is the number of scans (usually 5 for radiance), and A_L represents the individual dark corrected scans. The mean and std of the N number of scans in A_L is then calculated and the percent standard deviation is then calculated.

Thermal Correction

Although the MOS CCDs are temperature-controlled, the temperatures of the optical components in the spectrographs, the electronics, the MOBY fiber optics, and other system components are subject to environmental conditions. Because the ambient temperature and degree of thermal equilibrium depends on the measurement purpose (calibration vs. in-water radiometry), the radiometric responsivities of MOS instrument in MOBY was studied as a function of temperature. In December 2002, a temperature controlled bath was constructed and a set of measurements were acquired on the MOS instrument. Results show that for the blue spectrograph there is a thermal sensitivity on the order of 0.5% ADU/pix/sec per degree Celsius. Therefore a thermal correction is applied to the MOBY data, calibration and in-water data. The TT7 temperature was is used to correct the data. All the in-water and calibration data are corrected to 32°. The blue spectrograph's correction factor is 4.445e-3 (ADU/pix/sec)/deg and the red spectrograph's is 5.299e-3 (ADU/pix/sec)/deg. The thermally corrected Net data is calculated for each spectrograph, for the blue spectrograph this includes pixels 1-512 and for the red spectrograph pixels 513-1024. So in the equation below NET(1:512) represents the Net data for the blue spectrograph spectrograph and NET(513:1024) is for the red. ΔTmp is the TT7 board temperature and BCOEFF and RCOEFF is the thermal correction factor for the spectrograph blue and red spectrographs.

$$\begin{aligned} BSGchg &= 1 + (\Delta Tmp \times BCOEFF); \\ RSGchg &= 1 + (\Delta Tmp \times RCOEFF); \\ NET_{th}(1{:}512) &= NET(1{:}512) \times (BSGchg) \\ NET_{th}(513{:}1024) &= NET(513{:}1024) \times (RSGchg) \end{aligned} \qquad \textbf{(4)}$$

The result is $NET_{th}(\lambda)$ which is the Net data thermally corrected.

Averaging and Merging

At this point in the processing scheme the MOBY file consists of 15 sets of net radiance and irradiance and their associated SNR's. The net E_S taken before and after the L_U and E_D scans must be averaged to obtain one net E_S for each sensor and depth. Averaging the surface irradiance accounts for changing cloud cover and solar zenith angle during the L_U and E_D scans. Finally all scan sets are complied into the following variables.

Variable	Contents
1	Approximate wavelength (nm) of MOS2 Spectra (340.5859 to 900 nm)
2	Approximate wavelength (nm) of MOS2 Spectra (340.5859 to 900 nm)
3	**EdTop (ADU/pix/sec), P = 1.1**
4	Coefficient of Variation (%)
5	**Es (ADU/pix/sec)**
6	Coefficient of Variation (%)

7 **LuTop (ADU/pix/sec), P = 1.2**
8 Coefficient of Variation (%)
9 **Es (ADU/pix/sec)**
10 Coefficient of Variation (%)
11 **EdMid (ADU/pix/sec), P = 5.0**
12 Coefficient of Variation (%)
13 **Es (ADU/pix/sec)**
14 Coefficient of Variation (%)
15 **LuMid (ADU/pix/sec), P = 5.2**
16 Coefficient of Variation (%)
17 **Es (ADU/pix/sec)**
18 Coefficient of Variation (%)
19 **EdBot (ADU/pix/sec), P = 8.9**
20 Coefficient of Variation (%)
21 **Es (ADU/pix/sec)**
22 Coefficient of Variation (%)
23 **LuBot (ADU/pix/sec), P = 9.0**
24 Coefficient of Variation (%)
25 **Es (ADU/pix/sec)**
26 Coefficient of Variation (%)
27 **LuMOS (ADU/pix/sec), P = 11.1**
28 Coefficient of Variation (%)
29 **Es (ADU/pix/sec)**
30 Coefficient of Variation (%)

A complete data file for MOBY consists of L_u at four depths and E_d at three depths and a E_S for each. These depths are referred to as "Top, Mid, Bot and MOS" respectively. These complied files contain the complete spectroradiometer data set for MOBY and form the basis for conversion, computing derived integral and derivative quantities.

Stray light correction

The stray light correction is too complicated for me to discuss in detail here (Brown *et. al.* (2001) and Brown *et. al.* (2003)). The stray light correction algorithm iterates to a solution based on laser characterizations at the MOBY facility. The magnitude of this correction depends on wavelength and the relative spectral shape of the source being measured.

Conversion

Conversion is the process by which the net radiance or irradiance, NET, are converted to radiometric units. The radiance, L, (or irradiance, E,) is the product of the net radiance or irradiance, Net, and the system response function, S.

$$L(\lambda) = NETth(\lambda) \times S(\lambda) \qquad \textbf{(5)}$$

The radiance or irradiance immersion factor is included in the system response (except E_S). The irradiance immersion factor, F_W, is 1.52 for all wavelengths measured by Yuntao Ge. The radiance immersion factor is calculated as

$$F_w = 1.44291 + 6.8244./(\lambda - 149.7240) \qquad \textbf{(6)}$$

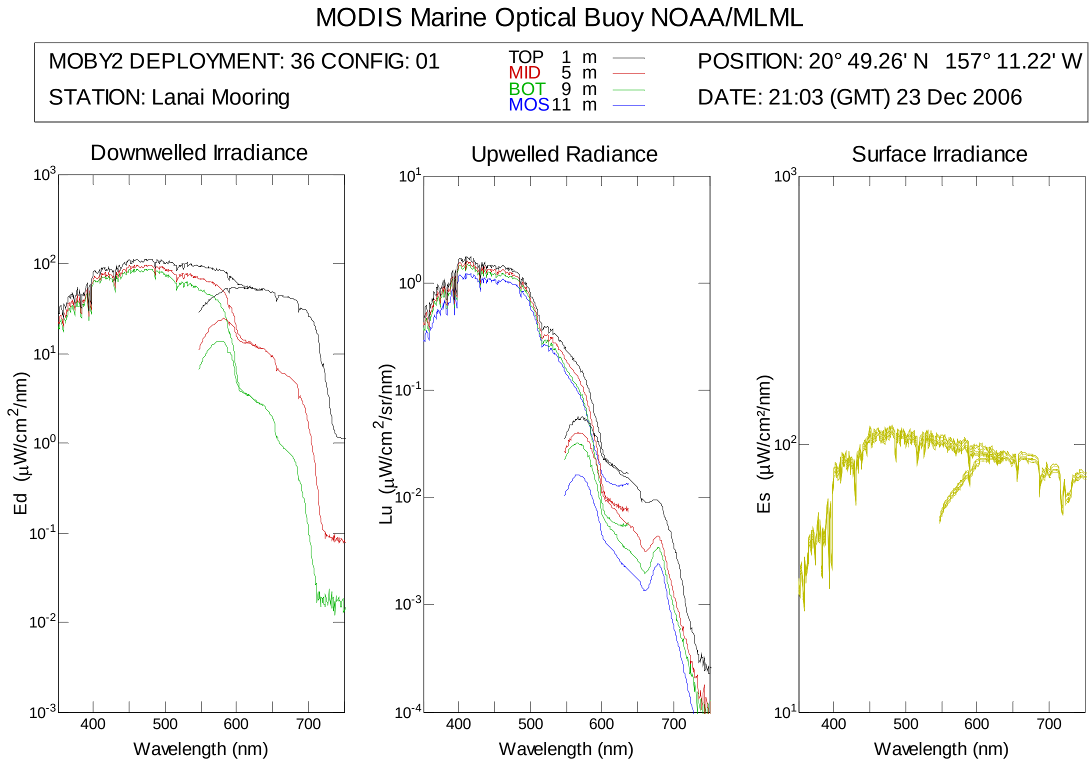

Figure 2. Converted MOBY Lu, Es and Ed data showing the spectral overlap between the red and blue spectrograph. Note the good agreement in the overlap, this is due to the straylight correction.

(Austin, 1976). Nominal wavelengths are replaced by a lookup table of calibrated wavelengths. Converted surface irradiance and upwelled radiance are shown in Fig. 2. The use of two spectrographs causes a wavelength overlap from 550-640 nm. The overlap is removed at 620 nm for each spectrograph.

A variety of errors may occur during data acquisition. Each CCD array may contain defective pixels that produce spurious values. The MOS prototype had just that problem and those values were replaced by a missing value code. MOBY has no known invalid pixels.

Derived Quantities

Diffuse spectral radiance attenuation coefficient, K_L, is computed between observed depths 1 and 2 as

$$K_L = -\frac{\ln\left[\frac{L_2 \times R_{N2}}{L_1 \times R_{N1}}\right]}{z_1 - z_2} \quad \textbf{(7)}$$

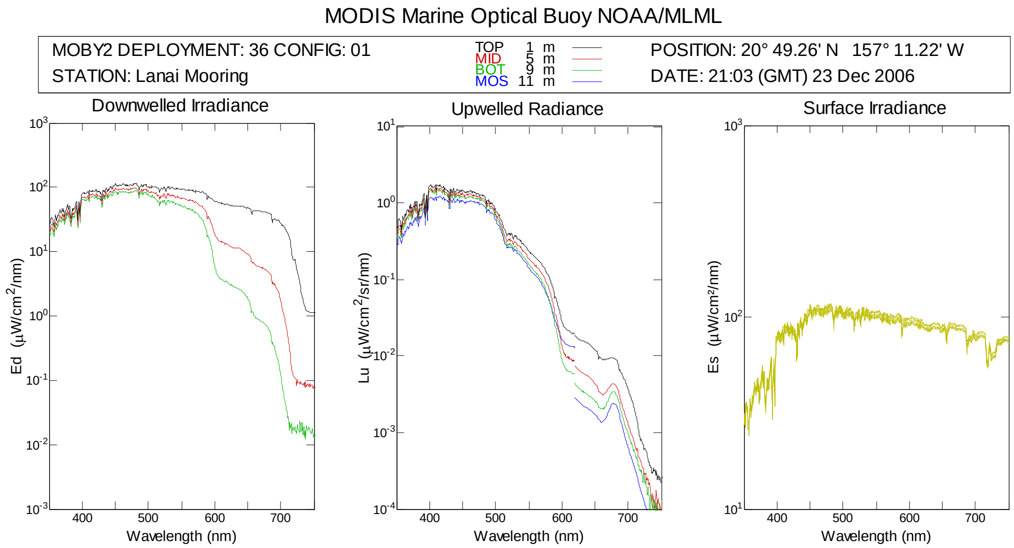

Figure 3. MOBY with the overlap removed at 620 nm.

where L_1 and L_2 are the radiance at the two depths, z_1 and z_2 are the depths, and R_{N1} and R_{N2} are the surface irradiance ratios computed as

$$R_{N1} = \frac{E_{SR}}{E_{s1}} \qquad R_{N2} = \frac{E_{SR}}{E_{s2}} \tag{8}$$

E_{SR} is the reference surface irradiance and E_{S1} and E_{S2} are the surface irradiances at depths 1 and 2. K_E, the irradiance attenuation coefficient, is computed similarly. Six such coefficients are computed based on radiance data between top-mid, top-bot, mid-bot, top-mos, mid-mos and bot-mos observation depths.

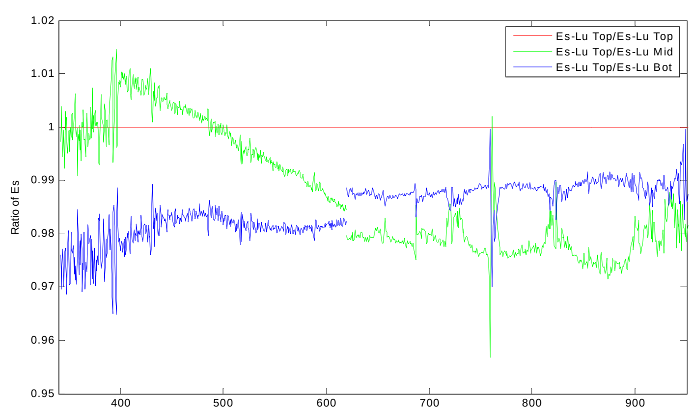

Figure 4. Ratios of E_s between the sampling times for L_u scans .

Normalization may be made spectrally or by use of a single spectral-mean surface irradiance. MOBY data are normalized using a spectral R while MOS uses a mean value. Figure 4 shows the ratios of E_s between the sampling times for which L_u and E_d scans were made at a single station. This shows about 5% variation in E_s between successive depths and slight spectral variation.

The water-leaving radiance $L_W(\lambda)$ is computed by first extrapolating the upwelled radiance, L_U, to just below the surface (using the radiance attenuation coefficients) then propagating L_{u0-} through the surface (using Fresnel reflectance and the n^2 law of radiance).

$$L_w = 0.543\ L_u(\lambda)\ \exp(K_L\,(Z_2 - Z_1))$$
$$0.543 = \frac{(1-\rho)}{n_w^{\,2}} \qquad \textbf{(9)}$$

The factor 0.543 is the air-water Fresnel reflectance, ρ, divided by the index of refraction of 35 psu at 16°C seawater (Eq. 9). Equation 9 accounts for two effects, $1/n_w^2$ applies the n^2 law of radiance and 1-p applies the Fresnel reflectance loss across the surface at normal incidence. Six such L_W's are computed using radiances at the top, mid, bot and mos depths combined with attenuation coefficients described above. The water-leaving radiances, L_W, are shown for those normalized by spectral E_s , Fig. 5

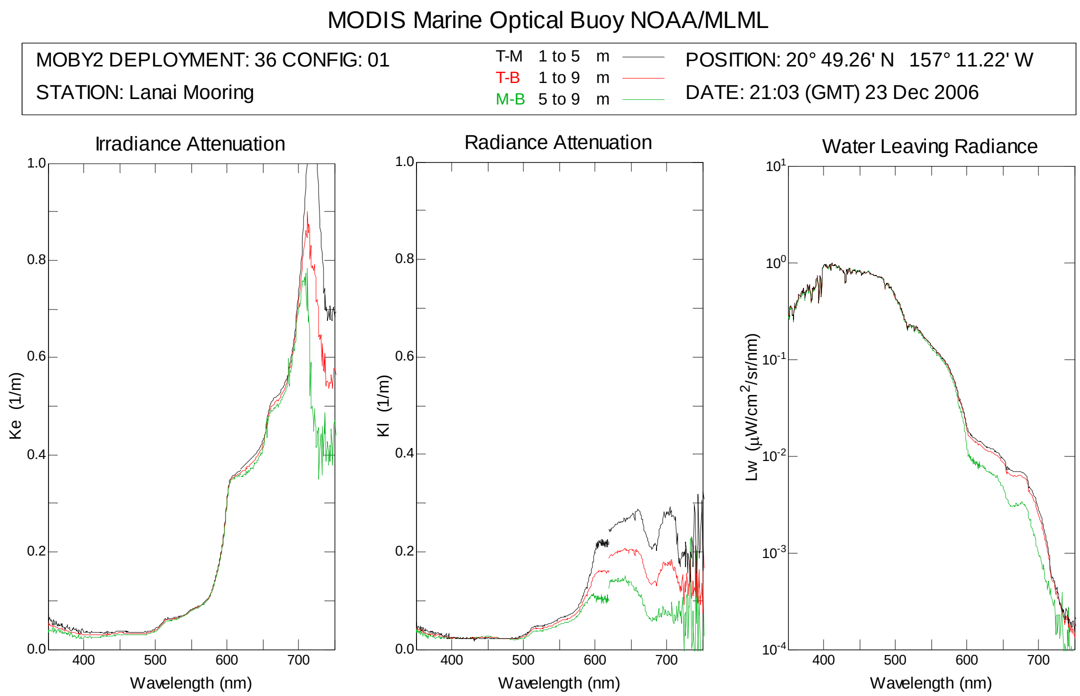

Figure 5. MOBY derived Ke, Kl and Lw.

"Unfortunately, L_W is not purely a characteristic of the water" (Gordon, 1988). To account for the effects of the atmosphere, variation in solar zenith angle and earth-sun distance, solar-normalized water leaving radiances, L_{WN}, are determined from the observed L_W as follows: where F_N is the solar normalizing factor (Gordon, 1988). $t(\lambda,\theta_o)$ is the diffuse atmospheric transmittance, ρ is the air-water Fresnel reflectance and accounts for reduction of the solar illumination as it crosses the air-water interface, θ_o is the solar zenith angle and r_{es} is the earth-sun distance on the day of the observation. As Gordon (1988) states L_{WN} is a function of the optical properties of the water and represents "the water-leaving radiances which would be observed if the atmosphere were removed and the sun where at the zenith." "Note that $L_W < L_{WN}$, so that L_{WN} represents the maximum water-leaving radiance that could be observed in the given viewing situation" (Gordon, 1988). Six such L_{WN}'s are calculated from the L_W at Z_t, Z_m, Z_b and Z_m. The selection of the "best" L_W requires a subjective interpretation, but will usually be that involving the surface and mid-depth data.

$$L_{WN} = \frac{L_w}{F_N}$$
$$F_N = \frac{t(\lambda,\theta_0)(1-\rho(\theta_0))\cos(\theta_0)}{r_{es}{}^2}$$
$$t(\lambda,\theta_0) = \exp\left[-(\frac{\tau_R}{2} + \tau_{oz}) / \cos(\theta_0)\right] \tag{10}$$
$$r_{es} = \frac{1}{1 + 0.0167\cos\left(2\pi\frac{D-3}{365}\right)}$$
$$\rho = \frac{1}{2}\frac{\sin^2(\theta_a - \theta_w)}{\sin^2(\theta_a + \theta_w)} + \frac{1}{2}\frac{\tan^2(\theta_a - \theta_w)}{\tan^2(\theta_a + \theta_w)}$$

The Rayleigh optical thickness, τ_R, is computed analytically, whereas the ozone optical thickness, τ_{oz} , is based on an atmospheric ozone content of 350 Dobsons and atmospheric sounder measurements. τ_{oz} past 740 nm has been log-linearly extrapolated from data provided by Howard Gordon (University of Miami, personal communication).

Finally the second L_{WN} are calculated using

$$L_{wn}(\lambda) = \frac{\frac{L_w}{Es}}{F_o / r_{es}} \tag{11}$$

A remote sensing reflectance is calculated as...

$$R_{sr}(\lambda) = \frac{L_w(\lambda)}{E_s(\lambda)} \tag{12}$$

Following the calculation of the attenuation coefficients and water-leaving radiances the following variables are added to the MOBY file:

Variable		Contents
31	Kl1	Diffuse Attenuation (1/m) from LuTop-LuMid
32	Kl2	Diffuse Attenuation (1/m) from LuTop-LuBot

33	Kl4	Diffuse Attenuation (1/m) from LuTop-LuMOS
34	Kl3	Diffuse Attenuation (1/m) from LuMid-LuBot
35	Kl5	Diffuse Attenuation (1/m) from LuMid-LuMOS
36	Kl6	Diffuse Attenuation (1/m) from LuBot-LuMOS
37	Ke1	Diffuse Attenuation (1/m) from EdTop-EdMid
38	Ke2	Diffuse Attenuation (1/m) from EdTop-EdBot
39	Ke4	Diffuse Attenuation (1/m) from EdMid-EdBot
40	Lw1	Water-Leaving Radiance, Lu1 and Kl1(Lu1-Lu2)
41	Lw2	Water-Leaving Radiance, Lu1 and Kl2(Lu1-Lu3)
42	Lw5	Water-Leaving Radiance, Lu1 and Kl4(Lu1-Lu4)
43	Lw7	Water-Leaving Radiance, Lu2 and Kl3(Lu2-Lu3)
44	Lw8	Water-Leaving Radiance, Lu2 and Kl5(Lu2-Lu4)
45	Lw9	Water-Leaving Radiance, Lu3 and Kl6(Lu3-Lu4)
46	Lwsn1	Solar-Normalized Water-Leaving Radiance, Lu1 and Kl1(Lu1-Lu2)
47	Lwsn2	Solar-Normalized Water-Leaving Radiance, Lu1 and Kl2(Lu1-Lu3)
48	Lwsn5	Solar-Normalized Water-Leaving Radiance, Lu1 and Kl4(Lu1-Lu4)
49	Lwsn7	Solar-Normalized Water-Leaving Radiance, Lu2 and Kl3(Lu2-Lu3)
50	Lwsn8	Solar-Normalized Water-Leaving Radiance, Lu2 and Kl5(Lu2-Lu4)
51	Lwsn9	Solar-Normalized Water-Leaving Radiance, Lu3 and Kl6(Lu3-Lu4)
52	Rrs1	Remote-Sensing Reflectance, Lw1 over Es VR9
53	Rrs2	Remote-Sensing Reflectance, Lw2 over Es VR9
54	Rrs5	Remote-Sensing Reflectance, Lw5 over Es VR9
55	Rrs7	Remote-Sensing Reflectance, Lw7 over Es VR17
56	Rrs8	Remote-Sensing Reflectance, Lw8 over Es VR17
57	Rrs9	Remote-Sensing Reflectance, Lw9 over Es VR25

Auxillary Data

Several integral properties are computed and stored in auxillary data files. A major objective in making these observations is to determine water-leaving radiances for comparison with satellite measured radiances. The SeaWiFS-weighted water-leaving radiances, L_{SW}, are computed as

$$L_{sw}(n) = \sum_{j=1}^{j=m} L_x(\lambda_j) Wt_n(\lambda_j) \quad \textbf{(13)}$$

where $Wt(\lambda)$ are the 8 SeaWiFS normalized response functions and L_X can be the water-leaving radiance or solar normalized water leaving radiance. Currently we compute the satellite band weighted water-leaving radiances for SeaWiFS, OCTS, MERIS, POLDER and MODIS Aqua and Terra. When other satellites become available their bands will be included.

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Symbols

ADU(λ)	Analog-Digital radiance or irradiance units
A(λ)	Raw data in ADU/pix/bin
A_L	Average lite (radiance or irradiance in ADU/pix/sec)
A_D	Average dark (ADU/pix/sec)
D	Sequential day of year from January 1
E_d	Downwelled Irradiance (μW/cm^2 nm)
E_S	Surface Irradiance (μW/cm^2 nm)
E_u	Upwelled Irradiance (μW/cm^2 nm)
E_{SR}	Reference Surface Irradiance (μW/cm^2 nm)
FLH	Chlorophyll Fluorescent Line Height at 685 nm
$F_N(\lambda)$	Solar normalizing factor
$F_W(\lambda)$	Immersion factor for radiance or irradiance
H_{oz}	Ozone scale height (cm)
S(λ)	Response function converting counts to radiometric units, includes radiance or irradiance immersion factor (execpt for surface irradiance)
K_E	Irradiance attenuation coefficient (/m), top/mid depth
K_L	Radiance attenuation coefficient (/m),
L_u	Upwelled Radiance (μW/cm^2 nm sr)
L_{u0-}	Upwelled Radiance just below the the surface, z = 0- (μW/cm^2 nm sr)
L_W	Water-leaving radiance (μW/cm^2 nm sr)
L_{WN}	Solar-normalized, water-leaving radiance
L_{SW}	Satellite-weighted water-leaving radiance
$M(\theta_o)$	Atmospheric path length
$M'(\theta_o)$	Atmospheric path length corrected for nonstandard pressure.
M_{oz}	Atmospheric path length for ozone
MOS	1000 Channel Marine Optical System
N	Number of scans to average
Net(λ)	Net radiance or irradiance (ADU/pix/sec)
P	Atmospheric pressure (mbar)
P_o	Standard atmospheric pressure (1013.25 mbar)
PAR	Photosynthetically active radiation (μMoles/cm^2)
RMSE	Root-Mean-Square Error
R_F	Fresnel Reflectance
R_{N1}	Surface irradiance ratio
SIS	38 Channel Surface Irradiance Spectrometer
SNR	Signal-to-Noise Ratio
$W_t(\lambda)$	SeaWiFS normalized response function
a_{oz}	Ozone absorption coefficients (/cm)
Δb	CCD binning factor
c	Speed of light
$\hat{h}$	Planck's constant
λ	Wavelength (nm)
m	Number of samples in smoothing function
n_w	Index of refraction of seawater
n_m	Index of refraction of material (ie. glass)

r_{es}	Earth-Sun distance (astronomical units)
ρ	Air-water Fresnel reflectance
Δt	Integration time
$t(\lambda,\theta_o)$	Diffuse atmospheric transmittance
τ_R	Rayleigh optical thickness
τ_{oz}	Ozone optical thickness for atmospheric ozone content of 350 Dobsons
θ_0	Solar zenith angle
w_i	Weights in smoothing function
z	Depth (m)

Appendix A

Listing of the raw MOBY data and it engineering information. The sensor shows which light source was illuminating the CCD. MUX pos is the Mux position number, each sensor has a assigned mux position. Int. Time is the integration time in seconds, and (B/R) denotes the intergration time of the blue and red spectrograph. The bin factor is the number of CCD pixels combined during readout. If Mirror position is in the down position then a light from one of the fibers is illuminating the spectrograph (except in the case of the intercal calibration lamps (RLED, BLED and LAMP). When the Mirror is inthe up position, as in the LuMOS, then the light source is from the optical port on the bottom of the MOS can, and not a fiber.

Scan#	Date and Time YYYY:MM:DD:HH:MM:SS	Sensor	MUX Pos	Int. Time (B/R)	Bin Factor (B/R)	Mirror Position
1	2006:12:16:20:31:45	DARK	8	0.75/0.75	16/16	1 DARK
2	2006:12:16:20:31:52	EsSFC	8	0.75/0.75	16/16	5 DOWN
3	2006:12:16:20:31:58	EsSFC	8	0.75/0.75	16/16	5 DOWN
4	2006:12:16:20:32: 3	EsSFC	8	0.75/0.75	16/16	5 DOWN
5	2006:12:16:20:32:10	DARK	8	0.75/0.75	16/16	1 DARK
6	2006:12:16:20:32:36	DARK	5	64/64	4/384	1 DARK
7	2006:12:16:20:33:47	LuMID	5	64/64	4/384	5 DOWN
8	2006:12:16:20:34:57	LuMID	5	64/64	4/384	5 DOWN
9	2006:12:16:20:36: 7	LuMID	5	64/64	4/384	5 DOWN
10	2006:12:16:20:37:17	LuMID	5	64/64	4/384	5 DOWN
11	2006:12:16:20:38:27	LuMID	5	64/64	4/384	5 DOWN
12	2006:12:16:20:39:37	DARK	5	64/64	4/384	1 DARK
13	2006:12:16:20:41: 6	DARK	8	0.75/0.75	16/16	1 DARK
14	2006:12:16:20:41:13	EsSFC	8	0.75/0.75	16/16	5 DOWN
15	2006:12:16:20:41:19	EsSFC	8	0.75/0.75	16/16	5 DOWN
16	2006:12:16:20:41:24	EsSFC	8	0.75/0.75	16/16	5 DOWN
17	2006:12:16:20:41:31	DARK	8	0.75/0.75	16/16	1 DARK
18	2006:12:16:20:41:59	DARK	9	40/40	6/384	1 DARK
19	2006:12:16:20:42:46	LuTOP	9	40/40	6/384	5 DOWN
20	2006:12:16:20:43:31	LuTOP	9	40/40	6/384	5 DOWN
21	2006:12:16:20:44:16	LuTOP	9	40/40	6/384	5 DOWN
22	2006:12:16:20:45: 2	LuTOP	9	40/40	6/384	5 DOWN
23	2006:12:16:20:45:47	LuTOP	9	40/40	6/384	5 DOWN
24	2006:12:16:20:46:33	DARK	9	40/40	6/384	1 DARK
25	2006:12:16:20:47:41	DARK	8	0.75/0.75	16/16	1 DARK
26	2006:12:16:20:47:48	EsSFC	8	0.75/0.75	16/16	5 DOWN
27	2006:12:16:20:47:54	EsSFC	8	0.75/0.75	16/16	5 DOWN
28	2006:12:16:20:48: 0	EsSFC	8	0.75/0.75	16/16	5 DOWN
29	2006:12:16:20:48: 6	DARK	8	0.75/0.75	16/16	1 DARK
30	2006:12:16:20:48:31	DARK	2	64/64	4/384	1 DARK
31	2006:12:16:20:49:42	LuBOT	2	64/64	4/384	5 DOWN
32	2006:12:16:20:50:52	LuBOT	2	64/64	4/384	5 DOWN
33	2006:12:16:20:52: 2	LuBOT	2	64/64	4/384	5 DOWN
34	2006:12:16:20:53:12	LuBOT	2	64/64	4/384	5 DOWN
35	2006:12:16:20:54:22	LuBOT	2	64/64	4/384	5 DOWN
36	2006:12:16:20:55:32	DARK	2	64/64	4/384	1 DARK
37	2006:12:16:20:56:59	DARK	8	0.75/0.75	16/16	1 DARK
38	2006:12:16:20:57: 6	EsSFC	8	0.75/0.75	16/16	5 DOWN

39	2006:12:16:20:57:11	EsSFC	8	0.75/0.75	16/16	5 DOWN
40	2006:12:16:20:57:17	EsSFC	8	0.75/0.75	16/16	5 DOWN
41	2006:12:16:20:57:23	DARK	8	0.75/0.75	16/16	1 DARK
42	2006:12:16:20:57:39	DARK	8	0.8/10	8/384	1 DARK
43	2006:12:16:20:57:55	LuMOS	11	0.8/10	8/384	3 UP
44	2006:12:16:20:58: 9	LuMOS	11	0.8/10	8/384	3 UP
45	2006:12:16:20:58:24	LuMOS	11	0.8/10	8/384	3 UP
46	2006:12:16:20:58:38	LuMOS	11	0.8/10	8/384	3 UP
47	2006:12:16:20:58:52	LuMOS	11	0.8/10	8/384	3 UP
48	2006:12:16:20:59: 8	DARK	8	0.8/10	8/384	1 DARK
49	2006:12:16:20:59:33	DARK	8	0.75/0.75	16/16	1 DARK
50	2006:12:16:20:59:40	EsSFC	8	0.75/0.75	16/16	5 DOWN
51	2006:12:16:20:59:45	EsSFC	8	0.75/0.75	16/16	5 DOWN
52	2006:12:16:20:59:51	EsSFC	8	0.75/0.75	16/16	5 DOWN
53	2006:12:16:20:59:57	DARK	8	0.75/0.75	16/16	1 DARK
54	2006:12:16:21: 0:24	DARK	7	2.5/2.5	8/64	1 DARK
55	2006:12:16:21: 0:33	EdMID	7	2.5/2.5	8/64	5 DOWN
56	2006:12:16:21: 0:41	EdMID	7	2.5/2.5	8/64	5 DOWN
57	2006:12:16:21: 0:49	EdMID	7	2.5/2.5	8/64	5 DOWN
58	2006:12:16:21: 0:56	EdMID	7	2.5/2.5	8/64	5 DOWN
59	2006:12:16:21: 1: 4	EdMID	7	2.5/2.5	8/64	5 DOWN
60	2006:12:16:21: 1:13	DARK	7	2.5/2.5	8/64	1 DARK
61	2006:12:16:21: 1:41	DARK	8	0.75/0.75	16/16	1 DARK
62	2006:12:16:21: 1:48	EsSFC	8	0.75/0.75	16/16	5 DOWN
63	2006:12:16:21: 1:54	EsSFC	8	0.75/0.75	16/16	5 DOWN
64	2006:12:16:21: 1:59	EsSFC	8	0.75/0.75	16/16	5 DOWN
65	2006:12:16:21: 2: 6	DARK	8	0.75/0.75	16/16	1 DARK
66	2006:12:16:21: 2:30	DARK	10	1.2/1.2	16/32	1 DARK
67	2006:12:16:21: 2:38	EdTOP	10	1.2/1.2	16/32	5 DOWN
68	2006:12:16:21: 2:44	EdTOP	10	1.2/1.2	16/32	5 DOWN
69	2006:12:16:21: 2:50	EdTOP	10	1.2/1.2	16/32	5 DOWN
70	2006:12:16:21: 2:56	EdTOP	10	1.2/1.2	16/32	5 DOWN
71	2006:12:16:21: 3: 2	EdTOP	10	1.2/1.2	16/32	5 DOWN
72	2006:12:16:21: 3: 9	DARK	10	1.2/1.2	16/32	1 DARK
73	2006:12:16:21: 3:35	DARK	8	0.75/0.75	16/16	1 DARK
74	2006:12:16:21: 3:42	EsSFC	8	0.75/0.75	16/16	5 DOWN
75	2006:12:16:21: 3:47	EsSFC	8	0.75/0.75	16/16	5 DOWN
76	2006:12:16:21: 3:53	EsSFC	8	0.75/0.75	16/16	5 DOWN
77	2006:12:16:21: 3:59	DARK	8	0.75/0.75	16/16	1 DARK
78	2006:12:16:21: 4:25	DARK	3	2/2	12/384	1 DARK
79	2006:12:16:21: 4:33	EdBOT	3	2/2	12/384	5 DOWN
80	2006:12:16:21: 4:40	EdBOT	3	2/2	12/384	5 DOWN
81	2006:12:16:21: 4:47	EdBOT	3	2/2	12/384	5 DOWN
82	2006:12:16:21: 4:54	EdBOT	3	2/2	12/384	5 DOWN
83	2006:12:16:21: 5: 1	EdBOT	3	2/2	12/384	5 DOWN
84	2006:12:16:21: 5: 9	DARK	3	2/2	12/384	1 DARK
85	2006:12:16:21: 5:33	DARK	8	0.75/0.75	16/16	1 DARK
86	2006:12:16:21: 5:40	EsSFC	8	0.75/0.75	16/16	5 DOWN
87	2006:12:16:21: 5:46	EsSFC	8	0.75/0.75	16/16	5 DOWN
88	2006:12:16:21: 5:51	EsSFC	8	0.75/0.75	16/16	5 DOWN

89	2006:12:16:21: 5:58	DARK	8	0.75/0.75	16/16	1 DARK
90	2006:12:16:21: 6:14	DARK	8	1/1	64/384	1 DARK
91	2006:12:16:21: 6:50	BLED	12	1/1	64/384	7 CALIB
92	2006:12:16:21: 6:56	BLED	12	1/1	64/384	7 CALIB
93	2006:12:16:21: 7: 2	BLED	12	1/1	64/384	7 CALIB
94	2006:12:16:21: 7: 9	DARK	8	1/1	64/384	1 DARK
95	2006:12:16:21: 7:25	DARK	8	1/1	384/64	1 DARK
96	2006:12:16:21: 8: 2	RLED	13	1/1	384/64	7 CALIB
97	2006:12:16:21: 8: 7	RLED	13	1/1	384/64	7 CALIB
98	2006:12:16:21: 8:13	RLED	13	1/1	384/64	7 CALIB
99	2006:12:16:21: 8:20	DARK	8	1/1	384/64	1 DARK
100	2006:12:16:21: 8:36	DARK	8	1/1	64/16	1 DARK
101	2006:12:16:21: 9:13	LAMP	15	1/1	64/16	7 CALIB
102	2006:12:16:21: 9:19	LAMP	15	1/1	64/16	7 CALIB
103	2006:12:16:21: 9:24	LAMP	15	1/1	64/16	7 CALIB
104	2006:12:16:21: 9:32	DARK	8	1/1	64/16	1 DARK