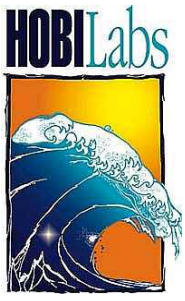
HydroRad Radiometers and Controller / Logging System

Prepared For
Indian Space Research Organisation
Space Application Centre

POST-PROCESSING SOFTWARE USER'S MANUAL

Version A: October 2006



Hydro-Optics, Biology & Instrumentation Laboratories

LIGHTING THE WAY IN AQUATIC SCIENCE

www.hobilabs.com support@hobilabs.com

Version A, October 2006: First version separate from System Manual

Table of Contents

1 INTRODUCTION

SAC-HOBI Tools is an Add-In for Microsoft Excel that loads, processes and displays data from the in-situ hyperspectral radiometer/logging system custom-built for SAC by HOBI Labs. Integration of these software functions into Excel provides a simple, familiar GUI while providing direct access to Excel's powerful analysis and display capabilities. Further, it enables users to experiment with and modify the algorithms used for deriving secondary parameters, using familiar Excel formulas.

1.1 System Overview

The system as a whole and its components are described in detail in the System User's Manual. Here we describe it briefly as it relates to this software.

The in-situ system consists of

- Four HydroRad radiometers measuring seven optical quantities:
    - Downwelling surface irradiance (E_S)
    - Subsurface downwelling irradiance at three depths (E_{d1}, E_{d2}, E_{d3})
    - Subsurface upwelling radiance at three depths (L_{u1}, L_{u2}, and L_{u3})
- A fluorometer measuring
    - Chlorophyll fluorescence
    - Turbidity
- A three-axis magnetic orientation sensor measuring
    - Tilt
    - Roll
    - Magnetic heading
- A HydroDAS logger/controller that governs the operation of the sensors, archives their raw data, processes the raw data, and sends processed data to its console port for transmission to shore via satellite.

1.2 Data Processing Steps

Data from the system undergo three major stages of processing: raw data archiving, primary processing, and derivation of secondary data, or post-processing. Archiving is done only in-situ, by the HydroDAS. Primary processing is performed both in-situ and by SAC-HOBI Tools. Post-processing is performed only by SAC-HOBI Tools.

1.2.1 Raw data archiving

Raw data are collected from individual instruments under the control of the HydroDAS, and stored on its hard disk in one file per instrument, with the file name extensions shown in the following table.

HydroDAS archives data into one file per instrument per day. The base name of these daily files is the four-digit year, followed by the three-digit day number, of the date on which the data were collected. For example, on the last day of 2006 the archive files would be named 2006365.TLT, 2006365.FLR, 2006365.HR1, etc.

File name extension	File contents
.TLT	Raw tilt, roll and compass data
.FLR	Raw fluorometer data
.HR1	Raw data from HydroRad #1 (measuring E_s)
.HR2	Raw data from HydroRad #2 (measuring E_{d1} and L_{u1})
.HR3	Raw data from HydroRad #2 (measuring E_{d2} and L_{u2})
.HR4	Raw data from HydroRad #2 (measuring E_{d3} and L_{u3})

1.2.2 Primary Data Processing

Primary processing can be done both by the HydroDAS firmware, and by SAC-HOBI Tools. It consists of the following steps:

- Calibrations are applied to raw HydroRad spectra, converting them to radiometric units;
- Average and maximum tilt (and heading) are calculated for each spectrum;
- Spectra within the tilt limits are averaged together (time-averaged);
- Time-averaged spectra are spectrally averaged within user-specified wavebands;
- Processed data are saved in a binary ".OUT" file;
- The file is transmitted to the console port.

When this processing is performed on the HydroDAS, the resulting binary .OUT file is archived along with the raw data files, with the same base name as the raw files. For example, the archived files for the last day of 2006 would include a file called 2006365.OUT that contains all the processed binary data generated on that day. SAC-HOBI Tools can load, display, and post-process such files, as well as reprocessing raw data sets. SAC-HOBI Tools does not generate .OUT files, but stores reprocessed data directly into Excel workbooks in the same format as if they were loaded from .OUT files.

Primary processing in SAC-HOBI Tools is explained in section 4.2. Details of the processed data files are explained in the System User's Manual.

1.2.3 Secondary processing: Derived quantities

In addition to duplicating the processing capabilities of the HydroDAS firmware (with some enhancements), SAC-HOBI Tools provides derivation of secondary quantities from the primary processed data. These derived quantities are:

- Water-leaving radiance (L_W)
- Normalized water-leaving radiance (L_{NW})
- Remote-sensing reflectance (R_{rs})
- Attenuation coefficients (K_d and K_{Lu})
- Chlorophyll concentration extracted from radiance

The algorithms for some of these, especially the normalized water-leaving radiance and chlorophyll concentration, are the subject of ongoing research and debate. Therefore we have designed SAC-HOBI Tools to permit SAC researchers to modify and experiment with them within Excel. Details are explained in section 5.

1.3 Charting

In addition to loading and processing data as described above, SAC-HOBI Tools provides tools for easy charting of both primary and derived data. Details are explained in section 6.

1.4 SAC-HOBI Tools Files

SAC-HOBI Tools consists of two main parts:

- The add-in file "SAC-HOBI Tools.XLA", which contains most of the executable code, and
- The workbook template "SAC-HOBI Tools.XLT", which contains pre-defined worksheets and support code to hold the loaded and processed data. The setup of this workbook is described in section 3.

A third file, "Install SAC-HOBI Tools.XLS" assists with installation (see section 2.3) but is not strictly required.

2 INSTALLATION

2.1 System Requirements

SAC-HOBI Tools requires a minimum of Excel 2002, Windows 2000, and a Pentium II-class computer with sufficient resources to support Excel. The preferred configuration is Excel 2003 or better, Windows XP or better, at least 500MB of RAM, and a clock speed of at least 1 GHz.

2.2 Security Settings

Because SAC-HOBI Tools contains executable programs that run within Excel, Excel may present warnings or even disable some features, depending on its security settings. To view and change Excel's security settings, select Macro->Security... from the Tools menu. We recommend a security setting of Medium. If the level is set above Medium, you must use the Manual Installation procedure shown in section 2.4, and some features may be disabled.

2.3 Automatic Installation

This procedure requires Excel's security level to be Medium or lower (see above).

First, copy the following files to a directory on your computer. If you later move these files to a different directory, you will need to run the installation again.

- "SAC-HOBI Tools.xla"
- "SAC-HOBI Tools.xlt"

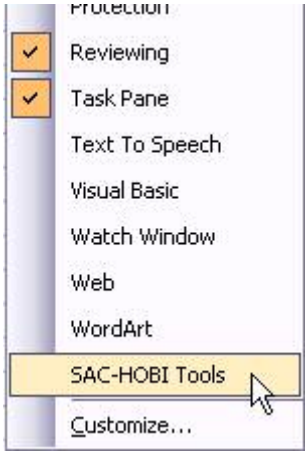
- "Install SAC-HOBI Tools.xls"

Double-click on the file "Install SAC-HOBI Tools.xls". If Excel displays a message warning that the file contains macros, click Enable Macros:

When asked if the file should be installed, click Yes.

A toolbar like the one shown below should then appear in the Excel window.

If the tool bar does not appear, pull down the View menu and look for the SAC-HOBI Tools item. If it appears without a check mark next to it, select it and the toolbar should appear.



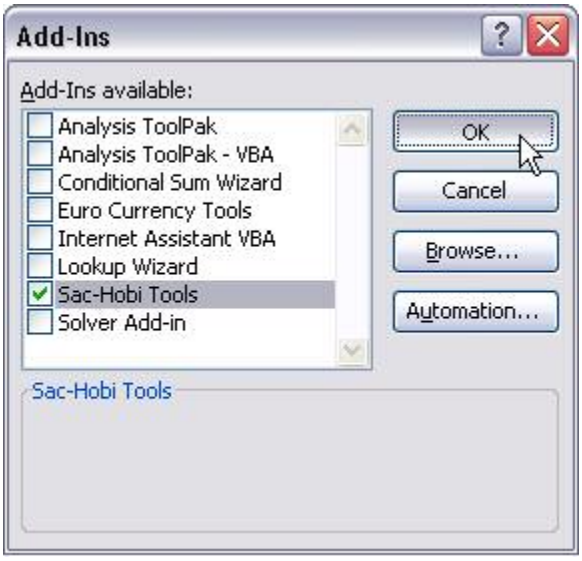
2.4 Manual Installation

Use this procedure if your Excel security setting is too high to permit the automatic procedure described above. Note however that a high security setting may also block some features of the software, and of workbooks you create with the Add-In.

- Start Excel
- Select Macro->Security... from the Tools menu.
- On the "Trusted Publishers" tab (if it is present), select "Trust all installed add-ins and templates". Click OK.

- Select Add-ins... from the Tools menu. If this command is disabled and there are no workbooks open in Excel, select New from the File menu, and open a blank workbook. Then select Add-ins... from the Tools menu.
- Click Browse...
- Navigate to the directory containing the add-in files, and select the file "SAC-HOBI Tools.xla".
- Excel may ask whether you wish to copy the file to the Add-ins folder. Click No.

- The file you selected should now appear in the add-ins list, with a checkmark. Click OK.



You should see a dialog announcing the presence of the Add-in, and its toolbar should appear. If you do not see the tool bar, select Toolbars->SAC-HOBI Tools from the View menu.

2.5 Reversing Installation

Once you have installed the Add-In, it will automatically load every time you start Excel, unless you move or rename the Add-In file. To uninstall the Add-in, open the Add-Ins dialog box as described above, and uncheck Sac-Hobi Tools.

3 WORKBOOK STRUCTURE

The template file "SAC-HOBI Tools.xlt" contains a number of worksheets set up specifically for the HydroDAS data, as well a various features that are not visible to the user but facilitate the handling of HydroDAS data. These include specially named cells and ranges of cells, hidden cells and sheets, and executable code. Because of the executable code, each time you open a file generated from this template Excel may present a warning that it contains macros. It is safe to enable these macros.

The workbook template includes 20 predefined worksheets. These are divided into categories indicated by the shading of their tabs at the bottom of the Excel window:

Blue shading indicates information that summarizes or controls other sheets. Yellow indicates primary data from individual instrument channels, and green indicates data derived from the primary data.

3.1 Summary Sheet

The "Summary" sheet holds information about loaded data:

- A list of files from which data have been loaded, and the number of samples in each (Figure 1). If the data were loaded from raw files, the ".OUT" file extension is replaced with an asterisk ("*").
- The serial numbers and channel identifications of the HydroRads whose data have been loaded (Figure 2).
- The array of wavelength bands applied to the data.

These tables all filled in automatically during the loading process and should not normally be changed by a user.

File Samples	File Name
102	2006001.OUT
102	2006002.OUT
102	2006003.OUT
102	2006004.OUT

Figure 1. File List

Instrument Information			
Serial No.	Channel	Units	Cal File
HR050142	A - Ed	W/m^2/nm	HR050141.CSV
HR050143	A - Ed	W/m^2/nm	HR050143.CSV
HR050143	B - Lu	W/m^2/sr/nm	HR050143.CSV
HR050145	A - Ed	W/m^2/nm	HR050144.CSV
HR050145	B - Lu	W/m^2/sr/nm	HR050144.CSV
HR050144	A - Ed	W/m^2/nm	HR050145.CSV
HR050144	B - Lu	W/m^2/sr/nm	HR050145.CSV

Figure 2. Instrument List—yellow highlighting indicates a mismatch between the calibration file and the instrument serial number**.**

3.2 Primary Data Sheets

The eight sheets with yellow-shaded tabs hold data loaded from the seven HydroRad channels and the fluorometer, and are named accordingly. For example the first sheet holds E_s (surface irradiance) data, from HydroRad #1.

In all these sheets, each line of data represents one sample (with averaging applied, if any). Each line starts with a sample sequence number, and the date and time the sample were recorded, then various housekeeping data, then the primary spectral data for the channel. Because Excel is limited to 255 columns in each worksheet and each spectral band occupies one column, the number of spectral bands in each sample is limited to about 230. SAC-HOBI Tools permits you to define as many bands as will fit within Excel's column limit. Excel can accommodate over 65,000 rows of data, permitting display of very long time series.

3.3 Params Sheet

This worksheet holds various parameters that are used during calculation of the derived data. These are described in further detail in section 5.

3.4 Derived Data Sheets

The 10 sheets with green-shaded tabs hold data derived from the primary data. These are similar in format to the primary data sheets, with each line representing one sample in time, and the spectral data presented with one column per spectral band.

Unlike the primary data sheets, these sheets also contain formulas that are used for derivation of the secondary data. These are described further in section 5.

3.5 Modifying Workbooks

You are free to add any number of worksheets and charts to workbooks created by SAC-HOBI Tools, and generally use all the normal Excel features to process and display.

However you should avoid the following changes which could interfere with the functions of SAC-HOBI Tools.

- Do not change the names of any of the predefined worksheets.
- Do not change the sequence of the predefined worksheets, or insert new sheets between them.
- Do not delete or change the names of any named cells or formulas.

3.6 Modifying the Workbook Template

If you prefer to change the format of all new workbooks you create with SAC-HOBI Tools, you can modify the template file ("SAC-HOBI Tools.xlt"). However you should first create a backup copy of the file in case you accidentally make a change that interferes with SAC-HOBI Tools functions. You must also obey the restrictions listed in section 3.5.

4 LOADING AND PROCESSING DATA

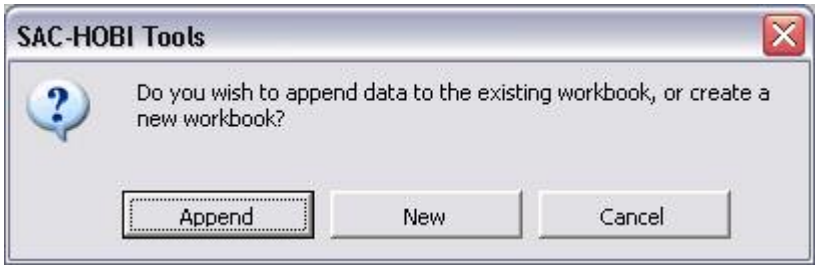
4.1 Loading Data Processed by the HydroDAS

The Load Processed Files... command on the SAC-HOBI Tools toolbar loads files containing binary packets generated by the HydroDAS's processing firmware.

Suitable files may be received via the satellite transceiver or USB offload from the HydroDAS's hard disk. Files received via satellite may contain text messages and other characters that are not part of the HydroDAS format, but the SAC-HOBI Tools will ignore these and find any properly-formatted binary packets in the file.

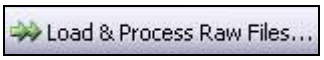
The command first presents a standard Windows file selection dialog box. You may select any number of files by using the control or shift keys in combination with the mouse. When you the click OK, the program will scan each file for HydroDAS data packets. The name of each file scanned, and the number of packets it contained, will be listed on the summary sheet. Note that it is possible for you to select files of any type, even those that do not actually contain appropriate data. In that case the file names will still be listed, but their sample counts will be zero.

If a SAC-HOBI workbook is already open and active when you select files to load, you will be presented with the option to either append the files to the open workbook, or to create a new workbook from the template.



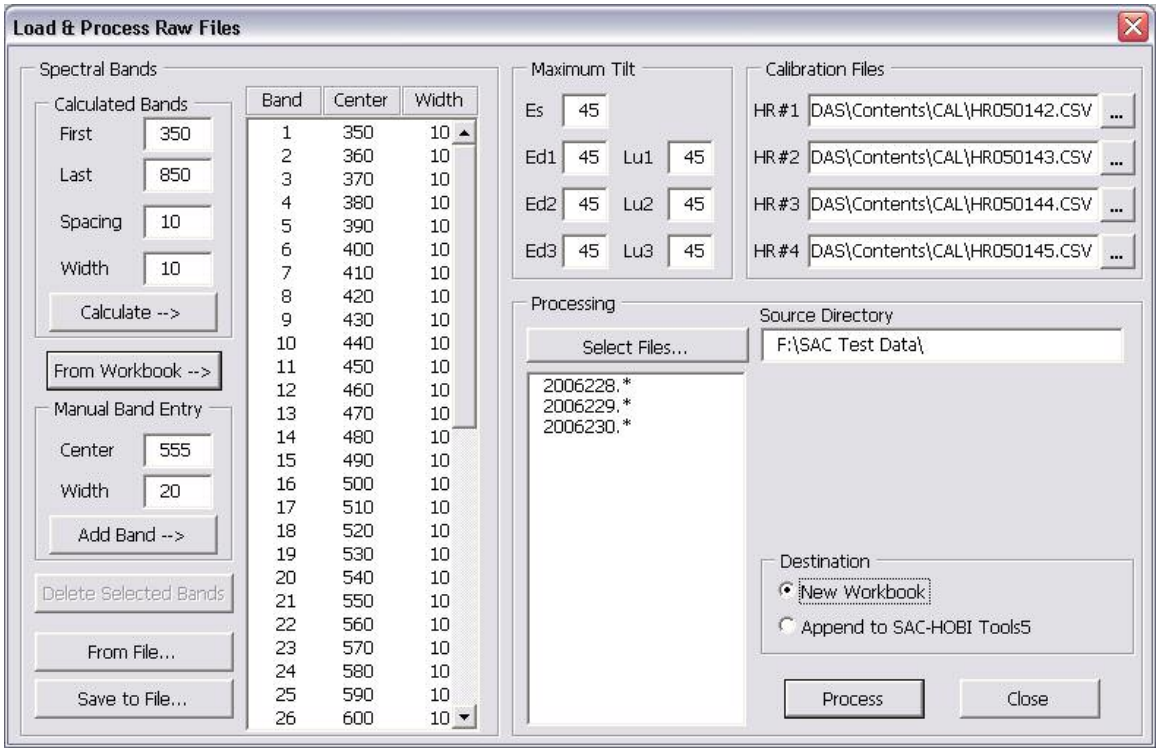
If you choose to append data to an existing workbook, the spectral bands of the data sets must exactly match each other. The software will check this and will not load the data if the bands do not match.

4.2 Loading and Processing Raw Data



The Load & Process Raw Files... command duplicates the processing performed by the HydroDAS firmware, with a few enhancements. This command presents the dialog box shown below, in which you set the following parameters:

- Spectral bands,
- Maximum tilt,
- HydroRad calibration files,
- Source files, and
- Destination.



4.2.1 Spectral Bands

Data are processed into the set of spectral bands you select in this dialog box. Whereas the HydroDAS firmware is limited to a maximum of 50 bands, SAC-HOBI Tools allows up to 230 bands (limited by the number of columns allowed by Excel). This allows, for example, placing bands every 2 nm from 350 to 800 nm, or every 2.5 nm from 350 to 850 nm, for full hyperspectral analysis.

To define the band set to be used, you can:

- Designate the first and last band centers, and a regular band spacing, then click Calculate to produce a set of uniformly-spaced, constant-width bands;
- Click From Workbook to use the same band set as the currently active workbook (this button is enabled only if a suitable workbook is active);
- Click From File... to load a band set from a file on your computer; or
- Enter an arbitrary set of bands one at a time, by entering the center wavelength and band width, then clicking Add Band, for each.

To save the currently displayed set of bands to a file for later use, click Save to File... To remove bands from the list, select them by clicking on them in the list (using the mouse in conjunction with the control or shift key to select multiple bands), then click Delete Selected Bands.

Note that if you wish to load new data into an existing workbook that already contains data, the band sets must match. To ensure they match, click From Workbook to load them from the existing workbook.

4.2.2 Maximum Tilt

You can enter a separate maximum tilt angle (in degrees) for each of the seven radiometric measurement channels. Spectra collected when the buoy tilt exceeds their corresponding maximum value will be excluded from the averaged output. To include all spectra, set the maximum tilt to 45 or higher.

4.2.3 Calibration Files

Each of the four HydroRads requires a calibration file containing coefficients for converting its raw data to radiometric units. You must ensure the calibration files are assigned to the correct instruments. If the software detects a mismatch between the instrument serial number and serial number stored in the calibration file, it will process the data but set a quality control flag in the loaded data. For details about quality control flags, see section 4.3.

4.2.4 Source Files and Directory

The Select Files... button presents a standard Windows open file dialog box, in which you can select an arbitrary set of files to process (use the control and/or shift keys in conjunction with the mouse to select multiple files). The files you select, and the directory holding them, appear in the Processing section of the Load & Process dialog box.

4.3 Viewing Data Worksheets

4.3.1 Missing Values

If no processed spectra are available from a particular sample, the cells corresponding to that sample will be left blank and shaded gray. This may result from transient problems, such as data transmission errors, or from normal events such high tilt values that exclude all spectra from the averaged data. That is most likely at times when light levels are low, leading to long integration times. This in turn results in fewer spectra per sample, while also increasing the probability that an individual spectrum will be influenced by buoy motion and excluded because of tilt.

4.3.2 QC Flags

Each of the primary data worksheets has a column for QC flags, and if any are set they are highlighted as shown below.

Sample #	Date	Time	Spectrum Count	QC Flags	Integ. Time
323	8/18/2006	9:06:29	1	High	4314
324	8/18/2006	9:09:23	2	High	3375
325	8/18/2006	11:29:23	8		134

A "cal" flag will appear if instrument serial number does not match the serial number in the calibration file used for processing it. Note that the instrument list on the Summary worksheet will also highlight discrepancies between calibration file names and instrument serial numbers (section 3.1).

The "high" flag will be set if an instrument's peak spectral readings are higher than another instrument at a shallower depth. Since the light level normally decrease at deeper depths, readings that are consistently too high may indicate a malfunction in one of the instruments, or a problem in the positioning of one of the light collectors. Occasional momentary high signal levels may be triggered by normal phenomena such as wave focusing.

5 SECONDARY PROCESSING: CALCULATING DERIVED PARAMETERS

After the primary data worksheets are loaded with processed data, either directly from HydroDAS files or processed from raw files, the secondary parameters are automatically derived from them and placed in their own worksheets.

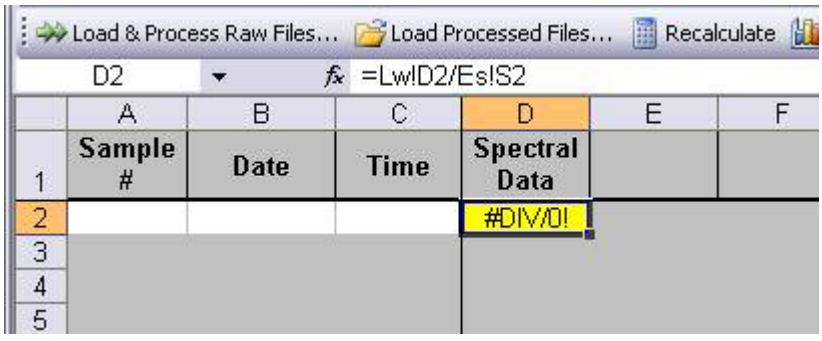
Some of these parameters are the subject of ongoing research, and will certainly require fine-tuning as data are accumulated over the life of the system. In order to allow SAC users to easily modify the algorithms used for this processing, they are expressed as normal Excel formulas in the derived parameter spreadsheets. Some are also supported by input parameters on the Params sheet.

We strongly recommend backing up the template file ("SAC-HOBI Tools.xlt") before making any changes to it.

5.1 Entering Algorithm Formulas

Each formula is entered in one key cell on the applicable spreadsheet of the workbook template. During the calculation process (triggered either by the loading of data, or by the Recalculate button), this formula is automatically copied throughout the full range of cells to which it applies.

The cells holding the formulas are highlighted with yellow, and on most sheets are in the column initially labeled "Spectral Data". For example:



Here the value of the cell is "#DIV/0!". This is normal in this case because no data have been loaded. The formula for calculating Remote Sensing Reflectance, R_{RS}, is shown above in the formula bar:

=Lw!D2/Es!S2

Lw!D2 refers to the first cell containing spectral data on the Lw (water-leaving radiance) sheet. Similarly, Es!S2 is the first spectral cell on the Es (downwelling surface irradiance) sheet. This implements the definition of Remote Sensing Reflectance,

$$R_{RS}(\lambda) = L_w(\lambda) / E_d(0^+, \lambda)$$

5.2 Entering Parameters

Some algorithms, particularly the normalized water-leaving radiance, are sufficiently complex that, for convenience, their key parameters are entered separately from the equations. These are gathered on the Params worksheet as shown below. Details of this worksheet will be explained along with the individual parameters.

For L_{NW} Sun Angle calculation			
Buoy Location	Latitude	Longitude	Time Zone
Degrees	10	72	5.5
Minutes	36	17	

For L_{nw} Atmospheric correction		
λ	$\tau_r(\lambda)$	$\tau_{Oz}(\lambda)$
	0	0

For L_W	
water-air trans.:	1
index of refraction	1.34

For Chlorphyll and Turbidity from Fluorometer	
Chl offset	52
Chl scale factor	0.0123
NTU offset	70
NTU scale factor	0.006

For Chlorophyll Extraction from L	
Chl coeff A	
Chl coeff B	
Chl lambda 1	
Chl lambda 2	

5.3 Initial Algorithms

5.3.1 Downwelling diffuse attenuation coefficients

Analytic equation:

$$K_d(\lambda) = \ln[E_d(z_1, \lambda) / E_d(z_2, \lambda)] / (z_2 - z_1)$$

where z_i is the depth of sensor i.

Since the system measures $E_d(z, \lambda)$ at three depths, (z_1, z_2, z_3), there will be three computations of K_d, corresponding to the depth combinations (z_1, z_2), (z_2, z_3), (z_1, z_3). The corresponding Excel equations are

```
=LN('Ed1'!S2/'Ed2'!S2)/('Ed2'!$N2-'Ed1'!$N2)
```

=LN('Ed2'!S2/'Ed3'!S2)/('Ed3'!$N2-'Ed2'!$N2)

=LN('Ed1'!S2/'Ed3'!S2)/('Ed2'!$N3-'Ed1'!$N1)

Note that the references to column N on the Ed sheets, which holds the depth values, are preceded by "$", indicating absolute references. The other references are relative.

5.3.2 Upwelling radiance attenuation coefficients

$$K_{Lu}(\lambda) = \ln[L_u(z_1, \lambda) / L_u(z_2, \lambda)] / (z_2 - z_1)$$

Similarly to K_d, we use measurements of L_u at three depths to calculate three K_{Lu} values:

=LN(Lu1!S2/Lu2!S2)/(Lu2!$N2-Lu1!$N2)

=LN(Lu2!S2/Lu3!S2)/(Lu3!$N2-Lu2!$N2)

=LN(Lu1!S2/Lu3!S2)/(Lu3!$N2-Lu1!$N2)

5.3.3 Water leaving radiance, $L_w(\lambda)$

To compute L_w, we must first propagate $L_u(z1)$ to the surface. To do this, we use the computation of K_{Lu} measured from $L_u(z_1)$ and $L_u(z_2)$. Hence, L_u just below the surface is estimated to be:

$$L_u(0^-) = L_u(z_1) \exp(K_{Lu}, z_1).$$

Then we propagate $L_u(0^-)$ through the air-water interface to obtain L_w:

$$L_w(\lambda) = L_u(0^-)\, t / n^2$$

In Excel,

=Lu1!S2*EXP(Klu12!D2*Lu1!$N2)*water_air_transmission/(index_of_refraction)^2

The symbolic names "water_air_transmission" and "index_of_refraction" refer to values entered in the appropriately labeled cells on the Params worksheet.

5.4 Remote sensing reflectance

$$R_{RS}(\lambda) = L_w(\lambda) / E_d(0^+, \lambda)$$

In Excel,

=Lw!D2/Es!S2

5.5 Normalized water-leaving radiance

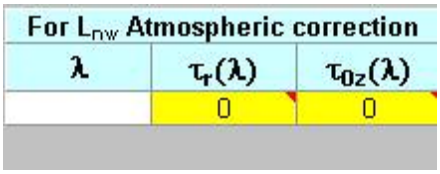
$$L_{wN}(\lambda) = L_w(\lambda) \exp\{ [\tau_r(\lambda)/2 + \tau_{0z}(\lambda)] [1/\cos\theta_0] \} / \cos\theta_0$$

where θ_0 is the solar elevation angle and $\tau_r(\lambda)$ and $\tau_{0z}(\lambda)$ are atmospheric transmission parameters. This equation involves a number of supporting parameters.

SAC-HOBI Tools includes a function called SunElevation, for computing the solar elevation angle θ_0. Sunelevation takes date, time, latitude, longitude and time zone arguments. The latitude, longitude and time zone are entered on the Params worksheet. The latitude and longitude are entered in degrees and minutes. North latitudes are entered as positive, South as negative. East longitudes are entered as positive and West as negative. The time zone is entered as an offset, in hours, from Greenwich Mean Time. India's time zone is +5.5 hours by this measure. Symbolic names are assigned to these parameters in the workbook template, and used in the following Excel equation for the sun angle:

```
=SunElevation(B2,Latitude_Degrees+Latitude_Minutes/60,Longitude_Degrees+
    Longitude_Minutes/60,Time_Zone)
```

The spectral quantities $\tau_r(\lambda)$ and $\tau_{0z}(\lambda)$ must also be entered in the Params sheet, in the form of Excel equations. These equations must be entered in the yellow-highlighted cells shown below.



As part of the secondary parameter derivation, this table will be expanded to include the complete list of wave bands, with their wavelengths shown in the λ column. The formulas entered in the yellow cells will also be copied so as to complete the table of $\tau_r(\lambda)$ and $\tau_{0z}(\lambda)$ values. In the delivered template, these cells hold simple formulas that are strictly for illustration. These must be replaced with formulas that are valid for

Finally, these elements are brought together in the Lnw worksheet, using the following Excel formula:

```
=Lw!D2*EXP((LOOKUP(E$1,Tau_r_table)/2+LOOKUP(E$1,Tau_0z_table))
    *(1/COS(D2)))/COS(D2)
```

where D2 contains the result of the SunElevation function, E$1 refers to the wavelength, and the LOOKUP function is used to find the values of $\tau_r(\lambda)$ and $\tau_{0z}(\lambda)$ corresponding to the wavelength.

5.6 Chlorophyll concentration

Various empirical algorithms are used for extracting chlorophyll concentration from ocean color data. We have implemented the following algorithm with the expectation that SAC scientists will choose input parameters that are appropriate to their deployment location, and possibly modify the equation.

$$C = \exp[\, A + B\, L_w(\lambda_1)/L_w(\lambda_2)\,]$$

Some scientists prefer L_{wN} instead of L_w in this formulation. The wavelengths, λ_1 and λ_2 and the parameters A and B are entered in the Params worksheet. The Excel equation we have entered in the Chl worksheet is

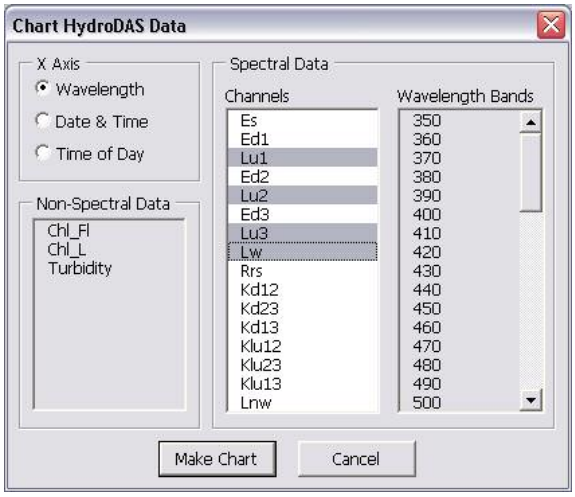
```
=EXP(chl_coeff_A+chl_coeff_B*OFFSET(Lw!D2,0,chl_lambda_1_band) /
        OFFSET(Lw!D2,0,chl_lambda_2_band)).
```

6 CHARTING DATA

The Chart Data... button opens a dialog box in which you can select any of the radiometer channels, and/or derived parameters to plot. Data can be plotted spectrally or as time series.

6.1 Spectral Charts

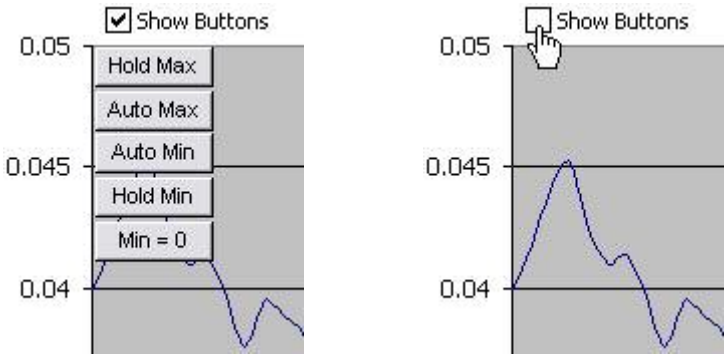
To display spectra, select the Wavelength option for the X Axis. In this mode you will only be able to select spectral quantities to chart, and the Wavelength Bands list will be disabled because the entire spectrum will be displayed. You can select any number of parameters to display within one chart. Of course since they will share one set of axes, some combinations of parameters will not be useful.



After you click Make Chart, the chart will display one spectrum of each of the parameters you select. The spectra represent one sample from the data time series. Below the chart, a horizontal scroll bar allows you to select which sample to display, or to scan through all the time samples in the dataset. The sample number and time of the currently-displayed sample are shown in the chart legend.

By default, the maximum of the Y axis automatically adjusts to the largest spectrum displayed, and the minimum is fixed at zero. However while scanning through a large data set with the scroll bar it is useful to be able to freely change between automatic and fixed scaling. While you can change the settings through the normal Excel functions, for more rapid control we provide a set of buttons in the upper left corner of

spectral plots. In case the buttons interfere with the graph contents, they can be hidden by unchecking Show Buttons above the chart area.



Hold Max fixes the maximum at its current value.

Auto Max sets the maximum to automatic (default setting)

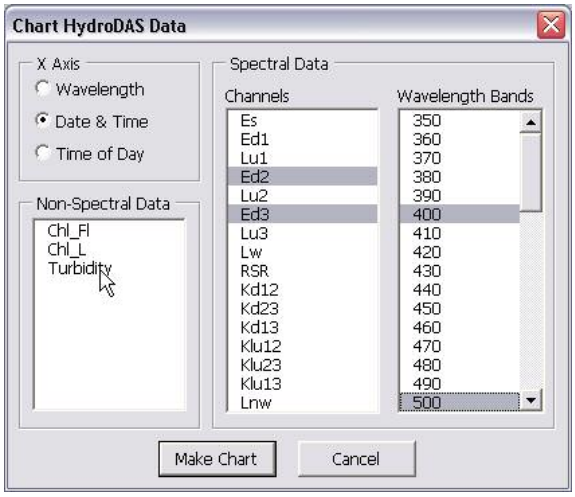
Auto Min sets the minimum to automatic

Hold Min fixes the minimum at its current value

Min = 0 fixes the minimum at zero (default setting)

The default settings can be changed in the chart template (see section 6.4).

6.2 Time-series Charts



To display time series, select the Time of Day or Date & Time option. In Date & Time mode, the X axis will display the date. In Time of Day mode, the x-axis will have a 24-hour range and if the dataset includes multiple days of data, the days will be overlaid.

Time-series charts display the parameters you select throughout the entire time range loaded in the present workbook. They do not include the scroll bar or axis-scaling buttons of the spectral charts (because they are not needed).

6.3 Modifying Charts

After creating a chart in SAC-HOBI Tools you can use the full capabilities of Excel to modify its format, rename it, add or remove data, or delete the chart.

6.4 Chart Template

The charts generated by this command are based on a template that is normally hidden within the workbook. To modify the default settings that will be used for future charts, for example the font styles of the axes or the position of the legend, you can modify this template. However before making any changes you should make a backup copy. To save a copy with the existing workbook template,

- Open "SAC-HOBI Tools.xlt"
- If the ChartTemplate tab is visible, click it to activate the template.
- If the ChartTemplate tab is not visible,
    - On the Format menu select Sheet->Unhide...
    - Select ChartTemplate in the Unhide dialog box, and click OK.
    - Click on the ChartTemplate tab in the workbook
- On the Edit menu, select Move or Copy Sheet...
- In the Move or Copy dialog box:

    - select (move to end) under Before sheet
    - check Create a copy

- click OK

This will create a new chart called “ChartTemplate (2)” which will serve as your backup. To restore this as the main template, change its name back to “ChartTemplate”. To change the name, right-click on its workbook tab, then select Rename from the popup menu.