Guidelines for Post Processing GER 1500 Spectral Data Files using a FSF Excel Template

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The NERC Field Spectroscopy Facility has created two Excel templates which can be used to post process the spectral data files from GER 1500 spectroradiometers. These will allow multiple spectral data files to be compiled into a single spreadsheet, interpolated to a 1nm interval, scaled for relative and absolute reflectance values or converted to spectral radiance or irradiance values. **Note:** to ensure that the macros in the templates run correctly please close all other excel spreadsheets while you use the template.

Contents:

1. Installation of Xlxtrfun Excel Add-In

The Excel templates for processing the GER signature or ASCII data use an *Add-In* feature called Xlxtrfun. This Add-In includes math functions such as linear or cubic spline interpolation and is available as a free download from the internet. Instructions are given below for installing and activating this *Add-Ins*.

This free download is available from Advanced Systems Design and Development at their website:

   http://www.xlxtrfun.com/XlXtrFun/XlXtrFun.htm

- Click on the **Download now** button and complete the optional registration form or click on the **Continue to Download Xlxtrfun->** button.

- Save the 739 Kbyte file xlxtrfunDistribution.zip to your computer.

To install the program follow the notes below:

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1. Exit (shut down, quit, stop) Excel.
2. Unzip `XlXtrFun.zip`.
3. Put `XlXtrFun.xll` wherever you want and use Excel's Add-In Manager to install `XlXtrFun.xll`.
     1. Start Excel.
     2. If a workbook is not already showing, open or create a new workbook.
     3. Click on *Tools – Add-Ins – Browse* to wherever you put `XlXtrFun.xll – OK – OK`.

For further information refer to the file `ReadMeXlxtrfunAnd SurfGen.html`

- From the Tools/Add-Ins menu in Excel ensure that the new *Xlxtrfun* Add-In is listed and activated.

Click OK to close the Add-In dialog.

- In Excel 2007, click the office button, select 'excel options' then 'add-ins' and ensure that the application Xlxtrfun is activated. To do this click on 'Go' to 'manage excel add-ins' then tick the Xlxtrfun box.
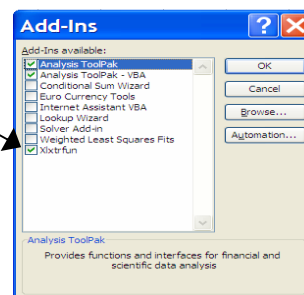
2. Post Processing Reflectance Data Files

The GER 1500 reflectance data files always include both the reference and target scans in each signature data file, this minimises the risk of incorrect calculations when ratioing the two scans to obtain relative reflectance values.

A separate template and guidance note is available for processing GER 1500 Dual Field of View data files.

Excel Macro Security Level

Before the Excel templates can be opened it is necessary for the Macro Security level to be set to allow the template's macro and Visual Basic code to be enabled.

- From the Excel *Tools* menu select *Options* and the *Security* tab.
- Click on the *Macro Security* button and change the *Security Level* to *Medium*.
- If using **Excel 2007** click on the 'office' button in the top left corner of the screen. Excel options – Trust center. Trust center settings – macro settings – enable all macros – OK.

This will allow the macros to be manually enabled when opening the Excel template.

Opening and Saving the GER 1500 Reflectance Template

- Start Excel and from the File menu Open and select the FSF Excel template:

  GER 1500 Reflectance Template_Ver 03.XLT
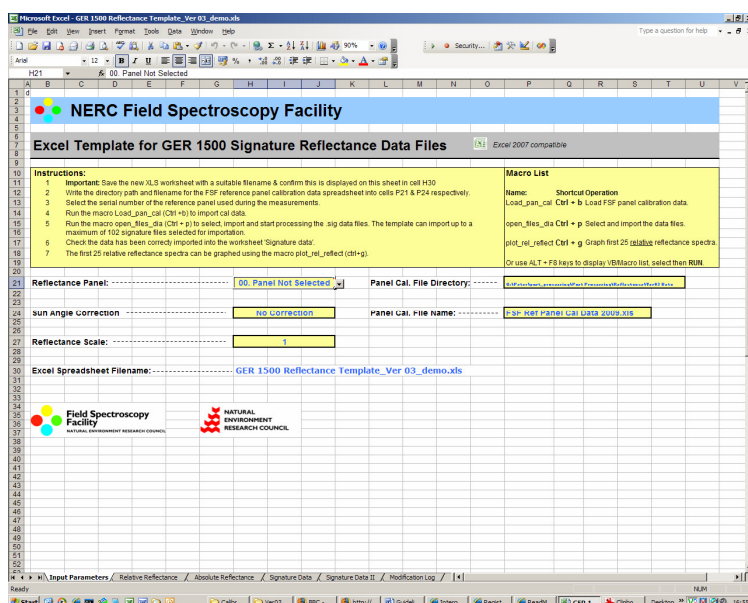
- In the Security Warning dialog click the **Enable Macros** button.

> **Note:**
> As the template is a read only document it needs be opened and renamed as an Excel XLS worksheet prior to running the macros.
> If using Excel 2007, it will need to be saved as a .xlsm (macro enabled excel worksheet).

The new spreadsheet will open on its *Input Parameters* worksheet as shown below:

- Save the spreadsheet as an XLS document (or .xlsm if using Excel 2007) with a name and in a directory of your choice. The new name is displayed in cell H30 of the Input Parameter worksheet.

Setting up the Input Parameters

The ***Input Parameter*** worksheet allows the user to select the reflectance panel used and specify the path\directory and root filename for the reflectance panel data files.
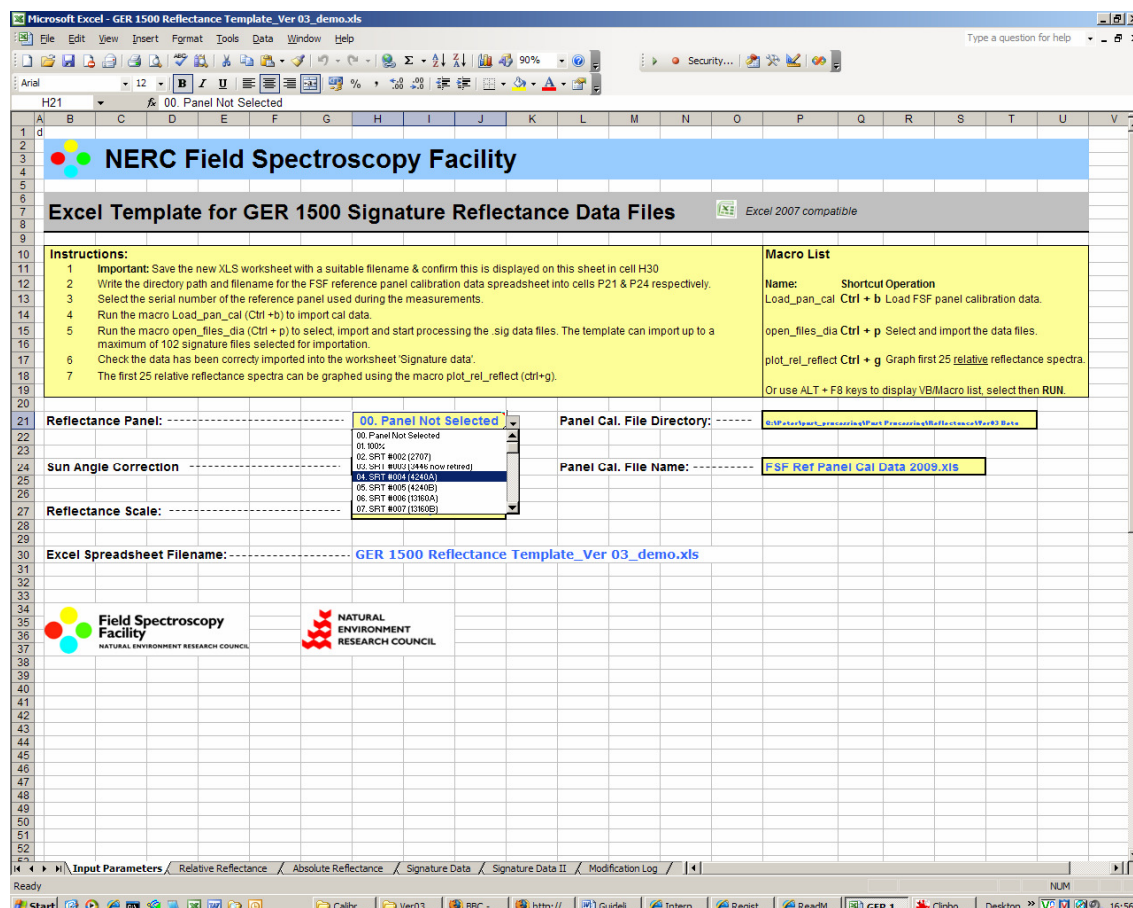
- Click on cell **H21** to bring up the pop down menu button. Click on the button to display the serial numbers of the NERC FSF calibrated Reference panels.

- Select the serial number of the panel used during the reference measurements. *This information will be used to convert the relative reflectance values into absolute spectral reflectance data based on the calibration of the specific reflectance panel used. If you do not require absolute reflectance data select "Panel Not Selected" from the list.*

- The calibration data for the Reference panels is stored in a separate Excel spreadsheet. Enter into cell **P21** the directory path where this spreadsheet is located on your computer.

- Enter into cell **P24** the name of the Reference panel calibration spreadsheet file. **NOTE:** It is important to ensure that the Reference panel calibration file corresponds to the same year that the measurements were taken. Files from previous years are archived on the FSF website, please contact FSF for further advice on this.

- Sun Angle Correction has not been implemented into the template at this stage.

- Set the Reflectance Scale (cell **H27**) to the desired level. Typically this is 1 or 100.

Macro for Importing the Selected Reference panel Calibration Data

Before the data can be processed it is necessary to run the macro *load_pan_cal.* This will read the selection in cell H21 and import the calibration data from the panel calibration spreadsheet into column B of the *Absolute Reflectance* worksheet.

• Use the short-cut keys ***Ctrl*** + ***b*** to load the selected panel calibration data.

The Excel spreadsheet is now ready to import data.

Importing Data with the GER 1500 template Macro

The Excel template can import up to a maximum of 102 GER reflectance data files from the selected directory.

Signature reflectance data from the GER spectroradiometers comprises of a file header with measurement parameters, and three columns of data with the wavelength scale, target spectral data and reference spectral data.

• Start the ***open_files_dia*** Macro from the Tools \ Macro\ Macros menu or use the short cut keys ***CTRL + p***

A 'File open' dialogue box will prompt you to select all the .sig files that you wish to import into the template. Highlight these and then click 'open'.

A prompt box will open showing the number of files selected for import. Click ok to this and the files will begin to be imported. During the importation procedure the data file names will appear and disappear from the Windows task bar. The procedure can take several minutes depending on the number of data files selected and the speed of your computer. A further delay is to be expected as Excel interpolates the relative reflectance values for each of the spectral data files.

The Signature Data Worksheet

The Signature Data (Signature Data II) worksheet(s) shows the original data with the file header slightly reformatted.

The Target and Reference raw spectral data columns are normalised within the GER software to counts per second.

A fourth column is added to each file to show the calculated reflectance values taken from the ratio of the raw target and reference data. When the reference data value is zero the reflectance value is set to zero.

Note:
A GPS system was not connected at the time of these measurements.

	A	B	C	D	E
1	///GER	SIGNATUR	FILE///		
2	Filename	gr082905_000.sig			
3	h_name=	gr082905_000.sig			
4	instrument=		2003		
5	target time=	29/08/2005	04:07:04	AM	
6	ref time=	29/08/2005	04:06:59	PM	
7	long=	00310.5085W	00310.5095W		
8	lati=	5555.4215N	5555.4213N		
9	gpstime=	150702.78	150656.77		
10	comm=				
11	memory slot=	338	337		
12	averaging=	2	2		
13	int. speed=	6	6		
14	optic=	5	5		
15	data=	Target	Reference	Reflectance	
16	276.59	298	297	100.3367	
17	278.59	286	301	95.0166113	
18	280.57	291	293	99.3174061	
19	282.56	290	289	100.346021	
20	284.53	294	294	100	
21	286.5	289	287	100.696864	
22	288.47	289	292	98.9726027	
23	290.43	286	291	98.2817869	

GER 1500 Signature data files imported to the template

Interpolated Relative Reflectance Data

The *Relative Reflectance* worksheet uses the *xlxtrfun spline* interpolation to expand the reflectance data in the signature files to a 1nm spectral interval and also restricts the spectral range to 350 – 1100nm.

This worksheet has been set up for 102 data files although this can be extended to suit your requirements. Please contact FSF staff for further details.

> **Note:**
> A text box with details on the Xlxtrfun add-in is shown in this work sheet. This can be deleted if required.

	A	B	C
1	Filename:	gr072705_000.sig	gr072705_001.sig
2			
3			
4		Relative	Relative
5	Wavelength	Reflectance	Reflectance
6	350	0.78	-0.34
7	351	-0.20	0.00
8	352	-0.14	-0.20
9	353	0.07	0.64
10	354	0.03	1.93
11	355	-0.05	1.25
12	356	-0.01	-0.40
13	357	0.13	-0.56
14	358	-0.04	0.04
15	359	-0.74	0.13
16	360	-0.94	-0.05
17	361	-0.30	-0.09
18	362	0.10	0.17
19	363	0.01	0.49
20	364	0.10	0.30
21	365	0.05	0.00
22	366	-0.75	0.39
23	367	-0.93	1.05

Relative reflectance data interpolated to a 1nm spectral

Absolute Reflectance Data

Spectral reflectance data from the Relative Reflectance worksheet is scaled to absolute reflectance values by multiplying each value with the calibration data for the selected Reflectance panel.

> **Note:**
> The Ref. Panel is selected from the drop down menu (cell H27) on the Input Parameters worksheet

	A	B	C	D
1		Filename:	gr072705_000.sig	gr072705_001.sig
2				
3				
4		Ref. Panel	Absolute	Absolute
5	Wavelength	SRT 13160A	Reflectance	Reflectance
6	350	0.949	0.82	-0.36
7	351	0.949	-0.21	0.00
8	352	0.949	-0.14	-0.21
9	353	0.949	0.07	0.67
10	354	0.949	0.03	2.04
11	355	0.949	-0.05	1.32
12	356	0.949	-0.01	-0.42
13	357	0.949	0.14	-0.59
14	358	0.949	-0.05	0.04
15	359	0.950	-0.78	0.14
16	360	0.950	-0.99	-0.05
17	361	0.950	-0.32	-0.10
18	362	0.950	0.11	0.18
19	363	0.950	0.01	0.52
20	364	0.950	0.11	0.31
21	365	0.950	0.05	0.00
22	366	0.950	-0.79	0.41
23	367	0.950	-0.98	1.11

Absolute reflectance data calculated using calibration data from the calibrated Reflectance panel SRT13160A

Graphing Relative Reflectance data with the Template Macro

A simple graphing macro **plot_rel_reflect** (or short-cut keys **Ctrl + g**) is available to graph the first 25 spectra in the *Relative Reflectance* worksheet. Use the Excel Chart Wizard or edit the source data to select your own data plots.

	A	B	C	D	E	F	G	H	I
1	Filename:	gr081805_000.sig	gr081805_001.sig	gr081805_002.sig	gr081805_003.sig	gr081805_004.sig	gr081805_005.sig	gr081805_006.sig	gr081805_007.sig
2									
3									
4		Relative	Relative	Relative	Relative	Relative	Relative	Relative	Relative
5	Wavelength	Reflectance	Reflectance	Reflectance	Reflectance	Reflectance	Reflectance	Reflectance	Reflectance
6	350	7.74	8.24	8.75	7.46	7.44	7.85	7.78	8.00
7	351	7.73	8.24	8.73	7.46	7.44	7.85	7.78	8.01
8	352	7.72	8.22	8.73	7.46	7.44	7.85	7.78	8.01
9	353	7.72	8.22	8.73	7.45	7.44	7.85	7.78	8.01
10	354	7.73	8.23	8.75	7.46	7.45	7.85	7.78	8.02
11	355	7.73	8.24	8.76	7.45	7.45	7.87	7.78	8.02
12	356	7.72	8.2						8.02
13	357	7.74	8.2						8.03
14	358	7.75	8.2						8.04
15	359	7.76	8.2						8.04
16	360	7.76	8.2						8.04
17	361	7.76	8.2						8.04
18	362	7.76	8.2						8.05
19	363	7.77	8.2						8.06
20	364	7.77	8.3						8.07
21	365	7.76	8.3						8.07
22	366	7.77	8.3						8.07
23	367	7.78	8.3						8.08
24	368	7.79	8.3						8.10
25	369	7.80	8.3						8.11
26	370	7.80	8.3						8.11
27	371	7.81	8.3						8.12
28	372	7.82	8.3						8.14
29	373	7.84	8.3						8.16
30	374	7.86	8.4						8.17
31	375	7.87	8.4						8.18
32	376	7.87	8.4						8.18
33	**Spline**								
34									
35	Returns the Y at a given X on the natural cubic spline curve defined by a given set of points.								
36									
37	XlXtrFun.xll (c) Scott Allen Rauch, Advanced Systems Design and Development, 1993-1999. www.netrax.net/~jdavita/XlXtrFun.htm								
38									
39	**Syntax**								
40									
41	Spline(ArrayOfXs , ArrayOfYs, GivenX , Extrapolate?)								
42									
43	ArrayOfXs — one-dimensional array of numbers, or a contiguous group of cells containing numbers arranged either in a row or a column. The values must be either constantly inc								

Chart inset (rows 11–32):

Relative Reflectance

Y-axis: Reflectance (0.0 to 14.0)
X-axis: Wavelength (nm) (350 to 1050)

Tabs: Input Parameters | **Relative Reflectance** | Absolute Reflectance | Signature Data | Refere

X-Y scatter plot of relative reflectance data using the plot_rel_reflect macro (short-cut keys Ctrl + g)

Note:
The spreadsheet can now be saved for further processing.

3. Post Processing Spectral Radiance / Irradiance Data Files

Each of the Field Spectroscopy Facility's GER 1500 spectroradiometers has a number of optional fore optic accessories, which can also be configured for spectral radiance or spectral irradiance measurements. However each configuration will have its own unique calibration file[1] and it is essential that this file be used when converting raw spectro-radiometric data into absolute radiance or irradiance values. The Excel template, which performs the necessary calculations on GER 1500 raw data, is described below. This template includes the calibration files for a variety of optical configurations.

Excel Macro Security Level

Before the Excel templates can be opened it is necessary for the Macro Security level be set to allow the template's macro and Visual Basic code to be enabled.
- From the Excel *Tools* menu select *Options* and the *Security* tab.
- Click on the *Macro Security* button and change the *Security Level* to *Medium*.
- If using **Excel 2007** click on the 'office' button in the top left corner of the screen. Excel options – Trust center. Trust center settings – macro settings – enable all macros – OK.

This will allow the macros to be manually enabled when opening the Excel template.

Opening and Saving the GER 1500 Radiometric Calculator Template

- Start Excel and from the File menu Open and select the FSF Excel template for calculating absolute spectral radiometric values from GER 1500 raw data files:

  GER 1500 Radiometric Calculator_Ver 03.XLT

- In the Security Warning dialog click the **Enable Macro** button.
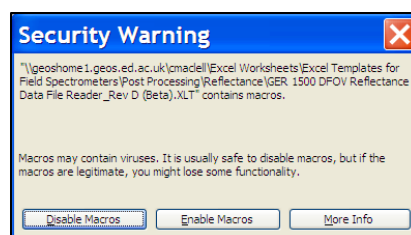
The new spreadsheet will open on it's *Input Parameters* worksheet as shown below:

Note:
As the template is a read only document it needs to be opened and renamed as an Excel .XLS worksheet, prior to running the macros.
If using **Excel 2007**, it will need to be saved as a .xlsm (macro enabled excel worksheet).
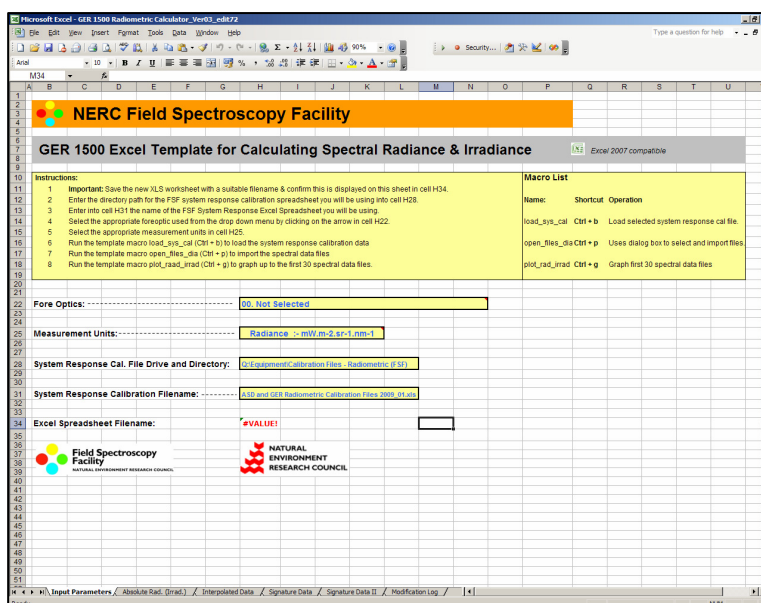
The 'Input Parameters' worksheet from the GER 1500 Spectral radiance & Irradiance Calculator spreadsheet.

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[1] Unlike the more commonly measured spectral reflectance.

- Save the spreadsheet as an .XLS document with a name and directory of your choice. The new name is displayed in cell H33 of the Input Parameter worksheet.

Setting up the Excel Template Parameters

The *Input Parameter* worksheet allows the user to select the calibration file for the optical configuration and the preferred measurement units for the data processing. The user also needs to specify the path/directory and root filename for the system response calibration file here.

- Click on cell **H22** to bring up the pop down menu button. Click on the button to display the 24 calibration files available for the four GER 1500 spectroradiometers and their various **Fore Optic** accessories, and then select the calibration file which matches the serial number of the GER 1500 used, and its fore optic. *This will be used to convert the raw data values into absolute spectral radiance or irradiance.*

- Click on cell **H25** and select from the drop down menu your measurement type and preferred units.
  - Radiance :- µW.cm-2.sr-1.nm-1
  - Radiance :- mW.m-2.sr-1.nm-1
  - Irradiance:- µW.cm-2.nm-1
  - Irradiance:- mW.m-2.nm-1

- The system response calibration data for the GER 1500 with its fore optic is stored in a separate Excel spreadsheet. Enter into cell **H28** the root directory path where this spreadsheet is located on your computer.

- Enter into cell **H31** the name of the System Response Calibration File which is stored on your computer.

> Note:
> It is critical that the correct system response calibration file is selected. Please ensure the instrument serial number and fore optic exactly matches your measurement setup. It is also important to ensure that the system response calibration file corresponds to the same year that the measurements were taken. Files from previous years are archived on the FSF website, please contact FSF for further advice on this.

Running the template Macros
The Excel template includes three macros
  - To load the GER 1500's system response calibration file
  - To import, format and calculate the radiometric values from the raw data files
  - To graph the first 30 calculated radiometric data files

Each of these Excel macros can be run from the Tools / Macro menu or using the short-cut keys listed on the Input Parameters worksheet.

Macro for Importing the System Response Calibration Data
Before the data can be processed it is necessary to run the macro *load_sys_cal* (Ctrl + b)*. This will read the file root and name in cells H28 and H31 and import the calibration data from the panel calibration spreadsheet into column B of the *Absolute Rad. (Irrad.)* worksheet.
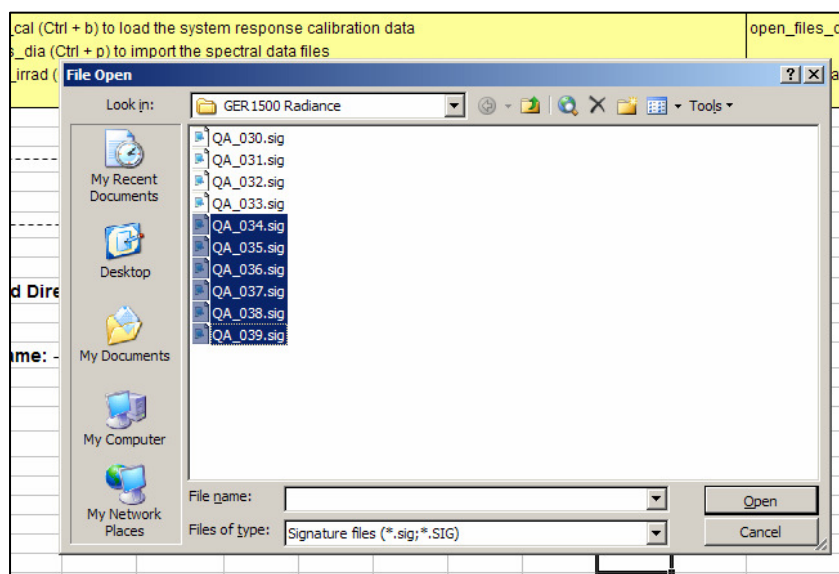
- Use the short-cut keys ***Ctrl*** + ***b*** to load the selected system response cal data. This will appear in column 'B' of the 'Absolute Rad (Irrad)' worksheet.

The Excel spreadsheet is now ready to import data.

Importing Data with the open_files_dia Macro

The Excel template can import up to a maximum of 102 GER raw data files from the selected directory. The raw data files from the GER spectroradiometers are comprised of a file header with measurement parameters, a column with the wavelength scale and two columns of Target and Reference spectral data[2]. Only the Target spectral data is used here.

• Start the ***open_files_dia*** Macro from the Tools \ Macro\ Macros menu or use the short cut keys ***Ctrl + p***

• A 'File open' dialogue box will prompt you to select all the .sig files that you wish to import into the template. Highlight these and then click 'open'.

A prompt box will open showing the number of files selected for import. Click ok to this and the files will begin to be imported. During the importation procedure the data file names will appear and disappear from the Windows task bar. The procedure can take several minutes depending on the number of data files selected and the speed of your computer. A further delay is to be expected as Excel interpolates to 1nm the raw data values for each of the spectral data files over the range 350 to 1090nm.

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[2] The two columns of GER 1500 *raw* spectral data are always normalised to unit time – counts per second.

The Signature Data worksheet

This worksheet shows up to 51 raw data files with the file header slightly reformatted.

A second worksheet, **Signature Data II**, is used to store raw files numbers 52 to 102.

	A	B	C
1	///GER	SIGNATUR	FILE///
2	Filename	**100_Std FOV_000.sig**	
3	h_name=	100_Std	FOV_000.sig
4	instrument=		2038
5	target time=	23/02/2006	18:32:18
6	ref time=	23/02/2006	18:32:10
7	long=		
8	lati=		
9	gpstime=		
10	comm=		
11	memory slot=		
12	averaging=	4	4
13	int. speed=	6	6
14	optic=	5	5
15	data=	Target	Reference
16	272.95	93	96
17	274.99	94	93
18	277.01	92	91

Note:
Only the Wavelength and Target data in the signature files are used in this template. Reference data is ignored.

Signature Data Worksheet - GER 1500 raw data files imported and formatted

The Interpolated Data Worksheet

The raw Target GER 1500 Signature data is interpolated to 1nm interval over spectral range 350 – 1090nm using the Xlxtrfun Spline add-in. Details of the Spline add-in are included in this worksheet.

	A	B	C
1	Filename:	100_Std FOV_000.:	100_Std FOV_001.: 10
2			
3			
4		Interpolated	Interpolated
5	Wavelength	Raw Data	Raw Data
6	350	124.02	125.92
7	351	127.65	127.34
8	352	130.84	126.77
9	353	130.02	129.97
10	354	129.94	133.96
11	355	135.98	134.20
12	356	141.34	135.51
13	357	141.06	141.66
14	358	143.66	147.22
15	359	151.57	149.18
16	360	153.58	151.17

Interpolated Data Worksheet

The Absolute Rad. (Irrad.) Worksheet

The interpolated data is converted to absolute spectral radiometric values by multiplying each value with its unique calibration factor (column B) from the chosen calibration file, cell H22 of the Input Parameters worksheet.
The data is further scaled to match the selected measurement units set in cell H25 of the Input Parameters worksheet.

	A	B	C	D	E
1		Filename:	100_Std FOV_000.:	100_Std FOV_001.:	100_Std FOV_002.:
2		Measurements Units:	mW.m-2.sr-1.nm-1	mW.m-2.sr-1.nm-1	mW.m-2.sr-1.nm-1
3					
4		Calibration File	Spectral	Spectral	Spectral
5	Wavelength	02. GER #2003 Std Lens	Radiance	Radiance	Radiance
6	350	1.31E-03	0.16	0.16	0.16
7	351	1.31E-03	0.17	0.17	0.17
8	352	1.32E-03	0.17	0.17	0.18
9	353	1.33E-03	0.17	0.17	0.18
10	354	1.33E-03	0.17	0.18	0.18
11	355	1.34E-03	0.18	0.18	0.18
12	356	1.35E-03	0.19	0.18	0.18

Absolute Rad. (Irrad.) Worksheet

Graphing Radiometric data with the plot_rad_irrad Macro
The graphing macro *plot_rad_irrad* automatically plots the first 30 available spectra in the Absolute Rad (Irrad) worksheet.

- From the Tools/Macros menu select and run the **plot_rad_irrad** macro or use the macro short-cut keys ***Ctrl* + *g***
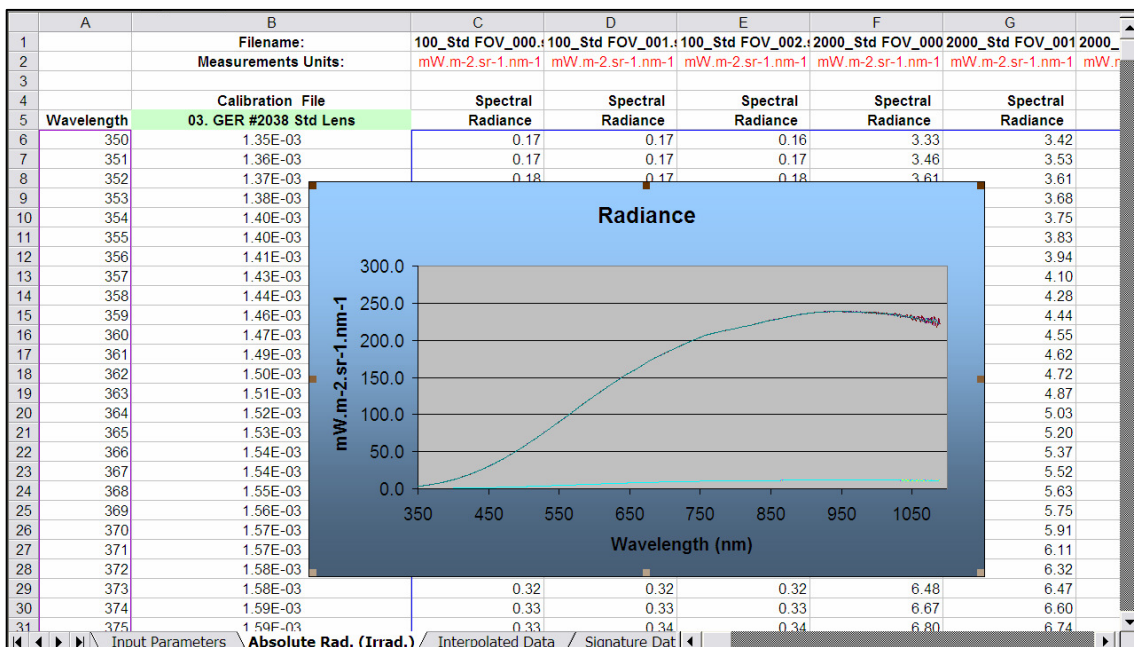
X-Y scatter plot of absolute spectral radiance in mW.m-2.sr-1.nm-1 using the plot_rad_irrad macro

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Note:
The spreadsheet can now be saved for further processing.