

FSF Application Note:-

Dual FOV Measurements with SVC HR-1024i Field Spectroradiometers – Bi-Conical Relative Reflectance Method

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Authors: Chris MacLellan, Dr. Andrew Gray

In field spectroscopy a single spectroradiometer is typically used to measure surface reflectance with comparison to a known spectral reflectance surface (calibrated white reflectance panel). Under stable ambient lighting conditions it is possible to measure several target surfaces with respect to a single reference measurement the calibrated panel. However, ambient light stability typically requires an updated reference measurement at best every 5 minutes and more typically every 30 seconds.

This application note outlines the method for using two field spectroradiometers (SVC HR-1024i) with two reference reflectance panels to collect reflectance data and compensate for variation in the ambient light level through prolonged target sampling periods. In this configuration only the reflectance data is used and it is therefore not necessary to have the spectroradiometers radiometrically calibrated for spectral irradiance and radiance.

- Equipment:**
- (i) Two SVC HR 1024i field spectroradiometers with PDA computers
 - Spectroradiometer #1 (Downwelling) - 4° FOV lens
 - Spectroradiometer #2 (Upwelling)- Fibre optic probe or fore optic lens
 - (ii) Two 25 x 25 cm calibrated reflectance panels with tripod mounts
 - (iii) Three tripods (spectroradiometer #1, and two reference panels)
 - (iv) Additional tripod, monopod or backpack for spectroradiometer #2





Equipment Setup:

- Use the Bluetooth interface to connect the PDA computers to their spectroradiometers. Ensure communication is working. For single operator mode place both PDAs on a belly board.
- Synchronise the PDA clocks.
- Ensure the “Scan Times” match on each of the PDA applications.
- Setup the fore optics. Setup working directories and base filename.
- Disable photo mode in both systems if the fibre optic is fitted to spectroradiometer #2.
- Enable photo mode in both systems if acquiring a target photo from spectroradiometer #2. This will ensure the measurement and data upload times are approximately equal.
- Typical maximum working for the Bluetooth interface is typically 50 – 100m.
- It is not essential that the reference panels are located together but it may assist to have them located near the centre edge of large plots. Mount the two reflectance panels on their tripods. Use spirit level to ensure the panel is horizontal. Ideally the panel should be at a height equivalent to the top of the target surface/canopy. For low vegetation and soil/ rock this may not be possible, the tripod should be lowered to its minimum height.
- Mount spectroradiometer #1 on a tripod ~ 0.5 to 1.0 metre above the reference panel. Use the spirit level and the HR-1024i alignment laser to ensure it has a nadir view and the fore optic is centred on the panel – refer to the HR-1024i user guide for FOV fore optic size and location with respect to the alignment laser. It is essential that the field of view of spectroradiometer is not greater than 80% of the panel dimensions. Spectroradiometer #1 will not move during the measurement sequences.
- The second field spectroradiometer (#2) is portable, taking measurements of both a reference reflectance panel and various target surfaces. It can be mounted on a monopod/tripod or backpack with fibre optic. However, it is essential that it is carefully aligned when viewing its reference panel. The alignment laser can be used when a FOV lens is fitted, but great care is required when using the fibre optic probe with pistol grip. Under these circumstances a laser pen fitted to the pistol grip or wrist support can aid alignment. Note the distance between the panel and the fibre is reduced in comparison to the 4° or 8° fore optic lenses.
- Test each spectroradiometer by acquiring a Reference scan. Note the reference scan data will only be saved after a Target scan. Practice clicking on both PDA screens to initiate near simultaneous acquisition of reference scans in the both spectroradiometers.

Dual Reference Panel Measurement:

Align both spectroradiometers to view their respective reference panels as shown in Figure 1.

1. Tap on the **Reference** buttons on each PDA screen to near simultaneously acquire a new reference scan in each spectroradiometer. Wait for the measurement to complete and the data to upload to the PDAs.
2. Tap on the **Target** buttons on each PDA screen to near simultaneously acquire a target reference scan in each spectroradiometer.
3. Switch the Graph plot modes in both PDAs from radiance to reflectance.
4. Record information in log sheet – “Target measurement of panel”. You can now proceed to take multiple target measurements. Always confirm the filenames match on both PDAs.

Dual Reference & Target Measurements:

1. Move spectroradiometer #2 to target area and align as necessary (preferably nadir mode).

2. Tap on the **Target** buttons on each PDA screen to near simultaneously acquire a target reference scan in each spectroradiometer.
3. Record information in log sheet – “Target measurement of *sample?*”, scan number or time.
4. Repeat for multiple targets.
5. It is recommended that spectroradiometer #2 periodically returns to its reference panel for a “Target”. This will be used to evaluate the effectiveness of the DFOV technique at compensating for variations in ambient lighting.

Note: The reflectance plot may now have deviated from its initial 100% straight line. With the exception of the data in the atmospheric water bands you may set your own limits (say $\pm 10\%$) for this level before initiating a new Reference scan.

6. Always finish a measurement sequence with a Target measurement of the reference panels.

Data Processing:

The reflectance data collected by spectroradiometer #1 is a comparison of the ambient light level at the time of the Target scan with respect to the ambient light level at the time of the Reference scan. As the two spectroradiometers are triggered simultaneously the time stamp on each file can be used to apply correction to compensate for variation in the ambient light level at the time of the target canopy measurement (spectroradiometer #2).

The reflectance data collected by spectroradiometer #2 uses the reference measurement of the panel at the start of a sequence. An error in the spectral data can occur if the ambient light level has changed between this reference and a target measurement. Using the reflectance data from spectroradiometer #1 it is possible to compensate for this and minimise the error.

The table below details the sequence for processing the data and applying spectral compensation to the reflectance data collected

Practice Data can be downloaded as a zip file from our website:

http://fsf.nerc.ac.uk/resources/guides/DFOV_Sample_Data.zip

Click on the following link under Under SVC HR-1024i:

“Practice data and field guide for using two SVC HR-1024i spectroradiometers in dual field of view (DFOV) configuration”

Spectroradiometer #1	Spectroradiometer #2
PDA Data	PDA Data
Copy data to PC or laptop Label Directory – Ambient Monitor	Copy data to PC or laptop Label Directory – Target Data
Use SVC application Tools menu to:- 1.Remove overlap data with Matching type - Reflectance	Use SVC application Tools menu to:- 1.Remove overlap data with Matching type - Reflectance
Note : This data should NOT be scaled with White Plate Correction	Use SVC application Tools menu to:- 2. Apply White Plate Calibration Correction using calibration reflectance data for panel #2

Use SVC application Tools menu to:- 2. Resample Spectral Data to 1nm interval over the range 350 – 2500 nm.
Use FSF Excel template to import data files into a spreadsheet.
Copy data in Reflectance tab into FSF DFOV spreadsheet - Ambient Light Data tab.

Use SVC application Tools menu to:- 3. Resample Spectral Data to 1nm interval over the range 350 – 2500 nm.
Use FSF Excel template to import data files into a spreadsheet.
Copy data in Reflectance tab into FSF DFOV spreadsheet – Reflectance Data tab.

FSF Excel Spreadsheets for HR-1024i data

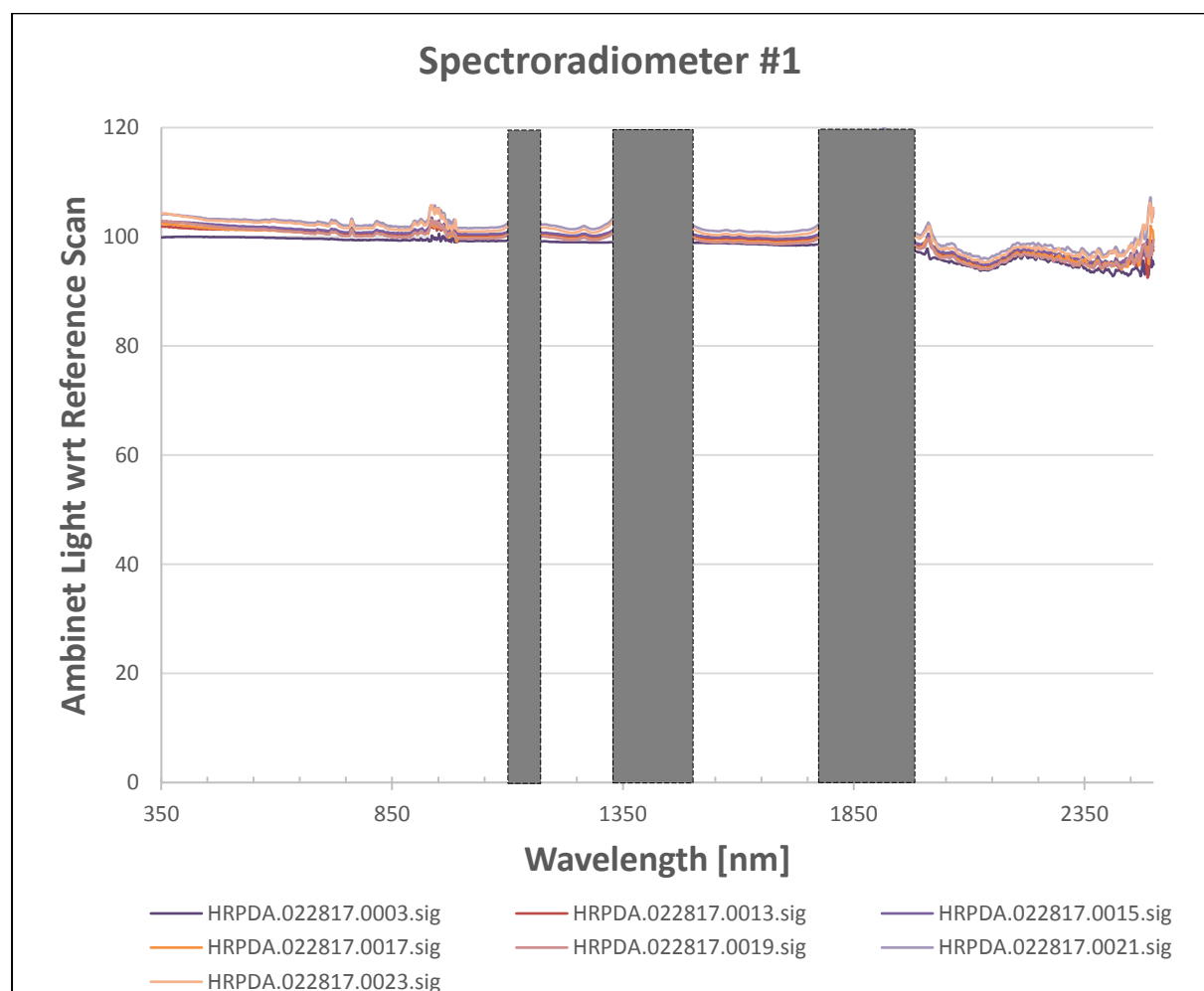
FSF have developed a range of Excel spreadsheet templates with macros to import and process multiple SIG data files.

Note it is essential that the data is pre-processed using the SVC tools to remove overlap data, interpolate to 1nm etc as detailed above.

1. SVC HR 1024i Data File Importer

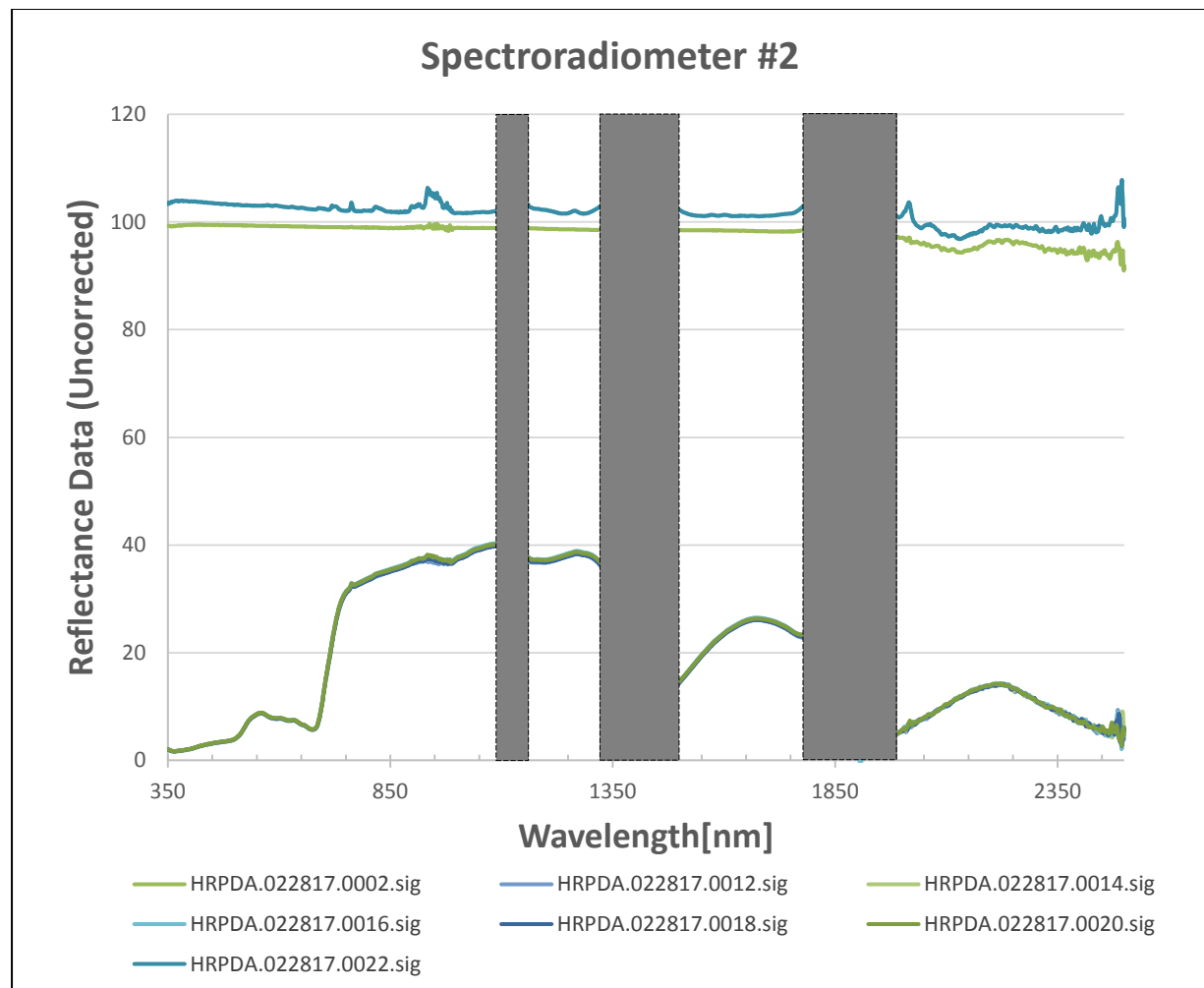
Use two separate spreadsheets to import the SIG data files acquired with the “Ambient Light” (#1) and “Plant Canopy” (#2) spectroradiometers. The Reference scans is designated time zero (t_0) for both spectroradiometers and each Target scan at near simultaneous times t_1 , t_2 etc.

Open the Reflectance Data tab for spectroradiometer **#1**. This represents the ambient light level with respect to the reference scan level at time zero. Plot the reflectance data.



The graph shows the variation in ambient light at various times from the reference level (100%). The major water absorption bands are also shown for illustration purposes. On a perfect 'blue sky' day the variation in ambient light levels could be negligible over periods of several minutes. In this example the illumination was variable with some cloud cover.

Open the Reflectance Data tab for spectroradiometer **#2**. This represents the uncorrected reflectance data for vegetation targets and 'Target' measurements of reference panel #2 at various times during the sequence.



Plots HRPDA.022817.0002 and0022.sig show the target reflectance data from the panel at the start and end of the measurement sequence. It is clear that the ambient light levels have changed significantly both inside and outside the atmospheric water absorption bands. However, although present, the change in ambient lighting is more difficult to visualise in the plant canopy reflectance data.

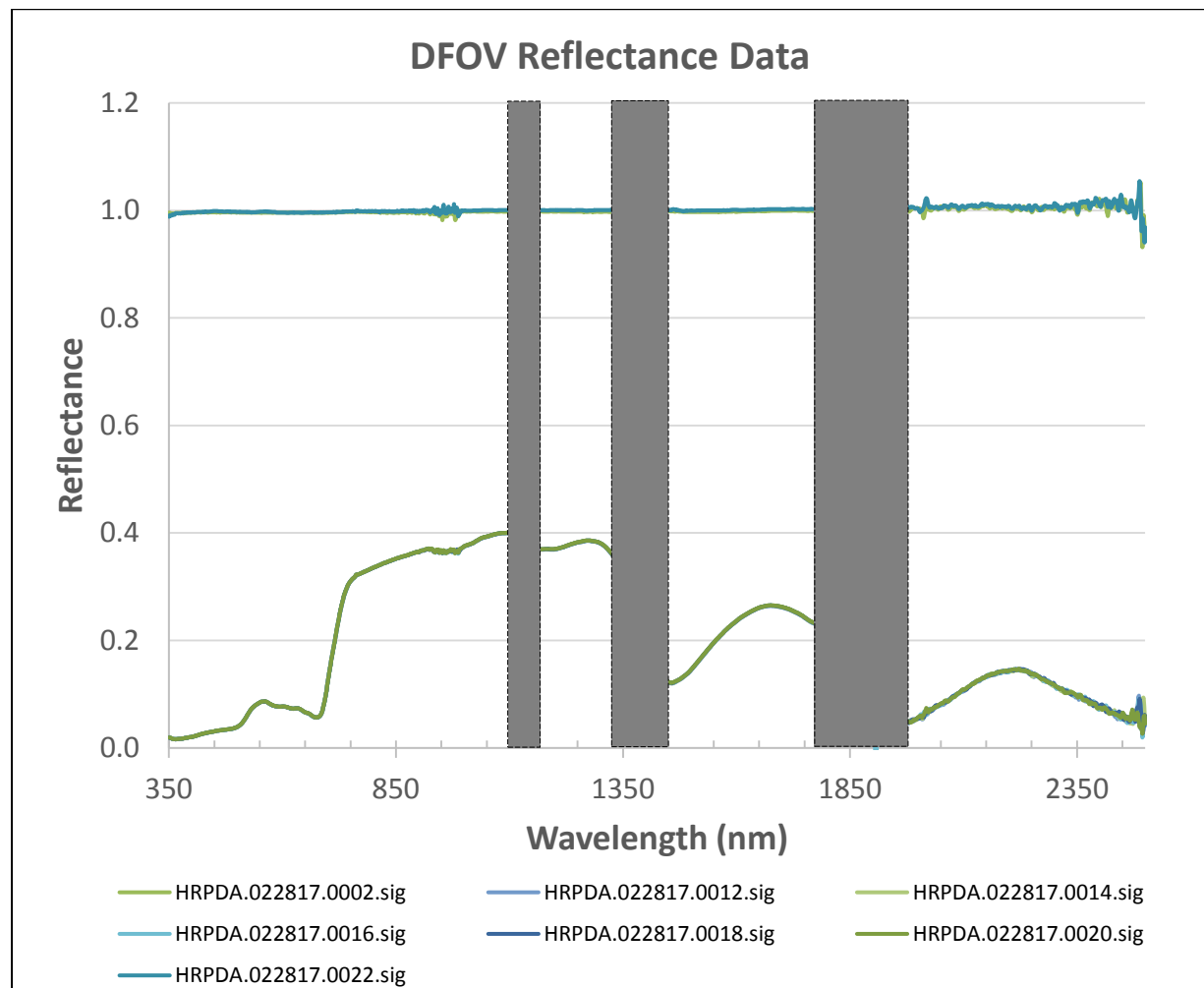
2. SVC HR 1024i DFOV Data Template – Bi-Conical Relative Reflectance Method

This template imports the pre-processed SIG data files from Spectroradiometer #1 and #2 into SIG #1 and SIG #2 tabs from which it generates the Ambient Light Data and Reflectance Data tabs as detailed above.

At this point it is essential to ensure that the filename sequences for the two data sets match the log sheet records. Any anomalies can be checked out by referring to the time stamp for the Target scan in the SIG data file headers.

This Excel template includes a DFOV tab which processes the reflectance data form Spectroradiometer #2 and spectrally adjusts it to compensate for the change in the ambient light level between the reference and target scans as measured by spectroradiometer #1.

Open the DFOV tab and plot the corrected reflectance data. Note this data is now normalised to 1. Again the effect of compensating for variations in the ambient light is more obvious in the reflectance data for the white reflectance panel, but there is a visible reduction in the variability of the plant reflectance data.



DFOV Calculations¹:

$$\text{Spectroradiometer \#1 Reflectance} = \frac{\text{Target Data Spectrometer \#1 at time } t_n}{\text{Reference Data Spectrometer \#1 at time } t_0}$$

$$\text{Spectroradiometer \#2 Reflectance} = \frac{\text{Target Data Spectrometer \#2 at time } t_n}{\text{Reference Data Spectrometer \#2 at time } t_0} * k$$

¹ Assumes all data has been pre-processed by SVC tools to remove overlapped data, interpolated to 1nm etc.

where k are the reflectance factors for the reference panel. This is applied using the SVC Tools / White Plate Correction.

$$\text{DFOV Reflectance} = \frac{\text{Reflectance Data Spectrometer \#2 at time } t_n}{\text{Reflectance Data Spectrometer \#1 at time } t_n}$$