Field Spectroscopy Facility
NATURAL ENVIRONMENT RESEARCH COUNCIL

Field Guide for the ASD FieldSpec Pro - White Reference Mode

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These tips provide reminders of the key processes involved in the setting up and use of the ASD FieldSpec Pro spectrometer for use in White Reference mode in the field. You should discuss your data requirements with the Pool Manager at your training session to decide whether this mode of operation is best suited to your application. For measurements requiring post-processing calibration to radiance or irradiance it is more appropriate to use Raw DN Mode (see user note ASD/Gen/01/02).

The advantage of saving data in WR mode is that the user gets an instantaneous view of the quality of the spectra being collected. The spectral curve shown on screen during WR mode of operation is closer to the final product than is seen when raw DN mode is used. This allows for real-time quality control of spectra since most errors (spectral steps etc) can be eliminated before the data are actually saved.

The ASD FieldSpec is full-range computer-controlled spectroradiometer, whereby a portable PC is used to control the scans collected by the instrument, while also allowing real-time on-screen visualisation of the data collected.

1. Power

Ensure all batteries (12V cells and internal batteries for the FieldSpec and Computer) are fully charged before departing into field. Ideally we recommend that you take a Voltmeter with you to check the charge of the 12V batteries, which should bear a charge of ~13V when fully charged.

Computer

Charge the Dell Latitude PC on the mains prior to use in the field. It is recommended that the PC be charged overnight after a full day's use in the field. When in use in the field, always use the Dell car charger with 12V battery converter to provide power to the computer, as the internal battery is unlikely to last very long without an external source plugged into it. A fully charged 12V battery providing power to a fully charged computer should provide a full day's power. If you do not connect an external 12V battery to the computer, the computer's internal power supply will last no more than approximately 1 hour in the field, because the software and spectrometer communications are very power-hungry.

Spectrometer

To provide power to the spectroradiometer, use one of the following:

- Mains power lead
- ASD 12V battery converter cable

When charging, the battery status LED on the front of the spectrometer housing will appear red in colour. When fully charged, this light will turn green. You should make sure that the spectrometer's internal battery is fully charged before going into the field. The internal battery takes ~4 hours to charge from flat status on a mains adapter. In the field you should always connect a 12V battery to the spectrometer to ensure that you will not be limited by battery problems.

2. Spectrometer Warm-up

It is recommended that you "warm up" the ASD FieldSpec prior to use for spectral measurement collection. We strongly recommend a warm up time of 30 minutes. This means that you should attach the mains supply or 12V battery and switch the spectrometer on, so that both lights appear on the front panel of the radiometer at least 30 minutes before use.

The reason for the long warm up time required for this instrument is that the three spectrometer arrays warm up at different rates once they have been powered up. This can result in spectral phenomena occurring in Users data, if an appropriate warm up time is not used. The main areas of concern are the overlap regions between the VNIR Silicon photodiode detector array and the SWIR1 InGaAs array; and at the SWIR1:SWIR2 detector overlay region. If a warm up time of less than 30 minutes is used, it is common to find that spectral steps will occur at the wavelength regions associated with the detector overlap regions described above (i.e. 1000nm and 1800nm). This is due to the fact that ASD and FSF derive all wavelength and radiometric calibrations after a 30 minute warm up. By using the appropriate warm up period, you will significantly increase the quality of your data and will minimise errors caused by warming of the spectrometer array inside, which are later difficult to rectify.

TIP - before leaving to go into the field, plug the spectrometer into the mains and power it up to begin the warm up period. This will ensure that you do not waste valuable battery power on warming the spectrometer up. Before leaving to go into the field, connect a 12V battery and leave the spectrometer switched on and warming up. By the time you reach your field site, the required 30 minute warm up period will be complete and you can commence your measurements straight away.

3. Setup

1. Ensure that the spectrometer is powered up and that an external battery source is connected.
2. Attach the parallel cable to the parallel port at the back of the spectrometer.
3. Attach the other end of the parallel cable to the printer port of the Dell PC.
4. Power up the Dell PC, ensuring that you have a 12V battery connected to it.

   NOTE that the spectrometer must always be switched on <u>before</u> the computer. Failing to do this when the parallel cable is connected can cause irreparable damage to the spectrometer arrays which can result in instrument malfunction.

5 Open Windows Explorer. Create a directory for yourself in the "Users" folder.
6 Start the ASD data collection software. The two versions relate to the colour screen for use in the lab RS^3), and a High Contrast RS^3 for ease of use in the field. Both operate in exactly the same way apart from the colour of the display.
7 Select the menu at the top of the screen called ***SPECTRUM SAVE.***
8 Type the full drive and path name of the folder in which to save your data (i.e. the folder you just created in Windows Explorer).
9 In the box labelled ***File Base***, think of a suitable root name for your spectra (up to 8 letters). This could be a site name, or surface type for instance "*beach1a"* for site 1a on the beach.
10 Set the ***Starting Spectrum*** to 0
11 Set the ***Number of Spectra to be Saved*** option to 1
12 Note that you can also perform timed measurements, but these are **not recommended** for reflectance measurements.
13 When the above parameters are set, click ***OK***.
14 Now choose the menu option named ***CONTROL*** and select the submenu called ***Adjust Configuration***.
15 Set the foreoptic to the appropriate setting (i.e. according to the optic you have attached). If using the contact probe, choose ***Bare Fibre*** here.

16 Change the ***Averaging*** to at least 25 for all three options (spectrum, dark current and white reference).
17 ***Averaging*** sets the spectrum averaging for each scan. Increasing the averaging improves the signal:noise ratio of your spectra, but be aware that more averaging means longer scan times. For field use it is recommended that you use a setting of 50 for each of the three options. 25 is the absolute minimum as below this, signal:noise ratios in the SWIR will fall to a level that spectra collected will be mostly dominated by noise.
18 In the pull-down menu at the top of the screen note that the data type is currently set to ***RAW DN*** (default). Leave this setting at Raw DN for the moment.

You are now ready to begin collecting data.

4. Data collection

To collect a scan with the ASD instrument, you must first position the pistol grip with the desired optic attachment over the target of interest. The pistol grip can be stabilised on a tripod, or hand held. If you are using the contact reflectance probe, this must be hand-held and pressed to the surface of the sample to be measured. Please see specific guidance notes for the contact probe in section 5.

4.1 Optimisation

Optimisation adjusts the sensitivity of the instrument's detectors according to the specific illumination conditions at the time of measurement. Therefore it is necessary to optimise the detectors regularly under field conditions to ensure that changing levels of downwelling irradiance do not cause the detectors to saturate.

To optimise, position the pistol grip over the Spectralon panel, viewing from nadir. Press the ***OPT*** button on the top left hand side of the screen. (Alternatively, press the ***CTRL*** and ***O*** keys on the keyboard.) The instrument should now optimise, and you will be able to visualise this process on-screen. Following this, you will hear a slight audible click within the instrument, and a prompt window will appear in the FR programme. This will prompt you to prepare for ***dark current collection.*** Click ***OK***. The instrument will proceed with dark current collection (see section 4.2), and at the end of the measurement, the screen will return to a normal measurement screen where the raw signal (DN) is displayed as a function of the sensitivity of the three detectors.

You should optimise the instrument at the start of each day's measurements, and repeat as necessary according to the changing irradiance conditions. As irradiance increases towards Solar noon, you may notice the detectors saturating. You must re-optimise at this point, and make a note on your instrument log sheet of the time of the optimisation.

4.2 Dark Current (DC)

A certain amount of electrical current generated by thermal electrons within the ASD is always added to that generated by incoming photons of light. This electrical component of the signal is false data, and is referred to by ASD as ***DARK CURRENT.*** The two SWIR detectors have an automatic dark current correction, performed on each measurement as it is collected by means of a dark pixel on the end of each array. However, the VNIR array does not have this facility and DC must be subtracted on a channel-by-channel basis.

As we have already shown, DC is automatically collected during every optimisation. We also recommend collecting additional DC measurements every 20 minutes in order to take into account the changing state of the VNIR detector. The DC is not saved as an actual measurement you can see, but is stored in the PC's memory and applied to every subsequent measurement. Use the ***DC*** button on the top toolbar to collect a DC measurement. The timer in the top left hand box will remind you of how recently your last DC measurement was collected.

Again, it is very important to make a note of the time when you collect DC measurements on your log sheet.

4.3 White Reference Scan

The first surface you measure should always be the Spectralon reference panel. So to begin with, position the pistol grip over the Spectralon panel.

In the FR collection software, allow for 2 screen refreshes to allow the spectrometer to adjust to the new surface. When you are happy that the signal from the Spectralon is stable, click the ***WR*** button which appears at the top left hand side of your screen, on the top menu bar.

This will then set the software collecting a ***WHITE REFERENCE*** scan. The computer will first perform a Dark Current measurement, and will prompt accordingly. The software will then collect a scan of the Spectralon panel and store this in the computer's memory. Every subsequent surface that the fibre optic measures will be displayed on-screen and saved as a ratio between the DN of the new surface relative to the DN of the Spectralon WR stored in the computer's memory.

The advantage of saving data in WR mode is that the user gets an instantaneous view of the quality of the spectra being collected. The spectral curve shown on screen during WR mode of operation is closer to the final product than is seen when raw DN mode is used. This allows for real-time quality control of spectra since most errors (spectral steps etc) can be eliminated before the data are actually saved.

Make sure that you write down the exact time and sky conditions of each white reference scan on your log sheets for future reference.

4.4 Checking the 100% line

The timer in the "white reference" window on the left hand side of the screen indicates the time elapsed since the last WR scan was collected. It is recommended that you check the quality of the 100% line of Spectralon every 2-3 minutes. This is easily performed by placing the Spectralon panel under the fibre optic at regular intervals. You should see a line appear on screen at around 100%, representing the Spectralon ratioed against itself. Look for deviations from 100% of this line. If any steps or slopes appear then you should collect another white reference scan using the ***WR*** button. This is essential in order to minimise the effects of the changing atmosphere on the resultant spectra.

4.5 Spectral Data Collection

Once you have collected your first white reference, you are ready to collect spectra. Point the pistol grip at the surface of interest (grass, sand, rocks etc). Allow for two screen refreshes, and when the graph on the screen stabilises, press the ***SPACE BAR*** to collect a scan. The computer will beep twice to confirm that the file has been saved, and the scan name in the bottom left hand corner of the screen will advance by one file (i.e. from *beach1a.000* to *beach1a.001;* where *beach1a.001* is the next scan to be saved).

After the beeps, you should move the pistol grip over a new target surface. Once the pistol grip is stabilised over the surface, wait for two screen refreshes and press the ***SPACE BAR*** again. You should hear two beeps again.

Repeat over a range of surfaces, making sure that you check the 100% line of the Spectralon reflectance regularly.

4.6 Spectralon Panel Care

Handle the Spectralon panel carefully - do not touch the surface. Mount the Spectralon on a tripod using the panel mounting clamp. If insects or dirt land on the surface gently blow them away - do not squash, crush, swipe as this will impair the surface of the panel. If the panel becomes dirty, please contact FSF for instructions on how to clean it.

4.7 Atmospheric water

Many people who have only ever used the spectroradiometer in the lab, are shocked to see some patches of extreme noise in their field data, centred at 1400 and 1800nm. These are normal in field data and are due to the presence of water vapour absorbing light in these wavelength regions as it passes through the atmosphere.

4.8 Weather conditions

It is recommended that you only collect field spectral measurements when the weather is fine and stable. Even hazy conditions can cause significant changes in irradiance which will have an impact on spectra collected using the ASD FieldSpec system. If it is necessary to sample in sub-optimal conditions, you must pay extra attention to the method described above, regularly checking the 100% reflectance line of Spectralon. If there are clouds passing overhead, wait for a large enough clear spell before collecting measurements. Do not be surprised if your data are of sub-optimal quality if collected under changeable conditions.

Ideally you should work when the sun is highest in the sky to minimise the effects of shadowing and solar zenith changes. Ideally 2 hours either side of Solar noon are perfect. (Solar noon =1pm BST)

You should not conduct fieldwork with the ASD in wet conditions as the electronic equipment is very sensitive to damp and should not be exposed to wet conditions.

4.9 Fibre Optic

The ASD FieldSpec has a very fragile fibre optic configuration. This is connected internally to the three instrument detectors and is therefore very expensive to replace and recalibrate if it should become damaged. A few tips on fibre care are provided below for your reference:

- Do not bend, crush or pull the fibre
- To store the fibre, coil it up gently and stow it away in the fibre compartment at the bottom of the carry case
- When installing the pistol grip or contact probe, take care not to overtighten the screw mounting as this can crimp the fibre and cause irreparable damage
- Always cover the fibre tip with the supplied plastic sleeve when not in use
- The fibre must remain dry so be sure to keep it away from damp/wet areas

4.10 Sampling Strategies

FSF cannot recommend particular sampling strategies as the ideal sampling will vary from project to project, and is under the responsibility of the PI. However, we can recommend that for each point measured, a number of spectra be collected (i.e. a number of Ref-Tar pairs). These can then be averaged to provide a certainty measure of the spectral variability over a fixed point in space. It is up to the PI to determine the most appropriate method for sampling the surfaces of interest with respect to spatial coverage.

4.11 Mounting

The pistol grip should ideally be mounted securely during field deployment, and this can be performed using a tripod arrangement. Try to mount the radiometer so that it is viewing from nadir. The spirit level supplied with the instrument will allow you to do this. You can also hand-hold the pistol grip, but this is not likely to be so stable.

4.12 Field Of View (FOV)

It is VERY important to accurately define the instantaneous field-of-view (IFOV) of the sensor before going into the field. You need to make sure that the size of the area you wish to measure is LARGE relative to the IFOV of the sensor. The FOV is approximately circular and will be 8, 18, or 23 (bare fibre) degrees depending on the optic attachment used. However, the sensitivity across the FOV is not uniform [(1)] and you should adopt a measurement procedure to take account of this. You should work out the range of heights you intend to use for the target radiometer mounting and then work out the diameter of the area to be measured. The reason that this is important is that if you measure an area which is infringed by an area of contrasting reflectance, it can lead to confusing spectra which are very difficult to analyse and correct after the event.

4.13 Log Sheets

It is immensely important to keep accurate log sheets when in the field. Document any changes in solar irradiance and also make a note of every filename and the corresponding surface.

4.14 Processing

If you are out in the field for more than 1 day, it is recommended that you process a couple of spectra of each measurement sequence in the evening (FSF Post Processing Templates can be downloaded from http://fsf.nerc.ac.uk/resources/post-processing). At least if you spot problems which might indicate a problem in data collection you will have a chance to rectify these on succeeding days. If you don't understand something, please contact FSF to discuss the problem, so that mistakes can be rectified quickly and easily.

> *It is always easier to resolve problems before you collect spectra, rather than trying to make sense of spectra collected using incorrect methods.*

5. Notes on using the Contact Reflectance Probe

The contact reflectance probe, provides the versatility of an internal light source for the FieldSpec. The probe contains a 100W halogen reflectorised lamp, with a fibre-optic input socket. It allows for spectral data collection regardless of weather, time of day or time of year. This configuration can be used in the field and also in the laboratory for spectral analysis of mineral solids and powders, soils, and also for leaf-scale vegetation studies.

Preliminary in-house investigations have shown that high-quality contact reflectance data collected using the ASD FieldSpec system permits the determination of subtle variations in mineral crystallinity and composition. SWIR spectra collected using the contact reflectance probe were found to exhibit improved S:N ratios, lower standard deviation and hence, less intrinsic uncertainty than spectra collected using more traditional laboratory techniques.

The repeatability of spectral measurements collected using contact reflectance instruments makes them ideal tools for spectroscopy researchers who require high quality laboratory spectra, but who do not have access to a suitable dark laboratory for collecting measurements using more traditional lab techniques. It is also very useful for those researchers interested in the generation of spectral libraries, and is recommended as an alternative method for collection of laboratory spectra. However, contact reflectance instruments cannot replace field spectral measurements where atmospheric correction of remotely-sensed imagery is required, since solar illumination and characterisation of surface reflectance under solar irradiance is necessary for this.

Some general tips for using the contact probe are provided below:

- When installing the fibre, make sure that you do not tighten the screw attachment too tightly, as doing so will cause the fibre optic cable to become crimped, and will result in expensive damage to the system.
- Warm up the lamp in the contact probe for 15 minutes prior to use.
- Optimise against a Spectralon surface. Make sure that the probe window sits flush against the surface of the panel for the duration of the optimisation.
- When measuring samples, the window of the probe must also be pressed firmly against the surface, so that no extraneous light can enter the fibre.
- If measuring leaves or samples of vegetation, you should use a black cloth covered tile and sandwich the leaf between the tile and the contact probe. This will ensure that no extraneous light enters the fibre during these measurements.

- Please note that the glass on the front of the probe can become hot, and can often cause burn scars on leaf surfaces. Therefore the probe is only recommended for measurements where destructive sampling is appropriate.
- The glass window on the front of the probe is composed of scratch resistant sapphire glass. It can be cleaned using a lint-free cloth or camera brush. Do not use cleaning reagents. If it becomes very dirty, contact FSF for appropriate cleaning advice.

6. SUMMARY of key points to remember in field

1. Always connect a 12V battery to the Dell computer using the car adapter and 12V converter, as the computer's internal batteries are not sufficient for a day in the field.
2. Beware of damage to the fibre optic when using the instrument.
3. Do not tighten the screw fitting for the pistol grip too much.
4. Do not stretch the fibre or pull it.
5. Only work when solar conditions are optimal - 2/3 hours either side of Solar noon and when it is sunny and clear. Be extra careful about working in sub-optimal conditions.
6. Warm up the instrument prior to use (30 minutes is recommended)
7. Keep accurate log sheets
8. Accurately determine the size of the IFOV at a given height before going into field.
9. Make sure that the IFOV is completely filled with the target of interest.
10. Wait for two screen refreshes before saving a scan, as the ASD takes a few seconds to stabilise over new surfaces.
11. Regularly check the 100% line of Spectralon reflectance, and where appropriate, update the white reference scan saved in memory.
12. Collect more than 1 spectrum over each target to get an idea of the spectral variability of each surface.
13. Don't be shocked to see atmospheric water absorption features in your spectra at 1400 and 1800nm
14. Process and examine a few spectra each evening to check that they are correct and of good quality.
15. Lack of power is actually one of the most common problems so….

MOST IMPORTANTLY - CHARGE YOUR BATTERIES EVERY NIGHT

Remember if you are not sure about something, ring FSF as most problems can be easily rectified over the telephone.

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References

1 Mac Arthur, Maclellan & Malthus, 2007. Determining the FOV and directional response of field spectroradiometers. Proceedings 5th EARSeL Workshop on Imaging Spectroscopy. Bruges, Belgium, April 23-25 2007