User Guide

Version: *2.0c*
Date: *07.07.2009*
Status: *Valid*
Author: *A. Hueni, Remote Sensing Laboratories, University of Zurich*
File: *\SPECCHIO_UserGuide_V2.0.docx*
Pages: *98*

Classification:
Distribution: *SPECCHIO Users*

History

Version	Date	Author	Remark
0.1	15.12.2006	A. Hueni	First valid version
0.2	13.02.207	A. Hueni	- Instructions for entering pathnames under UNIX - Updated installation description - Bug fix update - Tutorial
1.0c	14.02.2007	A. Hueni	- Bug fixes and added features - Version number of this document is now synchronized with the software version number.
1.0d	21.02.2007	A. Hueni	- Minor software changes - Some changes due to input from the first tutorial session
1.0f	29.05.2007	A. Hueni	Added features: - txt file reader - CORINE landcover class displayed as tree in Metadata editor
1.1	18.10.2007	A. Hueni	Updates due to: - adding multi-user capabilities to the data model and application. - pre-configuration of database connection details via the db_config.txt file - Admin functions not visible for normal users - Bug fixes
1.1a	03.11.2007	A. Hueni	- Software updates and bug fixes - Description of plot control - other minor changes
1.1b	06.11.2007	A. Hueni	- Change of the application bundle to flat file structure in order to prevent installation problems. Reflection of that change in the documentation.
1.1c	31.01.2008	A. Hueni	- Added spectral plot to metadata editor - Added campaign export functionality - Time format option in the export dialog
			- Bugfix: Position.Location field in Metadata editor now accepts alphanumeric input.

1.2	29.05.2008	A. Hueni	Major rework of the Metadata Editor: - Super-fast group updates - Shared data highlighting - Shared data update reimplementation - Shared data awareness for gonio and sun angle calculations - Direct selection of gonio and sun angle calculations from the 'sampling geometry field'
1.3	15.06.2008	A. Hueni	Added campaign import function. Some bugfixes.
1.3a	25.07.2008	A. Hueni	SPECCHIO would stall during data export due to the jgraph extension not being found. The application has been recompiled to include the jgraph extension in the needed extension list and jgraph is now bundled with the SPECCHIO application.
1.3c	26.09.2008	A. Hueni	(a) A switch in the Query Browser that lets you restrict the data to your own data only, (b) The Data Browser in the Metadata Editor is now contained in a scroll pane and thus also displays correctly on small screens.
2.0	12.03.2009	A. Hueni	Major update: - Database schema update to include reference panel handling including correction factors and uncertainty - Processing extension - Instrument and reference panel handling tools - Updated export/import functionality
2.0a	26.03.2009	A. Hueni	ENVI spectral library loading problem has been addressed.
2.0c	07.07.2009	A. Hueni	Numeric fields in the Metadata Editor now accept copy&paste operations. Support for new DB fields for instrument settings.

Table of Contents

1 Introduction

SPECCHIO is a spectral database combined with user-friendly interface software designed to store spectral data acquired by spectroradiometers and associated metadata. SPECCHIO was developed to support long term usability and data sharing between researchers.
For further information please refer to the SPECCHIO website (www.specchio.ch) and to the following articles:

Hueni, A., Kneubuehler, M., Nieke, J., Itten, K., 2009. PROCESSING EXTENSION FOR THE SPECTRAL DATABASE SPECCHIO. In: Proceedings EARSeL SIG IS, Tel Aviv, Israel.

Hueni, A., Nieke, J., Schopfer, J., Kneubühler, M., Itten, K., 2009. The spectral database SPECCHIO for improved long term usability and data sharing. Computers & Geosciences. Accepted for publication.

Hueni, A., Schopfer, J., Schläpfer, D., Kneubuehler, M., Nieke, J., 2008. PRE-PROCESSING OF DUAL-VIEW FIGOS DATA: TOWARDS OPERATIONAL BRDF RETRIEVAL. In: Proceedings ISPRS, Beijing.

Hüni, A. and Kneubühler, M. (2007). SPECCHIO: a system for storing and sharing spectroradiometer data. SPIE Newsroom, December 2007.
DOI: 10.1117/2.1200711.0956.
Online at http://spie.org/x18220.xml, PDF: 0956-2007-11-29.pdf

Hüni, A., Nieke, J., Schopfer, J., Kneubühler, M. & Itten, K. (2007). Metadata of Spectral Data Collections. 5th EARSeL Workshop on Imaging Spectroscopy, Bruges, Belgium.

Hüni, A., Nieke, J., Schopfer, J., Kneubühler, M. & Itten, K. (2007). 2nd Generation of RSL's Spectrum Database "SPECCHIO". ISMPSRS, Davos, Switzerland.

Hueni, A. & Tuohy, M. (2006). "Spectroradiometer Data Structuring, Pre-Processing and Analysis - An IT Based Approach." Journal of Spatial Science 51(2): 93-102.

Hueni, A. (2006). Field Spectroradiometer Data: Acquisition, Organisation, Processing and Analysis on the Example of New Zealand Native Plants. Institute of Natural Resources. Palmerston North, Massey University.

2 Installation and Configuration

2.1 Database

2.1.1 MySQL Instance

SPECCHIO runs on version 5 of MySQL database.
An online instance of the database is available on the db.specchio.ch database server.

The SPECCHIO database can as well be installed locally (MySQL is available from www.mysql.com). A SPECCHIO system installation package allowing local installation is available from RSL. RSL distributes the SPECCHIO system package free of charge to interested parties. Please direct expressions of interest to admin@specchio.ch.

2.1.2 Network Access

Note: this mainly applies if a locally administred instance of the SPECCHIO database must be configured for network access.

The SPECCHIO application can access the database over the network if the following configurations are performed:

- The IP addresses of all machines from which the users can connect are added to the user privileges. Alternatively a range of IP addresses can be configured using a netmask (see MySQL online documentation for details) or a value of '%' will allow access from any possible machine.
- The port of the MySQL server (3306 by default) must not be blocked by firewall

2.2 SPECCHIO Application

2.2.1 Java Version

SPECCHIO requires Java runtime environment (JRE) version 1.5 and higher.
To check the java version on your system open a system prompt (i.e. command window under Windows, terminal for Macintosh and UNIX systems) and type:

```
java -version
```

The output will be similar to:

```
java version "1.5.0_06"
Java(TM) 2 Runtime Environment, Standard Edition (build 1.5.0_06-b05)
Java HotSpot(TM) Client VM (build 1.5.0_06-b05, mixed mode)
```

2.2.2 Application Bundle

The SPECCHIO application plus the needed libraries are supplied as application bundle in ZIP file format. As a first step you must un-zip the ZIP archive.
The files contained in the bundle are described hereafter.

2.2.2.1 SPECCHIO Application Files

The SPECCHIO application is contained in a Java archive file: SPECCHIO_App_V<x.xx>.jar.
<x.xx> stands for the version tag, e.g. 1.0c, i.e. the jar file would be named SPECCHIO_App_V1.0c.jar.
The file db_config.txt contains database connection configurations.

2.2.2.2 *Java Library Extensions*

The following files are needed to run SPECCHIO:

- jcommon-1.0.5.jar
- jfreechart-1.0.2.jar
- jgraph.jar
- mysql-connector-java-3.1.13-bin.jar
- qcchart3djava.jar

The extensions are supplied in the same folder as the SPECCHIO application file.

2.2.3 Microsoft Windows

- Copy the whole content of the ZIP file (SPECCHIO_Application.jar, the db_config.txt and the libraries) to some new directory on your machine. It is recommended to create a new folder in C:\Program Files and copy the above files to this folder.
- To start the SPECCHIO Application double click the SPECCHIO_App_V<x.xx>.jar icon.

2.2.4 UNIX

The described installation procedure installs the software in a user directory. This implies that only users with access to this user account can run the software. For the installation on a server with access for every system user you need administrator rights on the concerned machine or have it installed by the system administrator.

- Copy the whole content of the ZIP file (SPECCHIO_Application.jar, the db_config.txt and the libraries) to some new directory on your user account.

To start the software locally either double-click the SPECCHIO_App_V<x.xx>.jar file (may not work on all UNIX systems) or alternatively open a shell (terminal), navigate to the directory containing the applications and type

```
java –jar SPECCHIO_App_V<x.xx>.jar
```

For remote execution when having installed the application in your home drive which is mapped on to the servers, type:

```
ssh –X <server_name> java -jar <path>/ SPECCHIO_App_V<x.xx>.jar
```

E.g. to use terra as server with version 1.0c of the SPECCHIO application:

```
ssh –X terra java -jar /home/rsl1/ahueni/SPECCHIO/SPECCHIO_App_V1.0c.jar
```

2.2.5 Apple Macintosh

- Double click the ZIP file. This will automatically unzip the file and create a new folder containing all SPECCHIO files.
- Copy the unzipped folder into the Applications (or some other directory of your choice)
- Double click the SPECCHIO_App_V<x.xx>.jar file to run SPECCHIO

3 Design of Sampling Experiments and Data Structuring

This section contains a description of a setup of a possible spectral sampling campaign. Users designing their own sampling campaigns and planning to load them into SPECCHIO can find some basic ideas on campaign planning and data structuring hereafter.

3.1 Overview

The data collected during sampling campaigns must be organised in a structured way in order to allow the automated import into the spectral database. Section 3.2 explains the background of the structure used and section 3.3 gives a practical example of a directory and file structure that should be adopted for data collection.
Preferably sampling experiments should be designed to include some form of data structuring from the beginning. Alternatively, existing data can be arranged to meet the requirements.

3.2 Hierarchical Structure

The concept of hierarchical data structure has been adapted from SpectraProc (Hueni 2006). SpectraProc was built on a fixed hierarchy of three levels. The following example is based on the sampling design used for SpectraProc campaigns.
A hierarchical data structure that reflects the real world and the setup of sampling campaigns for vegetation is used. This structure is derived from the following conditions:

1. Reflectances of several different species are captured
2. In order to describe the in-species variation, several specimens of a species are sampled
3. The variability of the specimens is described by several measurements per specimen

The spatial extent where a specimen is sampled is termed a sample site, thus a species contains a number of sample sites. The sites are numbered in the order of sampling. At each site, several readings are taken to capture the variation exhibited by the specimen in question. A site therefore contains a number of spectra. This leads to a hierarchical directory structure (Figure 1).

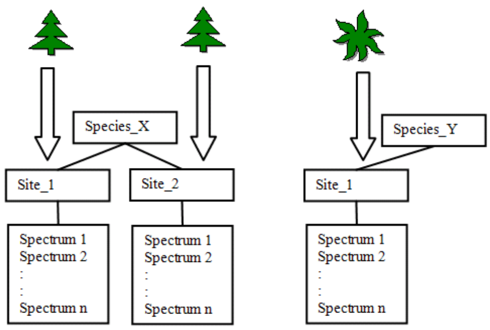


Figure 1: Hierarchical directory structure

Although the term species is used it essentially represents the different classes found in a study. These classes can either be assigned due to already existing classification systems for e.g. plants or minerals. In other cases a hypothesis might exist that a number of objects can be separated into classes. If so the setup of the experiment should mirror this hypothesis. If no such assumption exists all objects can be put into the same class (i.e. species) and the identification of classes could then be carried out by e.g. cluster analysis.

SPECCHIO builds up on the above concept of hierarchies. However there is no restriction on the number of levels used. Thus any level number (0:N) can be used.

3.3 Directory Structure and Spectral Files

This section lists examples of data structures employed to hold the files generated by spectroradiometers. Note that SPECCHIO enforces no particular structure. The provided examples are mere suggestions based on experience and you may decide to choose a different approach.

3.3.1 Structure to store Reflectance Spectra of several Species and Sampling Sites

A hierarchical structure as introduced in 3.2 is used to build the directory structure that holds the spectral files. Ideally, this directory structure is setup when designing the experiment.
Figure 2 shows an example of a directory structure containing ASD spectral files. The main directory 'Vegetation_example' holds all species directories of the study. This main directory is the folder that needs to be specified when creating a campaign in the database (cf. 5.2.4). The species directories contain the site directories.
The site directories contain all spectral files collected at these sites. The spectral files are auto-numbered by the ASD capturing software.

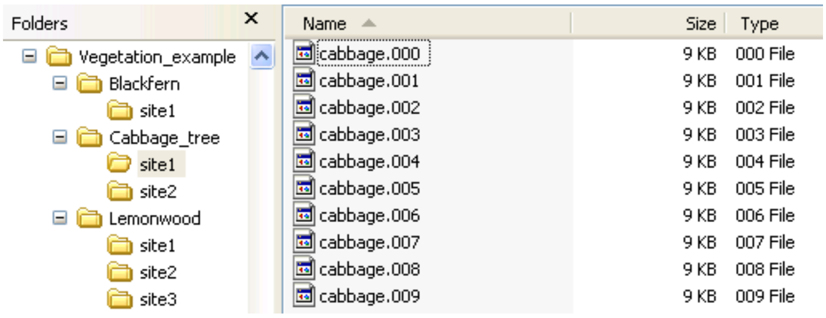


Figure 2: Example of a directory structures holding spectral files

Campaigns can contain spectra measured with different instruments and sensors, i.e. instruments of different sensor types and instruments with different calibration dates. The only restriction that is imposed is that a hierarchy (i.e. a folder) can contain only one file type.

3.3.2 Structure to store Reference and Target Spectra

If a spectroradiometer is configured to acquire radiances, the irradiance will commonly be characterised indirectly by measuring the radiance reflected by a reference panel. This may be preferable to the direct acquisition of reflectance data as information about the irradiance can be retrieved from the dataset.
The structure must therefore hold target and reference radiance spectra.
A possible structure is shown in Figure 3:

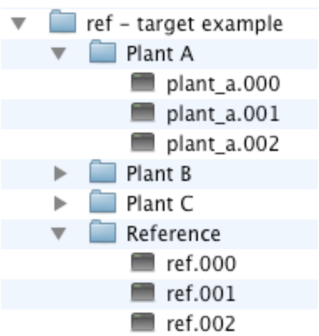


Figure 3: A possible structure for the storage of target and reference radiance spectra

4 SPECCHIO Concepts

4.1 Modelling of Hierarchies in the SPECCHIO Database and GUI

The hierarchical structure of a campaign is stored in the database using three tables:

- campaign
- hierarchy_level
- spectrum

The hierarchy_level table recursively models the folder structure of the campaign, i.e. any depth of a tree structure can be stored in only one table.
The data hierarchy is used in the GUI to build the contents of a component called 'Spectral Data Browser'. This browser shows the structure as defined on the file system and adds a campaign node to the top of the structure. Figure 4 shows a Spectral Data Browser component that visualises the directory structure of the example in Figure 2. Note the added top node 'Vegetation Example Campaign'.

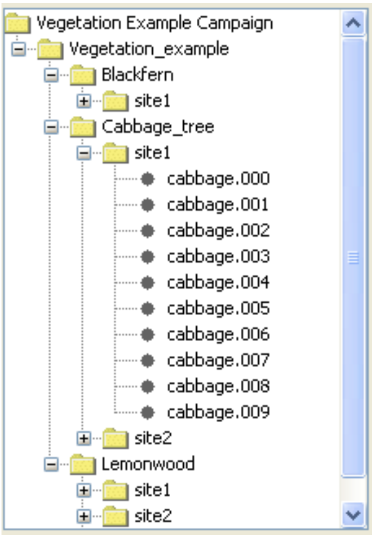


Figure 4: Example of a Spectral Data Browser component showing the directory structure holding spectral files

4.2 Time Data

SPECCHIO expects time data in UTC (Coordinated Universal Time). For practical purposes UTC is considered equivalent to GMT, however, the term UTC is recommended for technical contexts (U.S. Naval Observatory 2003).
The above implies that all computers capturing data for use in SPECCHIO should have their timezone set to GMT and their system time adjusted to UTC. The capturing date/time can be modified in the database using a special function in the Metadata Editor if a time different to UTC was used.

4.3 Metadata Quality Levels

The concept of metadata quality levels has been introduced to add a quality measure to spectral data. It is clear that by describing more metadata the spectral data quality is not improved as such. However the metadata can serve to increase the user confidence in the data as it defines the circumstances of the data capturing. The level A is foreseen to also include some quality measure for the spectral data.
Metadata quality levels are implemented and enforced by so called metadata policies. These policies define the mandatory metadata fields for each database table.
Quality levels are managed on spectrum level, i.e. each spectrum can have its own required quality. Required quality is a user defined level. It defines what metadata quality level the spectrum is supposed to reach at some point in time. Once all metadata required for the specified level are entered the attained quality level of the spectrum will be updated to reflect the required level.
When new data are loaded they have no required quality level defined and thus no metadata policies are enforced.
Currently the following levels have been defined or foreseen:

Level A: not implemented yet, the exact specification is to be defined. Reserved for spectra of high quality, probably requiring some pre-processing like atmospheric noise removal and smoothing.

Level B: defines the minimal set of metadata that must be entered to reach a metadata quality level of B. Level B should make spectral data useable by third persons who were not directly involved in the capturing process and are thus not familiar with the sampling circumstances. The required metadata fields are detailed hereafter (grouped by metadata groups as found in the metadata editor).

Campaign:

- □ Investigator

Spectrum:

- □ Sensor
- □ Instrument
- □ Foreoptic
- □ Landcover
- □ Target homogeneity
- □ Measurement unit
- □ Sampling environment
- □ Measurement type

Position:

- □ Latitude
- □ Longitude
- □ Altitude

Environmental condition:

- □ Cloud cover

Sampling geometry:

- □ Sensor zenith
- □ Sensor azimuth
- □ Illumination zenith
- □ Illumination azimuth

Target type:

- □ Target type

4.4 Data Links

Data links have been introduced as a means of defining relations between data sets or single spectra. I.e. data links are 1:1 relationships between either two hierarchies or two spectra. Data links are of a defined type. Implemented types are: (a) Photometer data and (b) Spectralon data.
Data links are in some cases set up automatically during campaign data loading. E.g. GER signature files include the spectra of both target and white reference.
For more information on data links see 5.2.5.1 and 5.2.6.2.10.2.
SPECCHIO uses data link information for e.g. the automatic calculation of reflectance from target and reference radiances.

4.5 Metadata

A number of metadata parameters are detailed hereafter. For more information on the metadata parameters supported by SPECCHIO please refer to the Metadata Editor section and to Hüni et al.(2007).

4.5.1 Cloud Cover

Description of the cloudiness of the sky by octas:
“For the total cloud amount, codes 0 to 8 show the fraction, in octas, of the celestial dome covered by all clouds. An octa is one eighth of the celestial dome, so we estimate how many eighths of the celestial dome are covered up by clouds“ (University of Washington undated)

Code	Definition
0	Clear
1	1 octa or less, but not zero
2-6	2-6 octas
7	7 octas or more, but not 8 octas
8	8 octas

Table 1: Cloud cover definition in octas (Source: University of Washington (undated))

4.5.2 Measurement Types

Three measurement types are currently distinguished:

- Single: The standard case when single measurements are taken. Single measurements are not grouped with other spectra by geometric or temporal conditions.
- Directional: Applies to goniometer measurements. A spectrum is part of a hemisphere and has a specific position given by its sampling geometry settings.
- Temporal: Applies to photometer data. Spectra have a specific capturing time on a common timeline.

4.5.3 Target Types

Target types are predefined in the database and can only be edited by the SPECCHIO administrator. Target types should always be chosen with the goal to help the search and selection of spectra for e.g. image classification tasks. The target types should therefore not be too detailed.
It is foreseen that target types can be grouped into categories. This might be implemented in future when the number of target types becomes a handling problem for the user.

4.5.4 Sensors and Instruments

SPECCHIO defines sensors and instruments. While these terms are sometimes interchanged in everyday scientific language, it is important to understand that sensors and instruments are modelled as two different entities in the database.
Sensors define the physical setup of sensors, i.e. number of channels, average wavelength and FWHM per channel, sensor type number (usually a code given by the manufacturer, e.g. 4 for ASD FSFR sensor). Sensors are defined only once in the database.

Instruments on the other hand are existing instances of a certain sensor type. There can be several different instruments that are all of one sensor type. Instruments also have a defined owner and a history of calibrations.
Consider the example of a GER 3700 instrument: this instrument is an instance of a GER 3700 sensor. The sensor defines the average wavelength per channel. As long as no calibration for the instrument has been entered into the database the channels defined in the sensor will be used for plotting and exporting spectral data. When calibrations are entered for instruments they override the sensor specifications. For further information please refer to Hüni et al.(2007). (**Note**: the handling if instrument calibration information is currently under re-design and not available in version 2.0).

4.6 Spaces, Space Factory and Data Processing using the Space Network

Starting with version 2.0 SPECCHIO offers interactive, configurable data processing. The concept is based on the feature spaces (Landgrebe 1997) and complex process flows can be realised by building networks consisting of spaces and processing modules. For detailed information please refer to: (Hueni, Kneubuehler et al. 2009).

Spaces are used throughout the system for processing, visualisation and file output. In all these cases, vector data must be related to spectral dimensions and this information is held by the space. Moreover, a space can hold only spectra that are of the same dimension.
The Space Factory is a conceptual, central component of the SPECCHIO system. It creates new spaces based on given inputs and contains the logic to form 'non-mixed' spaces.

Assume the use case of displaying spectral plots of a number of spectra. In a first step, the user will select the spectra to be plotted by effecting a subspace projection (Hüni, Nieke et al. 2007). Internally, this will yield a number of record id's that are matching the user's selection. These ids are now handed to the Space Factory. Internally, spaces are created for all existing combinations of the respective sensors, instruments, calibrations and measurement units associated with the spectra (see Figure 5).

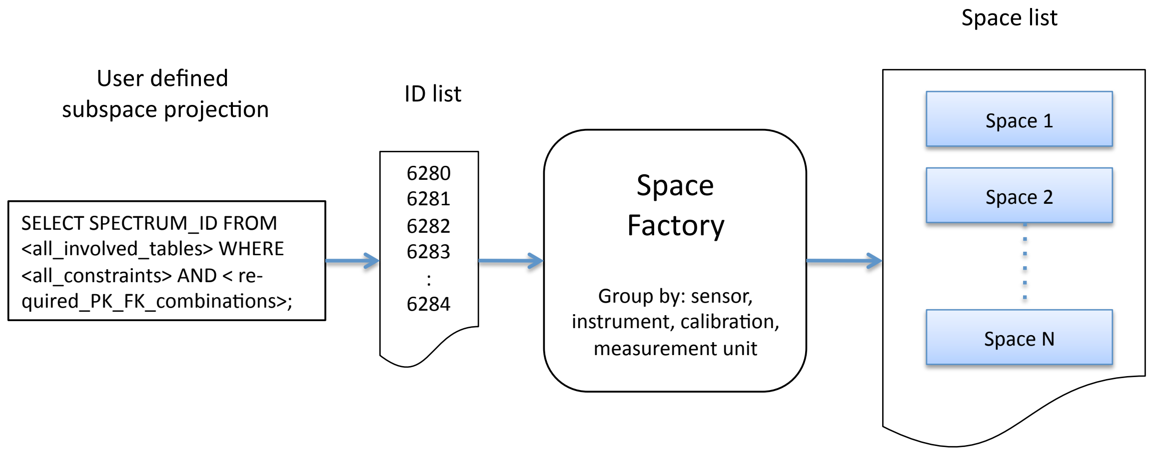


Figure 5: Building spaces based on user defined subspace projections

The Space Factory returns a list of the created spaces. Each space can now in turn be used as an input argument of a plotting class instance. Utilizing the Space Factory ensures that all spectra contained by a space have a common wavelength per band and the same measurement unit, i.e. the following processing modules do not need to carry out uniformity checks but can apply their algorithms directly, e.g. plotting of spectral vectors against the common wavelengths of the space.

Interactive, flexible and configurable data processing is based on the concept of the Space Network. Such networks consist of processing modules and data sinks/sources, connected by directed edges.

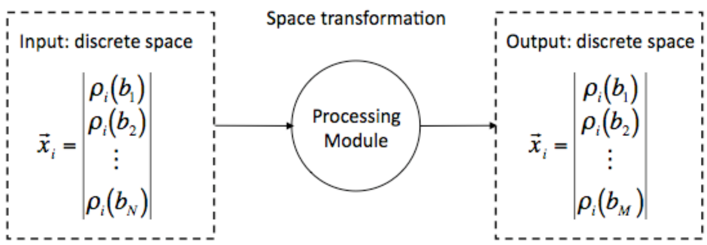


Figure 6: Transformation into a new space by a processing module

Processing modules are effecting a transformation on a space, i.e. the spectral data vectors of the input space are transformed to an output space. The algorithm of the processing module defines the dimensionality of the resulting space. This is illustrated in Figure 6 with an input space of dimensionality N being transformed into another discrete space of dimensionality M. Although processing modules tend to have singular input/output in most cases, they may have multiple inputs and generate multiple outputs.

5 Operation

5.1 Overview

5.1.1 Dataflow

A typical dataflow is illustrated in Figure 7. A spectroradiometer is used to capture the radiance of field objects. Optionally a GPS connected to the field laptop (where supported by the capturing software) records the spatial position of the field object. This is a recommended setup as the spatial position can later be automatically loaded into the database. Spectral and metadata are automatically saved on the field laptop.
These files are transferred to a laboratory computer where they are read by the SPECCHIO application and stored in the relevant tables in the spectral database.

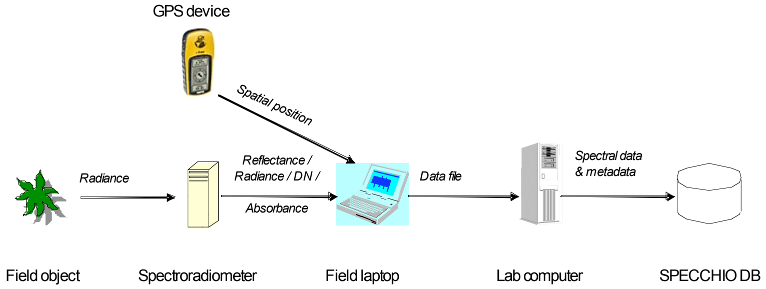


Figure 7: Dataflow and involved hardware

5.1.2 File System Interfaces

SPECCHIO provides input and output interfaces to the file system. Input file formats are:

- ASD binary file as produced by the ASD FieldSpecPro/FS3 spectroradiometers
- ENVI Spectral library files (SLB and SLI)
- GER signature files as produced by the GER 3700 (Files produced by other GER instruments remain subject to testing)
- TXT space formatted text files
- MFR Photometer OUT files
- Proprietary sensor definition file. Sensor definition files are an efficient way of defining new sensors in the database.
- GER calibration files
- XML type file format for campaign imports for data transfer between SPECCHIO databases

Output can be written in three data formats:

- CSV (Comma Separated Values) for subsequent import into various 3rd party applications like spreadsheets or statistic packages
- ENVI Spectral Library (SLB)
- XML type file format for campaign exports (for data transfer between SPECCHIO databases)

5.1.3 SPECCHIO Operation

SPECCHIO is campaign based, i.e. spectral data is grouped by campaigns. Advisably, a new campaign is created to hold data for every new sampling experiment. The spectral data files of a campaign must be held by a folder structure similar to the hierarchical structure introduced in 3.2. This structuring allows the automated loading of spectra into the database including the structure information.
Typically, the operations carried out for each campaign are:

1. Creation of a new campaign
2. Loading of spectra
3. Entering of metadata
4. Repeated data query, visualisation, processing and file output

New data can be added to ongoing campaigns by (a) storing them first in the already existing campaign data structure on the file system and (be) invoking the SPECCHIO loading operation for the respective campaign again. Only new spectra will be added to the database in this case.

5.2 SPECCHIO Application

5.2.1 Look and Feel

SPECCHIO is written in Java and has been setup to use the native operating system look and feel. The screenshots provided in the following sections have been taken on Windows XP and MacOS X. Depending on your system, the windows and widgets will look differently.
The functionality of the GUI is generally identical on all tested operating systems. There is however a minor difference in the selection of directory pathnames under UNIX. As a filename is required in the Open dialog, enter a dot '.' in the filename box (cf. Figure 8). Alternatively, on some UNIX machines just click the folder but do not double click, in this fashion the folder will be selected and no '.' has to be inserted in the filename box.

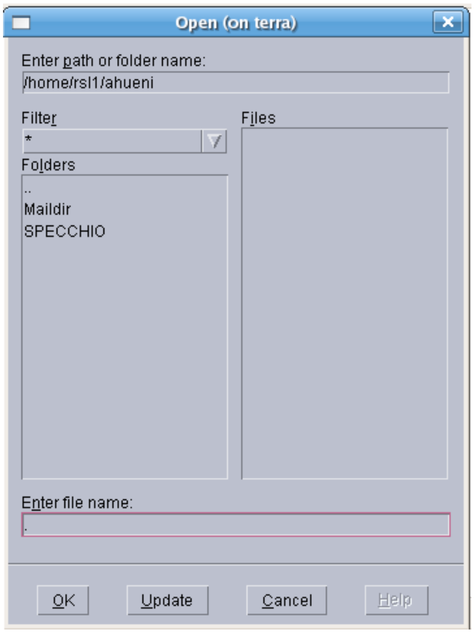


Figure 8: Specifying a pathname under UNIX using the dot '.' as entry in the filename box

Depending on the UNIX windowing system, some of the dialogs are not properly displayed unless they are maximized.

5.2.2 Main Window

The main window offers the main menu of the application and a progress report panel where the progress of certain processes (e.g. file loading) is reported (cf. Figure 9). The database connection status is shown in the progress report panel as well. The panel on the right side is currently not used but might be employed to display e.g. a log of operations or general user information.
All SPECCHIO functionality is started by entries in the main menu.

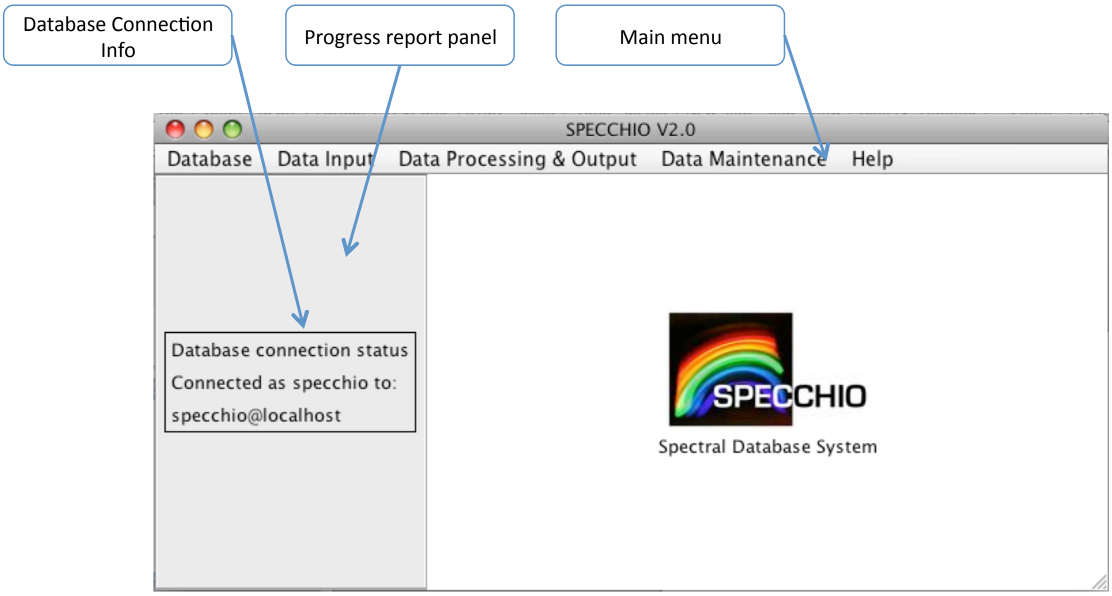


Figure 9: Main window

5.2.3 Connecting to a Database

SPECCHIO can be configured to automatically log into a database at the startup. In that case the connection parameters are read from the db_config.txt file. The database connection information panel (see also 5.2.2) always reflects the current connection status.
Connect to a different database instance or change the database user by using the 'Connect to database' dialog. To start this dialog, select 'Database'->'Connect to database' (cf. Figure 10).

Figure 10: Connect to database menu entry

All connections that are configured in the db_config.txt file are listed in a list box (Known connections). To change the current connection either select a preconfigured connection from the list box or alternatively enter the server that hosts the MySQL instance you want to connect to, the listening port of the database (port 3306 by default), the database instance name, the user name and password (this is the database user name and password, which is different from your local/network account) in the relevant text entry fields.
Press Connect to connect to the specified database/user.

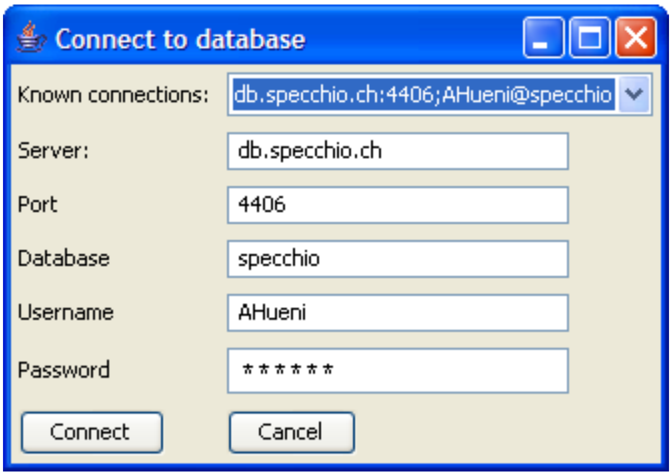


Figure 11: Connect to a database dialog

Starting from version 2.0, a database version check is carried out.
If a database with the wrong version is connected, a warning message is shown (Figure 12). The connection will still be set up, however, some functions will not work on older database versions. Old databases should be upgraded by the database administrator using the Upgrade function (see 5.2.11.6).

Figure 12: Database version warning message

5.2.4 Creating a new Campaign

To create a new Campaign, select 'Data Input '->'Create new campaign' (Figure 13). This brings up the new campaign dialog (Figure 14).

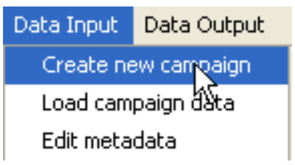


Figure 13: Create New Study menu entry

Enter a campaign name of 45 characters maximum length.
The main directory path is a file system pathname pointing to the directory that contains all hierarchies and spectra of this study. To set the path, select the 'Browse' button to display a directory tree (Figure 15) and select the appropriate directory. Note that when using a UNIX system you may have to enter a dot as filename (see 5.2.1).
Click 'Create' to create the new, empty campaign on the database. Note that there is no check if a campaign of the same name already exists. It is technically feasible to have two campaigns named the same. However, it is suggested to check on existing campaigns to avoid multiple campaigns with identical names.

A message box will appear once the campaign has been successfully created.
No automatic loading of spectral files is initiated when a new campaign is created. To load data into a new campaign use the function 'load campaign data'.

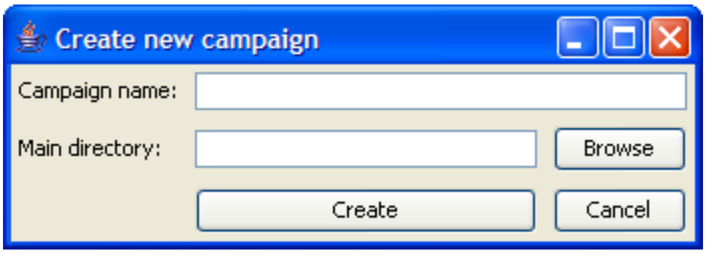


Figure 14: New campaign dialog

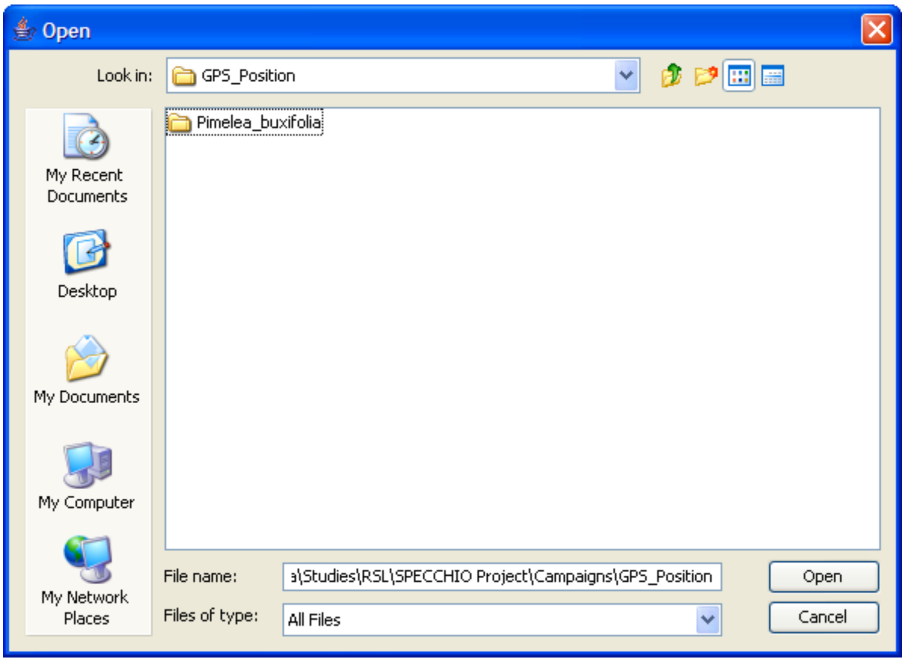


Figure 15: Directory selection dialog

5.2.5 Loading Campaign Data

To automatically load the spectral data files of a campaign select 'Data Input'->'Load campaign data' (Figure 16). Note that if different file types (e.g. ASD binary files and GER signature files) are occurring in the same campaign, hierarchies must contain only one file type. This restriction is due to two reasons: (a) the file loading process is instantiating one concrete file loader class and applies it to all files in a directory and (b) it is against common sense to put files from different instruments/sensors into one directory. Consider a case where one species is being sampled with ASD and GER. A logical folder setup would be: a species folder with two subfolders for ASD and GER. These subfolders then contain the spectral files.

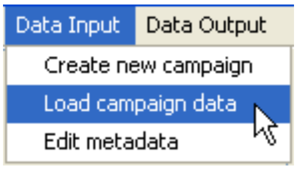


Figure 16: Loading campaign data menu entry

All names of the available campaigns of the current database user are contained in a combobox in the 'Load Spectral Data' dialog. Select the campaign that you want to load and click the 'Load' button. The loading progress is shown in the main window. A message box will appear once all data has been loaded to the system.
If a campaign is ongoing over a longer period of time, new data can be added by first loading the new files and hierarchies into the existing file structure on the hard disc and then running the loading process again. Each spectral data loading process will check if hierarchies and spectra already exist in the database. Only new hierarchies and spectra will be inserted.

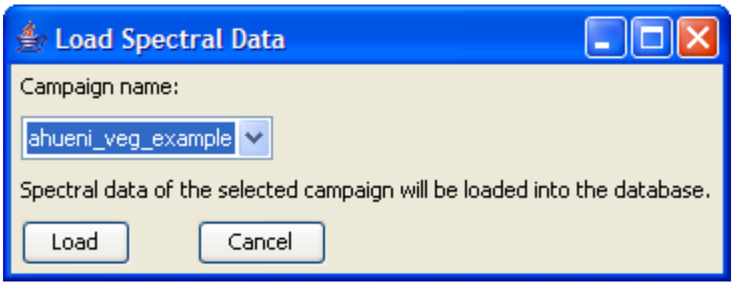
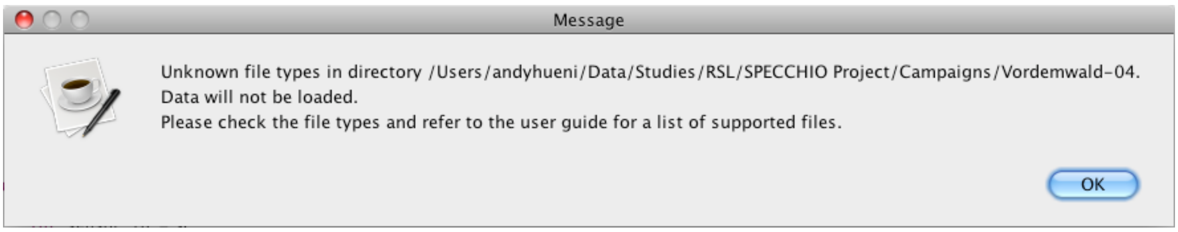


Figure 17: Load Spectral Data dialog

If a directory contains unknown file types, an according warning message is shown:



Make sure that the files in the indicated directory are supported by SPECCHIO.

5.2.5.1 GER Signature Files

These files hold two spectral measurements at once: the target and the white reference spectrum. When loading GER files two additional hierarchies are automatically created (named targets and references). The target and the reference keep the same filename (cf. Figure 18). A data link of the type 'Spectralon' is automatically inserted linking the target to the reference spectrum.

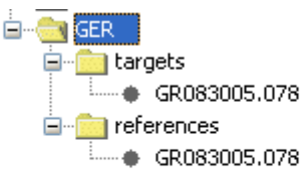


Figure 18 Automatically created hierarchies for GER files

5.2.5.2 MFR OUT Files

These files contain the capture time, the sun zenith angle and the spectral data for total, diffuse and direct irradiance.
The sun angle and the direct irradiance data are discarded and only the total and diffuse spectra are stored. Upon insert into the database two new sub hierarchies, named total and diffuse are automatically created (cf. Figure 19). The filenames assigned to the spectra are auto-generated using the capturing date and time.

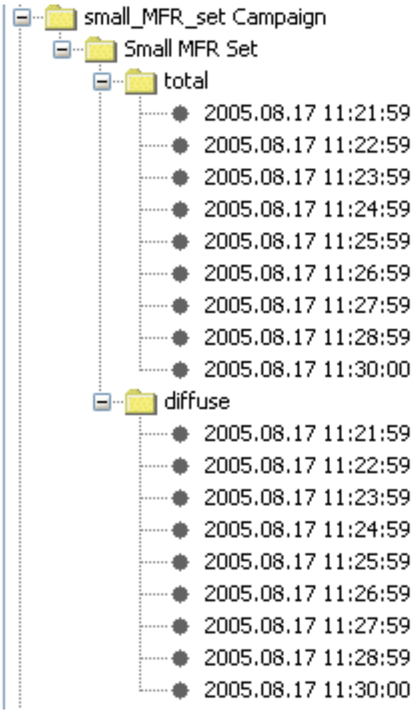


Figure 19: Automatically created total and diffuse hierarchies for MFR data

5.2.5.3 ENVI Spectral Library Files

These files can contain more than one spectrum. Upon loading each spectrum is saved separately. Note that the sensor definition (i.e. central wavelengths) is not read from the ENVI header file. Spectra loaded from ENVI SLB or ENVI SLI files are automatically assigned a sensor based on the number of channels if existing; this approach my produce wrong sensor assignments. Use the Metadata Editor to set a sensor if needed. Spectra names are read from the header file if available and stored in the database as spectral name entry with a spectral name type = 'ENVI Hdr'.
Note: the import routine expects the spectral library files to have extensions of either .slb or .sli, a valid example is given hereafter:

my_spectra.slb
my_spectra.hdr

5.2.5.4 TXT Space Formatted Text Files

These files are formatted as follows (specified using EBNF (Wirth 1977; ISO/IEC 1996)):

```
txt_file = header, data;
header = wsp, “wvl”, {wsp, spectrum_name};
```

```
data = {d_line};
d_line = wsp, wavelength, {wsp, value};
wsp = {space};
```

An example follows:

wvl	mean_090499	mean_020599
350.000	0.0246756	0.0229771
351.000	0.0246917	0.0228430
352.000	0.0247316	0.0229652
353.000	0.0248502	0.0231014
354.000	0.0250081	0.0232272
355.000	0.0250736	0.0232273
356.000	0.0249883	0.0233005
357.000	0.0249174	0.0233962
358.000	0.0250481	0.0234734
359.000	0.0252141	0.0235376
360.000	0.0253346	0.0236057
361.000	0.0253806	0.0236832

5.2.6 Editing Metadata

The SPECCHIO Metadata Editor is a powerful tool that allows you to enter metadata in a streamlined way, thus minimising the required user input.
To open the metadata editor select 'Data Input'->'Edit metadata' (Figure 20).

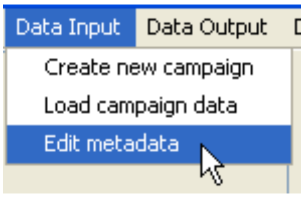


Figure 20: Selection of current study

5.2.6.1 Description of the Metadata GUI elements

The campaign editor consists of a control panel on the left side and a data area on the right side with three tabs for campaign, hierarchy and spectrum data (cf. Figure 21).
The control panel contains the following elements (from top to bottom):

- Campaign selection: only one campaign can be edited at the same time in one editor. Note that several metadata editors can be open simultaneously, each editing a different campaign. Note also that only campaigns belonging to the current user can be edited.
- Checkbox to highlight mandatory fields (mandatory fields only exist if a required quality level has been selected)
- Checkbox to highlight the shared data fields
- Checkbox to show the quality compliance in the tree of the spectral browser
- Checkbox to override the conflict detection when updating spectral groups
- Reset and Update buttons for campaign, hierarchy and spectrum data
- Spectral data browser that visualises the structure of the campaign as a tree. The data displayed in the hierarchy and spectrum data tabs depends on the selection in the spectral data browser (cf. also 4.1). Multiple selections are possible by using shift or control keys while selecting items with the mouse.

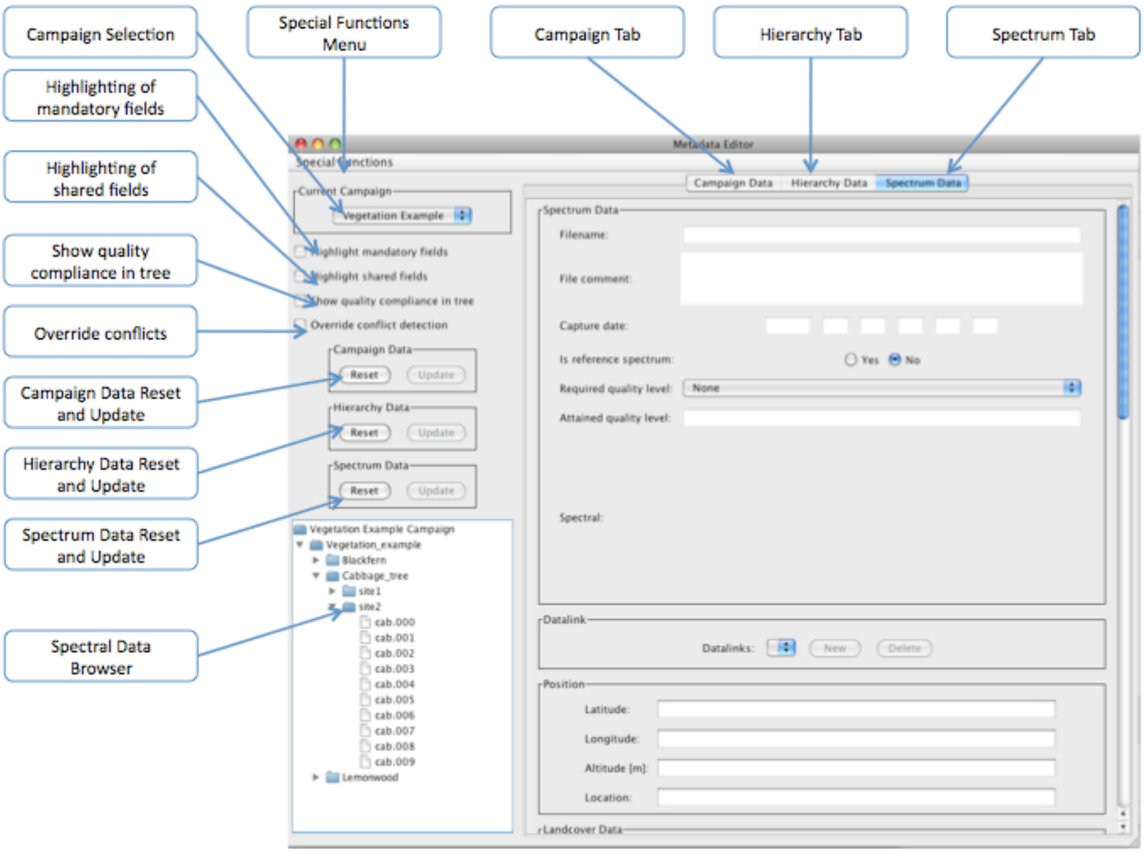


Figure 21: Metadata editor showing the campaign tab

A description of the information displayed by the tabs follows. Read only fields will be mentioned explicitly, all other fields are editable by default.

The campaign tab shows the following information:

- Campaign name
- Description of the campaign: some free text
- Investigator: the person in charge of this campaign (i.e. the user defining and loading the campaign). This field is filled automatically.
- Path: the file system path pointing to the main directory. This can be changed by clicking on the 'Browse' button next to it. Use this to change the campaign file path if the campaign folder was shifted on the hard disc after the creation of the campaign.

The hierarchy data tab displays information about the currently selected data hierarchy (cf. Figure 22):

- Name: hierarchy name taken from the corresponding folder name (read only)
- Description: free text
- Datalinks: links to other hierarchies (cf. also 4.4)

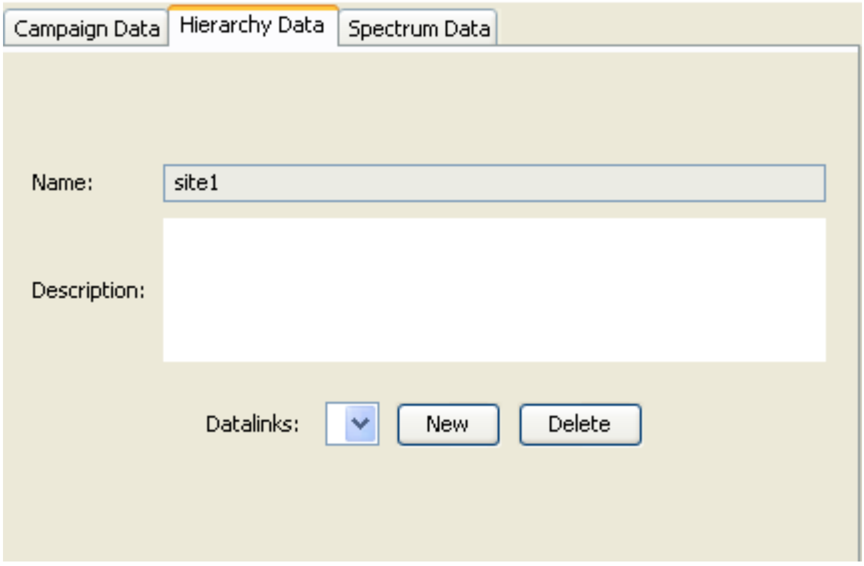


Figure 22: Hierarchy data tab

The spectrum data tab displays information about the selected spectrum or spectra. The data elements have been put into groups (cf. Figure 23 - Figure 25). These are described hereafter in detail.

Spectrum Data:

- Filename: usually the filename of the spectral file (in some cases filenames are automatically produces) (read only)
- File comment: Automatically contains user comments entered when capturing the spectrum (e.g. possible with ASD’s R3 capturing software).
- Capture date in 24h format (UTC) (read only)
- Loading date in 24h format (system time)
- Is reference: an option that can define this spectrum as being a reference spectrum. Only specchio_admin can set this field.
- Required quality level: a user definable level of metadata quality that this spectrum should reach (cf. also 4.3)
- Attained quality level: this field stays empty as long as not all required metadata according to the required quality level have been captured. Once all required data are entered the attained quality level will be equal to the required quality level (read only).
- Spectral plot: a plot of the spectrum (read only)

Datalink:

- Datalinks: lists all data links that this spectrum has to other spectra (cf. also 4.4 and 5.2.6.2.9)

Position:
Spatial and descriptive information about the capturing location. Coordinates are entered as degrees and fractions of degrees.

- Latitude: Northern hemisphere coordinates are positive, southern negative
- Longitude: West of Greenwich: positive. East of Greenwich: negative
- Altitude: metres above sea level
- Location: free text

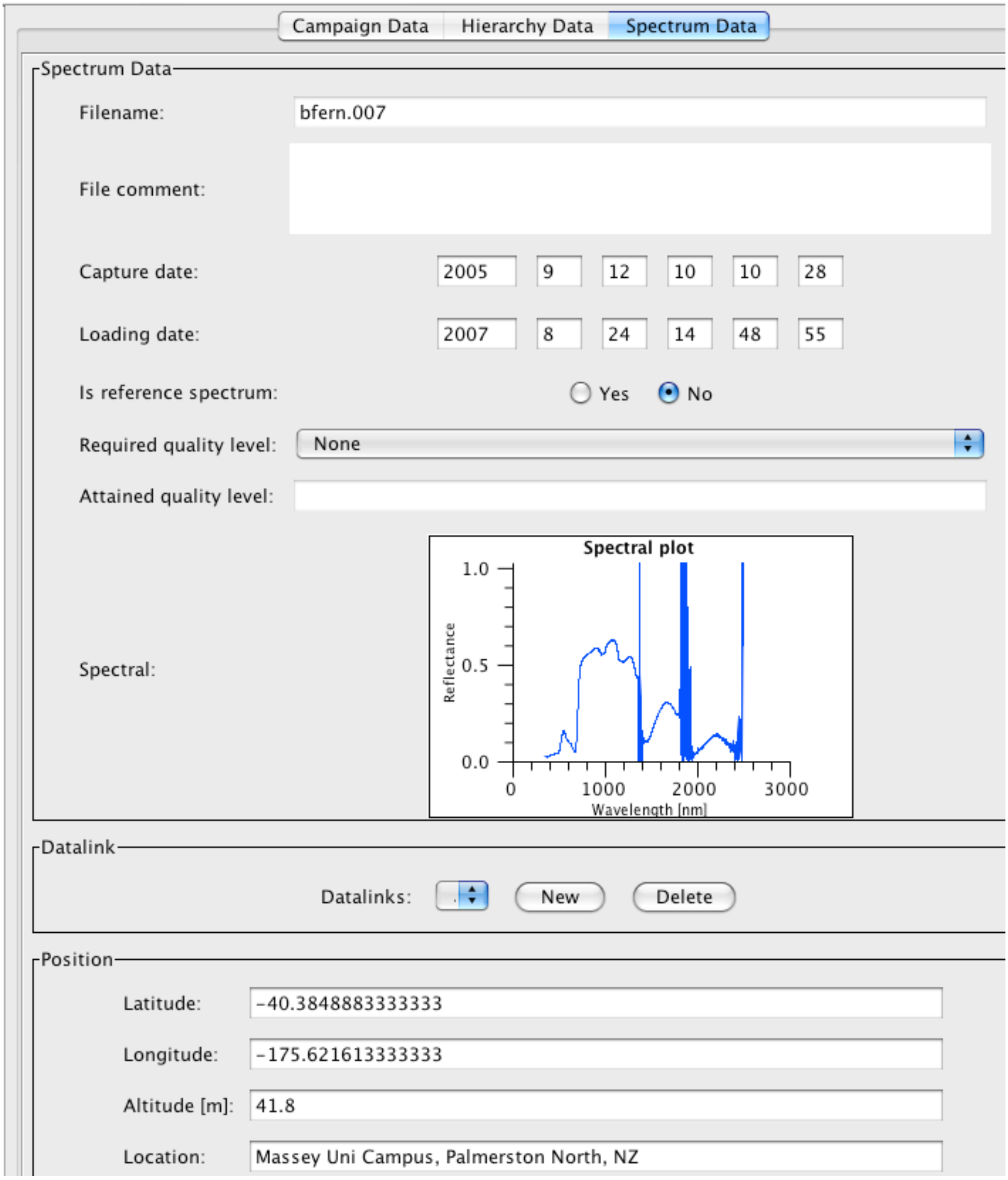


Figure 23: Spectrum data tab (part 1)

Landcover Data:
These landcover classes are based on the CORINE landcover scheme. They are ordered into three levels and visualized in the Metadata Editor using a tree structure. Only level 3 is stored for spectra. Levels 1 and 2 are merely displayed to help the selection of level 3.

Environmental Data:

- ☐ Cloud cover: in octas (cf. also 4.5.1)
- ☐ Ambient temperature: in degrees Celsius
- ☐ Air pressure: hPa
- ☐ Relative humidity: as percentage
- ☐ Wind speed: calm, breezy, windy, stormy
- ☐ Wind direction: direction from where the wind originates in 45 degree steps: N, NE, E, SE, S, SW, W, NW

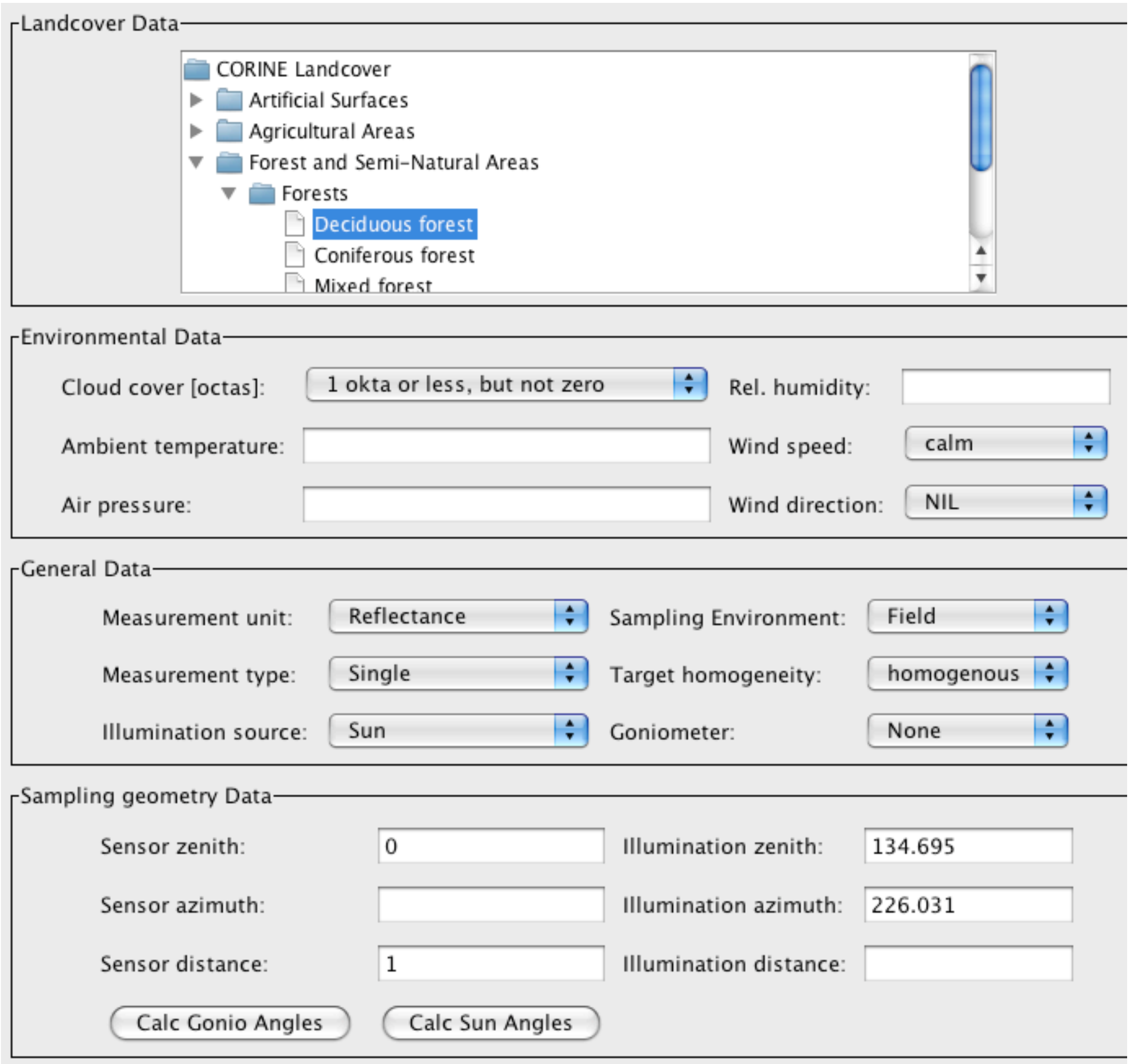


Figure 24: Spectrum data tab (part 2)

General Data:

- ☐ Measurement unit: Name of the spectral measurement unit (reflectance, absorbance, transmittance, DN, radiance)
- ☐ Measurement type: single, directional or temporal (cf. also 4.5.2)
- ☐ Illumination source: currently only the sun and a QTH lamp are defined as possible energy source. However, other sources can be entered by the administrator if needed.
- ☐ Sampling environment: Defines the general type of environment where the sampling took place: field, laboratory, hdrf to brf, or model. 'model' stands for simulated data using a computational model of some sort.
- ☐ Target homogeneity: Defines the possible values of homogeneity (Homogenous or Mixed)
- ☐ Goniometer: FIGOS or LAGOS

Sampling Geometry Data:
Numbers in this group can all be entered as floating point numbers.

- ☐ Sensor zenith: angle in degrees (where 0 degrees is equal to nadir)
- ☐ Sensor azimuth: angle in degrees measured relative to the principal plane. I.e. 0 degrees = the principal plane opposite of illumination source)
- ☐ Sensor distance: distance of sensor to target in metres
- ☐ Illumination zenith: angle in degrees (where 0 degrees is equal to nadir)
- ☐ Illumination azimuth: absolute angle in degrees
- ☐ Illumination distance: distance from source to target
- ☐ Two action buttons for the automatic calculation of goniometer and sun angles

Spectrum Names:

- ☐ A list of spectrum names. Two name types are currently supported: Latin and Common (ENVI Hdr is used internally for data read from ENVI spectral libraries). Further name types can be defined by the administrator. Use the Add, Edit and Remove buttons next to the list to change to contents of the list. To edit or remove an existing name selected it in the list and then click the appropriate button.

Target Type:

- ☐ Defines the target type and the abundance of this target type in the sampled object (cf. also 4.5.3). Further target types can be defined by the administrator. Use the Add, Edit and Remove buttons next to the list to change to contents of the list.

Sensor and Instrument Data: (cf. also 4.5.4)

- ☐ Sensor: sensor name
- ☐ Name: name of an instrument (this is the name given to the instrument by its owner)
- ☐ Foreoptic: degrees
- ☐ Button to bring up a new window showing information about the instrument (see Figure 26)

Reference Data:

- ☐ Name of the used reference panel
- ☐ Button to bring up a new window showing information about the reference panel (see Figure 27)

Pictures:

- ☐ A list of pictures plus captions. To add a new picture click on the 'Add' button to the right of the list. To remove a picture bring up the context sensitive menu (on Windows click the right mouse button) and choose 'Remove'. To change the caption, simply edit the text in the text box below the picture. Currently only the JPEG format is supported. Note: pictures should be reduced in size before loading to the database for speed reasons. Appropriate sizes are around 400-500 pixels width or height respectively.

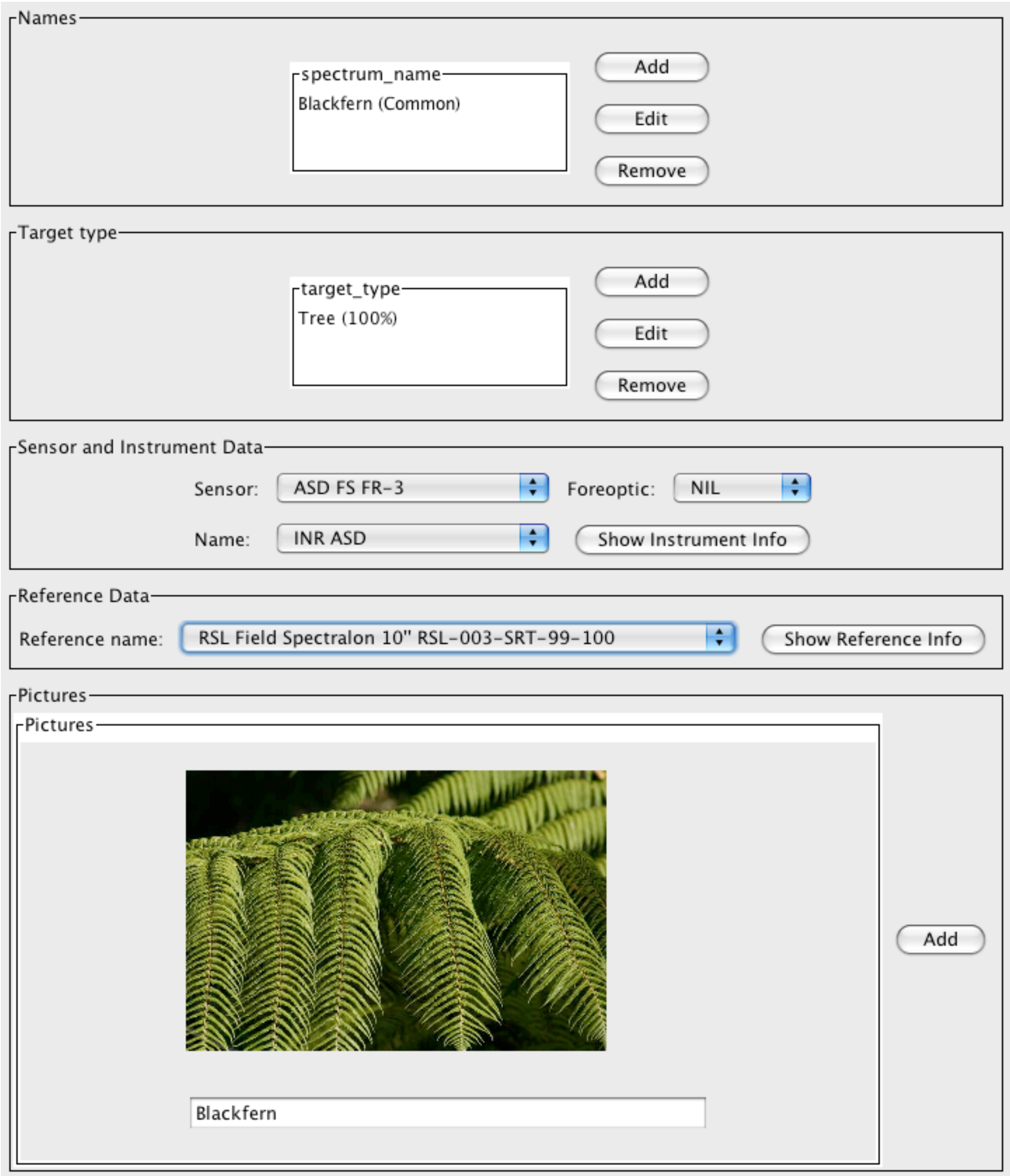


Figure 25: Spectrum data tab (part 3)

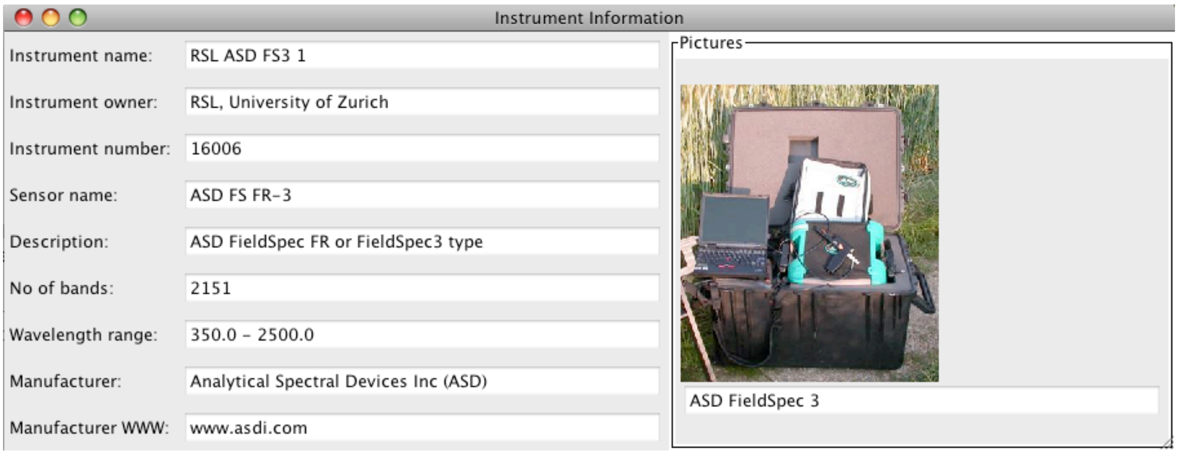


Figure 26: Instrument information window

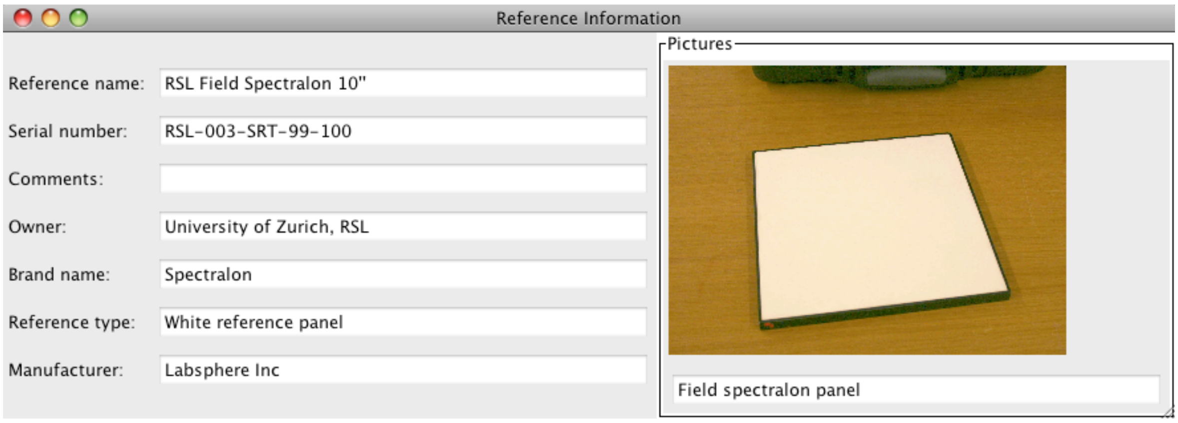


Figure 27: Reference panel information window

5.2.6.2 Operation Principles of the Metadata Editor

5.2.6.2.1 Displaying Metadata

The campaign tab automatically shows the campaign metadata of the selected campaign.
To display hierarchy metadata, select a hierarchy level in the spectral data browser.
To display spectrum metadata use the spectral data browser to select (a) a single spectrum, (b) multiple spectra (use shift and ctrl keys), (c) a single hierarchy or (d) multiple hierarchies (use shift and ctrl keys). Note: on Mac systems, the ctrl key is mapped to the ⌘ key.

5.2.6.2.2 Data Conflicts

Selecting several spectra at once can lead to data conflicts. E.g. the filename of spectra is usually unique per hierarchy. Therefore a filename cannot be displayed in the Filename field when more than one spectrum is selected. A conflict check is automatically carried out when a multiple selection happens. All conflicting fields are cleared and set to read-only and thus cannot be changed by the user.

5.2.6.2.3 Updates and Resets

The 'Update' button of the concerned metadata tab is activated as soon as a metadata field is edited by the user (cf. Figure 28 for an example).
Clicking 'Update' will commit all the changes that have been entered in the metadata fields of the relevant tab to the database. Clicking 'Reset' will discard any changes and redisplay the values as currently stored in the database.

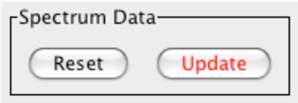


Figure 28: Activated 'Update' button for the spectrum data tab

The updates have been carried out when the 'Update' button reverts to being grey and disabled.

5.2.6.2.4 Group Updates

Group updates are an efficient way to define metadata that is identical for a group of spectra. E.g. consider the case of a shrub being sampled ten times in the field with no GPS unit connected to the system. All ten spectra will have roughly the same spatial position and thus can be updated as a group.
To carry out a group update select all spectra being part of the group. Note that only non-conflicting fields can be updated via group updates (see 5.2.6.2.5 how to perform updates on conflicting data). Enter the data that is shared by the spectra group (for the above example: latitude, longitude and altitude). Click 'Update'. All spectra in the group will be updated to have a spatial position with the entered lat, long and altitude. Note that all spectra of the spectra group are now referencing the same position record in the database, i.e. there is no data redundancy.
This shared record principle leads to conflicts when updating or deleting one or several spectra that belong to the same group. In the above example, three out of ten spectra would be selected to change their position again. This conflict is detected upon carrying out an update and an according option window is display (cf. Figure 29). The number of affected records is shown as well as the involved data group and the field name.
Selecting 'Apply to shared record' will update the shared record, i.e. all members of the original spectra group will refer to these new settings.
Selecting 'Create new record for selected spectra' will create a new entry in the database, i.e. the original, shared data is not changed.
Selecting 'Cancel update action' will not perform any update of the concerned field.

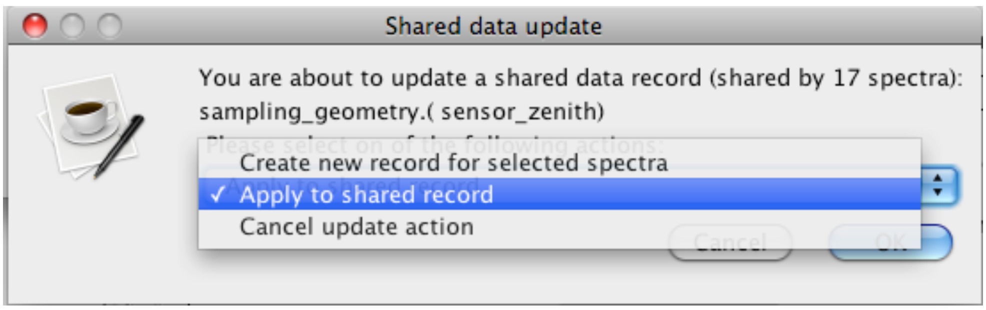


Figure 29: Shared data update warning for the sensor zenith field of the sampling geometry data group

5.2.6.2.5 Overriding the Conflict Detection

The conflict detection that disables updates of non-shared data in spectra groups can be switched off by selecting the 'Override conflict detection' checkbox on the control panel (cf. Figure 30).

Be sure that you know what you are doing: all previously individual metadata of the selected spectra might be replaced with the new data. Overriding conflicts may lead to some unwanted effects; depending on what metadata parameter it is updated.
The critical ones are: position, environmental data and sampling geometry. For these, only existing entries will be updated, i.e. if a group of spectra is updated and one of these spectra has no previous position record, then no new record will be inserted. This effect is due to the database model and additional software logic would be required to handle these special cases.
If you use the conflict overriding option, check carefully the results of your updates!

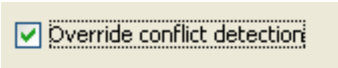


Figure 30: ‘Override conflict detection’ checkbox

5.2.6.2.6 Shared Field Colouring

Tick this checkbox (see Figure 31) to show which fields of the current spectra selection are shared with other spectra. It may help to understand what data is shared and what the effect of an update might be (update of shared records).

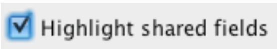


Figure 31: 'Highlight shared fields' checkbox

See Figure 32 for an example of shared field colouring. The spectrum ‘lemonwoo.004’ shares spectrum name and pictures with all other spectra under the ‘site1’ folder of the Lemonwood folder. The instrument information is not shared, as each spectrum has a direct link to the appropriate instrument.

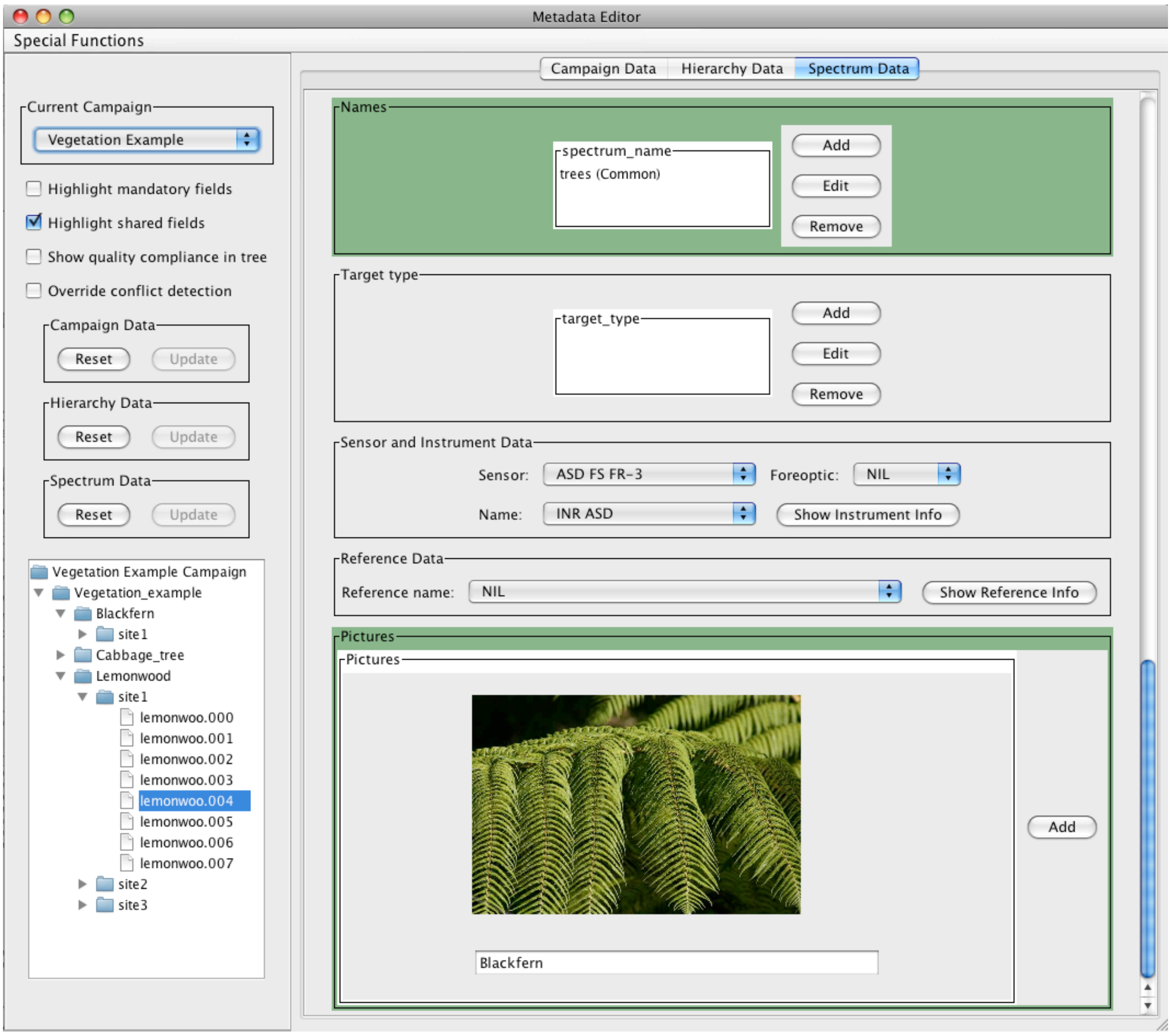


Figure 32: Example of shared field colouring

5.2.6.2.7 Mandatory Field Colouring

When a required quality level has been selected for a spectrum the mandatory fields can be high-lighted (cf. 4.3 for more information on metadata quality, cf. Figure 34 for an example of mandatory field colouring).
To use mandatory field colouring tick the 'Highlight mandatory fields' checkbox in the control panel (cf. Figure 33).

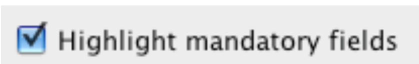


Figure 33: 'Highlight mandatory fields' checkbox

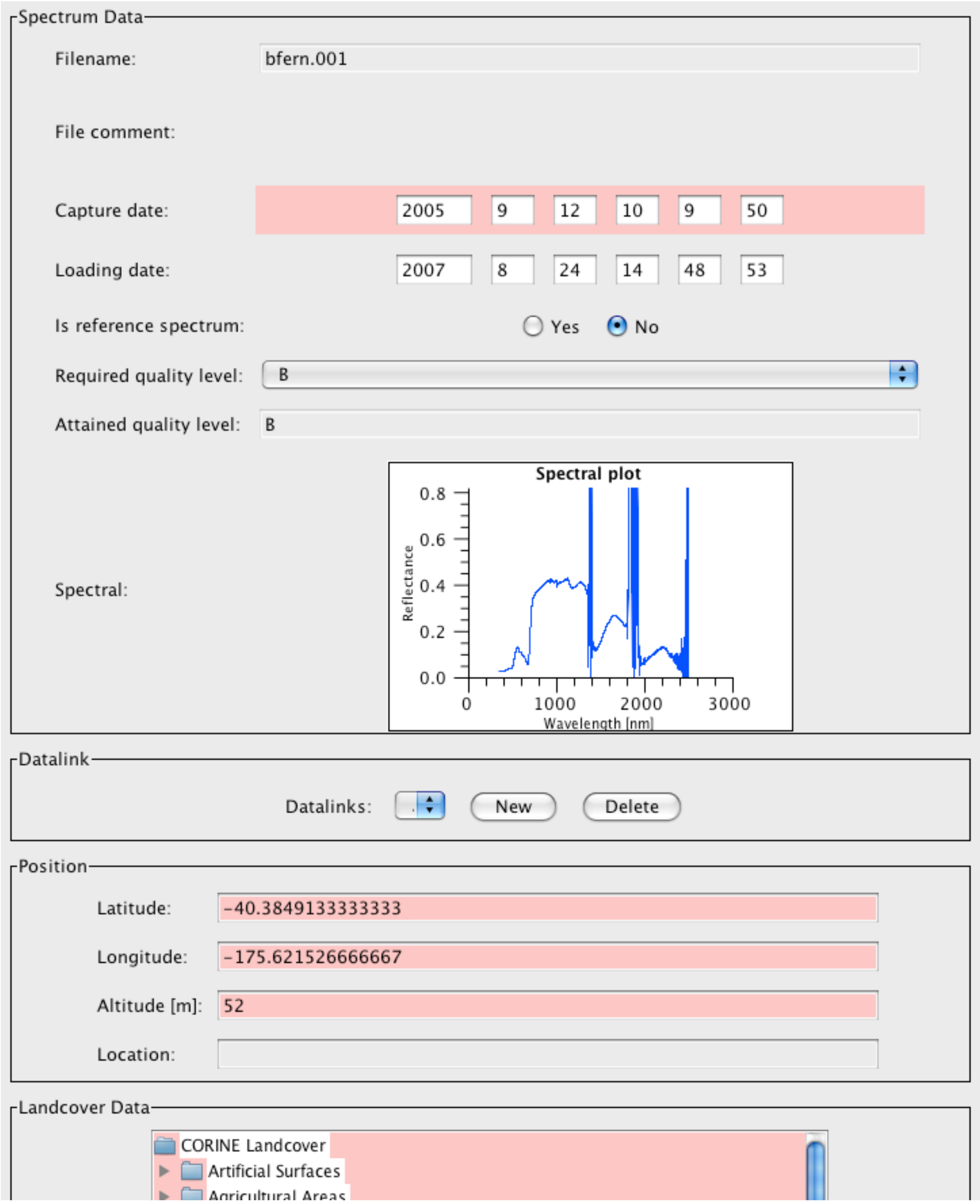


Figure 34: An example of mandatory field colouring

5.2.6.2.8 Showing the Quality Compliance in the Metadata Browser Tree

The metadata browser can display information about the quality compliance of the spectrum and the campaign. To switch on this option select the 'Show quality compliance in tree' checkbox in the control panel (cf. Figure 35).

Tree nodes that do not yet comply with the required quality level are indicated by an asterisk. Quality compliance is propagated upwards in the tree. If a spectrum does not comply then all parent hierarchies and the campaign itself will show an asterisk (cf. Figure 36 for an example).
Note that enabling this option reduces the responsiveness of the GUI as compliance checks have to be carried out on every metadata field.

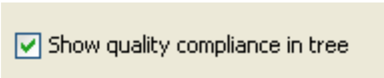


Figure 35: Show quality compliance in tree checkbox

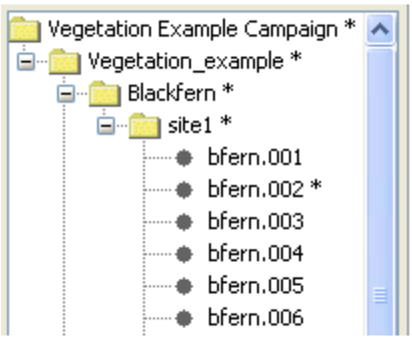


Figure 36: Quality non-compliance indicated by asterisks in the metadata browser

5.2.6.2.9 Definition of Data Links

Data links can be defined on spectrum and hierarchy level, i.e. spectra link to spectra and hierarchies to hierarchies. The definition of links is explained for spectrum datalinks hereafter. The definition of hierarchy datalinks is identical in terms of user interactions.
Clicking on ‘New’ right to the datalink list (cf. Figure 37) will open a new dialog (cf. Figure 38).

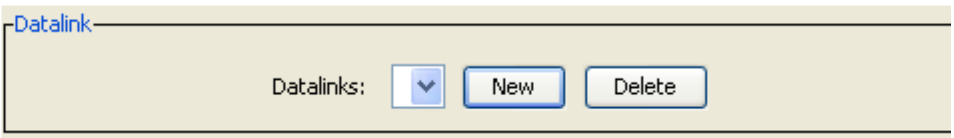


Figure 37: Datalink list and ‘New” and ‘Delete’ buttons

In this dialog use the spectral data browser to select the spectrum that shall be linked. The selected spectrum will be displayed in the right side in a read only field. Select the link type from the list box. Click ‘OK’ to create this link.
Note that the function ‘Link targets to references’ provides a quicker and easier option to create reference panel links (see 5.2.6.2.10.2).

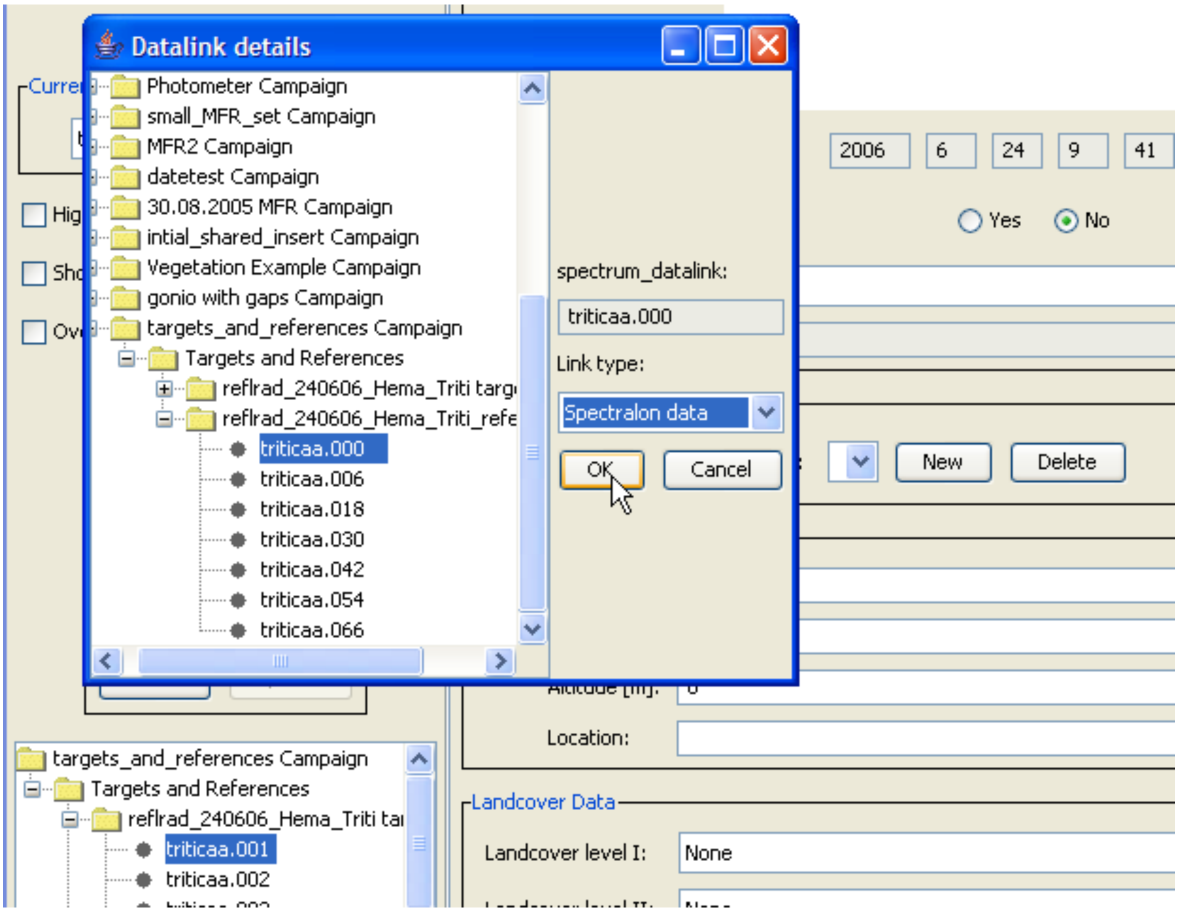


Figure 38: Definition of a datalink on spectrum level

5.2.6.2.10 Special Functions

The metadata editor provides some special data processing functions. They are either accessed via the metadata editor menu (cf. Figure 39) or via actions buttons in the spectrum tab.

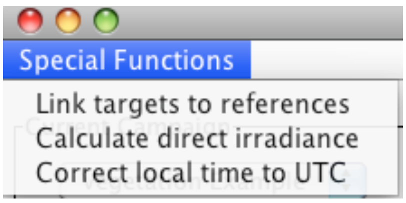


Figure 39: Metadata editor Special Functions menu

Note: The special functions offered by the menu do not depend on the currently selected campaign in the metadata editor but offer access to all campaigns.

5.2.6.2.10.1 Calculation of Goniometer Angles

RSL uses a standard protocol for the capturing of directional data using a goniometer (FIGOS/LAGOS). The sensor zenith and azimuth are given by the capturing sequence (Figure 40).

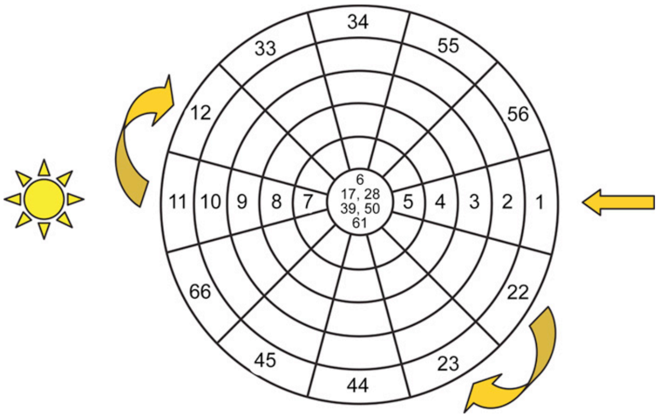


Figure 40: Data collection sequence of the RSL FIGOS/LAGOS system

A full directional set consists of 66 spectra. The routine expects a maximum number of 66 spectra, i.e. excessive spectra like white reference readings must be removed before the angles are calculated. The function can deal with gaps in the data, provided that the user can specify them. See Figure 41 for a screenshot of the dialog with the metadata editor in the background.

The following user actions are needed:

- ☐ In the spectral data browser of the metadata editor select a hierarchy that contains the spectrodirectional measurements. (cf. Figure 41 where the ‘target’ hierarchy has been selected in the metadata editor)
- ☐ Click the ‘Calc Gonio Angles’ button in the ‘Sampling Geometry’ section of the metadata editor. This will open the Goniometer Angle Calculation dialog. The selected hierarchy and the number of spectra is displayed in the according fields in the middle section of the dialog. If the wrong hierarchy was selected in the metadata editor, you can redefine your selection in the metadata editor while leaving the Goniometer Angle Calculation dialog opened. Changes in the spectral data browser of the metadata editor will be reflected within the Goniometer Angle Calculation dialog.
- ☐ If there are any gaps, specify the positions of the gaps in the Gaps input text field. The gap numbers must be separated with commas. Then click the ‘Insert gaps’ button and the total number of spectra plus inserted gap dummies will be shown in the read only field ‘Spectra + dummies’. Note that positions start with 0.
- ☐ Click ‘Calculate’. This fills the listbox one the right side of the dialog with a preview of the calculated angles. The line format is: <position>: <azimuth>/<zenith> <filename>
- ☐ Click ‘OK’ to insert the calculated angles into the database

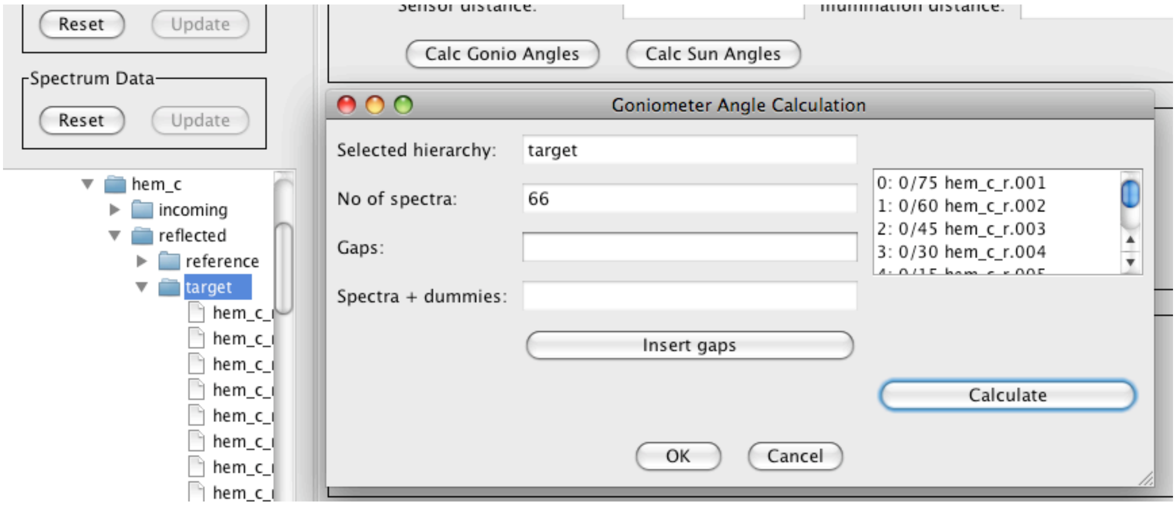


Figure 41: Goniometer angle calculation dialog

5.2.6.2.10.2 Linking Targets to References

This dialog can be used to automatically create a datalink of the type 'Spectralon' between target spectra and white reference spectra.

This function is applicable for campaigns where target and reference spectra are collected in separate spectral files. This is e.g. the case for campaigns utilising the ASD spectroradiometer in radiance mode. In order to tie the target to its corresponding white reference spectrum, a datalink on spectrum level must be inserted. This could be achieved manually for each spectrum using the metadata editor.

Target and reference spectra must be stored in separate hierarchies. The example shown in Figure 42 is taken from a goniometer campaign. In the left spectral data browser select the hierarchy containing the targets. In the right browser select the hierarchy containing the references. The selected hierarchies are displayed in the read only fields on the right side of the dialog.

Click link to create datalinks between targets and references.

Details on the algorithm:

The linking utilises the capture time stamps of the spectra. Consider two timelines: one for the targets and one for the references. A target must link to the most recent reference with the constraint that the reference capture time is smaller than the target capture time (see Figure 43).

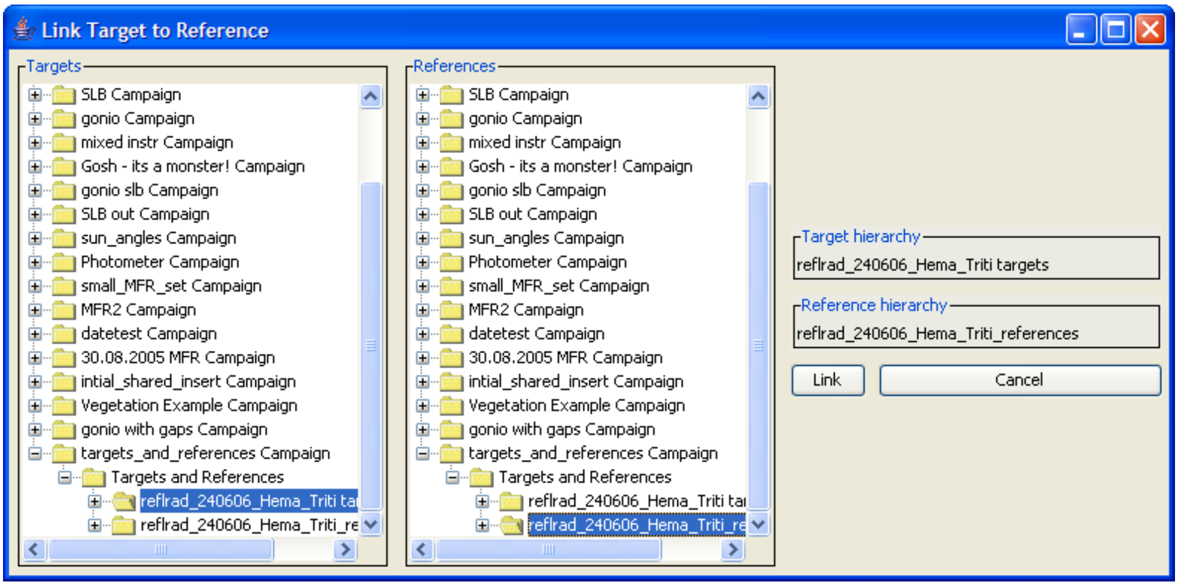


Figure 42: Link Target to Reference dialog

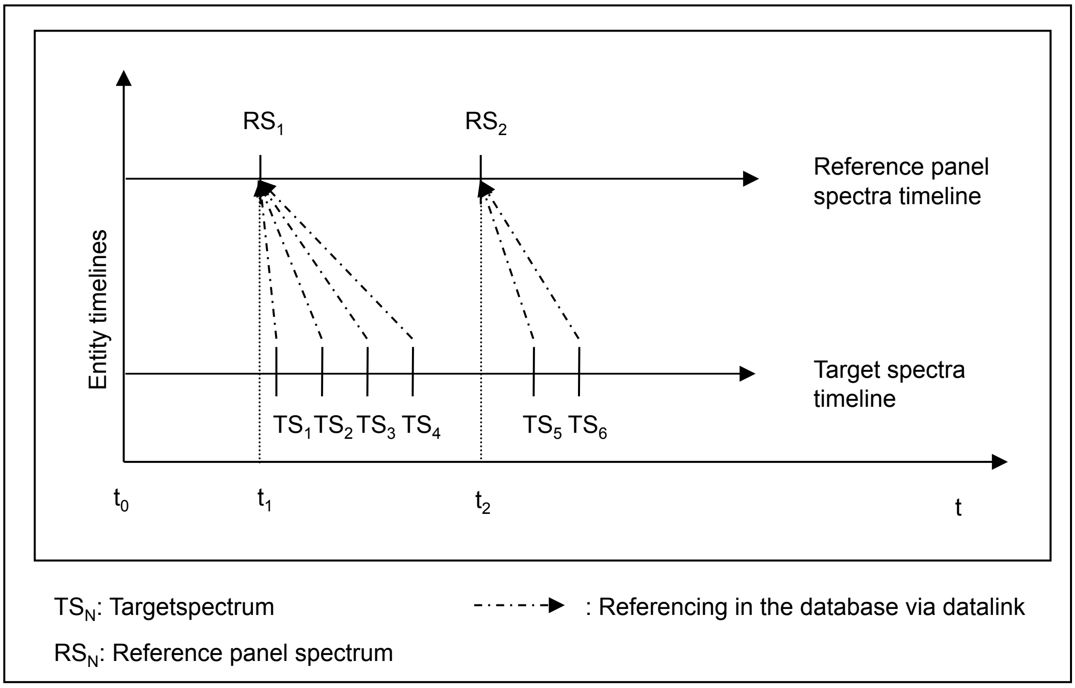


Figure 43: Referencing of reference panel spectra by target spectra based on timeline information

5.2.6.2.10.3 Calculation of Sun Angles

The sun angles are stored as part of the sampling geometry, namely as illumination zenith and azimuth. Sun angles can be calculated for a spectrum if the spatial position in latitude/longitude and the capture time in UTC are known.
Select the spectra to be processed in the spectral data browser of the metadata editor (see Figure 44). Note that any selection (single spectra, hierarchy and mixed cases) is possible.
The sun angle calculation dialog opens and the number of spectra is displayed. Click OK to calculate the sun angles and store the results in the database.

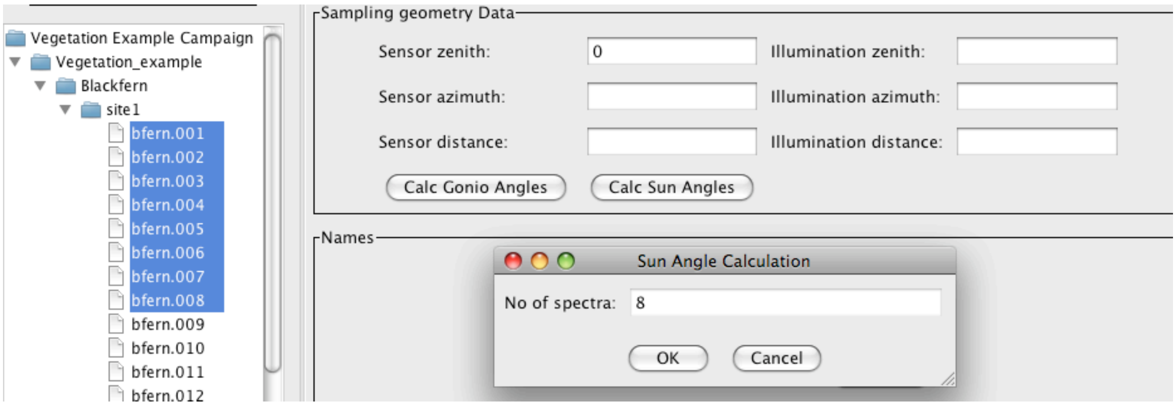


Figure 44: Sun Angle Calculation dialog

5.2.6.2.10.4 Direct Irradiance Calculation

The calculation of direct irradiances applies to photometers where the total and diffuse irradiance are known. Total and diffuse spectra must be stored in separate hierarchies (see Figure 45). Furthermore, all spectra need to have a defined sun zenith angle.
The calculation cannot be carried out on hierarchies already containing a 'direct' hierarchy. If a recalculation is needed first remove the 'direct' hierarchy from the database using the 'Data Re-mover' dialog.
Select the hierarchy containing the total and diffuse hierarchies. Note that they must be named 'total' and 'diffuse'. This will be autogenerated in the case of MFR file input. The selected hierarchy and the number of total/diffuse spectra pairs will be shown.
Click 'OK' to calculate the direct irradiance. A new hierarchy will be created called 'direct' (see Figure 46) containing all direct irradiance spectra.

Details on the algorithm:

For each channel i: direct_irr[i] = ((tot_irr[i] - diff_irr[i])/cos(sun_zenith));

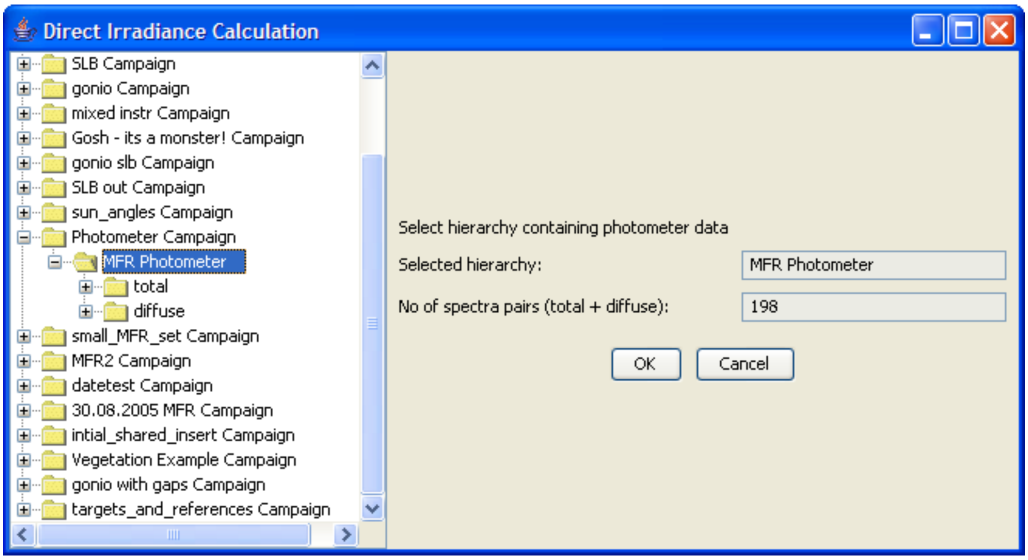


Figure 45: Direct Irradiance Calculation dialog

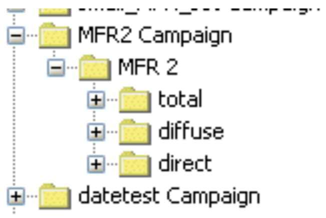


Figure 46: Direct irradiance hierarchy

5.2.6.2.10.5 UTC Time Correction

This tool is provided to handle cases where the capturing time is not in UTC.
Technically it applies a time shift based on the number of hours entered by the user in the UTC Time Correction dialog (see Figure 47).
Select the hierarchy containing the spectra that need to be time shifted. The selected hierarchy and the number of spectra are shown on the left in read only fields. The hours are specified as East of GMT.

The time shift is implemented as:

Date_time_in_milliseconds = Date_time_in_milliseconds – hours_east_of_gmt*millies_per_hour.

This means that if a time shift happens across midnight, the calendar date of the capture time will also be shifted (back or forth depending on the value of hours_east_of_gmt.
E.g. for a local capture time around 10am in Oceania a time shift of around 12 hours East of GMT is needed. The UTC time will then be 10pm the previous day.

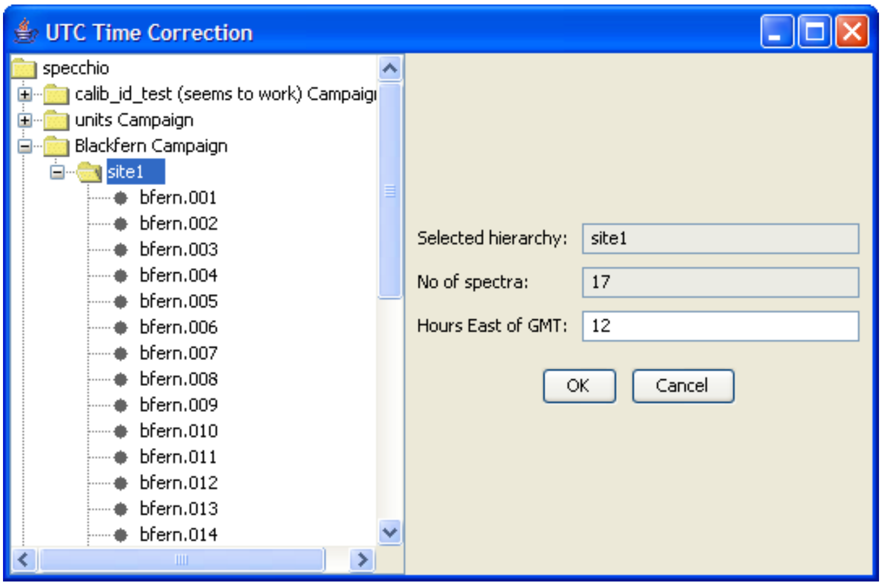


Figure 47: UTC Time Correction dialog

5.2.7 Querying Data

SPECCHIO features an intuitive way to query data by the means of the Query Builder (see Figure 50). To start the Query Builder select 'Data Processing & Output'->'Build query' from the main menu (see Figure 48).

Two principal ways of data selection are supported: (a) by specifying the needed data using a spectral data browser in the 'Browser' tab and (b) by entering restricting conditions in the 'Query conditions' tab. Actions on both of these tabs will result in the automatic building of an SQL query. The query is updated in real time on each user input. The number of resulting rows (should the query be executed) is displayed and updated along with the SQL query. The query can be copied from the text area for e.g. direct execution in an SQL prompt.
The selected spectra can be fed into three different further modules by pressing the respective buttons: 'Show report' ,'File export' and 'Process'.
Reports are described in 5.2.8.
File exports are detailed in 5.2.9.
Interactive processing is elaborated in 5.2.10.

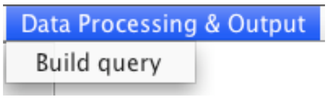


Figure 48: Build query menu entry

The data displayed in the Spectral Data browser can be restricted to the data of the current user by clicking the tickbox 'Show only my data.' (see Figure 49).

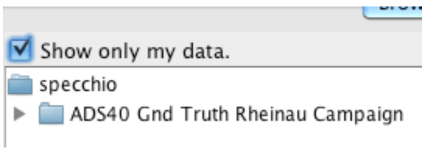


Figure 49: Restricting the data displayed in the spectral data browser to the current user

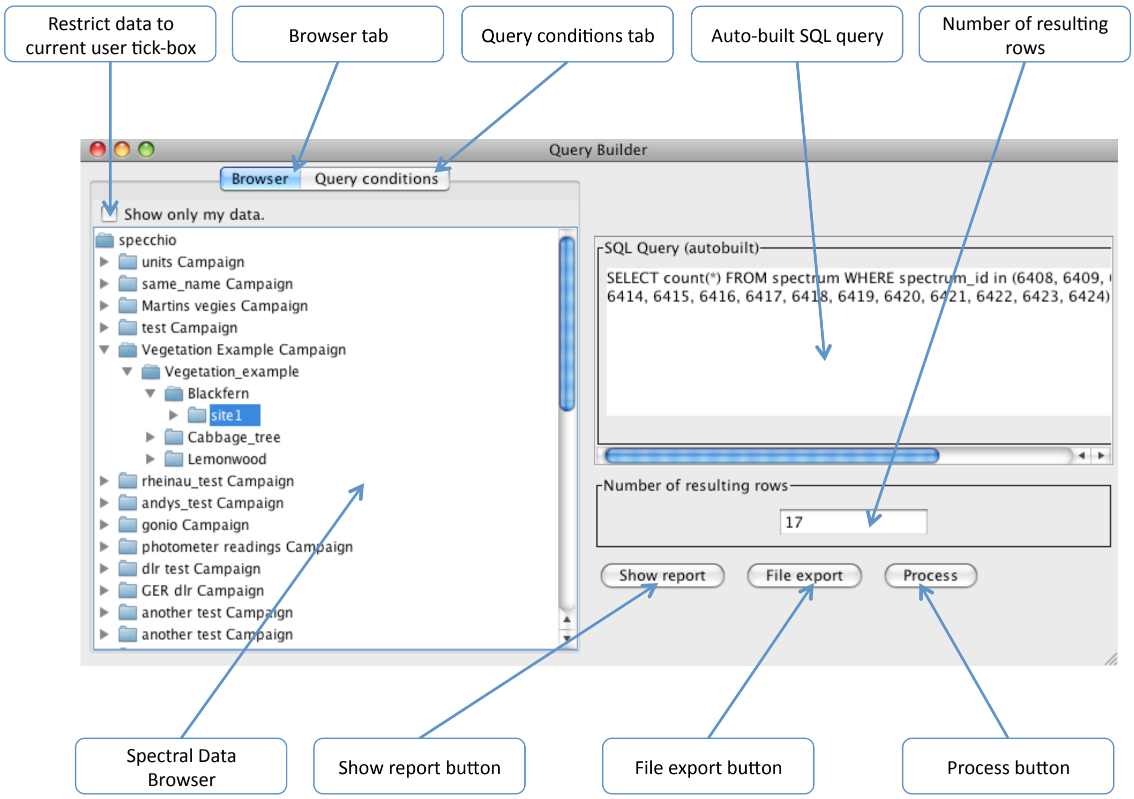
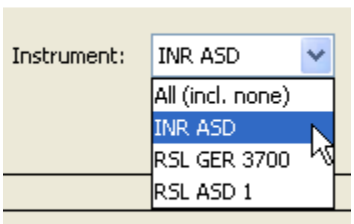


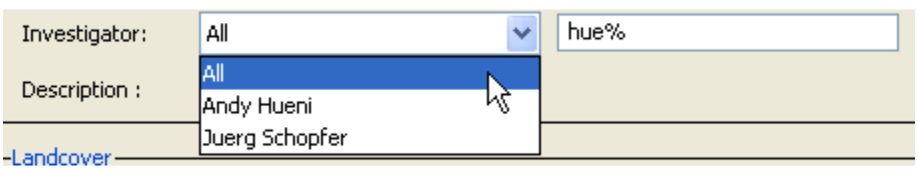
Figure 50: Query Builder dialog

The query conditions tab is grouped similarly to the Metadata Editor.
The basic query GUI components are:

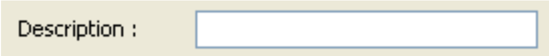
(a) Simple combobox : One out of several options can be selected. The default 'All (incl. none)' imposes no restriction on the rows to be returned.



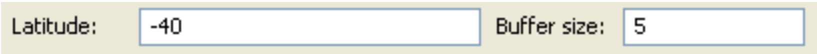
(b) Combobox with wildcard box: One of several options in the combobox can be selected. Alternatively a wildcard string can be entered in the wildcard box. Standard SQL wildcards can be used. These are: % for any string expression and _ for one character. Note that when selecting a combobox entry the wildcard string is automatically blanked. Similarly, if a specific combobox entry is selected and wildcards are entered the combobox reverts to the default 'All (incl. none)'.



(c) Wildcard text field: This takes any SQL wildcard string



(d) Numerical field with buffer: This consists of a main numerical field and a buffer that, when filled generates expressions of the type: field_name >= main_value – buffer AND field_name <= main_value + buffer.
When applied to e.g. spatial metadata like latitude, the effect is similar to buffering functions found in GIS systems.



(e) Multiple selection list: 0:N elements can be selected/deselected from the list by using ctrl and the mouse button. Note that the expressions built from the selected elements are logically related by OR and not by AND. I.e. the resulting expression has the SQL syntax ‘field_name in (<id> [, <id>])’.

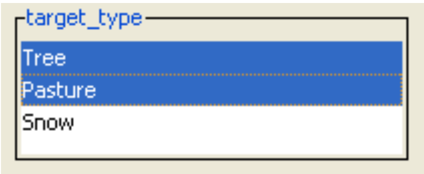


Figure 51 and Figure 52 show the query condition tab with some of the fields filled. The SQL query resulting from these entries is as follows:

```
SELECT count(*)
FROM spectrum, campaign, specchio_user, position, sampling_geometry
WHERE (specchio_user.first_name like 'spe%' OR specchio_user.last_name like
'spe%') AND spectrum.landcover_id = '49' AND (position.latitude >= -50.0 AND po-
sition.latitude <= -30.0) AND (position.altitude >= 30.0 AND position.altitude <=
70.0) AND (sampling_geometry.illumination_zenith >= 40.0 AND sam-
pling_geometry.illumination_zenith <= 50.0) AND spectrum.measurement_unit_id =
'1' AND spectrum.illumination_source_id = '1' AND spectrum.instrument_id = '1'
AND spectrum.campaign_id = campaign.campaign_id AND spectrum.user_id = spec-
chio_user.user_id AND spectrum.position_id = position.position_id AND spec-
trum.sampling_geometry_id = sampling_geometry.sampling_geometry_id AND cam-
paign.user_id = specchio_user.user_id AND specchio_user.user_id = posi-
tion.user_id AND specchio_user.user_id = sampling_geometry.user_id
```

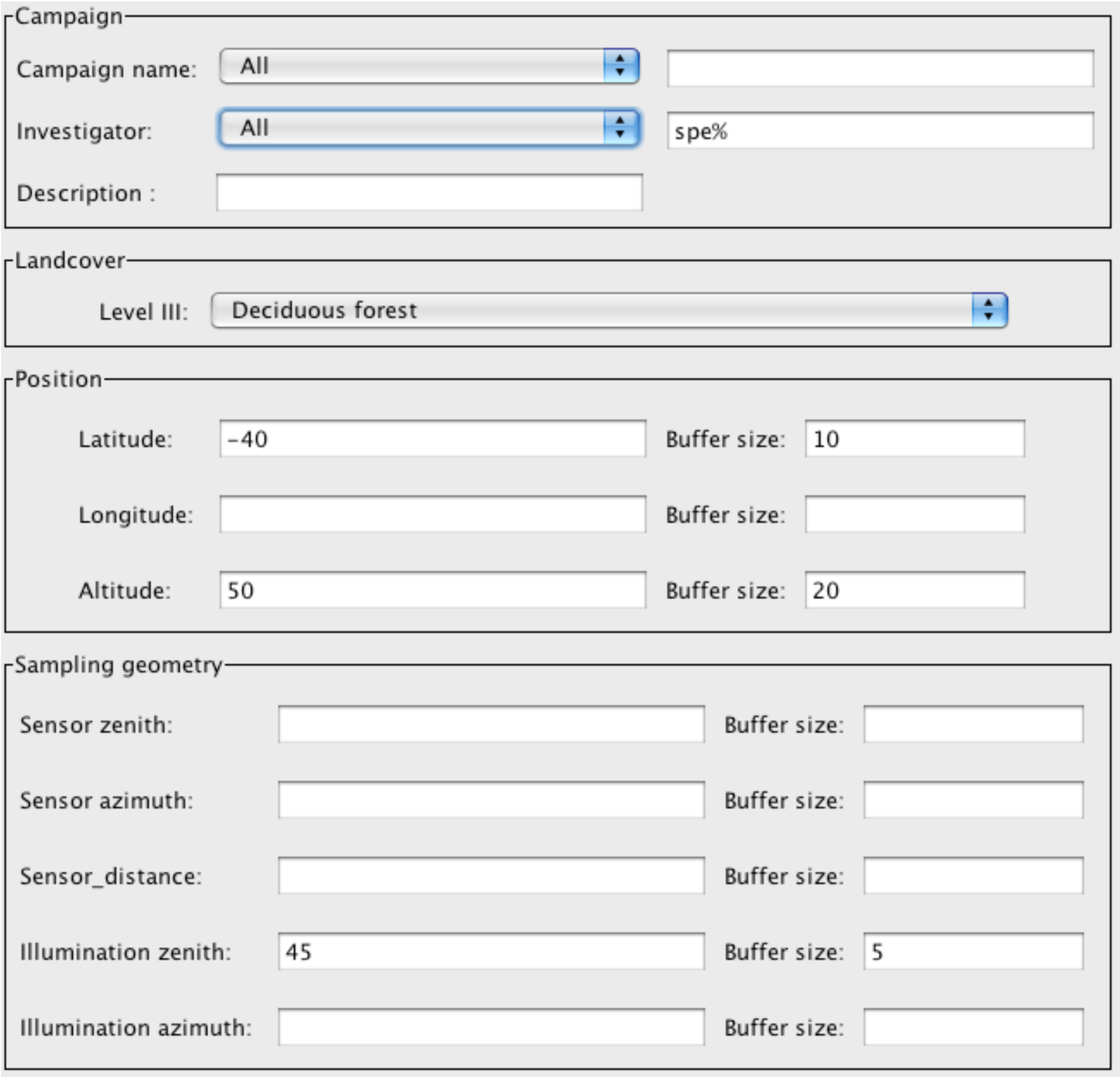


Figure 51: Query conditions tab (part 1)

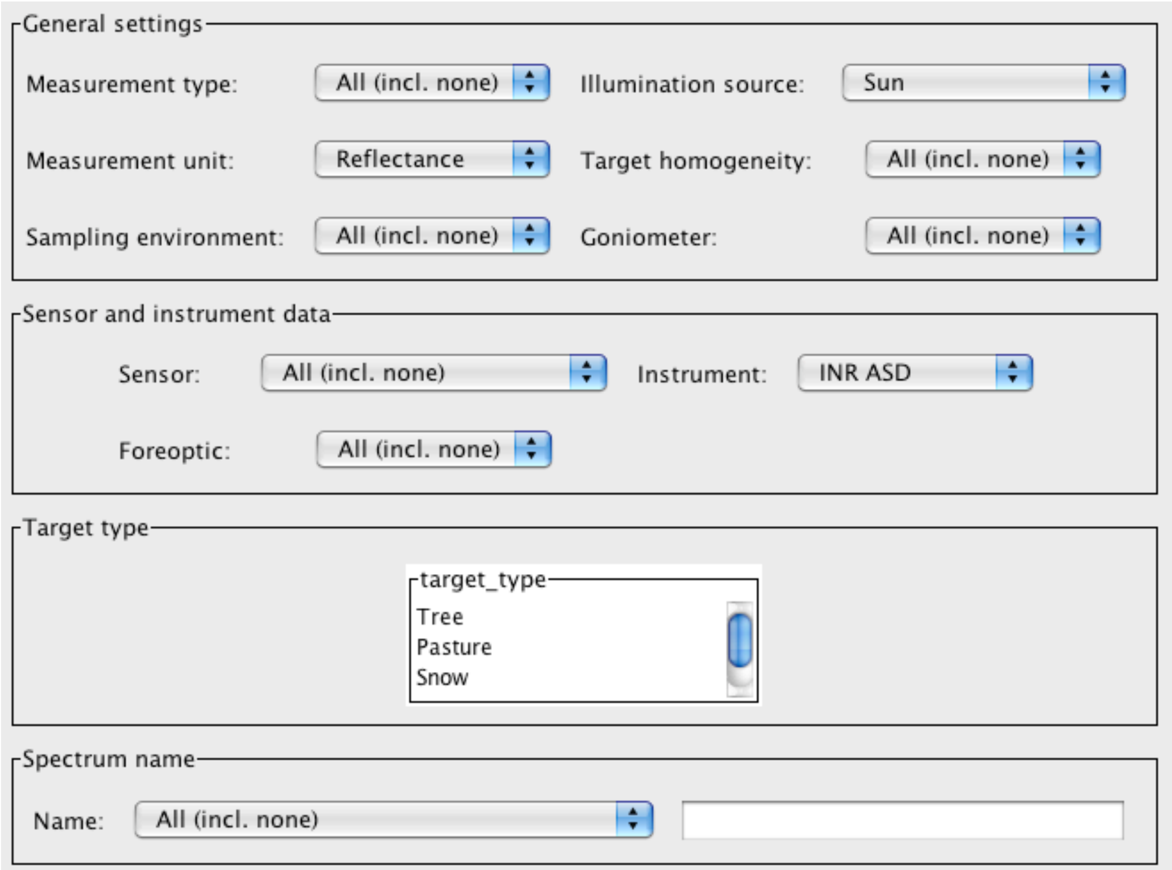


Figure 52: Query conditions tab (part 2)

5.2.8 Report Generation

Reports are generated by selecting the 'Show report' button in the Query Builder (see 5.2.7). The report consists of a Java frame displaying a list of spectrum report panels. Thus, for each spectrum being the result of a query built in the Query Builder, one spectrum report panel is added to the report frame.
A spectrum report consists of two main elements: (a) a spectral plot on the left side and (b) a scrollable list containing metadata values (see Figure 53). Pictures saved for a spectrum can be displayed by clicking on the button 'Show pictures' at the bottom of the metadata list. This will bring up a new frame containing all pictures of this spectrum (see Figure 54).
The spectral plot y axis is automatically scaled in order to correctly display spectra even when exhibiting strong atmospheric noise in the usual regions of 1350-1440nm, 1790-1980nm and 2360-2500nm. The algorithm consists of calculating the mean and standard deviation in the wavelength region 300-1200nm. The maximum of the y axis is then given by mean + 3 * standard deviation.
Spectra having no sensor definition cannot be plotted.
For sensors comprising broad and narrow band elements (e.g. MFR) only the narrow bands will be plotted.

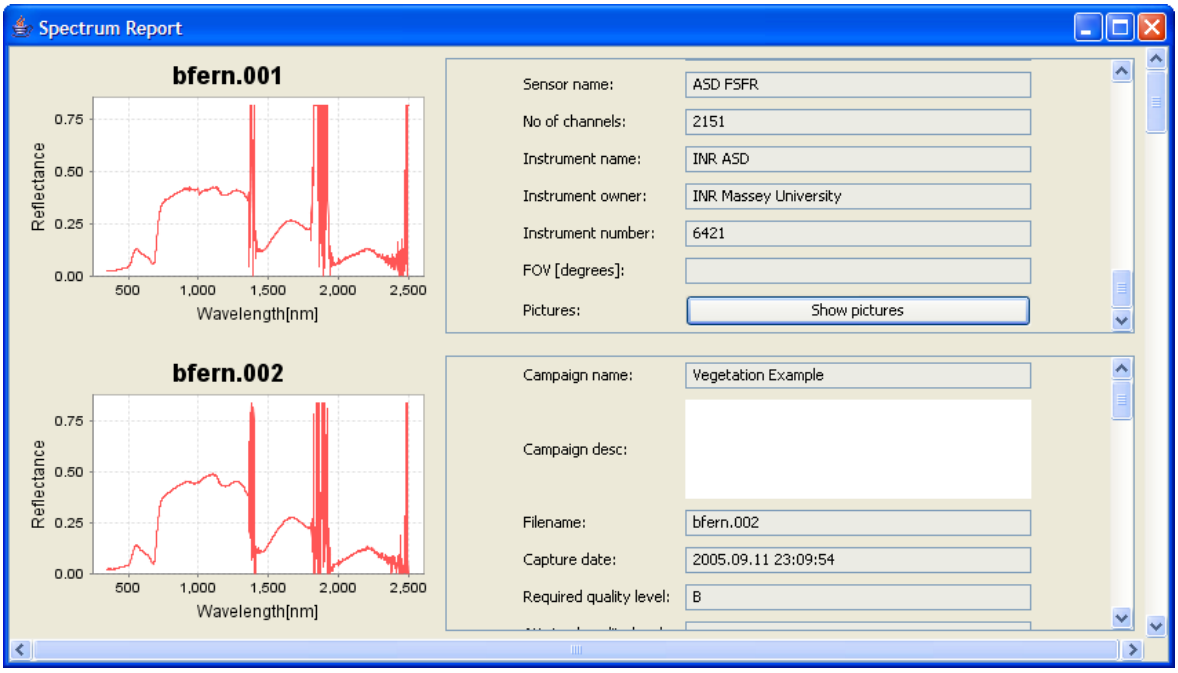


Figure 53: Spectrum report frame

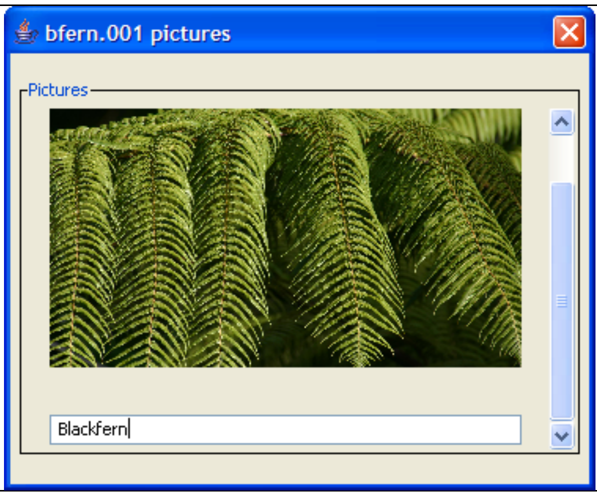


Figure 54: Spectrum report picture frame

5.2.9 File Output

File output is invoked by selecting the ‘Show report’ button in the Query Builder (see 5.2.7). A File output dialog will appear (see Figure 55).
Two file formats are currently supported:

- CSV: data is written to a text file as comma separated values. This file type can be e.g. read into Excel
- ENVI SLB: ENVI spectral library file consisting of a header (<file_name>.hdr) and a body (<file_name>.slb). Spectral data are written as floating point values, either 32bit or 64bit depending on the architecture of the machine; the datatype field in header file is set accordingly (datatype 4 or 5 respectively).

A target directory must be specified by clicking on the ‘Browse’ button. All files that are created during file output will be written to this directory. Note that when using a UNIX system you may have to enter a dot as filename (cf. 5.2.1).
A base name must be specified. This name should contain no characters that are not allowed in filenames (depending on the operating system). The base name is used to build the real filenames. Filenames use one of the following patterns:

<base name>_<sensor_name>.<file extension>

<base name>_<instrument_name>[cal<calibration sequence number>].<file extension>

If no instrument has been defined the sensor name will be used.
If an instrument has a defined calibration then the calibration sequence number is added to the filename. If the spectra being written have been captured with different instruments or different calibrations then for each combination of instrument and calibration a separate file will be written.
E.g. consider a campaign containing spectra captured with:

- An ASD instrument belonging to the Institute of Natural Resources, Massey University (named INR ASD) with calibration sequence number 1
- An ASD instrument belonging to the Remote Sensing Laboratories, University of Zurich (named RSL ASD 1) with no calibrations entered in the database
- A GER 3700 instrument belonging to the Remote Sensing Laboratories, University of Zurich (named RSL GER 3700) with no calibrations entered in the database

A CSV file output of this campaign with the option ‘Split header and body’ results in the following files:

The option ‘Split header and body’ is only available for CSV files (ENVI SLBs are automatically split into header and body).
Two time formats are possible. Select the Milliseconds if you easily want to plot a timeline.

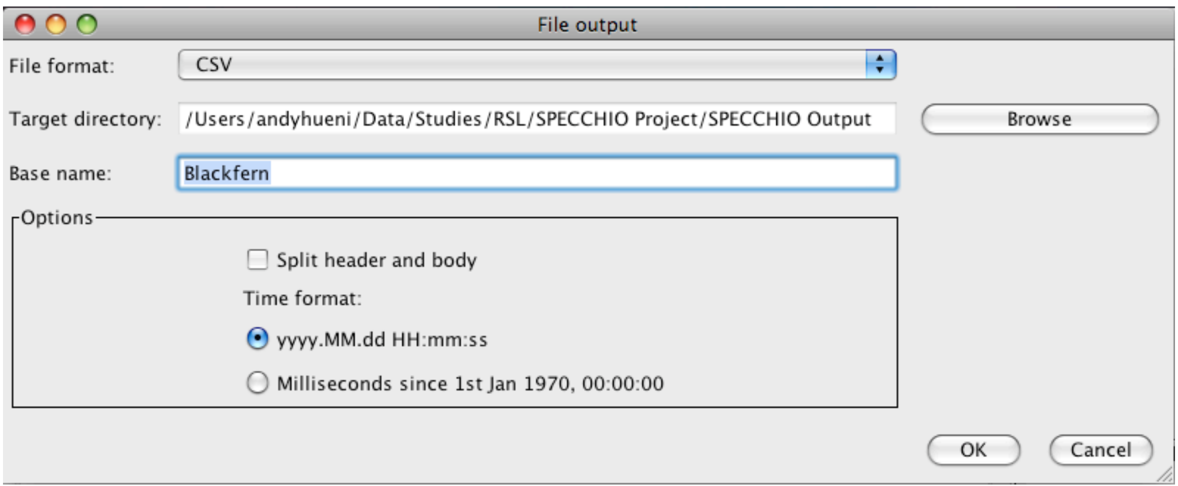


Figure 55: File output dialog

5.2.9.1 CSV File Format

The CSV file format contains a header and a body. If the file is not split then header and body are written into the same file.
Metadata are essentially adding dimensions a dataset, i.e. the total dimension is given by: number of spectral bands + number of metadata fields. The dimension of an output file is therefore:

Number of rows (lines) = total spectrum dimension
Number of columns = number of spectra + 1 dimension name column

The line format is specified by:

<dimension name>, <value>[,<value>]

A file example showing part of a header and body follows (Figure 56):

	A	B	C	D
1	Number	1	2	3
2	Comment			
3	Capture date	2005.09.11 23:09:50	2005.09.11 23:09:54	2005.09.11 23:09:58
4	Loading date	2006.12.11 18:23:03	2006.12.11 18:23:03	2006.12.11 18:23:03
5	Filename	bfern.001	bfern.002	bfern.003
6	Internal no of avg	10	10	10
7	Is reference	false	false	false
8	Latitude	-40.3849	-40.3849	-40.3849
9	Longitude	-175.622	-175.622	-175.621
10	Altitude	52	54.2	49.2
11	Location			
12	Campaign name	Vegetation Example	Vegetation Example	Vegetation Example
13	Campaign desc			
14	Landcover	Deciduous forest	Deciduous forest	Deciduous forest
15	Cloud cover [octas]	0		0
16	Ambient temp. [°C]	18		20
17	Air pressure			
18	Rel. humidity			
19	Wind direction	calm		calm
20	Wind speed			
21	Sensor zenith	0		0
22	Sensor azimuth			
23	Illumination zenith	47.7073	47.7025	47.6981
24	Illumination azimuth	21.975	21.9535	21.9333
25	Sensor distance			1
26	Illumination distance			
27	Measurement unit	Reflectance	Reflectance	Reflectance
28	Measurement type	Single		Single
29	Illumination source	Sun		Sun
30	Sampling environment	Field		Field
31	Spectrum names			Blackfern (Common) / Cyathea medullaris (Latin)
32	Target types			Tree (100)
33	350	0.0251693	0.02180227	0.021688519
34	351	0.026092373	0.022058768	0.021206077
35	352	0.026704058	0.02304296	0.022523083
36	353	0.026678136	0.023551108	0.023339724
37	354	0.025368243	0.022222875	0.021277064
38	355	0.02532748	0.022796206	0.022375558

Figure 56: CSV file example (loaded into Excel)

5.2.10 Interactive Processing using Space Networks

For an introduction to the concept of the Space Processing Network please refer to 4.6.

Pressing the 'Process' button in the Query Builder interface starts the processing tool. A number of spaces are placed on the processing plane of the Space Network Processor, depending on the query built in Query Builder.
Figure 57 shows a space containing 66 spectra, created based on a selection in the Query Builder.

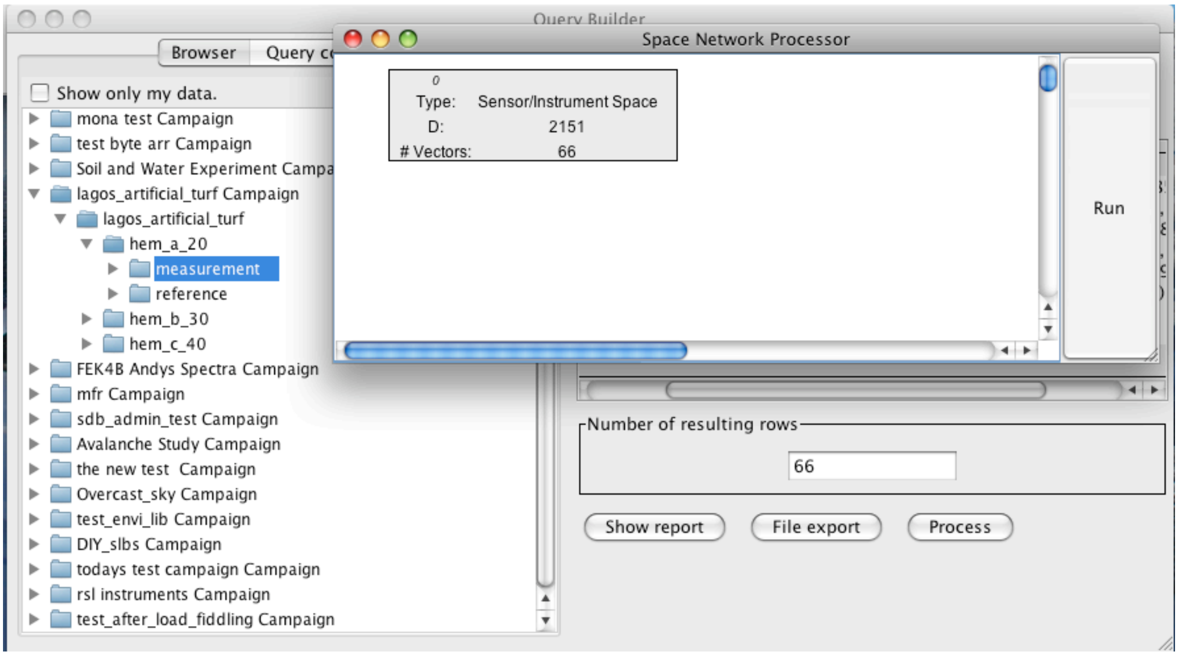


Figure 57: Space Network Processor interface with the Query Builder in the background

Figure 58 shows the common elements of the Space Network Processor: processing plane, spaces, edges, context sensitive menu of the processing plane and the Run button.

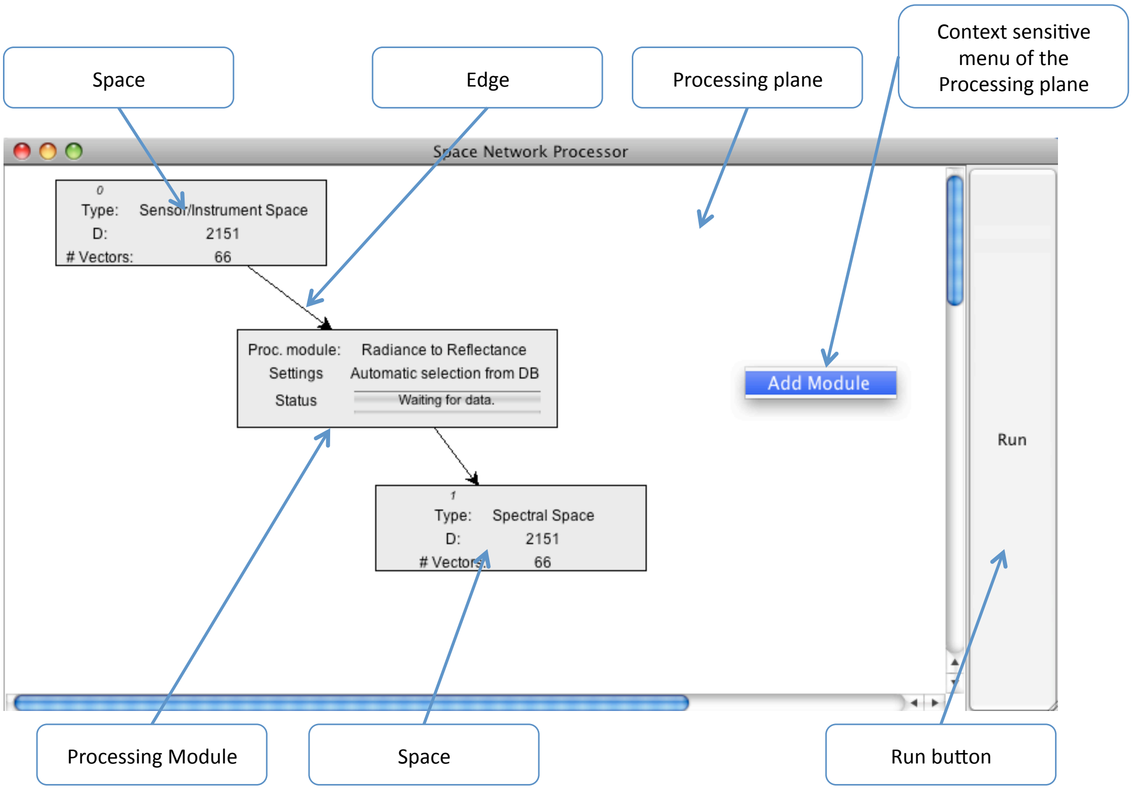


Figure 58: Elements of the Space Network Processor

5.2.10.1 Graphical Representations of Spaces and Modules

Spaces and modules are depicted as rectangular boxes (Figure 59).
The space displays the following information:

- A unique number (zero in the example below)
- A space type, which can be 'Sensor/Instrument Space' if loaded from the database or 'Spectral Space' if generated by a processing module.
- A dimension D, which is equal to the number of spectral bands of the spectra held by this space
- A number of vectors, which is equal to the number of spectra held by this space

The module displays the following:

- A module name
- Information about the configuration (if applicable)
- The current processing status (text and progress bar). During processing, the progress is shown by the progress bar.

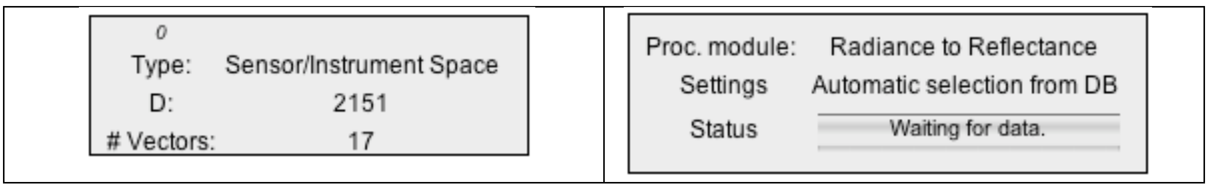


Figure 59: Examples of the graphical representation of a space (left) and a processing module (right)

Spaces and modules can be rearranged by dragging with the mouse. The edges are updated automatically.
A group of elements can be moved as single block. Selecting the elements by dragging a box around them using the mouse, then drag the selection (Figure 60).

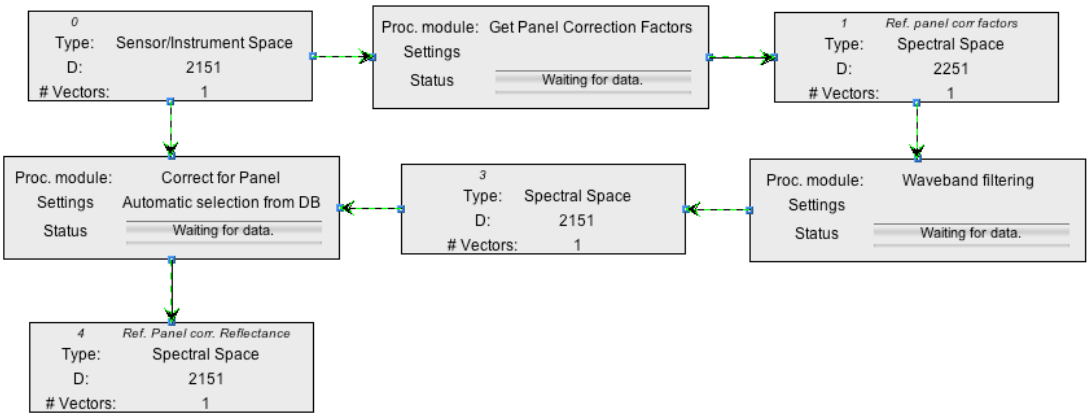


Figure 60: Multiple-selection of elements after dragging a box around them

5.2.10.2 Adding Modules and linking with Spaces

To add a module, click the mouse menu button over some empty area of the processing plane. This brings up the context sensitive menu shown in Figure 58. Select 'Add Module' and a selection of the available modules will appear (Figure 61). Select one of the modules, click 'OK' and a new module will be added to the processing plane.
To connect the module with an input space, click the menu button over the module. This displays the popup menu of the module (Figure 62). Select 'Set Input Spaces' and in the 'Input Space Selection' dialog select the number of the space to connect and click 'OK' (Figure 62). Note that all spaces are given a unique number, which is located on the top left of each space. Connecting an input space automatically generates an output space, which is added to the processing plane and connected with the module.

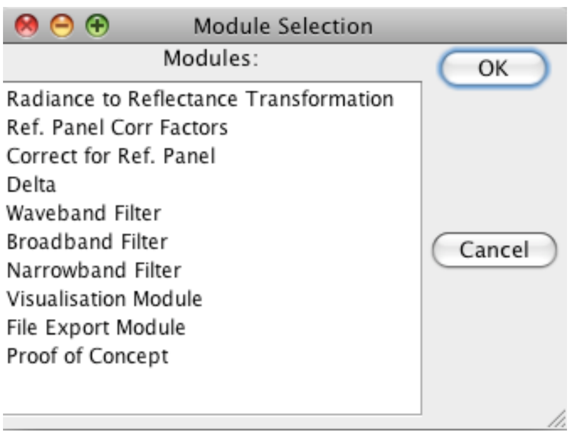


Figure 61: Module selection dialog

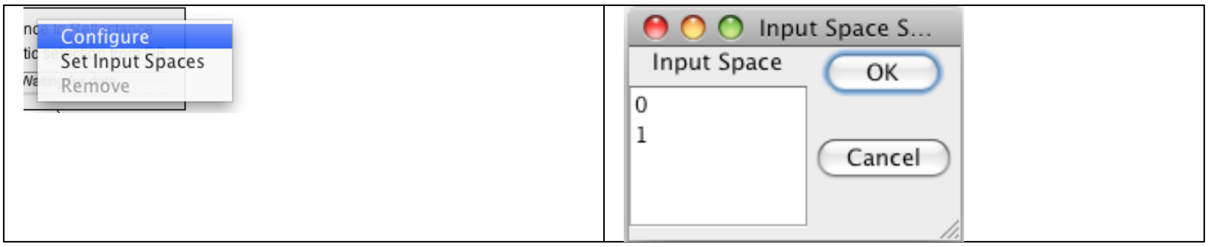


Figure 62: Popup menu of a module (left) and the input space selection dialog (right)

5.2.10.3 Configuration of Modules

Some modules may need configuration. To display the configuration dialog of a module click menu over the module and select 'Configure'.
The possible configuration settings of each module are detailed in the respective module description.

5.2.10.4 Processing Module Descriptions

5.2.10.4.1 Radiance to Reflectance Transformation

The module 'Radiance to Reflectance' is building ratios of target and reference panel radiances:

$$\rho = \frac{L_{tar}}{L_{ref}}$$

As a prerequisite, datalinks of the type 'Spectralon' must exist between the target spectra and the corresponding reference spectra. For an explanation of how such links are created please refer to 5.2.6.2.10.2.

5.2.10.4.2 Reference Panel Correction Factors

This module retrieves the correction factors for all reference panels that were used during data acquisition of the spectra contained by the input space.
As prerequisites, a reference panel must be set for the input spectra using the Metadata Editor (Figure 63) and calibration data for the panel must have been loaded to the database. Calibration data loading is a task of the system administrator. For details on the reference panel administration see 5.2.11.5.

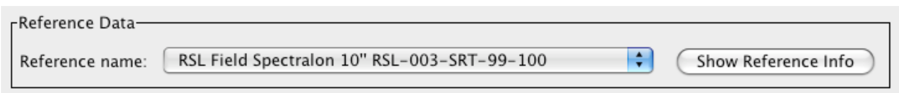


Figure 63: Reference panel setting in the Metadata Editor

If no calibration data can be found, a warning is displayed and the module creates no output space.

Figure 64 shows a processing chain that selects the panel correction factors and plots using a spectral line plot (Figure 65).

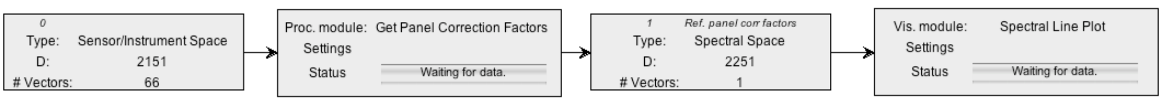


Figure 64: Processing chain selecting the correction factors and plotting them as a spectrum.

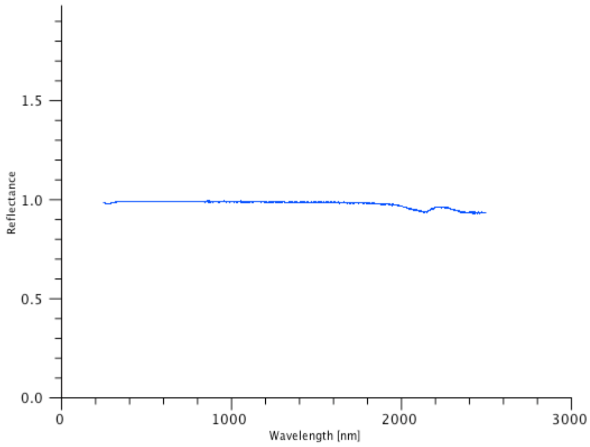


Figure 65: Reference panel correction factors

5.2.10.4.3 Correct for Reference Panel Non-Idealness

This module applies calibration factors to correct spectra for the reference panel non-idealness. These correction factors are selected from the database using the 'Reference Panel Correction Factors' module.
The module requires two inputs: the spectra to be corrected and the correction factors. The input space selection dialog offers the according choices (Figure 66).

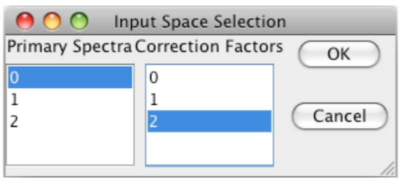


Figure 66: Input space selection for the 'Correct for Panel' module

Note that the dimensions of the spaces holding the spectra and correction factors must be identical (a check on the wavelengths is not carried out). In the example shown in Figure 67 a waveband filtering is applied to the correction factors as these were measured with a larger wavelength range.

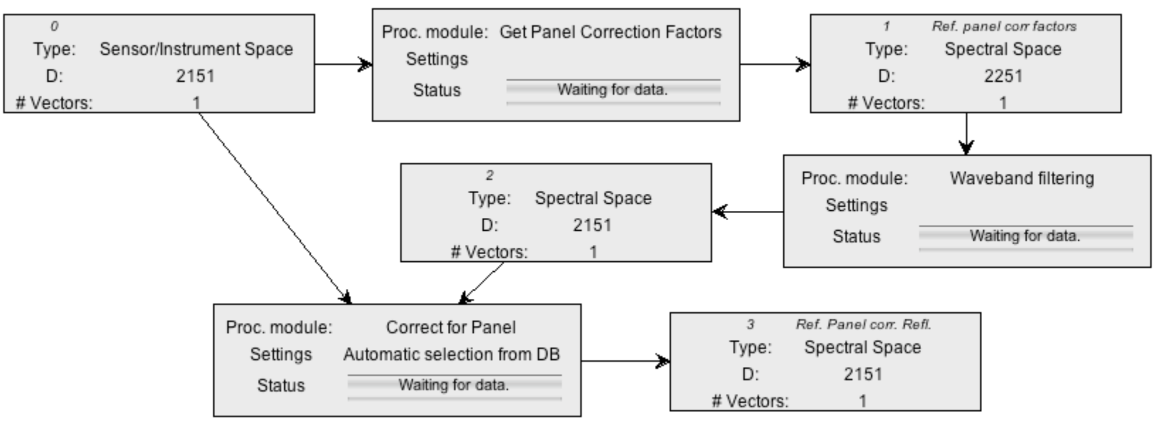


Figure 67: Space Processing Network for reference panel correction

The panel correction can be applied to radiance or reflectance values. However, correcting radiances for the panel will only make sense if followed by a radiance to reflectance conversion such that:

$$\rho = \frac{L_{tar}}{L_{ref}} \rho_{ref}$$

The correction procedure can handle multiple reference panels and multiple calibration coefficients and will apply the correct coefficients to the appropriate spectra.

5.2.10.4.4 Delta

This module calculates a delta value, i.e. the difference between two inputs A and B:

Delta = A – B

where:
A, B = MxN matrix of M spectra of dimensionality N

Thus, a delta vector is calculated by:

$$\vec{d}_m = \vec{a}_m - \vec{b}_m$$

where m = {1…M}

This implies that the input spaces must have identical number of vectors and dimensionalities.

The delta module takes two input spaces (Figure 68):

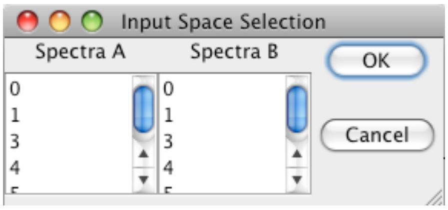


Figure 68: Input space selection for the Delta module

A possible use is the calculation of the difference between recorded reflectance and reference panel corrected reflectance. Figure 69 shows a processing network for this purpose and Figure 70 shows the according spectral plots generated by the network.

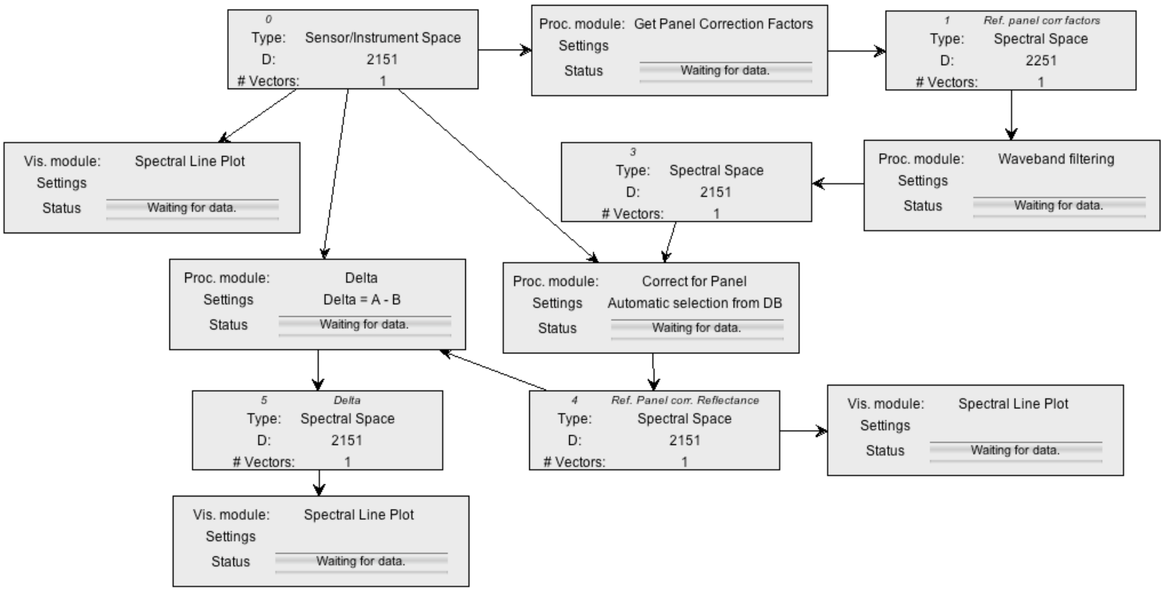


Figure 69: Space Processing Network for the panel correction and delta calculation

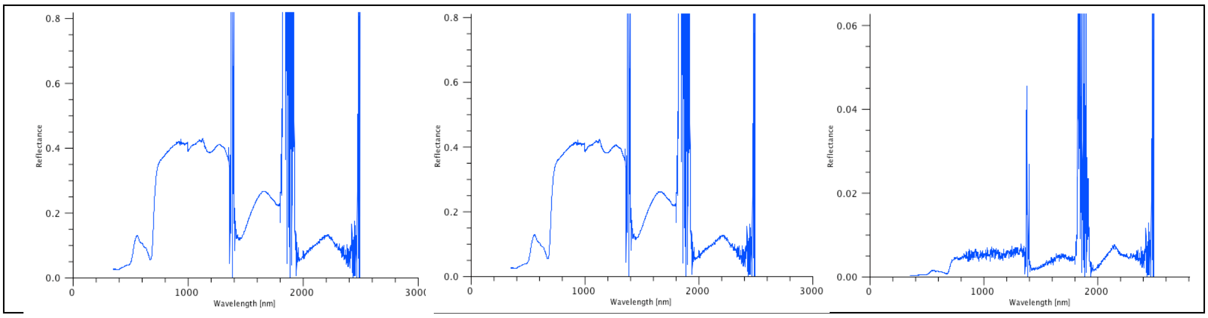


Figure 70: Spectral plots of: input spectrum (left), panel corrected spectrum (middle) and delta spectrum (left)

5.2.10.4.5 Waveband Filter

Waveband filtering is used to cut wavelengths regions from spectra. A typical example is the removal of noisy wavebands caused by water vapour absorption.
The wavebands are freely configurable. The 'Configure' menu brings up the 'Filter configuration' dialog (Figure 71).

Figure 71: Filter configuration window

To add a new filter region, click 'New' and enter the upper and lower wavelengths in nanometres in the Filter Definition dialog (Figure 72).

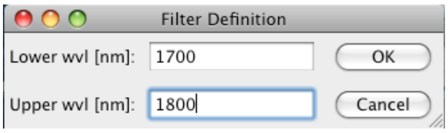


Figure 72: Filter definition dialog

To remove an existing filter region, select the region in the list and click 'Remove'.

5.2.10.4.6 Broadband and Narrowband Filters

The filters act on the element type of sensor elements. They are useful to process data of sensors that contain bands widely differing spectral resolutions.
An example is the MFR sunphotometer, which features one panchromatic band and 6 narrower bands. The value ranges of the broad and narrow bands are very different and even a simple plot cannot be created satisfactorily (see Figure 73). The broadband channel has been placed at the likely centre wavelength of 673nm. As the bands of the MFR are defined in the order of the broad-band followed by the narrowbands in the database, the plot shows two spectral lines. Mixing broad- and narrowbands should not be done from a physical point of view.

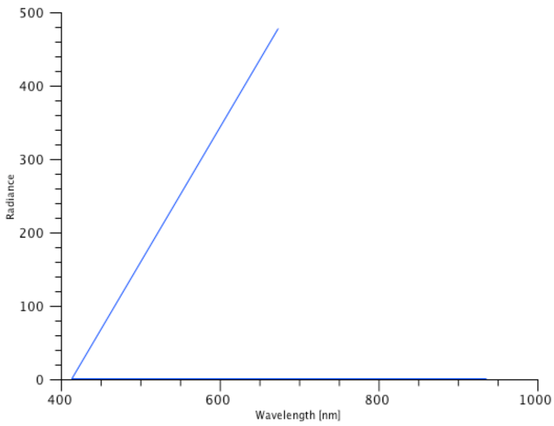


Figure 73: Spectral plot of broad- and narrowband MFR channels

Figure 74 shows a space processing network that illustrates the function of broad- and narrowband filters.

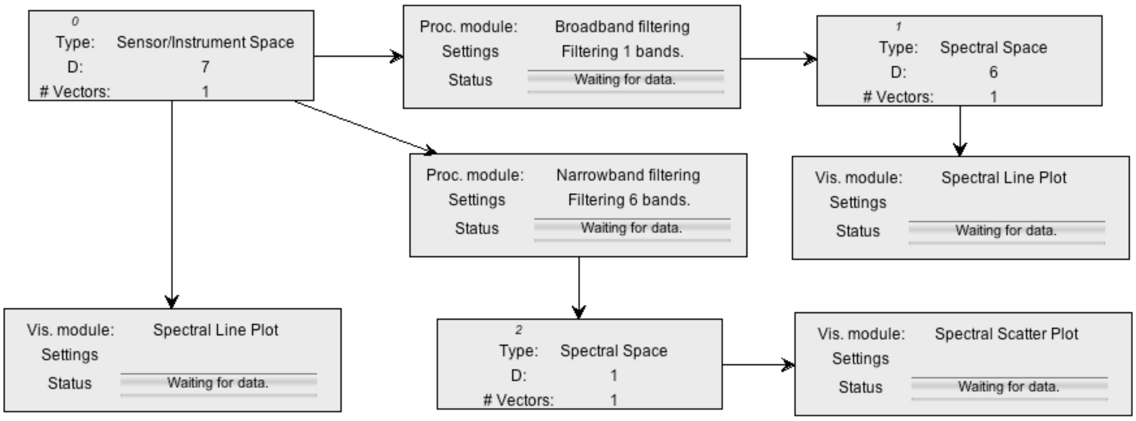


Figure 74: A space processing network demonstrating the function of broad- and narrowband filters

The plot shown in Figure 73 was generated by the 'Spectral Line Plot' of space number 0.
Figure 75 shows the plots of space 2 (Broadband value as a scatter plot) and space 3 (Narrowband channels as a spectral curve).

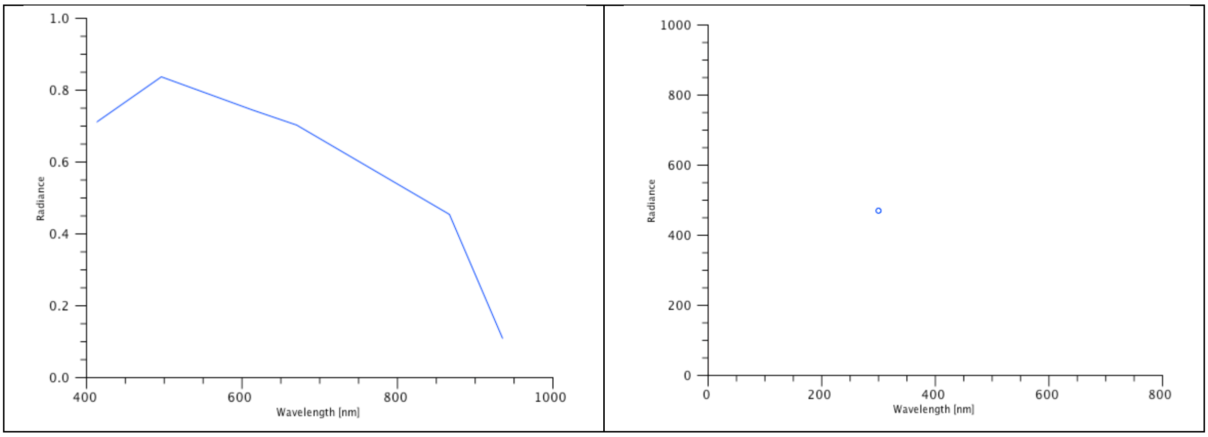


Figure 75: Plots of the narrowband channels (left) and of the broadband channel (right)

5.2.10.5 Visualisation Modules

Visualisation modules can be attached to any space and do not generate an output space but display a new window containing the respective plot or data explorer. A visualisation module can be configured to produce a number of plots/explorers as listed in the following sections. Data explorers are graphical components that allow interactive data exploration.
The titles of the plot windows do contain information about the plot type and the space the data was read from (Figure 76).

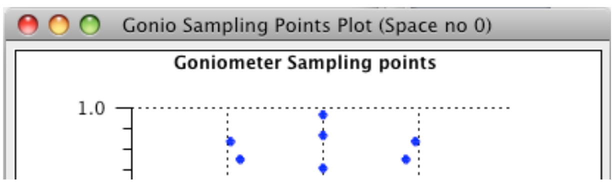


Figure 76: Information displayed in the window title

5.2.10.5.1 Spectral Line Plot

Use this plot to display one or more spectra as continuous curves. Spectra are plotted with an automatic colour shift from red to blue for easier interpretation.

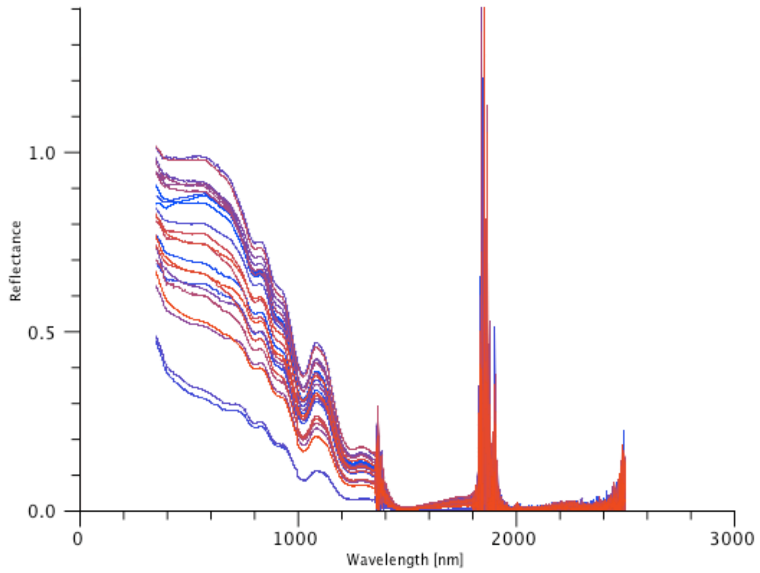


Figure 77: Spectral line plot of snow avalanche reflectance spectra

5.2.10.5.2 Spectral Scatter Plot

Use this plot to display values per spectral band as singular points. This is useful to plot e.g. data of sensors with just one band, e.g. MFR broadband, as single values cannot be visualized as line plots. Scatter plots are also useful to show the variation of the values per band. Figure 78 shows an example of the variation per channel for several MFR sunphotometer readings.
Note: the generation of scatter plots of several spectra with high dimensionality tends to be quite slow.

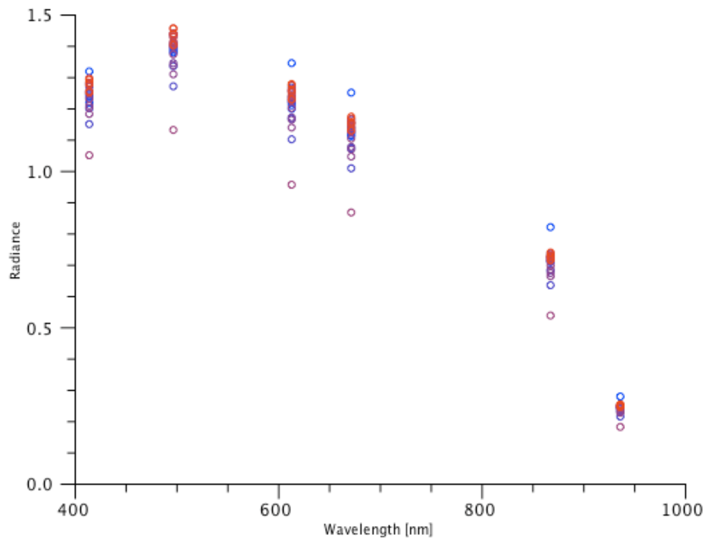


Figure 78: Scatterplot showing the variation per channel for several MFR sunphotometer readings

5.2.10.5.3 Gonio Sampling Points Plot

Use this plot to visualise the sampling positions of directional measurements acquired by a goniometer system. The plot is not expecting any specific number of points or particular geometry. The sampling points are projected from their angular definition (zenith/azimuth) onto a 2d Cartesian coordinate system (Figure 79).

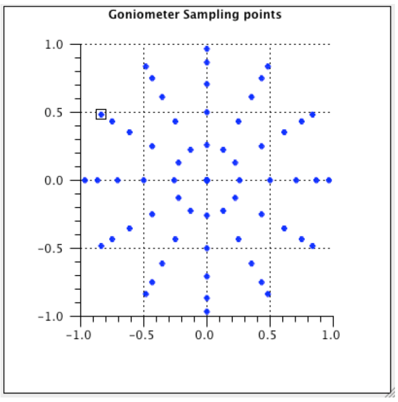


Figure 79: Goniometer sampling point positions

5.2.10.5.4 Gonio Hemisphere Explorer

The Hemisphere Explorer allows the interactive exploration of a spectrodirectional dataset, typically acquired by a goniometer system. Figure 80 shows an explorer window displaying a LAGOS (Laboratory goniometer system) dataset (Schopfer 2008).

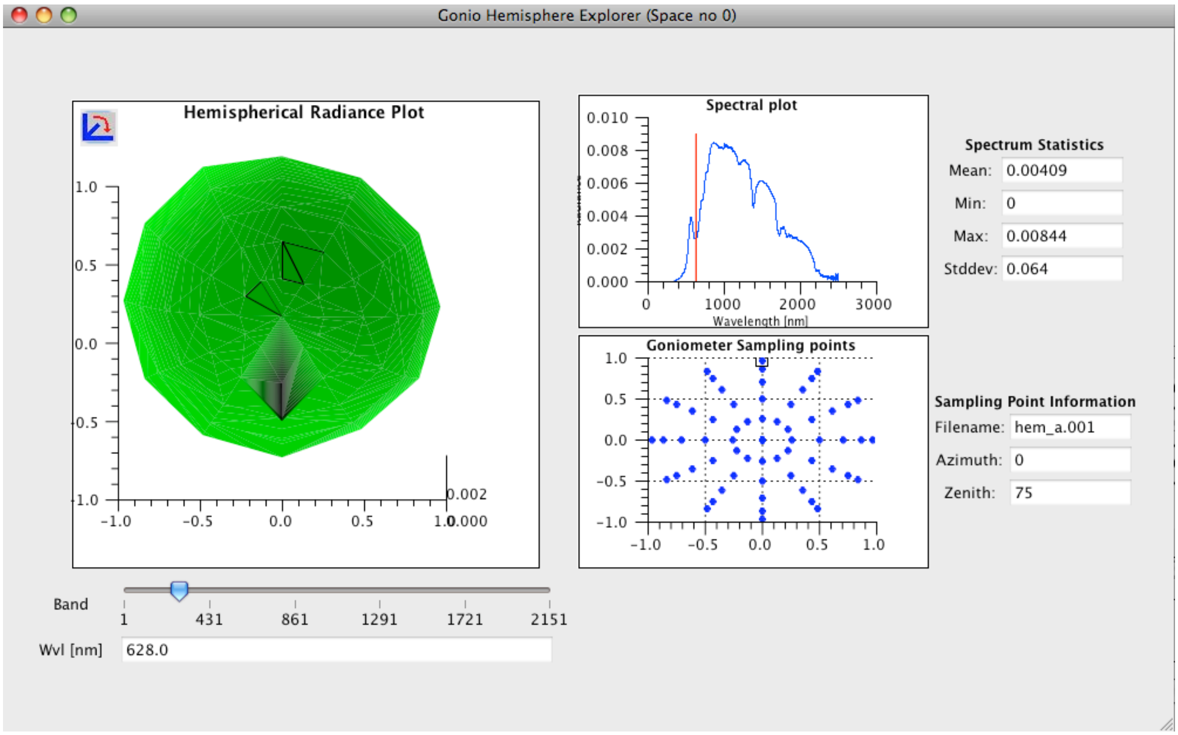


Figure 80: Gonio Hemisphere Explorer window

The explorer window comprises a number of components interacting with each other as described hereafter.

The hemispherical plot (Figure 81) displays an interpolated surface of a specific wavelength. Clicking the icon in the top-left of the plot brings up a control panel for plot adjustments (rotations).

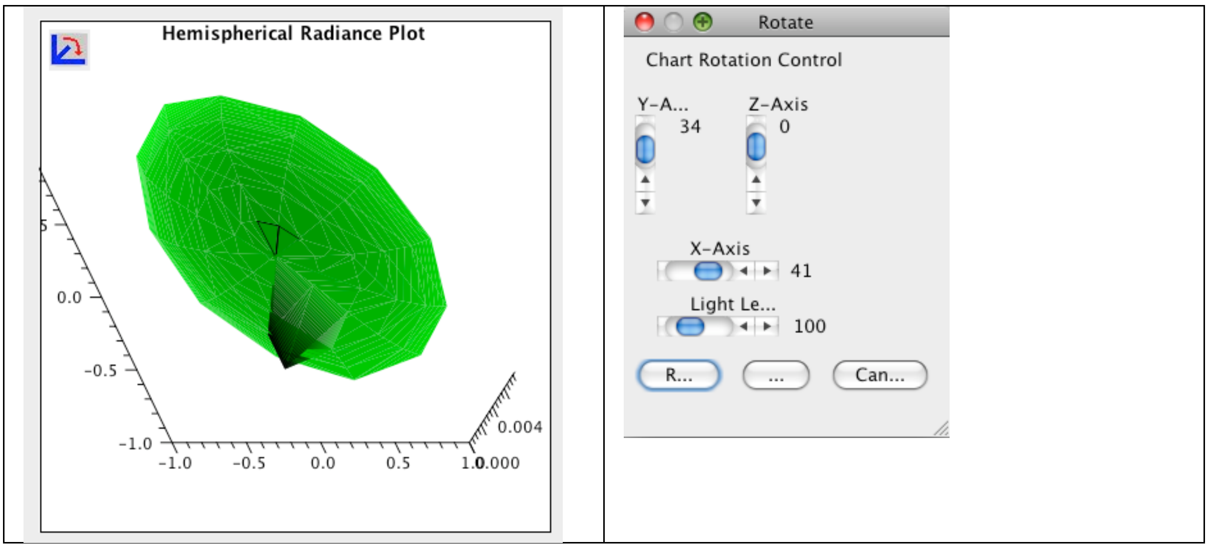


Figure 81: Interpolated 3D plot for a chosen wavelength (left) and rotation toolbox to manipulate the 3D plot

Use the band selection slider to select a spectral band for display (Figure 82). The wavelength text field below is reflecting the wavelength of the chosen band. Selecting a band triggers a re-plotting of both hemispherical plot and spectral plot.

Figure 82: Band selection slider and wavelength text field

The sampling points plot shows the sampling point positions projected onto a 2d Cartesian coordinate system (Figure 83). One of these points is always selected (indicated by the little square around it). Information about the selected point is shown in the text fields on the right of the plot: filename of the respective spectrum, azimuth and zenith angles of the observation geometry. Changing the selected sampling point (by clicking the mouse on another point) changes the spectrum displayed in the spectrum plot automatically.
The azimuth angle is measured relative to the solar principal plane, i.e. 0° = principal plane opposite of the illumination source.

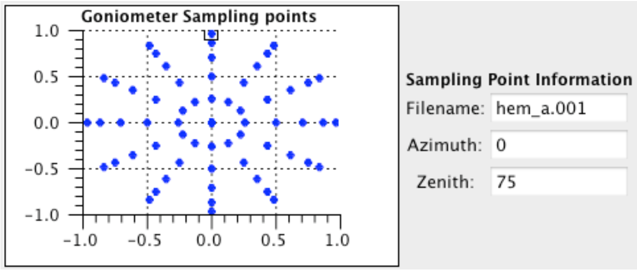


Figure 83: Sampling point position plot and information about the selected sampling point

The spectral plot component displays the spectrum of the selected sampling point (Figure 84). A red, vertical line indicates the current wavelength as selected by the band selection slider. The text fields on the right of the plot display spectral statistics of the current spectrum.

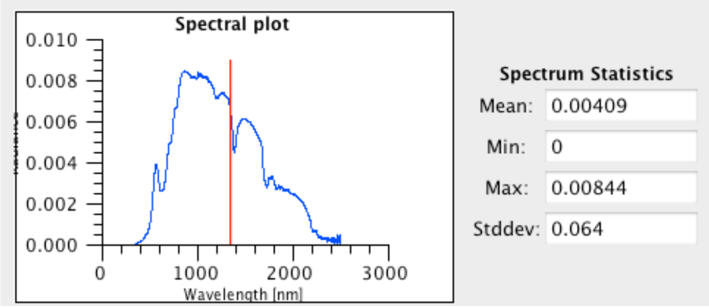


Figure 84: Spectral plot component with wavelength indicator and spectrum statistic information

5.2.10.5.5 Time Line Plot

Use a time line plot to plot a spectral band versus time. Figure 85 shows showing the direct irradiance over time for an MFR sunphotometer band with centre wavelength 496.4nm. The channel to be plotted can be chosen in the list below the plot. Time information is retrieved from the sampling time of the spectra.

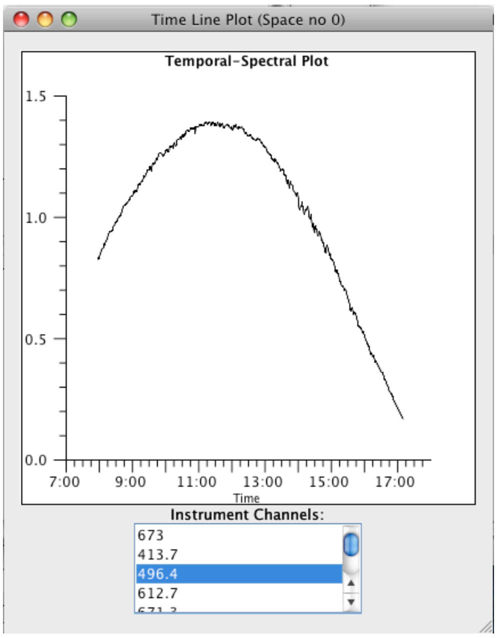


Figure 85: Time Line Plot showing the direct irradiance over time for centre wavelength 496.4nm

5.2.10.5.6 Time Line Explorer

The time line explorer consists of a time line plot and a spectral plot (Figure 86). The red bar in the time plot indicates what spectrum is plotted in the spectral plot, i.e. the spectral plot shows the spectrum taken at a certain time. The red bar in the spectral plot shows the currently selected instrument channel, which is plotted versus time in the time line plot.

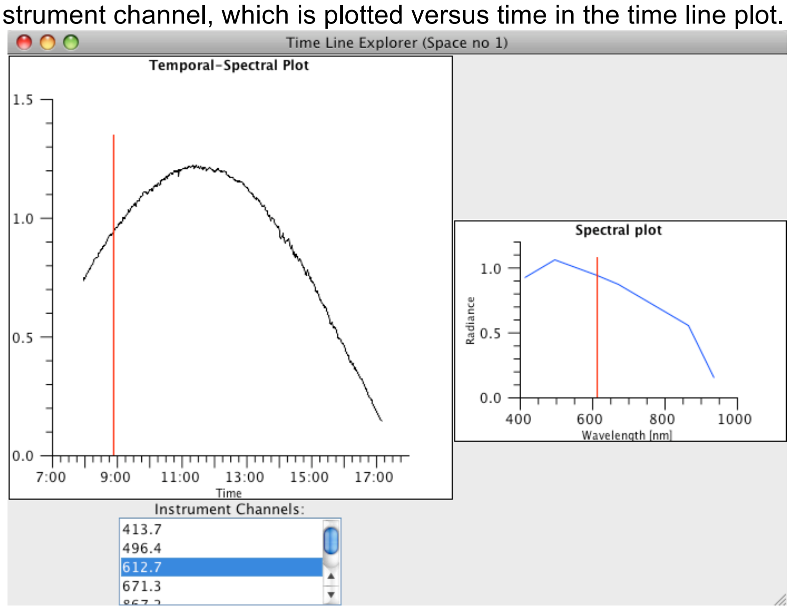


Figure 86: Time Line Explorer window

The example given in Figure 86 is using MFR sunphotometer data. A removal of the broadband channel is needed for the spectral plot to work properly. The according processing chain is shown in Figure 87.

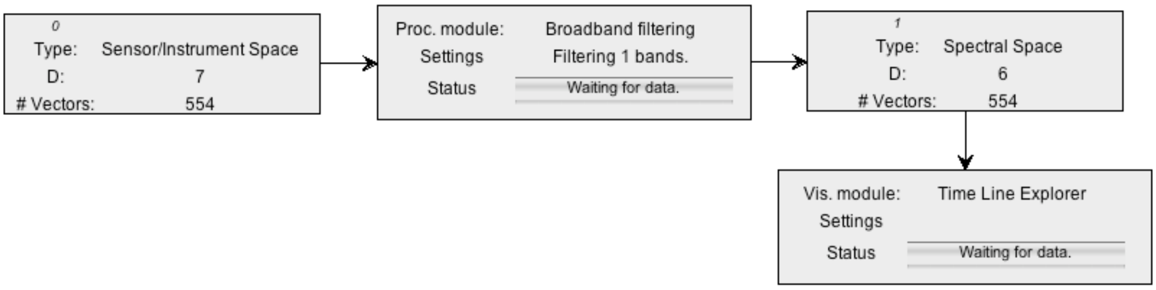


Figure 87: Processing chain for the exploration of the narrowband MFR channels in the Time Line Explorer

5.2.10.6 File Export Module

File export modules can be attached to any space and do not generate an output space but write the data to a file.
A file export module must be configured using its configuration dialog (Figure 88). The dialog is identical to the one described in 5.2.9.

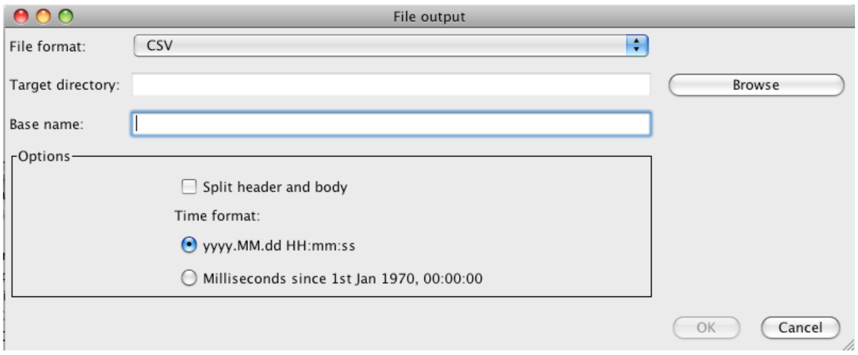


Figure 88: File export configuration

The spectral data written to the file reflects the data content of the space. The metadata is however mainly read from the database and may show some contradictions to the state of the space.

5.2.11 Data Administration

Apart from the 'Data Remover', the 'Campaign Export' and the 'Instrumentation Administration' tools, all functions described hereafter are available to the SPECCHIO database administrator only. Some data administration GUIs are provided, however, some of the data definition must be done using MySQL Browser.

5.2.11.1 Removing data

Spectra, hierarchies and campaigns can be removed from the database using the Data Remover (cf. Figure 89). Users can only remove their own data from the database.
Use the spectral data browser to select the nodes that should be removed and click the 'Remove' button. There is no further prompt to warn you! All data that is below the selected node will be deleted. E.g. if a campaign is selected then all hierarchies and spectra belonging to this campaign will be deleted. In addition, all metadata that has been entered for an object will be removed along with this object.

Removing data can take a long time: there is no progress report. When all specified data has been deleted the spectral browser will be updated (i.e. it no longer shows the deleted node plus any subnodes).

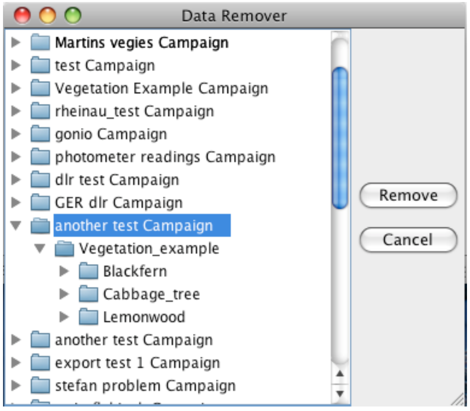


Figure 89: Data Remover dialog

5.2.11.2 Campaign Export

The campaign export functionality is used to write all data of a campaign to an xml file while retaining the relational structure. These xml files can then be used to import the campaign into another SPECCHIO database instance.

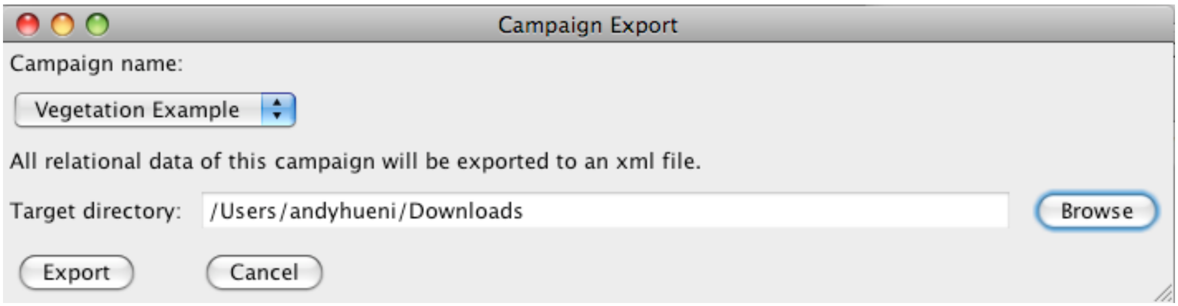


Figure 90: Campaign Export Dialog

The xml file structure contains all table entries that are required to reproduce the exported campaign in its relational structure. Entries are ordered by their inserting sequence, i.e. the campaign import will carry out the inserts in the order given by the file.

5.2.11.3 Campaign Import

The Campaign import function is only available for users that have the rights equal to the SPECCHIO database administrator user (sdb_admin). The import function requires an xml file created by the SPECCHIO campaign export function. The import will create an exact copy of the exported campaign and will insert new system table entries if required (e.g. new sensor definitions).

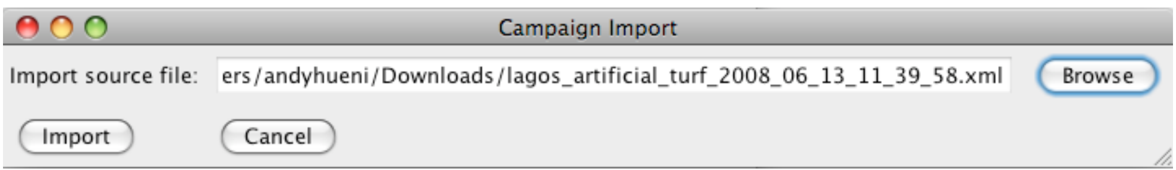


Figure 91: Campaign Import Dialog

The import function resolves all primary key – foreign key relations, making the imported campaign fitting seamless into the existing data environment, i.e. no possible conflicts between the imported and already existing campaigns.
Note: the involved databases must have matching database version! This is currently not checked. Further issues of system table duplication may arise if e.g. institute or user information are not identical in both databases.

5.2.11.4 Definition of new Sensors

New sensor can be defined by loading a sensor definition file. Select 'Data Maintenance'->'Load sensor definition' from the main menu.
In the Read Sensor Definition File dialog specify the sensor definition file and click 'OK' to read the file and insert a new sensor into the database (cf. Figure 92).

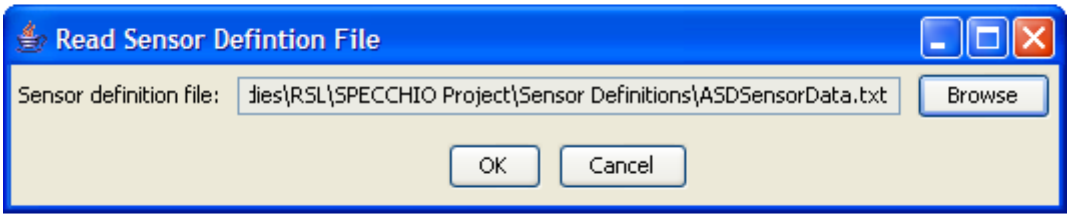


Figure 92: Read Sensor Definition File dialog

Sensor definition files are tab separated text files that can be edited in e.g. Excel (cf. Figure 93).

The file format is as follows:

```
Name             Description            Company         Type no        no of channels
<sensor name>    <sensor descr>         <company name>  <type number>  <no of channels>
Band             Average Wavelength(nm) FWHM (nm)
<band number>    <wavelength>           <fwhm>
```

The type number is a number given to a sensor, e.g. the ASD FSFR sensor has type number 4.
The type number is usually part of spectral data files and the data loader can use it to automatically assign the correct sensor to a spectrum.
The FWHM is currently not read into the database.

	A	B	C	D	E
1	Name	Description	Company	Type no	no of channels
2	ASD FSFR	ASD Fieldspec FR	ASD	4	2151
3	Band	Average Wavelength (nm)	Full Width at Half the Maximum FWHM (nm)		
4	1	350	2		
5	2	351	2		
6	3	352	2		
7	4	353	2		
8	5	354	2		
9	6	355	2		
10	7	356	2		
11	8	357	2		
12	9	358	2		
13	10	359	2		

Figure 93: Part of a sensor definition file being edited in Excel

5.2.11.5 Instrumentation Administration

The instrumentation administration comprises metadata editing for instruments and reference panels. Any user can open the dialogs but only administrators will be able to commit any changes to the database.
Editing data is identical with the function of the Metadata editor for spectral data. Every change of a field activates the 'Update' button.
The dialog consists of two tabs: (a) Instrument Data and (b) Reference Data.

5.2.11.5.1 Instrument Administration

The instrument data tab allows adding, editing and removing instruments and editing their metadata (Figure 94).

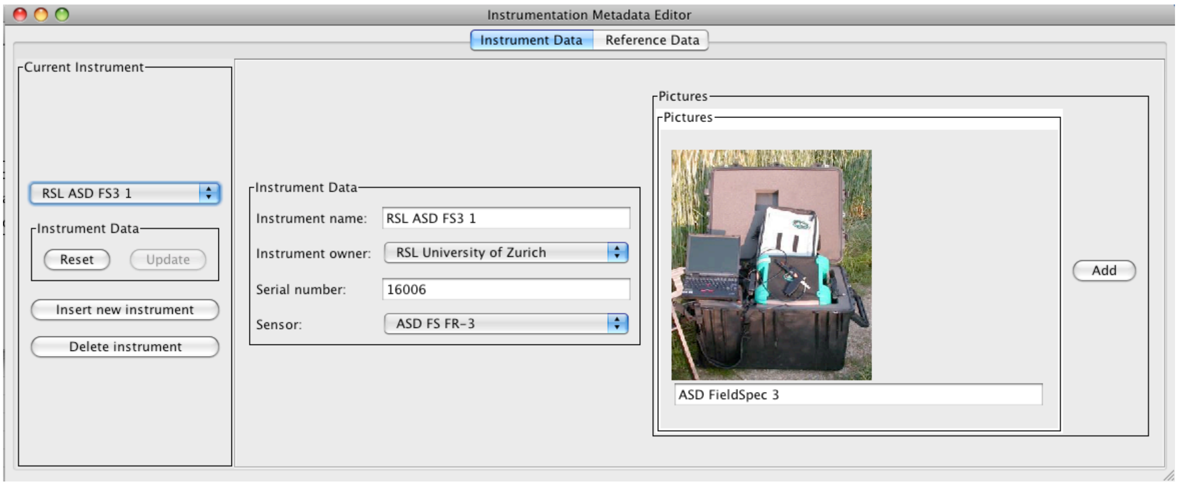


Figure 94: Instrument data tab of the instrumentation administration window

To edit or remove an instrument, select the instrument in the instrument list first.
Removing an instrument is achieved by clicking 'Delete instrument'. A confirmation dialog will be displayed (Figure 95):

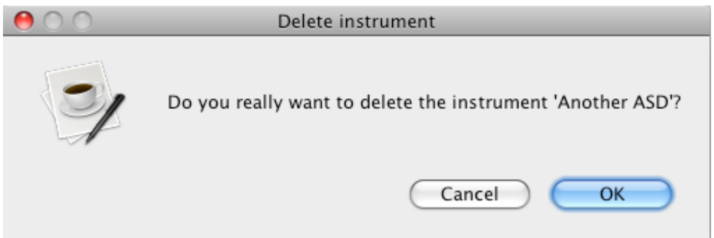


Figure 95: Instrument deletion confirmation dialog

An instrument cannot be deleted while still referenced by one or more spectra in the database. An according message will be shown if the delete action failed (Figure 96):

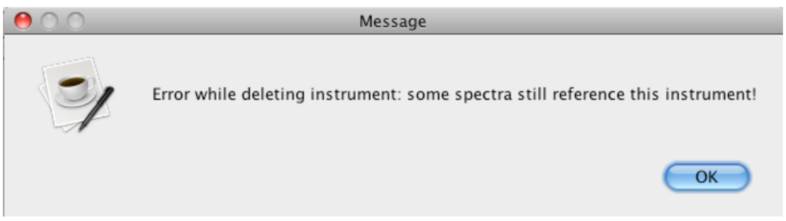


Figure 96: Instrument deletion error

The currently selected instrument will only be removed if no database constraints are violated.

To insert a new instrument, click ‘Insert new instrument’. A new record is created in the database and the instrument name is set to ‘dummy’ (Figure 97).

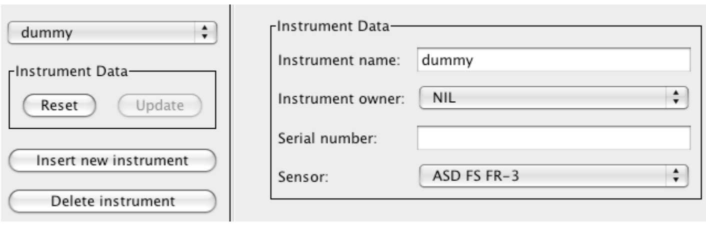


Figure 97: New 'dummy' instrument

The instrument can now be renamed and it’s metadata filled accordingly.

5.2.11.5.2 *Reference Panel Administration*

The reference data tab allows adding, editing and removing reference panels and related meta-data, in particular panel calibration data (Figure 98).

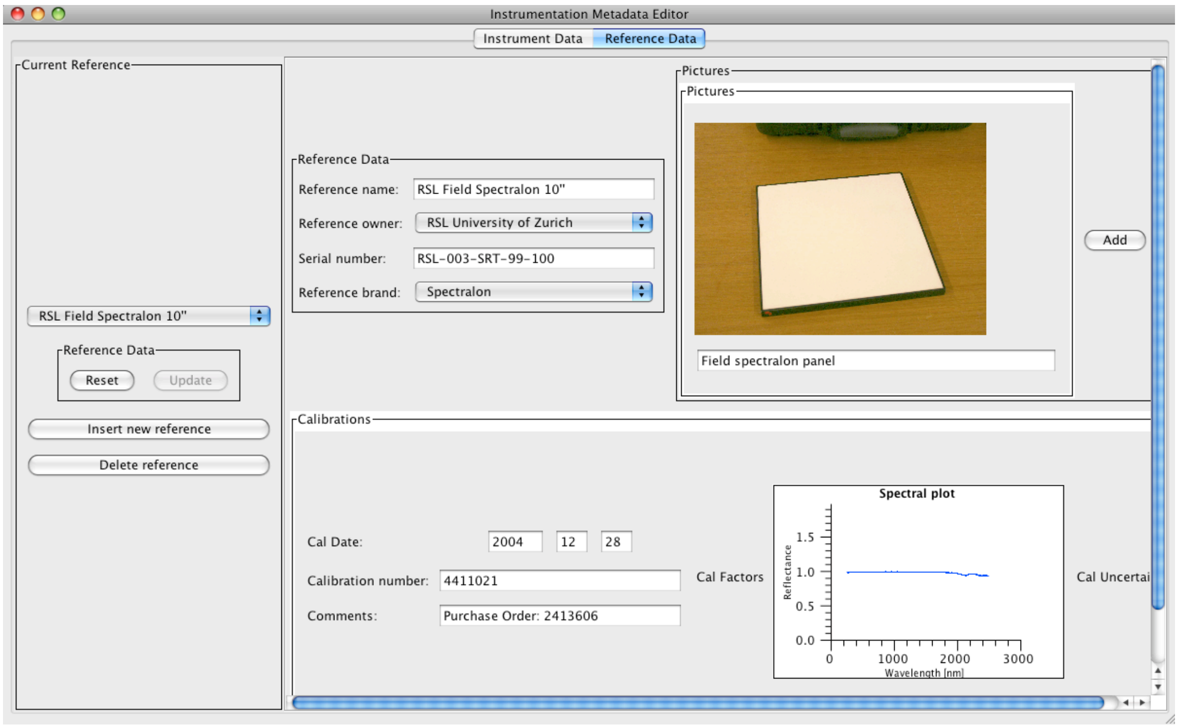


Figure 98: Reference data tab of the instrumentation administration window

To edit or remove a reference panel, select the reference in the reference list first.

Removing a reference is achieved by clicking 'Delete reference. A confirmation dialog will be displayed

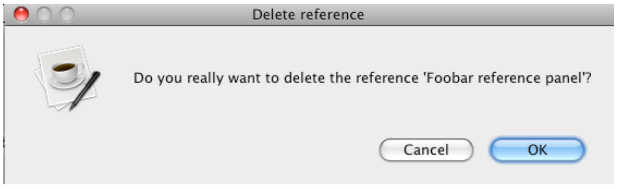


Figure 99: Reference deletion confirmation dialog

A reference panel cannot be deleted while still being referenced by one or more spectra in the database. An according message will be shown if the delete action failed (Figure 99). The currently selected reference will only be removed if no database constraints are violated.

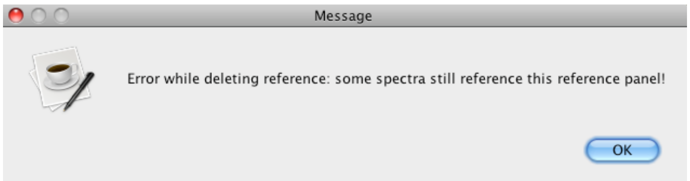


Figure 100: Panel deletion error

To insert a new reference, click 'Insert new reference. A new record is created in the database and the reference name is set to 'dummy' (Figure 101).

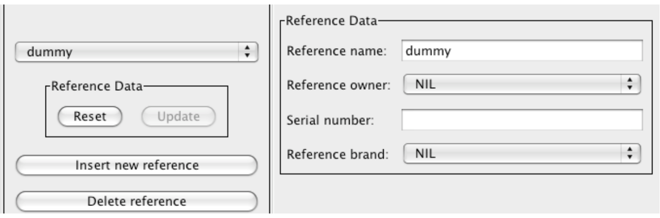


Figure 101: New 'dummy' reference

The reference can now be renamed and it's metadata filled accordingly.

To add a new calibration to a reference, click the menu button over the 'Calibrations' section of the Instrumentation Metadata Editor and choose 'Add calibration' (Figure 102).

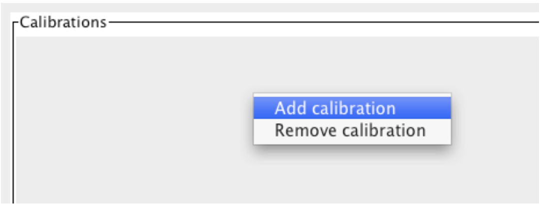


Figure 102: Popup menu for the reference calibrations

Use the file browser to select a calibration file (see below for a description of the file format) and click 'Open' (Figure 103).

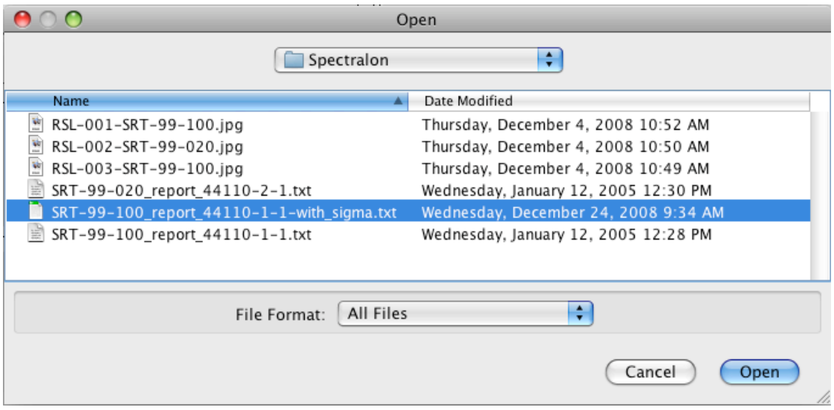


Figure 103: Calibration file selection dialog

A calibration file holds the calibration factors and uncertainty estimations for a reference panel in a tab separated value file:

```
wvl   rho   sigma
250   0.98  0.02
251   0.98  0.02
252   0.981 0.02
253   0.98  0.02
254   0.98  0.02
255   0.981 0.02
256   0.98  0.02
257   0.98  0.02
258   0.98  0.02
259   0.981 0.02
260   0.98  0.02
261   0.98  0.02
262   0.978 0.02
263   0.979 0.02
```

The wvl column holds the wavelength in nanometers, rho is the calibration factor linking the measured reference panel to the laboratory or national reference. I.e. in the above example, the panel is 98% reflective compared with an ideal panel. Sigma is the uncertainty estimate of rho, expressed as one standard deviation.
Note that before loading the calibration file, a sensor definition fitting the wavelengths of the calibration must be loaded to the database. E.g. in the case of Spectralon reference panels, the sensor definition is the Perkin-Elmer Lambda 19 sensor.
The calibration factors are used during the reference panel correction procedure as described in 5.2.10.4.2 and 5.2.10.4.3.

5.2.11.6 Database Upgrade

This feature was added to upgrade V1.1c and V1.1d databases to V2.0. Take care to run this function only once for every instance.

5.2.12 Linking to a GIS System

If a GPS unit is used to record the spatial position of the sampling sites during the sampling process every site in the database contains the latitude, longitude and altitude in WGS84 format. Alternatively, spatial positions can be set using the metadata editor.
The database tables can be accessed by a GIS system if ODBC connections are supported.
The connection is shown here on the example of ArcGIS on Microsoft Windows.

5.2.12.1 Setting up the SPECCHIO DB as a Data Source

Note that before the SPECCHIO DB can be configured as a data source the MySQL ODBC driver (available from the MySQL website) must be installed on the system.
Start 'Data Sources (ODBC)' from the Windows administrative tools. In the New Data Source dialog (Figure 104) select the MySQL ODBC Driver and click on 'Finish'.

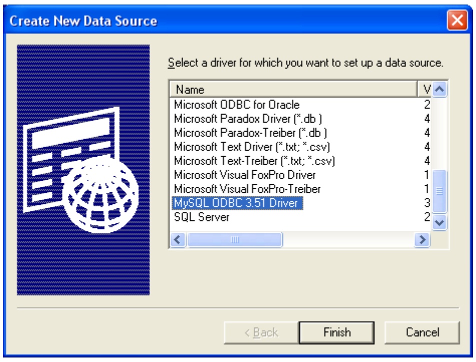


Figure 104: New Data Source dialog

This brings up the ODBC configuration dialog (Figure 105). Type in a name for the Data Source Name. Set the Server to the address of the database server. Enter the User name and Password. Select the database schema containing the spectral data from the Database dropdown list.

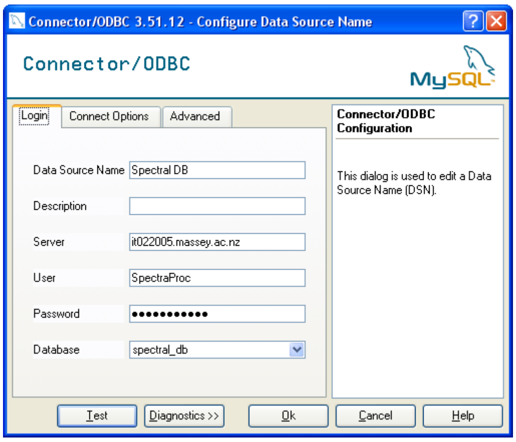


Figure 105: MySQL ODBC Configuration dialog

5.2.12.2 Establishing a Database Connection in ArcCatalog

Start ArcCatalog and select 'Add OLE DB Connection' (Figure 106).

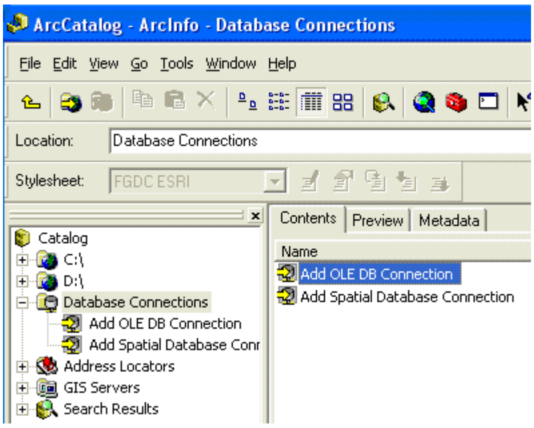


Figure 106: Adding an OLE DB Connection in ArcCatalog

In the Data Link Properties select ‘Microsoft OLE DB Provider for ODBC Drivers’ (Figure 107) and click ‘Next>>’.

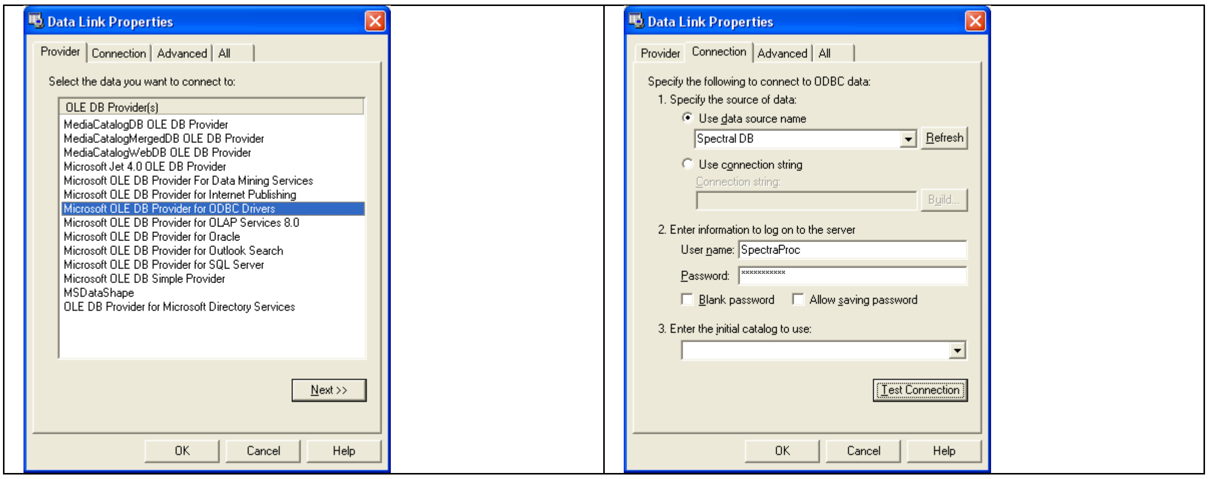


Figure 107: Data Link Properties; Provider tab (left) and Connection tab (right)

In the Connection tab select the data source from the dropdown list and enter again the username and password (Figure 107). Click ‘OK’.

The database is now listed in ArcCatalog and the tables are displayed when selecting the database (Figure 107).

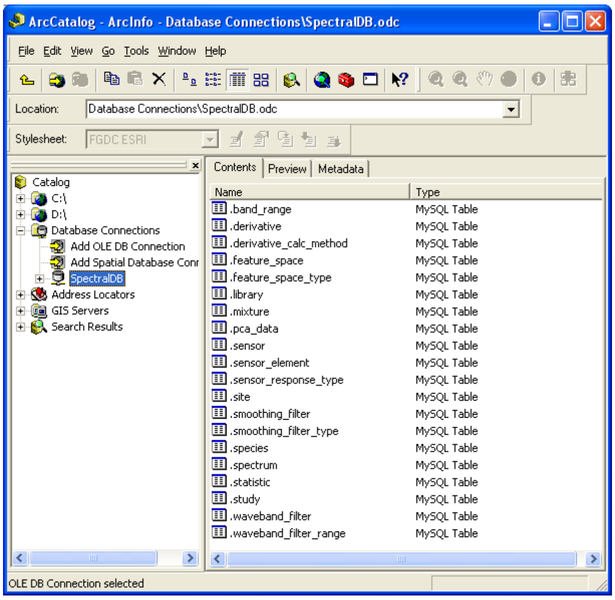


Figure 108: SPECCHIO and tables in ArcCatalog

5.2.12.3 Adding Table Data to a Map

To add table data to a map select ‘Add Data’ in ArcMap and choose the SPECCHIO under Database Connections (Figure 109). Then select the spectrum table as the data source (Figure 110). The spectra positions can then be displayed on the map by selecting ‘Display XY Data’ and using the longitude and latitude fields of the site table as X and Y coordinates.

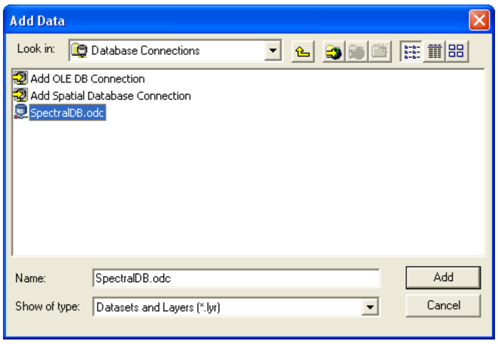


Figure 109: Selecting the specchio database as data source

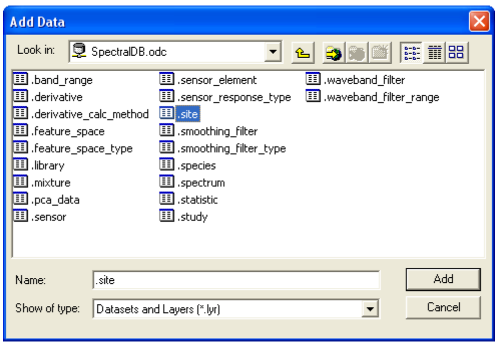


Figure 110: Selecting the spectrum table as data source

6 Tutorial

6.1 Overview

The tutorial is comprised of four parts illustrating the functionality of SPECCHIO:

1. Loading, Editing and Retrieving Data:
   The folder and directory structure of a sampling campaign, the creation of a new campaign, loading of data, editing of metadata and data retrieval is shown on a vegetation example. The data set contains ASD spectra of New Zealand native plants.
2. Handling of GER Files:
   The automatic splitting of GER files into target and reference radiances upon loading is demonstrated using a RSL GER3700 dataset.
3. Directional Data:
   The handling of directional data including sun angle and sensor geometry calculation and automated linking of target to reference spectra is demonstrated using RSL FIGOS goniometer data.
4. Data Querying, Processing and Exploration

Each part contains several exercises that are listed in a logical order. In order to support the learning process every exercise lists the relevant sections in the User Guide.

All tutorial data are available for downloading on www.specchio.ch.
The test data sets used for the specific tutorial parts are explicitly specified at the start of the respective section.

6.1.1 SPECCHIO Online Test Database

Relevant section: 5.2.3

An online test database is provided on db.specchio.ch. Please use this database for the tutorial exercise and all other tests you would like to carry out.
To change you database connection to the test database, select 'Database'->'Connect to database' from the main menu.
Connect to the test database by entering 'specchio_test' in the database connection dialog (cf. Figure 111). Note that the user name and password you received when creating a SPECCHIO account are identical for both the productive and the test databases (specchio, resp. specchio_test).

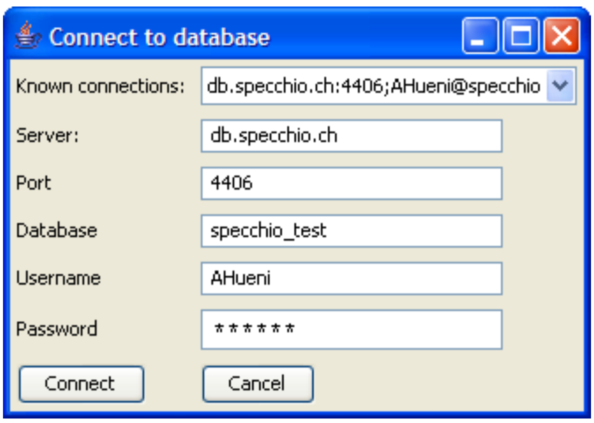


Figure 111: Connecting to the specchio_test database

6.1.2 Creating Campaigns on the Test Database

In order to keep things organised, always include your name in the campaign name by using the following template: <your name>_<campaign name>, e.g. Andy_veg_example. This will make it easier to find your campaigns in the Query Builder where you can see all campaigns of the other users as well (Note that the Query Browser includes a switch that will show only your own data).

6.1.3 Downloading Test Data Sets

The data sets used in this tutorial are available on the internet: http://specchio.ch/tutorial_data.php. The following data sets are provided as ZIP archives:

- vegetation_example.zip
- ger_example.zip
- gonio_example.zip

To download the ZIP files click on the links and select 'Save to Disk' in the web browser dialog (see Figure 112).
Unzip the ZIP files to some working directory on your machine, e.g. create a new folder called 'SPECCHIO_data' and unzip all datasets into this directory.

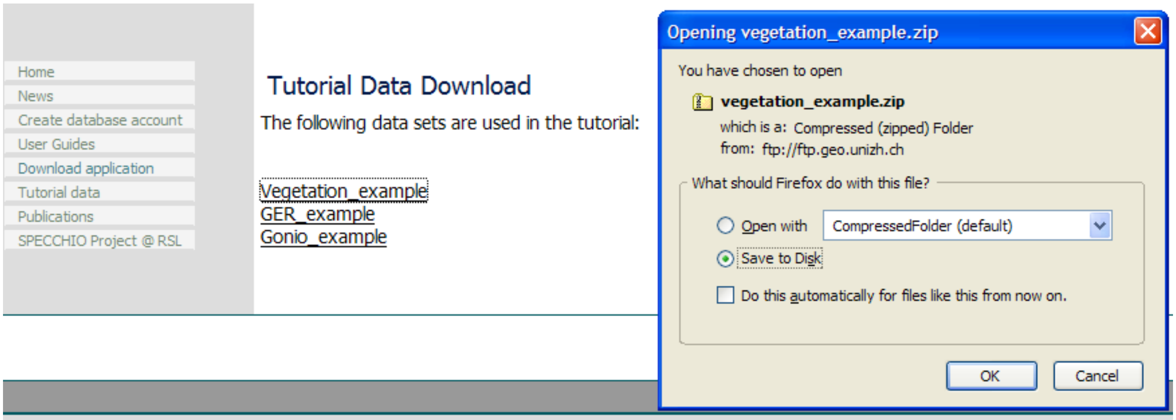


Figure 112: Tutorial data download page

6.2 Part 1: Loading, Editing and Retrieving Data

Data set: Vegetation_example

6.2.1 Examine the Folder and File Structure

Relevant sections: 3.2, 3.3

Open a filing system window and browse the directory structure of the 'Vegetation_example' folder. It contains three species folders: Blackfern, Cabbage tree and Lemonwood. Open each of these species folders and examine the contents of the site directories contained in them. Blackfern has only one sample site while Lemonwood and Cabbage tree have three resp. two. Also browse inside the site directories to find the ASD binary files (cf. Figure 113).

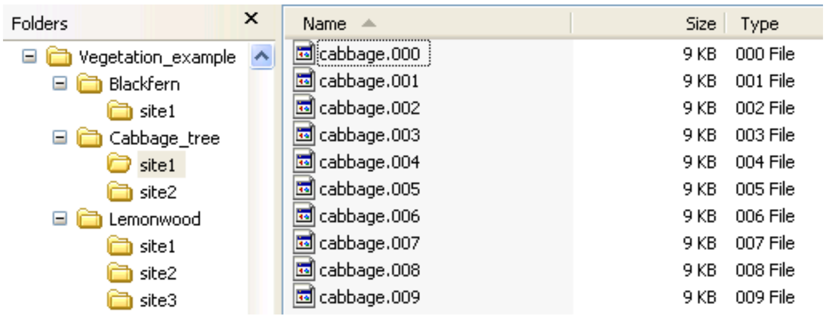


Figure 113: Folder and file structure of the Vegetation_example campaign

6.2.2 Creating a new Campaign and Loading the Spectra

Relevant sections: 5.2.4, 5.2.5

Create a new campaign by selecting 'Data Input '->'Create new campaign'. In the new dialog, enter <your name>_veg_example as campaign name, e.g. ahueni_veg_example. Set the Main directory to the Vegetation example folder (cf. Figure 114).

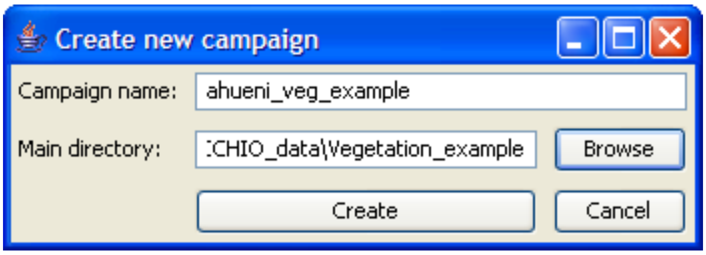


Figure 114: Creation of a new campaign for the vegetation example

Press the create button and a message box should pop up informing about the successful creation of the campaign (cf. Figure 11577).

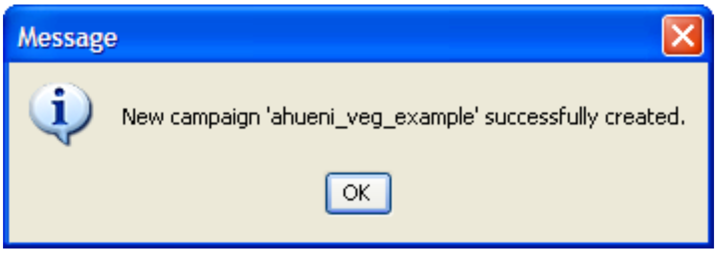


Figure 115: Message box informing on successful campaign creation

Once the campaign has been created load the spectral data of your campaign by selecting 'Data Input'->'Load campaign data' and selecting the campaign you just created (cf. Figure 116).

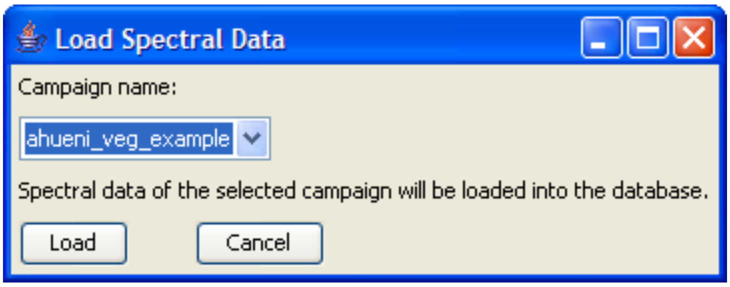


Figure 116: Loading spectral data into a campaign

A message box pops up when the campaign has been loaded (cf. Figure 117). A total of 64 spectral files should now have been loaded into the database.

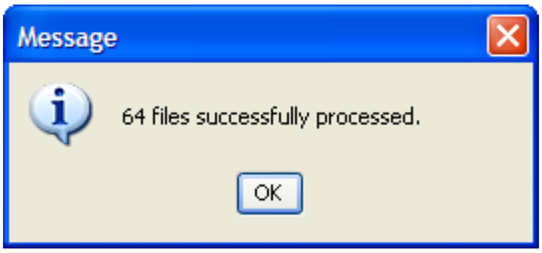


Figure 117: Message box showing the number of processed files during campaign loading

6.2.3 Get to Know Your Data

Relevant section: 5.2.7

Your data are now ready to be visualised and exported. Open the Query Builder by selecting 'Data Processing & Output'->'Build query'. In the Spectral Data Browser (the tree like display on the left side of the dialog) select your campaign (tick the box 'Show only my data' to restrict the displayed campaigns to your own) and explore the structure. Note that the database has stored the hierarchical structure of the campaign folder and displays it accordingly (cf. Figure 118). Also note that as you click around the tree (selecting folders or files) the SQL query and the number of resulting rows on the right side are updated simultaneously. You can also use Ctrl and Shift keys to do multiple selections.
Now select the first 6 spectra of the Blackfern, site1, (the number of resulting rows should be 6) and click on 'Show report'. A new window will appear looking similar to Figure 119. Note that a scrollable list containing the metadata is associated with every spectrum. Have a look at the metadata and note the data filled in automatically: filename, capture date, spatial position, measurement unit, sensor name, number of spectral channels, instrument name, owner and serial number.
The strong noise in the water bands is due to the generally high humidity found in New Zealand (maritime climate coupled with high yearly rainfall (up to 10 metres in Fjordland)).

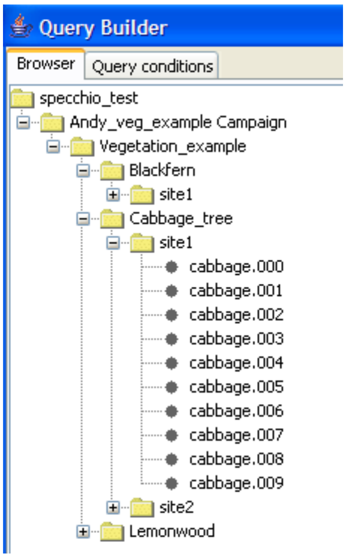


Figure 118: Vegetation example campaign shown in the Spectral Data Browser of the Query Builder

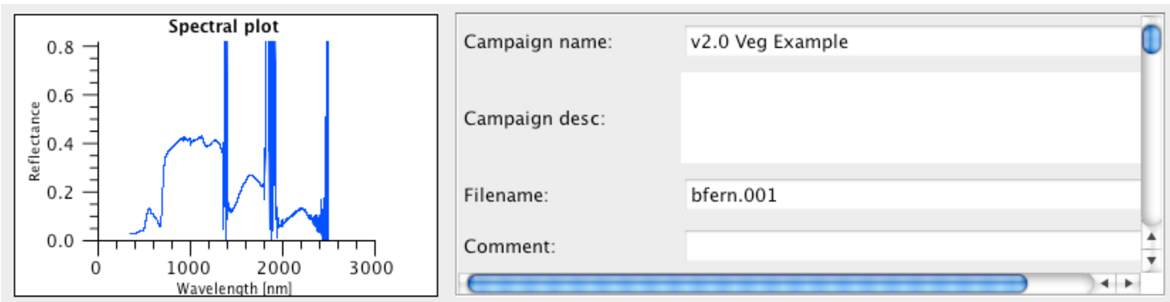


Figure 119: Part of the report on Blackfern spectra

6.2.4 Exporting Data to CSV

Relevant sections: 5.2.7, 5.2.9

Select File Export in the Query Builder (first select some data as described in 6.2.3). Specify CSV as file format, an output directory (use the Browse button to select a directory) and a base filename and then press 'OK' (cf. Figure 120) (see also 5.2.9).

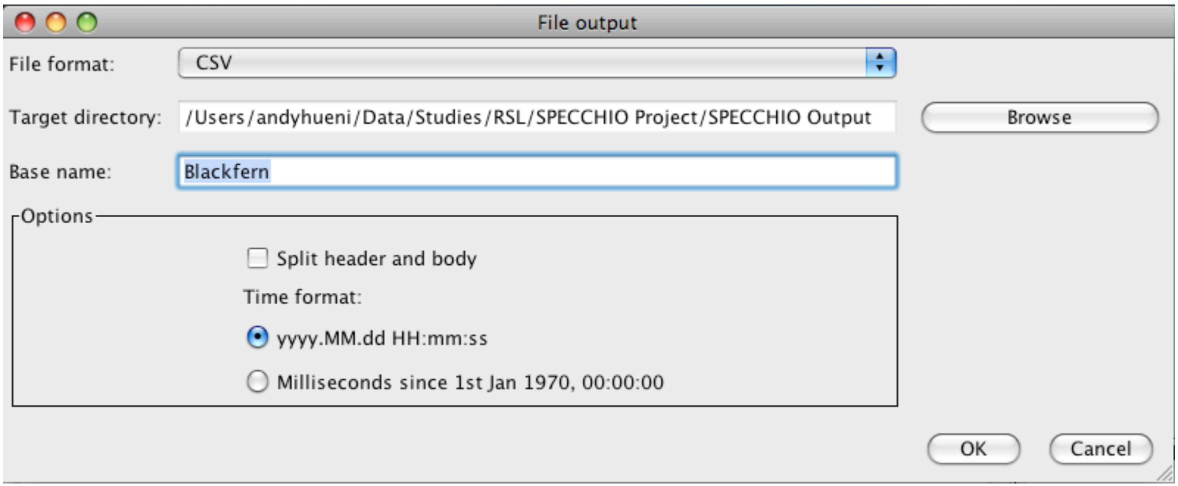


Figure 120: File export dialog

A message box will appear once the export is finished.
Use your file system browser to have a look at the output file that has been written into the output directory you specified (cf. Figure 121). The file name is partly auto-generated and includes the following parts:

- ☐ blackfern: the base name you specified
- ☐ INR_ASD: name of the instrument used to sample the data
- ☐ ASD FS FR-3: the sensor type

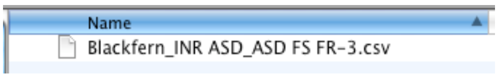


Figure 121: Exported CSV file

CSV files can be conveniently loaded into spreadsheet and statistics applications. Alternatively you can view them in a text editor.
CSV files can be split into header and body, where the header contains all metadata and the body consists of the channel and spectral information.
Figure 122 shows a spectral plot of the first six Blackfern spectra in Microsoft Excel. The first column contains the central wavelength of the bands in nanometres.

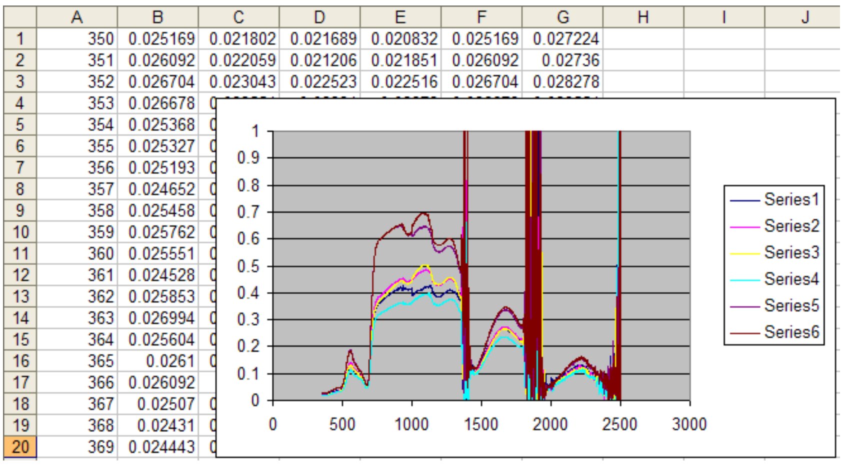


Figure 122: Example of a spectral (XY) plot in Microsoft Excel

6.2.5 Exporting Data to ENVI Spectral Libraries

Relevant sections: 5.2.7, 5.2.9

Note: this exercise assumes that you have access to ENVI. If this is not the case you may skip it.

As a first step repeat the process of file exporting as described for CSV Files in 6.2.4 but change the file format to ENVI SLB.
To open SLB files in ENVI, start ENVI and select 'Spectral'->'Spectral Libraries'->Spectral Library Viewer'. Specify an input file by selecting the .slb file (cf. Figure 123).

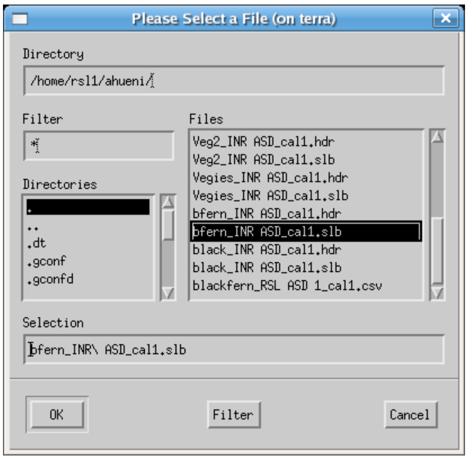


Figure 123: Selecting an slb file to load as spectral library

The spectra names can then be displayed in the Spectral Library viewer (cf. Figure 124) and plotted as Spectral Library Plots. Note that the maximum range of the Y axis must be set to 1 manually as otherwise only noise will be visible (cf. Figure 125).

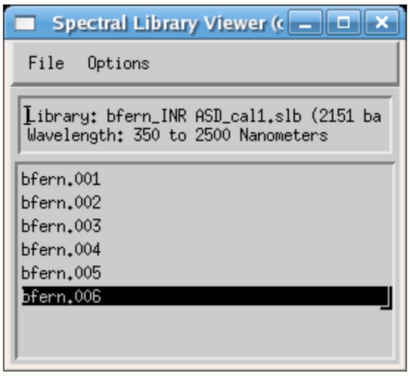


Figure 124: Spectra listed in the Spectral Library Viewer

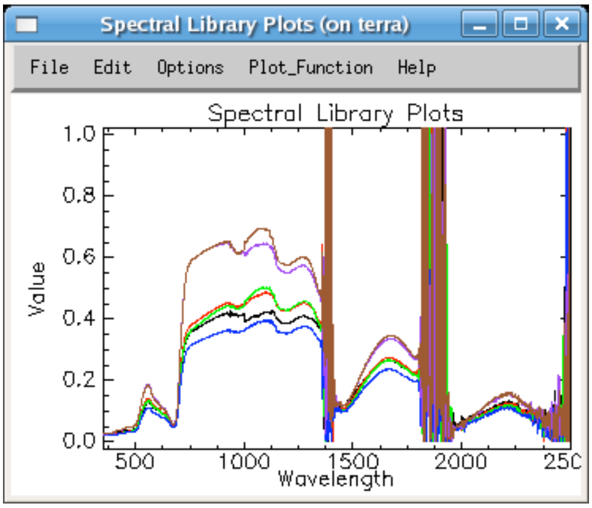


Figure 125: Blackfern spectra as Spectral Library Plots

6.2.6 Editing Metadata

Relevant section: 5.2.6

Open the metadata editor by selecting ‘Data Input’->’Edit metadata’ from the main menu and select your campaign. Note that in the ‘Campaign Data’ tab your name is automatically listed as Investigator.
Enter some description into the description text field, e.g. ‘Just a test’. Note that as soon as you change some data in the metadata editor the relevant ‘Update’ button (in this case the button in the campaign data section) gets activated (cf. Figure 126).
Perform the update by clicking on the update button. This stores your changes in the database.
The update is done when the ‘Update’ button reverts to being grey and inactive.

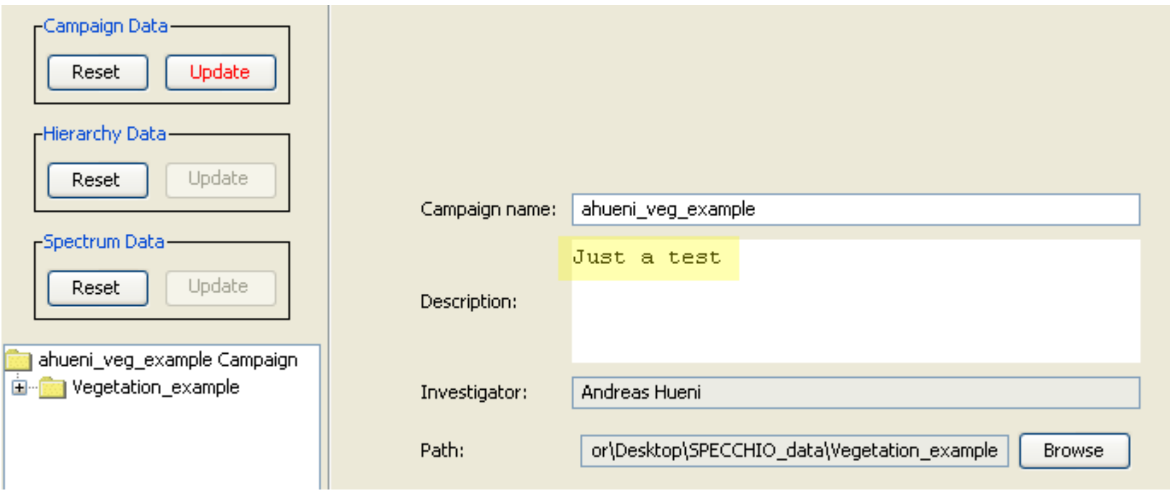


Figure 126: Editing the description of a campaign

Switch to the ‘Spectrum Data’ tab and select the ‘Blackfern’ folder in the Spectral Data Browser (cf. Figure 127).

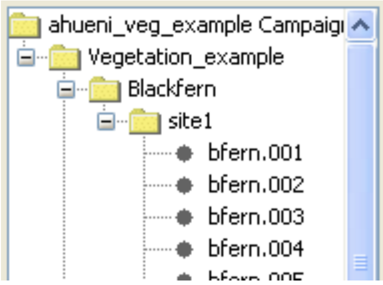


Figure 127: Selecting 'Blackfern' in the Spectral Data Browser of the Metadata Editor

By selecting multiple spectra (e.g. by selecting a folder or several single spectra) you automatically enter the so called ‘group update modus’. All data that you enter will apply to all the selected spectra. Note that some fields are not editable but greyed and inactive. These fields contain already individual spectrum metadata and are therefore disabled.
As all the spectra under the Blackfern hierarchy are of the same plant species and entering the plant names can be done for all spectra with a single operation. To enter a new name, click ‘Add’ in the ‘Names’ section. First type the common name ‘Blackfern’, then specify the type as ‘Common’ from the list (cf. Figure 128). In a similar manner enter the Latin name: ‘Cyathea medullaris’.

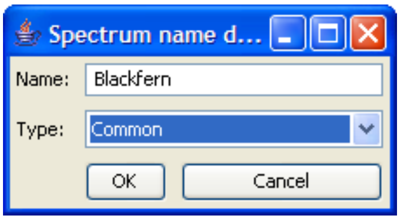


Figure 128: Entering a common name

The names now appear as shown in Figure 129. Note that the ‘Update’ button of the ‘Spectrum Data’ section has been activated. Perform now the update on the database by clicking the ‘Update’ button.

Figure 129: Spectrum names

All three species (Blackfern, Cabbage Tree and Lemonwood) are typical for New Zealand forests. They all share a common landcover type. To set the landcover for all spectra, first select the top folder called ‘Vegetation_example’.

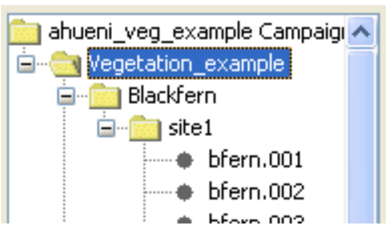


Figure 130: Selecting the top folder 'Vegetation_example'

Now select the landcover type 'Deciduous Forest' in the CORINE landcover tree (cf. Figure 131). Press 'Update' to apply the selected landcover type to all spectra of this campaign.
You can now check the fact that indeed all spectra have this landcover type set by selecting single spectra in the Spectral Data Browser.

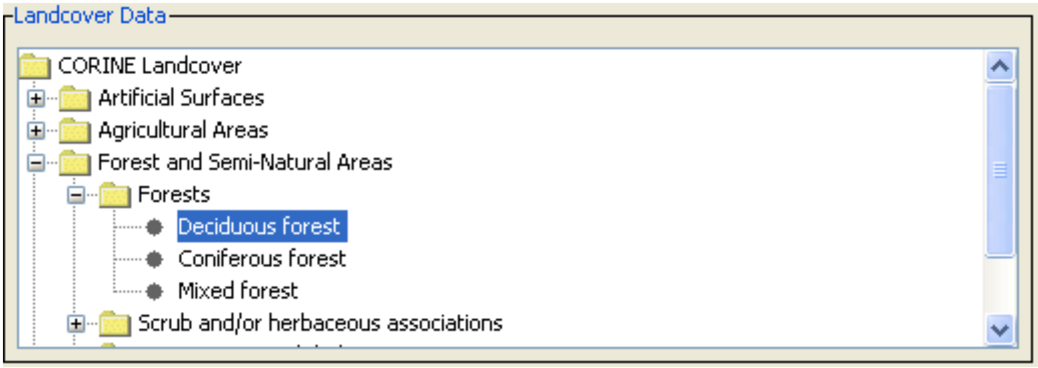


Figure 131: Specification of the landcover

Pictures taken at the sampling sites can be entered into the spectral database. Pictures for Blackfern and Lemonwood are provided in the vegetation_example.zip file. You will find the pictures alongside with the Vegetation_example folder in the directory where you un-zipping the data.

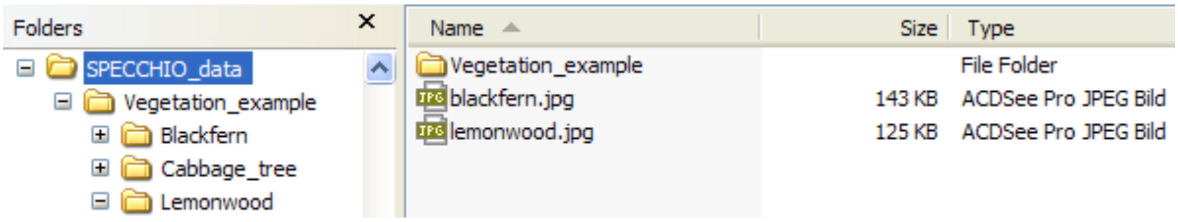


Figure 132: Location of the species pictures

To apply the Blackfern picture to all Blackfern spectra select the Blackfern hierarchy in the Spectral Data Browser. Click 'Add' in the Pictures section, browse to the Tutorial folder and select blackfern.jpg. To enter a caption, simply type it into the editable field below the picture (cf. Figure 133). Then update the database.

Figure 133: Example of a picture with a caption

In a similar manner insert the supplied lemonwood.jpg picture for all Lemonwood spectra.
Note that performing group updates not only speeds up the input process but also minimizes the amount of data stored in the database. All spectra in the selected group are referencing a single entry in the database, thus avoiding data redundancy.

A general problem of spectral data collections is the quality and trustability of the data. This is especially true if the data were collected by third parties and the sampling conditions are unknown. One way to improve the usability and shareability of spectral data is to include more metadata. SPECCHIO addresses this by the means of metadata quality levels (cf. 4.3).
In the Metadata Editor activate the checkboxes ‘Highlight mandatory fields’ and ‘Show quality compliance in tree’. Select the bfern.001 spectrum in the Spectral Data Browser and set the required quality level of this spectrum to B (cf. Figure 134).

Figure 134: Required quality level set to B

All required field should now be highlighted. Update the spectrum on the database. If the quality compliance is not shown in the tree, have it displayed properly by selecting your campaign explicitly again in the ‘Campaign Selection’ of the Metadata Editor (cf. Figure 21). All non-complying spectra plus the containing hierarchies are marked with an asterisk (cf. Figure 135).

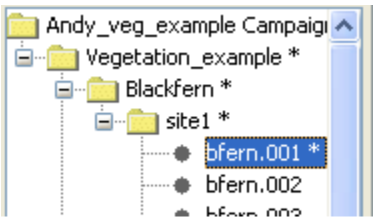


Figure 135: Non quality compliance indicated by asterisks

Fill in the missing metadata for the bfern.001 spectrum:

- ☐ Cloud cover: 1 okta or less, but not zero
- ☐ Measurement type: Single
- ☐ Sampling Environment: Field
- ☐ Target Homogeneity: homogenous
- ☐ Sensor zenith: 0
- ☐ Sensor azimuth: 180 (this is equivalent to the principal plane opposite the sun)
- ☐ Sensor distance: 1
- ☐ Illumination zenith: 40
- ☐ Illumination azimuth: 0 (In the Southern hemisphere the sun stands in the North at midday)
- ☐ Target type: Add a new target type by clicking the ‘Add’ button, then specify the target type as ‘Tree’ and set it’s abundance = 100

After updating the spectrum in the database, the non-compliance indicators in the spectral data browser should be removed.

6.3 Part 2: GER Files

Data set: GER_example
Relevant sections: 5.2.4, 5.2.5, 5.2.5.1, 5.2.7, 5.2.9

The GER files are contained in the GER_example folder. Explore the folder. You will notice that there are 10 files as created by the GER instrument. Create a new campaign to hold GER files (cf. Figure 136).

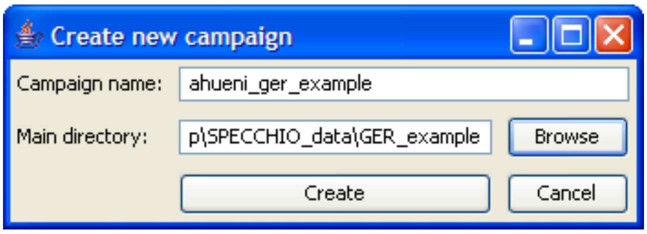


Figure 136: Creation of a GER example campaign

After creating the campaign load the spectral data into the database by selecting 'Data Input'->'Load campaign data' and selecting the campaign you just created (cf. Figure 137).

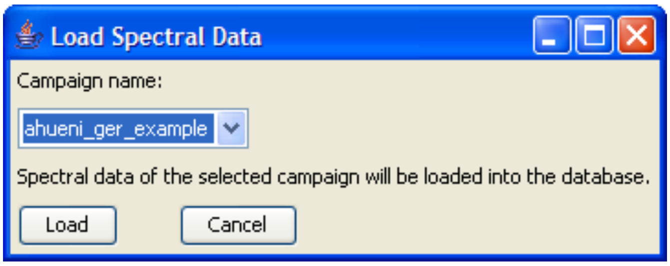


Figure 137: Loading spectral data into the GER campaign

Open the Query Builder. Open the tree of the GER campaign and study the contents. The files have been automatically split into target and reference spectra (cf. Figure 138). Remember that GER instruments write the sampled radiances of target and white reference into the same file. The names of the corresponding targets and references are identical, e.g. target GR083005.080 is associated with reference GR083005.080.

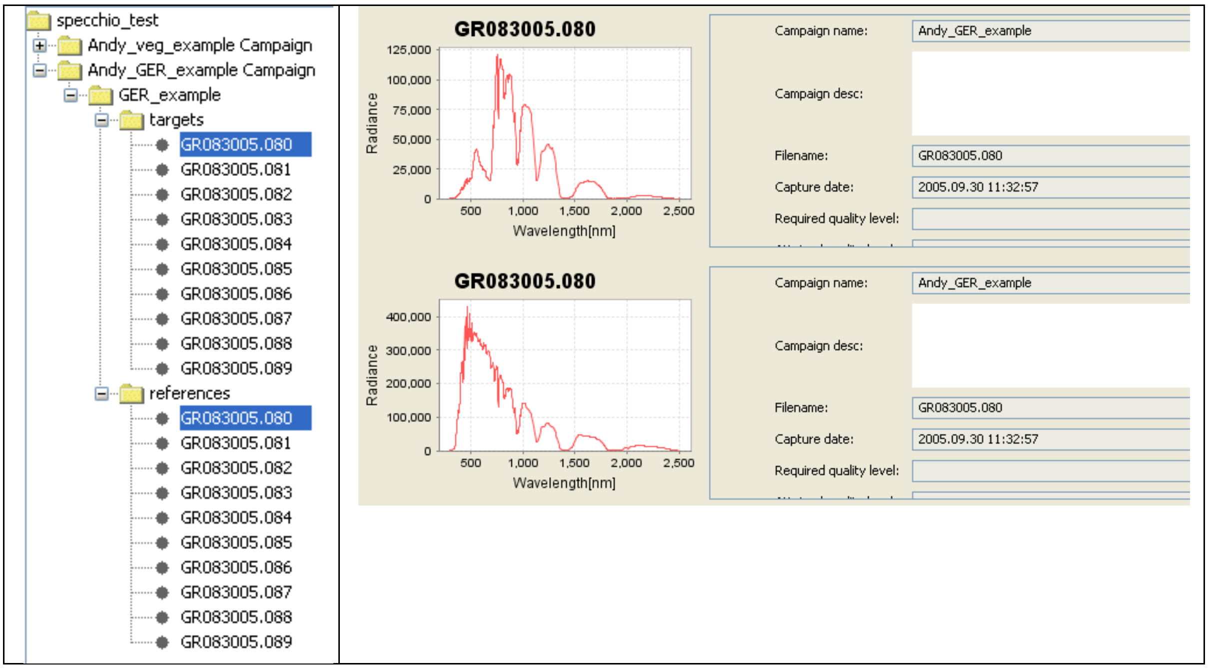


Figure 138: GER files split into target and reference spectra (left) and report showing target and reference spectra (right)

Targets and references are linked internally by a datalink on spectrum level (cf. 4.4). Open the Metadata Editor and display the spectrum data for one of the GER target spectra. Note that a link referring to the reference spectrum of the type Spectralon has been created (cf. Figure 139). These datalinks are used during radiance to reflectance conversion.

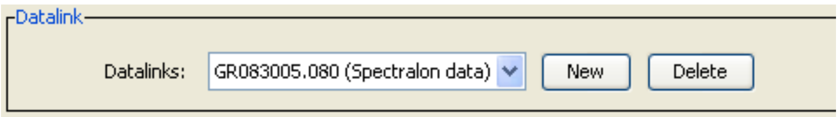


Figure 139: Automatically created link between target and reference spectra

6.4 Part 3: Directional Data

Data set: Gonio_example
Relevant sections: 5.2.4, 5.2.5, 5.2.6

This exercise uses FIGOS goniometer data. FIGOS is used at RSL to acquire spectrodirectional measurements in 66 points arranged on a hemisphere. For more information please refer to Schopfer et al. (2007).
Goniometer data is provided in the Gonio_example folder. It contains two subfolders: one holding the targets and one the references. The spectra of targets and references have been manually moved to these folders. This separation should be carried out before the data is loaded into SPECCHIO (alternatively all data can be loaded and the unwanted spectra removed using the Data Remover tool). It must also be noted that any surplus measurements must also be removed, i.e. the system expects 66 directional measurements maximum. SPECCHIO can however deal with gaps in the data as will be demonstrated hereafter.
Create a new campaign for goniometer data and load the campaign data.

If you explore the data in the Metadata Editor, you will find that the Measurement unit has been set to Radiance and the FOV to 3 degrees. Use a group update to set the Measurement type of all spectra of this campaign to 'Directional'.

In the Metadata Editor select the special function 'Link targets to references' (cf. 5.2.6.2.10.2). In the 'Link Target to Reference' dialog select the target and reference directories of the goniometer campaign as inputs (cf. Figure 140) and press 'Link'. The datalinks have now been created.
In the Metadata Editor explore the datalink settings (cf. Figure 139). You should find that the targets triticaa.001 – triticaa.005 are referencing the triticaa.000 white reference spectrum. Target triticaa.007 references triticaa.006 and so on and so forth. The linking mechanism is based on the spectrum capture time and does not depend on the spectrum file name.

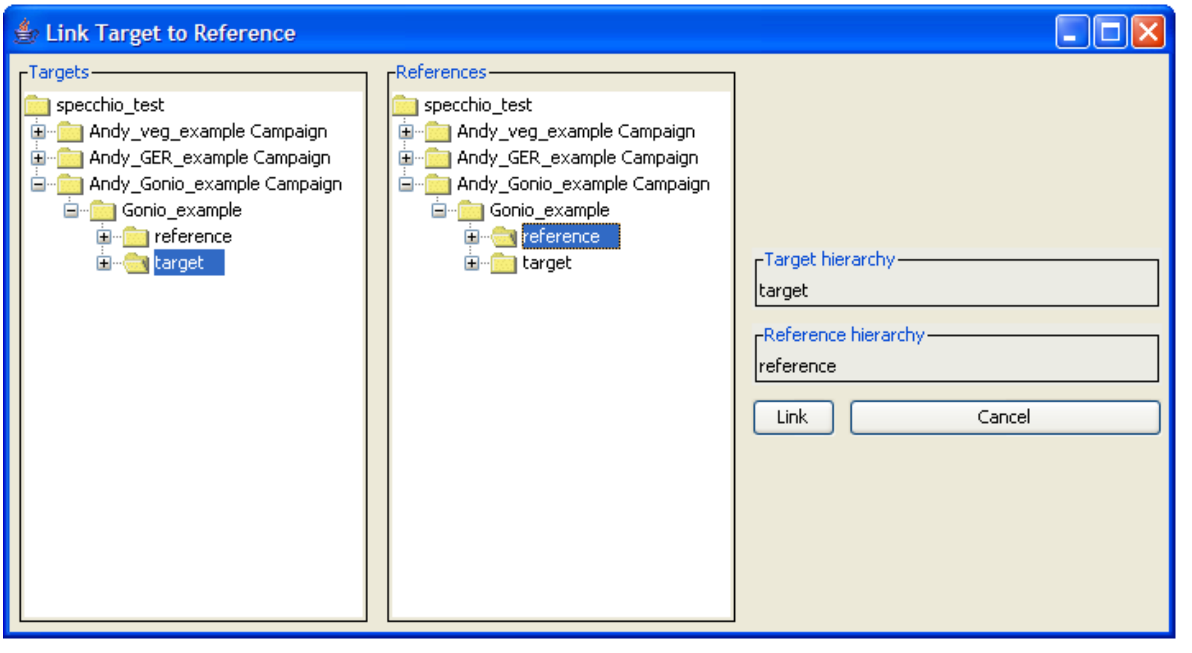


Figure 140: Specifying target and reference directories

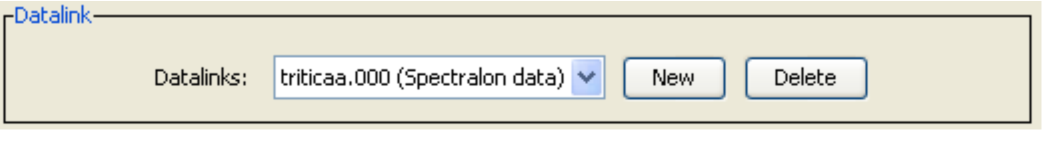


Figure 141: Example of an automatic created datalink

The illumination geometry (i.e. the sun zenith angle and azimuth) can be calculated automatically if the spatial position (latitude and longitude) and the capture time in UTC are known.
For the given dataset we assume that the time is local time and not UTC. This can be corrected by the special function 'Correct local time to UTC' (cf. 5.2.6.2.10.5). In the time correction dialog select the Gonio_example folder because the time shift should be applied to both target and reference spectra. The time difference to GMT is 2 hrs (East) as the sampling took place during summer in Switzerland, i.e. daylight saving applies (cf. Figure 142).

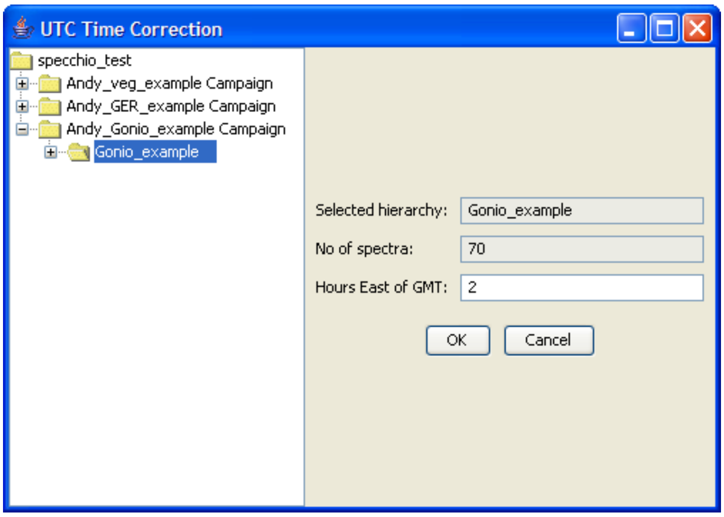


Figure 142: Applying a time shift to goniometer data

As a next step the coordinates of the sampling area must be defined. A position of N47° 22.400' E08° 32.438' is assumed. Positions must be entered as floating point degrees (GARMIN hddd.ddddd° format). This yields: N47.37333° E08.54063°.
In the Metadata Editor select the Gonio_example hierarchy in the Spectral Data Browser. As the position applies to all spectra of the campaign a group update should be carried out. Now enter the latitude (47.37333) and longitude (-8.54063). Longitudes East of Greenwich are negative.
Having entered position and time (do not forget to press the 'Update' button), the calculation of the illumination geometry can be carried out by clicking the 'Calc Sun Angles' button (cf. Figure 143).

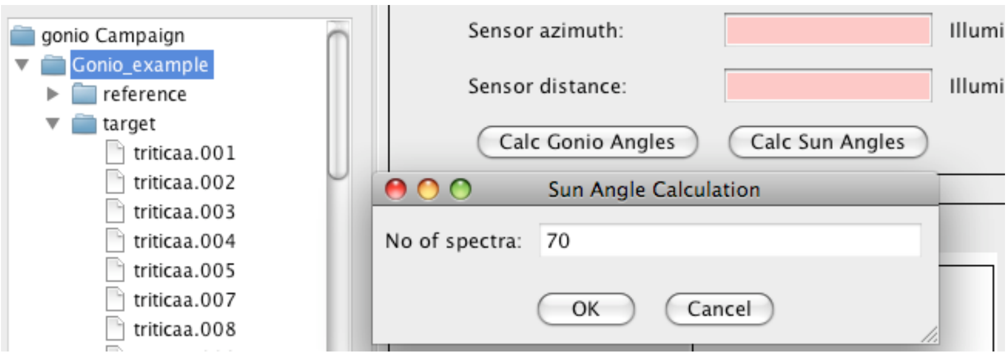


Figure 143: Sun angle calculation for goniometer data

Use the Spectral Browser of the Metadata Editor to check the sun angles that have been calculated. Every spectrum has been assigned slightly differing sun angles according to the individual capturing time.

The angles of the goniometer can be calculated for each spectrum using the 'Calc Gonio Angles' function (cf. 5.2.6.2.10.1). Select the target hierarchy and click the 'Calc Gonio Angles' button. On the left side of the dialog the number of spectra in the selected hierarchy is displayed (63 spectra). There are three spectra missing from the normal total of 66. If you study the names of the target spectra it seems that the missing spectra numbers are: 55, 56 and 57. Specify the gaps as 55,56,57 and press 'Insert gaps'. The total number of positions is shown in the field 'Spectra + dummies', i.e. 66 in this case. Press 'Calculate'. The list above the 'Calculate' button now contains the positions (starting at zero), the calculated angles and the spectrum filenames. Scroll down till you find the inserted dummies called 'gap dummy' (cf. Figure 144).

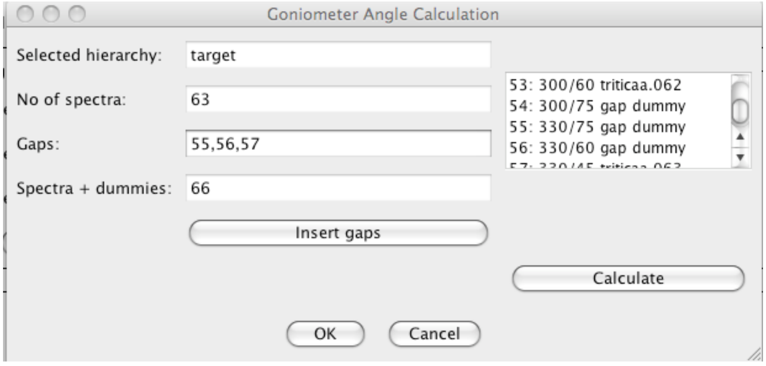


Figure 144: Inserted gaps and resulting angles

At this point you would have to refer to your field protocol in order to confirm that the gaps you specified did occur at the calculated angles. Let us assume that number 57 actually exists but number 60 is missing. Change the gap specification to: 55,56,60. Press 'Insert gaps' and 'Calculate' and check the list again. Once you are satisfied with the calculated angles press 'Ok' to store the angles in the database. Use the Metadata Editor to check that the angles have indeed been saved and are now correctly displayed.
E.g. for the spectrum triticaa.040 you should find a sensor zenith of 30° and azimuth = 270° (cf. Figure 145).

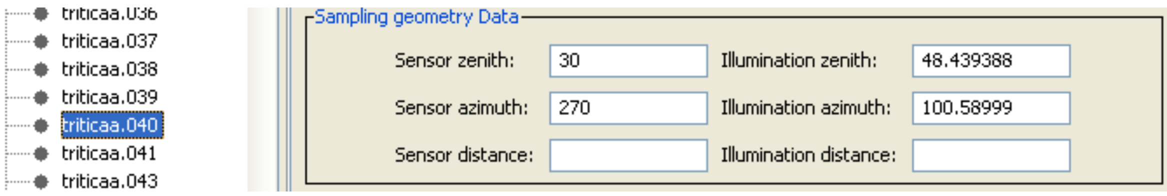


Figure 145: Calculated sensor zenith and azimuth angles

6.5 Part 4: Data Querying, Processing and Exploration

6.5.1 Converting Radiances to Reflectances

Data set: GER_example

The GER example data set contains reference and target measurements that have been linked automatically during data load. Our goal is the conversion of target radiances to reflectances using the respective function of the Space Network Processor.
Open the Query Builder, browse to your GER example, select the targets hierarchy (Figure 146) and press the 'Process' button.

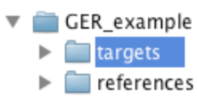


Figure 146: Selection of the target hierarchy of the GER example data set

A Space Network Processor window will open, containing a space holding the ten target spectra (Figure 147). The dimensionality of the space is 647, which is equal to the number of bands of the GER instrument.

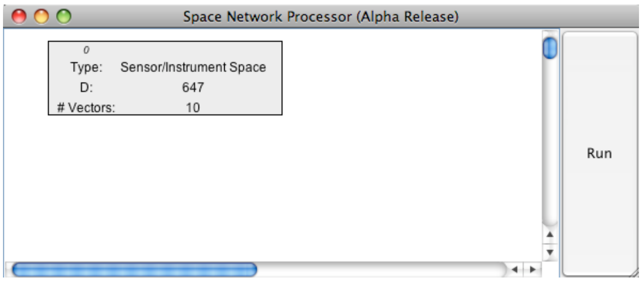


Figure 147: Space Network Processor window with space containing the target spectra

Add ‘Radiance to Reflectance Transformation’ as a new processing module to the processing plane by clicking the menu button over the processing plane and selecting the module.

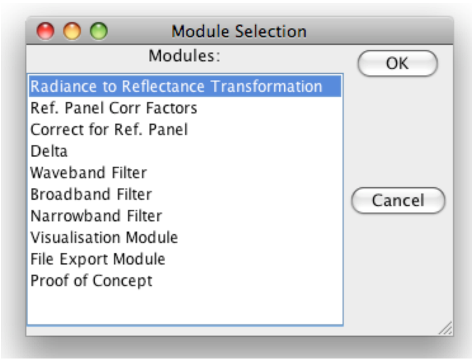


Figure 148: Selection of the ‘Radiance to Reflectance Transformation’ module

Connect the new module with the input space (space 0) by clicking the menu button over the module and selecting ‘Set Input Spaces’ in the module menu (Figure 149) and choosing space number 0 as input space (Figure 150).

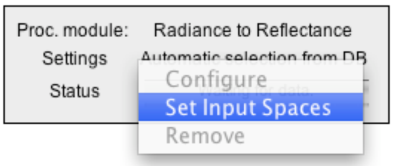


Figure 149: Module menu

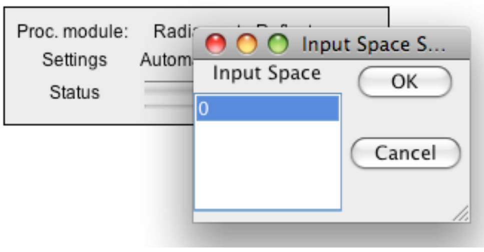


Figure 150: Input space selection for the ‘Radiance to Reflectance Transformation’ module

A new space is added to the processing plane automatically, containing to output of the 'Radiance to Reflectance Transformation' module (Figure 151).

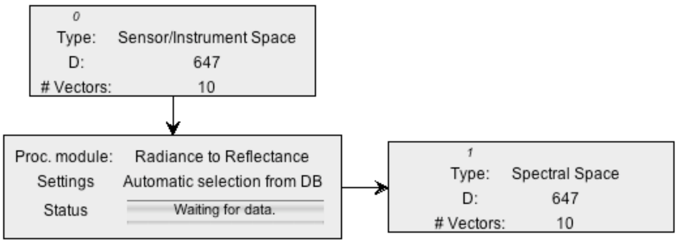


Figure 151: Input and output spaces of the 'Radiance to Reflectance Transformation' module

Now, we would like to see what this transformation is actually doing by plotting the input and output spectra.
Add two new modules of the type 'Visualisation Module' to the processing plane, configure them as 'Spectral Line Plot' and connect them with the input space (space 0) and the output space (space 1) respectively. Your Space Processing Network should now be similar to the one shown in Figure 152.

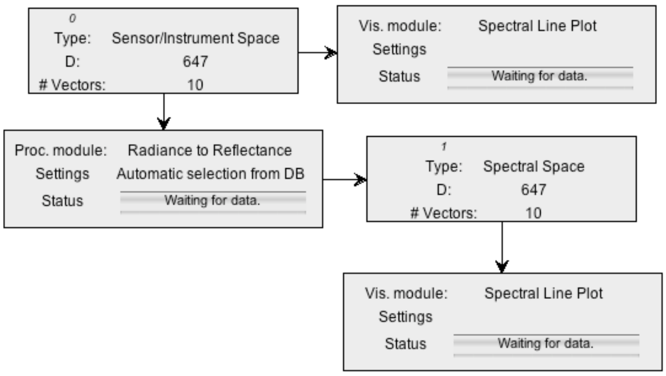


Figure 152: Space Processing Network for radiance to reflectance transformation and visualisation

Press the 'Run' button of the Space Network Processor and two spectral plots should appear (Figure 153).

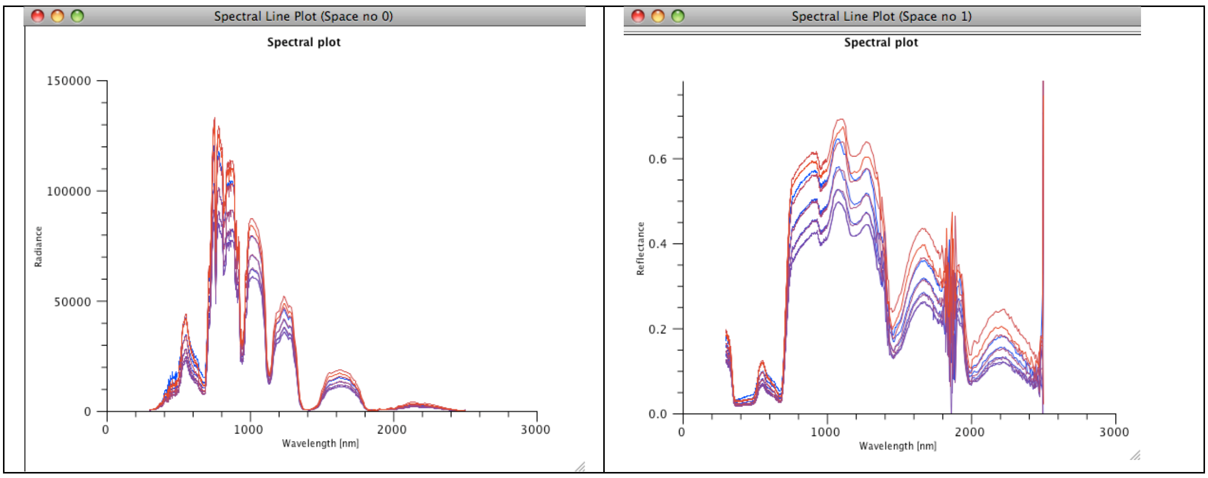


Figure 153: Spectral plots of radiance and calculated reflectance

The calculated reflectances show the typical features of a vegetation spectrum (green peak, red edge, water absorption features). The high reflectance in the UV-Blue of the first few bands is an artefact of the instrument and indicates an unreliable calibration of the according channels.

6.5.2 Data Queries

Data set: all campaigns loaded to the database.

If you worked through the whole tutorial a total of three new campaigns should now be loaded to the database. Note that you have access to campaigns other persons entered in the database. Queries on the database can thus return more rows than you might expect!
Open the Query Builder and switch to the 'Query conditions' tab.
In the wildcard field of the Campaign name type in your first or last name followed by the percentage sign, e.g. 'hueni%'. Alternatively, select your name from the investigators list.
The number of resulting rows should be 154 (if all 3 tutorial data sets were loaded).
Select 'Directional' as measurement type. The number of rows should drop to 70 and the autobuilt SQL statement looks similar to:

```
SELECT count(*) FROM spectrum, campaign WHERE name like 'hueni%' AND
spectrum.measurement_type_id = '2' AND spectrum.campaign_id = cam-
paign.campaign_id
```

As a matter of fact, the spectra selected by this query all belong to the goniometer campaign that you created in this tutorial. The same result set is returned when the goniometer campaign is selected implicitly.
The result set can be further restricted by e.g. sampling geometry conditions. Narrow the search for spectra with zenith angles between 0° and 30° by entering a sensor zenith angle of 15 and a buffer size of 15 and sensor azimuth of 90 with buffer size 90 (cf. Figure 154).

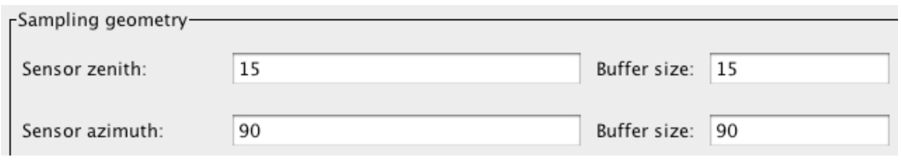


Figure 154: Specifying a sensor zenith/azimuth angles and buffer values

The resulting SQL statement should look like:

```
SELECT count(*) FROM spectrum, campaign, sampling_geometry WHERE cam-
paign.name = 'V2.0 Gonio Test' AND campaign.user_id = '1' AND (sam-
pling_geometry.sensor_zenith >= 0.0 AND sampling_geometry.sensor_zenith
<= 30.0) AND (sampling_geometry.sensor_azimuth >= 0.0 AND sam-
pling_geometry.sensor_azimuth <= 180.0) AND spectrum.measurement_type_id
= '2' AND spectrum.campaign_id = campaign.campaign_id AND spec-
trum.sampling_geometry_id = sampling_geometry.sampling_geometry_id
```

The number of resulting rows should be 17.

Press the 'Process' button in the Query Builder to load the selected data into the Space Network Processor. Add a new Visualisation Module, configure it as 'Gonio Hemisphere Explorer' and connect it with the input space (Figure 155).

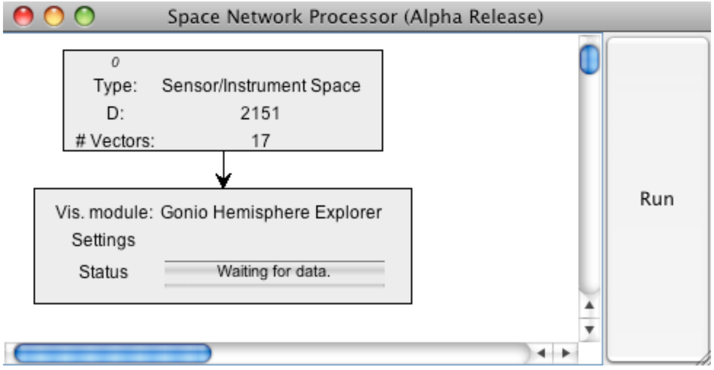


Figure 155: Gonio Hemisphere Explorer connected to the input space

Press the ‘Run’ button of the Space Network Processor. A Gonio Hemisphere Explorer window will open (Figure 156).

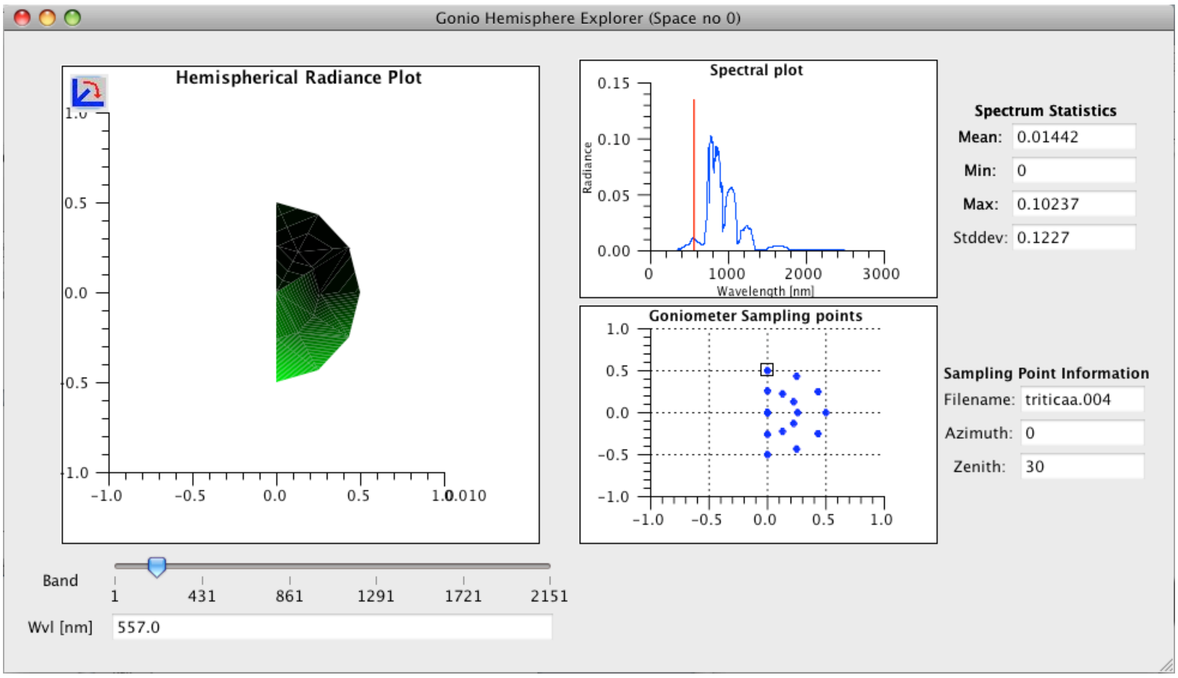


Figure 156: Gonio Hemisphere Explorer showing the data points selected in the Query Browser

Note that according to the selection in the Query Browser, only a limited number of points are displayed. The Gonio Hemisphere Explorer can handle any number of spectrodirectional data points and could thus be used on data stemming from different goniometer systems as well.

The data comprises spectrodirectional measurements of a wheat field (triticale). The hemispherical plot nicely illustrates the backward scattering of vegetation canopies (highest radiances are observed in the principal plane). The illumination source is at azimuth position 180° in the shown plot.

7 Change History

7.1 SPECCHIO Application

7.1.1 Added Features

SPECCHIO Version	Feature	Date
V1.0c	Spectra names are read from ENVI slb header files and stored as part of the filenames in the database. Spectra names from slb headers are also inserted into the spectra name table with a name type of 'ENVI Hdr'.	14.02.2007
	Database connection status is shown in main window	14.02.2007
V1.0d	Added ENVI SLI files to recognized file types	21.02.2007
	Automatic connect to localhost when louie.geo.unizh.ch is not available. Better error messages when connections to database fail.	21.02.2007
V1.0e	Landcover type selection in Metadata Editor now based on tree display.	10.04.2007
V1.0f	Support for loading TXT files.	29.05.2007
V1.1	Multiuser support.	18.10.2007
	Database connections configurable via db_config.txt file	
V1.1a	Lazy loading algorithm for spectral databrowser: allows efficient working with large datasets.	03.11.2007
V1.2	Super-fast group updates. Shared data highlighting. Shared data update reimplementation. Shared data awareness for gonio and sun angle calculations. Direct selection of gonio and sun angle calculations from the 'sampling geometry field'. Several progress reports added.	03.06.2008
V1.3	Added campaign import function. Added file comment to spectrum report. Added help menu item and specchio info dialog box.	15.06.2008
V2.0	Major rework of the whole code. Added instrumentation adminis-tration and Space Network Processor.	05.03.2009

7.1.2 Fixed Bugs

SPECCHIO Version	Problem	Fix	Date
V1.0a	ENVI SLB does not load into ENVI	Modification of HDR file	19.01.2007
	Group update using the 'over-ride conflict detection' option on positions is not updating all positions if each spectrum has its own position.	Individual update is now enforced in this case.	24.01.2007
	ASD files: zero coordinates (i.e. no GPS unit connected during sampling) trigger the creation of a positional record	Check for zero coordinates is car-ried out during reading of ASD files. Positions are only inserted if lat, long and altitude are all differ-	24.01.2007

	in the database with zero lat, long and altitude entries	ent from zero.	
	Some hidden dot files, e.g. .DStore prevent the correct loading of campaigns	Added filter for dot files.	26.01.2007
V1.0b	Missing date in ENVI slb crashes loading process	NIL date handling	14.02.2007
	The ENVI slb date bug fix crashes the loader process when determining the spectral file loader class	Explicitly create date array in asd file reader constructor	14.02.2007
	Sensor definition loader crashes because of new element_type_id	Add default narrowband element type id in insert procedure	14.02.2007
1.1	Previously inserted pictures are added along with new pictures.	Clear added picture list in picture metadata object.	18.10.2007
	Pictures not updated on screen in metadata editor	Revalidate the metadata editor.	18.10.2007
	Some dialogs (e.g. Query Builder) are not opening correctly after changing the database connection (this only applies if the dialogs were opened already with the former connection)	Update default statement and connection in the SQL Statement builder instance upon reconnect.	18.10.2007
1.1a	Goniometer angle calculation not working.	Carry out updates on view instead table.	03.11.2007
	Memory overflow when loading thousands of spectra.	Close finished streams and files.	03.11.2007
1.2	Shared data update/delete not working	Major redesign of the metadata editor update and shared data functions.	29.05.2008
1.3	Datalink group update somehow inserting too many rows	Clear internal lists after updates.	15.06.2008
2.0	Various	- architecture dependant data type for ENVI SLBs - thread safety for SQL statement builder - Foreoptic is now treated as FOV and bare fibre FOVs are correctly inserted for ASD readings.	05.03.2009
2.0a	ENVI SLB loading problems	- Data type awareness on input - Warning message if unknown file types exist in directory	26.03.2009
2.0c	Copy/Paste now working in numeric fields in the Metadata Editor	- Update allowed key list	07.07.2009

7.1.3 Known Bugs

SPECCHIO Version	Problem	Workaround
V2.0	Target type abundance: Number exception when no abundance specified	Always enter a target abundance when defining target types.
	Duplicate key error on update (only certain tables and not always occurring either)	No user workaround. Write email to SPECCHIO admin.
	Attained quality level is wrongly set even if not all fields comply	No user workaround
	Conflict detection is not working for data links.	If in doubt, check the links of the involved spectra to ensure they are set correctly. The datalinks will be replaced by new linking functions in the near future.

7.2 SPECCHIO Database

7.2.1 Added Features

SPECCHIO Database Version	Feature	Date
1.0a	Changed the column type of latitude, longitude and illumination angles from Float to Double to increase precision	24.01.2007
1.1	Multiuser capability added.	15.10.2007
1.1c	Changes for compatibility with the campaign export function.	29.05.2008
2.0	Various new features: reference panel links for spectra, reference panels, calibrations and according uncertainties, DB version	05.03.2009
2.0c	Instrument settings table	07.07.2009

8 References

Hueni, A. (2006). Field Spectroradiometer Data: Acquisition, Organisation, Processing and Analysis on the Example of New Zealand Native Plants. Institute of Natural Resources. Palmerston North, Massey University.

Hueni, A., M. Kneubuehler, et al. (2009). PROCESSING EXTENSION FOR THE SPECTRAL DATABASE SPECCHIO. EARSeL SIG IS, Tel Aviv, Israel.

Hüni, A., J. Nieke, et al. (2007). Metadata of Spectral Data Collections. 5th EARSeL Workshop on Imaging Spectroscopy, Bruges, Belgium.

ISO/IEC (1996). Information technology -- Syntactic metalanguage -- Extended BNF (14977). Geneva, Switzerland, ISO/IEC Copyright Office.

Landgrebe, D. (1997). On Information Extraction Principles for Hyperspectral Data. West Lafayette, IN, Purdue University.

Schopfer, J. (2008). SPECTRODIRECTIONAL GROUND-BASED REMOTE SENSING USING DUAL-VIEW

GONIOMETRY. Zurich, Remote Sensing Laboratories.

Schopfer, J., S. Dangel, et al. (2007). Dual Field-of-View Goniometer System FIGOS. ISPMSRS, 12-14 March 2007, Davos, Switzerland.

U.S. Naval Observatory. (2003). "What is Universal Time?", from http://aa.usno.navy.mil/faq/docs/UT.html.

University of Washington. (undated). "Total Cloud Amounts." from http://www.atmos.washington.edu/gcg/MG/tepps/SPOON/photoen/cover.html.

Wirth, N. (1977). "What can we do about the unnecessary diversity of notation for syntactic definitions?" Communications of the ACM **20**(11): 822-823.