User Guide

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1   Introduction

SPECCHIO is a database for storing spectral data acquired by spectroradiometers and their associated metadata, combined with a user-friendly interface.

SPECCHIO was first developed at the Remote Sensing Labs at the Geography Department, University of Zurich to support long term usability and data sharing between researchers.

SPECCHIO was then further enhanced through a project run by the University of Wollongong in 2012/2013. The alias of "AUS-SPECCHIO" represents this instance. This project was supported by the Australian National Data Service (ANDS). ANDS is supported by the Australian Government through the National Collaborative Research Infrastructure Strategy Program and the Education Investment Fund (EIF) Super Science Initiative.

"Specchio" is an Italian word meaning "mirror" or "looking glass". It can also be used to refer to a table of data or a scoreboard.

1.1   Document scope

SPECCHIO uses a Client-Server architecture. This User Guide details operation of the Client component of SPECCHIO.

This document focuses on the Windows operation of SPECCHIO for most of its descriptions, screen shots and examples. The operation of the SPECCHIO on Mac and Linux is equivalent and can be inferred from the Windows descriptions.

1.2   Intended audience

This document is intended for users who are:

- installing SPECCHIO on a desktop
- using SPECCHIO to input or browse data
- administrating the data within SPECCHIO

It also assumes that readers are familiar with:

- remote sensing and the disciplines and processes related to it
- the general operation of their own computer
- the general concept of a client-server architecture
-
- The Administration Guide is a separate document and is intended for users performing the following tasks:
- installing the Server side of SPECCHIO
- understanding the architecture
- understanding system requirements
- release notes
-

1.3 SPECCHIO ownership and access

SPECCHIO was originally built by the Remote Sensing Laboratories at the University of Zurich, and extended by Intersect for the School of Earth and Environmental Sciences at the University of Wollongong.

1.4 Copyright and licensing

This program is free software: you can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation, either version 3 of the License, or (at your option) any later version. This program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU General Public License for more details. You should have received a copy of the GNU General Public License along with this program. If not, see <http://www.gnu.org/licenses/>.

1.5 For Further Information

Please refer to the following documents for more information about SPECCHIO. Unless otherwise stated, they can be found in the SPECCHIO Installation kit.

SPECCHIO_ReleaseNotes.pdf can be found in each Installation Kit and provides installation instructions for the SPECCHIO Client.

SPECCHIO_Tutorial.pdf provides instruction in the operation of key areas of the SPECCHIO Client.

SPECCHIO_ServerInstallation.pdf provides system administrators with information to assist in managing and maintaining a SPECCHIO Server System.

SPECCHIO_VM.pdf provides information about the SPECCHIO Virtual Machine, basing on a VirtualBox CentOS virtual machine. The SPECCHIO VM is an easy solution to running a complete SPECCHIO server without the complex installation procedure of a complete native server installation.

SPECCHIO Web Site ([www.specchio.ch)](www.specchio.ch) General information about SPECCHIO. Some of this information may be related to other non-UOW versions of SPECCHIO.

SPECCHIO UoW (https://specchio.uow.edu.au) Installation kits for University of Wollongong version of the SPECCHIO Client and documentation for that version.

SPECCHIO GitHub (https://github.com/ahueni/SPECCHIO) Source code of SPECCHIO.

See also *Section 16 References* for a list of academic articles related to SPECCHIO and its use.

2   Overview of the SPECCHIO Application

SPECCHIO is a database for storing spectral data acquired by spectroradiometers and their associated metadata, combined with a user-friendly interface.

SPECCHIO organises the Spectra for each new sampling experiment into Campaigns. Users can view the Spectra for each Campaign by using the browser or by building a query.

SPECCHIO provides an API to access all system functionality from other programming languages via a Java bridge.

2.1   SPECCHIO Basic Operation

SPECCHIO has been setup to comply as much as possible with the look and feel of the operating system on which it is running.

The screenshots provided in the following sections have been taken on a macOS system. Depending on your operating system, the windows and widgets may look a little different.

2.1.1   macOS and Windows Operation

SPECCHIO uses the following mouse click combinations on Windows. This document describes SPECCHIO operation in terms of these Windows mouse click patterns.

Left Click   The normal selection or activation click.

Right Click   Context menu display.

Control+Left Click   Adding a single item to the selection. Control+Click adds the item clicked to any already selected items.

Shift+Left Click   Adding a range of items to the selection. Shift+Click adds the item clicked, plus any items between the last selected item and the currently selected item, to any already selected items.

Under macOS the Apple command key is equivalent to the Windows Control key.

There are a variety of Mac mouse types which can be used, and also a variety of settings for configuring the Mac mouse. The Mac user is advised to consider their mouse button settings prior to starting SPECCHIO operation so all of the above functions are accessible.

2.1.2   Unix Operation

As described under Mac Operation above, Unix users should also consider how to access on their computer the various mouse click combinations that are described in this document.

The functionality of the GUI is generally consistent across all tested operating systems.

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

2.2   SPECCHIO User Interface

SPECCHIO's Main Window opens when the application is started. It is used to launch all of SPECCHIO's functions.
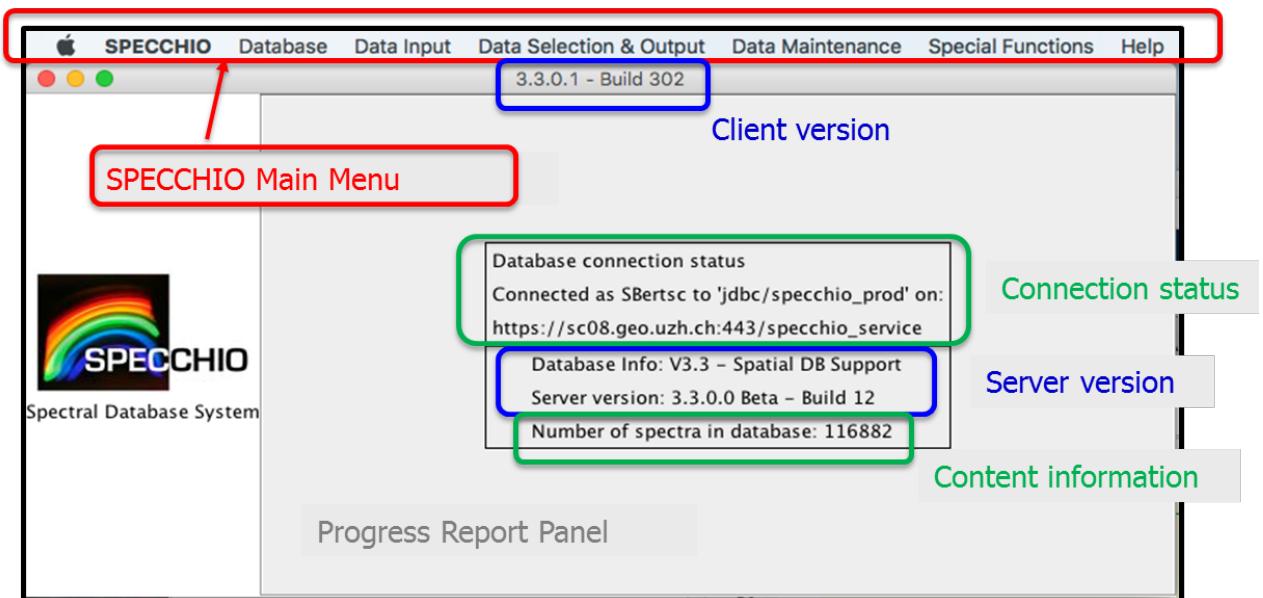
Figure 1: Main Window

Main menu   Select the SPECCHIO functions you wish to run from here.
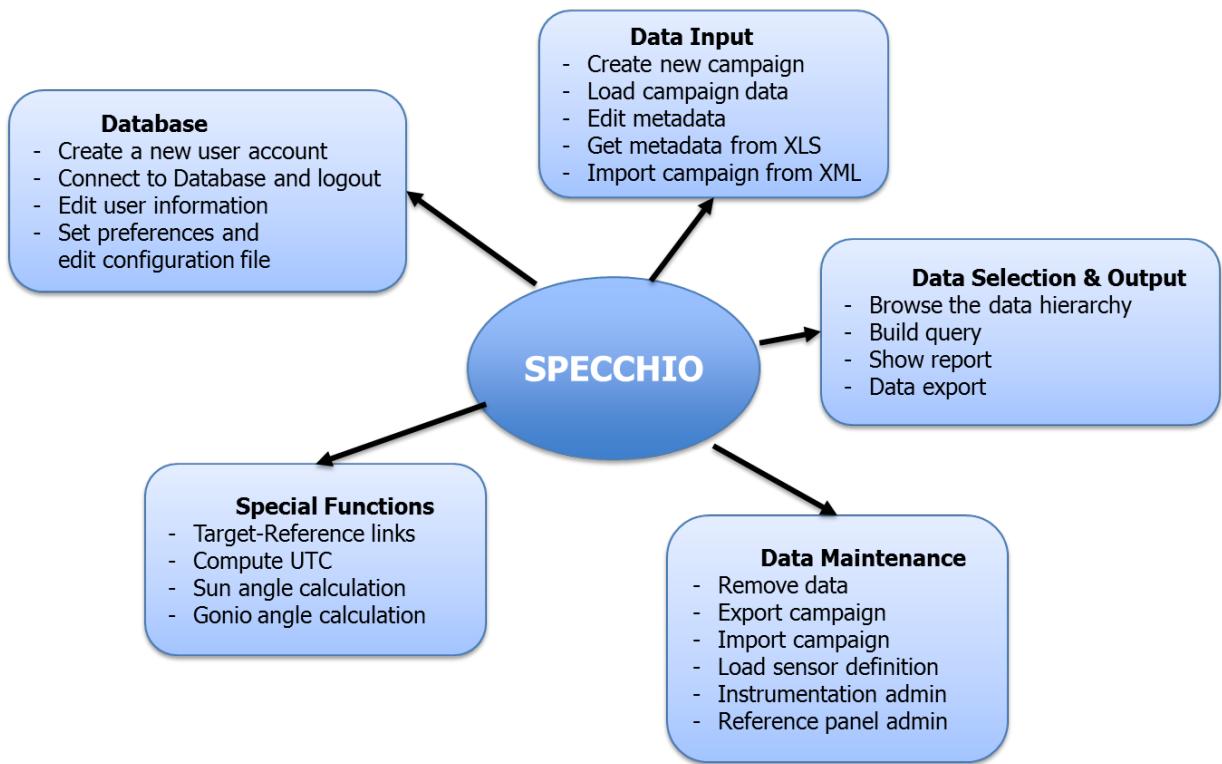
Progress Report Panel   Displays the database connection information and information about the progress of many of SPECCHIO's processes (e.g. file loading).

Database Connection Status   This information is displayed in the Progress Report Panel and shows the User Name you are logged in as, and the database you are logged in to.

The panel on the left side of this window is not used in this version of SPECCHIO.

2.3   Main Functions and Processes
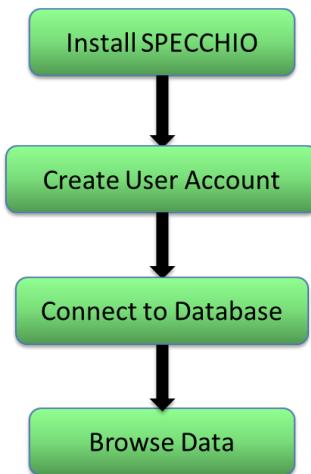
The following diagram illustrates the functions and tasks performed by SPECCHIO. Each section relates to a different menu item in the application, and is a generally described in a different section in the User Guide. Information about campaigns is in a separate section due to its size.

2.3.1   Installing and getting access to the database

This is a brief guide for getting started. Further information on installing and getting access to the database are contained in sections *3 (Installing SPECCHIO)* and 4 (Get Access to the SPECCHIO Database*)* respectively.

Browsing and querying the SPECCHIO database is documented in section *10 Data Selection & Output.*

First of all, you need to install the SPECCHIO client.

In order to get access to a SPECCHIO database, a User Account must be created.

Connect to a database by selecting any of your existing user account details.

SPECCHIO allows users to browse all data available in the database via the Campaign hierarchy.
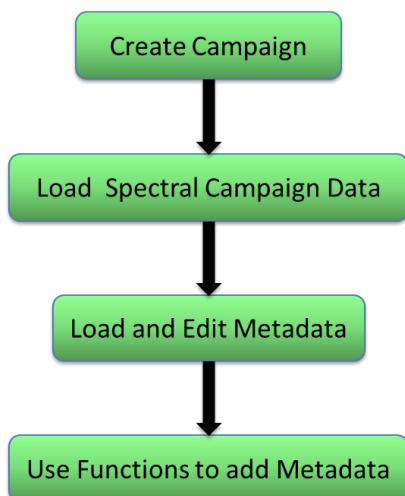
The Query Builder provides a way to select one or more Spectra based on their Metadata.

2.3.2   Data Loading Workflow

The process of **loading data** into SPECCHIO involves a number of steps. Depending on your acquisition device, some of these steps may not be needed because the information is recorded by your device and uploaded with the Spectral data.

Detailed information on how to **import, update, process and maintain Spectral data and related Metadata** can be found later in the document in section *9 (Data Input)*, in section *11 (Data Processing)* and in section *12 (Data Maintenance)*.

The basic operational flow in order to load data into SPECCHIO is as follows:

Create Campaign

This establishes a name for your Campaign and sets up structures in the SPECCHIO database to receive the Campaign Spectra and related data.

Load Spectral Campaign Data

This examines the format of the spectral data on your hard disk, parses its content from your hard disk and inserts into the SPECCHIO database.

Load and Edit Metadata

The Spectral Metadata that was not included in the Spectral files must be uploaded, either from an Excel file or manually using SPECCHIO's Metadata Editor.

Use Functions to add Metadata

Built-in functions in SPECCHIO can be used to generate additional metadata.

After these steps, your Campaign's Spectral data is complete and ready for use, exporting or publishing to ANDS (Australian National Data Service) if your SPECCHIO server supports the ANDS portal.

3   Installing SPECCHIO

3.1   Before you install

Check the following software requirements before installing SPECCHIO. You should consult your Systems Administrator if you have any queries.

SPECCHIO CLIENT (i.e., the desktop application) requires the following software. These should be installed in the following order:

- Java Runtime Environment v. 1.8
- SPECCHIO V3

3.2   Installing Java Runtime Environment

SPECCHIO requires that Java Runtime Environment (JRE) version 1.8 is already installed on your computer before installing SPECCHIO itself. To check the Java version on your system, open a command window under Windows, or a terminal for Macintosh or UNIX systems, and type:

```
java -version
```

The output will be similar to:

java version "1.8.0_152"

Java(TM) SE Runtime Environment (build 1.8.0_152-b16)

Java HotSpot(TM) 64-Bit Server VM (build 25.152-b16, mixed mode)

If you do not have Java installed, or the version number is less than 1.8, you should install an appropriate version of the Java Runtime Environment (JRE) from the internet at http://www.oracle.com/technetwork/java/javase/downloads/index.html.

Note: at the time of writing, Java 9 is not yet supported by the SPECCHIO client.

3.3   Installing SPECCHIO

3.3.1   Installing SPECCHIO for the First Time

The SPECCHIO application plus the libraries it uses are supplied as an application bundle in JAR file format. The installation bundle is usable on Windows, Mac and Unix systems. For Mac OS X, a special installation bundle is additionally provided, packaging the SPECCHIO application as Mac OS application.

The installation bundle is available from `www.specchio.ch` or via Git from `https://github.com/ahueni/SPECCHIO`

1. If getting the package from GitHub, navigate to the ready-to-install packages stored in the `pkg` directory. If downloading from the SPECCHIO web page, just click the required version in the Application Download.
2. Click on `specchio-client-installer.jar.` On the next page click on the link to *view the full file*. When asked, choose to keep or save the file – this will start the installation process.

3. Alternatively you may execute `java -jar specchio-client-installer.jar` from the command line or simply double-click the `specchio-client-installer.jar` in your file system.

4. Follow the prompts to install the software into a directory of your choice. You may need to create the directory folder using Windows Explorer before trying to install SPECCHIO, i.e., to install SPECCHIO to C:\SPECCHIO, first create the SPECCHIO folder using Windows Explorer before selecting the directory in the SPECCHIO installer. You may need Admin rights if you wish to install under C:\Program Files\Specchio.

Note	SPECCHIO does not currently support multi-user installations. SPECCHIO should usually be installed within the personal folder of each user wanting to use the software. This is the folder called `C:\Users\`*`UserName`* in Windows; `/Users/`*`username`* in Mac OS X; or `/home/`*`username`* in Unix and Linux.

3.3.2   Upgrading an Existing Installation

You can upgrade an existing installation by following the same procedure as for a new installation. Just install the new version of SPECCHIO into the same folder as your existing installation. You may wish to create a backup of your existing installation first.
Older versions of SPECCHIO store the database account information in a file named `db_config.txt`. New versions store this information in system preferences. Installations that still contain a `db_config.txt` file will continue to use it. Upgrading to a new version of SPECCHIO will not change the content of an existing `db_config.txt` file.

3.4   Launching SPECCHIO
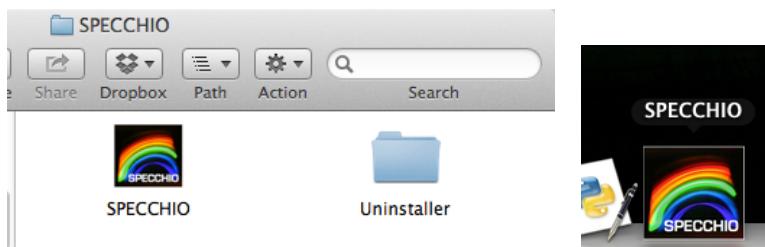
3.4.1   Windows

SPECCHIO should be available in a folder under the "Start" menu. This folder contains options for launching SPECCHIO on both 32-bit versions and 64-bit versions of Windows. Select the option that matches your version of Windows.

The SPECCHIO shortcut may also have been added to the Accessories or Startup folder, depending on your choices when the application was installed. Alternatively, you may search for the SPECCHIO folder using *Search programs and files* under the "Start" menu.

3.4.2   Mac OS X

In case you installed using the MacOS packaged installer open Finder, and navigate to the folder into which you installed SPECCHIO. Double click the SPECCHIO application icon. You may also drag the icon to your dock to make it accessible like any other packaged MacOS application.
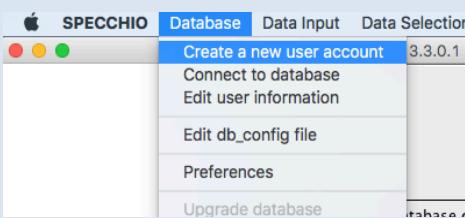
In case you installed the standard bundle (i.e. non Mac OS specific bundle), open Finder, and navigate to the folder into which you installed SPECCHIO. Navigate to the `macosx` folder and double-click on `specchio`.

3.4.3   Unix and Linux

Navigate to the folder into which you installed SPECCHIO. If using a graphical interface that supports it, you may be able to start the application by double-clicking on `specchio-client.jar`. Otherwise, execute `java -jar specchio-client.jar` from the command line.

- From the Main menu, select _Database – Create a new user account_

    to display the following dialog box:
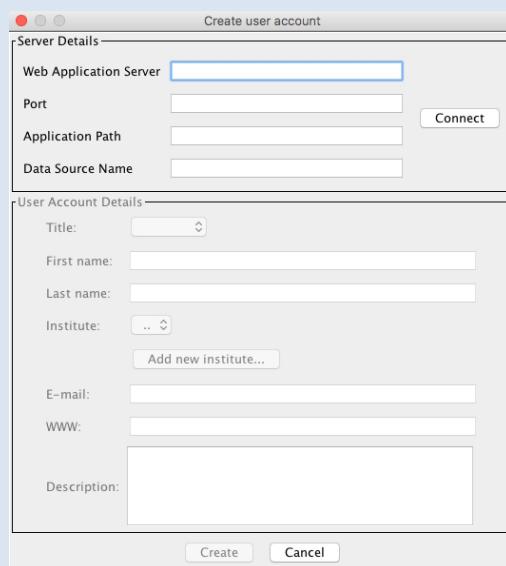
Figure 2: Create a new user account dialog

- Enter the _Web Application Server_, _Port_ and _Application Path_.

- To use the public ANDS-enabled database hosted by the University of Wollongong, use the following details:

Web Application Server: `specchio.uow.edu.au`

Port: `443`

Application Path: `/specchio_service`

- Data Source: `jdbc/specchio`

- To use the Worldwide SPECCHIO Online System, hosted by University of Zurich, use the following details:

  Web Application Server: `v473.vanager.de`

  Port: `443`

- Application Path: `/specchio_service`

- Data Source: Choose between productive and test servers: `jdbc/specchio_prod` and `jdbc/specchio_test`

- If you wish to use a different database, please ask the administrator of that database for the correct values.
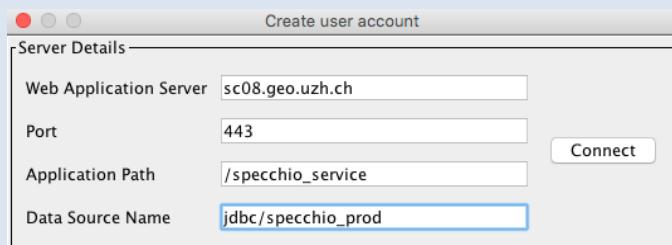
Figure 3: Server connection details (example for University of Zurich in-house SPECCHIO system)

- Click **Connect**.

  The remaining fields on the screen will become active. If ANDS Publishing is supported for your database, ANDS related fields will appear in the dialog box as shown below. See *Section 12 Publishing Data to ANDS* for more information about the ANDS service and its operation.
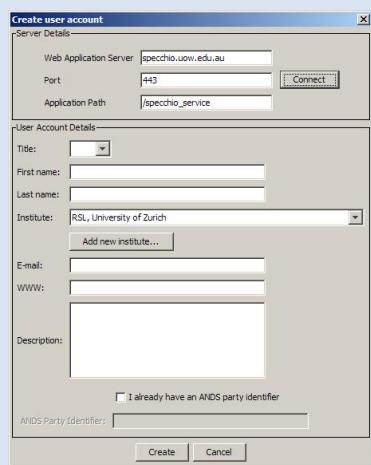
Figure 4: Create a user account dialog for ANDS users
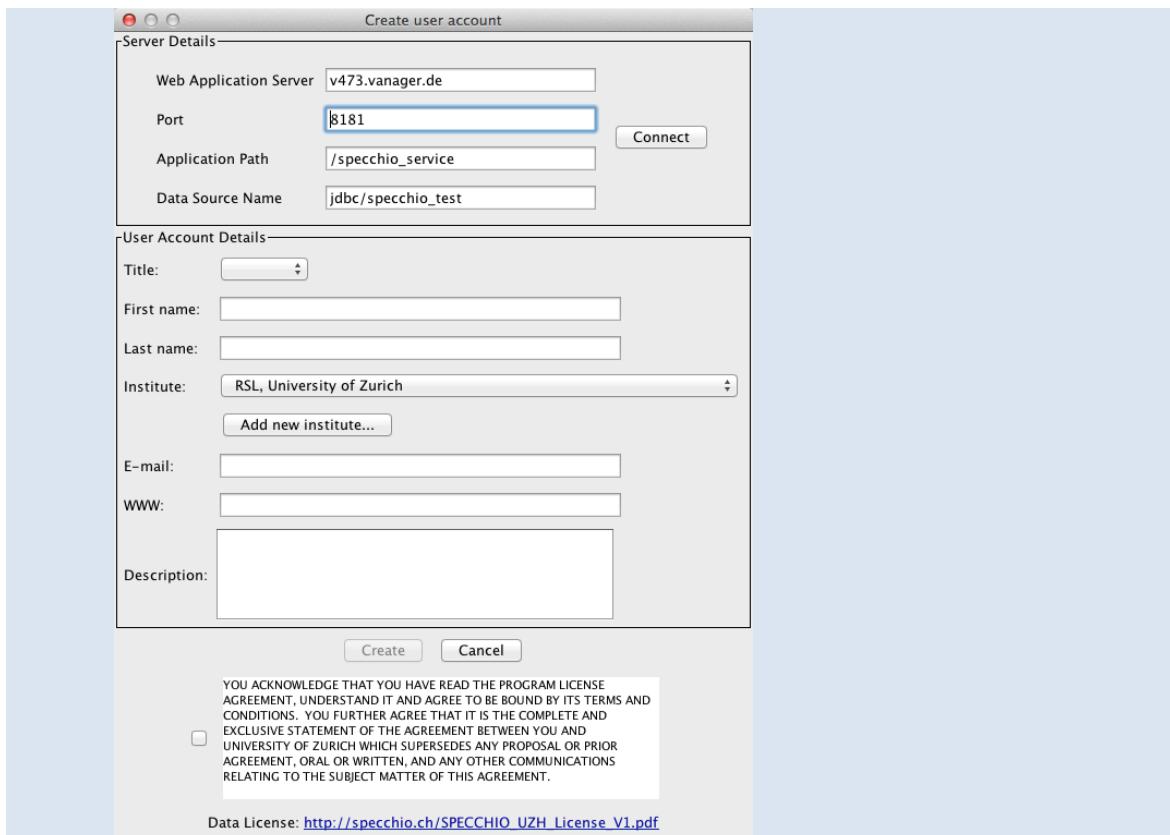
Figure 5: Create User Account dialog for non-ANDS users with specific server license agreement

- Select your *Title* and enter your *First name* and *Last Name*. These will be used to identify the data which you upload to SPECCHIO to other SPECCHIO users.

- Select the name of your *Institute* from the dropdown list.

If the name of your Institute is not present in the list, click on **Add new institute...**. This will cause the following dialog box to appear.
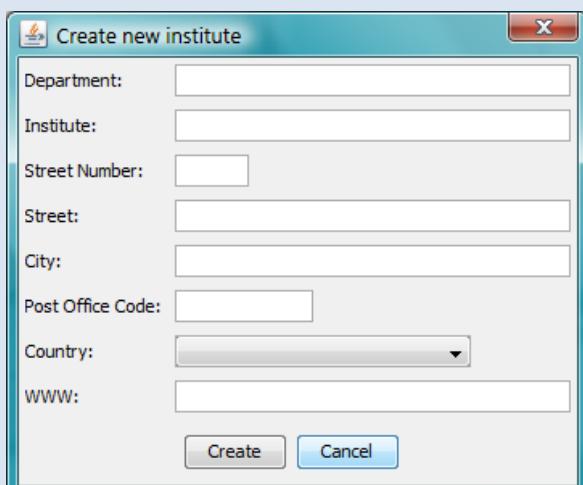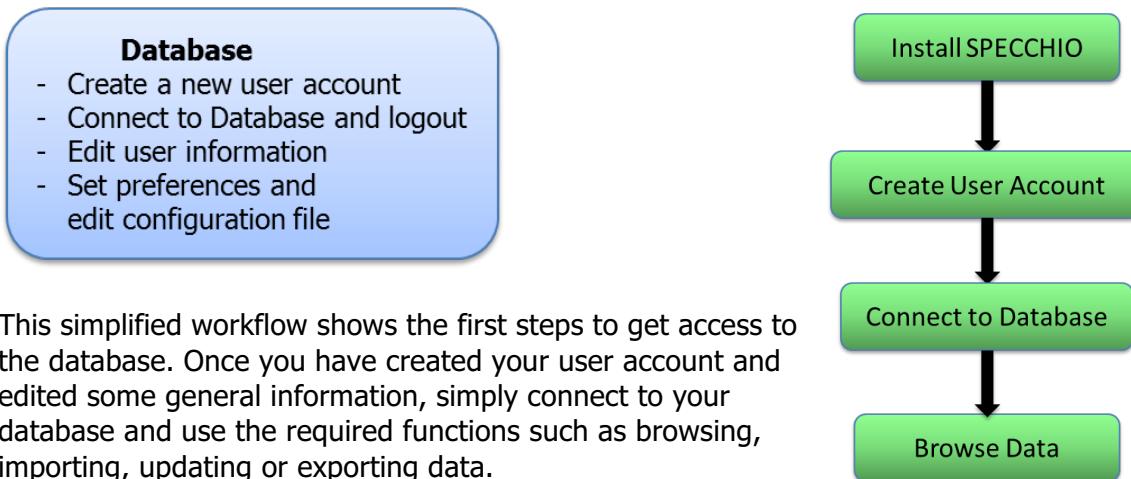
Figure 6: Create new institute dialog

Fill out all the details of your Institute. After checking it is complete and correct, click on **Create**. This will create an entry for your Institute on the SPECCHIO server.

- Enter your email address which other SPECCHIO users can use to contact you. This is a mandatory field.

- Enter a URL which other SPECCHIO users can use to access information about you. The URL is an optional field.

- Include a description of your role. This is a mandatory field.

- If your server's database supports ANDS Publishing and you already have an *ANDS Party Identifier*, set the checkbox and enter your *ANDS Party Identifier* in the relevant field. Take care when entering this field. You cannot change it later. If you do not have an ANDS Party Identifier, leave the checkbox unchecked and SPECCHIO will create one for you.

- Click on **Create**. The dialog box will close.
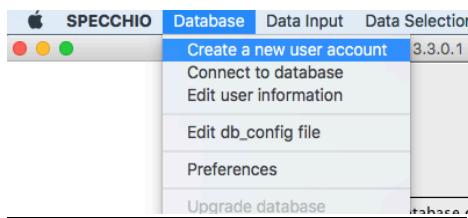
4   Get Access to the SPECCHIO Database

This section describes the functionalities of SPECCHIO's Main Menu item *Database*. You will find information on how to:

Database
- Create a new user account
- Connect to Database and logout
- Edit user information
- Set preferences and
  edit configuration file

Install SPECCHIO

Create User Account

Connect to Database

Browse Data

This simplified workflow shows the first steps to get access to the database. Once you have created your user account and edited some general information, simply connect to your database and use the required functions such as browsing, importing, updating or exporting data.

4.1   Create a new user account
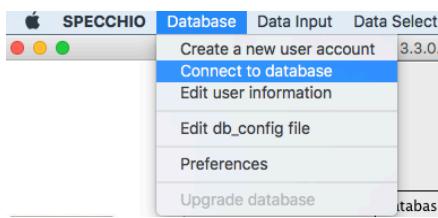
Warning   Take care to enter the details for a new Institute correctly. There is no function to change an Institute record nor to remove an Institute record from the SPECCHIO server. If there is a need to change or remove an Institute record, you will need to request your database administrator to do it for you. It is also possible to create a totally blank institute record.

4.2   Administrator Access

Certain SPECCHIO functions, such as uploading Instrument definitions and Calibrations, require administrator permission. For normal users, these menu operations are greyed out.

When the SPECCHIO database is created, it has an Administrator account defined. The User Name and Password for this account are not generally advertised. See your SPECCHIO Administrator if you require access to these administration functions.

4.3 Connect to Database
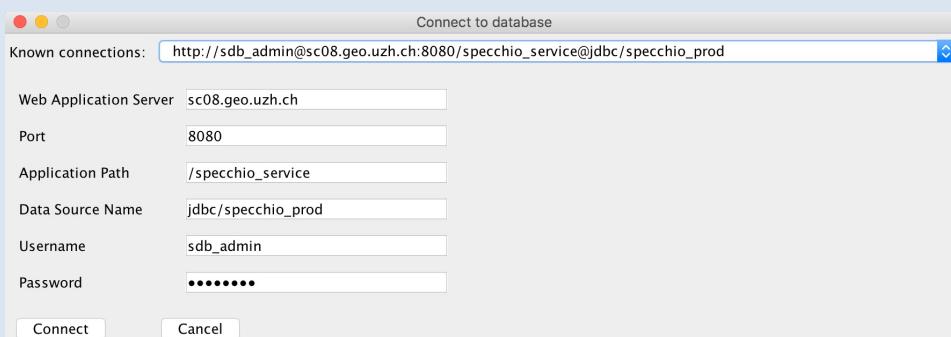
Because the user account details are kept in the database, connecting to the SPECCHIO database and logging in are performed as one operation.

Preconfigured information for your database and the log in accounts you have created on your computer is stored in the `db-config.txt` file on your computer. See *Section 4.1* for instructions on creating a User Account.

To connect to database from your computer:

- Start the SPECCHIO Application. On Windows it may be available under the Start menu; this may depend on your user rights and windows version.

- Once the SPECCHIO Main Window opens, select *Database - Connect to database* to display the connections dialog box:

Figure 7: Connect to database dialog

- If you are accessing SPECCHIO from the same machine you created your account from, the dialogue box should already be populated with your username and password.

- From the *Known connections* dropdown list, select the connection with your User Name following the `https://` characters. The User Name will be a contraction of your own First and Last Names.

- Inspect the values which are updated in the dialog box. It should not be necessary to change anything unless specifically requested by your database administrator.

- Click **Connect**. The dialog box will close and there will be short delay while the database is read. The details of your database and log in account will be displayed in the Progress Report Panel (the right hand panel of the Main Window) and the sub-menu items for SPECCHIO functions will now be active.

You can repeat this process at any time and log in as a different User, or even log in again as the same User.

To connect to database from a different computer:

- If you are accessing SPECCHIO from a different machine, the configuration file will not have your connection details, you may see the following message:
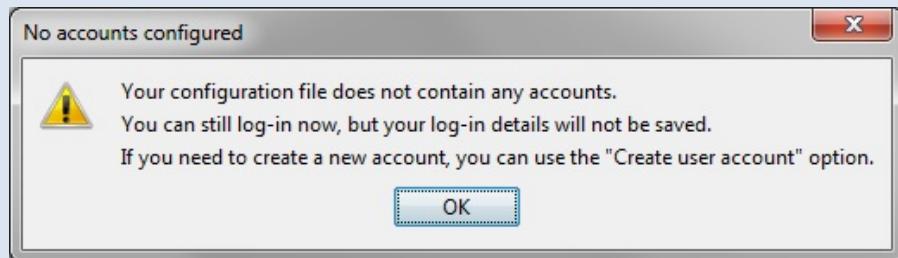
Figure 8: Connection warning

- You will need to manually enter the required information into the *Connect to database* dialog box or copy the full connection string from your original configuration file. You will need to know your Username and Password, as well as the connection details, before you can connect to the database. Refer to the connection details in section 4.1 (Create a new user account), or contact your administrator. Alternatively, you may copy the `db_config.txt` file. This file contains all connection details.
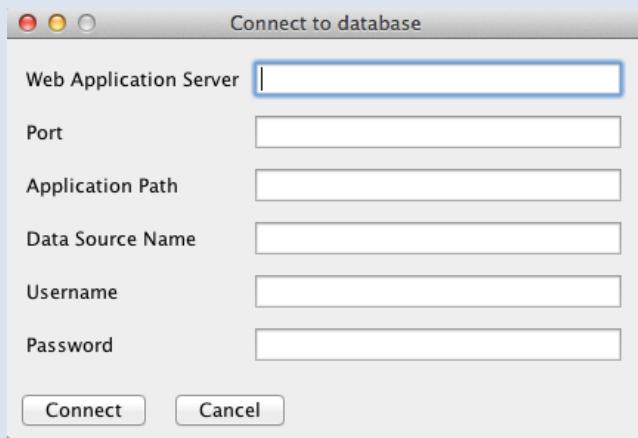
Figure 9: Connect to database dialog

- Fill in the connection details, as well as your Username and Password then click **Connect**. The dialog box will close and there will be short delay while the database is read. The details of your database and log in account will be displayed in the Progress Report Panel (the right-hand panel of the Main Window) and the sub-menu items for SPECCHIO functions will now be active.

4.4   Logging Out

There is no specific log out function for SPECCHIO. Closing the Main Window will close your database session. If you restart SPECCHIO, you will need to log in again.

If you select *Database* -*Connect to database* from the SPECCHIO Main Window menus while you are logged in, SPECCHIO will log you out before logging in again as the new User.

4.5   Edit user information

After logging in and connecting to the database, you can edit your User Information.

To Edit user information:

- From the Main menu, select *Database - Edit user information*. The following dialog box will be displayed showing your current User information:
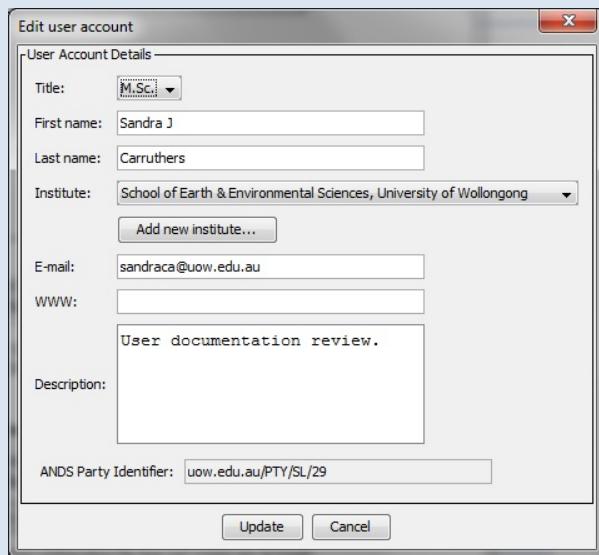
Figure 10: User Information update dialog

- Update the information as required. You cannot change the ANDS Party Identifier.
- Click **Update** to cause the changes to be written back into the database.

This process does not change your *User Name* or *Password*, so there is no requirement to change any of the account configuration stored on your own computer.

4.6   Edit db_config file

Older versions of SPECCHIO stored account details in a configuration file (`db_config.txt`) by default. If you have upgraded from previous versions then SPECCHIO will continue to read account data from the configuration file. Newer versions can be enforced to write data into the configuration file and load account details from it.
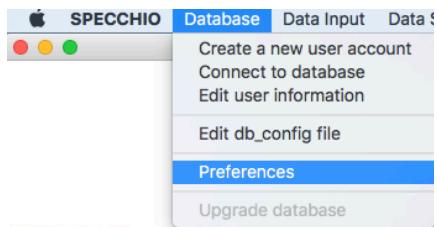
Using the db_config file can simplify working from different machines. However, care is required to maintain the file structure when editing it manually. Furthermore, installations in a multi-user environment should not use the db_config file based storage, as this will expose the connection information to other users having accounts on the same machine.

To create and/or edit the db_config file:

- From the Main menu, select *Database - Edit db_config file*. In case the menu item is greyed out, enable the editing of the db_config file in the SPECCHIO Preferences by setting the according switch (see *section 4.7).*
- The db_config file will be displayed in the default text editor of your

operating system.

4.7   Preferences

Preferences are stored in the system settings of your computer and define some aspects of how SPECCHIO works.

When uploading old ASD file formats, an optional creation of measurement unit folders can be chosen by activating the relevant box.

If ASD DN files are to be inserted, they will be inserted in addition to the calibrated spectrum (e.g. Radiance).

Input and output directories define the default directories that are used for file input and output, such as during campaign export/import operations (see 9.8).

To Change Preferences:

- From the Main menu, select *Database – Preferences*. The following dialog box will be displayed showing your current preferences:

Figure 11: User preferences dialog

- Update the information as required. The new settings are available immediately within SPECCHIO.
- Close the window.

5   Data structure and concepts

In this section you will find information about Campaigns and how they are structured. Please see *Section 7 Data Input* for information on how to set up a campaign and load metadata.

SPECCHIO organises the Spectra for each new sampling experiment into Campaigns. The Spectral data in each Campaign can be viewed and operated on together.

Campaigns can contain Spectra measured with different instruments and sensors, including instruments of different Sensor types and measurements done at different times using an Instrument which has been calibrated one or more times between these measurements.

Spectral data handling is based on the space concept; an understanding this paradigm is providing the background to understand how spectral data are handled by the software. This is of particular importance if higher-level languages (e.g. Matlab or R) are used to access SPECCHIO.

For details on the storage of metadata please refer to the following sections: 8.2 (Non-Redundant Storage), (Metadata Storage Levels) and ().

5.1   Campaign Hierarchy Structure

On your computer, the Spectral data files for a Campaign must be placed into a sub-folder structure which organises the Spectra according to their context or sampling design. SPECCHIO does not impose any restrictions on the complexity of Campaign and sub-folder hierarchies. SPECCHIO does not enforce any particular way of using this hierarchical structure. The hierarchy tree structure can have any number of levels and can be unbalanced, if desired. This sub-folder structure will be replicated in the SPECCHIO database when the Campaign data are uploaded.

The concept of a hierarchical data structure that is used in SPECCHIO has been adapted from SpectraProc (Hueni and Tuohy, 2006), which was built on a fixed hierarchy of three levels. However, SPECCHIO supports hierarchies of arbitrary shape and number of levels.

Preferably the design of sampling experiments should include hierarchical data structuring from the beginning. However, existing data can be re-arranged to meet these requirements.

There are some specific restrictions on the Campaign hierarchy tree structure.
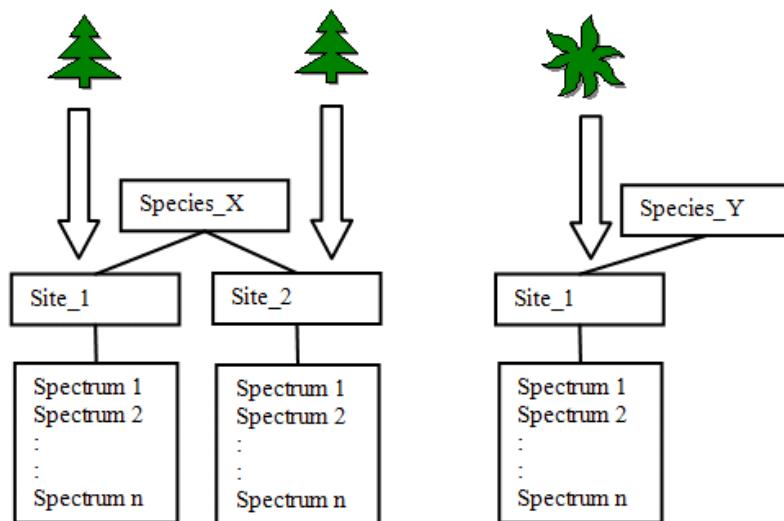
- No other files should be in the sub-folder tree except Spectral files. Keep images, PDF files and other files in a separate folder, probably next to the top-level folder of your tree hierarchy structure. While unknown files are generally ignored by the file loading process, it is recommended to not store them in the spectral data hierarchy operated on by SPECCHIO.

- To conveniently use SPECCHIO's goniometer angle calculation, all of the Spectra measured at the different angles should be put in one folder and observed in the defined sequence. There should be no other Spectra in that folder. The goniometer angle calculation has been designed for the use of the FIGOS and LAGOS goniometers system (RSL, University of Zurich).

New Spectra can be added to ongoing Campaigns by first adding the files for those Spectra into the existing Campaign sub-folder data structure on your computer's disk and then invoking the SPECCHIO load operation for the entire Campaign again. Only

new Spectra discovered in the sub-folder hierarchy will be added to the database. Existing Spectra will not be duplicated. New data can also be added to an existing campaign by adding a new loading path.

Example – Multiple sites for each species

In this example, each species is sampled at 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 the following hierarchical folder structure.

Figure 12: Hierarchical folder structure

Although the term "species" is used, it essentially represents the different classes found in a study. These classes can either be assigned according to already existing classification systems, e.g. for 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 a technique such as cluster analysis.

Figure 13 shows an example of a folder structure containing ASD Spectral files. The main folder `vegetation_example` holds all species sub-folders for the study. This main folder is the folder that needs to be specified in the *Main directory:* in the Campaign Creation dialog. See *Section 7.2 Creating a new Campaign.*

The three species folders contain their related site sub-folders.

The site sub-folders contain all Spectral files collected at these sites for that species.

The Spectral files are auto-numbered by the ASD capturing software within each site folder.

Figure 13: Example of a folder structures holding Spectral files

Example – 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 (Hueni et al., 2017, Milton et al., 2006).

The structure must therefore hold target and the related reference radiance Spectra in adjacent folders.
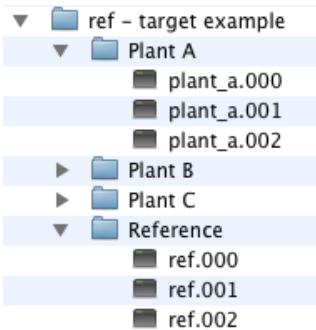
Figure 14: A possible structure for the storage of target and reference radiance Spectra

In this example, the `Reference` sub-folder holds the reference Spectra which relate to the Spectra in the `Plant A`, `Plant B` and `Plant C` sub-folders.

Note: it is also possible to deal with target and reference spectra by giving them according metaparameters.

5.2   Spaces and the Space Factory

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 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 et al., 2007). Internally, this will yield a number of record IDs 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 15).
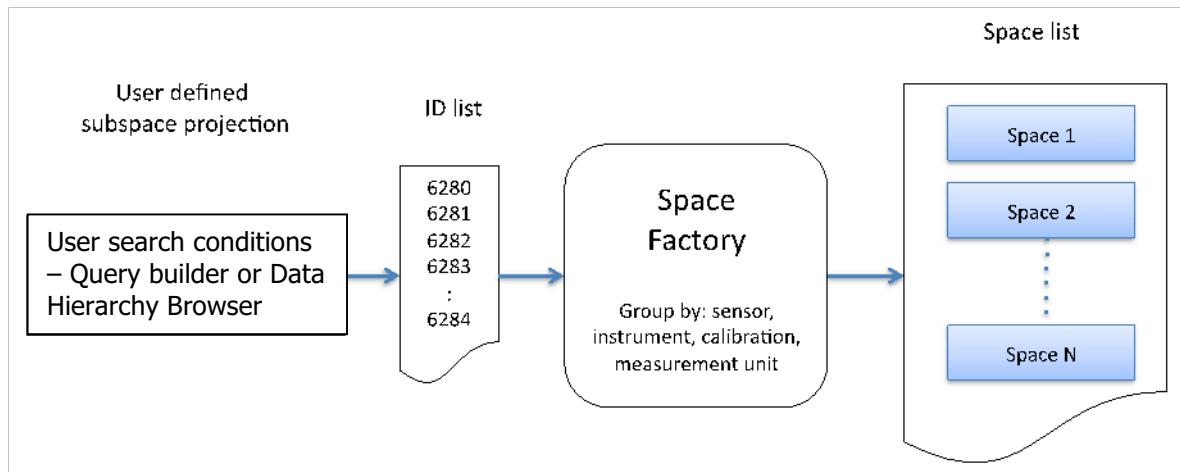
Figure 15: Building spaces based on user defined subspace projections

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.

6   Operational Dataflow

A typical dataflow is illustrated in Figure 16. 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. Spectra and Metadata are 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.
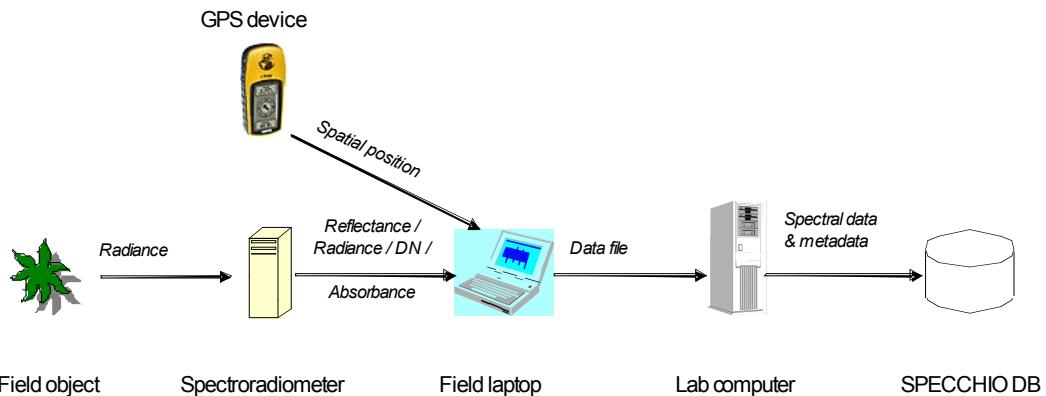
Figure 16: Dataflow and involved hardware

Typically, the operations carried out for each Campaign are:

- Creation of a new Campaign in SPECCHIO and linking it to the sub-folder of Spectra on your computer's disk

- Uploading of Spectra data from your local disk to the SPECCHIO database

- Entering of Metadata into the SPECCHIO database for the uploaded Spectra

- Repeated data query, visualisation, processing and file output based on the uploaded data

7   File Formats

7.1   Supported Input Spectrum File Formats

The following Spectrum file types are supported for loading into SPECCHIO Campaigns.

Each of the 14 file categories listed below is read by a separate file loader. Spectral files of different file types can be freely mixed in the input directories if required.

7.1.1   ASD Binary Files
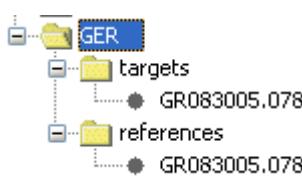
Standard or Format Owner	Analytical Spectral Devices
Devices	ASD FieldSpecPro/FS3 spectroradiometers
Supported Formats	Old file format – ASD FS3, ASD FS PRO and ASD FSVNIR binary files
Comments	To make the hierarchies compatible with data loaded from ASD Indico Version 7 Files, the SPECCHIO Preferences (see *section 4.7*) can be set to generate sub-folders for the old file format as well, e.g., for a radiance file: 📁 old_format ▶ 📁 Radiance ASD Calibration files (*.raw) as stored on ASD laptops can also be loaded using SPECCHIO's Spectrum load functions. This permits advanced users to explore the information content of the Calibrations they describe. (In the current release, loading *.ILL, *.REF files will cause an error.)

7.1.2   ASD Indico Version 7 Files

Standard or Format Owner	Analytical Spectral Devices
Devices	Indico Pro Software
Supported Formats	New file format – Indico Version 7
Comments	Subfolders will be created automatically during loading, depending on the selected unit during data acquisition. DN folders holding the raw digital numbers will always be created. Metadata read from the input file and common to DN spectra and processed spectra is shared automatically. ▼ 📁 ASD files of various instruments ▶ 📁 DN ▶ 📁 Radiance ▶ 📁 Reflectance Loading of ASD Calibration files of this version using the Spectrum
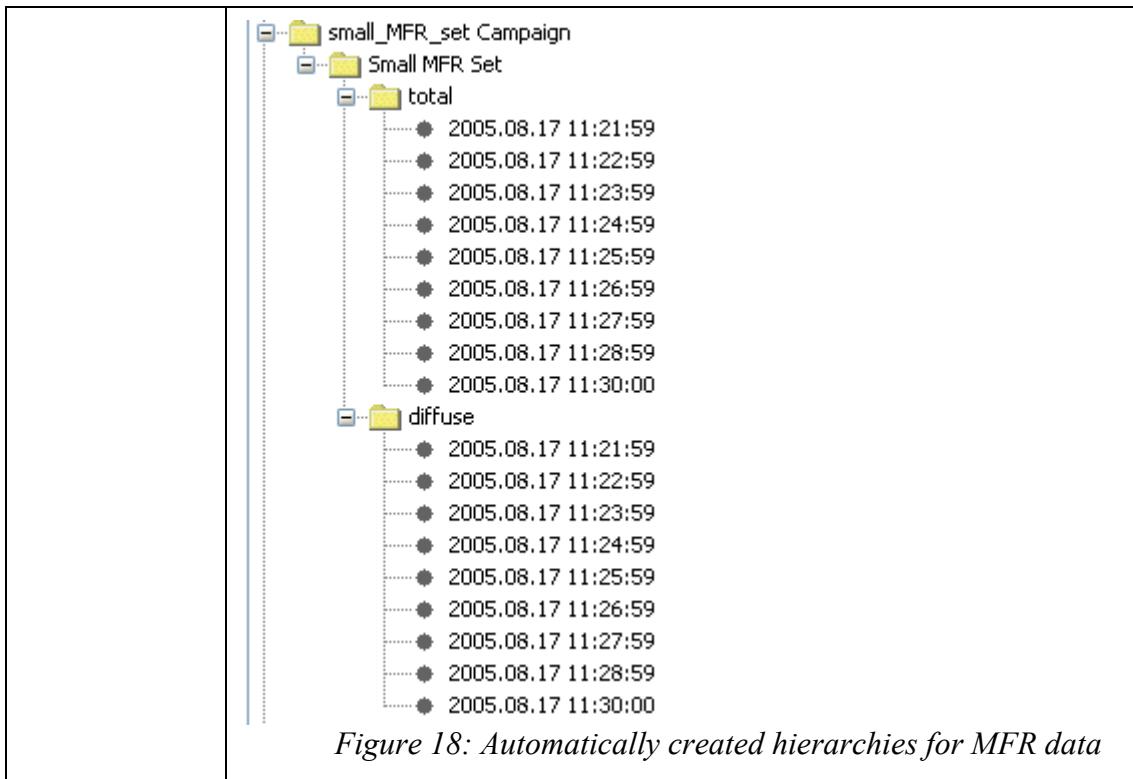
	load functions has not been tested and may not work.

7.1.3   GER Signature Files

Standard or Format Owner	Spectra Vista Corporation
Devices	GER 3700
Supported Formats	GER 3700 signature text files (Files produced by other GER instruments are untested)
Comments	These files hold two Spectral measurements at once: the Target Spectrum and the white Reference Spectrum. When read, two sub-folders named _targets_ and _references_ are created. The input file name is used as both the Target Spectrum's name in the _targets_ folder and the Reference Spectrum's name in the _references_ folder. A data link is created linking the Target Spectrum to the Reference Spectrum. *Figure 17: Automatically created hierarchies for GER files*

7.1.4   MFR OUT Files

Standard or Format Owner	
Devices	MFR Sun Photometer
Supported Formats	MFR Photometer OUT files MFR 7
Comments	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. When read, two sub-folders named _total_ and _diffuse_ are created. The input file name is used as both the name of the total Spectrum's name in the _total_ folder and the diffuse Spectrum's name in the _diffuse_ folder.

Figure 18: Automatically created hierarchies for MFR data

7.1.5   Microtops Sun photometer Files

Standard or Format Owner	Solar Systems
Devices	Microtops Sun Photometer
Supported Formats	Microtops text output files (TXT file extension)
Comments	When read, three sub-folders named *AOT, Spectrum* and *Spectrum StdDev* are created. The input file name is used as the name of the Spectrum's name in the generated sub-folders.

Each spectrum is augmented with its spatial position, sun zenith angle, air pressure and estimated atmospheric water content.

Figure 19: Automatically created hierarchies for MFR data

7.1.6   Bruker FTIR Files
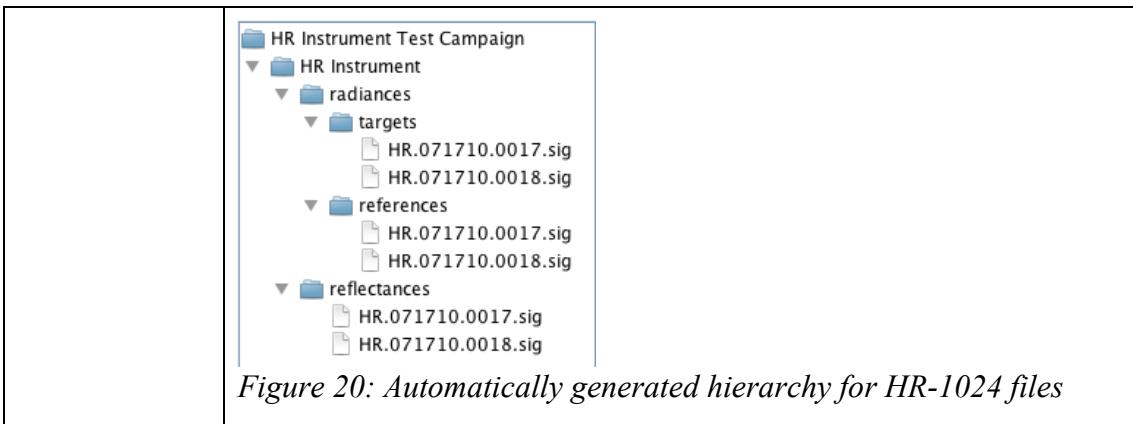
Standard or Format Owner	Bruker
Devices	Bruker FTIR
Supported Formats	Bruker FTIR text files with dpt extension
Comments	Example files supplied by CSIRO Perth.

Example files

```
3996.35288,7.62443
3994.42414,7.64596
3992.49539,7.65170
3990.56665,7.65495
3988.63791,7.67457
3986.70917,7.69236
3984.78043,7.69543
3982.85169,7.69582
3980.92294,7.70848
3978.99420,7.72674
…
```

7.1.7   SVC HR-1024 Files

Standard or Format Owner	Spectra Vista Corporation
Devices	SVC HR-1024
Supported Formats	SVC HR-1024 files
Comments	The HR-1024 stores radiances of reflectance panel, target and the computed target reflectance.

During the data loading, SPECCHIO generates a hierarchical structure to store these files, setting up data links that connect the reflectance to the target radiance and connecting the target radiance to the reference radiance. If the Instrument was set to acquire radiances only (i.e., no white reference taken), then no special structure will be created.

The acquisition time may be wrongly read as it appears that the date format depends on the settings of the computer used to operate the SVC. |

Figure 20: Automatically generated hierarchy for HR-1024 files

Note	For SPECCCHIO version pre 3.1: It is highly recommended to enter the Instrument into the database and load a wavelengths calibration. The wavelengths between instruments differ quite a lot and the standard Sensor definition pre-stored in SPECCHIO is only a poor representation of the real wavelengths.

Example files

```
/*** Spectra Vista HR-1024 ***/
name= \My Documents\HR1024_Data\HR.071710.0017.sig
instrument= HR: 0761008
integration= 2, 22, 20, 12, 50, 30
scan time=1, 1
optic= LENS14, LENS14
temp= 31.29, 0.41, -5.71, 31.53, 0.41, -5.77
battery= 7.7, 7.7
error= 0, 0
units= Radiance, Radiance
time= 7/18/10 9:47:09 AM, 7/18/10 9:47:31 AM
longitude= 11121.2335,W, 11121.2324,W
latitude= 5330.5955,N, 5330.5964,N
gpstime= 154336.000, 154356.000
comm=
memory slot= 0, 0
factors=
data=
344.2 56023.55 4381.86 7.82
345.8 54418.00 4186.00 7.69
347.3 56037.65 4365.57 7.79
348.9 59474.63 4568.75 7.68
…


/*** Spectra Vista SIG Data ***/
name= \My Documents\HR1024_Data\HR.080910.0010.sig
instrument= HR: 0971030
integration= 20, 19.2, 30, 200, 60, 30
scan time= 3, 3
scan settings= AD, AI, AD, AI
external data set1= 8224, 8224, 8224, 8224, 8224, 8224, 8224, 8224, 8224, 8224, 8224,
                   8224, 8224, 8224, 8224, 8224
external data set2= 8224, 8224, 8224, 8224, 8224, 8224, 8224, 8224, 8224, 8224, 8224,
                   8224, 8224, 8224, 8224, 8224
external data dark= 0,0,0,0,0,0,0,0
external data mask= 0
```

```
optic= LENS 4, LENS 4
temp= 36.21, 9.08, -5.30, 36.45, 9.08, -5.37
battery= 7.5, 7.4
error= 0, 0
units= Radiance, Radiance
time= 8/9/10 10:49:47 AM, 8/9/10 10:52:36 AM
longitude= 01116.9879,E, 01116.9933,E
latitude= 4806.4988,N, 4806.5075,N
gpstime= 084748.000, 085034.000
comm=
memory slot= 0, 0
factors=
data=
350.6 127369.73 4658.17 3.66
352.1 130962.30 4815.39 3.68
353.7 132239.65 4916.35 3.72
355.3 128726.40 4836.48 3.76
356.8 124030.10 4677.99 3.77
358.4 123421.08 4677.13 3.79
359.9 130810.10 4966.42 3.80
…
```

7.1.8   Apogee Files

Standard or Format Owner	Apogee Instruments
Devices	
Supported Formats	Apogee text files (restricted to a few tested files only – see example below)
Comments	The SPECCHIO Apogee file loader was added to SPECCHIO for one special case. That is the only Apogee file example that has been available for testing. Therefore, this file reader has not been well tested. It is provided "as is" and should be used with caution.

Example of supported Apogee format text file

```
" File: cachimbalito2\p5_2.TRM
" TRANS-> Wave:733.53nm  Pix:1050  Val: 25.767  Time:23ms  Avg:7  Sm:0  Sg:0  Tc:on
             Xt:1  Ch:1
 400.00  1.102E+000
 400.50  1.131E+000
 401.00  1.205E+000
 401.50  1.257E+000
 402.00  1.260E+000
 402.50  1.336E+000
 403.00  1.341E+000
 403.50  1.418E+000
 404.00  1.451E+000
 404.50  1.444E+000
 405.00  1.488E+000
…
```

7.1.9   ENVI Spectral Library Files

Standard or Format Owner	Exelis Visual Information Systems
Devices	ENVI Software Library
Supported Formats	ENVI Spectral library files (SLB and SLI)

Comments	The import routine reads each `.hdr` file in the folder. Each `.hdr` file refers to either an `.slb` or `.sli` file for the body of the Spectrum data. That is, Spectrum data are stored in pairs of files. For example:
	
	`my_spectra.hdr`
	`my_spectra.slb`
	
	or
	
	`my_spectra.hdr`
	`my_spectra.sli`
	
	Both `.slb` and `.sli` files can be uploaded in the same sub-folder.
	
	Each file pair can contain more than one Spectrum. If present, Spectrum names are read from the header file and stored in the database in the Filename Metadata Attribute.
	
	The File Type Metadata Attribute is set to _ENVI Hdr_.
	
	The Sensor definition (i.e. central wavelengths) is not read from the ENVI header file. You should define the correct Sensor using the _Data Maintenance - Load sensor definition_ menu functions. See _Section 12.2_.

7.1.10   Ocean Optics SpectraSuite Data Files

Standard or Format Owner	Ocean Optics
Devices	Ocean Optics Spectra Suite
Supported Formats	Ocean Optics Spectra Suite text files
Comments	The required file extension is .csv, although the files are not comma separated.

Example file

```
SpectraSuite Data File
++++++++++++++++++++++++++++++++++++++
Date: Wed Sep 15 19:14:15 CEST 2010
User: telerilevamento
Dark Spectrum Present: No
Reference Spectrum Present: No
Number of Sampled Component Spectra: 1
Spectrometers: HR4C1076
```

```
Integration Time (usec): 1000000 (HR4C1076)
Spectra Averaged: 10 (HR4C1076)
Boxcar Smoothing: 0 (HR4C1076)
Correct for Electrical Dark: No (HR4C1076)
Strobe/Lamp Enabled: No (HR4C1076)
Correct for Detector Non-linearity: No (HR4C1076)
Correct for Stray Light: No (HR4C1076)
Number of Pixels in Processed Spectrum: 3648
>>>>>Begin Processed Spectral Data<<<<<
Wavelength(nm); radiance(W*m-2*sr-1*nm-1)
717.00000;0.17904775
717.02000;0.17878146
717.04000;0.17849983
717.06000;0.17820124
…
```

7.1.11   Ocean Optics Ocean View Data Files

Standard or Format Owner	Ocean Optics
Devices	Ocean Optics Ocean View Software
Supported Formats	Ocean Optics Ocean View text files
Comments	The required file extension is .txt.

Example file

```
Data from Tree1_Day1_am_MAYP1114952_10-08-17-448.txt Node

Date: Wed Mar 25 10:08:17 GMT 2015
User: amacarth
Spectrometer: MAYP111495
Autoset integration time: false
Trigger mode: 0
Integration Time (sec): 8.500000E-1
Scans to average: 1
Electric dark correction enabled: true
Nonlinearity correction enabled: true
Boxcar width: 0
XAxis mode: Wavelengths
Stop averaging: false
Number of Pixels in Spectrum: 2068
>>>>>Begin Spectral Data<<<<<
649.693    838.02
649.795    -180.19
649.896    -91.96
649.997    -111.79
…
```

7.1.12   HDF5 Files containing FGI goniometer measurements

Standard or Format Owner	Finnish Geodetic Institute proprietary format

Devices	ASD in combination with the FIGIFIGO goniometer
Supported Formats	HDF5 files and XML files containing measurement data from FGI (Finish Geodetic Institute) goniometer measurements
	The newest data structure version (with a coupled xml-file, containing all the Metadata) is still experimental and is not yet not fully supported.
Comments	As there is more than one Spectrum per file, each Spectrum is saved separately. The name of each Spectrum is constructed from the Campaign name, the beam geometry (if HDRF or BRF), a data structure identifier and an auto numbered identifier (e.g. Snow7.HDRF.lib2.14).

7.1.13   UniSpec Single Channel

Standard or Format Owner	PP Systems
Devices	UniSpec SC
Supported Formats	UniSpec Single Beam text files
Comments	

7.1.14   UniSpec Double Channel SPU

Standard or Format Owner	PP Systems
Devices	UniSpec DC
Supported Formats	UniSpec Dual Beam text files
Comments	

7.1.15   SPECPR

Standard or Format Owner	U.S. Geological Survey
Devices	USGS PRISM software
Supported Formats	SPECPR
Comments	Search for more information about PRISM software and the SPECPR file format from the U.S. Geological web site.

7.1.16   Modtran Albedo File

Standard or Format Owner	Spectral Sciences Inc. and U.S. Air Force Research Laboratory
Devices	Modtran5 atmospheric radiative transfer model software
Supported Formats	Modtran Albedo files
Comments	More information can be found on the Modtran web site at http://www.Modtran5.com.

7.1.17   Excel files

Standard or Format Owner	Microsoft Excel Spreadsheet files
Devices	N/A
Supported Formats	.XLS files only - .CSV, .XLSX etc are not supported (.CSV files may be erroneously read as Ocean Optics SpectraSuite Data Files. See Section *7.1.10*.)
Comments	The first column of the Excel file must contain the Wavelength values in increasing order, with a heading in the first row. Each of the second and subsequent columns contains the data for a single Spectrum. The first row is the name of the Spectrum. Subsequent rows in the column contain the Spectrum values for the wavelengths specified in the first column. The Spectra's File name Metadata Attribute values are constructed from the Excel file name and the Spectrum name in the first row of the spreadsheet, separated with a "_" character. There can be no other data in the spreadsheet and the table of data must be rectangular with no gaps. Excel formatting is ignored. Only the first datasheet is read.

Example file

Figure 21: Top-left corner of example Spectrum spreadsheet

7.1.18   TXT Space Formatted Text Files

Note   TXT files are deprecated, except in the case where Reference Panel calibrations are loaded as Spectra. Please use the Excel file format instead.

Standard or Format Owner	N/A
Devices	IDL (Interactive Data Language) or ENVI text file output
Supported Formats	White space separated text files (as produced by IDL programs or ENVI when writing Spectral data to text files)
Comments	TXT Spectrum files can be created or viewed with a text editor.
	Each file can hold one or more Spectra.
	Values in each line are white space separated. Tabs are OK.
	Starting each line with whitespace is optional.
	The first line of the file is a heading line. The first value on this heading line must be "wvl". Its subsequent values are used as the File name Metadata Attribute values for the Spectra in SPECCHIO.
	Spectrum names cannot include spaces.
	All values on subsequent lines must be numeric. The first column is the wavelength in nanometres. Subsequent columns are the Spectrum values for each Spectrum at that wavelength.

Example

The following TXT Spectrum file example defines two Spectra named `mean_090499` and `mean_020599`. They each have observations at wavelengths from 350nm to 361nm.

```
    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
```

7.2   Supported Output Spectrum File Formats

Spectrum data can be written in two data formats.

- CSV (Comma Separated Values) for subsequent import into various 3rd party applications like spreadsheets or statistical packages
- ENVI Spectral Library (SLB)

8   Metadata

8.1   Research Groups and Accessing SPECCHIO Campaigns

When you upload data for a Campaign to SPECCHIO, all Users of your SPECCHIO database can access your Campaign. However, only you can modify or delete your Campaign unless you specifically allow others to have write access to it. This access is controlled by setting a Research Group of Users for each Campaign that you upload. Just as you can add other Users to the Campaign's Research Group, so you can remove them too.

The membership of each Research Group is stored as Metadata for the Campaign. Each Research Group applies only to one Campaign. (See *Section 6.9 Campaign-related Metadata* for more information about Metadata and *Section 7.5.2 Drag & Drop Options*

Drag & Drop is currently implemented for spatial metadata only. KML files containing points, polylines or polygons can be drag and dropped onto spatial fields to populate them.
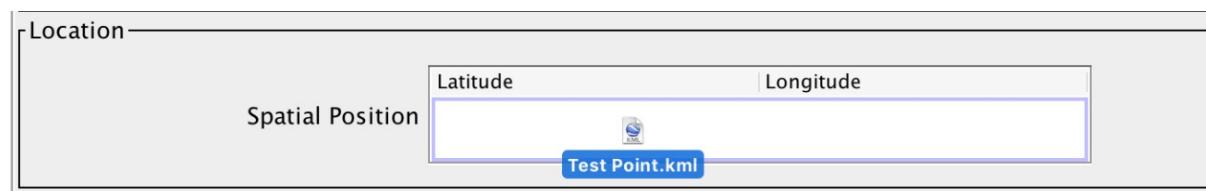
Figure 32: Dragging of a KML file onto a Spatial Position metadata field

Displaying and Editing Campaign Metadata for instructions to update it.)

When you add another SPECCHIO User to the Research Group for your Campaign, that User gets all the rights that you have for that Campaign. That is, they can modify the data, add to it or remove it. They can also change the membership of the Research Group.

It is not possible to remove yourself from the list of Users in the Research group.

8.2   Non-Redundant Storage

Many metaparameters constituting the spectral metadata are highly redundant, in particular as often measurements are being replicated for statistical reasons.

SPECCHIO supports non-redundant storage of metadata by creating links between spectra and values, allowing unique values to be stored only once for a group of spectra.

There are two storage methods within SPECCHIO:

Non-EAV Metadata	The following attributes are stored for all Spectra and are always displayed – Measurement unit, File format, Sensor, Instrument and Reference. If they are not relevant or no data is available, set them to *Nil*.
EAV Metadata	So that space is optimised, for all other Metadata Attributes

	SPECCHIO stores only those values which are set. They are stored in an Entity/Attribute/Value table, where one Metadata value is stored in each row of the table as an Attribute=Value pair (such as Ambient Temp=23.5). A cross-relation table between the Entity (i.e. the spectrum or the hierarchy (for details see 8.3)) and the Value stores a list of Spectra which are associated with this particular Attribute and Value. Details may be found in (Hueni et al., 2012).

8.3   Metadata Storage Levels

Starting with V3.3.0, SPECCHIO supports two different storage levels:

- Spectrum Level: metadata values are linked to individual spectra
- Hierarchy Level: metadata values are linked to hierarchies

Storage at hierarchy level results in a virtual inheritance of metaparamters set for a hierarchy to all spectra beneath this hierarchy. The significance of this can be appreciated by looking at an example. Consider a large campaign comprising 100'000 spectra. Some metadata, like and experimental design description, will apply to all spectra. If

8.4   Time Data

SPECCHIO expects acquisition times for Spectra acquisition to be in UTC (Coordinated Universal Time). For practical purposes UTC is considered equivalent to GMT. However, the term UTC is recommended for technical contexts (NOAA, 2003).

The above implies that all computers capturing data for use in SPECCHIO should have their time zone set to GMT and their system time adjusted to UTC. However, this is not usual, so the Spectrum acquisition date/time can be modified in the database if a time different from UTC was used. To deal with this general problem in a generic and traceable way, a metaparameter named Acquisition Time (UTC) has been added to enable the storage of both computer system time and UTC time for a spectrum.

Other times, such as Spectra upload times and calibration times, are usually stored in local time, that is, the time of the SPECCHIO server.

8.5   Data Links

For some calculations on Spectra, such as the conversion of a Radiance Spectrum to a Reflectance Factor Spectrum, SPECCHIO needs to know the related White Reference Spectrum for each Target Spectrum. Data links are used to define these relationships.

A Reference Data Link is a reference from a Target Spectrum to its related Reference Spectrum.

A Target Data Link is a reference from a Reference Spectrum to its related Target Spectrum or from a Target Spectrum to another Target Spectrum when an object was sampled with different instruments.

<u>Manufacturer</u>	A manufacturer of spectroradiometric instruments.
	The list of possible Manufacturers is a fixed table in SPECCHIO. Users cannot add to it, change it or even view it. If you require a new Manufacturer to be added, you must contact your System Administrator. The table as released with this version of SPECCHIO can be found in *Appendix B: Predefined Manufacturer Table* of this document.
	Each Manufacturer is assigned an integer Manufacturer ID.
<u>Sensor</u>	A description of a physical setup of a Sensor or a model of a spectroradiometric Instrument. A Sensor is usually identified by a Sensor type designator (also referred to as an "Instrument type" or "Instrument model") which is generally defined by the manufacturer.
	Each Sensor has a fixed number of bands, average wavelengths and FWHM (Full Width at Half Maximum) per channel, and a Sensor type number (usually a numeric code given by the manufacturer). Each Sensor Type is defined only once in the database. As released, SPECCHIO has a standard set of Sensors already defined in its database. The table as released with this version of SPECCHIO can be found in *Appendix C Predefined Sensor Table* of this document. However, new Sensors can be added to this list. Refer to *Section 9.4 Load sensor definition.*
	As of V3.1 of SPECCHIO, new sensors are automatically generated if no appropriate sensor is found during the loading of spectral input files.
	Each Sensor is assigned a unique integer Sensor ID by SPECCHIO.
<u>Instrument</u>	An instance of a certain Sensor Type. There can be several different Instruments that are all of one Sensor Type. Each Instrument has a defined owner. Each Instrument record in the Instrument Table refers to its related entry in the Sensor table so that its standard Sensor technical details can be accessed.
	As of V3.1 of SPECCHIO, new instruments are automatically added to the database when no matching instrument can be identified during data loading.
	Each Instrument is assigned a unique integer Instrument Number.
<u>Calibration</u>	Instruments optionally have a history of Calibrations. There are generally multiple Calibrations in that history, each Calibration being identified by either a date, and/or a Calibration Number which is a sequence number incremented each time the Instrument is sent for calibration. Calibration Numbers are unique for an Instrument. An Instrument Calibration defines an updated set of average wavelengths

	per band. When a Calibration is available, its information overrides the information in the Sensor record for the Instrument. As of V3.1 of SPECCHIO, new wavelength calibrations are automatically added to known instruments if differences in centre wavelengths are encountered during data loading.

A Provenance Data Link is a reference from a higher-level product to the spectral input data used in its production. Provenance Data Links are e.g. generated automatically when a spectral input contains target and reference radiances as well as derived reflectance factors, e.g. for SVC or Spectral Evolution instruments.

There are two types of calculation for which SPECCHIO uses Reference Spectra. The type is selected automatically based on Reference Spectrum's Metadata Attributes.
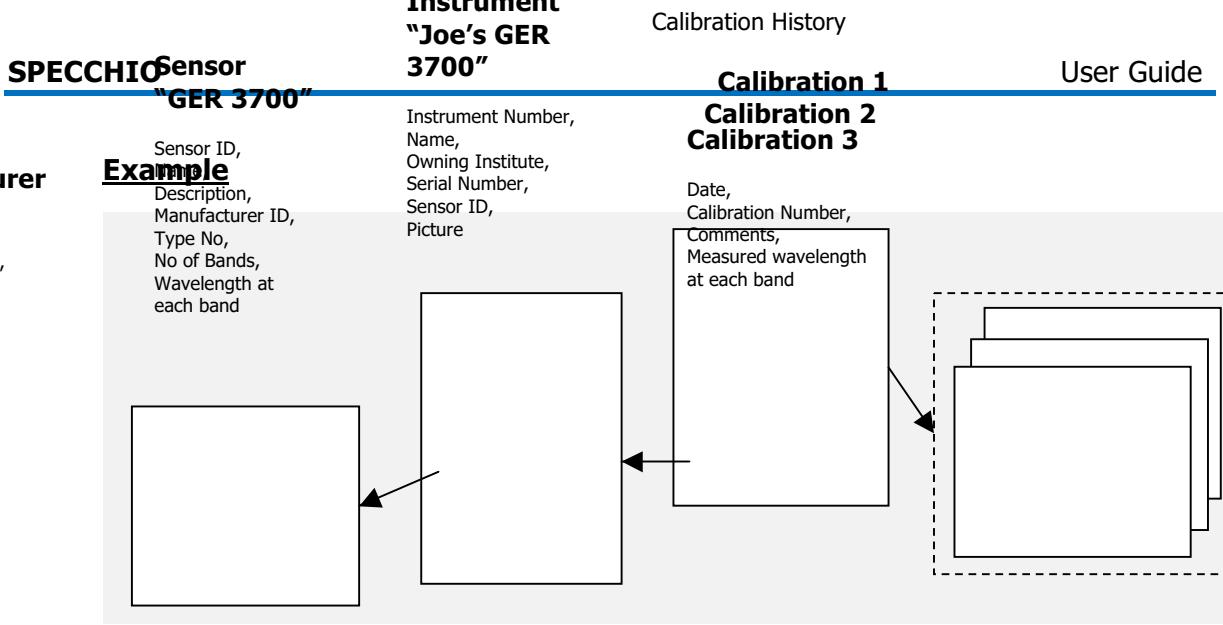
White Reference	The linked Spectrum is the Radiance Spectrum of a white Reference Panel, such as a Spectralon panel, in the same illumination conditions.
Cosine	The linked Spectrum is an Irradiance Spectrum, usually acquired with a cosine receptor.

In some cases data links are set up automatically during Campaign data loading. For example, GER signature files include the Spectra of both target and white reference.

Note	Data links do not make sense for Target Spectra with Measurement Units other than Radiance and for Reference Spectra other than Radiance or Irradiance. In other cases the results are undefined and they should not be set.
Note	The reflectance factor computation implemented in SPECCHIO is a simplified version, as each target spectrum needs to be linked to a reference spectrum. More scientific calculation can be achieved by using external code (e.g. Matlab or R).

8.6   Manufacturers, Sensors, Instruments and Calibrations

SPECCHIO defines Manufacturers, Sensors, Instruments and Calibrations, which each have their own table in the database.

**Instrument
"Joe's GER
3700"**

Calibration History

**Sensor
"GER 3700"**

Calibration 1
Calibration 2
Calibration 3

Instrument Number,
Name,
Owning Institute,
Serial Number,
Sensor ID,
Picture

**Manufacturer
"GER"**

Example

Sensor ID,
Description,
Manufacturer ID,
Type No,
No of Bands,
Wavelength at
each band

Date,
Calibration Number,
Comments,
Measured wavelength
at each band

Manufacturer ID,
Name,
URL,
Short Name

Figure 22: Relationship between an Instrument, its Calibrations, Sensor and Manufacturer

Consider the example above of Joe's GER 3700 Instrument. This Instrument is an instance of a GER 3700 Sensor. The Sensor defines the average wavelength per band. In turn, the Sensor has a reference to the Manufacturer record for that Sensor's Manufacturer.

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, the measured wavelengths override the Sensor specifications. For further information please refer to (Hueni & Kneubuehler, SPECCHIO: A System for Storing and Sharing Spectroradiometer Data, 2007).

8.7 Campaign-related Metadata

SPECCHIO allows Users to store Metadata about the Spectral data they have uploaded into SPECCHIO Campaigns. It is stored at two levels: Campaign-related Metadata and Spectrum-related Metadata.

The following Metadata Attributes can be set independently for each Campaign.

Campaign name	The name under which the Campaign is stored in the SPECCHIO database.
Description	A free format description of the Campaign.
Investigator	The person in charge of this Campaign (i.e. the User defining and loading the Campaign). This field is filled automatically and cannot be changed.
Path	The file system path pointing to the main folder from which this Campaign was uploaded.
	Multiple paths can be defined to support uploading of subsequent Spectral data from multiple computers. This is intended to assist when further data is uploaded for this Campaign.

Research Group Members	A list of Users of this SPECCHIO database who have permission to modify this Campaign. Each of these Users must be registered with a SPECCHIO User account.

8.8   Metadata Attributes

For more information on the Metadata parameters supported by SPECCHIO please refer to (Hüni and Kneubühler, 2007).

When Spectra are uploaded to a Campaign, the SPECCHIO upload process identifies Metadata found in the Spectrum files and copies it into SPECCHIO Spectrum Metadata fields for each Spectrum it uploads. Once uploaded, this Metadata can be viewed, edited, removed or added to.

Similar Metadata Attributes are grouped into named sections to facilitate management.

A few Metadata Attributes are permitted to take multiple values, such as Keywords or Processing Group Attributes. The SPECCHIO's Metadata Editor does not support addition of more than a single value, but does support viewing them. Multiple values for non-image Attributes can be added from Excel files. (See _Section 9.6)_

The Metadata Attribute tables below indicate those Attributes which are permitted to take multiple values. All others are limited to a single value.

Users cannot enter Metadata except into these already defined fields. If new Metadata Attributes are required, they can generally be defined easily. Contact your System Administrator with a detailed description of the Metadata field you need added and a specification for the data that it can contain.

Also see _Section 11.1 List available Metadata Elements_ for instructions for producing a machine readable list of Spectrum-related Metadata Attributes.

A number of the Metadata Attributes below take an element of a dropdown list for their value. The definition of these lists is either taken from user-managed SPECCHIO tables, such as Sensor or Instrument lists, or the definition is parameterised within the SPECCHIO database. Such parameterised lists can generally be changed. See your SPECCHIO system administrator if you require a change in any of these lists. The source of the dropdown list is explained for each relevant Metadata Attribute.

8.8.1   Associated Campaigns Group

Airborne Mission ID Multiple permitted	[Alpha string] Mission ID of an airborne mission that is associated with this spectrum

8.8.2   Campaign Details Group

Some formats for Spectrum files contain Campaign-related information, particularly HDF formatted files. When Spectrum files of these formats are loaded, the Campaign-related Metadata that they contain is loaded into these Attributes for each Spectrum. This allows you to review it and, if necessary, manually transfer it to the

Campaign-related Metadata fields described in *Section 6.9 Campaign-related Metadata.*

Note	The fields in this Group can store different values for each Spectrum in a Campaign. It is not recommended to enter Campaign Metadata into these Spectrum-related Metadata fields. Instead, use the Campaign Metadata fields described in *Section 6.9 Campaign-related Metadata.*

Agency Code	[Alpha string] Agency identifier of entity involved in the sample collection Copied from the Agency Code field if it is set in the related input Spectrum file when it is loaded.
Campaign Name	[Alpha string] Further specification of a particular Campaign. Mainly used where a SPECCHIO Campaign comprises several original sampling campaigns Copied from the Campaign Name field if it is set in the related Spectrum file (particularly HDF files) when it is loaded.
Project ID	[Alpha string] Any project identification applying to this Campaign Copied from the Project ID field if it is set in the related input Spectrum file when it is loaded.

8.8.3   Data Link Group

These Metadata Attributes relate to links between spectra, establishing relationships that help data processing, provenance and exploration.

Provenance Data Link Multiple permitted	[Integer] Points to a spectrum used in calculating the current spectrum
Reference Data Link Multiple permitted	[Integer] Points to a reference spectrum taken by the same instrument.
Target Data Link Multiple permitted	[Integer] Points to an other spectrum taken by a different instrument but of the same target or to a spectrum of the target if the referencing spectrum is a reference spectrum

8.8.4   Data Portal Group

These Metadata Attributes relate to the Publishing of the Spectrum on the Australian National Data Service (ANDS). See *Section 12 Publishing Data to ANDS* for more information about the use of the Attributes in this Group.

ANDS Collection Key Multiple permitted	[Alpha string] The ANDS Collection Keys under which this Spectrum has been Published. This Metadata Attribute is only available when accessing a SPECCHIO Server which is ANDS-enabled. This Attribute supports multiple values, with a new additional value written each time the Spectrum is part of a new Collection which is Published to ANDS. It is possible to edit this Metadata Attribute, but it is strongly recommended not to.
ANDS Collection Name Multiple permitted	[Alpha string] The names of the ANDS collections in which this Spectrum has been published. This Metadata Attribute is only available when accessing a SPECCHIO Server which is ANDS-enabled. This Attribute supports multiple values, with a new additional value written each time the Spectrum is part of a new Collection which is Published to ANDS.
ANDS Collection Description Multiple permitted	[Alpha string] The descriptions of the ANDS collections in which this Spectrum has been published. This Metadata Attribute is only available when accessing a SPECCHIO Server which is ANDS-enabled. This Attribute supports multiple values, with a new additional value written each time the Spectrum is part of a new Collection which is Published to ANDS.
Data Usage Policy	[Alpha string] String that defines the usage policy, for example "Please cite XXX et al" or "Inform the principal investigator" The value of this Attribute is copied to the Published Collection when this Spectrum is published to ANDS.
FOR Code Multiple permitted	[Dropdown List] SPECCHIO supports selection from a small relevant subset of the Field of Research codes defined by the Australian Bureau of Statistics (Australian Research Council, 2008). This Metadata Attribute is only available when accessing a SPECCHIO Server which is ANDS-enabled. The value of this Attribute is copied to the Published Collection when this Spectrum is published to ANDS.
Digital Object Identifier	[Alpha string] A digital object identifier (DOI). See http://www.doi.org/ for further information about DOIs. The value of this Attribute is copied to the Published Collection when this Spectrum is published to ANDS.

8.8.5 Environmental Conditions Group

These Metadata describe the environmental conditions at the time the Spectrum measurements were taken.

Air Pressure	[hPa] Ambient air pressure
Ambient Temperature	[Degrees Celsius] Ambient air temperature
Atmospheric Water Content	[Centimeter] Amount of water in the air column
Cloud Cover	[Percentage] Cloud cover as a percentage of the hemisphere
Relative Humidity	[Percentage] Relative air humidity
Sampling Environment	[Dropdown list] Describes where data were spectrally acquired, i.e. Field or laboratory
Weather Conditions	[Alpha string] Description of weather conditions
Wind Direction	[Degrees] Direction where wind is coming from Enter a bearing, that is, clockwise from North.
Wind Speed	[Metres/second] Speed of the wind

8.8.6   General Group

This Metadata Group collects together information about the Spectrum's file.

Acquisition Time	[Date/Time 24h] Time when Spectrum was measured.
Acquisition Time (UTC)	[Date/Time 24h] UTC time when Spectrum was measured. If the acquisition system's time was not set to UTC, then set the Acquisition Time (UTC) using the Compute UTC function described in section 11.1.1.
Acquisition Time Approximated	[Boolean] Check this box if the Acquisition time is not precisely known and has been approximated.
Acquisition Time (UTC) Approximated	[Boolean] Check this box if the computed time shift between the local Acquisition time and UTC is not precisely known and has been approximated.
Application Domain	Defines application domains, which are used to control the default metaparameter categories per application.
File Format	[Dropdown list] The format of the file from which this Spectrum was uploaded. This Attribute is always present and is generally set by SPECCHIO when the Spectrum is read. If no data is available, it should be set to Nil. Although this value can be changed, it is not advised. (All Spectra are stored internally in the database in SPECCHIO's internal Spectrum format.)

Raw Data Format	[Alpha string] Information on where data originated
File Name	[Alpha string] The name of the file from which this Spectrum was uploaded. In the case of input file formats which support multiple Spectra per file, such as XLS or TXT, the name of the Spectrum within the file is appended to this file name.
	Although this value can be changed, it is not advised. Changing it may result in duplicate Spectra when a subsequent Spectrum upload is performed for this Campaign.
File Version	[Alpha string] Version of the input file format
Loading Time	[Date/Time 24h] The system time when the Spectrum was loaded into database
	This value is automatically set to the SPECCHIO server's system time when the Spectrum is uploaded to SPECCHIO. Note that this may not be the same as the client's system time.
	The *Special functions/Correct local time to UTC* function does not operate on this time.
Measurement Unit	[Dropdown list] Describes the nature of the measurement - select from: *Reflectance*, *Radiance*, *Transmission*, *Absorbance*, *DNs*, *Irradiance*, *Mueller10*, *Mueller20* and *Wavelength*.
	This Attribute is mandatory and cannot be deleted.
	This Attribute is set automatically depending on the file format being read. However, for some formats it is not known and is therefore set to *Nil*. If it is not set, or is set incorrectly, plotting may not be correct.
Spectrum Number	[Integer] Some recording devices and file formats apply a number which is recorded in the Spectrum file. If a Spectrum is loaded from such a file format, the number will be placed into this Metadata field.
	If the file does not define a Spectrum Number, this Metadata Attribute remains unset. (Some file loaders may generate an artificial number. This behaviour is deprecated and should not be relied upon.)
	Note that this number is not the Spectrum ID and usually does not hold the same value as the Spectrum ID. The integer numbers which are displayed when Spectra are selected in the Query Builder or when a Spectrum is highlighted in the Hierarchy Viewer are Spectrum IDs.
	Spectrum Numbers can be changed in the Metadata Editor (but probably shouldn't be). Spectrum IDs cannot be changed.

8.8.7   Generic Target Properties Group

The Generic Target Properties Group holds data related to a Target or Sample.

In this context, a Sample is regarded as a sample taken from the Target and measured. Multiple Samples can be taken from any Target and measured

independently. They may have been taken from the Target in the field, or the Target may have been transported to a separate measuring facility and the Sample taken from the Target at that facility.

Typically, for each Campaign, there should be PDF uploaded to the Experimental Design Metadata item in the PDFs Metadata Group to explain the Target and Sample structure and the reasons for that structure.

Basic Target Type Multiple permitted	[Dropdown list] The basic target types are defined by the *Basic Target Type* taxonomy. These target definitions have been designed for small mapping units covering the typical pixel size of airborne imaging sensors, typically a few square metres. It is used generally where the CORINE system is not precise enough. This taxonomy is based on various land classification systems and has been refined within the APEX airborne imaging spectrometer spectral ground control work. Required additions to the taxonomy should be communicated to the SPECCHIO development team.
CORINE Land Cover	[Dropdown list] To define basic target types, either the taxonomy from the above list or from this dropdown list can be used as a reference.
Sample Collection Date	[Date/Time 24h] Time when the original sample was collected in the field. This will generally be a different from the time it was measured. The time zone is not specified. Note that the *Special functions/Correct local time to UTC* function does not operate on this time.
Sample Number	[Alpha string] Identification of the sample as collected This will not in general match the Spectrum Number or Spectrum ID. A Sample Number may be common to a variety of Spectra.
Site ID	[Alpha string] Identification of the site from which the sample was collected
Target Description	[Alpha string] Description of the Target
Target ID	[Alpha string] Identification of the Target that was collected
Target/Reference Designator	Defines if the measured object was a reference surface (e.g. white reference) or a target that is then compared to a reference
Tram Run	[alpha string] Refers to the number of a tram run within a sequence of runs

8.8.8   Geochemistry

Refer to section *13.1 List available Metadata Elements* to get an up-to-date list of this large collection of metaparameters.

8.8.9   Illumination Group

Polarization	[Alpha string] Description of illumination polarisation, typically "Horizontal" or "Vertical", but other comments may be used as well.
Polarization Direction	[Degrees] Polarisation direction, usually measured clockwise from vertical

8.8.10   Instrument Group

This Group of Attributes describes the specific **spectroradiometric** Instrument which was used to measure this Spectrum.

Instrument	[Dropdown list] The name of the **specific** Instrument used to take these measurements
	The drop down list is a list of Instruments which is created and maintained using the *Data maintenance/Instrument admin.* function.
	This Attribute is always present and cannot be deleted. It should be set if known. If no data is available, set it to *Nil*.
	This Attribute is generally set when Spectra are loaded, but should be checked to ensure that SPECCHIO determined it correctly.
Sensor	[Dropdown list] The name of the Sensor used in the specific Instrument used to take these measurements
	The dropdown list is a list of Sensors which is created and maintained using the *Data maintenance/Load sensor definition* function.
	If the Instrument Attribute above is set, this Sensor Attribute is ignored and the value stored in the Instrument record is used instead.
	This Attribute is always present and cannot be deleted. If not required, it can be set to *Nil*.
	This Attribute is generally set when Spectra are loaded, but should be checked to ensure that SPECCHIO has determined it correctly.
Calibration Number	[Integer] Calibration number of the most recent calibration for the Instrument at the time the measurements were taken
	Generally, the Acquisition Time is compared against the Calibration Time in the Instrument Calibration List to select the most appropriate calibration to use. This value is used if there is insufficient information available to use the dates.
	For some Spectrum file formats, this value is set automatically on Spectrum loading. Otherwise, it can be set manually.

Calibration (internal ID)	[Dropdown list] This ID refers to an internal instrument calibration (typically wavelength) of the instrument. It is set by SPECCHIO automatically and should not be changed manually.
Extended Instrument Name	[Alpha string] Instrument name This field can be used to further describe the Instrument used to capture this Spectrum, especially if the Instrument is not shown in the dropdown list of Instruments.
Instrument Serial Number	[Alpha string] Serial number of the Instrument As for Extended Instrument Name above, enter this value if the specific Instrument is not shown in the dropdown lists.

8.8.11   Instrument Settings Group

These attributes describe the settings of the Instrument at the time the Spectrum was acquired.

For some Instruments and file formats, the following Instrument settings are read from the Spectrum input file and set into the Spectrum Metadata. For others, these values must be recorded manually.

Automatic Dark Current Correction	[Alpha string] Indicates if Dark current has been compensated for by the Instrument If SPECCHIO loads this value from the input Spectrum file, it will set one of the values "ON" or "OFF".
Capturing Software Name	[Alpha string] Name of the Instrument operation software or data capture software
Capturing Software Version	[Alpha string] Version of the Instrument operation software or data capture software
Gain SWIR1	[Integer] ASD specific gain
Gain SWIR2	[Integer] ASD specific gain
Instrument Channel	[Alpha string] Channel designation for multi-channel instruments, e.g. irradiance and reflected radiance channels
Instrument Temperature	[Degrees Celsius] Internal temperature of the instrument
Integration Time	[ms] Integration time
Number of Internal Scans	[Integer] Number of Spectra recorded internally and averaged over by the Instrument
Offset SWIR1	[Integer] ASD specific offset
Offset SWIR2	[Integer] ASD specific offset

Time since last DC	[Integer] Seconds since last dark current measurement
	Not currently filled, even if it's in the input file.
UniSpec Spectral Resampling	[Alpha string] UniSpec specific setting; indicates if the resampling was ON or OFF
	If SPECCHIO loads this value from the input Spectrum file, it will set one of the values "ON" or "OFF".

8.8.12   Instrumentation Group

These attributes describe the Instrumentation used at the time the Spectrum was acquired.

For some file formats (particularly HDF files), the following Instrumentation settings are read from the Spectrum input file and set into the Spectrum Metadata. For other formats, it must be set manually.

Azimuth Sensor Type	[Alpha string] Sensor name used to measure the azimuth on a goniometric facility
Contact Probe	[Dropdown list] Contact probe instrumentation name, usually includes a light source and provides optical input to the spectrometer.
Goniometer	[Dropdown list] Goniometer name
Illumination Sources	[Dropdown list] Illumination source name, e.g. Sun or Hg lamp
Integrating Sphere	[Dropdown list] Integrating sphere name
Light Source Parameters	[Alpha string] Settings of artificial light source
Reference	[Dropdown list] Selected from the list of References defined in the SPECCHIO database.
	This Attribute is mandatory and cannot be deleted. If it is not relevant or no data is available, set it to _Nil_.
Reference Panel Levelled	[Boolean] Indicates if the reference panel was mounted on a stable support and carefully levelled
	- If the reference panel was not levelled, add this attribute without checking the box
	- If the reference panel was levelled, add this attribute and check the box
	The implications of not levelling the reference panel are described in (Hueni et al., 2017).

White Reference Panel Name	[Alpha string] Name of the white Reference Panel.
	Users do not have permission to add to SPECCHIO's Reference Panel table. When a Spectrum is being loaded and the Reference Panel it refers to is not in SPECCHIO's Reference Panel table, then the name of the Reference Panel will be written into this field. This provides the information needed for the user to resolve the Reference Panel link information after the Spectrum load is completed.

8.8.13   Keywords Group

Keywords can be used to search for particular Spectra in the SPECCHIO's Spectrum Query function.

Keyword Multiple permitted	[Alpha string] Freely chosen keyword that describes a Spectrum or a Spectral collection
	Take care with spelling and avoid leading or trailing spaces to avoid confusion when searching. Keyword searching is not case sensitive.

8.8.14   Location Group

This Group collects information about the capturing location. WGS84 (World Geodetic System of 1984) should be used as the reference Geoid for these measurements.

With Release 3.3.0.0, spatial geometries support based on the MySQL Spatial Extension was introduced, enabling spatial queries and new geometry types: point, polyline and polygon. Latitude and Longitude of the spatial position can be inserted for each measurement point. Depending on the selected Spatial Sampling Scheme (see section *8.8.22*), start and end point of e.g. a transect can be defined.

Altitude	[Metres] Altitude of spatial position
	This attribute can be generated by the function "Augment altitude" from the "Compute" menu, see section *9.6.2*. Mandatory attribute information is latitude and longitude.
Depth	[Metres] Distance from the Earth surface where sample was taken
Latitude (deprecated)	[Degrees] Latitude of spatial position
	Northern hemisphere coordinates are positive, southern hemisphere coordinates are negative. Coordinates are entered as floating point numbers for degrees and fractions of degrees.

Longitude *(deprecated)*	[Degrees] Longitude of spatial position
	Locations west of Greenwich are negative, east of Greenwich are positive. (That is, longitudes in Switzerland or Australia are positive.) Coordinates are entered as floating point numbers for degrees and fractions of degrees.
	If the longitude values are inserted as positive values instead of as negative values, the function "Switch longitude E-W" from the "Compute" menu can be used to convert all values of a selected node. This function can save considerable time if multiple coordinate values were inserted automatically from XLS (*see section 7.6* for this option).
	Note: older versions of SPECCHIO did not follow this common definition, but the used to define West of Greenwich as positive.
Position Approximated	[Boolean] Indicates if the spatial position was not properly recorded and had to be approximated by other means.
	This attribute is only to be used (with checking the box) if the spatial position (latitude, longitude) had to be approximated.
Location Name	[Alpha string] Usual name of the spatial position where the sampling took place
State	[Alpha string] Identifier of the State in which the observations were made.
	To avoid confusion in searching later, it is suggested to use the standard abbreviation for the state – for example, in Australia use NSW, Qld, Vic. Do not use periods, leading, embedded or trailing spaces in the field. Searching is not case sensitive.
Spatial Extent	Spatial extent of a spectrum in 2D space as a polygon defined by vertices given as latitude and longitude. Stored as spatial field using the MySQL Spatial Extension.
Spatial Position	Spatial location of a spectrum in 2D space as latitude and longitude. Stored as spatial field using the MySQL Spatial Extension.
Spatial Transect	Spatial extent of a spectrum in 2D space as a polyline defined by vertices given as latitude and longitude. Stored as spatial field using the MySQL Spatial Extension.
Waypoint ID	[Alpha string] Name or ID of a waypoint

8.8.15 Names Group

This Group collects the possible names for the species or objects in the Spectrum sample.

Common	[Alpha string] Common name given to target (applies particularly to plants)
ENVI	[Alpha string] Name extracted from ENVI header

Header	When ENVI Files are loaded (see *Section* 7.1.9 (ENVI Spectral Library Files), the content of the Spectrum Names tag is copied here if it is set in the input file.
Latin	[Alpha string] Latin (or scientific) name given to target

8.8.16   Optics Group

This Group permits describing specific optics which are attached to the recording Instrument.

FOV	[Integer degrees] Field of view of the Instrument used for the sampling. This may vary as a result of using a special foreoptic
Optics Name	[Alpha string] Designator given to the optics attached to the Instrument

8.8.17   PDFs Group

SPECCHIO supports uploading of up to two PDF files for each Spectrum. To optimise storage in the database, select all Spectra that a PDF file applies to and upload just once. Depending on your internet access speed, uploading large PDF files may be slow.

Experimental Design	[Attached PDF] Document describing the experimental design and the scientific reasons for doing so
Field Protocol	[Attached PDF] Copy of the field protocol filled in during data capture

8.8.18   Personnel Group

Investigator Multiple permitted	[Alpha string] Investigator's name
	It is not necessarily related to any SPECCHIO User's name and is not checked against the list of Users' names. Nor is this field checked against the Investigator field provided in the Campaign Metadata.
	This Metadata Attribute is supported to receive the Investigator name which is provided in some Spectrum file formats – for example, some HDF files.
	Users are generally encouraged to rely on the Campaign Metadata (either the Investigator, Research Group Members or Description fields) for this function.

8.8.19   Pictures Group

SPECCHIO supports uploading of up to four image types for each Spectrum. To optimise storage in the database, select all Spectra, ideally by selecting a storage hierarchy, to which an image applies to and upload it just once. Images are automatically rescaled to conserve storage space and improve data loading speeds. For such improved storage and performance, pictures are automatically resampled to

a size of 400 pixels (in width or height) while the aspect of width and height is retained.

| Warning | Do not use SPECCHIO as a photo repository; the automatic downscaling will degrade your photo resolution; it is only meant to document the spectral sampling conditions and target state. |

The supported uploadable image formats may vary between PC, Linux and Mac. JPEG is supported on all operating systems. GIF, PNG or TIFF may also be supported on some users' computers. When uploaded, all image formats are converted and stored as JPEG images. **These images can be viewed directly on the Metadata Editor screen.**

Sampling Environment Picture Multiple permitted	[Uploaded image file] Picture showing the general sampling environment in vicinity of the target
Sampling Setup Picture Multiple permitted	[Uploaded image file] Picture showing the positions of Sensor and illumination in relation to the target
Sky Picture Multiple permitted	[Uploaded image file] Picture of the sky, ideally taken hemispherically
Target Picture Multiple permitted	[Uploaded image file] Picture showing the target

8.8.20   Processing Group

These Attributes describe processing which has been performed on the Spectrum. These Attributes are added or set when that processing is done. This processing may be done by SPECCHIO, or it may be processing done by some other function connecting to the SPECCHIO database. This may be a Matlab program, a Java program, or a program written using any other tool or language.

While it is possible, generally these Attributes should not be edited manually.

Data Ingestion Notes Multiple permitted	[Alpha string] Notes produced by the data ingestion module during data loading into SPECCHIO Multiple Data Ingestion Notes may be added to each Spectrum.
DC Flag	[Integer] Designates this Spectrum as a dark current Spectrum The Metadata Attribute's value should be either 0 indicating False, or 1 indicating True. If the Metadata Attribute does not exist, this implies False.
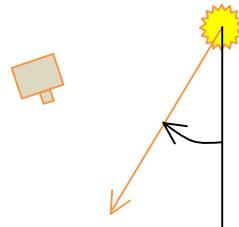
|	
Garbage Flag	[Integer] Designates this Spectrum is not intended for inclusion in the main experimental evaluation
	The Metadata Attribute's value should be either 0 indicating False, or 1 indicating True. If the Metadata Attribute does not exist, this implies False.
	If you create a node named "Garbage", all Spectra in the sub-tree below this node will have this flag set to 1 when they are loaded. The test for the node name is case sensitive.
	This flag can be set to exclude specific Spectra from processing. However, negative tests cannot be performed by the Query Builder, so this is intended for automated processing control. For manual management, Spectra which are not intended for processing should be placed in specific sub-folders.
	There are currently no SPECCHIO processes which test this flag. It is generally intended for use by non-SPECCHIO processes, such as processes written using Matlab.
Processing Algorithm Multiple permitted	[Alpha string] Description of processing algorithm applied to Spectrum
	Multiple Processing Algorithm fields may be added to each Spectrum.
	Each process which modifies a Spectrum should set an informative message into a new Metadata Attribute of this type for each Spectrum it modifies.
Processing Algorithm Note	[Alpha string] Processing notes are produced by the algorithm
Processing Level	[Floating point] Numeric designator of a specific processing level.
	This Metadata Attribute is provided to permit non-SPECCHIO programmatic processes to keep track of the level or amount of processing which they have performed on the related Spectrum.
	Generally, the levels are defined as:
	0.0 DN: Digital numbers 1.0 Radiance Spectra, as provided by the instrument 1.x Radiance Spectra, corrected 2.0 Reflectance Spectra, as provided by the instrument 2.x Reflectance Spectra, corrected
Processing Module Multiple permitted	[Alpha string] Name of processing module applied to Spectrum
	Multiple Processing Module Attribute values may be added to each Spectrum.
	This Metadata Attribute is provided to permit non-SPECCHIO programmatic processes to keep track of the level or amount of processing which they have performed on the related Spectrum.

| Source File

Multiple permitted | [Alpha string] Name of file that provided the original data

This applies if data is processed outside of SPECCHIO.

This Metadata Attribute is provided to permit non-SPECCHIO programmatic processes to keep track of the level or amount of processing which they have performed on the related Spectrum.

SPECCHIO does not use this value. |
| --- | --- |
| Solar Angle Computation | Notes produced by the SPECCHIO solar angle computation routine. |
| Time Shift

Multiple permitted | [Alpha string] This records the time shift processing that was applied to the Spectrum using the Special functions/Correct local time to UTC operation. See section 11.1.1 for more information on changing the times.

The Time Shift field will be overwritten if the Time Shift function is applied multiple times. |
| UTC Time Computation | [Alpha string] Note is produced by the SPECCHIO UTC computation routine |

8.8.21   Sampling
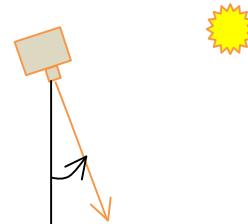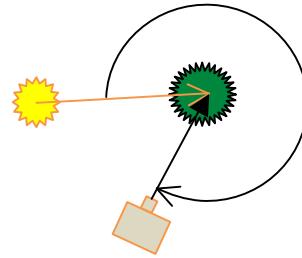
Numbers in this Group can all be entered as floating point numbers.

| Beam Geometry | [Dropdown list] SPECCHIO supports the nine fundamental beam geometry types describing the incoming and reflected beams.

For further information about the beam geometry types, please refer to (Schaepman-Strub et al., 2006, Schaepman-Strub et al., 2009) and Figure 23. |
| --- | --- |
| Illumination Azimuth | [Degrees] Absolute illumination source azimuth angle measured clockwise from geographic North.

This attribute is generated by the special function "Sun Angle Calculation", based on location attributes (longitude, latitude, altitude) and UTC acquisition time. |
| Illumination Distance | [Metres] Distance between the illumination source and target (for artificial illumination) |
| Illumination Zenith | [Degrees] Illumination source zenith angle measured from nadir.

This angle will always be between 0 and 90 degrees. If the Illumination is directly over the target, the value will be zero. |

θ   θ

	This attribute is generated by the special function "Sun Angle Calculation", based on location attributes (longitude, latitude, altitude) and UTC acquisition time.
Measurement Support Area	[Square metres] Area of the measurement support, i.e. the areas of the projected field of view.
	This attribute is generated by the function "Compute measurement support" from the "Compute" menu, see *section 9.6.1*.
Measurement Support Radius	[Metres] Radius of the measurement support, i.e. the radius of the projected field of view.
	This attribute is generated by the function "Compute measurement support" from the "Compute" menu.
Measurement Support Major Axis	[Metres] Major axis of the measurement support, i.e. the major axis of the elliptical projected field of view.
	This attribute is generated by the function "Compute measurement support" from the "Compute" menu.
Measurement Support Minor Axis	[Metres] Minor axis of the measurement support, i.e. the minor axis of the elliptical projected field of view.
	This attribute is generated by the function "Compute measurement support" from the "Compute" menu.
Sensor Azimuth	[Degrees] Sensor azimuth angle relative to the illumination angle The angle is measured clockwise from the Illumination Azimuth. A negative angle implies an anti-clockwise measurement direction. In this example, the Sensor Azimuth is approximately 300°.
Sensor Distance	[Metres] Distance of Sensor from the target
Sensor Zenith	[Degrees] Sensor zenith angle measured from nadir This angle will always be between 0 and 90 degrees. If the Sensor is directly over the target, the value will be zero.

Incoming/Reflected	Directional	Conical	Hemispherical
Directional	Bidirectional CASE 1	Directional–conical CASE 2	Directional–hemispherical CASE 3
Conical	Conical–directional CASE 4	Biconical CASE 5	Conical–hemispherical CASE 6
Hemispherical	Hemispherical–directional CASE 7	Hemispherical–conical CASE 8	Bihemispherical CASE 9
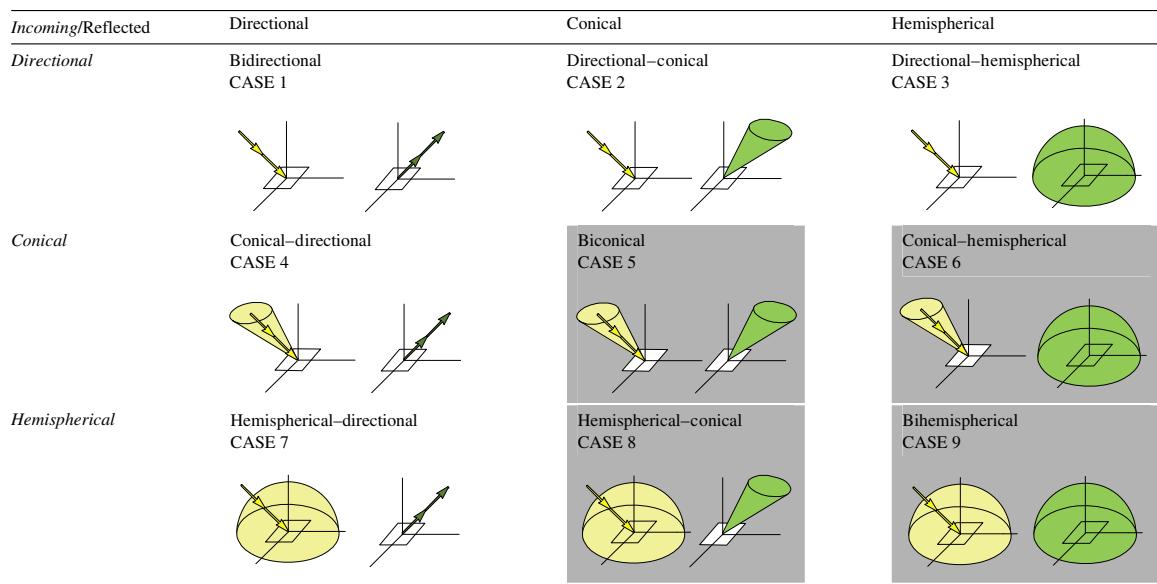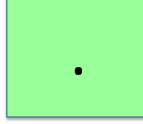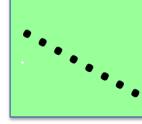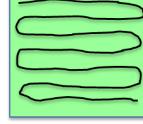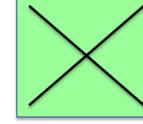
Figure 23: The nine beam geometry cases

8.8.22   Sampling Design Group

Spatial Sampling Scheme	[Dropdown list] SPECCHIO supports these Spatial Sampling Schemes: - Cross - Square - Transect - Sweep Square Transect Sweep Cross Random
Vegetation Sampling Scale	[Dropdown list] SPECCHIO supports these Sampling Scales: Leaf: Measurements at single leaf scale Plant: Measurements at single plant scale Stand: Measurements at stand scale, i.e. encompassing several plants

8.8.23   Scientific References Group

Citation Multiple permitted	[Alpha string] Publication to be cited when using these Spectral data
Publication	[Alpha string] Publication relevant to these Spectral data

Multiple permitted	

8.8.24   Soil Parameters Group

The Attributes in this Group have been provided to allow specification of the soil type according to the Australian Soil Classification.

The table below shows the list of Metadata Attributes provided by SPECCHIO and the type of data they hold. Please refer to the documents defining that classification system to see a detailed explanation of the meaning of each item.

At the time of writing this document, an explanation of this classification system can be found at (CSIRO, 2011).

Australian Soil Classification parameters	_ASC Order_	[Alpha string]
	ASC Sub-Order	[Alpha string]
	Sampling Lower Depth	[Metres]
	Sampling Upper Depth	[Metres]
	Horizon Desig. Master	[Alpha string]
	Horizon Desig. Sub. Division	[Alpha string]
	Horizon Name	[Alpha string]
	Horizon Number	[Integer]
Measurements	Each of the following measurements has two Metadata Attributes – the measurement itself and a description field which holds an alpha string describing the method used to determine that measurement. The table below lists the expected measurement unit, and gives a brief explanation where the name is not self-explanatory.	
	Air Dry Water Content	[g/g] Water content of air dried soil
	Available P	[%] Available phosphorus
	Bulk Density	[g/cm²]
	Carbon	[%]
	CEC	[cmol/Kg]
	Clay	[%]
	Coarse Sand	[%]
	Electrical Conductivity	[Deci-Siemens/Metre]
	Exchangeable Acidity	[cmol/Kg]

	Exchangeable Ca	[cmol/Kg]
	Exchangeable K	[cmol/Kg]
	Exchangeable Mg	[cmol/Kg]
	Exchangeable Na	[cmol/Kg]
	Extractable Fe	[mg/Kg]
	Fine Sand	[%]
	Geothite	[%]
	Gibsite	[%]
	Hematite	[%]
	Illite	[%]
	Kaolinite	[%]
	Montmorillonite	[%]
	pH CaCl2	[pH]
	pH Water	[pH]
	Silt	[%]
	Smectite	[%]
	Total K	[%]
	Total N	[%]
	Total P	[%]
	_Water Content 0_1 Bar_	[m^3 / m^3]
	Water Holding Capacity 15 Bar	[%]

8.8.25   Vegetation Biophysical Variables

% Crown Cover	[Percentage] Tree Crown Cover Percentage
Antheraxanthin	[ugrams/cm2] Carotenoid and xanthophyll pigment
Approx. Crown Diameter	[Metres] Estimated tree crown diameter
B-Carotene	[ugrams/cm2] Carotenoid pigment
Chlorophyll Content	[ugrams/ cm²] Chlorophyll content of the collected vegetation sample

Crown Relative Position	[Dropdown list] FPMRIS (DELWP) SOP 13 Measuring a Large Tree Plot
DBH	[Metres] Diameter at breast height
Dry Weight	[Grams] Dry weight of the collected vegetation sample
EPS	Epoxidation state of xanthophyll cycle pigments: (V+0.5*A)/(V+A+Z)
Height	[Metres] Height of vegetation
Leaf Area	[cm²] Leaf area of the sampled vegetation
Lutein	[ugrams/cm2] Carotenoid and xanthophyll pigment
Neoxanthin	[ugrams/cm2] Carotenoid and xanthophyll pigment
Specific Leaf Area	[cm²/gram] Calculated by: LeafArea[cm2]/DryMass[g]
Violaxanthin	[ugrams/cm2] Carotenoid and xanthophyll pigment
Water Content	[Grams/ cm²] Water content of the collected vegetation sample
Wet Weight	[Grams] Wet weight of the collected vegetation sample
Zeaxanthin	[ugrams/cm2] Carotenoid and xanthophyll pigment

9   Data Input

This section describes the functionalities of SPECCHIO's Main Menu *Data Input*. You will find information on how to load and edit data:

Data Input
- Create new campaign
- Load campaign data
- Edit metadata
- Get metadata from XLS
- Import campaign from XML

Create Campaign

↓

Load Spectral Campaign Data

↓

Load and Edit Metadata

↓

Use Functions to add Metadata
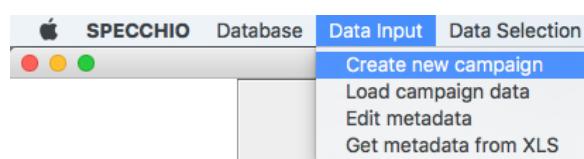
9.1   Overview of SPECCHIO Data Loading

The process of loading data into SPECCHIO involves a number of steps. Depending on your acquisition device, some of these steps may not be needed because the information is recorded by your device and uploaded with the Spectral data.

Create a Campaign	This establishes a name for your Campaign and sets up structures in the SPECCHIO database to receive the Campaign Spectra and other information. See Section 7.2 Creating a new Campaign.
Load Campaign Data	This examines the format of the Spectral data on your hard disk, parses its content from your hard disk and inserts into the SPECCHIO database. See Section 7.3 Loading Campaign Spectral Data.
Calculate Acquisition Times (UTC)	SPECCHIO expects Acquisition Times to be UTC, but many devices record a local time. SPECCHIO provides a function to calculate UTC based on local times. See Section 11.1.1 (Compute UTC).
Add Target-Reference Links	For acquisition devices which do not put this information into the Spectral files, you will need to enter this information manually. See section 10.1 and 10.2.
Complete Metadata upload	The Spectral Metadata that was not included in the Spectral files must be uploaded, either from an Excel file or manually entered using SPECCHIO's Metadata Editor. Refer to sections 9.5.4 (inserting metadata manually) and 9.7 (uploading from Excel files).
Calculate additional Metadata	Some Metadata values can be computed using functions of the Metadata Editor and SPECCHIO special functions. Refer to sections 9.6 and 11.1 respectively for further information on data requirements of these options.

After these steps, your Campaign's Spectral data is complete and ready for use, exporting or publishing to ANDS.

9.2   Creating a new Campaign

- From the Main menu, select *Data Input* - *Create new campaign*. This brings up the new Campaign dialog:
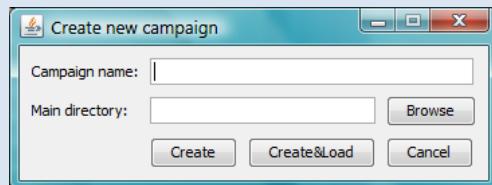
Figure 24: New Campaign dialog

- Enter the name you have selected for this Campaign. The maximum length is 45 characters.

- To set the *Main directory* field, click **Browse** to display a folder tree.

The *Main directory* path is a file system pathname pointing to the folder that contains all hierarchies and Spectra for this Campaign. When you load Spectral data, it will be loaded from this folder. Navigate to the required path on your hard disk.
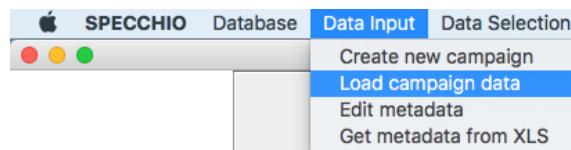
- Click **Create** to create the new empty Campaign in the database.

- A message box will appear once the Campaign has been successfully created. Click **OK** to close it.

- Click **Cancel** to close the Campaign creation dialog.

Note	It is not advisable to have two Campaigns with the same name. There is no check for the existence of a Campaign of the same name, so please check the names of the existing Campaigns before you create your own in order to avoid multiple Campaigns with identical or confusing names.

The Campaign is now ready to receive uploads of Spectral data.

It is also possible to use the **Create and Load** button to combine the operations of creating the Campaign and uploading the data. Read the next section before using this combined operation.

9.3   Loading Campaign Spectral Data

All Spectral data in the sub-folder tree at the disk location you specify will be loaded from your computer to the database as a single operation.

On your local disk drive, prepare a sub-folder structure which reflects the hierarchy you require for your data in SPECCHIO and put your Spectrum data files into this structure. See *Section 6.1 Campaign Hierarchy Structure* for more information on designing this structure.

The entire sub-folder tree must contain only Spectrum files, and each sub-folder within the tree must contain only files of one Spectrum file format.

When you start the Spectrum load process, SPECCHIO will process all sub-folders and files within this sub-folder tree and create a matching structure for your

Campaign in the database. For each sub-folder, it will use the various Spectrum File loaders listed in *Section 6.7 Supported Input Spectrum File Formats* until one reports that it can read a file in the sub-folder. It then processes all files in that sub-folder using that file loader. If any file cannot be read, it will report an error giving the name of the file that failed. Correct the offending file (either by removing it if it is not a Spectrum file, sorting it into a sub-folder with similarly formatted files, or finding an uncorrupted version of the file). Then restart the upload process. Those Spectra which have already been successfully uploaded will not be processed a second time.

To upload Campaign Spectral data:

- From the Main menu, select *Data Input - Load campaign data* to display the following dialog:
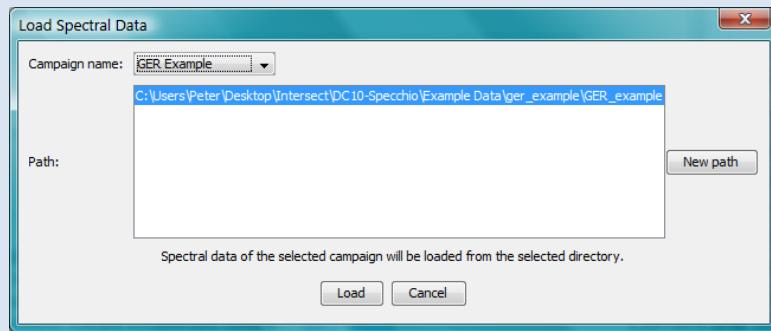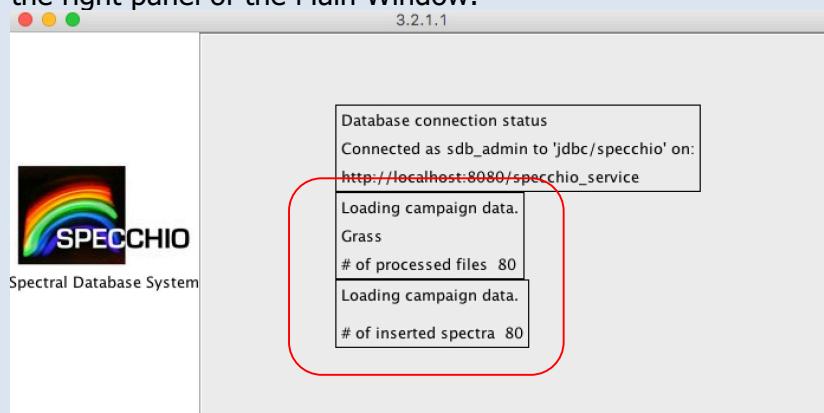
Figure 25: Load Spectral Data dialog

- From the list of *Campaign names* in the dropdown box, select the name of the Campaign into which you want to load data.

- Highlight the *Path* name which contains the Campaign data sub-folder tree on your computer. If the path name is not in the list, click **New Path**, navigate to the path on your computer and select it. It will now be highlighted.

- Click **Load**. The dialog box closes and the loading progress is shown in the right panel of the Main Window:

- A message box will appear once all data has been loaded to the system. Do not perform other operations on this Campaign until the load has completed.

- Click **OK** to clear the message box.

Note	After uploading your Spectral data to SPECCHIO, do not change the sub-folder structure on the hard disk that you set up and used. You will need this again if you wish to upload further Spectral data to this Campaign in the future.

9.3.1   Instrument and Sensor selection

SPECCHIO searches the existing Sensor and Instrument definitions in the database to find a match for the Spectrum data loaded. It sets the Instrument and Sensor Metadata Attributes for the Spectrum to the one it chooses.

If SPECCHIO does not find a match in its Instrument and Sensor tables, it will create an Instrument record and set the Spectrum's Instrument Metadata Attribute to refer to it. The Sensor Metadata Attribute will be filled with automatically generated sensor information if no matching sensor is found.

Note	After uploading Spectra, always use the Metadata Editor to check the settings of the Instrument and Sensor Type which SPECCHIO has tried to determine from the input Spectra characteristics. If they are not set or not correct, use the Metadata Editor to correct them.

See *Section 9.5.1 Metadata* for more information on the Metadata Editor.

9.3.2   Reference Panel selection

SPECCHIO searches its Reference Panel table and attempts to find a match for any Reference Panel specified in the input Spectrum.

If SPECCHIO does not find a match for the Reference Panel in its tables, it will set the Reference Panel Metadata Attribute value to *Nil*, and attempt to store the Reference Panel name in the *White Reference Panel Name* Metadata Attribute.

Note	After uploading Spectra, use the Metadata Editor to check the setting of the Reference Panel which SPECCHIO has tried to determine from the input Spectra. If it is not set or not correct, use the Metadata Editor to correct it.

See *9.5.1 Metadata* for more information on the Metadata Editor.

9.3.3   Handling Spectrum upload errors

Warning	If the message box advising successful completion does not appear, the upload did not complete normally. Check the count of uploaded Spectra to determine how much was completed. See below for information on recovering from upload errors.

If a folder contains unknown file types, mixed file types or files with invalid data, the loading process will try and skip these files. In the case of errors within files of known file format, a dialog box will generally appear, indicating the offending file and the cause of the problem.

You should check the cause of the problem, rectify it and attempt the upload again. Spectra which successfully uploaded the first time will not be uploaded again.

9.4   Loading Additional Spectral Data

If further Spectral data becomes available for your Campaign, it is possible to conveniently add it to your existing SPECCHIO Campaign.

There are a number of different scenarios which may apply.

9.4.1   Uploading Additional Spectral Data from the Same Computer

In this case, add the new Spectral data to the existing sub-folder structure on your computer's disk from which you uploaded the original Spectral data.

- Do not add any files other than Spectral data and ensure that all files within each sub-folder have the same file format.

- Do not change the file names of any of the original files.

- Do not change or rename the sub-folders, but you may add new sub-folders.

To upload the new Spectral data, follow the process described in *Section 7.39.3 Loading Campaign Spectral Data* Only the new data will be loaded.

Note	Additional Spectra can be added to XLS files and will be added when re-invoking the loading process.

After uploading new data you may need to set the Metadata for the new data. Depending on your Campaign Hierarchy design, the new data may be interspersed with your existing data. Take care not to delete or corrupt the Metadata on your existing data by ensuring that you select only your new Spectra when you update the Metadata.

Note	Existing metadata stored at hierarchy level is automatically inherited by spectra added beneath these hierarchies.

Warning	This particularly applies to UTC time changes, where applying the same time change a second time will add or subtract the time difference again, yielding an incorrect result.

9.4.2   Uploading Additional Spectral Data from a Second Computer

SPECCHIO permits multiple Paths to be stored against each Campaign. This permits the same data to be managed and augmented from multiple computers.

To upload from a second computer:

- On the second computer, make an exact copy of the entire Campaign folder tree as it was uploaded from the first computer. It does not have to be in the same location as it was on the first computer, but the sub-folder structure, sub-folder names and file names must be identical.

- Add the new hierarchy sub-folders and files into the existing sub-folder structure.

- From the Main menu, select *Data Input - Load campaign data*.

- From the *Campaign name* dropdown list, select the name of the Campaign you are uploading to. The list of paths in the *Path* box will change to be those defined for the selected Campaign.
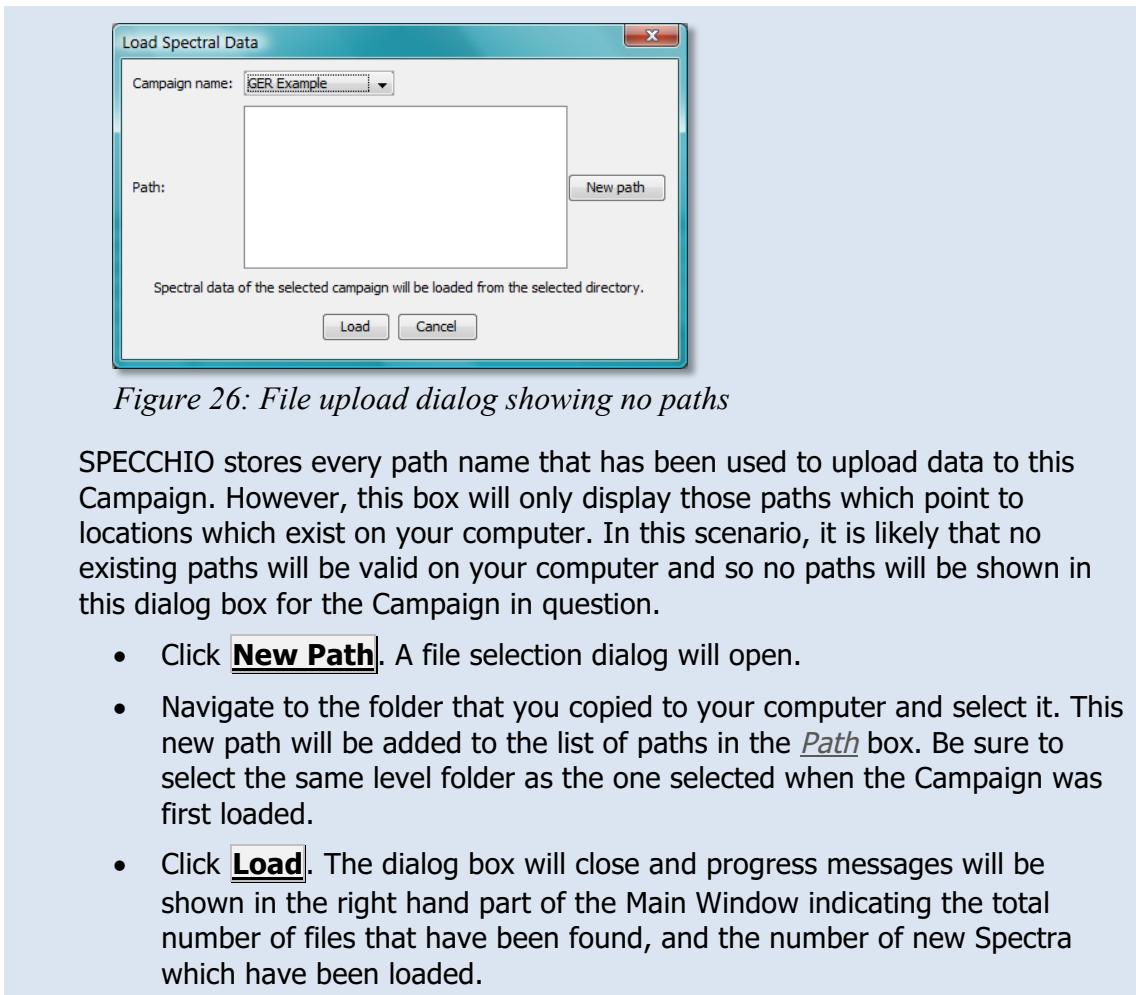
Figure 26: File upload dialog showing no paths

SPECCHIO stores every path name that has been used to upload data to this Campaign. However, this box will only display those paths which point to locations which exist on your computer. In this scenario, it is likely that no existing paths will be valid on your computer and so no paths will be shown in this dialog box for the Campaign in question.

- Click **New Path**. A file selection dialog will open.

- Navigate to the folder that you copied to your computer and select it. This new path will be added to the list of paths in the *Path* box. Be sure to select the same level folder as the one selected when the Campaign was first loaded.

- Click **Load**. The dialog box will close and progress messages will be shown in the right hand part of the Main Window indicating the total number of files that have been found, and the number of new Spectra which have been loaded.

Warning	If you select the folder above or below the one selected when the Campaign was first loaded, it will not be recognised as the same folder and will cause all of the existing data to be duplicated in your SPECCHIO Campaign.

9.4.3   Uploading Additional Spectral Data in a New Data Hierarchy

There are often cases when a new set of Spectra is required to be uploaded, and this new set does not relate to the existing Spectra in the Campaign. In this case, a new folder structure can be created at the top level of the Campaign.
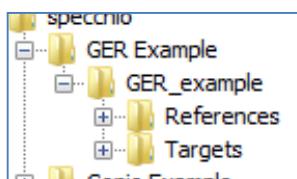

Figure 27: Data Hierarchy of GER example after initial load

In the above example, there is one sub-folder in the GER Example. If the user has performed a second largely independent part of the experiment, its results may be loaded as a new top level folder in the Campaign.
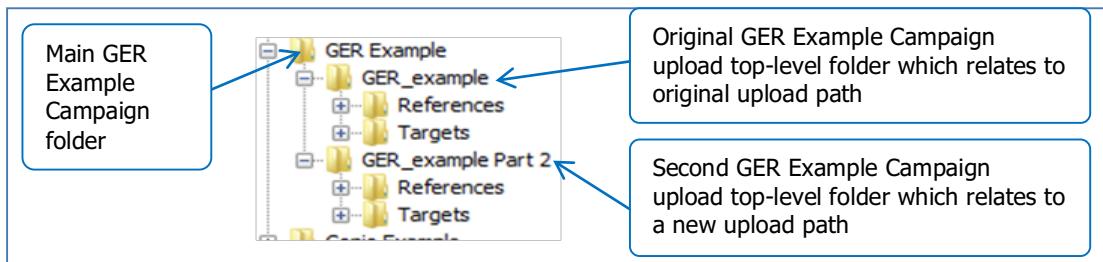
Figure 28: Data Hierarchy of GER example after loading second part

To upload a new data hierarchy to an existing Campaign:

- Prepare the second upload folder tree of Spectra on your computer and ensure it has a different name from the first one. It does not need to be in the same folder as the first one, owned by the same user as the first one, or even on the same computer as the first one.

- From the Main menu, select *Data Input* - *Load campaign data*.

- From the *Campaign name* dropdown list, select the name of the Campaign you are uploading to. The list of paths in the *Path* box will change to be those defined for the selected Campaign.
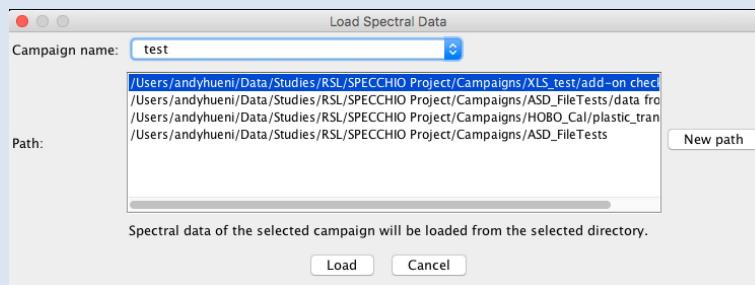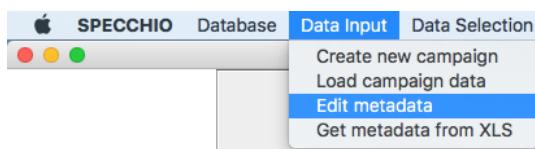
Figure 29: File upload dialog showing multiple paths

SPECCHIO stores every path name that has been used to upload data to this Campaign. However, in this box it will only display those paths which point to locations which exist on your computer. If the original data upload was done from this computer, it is likely that the original data upload path will be shown.

- Click **New Path**. A file selection dialog will open.

- Navigate to the folder that you created with the second data hierarchy and select it. This new path will be added to the list of paths in the *Path* box. Be sure to select the correct folder level.

- Click **Load**. The dialog box will close and progress messages will be shown in the right hand part of the Main Window indicating the total number of files that have been found, and the number of new Spectra which have been loaded.

9.5   Edit Metadata

9.5.1   Metadata Editor window

The SPECCHIO Metadata Editor allows you to enter and modify both Campaign and Spectrum Metadata. Refer to *Section 6.9 Campaign-related Metadata* and *Section 8.8 Metadata* for detailed information about Metadata stored by SPECCHIO.

To open the Metadata Editor select *Data Input* and *Edit metadata* from SPECCHIO's Main Menu. The following Metadata Editor window is displayed.
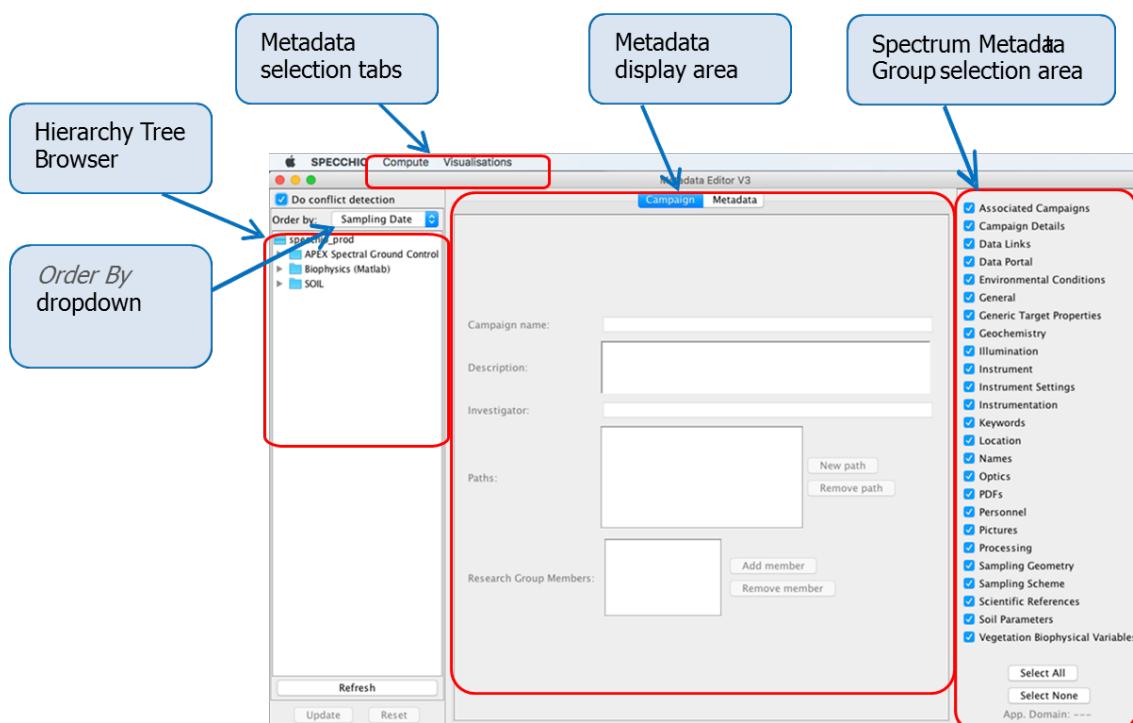
Figure 30: Metadata editor dialog

Hierarchy Tree Browser	Shows the Campaigns present in the database and allows selecting of Campaigns, sub-trees and Spectra.
Metadata selection tabs	Select either Campaign, to display and edit Campaign-related Metadata, or Metadata to display and edit Spectrum-related Metadata.
Metadata display area	This will show the Metadata selected by the Metadata selection tab.
Spectrum Metadata Group selection area	Click on these checkboxes to display or suppress the various Groups of Spectrum Metadata. Select All displays them all, and Select None hides them all.

9.5.1.1   Display options
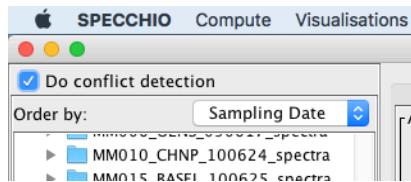
Figure 31: Display options in the Campaign navigation window of the Metadata editor

Metadata is most easily displayed using SPECCHIO's Metadata editor.

Order By dropdown	Select the sort order to use for Spectra in the Campaign navigation tree display. The sorting order of single spectra within a target folder can be defined here, however, the order of subfolders within a campaign as well as the order of the inserted campaign remains alphabetically ascending per default.
Do conflict detection	Switch off this option to speed up data selection. However, it is important to have this option switched on when verifying metadata values for several files. If a metadata value is the same for all selected spectra, this value will be shown. Otherwise, either the information "-- multiple values -- " or, in case of numeric data, the relevant value range is shown.

Uploaded documents such as target pictures and PDF's can be opened in an external viewer or copied to the clipboard.

9.5.1.2   Update options

| **Refresh** button	Click this button to update the Hierarchy Tree Browser after making changes which affect it.
Update button	Click this button to write all changed Metadata back into the database. This button is highlighted in red when changes are pending.
Reset button	Click this button to ignore all changes made since the last time the Update button was clicked and redisplay the Metadata panel from the database.

In this editor, whenever changes are made to any Metadata entries, they are saved in an action list. They are not written immediately to the database. When the **Update** button is clicked, the action list is processed and the database is updated. When the **Reset** button is clicked, the action list is discarded without being processed and the content of the Metadata display area is redisplayed from the database.

Warning	Click on **Update** after every change to a Metadata item. If you make multiple changes before clicking **Update**, these changes are written to the database, but not necessarily in the order in which you made them. This can yield unexpected results, as the last change you made may not be the last one to be written.

Metadata entry fields are of various types, including integer, floating point, alpha string, date/times or special lists. Generally, the editor restricts you to entering

values which are consistent with the data type. However, the editor does not perform validation checks on entered data. For example, while you must enter a valid number for the Relative Humidity, the editor will not reject negative values or values greater than 100.

Warning	Take care to enter numbers which are within the valid range for the Metadata Attribute you are entering. The editor will permit you to store values which are outside the valid range, which can be misleading or lead to unpredictable results later.

9.5.2   Drag & Drop Options

Drag & Drop is currently implemented for spatial metadata only. KML files containing points, polylines or polygons can be drag and dropped onto spatial fields to populate them.
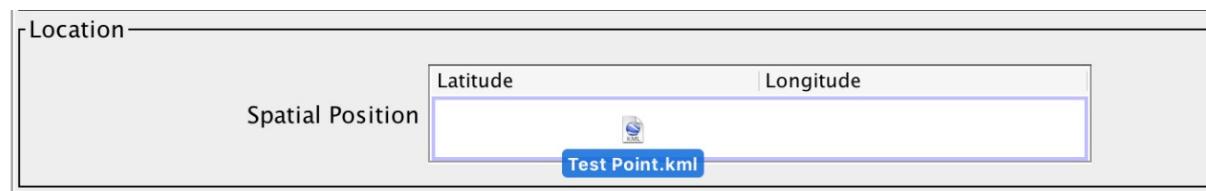
Figure 32: Dragging of a KML file onto a Spatial Position metadata field

9.5.3   Displaying and Editing Campaign Metadata

See *Section 6.9 Campaign-related Metadata* for detailed information about individual Campaign Metadata fields, their meanings and operation.

To edit a Campaign's Campaign-related Metadata:

- Click on the *Campaign* tab to highlight it and display Campaign-related Metadata.

- In the Campaign Tree Navigator, click on the Campaign for which you wish to edit the Metadata, or click on anything in that Campaign's sub-tree. The Metadata for that Campaign will be read from the database and displayed in the Metadata display area.

- Modify the Metadata Attribute values as you require.

- Click **Update** to cause these changes to be written to the database.

You can now click on another Campaign name and repeat this procedure.

Clicking on Metadata Group names in the Spectrum Metadata selection area does not affect the Campaign editing tab.

If you change the *Campaign Name* Attribute, click on the **Refresh** button to cause that change to be shown in the Campaign Tree Navigator.

9.5.4   Displaying and Editing Spectrum Metadata

See *Section 8.8 Metadata* for detailed information about individual Campaign Metadata fields, the way they are organised into Metadata groups, their meanings and operation.

In order to understand the operation of this Editor, it is helpful to understand how Spectrum Metadata are stored by SPECCHIO. Please refer to section 8.2 and 8.3.

Note	SPECCHIO allows changing of most Metadata fields, but for some Metadata Attributes it does not make sense. It could often be confusing and should not be done, except in unusual circumstances. For example, changing the *File Name* or *File Format* for a Spectrum does not make sense and may cause unexpected results in subsequent Spectrum upload operations. Changing the *Spectrum Number* is also rarely meaningful and could often be confusing. Changing the automatically set *Acquisition Time* and *Loading Time* values will generally be confusing. There are other cases too.

9.5.4.1   *Displaying a Single Spectrum's Metadata*

Displaying Metadata values is done using the Metadata Editor window.

To display a single Spectrum's Metadata:

- Using the hierarchy browser, select the Spectrum for which you wish to display the Metadata values.

- Click on the *Metadata* tab to display Spectrum Metadata.
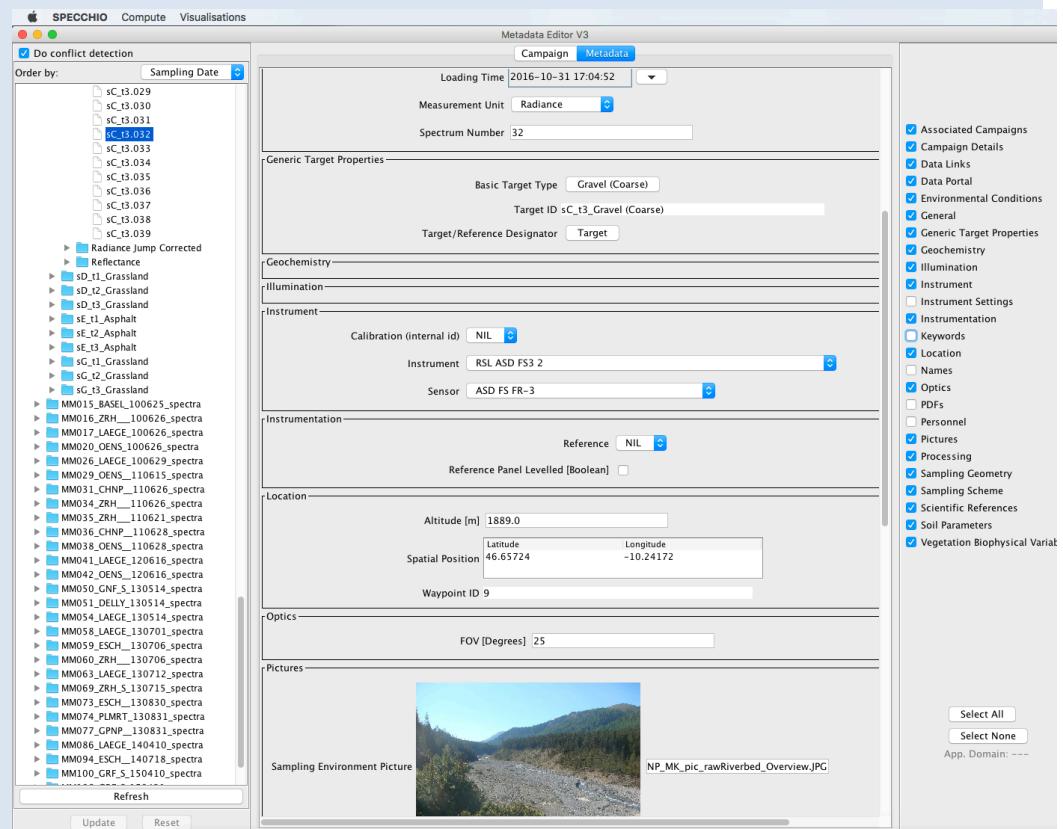
Figure 33: Metadata editor dialog

- Select or de-select the check boxes for the Metadata Groups. The check boxes are displayed on the right in the Spectrum Metadata Group selection area.

- Scroll to the required Metadata Group to see the values of the Metadata Attribute in that Group.

Note	Only Metadata Attributes which have values for the selected Spectrum are displayed.

9.5.4.2   *Editing Metadata for a Single Spectrum*

In each of the processes in this section, after you change or delete any Metadata value click **Update** to write your change back into the database. If that Metadata value is shared by another unselected Spectrum, the following dialog will be displayed.
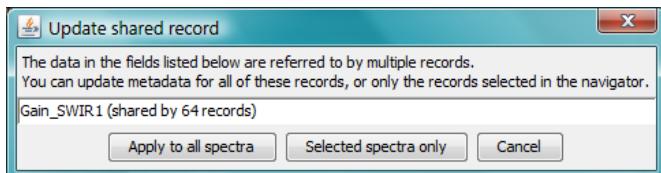

Figure 34: Shared data operation selector dialog

The second sentence in the dialog box will change to "You can *delete* metadata for all records…" if you have deleted the Metadata value rather than changed it.

This dialog allows you to select how you want the Entity/Attribute/Value table to be updated. The exact choice of options will depend on whether you performed a change or a delete.

Apply to all spectra	The shared record in the Entity/Attribute/Value table will be updated or deleted and therefore all Spectra which share this Metadata value will be affected by this change. Understand how widely the shared record is referenced when you use this option. It is possible for the value to be used for any other Spectrum in the entire database, although it is usually just shared by other Spectra in the same Campaign.
Selected spectra	Only the selected Spectrum will be affected. To achieve this, SPECCHIO will create a new entry in the Entity/Attribute/Value table and link only the selected Spectrum to it. For a delete operation, only the reference to the current Spectrum will be removed from the Entity list. No other Spectrum will be affected.
Cancel	Your change or delete request will be discarded and no changes for this Metadata value will be made. You should then click on **Reset** to cause the original database values to be redisplayed.

To modify a Metadata value:

- Display the Metadata Attribute values for the required Spectrum as described in the previous sub-section.

- Ensure that the check box for the required Metadata Group is ticked and scroll to that Metadata Group.

- Click in the field and type in the required value. When the field contains a valid value the **Update** button will become valid.

- Click **Update** to write the modified value back to the database. If the Metadata is shared by more than one Spectrum, the dialog in Figure 34:

will be displayed. Select your desired action and click **OK**.

To delete a Metadata value:

- Display the Metadata Attribute values for the required Spectrum as described in the previous sub-section.
- Ensure that the check box for the required Metadata Group is ticked and scroll to that Metadata Group.
- Right click on the name of the field you wish to delete. A **Delete** button will appear.
- Click on this **Delete** button. The Metadata field will disappear from the display and the **Update** button will become active.
- Click **Update** to write the change back to the database. If the Metadata is shared by other Spectra, the dialog in Figure 34: will be displayed. Select your desired action and click **OK**.

To add a new Metadata value:

- Display the Metadata Attribute values for the required Spectrum as described in the previous sub-section.
- Ensure that the check box for the required Metadata Group is ticked and scroll to that Metadata Group.
- Right click on any blank space within the Metadata Group's display box. A menu of Metadata items that can be added for that Group will be displayed.
- Click on the menu entry for the Metadata item you wish to add. A data entry field for the Metadata entry will be displayed.
- Enter the value you require for this Metadata field.
- Click **Update** to write this change back to the database.

9.5.4.3   _Editing Metadata for All Spectra in a Sub-tree of the Campaign tree_

SPECCHIO allows for simultaneous updating of Metadata for multiple Spectra. This feature is typically used when multiple Spectra have just been uploaded and a selection of their Metadata items shares the same values. This is a common scenario, as Metadata of Spectra are often highly redundant, especially when multiple measurements of the same object were acquired.

When multiple Spectra are selected (either by selecting a node in the Campaign Tree or by selecting multiple Spectra individually), the Metadata values that are common across all selected Spectra are displayed. For any Metadata Attribute for which even one Spectrum has a different value, or is missing that Attribute, the string _-- Multiple Values --_ is displayed. For Metadata Attributes which are selected from dropdown lists, the value _Nil_ is shown if the values are not the same for all Spectra.

To change a specific Metadata item for all Spectra under a node:

This method requires that the Metadata Attribute has the same value for all Spectra. See the next procedure if that is not the case.

- Navigate to the correct Campaign hierarchy node and click on it to

highlight it.

- Ensure that the check box for the required Metadata Group is ticked and scroll to that Metadata Group.

- Click in the field to be changed and type in the required new value. When the field contains a valid value the **Update** button will become valid.

- Click on the **Update** button to write the change back to the database for all Spectra for this node.

- If the Metadata value is shared with other Spectra not under the scope of this node, the dialog in Figure 34: will be displayed. Click on either **Apply to all spectra** if all Spectra which share this value are to be changed. Click on **Selected spectra only** if only the Spectra under this node are to have the Metadata Attribute value changed.

To delete a Metadata value from all Spectra under a node:

- Navigate to the correct Campaign hierarchy node and click on it to highlight it.

- Ensure that the check box for the required Metadata Group is ticked and scroll to that Metadata Group.

- Right click on the name of the field you wish to delete. A **Delete** button will appear.

- Click on this **Delete** button. The Metadata field will disappear from the display and the **Update** button will become valid.

- Click **Update** to write the change back to the database.

- If the Metadata value is shared with other Spectra not under the scope of this node, the dialog in Figure 34: will be displayed. There is a choice to either Apply to all spectra or Selected spectra only. Click **Apply to all spectra** if all Spectra which share this value are to have it deleted. Click **Selected spectra only** if only the Spectra under this node are to have the Metadata Attribute value deleted.

Warning   If you delete a Metadata Attribute which shows *-- multiple values --* in the current view, *all* values of this Metadata Attribute will be deleted from *all* selected Spectra, even if some Spectra have multiple values of the Attribute.

To reset a specific Metadata item for all Spectra under a node to have the same value:

- Navigate to the correct Campaign hierarchy node and click on it to highlight it.

- Ensure that the check box for the required Metadata Group is ticked and scroll to that Metadata Group. The value displayed in the Metadata field should be *-- Multiple Values --* to indicate that the values are not the same for all Spectra.

- Right click on the Metadata field name to show a **Delete** button. Click on the **Delete** button. The Metadata field will disappear from the screen.

- Click **Update** to write this change into the database. **This step is**

> **critical**.
>
> - Right click within the Metadata Group box to display a menu of Metadata Attributes that can be added to this Metadata Group. Click on the Metadata Attribute to be added back.
> - Enter the value you require for this Metadata Attribute.
> - Click **Update** to write this change back to the database.

9.5.4.4   *Editing Metadata for Multiple Unrelated Spectra*

The operations in the preceding section can be applied to multiple unrelated Spectra.
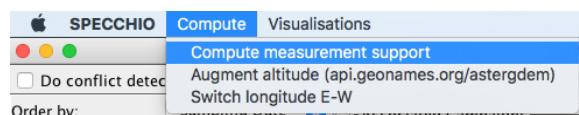
It is possible to select multiple Spectra by holding the Control key while clicking on each additional Spectrum to be selected. It is also possible to select a range of Spectra by selecting the first Spectrum and then holding the Shift key while you click on the last Spectrum in the range. (This is consistent with common Windows usage of the Control and Shift keys.) The operations in the preceding section will then apply to all selected Spectra.

Similarly, it is possible to select multiple nodes in the Campaign hierarchy and operate on all Spectra in those nodes.

Warning   Do not select multiple Spectra or nodes across different Campaigns and then update all selected Spectra to share the same Metadata values. If subsequent users select the **Apply to all spectra** button when editing Metadata, it will change the Metadata across both Campaigns, which is a very unexpected and confusing result.

9.6   Using the Metadata Editor functions

New functionalities have been added to the Metadata Editor for Release 3.3 (2017). They can be found in the *Compute* tab once the Metadata Editor was selected from the Main Menu.

9.6.1   Compute measurement support

This function computes two metadata attribute values: Measurement Support Area [m^2] and Measurement Support Radius [m] or Major/Minor Axes for elliptical, projected field of views respectively.

The computation is based on the following metadata attributes – make sure to have them inserted/calculated before using this function:

- Sensor Zenith and Sensor Distance
- Optics FOV (should automatically have been uploaded with the ASD data import, but may need manual definition for other sensors)

After applying this function, the user is informed by an info panel when the calculations are completed. Click on **OK** to remove this panel. The calculated

metadata values can be seen in the Sampling Geometry category:
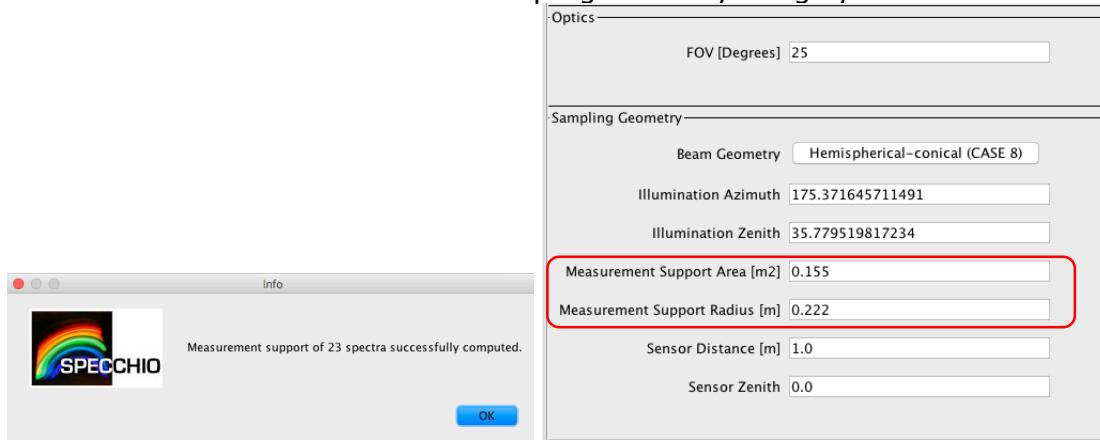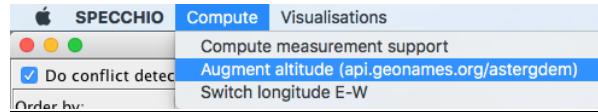
Figure 35: Example results of the measurement support calculation

9.6.2 Augment Altitude
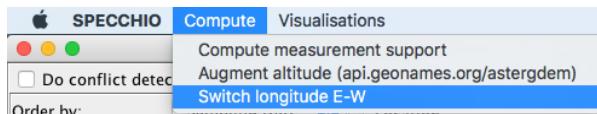
In case the **Altitude** information is missing, there is a built-in function which inserts the altitude information, based on latitude and longitude, by using the web service "geonames" (api.geonames.org/astergdem).

This service uses NASA's ASTER GDEM data which has a precision of 30 meters. Thus, this function should be used only if more accurate elevation data are not available.

Note: this function is only applicable for single spatial position coordinates. Other spatial positions such as transects are not (yet) supported by this function. An Internet connection is required to use this function.

9.6.3 Switch Longitude E-W
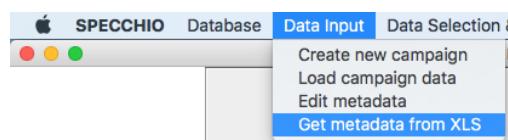
Note that **Longitudes** East of Greenwich (e.g. Switzerland and Australia) need to be a positive value. If your metadata was inserted as negative values, this can be changed by using the switch function from the *Compute* menu *Switch longitude E-W*:

9.6.4 Visualisations

Under the *Visualisations* tab, all visualisation options that are available in the Spectrum Browser are also provided for selected Spectra from the Metadata Editor. Please refer to section *10.1 The Spectrum Browser* for details.

9.7 Uploading Metadata from XLS (Excel) files

SPECCHIO supports uploading Metadata to your Campaign from Excel spreadsheet files saved as an .XLS file. It **does not** support loading form.CSV, .XLSX or other Excel file formats.
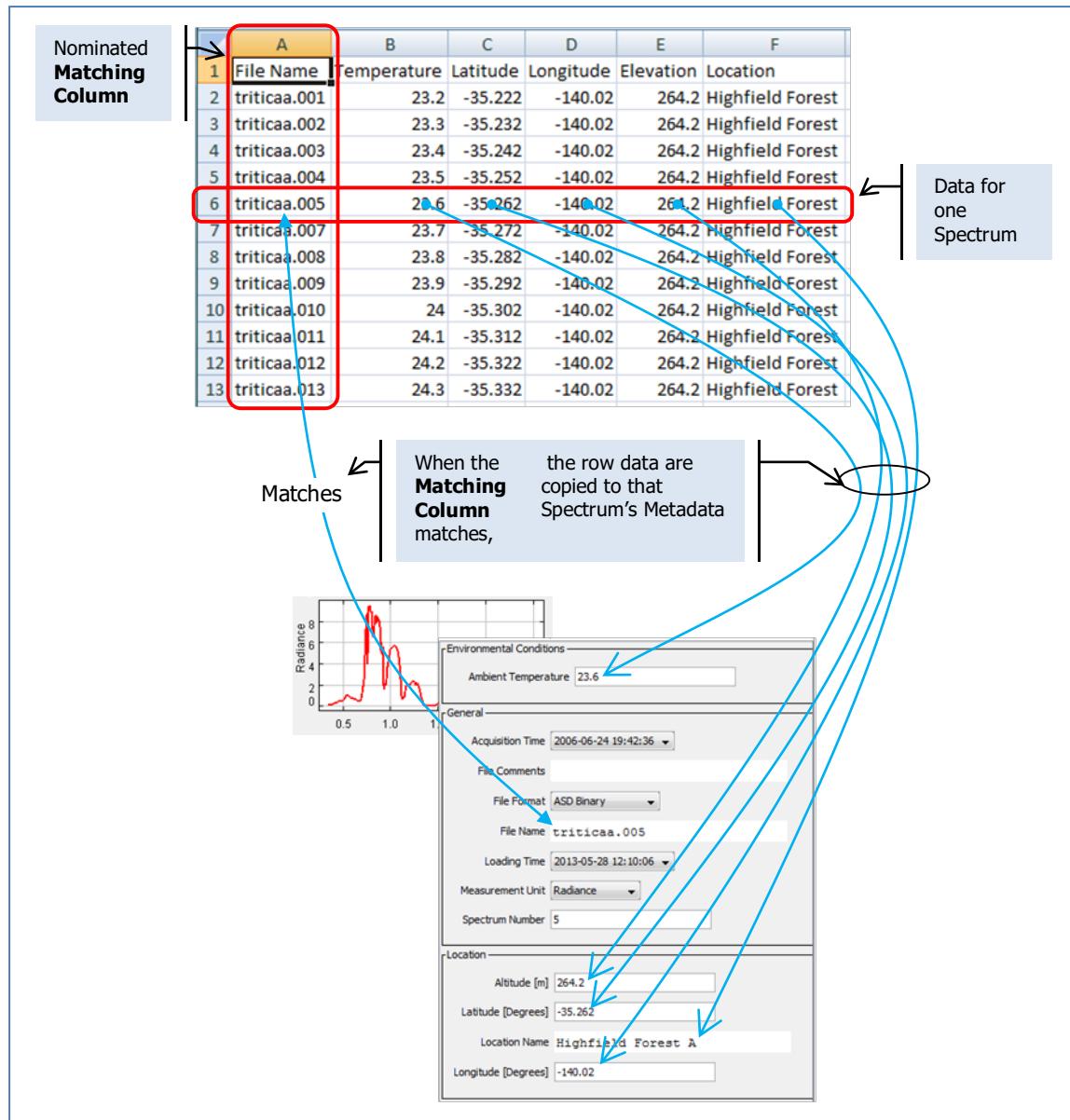
Figure 36: Uploading Metadata from XLS process

The operation of this process can be tailored as described below.

Input .XLS file format

Metadata Excel .XLS files must conform to the following conventions in order to be loaded correctly:

- Only the first data sheet is loaded.
- The first row must contain column headings. It will be displayed and referenced during the upload process, but it will not be uploaded. The column headings do not need to match Metadata Attribute names.
- Each row holds data which is uploaded to one Spectrum.
- The rows do not need to be sorted.

- One column, identified at upload time, is used as the Matching Column. It identifies which Spectrum will receive the data from each row.

- If a Spectrum is selected in the Matching Column in more than one row, all of these rows are ignored.

- Other columns contain the Metadata that will be uploaded.

- You can select to ignore some columns during the upload process.

Column selection operation

After you have selected the .XLS file to upload, the following panel is displayed as part of a larger dialog.
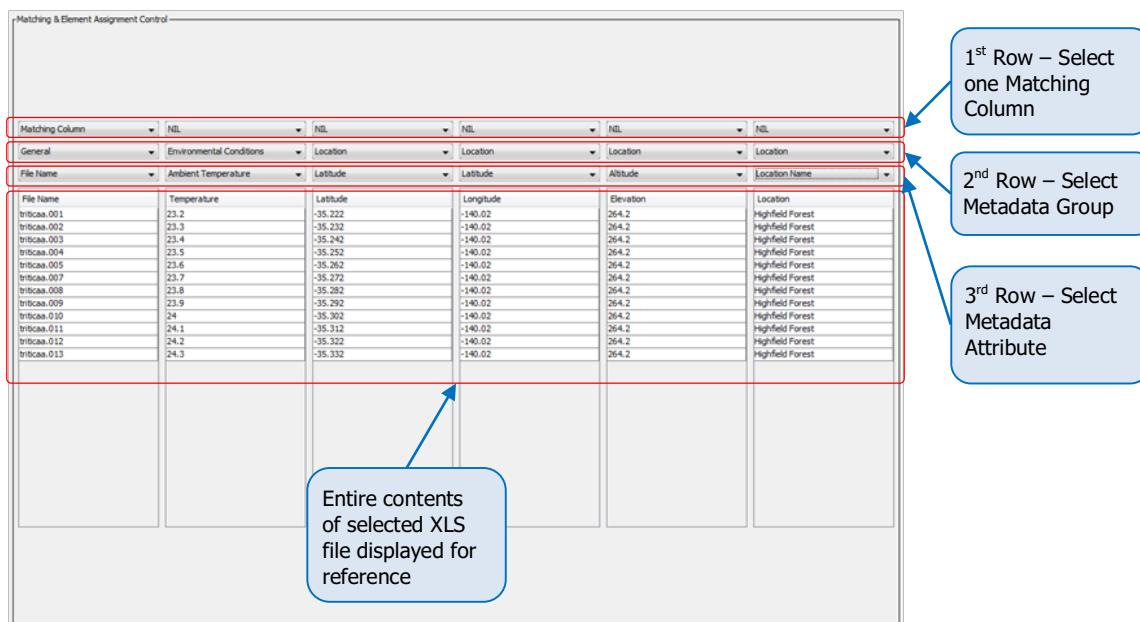

Figure 37: Matching & Element Assignment Control

This panel shows the contents of the .XLS file you have opened and allows you to select how it will be used.

The three rows of dropdown boxes are used as follows:

First row	Selecting the Matching Column In one of the columns only, select Matching Column from the drop down list. This indicates the column that will be used to search for the Spectrum to receive the Metadata for each row.	
Second Row	Selecting the Metadata Group In all columns that you want to use, select the Metadata Group that contains the Metadata Attribute which is listed in that column.	
Third Row	Selecting the Metadata Attribute In all columns that you want to use, select the Metadata Attribute which is listed in that column.	

After you have set up these three rows of selection parameters, the Assignment Details and Matching Details panels will show how the .XLS data will be uploaded. Use these panels to check that the upload is set up correctly before proceeding.

Spectru...	DB Value	Table Va...
285	triticaa.000	
286	triticaa.006	
287	triticaa.018	
288	triticaa.030	
289	triticaa.042	
290	triticaa.054	
291	triticaa.066	
418	triticaa.001	triticaa.001
419	triticaa.002	triticaa.002
420	triticaa.003	triticaa.003
421	triticaa.004	triticaa.004
422	triticaa.005	triticaa.005
423	triticaa.007	triticaa.007
424	triticaa.008	triticaa.008
425	triticaa.009	triticaa.009
426	triticaa.010	triticaa.010
427	triticaa.011	triticaa.011
428	triticaa.012	triticaa.012
429	triticaa.013	triticaa.013
430	triticaa.014	
431	triticaa.015	
432	triticaa.016	
433	triticaa.017	
434	triticaa.019	
435	triticaa.020	

Number of assignable columns: The number of columns in the .XLS file which remain unused

Number of assigned columns: The number of columns in the .XLS file which will be copied into Metadata Attributes

Number of spectra: The number of Spectra selected in the hierarchy tree browser (see below)

Number of matches: The number of selected Spectra which match data in the *Matching Column* of the .XLS file

Spectrum (First column) The Spectrum IDs of all selected Spectra

DB Value (Second column) The value from the SPECCHIO database of the Metadata Attribute which you have identified in the *Matching Column*
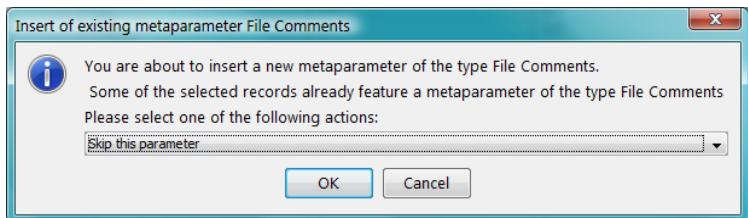
Table Value (Third column) The matched value from the *Matching Column* of the .XLS file. The data in this row will be loaded into the Metadata for this Spectrum.

Figure 34: Assignment & Matching Details dialog

To upload Metadata:

You must already have an Excel .XLS file containing the Metadata to upload.

If SPECCHIO finds a Metadata Attribute already exists for any Spectrum, SPECCHIO will ask how you wish to proceed by displaying the following dialog box, which lists the Metadata Attribute name that already exists (in this example, *File Comments*).

Select one of these three options from the dropdown list:

Skip this parameter	No data from this column of the XLS file will be loaded into the SPECCHIO database.
Insert anyway	Add another value for this Metadata Attribute. This option is not supported for some Metadata Attributes. For example, adding a second File Name or Spectrum Number is not permitted.
Delete existing and insert new values	The Metadata values in the XLS file will replace those in the Spectra.

Click **OK** to continue processing using the action you have selected.

Click **Cancel** to skip processing of this column. This has the same result as selecting *Skip this parameter*.

Adjusting the matching strings

If the data in the *Matching Column* of the XLS file is a partial match to the Metadata Attribute values in the database, you can use the REGEX box to assist in the match.
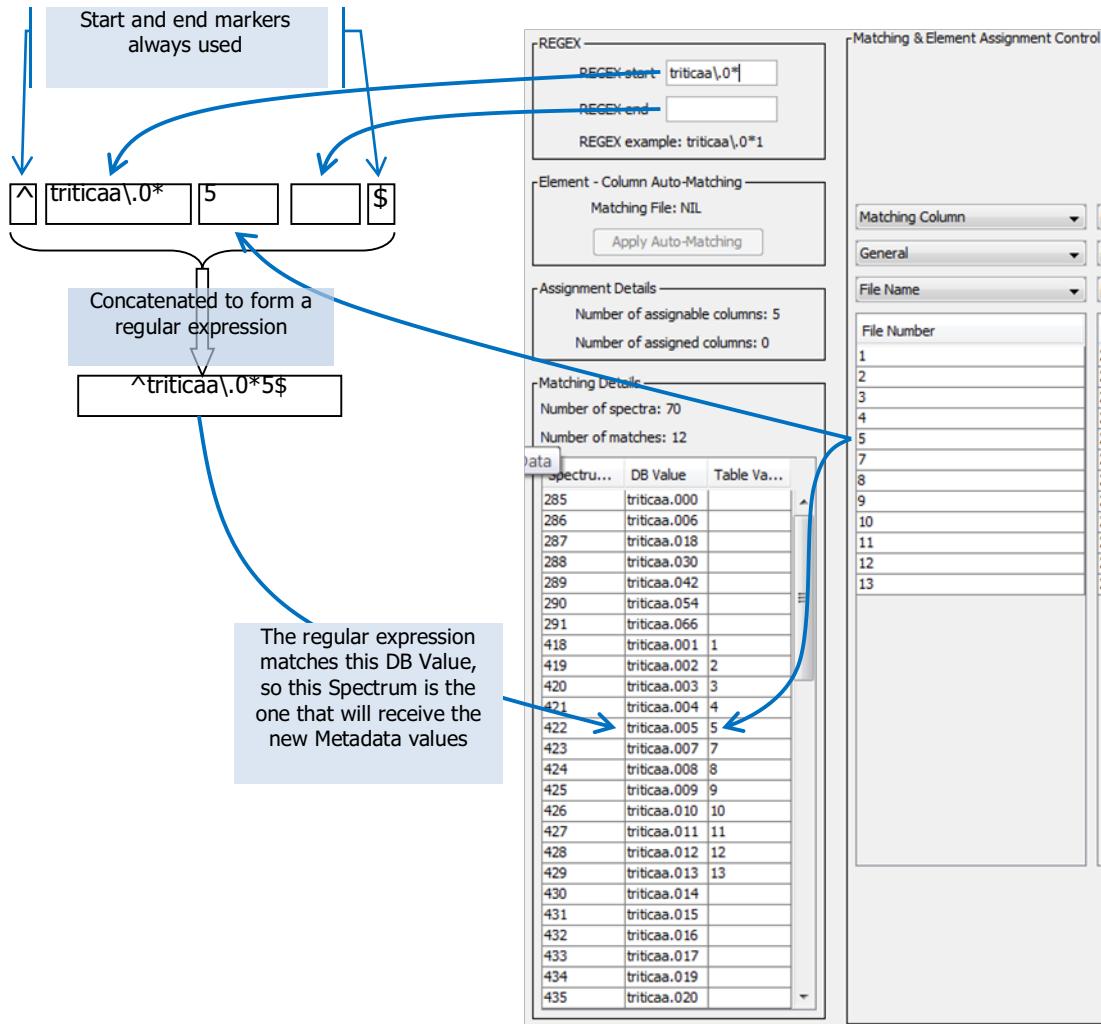
Figure 38: Using Regular Expressions for selecting Spectra

For each row of the XLS file, the data in the Matching Column is concatenated with the *REGEX start* and *REGEX end* contents to form a Regular Expression. The matching process is then performed using Regular Expressions. (See *Appendix A: Regular Expressions Tutorial*.) In the above example: the ∧ forces the matching to start at the beginning of the string; . is a special character so \ must be used to escape it, so \. matches the . in the file name; 0* matches any number of 0 characters; 5 matches 5; and the $ forces the match to complete at the end of the string.

Note	If a value in the *DB Value* column matches more than one row in the XLS file, no matching row will be shown in the *Table Value* column, and no Spectrum will be updated.

Using preconfigured column information

If you often load Metadata from XLS files, you can pre-configure the XLS column mappings you want to use. This will be more efficient and reduce your chance of making a mistake.

Create an extra XLS spreadsheet which lists the Column Names you've used in your spreadsheet along with the matching names SPECCHIO uses for these fields.
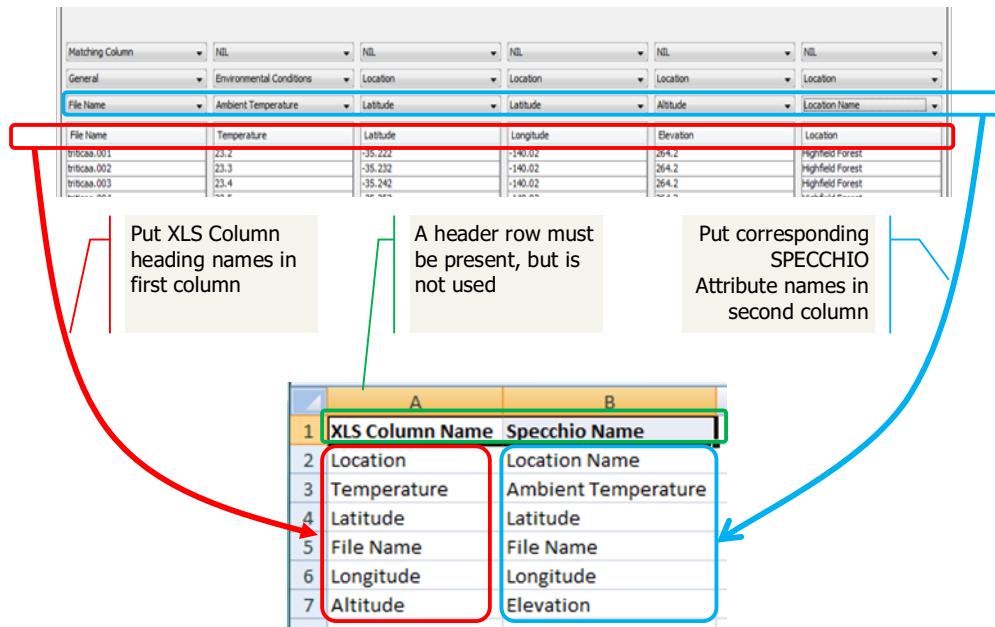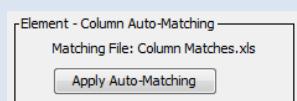
Figure 39: Setup up pre-defined column allocations

- The table must be in the first datasheet of the spreadsheet.

- Each SPECCHIO Metadata Attribute name must be on the same row as its matching XLS column name.

- The names in both columns are case sensitive.

- Leading and trailing spaces must be avoided.

- There must be a header row, but it is skipped over.

- The rows do not need to be sorted into any sequence.

- The file must be saved as an .XLS file. .CSV, XLSX or other Excel file formats are not supported.

To use a pre-configured column matching spreadsheet:

- Select *Data input* -*Get metadata from XLS* from the menus on the SPECCHIO Main Window. The following dialog will be displayed. Only those Campaigns to which you have write permission will be displayed.

- Select the Campaign, hierarchy node or Spectra to which you want the Metadata to be uploaded.

- Select *File* - *Open file...* from the menu bar on this screen. Browse to the .XLS Metadata file you have previously prepared and Open it.

- Select *File* - *Open Column-Element Matching File...* from the menu bar on this screen. Browse to the column mappings XLS file and open it. The name of file you have opened will be shown in the *Element – Column Auto-Matching* control.
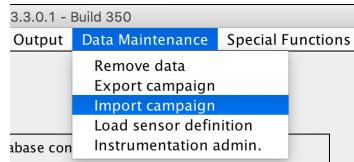

- Click on the **Apply Auto-Matching** button. The information from the column matching XLS file will be read and the drop down boxes in the

second two rows of the *Matching & Element Assignment Control* box will be updated.

- In the column that you wish to use as the Matching Column, in the top row dropdown box select *Matching Column*.

- Carefully review the information shown in the *Assignment Details* and *Matching Details* boxes and ensure it is correct.

- Click on the **Insert Selected Metadata** button.

9.8   Import campaign from XML file

| Note | In order to use this option, you must be logged in as an Administrator. |

The import function reads an XML file that was created by the SPECCHIO *Export campaign* function. The import will create an exact copy of the exported Campaign. It will also add any Sensor, Instrument or Calibration information that is referenced by this Campaign if it does not already appear in this database.

To import a Campaign:

- From the Main menu select *Data Maintenance* - *Import campaign*.
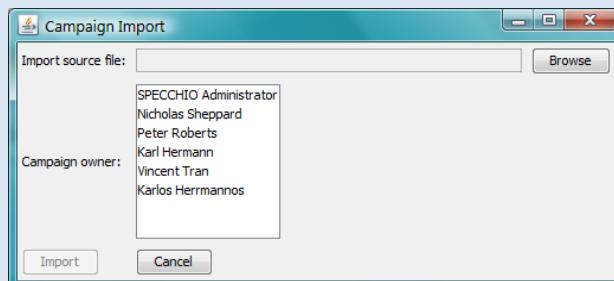
Figure 40: Campaign Import Dialog

- Click **Browse** to open a file dialog box.

- Select the XML file that you want to import into your current SPECCHIO database and close the dialog box.

- In the *Campaign Owner:* box, select the name of the Researcher who will be the imported Campaign's owner.

- Click **Import**. When the import is complete, the Campaign Import dialog will close.

To import a Campaign by drag and drop:

- Select the XML file that you want to import in the computer's file system, then drag and drop it onto panel holding the SPECCHIO icon in the main window (the panel borders will be highlighted blue):
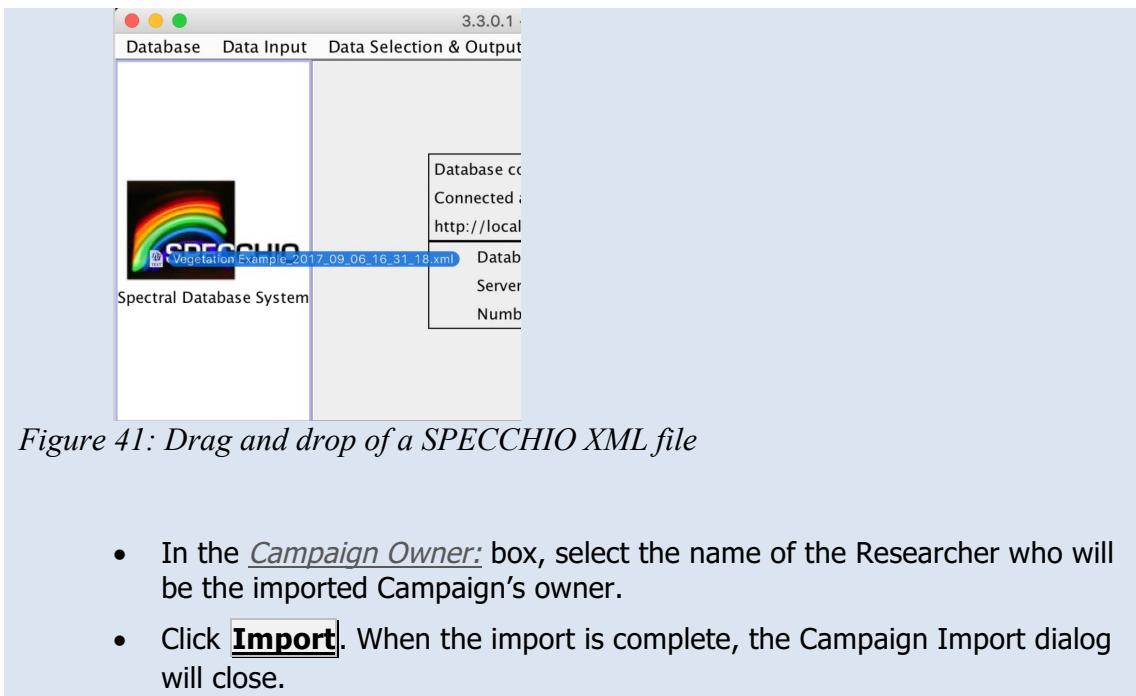
Figure 41: Drag and drop of a SPECCHIO XML file

- In the *Campaign Owner:* box, select the name of the Researcher who will be the imported Campaign's owner.

- Click **Import**. When the import is complete, the Campaign Import dialog will close.

To import a Campaign from a file on the SPECCHIO server:

- Depending on the internet connection between server and client it may be beneficial to copy the XML file onto filesystem of the SPECCHIO server and load it from there. To do this, supply the file path of the server as shown in the below example.
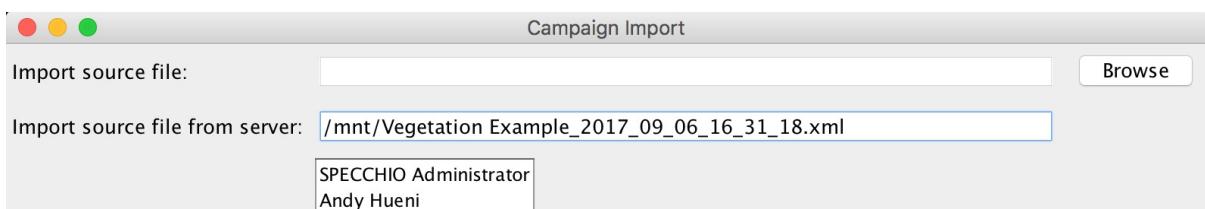
Figure 42: Specification of a file source on a SPECCHIO server

Notes	The Import database version must identical to the Export database version where the XML file was created. SPECCHIO does not check this. If they are not the same, the new Campaign will not be readable and the database may give unpredictable results.
	The name of the imported Campaign will be identical to the name of the exported Campaign. If you import into the same database you exported from, you will have two identically named Campaigns. To avoid confusion, it would be advisable to rename the newly imported one using the Metadata Editor to change the Campaign Metadata's Campaign Name value.
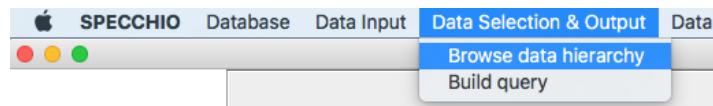
10   Data Selection & Output

This section describes the functionalities of SPECCHIO's Main Menu tab *Data Selection & Output*. Here you will find information on how to:

Data Selection & Output
- Browse the data hierarchy
- Build query
- Show report
- Data export

10.1 The Spectrum Browser

The SPECCHIO Spectrum Browser allows users to browse the Campaign hierarchy to locate Spectral data, and then to launch operations on the selected data. Those operations are selected by clicking the one of the row of six buttons in the right hand panel. The operation of these buttons is explained in sections with those names in this section.

From the Main menu, select *Data Processing & Output - Browse data hierarchy* to see the following window:
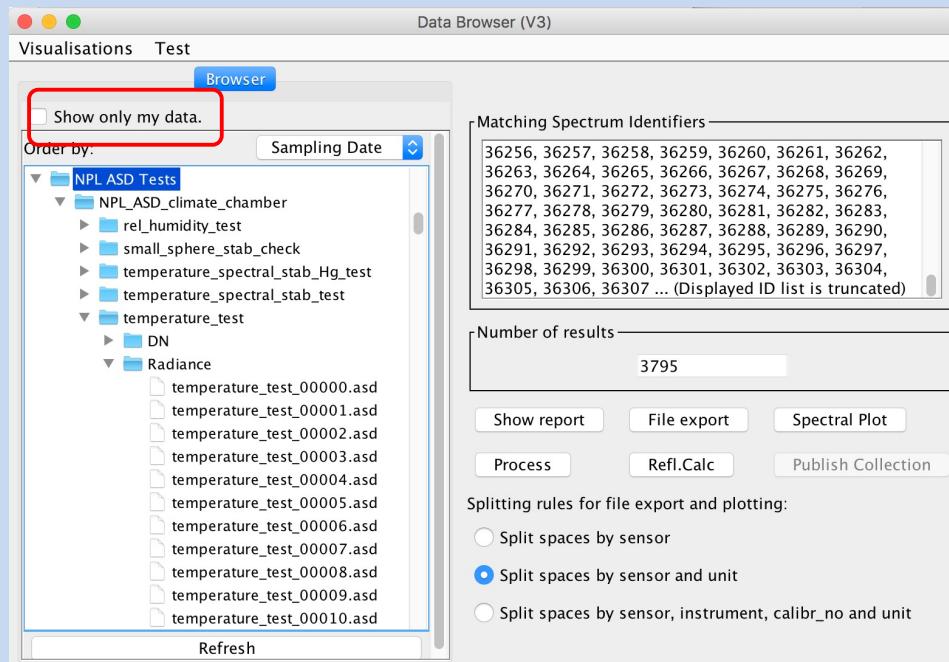
Figure 43: The main Browse data hierarchy window

- Browse options: In the hierarchy browser, all campaigns are shown when using the Browser menu. If you wish to browse only within the campaign data you have uploaded or for which you have been added to the Research Group, check the box *Show only my data.*

|	
Matching Spectrum Identifiers	The Spectrum IDs of the Spectra which are highlighted in the browse panel are listed in this box.
Number of results	The number of Spectra IDs listed in the Matching Spectra box is shown in this box.
6 action buttons	Of these six action buttons, Show Report, File Export, Process, Spectral plot and Refl. calc will become active when you have selected one or more Spectra. The Publish Collection button is only present if you are accessing an ANDS-enabled SPECCHIO Server and is only active if you have selected Show only my data. The operations these buttons initiate will be performed on the selected Spectra. Each of these buttons has a section in this chapter.
Splitting rules for file export and plotting:	Click on the radio buttons to select one of the options: Split spaces by sensor, Split spaces by sensor and unit or Split spaces by sensor, instrument, calibration_no and units. This selection will affect the operation if you select the Process, Spectral plot or File export buttons.

There are many places in the SPECCHIO operation when a Campaign Hierarchy browse control, such as the one below, is displayed as part of an operation dialog.
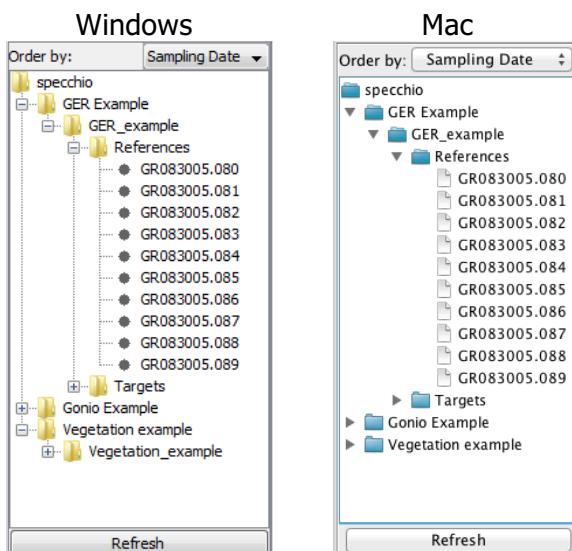
Figure 44: Campaign Hierarchy browse controls for Windows and Mac

This browse control operates much like a normal folder and file browser.
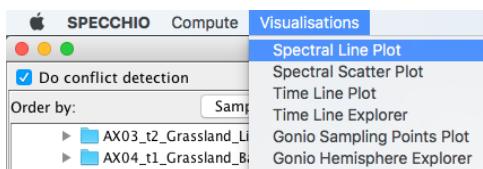
- Click on the ⊞ and ⊟ icons (or ▶ or ▼ for Mac) to cause the hierarchy levels to be expanded or collapsed.

- Select an individual Spectrum by clicking on it.

- Select a node in the hierarchy by clicking on it. This effectively selects all Spectra under this node.

- Select a second node or Spectrum by holding the Control key and clicking on it (or equivalent Mac mouse action).

- Select a range of Spectra, by clicking on the first Spectrum to select it, holding the Shift key and clicking on the last Spectrum (or equivalent Mac mouse action).

- Change your selection by clicking on the new item you want to select (without Control or Shift keys).

In addition, there are two options:

Order by:	Use the drop-down menu to choose the sort order for Spectra within each node. Often these three orders are the same, or at least similar, so you may not notice any change of sequence. The options are:	
	Sampling date	The Spectra are sorted in increasing order of the date and time in the Acquisition Time Metadata Attribute.
	Filename	The Spectra are sorted in increasing alphabetical order of the string in the Filename Metadata Attribute.
	Insert order	The Spectra are sorted in increasing order of the date and time in the Loading Time Metadata Attribute.
Refresh	Click this button to cause the Hierarchy Tree to be reloaded from the database. Use this button if the operation you have just performed, some background operation, or some other user has changed the database since this dialog box was opened.	

10.1.1 Visualisations

This menu item displays a drop down list of graphic visualisation options which you can apply to the Spectra listed in the Matching Spectra box. These options match those listed in *Section 15.5 Visualisation Modules*. Depending on the option and Spectra selected, some of these Visualisation options may take several minutes to process.
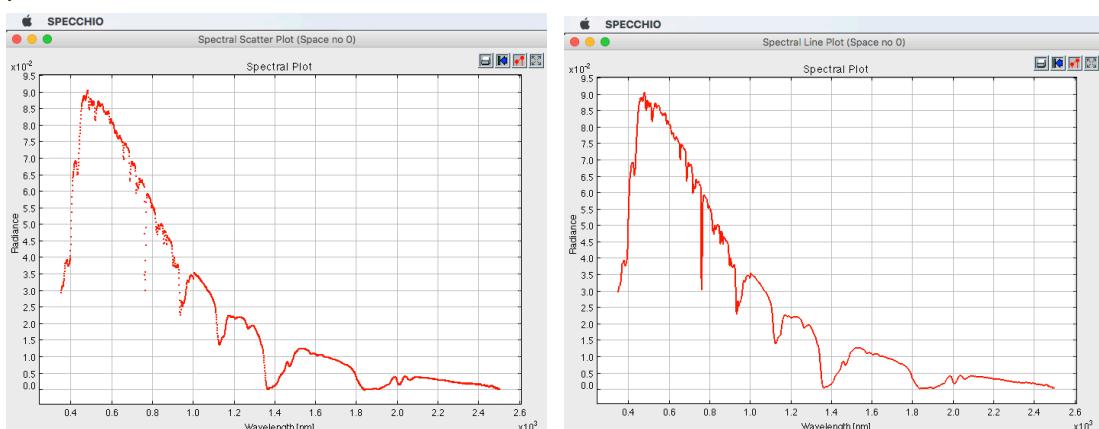
Figure 45: Visualization examples: spectral scattter plot (left) and spectral line plot
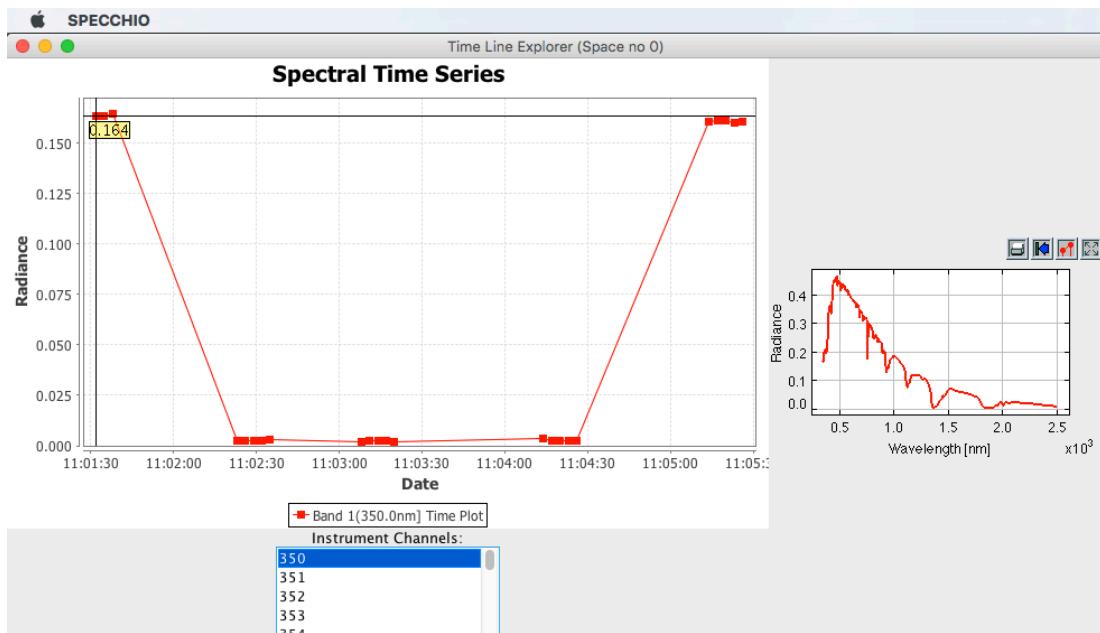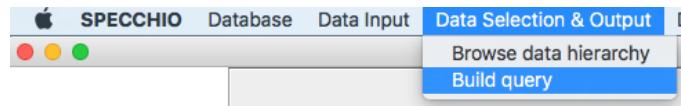
Figure 46: Visualization example: Time line explorer of a series of 25 spectra.

In the above example, the first 5 and the last 5 measurements are Spectralon reference data. Note that per default, always the first spectral band of the first selected spectrum is displayed in the spectral plot.

10.2 Query Builder

SPECCHIO's Query Builder provides a way to select one or more Spectra based on their Metadata, and then perform operations on all of these selected Spectra. The operations which can be performed on the selected Spectra are the same as for the Spectrum Browser, and are explained in the later sections of this Section.

To Launch the Query Builder select *Data Processing & Output - Build query* from the menu on SPECCHIO's Main Window.
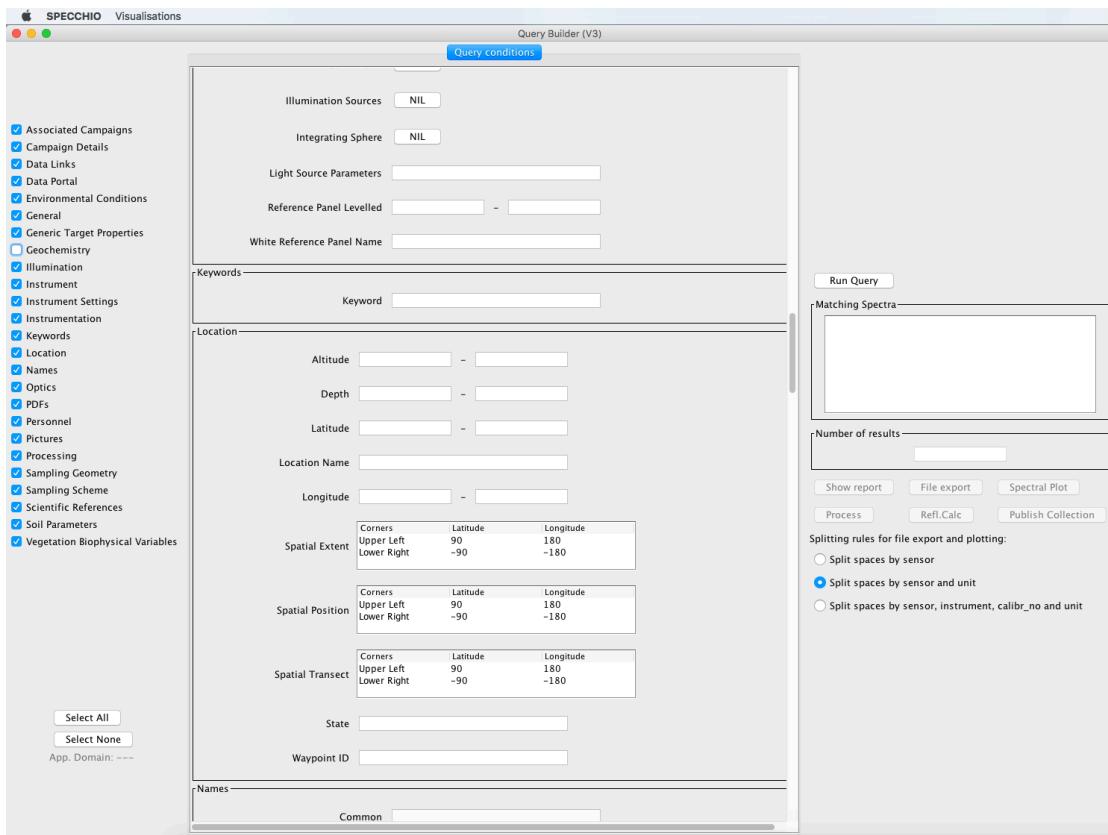
Figure 47: The main Query Builder window

The parts of this window are:

|	
Visualisations	This menu item displays a drop down list of graphic visualisation options which you can apply to the Spectra listed in the Matching Spectra box. These options match those listed in Section 13.5 Visualisation Modules. Depending on the option and Spectra selected, some of these Visualisation options may take several minutes to process.
Left panel	There is one box for each SPECCHIO Spectrum-related Metadata Group and within each box, all of the Metadata Attributes for that Group are listed with a data entry box.
Matching Spectrum Identifiers	The Spectrum IDs of the matching Spectra are listed in this box.
Number of results	The number of Spectra IDs listed in the Matching Spectra box is show in this box.
Six action buttons	The six action buttons, Show Report, File export, Process, Spectral plot, Refl. calc and Publish Collection will become active when you selected one or more Spectra. The operations they imply will be performed on the selected Spectra. Each of these buttons has a section in this Chapter.
Splitting rules for file export and plotting:	Click on the radio buttons to select one of the options: Split spaces by sensor, Split spaces by sensor and unit or Split spaces by sensor, instrument, calibration_no and units. This selection will affect the operation if you select the Process, Spectral plot or File export buttons. See the relevant option description section in this chapter for more information,

Queries are created by entering selection criteria into the Metadata Attribute controls in the left panel. A new query is performed every time any change is made in any Metadata entry box, after clicking on the **Run Query** button. Initially, no query is active so the Matching Spectra box is empty.

The searching follows these rules.

- A search condition is created by making the search conditions for a Metadata Attribute non-empty. Empty fields do not trigger any search conditions.

- Initially all Metadata query fields are empty. Even the data/time fields are empty, but the date/time dialog displays the current date and time in this case.

- Once a date/time selection field is modified, it cannot be made empty again. Therefore, searching will be done on this date/time until the dialog box is closed. This applies independently to the start and end date/times.

- A new query is performed every time any field is changed. Even if only one character is typed or removed, a new query is performed. For date/time fields, a new query is performed each time the date/time picker is closed.

- To be selected, a Spectrum must satisfy _all_ search criteria entered.

- The minima and maxima search conditions for a numeric or date/time Metadata Attribute are independent. That is, it is valid to enter just a minimum or just a maximum value.

- Numeric and date/time search ranges are inclusive. That is, if you enter a minimum Spectrum Number of "20", Spectra with Spectrum Number greater or equal to 20 will be selected.

- If a search condition for a Metadata Attribute is present, Spectra without that Metadata Attribute will never be selected.

- Strings can be wildcarded to enable more complex search behaviours; see 10.2.1 for details.

- With Release 3.3.0.0, spatial geometry support was introduced. When defining spatial query conditions, it is important to choose only the relevant spatial geometry type, depending on the spatial sampling scheme.

-

10.2.1   SQL Matching Strings

Matching strings are required to control the way string values entered in the Query Builder are matched versus metadata entries in the database.

When matching text strings, the SPECCHIO server uses a MySQL Query LIKE clause. Therefore, the following are supported.

%   Matches zero or more characters.

_   Matches exactly one character.

\   Causes the next character to be matched. That is, \% will match a % sign and _ will match an underscore character.

For dropdown lists, the test is not performed if _Nil_ is set. Otherwise, only those Spectra with exactly that value will be selected.

Notes	Text Metadata Attributes which are present, but empty, can be selected by using %, but not by _.
	Text Metadata Attributes which contain only a single space can be selected by using %, _ or a space.
	It is common for some Spectrum file formats to have a File Comment field which contains only a space. This is not so for other Metadata Attributes.

Warning	There is no option to search by Campaign Name, except for the Campaign Name in the Spectrum-related Metadata Group, Campaign Details. This is NOT the Campaign's name and will generally not be present. See *Section 6.10 Metadata* for more information on the Spectrum-related Campaign Details Group of Metadata Attributes.

After you have entered search criteria for the Spectra you wish to operate on, click the **Run Query** button, followed by one of the six action buttons. See the following sections for details of the operation of these buttons.

10.2.2   Entering Dates and Times

SPECCHIO uses a Date and Time selection dialog which is similar to many others. Here are a few tips for using it.
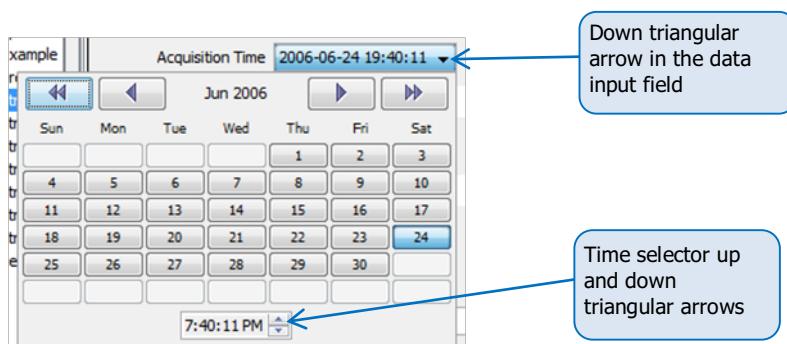
Figure 48: Date and Time picker dialog

- Select the Time first. (Because selecting the Date closes the dialog.)
- To change the Hours, click on the hour number in the Date and Time Picker (it will not be highlighted and the cursor will not move, but trust me) and then click on the time selector up and down triangles to adjust the number. (You cannot type in the number directly.)
- To change Minutes and Seconds, do as for Hours.
- Clicking on the required Date closes the dialog box, but only if the date is not already highlighted.
- If you do not want to change the date, click on the down triangle in the data input field to close the date picker.
-

10.3 Show Report

Reports are generated by clicking on the **Show report** button in the Query Builder or Spectrum Browser. It operates on all Spectra which are selected at the time this button is clicked.

Reports are shown in a window in the following form.
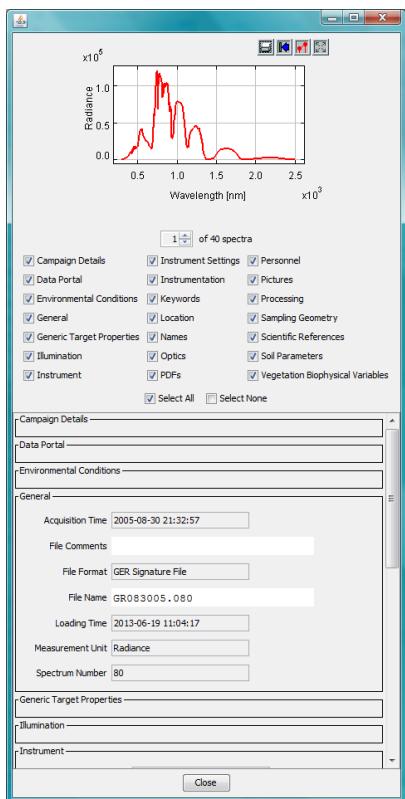
Figure 49: Spectrum report frame

Just below the Spectrum graph, the number of Spectra graphs in the report is shown with a control to allow you to select which Spectrum graph you wish to display.
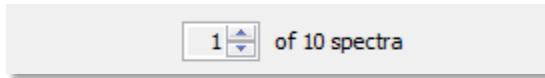
Figure 50: Spectrum Graph selection control

Click on the up and down arrows to cause the Spectrum graph display to cycle through the available Spectra. The selected graph is displayed after a short processing delay.
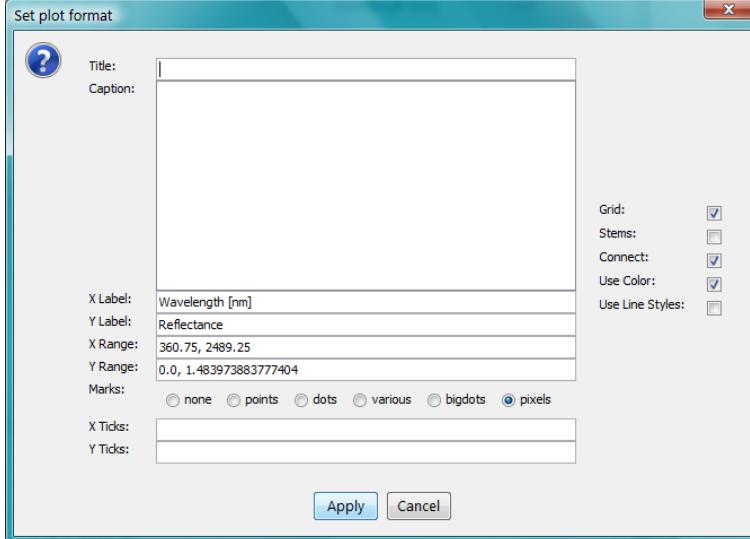
Click on the Metadata Group check boxes to enable or disable display of the respective Metadata Group.

For a larger display, documents such as target pictures and PDF's can be opened in an external viewer or copied to the clipboard.

Click on the **Close** button to close this window.

There are four action buttons at the top of this window.

	Print	Click on this button to Print the graph. The Metadata are not printed. It is recommended that you set the plot parameters first using the button to add a title and identifying information to your printed graph.
	Reset	Click on this button to reset the graph to its originally displayed form.

	Set plot parameters	Click on this button to change the display parameters for the graph. The following Dialog is displayed.

Figure 51: Plotting dialog

Title: Enter the Title you want to appear at the top of the printed page.

Caption: Enter text that you want to appear under the graph.

X/Y Label: Enter the labels that you want to use to label the X and Y axes.

X/Y Range: Enter the lowest and highest values that you want to appear on the X and Y axes. The two values in each question must be separated by a comma.

Marks: Select the way you want the data points represented on the graph.

X/Y Ticks: Place specific labels along the X and Y axes. For example, entering "Threshold 450.3, Maximum 670.23" will place the string "Threshold" at the point 450.3 along the axis and "Maximum" at 670.23.

Grid: If checked, the graph will include a grid.

Stems: If checked, each data point will be joined to the X axis by a straight line.

Connect: If checked, the data points will be joined by straight lines. If you check this option, it is probably best to select the option *None* for the *Marks:* question in order to show a thin clean line.

Use Color: If checked, the various data lines on the graph will be given different colours. If not checked, they will all be black.

Use Line Styles: If checked, the data points will be connected with dashed lines. This option has no effect unless

		Connect: is checked.
		These details are not remembered once you move away from viewing this graph.
	Fit data	Click on this button to set the graph axis parameters to values which fit the displayed axes to the data.

SPECCHIO scales the graph's Y Axis for Spectra with _Measurement unit_ set to _Reflectance_ to display correctly even when there is strong atmospheric noise in the usual regions of 1350-1440nm, 1790-1980nm and 2360-2500nm. For these graphs, the maximum Y value is set by calculating the mean and standard deviation in the wavelength region 300-1200nm and then setting...

$$Max\ Y\ Axis\ value = Mean + 3 * StdDev$$

When Spectra having no Sensor definition are plotted, the X-axis will represent bands and not wavelengths.

For sensors comprising broad and narrow band elements (e.g. MFR) only the narrow bands will be plotted.

10.4 Spectral plot

Using this option, plots of all currently selected Spectra are displayed.

Separate plots are created based on the setting of the _Splitting rules for file export and plotting:_ question in the _Query Builder_ or _Spectrum Browser_ dialogs.
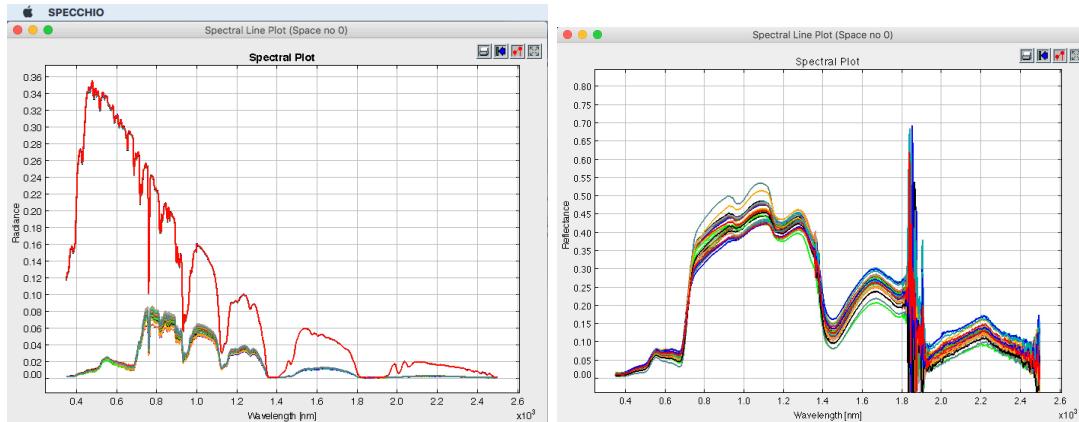
Figure 52: Spectral plot examples: target and reference panel radiance spectra (left), selected grass reflectance (right) plotted in separate graphs per measurement unit

> Note: The range of the Y-Axis is dynamically adjusted for the range of the selected spectra. Reflectance plots use a statistical approach including the VNIR range but excluding water vapour bands to avoid plot Y-Axis scale being dominated by noise.

The four plot options that are described in _Section 10.3 Show Report_ are also available for the Spectral Plot option. They relate to the four buttons shown at the top right of the above plotting windows.

10.5 Process

A separate chapter of this Use Guide is devoted to this topic. Please see _Section 12 Interactive Processing using Space Networks_.

10.6 Refl. calc

This function is the same as **Process**, except that if you have a set of Spectra selected which all have Data Links to white Reference Spectra, it will set up a transformation from Radiance to Reflectance for those Spectra as default operations in the Process window.

Refer to *Section 12* Interactive Processing using Space Networks for further information.

Note that the reflectance calculation implemented in SPECCHIO is rather simplistic. For a more scientific and elaborated workflow please refer to the SPECCHIO Reflectance Calculator written in Matlab.

10.7 File Export

Files are exported by clicking on the **File export** button in the Query Builder or Spectrum Browser. It operates on all Spectra which are selected at the time this button is clicked. The following window will open:
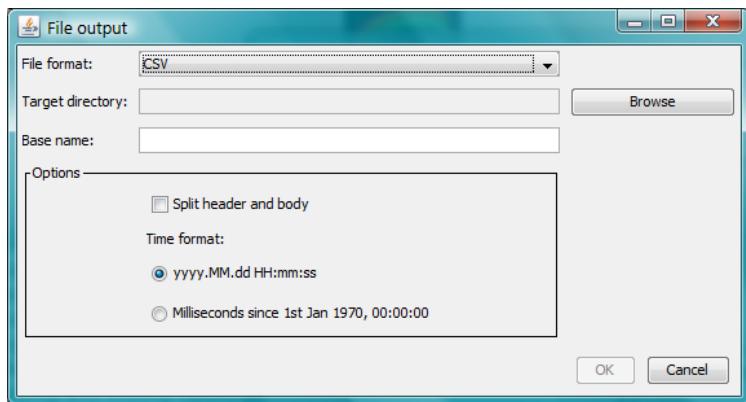
Figure 53: File output dialog

Controls are as follows:

File format:	Select from the drop down list.
CSV:	Data is written to a text file in comma separated value format. This file type can be read into Excel. A full description of the way CSV files are used can be found below at *Section 8.6.1 CSV Spectrum Export Format*.
ENVI SLB:	ENVI Spectral library file consisting of two files: a header file (<file_name>.hdr) and a body file (<file_name>.slb). Spectral data are written as floating point values, either 32 bit or 64 bit depending on the architecture of the machine. The datatype field in the header file is set accordingly (datatype 4 or 5 respectively).
Target folder:	Click **Browse** to select the folder into which the output files will be written.

| Base name:	Enter a character string which will be prefixed to the file name. This name should contain only characters that are allowed in filenames (depends on your operating system). The base name is used to build the real filenames according to one of the following patterns:
	`<base name>_<sensor_name>.<file extension>` `<base name>_<instrument_name>[cal<calibration sequence number>].<file extension>`
	The actual choice of naming pattern depends on the selection made in the _Splitting rules for exporting and plotting:_ question in the previous _Query builder_ dialog or _Data browser_ dialog.
	If no Instrument has been defined the Sensor name will be used.
Split header	Applies to CSV files only. The Spectra data will be split into two separate CSV files. The body file will have the string _BODY appended to the file name and _HDR is appended to the file name for the header file. (ENVI SLB files are always split into header and body.) The data are also split according to the selection made on the _Splitting rules for file export and plotting:_ question in the _Query Builder_ or _Spectrum Browser_ dialogs. See comment below about file naming.
Time format:	Select your desired time format. Selecting milliseconds makes it easier to use the timestamp as an X axis value in Excel plotting.

The data file names are constructed using the following components.

Campaign name	The Campaign name is always used in the output file name. It is not recommended to export data from multiple Campaigns at one time. The results are undefined.
Sensor name	The Sensor name is always used in the output file name. There will be separate files for each Sensor.
Unit type	If you select _Split spaces by sensor and unit_ or _Split spaces by sensor, instrument, calibration_no and units_, there will be separate files for each value of the Unit Metadata Attribute.
Calibration number	If you select _Split spaces by sensor, instrument, calibration_no and units_, there will also be separate files for each Calibration for each Sensor and Unit combination.

Example

Consider a Campaign containing Spectra captured with the following three Instruments:

- 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:

mixed instr_INR ASD_cal1_BODY.csv
mixed instr_INR ASD_cal1_HDR.csv
mixed instr_RSL ASD 1_BODY.csv
mixed instr_RSL ASD 1_HDR.csv
mixed instr_RSL GER 3700_BODY.csv
mixed instr_RSL GER 3700_HDR.csv

10.7.1   CSV Spectrum Export Format

Multiple Spectra are written into a single CSV file, with the data for each Spectrum in a separate column.

If the *Split header and body* option is selected, then the header and body are written into separate CSV files. Otherwise, they are written into a single CSV file header first.

The header contains as many lines as there are Metadata Attributes defined in all of the selected Spectra. The first column of each row is the Metadata Attribute name.

The body contains one row for each wavelength. The first column is the wavelength in nanometres and the subsequent columns are the values at those wavelengths for each selected Spectrum.

The following figure shows an Excel view of a CSV file created with three Spectra and the header and body written into the same file.

	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. [ºC]	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 54: CSV file example (loaded into Excel)

10.8 Export campaign

The Campaign export functionality writes all data of a Campaign to a single XML file which retains the hierarchy and Metadata structure of the Campaign. The information from the Sensors, Instruments and Calibrations used by the Campaign is also copied into the XML file.

These XML files can be used to import the Campaign into another SPECCHIO database instance.

The exported XML file will be named with the Campaign name, date and time of export.

To export a Campaign:

- From the Main menu select *Data Maintenance* - *Export campaign*.
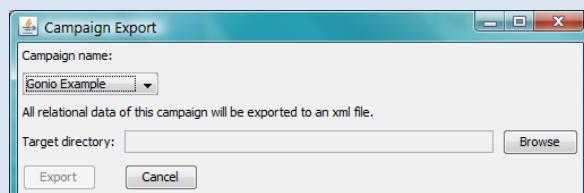
Figure 55: Campaign Export Dialog

- Select the Campaign you wish to export from the *Campaign name:* dropdown list.

- Click **Browse** to open a file dialog box.

- Select the folder into which you want the XML file to be written and close the dialog box.

- Click **Export**. The Campaign Export dialog box will close and a progress box will appear. When the export is complete, it will close.

10.9 Publish Collection

A separate chapter of this User Guide is devoted to this topic. Please see *Section 11 Publishing Data to ANDS*.

11   Data Processing

This section describes the functionalities of SPECCHIO's Main Menu tab *Special Functions.* Here you will find information on how to process data using SPECCHIO's special functions:

11.1 Functions to generate additional metadata

11.1.1   Compute UTC

This tool is provided to compute the capture time in UTC. Starting from SPECCHIO DB version 3.2.1, a new attribute called 'Acquisition Time (UTC)' is supported. The UTC time is computed from the 'Acquisition Date' Metadata Attribute by applying a time shift of a number of hours entered by the user.

To compute Acquisition Times in UTC:

- From the Main menu select *Special Functions* - *Compute UTC*.
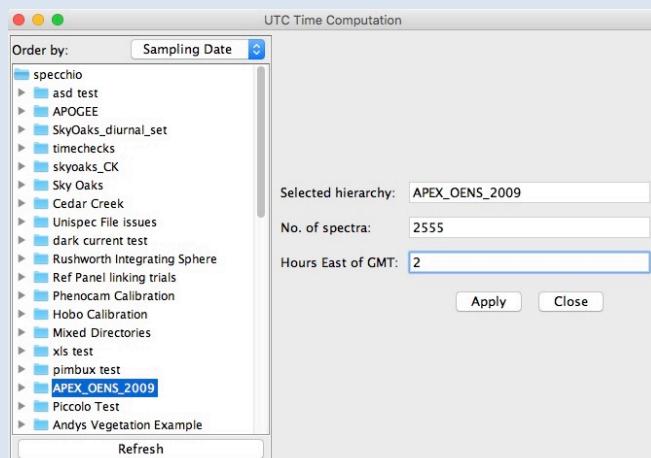
Figure 56: UTC Computation dialog

- Select the hierarchy node containing the Spectra that need UTC to be calculated, or select the individual Spectra files by holding down the Ctrl key. The first selected hierarchy name and the number of Spectra are shown on the right in read only fields.

- Enter the number of hours to adjust in the Hours East of GMT field. Use positive numbers for longitudes East of GMT (that is, the number for Australia will be positive).

- Click **Apply**.

- Close the dialog using the **Close** button.
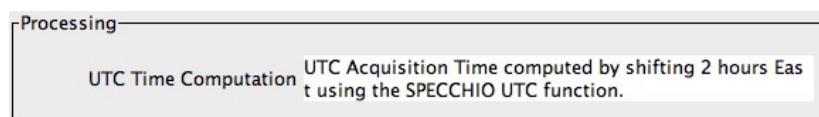
Note: if some error was made during the computation, e.g., the wrong number of hours was entered, reapplying the function will simply overwrite the already existing UTC values in the database.

As date/time fields are stored in milliseconds, the time shift is implemented as:

```
Date_time_in_milliseconds = Date_time_in_milliseconds –
            hours_east_of_gmt*milliseconds_per_hour.
```
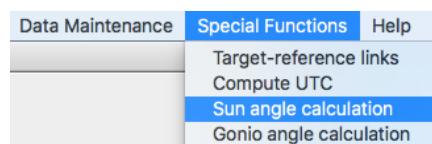
Therefore, if a time shift happens across midnight, the calendar date of the capture time will also be shifted back or forth, depending on whether `hours_east_of_gmt` is positive or negative. For example, for a local capture time around 10am in Oceania a time shift of around 12 hours East of GMT is needed. The UTC time will then be 10pm the previous day.

A UTC Time Computation Attribute value in the Processing Metadata Group is added to each Spectrum that has its UTC Acquisition Time computed by this function.

Figure 57: UTC Time Computation Metadata Attribute after applying a UTC Time computation

11.1.2   Calculation of Sun Angles
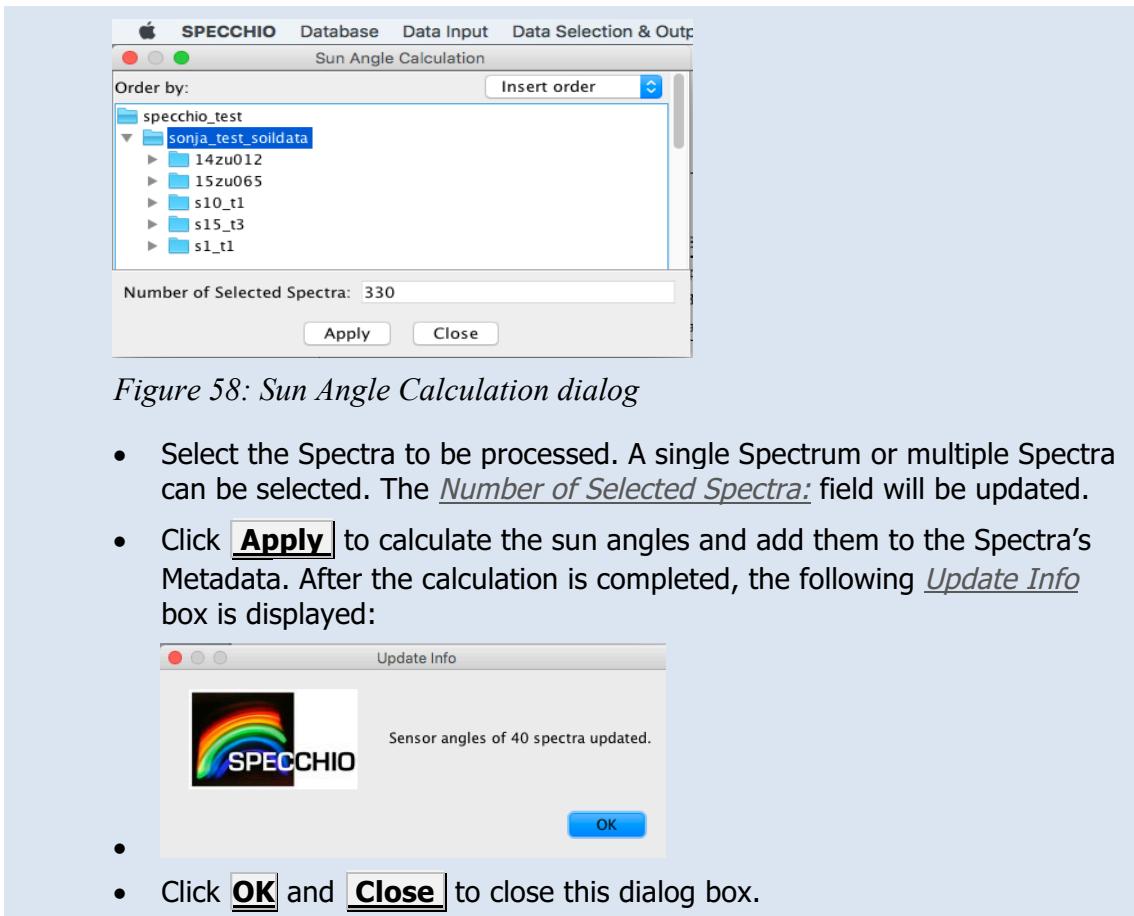
SPECCHIO provides a function to calculate sun angles based on the UTC date and time of the Spectrum acquisition and the spatial position in Latitude and Longitude of the acquisition location.

The sun angles are then automatically stored for each Spectrum as Metadata in the Illumination Group as *Illumination Zenith* and *Illumination Azimuth*.

To Calculate Spectra's Sun Angles:

- Ensure that the Acquisition Time (UTC) has been correctly set for all Spectra (see 11.1.1 on how to compute UTC).

- Ensure that the Spectra's locations are correctly set in the Location Group's Spatial Position Metadata Attributes.

- Select *Special Functions* and *Sun angle calculation* from the menu in the Main Window. A Hierarchy Tree Browser is displayed.

Figure 58: Sun Angle Calculation dialog

- Select the Spectra to be processed. A single Spectrum or multiple Spectra can be selected. The *Number of Selected Spectra:* field will be updated.

- Click **Apply** to calculate the sun angles and add them to the Spectra's Metadata. After the calculation is completed, the following *Update Info* box is displayed:

-

- Click **OK** and **Close** to close this dialog box.

Automatically, a new processing attribute value in the Processing Metadata Group is added to each Spectrum that has its illumination angle attributes computed by this function.

Applying this function twice is safe, as the calculated sun angles will always be the same.

Spectra, which do not have Latitude and Longitude and UTC Acquisition Time values, will not have sun angles calculated for them. If the Latitude or Longitude is outside of the normal ranges (for example, a Latitude value of 115 degrees), sun angles will be calculated, but they will not be meaningful. If UTC times are during the night for the spatial position, sun angles below the horizon will be calculated.

For Spectra with more than one location position (e.g. transects), the central position will be calculated and used as reference position for the sun angle calculation.

11.1.3   Calculation of Goniometer Angles

If a set of Spectra has been captured in a standard way using a supported goniometer, the Sensor orientation parameters (Sensor Zenith and Sensor Azimuth) Metadata Attributes for these Spectra can be computed and assigned using this function.

The supported goniometers are those that use the following measurement pattern.
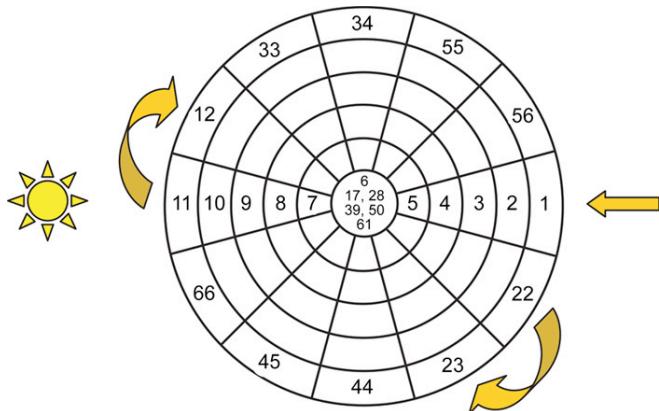
Figure 59: Data capture sequence of the RSL FIGOS/LAGOS system

A full directional set consists of 66 Spectra. These Spectra must be grouped under a single node in the Data Hierarchy Tree.

To calculate goniometer angles for a set of Spectra:

- From the Main menu select *Special Functions* and *Gonio angle calculation*.
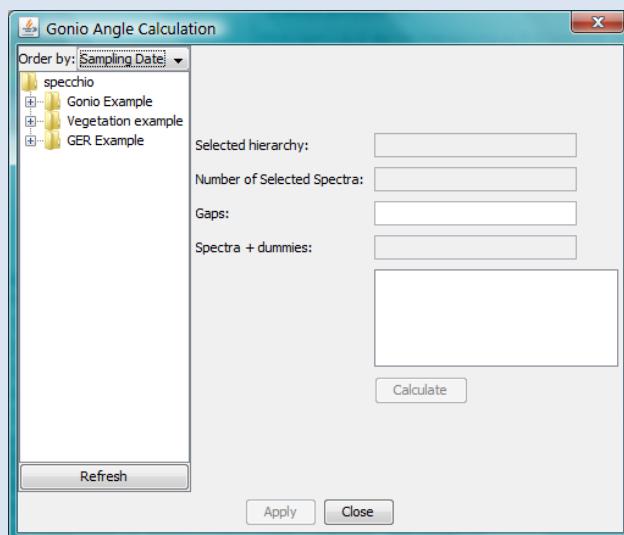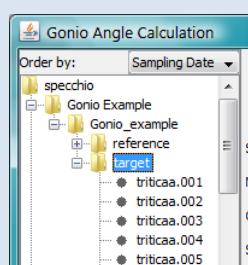
Figure 60: Goniometer angle calculation dialog

- In the data hierarchy browser of the Metadata Editor select the node that contains the spectrodirectional measurement Spectra for which you wish to calculate the Sensor directions.

If you have selected a valid node, SPECCHIO will scan the Spectra to extract the required information. It will take a few seconds. Valid nodes have 66 or fewer

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Spectra. You cannot select the Spectra directly.

- If there are fewer than 66 Spectra, enter the sequence numbers of the missing Spectra, separated by commas, in the *Gaps* field.

- Click **Calculate**. This will fill the *Spectra + dummies:* box with the total number of Spectra after the gaps are inserted. It should be exactly 66. It will also fill the calculation box with the Spectra names, sequence numbers and angles. For example,

  1: 0/75 triticaa.001

where the gonio sequence of triticaa.001 is "1", its Sensor Azimuth is "0" and its Sensor Zenith is "75".

- Review the results in these boxes carefully to see that they are correct. If not, you can repeat any of the steps above and click again on **Calculate**.

- When the results in this box are correct, click **Apply** and the results will be written to the database. After the calculation is completed, the following *Update Info* box is displayed:

-

- Click **OK** and **Close** to close this dialog box.

Automatically, a new processing attribute value in the Processing Metadata Group is added to each Spectrum that has its goniometer angle attributes computed by this function.

It is OK to repeat this process. It will overwrite any previous results.

11.2 Managing Target-Reference Links

You will need to add links from your target Spectra to the related reference Spectra if you want to use some of the Processing options of SPECCHIO.

Note   The dialog boxes for viewing existing links and adding new links appear similar, but there are important differences. Please compare the two dialog boxes carefully in the following sections.

In these dialogs, users with Administrator permission can view and change any data. Other users can view and operate on only the Campaigns they uploaded or for which they are in the Research Group.

11.2.1   Viewing or deleting existing Target-Reference links

From the Main menu, select *Special Functions - Target-reference links* menu items. The following dialog will be displayed. Ensure that the *Show existing links* tab is selected in the centre panel.
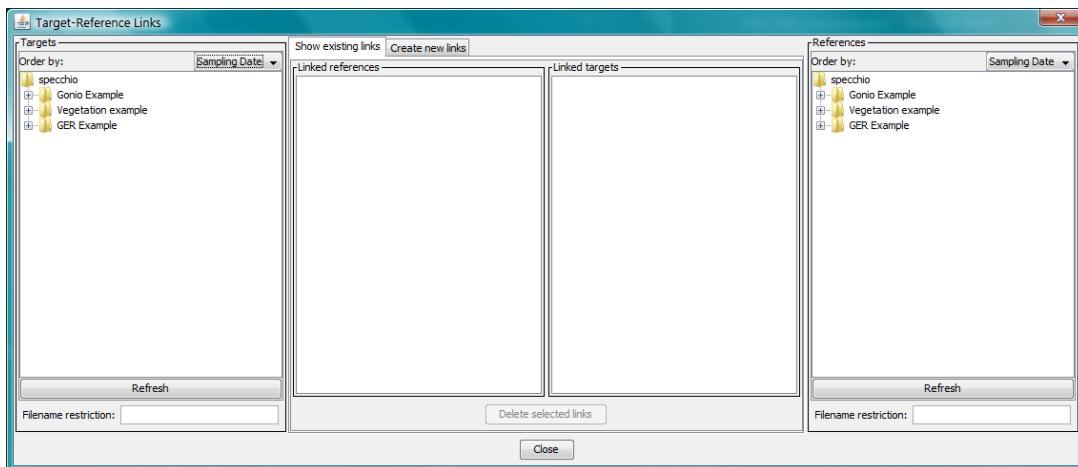
Figure 61: Viewing Target-Reference links

Selecting and expanding nodes within these data hierarchy browsers requires many database accesses, and so can take a little time to complete.

There are two halves to this dialog, which function completely independently.

Left hand side

Use this side to select Target Spectra and see their related Reference Spectra.
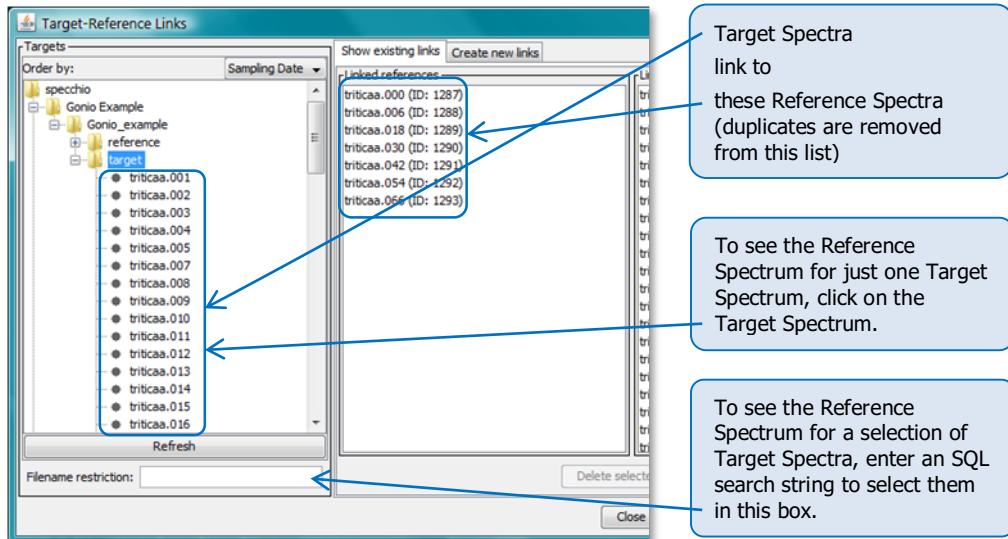
Figure 62: Viewing Target Spectra and their related Reference Spectra

Use this hierarchy tree browser to select one or more Spectra. Enter an SQL matching string in the *Filename restriction* field to restrict the Target Spectra selected. (See *Section 10.2.1*.) This does not affect the display of the Spectra in the hierarchy tree browser display. It only reduces the effectively selected Spectra to those that also match the SQL matching string.

The File Names of all Reference Spectra linked to the selected Spectra will be shown in the *Linked references* box. If you select the Campaign node and clear the *Filename restriction* field, all linked Reference Spectra in the Campaign will be displayed.

If any Target Spectrum is displayed in the *Linked References* box, a link has been set up in the wrong direction.

Because each Target Spectrum should not be linked to more than one Reference Spectrum, the number of Reference Spectra displayed should be less than the number of Target Spectra selected.

Right-hand side

Use this side of this dialog to select Reference Spectra and show their related Target Spectra. It operates in the same way as the left-hand side, but views the links in the reverse direction.
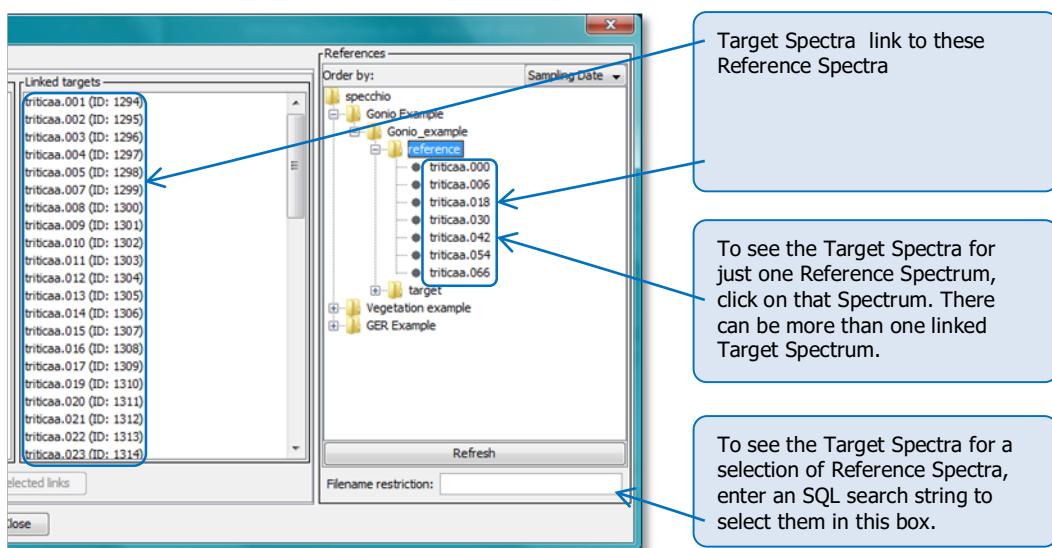
Figure 63: Viewing Reference Spectra and their related Target Spectra

If you select the Campaign node on the right hand side and clear the *Filename restriction* field, all Target Spectra with Reference Spectra links will be displayed.

If any Reference Spectrum is displayed in the *Linked targets* box, a link has been set up in the wrong direction.

Because each Reference Spectrum can be linked from many Target Spectra, the number of Spectra shown in the *Linked targets* box can be many more than the number of selected Spectra.

11.2.2   Deleting Existing Target-Reference Links

The option to delete existing links works simultaneously, but independently, on the two halves of the *Show existing links* dialog.

When the **Delete selected links** button is clicked, all links to and from the Spectra highlighted in the *Linked references* **and** *Linked targets* boxes will be deleted. It is possible to highlight Spectra in one of these boxes only.

After deleting, the *Linked references* and *Linked targets* boxes will be updated. This may take a little time.
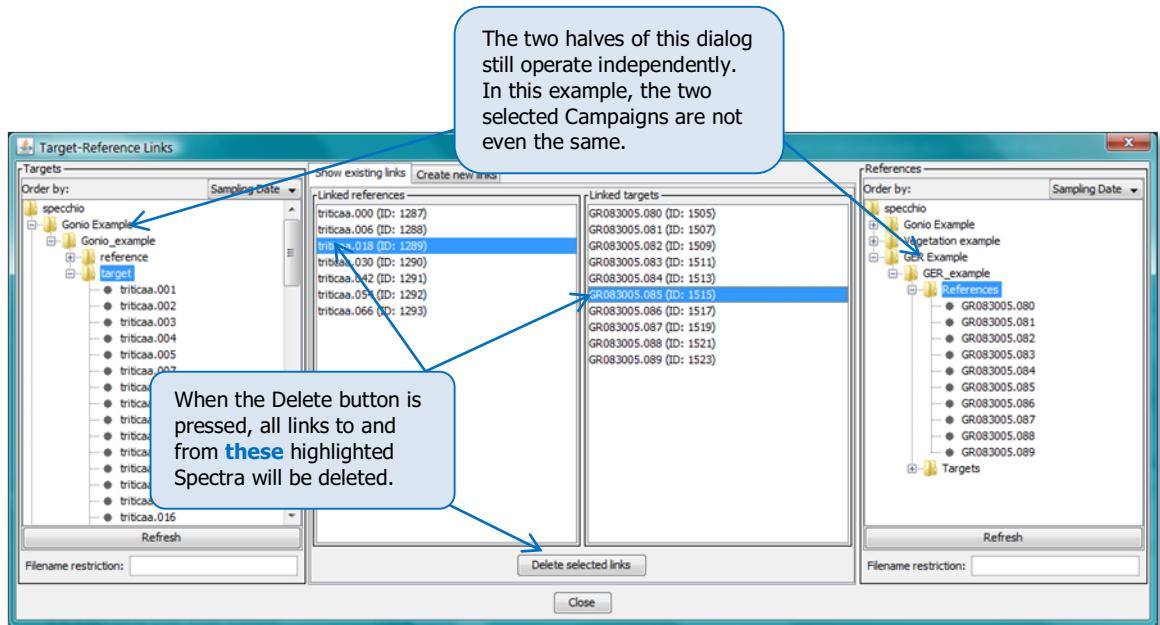
Figure 64: Deleting Target-Reference Spectra links

11.2.3 Adding new Target-Reference links

From the Main menu, select *Special Functions* - *Target-references links* menu items. Click on the *Create new links* tab in the centre panel to display the following dialog. (You can switch back and forth between the *Create new links* and *Show existing links* tabs at any time.)
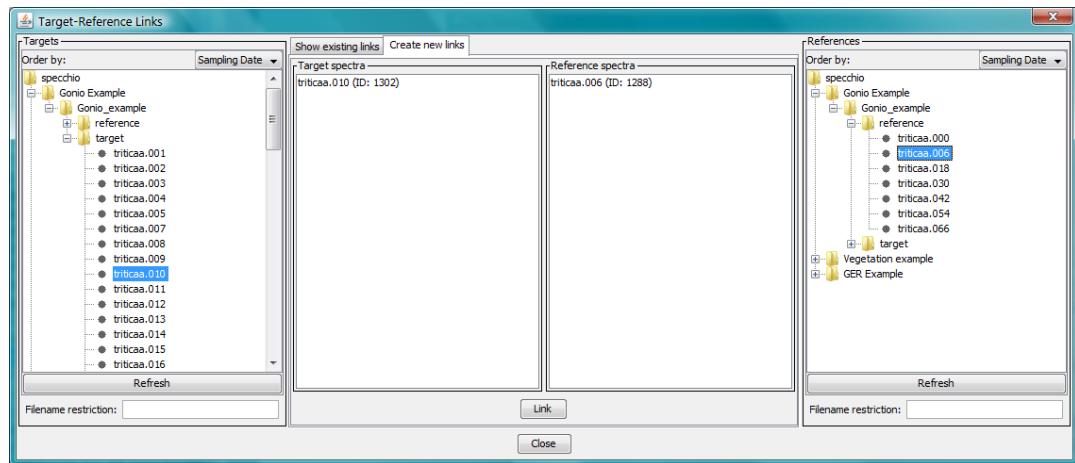
Figure 65: Creating a single new Target-Reference Spectra link

Notes   The left and right sides of this dialog do not operate independently, unlike the dialog which displays links in the previous section.

The positions of the Target Spectra and Reference Spectra boxes in the central panel are reversed when compared with the position of these boxes in the previous section.

To link a single Target and Reference Spectrum:

- Using the left-hand side *Targets* hierarchy tree browser, locate and select the Target Spectrum you wish to link. Its name will be displayed in the Target Spectra box.

- Using the right-hand side *References* hierarchy tree browser, locate and select the Reference Spectrum you wish to link. Its name will be displayed in the Reference Spectra box.
- Verify that the correct Target and Reference Spectra are displayed in the central *Target Spectra* and *Reference Spectra* boxes respectively. Ensure that they are also each in the correct box and not reversed.
- Click **Link** to create the link.

Warnings   Do not click the **Link** button twice. This will add the link twice, even though it is still displayed only once. Duplicated links generally do not cause problems in later processing, but may cause confusion if you later attempt to delete a duplicated link.

Before creating any link, check that the link does not already exist so you do not duplicate it.

It is also possible to create multiple links simultaneously by selecting multiple Target Spectra.

In addition, if multiple Reference Spectra are highlighted, as each Target Spectrum is processed, the Reference Spectrum with the closest Acquisition time Metadata Attribute is selected for linking.
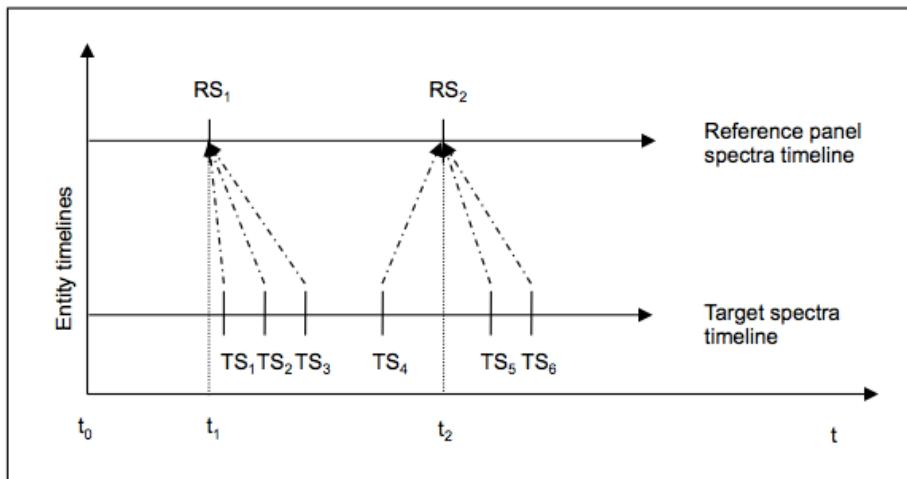
Figure 66: Referencing of reference panel Spectra by target Spectra based on timeline information

This function is useful for campaigns where Target and Reference Spectra are collected in separate Spectral files, for example, when using the ASD spectroradiometer in radiance mode.

Notes   The target-reference links assigned in this manner are a simplification. A more scientific approach to calculating reflectance factors from target and reference radiances is implemented in the Matlab based Reflectance Calculator.
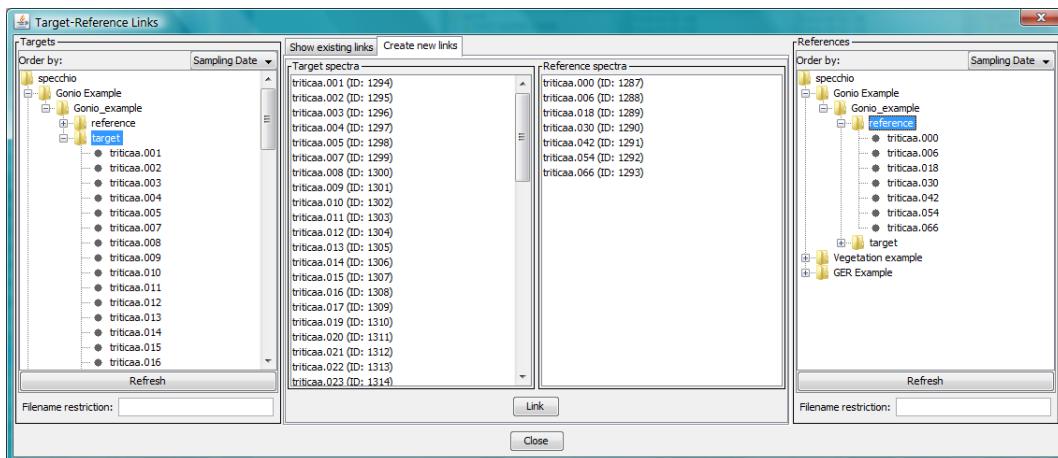
Figure 67: Creating multiple new Target-Reference Spectra links

To create links between multiple targets and references:

- Using the left-hand side *Targets* hierarchy tree browser, locate and select the Target Spectra you wish to link. You can do this by highlighting multiple Spectra or by highlighting a hierarchy node (as shown in Figure 67 above).

- If required, refine your selection by entering an SQL matching string in the related *Filename restriction* field. (See *Section 10.2.1*.)

- Using the right-hand side *References* hierarchy tree browser, locate and select the Reference Spectra you wish to link. You can do this by highlighting multiple Spectra or by highlighting a hierarchy node (as shown in Figure 67 above)

- If required, refine your selection by entering an SQL matching string in the related *Filename restriction* field. (See *Section 10.2.1*.)

- Verify that the correct Target and Reference Spectra are displayed in the central *Target Spectra* and *Reference Spectra* boxes respectively. Ensure that they are also each in the correct box and not reversed.

- Click **Link** to create the links according to the method described above.

11.2.4   Creating Data Links in the Metadata Editor

The dialog the link Targets and Reference as introduced in the above sections is set up to deal with single links between target and reference spectra.

For a more flexible approach Data Links can also be created in the Metadata Editor using a basic number input field to enter spectrum ids (Figure 68). Multiple entries are possible.

The easiest way to populate the field with a spectrum id is to open a Data Browser in a parallel window and just copy/paste spectrum ids as required. Information on referenced spectra can be shown as spectrum report by clicking the 'Show linked spectrum' button.
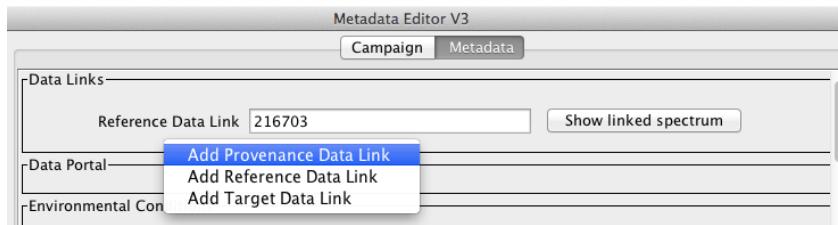
Figure 68: Editing of Data Links in the Metadata Editor

12   Data Maintenance

This section describes the functionalities of SPECCHIO's Main Menu tab *Data Maintenance*. You will find information on how to use these functions. Note that most of these functions require specific user permissions:

> **Data Maintenance**
> • Remove data
> • Load sensor definition
> • Instrumentation admin
> • Reference panel admin

12.1 Remove data

Spectra, hierarchies or entire Campaigns can be removed from the database using the Data Remover.

Users can only remove data from the database if they are a member of the Campaign's Research Group (see *Section 6.3 Research Groups and Accessing SPECCHIO Campaigns*. A user with Administrator permissions can remove all datasets irrespective of their owner.

To remove data:

- From the Main menu select *Data Maintenance* - *Remove data*. The following window is displayed. Only the Campaigns which you have permission to remove will be displayed:
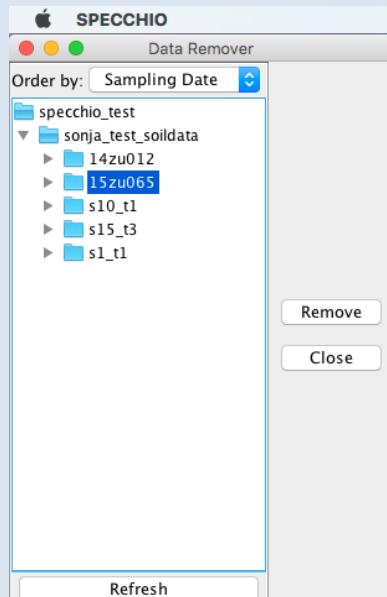
Figure 69: Data Remover dialog

- Use the Spectral data browser to select the nodes or Spectra that you wish to remove. Multiple Spectra and nodes can be selected by using the Shift and Control keys. You can select any node except the *Specchio* database root node. Selecting a Campaign node is valid.

- Click **Remove**. All data that is below the selected node or nodes will be deleted. For example, 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 the deleted objects will be removed along with the objects.
>
> - Close the dialog box by clicking **Close**.

Warning	There is no further prompt to warn you. The data are deleted as soon as you click the **Remove** button. This action cannot be undone.
	Removing data can take a long time. A progress bar shows which hierarchy is currently being removed.

12.2 Load sensor definition (Obsolete)

A new Sensor can be defined by loading a Sensor definition file. Once defined, it will appear in the dropdown list of Sensor names which appears at several places within SPECCHIO.

Note	This function is essentially obsolete as new sensors are automatically generated upon loading. The only information that usually may be a bit sparse is the exact sensor name or type designator as these are taken from information generated by the file readers in turn. Editing sensor information must be done directly on the database by an administrator, e.g. by using MySQL Workbench.

Warning	Take care when defining new sensors. There is no method of editing or inspecting Sensor information using the SPECCHIO Client. Therefore, there is no method of confirming that your data was entered correctly, so prepare your input Sensor definition file very carefully.

To load a Sensor Definition file:

- From the Main menu select *Data Maintenance* - *Load sensor definition*. The following dialog is displayed:
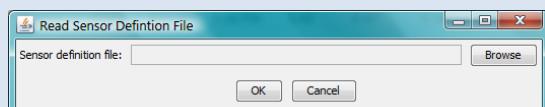
Figure 70: Read Sensor Definition File dialog

- Click **Browse**, navigate to the Sensor definition file and open it.
- Click **OK** to read the file and insert the new Sensor into the database.

Sensor definition files are a proprietary format tab separated text file that can be edited in a text editor or in Excel. The file format is as follows (the tab positions have been lined up for clarity):

```
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>
<band number>    <wavelength>  <fwhm>
<band number>    <wavelength>  <fwhm>
```

:
:

The first two rows define basic parameters of this Sensor, the first row being the names of the five parameters which are required and the second row being their values. These parameters must be provided in the given sequence. The names in the first row are required and must be correct.

<sensor name>	The name by which this new Sensor will be known to SPECCHIO. It will appear in the Sensor Metadata Attribute's dropdown list.
<sensor descr>	A short description of this Sensor
<company name>	The name of the company which manufactures this Sensor. It must exactly match the value in the short_name column for one of the manufacturers in SPECCHIO's predefined manufacturer's table. See Appendix B: Predefined Manufacturer Table for the list of manufacturers and their short_name values.
<type number>	SPECCHIO will attempt to match this integer number to the Instrument Type number in Spectrum files when they are read. This is used to automatically set the Sensor in the Spectrum's Metadata.
<no of channels>	The number of frequency channels measured by this Sensor. This must be the same as the number of lines in the Band Table in this file.

The third row must have the headings of the parameters for each band.

Rows 4 to 3 + <no of channels> must have three numeric values on each line.

`<band number>` An integer number, starting at 1 and incrementing for each band in the Band Table.

`<wavelength>` The central wavelength of this band in nanometers.

`<fwhm>` The Full Width at Half the Maximum value for this band. The value is difference of the upper and lower frequencies in nanometers. *This value is presently ignored. (It is included for possible later new features.)*

Notes on the file format.

- There must be exactly one tab character between each field.
- The lines must not start with a tab character.

Example

An Excel view of a Sensor Definition File.

Figure 71: Part of a Sensor definition file being edited in Excel

A text file view of the same file. Note that the tab positions do not appear to line up when displayed this way.

```
Name Description Company      Type no   no of channels
ASD FSFR   ASD Fieldspec FR  ASD       4         2151
Band Average Wavelength (nm) Full Width at Half the Maximum FWHM (nm)
1    350    2
2    351    2
3    352    2
4    353    2
5    354    2
6    355    2
7    356    2
8    357    2
9    358    2
10   359    2
11   360    2
12   361    2
13   362    2
14   363    2
15   364    2
16   365    2
17   366    2
18   367    2
19   368    2
20   369    2
21   370    2
```

12.3 Instrument Administration

Note   Any user can open the Instrument Administration dialogs but only Administrators can save changes to the database.

For each Instrument in the SPECCHIO database, the following fields are stored.

Field name	Format	Comments
Instrument name	Text string	This name will appear in the dropdown list of Instruments.
Instrument owner	Selected from dropdown list of Institutes	This Institute list is created in the Create new institute dialog. See *Section 3.4.*

Serial number	Text string	The Instrument's physical serial number.
Sensor	Selected from dropdown list of Sensors defined in database	Defines the Instrument type or model for this particular Instrument.
Pictures	JPEG image (on some users' computers, PNG, GIF or TIFF may also be supported.)	Multiple pictures of the Instrument may be uploaded to each Instrument definition.
Calibrations	See *Section 12.3.1 Instrument Calibrations*.	Multiple Calibrations make up the Calibration history for each Instrument.

To open the Instrument Administration dialog:

- From the Main menu select *Data Maintenance* and *Instrumentation Admin.*.

- Click in the *Instrument Data* tab.
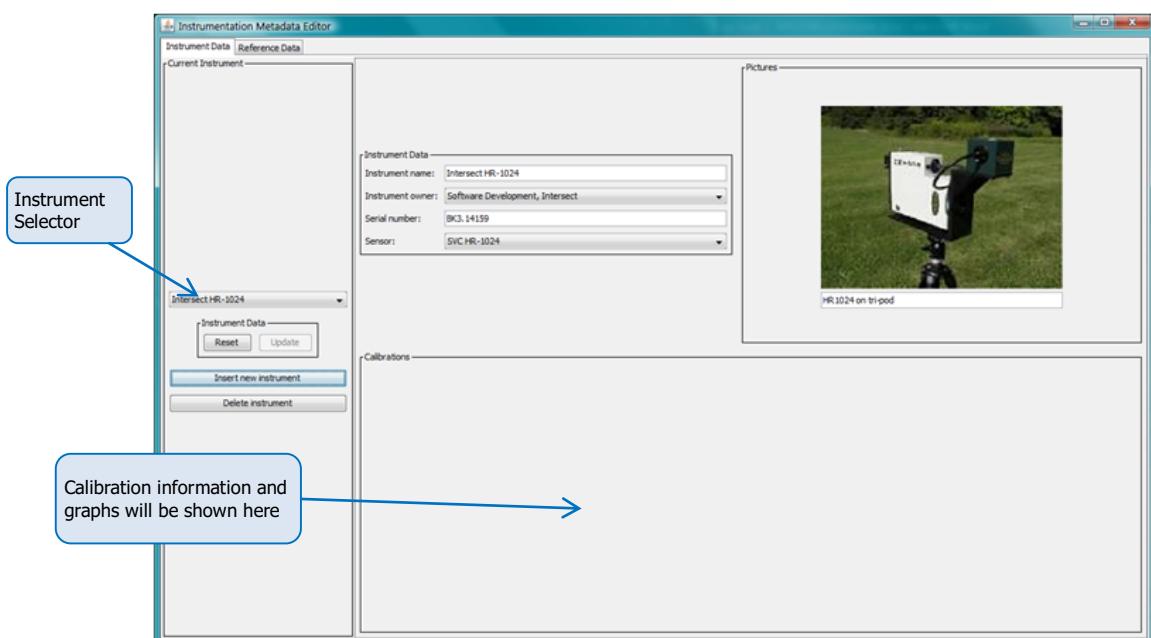
Figure 72: Instrument Data Editor

The various parts of this dialog and their operation are explained in the following table.

Instrument Selector	This dropdown list includes all Instruments in the SPECCHIO Instrument Table. Use this to select which Instrument you wish to view or edit.
Instrument Data	There are two related boxes with this title. One shows the data for the Instrument Selected by the Instrument Selector. You can modify the data displayed in this box. The other has two buttons.
Reset	Click this button to reset the display in the Instrument Data box with information re-read from the database.

Update	Click this button to write any updated data entered into the fields in the Instrument Data box back to the database. This button is only active for users with Administration permission.
Pictures	Any picture of the Instrument uploaded to the database is displayed in this box.
Calibrations	This box shows all Calibrations which have been uploaded for this Instrument.
Insert new instrument	Click this button to create a new Instrument in the database. Set the correct details for this new Instrument in the Instrument Data fields, and then click Update to write this new data back into the database. This button is only active if you have Administrator permissions.
Delete instrument	Click this button to delete the currently displayed Instrument. You must click OK in a confirmation dialog box which is displayed before the Instrument is deleted from the database. This button is only active if you have Administrator permissions. An Instrument cannot be deleted while still referenced by one or more Spectra in the database.

Each Instrument can have one or more pictures loaded. JPEG images are supported on all platforms. On some computer systems, GIF, PNG and TIFF may also be supported. It is recommended not to load large images to avoid lengthy upload times. Images should generally be re-sampled to be about 400 to 500 pixels high or wide.

To add a picture to the currently displayed Instrument definition:

- Right click anywhere within the *Pictures* box. A menu will be displayed.

- Click *Add picture* from this menu. A file selection dialog box is displayed.

- Select the image file you wish to upload. The image will appear in the *Pictures* box with a space for a caption below it.

- Click within the caption entry control and type in your required image caption.

- Click the **Update** button to load the image and caption to the database. (Larger images may take a short while to upload.)

Note | If you decide against uploading your new selected image, click the **Reset** button. Do not right click and select *Remove Image*. This may not yield the desired result when **Update** is clicked.

To remove a picture from the currently displayed Instrument definition:

- Right click on the image you wish to remove. A menu will be displayed.

- Click *Remove picture* from this menu. The picture and its caption will disappear from the *Pictures* box.

- Click Update to write this change to the database.

12.3.1   Instrument Calibrations

Note	SPECCHIO versions 3.1 and higher automatically insert wavelength calibration data upon spectral file loading. The manual handling of instrument calibrations as described here is essentially no longer required.

Each Instrument has an optional Calibration History with one or more Calibrations. When Spectra from an Instrument are processed, the Instrument's Calibration History is searched for the most recent Calibration at the time each Spectrum was acquired. If there is no Calibration History, or the acquisition time precedes the date of the first Calibration, the Instrument's Sensor definition is used instead.

For each Calibration, the following information can be stored.

Field name	Format	Comment
Calibration date	Date/time selected by date picker	The date on which this Calibration was performed. Where possible, SPECCHIO will use the Calibration with the most recent date and time which is prior to the Acquisition date/time of the Spectrum being processed.
Calibration number	Integer	The sequence number of this Calibration. If there is insufficient date information, and a Calibration Number is given in the Spectrum's Metadata, SPECCHIO will attempt to select a Calibration based on this Calibration sequence number. It usually starts at 0 and is incremented for each new Calibration. However, this is not a SPECCHIO requirement.
Comments	Text String	A comment about this Calibration.
Calibration wavelengths	Floating point array	Table of wavelengths of the centre of each band. The number of entries in this table must match the number of entries in the Sensor definition for this Instrument.

Calibrations can be added from a file or manually entered. If added from a file, they are complete Calibrations. If added manually, they are place markers only and do not contain enough information to be used as a Calibration. They should be replaced with a Calibration uploaded from a file when that information is available.

SPECCHIO supports the following formats for loading Instrument Calibrations.

- Unispec SPU files

- SpectraVista SIG files (Only HR-1024 has been tested)

Note	ASD calibration files cannot be loaded as SPECCHIO calibration files. The Spectra from these Instruments are adjusted according to the calibration within the ASD Instrument itself and so there is no requirement to load them here.

SPECCHIO reads the centre wavelengths of the Instrument bands from these files, but ignores the Spectrum values when reading these files as Calibration files. In normal operations, the same file which is used to load an Instrument Calibration would also be read by the general Campaign Spectra load process (see *9.1_Overview of SPECCHIO Data Loading*).

Note	Other file formats which also store centre wavelengths of bands (such as Ocean Optics, UniSpec single beam, GER 3700 or APOGEE) are not yet supported by SPECCHIO for Calibration file reading. Attempting to use these file formats may lead to unpredictable results.

To add a new place marker Calibration:

- Select the correct Instrument to display its data.

- Right click anywhere within the *Calibrations* box. A menu is displayed.

- Select *Add calibration* from this menu. A new Calibration with empty information is immediately loaded to the database and displayed.

- Enter the required Calibration identification parameters. You cannot enter the actual calibrated values.

- Click **Update** to write the new Calibration information back to the database.

To add a new complete Calibration from a file:

- Select the correct Instrument to display its data.

- Right click anywhere within the *Calibrations* box. A menu is displayed.

- Select *Add calibration from file* from this menu. A file selection dialog is displayed.

- Select the Calibration file (Unispec SPU file or SpectraVista SIG file) you wish to upload.

To remove a Calibration:

- Right click anywhere over the Calibration you wish to remove from this Instrument's information. A menu is displayed.

- Select *Remove calibration* from this menu. The Calibration information is immediately removed from the database and remove from the display in the *Calibrations* box.

Warning	Calibration removal is immediate and cannot be undone. Please take care not to select this option for Calibrations you do not wish to remove.

12.4 Reference Panel Administration

Note	In order to change or remove Reference Panel information, you must be logged in as an Administrator.

SPECCHIO stores a table of Reference Panel information. The Reference Panels in this list appear in the dropdown list for the Reference Metadata Attribute in the Instrumentation Group. This Metadata Attribute is used in some functions of the Space Processing Network described in *Section 13 Interactive Processing using Space Networks*, and in particular during the reference panel correction procedure as described in *Section 13.4.2 Reference Panel Correction Factors* and *Section 13.4.3 Correct for Reference Panel Non-Idealness*.

Each Reference Panel record holds the following information.

Field name	**Format**	**Comment**

Reference name	Text string	This name will appear in the dropdown list of Reference Panels, which is used to set the Reference Metadata Attribute in the Instrumentation Group.
Reference owner	Selected from dropdown list of Institutes	This Institute list is created in the Main Window. See *Section 4.1*.
Serial number	Text string	The Reference Panel's physical serial number
Reference brand	Selected from predefined dropdown list	There is presently only one brand (Spectralon) defined in SPECCHIO. If you require further brands to be added, speak to your System Administrator.
Pictures	JPEG image (on some users' computers, PNG, GIF or TIFF may also be supported.)	Multiple pictures of the Reference Panel may be uploaded to each Reference Panel definition.
Calibrations	See section *12.4.1 Reference Panel Calibrations*.	Multiple Calibrations make up the Calibration history for each Reference Panel.

When the SPECCHIO database is installed, the table of Reference Panels is empty.

To open the Reference Panel Administration dialog:

- Select *Data Maintenance* and *Instrumentation Admin.* from the menu on the Main Window.

- Click in the *Reference Data* tab.
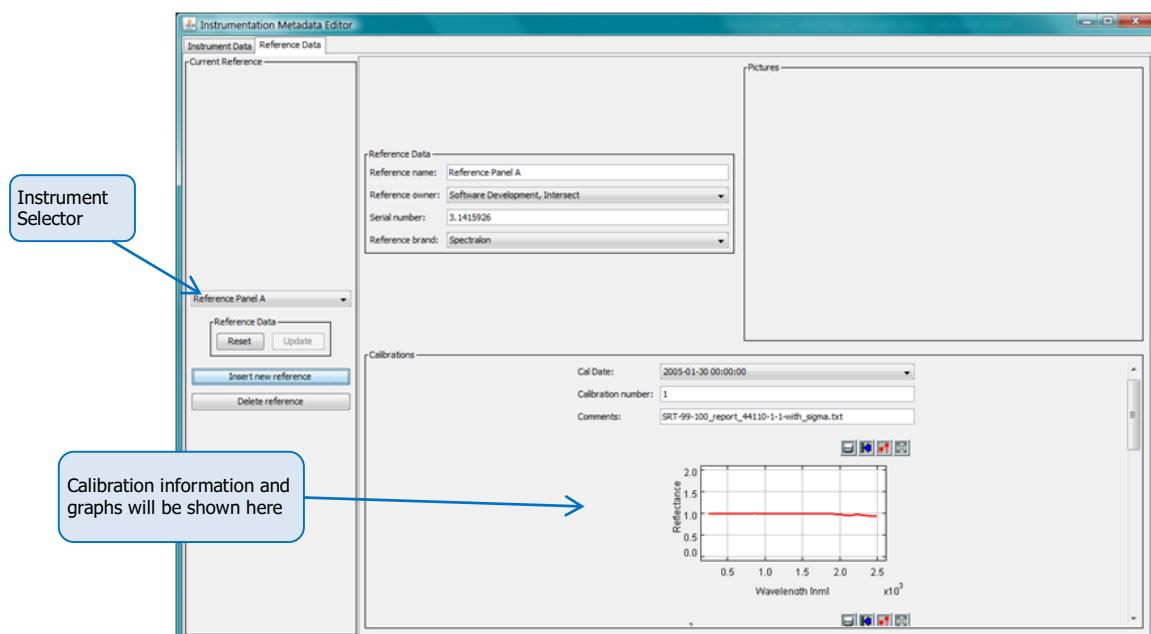
Figure 73: Reference Data Editor

The operation of the Reference Panel dialog is analogous to that for Instruments. Refer to *Section Instrument* and use the instructions in that section and its sub-section on *Instrument Calibrations* to understand the operation of Reference Panel viewing and maintenance.

12.4.1   Reference Panel Calibrations

Each Reference Panel can have one or more Calibrations defined. For each Calibration, the following information can be stored.

Field name	Format	Comment
Calibration date	Date/time selected by date picker	The date on which this Calibration was performed. Where possible, SPECCHIO will use the Calibration with the most recent date and time which is prior to the Acquisition date/time of the Spectrum being processed.
Calibration number	Integer	The sequence number of this Calibration. If there is insufficient date information, and a Calibration Number is given in the Spectrum's Metadata, SPECCHIO will attempt to select a Calibration based on this Calibration sequence number. It usually starts at 0 and is incremented for each new Calibration. However, this is not a SPECCHIO requirement.
Comments	Text String	A comment about this Calibration.
Calibration table	Table	A table of calibration values at various wavelengths with the following fields. Wavelength The wavelength in nanometres at which the Calibration values apply Rho The reflectance factor of the panel at this wavelength, in the range 0 to 1 Sigma The uncertainty estimate of the Rho value, expressed as a standard deviation

Calibrations can be added from a file or manually entered. If added from a file, they are complete Calibrations. If added manually, they are place markers only and do not contain enough information to be used as a Calibration. They should be replaced with a Calibration uploaded from a file when that information is available. Calibrations do not need to be loaded in chronological order, but they will be used according to their dates.

The Calibration file supplies the Wavelength/Rho/Sigma table. The Calibration date, Calibration number and comments must be manually updated after the table is loaded. This file is formatted as follows…

- A tab separated text file, usually with TXT extension.

- The first line must be a heading line. Its first value must be exactly "wvl" and there must be a heading for the Rho column.

- The entry for each wavelength is on a new line.

- The values on each line are in the sequence Wavelength, Rho and Sigma.

- The Sigma value is optional. However, if it is present, it must be present on all lines, and there must also be a heading for it in the first line of the file.

Note   For Spectralon calibration files as provided by LabSphere, if required, uncertainty information must be added by the user to the file before loading.

Example

```
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
    :
    :
```

Before loading a calibration file, a Sensor definition fitting the wavelengths of the calibration must be present in the database. In the case of Spectralon reference panels, the Sensor definition is the Perkin-Elmer Lambda 19 Sensor.

To add a new place marker Calibration:

- Select the correct Reference Panel to display its data.

- Right click anywhere within the *Calibrations* box. A menu is displayed.

- Select *Add calibration* from this menu. A new Calibration with empty information is immediately loaded to the database and displayed.

- Enter the required Calibration identification parameters. You cannot enter the actual calibrated values.

- Click **Update** to write the new Calibration information back to the database.

***To add a new complete Calibration from a file:***

- Select the correct Reference Panel to display its data.

- Right click anywhere within the *Calibrations* box. A menu is displayed.

- Select *Add calibration from file* from this menu. A file selection dialog is displayed.

- Select the Calibration file you wish to upload.

To remove a Calibration:

- Right click anywhere over the Calibration you wish to remove from this Instrument's information. A menu is displayed.

- Select *Remove calibration* from this menu. The Calibration information is immediately removed from the database and remove from the display in the *Calibrations* box.

Warning   Calibration removal is immediate and cannot be undone. Please take care not to select this option for Calibrations you do not wish to remove.

13   Help Functions

The Help functions do not affect your data or the SPECCHIO Database. They are selected from the menu on the Main Window.

13.1 List available Metadata Elements

This function will launch your computer's default text editor and open a text file which lists all of the Metadata Attributes which are supported by the connected database.

It shows the Metadata Groups, the Attributes in each Group, and the data type for each Attribute.

The data type values and their meanings are:

binary_val	The value is a binary stream of data representing an image, such as a JPEG image file.
boolean_val	A Boolean value. True if box is checked, False otherwise.
datetime_val	The value is selected from a date and time picker.
double_val	A floating point value
int_val	An integer value
string_val	An alphanumeric string or a PDF file
taxonomy_id	The value is chosen from a drop down list.
spectrum_id	An integer that refers to the id of a spectrum in the database.

13.2 Get SPECCHIO user contacts

This option is available to SPECCHIO administrators only.
It returns a list of user emails to enable the distribution of information about the SPECCHIO database, such as upgrade instructions or maintenance windows.

13.3 About

This function shows the version of the SPECCHIO Client that you are running and provides a link to the SPECCHIO web site.

14   Publishing Data to ANDS

Data from SPECCHIO can be published to the Research Data Australia (RDA) service of the Australian National Data Service (ANDS). From the ANDS website...

> *Research Data Australia, the flagship service of the Australian National Data Service (ANDS), provides a comprehensive window into the Australian Research Data Commons.*

> *Research Data Australia is an Internet-based discovery service designed to provide rich connections between data, projects, researchers and institutions, and promote visibility of Australian research data collections in search engines.*

> *ANDS is partnering with research institutions and data producing agencies to bring about four transformations to data - unmanaged to managed, disconnected to connected, invisible to findable and single use to reusable - that will enable Australia's research data to become a national strategic resource to support better, more efficient and defensible research, and improved policy input.*

> *ANDS is funded by the Australian Government through the National Collaborative Research Infrastructure Strategy (NCRIS) and the Education Investment Fund (EIF) Super Science Initiative.*

See http://www.ands.org.au/ and https://researchdata.ands.org.au/ for more information on ANDS and this service.

In SPECCHIO, you can only Publish data for which you are the owner or a member of the Research Group.

Publication from SPECCHIO involves these key steps.

1. Decide on the Spectra to be grouped together and published as a Collection. The Spectra can be all of a Campaign, part of a Campaign, or even be selected from multiple Campaigns.

2. Ensure that the Spectra in the Collection are complete and meet the minimum Metadata requirements for Publishing. See the following page for a description of Metadata used for Published Collections.

3. Decide on the Principal Investigator, and ensure their SPECCHIO User information is correct and up-to-date.

4. Publish the Collection, indicating the Collection name, Collection description and Principal Investigator.

5. SPECCHIO generates an ANDS Collection Key for this Collection and writes it to all Spectra in the Collection key Metadata Attribute in the Data Portal Group.

The ANDS Collection Key can be used to identify the Spectra in this Collection by searching for it using SPECCHIO's Query Builder. Each Spectrum will have one ANDS Collection Key Metadata value for each Collection in which it has been included.

Warning	Once Published, there is no way to retract the Publication using the SPECCHIO client. You will need to approach your System Administrator if you have Published in error.

When data are published, SPECCHIO reformats the Metadata from the selected Spectra into the RIF-CS format, which is an XML format involving two files. It then places those files in a discoverable location on the server. On a regular basis (currently daily), the RDA service inspects this location. If there are any RIF-CS files present, it copies them, validates them and, if they pass validation, publishes the Collection description on RDA for general access. Information about the RIF-CS format can be found on the ANDS website referred to at the start of this Chapter.

Note	The RIF-CS file is a logical reference to your Spectral data, so it's important to ensure that this data remains valid and accessible in the SPECCHIO database. This will ensure that it can be provided at a later time to those that request it based on the Published ANDS information.

In the Publication step, the SPECCHIO server fills RIF-CS fields using the following Metadata. Most Metadata is either automatically generated by SPECCHIO itself, or drawn from data set during the creation of user accounts and/or the publication process. Some other Metadata, however, must first be set in the metadata editor if you wish it to be sent to ANDS.

RIF-CS Field	SPECCHIO Field	Notes
Collection Key	The collection key generated by the SPECCHIO server. The University of Wollongong's server generates keys of the form `uow.edu.au/SL/COL/nnnn`, where nnnn is a serial number generated by the SPECCHIO server. This value will be as ANDS Collection Key in SPECCHIO's metadata.	Generated by SPECCHIO.
Collection Name	The collection name value specified in the ANDS Collection Key dialog. This value will be saved as ANDS Collection Name in SPECCHIO's metadata.	Mandatory, filled during publication.
Collection Description	The collection description specified in the ANDS Collection Key dialog. This value will be saved as ANDS Collection Description in SPECCHIO's metadata.	Mandatory, filled during publication.
Group	The institution of the principal investigator.	Mandatory, filled during account creation.
Date	The earliest Acquisition Time of any Spectrum in the Collection.	Mandatory.
Identifier (local)	An identifier generated by the SPECCHIO server. The University of Wollongong's server generates local identifiers of the form `Collection~nnnn` where nnnn is a serial number.	Generated by SPECCHIO.
Identifier (doi)	The Digital Object Identifiers associated with every Spectrum in the Collection.	Optional.
Location (electronic)	The e-mail address of the Principal Investigator.	Mandatory, filled during account creation.
Location (physical)	The Department and Institute of the Principal Investigator.	Mandatory, filled during account creation.

Coverage (temporal)	The range of Acquisition Times present amongst Spectra in the Collection.	Optional.
Coverage (spatial)	The Location Name of the last Spectrum in the Collection.	Optional.
RelatedObjects	The ANDS Party Identifier of the Principal Investigator.	Filled by SPECCHIO.
Subjects	The FOR Codes of all Spectra in the Collection.	Mandatory.
Rights	The Data Usage Policies of all Spectra in the Collection, or a standard-form text generated by the SPECCHIO server if no Spectra have policies.	Mandatory.

In addition, User Information for the nominated Principal Investigator is copied to the published files as follows (The User Information for the User doing the SPECCHIO publication operation is not used, unless of course, it's the same User.)
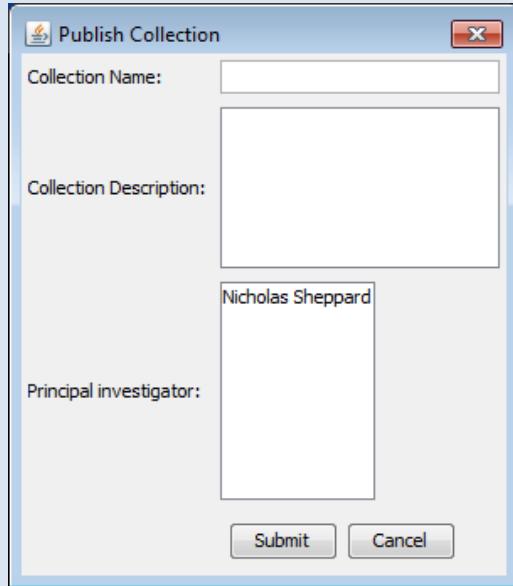
RIF-CS Field	SPECCHIO Field
Key	ANDS Party Identifier.
Group	Department and Institute.
Name	First Name and Last Name.
Description	Description
Relation	The ANDS Collection Key of the Collection just published.
Subjects	The FOR Codes of the Collection just published.

Refer to 4.1 for more information, especially information on the ANDS Party Identifier.

To Publish a Collection to ANDS:

- Ensure that all Spectra to be included in the Collection have their Metadata set correctly as described above.
- From the Main menu select *Data Processing & Output - Browse data hierarchy*.
- Set the *Show only my data* option.
- Select the Spectra to be included in the Collection in the Data hierarchy browser.
- Review carefully that you have selected the correct Spectra. (**Important** – do not skip this step, because you cannot retract once you have Published.)
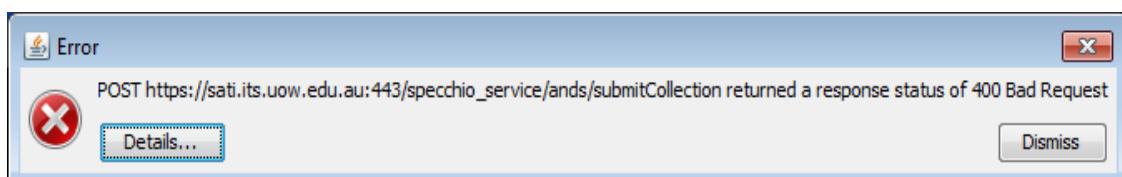
- Click **Publish**. The following dialog, which shows all members of the Research Group, is displayed:
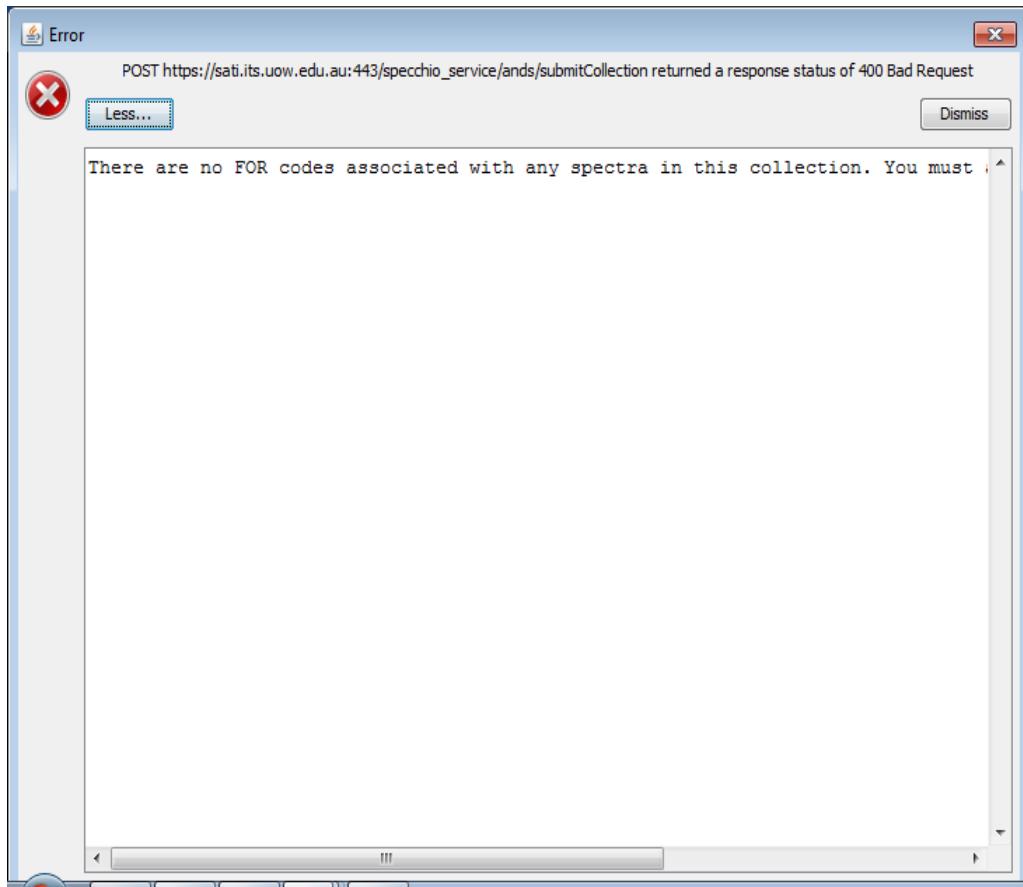

- Fill in the collection name and description. If the selected set of Spectra have already been published as a Collection, the dialog should be pre-filled with the existing name and description.

- Select the principal investigator from the list by clicking on the name.

- Click **Submit**. If the Collection Metadata is successfully validated, the Publication will proceed and a dialog box will be displayed showing the ANDS Collection Key that was assigned to this Publication. (If validation is not successful, an error dialog will be displayed.)

- Click **Close** to close the ANDS Collection Key dialog.

Alternatively, you can select _Build query_ instead of _Browse data hierarchy_ in the above process, and build a query to select the Spectra you want included in your Collection.

If any mistake in the Metadata is detected for the Spectra in your Collection, SPECCHIO will display an error dialog similar to the following:

Press **Details...** to display the error message returned from the server. This error message should explain the problem with the proposed Collection, as shown below.

Press **Dismiss** to remove the dialog. Correct the error and retry the Publication process.

15   Interactive Processing using Space Networks

For an introduction to the concept of the Spaces and the Space Factory please refer to *Section 5.2 Spaces and the Space Factory*.

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.
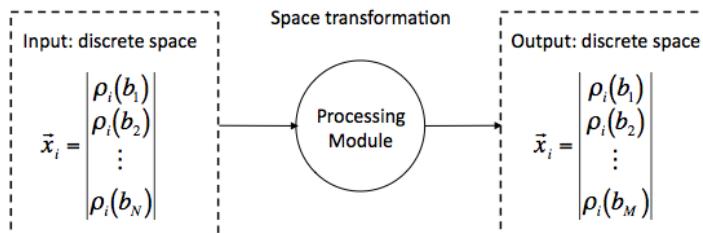

Figure 74: Transformation into a new space by a processing module

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 74 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.

Pressing the **Process** button in the Data Hierarchy Browser or Query Builder starts this processing tool. The window below appears.
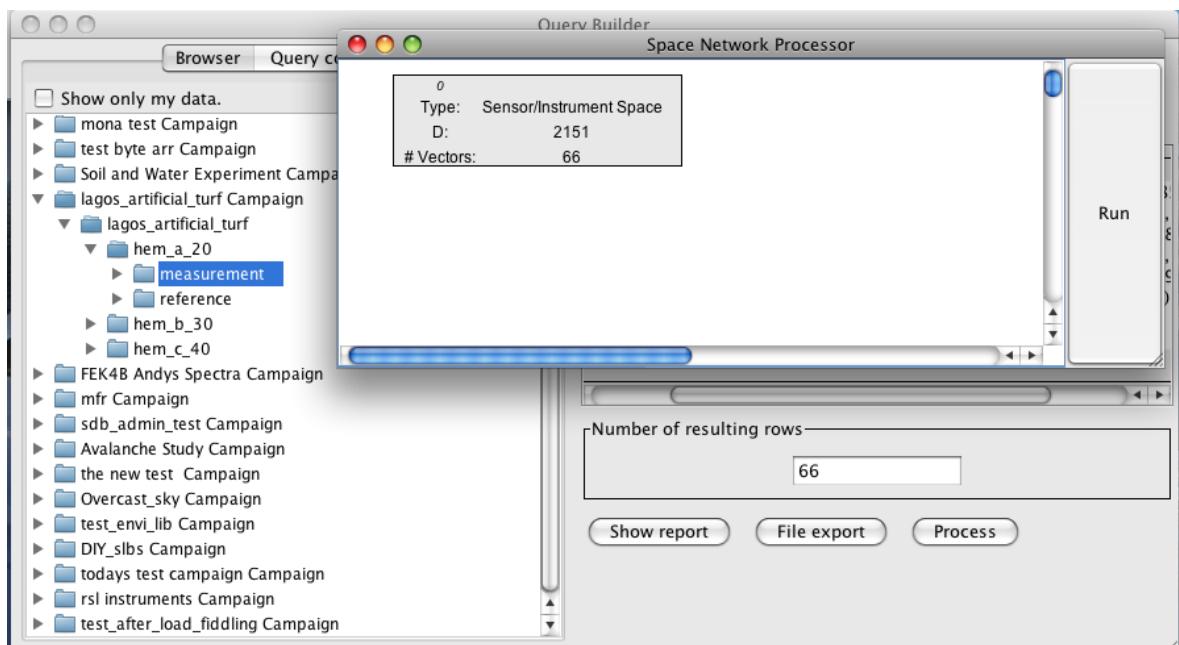

Figure 75: Space Network Processor interface with the Query Builder in the background

A number of spaces are placed on the processing plane of the Space Network Processor, depending on the query built in Query Builder.

Figure 75 shows a space containing 66 Spectra, created based on a selection in the Query Builder.

Figure 76 shows the common elements of the Space Network Processor: processing plane, spaces, edges, context sensitive menu of the processing plane and the Run button.
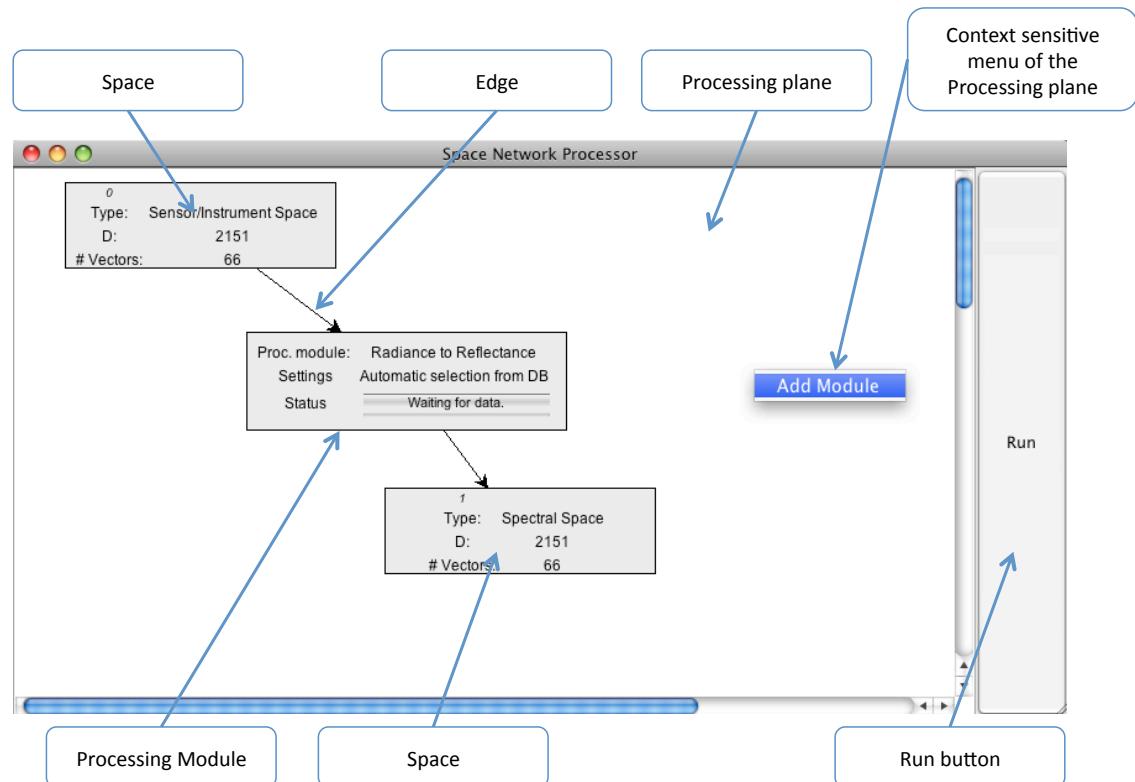

Figure 76: Elements of the Space Network Processor

15.1 Graphical Representations of Spaces and Modules

Spaces are depicted as rectangular boxes as shown here.
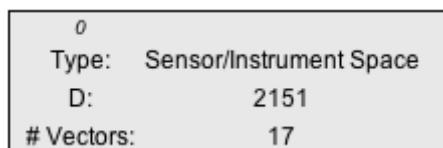
Figure 77: Examples of the graphical representation of a space (left) and a processing module (right)

Each space displays the following information:

[Integer]   A unique number (zero in the example below)

Type   A space type, which can be 'Sensor/Instrument Space' if loaded from the database or 'Spectral Space' if generated by a processing module.

D   A dimension D, which is equal to the number of Spectral bands of the Spectra held by this space

Vectors   A number of vectors, which is equal to the number of Spectra held
                   by this space

Modules are also depicted as rectangular boxes, but their contents are quite
different.
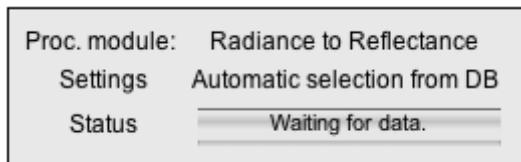
*Figure 78: Examples of the graphical representation of a space (left) and a
processing module (right)*

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

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. Select the elements by dragging
a box around them using the mouse, then drag the selection (Figure 79).
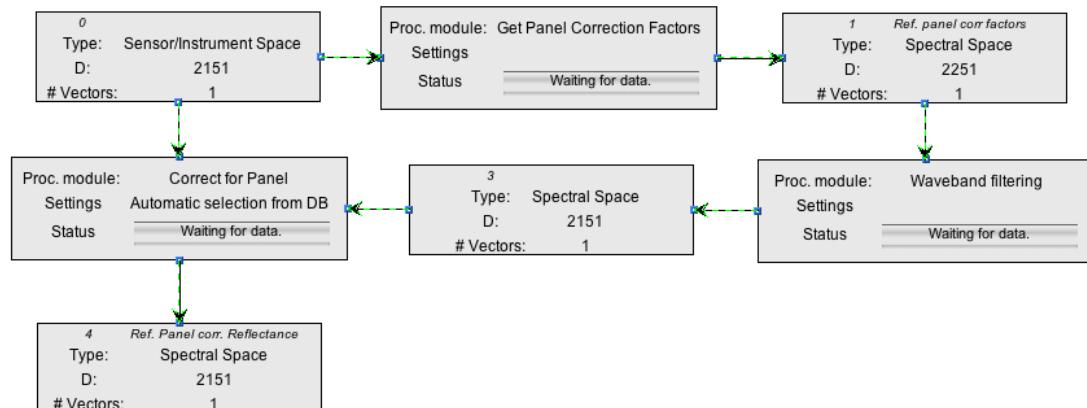
Figure 79: Multiple-selection of elements after dragging a box around them

15.2 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 76.
Select 'Add Module' and a selection of the available modules will appear (Figure 80).
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 81). Select 'Set Input Spaces'
and in the 'Input Space Selection' dialog select the number of the space to connect
and click 'OK' (Figure 81). 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.
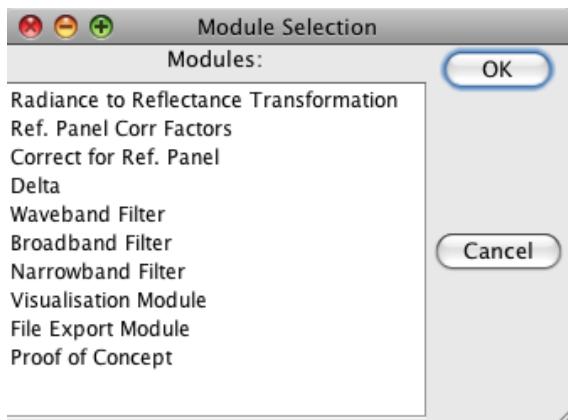
*Figure 80: Module selection dialog*
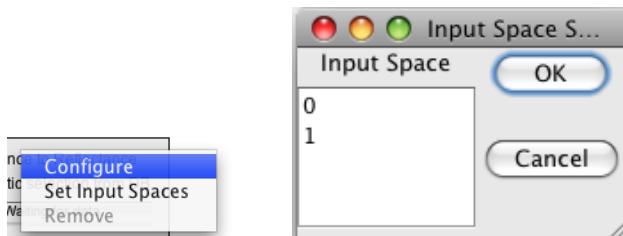
Figure 81: Popup menu of a module (left) and the input space selection dialog (right)

15.3 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.

15.4 Processing Module Descriptions

15.4.1 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 8.5 and 11.2.

15.4.2 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 82) 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 *Section Instrument* .
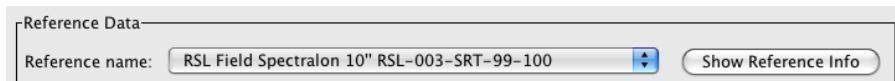
Figure 82: Reference panel setting in the Metadata Editor

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

Figure 83 shows a processing chain that selects the panel correction factors and plots using a Spectral line plot (Figure 84).
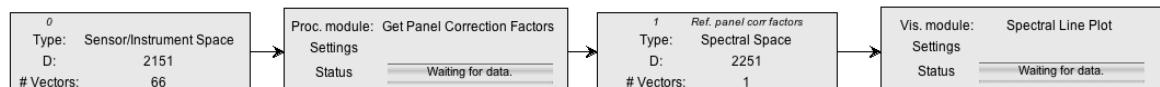
*Figure 83: Processing chain selecting the correction factors and plotting them as a Spectrum.*
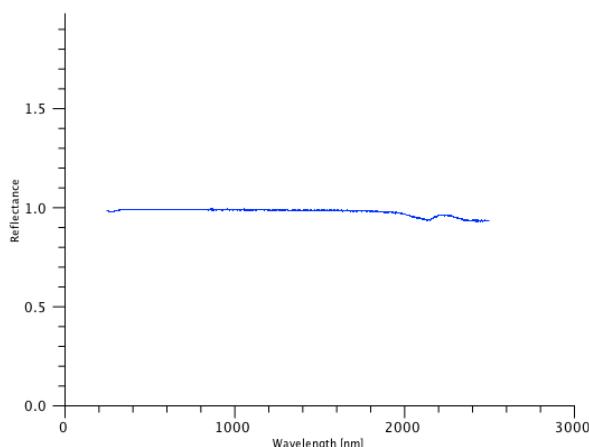
Figure 84: Reference panel correction factors

15.4.3   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 85).
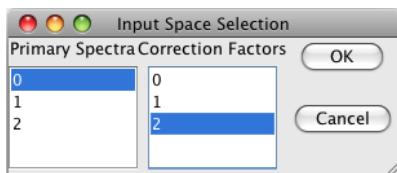

Figure 85: Input space selection for the 'Correct for Panel' module

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 869 a waveband filtering is applied to the correction factors as these were measured with a larger wavelength range.
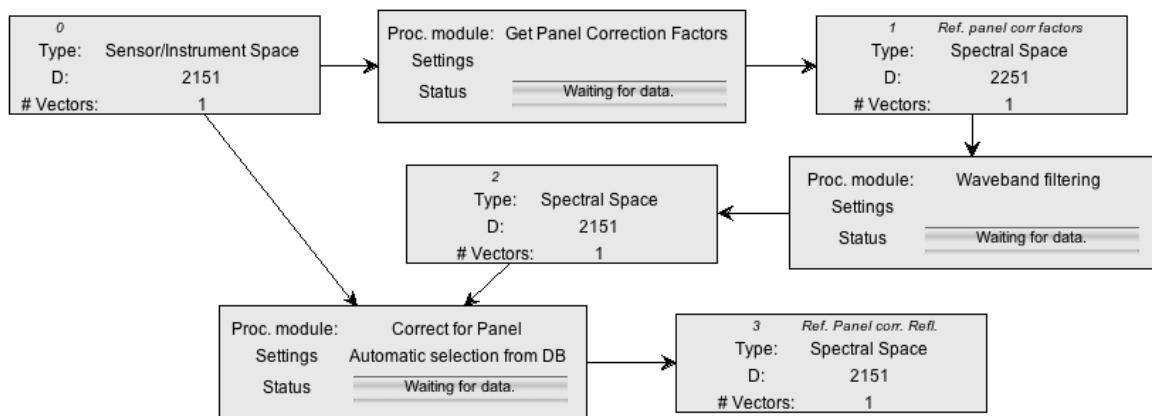
Figure 86: Space Processing Network for reference panel correction

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.

15.4.4   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 87):
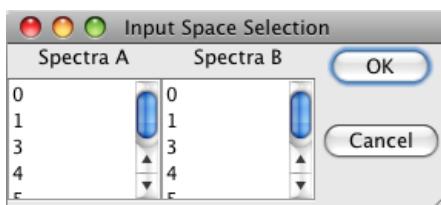
Figure 87: Input space selection for the Delta module

A possible use is the calculation of the difference between recorded reflectance and reference panel corrected reflectance. Figure 88 shows a processing network for this purpose and Figure 89 shows the according Spectral plots generated by the network.
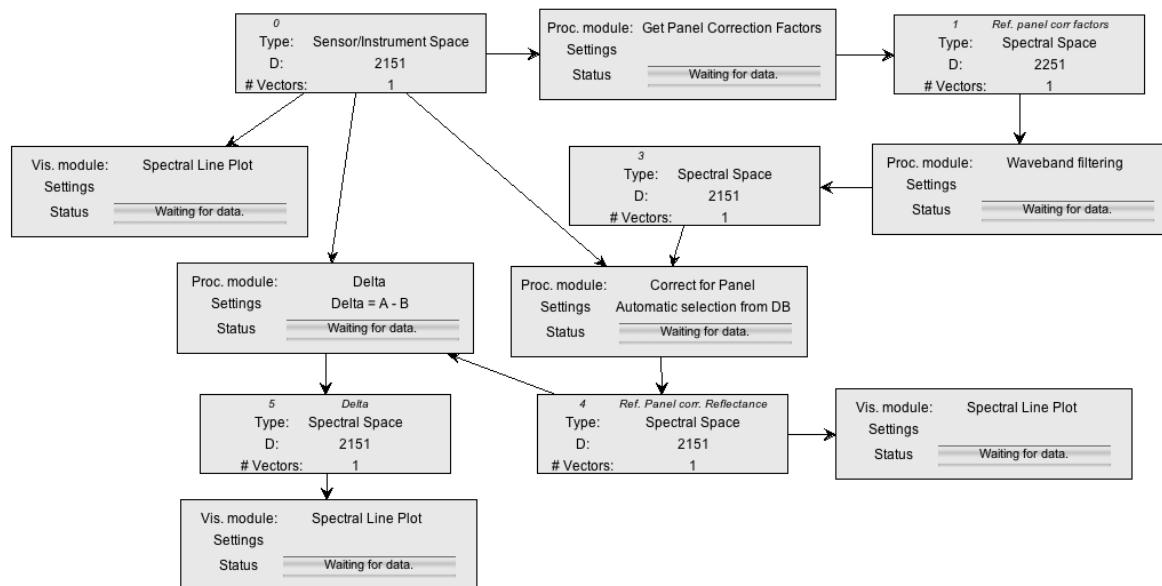

*Figure 88: Space Processing Network for the panel correction and delta calculation*
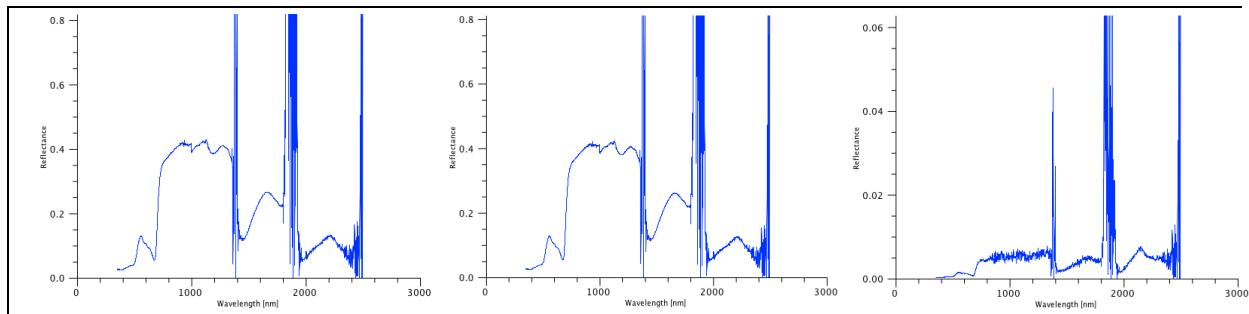
Figure 89: Spectral plots of: input Spectrum (left), panel corrected Spectrum (middle) and delta Spectrum (left)

15.4.5   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 90).
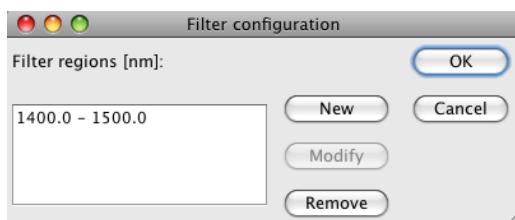

Figure 90: Filter configuration window

To add a new filter region, click 'New' and enter the upper and lower wavelengths in nanometres in the Filter Definition dialog (Figure 91).
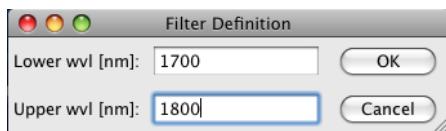

Figure 91: Filter definition dialog

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

15.4.6   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 92). 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 broadband 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.
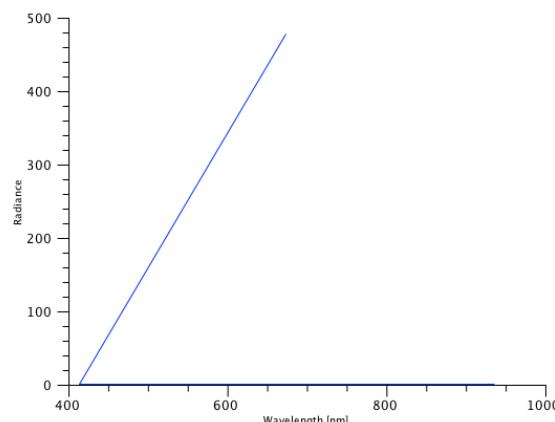

Figure 92: Spectral plot of broad- and narrowband MFR channels

Figure 93 shows a space processing network that illustrates the function of broad- and narrowband filters.
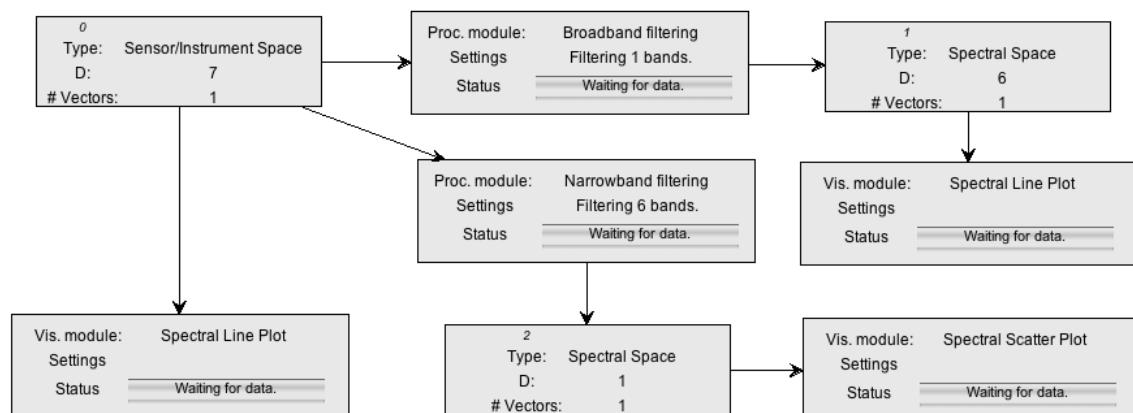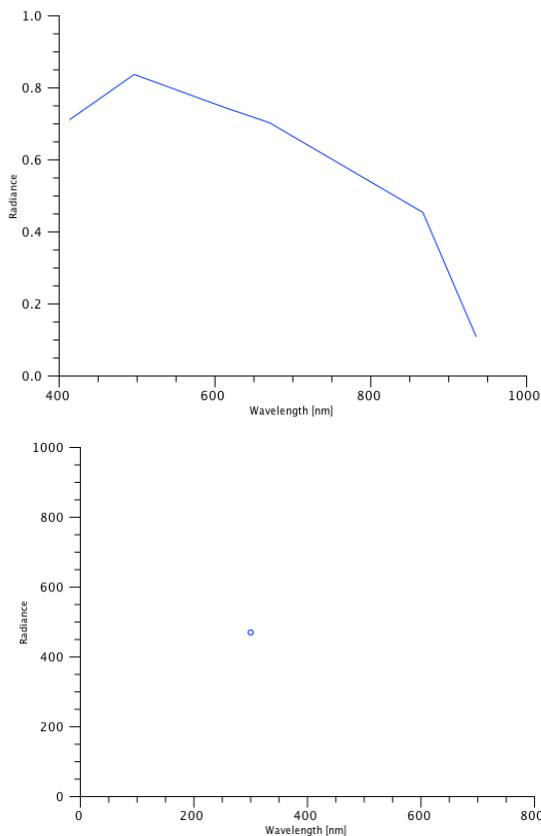

Figure 93: A space processing network demonstrating the function of broad- and narrowband filters

The plot shown in Figure 92 was generated by the 'Spectral Line Plot' of space number 0.

Figure 94 shows the plots of space 2 (Broadband value as a scatter plot) and space 3 (Narrowband channels as a Spectral curve).
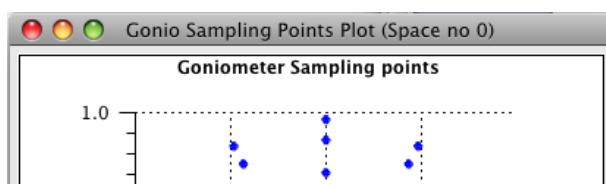

Figure 94: Plots of the narrowband channels (left) and of the broadband channel (right)

15.5 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 95).


Figure 95: Information displayed in the window title

15.5.1   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.
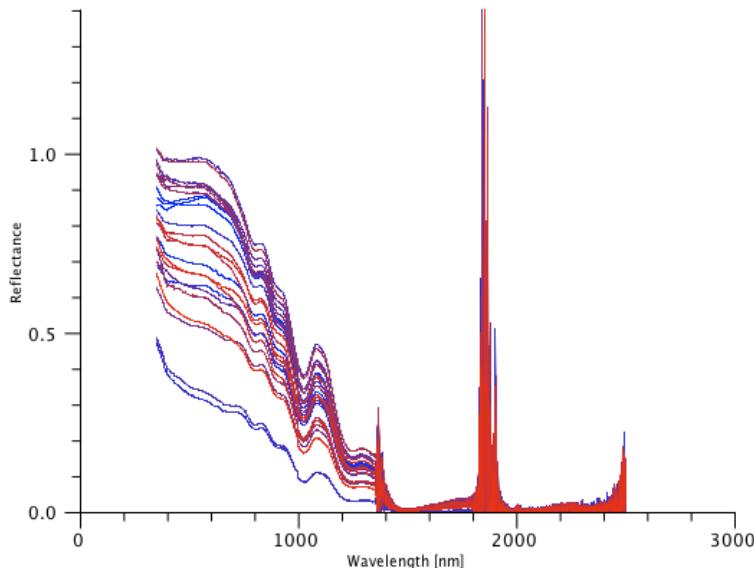
Figure 96: Spectral line plot of snow avalanche reflectance Spectra

15.5.2   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 970 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.
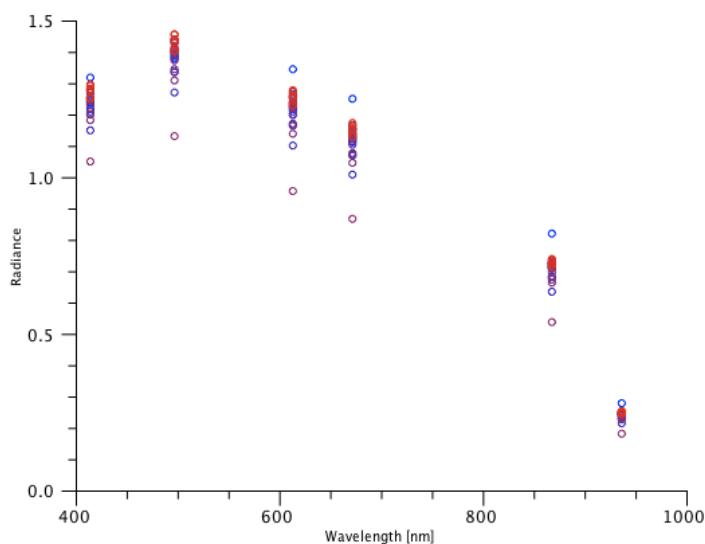
Figure 97: Scatterplot showing the variation per channel for several MFR sunphotometer readings

15.5.3   Gonio Sampling Points Plot

| Note	This function is currently unavailable due to licensing issues.

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 98).
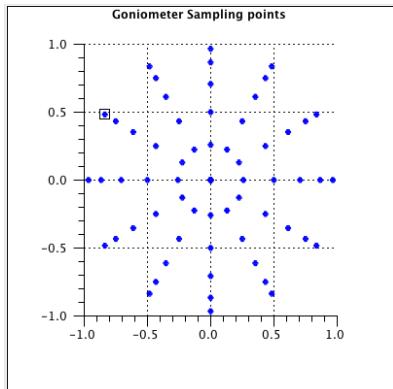
*Figure 98: Goniometer sampling point positions*

15.5.4   Gonio Hemisphere Explorer

Note	This function is currently unavailable due to licensing issues.

The Hemisphere Explorer allows the interactive exploration of a spectrodirectional dataset, typically acquired by a goniometer system. Figure 99 shows an explorer window displaying a LAGOS (Laboratory goniometer system) dataset (Schopfer 2008).
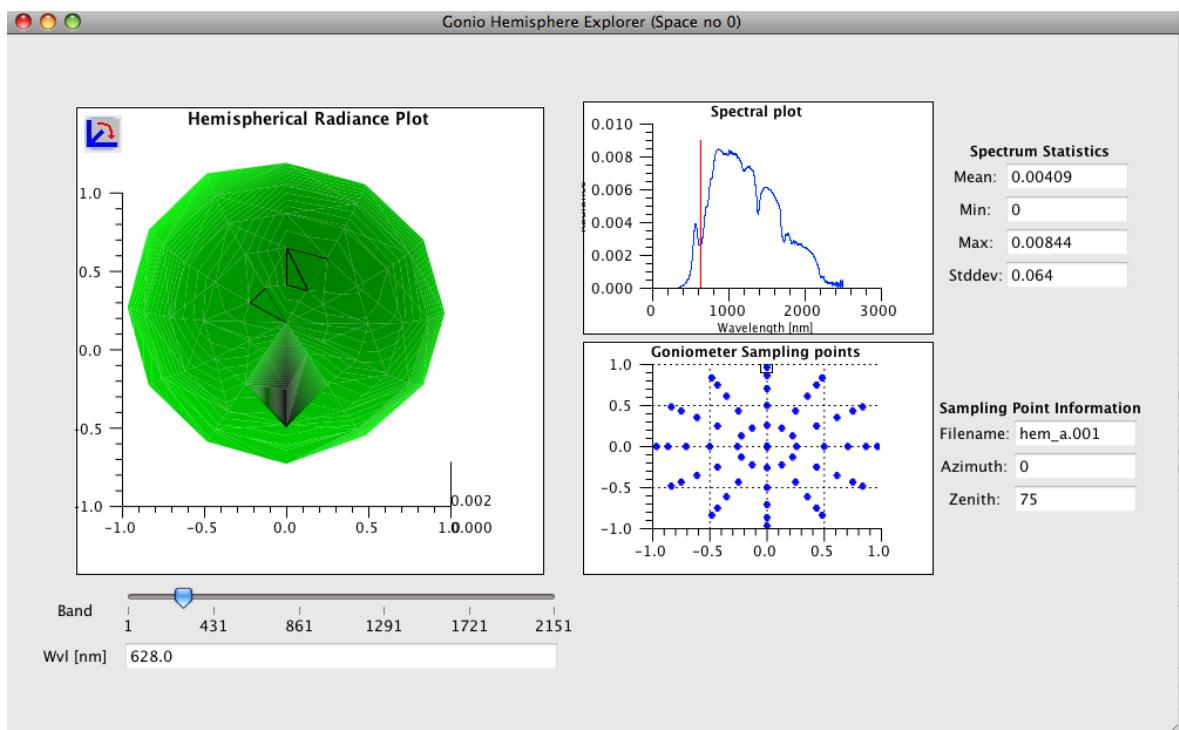
Figure 99: Gonio Hemisphere Explorer window

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

The hemispherical plot (Figure 100) 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).
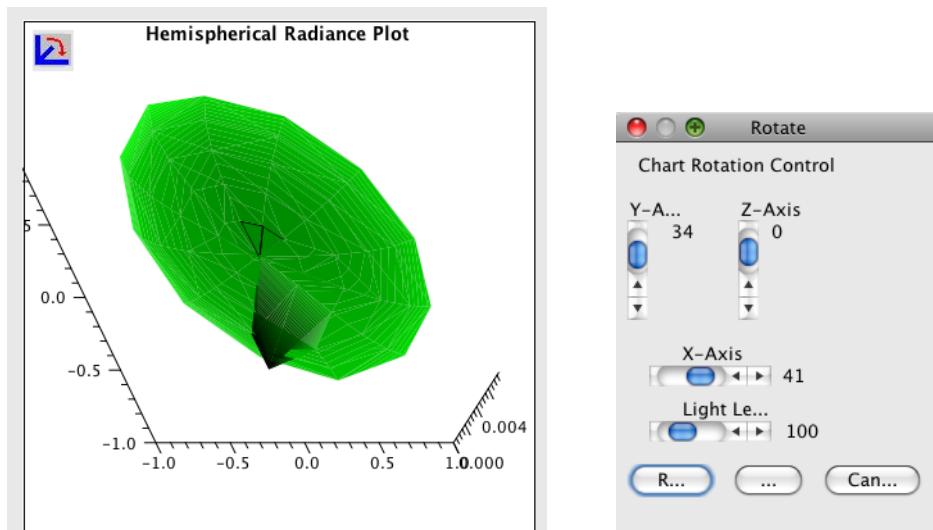
Figure 100: Interpolated 3D plot for a chosen wavelength (left) and rotation toolbox to manipulate the 3D plot

Use the band selection slider to select a Spectral band for display (Figure 101). 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 101: Band selection slider and wavelength text field

The sampling points plot shows the sampling point positions projected onto a 2d Cartesian coordinate system (Figure 102). 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.
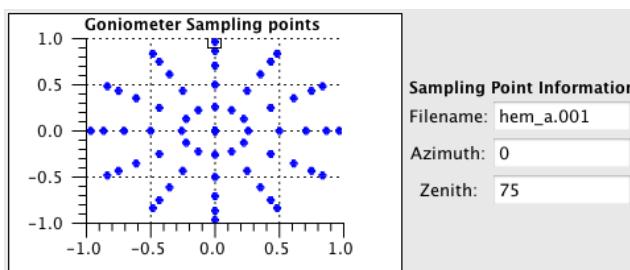
Figure 102: Sampling point position plot and information about the selected sampling point

The Spectral plot component displays the Spectrum of the selected sampling point (Figure 103). 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.
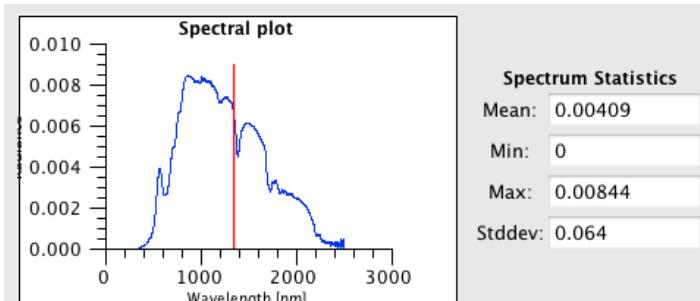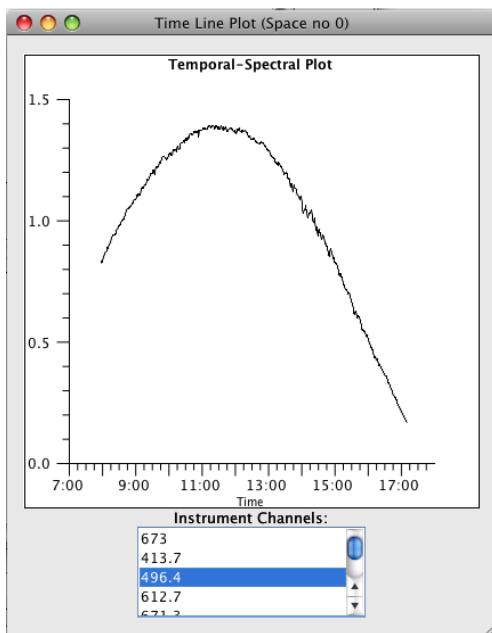
Figure 103: Spectral plot component with wavelength indicator and Spectrum statistic information

15.5.5   Time Line Plot
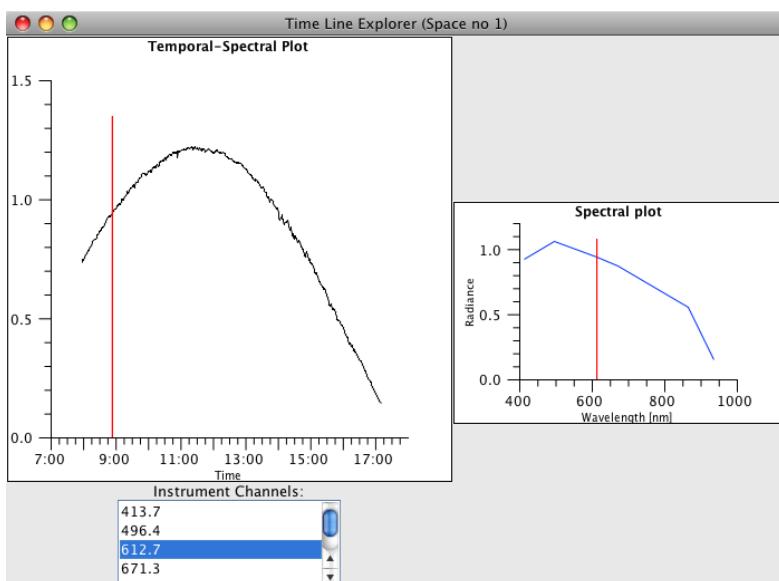
Use a time line plot to plot a Spectral band versus time. Figure 104 shows showing the direct irradiance over time for an MFR sunphotometer band with centre wavelength 496.4nm. The channel to be plotted can be chosen in the list below the plot. Time information is retrieved from the sampling time of the Spectra.

Figure 104: Time Line Plot showing the direct irradiance over time for centre wavelength 496.4nm

15.5.6   Time Line Explorer

The time line explorer consists of a time line plot and a Spectral plot (Figure 105). 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 105: Time Line Explorer window

The example given in Figure 105 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 106.
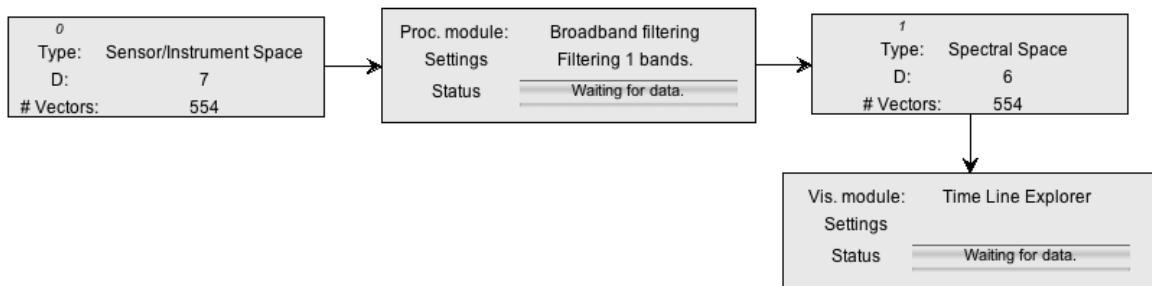
Figure 106: Processing chain for the exploration of the narrowband MFR channels in the Time Line Explorer

15.6 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 107). The dialog is identical to the one described in *Section 10.7.*
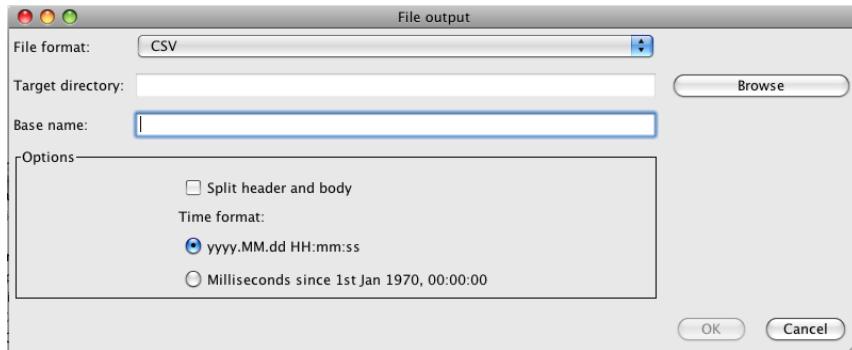
Figure 107: File export configuration

The Spectral data written to the file reflects the data content of the space. The Metadata is read from the database where possible.

16   Matlab Integration

The Matlab environment is a well-established tool in engineering, research and science. Matlab includes a Java Virtual Machine and thus allows the use of Java classes within Matlab code.

To extract Java code for a Matlab query from the SPECCHIO client:

- From the Main menu select *Data Processing & Output* and *Browse data hierarchy*. The Data Browser window will open.

- Using the Hierarchy Browser, select a Hierarchy node or a selection of Spectra. The Spectra IDs will appear in the *Matching Spectra* box.

- Right click in the *Matching Spectra* box. A menu will appear.

- Select *Copy Matlab-ready query to clipboard* from the menu.

- Switch to the Matlab application (or other application) and paste the query from the clipboard as you require.

It is also possible to use *Build query* instead of *Browse data hierarchy* in the process above. See *Section 8 Data Selection & Output* for more information about using these tools.

For more details on using Matlab with SPECCHIO data, please refer to the SPECCHIO MATLAB Guide **SPECCHIO_MatlabGuide.pdf**.

Example Matlab-ready query from Data Hierarchy Browser

The following is an example of what is placed on the clipboard by the above process when the data hierarchy browser is used.

```
query = Query('spectrum');
query.setQueryType(Query.SELECT_QUERY);


query.addColumn('spectrum_id')


cond = QueryConditionObject('spectrum', 'spectrum_id');
id_array = [65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84];
ids_list = java.util.ArrayList();
for i=1:size(id_array,2) ids_list.add(id_array(i)); end;
cond.setValue(ids_list);
cond.setOperator('in');
query.add_condition(cond);


ids = specchio_client.getSpectrumIdsMatchingQuery(query);
```

Example Matlab-ready query from Query Builder

The following is an example of what is placed on the clipboard by the above process when the query builder is used.

```
query = Query('spectrum');
query.setQueryType(Query.SELECT_QUERY);


query.addColumn('spectrum_id')


cond = SpectrumQueryCondition('spectrum', 'measurement_unit_id');
cond.setValue('0');
cond.setOperator('=');
query.add_condition(cond);
```

```
cond = EAVQueryConditionObject('eav', 'spectrum_x_eav', 'File Name', 'string_val');
cond.setValue('triti%%');
cond.setOperator('like');
query.add_condition(cond);


cond = SpectrumQueryCondition('spectrum', 'sensor_id');
cond.setValue('0');
cond.setOperator('=');
query.add_condition(cond);


cond = SpectrumQueryCondition('spectrum', 'instrument_id');
cond.setValue('0');
cond.setOperator('=');
query.add_condition(cond);


ids = specchio_client.getSpectrumIdsMatchingQuery(query);
```

17 R Integration

R integration uses the rJava package. For more information please see www.specchio.ch.

To extract R / Java code for a R query from the SPECCHIO client...

- Select *Data Processing & Output* and *Browse data hierarchy* from the menu on the Main Window. The Data Browser window will open.

- Using the Hierarchy Browser, select a Hierarchy node or a selection of Spectra. The Spectra IDs will appear in the *Matching Spectra* box.

- Right click in the *Matching Spectra* box. A menu will appear.

- Select *Copy R-ready query to clipboard* from the menu.

- Switch to the R application and paste the query from the clipboard as you require.

18   Python Integration

Python integration uses the JPype package. For more information please see
www.specchio.ch.

19   Glossary

The explanations of words and terms in this glossary include both those terms which may not be familiar to some readers and those which have a specific meaning in the context of SPECCHIO or this document.

ANDS	Australian National Data Service
	This body hosts the Research Data Australia (RDA) service. SPECCHIO supports publishing research data to this service. See http://www.ands.org.au/ and *Chapter* 14 Publishing Data to ANDS.
Calibration	The process of linking an Instrument's response to a defined physical input, for example, assigning the correct wavelengths to a band, or assigning factors that describe the relationship between radiance and recorded digital numbers.
Campaign	Refers to an activity during which Spectral samples were acquired. A Campaign is defined in a contextual sense. It is not restricted by any temporal or spatial properties.
Client-server	A commonly used networked computer architecture which involves a "server", which hosts a main computing facility such as a database or computation facility, and a number of "clients", which access the server using a network, such as an intranet or the internet. SPECCHIO uses this architecture.
FOR Codes	Field of Research Codes
	This coding system was designed and developed by the Australian Research Council (http://www.arc.gov.au/) to categorise areas of research. FOR Codes are widely used across Australian research bodies, such as universities and the CSIRO, and government departments, such as the Bureau of Census and Statistics. Lists of FOR Codes can be found at sites such as http://www.abs.gov.au/ausstats/abs@.nsf/Products/6BB427AB9696C22 5CA2574180004463E?opendocument.
HTTP/HTTPS	Hypertext Transfer Protocol
	HTTP is a very widely used network protocol, which is also used by SPECCHIO Clients to communicate with the SPECCHIO Server. HTTPS is the secure version of this protocol.
Instrument	In the context of this document, an individual spectroradiometric Instrument. Such an Instrument will have a serial number and an owner.
Instrument Type	A model or type of spectroradiometric Instrument. It will be described by a model number and manufacturer. In this document and the SPECCHIO client, this term is used interchangeably with the terms "Instrument Model", "Sensor" and "Sensor Type".

MySQL	The world's most widely used relational database management system (RDBMS) (according to Wikipedia). It is the RDMS used by the SPECCHIO Server. (See SQL.)
RDA	Research Data Australia Australian National Data Service's (ANDS) flagship service, which provides a comprehensive window into the Australian Research Data Commons. It is an Internet-based discovery service designed to provide rich connections between data, projects, researchers and institutions, and promote visibility of Australian research data collections in search engines. See http://researchdata.ands.org.au/.
Reference Panel	A calibrated reflective panel with known reflectance properties. It is usually white, but may be grey or even close to black. A Reference Panel can be measured under the same lighting conditions as a target sample in order to get an approximation of the Spectrum of the solar irradiance or to collect data for the conversion of a target radiance to reflectance factors.
Reference Spectrum	A Spectrum acquired over a Reference Panel.
Regular Expression	In computing, a regular expression (often abbreviated "regex" or "regexp") is a sequence of text characters, some of which are understood to be metacharacters with symbolic meaning, and some of which have their literal meaning, that together can be used by a regular expression processor to identify textual material of a given pattern. See (Oracle Technology Network, 2013, Wikipedia, 2013) for more information.
Sample	A Sample taken from a Target and measured, often at some later time, under controlled conditions. A sample will generally have a collection date/time and a measurement date/time, which will be different.
Sensor	See Instrument Type.
Spectralon	A particular brand of reflective reference panel, produced by LabSphere. Spectralon panels are available in various configurations, ranging from pure white to greyish and almost black. See Reference Panel.
SQL	Structured Query Language (sometimes pronounced "sequel") A special-purpose programming language designed for managing data held in a relational database management system (RDBMS).
Target Spectrum	Spectrum acquired by measuring the target, where the target is the object of interest.
TCP/IP	Transmission Control Protocol/Internet Protocol The common designator to refer to the protocols used for internet communication.

White Reference Spectrum	A Spectrum acquired over a reference panel that has a reflectance of close to 100%.

20   References

Australian Research Council, 2008. Australian and New Zealand Standard Research Classification (ANZSRC), http://www.abs.gov.au/ausstats/abs@.nsf/mf/1297.0

CSIRO, 2011. The Australian Soil Classification, http://www.clw.csiro.au/aclep/asc_re_on_line/soilhome.htm

Hueni, A., Damm, A., Kneubuehler, M., Schläpfer, D., Schaepman, M., 2017. Field and Airborne Spectroscopy Cross-Validation - Some Considerations. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 10(3), 1117 - 1135.

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 35(3), 557-565.

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

Hüni, A., Kneubühler, M., 2007. SPECCHIO: a system for storing and sharing spectroradiometer data. SPIE Newsroom(December 2007), 1-2, http://spie.org/x18220.xml.

Hüni, A., Nieke, J., Schopfer, J., Kneubühler, M., Itten, K., 2007. 2nd Generation of RSL's Spectrum Database "SPECCHIO". In: Proceedings Schaepman, M. E., Liang, S., Groot, N. E., Kneubühler, M. (Eds.), 10th Intl. Symposium on Physical Measurements and Spectral Signatures in Remote Sensing, Davos (CH), XXXVI, Part 7/C50, pp. 505–510.

Landgrebe, D., 1997. On Information Extraction Principles for Hyperspectral Data, Purdue University, West Lafayette, IN, 34 pp.

Milton, E. J., Fox, N. P., Schaepman, M., 2006. Progress in Field Spectroscopy. In: Proceedings Geoscience and Remote Sensing Symposium, Denver, CO, US, pp. 1966-1968.

NOAA, 2003. What is UTC or GMT Time?, http://www.nhc.noaa.gov/aboututc.shtml

Oracle Technology Network, 2013. Java Regular Expressions Tutorial, http://docs.oracle.com/javase/tutorial/essential/regex/index.html

Wikipedia, 2013. Regular Expression Description, http://en.wikipedia.org/wiki/Regular_expression

21   Document History

Version	Date	Author	Remark
0.1	15.12.2006	A. Hueni	First document version
1.0	14.02.2007	A. Hueni	Bug fixes and added features
1.1	18.10.2007	A. Hueni	Added txt file reader, multi-user capabilities, db_config.txt file, Admin functions.
1.2	29.05.2008	A. Hueni	Added Spectral plot, Campaign export, Metadata editor enhancements.
1.3	15.06.2008	A. Hueni	Added Campaign import function.
2.0	12.03.2009	A. Hueni	Major update: Added reference panel handling, processing extension, Instrument and reference panel tools. Updated export/import.
2.1	02.09.2010	A. Hueni	Added Instrument settings, Metadata enhancements, time selection, SVC-HR1024 Instrument, Instrument calibration, Apogee support.
2.2.0	02.05.2012	A. Hueni D. Kuekenbrink	Added FGI HDF file support, generic Metadata, target-reference link improvements, Metadata editor enhancements, ASD binary file format, Metadata date/time selection, beam geometries.
2.2.1		A. Hueni D. Kuekenbrink	Upgrade direct irradiance calculation for MFR-7, query builder/hierarchy browser split, space processing improvements, mixed folder data loading, UniSpec file loader, SPECPR file loader.
3.0	21.06.2013	Peter Roberts (Intersect)	UOW/Intersect overhaul: Database now referenced via HTTP front end, ANDS Collection export.
3.0.2	30.06.2014	Nicholas Sheppard (Intersect)	Updated the description of publishing to ANDS and added a mapping of SPECCHIO fields to RIF-CS output.
3.0.3	06/03/2015	Sandra Carruthers (UOW SEES)	Restructured the document, amended the installation and setup instructions and added diagrams for clarity.
3.1	05.03.2014	A. Hueni	Added calibration support and automatic sensor/instrument definition.
3.2	13.05.2015	A. Hueni L. Chisholm	Added information on new metaparamters for geochemistry and others. Updates due to Data Link upgrade. New input file formats added. Document restructuring and editing to render it more user friendly.

3.2.1.5	02.11.2016	A. Hueni	Added information about the db_config file, the SPECCHIO Preferences and the UTC Acquisition Time, which is now used to calculate sun angles.
			Mentioned Python support, details are on www.specchio.ch
3.3	20.02.2018	A. Hueni S. Bertschi	General update of user guide. Added information about new functions: spatial support, hierarchy metadata storage, metadata processing.

Appendix A: Regular Expressions Tutorial

Regular expressions are widely used across the computer industry when text string matching is required. They permit a rich array of sophisticated matching functionality.

A complete explanation of regular expressions is beyond the scope of this tutorial. Readers with a desire to see a complete list of all options should see the Java tutorial at http://docs.oracle.com/javase/tutorial/essential/regex/index.html.

The following is a quick summary of the most useful regular expression functions for SPECCHIO Users.

Simple string		A simple string containing no special characters will match those characters in a target string, regardless of where within the target string they occurs.	`mpl` will match the string `example` at the fourth character.
Start of string	`^`	The character `^` will match the beginning of the target string.	`^exa` will match `example`, but `^xa` will not.
End of string	`$`	The character `$` will match the end of the text string.	`le$` will match `example`, but `pl$` will not.
Any character	`.`	The period character will match any character.	`a.c` will match `abc`, `aac`, `adc`, `a7c` and `a-c` but it will not match `ac` or `abbc`.
Repeated character	`*`	Asterisk causes the matching to zero or more repetitions of the preceding character.	`ab*c` will match `ac`, `abc`, `abbc` or `abbbc`, but will not match `a7c` or `ahc`. It will match `aac` at the second character and `acc` at the first character, because there are zero characters between the `a` and `c` in those strings.
Repeated characters	`+`	The plus sign causes the matching to one or more repetitions of the previous character.	`ab+c` will match `abc`, `abbc` or `abbbc` but will not match `ac`.
Alternate characters	`[ ]`	Strings enclosed within square brackets will match any one of the characters within the brackets.	`a[123]b` will match `a1b`, `a2b` or `a3b` only. It will not match `ab` or any other substring.
Character ranges	`[-]`	Use `-` between `[]` to match one of range of characters.	`[0-9]` matches any digit. `[a-z]` matches any letter. `[a-z0-9]` matches any digit or letter.

Escape character	\	In order to match a special character, precede it with the backslash character. Special characters are []\^$.|?*+(){} Putting \ before other characters often has a special meaning, so should be avoided.	\\ will match \ \. will match . * will match * \[will match [
Combinations		Any of the above search methods can be combined.	^.c will match any string with c as its second character. ^abc$ will match the string abc only. abcd or aabc will not be matched. 1[abcd]+2 will match any combination of the characters a, b, c or d which occurs between the digits 1 and 2. [\[\]] will match either [or]. \.+ will match any run of periods. [0-9]+ will match any integer number. [0-9]+\.[0-9]* will match any number with a decimal point.

Appendix B: Predefined Manufacturer Table

manufacturer_id	name	www	short_name
1	Analytical Spe...	www.asdi.com	ASD
2	GER	NULL	GER
3	YES	NULL	YES
4	Beckman	NULL	BECKMAN
5	Labsphere Inc	www.labsphere.com	LABSPHERE
6	APOGEE	www.apogee-inst.com	APOGEE
7	Spectra Vista	www.spectravista.com/	SVC
8	Ocean Optics	www.oceanoptics.com	OceanOptics
	NULL	NULL	NULL

Appendix C: Predefined Sensor Table

sensor_id	name	description	response_type	sensor_type_no	no_of_channels	manufacturer_id
▶ 3	ASD FS FR-3	ASD FieldSpec FR or FieldSpec3 type	NULL	4	2151	1
4	GER 3700	GER 3700	NULL	3700	647	2
6	MFR-7	MFR-7 Rotating Shadowband Radiometer	NULL	7	7	3
7	Beckman UV-5240	Beckman UV-5240	NULL	5240	826	4
9	USGS Beckman UV-5240	Beckman UV-5240	NULL	5240	420	4
10	SVC HR-1024	Spectra Vista HR-1024	NULL	1024	1024	7