# DROACOR®

Drone Imagery Physical Atmospheric Correction
User Manual, Version 2.1

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*Updates:* see ReSe download page: www.rese-apps.com/software/download and check online through the self-update function.

# Contents

# Part A

# DROACOR - Drone Atmospheric Correction

# Chapter 1

# Introduction

DROACOR is a software package for automatic atmospheric compensation for reflectance retrieval from drone based imaging spectroscopy data. The DROACOR package also includes the GLIMPS software as an ENVI™ file viewer for image browsing and extraction of spectra. GLIMPS is also available separately as a free software distribution to bring the world of hyperspectral imaging to educational institutes and to occasional users.

The main features of DROACOR are:

- physical reflectance retrieval method, including adjacency correction,
- surface temperature and emissivity retrieval for TIR sensors,
- built-in support for hyperspectral sensor systems such as AISA (Specim), Blackbird (HAIP), CASI (Itres), Hyspex (NEO), Hyperspec (Headwall), Pika (Resonon), Shark (Corning), and more on demand,
- built-in support for multispectral imagery for Rededge (Micasense), Ultracam (Vexcel), DB2 (Laquinta), and standard 3- or 4-band sensor systems,
- built-in support for TIR imagery for single-channel cameras (FLIR-Duo) and hyperspectral TIR sensor systems,
- radiation parameters from LibRadtran radiative transfer model,
- low altitude adjacency radiance and irradiance correction,
- model based BRDF effects correction (BREFCOR),
- topographic illumination correction based on digital surface model input,
- image based cast shadow correction,
- optional below-cloud reflectance retrieval,
- panel based inflight radiometric calibration,
- spectral recalibration for VNIR and SWIR using oxygen band positions,

- water vapor retrieval by spectral fitting technique,
- aerosol optical thickness estimate by enhanced DOS method,
- adaptive atmospheric feature optimization,
- band interpolation or removal in fully absorbing regions,
- spectral polishing and detector gap correction,
- inclusion of GLIMPS for ENVI/ TIFF display,
- standard vegetation index and mineral mapping product outputs and
- fully, directory-based batch processing support.

The GLIMPS software included in DROACOR can be used for remote sensing image manipulation such as:

- ENVI™ file viewer for image browsing and extraction of spectra,
- multispectral and hyperspectral remote sensing image analysis and data quality control,
- standard normalization methods (dark/bright target correction),
- simple spectral indices (NDVI, ARVI, absorption depth, band ratio) and
- hyperspectral analysis (spectral angle mapper, best fit analysis).

This manual gives an overview of the main functions of the software, starting with the installation and setup and going through all menu items afterwards.

## 1.1 Installation

DROACOR is available here. The software is based on the IDL virtual machine platform (NV5 Geospatial Inc.) and is compatible to Windows, starting with Windows 10, Linux (tested on Ubuntu), and MacOSX. Note that most examples in this manual are given for Linux/MacOSX appearance, while the software will work the same on Windows operating systems.

The installation directory includes a stripped-down IDL virtual machine which is required to run all ReSe Software. Alternatively, the software may also be run on an existing IDL/ENVI installation (if available).

*Note for MacOSX:* On Mac OSX, a separate DROACOR.app software is downloaded which may be started right away, provided the X11 package is installed with version 2.7.11 or later (M1 processor is supported through Rosetta).

*Note for Windows:* On Windows, system security alerts are shown on first startup which are to be dismissed, as the software has no official registry with Mircosoft. If text appears blurry in the panels after startup do the following: Select the DROACOR.exe application and right-click and enter the ’Properties’ (compare Figure 1.2).

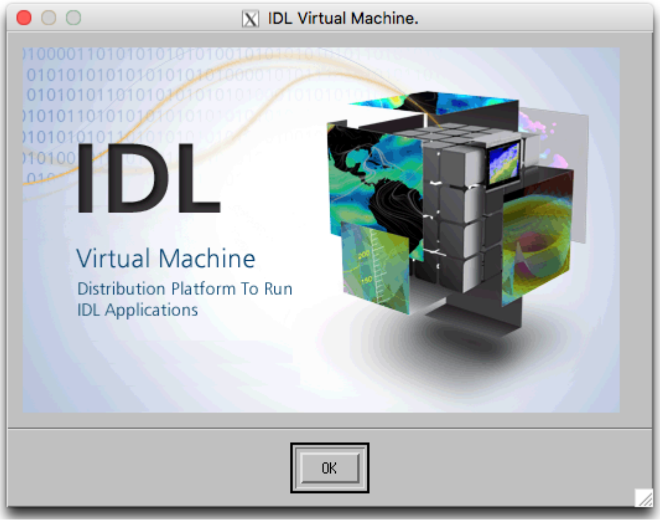


**Figure 1.1**: IDL splash screen.

Select 'Change high DPI Settings' in the Compatibility panel. In the popup window, the DPI scaling override is to be selected and set to 'System (Enhanced).

*Software Updates:* The DROACOR software can be updated using the option *'Check for Updates'* in the main GUI's *'Help'* menu, as long as a standard internet connection is available. In case of a failure of this function, a new download of the whole package is required; direct download links are provided upon request from ReSe.

*Proxy Server Setting:* A proxy server may be defined if you are using DROACOR behind a firewall. Setting a proxy server is required for automatic software updates and for online components installation. A proxy server may be set from the GUI of the software update panel. An example is shown in Figure 1.3. Please contact your local network administrator to get the applicable settings. The settings are written to the file 'rese_proxy.txt', situated in the 'bin' directory of your DROACOR installation. An example file is available in the bin directory which may be edited manually instead of using the GUI (useful for headless systems).

*Atmospheric LUT Installation:* For correction of imaging spectroscopy data, the atmospheric LUT is to be installed. This can be done through the menu 'Help' as shown in Figure 1.4. An open internet connection is required to install the database. In case the button >Check Connection< shows an error you may consider setting a proxy server (see above) or contact ReSe in order to obtain a direct download link.

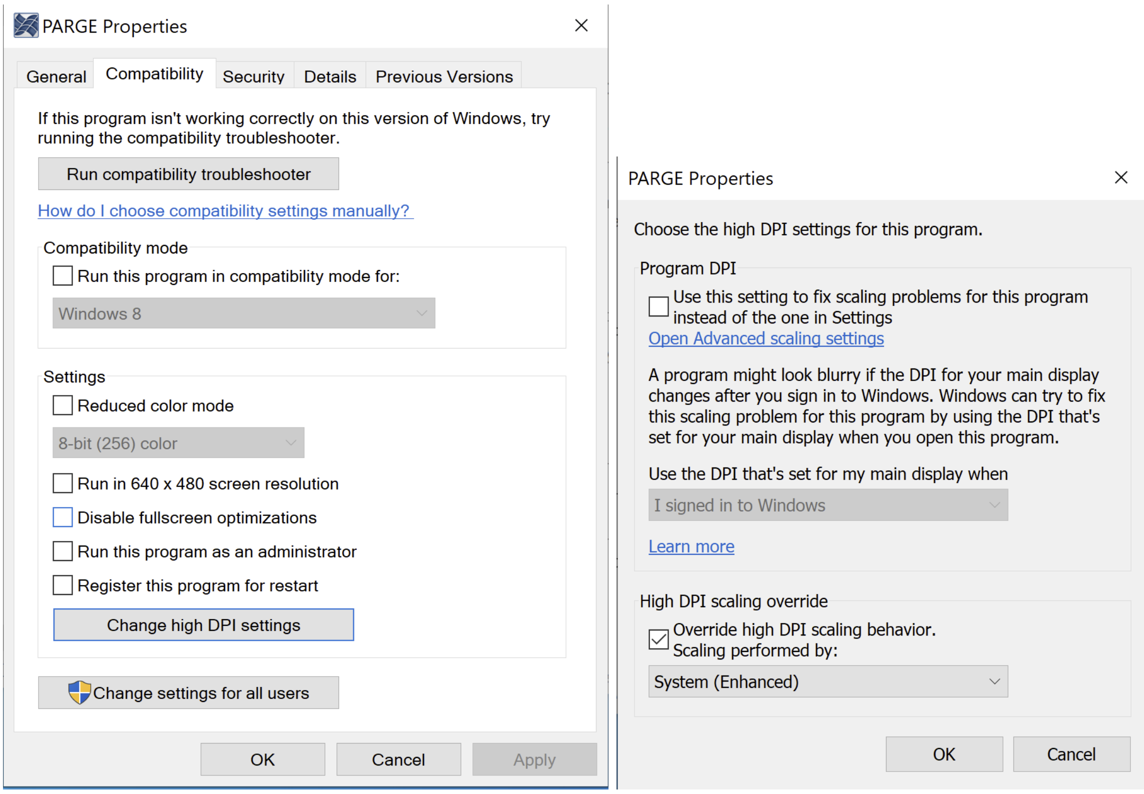


**Figure 1.2**: Windows font settings.

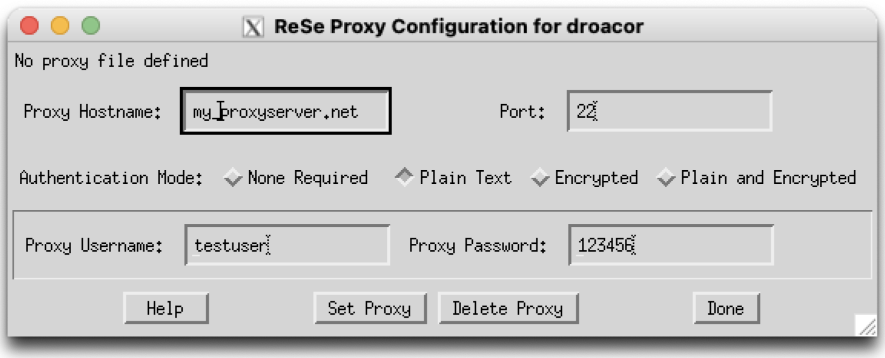


**Figure 1.3**: Proxy server setting.


**Figure 1.4**: Installation of atmospheric data base.

## 1.2 First Steps with DROACOR

To start DROACOR, double click the file "DROACOR.exe" (Windows) or "DROACOR.app" (MacOSX). This will open the software via the IDL virtual machine. Alternatively and on Linux, you may call the software from the command line, using the syntax:

```
xxx/ReSe_Software/idl89/bin/bin[xxxx]/idl -vm="xxx/droacor/bin/droacor.sav"
```

On startup, an IDL splash screen will appear which *OK* may be clicked to proceed. This will open the top level GUI of DROACOR as shown in Figure 1.5. The main GUI contains all functions of DROACOR in a main menu. The console window below shows messages according to the processing progress or eventual error messages.


**Figure 1.5**: Top level GUI of DROACOR with permanent console.

Functions:

The main panel shows the log of the latest process during and after execution. The progress bar below shows the progress if multiple files are processed by file number.

**Show Log File** As every process starts writing a log file, it is possible to display the last active log file by this function. Please send this log file to ReSe support in case of troubles.

**Clear Console** Clears the current display (without affecting the log file contents).

**Stop** The button let's you interrupt a process while running.

## 1.3 Workflow

DROACOR is built for fast and efficient processing of campaign data on the basis of directories. If data was laboratory-calibrated, only two steps are to be done: data import and data processing whereas some more initial steps are required for uncalibrated imagery. The software may be used out of the box for the supported sensor types only. Please contact ReSe Applications LLC if your sensor is not (yet) supported; more sensors can be supported as soon as there is a known demand for them.

### 1.3.1 Calibrated Imagery

High quality instruments are delivered with laboratory calibration applied to the imagery; typically a scaling factor on at-sensor radiance units. This applies to most imaging spectroscopy sensors but also to some multispectral cameras. The workflow for such data consists of the following steps:

1. Copy all the input data in original data format and original file naming to a local directory for processing. Don't forget to place the corresponding meta data files to the same directory.
2. Start the respective data import routine for your sensor. No calibration file and no reference file is required during data import.
3. After data import, the DROACOR reflectance processor can be started on the prepared imagery.
4. Additional steps such as topographic or BRDF correction may be applied subsequentially.
5. On the final reflectance imagery, standard vegetation or mineral products may be created.

NOTE: data has to be provided as radiance data scaled from the DROACOR internal unit $mWcm^{-2}sr^{-1}\mu m^{-1}$. Scaled (apparent) reflectances or other units can not be processed by this workflow.

### 1.3.2 Uncalibrated Raw Imagery

If no data calibration had been applied to the data, the raw digital numbers (DN) are to be converted to radiances for the processing. This is normally done by inflight calibration using a reference calibration panel with known reflectances. Calibration is done with one image only and can then be transferred to the whole campaign data for the processing. The following steps apply:

1. Identify one image scene with the calibration panels in it; possibly store this file and its auxiliary files to a separate directory.
2. Prepare an ENVI spectral library with the reflectances of the calibration panel(s).

3. Import the single file with a dummy/default calibration to DROACOR using the sensor-specific import routine - this is your *reference* file.

4. Run the inflight calibration (or dual panel calibration) on the single image scene and store the *cal file and write the outputs to the .json file of the reference image.

5. Copy all the input data in original data format and original file naming to a local directory for processing. Don't forget to add the corresponding meta data files.

6. Start the respective data import routine. Select the calibration file and the reference image from the inflight calibration.

7. After data import, the DROACOR reflectance processor can be started on the imported imagery.

8. Additional steps such as topographic or BRDF correction may be applied subsequentially.

9. On the reflectance imagery, standard vegetation or mineral products may be created.

NOTE: image calibration can normally be transferred between scenes, but it may happen that the sensor integration time is variable. For some sensors this can be accounted for if the parameter is found in the meta data.

Details about the above-mentioned steps can be found in the subsequent routine description.

### 1.3.3 TIFF Processing with Agisoft Metashape

DROACOR supports the processing of raw geometry TIFF data which may be transferred to Agisoft Metashape (or Pix4D) subsequently. The data may be calibrated by a panel as described above. The workflow after calibration is given as follows:

1. Copy all the input data in original data format and original file naming to a local directory for processing.

2. Start the respective data import routine. Select the calibration file and the reference image from the inflight calibration.

3. After data import, the DROACOR reflectance processor can be started on the imported imagery.

4. Additional steps such as topographic or BRDF correction may be applied subsequentially.

5. The output ENVI BSQ reflectance or data product files may be exported as TIFF.

6. The directory of the output TIFFs is to be imported to Agisoft Metashape to produce an orthomosaic.

7. In Agisoft Metashape, choose either ’Disabled’ or ’Mosaic’ for orthomosaic creation; note that the latter will scale the borders of the imagery to create a nice mosaic, what will reduce the accuracy of the reflectance outputs.

# Chapter 2

# Menu: File

The menu *File* offers some tools for handling of data and ENVI files.

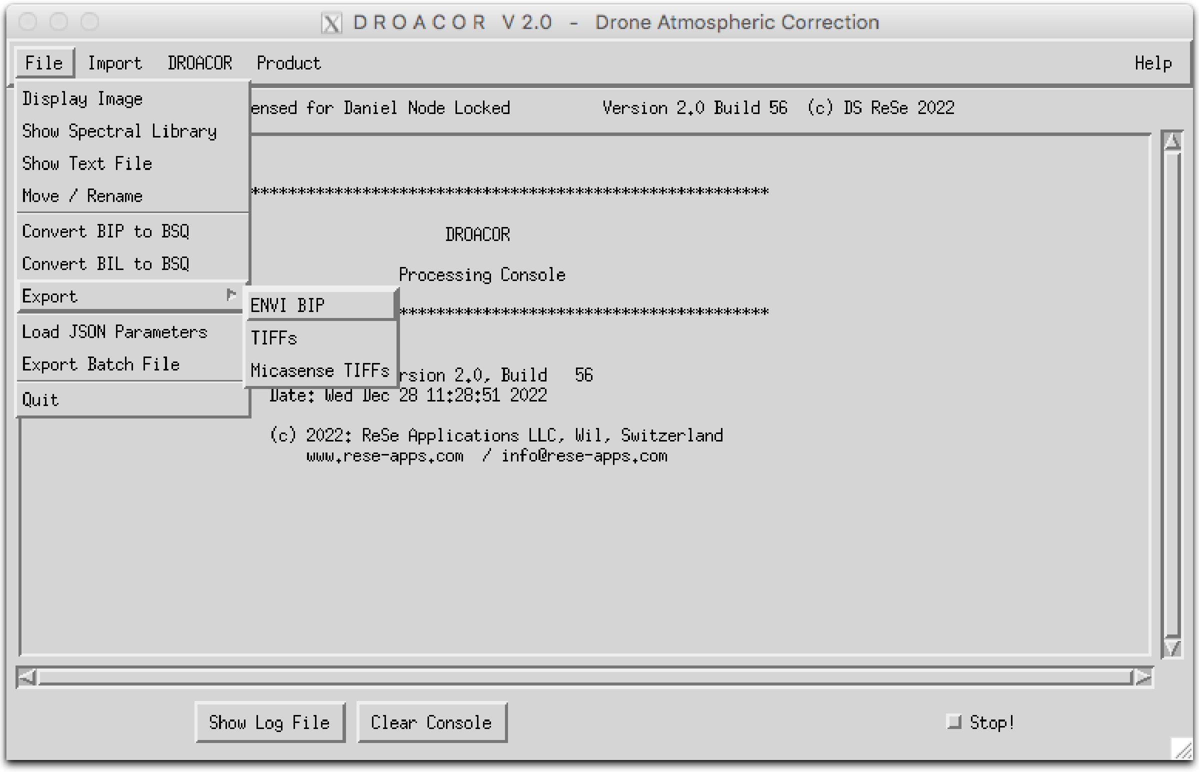


**Figure 2.1**: Top level graphical interface of DROACOR: "File".

*Import* is the menu for importing files into DROACOR for processing and is described in chapter 3. Then follows the menu on DROACOR in chapter 4 in which the processing software is explained.

NOTE: all details about the functions in the file display panel can be found in Part B of this user manual.

## 2.1 Display Image

The main image display consists of an overview image and zoom subset as shown in Fig. 2.2.

### 2.1.1 Overview Image

The overview image is either be displayed in a 100% view or in a downsampled displayed, depending on image size. The sampling factor of the browse image can not be changed. Clicking in the overview image will update the zoomed subset of the image and redraw the borders of the zoom image in the overview. Roaming is enabled if the button is pressed while moving the mouse in the image. The zoom window position may also be moved using the arrow keys on the keyboard.

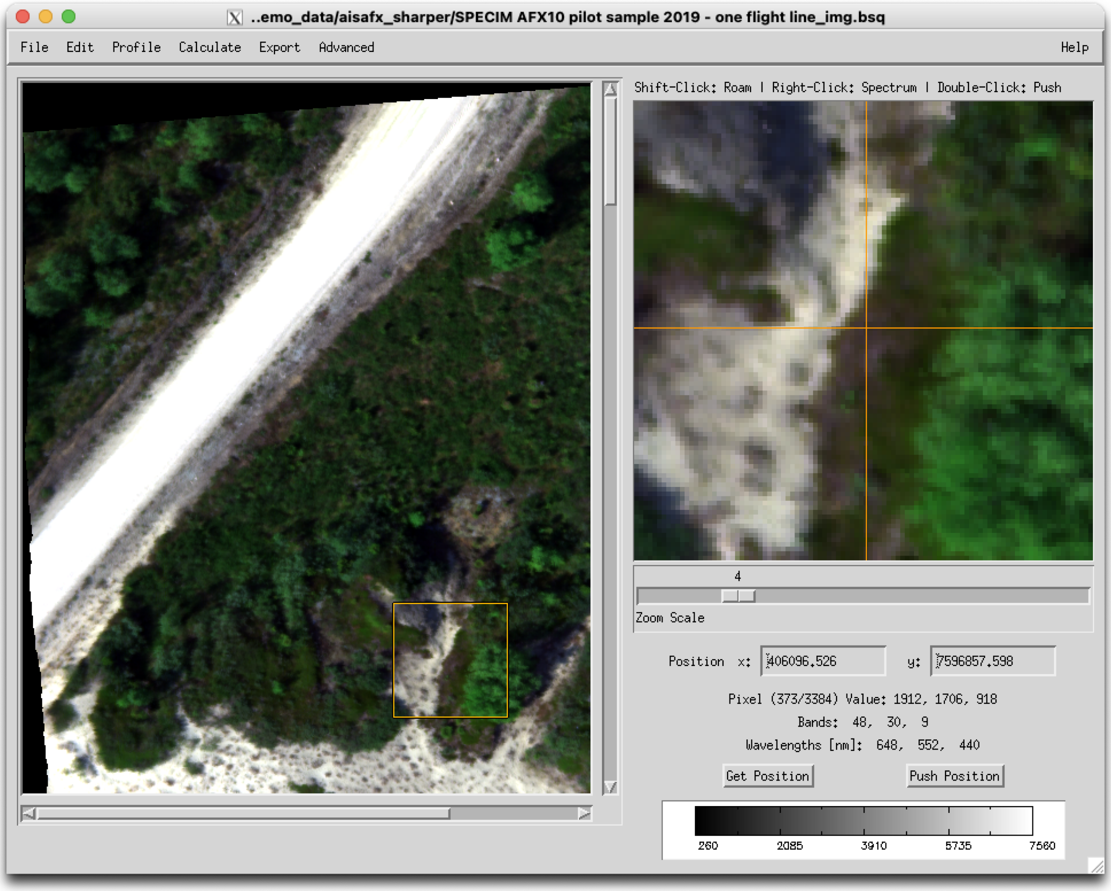


**Figure 2.2**: Image display main panel with overview and zoom image

### 2.1.2 Zoom-Window Options

Selecting the position on the zoom window and clicking the mouse may have the following effects:

(a) *Single click*: The coordinates of the actual pixel and the the original value(s) of the currently displayed image bands in the text below. If no georeferencing information is available, the pixel-coordinates appear.

(a) *Shift click*: The portion of the zoom window is roamed to the new position.

(a) *Right click*: As long as a multi-band image is displayed, a spectral plot window will appear (same as **Profile:Spectrum**) which lets you save and plot the current spectrum and also its data to a text file.

(a) *Double click*: The command 'Push Position' is performed, i.e. the current coordinates are stored for later use.

(a) *Scroll-wheel (or double tap on trackpad)*: The zoom factor is changed.

The position of the cursor may also be changed using the arrow keys on the keyboard. This will also update a possibly displayed profile window according to the new position.

### 2.1.3 Zoom Scale

The zoom scale can be changed from a 1-by-1 view to a factor 20 using the zoom bar. A factor of 0 shows an undersampled subset by a factor of 0.5.

### 2.1.4 Position field

A value may be entered directly such that the zoom focus will jump to the selected pixel - the spectrum may be updated for the such selected pixel. Hit $>$Return$<$ in either field to apply the selected coordinates.

### 2.1.5 Buttons: $>$Get Position$<$ and $>$Push Position$<$

The button **Get Position** reads the last stored position from any GLIMPS image display and updates all data and the cursor position accordingly. The **Push Position** command pushes the currently selected position to stash such that it can be used for further analysis in different windows. The same action may also be achieved by double-clicking the zoom window.

These buttons may be used to link the position between various different displays, e.g. for extracting spectra.

### 2.1.6 Colorbar

The displayed color bar shows the range of values displayed. It is useful for single band imagery and can be exported alongside with the image to show,e.g., the range of indexes displayed. For RGB image display, the color bar is not applicable.

## 2.2 Show Spectral Library

This menu offers functions for ENVI spectral library display and manipulation which are described in detail in Section 8.4

## 2.3 Show Text File

This menu offers the possibility to show an ASCII text file as described in Section 8.5

## 2.4 Move / Rename

This option opens a widget (c.f. Fig. 2.3) that offers an easy way to move, delete, or rename files from input directory to a new location (Output Base Directory). If directory only is given, files are moved to a new directory. If an output directory does not exist, a new (sub) directory is created. Extensions are changed for all files if dot is in the name of the output base directory. A prefix is added if a wild card is given after the name and a suffix is added to the name if a wildcard is given before the name (e.g. *.tif moves example.TIFF to example.tif).

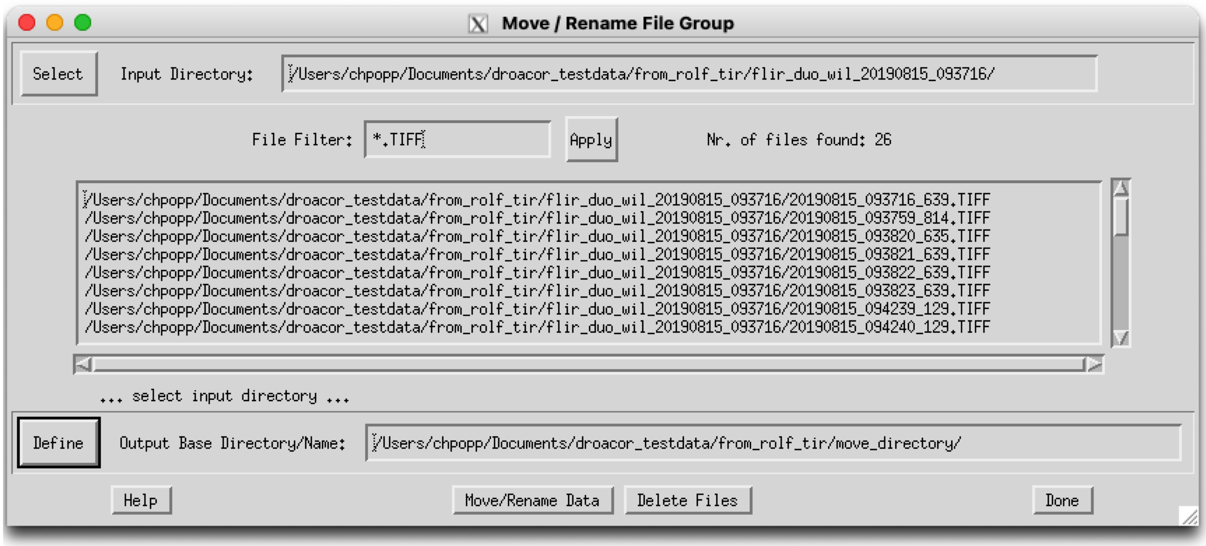


**Figure 2.3**: Move and/or rename group of files.

## 2.5 Convert BIP or BIL to BSQ

DROACOR internally relies on band sequential (BSQ) data storage order of imaging spectroscopy data. Band sequential data is stored as binary files where spectral bands are stored in wavelength increasing order. The functions *Convert BIP to BSQ* and *Convert BIL to BSQ* allow to convert an ENVI file of band interleaved by pixel (BIP) or band interleaved by line (BIL) data format into BSQ.

## 2.6 Export:ENVI BIP

Tranforms a BSQ output image to an ENVI BIP image. The output is named [input]_bip.img by default.

## 2.7 Export:TIFFs and Micasense TIFFs

Standard outputs of DROACOR are band sequential ENVI images. This routine allows to convert the output imagery to multiband TIFFs and is specifically meant for multispectral data. Output TIFFs may be fed into standard photogrammetric software for later processing.

Figure 2.4 shows the conversion panel, including the Micasense output option. For Micasense data, the original input TIFF directory is to be selected such that meta data are written correctly to the ouptut TIFF files. If no base directory is given, the output TIFFs will lack positioning information which is used for geometric processing.

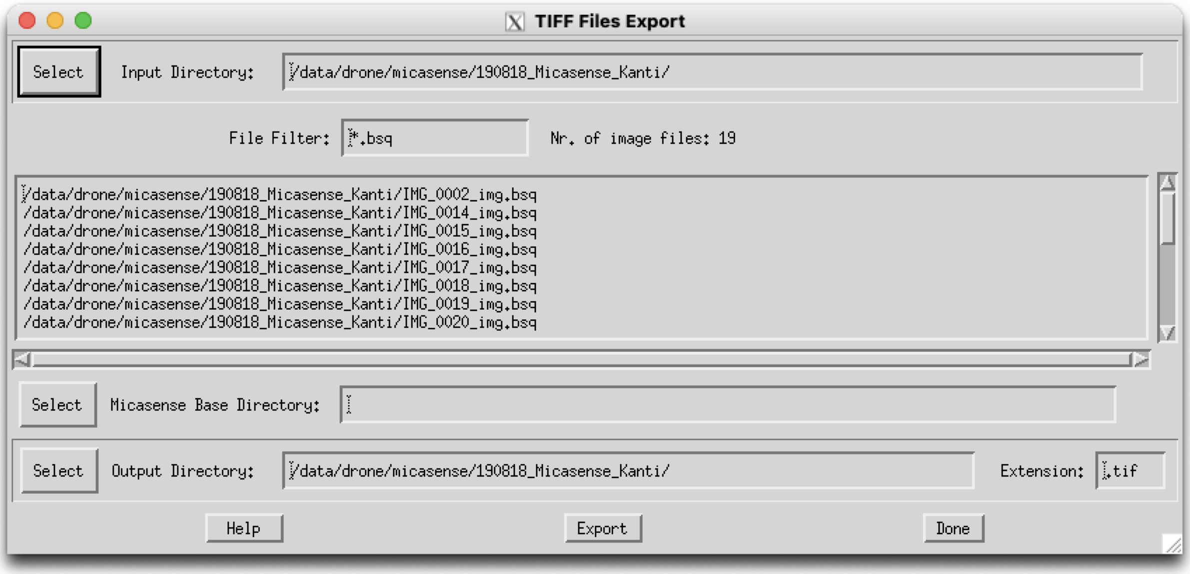


**Figure 2.4**: Export TIFF files from series of ENVI band sequential DROACOR outputs (with special options for Micasense Sensor).

## 2.8 Load JSON Parameters

Use this function to load parameters from a previously stored DROACOR JSON file (*.json). The loaded parameters are then used for further processing as defaults where applicable.

## 2.9 Export Batch File

This function exports a JSON formatted text file which may be used as template for batch processing. Details about batch processing can be found in Section 7.

# Chapter 3

# Menu: Import

For DROACOR processing, data needs to be imported and transformed depending on sensor configuration. DROACOR has an easy to use import function with predefined sensors which are exhibited in the Import Menu as shown in Figure 3.1.

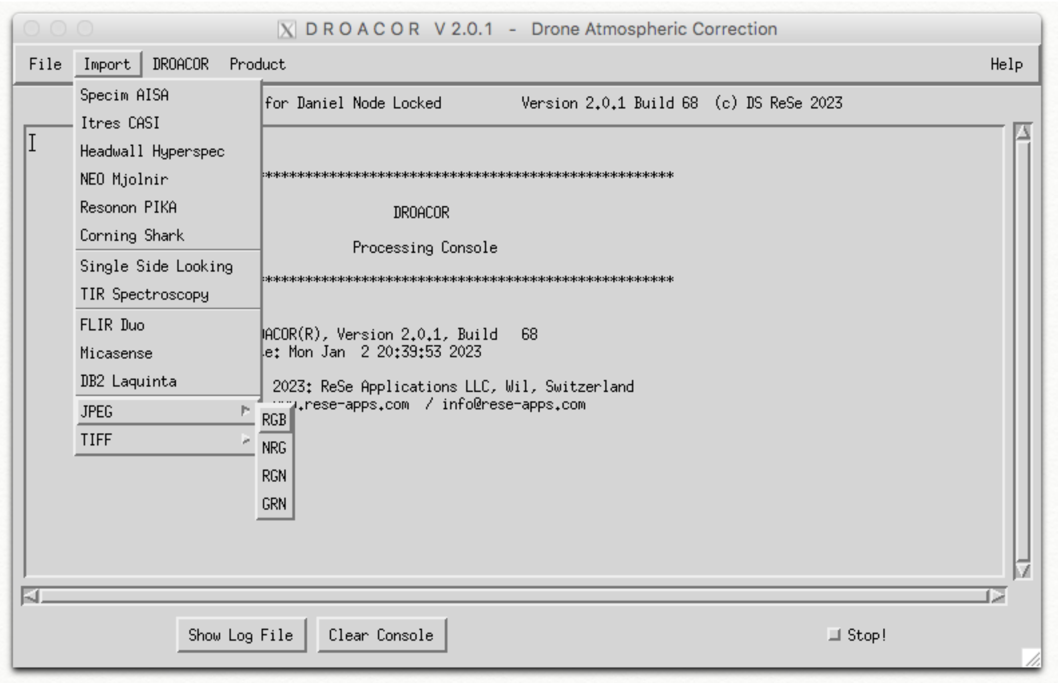


**Figure 3.1**: DROACOR import menu.

This way there is no need for initial sensor definition if you are using one of below:

- Specim AISA (e.g. Fenix, AISA FX)
- HAIP Blackbird
- Itres CASI (incl. µCASI)
- Headwall Hyperspec (e.g. Nano)
- NEO Mjolnir (VS620, Hyspex)

- Resonon PIKA
- Corning SHARK
- FLIR Duo
- Vexcel Ultracam
- Micasense Rededge
- DB Laquinta
- JPEG (1 or 3 band JPG imagery)
- TIFF (standard 1, 3 or 4 band TIFF imagery)

## 3.1 Imaging Spectroscopy Data Import

By clicking on *import* and selecting your sensor, an import prompt appears (see fig. 3.2).

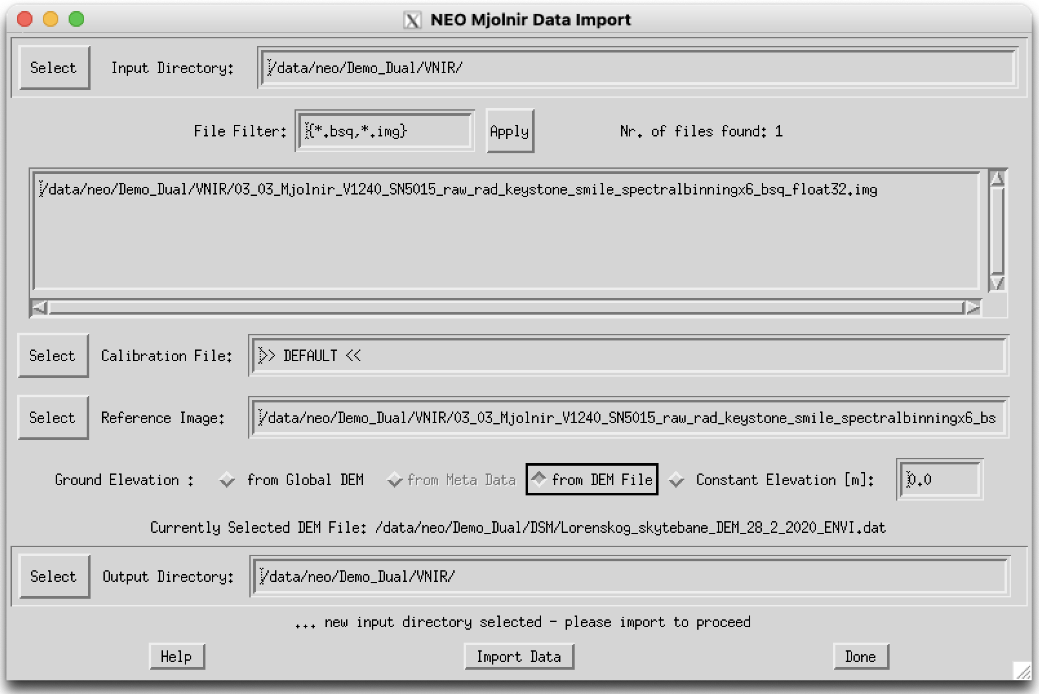


**Figure 3.2**: Import panel for Mjolnir data example.

### 3.1.1 Specim AISA

Required files, to be situated in same directory as input image:

- *SyncedNav*: synchronized GPS/INS file per image; same number of files as input files required.
- *FOV*txt: Internal sensor model (FOV) file - if not present, a default FOV of 38.4 degrees is assumed.
- *GLT or *GLT.dat: Geolocation table file; this file is required to create a scan angle file and for later BRDF correction.
- *wl*wls: wavelength reference file for accurate spectral calibration information (default: data from ENVI header are used)

### 3.1.2 HAIP Blackbird

Required files, to be situated in the same directory as the input image:

- *.hdr: ENVI header containing specific tags for radiometric processing. This header is created in PARGE automatically when processing the data.

### 3.1.3 Itres CASI

Input file: *.tif, PCI/Geomatice *.pix or ENVI file. Input files are converted to ENVI BSQ file during import.

Time zone: The import allows to select the time zone for import. The time is taken from the input file name which often is coded as local time. The time shift is the shift to UTC time, applicable to all data for import.

Required files, to be situated in same directory as input image:

- *glu*: Itres GLU envi file with auxiliary image layers - same number as input images
- *nad*: Itres NAD envi file with auxiliary image layers; alternatively to GLU file
- $$imgfile$$

  .txt: GPS/INS file per image; same number of files as input files required (alternative: *.acs)
- *wl*wls: wavelength reference file for accurate spectral calibration information (default: data from ENVI header are used)

### 3.1.4 Headwall Hyperspec

Required files, to be situated in same directory as input image:

- *imu_gps.txt: IMU/GPS file for whole data set (single file)
- settings.txt: Processing settings containing information about lens, exposure and time (single file)

### 3.1.5 NEO Mjolnir/Hyspex

Required files, to be situated in same directory as input image:

- .gcs: PARGE geocoding GCS file (one for each image with same base name)
- _sca.bsq: PARGE scan angle file (for geo-rectified imagery only)

### 3.1.6 Resonon PIKA

Required files, to be situated in same directory as input image:

- .bip or .bil: Original imagery in rectified or unrectified format.
- .lcf: ASCII file containing time stamp, roll,pitch, heading, lat,lon,alt corresponding to each image

For rectified imagery, the FOV of the sensor is read from the ENVI header (history tag), whereas a default value of 24 deg is assumed for unrectified imagery.

### 3.1.7 Corning SHARK

Required files, to be situated in same directory as input image:

- .bip : Original imagery in rectified or unrectified format.
- .nav.txt: ASCII file containing time stamp, roll,pitch, heading, lat,lon,alt corresponding to each image frame

A default value of 29.5 degrees is assumed for the FOV.

## 3.2 Single File Import

Standard processing with DROACOR assumes large data acquisitions with a considerable number of files to be processed in one step. However, for experimental processing, for side looking instruments and for hyperspectral thermal instruments, only single or few number of scenes are normally acquired. Thus, there is a possibilty to import and process such data on a single file basis.

### 3.2.1 Single Side Looking

Side looking data or horizontal data acquisitions from optical instruments are normally unrectified and are to be processed on a file-per-file basis. A manual import option is offered for such special cases, which allows to import single files instead of whole directories. The corresponding panel is shown in Figure 3.3.

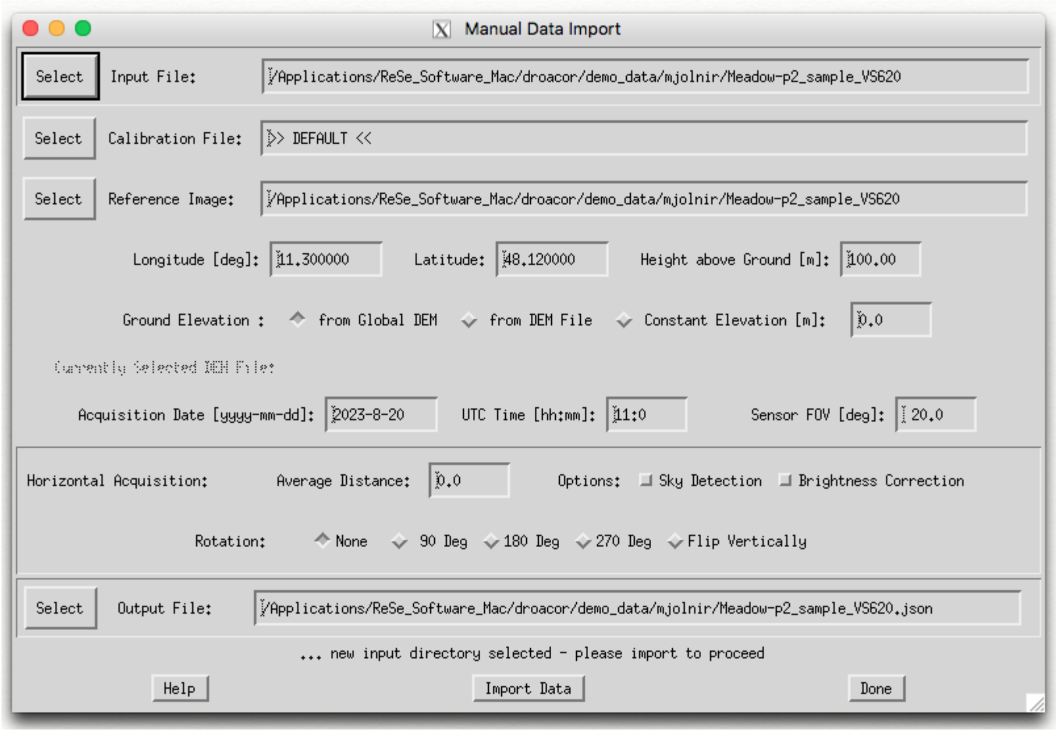


**Figure 3.3**: Panel for manual import of single files or horizontal/side looking data.

DROACOR Manual Single File Data Import
======================================
Generic data import for side looking and non-standard systems.

Inputs:
-------
Input File:
Name of ENVI or TIFF formatted input file. Possibly accompanied with
a PARGE scan angle file *_sca.bsq, containing scan geometry information.
Calibration File:
Standard calibration file for conversion of file to mW/(cm2 sr nm).
*.cal with c0/c1 in two columns
Reference Image (optional):
Image used for spectral recalibration (hyperspectral); if kept empty
the input image is used
Longitude: degrees East

Latitude: degrees North

Height above ground: sensor height above ground altitude

Ground Elevation:
From Global DEM (searches for the average ground elevation based on
the location of the images)
Constant Elevation (use for user defined ground elevation,
click in field and press < enter >), applicable for

whole campaign.
Acquisition Date:
date of data take, format yyyy-mm-dd
UTC (GMT) Time:
time of data take, format hh:mm
Sensor FOV (total)
total field of view of system; if scan angle file is given,
this parameter is not relevant.
Output File:
Name of output to be created.

For Horizontal Acquisition:

Average Distance:
Entering a value larger than zero triggers the horizontal acquisition
mode using a different geometric representation. The average distance
is entered here. if the scan file contains a pixel distance layer, the
pixel distance is read from the scan angle file during process.
Options:
- Sky Detection: detect sky portion and mask it
(for horizontal data acquisitions)
- Brightness Correction: empirical correction of image brightness
Rotation:
Rotation of unrectified image outputs (side looking)
given degrees of flipping

Actions:
-------
> Help <
Displays this help file
> Import Data <
Imports the data to the given location; reformats to ENVI BSQ
files for later processing and writes a *json parameter file.
> Done <
Closes the window

Outputs:
-------
The routine imports the data and writes a standard json file for processing.

xacimp_manual.txt, ReSe

## 3.3 Hyperspectral Specialities

### 3.3.1 Tripod

This function allows to import series of Tripod-based terrestrial data acquisitions. Supported systems are AISA Fenix/AFX and NEO Mjolnir/Hyspex. The import GUIs correspond to the panel shown in Figure 3.4 with the possibility to process entire directories.

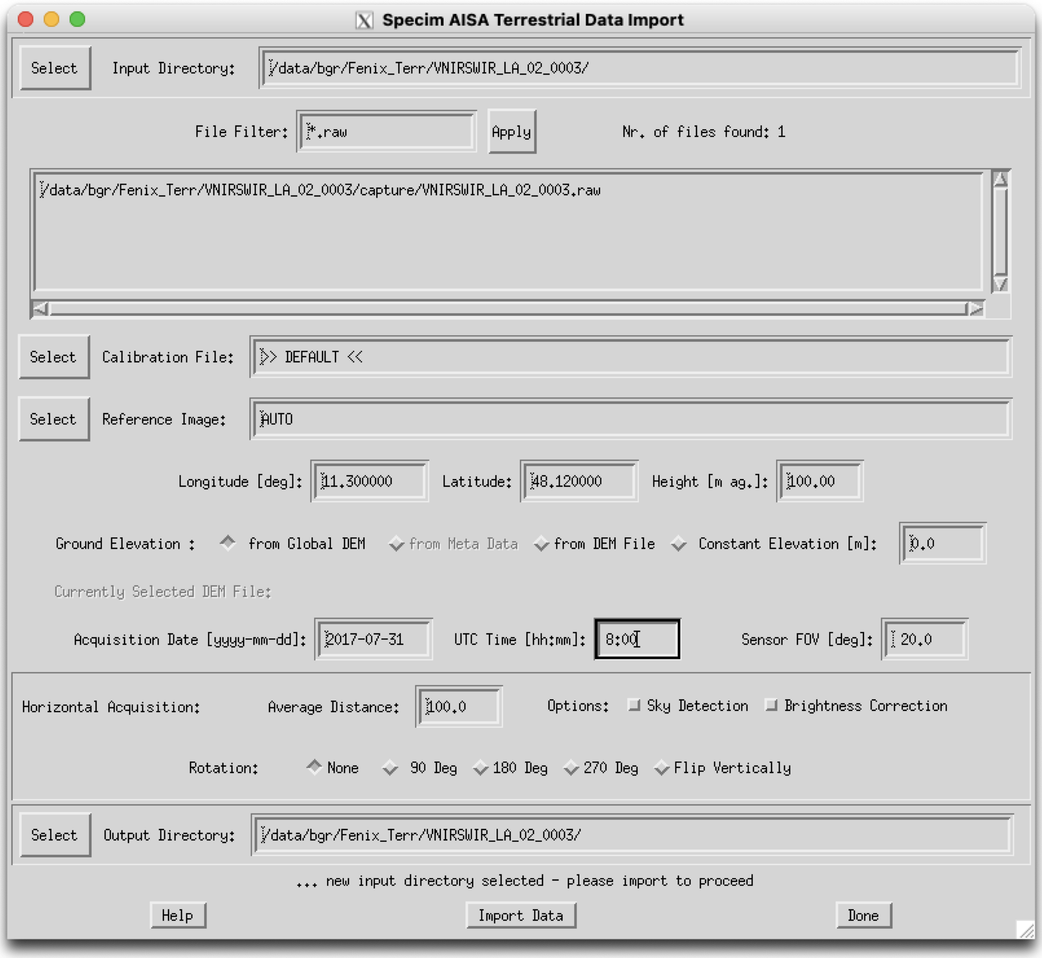


**Figure 3.4**: Panel for manual import of horizontal view data (specim example).

DROACOR Terrestrial/Tripod Data Import
========================================
Data import for tripod based horizontal scanner systems. Currently,
Hyspex Mjolnir and Specim Fenix/AFX are supported:

Hyspex/Mjolnir
--------------
For VS620: if data is selected in the VNIR directory, the software automatically
searches for the corresponding SWIR directory and creates a merged data cube
(in a new directory called 'merged'). Reflectance processing can then be done from there.

AISA
----
The input parent directory should contain the full set of a specim data structure.
This includes the subdirectory ./capture where the raw image files should be stored.
For the calibration file, one has to select any *.cal file in a calibrations

directory; the path of this file is then used as a basis for radiance conversion of the raw data.

```
Inputs:
-------
Input Directory:
   Directory containing series of images to be processed.
   Images are first to be imported using the sensor specific
   import function (just select any file in directory)
File Filter:
   this is the filter to select the files to be processed.
   Use wildcards '*' for selection; hit return to apply the filter.
Nr. of image files:
   Depending on the selected directory and file filter, the
   number found files is shown; use
List of files: t
   he list is updated based on directory and filter
   (this window is not meant for selection)
Calibration File:
   Allows the select a *.cal file from data provider or from
   inflight calibration to be written to the parameter file of
   all imported data sets.
   By default a standard scaling factor is used.
Reference Image (optional):
   Image which is used as a calibration reference. Default parameters
   such as the sensor spectral calibration is based on the reference image.
Longitude/Latitude/Height:
   Location of sensor; Lat/Lon as degrees East, degrees North
   Sensor height meters above ground altitude
Ground Elevation:
   From Global DEM: (searches for the average ground elevation based on
     the location of the sensor)
   From DEM File: Select DEM/DSM to
   Constant Elevation" (use for user defined ground elevation,
     click in field and press < enter >), applicable for whole campaign.
Acquisition Date:
   date of data take, format yyyy-mm-dd
UTC (GMT) Time:
   time of data take, format hh:mm
Sensor FOV (total)
   total field of view of system; if scan angle file is given,
   this parameter is not relevant.

Average Distance:
   Entering a value larger than zero triggers the horizontal acquisition
   mode using a different geometric representation. The average distance
   is entered here. if the scan file contains a pixel distance layer, the
   pixel distance is read from the scan angle file during process.
Options:
   - Sky Detection: detect sky portion and mask it
```

(for horizontal data acquisitions)
- Brightness Correction: empirical correction of image brightness
Rotation:
Rotation of unrectified image outputs (side looking)
given degrees of flipping

Output Directory:
Name of directory where the imported data sets and *.json
meta data files shall be written to.

Actions:
-------
> Help <
Displays this help file
> Import Data <
Imports the data to the given location; reformats to ENVI BSQ
files for later processing and writes a *json parameter file.
> Done <
Closes the window

Outputs:
-------
The routine imports the data and writes a standard json file for processing.
Reflectance processing can be done with the standard routines subsequently.

xacimp_tripod.txt, ReSe

### 3.3.2 TIR Spectroscopy

TIR spectroscopy data import can be supported by DROACOR upon request; the respective methods need some special support and instrument filters may need to be adapted. Please contact ReSe to learn about the status of hyperspectral thermal infrared data processing or if you'd like to unlock this functionality.

## 3.4 Multispectral Data Import

All multispectral import functions follow the same scheme. An import window is shown in Figure 3.5 as an example:

DROACOR Multispectral Data Import
==================================
For DROACOR processing, data needs to be imported and transformed
depending on sensor configuration.

Inputs:
------
Input Directory:
Directory containing series of images to be processed.

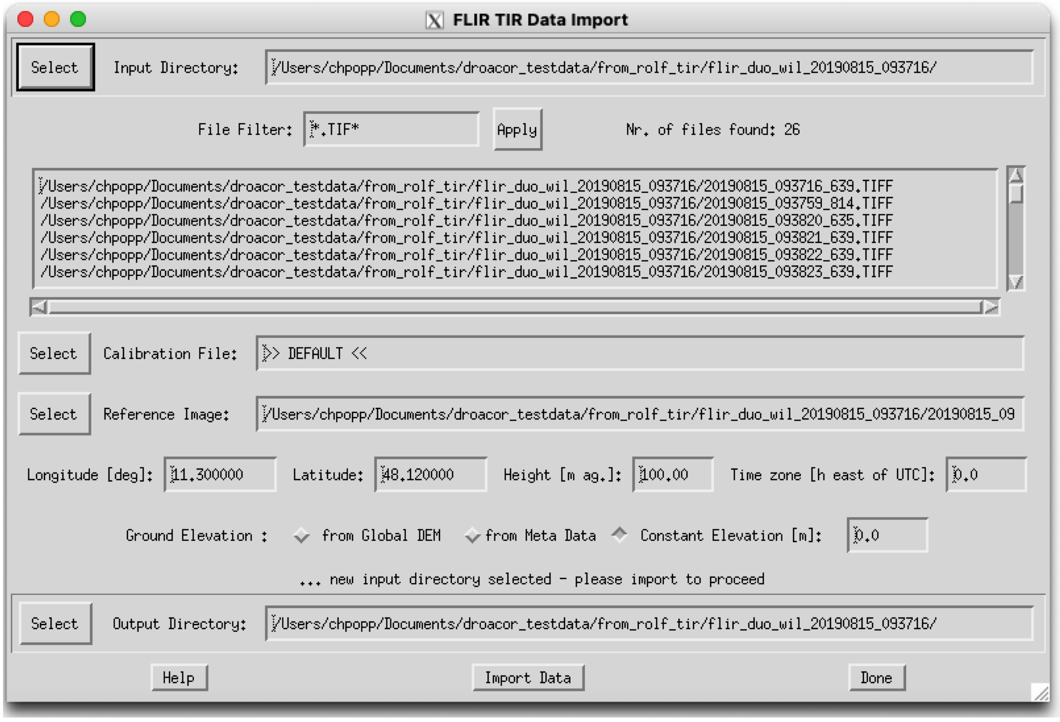


**Figure 3.5**: Panel for manual import of FLIR Duo data.

Images are first to be imported using the sensor specific
import function (just select any file in directory)

File Filter:
this is the filter to select the files to be processed.
Use wildcards '*' for selection; hit return to apply the filter.

Nr. of image files:
Depending on the selected directory and file filter, the
number found files is shown; use

List of files: the list is updated based on directory and filter
(this is not for selection)

Select Cal-File:
Allows to select a *.cal file from data provider or from
inflight calibration to be written to the parameter file of
all imported data sets.
By default a standard scaling factor is used.

Reference Image:
Image which is used as a calibration reference.
Default parameters may be derived from the reference image at
a later stage of processing.
for multispectral: if no cal file is given, an empirical calibration
is derived from the reference image
for hyperspectral: the spectral calibration is found from reference image

Ground Elevation:
From Global DEM (searches for the average ground elevation based on

the location of the images)
From Meta Data (reads ground elevation from Meta Data; if available..)
From DEM File: use a DEM/DSM for further processing.
Constant Elevation (use for user defined ground elevation,
click in field and press < enter >), applicable for
whole campaign

Output Directory:
Name of directory where the imported data sets and *.json
meta data files shall be written to.

Micasense Options:
Micasense Camera File: file describing the internal geometry of the
micasense image bands used for coregistering.

> Create < calculates the camera definition file by correlation analysis
on the selected reference image; the latter should be taken at standard
flight altitude and it should contain distinct, non-moving surface
structures

Actions:
-------
> Help <
Displays this help file

> Import Data <
Imports the data to the given location; reformats to ENVI BSQ
files for later processing and writes a *json parameter file.

> Done <
Closes the window

Outputs:
-------
The routine creates *bsq and *hdr files of converted input imagery
(where applicable) and writes a *.json file for each input image
found.

xac_import.txt, ReSe

### 3.4.1 FLIR Duo

The import of one-channel thermal infrared measurements from FLIR Duo is supported. The parameters and the use of this panel is mostly the same as with hyperspectral data. As meta data for such data is often missing, it is possible to provide standard meta data information in an additional row in the panel with the following parameters:

### 3.4.2 Vexcel Ultracam

Import 4-band Ultracam photogrammetric imagery. The GUI is similar to the one shown in Figure 3.5 and the corresponding parameters description can be found above. Note that Vexcel Ultracam files are usually TIFF files and are also typically imported and processed (e.g. to reflectance) as such, along with an associated JSON file.

### 3.4.3 Micasense

Micasense processing is done on the basis of co-aligned imagery, created from the single band TIFF imagery by warping based on a camera description file. As inputs, the first .tif file is to be given while corresponding files of additional bands are read automatically. Currently, 5-band Micasense standard configuration is supported; other configuration may be added upon request. The panel is shown in Figure 3.6.

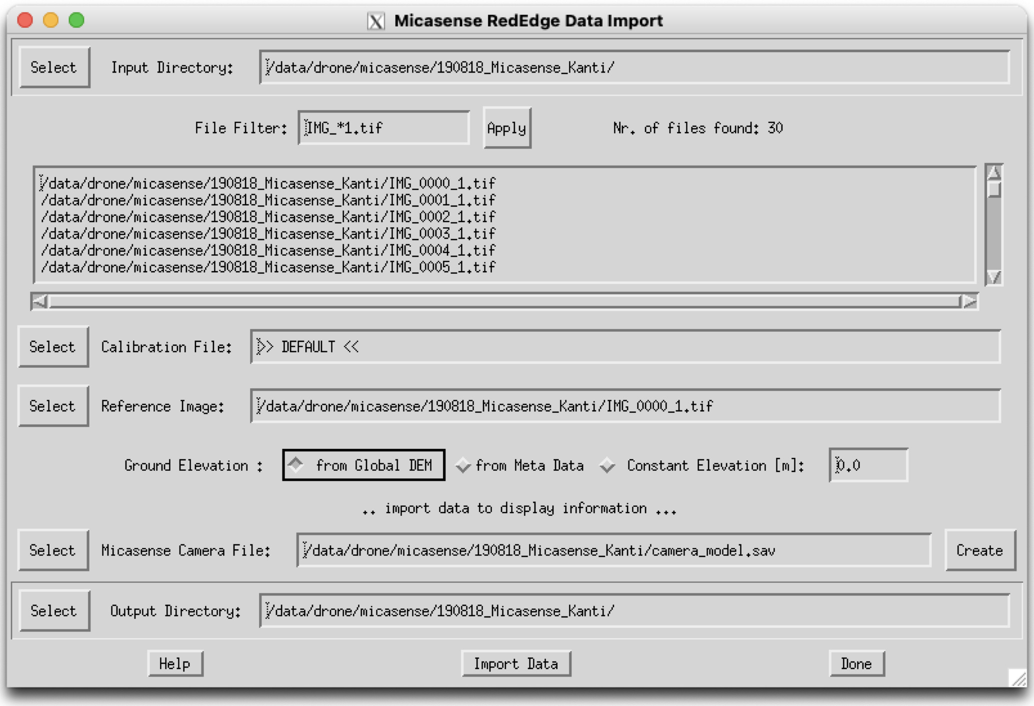


**Figure 3.6**: Panel for manual import of Micasense RedEdge M data.

Details are shown above.

### 3.4.4 DB2 Laquinta

This imports standard 4-band DB2 Laquinta imagery. No additional files are required for data import but EXIF meta data is to be complete in TIFF files to import. A default FOV of 47.2 x 36.4 degrees is assumed. The options are standard parameters as described above.

### 3.4.5 JPG or TIFF

The import of standard multispectral data is supported for three-band RGB JPEG or TIFF imagery as well as for selected multi-band tiff imagery. An example of an import window is shown in Figure 3.7. The storage order of the bands is to be taken as of the menu with a combination of three bands from B: Blue, G: Green, R: Red, and N: Near Infrared.

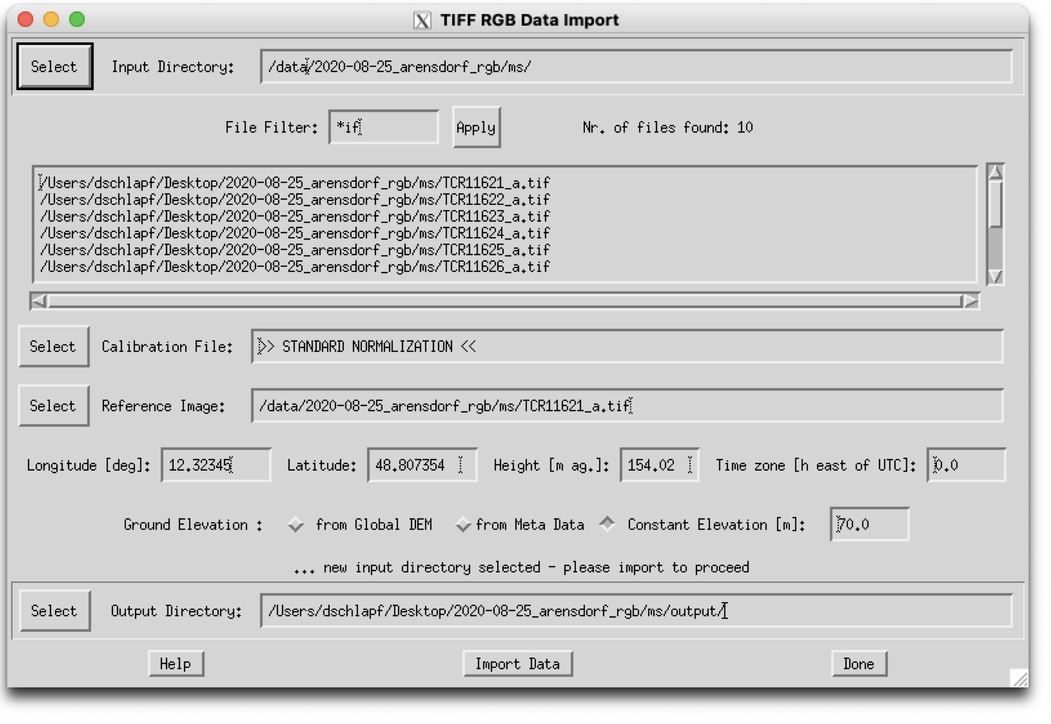


**Figure 3.7**: Import panel for standard TIFF data.

The parameters and the use of this panel is mostly the same as with hyperspectral data. As meta data for such data is often missing, it is possible to provide standard meta data information in an additional row in the panel with the following parameters:

DROACOR TIFF/JPEG Data Import
=============================
For DROACOR processing, data needs to be imported and transformed
depending on sensor configuration.

Inputs:
------
Input Directory:
    Directory containing series of images to be processed.
    Images are first to be imported using the sensor specific
    import function (just select any file in directory)
File Filter:
    this is the filter to select the files to be processed.

Use wildcards '*' for selection; hit return to apply the filter.
(note: this is case sensitive on Linux/MacOSX)
Nr. of image files:
Depending on the selected directory and file filter, the
number found files is shown; use

List of files: the list is updated based on directory and filter
(this is not for selection)

Select Cal-File:
Allows the select a *.cal file from data provider or from
inflight calibration to be written to the parameter file of
all imported data sets.
If no cal file is selected, a standard normalization based on image
statistics is performed.
Reference Image:
One selected image from the file list which may be used for relative
normalization at a later stage.
Longitude/Latitude:
Average Location of images used for irradiance calculation. This value is
overriden in case GPS location is found in TIFF/JPEG EXIF data.
After data import, the last value is written to this field.
Height [m a.g.]:
Flight altitude above ground of aircraft; this is the GPS altitude
minus the ground altitude as from the subsequent line.
Ground Elevation:
From global DEM (searches for the average ground elevation based on
the GPS location of the images)
From Meta Data (reads ground elevation from Meta Data if available)
Constant elevation (use for user defined ground elevation,
as from the adjacent field), applicable for
whole campaign.
Output Directory:
Name of directory where the imported data sets and *.json
meta data files shall be written to.

Actions:
-------
> Help <
Displays this help file

> Import Data <
Imports the data to the given location; reformats to ENVI BSQ
files for later processing and writes a *json parameter file.

> Done <
Closes the window

Outputs:
-------

The routine reads as many parameters as possible from JPEG/TIFF EXIF data and writes a *.json file for each input image found.

xac_import_tiff.txt, ReSe

# Chapter 4

# Menu: DROACOR

The DROACOR menu contains the main radiometric processing routines of DROACOR. The calibration function is required if panel based inflight calibration is to be performed whereas the processor function is the core reflectance retrieval or temperature-emissivity separation applicable in any case; compare Fig. 4.1 to Fig. 4.6.

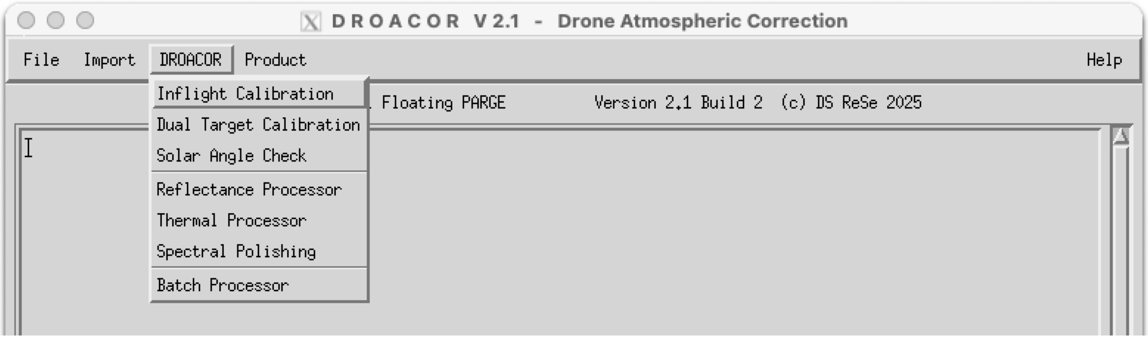


**Figure 4.1**: DROACOR menu

## 4.1 Inflight Calibration

This routine is to derive calibration constants from uncalibrated digital numbers of an image. It requires a target of known reflectance being present in the image. If the data is not calibrated, three steps are required:

1. Import the reference file raw data using the respective import function of DROACOR,
2. perform the inflight calibration and write the .cal file,
3. Import complete data set while selecting the such created .cal file.
4. Proceed to processing

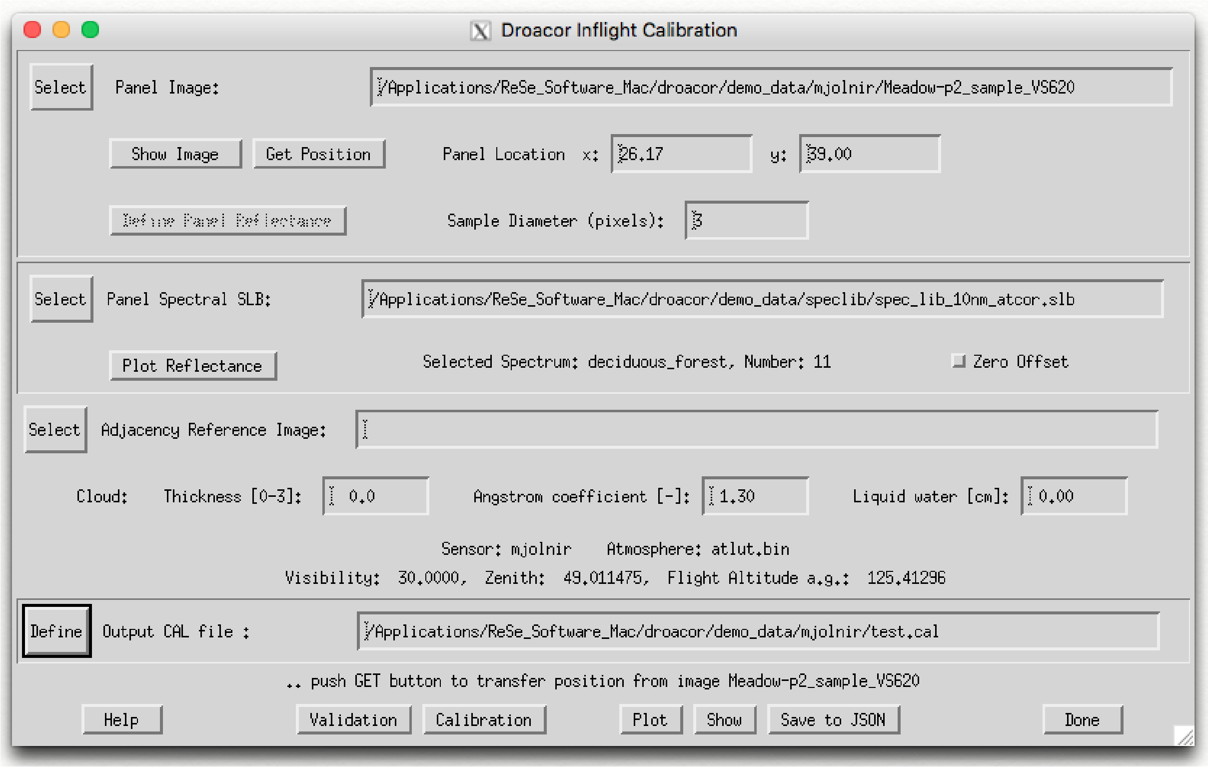


**Figure 4.2**: DROACOR Inflight Calibration.

DROACOR Inflight Calibration
============================

This routine is to derive calibration constants from uncalibrated
digital numbers of an image. It requires a target of known reflectance
being present in the image.
Preparation: before a calibration can be performed, an image is to be
imported to DROACOR by the standard import procedure.
Attention: After inflight calibration, the import is to be repeated,
using the generated calibration file.

Inputs:
------
Panel Image:
    Image to be used for calibration, containing the reference panels/target.

    >Show Image< : Displays the currently selected reference image

    >Get Position< : Get the position of the panel from
        reference image (after having used the funtion >Push
        Position< in the reference image display)

Panel Location: Pixel coordinates of center of reference target
        (as imported from displayed image)

> Define Panel Reflectance <
Allows to enter panel reflectance values manually
for multispectral imagery. The reflectance values are written
to an ENVI spectral library upon completion.

Sample Diameter: Diameter of square sample to be taken
(in pixels) around panel location center coordinates.

Panel Spectral SLB:
ENVI spectral library containing the spectrum of the
reference target (unitless reflectance or % reflectance)

If more than one spectrum are contained in the SLB, the
respective spectrum can be selected from a displayed list.

> Plot Reflectance <:
Plots all spectra of the currently selected spectral library file.

Button: Zero Offset: creates a calibration file with offset (c0)
set to zero.

Adjacency Reference Image (optional):
Reference image used for adjacency reference spectrum
calculation. This is useful if the panel has been measured on
the ground and not in flight. If kept empty, the reference
signatures are taken from the panel image itself.

Cloud:
optionally allow to define cloud parameters for below cloud
data acquisitions.
Thickness: thickness of cloud in km
Angstrom: doefficient of scattering (large particles have lower values)
Liquid water content: cm of liquid water in cloud

Information:
shows some currently valid parameters for inflight calibration

Output CAL file:
Name of calibration output file to be written (*.cal)

Actions:
-------
> Validation <
Uses the currently selected CAL file to calculate the
Bottom of atmosphere reflectance in comparison to the currently
selected spectral library spectrum. Additionally, the currently
valid calibration as stored in the JSON image parameter file is
plotted for comparison.

> Calibration <
  Uses the currently selected target reflectance for creation of new
  inflight calibration constants, which are stored in the selected,
  currently defined Output CAL file.

> Plot <
  Plots the calibration constants from the cal file in comparison to
  the currently active calibration constants from JSON file.

> Show <
  Shows the ASCII-Text Calibration file.

> Save to JSON <
  Saves the current calibration constants from the cal file to the
  JSON parameter file of the active reference image. This is required
  for later use in the processing.

> Done <
  Closes window

Outputs:
-------
The routine creates calibration files with center wavelength, offset
c0 (radiance offset)  and gain c1 (radiance/DN) for the conversion

  L= c0 + c1 * DN

NOTE: The cal files are not used in the processing directly as the
calibration constants are normally taken from the JSON files of a
reference image to be provided.

xac_ifcali.txt, DS

## 4.2 Dual Target Calibration

For improved inflight calibration, a combination of a dark and bright reference panel can be used. The respective procedure is supported in DROACOR here.

DROACOR Dual Panel Inflight Calibration
=======================================
This routine is to derive calibration constants from uncalibrated
digital numbers of an image. It requires two targets of known reflectance
being present in the image.

Preparation: before a calibration can be performed, an image is to be
imported to droacor by the standard import procedure.

Attention: After inflight calibration, the import is to be repeated,
using the generated calibration file.

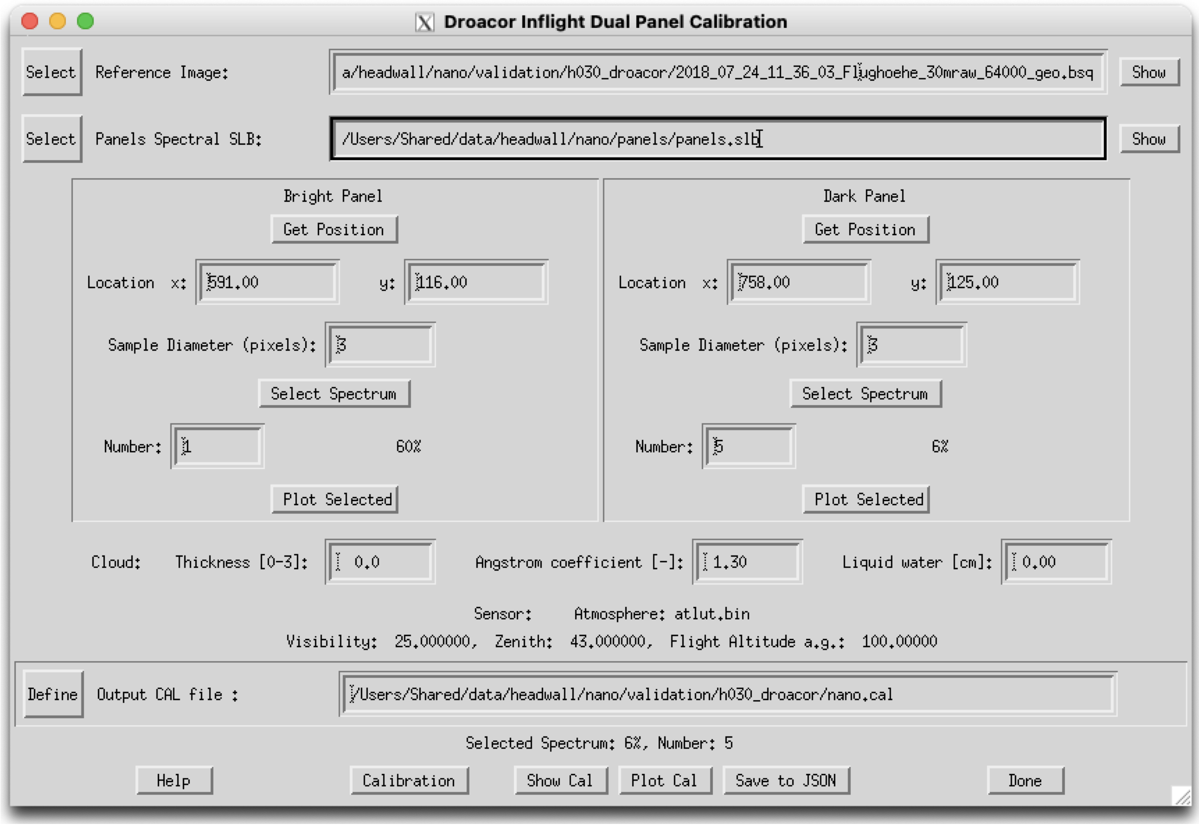


**Figure 4.3**: DROACOR Inflight Dual Panel Calibration.

Inputs:
------
Reference Image:
  Image to be used for calibration, containing the reference target.

  >Show< : Displays the currently selected reference
        image

Panel Spectral SLB:
  ENVI spectral library containing the spectrum of the
  reference target (unitless reflectance or % reflectance)

  The spectral library should contain the spectra of both
  reference panels.

  > Show <:
  Plots all spectra of the currently selected spectral
  library file.

Panels:
  Bright and Dark Panels are to be defined:

>Get Position< : Get the position of the panel from
reference image (after having used the funtion >Push
Position < in the reference image display)

Location: Pixel coordinates of center of reference target

Sample Diameter: Diameter of square sample to be taken
(in pixels) around panel location center coordinates.

> Select Spectrum <
Select the spectrum fitting to the respective panel

Cloud:
optionally allow to define cloud parameters for below cloud
data acquisitions.
Thickness: thickness of cloud in km
Angstrom: doefficient of scattering (large particles have lower values)
Liquid water content: cm of liquid water in cloud

Information:
shows some currently valid parameters for inflight calibration

Output CAL file:
Name of Calibration output file to be written (*.cal)

Actions:
-------
> Calibration <
Uses the currently selected target reflectance for creation of new
inflight calibration constants, which are stored in the selected,
currently defined Output CAL file.

> Plot Cal <
Plots the calibration constants from the cal file in comparison to
the currently active calibration constants from JSON file.

> Save to JSON <
Saves the current calibration constants from the cal file to the
JSON parameter file of the active reference image. This is required
for later use in the processing.

> Done <
Closes window

Outputs:
-------
The routine creates calibration files with center wavelength, offset
c0 (radiance offset) and gain c1 (radiance/DN) for the conversion

L= c0 + c1 * DN

NOTE: The cal files are not used in the processing directly as the
calibration constants are normally taken from the JSON files of a
reference image to be provided.

xac_ifcali2.txt, DS

## 4.3 Solar Angle Check

This is an interface to calculate the solar geometry (i.e. solar azimuth, elevation, and zenith angle) as a function of geographical coordinates and date and time. The widget shown in Fig. 4.4 is straightforward and might be used for example to verify the geometric condition during image acquisition.

**Figure 4.4**: Solar Geometry Calculation.

## 4.4 Reflectance Processor

This is the main atmospheric compensation routine for bottom of atmosphere reflectance retrieval.

```
DROACOR Reflectance Processing
==============================
This is the main atmospheric compensation routine for on-ground
reflectance retrieval.

Inputs:
------
Input Directory:
     Directory containing series of images to be processed.
     Images are first to be imported using the sensor specific
     import function (just select any file in directory)

     Sensor: the sensor is selected automatically based on the
         found JSON parameter files in the given directory.

     File Filter: this is the filter to select the files to be
          processed. Use wildcards '*' for selection;
          hit return to apply the filter.

File list (Nr. of image files):
    Depending on the selected directory and file filter, the
    list is updated  (note: no actions are related to this list)

Reference Image:
```

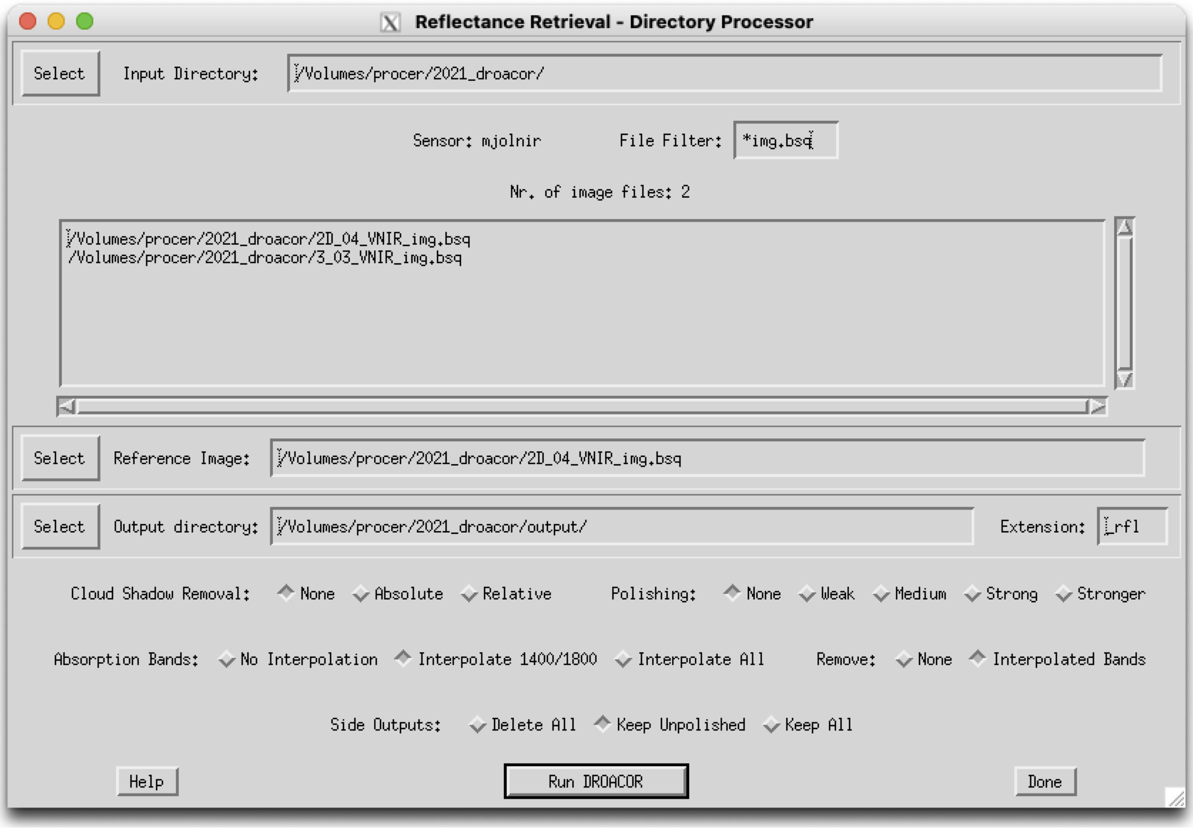


**Figure 4.5**: DROACOR main atmospheric correction processor.

Image which had been used for calibration. Default parameters such as the sensor calibration constants are taken from the JSON file of the Reference image. (first image is taken as reference if left empty)

Below Cloud Uniform Shading Correction:
This option can be applied if data is taken completely below cloud:
None: no cloud shading removal is applied
Absolut: cloud cover is calculated from image statistics
Relative: cloud cover is calculate relative to reference image

Polishing: Level of polishing to be applied:
None: No polishing is applied
(but feature interpolation is done)
Weak: Savitsky Golay Filter by a 7-band filter size
Medium: Savitsky Golay Filter by a 9 -band filter size
Strong: Derivative Filter from 7 bands with
2 band smoothing
Stronger: Derivative Filter from 9 bands with
3 band smoothing
Split band: Detector split band; first band of 2nd detector
for polishing and Jump Correction. Value of 0/1 means no
detector split

Jump Correction: Apply empirical brightness correction between SWIR and
VNIR spectral band at split band. The SWIR brightness is
adapted to VNIR by multiplicative adjustment.
- Mean: the adjustement is done by adjusting the mean
  reflectance 845-890 nm to the mean of 1005-1060 nm
- Trend: the trend in reflectance betweeen 845 adn 890 is
  extrapolated to the mean fo 1005 to 1060 nm

Interpolate Absorption Bands:
Bands of high water vapor absorption or sensor-specific
bands of low sensitivity may be treated by interpolation or removed completely
from the image. Choose one of the follwoing options:
- No Interpolation: Spectra are kept ’as is’ after feature optimization
  (only fully absorbing saturating bands are still interpolated)
- Interpolate 1400/1800: Only 1400 and 1800 nm absorption bands are
  interpolated.
- Interpolate All: Interpolates 940/1130/1400 and 1800nm
  atmospheric absorption bands

Remove: Spectral bands to remove completely from outputs.
None: leave all bands in the output
Interpolated Bands: remove bands interpolated in absorption bands
List: use band list in input json file; selected Bands are kept in output

Side Outputs: choose to store the main output only and
Delete All: only main output is kept
Keep Unpolished: main output and unpolished outputs are kept
(allows subsequent different polishing)
Keep All: will keep raw output, feature corrected output and
final outputs

Output Directory:
Name of directory, where all outputs shall be written to.
Extension: file extension of mainoutput files, default: _rfl
(will be *_rfl.bsq files)

Actions:
-------
> Run Droacor <
Applies the reflectance retrieval routine to each of the
selected images.

> Show Output <
Will show the last selected main output

Outputs:
-------
The routine may create the following outputs:
*_rfl.bsq : atmospherically corrected reflectance image
*_rfl.log : log file containing information about the processing per image

*_rfl_ft.bsq: feature enhanced and band-interpolated reflectance image
*_rfl_ft_ph.bsq: feature enhanced and polished reflectance image
*_rfl_ft_ph_rm.bsq: feature enhanced and band removed output

If side outputs are deleted in the process, the main output is simply:
*_rfl.bsq : fully corrected and polished image output.

xac_droacor.txt, DS

If side outputs are deleted in the process, the main output is simply: **_rfl.bsq*, i.e. fully corrected and polished image output; if ’Keep Unpolished’ is pushed, only two outputs, the unpolished and the polished (and optionally interpolated/cleaned) output named *_rfl_ph.bsq is stored.

## 4.5 Thermal Processor

This function starts the one-channel FLIR Duo thermal infrared retrieval of surface temperature. In order to unlock the functionality of the hyperspectral temperature-emissivity separation routine based on the NEM method please contact ReSe.
Following inputs are required:

**Input Directory** Directory containing series of images to be processed. Images are first to be imported using the sensor specific import function (compare Chapter 3) such that a parameter file *.json is available for each file to process. Just select any file in the directory to get the directory location.

1. **Sensor** the sensor is selected automatically based on the found JSON parameter files in the given directory.
2. **File Filter** this is the filter to select the files to be processed. Use wildcards ’*’ for selection; hit return to apply the filter.

**File List** Depending on the selected directory and file filter, the list of files to process is updated (note: no actions are related to this list)

**Output Directory** Name of directory, where all outputs shall be written to. The *.json files are also stored (and searched) in the output directory. So, it’s not recommended to have different output directories for data import and data processing.

1. **Temperature Extension** Extension to be written to the output file.
2. **Output Temperature Unit** Unit of temperature in output file. Options are: Celsius, Kelvin, and Kelvin scaled.

**Parameter Options** Processing options include:

- **Water Vapor** Atmospheric water vapor amount (in cm).
- **Ground Emissivity** (Average) emissivity of the surface.

- **Cold Pixel Threshold** Threshold to be applied for identification and correction of cold pixels. The value given here is applied as the ratio to the median of the measured radiance at sensor values of the scene.

**Run DROACOR** The action *Run DROACOR* applies the thermal retrieval routine to each of the selected images. This creates the following outputs:

- ***_tem.tif** raw atmospherically corrected temperature image
- ***_emi.tif** derived emissivity image (where applicable)
- ***_.log** log file containing information about the processing per image

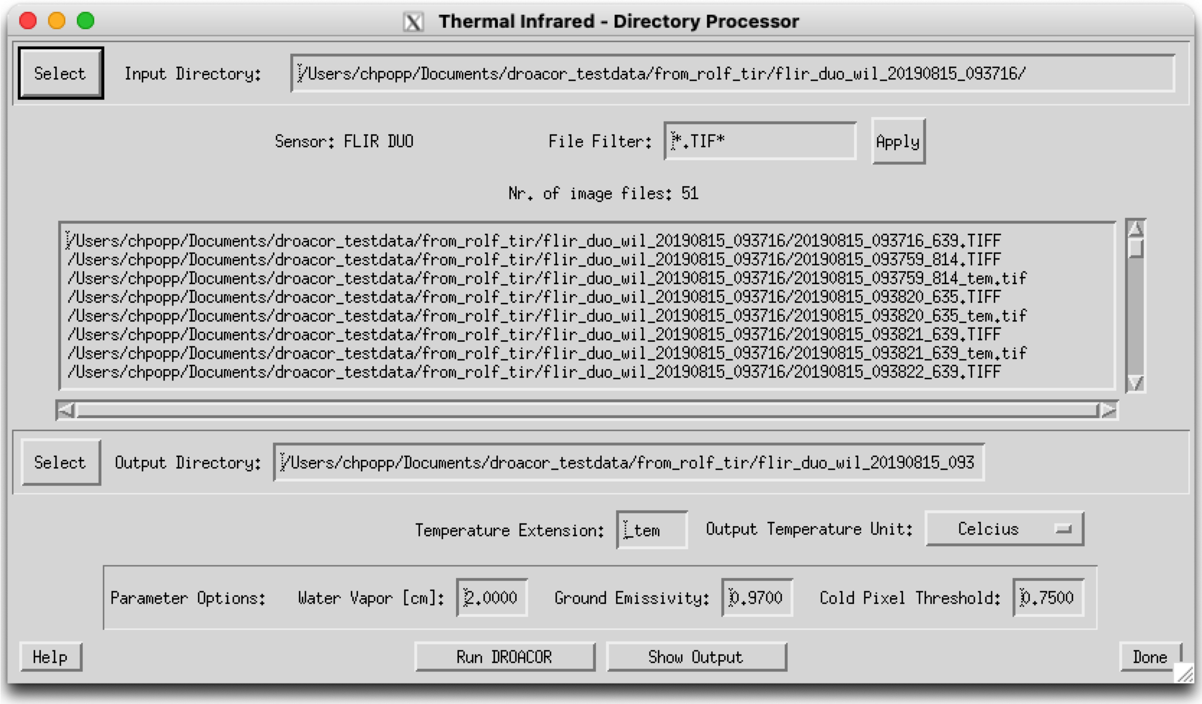


**Figure 4.6**: DROACOR main thermal processor.

## 4.6 Spectral Polishing

Spectral Polishing and Processing
=================================
This routine allows to apply spectral polishing and correction tools to
unfilted reflectance outputs.

Inputs:
------
Input Directory:
    Directory containing series of reflectance images to be processed.
    Images are to be created using the Reflectance processor without

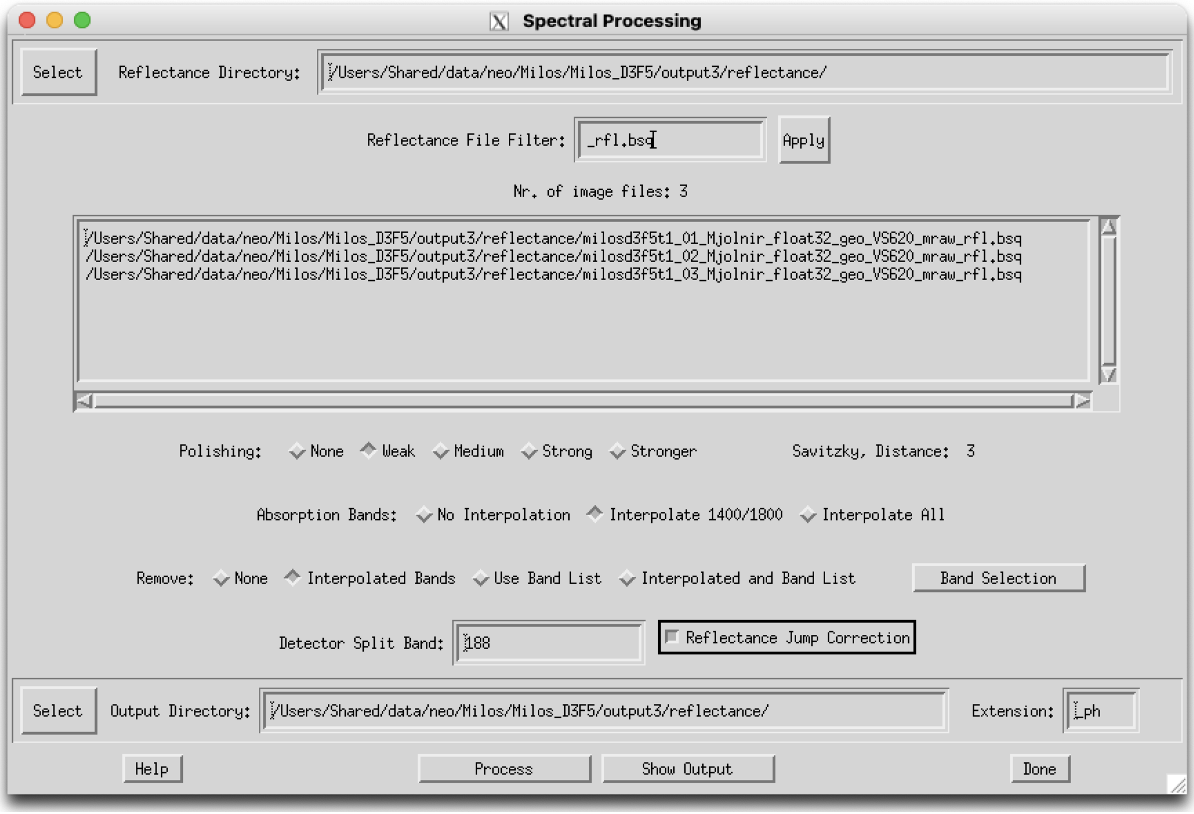


**Figure 4.7**: DROACOR spectral polishing panel.

band removal applied.

File Filter: this is the filter to select the files to be processed. Use wildcards '*' for selection; hit return to apply the filter.

File list (Nr. of image files):
Depending on the selected directory and file filter, the list is updated (note: no actions are related to this list)

Polishing: Level of polishing to be applied:
- None: No polishing is applied (but feature interpolation is done)
- Weak: Savitsky Golay Filter by a 7-band filter size
- Medium: Savitsky Golay Filter by a 9 -band filter size
- Strong: Derivative Filter from 7 bands with 2 band smoothing
- Stronger: Derivative Filter from 9 bands with 3 band smoothing

Absorption Bands: strong atmospheric absorption bands at 940/1130/1400/1800nm can be interpolated as selected

(None | Interpolate 1400/1800nm | Interpolate All).

Remove: Spectral bands to remove completely from outputs.
None: leave all bands in the output
Interpolated Bands: remove bands interpolated in absorption bands
Use Band List: selected Bands in 'Band Selection' are kept in output
Interpolated and Band list: will remove both interpolated bands and bands
not selected in band list.

Detector Split Band: first band of 2nd detector for polishing and jump
correction. Value of 0/1 means no detector split

Jump Correction: Apply empirical brightness correction between SWIR and
VNIR spectral band at split band. The SWIR brightness is
adapted to VNIR by multiplicative adjustment.
- Mean: the adjustement is done by adjusting the mean
reflectance 845-890 nm to the mean of 1005-1060 nm
- Trend: the trend in reflectance betweeen 845 adn 890 is
extrapolated to the mean fo 1005 to 1060 nm

Output Directory:
Name of directory, where all outputs shall be written to.
Extension: file extension of mainoutput files, default: _rfl
(will be *_rfl.bsq files)

Actions:
-------
> Process <
Apply the selected options to the whole directory

> Show Output <
Will show the last selected main output

Outputs:
-------
The routine may create the following default outputs:
*_rfl_ph.bsq : polished and corrected reflectance image
*_rfl_ft.bsq: feature enhanced and band-interpolated reflectance image
(if keep is set in input json file)

xac_polish.txt, DS

## 4.7 Batch Processor

Selecting this function allows to start a batch processing JSON file through the GUI. The JSON file has to be prepared according to the rules given in Section 7. The process starts immediatly after a valid JSON file is selected and its progress is visible in the standard processing console.

Attention: Batch processing by default overwrites existing outputs without notice.

# Chapter 5

# Menu: Product

The Product Menu contains procedures which can be applied to the reflectance outputs of DROACOR's main processing. This includes further processing steps such as illumination correction and standard bio/geophysical product derivation. Further applications are added to this menu successibly; please refer to the online help for more details about functions not represented in this manual.

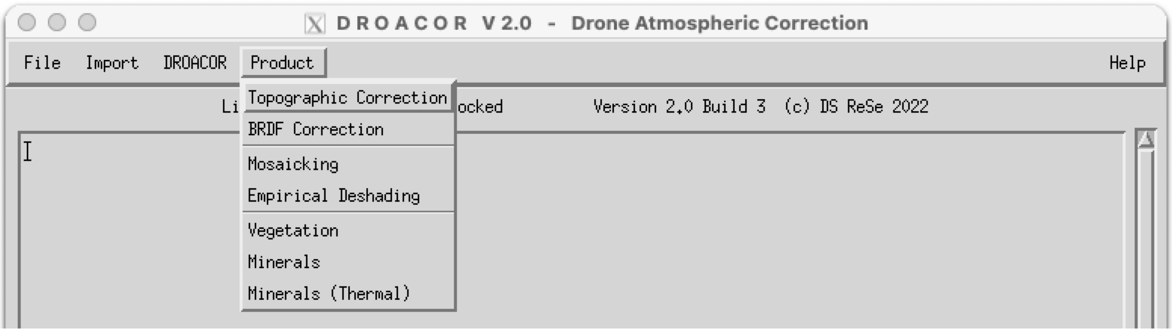


**Figure 5.1**: Product menu.

## 5.1 Topographic Correction

This module corrects the variation of the illumination in topography based on a digital elevation model. Additionally, it can perform a cast shadow correction.

Topographic Correction
======================
This module corrects the variation of the illumination in topography
based on a digital elevation model.

Inputs:
------
Input Directory:
    Directory containing series of reflectance images to be processed.

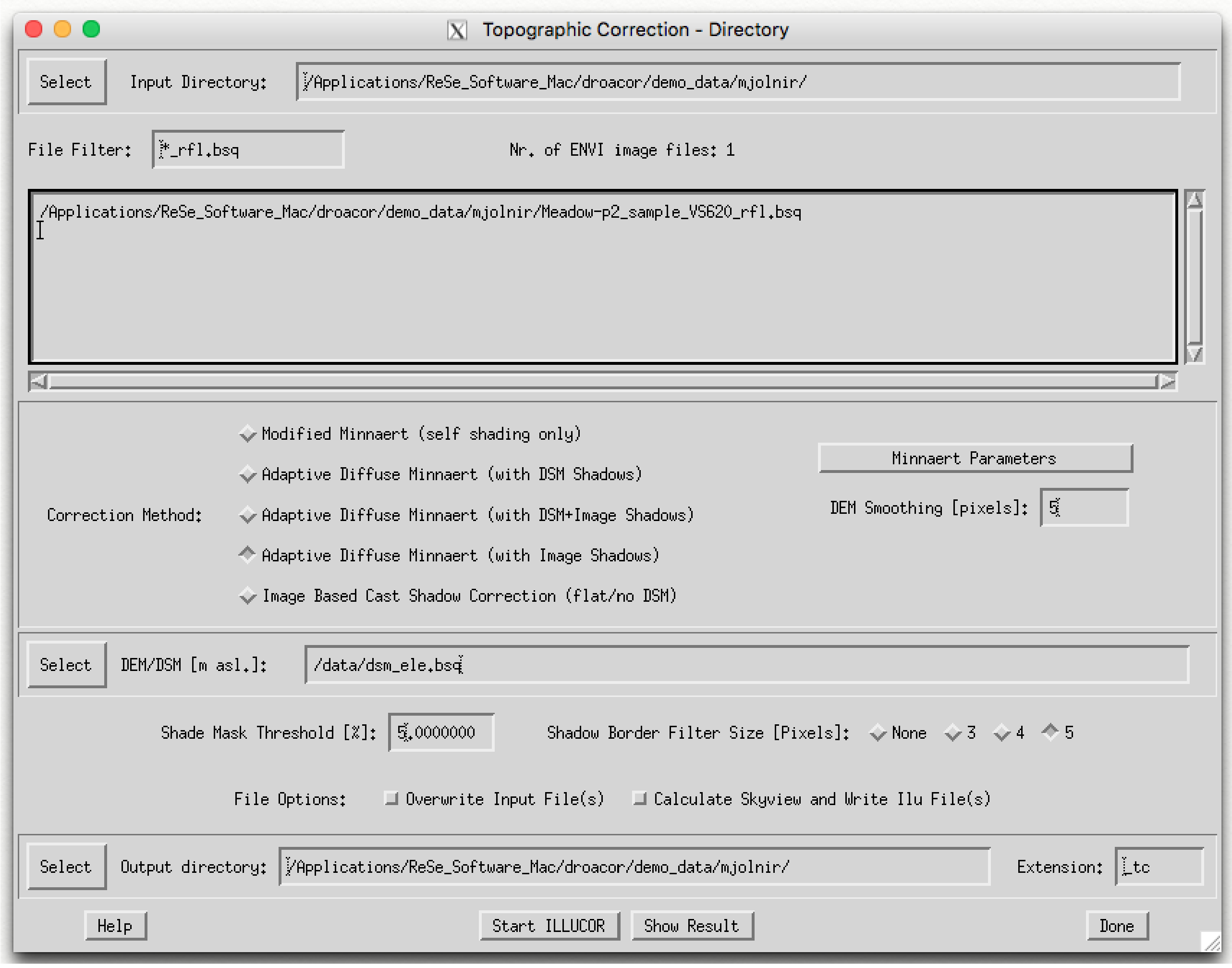


**Figure 5.2**: Topographic correction panel.

Images are to be processed to reflectance beforehand for best results.

File Filter: this is the filter to select the files to be processed.
Use wildcards '*' for selection;
hit return to apply the filter.

File list (Nr. of image files):
Depending on the selected directory and file filter, the list is updated (note: no actions are related to this list)

Correction Method:
- Modified Minnaert: incidence BRDF correction using a Modified Minnaert method (similar to ATCOR-4 standard method). No cast shadow correction is done.

- Adaptive Diffuse Minnaert: correction of shaded areas by adaptively considering the diffuse irradiance to avoid overcorrections.
(in combination with Modified Minnaert co)

- ..with DSM: cast shadow calculate from DSM ray tracing
- ..with DSM+Image: cast shadow as combination from ray tracing AND image
- ..with Image: cast shadow calculated from image only.
- Image Based Cast Shadow Correction: correction of cast shadows by image based shadow correction and adaptive estimate of diffuse irradiance in shaded pixels; no terrain correction!

BUTTON >Minnaert Parameters<:
Lower Threshold: lowest reduction value; lower values lead to higher corrections.
Exponent: Exponent of reduction function; 1: linea, 0.5 square root lower exponents lead to stronger reductions of extreme angles.
Equation: g = (cos(beta)/cos(30))^exp > thresh < 1

DEM Smoothing [pixels]:
Factor used to smooth the DEM when calculating the illumination
This is a square with the given number of pixel in image resolution.

DEM/DSM file:
DSM file which ideally covers the area covered by all images in the currently selected file list; Shadow correction can also be performed without setting a DEM with the last option above. If file is present the skyview factor is calculated from DEM.

Shade Mask Threshold:
Threshold for cast shadow detection; default value 5 (corresponds to a shading index of 0.05 in the cast shadow detection routine) increase the value slightly to find and correct more shadows.

Shadow Border Filter Size:
Diameter of shadow border filter; None: no filter applied, 5: +-2 pixels are considered at shadow edges.

File Options:
>Overwrite Input Files(s)<: will overwrite the input files instead of creating new files in the output directory.

>Calculate Skyview and Write Ilu File(s)<: will create a shadow file including incidence angle, skyview factor and cast shadow mask (by default, a first order approximation is done from DEM or Image)

Output Directory:
Name of directory, where all outputs shall be written to.

Extension: file extension of output files, default: '_tc'

Actions:
-------
> Start ILLUCOR <
Applies the topographic correction on the selected list of files.

> Show Result <
  Will show the first output image or the output related to the currently selected inputs from the displayed list.

> Done <
  Closes the window

Outputs:
-------
The routine creates the following outputs:

*_tc.bsq : topographically corrected imagery
*_tc.log : log file containing information about the processing per image
*_tc.json: output json file
*_tc_ilu.bsq: optional file containing the illumination as cosine of incidence
  angle for each pixel, the skyview factor and the shading in three layers.

xac_illucor.txt, DS

## 5.2 BRDF Correction

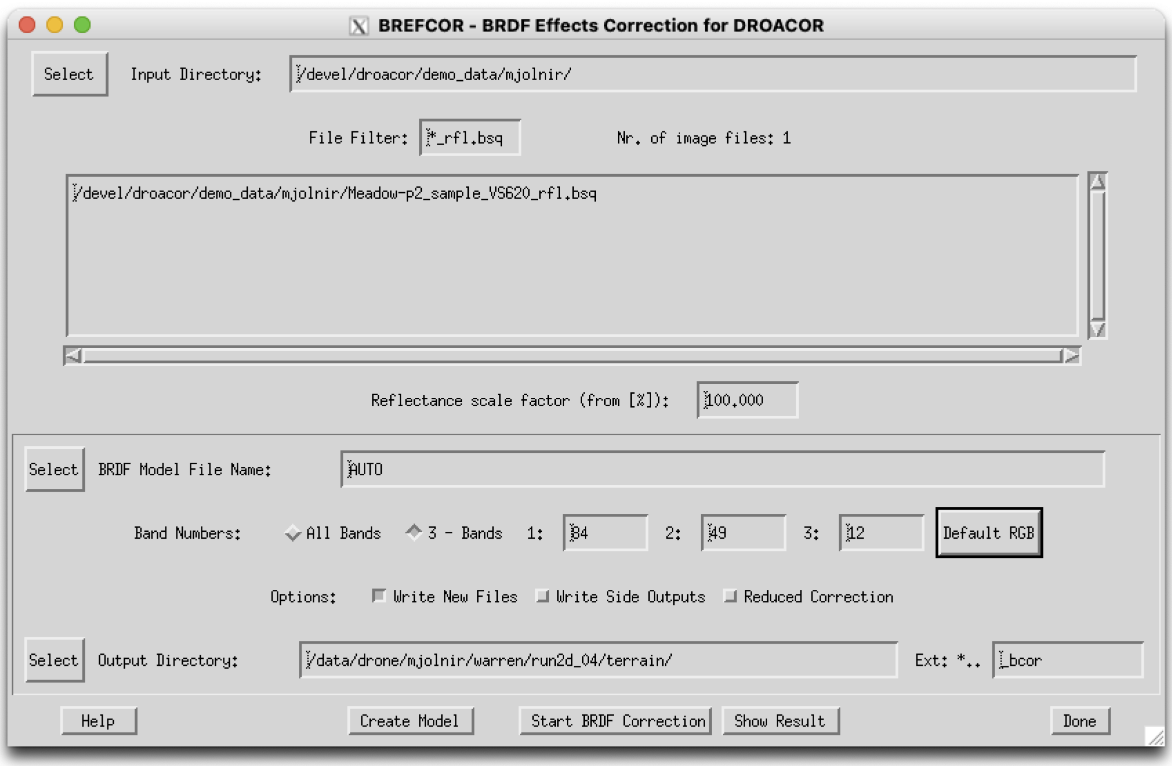


**Figure 5.3**: BRDF correction panel.

BREFCOR - Scan Angle Correction
====================================

A feature-reduced BREFCOR method is delivered as part of DROACOR for correction of observer BRDF effects using an unique cover-dependent approach.
The method uses the Ross-Thick-Li-Sparse reciprocal BRDF model kernels are used for correction of the imagery.
A standard BRDF model parameterization is provided with droacor and can be found in the bin/etc/ directory of the installation (brefcor_defaults.txt).
Replacing this file would also change the BRDF correction.

The following inputs are to be given:

Inputs Directory
----------------
A list of DROACOR reflectance files (*_rfl_*.bsq) is derived based on input directory and file filter. The respective *.json files are used for the meta data information.
If available, the viewing angles are read from the scan angle file, which should be named *_sca.bsq.
(alternatively, an estimate of the scan angles is calculated from image geometry)

Reflectance scale factor:
---------------
This is a constant factor which is to be applied to the input image (which has to be directional reflectance HDRF) to convert the image DNs to absolute reflectance values in [%].

Model Options
-------------
The BRDF model file name can be defined or selected here.
Using external models created in ATCOR-4 is possible.
if setting the name to AUTO or if the file name does not exist yeat, a standard model will be created upon execution.

Band Numbers:
-------------
By default all bands are corrected. For hyperspectral imagery, it may be useful to check the performance on an RGB sample first (this option is not available for in-place correction)

Options:
-------
Write New Files: creates new output files instead of converting the data in place.

Write Side Outputs: writes the ANIF and BCI output used for the BREFCOR correction.

Output Definition:
-----------------

The directory for all outputs, and the file name appendix can be
defined here. If the directory is not given, the outputs are stored
together with the input imagery using the given extension.

The Ext field is the extension which will be added to all input files
to store the output of the calculation.

Actions:
-------
> Create Model <
  A default model is interpolated to the sensor
  characteristics. The default model (brefcor_defaults.txt)
  is defined in the bin/etc directory of the droacor distribution.

> Start BRDF Correction<
  the model based BRDF correction is performed. If the selected model file is
  available, it is used for the correction; if not or if set to 'AUTO',
  it is created from scratch.

Restrictions:
------------
This routines requires
- no rotation tag in ENVI header
- heading parameter (acp.heading) is to be known for unrectified data.

Written by DS, ReSe Applications LLC xac_brefcor.txt

## 5.3 Mosaicking

This tools allows the mosaicking of a series of ortho-rectified images in an efficient way.

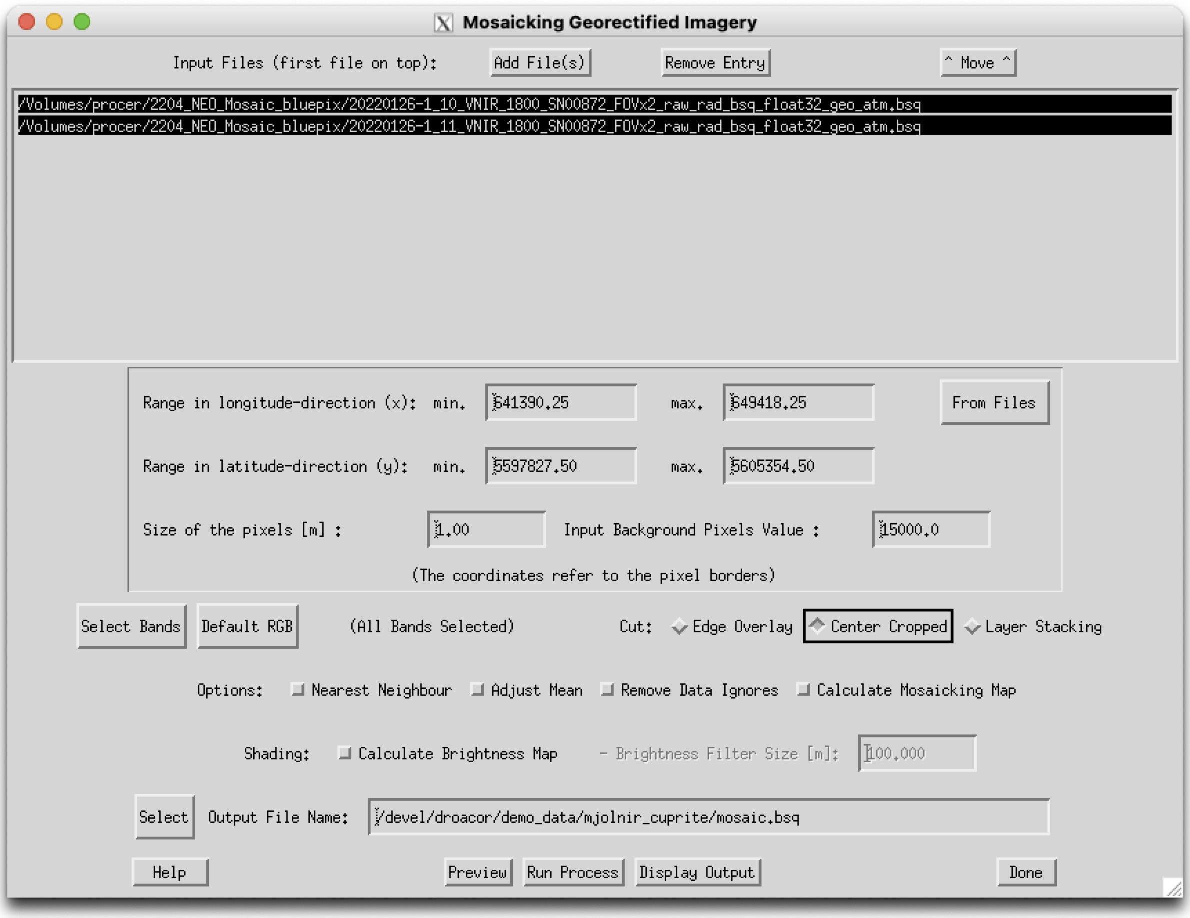


**Figure 5.4**: Mosaicking GUI.

### Inputs

**Input Files** (first file on top): List of files to be mosaicked. The files are stacked in the order of appearance (i.e the first file in the list is on top of the mosaicked output) Buttons:
*Add File(s)*: adds one or more new files
*Remove Entry*: removes the selected file(s)
*Move*: moves the file one position up (or rotates if already at top)

**Range** : Range in x and y direction to edge of pixels of the mosaicked product should be entered. The coordinates refer to the pixel borders (edges) on either side of the image.

**Pixel Size** : Size of output pixels in meters Note: the mosaicing uses a bilinear interpolation; no aggregation is done.

**Input Background Pixels Value** : Value of image background in input (and also in output, will remain the same there). Attention: If the envi header contains the 'background' tag, this one is used. Alternatively, the ENVI 'data ignore value' is taken as default here.

**Button >Select Bands<** : lets you select the bands to mosaic. Only selected bands will appear in output.

**Button >Default RGB<** : will select default RGB bands for VNIR (true color) or SWIR sensors automatically.

**Cut** : treatment of overlapping images, by
*Edge Overlay*: The mosaicking is such that the first file is in the list is strictly on top*Center Cropped*: While mosaicking, the routine tries to find the middle of the overlap area between the new image and all the images mosaicked so far as a cut line.*Layer Stacking*: The files are stacked in band sequential order on top of each other. The first image in the list rules the output dimensions. All bands are used in any case.

**Options** :

*Nearest Neighbour*: resampling to fixed grid is done by nearest neighbour resampling (default: bilinear interpolation).

*Adjust Mean*: The mean of the mosaiced files is adjusted to the mean of the first file per image band.

*Remove Data Ignores*: Pixels with data ignore values found in a reference band (i.e. the middle band of all bands) are treated as background.

*Calculate Mosaicking Map*: A file named _mosmap.bsq is written in parallel to the output, containing an integer map with numbers starting at 1 to n (number of input files) which shows for each pixel the used input file.

**Shading** :

*Calculate Brightness Map*: A file named _bright.bsq is written which contains the relative brightness for all mosaicked bands (for hyperspectral images, a subset of bands at 450, 600, 805, 1190, 2020nm is written).

*Brightness Filter Size*: Smoothing filter size in meters to use for relative brightness determination.

**Output definition** Name of output file to be written.

### Actions

**Preview** : the first of the selected bands is mosaicked at a resolution reduced by a factor of 2 and the result is displayed.

**Run Process** : The mosaicking is performed.

**Restrictions**

This routines requires georeferenced data with:

- same coordinate system for all files
- no rotation tag in ENVI header
- the background should be coded with zero-values
- all files should have the same number of bands for mosaicking (except for layer stacking)

*NOTE:* the input resolutions of the imagery may vary; non-matching resolutions are interpolated bilinearly to the target resolution.

## 5.4 Empirical Deshading

This routine applies an empirical cloud deshading (i.e., spatial illumination based brightness adjustment) of images or image mosaics based on the relative brightness.

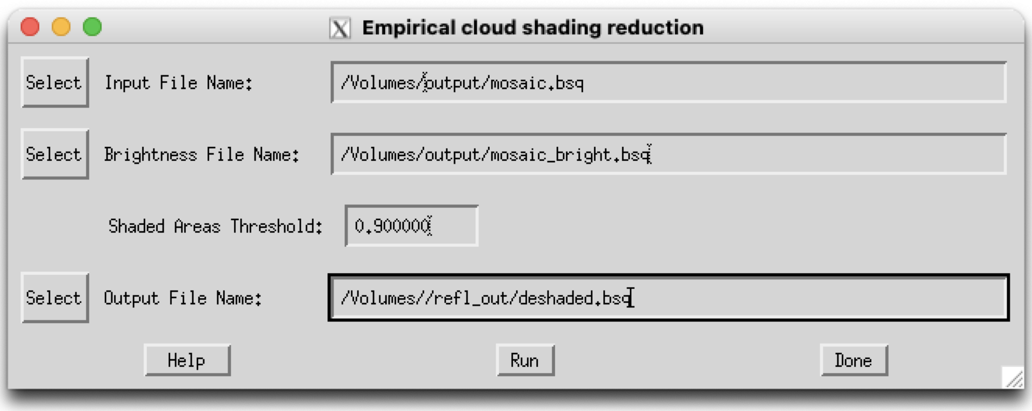


**Figure 5.5**: Deshading/Brighness Adjustment Tool.

**Inputs:**

**Input File** File to be corrected; typically a mosaicked output file, usually in reflectance units.

**Brightness File** File containing smoothed brightness of the imagery, at least for the blue and the NIR spectral band. The size and data type of the brightness map for up to 10 bands is the same as the image; for more than 10 bands, a subset of 2 to 5 bands at [450, 600, 805, 1190, 2020] nm wavelength are used for brightness calculation; bands in between get interpolated brightness. This file can be created by the ATCOR mosaicking routine (see above) as side output.

**Shaded Areas Threshold** relative brightness upper limit to image mean; i.e. only pixels darker than this factor from image mean are corrected.

**Output File** name of output file to be written.

**Action:**

**Run** Runs the brightness adjustment ('deshading').

**Procedure:** The routine reads the brightness in the blue spectral band and searches for the maximum relative brightness for the same pixels in the near infrared spectral bands. These two reference points are used to derive the coefficients for wavelength dependent correction. Using an Angstrom function of form $k \cdot \lambda^{-\alpha} < 1$, a wavelength dependent correction factor is then applied to the pixels below threshold.

**Restrictions:** This routine is still in development ... please approach us with sample data if results are not as expected.

## 5.5 Vegetation

This productivity tool allows to calculate a series of vegetation indices from a group of files in a directory.

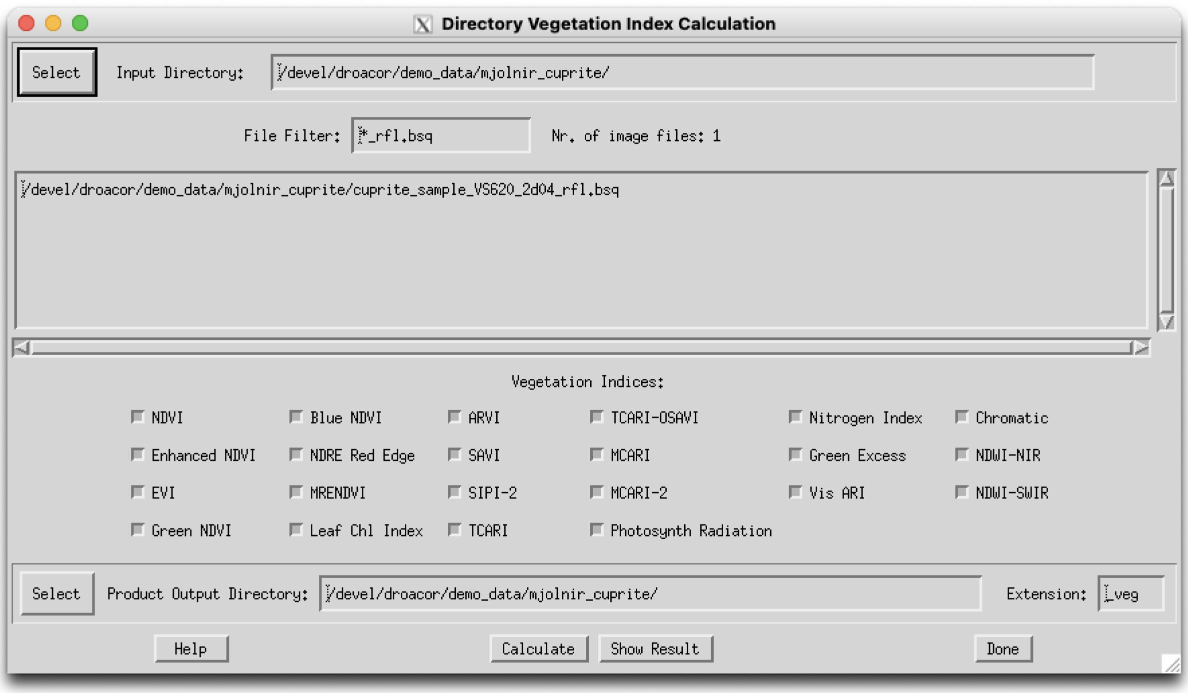


**Figure 5.6**: Vegetation index calculation panel.

Vegetation Index Calculation
============================
This productivity tool allows to calculate a series of vegetation
indices from a group of files in a directory.

Inputs:
------
Input Directory:
    Directory containing series of images to be processed.
    Images are should be reflectance outputs of DROACOR.

File Filter: this is the filter to select the files to be
    processed. Use wildcards '*' for selection;
    hit >return< to apply the filter. Default is *rfl.bsq

File list (Nr. of image files):
    Depending on the selected directory and file filter, the
    list is updated (note: no actions are related to this list)

Vegetation Indicices:
    a list of vegetation indices is displayed and can be selected
    Greyed-out indices are not available due to missing spectral
    bands. Details about the indices - see below.

Output Directory:
    Name of directory, where all outputs shall be written to.
    Extension: file extension of output files, default: _veg

Actions:
-------
> Calculate <
    Calculates the selected vegetation indexes on the input files.

> Show Result <
    Shows first or selected file from the list

> Done <
    Closes the window

Outputs:
-------
The routine creates the following outputs:

*_veg.bsq : File containing the selected vegetation indices in a BSQ
        format (one band per index)

```
Vegetation indices:
===================:

NDVI                    Equation: (NIR-Red)/(NIR+Red)
Enhanced NDVI           Equation: (NIR-Green+2*Blue)/(NIR+Green+2*Blue
EVI                     Equation: 2.5*(NIR-Red)/(NIR+6*red-7.5*blue+1)
Green NDVI              Equation: (NIR-Green)/(NIR+Green)
Blue NDVI               Equation: (NIR-Blue)/(NIR+Blue)
NDRE Red Edge           Equation: (nir-RE)/(nir+RE)
MRENDVI Red Edge        Equation: (nir-RE)/(nir+RE-2*blue)
Leaf Chl Index          Equation: (nir-RE)/(nir+red)
ARVI                    Equation: (NIR-g*(Blue-red))/(NIR+g*(blue-red)
SAVI                    Equation: 1.5 * (nir-red)/(nir_red+0.5)
SIPI-2                  Equation: (nir-green)/(nir-red)
TCARI                   Equation: 3*((RE-red)-0.2(RE-green)*RE/red)
TCARI-OSAVI             Equation: 3*((RE-red)-0.2(RE-green)*RE/red)/1.16*(nir-red)/nir+red+0.16
MCARI                   Equation: 3*((RE-red)-0.2(RE-green)*RE/red)
MCARI-2                 Equation: (1.5*(2.5*(nirband-redband)-1.3*(nirband-greenband)))/ sqrt((2*nirban
Photosynth Radiation    Equation: (green-yellow)/(green+yellow)
Green Excess            Equation: 2*green- red - blue
Nitrogen Index          Equation: (705nm/(717nm+491nm)
Vis ARI                 Equation: (green-red)/(green + red - blue) [-1,1]
Chromatic               Equation: green/(red + green + blue)
NDWI-NIR                Equation: (green-nir)/(green+nir)
NDWI-SWIR               Equation: (nir-swir)/(nir+swir)



xac_vegindex.txt, DS
```

The vegetation indexes according to table 5.1 are supported and calculated in DROACOR. Indexes not available due to missing spectral bands are automatically greyed out in the GUI.

| Index | Equation |
|---|---|
| NDVI | $(NIR - Red)/(NIR + Red)$ |
| Enhanced NDVI | $(NIR - Green + 2 * Blue)/(NIR + Green + 2 * Blue)$ |
| Green NDVI | $(NIR - Green)/(NIR + Green)$ |
| Blue NDVI | $(NIR - Blue)/(NIR + Blue)$ |
| NDRE Red Edge | $(nir - RE)/(nir + RE)$ |
| Leaf Chl Index | $(nir - RE)/(nir + red)$ |
| ARVI | $(NIR - g * (Blue - red))/(NIR + g * (blue - red)$ |
| SAVI | $1.5 * (nir - red)/(nir + red + 0.5)$ |
| SIPI-2 | $(nir - green)/(nir - red)$ |
| TCARI | $3 * ((RE - red) - 0.2(RE - green) * RE/red)$ |
| TCARI-OSAVI | $\frac{3*((RE-red)-0.2(RE-green)*RE/red}{1.16*(nir-red)/(nir+red+0.16)}$ |
| MCARI | $3 * ((RE - red) - 0.2(RE - green) * RE/red)$ |
| MCARI-2 | $\frac{1.5*(2.5*(nir-red)-1.3*(nir-green))}{\sqrt{(2*nir+1)^2-(6*nir-5*\sqrt{green})-0.5}}$ |
| Photosynth Radiation | $(green - yellow)/(green + yellow)$ |
| Green Excess | $2 * green - red - blue$ |
| Vis ARI | $(green - red)/(green + red - blue)[-1, 1]$ |
| Chromatic | $green/(red + green + blue)$ |
| NDWI-NIR | $(green - nir)/(green + nir)$ |
| NDWI-SWIR | $(nir - swir)/(nir + swir)$ |

Table 5.1: Vegetation index selection supported by Droacor product generation

## 5.6 Minerals

This productivity tool calculates the inverse spectral angle for a number of selected minerals.

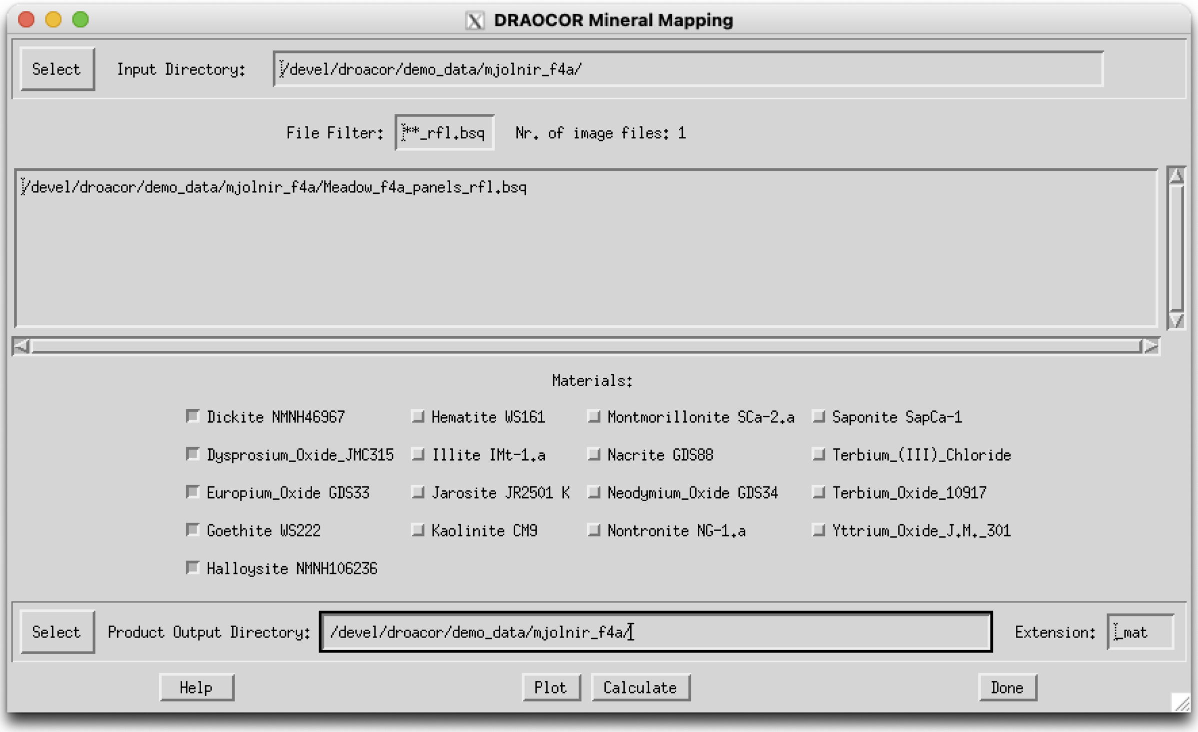


**Figure 5.7**: Minerals spectral angle mapping.

## 5.7 Minerals (Thermal)

This routines supports the minerals mapping using thermal emissivity data by inverse spectral angle. The options and parameters are the same as in the procedure for VIS/NIR/SWIR above.

The underlying spectral library can be found in *droacor/bin/etc/droacor_minerals_tir.slb*. The panel adapts to the spectral library showing the available minerals as shown in Figure 5.8.

Minerals Detection
==================
This productivity tool calculates the inverse spectral angle for a number
of selected minerals.

Inputs:
------
Input Directory:

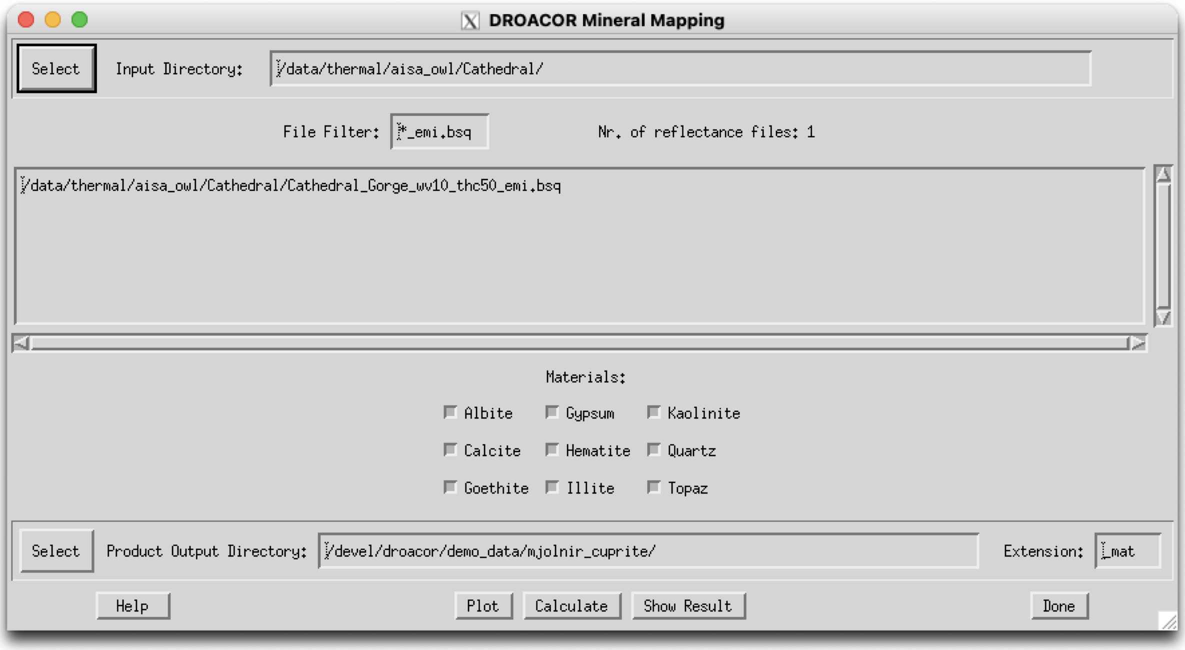


**Figure 5.8**: Minerals emissivity based spectral angle mapping.

Directory containing series of images to be processed.
Images are should be reflectance outputs of DROACOR.

File Filter: this is the filter to select the files to be processed. Use wildcards '*' for selection; hit >return< to apply the filter. Default is *rfl.bsq

File list (Nr. of image files):
Depending on the selected directory and file filter, the list is updated (note: no actions are related to this list)

Mineral Spectra:
a list of mineral spectra is shown.

Output Directory:
Name of directory, where all outputs shall be written to.
Extension: file extension of output files, default: _veg

Actions:

---

> Plot <
Plots all currently selected endmember spectra

> Calculate <
Calculates the inverse spectral angle (1/SAM)

> Show Result <

Shows first or selected file from the list

> Done <
Closes the window

Outputs:
-------
The routine creates the following outputs:

*_mat.bsq : File containing the mineral mapping outputs
(one band per mineral) - larger values are better agreement
between spectra.

Procedure:
---------
The minerals spectral library can be found in the bin directory of the droacor installation.
The file may be replaced by alternative spectral libraries according
if the unmixing is to be configured by the end user.

ATTENTION: selecting a large number of spectra simultaneously may
result in memory management problems; it is recommended to select no
mor than up to 6 spectra per calculation.

xac_minerals.txt, DS

# Chapter 6

# Menu: Help

The help menu gives direct access to help ressources and allows to install and update the DROACOR installation; compare Fig. 6.

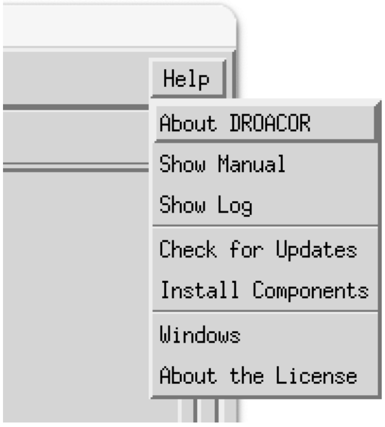


**Figure 6.1**: DROACOR help menu

## 6.1 Help Information

**About Droacor** : Shows the release and version and some credits.

**Show Manual** : Displays this manual which normally can be found on the top level of the droacor installation directory; named *DROACOR_Manual.pdf*.

**Show Log** : This will show the latest log file which had been written. Please use this function in case of problems and provide the log file to ReSe for support requests.

## 6.2 Check for Updates

ReSe Software is updated frequently based on user inputs without notification to end users. The following steps allow to check for the latest version and for an automatic update of your installed software by download of the latest binary.

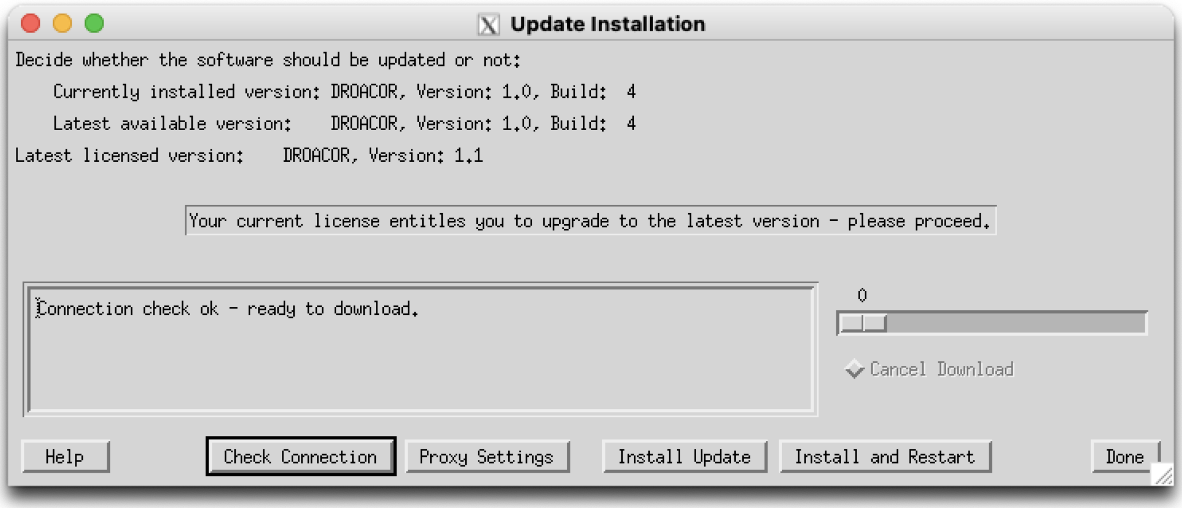


**Figure 6.2**: Update check-function for DROACOR.

The above path lets the software check for a new update via an internet connection. The above installation window provides following functions:

**Check Connection** : Tries to download a dummy file from the ReSe Download server to check if settings are ok.

**Proxy Settings** : This will allow to set a proxy server to allow internet connections behind a fire wall. Push 'Check Connection' after settings to make them active. Also see Section 6.2.1.

**Install Update** : This will download the latest binary for the current version and replace the current binary (which will be overwritten).

**Install and Restart** : Download the latest binary and restart the software after download.

Please note that the described update function only works for minor releases (x.x.x and new builds). Major releases (x.x) usually require a full reinstall.

### 6.2.1 ReSe Proxy Settings

Sitting behind a firewall sometimes requires to set the proxy server in order to allow floating licenses to work or for automatic updates to be installed.

The purpose of this program is to provide an interface for internet server proxy settings.

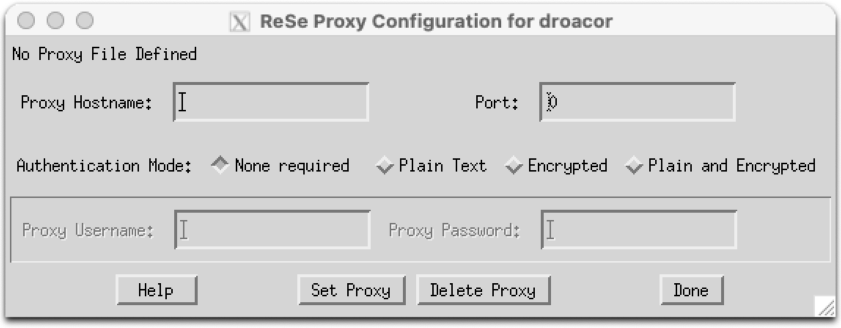


**Figure 6.3**: DROACOR proxy settings window

The proxy configuration window takes the following inputs:

**Proxy Hostname** : internet name or IP address of the proxy host

**Proxy Port** : port number for connection (often 8080)

**Proxy Authentication** : Type of authentication:

**None** No login is required

**Plain Text** login is performed in plain text

**Encrypted** login is encrypted before being sent to proxy server

**Plain and Encrypted** the system chooses whether the login shall be encrypted based on the server's properties

**Proxy Username** User name for proxy authentication

**Proxy Password** Password for proxy authentication (this is shown in plain text)

The proxy configuration window provides the following actions:

**Set Proxy** This reads the current proxy settings and writes the proxy file rese_proxy.txt to the software installation

**Delete Proxy** This will delete the proxy file and settings.

The resulting proxy settings are stored in a file named rese_proxy.txt in the bin directory of the software installation; the currently active proxy file is displayed in the top row of the panel. The location of the file is usually in the bin directory, or where the rese_license.pro resides. The file may also be edited manually for configuration.

## 6.3 Install Components

The standard atmospheric LUT is not distributed with the standard installer but is to be installed from the ReSe servers. The LUT is required for imaging spectroscopy data processing. It may installed semi-automatically through this panel:
The following actions are possible:

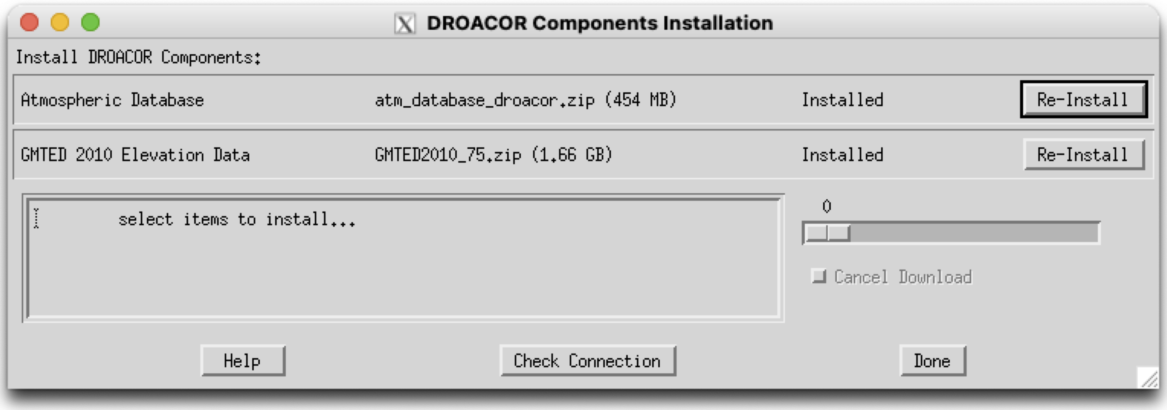


**Figure 6.4**: Update check-function for DROACOR

**(atm database) Install / Re-Install** Download the atmospheric Database LUT and places the files into the atm_database directory of the droacor installation.

**(GMTED) Install / Re-Install** Download the GMTED global elevation data file for potentail later use for topographic correction. Note: for drone processing the global data set is most probably too rough at about 150m resolution; therefore it is strongly recommende to use local DSM data for topogrpaphic processing.

**Check Connection** Shows if internet connection is stable and active

NOTE: the proxy configuration as set with the function 'Check for Updates' are applicable for this installer as well; see Section 6.2.1.

## 6.4 Windows

Shows a list of all currently opened widget windows. Let's you switch or delete them directly.

## 6.5 About the License

This function shows the contents of your license file (rese_license.pro) - if available, or alternatively shows all information to apply for a license such as it is displayed if starting the DROACOR software without active license.

# Chapter 7

# Batch Processing

For the DROACOR process, a convenient graphical user interface is available. For rapid and efficient processing of large data sets, batch jobs can also be submitted.

## 7.1 Starting DROACOR from Console

DROACOR can be started directly from a console or from a different processing environment using the standard call to IDL runtime environment. This call will show a splash screen when starting IDL unless an IDL RT or a full IDL license is installed on the processing computer. RT licenses can be acquired from NV5 (https://www.nv5geospatialsoftwar at a significantly reduced price than full IDL licenses.

The call in a windows environment is:

```
[idlpath]\idlrt.exe -rt="[droacorpath]\bin\droacor.sav"
        -args batchfile.json
```

where [idlpath] is the path to the idl installation, typically something like ..\idl87\bin\bin.x86_64\

On a unix/macOSX system, the call syntax is as follows:

```
[idlpath]/idl -rt="[droacorpath]\bin\droacor.sav"
        -args batchfile.json
```

The [idlpath] in this case is something like ../idl87/bin/.
After execution, the idl session quits and throws an error status of ’1’ if an error occurred during processing.

ATTENTION: These routines are overwriting existing outputs.

## 7.2 Batch Processing Input File

The input file for batch processing is a DROACOR standard JSON file. The tags used for batch processing input are compiled and described in the subsequent list. Other parameters of the descriptive JSON files are set automatically during data import and

processing. Parameters set to zero or parameters not set in the batch input file are assigned automatically as far as applicable.
A template batch JSON file can be created by using the function Export Batch File in the file menu (c.f. section 2).

```
;
File names:
;
ACF  imgdir:'', $       ;B directory of image files to process
     outdir:'',$        ;B directory of (reflectance) output files
     prddir:'', $       ; directory of products
     ffilt:ffilt, $     ;B file filter for input files in imgdir; including type extension
     radext:'*.bsq', $ ;B file filter for input files in imgdir; including type extension
     rflext:'_rfl', $  ;B extension of reflectance outputs;; no type extension
     brfext:'_br', $   ;B extension of BRDF correction outputs;; no type extension
     emiext:'_emi', $  ;B extension of emittance thermal outputs - emissivity - temperature;
     temext:'_tem', $  ;B extension of  temperature;;
     ele:'', $          ;B current dem file
     cal:'', $          ;B cal file name (including path)
     atlut:'', $        ;B file name of intermeediately saved atmot LUT
     brmod:'AUTO', $    ;B brdf model file
     brext:'_bcor', $  ;B brdf correction file extension
     refimg:'AUTO', $  ;B reference file used for calibration - 'AUTO' for automatic reference image calculati
     mosaic:'', $      ;B mosaic output file
     bright:'', $      ;B brightness mosaic output file
     mosshade:'', $    ;B shade corrected output mosaic
     vali:''}          ; validation data output
;
;.
Process parameters:
;
ACP  sensor:'', $                ;B sensor name (droacor sensor identifier); supported sensors:
                                 ; micasense, laquinta, TIFF, JPEG, nano, casi,
                                 ; mjolnir, aisafx, shark, pika, ultracam, aisa_ter
     fov: double([20., -1]), $  ; B detector total FOV  x/y [deg]
     elesrc:'meta', $           ; B source of ground altitude: 'global','meta','dsm','fixed'
     lat:48.12d, $              ;O longitude
     lon:11.30d, $              ;O longitude
     gndalt:0.0d, $             ;O average/reference ground altitude [m]
     distance:0.0d, $           ;B average target distance (for horizontal scan) [m]
     timezone:0., $             ;O hours east of Greenwich (UTC)
     fcref:100.0d, $            ;B scalefactor from % for reflectance output
     fctem:10.0d, $             ;B scalefactor from Temperature K for thermal output
     digno:15000d, $            ;B data ignore value of outputs  - for reflectance this should be 15000
     rotation:0, $              ;B  output rotation angl e(negative, e.g -360: flip vertically -180:
                      $         ;  flip and rotate; 180 rotate only)
     background:-1, $           ;B image background value
     cloudshade:'None',  $      ;B cloud shading removal - yes or none...
     psize:1.0d,  $             ;B pixelsize m
     overwrite:0, $             ;B Overwrite options [0: no overwrite, 1: overwrite]
     keep:0, $                  ;B Keep options: 0: don't keep; 1: keep unfiltered output
                                     2: keep all outputs of reflectance retrieval
     removeint:'{0, 0, 0}', $   ;B Flags how to treat bands after processing [rem,opt,void]:
                                 ; 1st: 0:none / 1 remove bands; 2nd opt: 1 : remove interpolated,
                                 ;  2:use bandlist acp.bands,3: use bandlist and interpolated
     sp_interpol:'{0,0,1,1}',$  ;B Spectral Interpolation flags for 940,1130,1400 and 1800 nm
                                    (interpolate: 1, no interpolation 0)
     polish_statopt:'{3,0,2,0}' ;B statistical polishing options {bands, smoothing, filtertype, jumpfixflag}
                                 ; bands: number of bands on each side, smoothing: bands to smooh
                                 ; filtertype: 0: no polishing, 1: derivative; 2:Savitzky-Golay
     splitband:0,  $            ;B Spectral Split band for spectral calibration;
                                 ; first band of 2nd detector - 0: vnir only 1: swir only
     rangeoverride:0, $         ;B override default ranges flag in batch processing
                                  (for next 6 parameters; 0: no override 1: override)
     refl_range:[0, 1.5d], $    ;B reflectance range for output (min/max, unitless)
     wvlrange:[400, 2450.], $   ;B wavelength range for output
     int940:[920.0, 955.0d], $  ;B Default interpolation range 940 nm
     int1130:[1110.0, 1160.0d], ;B Default interpolation range 1130 nm
     int1400:[1330.0, 1430.0d], ;B Default interpolation range 1400 nm
     int1800:[1800.0, 1970.0d]  ;B Default interpolation range 1800 nm
```

```
     bands:'',                   ;B list of output bands in ENVI String format -
                                 ;  negative numbers are not included in output mosaic.
                                 ;  other bands will be removed from output, # starting at 1
;
;
Batch parameters:
;
ACT  skipimport:0, $             ;B Flag for skipping (1) import or re-import (0) single files
     reflect:1, $                ;B Flag for reflectance retrieval
     topocor:0, $                ;B Flag for topogration ILLU correction
                                         1: do it, 2: do and delete inputs (not yet supported)
     brefcor:0, $                ;B Flag for Brefcor correction
     mosaic:0, $                 ;B Flag for Mosaicking
     deshade:0, $                ;B Flag for Deshading
     preview:0, $                ;B Flag for Preview generation
     shade_range:[0.05d, 0.2],  ;B Thresholds for cast shadow detection
     dem_fact:3,  $              ;B DEM smoothing factor for topographic correction
     dem_writeillu:0,  $         ;B Write Illumination file in topographic correction
     mos_psize:1.0,  $           ;B mosaicking output pixel size
     mos_range:'{0.0, 0.0, 0.0, 0.0}', $  ;B mosaicing output coordinate range (xmin, xmax, ymin, max)
     mos_center:1, $             ;B center cropped mosaicing
     mos_adjust:0, $             ;B mosaicking brightness adjustment
     br_filter:20, $             ;B shade brightness filter size in meters
     br_thresh:0.95, $           ;B shade brightness threshold
     pre_bands:'cir', $          ;B preview band combination (choice: 'rgb','cir' or 'swir')
     pre_type:'jpeg'             ;B output type (default 'jpeg', lossless: 'png'
;
```

# Part B

# GLIMPS - Image Display and Analysis

# Chapter 8

# Menu: File

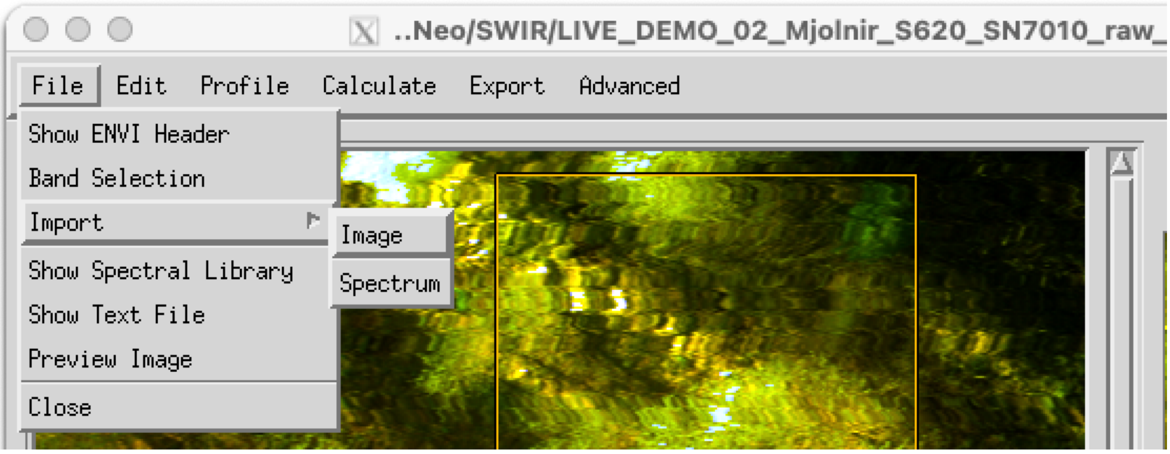


**Figure 8.1**: File menu. in image display.

The menu *'File'* (c.f. Fig. 8.1) offers some tools for handling of the data and ENVI files. Below, a short description of the individual functions is given:

## 8.1 Show ENVI Header

Displays the ENVI header of the currently displayed image in a new editable window. This allows to make changes to the ENVI header. Note that the file needs to be loaded from scratch if fundamental changes have been made to the header in order to avoid inconsistencies.

## 8.2 Band Selection

Allows to select a new combination of spectral bands and updates the display (Fig. 8.2). The options are *single band*, *RGB* (by default), *CIR*, and *SWIR* where GLIMPS loads pre-defined bands which, however, can be altereted using e.g. the *Red* - *Green* - *Blue* sliders or by entering the band number manually in the respective field.

The default wavelengths for display in nm are: RGB [650, 550, 440], CIR [810, 640, 500], and SWIR [1080,1650,2250].

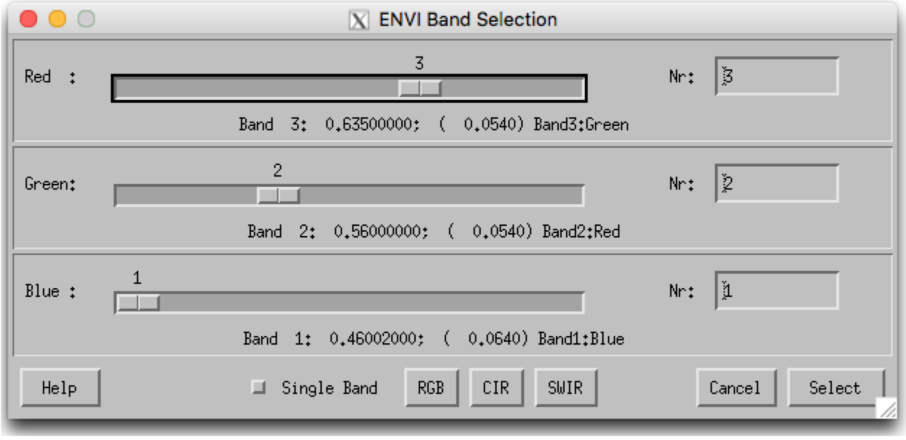


**Figure 8.2**: Band selection dialog for ENVI file display.

## 8.3 Import Image

Imports an image file (TIFF/GEOTIFF/JPG) and converts it to an ENVI file. Some standard formats are supported for importing data layers to an ENVI BSQ for use in ReSe Software:

**TIFF** Imports a standard or multiband TIFF image to an envi file. Geometry coordinate information is optionally read from a .tfw world file.

**Geo-TIFF** Multi-Band GEOTIFF file in band ascending order; GEOTIFF header tags are required for coordinates definition.

**NRGB-Geo-TIFF** Geotiff in 4-band configuration, storage order N-R-G-B. The data will be reordered in wavelength ascending order upon import (choose 'reverse order' if asked).

**JPEG** standard RGB JPG image to an envi file. Geometry information is optionally read from a .jfw world file.

**JPEG2000-Geo** JPEG2000 file (extension .jp2) with embedded georeferencing information in geotiff or gml format.

## 8.4 Show Spectral Library

The purpose of this option is to provide a resizable window to plot, handle, and analyze an ENVI spectral library file. GLIMPS will ask for a spectral library file (∗.slb, ∗sli). Either choose one of your own or one that is already provided in the 'demo_data'

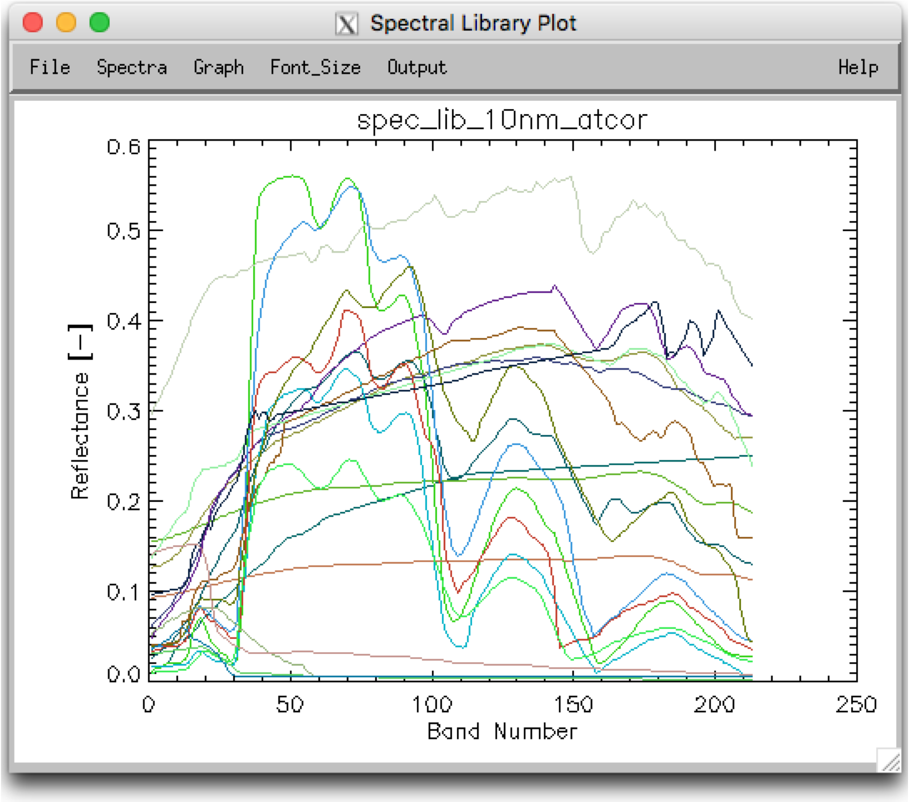


**Figure 8.3**: Spectral library plot interface

directory. GLIMPS then opens its *Spectral Library Plot* window as illustrated in Fig. 8.3.

The *Spectral Library Plot* window offers some functions that are summarized as follows:

**File:Show ENVI Header** Shows ENVI header of currently selected SLB.

**File:Show Data** Display the data as an ASCII text table, which optionally may be used in spreadsheet software such as MS Excel.

**File:Preview** Shows the currently displayed graphics in a OS-dependent standard graphics file viewer application.

**File:Print** Print the contents by postscript-printing (note: use the preview function to print on MacOSX).

**File:Print Setup** Prepare for printing.

**File:Done** Close the window.

**Spectra:Reload** Reloads the data and redraws the spectra (in case some data had been changed).

**Spectra:Select** Select the spectra to be displayed from the list of all spectra in the spectral library file.

**Spectra:Save as Text** Save the displayed data to an ASCII table file.

**Spectra:Save as SLB** Save the displayed data to an ENVI SLB file.

**Graph:Titles** Change graph title and x/y axis titles.

**Graph:Y-Axis** Change the range of the Y-axis (comma separated numbers).

**Graph:X-Axis** Change the range of the X-axis (comma separated numbers).

**Graph:Toggle X-Axis** Switch between wavelength and band number display on the X-axis. This option is only available if the wavelength tag is found in the ENVI header.

**Graph:Reset Range** Adjusts the range automatically to the data on both axis, according to the respective minimum/maximum values.

**Graph:Toggle Legend** Inserts a legend for the given graph.

**Graph:Legend Position** Change legend position (by relative display x/y coordinates).

**Graph:Legend Labels** Change labels of legend list.

**Graph:Set Display Size** Set the size of the display to given numbers in cm.

**Font_Size** Change the font size to one of the given numbers.

**Output** The currently displayed spectrum may be saved either as EPS file or to any of the displayed raster image outputs.

**Help:About** Displays the *Spectral Library Plot* help text.

## 8.5 Show Textfile

Use this function if you need to dispaly edit a plain text file which comes together with the data to be processed. The file is opened in a simple editor and may be changed and saved. Simple copy-paste is also enabled in this small editor. For opening and printing the file in an OS-native text editor, you may use the preview function. The function comes handy if an ENVI header needs to be checked or updated. Selecting the ’Save’ or the ’Save As’ function in the submenu will allow to overwrite the file or to create a new one.

## 8.6 Preview Image

Opens the currently displayed image as JPG in the native image file viewer of the operating system. The image can then be easily saved in various formats from the native image file viewer and printed.

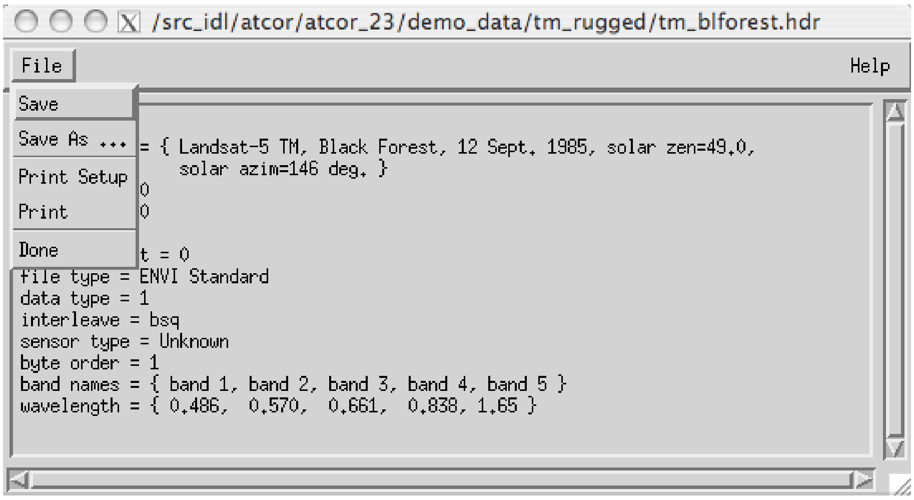


**Figure 8.4**: Simple text editor to edit plain text ASCII files

## 8.7 Close

Closes the currently displayed image and all related windows.

# Chapter 9

# Menu: Edit

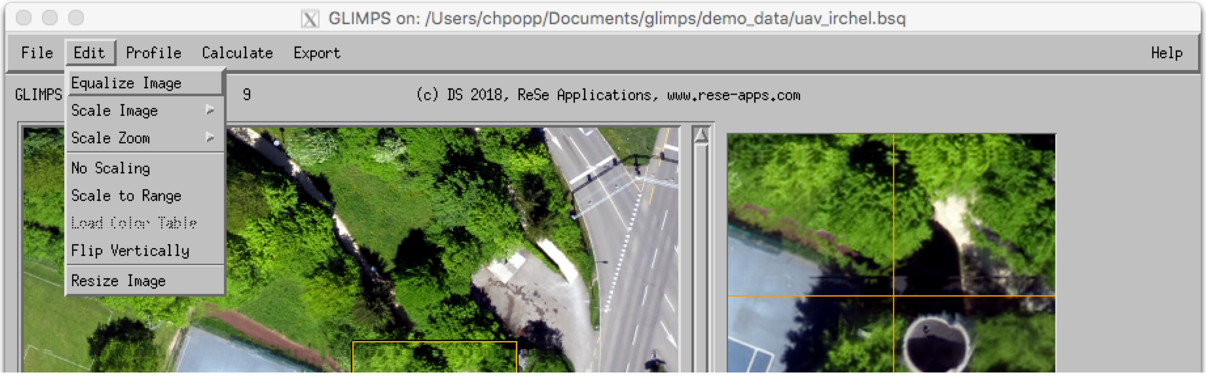


**Figure 9.1**: Top level graphical interface of GLIMP: "Edit".

The menu *'Edit'* (c.f. Fig. 9.1) allows basic image manipulation such as histogram scaling. Below, a description of the functions is given.

## 9.1 Equalize Image

Performs a histogram equalization on all bands that have been selected by the band selection tool and scales the whole image accordingly.

## 9.2 Scale Image

Applies standard linear scaling on the imagery using the following differing methods: Mean-1, Mean-2, Mean-3, Lin 1%, Lin 2%, Lin 4%, and RGB 2%. In the following $avg$ is the average value of a specific image channel and $\sigma$ the corresponding standard deviation:

- Mean-1: Linearly scales each of the three image channels between a minimum value determined by $avg - 3 \times \sigma$ and a maximum determined by $avg + 3 \times \sigma$.
- Mean-2: Linearly scales each of the three image channels between a minimum value determined by $avg - 2.5 \times \sigma$ and a maximum determined by $avg + 2.5 \times \sigma$.

- Mean-3: Linearly scales each of the three image channels between a minimum value determined by $avg - 1.8 \times \sigma$ and a maximum determined by $avg + 1.8 \times \sigma$.
- Lin 1%: Linearly scales each of the three image channels between a minimum value determined by the 1% percentil and a maximum value determined by the 99% percentil of the number of band's values based on histogram analysis
- Lin 2%: Linearly scales each of the three image channels between a minimum value determined by the 2% percentil and a maximum value determined by the 98% percentil of the band's values.
- Lin 4%: Linearly scales each of the three image channels between a minimum value determined by the 4% percentil and a maximum value determined by the 96% percentil of the band's values.
- RGB 2%: Same as 'Lin 2%' but the minimum and maximum values are determined from all three bands and the three bands are then scaled together such that the respective scaling of all bands remains the same (no color changes)

## 9.3 Scale Zoom

Applies the standard linear scaling on the imagery using the above-described six differing methods, but using the statistics of the currently displayed zoom window.

## 9.4 No Scaling

Reverts to an unscaled display of the image.

## 9.5 Scale to Range

Scales a single-band image linearly to a range entered as lower and upper limit as two comma-separated values. Although intended to be used for single-band images, this option also works with three-channels images where each channel is scaled to the specified range separately. The function may also be used for thresholding by entering two values very close to each other.

## 9.6 Load Color Table

This option is applicable for single band display only, e.g. to display index values. It opens a window (Fig. 9.2) to either load one of the standard IDL/ENVI pre-defined color tables or to define and apply a user-defined transfer function, including some other options.

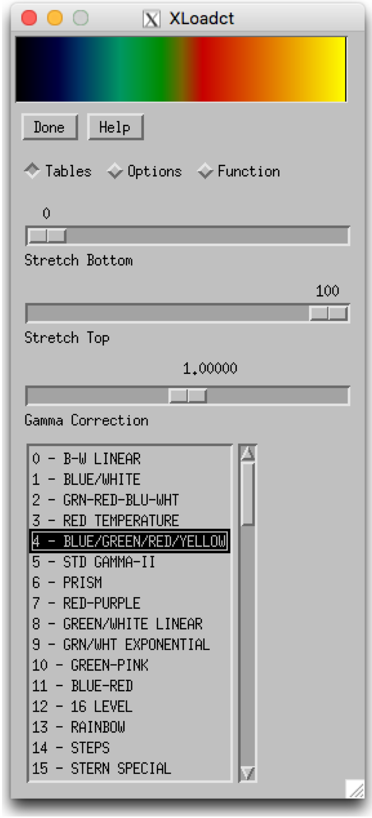


**Figure 9.2**: Color table menu.

## 9.7 Flip Vertically

Flips the image display vertically, e.g. which is suitable for unrectified images which may appear mirrored depending on data acquisition.

## 9.8 Resize Image

This tool allows to resize the currently displayed image to new spatial dimensions, optionally based on a reference image. A bilinear resampling is applied. Fig. 9.3 displays the window which pops up when choosing the image resize option. The following inputs are necessary:

- Input cube: name of input data file to be resized.
- Upper Left Corner: coordinates of upper left corner pixel (ENVI convention: lower left edge of upper left corner pixel is pixel 1/1) - the button **Get UL Position from Cursor** may be used to load coordinates - use the button **Push Position** in any displayed image first to transfer coordinates).
- Output Pixel Size (m): the pixel size of the re-dimensioned image in meters.

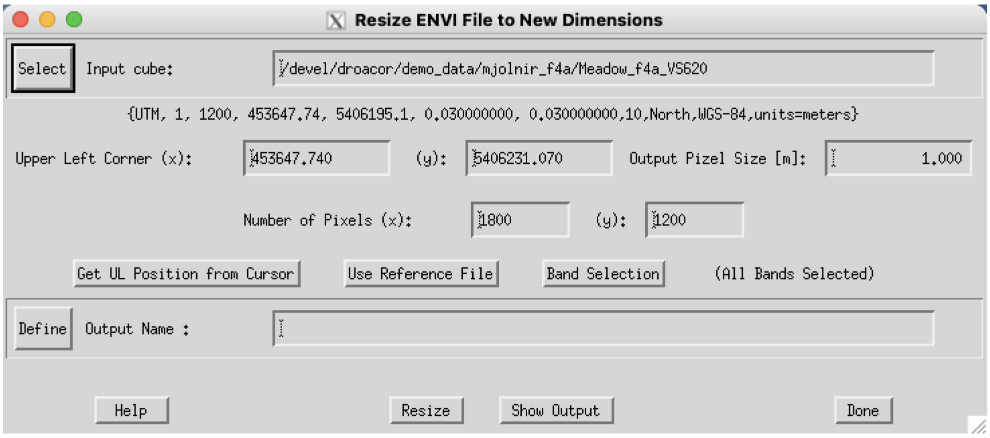


**Figure 9.3**: Image resize panel.

- Number of Pixels: size of output file in pixels in x and y direction (ncols, nrows) starting at upper left corner.
- Use Reference File: the coordinates of a reference file may be used to determine the limits and resolution of the resized image.
- Band Selection: select the spectral bands to be included in the resized output.
- Output Name: name of the resized output file to be created.

# Chapter 10

# Menu: Profile


**Figure 10.1**: Top level graphical interface of GLIMP: "Profile".

The menu *'Profile'* (c.f. Fig. 10.1) allows quick plotting of vertical and horizontal profiles as well as spectra from the image data. A separate plotting window will be opend for each profile option whose available functions are described in Sec. 10.4.

## 10.1 Horizontal

Opens a window for a horizontal profile through the whole image of the currently displayed bands; for RGB images, three profiles are shown in the respective colors (see Fig. 10.2. If a single band profile is required, the band selection is to be changed to single band display. The profile is updated for the cursor location in the zoom window whenever the zoom window is clicked.

## 10.2 Vertical

Opens a window for a vertical profile through the image (of the first band only). The profile is updated for the cursor location in the zoom window whenever the zoom window is clicked.

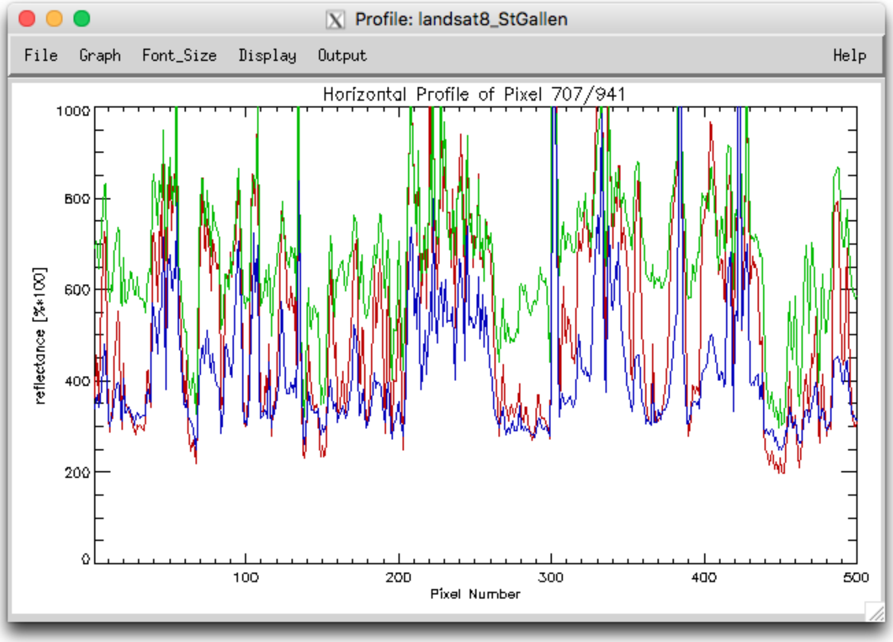


**Figure 10.2**: Profile plot window.

## 10.3 Spectrum

Opens a window for a spectrum of the image (for images with 4 and more bands only); click on an image location to show the spectrum directly. For multispectral data, the band positions are shown as red squares. The spectrum is updated for the cursor location in the zoom window whenever the zoom window is clicked. With the 'collect' option, spectra in an image may be collected and stored as SLB for later use.

## 10.4 Profile window options

Fig.10.2 and 10.3 show the plot windows which open once a profile option as well as an image location is chosen. The following functions are available from within these plot windows.

**File:Show Data** Opens a window and displays the data as an ASCII text table.

**File:Open File** Opens a different spectral library for intercomparison.

**File:Preview** Displays the current profile display as PDF in the native image file viewer of the operating system.

**File:Print** Print the contents by postscript-printing.

**File:Print Setup** Prepare for printing.

**File:Done** Close the window.

**Spectra:Reload** Reload the last selected spectrum and updates the plot (if eg. the envi header had changed)

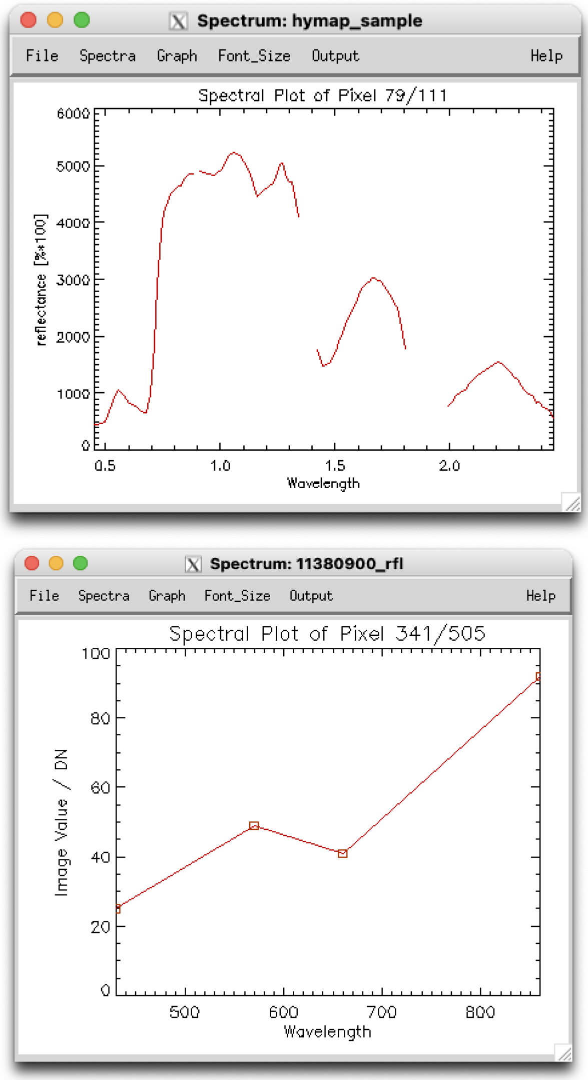


**Figure 10.3**: Spectrum plot windows for hyperspectral (left) and multispectral (right) data.

**Spectra:Collect** Collect a spectrum and start a new one.

**Spectra:Save as TXT** Save the displayed data to an ASCII text table file.

**Spectra:Save as SLB** Save the displayed data to an ENVI spectral library file.

**Graph:Titles** Change graph title and x/y axis titles.

**Graph:Y-Axis** Change the range of the Y-axis (comma separated numbers).

**Graph:X-Axis** Change the range of the X-axis (comma separated numbers).

**Graph:Toggle X-Axis** Switch between wavelength and band number display on the X-axis. This option is only available if the wavelength tag is found in the ENVI header.

**Graph:Reset Range** Adjusts the range automatically to the data on both axis, according to the respective minimum/maximum values.

**Graph:Set Display Size** Option to set the display size (in cm).

**Font_Size:** Change the font size to one of the given numbers.

**Output** The currently displayed spectrum or profile may be saved either as EPS file or to any of the displayed raster image outputs.

**Help:About** Displays the *Profile* online help.

## 10.5 Spectrum Window

This allows the set the averaging window for spectrum display. The given number are the number of pixels of a square sample taken at the pixel location. Even numbers are rounded to the next impair number. By default, single pixel values are read)

# Chapter 11

# Menu: Calculate


**Figure 11.1**: Top level graphical interface of GLIMP: "Calculate".

The menu *'Calculate'* (c.f. Fig. 11.1) offers various options for image processing and statistical analysis, such as radiometric correction, the calculation of band indices, or spectral classification.

## 11.1 Empirical Correction

This function is to perform an empirical radiometric correction of any imagery based on reference spectra. It is based on a simple empirical radiometric correction approach where all pixels in an image are adjusted to a bright and/or dark reference, arbitrarily found in the image itself or from ground measurements. Fig. 11.2 depicts the corresponding interface where the following parameters may/should be provided:

- *Endmember from Image*: this allows to set the location from the currently displayed image (use *'Push Position'* button there). Using the *'Get'* button will copy the last selected coordinates. *Sample Diameter* is the diameter of a square sample to be taken at the given position.

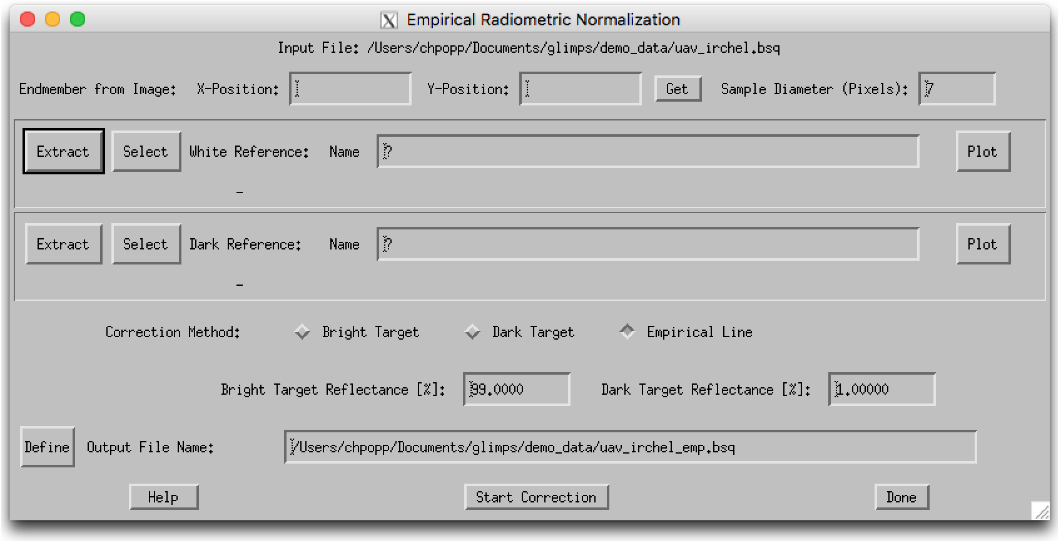


**Figure 11.2**: Empirical correction window.

- White/Dark Reference: a white and/or black reference spectrum can be defined in these two fields as follows:
  - *Extract:* will extract an endmember from the image itself using the position given in the first line at the top of the panel. This will create a new spectral library file with mean and standard deviation of the selected endmember.
  - *Select:* allows to select an endemember from an existing or a newly created spectral libary.
  - *Name:* name of the last selected endmember; this routine always uses the first spectrum in a spectral library.
  - *Plot:* will plot the currently selected endmember spectrum - just for quality control.
- Correction method:
  - *Bright target:* performs a bright target normalization such that: $\rho_{out} = DN_{in}/DN_{bright} \cdot \rho_{bright}$.
  - *Dark target:* performs a dark target correction using a single dark target spectrum such that $DN_{out} = DN_{in} - DN_{dark}$.
  - *Empirical line:* performs an empirical line correction such that $\rho_{out} = (DN_{in} - DN_{dark})/DN_{bright} \cdot \rho_{bright} + \rho_{dark}$.
- Bright Target Reflectance: this is the average reflectance of the bright target reference ($\rho_{bright}$), default: 99%.
- Dark Target Reflectance: this is the average reflectance of the dark target reference($\rho_{dark}$), default: 1%.

- Output File Name: Name of the output file; this will be in floating point reflectance [%] by default.
- Help: displays the online help of the empirical radiometric correction module.
- Start Correction: runs the application.
- Done: closes the window.

## 11.2 Dark Target Correction

This routine performs a dark target signature correction by searching for the darkest pixels in the red image of the cube and using the respective spectra for correction of the whole image. Instead of providing a given dark target reference as in the empirical correction, this routine searches for the darkest pixels automatically in the image. Fig. 11.3. depicts the corresponding interface.

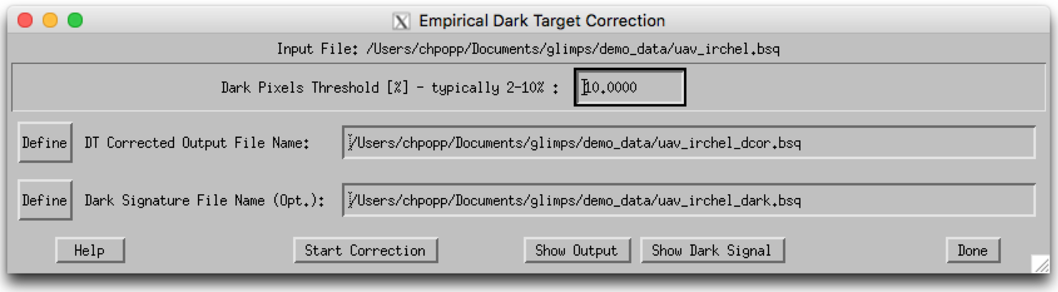


**Figure 11.3**: Dark target correction window.

The following parameters may/should be provided:

- Dark Pixels Threshold: percentage of number of dark pixels (typical 5-10%). The percentage of darkest pixels is used to find the dark pixel reference.
- DT Corrected Output Filename: name of the corrected output file.
- Dark Signature Filename: optional - name of the file which stores the dark signature. Leave this field empty, if this file is not to be stored.
- Help: displays the online help of the dark target correction module.
- Start Correction: runs the application.
- Show Output: displays the corrected image.
- Show Dark Signal: displays the dark signal image which is spatially interpolated from the single dark pixels.
- Done: closes the window.

## 11.3 Band Index

This option allows to calculate a spectral band index from the currently displayed multi/hyperspectral imagery such as band ratio or NDVI-type of indices. The resulting image is stored in a separate file. Fig. 11.4. depicts the corresponding interface where the following parameters may/should be provided:

- Band Index Type: select one of the currently implemented band indices which are:
  - *Band Ratio:* a simple band ratio calculation ($Ratio = Band1/Band2$) where the band number of the nominator and denominator must be provided.
  - *NDVI:* computes the normalized difference vegetation index ($NDVI = (NIR - Red)/(NIR + Red)$ where the band numbers of the near infrared and red bands have to be provided.
  - *NDRE:* computes the normalized difference red edge index ($NDRE = (NIR - Rededge)/(NIR + Redredge)$ where the band numbers of the near infrared and a band in the vegetation rededge (approx. 760nm) have to be provided.
  - *ARVI:* computes the atmospherically resistent vegetation index, defined as $ARVI = (NIR-Red-Blue)/(NIR+Red-Blue)$ where the band numbers of the near infrared, red, and blue spectral bands have to be provided.
  - *SAVI:* computes the soil adjusted vegetation index, defined as $SAVI = (1 + 0.5) * (NIR - Red)/(NIR + Red + 0.5)$ where the band numbers of the near infrared and red spectral bands have to be provided.
  - *MCARI:* computes the modified chlorophyll absorption ratio index, defined as $MCARI = (Rededge - Red) - 0.2 * (Rededge - Green) * (Rededge/Red)$ where the band numbers of the near red edge, red, and green spectral bands have to be provided.
  - *PRI:* computes the photosynthesis ratio index, defined as $PRI = (Green - Yellow)/(Green + Yellow)$ where the band numbers of the yellow (570nm) and green (531nm) spectral bands have to be provided. (Note that the PRI index is only applicable for high spectral resolution instruments with the 531nm band)
  - *Absorption Depth:* computes the relative absorption depth similar to $Depth = CenterBand/Interpolate(leftwing; rightwing)$ where the band numbers of the center, leftwing, and rightwing bands have to be provided.
- Output File Name: name of the output file where the calculated band index should be stored.
- Help: displays the online help of the band index module.
- Calculate: computes the index, stores the result as floating point value to a file and displays the result in a new window.
- Done: closes the window.

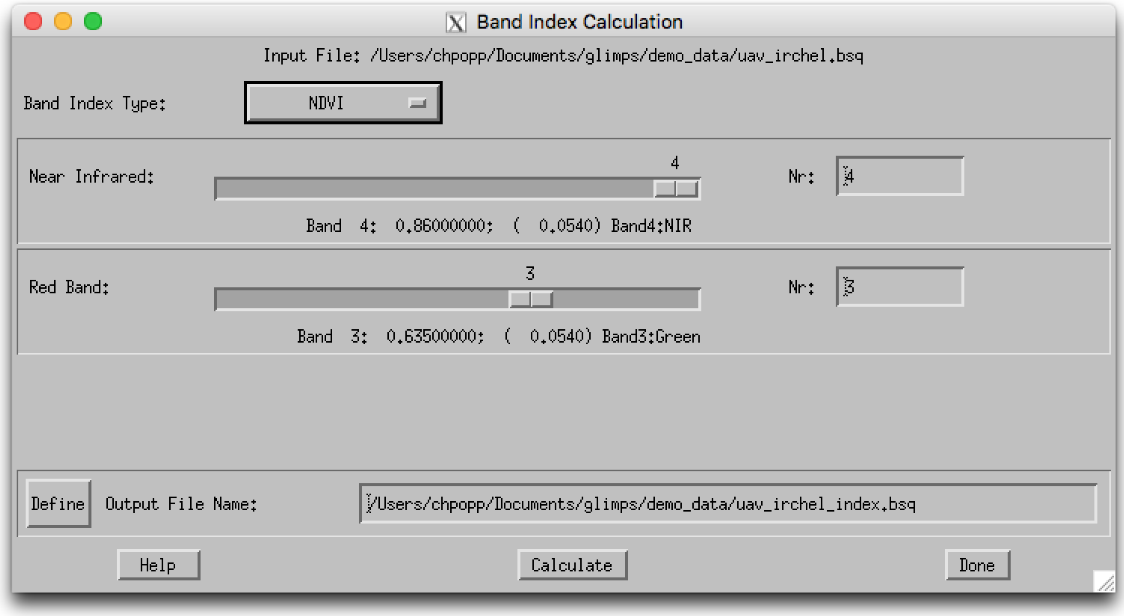


**Figure 11.4**: Band index window.

## 11.4 Spectral Classification

This option allows to calculate a spectral quantification/classification using the spectral angle mapper or a spectral fitting technique in combination with endmember spectra which may either be image-based or from external sources. Fig. 11.5. depicts the corresponding interface where the following parameters may/should be provided:

- Endemember from Image: this allows to set the location from the currently displayed image (*'Push'* button there). Using the *'Get'* button will copy the last selected coordinates.
- Sample Diameter: this is the diameter of a square sample to be taken at the given position
- Endmember:
  - *Extract:* will extract an endmember from image using the position given above. This will create a new spectral library file with mean and standard deviation of the selected endmember.
  - *Select:* allows to select an endemember from an exisisting spectral libary.
  - *Name:* name of the last selected endmember. This name may be changed to assign,e.g., class names of the output.
  - *Plot:* will plot the currently selected endmember spectrum.
  - *Clear:* will clear this endmember from the list.
- Spectral Classification/Quantification method:

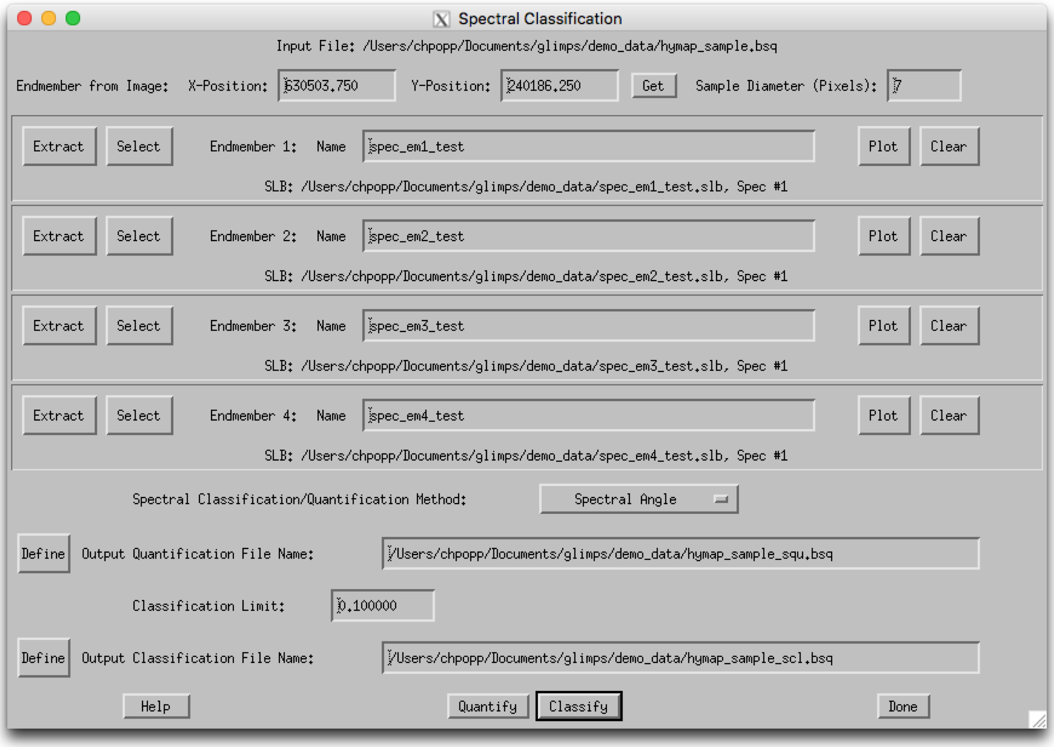


**Figure 11.5**: Band index window.

  - *Spectral Angle (SAM):* this performs the spectral angle mapper method (minimum spectral angle against pre-defined reference spectra). Spectral angle mapper output is a quantification name with the respective angles.
  - *Inverse Spectral Angle:* this performs the spectral angle mapper method, but inverts the resulting spectral angle such that larger numbers are closer matches. Spectral angle mapper output is a quantification name with the respective angles.
  - *Best Fit:* this performs a best fit based on a RMS deviation analysis.

- Output Quantification File Name: defines the file to contain the quantification values for each endmember spectrum, without thresholding/classification.
- Classification Limit: this is the upper limit to be used for classification, i.e., only pixels with quantification values below this limit are put in a class. Please consult the quantification output to adjust this value to reasonable number
- Output classification name: defines a file to be created which will contain the classification map based on the given rule limit.
- Quantify: computes the quantification rule image which may be used for classification.
- Classify: runs the classification using the contents of the currently selected quantification output; limits may be adjusted

- Help: displays the online help of the spectral classification module.
- Done: closes the window.

## 11.5 Change Detection

This function searches for differences between two images and displays the corresponding statistics. For now, only single bands are compared. Fig. 11.6. depicts the corresponding interface where the following parameters may/should be provided:

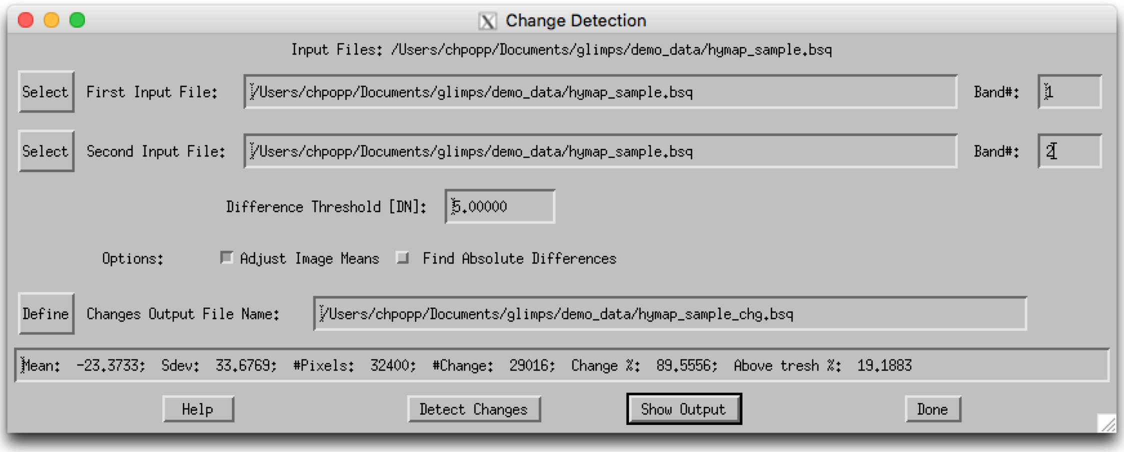


**Figure 11.6**: Change detection window.

- First Input File: first file and band number to check. Must have same spatial dimensions as the second input file.
- Second Input File: first file and band number to check. Must have same spatial dimensions as the first input file.
- Difference Threshold [DN]: minimum difference to be considered a change between two images in digital numbers [DN]; differences below the threshold value are set to zero and considered being below the noise level.
- Options:
  - *Adjust Image Means:* will adjust the mean values of the two images before calculating differences.
  - *Find Absolute Difference:* will take the absolute value from the differences, i.e. all changes are shown whether positive or negative. By default only positive changes are shown.

### 11.5.1 Actions

- Output File Name: file to be created (single band image of differences).
- Help: displays the online help of the spectral classification module.
- Detect Changes: runs the application.
- Show Output: displays the difference images.
- Done: closes the window.

## 11.6 Statistics

This procedure calculates the statistics per spectral band from the current image and stores the result as a SLB file with the spectra: Minimum,5% Percentile,Median,95% Percentile,Maximum,Mean, and Standard Deviation of the whole image.

## 11.7 Image Filter

This allows to apply standard spatial filters to imagery. Outputs will be filtered band-by band with the respective filter size and selected function.

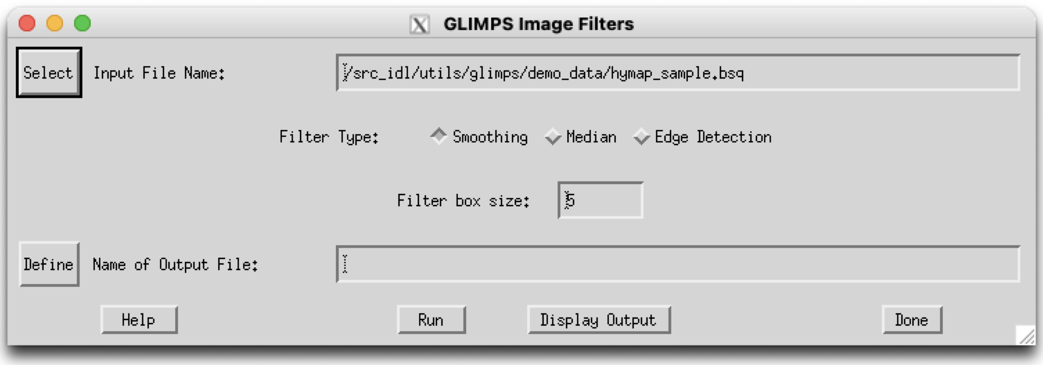


**Figure 11.7**: Scatterplot analysis window.

## 11.8 Scatterplot Analysis

Want to know if data outputs are correlated against each other? This function helps to understand spatial correlations between images of the same spatial dimensions. Two images are read and plotted against each other and a statistical analysis is performed after applying a polynomial fit based on Chi-Square optimization. Fig. 11.8 depicts the corresponding interface where the following parameters may/should be provided:

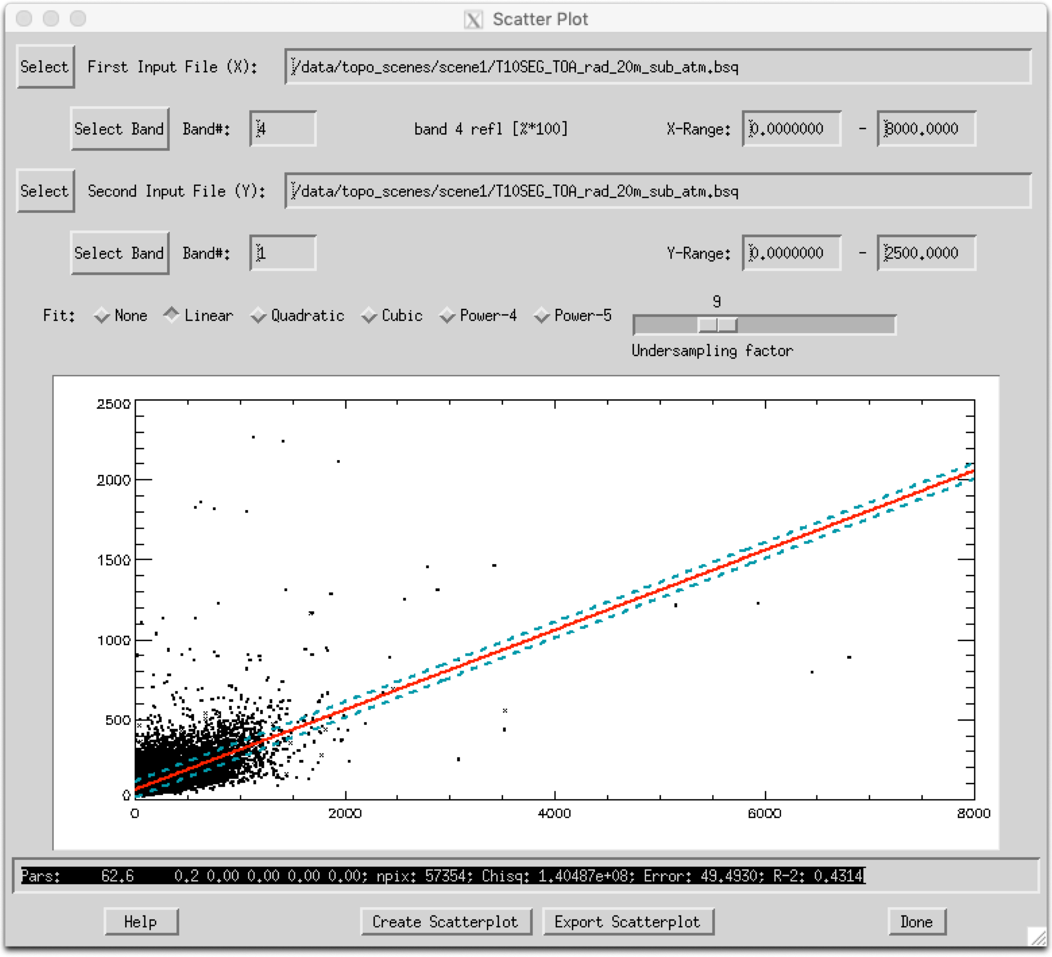


**Figure 11.8**: Scatterplot analysis window.

**First Input File** select the first file to be analysed (on x-axis)

**Select Band** select the band to be used (only one band at once)

**X-Range** Range to be plottet (the analysis is always done on full range). Setting 0/0 here will use default scaling

**Second Input File** select the first file to be analysed (on y-axis) can be same file if two bands of the same file are to be compared.

**Select Band** select the 2nd band to be used (only one band at once)

**Y-Range** Range to be plottet (the analysis is always done on full range). Setting 0/0 here will use default scaling

**Fit** Degree of fit to be applied on the selected data set. Default: linear fit (1st degree), None: will not perform a fit and draws no fitting line

**Undersampling Factor** Factor to increase calculation speed Default: 10, ie. only every 10th pixel is analysed. Increase the factor for faster display; decrease the factor for higher accuracy.

**Pars** parameters from fit;

- the first 6 numbers are the coefficients of a polynomial fit,
- npix: number of analysed pixels (after undersampling)
- Chisq: Chi-Square number of the fit
- Error: average absolute error of fit (in y-unit numbers)
- R-2: R-Square goodness of fit (the data may be copied for later use)

Actions

**Create Scatterplot** Updates the scatterplot and statistics in the current window

**Export Scatterplot** Recreates the currently displayed plot in a separate window.

# Chapter 12

# Menu: Export

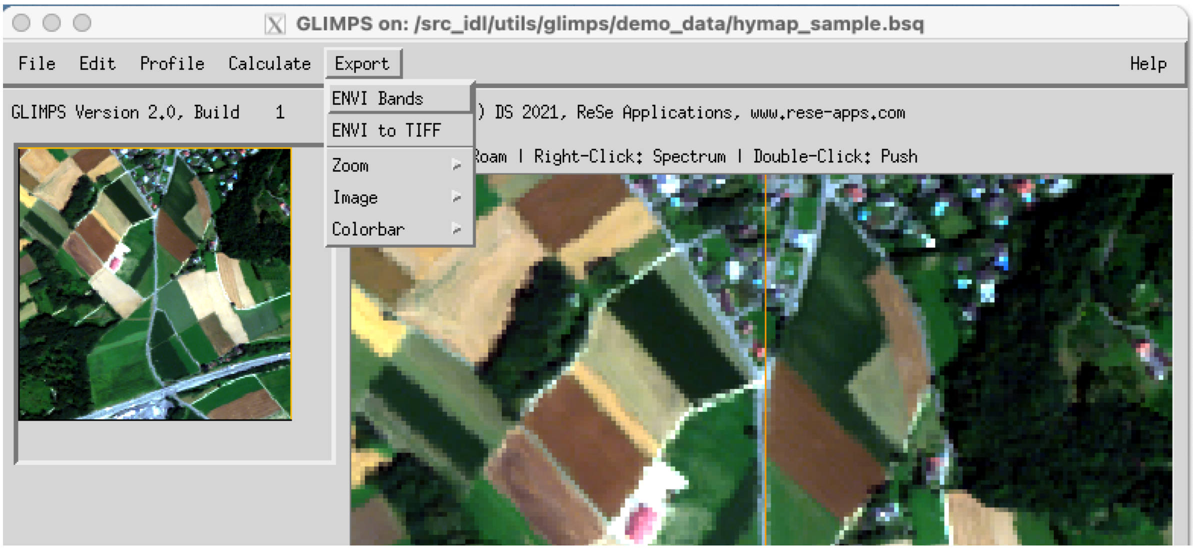


**Figure 12.1**: Top level graphical interface of GLIMPS: "Export".

Export (c.f. Fig. 12.1) allows to export the currently displayed image of either the zoom or the full image window to one of the given image data formats. The displayed image may be exported as a scaled 8bit/24bit image to the available standard image formats. Furthermore, the displayed color bar may be exported for use in publications (makes sense for single band images only). Below, a decription of the individual functions is given.

## 12.1 ENVI Bands

Exports the currently displayed image (e.g. a RGB based on three spectral bands or a single band) to a new BSQ file.

## 12.2 ENVI to TIFF

Converts a selected ENVI BSQ file to a multi-channel TIFT file; the output TIFF will contain all spectral data. An TIFF world file (.tfw) is written containing the geometric information.

## 12.3 Zoom

Exports the currently displayed content of the zoom window. One of the following file formats can be chosen: GIF, PICT, PNG, TIFF, JPEG.

## 12.4 Image

Exports the currently displayed content of the image window. One of the following file formats can be chosen: GIF, PICT, PNG, TIFF, JPEG.

## 12.5 Colorbar

Exports the currently displayed colorbar. One of the following file formats can be chosen: EPS, GIF, or JPEG.

# Chapter 13

# Menu: Advanced

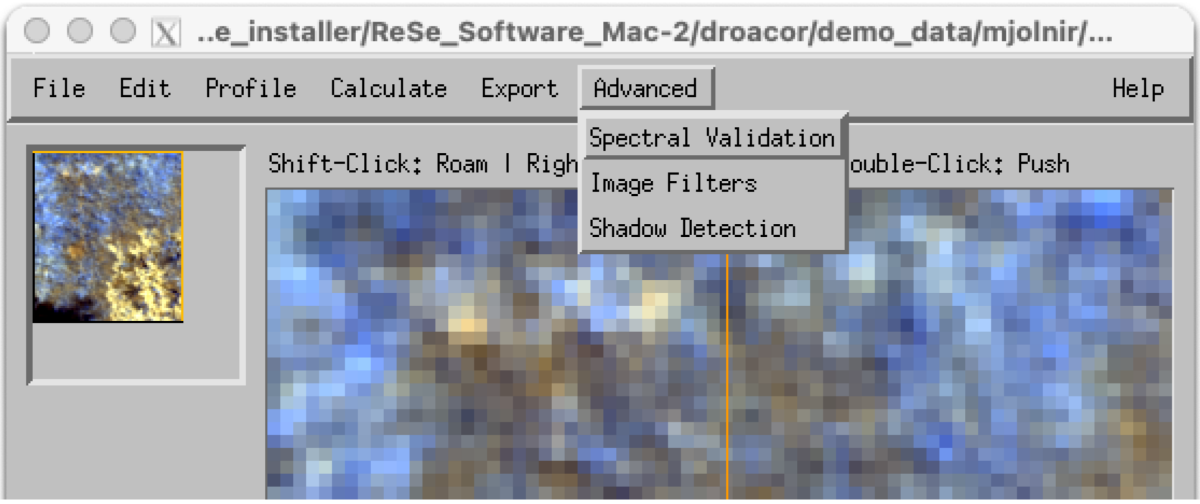


**Figure 13.1**: Top level graphical interface of GLIMP: "Advanced".

The menu *'Advanced'* (c.f. Fig. 13.1) offers some additional functionality, i.e. tools to validate image based-spectra, image filtering, and shadow detection .

## 13.1 Spectral Validation

The goal of this tool is to compare and validate spectra from different image files at the same location and store them in a spectral library. The corresponding menu is depicted in Fig. 13.2)

**File list** : use the the buttons 'Add File', 'Remove Entry' and 'Move' to create a list of image files to be compared. The files should cover the same area. For raw imagery: they should have the same dimensions For rectified imagery; pixels to be compared should be present.

**Position in Image** : coordinates of spectrum to be analyzed. use the button 'Push Position' in the image display to 'Get' the position here. The position is given

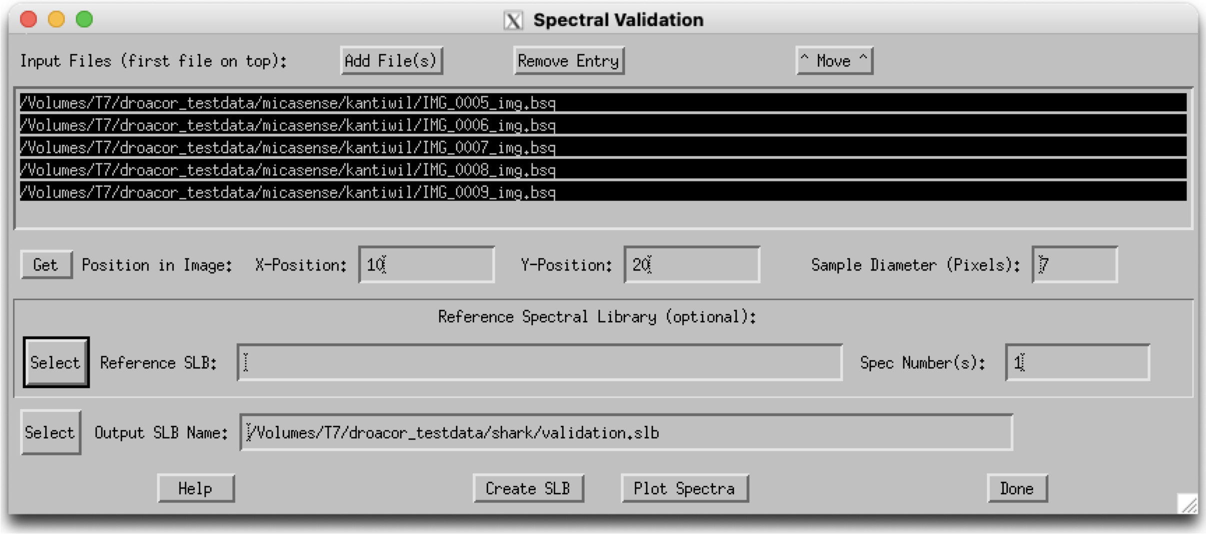


**Figure 13.2**: Graphical interface spectral validation.

in pixels for unrectified imagery and in geographic coordinates for rectified imagery. Sample diameter: diameter of quadratic sample to be taken from image(s)

**Optional Reference Spectral Library** : ENVI Spectral libary of reference spectra to be used. When 'Select' is pushed, one or more spectra to be evaluated together with the image spectra can be selected.

**Output SLB Name** : Name of the spectral library to be created on 'Run'. The slb will contain the image spectra and optionally the reference spectra, resampled to the wavelengths of the image spectra.

**Actions** : *Run*: extracts the spectra, resamples the spectral library, adjusts the units and writes a new spectral library. *Plot Spectra*: Will show the spectral library in the standard Glimps Spectral Library viewer.

**Outputs** : Spectral library for plotting.

Notes: the procedure tries to adjust the spectra to reflectance in [%] based on the tag 'z plot title' in the envi headers as follows:

*default*: no adjustment

*if the y-title contains '[-]'*: the spectrum is multiplied by 100 (e.g. for laboratory spectra)

*if the y-title contains '*100'*: the spectrum is divided by 100 (e.g. for standard droacor/atcor outputs)

Adjust the envi headers accordingly, if the units do not fit.

## 13.2 Image Filters

This routine filters an image file band-by-band with a specific filter and its GUI is shown in Fig. 13.3).

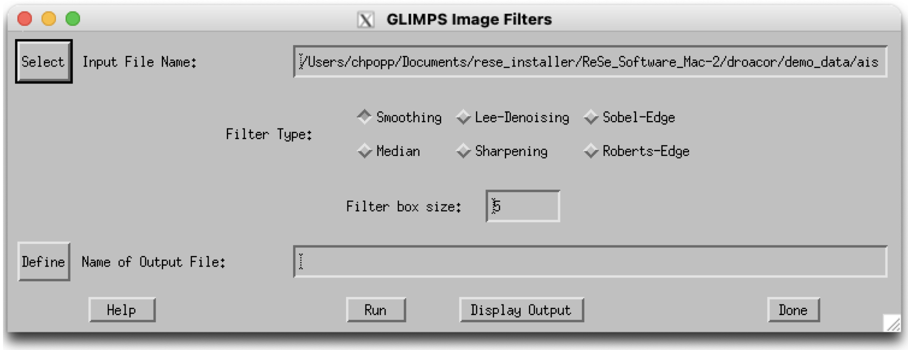


**Figure 13.3**: Image filter window.

**Input** : Input file to be filtered

**Filter Type** :
*Smoothing*: standard filtering, including image edges
*Median*: standard median value filter
*Lee-Denoise*: Lee filtering to remove high frequency noise in image
*Sharpening*: image sharpening, amplification of high pass filtered image contents
*Sobel Edge*: Edge detection routine based on a 3x3 mask
*Roberts Edge*: Edge detection based on a 2x2 mask

**Filter Box Size** : Side length of square filter box (does not apply to edge detection filters)

**Name of Output File:** : Filtered output file which will have the same dimensions and data type as input.

## 13.3 Shadow Detection

This tool detects the fractional shadows in the image and saves a floating point fractional shaodw (illumination) file. Thereby, a combined index is created based on NIR brightness, and two red/blue and green/blue indices which results in a scaled number proportional to the cast shadow. The corresponding menu is illustrated in Fig. 13.4)

**Input File Name** : reflectance file to be analysed, requires at least 4 bands (BRGN) and has to be in reflectance units (0-1 or scaled reflectances). Apparent reflectance input is recommended for this shadow detection routine.

**Options** :

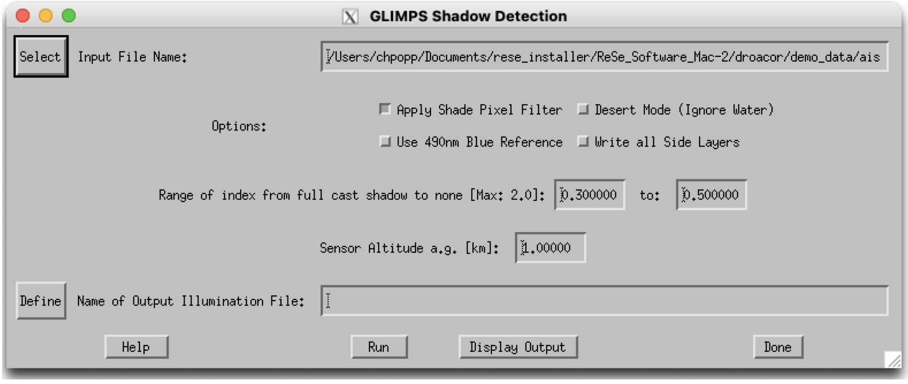


**Figure 13.4**: GUI of shadow detection tool.

*Apply Shade Pixel Filter*: filters single pixels within full cast shadow areas
*Use 490 nm Blue Reference*: uses a blue band at 490 nm instead of 450 nm for hyperspectral instruments (or 430 for multispectral)
*Desert Mode (Ignore Water)*: water areas are not explicetely masked and treated as land (and thus mostly detected as shadows, this avoids misclassifications as water of shaded areas)
*Write all Side Layers*: creates a file containing all indices calculated during the processing in 5-7 layers. This function may be useful to find the appropriate range limits for a sensor system or imaging situation

**Range of index** : The lower and upper boundary can be set in order to derive a continuous fractional shadow from index. Larger values will result in large fractions of shadows being detected. The range can not exceed 0 to 2 in any case (default values : 0.3 to 0.5)

**Slope File Name** : Name of input Slope file to be used for illumination calculation (the corresponding *_asp.bsq' file needs also to be present)

**Solar Zenith/Azimuth** : solar angles [zenith/azimuth] for this data set. These values only required for terrain illumination and skyview option

**Sensor altitude** : Altitude of aircraft above ground level in km

**Name of Output Illumination File** : Illumination/shadow fraction file from parameters

As output, a floating point illumination map is created containing a quantitative estimate of the fractional cast shadow. Optionally, all indices used in the calculation are written in additional layers. Layer 1 always contains the illumination output, usable for atmospheric correction.