GLIMPS

User Manual, Version 2.0, June 2021

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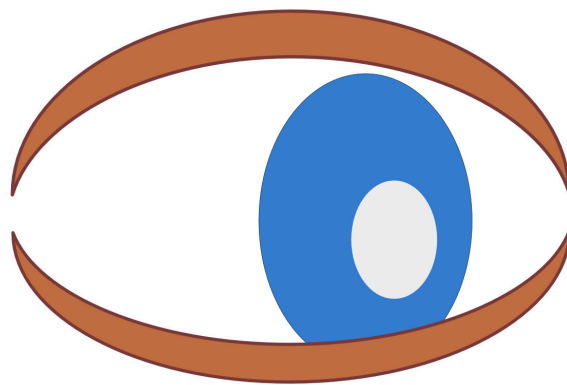
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Updates: see ReSe download page: www.rese-apps.com/software/download and check online through the self-update function.

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Chapter 1

Introduction

GLIMPS is a free software package for remote sensing and imaging spectroscopy and muiltispectral remote sensing data viewing and image analysis. It has been built to bring the world of hyperspectral imaging to educational institutes as well as to provide a tool for browsing distributed data. GLIMPS is part of the ReSe Software family and is included as part of the professional packages PARGE, DROACOR, ATCOR, and MODO.

The main features of GLIMPS are:

- ENVI^{TM} file viewer for image browsing and extraction of spectra,

- multispectral and hyperspectral remote sensing image analysis and data quality control,

- native multiband TIFF and RGB JPG support,

- standard normalization methods (dark/bright target correction),

- simple spectral indices (standard vegetation indices, absorption depth, band ratio),

- hyperspectral analysis (spectral angle mapper, best fit analysis),

- ENVI^{TM} spectral library viewer,

- standard data import and export routines (Geotiff and spectral libraries), and

- means for image rectification on the basis of PARGE and IGM file outputs.

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. A short tutorial/educational exercise based on the included demo data concludes the manual.

1.1 Installation

GLIMPS is available from ReSe's download page: www.rese-apps.com/software/download. The software is compatible to Windows, starting with Windows 7, Linux and MacOSX the like. Note that example pictures in this manual are given for Linux/MacOSX appearance, while the software will work equally on Windows operating systems.

First time users are asked to register in order to get access to the download area. After registration, a ReSe Software directory is downloaded to your computer. It contains the Glimps software which is a part of the generic ReSe installer utility which allows to install all ReSe Software. The installation directory includes a stripped-down IDL virtual machine version 8.7 which is required to run all ReSe Software. Alternatively, the software may also be run on an existing IDL/ENVI installation (if available). In order to run the software through a different IDL installation, you either have to adjust the paths in the file GLIMPS.ini situated beneath the GLIMPS.exe (Windows only) or start the software by opening the file 'glimps.sav' with the IDL version of your choice.

Note for MacOSX: On Mac OSX, a separate Glimps.app software is downloaded which may be started right away, provided the X11 package is installed with version 2.8.0.

1.1.1 Updates

The GLIMPS 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. Note that GLIMPS runs on either IDL or the IDL virtual machine. The respective license terms of Harris geospatial apply. Therefore, users who do not have access to an IDL license may use the free IDL virtual machine which is part of the standard software installation.

1.2 First Steps with GLIMPS

To start GLIMPS, double click the file "GLIMPS.exe" (Windows) or "GLIMPS.app" (MacOSX). This will open the software the IDL virtual machine. An IDL splash screen will appear in case you don't own a complete IDL license; which may be clicked to proceed. If you own an IDL license, then add the glimps directory to the IDL search path in the IDL preferences. The glimps software may then be started by typing glimps on the IDL prompt or by opening the file 'glimps.sav' with the licensed IDL installation.

After accepting the terms of use (Fig. 1.1), GLIMPS will ask for an image file (Fig. 1.2) to start the application [1].

Either choose one of your own or one that is already provided in the *'demo_data'* directory; if cancelling a demo data set is loaded automatically. An initial dialog (Fig. 1.2) then allows

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[1]Note: a number of image file formats such as .jpg and .tiff can be loaded, GLIMPS will try to read them as ENVI-formatted file and will eventually write an ENVI header file. The ENVI format is a raw binary file, accompanied by an ASCII header $*$.hdr; for best performance in GLIMPS it should be stored in band sequential order
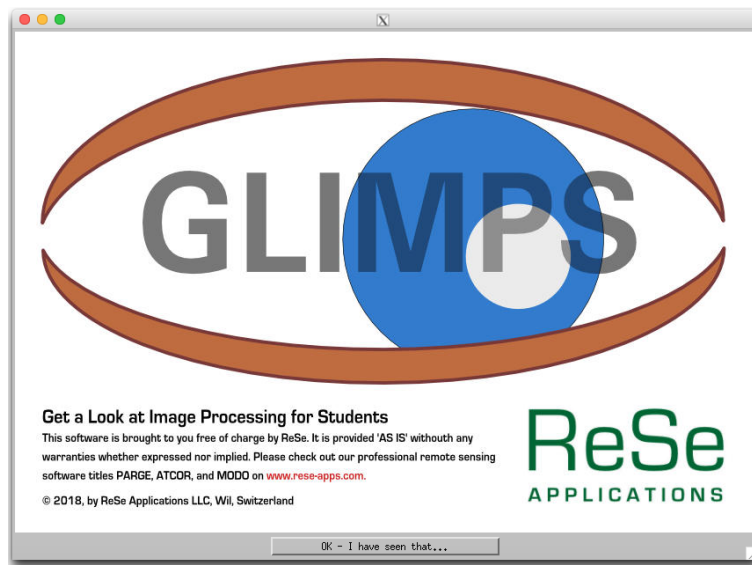
Figure 1.1: *GLIMPS startup screen including terms of use.*

to select the band(s) to display - either a true color, CIR color, or a single band mode may be selected. After band selection, GLIMPS opens its main user interface and the selected image is displayed (Fig. 1.3).
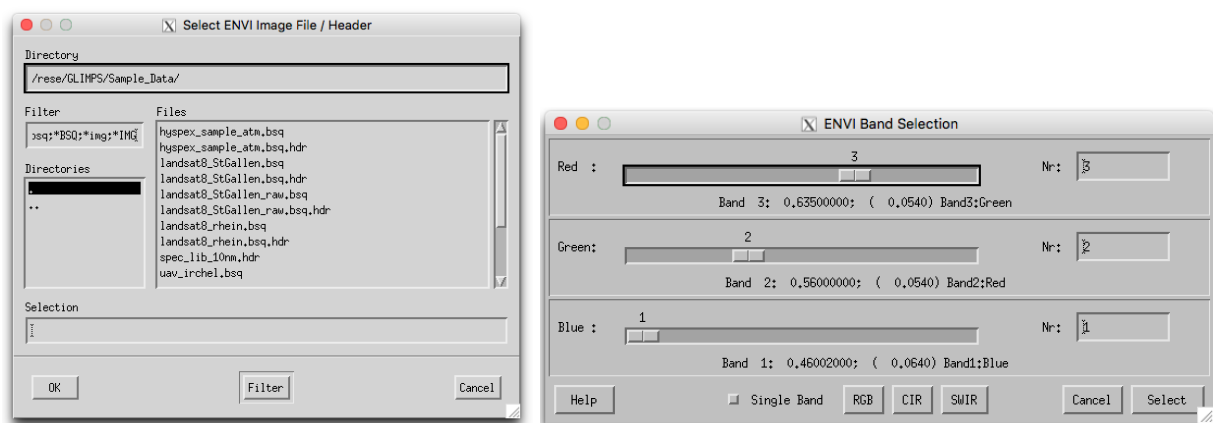
Figure 1.2: *File and band selection window.*

1.3   Menus Overview

Here, a brief overview of the different modules and core functions that are available from GLIMPS' main GUI is given. More detailed information can be found in the subsequent chapters.
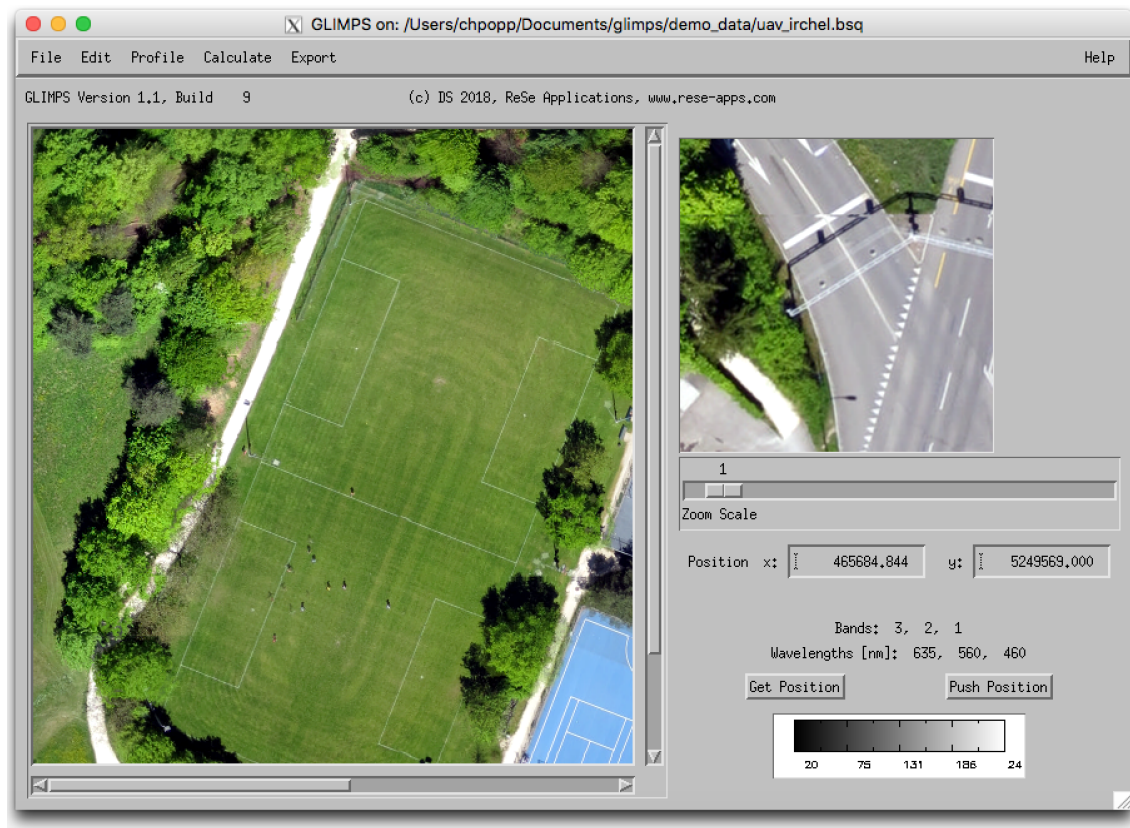
Figure 1.3: GLIMPS' main GUI.

The functions in the *"File"* menu allow the display of an image file, the on-screen display of header files etc, see Fig. 2.1. Furthermore it contains import functions for standard image data and spectral libraries. More details about this menu are given in chapter 2.

The functions in the *"Edit"* menu allow basic image manipulation such as histogram scaling or image resizing, see Fig. 3.1. More details about this menu are given in chapter 3.

The functions in the *"Profile"* menu allow displaying and plotting profiles and spectra from selected image locations, see Fig. 4.1. More details about this menu are given in chapter 4.

The functions in the *"Calculate"* menu allow basic image processing and statistical analysis such as radiometric correction, index calculation, or spectral classification, see Fig. 5.1. More details about this menu are given in chapter 5.

The functions in the *"Export"* menu offers data export options, see Fig. 6.1. More details about this menu are given in chapter 6.

The menu *"Advanced"* is only available if GLIMPS is started from one of ReSe's professional software packages (PARGE,ATCOR, DROACOR). It offers tools for spectral validation, advanced filters and shadow detection.

The *"Help"* menu allows browsing of the GLIMPS user manual, provides a link to web resources, displays license and credits information, and serves to update your software.

1.4 Display Image

The main image display consists of an overview image and zoom subset as shown in Fig. 1.4.

1.4.1 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.
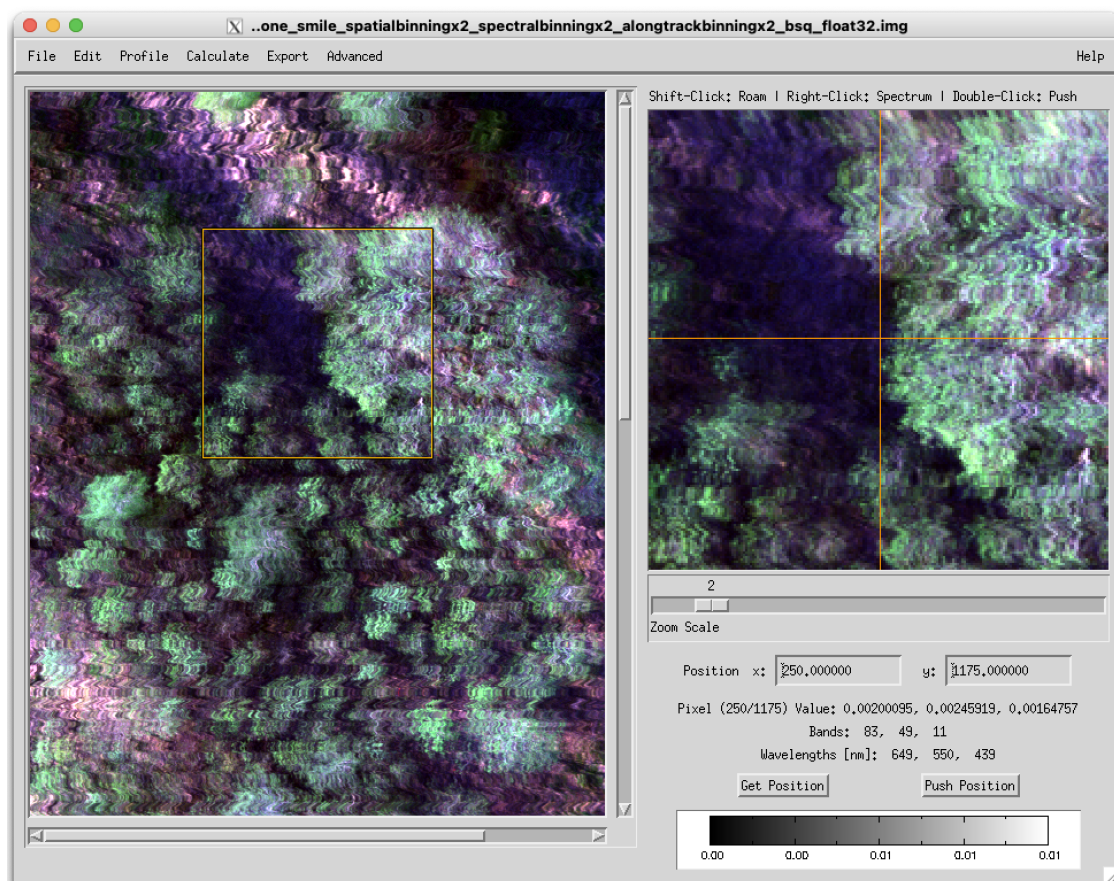
Figure 1.4: *Image display main panel with overview and zoom image*

1.4.2 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.

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

(c) *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.

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

(e) *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.

1.4.3 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.

1.4.4 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.

1.4.5 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.

1.4.6 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.

Chapter 2

Menu: File

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

The menu *'File'* (c.f. Fig. 2.1) offers some tools for handling of the data and ENVI files. Below, a short description of the individual functions is given:

2.1 Display Image

Allows to open an additional image file for analysis, either ENVI, TIFF or JPEG images are allowed. This menu item is only available in the GLIMPS main window. The new window will be closed if the main Glimps window was closed. The main window may be recognized by the Glimps version title text, which is not shown in sub-windows.

2.2 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.

2.3 Band Selection

Allows to select a new combination of spectral bands and updates the display (Fig. 2.2). 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].
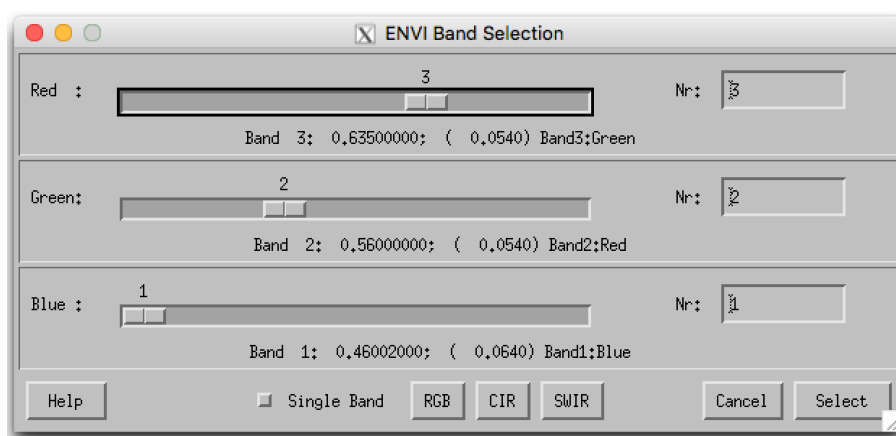
Figure 2.2: *Band selection dialog for ENVI file display.*

2.4 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 with GLIMPS: [This function is only available in the GLIMPS main Window]

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

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

2.5 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' directory. GLIMPS then opens its *Spectral Library Plot* window as illustrated in Fig. 2.3.
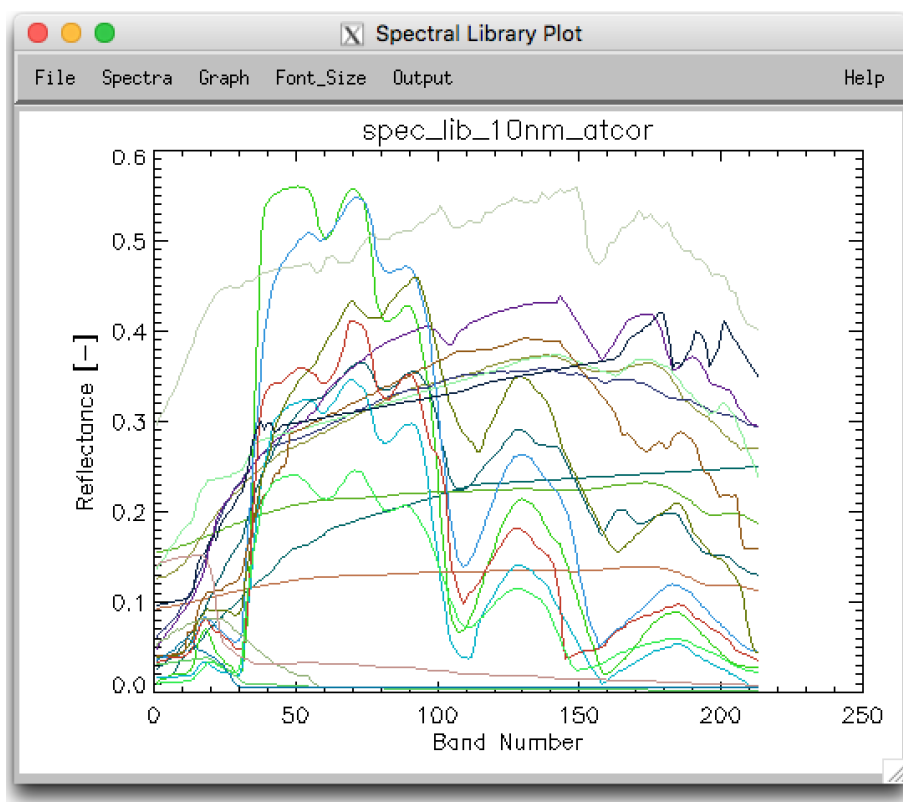
Figure 2.3: *GLIMPS' spectral library plot interface*

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.

2.6   Show Textfile

Use this function if you need to 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.
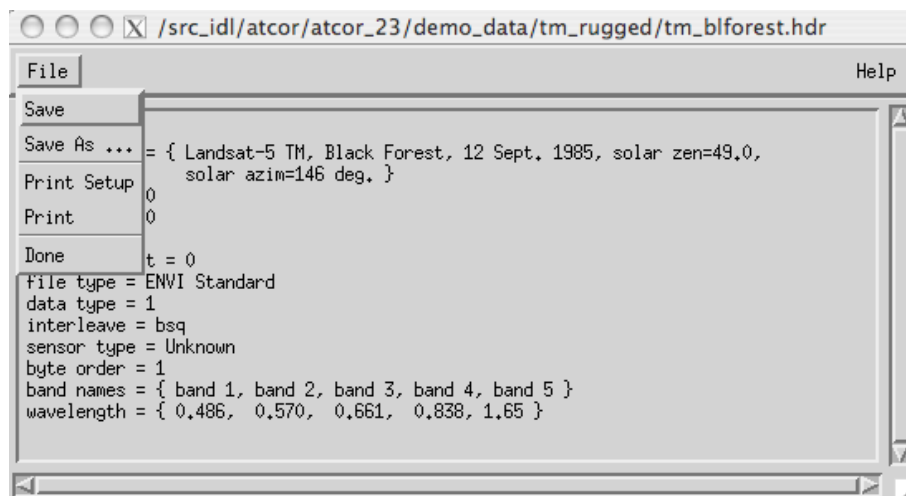
Figure 2.4: *Simple text editor to edit plain text ASCII files*

2.7   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.

2.8   Close

Closes the GLIMPS application. Closing the main GUI window will also quit GLIMPS and all related sub-displays.

Chapter 3

Menu: Edit
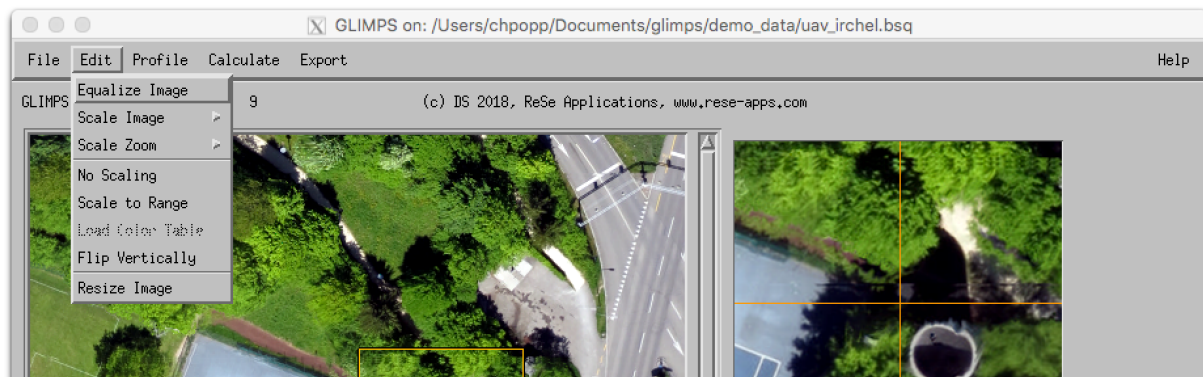
Figure 3.1: *Top level graphical interface of GLIMP: "Edit".*

The menu *'Edit'* (c.f. Fig. 3.1) allows basic image manipulation such as histogram scaling. Below, a description of the functions is given.

3.1 Equalize Image

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

3.2 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 σ 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)

3.3   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.

3.4   No Scaling

Reverts to an unscaled display of the image.

3.5   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.

3.6 Load Color Table

This option is applicable for single band display only, e.g. to display index values. It opens a window (Fig. 3.2) 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.
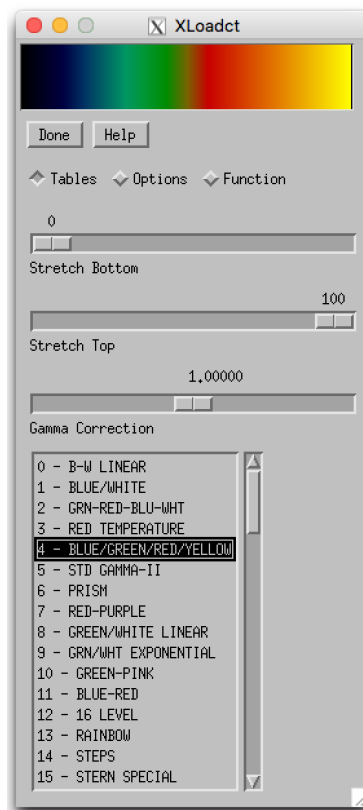
Figure 3.2: *Color table menu.*

3.7 Flip Vertically

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

3.8 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. 3.3 displays the window which pops up when choosing the image resize option. The following inputs are necessary:
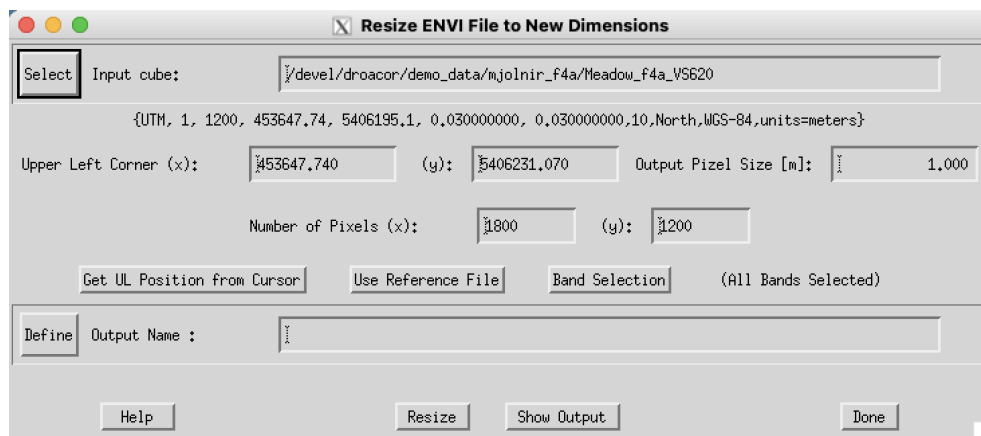
Figure 3.3: *Image resize panel.*

- 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.

- 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 4

Menu: Profile
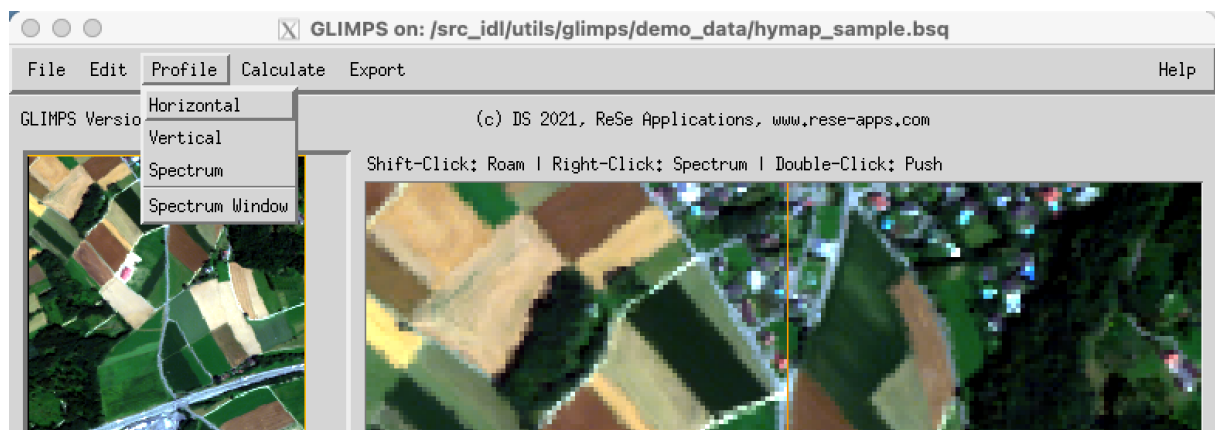
Figure 4.1: *Top level graphical interface of GLIMP: "Profile".*

The menu *'Profile'* (c.f. Fig. 4.1) 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. 4.4.

4.1 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. 4.2. 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.

4.2 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.
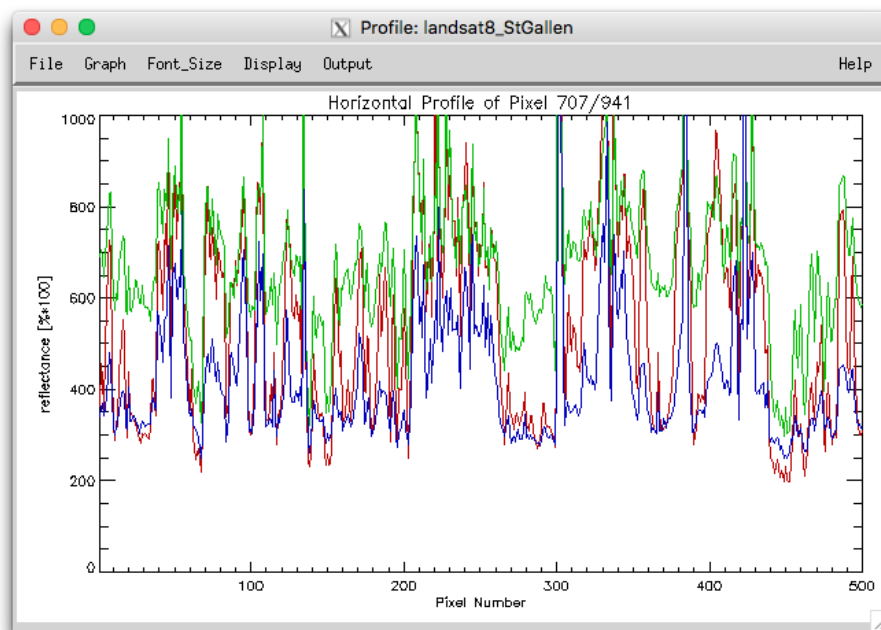
Figure 4.2: *Profile plot window.*

4.3 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.

4.4 Profile window options

Fig.4.2 and 4.3 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.
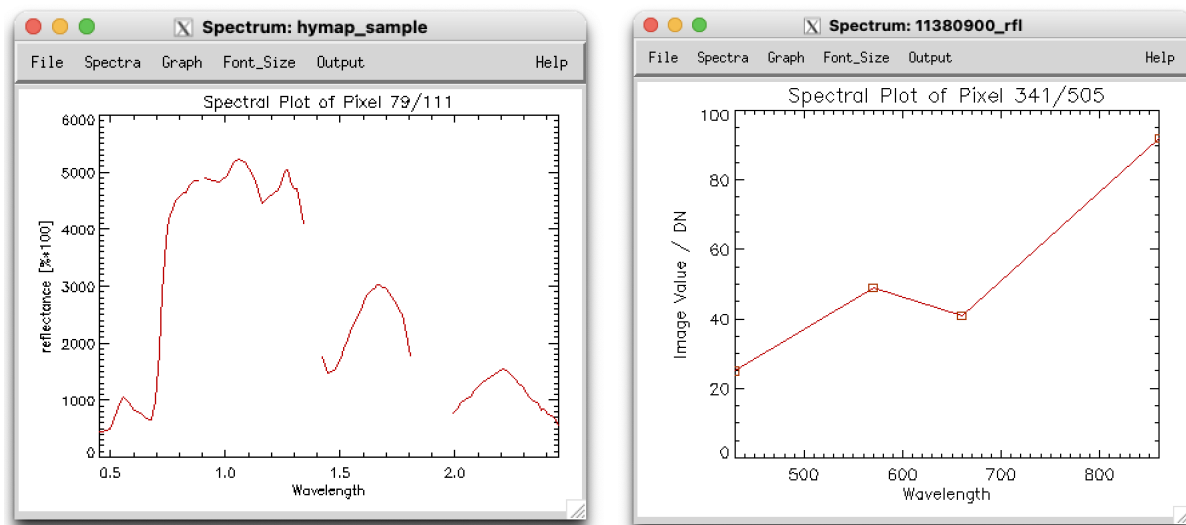
Figure 4.3: *Spectrum plot windows for hyperspectral (left) and multispectral (right) data.*

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)

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.

4.5   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 5

Menu: Calculate
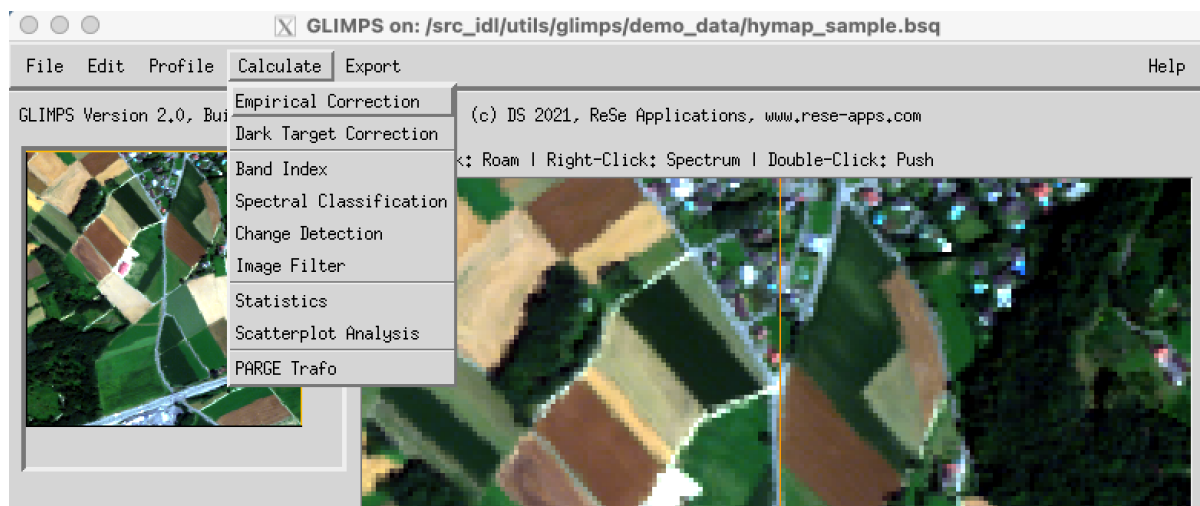
Figure 5.1: Top level graphical interface of GLIMP: "Calculate".

The menu *'Calculate'* (c.f. Fig. 5.1) offers various options for image processing and statistical analysis, such as radiometric correction, the calculation of band indices, or spectral classification.

5.1 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. 5.2 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
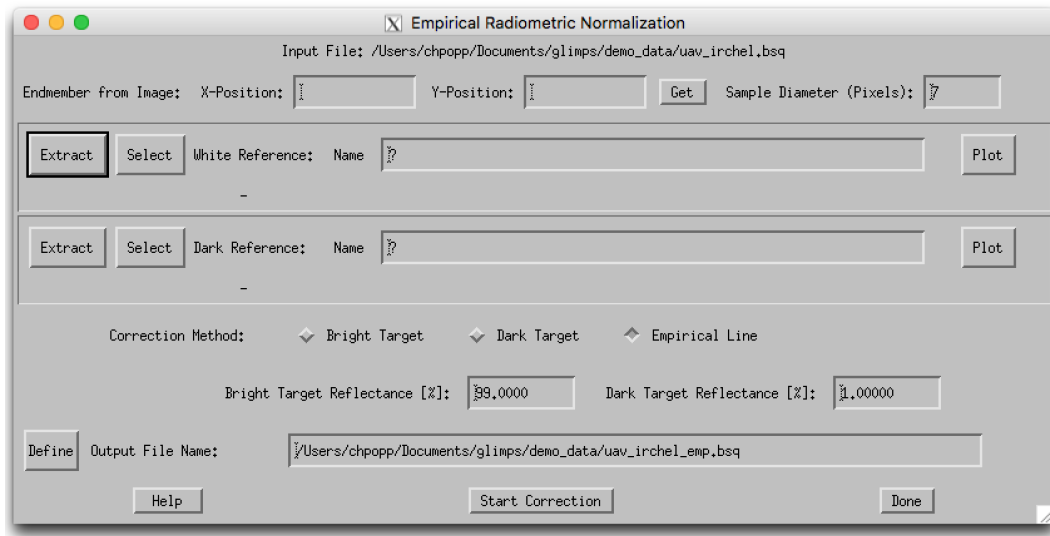
Figure 5.2: *Empirical correction window.*

selected coordinates. *Sample Diameter* is the diameter of a square sample to be taken at the given position.

- 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 (ρ_{bright}), default: 99%.

- Dark Target Reflectance: this is the average reflectance of the dark target reference(ρ_{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.

5.2   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. 5.3. depicts the corresponding interface.
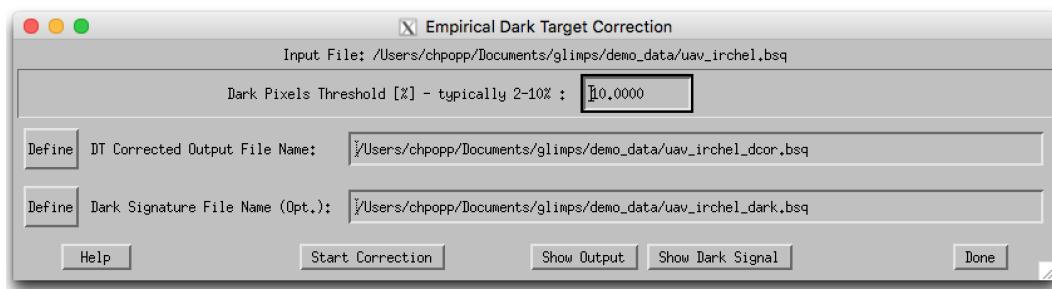
Figure 5.3: *Dark target correction window.*

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.

5.3 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. 5.4. 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 ($NDRE = (NIR - Rededge)/(NIR + Rededge)$ 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.
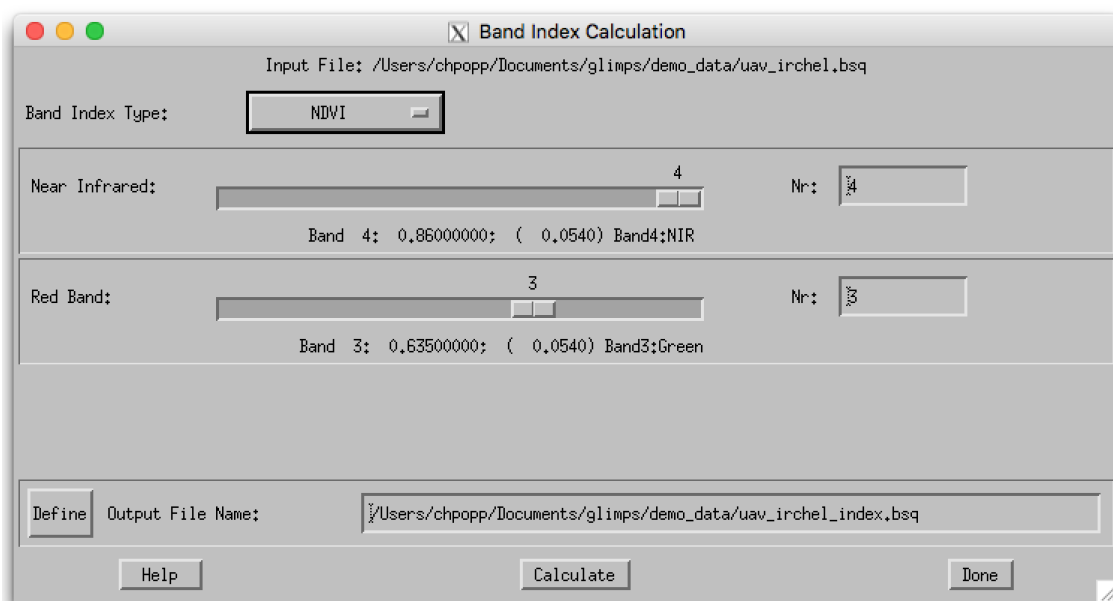
Figure 5.4: *Band index window.*

5.4   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. 5.5. 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:
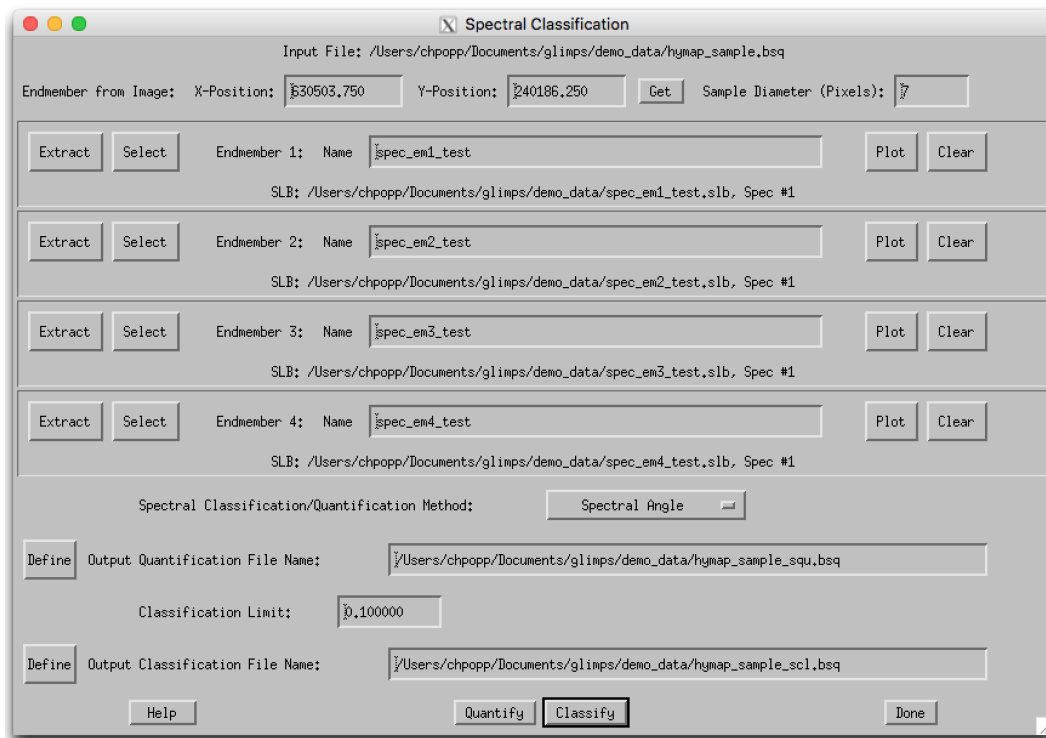
Figure 5.5: *Band index window.*

- *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 endememember 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:

- *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.

5.5 Change Detection

This function searches for differences between two images and displays the corresponding statistics. For now, only single bands are compared. Fig. 5.6. depicts the corresponding interface where the following parameters may/should be provided:
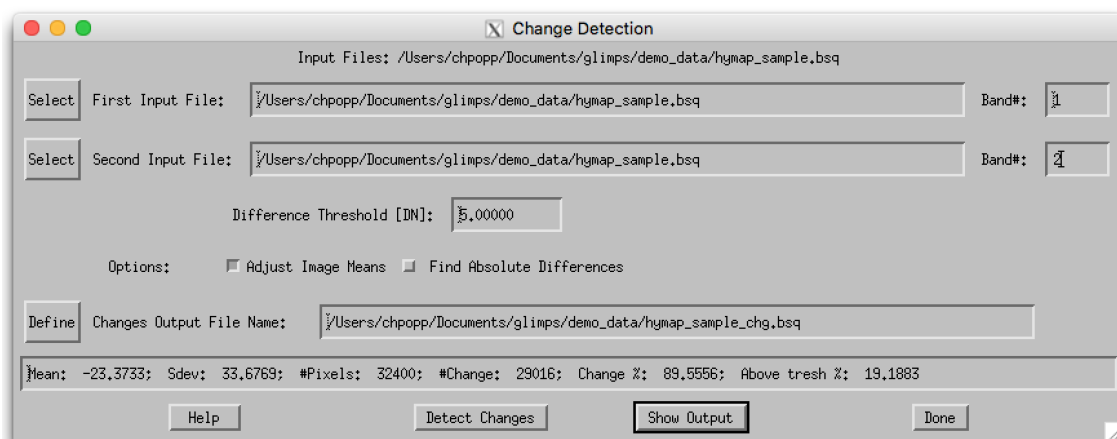
Figure 5.6: *Change detection window.*

- 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.

5.5.1   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.

5.6   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.

5.7   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.

5.8   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
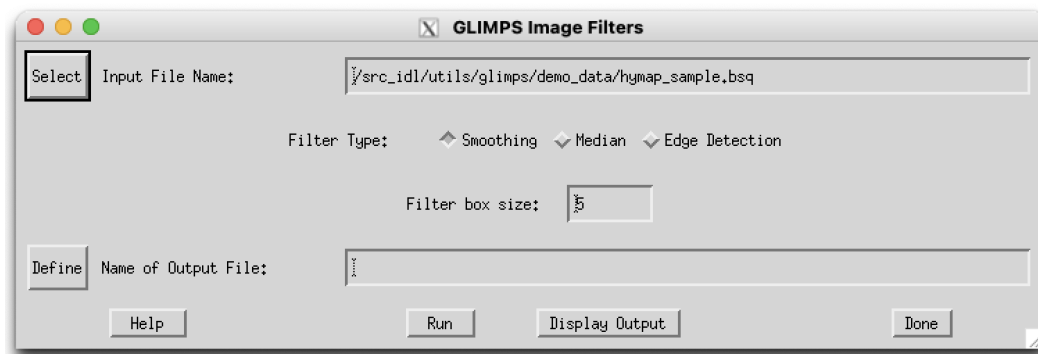
Figure 5.7: *Scatterplot analysis window.*

after applying a polynomial fit based on Chi-Square optimization. Fig. 5.8 depicts the corresponding interface where the following parameters may/should be provided:

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
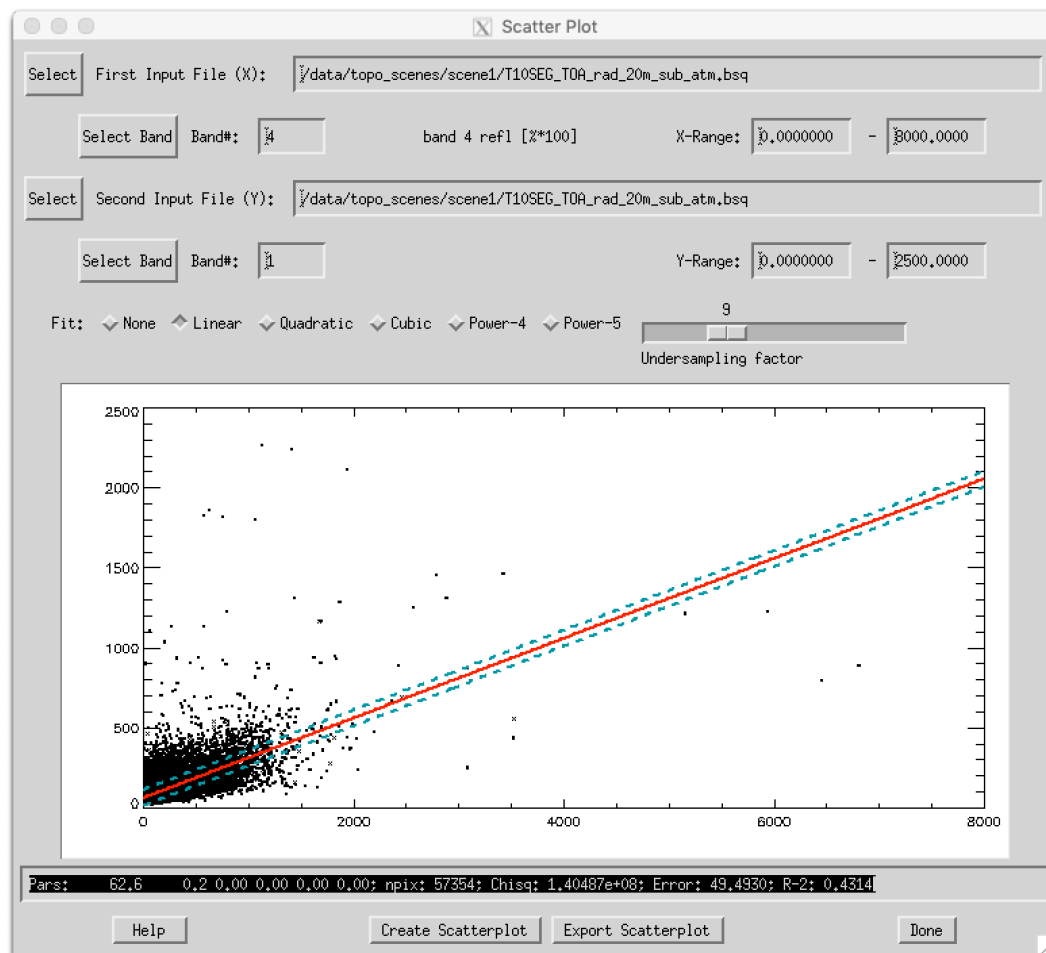
Figure 5.8: *Scatterplot analysis window.*

Create Scatterplot Updates the scatterplot and statistics in the current window

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

5.9 PARGE Trafo

This tool is an interface for image rectification of PARGE outputs. It is useful for data end users who receive their airborne scanner data from providers in unrectified format but with all relevant information from PARGE processing (i.e. the parge processing status .gcs and the image geometry map _igm.bsq). Some of its functions may also be used without having access to PARGE outputs. The end user may produce orthorectified outputs using this data according to their needs. Fig. 5.9 shows its graphical user interface and its individual functions are described below. Much more detailed information can be found in the PARGE manual which comes with the PARGE distribution.

File:Restore Status restores all variables. Use this when starting the process or to switch
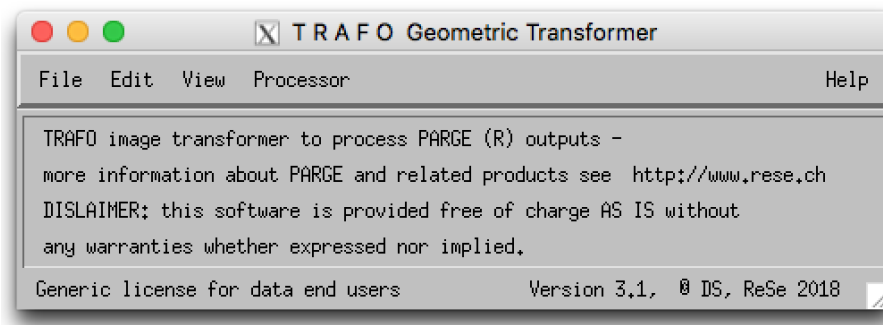
Figure 5.9: *TRAFO geometric transformer window.*

to a different image or to reset custom settings.

File:Show Status displays some information about the current status as loaded with re-store status.

File:Export will export some of the PARGE internal data; either exporting the mapping information to an ENVI GLT file or exporting e.g. navigation, attitude, or internal sensor orientation data to text files.

File:Quit quits TRAFO.

Edit:Convert BIP to BSQ converts an ENVI input data cube from BIP ('Band Interleaved by Pixel') data format to BSQ (Band Sequential).

Edit:Convert BIL to BSQ converts an ENIV input data cube in BIL ('Band Interleaved by Line') data format to BSQ.

Edit:Show Text File a convenient way to browse and edit any ASCII file on the current working directory (e.g to look at an ENVI Header or at some ASCII auxiliary data); same function as in main GLIMPS menu.

View:Plot Image Area an approximate guess of the image extent on the surface is plotted together with the (optional) extent of the DEM.

View:Plot Raw GPS the raw GPS data in geographic coordinates are plotted.

View:Plot Flightpath the flightpath GPS parameters (x,y,z, x/y) in metric coordinates are plotted.

View:Plot Attitude displays the four attitude data parameters in one window.

Processor:Define Process Parameters allows to select the image file (ENVI data cube) to be processed. The dimensions of this file need to be in agreement to the dimensions stored in the PARGE status file. This allows to process (e.g.) a vegetation index in the unrectified image and convert the outputs only to the final geometry.

Processor:Geocoded Band Preview a single channel from the image is geocoded and displayed directly on screen.

Processor:Cube Rectification rectifies the data from acquisition geometry to the geometry as given in the window. A band range can be given to reduce the output file size. Supports optional interpolation of the outputs. More information can be found in the online help menu of this option's interface.

Processor:Rotated Rectification rectifies the data from acquisition geometry to the geometry as given in the panel. A rotation angle helps to avoid unnessesary black (void) data outside of the image extent. This output is readable by ENVI. More information can be found in the online help menu of this option's interface.

Processor:Process Band or RGB geocodes three bands to a RGB image or single band to a grayscale image. TIFF, JPEG and ENVI file formats may be written. The resampling method can be chosen. Supports optional interpolation of the outputs. Additional information can be found in the online help menu of this option's interface.

Help displays the online help and legal information.

Chapter 6

Menu: Export
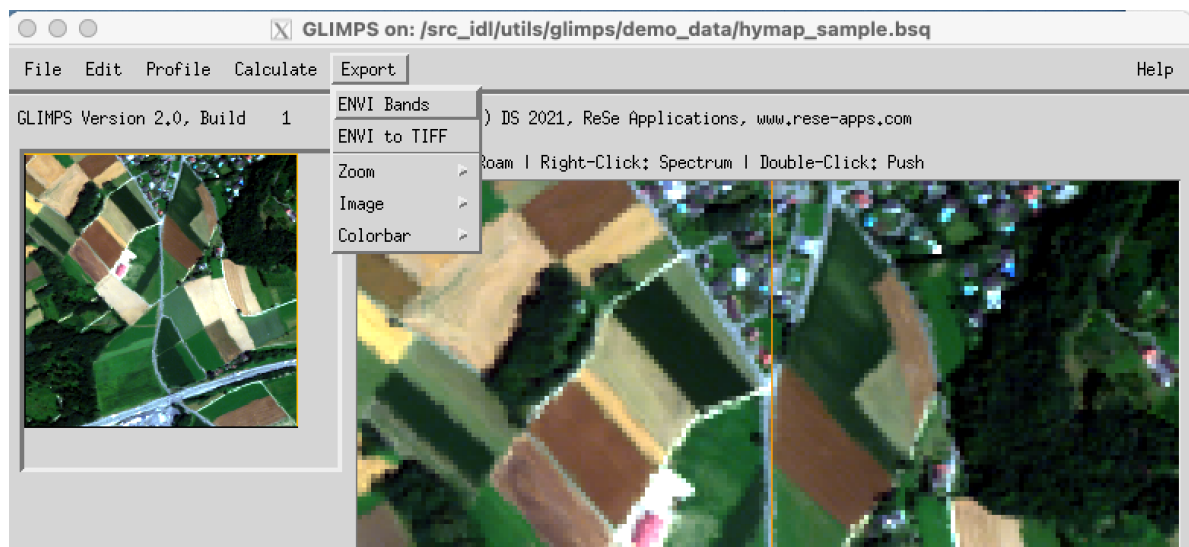
Figure 6.1: *Top level graphical interface of GLIMPS: "Export".*

Export (c.f. Fig. 6.1) 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.

6.1 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.

6.2   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.

6.3   Zoom

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

6.4   Image

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

6.5   Colorbar

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

Chapter 7

Tutorial Exercise

The below exercises shall help to better understand multispectral and hyperspectral remote sensing data on the basis of the GLIMPS software functions. Sample data sets are included or are provided upon request.

7.1   Image Display

Start the GLIMPS software and select a hyperspectral sample data set (e.g. the hymap sample subset). Select an RGB display first and change to CIR or SWIR display. Describe the differences in appearance. Which natural features are more pronounced in the CIR or SWIR display? Which color is assigned to which wavelength by default?

7.2   Spectral Dimension

Use the Z-Profile (Spectrum) function or middle-click in the zoom window to display the full spectrum of the image. Analyze the spectrum and search for object specific features. Write down wavelengths where specific features are visible. Now, display the image using three bands at the given wavelengths and try to analyze what's displayed in the image.

7.3   Spectral Index

Chlorophyll is known to absorb the light in the red spectral range but also at wavelengths below 500 nm (compare Fig. 7.1. Analyze the reflectance spectra of vegetation pixels and write down the maximum visible absorption area (i.e. the wavelength range of lowest reflectances), and compare to the given figure. Try to find an index (i.e., a formula) of two bands which is related to the absorption strenght of chlorophyll. Use the function **Calculate:Band Index** to calculate a simple band ration which should show the parameter. Also calculate the NDVI in the same window and compare the two results. Are there any differences between the results visible?
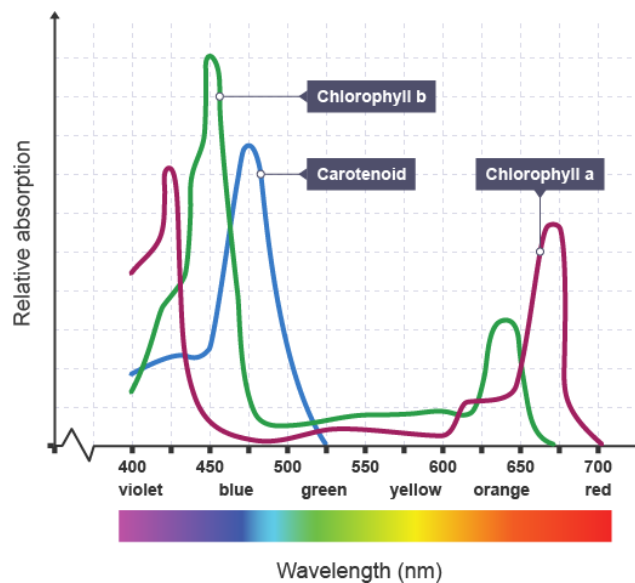
Figure 7.1: *Chlorophyll and Carotenoid absorption. [Source: BBC: Science of food production, www.bbc.com/education/guides/z23ggk7/revision/2]*

7.4 Spectral Mapping and Classification

Search for up to three object types in the image, you'd like to classify in the whole image. Select the image and display its spectrum. Save each of the spectra as a spectral library. Use the function **Calculate: Spectral Classification** and use the 3 spectral libraries as endmembers for a spectral angle mapping. Do a quantification first and select the appropriate threshold after checking the quantification result to derive a classification map.