StackProf **V1.02**

Measurements on stacked profiles

User manual

By Laurent Pourchet (IPGP),

English version by Arthur Delorme (IPGP)

July 7, 2021

This document presents the functions and use of the StackProf application, version 1.02 (June 11, 2021).

This software was developed at Institut de physique du globe de Paris (IPGP), in collaboration with the French National Institute of Geographic and Forest Information (IGN). This project was funded by TOSCA, CNES and IPGP.

Summary

Purpose of the software

The software makes it possible to perform measurements on stacked profiles from displacement maps produced by the MicMac photogrammetry software from IGN (French National Institute of Geographic and Forest Information).

Terms used in this document

- Trace: series of segments connected one behind the other
- Trace file: file that contains one of more traces
- Project: a project corresponds to all the parameters necessary to carry out the measurements on the stacked profiles

Supported platforms

- Linux Ubuntu 18.04 64 bits and higher; GLIBC version 2.27 minimum, libstdc++.so.6.0.25 minimum

- macOS 10.14 and higher (tested on 10.14.6 and 10.15)

Limitations

- Maximum dimensions of input images: 100,000 x 100,000 pixels

- For georeferencing functions, the expected world files must respect the following constraints:
  - x and y dimensions of the pixel (A; x-scale and E; y-scale) must be identical in absolute value
  - Rotation parameters x and y (D; y-skew and B; x-skew) must be zero

- The software calculations consider the pixel of the images to be square

- Profile calculation cannot be interrupted

Expected files and input information

The input files are the output images Px1, Px2, deltaZ and the correlation score map from MicMac. For the correlation score map, the .tif float format is also accepted.
The axes of the components of the vector (Px1, Px2) are oriented in the following way:

- Px1: positive to the right
- Px2: positive downwards
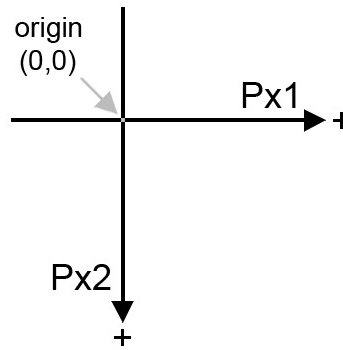
The functions related to georeferencing require:

- For an image used alone as an input file: the presence of its corresponding world file

- For several images used together as input files: the presence of at least one world file corresponding to one of the images

- The EPSG code of the coordinate system or information on it (example of information for EPSG code 32611: "WGS 84 / UTM zone 11N")

- Write access for the software on the directories of the input images

Starting the software

Ubuntu

- For non-4K displays: run the **stackprof.sh** script
- For 4K displays: run the **stackprof4Kscreen.sh** script

macOS

Run the **stackprof.app** application

- The application is not "signed". macOS may display a warning message and refuse to run the application. The "Install an application from an unidentified developer" section of this page: https://support.apple.com/fr-fr/HT202491 should resolve the issue.
- An empty window appears in addition to the others. It can be minimized. Closing it corresponds to a request to quit the application. The name of the open file appears in its title.
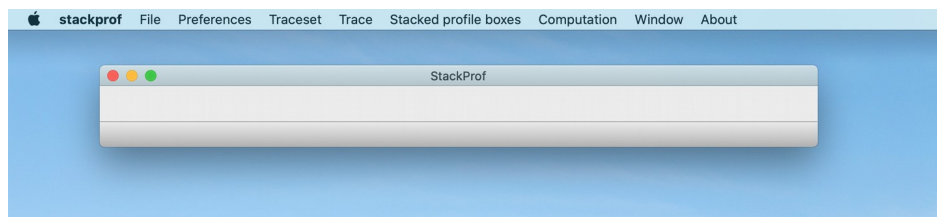
- The application requires that the scroll bars be visible at all times. In macOS "System Preferences", "General" section, for the "Show scroll bars" option, choose: "Automatically based on mouse or trackpad' or "Always"
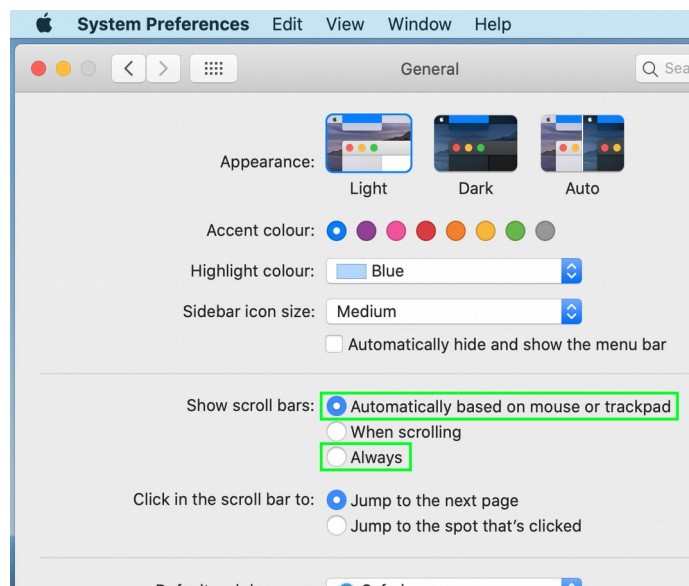
- The application may require accessibility permission to be allowed to adjust the position of the mouse cursor. On macOS 10.15: in macOS "System Preferences", "Security &

Privacy" section, "Privacy" tab: in the "Accessibility" section, check the box for the application in the list.
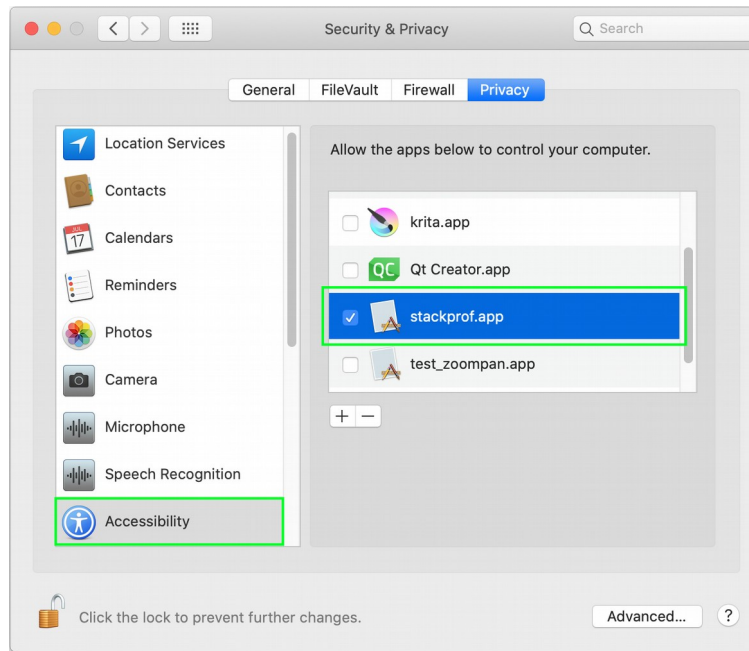
This box may need to be re-checked after a new installation (even if it already appears checked).

Configuration at first launch

To speed up the viewing of the images, the application uses a dedicated directory (called "*cache storage*" in this document) to store, among other things, different zoom levels (image pyramid) for input images.
When launching the software for the first time, it will prompts you to select this directory. This is obligatory.
The user must have read and write rights on this directory.
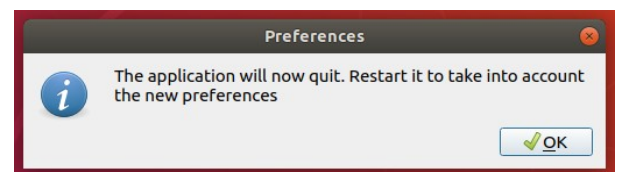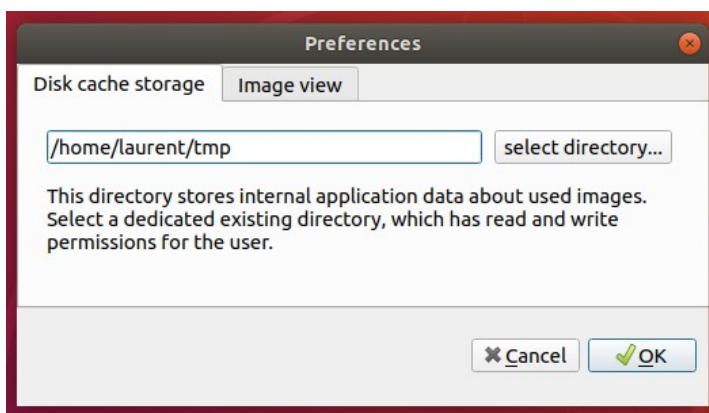
→ Select an empty, dedicated directory, then quit and relaunch the software
⇨ The prompt to select the cache storage should not reappear

The chosen directory is visible and modifiable by going to the main menu:
"Preferences" → "Disk and RAM usage" → "Disk cache storage" tab

Usage

General principle

1. Draw a trace on the fault to be measured, from an image

2. Create a measurement project and import the trace

3. Add boxes of stacked profiles to the project, along the trace. Perform measurements on the profiles.

Trace

- The software allows you to draw and store one or more traces in a single trace file

- The traces are saved in .jtraces files (JSON format)

Project

- Only one trace can be imported per measurement project

- The projects are saved in .jstackprof files (JSON format)

- It is possible to modify the trace from the project and export it in .jtraces format

- It is possible to create a project without importing a trace
  The project is then created with a "default" trace, which contains only two points.

Georeferencing

The software allows you to manage georeferenced or non-georeferenced traces and projects. The use of a georeferenced trace in a non-georeferenced project, or vice versa, is not authorized by the sotfware. However, the formats of the trace and project files are designed to facilitate conversion outside the software. See chapter "Converting georeferenced files to non-georeferenced (and vice versa)".

Georeferencing management

Traces and projects are georeferenced independently. This makes it possible to use, in a project, a trace drawn on an image whose resolution and/or georeferencing are different from those of the project. When importing a trace into a project, a conversion is performed if necessary.

The software requires:

- For the creation of traces:
  - The world file of the image used to draw
  - The EPSG code of the coordinate system corresponding to the image (or information about it)
- For the creation of projects:
  - The world file(s) of the input image(s) (at least one file is strictly necessary)
  - The EPSG code of the coordinate system corresponding to the image(s) (or information about it)

World file names must follow one of the three conventions described here: https://en.wikipedia.org/wiki/World_file ['add a 'w' at the end of the image filename; or concat first extension character, last extension character, and a 'w' at the end of the image filename; or use .wld extension]

Memorization of the EPSG codes of the images used

Beyond the software trace and project files, for each input image file, the software saves the entered EPSG code in a dedicated file. This file is located in the original directory of the image, has a name similar to the input image, and has extension ".jepsg" (JSON format). .jepsg files are used for:

- pre-fill the EPSG code in the software, when the image has already been used in the application before
- carry out additional checks when opening a trace or project file

The right to write to the directory of an input image is therefore necessary.

* If you move an image file used in a project to another directory, it is recommended that you also move its corresponding .jepsg file.

Create traces

Accepted image formats

- .tif float (the value "Nan" ("Not a Number") for the pixels is accepted)
- .tif 16 bits signed integer
- .tif 16 bits unsigned integer
- .tif 8 bits

Maximum dimension of input images: 100,000 x 100,000 pixels.

Procedure

From the main menu: "TraceSet" → "new Set"
⇨ A windows appears allowing you to choose whether the set of traces should use georeferencing
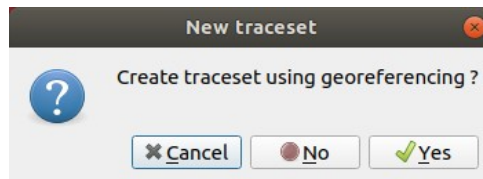
⇨ An image file selection window appears
→ Select an image file that will serve as a reference to draw the traces on

⇨ If georeferencing is used, a window containing the identified georeferencing information appears with three sections:

- The "Image(s)" section recalls the name of the selected image
- The "World file data" section displays the information loaded from the world file corresponding to the image. No modification of this information is possible here.
- The "EPSG Code" section:
  - If the image has already been used in the software:
    - The EPSG code is pre-filled
    - The "set" button is disabled
      → The code can be changed if necessary
      ⇨ The "set" button becomes available when the field contains only numbers
      → Click on "set" to save the EPSG code
      The EPSG code can be changed as many times as necessary in the event of an error.
      → Press OK
    - The EPSG code can be selected from a list, by clicking on "select from list…" (see below)
  - If the image has never been used in the software:

- An orange message indicates that the EPSG code was not found (from a .jepsg file)
- The field is empty
- The "set" button is disabled
  → Enter the EPSG code in the field
  ⇨ The "set" button becomes available when the field contains only numbers
  → Click on "set" to save the EPSG code. At this point, the EPSG code can be changed as many times as necessary in the event of an error.
- The EPSG code can be selected from a list, by clicking on "select from list..." (see below)

Note: when "set" is clicked (and the EPSG code is accepted), the software immediately and silently updates the .jepsg file of the image.

Selecting the EPSG code from a list

It is possible to find the EPSG code of a coordinate system of which only the name is known.
→ Click on "select from list..."
⇨ A window appears
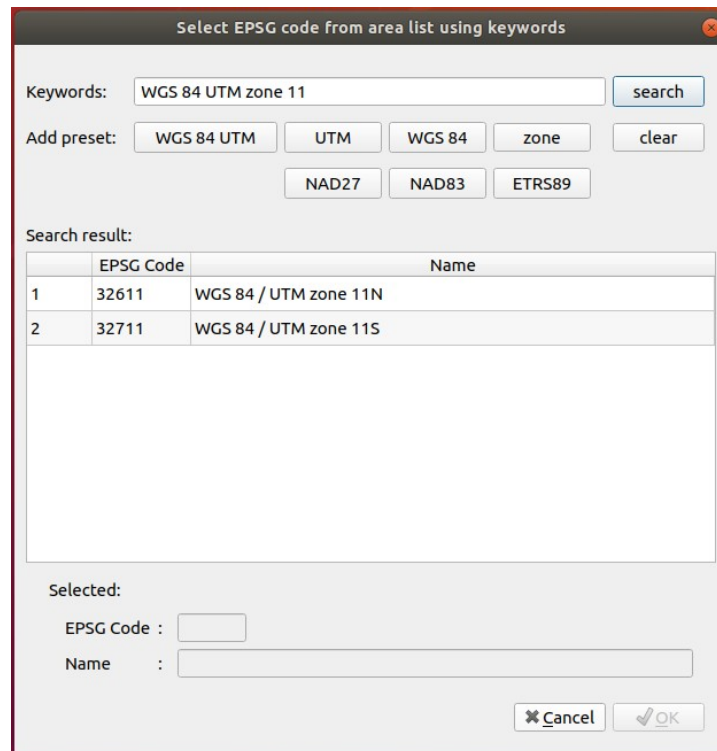
Example of search result with the keywords "WGS 84 UTM zone 11"

The EPSG code search is performed by keywords. The coordinate systems whose denomination contains all the keywords are displayed in the list of results. The keywords must be entered in the "Keywords" field. Some often used keywords have dedicated buttons to simplify input (see the "Add preset" section)

→ Once the keywords have been entered, click on "search"
⇨ The results appear in the list
→ Adjust the search if needed
→ Select the desired coordinate system from the list and validate with "OK"
⇨ The corresponding EPSG code is assigned to the section "EPSG Code"
⇨ The "OK" button in the window becomes available when an EPSG code has been entered and is has been correctly saved (in the .jepsg file corresponding to the image). If the EPSG code is changed again, the "OK" button is disabled and requires the "Set" button to be pressed.
→ Press OK
⇨ The window disappears

⇨ If the image has never been used in the software, its image pyramid is created and stored in the cache storage for future uses. The creation of the image pyramid can take from several seconds to several minutes, depending on the size of the image. A window with a progress bar is displayed during the operation.
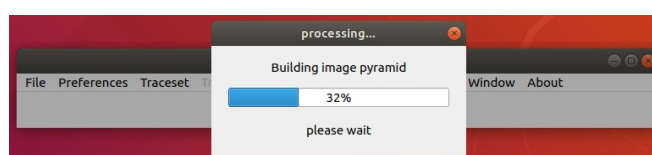
⇨ Three new windows appear:
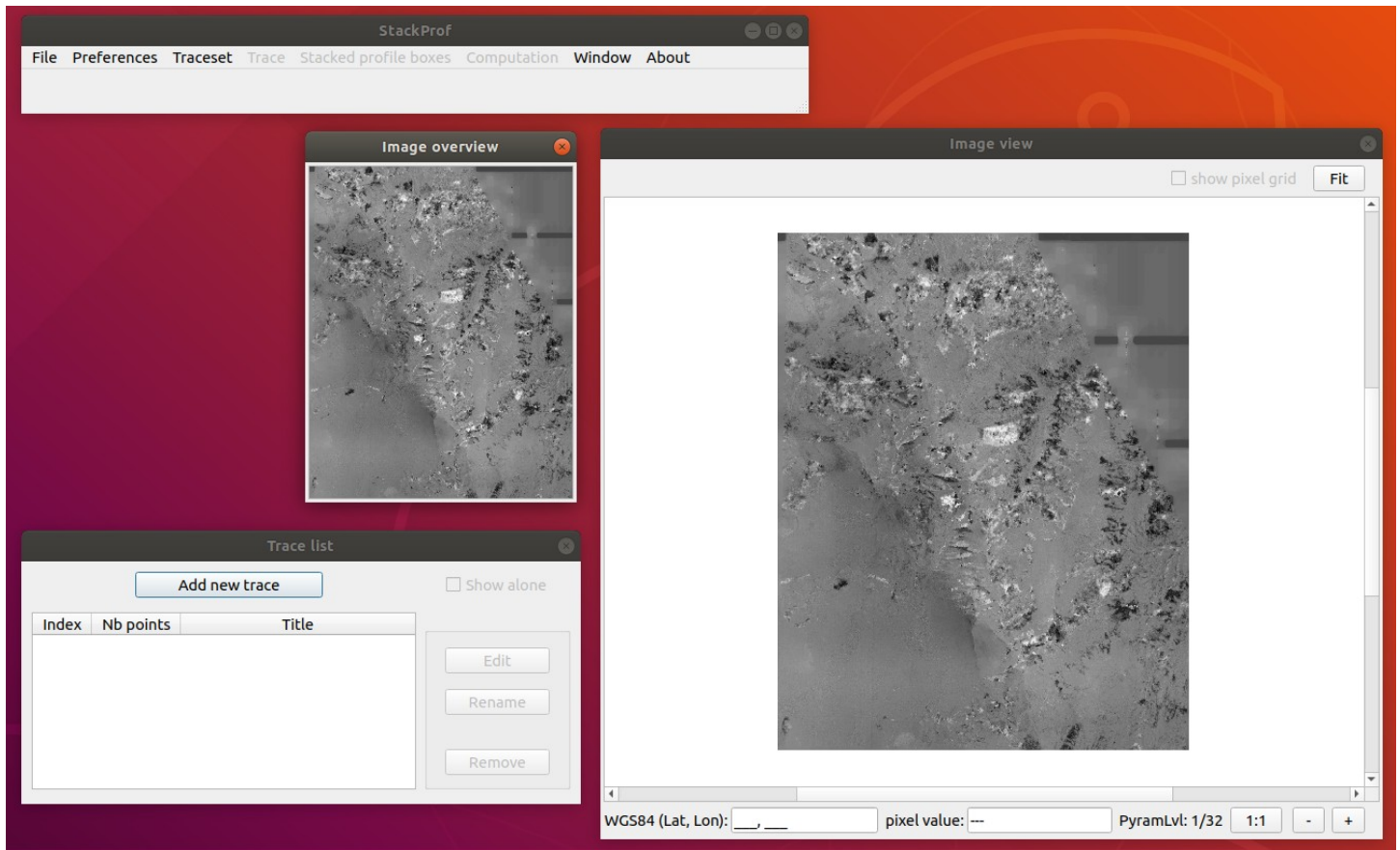
- A window called "Image view"
- A window called "Image overview"
- A window called "Trace list"

The "Image view" window

For the creation of traces, this window allows the graphic editing of the traces.

Features

- Displays the selected reference image
- Displays, at the bottom of the window:
  - If the trace uses georeferencing: the WGS 84 position of the mouse
  - If the trace does not use georeferencing: the position of the mouse in pixels in the image
  - The pixel value at the mouse position
    The pixel value comes from the input image only if the current zoom is greater than or equal to 1. Otherwise, the pixel value comes from the image pyramid and therefore comes from one or more successive bilinear interpolations.
  - The current pyramid image level (called "PyramLvl" for "Pyramid Level")
    A value of PyramLvl of 1/1 indicates that the displayed image uses the original image.
    A value of PyramLvl other than 1/1 (i.e. 1/2, 1/4, etc.) indicates that the displayed image used an image from the image pyramid.
- The window is resizable
- Zoom/de-zoom and movements in the image are possible
- The center of the image can be repositionned using the mouse
- The image can be adjusted to the dimensions of the window, so that it is fully visible within it
- Automatic equalization of the histogram of the image part visible in the window
- A grid outlining the pixels can be displayed (displays only when the pixels are of sufficient size)

If this window is closed, it can be reopened via the main menu: "Window" → "Image view". If the window is only located below another window, performing this action brings the window to the foreground.

Usage

- To resize the window:
  Drag edges or corners with the mouse
- To zoom/de-zoom:
  - Move the mouse wheel or touchpad forward/backward. Or use the "+" and "-" buttons or keyboard shortcuts: "j" to zoom; "h" to zoom out.
  - The zoom/de-zoom works by focusing on the center of the window
- To move around the image:

- Use scroll bars on the edges of the image

- Use the keyboard direction keys with:
  - Under Ubuntu: right click and hold + mouse movement
  - Under macOS: Ctrl + click and hold + mouse mouvement
  - ⇨ The portions of the image required for display are loaded upon release

- To reposition the center of the image:
  Position the mouse cursor on the point of the image which must become the center of the view and:

  - Under Ubuntu: double left click

  - Under macOS: double click
    (If the view is not repositioned on the chosen point, check the accessibility permission of the software: see chapter "Starting the software")

- To adjust the zoom level to 1:1: click on "1:1" or keyboard shortcut: space bar

- To adjust the image current to the current window: click on "Fit" or keyboard shortcut: "f"

- To display or hide the grid which outlines the pixels: check/uncheck the "show pixel grid' box or keyboard shortcut: "g"
  The grid is only displayed when the pixels are of sufficient size.
  The checkbox is only available when the grid is viewable.

The "Image overview" window

Displays the entire image in a reduced, fixed size version.
This window is used to find your way around the image, the Image view only displaying a portion of the image.
The rectangle indicates what is currently displayed in the Image view.
The rectangle does not appear if:

- The Image view displays the whole image

- The Image view is completely outside the image

This window transmits the following commands to the Image view, with the same mouse and keyboard actions as the Image view:

- Zoom/de-zoom

- Adjust the zoom level to 1:1

- Reposition the center of the image

- Adjust the image to the current window

If this window is closed, it can be reopened via the main menu: "Window" → "overview". If the window is only located below another window, performing this action brings the window to the foreground.

The "Trace list" window

- Displays the list of traces

- Allows to add or delete traces

- Allows to switch a trace to "edit" or "locked' mode

- If the list contains several traces, the selected trace can be displayed alone (use the "show alone" checkbox)

If this window is closed, it can be reopened via the main menu: "Window"→"Trace list".
If the window is only located below another window, performing this action brings the window to the foreground.

Trace edition
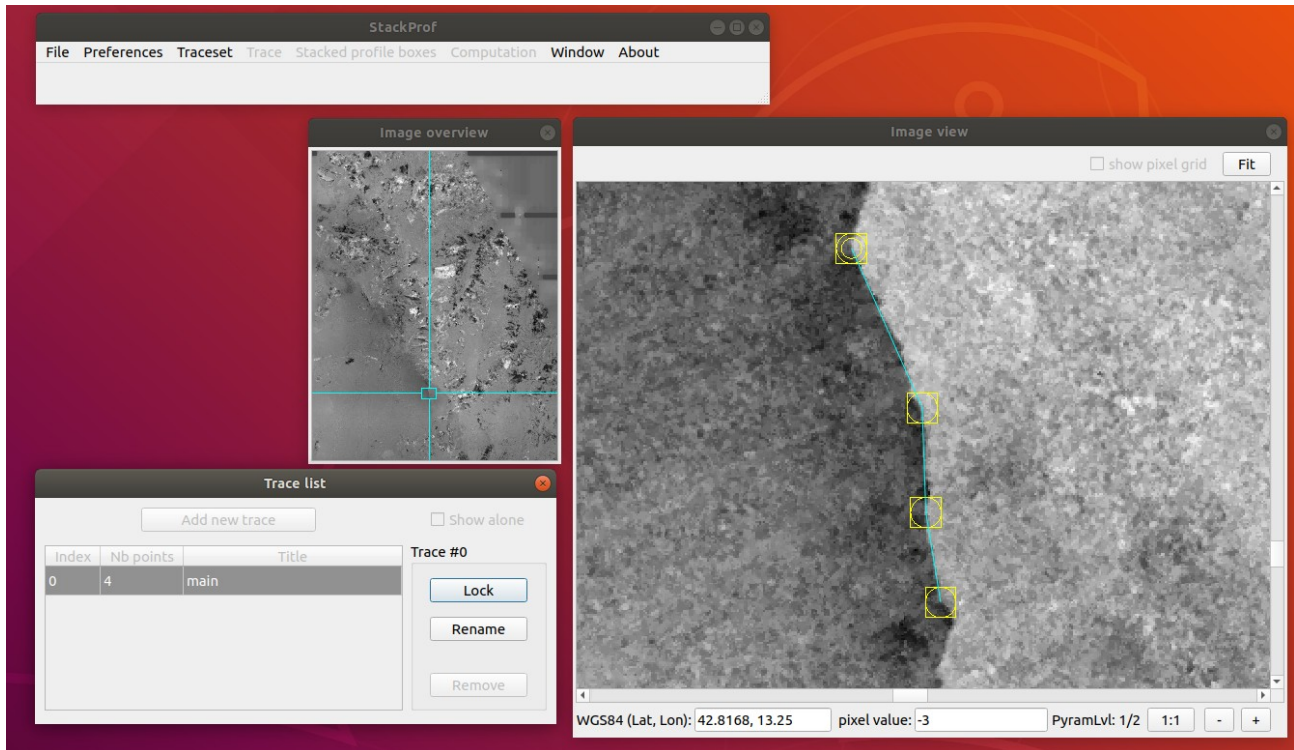
Add a new trace

→ Click on "Add new trace" and enter a name
If no name is entered, the name is initialized to "no name". The following ASCII characters are accepted:
a-z, A-Z, 0-9, _, space and point

The name makes it easier to find your way around than a trace number, for example (both for editing several traces and for the future import of a track into a project).

A trace that has just been added does not contain any points. To add points to a trace, you must switch this trace to "edit" mode.

Edit a trace

The trace edit mode allows for the trace being edited: adding, inserting, modifying position and deleting points.

→ Select the trace to edit in the list of traces and click on "Edit" on the right
⇨ The list of traces is desactivated

In the Image view, the trace points are displayed with a yellow circle in a yellow square. The first point of the trace is displayed with a yellow square and two yellow circles.
The size of these graphic elements depends on the proximity between the points entered. It updates according to the additions and deletions of points (but not when modifying the position of a point, in this version of the software).

→ Click in the Image view to give it the focus

- Actions:
    - Add a point at the end of the trace:
    Shift + left click at the desired position

    - Delete a point:
    Position the mouse in the yellow square of the point
    ⇨ The square turns red
    → Press "d' (like "delete")

    - Insert a point between two points:
    → Position the mouse near the segment between the two points
    → Press "i" (like "insert")
    ⇨ A point is inserted

    - Modify the position of a point:
    → Position the mouse in the yellow square of a point
    ⇨ The square turns red
    → Left click and hold + move the mouse to move the point

  Notes:
    - Controls affecting zooming and moving in the image are still possible

    - The distance between two successive points cannot be less than 1.0 image pixel. If the case arises, the action is silently refused.

    - Press the "r" key changes the colors of the traces to dark blue and the points to pink. This alternate set of colors can be useful when the image is very bright. Pressing the "r" again returns to the original colors.

Add or edit another trace in the same set of traces

Lock the current trace by clicking on "Lock" and proceed to add or edit of the other trace.

Modify the EPSG code of the set of traces

From the main menu: "TraceSet" → "set EPSG Code" (or "Window" → "Georeferencing Info")
⇨ The window containing the georeferencing information appears.
The OK button of the window is available when the EPSG code has not been modified or when it has been modified and accepted by the software.

Save a trace file

Once the trace(s) has been entered, to save the whole in a trace file:
From the main menu: "TraceSet" → "Save Set" (or "Save Set As...") and enter a file name
The ".jtraces" extension is added automatically.

The save is refused if traces contain less than two points. In this case, a message indicates it and the user must delete or edit the traces concerned.

Open a trace file

From the main menu: "TraceSet" → "Open "
If the image used as a reference is not found at the location indicated by the trace file, the software proposes to select an image with similar characteristics (dimensions and georeferencing in particular, if applicable) to replace it. This is typically the case if the image has been moved to another directory or if the trace file has been edited on another computer.

* If you move an image file to another directory and if the trace uses georeferencing, it is recommended that you also move its corresponding .jepsg file.

Create a measurement project

Constraints on input files

The software only accepts images aligned with each other, namely:

- Identical pixel width for Px1, Px2 images; and deltaZ if applicable
- Identical pixel height for Px1, Px2 images; and deltaZ if applicable
- The data format of Px1 and Px2 images must be the same
- The width and height in pixels of the correlation score map must be the same as Px1 and Px2 images

Additional constraints for georeferenced projects

- Identical content of the world files
- Identical EPSG codes

As indicated earlier in this document, creating a project requires at least one world file corresponding to one of the input images. If more than one input image has a world file, the software checks that they are the same.

Accepted formats

- For Px1, Px2 and deltaZ images:
    - .tif float
    - .tif 16 bits signed integer
- For the correlation score map:
    - .tif byte
    - .tif float
- Maximum dimension of the input images: 100,000 x 100,000 pixels

For files containing floats, the "Nan" value (for "Not a Number") is accepted. The calculations take this into account by considering "Nan" as "missing value for the pixel". This can produce fragmented profiles. The user can therefore preprocess the data by filtering values and replacing them with "NaN".

Procedure

→ From the main menu: "File" → "new Project"
⇨ A window appears with several sections to fill in the input files and the trace to be used:

- The first section relates to horizontal displacement maps:
  - Choice of Px1 and Px2 files
  - Choice of correlation score map file (optional)
- The second section relates to single component map:
  - File choice (for deltaZ typically)
  - Choice of correlation score map file (optional)
- A checkbox that allows to choose whether the project should use georeferencing
- A last section to choose the trace to be used in the project.
  Two possibilities:
  - Import a trace from a trace file
  - Add a default trace containing only two points

To import a trace from a trace file:
→ Uncheck the "Add a default trace" box
→ Click on "select file..." and select the .jtraces file containing the trace to import
⇨ The "select trace" button becomes available

→ Click on "select trace" to select a trace file

⇨ A window appears with the list of traces of the file

→ Click on the trace to import in the list and click on OK
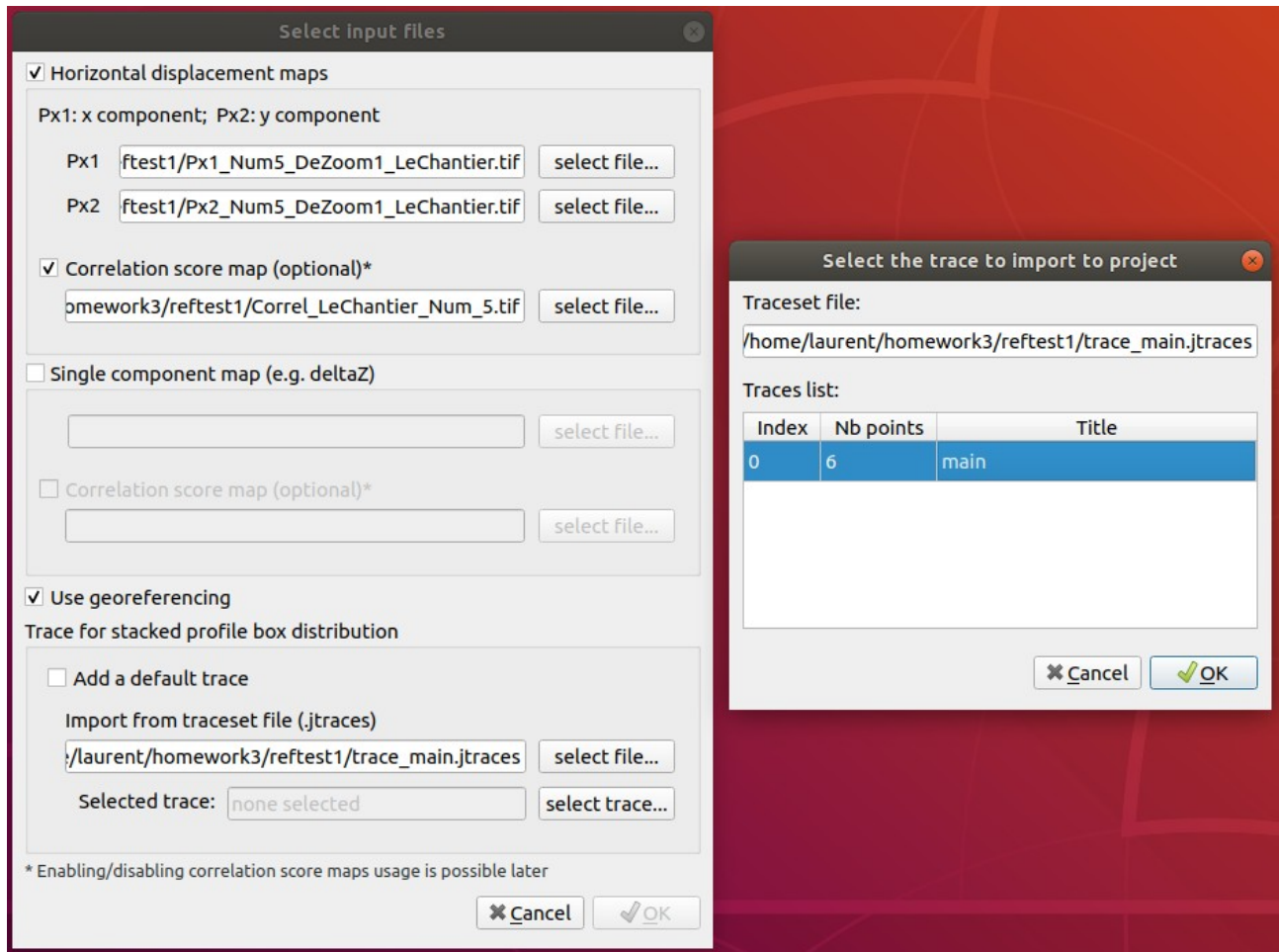
To add a default trace:

→ Check the "Add a default trace" box

Notes:

- The use of correlation score map files shown in this window can be disabled later. It is not possible to add correlation score map files to the project later (at least through the graphical user interface).

- To avoid entry errors, the OK button in this window becomes available only when all entries are correctly completed. An entry is correctly completed if:

  - Its checkbox is **checked and its field filled**

    or

  - Its checkbox is **unchecked**

- The use of a georeferenced trace in a non-georeferenced project, or vice versa, is not authorized by the software. The software will refuse to import the selected trace if the case arises.

→ Click on OK

⇨ If the project uses georeferencing:

- If an EPSG code corresponding to the input images is identified in the .jepsg file, it is used

- The georeferencing information window appears to confirm or modify the EPSG code. Once the EPSG code has been entered and validated, the software proposes to assign this EPSG code to the different input images for future use (refusing this proposal has no impact on the editing of the project)

⇨ The software performs checks on the consistency of the input files. Any detected inconsistency is reported.
⇨ The selected trace is imported in the project by performing a coordinate system conversion, if necessary. If the converted trace would not appear in the geographic area, because it is located elsewhere in the planet, the software indicates it and refuses its import.
⇨ A window appears to enter the conversion factors for the pixel values:
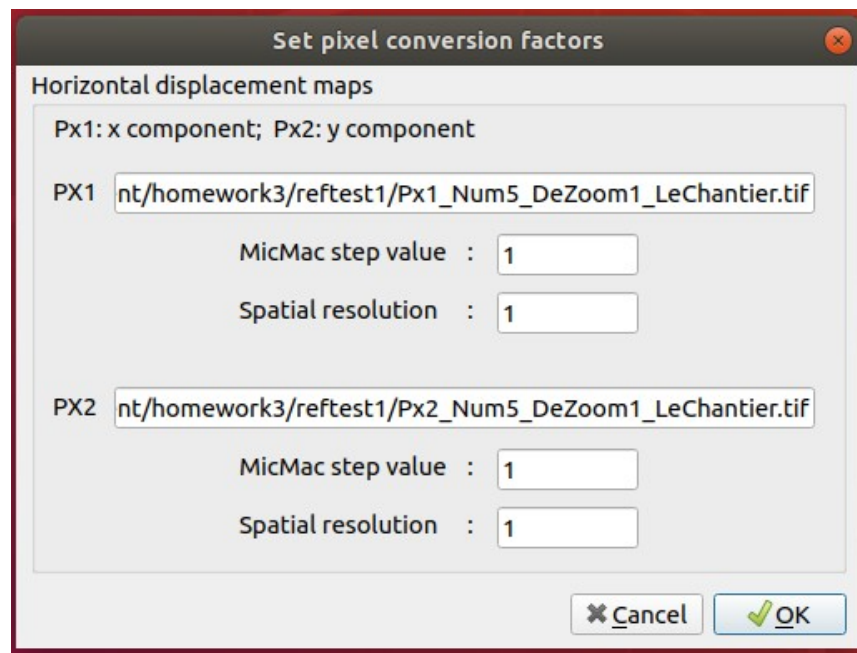
Example window, after selecting Px1 and Px2 as input files, without deltaZ

For a given input image, the pixel values will be multiplicated by the MicMac step value and the Spatial resolution. This multiplication is also applied for the display of the pixel value at the bottom of the Image view window.

Note: in the MicMac MM2DPosSism command, the default step value is usually 0.05 px at the last iteration. Check the MEC/param_LeChantier_Compl.xml file.

⇨ The software offers to choose which input image to load in the Image view
Viewing the other input images is possible later.
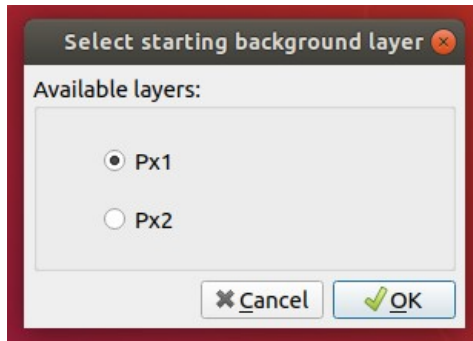
⇨ As for the creation of traces, the software builds the image pyramid in the cache storage if this image has never been used previously

⇨ Two new windows appear:

- A window called "Image view" with the image and the imported trace visible
- A window called "Image overview"

These two windows have the same functions as those described in the "Create traces" chapter.

Edit the trace from the project

This action is possible but will delete all the existing profile boxes and corresponding measurements. If necessary, as a precautionary measure, the software asks for a double confirmation before entering in the edition of the trace.
The trace editing functions are the same as for a trace file (but only one trace is editable: the project trace). To be able to add stacked profile boxes again, quit editing the trace.

- To enter trace editing: From the main menu: "Trace" → "Edit"

- To exit trace editing: From the main menu: "Trace" → "Lock"

Rename the project trace

From the main menu: "Trace" → "Rename"

Export the project trace

From the main menu: "Trace" → "Export"
Enter the name of the file that will contain the trace. The ".jtraces" extension is added automatically.

Check the project georeferencing information

From the main menu: "Window" → "Georeferencing info"

Check the input files used in the project

From the main menu: "Window" → "Project input files"

Display of input images in Image view

If the project has several input images, the "Image view" window allows you to switch between the different images. This is the role of the tabs located at the top left of the window.
If the image corresponding to the selected tab has never been used in the software, the software builds its image pyramid in the cache storage at the time of the swap request.
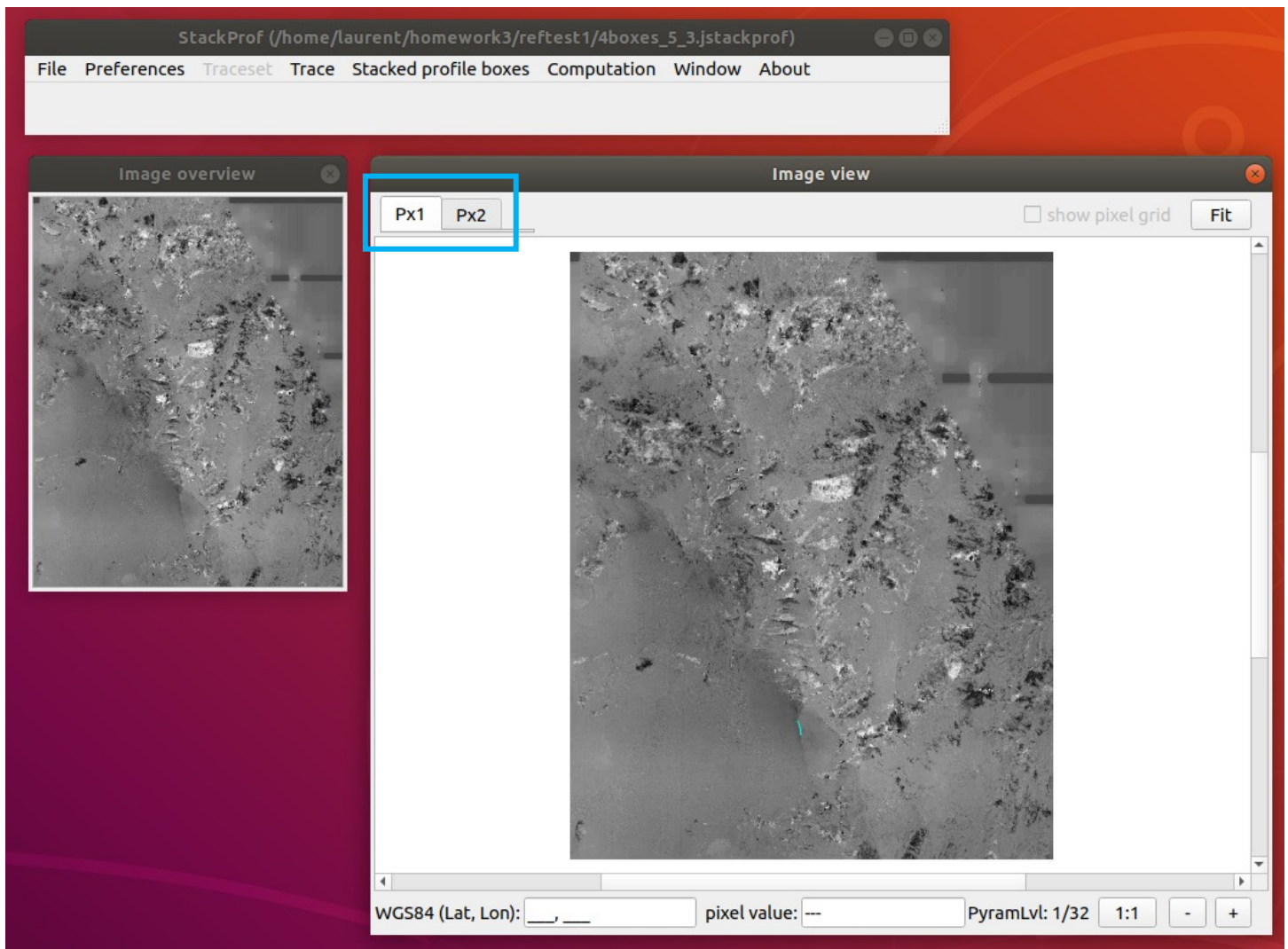
Location of tabs to switch between images in Image view

Add profile boxes

To add profile boxes, three methods are available:

- Adding boxes one by one by choosing the position of the center of the box on the trace
- Automatic distribution of boxes as close as possible to each other
- Automatic distribution of boxes by choosing the distance between the centers of the boxes
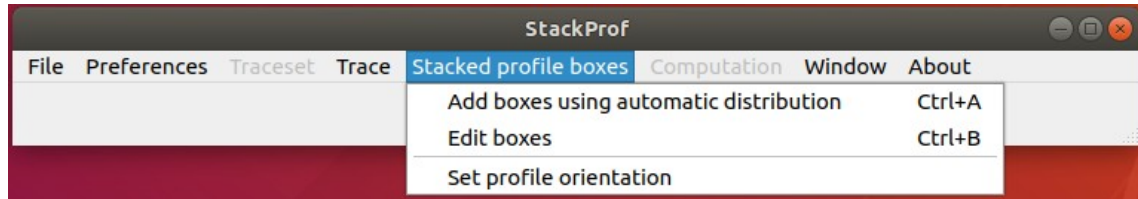
Edit existing boxes

Any added box can be edited to modify:

- Its length (dimension perpendicular to the trace)
- Its width (dimension parallel to the trace)
- Its position along the trace

The list of profile boxes appears in a dedicated window called "Box edition". To display this window, from the main menu: "Stacked profile boxes" → "Edit boxes"

The list shows the boxes numbered and sorted along the trace from the first to the last point of the trace.

When a box is selected from the list:

- In the Image view, the box appears in red
- In the right part of the "Box edition" window:
  - Its length and width appear
    To change its length and/or width:
    → Adjust the values in the input boxes
    → Press "Set"
  - Its position along the trace can be adjusted by moving its current center in steps of -20, -5, -1, +1, +5 and +20 pixels
  - The box can be deleted by clicking on "remove"

It is also possible to select a box from the Image view:
→Select the Image view to give it the focus
→Hover the box with the mouse
⇨The edge of the box is colored yellow
→Press "s" (like "select")
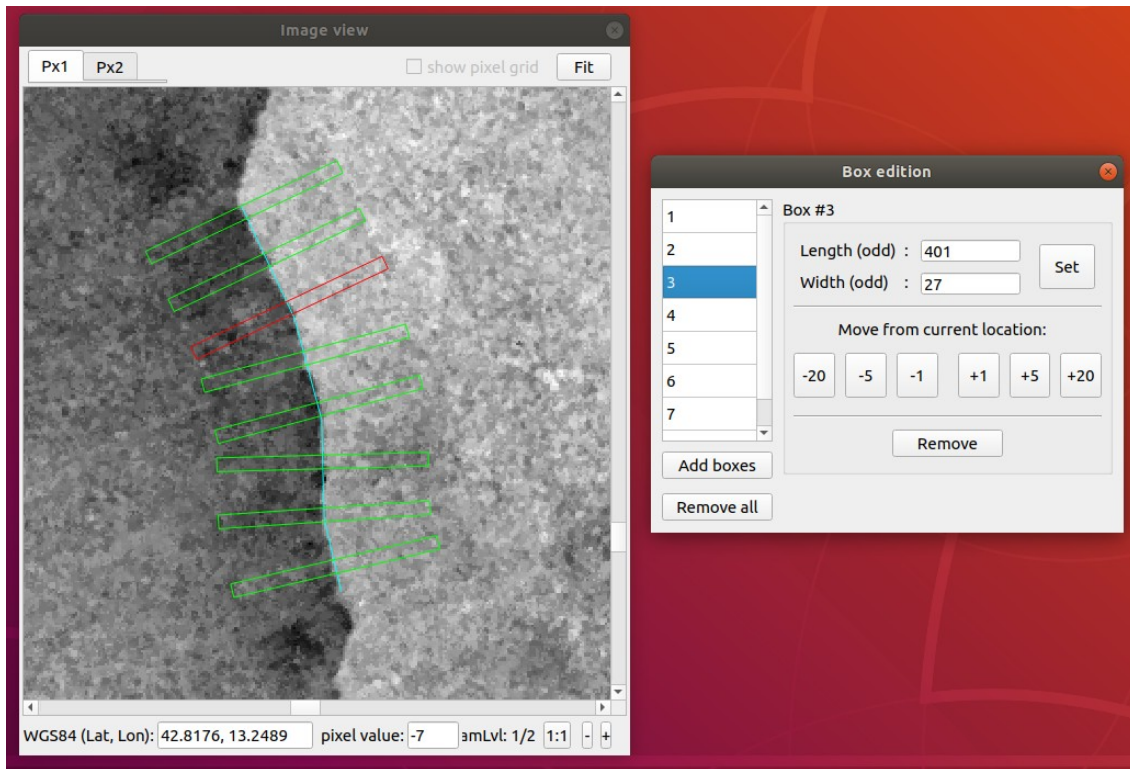
Add boxes one by one
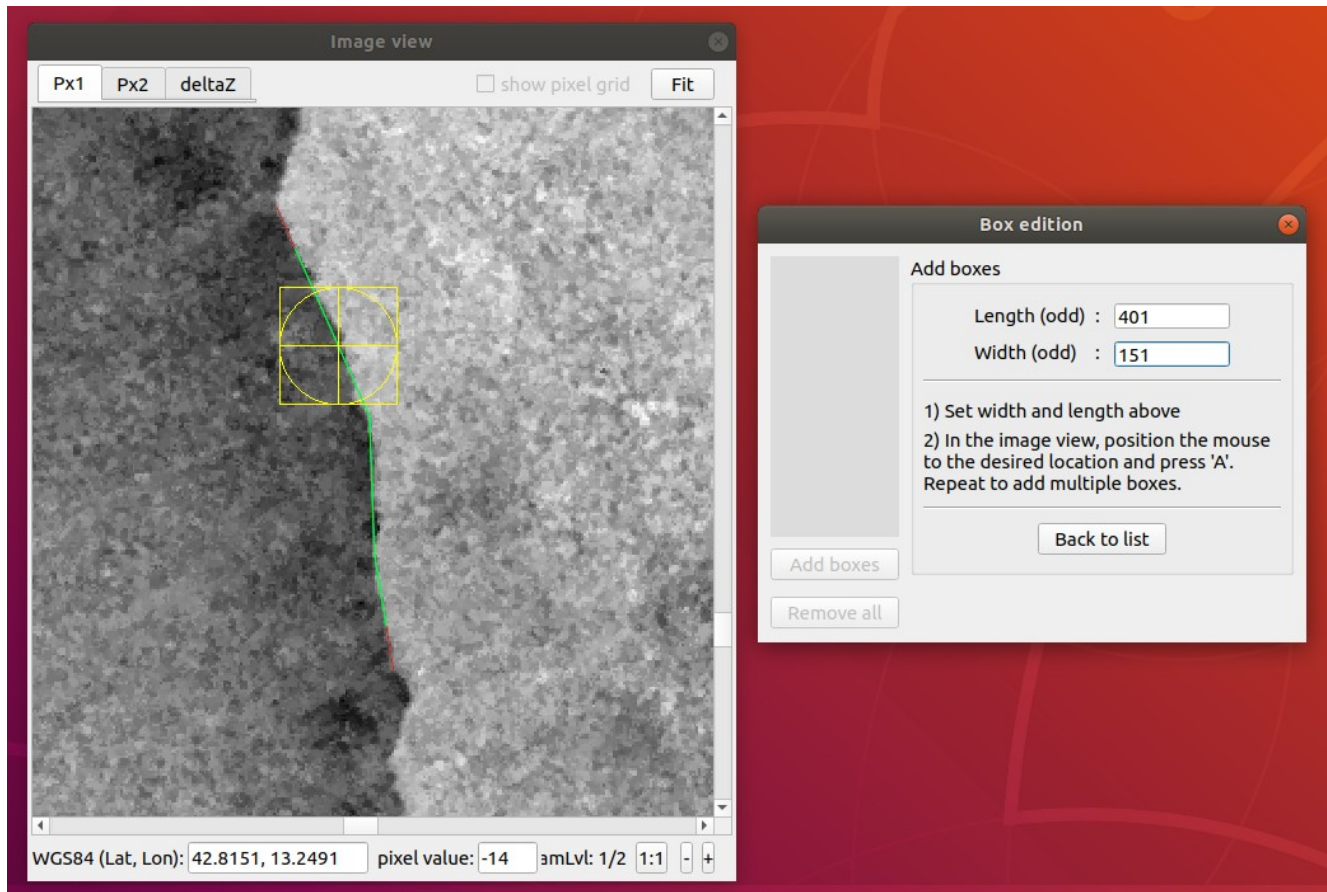
Adding a box is carried out in two steps:

- Step 1: in the "Box edition" window
    → Click on "Add boxes" below the list of boxes
    → Indicate the desired length and width for the box to be added
    ⇨ If the parameters allow the addition of a box:
    - The trace is colored green and red in the Image view (green section: possible locations; red sections: impossible locations)
    - a yellow target locked on the trace follows the mouse cursor
- Step 2: in the Image view:
    - Select the Image view to give it the focus
    - Position the mouse at the desired location for the center of the box (the functions affecting the zoom and movement in the image are still available)
    - Press "a" (like "add')

⇨ The box is added

Each press of the "a" key adds a new box.
The length and/or width values can be changed. These new values will apply to the next added boxes.

Automatic distribution of boxes

From the main menu: "Stacked profile boxes" → "Add boxes using automatic distribution" and choose one of the two methods.
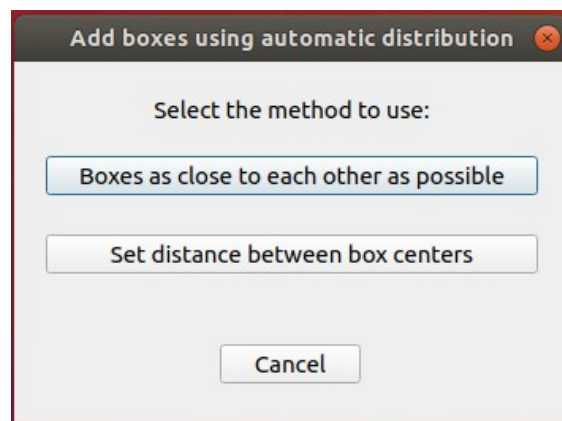
Distribution as close as possible to each other
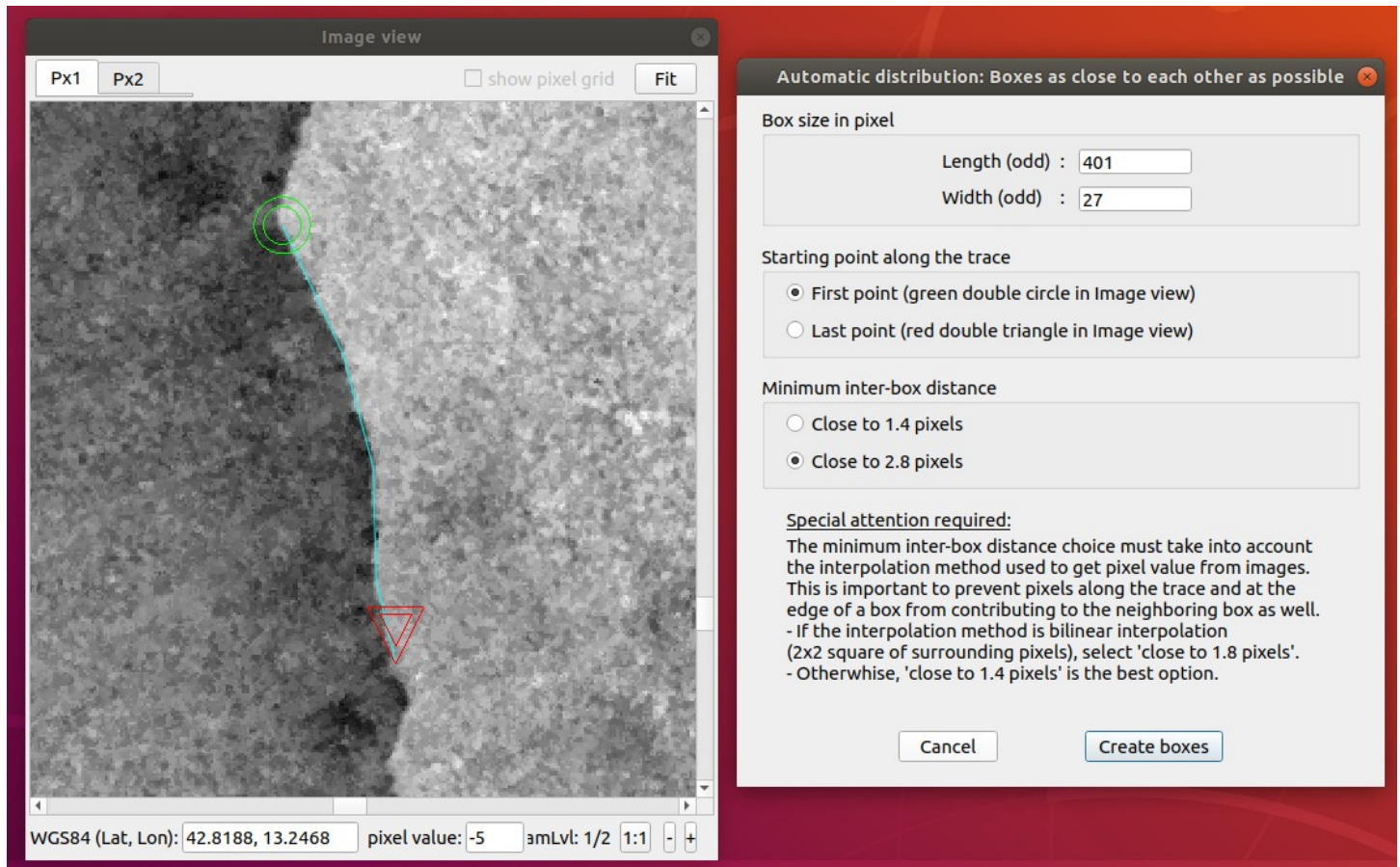
The window allows you to choose:

- The length of the boxes

- The width of the boxes

- The end of the trace at which to start the distribution of boxes
  The "Image view" window displays marks at the ends of the trace to help this choice
  (double green circle: first point of the trace; double red triangle: last point of the trace)

- The minimum distance between two successive boxes
  This is the distance between the edges of neighboring boxes, closest to the trace. The
  principle is to prevent a pixel closest to the trace from contributing to two successive
  boxes. The choice depends mainly on the pixel extraction method that will be used to
  calculate the profiles:
  - If the extraction will be "nearest pixel": choose "Close to 1.4 pixels" (the distance
    between the edges of the boxes will be slightly greater than $\sqrt{2}$)
  - If the extraction will be "bilinear interpolation (2x2 square of surrounding pixels)":
    choose "Close to 2.8 pixels" (the distance between the edges of the boxes will be
    slightly greater than $\sqrt{8}$)

See the "Implementation of bilinear interpolation" chapter for more details on the "bilinear interpolation (2x2 square of surrounding pixels)" extraction method.
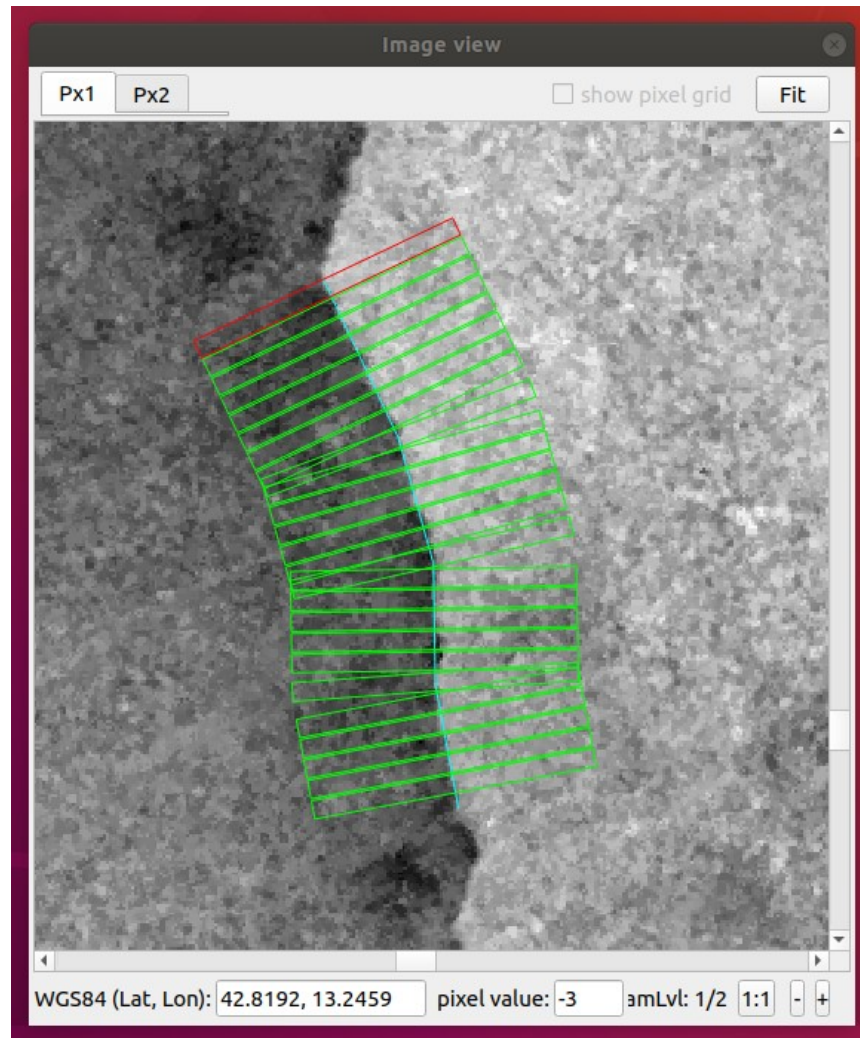
Example of nearest distribution result

The length and width must be odd values. An even entered value appears in red and prevents validation of the window.

→ Click on "create boxes" to start the distribution
The distributed boxes appear on the trace in the Image view and are added to the list in the "Box edition" window.

Distribution by choosing the distance between the centers of the boxes
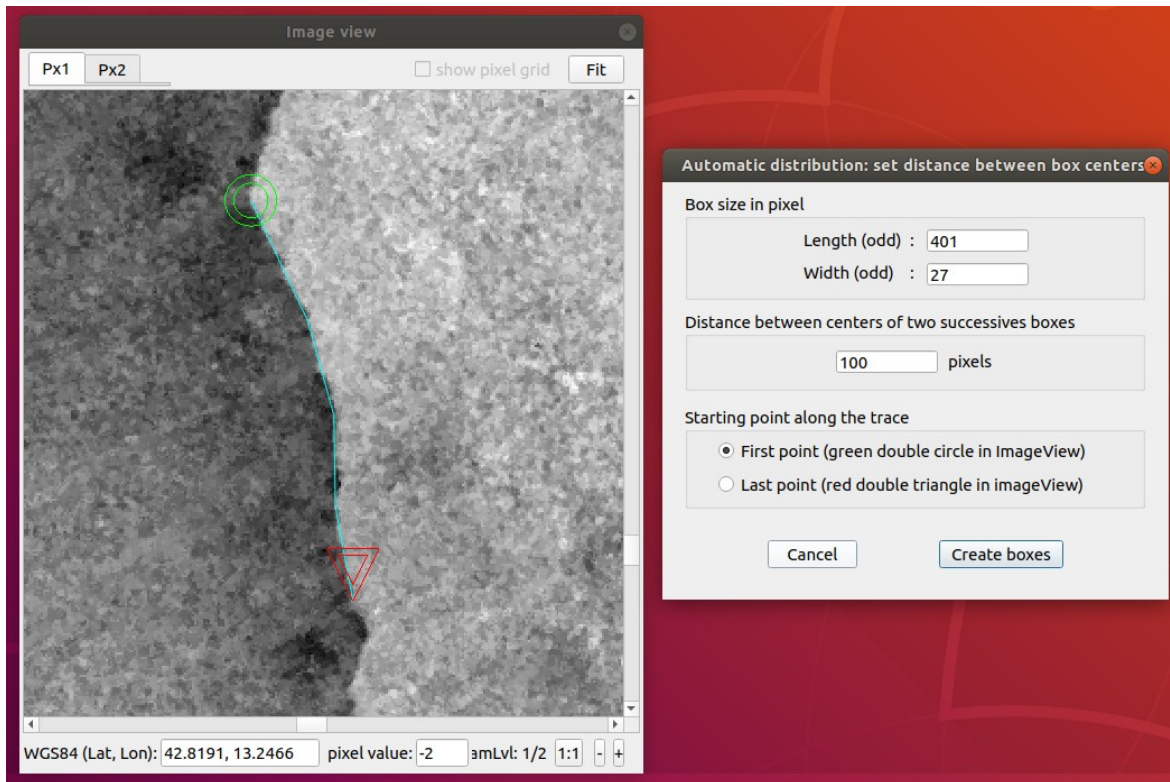
The distributed boxes appear on the trace in the Image view and are added to the list in the "Stacks edition" window.
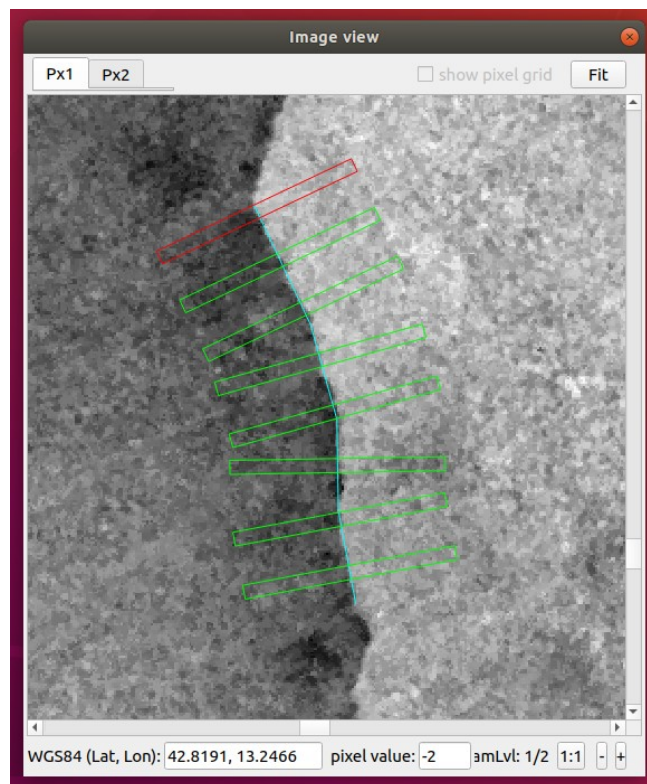
Example of a distribution result

Profile calculation

Configuration

From the main menu, choose: "Computation" → "Compute stacked profiles"

Example of a configuration window with the correlation score maps (given as input during the creation of the project) selected for Px1 and Px2 on the one hand and for deltaZ on the other hand

This window allows you to choose the calculation parameters and to launch the calculation:

- Choice of the interpolation method
  This interpolation applies to the extraction of pixels from input images and correlation score maps. See the "Implementation of bilinear interpolation" chapter for more details on the "bilinear interpolation (2x2 square of surrounding pixels)" method

- Choice of the method for profile stacking: mean or median
- Configure the use of correlation score maps:
    - Whether or not to use the correlation score map
    - If used, the correlation score is used as a weight (see formulas below) and additional options are available:
        - Filtering of the pixel value in the input images, if the corresponding correlation score if strictly below a threshold
        - Powering the correlation score used for the weighting

Mathematical formulas used

Stacking profiles reduces each set of values to its mean, median, weighted mean, or weighted median. An absolute deviation from this value is also calculated.

- Without using a correlation score map:

mean	absolute mean deviation
$\frac{1}{N}\sum_{i=1}^{N} v_i$	$\frac{1}{N}\sum |v_i - mean|$

median	absolute deviation from the median
Usual definition. In the case of an even list of values, the median will be the arithmetic mean of the two central elements	$\frac{1}{N}\sum |v_i - median|$

- With use of a correlation score map (without powering):

    The correlation score is used as the weight (symbol w in the formulas below)

weighted mean	absolute deviation from the weighted mean
$\frac{\sum w_i v_i}{\sum w_i}$	$\frac{\sum w_i |v_i - weighted\ mean|}{\sum w_i}$

weighted median	absolute deviation from the weighted median
element v_k satisfying these conditions: $\sum_{i=1}^{k-1} w_i \leq 1/2$ et $\sum_{i=k+1}^{N} w_i \leq 1/2$ If two elements satisfy these conditions, then the weighted median will be the average of the two elements	$\frac{\sum w_i |vi - weighted\ median|}{\sum w_i}$

- With use of a correlation score map **and with powering**:

The above formulas apply with the weights raised to the power p indicated: w_i^p replaces w_i in these formulas.

→ Select the desired parameters and click on "Run computation"
⇨ The calculation of the stacked profiles is executed
It may take from several seconds to several minutes. A window with a progress bar is displayed during the calculation.
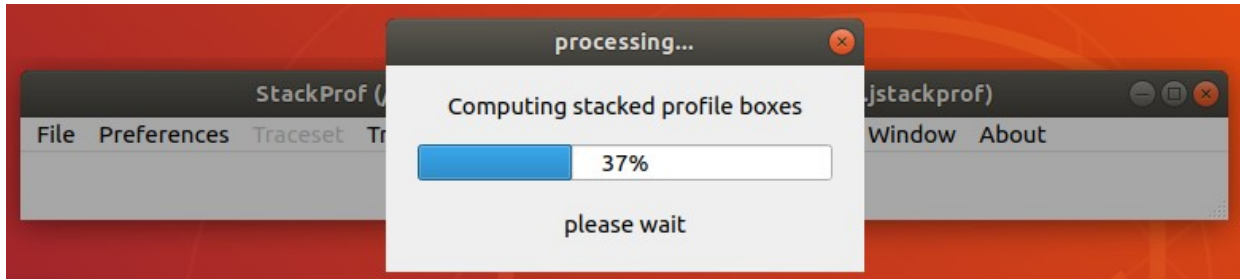
Once the calculations are complete, it is possible to edit the measurements on the profiles.

Editing profiles

From the main menu: "Computation " → "Edit stacked Profiles"
⇨ The profile editing window appears
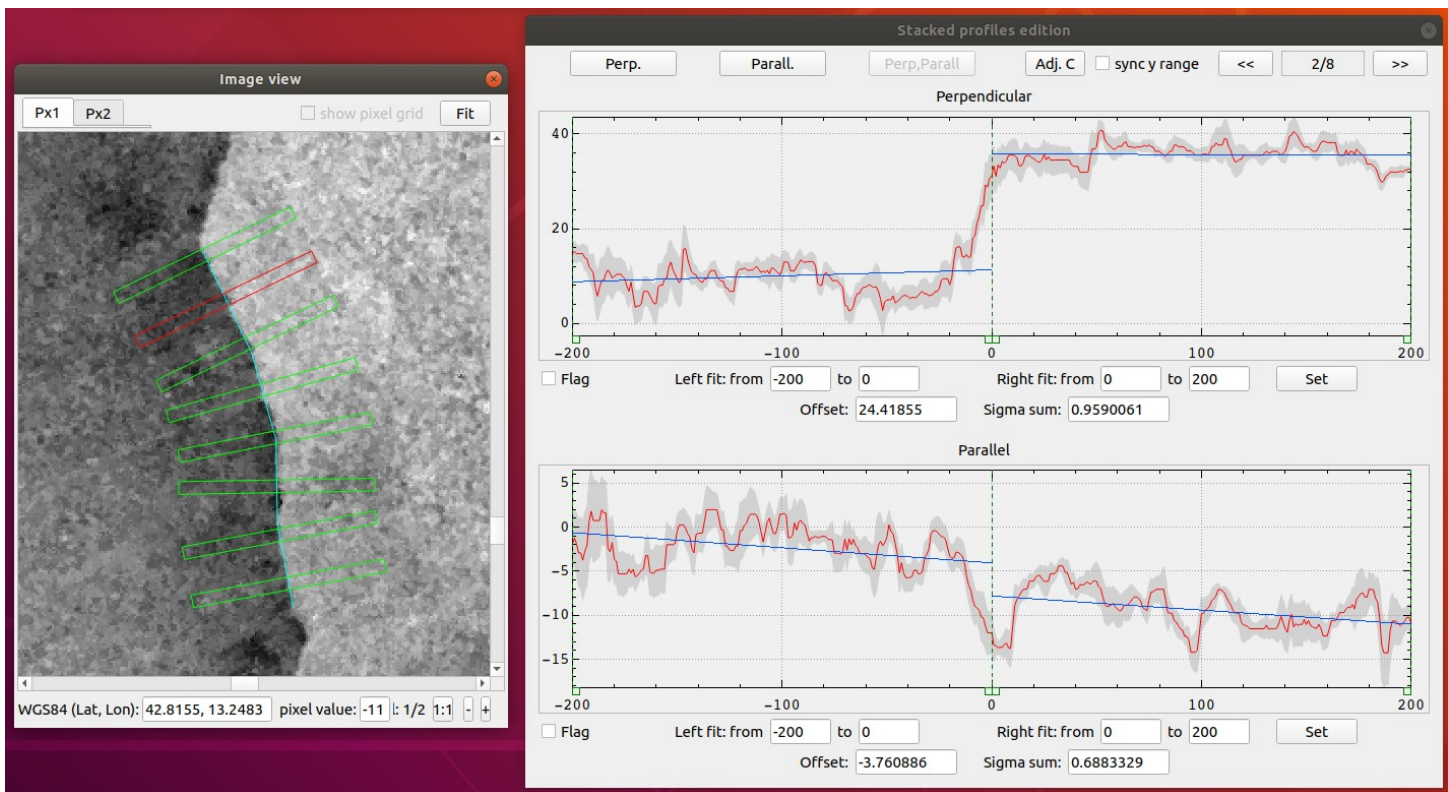
- Resizing the window resizes the displayed graphic(s)

- The buttons at the top left of the window are used to switch the display between the different possible combinations.
  The "All" button (visible only if Px1, Px2 and deltaZ were given as input when creating the project) corresponds to the display of the three components: Perpendicular, Parallel and deltaZ.

- The "sync y range" checkbox:

  - not checked: the extent of each graph on the y-axis is computed independantly

  - checked: the graphs share the same extent on the y-axis

- The << and >> buttons allow you to go respectively to the previous or next box.
  Keyboard shortcuts:

  - Go to the previous box: Ctrl + Page Up   or   Ctrl + S
  - Go to the next box: Ctrl + Page Down   or   Ctrl + D
  - Go to the first box in the list: Ctrl + Start   or   Ctrl + G
  - Go to the last box in the list: Ctrl + End   or   Ctrl + H

- The display area of the box number being edited is interactive. Click on it to enter the box number to reach, and press Enter. Or cancel the operation by clicking on the total of boxes.

- In the Image view, the box being edited appears in red

- The selection of a box from the Image view is possible:
  →Give the focus to the Image view
  →Hover the box with the mouse
  ⇨The edge of the box is colored yellow
  →Press the "s" key (like "select")

- The meaning of the curves, envelopes around the curves and units of the graphs can be viewed in a separate window.
  → From the main menu: "Window" → "Profile graphics info"

Component	Curve: method for profile stacking	Envelope area
Perpendicular & parallel	weighted median	and - absolute deviation around weighted media
Single component (e.g. deltaZ)	N/A	N/A

Units:
  x: pixel
  y: meter

Close

Presentation of a graph
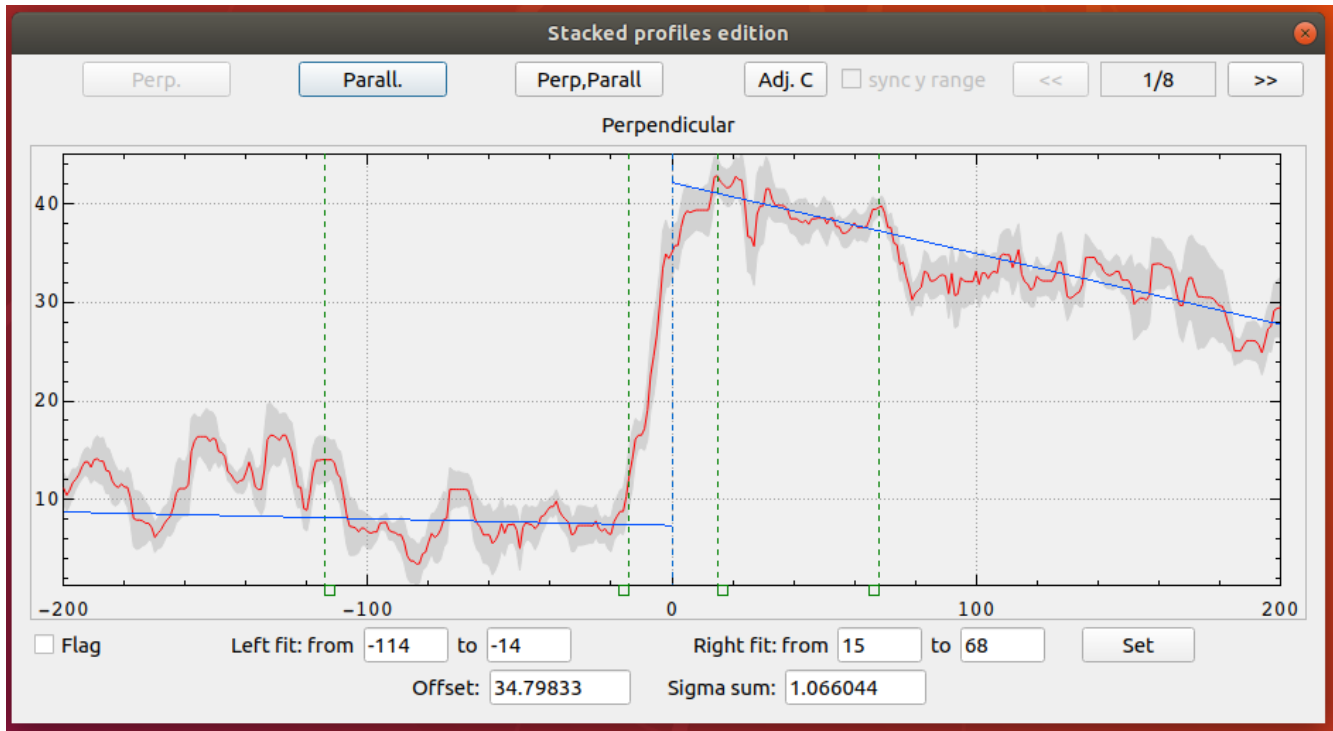
- The zero of the x-axis corresponds to the center of the box

- The main curve corresponds to the profile generated by the stacking of profiles

- The envelope corresponds to the main curve, to which has been added and subtracted the absolute deviation corresponding to each value of the curve

- The four vertical bars with small squares at the bottom of the graph allow you to define the two ranges on the x-axis for the calculation of linear regressions. They are pre-positioned at the ends:

    - For the part to the left (from the center of the profile): smallest value of x and zero

    - For the part to the right (from the center of the profile): zero and greatest value of x

  They are called "*rulers*" in the reste of this document.

- A vertical bar is pre-positioned at abscissa zero. It defines the position used for the measurement. This position can be changed. It is called "*profile center*" in this document.
  This bar is invisible if one of the four rulers is located on the same abscissa, unless the center of the profile is being adjusted (see the "Adjusting the profile center ("Adj. C" mode)" chapter).

Meaning of the numerical values below each profile

- The positions of the four rulers are shown below the graph

    - For the part to the left of the profile center: "Left fit: from ... to ..."

    - For the part to the right of the profile center: "Right fit: from ... to ..."

- Offset:
  Corresponds to the difference between the two y-axis values at the center of the profile, results of the left and right linear regressions (intercepts of the regression lines)

- Sigma sum:
  Corresponds to the sum of the standard errors on the y-intercepts of the left and right linear regressions

Adjusting the values for the linear regressions
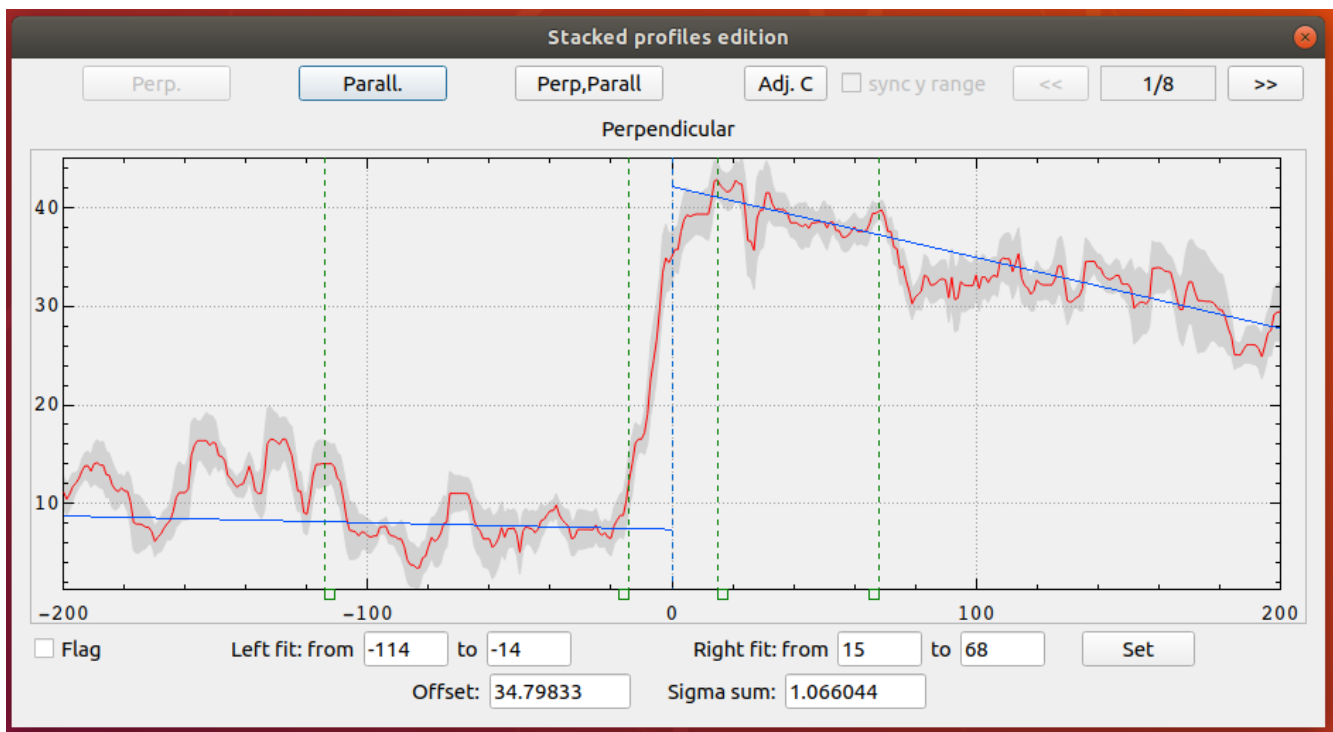
The "Adj. C" button at the top of the window (or "L/R", see below) switches between the adjustment modes. It displays the mode that will become enabled after clicking the button. Two adjustment modes are available:

- Adjustment of the left and right rulers: "L/R" button (for "Left/Right")

- Adjustment of the center of the profile, for the measurement of the offset and Sigma sum; "Adj. C" button (for "Adjust center")

The "L/R" is enabled by default.
To switch between modes, click on the button or use the keyboard shortcut: Ctrl + Shift

Adjusting the left and right rulers ("L/R" mode)

In this mode, adjustment of the center of the profile is not possible.

To modify the position of the left and right rulers:

- Left click maintained on the ruler (or its small square) + mouse movement
  A ruler turns red when hovered or in motion

  or

- Change the value in the field corresponding to this ruler, below the graph, and click on "Set"
  It is possible to modify several ruler values at once.
    - If a value entered does not allow the calculation, it appears in red
    - If a value entered conflicts with another ruler value, both values appear in red

Adjusting the profile center ("Adj. C" mode)
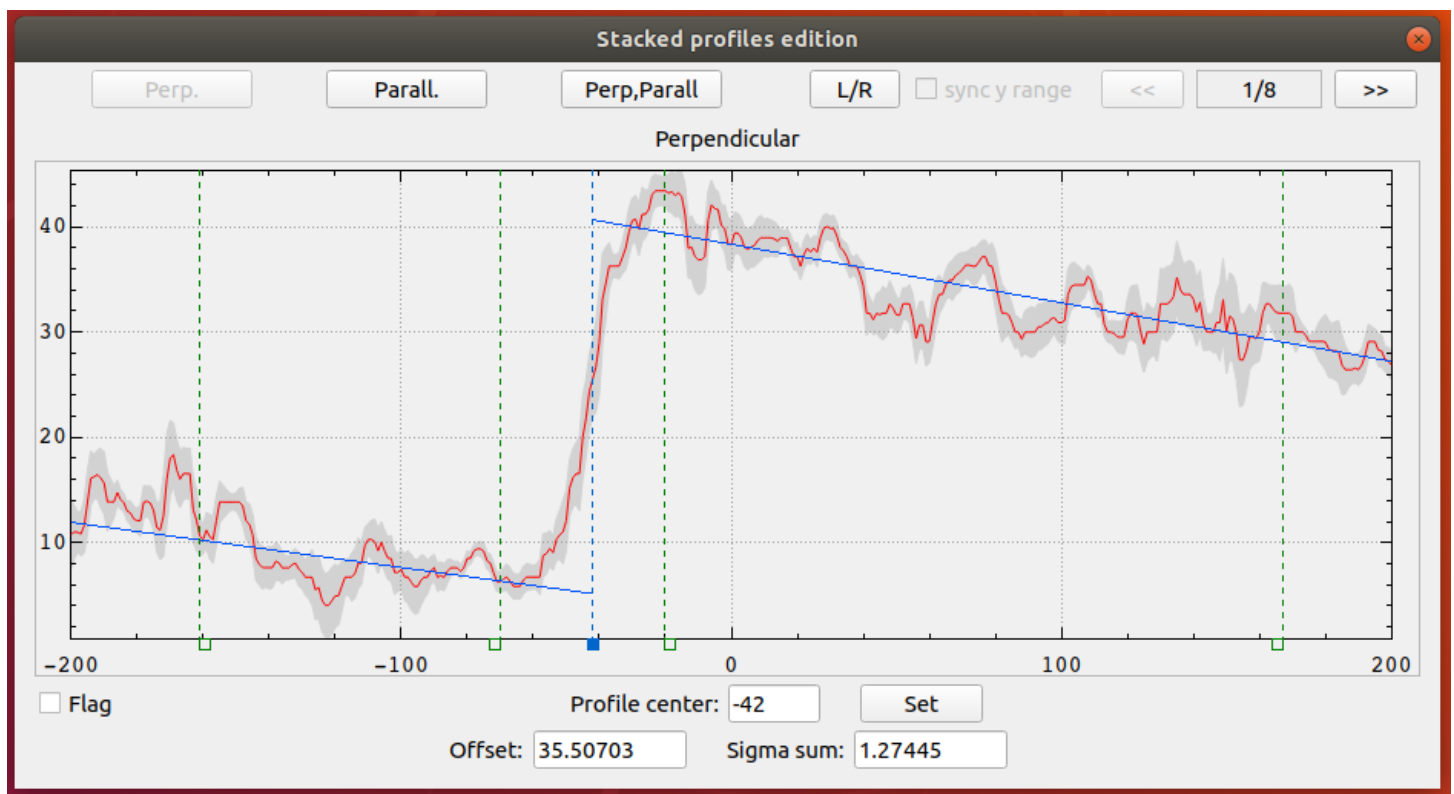
In this mode, adjustment of the left and right rulers is not possible.
The vertical bar that corresponds to the center of the profile becomes a ruler, with its small colored square.

To modify the position of the center:

- Left click maintained on the ruler (or its small square) + mouse movement
  The ruler turns red when hovered or in motion

or

- Change the value in the field corresponding to this ruler, below the graph, and click on "Set"
  If the entered value does not allow the calculation, it appears in red

If necessary, the positions of the left and right rulers are adjusted by the software so that each pair of left and right rulers are always located on either side of the center of the profile.

Profile reporting

Each profile has a checkbox labeled "Flag", at the bottom left of the window.
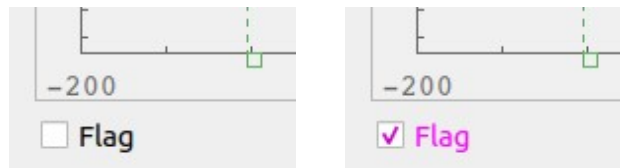
The meaning of this flag is at the user's discretion. It may be, for example, to mark profiles not to be considered for the study. The state of the flag will be found in the measurements export file. In addition, for exporting measurements, options specific to the flagged profiles are available:

- Do not export the offset measurements and other parameters of linear regressions
- Do not export the curve data

For projects using Px1 and Px2, the perpendicular and parallel profile flag can be checked/unchecked with a single click: Shift + click on one of the two flags.

Appearance of graphics
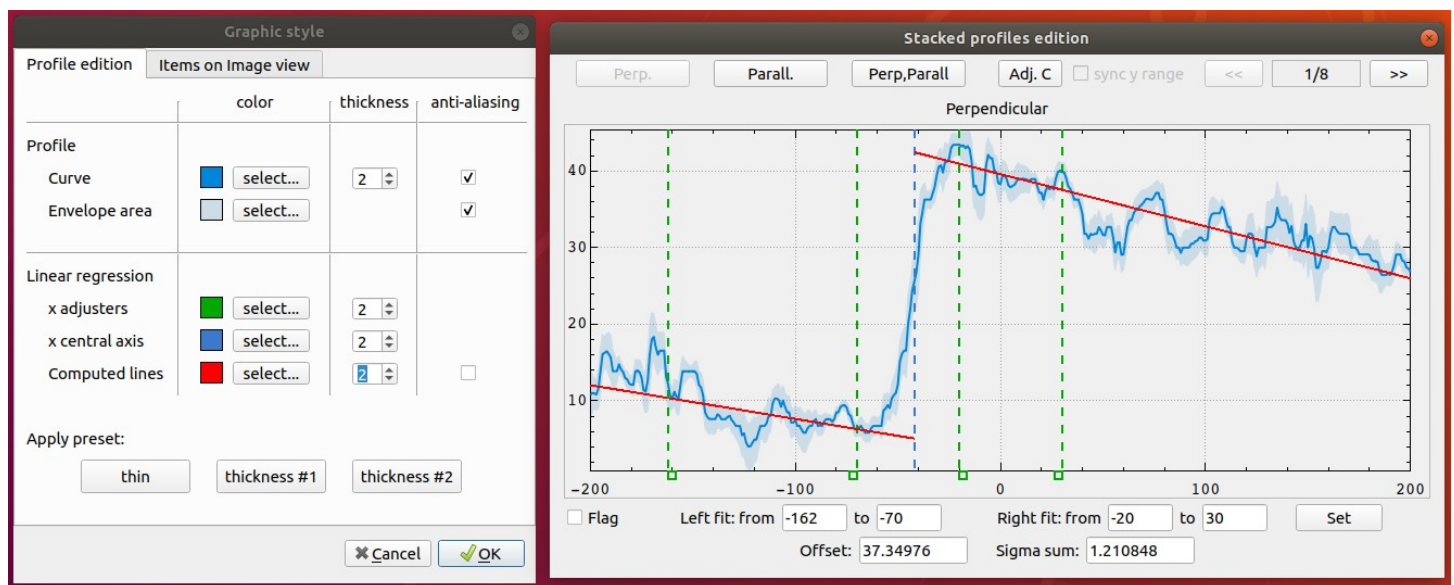
It is possible to modify the color and thickness of certain elements of the graphics.
This may be necessary when using a very high resolution screen.

From the main menu, choose: "Preferences" → "Graphic style"

The settings are saved and will be used the next time the software is started.
Three presets (hard-coded in the software) are also available at the bottom of the window: thin, thickness #1 and thickness #2.

Profile orientation

The boxes are oriented perpendicular to the trace, but this does not impose the orientation of the profile.
By default, the software considers that the direction of the y-axis of the profile is aligned (locally) with that which goes from the first point of the trace to the last.
It is possible to reverse this direction. The consequence is the "reversal" of the profiles.
From the main menu, choose: "Stacked profile Boxes" → "Set profile orientation"
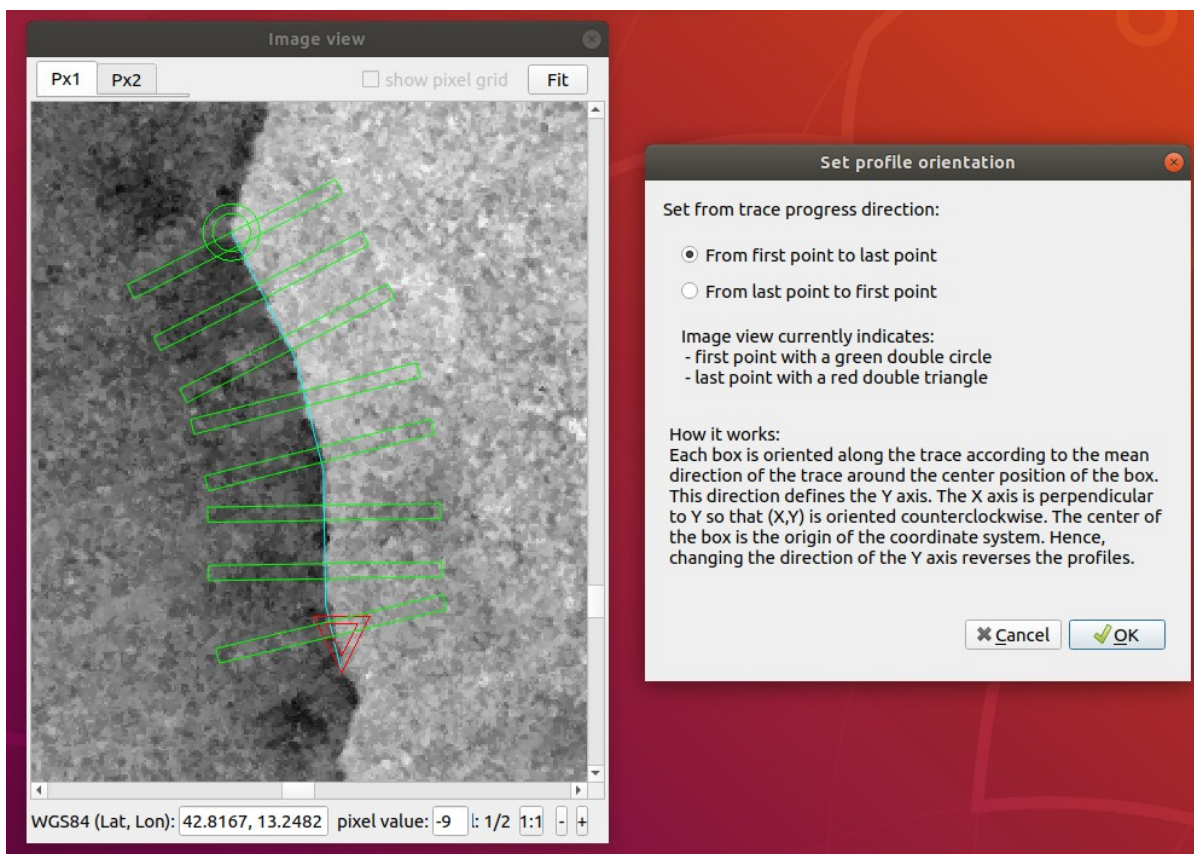
This action can be performed at any time. The software adjusts the rulers and the profile center to take into account the new orientation.

- When exporting measurements, this choice of orientation modifies:
    - The order of registration of boxes
    - The data of the boxes which depend on this parameter (in particular the azimuth. See the "The ASCII format"chapter)

The numbering of the boxes is not affected.

- The numbering and order of boxes in the graphical user interface are not affected by this parameter. The boxes remain numbered and ordered from the first point to the last point of the trace.
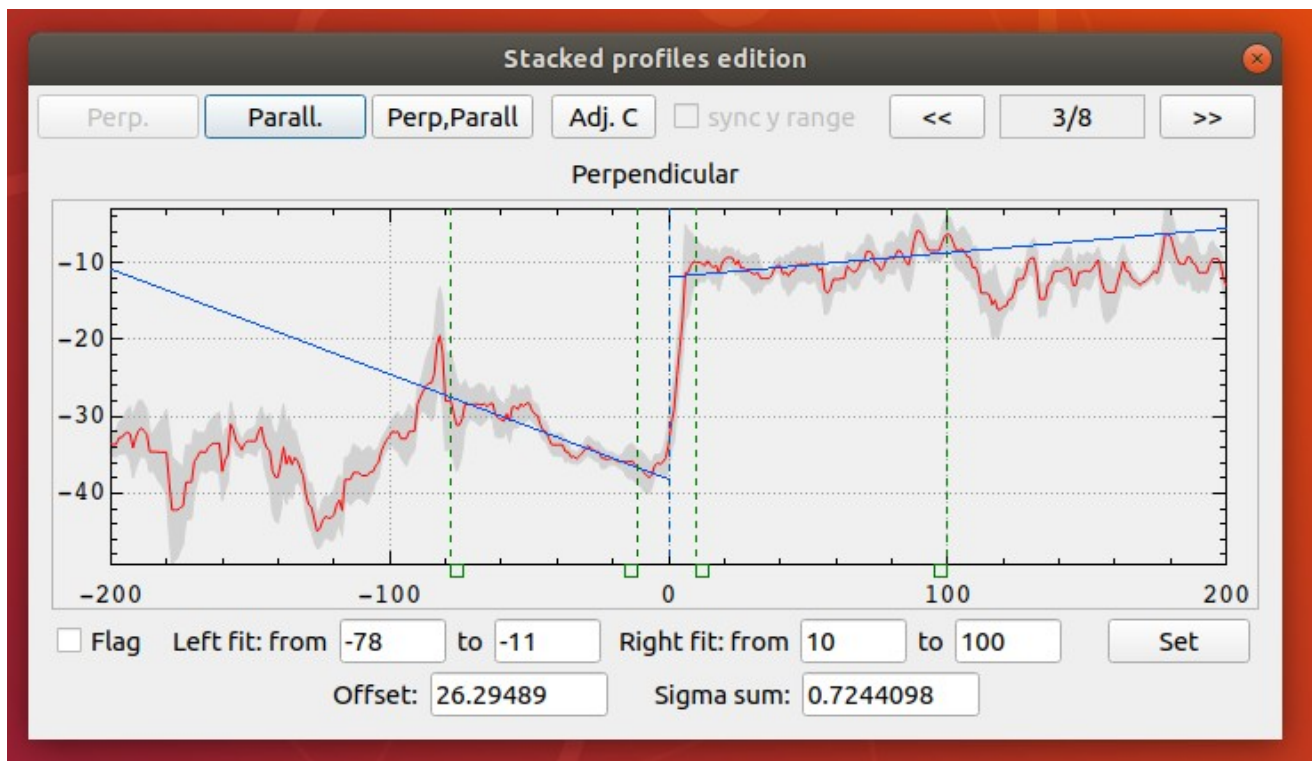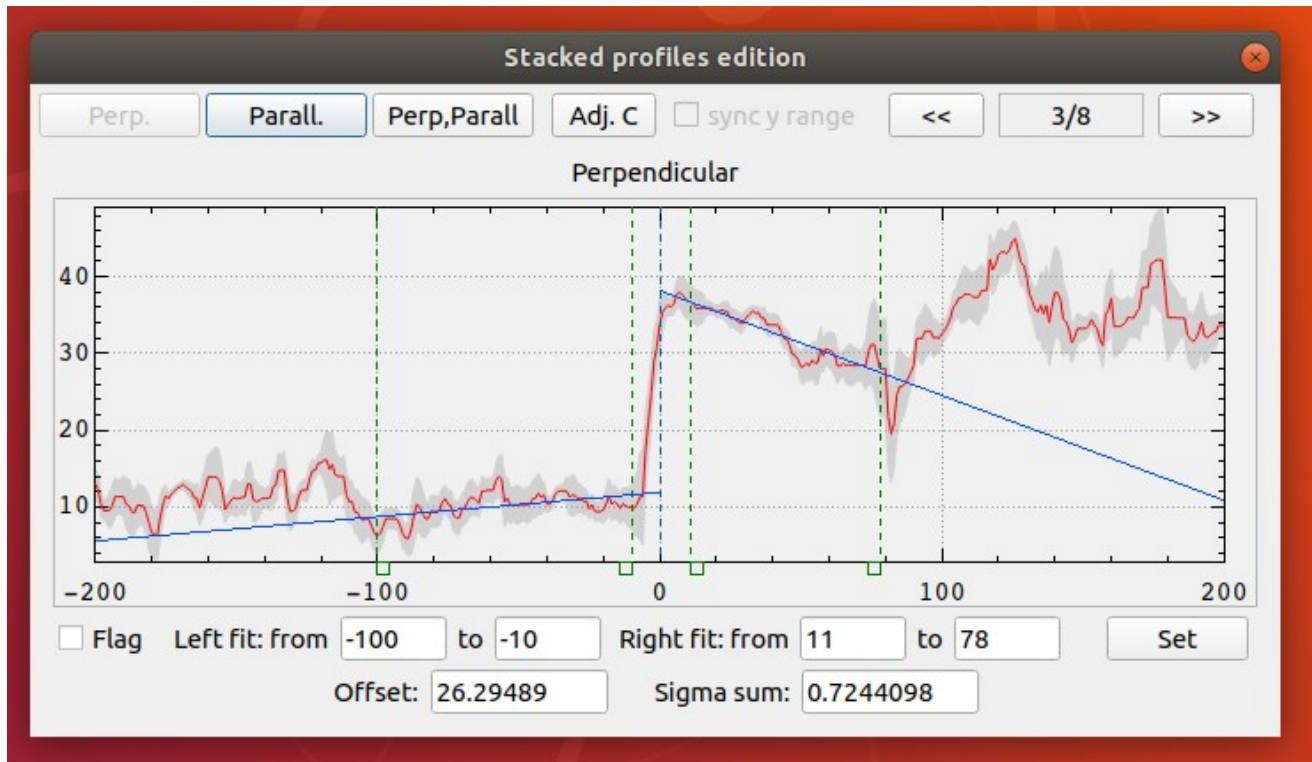
Example before/after a modification of the orientation of the profiles

Change the conversion factors for pixel values

From the main menu: "Computation" → "set pixel conversion factors"

Export measurements

From the main menu: "Computation" → "export results"
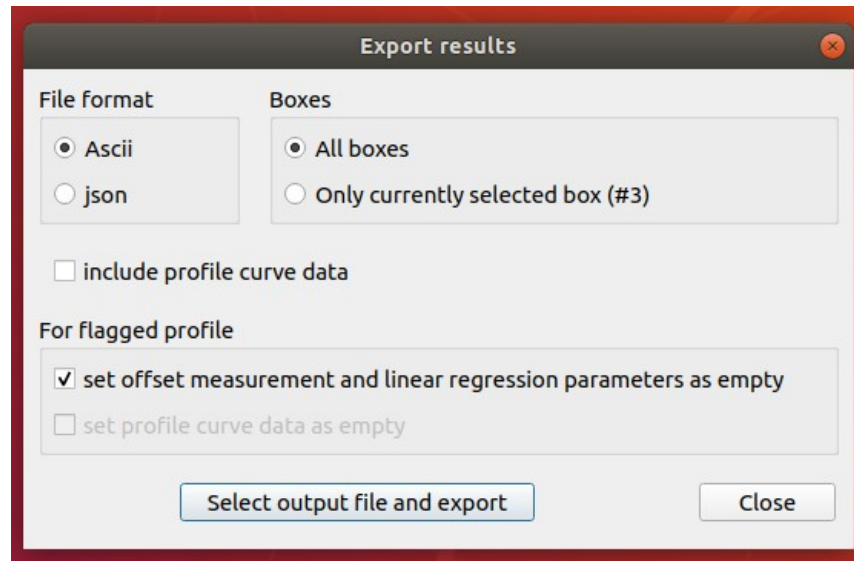
The measurements can be exported in ASCII and JSON text formats.
The export can contain measurements for:

- All the boxes of the project

  or

- Only the currently selected box

Check "include profile curves data" to add the (x,y) values of each point of the profile curve.
The options specific to the flagged profiles can be used, if the context allows it:

- Do not export the offset measurements and other parameters of linear regressions
- Do not export the curve data

The export files also contain all the project information, with the exception of the points of the trace used.

The ASCII format

The fields are separated by a semicolon.

The ASCII format contains a section that lists the boxes and measurements of the profiles by component.
The data in this section are listed by order of assumed importance. "Offset" and "sigma sum" are therefore entered in the first columns:

| 88	Boxes are ordered along the trace, taking into account the selected profil orientation. Azimuth degree and unit vector direction values also.							
89	component	Perp						
90	boxId	bNoWarningFlagByUser	linearRegression_isComputed	yOffsetAtX0	sigmabSum	leftSide_isComputed	leftSide_a_slope	leftSide_b_Inter
91	1	true	true	31.021228786895	0.93363343824465	true	-0.02290003905912	7.854803620051...
92	2	true	true	25.308678549077	0.91469824513465	true	-0.00053938101964	9.702252999720...
93	3	true	true	26.294891191538	0.72440983741874	true	0.03167027425111	11.898277498280...
94	4	true	true	20.566446642487	0.72021807830016	true	-0.00079477233808	10.944650801687...
95	5	true	true	24.815501578264	0.82670730817894	true	-0.00267455661433	16.046344306771...
96	6	false	N/A					
97	7	true	true	19.373405853625	0.75211953316284	true	-0.00427181155794	16.492120260921...
98	8	true	true	18.067418763389	0.96724245840851	true	-0.02769398152071	15.613750885547...
99								
100	component	Parall						
101	boxId	bNoWarningFlagByUser	linearRegression_isComputed	yOffsetAtX0	sigmabSum	leftSide_isComputed	leftSide_a_slope	leftSide_b_Inter
102	1	true	true	-6.0099436168801	0.5312084029801	true	-0.02082829122681	-4.877014417430...
103	2	true	true	-4.270941484239	0.66894172329073	true	-0.01480243945829	-3.553181408636...
104	3	true	true	-6.7418180800934	0.77840638070408	true	-0.00482932141355	-1.526852349660...
105	4	true	true	6.099570344913	0.79569443083626	true	-0.00290340097071	0.928395390460...
106	5	true	true	1.8395326191786	0.7729364533792	true	-0.02052865355448	-0.595908252531...
107	6	false	N/A					
108	7	true	true	6.1052723745204	0.60624301722438	true	-0.02872760498082	6.335655679822...
109	8	true	true	1.0452785690187	0.7395510998224	true	-0.01821284197944	5.787824383447...
110								

- If the project is georeferenced, the center of each box, in WGS 84 coordinates, is indicated in the columns: **centerPoint_lat** and **centerPoint_lon**

- The box orientation is indicated, among other things, in the **azimuthDegree** column. This value is an angle in decimal degrees. The angle is measured clockwise with respect to an upward vertical axis (0°). Its value depends on the choice of orientation of the profiles.
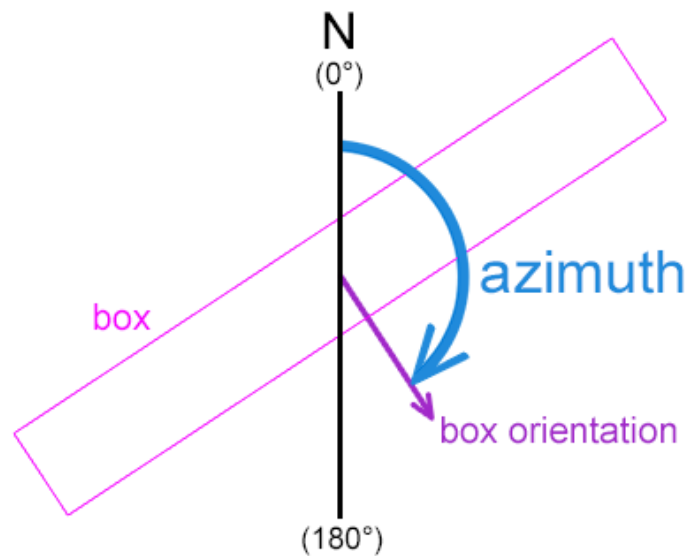
- The distance along the trace between the first point of the trace and the center of each box is indicated:
  - In meters, if the project is georeferenced
  - In image pixels, if the project is not georeferenced

  The column name contains the unit (meters or image pixels).

See the "Description of the export files" chapter for details on export files.

Summary of mouse actions and keyboard shortcuts (excluding functions of the main menu)

Image view navigation:

- Movement: *PC*   : right click maintained
              Mac   : Ctrl + click maintained
              Direction keys
              Window scroll bars

  From the Image view and the Overview:

- Center the image at the mouse position: *PC*   : left double click
                                            Mac   : double click

- De-zoom / zoom   : "h" / "j"
                    : Mouse wheel

- Set the zoom level to 1:1: space bar

- Adjust the image to the dimensions of the window: "f" (like "fit")

Trace edition:

- Add a point at the end of the trace: *PC*   : Shift + left click
                                         Mac   : Shift + click

- Point insertion: "i" (like "insert")

- Point deletion: "d' (like "delete")

Adding boxes one by one: "a" (like "add')

Select a box in the Image view: "s" (like "select")

Profile editing:

- Go to the previous box   :   Ctrl + Page Up   or   Ctrl + S
- Go to the next box   :   Ctrl + Page Down   or   Ctrl + D
- Go to the first box in the list   :   Ctrl + Start   or   Ctrl + G
- Go to the last box in the list   :   Ctrl + End   or   Ctrl + H
- Go to a box using its number:
  Click on the number of the current box and enter the desired box number (cancel by clicking on the total of boxes)

- Change adjustment mode for the rulers ("Adj. C" or "L/R"): Ctrl + Shift

- Check/uncheck the two flags for perpendicular and parallel offset at the same time: Shift + click on one of the two flags

Description of the export files

- JSON export file: see the stackprof_export_json_desc.pdf file
- ASCII export file: see the stackprof_export_ascii_desc.pdf file

Descriptions of trace and project files

- Trace file: see the stackprof_io_jtraces_desc.pdf file
- Project file: see the stackprof_io_jstackprof_desc.pdf file

Converting georeferenced files to non-georeferenced (and vice versa)

The use of a georeferenced trace in a non-georeferenced project, or vice versa, is not authorized by the software. But it is possible to convert, outside the software, the trace or project file to make it non-georeferenced or vice versa.

Converting non-georeference files to georeferenced

- For a trace file:
    - The parameters of the `backgroundImage_geoRefInfos` JSON object must correspond to the coordinate system (EPSG code) and to the world file data of the image used
    - The `bUseGeoRef` JSON key must be set to `true`
- For a project:
    - The parameters of the `ImagesSet_geoRefInfos` JSON object must correspond to the coordinate system (EPSG code) and to the world file data of the image(s) used
    - The `bUseGeoRef` JSON key must be set to `true`

Converting georeferenced files to non-georeferenced

The bare minimum to convert a georeferenced trace or project file to non-georeferenced is to pass its `bUseGeoRef` key to `false`.
The next time the software saves the file, the value of the JSON key of the EPSG code will be replaced by `EPSG:notSet`. The settings corresponding to the `worldFileContent` world file object are preserved.

Adjust the scale and position of a non-georeferenced trace for importing into a project

In the software, when a trace or project file is created without georeferencing, the parameters corresponding to the world file are set to these values:

```
"worldFileContent": {
    "0_A_xScale": 1,
    "1_D_rotationTerms_1": 0,
    "2_B_rotationTerms_2": 0,
    "3_E_yScale": -1,
    "4_C_xTranslationTerm": 0,
    "5_F_yTranslationTerm": 0
  }
```

When importing a traceto a non-georeferenced project, the software uses the parameters from the `worldFileContent` object from the trace file to perform the scaling and positioning of the trace. It is therefore possible to adapt the scale and position of the trace for importing to a project by adjusting the `worldFileContent` values of the trace file.

Example:
Parameters to be specified in the worldFileContent JSON object of the trace file, so that the trace is imported twice as large, and shifted by 300 pixels horizontally to the right and 100 pixels vertically upwards:

```
"worldFileContent": {
    "0_A_xScale": 2,
    "1_D_rotationTerms_1": 0,
    "2_B_rotationTerms_2": 0,
    "3_E_yScale": -2,
    "4_C_xTranslationTerm": 300,
    "5_F_yTranslationTerm": 100
  }
```

Editing of trace and project files outside the software

Trace and project files can be created or edited, either manually or by a third-party application. When loading a trace of project file, the software checks the content of the file. At the first error detected, the software signals the corresponding section and refuses to load the file.
See the file descriptions to know the constraints to be observed when editing files outside the software.

Implementation of bilinear interpolation

It uses the four neighboring pixels of the considered position ("2x2 square of surrounding pixels")
The pixel which includes the considered position is called below "reference pixel".
The position in the reference pixel determines the percentage of contribution of neighboring pixels, but also which neighboring pixels contribute.
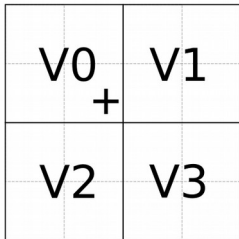
V0	V1
V2	V3

+: considered position
V0, V1, V2, V3: the four pixels that contribute in bilinear interpolation

Neighboring pixels that contribute to bilinear interpolation depending on the position in the reference pixel:
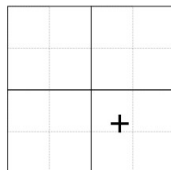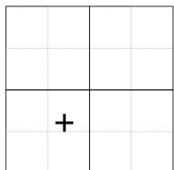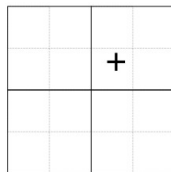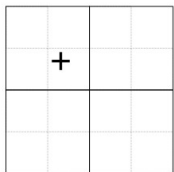
The formula used to calculate the pixel value is:
pixelValue = v01*PercentFactorForY0 + v23*(1.0-PercentFactorForY0)
with:
   v01 = V0*PercentFactorForX0 + V1*(1.0-PercentFactorForX0)
   v23 = V2*PercentFactorForX0 + V3*(1.0-PercentFactorForX0)
   PercentFactorForX0: the weighting for the reference pixel (V0) on the horizontal axis
   PercentFactorForY0: the weighting for the reference pixel (V0) on the vertical axis

Other application settings

Use of RAM for image visualization

It is possible to configure the maximum amount of RAM used to visualize images.
From the main menu: "Preferences" → "Disk and RAM usage" → "Image view" tab.

The parameter to configure corresponds to the maximum amount of RAM used to visualize one of the input images. The default value is 512 Megabytes.
The maximum amount of RAM used corresponds to this parameter multiplied by the number of images visualized. For example, if the project has three input images (Px1, Px2 and DeltaZ), the maximum amount of RAM used will be the value of the parameter multiplied by three.
RAM is only claimed and used by the software if the corresponding image is visualized.
A modification of this parameter is taken into account the next time the software is started.
Increasing this value does not imply faster performance.

Content of the cache storage and cleaning

As noted at the beginning of this document, the software builds, stores on disk, and uses different zoom levels (image pyramid) for each input image. These image pyramids are stored in the "cache storage" directory. A subdirectory is created for each input image.
To free up disk space, quit the application and delete the subdirectories corresponding to the input images that are no longer used. In the cache storage directory, the ZLIstorageContent.json file is used to find out the correspondence between an input image and its subdirectory in the cache storage. It is not necessary (and it is not advised) to modify the content of the ZLIstorageContent.json file.

Error messages and their common causes

- "The EPSG code of the selected image is different"
The trace file contains an EPSG code for the associated image that is different from that contained in the .jepsg file corresponding to the image. The most common cause is an image selection error when replacing an image in a trace file where the image is missing. If the cause is other: delete the .jepsg file of the image concerned, re-select the EPSG code in the software and save the trace or project file.

- "Unsync EPSG Code found in .jepsg files for images"
The most common cause is an error selecting one or more images when creating the project. The input images of a project must all have the same EPSG code (.jepsg files).
If the cause is other: delete the .jepsg file(s) of the affected images concerned, re-select the EPSG code in the software and save the project.

- "EPSG code (EPSG:xxxx) is unknown by PROJ database"
If it is not an error entering the EPSG code from the graphical user interface, check that the EPSG code entered in the .jtraces or .jstackprof file respects the expected format. The last cause may be that the PROJ database (the proj.db file delivered with the software) does not actually know the code.

- "The world file data of the selected image is different"
The most common cause is an error selecting one or more images when creating a project.
The input images of a project must all have the same world file content (for projects, at least one world file for all input images is required).

- "World file data found from images are unsync"
Cause of error: the world files corresponding to the input images of the project are not identical. At least one world file for all input images is required. If there are more than one, they must have the same content.

- "Loaded but can not be used" ("WorldFile data: error reading file")
The values in the world files corresponding to the image(s) are not compatible with the software. Check that the contraints of the software are respected.

- "World file for image not found or failed to load" ("WorldFile data: file not found")
The software found no world file for the input image(s) or failed to read it. Check that the world file for the image exists in the same directory as the image (for projects, at least one world file for all input images is required).

- "Missing mandatory input file for Px1" / ~ "for Px2"
The project is configured to use Px1 and Px2. The two corresponding input files must therefore be present.

- "Missing correlation score map input file for Px1,Px2" / ~ "for deltaZ"
The project is configured to use a correlation score map for Px1 and Px2 / ~ for deltaZ. The file must therefore be present.

- "Input files for Px1 and Px2 have to be different"
Cause of error: the choices made for Px1 and Px2 point the same file.

- "(displacement map) file format not supported for file <input type>"
The file selected as the displacement map is not in a supported format.

- "(correlation score map) file format not supported for file <input type>"
The file selected as the correlation score map is not in a supported format.

- "Px1 and Px2 don't have the same width, height or basetype"
Cause of error: the files selected for Px1 and Px2 do not have the same characteristics (width, height or data type).

- "failed to load json; error #1" / "failed to load json; error #2"
Indicates that the .jtraces or .jstackprof file contains an error in the JSON notation.

- "key not found"

- "invalid value for key"

- "error getting value for key"

- "failed to load json from JsonObject"
Correspond to trace or project file loading errors. These errors usually indicate the affected JSON object. This type of error can occur if the file has been modified from outside the software and contains a data-related error.

- "Critical error" / "Fatal error"
This type of error should never be encountered. If this is the case, you are strongly advised to quit the software without exporting the measurements or saving the project (the project data are probably in an unstable state). The error message gives this recommendation.

- "Dev Error #xxx" / "Internal dev Error #xxx"
This type of error should never be encountered. It indicates that the software implementation should have detected an error related to the use case encountered.

[End of document]