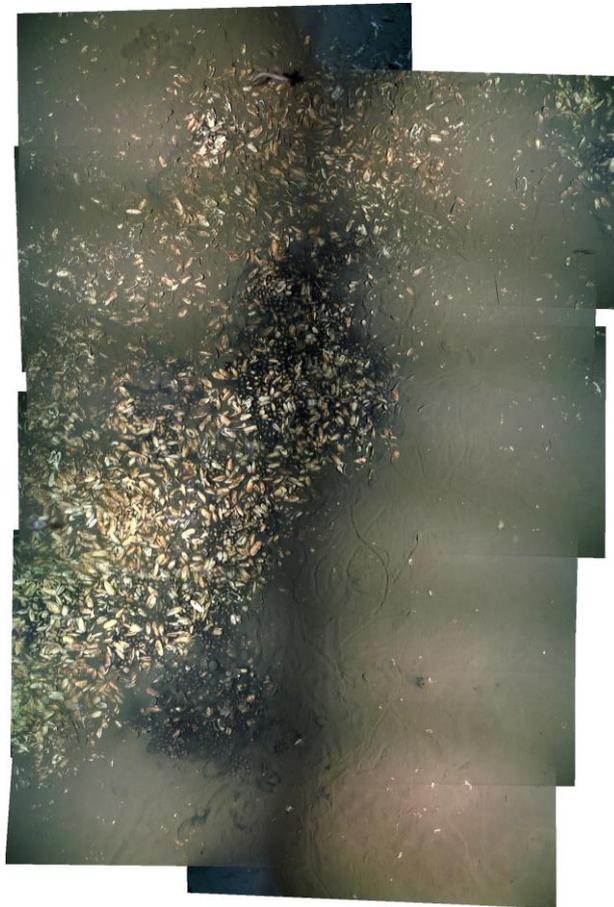


LAPMv2 6.0 - User Manual

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Author: Yann Marcon

LAPMv2

Large Area Photo-Mosaicking Tool v2

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The LAPMv2 program (or Large-Area Photo-Mosaicking Tool v2) was specifically developed for seafloor mapping applications. It is capable of handling datasets of thousands of images, and relies on robust feature detection and matching algorithms (SIFT) as well as on navigation data from underwater vehicles (ROV, AUV, etc.) for the production of photomosaics. Final photomosaics are geo-referenced and saved as GeoTiff for direct import into a Geographic Information System (GIS).

LAPMv2 is NOT a panorama program. Although it can be run on any image dataset, it cannot achieve the same quality as dedicated programs for the production of panoramas.

The LAPMv2 program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

LAPMv2 is available at:

<http://www.lapm.eu.com>

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Chapter 1 Installing LAPMv2

LAPMv2 is a stand-alone and installation-free program that runs under 64-bit Windows, Mac OS X and Linux operating systems. It can be downloaded at <http://www.lapm.eu.com>.

1.1 Windows systems

To start the installation, run (double-click) one the installer files and follow the instructions:

- *LAPMv2.X.X_Installer_web.exe*: this package file installs LAPMv2 and downloads the MATLAB Runtime from the internet (if not already installed).
- *LAPMv2.X.X_Installer_mcr.exe*: this package file includes both LAPMv2 and the MATLAB Runtime (use this option if an internet connection is not available).

1.2 Mac OS X systems

To start the installation, run (double-click) one the installer files and follow the instructions:

- *LAPMv2.X.X_Installer_web.app*: this package file installs LAPMv2 and downloads the MATLAB Runtime from the internet (if not already installed).
- *LAPMv2.X.X_Installer_web.app*: this package file includes both LAPMv2 and the MATLAB Runtime (use this option if an internet connection is not available).

Once the installation is finished, open a command terminal (in *Applications* → *Utilities* → *Terminal*), type the following command (single command with only a blank space between the two lines) and press [Enter]:

```
../../Applications/LAPM_Tool/LAPMv2/application/run_LAPMv2.sh  
../../Applications/MATLAB/MATLAB_Runtime/v90
```

LAPMv2 will start within a few seconds to a few minutes (depending on the computer speed and on whether LAPMv2 is started for the first time).

Remark: the command above is only valid if LAPMv2 and the MATLAB Runtime are installed in their respective default installation folders. If not, amend the folder paths in the command above to point to the correct directories.

1.3 Linux systems

To start the installation, run one the installer files by typing the following command in a terminal: **./LAPMv2.X.X_Installer_web.install** (where *X.X* is the version number). Wait a moment (it may take several minutes) and follow the instructions that appear on the screen.

There are two types of installers:

- *LAPMv2.X.X_Installer_web.install*: this package file installs LAPMv2 and downloads the MATLAB Runtime from the internet (if not already installed).
- *LAPMv2.X.X_Installer_mcr.install*: this package file includes both LAPMv2 and the MATLAB Runtime (use this option if an internet connection is not available).

Remark: running the installer in Linux may require 'root' permissions; this is done with the following commands:

- *in most Linux distributions: `sudo ./LAPMv2.X.X_Installer_web.install`,*
- *or if 'sudo' is not installed): `su root ./LAPMv2.X.X_Installer_web.install`.*

Once the installation is finished, open a command terminal, type the following command (single command with only a blank space between the two lines) and press [Enter]:

```
./usr/LAPM_Tool/LAPMv2/application/run_LAPMv2.sh  
/usr/local/MATLAB/MATLAB_Runtime/v90
```

LAPMv2 will start within a few seconds to a few minutes (depending on the computer speed and on whether LAPMv2 is started for the first time).

Remark: the command above is only valid if LAPMv2 and the MATLAB Runtime are installed in their respective default installation folders. If not, amend the folder paths in the command above to point to the correct directories.

Remark: running LAPMv2 does normally not require the 'root' permissions. However, LAPMv2 requires writing access to the folder that contains the images.

Chapter 2 Getting started step-by-step

2.1 Formatting of the dataset

Formatting the dataset must be done for every new mosaicking project before running LAPMv2. Later changes in the file system (file names, image order, etc.) may cause errors during the mosaicking process.

To ensure that all data are correctly formatted, follow this checklist:

- Create a folder for the new project; the full path to the project folder **must not contain spaces**.
- Copy all images to be mosaicked into the project folder.
- Convert all images to either JPEG or TIF format and ensure that image filenames have a valid format (cf. Chapter 4.1).
- Create the **sequence file** (cf. Chapter 4.2) and copy it into the project folder.
- Create the **navigation file** (cf. Chapter 4.3) and copy it into the project folder.
- Create the **sensor list file** (cf. Chapter 4.4) and copy it into the project folder.

2.2 The mosaicking workflow

Once the checklist given in Chapter 2.1 has been completed, launch LAPMv2 by running the main executable file of the program. Dialog boxes will open to ask for (1) the project folder and (2) the sequence file. The main menu of the graphical user interface will then be displayed.

Mosaics can be created in two different ways:

- Using navigation data only (fastest but least accurate method)
- Using feature matching and navigation data

Note that, unlike in LAPM Tool v1, LAPMv2 (or LAPM Tool v2) **requires** the navigation data to be provided.

2.2.1 Mosaicking with navigation data only

1. First, go to the '**Navigation data**' menu, load the navigation file and plot it to ensure it looks consistent. If not, try filtering the data with the 'Reconstruct trajectory' option (cf. Chapter 3.4 for details).
2. Select '**Assemble mosaic**'. When prompted, select the **desired navigation data**.

The mosaicking process can take a long time, depending on the type of mosaic output (mosaic image or mosaic dataset), on the chosen resolution, and on the blending option.

3. Final mosaics are stored in the project folder, within the '\mosaic' or the '\GeoTiff_mosaic' subfolder.

2.2.2 Mosaicking with feature matching and navigation data

1. In the '**Navigation data**' menu, load the navigation file and plot it to ensure it looks consistent. If not, try filtering the data with the 'Reconstruct trajectory' option (cf. Chapter 3.4 for details).
2. Skip this step if feature matches already exist for this project. If the project is new and that feature matches have not been computed, select '**Detect & match features**'.

The feature detection and matching can be a very slow process. This can be speeded-up by changing the default '**SIFT detection parameters**' in '**Advanced settings**' menu. In particular, the 'Speed SIFT' option can significantly speed up the process by lowering the resolution of the images during the feature detection and matching (it does not affect the resolution of the final mosaic).

3. Select the '**Browse through pairs of images**'. The 'match selector' interface will open, which allows to rapidly browse through all pairs of images within the mosaic and to visualize all computed links. Use this interface to delete erroneous links and to add new links between pairs where the automatic feature detection failed. If time allows, try to link as many pairs as possible.
4. Skip this step if the mosaic is made of a single line, and that the trajectory does not cross itself. If the mosaic is composed of several adjacent overlapping lines, then add links between adjacent (i.e. non-consecutive) images. This can be done either manually with the match selector (option '**Browse through pairs of images**') or automatically ('**Find sidelinks**' button). This is an important step, which can contribute to significantly improving the quality of the mosaic.
5. Select '**Refresh file system**'.
6. Select '**Global registration (linear)**' or '**Global registration (non-linear)**'. At the end of the process, the estimated topology will be displayed by selecting 'Plot topology'. If the topology looks erroneous, go back to step 5 and either delete erroneous links or add additional ones between new pairs of adjacent images.
7. Select '**Assemble mosaic**'. When prompted, select the **desired navigation data**.

The mosaicking process can take a long time, depending on the type of mosaic output (mosaic image or mosaic dataset), on the chosen resolution, and on the blending option.

8. Final mosaics are stored in the project folder, within the '\mosaic' or the '\GeoTiff_mosaic' subfolder.

Chapter 3 Description of menus and interfaces

3.1 Main menu

The main menu of LAPMv2 was designed to guide the user through various steps of the mosaicking workflow. However, the mosaicking workflow can be entirely automatized by using the batch mode (cf. Chapter 3.2).

3.2 General settings

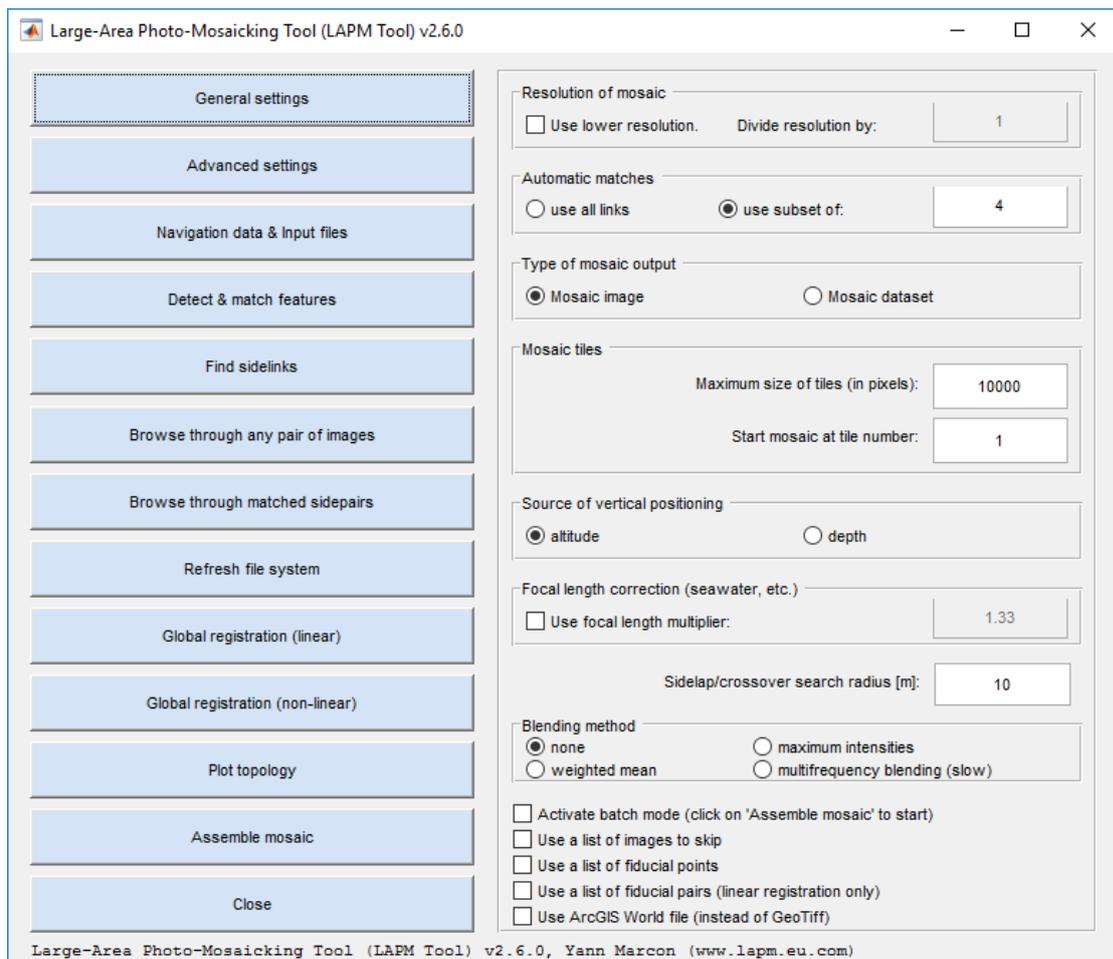


Figure 3.1. GUI of the ‘General settings’ menu.

Resolution of mosaic: this parameter controls the resolution of the final mosaic. Lowering the resolution significantly speeds up the mosaic construction.

Remark: changing this parameter affects only the mosaic construction, not the feature detection and matching.

Automatic matches: set here the number of links that should be used to match each pair of images (either all links or a subset of links). Subsets of links are automatically chosen within

the full set, so as to be well distributed (widespread). Subsets cannot contain less than 4 links.

Remark: this parameter does not affect the manually added links (if available, manual links are used in any case).

Type of mosaic output: choose here the format of the final mosaic files. *Mosaic image:* the mosaic is saved as a large image file, which is tiled to the user-defined tile size. Each tile is geo-referenced and saved as a GeoTiff file. *Mosaic dataset:* each image is geo-referenced and saved as a separate GeoTiff file. This mode is much faster, but requires the use of a GIS program to display the mosaic.

Mosaic tiles: constructing a *mosaic image* can be very demanding in terms of computing resources. In order not to exceed the computer memory limitations, it can be necessary to limit the maximum size of the mosaic files. To do so, the mosaic can be divided into square tiles of defined size, which are then constructed independently from each other. This is done automatically if the mosaic exceeds the tile size limit.

- **Maximum size of tiles (in pixels):** set here the maximum tile width (or height).
- **Start at mosaic tile:** choose here which tile should be constructed first; this option is useful to continue the construction of a multi-tile mosaic without restarting from the beginning.

Remark: memory requirements are much higher if the multifrequency blending option is activated. Therefore, the tile size should be set accordingly.

Source of vertical positioning data: choose here which dataset should be used to assess the vertical position of the camera. The altitude data generally yields better results. Depth data should only be used if altitude data is not available.

Focal length correction: use this option to apply a *seawater* (or similar) coefficient to the focal lens.

Sidelap/crossover search radius: set here the maximum search radius for the sidelap detection. For each image, the search for sidelap/crossover will be performed within the defined radius.

Blending method: choose here the blending method.

- **None:** the mosaic is not blended; each pixel within overlap areas is taken from the image, for which the pixel is closest to the centre of the image.
- **Maximum intensities:** the mosaic is not blended; pixels with the highest intensities are shown; this option may cause some blurring in overlap areas.
- **Weighted mean:** pixels intensities within overlap areas are weighted averages of the

pixel intensities of the *closest two images* (i.e. images for which the pixels are closest to the centre). The weighting coefficient is based on the distances of the pixels to the centres of both images.

- **Multifrequency blending (slower):** the multifrequency blending renders a rather seamless mosaic but is much slower and more demanding in terms of computing resources than the other methods. It is recommended to first create the mosaic without the blending, in order to check if the registration is correct.

Activate batch mode: check this option to activate the *batch mode*. The batch mode performs the following actions automatically: (1) search for features along the image sequence, (2) search for sidelap/crossover based on navigation data, (3) compute the linear global registration, (4) iteratively search for new sidelap/crossover and compute the linear global registration until no additional sidelap/crossover is found, (5) compute the non-linear global registration, (6) plot the topology (using the non-linear global registration), and (7) assemble the mosaic.

Remark: once this option is activated, click on 'Assemble mosaic' to start the batch mode.

Use a list of images to skip: this option allows ignoring/skipping some images during the construction of the mosaic. Refer to Chapter 4 for details about the structure of the *skip* file.

Use a list of fiducial points: in large mosaics the global registration sometimes produces unexpected results. Fiducial points can be used to constrain the navigation data and/or to anchor a few key points in order to force the global registration towards a more correct solution. Refer to Chapter 4 for details about the structure of the *fiducial points* file.

Use a list of fiducial pairs: *Anchoring* a pair of unmatched images will preserve the relative position of both images during the linear global registration. The relative position is taken from the navigation data. Refer to Chapter 4 for details about the structure of the *fiducial pairs* file.

Use ArcGIS World file: choose here the type of geo-referencing data for the final mosaic files. Uncheck the box to save the mosaic files as GeoTiff files with a Geographic Coordinate System WGS84. Check the box to save the mosaic files as baseline Tiff files with ArcGIS World files (.tfw). In this case, the coordinate system uses either a Universal Transverse Mercator (UTM) or a Universal Polar Stereographic (UPS) projection. The coordinate system is determined automatically from the latitude and longitude data given in the navigation file.

3.3 Advanced settings

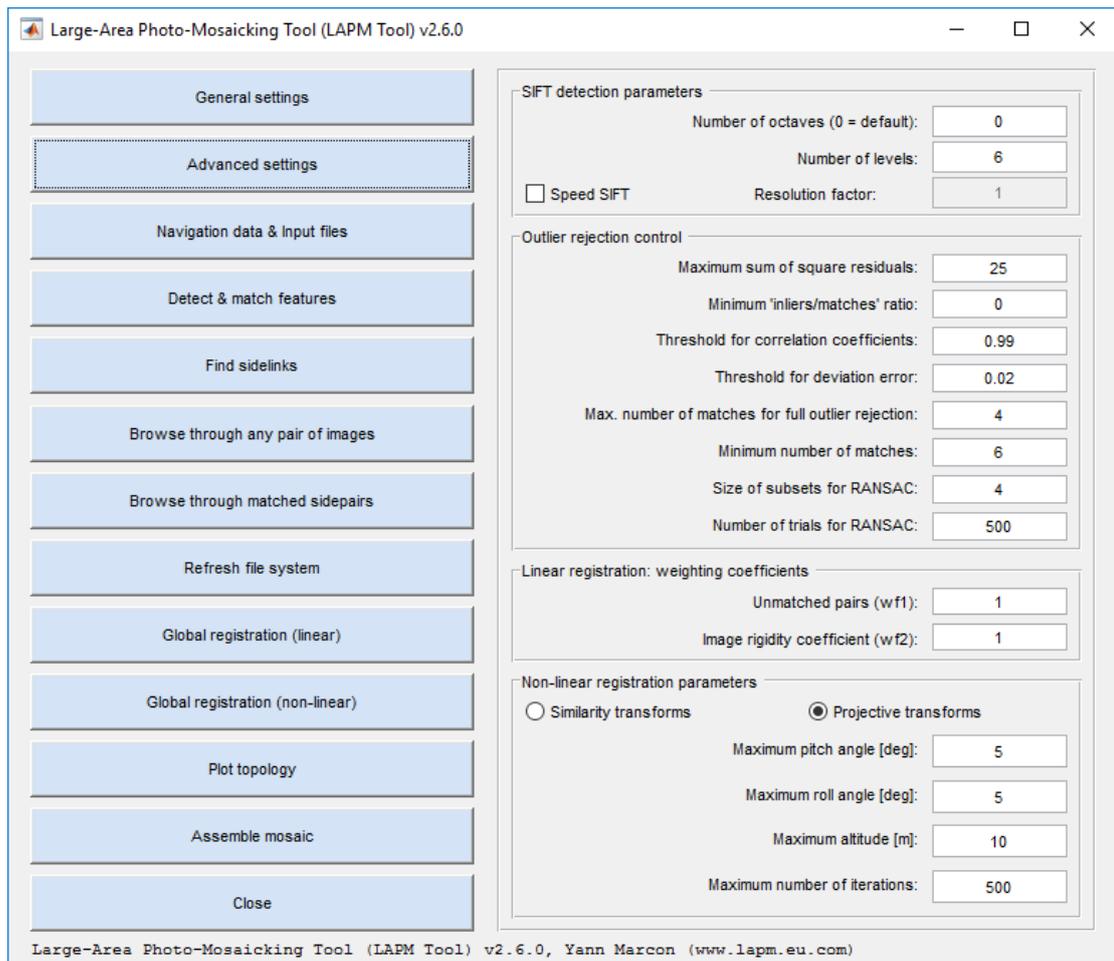


Figure 3.2. GUI of the ‘Advanced settings’ menu.

SIFT detection parameters: for more information about the Scale-Invariant Feature Transform (SIFT) algorithm, refer to the work of Lowe (2004)*.

- **Number of octaves:** number of octaves of the DoG space scale. Set the value to 0 to use the maximum number of DoG possible.
- **Number of levels:** number of levels per octave of the DoG space scale
- **Speed SIFT:** activate this option to speed up the detection and matching process; if activated, the resolution of the images is divided by the resolution factor during the feature detection and matching process, thus allowing to ‘trade accuracy for speed’.
Remark: the resolution of the final mosaic will not be affected by this option.

* Lowe, D.G. 2004. Distinctive Image Features from Scale-invariant Keypoints. *International Journal of Computer Vision*, 60 (2), p91–110.

Outlier rejection control: the outlier rejection helps to discard erroneous links between pairs of images. The sensitivity of the outlier rejection can be controlled by the following parameters:

- **Maximum sum of square residuals:** matches for which the sum of square residuals is higher than the threshold defined here will be rejected (outliers);
- **Minimum 'inliers/matches' ratio:** inliers are retained only if the ratio of inliers by the total amount of matches is higher than this threshold value. Lowering this value can significantly increase the number of matched pairs of images; however, such pairs should be visually checked to ensure that no erroneous link remains.
- **Threshold for correlation coefficients:** Threshold value used to filter out any remaining outlier, based on the correlation coefficients of the selected inliers. The correlation is based on the squared distance between each link to all other links on both images of the pair. Any value between 0 (low correlation) and 1 (high correlation).
- **Threshold for deviation error:** Threshold value used to filter out any remaining outlier, based on the deviation error of the selected inliers. The idea is that the squared distances (between each match to all other matches) of image 1 plotted against the squared distances of image 2 should ideally align along the regression line $y = x$. In this context, the *deviation* is the absolute value of the difference between the squared distances of images 1 and 2. Any value above 0.
- **Max. number of matches for full outlier rejection:** The full outlier rejection process (i.e. RANSAC + filtering by correlation + filtering by deviation estimation) can be an extremely slow process if the amount of matches is large. However, the full outlier rejection is mostly needed when the amount of matches is low, i.e. when the RANSAC alone may fail to eliminate every outlier, and that additional filtering is required. Therefore, in case of large amounts of matches, the outlier rejection can be significantly sped-up by turning off the additional filtering (correlation and deviation estimation), and by applying the RANSAC only. This option is controlled here by setting a minimum number of matches, above which the RANSAC only will be applied. Any value equal to or above 4 (or '-1' to deactivate this option).
- **Minimum number of matches:** Minimum number of matches to select during the outlier rejection (if this number cannot be reached, then the link is discarded). Any value equal to or above 4.
- **Size of subsets for RANSAC:** Number of matches to use in each subset for the homography estimation during the RANSAC outlier rejection (it is only used for the outlier rejection, not for the image registration). Any value equal to or above 4.
- **Number of trials for RANSAC:** Number of trials to perform during the RANSAC outlier rejection (high value = better but slower outlier rejection). Any value equal to or above 1.

Weighting coefficients for linear global registration: the global registration consists in minimizing the total residuals from all links and all images of the mosaic. When all images are linked together this method allows to compute for each image the best homography, i.e. the homography that leads to the lowest global error.

- **Unmatched pairs (wf1):** this coefficient controls the weight of the unmatched pairs of consecutive images (i.e. image pairs of the image sequence for which the automatic feature detection matching failed between non-consecutive images; in such case, the image alignment uses the navigation data). When $wf1 = 1$, *unmatched* and *matched* pairs have the same weight.
- **Image rigidity coefficient (wf2):** this coefficient controls the level of distortion of the images (higher number = lower distortion).

Non-linear registration parameters: It is possible to put constraints on the camera pitch, roll and altitude in order to prevent aberrations in the non-linear solution.

- **Similarity transforms / Projective transforms:** The 'similarity transforms' (4 DoF) mode will optimised four pose parameters (eastings, northings, altitude, heading). The 'projective transforms' (8 DoF) will optimise all six pose parameters (eastings, northings, altitude, heading, pitch, roll).
- **Maximum pitch/roll angles:** these values constrain the non-linear registration by ensuring that optimised pitch and roll angles do not exceed the maximum pitch/roll angles. It helps prevent the non-linear optimisation to yield to converge towards an unrealistic solution. The maximum pitch/roll angles must be given in degrees.
- **Maximum altitude:** this value constrains the non-linear registration by ensuring that optimised altitude values do not exceed the maximum altitude value. It helps prevent the non-linear optimisation to yield to converge towards an unrealistic solution. The maximum altitude must be given in metres.
- **Maximum number of iterations:** maximum number of iterations of the non-linear optimisation. If the non-linear registration actually reaches the maximum number of iteration, you may consider increasing this value to yield finer results.

3.4 Navigation data

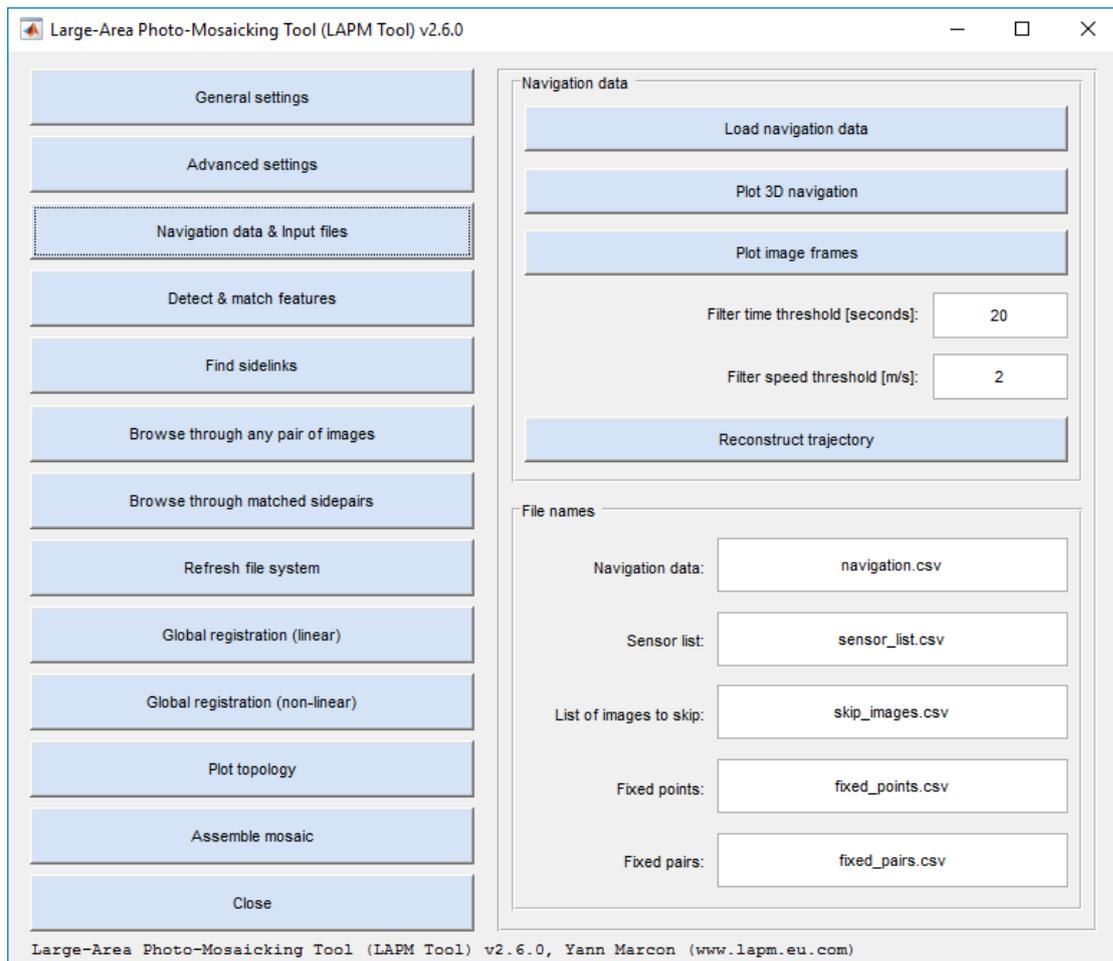


Figure 3.3. GUI of the 'Navigation data' menu.

Navigation data:

- **Load navigation data:** reads the navigation file and load the navigation data into the program.
- **Plot 3D navigation:** select this option to visualize the navigation data. This is useful to check that the navigation data was correctly loaded or to check the quality of the trajectory reconstruction.
- **Plot image frames:** select this option to visualize the topology of the mosaic, based on the navigation data only. This is useful to check that the navigation data was correctly loaded or to check the quality of the trajectory reconstruction.
- **Filter time threshold [seconds]:** the time threshold is used to filter the navigation data based on the time-lag between two data points. Whenever a pair of consecutive points has a time-lag that is higher than the time threshold, the navigation dataset is split in individual segments. The smoothing is then applied to each segment independently.

- **Filter speed threshold [m/s]:** the speed threshold is used to filter the navigation data based on the speed. For instance, if the speed necessary to move from A to B is higher than the speed threshold, then the point B is filtered out and re-interpolated.
- **Reconstruct trajectory:** select this option to filter and smooth the navigation data, based on the defined time and speed thresholds.

File names: define here the name of the different input files. All files must be located in the project folder (cf. Chapter 4 for details about the file formats).

3.5 Match selector

The 'match selector' is the interface, which allows the user to visualize and edit all links within any pair of images. To start the match selector, select either '**Browse through pairs of images**' or '**Browse through matched sidepairs**'. Several actions can be done from this interface:

- To generate new automatic links in a pair of images, select 'Automatic matches'. This will erase any prior 'automatic' links within the pair and generate new ones. All 'manual' links are left untouched.
- To visualize existing links (both automatic and manual), select 'Display current matches'.
- To delete a link, first select it (left-click) and then right-click on it.
- To create a new link, first make sure that the existing matches are hidden (the ability to create a link is disabled when links are displayed). Then select the desired point on the left image first and then on the right image. The link will appear.

The '**Browse through matched sidepairs**' option allows the user to browse through the existing sidelinks only. This is useful to quickly review the quality of the sidelap/crossover matching.

Important: do not forget to save changes before moving to the next pair of images, otherwise any manual change will be lost.

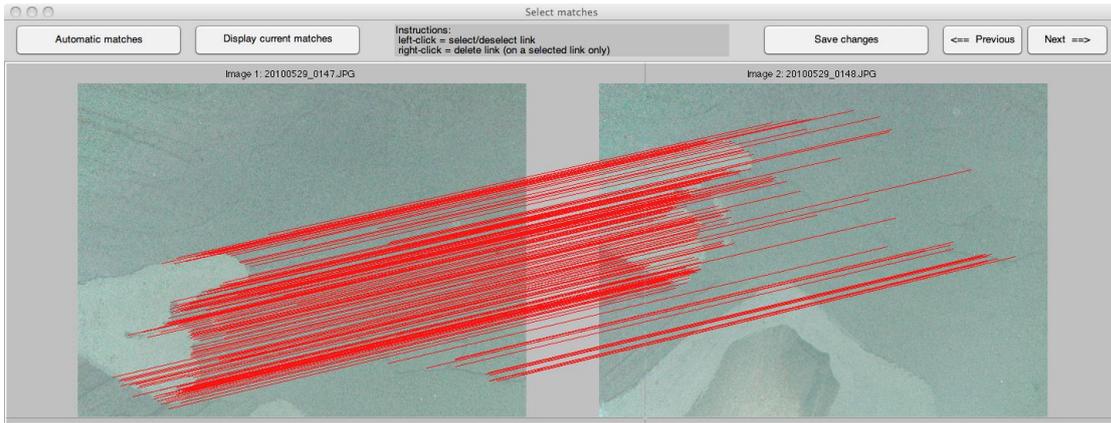


Figure 3.4. Interface of the match selector. Links can be manually edited.

3.6 Plot topology

The 'plot topology' option allows visualizing the mosaic topology, either from the navigation data or from the linear and non-linear global registrations. The topology is plotted both in metres and in pixels. This is useful to ensure that the overall shape and dimensions of the mosaic are correct before starting the actual construction of the mosaic files (which can take a very long time).

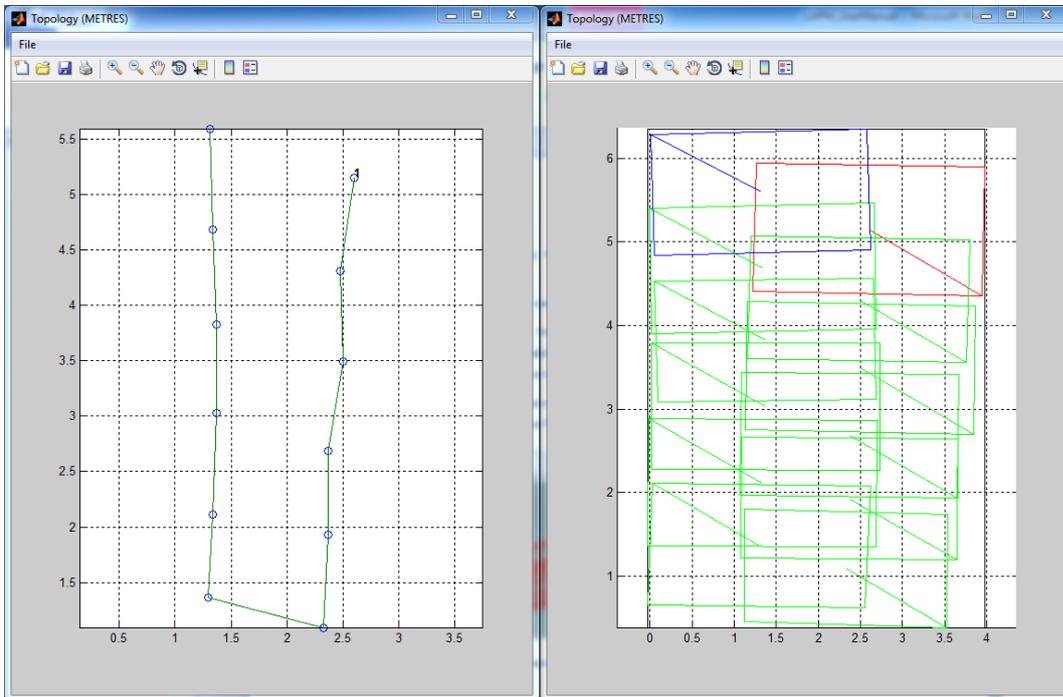


Figure 3.5. View of the plotted topology. Left: centre point of each image, together with image numbers (every 25 numbers). Right: frame of transformed images on the mosaic plane. The red and blue frames indicate respectively the first and last images of the mosaic. In each frame, the *half-diagonal* line points towards the top-left corner of the image. Units are in metres.

Chapter 4 Format of the input files

4.1 Images

Input images must be either in the JPEG or TIF format. Image filenames *must* contain the date- and time-stamps, and be named according to the following format:

x...x_YYYYMMDD_hhmmssddd_x...x.jpg

With **x** = alphanumeric character, **YYYY** = year, **MM** = month, **DD** = day, **hh** = hours, **mm** = minutes, **ssddd** = seconds with three decimals (fill with zeroes if decimals are not known).

Example: **M832_20100331_180721120_img00003.tif** corresponds to a photo taken at 18:07:21.12 on March 31st, 2010.

4.2 Sequence file

The sequence file must be a comma-separated (.csv) file with one column:

Line 1+ column 1: filename with extension (but without path); filenames must be sorted in the order, in which the images should be mosaicked.

Remark: the sequence file (and not the navigation file) determines the order of the images.

Important: the sequence file must be defined **before** starting the project and it **must not** be changed afterwards. Any later change in the sequence file will mess up the file system. If the sequence file has to be changed, then a new project should be created.

4.3 Navigation file

The navigation file must be a comma-separated (.csv) file, with ten columns. It must be placed in the project folder. The structure of the navigation file is as follow:

Line 1: header row.

Example of header row:

Filename,latitude,longitude,depth,altitude,heading,roll,pitch,sensor_id,focal

Line 2: unit row: for each column, units should be given in squared brackets (see below).

Example of unit row:

String,[dd],[dd],[m],[m],[rad],[rad],[rad],integer,[mm]

Line 3+ column 1: filename with extension but without path (string, no unit).

Line 3+ column 2: latitude in decimal degrees [dd].

Line 3+ column 3: longitude in decimal degrees [dd].

Line 3+ column 4: depth ([m] or [mm]); this field is not necessarily used but the column is

required (fill it in with zeroes if the depth data is not available)

Line 3+ column 5: altitude ([m] or [mm]).

Line 3+ column 6: heading ([deg] or [rad]).

Line 3+ column 7: roll ([deg] or [rad]).

Line 3+ column 8: pitch ([deg] or [rad]).

Line 3+ column 9: sensor ID (integer, no unit); for each image, provide here the ID number of the camera sensor. The ID number refers to the first column of the **sensor list file**.

Line 3+ column 10: focal length ([mm] or [m]); this column allows the user to provide a different focal length for each image. Set this field to zero to use the lens focal length provided in **sensor list file**.

4.4 Sensor list file

The sensor list file must be a comma-separated (.csv) file, with fifteen columns. It must be placed in the project folder. The structure of the navigation file is as follow:

Line 1: header row.

Example of header row:

Sensor.id,platform,camera.name,sensor.width,sensor.height,sensor.principalpointX,sensor.principalpointY,sensor.width,sensor.height,sensor.focal,offset.longitudinal,offset.transversal,offset.vertical,offset.roll,offset.pitch,offset.heading,comments

Line 2: unit row: for each column, units should be given in squared brackets (see below).

Example of unit row:

Integer,string,string,[pixels],[pixels],[pixels],[pixels],[mm],[mm],[mm],[m],[m],[m],[rad],[rad],[deg],string

Line 3+ column 1: sensor ID (integer, no unit).

Line 3+ column 2: name of platform on which the camera is mounted (text string without comma).

Line 3+ column 3: name/type of the camera (text string without comma).

Line 3+ column 4: width of the camera sensor in pixels [pixels].

Line 3+ column 5: height of the camera sensor in pixels [pixels].

Line 3+ column 6: principal point X of the camera sensor in pixels [pixels].

Line 3+ column 7: principal point Y of the camera sensor in pixels [pixels].

Line 3+ column 8: width of the camera sensor in metrics ([m] or [mm]).

Line 3+ column 9: height of the camera sensor in metrics ([m] or [mm]).

Line 3+ column 10: focal length of the camera lens ([m] or [mm]).

Line 3+ column 11: longitudinal offset ([m] or [mm]).

Line 3+ column 12: transversal offset ([m] or [mm]).

Line 3+ column 13: vertical offset ([m] or [mm]).

Line 3+ column 14: roll offset ([deg] or [rad]).

Line 3+ column 15: pitch offset ([deg] or [rad]).

Line 3+ column 16: heading offset ([deg] or [rad]).

Line 3+ column 17: comments (text string without comma).

Columns 9 to 14 contain the ***decentring parameters of the camera***: navigation (easting, northing, altitude) and attitude (pitch, roll, yaw) data generally describe the position and direction of the positioning sensor of the platform (ROV, AUV, etc.), and not that of the camera. In order to optimize the quality of the mosaic, information about the position of the camera in relation to the positioning sensor can be provided.

- **Longitudinal offset [m]**: longitudinal offset of the camera in relation to the positioning sensor. The longitudinal axis is directed towards the front (i.e. positive values towards the front side of the platform).
- **Transversal offset [m]**: transversal offset of the camera in relation to the positioning sensor. The transversal axis is directed towards the starboard side (i.e. positive values towards the right side of the platform).
- **Vertical offset [m]**: vertical offset of the camera in relation to the positioning sensor. The vertical axis is directed downwards (i.e. positive values towards the bottom of the platform).
- **Roll offset [rad] or [deg]**: angular offset of the sensor around the longitudinal axis (x-axis) of the platform. Positive roll angles are clockwise, i.e. camera optical axis rotates towards port side (left) around longitudinal axis.
- **Pitch offset [rad] or [deg]**: angular offset of the sensor around the transversal axis (y-axis) of the platform. Positive pitch angles are clockwise, i.e. camera optical axis rotates towards front of platform around transversal axis.
- **Heading offset [rad] or [deg]**: angular offset of the sensor around the vertical axis (z-axis) of the platform. Positive heading angles are clockwise, i.e. camera orientation rotates starboard side (left) around z axis towards.

4.5 List of images to skip

The list of fiducial points must be given in a comma-separated text file, and placed in the same folder as the images. The structure of the file must be as follow:

One line per point. Lines can contain up to 1 column.

Line 1+ column 1: number of image to skip (according to the order given in the sequence file).

4.6 List of fiducial points

The list of fiducial points must be given in a comma-separated text file, and placed in the same folder as the images. The structure of the file must be as follow:

One line per point. Lines can contain up to 5 columns.

Line 1+ column 1: image number (according to the order given in the sequence file).

Line 1+ column 2: (optional) horizontal coordinate in pixels; the coordinate [1 1] corresponds to the centre of the top-left pixel of the image.

Line 1+ column 3: (optional) vertical coordinate in pixels; the coordinate [1 1] corresponds to the centre of the top-left pixel of the image.

Line 1+ column 4: (optional) latitude of the point (in decimal degrees).

Line 1+ column 5: (optional) longitude of the point (in decimal degrees).

Remark: If columns 2 to 5 are not defined, fiducial point will be applied to the central pixel of the image, and its position will be assessed from the navigation data.

4.7 List of fiducial pairs

The list of fiducial pairs must be given in a comma-separated text file, and placed in the same folder as the images. The structure of the file must be as follow:

One line per image pair. Lines can contain up to 2 columns.

Line 1+ column 1: number of image 1 (according to the order given in the sequence file).

Line 1+ column 2: number of image 2 (according to the order given in the sequence file).

Chapter 5 LAPM Toolbar/Toolbox for ArcGIS

LAPMv2 is provided with both the *LAPM Toolbar for ArcGIS* and the *LAPM Toolbox for ArcGIS*. Both are aimed at facilitating the import of the output of LAPMv2 into ArcGIS. Loading rasters into an ArcGIS Mosaic Dataset normally requires several steps (creating a file geodatabase, creating a mosaic dataset, defining the no data value, setting the mosaic parameters, constructing the overviews, building the footprints and boundaries, etc.). In the case of very large photomosaics with hundreds or thousands of Geotiff images, each of these steps may take a long time.

The LAPM Toolbar and Toolbox for ArcGIS allow the user to batch these steps into one single process. Therefore, both the toolbar and the toolbox offer similar functionalities. The main difference is that the toolbar is dockable into the ArcGIS menu bar.

5.1 LAPM Toolbar for ArcGIS

The LAPM Toolbar for ArcGIS is an ESRI add-in file (.esriaddin). The installation of the LAPM Toolbar for ArcGIS can be done either by double-clicking on the *LAPMToolbar.esriaddin* file, or by importing it directly from ArcMap (menu: *Customize* → *Add-In Manager*). Finally, in order to display the toolbar within ArcMap, go to the menu: *Customize* → *Toolbars* → *LAPM Toolbar*.

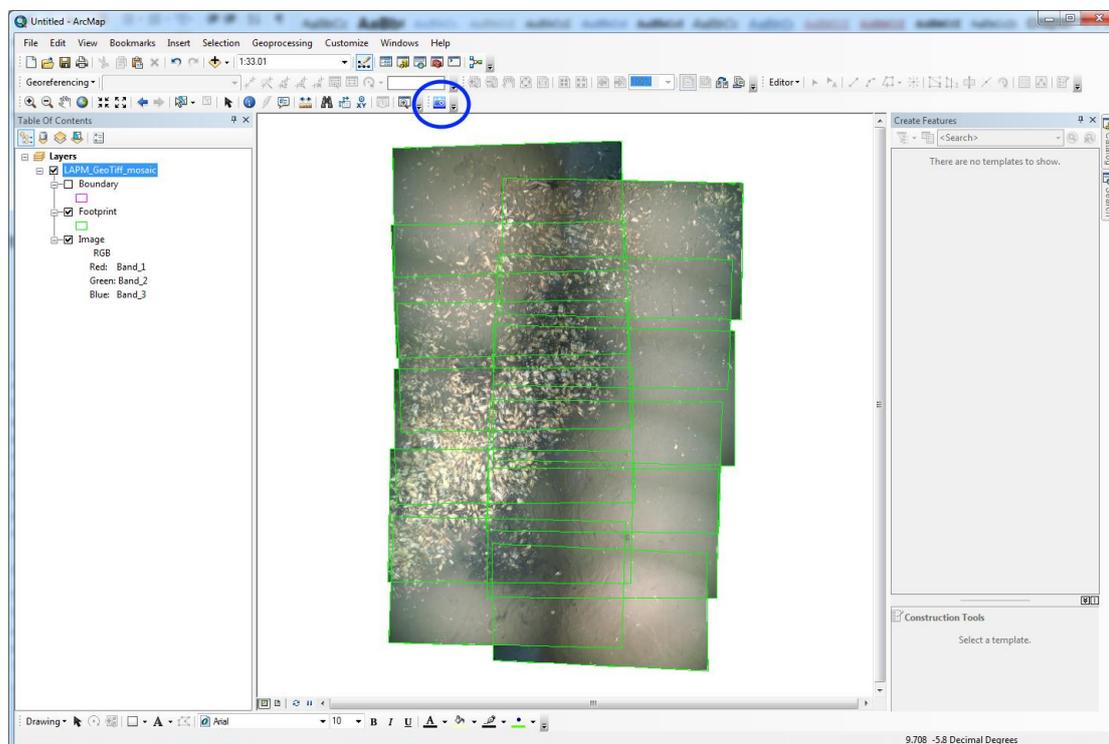


Figure 5.1. Example of a mosaic dataset as produced by the LAPM Toolbar. The blue circle shows the LAPM Toolbar for ArcGIS.

The toolbar comes with the following option:

- **LAPM Tool → Mosaic Dataset:** Imports all rasters contained within the given folder into a Mosaic Dataset. Raster pyramids are not computed.

Remark: in order to display the progress of the mosaic import, it is recommended to open the 'Python window' of ArcGIS (menu: *Geoprocessing → Python*) **before** starting the import.

5.2 LAPM Toolbox for ArcGIS

The LAPM Toolbox for ArcGIS can be installed as follow:

- in ArcMap or ArcCatalog, go to menu: *Geoprocessing → ArcToolbox*,
- right-click on *ArcToolbox → Add Toolbox*,
- select the LAPM Toolbox.

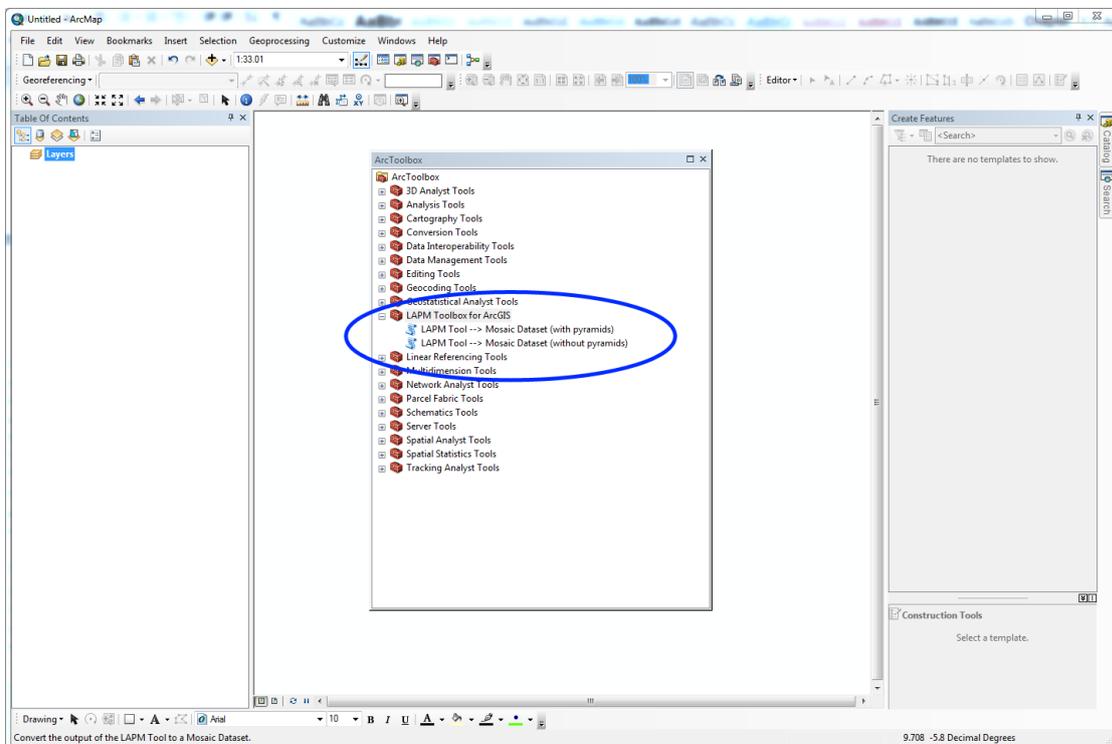


Figure 5.2. Menu of the LAPM Toolbox for ArcGIS.

The toolbox comes with the following options:

- **LAPM Tool → Mosaic Dataset (with pyramids):** computes pyramids for all rasters contained within the given folder and imports the rasters into a Mosaic Dataset.
- **LAPM Tool → Mosaic Dataset (without pyramids):** Imports all rasters contained within the given folder into a Mosaic Dataset, without computing the pyramids. In the case of large photomosaics, this method may be significantly faster.