MEANDER STATISTICS TOOLBOX (MStaT v1.1) – USER'S MANUAL

Introduction

Meander Statistics Toolbox (MStaT) is a standalone software designed for comprehensive characterization of the planform geometry of meandering channels. MStaT allows to analyze a large number of geometric variables of the meandering planform such as arc-wavelength, sinuosity, curvature, amplitude, inflection point, among others. It also performs a Wavelet Transform type analysis to obtain a power spectrum of meandering signals. Applications of the toolbox includes i) re-meanderization of channelized streams, ii) analyzing the influence of sinuosity on surface water and groundwater interrelationship, iii) designing in/near stream infrastructures.

MStaT offers three independent modules: 1) Meander Morphometric Module, 2) Migration Module and 3) Confluence Module. Meander Morphometric Module characterizes the planform geometry and analyzed the meandering signal. Migration Module calculates the lateral migration rate and analyzes the migration signature. Confluence Module quantifies the influence of the tributary stream on the planform geometry of the main channel.

This user manual provides detailed guidance to run MStaT software, including installation, setup and preparation procedures, and to perform analyses using the three modules.

SETUP

- Download and install MATLAB Runtime version 9.0 (R2015b) at http://www.mathworks.com/products/compiler/mcr/index.html (Administrator right is required to run MCRInstaller).
- Download latest version of MStaT from LINK HERER. Open the folder named “for redistribution” and run the application (.exe file).
- Although MStaT software is available only for Windows x64 environment, MATLAB source code is made available at GitHub (https://github.com/ldominguezruben/mstat) for users with other OS environments.

1. MStaT MENUBAR

Menu bar of MStaT software is shown in Figure 1. In the menu bar, buttons for creating new project, opening input file, saving current project, measurement ruler, zoom in, zoom out, pan and data cursor tool are provided.

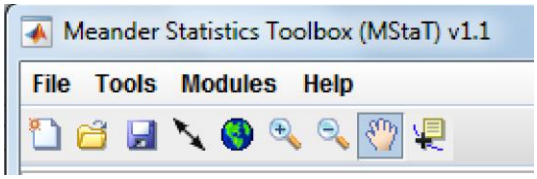

Figure 1.- Menu toolbar of MStaT.

File tab allows to start new project (New), open input files of centerline coordinates for analysis (Open), export results (Export) and close the software (Close). More guidance on opening files is provided in the later section.

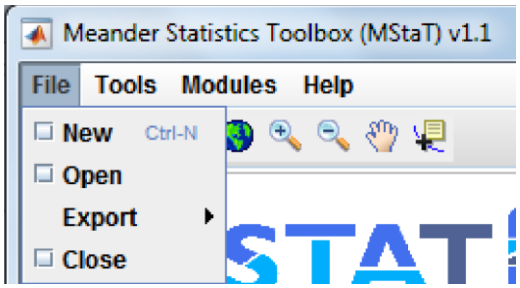

Figure 2.- Menu toolbar: File tab.

Tools tab provides advanced analysis tools (River Statistics, Wavelet Analysis) and allows to add background image (Add Background Image). Note that these tools are available only for Meander Morphometric Module, which is the default module of MStaT. More description of the tools is provided in the later section.

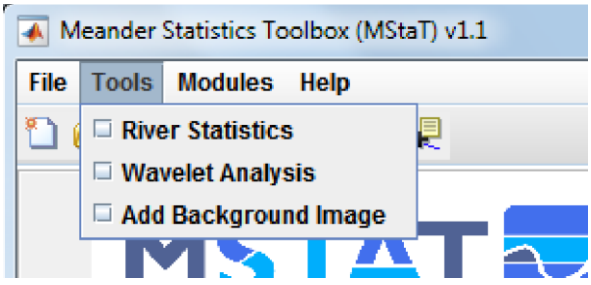

Figure 3.- Menu toolbar: Tools tab.

Module tab allows to select module that the user wishes to run. Meander Morphometric Module is set as the default module, and Migration Module and Confluence Module can be accessed through Module tab.

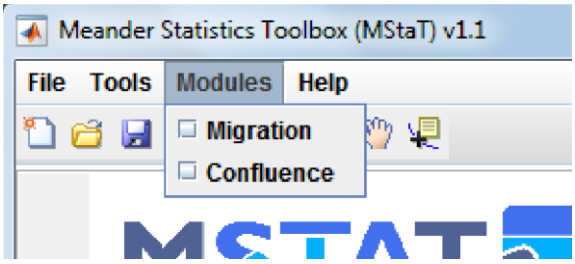

Figure 4.- Menu toolbar: Modules tab.

Help tab provides access to MStaT manual (Users Guide) and to blog website with the latest software updates (Check for Updates; https://meanderstatistics.blogspot.com/).

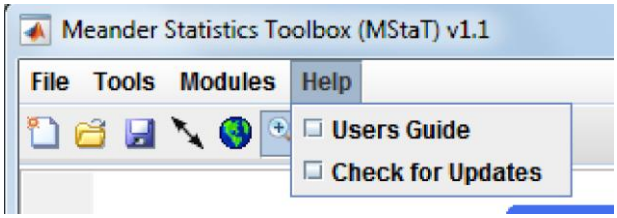

Figure 5.- Menu toolbar: Help tab.

2. Open file

Centerline coordinates are imported following the procedure presented below. Multiple files can be imported at the same time.

- Click on File tab and select Open. This opens a new panel.
- Select the file(s) that contains centerline coordinates of the study reach in the formats of .txt, .xls, .xlsx or .kml. Multiple fines can be selected.
- Once centerline file is selected, the coordinate system needs to be specified. MStaT accepts Projected UTM and Geographic WGS 84 coordinate systems.
- Enter the average width of the study reach. If multiple inputs are provided, the average width needs to be specified for each file.
- The input panel allows to add or delete files with + and - buttons.

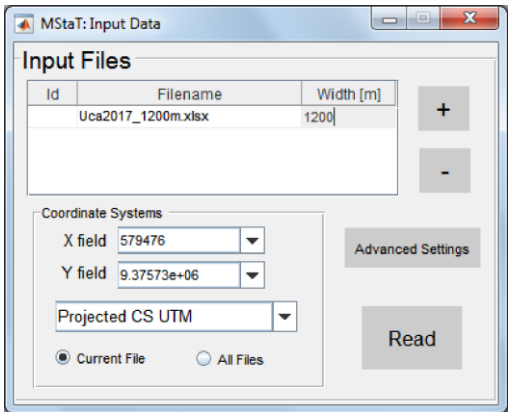

Figure 6.- Input panel of MStaT.

- Click Advanced Settings if the user wishes to modify settings for smoothing of the centerline.
    - In the advanced setting, the user can specify the average width, centerline decomposition level (= 5 by default), polynomial order for centerline smoothing (= 3 by default), number of windows for smoothing (= 7 by default), and number of points analyzed. A window on the right visualizes the processed centerline, as well as the raw centerline.
    - Click Save & Close to finalize the modification and close the advanced setting.
- Once all is complete, click Read button to import the centerline file.

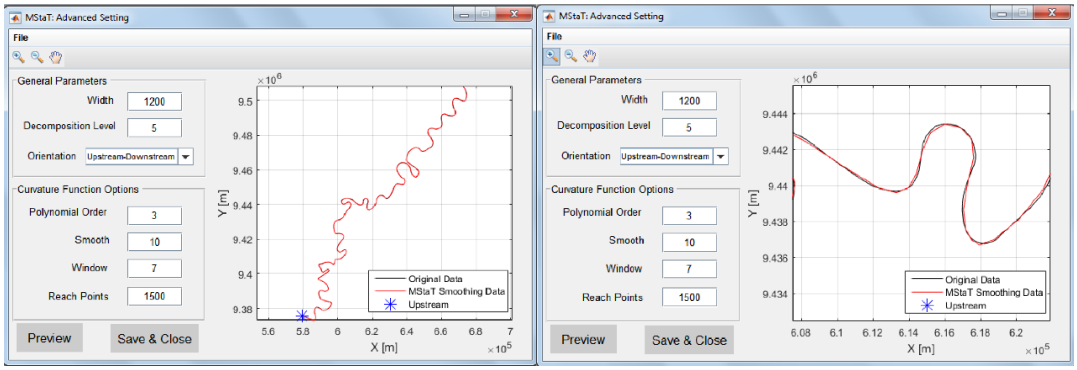

Figure 7.- Advanced setting.

All example cases can be found and downloaded from https://github.com/ldominguezruben/mstat/examples.

3 Run MStaT: Open file, Run module and Visualize results

3.1 Meandering Morphometric Module

The window shows the i) centerline (Equally Spaced Data), ii) points of inflection (Inflection Points), iii) a line connecting the inflection points (Inflection Line), iv) points of maximum curvature of each meander bend (Maximum Curvature Points) and v) a point indicating the upstream end (Upstream).

In the right side of the window, the user can specify the meander bend for detailed inspection by selecting the ID of the bend and clicking Go button. The parameters that are considered are:

- Sinuosity
- Arc-wavelength
- Wavelength
- Amplitude
- Upstream Length (distance between upstream inflection point and max curvature point)
- Downstream Length (distance between downstream inflection point and max curvature point)
- Meander orientation

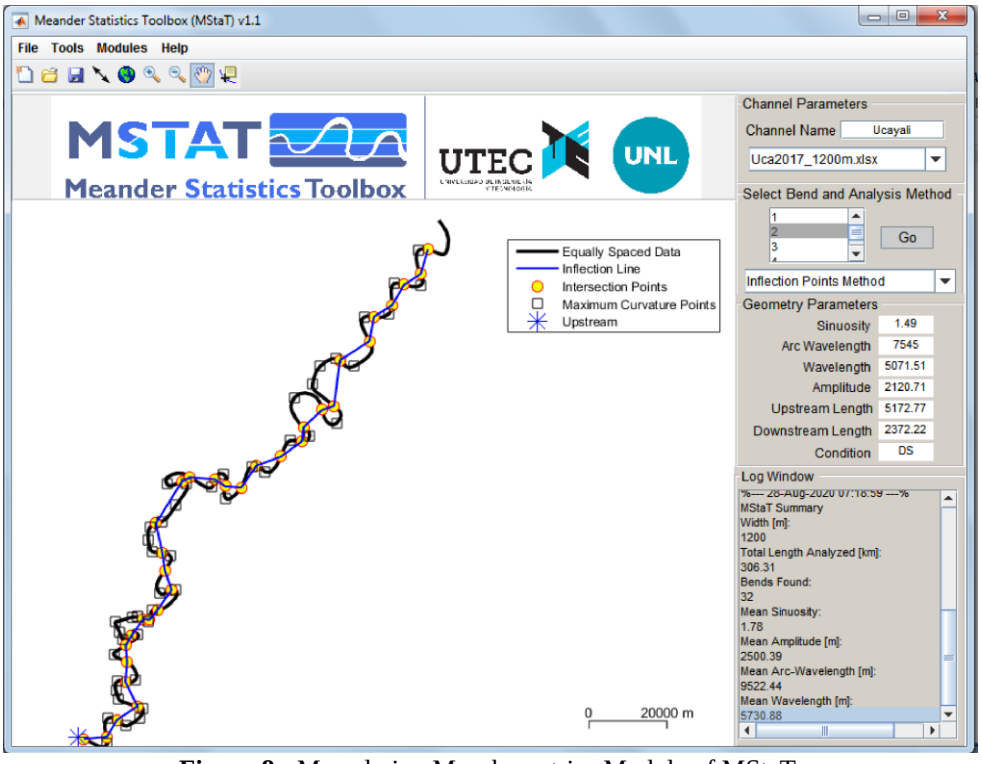

Figure 8.- Meandering Morphometrics Module of MStaT.

3.1.1 Tools

Tools tab provides two advanced analysis tools: River Statistics tool and Wavelet Analysis tool, as well as a tool that allows to insert back ground image (Add Background Image).

3.1.1.1 River Statistics

This tool generates a table with the planform geometry parameters of all the meander bends detected. The table can be exported in Excel® file for further analysis.

MStaT: Statistic Variables

Export

	Bend ID	Sinuosity	Arc Wavelenght [m]	Wavelength [m]	Amplitude [m]	Condition	Upstrem Length [m]	Downstream Length [m]
1	1	1.4600	8.7230e+03	5.9682e+03	1.8475e+03	DS	6.7425e+03	1.9805e+03
2	2	1.4900	7545	5.0715e+03	2.1207e+03	DS	5.1728e+03	2.3722e+03
3	3	1.7700	1.1191e+04	6.3054e+03	2.7803e+03	C	NaN	NaN
4	4	1.7500	1.2253e+04	6.9819e+03	3.4928e+03	C	NaN	NaN
5	5	1.6700	8.4248e+03	5.0489e+03	2.5658e+03	US	2.9426e+03	5.4822e+03
6	6	1.8300	8.0396e+03	4.3846e+03	3.2426e+03	US	3.8804e+03	4.1592e+03
7	7	2.2400	6.5199e+03	2.9099e+03	1.0840e+03	DS	4.7066e+03	1.8133e+03
8	8	2.9000	1.4981e+04	5.1665e+03	5.3996e+03	C	NaN	NaN
9	9	1.3200	2.1292e+03	1.6103e+03	600.3600	DS	1.3241e+03	805.0600
10	10	1.2100	3.9010e+03	3.2312e+03	995.6000	DS	2.5629e+03	1.3381e+03
11	11	1.4600	9.0983e+03	6.2286e+03	860.2900	DS	7.9219e+03	1.1764e+03
12	12	1.8700	1.0031e+04	5.3692e+03	3.1642e+03	US	3.5226e+03	6.5081e+03
13	13	1.4000	6.5432e+03	4.6696e+03	1.8369e+03	DS	4.3080e+03	2.2352e+03
14	14	1.4500	1.0990e+04	7.5704e+03	2.8194e+03	C	NaN	NaN
15	15	1.2100	1.5092e+04	1.2495e+04	1.9432e+03	C	NaN	NaN
16	16	4.9400	1.2289e+04	2.4872e+03	1.3642e+03	US	4.0841e+03	8.2045e+03
17	17	1.3400	8.6791e+03	6.4791e+03	2.0652e+03	DS	6.5077e+03	2.1714e+03
18	18	2.0700	6.3985e+03	3.0957e+03	2.3336e+03	US	2.9926e+03	3.4058e+03
19	19	2.0300	8.5628e+03	4.2156e+03	3.1270e+03	US	3.2762e+03	5.2866e+03
20	20	1.0700	7.2414e+03	6.7463e+03	753.4000	DS	6.1910e+03	1.0503e+03
21	21	1.3400	9.0854e+03	6.7843e+03	2.2540e+03	US	2.7629e+03	6.3225e+03
22	22	1.1900	7.9457e+03	6.6986e+03	1.9332e+03	DS	4.8837e+03	3.0620e+03
23	23	1.5400	5.5916e+03	3.6358e+03	1.7924e+03	US	2.7234e+03	2.8682e+03
24	24	2.8800	1.8662e+04	6.4729e+03	7.1329e+03	US	8.7158e+03	9.9466e+03
25	25	3.5500	1.1569e+04	3.2578e+03	4.4120e+03	DS	6.1279e+03	5.4410e+03
26	26	1.6200	1.9029e+04	1.1760e+04	6.1514e+03	C	NaN	NaN
27	27	1.4600	1.3255e+04	9.0824e+03	3.2538e+03	US	4.4387e+03	8.8164e+03
28	28	1.4900	9.5170e+03	6.3874e+03	2.4587e+03	DS	6.9403e+03	2.5766e+03
29	29	1.1800	6.5555e+03	5.5487e+03	1.4078e+03	DS	4.1691e+03	2.3864e+03

Figure 9.- River Statistics summary of Morphometric Module MStaT.

3.1.1.2 Wavelet Analysis

The tool generates four figures for i) variation of normalized curvature along the centerline (Signature of the channel curvature; upper left), ii) planform of the centerline (River Centerline; upper right), iii) spatial pattern of wavelet spectrum of normalized arc-wavelength at the specified confidence percentile (Wavelet Spectrum; lower left) and iv) reach average wavelet spectrum of the normalized arc-wavelength (Global Wavelet Spectrum; lower right).

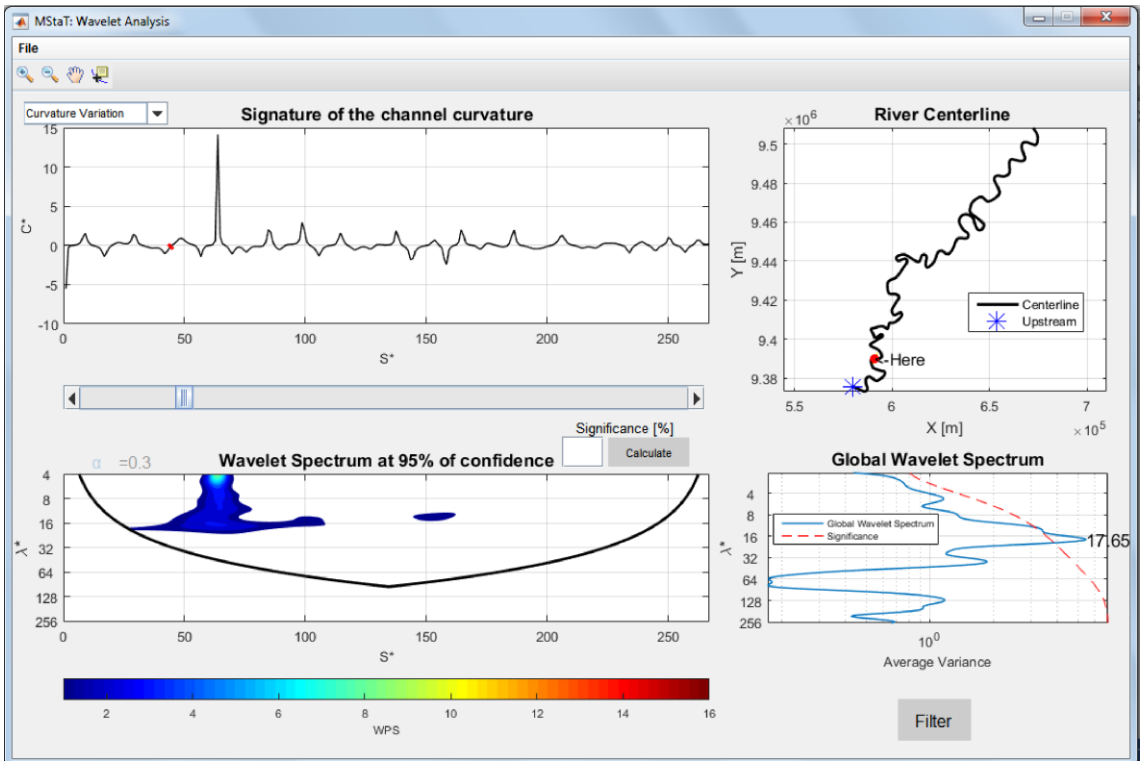

Figure 10.- Wavelet Analysis of Meandering Morphometrics Module MStaT.

Filter button lets the user to filter out meander bends according to the value of meander arc-wavelength and sinuosity from the wavelet analysis. The user can specify the minimum and maximum values of the arc-wavelength and sinuosity to be included in the analysis.

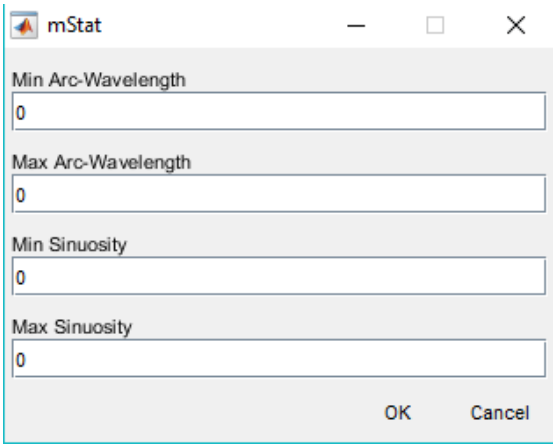

Figure 11.- Filter window of Wavelet Analysis of Meandering Morphometrics Module.

The figures generated in the wavelet analysis can be exported by selecting Export Figure as Graphics in File tab. Select the figure that the user wishes to save, then click Export button.

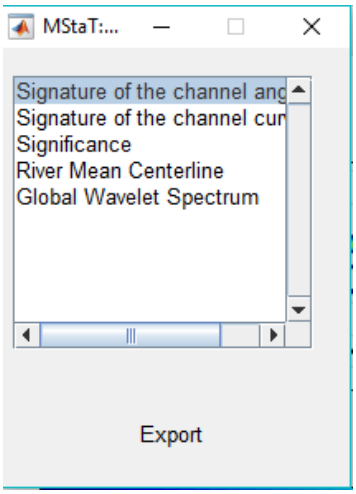

Figure 12.- Print and export window for the figures in Wavelet Analysis tool of Meandering Morphometric Module.

A new window appears, showing the figure selected. In this window the user can optionally add colorbar and legend to the figure.

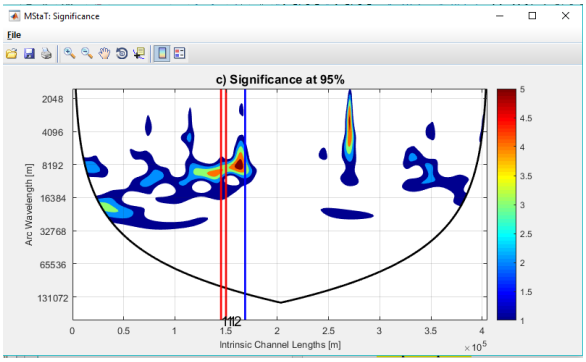

Figure 13.- Wavelet plot and export Wavelet Analysis of Meandering Morphometric Module MStaT.

The export settings can be modified at Export Setup in File tab. In the export setting window, size of the figure, color rendering, fonts and lines can be modified. The style configuration can be saved for future use. The saved style can be read by clicking Load bottun in the Export Styles at the bottom of the window.

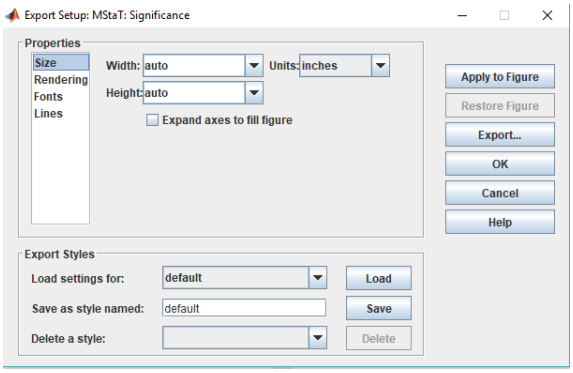

Figure 14.- Edition of Wavelet Analysis of Meandering Morphometrics Module MStaT.

To save the image, select Save As… in File tab, click save icon in the menu bar or click Export in the Export Setup window. The image can be saved as various image format, including JPEG and PNG formats (.jpg, .png), PDF format (.pfd), MATLAB figure format (.fig), vector format (.eps and svg) and tiff image format (.tif).

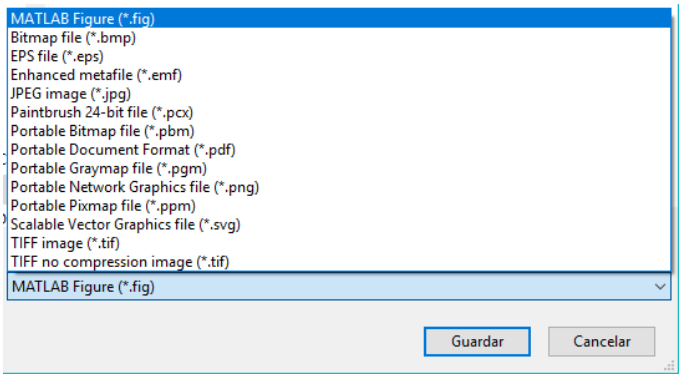

Figure 15.- Format file option of Wavelet Analysis of Meandering Morphometrics Module MStaT.

3.1.1.3 Background image options

A background image can be added to facilitate the analysis by clicking Add Background Image in Tools tab. The image must be in .tiff format and georeferenced with the same coordinate system as the centerline coordinates. Detailed information on preparing the background image is found at the following link (https://mdl.library.utoronto.ca/technology/tutorials/how-georeference-images-arcgis).

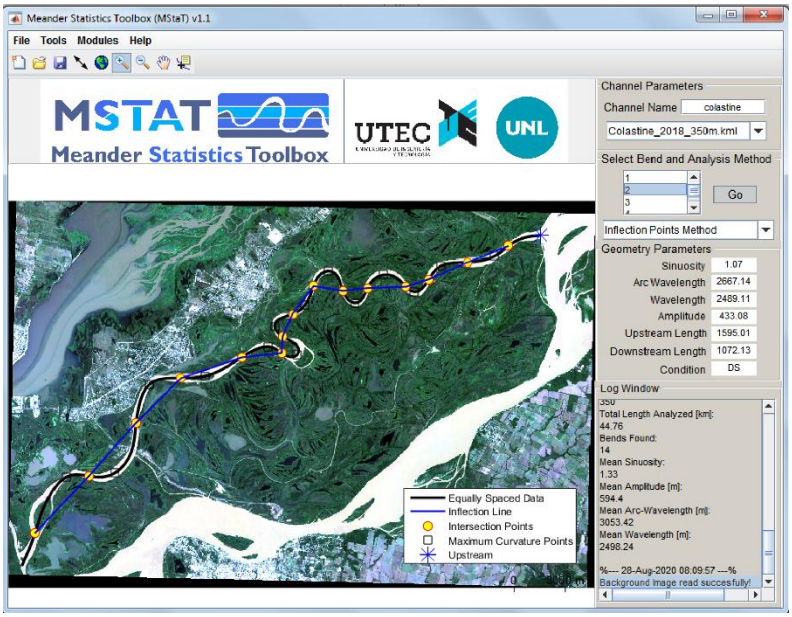

Figure 16.- Background image of Meandering Morphometrics Module MStaT.

3.1.1.4 Export output files

The results can be exported by selecting Export in File tab as the following file format:

- Matlab file (.mat),
- Excel file (.xls),
- KMZ File (.kmz) and
- Graphics (.tif).

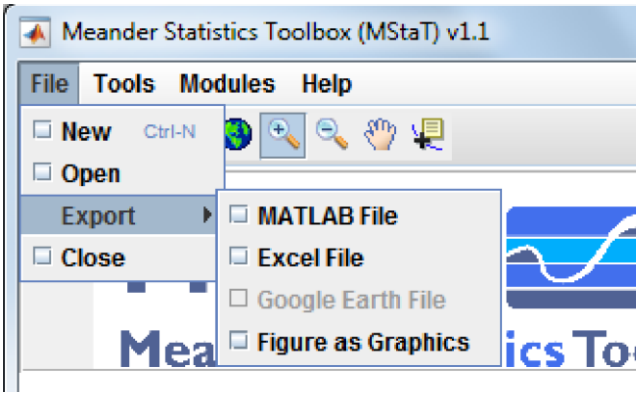

Figure 17.- Export Tools of Meandering Morphometrics Module MStaT.

3.2 Migration Module

The migration module is easily accessible through the initial menu (Figure 3). The incorporation of data must be carried out as indicated in Section 2. Once the geometric parameters of the incorporated signal have been set, it is necessary to indicate the year corresponding to the signals read. Remember that it is only possible to read 2 files at a time of analysis.

Additionally, the module allows to identify the cutoffs as well as the maximum migration registered for the analyzed period.

The graphics visualization of the module is divided into 3 axes where the incorporated signals (in coordinate system) are displayed along with the vectors generated by the migration of the signal. In addition, the migration per year is presented as the angle of orientation of this with respect to the north. Finally, the wavelet visualization of the signal resulting from the migration rate is presented (See Figure 18).

The module's possible export files are .mat and graphic files.

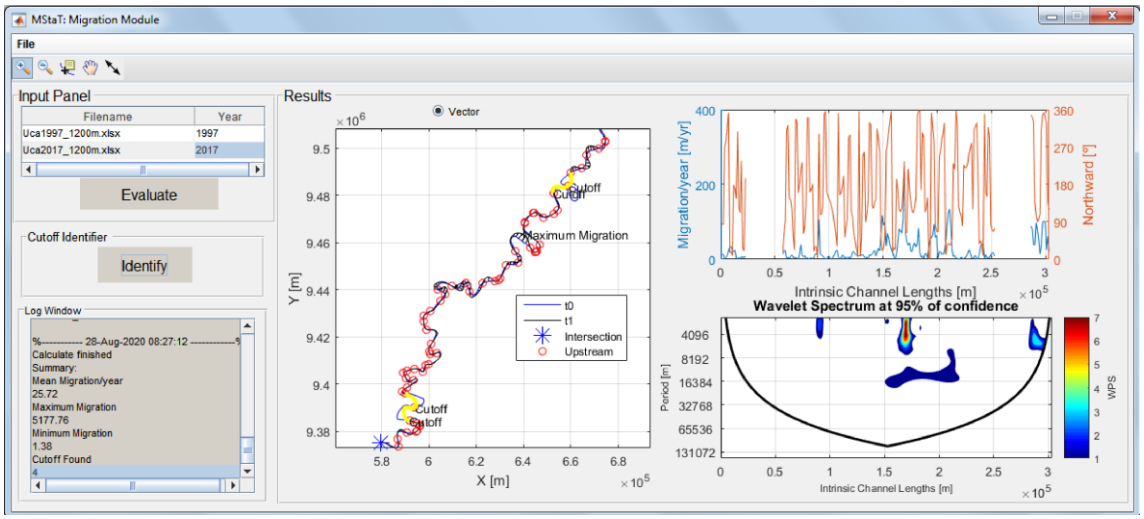

Figure 18.- Migration Module MStaT.

3.3 Confluence Module

The confluence module reads the files as indicated in Section 2. The minimum of files is two, one the main channel and the tributary. Remember that the files of each channel cannot be itemized. Once read it is necessary to identify the file class (Main or Tributary Channel). Once this is defined, the module gives as a result, among other variables, the confluence angle and the influencing distances of the tributary.

The output files are of type .mat and graphics.

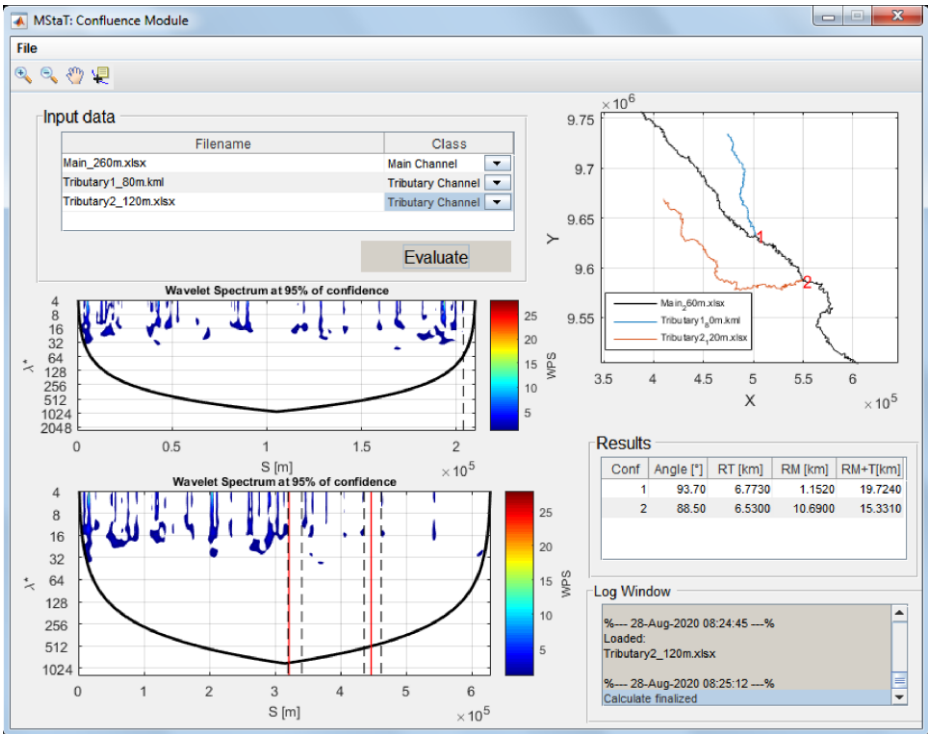

Figure 19.- Confluence Module MStaT.

4 Recommendations

- The input files should not be longer as this increases the calculation time significantly.
- The delta time for the Migration Module should not be prolonged to avoid errors in digitization and large changes in the morphology of the centerline.
- The Confluence Module is qualitative and allows us to have a preliminary result of the influence generated by a tributary on the main channel.
- The tributary channel must intercept the centerline of the main one so that the module can detect it as a confluence.